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MINERAL OCCURRENCES AND EXPLORATION POTENTIAL OF THE EARAHEEDY AREA WESTERN AUSTRALIA

by P. B. Abeysinghe

Geological Survey of Western Australia

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

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P. B. Abeysinghe

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This is an amended version as of August 2005. The section on Mount Teague and Mount Lockeridge base metal prospects (page 37) has been amended.

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Cover photograph:
Kaljahr Pinnacle — a dolerite intruding the Coonabildie Formation, showing laterite capping (LEE STEERE 1:100 000 map sheet)

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Mineral occurrences and exploration potential of the Earaheedy area, Western Australia

by

P. B. Abeysinghe

Abstract

The Earaheedy area in Western Australia is centred on latitude 25°30'S and longitude 121°30'E and covers an area of about 84 000 km^2. There are currently no operating mines in the area, although there was minor gold production in the 1930s. The area includes a number of tectonic units, and most of the area is covered by the Palaeoproterozoic Earaheedy Basin, the northwestern part of the Neoproterozoic Officer Basin, and the northern portion of the Archaean Yilgarn Craton.

Mineral commodities known in the area include iron, copper, lead, zinc, nickel, platinum group elements, gold, diamond, uranium, manganese, silver, barite, gypsum, salt, and construction material, but reported mineral production from the area has been only for gold from the Mount Eureka mining centre in the mid-1930s. Altogether, 182 mineral occurrences have been recorded with more than 80% of these in the Earaheedy Basin. The mineral occurrences have been assigned to different mineralization styles:

- hydrothermal — vein style (gold, base metal, nickel, manganese, and barite);
- kimberlite and lamproite intrusions style (diamond);
- stratabound sedimentary — carbonated-hosted style (base metals);
- sedimentary — supergene-enriched granular iron-formation style (iron);
- regolith style (gold, diamond, manganese, uranium, gypsum, and salt);
- undivided style (construction materials).

Grassroots discoveries of nickel–copper sulfides and platinum group elements have been made in the Gerry Well greenstone belt, west of the Collurabbie Hills, where metal grades in drill intersections suggest that this area may be a new nickel province. The prospective areas for base metal mineralization include the northern boundary zones of the Earaheedy and Yerrida Basins, the boundary zone between Archaean basement rocks in the Marymia Inlier and the Palaeoproterozoic rocks of the Earaheedy Basin, and the area around the Shoemaker impact structure. The Quadrio Lake area in the Mesoproterozoic Oldham Inlier is prospective for barite, base metals, and possibly gold. The most prospective areas for gold mineralization are the greenstone belts in the Yilgarn Craton, south of the Earaheedy Basin. The economic potential of the Frere Formation for iron is highest in the Stanley Fold Belt. The most prospective areas for diamond in kimberlite and lamproite intrusions are likely to be the boundary zones between Archaean basement rocks and the Palaeoproterozoic rocks. Other possible diamond accumulations could be in regolith deposits associated with palaeochannels containing material derived from basement Archaean rocks in the Yilgarn Craton and Proterozoic rocks in the Earaheedy Basin. Prospective areas for uranium mineralization are in calcrete and palaeochannels associated with or adjoining the Shoemaker impact structure. The Wongawol, Chiall, and Frere Formations on the KINGSTON and STANLEY 1:250 000 sheets are prospective for manganese mineralization.

KEYWORDS: mineral occurrences, mineralization, exploration, Earaheedy Basin, Officer Basin, Collier Basin, Yerrida Basin, Gunbarrel Basin, Marymia Inlier, Ward Inlier, Oldham Inlier, Imbin Inlier, Malmac Inlier, Yilgarn Craton, Scorpion Group, Salvation Group, regolith, copper, lead, zinc, nickel, platinum group elements, diamond, gold, iron, uranium, manganese, silver, gypsum, salt, construction material.

Introduction

This Report aims to promote and enhance the mineral prospectivity of the Earaheedy area, which is covered by the BULLEN*, TRAINOR, NABBERU, STANLEY, and KINGSTON 1:250 000 map sheets (Fig. 1). The text is accompanied by a 1:500 000-scale geology map (Plate 1) and a digital dataset on a CD-ROM, and presents a review of the regional geology, history of mineral exploration activities in the area, main mineral occurrences, mineralization controls, and potential for further mineralization. Plate 1 shows the mineral occurrences, indicating commodity and mineralization style, on a simplified interpretation of the bedrock geology and regolith. The Report also incorporates numerous modifications and revisions of stratigraphic units as well as the boundaries of some tectonic units introduced during geological mapping of the area by the Geological Survey of Western Australia (GSWA) from 1999 to 2003. Most of the modifications to geological units are in areas covered by NABBERU, KINGSTON, and parts of STANLEY.

Extracts from GSWA's GIS-based Western Australian mineral exploration activities (EXACT) and Western Australian mineral occurrence (WAMIN) databases are provided. These databases have been developed as a major initiative to improve access to information on minerals and mineral exploration in Western Australia. Details of mineral exploration, mineral occurrences, and other geoscientific information have been compiled from the following sources:

- the large dataset of open-file statutory mineral-exploration reports held in GSWA's Western Australian mineral exploration (WAMEX) database;
- the Western Australian mines and mineral deposits information (MINEDEX) database;
- books, journals, and industry publications and datasets;
- regional geological surveys, and airborne geophysical, and remote-sensing datasets.

Appendix 1 presents the key to the mineral occurrences on Plate 1. Where mineral occurrences are referred to in this Report, they are also identified by a WAMIN 'deposit name' and the WAMIN 'deposit number' shown thus: Jewill 1 (*10787*). Appendix 2 defines the terms used in the WAMIN and EXACT databases.

The accompanying CD-ROM contains datasets from the mineral occurrences (WAMIN) database, the spatial index of exploration activities (EXACT database), digitized geology, and digitized regolith. It also includes files of geophysical, remote-sensing, mining tenement position, and topographic data. The CD-ROM contains the files necessary for viewing the data in the ArcView GIS environment plus a self-loading version of GSWA's GeoVIEWER.WA software package modified to suit this particular dataset. Metadata statements on the geological, geophysical, and topographic datasets are also provided. Appendix 3 gives a brief description of the digital datasets included on the CD-ROM.

Location

The Earaheedy study area encompasses a number of tectonic units that include most of the Earaheedy Basin; the northwestern Officer Basin; a portion of the Collier Basin; the Scorpion, Salvation, Gunbarrel, and Yerrida Basins; the Malmac, Oldham, Ward, and Imbin Inliers; the easterly portion of the Marymia Inlier; and a small area of the northern border of the Yilgarn Craton (Plate 1 and Fig. 1).

Physiography

The relief of the study area decreases from west to east (Fig. 2), with a maximum height of 913 m at Mount Methwin in the north-central part of NABBERU and a minimum height of 359 m at the northeastern corner of TRAINOR. On the basis of relief, the report area can be broadly grouped into the following four types (Fig. 2):

- areas of high relief (>700 m) containing ridges and hills of resistant rocks with steeper dips, restricted to localities around Mount Methwin in the central-northern part of NABBERU, and at Mount Essendon, Clover Tabletop, and Yibbie Range on southwestern BULLEN;
- areas of moderate to high relief (600–699 m) consisting of low hills of resistant rocks with shallow dips, mostly restricted to the western half of BULLEN and northwestern NABBERU (e.g. areas south and north of Marymia, at Mount Lockeridge and at Mount Teague in the Frere Range);
- areas of moderate relief (500–599 m), mostly in the central zone of the study area covered with plateaus, mesas, and buttes of silcrete and ferricrete (e.g. Princess Range on KINGSTON, Hawkins Knob on NABBERU). Areas of moderate relief also include some sandplains and sheetwash areas (includes colluvium and alluvium), on all five map sheets;
- areas of low relief (<499 m) mostly around claypans and lake systems at the eastern border of the study area and around lakes at the eastern border of BULLEN, the western and eastern borders of TRAINOR, the eastern half of STANLEY, and the northern area of KINGSTON. These areas generally represent the infilled trunk drainages of the Cretaceous–Tertiary palaeodrainage system, and consist of bare salt lakes, dunes, and sheets of eolian sand and alluvial material adjacent to salt lakes, and calcreted valley floors (van de Graaff et al., 1977; e.g. areas around Lake Carnegie on KINGSTON, Lake Burnside on STANLEY, and Lake Aerodrome on TRAINOR).

Rocks such as quartzite and iron formation that are relatively more resistant form topographically high features, whereas rocks such as shale form low rounded hills, and carbonate rocks weather to more rugged topography. Surrounding most areas of outcrop are gently sloping pediments of rock fragments in loamy soil. These pass downslope into extensive sheetwash plains, where thick soil horizons with fewer rock fragments have developed. Broad ill-defined drainages are filled with alluvium, and in their lower reaches incised watercourses have been cut into the alluvium (Bunting, 1986).

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* Capitalized names refer to 1:250 000 map sheets, unless otherwise indicated.

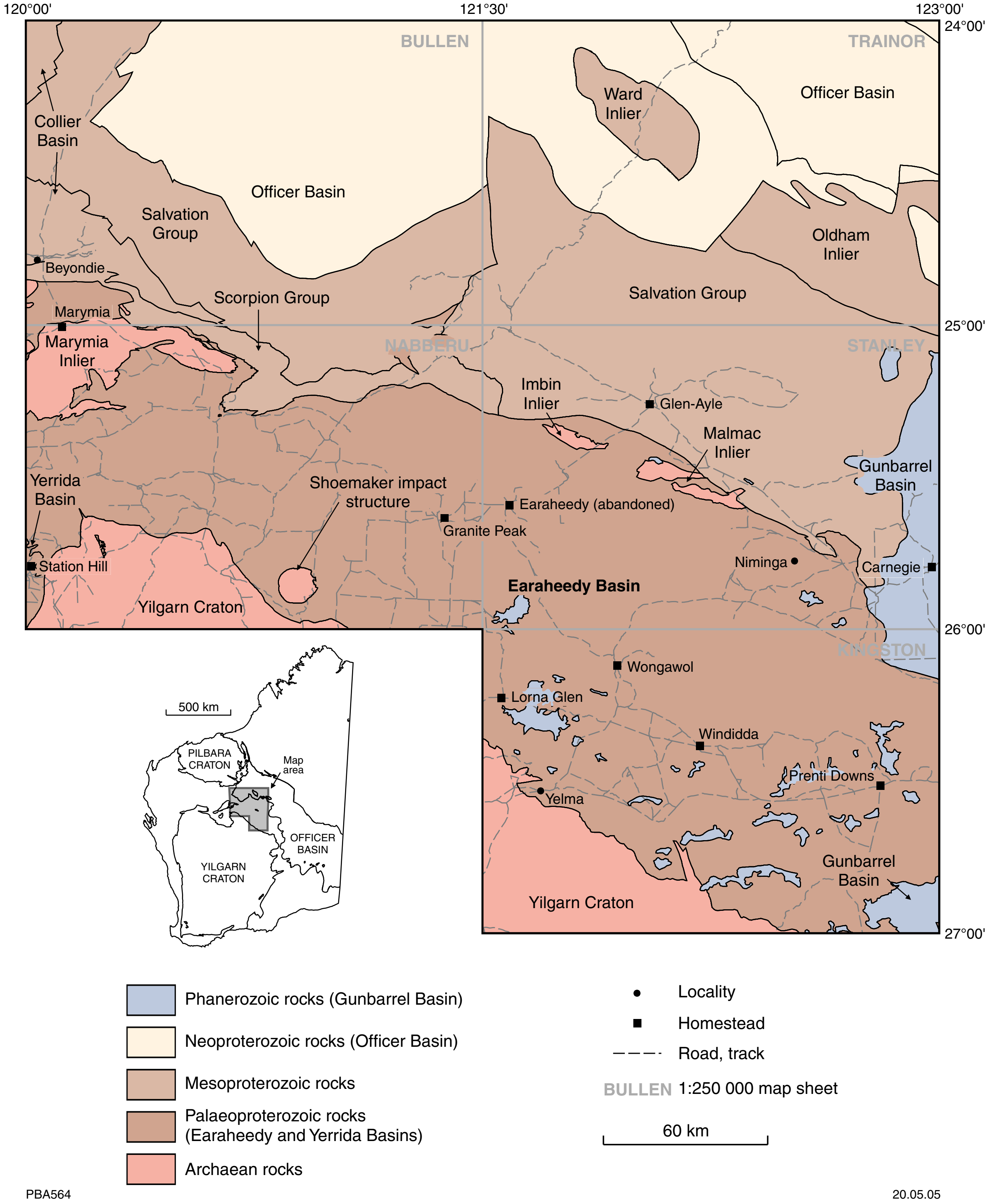

Figure 1. Tectonic units and location map of the Earaheedy study area

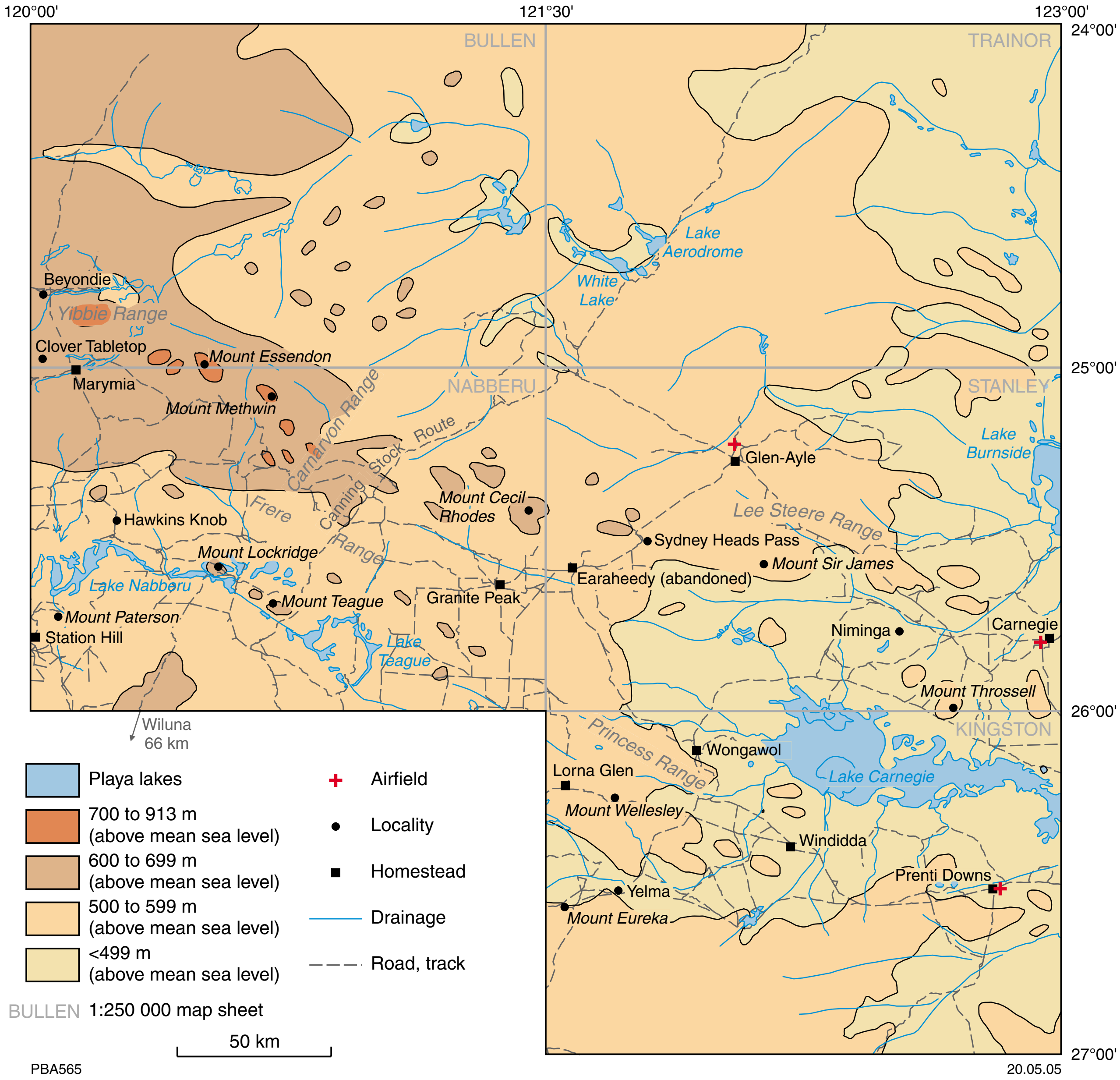

Figure 2. Physiographic features of the Earaheedy area

The streams and lakes in the area are ephemeral, with water flowing only after heavy rain. Ancient drainage systems that ceased significant flow in the Middle Miocene along with major salt-lake systems form part of an extensive palaeodrainage system. A major playa-lake system consisting of lakes Gregory (on PEAK HILL), Nabberu and Teague (on NABBERU), Carnegie (on KINGSTON), and Wells (on ROBERT) crosses the area from west-northwest to east-southeast. The drainage on the eastern side of TRAINOR flows northeasterly into Lake Burnside (on STANLEY), whereas on northern KINGSTON southerly, easterly, and northerly drainages feed Lake Carnegie. Bunting (1986) identified three physiographic units in the above drainage systems:

- flat, bare, and salt lakes that are covered with a few centimetres of water after heavy rain;
- dunes and sheets of eolian and alluvial material marginal to the salt lakes;
- calcreted valley floors, commonly tributaries of or marginal to the main salt lakes.

Another conspicuous physiographic feature of the study area is the desert sandplain. The sand is eolian with longitudinal dunes prominent in many areas, particularly on TRAINOR.

Climate

The climate of the study area is semi-arid to arid, with a mean annual rainfall of about 230 mm. The area is subject to drought as well as localized short-term floods, with its wettest period from December to June. February is the wettest month with an average rainfall of 40 mm. During January to March thunderstorms can produce heavy localized falls in short periods. Although rare, tropical lows or weakening tropical cyclones that originate off the Pilbara coast can bring widespread rain to the region. January is the hottest month with an average maximum of around 40°C and minimum of 25°C. July is the coolest month with an average maximum of around 20°C and minimum of 6°C (data from Commonwealth Bureau of Meteorology website: <http://www.bom.gov.au>).

Access

The roads in the area are mainly graded and gravel roads that link Wiluna township (south of the report area) to the homesteads at Granite Peak, Earaheedy, Glenayle, Carnegie, Wongawol, Windidda, and Prenti Downs (Fig. 2). The Canning Stock Route, which starts northwards from Wiluna, runs broadly in a northeasterly direction, passing south of Mount Lockeridge and Mount Teague on NABBERU and White Lake and Lake Aerodrome on TRAINOR.

Previous work

In 1874 the explorer John Forrest crossed NABBERU and STANLEY, during which various localities on NABBERU were named (e.g. Sweeney Creek, Frere Range, Kennedy Creek, Pierre Spring, and various hills in the Carnarvon Range). Ernest Giles travelled across the northern portion of BULLEN in 1876 while traversing the Gibson Desert (Giles, 1889a,b). During 1892–96, Lawrence Wells traversed KINGSTON from east to northwest and during 1897, David Carnegie traversed the southeastern corner of KINGSTON (Bunting, 1980a).

H. W. B. Talbot carried out the first geological investigations and produced the earlier geological maps of the report area. His first reconnaissance survey was carried out during the construction of the Canning Stock Route in 1908 (Talbot, 1910). Subsequent reconnaissance traverses were made during 1912–13 (Talbot, 1914, 1919, 1920, 1926).

Other contributions to the geology of the study area, prior to 1980, included Mabbutt et al. (1963), Horwitz and Daniels (1967), Horwitz and Mann (1975), Sanders and Harley (1971), Horwitz (1975a,b), Hall and Goode (1975, 1978), and Hall et al. (1977). Lambourn (1972) produced an interpretation of the aeromagnetic data on KINGSTON. The Bureau of Mineral Resources (BMR, now Geoscience Australia) published a gravity map in 1970 (showing Bouger anomalies) and a total magnetic intensity map in 1988 (Bureau of Mineral Resources, 1988). Butler (1974), a mineral exploration geologist, first identified the 'Lake Teague Ring Structure' (now known as the Shoemaker impact structure). The structure was later described in more detail by Bunting et al. (1980) and Pirajno (2002).

Systematic regional geological mapping of the study area was carried out by GSWA in the early 1980s (Bunting, 1980a,b; Brakel and Leech, 1980; Leech and Brakel, 1980; Commander et al., 1982; and Bunting et al., 1982).

In 1981 BMR produced a Bulletin that described the geology of the Officer Basin (Jackson and van de Graaff, 1981). Grey (1984) carried out detailed biostratigraphic studies of stromatolites from the Earaheedy Group. The geology of the Bangemall Group (now Bangemall Supergroup) was described by Muhling and Brakel (1985). Bunting (1986) described the geology of the eastern part of the then 'Nabberu Basin' that covered most of the report area. Williams (1990a,b, 1992) described the 'Savory Basin' and the 'Bangemall Basin'. More recently, these three basins (Savory, Bangemall, and Nabberu) have been redefined. The Savory Basin is now considered to be the northwestern extension of the Officer Basin (Tyler and Hocking, 2002). The Bangemall Basin is separated into the Collier and Edmund Basins (Martin and Thorne, 2001), and two smaller basins to the east — the Scorpion and Salvation Basins (Hocking et al., 2000a; Grey et al., 2005). The Nabberu Basin is separated into the Earaheedy Basin and a number of other basins (Tyler and Hocking, 2002). The tectonic units of the report area are described in Tyler and Hocking (2002).

In 1997 GSWA commenced a project to undertake geological mapping of the Earaheedy Basin at 1:100 000 scale. Maps and explanatory notes have been produced for the CUNYU (Adamides et al., 1998, 1999), MERRIE (Adamides, 1999, 2000), FAIRBAIRN (Pirajno et al., 1999, Adamides et al., 2000a), METHWIN (Hocking and Jones, 1999, 2002), EARAHEEDY (Adamides et al., 2000b; Hocking et al., 2001a), and WONGAWOL (Jones, 2002a,b) 1:100 000 sheets. A combined explanatory notes has been produced for the NABBERU (Pirajno, 1999) and GRANITE PEAK (Jones and Pirajno, 2000) 1:100 000 sheets (Pirajno et al., 2004a). In addition, 1:100 000 maps have been published for NABBERU (Pirajno, 1999), RHODES (Pirajno et al., 2000), MUDAN (Pirajno and Hocking, 2001), GLENAYLE (Pirajno and Hocking, 2002), and LEE STEERE (Hocking and Pirajno, 2004). The WINDIDDA (Jones and Hocking, in prep.), COLLURABBIE (Jones, in prep.), and VON TREUER (Pirajno, in prep.) 1:100 000-scale maps are being compiled.

Geological mapping of the Savory Basin resulted in the production of second editions of 1:250 000 sheets and explanatory notes for BULLEN and TRAINOR (Williams, 1995a,b; Williams et al., 1995a,b). In 2003 a second edition of the NABBERU 1:250 000 sheet was produced (Hocking et al., 2003). GSWA mapping projects have led to the identification and definition of numerous new rock units, abandoning many stratigraphic units that were used earlier (Bagas et al., 1999; Martin et al., 1999, Hocking et al., 2000a,b; Martin and Thorne, 2001, Hocking et al., 2003).

During 1997–2002, GSWA carried out a regional geochemical sampling and regolith mapping program in the Earaheedy area and produced regolith geochemistry series explanatory notes for the NABBERU (Morris et al., 1997), STANLEY (Morris et al., 2000), and KINGSTON (Pye et al., 2000) 1:250 000 sheets and the NICHOLLS 1:100 000 sheet (Sanders, 2002). Additional information related to the regolith geochemical mapping programs and mineralization in the region is given in Morris et al. (1998, 2003).

In addition to the information from open-file data that will be discussed under the sections on **Exploration and mining history** and **Mineralization**, mineral commodities within the study area have been discussed by Bunting (1980a), Bunting et al. (1982), Commander et al. (1982), Bunting (1986), Adamides (2000), Adamides et al. (2000a), Pirajno and Adamides (2000), Hocking et al. (2000a,c), Hocking et al. (2001a), Hocking and Jones (2002), Pirajno (2002), Morris et al. (2003), Pirajno et al. (2004a,b), and Pirajno (2004).

Regional geology

The area dominantly includes the Palaeoproterozoic Earaheedy Basin (in the south) and the Neoproterozoic Officer Basin (in the north). It also includes small portions of the Archaean Yilgarn Craton, Marymia Inlier, and Malmac Inlier, the Palaeoproterozoic Imbin Inlier and Yerrida Basin, the Mesoproterozoic Scorpion and Salvation Basins (which probably correlate with the Collier and Edmund Basin successions respectively (Hocking et al., 2003), the Mesoproterozoic Collier Basin and Ward and Oldham Inliers, and the Phanerozoic Gunbarrel Basin (Fig. 1).

Archaean geology

Yilgarn Craton

Archaean rocks exposed in the southwestern portions of Nabberu and Kingston are assigned to the Eastern Goldfields Granite–Greenstone Terrane, which has an assemblage of granitic and greenstone rocks that probably formed between 2780 and 2630 Ma (Griffin, 1990; Myers and Swager, 1997).

Greenstone belts

The four Archaean greenstone belts within the Yilgarn Craton on Nabberu and Kingston are mostly covered by laterite and are poorly exposed (Plate 1).

Merrie greenstone belt

The rocks in the Merrie greenstone belt exhibit varying degrees of alteration, and contain quartz, chlorite, epidote, biotite, and carbonate (Bunting et al., 1982; Adamides et al., 1999; Adamides, 2000; Hocking et al., 2003; Farrell and Adamides, 2000). Sparsely exposed mafic rocks include fine- and medium-grained varieties; amphibolite was intersected in drillholes in the southern part of the Merrie greenstone belt (Adamides, 2000). On Cunyu (1:100 000) the southern extension of the Merrie greenstone belt was informally called the ‘Cunyu greenstone belt’ by Griffin (1990), Adamides et al. (1999), and Adamides (1999).

Greenstone belt near Horse Well

A small greenstone belt is located along a major fault between two bodies of hornblende–quartz monzonite south of Horse Well on Nabberu (Fig. 3; Bunting et al., 1982; Pirajno, 1999; Hocking et al., 2003). The greenstone belt contains metamorphosed mafic–ultramafic and felsic volcanic rocks. The main rock type is metabasalt (Bunting et al., 1982; Pirajno, 1999; Pirajno et al., 2004a). Griffin (1990) referred to this greenstone belt as the Bridle Face greenstone belt.

Mount Eureka greenstone belt

The Mount Eureka greenstone belt (Griffin, 1990; Jones, 2002a,b) lies within the granitic rocks of southwestern Kingston and consists of steeply easterly dipping, metamorphosed mafic, ultramafic, sedimentary, and possible felsic volcanic rocks. The predominant rock type is fine-grained metabasalt, particularly in areas north of Mount Eureka (Fig. 2). Metamorphosed komatiitic basalt displays spinifex texture in places and is intruded by medium- to coarse-grained metagabbro. The basalt

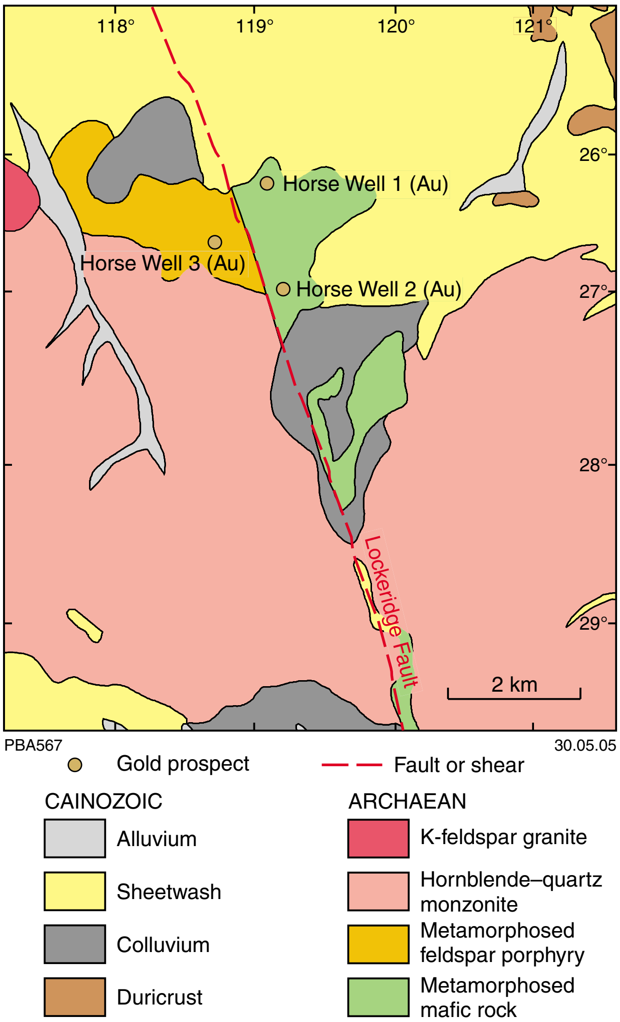

Figure 3. Greenstone belt at Horse Well (after Pirajno, 1999)

commonly lacks strong foliation and contains thin bands of chert, shale, and chlorite schist (Bunting, 1980a,b; Jones, 2002a,b). The ultramafic rocks are represented by a buff-coloured siliceous and ferruginous caprock (Bunting, 1980a,b).

Poorly bedded, kaolinized volcanic rocks, of possible volcaniclastic origin, are exposed south of Irwin Bore. Banded iron-formation and associated ferruginous banded chert form an intermittent strike ridge, 20 km long, extending from south of Doyle Well to 20 km southeast of Irwin Bore (Bunting, 1980a).

Gerry Well greenstone belt

The northern part of the Gerry Well greenstone belt (Griffin, 1990) is exposed 35 km south-southeast of Old Windidda on KINGSTON, and consists mainly of a complex strike ridge of banded-iron formation, ferruginous chert, and interbedded shale. At the eastern side of the ridge, the predominant rock type is red-and-black banded jaspilite, whereas the western side contains a grey chert-breccia. A few kilometres northeast of the above rocks, poor exposures of felsic volcanic and banded shaly rocks with minor chert are white, kaolinitic, and contain sparse feldspar laths and subrounded quartz grains (Bunting, 1980a,b). Greenstones have also been intersected under cover, at depths of less than 70 m, during exploration drilling for gold by BHP and North Ltd in the late 1990s. These include mafic, ultramafic, granitic, and metasedimentary rocks of varying composition (Butterworth, 1999a,b, 2000). More recent drilling in the area has shown that the ultramafic rocks host nickel–copper sulfides and platinum group elements (PGE; Falcon Minerals Limited, 2004).

Granitic rocks

Archaean granitic rocks of the northern margin of the Archaean Yilgarn Craton are exposed in the southwest of the study area (Plate 1; Fig. 1).

Most of the granite on MERRIE (1:100 000) is ferruginized and silcretized, medium grained, biotite rich, and porphyritic (Adamides, 2000). On NABBERU (1:100 000), the granitic rocks south and west of Horse Well (Fig. 3) are of two types: hornblende-bearing quartz monzonite and medium-grained leucocratic K-feldspar granite. Hornblende-bearing quartz monzonite forms a massive, internally undeformed, discrete pluton cut by the north-northwesterly trending Lockeridge Fault. Medium-grained leucocratic K-feldspar granite outcrops on the northwestern margin of the hornblende-bearing quartz monzonite (Pirajno, 1999; Hocking et al., 2003; Pirajno et al., 2004a).

Deeply weathered granitic rocks on southwestern KINGSTON are poorly exposed north and south of Mount Eureka. Most of these are monzogranites (Bunting, 1980a; Jones, 2002a).

Metasedimentary rocks

On MERRIE (1:100 000) areas of duricrust material showing laminated structures and containing quartz, actinolite, and epidote have been interpreted as remnants of metasedimentary rocks (Adamides, 2000).

Felsic porphyry and felsic volcaniclastic rocks

Minor felsic porphyry and felsic volcaniclastic rocks are exposed in the Yilgarn Craton on MERRIE (1:100 000) (Adamides, 2000).

Teague Granite

The Teague Granite (Fig. 4), associated with the Shoemaker impact structure (discussed under **Structure and deformation**) on NABBERU (1:100 000), has a magmatic age of 2648 Ma (Nelson, 1997; Pirajno, 2002).

Bunting et al. (1980) recognized two lithologies in the Teague Granite: a medium-grained leucogranite and a quartz syenite. Pirajno (2002) carried out more detailed field and petrographic studies and subdivided the Teague Granite into three types: aegirine-augite-bearing orthoclase–albite granite or syenite (in places cut by pegmatite veins); albite–quartz–microcline granite or quartz syenite; and leucocratic alkali-feldspar granite. The reddish-coloured Teague Granite exhibits a texture and mineral composition that supports an origin from intense alkali metasomatism of an original granitic rock (Pirajno, 2002).

Pirajno (2002) considered two possibilities for the origin of the Teague Granite. One possibility is that the Teague Granite may be one of the alkaline plutons in the Yilgarn Craton, emplaced between 2650 and 2630 Ma (Smithies and Champion, 1999). The other possibility, on the basis of its metasomatic character, is that the Teague Granite is linked to the Shoemaker impact structure (Pirajno, 2002). The first case is supported by the mineralogy and texture of the Teague Granite, which indicate that it has undergone metasomatic processes related to the cooling of an alkali melt. The second possibility is supported by mineralogical, textural, and chemical features reflecting metasomatic processes that are related to a heat source generated by the Shoemaker impact structure. However, the precise origin of the granite remains unresolved (Pirajno, 2002; Pirajno et al., 2003).

Marymia Inlier

The eastern end of the Archaean Marymia Inlier outcrops on NABBERU and BULLEN (Fig. 1). The main portion of the inlier is on PEAK HILL and COLLIER west of the report area. The inlier is interpreted to be part of the Yilgarn Craton, although it is not yet clear which granite–greenstone terrane it relates to (i.e. Murchison, Southern Cross, or Eastern Goldfields).

The Marymia Inlier lies within Proterozoic rocks of the Capricorn Orogen (Bagas, 1998a) and consists of the Plutonic Well and Baumgarten greenstone belts and adjacent granitic rocks. The greenstone belts lie mainly outside the study area and were described by Bagas (1998b), but a small portion of the Baumgarten greenstone

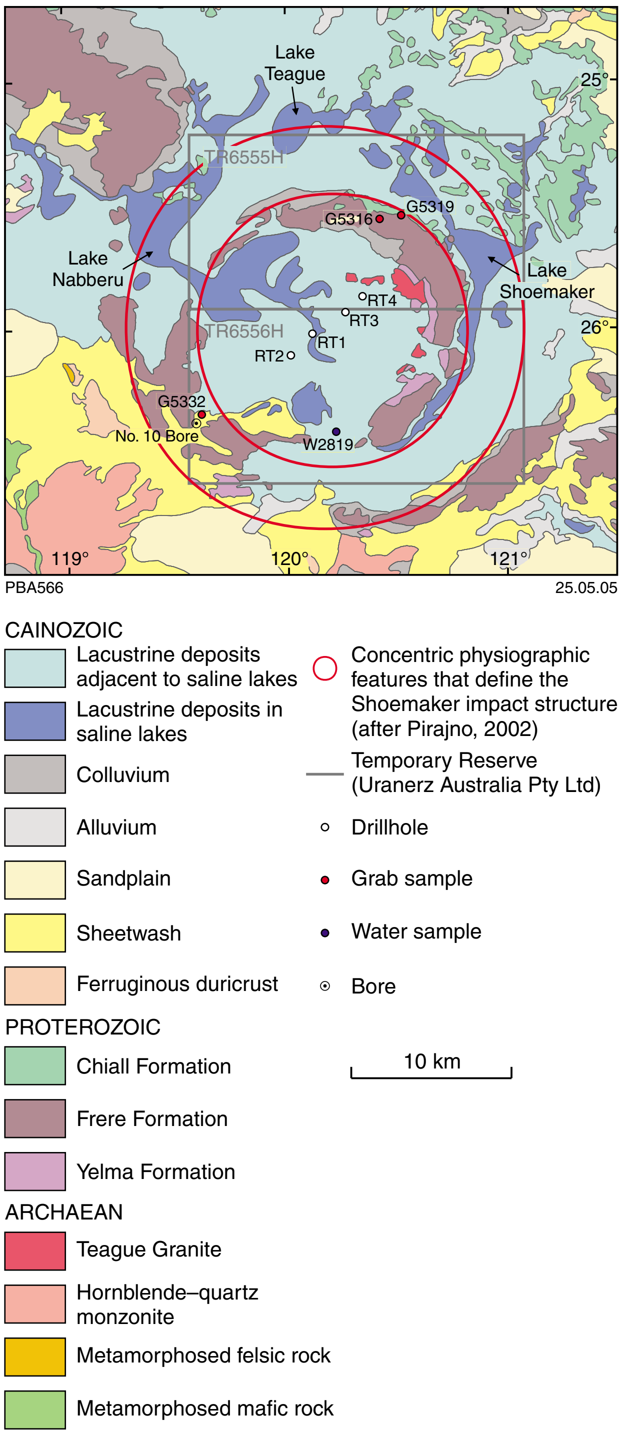

Figure 4. Geology around the Shoemaker impact structure and Temporary Reserves for uranium exploration in 1978 (geology after Hocking et al., 2003)

belt is exposed at the central-western edge of FAIRBAIRN (1:100 000).

In the report area, granitic rocks of the Marymia Inlier outcrop in the northern half of FAIRBAIRN (1:100 000) and the northwestern portion of METHWIN (1:100 000). The undivided granitic rocks on FAIRBAIRN are commonly weathered and exposed in patchy outcrops or breakaways. Some of these granitic rocks are identified as monzogranite consisting of microcline megacrysts set in a matrix of feldspar, quartz, biotite, muscovite, sericite, chlorite, and titanite. Drill cuttings from several drillholes, west of the vermin-proof fence, revealed that the monzogranite is locally affected by potassic alteration, resulting in the formation of biotite of hydrothermal origin (Adamides et al., 2000a; Hocking and Jones, 2002). On northwestern METHWIN, granitic rocks are typically weathered and exposed as low-lying irregular outcrops of silcrete, kaolinitic saprock, and rare fresh rock. Fresh rocks are typically equigranular, medium- to coarse-grained monzogranite consisting of K-feldspar, plagioclase, quartz, biotite, and secondary muscovite (Hocking and Jones, 2002).

Malmac Inlier

The Archaean Malmac Inlier (Horwitz, 1976) consists of various granitic rocks of a basement inlier outcropping north of the Lee Steere Range (Figs 1 and 2). The dome forms a structural high in the Stanley Fold Belt and covers an area of about 200 km^2. The poorly exposed granitic rocks are medium to coarse grained, porphyritic, and strongly foliated. The rocks, mostly covered by eolian sand, are unconformably overlain by deeply weathered Yelma Formation of the Earaheedy Group (Commander et al., 1982; Bunting, 1986). Pirajno and Hocking (2002) and Hocking and Pirajno (2004) mapped the granitic rocks in the Malmac Inlier on GLENAYLE and LEE STEERE (1:100 000) as the Malmac Granite, and identified the rocks as weathered monzogranite. These rocks are cut by quartz veins near the contact with country rock. Uranium–lead sensitive high-resolution ion microprobe (SHRIMP) zircon age determinations of the Malmac Granite yielded a c. 2550 Ma age (Nelson, 2002).

Palaeoproterozoic geology

Yerrida Basin

The Yerrida Basin (Pirajno et al., 1996; Occhipinti et al., 1997; Bagas, 1998b; Pirajno and Adamides, 1998) contains the Windplain and Mooloogool Groups (Pirajno et al., 2004a,b). It is the oldest Palaeoproterozoic basin in the report area (c. 2.17 Ga, Pirajno et al., 2004a,b) and is exposed in a small area in the southwestern corner of NABBERU (Fig. 1).

The Yerrida Basin was initiated as an intracratonic sag, within which siliciclastic rocks (originating from low-relief areas) and evaporites accumulated (Windplain Group). The basin was rejuvenated after a hiatus of almost 340 million years, when it deepened to become a foreland basin in response to compression and orogenic uplift in the west (Pirajno et al., 2004b).

Earaheedy Basin

The study area contains most of the Palaeoproterozoic Earaheedy Basin (a part of the earlier 'Nabberu Basin'; Bunting, 1986; Tyler and Hocking, 2002; Cawood and Tyler, 2004; Fig. 1). The basin lies at the eastern end of the Capricorn Orogen, which was formed during the Palaeoproterozoic, between 2200 and 1780 Ma (Tyler and Thorne, 1990; Occhipinti et al., 1998; Tyler and Hocking, 2002; Cawood and Tyler, 2004).

The Earaheedy Basin unconformably overlies rocks of the Yilgarn Craton, Yerrida Basin, and possibly the Bryah Basin, and is interpreted to have been much larger than its present-day exposure, extending farther to the southwest, southeast, and to the north and east, where it is covered by the Proterozoic Collier and Officer Basins (Pirajno et al., 2004b). Pirajno et al. (2004b) described the regional structure of the Earaheedy Basin as an asymmetric east-plunging syncline, with a vertical to locally overturned northern limb, due to compressive movements from the northeast, which created the Stanley Fold Belt (described in **Structure and deformation**) along the exposed northern margin of the Earaheedy Basin.

Regional stratigraphic relationships indicate that the Earaheedy Basin is younger than the Yerrida Basin (2200 Ma; Woodhead and Hergt, 1997; 1840 Ma, Rasmussen and Fletcher, 2002) and older than the Scorpion Group (which is currently correlated with the 1465–1620 Ma Edmund Group), and appears to be unaffected by the c. 2000 Ma Glenburgh Orogeny (Cawood and Tyler, 2004) and the 1800 Ma Capricorn Orogeny (Jones et al., 2000a; Hocking et al., 2001a).

Earaheedy Group

The stratigraphy of the Earaheedy Group was initially formalized by Hall et al. (1977) and Bunting et al. (1977), and was later modified by Bunting (1986), Jones et al. (2000b), and Hocking et al. (2000b). Pirajno et al. (2004a) concluded that the depositional age of the Earaheedy Group must be younger than 1.84 Ga. This was based on geochronological data for the Mooloogool Group (Maraloou Formation, c. 1.84 Ga; Rasmussen and Fletcher, 2002), the Malmac Inlier (c. 2.55 Ga; Nelson, 2002), and the Imbin Inlier (c. 2.0 Ga; Nelson, 2001). SHRIMP U–Pb dating of detrital zircons from the Yelma Formation gives a maximum depositional age of 2.03 Ga (Nelson, 1997).

The Earaheedy Group consists of the Tooloo Subgroup and the overlying Miningarra Subgroup (Fig. 5).

Tooloo Subgroup

The Tooloo Subgroup (Fig. 5) has an estimated thickness of 2700 m and contains the Yelma and Frere Formations, and the Yadgimurrin, Sweetwaters Well, and Windidda Members (only the last two members are shown on Plate 1; Bunting, 1986; Jones et al., 2000a,b; Hocking et al., 2000b).

Yelma Formation

The Yelma Formation (Plate 1) is the basal unit of the Earaheedy Group and its base is defined by an unconformity, either with the Archaean basement rocks of the granite–greenstone terrane of the Yilgarn Craton or, farther west, with the Palaeoproterozoic rocks of the Mooloogool Group. The Yelma Formation is conformably overlain by the Frere Formation, and contains shale, sandstone, and carbonate, and records a regional marine transgression (Bunting, 1986; Adamides et al., 2000a; Pirajno et al., 2004a). A basal conglomeratic unit, the Yadgimurrin Member, is present locally.

A unit called the 'Troy Creek Beds' (Bunting et al., 1982; Commander et al., 1982) was initially thought to be an older suite of metamorphosed rocks unconformably underlying the Yelma Formation, but the rocks are now considered to be dynamically metamorphosed sedimentary rocks of the Earaheedy Group deformed in the Stanley Fold Belt, and the term 'Troy Creek Beds' has been abandoned (Hocking and Jones, 1999; Pirajno et al., 1999b; Hocking et al., 2000b; Pirajno et al., 2000; Pirajno and Hocking, 2001; Hocking and Jones, 2002).

Yadgimurrin Member: The Yadgimurrin Member is a localized conglomeratic member at the base of the Yelma Formation, consisting of more than 100 m of boulder conglomerate containing clasts up to 1 m across of granite, quartzite, and chert enclosed in an arkosic matrix. Associated with this conglomerate are pods and veins of jasperoidal chert and quartz (Bunting, 1986; Adamides et al., 2000a). The Yadgimurrin Member is restricted to a small area of outcrops on FAIRBAIRN (1:100 000) and adjacent MARYMIA (1:100 000; outside report area), and therefore is not shown on Plate 1.

Sweetwaters Well Member: The Sweetwaters Well Member forms the upper part of the Yelma Formation. It is about 100 m thick (Hocking et al., 2000b) with the type locality around the southern margin of an island in Lake Nabberu (MGA 272000E, 7144800N). The Sweetwaters Well Member is also recognized along the deformed northern margin on METHWIN (1:100 000; Hocking and Jones, 1999) and FAIRBAIRN (1:100 000; Adamides et al., 2000a). The rock types of this member include stromatolitic and laminated dolomite, locally brecciated and commonly chertified. Minor siltstone and sandstone interbeds are present. The Sweetwaters Well Member is an important unit because it hosts sulfide mineralization (see **Mineralization**)

Frere Formation

The Frere Formation (Plate 1 and Fig. 5) is named after the Frere Range along the northern side of Lake Nabberu on NABBERU (Hall and Goode, 1978; Goode et al., 1983; Bunting, 1986). The formation is exposed both along the southern and northern margins of the Earaheedy Basin and is folded into a broad easterly trending, southerly verging asymmetric synclinal structure, with a steep to overturned northern limb (Pirajno et al., 2004a,b).

The Frere Formation typically consists of several units of granular and supergene-enriched iron-formations separated by shale, siltstone, chert, and jasper beds. Although shale is more abundant, granular iron-formation (Fig. 6) is the most characteristic and was the focus of iron ore exploration in the 1970s. The iron formation units generally increase in thickness and abundance in a northwesterly direction, and form resistant strike ridges and cuestas, whereas the intervening shales occupy valleys or broad, colluvium-covered flats (Bunting, 1986).

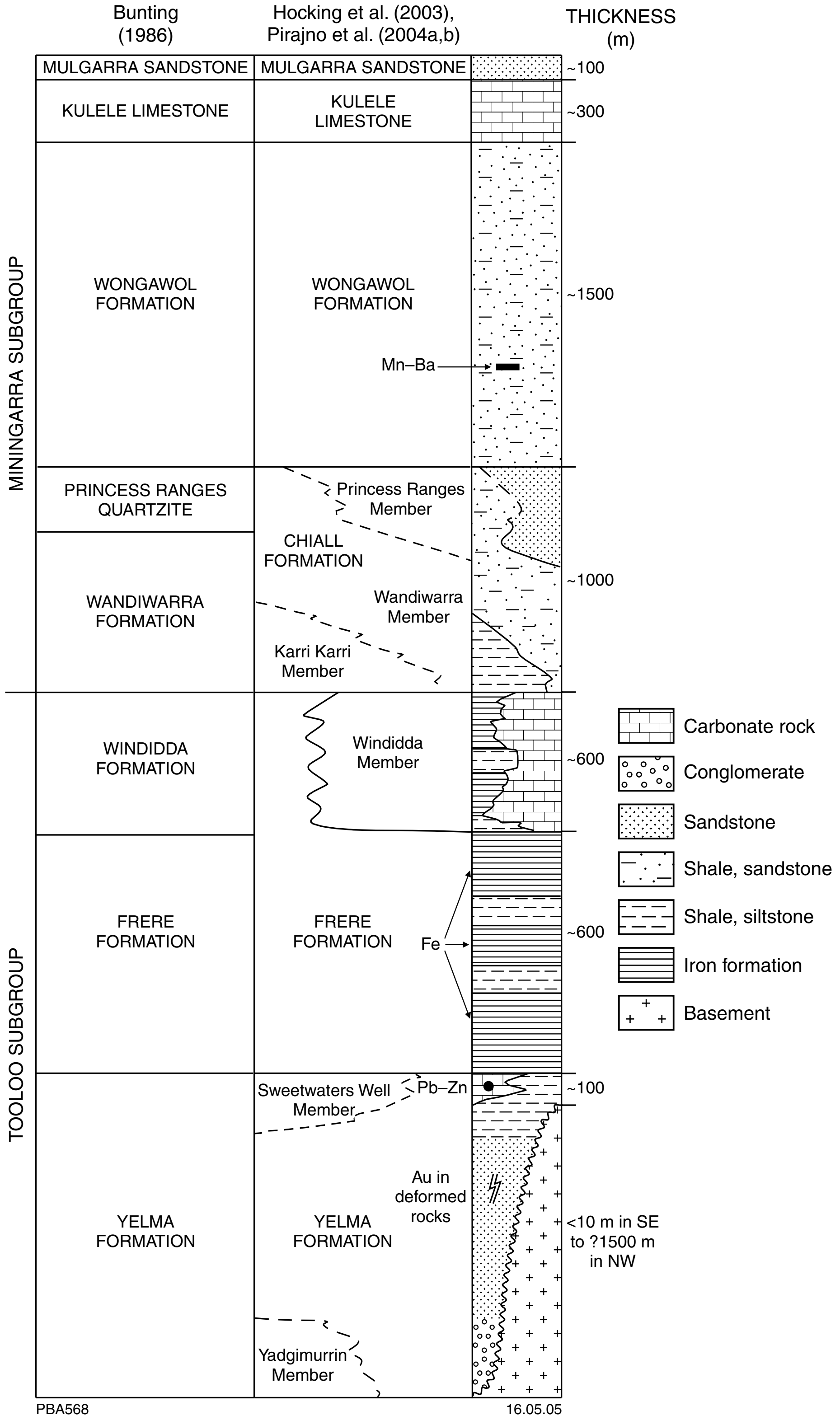

Figure 5. Stratigraphy of the Earaheedy Basin (after Pirajno et al., 2004b)

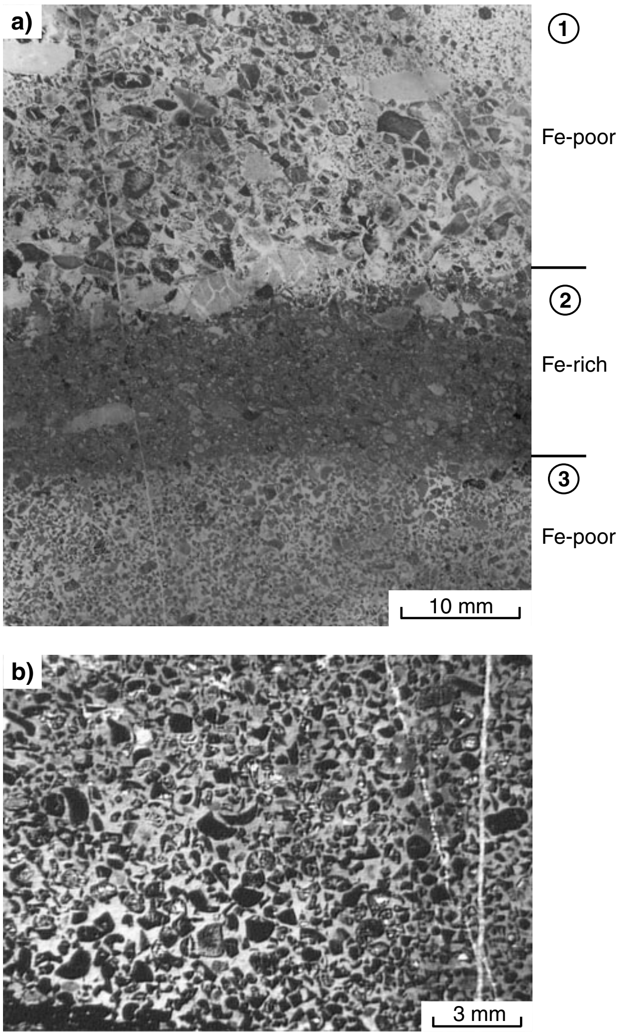

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Figure 6. **Granular iron-formation textures (Frere Formation): a) showing association of coarse mainly cherty intraclastic (1), ferruginous (2), and finer peloidal facies (3); polished section, GSWA 149328; b) typical peloidal texture; polished section, GSWA 149328 (after Adamides et al., 2000a)**

Bunting (1986) estimated the total thickness of the Frere Formation as about 1200 m, but Hocking and Jones (2002) suggested that the thickness was closer to 600 m because Bunting's estimate may include structural repetition in the Stanley Fold Belt. Individual beds of granular iron-formation are up to 1 m thick, but typically 5–30 cm thick and consist of peloids of hematite, jasper or chert in a cement of chalcedony, chert or jasper (Bunting, 1986; Hocking and Jones, 2002). Angular chert and jasper intraclasts are common and up to 20 cm in length. Fine platy hematite is the dominant oxide and magnetite is less common, but where present it exhibits euhedral porphyroblasts overprinting hematite. Magnetite is commonly partly or pervasively altered to maghemite. The iron oxide minerals and clasts are cemented by orthochemical chert or allochemical chalcedony or carbonate. The Frere Formation on Fairbairn, Nabberu, Merrie, and Methwin (all 1:100 000) was described in Adamides (2000), Adamides et al. (2000a), Hocking and Jones (2002), and Pirajno et al. (2004a).

Detailed studies of the granular iron-formations of the Frere Formation (Hall and Goode, 1978; Goode et al., 1983; Bunting, 1986) indicate textural similarities to iron formations of the Lake Superior region of North America (Gross, 1972; Kimberley, 1989; Morey, 1983). Peloidal textures, orthochemical and allochemical cements, iron-rich chlorite, and the presence of accessory minerals such as minnesotaite and stilpnomelane are common in both areas. These features have been interpreted as the result of chemical deposition followed by limited reworking of sediment while still plastic (Beukes and Klein, 1990, 1992). Tobin (1990) recognized in the Frere Formation eight distinct microbial assemblages, similar to those in the Gunflint Iron Formation of the Lake Superior region in North America and the Duck Creek Dolomite in Western Australia. He agreed with the interpretation by Goode et al. (1983) that the allochems containing microbial assemblages of the Frere Formation were deposited on shoals above storm wavebase. Hocking and Jones (2002) suggested that two apparently dissimilar depositional environments are juxtaposed in the Frere Formation, and argued that the sedimentary structures in the granular iron-formation indicate deposition largely by traction currents, in shallow-water conditions. This is consistent with models proposed for the formation of granular iron-formation elsewhere, where chemically precipitated sedimentary beds are disrupted and agitated by current action either before lithification or during partial lithification (Beukes and Klein, 1990). The lack of current-produced sedimentary structures in shale, siltstone, and mudstone horizons indicates quiet-water deposition by suspension or turbidity current processes, below fair-weather wavebase (Hocking and Jones, 2002).

Pirajno et al. (2004b) stated that the Frere Formation granular iron-formation has a strong magnetic signature even through significant overburden, and is negatively magnetized in the south and positively magnetized in the north (Stanley Fold Belt). Overall, the Frere Formation forms an almost continuous zone of high total magnetic intensity on aeromagnetic images, delineating the present-day geometry of the basin.

Windidda Member; The former 'Windidda Formation' is now identified as the Windidda Member of the Frere Formation (Hocking et al., 2003). The Windidda Member (Fig. 5) consists of a sequence of carbonate and fine-grained clastic rocks in the southeastern part of the Earaheedy Basin, between the Frere and Chiall Formations. This unit is mainly grey to pink coloured, and consists of laminated or stromatolitic carbonate, interbedded with maroon or grey-green micaceous mudstone and shale with some intraclastic breccia beds and jaspilitic chert beds. The maximum thickness of the member is estimated to be about 800 m. The Karri Karri Member at the northern and western sides of the exposed Earaheedy Basin is now considered to be part of the Chiall Formation and not a part of the 'Windidda Formation' (Hocking et al., 2000b). The Windidda Member in the north reflects the development of a carbonate lagoonal environment (Pirajno et al., 2004a).

Miningarra Subgroup

The Miningarra Subgroup (Fig. 5) has a total thickness of at least 2500 m and contains the Chiall Formation, Wongawol Formation, Kulele Limestone, and Mulgarra Sandstone (Bunting, 1986; Hocking et al., 2000b).

Chiall Formation

The Chiall Formation (Fig. 5 and Plate 1) as defined by Hocking et al. (2000b) occupies the central part of the Earaheedy Basin, and consists of the Karri Karri, Wandiwarra, and Princess Ranges Members. Only the Karri Karri Member is shown on Plate 1. The Wandiwarra and Princess Ranges Members (Hocking et al., 2000b) supercede the 'Wandiwarra Formation' and 'Princes Ranges Quartzite' of Hall et al. (1977). The Karri Karri Member at the base of the Chiall Formation was previously thought to be a fine-grained facies of the 'Windidda Formation'.

The Chiall Formation has a maximum depositional age of about 1875 Ma (Halilovic et al., 2004), and consists of shale, siltstone, and mudstone intercalated with thick sandstone beds and intraclastic breccia. The formation represents a change from combined chemical and fine-grained clastic sedimentation to coarser grained clastic deposition. The base of the formation in the south is a breccia of poorly sorted, angular carbonate clasts in a ferruginized and glauconitic sandstone matrix (Pirajno et al., 2004b). On WONGAWOL (1:100 000), to the southeast, the Chiall Formation rests on the Windidda Member, and the contact is marked by a breccia consisting of angular carbonate clasts, which is interpreted as a submarine hardground (Jones et al., 2000b) or seismite or a tsunamite (Pirajno et al., 2004b). Farther east the Chiall Formation is overlain by the Wongawol Formation, and the contact is taken as the highest medium-grained sandstone. To the north the lower part of the Chiall Formation consists of a thick succession of shale, siltstone, and mudstone, which has been assigned to the Karri Karri Member (Pirajno et al., 2004b).

Hocking and Jones (2002) suggested that the maximum thickness of the Chiall Formation may only be about 1000 m, which is less than the 1500 m suggested by Bunting (1986). They considered that the thickness estimated by Bunting (1986) includes structural repetition of the unit.

Wongawol Formation

The Wongawol Formation (Fig. 5 and Plate 1) consists of arkosic and lithic sandstone, thin-bedded siltstone, shale, mudstone, intraclastic breccia, and carbonate–glauconite breccia (Bunting, 1986; Pirajno et al., 2004b). Sandstone in the Wongawol Formation is fine to very fine grained and locally glauconitic, with bands composed of subangular to subrounded glauconite peloids, which are locally replaced by, or partly enclose, rhombs of brown carbonate (Hocking et al., 2001a). Carbonate bands increase in abundance higher in the sequence. They are commonly 2–3 m thick, parallel to wavy laminated, and consist of thinner beds around 10–30 cm thick interbedded with fine-grained sandstone. Peloidal horizons associated with the carbonates contain peloids of carbonate, glauconite, recrystallized chert, ferruginous chert, and iron oxides, in a fine-grained matrix that originally may have been carbonate (Bunting, 1986; Hocking et al., 2001a). Bunting (1986) suggested that the formation was 1500 m thick, but faulting and folding may have exaggerated the true thickness (Pirajno et al., 2004b). Towards the top of the formation, thin (1–2 cm thick) volcaniclastic beds are interpreted as distal ashfall deposits (Pirajno et al., 2004b).

Kulele Limestone

The Kulele Limestone (Fig. 5) consists of various interbedded limestone types that form crude cyclic sequences, separated by thicker units of micaceous shale, mudstone, and fine-grained sandstone (Bunting, 1986). The main rock types consist of calcarenite, stromatolitic limestone, intraclastic carbonate breccia, oolitic and pisolitic limestone, micaceous shale and sandstone, rare dolomite, and fine-grained quartzose or feldspathic sandstone. Carbonate units are stromatolitic, oolitic, and pisolitic. Large individual stromatolite domes are up to 3.5 m high and 4 m wide (Pirajno et al., 2004b). The base of the limestone is gradational with the Wongawol Formation, but is taken as the base of a continuous, 1 m-thick bed in stromatolitic limestone or cross-bedded calcarenite. The top is taken as the base of the continuous, thick quartz arenite, which is the lowest unit of the Mulgarra Sandstone. The limestone is about 300 m thick in its type locality near Mount Throssell (between 26°01'00"S, 122°39'00"E and 25°59'30"S, 122°42'00"E), and its distribution is restricted to northeastern KINGSTON and southern STANLEY, except for one important outlier at Thurraguddy Bore on STANLEY (Bunting, 1986).

Mulgarra Sandstone

The Mulgarra Sandstone consists of sandstone (Fig. 5; locally glauconitic), shale, and minor carbonate, with a maximum thickness of at least 100 m (Pirajno et al., 2004b). The thickness of the Mulgarra Sandstone is not certain due to poor exposure, but may be about 100 m (Bunting, 1986). The unit is very similar to the Wongawol Formation (Pirajno et al., 2004b). The distribution of the Mulgarra Sandstone in the study area is limited to southeastern STANLEY and northeastern KINGSTON. The zircons from the Mulgarra Sandstone (top of the Earaheedy Group) yielded U–Pb SHRIMP ages of c. 1808 Ma (Halilovic et al., 2004).

Imbin Inlier

Williams et al. (1981) mapped an area of felsic porphyry about 10 km north-northeast of Imbin Rockhole on STANLEY. Pirajno and Hocking (2001) identified the rocks as rhyodacite porphyry, which was dated by Nelson (2001) at 1990 Ma. The area of rhyodacite porphyry is called the Imbin Inlier (Tyler and Hocking, 2002).

Mesoproterozoic geology

Edmund and Collier Basins

The Mesoproterozoic Collier and Edmund Basins (Fig. 1) replace the former 'Bangemall Basin' (Martin and Thorne, 2001). After re-evaluation of the lower succession in the northwest 'Bangemall Basin', Martin et al. (1999) changed the Bangemall Group to Bangemall Supergroup, the Edmund Subgroup to Edmund Group, and the Collier Subgroup to Collier Group. On NABBERU rocks previously assigned to the Collier Group (Hocking and Jones, 2002) are now placed in the Scorpion Group (a probable correlative of the Edmund Group), and overlying rocks are placed in the Salvation Group (a probable correlative of the Collier Group; Hocking et al., 2003). On BULLEN only the Collier Group is represented, and on TRAINOR the older Mesoproterozoic sedimentary rocks are in the Ward and Oldham Inliers.

Collier Group rocks unconformably overlie the Earaheedy and Scorpion Groups, and consist of only the Backdoor and Calyie Formations (Muhling and Brakel, 1985; Martin et al., 1999). Martin and Thorne (2001) suggested that the age of the Collier Group may be between 1210 and 1070 Ma. The Wonyulgunna Sandstone that was previously assigned to the Collier Group is now included within the Scorpion Group (Hocking et al., 2003).

Scorpion Group

The Mesoproterozoic Scorpion Group (Fig. 1 and Plate 1) is a probable correlative of the lower parts of the latest Palaeoproterozoic – early Mesoproterozoic Edmund Group (Hocking et al., 2000b) at the northern margin of the Earaheedy Group on NABBERU, and may correlate with the Quadrio Formation and Cornelia Sandstone (Hocking et al., 2000a,b) in the northern portions of the Ward and Oldham Inliers on TRAINOR.

Based on U–Pb SHRIMP dating, deposition of the Edmund Group occurred between 1620 and 1460 Ma (Martin and Thorne, 2002). Stromatolites in the Scorpion Group are similar to those in the lower Edmund Group.

The Scorpion Group was raised from subgroup to group status by Hocking et al. (2000b) following elevation of the Bangemall 'Group' to Supergroup status (Martin et al., 1999). Despite even earlier status as a group (Bunting et al., 1982), Williams (1990b) recognized the Scorpion Group as a subgroup of the 'Bangemall Group'. The Scorpion Group consists of evaporitic dolomite overlain by mixed sandy and siliciclastic rocks deposited in a northward-deepening coastal setting, sourced from adjacent areas to the south. On NABBERU, Hocking et al. (2003) subdivided the Scorpion Group into the Millury Formation, Willy Willy Formation, and Wonyulgunna Sandstone.

Ward and Oldham Inliers

The Mesoproterozoic to ?Palaeoproterozoic Ward and Oldham Inliers (Fig. 7) are within the northwestern part of the Officer Basin (Fig. 1; Hocking et al., 2000a). The inliers are onlapped by or faulted against the Neoproterozoic sedimentary rocks of the Sunbeam Group and the overlying Boondawarri Formation of the northwest Officer Basin (Bagas et al., 1999). The rocks in the Oldham Inlier consist of well-indurated sandstone with lenses of siltstone, shale, and conglomerate, which were initially mapped as the Cornelia Sandstone (Brakel and Leech, 1980) or Cornelia Formation (Williams, 1992, 1995a). Hocking et al. (2000a,b) subdivided the Cornelia Sandstone into the Oldham Sandstone, the Quadrio Formation, and a redefined Cornelia Sandstone.

Salvation Group

Hocking and Jones (2002) defined a new group called the 'Salvation Group' that includes the Glass Spring, Brassey Range, Jilyili, and Coonabildie Formations. The rocks of this group are distributed mostly over the northern parts of NABBERU and STANLEY, between the northwestern Officer Basin in the north and the Collier and Earaheedy Basins and Scorpion Group in the south. The Salvation Group has a minimum age of 1070 Ma (Wingate et al., 2004), based on radiometric dating of dolerites that intrude these formations.

The extent, age, and possible correlatives of the Salvation Group are uncertain, but the group immediately overlies, and may be conformable on, the Collier Group (Hocking, R. M., 2003, written comm.) A SHRIMP U–Pb age date of 1300 Ma for detrital zircons represents a maximum depositional age for the Collier Group (Nelson, 2002; Morris et al., 2003). A SHRIMP baddeleyite mean age of 1066 ± 14 Ma for the Glenayle Dolerite, which intrudes the Salvation Group, gives a maximum age for deposition of the Salvation Group (Wingate, 2003).

Mafic intrusive rocks

Glenayle Dolerite

Hocking et al. (2000b) assigned the name Glenayle Dolerite to a series of dolerite (microgabbro) sills that intrude rocks of the Salvation Group and parts of the Earaheedy Group on northeastern NABBERU and on northern and eastern STANLEY. These mafic sills typically consist of clinopyroxene (50–55 vol.%) and labradorite (30–35 vol.%), with accessory ilmenite, titanomagnetite, and apatite. Intrusive mafic sills have been recorded on TRAINOR, BULLEN, and STANLEY. On GLENAYLE and MUDAN (1:100 000) Pirajno and Hocking (2001, 2002) recognized three members within the Glenayle Dolerite: the Weld Spring, Parker Range, and Yallum Hill Members, none of which are differentiated on Plate 1.

Wingate (2003) obtained SHRIMP U–Pb baddeleyite ages of 1068 ± 20 and 1063 ± 21 Ma for the Glenayle Dolerite, and considered these ages to be the time of crystallization. The younger K–Ar ages of 968 and 917 Ma obtained for the Glenayle Dolerite by Nelson (2002) are considered to be due to loss of radiogenic Ar from K–Ar samples (Wingate, 2003). The dolerite sills intruding the Edmund and Collier Groups in the western part of the Bangemall Supergroup have SHRIMP baddeleyite and zircon ages of 1070 ± 6 Ma (Wingate, 2002). This indicates that the Glenayle Dolerite and dolerite sills in the western part of the Bangemall Supergroup were emplaced during the same magmatic event. This is further confirmed

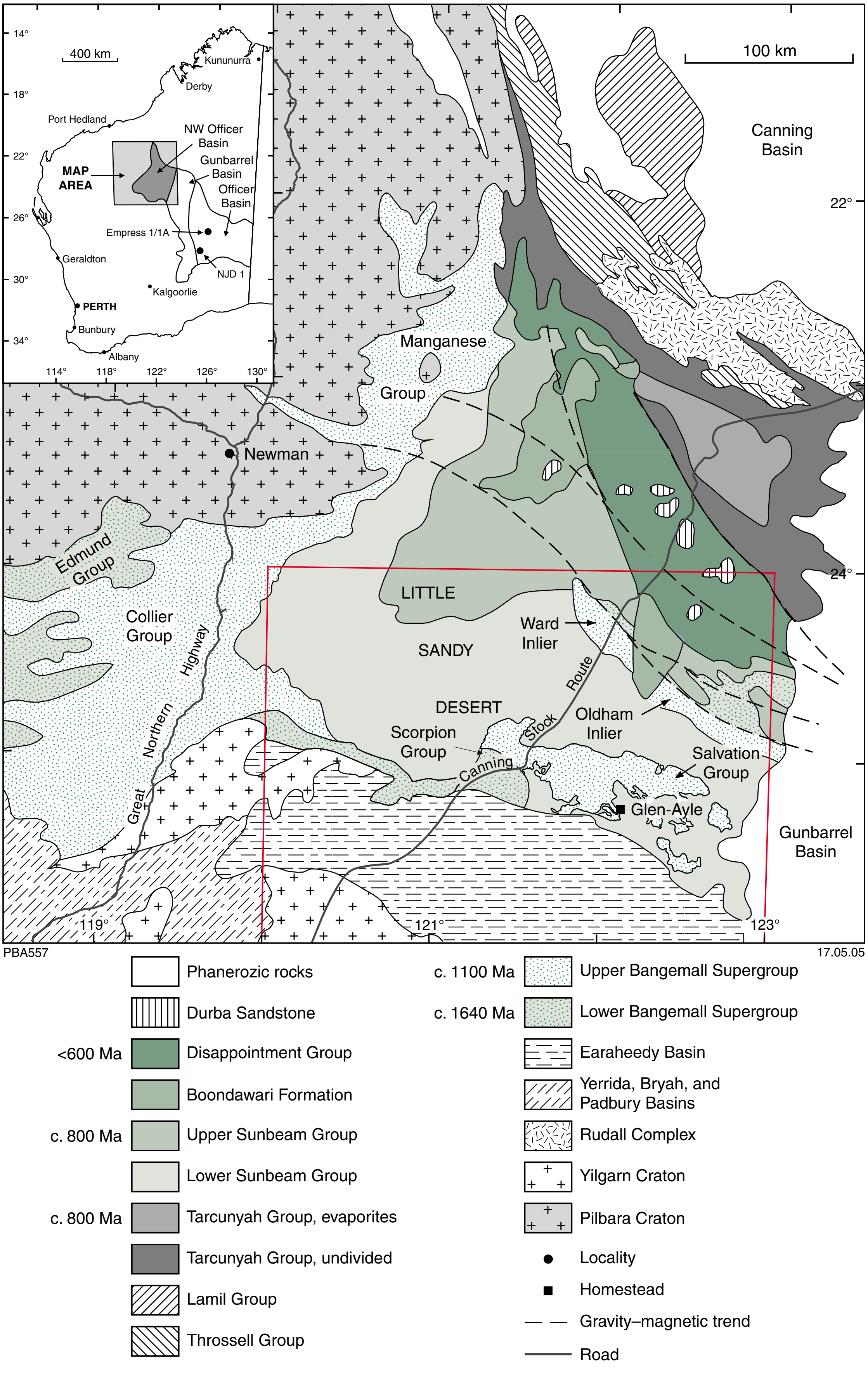

Figure 7. Regional setting of the Oldham Inlier (after Hocking et al., 2000b)

by the close correspondence of palaeomagnetic directions and poles in the above rocks in both areas (Wingate, 2003). Similar ages have been determined for mafic igneous rocks in the northwestern Yilgarn Craton, at the base of the GSWA Empress 1/1A drillhole in the western Officer Basin (Stevens and Apak, 1999), and in the Giles Complex of west-central Australia (Glikson et al., 1996). Wingate et al. (2004) called these mafic igneous rocks the Warakurna Large Igneous Province (see Morris and Pirajno, 2005).

Prenti Dolerite

The Prenti Dolerite intrudes the Glenayle Dolerite and consists of aphanitic to very fine grained dolerite sills and dykes (Pirajno and Hocking, 2002; Wingate, 2003). This rock is petrographically similar to the sills intruding the Earaheedy Group at the eastern border of KINGSTON, about 19 km east of Prenti Downs. It typically contains plagioclase (An_{56-70}, 50–55%) and granular augite, with an intergranular–glomeroporphyritic texture. It has not been determined whether the Glenayle Dolerite and Prenti Dolerite are comagmatic or represent separate magmatic events, so the latter is included within the Glenayle Dolerite on Plate 1.

Other mafic intrusive rocks

A number of mafic dykes, mainly identified by the interpretation of aeromagnetic anomalies, are reported from EARAHEEDY, RHODES, NABBERU, MERRIE, and FAIRBAIRN (all 1:100 000). These may not be related to the Glenayle and Prenti Dolerites discussed above, but may be part of a post-cratonization dyke suite (Hallberg, 1987) that is developed throughout the Yilgran Craton.

Neoproterozoic geology

Officer Basin

Walter and Gorter (1994), Walter et al. (1995), and Tyler and Hocking (2002) included the Neoproterozoic Officer Basin (Fig. 1) in the Centralian Superbasin.

The region previously assigned to the 'Savory Basin' (Williams, 1992) is now considered to be the northwestern extension of the Officer Basin (Perincek, 1996; Bagas et al, 1999; Tyler and Hocking, 2002). The rocks within it are placed in the Sunbeam Group, Boondawari Formation, Disappointment Group, and Durba Sandstone.

Sunbeam Group

The Sunbeam Group (Bagas et al., 1999) includes the Watch Point, Coondra, Spearhole, Mundadjini, and Skates Hills Formations, and was named after Sunbeam Creek on TRAINOR. It is equivalent to the Depositional Sequence B of Williams (1992). Rocks of the Sunbeam Group outcrop on BULLEN and TRAINOR (Plate 1). The rocks previously assigned to the lower part of the Sunbeam Group were placed in the slightly older Salvation Group by Hocking and Jones (2002).

The Sunbeam Group consists of sandstone, siltstone, conglomerate, shale, mudstone, dolomite, stromatolitic dolomite, and evaporitic rocks. The group overlies or is in faulted contact with various Mesoproterozoic units of the Collier and Edmund Basins and the Oldham and Ward Inliers. The Sunbeam Group is a lateral equivalent of the oldest part of the Officer Basin succession to the east — the Buldya Group (Grey et al., 2005). In the northeast the Sunbeam Group is unconformably overlain by or is in faulted contact with the Boondawari Formation and the Disappointment Group (Bagas et al., 1999). Along the eastern margin the Sunbeam Group is unconformably overlain by Carboniferous–Permian rocks. The Sunbeam Group has an age of c. 820 Ma (Bagas et al., 1999).

Boondawari Formation

The Boondawari Formation is named after Boondawari Soak on ROBERTSON (Williams, 1992). It can be traced discontinuously northwards from southeast of the Ward Hills in the central part of TRAINOR to the northeastern border of ROBERTSON. To the north the Boondawari Formation is unconformably overlain by the McFadden Formation (Disappointment Group). The Boondawari Formation includes glacigenic diamictite, sandstone, siltstone, and shale. The diamictite is commonly overlain by a red-brown, coarse- to medium-grained flaggy sandstone, which is interbedded with sandy siltstone and cobble conglomerate lenses (Williams, 1992, 1995a; Williams et al., 1995a). It has an age of c. 600 Ma (Walter et al., 2000; Grey et al., 2005).

Disappointment Group

The Disappointment Group (Plate 1), named after Lake Disappointment on GUNANYA by Bagas et al. (1999), includes the McFadden, Tchukardine, and Woora Woora Formations and is exposed on northeastern TRAINOR. Outside the report area it outcrops on southeastern BALFOUR DOWNS, southwestern RUDALL, and western MADLEY.

The McFadden Formation is the only formation of the Disappointment Group within the report area. On northeastern TRAINOR it is poorly exposed and consists predominantly of a coarse-grained arenaceous sequence, characterized by laminated to thick-bedded, commonly flaggy, fine- to coarse-grained sandstone, interbedded with similarly bedded feldspathic sandstone and quartz and feldspathic wacke. It disconformably or unconformably overlies the Skates Hill Formation in the south and the Boondawari Formation in the west, and is unconformably overlain by the Durba Sandstone (Williams, 1992, 1995a). The McFadden Formation was deposited in eolian dunes (Grey et al., 2005), probably during the Paterson Orogeny at about 550 Ma (Williams, 1992; Bagas et al., 1999).

Durba Sandstone

The Durba Sandstone is restricted to a few small outliers scattered along the northeastern margin of TRAINOR, and is an upward-fining sequence, possibly of fluvial origin (Muhling and Brakel, 1985). The basal unit of the sandstone is a polymictic pebble to cobble conglomerate up to 1 m thick. The conglomerate is overlain by a red-brown, coarse- to medium-grained sandstone, containing a few scattered pebbles. The highest units exposed on TRAINOR are fine- to medium-grained sandstones containing a few siltstone clasts (Williams, 1995a). The Durba Sandstone is of unknown age, although the tectonic models and stratigraphic relationships imply that it is also related to the Paterson Orogeny at about 550 Ma (Grey et al., 2005).

Unassigned ?Proterozoic geology

Sydney Heads Pass Conglomerate

The Sydney Heads Pass Conglomerate outcrops in a small area around Sydney Heads Pass (MGA 377400E 7178500N) in the northern part of EARAHEEDY (1:100 000; Hocking et al., 2001a). Up to 20 m of conglomerate is exposed in a cliff face. It is a cobble to boulder conglomerate that contains clasts of Earaheedy Group rocks (ferruginous sandstone), quartz, and chert. The conglomerate is interpreted as a fluvial deposit, but its stratigraphic position is uncertain. It post-dates deformation of the Earaheedy Group, but is moderately folded and faulted, suggesting that it is older than the unfolded Neoproterozoic rocks to the north on MUDAN (1:100 000; Hocking et al., 2001a). Because it is only preserved in a very small area, probably much less than 1 km^2, it has not been shown on Plate 1.

Phanerozoic geology

Gunbarrel Basin

The Phanerozoic Gunbarrel Basin (Fig. 1) consists of an essentially undeformed, northward-thickening sequence of Palaeozoic and Mesozoic rocks that was assigned to the Officer Basin before 1994 (Hocking, 1994; Hocking et al., 1994; Hocking and Preston, 1998; Apak and Moors, 2000, 2001). The Gunbarrel Basin onlaps the Yilgarn Craton and adjacent units, overlies the Officer Basin, and is onlapped by the Cainozoic sequence of the Eucla Basin. The Officer and Gunbarrel Basins have been differentiated because there was significant deformation of the Neoproterozoic succession in the Officer Basin (during the Paterson and Petermann Orogenies), and above this the eruption of the Cambrian Table Hill Volcanics in the Gunbarrel Basin represents a significant and widespread magmatic event (Hocking et al., 1994).

In Western Australia the Gunbarrel Basin succession is up to 1.5 km thick, and contains Cambrian volcanic rocks overlain by mid-Palaeozoic, Upper Carboniferous – Lower Permian, and Cretaceous siliciclastic rocks (Jackson and van de Graaff, 1981; Iasky, 1990; Hocking, 1994). The basin is not discriminated from the Officer Basin in South Australia. The Gunbarrel Basin consists of the Kingston Shelf and Sheriff Shelf. Within the area covered by this Report, the basin is represented by the westerly portion of the Kingston Shelf, which contains a sequence of Phanerozoic sedimentary rocks that is probably less than 1 km thick. It overlies Precambrian rocks of the Yilgarn Craton and the Albany–Fraser Orogen. The Sherriff Shelf at the eastern side of the Kingston Shelf overlies sedimentary rocks of the Officer Basin and contains a 1.5 km-thick sequence of sedimentary and volcanic rocks (Hocking, 1994).

Paterson Formation

The Paterson Formation (Plate 1) is a unit originally defined for Permian sedimentary rocks of the southern Canning Basin (Talbot, 1920; Traves et al., 1956) and later extended by Lowry et al. (1972) to the Officer Basin. The unit contains conglomerate (diamictite), sandstone, and claystone, representing glacial, fluviatile, and glaciolacustrine environments. The formation outcrops mostly on KINGSTON and STANLEY with small occurrences on NABBERU.

On KINGSTON the Paterson Formation is exposed in breakaways as flat-lying and undeformed rocks, rarely with a measurable dip. It consists of either glacial rocks (conglomeratic) with pebbles and boulders set in a clay matrix, glaciolacustrine rocks interbedded with and overlying the glacial rocks, or fluviatile deposits at the top of the formation (Bunting, 1980a). Clasts of Palaeoproterozoic Frere Formation (Earaheedy Basin), Archaean granitic rocks, and rare mafic and felsic rocks are present. Lacustrine and glaciolacustrine rocks are also exposed at Mount Wellesley. The claystone and siltstone of this unit are white, kaolinitic, thinly laminated, and contain rare dropstones. Lenses of fluviatile deposits are well exposed 5 km west of Jump Up Bore (about 16 km south of Prenti Downs Homestead in the eastern part of KINGSTON). Fluviatile deposits at the top of the Paterson Formation are interbedded with either glacial or glaciolacustrine rocks. Undivided Paterson Formation rocks outcrop north and east of Prenti Downs, around the Collurabbie Hills and Carclew Range, and southeast of Warren Bore on KINGSTON (Bunting, 1980a,b; Jones, 2002a).

On southwestern STANLEY, cross-bedded fluviatile deposits with consistent north to north-northeast palaeocurrent directions outcrop above the Palaeoproterozoic Chiall Formation (Williams et al., 1981; Commander et al., 1982; Hocking et al., 2001a).

In the southeastern areas of NABBERU, glacial to fluvioglacial poorly sorted sandstone, siltstone, and polymictic conglomerate of the Paterson Formation overlie Frere Formation rocks, (Hocking et al., 2003).

On a regional scale the exposures and lags of the Paterson Formation on STANLEY and KINGSTON are the edges of the deposits resulting from the Gondwana-wide, continental-scale glaciation in the late Carboniferous and Early Permian (Hocking and Preston, 1998). There is an unconformable relationship with older rocks regionally, but local relationships are sometimes complicated by the similarity in lithology and orientation of underlying units (Hocking et al., 2001a). Jones (2002a) identified other relict glacigene units at Princess Ranges on northern WONGAWOL (1:100 000), consisting of siliceous duricrust with occasional boulders.

Bardsley Formation

The Bardsley Formation, recognized in and adjacent to the headwaters of Troy Creek in the southern-central part of RHODES (1:100 000), post-dates the Collier Group and pre-dates Oligocene or Eocene duricrust. It consists of poorly sorted, variably ferruginized lithic sandstone and granule conglomerate infilling an irregular topography underlying the Earaheedy Group (Hocking et al., 2000b), but has not been shown on Plate 1 due to its limited extent.

Regolith

Regolith is the unconsolidated to indurated rock layer on bedrock, and consists of a variety of transported or residual materials as the products of weathering, mass wasting, erosion, and transport (Hocking and Cockbain, 1990; Hocking et al., 2001b). A digital dataset of the regolith layer (1:500 000) of the Earaheedy project area is included in the CD-ROM that accompanies this Report. This digital map is an extract from the 1:500 000-scale regolith map of Western Australia. The various regolith units identified on the map are lacustrine (*L*), alluvium (*A*), slope deposits (*C*), sandplain (*S*), calcrete (*calcrete)*, and exposed rock (*X*). Included in the lacustrine units are lakes, playas, and fringing dunes. Grouped under alluvium are alluvial deposits in channels and floodplains. The slope deposits include colluvium and sheetwash deposits. Also classified under colluvium are sand, silt, and clay in alluvial and eolian depressions. The sandplain unit includes sand of mixed origin, and includes residual, sheetwash, and eolian sands. Calcrete units include surficial sand and gravel, cemented into a hard mass by calcium carbonate, and massive, nodular, and sheet-like accumulations of carbonate (commonly alluvial but locally residual), and minor opaline silica. Exposed rock includes fresh rock, weathered rock, subcrop, saprolite, and bouldery lag.

Structure and deformation

Shoemaker impact structure

The Shoemaker impact structure (Pirajno and Glikson, 1998; Pirajno, 2002; Pirajno et al., 2003), formerly known as the 'Lake Teague Ring Structure' (Butler, 1974), is a well-defined physiographic and topographic feature, 28 km in diameter, with two concentric rings of upland areas and low hills, at the southern margin of the Earaheedy Basin (Figs 1, 4, and 8). It is one of the oldest known impact features in Australia, with a possible age between 1300 Ma (Ar–Ar on feldspar) and 568 Ma (K–Ar age on illite–smectite). The 568 Ma age may represent resetting linked to far-field tectonic events such as the Petermann Orogeny (Pirajno, 2002; Pirajno et al., 2003).

The Shoemaker impact structure consists of two concentric ring structures, with an inner ring syncline and an outer ring anticline. These structures affect rocks of the Earaheedy Group (Yelma, Frere, and Chiall Formations) and almost completely surround a central basement uplift of Archaean core (Figs 4 and 8). The granite–greenstone basement rocks are only exposed within the eastern part of the central structure, on the inside of the inner ring. The granitic rocks that outcrop in the eastern part of the 12 km-diameter inner structure constitute the Teague Granite discussed earlier. The central and western parts of the inner structure are covered by Cainozoic lake sediments and sand dunes (Pirajno, 2002).

The eastern side of the structural uplift is characterized by a zone of high total magnetic intensity, and contains the only exposures of granitic rocks. Zones of hydrothermal alteration are present in rocks of the eastern rings. The total magnetic intensity pattern suggests that the upper parts of the original impact structure were eroded and the entire structure is probably tilted towards the east (Pirajno et al., 2003). For this reason the exposed diameter of the structure does not necessarily reflect its original extent. Traces of near-circular features in granite–greenstone basement rocks, discernable on magnetic maps, are interpreted as ring faults or impact-induced crustal fractures. These features extend up to 45–50 km from the centre of the impact structure (Pirajno et al., 2003).

Stanley Fold Belt

The Stanley Fold Belt is a structural domain forming the northern limb of a steep to overturned asymmetric regional syncline in the Earaheedy Basin (Fig. 9). It trends west to west-northwest from the Lee Steere Range and then swings to a southwest to west-southwest direction in the Yerrida Basin. In the study area the Stanley Fold Belt is on parts of northern NABBERU and central STANLEY (Fig. 9).

The Stanley Fold Belt is a zone of folding and sinistral strike-slip deformation that occurred as a result of compression from the northeast (Hocking et al., 2001a). Deformation in the fold belt was focused on a pre-existing zone of weakness, probably a west-northwesterly trending deep crustal suture between the Yilgarn Craton and younger crustal rocks to the north (Hocking et al., 2001a). At Sydney Heads Pass on EARAHEEDY (1:100 000), the strong deformation in the Stanley Fold Belt is typically shown by the Z-style vergence of folds in more competent units of the Yelma and Frere Formations. In this area the folds are associated with the development of penetrative axial-planar cleavage, with bedding–cleavage intersection lineations showing a gentle (20°) westerly plunge. The intensity of deformation in the Stanley Fold Belt progressively decreases southwards (Hocking et al., 2001a).

The fold belt has not been differentiated in this dataset because its southern boundary with the less deformed part of the Earaheedy Basin is transitional, and it extends into the Yerrida Basin.

Exploration and mining history

Figure 10 and Plate 1 show the mineral occurrences in the study area. The Earaheedy area is underexplored and there are currently no operating mines. The earliest open-file exploration data held by the Western Australian

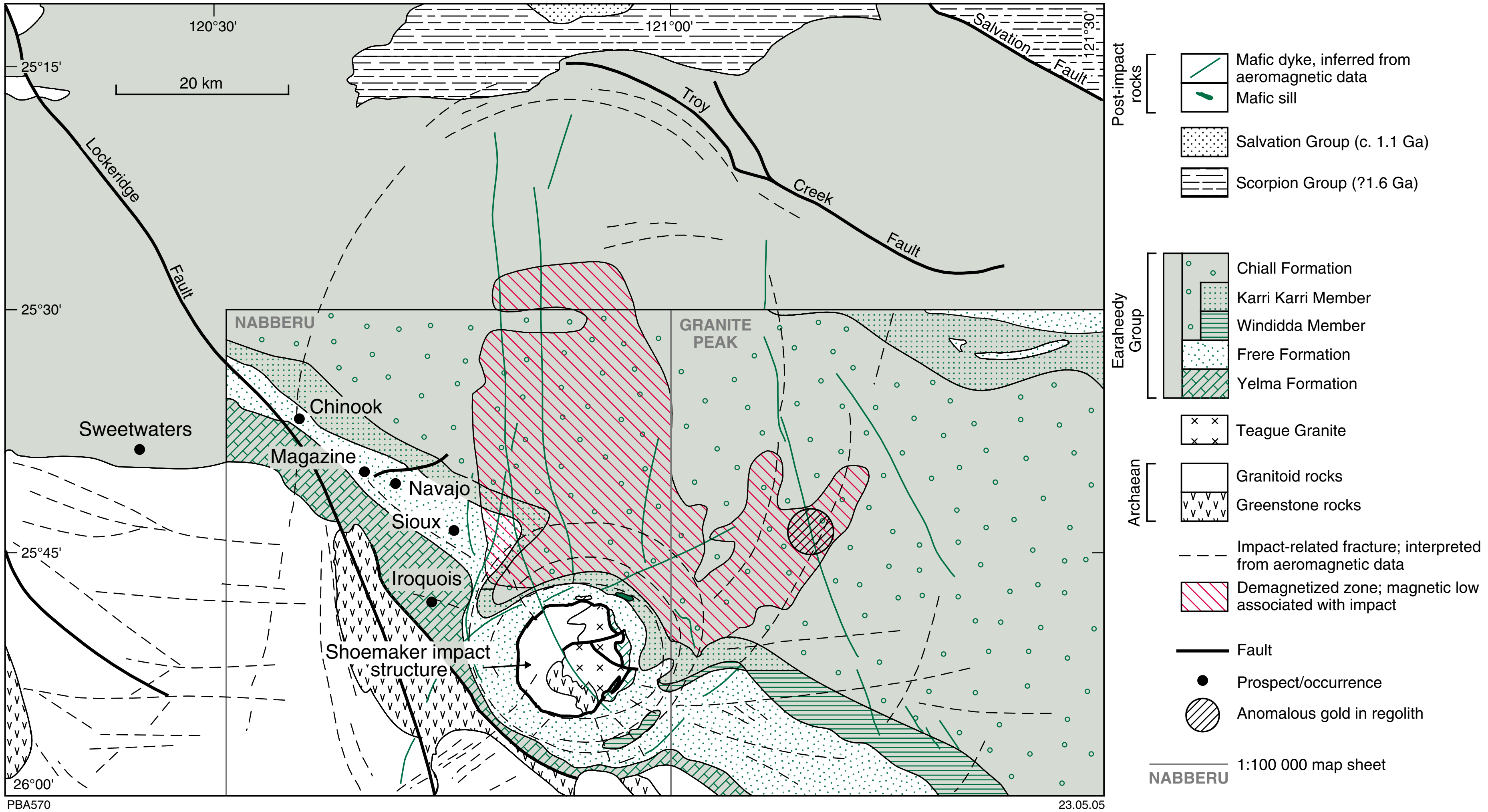

Figure 8. Simplified geological map around the Shoemaker impact structure (after Pirajno, 2002)

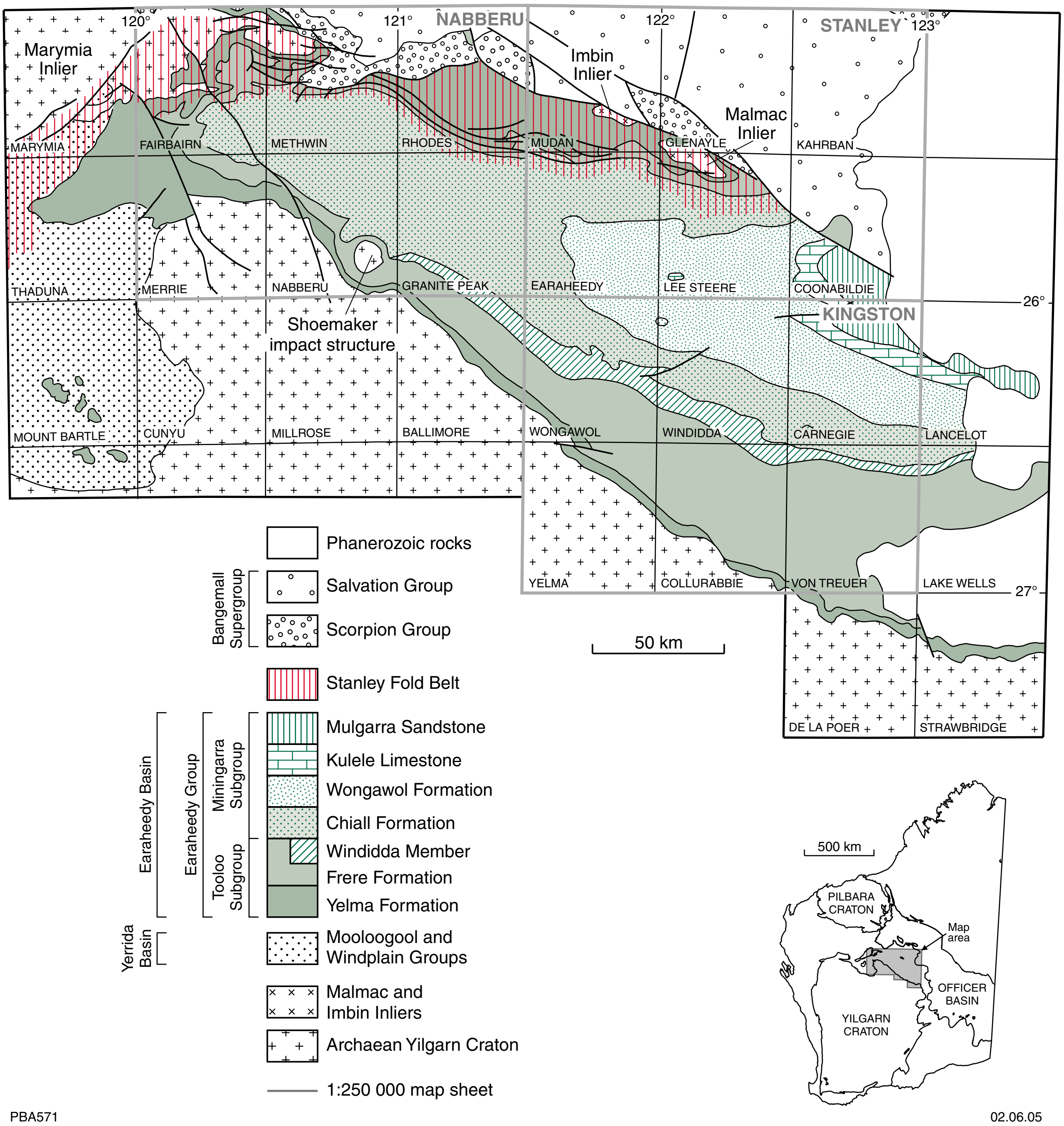

Figure 9. Simplified geology of the Earaheedy Basin with overprint showing the location of Stanley Fold Belt (after Hocking et al., 2001a)

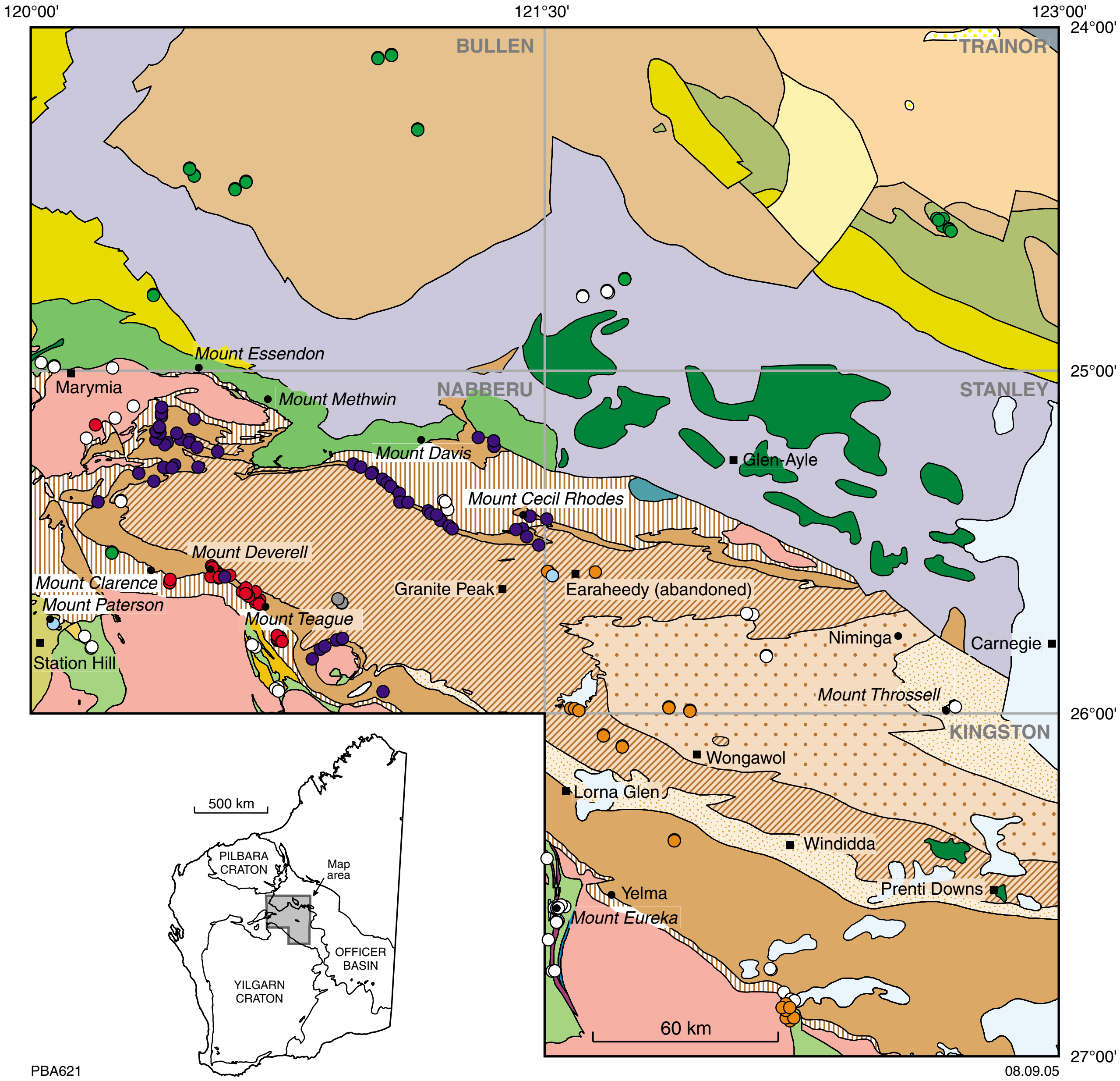

Figure 10. Distribution of 182 mineral occurrences of the Earaheedy area (legend on opposite page)

Department of Industry and Resources for the study area were submitted in the late 1960s for base metals, but about 80% of the exploration activities occurred after 1990. The commodities targeted were gold, base metals, iron, diamond, and uranium. Although manganese, barite, and gypsum are known in the area, there has been no systematic exploration for these commodities.

The following paragraphs briefly describe the history of exploration for gold, base metals, nickel, iron, uranium, and diamond in the study area.

Gold, base metals, and nickel

From around the early 1970s, the Earaheedy area has been explored for gold and base metals (Table 1). The greenstone belts of the Yilgarn Craton and Marymia Inlier have been the main targets for gold. Encouraging exploration results for gold have also been obtained from areas such as Mount Eureka, Cunyu, Horse Well, and Windidda (significant results are discussed in the gold section in **Mineralization**).

There was a small amount of gold production with about 3 kg (at an average grade of about 21 ppm Au) reported during 1932–37 from the Mount Eureka (Plate 1) gold mining centre on Kingston, from historical production sites recorded as Mount Eureka East (1611 g), Mount Eureka (1240 g), and Little Greta (146 g).

Both gold and base metals have been sought in Yelma Formation rocks around Sweetwaters Well, Mount Lockeridge, Mount Teague, and Troy Creek on Nabberu.

PERMIAN
□ Paterson Formation
PROTEROZOIC
🟨 Durba Sandstone
🟧 Disappointment Group
🟨 Boondawari Formation
🟫 Sunbeam Group
⬛ Tarcunyah Group
🟩 Dolerite
🟪 Salvation Group
🟨 Collier Group
🟩 Edmund Group
🟩 Scorpion Group
Earaheedy Group
🟫 Mulgarra Sandstone and Kulele Limestone
🟫 Wongawol Formation
▨ Chiall Formation
🟫 Windidda Member
🟫 Frere Formation
▥ Yelma Formation
🟦 Imbin Inlier
🟨 Yerrida Group
ARCHAEAN
🟩 Metamorphosed mafic rock
🟦 Banded iron-formation
🟨 Metamorphosed felsic rock
🟥 Granitic rock
🟨 Metasedimentary rock
🟪 Metamorphosed ultramafic rock
MINERAL OCCURRENCE
● Base metal
● Construction material
● Energy
● Industrial mineral
● Iron
○ Precious metal
● Steel industry metal

• Locality
■ Homestead

KINGSTON 1:250 000 map sheet

PBA621a 29.04.05

Although the Yelma Formation has been primarily targeted for base metals, exploration has identified significant gold-mineralized zones (encouraging exploration results for base metals and gold are discussed in **Mineralization**).

Exploration for nickel in the area is relatively recent and centred on the Gerry Well and Mount Eureka greenstone belts on Kingston. The companies involved include WMC Resources and Falcon Minerals Ltd. Grassroots discoveries of significant nickel–copper sulfide and PGE have been reported from drilling in the Gerry Well greenstone belt west of Collurabbie (further details are provided in **Mineralization**).

Iron

During 1973–78, Amax Exploration (Australia) and Broken Hill Proprietary Ltd (BHP) targeted iron in the supergene-enriched granular iron-formation of the Frere Formation (Plate 1) on Nabberu and the western part of Stanley.

Amax assayed 183 surface samples from the Frere Formation, mainly from the supergene-enriched granular iron-formation (Robinson and Gellatly, 1978). Of these, 171 samples were from the Miss Fairbairn Hills, Ivan Well, Frere Range, Hawkins Knob, and Mount Cecil Rhodes areas on Nabberu. Of the remaining 12 samples, 8 were from the Windidda area on Kingston, 3 from Mount Ooloongathoo on Stanley, and 1 from the northeastern corner of Wiluna (south of Nabberu). The anomalous areas at Miss Fairbairn Hills, Ivan Well, Frere Range, and Hawkins Knob were drilled by Amax and BHP (Robinson and Gellatly, 1978; Broken Hill Proprietary Limited, 1978). Results from these programs are discussed in the iron section in **Sedimentary — granular iron-formation mineralization.**

Uranium

From the early 1970s to 1980, Esso Australia Ltd and Uranerz Australia Pty Ltd carried out uranium exploration in palaeodrainages and calcrete areas around Fyfe Well, Bridle Face Outcamp, and the Shoemaker impact structure (Table 2). The Fyfe Well area, explored by Esso Australia Ltd, produced encouraging results, which will be discussed in the uranium section in **Regolith mineralization**. Western Mining Corporation and Magnet Metals targeted unconformity-related uranium mineralization in the late 1970s at Mount Davis and in the Malmac Inlier. The results were not encouraging (Table 2).

Diamond

From the late 1980s onwards, Stockdale Prospecting Ltd, Resolute Resources, Great Central Mines NL, CRA Exploration Pty Ltd, and Western Mining Corporation explored for diamonds in a number of areas on Nabberu, Bullen, Stanley, and Trainor (Table 3). The exploration results indicate diamond mineralization in lamproite and kimberlite rocks at Miss Fairbairn Hills, Methwin,

Table 1. Summary of exploration activities for gold and base metals in the Earaheedy area

Locality	*Exploration activities*	*References*
Mount Eureka (Fig. 17)	Surface sampling, geological mapping, and drilling during 1985–94 by Sundowner Minerals NL, Glengarry Mining NL, and Pegasus Gold Australia Pty Ltd within 2 to 3 km of Mount Eureka	Hutchison (1996, 1997); Kitto (1985); Shaw and Associates (1985); Powell (1986); Robertson (1987); Doust (1994); Cullen Resources (2003a,b)
Irwin Bore (Fig. 17)	Surface sampling and drilling during 1985–91 by Sundowner Minerals NL and ACM Gold Ltd for gold 1 to 2 km south of Irwin Bore	Kitto (1985); Schusterbauer (1989a,b); Colville (1990, 1991)
Cunyu (Fig. 16)	Surface sampling and followup drilling during 1992–98 by Galtrad Pty Ltd, Cyprus Gold Australia, and Plutonic Operations Ltd at Cunyu North and Cunyu South in the Cunyu woolshed area in the Merrie greenstone belt	Multi Metal Consultants Proprietary Limited (1992); Roberts and Jockel (1994a,b); Wetherall (1995a,b); Grey (1996a,b, 1997a,b); Halilovic (1997); Rieth (1998)
Troy Creek (Fig. 20)	Surface sampling and drilling during 1990–95 by Aztec Mining Co. Ltd, Sons of Gwalia NL, and Stockdale Prospecting Ltd in the Troy Creek area	Kellow (1991); Smith (1993, 1994); Perring (1994); Mitchell (1994)
Windidda (Plate 1)	Surface sampling and drilling during 1998–2000 by North Ltd in the area south of Windidda	Butterworth (1999a,b, 2000)
Sweetwaters Well, Mount Lockeridge, and Mount Teague (Fig. 23)	Aeromagnetic surveys, geological mapping, surface sampling, and drilling during the 1970–90s by Broken Hill Pty Co. Ltd, Dampier Mining Co. Ltd, RGC Exploration Pty Ltd, and Cladium Mining Pty Ltd in the areas around Sweetwaters Well, Mount Lockeridge, and Mount Teague	Hall and Haslett (1978); Hall (1979); Bunting et al. (1982); Edgar (1993, 1994); Feldtmann (1995); Glover (1996); Dorling (1996a,b, 1997a,b, 1998)
Miss Fairbairn Hills (Fig. 21)	Aeromagnetic surveys, surface sampling, and drilling around 1979 by Chevron Exploration Corporation in Temporary Reserves 6807H and 6808H. Aeromagnetic surveys, ground magnetic surveys, loam sampling, and drilling during 1993–95 by Northling Pty Ltd west of Miss Fairbairn Hills	Chevron Exploration Corporation (1979); Geach (1994)
Quadrio Lake (on TRAINOR*, Plate 1)	Geological mapping and surface sampling in 2000 by Dominion Mining Ltd around Quadrio Lake	Dominion Mining Limited (2003)
Clover Tabletop (northwestern NABBERU) and southwestern BULLEN)	Stream-sediment, soil, and rock-chip sampling during 1989 by Newmont Australia Ltd in the Clover Tabletop area. Assays did not produce anomalous base metal or gold values	Eisenlohr (1989)
Simpson Well	Geological mapping, aeromagnetic surveys, and surface soil sampling during 1992–96 by Galtrad Pty Ltd and Alkane Exploration NL in areas around Simpson Well (mostly outside the study area)	Multi Metal Consultants Proprietary Limited (1992, 1993); Middleton (1994, 1995, 1996)
Kulonoski East Well (southwestern BULLEN)	Reconnaissance exploration work during 1980–83 by Oilmin NL in areas 15 km northeast of Kulonoski East Well	Oilmin et al. (1983); Williams et al. (1995b)
Cooma Well (southwestern BULLEN)	Drilling on magnetic anomalies during 1981–83 by Oilmin NL in areas 10 km northeast and 3 km southwest of Cooma Well. Drillholes intersected fine-grained dolerite and basalt beneath laterite, but no mineralized intersections	Oilmin et al. (1983); Williams et al. (1995b)

NOTE: * Capitalized names refer to 1:250 000 geological maps

Table 2. Summary of exploration activities for uranium in the Earaheedy area

Locality	*Exploration activities*	*References*
Fyfe Well prospect (Fig. 31)	Radiometric surveys, surface sampling, and drilling during the early 1970s by Esso Australia Ltd in calcrete associated with the Lake Teague and Lake Nabberu playa-lake systems. Targeted uranium in a setting similar to the Yeelirrie uranium deposits 80 km southwest of Wiluna (~400 km southwest of Lake Teague). Results were encouraging (discussed in **Mineralization**)	Lindeman (1972)
Bridle Face Outcamp (Fig. 32)	Reconnaissance radiometric surveys, surface sampling, and drilling during 1979–80 by Uranerz Australia Pty Ltd at Bridle Face Outcamp (Temporary Reserves 7364H and 7365H), about 12 km south of Mount Teague. Some anomalous uranium intersections in calcrete, but no consistent mineralization. Intersections include 1 m at 220 ppm U_3O_8 of calcareous clayey sand in hole SA9 from 1 m depth and 4 m at 192.5 ppm U_3O_8 of siliceous to dolomitic calcrete in hole SG6 from 1 m depth	Taylor (1980a,b)
Shoemaker impact structure (Fig. 4)	Radiometric, resistivity, and magnetic surveys, surface sampling, geological mapping, and drilling during 1978 by Uranerz Australia Pty Ltd around the Shoemaker impact structure within Temporary Reserves 6555H and 6556H. Targeted vein-type uranium in Palaeoproterozoic rocks. Anomalous assays obtained include 15 ppm U_3O_8 from each of 3 grab samples G5316, G5319, and G5332 and 35 ppb U_3O_8 from a water sample (W2819)	Uranerz Australia Proprietary Limited (1978)
Mount Davis (Fig. 33)	Surface sampling and drilling during 1979 by Western Mining Corporation east of Mount Davis on NABBERU* extending to south of Salvation Well on STANLEY (in Temporary Reserves 6705H, 6706H, 6711H, and 6648H). Targeted faulted unconformity between Palaeoproterozoic Yelma Formation and Mesoproterozoic Scorpion Group rocks. Highest assays: 2.84 ppm U, 1100 ppm Ni, 170 ppm Cu, 3100 ppm Pb, and 1550 ppm Zn	Western Mining Corporation (1979)
Malmac Inlier (Fig. 34)	Airborne radiometric surveys, reconnaissance geological mapping, and surface sampling in the late 1970s by Magnet Metals in Temporary Reserve 6379 covering the Archaean Malmac Inlier on STANLEY. Targeted unconformity-related uranium deposits in the sedimentary rocks of the Palaeoproterozoic Yelma Formation at the base of the Earaheedy Group overlying the Malmac Inlier. Results were not encouraging	Magnet Metals (1977a,b); Commander et al. (1982); Bunting (1986)

NOTE: * Capitalized names refer to 1:250 000 geological maps

Jewill, and Mount Throssell (these areas are discussed in **Kimberlite and lamproite mineralization**). The exploration results also indicate diamond mineralization in regolith material at Jewill, Hawkins Knob North, McConkey Hill, and Nuneri Pool (results are discussed in **Regolith mineralization**).

Mineralization

The Earaheedy study area includes gold, iron, base metals, diamond, uranium, manganese, silver, barite, gypsum, salt, and construction materials. Altogether, 182 mineral occurrences (Fig. 10; Plate 1) consisting of 59 iron, 31 base metal (including 1 associated with silver), 40 gold (including 3 historical production sites and 1 deposit), 14 diamond, 12 manganese, 10 barite, 5 gypsum, 5 salt, 3 construction material, and 2 uranium sites have been recorded (Appendix 1). Mineral occurrences are discussed below under the headings of mineralization styles as listed in Appendix 2, Table 2.3. WAMIN numbers as listed in Appendix 1 are provided in brackets (see Appendices 1 and 2 for explanation and MGA coordinates).

Kimberlite and lamproite mineralization

Precious mineral — diamond

Diamonds associated with lamproite intrusions are known from areas around Miss Fairbairn Hills, Jewill, Methwin, and Mount Throssell.

Table 3. Summary of exploration activities for diamonds in the Earaheedy area

Prospect	*Exploration activities*	*References*
Miss Fairbairn Hills (Fig. 11)	Airborne and ground magnetometer surveys, stream-sediment sampling, deflation loam sampling, geological mapping, trenching, and drilling during 1990–96 by Stockdale Prospecting Ltd and to a lesser extent by Resolute Resources Ltd west of Miss Fairbairn Hills	Merritt (1991); Mitchell (1993)
Methwin (Fig. 12)	Airborne and ground magnetometer surveys, stream-sediment sampling, loam sampling, geological mapping, trenching, and drilling during 1993–94 by Stockdale Prospecting Ltd and Great Central Mines NL west of Mount Methwin	Bartlett (1993); Davie-Smythe (1994)
Jewill (Fig. 13)	Magnetic surveys, loam sampling, and drilling during 1988 by CRA Exploration Pty Ltd at Jewill, 30–40 km north-northwest of Lake Carnegie	May and Aravanis (1988a); Clifford (1993)
Mount Throssell (Fig. 14)	Stream-sediment, loam, and rock-chip sampling during 1988 by Western Mining Corporation around Mount Throssell. Indicated diamond mineralization in lamproite and kimberlite rocks	Western Mining Corporation (1988)
Hawkins Knob North (Fig. 11)	Stream sediment and loam sampling during 1993 by Stockdale Prospecting Ltd at Hawkins Knob North	Campbell (1993); Mitchell (1995a,b)
McConkey Hill (Fig. 28)	Gravel and loam sampling during 1985 by CRA Exploration Pty Ltd from Glenayle in the south to McConkey Hill and White Lake in the north	Young (1987)
Nuneri Pool (Fig. 13)	Magnetic surveys, loam sampling, and drilling during 1988 by CRA Exploration Pty Ltd in the area around Nuneri Pool on STANLEY (1:250 000)	May and Aravanis (1988a,b)

Miss Fairbairn Hills

Diamondiferous kimberlitic material was intersected, at depths between 19 and 39 m, at Miss Fairbairn Hills (Dmd) 1 (*10915*) during drilling by Stockdale Prospecting Ltd on magnetic anomaly MA47 (Fig. 11; Merritt, 1991). Two bulk samples from trenches over the magnetic anomaly returned 52 macrodiamonds and microdiamonds (0.0005 to 0.7985 carats), totalling 0.82645 carats in one sample. One diamond weighing 0.035 carats was recovered from a second sample (Mitchell, 1993).

Two microdiamonds were recovered from drilling at Miss Fairbairn Hills (Dmd) 2 (*10923*) on magnetic anomaly MA50 (Fig. 11). These diamonds were in a fine-grained, dark-grey kimberlitic material intersected at 79–89 m depth. The partially exposed kimberlite has an interpreted size of 0.5 ha (Mitchell, 1993, 1995a).

Three microdiamonds recovered from drilling at Miss Fairbairn Hills (Dmd) 3 (*10915*) on magnetic anomaly MA06 (Fig. 11) were from kimberlitic material intersected at depths of 110–116 m. The kimberlite is not exposed and its subsurface horizontal extent at 90 m depth is inferred to be 1.8 ha (Mitchell, 1993, 1995a).

Methwin

Four microdiamonds were recovered in drilling by Stockdale Prospecting Ltd and Great Central Mines NL at Methwin (*11326*). The diamonds are from possible kimberlitic material at 26–44 m depth over magnetic anomaly ME22 (Fig. 12). The basement rocks intersected in drillholes on anomaly ME22 consist predominantly of gneiss and mafic or ultramafic rock types similar to granite–greenstone belts. Stringers and lenses of a sheared possible ultramafic rock type, tentatively identified as metakimberlite are within the basement (Davie-Smythe, 1994).

In 1993 four gem-quality macrodiamonds were recovered from bulk gravel and loam sampling by Stockdale Prospecting and Great Central Mines in the Two Pools area (exact location is not given), in addition to another three found previously (Resource Information Unit, 1995). The Two Pools area is within the areas discussed above and the four diamonds are likely to be those returned from magnetic anomaly ME22, but the source of the other three diamonds is not known.

Jewill

Aircore drilling by CRA Exploration Pty Ltd on magnetic anomalies located five small lamprophyre bodies, from which two macrodiamonds and five microdiamonds were recovered at Jewill 2 (*10786*; Fig. 13; Aravanis and May, 1988). Drillchips from two drillholes at Jewill 3 (*10784*), 21 km northwest of Nuneri Pool, yielded 31 diamonds

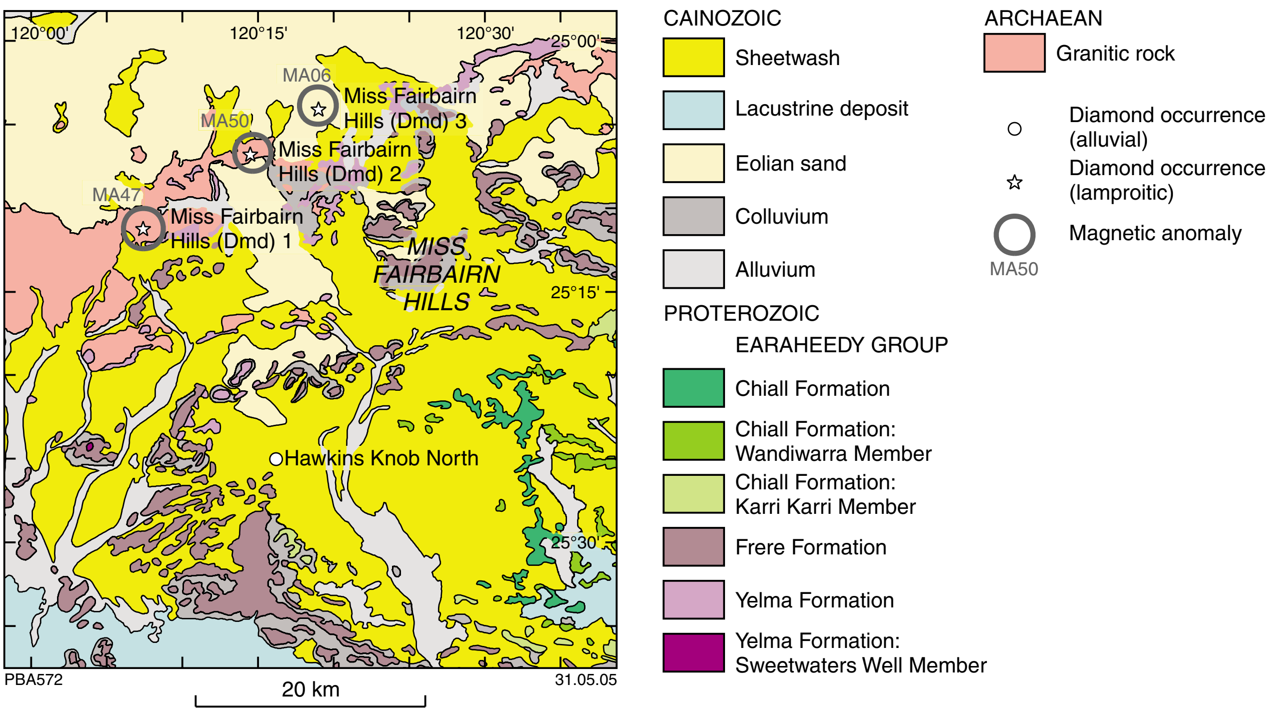

Figure 11. Diamond occurrences in the Miss Fairbairn Hills area (geology after Hocking et al., 2003)

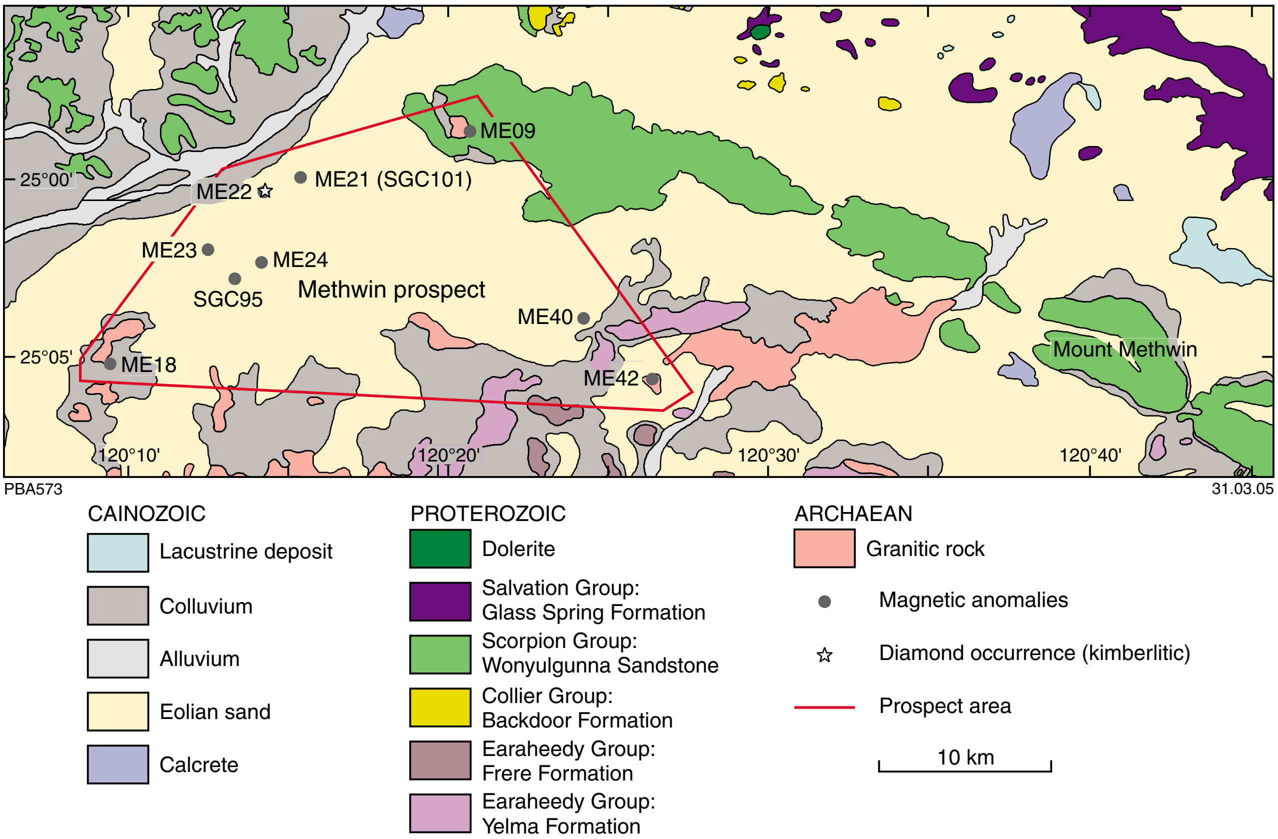

Figure 12. Magnetic anomalies and diamond occurrences east of Mount Methwin (geology after Williams et al., 1995b; Hocking et al., 2003)

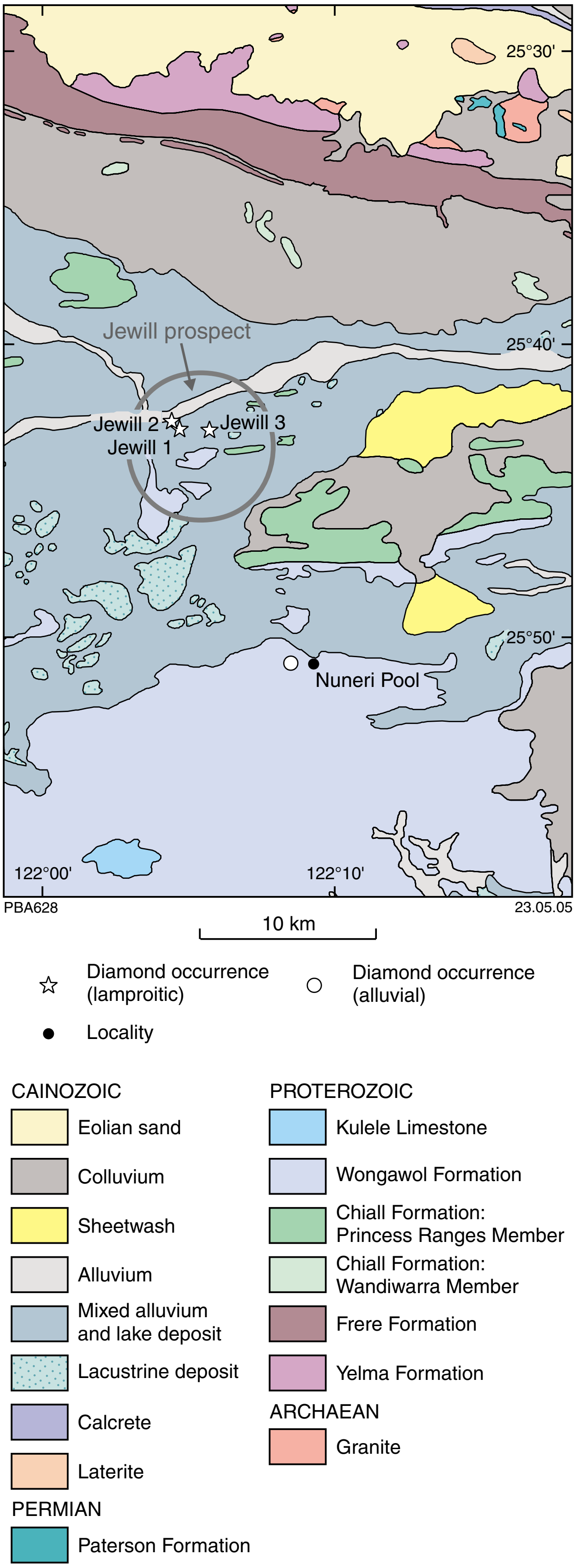

Figure 13. Diamond occurrences around Jewill and Nuneri Pool (geology after Williams et al., 1981)

including a 1.73 carat diamond, but most of the diamonds were less than 4 mm in size. Processing of 2050 kg of lamprophyre led to a preliminary estimate of 5 carats per 100 t. Geochemical results of chip samples indicated that they were from lamprophyre intrusions (May and Aravanis, 1988a; Clifford, 1993).

Mount Throssell

Western Mining Corporation recovered one microdiamond from the BJ1 sill at Mount Throssell (*11333*), 3 km east-northeast of Mount Throssell (Fig. 14). This sill, identified as an ultramafic lamprophyre, was discovered by a trail of indicator minerals from stream sediment samples near Mount Throssell. This trail also led to the discovery of four small alkaline ultramafic rock bodies (BJ2–5; Western Mining Corporation, 1988).

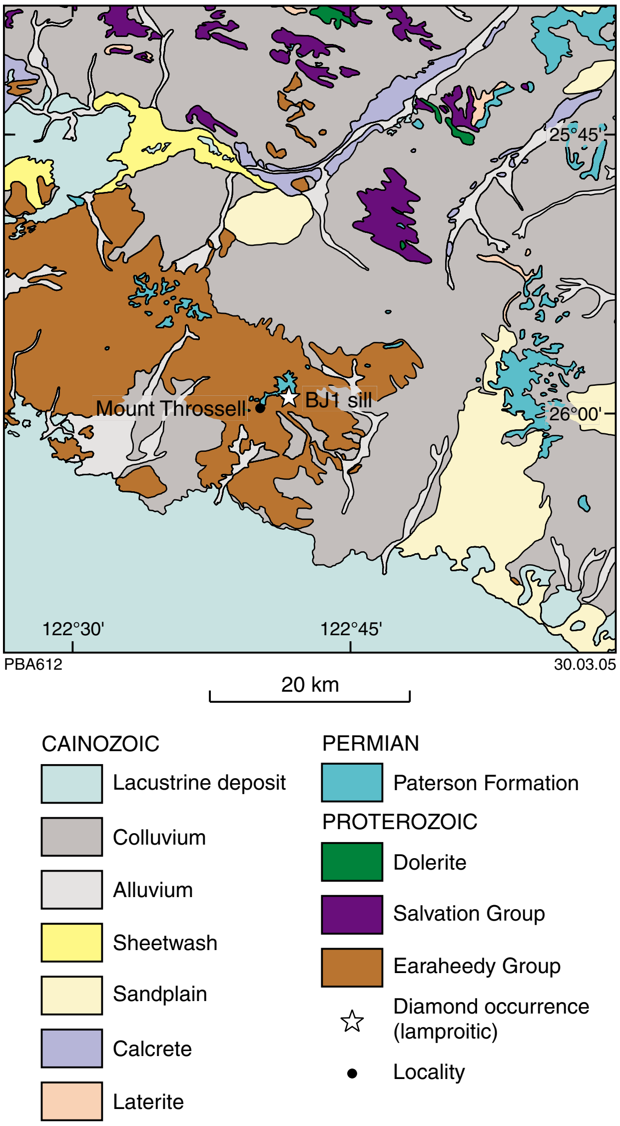

Figure 14. Diamond occurrence near Mount Throssell (geology after Bunting 1980a; Williams et al., 1981)

Orthomagmatic mafic and ultramafic mineralization — undivided

Steel industry metal — nickel

Collurabbie

In 2003 WMC Resources Ltd reported the discovery of a zone of combined nickel, copper, and PGE at the Collurabbie project, in the Gerry Well greenstone belt west of Collurabbie Hills on KINGSTON (Fig. 15). Drilling by WMC Resources Ltd in joint venture with Falcon Minerals Ltd at the Collurabbie–Olympia prospect (*17740*) returned significant intercepts in two holes with 26 m at 0.73% Ni, 0.08% Cu, and 0.03 g/t Pt + Pd and 28 m at 0.61% Ni, 0.03% Cu, and 0.06 g/t Pt + Pd. A drillhole in the Collurabbie–Agora prospect (*17441*) intersected 14 m at 0.57% Ni, 0.19% Cu, and 0.43% Pt + Pd. WMC Resources considered at least some of the mineralization in the above holes to be derived from the weathering of primary sulfide mineralization (Falcon Minerals Limited, 2003a,b, 2004; WMC Resources Limited, 2004a)

Deeper drilling at the Olympia prospect during July to October 2004 intersected a number of significant mineralized horizons, including 8 m at 1.23% Ni, 1.62% Cu, and 3.8 g/t PGE and 5.77 m at 3.00% Ni, 1.96% Cu and 5.29 g/t Pt + Pd. The mineralization has been identified within two parallel ultramafic horizons, known as Beta and Gamma, that trend north-northwesterly in a zone now estimated to extend over 20 km in strike. Geochemical anomalism, indicative of the nickel, copper, and PGE mineralization at Collurabbie, has been defined within this zone by nearsurface aircore drilling over a total strike length of 8 km within the Gamma horizon. To date the only bedrock drilling of this anomaly has been at the Olympia prospect. Within the Beta horizon, WMC Resources has intersected disseminated sulfide mineralization over 7 km of strike with the mineralization open to the north and south and at depth. In November 2004 WMC Resources announced that the above drilling results suggest a new nickel province at Collurabbie (WMC Resources Limited, 2004b).

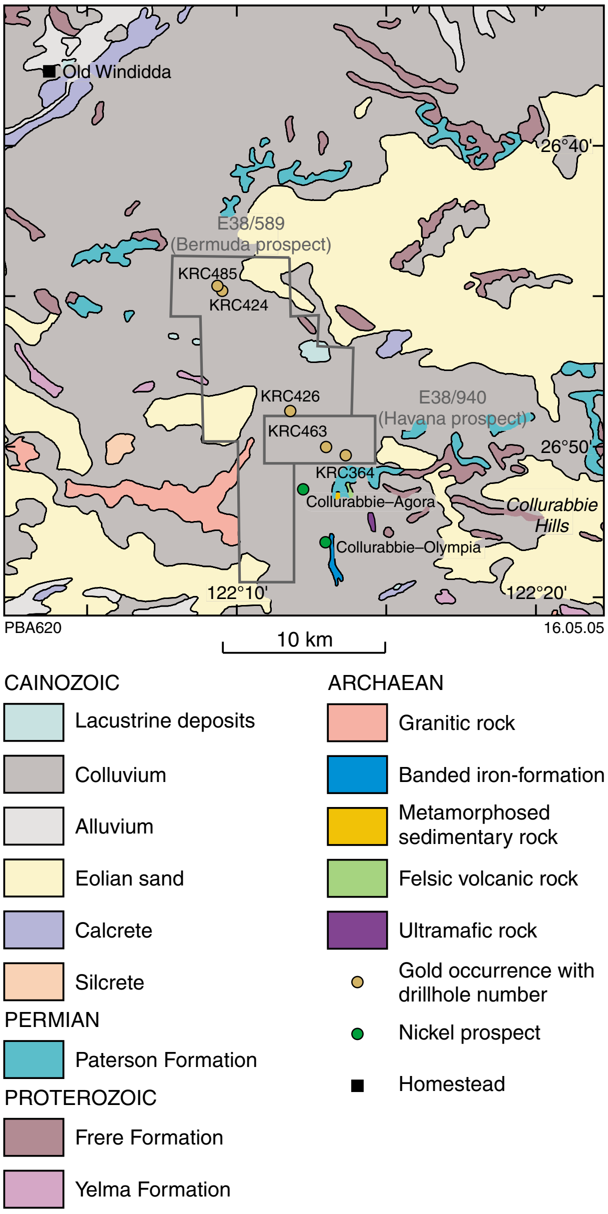

Figure 15. Gold and nickel mineralization in areas south of Old Windidda Homestead (geology after Bunting, 1980b)

Vein and hydrothermal mineralization

Precious metal — gold

Cunyu area

At Cunyu North drilling during 1996–98 by Cyprus Gold Australia intersected significant auriferous quartz veins (Table 4) at Cunyu Woolshed 1–3 (*11365*, *12837*, *11368*) in the Paris and Hektor prospects (Fig. 16). The mineralization is hosted by a narrow, steeply westerly dipping structure within sheared and variably quartz-veined basalts. The basalt is strongly foliated and dips steeply to the north and west near the hinge zone of a synclinal axis. The mineralization is associated with sericite, chlorite, pyrite, and carbonate alteration. Mineralization in the Hektor prospect is associated with variably ferruginous saprolitic material after basaltic and doleritic rocks (Roberts and Jockel, 1994a; Wetherall, 1995a; Grey, 1996a, 1997a; Halilovic, 1997; Rieth, 1998).

Mount Eureka centre

Gold mineralization is known in a number of localities within 2 to 3 km of Mount Eureka (Plate 1, Fig. 17), and also at Rubys Find and Irwin Bore, within about 20 km of Mount Eureka.

Significant gold occurrences at Mount Eureka 1–7 (*11439*, *11441*, *11443*, *11465*, *11466*, *11633*, *11637*) are summarized in Table 5. These include 10.2 and 8.1 ppm Au from shaft dumps, 11.97 ppm from a trench sample, and drillhole intersections of 2 m at 3.7 ppm Au and 2 m at

Table 4. Significant gold intersections at Cunyu North

Prospect	*Description*
Paris (Fig. 16)	4 m at 2 ppm Au from 28 m in RAB hole CNRB 157. Mineralization is in sheared saprolitic basalt with quartz stringers. The basalt is strongly foliated and has undergone pyritic and sericitic alteration. The mineralized structure strikes at 330° and appears to have 200–300 m of dextral movement. The basalt hosting gold mineralization dips steeply to the north and west near the hinge zone of a synclinal axis (Grey, 1996a, 1997a)
Paris	4 m at 1.08 ppm Au from 48 m in RC hole CNAC 711 (also same hole 4 m at 0.14 ppm Au from 32 m and 5 m at 0.17 ppm Au from 60 m). This hole is close to CNRB 157 above and confirms the mineralization intersected. RAB hole CNRB 148 south of CNAC 711 had an intersection of 8 m at 0.13 ppm Au from 40 m. Followup drilling did not indicate lateral extensions to above mineralized intersections. The mineralization is interpreted to be hosted by a narrow, steeply west dipping structure within sheared and variably quartz-veined basalts. This zone is considered to be open at depth (Grey, 1996a; Rieth, 1998)
Paris	12 m at 0.78 ppm Au from 28 m in RAB hole CNRB 181 (including 4 m at 1.15 ppm Au from 32 m), which is an extension of earlier reported 4 m at 2 ppm Au in CNRB 157. Alteration includes sericite, chlorite, pyrite, and carbonate (Grey, 1997a)
Hektor (Fig. 16)	4 m at 3.28 ppm Au from 36 m in RAB hole CNVR 695. The mineralization is hosted by quartz-veined saprolitic mafic rocks with some remnant boxworks after pyrite. Hole CNVR 699 (close to CNVR 695) had an intersection of 4 m at 0.12 ppm Au from 32 m. Further followup work confirmed a weakly mineralized structure, but no grade continuity. Mineralization in all these holes is associated with variably ferruginous saprolitic material after basaltic and doleritic rocks. Anomalous Ni, Co, and Cr values were returned from holes south of Hektor prospect and the area is considered to have potential for nickel mineralization (Rieth, 1998)
Hektor	4 m at 0.46 ppm Au from 32 m in RAB hole CNVR 689. Nearby hole CNRB 688 had an intersection of 4 m at 0.36 ppm Au from 36 m. The mineralization is associated with mafic saprolite (Rieth, 1998)

3.32 ppm Au. The gold mineralization in the area is along a north-trending shear zone within felsic-dominated rocks with quartz veining and pyrite. Gold is also in quartz veins in silicified carbonate schist commonly at the contacts with thin chert bands (Hutchison, 1996, 1997; Kitto, 1985; Shaw and Associates, 1985; Powell, 1986, Robertson, 1987; Doust, 1994).

About 4 km south of Mount Eureka, significant gold has been intersected by drilling along the Central and Galway zones at Southern Mount Eureka 1–9 (*15389–15397*; Fig. 17). Some of the best intersections in the Central zone include 8 m at 4.28 ppm Au, 38 m at 1.08 ppm Au, 5 m at 2.4 ppm Au, and 9 m at 6.2 ppm Au (Table 5). In the Central zone at least three shallowly

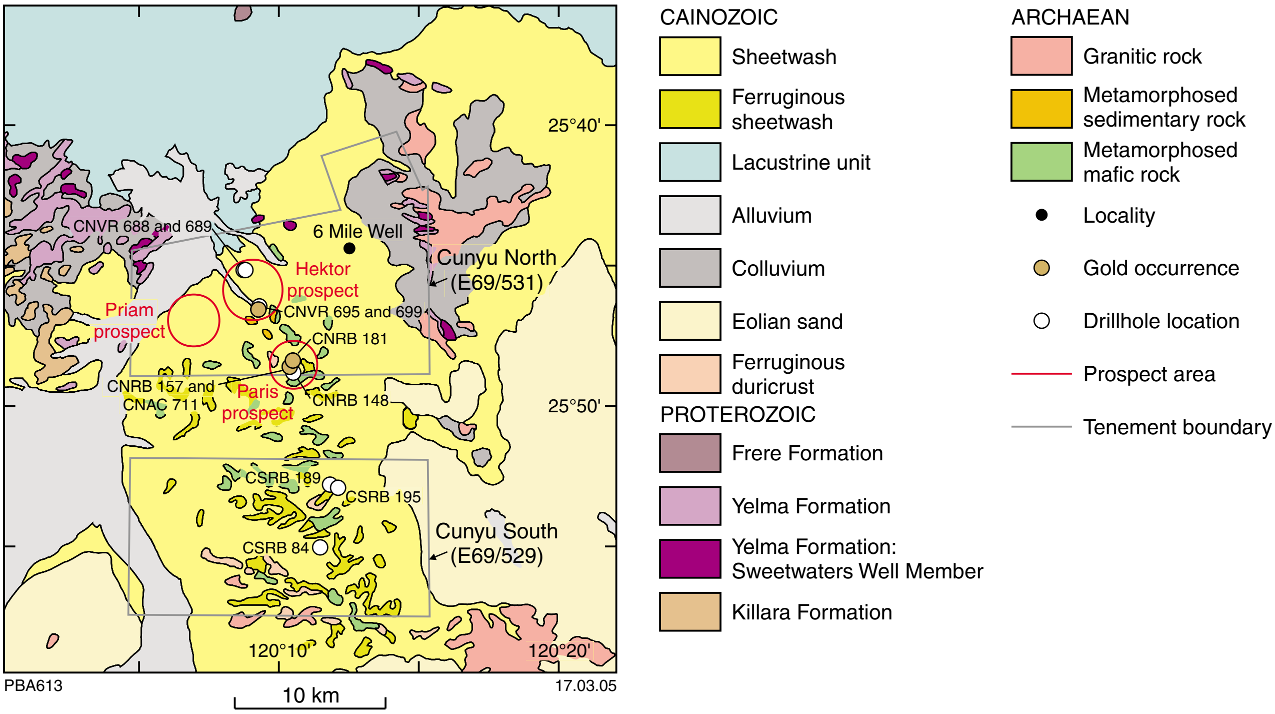

Figure 16. Gold prospects near Cunyu (geology after Hocking et al., 2003)

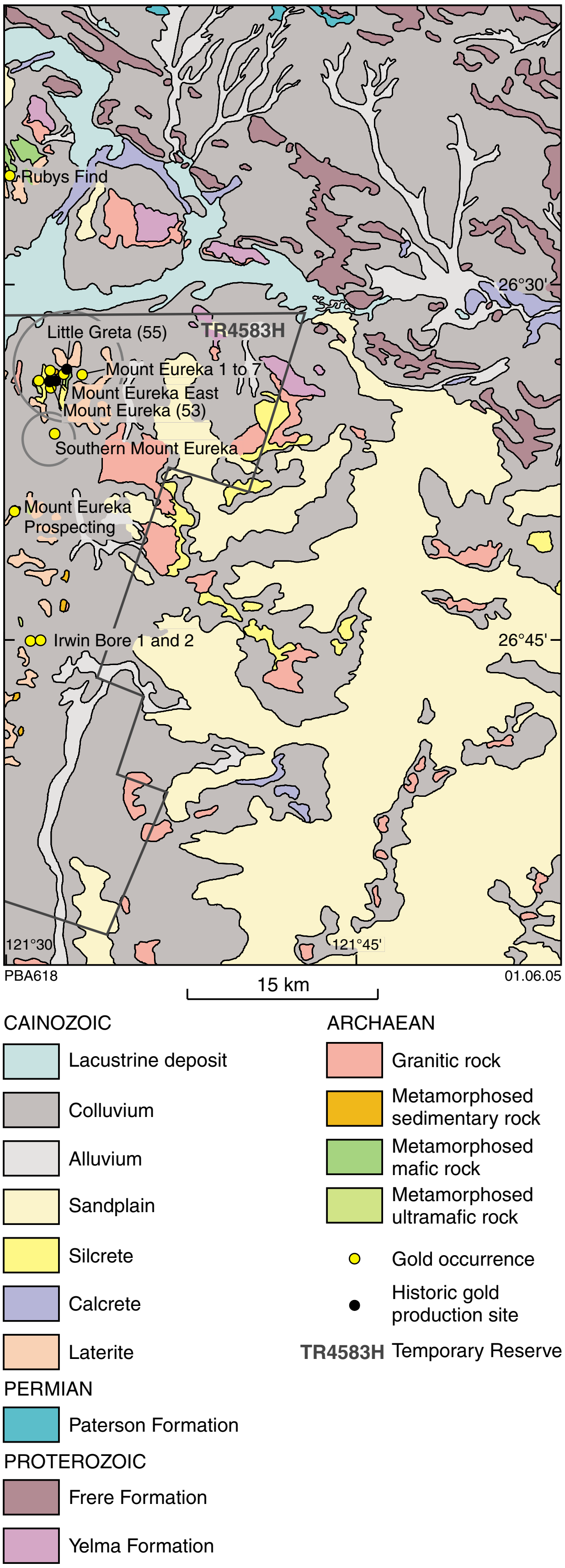

Figure 17. Regional geology and gold mineralization around Mount Eureka (geology after Bunting, 1980b)

dipping mineralized zones with easterly trends, extending up to 300 m, have been identified. The mineralization is hosted in a suite of mafic rocks that are overlain by barren ultramafic rocks (Cullen Resources Limited, 2003a,b).

In the Galway zone significant gold intersections include 6 m at 3.64 ppm Au and 6 m at 5.06 ppm Au, in steeply dipping shear zones at and near the contacts with mafic and ultramafic rocks (Table 5). This prospect is considered to have less potential than the Central prospect (Cullen Resources Limited, 2003a,b).

At Irwin Bore 1 (*11444*) samples from old gold workings returned significant gold assays during exploration. A sample of hematitic quartz, 0.7 km west-southwest of Irwin Bore, assayed 6 ppm Au (Kitto, 1985; Schusterbauer, 1989a,b; Colville, 1990). Another sample of ferruginous chert from Irwin Bore 2 (*11445*), 0.8 km south-southeast of Irwin Bore, assayed 1.44 ppm Au.

Colville (1991) reported an assay of 4.16 ppm Au from a rock chip sample about 1 to 2 km south of Irwin Bore (exact location is uncertain). Holes drilled by ACM Gold Ltd during 1988–90 had significant gold intersections (Table 6). The exact locations of these holes are uncertain, but they are about 1 to 2 km south of Irwin Bore.

At Rubys Find (*11442*; Fig. 7), about 16 km north-northwest of Mount Eureka, two samples from shaft dumps collected by Sundowner Minerals NL during 1985 assayed 10.2 and 8.1 ppm Au (Kitto, 1985). The samples are presumably associated with weathered mafic rocks. Rock chip samples collected by Hunter Resources Ltd during 1990 from nearby locations assayed 4.72 ppm Au from a talcose schist, and 5.87 ppm Au from a quartz vein (Leishman, 1990).

Windidda

At Windidda South (Au) 1–5 (Bermuda and Havana prospects), drilling in the 1990s showed gold intersections greater than 1 ppm (Table 7; *11478*, *11623*, *11624*, *11631*, *11632*; Fig. 15). The best intersection was 2 m at 5.20 ppm from hole KRC463 from the Havana prospect. The mineralization, presumably associated with quartz veining, includes sericite–silica–carbonate alteration zones (Butterworth, 1999a,b) in an Archaean greenstone belt that forms a complex strike-ridge of banded iron-formation, ferruginous chert, and interbedded shale.

Crack O’Dawn

There are two gold prospects at Crack O’Dawn (Plate 1), identified as Crack O’Dawn 1 (Au) and Crack O’Dawn 2 (Au) in the WAMIN database (*11688* and *11689*). These gold prospects, associated with the Lockeridge Fault, were identified during the mapping of NABBERU (1:100 000; Pirajno, 1999).

Horse Well

Mineralization at Horse Well 1 (Au) (11690) is related to schistose mafic rocks (Plate 1). The deposit contains an inferred resource estimated at 0.46 Mt at 4.7 ppm Au (Great Central Mines Limited, 1999). Two other gold

Table 5. Significant gold intersections in the Mount Eureka area

Locality	*Description*
Mount Eureka 1 occurrence (11465), about 1 km north of Mount Eureka (RAB hole YRB16)	1 m at 2.27 ppm Au from 25 m. Rocks intersected are mafic schist, and sedimentary, and volcanic rocks. Number of shears and faults are found in the area (Hutchison, 1996)
Mount Eureka 2 occurrence (11466), about 0.6 km east-southeast of Mount Eureka (RAB hole YRB24)	1 m at 2.7 ppm Au from 16 m. Further drilling to test this mineralization resulted in more significant intersections: 6 m at 1.46 ppm Au from 12 m in hole YRC07 and 8 m at 1 ppm Au from 84 m in hole YRC08 (including 2 m at 3.32 ppm Au from 88 m). Holes intersected mafic schist, and sedimentary and volcanic rocks. The mineralization is along a north–south shear zone within felsic-dominated lithologies with quartz veining and pyrite (Hutchison, 1996, 1997)
Mount Eureka 3 occurrence (11439), about 0.2 km northeast of Mount Eureka (a number of RAB holes)	Significant gold intersections including 2 m at 11 ppm Au from 12 m in hole MER4; 2 m at 2.57 ppm Au from 20 m in hole MER54 (50 m north of MER4); 2 m at 1.31 ppm Au from 20 m in hole MER48 (100 m northeast of MER4); 1 m at 15 ppm Au from 63 m in hole YP80 (close to MER4). Mineralization in MER4 is in weathered saprolitic zone and in MER5 in quartz-veined silicified porphyry. Also holes MER55, MER58, YP81, and YP82 near above holes had intersections greater than 1 ppm Au. Two samples from shaft dumps near Mount Eureka assayed 10.2 ppm Au and 8.1 ppm Au and a trench sample assayed 11.97 ppm Au (Kitto, 1985; Shaw and Associates, 1985; Powell, 1986; Robertson, 1987; Doust, 1994)
Mount Eureka 4 occurrence (11637), about 0.8 km northeast of Mount Eureka (old gold workings)	Gold is in quartz veins in silicified carbonate schist, commonly at the contacts with thin chert bands (Bunting, 1980a,b)
Mount Eureka 5 occurrence (11443), about 1.2 km northeast of Mount Eureka	A sample from shaft dumps assayed 1.53 ppm Au. The mineralization is associated with ferruginized cherty material (Kitto, 1985)
Mount Eureka 6 occurrence (11633), about 0.5 km southeast of Mount Eureka (old gold workings)	Gold is in quartz veins in silicified carbonate schist, commonly at the contacts with thin chert bands (Bunting, 1980a,b)
Mount Eureka 7 occurrence (11441), about 2.5 km northeast of Mount Eureka (a number of RAB drillholes)	Significant gold intersections include: 2 m at 2.95 ppm Au in hole EER68 from 12 m in schistose regolith material; 2 m at 3.7 ppm Au in hole EER39 from 14 m in clay; 2 m at 1.43 ppm Au in hole EER34 from 8 m in quartz-veined clay (Robertson, 1987)
Central zone, about 4 km south of Mount Eureka	More than 30 holes had significant intersections. Some of the best intersections include 8 m at 4.28 ppm Au in hole MERC60 from 86 m depth, 38 m at 1.08 ppm Au in hole MERC62 from 45 m depth of, 5 m at 2.4 ppm Au in hole MEAC15 from 58 m depth, 9 m at 6.2 ppm Au in hole MERC75 from 98 m (Cullen Resources Limited, 2003a,b)
Galway zone, about 5 km south of Mount Eureka	Significant intersections include 6 m at 3.64 ppm Au in MEAC130 from 38 m depth, and 6 m at 5.06 ppm Au in MEAC147 from 40 m depth (Cullen Resources Ltd, 2003a,b)

Table 6. Significant gold intersections in drillholes 1 to 2 km south of Irwin Bore

Drillhole	*Intersection*
RAB hole MTE19	4 m at 3.3 ppm Au from 76 m
RAB hole MTE23	4 m at 1 ppm Au from 64 m
RAB hole MTE27	2 m at 1.8 ppm Au from 34 m
RAB hole MTE85	4 m at 1 ppm Au from 40 m
RAB hole MTE83	4 m at 1.21 ppm Au from 36 m
RC hole RC6	5 m at 5.82 ppm Au from 60 m
RC hole RC2	49 m at 0.71 ppm Au from 40 m
RC hole RC3	2 m at 3.1 ppm Au from 61 m
Diamond drillhole DD1	1.88 m at 1.97 ppm Au from 132.8 m, 1.1 m at 1.77 ppm Au from 159.9 m; 3 m at 1.33 ppm Au from 168 m, and 1 m at 2.78 ppm Au from 206 m
Diamond drillhole DD2	1 m at 1.59 ppm Au from 63 m and 1 m at 1.19 ppm Au from 177 m

SOURCES: Schusterbauer (1989a,b); Colville (1990, 1991)

prospects close to Horse Well (Pirajno, 1999) are Horse Well 2 (Au) (*11691*) and Horse Well 3 (Au) (*11692*). The Horse Well mineralization is spatially associated with the Lockeridge Fault in the south of NABBERU (1:100 000) and is hosted by a west-dipping shear zone system (Pirajno et al., 2004a).

Steel industry metal — manganese

Earaheedy

Adamides et al. (2000b) identified four manganese occurrences, Earaheedy (Mn) 1–4 (*11674–11677*), at the eastern and western sides of the abandoned Earaheedy Homestead (Fig. 18). The mineralization is related to structurally controlled hydrothermal veins containing quartz–iron–manganese oxides hosted by shale units of the Karri Karri Member of the lower Chiall Formation (Adamides et al., 2000b; Pirajno and Adamides, 2000; Hocking et al., 2001a; Morris et al., 2003). The veins

Table 7. Significant gold intersections in areas southeast of the Old Windidda Homestead

Prospect	*Gold intersection*
Bermuda (16.2 km southeast of Old Windidda Homestead)	2 m of 1.21 ppm Au from 144 m in RC hole KRC424
Bermuda (16 km southeast of Old Windidda Homestead)	2 m at 1.00 ppm Au from 156 m in hole KRC485
Bermuda (24 km southeast of Old Windidda Homestead)	2 m at 1.55 ppm Au from 80 m in RC hole KRC426
Havana (27.5 km southeast of Old Windidda Homestead)	2 m at 5.20 ppm Au from 30 m in RC hole KRC463
Havana (28.5 km southeast of Old Windidda Homestead)	2 m at 2.45 ppm Au from 70 m in RC hole KRC364

SOURCE: Butterworth (1999a,b, 2000)

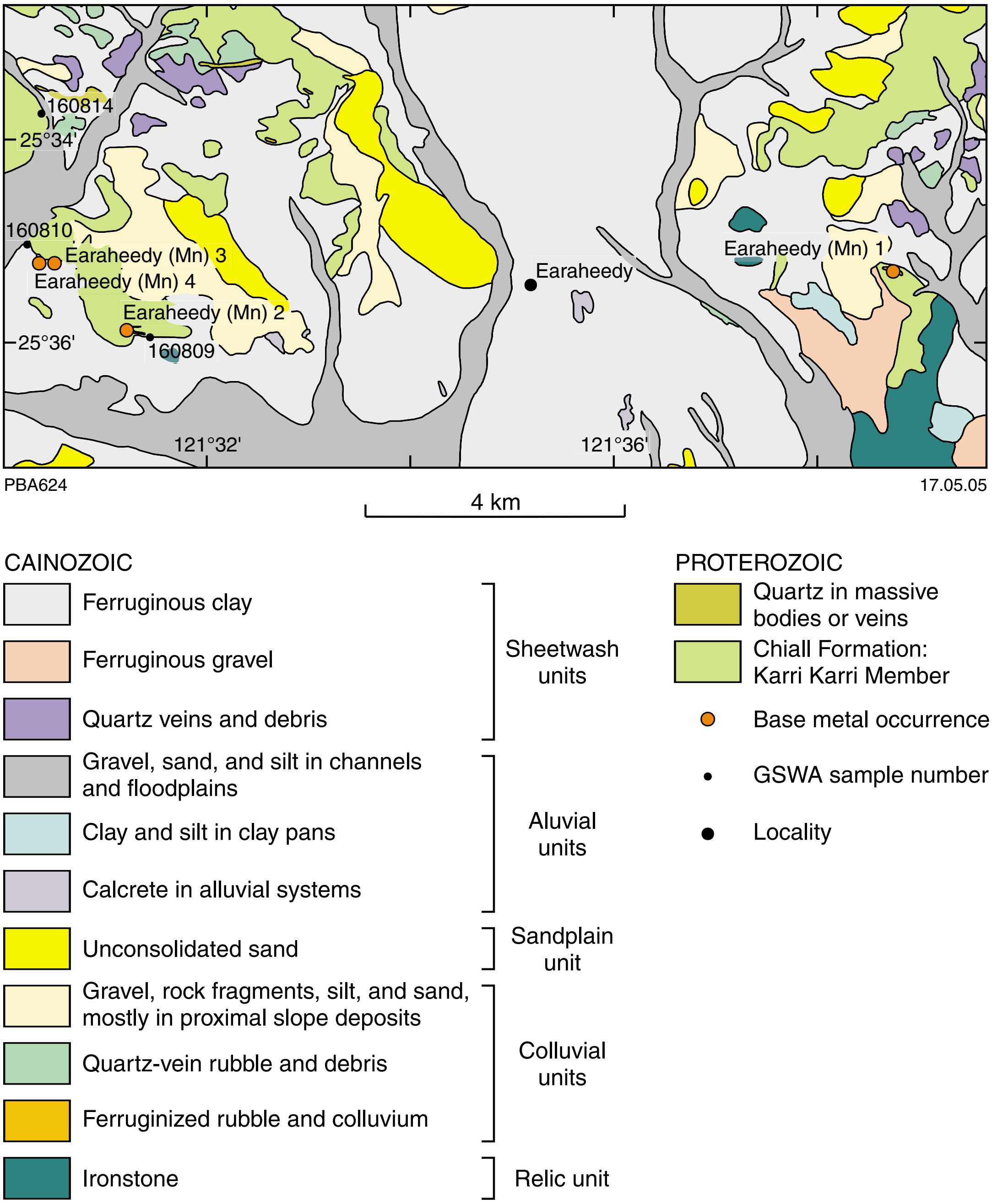

Figure 18. Geology around manganese occurrences near Earaheedy (after Adamides et al., 2000b)

form bodies of massive quartz–ironstone with a maximum thickness of 8 m and a strike length of up to 80 m, and are possibly related to supergene processes (Hocking et al., 2001a). These occurrences are the same as those described by Bunting (1986) as bands controlled by joints and bedding-plane fractures in the steeply dipping sedimentary rocks. Four pooled samples (Bunting, 1986), taken at 2 m intervals across strike assayed 27% Mn, 2.3% Fe, and 36.8% SiO_2. Three samples (GSWA 160809, 160810, and 160814; Fig. 18) collected by Hocking et al. (2001a) from localities close to the above occurrences assayed 12.5–39% Mn and 4.7–32% Fe.

Breakaway Bore

The Breakaway Bore (Mn) 1–3 prospects (*11678–11680*) are about 1–4 km southeast of Breakaway Bore (Fig. 19) on EARAHEEDY (1:100 000). These occurrences are associated with hydrothermal veins containing quartz and iron–manganese oxides within the Palaeoproterozoic Chiall Formation (Adamides et al., 2000b; Hocking et al., 2001a).

Base metal — copper, zinc (and gold)

Troy Creek area

Copper, zinc, and gold mineralization is hosted by rocks of the Yelma Formation in the Stanley Fold Belt, represented by black graphitic shale, dolomitic siltstone, pyritic shale, and siltstone. Exploration work, reported by Smith (1993) and Kellow (1991), identified two mineralized zones: Gossan and North Chert (Fig. 20).

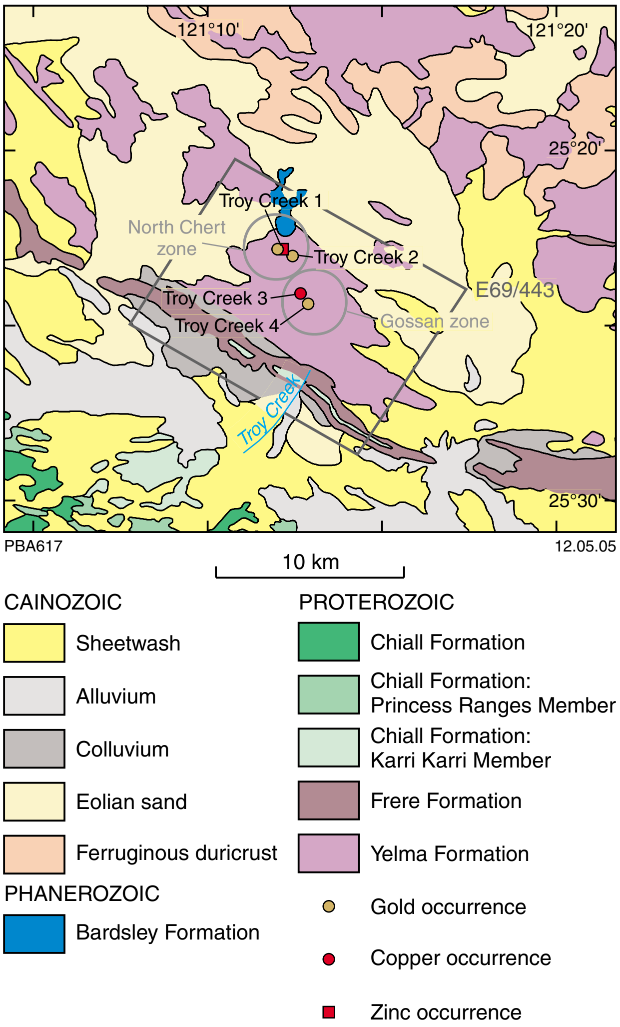

Figure 20. Base metal and gold occurrences around Troy Creek (geology after Hocking et al., 2003)

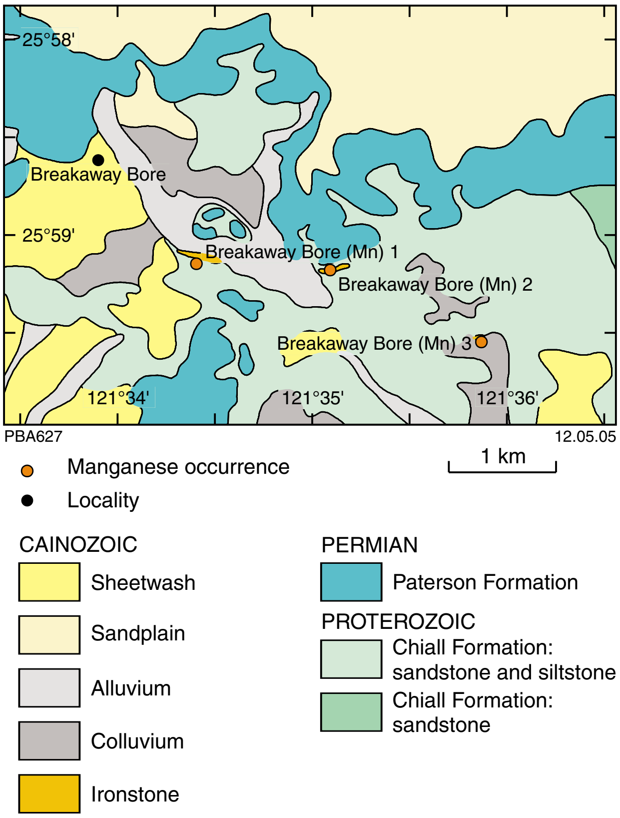

Figure 19. Geology around manganese occurrences near Breakaway Bore (after Adamides et al., 2000b)

At Troy Creek 3 (*12625*), drilling of the Gossan zone intersected 9.6 m at 0.34% Cu and 1.5 m at 2.98% Cu. Intersections in other drillholes include 3 m at 0.34% Cu, and 3 m at 0.22% Cu. In the Gossan zone at Troy Creek 4 (*10807*) gold was intersected in two drillholes (6 m at 0.44 ppm and 1 m at 3.2 ppm; Kellow, 1991).

At Troy Creek 1 (*12411*) drilling of the North Chert zone intersected 1.1 m at 0.62 % Zn and 3.7 m at 0.63 ppm Au. The mineralization in this zone has a strike length of about 600 m and contains anomalous copper, zinc, antimony, gold, and silver in siltstone, dolomitic rocks, graphitic shale, and pyritic black siltstone. At Troy Creek 2 (*12648*), in the North Chert zone, a drill sample assayed 1.03 ppm Au (Kellow, 1991) in dolomitic siltstone, possibly of the Yelma Formation, with extensive quartz veining and minor sulfides and hematite.

Although Troy Creek mineralization is classified here as of vein and hydrothermal type, F. Pirajno (2004, written comm.) suggests that it may be of stratabound shale-hosted type with affinities to the Mississippi Valley-type (MVT) mineralization at Sweetwaters Well, Mount Teague, and Mount Lockeridge (see **Stratabound sedimentary — carbonate-hosted mineralization** below). Similar mineralization may be present in rocks of the Yelma Formation elsewhere in the Earaheedy Basin (Pirajno, F., 2004, written comm.).

Miss Fairbairn Hills

At Miss Fairbairn Hills (Cu) (*11429*), drilling of magnetic anomaly 2PC145 (Fig. 21) intersected 4 m at 2.43% Cu from 58 m in a sulfide-rich zone. Host rocks include arenaceous shales intruded by mafic rocks (Geach, 1994), but the area also has subsurface monzogranite with potassic alteration (Hocking et al., 2003). The mineralization could be related to the circulation of hydrothermal fluids during the deformation of the Stanley Fold Belt.

Industrial mineral — barite

Quadrio Lake

Barite veins associated with hematite at Quadrio Lake (*10682–10689*, *10693*, *13084*; Fig. 22; Hocking et al., 2000c) contain anomalous gold, arsenic, and antimony values and extend over an area of at least 500 × 2000 m. According to Sanders (2002), the barite–hematite vein mineralization extends for at least 6 km between Quadrio Lake and Phenoclast Hill, and is typically orientated between 220° and 270°, with veins up to 50 cm across.

Barite–hematite mineralization is hosted by sedimentary rocks of the Mesoproterozoic Oldham Inlier that are overlain and onlapped by Neoproterozoic sedimentary rocks of the Sunbeam Group in the northwest Officer Basin (Bagas et al., 1999). Mineralization is in the Quadrio Formation, which is a dominantly fine grained shaley unit with locally developed sandstone and chert intervals.

Barite–hematite veinlets are also present in the GSWA Trainor 1 drillhole, about 10 km northeast of Quadrio Lake

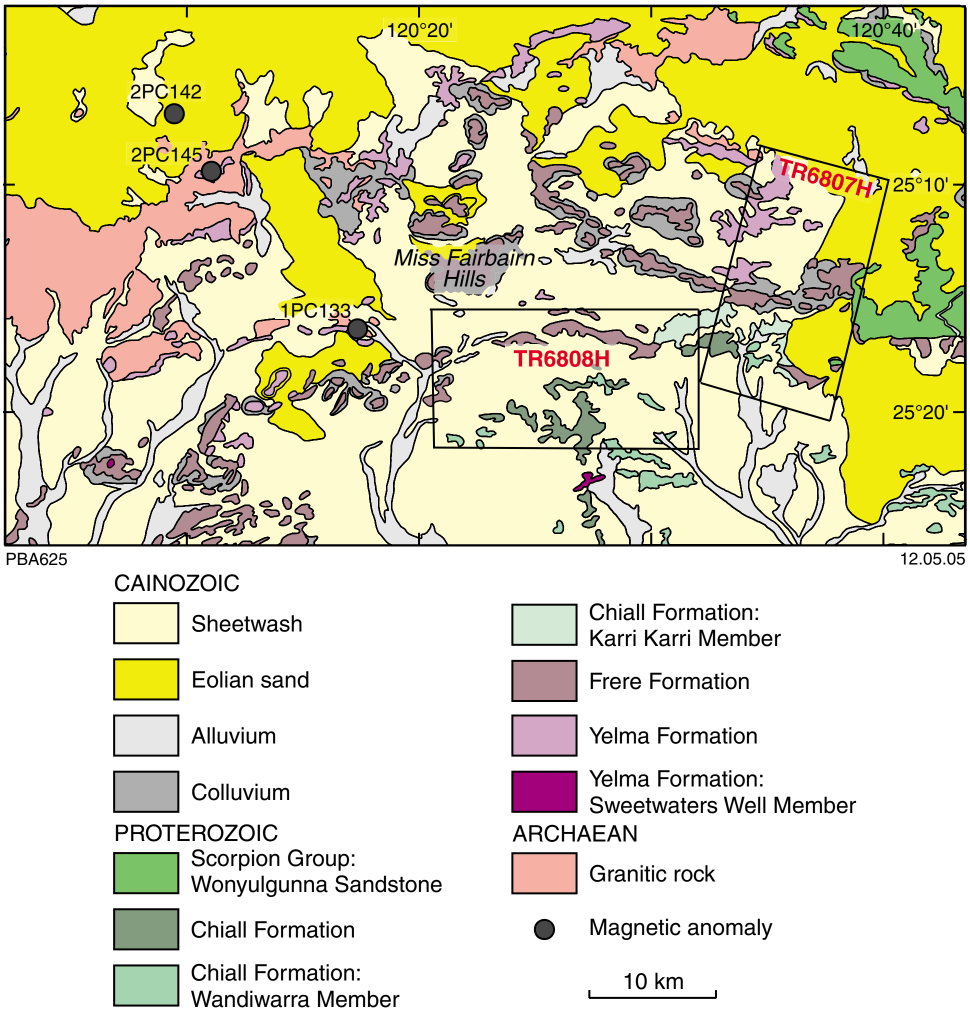

Figure 21. Regional geology around Miss Fairbairn Hills and areas explored for copper (geology after Hocking et al., 2003)

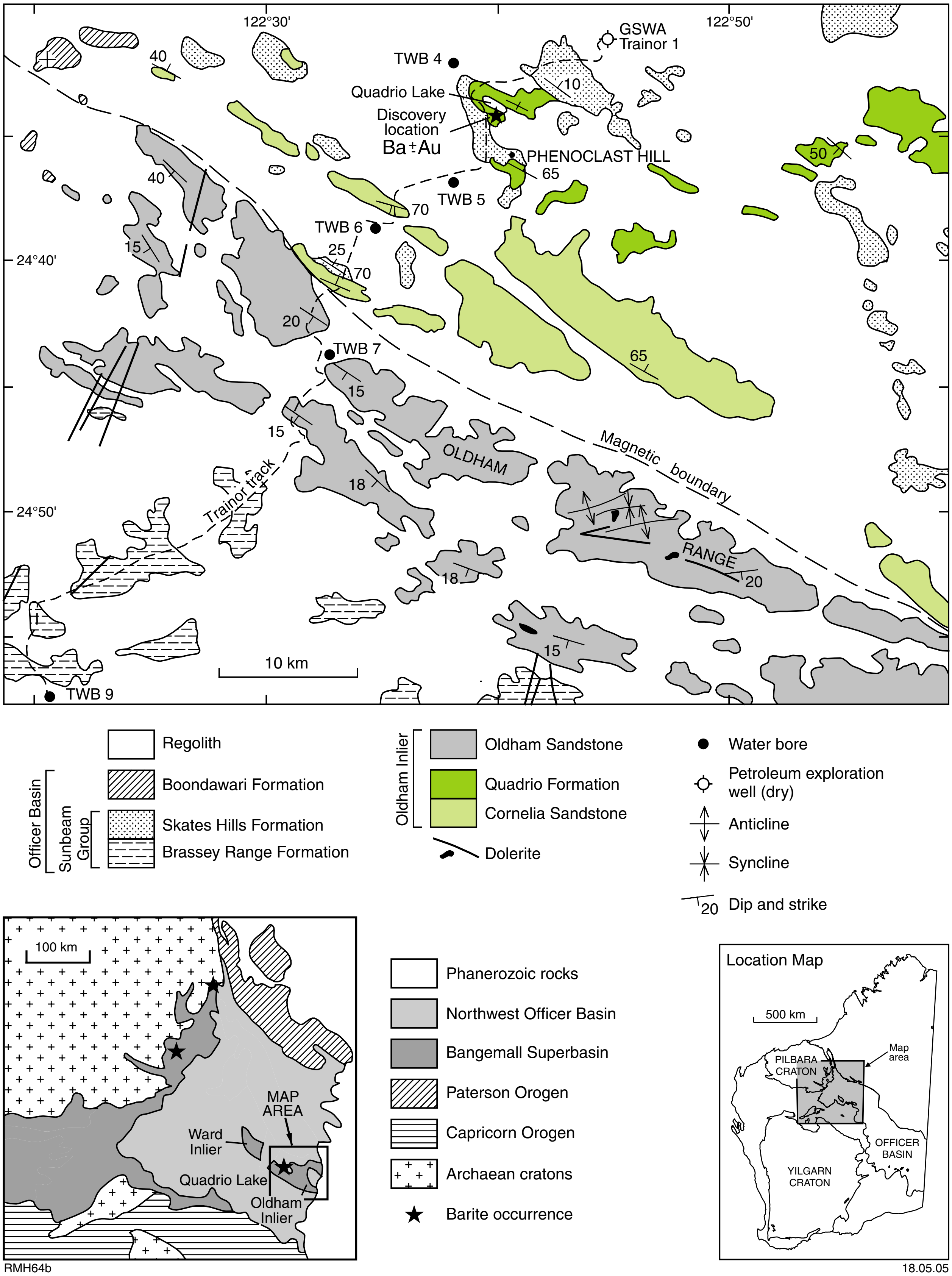

Figure 22. Geological map of the area around Quadrio Lake (after Hocking et al., 2000c)

(Fig. 22). The veinlets are locally associated with pyrite, in hydrothermally altered dark-grey mudstone lithologically similar to the Quadrio Formation (Stevens and Adamides, 1998; Hocking et al., 2000c).

Since Quadrio Lake mineralization post-dates deformation of the Quadrio Formation, Hocking et al. (2000c) suggested that the Quadrio Lake barite is part of the same event that produced the Telfer gold mineralization and other metalliferous occurrences associated with the Throssell and Lamil Groups.

Stratabound sedimentary — carbonate-hosted mineralization

Stratabound sedimentary — carbonate-hosted base metal mineralization is known from around Sweetwaters Well, Mount Teague, and Mount Lockeridge (Fig. 23).

Base metal — lead, zinc, and copper

Sweetwaters Well

Stromatolitic carbonate rocks of the Sweetwaters Well Member in the upper parts of the Yelma Formation contain carbonate-hosted MVT base metal mineralization (Pirajno, 2002, 2004), particularly in an area 3.5 km southeast of Sweetwaters Well (Fig. 23).

At Sweetwaters Well (*13027*) a dolomite grab sample assayed 6% Pb, 53 ppm Ag, 31.4 ppm As, 80 ppm Co, 70 ppm Cu, 1900 ppm Mn, 105 ppm Ni, and 230 ppm Zn (Hall and Haslett, 1978). In the Sweetwaters Well Member, coarsely crystalline galena forms small veins, stringers, and cavity fillings within the dolomite. In places galena is between the columns of small, digitate stromatolites. Thin pyrite stringers, now replaced by limonite, also cut the dolomite (Hall and Haslett, 1978; Hall, 1979; Bunting et al., 1982; Bunting, 1986; Adamides, 1999, 2000; Morris et al., 2003).

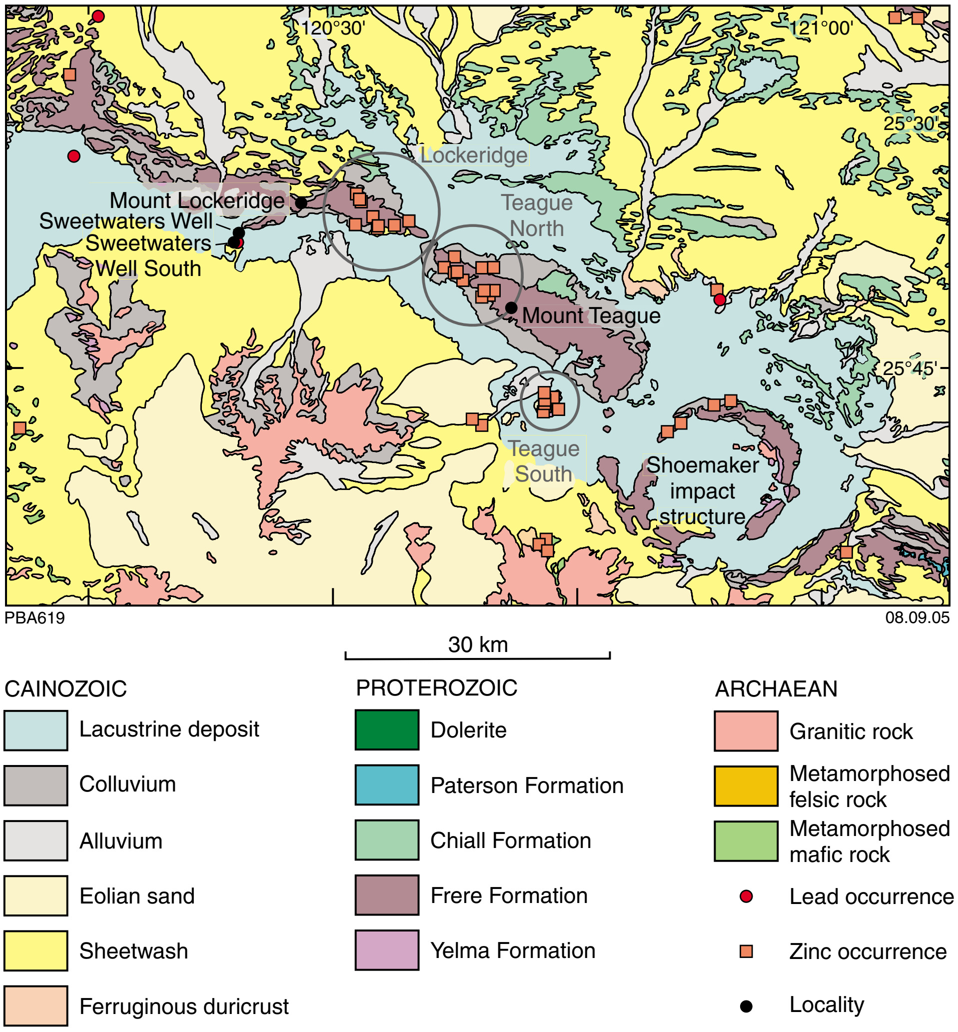

Figure 23. Base metal prospects around Sweetwaters Well, Mount Lockeridge, and Mount Teague (geology after Hocking et al., 2003)

At Sweetwaters Well South (*10883*), 4.4 km southeast of Sweetwaters Well, drilling by Dampier Mining Co. Ltd intersected 1 m at 1.6% Pb from 9 m depth, and in a nearby hole intersected 5 m at 0.52 – 0.82% Pb from 9 m depth (Hall and Haslett, 1978; Hall, 1979).

According to Bunting (1986), the presence of galena in veins and replacement patches suggests that mineralization was introduced during later diagenesis. The galena is in solution cracks and pre-dates the stylolization of the dolomite, and in this respect it shows similarities to Phanerozoic carbonate-hosted lead deposits elsewhere. However, Bunting (1986) also suggested that features such as the association of black shale and dolomite beneath the mineralized outcrops, the possible growth of stromatolites in an evaporitic environment, and the occurrence of mineralization between the Lockeridge and the Merrie Faults (Plate 1) show similarities to other areas of significant stratiform base-metal mineralization, such as the shale-hosted deposits at McArthur River in the Northern Territory.

Adamides (2000), based on mapping on MERRIE (1:100 000), suggested that rocks of the Karri Karri Member of the Chiall Formation, having lithologies with black-shale affinities, may have acted as repositories for a number of elements, including manganese, barium, copper, zinc, uranium, and vanadium, as is the case in black-shale basins (Coveney and Martin, 1983). Subsequent mobilization of these elements by tectonism have led to concentration in suitable rock types, such as carbonates, resulting in the formation of sediment-hosted, epigenetic base metal deposits.

Pirajno (2002) stated that the Sweetwaters Well Member sulfide and sulfate mineralization has many features consistent with carbonate-hosted MVT deposits, such as colloform textures, a shelf carbonate host at the margins of the basin, and low-temperature and moderate-salinity fluids.

McQuitty and Pascoe (1998) suggested that the Magellan lead deposit (on WILUNA, south of the study area) and the Sweetwaters Well Member zinc–lead occurrences were formed as part of the same MVT mineralizing event. The lead resource of the Magellan deposit is estimated at about 220 Mt at 2.2% Pb (McQuitty and Pascoe, 1998).

Mount Teague and Mount Lockeridge

Exploration around Mount Lockeridge and Mount Teague identified a number of areas of zinc and lead mineralization. The mineralization in these areas (designated as Teague South, Teague North, Lockeridge, and Lockeridge SW; Fig. 23) are stratabound shale-hosted types and may have affinities with the MVT occurrences at Sweetwaters Well (Pirajno, F., 2004, written comm.).

Teague South

The Teague South area consists of the carbonate-dominated Sweetwaters Well Member of the Yelma Formation overlain by the granular iron-formation, hematitic cherts, and banded iron-formation of the Frere Formation. To the south the area is bordered by the Archaean rocks of the Yilgarn Craton (Edgar, 1993). Rock chips returned anomalous base metal values with maximum assays of 0.78% Zn, 0.32% Cu, and 0.73% Pb from samples from the Iroquois prospect (Fig. 24). The highest assays in soil samples were 96 ppm Cu, 209 ppm Pb, and 127 ppm Zn.

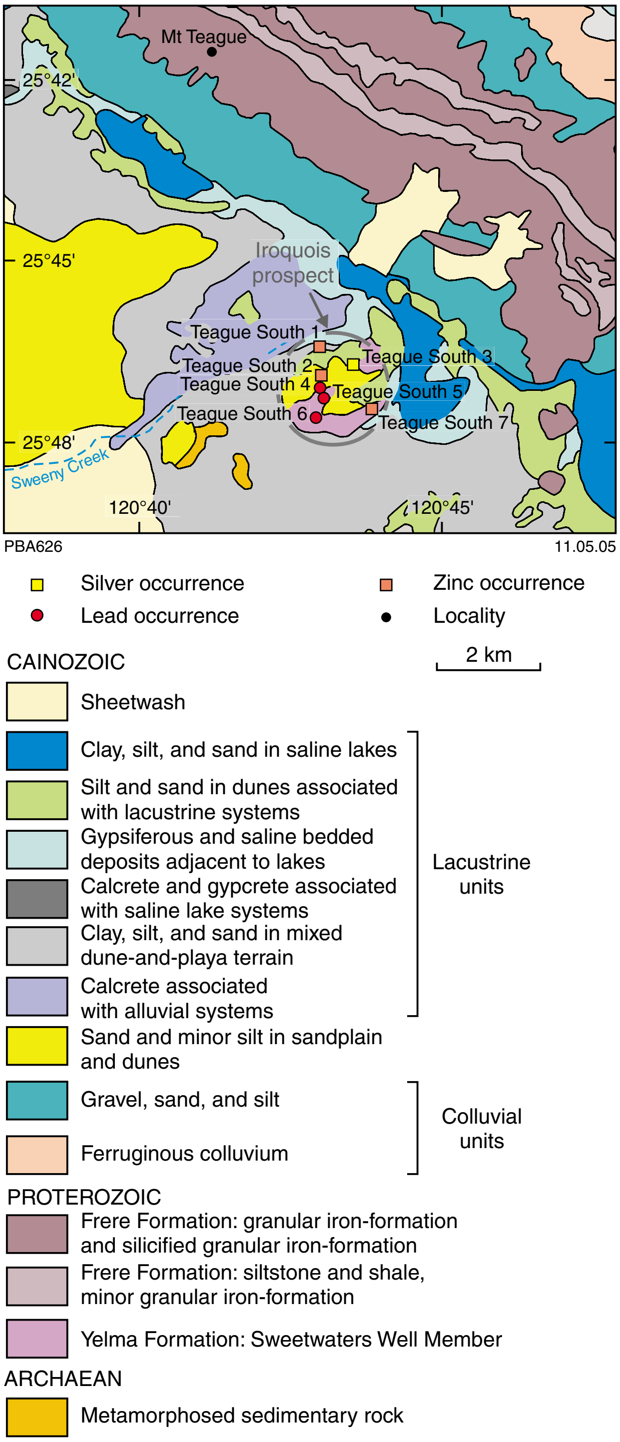

Figure 24. Base metal mineralization at Teague South (geology after Hocking et al., 2003)

Table 8. Significant base metal intersections at the Iroquois prospect in the Teague South area

Locality	*Mineralized intersection*
Teague South 1 occurrence (*11413*), 9.6 km south-southeast of Mount Teague	2 m at 1% Zn and 32 ppm Pb from 18 m in hole TRC 11 (Dorling, 1997a)
Teague South 2 occurrence (*11412*), 10.5 km south-southeast of Mount Teague	2 m at 1.23% Zn and 0.08% Pb in hole TRC 5 from 34 m and 8 m at 1.19% Pb from 29 m in the same hole (Dorling, 1997a)
Teague South 3 occurrence (*11406*), 10.5 km south-southeast of Mount Teague	4 m at 22 ppm Ag from 30 m and 2 m at 0.9% Pb from 38 m in hole TRC 9 (Edgar, 1994)
Teague South 4 occurrence (*11405*), 10.8 km south-southeast of Mount Teague	10 m at 3.5% Pb from 34 m in hole TRC 4 (Edgar, 1994)
Teague South 5 occurrence (*11404*), 11.3 km south-southeast of Mount Teague	10 m at 1.86% Pb and 0.98% Zn from 16 m in hole TRC 3 (Edgar, 1994)
Teague South 6 occurrence (*11403*), 11.7 km south-southeast of Mount Teague	2 m at 4.48% Pb in RC hole TRC 2 (Edgar, 1994)
Teague South 7 occurrence (*11414*), 12 km south-southeast of Mount Teague	2 m at 1.131% Pb and Zn (0.96% Zn and 0.1710% Pb) from 28 m in hole TRC 13 (Dorling, 1997a)

Drillholes at Teague South 1–7 (*11413*, *11412*, *11406*, *11405*, *11404*, *11403*, *11414*) at the Iroquois prospect drilled by RGC Exploration Pty Ltd intersected significant zinc and lead (Table 8). One hole intersected 4 m at 22 ppm Ag (Edgar, 1994; Dorling, 1997a). The base metal mineralization is associated with a shallow (up to 35 m) subhorizontal horizon, rich in base metals and manganese oxide, overlying carbonate-rich rocks of the Yelma Formation. Lead is more predominant in drillhole intersections at Teague South 4–6 (*11405*, *11404*, *11403*). The mineralization in the area may be of Mississippi Valley-type, similar to that at Magellan on WILUNA.

Teague North

Drilling by RGC Exploration intersected significant zinc and lead mineralization at Teague North 1–10 (*11419*, *11425*, *11418*, *11426*, *11427*, *11424*, *11410*, *11409*, *11407*, *11408*) in carbonate rocks, in particular the Sweetwaters Well Member (Table 9, Fig. 25; Edgar, 1994; Feldtmann, 1995, 1996; Dorling, 1997a,b, 1998). Pirajno (1999) also identified lead and zinc mineralization in subsurface material in stromatolitic and laminated dolomite at Teague North 11 (*11686*), 2.5 km northwest of Mount Teague.

Mount Lockeridge

Drilling at Lockeridge 1–7 (*11415*, *11417*, *11416*, *11411*, *11422*, *11423*, *11421*) at the Chinook prospect, by RGC Exploration, intersected significant zinc and lead mineralization in carbonate rocks of the Yelma Formation (Table 10, Fig. 26; Feldtmann, 1996; Dorling, 1996b, 1997b, 1998). Pirajno (1999) also identified lead and zinc mineralization at Lockeridge 8 (*11687*), 5.5 km southeast of Mount Lockeridge.

Sedimentary — granular iron-formation mineralization

Iron

Iron mineralization is widespread in the Frere Formation, which is exposed in a number of areas on NABBERU and parts of STANLEY and KINGSTON. During 1973–78, Amax Exploration (Australia) Inc. and Broken Hill Pty Ltd carried out iron exploration in the granular and supergene-enriched iron-formations of the Frere Formation. The areas explored were Miss Fairbairn Hills, Ivan Well, Frere Range, Mount Cecil Rhodes, Hawkins Knob, and Mount Ooloongathoo (Fig. 27a).

The granular- and supergene-enriched iron-formations of the Frere Formation are separated by shale, siltstone, chert, and jasper beds. Iron-enriched horizons are in hematite-enriched granular iron-formation and in supergene-enriched iron-formation. The former iron enrichment is more common in the areas of Miss Fairbairn Hills, northwest of Ivan Well, and in the Frere Range, whereas the latter enrichment is more common at Frere Range and Hawkins Knob (Fig. 27a). The granular iron-formation (Fig. 6) is estimated to be 300 m thick, and the overlying supergene-enriched iron-formation is estimated to be less than 150 m thick, with the two separated by shale (Adamides et al., 2000a).

The surface expression of the granular iron-formation is more consistently well developed than the overlying supergene-enriched iron-formation. The granular iron-formation in the Miss Fairbairn Hills area has a high iron content, but this decreases to the west and south through Hawkins Knob and Mount Deverell, northwest of Frere Range (Fig. 27b). The supergene-enriched iron-formation is dark grey to purple-black and consists

Table 9. Significant base metal intersections in the Teague North area

Locality	*Mineralized intersection*
Teague North 1 occurrence (*11419*), 8.8 km northwest of Mount Teague in Magazine prospect	26 m at 0.46% Zn+Pb from 304 m including 2 m at 1.16% Zn and 2 m at 1.24% Zn in hole TDH 29. Mineralization is associated with dolomitic rocks of the Yelma Formation (Dorling, 1998)
Teague North 2 occurrence (*11425*), 8.8 km northwest of Mount Teague in Navajoh prospect	Intersection of 4 m at 1.18% Zn and 0.41% Pb from 74 m in hole TRC 48 m. Mineralization is associated with dolomitic rocks of the Yelma Formation (Feldtmann, 1996; Dorling, 1997b)
Teague North 3 occurrence (*11418*), 6 km northwest of Mount Teague in Magazine prospect	Intersection of 54 m at 0.5% Zn+Pb from 323 m in hole TDH28. Intersection includes 6 m at 1.75% Zn from 354 m and 2 m at 3% Zn and 0.12% Pb from 355 m. Mineralization is in dolomitic rocks (Dorling, 1998)
Teague North 4 occurrence (*11426*), 7.5 km northwest of Mount Teague in Navajoh prospect	Intersection of 3 m at 1.16% Zn and 0.19% Pb from 111 m in hole TRC 49. Mineralization is in dolomitic rocks (Feldtmann, 1996; Dorling, 1997b)
Teague North 5 occurrence (*11427*), 7.4 km northwest of Mount Teague in Navajoh prospect	Intersection of 1 m at 1.02% Zn and 0.5% Pb from 147 m in hole NRC 8. Mineralization is associated with dolomitic rocks of the Yelma Formation (Feldtmann, 1996; Dorling, 1997b)
Teague North 6 occurrence (*11424*), 6.3 km northwest of Mount Teague in Navajoh prospect	Intersection of 13 m at 2.36% Zn and 0.72% Pb from 103 m in hole TRC 47. Mineralization is in dolomitic rocks (Feldtmann, 1996; Dorling, 1997b)
Teague North 7 occurrence (*11410*), 4 km northwest of Mount Teague in Navajoh prospect	Intersection of 4 m at 1.69% Zn and 0.54% Pb from 127 m in hole NRC 9. Mineralization is in dolomitic rocks (Dorling, 1996)
Teague North 8 occurrence (*11409*), 3.2 km northwest of Mount Teague in Navajoh prospect	Intersection of 6 m at 1.86% Zn and 0.23% Pb from 210.5 m in hole TDH 20. Mineralization is in partially oxidized material associated with dolomitic rocks (Dorling, 1996b)
Teague North 9 occurrence (*11407*), 3.2 km northwest of Mount Teague in Navajoh prospect	Intersection of 7.3 m at 2.65% Zn+Pb from 150 m in hole TDH 4. Mineralization is in dolomitic rocks (Edgar, 1994)
Teague North 10 occurrence (*11408*), 3.7 km northwest of Mount Teague in Navajoh prospect	Intersection of 2 m at 1.58% Zn from 136 m in hole TRC 81. Mineralization is in dolomitic rocks (Feldtmann, 1995)

Table 10. Significant base metal intersections at the Chinook prospect in the Mount Lockeridge area

Locality	*Mineralized intersection*
Lockeridge 1 occurrence (*11415*), 1.2 km north of Mount Lockeridge	Intersection of 28 m at 0.81% Pb and Zn from 223 m in hole TDH 23. Includes 1 m at 4.2% Pb and Zn and 3 m at 1.75% Pb and Zn. Mineralization is in dolomitic rocks (Dorling, 1998)
Lockeridge 2 occurrence (*11417*), 0.8 km north-northeast of Mount Lockeridge	Intersection of 8 m at 0.56% Zn and Pb from 218 m in hole TDH 30. Includes 2 m at 1.23% Zn. Mineralization is in dolomitic rocks (Dorling, 1998)
Lockeridge 3 occurrence (*11416*), 0.6 km north-northeast of Mount Lockeridge	Intersection of 63 m at 0.43% Zn and Pb from 182 m in hole TDH 24. Includes 2 m at 1.4% Zn and Pb and 4 m at 1.27% Zn and Pb. Mineralization is in dolomitic rocks (Dorling, 1998)
Lockeridge 4 occurrence (*11411*), 2 km southeast of Mount Lockeridge	Intersection of 11 m at 1.33% Zn and 0.18% Pb from 222.5 m in hole TDH 14. Mineralization is in dolomitic rocks (Dorling, 1996b)
Lockeridge 5 occurrence (*11422*), 2.2 km south of Mount Lockeridge	Intersection of 4 m at 1.08% Zn and 0.25% Pb from 64 m in hole TRC 69. Mineralization is in dolomitic rocks (Feldtmann, 1996; Dorling, 1997b)
Lockeridge 6 occurrence (*11423*), 3.3 km southeast of Mount Lockeridge	Intersection of 4 m at 2.81% Zn and 1.19% Pb from 127 m in hole TRC 70. Mineralization is in dolomitic rocks (Feldtmann, 1996; Dorling, 1997b)
Lockeridge 7 occurrence (*11421*), 3.4 km southeast of Mount Lockeridge	Intersection of 7 m at 1.16% Zn and 1.12% Pb from 60 m in hole TRC 65. Mineralization is in dolomitic rocks (Feldtmann, 1996; Dorling, 1997b)

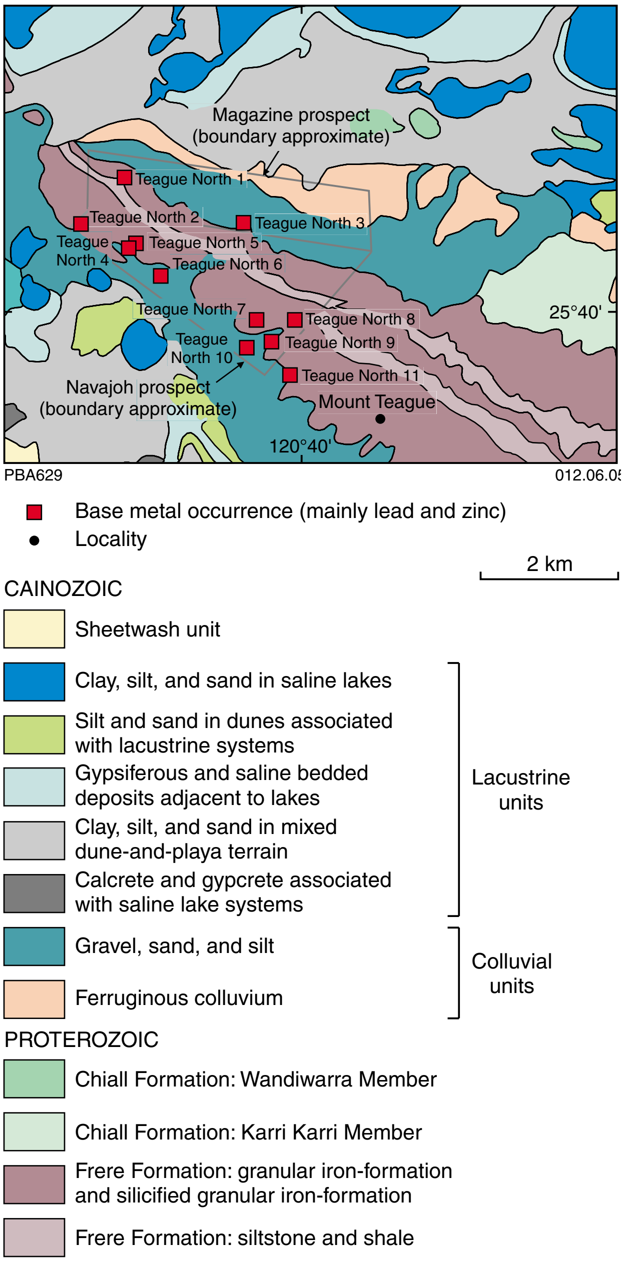

Figure 25. Base metal mineralization at Mount North (geology after Hocking et al., 2003)

of finely laminated hematite and chert. There are a few interbeds of granular iron-formation and more common shale bands within the formation (Broken Hill Proprietary Limited, 1978). The iron formations become more siliceous eastwards, and the top of the Frere Formation on KINGSTON is marked by a distinct chert unit (Hall and Goode, 1978).

There are numerous surface showings of hematite, hematite–goethite, and goethite over the whole strike length of the Frere Formation on NABBERU, and minor quantities on STANLEY, WILUNA, and KINGSTON (Robinson and Gellatly, 1978). Hematite and hematite–goethite exhibit laminated to massive textures and the more massive varieties have a coarse pelletal texture. The hematite–goethite occurrences tend to be preferentially in certain stratigraphic zones, generally overlying shale units. Robinson and Gellatly (1978) recognized eight zones of hematite–goethite in the Frere Formation (Table 11). However, these zones cannot be easily identified in some areas, particularly around Ivan Well and Miss Fairbairn Hills. Most of the hematite–goethite zones are near the top of the Frere Formation, generally as localized lenticular zones of iron enrichment. Detailed traversing along strike shows that high-grade hematite zones may

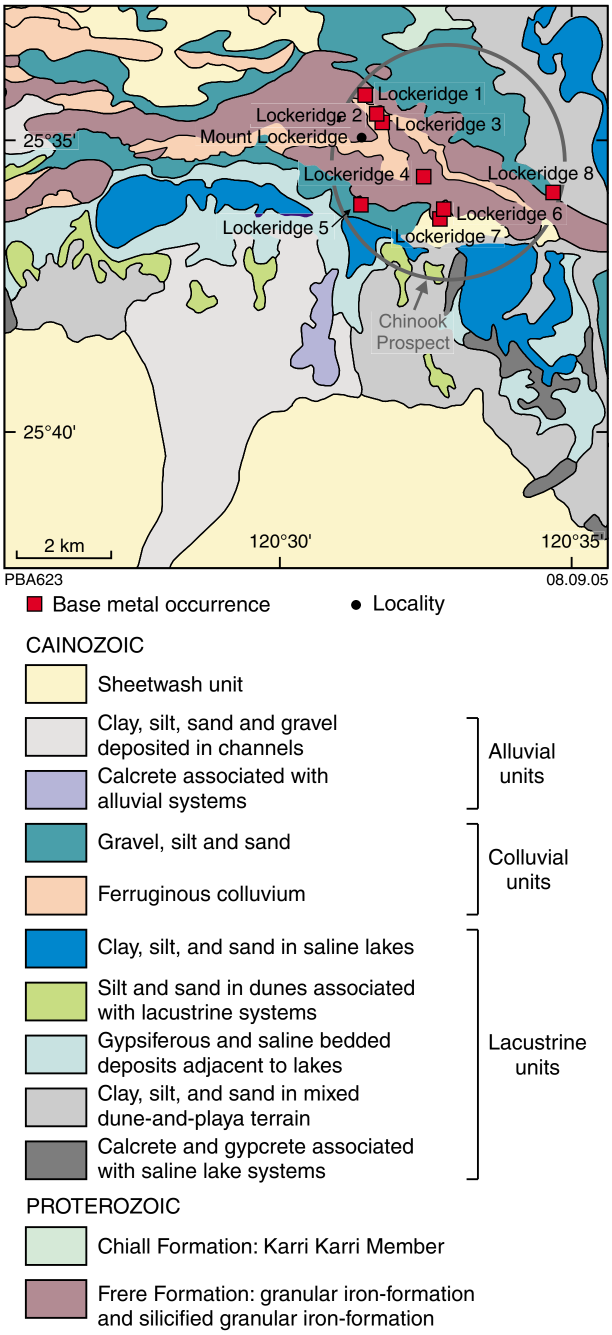

Figure 26. Base metal mineralization near Mount Lockeridge (geology after Hocking et al., 2003)

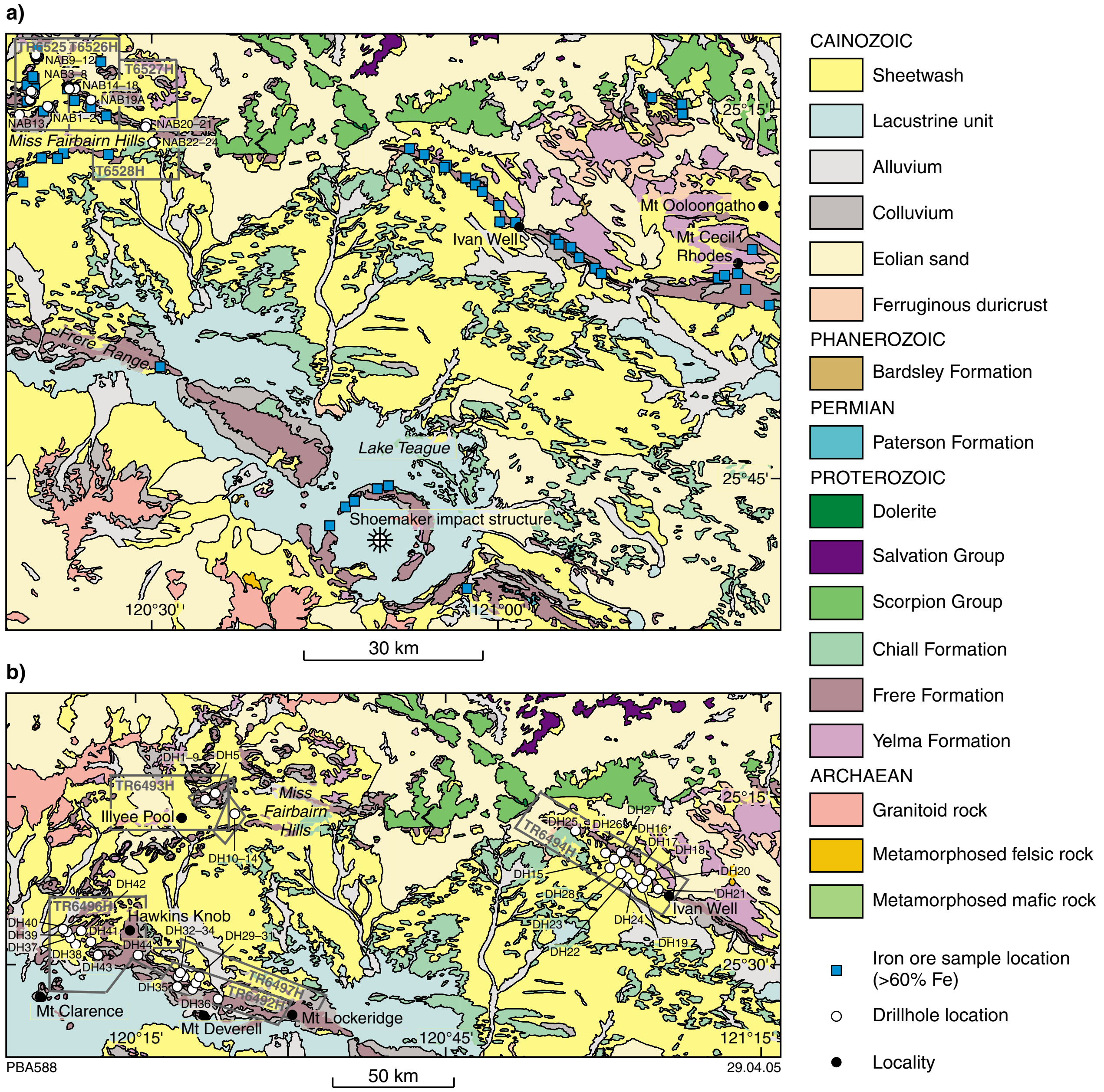

Figure 27. Areas explored for iron by: a) Amax Exploration (Australia); b) Broken Hill Proprietary Limited (geology after Hocking et al., 2003)

be discontinuous and grade laterally into iron-depleted or partially enriched jaspilite and hematite quartz schist. The most persistent of these eight zones is ‘zone 4’, the main pelletal (granular) hematite zone that has been recognized at Frere Range and Ivan Well. This zone can be recognized by both its thick granular character and the presence of a characteristic buff granular chert marker that is commonly 15–50 m above the zone.

Samples with more than 60% Fe are known from Miss Fairbairn Hills, Ivan Well, Frere Range, Mount Cecil Rhodes, Hawkins Knob, and Mount Ooloongathoo (Fig. 27). Summaries of exploration at these areas are given below.

Miss Fairbairn Hills

The Miss Fairbairn Hills area is characterized by northeast-trending line of hills of predominantly layered granular iron-formation of the Frere Formation. Amax Exploration (Australia) assayed 80 surface samples from the Miss Fairbairn Hills area. The iron occurrences at Miss Fairbairn Hills North (Fe) 1–18 (*11818–11820*, *11830–11835*, *11838*, *11839*, *11844*, *11846*, *11847*, *11849*, *11861*, *12916*, *12919*) and Miss Fairbairn Hills South (Fe) 1–6 (*11852*, *11854*, *11855*, *11857*, *11859*, *12923*) had samples assaying more than 60% Fe up to a maximum of 64.10%, averaging 61.50% (Robinson and Gellatly, 1978). The phosphorus content of the 27 samples

Table 11. Hematite–goethite zones of the Frere Formation

Zone	*Description*
1	At the base of Frere Formation. Observed only southeast of Nabberu Dome area. Thickness of 36–96 m estimated. An inferred strike length of 8 km. Averaging 61.2% Fe over 58 m. Average 0.02% P and 0.09% S
2	Above the Canning Gap Shale Member and in the Frere Range. Iron content (up to 56% Fe) does not reach ore grade
3	Near Ivan Well. Thin unit (10–15 m). In excess of 60% Fe and averaging 0.04% P. Pelletal textures present
4	In many areas of NABBERU*; around Ivan Well in northeastern NABBERU, around Canning Gap at the central part, and in Miss Fairbairn Hills area in northwestern NABBERU. Thickness varies from 30 to 60 m. Lacks local continuity, although can be traced intermittently. Main pelletal hematite member and the most prospective hematite zone in the area. Commonly around 60% Fe with averages of 0.04% P and 0.08% S
5	Goethite zone distributed in several widely spread localities on NABBERU including 6 km west of Carnarvon Range, Mount Cecil Rhodes, and near Canning Gap. Also near Windidda on KINGSTON. Around 53–58% Fe and both P and S are variable and commonly >0.2%. This zone is a good stratigraphic marker, but not potential ore
6 and 7	Both have similar characteristics and consist of laminated to massive hematite with possible thin shale intersections. Locally have zones of manganese enrichment and are both underlain and overlain by shale. Thickness up to 80 m, but this may include minor shale partings. Around 0.05 – 0.10% P and S tends to be higher than average
8	Consists of thinly laminated platy hematite intercalated with hematitic shale bands. Thickness around 5–10 m. No commercial significance, but a good stratigraphic marker

NOTE: * Capitalized names refer to 1:250 000 geological maps
SOURCE: Robinson and Gellatly (1978)

ranged from 0.01 to 0.34% (average 0.05%) and the sulfur content ranged from 0.05 to 0.14% (average 0.09%). The majority of the high-assay samples were from the northern areas of Miss Fairbairn Hills.

Drilling by Amax Exploration on Temporary Reserves 6525H–6528H (Fig. 27a) produced best intersections of 14 m at 59.3% Fe (hole NAB2, 12–26 m), 8 m at 53.9% Fe (hole NAB20, 0–8 m), and 8 m at 47.8% Fe (hole NAB19A, 0–8 m; Robinson and Gellatly, 1978). The iron content of drill samples ranged from 22.8 to 60.9% with an average of about 44%. The holes intersected alternating layers of hematite, goethite, and jaspilite with numerous shale bands at various depths. Drilling results showed that there was no consistent correlation between iron content and depth.

Drilling by Broken Hill Pty Ltd on TR6493 (Fig. 27b) in the Miss Fairbairn Hills produced the best intersection of 9 m at 50.3% Fe (with 0.035% P) in granular iron-formation at 14–23 m depth in hole DH5. This hole is close to NAB2 (drilled by AMAX Exploration), which had an intersection of 14 m at 59.3% Fe. The iron content of samples in holes drilled by Broken Hill Pty Ltd ranged from 22.6 to 50.3% with an average of 31.4% (Broken Hill Proprietary Limited, 1978). This average value is significantly lower than that shown by drilling by Amax Exploration in the Miss Fairbairn Hills area.

Ivan Well

The Ivan Well area is characterized by northwesterly trending granular iron-formation of the Frere Formation, which at its western end trends in a west-northwesterly direction (Fig. 27a). Amax Exploration (Australia) assayed 55 surface samples, mainly from the supergene-enriched granular iron-formation (Robinson and Gellatly, 1978). The iron occurrences at Ivan Well North (Fe) 1–10 (*12327–12334*, *12929*, *12931*) and Ivan Well South (Fe) 1–6 (*12335–12337*, *12371*, *12372*, *12935*) had samples assaying more than 60% Fe, ranging from 60.3 to 68.0% Fe, and averaging 62.60% Fe, and an average of 0.16% P (range 0.01 to 2.02%), and 0.07% S (range 0.02 to 0.20%).

Percussion drilling by Broken Hill Pty Ltd on TR6494 (Fig. 27b), 20 km northwest of Ivan Well, gave assays ranging from 15 to 42% Fe, averaging 34.13% Fe. The better intersections were in holes DH26, DH15, and DH21. Hole DH26 drilled on moderately iron enriched granular iron-formation intersected 10 m at 40% Fe from the surface and then from 10 m intersected 8 m at 30.7% Fe. Hole DH15 intersected 4 m at 41.6% Fe from the surface, but the average assay of remainder of the hole to 57 m was only 25.4% Fe. Hole DH21 intersected 7 m at 43% Fe from the surface, but from 7 m remained in shale till its depth of 12 m.

Such depletion of iron with depth was reflected in a number of other holes, and this led Broken Hill Pty Ltd to conclude that enrichment of iron observed at the shallower depths was due to surficial lateritization (Broken Hill Proprietary Limited, 1978).

Frere Range

The area within Frere Range discussed in this section includes the southwesterly trending granular iron-formation of the Frere Formation on Nabberu, extending from around Hawkins Knob through the Frere Range to the Shoemaker impact structure in the southeast (Fig. 27a). Amax Exploration (Australia) assayed 27 surface samples from this area during their 1973–76 program. The iron occurrences at Frere Range (Fe) 1–7 (*12383–12388*, *12941*) assayed more than 60% Fe, ranging from 60.0 to 69.6% Fe, and averaging 62.57% Fe, and an average of 0.03% P (range 0.02 to 0.05%), and 0.18% S (range 0.10 to 0.37%). The highest assay of 69.6% Fe was from sample P32301 about 6.5 km south-southwest of the southern end of the Lake Teague.

Drilling by Broken Hill Pty Ltd did not produce encouraging results. Assays ranged between 15 and 47.2% Fe, averaging 24.9% Fe (Broken Hill Proprietary Limited, 1978). The best intersections were obtained in drillholes DH30 and DH33 (Fig. 27b). Drillhole DH30 intersected supergene-enriched iron-formation to a depth of 16 m averaging 47.2% Fe. Drillhole DH33, drilled on an outcrop of supergene-enriched iron-formation, intersected 7 m at 38.8% Fe from the surface and then 19 m at 41.6% from 7 m.

Hawkins Knob

A sample at Hawkins Knob (Fe) (*12943*) assayed 65.90% Fe and 0.13% P. Seven percussion holes (DH37–43, Fig. 27b) drilled by Broken Hill Pty Ltd on TR 6496 in the Hawkins Knob area had drillchip assays ranging from 10 to 49% Fe with an average of 29.43% Fe (Broken Hill Proprietary Limited, 1978). Four holes (DH37–40) were drilled along an approximate north-northwest line, at right angles to the regional trend of the granular iron-formation, to test patchy surface enrichments. However, no significant iron mineralization was intersected except for 9 m at 45% Fe from the surface in hole DH38, and the highest assay of 3 m at 49% Fe in hole DH39 from 11 m. The remaining three holes also were drilled at right angles to the regional trend of the granular iron-formation, to test patchy surface enrichments. However, there were no significant intersections, the best being 3 m at 34% Fe from the surface in hole DH43.

Mount Cecil Rhodes

Granular iron-formation collected by Amax Exploration at Mount Cecil Rhodes (Fe) 1, 3, and 5 (*12374*, *12373*, *12375*) assayed more than 60% Fe. The surface samples were from an area 2–8 km south of Mount Cecil Rhodes, and assays ranged from 61.20 to 63.90% Fe, averaging 62.77% Fe. The phosphorus and sulfur contents of these samples averaged 0.05% P (range 0.03 to 0.08%) and 0.06% S (range 0.04 to 0.10%) respectively.

More recently, Pirajno et al. (2000) identified two occurrences of iron in granular iron-formation and laminar granular iron-formation at Mount Cecil Rhodes (Fe) 2 (*11777*) and Mount Cecil Rhodes (Fe) 4 (*11776*), 5.5 km south and 7 km south-southwest of Mount Cecil Rhodes respectively. Jones and Pirajno (2000) also identified an occurrence of iron in laminar granular iron-formation at Mount Cecil Rhodes (Fe) 6 (*11778*), 11.6 km south-southeast of Mount Cecil Rhodes.

Mount Ooloongathoo

At Mount Ooloongathoo (*12980*; Fig. 27a), a surface sample collected by Amax Exploration assayed 60.4% Fe, 0.06% P, and 0.08% S.

Regolith mineralization

Precious mineral — diamond

Jewill

Two macrodiamonds and 2 microdiamonds were found by CRA Exploration Pty Ltd in loam samples at Jewill 1 (*10787*; Fig. 13; Aravanis and May, 1988). In addition, numerous samples returned chromite grains with kimberlitic affinities, and many octahedral leucoxene pseudomorphs and picroilmenite. Further loam sampling at this location returned 33 chromite grains and 9 microdiamonds (May and Aravanis, 1988a).

Hawkins Knob North

Stockdale Prospecting discovered a microdiamond (0.011 carat) from a loam sample at Hawkins Knob North (*10731*; Fig. 11), 8 km north-northeast of Hawkins Knob. This sample is from an area covered with sheetwash material such as silt and sand deposited on low-gradient slopes with no clear channelized pattern. Other samples from the area yielded possible kimberlitic spinels and also pyrope garnet as indicator minerals (Campbell, 1993; Mitchell, 1995a,b). Areas of both microdiamond and pyrope samples were followed up by further sampling, but failed to recover any other diamonds or microdiamonds except for a few chrome spinels.

McConkey Hill

Loam samples collected by CRA Exploration Pty Ltd from McConkey Hill 1 (*10697*, 6.5 km north of McConkey Hill), McConkey Hill 2 (*10698*, 7 km north of McConkey Hill), and McConkey Hill 3 (*10696*, 9 km northwest of McConkey Hill), returned macrodiamonds, each of +4 mm size (Fig. 28). These and other loam samples also returned a large number of chromite grains (Young, 1987).

Nuneri Pool

CRA Exploration Pty Ltd discovered one microdiamond from a loam sample at Nuneri Pool (*10801*; Fig. 13). Thirty-eight samples from the area also returned 362 chromite, and 9 picroilmenite grains. However, none of these samples appear to have derived from a primary diamondiferous source, and drilling at some of these anomalies did not indicate any kimberlitic or lamproitic bodies (May and Aravanis, 1988a,b).

Steel industry metal — manganese

Yunga Pool

At Yunga Pool (Mn) 1–2 (*11672–11673*), 8–13 km southwest of Yunga Pool (Fig. 29), manganese forms

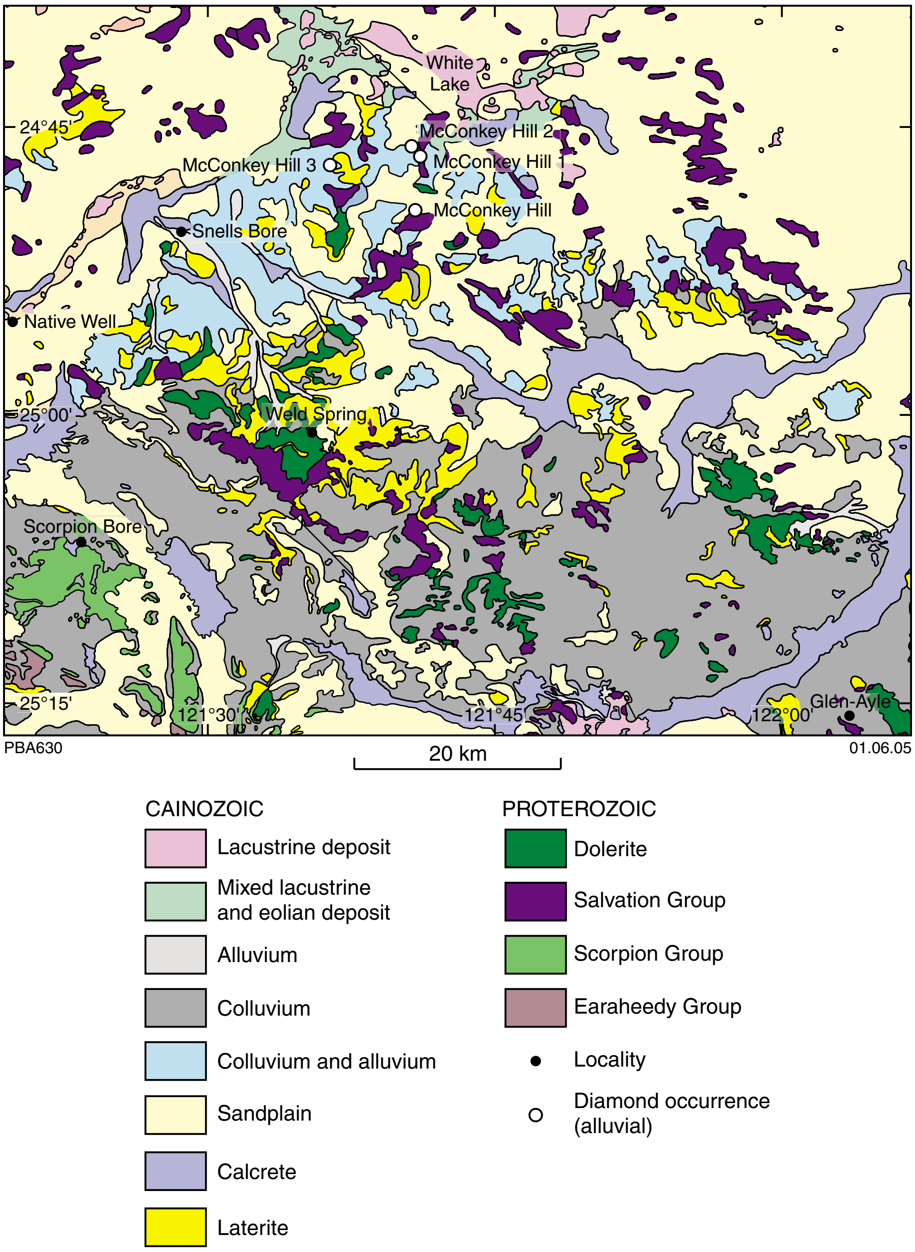

Figure 28. Alluvial diamond occurrences around McConkey Hill (geology after Williams et al., 1981, 1995a,b; Hocking et al., 2003)

thin beds in regolith associated with the sandstones and siltstones of the Wongawol Formation (Pirajno and Adamides, 2000; Adamides et al., 2000b; Hocking et al., 2001a; Morris et al., 2003). The mineralization occurs as 5–30 cm-thick beds, hosted in weakly feldspathic quartz sandstone containing clastic white mica, glauconite, and accessory amounts of zircon and tourmaline. The local association of these beds with jasper suggests that mineralization may represent chemical sediments.

Skull Soak

At Skull Soak (Mn) 1–2 (*11694–11695*), 3.8 km south-southwest and 8.7 km south-southeast of Skull Soak respectively (Fig. 30), manganese mineralization is in shale, mudstone, and siltstone of the Chiall Formation of the Miningarra Subgroup (Jones, 2002a). The manganese mineralization in these localities is presumably related to enrichment due to Cainozoic weathering.

Little Banjo Bore

At Little Banjo Bore (*11693*) manganese is associated with siltstone, shale, and minor iron formation in the Frere Formation of the Tooloo Subgroup. The mineralization may be due to enrichment caused by Cainozoic weathering.

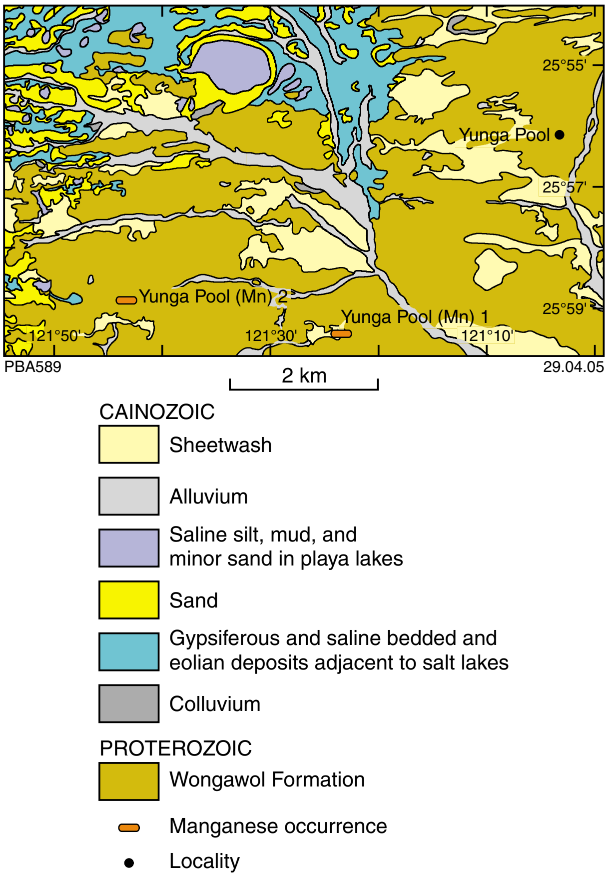

Figure 29. Manganese occurrences around Yunga Pool (geology after Adamides et al., 2000b)

Energy mineral — uranium

Fyfe Well

Esso Australia Ltd discovered carnotite at Fyfe Well 1 and 2 (*10854*, *11685*), 6 – 7.5 km west of Fyfe Well (Fig. 31; Lindeman, 1972). The carnotite at Fyfe Well 1 was found in a 1 m deep trench that exposes three lenses of carnotite-encrusted calcrete, each no more than a metre thick. At Fyfe Well 2 carnotite was in a nearby calcrete outcrop.

Drilling by Esso (to depths between 5 and 35 m) obtained intersections ranging from 50 to 850 ppm U_3O_8 (averaging about 122 ppm). Carnotite is the only uranium mineral found in the area explored (Lindeman, 1972). Uranerz Australia Pty Ltd obtained intersections of 1 m at 220 ppm U_3O_8 in calcareous clayey sand and 4 m at 192.5 ppm U_3O_8 in calcrete at Bridle Face Outcamp (Fig. 32; Table 2). Uranium exploration at Mount Davis (Fig. 33) and the Malmac Inlier (Fig. 34) was not encouraging (Table 2).

Bunting (1986) suggested, based on the Cainozoic drainage patterns, that the immediate source of the uranium may have been sedimentary rocks of the Earaheedy Group rather than the granitic rocks of the Archaean basement.

Industrial minerals

Gypsum

Playa lakes on Bullen and Nabberu (Fig. 35) contain gypsum occurrences at Ten Mile Lake (*3801*), Terminal Lake North (*3802*), Terminal Lake West (*11644*), Lake Wilderness (*3863*), and Lake Nabberu (*3860*).

Gypsum at Terminal Lake North and West forms a layer under a salt crust and islands in the lake. At Terminal Lake North, gypsum forms dunes and benches up to 8 m thick along the lake margin. Evaporation has produced 0.3 m of unusual ‘flower gypsum’. Chemical analysis of a random sample of hardened crust from Terminal Lake North gave 94.2% gypsum and 0.3% calcite, and granular material gave 93.3% gypsum and 0.2% calcite (Leech and Brakel, 1980; Jones, 1994; Williams et al., 1995b).

At Ten Mile Lake, gypsum forms a layer under salt crust and islands in the lake. It also forms dunes and benches up to 5 m thick along the lake shore. As at Terminal Lake, evaporation has produced 0.3 m of unusual ‘flower gypsum’ (Leech and Brakel, 1980; Jones, 1994).

At Lake Nabberu, kopi gypsum occurs in the lake and forms gypcrete in the dunes (Chivas et al., 1991; Jones, 1994). At Lake Wilderness, gypsum occurs in playa lakes (Leech and Brakel, 1980; Jones, 1994; Williams et al., 1995b).

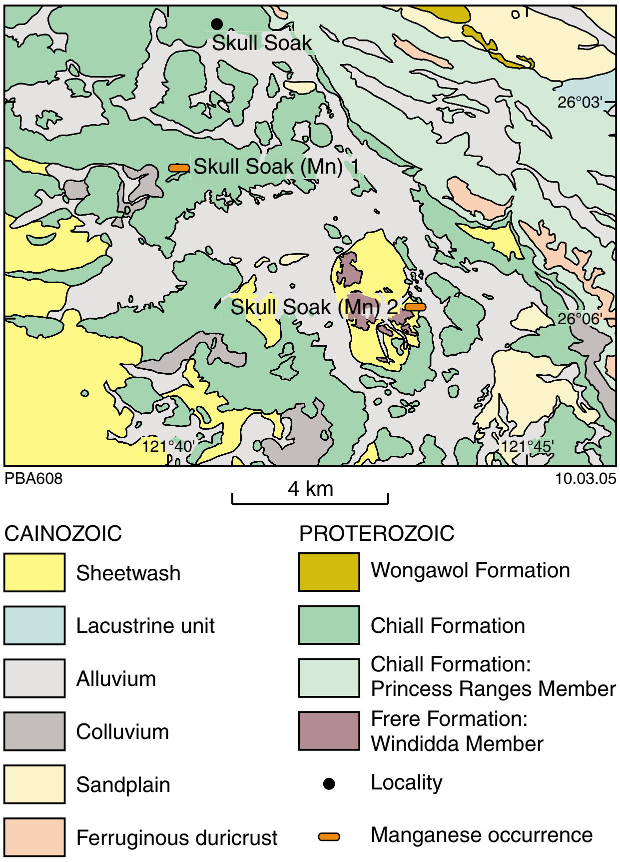

Figure 30. Manganese occurrences around Skull Soak (geology after Jones, 2002a)

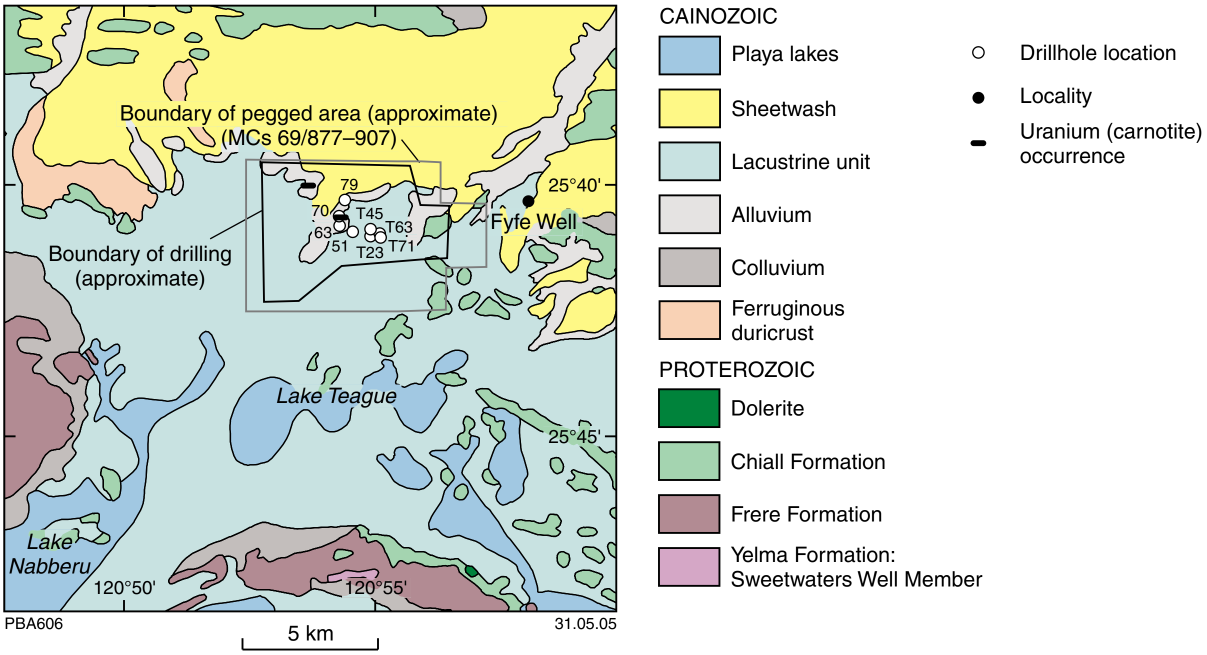

Figure 31. Uranium mineralized areas west of Fyfe Well (geology after Hocking et al., 2003)

Salt

Salt (halite) is in playa lakes at Yanneri Lake (*11645*) and Yanneri Lake North (*11646*; Fig. 35) on BULLEN, and at White Lake (*11640*) on TRAINOR (Williams et al., 1995b). Halite is also in the Neoproterozoic Mundadjini Formation of the Sunbeam Group at Mystery Hill 1 (*11641*) and Mystery Hill 2 (*11643*), 7.3 km south and 9 km southwest of Mystery Hill respectively.

The presence of halite, gypsum, and barite in this formation elsewhere enhances the possibility of finding larger evaporite deposits (Williams et al., 1995b).

Mineralization — undivided

Construction material — building stones

Flagstones and slabs for local use have been produced from a small shale quarry at Mount Paterson (*11653*; Fig. 32) on NABBERU. Bunting et al. (1982) noted that fissile shale from the Palaeoproterozoic Yelma Formation had potential to produce slabs up to 1 m across and 20 to 30 mm thick.

Mineralization controls and exploration potential

The Earaheedy area is prospective for gold, base metals, iron, diamond, uranium, manganese, silver, barite, gypsum, and salt occurring in various mineralization styles. Interpreted prospective areas are shown in Figure 36.

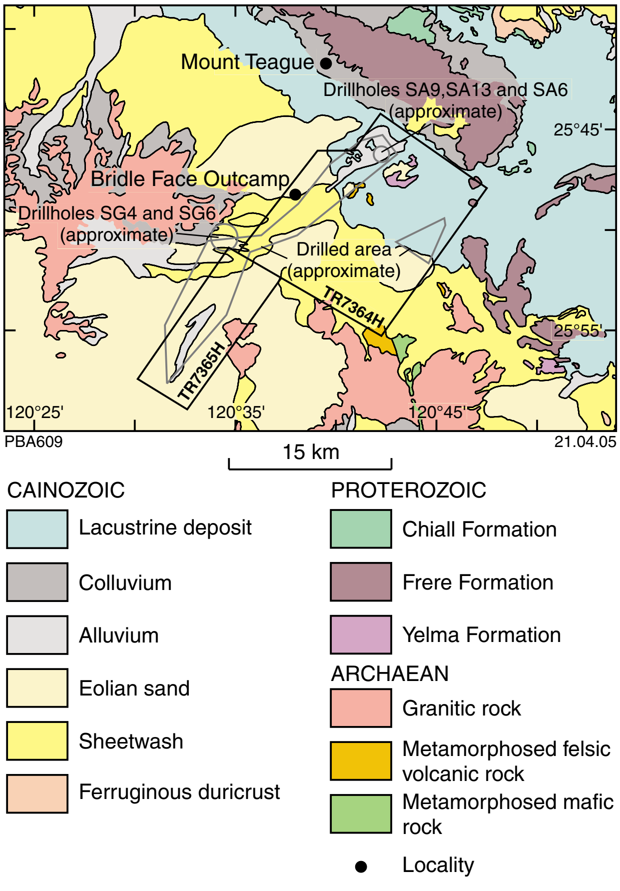

Figure 32. Areas explored for uranium around Bridle Face Outcamp (geology after Hocking et al., 2003)

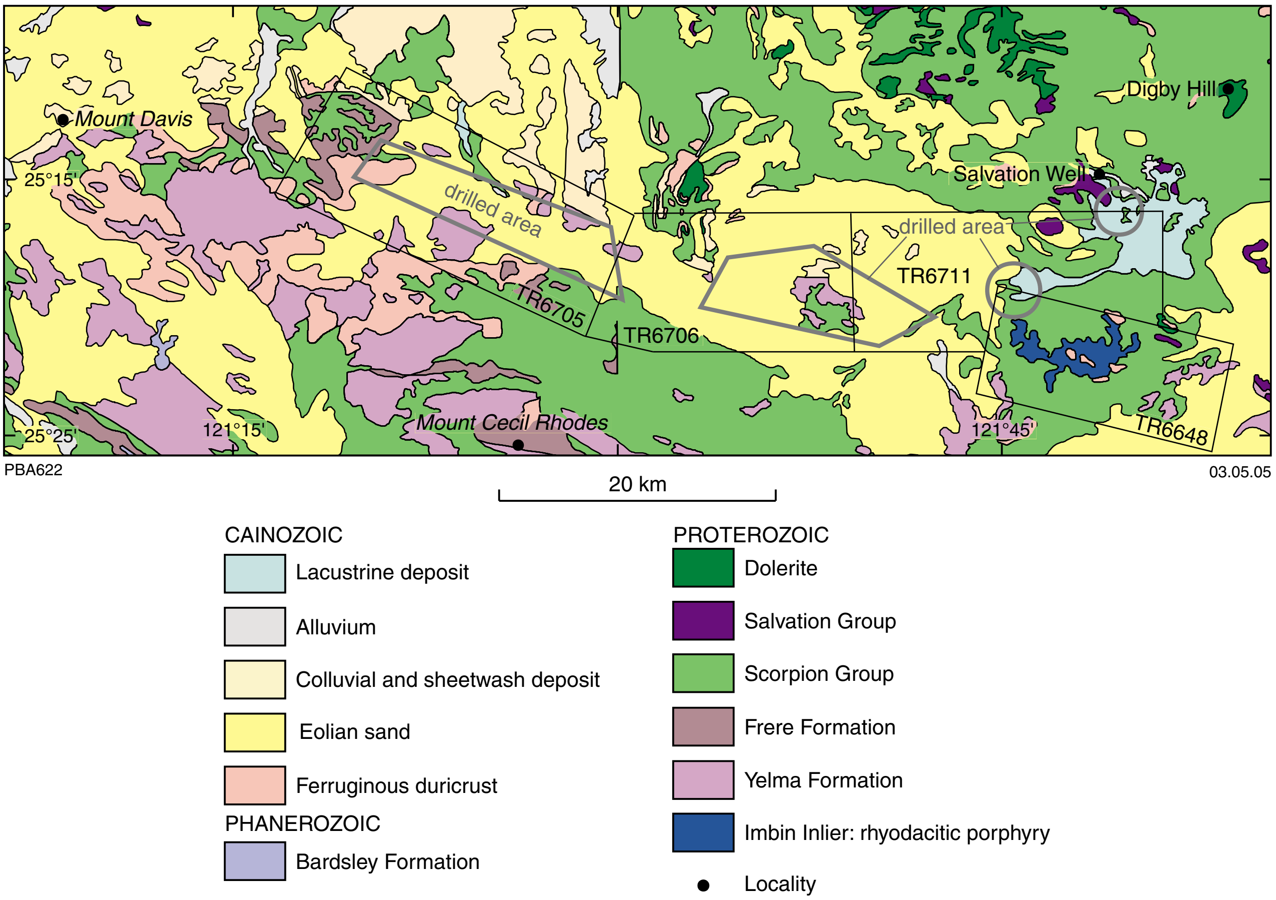

Figure 33. Geology around Temporary Reserves 6705H, 6706H, 6711H and 6648H east of Mount Davis (geology after Williams et al., 1981; Hocking et al., 2003)

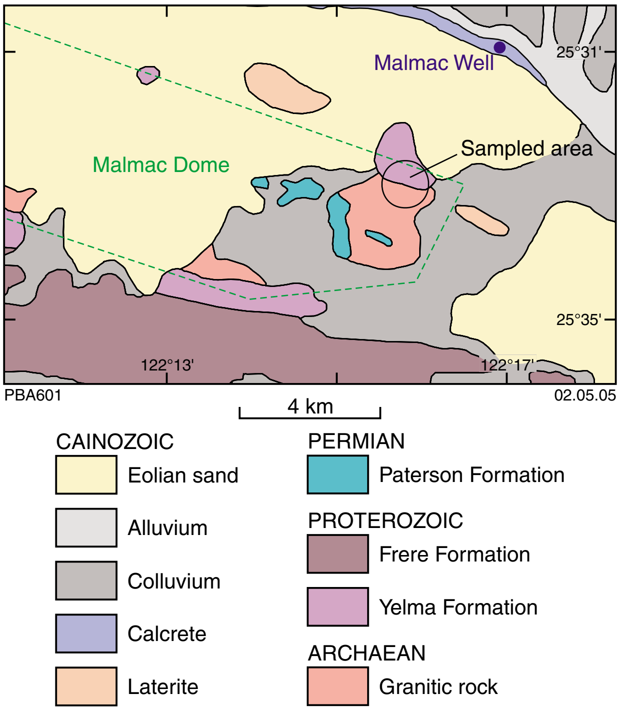

Figure 34. Geology within Temporary Reserve 6379H around the Malmac Inlier (geology after Williams et al., 1981)

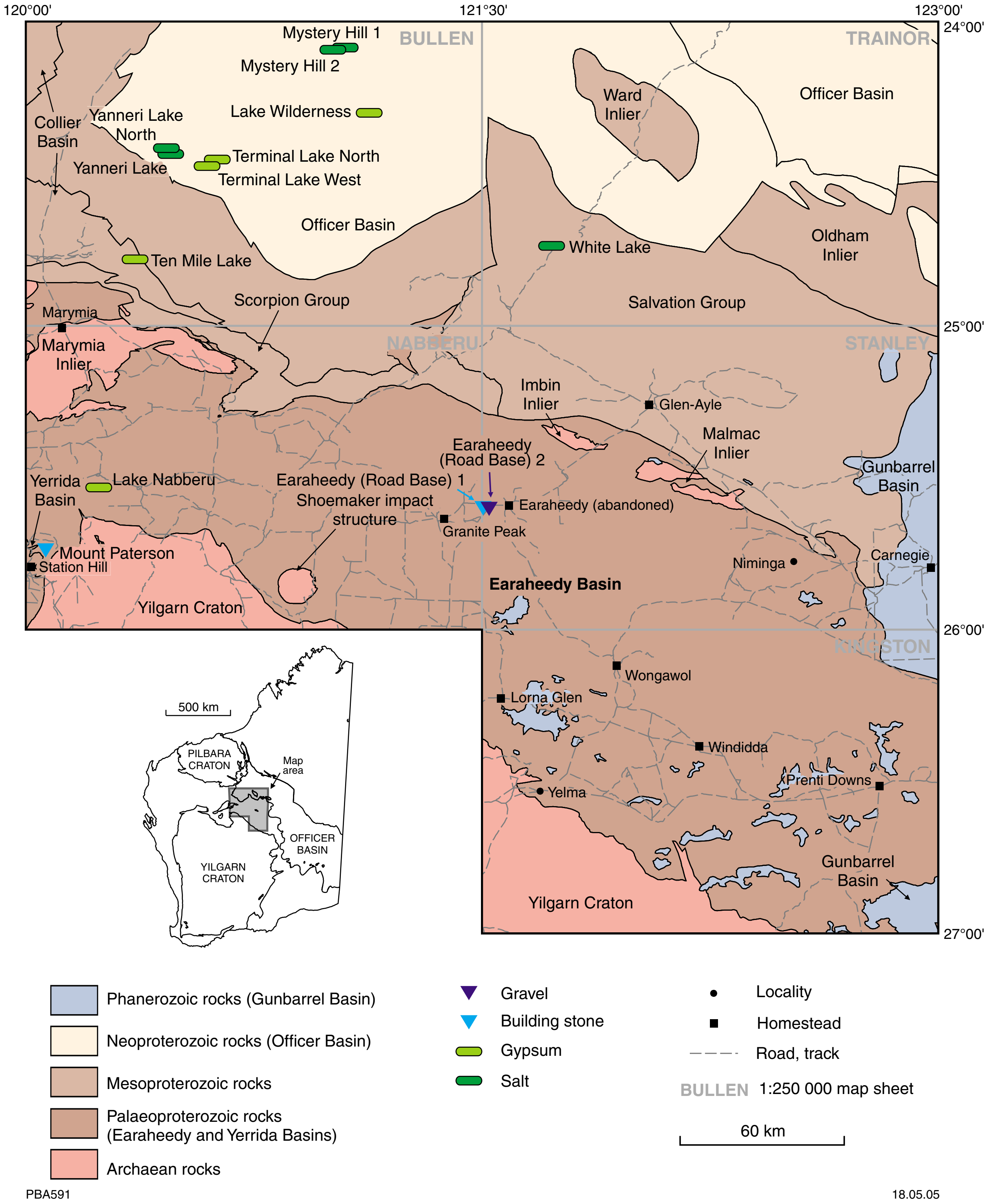

Figure 35. Gypsum, salt, and construction material occurrences in the Earaheedy project area

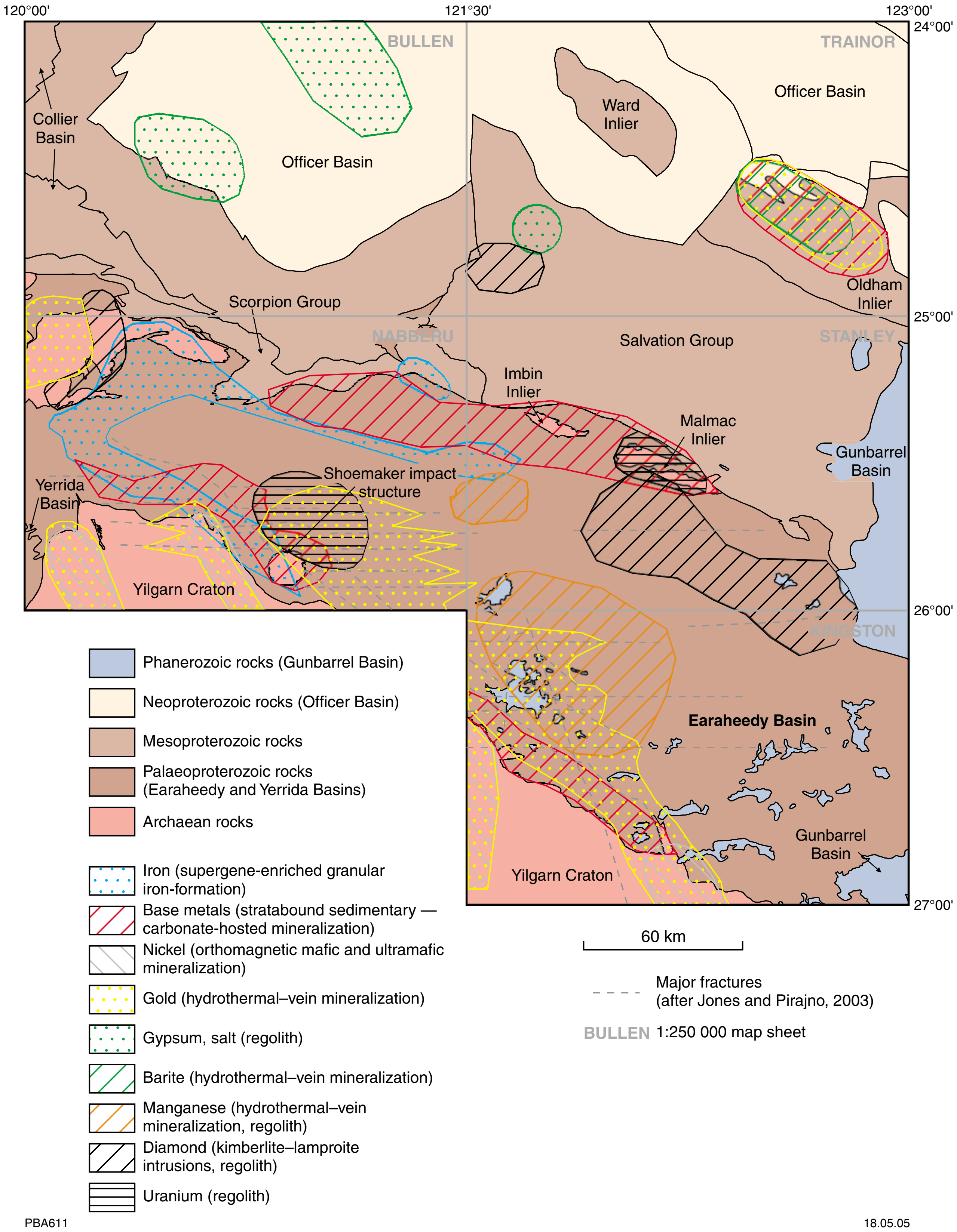

Figure 36. Areas prospective for mineral commodities in the Earaheedy area

Kimberlite and lamproite mineralization

Diamond

The boundary between the Archaean Marymia Inlier and the Earaheedy Basin is known to be prospective for diamond mineralization, as at Miss Fairbairn Hills and Methwin (Figs 11 and 12).

Another prospective area could be the boundary zone between the Archaean Malmac Inlier and the Earaheedy Basin around Lee Steere Range in the central parts of STANLEY. The diamond occurrences at the Jewill prospect (Fig. 13) are broadly within this boundary zone that is about 20 km south of the Malmac Inlier within the Earaheedy Basin.

Because surface exposures of kimberlite and lamproite intrusions are unknown in the study area, the most effective tools for diamond exploration are magnetic geophysical surveys and surface sampling. Magnetic anomalies from geophysical data and circular features from Landsat images are potential targets for possible diamondiferous kimberlite and lamproite intrusions.

Orthomagmatic mafic and ultramafic mineralization

Nickel, copper, and PGE

As stated under **Mineralization**, recent exploration activities in the Gerry Well greenstone belt, west of Collurabbie Hills on KINGSTON, has suggested the presence of a new nickel province with nickel sulfide and PGE mineralization associated with ultramafic rocks. Other greenstone belts such as those near Mount Eureka, Horse Well, and Cunyu in the Earaheedy study area may also have potential for nickel sulfide and PGE mineralization.

Vein and hydrothermal mineralization

Gold

The most prospective areas for gold mineralization are the greenstone belts in the Yilgarn Craton, south of the Earaheedy Basin. These include greenstone belts at Mount Eureka (Fig. 17), Merrie, Cunyu (Fig. 16), Horse Well (Fig. 3), Marymia Inlier, and south-southeast of Old Windidda Homestead (Fig. 15). Although Archaean rocks in these greenstone belts are not well exposed, exploration drilling has revealed a large area of Archaean rocks in the subsurface that may be prospective.

The deformed rocks in the Stanley Fold Belt at the northern margin of the Earaheedy Basin may also be prospective for vein and hydrothermal mineralization, as in the Troy Creek area on northwest NABBERU.

Jones and Pirajno (2003) highlighted east–west structures, extending from the Earaheedy Basin into the Yilgarn Craton, that may have facilitated the interaction of hydrothermal fluids with gold-bearing greenstone rocks in the Yilgarn Craton to cause a redistribution of gold along these structures. According to these authors, further greenfields exploration is warranted in the Earaheedy Basin and to test the mineralizing potential of younger structural events.

Copper and zinc

Base metals are known in Palaeoproterozoic carbonate rocks such as the Sweetwaters Well Member, and in other stromatolitic carbonate rocks of the Yelma Formation in the Earaheedy Basin. These base metals can be reactivated, remobilized, and deposited due to hydrothermal activity triggered by deformation. Significant copper and zinc mineralization of vein and hydrothermal type in the Stanley Fold Belt are already known in the Miss Fairbairn Hills and Troy Creek areas of NABBERU, and other prospective areas are likely to be present along this fold belt, extending to the Malmac Inlier on STANLEY and towards Beyondie and farther northeast on BULLEN.

The Quadrio Lake area (Fig. 22), in the Mesoproterozoic Oldham Inlier, is prospective for base metal mineralization, and the Quadrio Formation is known to carry gold-bearing barite–hematite mineralization. Hocking et al. (2000c) suggested that the tectonic setting of Quadrio Lake (an intracontinental basin) is conducive to sedimentary exhalative (SEDEX)-type mineralization. In models of SEDEX deposits, the mineralization can extend for hundreds of metres to kilometres from feeder channels (Fig. 37). The model envisages three main facies comprising a vent complex, proximal stratabound sulfide ore, and distal stratabound sulfate and oxide ore. A halo of hydrothermal alteration surrounds the feeder channel. The presence of anomalous gold, arsenic, and antimony in barite suggests that hydrothermal fluids carried these in solution and precipitated in sites distal to the venting structures (Hocking et al., 2000c).

Another area that may be prospective for base metals is the Shoemaker impact structure on southern NABBERU (Fig. 8). There is also evidence of hydrothermal activity in the rocks of the impact aureole. Outcrops of Teague Granite in the east and southeast indicate fracture-controlled sericitic alteration and are partially or totally silicified. A number of northeasterly trending, milky-white quartz veins (associated with northeasterly and north-northeasterly trending fractures in hornblende–quartz–monzonite) in the southwest of the impact structure indicate hydrothermal activity in the area. The chert pods along the eastern margin of the central uplift may have formed by precipitation from hydrothermal fluids that circulated along lithological boundaries or along faults in the eastern sector of the Shoemaker impact structure (Pirajno, 2002).

Uranium

The areas adjoining or within unconformities between Archaean and Proterozoic rocks may be prospective for uranium mineralization, in particular, areas of

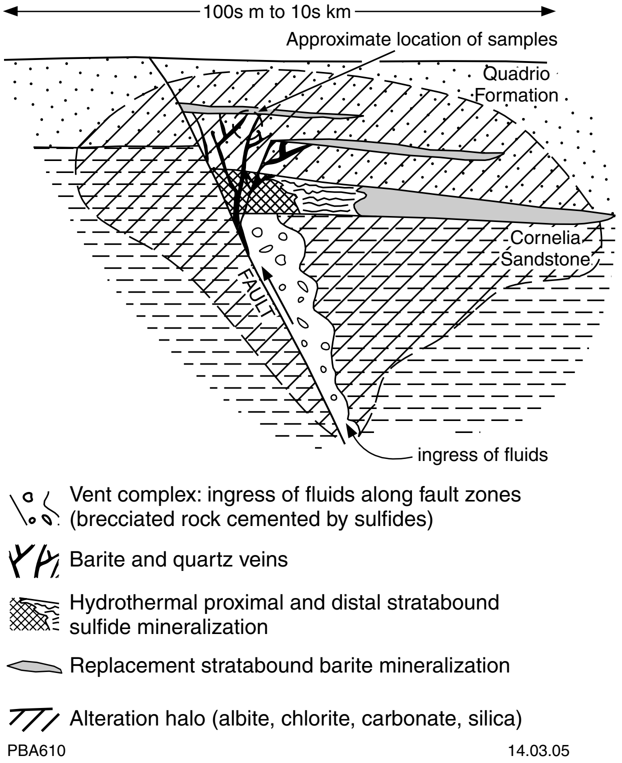

Figure 37. Ore deposit model, showing vent, replacement-style proximal sulfide, and distal oxide–sulfate facies (geology after Hocking et al., 2003)

conglomeratic rocks associated with veins of jasperoidal chert and quartz that may have formed from hydrothermal fluids that were channelled along the contact between the Marymia Inlier and the Yelma Formation, northwest of Grasscutter Well on Nabberu. Other similar prospective environments include those around Malmac Inlier near the northern boundary of the Earaheedy Basin. Although some exploration for uranium has already been carried out in these areas (discussed in **Mineralization**), more exploration using modern geophysical and remote sensing techniques may provide a better assessment of uranium in the area.

Barite

Barite–hematite veins in the Mesoproterozoic Quadrio Formation near Quadrio Lake suggest that this formation is an important target for barite. The Quadrio Formation is in the northern parts of the Oldham and Ward Inliers on Trainor.

Stratabound sedimentary — carbonate-hosted mineralization

Lead, zinc, and copper

Although known occurrences of stratabound sedimentary — carbonate-hosted base metal mineralization in the study area are restricted to stromatolitic carbonate rocks in the Sweetwaters Well Member of the upper parts of the Yelma Formation on southwestern Nabberu, there is potential for such mineralization in the same unit on Stanley and Kingston. For example, the Yelma Formation may be prospective for base metal mineralization about 20 km north and east of Mount Eureka on Kingston and at the unconformity with the Malmac Inlier in the Lee Steere Range on Stanley.

Pirajno and Adamides (2000) suggested that the association of glauconite-rich beds and stratiform iron–manganese oxides in the Earaheedy Basin is typical of continental shelf environments, and therefore stratabound sulfide deposits may be present as lateral facies equivalents of glauconite-bearing sandstones and the iron and manganese oxides. Pirajno (2004) stated that along the southern margin of the Earaheedy Basin, there is pervasive stratabound silicification, dolomitization, and stilpnomelane alteration of the iron formation beds. The same alteration is noted along crosscutting easterly trending structures of the Earaheedy Basin. Based on these observations, Pirajno (2004) suggested that the potential for stratabound base metal mineralization in the Earaheedy Basin is greatly enhanced.

Sedimentary — granular iron-formation mineralization

Iron

Broken Hill Proprietary Limited (1978) concluded that both the Hamersley and Earaheedy Basins show similarities in style and chemistry of sedimentation, but no structural traps have been found in the Earaheedy Basin that are similar to those in the Hamersley Basin and could act as favourable sites for hematite mineralization. Broken Hill Pty Ltd also noted that there was a strong magnetic response over granular iron-formation, indicating that the unit contains considerable amounts of magnetite. The supergene-enriched granular iron-formation shows a generally weaker aeromagnetic response, particularly in northern areas of the Earaheedy Basin (Broken Hill Proprietary Limited, 1978).

A comparison between drilling assay data and outcrop assay data from different localities on Nabberu indicates that the highest iron assays are from surface samples (many assaying >60% Fe); these samples are from supergene-enriched regolith material. Although the grade of iron of the fresh or unaltered granular iron-formation in the Frere Formation is generally less than 30%, Pirajno and Adamides (2000) suggested that further oxidation or hydrothermal activity along faults could also enhance the iron content of the granular iron-formation to values up to 60% Fe. The higher assays for iron in regolith over the iron formations in many areas of Nabberu suggest that further exploration is needed before discarding the area as uneconomic. Although the available drilling information suggests that granular iron-formation is of too low a grade to be of economic interest, the extent of drilling was limited and would appear to be insufficient to rule out any positive conclusions. Pirajno and Adamides (2000) suggested that the economic potential of the Frere

Formation is likely to be highest in the Stanley Fold Belt, which forms the northern limb of an asymmetric regional syncline in the Earaheedy Basin.

Regolith mineralization

Diamond

Alluvial diamond deposits may be present in palaeochannels that have drained basement Archaean and Proterozoic rocks in the Yilgarn Craton and Earaheedy Basin, where kimberlitic and lamproitic bodies are known. Such palaeochannels could be present in the tectonic units adjoining the Yilgarn Craton and Earaheedy Basin. Other prospective areas for eluvial diamonds include regolith material along the boundary zones that have been tectonically active between the Yilgarn Craton and the Earaheedy Basin.

Manganese

Although economic deposits of manganese are yet to be found in the study area, various occurrences of manganese are known in the Wongawol, Chiall, and Frere Formations on WONGAWOL and EARAHEEDY in the central part of the Earaheedy Basin (Figs 18, 19, 29, and 30). Anomalous manganese concentrations in the regolith cover the above formations towards the eastern end of the Earaheedy Basin (Morris et al., 2003). The association of manganese-rich beds with jasper in the Wongawol Formation suggests that the mineralization represents chemical sedimentation, whereas manganese concentrations in the Chiall and Frere Formations appear to be a result of enrichment due to Cainozoic weathering. On this basis, the Wongawol, Chiall, and Frere Formations on KINGSTON and STANLEY are targets for further manganese exploration.

Uranium

The calcrete and palaeochannels associated with or adjoining the Shoemaker impact structure remain prospective for uranium mineralization. Exploration has identified carnotite mineralization west of Fyfe Well (Fig. 31), and anomalous uranium at the Shoemaker impact structure. The source of carnotite in the calcrete material is yet to be established, although Bunting (1986), based on the Cainozoic drainage patterns, suggested that the immediate source of the uranium may have been sedimentary rocks of the Earaheedy Group. Application of the latest remote sensing and geophysical techniques would provide a better understanding of the palaeodrainage patterns that could be used to target further areas for uranium exploration.

Gypsum and salt

Gypsum and salt occurrences are known in numerous playa lake systems on NABBERU, BULLEN, and TRAINOR. Similar gypsum occurrences are likely to be present in other playa lake systems on STANLEY and KINGSTON.

Conclusions

The Earaheedy area is prospective for gold, base metals, iron, diamond, uranium, manganese, silver, barite, gypsum, and salt occurring in various mineralization styles. Interpreted prospective areas are shown in Figure 33.

In the Yilgarn Craton gold mineralization is mostly in the Archaean greenstone belts, with the most prospective areas south of the Earaheedy Basin. The east–west structures that extend from the Earaheedy Basin into the Yilgarn Craton may have facilitated redistribution of gold from gold-bearing greenstone rocks, and therefore such east-west structures and other associated structural and geological traps in the Earaheedy Basin are potential targets for gold.

Prospective areas for nickel and PGE mineralization are the Gerry Well, Mount Eureka, Horse Well, and Cunyu greenstone belts.

Base metal mineralization of Mississippi Valley-type is in the stromatolitic carbonate rocks in the Sweetwaters Well Member of the Yelma Formation in the Sweetwaters Well, Mount Teauge, and Mount Lockeridge areas. Other areas of this unit remain prospective for this style of mineralization.

The highest potential for iron in the Frere Formation is likely to be in the Stanley Fold Belt.

Diamonds are in kimberlitic intrusions west of Miss Fairbairn Hills, Methwin, and Jewill, and in regolith material covering rocks of the Earaheedy and Officer Basins. The most prospective areas for diamond in kimberlite and lamproite intrusions may be the boundary zones between Archaean basement rocks and the Palaeoproterozoic rocks. The regolith associated with palaeochannels containing material derived from basement Archaean and Proterozoic rocks in the Yilgarn Craton and Earaheedy Basin respectively could also be prospective for alluvial diamond concentrations.

Calcrete areas and palaeochannels associated with or adjoining the Shoemaker impact structure are prospective for uranium mineralization.

The Wongawol, Chiall, and Frere Formations on KINGSTON and STANLEY are prospective for manganese mineralization.

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Appendix 1

List of mineral occurrences in the Earaheedy area

KEY TO OPERATING STATUS

Italic numbers	Mineral occurrence or prospect
Plain numbers	Mineral deposit
Bold and italic numbers	Abandoned pit

KEY TO COMMODITY CODES

Ag	Silver	Gp	Gypsum	PGE	Platinum group elements
Au	Gold	Gvl	Gravel	Salt	Salt
Brt	Barite	Mn	Manganese	Sh	Shale
Cu	Copper	Ni	Nickel	U	Uranium
Dmd	Diamond	Pb	Lead	Zn	Zinc
Fe	Iron				

KEY TO LOCATIONS

EAST	MGA Easting
NORTH	MGA Northing

PRECIOUS MINERAL

☆ **Kimberlite and lamproite intrusions**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
10784	Dmd	408650	7155600	Jewill 3
10786	Dmd	410088	7155580	Jewill 2
10787	Dmd	408213	7155975	Jewill 1
10915	Dmd	213403	7209763	Miss Fairbairn Hills (Dmd) 1
10921	Dmd	227037	7220430	Miss Fairbairn Hills (Dmd) 3
10923	Dmd	221737	7216390	Miss Fairbairn Hills (Dmd) 2
11326	Dmd	220687	7232610	Methwin
11333	Dmd	469445	7125984	Mount Throssell

⬭ **Regolith — residual to eluvial placers**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
10696	Dmd	359337	7258161	McConkey Hill 3
10697	Dmd	366937	7259461	McConkey Hill 1
10698	Dmd	366537	7259861	McConkey Hill 2
10731	Dmd	224299	7189987	Hawkins Knob North
10801	Dmd	414363	7142485	Nuneri Pool
11331	Dmd	203700	7232960	Two Pools

PRECIOUS METAL

◆ **Vein and hydrothermal — undivided**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
10807	Au	320422	7188820	Troy Creek 4
11365	Au	216549	7142298	Cunyu Woolshed 1
11368	Au	214588	7146023	Cunyu Woolshed 3
11439	Au	353966	7060525	Mount Eureka 3
11441	Au	356208	7061090	Mount Eureka 7
11442	Au	350908	7076564	Rubys Find
11443	Au	354908	7061120	Mount Eureka 5
11444	Au	352808	7040235	Irwin Bore 1
11445	Au	353508	7040300	Irwin Bore 2
11465	Au	353938	7061360	Mount Eureka 1
11466	Au	353138	7060560	Mount Eureka 2
11478	Au	416357	7041310	Windidda South (Au) 1
11623	Au	416087	7041610	Windidda South (Au) 2
11624	Au	420157	7033960	Windidda South (Au) 3
11631	Au	422137	7031760	Windidda South (Au) 4
11632	Au	423227	7031260	Windidda South (Au) 5
11633	Au	354012	7060047	Mount Eureka 6
11637	Au	354515	7060822	Mount Eureka 4
11688	Au	264637	7143560	Crack O’Dawn 1 (Au)
11689	Au	263637	7144260	Crack O’Dawn 2 (Au)
11690	Au	271470	7130781	Horse Well 1 (Au)
11691	Au	270737	7130160	Horse Well 3 (Au)
11692	Au	271637	7129460	Horse Well 2 (Au)
11699	Au	351552	7050350	Mount Eureka South
12411	Au Zn	319147	7191697	Troy Creek 1
12648	Au	319637	7191347	Troy Creek 2

PRECIOUS METAL

◆ **Vein and hydrothermal — undivided**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
12837	Au	216731	7142706	Cunyu Woolshed 2
15389	Au	354297	7056488	Southern Mount Eureka 2
15390	Au	354343	7056492	Southern Mount Eureka 1
15391	Au	354236	7056531	Southern Mount Eureka 3
15392	Au	353950	7055850	Southern Mount Eureka 4
15393	Au	354245	7056484	Southern Mount Eureka 5
15394	Au	354134	7056488	Southern Mount Eureka 6
15395	Au	354310	7056506	Southern Mount Eureka 7
15396	Au	354036	7056059	Southern Mount Eureka 8
15397	Au	353900	7055950	Southern Mount Eureka 9
15398	Au	355135	7061531	Little Greta (53)
15399	Au	353938	7060547	Mount Eureka (53)
15400	Au	354379	7060620	Mount Eureka East

⬬ **Regolith — alluvial to beach placers**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
10729	Au	203737	7232960	Marymia (Au)

STEEL INDUSTRY METAL

✚ **Orthomagmatic mafic and ultramafic — undivided**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
17440	Ni PGE	422140	7025900	Collurabbie–Olympia
17441	Ni PGE	420895	7029150	Collurabbie–Agora

◆ **Vein and hydrothermal — undivided**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
11674	Mn	364000	7169200	Earaheedy (Mn) 1
11675	Mn	351400	7168000	Earaheedy (Mn) 2
11676	Mn	350200	7169200	Earaheedy (Mn) 3
11677	Mn	349950	7169200	Earaheedy (Mn) 4
11678	Mn	357200	7125100	Breakaway Bore (Mn) 1
11679	Mn	358350	7125050	Breakaway Bore (Mn) 2
11680	Mn	359650	7124400	Breakaway Bore (Mn) 3

⬬ **Regolith — residual and supergene**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
11672	Mn	392100	7124600	Yunga Pool (Mn) 1
11673	Mn	385950	7125600	Yunga Pool (Mn) 2
11693	Mn	387900	7082700	Little Banjo Bore (Mn)
11694	Mn	366900	7116400	Skull Soak (Mn) 1
11695	Mn	372400	7112900	Skull Soak (Mn) 2

BASE METAL

◆ **Vein and hydrothermal — undivided**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
11429	Cu	216297	7214420	Miss Fairbairn Hills (Cu)
12625	Cu	320049	7189367	Troy Creek 3

BASE METAL

🟦 **Stratabound sedimentary — carbonate-hosted**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
10883	Pb	239149	7163811	Sweetwaters Well South
11403	Pb	270916	7145218	Teague South 6
11404	Pb Zn	271118	7145816	Teague South 5
11405	Pb	271017	7146139	Teague South 4
11406	Ag Pb	271914	7146861	Teague South 3
11407	Pb Zn	265117	7158305	Teague North 9
11408	Zn	264386	7158100	Teague North 10
11409	Zn Pb	265623	7158851	Teague North 8
11410	Pb Zn	264603	7158837	Teague North 7
11411	Pb Zn	253011	7166992	Lockeridge 4
11412	Zn Pb	271044	7146515	Teague South 2
11413	Zn Pb	270975	7147389	Teague South 1
11414	Pb Zn	272461	7145509	Teague South 7
11415	Zn Pb	251290	7169546	Lockeridge 1
11416	Zn Pb	251797	7168688	Lockeridge 3
11417	Zn Pb	251626	7168949	Lockeridge 2
11418	Zn Pb	264336	7161411	Teague North 3
11419	Zn	261487	7162613	Teague North 1
11421	Zn Pb	253502	7165671	Lockeridge 7
11422	Zn Pb	251225	7166074	Lockeridge 5
11423	Zn Pb	253608	7165973	Lockeridge 6
11424	Zn Pb	262401	7159956	Teague North 6
11425	Zn Pb	260457	7161380	Teague North 2
11426	Zn Pb	261514	7160787	Teague North 4
11427	Zn Pb	261792	7160924	Teague North 5
11686	Pb Zn	265537	7157460	Teague North 11
11687	Pb Zn	256737	7166560	Lockeridge 8
13027	Pb	239270	7164910	Sweetwaters Well

IRON

🟦 **Sedimentary — granular iron-formation**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
11776	Fe	339550	7182100	Mount Cecil Rhodes (Fe) 4
11777	Fe	342500	7182900	Mount Cecil Rhodes (Fe) 2
11778	Fe	347350	7177700	Mount Cecil Rhodes (Fe) 6
11800	Fe	333850	7209350	CSR 7 Well 4
11801	Fe	333800	7209500	CSR 7 Well 3
11802	Fe	333650	7211150	CSR 7 Well 2
11803	Fe	329100	7212200	CSR 7 Well 1
11818	Fe	237560	7209168	Miss Fairbairn Hills North (Fe) 12
11819	Fe	243967	7210221	Miss Fairbairn Hills North (Fe) 15
11820	Fe	252506	7206490	Miss Fairbairn Hills North (Fe) 18
11830	Fe	236792	7208427	Miss Fairbairn Hills North (Fe) 11
11831	Fe	235199	7211333	Miss Fairbairn Hills North (Fe) 9
11832	Fe	234208	7210042	Miss Fairbairn Hills North (Fe) 10
11833	Fe	235371	7212123	Miss Fairbairn Hills North (Fe) 8
11834	Fe	234155	7212654	Miss Fairbairn Hills North (Fe) 7
11835	Fe	235215	7213865	Miss Fairbairn Hills North (Fe) 6
11838	Fe	235707	7217611	Miss Fairbairn Hills North (Fe) 3
11839	Fe	235669	7218595	Miss Fairbairn Hills North (Fe) 2
11844	Fe	235707	7220487	Miss Fairbairn Hills North (Fe) 1
11846	Fe	241496	7210271	Miss Fairbairn Hills North (Fe) 14
11847	Fe	243967	7209181	Miss Fairbairn Hills North (Fe) 16
11849	Fe	245330	7216787	Miss Fairbairn Hills North (Fe) 4
11852	Fe	246766	7201399	Miss Fairbairn Hills South (Fe) 1
11854	Fe	239913	7201934	Miss Fairbairn Hills South (Fe) 2
11855	Fe	236648	7201108	Miss Fairbairn Hills South (Fe) 4
11857	Fe	229365	7199028	Miss Fairbairn Hills South (Fe) 6
11859	Fe	233922	7196529	Miss Fairbairn Hills South (Fe) 5
11861	Fe	246335	7207782	Miss Fairbairn Hills North (Fe) 17
12327	Fe	292441	7203135	Ivan Well North (Fe) 1
12328	Fe	298110	7200516	Ivan Well North (Fe) 4
12329	Fe	301088	7198328	Ivan Well North (Fe) 5
12330	Fe	302487	7197251	Ivan Well North (Fe) 6
12331	Fe	303599	7196103	Ivan Well North (Fe) 7
12332	Fe	306111	7193843	Ivan Well North (Fe) 8
12333	Fe	306362	7191045	Ivan Well North (Fe) 9
12334	Fe	308730	7191045	Ivan Well North (Fe) 10
12335	Fe	314721	7188354	Ivan Well South (Fe) 1
12336	Fe	315367	7187493	Ivan Well South (Fe) 2
12337	Fe	318452	7185268	Ivan Well South (Fe) 4
12371	Fe	320856	7183546	Ivan Well South (Fe) 5
12372	Fe	321861	7182649	Ivan Well South (Fe) 6
12373	Fe	340539	7182628	Mount Cecil Rhodes (Fe) 3
12374	Fe	344652	7186998	Mount Cecil Rhodes (Fe) 1
12375	Fe	343752	7180324	Mount Cecil Rhodes (Fe) 5
12383	Fe	255250	7166062	Frere Range (Fe) 1
12384	Fe	283689	7143180	Frere Range (Fe) 3
12385	Fe	285048	7144156	Frere Range (Fe) 4
12386	Fe	288434	7146242	Frere Range (Fe) 5
12387	Fe	290137	7146759	Frere Range (Fe) 6
12388	Fe	302269	7129805	Frere Range (Fe) 7
12916	Fe	235094	7214142	Miss Fairbairn Hills North (Fe) 5
12919	Fe	240317	7212227	Miss Fairbairn Hills North (Fe) 13
12923	Fe	239076	7200998	Miss Fairbairn Hills South (Fe) 3
12929	Fe	294663	7202195	Ivan Well North (Fe) 2
12931	Fe	297790	7200110	Ivan Well North (Fe) 3
12935	Fe	317188	7187023	Ivan Well South (Fe) 3
12941	Fe	281434	7139982	Frere Range (Fe) 2
12943	Fe	217589	7189594	Hawkins Knob (Fe)
12980	Fe	349561	7186093	Mount Ooloongathoo

ENERGY MINERAL

⬬ **Regolith — calcrete**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
10854	U	289737	7158360	Fyfe Well 1
11685	U	288637	7159510	Fyfe Well 2

INDUSTRIAL MINERAL

◆ **Vein and hydrothermal — undivided**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
10682	Brt	465370	7282000	Quadrio Lake
10683	Brt	465550	7282750	Quadrio Lake
10684	Brt	464420	7283340	Quadrio Lake
10685	Brt	463830	7283900	Quadrio Lake
10686	Brt	465750	7283820	Quadrio Lake
10687	Brt	465530	7281480	Quadrio Lake
10688	Brt	467490	7280620	Quadrio Lake
10689	Brt	467690	7280340	Quadrio Lake
10693	Brt	468100	7279760	Quadrio Lake
13084	Brt	465437	7282160	Quadrio Lake (Ba) 1

⬬ **Regolith — lacustrine**

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
3801	Gp	232560	7256704	Ten Mile Lake
3802	Gp	259296	7293713	Terminal Lake North
3860	Gp	222000	7173200	Lake Nabberu
3863	Gp	309908	7311305	Lake Wilderness
11640	Salt	371713	7263831	White Lake
11641	Salt	301792	7335325	Mystery Hill 1
11643	Salt	297823	7334284	Mystery Hill 2
11644	Gp	256042	7291218	Terminal Lake West
11645	Salt	243909	7295411	Yanneri Lake
11646	Salt	242510	7297655	Yanneri Lake North

WAMIN No.	*COMMODITY*	*EAST*	*NORTH*	*DEPOSIT NAME*
CONSTRUCTION MATERIAL				
⬭ **Regolith — residual and supergene**				
11683	Gvl	352000	7167650	Earaheedy (Road Base) 2
▽ **Undivided**				
11653	Sh	205324	7149851	Mount Paterson
11682	Sh	351400	7167800	Earaheedy (Road Base) 1

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 GSWA’s WAMEX (Western Australian mineral exploration) database of statutory open-file company reports 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 Plate 1 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);
- mineralization style (symbol shape).

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), the west Pilbara (Ruddock, 1999), the east Kimberley (Hassan, 2000), the east Pilbara (Ferguson and Ruddock, 2001), the north Kimberley (Ruddock, 2003), and the west Kimberley (Hassan, 2004).

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 Industry and Resources’ (DoIR’s) mines and mineral deposits information database (Cooper et al., 2003). 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***).

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 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 Plate 1 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

Table 2.1. WAMIN authority table for commodity groups

WAMIN commodity group	*Typical commodities*	*Symbol colour*
Precious mineral	Diamond, semi-precious gemstones	⬜
Precious metal	Ag, Au, PGE	🟨
Steel-industry metal	Co, Cr, Mn, Mo, Nb, Ni, V, W	🟧
Speciality metal	Li, REE, Sn, Ta, Ti, Zr	🟩
Base metal	Cu, Pb, Sb, Zn	🟥
Iron	Fe	🟦
Aluminium	Al (bauxite)	🟫
Energy mineral	Coal, U	⬛
Industrial mineral	Asbestos, barite, fluorite, kaolin, talc	🟩
Construction material	Clay, dimension stone, limestone	🟦

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 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).

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 (see Table 2.1)*
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	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 — unconformity	U	◇
Vein and hydrothermal — undivided	Au, Ag, Cu, Pb, Zn, Ni, U, Sn, F	
Stratabound volcanic and sedimentary — volcanic-hosted sulfide	Cu, Zn, Pb, Ag, Au, Ba	△
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, Ba	
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 — granular iron formation	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 — lacustrine	Gypsum, halite	
Regolith — residual and supergene	Al, Au, Ni, Co, Mn, V, Fe crustals, Fe scree	
Regolith — residual to eluvial placers	Au, Sn, Ti, Zr, REE, diamond	
Undivided	Construction materials, various	▽

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

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 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 1:50 000-scale sheet. Even though a query may be entered as a single point (either MGA or latitude/longitude coordinates), the resulting search will produce all reports for the 1:50 000-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

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* 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	>1	>0.5 ppm
Silver	>1	>35 ppm
Platinum	>1	>0.7 ppm
Lead	>1	>1%
Zinc	>1	>0.5%
Copper	>1	>0.25%
Nickel	>1	>0.2%
Cobalt	>1	>0.02%
Chromium	>1	>5% Cr_2O_3
Vanadium	>5	>0.1%
Tin	>5	>0.02%
Iron	>5	>40% Fe
Manganese	>5	>25%
Uranium	>2	>300 ppm U
Diamonds	na	any diamonds
Tantalum	>5	>200 ppm
Tungsten	>1	>1000 ppm (0.1%)
Placer deposits		
Gold	na	>300 mg/m^3 in bulk sample
Diamonds	na	any diamonds
Heavy minerals	>5	>2% ilmenite

NOTE: Modified from Rogers and Hart (1995)
na: not applicable

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
GCDR	Geochemistry drilling (includes auger and RAB drilling for deep sampling)
Mineralogical	
HM	Heavy mineral surveys (ilmenite, zircon, monazite, garnet, gold, tin, tantalum)
DSAM	Diamond sampling surveys (stream sediment, loam)
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

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 published sources (geological maps, topographic maps, and TENGRAPH — DoIR'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 analysed (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 or CD);
- 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).

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Appendix 3

Description of digital datasets on CD-ROM

There are three principal components of this study, which are this report, Plate 1, 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 GeoVIEWER.WA 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 Plate 1 is described in Appendix 2. The dataset on the CD-ROM includes textual and numeric information on:

- location of the occurrences (MGA 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 open-file reports) defining the locations and descriptions of exploration activities in the area. EXACT, for the Earaheedy area, was compiled between 2002 and 2003, 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 the Western Australian mineral exploration, WAMEX, database), 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 I-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 WAMEX* database held by the Department of Industry and Resources (DoIR), 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* (DoIR's mines and mineral deposits information) database (Cooper et al., 2003) 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 center;
- 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 (DoIR's electronic tenement graphics system) shows the position of mining tenements

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* The WAMEX, MINEDEX, and TENGRAPH databases are available on the DoIR website at <www.doir.wa.gov.au>.

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 1:500 000 scale, based on compilation of the Geological Survey of Western Australia (GSWA) mapping. The full details of the solid geology and regolith are on the CD-ROM. 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 Plate 1 for simplicity.

Geophysics

The aeromagnetic and radiometric data covering the area are presented in the form of pseudocolour images. The data used to create these images is a composite of regional survey data, flown at 1500 line spacing (BULLEN and TRAINOR 1:250 000 map sheets) acquired by Geoscience Australia (GA) in 1984 and 400 m line spaced surveys acquired between 1986 and 1996 by GA and GSWA for the National Geoscience Mapping Accord (NABBERU, STANLEY, and KINGSTON 1:250 000 map sheets). The data have been merged to single datasets; total magnetic intensity and total count radiometric, with a grid cell size of approximately 20 m.

Regional gravity data collected by GA at 11 km station interval are presented as a Bouguer anomaly image, in pseudocolour, with a grid cell size of approximately 800 m.

The colour images presented show variations of blue through to red representing low to high values. The data are disparate due to variations in line spacing, flying height and spectrometer crystal size, which are evident on the BULLEN and TRAINOR map sheets.

Digital data for these surveys, in either point located or gridded formats, can be downloaded free of charge from the GA website at <http://www.ga.gov.au/adds>.

Landsat

Landsat TM imagery has been acquired for all the 1:250 000-scale map sheets in the Earaheedy study. The raw data are available commercially through the Remote Sensing Services section of the Department of Land Information (DLI). 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 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).

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Appendix 4

Review and highlights of GSWA's regolith geochemistry program in the Earaheedy area

During 1997–2002, the Geological Survey of Western Australia (GSWA) produced regolith geochemical maps along with Explanatory Notes of the NABBERU*, STANLEY, and KINGSTON 1:250 000 map sheets, and the NICHOLLS 1:100 000 map sheet from the Earaheedy area (Morris et al., 1997, 2000; Pye et al., 2000; Sanders, 2002). Based on regolith sampling, Morris et al. (2003) identified eight areas of potential mineralization on NABBERU, STANLEY, and KINGSTON (Table 4.1). But only two of these areas (Sweetwaters Well and Mount Rhodes near Troy Creek) have demonstrated mineralization. The following discussion is mostly restricted to anomalous mineralizing trends of precious and base metals and uranium observed in the above sheets. Anomalous assays of samples are taken as those above 2.5 × standard deviation of the mean.

Table 4.1. Anomalous elements in regolith from eight areas of potential mineralization on the NABBERU, STANLEY, and KINGSTON 1:250 000 map sheets

Site	*Anomalous elements*	*Known mineralization*
Sweetwaters Well	Fe, Mg, As, W	Zn–Pb–Cu
Blue Hill	Fe, Mn, Ce, Co, Cu, La, Li, Ni, Sn, W, Zn, Zr	–
Mount Davis	Cr, Ni, Pd	–
Weld Spring	Ti, Fe, Ag, Bi, Co, Cr, Ga, In, Mo, Pd, Pt, Sb, Sc, Sn, Ta, Th, V, Zr	–
Mount Rhodes	Mo, Fe, As, Bi, Pd, Sb, Th	–
Mingol Camp	Mn, K, Ba, Be, Ce, Co, Cu, La, Li, Pb, Rb	–
Mount Wellesley	Fe, Mn, K, As, Be, Bi, Cd, Ce, Co, Ga, In, La, Li, Pb, Pd, Rb, Sb, Sn, Te, Th, Y, Zn	–
Greenstones	Ti, Al, Ag, As, Au, Cr, Cu, Ga, Ni, Pd, Pt, Rb, Sb, Sc, Sn, Te, V	–

SOURCE: Morris et al. (2003)

NABBERU (1:250 000)

Regolith mapping of NABBERU involved collection of 999 regolith samples comprising 288 stream-sediment, 397 sheetwash, 191 sandplain, 93 soil, and 38 lake-sediment samples, at a nominal sampling density of one per 16 km^2 (Morris et al., 1997). The results of the program suggest an area of mafic rocks in the southwest of the map sheet. Table 4.2 and Figure 4.1a–f summarize the results of geochemical analyses of these samples.

KINGSTON (1:250 000)

Regolith mapping of KINGSTON involved collection of 998 regolith samples at a nominal sampling density of one per 16 km^2. These include 355 stream-sediment, 326 sheetwash, 227 sandplain, and 90 lake-sediment samples. There are high chalcophile-index scores (i.e. summed standards scores for As, Sb, Bi, Mo, Ag, Sn, W, Se) over the upper part of the Frere Formation and lower Windidda Member, in an east-southeasterly trending belt near the Wellington Range. This area coincides with closely spaced regional-scale faults. Parts of Wongawol Formation and Kulele Limestone in northern KINGSTON have regolith with high concentrations of several analytes including K_2O, Ce, La, Li, Rb, and Ta (Pye et al., 2000). Table 4.3 and Figure 4.2a–e summarize the results of geochemical analyses of these samples.

STANLEY (1:250 000)

Regolith mapping of STANLEY involved collection of 1012 regolith samples at a nominal sampling density of one per 16 km^2 (Morris et al., 2000). They comprised 368 sheetwash, 315 sandplain, 212 stream-sediment, 53 lake-sediment, and 64 soil samples. Geochemical trends of these samples led to the identification of stratabound manganese-related mineralization in parts of the Wongawol Formation in the southern-central part of STANLEY and structurally controlled manganese–barite and base metal mineralization over parts of the Earaheedy Group near Earaheedy (see Fig. 18 in main text; Morris et al., 2000). Table 4.4 and Figure 4.3a–g summarize the results of geochemical analyses of precious metals, base metals, and uranium.

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* Capitalized names refer to standard 1:250 000 map sheets unless otherwise indicated.

Table 4.2. Geochemical trends of precious metals, base metals, and uranium on the Nabberu 1:250 000 sheet

Element	*Comment*
PRECIOUS METALS	
Gold	Out of 999 regolith samples collected from Nabberu (1:250 000), the highest assay of gold was 11 ppb in sample GSWA 140876, about 10 km west-southwest of Forbes Outcamp (Fig. 4.1a). This is a sheetwash sample containing some fragments of vein quartz, sandstone, and ferruginous granules (Morris et al., 1997). The second best assay of 6 ppb Au was from two regolith samples GSWA 141433 and GSWA 137928. The former is from regolith material overlying granitic rocks of the Yilgarn Craton, about 25 km southwest of Crack O'Dawn where there is known gold mineralization, and the latter sample is from the regolith material overlying the Chiall Formation, about 15 km southwest of Granite Peak. Another 4 samples returned the next best assay of 5 ppb Au, and 2 of these (GSWA 141493 and GSWA 141783) approximately coincide with the northwesterly regional gold mineralization trend observed at Horse Well and Crack O'Dawn. The other 2 samples with assays of 5 ppb Au are GSWA 141096 about 35 km north-northeast of Troy Creek, associated with the regolith of Scorpion Group rocks, and GSWA 141043 from regolith material at the border zone of the Marymia Inlier In total there are 16 anomalous gold samples (>2 ppb) on Nabberu, including the 8 samples already discussed. Of the remaining 8 samples, 2 are from areas close to Crack O'Dawn, 3 from areas south of Granite Peak, associated with the regolith material of the Chiall Formation, 1 from about 14 km west-southwest of Troy Creek, 1 about 15 km northwest of Mount Davis from regolith material associated with the Salvation Group rocks, and the other from the regolith material associated with the Yelma Formation regolith material, about 8 km north-northwest of the western side of Miss Fairbairn Hills (Fig. 4.1a)
Silver	Five regolith samples (Fig. 4.1a) from areas at the western half of Nabberu returned assays ranging from 1.31 to 1.6 ppm Ag (Morris et al., 1997). Two of these, GSWA 140836 (about 8 km west of Carnarvon Range) assaying 1.39 ppm Ag, and GSWA 141622 (11 km west-northwest of Sweetwaters Well) assaying 1.60 ppm Ag are in the regolith material overlying the Frere Formation. The other (GSWA 141621, 11 km west of Sweetwaters Well) assaying 1.37 ppm Ag is from the regolith overlying the Yelma Formation. During previous exploration programs, grab samples from dolomitic rocks of Sweetwaters Well Member of the Yelma Formation, 3.5 km southeast of Sweetwaters Well, yielded assays up to 53 ppm Ag. Furthermore, 10.5 km south-southeast of Mount Teague there was an intersection of 4 m at 22 ppm Ag from 30 m in hole TRC 9, in rocks overlying carbonate-rich rocks of the Yelma Formation Other regolith samples with anomalous silver on Nabberu include GSWA 14114 (3 km southwest of Lake King) from the regolith material overlying dolomite and sandstone of the Yelma Formation, and sample GSWA 140909 (35 km west of Mount Methwin) from the regolith material overlying granitic rock, with silver assays of 1.34 and 1.31 ppm respectively (Fig. 4.1a)
Palladium	One sample (GSWA 141073) from near Mount Davis returned the highest assay of 6 ppb Pd from 999 regolith samples collected from Nabberu. The sample is at the contact zone of the Scorpion and Salvation Group rocks (Fig. 4.1b). Two more samples (GSWA 140851 and 140852) from the boundary zone of the Marymia Inlier and Earaheedy Basin rocks, 6–10 km southwest of Miss Fairbairn Hills, assayed 4 ppb Pd (Morris et al., 1997)
Platinum	Platinum concentrations in regolith of Nabberu are low, with most samples assaying below detection levels of 5 ppb (Morris et al., 1997). One sample (GSWA 141073) from near Mount Davis (Fig. 4.1b) assayed 8 ppb Pt (this sample also has the highest palladium of 6 ppb). Two more samples, GSWA 141257 (15 km south of Forbes Outcamp) and GSWA 141084 (34 km northeast of Mount Davis), returned anomalous platinum assays of 7 ppb and 6 ppb Pt. The former sample is from the regolith overlying the Palaeoproterozoic Chiall Formation and the latter from the regolith overlying the Mesoproterozoic Salvation Group
BASE METALS	
Lead	Lead values from regolith samples on Nabberu are generally low (Morris et al., 1997). However, a few samples from near Sweetwaters Well and east of Mount Teague, where there is known lead mineralization, and a few from the regolith overlying the Frere, Yelma, and Chiall Formations had anomalous lead values (Fig. 4.1c). The samples with higher assays, however, are from locations outside the known lead-mineralized areas. For instance, the highest assay of 60 ppm Pb and the next higher assay of 51 ppm Pb were returned from samples GSWA 141027 (14 km north of the western side of Miss Fairbairn Hills) and GSWA 140832 (24 km east of the eastern side of Miss Fairbairn Hills) collected from the regolith overlying the Yelma Formation (Fig. 4.1c)
Zinc	The highest zinc value of regolith samples from Nabberu is 379 ppm (sample GSWA 138000), 11 km north of Mount Cecil Rhodes, overlying the Scorpion Group rocks (Fig. 4.1d; Morris et al., 1997). Two samples (GSWA 137990 and 137991) from the regolith material overlying the Scorpion Group, with relatively higher assays of 145 and 123 ppm Zn, are from respective locations 3.8 km north and 4.4 km north-northeast of Troy Creek, where there is a known zinc occurrence in drill intersections. Two other samples GSWA 140888 (about 17 km west of Troy Creek) and GSWA 141573 (about 4 km southeast of Blue Hill) from the regolith material overlying the Chiall Formation, assayed 149 and 151 ppm Zn respectively. The latter sample also has anomalous copper (99 ppm). Another sample GSWA 141815 (9 km northeast of Hawkins Knob) from the regolith material derived from the Chiall Formation in the east, assayed 143 ppm Zn. There was no anomalous zinc from regolith samples around Mount Lockeridge and Mount Teague areas where there is known zinc mineralization in drill intersections

Table 4.2. (continued)

Element	*Comment*
Copper	Copper values of regolith samples from NABBERU are generally low with only one sample (GSWA 141501) out of 999 samples assaying above 100 ppm Cu. This sample (GSWA 141501), from about 16 km northwest of Cunyu Woolshed (Fig. 4.1e), assayed 120 ppm Cu and is from the regolith material overlying the Killara Formation, which consists of a sequence of aphyric lavas and microgabbro sills. The majority of the other anomalous copper samples are concentrated in areas west and south of Cunyu Woolshed and are from the regolith overlying the Archaean Merrie greenstone belt, consisting of metamorphosed mafic and granitic rocks of the Yilgarn Craton. Outside the above areas only two samples assayed above 80 ppm Cu, and these are GSWA 141573 (99 ppm Cu), about 4 km southeast of Blue Hill, and GSWA 140994 (80 ppm Cu), about 13 km north-northeast of Mount Davis. Sample GSWA 141573 is from the regolith overlying the Chiall Formation and the other from calcrete overlying the Salvation Group rocks. None of the above anomalous samples are close to known copper-mineralized areas. However, sample GSWA 137989 from the regolith material overlying Scorpion Group rocks, 8 km northwest of Troy Creek where there is known base metal mineralization, had 52 ppm Cu
Uranium	Uranium values obtained from regolith samples on NABBERU are low with only 5 samples assaying above the anomalous value of 4.4 ppm (Fig. 4.1f). The highest assay was 21 ppm U in GSWA 141880, near Fyfe Well, where there is known uranium mineralization associated with calcrete (Morris et al., 1997). Four other anomalous samples, GSWA 141790 (9 ppm U), GSWA 141447 (5.5 ppm U), GSWA 141602 (4.6 ppm U), and GSWA 141474 (4.6 ppm U), are from calcrete material overlying the granitic rocks, the Yelma Formation, and the Frere Formation. Another sample (GSWA 141415) from lacustrine material, 6 km north of Mount Paterson, assayed 6.4 ppm U

NICHOLLS (1:100 000)

Regolith mapping of the NICHOLLS (1:100 000) sheet involved collection of 175 regolith samples at a nominal sampling density of one per 16 km^2 (Sanders, 2002). The samples consisted of 91 stream-sediment, 37 sandplain, 28 sheetwash, 18 soil, and 1 lake-sediment sample. Geochemical trends of these samples led to the identification of extensions to Quadrio Lake barite–hematite stockworks (Hocking et al., 2000) to the north, northeast, and southeast along the trend of the Cornelia Range (Sanders, 2002). Table 4.5 summarizes the results of geochemical analyses of these samples.

References

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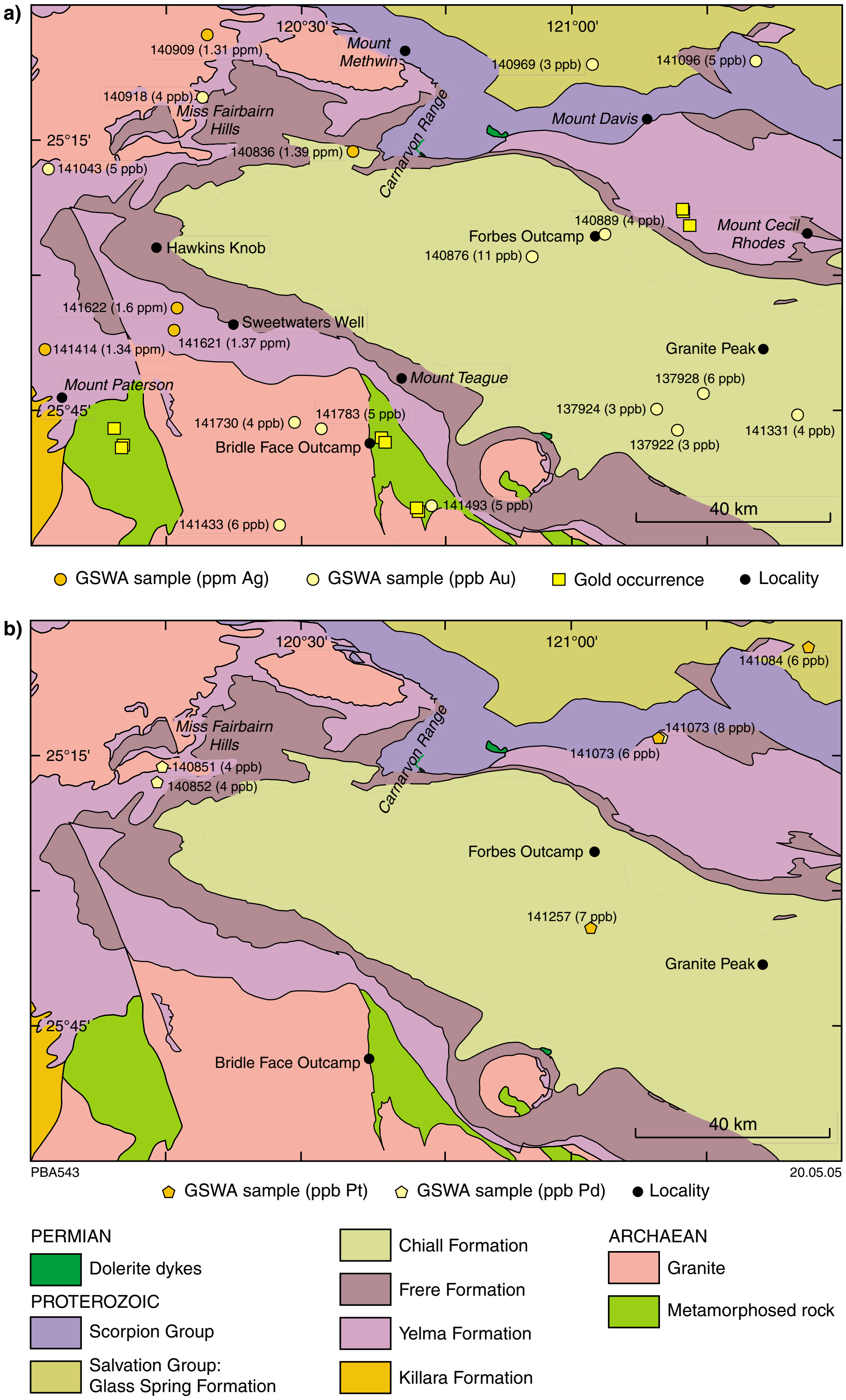


Figure 4.1. Regolith samples with anomalous assay values from NABBERU (1:250 000): a) gold and silver; b) palladium and platinum; data from Morris et al. (1997)

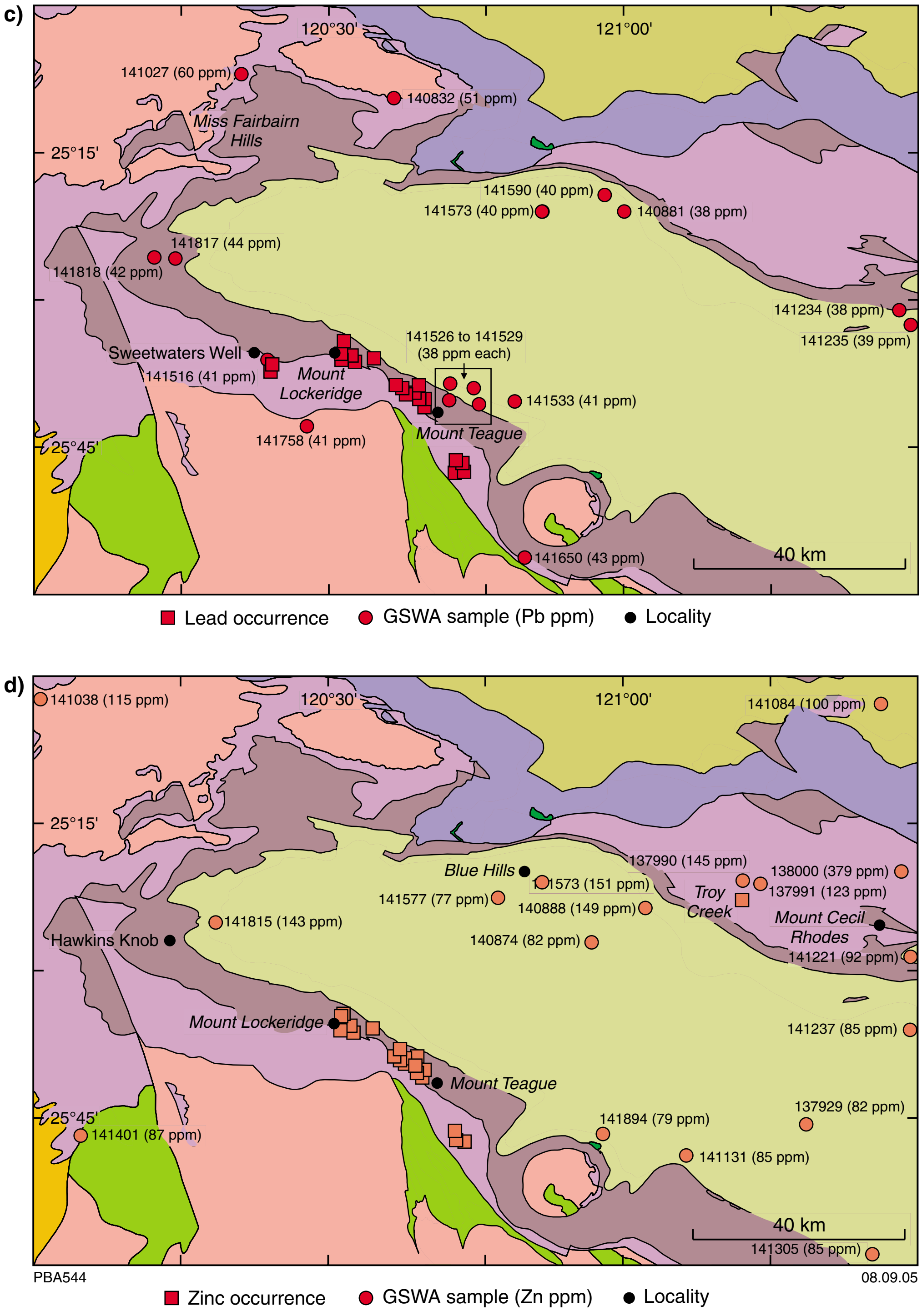


Figure 4.1. Regolith samples with anomalous assay values from NABBERU (1:250 000): c) lead; d) zinc; data from Morris et al. (1997)

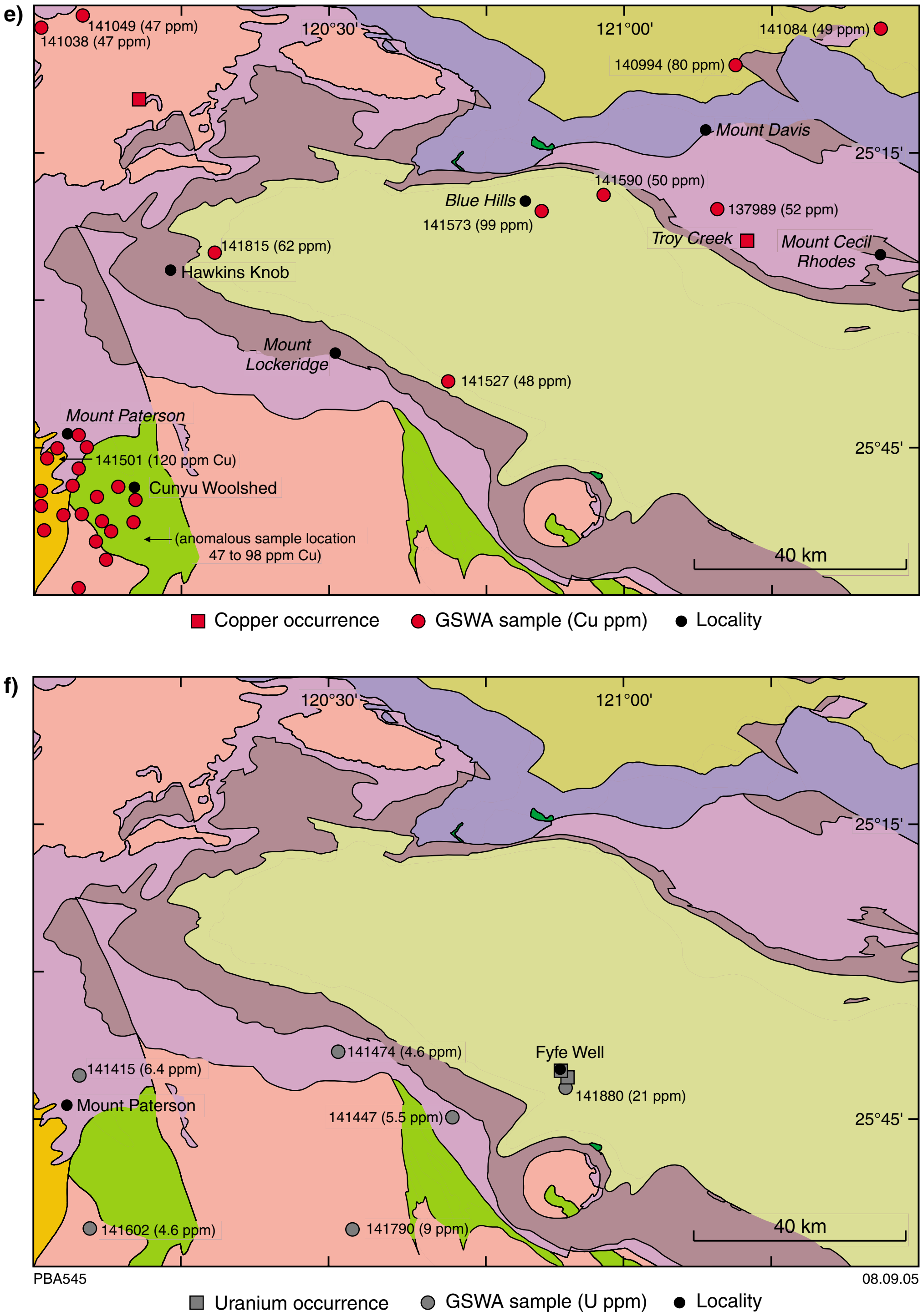


Figure 4.1. Regolith samples with anomalous assay values from Nabberu (1:250 000): e) copper; f) uranium; data from Morris et al. (1997)

Table 4.3. Geochemical trends of precious metals, base metals, and uranium on the KINGSTON 1:250 000 sheet

Element	*Comment*
PRECIOUS METALS	
Gold	The gold assays of regolith samples from KINGSTON is low, the maximum value being 4 ppb in sample GSWA 166126, from close to the Archaean greenstone–granitic contact near the gold-mineralized Mount Eureka greenstone belt (Fig. 4.2a; Pye et al., 2000). Five other samples assayed 3 ppb Au each. Of these, 2 samples (GSWA 166714 and 167126) are from the regolith overlying the Palaeoproterozoic Frere Formation, 9 km southwest and 27 km south of Prenti Downs respectively. Other 3 samples are: GSWA 167155 (just south of Lake Carnegie) from the regolith overlying the Palaeoproterozoic Wongawol Formation, GSWA 166685 (8 km northwest of Twin Swamps Bore) from the Palaeoproterozoic Wandiwarra Member of the Chiall Formation, and GSWA 166115 (28 km south-southwest of Old Windidda) from the regolith overlying Archaean granite
Silver	The maximum value of silver obtained from the regolith samples on KINGSTON is only 0.6 ppm, and this was from a sandplain sample GSWA 166417 overlying Archaean granitic, 22 km southeast of Mount Eureka (Fig. 4.2a; Pye et al., 2000). Two other samples (GSWA 166659 and 166660), from the south-central border of KINGSTON, overlying the Archaean granite–greenstone belt and the Frere Formation respectively, returned assays of 0.4 ppm
Palladium	The palladium values of regolith samples from KINGSTON are very low, the highest being 4 ppb in sample GSWA 166442 from the regolith material overlying the Windidda Member of the Frere Formation, 17 km east of Mount Wellesley (Fig. 4.2a; Pye et al., 2000). Two other samples overlying granite–greenstone regolith in the southwestern part of KINGSTON returned assays of 3 ppb Pd each
Platinum	Like palladium, the platinum values of regolith samples from KINGSTON are also very low (Pye et al., 2000). Sample GSWA 166247 from lateritic regolith, near the Rubys Find gold occurrence, returned an assay of 9 ppb Pt (Fig. 4.2a), and 3 other samples overlying granitic regolith at the southwestern corner of KINGSTON returned assays of 6 ppb Pt each
BASE METALS	Although there are no known base metal occurrences on KINGSTON, regolith samples from different parts of the sheet indicate anomalous base metal assays. The following is a brief discussion on these anomalous samples
Lead	The samples with anomalous lead assays on KINGSTON are mostly from the regolith overlying the Palaeoproterozoic Windidda and Wandiwarra Members of the Frere and Chiall Formations respectively. The highest assay of 118.9 ppm Pb is from sample GSWA 166713, about 7 km northeast of Windidda (Fig. 4.2b; Pye et al., 2000). This sample and a few other nearby samples with relatively high assays of lead are from the Windidda Member. A number of regolith samples near and north of Mount Wellesley are also relatively high in lead. For example, samples GSWA 166338 and 166332 from the Palaeoproterozoic Wandiwarra Member, 17 km and 25 km north of Mount Wellesley, assayed 65.9 and 57.3 ppm Pb respectively. Another sample (GSWA 167143) of regolith material from the Palaeoproterozoic Kulele Limestone, 4 km south-southwest of Bullah, returned 65.6 ppm Pb
Zinc	Most of the regolith samples with relatively high zinc assays are from locations at the southeastern sector of the sheet, associated with regolith material overlying the Palaeoproterozoic Frere Formation and the Lower Permian Paterson Formation (Pye et al., 2000). Of these, the highest and second-highest assays of 312 and 181 ppm were in samples GSWA 166828 and 166818 from the Palaeoproterozoic Frere Formation (Fig. 4.2c). One sample (GSWA 166247), 16 km north-northwest of Mount Eureka, in the Mount Eureka greenstone belt assayed 128 ppm. Another sample from regolith overlying the Lower Permian Paterson Formation (GSWA 166548) near Mount Wellesley had a relatively high assay of 132 ppm Zn
Copper	The highest assay of 203 ppm Cu on KINGSTON is in the regolith sample GSWA 166247 (which also has 128 ppm Zn) overlying the Mount Eureka greenstone belt (Fig. 4.2d). In the same area, 3 other samples (GSWA 166325, 166124, and 166602) overlying the Mount Eureka greenstone belt returned relatively high copper assays of 88–93 ppm. Sample GSWA 166857 from the regolith overlying a Proterozoic dolerite sill, 4 km east-southeast of Prenti Downs, assayed 111 ppm Cu. One sample GSWA 165133 from the Palaeoproterozoic Frere Formation, 9 km south-southeast of Prenti Downs, returned a relatively high assay of 94 ppm Cu. Another sample GSWA 167257 from regolith overlying the Palaeoproterozoic Princess Ranges Member of the Chiall Formation, 13 km northwest of Prenti Downs, returned an anomalous assay of 72 ppm (Pye et al., 2000)
Uranium	Regolith samples with anomalous uranium on KINGSTON are mostly from material overlying the Frere Formation. A few samples overlying granitic rocks also returned anomalous uranium. The highest assay of 10.9 ppm U is from the lake sediment sample GSWA 166747 overlying the Frere Formation, 4 km west of Warren Bore, and another sample GSWA 166753 overlying the Frere Formation from the same area (4.5 km northeast of Warren Bore) returned an anomalous assay of 4.5 ppm U (Fig. 4.2e). Two more samples overlying the Frere Formation, 4 km southwest of Lorna Glen and 4 km west of No 16 Well, returned assays of 4.4 ppm U (GSWA 166528) and 3.8 ppm U (GSWA 166467) respectively. Other regolith samples with anomalous uranium include: calcrete sample GSWA 166571 (5.1 ppm U) 7 km southwest of Jackie Well, overlying the Windidda Member of the Frere Formation and sample GSWA 166526 (5.1 ppm U) 2 km southeast of Red Bluff, overlying granite–greenstone rocks (Pye et al., 2000)

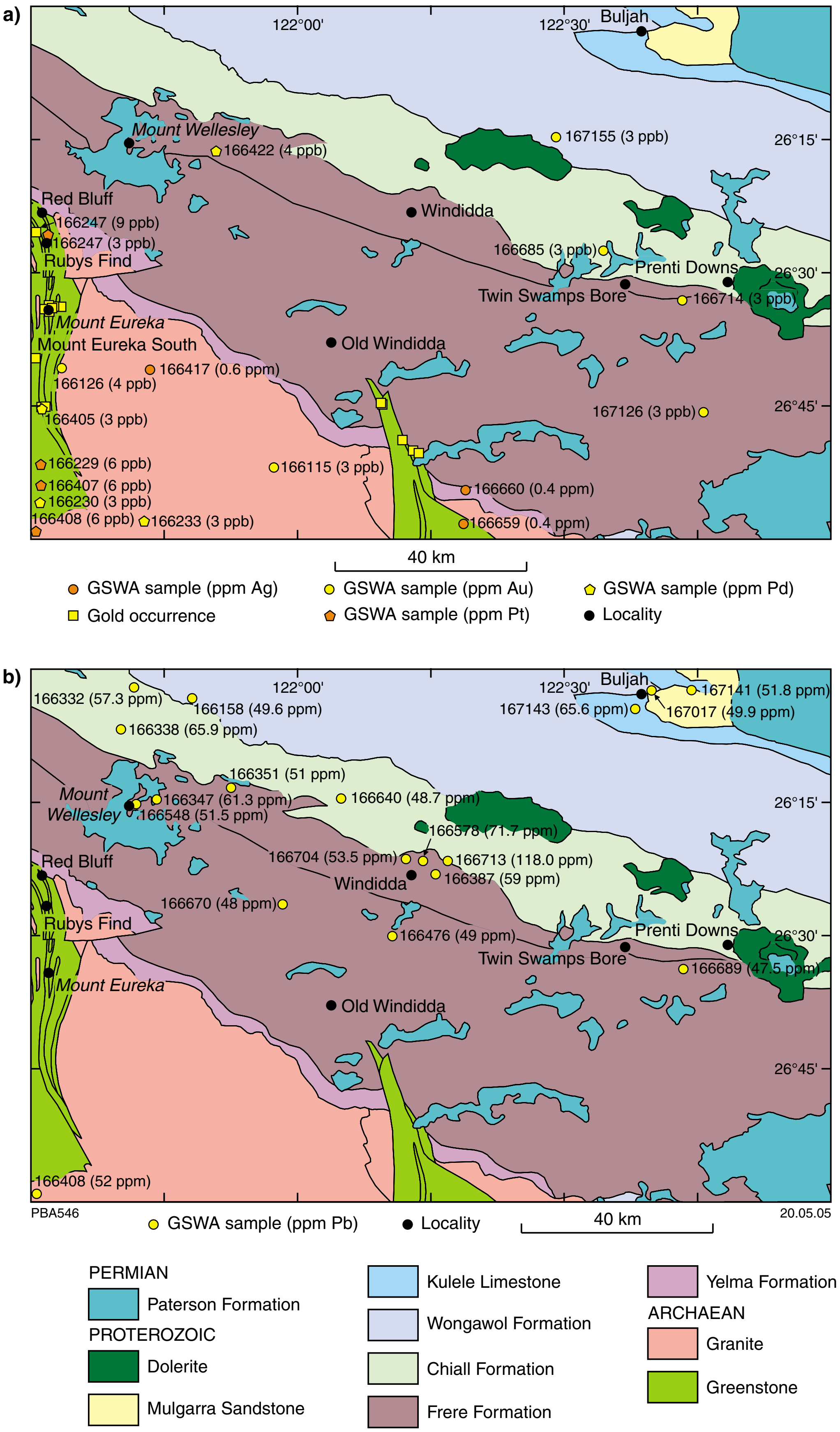


Figure 4.2. Regolith samples with anomalous assay values from KINGSTON (1:250 000): a) gold, silver, palladium, and platinum; b) lead; data from Pye et al. (2000)

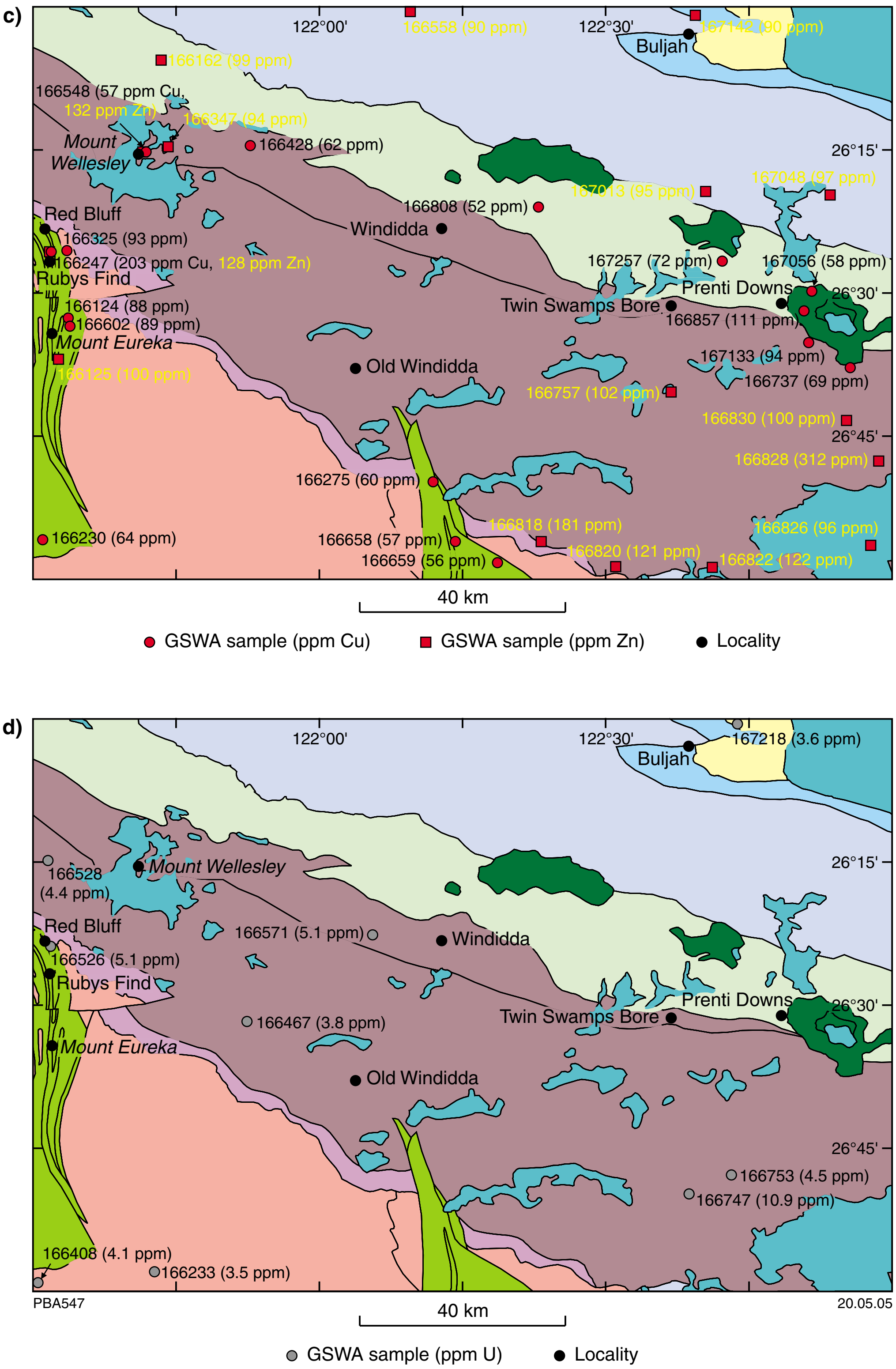


Figure 4.2. Regolith samples with anomalous assay values from Kingston (1:250 000): c) copper and zinc; d) uranium; data from Pye et al. (2000)

Table 4.4. Geochemical trends of precious metals, base metals, and uranium on the STANLEY 1:250 000 sheet

Element	*Comment*
PRECIOUS METALS	
Gold	Gold assays of regolith samples from STANLEY are very low, and only 3 out of 1012 regolith samples collected returned assays above 5 ppb Au (Morris et al., 2000). Sample GSWA 167801 with the highest assay of 23 ppb Au is from lateritic regolith overlying the Mesoproterozoic Salvation Group, 22 km east-southeast of Glenayle (Fig. 4.3b). Another sample (GSWA 167339), also overlying the Salvation Group rocks, 30 km northeast of Glenayle, assayed 5 ppb Au. The second highest assay of 7 ppb Au is in sample GSWA 167422 overlying the Permian Paterson Formation, about 36 km south of Earaheedy
Silver	Silver content of regolith samples from STANLEY is also very low. Out of 1012 samples only 5 returned assays equal to or greater than 0.7 ppm Ag (Fig. 4.3b; Morris et al., 2000). All these samples are from areas in the northern half of STANLEY, from material overlying either Mesoproterozoic Salvation Group rocks or dolerite
Palladium	Palladium content in regolith samples from STANLEY is very low with only 6 samples out of 1012 regolith samples assaying above or equal to 3 ppb (Morris et al., 2000). Four of these are from material overlying either dolerite or Mesoproterozoic Salvation Group rocks, and the other 2 are from the regolith overlying the Yelma Formation (Fig. 4.3c)
Platinum	Ten out of 1012 regolith samples collected from STANLEY returned assays of platinum greater than or equal to 5 ppb (Morris et al., 2000). Nine of these, with assays ranging from 5 to 9 ppb Pt are from the material overlying either Mesoproterozoic Salvation Group rocks or dolerite, mostly in the northwestern part of STANLEY (Fig. 4.3c)
BASE METALS	
Lead	Ten out of 1012 regolith samples from STANLEY returned assays of lead greater than or equal to 73 ppm (Morris et al., 2000). Most of these anomalous samples are from the regolith overlying the Palaeoproterozoic Wongawol Formation, Frere Formation, and Princess Ranges Member of the Chiall Formation (Fig. 4.3d), for example GSWA 168062 (98 ppm Pb) and GSWA 168439 (79 ppm Pb) are from the sheetwash material overlying the Princess Ranges Member, a few kilometres west of Jubblejarrah Pool (these samples also have anomalous copper assays). Another 4 anomalous lead samples (78–101 ppm Pb), 14–25 km west of Mount Throssell, are from the regolith overlying the Wongawol Formation, close to the contact with the Kulele Limestone
Zinc	Eleven samples out of 1012 regolith samples collected from STANLEY returned zinc assays greater than or equal to 100 ppm (Morris et al., 2000). Ten of these, assaying 100–195 ppm Zn, are from the regolith material overlying (or close to) Proterozoic dolerite, mostly concentrated in localities between Glenayle and Marlooyanoo Hill (Fig. 4.3e). The remaining sample (assaying 100 ppm) is from the regolith material overlying the Palaeoproterozoic Wongawol Formation
Copper	Eight out of 1012 regolith samples from STANLEY returned assays of copper greater than or equal to 86 ppm (Morris et al., 2000). These samples are mostly from regolith overlying the Mesoproterozoic Salvation Group or Proterozoic dolerite. However, the highest assay of 127 ppm Cu is in sheetwash sample GSWA 168062 overlying the Princess Ranges Member of the Chiall Formation, 5 km northwest of Jubblejarrah Pool (Fig. 4.3f). Another sample GSWA 168439, also overlying the Princess Ranges Member, and 4 km west-southwest of the above sample returned an assay of 91 ppm Cu. Four samples of regolith material overlying dolerite between Brassey Range and Parker Range returned assays of 86–113 ppm Cu
Uranium	The uranium values of regolith samples from STANLEY are generally low, the maximum being 5.8 ppm in sample GSWA 167894 from Kahrban Creek on northeastern STANLEY (Fig. 4.3g). This sample is from the regolith derived from the Mesoproterozoic Salvation Group. Two other samples GSWA 168417 (11 km downstream from the previous sample) and GSWA 168138, also of regolith derived from the Mesoproterozoic Salvation Group, returned assays of 4.9 and 5.3 ppm U respectively. Two samples GSWA 168348 (northern side of Lake Carnegie) and GSWA 168250 (15 km north of Lake Carnegie), overlying the Palaeoproterozoic Wongawol Formation, returned assays of 5.15 and 4.25 ppm U respectively. Sheetwash sample GSWA 167680, near Wilson Bore, has an assay of 4.95 ppm U, and the main rock type exposed in the area is the Palaeoproterozoic Wongawol Formation. Two sheetwash samples (GSWA167550 and 167748), east of Earaheedy, overlying the Palaeoproterozoic Wandiwarra Member of the Chiall Formation returned assays of 4.3 ppm U each

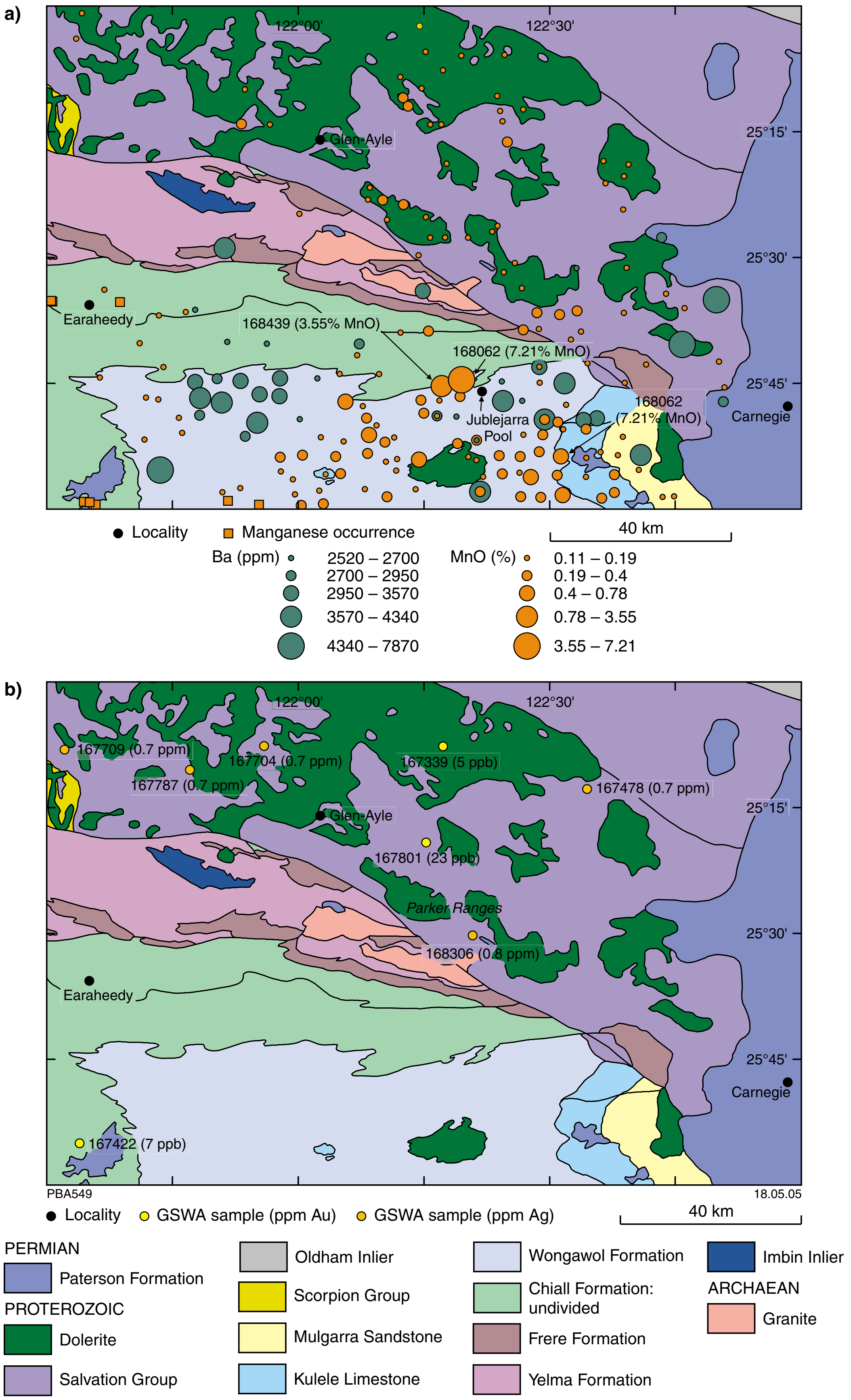


Figure 4.3. Regolith samples with anomalous assay values from STANLEY (1:250 000): a) manganese and barium; b) gold and silver; data from Morris et al. (2000)

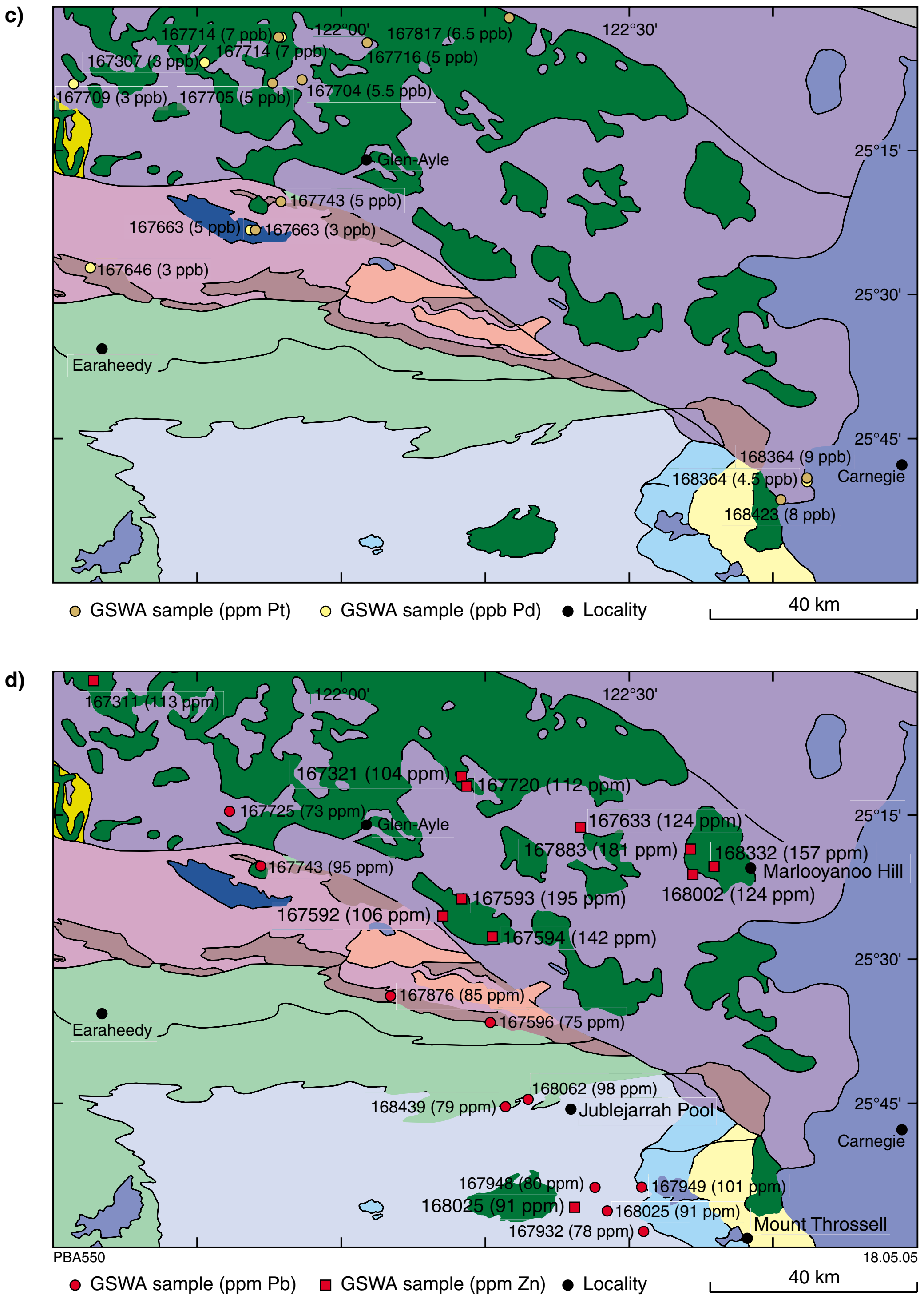


Figure 4.3. Regolith samples with anomalous assay values from Stanley (1:250 000): c) palladium and platinum; d) lead and zinc; data from Morris et al. (2000)

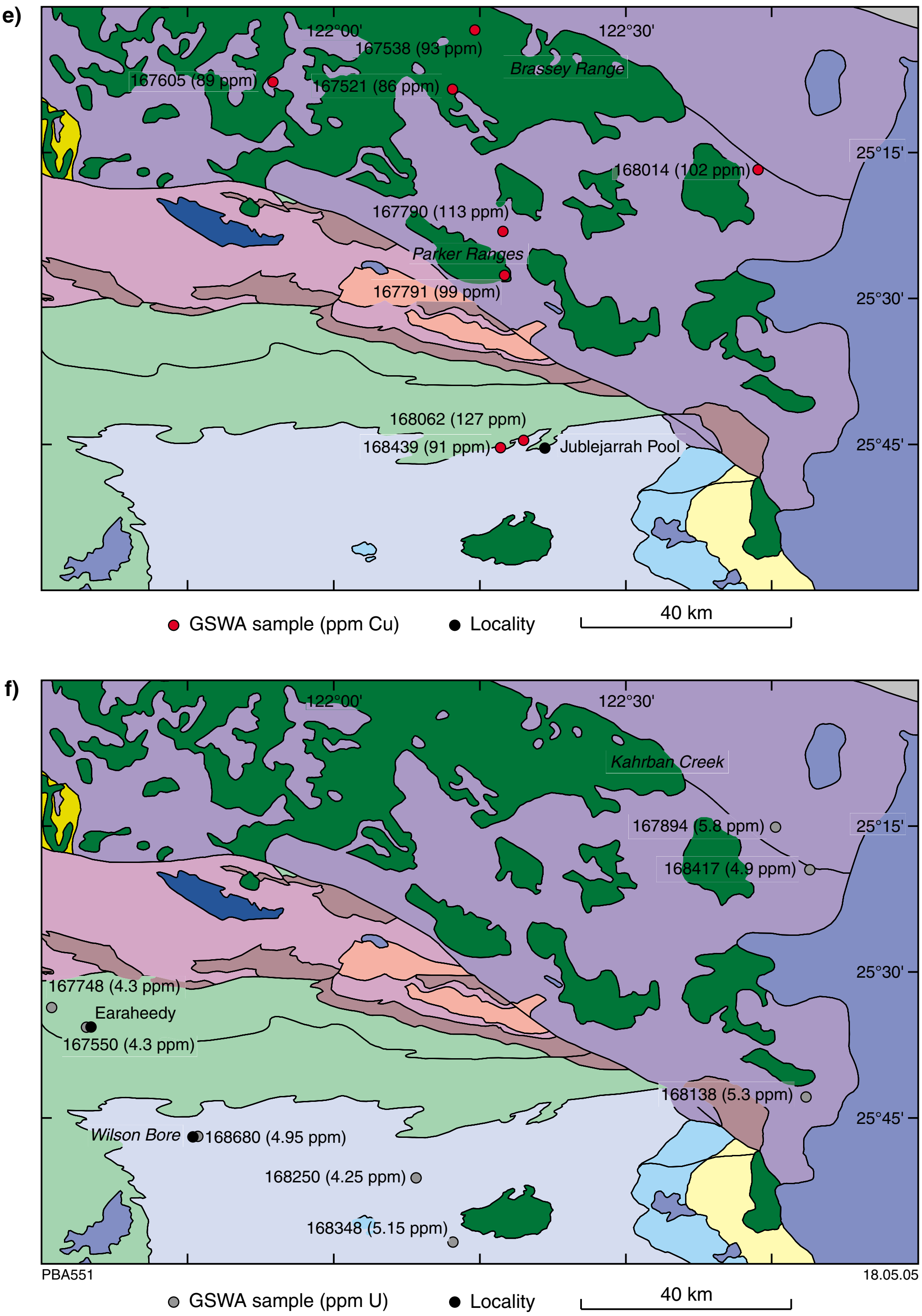
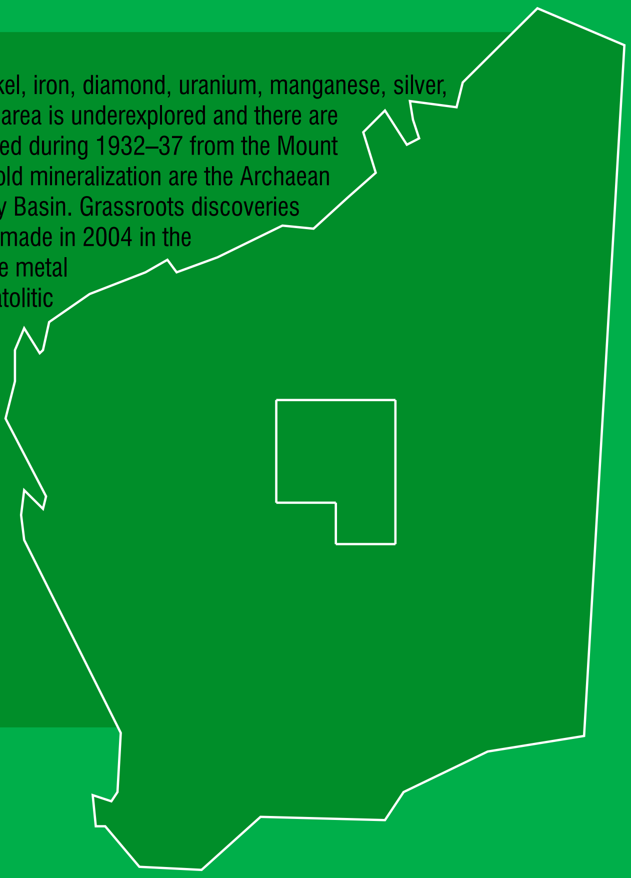


Figure 4.3. Regolith samples with anomalous assay values from Stanley (1:250 000): e) copper; f) uranium; data from Morris et al. (2000)

Table 4.5. Geochemical trends of precious metals, base metals, and uranium on the NICHOLLS 1:250 000 sheet

Element	*Comment*
PRECIOUS METALS	
Gold	The gold content of regolith samples from NICHOLLS (1:100 000) is very low, the highest being 2 ppb from 17 samples out of the 175 samples collected (Sanders, 2002). Most of these samples are from the material overlying the Mesoproterozoic rocks of the Oldham Inlier — Cornelia Sandstone, Quadrio Formation, and the Oldham Sandstone
Silver	The silver content of regolith samples from NICHOLLS is also very low with only 2 samples returning assays equal to or greater than 0.4 ppm out of 175 samples collected (Sanders, 2002). The highest silver assay is 0.5 ppm in sample GSWA 152125 (11 km northwest of Quadrio Lake) from the material overlying the Neoproterozoic Skates Hills and Mesoproterozoic Quadrio Formations. The next best assay of 0.4 ppm Ag is in sample GSWA 152196, from about 25 km east of Brassey Range, from the regolith overlying Neoproterozoic Brassey Range rocks
Palladium	The highest assay of palladium in regolith samples from NICHOLLS is only 2 ppb, in 11 samples out of 175 collected (Sanders, 2002). Six of these 11 are from the material overlying the Mesoproterozoic Oldham Sandstone in the Oldham Range. Of the remaining 5 samples, 2 are from the material overlying the Mesoproterozoic Quadrio Formation in the Quadrio Lake area, 2 from the material overlying the Neoproterozoic Skates Hills Formation west of Quadrio Lake, and the other is also from material overlying the Skates Hills Formation, southeast of Cornelia Range
Platinum	Only 4 samples out of 175 regolith samples from NICHOLLS returned assays of greater than or equal to 4 ppb Pt (Sanders, 2002). These 4 samples also had anomalous assays of 2 ppb Pd. Two of these are from the regolith overlying the Mesoproterozoic Oldham Sandstone in the Oldham Range, and the other 2 (one sample from near Quadrio Lake and the other east of Cornelia Range) are from the material overlying the Neoproterozoic Skates Hills Formation
BASE METALS	
Copper	The copper content of regolith samples from NICHOLLS is very low, with only 5 samples assaying more than 50 ppm Cu (Sanders, 2002). Three of these samples, GSWA 171598 (122 ppm), GSWA 152103 (83 ppm), and GSWA 176923 (50 ppm), are from the regolith overlying the Mesoproterozoic Oldham Sandstone in the Oldham Range. Of the remaining anomalous copper samples, GSWA 171555 with 51 ppm Cu is from the regolith material overlying the Mesoproterozoic Cornelia Sandstone, and GSWA 152156 with 60 ppm Cu is from the regolith overlying the Neoproterozoic Skates Hills Formation
Lead	Only 2 samples out of 175 regolith samples from NICHOLLS returned assays of more than 60 ppm Pb (Sanders, 2002). These are samples GSWA 152194 (138 ppm Pb) and GSWA 171575 (69 ppm Pb) from the regolith overlying the Mesoproterozoic Cornelia Sandstone near the Cornelia Range
Zinc	Only 4 out of 175 regolith samples from NICHOLLS gave assays of more than 90 ppm Zn (Sanders, 2002). Sample GSWA 152155, about 30 km east of Quadrio Lake and overlying Mesoproterozoic Quadrio Formation, returned the highest assay of 264 ppm Zn. The other 3 samples are GSWA 171555 (178 ppm Zn) overlying the Mesoproterozoic Cornelia Sandstone in the Cornelia Range, sample GSWA 171542 (90 ppm Zn) overlying the Neoproterozoic Skates Hills Formation about 7 km northeast of Quadrio Lake, and sample GSWA 171598 (97 ppm Zn) overlying the Mesoproterozoic Oldham Sandstone in Oldham Range
Uranium	Uranium values obtained from regolith samples on NICHOLLS are very low with only 3 samples yielding above the anomalous value of 2.2 ppm U (Sanders, 2002). The highest assay is 3.62 ppm U in calcrete sample GSWA 152156, 26 km east of the Quadrio Lake. The other 2 anomalous samples are GSWA 176940 (2.69 ppm U) overlying the Mesoproterozoic Oldham Sandstone about 6 km south of Oldham Range, and GSWA 171542 (2.26 ppm U) overlying the Neoproterozoic Skates Hills Formation about 7 km northeast of Quadrio Lake

The Earaheedy area is prospective for gold, base metals, nickel, iron, diamond, uranium, manganese, silver, barite, gypsum, and salt in various mineralization styles. The area is underexplored and there are currently no operating mines. About 3 kg of gold was produced during 1932–37 from the Mount Eureka gold mining centre. The most prospective areas for gold mineralization are the Archaean greenstone belts in the Yilgarn Craton, south of the Earaheedy Basin. Grassroots discoveries of nickel–copper sulfides and platinum group elements were made in 2004 in the Gerry Well greenstone belt, west of the Collurabbie Hills. Base metal mineralization of Mississippi Valley-type occurs in the stromatolitic carbonate rocks of the Yelma Formation. The economic potential for iron is highest in the Frere Formation and likely to be in the Stanley Fold Belt. Diamonds occur in kimberlitic intrusions and in regolith material. Calcrete areas and palaeochannels associated with or adjoining the Shoemaker impact structure are prospective for uranium mineralization. The Wongawol, Chiall, and Frere Formations are prospective for manganese mineralization. This Report is accompanied by a 1:500 000-scale geology map, and a digital dataset on a CD-ROM, and presents a review of the regional geology, history of mineral exploration activities, main mineral occurrences, mineralization controls, and potential for further mineralization.



This Report is published in digital format (PDF) as part of a digital dataset on CD. It is also available online at: www.doir.wa.gov.au/gswa/onlinepublications. Laser-printed copies can be ordered from the Information Centre for the cost of printing and binding.

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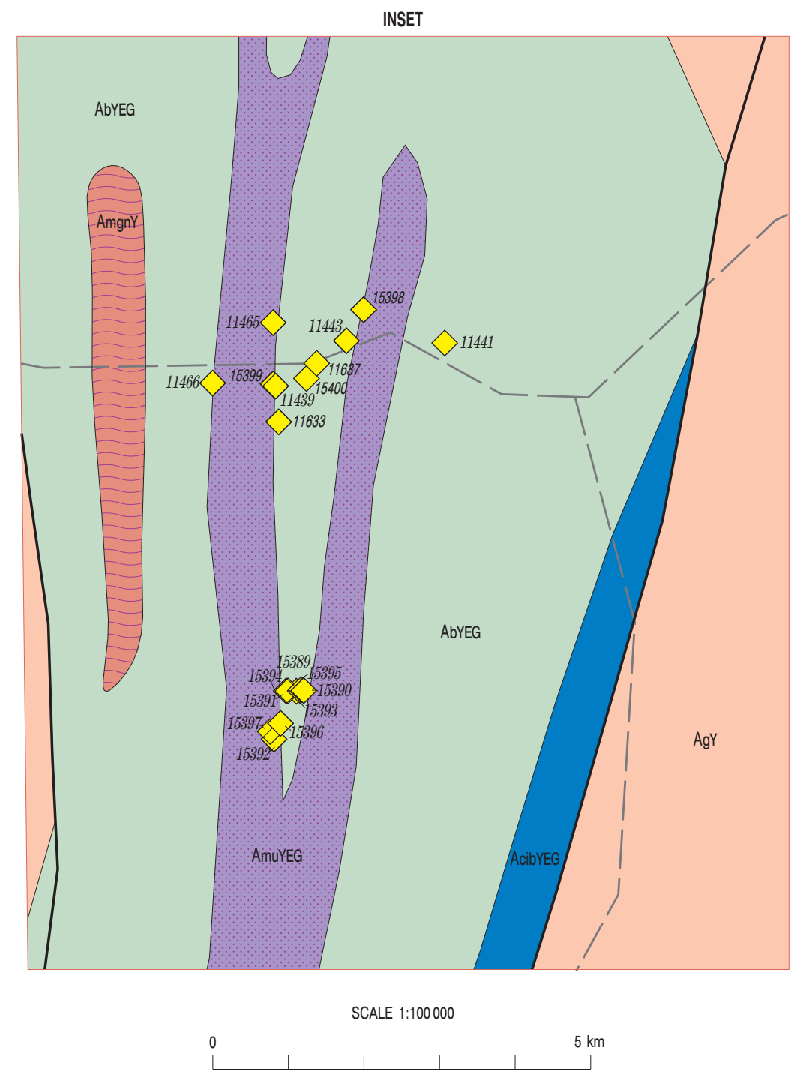
ABEYSINGHE   Mineral occurrences and exploration potential of the Earaheedy area, Western Australia   REPORT 96

INSET



MINERAL OCCURRENCES

The detailed list of mineral occurences is in Appendix 1 of Report 96

MINERALIZATION STYLES	MINERAL AND ROCK COMMODITY GROUPS
☆ Kimberlite and lamproite	○ Precious mineral
✚ Orthomagmatic mafic and ultramafic	● Precious metal
◇ Vein and hydrothermal	● Steel industry metal
☐ Stratabound sedimentary and/or sedimentary banded iron-formation	● Base metal
▭ Regolith hosted	● Iron
▽ Undivided	● Energy
	● Industrial mineral
	● Construction material

Mineral occurrences and numbers are from the GSWA WAMIN database

OPERATING STATUS AND SITE IDENTIFICATION NUMBER

Abandoned mine	e.g. *11653*
Mineral deposit	e.g. 11699
Mineral occurrence or prospect	e.g. *11326*

Geological boundary
Fault
Fault, concealed
Meteorite impact crater ⊕
Road, unsealed
Track
Homestead ■ Station Hill
Underground gas pipeline
Vermin proof fence (in part abandoned)
Watercourse
Lake
Well, bore, or pool ●
Abandoned (abd)

DATA DIRECTORY

Theme	Data Source	Data Currency	Agency
Geology	1:500 000 Interpreted Bedrock Geology of WA*	2003 — 2004	Dept of Industry and Resources
Mineral occurrences (non-confidential)	MINDEX*	APRIL 2005	Dept of Industry and Resources
	WAMIN	APRIL 2005	Dept of Industry and Resources
Topography	DLI and GSWA field survey	2004	Dept of Land Information

*GSWA and DoIR databases are viewable online (www.doir.wa.gov.au/aboutus/geoview_launch.asp) or can be downloaded from the GSWA Data and Software Centre (www.doir.wa.gov.au/GSWA/downloadcentre)

Mineral occurrence data compiled by P. B. Abeysinghe 2004

Geology compiled by R. M. Hocking 2004–05 from 1:500000 Interpreted Bedrock Geology of Western Australia (prelim. ed.) and published GSWA maps (see sheet index) and unpublished geological data

Geochronology by:
(1) M. T. D. Wingate, 2002, unpublished data; L. Hanley and M. T. D. Wingate, 2000, Australian Journal of Earth Sciences, v. 47, p. 1029–1040.
(2) M. R. Walter et al., 2000, Precambrian Research, v. 100, p. 371–433.
(4) D. R. Nelson, 2004, GSWA geochronology dataset, GSWA 154668.
(6) D. R. Nelson, 2004, GSWA geochronology dataset, GSWA 177101.
(9) M. T. D. Wingate, 2002, GSWA Record 2002/4, p. 48.
(10) D. R. Nelson, 2004, GSWA geochronology dataset, GSWA 161286.
(11) D. R. Nelson, 2002, GSWA geochronology dataset, GSWA 168983.
(13) D. R. Nelson, 2004, GSWA geochronology dataset, GSWA 161282.
(14) D. R. Nelson, 2004, GSWA geochronology dataset, GSWA 161285.
(15) D. R. Nelson, in prep., GSWA geochronology dataset, GSWA 171773.
(16) S. Reddy, 2003, written communication.
(17) J. Halilovic et al., 2004, Precambrian Research, v. 128, p. 343–366.
(18) D. R. Nelson, 2001, GSWA geochronology dataset, GSWA 132415.
(19) D. R. Nelson, 1997, GSWA geochronology dataset, GSWA 118995; F. Pirajno, 2002, GSWA Report 82.
(21) B. Rasmussen and I. R. Fletcher, 2002, Earth and Planetary Science Letters, v. 197, p. 287–299.
(23) D. R. Nelson, 1997, GSWA geochronology dataset, GSWA 118996.
(24) D. R. Nelson, 2002, GSWA geochronology dataset, GSWA 168984.
(25) D. R. Nelson, 1997, GSWA geochronology dataset, GSWA 142815.
(26) D. R. Nelson, 1999, GSWA geochronology dataset, GSWA 148397.

Interpreted geochronology:
(2) L. Bagas, 2003, GSWA Annual Review 2002–03, p. 43–52.
(5) L. Bagas, 2004, Lamil (sheet 3254): GSWA 1:100 000 Geological Series.
(7) D. B. McMartin and A. M. Thorne, 2002, GSWA Record 2005/15, p. 6–7.
(8) D. B. McMartin and A. M. Thorne, 2004, Precambrian Research, v. 128, p. 385–409.
(12) D. B. McMartin, 2003, GSWA Annual Review 2002–03, p. 53–59.
(20) S. Sheppard et al., 2001, GSWA Record 2001/5, p. 3–4.
(22) S. A. Occhipinti et al., 2004, Precambrian Research, v. 148, p. 237–255.

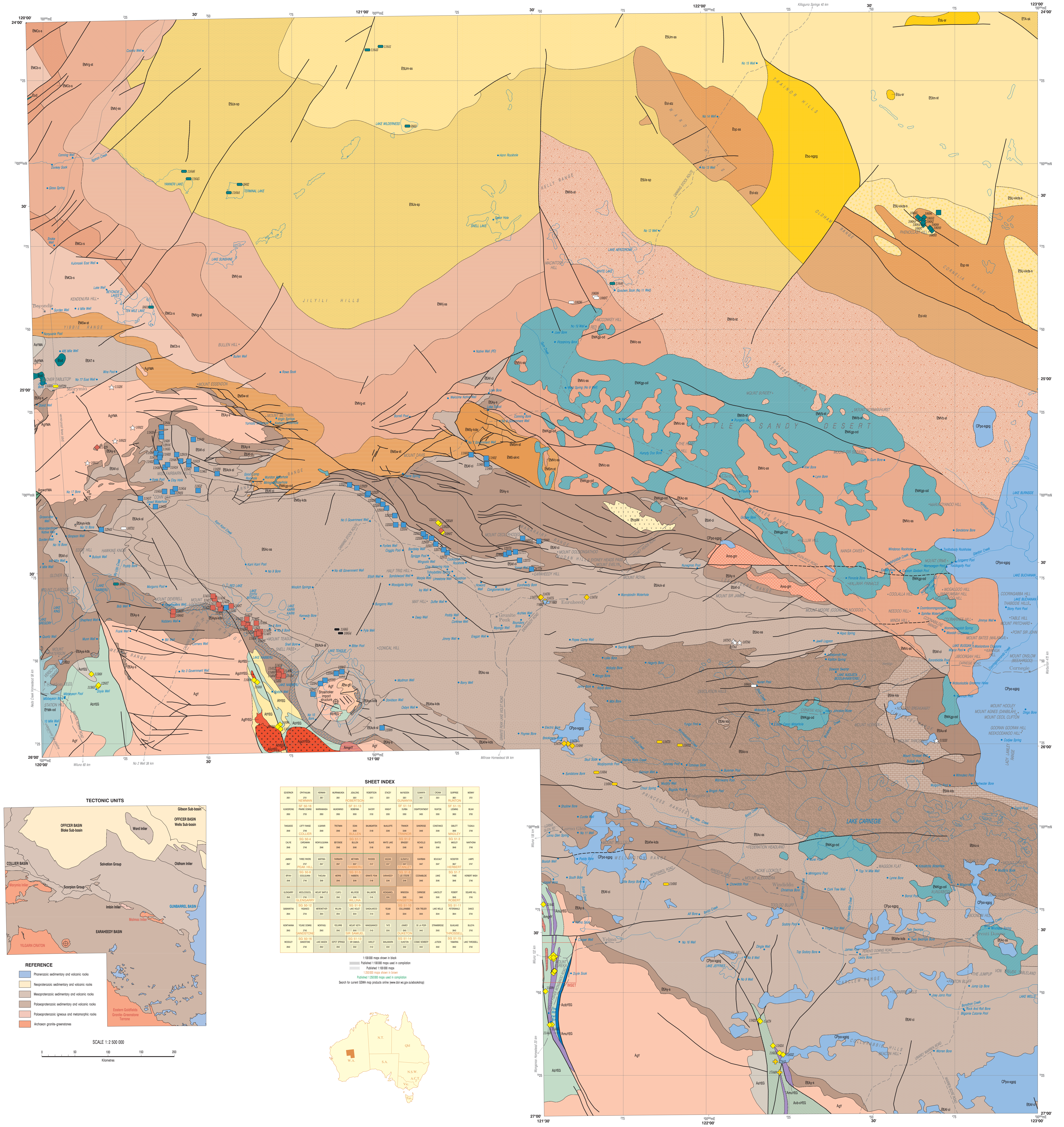
Edited by C. Strong and C. Brien

Cartography by D. Ladbrook

Published by the Geological Survey of Western Australia. Digital and hard copies of this map are available from the Information Centre, Department of Industry and Resources, 100 Plain Street, East Perth, WA, 6004. Phone (08) 9222 3459, Fax (08) 9222 3444

Web www.doir.wa.gov.au   Email geological.survey@doir.wa.gov.au

The recommended reference for this map is:
ABEYSINGHE, P. B., and HOCKING, R. M., 2005, Mineralization and geology of the Earaheedy area (scale 1:500000): Western Australia Geological Survey, Report 96, Plate 1.



TECTONIC UNITS

REFERENCE

🟦	Phanerozoic sedimentary and volcanic rocks
🟨	Neoproterozoic sedimentary and volcanic rocks
▨	Mesoproterozoic sedimentary and volcanic rocks
▨	Palaeoproterozoic sedimentary and volcanic rocks
▨	Palaeoproterozoic igneous and metamorphic rocks
🟧	Archaean granite–greenstones

SCALE 1:2 500 000
0 50 100 150 200
Kilometres

SHEET INDEX

1:100 000 maps shown in black
▨ Published 1:100 000 maps used in compilation
▨ Published 1:100 000 maps
1:250 000 maps shown in brown
Published 1:250 000 maps used in compilation
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PHANEROZOIC / PALAEOZOIC / CARBONIFEROUS–PERMIAN		CPpa-sgpg	**PATERSON FORMATION:** conglomerate with sandstone and siltstone; generally of glacigene origin	GUNBARREL BASIN
NEOPROTEROZOIC	c. 510 Ma [1]	Ɛod	Dolerite dyke, sill, and plug; fine- to medium-grained dolerite	

Paterson Orogeny (c. 550 Ma) [2]

<600 Ma [3]		Ƥdu-sr	**DURBA SANDSTONE:** sandstone, pebbly in places; minor conglomerate	OFFICER BASIN; CENTRALIAN SUPERBASIN
	Disappointment Group	ƤDlm-st	**McFADDEN FORMATION:** sandstone; minor siltstone and conglomerate	
c. 600 Ma [3] <752 Ma [4]		Ƥbo-sgpg	**BOONDAWARI FORMATION:** conglomerate, sandstone, siltstone, diamictite, and dolomite; fluvial and fluvioglacial origin	

Miles Orogeny (c. 720 Ma) [5]

	Sunbeam Group	ƤSU-xkds-s	**SKATES HILLS FORMATION:** stromatolitic dolomite, sandstone, siltstone, chert, and basal conglomerate; evaporite pseudomorphs	OFFICER BASIN; CENTRALIAN SUPERBASIN
	Sunbeam Group	ƤSUm-ss	**MUNDADJINI FORMATION:** sandstone, siltstone, and minor conglomerate, shale, mudstone, and dolomite (locally stromatolitic); evaporite pseudomorphs	
	Sunbeam Group	ƤSUs-sp	**SPEARHOLE FORMATION:** sandstone, in part pebbly, siltstone, and local conglomerate lenses	
<1064 Ma [6]		ƤTA-sk	**Tarcunyah Group:** undivided; sandstone, siltstone, mudstone, and stromatolitic and non-stromatolitic dolomite; minor conglomerate	

Edmundian Orogeny (1070–755 Ma) [7 8]

MESOPROTEROZOIC; c. 1070 Ma [9]	Warakurna Large Igneous Province	ƤWKgp-od	**GLENAYLE and PRENTI DOLERITES:** dolerite sill, dyke, and plug; fine- to coarse-grained dolerite	
	Salvation Group	ƤMVj-ss	**JILYILI FORMATION:** sandstone and siltstone; minor shale, mudstone, and conglomerate	
<1230 Ma [10]	Salvation Group	ƤMVb-st	**BRASSEY RANGE FORMATION:** sandstone; lesser siltstone and shale	
	Salvation Group	ƤMVg-st	**GLASS SPRING FORMATION:** sandstone; minor conglomerate and siltstone	
<1330 Ma [11]	Salvation Group	ƤMVc-ss	**COONABILDIE FORMATION:** sandstone, micaceous siltstone, and shale	
c. 1070 Ma [5]	Collier Group	ƤMCc-s	**CALYIE FORMATION:** quartz sandstone, and minor siltstone, mudstone, conglomerate, and dolostone	COLLIER BASIN
	Collier Group	ƤMCb-s	**BACKDOOR FORMATION:** siltstone, mudstone, and thin- to thick-bedded sandstone; minor chert and dolostone	COLLIER BASIN
<1210 Ma [9 12] <1340 Ma [13]		Ƥol-stz	**OLDHAM SANDSTONE:** silicified quartz sandstone; local pebbly lenses	Ward and Oldham Inliers
<1670 Ma [14]		Ƥqc-ss	**QUADRIO FORMATION and CORNELIA SANDSTONE:** shale, siltstone, chert, and minor sandstone; quartz sandstone to quartzite, and minor siltstone	Ward and Oldham Inliers
1460 Ma [7]	Scorpion Group	ƤMS-skvc	**Scorpion Group:** undivided; evaporitic and stromatolitic dolomite, and sandstone; lesser siltstone	
	Scorpion Group	ƤMSm-st	**MILLURY FORMATION:** quartz sandstone; minor siltstone, local evaporite pseudomorphs	
	Scorpion Group	ƤMSy-kds	**WILLY WILLY FORMATION:** interbedded stromatolitic dolomite and siltstone; minor sandstone	
<1750 Ma [15]	Scorpion Group	ƤMSw-st	**WONYULGUNNA SANDSTONE:** quartz sandstone; minor cobble conglomerate, siltstone, and mudstone	

Stanley Fold Belt (1790–1650 Ma) [16]

PALAEOPROTEROZOIC; <1808 Ma [17]	Earaheedy Group	ƤEAu-st	**MULGARRA SANDSTONE:** sandstone; minor shale, limestone, and granule conglomerate; locally glauconitic	EARAHEEDY BASIN
	Earaheedy Group	ƤEAk-kls	**KULELE LIMESTONE:** stromatolitic limestone, micaceous siltstone, mudstone, and fine-grained sandstone	
	Earaheedy Group	ƤEAo-s	**WONGAWOL FORMATION:** sandstone, shale, dolomite, dolomitic siltstone, and conglomerate	
	Earaheedy Group	ƤEAT-s	**Tooloo Subgroup:** undivided; siltstone, sandstone, dolomite, and granular iron-formation	
<1876 Ma [17]	Earaheedy Group	ƤEAc-ss	**CHIALL FORMATION:** undivided; siltstone and sandstone; minor conglomerate	
	Earaheedy Group	ƤEAck-sl	**Karri Karri Member:** shaly siltstone	
	Earaheedy Group	ƤEAfw-kds	**FRERE FORMATION** **Windidda Member:** stromatolitic limestone and siltstone, jasper, and peloidal jasper	
	Earaheedy Group	ƤEAf-ci	Undivided; peloidal chert, granular iron-formation, granular siliceous iron-formation, siltstone, and sandstone	
<1990 Ma [18]	Earaheedy Group	ƤEAys-kds	**YELMA FORMATION** **Sweetwaters Well Member:** stromatolitic dolomite and limestone; lesser siltstone and sandstone	
<2027 Ma [19]	Earaheedy Group	ƤEAy-s	Undivided; sandstone, dolomite (locally stromatolitic), siltstone, and shale; minor conglomerate and limestone	

Capricorn Orogeny (1830–1780 Ma) [20]

c. 1840 Ma [21]	Mooloogool Group	ƤYMk-od	**KILLARA FORMATION** Dolerite sills; locally intercalated with tholeiitic basalt	YERRIDA BASIN

Glenburgh Orogeny (2005–1960 Ma) [22]

PROTEROZOIC; c. 1990 Ma [18]		ƤfcpIM	Porphyritic rhyodacite	Imbin Inlier
ARCHAEAN; c. 2550 Ma [24]		Ama-gm	**MALMAC GRANITE:** weathered monzogranite	Malmac Inlier; YILGARN CRATON

AgY AmgnY Ætе-gfl

AgY Granitic rock
c. 2650 Ma [25] AmgnY Quartzofeldspathic granitic gneiss; locally migmatitic; includes local mafic bands and enclaves
c. 2648 Ma [23] Æte-gfl **TEAGUE GRANITE:** leucocratic K-feldspar granite and quartz syenite; within Shoemaker Impact Structure

AgchYEG AgflYEG

c. 2664 Ma [26] AgchYEG Hornblende quartz monzonite
AgflYEG Leucocratic K-feldspar granite

AsYEG AcibYEG AfYEG AfaYEG
AbYEG Axb-sYEG AmuYEG

AsYEG	Siliciclastic sedimentary rock, undivided; includes sandstone, siltstone, shale, and chert; metamorphosed
AcibYEG	Banded iron-formation
AfYEG	Felsic volcanic and volcaniclastic rocks, undivided; metamorphosed
AfaYEG	Andesite, commonly with plagioclase and/or hornblende phenocrysts; metamorphosed
AbYEG	Mafic volcanic rock, undivided; metamorphosed
Axb-sYEG	Interlayered mafic volcanic rocks and siliciclastic sedimentary rocks; metamorphosed
AmuYEG	Metamorphosed ultramafic rock, undivided; includes talc–chlorite(–carbonate) and tremolite–chlorite schist

East Yilgarn Granite–Greenstone Terrane

AgYMA Granitic rock

AsYMA AmwaYMA

AmwaYMA	Amphibolite
AsYMA	Siliciclastic sedimentary rock, undivided; includes sandstone, siltstone, shale, and chert; metamorphosed

Marymia Inlier
YILGARN CRATON

Department of Industry and Resources
ALAN CARPENTER, M.L.A.
MINISTER FOR STATE DEVELOPMENT
JIM LIMERICK
DIRECTOR GENERAL

Geological Survey of Western Australia
TIM GRIFFIN
DIRECTOR

SCALE 1:500 000
5000 0 5 10 15 20 25 30 35 40 45 50
Metres 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 51

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 96 PLATE 1

MINERALIZATION AND GEOLOGY OF THE EARAHEEDY AREA

Version 1.1 — August 2005