REPORT
74

GOVERNMENT OF
WESTERN AUSTRALIA

# MINERAL OCCURRENCES AND EXPLORATION POTENTIAL OF THE EAST KIMBERLEY

by L. Y. Hassan

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

DEPARTMENT OF MINERALS AND ENERGY

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L. Y. Hassan

Perth 2000

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**Cover photograph: Argyle AK1 mine and processing plant (photograph courtesy of Argyle Diamonds)**

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# Mineral occurrences and exploration potential of the east Kimberley

by

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## Abstract

Gold was discovered in the east Kimberley in 1885 and small quantities of gold have been produced intermittently since that time. Modern exploration of the area commenced in the 1950s and reached a peak during the late 1970s and early 1980s following the discovery of the world-class diamond deposit at Argyle. This exploration resulted in the discovery of platinum group element (PGE), nickel, rare earth element (REE), niobium, tantalum, fluorite, and base metal deposits.

The oldest tectonic units in the east Kimberley are the Palaeoproterozoic Lamboo Complex and Granites–Tanami Complex. The Lamboo Complex formed as a result of convergence and collision between the Kimberley and North Australian Cratons. Three north–northeasterly trending terranes have been identified in the Lamboo Complex: Eastern zone, Central zone, and Western zone. The Granites–Tanami Complex probably formed within the North Australian Craton. The complexes are overlain by a number of sedimentary basins, which range in age form Palaeoproterozoic to Devonian. The Halls Creek Orogen, which includes the Lamboo Complex and the deformed parts of various sedimentary basins, records periodic tectonism until the Carboniferous.

The three tectonostratigraphic zones of the Palaeoproterozoic Lamboo Complex show quite different styles and types of mineralization. Most of the gold mineralization is in the Eastern zone, where it is concentrated in the mafic volcanic and sedimentary rocks of the Biscay Formation, or in the immediately overlying sedimentary rocks of the Olympio Formation and its alkaline volcanic members (Butchers Gully Member and Maude Headley Member). In the Eastern zone, there is also significant REE–niobium–tantalum–tin–beryllium mineralization hosted by alkaline volcanic rocks of the Butchers Gully Member; base metal mineralization in distal volcaniclastic sedimentary rocks within the Biscay Formation; and stratabound tungsten mineralization, possibly volcanic exhalative in origin, hosted by the Ding Dong Downs Volcanics, Saunders Creek Formation, Biscay Formation, and Butchers Gully Member. In the Central zone, volcanogenic massive sulfide (VMS) deposits are hosted by the Koongie Park Formation, and possible porphyry copper mineralization is hosted by the Angelo Microgranite and the McHale Granodiorite. Layered mafic intrusions host PGE, chromite, and nickel–copper mineralization in the Central zone, and to a lesser extent in the Western zone.

Significant gold mineralization has recently been discovered in the Palaeoproterozoic Granites–Tanami Complex in the southeast of the area. Gold mineralization in the Larranganni area, including the Kookaburra deposit, has strong stratigraphic control, with the occurrences confined to two sequences of folded mafic volcanic and sedimentary rocks that have been informally named the Bald Hill sequence and the Quartz Ridge sequence. The relationship of these sequences to the stratigraphic succession in the Northern Territory is uncertain. Some gold mineralization is also associated with uranium at the unconformity between the Granites–Tanami Complex and the overlying Birrindudu Basin. The controls on mineralization in the newly discovered Coyote deposit are not yet clearly understood.

The c.1200 Ma diamondiferous Argyle AK1 lamproite pipe is related to a splay of the Halls Creek Fault, which is a major tectonic suture that has shown discontinuous movement since the Palaeoproterozoic. The Neoproterozoic Cummins Range Carbonatite (containing REE and tantalum) is located near the southern end of the Halls Creek Fault.

There is also a strong stratigraphic control on mineralization in some of the younger basins. Mississippi Valley-type mineralization is associated with Devonian reef complexes on the Lennard Shelf in the Canning Basin where zinc–lead–silver ore is currently mined at Kapok. Possible Mississippi Valley-type mineralization is also hosted by the Mesoproterozoic Bungle Bungle Formation in the Osmond Basin. There is minor native copper mineralization within amygdaloidal basalts of the Cambrian Antrim Plateau Volcanics. Copper mineralization of possible volcanic exhalative origin is widespread in interflow sedimentary rocks within the Carson Volcanics in the Palaeoproterozoic Kimberley Basin. Subeconomic copper mineralization of probable syngenetic origin is also widespread in the Teronis Member of the Elgee Siltstone and in shale at the base of the Middle Pentecost Sandstone in the Kimberley Basin.

Epigenetic base metal and fluorite mineralization in the Palaeoproterozoic Speewah Basin is associated with faults, possibly related to caldera collapse, and may be as young as Tertiary.

**KEYWORDS:** mineralization, exploration, Halls Creek Orogen, Lamboo Complex, Canning Basin, Granites–Tanami Complex, diamonds, gold, base metals, platinum group elements, nickel, chromite, tungsten, tin, rare earth elements, tantalum, niobium, beryllium, fluorite, uranium.

# Introduction

Until the discovery of diamonds at Argyle, and the commencement of mining of quartz-stockwork vein gold mineralization at Palm Springs, the east Kimberley area had the reputation for hosting scattered, small, non-economic mineral occurrences. The aim of this study is to show the distribution of reported mineralization and exploration activity in a GIS database, to relate the mineralization to the geological setting, and to highlight the prospectivity of the east Kimberley area for a range of different commodities and mineralization styles.

Details of mineral exploration, mineral occurrences, and other geoscientific information for the study have been compiled from the following sources:

- the large number of open-file statutory mineral exploration reports held in the Western Australian mineral exploration (WAMEX) database at the Department of Minerals and Energy (DME);
- the database of Western Australia's mines and mineral deposits information (MINEDEX) held at DME;
- information published in books, journals, company reports to shareholders, and on the internet;
- regional geological surveys, airborne geophysical datasets, and remote-sensing datasets.

The mineral prospectivity study of the east Kimberley has three main parts: this Report, Plates 1 and 1a of this Report, and a digital dataset on CD-ROM. This Report reviews the regional geology of the area, the history of mining and exploration, examples of mineral occurrences for each style of mineralization, the mineralization controls, and the potential for further discoveries. Where mineral occurrences are mentioned in the Report for the first time, they are also identified by the WAMIN 'deposit number' shown thus: Palm Springs (2223). It should be noted that the WAMIN deposit numbers given in this Report differ from WAMIN deposit numbers in Sanders (1999) because the database was moved from MS Access to an Oracle platform between the writing of the two reports.

Plates 1 and 1a show the mineral occurrences, indicating commodity and mineralization style, on a geological map showing solid geology with a simplified regolith overprint at 1:500 000 scale. The key to the mineral occurrences on Plates 1 and 1a is provided in Appendix 1.

The accompanying CD-ROM includes all the data used to compile the map and Report, and also includes files of geophysical, remote-sensing, and topographic data. The CD-ROM contains the files necessary for viewing the data in the ArcView GIS environment, and a self-loading version of the ArcExplorer software package modified to suit this particular dataset. Metadata statements on the geological, geophysical, and topographic datasets are also provided.

Appendix 2 defines the terms used in the Geological Survey of Western Australia (GSWA) mineral occurrence database (WAMIN) and exploration activity database (EXACT), and Appendix 3 gives a description of the digital datasets included on the CD-ROM.

# Location, land access, and physiography

This Report covers the east Kimberley area of Western Australia, which includes the LISSADELL*, DIXON RANGE, GORDON DOWNS, MOUNT RAMSAY, MOUNT BANNERMAN, and BILLILUNA 1:250 000 map sheets (Fig. 1).

The sealed Great Northern Highway runs through the area in an east-northeasterly direction. The other major access road in the area is the unsealed Duncan Highway, which joins the Great Northern Highway at Halls Creek, the major town in the area (population about 1300 in 1995). Station tracks also provide access to many parts of the area. More remote areas, especially in the southern part of the area, are best accessed by helicopter.

Pastoral stations, conservation reserves, and reserves for the use and benefit of aboriginal inhabitants occupy a large percentage of the area of the east Kimberley. Standard guidelines have been developed to cover mineral exploration and mining in the different types of conservation reserves, proposed conservation reserves, and other environmentally sensitive areas. These guidelines are summarized in the DME Information Series pamphlet no. 11 (Department of Minerals and Energy, 1995).

As well as the Mining Act 1978, all new tenements and exploration licence renewals are also subject to the legislation and procedures of the Commonwealth Native Title Act 1993, except where it is determined that the applications cover land where native title has been extinguished.

Most of the project area is a wide belt of rough country and low rounded hills between the Kimberley Plateau to the west and the Victoria River Plateau to the east. The southern part of the area is an almost flat plain forming part of the Sturt Plateau and Canning Plain. More detailed descriptions of the physiography are given in Dow and Gemuts (1969), Beard (1979), and Warren (1994a).

# Previous work

The first geological mapping in the East Kimberley area was carried out by Hardman (1885) who also reported on the potential for gold and other minerals. Woodward (1891) and Smith (1898) gave detailed descriptions of the gold workings. Talbot (1910) contributed to the knowledge of the geology of the area in his traverse of the country between the Tanami in the Northern Territory and Halls Creek. The first detailed maps of some of the gold mining centres and base metal and tin prospects were made by the Aerial, Geological and Geophysical Survey of Northern Australia (AGGSNA) in the late 1930s (Jones, 1938; Finucane, 1938a,b, 1939a,b; Finucane and Sullivan,

* Capitalized names refer to standard map sheets

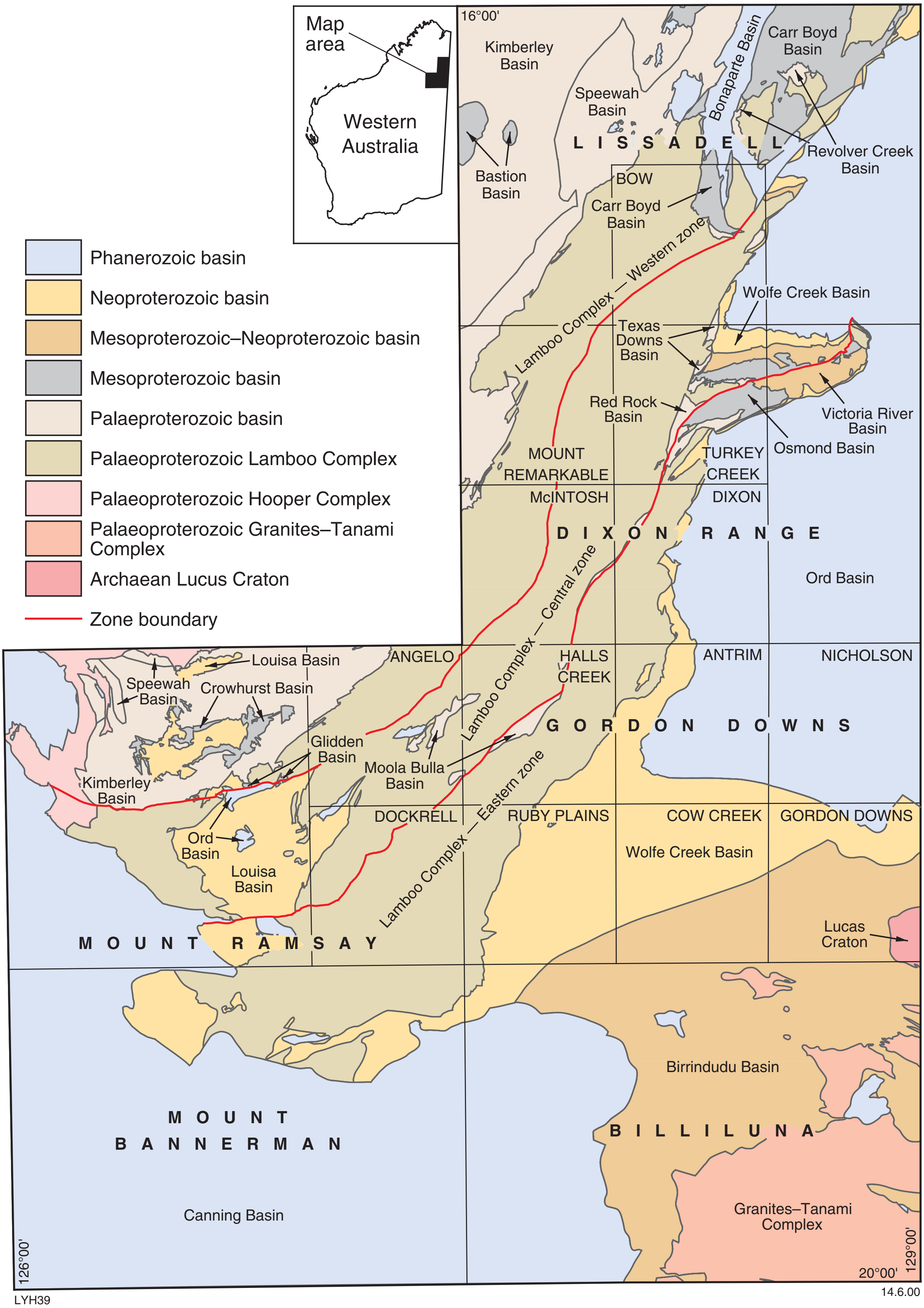


**Figure 1. Tectonic sketch map of the east Kimberley showing the tectonostratigraphic subdivision of the Lamboo Complex, the Granites–Tanami Complex, the Proterozoic and Phanerozoic basins, and published 1:100 000- and 1:250 000-scale map sheets (e.g. ANTRIM). Scale — 1 cm : 20 km (approximately)**

1939). Harms (1959) described the geology of the area and also gave descriptions of the gold, iron ore, chromium, uranium, base metals, tin, tungsten, and other mineral occurrences.

Geological mapping of the east Kimberley, at a scale of 1:250 000, was carried out jointly by the GSWA and the Bureau of Mineral Resources (BMR; now the Australian Geological Survey Organisation, AGSO) between 1962 and 1977. Maps include DIXON RANGE (Dow and Gemuts, 1967), LISSADELL (Plumb, 1968), GORDON DOWNS (Gemuts and Smith, 1968), MOUNT RAMSAY (Roberts et al., 1968), BILLILUNA (Blake et al., 1977), and MOUNT BANNERMAN (Yeates and Muhling, 1977). Dow et al. (1964) describes the geology of the Ord River area. A Bulletin on the geology of the east Kimberley and its mineral occurrences, with an accompanying 1:500 000 colour map, was compiled by Dow and Gemuts (1969), and Gemuts (1971) describes the metamorphic and igneous rocks of the Lamboo Complex.

During 1990–1995, part of the area was remapped at scales of 1:100 000 and 1:250 000 by GSWA and AGSO as part of the National Geoscience Mapping Accord (NGMA) Kimberley–Arunta Project. This mapping program included geochronological, whole-rock geochemical, petrological, and remote-sensing studies. The map sheets covered by this program are shown on Figure 1. Explanatory notes and maps have been published for the following 1:100 000 sheets: MOUNT REMARKABLE (Sheppard et al., 1997a), DOCKRELL (Tyler et al., 1998a), RUBY PLAINS (Blake et al., 1997), ANGELO (Griffin et al., 1998), and HALLS CREEK (Blake et al., 1999b). Maps only have been published for the following 1:100 000 sheets: ANTRIM (Blake and Warren, 1996), BOW (Sheppard et al., 1997b), TURKEY CREEK (Tyler et al., 1997a), MCINTOSH (Tyler et al., 1997b), and DIXON (Tyler et al., 1998b). Preliminary notes on the geology of DIXON, southeast MCINTOSH, and northernmost HALLS CREEK are in Warren (1997). Explanatory notes and a map have also been published for LISSADELL (1:250 000; Thorne et al., 1999), and maps for MOUNT RAMSAY (Tyler et al., 1998c) and DIXON RANGE (Tyler et al., 1998d). The Devonian Reef complexes of the Canning Basin on the western side of MOUNT RAMSAY have been mapped at a scale of 1:100 000 (Hocking and Playford, 1998a,b) and at 1:50 000 (Playford and Hocking, 1998).

Aeromagnetic and gravity data at a scale of 1:250 000 have been published by AGSO and are also available in digital format.

The Department of Resources Development and Department of Minerals and Energy (1997) reported on the prospectivity of the area as part of a joint study. Sanders (1999) discusses the mineralization of the Halls Creek Orogen and describes many of the mineral occurrences in detail; the author of this Report was involved in compiling Plate 1 (Sanders and Hassan, 1999) of Sanders (1999).

# Regional geology

The east Kimberley area covers most of the Halls Creek Orogen, as well as the eastern end of the King Leopold Orogen, part of the Granites–Tanami Complex, and parts of the Speewah, Kimberley, Ord, Bonaparte, Canning, and Birrindudu Basins (Fig. 1).

The solid geology map on Plate 1, and the digital solid geology map accompanying this Report, are based on the NGMA 1:100 000-scale geological maps where these are available, and on 1:250 000 scale geological maps. In the case of BILLILUNA and MOUNT BANNERMAN, where there is no recent mapping, there has been some interpretation based on open-file and published company data, and aeromagnetic and Landsat TM images. The regolith layer is also based on the 1:100 000-scale and 1:250 000-scale geological maps.

## Halls Creek Orogen

Development of the Halls Creek Orogen between the Kimberley Craton (which underlies the Kimberley and Speewah Basins) to the northwest and the North Australian Craton to the east commenced during the Palaeoproterozoic (Sheppard et al., 1999). Intermittent deformation took place until the end of the Palaeozoic (Tyler et al., 1995). The plutonic rocks, and deformed and metamorphosed Palaeoproterozoic sedimentary and volcanic rocks, are referred to as the Lamboo Complex (Gemuts, 1971; Griffin and Grey, 1990a). The folded margins of the Speewah and Kimberley Basins, and the deformed parts of sedimentary basins resulting from later tectonism during the Proterozoic and Phanerozoic are also included in the Halls Creek Orogen. A summary of the geological history of the Halls Creek Orogen is given in Table 1.

### Palaeoproterozoic Lamboo Complex

Tyler et al. (1995) recognized three zones in the Lamboo Complex, each with a distinct stratigraphy, and metamorphic and deformation history (Fig. 2; Table 1). The Eastern zone is separated from the Central zone by the Angelo – Halls Creek – Osmond Fault System. The Central and Western zones are separated by a combination of the Ramsay Range Fault and the Springvale Fault; in the northern part of the Lamboo Complex, this boundary is largely obscured by granitoid. The three zones have been interpreted as tectonostratigraphic terranes that were brought into their current positions by a combination of subduction and large-scale strike-slip faulting by c. 1820 Ma, when they were all intruded by plutons of granite and gabbro (Tyler et al., 1995; Sheppard et al., 1999). The different geophysical nature of the crust on either side of the Lamboo Complex (Shaw et al., in press), and the presence of terranes, is indicative of a Palaeoproterozoic plate margin (Tyler et al., 1999). This contrasts with earlier models that described the Lamboo Complex as intracratonic on the basis of correlation of rock units across the Halls Creek Fault (Hancock and Rutland, 1984; Page and Hancock, 1988).

#### *Eastern zone*

In the Eastern zone, low- to medium-grade metasedimentary and meta-igneous rocks of the c. 1880–1840 Ma

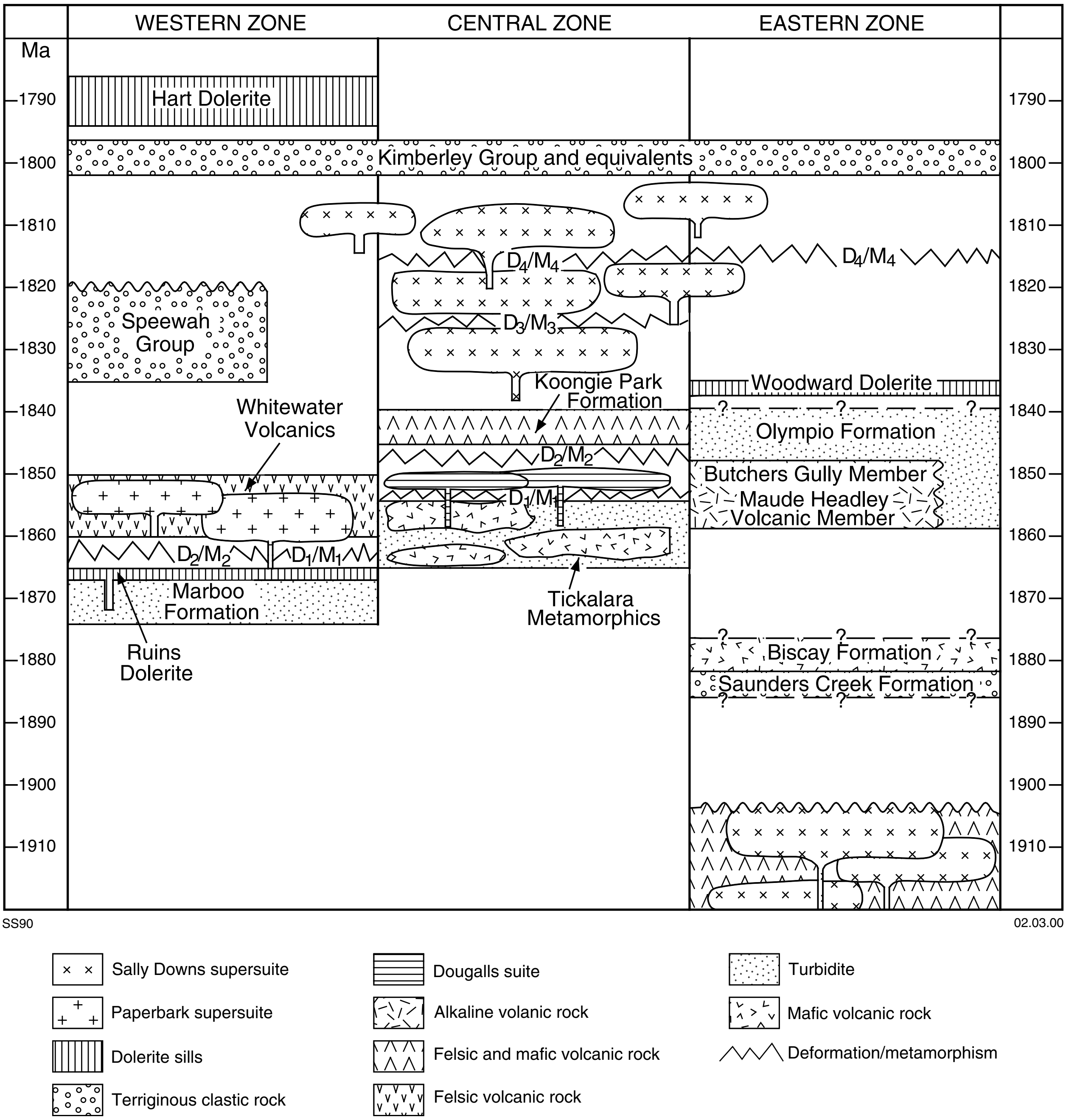


**Figure 2. Simplified time–space plot for the three zones of the Lamboo Complex (after Sheppard et al., 1999)**

Halls Creek Group unconformably overlie c. 1910 Ma mafic and felsic volcanic rocks of the Ding Dong Downs Volcanics, and c. 1910 Ma granitoids of the Sophie Downs suite (Griffin and Tyler, 1992; Blake et al., 1999b). The Ding Dong Downs Volcanics (*Ɇv*) include metamorphosed amygdaloidal basalt, metamorphosed rhyolite, and minor intercalated metasedimentary rocks. The Sophie Downs suite includes the Sophie Downs Granophyre Member (*Ɇvg*), the Esaw Monzogranite, and the Junda Microgranite (*Ɇgv*; Tyler et al., 1998a).

The Halls Creek Group as redefined by Griffin and Tyler (1992) consists of, in ascending order, the Saunders Creek Formation, Biscay Formation, and Olympio Formation.

The Saunders Creek Formation (*ɆHs*) consists predominantly of sandstones and conglomerates (Dow and Gemuts, 1969; Tyler et al., 1995). The sediments were deposited in a braided fluvial system with a lower energy, transitional marine environment towards the top (Hancock, 1991). Felsic, lithic tuffs have been recognized in the Castle Creek Anticline area (Buckovic et al., 1982) on HALLS CREEK and ANTRIM.

The Biscay Formation (*ɆHr*) conformably overlies the Saunders Creek Formation and consists predominantly of metamorphosed massive basaltic lava flows, local pillow lavas, laminated mafic volcaniclastic deposits, and fragmental deposits. The mafic volcanic rocks are inter-

**Table 1. Summary of the geological history of the Halls Creek Orogen**

| | *Kimberley Basin* | *Lamboo Complex* | | |
|---|---|---|---|---|
| *Age (Ma)* | | *Western zone* | *Central zone* | *Eastern zone* |
| 2500–1910 | unexposed Kimberley Craton | | | • > 2500 Ma North Australian Craton |
| c. 1920–1910 | | | | • Eruption of the Ding Dong Downs Volcanics<br>• Intrusion of granitoids of the Sophie Downs suite |
| c. 1880 | | | | • Uplift and erosion. Deposition of Saunders Creek Formation and Biscay Formation |
| c. 1870 | | • Deposition of Marboo Formation | | |
| 1865–1850 | | ---- HOOPER OROGENY ---- | | |
| c. 1865 | | | • Deposition of protoliths of the Tickalara Metamorphics | |
| 1863 | | | • Intrusion of Rose Bore Granite | |
| 1865–1850 | | • $D_1$ recumbent folding – $M_1$<br>• Deposition of Whitewater Volcanics<br>• Intrusion of Greenvale and Castlereagh Hill Porphyries<br>• Intrusion of layered mafic–ultramafic intrusions (including Springvale and Wilagee intrusions)<br>• Intrusion of granitoid and gabbro of the Paperbark supersuite<br>• Contact metamorphism of Marboo Formation | • Intrusion of massive gabbro, and layered mafic–ultramafic intrusions including Panton intrusions<br>• Intrusion of protolith of felsic gneiss<br>• Early thrusting ($D_1$) and medium- to high-grade metamorphism ($M_1$) | • Deposition of lower part of the Olympio Formation<br>• Eruption of Maude Headley Member |
| c. 1850 | | • $D_2$ upright folding – $M_2$ | • Deformation and metamorphism of Tickalara<br>• Metamorphics under high-T, low- to moderate-P metamorphic conditions ($D_2$–$M_2$)<br>• Intrusion of gabbro–diorite and tonalite–trondhjemite sheets of the Dougalls suite | • Eruption of Butchers Gully Member |
| <1847 | | | | • Deposition of upper Olympio Formation<br>• Intrusion of Woodward Dolerite |
| c. 1845 | | | • Deposition of Koongie Park Formation<br>• Deposition of Winnama Formation<br>• Intrusion of Angelo Microgranite | |
| c. 1840 | | | • Intrusion of Sally Malay layered mafic–ultramafic intrusions | |
| 1835–1805 | ---- HALLS CREEK OROGENY ---- | | | |
| 1835–1830 | • Deposition of the Speewah Group in the Speewah Basin | • Uplift and erosion | • Intrusion of Mabel Downs Tonalite and McHale Granite | |
| c. 1830 | | | • Intrusion of mafic–ultramafic intrusions including McIntosh intrusion, and Lamboo Ultramafics. Formation of $D_3$ folds and prominent foliation in Mabel Downs Tonalite synchronous with epidote–amphibolite facies metamorphism ($M_3$) | |

**Table 1.** (continued)

| Age (Ma) | Kimberley Basin | Lamboo Complex: Western zone | Lamboo Complex: Central zone | Lamboo Complex: Eastern zone |
|---|---|---|---|---|
| c. 1827 | | | • Intrusion of Loadstone Monzogranite<br>• Deposition of Moola Bulla Formation in Moola Bulla Basin | • Layer-parallel shearing ($D_3$) related to south-westerly directed extension |
| 1820–1810 | | | • Tight, upright, northeasterly plunging $D_4$ folds.<br>• Activation of shear zones under greenschist to lower amphibolite conditions ($M_4$) | • Upright to moderately inclined, open to isoclinal folding ($D_4$) accompanied by greenschist to lower amphibolite facies metamorphism ($M_4$) |
| c. 1821 | | | • Intrusion of Sally Downs Tonalite | |
| 1835–1805 | | • Intrusion of gabbroic rocks, including Emull Gabbro<br>• Metamorphism of Marboo Formation and Neville Granodiorite to form Amherst Metamorphics | | |
| 1825–1805 | | • Intrusion of other Sally Downs supersuite granitoids and gabbros together with Spring Creek layered mafic–ultramafic intrusion | | |
| c. 1805–1785 | | | • Intrusion of granitoids of the San Sou suite | |
| 1800–1790 | • Deposition of Kimberley Group in the Kimberley Basin | | • Deposition of the Revolver Creek, Texas Downs and Red Rock Formations | |
| c. 1790 | • Intrusion of the Hart Dolerite sills into the Speewah and Kimberley Groups | | | |
| c. 1740 | | | | • Intrusion of Sn-bearing pegmatites |
| c. 1500 | • Deposition of Crowhurst and Bastion Groups | | • Deposition of Mount Parker Formation and Bungle Bungle Dolomite in Osmond Basin<br>• Deposition of Wade Creek Formation, Ahern Formation, and Helicopter Siltstone in Victoria River Basin | |
| | • Deposition of Glidden and Carr Boyd Groups | | | |
| c. 1200 | • Intrusion of Argyle lamproite pipe | | | |
| c. 1000 | YAMPI OROGENY | | | |
| | • Large-scale sinistral strike-slip faulting and associated folding ($D_5$). Greenschist facies metamorphism ($M_5$)<br>• Intrusion of dolerite and porphyry dykes | | | |
| c. 610 – c. 800 | • Deposition of the Louisa Downs Group in the Louisa Basin | | • Deposition of Ruby Plains Group in Wolfe Creek Basin<br>• Deposition of Duerdin and Albert Edward Groups in Wolfe Creek Basin | |
| c. 560 | KING LEOPOLD OROGENY | | | |
| c. 560 | • Northwesterly directed folding and thrusting of Kimberley Group rocks. Reactivation of major faults ($D_6$)<br>• Deposition of the Lally Conglomerate, and eruption of the continental flood basalts of the Antrim Plateau Volcanics in the Ord and Bonaparte Basins | | | |
| 400–300 | ALICE SPRINGS OROGENY | | | |
| 400–300 | • Reactivation of major faults and associated north-northeasterly trending folding ($D_7$) | | | |
| 370–300 | • Deposition of siliciclastics and carbonates in the Ord and Bonaparte Basins | | | |
| 380–200 | • Deposition of carbonates and siliciclastics in the Canning Basin | | | |
| 70–50 | | • Formation of plateau surface | | |
| 20 to present | | • Uplift and dissection of plateau surface | | |

**SOURCE:** Sheppard et al. (1997), Griffin et al. (1998), Tyler (2000) calated with minor felsic volcanic rocks, pelitic and psammitic rocks, and carbonate rocks (Sheppard et al., 1999). The felsic volcanic rocks have been dated by sensitive high-resolution ion microprobe (SHRIMP) at 1880 Ma ± 3 Ma (Blake et al., 1999b).

The Olympio Formation (*ⱣHo*) disconformably overlies the Biscay Formation, and consists predominantly of a monotonous succession of turbiditic quartz wacke, greywacke, arkosic sandstone, and quartz sandstone, with interbedded siltstone and mudstone (Tyler et al., 1995). Near the base of the Olympio Formation there are two alkaline volcanic members: the Maude Headley Member (*ⱣHov*) and the Butchers Gully Member (*ⱣHob*). The Maude Headley Member consists of metamorphosed andesitic to trachytic volcanic and volcaniclastic rocks with a carbonate-rich matrix. It has been dated by SHRIMP at 1857 ± 5 Ma (Page and Hancock, 1988). The Butchers Gully Member consists of trachyandesite lavas and intrusions, together with associated volcaniclastic deposits (Tyler et al., 1995). Zircons from a pillow lava in the Butchers Gully Member have been dated by SHRIMP at 1848 ± 3 Ma (Blake et al., 1999b). Detrital zircons from the upper part of the Olympio Formation have been dated by SHRIMP at 1847 ± 6 Ma, which gives a maximum age for deposition (Blake et al., 1999b). The Biscay Formation and lower part of the Olympio Formation were intruded by the Woodward Dolerite prior to deformation and regional metamorphism (Tyler et al., 1998a).

About 20 Ma separates the Biscay Formation from the lower part of the Olympio Formation, but there is no evidence that the Biscay Formation was deformed before deposition of the Olympio Formation (Tyler et al., 1995). Sheppard et al. (1999) suggests that the geological history of the Halls Creek Group, and chemistry of the basalt in the Biscay Formation, is consistent with a passive margin setting. This setting is also consistent with intraplate 'hot-spot' volcanism of the Butchers Gully and Maude Headley Members (Taylor et al., 1995).

### *Central zone*

There are no exposures of basement rocks in the Central zone; the oldest rocks recognized are the Tickalara Metamorphics (Sheppard et al., 1999). The Koongie Park Formation post-dates the Tickalara Metamorphics in the southern part of the area. There is uncertainty about the stratigraphic relationship of a fault-bounded wedge of Milba Formation on HALLS CREEK to the other units (Blake et al., 1999b) so it is placed at the base of the map reference on Plate 1 for convenience.

The Tickalara Metamorphics (*ⱣmT*) consists of mafic metavolcanic rocks including massive, amygdaloidal and pillowed basalt, volcaniclastic rocks, and volcanic breccia with interbedded mudstones, siltstones, sandstones, carbonate, and calc-silicate units (Tyler et al., 1995). Conformable amphibolites (*ⱣmTo*) and possible metamorphosed mafic–ultramafic layered intrusions (*ⱣmTon*) are also present (Sheppard et al., 1999). Detrital zircons in turbiditic sedimentary rocks give a maximum age of c. 1865 Ma for the sequence (Tyler and Page, 1996). The sequence was intruded by sheets of tonalite with subordinate granite and trondhjemite (*ⱣmTg*) and metamorphosed at c. 1850 during the Hooper Orogeny (Tyler and Page, 1996). The metamorphic grade varies from high grade in the northern part of the zone, to medium grade to the southwest (Tyler et al., 1995). Sheppard et al. (1999) interpreted the basalts of the Tickalara Metamorphics to have formed in an oceanic island arc – backarc basin above a southeast-dipping subduction zone, or in an ensialic basin along the margin of the Kimberley Craton above a northwest-dipping subduction zone. The Hooper Orogeny is thought to reflect accretion of the island arc to the Kimberley Craton, or closure of the marginal basin (Sheppard et al., 1999).

The Koongie Park Formation (*Ɽe*) consists of metamorphosed mafic volcanic rocks, felsic volcanic and volcaniclastic rocks, turbiditic sandstone, siltstone, and mudstone, and interbedded chert, banded iron-formation (BIF), and carbonate rock (Orth, 1997; Griffin et al., 1998). Sewell (1999) informally divided the Koongie Park Formation in the Koongie Park area into three members: Coolibar tuff member; Camp shale member; and Weldon Creek lava member. The Coolibar tuff member consists of layered rhyolitic and dacitic lapilli and crystal tuffs. Overlying the Coolibar tuff member is the Camp shale member, which consists of siltstones and interbedded andesitic to dacitic volcaniclastic rocks and lavas, and includes the base-metal bearing 'Mimosa interval'. Spherulitic dacite and rhyolite lava flows of the Weldon Creek lava member overlie the Camp shale member. Orth (1997) proposed the term Onedin Member to include the Camp shale member and 'Mimosa interval' of Sewell (1999). SHRIMP U–Pb zircon dating of three rhyolite samples from the Koongie Park Formation on HALLS CREEK gave ages of 1845–1840 Ma (Page et al., 1994). The Koongie Park Formation is interpreted to have been deposited in a basin near the southeastern edge of the Kimberley Craton, associated with extension behind the convergent–strike-slip plate margin (Sheppard and Hassan, 2000).

The Milba Formation (*Ɽz*) is confined to fault-bounded wedges along the eastern edge of the Central zone and its relationship to other rock units is not known. It consists of greywacke, siltstone, sandstone, marble, impure calcareous rocks, chert, and minor mafic lavas and sills (Blake et al., 1999b).

### *Western zone*

The Western zone is a continuation of the Hooper Complex in the King Leopold Orogen (Tyler et al., 1995; Sheppard and Hassan, 2000; Griffin et al., in press). The oldest rocks exposed are those of the Marboo Formation. The Marboo Formation (*Ɽm*) consists of metamorphosed turbiditic sandstone, siltstone, and mudstone (Griffin and Tyler, 1992; Tyler et al., 1999). The maximum age of deposition is c. 1870 Ma based on SHRIMP U–Pb dating of detrital zircon (Tyler et al., 1995, 1999); the minimum age is given by a high-level intrusive stock in the Marboo Formation dated at 1858 ± 5 Ma (Tyler et al., 1999).

The Whitewater Volcanics (*Ɽw*) unconformably overlies the Marboo Formation, and consists of dacitic to rhyolitic ignimbrites, minor lava flows, lapilli tuff, and volcanogenic sedimentary rocks (Thorne et al., 1999). Two samples of Whitewater Volcanics have been dated at c. 1855 Ma using SHRIMP U–Pb geochronology (Griffin et al., in press). The volcanic rocks have been intruded by high-level porphyry intrusions (*ⱣgPh*), and granitoid (*ⱣgPc*) and gabbro (*ⱣgPo*) of the Paperbark supersuite dated at 1865–1850 Ma. The volcanic rocks, porphyries, and granitoids are all cogenetic (Griffin et al., in press).

The Amherst Metamorphics consists of high metamorphic grade paragneisses (*ⱣmAm*) and orthogneisses (*ⱣmAgn*) that were intruded by c. 1820 Ma granitoids (Griffin et al., 1998). The Amherst Metamorphics is interpreted to have formed as a result of high-grade metamorphism of the Marboo Formation and c. 1860 Ma Neville Granodiorite (Paperbark supersuite) between 1860 and 1805 Ma (Griffin et al., 1998).

### Younger granitoids and associated gabbros of the Lamboo Complex

The distribution of the younger granitoids in the Halls Creek Orogen is shown on Figure 3. The Sally Downs supersuite ranges in age from c. 1835 to 1805 Ma and consists of sixteen separate granitoid intrusions (*ⱣgSg*) and coeval gabbroic intrusions (*ⱣgSo*; Sheppard et al., 1995). The older intrusions are restricted to the Central zone, but intrusions in the supersuite that are younger than c. 1820 Ma (e.g. the 1808 Ma Mount Christine Granitoid) also intrude the Eastern and Western zones.

The San Sou suite (*ⱣgSe*) is restricted to the southern part of the Lamboo Complex and includes the c. 1805 Ma Eastman Granite and the c. 1790 Ma San Sou Monzogranite. The Eastman Granite intrudes the southern part of the Central zone. The San Sou Monzogranite outcrops in the southern part of the Eastern zone on DOCKRELL. The San Sou Monzogranite is the youngest known granite in the Lamboo Complex, but is of similar age to The Granites Granite in the Granites–Tanami Inlier (Page and Sun, 1994).

### Layered mafic–ultramafic intrusions in the Lamboo Complex

Layered mafic–ultramafic intrusions are confined to the Central and Western zones of the Lamboo Complex. Hoatson (1997, in press) divided the layered mafic–ultramafic intrusions in the Halls Creek Orogen into seven major groups on the basis of their field relationships, geochronology, style and intensity of deformation, and types of mineralization. The groups (numbered I to VII) were emplaced during at least three separate periods: 1855 Ma, 1845 Ma, and 1830 Ma (Hoatson, 1997).

Group I (e.g. Panton) intrusions (*Ᵽaa*) are coeval with Group II and Group III intrusions at c. 1855 Ma. The Group I intrusions are strongly differentiated and have the highest ratio of ultramafic to mafic cumulates. They have been deformed to produce steeply dipping folded bodies (Hoatson, 1997) and they are restricted to the Central zone. Group II (e.g. Springvale) intrusions (*Ᵽas*) are restricted to the Western zone. They are moderately dipping, sheet-like mafic bodies (Hoatson, 1997). The Group III Toby Gabbro in the Western zone is the sole representative of the Group III intrusions. It is a high level intrusion consisting of gabbroic and doleritic rocks of non-cumulus origin (Hoatson, 1997), and is considered to be part of the Paperbark supersuite (*ⱣgPo*; Sheppard et al., 1997c; Tyler et al., 1997b).

The Group V (Sally Malay) intrusions (*Ᵽay*) are differentiated mafic–ultramafic intrusions that have been dated at c. 1840 Ma (Hoatson, 1997), and are restricted to the Central zone. These intrusions are coeval with mafic and felsic volcanic rocks of the Koongie Park Formation (Hoatson and Blake, in press).

The Group IV (Wild Dog Creek) intrusions of Hoatson (1997) are sheet-like gabbroic bodies coeval with the Sally Downs supersuite (*ⱣgSo*) in the Central zone. Group VI (McIntosh; *Ᵽam*) intrusions also occur in the Central zone and include the large 1830 Ma funnel-shaped, gabbroic McIntosh intrusion and smaller sheet-like gabbroic bodies, such as the Armanda intrusion (Hoatson, 1997). Group VII (Black Hills Yard; *Ᵽa*) intrusions intrude unlayered gabbroic rocks of the Paperbark supersuite in the Western zone (Hoatson, 1997).

The layered mafic–ultramafic Lamboo and Eastman Bore intrusions (*Ᵽa*), which intrude the c. 1845 Ma Koongie Park Formation in the southern part of the Central zone, are not included in the classification of Hoatson (1997). Layered mafic–ultramafic intrusions within the Tickalara Metamorphics are also excluded.

## King Leopold Orogen

The King Leopold Orogen includes the Palaeoproterozoic metasedimentary and igneous rocks of the Hooper Complex and the deformed margins of the Speewah and Kimberley Basins (Griffin and Grey, 1990a). The Hooper Complex outcrops on the western side of MOUNT RAMSAY. It includes the Marboo Formation, the Whitewater Volcanics, and granitoids of the Paperbark supersuite. The Hooper Complex is a continuation of the Western zone of the Lamboo Complex (Tyler et al., 1995, 1999; Griffin et al., in press).

## Hooper Orogeny

The Hooper Orogeny was first recognized in the Hooper Complex of the King Leopold Orogen (Tyler and Griffin, 1990; Griffin et al., 1993). During the Hooper Orogeny, rocks of the Marboo Formation in the Western zone of the Lamboo Complex, and the Tickalara Metamorphics in the Central zone, were affected by two phases of deformation. The Marboo Formation was deformed and metamorphosed ($D_1$–$M_1$) between c. 1870 and c. 1865 Ma before being unconformably overlain by the Whitewater Volcanics (Tyler et al., 1995, 1999). A second period of deformation and metamorphism ($D_2$–$M_2$) occurred either prior to, or contemporaneously with, intrusion of the Paperbark supersuite between 1865 and 1850 Ma (Griffin

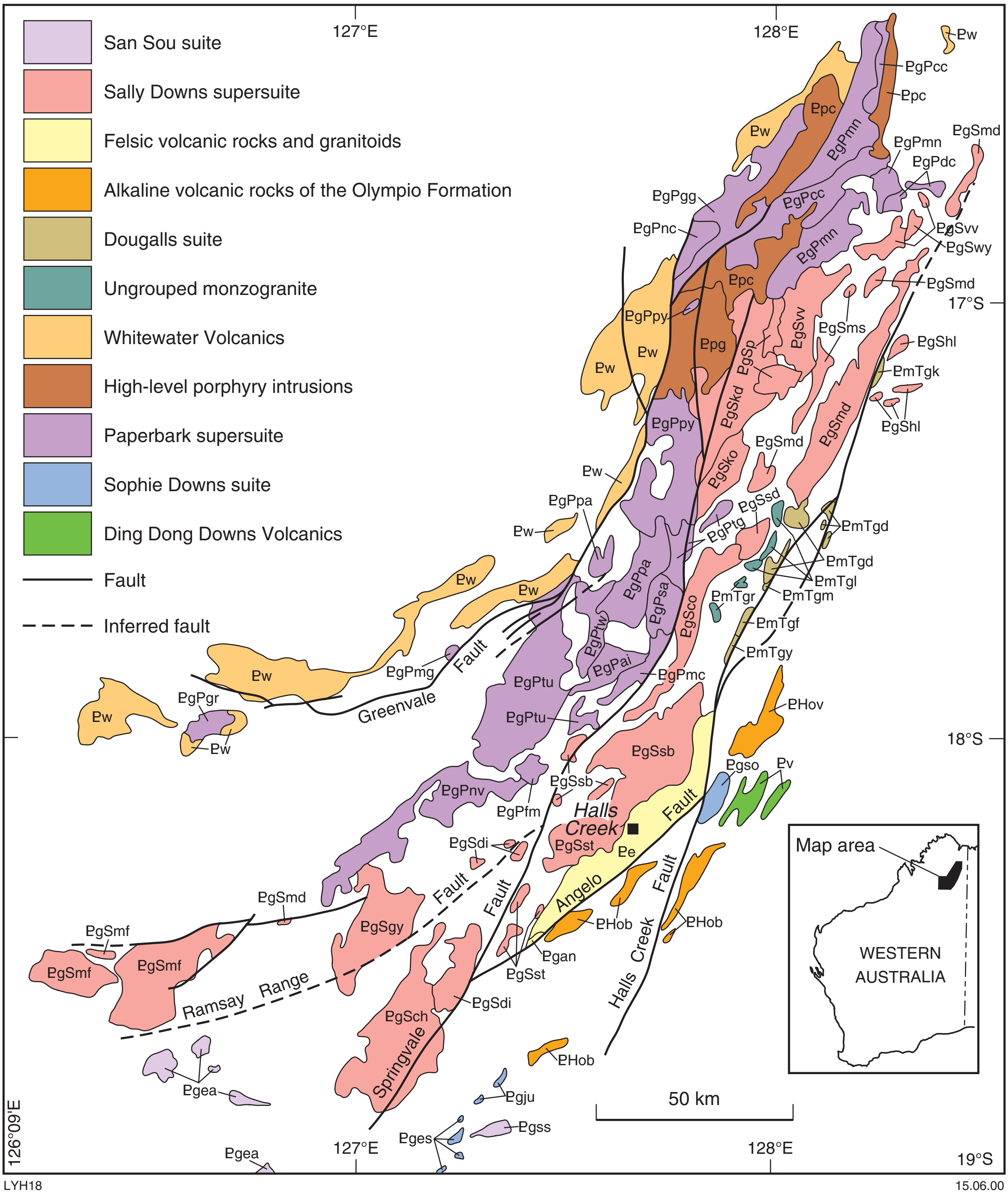


**Figure 3. Granitoids and felsic volcanic rocks of the Halls Creek Orogen (after Sanders, 1999)**

# Key to granitoid and felsic volcanic rocks of the southern Halls Creek Orogen

## San Sou suite (1805–1790 Ma)

Eastern zone

| | |
|---|---|
| Ᵽgea | Eastman Granite |
| Ᵽgss | San Sou Monzogranite |

## Sally Downs supersuite (c. 1835–1805 Ma)

Western, Central and Eastern zones

| | | | |
|---|---|---|---|
| ᏢgSco | Corrara Granite | ᏢgSmf | Mount Fairbairn Monzogranite |
| ᏢgSch | Mount Christine Granitoid | ᏢgSms | Magotty Springs Monzogranite |
| ᏢgSdi | Dillinger Monzogranite | ᏢgSp | unnamed monzogranite and granodiorite |
| ᏢgSgy | Grimpy Monzogranite | ᏢgSsb | Shepherds Bore Granite |
| ᏢgShl | McHale Granodiorite | ᏢgSsd | Sally Downs Tonalite |
| ᏢgSkd | Kevin Dams Monzogranite | ᏢgSst | Loadstone Monzogranite |
| ᏢgSko | Koondooloo Monzogranite | ᏢgSvv | Violet Valley Tonalite |
| ᏢgSmd | Mabel Downs Tonalite | ᏢgSwy | Wesley Yard Monzogranite |

## Felsic volcanic rocks and granitoids (c. 1845 Ma)

Central zone

| | |
|---|---|
| Ᵽe | Koongie Park Formation |
| Ᵽgan | Angelo Microgranite |

## Alkaline volcanic rocks of the Olympio Formation (1848–1856 Ma)

Eastern zone

| | |
|---|---|
| ᏢHob | Butchers Gully Member |
| ᏢHov | Maude Headley Member |

## Tickalara Metamorphics granitoids

Central zone

### Dougalls suite (c. 1850 Ma)

| | | | |
|---|---|---|---|
| ᏢmTgd | Dougalls Tonalite | ᏢmTgm | Monkey Yard Tonalite |
| ᏢmTgf | Dead Finish Tonalite | ᏢmTgy | Black Duck Tonalite |
| ᏢmTgk | Corkwood Tonalite | | |

### Ungrouped monzogranite (c. 1865 Ma)

| | |
|---|---|
| ᏢmTgl | Fletcher Creek Monzogranite |
| ᏢmTgr | Rose Bore Granite |

## Whitewater Volcanics (1865–1850 Ma)

Western zone

| | |
|---|---|
| Ᵽw | Whitewater Volcanics |

## High-level porphyry intrusions (1865–1850 Ma)

| | |
|---|---|
| Ᵽpc | Castlereagh Hill Porphyry |
| Ᵽpg | Greenvale Porphyry |

## Paperbark supersuite (1865–1850 Ma)

| | | | |
|---|---|---|---|
| ᏢgPai | Airfield Granodiorite | ᏢgPnc | Neil Creek Monzogranite |
| ᏢgPcc | Crooked Creek Granite | ᏢgPnv | Neville Granodiorite |
| ᏢgPdc | Dinner Creek Tonalite | ᏢgPpa | Paperbark Granite |
| ᏢgPfm | Gnewing Granodiorite | ᏢgPpy | Pandanus Yard Monzogranite |
| ᏢgPgg | Gordons Gorge Granite | ᏢgPsa | Sandy Dam Monzogranite |
| ᏢgPgr | Little Gold River Microgranodiorite | ᏢgPtg | Togo Monzogranite |
| ᏢgPmc | Mussel Creek Granite | ᏢgPtu | Tumagee Granite |
| ᏢgPmg | Mad Gap Monzogranite | ᏢgPtw | Top Water Tonalite |
| ᏢgPmn | Mount Nyulasy Granite | | |

## Sophie Downs suite (c. 1910 Ma)

Eastern zone

| | |
|---|---|
| Ᵽges | Esaw Monzogranite |
| Ᵽgju | Junda Microgranite |
| Ᵽgso | Sophie Downs Granophyre |

## Ding Dong Downs Volcanics (c. 1910 Ma)

| | |
|---|---|
| Ᵽv | Ding Dong Downs Volcanics |

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et al., 1993; Tyler et al., 1995, 1999). The Hooper Orogeny is interpreted to correspond to the accretion of the island arc basalts (Tickalara Metamorphics) of the Central zone to the Kimberley Craton (Myers et al., 1996; Sheppard et al., 1997c, 1999).

## Halls Creek Orogeny

The earliest period of deformation in the Eastern zone involved layer-parallel shearing ($D_3$) related to extension during the Halls Creek Orogeny. This was followed by a second period of deformation ($D_4$) that resulted in the formation of open to isoclinal folds with east-northeasterly to northeasterly trending fold axes (Tyler et al., 1998a). The Halls Creek Orogeny also affected rocks of the Tickalara Metamorphics in the Central zone and the syn-orogenic granitoids and mafic rocks of the Sally Downs supersuite (Tyler and Page, 1996; Thorne et al., 1999). The Halls Creek Orogeny is interpreted to be the result of collision of the Eastern zone with the combined Central and Western zones at c.1800 Ma (Tyler and Page, 1996).

## Palaeoproterozoic Granites–Tanami Complex and Archaean Lucas Craton

There has been no recent mapping by the GSWA in the area of the Granites–Tanami Complex on BILLILUNA and the geology on Plates 1 and 1a and the digital map is largely based on Blake et al. (1977). However, PNC Exploration (Australia) (Pearcey et al., 1988) and Blake (1996a) mapped late Archaean gneiss, granite, quartzite, conglomerate, and calc-silicate rock in the vicinity of Browns Range Dome. Uranium–lead SHRIMP ages on detrital zircons from the metasedimentary rocks of the Browns Range Dome area indicate a maximum depositional age of 2507 ± 22 Ma (Page et al., 1995). These rocks were intruded by leucogranite dated at 2510 Ma and have been interpreted as part of the Archaean Lucas Craton (*AmB*; Myers et al., 1996; Tyler, 2000).

Greywacke, sandstone, siltstone, and mudstone, with minor quartzite, banded chert, basalt, dolerite, gabbro, and felsic porphyry (*ṔmG*), was mapped as Killi Killi 'Beds' by Blake et al. (1977). However, recent mapping by the Northern Territory Geological Survey (Hendrickx et al., 2000) suggests that there are three main lithological units present in the Northern Territory: the MacFarlane Peak Group, overlain by the Dead Bullock Formation, which in turn is overlain by the Killi Killi Formation. The MacFarlane Peak Group consists of mafic volcanic and volcaniclastic rocks with minor clastic sedimentary rocks and calc-silicate rocks. The Dead Bullock Formation consists of dark-grey massive to laminated siltstone, carbonaceous shale with minor BIF, and calc-silicate rocks. The Killi Killi Formation consists predominantly of turbiditic sandstone and siltstone.

Glengarry Resources (1999, written comm.*) suggested that the sedimentary and mafic rocks of the informally named 'Bald Hill Sequence', which hosts the Kookaburra and other deposits, are correlated with the Mount Charles Formation in the Northern Territory. However, Hendrickx et al. (2000) regard the Mount Charles Formation as equivalent to the Pargee Sandstone (see below) and restrict it to the Tanami Mine basalt sequence just north of the Tanami mines in the Northern Territory. The 'Bald Hill Sequence' is possibly correlated with the Dead Bullock Formation, which hosts the Dead Bullock soak and Granites gold deposits (Hendrickx et al., 2000).

Because of the uncertainty in correlating the newly mapped Northern Territory sequence with the rocks previously mapped as Killi Killi 'Beds' on the Western Australian side of the border, they are shown as undifferentiated (*ṔmG*) on Plate 1 and the digital map.

The Pargee Sandstone (*ṔmGpg*) unconformably overlies the rocks previously mapped as Killi Killi 'Beds'. It consists of sandstone and minor conglomerate (Blake et al., 1977).

The Slatey Creek Granite (*ṔgGsl*) intrudes the rocks previously mapped as Killi Killi 'Beds', 75 km east-southeast of Billiluna Homestead. Elsewhere, the granite is exposed only in cliffs where it is overlain by sandstone of the Lewis Range Sandstone (Redcliffe Pound Group; Blake et al., 1977).

## Palaeoproterozoic basins

Sedimentary and volcanic rocks of the Speewah and Kimberley Basins unconformably overlie the Western zone of the Lamboo Complex and the Hooper Complex. The Kimberley Basin covers an area of about 160 000 $km^2$ (Plumb et al., 1981) and underlies most of the Kimberley Plateau. The Moola Bulla Formation is thought to be a time equivalent of the Speewah Group, and the Red Rock, Revolver Creek, and Texas Downs Basins are possible time equivalents of the Kimberley Basin (Thorne et al., 1999).

### Speewah Basin

The Speewah Group (*ṔS*) is considered to have been deposited in a separate basin from the Kimberley Group, on the basis of a significant unconformity between the Speewah Group and the overlying Kimberley Group and different palaeogeographies (Griffin et al., 1993; Thorne et al., 1999). The Speewah Group includes the O'Donnell Formation, Tunganary Formation, Valentine Siltstone, Lansdowne Arkose, Luman Siltstone, and Bedford Sandstone. These formations form part of a transgressive–regressive cycle with fluvial sands passing into or alternating with shallow-marine facies and then back into fluvial sands (Plumb et al., 1981). Palaeocurrent measurements suggest that sediment was transported from the northeast and east (Gellatly et al., 1970). Zircons from a felsic volcanic unit in the Valentine Siltstone gave a SHRIMP U–Pb date of 1834 ± 3 Ma (AGSO OZCHRON

* Internet document on the world-wide web. Accessed 9 December 1999.

database). Thus, the group was deposited during the early stages of the Halls Creek Orogeny, and is older than most granites in the Sally Downs supersuite.

### Moola Bulla Basin

Sedimentary rocks of the Moola Bulla Formation (*Ꝑl*) in the Moola Bulla Basin are disconformable on the Koongie Park Formation (Griffin et al., 1998) in the Central zone of the Lamboo Complex. The Moola Bulla Formation may be a time equivalent of the Speewah Group (Dow and Gemuts, 1969; Griffin and Tyler, 1992; Blake et al., 1999b). The Moola Bulla Formation includes sandstones, conglomerates, mudstones, and shales, which are interpreted to have formed in a fluvial and lacustrine to marine environment with a provenance to the southwest (Blake et al., 1999b).

### Kimberley Basin

The Kimberley Group unconformably and disconformably overlies the Speewah Group (Griffin et al., 1993; Thorne et al., 1999). The Kimberley Group is interpreted to have been deposited within a broad, semi-enclosed, shallow-marine basin (Plumb et al., 1981). Palaeocurrent indicators in the Kimberley Group indicate sediment transport from the north and north-northwest (Gellatly et al., 1970).

The King Leopold Sandstone (*ꝐKl*) at the base of the Kimberley Group consists of medium- to coarse-grained sandstone and has medium- to large-scale trough cross-stratification (Thorne et al., 1999).

The Carson Volcanics (*ꝐKc*) conformably overlies the King Leopold Sandstone, and consists of interlayered massive to amygdaloidal basalt, quartz sandstone, feldspathic sandstone, siltstone, and chert (Thorne et al., 1999).

The Warton Sandstone (*ꝐKw*) conformably overlies the Carson Volcanics and consists of coarse-grained quartz sandstone with minor feldspathic sandstone. The sandstone has medium- to large-scale trough cross-stratification and horizontal planar stratification (Thorne et al., 1999).

The Elgee Siltstone (*ꝐKe*) conformably overlies the Warton Sandstone and consists predominantly of red-brown siltstone with thin interbedded quartz sandstone (Plumb, 1968). Bruinsma (1970) subdivided the Teronis Member, at the base of the Elgee Siltstone, into four units: Teronis I consisting of grey-green sandstone with minor siltstone and shale; Teronis II consisting of grey-green shale and siltstone with minor fine-grained sandstone and oolitic and algal dolomite; Teronis III consisting of red-brown siltstone and minor shale; and Teronis IV consisting of green shale, siltstone, sandstone, calcareous sandstone and siltstone, and algal dolomite. Subeconomic syngenetic copper mineralization is widespread in the Teronis IV unit. Owen (1970) suggested that the Teronis Member was deposited on a tidal flat, or open, shallow lagoon.

The Pentecost Sandstone (*ꝐKp*) has been subdivided into three units. The lower unit consists of thinly bedded to laminated quartz sandstone; the middle unit consists of planar-stratified or cross-stratified quartz sandstone and siltstone, with glauconitic sandstone and shale at the base; and the upper unit consists of massive, trough cross-bedded quartz sandstone and pebbly sandstone (Thorne et al., 1999).

### Red Rock Basin

The Red Rock Formation (*Ꝑk*), which is a time equivalent of the Kimberley Group, is faulted against the Olympio Formation in the Eastern zone of the Lamboo Complex, is unconformable on the Winnama Formation in the Central zone in the Osmand Range, and overlies the Moola Bulla Formation (east of Halls Creek; Tyler, 2000). The Red Rock Formation consists of sandstone, conglomerate, siltstone, mudstone, massive to amygdaloidal basalt flows, and basaltic breccia (Tyler et al., 1997a).

### Texas Downs Basin

Sedimentary rocks of the Texas Downs Formation (*Ꝑx*), in the Texas Downs Basin, overlie the Red Rock Formation and McHale Granodiorite with angular unconformity (Thorne et al., 1999). The formation consists of sandstone, siltstone, minor conglomerate, and basalt (Thorne et al., 1999). The age of the Texas Downs Formation is poorly constrained but it is believed to be broadly coeval with the lower part of the Kimberley Group (Thorne et al., 1999).

### Revolver Creek Basin

In the Revolver Creek Basin, the Revolver Creek Formation (*Ꝑr*) unconformably overlies the Marboo Formation, Whitewater Volcanics, and Castlereagh Hill Porphyry, and is overlain by the Carr Boyd Group (Thorne et al., 1999). The formation consists of sandstone, conglomerate, siltstone, dolerite, and basalt, and is thought to be coeval with the lower part of the Kimberley Group (Thorne et al., 1999).

### Hart Dolerite

The Hart Dolerite (*Ꝑdh*) consists of a series of massive dolerite sills and less extensive granophyre that intrude the Speewah Group and lower part of the Kimberley Group. The Hart Dolerite has been dated at c. 1790 Ma using SHRIMP U–Pb geochronology (Thorne et al., 1999). Alvin (1993) proposed the term Yilingbun granophyre for the granophyric phase, which intrudes the dolerite in the Speewah Valley.

## Mesoproterozoic basins

### Bastion Basin

The Bastion Group (*ꝐB*) unconformably overlies the Kimberley Group in the Bastion Basin. The Bastion Group includes three formations: the Mendena Formation, consisting of sandstone with minor siltstone and carbonate; the Wyndham Shale, consisting of siltstone with minor sandstone; and the Cockburn Sandstone, consisting of quartz sandstone and micaceous sandstone (Thorne et al., 1999). The age of the Bastion Group is uncertain but it is younger than the c. 1790 Ma Hart Dolerite and older than the c. 540 Ma Antrim Plateau Volcanics, which overlie the group.

## Crowhurst Basin

The Crowhurst Group (*ḂR*) unconformably overlies the Pentecost Sandstone of the Kimberley Group in the Crowhurst Basin, and may be equivalent to the Birrindudu Basin (Tyler et al., 1998e). The group consists of four formations: the Hilfordy Formation, consisting of sandstone with interbedded siltstone and shale; the Liga shale, consisting of shale and micaceous siltstone; the Collett Siltstone, consisting of laminated siltstone with minor interbedded dolomite; and the Hibberson Dolomite, consisting of dolomite, which is commonly stromatolitic (Griffin and Grey, 1990b; Tyler et al., 1998c).

## Osmond Basin

The Mount Parker Formation (*Ḃt*) in the Osmond Basin, consists of sandstone and conglomerate that was deposited conformably on the Texas Downs Formation (Tyler et al., 1997a). The Mount Parker Formation is conformably overlain by the Bungle Bungle Dolomite (*Ḃu*).The Bungle Bungle Dolomite includes dolomite, which is commonly stromatolitic, dolomitic sandstone, siltstone, mudstone, stromatolitic chert, and chert breccia (Tyler et al., 1997a). Felsic, lithic, vitric tuffs have been reported near the base of the Bungle Bungle Dolomite (de Angelis, 1984). The Mount Parker Formation and Bungle Bungle Dolomite may be equivalents of the Birrindudu Group.

## Carr Boyd Basin

The Carr Boyd Group (*Ḃc*) of the Carr Boyd Basin unconformably overlies Palaeoproterozoic rocks of the Lamboo Complex and the Revolver Creek Basin (Thorne and Tyler, 1996). Lower units of the Carr Boyd Group have been

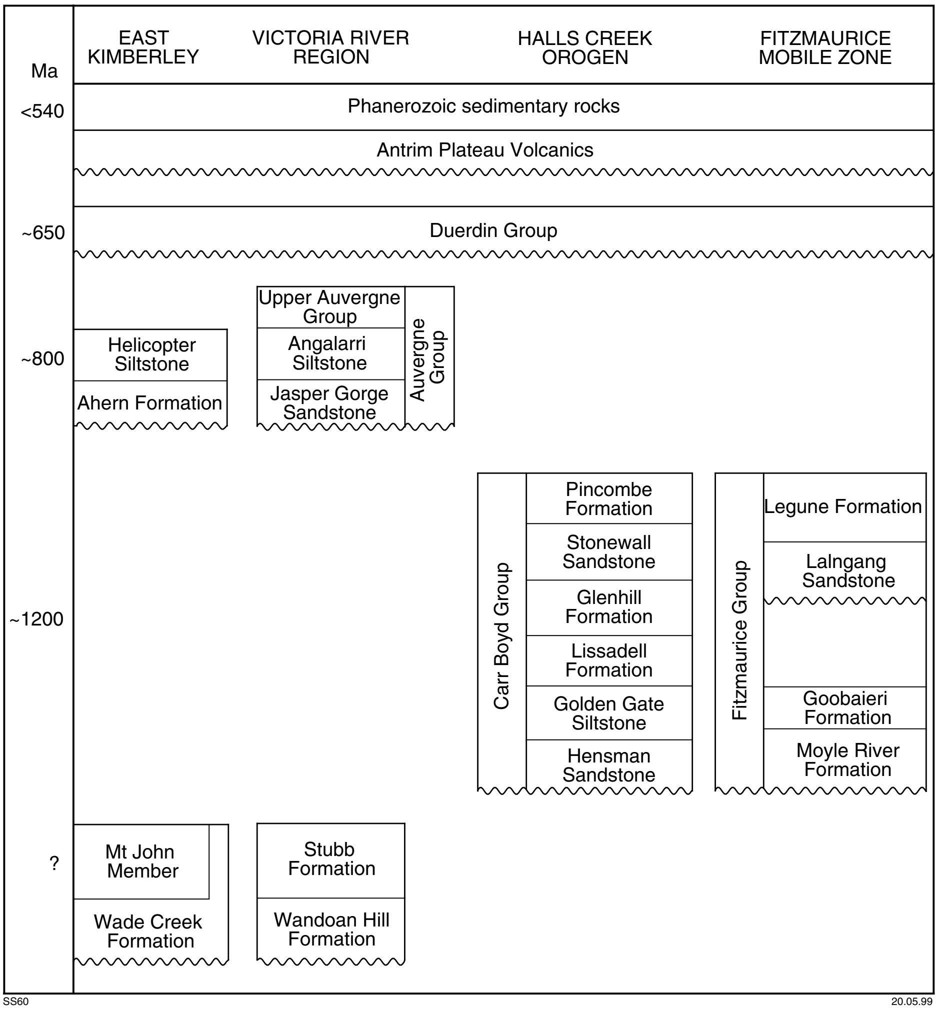


**Figure 4. Regional correlation of Mesoproterozoic to Phanerozoic rocks in the east Kimberley (after Thorne et al., 1999)**

correlated with the Auvergne Group in the Victoria River Basin (Sweet, 1977), but more recent work suggests that the Carr Boyd Group is older and probably correlates with the Fitzmaurice Group of the Fitzmaurice Mobile Zone in the Northern Territory (Thorne and Tyler, 1996; Thorne et al., 1999; Fig. 4). The Carr Boyd Group is interpreted to have formed in a sandy, braided delta complex and an adjacent siliciclastic marine shelf (Thorne and Tyler, 1996).

The Carr Boyd Group includes the Hensman Sandstone, Golden Gate Siltstone, Lissadell Formation, Glenhill Formation, Stonewall Sandstone, Pincombe Formation, and Bandicoot Range beds, but the upper two units do not outcrop in the study area. The Hensman Sandstone consists predominantly of quartz arenite with minor siltstone and conglomerate. The base of the Golden Gate Siltstone consists of a thin green siltstone and sandstone unit; this is overlain by a 7–10 m-thick ferruginous sandstone and sandy ironstone unit, which hosts the Pompeys Pillar and Matsu iron deposits. The remainder of the Golden Gate Siltstone consists of interbedded argillite and quartz sandstone. The Lissadell Formation consists of quartz arenite and lithic quartz sandstone interbedded with siltstone. The Glenhill Formation consists of interbedded siltstone and sandstone. The Stonewall Sandstone consists of quartz sandstone and pebbly sandstone with minor interbedded siltstone.

### Glidden Basin

The Glidden Group (*ᵽG*) of the Glidden Basin overlies the Amherst Metamorphics and Carson Volcanics of the Kimberley Group on MOUNT RAMSAY (Tyler et al., 1998c). The group includes the Harms Sandstone (quartz sandstone with interbedded shale), Matheson Formation (shale, siltstone, and minor sandstone), Forman Sandstone (quartz sandstone), and Maddox Formation (black shale, siltstone, and minor shale; Grey and Griffin, 1990).

## Mesoproterozoic Yampi Orogeny

The Yampi Orogeny produced large-scale shearing in the crystalline rocks of the Hooper Complex, and northeasterly trending folding and thrusting in the Kimberley Basin (Tyler and Griffin, 1990; Griffin et al., 1993). Ductile strike-slip faulting ($D_5$) along north-northeasterly trending structures that initially formed during the Palaeoproterozoic in the Halls Creek Orogen is also interpreted to be related to the Yampi Orogeny (Tyler et al., 1995). Potassium–argon ages from sheared granitoid rocks from the Hooper Complex place age limits of between 1475 ± 12 and 999 ± 9 Ma on the Yampi Orogeny (Shaw et al., 1992).

## Mesoproterozoic to Neoproterozoic basins

### Victoria River Basin

The Mesoproterozoic Wade Creek Formation has been correlated with lower units of the Victoria River Basin in the Northern Territory, whereas the Neoproterozoic Ahern Formation and Helicopter Siltstone correlate with the Auvergne Group of the Victoria River Basin in the Northern Territory (Dow and Gemuts, 1969; Thorne et al., 1999; Fig. 4).

The Wade Creek Formation (*ᵽs*) lies unconformably on the Bungle Bungle Dolomite (Grey and Griffin, 1990; Tyler et al., 1997a). It consists of sandstone, conglomerate, siltstone, mudstone, and chert breccia (Tyler et al., 1997a). The Neoproterozoic Ahern Formation and Helicopter Siltstone (*ᵽf*) unconformably overlie the Wade Creek Formation. The Ahern Formation consists of sandstone with minor interbedded pebbly sandstone, conglomerate, and siltstone (Thorne et al., 1999). The Helicopter Siltstone, which conformably overlies the Ahern Formation, consists of laminated micaceous siltstone interlayered with quartz sandstone (Thorne et al., 1999).

### Birrindudu Basin

The Birrindudu Basin contains the Birrindudu and Redcliffe Pound Groups, and rocks correlated with the Redcliffe Pound Group.

The Birrindudu Group (*ᵽY*) rests unconformably on rocks of the Granites–Tanami Complex. It consists of the Gardiner Sandstone, Talbot Well Formation, and Coomarie Sandstone. The Gardiner Sandstone consists predominantly of sandstone with minor siltstone and shale, and glauconitic sandstone beds. Conglomerate is present at the base of the Gardiner Sandstone. The Talbot Well Formation consists of stromatolitic chert, sandstone, siltstone, and limestone. The Coomarie Sandstone is composed of sandstone (Blake et al., 1977).

The Redcliffe Pound Group (*ᵽD*) includes the Lewis Range Sandstone, the Murraba Formation, and the Erica Sandstone. The Denison beds, the Jawilga beds, and the Boee beds are probable correlatives of the Redcliffe Group (Blake et al., 1977; Grey, 1990).

## Neoproterozoic basins

### Wolfe Creek Basin

Neoproterozoic glacigene rocks of the Wolfe Creek Basin unconformably overlie rocks of the Victoria River and Carr Boyd Basins, and rocks of the Lamboo Complex. The Wolfe Creek Basin includes the Ruby Plains Group, Duerdin Group, and Albert Edward Group (Blake et al., 1997; Thorne et al., 1999).

The Ruby Plains Group (*ᵽP*) is interpreted to represent shallow marine-shelf deposits (Blake et al., 1997). The group includes the Mount Kinahan Sandstone, the Eliot Range Dolomite, and the Iljarra Sandstone.

The Duerdin Group (*ᵽE*) is a glacial sequence that includes the Fargoo Tillite, Frank River Sandstone, Moonlight Valley Tillite, Jarrod Sandstone Member, Johnny Cake Shale Member, and Ranford Formation (Dow and Gemuts, 1969). It is correlated with the lower part of the Marinoan glacial sequence in central and southern Australia (Corkeron et al., 1996).

The Albert Edward Group (*ⱣL*) includes the Mount Forster Sandstone, Elvire Formation, Boonal Dolomite, Timperley Shale, Nyuless Sandstone, and Flat Rock Formation (Dow and Gemuts, 1969). The group is interpreted to have been deposited in shallow water and is equivalent to the upper part of the Marinoan glacial sequence in central and southern Australia (Corkeron et al., 1996).

### Louisa Basin

Sedimentary rocks of the Columbo Sandstone, Kuniandi Group, and Louisa Downs Group were deposited in the Louisa Downs Basin. They are correlated with units in the Wolfe Creek Basin (Corkeron et al., 1996). The Columbo Sandstone (*Ᵽc*) includes sandstone and chert-pebble breccia that overlie the Kimberley and Crowhurst Group (Tyler et al., 1998c). The Kuniandri Group (*ⱣN*) includes the Landrigan Tillite, Stein Formation, Wirara Formation, and Mount Bertram Sandstone (Tyler et al., 1998c). Five formations are included within the Louisa Downs Group (*ⱣI*): the Egan Formation, Yurabi Formation, McAlly Shale, Tean Formation, and Lubbock Formation (Tyler et al., 1998c).

## Neoproterozoic King Leopold Orogeny

The King Leopold Orogeny ($D_6$) produced extensive west-northwesterly trending folding and thrusting in the King Leopold Ranges along the southwestern margin of the Kimberley and Speewah Basins (Griffin and Myers, 1988; Tyler and Griffin, 1990), together with the reactivation of shear zones in the Hooper Complex (Tyler et al., 1991; Shaw et al., 1992). Reactivated shear zones have given K–Ar ages of c. 560 Ma (Shaw et al., 1992). In the Lamboo Complex, the King Leopold Orogeny produced sinistral strike-slip faulting, folding, and uplift of Neoproterozoic glacigene rocks (Griffin et al., 1998; Thorne et al., 1999).

## Phanerozoic basins

### Ord and Bonaparte Basins

The Ord Basin lies to the east of the Halls Creek Fault and the Bonaparte Basin lies to the west and north of the Halls Creek Fault. The Cambrian Antrim Plateau Volcanics (*Єa*) is the only formal unit common to both basins. In the northern part of the area, the Antrim Plateau Volcanics is about 200 m thick and unconformably overlies Palaeoproterozoic to Mesoproterozoic rocks, whereas further south, it is about 1000 m thick, and unconformable on the Neoproterozoic Duerdin and Albert Edward Groups of the Wolfe Creek Basin (Mory and Beere, 1988; Thorne et al., 1999). The Antrim Plateau Volcanics consist of massive to amygdaloidal basalt and basaltic breccia with minor interbedded sedimentary rock. The Mount Close Chert Member consists of laminated, stromatolitic chert and chert breccia (Mory and Beere, 1988; Thorne et al., 1999).

The Cambrian Goose Hole Group (*ЄG*) overlies the Antrim Plateau Volcanics in the Ord Basin. It includes the Headleys Limestone, Nelson Shale, Linnekar Limestone, Panton Formation, Eaglehawk Sandstone, and Overland Sandstone (Mory and Beere, 1988; Tyler et al., 1997b; Thorne et al., 1999).

The Devonian Mahony Group (*DM*) conformably overlies the Cambrian Goose Hole Group in the Ord Basin, and includes sandstone, pebbly sandstone, and conglomerate (Mory and Beere, 1988).

The Cockatoo Group (*DC*) is interpreted as a mixed alluvial-fan–fluvial–eolian–shallow-marine succession deposited in response to active strike-slip faulting along the Glenhill – Revolver Creek – Carr Boyd Fault system ($D_6$; Alice Springs Orogeny) in the Bonaparte Basin (Thorne and Tyler, 1996; Thorne et al., 1999). In the study area, the Cockatoo Group includes the Ragged Range Conglomerate, the Cyril Sandstone, the Kellys Knob Sandstone, and the Galloping Creek Formation (Thorne et al., 1999).

### Canning Basin

#### *Lennard Shelf*

Devonian limestones (*Dr*) form part of the Devonian 'Great Barrier Reef' on the Lennard Shelf (Griffin et al., 1993). The reef complexes include oolitic, cyanobacterial, stromatoporoid, and stromatolitic limestones, and debris flow deposits. This grouping includes the Pillara Limestone, Sadler Limestone, Gogo Formation, Virgin Hills Formation, Nullara Limestone, Winjana Limestone, Bugle Gap Limestone, and Piker Hills Formation on MOUNT RAMSAY (Tyler et al., 1998c).

Devonian boulder, cobble, and pebble conglomerates (*Dg*) are interpreted to have formed in platform and basinal settings. They include the Sparke Conglomerate, Elma Conglomerate, and Barramundi Conglomerate. Locally, the conglomerates interfinger with the reef complex limestones (Tyler et al., 1998c).

The Late Devonian to Early Carboniferous Fairfield Group (*DCF*) consists of limestone, sandstone, siltstone, and shale deposited in a shallow-marine environment (Tyler et al., 1998c). The Fairfield Group is overlain by the Late Carboniferous to Early Permian Grant Group (*P*).

#### *Remainder of Canning Basin*

Shallow-marine to fluvial sandstones and conglomerates of the Permian Noonkanbah Formation and Liveringa Group (*P*) were deposited in the Fitzroy Trough on MOUNT RAMSAY (Tyler et al., 1998c). These formations are also present on MOUNT BANNERMAN and BILLILUNA where they are overlain by Triassic sedimentary rocks. Ordovician marine sedimentary rocks (*Oc*) and Devonian fluviatile sedimentary rocks (*Dk*) lie beneath Carboniferous and Permian sedimentary rocks on the Billiluna Shelf (Blake et al., 1977).

## Palaeozoic Alice Springs Orogeny

The 400–300 Ma Alice Springs Orogeny ($D_7$) is the youngest phase of major faulting and folding in the east Kimberley. During this period there was reactivation of the Halls Creek Fault and other northeasterly trending faults in the Halls Creek Orogen, and also a period of north-northeasterly sinistral strike-slip faulting in the Pillara Range in the Canning Basin (Thorne and Tyler, 1996).

## Regolith

A veneer of unconsolidated or partly consolidated sediments including sand, silt, soil, calcrete, and silcrete covers much of MOUNT BANNERMAN and BILLILUNA, and is locally developed in the vicinity of rivers and creeks in the remainder of the area (Plumb and Gemuts, 1976; Warren, 1994a). There are also areas of ferricrete and ferruginous pisolitic gravel that represent remnants of a pre-Miocene land surface (Blake, 1996b).

# Exploration and mining

## 1882–1964

Gold was the first mineral to be discovered in the east Kimberley region in September 1882 by two prospectors, Philip Saunders and Adam Johns. Johns was alerted to the possible gold potential of the Kimberley by Alexander Forrest when they met at Pine Creek at the end of Forrest's 1879 Kimberley expedition (Playford and Ruddock, 1985). Due to lack of water and Johns' illness, Saunders and Phillips were unable to follow the gold to its source. Saunders' account of their discovery was published in the South Australian Advertiser in 1883 (reprinted in Clement and Bridge, 1991). During the Kimberley Survey Expedition in 1884, Edward Hardman (Government geologist attached to the expedition) found auriferous quartz reefs and alluvial gold over a large area traversed by the Margaret, Mary, Elvire, Panton, and Ord rivers (Hardman, 1885). Hardman (1885) also noted copper mineralization on the Margaret River (Me No Savvy), lead and zinc mineralization on the Ord River, and alluvial tin and semiprecious stones. Although Hardman (1885) did not have sufficient time in the area to show that payable gold deposits existed, his report and coloured geological map showing auriferous areas enabled the prospecting party of Charles Hall and John Slattery to obtain the first payable amounts of gold near Old Halls Creek in 1885 (Playford and Ruddock, 1985).

The ensuing Kimberley gold rush reached its peak in mid 1886 when thousands of diggers from the southern parts of Western Australia, the Eastern colonies, and New Zealand came to work the alluvial deposits and rich narrow quartz reefs at the Ruby Creek, Mount Bradley – Brockman, Mount Dockrell, Halls Creek, and Mary River centres. This led to the proclamation in May 1886, of the Kimberley as the first goldfield in Western Australia. However, by the time Woodward visited the area as Government geologist in 1890, most of the alluvial and underground workings had been abandoned (Woodward, 1891) due to the remoteness of the area, lack of water, illness and disease, shortage of fuel, small size of the deposits, and the discovery of richer fields in the Pilbara, Murchison, and Eastern Goldfields. The Ruby Queen mine, the largest of the historical mines, continued production until 1908, then produced sporadically between 1938 and 1964. There was also minor production from the other mining centres mentioned above between 1935 and 1960.

Recorded historical (pre-1964) production is relatively low, totalling 1056.8 kg, and consisting of 511.5 kg of alluvial and dollied gold and 545.3 kg of lode gold. However, production was probably significantly higher as there were no reporting requirements for gold produced prior to 1896 and gold produced between 1896 and 1898 during the peak of the gold rush probably went largely unreported in order to avoid the gold tax of 2s 6d per ounce.

The Tanami gold mine in the Northern Territory was discovered in 1900. Talbot found quartz with up to 5 g/t of gold to the east of Larranganni Bluff in the Granites–Tanami Complex in Western Australia in 1909. This followed his visit to the Tanami mine when he made a traverse from the Tanami mine to Halls Creek to determine if the formation hosting the Tanami deposit continued into Western Australia. The Kookaburra deposit was found by Glengarry Resources NL in 1995 not far from one of Talbot's sampling sites (Doust, 1997).

The State's largest fluorite deposit was discovered on Speewah Station in 1905 by botanist W. V. Fitzgerald (Simpson, 1951). Blatchford (1928) visited the occurrence and discovered an additional three fluorite veins; he also reported on the nearby Martins lead–silver prospect. A lead–silver deposit was also discovered near Mount Amherst during an AGGSNA survey (Jones, 1938). However, there was no historical production of base metals or fluorite because the distance to port made them uneconomical to mine.

Exploration by mining companies commenced in the 1950s. During 1954, the BMR carried out an airborne radiometric survey over part of the area and published a list of 54 well-defined anomalies (Goodeve, 1955). Torbernite had previously been discovered in the Dunham River area by United Uranium NL and Western Uranium, but the survey resulted in a sudden increase in uranium exploration in the area (Harms, 1959). Amongst these companies was Rio Tinto Finance and Exploration who searched for uranium deposits in black shale, chlorite schist, carbonate, and calc-silicate rocks adjacent to granites (i.e. similar to Rum Jungle, Northern Territory), for uranium in major faults cutting Proterozoic sedimentary and volcanic rocks, and for uranium in shear zones in granite (similar to Edith River, Northern Territory). Most radiometric anomalies coincided with lateritic ridges and were considered to be caused, in part, by topographic effects combined with moderate background radiation.

The iron ore deposits at Pompeys Pillar were discovered and explored by the Broken Hill Company during the late 1950s (Harms, 1959). Further exploration and resource evaluation were carried out by Bell Brothers, Planet Management and Research, Sentinel Mining Company, and Western Mining Corporation between 1961 and 1973.

Between 1960 and 1961, New Consolidated Goldfields Australia carried out exploration for sandstone–conglomerate-hosted gold and uranium mineralization in the basal conglomerates of the Upper Proterozoic rocks in the Gardiner Range area, and discovered uranium–xenotime mineralization in the Killi Killi area. However, a considerable amount of follow-up exploration in the area failed to find economic mineralization. New Consolidated Goldfields also found traces of gold in Slatey Creek, and in a creek draining the northern slopes of Junction Hill in the Granites–Tanami Complex.

Between 1961 and 1963, Peko Mines carried out exploration of previously identified copper occurrences at Mount Angelo, New Homestead (near Lamboo Homestead), and the Venture 3 or Golf Course prospect near Halls Creek.

Base metal gossans at Little Mount Isa and Ilmars were discovered in 1962 during regional mapping of GORDON DOWNS (Gemuts, 1963). Platinum-bearing chromite in the Panton Sill was also discovered between 1962 and 1963 during the regional mapping program on DIXON RANGE; assays of up to 3 g/t Pt were recorded (Dow and Gemuts, 1967).

Between 1963 and 1966, Pickands Mather and Company International carried out regional stream-sediment sampling over most of the east Kimberley area. Follow-up of the anomalies outlined by this program led to the discovery of many base metal (e.g. Gentle Annie), nickel–copper (e.g. Bow River), and chromite (e.g. Lamboo) prospects. This was the beginning of modern intensive mineral exploration in the Kimberley region.

## 1965–1975

Between the mid 1960s and the mid 1970s, the main targets of exploration were volcanogenic massive sulfide (VMS) and volcanic exhalative base-metal deposits; copper–nickel sulfides and platinum group elements (PGE) associated with layered mafic intrusions; and sandstone-hosted and unconformity-type uranium deposits. There was also some exploration for hydrothermal lode gold and porphyry-type copper and, from 1972 onwards, for Mississippi Valley-type mineralization and diamonds.

Pickands Mather and Company International discovered VMS-style mineralization in the Koongie Park Formation at Moola Bulla and at Koongie Park, southwest of Halls Creek between 1966 and 1968. Follow-up work by Kennecott Explorations (Australia) between 1972 and 1976 led to significant intersections of copper, lead, and zinc in the Koongie Park Formation at the Gordon Downs One (Golf Course), Gordon Downs Two (Mount Angelo North), Gordon Downs Three (Koongie Park), Eastman, and Mount Ramsay Three (Dusty Bore) prospects.

Platinum group element mineralization was discovered in an ultramafic intrusion, informally referred to as the Eastman intrusion, by Kennecott Explorations (Australia) Limited during 1974.

Broken Hill Proprietary Company (BHP), Australian Anglo American, Planet Management and Research, and Planet Mining Company found widespread copper mineralization in the Carson Volcanics between 1968 and 1972. Concentrations of native copper were found in the Antrim Volcanics in 1968 by Metals Exploration NL at Cuddys prospect, but no economic copper mineralization was found.

In 1972, Endeavour Oil Company NL found gossans in Devonian limestone of the Lennard Shelf at Ross Hill that assayed up to 27% Zn and 10% Pb. Mississippi Valley-type base metal gossans were also found in carbonates of the Winnama Formation in the Osmand Valley by Australian Anglo American in 1972. Trend Exploration intersected significant lead mineralization in the Bungle Bungle Dolomite in 1973.

Australian Anglo American discovered the Sally Malay nickel–copper–cobalt deposit during a stream-sediment and gossan survey during 1973. Nickel–copper mineralization in mafic–ultramafic intrusions was also found at the Keller Creek, McKenzies Spring, Coolumbooloo, Springvale, Billymac, Corkwood, and Melon Patch prospects.

Although uranium exploration did not locate any significant uranium deposits during this period, Trend Exploration discovered highly anomalous niobium, yttrium, tin, and fluorite mineralization, associated with a radiometric anomaly, at a prospect that is now known as the Brockman deposit.

## 1975–present

Exploration boomed in the east Kimberley from the mid 1970s following the discovery of diamonds in the north Kimberley in 1973 and the diamondiferous lamproite pipes at Ellendale in the west Kimberley in 1977. The results of this exploration for various commodities are discussed below.

### Diamond

From the mid-1970s, diamond became a major exploration target in the east Kimberley area. The Ashton Joint Venture recovered two diamonds from Smoke Creek during a reconnaissance-sampling program in August 1979. Follow-up sampling in October 1979 led to the discovery of the Argyle AK1 pipe, the largest diamond deposit in the world (Boxer and Jaques, 1990). Mining commenced in 1985. Alluvial diamonds have also been mined from drainages and palaeodrainages draining the Argyle AK1 pipe (Upper Smoke Creek, Limestone Creek, Bow River). Exploration for other lamproites and kimberlites has continued throughout the east Kimberley.

## Gold

Most recent gold exploration in the Lamboo Complex has been in the vicinity of known lode gold and alluvial workings. There was minor production of alluvial gold from the Majeed area (Red Gully, Sam Hazlett Creek, Chinaman Creek, Majeed Creek, Blue Bar Creek, and White Elvire River) by 125 Nominees between 1981 and 1983 and from the Mary River and its tributaries by Roebuck Resources NL and Alcott Holdings between 1988 and 1989. The development of carbon-in-pulp technology led to exploration for stockwork deposits in the vicinity of the old high-grade lode mines that could be mined by low-cost open-pit techniques. The Palm Springs mine (incorporating the old Butchers Gully workings) and the Nicolsons Find mine (50 km to the west) are examples of old mines with resources in quartz stockwork. Precious Metals Australia commenced open-pit production at the Palm Springs mine in April 1995, and 2272 kg of gold was produced before the mine was placed on care and maintenance in April 1997 as a result of falling gold prices (Precious Metals Australia Limited, 1997).

Gold exploration has also been carried out in the Granites–Tanami Complex. Anomalous gold was first reported in the Larranganni Bluff area by Talbot (1910), but it was not until 1983 to 1988 that CRA Exploration, Dry Creek Mining NL, and Mr A. R. Burns carried out exploration for Granites-style gold mineralization in this area. A costean in an area with anomalous arsenic exposed two 40 cm-thick quartz veins assaying 1.29 and 2.18 g/t Au respectively, but the tenement was relinquished; this is now the Cuckoo prospect of Glengarry Resources NL. In 1995, Glengarry Resources NL completed a program of regional geochemical sampling using a power auger. Follow-up of a gold anomaly led to the announcement of the discovery of the Kookaburra deposit on 24 November 1995 (Doust, 1997) and other prospects including Sandpiper, Hawk, Finch, Osprey, Albatross, and Cuckoo North.

Acacia Resources (now Anglogold) is also actively exploring for gold in the Tanami region of Western Australia. Acacia Resources recently announced the discovery of extensive high-grade gold mineralization in several zones over an area of 800 × 200 m with intersections up to 8 m at 458 g/t at the Coyote prospect (Acacia Resources Limited, 1999).

## Base metals

Exploration for volcanogenic massive sulfide (VMS) and volcanogenic exhalative base metal deposits, mainly in the vicinity of the earlier discoveries, has continued since 1975. The most significant deposits defined are Mount Angelo North and Sandiego in the Koongie Park area (Sewell, 1999).

Intense exploration for Mississippi Valley-type mineralization in the Lennard Shelf continued during this period, particularly by BHP Minerals and Billiton Australia. Base-metal bearing gossans were discovered in the Horse Spring Range area (Enigma gossan) and at Findlay Hill. The Kapok deposit, a blind deposit 350 m below surface and on the western margin of the study area, was discovered by BHP Minerals in 1989 as the result of aeromagnetic interpretation (Ferguson, 1999). Mining of the Kapok deposit by Western Metals commenced in 1997.

## Nickel–copper and PGE

Exploration for nickel–copper and PGE mineralization in mafic–ultramafic intrusions has continued since 1975, mainly in the vicinity of previously discovered occurrences.

## Uranium

Between 1980 and 1984, Mineral Reserves and Energy Reserves Canada carried out extensive radiometric and geobotanical exploration for unconformity-type uranium at the contact between the Tanami Complex and overlying Gardiner Sandstone in the Birrindudu area (Gardner Range, Laranganni Bluff, and Killi Killi Hills). This resulted in the discovery of the Don uranium–gold occurrence. BHP Minerals and PNC Exploration Australia carried out further exploration in this region, but no significant uranium deposits were found.

## Rare earth elements and niobium–tantalum

The Cummins Range carbonatite was discovered by CRA Exploration during the follow-up of an aeromagnetic anomaly. The airborne survey was flown in 1978 over the inferred junction of the Halls Creek Orogen and the King Leopold Orogen, south of Cummins Range, primarily in the search for kimberlites. Drilling carried out between 1982 and 1984 gave an indicated resource of 3 to 4 Mt at a grade of 2 to 4% total rare earth oxides (REO), but this was considered too low to be mined economically (Andrew, 1990).

West Coast Holdings followed up an area of anomalous niobium, yttrium, tin, and fluorite discovered by Trend Exploration in tuffs near Halls Creek and by 1988 had defined a resource at the Brockman deposit.

## Tungsten

Union Oil Development Corporation explored for tungsten in the eastern zone of the Lamboo Complex using ultraviolet (UV) lamping. About 90 scheelite occurrences were found over a strike length of 20 km in the Castle Creek (Berthas Butt) area. The best intersection from follow-up drilling was 2.5 m at 0.96% $WO_3$ in BB1 at Glory Rock Hole (Blight, 1983).

# Mineralization

The 1333 mineral occurrences in the east Kimberley are shown on Figure 5 and on Plates 1 and 1a. The mineral occurrences on Plates 1 and 1a are grouped by mineral

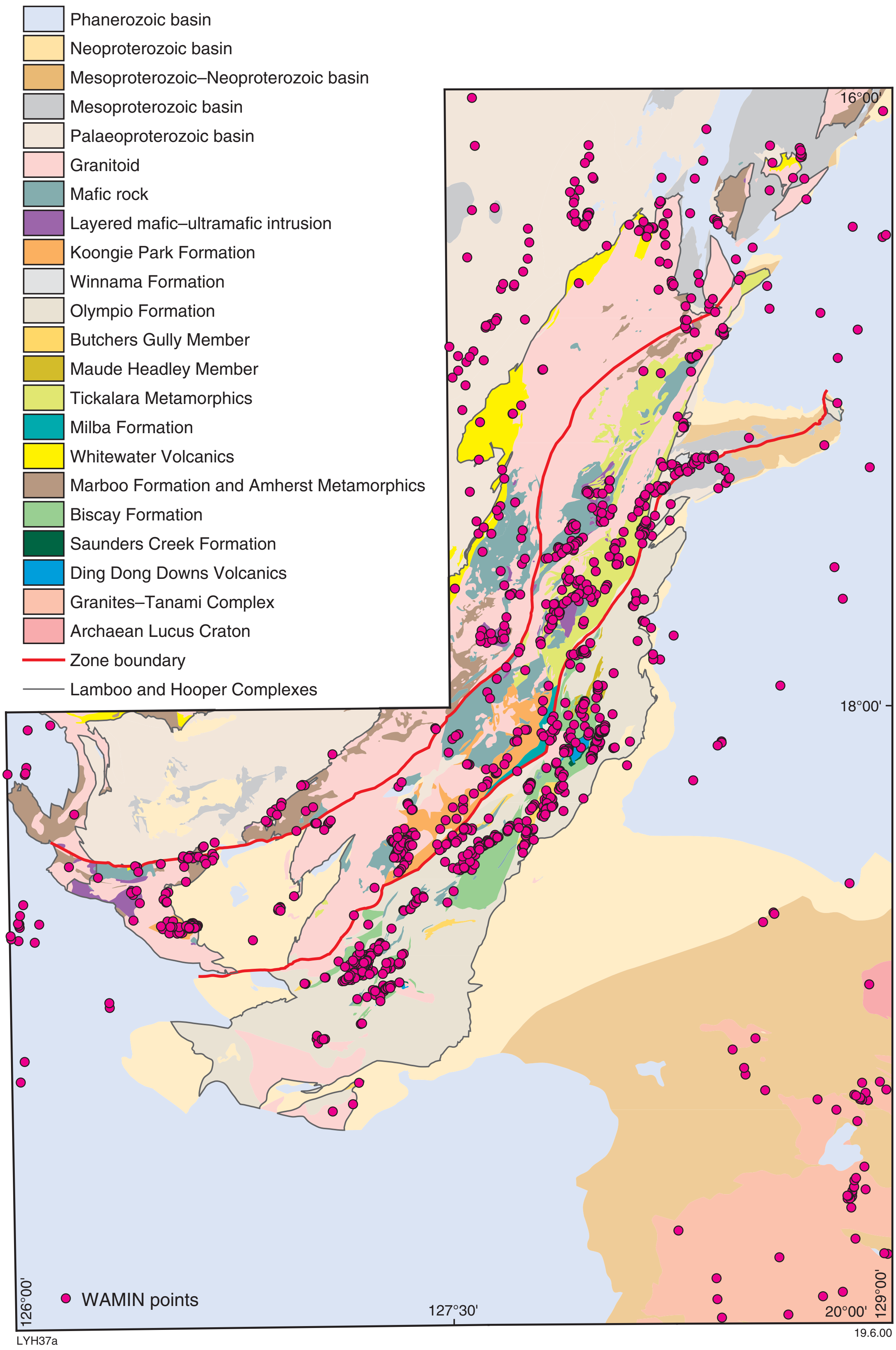


**Figure 5. Tectonic sketch showing distribution of mineral occurrences in the east Kimberley. Scale — 1 cm : 20 km (approximately)**

commodity and by mineralization style. Symbol colours on the Plates are used to distinguish commodity groups and symbol shapes are used to distinguish mineralization styles. For the convenience of description in the section below, mineralization style is used as a main heading followed by each of the commodity groups under various subheadings. Mineral occurrences referred to below are also identified by the WAMIN 'deposit number' shown thus: Palm Springs (2223).

## Mineralization in kimberlite and lamproite intrusions

Only three mineral occurrences in kimberlite and lamproite intrusions have been identified in the east Kimberley area, but one of these, the Argyle AK1 pipe diamond deposit (1106; Fig. 6), is by far the most economically important mineral deposit discovered to date in the area.

### *Precious mineral — diamond*

#### *Argyle AK1*

The Argyle AK1 pipe is a diatreme consisting of olivine lamproite pyroclastic and reworked pyroclastic rocks, intruded by rare olivine lamproite dykes. The pyroclastic rocks have been divided into 'sandy tuffs' that contain grains of country rock, and 'non-sandy tuffs' that do not contain any quartz grains. A detailed petrographic description of the pipe is given in Jaques et al. (1986). The pipe intrudes Palaeoproterozoic to Mesoproterozoic sedimentary rocks of the Carr Boyd Group and Revolver Creek Formation, and has been dated at 1178 ± 47 Ma using Rb–Sr dating of phlogopite and the whole-rock isochron (Pidgeon et al., 1989). At the surface, the pipe is about 2 km long and varies from 500 m wide at the northern end to 150 m at the southern end. The shape of the pipe has been affected by post-intrusion faulting and regional tilting of about 30° to the north. Diamonds are most abundant in the sandy tuff, where they are present in juvenile lamproite clasts and as liberated grains in the matrix of the tuffs; diamonds are also present in the non-sandy tuff and the lamproite dykes (Boxer and Jaques, 1990). The pre-mining surface grade was about 5 cts/t, which is much higher than that of other diamond deposits around the world, but only about 5% of the diamonds are gem quality with the remainder being cheap-gem (40%) and industrial diamonds (55%; Jaques et al., 1986). Since mining commenced in 1985, recorded production to December 1999 has been 366.8 Mcts. The resources and reserves for Argyle AK1, as at 31 December 1999, are proved reserves of 62.9 Mt at 2.6 cts/t, probable reserves of 0.9 Mt at 3.3 cts/t, and measured, indicated, and inferred resources of 145.2 Mt at 2.9 cts/t (Ashton Mining Limited, 2000).

#### *Lissadell Road Dykes*

The Lissadell Road Dykes (1110) are an en echelon series of altered lamproite dykes and stringers that range from

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**Figure 6. Argyle AK1 mine — terrace of east ridge wall (photograph courtesy of Argyle Diamonds)**

a few millimetres to one metre in width and have been emplaced in tension gashes resulting from east-northeast shear movement (Jaques et al., 1986). Moonstone Diamond Corporation recovered 500 macrodiamonds during bulk testing of the dykes in 1992, with spot grades up to 24 cts/t (Bester, 1999).

#### *Maude Creek Dyke*

CRA Exploration recovered a small diamond (0.05 cts) from a 4.6 t sample from the Maude Creek Dyke (1115; Fielding, 1983) and five microdiamonds from two samples totalling 80 kg from this dyke (Smith, 1978; Fielding, 1983). The dyke intrudes the Hart Dolerite and is 1.5 m wide. An aerial photo-lineament, together with the distribution of kimberlitic indicator minerals, suggests that the dyke extends for about 2 km (Smith, 1978). Petrographically, the dyke resembles a kimberlite in that it contains abundant picroilmenite and pyrope macrocrysts, dunitic xenoliths, and traces of diamond; however, the spinel composition is not typical of kimberlite (Jaques et al., 1986).

## Mineralization in carbonatite and alkaline igneous intrusions

Only four mineral occurrences have been classified as carbonatite and alkaline igneous intrusions. By far the largest of these is the Cummins Range (REE) carbonatite deposit (1119). The Cummins Range intrusion is a composite, subvertical stock consisting of an outer layer of pyroxenite and inner zones of carbonated mica-rich pyroxenite with numerous steeply dipping carbonatite veins that have been weathered to silicified ironstone breccia at the surface. The stock measures 1.8 by 1.7 km in plan (Fitton, 1981; Andrew, 1990). The intrusion has been dated at 800 Ma (Pidgeon et al., 1989). Both sovite (calcite dominant) and beforsite (dolomite dominant) carbonatite phases are present. The carbonatite is anomalous in REE, $P_2O_5$, and tantalum. Zircon, sphene, baddeleyite, monazite, aeschynite, pyrochlore, columbite, and allanite are the main accessory minerals in the carbonatite (Andrew, 1990). There is an indicated resource of 6.3 Mt to 50 m depth at 0.5–1.0% total REO using a 0.5% cutoff (4.6 Mt at 1.0–2.0% if 1% cutoff is used; 0.6 Mt at 2.0–2.5% if 2.0% cutoff is used; Weir, 1989). The European grade of 50 to 100 ppm $Eu_2O_3$ is comparable with that of the Mountain Pass deposit in California (Weir, 1989). However, the overall REO grade was considered too low to be mined economically (Andrew, 1990). Cummins Range (REE 2) (5961) is a possible satellite body of the main Cummins Range (REE) deposit as it contains anomalous $P_2O_5$ and REE (Fitton, 1981; Dundas Gold Corporation NL, 1984).

Pods of carbonatite breccia with anomalous REE have been found in a small altered syenite intrusion that intrudes the Tickalara Metamorphics at Copperhead (1122; Rugless and Pirajno, 1994, 1996). A possible carbonatite dyke is also associated with fluorite mineralization at West Ridge (2399; Alvin, 1993; Rogers, 1998).

## Orthomagmatic mafic and ultramafic mineralization

### Mineralization in layered mafic intrusions

A total of 188 occurrences have been classified as ‘orthomagmatic mafic and ultramafic — layered mafic’. Of these, 176 are in the Central zone of the Lamboo Complex; the remaining 12 are in the Western zone. The occurrences have been divided according to the main commodity into steel-industry metal (94 occurrences), precious metal (52 occurrences), base metal (35 occurrences), industrial mineral (six occurrences), and construction material (one occurrence).

Layered mafic–ultramafic intrusions in the Halls Creek Orogen occur in the Central and Western zones of the Lamboo Complex (Fig. 7). According to Hoatson (1997, in press) the intrusions were emplaced during at least three separate periods, and they may be divided into seven major groups on the basis of their field relationships, geochronology, style and intensity of deformation, and types of mineralization (see **Regional Geology**, p. 4, and Fig. 8). Significant mineralization occurs in two of Hoatson’s seven groups: the 1855 Ma Group I (e.g. Panton intrusion) and the 1845 Ma Group V (e.g. Sally Malay intrusion). There is also some mineralization in the 1855 Ma Group II (e.g. Springvale intrusion) and the Group IV Wild Dog Creek Gabbro. There is potential for mineralization in the 1830 Ma Group VI (e.g. McIntosh intrusion).

Significant mineralization also occurs in the Lamboo intrusion and the Eastman Bore intrusions, which intrude the c. 1845 Koongie Park Formation, but these are located outside the area studied by Hoatson (1997, in press). In addition, there are mineralized layered mafic intrusions within the Tickalara Metamorphics that have been metamorphosed to granulite facies and that pre-date the seven groups of Hoatson (1997).

#### *Steel-industry metal — nickel (copper, cobalt)*

Most of the nickel occurrences are in Group V intrusions in the Central zone of the Lamboo Complex and the most significant is the Sally Malay deposit (653). The deposit is hosted by norite at the base of the Sally Malay intrusion where mineralization occurs as two keel-shaped lenses of massive pyrrhotite–pentlandite–chalcopyrite, 3–40 m thick. The massive sulfides are overlain by minor stringer-style chalcopyrite–pyrrhotite–pentlandite mineralization (Shedden and Barnes, 1996). On the basis of their textures, compositions, and basal distribution, Thornett (1981) suggested that the sulfides in the Sally Malay deposit formed by the gravity segregation of an immiscible sulfide liquid, with the sulfides possibly being derived from graphite–pyrrhotite gneisses within the Tickalara Metamorphics. The Sally Malay deposit has an indicated and inferred resource of 3.85 Mt averaging 1.79% Ni, 0.73% Cu, and 0.10% Co (Shedden and Barnes, 1996). Group V (Sally Malay) intrusions also host nickel–copper sulfide mineralization at the Keller Creek (e.g. 642),

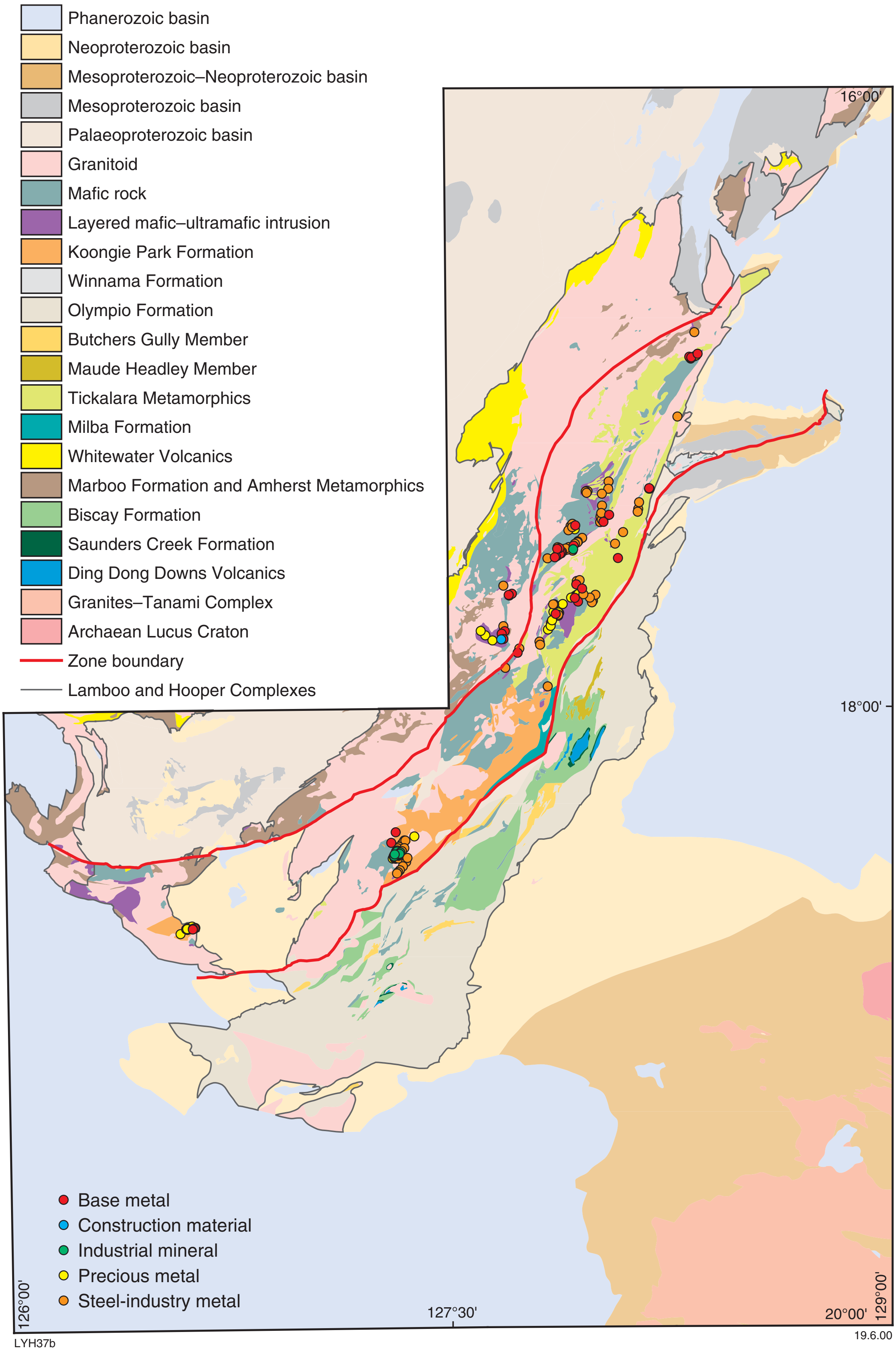


**Figure 7. Tectonic sketch showing distribution of mineralization associated with layered mafic–ultramafic intrusions. Scale — 1 cm : 20 km (approximately)**

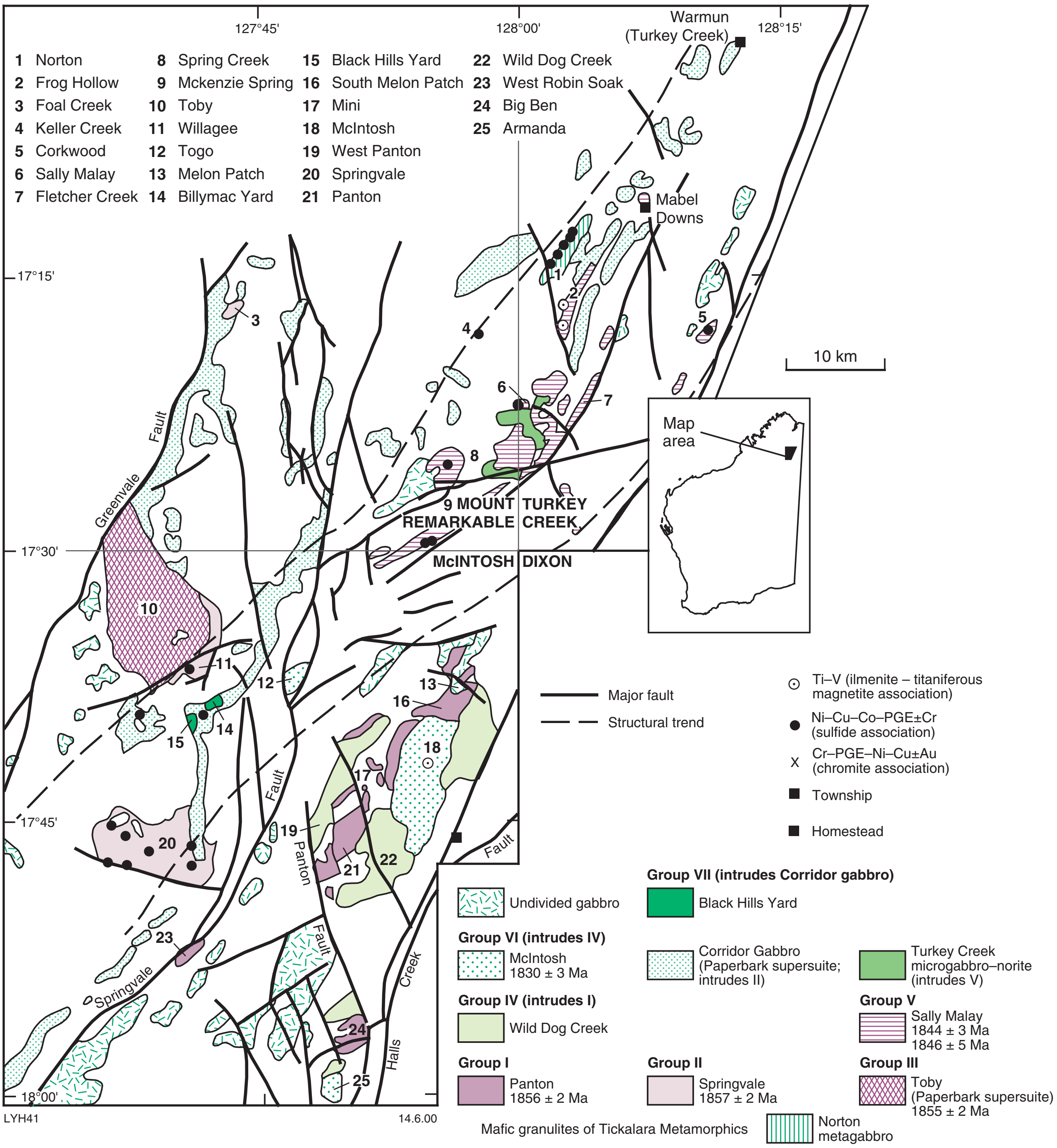


**Figure 8. Distribution and classification of layered mafic intrusions in part of the Lamboo Complex (after Hoatson, 1997)**

McKenzies Spring (e.g. 661), Corkwood (e.g. 641), Bulldust Flat (762), and Melon Patch prospects (e.g. 663). Nickel–copper–cobalt-bearing gossans have also been found in the Group V Spring Creek intrusion (e.g. Spring Complex 2, 7; and Coolumbooloo Yard, 4703). At Spring Complex 3 (10), a nickel–copper–cobalt gossan is interpreted to be related to mobilized sulfides in xenoliths of ultramafic–mafic rocks of the Spring Complex within granitoid (Lemcke, 1981).

A layered mafic–ultramafic intrusion is clearly recognizable in Tickalara Metamorphics in the Central zone of the Lamboo Complex in the Bow River area despite granulite facies metamorphism. This intrusion contains low-grade, primary disseminated sulfides in norite, and also bands of massive pyrrhotite and minor chalcopyrite, which could be primary or metamorphic in origin at Bow River (Ni–Cu) (667). The best percussion-drill intersection obtained by Pickands Mather and Company International was 4.57 m at 1.22% Ni and 0.43% Cu (Lewis, 1966). Gossans have also been found in ultramafic rocks of the Tickalara Metamorphics to the north-northeast of Alice Downs at prospects known as Cabernet (639), Shiraz (2868), and Malbec (2869). At Cabernet, gossan samples assayed up to 7.23% Ni and 3.7% Cu and the best intersection was 16 m at 0.9% Ni and 1.4% Cu, including 4 m at 2.38% Ni and 1.3% Cu (Mazzoni, 1976).

Nickel–copper mineralization has also been recorded from the Group IV Wild Dog Creek Gabbro (e.g. Mabel Hill (Ni–Cu) 1; 5285) where the best drill intersection was 3.8 m at 1.43% Ni and 0.3% Cu (Shaw, 1978).

In the Western zone of the Lamboo Complex, a mineralized norite with up to 40% matrix sulfides (predominantly pyrrhotite with minor chalcopyrite and pentlandite) was intersected in a percussion drillhole at Billymac Yard D (5288; Western Mining Corporation Limited, 1980). This unit has been mapped as part of the Paperbark supersuite on McIntosh; the unit is referred to as the Corridor gabbro by Hoatson (1997). Minor nickel–copper-bearing gossan has been found in gabbro and norite of the Paperbark supersuite at Springvale 7 (4758).

### Steel-industry metal — chromium (PGE)

Most chromium occurrences are in the Central zone of the Lamboo Complex, in the Group I Panton intrusions (e.g. Panton 2, 5272; Mini M, 819; Big Ben, 817), and in the younger Lamboo intrusions (e.g. Lamboo (Cr 1), 831). The chromite typically occurs as stratiform chromitite layers ranging in width from a few centimetres to 2.4 m. In the Western zone, chromium is also present in the Group II Springvale intrusion (e.g. Springvale 1, 814) and Wilagee intrusion (e.g. Toby South, 812). Where significant PGE grades have been reported in addition to chromite, the occurrences have been classified as precious metal (see **Precious metal — PGE (gold, nickel, chromium)** below).

### Steel-industry metal — titanium

Ilmenite-rich bands and lenses up to 150 m long and 30 m wide have been reported from gabbro and norite of the ?Sally Malay intrusions in the Ord Crossing area (838, 5198, 5199, 5200; El-Ansary, 1971). Lenses of ilmenite are also present in one of the Sally Malay intrusions at Frog Hollow North Lens (842) and Frog Hollow South Lens (843; Hoatson, 1995).

### Precious metal — PGE (gold, nickel, chromium)

Occurrences of PGE are almost entirely restricted to the Central zone of the Lamboo Complex. Of these, many PGE occurrences are associated with chromitite layers in Group I Panton intrusions. The most significant of these occurrences is the Panton deposit (825) in the Panton intrusion. This intrusion consists of a lower ultramafic unit and an upper gabbroic unit that includes gabbronorite, gabbro, and anorthosite. There are five stratiform chromitite layers, each with a strike length of greater than 4.5 km, within the lower ultramafic unit of the intrusion. The uppermost of these layers, designated the A-seam, has an indicated and inferred resource of 2.0 Mt at 6.02 g/t PGE–Au and 0.28% Ni (Perring and Vogt, 1991). Other examples of PGE mineralization associated with chromitites in Group I Panton intrusions include Mini M (Cr–PGE) 2 (12), Togo 5A (828), Alice Downs 4 (3571), and Melon Patch 7 (3561).

Chromitite seams in the strongly folded c. 1810–1830 Ma Lamboo intrusion also contain PGE mineralization (e.g. Lamboo (PGE 1), 6142) where PGE minerals (including sudburyite, sperrylite, geversite, and stibiopalladinite) are enclosed within violarite and silicates in chromitite layers adjacent to, or within, coarse-textured olivine orthocumulate (O'Shea, 1987).

Significant PGE mineralization has also been recorded from chromitite horizons within the Eastman Bore intrusion (e.g. 835, 1044, and 5705; Union Corporation (Australia) Proprietary Limited, 1975; Barrett, 1982).

In the Western zone of Lamboo Complex, minor PGE mineralization is associated with chromitites in leucotroctolite and anorthosite in the Group II Springvale intrusion (e.g. Springvale 2, 3517).

### Base metal — copper (nickel, PGE, chromium)

In the Central zone of the Lamboo Complex, copper-rich gossans, which probably represent remobilized magmatic sulfides, are associated with Group I Panton intrusions (e.g. Mini M (Cu), 3511; MI-2b, 5370; Melon Patch 1, 663); Group V Sally Malay intrusions (e.g. McKenzies Spring 2, 4737) and Spring Creek intrusion (e.g. Coolumbooloo Yard 2, 5268); and the Group VI McIntosh intrusion (e.g. McIntosh A, 766).

In the Western zone of the Lamboo Complex, copper-bearing gossans are present in the Group II Springvale intrusion (e.g. Springvale 5, 4756) and in younger gabbro of the Paperbark supersuite, referred to as the Corridor gabbro by Hoatson (1997; e.g. Billymac Yard A, 806).

### Industrial mineral — asbestos

Chrysotile veins occur in serpentinized peridotite of the Lamboo intrusion in the Central zone of the Lamboo Complex. An order of magnitude estimate of the resources at the Lamboo prospects (Lamboo (asbestos 2), 5486; Lamboo (asbestos 3), 5487; and Lamboo (asbestos 4), 5488) is 15 to 20 Mt containing 7–10 volume percent chrysotile (Betts, 1976; but note that this does not conform to the present JORC code). An asbestos seam has also been reported from a carbonated ultramafic (?Sally Malay) intrusion at Ord Crossing (asbestos) (5201).

### Industrial mineral — talc

Pickands Mather and Company International (1965) reported 'reasonably high grade' talc in a shear zone in the Lamboo intrusion at Lamboo (talc) (5103).

### Construction material

There is black dimension stone, reported to have characteristics superior to the Black Hill Norite in South Australia, in the Springvale intrusion at McIntosh B (2765). The rock is a magnetite gabbro and has a uniform grainsize: about 1–1.5 mm for feldspar and 3 mm for pyroxene (Temby, 1994).

## Undivided mineralization

Occurrences in the East Kimberley area that are associated with mafic dykes and intrusions, which are not obviously layered, have been classified as 'orthomagmatic mafic and ultramafic — undivided'. A total of 11 occurrences have been identified including seven base metal occurrences, three steel-industry metal occurrences, and one construction material occurrence.

### *Base metal — copper, zinc, lead (silver)*

In the Central zone of the Lamboo Complex, copper–nickel–PGE mineralization has been intersected in amphibolite of the Tickalara Metamorphics at Eileen Bore (764); the mineralization has probably been mobilized during metamorphism. A gossan with small amounts of malachite and visible gold is associated with amphibolite at Louisa Downs 3 (6312). At Emull (1147), base metal mineralization occurs in serpentinite close to its contact with the Koongie Park Formation. It is not certain whether the sulfides are primary in origin or whether they represent assimilated volcanogenic mineralization (Sanders, 1999).

In the Red Rock Basin, minor malachite and azurite has been reported from basalt or dolerite of the Red Rock Formation at Fish Hole Waterhole (2483) and Osmond Range West (2485; Dow and Gemuts, 1969).

### *Steel-industry metal — nickel, cobalt (copper)*

A nickel–copper-bearing gossan containing malachite and secondary copper sulfides is associated with gabbro and pyroxenite of the Sally Downs supersuite at Osmond Valley (Ni–Cu) (810). Anomalous cobalt is associated with small veinlets of pyrrhotite in a fine-grained mafic dyke that intrudes gabbro and norite of the Sally Downs supersuite at McKenzies Spring 10 (5204).

### *Construction material*

Gabbro suitable for building stone is present at Halls Creek North (6474).

## Disseminated and stockwork mineralization in plutonic intrusions

### *Base metal — copper (molybdenum, silver, gold)*

A total of seven mineral occurrences have been classified as 'disseminated and stockwork in plutonic intrusions'. These occurrences are all base metal occurrences in the Central zone of the Lamboo Complex. It is not certain whether these occurrences are porphyry copper deposits or whether they should be classified as 'vein and hydrothermal — undivided'.

At Mount Angelo Porphyry (1098), mineralization is hosted by sheared Angelo Microgranite that shows evidence of silicic, sericitic, and chloritic alteration. The microgranite is probably the subvolcanic equivalent of felsic volcanic rocks in the Koongie Park Formation (Sheppard et al., 1995). Chalcopyrite occurs as disseminations and veinlets with minor bornite, tetrahedrite, pyrite, sphalerite, and molybdenite in the primary zone and malachite, chrysocolla, and minor native copper in the oxidized zone (Blain, 1969). The deposit has an indicated resource of 144 Mt at greater than or equal to 0.2% Cu (Sewell, 1999). Anomalous molybdenum and silver levels are also present, with intersections up to 3 m at 50.4 g/t Ag and 3.05 m at 0.25% Mo reported (Pickands Mather and Company International, 1967b). Gold values are subeconomic; the best intersection is 8 m at 0.2 g/t (Sewell, 1999).

The McHale Granodiorite of the Sally Downs supersuite hosts the McHales (1093) and Killarney occurrences (e.g. Killarney 1, 1087). At these occurrences, mineralization occurs as vein and fracture fillings and as disseminated copper mineralization in granitoid. The granitoid shows evidence of propyllitic, sericitic, potassic, silicic, and argillic alteration and a number of magmatic–hydrothermal breccia dykes have been recognized (Witt and Sanders, 1996). The mineralization has been interpreted as porphyry copper by Stratin Minerals Proprietary Limited (1972) and Witt and Sanders (1996). An alternative interpretation (Scott, 1973) is that it is related to volcanic rocks unconformably overlying the granite (Texas Downs Formation).

## Pegmatitic mineralization

A total of seven pegmatitic occurrences have been recorded. They are all at the southern end of the Eastern zone of the Lamboo Complex and include six speciality metal occurrences and one steel-industry metal occurrence.

### *Speciality metal — tin, tantalum, niobium, lithium, beryl*

A pegmatite at Columbian Creek (5754) contains scattered crystals of spodumene, beryl, columbite, and cassiterite. Cassiterite has also been recorded from small pegmatites at Mount Heartbreak F (926), Mount Cross (Sn 1) (969), Mount Cross 4 (6380), Junda 3 (5914), and Minneroo Pool 1 (976). An imprecise SHRIMP date of 1740 ± 40 Ma has been obtained on one of these pegmatites (AGSO OZCHRON database).

### *Steel-industry metal — tungsten*

At Junda 1 (961), there are moderately coarse crystals (4 to 20 mm across) of scheelite in a pegmatitic vein (300 × 3 m) within mica schist; the scheelite is restricted to a zone about 15 m in length.

## Skarn mineralization

A total of 22 occurrences have been classified as skarn, but the genesis of many of these occurrences as 'typical skarns' is doubtful (see **Mineral controls and exploration potential**, p. 49). The occurrences have been subdivided according to their major commodity into base metal (15), steel-industry metal (4), speciality metal (2), and industrial mineral (1).

### *Base metal — copper, zinc, lead, silver (molybdenum, tin, tungsten)*

Most of the base metal occurrences classified as skarn (12) are within calc-silicate horizons of the Tickalara Metamorphics, in the Central zone of the Lamboo Complex. Examples are Melon Patch Well A (1050), White Rock Well (1085), and Wills Creek B1 (1063). There is no obvious association with granitic rocks except at Wills Creek B6 (1078), where Western Mining Corporation Limited (1979) reported malachite and chalcopyrite in quartz–garnet–scapolite–diopside skarn, containing up to 16.5% Cu and 80 ppm Ag, associated with quartz veins and slivers of foliated tonalite (?Monkey Yard Tonalite).

Chadwick (1984) reported zinc and lead mineralization in weathered epidote–garnet–diopside–calcite skarn within the Koongie Park Formation at BB Hill (3298). Gossan has also been reported from limestone of the Winnama Formation near its contact with dolerite at Osmond Valley (Zn 7) (5530; Codner, 1973).

In the Eastern zone, epidote–calcite–titanite–diopside–vesuvianite–andradite–grossular skarn with anomalous copper, silver, and molybdenum values has been reported from the Biscay Formation in the Taylor Lookout area at Skarn A (5743; Mazzoni, 1979).

### *Steel-industry metal — tungsten (tin)*

Two scheelite-bearing skarns have been reported from the Koongie Park Formation, in the Central zone of the Lamboo Complex, at Central Skarn (3299) and Southern Skarn (3300).

In the Eastern zone of the Lamboo Complex, scheelite- and cassiterite-bearing skarn occurs in the Butchers Gully Formation close to a pegmatite at Mount Heartbreak A (887). Scheelite-bearing calc-silicate rock and carbonated mafic tuff of the Ding Dong Downs Volcanics at Frog Creek (930) have been interpreted as skarn mineralization by Sanders (1999).

### *Speciality metal — tin (silver)*

In the Eastern zone of the Lamboo Complex, cassiterite-bearing skarns have been reported from the Butchers Gully Member at Mount Cross (Sn 2) (972) and from the Biscay Formation at Taylor Lookout 7 (5748).

### *Industrial mineral — garnet*

Garnet-bearing skarn or calc-silicate rock has been reported from the Tickalara Metamorphics at Garnet Hills (5613) in the Central zone of the Lamboo Complex.

## Stratabound volcanic and sedimentary mineralization

In the east Kimberley area, occurrences included under 'stratabound volcanic and sedimentary' include: VMS deposits associated with proximal felsic volcanic rocks; volcanic exhalative deposits associated with distal volcaniclastic sediments; REO and tantalum mineralization associated with alkaline volcanic rocks; native copper mineralization in mafic volcanic rocks; and mineralization associated with interflow sedimentary rocks and tuffs in mafic volcanic units. In the database, the deposits in this category have been subdivided into volcanic-hosted sulfide, sedimentary-hosted sulfide, volcanic oxide, and undivided. However, this classification has been somewhat arbitrary because many of the deposits are hosted by tuffaceous sedimentary rocks or a mixture of rock types. Consequently, 104 of the 171 occurrences in this category have been classified as undivided, but many of these are genetically related to those classified as volcanic-hosted sulfide or sedimentary-hosted sulfide. For the purposes of discussion, all of the occurrences are considered under the main heading of 'stratabound volcanic and sedimentary' and the subheadings of the main commodity types present. There is a total of 131 base metal, 14 steel-industry metal, 13 precious metal, eight speciality metal, one energy mineral, one industrial mineral, and three precious mineral occurrences in the stratabound volcanic and sedimentary category (Fig. 9).

### *Base metal — copper, lead, zinc, silver*

A significant number (53) of the base metal occurrences in the stratabound volcanic and sedimentary category are within the Koongie Park Formation in the Central zone of the Lamboo Complex. The Koongie Park Formation in the Koongie Park area has been informally divided into three members by Sewell (1999): Coolibar tuff member; Camp shale member; and Weldon Creek lava member. The basal part of the Camp shale member, termed the 'Mimosa interval' by Sewell (1999), consists of intercalated chert, chloritic schist, banded magnetite or pyrrhotite–chlorite rock, black shale, impure dolomite, and andesitic lava and volcaniclastic rocks. The 'Mimosa interval' hosts the Sandiego (1125) and Mount Angelo North (1137) deposits and many other smaller VMS prospects in the Koongie Park area.

At Sandiego, zinc–lead–copper–silver(–gold) mineralization occurs along the western limb of a fold over a strike length of 350 m. There is a crude zonation at Sandiego from massive sphalerite, pyrrhotite, and accessory galena at the base of the deposit to a zone of stringers of chalcopyrite and pyrite at the top of the deposit. The inferred resource at Sandiego includes 0.335 Mt at 6.71% Cu and 288 g/t Ag in the supergene zone, and 4.3 Mt at 0.51% Cu, 0.83% Pb, 7.9% Zn, and 31 g/t Ag in the primary sulfide zone (Sewell, 1999). At Mount Angelo North, massive copper–silver mineralization is hosted by shales within a tuffaceous horizon in the 'Mimosa interval' and disseminated and stringer copper mineralization is present in the overlying Weldons Creek lava member. The

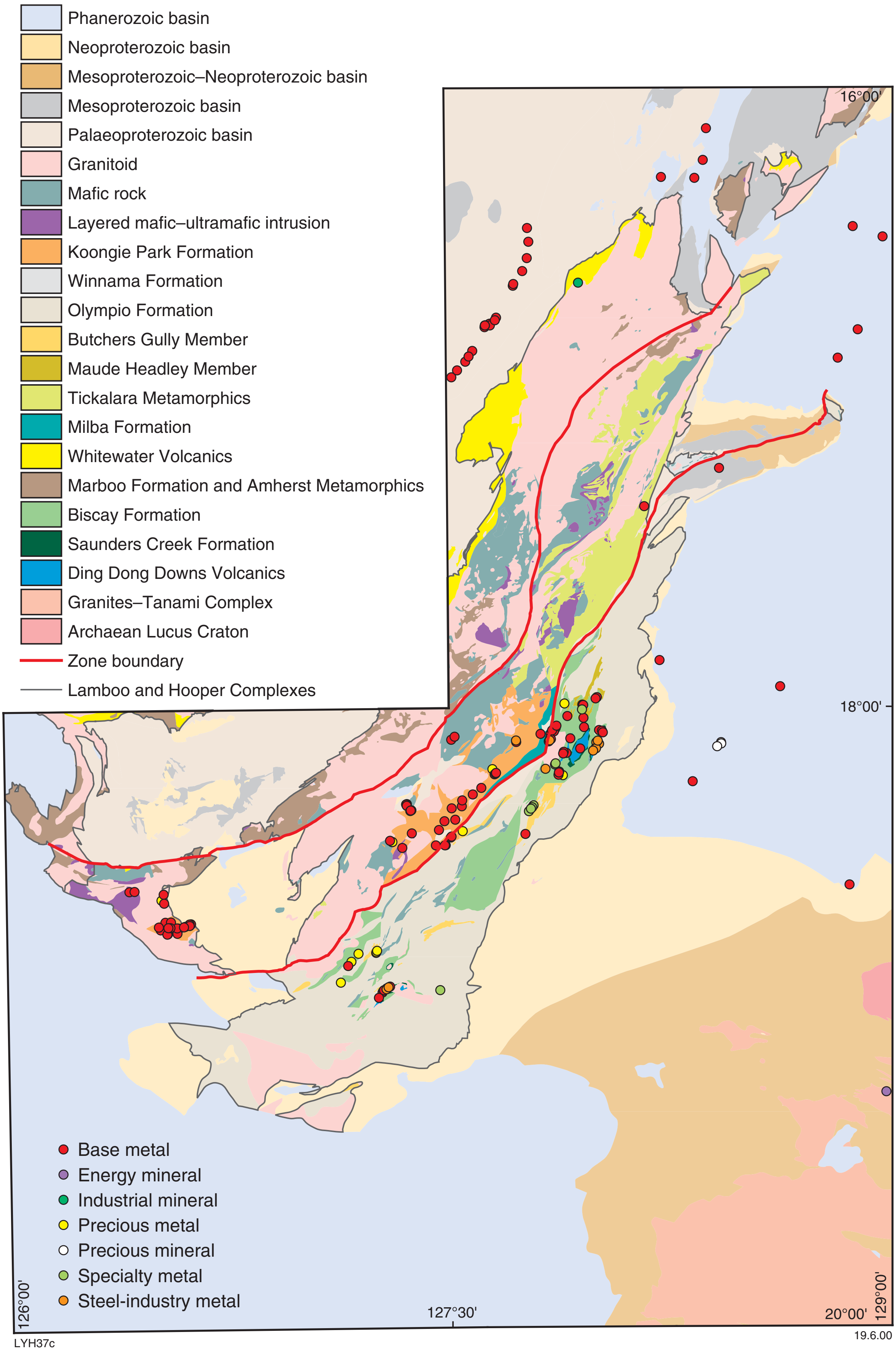


**Figure 9.** **Tectonic sketch showing distribution of stratabound volcanic and sedimentary deposits. Scale — 1 cm : 20 km (approximately)**

inferred resource for Mount Angelo North includes: 0.076 Mt at 1.0% Cu and 9.6 g/t Ag in the gossan zone; 0.035 Mt at 1.1% Cu and 45.0 g/t Ag in the Ag-rich supergene zone; 0.011 Mt at 7.7% Cu and 19.1 g/t Ag in the Cu-rich supergene zone; and 0.2 Mt at 2.0% Cu in the primary sulfide zone (Sewell, 1999).

In the Louisa Downs area, subeconomic base metal mineralization is associated with distal volcaniclastic sediments, chert, and tuffs of the Koongie Park Formation (e.g. Landrigan Creek, 1139; Eastman Yard 1, 5398; and Bullock Bore 1, 1140). At Landrigan Creek, a copper–zinc–silver–gold zone is underlain by a lead–molybdenum zone (Platts, 1983).

In the Tickalara Metamorphics, the only stratabound volcanic and sedimentary base metal occurrence reported is the Tickalara occurrence (1252) where malachite-bearing gossan occurs in quartz–muscovite–feldspar schist interpreted by Hoyle (1976) as a felsic volcanic or pyroclastic rock.

At Morgans Grave (1300 and 5959), to the northwest of Louisa Downs, gossans are associated with quartz–chlorite–sericite schist within an area mapped as amphibolite with intercalated metasedimentary rocks on MOUNT RAMSAY. Here, massive pyrrhotite was intersected in a diamond drillhole. The mineralization was interpreted as volcanogenic by Menzies and Ross (1982) but as a mineralized shear by Sanders (1999).

Most of the stratabound volcanic and sedimentary base metal occurrences in the Eastern zone of the Lamboo Complex are in the Biscay Formation (31 occurrences) with a few occurrences in the Ding Dong Downs Volcanics (four occurrences), the Butchers Gully Member (two occurrences), and the Maude Headley Member (two occurrences).

The most important occurrences are Ilmars Central (1180) and Little Mount Isa (1188). At Ilmars Central, zinc–lead–copper–silver–gold mineralization is in the Biscay Formation at the contact between chlorite–quartz schist and calc-silicate rocks close to felsic volcanic rocks (Sewell, 1999). Little Mount Isa is possibly on the same stratigraphic horizon as Ilmars Central. At Little Mount Isa, two parallel zones of gossan are separated by 6 m of chlorite schist. The gossan horizons change to pyritic black shale at depth (Sewell, 1999). Hemimorphite and cerussite-rich gossans are associated with meta-rhyolite and chert 4 km south along strike from Ilmars Central at Twin Hills (1192, 5728; Sewell, 1999). Gossans in chloritic and graphitic schists and dolomite of the Biscay Formation at Gentle Annie B (1202) are similar in style to Ilmars (Harris, 1967). At Taylor Lookout 6 (5745), there are small gossanous stringers in felsic volcanic rock within the Biscay Formation.

Gossans with minor amounts of base metals have been reported in association with felsic volcanic rocks of the Maude Headley Member (e.g. Palm Creek, 5377) and Butchers Gully Member (e.g. Ruby Queen – Brockman 2, 5074).

Native copper occurs in thin quartz veins and quartz–calcite amygdales within basalt of the Ding Dong Downs Volcanics at Ding Dong Downs (Cu) (2429). Minor base-metal gossans are associated with the Ding Dong Downs Volcanics in felsic volcaniclastic rocks at Castle Creek 15 (5051) and in black shales at Sophie Downs (Zn) 3 (4918).

In the Kimberley Basin, widespread, but patchy, copper mineralization in interflow sediments and tuffaceous flow tops of basalt of the Carson Volcanics has been interpreted as volcanogenic by Planet Management and Research Proprietary Limited (1971). The most significant of these occurrences is Carson Volcanics 9 (2440) where mineralization is concentrated along a northeasterly and a northwesterly trending fault, and also in the interflow sedimentary rocks. An inferred resource of 1.8 Mt at 0.51% Cu has been estimated for this deposit (Australian Anglo American Limited, 1971).

In the Osmond Basin, a felsic lithic tuff near the base of the Bungle Bungle Formation at Paradise Creek (Cu B) (2517) was reported to contain 0.57 to 0.61% Cu and 4 ppm Ag (de Angelis, 1984). The copper occurs as chrysocolla and sky blue turquoise.

In the Ord Basin, rounded pieces of native copper up to 2.5 cm long have been found in creek beds and in vesicular basalt of the Cambrian Antrim Plateau Volcanics at Cuddys Find (2522). The native copper is sheathed in cuprite and has been interpreted by Erskine et al. (1970) to be Michigan-type copper — native copper in vescicular basalt and agglomerate resulting from remobilization of primary copper in a thick sequence of basalt into permeable layers during metamorphism (White, 1968). Native copper, cuprite, and chrysocolla segregations in basaltic agglomerate of the Antrim Plateau Volcanics can be traced over a strike length of 5 km at Panton-Elvire (Cu) (2505). Boulders of prehnite up to 1 m in diameter that have weathered out of basalt of the Antrim Plateau Volcanics at Dunham Crossing (2487) also contain native copper (Harms, 1959). Traces of chalcopyrite are associated with calcite in siliceous sinter of the Antrim Plateau Volcanics at Mount Wittenoom (5422; Clarke and Blockley, 1961).

### *Steel-industry metal — tungsten*

In the Taylor Lookout area, at Taylor Lookout 1 (942), discontinuous scheelite mineralization occurs over a strike length of over 1 km within a calc-silicate horizon in the Biscay Formation in the Eastern zone of the Lamboo Complex. This mineralization has been classified as stratabound volcanic and sedimentary in this study, but Sanders (1999) interpreted it as skarn or hydrothermal mineralization related to the San Sou Monzogranite. Scheelite also occurs in the Ding Dong Downs Formation at Berthas Butt in the Eastern zone, where it is hosted by mafic tuff (e.g. Castle Creek 33, 5872), felsic tuff (e.g. Glory Rock Hole 8, 5846), and epidote-bearing chert (e.g. Castle Creek 22, 5837). This mineralization is almost certainly related to scheelite mineralization occurring in epidote-quartzite rock (of controversial origin) in the Berthas Butt area, and may be volcanic exhalative in origin (see **Stratabound sedimentary mineralization**, p. 31).

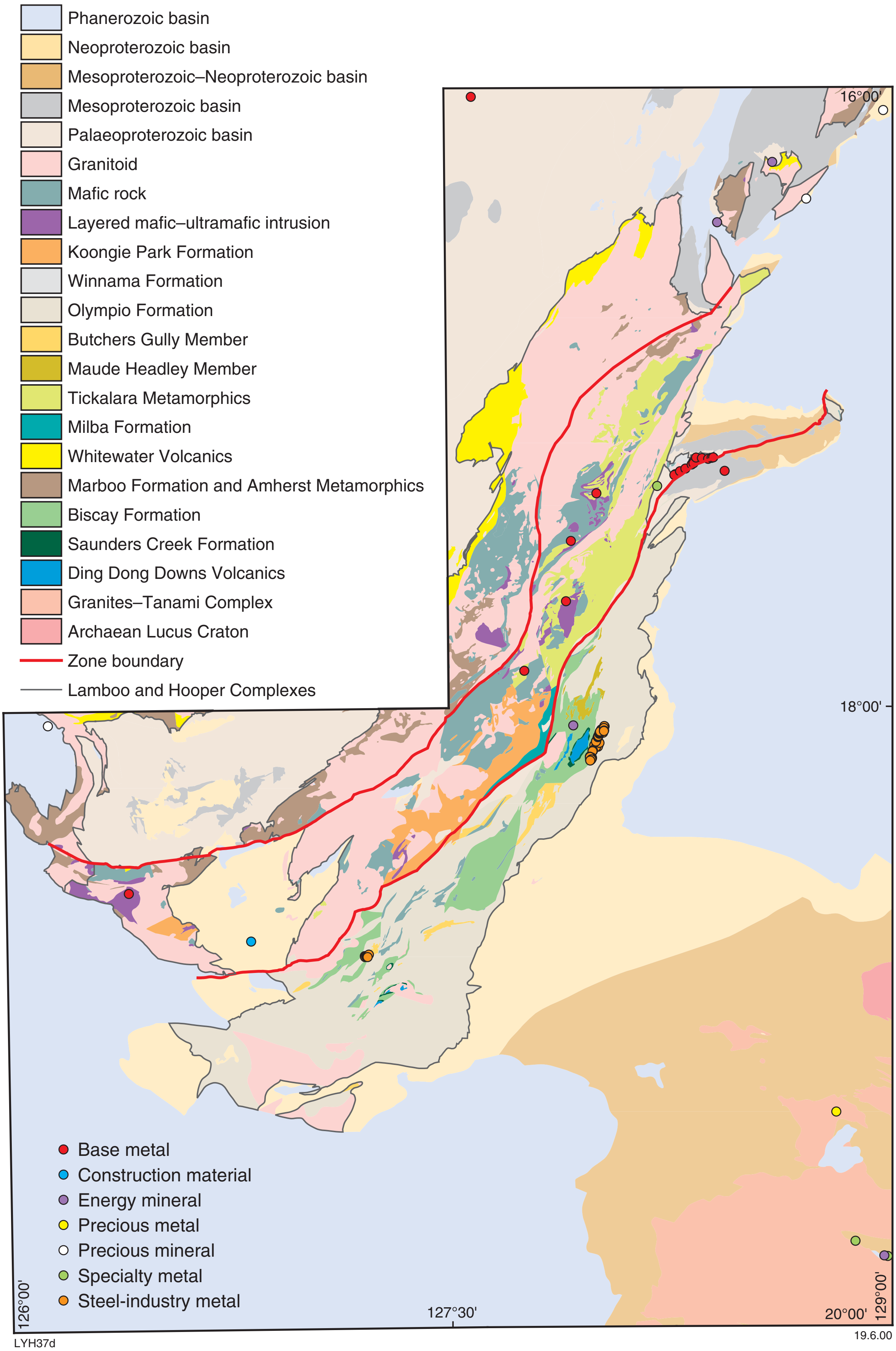


**Figure 10. Tectonic sketch showing distribution of clastic-hosted stratabound sedimentary deposits. Scale — 1 cm : 20 km (approximately)**

### Precious metal — gold

There are several gold occurrences that are possibly volcanogenic within the Biscay Formation in the Eastern zone of the Lamboo Complex. Gold is associated with galena and malachite in a rock described as microdacite at Lulu (6440; Dam Gold NL, 1997). Fine-grained gold is associated with pyrite in BIF at Freda (6437; Dam Gold NL, 1997). At Mount Carmel East 2 (6094), gossanous siliceous basalt or basaltic andesite exposed in a pit contains anomalous gold, silver, and base metals (Robinson, 1989).

At Dockrell East 2 (6393), brecciated felsic tuff with fragments of quartz and feldspar in a green chloritic matrix is overlain by chert; both tuff and chert contain gold mineralization. This area was mapped as Olympio Formation on DOCKRELL (Tyler and Griffin, 1994) but has been reinterpreted as Butchers Gully Member on Plate 1. Minor gold mineralization is associated with black shale in the Butchers Gully Member at Koongie Rockholes 2 (6066).

### Speciality metal — REE, niobium, tantalum, beryllium, gallium

There is an unusual style of REE–niobium–tantalum mineralization in the Eastern zone of the Lamboo Complex that is hosted by alkaline volcaniclastic rocks of the Butchers Gully Member, Maude Headley Member, and Biscay Formation. The most significant occurrence of this type is the Brockman deposit (1102, 6111, 6112, 6113) in the informally named ‘Niobium tuff’ of the Butchers Gully Member. The Niobium tuff has been interpreted as an ashflow tuff (Ramsden et al., 1993) or tuffaceous volcaniclastic deposit (Taylor et al., 1995). Taylor et al. (1995) suggests that the volcanic sequence at Brockman was erupted from a small volcanic shield complex probably in a rift-related basin in a shallow-marine setting. The Niobium tuff outcrops along the western flank of a southwest-plunging syncline over a strike length of 3.5 km and varies in thickness from 5 to 35 m (Ramsden et al., 1993). The mineralization is very fine grained (< 20 µm). Ore minerals include gel-zircon (which includes heavy REE and some niobium), thorite (which includes heavy REE), altered columbite, complex Y–REE niobates, fluorocarbonates (including bastnaesite, parisite, and synchisite that contain light REE), fluorite, bertrandite, gallium-bearing K-mica, and base metal sulfides (principally sphalerite; Ramsden et al., 1993). The Brockman deposit has a measured resource of 4.29 Mt at 0.44% $Nb_2O_5$, 0.027% $Ta_2O_5$, 0.124% $Y_2O_3$, 1.04% $ZrO_2$, 0.011% Ga, 0.035% $HfO_2$, and 0.09% REO, and an indicated and inferred resource of 45 Mt at similar grades (Chalmers, 1990).

Anomalous niobium is present in felsic volcanic rocks of the Maude Headley Member at Ding Dong Downs (Nb) (5380). Altered trachyte within mafic tuffs that have been mapped as Biscay Formation on HALLS CREEK contains anomalous niobium, fluorine, and zirconium at Sophie Downs 1 (1103) and Sophie Downs 2 (5916).

### Industrial mineral — fluorite

At Archie Creek (2391), fluorite is present as an accessory mineral in rhyolite, as large dark-purple sheared crystals in rhyolitic tuff, and in volcanogenic sedimentary rocks of the Whitewater Volcanics in the Western zone of the Lamboo Complex (Harrop, 1977). Fluorite is also present as an accessory mineral at Brockman (see above).

### Precious mineral — prehnite

At the Valley occurrence (6406), prehnite fragments, which have been weathered from scoriaceous basalt of the Cambrian Antrim Plateau Volcanics, are concentrated on the surface along a north-northwesterly trending zone 150 m long and 40 m wide. The colour of the prehnite varies from green to golden yellow to white to clear. About 500 kg of good-quality material, suitable for cutting as a semiprecious stone or for carving as a jade substitute, has been produced from a small pit. A resource estimate of 174 t (not recognized under the JORC code) has been made (Mullumby, 1994). Similar occurrences are present at the Mound (6407), where approximately 15 kg of prehnite has been produced and a resource estimate of 138 t (not recognized under the JORC code) has been made (Mullumby, 1994), and at New Deposit (6409).

### Energy mineral — uranium (copper)

At Mount Junction (6262), ferruginous chert with anomalous uranium and copper is associated with altered volcanic rocks and shale of the Killi Killi ‘Beds’ in the Granites–Tanami Complex (Pearcey et al., 1988). This is possibly volcanogenic in origin.

# Stratabound sedimentary mineralization

## Clastic-hosted mineralization

A total of 104 occurrences have been classified as ‘stratabound sedimentary — clastic-hosted’. These occurrences have been further subdivided according to their main commodity into steel-industry metal (73 occurrences), base metal (19 occurrences), energy mineral (four occurrences), speciality metal (three occurrences), precious mineral (three occurrences), precious metal (one occurrence), and construction material (one occurrence; Fig. 10).

### Steel-industry metal — tungsten (molybdenum)

In the Eastern zone of the Lamboo Complex, in the Berthas Butt area, mineralization outcrops over a strike length of 20 km around the Castle Creek Anticline (Buckovic et al., 1982; Fig. 11). The mineralization is mainly hosted by epidote quartzite of the Saunders Creek Formation (informally called the ‘Upper quartzite’), such as at Glory Rock Hole 1 (868), Rock Pile 1 (849), and Snake Gully North (873). Some mineralization is also present in epidote quartzite within the Ding Dong Downs Volcanics (informally called the ‘Lower quartzite’), such as at Late Night (876) and Castle Creek 12 (5047). The mineralized epidote quartzites in both the Upper and Lower quartzites grade laterally into feldspathic sand-

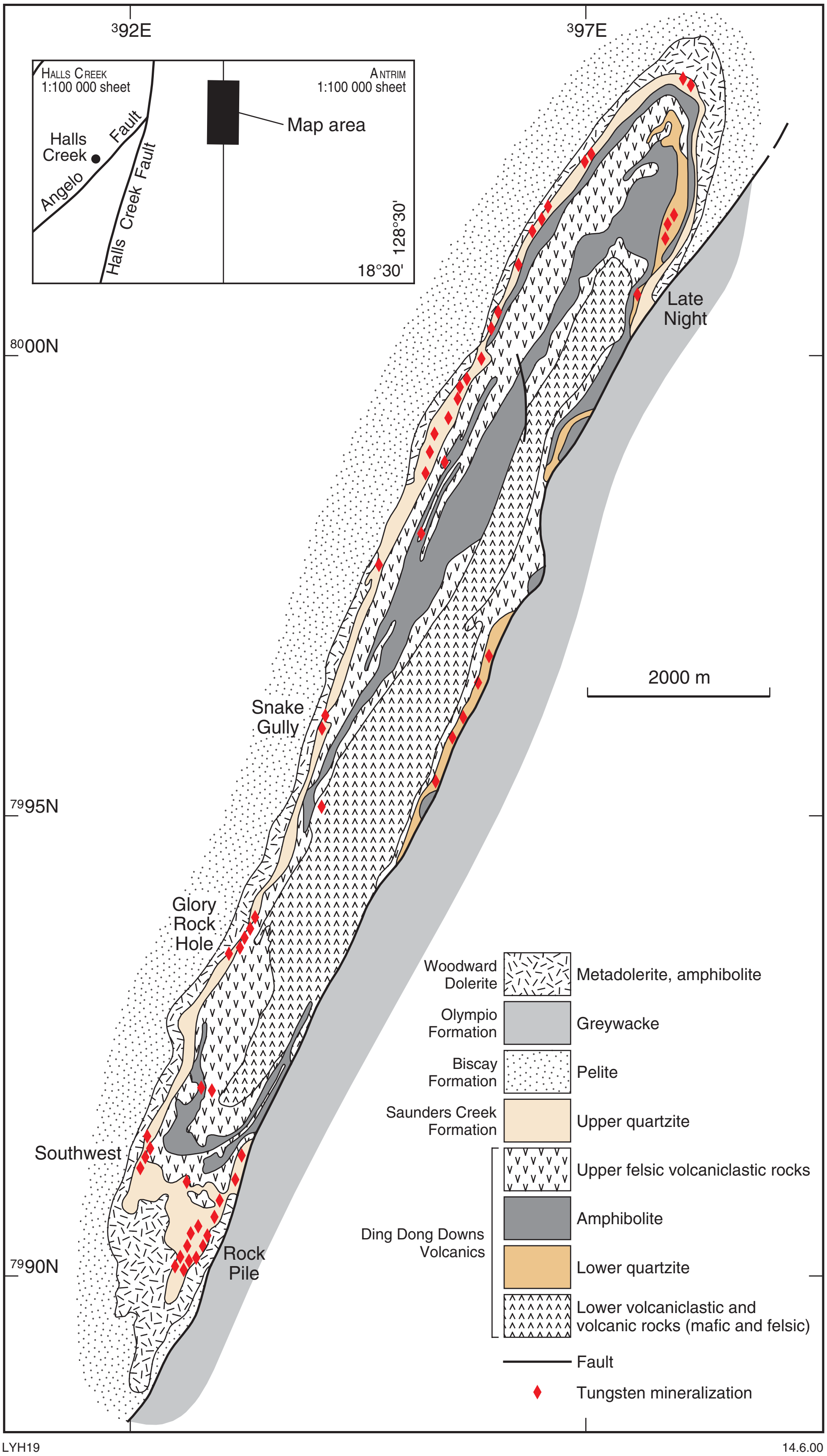


**Figure 11. Geological map of the Castle Creek anticline showing tungsten occurrences near Halls Creek (after Buckovic, 1982; Blight, 1983; Ririe, 1989; and Sanders, 1999). Minor differences between the geology shown on this map and that on HALLS CREEK (Blake et al., 1999a) and ANTRIM (Blake and Warren, 1996) may be due to differences in the scale and interpretation of the mapping**

stones and felsic crystal tuffs (Buckovic et al., 1982). The scheelite is disseminated within the quartzites as broad tabular zones; within the zones, the scheelite mineralization generally conforms well to stratification within the quartzites, although some mineralization is cross-cutting (Buckovic et al., 1982). Surface grades are up to 6.8% $WO_3$ (Buckovic et al., 1982), but the highest drill intersections were 0.5 m at 2.38% $WO_3$ and 1.4 m at 0.34% $WO_3$ from a diamond drillhole at Glory Rock Hole 2 (5840; Blight, 1983). Powellite ($CaMoO_4$) is associated with scheelite at Late Night (Blight, 1983).

Elsewhere in the Eastern zone, in the South Dockrell area, stratabound scheelite is associated with multiple thin beds of epidote quartzite and tourmalinites (e.g. South Dockrell 1, 884). The epidote quartzites are similar to those at Berthas Butt, but are thinner and much finer grained. The tourmalinites consist of interlaminated fine-grained quartz and fine euhedral tourmaline laths. The epidote quartzites and tourmalinites are interbedded with chloritic tuffaceous siltstones and minor mafic volcaniclastic rocks and amphibolites (Goldner, 1984). The rocks were interpreted as Biscay Formation by Goldner (1984), but are now considered to be part of the Olympio Formation (Tyler et al., 1998a). They probably belong to the Butchers Gully Member (Tyler, I. M., 1999, pers. comm.).

### *Base metal — copper, lead, zinc (silver)*

In the Central zone of the Lamboo Complex, a number of base-metal bearing gossans have been reported from feldspathic sandstones of the Winnama Formation (e.g. Osmond Valley (Ag–Pb–Zn), 5531). There are also a few scattered occurrences of base-metal bearing gossans in metasedimentary rocks of the Tickalara Metamorphics (e.g. Little Panton (Cu), 5343).

In the Kimberley Basin, at Menuairs Dome 3 (4543), there is extensive malachite staining in shale at the base of the Middle Pentecost Sandstone. This copper enrichment continues over a strike length of 200 km but most of the dome is outside the east Kimberley area. No ore-grade values were intersected in exploration drilling, suggesting surface enrichment of weakly anomalous syngenetic copper (Australian Anglo American Limited, 1971).

In the Osmond Basin, native copper is hosted by clean, porous oxidized sandstone and siltstone of the Bungle Bungle Dolomite at Paradise Creek (Cu A) (2508). The best drilling intersection by Samin Australia was 25 m at 0.34% Cu (de Angelis, 1984).

### *Energy mineral — uranium*

At Rustlers (5797), in the Eastern zone of the Lamboo Complex, anomalous uranium occurs within the Biscay Formation in ferruginous pods in chloritic sandstone close to its contact with carbonaceous schist.

In the Bonaparte Basin, sandstone of the Devonian Galloping Creek Formation hosts secondary uranium minerals at Horse 7 (5341).

In the Birrindudu Basin at Killi Killi 2 (5403), abundant uranium ochres are exposed in a pit within the basal conglomerate of the Gardiner Sandstone, but these extend only to a depth of 60 to 90 cm, suggesting that there has been surface enrichment (i.e. they are probably not typical sandstone-hosted uranium deposits). Uranium is also associated with xenotime in grit and conglomerate beds at the base of the Gardiner Sandstone at Killi Killi 1 (5316) and Killi Killi West (5317).

### *Speciality metal — REE*

At Junior (5315), fine-grained sandstone of the Palaeoproterozoic Red Rock Formation in the Red Rock Basin contains abundant heavy minerals. Rock-chip samples assayed up to 3.9% total REE and 0.4% Th. X-ray fluorescence (XRF) scans showed a predominance of light REE (Ce and La) suggesting that the ore mineral is monazite (Campana et al., 1973).

Rare earth element mineralization is also present in xenotime associated with uranium in basal grits and conglomerate of the Gardiner Sandstone in the Birrindudu Basin at Killi Killi 1 and Killi Killi West (as mentioned above).

### *Precious mineral — diamond*

Gem-quality diamonds are said to have been recovered by Bulletin Trading from the basal Barramundi Conglomerate at Barramundi Range in the Canning Basin (Davies, 1990); however, later work failed to find any diamonds (Sabminco NL, 1993).

### *Precious mineral — zebra stone*

Zebra stone occurrences in the Ranford Formation of the Wolfe Creek Basin have been worked at Lake Argyle 1 (5611) and Lake Argyle 2 (6497). The stone is carved and sold to tourists in Kununurra, Wyndham, and Perth as ('precious') ornamental items.

### *Construction material — sandstone*

Small quantities of sandstone of the Neoproterozoic Lubbock Formation in the Louisa Basin have been quarried at Berrangi Creek (6471) and used locally.

## Carbonate-hosted mineralization

A total of 37 occurrences have been classified as 'stratabound sedimentary — carbonate-hosted'. All are base metal occurrences (Fig. 12).

### *Base metal — lead, zinc, copper (silver, gold, molybdenum, tungsten, tin)*

Significant carbonate-hosted base metal mineralization is being mined at Kapok (6472) near the eastern end of the Lennard Shelf. The Kapok mine is part of the Lennard Shelf Project that includes the Cadjebut, Goongewa, and Pillara mines to the west of the study area boundary. The Mississippi Valley-type lead–zinc mineralization at Kapok,

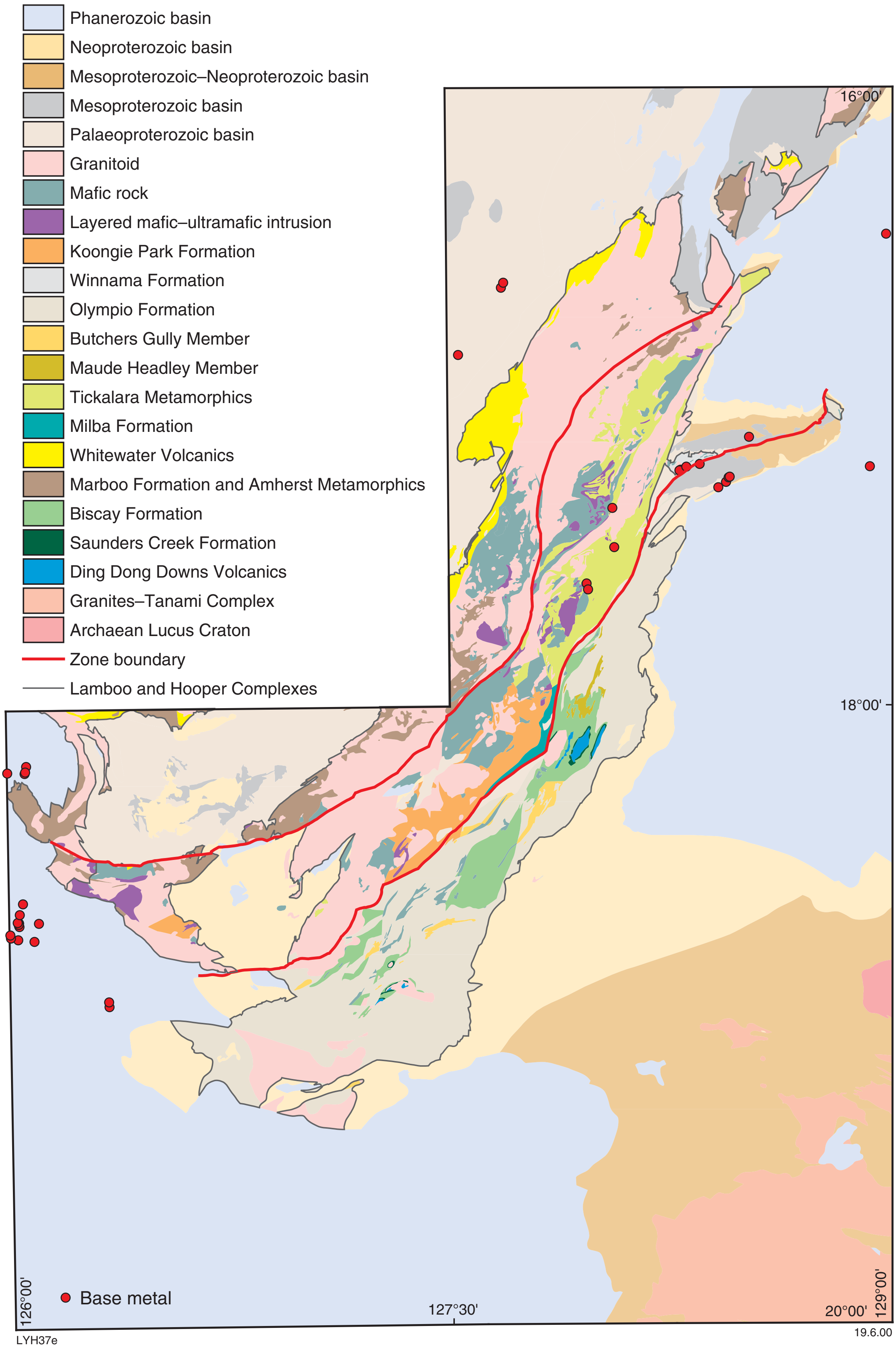


**Figure 12. Tectonic sketch showing distribution of carbonate-hosted stratabound sedimentary deposits. Scale — 1 cm : 20 km (approximately)**

like that at Cadjebut, is hosted by the Devonian Pillara Limestone in the Emmanuel Ranges (Fig. 13) close to a splay fault of the Cadjebut Fault (Ferguson, 1999). At the end of December 1999, the total measured, indicated, and inferred resources were 5.210 Mt at 8.0% Zn and 7.9% Pb and the total proved and probable reserves were 3.449 Mt at 6.9% Zn and 5.7% Pb (Western Metals Limited, 2000).

At Horse Spring Range 1 (5437), a copper–lead–zinc gossan is associated with black siltstone intercalated with fine-grained crystalline micrite and intraformational calcareous breccia of the Devonian Virgin Hills Formation near the Lindner Fault. Gossan samples contained up to 34% Zn, 6% Cu, 5% Pb, and 192 ppm Ag. The best drill intersection was 3 m (2 m true width) at 9.96% Zn and 0.49% Pb (Urquhart, 1983).

Mississippi Valley-type mineralization has also been reported from the Ross Hill area (e.g. Ross Hill 1, 5647; Findlay Hill 2, 5443; Teichart Hills, 5659; Pinnacles Lead, 6473; and Christmas Creek Reef 5, 5636).

Remobilized syngenetic or Mississippi Valley-type mineralization occurs in the Proterozoic Bungle Bungle Dolomite in the Osmond Basin. At Trend 1 (2518), rock-chip samples of gossan assayed up to 3.0% Pb; the best drill intersection was 12 m at 1.2% Pb (Trend Exploration Proprietary Limited, 1973). At Paradise Creek (Pb) (2507), two thin galena-bearing stromatolitic dolomite beds can be traced over a strike length of 2 km. Rock-chip samples from Paradise Creek (Pb) assayed up to 6.2% Pb (McIntyre, 1981); the best drill intersection was 1 m at 4.81% Pb (de Angelis, 1983). The galena occurs as blebs and veins within fractures and solution lines associated with soft-sediment deformation. Galena is commonly associated with pyrite and chert, and it also occurs in black carbonaceous laminae (de Angelis, 1983). Copper and zinc-bearing gossan is present in Bungle Bungle Dolomite at Trend 2 (5373).

In the Central zone of the Lamboo Complex, there are narrow zones of patchily developed copper(–tungsten–gold–tin) mineralization in calc-silicate rocks of the Tickalara Metamorphics at Alice Downs (1045). The best exploration drilling intercept was 2 m at 1.7% Cu (Chadwick, 1985). Gossans have also been reported from calcareous rocks of the Tickalara Metamorphics (e.g. Sally Downs C, 5030), where a gossan containing anomalous copper and molybdenum occurs in graphitic carbonate rocks. Minor copper-bearing gossans have been reported from limestone of the Winnama Formation (e.g. Osmond Valley (Cu 1), 5522).

In the Kimberley Basin, there is widespread sub-economic syngenetic copper mineralization in dolomite and shale in the uppermost unit of the Teronis member of the Elgee Sandstone (e.g. Teronis 3, 4510; Owen, 1970). At Teronis 1 (4489), there has been some secondary chalcocite enrichment (Hawley, 1970).

In the Ord Basin, there are small low-grade patches of secondary copper mineralization at Mount Elder (6483) in the uppermost limestone of the Cambrian Panton Formation of the Goose Hole Group (Dow and Gemuts, 1969).

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**Figure 13. Photograph of the Devonian reef complex in the Emmanuel Ranges near the site of the Kapok mine**

## Undivided mineralization

This classification of stratabound sedimentary mineralization includes occurrences that are hosted by sedimentary rocks that are neither clastic nor carbonate (e.g. chert), occurrences hosted by a mixture of sedimentary types, and occurrences where the nature of the host rock is uncertain either because of metamorphism or because the host was not reported. A total of nine occurrences have been classified as 'stratabound sedimentary — undivided'. These include seven base metal occurrences and two steel-industry metal occurrences.

### *Base metal — copper, lead, zinc, silver*

Minor base-metal bearing gossans occur in metasedimentary rocks of the Tickalara Metamorphics in the Central zone of the Lamboo Complex (e.g. Wills Creek A, 1059).

In the Ord Basin, at Discovery Yard (2506), there is a layer of banded chalcocite and malachite mineralization about 30 cm thick at the contact between limestone and sandstone in the Headleys Limestone, just above its contact with basalt of the Antrim Plateau Volcanics (Ball, 1966).

### *Steel-industry metal — vanadium, chromium, molybdenum*

At Sally Malay Bore 5 (5597) and Sally Malay Bore 6 (5598), vanadium–chromium–molybdenum gossans are associated with BIF in the Tickalara Metamorphics in the Central zone of the Lamboo Complex.

# Sedimentary mineralization — banded iron-formation (supergene enriched)

### *Iron*

A total of seven occurrences have been classified as 'sedimentary — banded iron-formation (supergene enriched)'. The most important of these are high-grade supergene hematite and low-grade porous limonite iron ore deposits hosted by the Golden Gate Siltstone in the Carr Boyd Basin. These include the Pompeys Pillar (including Sam, 5344; Central, 5345; Tony, 5346; and Peter, 5349) and Matsu (5348) deposits (Harms, 1959; Brown, 1973). The hematite mineralization grades laterally and vertically into siliceous hematite and ferruginous shale; sedimentary features such as cross-bedding, ripple marks, and mudcracks indicate shallow-water deposition (Harms, 1959). There is an indicated resource at Sam of 8 Mt and Tony of 7 Mt at greater than or equal to 60% Fe, an inferred resource at Peter of 1.6 Mt and Central of 0.76 Mt at greater than or equal to 60% Fe, and an inferred resource at Matsu of 177 Mt at greater than or equal to 45% Fe (Brown, 1973).

In the Central zone of the Lamboo Complex, at Osmond Valley (Fe) (3295), BIF containing a large amount of specular hematite is interbedded with chert within metasandstone of the Winnama Formation (Harder, 1983).

In the Granites–Tanami Complex, a small deposit of siliceous iron ore at Black Hill (5419) has been interpreted as a surficial concentration in metasedimentary rocks of the Killi Killi 'Beds' (Clarke and Blockley, 1961)

# Vein and hydrothermal mineralization

## Undivided mineralization

A total of 548 mineral occurrences in the east Kimberley area have been classified as 'vein and hydrothermal — undivided'. For convenience of description, these have been further subdivided on the basis of the main commodity present into precious metal (262 occurrences), base metal (222 occurrences), industrial mineral (23 occurrences), steel-industry metal (18 occurrences), energy mineral (17 occurrences), and speciality metal (six occurrences; Fig. 14); however, many of these occurrences are polymetallic so that the subdivision has often been partly arbitrary. The reader is referred to the list of commodities in each occurrence next to the WAMIN number in Appendix 1.

### *Precious metal — gold*

In the Lamboo Complex, there is a marked concentration of vein and hydrothermal gold occurrences in the Eastern zone. Many of the occurrences define a northeasterly trend roughly parallel to the boundary with the Central zone, 7–12 km east of the boundary (Figs 14 and 15). Most of these (112 occurrences) are within the Biscay Formation. A significant number also occur in the Olympio Formation (52 occurrences), typically close to its contact with either the Biscay Formation or the Butchers Gully Member and within the Butchers Gully Member (21 occurrences). There are a few vein and hydrothermal gold occurrences in the Central zone, mainly in the Koongie Park Formation, Sally Downs supersuite, and Loadstone Monzogranite, and in the Western zone, mainly in the Amhurst Metamorphics. Significant vein and hydrothermal gold deposits are also present in the Granites–Tanami Complex. Examples from each area are briefly described below.

#### *Lamboo Complex — Eastern zone*

#### Brockman – Mount Bradley area

The regional setting of the Palm Springs openpit mine (2223; Fig. 16) together with that of the historical workings in the Brockman – Mount Bradley area including Faugh-A-Ballagh (2232), Golden Crown (2224), Lady Margaret (2233), Deimos (2235), Io (2234), Titan (4284), Europa (4288), and Mount Bradley (2236) is shown on Figure 17. Most of the mines in this area are hosted by trachyandesite of the Butchers Gully Member, which has been structurally repeated by high-amplitude isoclinal folding ($D_5$; Sanders, 1999). Production figures

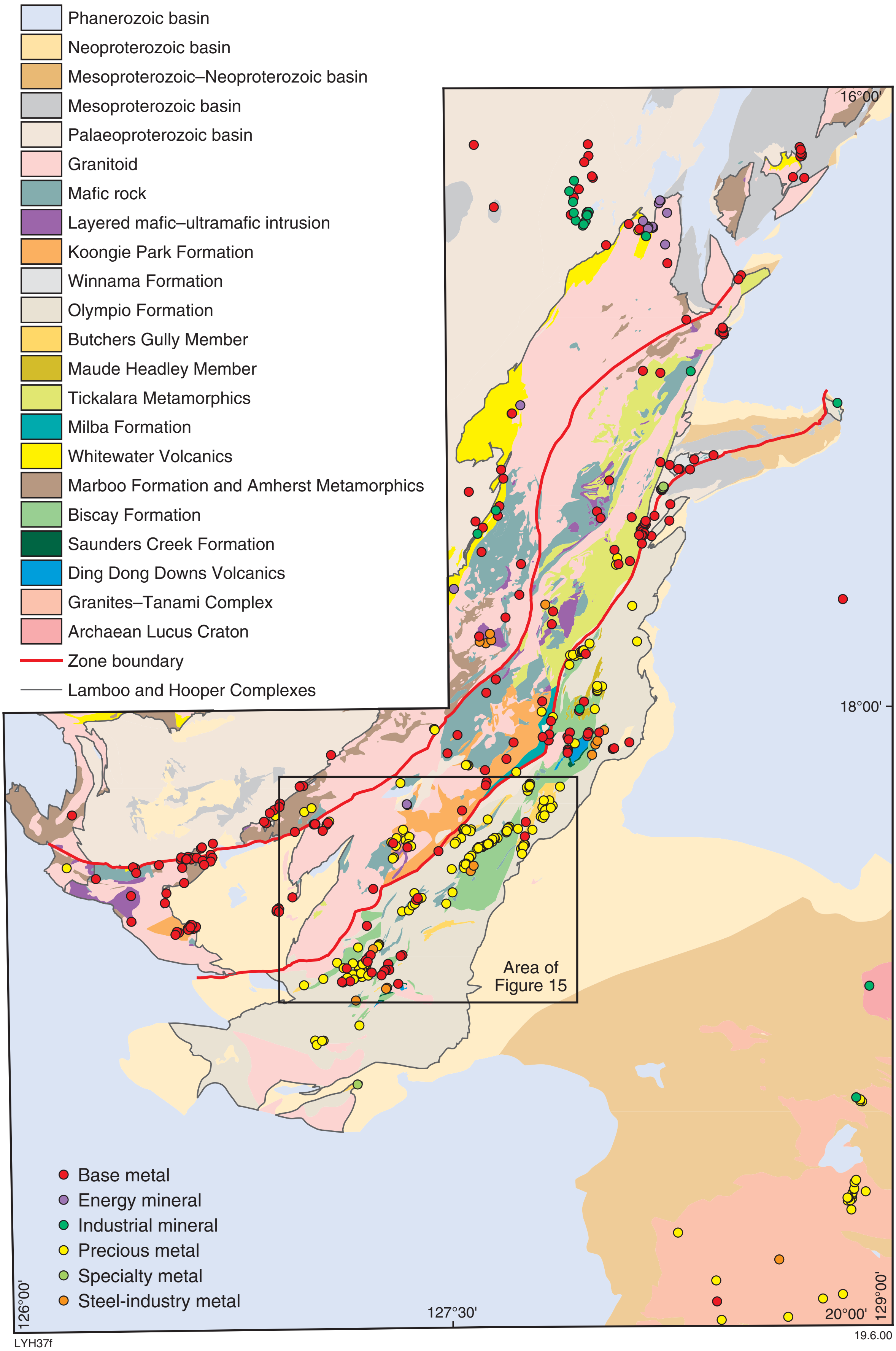


**Figure 14. Tectonic sketch showing distribution of undivided vein and hydrothermal deposits. Scale — 1 cm : 20 km (approximately)**

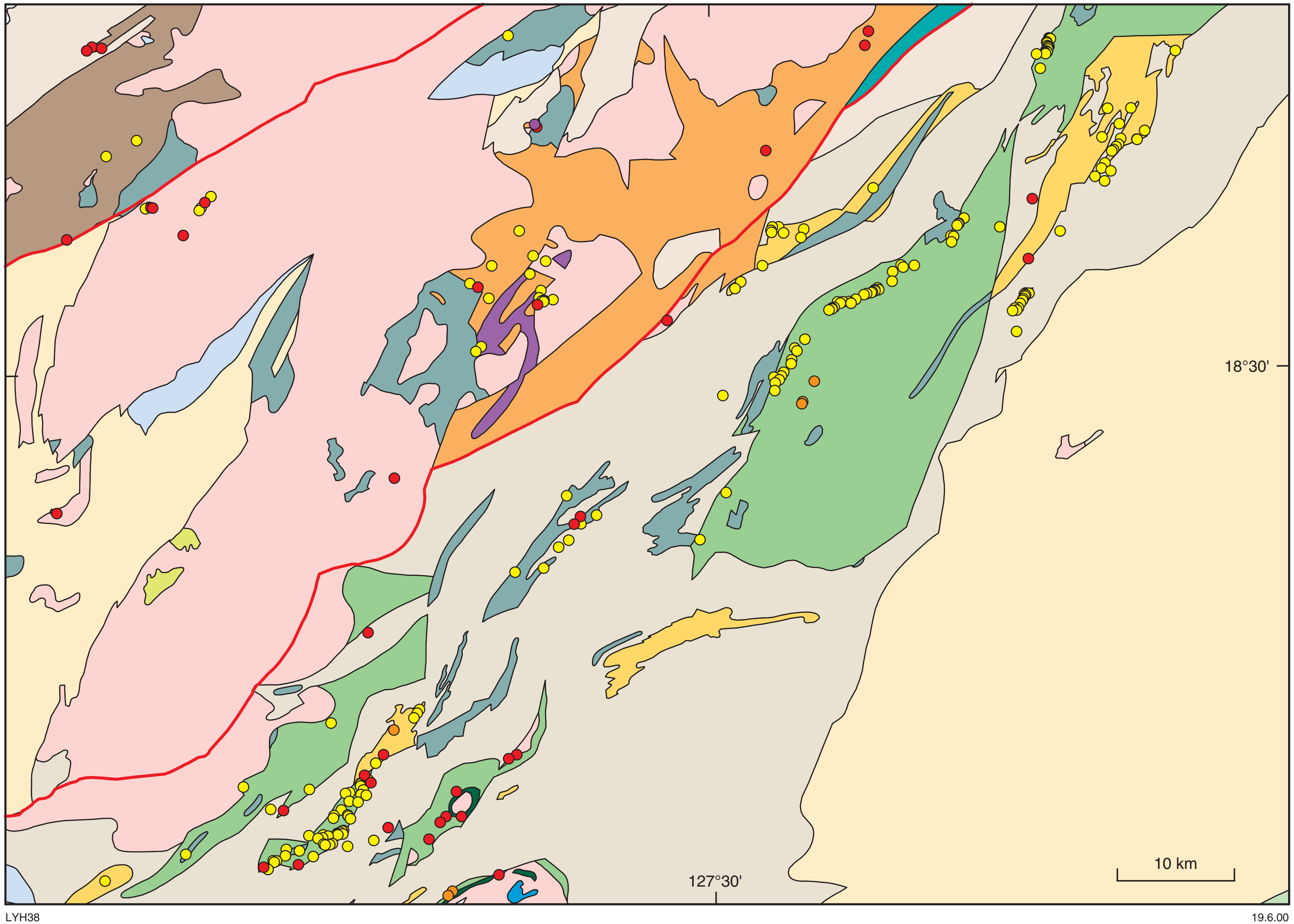


**Figure 15. Enlargement of portion of Figure 14 showing the distribution of gold deposits in the southeastern part of the Lamboo Complex. See Figure 14 for key to symbols and colours**

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**Figure 16. Photograph of the Palm Springs mine**

for the historical mines are given in Table 2. Between April 1995 and June 1997, the Palm Springs mine produced 2272 kg of gold (Precious Metals Australia Limited, 1997); this is more than double the total recorded pre-1964 production for the east Kimberley.

The quartz stockwork mineralization at Palm Springs is confined to a 30 m-wide fractured andesite of the Butchers Gully Member in a tightly folded south-southwest plunging anticline (Fig. 18). Numerous quartz veins cross-cut the anticline axis; these are probably tension veins related to the Ruby Queen Shear zone, which runs roughly parallel to the anticlinal axis (Fig. 18). Gold mineralization is associated with pyrite, minor arsenopyrite, and pyrrhotite in the quartz veins and in the altered wallrocks. Intense alteration of the andesite has produced an albite–ankerite–sericite–chlorite–quartz–pyrite assemblage (Sanders, 1999). The high sulfide content of the ore prevented mining of the ore below the zone of oxidation in the original Butchers Gully (Sams) mine in the 1930s (Barnes, 1985a).

### Ruby Queen mining centre

Gold mineralization at the Ruby Queen mining centre is associated with a series of narrow, subvertical quartz veins, concordant with the bedding and foliation, in steeply dipping greywacke of the Olympio Formation (Dow and Gemuts, 1969). The veins are related to the north-northeast trending Ruby Queen Shear zone (Sanders, 1999). The Ruby Queen mine (2237) was the largest historical producer of gold in the east Kimberley. Prior to 1908, the Ruby Queen mine produced 9833 t at 19.66 g/t (193.3 kg), and between 1938 and 1964, it produced 3179 t at 17.1 g/t (54.3 kg). The quartz reef at Ruby Queen averaged 0.9 m in width and most of the gold was at the contact between the reef and the wallrocks (Smith, 1898). Other workings in the group include the St Lawrence (2238), West and Left (2239), Goliath (2240), Rising Sun (2243), and Sunny Corner (2244) mines. The mines are described in detail by Finucane (1939a) and Sanders (1999). Production figures for these mines are included in Table 2.

### Kerry–Reform–Darcys

An arcuate group of workings lies within the Biscay Formation, and is aligned roughly parallel to its faulted contact with the Olympio Formation but 1–1.5 km east of the contact (Fig. 15). The official recorded production from the largest mine was 6.5 kg from the Reform mine (2259) in 1894, but company records (Eupene, 1983) suggest that production was considerably greater. The mineralization at the Reform mine is related to several shear-parallel quartz veins in a 1.5 m wide shear zone within siltstone and silicified shale (Sanders, 1999). A single stamp battery is said to have produced 300 oz (9.3 kg) from 300 t of ore from the Shane mine (2260; 2.4 km southwest of the Reform mine) between 1950 and 1961 (Eupene, 1983). Copies of mint returns were given in support of this claim but there are no localities shown on the mint returns. The gold in the Shane mine appears to have been in small rich shoots in metasedimentary rocks and tuffs of the Biscay Formation (Eupene, 1983).

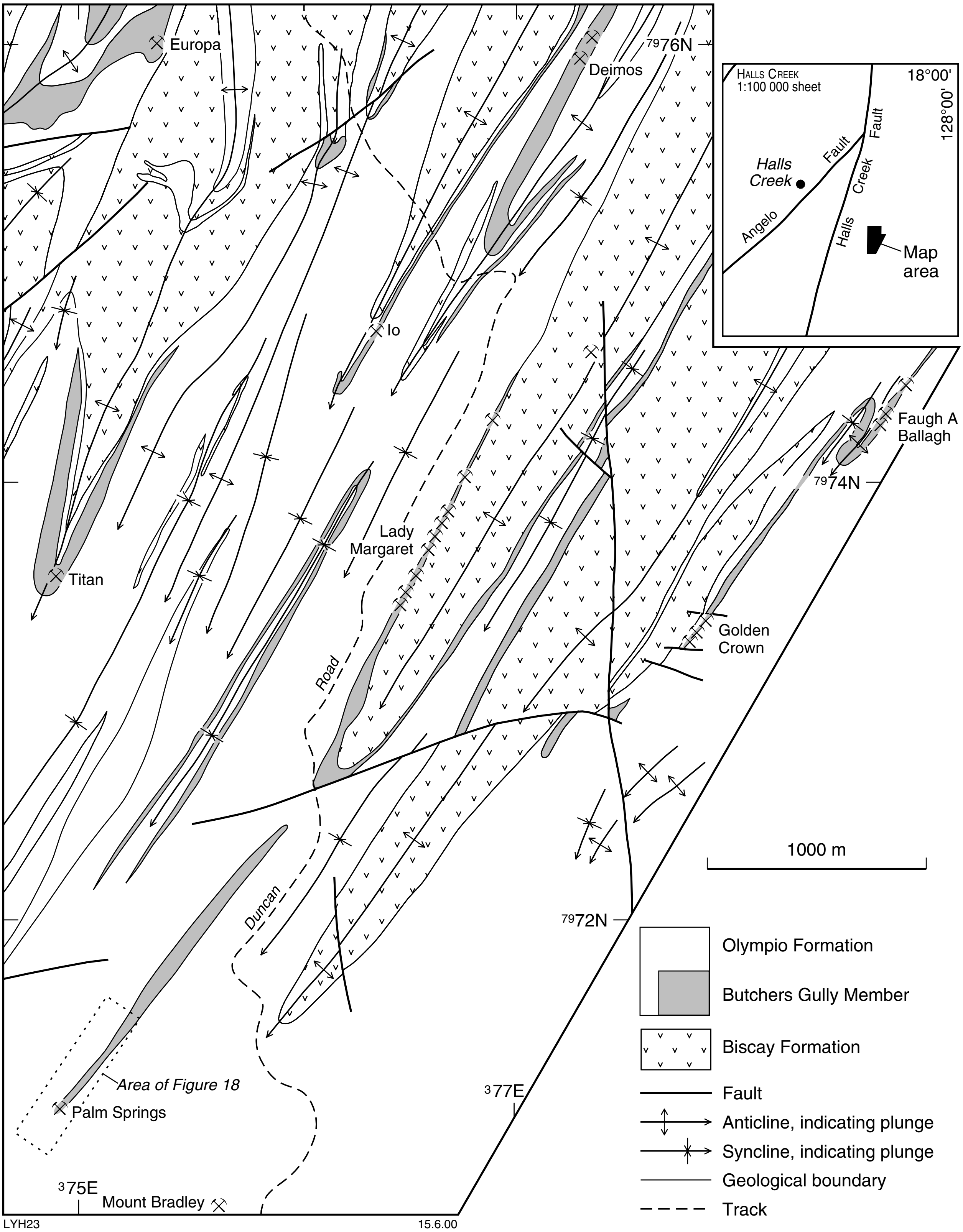


**Figure 17. Brockman – Mount Bradley area — geology and location plan, 1995 (after Sanders, 1999). Differences between the geology shown on this map and that on HALLS CREEK (Blake et al., 1999a) may be due in part to differences in the scale and interpretation of the mapping**

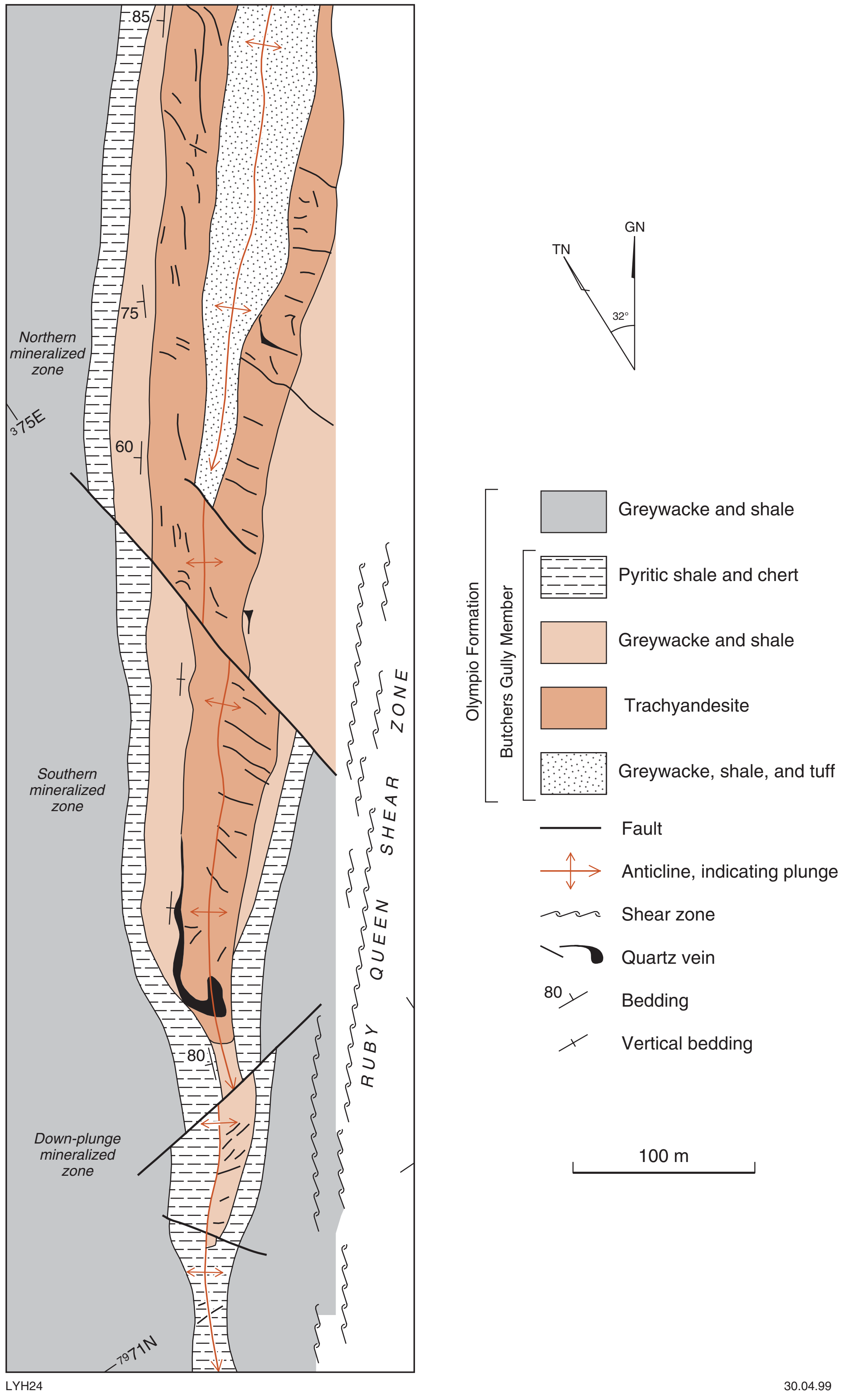


**Figure 18. Simplified geology — Palm Springs mine area (after Sanders, 1999)**

**Table 2. Historical gold production from the east Kimberley (up to 1964)**

| *Mine name* | *Year* | *Alluvial and dollied gold (kg)* | *Ore treated (t)* | *Lode gold (kg)* |
|---|---|---|---|---|
| **Mary River Goldfield** | | | | |
| Reform | Pre-1897 | – | 405 | 6.5 |
| Newlook[(a)] | Pre-1897 | 32.1 | – | – |
| PA99[(a)] | 1940–1941 | – | 48 | 1.7 |
| PA151[(a)] | 1950 | 0.4 | – | – |
| **Total** | | **32.5** | **453** | **8.2** |
| **Halls Creek Goldfield** | | | | |
| Jubilee | Pre-1897 | – | 23 | 14.0 |
| Lady Broome | Pre-1897 | – | 406 | 0.9 |
| Jacksons[(b)] | Pre-1891 | – | 78 | 1.6 |
| Gladstone[(b)] | Pre-1891 | – | 2 | 0.1 |
| Black Mount[(b)] | Pre-1891 | – | 8.5 | 0.1 |
| unnamed[(a)] | Pre-1928 | – | 96 | 1.9 |
| PA84[(a)] | 1938–1939 | – | 10 | 0.4 |
| PA112[(a)] | 1941 | – | 9 | 0.5 |
| PA118[(a)] | 1942 | – | 10 | 0.5 |
| PA108[(a)] | 1942 | 0.9 | – | – |
| PA115[(a)] | 1943 | – | 82 | 1.6 |
| PA158[(a)] | 1953 | – | 9 | 0.5 |
| PA161[(a)] | 1953 | – | 3 | 0.1 |
| **Total** | | **0.9** | **736.5** | **22.2** |
| **Brockman – Mount Bradley** | | | | |
| Afgan | Pre-1897 | – | 96 | 2.1 |
| Brockman King | Pre-1897 | – | 87 | 1.1 |
| Faugh-A-Ballagh | Pre-1897 | – | 15 | 0.5 |
| Golden Crown | Pre-1897 | – | 1 172 | 39.8 |
| Southern Cross | Pre-1897 | – | 5 | 0.1 |
| Mount Bradley[(a)] | Pre-1928 | – | 2 500 | 56.4 |
| Mount Bradley | 1940–1942 | – | 196 | 1.6 |
| Lady Margaret[(a)] | Pre-1938 | – | 98.5 | 7.2 |
| Lady Margaret No. 1 North[(a)] | Pre-1938 | – | 20.8 | 0.5 |
| Lady Margaret No. 4 North[(a)] | Pre-1938 | – | 6.6 | 0.3 |
| PA78[(a)] | 1938–1939 | 0.2 | – | – |
| PA93[(a)] | 1939 | – | – | 0.1 |
| PA97[(a)] | 1940 | 0.2 | 7 | 0.4 |
| **Total** | | **0.4** | **4 203.9** | **110.1** |
| **Grants Creek area** | | | | |
| Lone Hand[(c)] | Pre-1898 | – | – | 8.1 |
| Comet | Pre-1897 | – | 29 | 4.2 |
| Star of Kimberley | Pre-1897 | – | 1 | 0.1 |
| Perseverance[(c)] | Pre-1898 | – | 5.1 | 0.9 |
| unnamed[(a)] | Pre-1923 | – | 3 | 0.5 |
| PA96[(a)] | 1940 | – | 3 | 0.1 |
| PA162[(a)] | 1955 | 0.2 | – | – |
| **Total** | | **0.2** | **41.1** | **13.9** |
| **Mount Dockrell Goldfield** | | | | |
| Lady Hopetoun | Pre-1897 | – | 41 | 10.0 |
| Victoria | Pre-1897 | – | 4 | 3.8 |
| PA59[(a)] | 1935 | – | 37 | 0.8 |
| unnamed[(a)] | 1935 | – | – | 0.8 |
| Mount Minaird[(a)] | 1936 | – | 187 | 5.3 |
| Western Lead | 1935–1942 | – | 219 | 2.3 |
| Irish Lass | 1937–1943 | 0.7 | 346 | 8.3 |
| Old Mac | 1938–1940 | – | 239 | 5.6 |
| Erin-Go-Bragh | 1939–1941 | – | 62 | 1.7 |
| PA75[(a)] | 1938 | 0.6 | – | – |
| PA102[(a)] | 1940 | – | 26 | 0.4 |
| PA101[(a)] | 1940–1941 | – | 83 | 0.7 |
| unnamed[(a)] | 1941 | – | 16 | 0.1 |
| Old Golden Dream | 1941–1942 | – | 93 | 0.8 |
| Sundry Claims[(a)] | – | – | 163 | 2.8 |
| **Total** | | **1.3** | **1 516** | **43.4** |

**Table 2.** (continued)

| *Mine name* | *Year* | *Alluvial and dollied gold (kg)* | *Ore treated (t)* | *Lode gold (kg)* |
|---|---|---|---|---|
| **Ruby Creek Goldfield** | | | | |
| No. 1 North Ruby Queen | Pre-1897 | – | 194 | 5.8 |
| Rising Sun | Pre-1897 | – | 586 | 15.3 |
| Sunny Corner | Pre-1897 | – | 22 | 1.8 |
| West and Left | Pre-1897 | – | 690 | 29.5 |
| West and Left | 1938–1941 | – | 10 | 0.35 |
| St Lawence | Pre-1902 | – | 1 510 | 47.7 |
| St Lawence | 1938 | – | 10 | 0.2 |
| Ruby Queen (claim 61) | Pre-1908 | – | 9 833 | 193.3 |
| Ruby Queen (claim 97) | 1938-1964 | 0.1 | 3 179 | 54.3 |
| unnamed[(a)] | Pre-1928 | – | 153 | 3.9 |
| PA79[(a)] | 1938 | – | 93 | 0.7 |
| Goliath[(a)] | 1938–1942 | – | 123 | 3.2 |
| Goliath[(a)] | 1940 | – | 7 | 0.2 |
| PA91[(a)] | 1939 | – | 120 | nk |
| PA93[(a)] | 1939 | 0.4 | – | – |
| PA96[(a)] | 1939 | – | 12 | 0.1 |
| unnamed[(a)] | 1939 | 0.1 | – | – |
| Shorts Hope | 1940 | – | 51 | 0.1 |
| Darcys mine | 1941–1942 | 0.5 | 79 | 1.9 |
| PA124[(a)] | 1947 | 0.4 | 8 | 0.2 |
| **Total** | | **1.5** | **16 680** | **358.6** |

**SOURCE:** Geological Survey of Western Australia gold production statistics database (GOLDSTATS) except where indicated
**NOTES:** (a) Dow and Gemuts (1969)
(b) Woodward (1891)
(c) Smith (1898)
nk not known

Production from the Kerry mine (2262), at the southern end of belt, in the same period is reputed to be about 2000 oz (62.2 kg; Eupene, 1983), although no official production is recorded. The Darcys (2253) workings, at the northern end of the trend, are on quartz veins along a shear zone. Recorded production from Darcys is 1.905 kg plus 0.499 kg of dollied gold. Mullumby (1986) reported that selected dump samples contained up to 28.8% Pb, 1.14 ppm Ag, and 1.42% W.

### Old Halls Creek area

The Old Halls Creek area is where the first gold rush occurred in Western Australia, and the first gold mines opened here. Mines included Jubilee (2246), Lady Broome (2250), Jacksons Reef (2251), Black Mount (6131), and Gladstone (2249). Most gold from this area probably went unreported (Playford and Ruddock, 1985); published production figures are included in Table 2. The mines are hosted by the Biscay Formation. At the Jubilee mine, gold was mined from cross-cutting quartz veins that contained abundant argentiferous galena and copper oxide (Woodward, 1891; Smith, 1898). At Jacksons Reef, gold mineralization was associated with a quartz reef and quartz stringers parallel to the schistosity.

### Mount Dockrell area

Most of the workings in the Mount Dockrell area are on quartz veins along shears in the Biscay Formation or Butchers Gully Member. Many of the quartz veins contain significant galena and high silver values in addition to gold (Woodward, 1891). At McNeils (2321), rich specimen gold was obtained at the intersection of shears. Other significant producers were the Victoria (2318), Irish Lass (2324), and Old Mac (2332) mines (see Table 2; note that Lady Hopetoun (2322) was an amalgamation of the Victoria, McNeils, Hard Labour, and Black Prince leases; Woodward, 1891).

### Grants Creek area

Most gold in the Grants Creek area was mined from quartz veins in the Biscay Formation. The most significant producers were the Lone Hand (2221), Comet (2218), Perseverance (2212), and Star of Kimberley (2211) mines (see Table 2). Galena and silver was associated with the gold mineralization (Smith, 1898).

### Christmas Creek

At Christmas Creek 1 (2300) there is an auriferous quartz–sulfide stockwork in sheared dolerite; the dolerite here differs from the Woodward Dolerite in that it is highly magnetic (Barnes, 1985b).

## *Lamboo Complex — Central zone*

### Nicolsons Find

At Nicolsons Find (2340), mineralized quartz veins within felsic volcanic rocks of the Koongie Park Formation are related to the Nicolson Fault; anomalous As and Pb values are associated with the gold mineralization (Sanders, 1999). Trial mining of the deposit was undertaken by Precious Metals Australia in 1996; 15 000 t at 5.08 g/t (76.2 kg) was treated at the Palm Springs plant (Precious Metals Australia Limited, 1996). The inferred resource at June 1997 was 278 000 t at 5.54 g/t (Precious Metals Australia Limited, 1997).

## Lady Helen

At Lady Helen (also known as Moola Bulla, 2339), there are shallow workings in gossanous vuggy quartz veins in a shear in mafic rock of the Sally Downs supersuite close to the contact with the Loadstone Granite. Silver and arsenic are associated with the gold mineralization (Mullumby, 1989; Sanders, 1999). On the basis of panning, Mullumby (1989) estimated that the maximum resource was about 1000 t at 10 g/t, but note that this is an order of magnitude estimate only and is not a formal resource under the JORC code.

### *Lamboo Complex — Western zone*

Minor gold mineralization is associated with silver and base metal mineralization in quartz veins within the Amherst Metamorphics at Me No Savvy C (1275). At the Jailhouse Creek prospect (2345 and 2347), low-grade gold and silver are associated with base metals in quartz veins in felsic lithic crystal tuff of the Whitewater Volcanics. Hunter Resources Limited (1991) interpreted the veins in the area to be epithermal because some have bladed textures. There are no official records of gold production from the Western zone.

### *Granites–Tanami Complex*

Gold was discovered in the Granites–Tanami Complex at the Tanami mine in the Northern Territory in 1900. Additional gold mineralization was discovered at Dead Bullock Soak and Callie in the Northern Territory in 1988 and 1991 respectively. The Granites–Tanami Complex in Western Australia was largely neglected until the discovery of the Kookaburra deposit in 1995 followed by the discovery of Coyote in 1999, with its spectacular, high-grade intercepts. The area of the Granites–Tanami Complex is now almost completely under tenure.

## Larranganni area

Quartz samples containing anomalous gold were first reported from the Larranganni area by Talbot (1910), but it was not until 1983 that any significant effort was made to follow up Talbots's discovery (Doust, 1997). Glengarry Resources NL has reported significant gold mineralization over a 15 km strike length within folded mafic volcanic and sedimentary rocks that have been informally named the Bald Hill sequence (Glengarry Resources, 1999, written comm.; Quinn, 1999; Fig. 19). Carbonate, sericite, quartz, iron, and chlorite alteration is associated with the gold mineralization. Some gold mineralization occurs 800 m to the west in a similar sequence informally named the Quartz Ridge sequence. These sequences have been

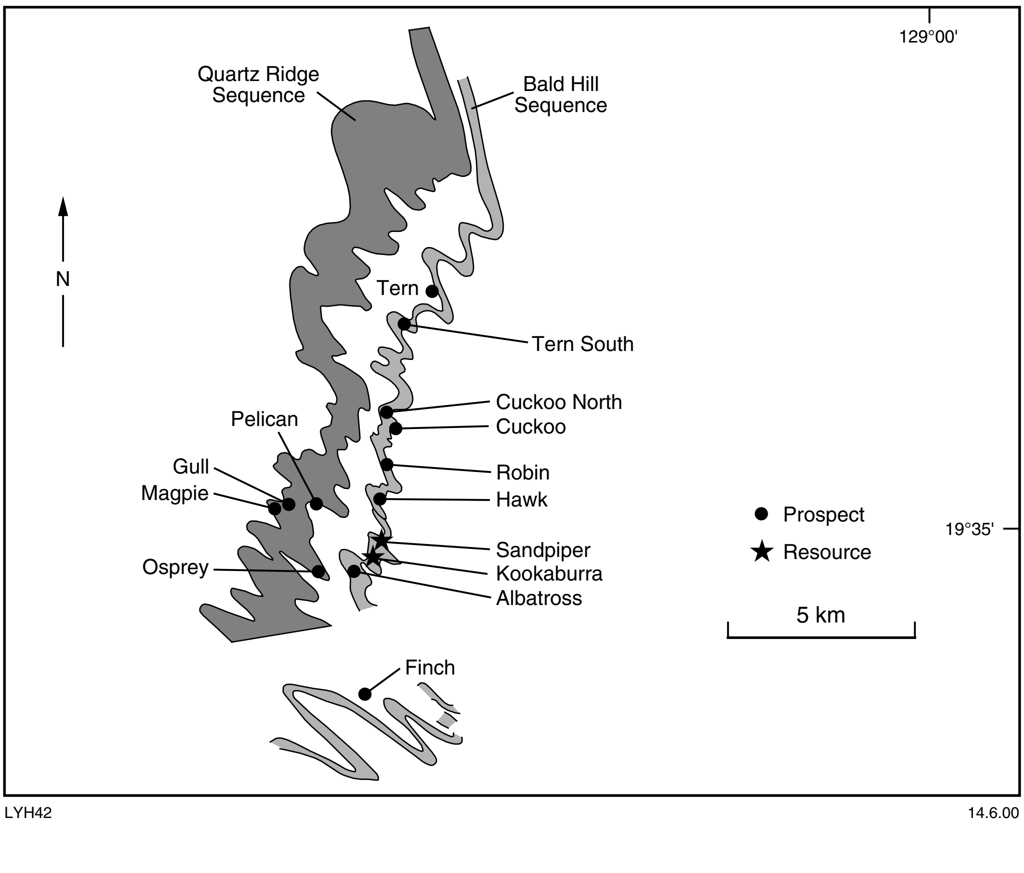


**Figure 19. Distribution of gold deposits in the Larranganni area (after Quinn, 1999)**

correlated with the Mount Charles beds in the Northern Territory (Glengarry Resources NL, 1999, written comm.). The Kookaburra deposit (6074) is situated in the Bald Hill sequence to the south of a west-northwesterly trending fault (Fig. 19) and contains multiple quartz veins in a brecciated ferruginous unit (Doust, 1997). The Kookaburra deposit is estimated to have an indicated resource of 1.5 Mt at 2.1 g/t (100 000 oz; 3110 kg) and an inferred resource of 0.2 Mt at 2.1 g/t (15 000 oz; 467 kg) using a cutoff grade of 0.5 g/t (Glengarry Resources NL, 1996). The Sandpiper deposit (6075), which lies just to the north of the west-northwesterly trending fault, contains an additional indicated and inferred resource of 0.58 Mt at 3.22 g/t (60 000 oz; 1866 kg; Glengarry Resources NL, 1998). Other prospects spread over a 15 km strike length (including Hawk, Finch, Osprey, Albatross, and Cuckoo North) have given significant drill intersections (Glengarry Resources NL, 1999a).

### Coyote

Spectacular high-grade gold mineralization has been intersected over an area of 800 × 200 m at the Coyote prospect (6466). Better intersections include 8 m at 458 g/t gold from a depth of 105 m, and 13 m at 39 g/t gold from a depth of 174 m. Oxidation extends to a depth of greater than 100 m. Free gold is commonly visible but sulfides are rare, even in fresh rock (Acacia Resources Limited, 1999). The mineralization is said to be hosted by nonmagnetic sedimentary rocks of the Killi Killi Formation, informally referred to as the Madigan beds (Tanami Gold NL, 1999).

### Other areas

At the Camel prospect (6467), there is a sheeted vein system that is axial planar to a major northwesterly plunging fold in metadolerite. Veins also occur along the contact between metadolerite and metasedimentary rocks. The associated gold–arsenic anomaly extends for 5 km (Glengarry Resources NL, 1999b).

Gold occurs in narrow, steeply dipping, northerly trending anastomosing quartz veins (associated with shear zones) and in minor saddle reefs and shallow-dipping quartz veins at the Venus prospect (5809, 5810, and 5811). The veins are in altered and deformed Killi Killi ‘Beds’ close to its unconformity with the Gardiner Sandstone (Stocklemayer and Rothnie, 1987). Gold is also associated with uranium at the Don prospect (5793), 2.8 km west-northwest of the Venus prospect (see **Unconformity-related mineralization**, p. 48).

## *Base metal — copper, lead, zinc, silver*

The distribution of base metal vein and hydrothermal occurrences is shown on Figure 14. In addition to the occurrences classified as base metal occurrences, many of the gold occurrences also contain significant base metals. Base metal vein and hydrothermal occurrences fall within a wide range of stratigraphic units in all three zones of the Lamboo Complex and in the overlying younger basins. Only one occurrence has been recorded from the Granites–Tanami Complex. A few examples from different stratigraphic settings are briefly described below.

### *Lamboo Complex — Eastern zone*

At Horrys Copper Show (2330), in the Mount Dockrell area, Cu–Au–Ag mineralization is hosted by a gossanous quartz vein within a shear zone at the contact between the Olympio and Biscay Formations. The high-grade zone is about 2.4 m wide and extends 60 m along the shear zone, but a zone of sporadic mineralization is about 7.4 m wide and extends 900 m along the shear zone. At the Hanging Drum Copper Show (2331), which is also near Mount Dockrell, there is abundant malachite in a quartz-filled shear in black shale of the Olympio Formation (Barber, 1971; Sanders, 1999). Small high-grade lenses of copper mineralization are associated with quartz and sheared greywacke of the Olympio Formation on a narrow, near-vertical, northeasterly trending fault at Mount Kinahan (1211, 5078, and 5083). Minor copper mineralization occurs in quartz veins in the Ding Dong Downs Volcanics at Saunders Creek Anticline (5100, 5101, and 5102) and in the Biscay Formation at Sophie Downs (Cu) 1 (4822). At Ding Dong Downs (Pb–F) (1104), there is coarse-grained galena and purple fluorite in a breccia zone within the Maude Headley Member. The breccia has been interpreted as a breccia pipe by Fletcher (1981), but Johnson (1981) has interpreted it as tectonic breccia.

### *Lamboo Complex — Central zone*

At the Calico Spring prospect (e.g. 1222, 5541, 5542), gossanous and malachite-bearing quartz veins, up to 300 m long, occur over a strike length of 3 km. The veins are aligned parallel to the stratigraphy and a north-northeasterly trending splay off the Halls Creek Fault, and they are hosted by the Tickalara Metamorphics and the McHale Granodiorite (Australian Anglo American Limited, 1973; Sanders, 1999). The Eastman Bore intrusion hosts possible remobilized primary copper mineralization in shears (e.g. Eastman Bore (Cu 3), 6212). At Bullock Bore 3 (4299) and Bullock Bore 4 (4301), in the same general area, copper mineralization is associated with shear zones in tuffs of the Koongie Park Formation. Koongie Park 2 (5725) and Ten Minute (Cu 2) (2530) are other examples of mineralization hosted by the Koongie Park Formation. Possible epithermal lead–barite mineralization occurs in granite of the Sally Downs supersuite at Boxers (1221) in Lake Argyle. The mineralized vein contains brecciated country rock suggesting it is a filling of a minor fault (Harms, 1959). The vein trends 020°, which is parallel to the Carr Boyd Fault.

### *Lamboo Complex — Western zone*

The only recorded production of base metals from the ‘vein and hydrothermal — undivided’ style of deposit in the east Kimberley area is from Black and Glidden (1257; 6.24 t of lead and 1045.7 g of silver from 9.41 t of ore; Blockley, 1971). At Black and Glidden, mineralized quartz veins are hosted by the Amherst Metamorphics and are related to the Lubbock Range Fault. Sporadic mineralization occurs over a strike length of 2200 m and individual veins are up to 20 m long and 3 m wide. Widespread quartz vein mineralization at Me No Savvy (1272, 1274, and 1277) is also hosted by the Amherst Metamorphics and related to the Glidden Fault. Copper mineralization in the Whitewater Volcanics is associated with shear zones at the Base Metal Prospect (1340) and Mount Remarkable 2 (1334), and with epithermal quartz veins at Jailhouse Creek 2 (2346).

### *Speewah Basin*

Lead–copper–silver(–gold–antimony) quartz vein mineralization in the Speewah Basin is hosted by the granophyric phase of the Hart Dolerite (termed the Yilingbun Granophyre by Alvin, 1993). Examples include Martins (1500), Calamondah (1501), Speewah IV (1503), Speewah V (1504), and Speewah VI (1505). Some base metals are also associated with epithermal fluorite veins (e.g. Martins (fluorite), 2428).

### *Kimberley Basin*

At Campbellmerry (2966), brecciated copper mineralization occurs within narrow shears parallel to major northwesterly trending faults in the Pentecost Sandstone (Harms, 1959).

### *Bastion Basin*

At Plants (6488), there are minor veins of copper carbonates, oxides, and chalcocite in siltstone of the Mendena Formation (Harms, 1959).

### *Carr Boyd Basin*

Disseminated galena and lead oxides occur in a silicified breccia zone within sandstone of the Golden Gate Siltstone at the Carr Boyd prospects (e.g. 2520; Pickands Mather and Company International, 1966)

### *Ord Basin*

Minor veins with malachite in the Cambrian Headleys Limestone are exposed in a road cutting at Brook Creek (5250).

### *Granites–Tanami Complex*

Copper mineralization is associated with ferruginous quartz along an east-southeasterly trending fault in the Killi Killi ‘Beds’ at Errol Bore (5720; Pratt, 1979).

## *Industrial mineral — fluorite*

The Speewah Basin hosts Western Australia’s largest fluorite deposit (Fig. 20). In the Main zone, there are at least nine fluorite vein sets over a strike length of 7.5 km that are related to a north-northeasterly trending splay fault of the Greenvale Fault. The largest of these is B Vein (5352), which is 700 m long and up to 10 m wide. The total published resource for A Vein (2397), B Vein (5352), and C Vein (5354) is 1.89 Mt measured, 0.41 Mt indicated, and 1.59 Mt inferred at 25% $CaF_2$ using a 13% $CaF_2$ cutoff grade (Rogers, 1998). Additional veins outcrop over an area of 30 × 8 km. The veins are hosted by granophyre

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**Figure 20. Photograph of the A vein at Speewah**

and dolerite of the Hart Dolerite, arkose of the Lansdowne Arkose, siltstone and mudstone of the Valentine Siltstone, and a tectonic and hydrothermal breccia informally termed the Doon Doon breccia (Rogers, 1998). The veins have epithermal textures, and fluid-inclusion studies indicate that they have trapping temperatures of about 150 to 170°C (Rogers, 1998). Samarium–neodymium dating of fluorite in the veins gave an age of 120 Ma (Rogers, 1998). A possible carbonatite dyke is associated with fluorite mineralization at West Ridge (2399; Alvin, 1993; Rogers, 1998; see **Mineralization in carbonatite and alkaline igneous intrusions**, p. 22).

Minor fluorite is present at the Frog prospect in the Whitewater Volcanics in the Western zone of the Lamboo Complex. It occurs both as separate veins (e.g. Frog 8; 5334) and in breccia zones in association with uranium mineralization (e.g. Frog 4; 2370).

Purple fluorite is also associated with brecciated cross-cutting quartz veins in felsic volcanic rocks of the Maude Headley Member at Ding Dong Downs (F) (5379) in the Eastern zone of the Lamboo Complex.

### Industrial mineral — barite

Barite is associated with some of the fluorite veins in the Speewah Basin and some separate barite veins also occur in this area (e.g. Main Shear North, 2423). Boulders of coarsely crystalline barite have also weathered from a vein in the Mabel Downs Tonalite at Mabel Downs (Ba) (6494) in the Central zone of the Lamboo Complex.

### Steel-industry metal — tungsten

All known tungsten vein deposits in the study area are in the Eastern zone of the Lamboo Complex. Scheelite occurs in quartz veins in Biscay Formation at Ruby Plains (5900, 5901, 5902) and in the Woodward Dolerite at Balara (959). Tungsten mineralization is also in quartz veins in the Berthas Butt (e.g. Castle Creek 9, 5044), Taylor Lookout (e.g. Taylor Lookout 4, 945), and Mount Dockrell (North Dockrell, 882) areas, but at these places it is associated with stratabound scheelite mineralization (see **Stratabound sedimentary mineralization**, p. 31) and has probably been remobilized from this style of mineralization.

### Steel-industry metal — nickel

A gossan with anomalous nickel and copper occurs on the faulted contact between the Springvale intrusion and the Airfield Granodiorite at Springvale 8 (5187) and Springvale 10 (5189). Gossan with anomalous nickel and copper also occurs on shears within the Springvale intrusion (e.g. Springvale 9, 5188). Pickands Mather and Company International (1968) considered this mineralization to be remobilized primary sulfides.

### Steel-industry metal — molybdenum

Pickands Mather and Company International (1967a) reported rumours of a molybdenite occurrence associated with calc-silicate rocks at Mabel Hill (5169); they found anomalous Mo in creeks draining Mabel Hill but did not follow it up.

### Energy mineral — uranium

All but one of the 17 uranium occurrences (classified as 'vein and hydrothermal — undivided') are in the Western zone of the Lamboo Complex. At Antares (2380), secondary uranium mineralization occurs in fractures and joints in felsic tuff in the Whitewater Volcanics; there are several mineralized zones up to 20 m long and 10 m wide. At the Frog prospect, secondary uranium mineralization also occurs within the Whitewater Volcanics on joints and shears (e.g. Frog 1, 2348) and in breccia zones associated with fluorite (e.g. Frog 4, 2370). At Dunham River B (2378), torbernite occurs in a brecciated dolerite dyke along the Dunham Fault zone and in mineralized quartz veins in sheared Crooked Creek Granite adjacent to the dyke (Fraser, 1955; Dale, 1976). At Donkey Creek (4804), secondary uranium mineralization occurs in siltstone of the Golden Gate Siltstone of the Carr Boyd Basin in the Dunham Fault zone (Dale, 1976).

The only other known uranium occurrence is John Galt (U) (5350), which is in the Red Rock Formation of the Red Rock Basin. At this locality, there are specks of carnotite in silicified sandstone boulders; boulders of mylonitic breccia also occur with autunite and torbernite on cleavage planes.

### Speciality metal — REE

At the John Galt (REE 1) prospect (1105), xenotime occurs as veinlets or segregations up to 30 cm thick in quartz veins, which follow joints and small faults in sandstone of the Red Rock Formation of the Red Rock Basin. Some xenotime is also present as impregnations in the sandstone. The mineralization is exposed on the faulted east wall of a mesa. Mascot Mining estimated an indicated resource of 51 250 t at 0.41% total REE (pre-JORC code; Campana, 1973; Reisgys, 1987). Additional xenotime-bearing veins are present at John Galt (REE 2) (5318) and John Galt (REE 3) (5319).

Xenotime has also been reported from the Lucas Craton and the Granites–Tanami Complex. At Browns Range Dome (6260), there is a vein of xenotime, 10–30 cm thick and 15 m long, and also a series of smaller xenotime veins associated with vuggy quartz and hematite alteration in the Archaean Browns Range Metamorphics of the Lucas Craton. At Whites Beach (6141), minor xenotime, of possible hydrothermal origin, occurs in kaolinitic shale of the Killi Killi 'Beds' in the Granites–Tanami Complex.

### Speciality metal — bismuth

At Shiddi Creek (5673), anomalous bismuth and gold mineralization are present in quartz–plagioclase–sericite schist and fine-grained dolomitic carbonate rock that has been interpreted by Fraser and Doe (1975) as Biscay Formation, but which could be Butchers Gully Member (Tyler, I. M., 1999, pers. comm.).

## Unconformity-related mineralization

### Energy mineral — uranium

There are six unconformity-related uranium occurrences within the study area, and all are in the Gardiner Range area at, or close to, the unconformable contact between the Killi Killi 'Beds' of the Granites–Tanami Complex and the overlying Gardiner Sandstone of the Birrindudu Basin. At the Don prospect (5793), uraninite and secondary uranium minerals (and gold) occur in siltstones and carbonaceous shales of the Killi Killi 'Beds'. They occur along an east-northeasterly trending fault, close to the unconformity between the Killi Killi 'Beds' and Gardiner Sandstone. The best intersection obtained from exploration drilling was 0.11 m at 4.65% U and 2.0 ppm Au in BIR1 (Laporte, 1981). At Mount Mansbridge 1 (5805), there is a zone of kaolinized black shale with pyritic quartz veins in the Killi Killi 'Beds' marked by high background spectrometer counts and a strong biochemical anomaly. Samples from pits assayed up to 980 ppm U and 0.16 ppm Au; xenotime is also present in the pits (Sutherland, 1983).

# Regolith mineralization

## Alluvial to beach placer mineralization

A total of 162 occurrences have been classified as 'regolith — alluvial to beach placers'. These have been further subdivided according to their major commodity into precious metal (107 occurrences), precious mineral (32 occurrences), speciality metal (13 occurrences), and steel-industry metal (10 occurrences).

### Precious metal — gold

Most of the alluvial gold occurrences in the study area are in the Eastern zone of the Lamboo Complex. They are concentrated in creeks and rivers draining primary vein and hydrothermal deposits. Alluvial workings in the Old Halls Creek area (e.g. Nuggety Gully 1, 2730) probably produced significant amounts of gold in the early years, but most of the early production is unrecorded. More recently, alluvial gold was mined from the Mary River area (e.g. Mary River 1, 6169). Between 1988 and 1990, 72.02 kg of gold was produced from the Mary River and its tributaries (Roebuck Resources NL, 1990).

Alluvial gold has been reported from the Gardiner Range area near the boundary of the Granites–Tanami Complex and the Birrindudu Basin at Lewis Creek (5826; De Havelland, 1986) and Slatey Creek (5417; Clarke and Blockley, 1961). Harms (1959) also reports that alluvial gold has been found in Prospect Creek (6486), which drains the Carr Boyd Basin.

### Precious mineral — diamond

Significant quantities of gem-quality alluvial diamonds, derived from the Argyle AK1 pipe, are being mined from Upper Smoke Creek (1108), Lower Smoke Creek (1109), Limestone Creek (1107), and Bow River (alluvials) (1113). The Argyle alluvials (Smoke Creek and Limestone Creek) had a total measured, indicated, and inferred resource of 45 Mt at 0.2 ct/t and a reserve of 5.8 Mt at 0.24 ct/t at 31 December 1999 (Ashton Mining Limited, 2000).

At Barramundi Range 2 (6387), gem-quality diamonds are said to have been recovered from the bank of Middle Creek, which may be a palaeodrainage channel of the Leopold River (Davies, 1990).

Small diamonds or microdiamonds have also been found in the vicinity of the Durack Range (e.g. Lightning Creek, 5376), near Gordon Downs Homestead (e.g. Gordon Downs 1, 6028), and in the northwest corner of MOUNT BANNERMAN at Salt Creek (6420) and Wattle Spring Creek (6422).

### Precious mineral — topaz

Abundant clear topaz (up to 55% of heavy mineral concentrate) was found in a stream-sediment concentrate from Argyle Dykes 3 (3004) during diamond exploration (Brown, 1992). It is not known if there is any topaz of significant size in the area. The topaz was possibly derived from a lamproite dyke, but the source was not traced.

### Speciality metals — tin, tantalum, niobium (gold, tungsten)

In the southern part of the Halls Creek Orogen, alluvial tin has been reported from Mount Cross 3 (6379). Alluvial tin, tantalum, niobium, and tungsten occur at Junda 2 (965) and Junda 4 (5915); alluvial tin and gold occur at Minneroo Pool 3 (5822). Alluvial tin has also been recorded in the northern part of the east Kimberley area (e.g. Neil Creek 1, 966).

### Speciality metal — heavy minerals, REE

Xenotime and monazite have been recorded from recent alluvium and raised cobble wash at Corkwood Yard (3005).

### Steel-industry metal — tungsten, titanium, vanadium

Alluvial scheelite occurrences include Foal Creek (968) in the northern part of the Halls Creek Orogen and Hangmans (W) (5909) in the southern part of the Orogen. Alluvial vanadiferous ilmenite has been reported from Speewah Valley (Ti) (844).

## Residual to eluvial placer mineralization

A total of 37 occurrences have been classified as 'regolith — residual to eluvial placers'. These include 33 precious metal occurrences, two base metal occurrences, one steel-industry metal occurrence, and one speciality metal occurrence.

### Precious metal — gold

Eluvial gold occurs in close association with primary gold. Examples include Top of Bucket (6185) near Mount

Dockrell, Comet Hill (3213) in the Grants Patch area, and Christmas Creek 6 (6071) at the southern end of the Halls Creek Orogen. Early prospectors worked the eluvial gold by dry-blowing, but more recently, metal detectors have been used to locate eluvial gold. Unfortunately, some of the recent operators have used bulldozers (apparently without approval from DME) to remove surface soil, and this has caused serious environmental degradation.

#### *Base metal — copper*

At Copper Flats (2756) in the Ord Basin, there are abundant pebble-sized fragments of secondary copper minerals and copper-stained shale in skeletal soil over an area 1000 × 600 m (Matheson, 1996). Several agate boulders containing abundant chalcopyrite were reported from Eastman (Cu) A (790) near the southern contact of the Eastman Bore intrusion (Lewis, 1968).

#### *Steel-industry metal — tungsten*

There is a colluvial scheelite concentration in surface rubble at Sophie Downs North (933).

### Residual and supergene mineralization

A total of eight occurrences have been classified as 'regolith — residual and supergene'. These include four steel-industry metal occurrences, two energy mineral occurrences, one base metal occurrence, and one industrial mineral occurrence.

#### *Steel-industry metal — nickel*

Lateritic nickel mineralization is associated with the Lamboo intrusion. An intersection of 18 m at 1.0% Ni was obtained in diamond drilling at Lamboo (Ni 1) (6155; Chadwick, 1986).

#### *Energy mineral — uranium*

At Spinifex (2727), secondary uranium mineralization has resulted from supergene enrichment of uranium on joints and breccia zones adjacent to the Revolver Fault. Up to 13.5% $U_3O_8$ was obtained in selected surface samples, but uranium values decrease rapidly with depth in trench sampling (Bianconi, 1973). Secondary uranium minerals have also been reported in association with the Esaw Monzogranite at A1 (6194).

#### *Base metal — copper, silver (gold)*

The oxide zone of the Sandiego deposit (Sandiego (oxide), 1128) has been classified in the 'regolith — residual and supergene' category (see **Stratabound volcanic and sedimentary mineralization**, p. 27).

#### *Industrial mineral — magnesite*

There is residual magnesite on the Lamboo intrusion at Lamboo (magnesite) (5163).

# Mineral controls and exploration potential

## Mineralization in kimberlite and lamproite intrusions

#### *Precious mineral — diamond*

The Argyle AK1 pipe is situated near the eastern margin of the Halls Creek Orogen, on a splay of the Halls Creek Fault that is inferred to be the zone of weakness along which the olivine lamproite magma ascended (Boxer et al., 1989). Interaction of the magma with groundwater in the partly consolidated sediments of the Carr Boyd Group into which the diatreme was intruded caused phreatomagmatic explosions resulting in mixing of sand grains with the magma to form sandy tuffs (Boxer et al., 1989). Inclusions within the diamonds indicate that they formed in both mantle eclogite and mantle peridotite, and are thus regarded as xenocrysts in their olivine lamproite host rock (Boxer and Jaques, 1990).

The Lissadell Road Dykes were probably intruded into en echelon tension gashes associated with the same deep-seated fracture as the Argyle diatreme, 6 km to the north (Boxer et al., 1989).

There is potential for further discoveries of lamproitic and kimberlitic diamond occurrences associated with the many deep-seated faults in the east Kimberley area. On the basis of the distribution of kimberlitic indicator minerals in stream gravels, Fielding (1983) suggested that there could be a further eight or more kimberlitic dykes in the Maude Creek area and five or more in the Devils Elbow area. There are also several alluvial diamond occurrences away from the palaeodrainages of the Argle AK1 deposit that are worthy of follow-up for lamproitic or kimberlitic diamond deposits.

## Mineralization in carbonatite and alkaline igneous intrusions

According to Andrew (1990), the Cummins Range (REE) carbonatite deposit lies at the Junction of the Halls Creek and King Leopold Orogens. This is not obvious on Plate 1, but there has been no recent mapping on MOUNT BANNERMAN. On the basis of Nd and Sr isotope data, Sun et al. (1986) suggested that the carbonatite was derived from an ocean island basalt-type source within a depleted mantle. Weathering processes including leaching, dissolution, and silicification of the carbonatite have led to enrichment in resistate minerals and concentration of REE, niobium, and phosphorus. Weathering has also caused hydration of biotite to form hydrobiotite and vermiculite (Andrew, 1990).

The Cummins Range (REE) deposit is a significant unexploited REE, niobium, and phosphorus resource. The presence of minor carbonatites at Copperhead and in the Speewah Valley, together with the presence of the Bow Hill lamprophyre dykes, suggests that the east

Kimberley may be an alkali igneous province. There is potential for other carbonatite deposits to be found along major tectonic boundaries such as the Halls Creek Fault zone.

## Orthomagmatic mafic and ultramafic mineralization

### *Steel-industry metal — nickel (copper, cobalt)*

Layered mafic intrusions of Hoatson's (1997, in press) Group V are hosts to most of the nickel occurrences in the Lamboo Complex. At the Sally Malay deposit, sulfides are concentrated at the base of the intrusion. In some deposits (e.g. Corkwood), there may have been some remobilization of sulfides as there is irregular mineralization at different levels within the intrusion. Hoatson (1997, in press) suggested that the feeder zone of Group V intrusions is particularly prospective for deposits similar to the Voiseys Bay Ni–Cu–Co deposit in Labrador, Canada (Naldrett et al., 1996).

Intrusions other than those of Hoatsons Group V are also prospective. Nickel mineralization occurs in ultramafic rocks within the Tickalara Metamorphics at Bow River and Cabernet, in Group IV (Wild Dog Creek Gabbro) at Mabel Hill within the Central zone of the Lamboo Complex, and in the Paperbark supersuite at Billymac Yard D in the Western zone of Lamboo Complex.

### *Steel-industry metal — PGE, chromium*

Group I Panton intrusions host many of the PGE and chromium occurrences in the Central zone of the Lamboo Complex. According to Perring and Vogt (1991), chromitite layers in the Panton Sill resulted from chromite saturation when silica-contaminated resident magma mixed with new pulses of primitive magma. Platinum group element grades peak towards the base of the A-seam at the Panton deposit. Perring and Vogt (1991) suggests that the magma-mixing event induced sulfur saturation and that the immiscible sulfide phase rapidly scavenged PGE, Ni, and Cu from the liquid before concentrating onto the floor of the magma chamber. Platinum group element-bearing chromitite horizons in the Lamboo and Eastman Bore intrusions in the Central zone, and the Group II Springvale intrusion in the Western zone, probably have a similar origin. Hoatson (1997) suggested that the upper parts of the Group VI McIntosh intrusions have potential for remobilized Au–Pd–Cu mineralization similar to the Platinova reef of the Skaergaard intrusion in East Greenland (Anderson et al., 1998).

### *Steel-industry metal — titanium, vanadium*

Ilmenite is hosted by upper gabbroic parts of the Group V Sally Malay intrusions indicating potential for economic titanium and possibly vanadium. Hoatson (1997) also suggested that the upper parts of the Group VI McIntosh intrusions have potential for stratabound titaniferous magnetite layers.

### *Base metal — copper (nickel, PGE, chromium)*

Remobilized magmatic sulfides are associated with Group I Panton intrusions, Group V Sally Malay intrusions and the Spring Creek intrusion, and the Group VI McIntosh intrusion in the Central zone; and the Group II Springvale intrusion in the Western zone. All of the layered intrusions in the East Kimberley have potential to host this style of deposit.

## Disseminated and stockwork mineralization in plutonic intrusions

### *Base metal — copper (molybdenum, silver, gold)*

On the basis of the presence of magmatic–hydrothermal breccia dykes and styles of alteration typically associated with porphyry copper systems, Witt and Sanders (1996) concluded that the copper occurrences in the McHales Granodiorite of the Sally Downs supersuite were of porphyry copper style. There is also a possibility that the occurrences are related to hydrothermal activity along the Halls Creek and Angelo Fault zones (Witt and Sanders, 1996) or have been derived from the volcanic rocks unconformably overlying the granitoid (Scott, 1973). Sheppard et al. (1997c) and Tyler et al. (in prep.) suggest that older granitoids (1835–1820) of the Sally Downs supersuite were emplaced into a convergent continental margin, above a northwesterly dipping subduction zone. Therefore, there is the potential for porphyry-copper style mineralization in other granitoids of this age.

## Pegmatitic mineralization

Sanders (1999) has suggested that the tin–tantalum–niobium–tungsten pegmatites in the Dockrell area are related to the waning stages of the 1788 Ma San Sou Monzogranite, as the imprecise SHRIMP date of 1740 ± 40 Ma obtained on one of these pegmatites is almost within error of the age of the San Sou Monzogranite. However, the San Sou Monzogranite is not an S-type granite (the type of granite usually associated with tin deposits).

All pegmatites discovered to date have been small, and the potential for an economic deposit seems to be low.

## Skarn mineralization

Most of the occurrences described by companies as skarns have no obvious association with granitoids. However, tonalite has been reported in association with the Wills Creek B6 occurrence. It is possible that the Monkey Yard Tonalite is more widespread than indicated on DIXON and that it has played a role in forming the skarns in the Tickalara Metamorphics in the Central zone. However, the Tickalara Metamorphics contains medium- to high-grade rocks and therefore all calc-silicate horizons will be dominated by a 'skarn-like' mineralogy. The skarn-like mineralogy is thus probably completely unrelated to the Monkey Yard Tonalite. The San Sou Monzogranite or pegmatites may have played a role in the Taylor Lookout and Mount Heartbreak areas in the southern part of the Eastern zone as suggested by Sanders (1999). An alternative explanation is that the calc-silicate horizons contained syngenetic or volcanic exhalative mineralization that was recrystallized during metamorphism (see **Stratabound volcanic and sedimentary mineralization** below, and **Stratabound sedimentary mineralization**, p. 52).

## Stratabound volcanic and sedimentary mineralization

### *Base metal — copper, lead, zinc, silver*

In the Central zone of the Lamboo Complex, the stratabound volcanic and sedimentary base-metal occurrences within the Koongie Park Formation are related to both proximal and distal felsic volcanism. Sulfides appear to have been mobilized during late folding. At Sandiego, rich shoots are aligned parallel to the fold axes on tight folds (Sewell, 1999). The 'Mimosa interval' of the Camp shale member hosts most of the occurrences in the Koongie Park area and can be regarded as highly prospective, especially in fold hinges where sulfides may have been concentrated.

In the Eastern zone of the Lamboo Complex, base metal mineralization in the Ilmars – Little Mount Isa – Twin Hills area is in distal volcaniclastic sedimentary rocks associated with felsic volcanic rocks within the Biscay Formation. At Ilmars Central, mineralization has been concentrated near cross-cutting east–west faults (Sewell, 1999). Little is known about the other occurrences in the Biscay Formation, but most of them are associated with interflow sedimentary rocks or tuffs and probably formed in a distal environment. The Biscay Formation has potential for low-grade base metal mineralization with higher grades in the vicinity of felsic volcanic rocks or where mineralization has been concentrated by folding or faulting. There is also potential for base metal mineralization in felsic volcanic rocks of the Maude Headley Member, Butchers Gully Member, and Ding Dong Downs Volcanics.

In the Kimberley Basin, the presence of copper occurrences in the Carson Volcanics over a strike length of greater than 70 km, together with the concentration of copper in chert, sandy interflow sediments, and tuffaceous flow tops of basalt of the Carson Volcanics, supports the interpretation by Planet Management and Research Proprietary Limited (1971) that the mineralization is volcanogenic in origin. Faulting appears to have been significant in concentrating the mineralization. The faults at Carson Volcanics 9 appear to be syndepositional because there is a change in stratigraphy to the north of this deposit (Planet Management and Research Proprietary Limited, 1971; Sanders, 1999). It is possible that other concentrations of copper may have formed where there are syndepositional faults.

In the Osmond Basin, the possible volcanogenic copper occurrence in felsic lithic vitric tuffs near the base of the Bungle Bungle Dolomite at Paradise Creek (Cu B) (de Angelis, 1984) was not followed up by Samin Australia, but is worthy of further investigation.

In the Ord Basin, native copper in vesicular basalt of the Cambrian Antrim Plateau Volcanics is possibly of Michigan type, but there is no evidence that it has been concentrated by metamorphic processes as in the Michigan area (White, 1968). Harms (1959) interpreted the native copper in boulders of prehnite at Dunham Crossing as steam-hole fillings by late magmatic volatiles during solidification of the lavas. No economic concentrations of this style of mineralization have yet been found, but there is potential for new finds.

### *Steel-industry metal — tungsten*

The stratabound scheelite mineralization in the Taylor Lookout area is confined to a calc-silicate horizon within the Biscay Formation. The mineralization is possibly related to the San Sou Monzogranite that outcrops 1–1.5 km away as suggested by Sanders (1999), but this would not explain the stratabound nature of the mineralization. The granite may, however, be responsible for remobilizing tungsten into the later cross-cutting veins in the area (see **Vein and hydrothermal mineralization**, p. 57). The origin of mineralization at Berthas Butt is highly controversial, but a volcanic exhalative model is possible (see **Stratabound sedimentary mineralization**, p. 52).

### *Precious metal — gold*

Some gold occurrences within the Biscay Formation in the Eastern zone of the Lamboo Complex (e.g. Lulu, Freda, and Mount Carmel East 2) are possibly volcanogenic in origin. According to Kinnane (1983), gold in the Dockrell area is located around fossil volcanic fumarolic vents in the Biscay Formation, but no specific locations were given. The Butchers Gully Member also hosts possible volcanogenic gold mineralization. There is the possibility that further volcanogenic mineralization will be found, although most gold mineralization appears to have been remobilized into later structures (see **Vein and hydrothermal mineralization** below).

### *Speciality metal — REE, niobium, tantalum, beryllium, gallium*

Ramsden et al., (1993) suggested that the 'Niobium tuff' of the Butchers Gully Member at the Brockman deposit was originally enriched in incompatible elements and fluorine, and that the mineralization is the result of alteration and remobilization of magmatic minerals such as columbite and zircon by F-rich deuteric solutions that were retained in the tuff. The presence of anomalous niobium in alkaline volcanic rocks of the Maude Headley Member and in trachyte within mafic tuffs that have been mapped as Biscay Formation suggests that these rocks may also have potential for REE – rare metal deposits, especially where the presence of fluorite indicates that F-rich solutions could have been available to transport REE, beryllium, tantalum, and niobium, and deposit them in economic concentrations.

### Precious mineral — prehnite, agate

Prehnite has formed as a vesicle filling in the Cambrian Antrim Plateau Volcanics. There is potential for further deposits of this type within the Antrim Plateau Volcanics. There is also potential for agate deposits formed in a similar way.

# Stratabound sedimentary mineralization

## Clastic-hosted mineralization

### Steel-industry metal — tungsten (molybdenum)

The origin of the stratabound scheelite mineralization in the Berthas Butt and South Dockrell areas is controversial. For the purposes of this study, the mineralization type is classified as 'stratabound sedimentary — clastic-hosted', but an alternative classification could be 'stratabound volcanic and sedimentary — volcanic oxide'. On the basis of the presence of gypsum casts and quartz layers that possibly replaced anhydrite, Ririe (1989) proposed that tungsten mineralization in the Berthas Butt area formed in a continental-sabkha playa basin, similar to Searles Lake in Canada where brines contain up to 70 ppm $WO_3$ and the playa muds contain up to 118 ppm $WO_3$. Trudu (1990) questioned Ririe's (1989) interpretation and suggested that the mineralization was related to the Sophie Downs Granophyre Member, and that the tungsten-bearing solutions followed the most porous units in the stratigraphy, that is, the quartzites. However, recent studies (Blake et al., 1999b) show that the c.1910 Ma Sophie Downs Granophyre Member is unconformably overlain by the c. 1880 Saunders Creek Formation (see Table 1), so there can be no genetic relationship between the granophyre and mineralization in the Saunders Creek Formation.

Sanders (1999) suggested that the stratabound tungsten mineralization in both the Berthas Butt area and the Dockrell area was related to post-tectonic, granite-derived fluids that were focused into anticlinal domes and along zones of permeability. Sanders (1999) proposed that the fluids were related to 1740 ± 40 Ma tin-bearing pegmatites, which in turn may have been related to the waning stages of the c. 1780 Ma San Sou Monzogranite. However, the nearest outcrop of San Sou Monzogranite to the South Dockrell area is 13.5 km away, and the Berthas Butt area is 50 km from the nearest outcrop of granitoid of the San Sou suite. Therefore, there is unlikely to be any genetic relationship between the tungsten mineralization and the San Sou suite.

Textural and fluid-inclusion data (fluid inclusions within the scheelite have been annealed) indicate that the scheelite at Berthas Butt pre-dates the last main phase of deformation of the rocks (?$M_4$; Blight, 1983; Ririe, 1989). There is also textural evidence that scheelite in epidote quartzites and tourmalinites in the South Dockrell area pre-dates the main phase of regional metamorphism (?$M_4$; Goldner, 1984).

An alternative origin for the tungsten mineralization is that it may be related to volcanic exhalative activity or hot-spring activity. For comparison, the Felbertal stratabound scheelite deposit in Austria, which is one of the largest tungsten deposits in the world, is hosted in a metabasalt sequence and is interpreted to have formed as hot-spring sinters in a narrow rift graben during the initial stage of island-arc evolution (Plimer, 1987). A similar genesis has been proposed for the amphibolite- and tourmalinite-hosted stratabound scheelite deposits in the Broken Hill area, New South Wales, and the tourmalinite-hosted tungsten mineralization in West Greenland (Plimer, 1987). In both the South Dockrell area and the Berthas Butt area, tungsten-bearing epidote quartzites are closely associated with volcaniclastic sedimentary rocks, suggesting a link with volcanic exhalative activity. The close association between epidote and scheelite could be explained by the replacement of feldspars in the quartzite by epidote resulting from exhalative activity. The tourmalinites at South Dockrell could be volcanic exhalative in origin, similar to that suggested by Plimer (1987) for scheelite-bearing tourmalinites elsewhere. The presence of tourmalinites would also be consistent with metamorphism of a boron-rich evaporite deposit. It is possible that volcanic exhalations were concentrated in a playa environment.

There is statabound tungsten mineralization in a range of formations of different ages in the Eastern zone including the Ding Dong Downs Volcanics and the Saunders Creek Formation at Berthas Butt and, possibly, the Butchers Gully Member at South Dockrell. The calc-silicate rock-hosted tungsten and base metal mineralization in the Biscay Formation in the Taylor Lookout area is probably of similar origin. Although no economic mineralization of this style has been found in the study area to date, this type of mineralization has the potential to be economic, as illustrated by the Felbertal stratabound scheelite deposit in Austria. There is also potential for other exhalative-type mineralization (e.g. gold and base metal) to be associated with the tungsten. The presence of epidote quartzite, tourmalinite, exhalative chert, or calc-silicate rock could be used as an exploration guide.

### Base metal — copper, lead, zinc

The base-metal bearing gossans in feldspathic sandstones of the Winnama Formation in the Central zone of the Lamboo Complex are inferred to be syngenetic in origin, although there is little detailed information about them. The base-metal bearing gossans hosted by graphitic schists of the Tickalara Metamorphics are possibly also syngenetic. However, as the host rocks have been strongly metamorphosed, it is not certain whether these occurrences are syngenetic or hydrothermal.

In the Kimberley Basin, the extensive malachite staining in shale at the base of the middle Pentecost Sandstone, over a strike length of 200 km around Menuairs Dome in the northwestern part of the study area, suggests a stratigraphic control. However, exploration drilling has shown that the grade drops off with depth, suggesting probable surface enrichment. This unit could be worth exploring in the vicinity of faults, where it is possible that economic grades of mineralization are concentrated.

In the Osmond Basin, native copper at Paradise Creek (Cu A) fills pore spaces in the hosting sandstone and siltstone of the Bungle Bungle Dolomite, but the source of the copper is unknown. It could be volcanic exhalative in origin because copper mineralization has been reported in association with tuffs at Paradise Creek (Cu A). It could also be of hydrothermal origin and related to the nearby fault.

### *Energy mineral — uranium*

The controls on the uranium mineralization at Rustlers (in the Biscay Formation in the Eastern zone of the Lamboo Complex) are unknown. Horse 7 (in the Bonaparte Basin) and the Killi Killi deposits (in the Birrindudu Basin) are possibly sandstone-uranium type occurrences, but surface enrichment has probably played a significant role in concentrating uranium at these occurrences.

There has been considerable exploration for uranium both in the Birrindudu Basin and in the King Leopold Sandstone at the base of the Kimberley Basin, but no significant uranium mineralization has been found; most radiometric anomalies have been due to thorium. This tends to downgrade the potential of the area.

### *Speciality metal — REE*

Fluviatile processes have probably played a significant role in concentrating heavy minerals at Junior where monazite is concentrated in heavy mineral bands in fine-grained sandstone of the Palaeoproterozoic Red Rock Formation. Xenotime in basal grits and conglomerate of the Gardiner Sandstone in the Birrindudu Basin at Killi Killi 1 and Killi Killi West could be detrital, or the product of surface enrichment.

### *Precious mineral — diamond*

The gem-quality diamonds said to have been recovered from the basal Barramundi Conglomerate of the Canning Basin at Barramundi have kimberlitic rather than lamproitic characteristics and are inferred to have been transported from the Kimberley Craton to the east and deposited in the Devonian palaeoplacer (Davies, 1990). Since no further diamonds have been found in the area despite intensive drilling, there is some doubt about the authenticity of the reported occurrence and hence the prospectivity of the area may be downgraded.

## Carbonate-hosted mineralization

### *Base metal — lead, zinc, copper (silver, gold, molybdenum, tungsten, tin)*

A large number of occurrences of Mississippi Valley-type mineralization have been found in the Devonian limestones of the Lennard Shelf area of the Canning Basin, and it remains a highly prospective area.

The Kapok deposit probably has similar ore controls to the nearby Cadjebut mine. At Cadjebut, rhythmically banded ore is hosted by evaporites that Tompkins et al. (1994a, 1997) interpreted as the source of sulfur. A later phase of mineralization is represented by sulfides in vugs and cavities. The second phase of mineralization is interpreted by Tompkins et al. (1994b, 1997) to be related to a period of reefal platform emergence and minor uplift of the Lennard Shelf coinciding with the waning stages of the Alice Springs Orogeny. The Cadjebut and Kapok orebodies are situated close to the Cadjebut Fault and a splay of this fault. The Cadjebut Fault is a synsedimentary (Late Devonian), normal fault, which in turn is a splay of the Pinnacle Fault. The Pinnacle Fault was probably the main basin-tapping fluid conduit for the mineralizing brines for both mineralizing events (Tompkins et al., 1997). Oil and gas generation in the basin, triggered by a fall in sea level, may have been a contributing factor to the generation of overpressured fluid that deposited the breccia ore (Tompkins et al., 1997).

The Lindner Fault probably played a role in the localization of mineralization at Horse Spring Range, 59 km north of Kapok.

In the Osmond Basin, the stratabound nature of the galena in carbonates of the Bungle Bungle Formation suggests that it is syngenetic in origin. Soft-sediment compaction and dewatering may have resulted in mobilization and concentration of the sulfides as suggested by de Angelis (1983). Organic matter may have played a role in precipitating or concentrating the base metals. It is also possible that the ore metals are volcanic exhalative in origin because chert is associated with the lead mineralization at Paradise Creek (Pb), and de Angelis (1984) has reported copper mineralization associated with felsic, lithic, vitric tuff at Paradise Creek (Cu B). This area is considered to be prospective, especially because most of the exploration holes drilled during the 1980s failed to meet their target or ended prematurely in mineralization due to difficult drilling conditions.

Sanders (1999) proposed a granitoid-related skarn origin for the minor copper(–tungsten–gold–tin) mineralization in calc-silicate rocks and marbles of the Tickalara Metamorphics in the Central zone at Alice Downs, but Chadwick (1985) considered that they could be primary exhalative in origin.

Although syngenetic copper mineralization in dolomite and shale in the upper part of the Teronis member of the Elgee Sandstone is widespread, no economic mineralization has yet been found in the Kimberley Basin. It is possibly worth exploring in the vicinity of faults where there may have been some greater concentration of copper.

In the Ord Basin, low-grade copper mineralization at Mount Elder, in limestone of the Cambrian Panton Formation of the Goose Hole Group, has been interpreted by Dow and Gemuts (1969) to be sedimentary in origin, but they did not consider the mineralization to be economic.

## Undivided mineralization

### *Base metal — copper, lead, zinc, silver*

In the Lamboo Complex, the origin of the base metal mineralization in the Tickalara Metamorphics and the

Biscay Formation is unknown, but the mineralization could be volcanic exhalative in origin. Copper mineralization in the Headleys Limestone of the Ord Basin at Discovery Yard was possibly derived by secondary enrichment from the underlying basalt of the Antrim Plateau Volcanics (Ball, 1966).

#### *Steel-industry metal — vanadium, chromium, molybdenum*

In the Central zone of the Lamboo Complex, at Sally Malay Bore 5 and Sally Malay Bore 6, the association of the vanadium–chromium–molybdenum gossans with BIF of the Tickalara Metamorphics suggests that mineralization could be volcanogenic exhalative in origin.

#### *Precious metal — gold*

The gold in silicified black shale and dolomite of the Biscay Formation at Woodward Creek (Au) is possibly syngenetic or volcanic exhalative in origin.

## Sedimentary mineralization — banded iron-formation (supergene enriched)

#### *Iron*

Field evidence, including the presence of cross-bedding visible in the hematite ore in the Pompeys Pillar area, indicates that the ore has been little changed since deposition, apart from the leaching of silica, and that the iron is sedimentary in origin (Harms, 1959). The subsequent discovery of enormous resources of iron ore in the Pilbara has made it unlikely that iron ore in the Pompeys Pillar area will be mined in the foreseeable future.

## Vein and hydrothermal mineralization

### Undivided mineralization

Many of the vein- and hydrothermal-related mineral occurrences in the east Kimberley are polymetallic, but they have been subdivided according to the main commodity (see **Mineralization**, p. 19). Sanders (1999) suggested that there is a sequential pattern of metal zonation (i.e. Au-only to Au–Pb–As–Cu(–Zn) to Cu–Au–Ag to Cu–Mo–Ag–Sn–W to W(–Sn) to Sn–Ta–Nb) that shows a positive correlation with the $M_4$ metamorphic grade of the host rock in the Eastern zone of the Lamboo Complex. According to Sanders, gold-only occurrences are mainly hosted by rocks of low metamorphic grade (greenschist facies); base-metal bearing gold occurrences are mainly hosted by rocks metamorphosed to upper greenschist to lower amphibolite facies; and W(–Sn) or Sn(–W) mineralization is hosted by rocks metamorphosed at low to mid-amphibolite facies. Sanders (1999) states that there was an absence of gold mineralization in all areas that contain tin or tungsten mineralization, and hypothesizes that 'the gold mineralization may be part of a larger metal suite (of possible granite association) that was deposited at a time when the geothermal gradient was still relatively high, but post-peak metamorphic in timing'.

Dow and Gemuts (1969) suggested that gold and base metal mineralization in the Lamboo Complex may be related to the Sophie Downs suite, but these granitoid rocks have been dated at c. 1910 Ma (Blake et al., 1999b) and thus pre-date the gold and base metal mineralization hosted by the c. 1880 Ma Biscay Formation. The only granitoid with an age that could be related to mineralization in the Eastern zone is the c. 1790 Ma San Sou Monzogranite. Sanders (1999) suggests that the San Sou Monzogranite is more extensive in the subsurface, but there is no evidence for this.

Alternative controls on vein and hydrothermal mineralization are given below.

#### *Precious metal — gold*

*Lamboo Complex — Eastern zone*

Dow and Gemuts (1969) were the first to recognize the strong stratigraphic control on gold mineralization in this area. They pointed out that all of the economic mines are located close to the boundary between the Biscay and Olympio Formations. This study has provided further evidence of strong stratigraphic control on mineralization. As stated in the **Mineralization** section (p. 19), 112 of the total of 262 vein and hydrothermal gold occurrences within the whole of the east Kimberley area are within the Biscay Formation in the Eastern zone of the Lamboo Complex. Another 52 occurrences are in the Olympio Formation, generally close to its contact with either the Biscay Formation or the Butchers Gully Member, and 21 occurrences are within the Butchers Gully Member, near the base of the Olympio Formation. There are hardly any gold occurrences in the Olympio Formation away from its contact with the Biscay Formation.

Warren (1994b) suggested that the Butchers Gully Member, which contains high concentrations of incompatible elements such as zirconium, yttrium, and niobium, was the most likely source-rock for both gold and chemically active fluids. The mafic volcanic rocks, volcaniclastic rocks, and interflow sedimentary rocks of the Biscay Formation are another possible source of the gold. Kinnane (1983) suggested that the gold in the Dockrell area was located around fossil volcanic fumarolic vents in the Biscay Formation.

Gold has been mobilized into steeply dipping, northeasterly trending shears, conformable quartz veins, and cross-cutting quartz veins. Dow and Gemuts (1969) stated that the quartz reefs in the Ruby Queen area have been folded, but Sanders (1999) could find no evidence of this. According to Griffin and Tyler (1992) and Warren (1997), the mineralization at Ruby Queen occurs along sinistral strike-slip faults and antithetic tension veins that are related to the fourth deformation in the Eastern zone ($D_6$). This is related to the Palaeozoic Alice Springs Orogeny and therefore the gold deposits are unlikely to be related to the $M_4$ isograds as suggested by Sanders (1999). At Palm Springs, the quartz stockwork mineralization in trachyandesite of the Butchers Gully Member is a series of tension veins, related to the same shear system as that at Ruby Queen (Sanders, 1999; Fig. 18). Most of the other workings in the Brockman – Mount Bradley area are also in the trachyandesite of the Butchers Gully Member, which is structurally repeated by high-amplitude isoclinal folding ($D_5$) of the Mesoproterozoic Yampi Orogeny, suggesting that this unit fractured more readily during sinistral faulting ($D_6$; Sanders, 1999). At Old Halls Creek, mineralization occurs along the Halls Creek Fault, in shears parallel to this fault, and in related tension veins. The Kerry–Reform–Darcys group of workings in the Biscay Formation is related to northwesterly to north-northwesterly trending shears parallel to the arcuate boundary between the Biscay and Olympio Formations. Gold mineralization in the Dockrell and Grants Creek area is also along shears parallel to the regional faults; the richest mineralization in the Dockrell area developed at the intersection of two shears at McNeils.

The main gold-mining centres in the Eastern zone have been intensely prospected for gold. However, in the past, only rich high-grade veins and lodes were mined. If the gold could not be readily extracted by dollying or amalgamation, the area was abandoned. Veins with abundant sulfide, such as those at the original Butchers Gully (now Palm Springs) mine, could not be profitably worked. With new processing technology and open-pit mining techniques, it is probable that some of the old mining areas could be profitably worked. In particular, quartz stockwork mineralization in trachyandesite of the Butchers Gully Member in the Brockman – Mount Bradley area is an obvious exploration target.

Further south in the Eastern zone, where exposure is poorer and there has been less prospecting and exploration activity, there is potential for further discoveries of gold. The mafic rocks in the Christmas Creek area would be worth further investigation. The anomalous bismuth and gold mineralization in schist and dolomitic rock, possibly belonging to the Biscay Formation or Butchers Gully Member at Shiddi Creek, is also worth following up.

### *Lamboo Complex — Central zone*

In comparison to the Eastern zone, there is very little known gold mineralization in the Central zone. The most significant gold occurrence in the Central zone is at Nicolsons Find, where auriferous quartz veins in the Koongie Park Formation are related to the northerly trending, steeply dipping Nicolsons Fault (Sanders, 1999). Other shear-related gold mineralization in the Nicolsons Find area is hosted by the Loadstone Monzogranite and the Lamboo intrusion. The gold could have been derived from volcanogenic mineralization in the Koongie Park Formation or from primary mineralization in the Lamboo intrusion.

An epithermal origin for the gold at Lady Helen is suggested by the widespread occurrence of hydraulic fractures and brecciation and the vuggy nature of the veins (Pirajno et al., 1994). This evidence also suggests that the veins formed in late brittle structures that post-dated the Loadstone Monzogranite and were probably initiated at about 1300–1100 Ma (Pirajno et al., 1994; Sanders, 1999).

There is potential for further gold mineralization in the Central zone along the Springvale Fault and other late faults, especially where they cut the Koongie Park Formation.

### *Lamboo Complex — Western zone*

In the Western zone, the Glidden Fault and Lubbock Range Fault have played a role in localizing gold and base metals at Me No Savvy and at Black and Glidden (also at Soda Springs in the Central zone to the south of the Lubbock Range Fault). The Amherst Metamorphics is a possible source of the gold. Low-grade gold–silver mineralization in epithermal veins in felsic tuffs of the Whitewater Volcanics at Jailhouse Creek is localized on a west-northwesterly trending fault. It is possibly related to the same epithermal system that produced the fluorite and base metal mineralization in the Speewah Basin. There is potential for further epithermal mineralization, particularly in the vicinity of the Dunham and Greenvale Faults.

### *Speewah Basin*

To date, only minor gold mineralization has been found in association with base-metal and fluorite veins in the Speewah Basin, but Rogers (1998) suggested that there could be rich epithermal gold mineralization at depth.

### *Granites–Tanami Complex*

Gold mineralization in the Larranganni area shows a particularly strong stratigraphic control with the occurrences being confined to two sequences of folded mafic volcanic and sedimentary rocks that have been informally named the Bald Hill sequence and the Quartz Ridge sequence (Glengarry Resources NL, 1999, written comm.; Quinn, 1999; Fig. 19). Glengarry Resources NL (1999, written comm.) has correlated these sequences with the Mount Charles Beds at the Tanami and Granites–Callie mines in the Northern Territory. The company also highlighted other similarities between the Larranganni mineralization and that of the Tanami and Granites–Callie mines: similar style of alteration (carbonate, sericite, quartz, iron, and chlorite), folded rocks along a northerly trend, major west-northwesterly cross-cutting structures (Trans-Tanami Fault System), and a strong regional gravity anomaly.

The Kookaburra and Sandpiper occurrences are localized on a west-northwesterly fault suggesting that these cross-cutting structures were important channelways for ore fluids. The widespread occurrence of large, randomly orientated muscovite flakes in felsic arenite, together with the gravity low, suggests the presence of a granitoid body beneath the Larranganni area (Glengarry Resources NL, 1999, written comm.). The granitoid could have been the source of the ore fluids; however, the strong stratigraphic control on the gold occurrences suggests that either the mafic rocks or volcanogenic exhalative chert, or both, were the source of the gold and that the granitoid acted as a heat source to mobilize gold-bearing fluids into the west-northwesterly trending fractures. Alternatively, these fault systems could be very young (e.g. Alice Springs Orogeny) and mineralization completely unrelated to the granite. As exploration continues in this area, more definitive evidence on the controls on mineralization may be revealed. Very little is known about the ore controls of the newly discovered Coyote deposit, but Glengarry Resources NL (1999b) regards the entire area between Coyote and the Larranganni area to be prospective, in addition to areas further west (e.g. around the Camel prospect).

Gold at the Venus prospect appears to have been localized in shears, saddle reefs, and veins related to the tight folding of the Killi Killi 'Beds'. As the mineralization is close to the unconformity between the Killi Killi 'Beds' and the Gardiner Sandstone of the Birrindudu Group, the unconformity may have played a role in the localization of the gold. Other shears and veins in the vicinity of the unconformity are worth exploring for gold (see also **Unconformity-related mineralization**, p. 57).

### Base metal — copper, lead, zinc (silver, gold, fluorite, barite)

In the Eastern zone of the Lamboo Complex, base metals are associated with many of the auriferous veins and, in these cases, would obviously have similar controls to the gold mineralization. The copper and zinc occurrences in the Saunders Creek and Sophie Downs areas are related to east-northeasterly and northerly trending faults. The copper may have been derived from primary copper in the Ding Dong Downs Volcanics or the Biscay Formation, whereas the zinc may have been derived from black shales in the Biscay Formation. The Mount Kinahan copper occurrences are in greywacke of the Olympio Formation along an east-northeasterly trending fault that cuts through Neoproterozoic sedimentary rocks of the Albert Edward Group. It is not known whether the mineralization was on a pre-existing fault, which was reactivated during the Neoproterozoic, or whether the mineralization is Neoproterozoic or younger in age (Sanders, 1999). The age and controls on coarse-grained galena and purple fluorite in a breccia zone within the Maude Headley Member at Ding Dong Downs (Pb–F) is also uncertain, with the breccia being interpreted by Fletcher (1981) as a breccia pipe but by Johnson (1981) as a tectonic breccia.

Although there are many base-metal vein occurrences in the Eastern zone, most are minor in extent and, to date, there is no evidence that any of them would be economic to work.

In the Central zone, copper-bearing quartz veins hosted by the Tickalara Metamorphics and the McHale Granodiorite at the Calico Spring prospect are related to a north-northeasterly trending splay off the Halls Creek Fault. Copper mineralization in shears in the Eastman Bore intrusion is possibly remobilized primary mineralization. Base metal mineralization associated with shear zones in tuffs of the Koongie Park Formation could be remobilized volcanogenic mineralization. Lead–barite mineralization at Boxers is possibly related to the Carr Boyd Fault.

In the Western zone, mineralization at Black and Glidden and Me No Savvy is hosted by the Amherst Metamorphics and related to the Lubbock Range and Glidden Fault system. The mineralized quartz veins are typically massive and probably mesothermal in origin (Sanders, 1999); however, at both of these localities there is also carbonate-rich Pb–Zn–Ag–F–Ba mineralization that Sanders (1999) has interpreted as being either closely related to the quartz vein mineralization (and of possible granitic origin) or as a later phase of mineralization that has followed pre-existing mineralized structures. The latter theory is favoured here because the faults post-date the granitoids. Epithermal copper mineralization in the Whitewater Volcanics is associated with the Greenvale Fault and other late faults.

In the Speewah Basin, Rogers (1998) has suggested that the mineralization is epithermal and related to caldera collapse and later movement of hydrothermal solutions along fractures (see section immediately below on fluorite). Rogers (1998) has also suggested that there could be vertical zonation, with various levels prospective for gold and base metals.

In the Kimberley Basin, copper mineralization at Campbellmerry is related to narrow shears parallel to major northwesterly trending faults in the Pentecost Sandstone (Harms, 1959).

In the Bastion Basin, minor veins of copper mineralization in siltstone of the Mendena Formation at Plants are possibly remobilized syngenetic sulfides.

In the Carr Boyd Basin, disseminated galena and lead oxides in silicified breccia zones within sandstone of the Golden Gate Siltstone at the Carr Boyd prospects may be related to splays of the Carr Boyd Fault.

In the Ord Basin at Brook Creek, minor veins with malachite in the Cambrian Headleys Limestone are probably related to the nearby west-northwesterly trending fault. The proximity of the mineralization to barite and fluorite veins suggests that the mineralization is epithermal.

In the Granites–Tanami Complex at Errol Bore, copper mineralization is related to an east-southeasterly trending fault in the Killi Killi 'Beds'.

### Industrial mineral — fluorite

In the Speewah Basin, fluorite veins in the Speewah Group and Hart Dolerite in the Speewah Valley area have epithermal textures and there is evidence of volcanic pyroclastic vent-like bodies (Rogers, 1998). Fluid-inclusion studies indicate that the veins have trapping temperatures of about 150 to 170°C (Rogers, 1998). Galena from fluorite veins has given model-lead ages between 15 and 131 Ma and direct Sm–Nd dating of the veins gave an age of 120 Ma (Rogers, 1998). If the age dating is correct, then this suggests a previously unrecognized mineralizing event. The fact that one fluorite vein cuts the Antrim Plateau Volcanics indicates that the mineralization is post-Cambrian (Rogers, 1998). A possible carbonatite dyke is associated with fluorite mineralization at West Ridge and may be genetically related to the mineralization (Alvin, 1993; Rogers, 1998). On the basis of aeromagnetic data and aerial photographs, Rogers (1998) identified circular and curvilinear structures inferred to be ring structures within the Speewah Dome. Rogers (1998) suggested that fractures related to caldera collapse and later faulting may have acted as pathways for hydrothermal fluids.

In the western zone of the Lamboo Complex, minor fluorite associated with uranium at the Frog prospect, in the Whitewater Volcanics, is probably epithermal in origin, as is the fluorite associated with brecciated cross-cutting quartz veins in felsic volcanic rocks of the Maude Headley Member at Ding Dong Downs (F) in the Eastern zone.

#### Industrial mineral — barite

Barite associated with some of the fluorite veins in the Speewah Basin would have the same ore controls as the fluorite (see above). The barite occurrence in the Mabel Downs Tonalite at Mabel Downs (Ba) in the Eastern zone of the Lamboo Complex is probably related to a fault parallel to the Halls Creek Fault.

#### Steel-industry metal — tungsten

Scheelite occurrences at Ruby Plains and Balara in the Eastern zone of the Lamboo Complex are possibly related to northwesterly trending faults. Other tungsten vein mineralization in the Eastern zone in the Berthas Butt, Taylor Lookout, and Mount Dockrell areas is associated with stratabound scheelite mineralization (see **Stratabound sedimentary mineralization**, p. 52) and has probably been remobilized from this style of mineralization.

#### Steel-industry metal — nickel

Nickel–copper mineralization on the faulted contact between the Springvale intrusion and the Airfield Granodiorite is probably remobilized primary sulfides.

#### Steel-industry metal — molybdenum

The nature of the rumoured molybdenite occurrence at Mabel Hill is not known, but it is worthy of follow-up.

#### Energy mineral — uranium

Uranium occurrences in the Western zone of the Lamboo Complex are localized along the Dunham Fault zone and other late faults in the Whitewater Volcanics.

#### Speciality metal — REE

At the John Galt prospect, xenotime mineralization in sandstone of the Red Rock Formation within the Red Rock Basin is probably related to the northeasterly trending fault that forms the eastern wall of the mesa on which the deposit is located. Xenotime from Browns Range Dome in the Archaean Lucas Craton is associated with vuggy quartz and hematite alteration in the Browns Range Metamorphics, but controls on mineralization are unknown.

### Unconformity-related mineralization

#### Energy mineral — uranium

The main control on the uranium deposits in the Gardiner Range area is the unconformable contact between the Killi Killi 'Beds' and the Gardiner Sandstone. Faults and the presence of carbonaceous shales within the Killi Killi 'Beds' probably also played a role in the localization of the deposits. Despite extensive exploration, no economic deposits have been discovered.

## Regolith mineralization

#### Precious metal — gold

Alluvial and eluvial gold have been worked since 1885. They continue to provide an attractive target for small companies and individual metal detector operators, but tonnages are typically too low to be of interest to major companies.

#### Precious mineral — diamond

Gem-quality diamonds in present day and palaeodrainage channels draining the Argyle AK1 pipe will continue to be a high-priority exploration target. Alluvial diamonds elsewhere in the area are significant because they suggest that there are other sources of primary diamonds that have not yet been located.

#### Steel-industry metal — nickel

Lateritic nickel occurrences associated with the Lamboo intrusion, and possibly other ultramafic intrusions in the Lamboo Complex, may become exploration targets now that the technology for treating lateritic ore has been developed.

#### Other commodities — tin, tantalum, scheelite, heavy minerals

Minor occurrences of alluvial tin, tantalum, niobium, scheelite, and heavy minerals have been reported from the study area. None of these have yet been proved to be economic, but they are a useful indicator to primary mineralization in the area.

# Conclusion

The east Kimberley region hosts a wide range of mineral commodities with a variety of styles. The Argyle AK1 mine is the World's largest diamond mine and the Kapok mine is part of Western Australia's second-largest zinc-producing project (Western Metals' Lennard Shelf project). Significant deposits of base metals, gold, PGE, nickel, REE, niobium, tantalum, tin, and fluorite have also been discovered. The mineralization shows a very strong

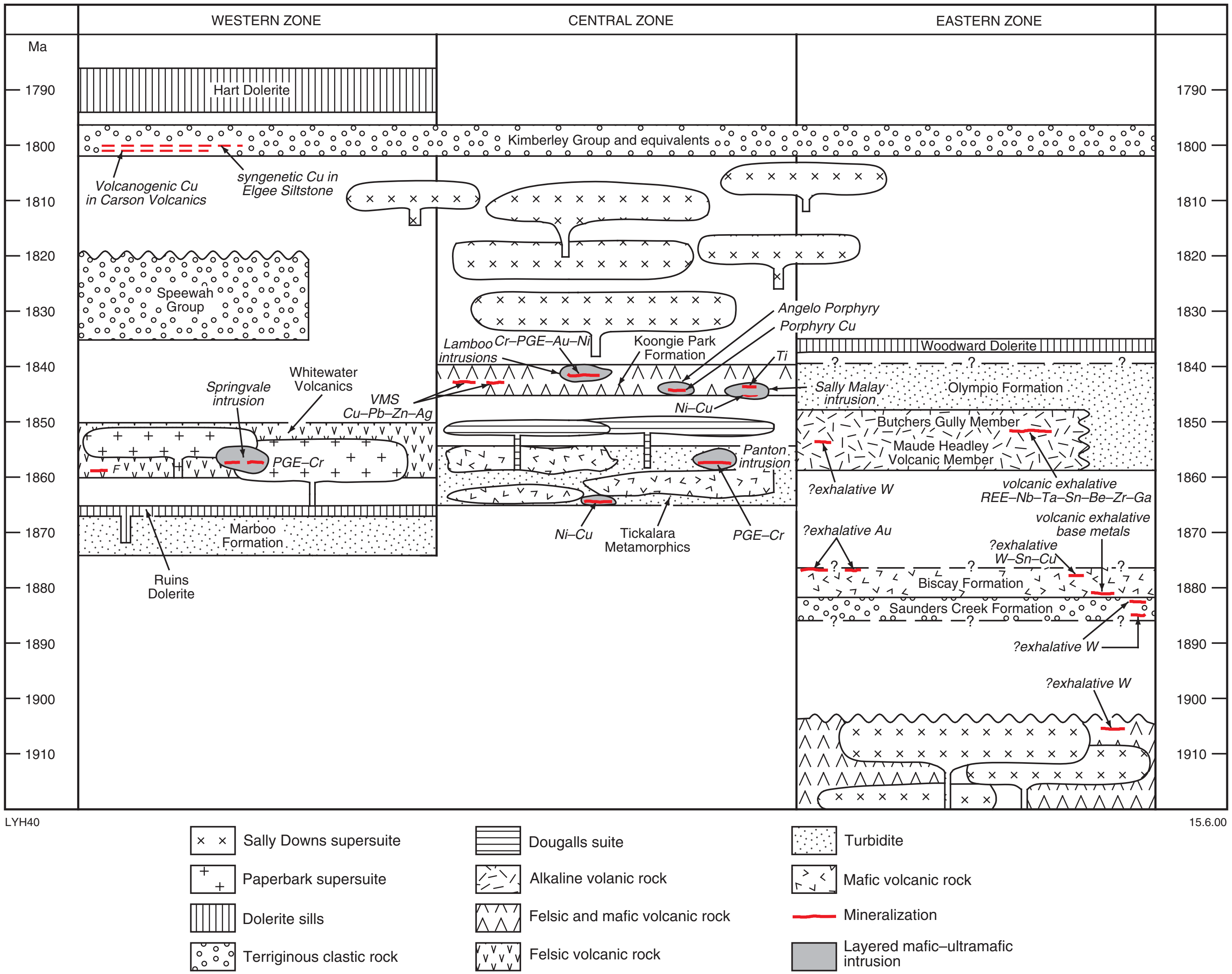



**Figure 21. Time–space plot for the three zones of the Lamboo Complex (from Figure 2, this Report) showing mineralization**

relationship to the stratigraphic and tectonic development of the area. This relationship should be a useful tool in future exploration of the area.

In the Palaeoproterozoic Lamboo Complex, where many of the occurrences are sited, different types of mineralization occur in the Eastern, Central, and Western zones (Fig. 21).

Most gold occurrences are in the Eastern zone of the Lamboo Complex. Nearly half the gold occurrences in the east Kimberley are in the Biscay Formation, with significant numbers in the Butchers Gully Member and in the Olympio Formation close to its contact with the Biscay Formation. Most of these occurrences are situated on northeasterly trending faults, but these faults are typically barren away from the contact between the Biscay and Olympio Formations. The Biscay Formation, and possibly the Butchers Gully Member, probably contained significant amounts of volcanic-exhalative gold that was later mobilized along the northeasterly trending shears, probably during the Alice Springs Orogeny. Although historical production of gold in the east Kimberley is quite low, a significant amount of gold probably went unrecorded and most of the workings were very shallow. The fact that the open-pit mine at Palm Springs produced 2272 kg gold in its two years of operation, which is more than twice the historical (pre-1964) gold production for the east Kimberley, indicates that there is potential for other old workings to be mined by opencut techniques.

Alkaline volcanic rocks of the Butchers Gully Member in the Eastern zone also host the large Brockman REE–Nb–Ta–Sn–Be–Zr–Ga deposit. This deposit remains undeveloped but is a significant resource. Anomalous niobium values have also been reported from felsic volcanic rocks in the Maude Headley Member and Biscay Formation indicating that these units are also prospective for this unusual style of volcanogenic deposit.

Epidote quartzites in the Ding Dong Downs Volcanics and Saunders Creek Formation host stratabound tungsten mineralization in the Berthas Butt area. Stratabound tungsten is also hosted by epidote quartzites and tourmalinites of the ?Butchers Gully Member in the North Dockrell area and by calc-silicate rocks within the Biscay Formation in the Taylor Lookout area. This mineralization is interpreted here to be volcanic exhalative in origin. Although the known occurrences are subeconomic, there is potential for a world-class tungsten deposit to be found. The Biscay Formation is also prospective for volcanic exhalative base-metal mineralization: examples include Ilmars and Little Mount Isa.

In the Central zone of the Lamboo Complex, the Koongie Park Formation hosts massive-sulfide mineralization that is probably remobilized VMS-style mineralization. Resources of copper, lead, zinc, and silver have been defined at Sandiego and Onedin in the Koongie Park area and at Mount Angelo North indicating that the Koongie Park Formation is highly prospective. A large low-grade copper deposit of possible porphyry-copper style mineralization has been defined at Mount Angelo Porphyry in the Angelo Microgranite. In addition, the McHales Granodiorite also contains possible porphyry copper mineralization.

Platinum group element – chromium mineralization in the Central zone is hosted by the c. 1855 Ma Panton intrusions, and also by the younger Lamboo and Eastman Bore intrusions. Nickel–copper mineralization is at the base of the c. 1845 Ma Sally Malay layered intrusions and includes the significant Sally Malay deposit. Metamorphosed layered mafic intrusions within the Tickalara Metamorphics also host significant nickel–copper mineralization. No significant mineralization has yet been found in the c. 1830 Ma McIntosh intrusion, but because of its large size, it has potential to host vanadiferous magnetite or ilmenite deposits.

In the Western zone, minor PGE–chromium mineralization is hosted by the c. 1855 Ma Springvale intrusions. Minor epithermal gold and fluorite mineralization is also hosted by the Whitewater Volcanics in the Western zone.

The major faults that define the boundaries of the three zones in the Lamboo Complex are deep crustal structures that have moved intermittently from the Palaeoproterozoic to the Phanerozoic, and thus have significant potential to host kimberlitic and lamproitic diamond deposits and carbonatites. The Argyle AK1 lamproite, the largest diamond mine in the world, is located on a splay of the Halls Creek Fault, which defines the boundary between the Eastern zone and the Central zone. The Cummins Range Carbonatite may also be related to the Halls Creek Fault.

The recent discoveries of gold at the Coyote prospect and in the Larranganni area demonstrate that the Western Australian portion of the Granites–Tanami Complex is as prospective as the Granites – Callie – Dead Bullock Soak area in the Northern Territory.

Younger sedimentary basins also host significant mineralization. Mississippi Valley-type base metal mineralization is being mined at Kapok (part of Western Metals' Lennard Shelf project) in the Canning Basin, and the large number of occurrences of this type confirms the potential of the Devonian reef limestones for this type of deposit. Possible Mississippi Valley-type mineralization is also present in the Bungle Bungle Dolomite in the Osmond Basin. The Speewah Basin contains significant epithermal fluorite and base metal mineralization, which is possibly related to caldera collapse during the Cretaceous (Rogers, 1998). The Carson Volcanics in the Palaeoproterozoic Kimberley Basin hosts copper mineralization of possible volcanic-exhalative origin. Stromatolitic dolomites of the Teronis Member of the Elgee Siltstone, and shale at the base of the Middle Pentecost Sandstone in the Kimberley Basin, host subeconomic copper mineralization. Basalts of the Cambrian Antrim Plateau Volcanics have potential for Michigan-style copper mineralization, and also for ornamental stones such as prehnite and agate.

# References

ACACIA RESOURCES LIMITED, 1999, Quarterly report to the Australian Stock Exchange for the quarter ended 30 September 1999 (unpublished).

ALVIN, M. P., 1993, The nature, depositional conditions, and source of ore fluids and solutes of the Speewah fluorite deposit, East Kimberley region, Western Australia: University of Western Australia, Department of Geology, BSc Honours thesis (unpublished).

ANDERSON, J. C. Ø., RASMUSSEN, H., NIELSEN, T. F. D., and RØNSBO, J. G., 1998, The Triple Group and the Platinova gold and palladium reefs in the Skaergaard Intrusion: stratigraphic and petrographic relations: Economic Geology, v. 93, p. 488–509.

ANDREW, R. L., 1990, Cummins Range carbonatite, *in* Geology of the mineral deposits of Australia and Papua New Guinea, Volume 1 *edited by* F. E. HUGHES: Australasian Institute of Mining and Metallurgy, Monograph 14, p. 711–713.

ASHTON MINING LIMITED, 2000, Annual report to the Australian Stock Exchange for 1999 (unpublished).

AUSTRALIAN ANGLO AMERICAN LIMITED, 1971, Annual report 1971 — an assessment of the Kimberley Group as a copper province including work done by Australian Anglo American Limited on Temporary Reserves 5001H, 5013H and 5297H: Western Australia Geological Survey, M-series, A2381 (unpublished).

AUSTRALIAN ANGLO AMERICAN LIMITED, 1973, Halls Creek project — results of exploration of mineral claims during 1973: Western Australia Geological Survey, M-series, A5210 (unpublished).

BALL, A. J., 1966, Discovery Yard copper anomaly, Kimberley region, Western Australia; Pickands Mather and Company International: Western Australia Geological Survey, M-series, A466 (unpublished).

BARBER, T. St J., 1971, Geological reconnaissance south of Halls Creek; Pickands Mather and Company International: Western Australia Geological Survey, M-series, A761 (unpublished).

BARNES, G. B., 1985a, Mt Bradley annual report — prospecting licences 80/151–80/154 — 17th November, 1983 to 31st December, 1984; Interwest Limited and Asian West Coast Finance Limited: Western Australia Geological Survey, M-series, A14853 (unpublished).

BARNES, G. B., 1985b, Christmas Creek annual report for September 1983 to 17 November 1984 — prospecting licences 80/162–165; M. H. Ynema: Western Australia Geological Survey, M-series, A14856 (unpublished).

BARRETT, F. M., 1982, Annual report 1981 — Eastman Bore; Inco Australia Limited: Western Australia Geological Survey, M-series, A11116 (unpublished).

BEARD, J. S., 1979, The vegetation of the Kimberley area: Vegetation Survey of Western Australia, 1:1 000 000 Vegetation Series, Explanatory Notes to Sheet 1: Perth, University of Western Australia Press, 118p.

BESTER, G., 1999, Register of Australian Mining 1998–1999: Perth, Western Australia, Resource Information Unit, 652p.

BETTS, D., 1976, Progress report on Mount Ramsay Three; Kennecott Explorations (Australia) Limited: Western Australia Geological Survey, M-series, A7197 (unpublished).

BIANCONI, F., 1973, Detailed investigations on projects: K1 — Horse, K2 — Ten Minutes, K3 — Spinifex; Metals Miniere Exploration Proprietary Limited, Uranerz Australia Proprietary Limited, Uranerzbergbau GMBH and Company: Western Australia Geological Survey, M-series, A6119 (unpublished).

BLAIN, C. F., 1969, Geology and mineralisation of the Mt Angelo copper occurrence, East Kimberley region, Western Australia: London, Imperial College, MSc thesis (unpublished).

BLAKE, D. H., 1996a, Gordon Downs, W. A. Sheet 4660 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

BLAKE, D. H., 1996b, How ancient is the Bungle Bungle Range of the East Kimberley, Western Australia?: Australian Geological Survey Organisation, Research Newsletter, v. 24, p. 4–6.

BLAKE, D. H., GRIFFIN, T. J., TYLER, I. M., THORNE, A. M., and WARREN, R. G., 1999a, Halls Creek, W.A. Sheet 4461: Australian Geological Survey Organisation, 1:100 000 Geological Series.

BLAKE, D. H., PASSMORE, V. L., and MUHLING, P. C., 1977, Billiluna, W.A.: Australia BMR, 1:250 000 Geological Series Explanatory Notes, 28p.

BLAKE, D. H., TYLER, I. M., GRIFFIN, T. J., SHEPPARD, S., THORNE, A. M., and WARREN, R. G., 1999b, Geology of the Halls Creek 1:100 000 sheet area (4461), Western Australia: Australian Geological Survey Organisation, 36p.

BLAKE, D. H., TYLER, I. M., and SHEPPARD, S., 1997, Geology of the Ruby Plains 1:100 000 sheet area (4460), Western Australia: Australian Geological Survey Organisation, 15p.

BLAKE, D. H., and WARREN, R. G., 1996, Antrim, W.A. Sheet 4561 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

BLATCHFORD, T., 1928, Geological observations made while travelling in West Kimberley up the valleys lying between the Pentecost and King Rivers, then eastwards across the Durham and Ord Rivers as far as the Argyle Station and Behn River: Western Australia Geological Survey, Annual Report 1927, p. 10–15.

BLIGHT, D. F., 1983, Report on the diamond drilling programme at the Berthas Butt prospect, east Kimberley region, Western Australia; Union Oil Development Corporation: Western Australia Geological Survey, M-series, A12508 (unpublished).

BLOCKLEY, J. G., 1971, The lead, zinc and silver deposits of Western Australia: Western Australia Geological Survey, Mineral Resources Bulletin 9, 234p.

BOXER, G. L., LORENZ, V., and SMITH, C. B., 1989, The geology and volcanology of the Argyle (AK1) lamproite diatreme, Western Australia, *in* Kimberlites and related rocks, Volume 1 — their composition, occurrence, origin and emplacement *edited by* J. ROSS: Geological Society of Australia, Special Publication, no. 14, p. 140–152.

BOXER, G. L., and JAQUES, A. L., 1990, Argyle (AK1) diamond deposit, *in* Geology of the mineral deposits of Australia and Papua

New Guinea *edited by* F. E. HUGHES: Australasian Institute of Mining and Metallurgy, Monograph 14, p. 697–706.

BROWN, G. A., 1973, Pompey's Pillar iron ore deposits; Planet Management and Research Proprietary Limited: Western Australia Geological Survey, M-series, A1445 (unpublished).

BROWN, R., 1992, Argyle dykes; Moonstone Mines NL: Western Australia Geological Survey, M-series, A37444 (unpublished).

BRUINSMA, J. W., 1970, Petrology, environment of deposition and mineralization of the Teronis Member – Elgee Siltstone Formation – Chamberlain Valley – Durack Range, W.A.; Planet Management and Research Proprietary Limited: Western Australia Geological Survey, M-series, A1487 (unpublished).

BUCKOVIC, W. A., BESLEY, R. E., and WILLET, G. C., 1982, Bertha's Butt project, east Kimberley region, W.A.; Union Oil Development Corporation: Western Australia Geological Survey, M-series, A11172 (unpublished).

CAMPANA, B., 1973, John Galt xenotime project — report on the 1973 detailed investigations; Mascot Mining Proprietary Limited: Western Australia Geological Survey, M-series, A6339 (unpublished).

CAMPANA, B., COCQUIO, D. S., CAVALLI, D., GATZWEILER, R., BIANCONI, F., and LA MELA, V., 1973, The 1972 uranium–rare earths search in the Kimberley Goldfield, Western Australia; Metals Miniere Exploration Proprietary Limited, Uranerz Australia Proprietary Limited, Uranerzbergbau GMBH and Company: Western Australia Geological Survey, M-series, A3615 (unpublished).

CHADWICK, R. C., 1984, Palm Well Exploration Licence E80/81 — annual and final exploration report; West Coast Holdings Limited: Western Australia Geological Survey, M-series, A13767 (unpublished).

CHADWICK, R. C., 1985, Alice Downs report — Exploration Licence E80/112 — annual and final exploration report; West Coast Holdings Limited: Western Australia Geological Survey, M-series, A14812 (unpublished).

CHADWICK, R. C., 1986, Lamboo prospect — annual exploration report; West Coast Holdings Limited: Western Australia Geological Survey, M-series, A18596 (unpublished).

CHALMERS, D. I., 1990, Brockman multi-metal and rare earth deposit, *in* Geology of the mineral deposits of Australia and Papua New Guinea *edited by* F. E. HUGHES: Australasian Institute of Mining and Metallurgy, Monograph 14, p. 707.

CLARKE, A. B., and BLOCKLEY, J. G., 1961, A report on a geological reconnaissance, Billiluna area (Temporary Reserve 1784H), Kimberley Goldfield, Western Australia; New Consolidated Gold Fields (Australasia) Proprietary Limited: Western Australia Geological Survey, M-series, A1982 (unpublished).

CLEMENT, C., and BRIDGE, P., (editors), 1991, Kimberley Scenes: Perth, Western Australia, Hesperian Press, 294p.

CODNER, C. C., 1973, Halls Creek project — results of exploration of mineral claims; Australian Anglo American Limited: Western Australia Geological Survey, M-series, A3660 (unpublished).

CORKERON, M., GREY, K., LI, Z. X., and POWELL, C. McA., 1996, Neoproterozoic glacial episodes in the Kimberley region, northwestern Australia: Geological Society of Australia, Abstracts, v. 41, p. 97.

DALE, G. R., 1976, Summary report — Donkey Creek (Dunham River) uranium prospect — Kimberley Goldfield Western Australia: Western Australia Geological Survey, M-series, A6824 (unpublished).

DAM GOLD NL, 1997, Summary exploration E80/1290–E80/1355: Western Australia Geological Survey, M-series, A39239 (unpublished).

DAVIES, H., 1990, Photogeology of the Barramundi Range tenements (E80/1338 to E80/1340); Bulletin Trading Limited: Western Australia Geological Survey, M-series, A37941 (unpublished).

de ANGELIS, M., 1983, Osmond Range project — progress report for 1982; Samin Australia Proprietary Limited: Western Australia Geological Survey, M-series, A12301 (unpublished).

de ANGELIS, M., 1984, Osmond Range project — progress report for 1983; Samin Australia Proprietary Limited: Western Australia Geological Survey, M-series, A13233 (unpublished).

de HAVELLAND, D. W., 1986, Gold and ghosts — a prospectors guide to metal detecting in Australia and history of the Australian gold fields. Volume 2 — Western Australia: Perth, Western Australia, Hesperian Press, 382p.

DEPARTMENT OF MINERALS AND ENERGY, 1995, Guidelines for the application of environmental conditions for onshore mineral exploration and development on conservation reserves and other environmentally sensitive land in Western Australia: Department of Minerals and Energy, Western Australia, Information Series No. 11, 32p.

DEPARTMENT OF RESOURCES DEVELOPMENT and DEPARTMENT OF MINERALS AND ENERGY, 1997, Regional Mineral Prospectivity Study — The Kimberley Region: Department of Resources Development, Western Australia, 95p.

DOUST, G., 1997, The Kookaburra discovery — a paradox or appointment? *in* New generation gold mines '97 — case histories of discovery: Australian Mineral Foundation, p. 10.1–10.11.

DOW, D. B., and GEMUTS, I., 1967, Dixon Range, W.A.: Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes, 15p.

DOW, D. B., and GEMUTS, I., 1969, Geology of the Kimberley region, Western Australia — The East Kimberley: Western Australia Geological Survey, Bulletin 120, 135p.

DOW, D. B., GEMUTS, I., PLUMB, K. A., and DUNNET, D., 1964, The geology of the Ord River region, Western Australia: Australia BMR, Record 1964/104 (unpublished).

DUNDAS GOLD CORPORATION NL, 1984, Report on operations, Mt Bannerman – Cummins Range, Exploration Licence 80/117, 30/07/83–30/07/84: Western Australia Geological Survey, M-series, A14239 (unpublished).

EL-ANSARY, M., 1971, Geological report — Ord Crossing area, Tickalara Bore area; Pickands Mather and Company International: Western Australia Geological Survey, M-series, A711 (unpublished).

ERSKINE, J., FIDLER, R., and GOSLING, T., 1970, Antrim copper project, joint venture, progress report no. 2; Metals Exploration NL, Freeport of Australia Incorporated, and Anglo American Corporation (Australia) Limited: Western Australia Geological Survey, M-series, A1709 (unpublished).

EUPENE, G. S., 1983, An assessment of the Philip tenements, Mary River Goldfield, Halls Creek, W.A.; Mr J. Martin: Western Australia Geological Survey, M-series, A12949 (unpublished).

FERGUSON, K. M., 1999, Lead, zinc, and silver deposits of Western Australia: Western Australia Geological Survey, Mineral Resources Bulletin 15, 314p.

FIELDING, D., 1983, Final report on mineral claims 80/5359–5388 Maude Creek and 80/5333–5358 Devils Elbow Lissadell, Western Australia; CRA Exploration Proprietary Limited: Western Australia Geological Survey, M-series, A11800 (unpublished).

FINUCANE, K. J., 1938a, The Mount Dockerell gold mining centre, East Kimberley District: Aerial, Geological and Geophysical Survey of Northern Australia, Western Australia Report 29, 6p.

FINUCANE, K. J., 1938b, Tin–columbite deposits southeast of Mount Dockerell, East Kimberley district: Aerial, Geological and Geophysical Survey of Northern Australia, Western Australia Report 30, 4p.

FINUCANE, K. J., 1939a, The Grants Creek gold mining centre, East Kimberley District: Aerial, Geological and Geophysical Survey of Northern Australia, Western Australia Report 40, 8p.

FINUCANE, K. J., 1939b, The Halls Creek – Ruby Creek area, East Kimberley district: Aerial, Geological and Geophysical Survey of Northern Australia, Western Australia Report 27, 13p.

FINUCANE, K. J., and SULLIVAN, C. J., 1939, The Mary River gold mining centre, East Kimberley District: Aerial, Geological and Geophysical Survey of Northern Australia, Western Australia Report 41, 2p.

FITTON, A., 1981, Annual report for 1980 on mineral claims 80/8382–6401, 80/6451–6462, Cummins Range, Mt Bannerman, Western Australia; CRA Exploration Proprietary Limited: Western Australia Geological Survey, M-series, A10497 (unpublished).

FLETCHER, R. J., 1981, Ding Dong Downs mineral claims — East Kimberley goldfield, Western Australia — progress report 1980; Carpentaria Exploration Company Proprietary Limited: Western Australia Geological Survey, M-series, A10282 (unpublished).

FRASER, R. B., 1955, Report on investigation of radioactive anomalies — Halls Creek area, W.A.; Rio Tinto Finance and Exploration Limited: Western Australia Geological Survey, M-series, A2029 (unpublished).

FRASER, W. J., and DOE, A. R. D., 1975, Final report on Temporary Reserve 5950H, Shiddi Creek, Western Australia: Western Australia Geological Survey, M-series, A2029 (unpublished).

GELLATLY, D. C., DERRICK, G. M., and PLUMB, K. A., 1970, Proterozoic palaeocurrent directions in the Kimberley Region, Northwestern Australia: Geological Magazine, v. 3, p. 249–257.

GEMUTS, I., 1963, Preliminary report on copper mineralization in the Duffers Limestone, near Halls Creek, Kimberley Goldfield: Western Australia Geological Survey, Record 1963/28, 7p.

GEMUTS, I., 1971, Metamorphic and igneous rocks of the Lamboo Complex, East Kimberley Region, Western Australia: Australia BMR, Bulletin 107, 71p.

GEMUTS, I., and SMITH, J. W., 1968, Gordon Downs, W.A.: Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes, 23p.

GLENGARRY RESOURCES NL, 1996, Kookaburra gold deposit — resource estimate: announcement to Australian Stock Exchange, 12/11/1996 (unpublished).

GLENGARRY RESOURCES NL, 1998, Quarterly report to Australian Stock Exchange for the quarter ended 31 March 1998 (unpublished).

GLENGARRY RESOURCES NL, 1999a, Larranganni project drilling results: Media release, 27/05/1999 (unpublished).

GLENGARRY RESOURCES NL, 1999b, Quarterly report to Australian Stock Exchange for the quarter ended 30 September 1999 (unpublished).

GOLDNER, P. T., 1984, Report on the Mount Dockrell prospect (MC's 80/8035 to 8046, 80/9469 and 80/11057 to 11059) — Halls Creek district, East Kimberley province, Western Australia: Western Australia Geological Survey, M-series, A13684 (unpublished).

GOODEVE, P. E., 1955, Airborne scintillometer survey Halls Creek – Wyndham region, Western Australia, June–September, 1954: Australia BMR, Record 1955/108, 2p.

GREY, K., 1990, Birrindudu Basin, *in* Geology and mineral resources of Western Australia: Western Australia Geological Survey, Memoir 3, p. 349–362.

GREY, K., and GRIFFIN, T. J., 1990, Local sedimentary successions related to the orogens, *in* Geology and mineral resources of Western Australia: Western Australia Geological Survey, Memoir 3, p. 249–252.

GRIFFIN, T. J., and GREY, K., 1990a, King Leopold and Halls Creek Orogens, *in* Geology and mineral resources of Western Australia: Western Australia Geological Survey, Memoir 3, p. 232–255.

GRIFFIN, T. J., and GREY, K., 1990b, Kimberley Basin, *in* Geology and mineral resources of Western Australia: Western Australia Geological Survey, Memoir 3, p. 293–304.

GRIFFIN, T. J., and MYERS, J. S., 1988, Geological Note: A Proterozoic terrane boundary in the King Leopold Orogen, Western Australia: Australian Journal of Earth Sciences, v. 35, p. 131–132.

GRIFFIN, T. J., PAGE, R. W., TYLER, I. M., and SHEPPARD, S., in press, Tectonic implications of Palaeoproterozoic post-collisional, high-K felsic igneous rocks from the Kimberley region of northwestern Australia: Precambrian Research.

GRIFFIN, T. J., and TYLER, I. M., 1992, Geology of the southern Halls Creek Orogen — a summary of field work in 1992: Western Australia Geological Survey, Record 1992/17, 28p.

GRIFFIN, T. J., TYLER, I. M., ORTH, K., and SHEPPARD, S., 1998, Geology of the Angelo 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 27p.

GRIFFIN, T. J., TYLER, I. M., and PLAYFORD, P. E., 1993, Lennard River W.A. (3rd edition): Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes, 56p.

HANCOCK, S. L., 1991, Tectonic development of the Lower Proterozoic basement in the Kimberley district of northwestern Australia: University of Adelaide, PhD thesis (unpublished).

HANCOCK, S. L., and RUTLAND, R. W. R., 1984, Tectonics of an early Proterozoic geosuture — the Halls Creek orogenic sub-province, northern Australia: Journal of Geodynamics, v. 1, p. 387–432.

HARDER, G. C., 1983, Relinquishment report to the W.A. Department of Mines for the Osmond Valley E.L. 80/73; Minatome Australia Proprietary Limited: Western Australia Geological Survey, M-series, A12533 (unpublished).

HARDMAN, E. T., 1885, Report on the geology of the Kimberley District, Western Australia: Western Australia Parliamentary Paper, no. 34, 38p.

HARMS, J. E., 1959, The geology of the Kimberley Division, Western Australia, and of an adjacent area of the Northern Territory: University of Adelaide, MSc thesis (unpublished).

HARRIS, J., 1967, Gentle Annie Creek area — final report 1966; Pickands Mather and Company International: Western Australia Geological Survey, M-series, A475 (unpublished).

HARROP, D. W., 1977, Final report on TR 6337H (Bow Hill) — Kimberley goldfield — 1977 campaign; Minatome Australia Proprietary Limited: Western Australia Geological Survey, M-series, A7262 (unpublished).

HAWLEY, D. L., 1970, Annual report Temporary Reserve $5001^{H}$ — Durack Range, Western Australia; Planet Mining Company: Western Australia Geological Survey, M-series, A25 (unpublished).

HENDRICKX, M., VANDENBERG, L., CRISPE, A., SLATER, K., DEAN, A., WYGRALAK, A., and SMITH, J., 2000, Palaeoproterozoic stratigraphy and correlations of the Tanami Region, Northern Territory — preliminary results, *in* Annual geoscience exploration seminar (AGES), Darwin, 21 March 2000: record of abstracts: Northern Territory Geological Survey, Geological Survey Record GS2000-0010.

HOATSON, D. M., 1995, New mineral discoveries in the East Kimberley: Australian Geological Survey Organisation, Research Newsletter 22, p. 9–11.

HOATSON, D. M., 1997, Geology and mineralisation of the Palaeoproterozoic layered mafic–ultramafic intrusions in the Halls Creek Orogen, Western Australia: Australian Geological Survey Organisation, Record 1997/44, p. 61–64.

HOATSON, D. M., in press, Mineralisation and economic potential of the Palaeoproterozoic layered mafic–ultramafic intrusions *in* Geology and economic potential of the Palaeoproterozoic layered mafic–ultramafic intrusions in the East Kimberley, Western Australia *edited by* D. M. HOATSON and D. H. BLAKE: Australian Geological Survey Organisation, Bulletin 246.

HOATSON, D. M., and BLAKE, D. H., in press, Geology and economic potential of the Palaeoproterozoic layered mafic–ultramafic intrusions in the East Kimberley, Western Australia: Australian Geological Survey Organisation, Bulletin 246.

HOCKING, R. M., and PLAYFORD, P. E., 1998a, Pillara Range – Emanuel Range – Sparke Range area (1:100 000), *in* Devonian reef complexes of the Canning Basin *by* P. E. PLAYFORD (in prep.): Western Australia Geological Survey, Bulletin 145, Plate 4.

HOCKING, R. M., and PLAYFORD, P. E., 1998b, Fossil Downs area (1:100 000), *in* Devonian reef complexes of the Canning Basin *by* P. E. PLAYFORD (in prep.): Western Australia Geological Survey, Bulletin 145, Plate 3.

HOYLE, M. W., 1976, Halls Creek north regional — annual report — January 1976 — Tickalara prospect, Marty prospect, Springvale prospect; Australian Anglo American Limited: Western Australia Geological Survey, M-series, A6371 (unpublished).

HUNTER RESOURCES LIMITED, 1991, Jailhouse Creek — E80/1116 — annual report for 1990; Hunter Resources Limited: Western Australia Geological Survey, M-series, A32294 (unpublished).

JAQUES, A. L., LEWIS, J. D., and SMITH, C. B., 1986, The kimberlites and lamproites of Western Australia: Western Australia Geological Survey, Bulletin 132, 268p.

JOHNSON, G., 1981, Ding Dong Downs Project, East Kimberley Goldfield, Western Australia; Carpentaria Exploration Company Proprietary Limited: Western Australia Geological Survey, M-series, A10452 (unpublished).

JONES, F. H., 1938, The Mount Amherst gold and silver–lead deposits, East Kimberley District: Aerial, Geological and Geophysical Survey of Northern Australia, Western Australia Report 31, 4p.

KINNANE, N. R., 1983, Annual report, G.M.L.'s Mt Dockrell area — Kimberley region — North Western Australia; Arcadia Minerals Limited: Western Australia Geological Survey, M-series, A12791 (unpublished).

LAPORTE, B. P., 1981, Birrindudu project — 1981 exploration report; Mineral Reserves group, Incorporated: Western Australia Geological Survey, M-series, A10777 (unpublished).

LEMCKE, D. J., 1981, Spring Complex — interim report; Australian Anglo American Limited: Western Australia Geological Survey, M-series, A15543 (unpublished).

LEWIS, P. G., 1966, Final report, Bow River copper–nickel prospect, Kimberley region; Pickands Mather and Company International: Western Australia Geological Survey, M-series, A4684 (unpublished).

LEWIS, P. G., 1968, Report on the Louisa Downs Serpentinite and nearby mineral occurrences, Kimberley region; Pickands Mather and Company International: Western Australia Geological Survey, M-series, A500 (unpublished).

McINTYRE, G. A., 1981, Osmond Range project — progress report for 1981; Carpentaria Exploration Company Proprietary Limited: Western Australia Geological Survey, M-series, A10769 (unpublished).

MATHESON, S. R., 1996, Copper Flats — OHT prospect; Halls Creek Minerals NL and Mr H. G. Shulda: Western Australia Geological Survey, M-series, A49870 (unpublished).

MAZZONI, P., 1976, Alice Downs — Mineral Claims 80/4892–80/4907, 80/4937–80/4945 — Annual Report; Western Mining Corporation Limited: Western Australia Geological Survey, M-series, A6672 (unpublished).

MAZZONI, P., 1979, Annual report, McClintock Temporary Reserve 6698H, 2 June 1978 to 1 June 1979; Western Mining Corporation Limited: Western Australia Geological Survey, M-series, A8433 (unpublished).

MENZIES, J., and ROSS, D., 1982, Morgans Grave report; Amax Australia Limited: Western Australia Geological Survey, M-series, A11618 (unpublished).

MORY, A. J., and BEERE, G. M., 1988, Geology of the onshore Bonaparte and Ord Basins: Western Australia Geological Survey, Bulletin 134, 184p.

MULLUMBY, B. G., 1986, Report on Darcy's prospect — Halls Creek area — Kimberley Mineral Field — Western Australia: C. E. DEVENISH and J. R. DEVENISH: Western Australia Geological Survey, M-series, A19785 (unpublished).

MULLUMBY, B. G., 1989, Summary report — testing of the Moola Bulla gold prospect — GML 80/151, P80/982, P80/983 — Kimberley Mineral Field — Western Australia; Auridium NL: Western Australia Geological Survey, M-series, A28272 (unpublished).

MULLUMBY, B. G., 1994, Annual report 11/2/93–10/2/94 — exploration licence E80/1479 — Flora Valley Station — Kimberley Mineral Field — Western Australia; Auridium NL: Western Australia Geological Survey, M-series, A41749 (unpublished).

MYERS, J. S., SHAW, R. D., and TYLER, I. M., 1996, Tectonic evolution of Proterozoic Australia: Tectonics, v. 15, p. 1431–1446.

NALDRETT, A. J., KEATS, H., SPARKES, K., and MOORE, R., 1996, Geology of the Voisey's Bay Ni-Cu-Co deposit, Labrador, Canada: Exploration and Mining Geology, v. 5, p. 169–179.

ORTH, K., 1997, Notes on the geology of the Koongie Park Formation southwest of Halls Creek, Western Australia: Australian Geological Survey Organisation, Record 1997/25, 18p.

O'SHEA, P. D., 1987, Annual report for EL 80/464 — Lamboo – Loadstone Hill project, 1986; Hunter Resources Limited: Western Australia Geological Survey, M-series, A19546 (unpublished).

OWEN, D. E., 1970, Depositional environment of the Teronis Member of the Elgee Siltstone, Chamberlain River Valley, Kimberley area, Western Australia; Planet Management and Research Proprietary Limited: Western Australia Geological Survey, M-series, A729 (unpublished).

PAGE, R. D., BLAKE, D. H., SUN, S. S., TYLER, I. M., GRIFFIN, T. J., and THORNE, A. M., 1994, New geological and geochronological constraints on volcanogenic massive sulphide prospectivity near Halls Creek (W.A.): Australian Geological Survey Organisation, Research Newsletter 20, p. 5–7.

PAGE, R. W., and HANCOCK, S. L., 1988, Geochronology of a rapid 1.85–1.86 Ga tectonic transition — Halls Creek Orogen, northern Australia: Precambrian Research, v. 40, p. 447–467.

PAGE, R. W., and SUN, S. S., 1994, Evolution of the Kimberley Region, W.A., and adjacent Proterozoic inliers — new geochronological constraints: Geological Society of Australia, Abstracts, no. 37, p. 332–333.

PAGE, R. W., SUN, S. S., and BLAKE, D. H., 1995, Geochronology of an exposed late Archaean basement terrane in the Granites–Tanami region: Australian Geological Survey Organisation, Research Newsletter 22, p. 19–20.

PEARCEY, D., KEPERT, D., and ROTHCHILD, F., 1988, The Granites–Tanami project — 1988 field season report; PNC Exploration (Australia) Proprietary Limited: Western Australian Geological Survey, M-series, A25982 (unpublished).

PERRING, R. J., and VOGT, J. H., 1991, The Panton Sill, *in* Mafic–Ultramafic Complexes of Western Australia: Guidebook for the post-symposium field excursion *edited by* S. J. BARNES and R. E. T. HILL: 6th International Platinum Symposium, Perth, Excursion guidebook no. 3, p. 97–106.

PICKANDS MATHER AND COMPANY INTERNATIONAL, 1965, New Lamboo copper nickel anomaly: Western Australian Geological Survey, M-series, A448 (unpublished).

PICKANDS MATHER AND COMPANY INTERNATIONAL, 1966, Final Report Carr Boyd Range lead anomaly — Western Australia: Western Australian Geological Survey, M-series, A463 (unpublished).

PICKANDS MATHER AND COMPANY INTERNATIONAL, 1967a, Annual report to the Government — Kimberley Temporary Reserves 2686H & 2687H: Western Australian Geological Survey, M-series, A472 (unpublished).

PICKANDS MATHER AND COMPANY INTERNATIONAL, 1967b, Diamond drilling results at Mt Angelo: Western Australian Geological Survey, M-series, A477 (unpublished).

PICKANDS MATHER AND COMPANY INTERNATIONAL, 1968, Annual Report Springvale area — East Kimberley region: Western Australian Geological Survey, M-series, A498 (unpublished).

PIDGEON, R. T., SMITH, C. B., and FANNING, C. M., 1989, Kimberlite and lamproite emplacement ages in Western Australia, *in* Kimberlites and related rocks, Volume 1 — their composition, occurrence, origin and emplacement *edited by* J. ROSS: Geological Society of Australia, Special Publication, no. 14, p. 369–381.

PIRAJNO, F., RUGLESS, C. S., GRIFFIN, T. J., and TYLER, I. M., 1994, Hydrothermal vein gold and base metal deposits in the Halls Creek Province, East Kimberley, Western Australia: Geological Society of Australia, Abstracts, no. 37, p. 347.

PLANET MANAGEMENT AND RESEARCH PROPRIETARY LIMITED, 1971, Copper mineralization in the Carson Volcanics, Durack Range, Western Australia: Western Australian Geological Survey, M-series, A1723 (unpublished)

PLATTS, W. D., 1983, Report on base metal exploration at Eastman Yard, Kimberley Region, W.A., 1982; Broken Hill Company Proprietary Limited: Western Australian Geological Survey, M-series, A12375 (unpublished).

PLAYFORD, P. E., and HOCKING, R. M., 1998, Bugle Gap area (1:50 000), *in* Devonian reef complexes of the Canning Basin *by* P. E. PLAYFORD (in prep.): Western Australia Geological Survey, Bulletin 145, Plate 5.

PLAYFORD, P. E., and RUDDOCK, I., 1985, Discovery of the Kimberley Goldfield: Royal Western Australian Historical Society, Journal and Proceedings, v. 9(3), p. 76–106.

PLIMER, I. R., 1987, The association of tourmalinite with stratiform scheelite deposits: Mineralium Deposita, v. 22, p. 282–291.

PLUMB, K. A., 1968, Lissadell, W.A.: Australia BMR, 1:250 000 Geological Series Explanatory Notes, 31p.

PLUMB, K. A., DERRICK, G. M., NEEDHAM, R. S., and SHAW, R. D., 1981, The Proterozoic of Northern Australia, *in* Precambrian of the Southern Hemisphere — Developments in Precambrian Geology 2 *edited by* D. R. HUNTER: Amsterdam, Elsevier, p. 205–307.

PLUMB, K. A., and GEMUTS, I., 1976, Precambrian geology of the Kimberley region, Western Australia: 25th International Geological Congress, Sydney, N.S.W., 1976, Excursion Guide 44C, 69p.

PRATT, N. K., 1979, Report on exploration of mineral claim 80/6574–EB1 Grid — July–December 1979; Cultus Pacific NL: Western Australia Geological Survey, M-series, A8863 (unpublished).

PRECIOUS METALS AUSTRALIA LIMITED, 1996, More high grades at Nicolson: Announcement to Australian Stock Exchange 08/05/1996 (unpublished).

PRECIOUS METALS AUSTRALIA LIMITED, 1997, Quarterly report to Australian Stock Exchange for the quarter ended 30 June 1997 (unpublished).

QUINN, M., 1999, Glengarry focus on proving million ounce resource: Gold Mining Journal, May, 1999, p. 22.

RAMSDEN, A. R., FRENCH, D. H., and CHALMERS, D. I., 1993, Volcanic-hosted rare-metals deposit at Brockman, Western Australia — mineralogy and geochemistry of the Niobium Tuff: Mineralium Deposita, v. 28, p. 1–12.

REISGYS, L., 1987, John Galt xenotime deposit — mining lease 80/40 — Kimberley, Western Australia — summary of previous work; Mascot Mining Proprietary Limited: Western Australia Geological Survey, M-series, A20907 (unpublished).

RIRIE, G. T., 1989, Evaporites and stratabound tungsten mineralisation: Geology, v. 17, p. 139–143.

ROBERTS, H. G., HALLIGAN, R., and PLAYFORD, P. E., 1968, Mount Ramsay, W.A.: Australia BMR, 1:250 000 Geological Series Explanatory Notes, 24p.

ROBINSON, S. H., 1989, Annual report — Mt Carmel East — E80/540; Australian United Gold NL: Western Australia Geological Survey, M-series, A27484 (unpublished).

ROEBUCK RESOURCES NL, 1990, Annual report to the Australian Stock Exchange for 1990 (unpublished).

ROGERS, K. A., 1998, Speewah fluorite deposit, *in* Geology of Australian and Papua New Guinean mineral deposits *edited by* D. A. BERKMAN, and D. H. MACKENZIE: Australasian Institute of Mining and Metallurgy, Monograph 22, p. 387–392.

RUGLESS, C. S., and PIRAJNO, F., 1994, Copperhead Carbonatite Complex — a newly discovered carbonatite–syenite plug in the Lamboo Complex of the east Kimberley, Western Australia: Geological Society of Australia, Abstracts, no. 37, p. 385–386.

RUGLESS, C. S., and PIRAJNO, F., 1996, Geology and geochemistry of the Copperhead Albitite 'Carbonatite' Complex, east Kimberley, Western Australia: Australian Journal of Earth Sciences, v. 43, p. 311–322.

SABMINCO NL, 1993, Diamond Mountain project — exploration report August 1993 to October 1993: Western Australia Geological Survey, M-series, A39524 (unpublished).

SANDERS, T. S., 1999, Mineralization of the Halls Creek Orogen, east Kimberley region, Western Australia: Western Australia Geological Survey, Report 66, 44p.

SANDERS, T. S., and HASSAN, L. Y., 1999, Mineral occurrences of the Halls Creek Orogen, Western Australia (1:1 000 000) *in* Mineralization of the Halls Creek Orogen, east Kimberley region, Western Australia *by* T. S. SANDERS: Western Australia Geological Survey, Report 66, Plate 1.

SCOTT, A. K., 1973, Killarney copper prospect, W.A. — report on investigations to 31st December, 1972 — final report; CRA Exploration Proprietary Limited: Western Australia Geological Survey, M-series, A7936 (unpublished).

SEWELL, D. M., 1999, The Koongie Park and Little Mount Isa zinc–copper–lead deposits: east Kimberley region, Western Australia, *in* Lead, zinc, and silver deposits of Western Australia *by* K. M. FERGUSON: Western Australia Geological Survey, Mineral Resources Bulletin 15, p. 139–142.

SHAW, R. D., MEIXNER, A. J., and MURRAY, A. S., in press, Regional geophysical framework and setting of mafic–ultramafic intrusions: tectonic implications, *in* Geology and economic potential of the Palaeoproterozoic layered mafic–ultramafic intrusions in the East Kimberley, Western Australia *edited by* D. M. HOATSON and D. H. BLAKE: Australian Geological Survey Organisation, Bulletin 246.

SHAW, R. D., TYLER, I. M., GRIFFIN, T. J., and WEBB, A., 1992, New K–Ar constraints on the onset of subsidence in the Canning Basin, Western Australia: Australia BMR, Journal of Australian Geology and Geophysics, v. 13, p. 31–35.

SHAW, R. W. L., 1978, Mabel Hill prospect — results of exploration of mineral claims 80/5292 and 80/5293; Australian Anglo American Limited: Western Australia Geological Survey, M-series, A8462 (unpublished).

SHEDDEN, S. H., and BARNES, G. J., 1996, East Kimberley nickel province — characteristics and origin of the Sally Malay Ni–Cu–Co deposit, East Kimberley, Western Australia, *in* Nickel '96 — mineral to market *edited by* E. J. GRIMSEY and I. NEUSS: Australasian Institute of Mining and Metallurgy, Publication Series No. 6/96.

SHEPPARD, S., GRIFFIN, T. J., and TYLER, I. M., 1995, Geochemistry of felsic igneous rocks from the southern Halls Creek Orogen: Western Australia Geological Survey, Record 1995/4, 81p.

SHEPPARD, S., GRIFFIN, T. J., and TYLER, I. M., 1997c, The tectonic setting of granites in the Halls Creek and King Leopold Orogens, Northwest Australia: Australian Geological Survey Organisation, Record 1997/44, p. 107–109.

SHEPPARD, S., and HASSAN, L. Y., 2000, Tectonic evolution and mineralization of the east Kimberley, *in* GSWA 2000 extended abstracts: Geological data for W.A. explorers in the new millennium: Western Australia Geological Survey, Record 2000/8, p. 22–24.

SHEPPARD, S., THORNE, A. M., and TYLER, I. M., 1997b, Bow, W.A. Sheet 4564: Western Australia Geological Survey, 1:100 000 Geological Series.

SHEPPARD, S., TYLER, I. M., GRIFFIN, T. J., and TAYLOR, W. R., 1999, Palaeoproterozoic subduction-related and passive margin basalts in the Halls Creek Orogen, northwest Australia: Australian Journal of Earth Sciences, v. 46, p. 679–690.

SHEPPARD, S., TYLER, I. M., and HOATSON, D. M., 1997a, Geology of the Mount Remarkable 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 27p.

SIMPSON, E. S., 1951, Minerals of Western Australia, Volume 2: Perth, Western Australia, Government Printer, 675p.

SMITH, C. B., 1978, Annual report on mineral claims 80/5333–5388, 80/5646–5647, 80/5662–5666 and 80/5671–5677 and annual and final report on mineral claims 80/5667–5670, Kimberly Goldfield, Western Australia; CRA Exploration Proprietary Limited: Western Australia Geological Survey, M-series, A7855 (unpublished).

SMITH, R. N., 1898, State of mining in the Kimberley District of Western Australia: Western Australia Geological Survey, Bulletin 2, p. 7–23.

STOCKLEMAYER, V., AND ROTHNIE, C., 1987, The Billiluna uranium project: report on the 1986 field program; Canadian Energy Resources Proprietary Limited and BHP Minerals: Western Australia Geological Survey, M-series, A20338 (unpublished).

STRATIN MINERALS PROPRIETARY LIMITED, 1972, Geological report on Kimberley prospects: Western Australia Geological Survey, M-series, A3817 (unpublished).

SUN, S-S., JAQUES, A. L., and McCULLOCH, M. T., 1986, Isotopic evolution of the Kimberley Block, Western Australia: Geological Society of Australia; 4th International Kimberlite Conference, Perth, W.A., 1986, Extended Abstracts; Abstracts Series, no. 16, p. 346–348.

SUTHERLAND, W. D., 1983, Billiluna Project — 1982 field program; Sigma Resources Group Incorporated: Western Australia Geological Survey, M-series, A12076 (unpublished).

SWEET, I. P., 1977, The Precambrian geology of the Victoria River region, Northern Territory: Australia BMR, Bulletin 168, 73p.

TALBOT, H. W. B., 1910, Geological observations in the country between Wiluna, Halls Creek and Tanami: Western Australia Geological Survey, Bulletin 39, 88p.

TANAMI GOLD NL, 1999, Quarterly report to Australian Stock Exchange for the quarter ended 31 December 1999 (unpublished).

TAYLOR, W. R., PAGE, R. W., ESSLEMONT, G., ROCK, N. M. S., and CHALMERS, D. I., 1995, Geology of the volcanic-hosted Brockman rare-metals deposit, Halls Creek Mobile Zone, northwest Australia. I — volcanic environment, geochronology and petrography of the Brockman volcanics: Mineralogy and Petrology, v. 52, p. 209–230.

TEMBY, P. A., 1994, First annual report on EL 80/01553 McIntosh for the period ended 13 April, 1994; Clutha Minerals Limited: Western Australia Geological Survey, M-series, A41771 (unpublished).

THORNE, A. M., SHEPPARD, S., and TYLER, I. M., 1999, Lissadell, W.A. (second edition): Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes, 68p.

THORNE, A. M., and TYLER, I. M., 1996, Mesoproterozoic and Phanerozoic sedimentary basins in the northern Halls Creek Orogen — constraints on the timing of strike-slip movement on the Halls Creek Fault system: Western Australia Geological Survey, Annual Review 1995–96, p. 156–168.

THORNETT, J. R., 1981, The Sally Malay deposit — gabbroid-associated nickel–copper sulphide mineralization in the Halls Creek mobile zone, Western Australia: Economic Geology, v. 76, p. 1565–1580.

TOMPKINS, L. A., EISENLOHR, B., GROVES, D. I., and RAETZ, M., 1997, Temporal changes in mineralization style at the Cadjebut Mississippi Valley-type deposit, Lennard Shelf, W.A.: Economic Geology, v. 92, p. 843–862.

TOMPKINS, L. A., PEDONE, V. A., ROCHE, M. T., and GROVES, D. I., 1994a, The Cadjebut deposit as an example of Mississippi Valley-type mineralization on the Lennard shelf, Western Australia — single episode or multiple events?: Economic Geology, v. 89, p. 450–466.

TOMPKINS, L. A., RAYNOR, M. J., GROVES, D. I., and ROCHE, M. T., 1994b, Evaporites: In situ sulfur source for rhythmically banded ore in the Cadjebut Mississippi Valley-type Zn–Pb deposit, Western Australia: Economic Geology, v. 89, p. 467–492.

TREND EXPLORATION PROPRIETARY LIMITED, 1973, Final report MC's Osmond Range: Western Australia Geological Survey, M-series, A6472 (unpublished).

TRUDU, A. G, 1990, Comment on 'Evaporites and stratabound tungsten mineralization': Geology, v. 18, p. 188–189.

TYLER, I. M., 2000, Geological map of the east Kimberley region (1:500 000) *in* Geology of the King Leopold and Halls Creek Orogens *by* I. M. TYLER, T. J. GRIFFIN, S. SHEPPARD, and A. M. THORNE: Western Australia Geological Survey, Bulletin 143, Plate 5.

TYLER, I. M., and GRIFFIN, T. J., 1990, Structural development of the King Leopold Orogen, Kimberley Region, Western Australia: Journal of Structural Geology, v. 12, p. 703–714.

TYLER, I. M, and GRIFFIN, T. J., 1994, Dockrell, W.A. Sheet 4360: Western Australia Geological Survey, 1:100 000 Geological Series.

TYLER, I. M., GRIFFIN, T. J., PAGE, R. W., and SHAW, R. D., 1995, Are there terranes within the Lamboo Complex of the Halls Creek Orogen?: Western Australia Geological Survey, Annual Review 1993–94, p. 37–46.

TYLER, I. M., GRIFFIN, T. J., PLAYFORD, P. E., and HOCKING, R. M., 1998a, Mount Ramsay, W.A. (2nd edition): Western Australia Geological Survey, 1:250 000 Geological Series.

TYLER, I. M., GRIFFIN, T. J., and SHAW, R. D., 1991, Early Palaeozoic tectonism and reactivation of pre-existing basement structures at the margins of the Kimberley Craton, Western Australia: Geological Society of Australia, Abstracts 31, p. 70–71.

TYLER, I. M., GRIFFIN, T. J., and SHEPPARD, S., 1998b, Geology of the Dockrell 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 24p.

TYLER, I. M., GRIFFIN, T. J., SHEPPARD, S., and THORNE, A. M., in prep., Geology of the King Leopold and Halls Creek Orogens: Western Australia Geological Survey, Bulletin 143.

TYLER, I. M., HOATSON, D. M., GRIFFIN, T. J., SHEPPARD, S., BLAKE, T. H., and WARREN, R. G., 1997a, McIntosh, W.A. Sheet 4462: Western Australia Geological Survey, 1:100 000 Geological Series.

TYLER, I. M., and PAGE, R. W., 1996, Palaeoproterozoic deformation, metamorphism and igneous intrusion in the central zone of the Lamboo Complex, Halls Creek Orogen: Geological Society of Australia, Abstracts, no. 41, p. 450.

TYLER, I. M., PAGE, R. W., and GRIFFIN, T. J., 1999, Depositional age and provenance of the Marboo Formation from SHRIMP U–Pb zircon geochronology: implications for the early Palaeozoic tectonic evolution of the Kimberley region, Western Australia: Precambrian Research v. 95, p. 225–243.

TYLER, I. M., PIRAJNO, F., BAGAS, L., MYERS, J. S, and PRESTON, W. A., 1988c, The geology and mineral deposits of the Proterozoic in Western Australia: Australian Geological Survey Organisation, Journal of Australian Geology and Geophysics, v. 17, p. 223–244.

TYLER, I. M., THORNE, A. M., HOATSON, D. M., and BLAKE, D. H., 1997b, Turkey Creek, W.A. Sheet 4563: Western Australia Geological Survey, 1:100 000 Geological Series.

TYLER, I. M., THORNE, A. M., SHEPPARD, S., HOATSON, D. M., GRIFFIN, T. J., BLAKE, D. H., and WARREN, R. G., 1998d, Dixon Range, W.A.: Western Australia Geological Survey, 1:250 000 Geological Series.

TYLER, I. M., WARREN, R. G., and BLAKE, D. H, 1998e, Dixon, W.A. Sheet 4562: Western Australia Geological Survey, 1:100 000 Geological Series.

UNION CORPORATION (AUSTRALIA) PROPRIETARY LIMITED, 1975, Eastmans Bore prospect — final report: Western Australia Geological Survey, M-series, A6134 (unpublished).

URQUHART, K., 1983, Lennard Shelf regional Pb–Zn exploration — Horse Spring Range prospect, Kimberley Mineral Field, Western Australia, Annual Report 1982; Broken Hill Company Proprietary Limited: Western Australia Geological Survey, M-series, A12485 (unpublished).

WARREN, R. G., 1994a, Landscape evolution in the East Kimberley region, Western Australia: AGSO Research Newsletter, 20, p. 14–16.

WARREN, R. G., 1994b, Gold mineralisation in the northern East Kimberley gold district, Western Australia, *in* Australian mining looks north — the challenges and choices *edited by* C. P. HALLENSTEIN: Australasian Institute of Mining and Metallurgy, Publication Series 5/94, p. 117–121.

WARREN, R. G., 1997, Reconnaissance geological mapping in Dixon, SE McIntosh and northernmost Halls Creek 1:100 000 sheet areas, East Kimberley, W.A. 1992–93: Australian Geological Survey Organisation, Record 1997/26, 54p.

WEIR, D. J., 1989, Review of the Cummins Range Carbonatite, ML 80/266, Mt Bannerman SE52-13, W.A.; CRA Exploration Proprietary Limited: Western Australia Geological Survey, M-series, A29963 (unpublished).

WESTERN METALS LIMITED, 2000, Announcement to the Australian Stock Exchange, 15 February 2000 (unpublished).

WESTERN MINING CORPORATION LIMITED, 1979, Annual report — Wills Creek: Western Australia Geological Survey, M-series, A8602 (unpublished).

WESTERN MINING CORPORATION LIMITED, 1980, Sandy Creek terminal report: Western Australia Geological Survey, M-series, A9091 (unpublished).

WHITE, W. S., 1968, The native-copper deposits of Northern Michigan, *in* Ore deposits of the United States, 1933–1967 *edited by* J. D. RIDGE: American Institute of Mining, Metallurgical, and Petroleum Engineers, Incorporated, New York, p. 303–324.

WITT, W. K., and SANDERS, T., 1996, Magmatic–hydrothermal breccia dykes and hydrothermal alteration in the McHale Granodiorite, Halls Creek Orogen — a possible porphyry system: Western Australia Geological Survey, Annual Review 1995–96, p. 104–110.

WOODWARD, H. P., 1891, Report on the goldfields of the Kimberley District, Western Australia: Western Australia Parliamentary Paper 18.

YEATES, A. N., and MUHLING, P. C., 1977, Mount Bannerman, W.A.: Australia BMR, 1:250 000 Geological Series Explanatory Notes, 24p.

# Appendix 1

# List of mineral occurrences

## MINERAL OCCURRENCES OF THE EAST KIMBERLEY

* KEY TO OPERATING STATUS

| | |
|---|---|
| **Bold numbers** | Operating mine |
| ***Bold and italic numbers*** | Abandoned mine |
| Plain numbers | Mineral deposit |
| *Italic numbers* | Mineral occurrence or prospect |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **PRECIOUS MINERAL** | | | | |
| Kimberlite and lamproite intrusions | | | | |
| **1106** | Dmd | 434452 | 8152084 | Argyle Ak1 |
| 1110 | Dmd | 426237 | 8147785 | Lissadell Road Dykes |
| *1115* | Dmd | 368433 | 8148169 | Maude Creek Dyke |
| Stratabound volcanic and sedimentary – undivided | | | | |
| 6406 | Prh | 438879 | 7997028 | Valley |
| 6407 | Prh | 438935 | 7996570 | Mound |
| *6409* | Prh | 437483 | 7995566 | New Deposit |
| Stratabound sedimentary – clastic-hosted | | | | |
| 5611 | Zebr | 469282 | 8191257 | Lake Argyle 1 |
| *6386* | Dmd | 198312 | 8002677 | Barramundi Range 1 |
| *6497* | Zebr | 496776 | 8222894 | Lake Argyle 2 |
| Regolith – alluvial to beach placers | | | | |
| ***1107*** | Dmd | 436647 | 8150862 | Limestone Creek |
| **1108** | Dmd | 434447 | 8153897 | Upper Smoke Creek |
| 1109 | Dmd | 435745 | 8155561 | Lower Smoke Creek |
| ***1113*** | Dmd | 455253 | 8160220 | Bow River (alluvials) |
| *2764* | Dmd | 475733 | 8103158 | Hidden Valley |
| *3002* | Dmd | 426332 | 8144958 | Argyle Dykes 1 |
| *3003* | Dmd | 425833 | 8145758 | Argyle Dykes 2 |
| *3004* | Toz | 425733 | 8148058 | Argyle Dykes 3 |
| *3309* | Dmd | 450033 | 8173958 | Smoke Creek |
| *3312* | Dmd | 444033 | 8169758 | Flying Fox Creek |
| *3335* | Dmd | 426033 | 8152958 | Glen Hill A |
| *3336* | Dmd | 416333 | 8158858 | Pompey A |
| *3337* | Dmd | 416733 | 8168958 | Pompey B |
| *3338* | Dmd | 418433 | 8178608 | Blatchford A |
| *3339* | Dmd | 418633 | 8178808 | Blatchford B |
| *3340* | Dmd | 418133 | 8182708 | Blatchford C |
| *3341* | Dmd | 427632 | 8186258 | Blatchford D |
| *3342* | Dmd | 418033 | 8182158 | Blatchford E |
| *3343* | Dmd | 430933 | 8161358 | Glen Hill B |
| *3344* | Dmd | 430533 | 8164458 | Glen Hill C |
| *5164* | Dmd | 349437 | 8187384 | Durack River 1 |
| *5165* | Dmd | 347744 | 8170450 | Durack River 2 |
| *5166* | Dmd | 353663 | 8133558 | Durack River 3 |
| *5167* | Dmd | 347132 | 8124598 | Durack River 4 |
| *5192* | Dmd | 341351 | 8138426 | Site 3603 |
| *5376* | Dmd | 345986 | 8115744 | Lightning Creek |
| *6028* | Dmd | 457503 | 7935715 | Gordon Downs 1 |
| *6029* | Dmd | 457821 | 7935229 | Gordon Downs 2 |
| *6030* | Dmd | 453771 | 7932270 | Gordon Downs 3 |
| *6387* | Dmd | 190216 | 8000949 | Barramundi Range 2 |
| *6420* | Dmd | 189147 | 7882151 | Salt Creek |
| *6422* | Dmd | 187735 | 7874775 | Wattle Spring Creek |
| **PRECIOUS METAL** | | | | |
| Orthomagmatic mafic and ultramafic – layered mafic | | | | |
| *12* | Pt Pd Cr | 379273 | 8042874 | Mini M (Cr-PGE) 2 |
| *814* | Cr | 354583 | 8035158 | Springvale 1 |
| *819* | PGE Cr | 378933 | 8043558 | Mini M |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **PRECIOUS METAL** | | | | |
| Stratabound volcanic and sedimentary – undivided | | | | |
| ***2338*** | Au Ag As (Pb Cu) | 315634 | 7921702 | Dockrell East 1 |
| *5575* | Au | 357151 | 7987370 | Campbell |
| *6393* | Au | 315729 | 7921948 | Dockrell East 2 |
| ***6394*** | Au | 315967 | 7922448 | Green Leader |
| *6437* | Au | 306793 | 7918506 | Freda |
| *6440* | Au Pb Cu | 309320 | 7921377 | Lulu |
| Stratabound sedimentary – clastic-hosted | | | | |
| *5719* | Au Ag (Cu U) | 480045 | 7865021 | Mount Brophy |
| Orthomagmatic mafic and ultramafic – layered mafic | | | | |
| 825 | PGE | 376963 | 8037258 | Panton |
| *828* | Pd Pt Cr V Ti | 380965 | 8043186 | Togo 5A |
| *835* | PGE Cr Au | 245679 | 7928396 | Eastman Bore (PGE 1) |
| *1044* | PGE Au Cr | 247932 | 7930258 | Eastman Bore (PGE 2) |
| *3189* | PGE | 386532 | 8073058 | Koondooloo Yard |
| *3517* | PGE Cr | 352933 | 8036758 | Springvale 2 |
| *3536* | PGE Cr | 357133 | 8033358 | Springvale 3 |
| *3539* | PGE Cr | 386623 | 8049268 | Melon Patch 3 |
| *3543* | PGE Cr | 387233 | 8049658 | Melon Patch 4 |
| *3545* | PGE Cr | 385233 | 8048658 | Melon Patch 5 |
| *3546* | PGE Cr | 380633 | 8042158 | Melon South |
| *3557* | Au PGE Cr | 387633 | 8049858 | Melon Patch 6 |
| *3561* | PGE | 387833 | 8049958 | Melon Patch 7 |
| *3565* | PGE Cr | 378033 | 8039558 | Panton North 1 |
| *3567* | PGE Cr | 377933 | 8038558 | Panton North 2 |
| *3568* | PGE Cr | 378433 | 8040558 | Panton North 3 |
| *3569* | PGE Cr | 380633 | 8043358 | Alice Downs 3 |
| *3571* | PGE | 382233 | 8046358 | Alice Downs 4 |
| *5470* | PGE | 329233 | 7963323 | Dusty Bore 2 |
| *5697* | PGE Au Cr | 247822 | 7930225 | Eastman Bore (PGE 3) |
| *5698* | PGE Au Cr | 247681 | 7930120 | Eastman Bore (PGE 4) |
| *5705* | PGE Cr | 249251 | 7930174 | Eastman Bore (PGE 5) |
| *5951* | Cr PGE | 250973 | 7930611 | Eastman Bore (PGE 6) |
| *5952* | Cr PGE | 250680 | 7930382 | Eastman Bore (PGE 7) |
| *5953* | PGE Cr | 249846 | 7930286 | Eastman Bore (PGE 8) |
| *5954* | PGE | 248163 | 7929897 | Eastman Bore (PGE 9) |
| *5955* | PGE | 248480 | 7930493 | Eastman Bore (PGE 10) |
| *5956* | PGE Cr | 248099 | 7930373 | Eastman Bore (PGE 11) |
| *6142* | PGE Cr Ni | 323703 | 7956385 | Lamboo (PGE 1) |
| *6143* | PGE | 323647 | 7956464 | Lamboo (PGE 2) |
| *6150* | PGE Au | 323600 | 7956544 | Lamboo (PGE 3) |
| *6151* | PGE Cr | 322670 | 7957902 | Lamboo (PGE 4) |
| *6152* | PGE Cr | 324092 | 7957107 | Lamboo (PGE 5) |
| *6153* | PGE Cr | 324822 | 7960693 | Lamboo (PGE 6) |
| *6156* | PGE Cr | 325129 | 7960984 | Lamboo (PGE 7) |
| *6158* | PGE Au Ni | 321861 | 7955654 | Lamboo (PGE 8) |
| *6159* | PGE | 322574 | 7955332 | Lamboo (PGE 9) |
| *6160* | PGE Au Ni | 323002 | 7958203 | Lamboo (PGE 10) |
| *6161* | PGE Cr | 322963 | 7958298 | Lamboo (PGE 11) |
| *6162* | PGE Cr | 323585 | 7959315 | Lamboo (PGE 12) |
| *6163* | PGE Au Ni | 325563 | 7961674 | Lamboo (PGE 13) |
| *6164* | PGE | 321498 | 7955390 | Lamboo (PGE 14) |
| *6195* | PGE Au Cr | 248369 | 7930416 | Eastman Bore (PGE 12) |
| *6209* | PGE Cr | 248290 | 7930582 | Eastman Bore (PGE 13) |
| *6210* | PGE Cr | 248179 | 7930194 | Eastman Bore (PGE 14) |
| *6211* | PGE Cr | 249782 | 7931115 | Eastman Bore (PGE 15) |
| *6221* | PGE | 250108 | 7930178 | Eastman Bore (PGE 16) |
| *6226* | PGE Cr | 248068 | 7930202 | Eastman Bore (PGE 17) |
| *6228* | PGE | 248227 | 7930305 | Eastman Bore (PGE 18) |

## KEY TO COMMODITY CODES

Minor commodities shown in brackets

| | | | |
|---|---|---|---|
| Ag | silver | Nb | niobium |
| Al | aluminium | Ni | nickel |
| As | arsenic | P | phosphorus |
| Asbc | asbestos; chrysotile | Pb | lead |
| Au | gold | Pd | palladium |
| Bi | bismuth | PGE | platinum group elements |
| Brl | beryl | Prh | prehnite |
| Brt | barite | Pt | platinum |
| Bsbg | building stone; black granite | REE | rare earth elements |
| Bsdo | building stone; dolerite | Sb | antimony |
| Cd | cadmium | Sn | tin |
| Co | cobalt | Sst | sandstone |
| Cr | chromium | Ta | tantalum |
| Cu | copper | Ti | titanium |
| Dmd | diamond | Tlc | talc |
| Fe | iron | Toz | topaz |
| Fl | fluorite | U | uranium |
| Ga | gallium | V | vanadium |
| Grt | garnet | Vrm | vermiculite |
| Hf | hafnium | W | tungsten |
| Ilm | ilmenite | Xen | xenotime |
| Li | lithium | Zebr | zebra rock |
| Mag | magnetite | Zn | zinc |
| Mgs | magnesite | Zr | zirconium |
| Mo | molybdenum | | |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **PRECIOUS METAL** | | | | |
| | Stratabound volcanic and sedimentary – volcanic-hosted sulfide | | | |
| 6094 | Au Ag Pb Zn | 303021 | 7911062 | Mount Carmel East 2 |
| | Stratabound volcanic and sedimentary – sedimentary-hosted sulfide | | | |
| 3170 | Au | 382895 | 8010833 | Woodward Creek (Au) |
| 5385 | Ag (Bi Pb Cu Zn) | 238916 | 7940336 | Mount Ramsay 3 |
| 5802 | Ag (Au Cu) | 321353 | 7961270 | Emull North 1 |
| 5803 | Au | 321435 | 7961329 | Emull North 2 |
| 5804 | Au | 382337 | 7985218 | Gentle Annie D |
| 6066 | Au | 346552 | 7965208 | Koongie Rockholes 2 |
| | Vein and hydrothermal – undivided | | | |
| 1069 | Au Ag | 401746 | 8062831 | Wills Creek B2 |
| 1220 | Ag | 374726 | 8007941 | Armanda |
| 1275 | Au Cu Ag | 250586 | 7955646 | Me No Savvy C |
| 1315 | Au Pb Ag | 293263 | 7967595 | Soda Spring 1 |
| 1318 | Au Cu Ag | 293554 | 7967712 | Soda Spring 2 |
| 1322 | Au | 297853 | 7967445 | Soda Spring 3 |
| 1326 | Au Cu Ag | 298009 | 7967663 | Soda Spring 4 |
| 2210 | Au | 407083 | 8045708 | Slinkey Hill |
| 2211 | Au Ag Pb Cu Zn | 386805 | 8027837 | Star of Kimberley |
| 2212 | Au Ag (Pb Zn) | 384890 | 8028088 | Perseverance |
| 2214 | Au Ag | 385873 | 8028239 | Moodys |
| 2215 | Au Ag (Pb Zn) | 388965 | 8029611 | Wilsons Reef |
| 2216 | Au | 388743 | 8028368 | Caledonian |
| 2217 | Au | 388462 | 8029188 | Scottish Chief |
| 2218 | Au | 389062 | 8029188 | Comet |
| 2219 | Au | 389369 | 8029468 | Lady Kimberley |
| 2220 | Au (Cu Pb) | 389598 | 8029682 | Panton Queen |
| 2221 | Au Ag Pb | 389574 | 8029868 | Lone Hand |
| 2223 | Au | 374956 | 7971075 | Palm Springs |
| 2224 | Au | 377977 | 7973554 | Golden Crown |
| 2232 | Au | 378645 | 7974291 | Faugh A Ballagh |
| 2233 | Au | 376598 | 7973608 | Lady Margaret |
| 2234 | Au (Pb) | 376483 | 7974868 | Io |
| 2235 | Au | 377474 | 7976218 | Deimos |
| 2236 | Au | 375755 | 7970840 | Mount Bradley |
| 2237 | Au (Pb As) | 367721 | 7958932 | Ruby Queen |
| 2238 | Au | 367555 | 7959099 | St Lawrence |
| 2239 | Au | 368269 | 7959909 | West and Left |
| 2240 | Au | 368398 | 7960115 | Goliath |
| 2241 | Au | 368475 | 7960226 | Ruby Queen Extended North |
| 2242 | Au | 368373 | 7960306 | Triumph |
| 2243 | Au | 368761 | 7960377 | Rising Sun |
| 2244 | Au | 368475 | 7960393 | Sunny Corner |
| 2246 | Au Pb Ag (Cu) | 369733 | 7979606 | Jubilee |
| 2249 | Au | 370178 | 7980860 | Gladstone |
| 2250 | Au Pb Ag (Cu) | 370279 | 7981855 | Lady Broome |
| 2251 | Au | 370490 | 7982152 | Jacksons Reef |
| 2253 | Au Pb Ag W Ti | 363211 | 7966798 | Darcys |
| 2254 | Au | 362148 | 7964759 | Deep Mine |
| 2255 | Au | 362099 | 7965292 | Three Shafts |
| 2256 | Au | 362743 | 7966294 | Darcys 2 |
| 2257 | Au | 362774 | 7966349 | Darcys 3 |
| 2258 | Au | 362624 | 7966183 | Darcys 4 |
| 2259 | Au | 349615 | 7956442 | Reform |
| 2260 | Au | 348440 | 7954347 | Shane |
| 2261 | Au | 348480 | 7954680 | Sandra |
| 2262 | Au | 347079 | 7952706 | Kerry |
| 2263 | Au | 347424 | 7952973 | Big Red |
| 2264 | Au | 346965 | 7953193 | Danny |
| 2266 | Au | 347041 | 7952051 | Mays Patch |
| 2268 | Au | 357065 | 7961400 | Chinamens |
| 2269 | Au | 358962 | 7962757 | Lynas |
| 2270 | Au | 355382 | 7960495 | McPhees Creek |
| 2271 | Au | 358009 | 7962607 | New Prospect |
| 2272 | Au | 357835 | 7962789 | Sams Creek |
| 2273 | Au | 357112 | 7962218 | Camp Prospect |
| 2275 | Au | 353556 | 7959519 | Blue Bar |
| 2276 | Au | 353961 | 7959860 | Blue Bar Central |
| 2277 | Au | 354660 | 7960257 | Blue Bar North |
| 2278 | Au | 353556 | 7959519 | Blue Bar East |
| 2279 | Au | 354890 | 7960337 | New Prospect 2 |
| 2280 | Au | 351929 | 7959026 | Poverty Creek Central |
| 2281 | Au | 352651 | 7959526 | Yellow Creek |
| 2282 | Au | 353383 | 7959658 | Straight Creek |
| 2285 | Au | 355580 | 7960662 | Kaolin |
| 2286 | Au | 355826 | 7960828 | Spear Gully |
| 2287 | Au Pb | 324847 | 7936526 | 20 Mile |
| 2289 | Au Pb | 327292 | 7936875 | Juggler Bow |
| **PRECIOUS METAL** | | | | |
| | Vein and hydrothermal – undivided | | | |
| 2291 | Au | 328570 | 7938661 | Montys |
| 2292 | Au | 329433 | 7939258 | Montys Extended |
| 2295 | Au | 331808 | 7941400 | Baxters |
| 2299 | Au Cu Pb | 346767 | 7965581 | Koongie Rockholes 1 |
| 2300 | Au | 293783 | 7890373 | Christmas Creek 1 |
| 2302 | Au | 296810 | 7890352 | Christmas Creek 2 |
| 2305 | Au (W) | 294362 | 7888807 | Christmas Creek 3 |
| 2318 | Au | 311635 | 7918414 | Victoria |
| 2321 | Au Pb Ag | 311643 | 7918485 | McNeils |
| 2322 | Au | 311643 | 7918239 | Lady Hopetoun |
| 2324 | Au (Cu Pb) | 310072 | 7914400 | Irish Lass |
| 2325 | Au | 309600 | 7914110 | Erin go Bragh Southwest |
| 2326 | Au | 309703 | 7914070 | Erin go Bragh Southeast |
| 2327 | Au | 309324 | 7915493 | Hazletts |
| 2328 | Au | 309012 | 7913229 | Carol 1 |
| 2329 | Au | 306423 | 7912699 | Western Lead |
| 2332 | Au (Pb) | 310675 | 7916932 | Old Mac |
| 2333 | Au | 311429 | 7916866 | Kathleen |
| 2334 | Au | 312302 | 7918771 | Ross and McIntyre |
| 2335 | Au Pb | 316680 | 7924787 | Hangmans (Au A) |
| 2336 | Au | 316481 | 7924462 | Hangmans (Au B) |
| 2337 | Au | 316204 | 7924065 | Hangmans (Au C) |
| 2339 | Au Ag (As) | 348150 | 7988854 | Lady Helen |
| 2340 | Au | 326386 | 7963567 | Nicolsons Find |
| 2341 | Au Pb Ag | 326108 | 7962010 | Nicholsons Find South |
| 2342 | Au | 327465 | 7963113 | Burnt Out |
| 2343 | Au | 325200 | 7965704 | Springvale Fault Prospect |
| 2344 | Au As Pb Ag | 336288 | 8001740 | Gnewing Bore 1 |
| 2345 | Au Ag | 409566 | 8179905 | Jailhouse Creek 1 |
| 2347 | Au Pb | 409247 | 8179916 | Jailhouse Creek 3 |
| 2733 | Au | 378705 | 8005972 | Duffers |
| 2736 | Au | 346710 | 7965749 | Big Mac |
| 2739 | Au | 371423 | 7965695 | Halls Gully 1 |
| 2874 | Au | 401313 | 8060418 | Wills Creek C2 |
| 2875 | Au | 408820 | 8032989 | Black Duck Creek D |
| 3198 | Au | 384633 | 8024658 | Katy Yard 2 |
| 3214 | Au | 389933 | 8029058 | Comet Hill (primary) |
| 3326 | Au | 301633 | 7918158 | Mount Dockrell 1 |
| 3327 | Au | 312132 | 7917458 | Mount Dockrell 2 |
| 4284 | Au | 375002 | 7973738 | Titan |
| 4288 | Au | 375478 | 7976188 | Europa |
| 4802 | Au | 279563 | 7970678 | Dead Horse 5 |
| 4940 | Au | 394516 | 8015213 | Dry Creek 1 |
| 4942 | Au | 394794 | 8015715 | Kangaroo Hole |
| 5255 | Au Ag (Cu) | 320988 | 7961196 | Emull West 2 |
| 5420 | Au | 490540 | 7836506 | Larranganni Bluff 1 |
| 5421 | Au | 485725 | 7835527 | Larranganni Bluff 2 |
| 5506 | Au | 349515 | 7965855 | Whopper 1 |
| 5507 | Au | 349275 | 7965137 | Whopper 2 |
| 5508 | Au | 345985 | 7962727 | Whopper 3 |
| 5509 | Au | 344135 | 7961347 | Whopper 4 |
| 5510 | Au | 343645 | 7960767 | Whopper 5 |
| 5578 | Au | 396331 | 8016932 | Dry Creek 2 |
| 5581 | Au | 394568 | 8015718 | Dry Creek 3 |
| 5582 | Au | 394688 | 8015559 | Dry Creek 4 |
| 5583 | Au | 394640 | 8016440 | Dry Creek 5 |
| 5584 | Au | 394545 | 8017130 | Dry Creek 6 |
| 5609 | Au | 386579 | 7996576 | Bertha Peak |
| 5614 | Au | 329258 | 7943060 | Woodward Range |
| 5800 | Au | 365657 | 7986343 | Elvire |
| 5809 | Au | 489245 | 7868644 | Venus 1 |
| 5810 | Au | 488531 | 7868818 | Venus 2 |
| 5811 | Au | 488579 | 7869367 | Venus 3 |
| 5821 | Au Pb Ag Cu | 309611 | 7895749 | Minneroo Pool 2 |
| 5945 | Au | 312941 | 7920196 | South Dockrell 9 |
| 5963 | Au | 348937 | 7955448 | Charlies Pride |
| 5964 | Au | 348747 | 7955682 | Sarah Barton |
| 5965 | Au | 347805 | 7953616 | Ginavieve |
| 5966 | Au | 347607 | 7953298 | Julie |
| 5992 | Au | 381267 | 7981123 | Poverty Gully 3 |
| 6067 | Au | 346830 | 7966042 | Koongie Rockholes 3 |
| 6068 | Au | 347362 | 7966050 | Koongie Rockholes 4 |
| 6069 | Au | 347791 | 7965534 | Koongie Rockholes 5 |
| 6072 | Au | 296259 | 7890267 | Christmas Creek 7 |
| 6074 | Au | 485500 | 7833700 | Kookaburra |
| 6075 | Au | 485700 | 7834100 | Sandpiper |
| 6076 | Au | 485700 | 7835200 | Hawk |
| 6077 | Au | 485800 | 7835950 | Robin |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **PRECIOUS METAL** | | | | |
| | Vein and hydrothermal – undivided | | | |
| 6078 | Au | 486319 | 7837277 | Cuckoo |
| 6079 | Au | 486427 | 7837428 | Cuckoo North |
| 6080 | Au | 486535 | 7839757 | Tern South |
| 6081 | Au | 487100 | 7840600 | Tern |
| 6082 | Au | 484100 | 7833200 | Osprey |
| 6083 | Au | 485000 | 7833300 | Albatross |
| 6084 | Au | 485400 | 7830000 | Finch |
| 6085 | Au | 484468 | 7834210 | Pelican |
| 6086 | Au | 484269 | 7834237 | Gull |
| 6087 | Au | 484018 | 7834250 | Magpie |
| 6095 | Au | 296707 | 7912399 | Mount Carmel 1 |
| 6101 | Au | 289809 | 7910118 | Mount Carmel 2 |
| 6107 | Au | 311882 | 7917903 | Mount Dockrell 8 |
| 6119 | Au Ag | 348553 | 7988677 | Moola Bulla 3 |
| 6121 | Au | 347989 | 7988900 | Moola Bulla 4 |
| 6125 | Au | 370463 | 7982202 | Jacksons Reef North |
| 6126 | Au | 370590 | 7982133 | Jacksons Reef East |
| 6127 | Au Pb Ag | 370310 | 7981764 | Lady Broome No. 1 North |
| 6128 | Au | 370336 | 7981543 | Old Halls Creek 1 |
| 6129 | Au | 370473 | 7981481 | Old Halls Creek 2 |
| 6130 | Au | 370395 | 7981396 | Old Halls Creek 3 |
| 6131 | Au | 370256 | 7981075 | Black Mount |
| 6132 | Au | 370144 | 7980933 | No. 2 South Black Mount |
| 6133 | Au | 370369 | 7981252 | Mount Black North |
| 6134 | Au | 369408 | 7980829 | Old Halls Creek 4 |
| 6135 | Au | 370315 | 7980998 | Old Halls Creek 5 |
| 6136 | Au | 370408 | 7981416 | Old Halls Creek 6 |
| 6139 | Au | 330475 | 7940661 | Head of the Garden 2 |
| 6154 | Au | 322602 | 7959934 | Lamboo (Au 1) |
| 6157 | Au | 321956 | 7955805 | Lamboo (Au 2) |
| 6165 | Au | 321498 | 7955390 | Lamboo (Au 3) |
| 6174 | Au (Pb W) | 310779 | 7915439 | Native Sulphur |
| 6176 | Au | 308488 | 7913284 | Pete |
| 6177 | Au | 309235 | 7913316 | Susy |
| 6181 | Au | 308616 | 7913197 | Carol 2 |
| 6183 | Au | 309639 | 7914181 | Erin go Bragh North |
| 6184 | Au | 310124 | 7914141 | Mary-anne |
| 6193 | Au | 310536 | 7913085 | Gossan Zone |
| 6244 | Au | 362322 | 7965230 | Darcys 5 |
| 6255 | Au | 340647 | 7939305 | Blue Hills South |
| 6256 | Au | 342883 | 7943334 | Blue Hills North |
| 6257 | Au | 342600 | 7951628 | Golden Plains 1 |
| 6258 | Au | 366274 | 7966056 | Halls Gully 7 |
| 6269 | Au | 375840 | 7972543 | Mount Bradley 2 |
| 6313 | Au | 326910 | 7959983 | Shiftys Reef |
| 6314 | Au | 327052 | 7960602 | Paddock Well 1 |
| 6315 | Au | 327124 | 7959697 | Paddock Well 2 |
| 6316 | Au | 327227 | 7959745 | Paddock Well 3 |
| 6317 | Au | 327322 | 7959753 | Paddock Well 4 |
| 6318 | Au | 327282 | 7959650 | Paddock Well 5 |
| 6319 | Au | 328084 | 7959824 | Paddock Well 6 |
| 6320 | Au | 322851 | 7962711 | White Horse |
| 6340 | Au | 475268 | 7798193 | Billiluna |
| 6342 | Au | 324251 | 7982393 | Billabong |
| 6343 | Au | 352405 | 7959630 | Yellow Creek 2 |
| 6344 | Au | 352866 | 7959638 | Yellow Creek 3 |
| 6347 | Au | 355922 | 7960677 | Jocks Find |
| 6348 | Au | 351929 | 7959106 | Poverty Creek North |
| 6349 | Au | 351675 | 7958939 | Poverty Creek West |
| 6350 | Au | 352112 | 7959169 | Poverty Creek East |
| 6351 | Au | 355446 | 7969384 | Teds Find |
| 6352 | Au | 355287 | 7960431 | McPhees Creek West |
| 6353 | Au | 355604 | 7960574 | McPhees Creek East |
| 6369 | Au (As) | 336510 | 8001383 | Gnewing Bore 2 |
| 6373 | Au Pb Cu Zn Ag | 298853 | 7968636 | Eastern Shear 2 |
| 6381 | Au Ag | 347632 | 7988788 | Moola Bulla 6 |
| 6382 | Au | 375258 | 7971512 | Wolfdale |
| 6383 | Au | 376417 | 7973107 | Afghan |
| 6384 | Au | 374401 | 7970369 | Deeps Extension |
| 6385 | Au | 375226 | 7969980 | Phoenix |
| 6390 | Au (Cu Pb) | 204997 | 7951928 | Mount Fairbairn 2 |
| 6403 | Au | 289900 | 7972060 | Dead Horse 1 |
| 6404 | Au | 292507 | 7973416 | Glidden 2 |
| 6424 | Au Pb Cu Ag | 311676 | 7917511 | Crowter |
| 6427 | Au | 311921 | 7918644 | Mount Dockrell 4 |
| 6428 | Au | 311762 | 7918271 | Mount Dockrell 5 |
| 6429 | Au Pb Cu | 310595 | 7915662 | Gordons |
| 6430 | Au Pb Cu W | 310543 | 7915768 | Galena |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **PRECIOUS METAL** | | | | |
| | Vein and hydrothermal – undivided | | | |
| 6431 | Au | 310000 | 7916191 | Cheryl |
| 6432 | Au | 310357 | 7917607 | Lyn |
| 6435 | Au | 309373 | 7915715 | Jack Shaw |
| 6436 | Au | 307270 | 7917951 | Fred |
| 6445 | Au | 309889 | 7914287 | Crackerjack |
| 6448 | Au | 308871 | 7913956 | Ross |
| 6449 | Au | 308448 | 7914061 | Goddards Find |
| 6450 | Au | 308407 | 7913810 | Linda 1 |
| 6452 | Au | 308010 | 7913757 | John |
| 6453 | Au | 307230 | 7913995 | Janette |
| 6454 | Au | 310722 | 7917686 | Cath |
| 6455 | Au | 307600 | 7912209 | Martins Find |
| 6458 | Au | 303737 | 7911111 | Denise |
| 6459 | Au | 304174 | 7911852 | Boothey |
| 6460 | Au (Cu) | 304465 | 7911839 | Michelle |
| 6461 | Au | 304267 | 7911733 | Chris |
| 6462 | Au | 305219 | 7912275 | Jan |
| 6463 | Au | 305299 | 7912818 | Helen |
| 6464 | Au Pb | 303963 | 7916245 | Coxes Find |
| 6465 | Au | 309122 | 7923626 | Sharon |
| 6466 | Au | 482385 | 7799797 | Coyote |
| 6467 | Au | 439058 | 7790546 | Camel |
| 6468 | Au | 423448 | 7821746 | Afghan 2 |
| 6469 | Au | 437106 | 7804651 | Bandicoot |
| 6470 | Au | 462845 | 7791642 | Hutches Find |
| 6475 | Au | 389717 | 8029820 | Brockman King 1 |
| 6476 | Au | 376201 | 7972913 | Brockman King 2 |
| 6477 | Au | 375994 | 7972659 | Southern Cross |
| 6478 | Au | 367864 | 7959131 | No 1 North Ruby Queen |
| 6479 | Au | 367364 | 7958885 | St Lawence Extended South |
| 6480 | Au | 368023 | 7959504 | Pyramid |
| 6481 | Au | 368205 | 7959766 | Union |
| 6482 | Au | 393700 | 8008834 | Mount Coghlan 2 |
| 6522 | Au | 378003 | 7973529 | New Golden Crown |
| 6530 | Au | 310191 | 7914443 | Old Golden Dream |
| 6534 | Au | 367703 | 7957105 | Shortts Hope |
| 6537 | Au | 312772 | 7913593 | Mount Miniard |
| 6556 | Au | 391835 | 8032257 | Granite |
| | Regolith – alluvial to beach placers | | | |
| 2290 | Au | 327435 | 7936939 | Juggler Bow (eluvial) |
| 2293 | Au | 330308 | 7940677 | Head of the Garden 1 |
| 2301 | Au | 295624 | 7890183 | Christmas Creek 4 |
| 2728 | Au | 382660 | 7978775 | Twelve Mile |
| 2729 | Au | 389409 | 7976550 | Elvire River A |
| 2730 | Au | 377833 | 7974858 | Nuggety Gully 1 |
| 2732 | Au | 388292 | 8023458 | Katy Yard 1 |
| 2761 | Au | 401232 | 8060358 | Wills Creek C1 |
| 2766 | Au | 410533 | 8040258 | Black Duck Creek A |
| 2767 | Au | 410832 | 8040058 | Black Duck Creek B |
| 2768 | Au | 411532 | 8039758 | Black Duck Creek C |
| 2876 | Au | 400234 | 8021458 | Saunders Creek (Au) |
| 2984 | Au | 408334 | 8048158 | Chestnut Creek |
| 2994 | Au | 407433 | 8045458 | Slinkey Hill (alluvial) |
| 2996 | Au | 408534 | 8048658 | Lower O'Driscoll Creek |
| 2997 | Au | 408134 | 8050158 | Ball Mill Creek |
| 2998 | Au | 408333 | 8047258 | O'Driscoll Creek |
| 3159 | Au | 395233 | 8005458 | Coghlan East |
| 3194 | Au | 414433 | 8026958 | Wilson Yard |
| 3195 | Au | 414433 | 8026358 | Panton-Elvire (Au) |
| 3196 | Au | 414333 | 8028258 | Hardmans Bend |
| 3197 | Au | 421733 | 8034958 | Big Bend |
| 3228 | Au | 413633 | 8037658 | Sluice Plant |
| 3229 | Au | 411133 | 8047858 | Steep Creek |
| 3328 | Au | 312133 | 7916258 | Mount Dockrell 3 |
| 3329 | Au | 311040 | 7917779 | Lois |
| 3330 | Au | 311216 | 7917193 | Wattle Creek |
| 3356 | Au | 405033 | 7988458 | Elvire River B |
| 5378 | Au | 388648 | 8006914 | Ding Dong Downs (Au) |
| 5411 | Au | 487582 | 7860956 | Gardiner Range 1 |
| 5412 | Au | 491373 | 7868446 | Gardiner Range 2 |
| 5416 | Au | 495647 | 7875069 | Junction Hill |
| 5417 | Au | 489270 | 7874699 | Slatey Creek |
| 5585 | Au | 394545 | 8017130 | Dry Creek 7 |
| 5610 | Au | 366036 | 7967947 | White Elvire River |
| 5615 | Au | 351651 | 7961083 | Koongie Park |
| 5820 | Au | 293894 | 7891556 | Christmas Creek 5 |
| 5826 | Au | 447496 | 7877644 | Lewis Creek |
| 5827 | Au | 446980 | 7880038 | Lewis Creek North |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **PRECIOUS METAL** | | | | |
| | Regolith – alluvial to beach placers | | | |
| 5935 | Au | 311163 | 7920324 | Poachers Creek 1 |
| 5936 | Au W Sn | 311591 | 7918990 | Poachers Creek 2 |
| 5938 | Au | 312504 | 7919887 | Horseshoe Creek 1 |
| 5941 | Au W | 312711 | 7920078 | Horseshoe Creek 2 |
| 5942 | Au Sn | 312663 | 7920204 | Horseshoe Creek 3 |
| 5943 | Au W Sn | 312917 | 7919975 | Horseshoe Creek 4 |
| 5944 | Au | 310933 | 7919847 | South Dockrell 8 |
| 5946 | Au | 313243 | 7920197 | South Dockrell 10 |
| 5962 | Au | 348800 | 7955338 | Kerry-Ann |
| 5984 | Au | 369493 | 7965480 | Halls Gully 3 |
| 5985 | Au | 369121 | 7964900 | Halls Gully 4 |
| 5986 | Au | 368890 | 7964917 | Halls Gully 5 |
| 5987 | Au | 368819 | 7964766 | Halls Gully 6 |
| 5990 | Au | 380609 | 7979781 | Poverty Gully 1 |
| 5991 | Au | 380993 | 7980831 | Poverty Gully 2 |
| 5993 | Au | 381452 | 7980437 | Saunders Creek 2 |
| 5994 | Au | 382183 | 7981073 | Northern Creek |
| 5999 | Au | 357735 | 7963516 | Red Gully |
| 6000 | Au | 357759 | 7962912 | Sam Hazlet Creek |
| 6007 | Au | 357409 | 7962761 | Chinaman Creek |
| 6011 | Au | 355084 | 7961444 | McPhee Creek 2 |
| 6013 | Au | 355393 | 7961047 | McPhee Creek 3 |
| 6014 | Au | 354965 | 7961578 | Blue Bar Creek |
| 6024 | Au | 354483 | 7960491 | Ruby Plains Alluvials 1 |
| 6025 | Au | 355039 | 7961118 | Ruby Plains Alluvials 2 |
| 6026 | Au | 355491 | 7960880 | Ruby Plains Alluvials 3 |
| 6027 | Au | 378395 | 7973917 | Nuggety Gully 2 |
| 6034 | Au | 376298 | 7976028 | Upper Spring Creek |
| 6035 | Au | 376417 | 7978145 | Middle Spring Creek |
| 6036 | Au | 376047 | 7979415 | No Name Creek |
| 6037 | Au | 378243 | 7976386 | Eastern Twin Creek |
| 6040 | Au | 377674 | 7976928 | Western Twin Creek |
| 6046 | Au | 382238 | 7972073 | Donkey Creek 2 |
| 6049 | Au | 375078 | 7971602 | Butchers Creek |
| 6053 | Au | 375885 | 7971761 | Brockman Creek |
| 6057 | Au | 371597 | 7961718 | Ruby Creek |
| 6070 | Au | 346536 | 7965685 | Koongie Rockholes 6 |
| 6091 | Au | 297003 | 7912401 | 8 oz Creek |
| 6102 | Au | 289423 | 7910234 | Janet Creek |
| 6103 | Au | 307153 | 7934694 | Syenite Camp |
| 6104 | Au | 310472 | 7919075 | Lee 1 |
| 6105 | Au | 310433 | 7918670 | Lee 2 |
| 6106 | Au | 309202 | 7917773 | Lee 3 |
| 6116 | Au W | 381908 | 7984255 | Gentle Annie E |
| 6137 | Au | 369654 | 7980155 | Jubilee Creek |
| 6138 | Au | 349289 | 7955790 | East Mary River |
| 6169 | Au | 349281 | 7956191 | Mary River 1 |
| 6171 | Au | 318320 | 7923807 | Fly Creek |
| 6173 | Au | 311933 | 7914998 | Bucket Creek 1 |
| 6185 | Au | 310648 | 7915860 | Top of Bucket |
| 6186 | Au | 310520 | 7914927 | Bucket Creek South |
| 6188 | Au | 310124 | 7914268 | O'Romnys |
| 6192 | Au | 311870 | 7914007 | Upper Willy Willy Creek |
| 6231 | Au | 376316 | 7974895 | Io (alluvials) |
| 6252 | Au | 339827 | 7953857 | Mary River 2 |
| 6253 | Au | 347354 | 7954075 | Thompson Creek |
| 6254 | Au | 344629 | 7951866 | Six Mile Creek |
| 6266 | Au | 345216 | 7950877 | Six Mile Creek 2 |
| 6276 | Au | 332118 | 7941015 | Garden Creek 4 |
| 6287 | Au | 350336 | 7957624 | Specimen Creek |
| 6288 | Au | 350635 | 7956346 | 25 oz Creek |
| 6289 | Au | 346780 | 7955830 | Hopeful Creek |
| 6290 | Au | 346582 | 7955305 | Little Gold Creek |
| | Regolith – residual to eluvial placers | | | |
| 2296 | Au | 331840 | 7941511 | Baxters (eluvial) |
| 2737 | Au | 371287 | 7965258 | Halls Gully 2 |
| 3213 | Au | 389933 | 8029058 | Comet Hill (eluvial) |
| 6071 | Au | 295624 | 7890183 | Christmas Creek 6 |
| 6189 | Au | 309195 | 7913157 | No-name Creek |
| 6299 | Au | 349479 | 7956861 | Bills Patch |
| 6300 | Au | 346320 | 7953766 | Car Body Creek |
| 6301 | Au | 346090 | 7951448 | Susan Peter Creek |
| 6302 | Au | 346852 | 7951622 | Susan Peter |
| 6305 | Au | 348730 | 7954000 | Fine Gold Creek |
| 6308 | Au | 346129 | 7955782 | Mary River 3 |
| 6310 | Au | 348902 | 7957732 | Dam Creek |
| 6311 | Au | 344346 | 7951152 | Golden Plains 2 |
| 6336 | Au | 347939 | 7956576 | Mary River 4 |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **PRECIOUS METAL** | | | | |
| | Regolith – residual to eluvial placers | | | |
| 6345 | Au | 354065 | 7959797 | Blue Bar West |
| 6346 | Au | 354390 | 7960162 | Little Blue Bar Creek |
| 6354 | Au | 358549 | 7962574 | Golden Fleece - Argonaut |
| 6400 | Au | 352140 | 7958212 | Poverty Creek 2 |
| 6425 | Au | 311175 | 7916493 | 1972 |
| 6426 | Au | 310913 | 7916297 | The Patch |
| 6433 | Au | 308294 | 7920311 | Kerry 2 |
| 6434 | Au | 309135 | 7913320 | Jackie |
| 6442 | Au | 308659 | 7915001 | Leonora |
| 6443 | Au | 308897 | 7914921 | Leonora East |
| 6444 | Au | 308989 | 7915212 | Shirleys |
| 6446 | Au | 309730 | 7915953 | Josy |
| 6447 | Au | 310101 | 7915424 | Sara |
| 6451 | Au | 308236 | 7913744 | Linda 2 |
| 6456 | Au | 305907 | 7913241 | Alison |
| 6457 | Au | 305365 | 7911535 | Leo |
| 6486 | Au | 456130 | 8194473 | Prospect Creek |
| 6514 | Au Ag | 399835 | 8006757 | Number 1 |
| 6546 | Au | 346651 | 7951818 | New Look |
| 6730 | Au | 377433 | 7975458 | Rosies Flat |
| | Regolith – residual and supergene | | | |
| 2222 | Au | 394489 | 8016138 | Dry Creek (alluvial) |
| 2252 | Au | 369847 | 7981472 | Olympio (alluvial) |
| 2265 | Au | 348830 | 7954624 | Ann-Marie |
| 2288 | Au | 325101 | 7936287 | 20 Mile (alluvial) |
| **STEEL INDUSTRY METAL** | | | | |
| | Orthomagmatic mafic and ultramafic – layered mafic | | | |
| 5 | Ni Cu Co | 385047 | 8074259 | Spring Complex 1 |
| 7 | Cu Ni Co | 385699 | 8075036 | Spring Complex 2 |
| 10 | Ni Cu Co | 384286 | 8072719 | Spring Complex 3 |
| 13 | Cr | 380652 | 8042542 | Togo 5B |
| 639 | Ni Cu | 393034 | 8047578 | Cabernet |
| 640 | Ni (Cu) | 361734 | 8023558 | West Robin Soak |
| 641 | Ni Cu Co | 413316 | 8087584 | Corkwood 1 |
| 642 | Ni Cu Pt | 390673 | 8086758 | Keller Creek 1 |
| 652 | Cu Ni | 387904 | 8068941 | Ord Crossing (Ni-Cu) |
| 653 | Ni Cu Co | 396283 | 8081558 | Sally Malay |
| 659 | Ni Cu | 423236 | 8113365 | Turkey Creek (Ni-Cu) |
| 666 | Cu Ni Au | 387283 | 8054608 | Melon Patch 2 |
| 667 | Cu Ni Ag | 429277 | 8134890 | Bow River (Ni-Cu) |
| 762 | Ni Cu | 403810 | 8072068 | Bulldust Flat |
| 775 | Ni Cu | 400952 | 8067949 | Wills Creek (Cu-Ni) Alpha |
| 810 | Cu Ni | 422622 | 8095686 | Osmond Valley (Ni-Cu) |
| 812 | Cr (PGE) | 361033 | 8052908 | Toby South |
| 817 | Cr | 376883 | 8016958 | Big Ben |
| 831 | Cr | 321821 | 7956163 | Lamboo (Cr 1) |
| 838 | Ti | 389201 | 8069999 | Ord Crossing (Ti) |
| 842 | Ti | 398632 | 8090158 | Frog Hollow North Lens |
| 843 | Ti | 398533 | 8087558 | Frog Hollow South Lens |
| 2868 | Ni Cu | 392690 | 8046983 | Shiraz |
| 2869 | Ni Cu | 393933 | 8049682 | Malbec |
| 2877 | Ni Cu PGE | 366733 | 8030458 | Springvale A |
| 3554 | Cr (Cu) | 391933 | 8048658 | White Rock Well 2 |
| 3560 | Ni Cu PGE | 389632 | 8049858 | White Rock Well 3 |
| 4205 | Ni Cu | 429285 | 8143523 | Salt Lick Creek (Ni-Cu) |
| 4703 | Ni Cu | 385632 | 8073858 | Coolumbooloo Yard |
| 4739 | Ni Cu | 380929 | 8064252 | McKenzies Spring 4 |
| 4740 | Ni Cu | 380726 | 8063938 | McKenzies Spring 5 |
| 4743 | Ni Cu | 380357 | 8063883 | McKenzies Spring 6 |
| 4745 | Ni Cu | 380118 | 8063497 | McKenzies Spring 7 |
| 4747 | Ni Cu | 380413 | 8066665 | McKenzies Spring 9 |
| 4758 | Ni Cu | 361033 | 8038458 | Springvale 7 |
| 4760 | Ni Cu Co | 398533 | 8078158 | Tickalara Bore 3 |
| 4762 | Ni Cu | 388282 | 8054908 | Melon Patch 8 |
| 5104 | Cr (Zn PGE) | 322376 | 7957117 | Lamboo (Cr 2) |
| 5105 | Cr | 325695 | 7961907 | Lamboo (Cr 3) |
| 5110 | Cr | 325443 | 7961521 | Lamboo (Cr 4) |
| 5113 | Cr (PGE) | 326032 | 7961819 | Lamboo (Cr 5) |
| 5116 | Cr | 323738 | 7959630 | Lamboo (Cr 6) |
| 5117 | Cr (PGE) | 323340 | 7959061 | Lamboo (Cr 7) |
| 5126 | Cr | 323116 | 7958294 | Lamboo (Cr 8) |
| 5128 | Cr | 322151 | 7955529 | Lamboo (Cr 9) |
| 5129 | Cr | 322335 | 7955714 | Lamboo (Cr 10) |
| 5132 | Cr | 322548 | 7955833 | Lamboo (Cr 11) |
| 5135 | Cr | 322706 | 7955780 | Lamboo (Cr 12) |
| 5137 | Cr | 323593 | 7955410 | Lamboo (Cr 13) |

## STEEL INDUSTRY METAL

### Orthomagmatic mafic and ultramafic – layered mafic

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 5140 | Cr | 322032 | 7956614 | Lamboo (Cr 14) |
| 5141 | Cr | 323513 | 7956402 | Lamboo (Cr 15) |
| 5143 | Cr | 323752 | 7956574 | Lamboo (Cr 16) |
| 5152 | Cr | 323952 | 7956826 | Lamboo (Cr 17) |
| 5159 | Cr | 324188 | 7956985 | Lamboo (Cr 18) |
| 5161 | Cr | 325657 | 7959140 | Lamboo (Cr 19) |
| 5162 | Cr | 324360 | 7957341 | Lamboo (Cr 20) |
| 5197 | Ni Cu Ag Au (Pt) | 395610 | 8075629 | Tickalara Bore 4 |
| 5198 | Ti | 385801 | 8066004 | Ord Crossing (Ti) 2 |
| 5199 | Ti | 387599 | 8068729 | Ord Crossing (Ti) 3 |
| 5200 | Ti | 385788 | 8065448 | Ord Crossing (Ti) 4 |
| 5202 | Ni Cu | 395733 | 8077558 | Tickalara Bore 5 |
| 5203 | Ni Cu Au Co | 396205 | 8076515 | Tickalara Bore 6 |
| 5262 | Ni Cu | 382615 | 8065371 | McKenzies Spring 11 |
| 5265 | Ni | 380833 | 8066158 | Donkey Valley 2 |
| 5266 | Ni Cu Co | 382583 | 8066008 | Donovans Reef |
| 5272 | Ni | 373943 | 8032931 | Panton 2 |
| 5273 | Cr | 374155 | 8031821 | Panton 3 |
| 5285 | Ni Cu | 379200 | 8046268 | Mabel Hill (Ni-Cu) 1 |
| 5286 | Ni Co | 378821 | 8046247 | Mabel Hill (Ni-Cu) 2 |
| 5287 | Ni Cu | 429971 | 8135214 | Bow River G |
| 5288 | Ni Cu | 363141 | 8049393 | Billymac Yard D |
| 5292 | Ni Cu | 381676 | 8064465 | McKenzies Spring 14 |
| 5301 | Ni Cu | 387525 | 8068417 | McKenzies East 1 |
| 5302 | Ni Co Cu | 386595 | 8067893 | McKenzies East 2 |
| 5304 | Ni Cu | 384405 | 8066717 | McKenzies East 4 |
| 5305 | Ni Cu | 383795 | 8065781 | McKenzies East 5 |
| 5306 | Ni Cu | 383351 | 8066220 | McKenzies East 6 |
| 5310 | Ni Cu Co | 396018 | 8078899 | Mabel Downs 3 |
| 5311 | Ni Cu | 390858 | 8086797 | Keller Creek 2 |
| 5312 | Ni Cu | 391123 | 8086718 | Keller Creek 3 |
| 5313 | Ni Cu | 390448 | 8086612 | Keller Creek 4 |
| 5314 | Ni Cu | 390792 | 8086096 | Keller Creek 5 |
| 5372 | Ni | 376798 | 8062690 | McKenzie No. 1 |
| 5514 | Ni (Cu) | 413093 | 8087584 | Corkwood 2 |
| 5594 | Cu Ni Co Cr | 409235 | 8080357 | Sally Malay Bore 2 |
| 5595 | Cu Ni Co | 409035 | 8079357 | Sally Malay Bore 3 |
| 5596 | Cu Ni Co | 409535 | 8082757 | Sally Malay Bore 4 |
| 5612 | Ni Cu Co | 396226 | 8085791 | Eskimo Knoll |
| 5787 | Cr (PGE) | 324781 | 7958061 | Lamboo (Cr 21) |
| 5788 | Cr (PGE) | 326294 | 7954201 | Lamboo (Cr 22) |
| 5789 | Cr (PGE) | 325144 | 7952627 | Lamboo (Cr 23) |
| 5790 | Cr | 324072 | 7951237 | Lamboo (Cr 24) |
| 5791 | Cr | 323463 | 7950550 | Lamboo (Cr 25) |
| 5792 | Cr | 323040 | 7950100 | Lamboo (Cr 26) |
| 6140 | Cr (PGE) | 326767 | 7955628 | Lamboo (Cr 27) |

### Orthomagmatic mafic and ultramafic – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 763 | Ni Cu Co | 402983 | 8068308 | Cattle Creek |
| 5204 | Co | 375882 | 8062487 | McKenzies Spring 10 |

### Pegmatitic

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 961 | W | 320429 | 7915784 | Junda 1 |

### Skarn

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 887 | W (Sn) | 314987 | 7907639 | Mount Heartbreak A |
| 930 | W Sn Ta Au | 316639 | 7903935 | Frog Creek |
| 3299 | W (Sn) | 368533 | 8001158 | Central Skarn |
| 3300 | W | 365833 | 8000358 | Southern Skarn |

### Stratabound volcanic and sedimentary – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 934 | W | 376132 | 7987481 | Sophie Downs South |
| 941 | W | 377620 | 7997669 | Sophie Downs West |
| 942 | W | 319739 | 7909041 | Taylor Lookout 1 |
| 944 | W | 319406 | 7909001 | Taylor Lookout 3 |
| 5046 | W | 395275 | 7996450 | Castle Creek 11 |
| 5833 | W | 394320 | 7997069 | Castle Creek 18 |
| 5834 | W | 394273 | 7996990 | Castle Creek 19 |
| 5837 | W | 393979 | 7994886 | Castle Creek 22 |
| 5839 | W | 394177 | 7994814 | Castle Creek 23 |
| 5846 | W | 393153 | 7994008 | Glory Rock Hole 8 |
| 5872 | W | 394799 | 7997565 | Castle Creek 33 |
| 5911 | W | 319334 | 7908700 | Taylor Lookout 10 |
| 5912 | W | 320072 | 7909406 | Taylor Lookout 11 |
| 6366 | Mo Ag (As) | 365585 | 7997607 | Tiger 2 |

### Stratabound sedimentary – clastic-hosted

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 849 | W | 392420 | 7991055 | Rock Pile 1 |
| 868 | W | 393105 | 7994117 | Glory Rock Hole 1 |
| 873 | W | 393693 | 7996133 | Snake Gully North |
| 876 | W Mo | 396722 | 8000397 | Late Night |
| 884 | W Sn Ta | 311564 | 7920544 | South Dockrell 1 |
| 2633 | W | 392034 | 7991938 | Southwest 1 |
| 5036 | W | 397251 | 8002678 | Castle Creek 1 |
| 5037 | W | 397132 | 8002758 | Castle Creek 2 |
| 5038 | W | 397064 | 8001247 | Castle Creek 3 |
| 5039 | W | 396071 | 8001548 | Castle Creek 4 |
| 5040 | W | 395307 | 7999888 | Castle Creek 5 |
| 5041 | W | 395204 | 7999617 | Castle Creek 6 |
| 5042 | W | 394680 | 7998426 | Castle Creek 7 |
| 5043 | W | 395921 | 8001342 | Castle Creek 8 |
| 5047 | W | 395140 | 7996172 | Castle Creek 12 |
| 5048 | W | 394990 | 7995918 | Castle Creek 13 |
| 5049 | W | 394862 | 7995386 | Castle Creek 14 |
| 5831 | W | 393574 | 7995918 | Snake Gully South |
| 5836 | W | 394193 | 7995267 | Castle Creek 21 |
| 5840 | W | 393010 | 7994016 | Glory Rock Hole 2 |
| 5841 | W | 393066 | 7994007 | Glory Rock Hole 3 |
| 5842 | W | 393066 | 7993968 | Glory Rock Hole 4 |
| 5843 | W | 393018 | 7993904 | Glory Rock Hole 5 |
| 5844 | W | 392955 | 7993817 | Glory Rock Hole 6 |
| 5845 | W | 392931 | 7993762 | Glory Rock Hole 7 |
| 5847 | W | 391981 | 7991814 | Southwest 2 |
| 5848 | W | 392076 | 7991711 | Southwest 3 |
| 5849 | W | 392005 | 7991711 | Southwest 4 |
| 5850 | W | 392608 | 7991521 | Castle Creek 24 |
| 5851 | W | 392457 | 7991385 | Castle Creek 25 |
| 5852 | W | 392330 | 7991401 | Castle Creek 26 |
| 5853 | W | 392449 | 7991259 | Castle Creek 27 |
| 5854 | W | 392751 | 7991402 | Castle Creek 28 |
| 5855 | W | 392711 | 7991243 | Castle Creek 29 |
| 5856 | W | 392539 | 7991118 | Castle Creek 30 |
| 5857 | W | 392532 | 7991071 | Castle Creek 31 |
| 5858 | W | 392285 | 7991039 | Rock Pile 2 |
| 5859 | W | 392531 | 7990952 | Rock Pile 3 |
| 5860 | W | 392515 | 7990856 | Rock Pile 4 |
| 5861 | W | 392396 | 7990746 | Rock Pile 5 |
| 5862 | W Ag (Cu Pb) | 392293 | 7990603 | Rock Pile 6 |
| 5863 | W | 392214 | 7990578 | Rock Pile 7 |
| 5864 | W | 392174 | 7990721 | Rock Pile 8 |
| 5865 | W | 392111 | 7990547 | Rock Pile 9 |
| 5866 | W | 392111 | 7990444 | Rock Pile 10 |
| 5867 | W | 392055 | 7990865 | Rock Pile 11 |
| 5868 | W | 392373 | 7990960 | Rock Pile 12 |
| 5869 | W | 392341 | 7990904 | Rock Pile 13 |
| 5870 | W | 392349 | 7990840 | Rock Pile 14 |
| 5873 | W | 394379 | 7997490 | Castle Creek 34 |
| 5874 | W | 395418 | 7996767 | Castle Creek 35 |
| 5875 | W | 394211 | 7997402 | Castle Creek 36 |
| 5876 | W | 394167 | 7997236 | Castle Creek 37 |
| 5878 | W | 394846 | 7998800 | Castle Creek 38 |
| 5879 | W | 394910 | 7998974 | Castle Creek 39 |
| 5880 | W | 394950 | 7999069 | Castle Creek 40 |
| 5881 | W | 395005 | 7999188 | Castle Creek 41 |
| 5882 | W | 394934 | 7999125 | Castle Creek 42 |
| 5883 | W | 395014 | 7999252 | Castle Creek 43 |
| 5884 | W | 395339 | 8000037 | Castle Creek 44 |
| 5885 | W | 395444 | 8000342 | Castle Creek 45 |
| 5886 | W | 395476 | 8000516 | Castle Creek 46 |
| 5887 | W | 395540 | 8000660 | Castle Creek 47 |
| 5888 | W | 395603 | 8000842 | Castle Creek 48 |
| 5889 | W | 397016 | 8002073 | Castle Creek 49 |
| 5890 | W | 397056 | 8001167 | Castle Creek 50 |
| 5891 | W | 397000 | 8001000 | Castle Creek 51 |
| 5926 | W | 311676 | 7920205 | South Dockrell 2 |
| 5927 | W | 312087 | 7920344 | South Dockrell 3 |
| 5928 | W | 312286 | 7920450 | South Dockrell 4 |
| 5929 | W | 312495 | 7920553 | South Dockrell 5 |
| 5930 | W | 313020 | 7921087 | South Dockrell 6 |
| 5931 | W | 312584 | 7920193 | South Dockrell 7 |

### Stratabound sedimentary – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 5597 | V Mo | 411435 | 8084757 | Sally Malay Bore 5 |
| 5598 | V Cr Mo | 411535 | 8085357 | Sally Malay Bore 6 |

### Vein and hydrothermal – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 882 | W | 314487 | 7923031 | North Dockrell |
| 945 | W | 319500 | 7909249 | Taylor Lookout 4 |
| 959 | W (Sn) | 308356 | 7904668 | Balara |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **STEEL INDUSTRY METAL** | | | | |
| | Vein and hydrothermal – undivided | | | |
| 5044 | W | 392679 | 7992521 | Castle Creek 9 |
| 5045 | W | 392743 | 7992481 | Castle Creek 10 |
| 5169 | Mo | 376023 | 8046164 | Mabel Hill |
| 5187 | Ni Cu | 354781 | 8032327 | Springvale 8 |
| 5188 | Ni Cu | 356726 | 8033385 | Springvale 9 |
| 5189 | Ni Cu | 352557 | 8032883 | Springvale 10 |
| 5191 | Ni Cu | 356223 | 8035714 | Springvale 12 |
| 5835 | W | 393915 | 7996180 | Castle Creek 20 |
| 5871 | W | 394640 | 7997474 | Castle Creek 32 |
| 5892 | W | 397024 | 8001278 | Castle Creek 52 |
| 5900 | W (Sn) | 349424 | 7951099 | Ruby Plains 1 |
| 5901 | W (Sn) | 349350 | 7950924 | Ruby Plains 2 |
| 5902 | W (Sn) | 350418 | 7952851 | Ruby Plains 3 |
| 5910 | W | 319135 | 7908874 | Taylor Lookout 9 |
| 6364 | W (As Bi) | 459635 | 7812157 | Hermes |
| | Regolith – alluvial to beach placers | | | |
| 844 | Ilm V | 391503 | 8206338 | Speewah Valley (Ti) |
| 968 | W | 364933 | 8082658 | Foal Creek |
| 2873 | Ilm Mag | 474333 | 8150558 | Ord (HM) |
| 3489 | W | 367083 | 8069908 | Ord River Tributary 1 |
| 3490 | W | 367633 | 8072658 | Ord River Tributary 2 |
| 3492 | W | 384233 | 8058308 | Reedy Creek |
| 3494 | W | 355933 | 8012408 | Little Panton (W) |
| 3496 | W | 368433 | 8062458 | Sandy Creek Tributaries 1 |
| 3499 | W | 359733 | 8058058 | Sandy Creek Tributaries 2 |
| 5909 | W | 320618 | 7929931 | Hangmans (W) |
| | Regolith – residual and supergene | | | |
| 5570 | Ni (Cr) | 323127 | 7980773 | Moola Bulla 2 |
| 6155 | Ni | 324850 | 7960721 | Lamboo (Ni 1) |
| 6166 | Ni | 325387 | 7961260 | Lamboo (Ni 2) |
| 6167 | Ni | 324769 | 7960716 | Lamboo (Ni 3) |
| | Regolith – residual to alluvial | | | |
| 933 | W | 382483 | 7994308 | Sophie Downs North |
| **SPECIALITY METAL** | | | | |
| | Carbonatite and alkaline igneous intrusions | | | |
| 1119 | REE P Zr Nb Vrm | 306820 | 7867004 | Cummins Range (REE) |
| 1122 | REE | 377371 | 8041350 | Copperhead |
| 5961 | REE Nb P | 299571 | 7864392 | Cummins Range (REE 2) |
| | Pegmatitic | | | |
| 926 | Sn | 317617 | 7909540 | Mount Heartbreak F |
| 969 | Sn | 323546 | 7917209 | Mount Cross (Sn 1) |
| 976 | Sn Ta Nb | 309915 | 7895948 | Minneroo Pool 1 |
| 5754 | Sn Nb Ta Li Brl | 314765 | 7907479 | Columbian Creek |
| 5914 | Ta | 320160 | 7917905 | Mount Cross 4 |
| 6380 | Sn | 323289 | 7917633 | Junda 3 |
| | Skarn | | | |
| 972 | Sn | 323973 | 7917638 | Mount Cross (Sn 2) |
| 5748 | Sn Ag | 319408 | 7908764 | Taylor Lookout 7 |
| | Stratabound volcanic and sedimentary – volcanic | | | |
| 1102 | Zr Y Nb Ta Hf Ga REE Al Fl | 371853 | 7974444 | Brockman 1 |
| 1103 | Nb Zr Fl | 379537 | 7989043 | Sophie Downs 1 |
| 5380 | Nb | 389176 | 8008710 | Ding Dong Downs (Nb) |
| 5916 | Nb Zr Fl REE | 379727 | 7989456 | Sophie Downs 2 |
| 6111 | Zr REE Fl Nb | 371374 | 7973752 | Brockman 2 |
| 6112 | REE Zr Nb Fl | 370215 | 7972347 | Brockman 3 |
| 6113 | Nb Sn REE Fl | 370924 | 7973247 | Brockman 4 |
| | Stratabound volcanic and sedimentary – undivided | | | |
| 5750 | Sn Ag | 318551 | 7908391 | Taylor Lookout 8 |
| | Stratabound sedimentary – clastic-hosted | | | |
| 5315 | REE | 416033 | 8088558 | Junior |
| 5316 | REE U | 498449 | 7813401 | Killi Killi 1 |
| 5317 | REE U | 486910 | 7818835 | Killi Killi West |
| | Vein and hydrothermal – undivided | | | |
| 1105 | REE (U) | 417730 | 8087637 | John Galt (REE 1) |
| 5318 | REE (U) | 417929 | 8087815 | John Galt (REE) 2 |
| 5319 | REE | 418206 | 8088358 | John Galt (REE) 3 |
| 5673 | Bi (Au) | 308963 | 7874679 | Shiddi Creek |
| 6141 | REE (P U) | 487123 | 7870098 | Whites Beach |
| 6260 | REE | 491828 | 7909971 | Browns Range Dome |

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **SPECIALITY METAL** | | | | |
| | Regolith – alluvial to beach placers | | | |
| 890 | Sn Ta | 314832 | 7907758 | Mount Heartbreak B |
| 891 | Sn Ta | 313933 | 7907908 | Mount Heartbreak C |
| 895 | Sn Ta | 311832 | 7905408 | Mount Heartbreak D |
| 898 | Sn Ta | 314883 | 7906058 | Mount Heartbreak E |
| 965 | Ta Nb Sn W | 320124 | 7917762 | Junda 2 |
| 966 | Sn | 374633 | 8130158 | Neil Creek 1 |
| 3005 | REE | 415032 | 8086158 | Corkwood Yard |
| 3376 | Sn Ta Nb | 351933 | 8097958 | Mount Remarkable 7 |
| 3378 | Sn | 352333 | 8111408 | Mount Remarkable 8 |
| 3488 | Sn | 374933 | 8130308 | Neil Creek 2 |
| 5822 | Sn Ta Nb Au | 310063 | 7895964 | Minneroo Pool 3 |
| 5915 | Ta | 318770 | 7917585 | Junda 4 |
| 6379 | Sn | 323075 | 7917109 | Mount Cross 3 |
| | Regolith – residual to elluvial | | | |
| 3156 | Sn | 390033 | 8011158 | Saunders Creek (Sn) |
| **BASE METAL** | | | | |
| | Orthomagmatic mafic and ultramafic – layered mafic | | | |
| 661 | Cu Ni | 382019 | 8065031 | McKenzies Spring 1 |
| 663 | Cu Ni PGE | 387083 | 8053408 | Melon Patch 1 |
| 771 | Cu (Ni) | 389183 | 8051908 | White Rock Well West |
| 806 | Cu Ni | 364085 | 8050038 | Billymac Yard A |
| 1037 | Cu | 362935 | 8049627 | Billymac Yard B |
| 2719 | Cu Ni Au | 401983 | 8062808 | Wills Creek D |
| 2878 | Zn (Ni Cu Cr) | 366133 | 8028958 | Springvale B |
| 3511 | Cu (Cr) | 379733 | 8042858 | Mini M (Cu) |
| 4737 | Cu Ni | 381647 | 8064749 | McKenzies Spring 2 |
| 4738 | Cu Ni | 381205 | 8064307 | McKenzies Spring 3 |
| 4746 | Cu Ni | 379842 | 8063404 | McKenzies Spring 8 |
| 4753 | Cu | 361533 | 8036658 | Springvale 4 |
| 4756 | Cu | 360432 | 8035758 | Springvale 5 |
| 4757 | Cu | 361033 | 8033864 | Springvale 6 |
| 4759 | Cu Ni | 398833 | 8078258 | Tickalara Bore 2 |
| 4952 | Cu | 427981 | 8134070 | Bow River A |
| 4953 | Cu | 427742 | 8134427 | Bow River B |
| 4954 | Cu | 427610 | 8134533 | Bow River C |
| 4955 | Cu | 427465 | 8134745 | Bow River D |
| 4956 | Cu | 428166 | 8134533 | Bow River E |
| 4957 | Cu | 430441 | 8135816 | Bow River F |
| 4964 | Cu | 250700 | 7930518 | Eastman (Cu) C |
| 5254 | Zn Cu Pb Ag | 320984 | 7961025 | Emull West 1 |
| 5263 | Cu | 381041 | 8066336 | McKenzies Spring 12 |
| 5264 | Cu Ni | 380253 | 8066088 | Donkey Valley 1; Survey One; Su1 |
| 5268 | Cu Ni | 386733 | 8074458 | Coolumbooloo Yard 2 |
| 5291 | Cu Ni | 379426 | 8063063 | McKenzies Spring 13 |
| 5293 | Cu Ni | 396799 | 8075735 | Tickalara Bore 8 |
| 5303 | Cu | 386135 | 8067217 | McKenzies East 3 |
| 5368 | Cu Ni Co | 322573 | 7964800 | Lamboo (Cu-Ni) |
| 5370 | Cu | 386569 | 8048568 | MI-2b |
| 5566 | Cu (Ni) | 356397 | 8071431 | Paynes Gossan East |
| 5571 | Cu Ni | 413117 | 8087770 | Corkwood 3 |
| 6213 | Cu PGE | 250100 | 7930297 | Eastman Bore (Cu 4) |
| 6218 | Cu | 250068 | 7930058 | Eastman Bore (Cu 5) |
| | Orthomagmatic mafic and ultramafic – undivided | | | |
| 14 | Cu Ni | 389233 | 8038958 | Eileen Bore 2 |
| 764 | Ni Cu PGE | 389583 | 8040158 | Eileen Bore |
| 766 | Cu | 387714 | 8047239 | McIntosh A |
| 1147 | Zn Cu Pb Ag Au (Cd Bi) | 321408 | 7961056 | Emull |
| 2483 | Cu | 413396 | 8074317 | Fish Hole Waterhole |
| 2485 | Cu | 418946 | 8088477 | Osmond Range West |
| 6312 | Cu (Au Ag) | 230412 | 7939006 | Louisa Downs 3 |
| | Disseminated and stockwork in plutonic intrusions | | | |
| 1087 | Cu Ag | 425354 | 8109657 | Killarney 1 |
| 1093 | Cu | 425235 | 8111162 | McHales |
| 1098 | Cu Mo Ag | 338700 | 7958663 | Mount Angelo Porphyry |
| 5297 | Cu | 425420 | 8109949 | Killarney 2 |
| 5298 | Cu | 425558 | 8109869 | Killarney 3 |
| 5299 | Cu | 425420 | 8109446 | Killarney 4 |
| 5300 | Cu | 425062 | 8109499 | Killarney 5 |
| | Skarn | | | |
| 1050 | Cu | 381751 | 8051305 | Melon Patch Well A |
| 1054 | Cu | 383233 | 8056088 | Melon Patch Well B |
| 1055 | Cu | 383733 | 8054298 | Melon Patch Well C |
| 1063 | Cu Zn Ag | 400383 | 8066258 | Wills Creek B1 |
| 1071 | Cu | 397933 | 8053058 | Wills Creek B4 |

## BASE METAL

Skarn

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 1074 | Zn Ag | 397539 | 8052431 | Wills Creek B5 |
| 1078 | Cu Ag | 397133 | 8051508 | Wills Creek B6 |
| 1085 | Cu Zn Ag | 392188 | 8049536 | White Rock Well |
| 3298 | Zn (Pb) | 369133 | 8001158 | BB Hill |
| 3306 | Cu | 398733 | 8063258 | Sally Downs A |
| 3307 | Zn | 392333 | 8051358 | Sally Downs B |
| 5032 | W | 393833 | 8057958 | Sally Downs D |
| 5290 | Cu | 393160 | 8061216 | Wills Creek B7 |
| 5530 | Zn | 430150 | 8097485 | Osmond Valley (Zn 7) |
| 5743 | Cu Ag Mo | 320075 | 7909328 | Skarn A |

Stratabound volcanic and sedimentary – volcanic-hosted sulfide

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 1125 | Cu Zn Pb Ag (Au) | 340032 | 7968758 | Sandiego (sulphide) |
| 1133 | Zn Cu Pb | 346223 | 7974088 | Onedin |
| 1135 | Zn Pb Cu | 346373 | 7976196 | Gosford |
| 1136 | Zn Pb Cu | 343893 | 7969288 | Atlantis |
| 1167 | Cu Ag (Au) | 357931 | 7985518 | Golf Course 1 |
| 1192 | Zn Pb | 377528 | 7997683 | Twin Hills 1 |
| 5074 | Zn Ag | 368964 | 7964212 | Ruby Queen - Brockman 2 |
| 5377 | Zn Ag | 389277 | 8010435 | Palm Creek |
| 5472 | Cu | 358447 | 7986020 | Golf Course 3 |
| 5480 | Cu (Zn) | 342558 | 7963270 | Angelo Valley 2 |
| 5572 | Zn Pb Cu | 389605 | 8010286 | Dry Creek South |
| 5689 | Cu | 241022 | 7928204 | Eastman Bore East |
| 5696 | Zn Pb Cu | 249008 | 7931300 | Bullock Bore 10 |
| 5728 | Zn Pb | 377298 | 7997302 | Twin Hills 2 |
| 5745 | Cu Ag | 318441 | 7908351 | Taylor Lookout 6 |
| 6279 | Pb Zn | 350139 | 7978313 | Mother O'Neil |

Stratabound volcanic and sedimentary – sedimentary-hosted sulfide

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 1169 | Ag Pb Zn | 374346 | 7999969 | Duffer Range 1 |
| 1180 | Cu Zn Pb Au Ag | 379320 | 8001317 | Ilmars Central |
| 1188 | Zn Pb Cu | 377972 | 8000047 | Little Mount Isa |
| 1197 | Cu Zn Pb (Sn) | 381033 | 7986508 | Gentle Annie A |
| 1202 | Cu Pb Zn Ag (Sn) | 380773 | 7985376 | Gentle Annie B |
| 1206 | Cu Pb Zn Ag Au | 389900 | 8002397 | Bullman |
| 1252 | Cu (Zn) | 411387 | 8081329 | Tickalara |
| 2531 | Cu | 326322 | 7974741 | Ten Minute (Cu 3) |
| 2871 | Zn Pb Cu | 342433 | 7997858 | Five Mile B |
| 4805 | Zn Pb Cu Ag | 379773 | 8002115 | Ilmars North |
| 4812 | Zn Cu Ag | 379130 | 8000861 | Ilmars Range |
| 4817 | Zn Cu | 377805 | 7998517 | Discovery Hill |
| 4818 | Pb | 378067 | 7998092 | Quartz blow |
| 4820 | Cu Pb | 379591 | 8002621 | Ilmars Syncline |
| 4882 | Zn | 389689 | 8005720 | Sophie Downs (Zn) 1 |
| 4918 | Zn | 384992 | 7998378 | Sophie Downs (Zn) 3 |
| 4923 | Zn | 382637 | 7993563 | Sophie Downs (Zn) 4 |
| 4924 | Zn | 382439 | 7992968 | Sophie Downs (Zn) 5 |
| 4946 | Zn | 394503 | 8013096 | Panton River (gossan) 1 |
| 4947 | Zn | 394026 | 8012646 | Panton River (gossan) 2 |
| 5017 | Cu Ag | 316617 | 7905635 | Cummins Range (Bm) D |
| 5019 | Ag Cu | 320609 | 7909662 | Cummins Range (Bm) E |
| 5035 | Ag Cu | 395254 | 8001343 | Cow Creek Gossan |
| 5088 | Cu | 380922 | 7986178 | Gentle Annie C |
| 5093 | Zn | 378474 | 8001198 | Gossan Z |
| 5095 | Cu Pb Zn | 380036 | 8002904 | Ilmars North 2 |
| 5236 | Cu Ag | 305639 | 7917006 | Black Bishop Hill B |
| 5326 | Cu | 326369 | 7974720 | Ten Minute (Cu 4) |
| 5327 | Cu | 326544 | 7974265 | Ten Minute (Cu) 5 |
| 5369 | Zn | 383935 | 8006357 | EM35 |
| 5381 | Cu | 324970 | 7959199 | New Homestead |
| 5384 | Pb | 239687 | 7942464 | Mount Ramsay 2 |
| 5387 | Zn Pb | 239861 | 7939267 | Mount Ramsay 15A |
| 5471 | Zn Pb | 358302 | 7985762 | Golf Course 2 |
| 5786 | Cu | 237990 | 7930729 | Landrigan Creek 2 |
| 6278 | Pb Zn | 353196 | 7980655 | Weldens Creek |

Stratabound volcanic and sedimentary – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 943 | Cu Mo Ag W | 319112 | 7908652 | Taylor Lookout 2 |
| 946 | Cu Mo Ag | 318067 | 7907899 | Taylor Lookout 5 |
| 982 | Cu | 319495 | 7908891 | Cummins Range (Bm) A |
| 988 | Cu | 317912 | 7907519 | Cummins Range (Bm) B |
| 997 | Cu Pb Zn Ag | 318308 | 7908203 | Cummins Range (Bm) C |
| 1134 | Cu Pb Zn | 338073 | 7965613 | Hanging Tree |
| 1137 | Cu Ag (Zn) | 340478 | 7960183 | Mount Angelo North |
| 1138 | Cu Pb Zn Ag | 241208 | 7928301 | Eastman Bore (Cu-Pb-Zn) |
| 1139 | Cu Zn Pb Ag Au Mo | 238659 | 7929724 | Landrigan Creek |
| 1140 | Cu Zn Pb | 249480 | 7931895 | Bullock Bore 1 |
| 1144 | Cu Zn Pb Au Bi | 248964 | 7931828 | Bullock Bore 6 |

## BASE METAL

Stratabound volcanic and sedimentary – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 1160 | Zn Cu Ag Pb | 320582 | 7961758 | Location 5 |
| 1178 | Cu Zn Ag Pb (Au) | 328362 | 7964407 | Dusty Bore 1 |
| 1214 | Zn Cu Pb Ag | 244786 | 7929667 | Daves Gossan |
| 1215 | Cu Pb Zn Ag | 247441 | 7931007 | Eastman Yard East 1 |
| 1271 | Cu | 383632 | 7993158 | Brim Creek |
| 1300 | Cu | 227456 | 7943354 | Morgans Grave |
| 2429 | Cu | 388533 | 7994758 | Ding Dong Downs (Cu) |
| 2433 | Cu | 342467 | 8127378 | Carson Volcanics 4 |
| 2434 | Cu | 344519 | 8129853 | Carson Volcanics 5 |
| 2435 | Cu | 349944 | 8136808 | Carson Volcanics 6 |
| 2436 | Cu | 355948 | 8146225 | Carson Volcanics 7 |
| 2438 | Cu | 356243 | 8146535 | Carson Volcanics 8 |
| 2440 | Cu | 358449 | 8148701 | Carson Volcanics 9 |
| 2441 | Cu | 364447 | 8160113 | Carson Volcanics 10 |
| 2442 | Cu | 364591 | 8160728 | Carson Volcanics 11 |
| 2443 | Cu | 367785 | 8165352 | Carson Volcanics 12 |
| 2445 | Cu | 369424 | 8169979 | Carson Volcanics 13 |
| 2452 | Cu | 369507 | 8180737 | Carson Volcanics 15 |
| 2463 | Cu | 369981 | 8175822 | Carson Volcanics 16 |
| 2465 | Cu | 354326 | 8145292 | Carson Volcanics 17 |
| 2466 | Cu | 347456 | 8132948 | Carson Volcanics 20 |
| 2467 | Cu | 348626 | 8134801 | Carson Volcanics 21 |
| 2468 | Cu | 355967 | 8146459 | Carson Volcanics 22 |
| 2469 | Cu | 354470 | 8145908 | Carson Volcanics 23 |
| 2471 | Cu | 354470 | 8145908 | Carson Volcanics 24 |
| 2476 | Cu | 354470 | 8145908 | Carson Volcanics 26 |
| 2477 | Cu | 356247 | 8145920 | Carson Volcanics 27 |
| 2479 | Cu | 358011 | 8147776 | Carson Volcanics 28 |
| 2480 | Cu | 354470 | 8145908 | Carson Volcanics 33 |
| 2481 | Cu | 354470 | 8145908 | Carson Volcanics 35 |
| 2487 | Cu | 433459 | 8216415 | Dunham Crossing |
| 2488 | Cu | 485900 | 8181434 | Behn Gorge |
| 2498 | Cu | 432317 | 8205091 | Dunham Station |
| 2499 | Cu | 487700 | 8144562 | Wild Dog |
| 2500 | Cu | 496575 | 8177751 | Rosewood Wall A |
| 2502 | Cu | 480547 | 8134409 | Spring Hill |
| 2505 | Cu | 416875 | 8026351 | Panton-Elvire (Cu) |
| 2517 | Cu Ag | 438133 | 8095008 | Paradise Creek (Cu B) |
| 2522 | Cu | 459983 | 8017014 | Cuddys Find |
| 2529 | Cu | 326592 | 7974868 | Ten minute (Cu 1) |
| 2872 | Zn | 343633 | 7998958 | Five Mile C |
| 4831 | Cu Ag Zn | 342333 | 7962958 | Angelo Valley 1 |
| 4988 | Pb Cu Zn | 240331 | 7932460 | Margaret River Gossan 1 |
| 4989 | Pb Zn Ag (Au) | 242312 | 7932534 | Margaret River Gossan 2 |
| 5051 | Cu Ag | 396311 | 8001105 | Castle Creek 15 |
| 5052 | Zn Cu Ag | 396616 | 8000522 | Castle Creek 16 |
| 5398 | Zn (Pb) | 244921 | 7930389 | Eastman Yard 1 |
| 5399 | Zn (Pb) | 244246 | 7929888 | Eastman Yard 2 |
| 5400 | Cu | 244573 | 7929792 | Eastman Yard 3 |
| 5422 | Cu | 484771 | 7946181 | Mount Wittenoom |
| 5501 | Pb Ag Cu Zn | 342610 | 7973361 | Gossan Area 5 |
| 5502 | Cu (Zn) | 336970 | 7960117 | Blue Hills |
| 5778 | Ag Cu Pb Zn | 244528 | 7930144 | Eastman Yard 4 |
| 5780 | Cu Ag | 244480 | 7928877 | Eastman Yard 5 |
| 5781 | Cu Ag | 244626 | 7928493 | Eastman Yard 6 |
| 5782 | Pb Zn Ag | 244519 | 7930434 | Eastman Yard 7 |
| 5783 | Pb | 246967 | 7930806 | Eastman Yard East 2 |
| 5784 | Pb Zn | 242121 | 7930523 | Eastman Yard 8 |
| 5785 | Cu | 241382 | 7930515 | Eastman Yard 9 |
| 5959 | Ag Cu Pb | 229272 | 7943454 | Morgans Grave 2 |
| 6277 | Cu | 428735 | 7983057 | Coolibah Creek |
| 6324 | Cu | 328219 | 7972643 | Dim Whiddy (Cu1) |
| 6326 | Cu | 327822 | 7972392 | Dim Whiddy (Cu2) |
| 6327 | Pb | 327954 | 7972564 | Dim Whiddy (Pb) |
| 6356 | Cu Zn Ag (Au) | 340200 | 7960143 | Mount Angelo North 2 |
| 6367 | Ag Zn | 365655 | 7997067 | Tiger 3 |
| 6495 | Cu | 429307 | 8198672 | Cassidys |
| 6496 | Cu | 417380 | 8198987 | Dunham River (Cu) |

Stratabound sedimentary – carbonate-hosted

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 1045 | Cu W Au (Sn) | 400433 | 8066258 | Alice Downs |
| 2507 | Pb | 431034 | 8096058 | Paradise Creek (Pb) |
| 2518 | Pb | 440501 | 8089634 | Trend 1 |
| 2519 | Cu | 448721 | 8105783 | Osmond Range |
| 2523 | Cu | 497820 | 8178523 | Rosewood Wall B |
| 4489 | Cu | 344481 | 8135078 | Teronis 1 |
| 4506 | Cu | 359833 | 8159158 | Teronis 2 |
| 4510 | Cu | 360633 | 8160958 | Teronis 3 |
| 5030 | Cu (Mo) | 390533 | 8053258 | Sally Downs C |

## BASE METAL

### Stratabound sedimentary – carbonate-hosted

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| *5033* | Cu Ag | 391061 | 8051128 | Alice Downs 5 |
| *5193* | Zn | 399766 | 8080313 | Fletcher Creek |
| *5373* | Cu Zn | 437722 | 8087702 | Trend 2 |
| *5374* | Zn | 441413 | 8091254 | Trend 3 |
| *5375* | Zn | 441803 | 8091499 | Trend 4 |
| *5437* | Zn Cu Pb Ag | 189200 | 7984995 | Horse Spring Range 1 |
| *5440* | Pb Zn | 189742 | 7987523 | Horse Spring Range 2 |
| *5443* | Pb Zn | 182982 | 7985155 | Findlay Hill 2 |
| *5461* | Zn | 189398 | 7985511 | Horse Spring Range 3 |
| *5462* | Zn Pb | 219635 | 7901507 | Black Spur 1 |
| *5466* | Zn Pb | 219485 | 7903207 | Black Spur 2 |
| *5522* | Cu | 424196 | 8093992 | Osmond Valley (Cu 1) |
| *5523* | Cu | 423787 | 8093754 | Osmond Valley (Cu 2) |
| *5525* | Cu | 426247 | 8095090 | Osmond Valley (Cu 3) |
| *5636* | Zn Pb Ag Cu | 186932 | 7925440 | Christmas Creek Reef 5 |
| *5637* | Zn Pb | 192756 | 7924868 | Christmas Creek Reef 7 |
| *5647* | Zn Pb | 187226 | 7931457 | Ross Hill 1 |
| *5648* | Zn Pb | 187147 | 7930861 | Ross Hill 2 |
| *5650* | Zn Pb | 187202 | 7930543 | Ross Hill 3 |
| *5651* | Zn Pb | 187369 | 7930195 | Ross Hill 4 |
| *5652* | Zn Pb | 187091 | 7930965 | Ross Hill 5 |
| *5653* | Zn Pb | 186742 | 7931631 | Ross Hill 6 |
| *5657* | Cu Pb Zn | 188618 | 7938317 | North Laidlow |
| *5659* | Pb Zn | 194349 | 7931342 | Teichart Hills |
| *5660* | Zn Pb | 187475 | 7934456 | Laidlaw Range |
| **6472** | Zn Pb | 184323 | 7926076 | Kapok |
| *6473* | Pb | 184107 | 7927155 | Pinnacles Lead |
| *6483* | Cu | 492026 | 8095245 | Mount Elder |

### Stratabound sedimentary – clastic-hosted

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| *3* | Zn Pb Ag | 394311 | 8085950 | Keller Creek East |
| *4* | Zn | 385187 | 8068916 | Spring Four |
| *2508* | Cu | 440134 | 8093958 | Paradise Creek (Cu A) |
| *4543* | Cu | 349426 | 8227607 | Menuairs Dome 3 |
| *5343* | Cu (Zn) | 368549 | 8022500 | Little Panton (Cu) |
| *5371* | Cu | 383454 | 8047367 | MI-10 |
| *5401* | Zn | 227245 | 7942765 | Mount Ramsay 20 |
| *5519* | Zn | 422503 | 8092749 | Osmond Valley (Zn 1) |
| *5520* | Zn | 422172 | 8092484 | Osmond Valley (Zn 2) |
| *5521* | Zn | 424196 | 8093820 | Osmond Valley (Zn 3) |
| *5524* | Zn | 426115 | 8094773 | Osmond Valley (Zn 4) |
| *5527* | Cu | 428933 | 8097207 | Osmond Valley (Cu 4) |
| *5528* | Zn | 428363 | 8096228 | Osmond Valley (Zn 5) |
| *5529* | Zn | 428985 | 8096678 | Osmond Valley (Zn 6) |
| *5531* | Ag Pb Zn | 429935 | 8098717 | Osmond Valley (Ag-Pb-Zn) |
| *5532* | Zn | 432028 | 8098503 | Osmond Valley (Zn 8) |
| *5533* | Zn | 434237 | 8098252 | Osmond Valley (Zn 9) |
| *5534* | Zn | 435481 | 8098609 | Osmond Valley (Zn 10) |
| *5535* | Cu Ag | 436063 | 8098768 | Osmond Valley (Cu-Ag) |

### Stratabound sedimentary – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| *1059* | Cu Zn Pb Ag (Sn) | 401373 | 8061760 | Wills Creek A |
| *2506* | Cu | 456083 | 8152058 | Discovery Yard |
| *5307* | Cu PGE (Ni) | 411037 | 8084330 | Sally Malay Bore 1 |
| *5308* | Zn | 391558 | 8085646 | Mabel Downs 1 |
| *5309* | Cu | 392525 | 8080751 | Mabel Downs 2 |
| *5537* | Zn Pb | 426737 | 8093661 | Osmond Valley (Zn-Pb) |
| *5538* | Cu | 417913 | 8095474 | Unnamed (Cu) |

### Vein and hydrothermal – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| *11* | Cu (Ag Zn) | 378791 | 8043735 | Mini M (Cu) 2 |
| *794* | Cu | 250332 | 7930308 | Eastman (Cu) B |
| *797* | Cu | 248933 | 7930038 | Eastman (Cu) D |
| *1070* | Cu Zn | 402183 | 8060608 | Wills Creek B3 |
| *1104* | Pb Fl | 388103 | 8008194 | Ding Dong Downs (Pb-F) |
| *1210* | Cu | 314003 | 7914686 | McLintock Range |
| *1211* | Cu | 400108 | 7994599 | Mount Kinahan A |
| *1212* | Pb | 249430 | 7931749 | Bullock Bore 7 |
| *1213* | Cu | 249983 | 7930938 | Bullock Bore 2 |
| *1216* | Cu Zn Pb Fl | 314532 | 7944558 | Lamboo No. 1 |
| *1217* | Cu Ag (Au) | 279974 | 7936549 | Margaret River 1 |
| *1218* | Cu Ag | 280733 | 7937658 | Margaret River 2 |
| *1219* | Cu Ag Au | 280847 | 7937317 | Margaret River 3 |
| *1221* | Pb Ag Brt Fl | 464521 | 8198924 | Boxers |
| *1222* | Cu | 411476 | 8074409 | Calico Spring 1 |
| *1240* | Cu | 406891 | 8077361 | Corkwood West |
| *1241* | Cu | 445912 | 8163855 | Excelsior Range |
| *1242* | Cu | 398858 | 8090539 | Froghollow Spring |
| *1243* | Cu | 417138 | 8097068 | Mabel Downs East |

## BASE METAL

### Vein and hydrothermal – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| *1244* | Cu Pb (Zn Ni) | 354483 | 7987008 | Moola Bulla |
| *1245* | Cu Zn Ag | 374932 | 8011596 | Palm Spring 1 |
| *1247* | Cu | 378333 | 8039158 | Roses Bore |
| *1249* | Pb | 358333 | 8019404 | Springvale (Pb) |
| *1250* | Pb Ag | 354933 | 8014658 | Three Sisters |
| *1251* | Cu | 394486 | 8079452 | Tickalara Bore |
| *1256* | Pb Ag Fl | 417133 | 8128958 | Turkey Creek (Pb-Ag-F) |
| ***1257*** | Pb Ag Cu Zn (Au) | 286537 | 7964929 | Black and Glidden |
| *1259* | Pb Ag Zn (Au Cu) | 280925 | 7974144 | Dead Horse Creek |
| *1262* | Cu Pb Ag | 276283 | 7967958 | Dead Horse Bore Yard |
| *1264* | Pb Ag | 256418 | 7956748 | Hells Gate Southwest |
| *1265* | Pb Ag Zn | 257065 | 7955676 | Hells Gate Southeast |
| *1268* | Cu Pb | 257226 | 7960747 | Hells Gate North |
| *1272* | Cu Pb Zn Ag Au | 248362 | 7956018 | Me No Savvy A |
| *1274* | Cu Au Ag Pb | 248816 | 7955305 | Me No Savvy B |
| *1277* | Cu Ag | 249484 | 7955088 | Me No Savvy D |
| *1327* | Cu | 237932 | 7953058 | Taylor River |
| *1329* | Zn Cu Pb Ag | 240632 | 7942958 | Lilyhole Bore |
| *1332* | Cu | 419633 | 8168158 | Camel Creek Yard |
| *1333* | Cu | 351083 | 8075858 | Mount Remarkable 1 |
| *1334* | Cu Pb | 359033 | 8077908 | Mount Remarkable 2 |
| *1335* | Cu Pb | 359633 | 8081308 | Mount Remarkable 3 |
| *1337* | Cu Pb | 348682 | 8086458 | Mount Remarkable 4 |
| *1340* | Cu Pb Ag (Mo Au Sn) | 363983 | 8114408 | Base Metal Prospect |
| *1341* | Cu | 405831 | 8182155 | O'Donnell Range |
| *1344* | Cu | 229432 | 7951958 | Palm Spring 2 |
| *1378* | Zn Cu Pb Ag | 367346 | 8060623 | Snake |
| *1380* | Cu (Ag Pb) | 288689 | 7981410 | Mount Amherst 2 |
| *1381* | Pb Cu Ag | 299455 | 7992388 | Blackfellow Creek |
| *1497* | Cu Pb | 391223 | 8210658 | Speewah 1 |
| ***1500*** | Pb Cu Ag Au Sb | 391436 | 8206501 | Martins |
| *1501* | Cu Pb Ag | 389932 | 8204278 | Calamondah |
| *1503* | Cu | 387973 | 8194608 | Speewah IV |
| *1504* | Cu Pb | 386193 | 8191598 | Speewah V |
| *1505* | Cu Pb Ag | 385132 | 8185478 | Speewah VI |
| *1506* | Cu | 427733 | 8094458 | Osmond Creek |
| *1507* | Cu | 424037 | 8094604 | Wallys |
| *1508* | Cu | 429233 | 8098058 | Mount Parker |
| *1509* | Pb | 420433 | 8096058 | Palms Yard |
| *2209* | Cu | 423537 | 8094604 | Minatome |
| *2330* | Cu Au Ag | 306327 | 7911516 | Horrys Copper Show |
| *2331* | Cu Au Ag | 311982 | 7919158 | Hanging Drum Copper Show |
| *2346* | Pb | 409646 | 8180382 | Jailhouse Creek 2 |
| *2520* | Pb Ag | 467624 | 8206438 | Carr Boyd 1 |
| *2521* | Pb Cu Ag | 436134 | 8099558 | Osmond Creek (Pb) |
| *2530* | Cu | 326694 | 7974590 | Ten Minute (Cu 2) |
| *2720* | Cu | 414002 | 8070631 | Frank River |
| *2721* | Cu | 312282 | 7931358 | Hangman Creek |
| *2722* | Cu | 389844 | 8011500 | Mount Coghlan |
| *2723* | Cu | 326767 | 7959392 | New Lamboo |
| *2725* | Cu | 228711 | 7952281 | Pond Spring |
| *2758* | Pb Cu | 364133 | 8114458 | Middletons |
| *2870* | Cu (Au) | 344633 | 7999558 | Five Mile A |
| *2924* | Cu | 406242 | 8061708 | Ord (Cu) |
| *2966* | Cu | 350468 | 8210427 | Campbellmerry |
| *3155* | Pb Zn Ag | 390478 | 8028568 | Alice Downs 2 |
| *3384* | Cu | 415033 | 8077858 | Frank River 2 |
| *3385* | Cu | 420683 | 8082008 | Frank River 3 |
| *4299* | Cu | 245106 | 7928921 | Bullock Bore 3 |
| *4301* | Cu Ag | 244376 | 7929191 | Bullock Bore 4 |
| *4641* | Cu | 353682 | 8073658 | Mount Remarkable 9 |
| *4643* | Cu | 361032 | 8091158 | Mount Remarkable 10 |
| *4644* | Cu | 360232 | 8094358 | Mount Remarkable 11 |
| *4645* | Cu | 353233 | 8064958 | Mount Remarkable 12 |
| *4799* | Cu | 281220 | 7975045 | Dead Horse 2 |
| *4800* | Cu | 279034 | 7972689 | Dead Horse 3 |
| *4801* | Cu | 277571 | 7971648 | Dead Horse 4 |
| *4803* | Cu | 275525 | 7968561 | Dead Horse 6 |
| *4822* | Cu | 377217 | 7997620 | Sophie Downs (Cu) 1 |
| *4830* | Cu | 337845 | 7958040 | Mount Angelo South |
| *4832* | Pb | 466896 | 8209666 | Carr Boyd 2 |
| *4834* | Pb Ag | 467161 | 8206279 | Carr Boyd 3 |
| *4838* | Pb Ag | 467545 | 8207272 | Carr Boyd 4 |
| *4842* | Pb Ag (Zn) | 467703 | 8207153 | Carr Boyd 5 |
| *4846* | Pb Zn Ag | 467305 | 8207576 | Carr Boyd 6 |
| *4847* | Pb Zn Ag | 467293 | 8208767 | Carr Boyd 7 |
| *4864* | Cu Zn Ag | 377456 | 7999769 | Gossan Y |

## BASE METAL

Vein and hydrothermal – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 4915 | Zn | 383947 | 7998948 | Sophie Downs (Zn) 2 |
| 4916 | Cu | 384807 | 8000468 | Sophie Downs (Cu) 2 |
| 4917 | Cu | 384317 | 7997981 | Sophie Downs (Cu) 3 |
| 4919 | Cu | 384066 | 7994396 | Sophie Downs (Cu) 4 |
| 4920 | Cu | 384053 | 7994238 | Sophie Downs (Cu) 5 |
| 4921 | Cu | 384039 | 7993695 | Sophie Downs (Cu) 6 |
| 4922 | Cu | 383973 | 7993219 | Sophie Downs (Cu) 7 |
| 4930 | Cu Pb | 438808 | 8143634 | Mount Pitt A |
| 4931 | Cu Pb | 438404 | 8143634 | Mount Pitt B |
| 4932 | Cu Pb | 439792 | 8142662 | Mount Pitt C |
| 4933 | Cu | 439691 | 8142826 | Mount Pitt D |
| 4936 | Cu | 439678 | 8143445 | Mount Pitt F |
| 4937 | Cu Pb | 439537 | 8144872 | Mount Pitt E |
| 4938 | Cu Pb | 439352 | 8145163 | Mount Pitt H |
| 4951 | Pb | 410888 | 8129704 | Bow River (Pb) |
| 4958 | Cu | 426406 | 8148000 | Salt Lick Creek (Cu) |
| 4961 | Pb Cu | 249391 | 7931603 | Bullock Bore 9 |
| 4965 | Cu | 248306 | 7930386 | Louisa Downs 1 |
| 4966 | Zn Cu Pb Co | 251217 | 7931021 | Louisa Downs 2 |
| 5053 | Cu Ag | 395307 | 8000483 | Castle Creek 17 |
| 5054 | Zn | 319835 | 7917769 | McClintock Range 1 |
| 5056 | Cu Zn (Ni) | 320270 | 7915639 | McClintock Range 2 |
| 5058 | Cu (Pb Zn) | 318948 | 7915639 | McClintock Range 3 |
| 5063 | Cu (Zn) | 318446 | 7915136 | McClintock Range 4 |
| 5067 | Cu (Pb Zn) | 317493 | 7913694 | McClintock Range 5 |
| 5073 | Cu Ag | 368713 | 7963339 | Ruby Queen - Brockman 1 |
| 5075 | Pb Zn | 329904 | 7940638 | Garden Creek 1 |
| 5076 | Zn | 330433 | 7941287 | Garden Creek 2 |
| 5078 | Cu Ag | 400253 | 7994678 | Mount Kinahan B |
| 5083 | Cu Ag | 400637 | 7994824 | Mount Kinahan C |
| 5084 | Cu | 406060 | 7996958 | Mount Kinahan D |
| 5094 | Zn | 378037 | 8004571 | Gossan X |
| 5097 | Cu | 245980 | 7955458 | Me No Savvy 1 |
| 5098 | Cu | 246178 | 7955431 | Me No Savvy 2 |
| 5099 | Cu Au Ag | 245763 | 7954976 | Me No Savvy 3 |
| 5100 | Cu | 391086 | 7999097 | Saunders Creek Anticline 1 |
| 5101 | Cu | 391536 | 8000552 | Saunders Creek Anticline 2 |
| 5102 | Cu | 391258 | 8000076 | Saunders Creek Anticline 3 |
| 5190 | Cu Ni | 352387 | 8034748 | Springvale 11 |
| 5205 | Cu (Au) | 395782 | 8077065 | Tickalara Bore 7 |
| 5229 | Pb | 355037 | 7982775 | Halls Creek 1 |
| 5230 | Pb | 354733 | 7981570 | Halls Creek 2 |
| 5233 | Cu Zn Ag | 313604 | 7920922 | Mount Dockrell 6 |
| 5234 | Cu | 312532 | 7918528 | Mount Dockrell 7 |
| 5235 | Ag Cu | 305058 | 7916146 | Black Bishop Hill A |
| 5237 | Zn Ag | 324994 | 7920922 | Hydrothermal Lens A |
| 5238 | Cu | 324306 | 7920578 | Hydrothermal Lens B |
| 5240 | Cu | 400733 | 8065758 | Dougals-Ord River |
| 5248 | Cu | 392998 | 8198692 | Speewah A |
| 5249 | Cu | 392682 | 8199208 | Speewah B |
| 5250 | Cu Brt Fl | 482350 | 8048138 | Brook Creek |
| 5251 | Cu | 468572 | 8198631 | Mons Mont |
| 5252 | Cu | 361799 | 8041527 | Springvale 13 |
| 5257 | Cu Pb Zn Ag | 321672 | 7960886 | Emull East |
| 5267 | Cu | 366727 | 8049651 | Billymac Yard C |
| 5271 | Pb Zn Cu Ag Au | 293878 | 7967653 | Mount Amherst 1 |
| 5278 | Cu Ag | 246655 | 7955544 | Me No Savvy 4 |
| 5279 | Cu (Au) | 245953 | 7955795 | Me No Savvy 5 |
| 5280 | Cu | 247654 | 7954993 | Me No Savvy 6 |
| 5281 | Cu Ag | 247832 | 7955147 | Me No Savvy 7 |
| 5282 | Cu Ag | 251429 | 7955676 | Me No Savvy 8 |
| 5294 | Cu | 289510 | 7981304 | Mount Amherst 3 |
| 5295 | Pb Cu | 288240 | 7981093 | Mount Amherst 4 |
| 5296 | Cu | 293719 | 7967680 | Mount Amherst 5 |
| 5320 | Cu | 418021 | 8087630 | John Galt (Cu) 1 |
| 5321 | Cu | 417916 | 8087432 | John Galt (Cu) 2 |
| 5322 | Cu | 417545 | 8087154 | John Galt (Cu) 3 |
| 5323 | Cu | 417690 | 8087048 | John Galt (Cu) 4 |
| 5324 | Cu | 418326 | 8087815 | John Galt (Cu) 5 |
| 5325 | Cu | 418431 | 8088186 | John Galt (Cu) 6 |
| 5383 | Cu Zn Pb | 227997 | 7941993 | Mount Ramsay 1 |
| 5388 | Pb Zn | 240098 | 7939442 | Mount Ramsay 15B |
| 5390 | Cu | 280080 | 7937072 | Margaret River 4 |
| 5391 | Cu | 285687 | 7941538 | Margaret River 5 |
| 5392 | Cu | 229867 | 7950237 | Mount Ramsay 7 |
| 5393 | Cu | 253574 | 7954602 | Mount Ramsay 10 |
| 5395 | Cu | 246959 | 7946664 | Mount Ramsay 9 |
| 5396 | Pb Zn | 256432 | 7954337 | Mount Ramsay 11 |
| 5397 | Cu | 254130 | 7953147 | Mount Ramsay 13 |
| 5402 | Pb Zn | 296487 | 7965309 | Mount Amherst 6 |
| 5541 | Cu | 411518 | 8074198 | Calico Spring 2 |
| 5542 | Cu | 411275 | 8074388 | Calico Spring 3 |
| 5543 | Cu | 411254 | 8074102 | Calico Spring 4 |
| 5544 | Cu | 410894 | 8074039 | Calico Spring 5 |
| 5545 | Cu | 411910 | 8074748 | Calico Spring 6 |
| 5546 | Cu | 410862 | 8073552 | Calico Spring 7 |
| 5548 | Cu | 410598 | 8073213 | Calico Spring 8 |
| 5550 | Cu | 410111 | 8072949 | Calico Spring 9 |
| 5551 | Cu | 410418 | 8072949 | Calico Spring 10 |
| 5552 | Cu | 410460 | 8072854 | Calico Spring 11 |
| 5553 | Cu | 410926 | 8072324 | Calico Spring 12 |
| 5554 | Cu | 411392 | 8071679 | Calico Spring 13 |
| 5556 | Cu | 410873 | 8070811 | Calico Spring 14 |
| 5557 | Cu | 410460 | 8070991 | Calico Spring 15 |
| 5558 | Cu | 409540 | 8071012 | Calico Spring 16 |
| 5559 | Cu | 411582 | 8075203 | Calico Spring 17 |
| 5560 | Cu | 411571 | 8075425 | Calico Spring 18 |
| 5561 | Cu | 411878 | 8076071 | Calico Spring 19 |
| 5599 | Cu Ag | 420335 | 8076157 | Frank River 4 |
| 5600 | Cu Ni | 410535 | 8067957 | Mount Ranford |
| 5693 | Pb | 249755 | 7931673 | Bullock Bore 8 |
| 5702 | Cu (Pb) | 243870 | 7928133 | Eastmans No. 2 |
| 5720 | Cu | 437417 | 7797159 | Errol Bore |
| 5725 | Cu | 346273 | 7972569 | Koongie Park 2 |
| 5727 | Cu | 375076 | 7998824 | Duffer Range 2 |
| 5742 | Cu Ag | 323472 | 7910653 | Surprise |
| 5758 | Cu | 369046 | 7968462 | Butcher Creek |
| 5770 | Cu | 280847 | 7936311 | Margaret River 6 |
| 5957 | Cu (Au) | 248608 | 7930016 | Eastman Bore (Cu 1) |
| 5958 | Cu | 248441 | 7929961 | Eastman Bore (Cu 2) |
| 6093 | Cu | 303362 | 7911302 | Mount Carmel East 1 |
| 6212 | Cu (Au) | 249219 | 7930836 | Eastman Bore (Cu 3) |
| 6333 | Pb Cu Zn Ag | 341082 | 7993021 | Moola Bulla 5 |
| 6355 | Pb Zn Cu (As Au) | 362122 | 7991010 | Elvire Gossan |
| 6362 | Cu Pb Zn Ag | 252955 | 7959010 | Hells Gate 1 |
| 6363 | Pb Zn Ag | 253320 | 7959383 | Hells Gate 2 |
| 6365 | Pb (Au) | 364678 | 7996904 | Tiger 1 |
| 6372 | Pb Cu Zn Ag Au | 298337 | 7968128 | Eastern Shear 1 |
| 6375 | Pb Zn (Au Cu Ag) | 281031 | 7973814 | Dead Horse Creek 2 |
| 6388 | Pb Cu Zn | 228121 | 7932805 | Bohemia |
| 6389 | Pb Zn | 215409 | 7948076 | Mount Fairbairn 1 |
| 6399 | Cu Au | 206901 | 7970784 | Cabbage Tree |
| 6405 | Cu | 246297 | 7952071 | Glidden 3 |
| 6487 | Cu | 445022 | 8162377 | Mount Evelyn Range |
| 6488 | Cu | 357609 | 8188194 | Plants |
| 6493 | Cu | 397726 | 8174591 | Moonlight Valley Yard |

Regolith – residual to eluvial placers

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 790 | Cu | 245184 | 7928242 | Eastman (Cu) A |
| 2756 | Cu | 479368 | 8059458 | Copper Flats |

Regolith – residual and supergene

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 1128 | Cu Ag Au | 340032 | 7968758 | Sandiego (oxide) |

## IRON

Sedimentary – banded iron-formation (supergene enriched)

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 3295 | Fe | 421132 | 8096358 | Osmond Valley (Fe) |
| 5344 | Fe | 421018 | 8162003 | Pompeys Pillar - Sam |
| 5345 | Fe | 421049 | 8161145 | Pompeys Pillar - Central |
| 5346 | Fe | 421383 | 8160180 | Pompeys Pillar - Tony |
| 5348 | Fe | 428019 | 8155789 | Matsu |
| 5349 | Fe | 421716 | 8160740 | Pompeys Pillar - Peter |
| 5419 | Fe | 490540 | 7871090 | Black Hill |

## ENERGY MINERAL

Stratabound volcanic and sedimentary – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 6262 | U (Cu) | 497953 | 7872277 | Mount Junction |

Stratabound – sandstone-hosted U

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 2726 | U V | 436239 | 8184154 | Horse 1 |
| 5340 | U | 437337 | 8183545 | Horse 2 |
| 5342 | U Cu | 437575 | 8182248 | Horse 10 |

Stratabound sedimentary – clastic-hosted

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 4638 | U | 457133 | 8204358 | Revolver Creek |
| 5341 | U | 437456 | 8182804 | Horse 7; DH1 |
| 5403 | U REE | 497223 | 7813617 | Killi Killi 2 |
| 5797 | U (Cu Zn) | 386050 | 8003006 | Rustlers |

### ENERGY MINERAL

Vein and hydrothermal – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 2348 | U | 414512 | 8181006 | Frog 1 |
| 2370 | U Fl | 412885 | 8181291 | Frog 4 |
| 2371 | U Fl | 414554 | 8180855 | Frog 6 |
| 2377 | U | 417233 | 8190458 | Dunham River A |
| 2378 | U | 416549 | 8189548 | Dunham River B |
| 2380 | U Fl P | 367088 | 8117406 | Antares |
| 2528 | U (Pb V Cu) | 326520 | 7974812 | Ten Minute (U) |
| 4656 | U | 419533 | 8186158 | Dunham River C |
| 4657 | U | 418833 | 8174858 | Dunham River D |
| 4804 | U | 416976 | 8190610 | Donkey Creek |
| 5329 | U | 343342 | 8051763 | Anomaly A3 |
| 5330 | U | 414345 | 8180815 | Frog 2 |
| 5331 | U | 414250 | 8181225 | Frog 3 |
| 5332 | U Fl | 412877 | 8180942 | Frog 5 |
| 5333 | U Fl | 412702 | 8180484 | Frog 7 |
| 5335 | U | 410933 | 8183258 | Last |
| 5350 | U | 417373 | 8087346 | John Galt (U) |

Vein and hydrothermal – unconformity

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 5793 | U Au (REE) | 486462 | 7870419 | Don |
| 5795 | U | 490098 | 7844638 | Birrindudu 2 |
| 5805 | U (Au Xen) | 451047 | 7890625 | Mount Mansbridge 1 |
| 5806 | U | 442861 | 7886593 | Mount Mansbridge 2 |
| 5807 | U | 473312 | 7868745 | Oracle |
| 5808 | U | 454548 | 7872015 | Jaimani |

Regolith – residual and supergene

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 2727 | U Pb | 456268 | 8210506 | Spinifex |
| 6194 | U | 320175 | 7908656 | A1 |

### INDUSTRIAL MINERAL

Carbonatite and alkaline igneous intrusions

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 2399 | Fl Brt Ag | 386649 | 8183213 | West Ridge |

Orthomagmatic mafic and ultramafic – layered mafic

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 5103 | Tlc | 322045 | 7956191 | Lamboo (talc) |
| 5168 | Asbc | 322997 | 7957936 | Lamboo (asbestos 1) |
| 5201 | Asbc | 385973 | 8065951 | Ord Crossing (asbestos) |
| 5486 | Asbc | 324254 | 7957639 | Lamboo (asbestos 2) |
| 5487 | Asbc | 323962 | 7957123 | Lamboo (asbestos 3) |
| 5488 | Asbc | 322217 | 7956898 | Lamboo (asbestos 4) |

Skarn

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 5613 | Grt | 384415 | 8055317 | Garnet Hills |

Vein and hydrothermal – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 1338 | Fl | 358333 | 8079808 | Mount Remarkable 5 |
| 1339 | Fl | 351783 | 8071458 | Mount Remarkable 6 |
| 2397 | Fl Cu (Au) | 391041 | 8186397 | A Vein |
| 2398 | Fl Pb Cu | 386902 | 8183407 | West Vein |
| 2405 | Fl Brt | 386183 | 8186158 | West Ridge North |
| 2420 | Fl | 386283 | 8197658 | North Shear |
| 2423 | Brt | 384583 | 8193858 | Main Shear North |
| 2428 | Fl | 385933 | 8190058 | Martins (fluorite) |
| 5334 | Fl | 412041 | 8177799 | Frog 8 |
| 5351 | Fl | 391161 | 8186497 | A Vein East |
| 5352 | Fl | 390682 | 8185303 | B Vein |
| 5353 | Fl | 391201 | 8186245 | North B Vein |
| 5354 | Fl | 390950 | 8186298 | C Vein |
| 5355 | Fl | 391015 | 8186298 | C Vein East Branch |
| 5356 | Fl | 391518 | 8186495 | Cross Vein |
| 5357 | Fl | 390420 | 8183135 | D Vein |
| 5362 | Fl | 391227 | 8185516 | G Vein |
| 5365 | Fl | 389388 | 8181600 | South Vein |
| 5366 | Fl | 390975 | 8185265 | East Vein |
| 5367 | Fl | 389758 | 8182024 | F Vein |
| 5379 | Fl | 388309 | 8008930 | Ding Dong Downs (F) |
| 6484 | Asbc | 480409 | 8118247 | J41 Trig |
| 6494 | Brt | 427970 | 8129540 | Mabel Downs (Ba) |

Stratabound volcanic and sedimentary – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 2391 | Fl | 387742 | 8161205 | Archie Creek |

Regolith – residual and supergene

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 5163 | Mgs | 322811 | 7955965 | Lamboo (magnesite) |

### CONSTRUCTION MATERIAL

Orthomagmatic mafic and ultramafic – layered mafic

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 2765 | Bsbg | 360258 | 8033738 | McIntosh B |

### CONSTRUCTION MATERIAL

Orthomagmatic mafic and ultramafic – undivided

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| 6474 | Bsdo | 361092 | 7988784 | Halls Creek North |

Stratabound sedimentary – clastic-hosted

| NUMBER | COMMODITY | EASTING | NORTHING | NAME |
|---|---|---|---|---|
| **6471** | Sst | 270947 | 7925740 | Berrangi Creek |

## Appendix 2

# WAMIN and EXACT databases

## WAMIN database (mineral occurrences)

The WAMIN (Western Australian mineral occurrence) database of the Geological Survey of Western Australia (GSWA) contains geoscience attribute information on mineral occurrences in Western Australia. The database includes textual and numeric information on the location of the occurrences, location accuracy, mineral commodities, mineralization-style classification, order of magnitude of resource tonnage and estimated grade, ore and gangue mineralogy, details of host rocks, and both published and unpublished references. Each of the occurrences in WAMIN is identified by a unique 'deposit number'.

The WAMIN database uses a number of authority tables to constrain the essential elements of a mineral occurrence, such as the operating status, the commodity group, and the style of mineralization. In addition, there are parameters that dictate whether the presence of a mineral or an analysed element is sufficiently high to rank occurrence status; this Report only deals with mineral occurrences. These and other attributes were extracted either from open-file mineral exploration reports in WAMEX (Western Australian mineral exploration database) or from the published literature.

Those elements of the database that were used to create the symbols for mineral occurrences and tabular information displayed in Plates 1 and 1a, and Appendix 1 of this Report, are:

- occurrence number and name (deposit number and name);
- operating status (font style of deposit number);
- position and spatial accuracy (symbol position);
- commodity group (symbol colour); and
- mineralization style (symbol shape).

The elements of the database used for symbology in Plates 1 and 1a and Appendix 1 are operating status, commodity group, and mineralization style. These parameters have previously been defined for the GSWA mineralization mapping projects that have been completed for prospectivity enhancement studies of southwest Western Australia (Hassan, 1998), the north Eastern Goldfields (Ferguson, 1998), the Bangemall Basin (Cooper et al., 1998), and the west Pilbara (Ruddock, 1999).

## Operating status

The database includes mineralization sites (referred to as deposits) ranging from small, but mineralogically significant, mineral occurrences up to operating mines. The classification includes all MINEDEX sites with established resources: MINEDEX is the Department of Minerals and Energy (DME) mines and mineral deposits information database (Townsend et al., 1996, 2000). All occurrences in the WAMIN database are assigned a unique, system-generated number (deposit number). The font style of this number (bold, italicized, and so on) is used as the coding to indicate operating status both on the face of the map and in Appendix 1 of this Report. The system used is:

- Mineral occurrence — any economic mineral exceeding an agreed concentration and size found in bedrock or regolith (italic serif numbers, e.g. *1212*).
- Prospect — any working or exploration activity area that has found subeconomic mineral occurrences, and from which there is no recorded production (italic serif numbers, e.g. *1138*).
- Mineral deposit — economic minerals for which there is an established resource figure (serif numbers, e.g. 1137).
- Abandoned mine — workings that are no longer operating, or are not on a care-and-maintenance basis, and for which there is recorded production, or where field evidence suggests that the workings were for more than prospecting purposes (bold–italic sans serif numbers, e.g. ***2321***).
- Operating mine — workings that are operating, including on a care-and-maintenance basis, or that are in development leading to production (bold sans serif numbers, e.g. **1106**).

The names of the occurrences, and any synonyms that may have been used, are derived from the published literature and from open-file reports (in WAMEX). Names that appear in the MINEDEX database have been used where possible, although there may be differences created because MINEDEX uses site names based on overall production and resources, whereas WAMIN may show names of individual occurrences at a MINEDEX site.

## Commodity group

The WAMIN database includes a broad grouping that is based on the potential end-use or typical end-use of the

**Table 2.1. WAMIN authority table for commodity groups**

| *Commodity group* | *Typical commodities* | *Symbol colour* |
|---|---|---|
| Precious mineral | Diamond, semi-precious gemstones | (white) |
| Precious metal | Ag, Au, PGE | (yellow) |
| Steel-industry metal | Co, Cr, Mn, Mo, Nb, Ni, V, W | (orange) |
| Speciality metal | Li, REE, Sn, Ta, Ti, Zr | (light green) |
| Base metal | Cu, Pb, Zn, Sb | (red) |
| Iron | Fe | (blue) |
| Aluminium | Al (bauxite) | (dark orange) |
| Energy mineral | Coal, U | (black) |
| Industrial mineral | Asbestos, barite, kaolin, talc | (dark green) |
| Construction material | Clay, dimension stone, limestone | (light blue) |

principal commodities comprising a mineral occurrence. The commodity group, as listed in Table 2.1, determines the particular colour for the mineral occurrence symbols in Plates 1 and 1a, and Appendix 1.

The commodity groupings are based on those published by the Mining Journal (1998) with modifications, as shown in Table 2.2, to suit the range of minerals and end-uses for the mineral output of Western Australia.

## Mineralization style

There are a number of detailed schemes for classifying mineral occurrences into groups representing different styles of mineralization, with the scheme of Cox and Singer (1986) probably being the most widely used. The application of this scheme in Western Australia would necessitate modifications to an already complex scheme, along the lines of those adopted by the Geological Survey of British Columbia (Lefebure and Ray, 1995; Lefebure and Hoy, 1996). Representing the style of mineralization on the face of a map cannot be simply and effectively achieved if the scheme adopted is too complex.

The Geological Survey of Western Australia has adopted the principles of ore deposit classification from Evans (1987) with some modifications based on Edwards and Atkinson (1986). This scheme works on the premise that 'If a classification is to be of any value it must be

**Table 2.2. Modifications made to the Mining Journal Ltd (1998) commodity classification**

| *Commodity group (Mining Journal Ltd, 1998)* | *Commodities* | *Changes made for WAMIN commodity group* |
|---|---|---|
| Precious metals and minerals | Au, Ag, PGE, diamonds, other gemstones | Diamond and other gemstones in precious minerals group; Au, Ag, and PGE in precious metals group |
| Steel-industry metals | Iron ore, steel, ferro-alloys, Ni, Co, Mn, Cr, Mo, W, Nb, V | Fe in iron group |
| Speciality metals | Ti, Mg, Be, REE, Zr, Hf, Li, Ta, Rh, Bi, In, Cd, Sb, Hg | Sn added from major metals; Sb into the base metals group |
| Major metals | Cu, Al, Zn, Pb, Sn | Cu, Pb, and Zn into the base metals group; Al (bauxite) into aluminium group; Sn in speciality metals |
| Energy minerals | Coal, U | No change |
| Industrial minerals | Asbestos, sillimanite minerals, phosphate rock, salt, gypsum, soda ash, potash, boron, sulfur, graphite, barite, fluorspar, vermiculite, perlite, magnesite/ magnesia, industrial diamonds, kaolin | No change |

**Table 2.3. WAMIN authority table for mineralization styles and groups**

| *Mineralization style* | *Typical commodities* | *Group symbol*[(a)] |
|---|---|---|
| Carbonatite and alkaline igneous intrusions | Nb, Zr, REE, P | ☆ |
| Kimberlite and lamproite intrusions | Diamond | |
| Disseminated and stockwork in plutonic intrusions | Cu, Mo, Au | ⬡ |
| Greisen | Sn | |
| Pegmatitic | Sn, Ta, Nb, Li | |
| Skarn | W, Mo, Cu, Pb, Zn, Sn | |
| Orthomagmatic mafic and ultramafic — komatiitic or dunitic | Ni, Cu, Co, PGE | ✚ |
| Orthomagmatic mafic and ultramafic — layered-mafic intrusions | Ni, Cu, Co, V, Ti, PGE, Cr | |
| Orthomagmatic mafic and ultramafic — undivided | Ni, Cu, Co, V, Ti, PGE, Cr | |
| Vein and hydrothermal — undivided | Au, Ag, Cu, Pb, Zn, Ni, U, Sn, F | ◇ |
| Vein and hydrothermal — unconformity | U | |
| Stratabound volcanic and sedimentary — volcanic-hosted sulfide | Cu, Zn, Pb, Ag, Au | △ |
| Stratabound volcanic and sedimentary — sedimentary-hosted sulfide | Pb, Zn, Cu, Ag | |
| Stratabound volcanic and sedimentary — volcanic oxide | Fe, P, Cu | |
| Stratabound volcanic and sedimentary — undivided | Pb, Zn, Cu, Ag, Au, Fe | |
| Stratabound sedimentary — carbonate-hosted | Pb, Zn, Ag, Cd | □ |
| Stratabound sedimentary — clastic-hosted | Pb, Zn, Cu, Au, Ag, Ba, Cd, U | |
| Stratabound sedimentary — undivided | Pb, Ba, Cu, Au | |
| Sedimentary — banded iron-formation (supergene enriched) | Fe | |
| Sedimentary — banded iron-formation (taconite) | Fe | |
| Sedimentary — undivided | Mn | |
| Sedimentary — basin | Coal, bitumen | ○ |
| Regolith — alluvial to beach placers | Au, Fe pisolites, Ti, Zr, REE, diamond, Sn | ▭ |
| Regolith — calcrete | U, V | |
| Regolith — residual and supergene | Al, Au, Ni, Co, Mn, V, Fe scree | |
| Regolith — residual to eluvial placers | Au, Sn, Ti, Zr, REE, diamond | |
| Undivided | Various | ▽ |

**NOTE:** (a) The white symbol colour used in this table does not indicate the commodity group in Table 2.1

capable of including all known ore deposits so that it will provide a framework and a terminology for discussion and so be of use to the mining geologist, the prospector and the exploration geologist'. The system below is based on an environmental–rock association classification, with elements of genesis and morphology where they serve to make the system simpler and easier to apply and understand (Table 2.3).

To fully symbolize all the mineralization style groups would result in a system that is too complex. As the full details of the classification are preserved in the underlying WAMIN database, the chosen symbology has been reduced to nine shapes (Table 2.3).

## Mineral occurrence determination limits

Any surface expression of mineralization (gossan or identified economic mineral) is an occurrence. Subsurface or placer mineralization is included as an occurrence where it meets the criteria given in Table 2.4.

Professional judgement is used if shorter intercepts or surface occurrences at higher grade (or vice versa) are involved. Any diamonds or gemstones would be mineral occurrences, including diamondiferous kimberlite or lamproite.

# EXACT database (exploration activities)

The EXACT* database is a GIS-based spatial index, for exploration activities in WAMEX, which has been developed by the GSWA to improve access to information in open-file mineral exploration reports (Ferguson, 1995). A major limitation to data retrieval in WAMEX, in its current form, is the difficulty in selecting reports that cover a specific area and, further, in precisely locating various individual exploration activities described within a selected report.

In the current WAMEX database, when spatial parameters are used to make data searches, the results of

* The EXACT database is a GIS-based spatial index of **EX**ploration **ACT**ivities. This term supersedes the acronym SPINDEX (Spatial Index) used in Cooper et al. (1998), Ferguson (1998), and Hassan (1998).

**Table 2.4. Suggested minimum intersections for mineral occurrences in drillholes or trenches**

| *Element* | *Intersection length (m)* | *Grade* |
|---|---|---|
| **Hard rock and lateritic deposits** | | |
| Gold | >5 | >1 ppm |
| Silver | >10 | >1 ppm |
| Platinum | >0.5 | >1 ppm |
| Lead | >5 | >0.5% |
| Zinc | >5 | >2% |
| Copper | >5 | >0.5% |
| Nickel | >5 | >0.5% |
| Cobalt | >5 | >0.1% |
| Chromium | >0.2 | >5% $Cr_2O_3$ |
| Vanadium | >5 | >0.1% |
| Tin | >5 | >0.02% |
| Iron | >5 | >40% Fe |
| Manganese | >5 | >25% |
| Uranium | >5 | >1000 ppm U |
| Diamonds | na | any diamonds |
| Tantalum | >5 | >200 ppm |
| Tungsten | >5 | >1000 ppm (0.1%) |
| **Placer deposits** | | |
| Gold | na | >300 mg/m$^3$ in bulk sample |
| Diamonds | na | any diamonds |
| Heavy minerals | >5 | >2% ilmenite |

searches are constrained to very large areas. The smallest search polygon that can be effectively used to locate reports in WAMEX is the area of a 1:100 000-scale sheet. Even though a query may be entered as a single point (either AMG or latitude/longitude coordinates), the resulting search will produce all reports for the 1:100 000-scale sheet in which that single point is located. Hence, for example, it is not possible to restrict report selection to small areas of prospective ground of particular interest to the user. As a consequence these WAMEX searches are time consuming, and they have become more time consuming as the number of open-file reports has increased with continuing releases of data.

The EXACT spatial index overcomes this problem and allows easy access to data on specific areas of previous exploration activity. It also provides a spatial representation of the intensity of past exploration, thereby highlighting prospective areas that may have been lightly or inadequately tested by various earlier exploration methods.

The spatial index consists of an attribute database, developed in Microsoft Access, which is linked to ArcView for spatial representation. In the CD-ROM, the dataset includes tabulated textual and numeric information that has been retrieved from open-file mineral exploration reports and attached to individual exploration activities. The areas of exploration activity are digitized (as polygons, lines, or points) using the computer-assisted drafting (CAD) system Microstation, converted into Arc/Info, and then transferred into ArcView to enable an interactive display of EXACT. The positional data are digitized from hard-copy maps and plans in mineral exploration reports, using various

**Table 2.5 Types of exploration activity detailed in the EXACT database**

| *Activity type* | *Description* |
|---|---|
| **Geological** | |
| GEOL | Geological mapping |
| AMS | Airborne multispectral scanning |
| LSAT | Landsat TM data |
| **Geophysical** | |
| AEM | Airborne electromagnetic surveys |
| AGRA | Airborne gravity surveys |
| AMAG | Airborne magnetic surveys |
| ARAD | Airborne radiometric surveys |
| MAG | Magnetic surveys |
| EM | Electromagnetic surveys (includes TEM, SIROTEM) |
| GEOP | Other geophysical surveys (includes IP, resistivity) |
| GRAV | Gravity surveys |
| RAD | Radiometric surveys (includes downhole logging) |
| SEIS | Seismic surveys |
| **Geochemical** | |
| SOIL | Soil surveys |
| SSED | Stream-sediment surveys |
| REGO | Regolith surveys (includes laterite, pisolite, ironstone, and lag) |
| NGRD | Non-gridded geochemical surveys (includes chip, channel, dump, and gossan) |
| ACH | Airborne geochemistry |
| **Mineralogical** | |
| HM | Heavy mineral surveys |
| **Drilling** | |
| DIAM | Diamond drilling |
| ROT | Rotary drilling (predominantly percussion drilling) |
| RAB | RAB drilling (includes other shallow geochemical drilling such as auger) |
| RC | RC drilling |
| **Mineral resources** | |
| MRE | Mineral resource estimate |
| **Hydrogeological** | |
| HYDR | Groundwater surveys |

published sources (geological maps, topographic maps, and TENGRAPH — DME's electronic tenement-graphics system) for georeference purposes. The types of exploration activity detailed are essentially those used in WAMEX, with some rationalization, and these are listed in Table 2.5. In the table, the 25 activities are grouped as follows:

- Geological activities (and remote sensing activities)
- Geophysical activities
- Geochemical activities
- Mineralogical activities
- Drilling activities
- Mineral resources
- Hydrogeological activities.

The above groups relate to those specified in the statutory guidelines for mineral exploration reports (Department of Minerals and Energy, 1995).

For each separate exploration activity the following statistics have been compiled:

- description of activity
- sample types and numbers
- elements analyzed (asterisk symbol (*) against elements for a rough guide to anomalism)
- metres of drilling and number of holes
- scales of presentation of data in reports.

The activity data are also linked in the dataset to the following related information taken from WAMEX:

- A-numbers (WAMEX accession numbers for individual reports)
- I-numbers (WAMEX item numbers for single or groups of reports on microfiche)
- company or companies that submitted reports
- period of exploration (years)
- mineral commodities sought
- summaries (annotations) of exploration projects included in individual item numbers.

In ArcView, the exploration activities are included as spatial **themes**, which are displayed as polygons, lines, or points on the interactive on-screen map known as the **view**. The **table of contents** (i.e. map legend) provided alongside the **view** allows access to the **themes**, so that any **theme** or combination of **themes** may be displayed. Details (taken from attribute tables) of any **theme** can be accessed on screen, and **queries** can be carried out either as spatial queries through a **view** or as textual queries direct from the attribute tables. Further details (with examples) of displays, queries, charts, and view layouts are provided by Ferguson (1995).

## References

COOPER, R. W., LANGFORD, R. L., and PIRAJNO, F., 1998, Mineral occurrences and exploration potential of the Bangemall Basin: Western Australia Geological Survey, Report 64, 42p.

COX, D. P., and SINGER, D. A., 1986, Mineral deposit models: United States Geological Survey, Bulletin 1693, 379p.

DEPARTMENT OF MINERALS AND ENERGY, 1995, Guidelines for mineral exploration reports on mining tenements: Perth, Department of Minerals and Energy, 12p.

EDWARDS, R., and ATKINSON, K., 1986, Ore deposit geology and its influence on mineral exploration: London, Chapman and Hall, 466p.

EVANS, A. M., 1987, An introduction to ore geology: Oxford, Blackwell Scientific Publications, 358p.

FERGUSON, K. M., 1995, Developing a GIS-based exploration-activity spatial index for the WAMEX open-file system: Western Australia Geological Survey, Annual Review 1994–95, p. 64–70.

FERGUSON, K. M., 1998, Mineral occurrences and exploration potential of the north Eastern Goldfields: Western Australia Geological Survey, Report 63, 40p.

HASSAN, L. Y., 1998, Mineral occurrences and exploration potential of southwest Western Australia: Western Australia Geological Survey, Report 65, 38p.

LEFEBURE, D. V., and HOY, T., (editors), 1996, Selected British Columbia Mineral Deposit Profiles, Volume 2 — Metallic Deposits: British Columbia Ministry of Employment and Investment, Open File 1996-13, 171p.

LEFEBURE, D. V., and RAY, G. E., (editors), 1995, Selected British Columbia Mineral Deposit Profiles, Volume 1 — Metallics and Coal: British Columbia Ministry of Employment and Investment, Open File 1995-20, 135p.

MINING JOURNAL LIMITED, 1998, Mining Annual Review, Volume 2 — Metals & Minerals: London, Mining Journal Limited, 112p.

RUDDOCK, I., 1999, Mineral occurrences and exploration potential of the west Pilbara: Western Australia Geological Survey, Report 70, 63p.

TOWNSEND, D. B., GAO MAI, and MORGAN, W. R., 2000, Mines and mineral deposits of Western Australia: digital extract from MINEDEX — an explanatory note: Western Australia Geological Survey, Record 2000/13, 28p.

TOWNSEND, D. B., PRESTON, W. A., and COOPER, R. W., 1996, Mineral resources and locations, Western Australia: digital dataset from MINEDEX: Western Australia Geological Survey, Record 1996/13, 19p.

## Appendix 3

# Description of digital datasets on CD-ROM

There are three principal components of this study, which are this Report, Plates 1 and 1a, and a CD-ROM containing digital datasets for use with database or GIS software. The CD-ROM includes all the data used to compile the map and Report, and also includes files of exploration and mining activity, geophysical, remote sensing, and topographic data. The CD-ROM also includes the files necessary for viewing the data in the ArcView GIS environment, and a self-loading version of the ArcExplorer software package modified to suit this particular dataset.

## Mineral occurrences (WAMIN)

The mineral occurrence dataset (from WAMIN, the Western Australian mineral occurrence database) as used in this Report and on Plates 1 and 1a is described in Appendix 2. The dataset on the CD-ROM includes textual and numeric information on:

- location of the occurrences (AMG coordinates, latitude and longitude, geological province, location method, and accuracy);
- commodities and commodity group;
- mineralization classification and morphology;
- order of magnitude of resource tonnage and estimated grade;
- mineralogy of ore and gangue;
- details of host rocks;
- both published and unpublished references.

## EXACT

The EXACT dataset (from EXACT, Geological Survey of Western Australia's spatial index of exploration activities) as used in this Report is described in Appendix 2. The dataset on CD-ROM contains spatial and textual information (derived from WAMEX open-file reports) defining the locations and descriptions of exploration activities in the area. EXACT, for the east Kimberley area, was compiled between 1996 and 1998, and contains information on types of mineral exploration activity such as statistics relating to:

- report numbers
- sample types and numbers
- elements assayed
- metres of drilling and number of holes
- scales of presentation of the data.

Positional data were taken from hard-copy maps of various scales, from company reports (in WAMEX), located from coordinate and/or geographical information (from topographic maps or Landsat images), and then digitized. Table 2.5 (in Appendix 2) lists the exploration activity types.

The activity data are linked to more general data concerning the individual open-file reports (commonly defined in WAMEX by accession A-numbers) and individual exploration projects (commonly defined in WAMEX by open-file Item-numbers). This information includes the company or companies involved in the project, the commodities explored for, the timing of the project, names of localities in the project, and a summary (annotation) of the project, including exploration concept, activities, and a synopsis of results.

## WAMEX

All relevant open-file company mineral exploration reports for the area, indexed in the Department of Minerals and Energy (DME) WAMEX database were referred to for this study. Information extracted from these reports was used to analyse the historical trends in exploration activity and target commodities.

## MINEDEX

The MINEDEX database (Townsend et al., 1996, 2000) has current information on all mines, process plants, and deposits, excluding petroleum and gas, for Western Australia. Mineral resources included in MINEDEX must conform to the Joint Ore Reserves Committee (JORC) (1999) code to be included in the database. The database contains information relevant to WAMIN under the following general headings:

- commodity group and minerals
- corporate ownership and percentage holding
- site type and stage of development
- location data (a centroid) including map, shire, mining district, and centre
- current mineral resource estimates
- mineralization type
- tectonic unit
- tenement details.

MINEDEX contains all the relevant resource information and WAMIN uses the unique MINEDEX site number as a cross-reference for this information. WAMIN may contain pre-resource global estimates that do not conform to the JORC (1999) code, and are not included in MINEDEX.

## TENGRAPH

The TENGRAPH database (DME's electronic tenement-graphics system) shows the position of mining tenements relative to other land information. TENGRAPH provides information on the type and status of the tenement and the name(s) and address(es) of the tenement holders (Department of Minerals and Energy, 1994). It should be borne in mind that the tenement situation is constantly changing and that current tenement plans should be consulted before making any landuse-based decisions or applying for tenements.

## Solid geology and regolith

The solid geology and regolith incorporates an interpretation of the study area, at 1:100 000 scale, based on a recent compilation of the Geological Survey of Western Australia (GSWA) mapping, aeromagnetics (TMI images), and Landsat TM imagery. The full details of the solid geology and regolith are on the CD-ROM. The regolith on Plates 1 and 1a is a simplified version of the digital dataset on the CD-ROM, and uses two overprints to distinguish relict and depositional regimes. The CD-ROM also includes a large number of solid geology and regolith units that are smaller than 250 000 $m^2$ in area that were omitted from Plates 1 and 1a for simplicity.

## Geophysics

The aeromagnetic data covering the area are presented in the form of a total magnetic intensity (TMI) colour image. The data used to create the image were flown in 1995 for the National Geoscience Mapping Accord (between Australian Geological Survey Organisation (AGSO) and GSWA), mostly at a line spacing of 400 m, and gridded to a cell size of 800 m for the colour image. More-detailed data, gridded to a cell size of 100 m, may be obtained from AGSO.

Measurements of the background radiation using an airborne crystal usually took place concurrently with the AGSO aeromagnetic surveys over the area. The colour image on the CD-ROM shows the comparative K–Th–U ratios as red–green–blue (RGB). The data are relatively disparate in nature as variations in the crystal size and flying height were not tightly constrained over the area.

A regional gravity survey by AGSO, at a nominal station spacing of 11 km, is presented in the digital dataset as an image showing the Bouguer anomaly, gridded to a cell size of 5 km.

## Landsat

Landsat TM imagery has been acquired for all the 1:250 000-scale map sheets in the east Kimberley study. The raw data are available commercially through the Remote Sensing Services section of the Department of Land Administration (DOLA). Images are included in the digital package that preserve the original 25 m pixel size, but these cannot be reverse-engineered back to any bands or band ratios of the original 6-band dataset.

Both image datasets comprise a patchwork of 1:250 000-scale map tiles. The simplest of the two uses a decorrelation stretch of the first principal component of bands 1, 2, 3, 4, 5, and 7, written out as an 8-bit dataset that can be viewed as a monochrome image. The second, more complex, image can be viewed in colour, and was created using a decorrelation stretch of bands 4, 5, and 7.

## Cultural features

Selected roads and tracks are given as a single dataset, and range from sealed highways through shire roads to major station tracks. The digital data in this file were captured by digitizing from Landsat imagery.

Place names for the area, in a separate file, are given for major hills, stations, and communities. More-comprehensive topographical and cultural data, including drainage, can be obtained from the Australian Land Information Group (AUSLIG).

## References

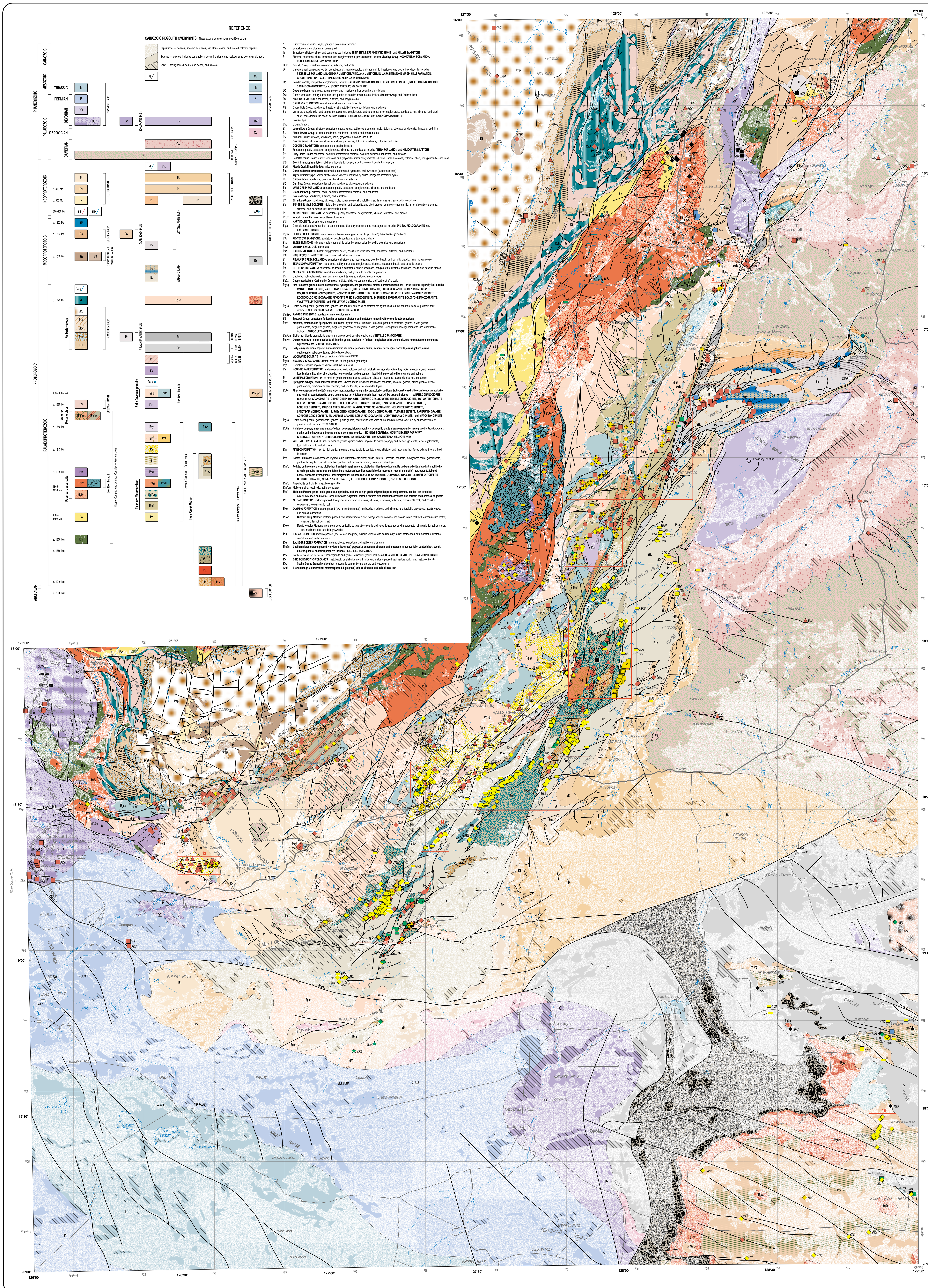
DEPARTMENT OF MINERALS AND ENERGY, 1994, TENGRAPH customer user manual: Perth, Department of Minerals and Energy, 50p.

FERGUSON, K. M., 1995, Developing a GIS-based exploration-activity spatial index for the WAMEX open-file system: Western Australia Geological Survey, Annual Review 1994–95, p. 64–70.

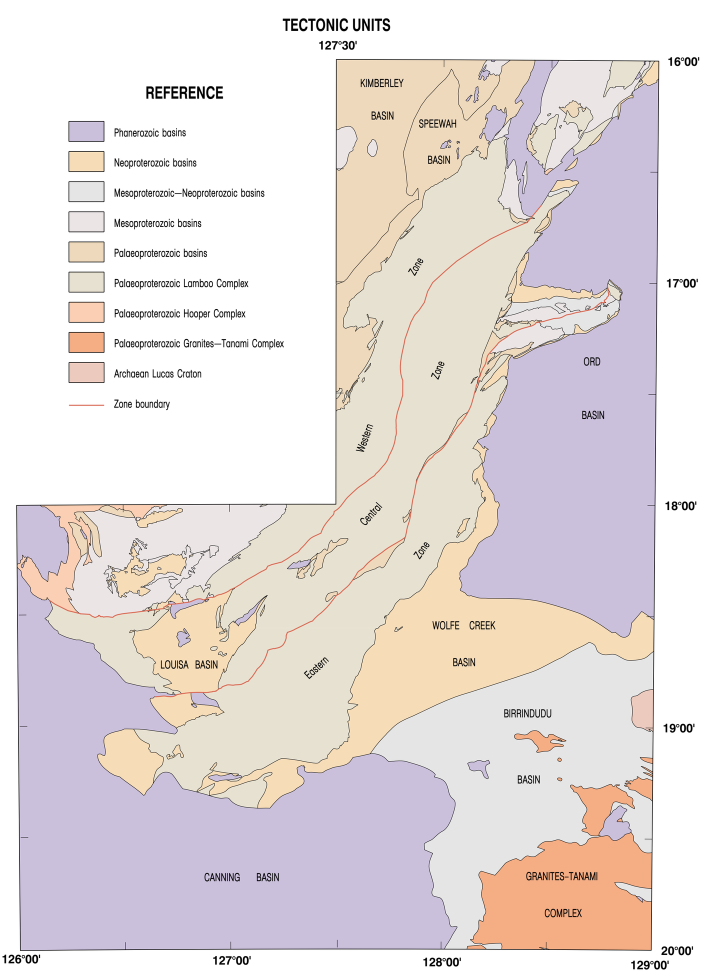
JOINT ORE RESERVES COMMITTEE OF THE AUSTRALASIAN INSTITUTE OF MINING AND METALLURGY, AUSTRALIAN INSTITUTE OF GEOSCIENTISTS, and MINERALS COUNCIL OF AUSTRALIA (JORC), 1999, Australasian code for reporting of mineral resources and ore reserves: Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists, and Minerals Council of Australia, 16p.

TOWNSEND, D. B., GAO MAI, and MORGAN, W. R., 2000, Mines and mineral deposits of Western Australia: digital extract from MINEDEX — an explanatory note: Western Australia Geological Survey, Record 2000/13, 28p.

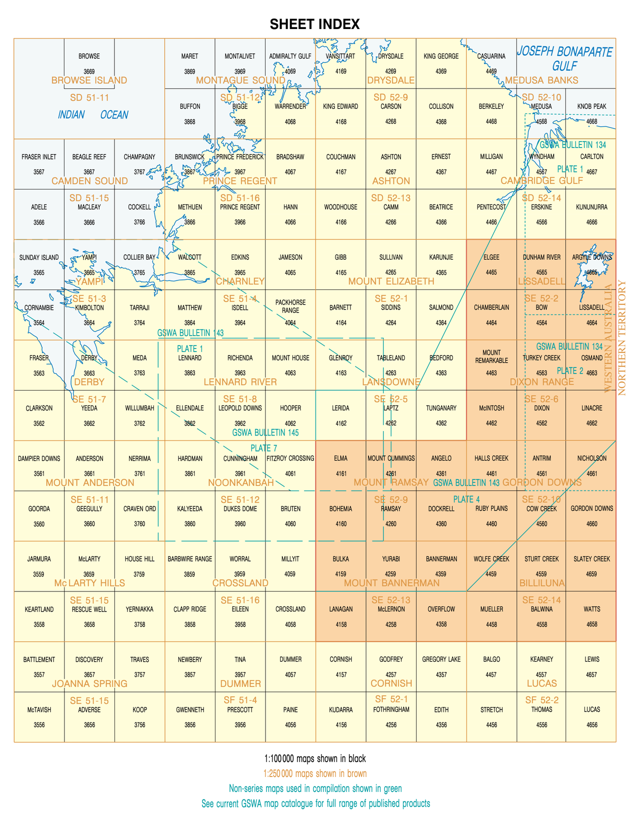
TOWNSEND, D. B., PRESTON, W. A., and COOPER, R. W., 1996, Mineral resources and locations, Western Australia: digital dataset from MINEDEX: Western Australia Geological Survey, Record 1996/13, 19p.



## TECTONIC UNITS

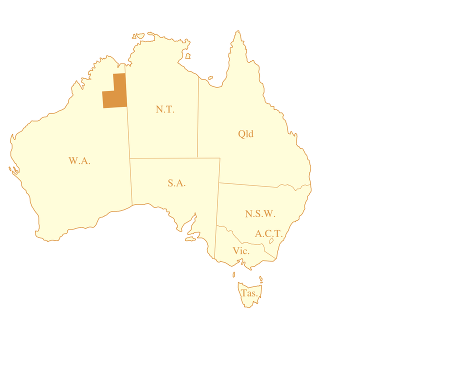


## SHEET INDEX



## SYMBOLS

## MINERAL OCCURRENCES



**Mineral occurrence data compiled by L. Y. Hassan**

**Geology and geochronology compiled by I. M. Tyler, R. Flint, and L. Y. Hassan using published geological data (references in GSWA Report 74), and open file WAMEX reports**

Edited by N. Tetlaw and K. Greenberg

Cartography by P. Taylor and D. Wallace

Mineralization information on this map is from non-confidiental data held in the WAMIN database, GSWA at June 2000

Topography from the Department of Land Administration with modifications from geological field survey

Published by the Geological Survey of Western Australia. Copies available from the Information Centre, Department of Minerals and Energy, 100 Plain Street, East Perth, WA, 6004. Phone (08) 9222 3459, Fax (08) 9222 3444

This map is also available in digital form

Plotted by the Geological Survey of Western Australia

The recommended reference for this map is:
HASSAN, L. Y., TYLER, I. M., and FLINT, R., 2000, Mineralization and Geology of the east Kimberley (1:500 000), *in* Mineral occurrences and exploration potential of the east Kimberley *by* L. Y. HASSAN: Western Australia Geological Survey, Report 74, Plate 1

Department of Industry and Resources

Geological Survey of Western Australia

CLIVE BROWN, M.L.A.
MINISTER FOR STATE DEVELOPMENT

JIM LIMERICK
DIRECTOR GENERAL

TIM GRIFFIN
DIRECTOR

SCALE 1:500 000

5000 Metres 0 5 10 15 20 25 30 35 40 45 50 Kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM: GEOCENTRIC DATUM OF AUSTRALIA 1994
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM

Grid lines indicate 25 000 metre interval of the Map Grid Australia Zone 50

The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94)
GDA94 positions are compatible within one metre of the datum WGS84 positions

Reference points to align maps based on the previous datum, AGD84, have been placed near the map corners

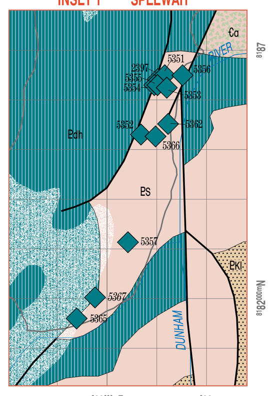
**GEOLOGICAL SURVEY OF WESTERN AUSTRALIA**

**REPORT 74 PLATE 1**

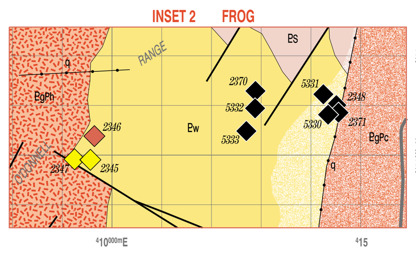
# MINERALIZATION AND GEOLOGY OF THE EAST KIMBERLEY

Version 1.1 — July 2003

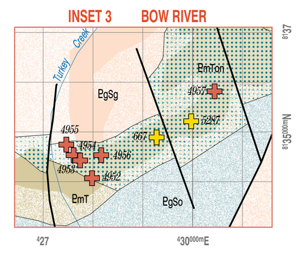
INSET 1 SPEEWAH



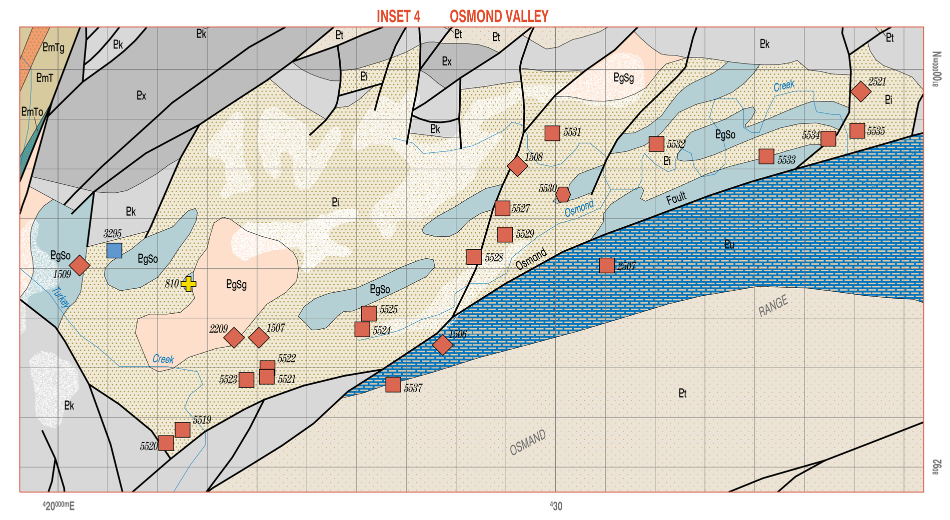
INSET 2 FROG



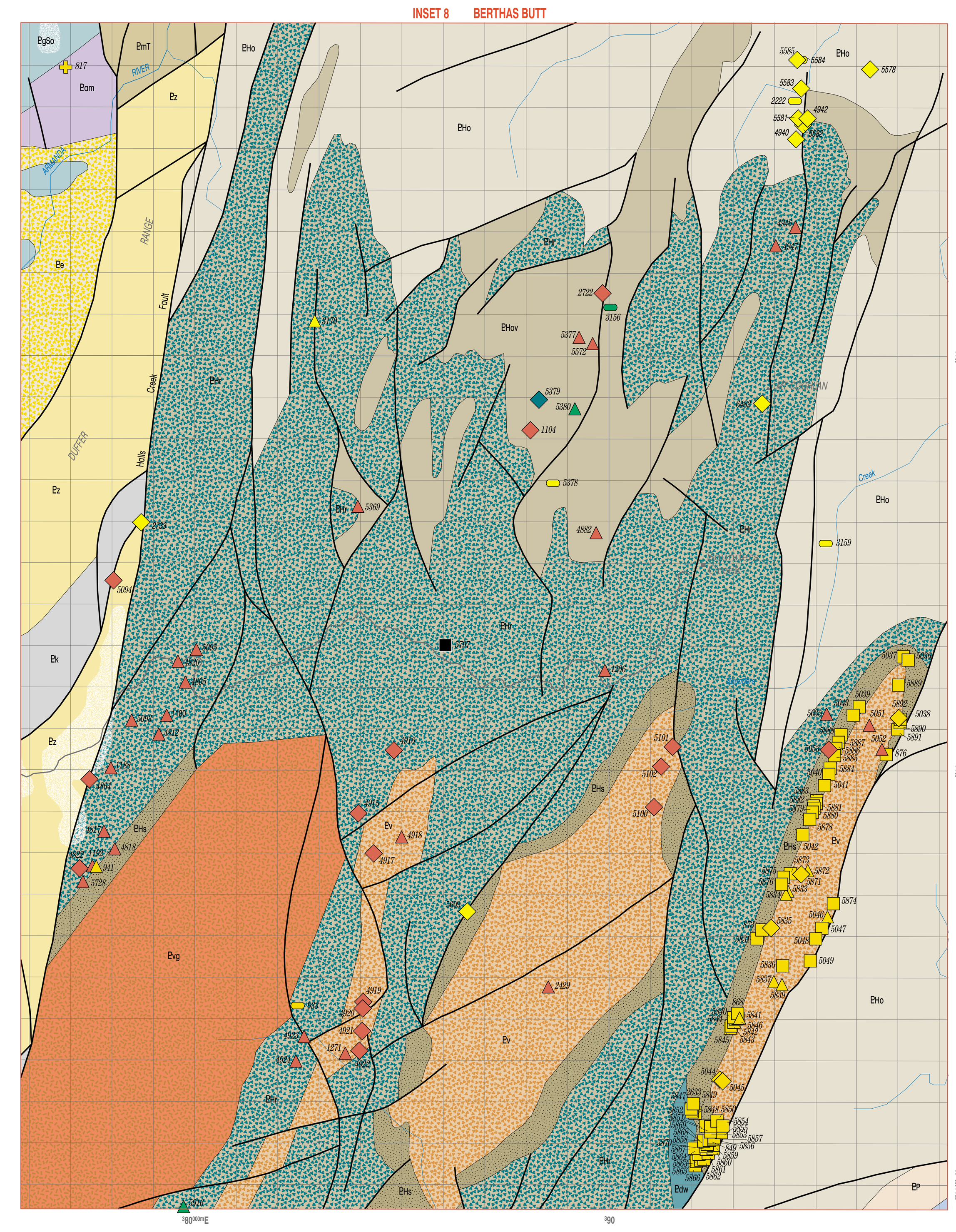
INSET 3 BOW RIVER



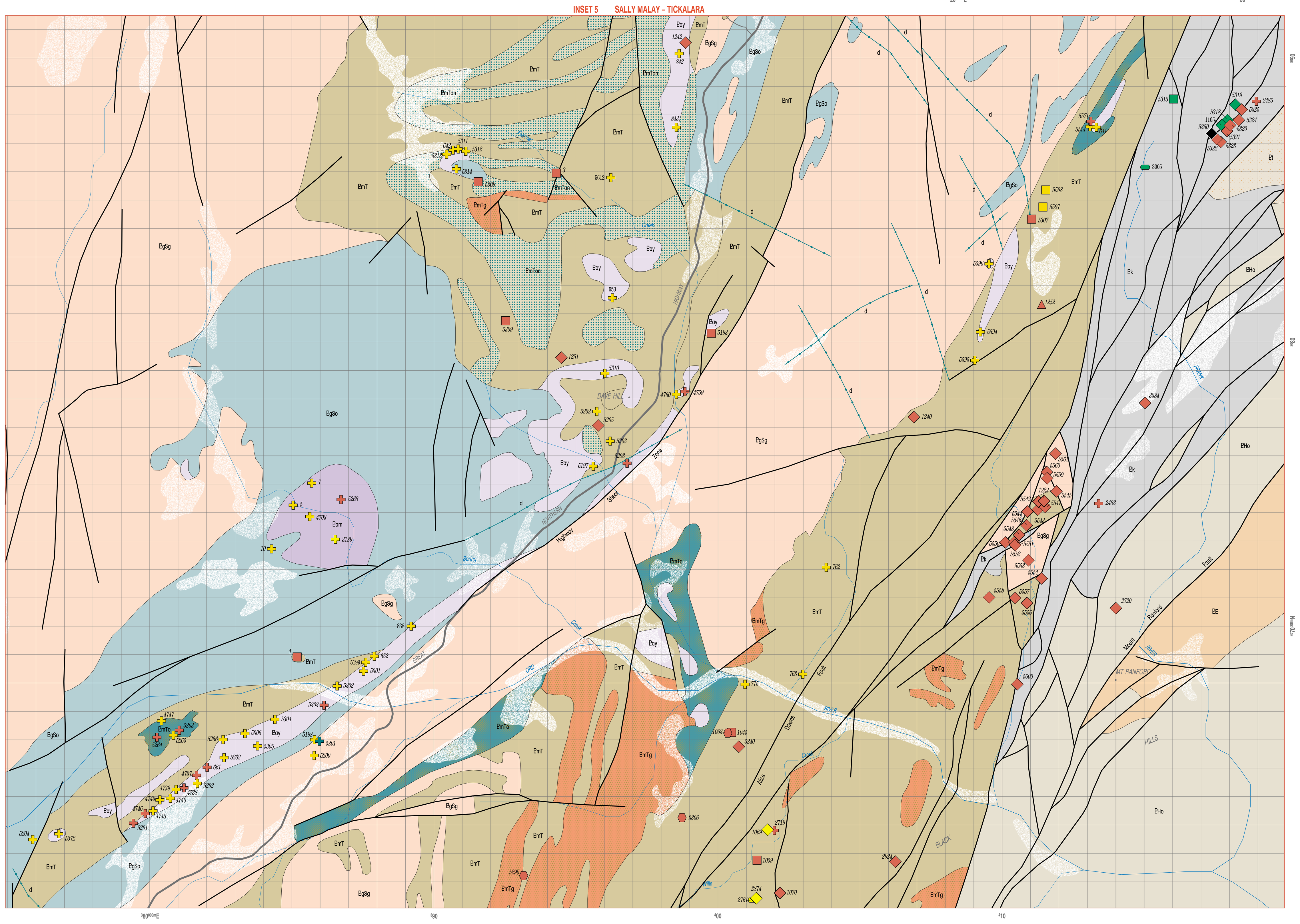
INSET 4 OSMOND VALLEY



INSET 8 BERTHAS BUTT



INSET 5 SALLY MALAY – TICKALARA



MINERAL OCCURRENCES

- Kimberlite, lamproite, and carbonatite mineralization
- Orthomagmatic mafic and ultramafic mineralization
- Pegmatitic, skarn, greisen, and porphyry mineralization
- Vein and hydrothermal mineralization
- Stratabound volcanic and sedimentary mineralization
- Stratabound sedimentary mineralization
- Mineralization in the regolith

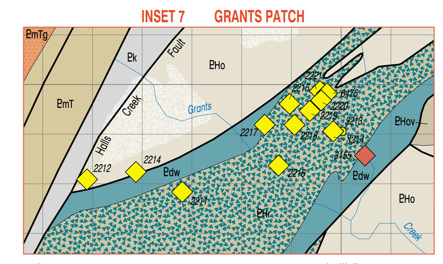
- Precious mineral
- Precious metal
- Steel industry metal
- Speciality metal
- Base metal
- Iron
- Energy
- Industrial mineral
- Construction material

KEY TO OPERATING STATUS

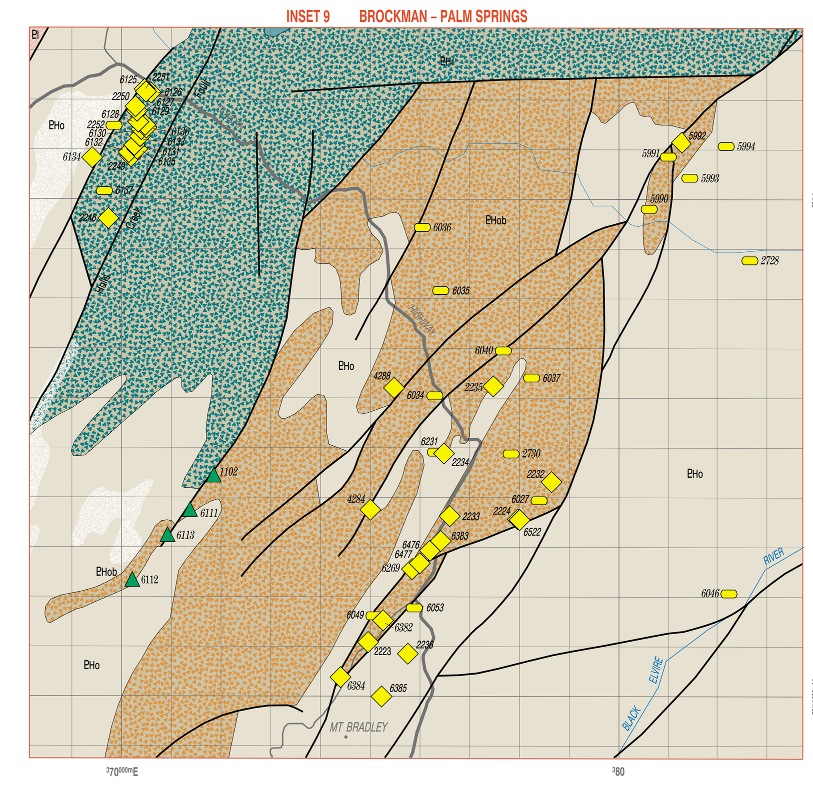
| | |
|---|---|
| Bold numbers | Operating mine |
| *Bold and italic numbers* | Abandoned mine |
| Plain numbers | Mineral deposit |
| *Italic numbers* | Mineral occurrence or prospect |

Full mineral listing in Appendix 1 of Report 74

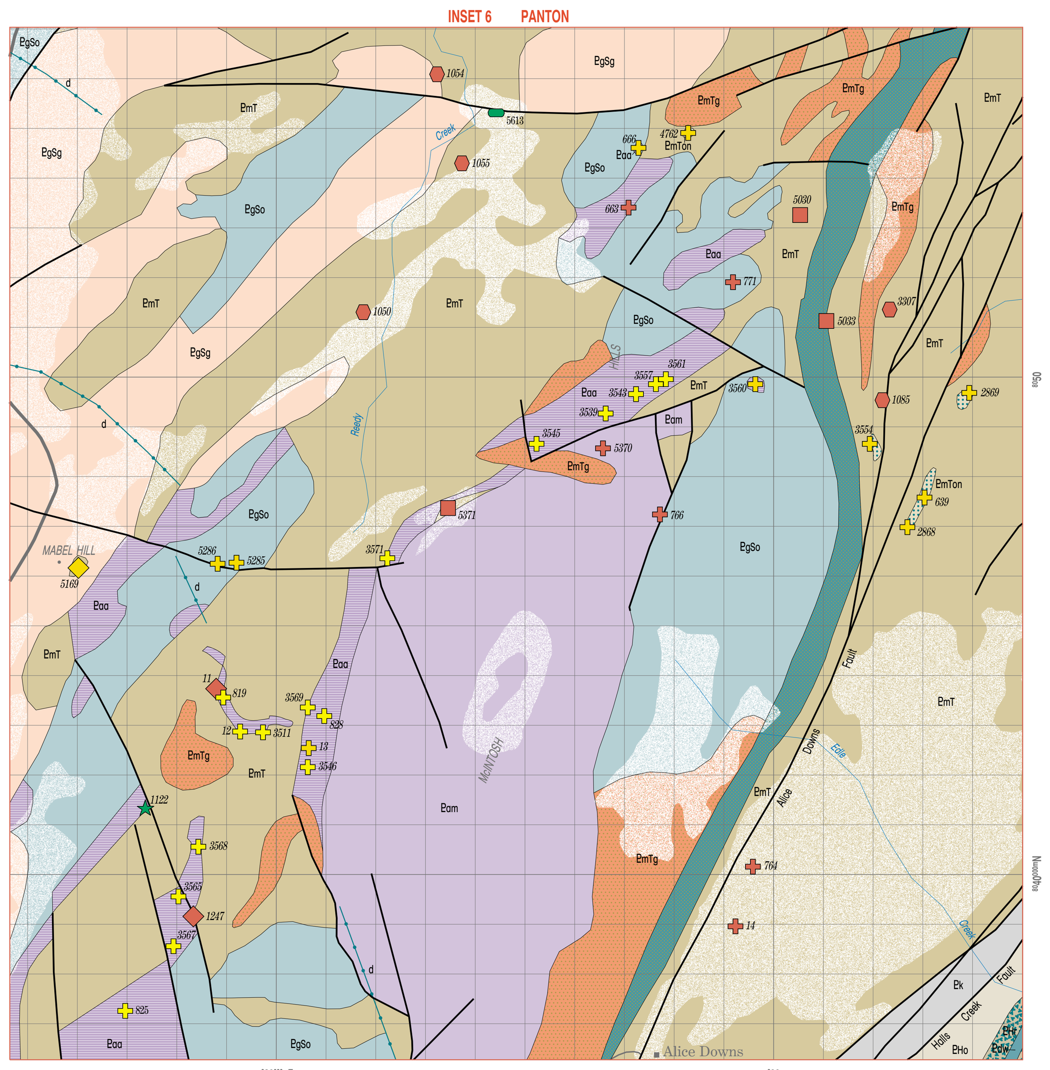
INSET 7 GRANTS PATCH



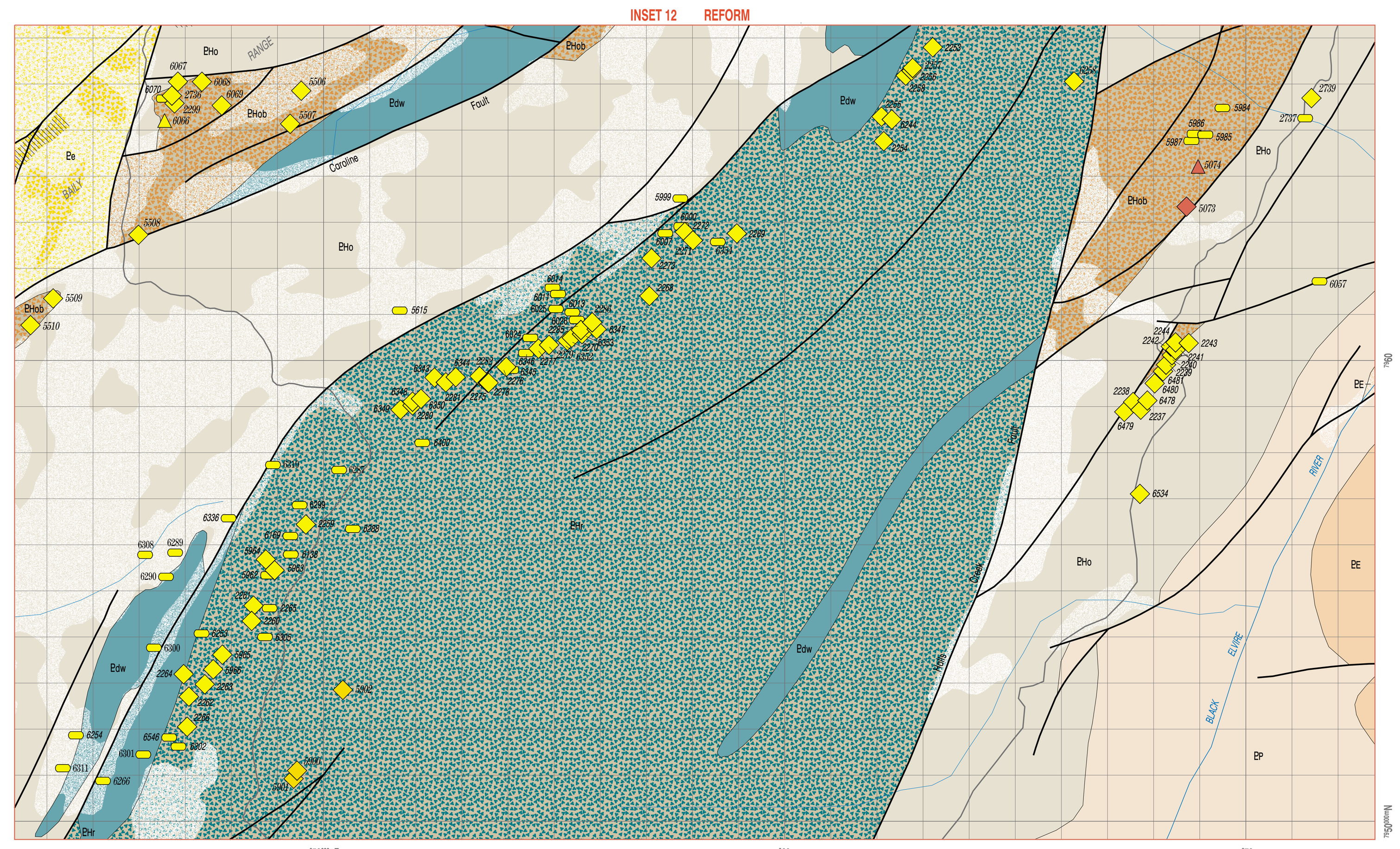
INSET 9 BROCKMAN – PALM SPRINGS



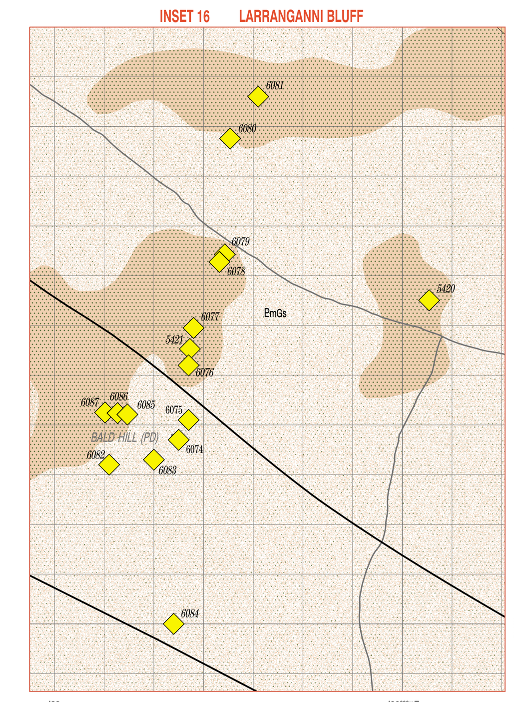
INSET 6 PANTON



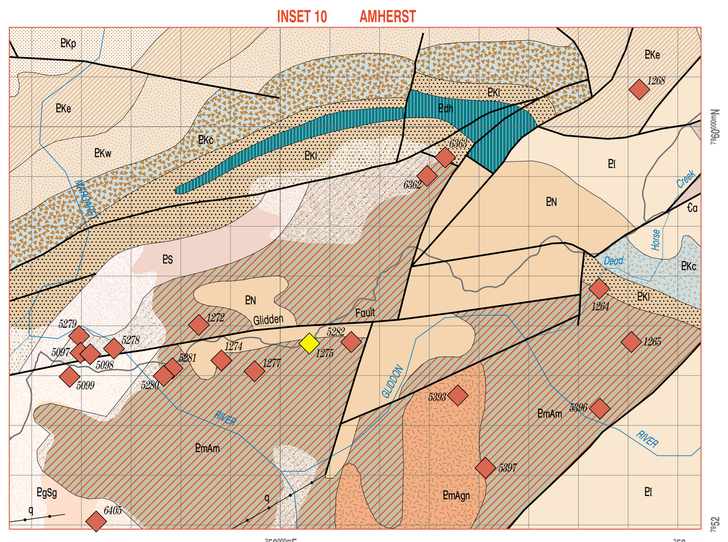
INSET 12 REFORM



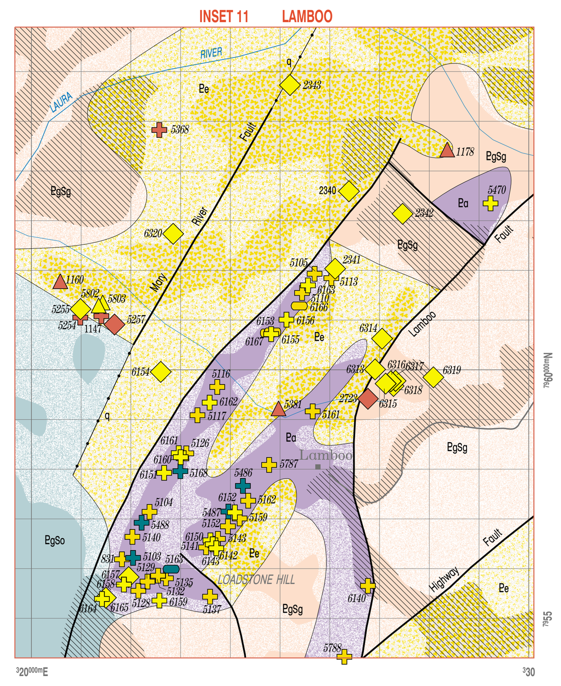
INSET 16 LARRANGANNI BLUFF



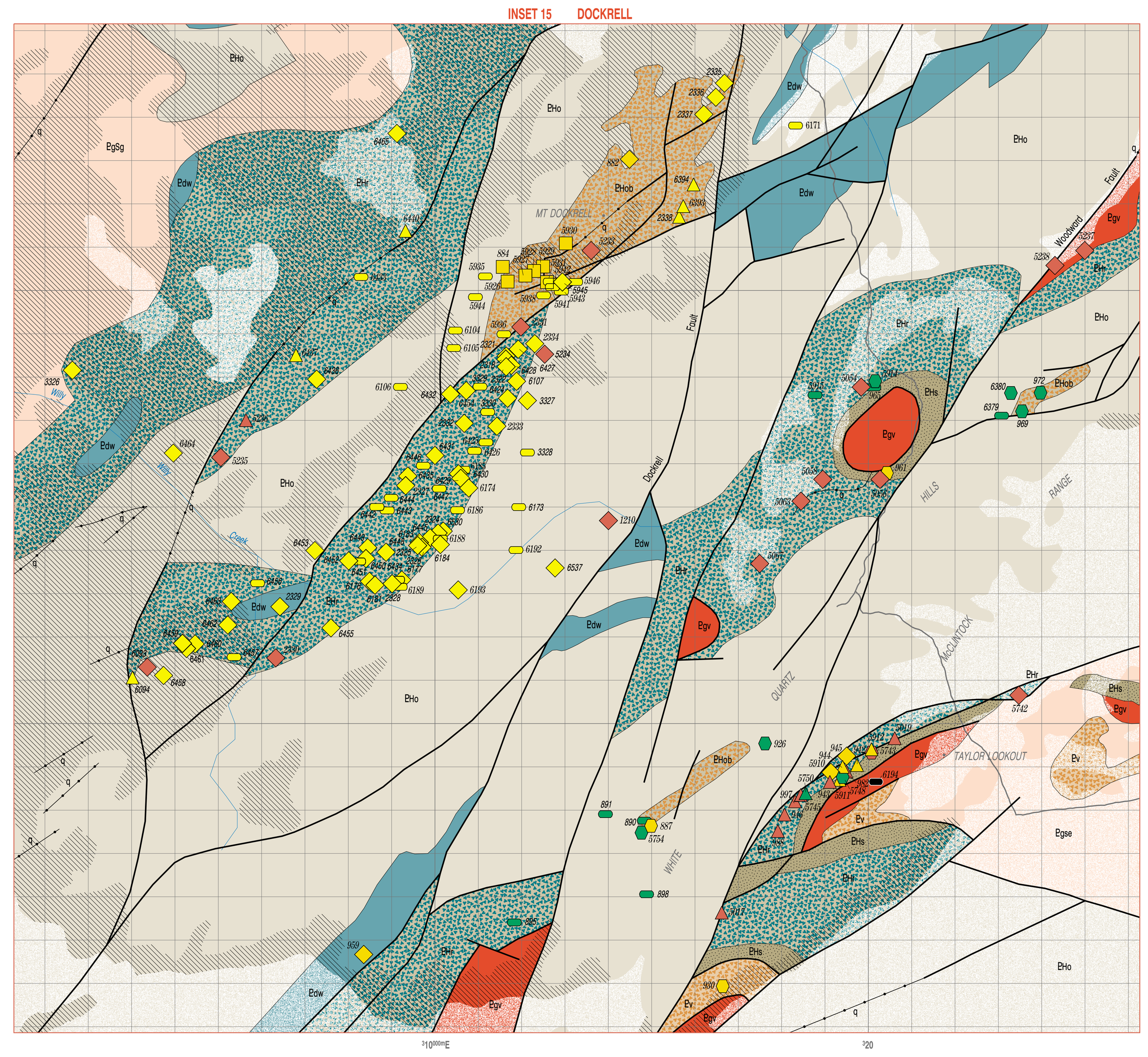
INSET 10 AMHERST



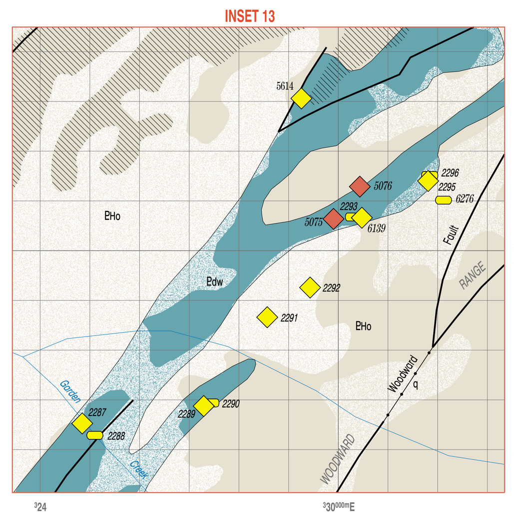
INSET 11 LAMBOO



INSET 15 DOCKRELL



INSET 13



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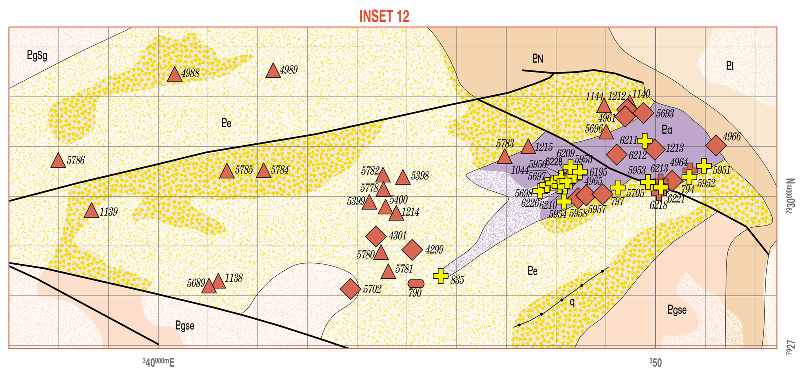

# EAST KIMBERLEY INSET MAPS

FOR REFERENCE SEE PLATE 1

Department of Industry and Resources

Geological Survey of Western Australia

CLIVE BROWN, M.L.A.
MINISTER FOR STATE DEVELOPMENT

JIM LIMERICK
DIRECTOR GENERAL

TIM GRIFFIN
DIRECTOR

SCALE 1:100 000

1000 0 1 2 3 4 5 6 7 8 9 10
Metres Kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM: GEOCENTRIC DATUM OF AUSTRALIA 1994
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM

Grid lines indicate 1000 metre interval of the Map Grid Australia Zone 52

The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94)
GDA94 positions are compatible within one metre of the datum WGS84 positions

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

REPORT 74 PLATE 1A

# MINERALIZATION AND GEOLOGY OF THE EAST KIMBERLEY

Version 1.1 — July 2003