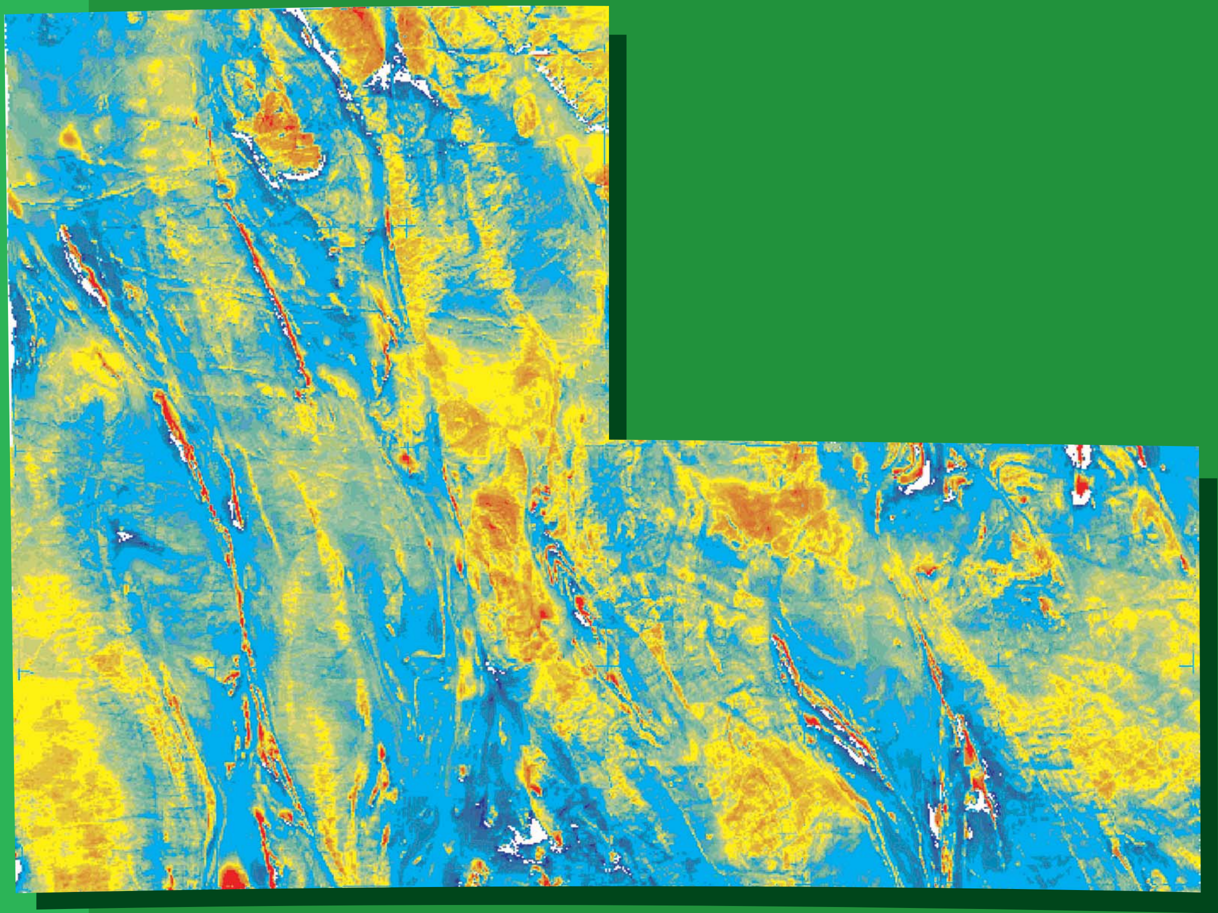
REPORT
83

GOVERNMENT OF
WESTERN AUSTRALIA

EAST YILGARN GEOSCIENCE DATABASE 1:100 000 GEOLOGY OF THE NORTH EASTERN GOLDFIELDS PROVINCE — AN EXPLANATORY NOTE

by P. B. Groenewald, M. G. M. Painter, and M. McCabe



GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

DEPARTMENT OF MINERALS AND ENERGY

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Cover photograph:
Airborne magnetic survey of the north Eastern Goldfield Province, covering the WILUNA, SIR SAMUEL, and DUKETON 1:250 000 sheets, as provided in simplified form (400 m pixels) in the database (data from AGSO).

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East Yilgarn Geoscience Database, 1:100 000 geology of the north Eastern Goldfields Province — an explanatory note

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P. B. Groenewald, M. G. M. Painter, and M. McCabe

Abstract

Eighteen published 1:100 000-scale geological maps of the north Eastern Goldfields Province, Western Australia, are collated as geospatially referenced digital information in Phase 2 of the East Yilgarn Geoscience Database project. The 50 000 km^2 area of the WILUNA, SIR SAMUEL, and DUKETON 1:250 000 map sheets, extending from Cunyu to Cosmo Newbery, includes the Agnew–Wiluna, Yandal, and Duketon greenstone belts. Original map boundary discrepancies have been resolved and standardized rock type definitions applied to provide a seamless map of outcrop and regolith. Additional data themes include aeromagnetic constraints on concealed lithological and structural features; a 1:500 000-scale interpretation of Precambrian geology beneath younger cover; mine site, mineral occurrence, and exploration records; mineral resource locations and statistics (MINEDEX); tenement distribution and status information (TENGRAPH); and pseudocolour images derived from Landsat TM data.

The outcrop geology of this poorly exposed region reveals only segments of Archaean lithostratigraphy, with little continuity within the greenstone belts and no definitive data to allow correlation between them. Interpretations of tectonic settings and the complex deformation history are limited by the lack of fresh outcrop. Geochronology constrains crustal development to between 2750 and 2640 Ma, with xenocrystic zircons in felsic volcanic rocks indicating an as yet unrecognized 3000 Ma or older sialic source region. Extensive outcrops of the Palaeoproterozoic Yerrida and Earaheedy Groups, in the northwest and northeast respectively, represent depositional basins associated with the Capricorn Orogen. There are a few minor exposures of Permian conglomerates and sandstones. Most of the area is covered by transported and residual regolith.

There is gold mineralization in all the major greenstone belts, and despite more than a century of highly productive mining, the combined identified gold resources discovered in the area during the last decade are estimated to exceed 17 million ounces. More than 0.5 million tonnes of nickel have been mined from predominantly disseminated sulfide deposits in the Agnew–Wiluna belt since 1978, and considerable reserves remain.

KEYWORDS: Archaean geology, greenstones, GIS data base, Yilgarn Craton, Eastern Goldfields, Yandal, Agnew–Wiluna, Duketon, remote sensing, mineral resources, gold, nickel.

Introduction

The Geological Survey of Western Australia (GSWA) and the Australian Geological Survey Organisation (AGSO) have collaborated in the National Geological Mapping Accord (NGMA) to complete geological mapping of the Eastern Goldfields region. Eighteen published NGMA 1:100 000-scale geological maps (Table 1, Figs 1 and 2), covering the northernmost 50 000 km^2 of the Eastern Goldfields region between Cunyu and Cosmo Newbery, are collated in this Report as a seamless digital dataset that represents the second phase of the East Yilgarn Geoscience Database. Phase 1 of this database comprises twenty NGMA 1:100 000-scale maps covering the southernmost part of the Eastern Goldfields region (Groenewald et al., 2000). The continued upgrading and expansion of this database, in combination with ongoing advances in information technology that allow rapid manipulation and analysis of great volumes of information, will maintain currency of a spatial data resource for future advances in mineral exploration.

This Report provides an explanation of the nature and origin of the digital themes into which the data have been divided, with details of metadata and attribute and look-

Table 1. The eighteen 1:100 000-scale geological maps collated in the second phase of the East Yilgarn Geoscience Database project

Sheet	*Number*	*Source*	*Map reference*	*Explanatory Notes reference*
BANJAWARN	3242	GSWA	Farrell and Griffin (1997)	
COSMO NEWBERY	3442	GSWA	Griffin and Farrell (1998)	
DE LA POER	3443	AGSO	Stewart (1996)	Stewart (1999)
DUKETON	3342	GSWA	Farrell and Langford (1996)	Langford and Farrell (1998)
TATE	3243	AGSO	Champion (1996)	
URAREY	3343	AGSO	Champion and Stewart (1994)	Stewart (1999)
DARLOT	3142	GSWA	Wyche and Westaway (1996)	Westaway and Wyche (1998)
DEPOT SPRINGS	2942	GSWA	Wyche and Griffin (1998)	
MOUNT KEITH	3043	AGSO	Jagodzinski et al. (1997)	Jagodzinski et al. (1999)
SIR SAMUEL	3042	GSWA	Liu et al. (1996)	Liu et al. (1998)
WANGGANNOO	3143	AGSO	Lyons et al. (1996)	
YEELIRRIE	2943	AGSO	Champion and Stewart (1998)	
BALLIMORE	3145	AGSO	Blake and Whitaker (1996a)	Whitaker et al. (2000)
CUNYU	2945	GSWA	Adamides et al. (1998)	Adamides et al. (1999)
LAKE VIOLET	3044	AGSO	Stewart and Bastrakova (1997)	Stewart (1997)
MILLROSE	3045	GSWA	Farrell and Wyche (1997)	Farrell and Wyche (1999)
SANDALWOOD	3144	AGSO	Blake and Whitaker (1996b)	Whitaker et al. (2000)
WILUNA	2944	GSWA	Langford and Liu (1997)	Langford et al. (2000)

up tables provided in the readme and data dictionary files on the accompanying compact discs. Although summaries of the geological setting and economic geology are provided, for more detailed information the user is referred to numerous other publications, including the Explanatory Notes produced in conjunction with the original maps (Table 1). Rock types and the identification codes used in the map data are defined in Appendix 1.

Location, access, and physiography

This dataset comprises eighteen 1:100 000-scale maps in the areas between latitudes 26°S and 28°S and longitudes 120°E to 123°E, equivalent to the WILUNA* (SG 51-9), SIR SAMUEL (SG 51-13), and DUKETON (SG 51-14) 1:250 000 maps (Figs 1 and 2).

The sealed Goldfields Highway passes through the western part of the area (Fig. 2), and continues as the unsealed road from Wiluna to Meekatharra, allowing access to the northwestern limits of the area. Good-quality gravel roads extend east from Wiluna to the Granite Peak, Lorna Glen, and Wongawol homesteads. A sealed road from Leinster to Sandstone traverses the southwestern part of the area. An unsealed road extends northeast from Leinster to the Bronzewing gold mine, and joins the unsealed road that leaves the Goldfields Highway 35 km south of Leinster and extends to Millrose in the north. In the southwest, unsealed roads connect the Duketon mining centre to Laverton, and the Banjawarn Homestead. Unsealed roads to several minor mining centres and pastoral holdings, together with fence-line tracks, provide reasonable access throughout the area.

* Capitalized names refer to standard 1:100 000 map sheets, unless otherwise indicated.

The landscape is relatively subdued, with elevation ranging from 430 to 650 m above the Australian Height Datum (AHD). The physiography comprises three main landform components, all related to the underlying geology:

- Several large playa lakes, claypans, and associated alluvial channels represent southeasterly to easterly trending palaeodrainage systems that have evolved since the Early Cretaceous. The lakes are flanked by dunes of quartz sand or gypsum (or both) that are typically stabilized by vegetation. These dunes separate many small lakes and saltpans.
- Expanses underlain by gneiss and granitoid rocks are undulating plains, typically comprising sandy soils that commonly overlie siliceous duricrust, which in turn overlies kaolinitized granite, as revealed in the common breakaways. The extensive areas covered by siliceous or ferruginous duricrusts ('laterite' in many early descriptions) suggest a considerable period in which no appreciable erosion occurred.
- The greenstones commonly form subdued strike ridges, with low plateaus of duricrust and deeply weathered bedrock. Outcrop amounts to less than 10% of the area and is commonly of poor quality and deeply weathered. The most pronounced topography in the area is in the area west of Mount Alice (MGA 226540 7079500), where flat-lying sandstones and dolerites cap the hills at about 640 m AHD.

The database

The original versions of the 1:100 000-scale geological maps were created either through direct digital compilation by AGSO geologists, or digitizing of hand-drawn compilations to generate the GSWA maps. Precision and fidelity of data transfer to the format appropriate for the current work was maintained through comparison with the

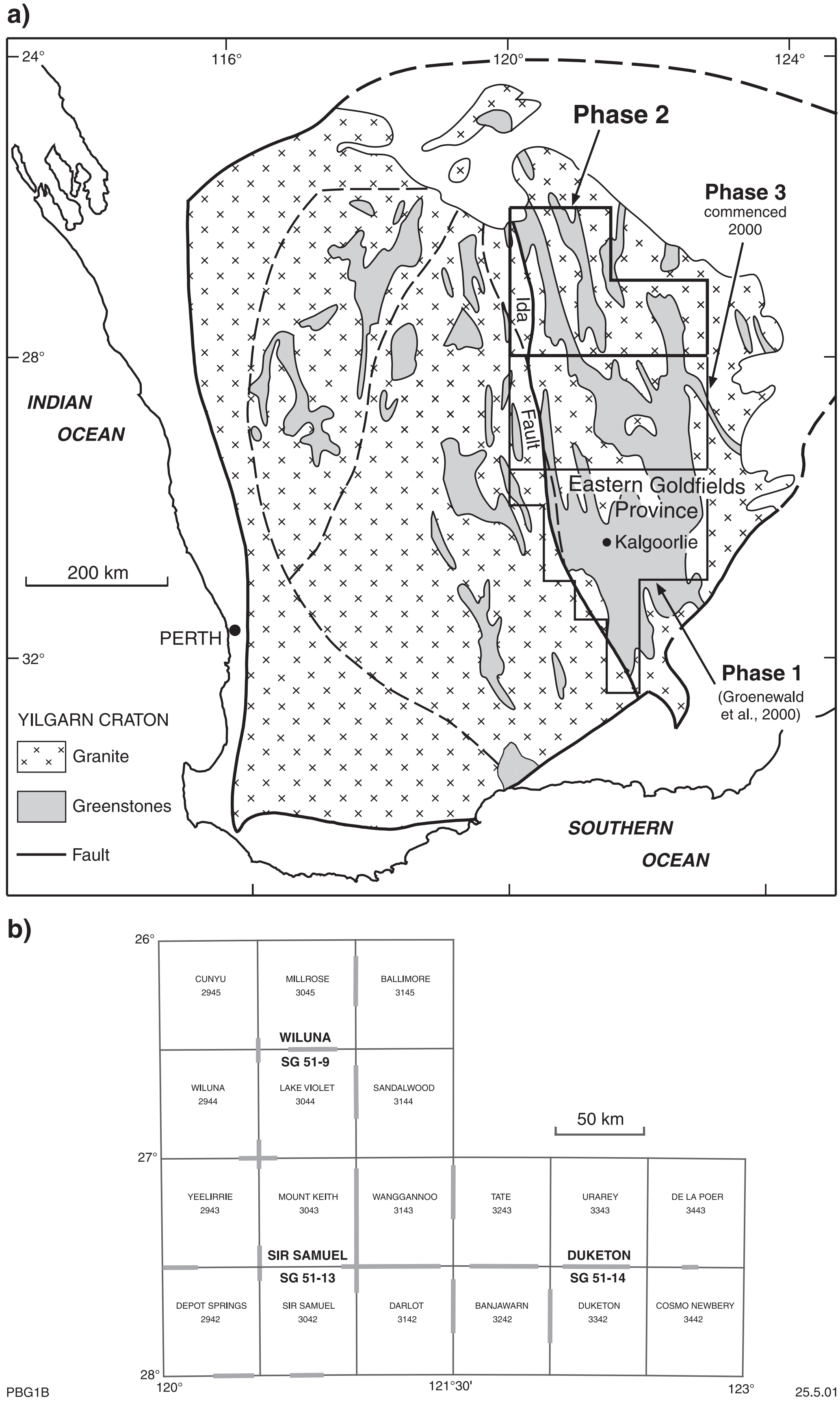


Figure 1. a) Areas covered in the first and second phases of the East Yilgarn Geoscience Database project; b) The 1:100 000-scale maps collated in the database. Margins adjusted in this compilation are indicated by heavy line segments

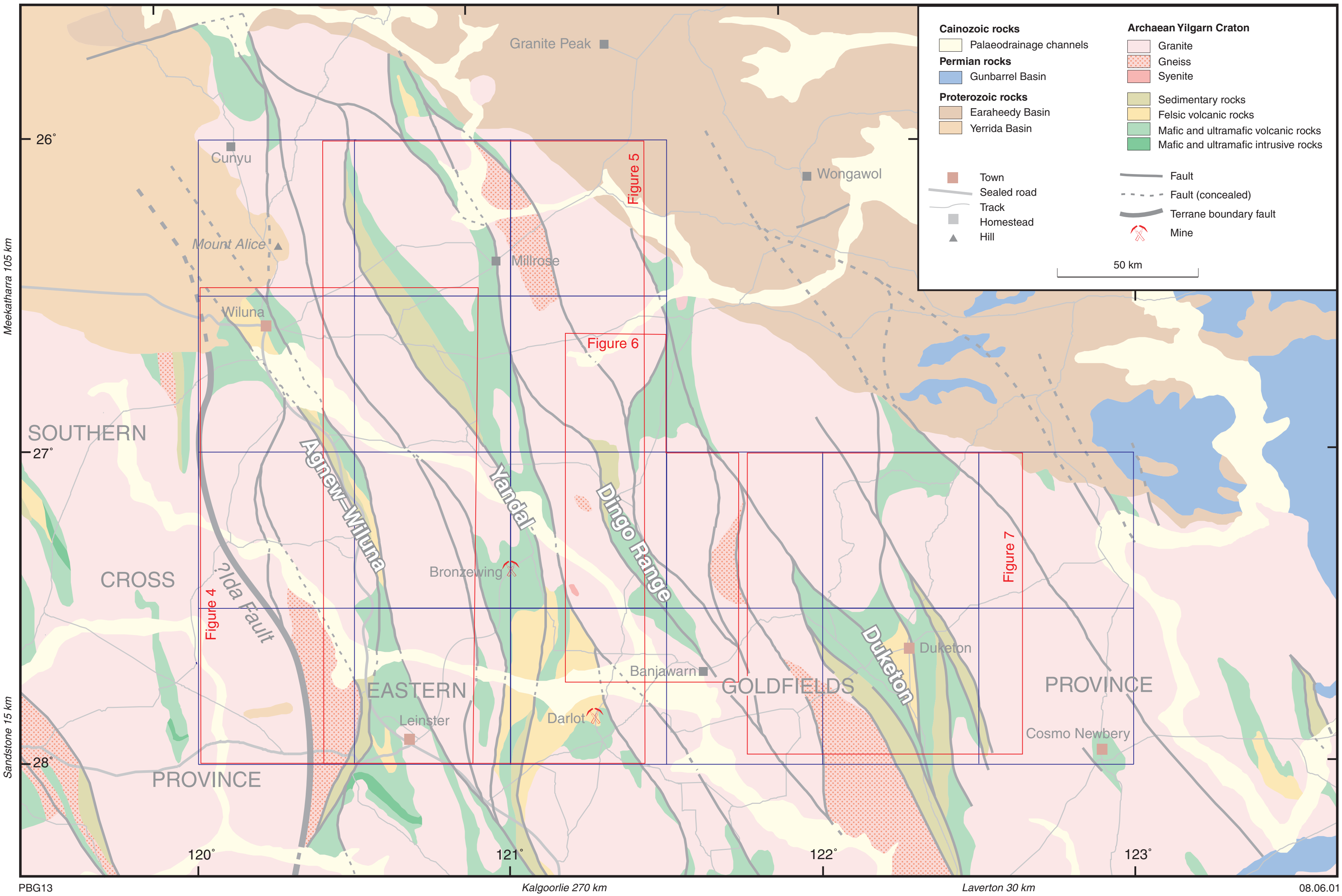


Figure 2. Simplified regional geology of the north Eastern Goldfields Province, covering the WILUNA, SIR SAMUEL, and DUKETON 1:250 000 sheets (modified from Ferguson, 1998). The greenstone belts are labelled in white

published maps. Any discrepancies between adjacent published 1:100 000-scale map sheets were resolved to provide seamless continuity. Most adjustments could be made confidently after examination of aerial photographs or Landsat TM (Thematic Mapper) images, although remapping along the boundaries between several adjacent maps (Fig. 1b) was needed to confirm the continuity, identity, and distribution of several rock units or structural features.

Attention has been paid to the definition of geological rock units or subdivisions shown on the maps, with checking of field notes, Explanatory Notes, or other published material to allow application of the standardized codes developed for Phase 1 of the database (Groenewald et al., 2000). Where necessary, new rock codes have been added to the standardized set. Definitions of all the codes applied in the database are provided in Appendix 1.

The database was assembled using Environmental Systems Research Institute (ESRI) computer software ArcInfo 8.0.1 to yield seamless layers within a digital map library. This library was then converted into formats suitable for application of the popular GIS software packages ArcView, ArcExplorer, and MapInfo. Details of the directory structure, data dictionary, and other metadata are provided in text files on the compact disk.

Themes

Geology

The outcrop geology is recorded in several layers according to data type. The outcrop position and extent are either polygons or lines, depending on the form of the rock units. Planar units that intersect the surface but have widths too narrow to be represented as polygons on the original maps are presented as linear features. Attributes of each rock unit include an identification label code, for which standardized definitions suitable for a map legend in hard copy form are provided in look-up tables. Subsurface records of lithologies (drillholes, costeans) are provided as points in the mine workings and exploration coverage (see below). Recognized faults or shears are included in the line data layer. The concealed geology layer shows the inferred positions of geological boundary features, faults, and dykes interpreted from aeromagnetic images. Structural orientation records are in a point data layer, with measurements provided in the clockwise format (with dip direction taken as 90° greater than strike). Outcrop fold annotation is also provided in the point data layer.

Figure 3 shows an example of the outcrop geology content of the database and possible data combinations that can be generated using the various themes described below.

Regional interpreted bedrock geology

The interpreted bedrock geology theme provided in the database is a map of the interpreted distribution of Precambrian rock types beneath younger cover. This has been duplicated from the base map used to relate mineralization to geological settings in the north Eastern Goldfields Province (Ferguson et al., 1998). Once again, polygon, line, and point data are in separate layers. Note that the map of interpreted solid geology was compiled for presentation at a scale of 1:500 000 and thus may not conform precisely to the 1:100 000-scale outcrop maps.

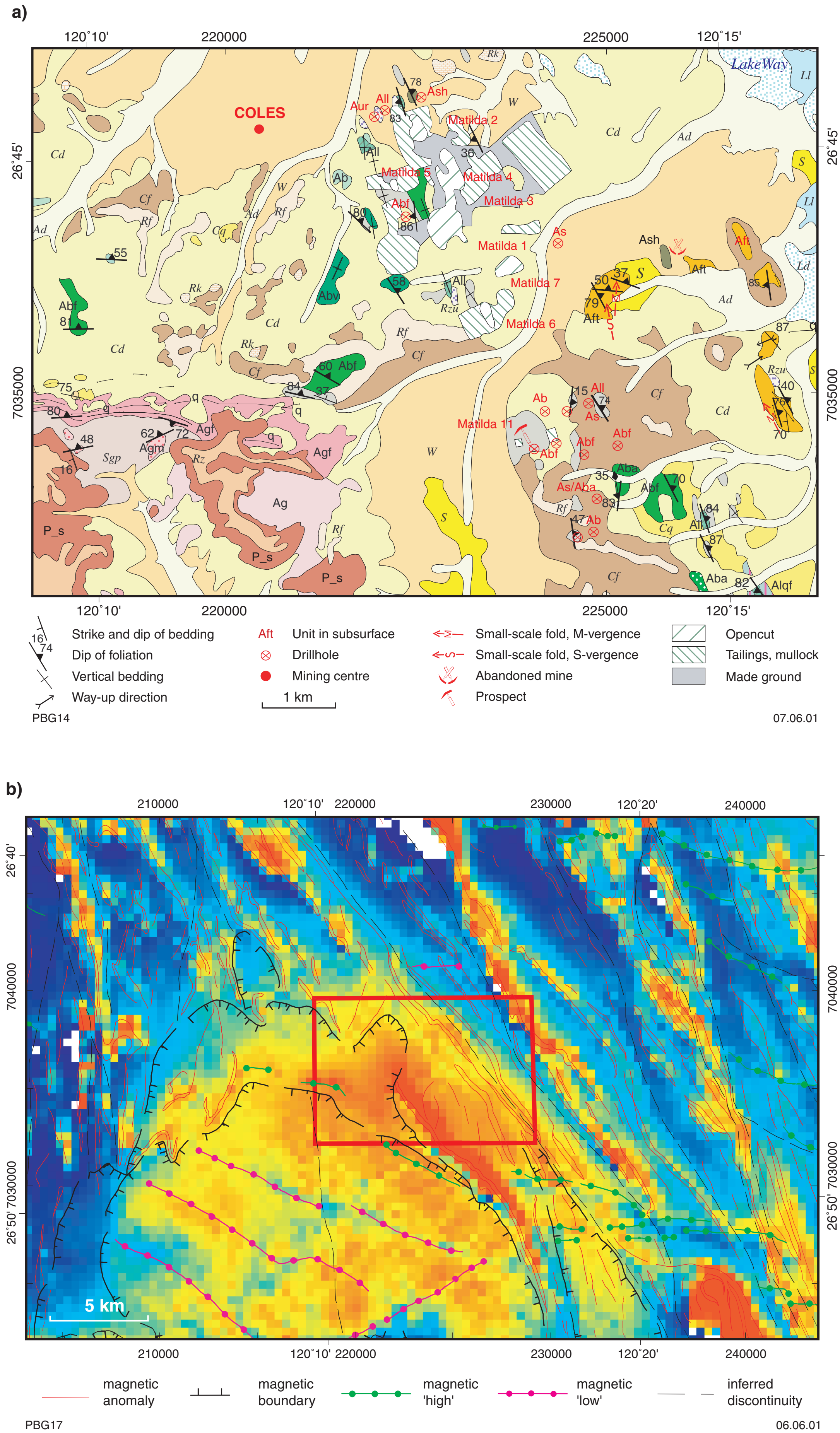
Airborne magnetic survey

The airborne magnetic survey theme has been derived from the historic Bureau of Mineral Resources (BMR, now AGSO) and AGSO datasets. The false-colour image has been rendered in red, green, and blue intensity layers to allow replication of the standard geophysical pseudocolour spectrum in ArcView. Although the pixel size of 400 m used in this coverage may not allow detailed interpretation of the outcrop geology at 1:100 000 scale, it does contribute to interpretation of the geology on a regional scale, particularly in areas of very poor outcrop. More detailed geophysical data, based on airborne magnetic and radiometric surveys using 400 m flight-line spacing, may be purchased from AGSO. The magnetic features identified in this detailed coverage are provided as a line theme in the present database. This represents features in the original digital data, such as linear anomalies, boundaries around zones of different magnetic texture, and inferred discontinuities. This information was not inferred with reference to geological characteristics and is not a geological interpretation. Examination of the features in conjunction with geological mapping may assist with interpretation of structures, boundaries, and magnetic anomalies.

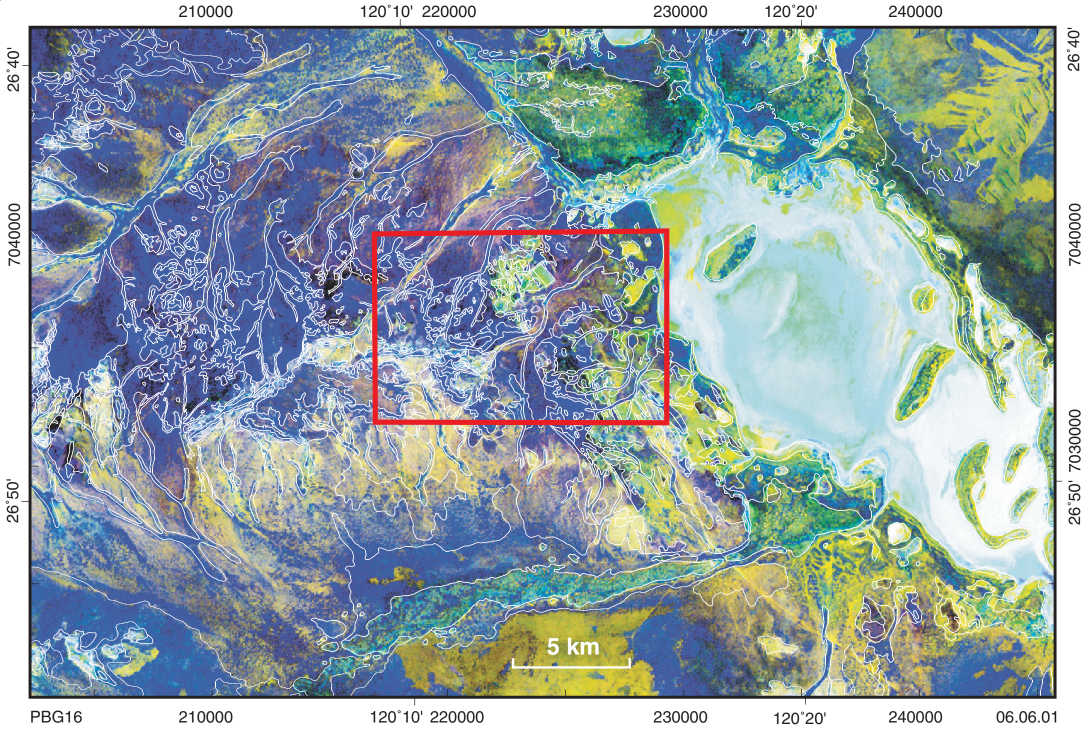
Landsat TM layers

Two images were prepared from Landsat TM data collected in January and February 1998, providing coverage in which many of the recent exploration grids are visible. A mosaic of the data provides seamless coverage through correlation of invariant targets in areas of overlap and normalization through robust regression techniques by the Western Australian Department of Land Administration (DOLA). Spatial accuracy better than 50 m and pixel size of 25 m have been preserved. The data have undergone decorrelation stretch processing. Raw data may be obtained from the Satellite Remote Sensing Services branch of DOLA.

A monochromatic (grey-scale) layer shows principal component values derived from Landsat TM bands 1, 4, and 7 using standard eigenvector formulae. In addition, a pseudocolour image was prepared using ratios between bands 2, 3, 4, 5, and 7 to distinguish between iron- and silica-rich areas, and vegetation- and outcrop-dominated areas. Light-tan colouration is equivalent to recent alluvium, the lakes are light blue, mafic rock outcrops commonly range from purple through Prussian blue to lighter blue-green, lateritic areas are dark brown, and kaolinite-enriched areas (granitic) are a bluish off-white.


a)
120°10'
220000
225000
120°15'
26°45'
7035000
LakeWay
COLES
Matilda 1
Matilda 2
Matilda 3
Matilda 4
Matilda 5
Matilda 6
Matilda 7
Matilda 11
Strike and dip of bedding
Dip of foliation
Vertical bedding
Way-up direction
Aft
Unit in subsurface
Drillhole
Mining centre
1 km
Small-scale fold, M-vergence
Small-scale fold, S-vergence
Abandoned mine
Prospect
Opencut
Tailings, mullock
Made ground
PBG14
07.06.01
b)
210000
120°10'
220000
230000
120°20'
240000
26°40'
7040000
7030000
26°50'
5 km
magnetic anomaly
magnetic boundary
magnetic 'high'
magnetic 'low'
inferred discontinuity
PBG17
06.06.01

c)



d)

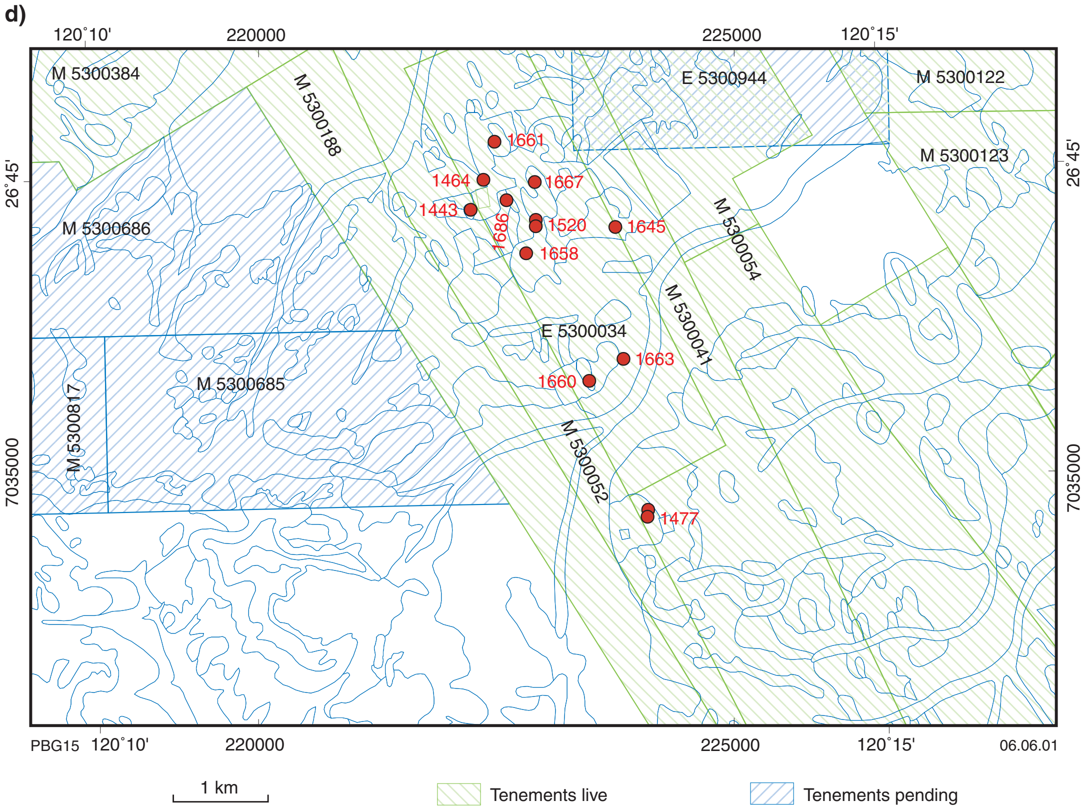


Figure 3. Illustrative plots generated from the database for a small part of coverage, located as shown in Figure 4: a) Outcrop geology, (rock types coded as in Appendix 1), with standard structural symbols, mine site, and subsurface data points. b) Magnetic coverage (image has 400 m pixels), with features interpreted from detailed surveys. The red box indicates the area shown in (a). c) Landsat TM coverage of the area shown in (b), with the observed geological boundaries superimposed on the pseudocolour image. The red box indicates the area shown in (a). d) TENGRAPH and MINEDEX coverage of the area shown in (a), illustrating the way in which tenement extent and status may be shown together with mineral resource indexing

Localities of mine workings, prospects, and subsurface observations

Information in this theme has been taken directly from the eighteen published 1:100 000-scale geological maps for the region, on which are shown localities of historical and currently operating (at map publication date — see Table 1) mines and batteries, as well as prospects, mineral occurrences, and subsurface rock types revealed by mineral exploration. In view of the predominance of gold workings in the area, a mine site in the database is only labelled with a commodity code when it is not gold. The high level of exploration activity throughout the region in the 1980s and 1990s resulted in a marked increase in the resource inventory, particularly near abandoned mines. For this reason, the more recent findings, as shown by the Department of Minerals and Energy's (DME's) mines and mineral deposits information database (MINEDEX; see below), may bear historical names for localities slightly different from those shown in the historical mine-workings dataset. Similarly, present large-scale opencut mining operations have commonly amalgamated several historical mine sites.

MINEDEX — mineral resources

The extract from the MINEDEX database included in the present database provides the following information, either directly as point attribute information or in look-up tables:

- commodity groups, projects, and sites;
- corporate ownership and percentage holding;
- site type and stage of development;
- site coordinates;
- current (at date of compact disc compilation) mineral resource estimates.

Details of the classifications and abbreviations used in the tables are provided in Appendix 2.

TENGRAPH — a record of the extent, location, and status of tenements

The tenement information, extracted from DME's electronic tenement graphics system (TENGRAPH), within the database (current at the date of compact disc compilation) demarcates the extent and location of tenements, with the following additional data in the attribute table:

- tenement identification (Tenid; e.g. M 2600261 refers to mining licence M 26/261;
- survey status (Survstatus), indicating whether or not the tenement has been surveyed;
- status of the tenement (Tenstatus), referring to whether the tenement application has been granted (L) or is under application (P);
- dates and times of submission of application, granting, and expiry of tenement holding.

In view of the continuous and ongoing changes in the tenement situation, current tenement plans should be consulted at the DME offices in Perth and Kalgoorlie before any landuse decisions or tenement applications are made.

RoxMap.WA — map extraction from the database

At the Kalgoorlie or Perth offices of GSWA, public access to the East Yilgarn Geoscience Database is provided by RoxMap.WA, a computer program that allows selected maps to be generated. Plots may be made of geological, MINEDEX, and TENGRAPH data, selected in terms of content, scale, and extent, for any area covered by the East Yilgarn Geoscience Database. Appropriate legends and marginalia are created automatically. The map layout has been modelled on GSWA's standard 1:100 000-scale map product, with adjustments to meet the diverse demands of variable scale and size. In addition to a standard locality diagram, showing the extent and position of the map created relative to a quarter-degree index grid, the context of the plotted area is illustrated on a regional interpretation of the Precambrian geology. The currency and source of themes plotted is listed, together with the date and time of extraction.

When creating a map, parameters must be selected from three ranges of alternatives, as follows:

- page size — A0, A1, A2, A3, or A4;
- scale — 1:25 000, 1:50 000, 1:100 000, or 1:250 000;
- one or more of the themes — outcrop geology, structural line features, structural point features, interpreted geology, MINEDEX, mining–subsurface data, tenements, and topography (localities and roads only). The user may choose whether or not the selected features are labelled individually.

Some limitations on the map product are necessary to conform to available space on the various page sizes; for example, the 1:250 000-scale maps can only be plotted on an A0 or A1 page, whereas the A4 and A3 plots are limited to a scale of 1:25 000 or 1:50 000. The reason for this is that legends are generated for the area covered by each map, and certain combinations of scale and extent yield legends too large to fit in the space available on the smaller pages. In the case of the A4 page size, the legend plots as a second page.

The area to be shown in the map is chosen interactively after selection of the three primary parameters. A simplified topocadastral or interpreted regional geology map of the area covered by the database is shown, together with a mobile rectangle illustrating the extent of the area allowed by the selected parameters. This mobile rectangle is positioned by the viewer on the selected area and the chosen map will be generated. Alternatively, coordinates of the center of the area to be plotted can be entered.

Geological setting of the north Eastern Goldfields Province

The Eastern Goldfields Province is a c. 2.7 Ga granite–greenstone terrain that makes up the eastern third of the Yilgarn Craton (Fig. 1a; Gee et al., 1981; Griffin, 1990; Myers, 1997). The western limit to the province, in the Menzies–Coolgardie area, is marked by the Ida Fault (Figs 1a and 2), which is an east-dipping, crustal-scale structure (Swager et al., 1997) separating the Eastern Goldfields greenstones from the largely older succession of the Southern Cross Province. The northward continuation of this fault is not well defined, but is inferred to lie west of the Agnew–Wiluna greenstone belt. The northern margin of the Eastern Goldfields Province is concealed beneath Proterozoic sedimentary rocks of the Yerrida and Earaheedy Basins, whereas Phanerozoic sedimentary rocks of the Gunbarrel Basin obscure the eastern margin.

The age of the Eastern Goldfields greenstones has been constrained to between 2750 and 2655 Ma by sensitive high-resolution ion microprobe (SHRIMP) U–Pb zircon analyses of various rock types (Kent and Hagemann, 1996; Nelson, 1997a,b, 1998, 2000; Krapez et al., 2000). Although no rock types older than 2.75 Ga have been identified in the Eastern Goldfields Province, pre-existing continental crust is suggested by the presence of xenocrystic zircons older than 3.0 Ga in felsic metavolcanic rocks (Compston et al., 1986; Nelson, 1997a), combined with geochemical evidence that the trace element characteristics of some mafic rocks represent contamination of primitive ultramafic magma by older sialic crust (Arndt and Jenner, 1986; Barley, 1986; Lesher and Arndt, 1995), and that the granitoids were generated through repeated crustal reworking (e.g. Wyborn, 1993). The possible basement has not been identified in the Eastern Goldfields Province. West of the Ida Fault, geochronological data indicate a c. 3.0 – 2.9 Ga age for the extensive mafic-dominated greenstones of the Southern Cross Province (Pidgeon and Wilde, 1990; Nelson, 1999). The locality of this boundary in the north Eastern Goldfields Province is uncertain and probably lies within the database area west of the Agnew–Wiluna greenstone belt (Fig. 2). Widespread felsic volcanism occurred in the Yilgarn Craton between c. 2.76 and 2.70 Ga (Pidgeon and Wilde, 1990; Pidgeon and Hallberg, 2000), with several such volcanic centres in the eastern part of the Eastern Goldfields Province.

The greenstones of the south Eastern Goldfields Province were subdivided into several postulated tectonostratigraphic ‘terranes’ bounded by major shear zones by Swager et al. (1990, 1995) and Swager (1995, 1997). Other interpretations have suggested subdivision into only two principal regions — a back-arc rift and a volcanic arc (Barley et al., 1989; Morris and Witt, 1997) — or into the Kalgoorlie and Edjudina–Laverton greenstones (Groenewald et al., 2000), with possible smaller structural domains within the lithotectonic settings. Extrapolation of suggested subdivisions to the north is hampered by the lack of exposure and detailed geochronology. The range of rock types is very similar in the northern and southern parts of the Eastern Goldfields Province, and the similarity between successions in the Wiluna – Mount Keith area and the northwestern Kalgoorlie greenstones has been noted by Liu et al (1996), and a direct correlation postulated by Libby et al. (1997).

Greenstone belts

Four major greenstone belts exist in the north Eastern Goldfields Province and there are several smaller areas of very poorly exposed greenstones (Fig. 2). The greenstones consist of the metamorphosed ultramafic, mafic, and felsic volcanic or intrusive igneous rocks and immature sedimentary rocks that are typical of Archaean supercrustal successions. The typically poor exposure makes recognition or correlation of lithostratigraphic sequences difficult. Although indicators of younging direction are rarely preserved in the greenstones, pillow lava and sedimentary structures as well as differentiation trends in mafic intrusions provide consistent younging directions in many areas. Much of the geological interpretation summarized here is based on data obtained from mineral-exploration drilling programs and images obtained from regional (400 m line spacing) and local, more detailed, airborne magnetic surveys.

Agnew–Wiluna greenstone belt

The Agnew–Wiluna greenstone belt, in the western part of the north Eastern Goldfields Province, extends from beneath the Yerrida Group in the north to a southern limit about 30–40 km south of the database area (Fig. 2; Liu, 2000; Farrell, 1999). Although these greenstones have in the past been divided into the Wiluna, Coles Find, Mount Keith – Perseverance and Agnew greenstone belts (Griffin, 1990), the distinctions are described here as domainal because interpretations of primarily separate origins are uncertain.

In the south, the eastern boundary of the Agnew–Wiluna greenstone belt is the Perseverance Fault (Fig. 4), which is a possible northern equivalent of the Keith–Kilkenny Lineament (Williams, 1974) or Kilkenny Shear Zone (Chen et al., 2001). This boundary becomes obscure to the north and splays into a series of minor faults. The western margin comprises the Waroonga Shear Zone – Miranda Fault system (1 on Fig. 4) in the south, the Emu Fault (2), and the Erawalla Fault (12) farther north. The Kathleen Valley – Yakabindie domain (7) in the central-western part lies within the boundary fault system, while the Matilda domain (9) in the northwest lies west of the Erawalla Fault and the contact relations with surrounding granitic rocks are unclear.

The southern and southwestern parts of the Agnew–Wiluna greenstone belt comprise a sequence of metamorphosed mafic and ultramafic volcanic rocks (extending south of the database area) overlain by metasedimentary rocks. Several macroscopic folds structurally control sections of the lithostratigraphy and are separated by north-trending faults. Along the western margin, adjacent to the Waroonga Shear Zone, greenstones are interleaved with granitoid and the Jones Creek Conglomerate. Although the eastern limit of this domain has been interpreted as the Sir Samuel Fault (4 on Fig. 4; Liu et al, 1998), a tentative correlation with the eastern Perseverance domain (8) has been made across this feature (Hill et al., 1990; Barnes et al., 1995). The Perseverance domain, comprising the ‘upper greenstones’ of Naldrett and Turner (1977), is exposed north of Leinster along the eastern part of the Agnew–Wiluna greenstone belt and comprises mafic and felsic volcanic rocks, sedimentary rocks, and an ultramafic unit. The ultramafic unit is komatiitic with substantial adcumulate intervals that host nickel sulfide deposits. This has been traced northwards

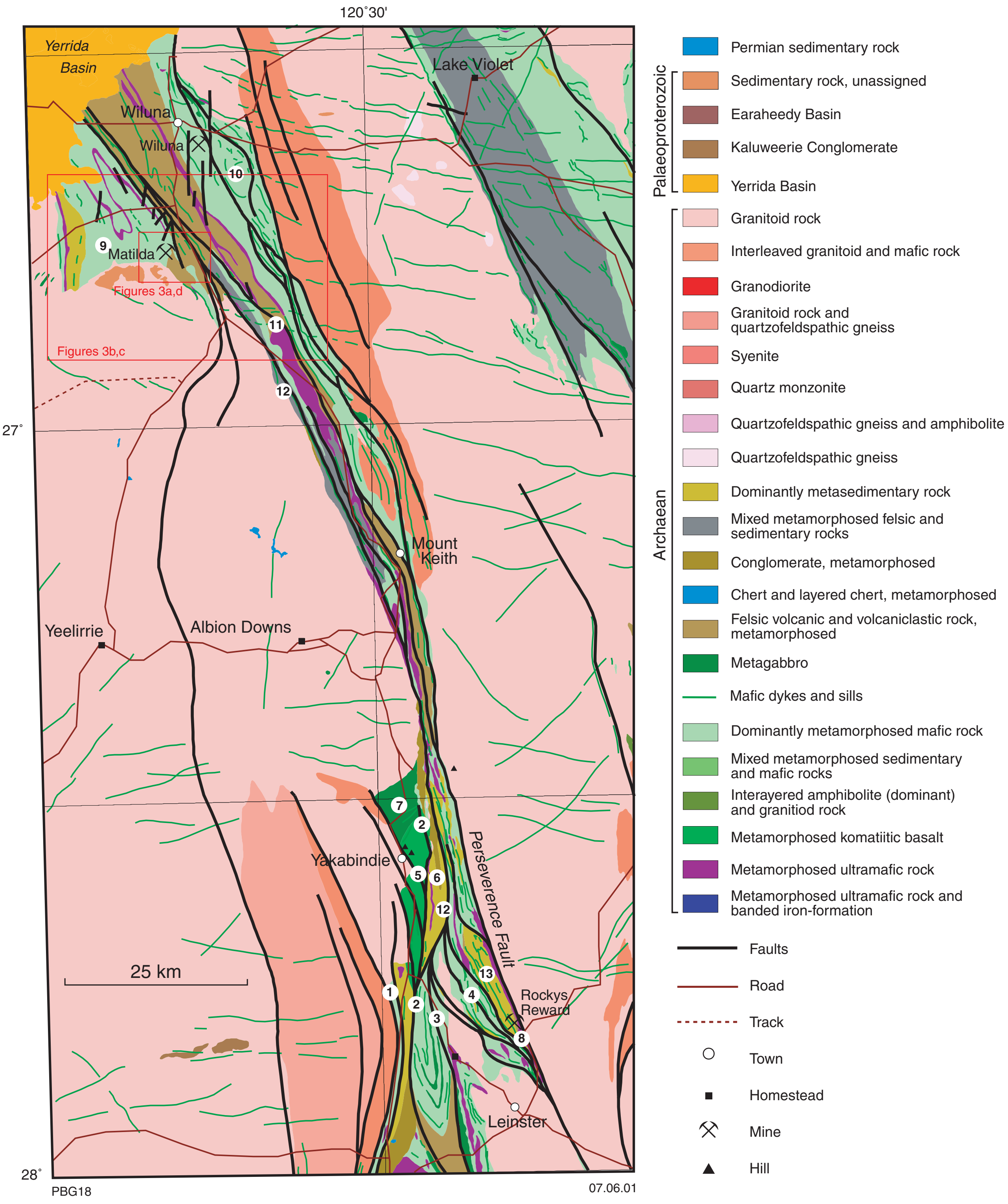


Figure 4. Simplified geology of the Agnew–Wiluna greenstone belt (after Ferguson et al., 1998. Numbers refer to localities mentioned in the text: 1 — Waroonga shear zone, 2 — Emu Fault, 3 — Halfway Fault, 4 — Sir Samuel Fault, 5 — Yakabindie Fault, 6 — Jone Creek, 7 — Yakabindie domain, 8 — Perseverence nickel mine, 9 — Matilda domain, 10 — Wiluna domain, 11 — Honeymoon Well, 12 — Erawalla Fault, 13 — Perseverence domain

along strike for at least 100 km (Hill et al., 1990), and possibly as much as 150 km (Liu et al, 1995). Precise correlation is complicated because the north-northwesterly strike is parallel to the dominant orientation of the strong shear and locally intense foliation, and contacts between different rock types are commonly the loci of shear.

The Yakabindie domain, between the Yakabindie Fault and Emu Fault (7 on Fig. 4) is dominated by the layered Kathleen Valley gabbro complex and the thick tholeiitic Mount Goode basalt sequence. A differentiated layered sequence indicates that the gabbro youngs to the south-southeast and that the typically moderate to steep north-northwesterly dip is inverted.

The Jones Creek Conglomerate unconformably overlies the older greenstone sequences in the southern Agnew–Wiluna greenstone belt, postdates significant granitoid magmatism, is strongly deformed in the zones of maximum shear, and is locally metamorphosed to amphibolite facies (Liu, 1997). The conglomerate varies compositionally from a variety with granitoid clasts in an arkosic matrix to one comprising a predominance of mafic clasts and matrix material. This variation has been attributed to an origin as alluvial-fan deposits in a linear, partly fault bounded basin with a granitic–mafic provenance to the west and a mafic–ultramafic provenance to the east (Marston and Travis, 1976).

The northern part of the Agnew–Wiluna greenstone belt is divided by the Erawalla Fault into the eastern Wiluna and western Matilda domains (10 and 9 on Fig. 4 respectively; Hagemann et al., 1992; Langford et al., 2000), with strongly sheared metasedimentary rocks adjacent to the fault possibly equivalent to the Jones Creek Conglomerate. In the Wiluna domain, the identified lithostratigraphy includes the west-younging sequences around the Wiluna mining centre (Hagemann et al., 1992) and farther south near the Honeymoon Well nickel deposit (Gole and Hill, 1990). The lithostratigraphy throughout this domain comprises lower units of komatiitic and tholeiitic basalt, with gabbro at various levels, overlain by felsic volcanic and sedimentary rocks, and then the regional ultramafic unit. An uppermost unit consists of sedimentary and felsic volcanic rocks. Correlation of this sequence allowed Lui et al. (1998) to postulate a continuous extent of nearly 150 km for the nickeliferous ultramafic unit. In the Matilda domain, lithologies are mainly mafic, but very poorly exposed and possibly repeated by folding. There is no readily identifiable lithostratigraphy, but the local presence of banded iron-formation (BIF) and the absence of a substantial ultramafic unit suggest that the sequence differs from that east of the Erawalla Fault.

The geochronology of the Agnew–Wiluna greenstone belt is poorly constrained. A microdiorite dyke in the Wiluna mine yielded a SHRIMP zircon date of 2749 ± 7 Ma (Kent and Hagemann, 1996), and if this represents the true magmatic age, then the greenstone succession at Wiluna is older than the c. 2.7 Ga greenstones that predominate in most of the Eastern Goldfields Province (Nelson, 1997a). The older age for greenstones in the Agnew–Wiluna greenstone belt is supported by the conventional U–Pb zircon age of 2795 ± 38 Ma for a granophyric differentiate within the Kathleen Valley layered gabbro near Yakabindie (Cooper and Dong, 1983), although a SHRIMP U–Pb zircon age of 2720 ± 14 Ma for deformed felsic volcanic rock from the Rockys Reward mine near Leinster is indistinguishable from some similar rock types in the south Eastern Goldfields Province (Nelson, 1997a,b). The Jones Creek Conglomerate has a maximum depositional age, based on SHRIMP U–Pb data from zircon populations, of 2667 ± 6 Ma (Nelson, 2000).

Yandal greenstone belt

The Yandal greenstone belt is situated east of the Agnew–Wiluna greenstone belt, with a 20 to 40 km-wide granitoid and gneiss interval between the belts (Figs 2 and 5). The two greenstone belts are parallel for much of their length, but the Yandal greenstone belt becomes more south trending in the south and almost converges on the southern Perseverance domain. Domains equivalent to the Lake Violet, Millrose, and Yandal belts of Bunting and Williams (1977, 1979) have been combined as the Yandal greenstone belt since subsurface continuity has been recognized. The total length of the belt is about 200 km from the southern edge of the study area to near the northern limit on CUNYU and MILLROSE. Contacts with the surrounding granitoids have been largely interpreted as faults: the Mount McClure Fault in the southwest, Moilers Shear Zone along the northwestern boundary, and Ninnis Fault along the eastern boundary. The central section of the belt is strongly attenuated and provides a narrow link between the northern and southern sections.

Outcrop mapping produced limited information on this belt because surface exposure amounts to less than one percent of the area and there is a deep weathering profile. A considerable number of exploration drillholes have provided supplementary information regarding the distribution of the rock types, but interpretations of their extent and the form of large-scale structures have required geophysical studies.

The Yandal greenstone belt contains several major gold deposits (Jundee–Nimary, Bronzewing, Mount McClure and Darlot) and numerous smaller deposits, and remains an area of ongoing gold exploration activity (Phillips et al., 1998). More than 14 million ounces of gold have been discovered in the belt in the last decade (Phillips and Anand, 2000). Although a number of thin komatiite and high-Mg basalt units are present in the succession of predominantly mafic volcanic and felsic volcanic or volcaniclastic rock types, the thick units of ultramafic rocks that characterize the Agnew–Wiluna belt are absent and there is no known economic nickel mineralization.

The southern part of the Yandal greenstone belt is bisected by the north-northeasterly trending Ockerburry Fault Zone (Fig. 5), which is possibly more than 1 km wide and consists of strongly sheared felsic volcanic or volcaniclastic rock (Westaway and Wyche, 1998; Liu, in press). West of the Ockerburry Fault zone, three lithostratigraphic packages have been distinguished in the structurally complex area between this fault zone and the Mount McClure Fault. Adjacent to the western granite–

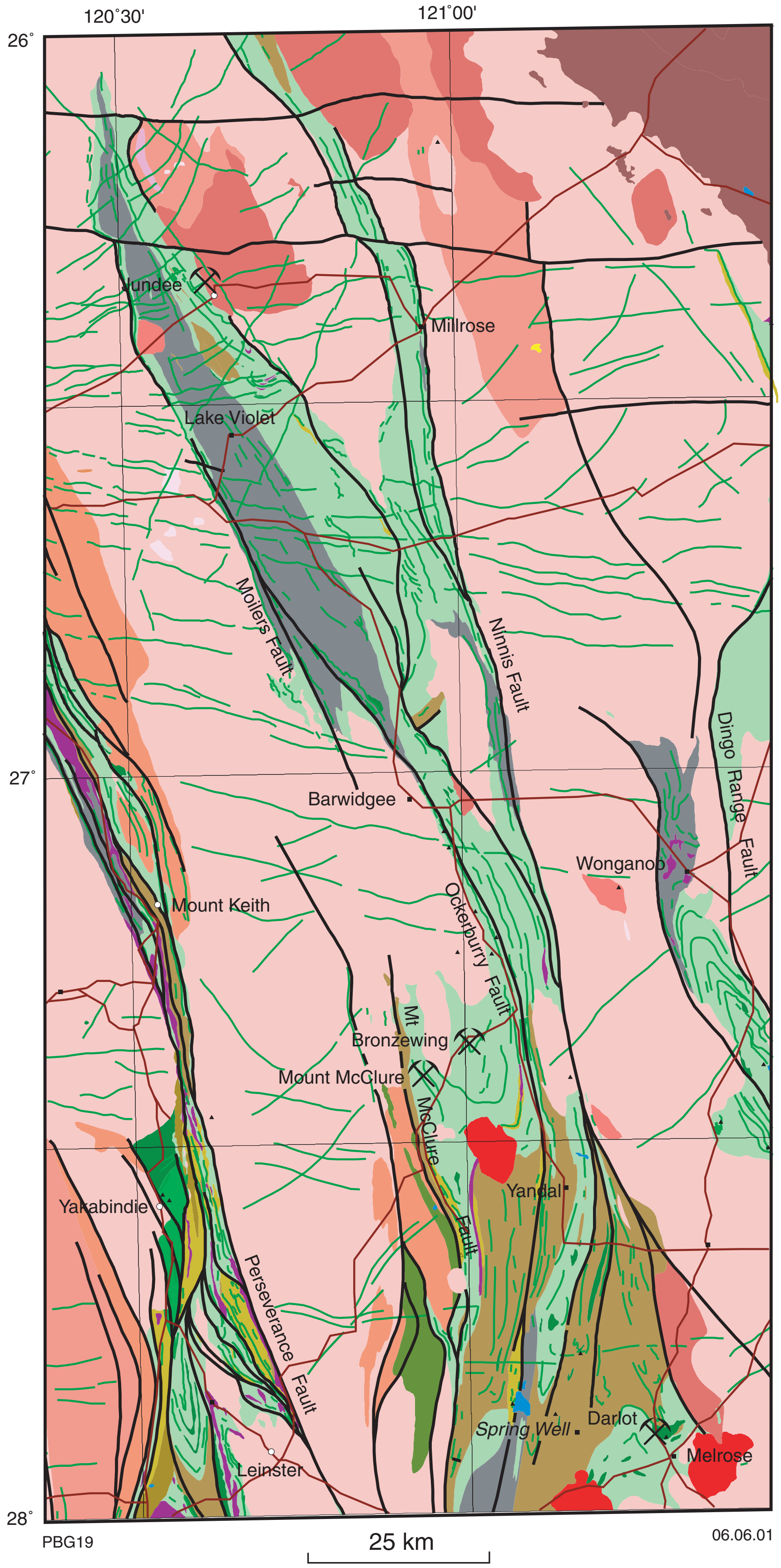


Figure 5. Simplified geology of the Yandal greenstone belt (after Ferguson et al., 1998). See Figure 4 for legend

greenstone contact of the Yandal belt, a zone of felsic schists, 0.5 – 1 km wide, north-northwest of Mount McClure gives way southward to foliated felsic volcanic or volcaniclastic rocks with chert, sedimentary rock, and basaltic rock interbeds. This sequence is overlain by an east-younging, mafic-dominated sequence with interbeds of chert, shale, tuffaceous sedimentary rocks, and komatiite. Farther east, and abutting the Ockerburry Fault Zone, a package of very poorly exposed felsic volcanic, volcaniclastic, and sedimentary rocks has been identified from the limited drillcore and magnetic data.

The area east of the Ockerburry Fault Zone is dominated by mafic volcanic rocks and a calc-alkaline volcanic complex that is well exposed over an area of about 80 km^2 near Spring Well (Giles, 1982; Westaway and Wyche, 1998). The Spring Well Complex comprises a well preserved assemblage of rhyolite, dacite, and rhyolitic ignimbrite flows, and a variety of breccias and lapilli tuffs. These are closely associated with a large volume of high-level intrusive, and possibly volcanic, rocks ranging in composition from andesite to basaltic andesite. Felsic tuffaceous and other volcaniclastic rocks are interbedded with mafic volcanic rocks north and east of the volcanic centre. Mafic intrusions at several levels in the sequence are locally characterized by internal differentiation or layering. The sporadic exposure of the sequence combined with local mesoscale folds and changes in younging direction have made it difficult to determine the lithostratigraphy or interpret the rapid facies changes in the felsic volcanic succession. Westaway and Wyche (1998) considered the high proportion of pyroclastic rocks and the large volume of volcanic breccias near the volcanic centre as evidence of a continental stratavolcano.

Although poor exposure and a scarcity of younging indicators hinder determination of a detailed stratigraphy for the northern part of the Yandal greenstone belt, outcrop mapping and examination of numerous mineral exploration drillholes (Stewart, 1997; Farrell and Wyche, 1999; Phillips et al., 1998) have allowed this part of the belt to be divided into three main lithological packages:

- an eastern sequence dominated by mafic and ultramafic rocks, with locally abundant felsic volcanic and subvolcanic rocks (the Middle Greenstone Sequence of Phillips et al., 1998);
- a thick central sequence of felsic volcanic, volcaniclastic, and sedimentary rocks, with numerous chert, ferruginous chert, and BIF units (the Upper Greenstone Sequence of Phillips et al., 1998);
- a thin western sequence of mafic and ultramafic rocks, with common pillow lavas and gabbroic sills, and prominent chert and BIF units (the Lower Greenstone Sequence of Phillips et al., 1998).

Pillow lava structures in high-Mg basalt in the mafic- and ultramafic-dominated eastern sequence indicate younging to the west. This is supported by sedimentary structures in drillcore from the Jundee mine. However, the younging direction of the western sequence and its relationship with the remainder of the Jundee domain are unclear. In the north, the belt splits into two arms separated by an extensive area of granitic rocks and gneiss.

There are few published geochronological data from the Yandal greenstone belt. A sample of crystal-rich porphyritic rhyolite from the Spring Well Complex (MGA 318440 6912560) yielded a SHRIMP U–Pb zircon age of 2690 ± 6 Ma (Nelson 1997b), which is probably the age of felsic volcanism. A porphyritic rhyolite from the Darlot mine (MGA 330004 6913767) east of Spring Well has an age of 2702 ± 5 Ma (Nelson, 1997b). In the northern part of the belt, a SHRIMP U–Pb zircon age of 2669 ± 10 Ma was obtained for a dacite porphyry from within the central sequence (Nelson, 1998). These age data suggest that different felsic volcanic centres were active at different times over a period of possibly 30 million years. Post-mineralization dykes at Jundee and Mount McClure have SHRIMP zircon ages of c. 2660 Ma (Yeats et al., 1999), whereas mineralized and post-mineralization dykes at Jundee have yielded dates of 2678 ± 5 and 2669 ± 7 Ma respectively (Yeats et al., 2000).

Dingo Range and Mount Eureka greenstone belts

Principal exposures of the Dingo Range greenstone belt extend from SANDALWOOD through WANGGANNOO to DARLOT and BANJAWARN (Fig. 2). Only the western part of the Mount Eureka greenstone belt falls in the database area, along the eastern margin of BALLIMORE and SANDALWOOD. The bounding structures of these greenstone belts are interpreted largely from magnetic data. The eastern margin of the Dingo Range greenstone belt, and western margin of the Mount Eureka greenstone belt, is probably a strike-slip fault with a sinistral displacement of several kilometres (Fig. 6). A clearly faulted margin is also present along the western boundary in the north of the Dingo Range greenstone belt, but along the southern half of this margin the irregular attenuation of BIF units evident on the magnetic image suggests that the adjacent granite is a crosscutting intrusion.

These greenstone belts comprise mafic and ultramafic rock types, including basalts, gabbros and peridotites, with common, thin interbeds of chert and BIF, and some layers of strongly deformed felsic rock. Although a paucity of younging direction indicators and the poor quality of outcrop preclude determination of any systematic lithostratigraphy, an inferred succession comprises lower basalts, with minor felsic volcanic, sedimentary, and chert subunits, overlain by felsic volcanic and sedimentary rocks (Griffin, 1990). A north-northwesterly plunging, tight to isoclinal antiform is the principal structure of the Dingo Range greenstone belt. Liu and Chen (1998b) interpreted this as a D_2 refold of an isoclinal D_1 fold.

Although a number of gold prospects have been identified in this belt, there are no active gold mines.

Duketon greenstone belt

The Duketon greenstone belt (Langford and Farrell, 1998) occupies much of DUKETON, with minor extensions onto TATE, BANJAWARN, and URAREY (Figs 2 and 7). The belt extends south from the study area and impinges onto the Laverton greenstones. Boundaries with the adjacent

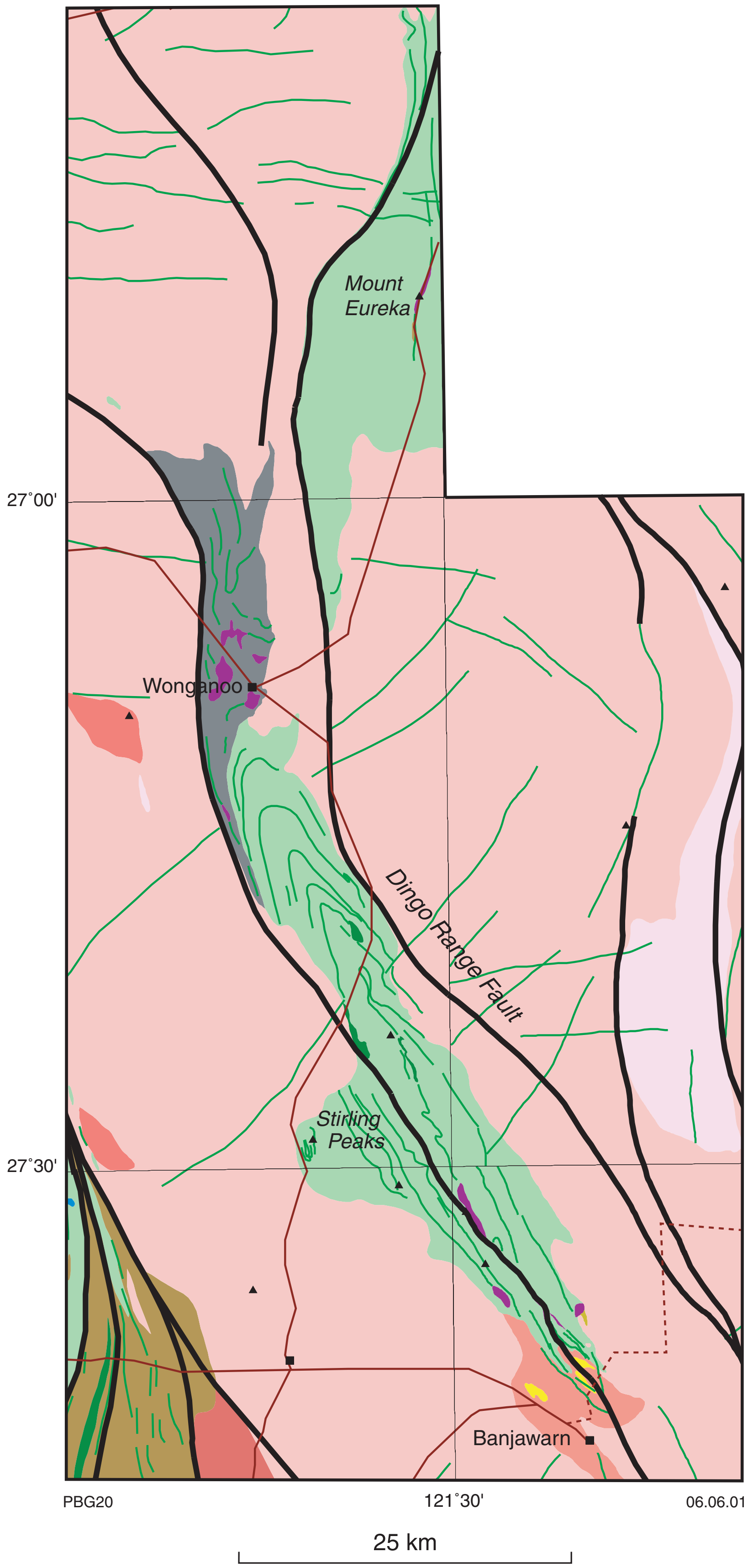


Figure 6. Simplified geology of the Dingo Range and Mount Eureka greenstone belts (after Ferguson et al., 1998). See Figure 4 for legend

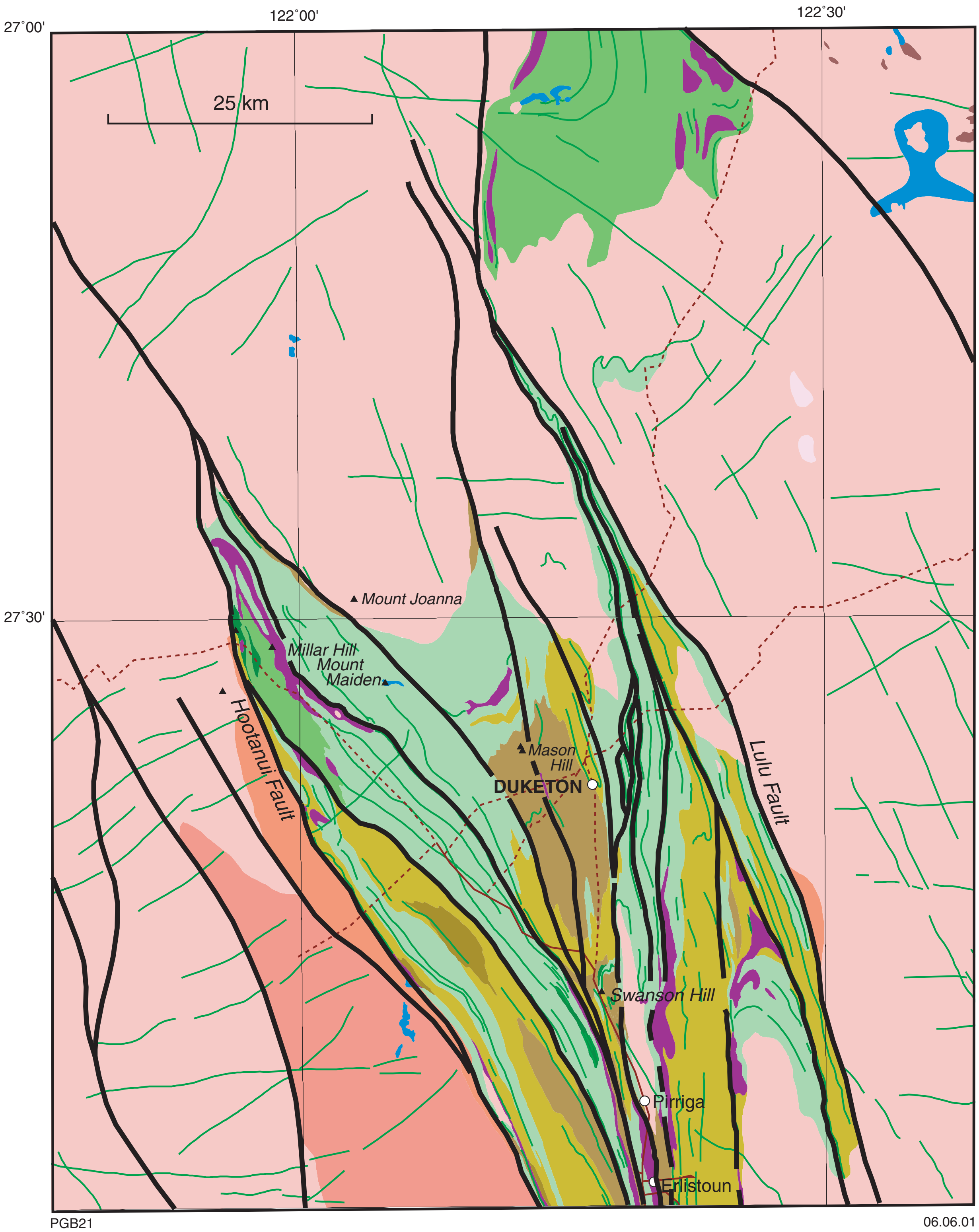


Figure 7. Simplified geology of the Duketon greenstone belt (after Ferguson et al., 1998). See Figure 4 for legend

granites are the Hootanui and Lulu Faults in the west and east respectively. Both of these structures are interpreted from intense shearing in outcrop and marked discontinuities in magnetic data. The northern boundary is clear on the magnetic images, but is not exposed, and it is not known if it is tectonic or intrusive. A series of lineaments on the magnetic image converge southward in the Duketon greenstone belt and may indicate structural convergence in that direction.

The Duketon greenstone belt contains a wide range of rock types, including mafic and ultramafic rocks, felsic volcanic and volcaniclastic rocks, chert, shale, sandstone, and conglomerate. Poor surface exposure, typical deep weathering, lack of reliable younging indicators, and structural complexity have prevented recognition of any well-constrained lithostratigraphy. Mafic rocks make up about half of the greenstone area and are mostly tholeiitic basalts, komatiitic basalts, and gabbros, but metamorphism and weathering prevent detailed interpretation. Similarly, although a considerable volume of felsic volcanic, volcaniclastic, and sedimentary rocks are present, the only possible markers are BIF units, and lack of continuous outcrop and way-up indicators precludes any sequence identification. In the central, possibly uppermost, part of the belt, the exposed greenstones are exclusively felsic volcanic and volcaniclastic rocks. Conglomerates with felsic volcanic and granitic clasts near the western margin may represent a similar setting to the Jones Creek Conglomerate in the Agnew–Wiluna greenstone belt (Wyche and Farrell, 2000).

The felsic igneous rocks in the Duketon greenstone belt are typically too deeply weathered to be suitable for geochronological sampling and no SHRIMP data are available.

Archaean geology

In the following outline, descriptions are based on the Explanatory Notes listed in Table 1, and all rock codes applied in standardizing the maps for the database are tabulated in Appendix 1. Although the most commonly used codes are specifically addressed below, a detailed description of all rock units is beyond the scope of this Report. More details of definition and petrography are provided in the original Explanatory Notes. Although all rock types described below have undergone recrystallization under metamorphic conditions ranging from lower greenschist to upper amphibolite facies, igneous or sedimentary names and terminology are used where protolith characteristics are recognized.

Ultramafic rocks

Ultramafic rocks are present in all the greenstone belts of the north Eastern Goldfields Province, but are most common in the Agnew–Wiluna greenstone belt. Deeply weathered exposures are classified as 'undivided' (*Au*) because protoliths cannot be determined with certainty. Common lithologies include talc–chlorite(–carbonate) schist (*Aut*) and tremolite–chlorite (*Aur*) schist. Siliceous caprock (*Rzu*), in which relict cumulate texture is locally recognizable, is commonly associated with these rocks. Ultramafic rocks with talc–carbonate(–serpentine) assemblages (*Auc*) are scattered in all the greenstone belts.

Intense serpentinization has obliterated all primary textures to produce massive serpentinite (*Aus*). Less intense serpentinization allows identification of primary textures and classification of the rock. There is a common association between serpentinized komatiite (*Auk*), peridotite (*Aup*) and dunite (*Aud*), which may represent ponding and differentiation of komatiitic flows. Komatiite is exposed in the Agnew–Wiluna and Dingo Range greenstone belts, in the minor greenstone outcrops on southeastern COSMO NEWBERY, and in subsurface localities of the Yandal belt. These rocks have relict olivine-spinifex texture (e.g. 2 km southwest of Mount Keith mine; Jagodzinski et al., 1999). Dunite (*Aud*), in which adcumulate to mesocumulate textures are preserved, is exposed on DUKETON only, but is present in the subsurface on WILUNA, MOUNT KEITH, and SIR SAMUEL. Peridotite (*Aup*) is preserved in the Agnew–Wiluna, Yandal, Dingo Range, and Duketon greenstone belts, with good exposures preserved at Hootanui (MGA 398440 6957450). Mappable units of pyroxenite (*Aux*) are only associated with peridotite in layered intrusions, but thin interlayers within komatiitic basalt units probably represent cumulates that developed in the thicker flows. These rocks are variably altered to tremolite, with pseudomorphic replacement of the pyroxene by amphibole.

Mafic extrusive rocks

Mafic rocks make up the largest proportion of the greenstone belts. Recognition of protoliths is difficult because outcrops are commonly deeply weathered, leading to large areas labelled as indeterminate mafic rocks (*Ab*). Most, however, were probably tholeiitic basalt flows (*Abv*), some of which were amygdaloidal (*Aby*) or porphyritic. Basaltic andesite (*Abi*) in the Yandal greenstone belt locally contains plagioclase phenocrysts (*Abip*) or is epidotized (*Abie*).

Komatiitic (high-Mg) basalt (*Abm*) is present in all greenstone belts in the north Eastern Goldfields Province. Pyroxene-spinifex textures and amygdales are preserved in fresh exposures, and pillows are present locally (*Abml*). In the Rose Hills area (MGA 268340 7074160) on MILLROSE, komatiitic basalt is relatively fresh and undeformed, with abundant varioles and spinifex texture.

Basalt, dolerite, and gabbro (*Abo*) are commonly interleaved on a scale too small to represent separately in the database. On southeastern COSMO NEWBERY, outcrops of this rock type extend over an area of 70 km^2. Interlayering of grain-size variations suggests originally layered flows, but recrystallization has obscured much of the primary fabric, rendering interpretation equivocal.

Packages of foliated, interleaved greenstone and granitoid layers (*Abg*) are up to 1.5 km wide (e.g. west of the Yandal greenstone belt). Low, narrow, north-northwesterly trending ridges are defined by individual layers of greenstone or granitoid up to 50 m thick. Local gneissic banding is defined by segregation of mafic and felsic minerals (e.g. at MGA 291100 6961500 and 290500 6963500).

The Mount Goode Basalt (*Abmg*; Liu et al., 1998) comprises an extensive suite of massive, fine-grained tholeiitic metabasalt in the Agnew–Wiluna greenstone belt, north of Lake Miranda on SIR SAMUEL. The upper part of the Mount Goode Basalt is commonly porphyritic (*Abmgp*) with areas in which plagioclase phenocrysts comprise up to 15%, and occasionally 30%, of the rock. Pillow basalt, with plagioclase phenocrysts up to 20 cm across, shows strong to moderate strain in good exposures on an island in Lake Miranda (MGA 259550 6937760).

Felsic extrusive rocks

Deeply weathered and metamorphosed felsic rocks of probable volcanic and volcaniclastic origin (*Af*) foliated to schistose (*Afs*) in many places, are common in the Agnew–Wiluna, Yandal, and Duketon greenstone belts. These rocks contain small euhedral or embayed quartz phenocrysts. In the schistose rocks (*Afs*), the schistosity is typically defined by white mica — such rocks are common in major fault or shear zones. Fresh, little-deformed felsic rocks, exposed in the 80 km^2 Spring Well Complex (MGA 318900 6913150) and at several other localities, contain clear textural evidence of a volcanic origin (*Afv*). Units at Darlot that contain massive to laminated bands, 2–10 cm thick (average 4 cm), and local graded beds were interpreted as pyroclastic fall deposits (*Afsv*; Westaway and Wyche, 1998). Felsic volcanic breccia (*Afx*) in the Spring Well Complex and southeast of Yandal Well, is poorly sorted, matrix supported, lacks internal stratification, and contains a range of volcanic clast types (Westaway and Wyche, 1998). Other felsic rock types mapped in the complex include lapilli tuffs (*Aftl*), plagioclase or quartz porphyry (*Afp*), and fine-grained andesitic basalt units (*Abi* — possibly intrusive; Wyche and Westaway, 1996; Giles 1980, 1982). Fine-grained intermediate rocks (*Afi*) are widespread in the northern Yandal and eastern Duketon greenstone belts, as outcrops and in exploration drillholes. The criteria commonly used for recognition of these rocks are a fine grain size, and a felsic composition with the presence of plagioclase and absence of quartz phenocrysts. A coarsely porphyritic variant is also present.

Clastic sedimentary rocks

Clastic sedimentary rocks are present in all the greenstone belts. Undivided sedimentary rock (*As*) is either poorly exposed, deeply weathered or comprises a sedimentary rock sequence that cannot be subdivided at 1:100 000 scale. Shale and slate (*Ash*) are very common and may be used as marker units. In the Agnew–Wiluna, Yandal, and Duketon greenstone belts, sedimentary sequences dominated by these units also contain local quartzite (*Asq*), sandstone (*Ass*), and conglomerate (*Asc*). Interflow sedimentary units (*As, Ash*) are common in volcanogenic sequences. Shale units in such sequences have usually taken up strain, so that the cleavage is either parallel or subparallel to compositional layering.

Dolomite (*Askd*) is present within a sedimentary sequence on WILUNA and several exposures of limestone (*Askl*) are associated with interflow sedimentary rocks in a basalt sequence on LAKE VIOLET.

Volcaniclastic felsic conglomerate and sandstone interbanded with tuff (*Asf*) is uncommon in the north Eastern Goldfields Province. This rock type is associated with felsic volcanic sequences on LAKE VIOLET, but is present in isolation on WILUNA.

The Jones Creek Conglomerate is a post-D_1 sedimentary sequence, up to 1000 m thick, in the southern part of the Agnew–Wiluna greenstone belt. The dominant lithology is a variably deformed conglomerate with granitic clasts and matrix (*Asjc*) and subordinate interbedded arkose (*Asjct*) and, to the east, less common conglomerate with mafic matrix (*Asjcb*). A detailed description of the Jones Creek Conglomerate is presented by Jagodzinski et al. (1999).

Chemical sedimentary rocks

Chert (*Ac*) and banded iron-formation — commonly oxide facies (*Aci*), locally silicate facies (*Acis*) — are common chemical sedimentary rocks of the north Eastern Goldfields Province. These units typically define the best available markers for magnetic correlation of outcrops or delineation of structures. Thin units of jaspilite (*Acj*) are present on LAKE VIOLET and URAREY.

Mafic intrusive rocks

Mafic intrusive rocks are common throughout all greenstone belts of the north Eastern Goldfields Province. Although metamorphic amphibole has commonly replaced original pyroxene, this is typically pseudomorphic and primary textures are recognizable, allowing the use of igneous terminology in most instances. Undivided medium- to coarse-grained mafic rock (*Ao*) is commonly deeply weathered.

Dolerite (*Aod*) or microgabbro is common as concordant layers in basalt. It is unclear whether these rocks represent sills or coarser grained portions of thick lava flows, but it is likely that both modes of origin are common. In moderately deformed sequences, basalt tends to absorb much of the strain so that only a weak foliation is present in doleritic layers. Intersertal to ophitic textures are commonly preserved in weakly deformed specimens despite amphibole and chlorite pseudomorphism.

Tabular bodies of medium- to coarse-grained metagabbro (*Aog*) are common as concordant units within greenstone packages. Most units were probably emplaced as sills, although the relationships to the host rock are typically obscure. Compositional variations include pyroxenitic gabbro (*Aogx*), olivine gabbro (*Aogv*), leucogabbro (*Aogl*), porphyritic gabbro and microgabbro (*Aogp*), and quartz-bearing gabbro and microgabbro

(*Aogq*). Compositional and cumulus layering indicative of differentiation is evident in many intrusions. In some areas this provides the only indication of younging direction, as in the minor sill adjacent to the Hootanui Fault at Hootanui (MGA 395150 6957850) in which a hornblende quartz granophyre (*Aoy*) top indicates younging toward the centre of the Duketon greenstone belt.

The Kathleen Valley Layered Intrusion is a large, compositionally layered sill on MOUNT KEITH and SIR SAMUEL. Compositional layering trends indicate that it is overturned and thus southeasterly younging, despite the steep northwesterly dip of primary igneous layering. From the stratigraphic base upwards, the intrusion comprises seven distinct layers (Jagodzinski et al., 1999; Liu, 2000):

- a gabbro unit (*AaKVr*), at least 1100 m thick, with rhythmic layering defined by varying proportions of amphibole and plagioclase;
- an anorthositic gabbro and anorthosite (*AaKVa*) layer, up to 1700 m thick, with plagioclase (labradorite) as both phenocryst and groundmass phases;
- a unit of medium-grained metagabbro (*AaKVo*) about 1500 m thick;
- a metamorphosed pyroxenitic gabbro (*AaKVox*) about 100 m thick;
- a 500 m-thick quartz gabbro and tonalite (*AaKVqt*) layer;
- a 200 m-thick quartz-bearing gabbro (*AaKVq*) layer;
- a 100 m-thick coarse-grained metagabbro (*AaKVo*).

Granitoid rock types

Granitic rocks are the dominant component of the Yilgarn Craton, but are commonly poorly exposed or strongly weathered. In the study area, most outcrops are in breakaways where variably kaolinitized granite is exposed below eroded silcrete duricrust surfaces, or as variably weathered remnants in areas of quartzofeldspathic sand, or more rarely as isolated, relatively fresh pavements and tors. The classification of many granitoid occurrences has been adjusted to conform more closely with the standard definitions used in the south Eastern Goldfields Province, with compositional rather than grain-size criteria used for identification.

Champion and Sheraton (1997) and Champion (1997) argued that it is not possible to classify the granites on the basis of age relative to deformational events in the poorly exposed Eastern Goldfields environment, although some granitic magmatism synchronous with felsic volcanism in the greenstone belts was pretectonic. On the basis of detailed petrographic and geochemical studies, Champion and Sheraton (1997) subdivided the granites in the north Eastern Goldfields Province into five groups: high-Ca (>60% of total granites), low-Ca (>20–25%), mafic (<5–10%), high-HFSE (high field-strength element; <5–10%), and syenitic groups (<5%). Although used on MOUNT KEITH, and probably suitable for future work, this subdivision could not be applied in the present collation because of the lack of widespread geochemical information and, therefore, all granite units on MOUNT KEITH have been reassigned.

Large areas of granitoid outcrop are too weathered to allow classification, apart from the recognition of common granitic characteristics (*Ag*). Monzogranite (*Agm*), the most common identifiable rock type, is typically leucocratic with less than 10 modal percent mafic mineralogy, and varies locally from massive to foliated (*Agmf*) or porphyritic (*Agmp*). The geochronology of the monzogranite units is constrained by a range of SHRIMP U–Pb zircon ages recorded by Nelson (1997a) that includes 2685 ± 7 Ma for granite adjacent to the Jones Creek Conglomerate (MGA 258900 6962100), 2669 ± 6 Ma at Kens Bore (MGA 304540 6958450), 2648 ± 19 Ma on WILUNA (MGA 231670 7119300), and 2637 ± 8 Ma on DUKETON (MGA 390250 6914950).

The distribution of granodiorite (*Agg*) is more restricted. A granodiorite intrusion in the northwestern corner of DARLOT is poorly exposed and at least partly monzogranitic (Westaway and Wyche, 1998). There is an extensive intrusion with common zoned plagioclase and mafic xenoliths, east of Melrose Homestead on DARLOT. This intrusion may be comagmatic with the nearby, less extensive Weebo Granodiorite (*Aggwe*), which has a distinct fine-grained marginal phase (*Aggwea*). The less common, more mafic hornblende granodiorite and biotite tonalite (*Agt*) intrude the greenstones. A large tonalite to biotite tonalite (*Agt*) body intrudes greenstones 3.5 km southwest of Mount Grey (MGA 315650 6963650) on WANGGANNOO, and there are smaller intrusions 6 km east of Barwidgee Homestead (MGA 300250 7008700) on MOUNT KEITH. Reported SHRIMP U–Pb zircon ages are 2666 ± 6 Ma for a granodiorite at Daylight Well (MGA 340050 6907550), and 2658 ± 7 Ma for hornblende–biotite granodiorite at Weebo (MGA 317450 6903650; Nelson 1997a).

Alkaline intrusions are scattered throughout the north Eastern Goldfields Province. The largest alkaline intrusions vary in composition from quartz monzonite (*Agzq*) to monzonite (*Agz*) and quartz monzodiorite (*Agdq*) on MILLROSE. These intrusions, which are exposed in the northern part of MILLROSE but are only in the subsurface west of Lake Ward, correspond to prominent highs on magnetic imagery (Farrell and Wyche, 1999). The Wadarrah Quartz Monzonite (*Agzwa*) is a titanite–biotite–hornblende quartz monzonite on DARLOT (Johnson, 1991; Westaway and Wyche, 1998) for which a SHRIMP zircon date of 2644 ± 13 Ma has been reported (MGA 324300 6961050; Nelson, 1998). The quartz monzonite contains local greenstone xenoliths and a possible flow foliation in an otherwise massive intrusion.

Syenite to quartz syenite (*Ags*) forms several moderately sized intrusions near Woorana Soak (MGA 322150 6959650) and Red Hill (MGA 325440 6994460) on WANGGANNOO. Minor syenitic intrusions are present in the subsurface 700 m south of Option Bore on MILLROSE (MGA 253540 7075750) and exposed 5.5 km north-northwest of Barletts Bore on BALLIMORE (MGA 302200 7102000 and MGA 300650 7101150).

Numerous minor intrusions, typically plutons or dykes of porphyritic diorite to monzodiorite (*Agdp*), outcrop at widespread localities throughout the area. These have been of interest at major gold mines as providing possible constraints on the relative age of mineralization. Yeats et al. (2000) reported dates of 2678 ± 5 and 2669 ± 7 Ma for mineralized and post-mineralization dykes respectively, at Jundee.

Foliated to gneissic granite (*Agn*) is typically present between greenstone belts and granites. The areas are also the loci of units comprising metre-scale interlayering of felsic gneisses and sheared mafic greenstone (*Agb*), particularly along both the eastern and western margins of the granite mass separating the Agnew–Wiluna and Yandal greenstone belts, and west of the southern part of the Agnew–Wiluna belt. These lithologically heterogeneous units are clearly visible on magnetic images. A sample of gneissic granite from an outcrop between the Agnew–Wiluna and Yandal belts (Parmelia Pit, MGA 295650 6952350) has a SHRIMP U–Pb zircon age of 2738 ± 6 Ma (Nelson, 1998), which is one of the oldest granite ages recorded in the Eastern Goldfields Province. In contrast, a granitic gneiss on DUKETON (MGA 402950 6914550) has a likely protolith age of 2697 ± 6 Ma, with evidence of other events at 2620 ± 10 and 2594 ± 4 Ma (Nelson, 1998).

Dykes and veins

Numerous dykes and veins crosscut the lithologies of the north Eastern Goldfields Province. Among the most common varieties are quartz veins and pods (*q*), aplite (*a*), granite (*g*), and pegmatite (*p*). Although not specifically dated, field relations suggest that these features are Archaean in age.

Metamorphic rocks

Although all Archaean rock types in the area have undergone at least low-grade metamorphism, protoliths are commonly recognized and the terminology used here is based on primary composition. However, there are several areas in which protolith identity is obscure, largely because of intense deformation combined with recrystallization. Such rocks are classified using metamorphic terminology and a primary rock type may only be inferred from compositional characteristics.

Of the low- to medium-grade metamorphic rocks, the more common lithologies are: amphibolite (*Ala*) or banded amphibolite (*Alan*); quartzofeldspathic schists that contain biotite (*Alqb*), chlorite (*Alql*), or muscovite (*Alqm*), or are very felsic (*Alqf*); and mafic schists (*Alb, All*). An outcrop of aluminous schist (*Ald*) on SIR SAMUEL contains coarse-grained remnants of andalusite and cordierite. There is a high-grade pyroxene hornfels (*Ahbx*) 2.5 km west-northwest of Granite Well on LAKE VIOLET.

Gneissic rocks

Most gneissic rocks of the north Eastern Goldfields Province had granitic protoliths. The distinction between quartzofeldspathic gneiss (*Ang*) and gneissic granitoid (*Agn*) is usually based on the degree of development of gneissosity. The quartzofeldspathic gneisses are locally migmatitic. Rare calc-silicate (*Ank*) and quartzitic (*Anq*) gneisses in the northern part of the area represent enclaves of metasedimentary rock within granite and gneissic granite.

Archaean deformation and metamorphism

Although several studies of the structural geology of the north Eastern Goldfields Province have been published (e.g. Platt et al., 1978; Eisenlohr, 1989, 1992; Farrell, 1997; Vearncombe, 1998; Vearncombe et al., 2000; Liu and Chen, 1998a,b; Chen, 1998; Chen et al., 2001), the interpretations are diverse and correlation with the tectonic events in the south is uncertain. Evidence of the earliest deformation is mostly obscured by the regional steep, north to northwesterly trending fabrics generated in subsequent events. There is evidence for early horizontal tectonic activity. This evidence includes the presence of refolded isoclinal folds in the Dingo Range greenstone belt (Liu and Chen, 1998b), and folded bedding-parallel foliation at Ockerburry Hill in the southern Yandal greenstone belt (Chen, S. F., 2000, written comm.) and in the Lawlers area of the southern Agnew–Wiluna greenstone belt (Platt et al., 1978). Bedding-parallel shear supports the possibility of early thrust faulting in the north, equivalent to that recognized at several localities in the south.

As in the south Eastern Goldfields Province, the second major deformation was regional east-northeast–west-southwest shortening that produced north-northwesterly trending folds, faults, and attenuation of the greenstone belts. The steep penetrative foliation generated by this event is strongly heterogeneous and ranges from pervasive in some areas to relatively minor in others. The folds are upright with a typically gentle northerly plunge, and an L_2 mineral elongation lineation, also plunging to the north at a shallow to moderately steep angle. The major faults that define the margins of most greenstone belts in the area have been identified as zones of D_2 strain on the basis of S_2 foliations and associated lineations (Chen et al., 2001). Evidence of reverse, and both dextral and sinistral, shear in different areas suggests the onset of a transpressional regime (Liu and Chen, 1998b).

The third deformation event is interpreted to have had a major effect on the final arrangement of the greenstone belts. Farrell (1997) assigned this deformation to north-northeasterly shortening with shallowly northerly plunging upright folds generated with progressive partitioning of shear into the shear zones, accompanied by widespread development of crenulation and pencil cleavages. The D_3 movement was identified as mainly sinistral in the northwesterly trending shear zones and mainly dextral in the northerly trending zones by Vearncombe (1998), who argued that these directions represent a conjugate set generated by bulk inhomogeneous shortening during east–west compression. Chen (1998) and Chen et al. (2001) attributed the D_3 folding and shear to an environment of sinistral strike-slip movement, with evidence from S–C fabrics and asymmetry of folds and porphyroclasts supporting an interpretation of sinistral transpression. In this model, restraining jogs that formed in the transpressional regime were loci of diagonal shear zones, and of folding.

The last significant deformation includes widespread brittle fracturing. Numerous easterly, east-northeasterly, and northwesterly trending lineaments were exploited by mafic dykes. These fractures postdate all ductile deformation, but some are faults and show evidence of minor sinistral, dextral or normal displacement (e.g. Vearncombe, 1998). Other post-D_3 structures, in the form of kink folds and subhorizontal crenulations, have been identified in several localities in association with small-scale faults and quartz veining (Farrell, 1997). Although the age of these structures is uncertain, and they do not necessarily represent only one period of deformation, a Palaeoproterozoic age is indicated by the 2420 Ma age of the east-trending dykes (Nemchin and Pidgeon, 1998).

All greenstones in the Eastern Goldfields Province have been metamorphosed, commonly to greenschist or (more locally) prehnite–pumpellyite facies, with evidence of amphibolite facies typically near granite–greenstone contacts. This distribution of peak metamorphic grade is likely to represent the thermal effects of the large monzogranite bodies that separate the greenstone belts.

There is evidence for three phases of regional metamorphism in the north Eastern Goldfields Province, as is the case for the southern part of the province. The earliest metamorphic event for which there is any evidence is indicated by the development of D_1 fabrics. Although the uncommon local preservation of these fabrics precludes assessment of any detailed characteristics of this event, a metamorphic grade in the greenschist- to amphibolite-facies range is deduced from remnant chloritic foliation in phyllites and relict amphibole crystals in an early fabric overprinted by the S_2 foliation. The evidence for regional metamorphism associated with the D_2 orogenic compression and the emplacement of voluminous granites is better preserved. In all the greenstones, low- to medium-grade metamorphic mineral assemblages define the axial-planar foliation in F_2 folds and the schistose fabric of the shear zones. Amphibolite-facies assemblages are only within 1–2 km of the granite–greenstone contacts. Subsequent foliation development associated with D_3 has not been studied in detail, but appears to be limited to relatively lower greenschist-facies conditions.

Proterozoic geology

Mafic and ultramafic dykes

Undeformed Proterozoic dykes (*Ᵽdy*)*, mainly of fine- to medium-grained gabbro, but ranging in composition from pyroxenite through gabbronorite to granophyre, intrude the Archaean granitoids and greenstones with easterly to northeasterly and north-northwesterly trends. Although locally exposed as ridges, the great majority of dykes are covered by surficial deposits. Recognition of their widespread distribution, abundance, and extent has depended upon regional airborne magnetic surveys. These intrusions were grouped as the Widgiemooltha Dyke Suite by Sofoulis (1966) and described in some detail by Hallberg (1987). An early Proterozoic age was confirmed for an easterly trending dyke by Nemchin and Pidgeon (1998). Northeasterly trending dykes with similar characteristics may be attributed to the 1220 Ma Mesoproterozoic Fraser Dyke Swarm in the south Eastern Goldfields Province (Wingate et al., 2000). Gabbro sills are associated with basaltic lava flows in the Yerrida Group (see below) and dykes of the same age (c. 2200 Ma) are likely. In areas covered by the Yerrida Group on Cunyu, northeasterly trending magnetic anomalies are better defined than those trending westerly or northwesterly, and hence may represent dykes extending to shallower levels, with dykes in other orientations partly obscured by the Palaeoproterozoic cover.

* Ᵽ is labelled as *P_* in the database and Appendix 1.

Yerrida and Earaheedy Basins

Palaeoproterozoic volcanic and sedimentary rocks in the far northeastern and northwestern parts of the area were deposited in the Yerrida and Earaheedy Basins (Fig. 2).

Yerrida Basin

The northwestern part of the database area (Fig. 2), on Cunyu and Wiluna, contain the 2200 Ma (Woodhead and Hergt, 1997) Yerrida Group. This group is a redefined subdivision of a sequence and area previously ascribed to the Glengarry Basin (Gee and Grey, 1993; Pirajno et al., 1996, 1998). The minor deformation of the Yerrida Group is characterized by gentle dips and local open, northwesterly plunging folds (Adamides et al., 1999).

Windplain Subgroup — Juderina Formation

The basal Juderina Formation (*ᵽYj*), of the lower Windplain Subgroup, comprises a sedimentary sequence dominated by mature siliciclastic arenite, cross-stratified conglomerates, and intercalated siltstone deposits of the Finlayson Member (*ᵽYjf*), with less common silicified evaporites and laminated stromatolitic chert and carbonate beds of the Bubble Well Member (*ᵽYjb*). This sequence has been attributed to deposition in an extensional rift environment (Pirajno et al., 1996).

Mooloogool Subgroup — Killara Formation

The Mooloogool Subgroup unconformably overlies the Woodplain Subgroup and is represented only by the Killara Formation (*ᵽYk*) in the database area. This comprises a sequence of aphyric lavas (*ᵽYkb*) and microgabbro sills (*ᵽYkd*), intercalated with thin chertified volcaniclastic rocks and minor nontronite layers. The Bartle Member (*ᵽYkc*) of the Killara Formation consists of variably laminated or brecciated chert and chertified sedimentary rocks with evaporite affinities. These rocks were interpreted as continental flood basalts and interflow sedimentary units (Pirajno et al., 1996, 1998).

Earaheedy Basin

The Earaheedy Group outcrops in the northeastern parts of Ballimore and De La Poer (Fig. 2) and consists of clastic and chemical sedimentary rocks deposited in coastal to shallow-marine environments of the Palaeoproterozoic Earaheedy Basin (Hocking et al., 2000). The sedimentary bedding dips at very low angles to the northeast (<5° on Ballimore, 0–15° on De La Poer) because this area is on the southwestern limb of a regional-scale open syncline that plunges southeasterly at a low angle. Metamorphism is of very low grade.

The age of these rocks is not well constrained. A maximum age of 1850 Ma is provided for the Chiall Formation by detrital zircons (U–Pb SHRIMP; Halilovic, J., 2000, written comm.; Hocking and Jones, in prep.). Deformation of the basin occurred in an orogenic event that Jones et al. (2000a) tentatively correlated with the 1790–1760 Ma second stage of the Yapungku Orogeny (Bagas and Smithies, 1998). Grey (1994) noted a lack of similarity between the stromatolite taxa of the Earaheedy Group and other occurrences recognized as younger than 1800 Ma elsewhere in the world, and suggested a possible age of 1900–1800 Ma.

The formalized stratigraphic subdivision of the Earaheedy Group by Hall et al. (1977) identified the Tooloo (lower) and Miningarra (upper) Subgroups. The inferred disconformity between the subgroups has been interpreted as rapid transgression after a lengthy period of minimal deposition, with localized intraformational conglomerates representing disrupted submarine hardground (Jones et al., 2000b). The assemblage of commonly fine grained clastic, ferruginous, and carbonate sedimentary deposits making up the Earaheedy Group has been interpreted as the result of sedimentation on a passive margin along the edge of the Yilgarn Craton, possibly with mid-ocean ridge volcanism nearby to account for the high iron content of the Frere Formation (Jones et al., 2000b).

The basal part of the Tooloo Subgroup consists of the Yelma Formation (*ⱣEy*), which comprises pebbly sandstone (*ⱣEya*), arkose, shale, siltstone, conglomerate, stromatolitic dolomite (*ⱣEyc*), and minor chert breccia. Sedimentary structures and facies relations indicate a coastal setting with both fluvial and shallow-marine components. These rocks are overlain conformably by the Frere Formation (*ⱣEf*), which has up to three units of granular iron-formation (*ⱣEfg*), consisting of jasperoidal, peloidal iron-oxide beds, separated by variably ferruginous shale, siltstone, sandstone, jasper, and chert beds (*ⱣEfs*). Although stromatolitic carbonate, siltstone, and shale of the Windidda Formation (*ⱣEd*) have been interpreted to conformably overlie the Frere Formation on Ballimore based on two small exposures (Whitaker et al., 2000), Jones et al. (2000a) suggested that it is actually a correlative of the upper Frere Formation in adjacent areas.

The uppermost Miningarra Subgroup is represented in the map area by only the Chiall Formation, comprising the Karri Karri Member (*ⱣEck*) dominated by shale and siltstone and the overlying Wandiwarra Member (*ⱣEcw*) dominated by sandstone and shale.

Proterozoic sedimentary rocks of fluvial origin

Probable Proterozoic outliers of fluvial origin overlie the Yilgarn Craton at several localities distal to the northern sedimentary basins. The largest exposure is that of the flat-lying Kaluweerie Conglomerate on Depot Springs (Allchurch and Bunting, 1976). The lowermost unit, a polymictic conglomerate (*Ɐkc*), contains clasts of local provenance (including granite, gneiss, basalt, and BIF) and a matrix containing little or no clay or silt. The overlying lithic sandstone unit (*Ɐks*) varies from fine to coarse grained, and locally contains similar clasts to the conglomerate.

Permian rocks

Outliers of Permian glacial deposits unconformably overlying the Archaean Yilgarn Craton are mostly assigned to the Paterson Formation of the Gunbarrel Basin. Conglomerate (*Pac*) contains granite and greenstone clasts, commonly with striations, in a clay- and silt-rich matrix. Claystone and siltstone units (*Pah*) are flat lying and locally contain drop stones. Sandstone to pebbly sandstone units (*Pas*) probably represent fluvial deposits. Unassigned conglomerate (*Psc*) and claystone and siltstone (*Psh*) on Sir Samuel, Darlot, and Duketon have been correlated with the Paterson Formation (e.g. Westaway and Wyche, 1998).

Regolith

Most of the area is overlain by regolith, either as unconsolidated sedimentary material or in the form of saprolite and other in situ derivatives of weathering. Considerable investigation of the regolith in the Yandal greenstone belt has been undertaken as a CRC-LEME project (Anand, 2000). In particular, this project recognized that weathering and drainage systems evolved over the last 60 million years. These studies revealed that the depth of palaeochannels may exceed 100 m, the weathering is commonly as deep as 150 m, and 90% of the area is covered by transported overburden ranging in thickness from 3 to 40 m (Anand, 2000).

The subdivision and classification of regolith types in the database has been modified to conform with the most recent classification system documented by Hocking et al. (2001). Several areas have been remapped in the course of eliminating discordance between the original sheets, resulting in reclassification of the regolith in large areas. The unit definitions and interpretation are described in Appendix 1.

The most widespread feature of the north Eastern Goldfields region is the coverage of at least 90% of the area by regolith.

Alluvial deposits

Alluvium (*Ad*) occupies present-day drainage channels and floodplains, and consists of unconsolidated clay, silt, sand, and pebbles. Calcrete developed in these and older drainage channels (*Ak*) locally contains uranium.

Colluvial deposits

Colluvium (*Cd*) is common on sloping or irregular ground and contains a large component of coarse-grained proximal debris. The finer grained matrix material is locally ferruginous. Colluvium is also subdivided to indicate dominant provenance rock types, such as ferruginous gravel (*Cf*), banded iron-formation (Cfc_i), quartz vein (*Cq*) or silica caprock over ultramafic rocks (*Czu*). Areas of particularly thin colluvium are indicated by composite codes, for example, areas where colluvium rests upon mafic volcanic rock are coded *Cd/Abv.*

Sheetwash deposits

Sheetwash (*W*) is common on broad, gently sloping plains, and consists of reddish, ferruginous fine sand to clay in thick packages. The material has been transported and substantially reworked. Flat areas in which ferruginous gravel rests on these deposits are also distinguished (*Wf*).

Sandplain deposits

Plains and dunes of eolian sand (*S*) cover extensive areas as sheets of variable thickness adjacent to salt-lake margins and on duricrust plateaus overlying granitoid. This fine-grained and clean quartz sand may contain layers of ferruginous nodules. Unconsolidated deposits of sand within old valley systems (S_v) also have eolian characteristics in some areas. Quartzofeldspathic sand and gravel deposits overlying granitoids (*Sgp*) commonly contain some lithic fragments that indicate a largely proximal origin.

Lacustrine deposits

Playa deposits within salt lakes and claypans (L_l) consist of interbedded argillites, arenites, and evaporite minerals (gypsum and halite), locally intermixed with sandplain deposits (L_m). These are commonly surrounded by dunes of sand, silt, and gypsum (L_d) derived from the lakes and sandplains. Many of these dunes are now stabilized by vegetation.

Residual deposits

Ferricrete or ferruginous duricrust (*Rf*), previously termed laterite on several of the published 1:100 000 maps, is widespread. Breakaways or erosional scarps commonly bound the ferruginous duricrust outcrops and reveal highly weathered (bleached and mottled) rocks that can be identified by locally preserved textural features. These lateritization profiles are up to 100 m thick. The ferricrete is typically yellowish brown to dark brown, locally black, and commonly massive to nodular or pisolitic. Where duricrust has formed directly from the underlying bedrock, original structures and textures are commonly preserved, which is represented by the use of composite codes (e.g. *Rf/Ab*). On several of the published maps used to compile the database, units shown as ‘laterite’ included ferricrete, reworked ferricrete (e.g. scree slopes), ‘hardpan’, and gravelly or pisolitic soils, together with nodular carbonate (‘kankar’) or calcrete, which although relatively common, is rarely extensive enough to warrant separation at 1:100 000 scale. On maps where these relict lithologies were grouped, the rock units are described as ‘residual regolith and reworked products, undivided’ (*R*).

Silica caprock (*Rzu*) is a subvitreous siliceous rock, typically light brown to off-white in colour, that is developed mainly over deeply weathered ultramafic rocks, particularly over serpentinized peridotite where olivine cumulate textures are locally preserved. Chrysoprase and jasperoidal chalcedony are present locally. Silcrete (*Rz*) is commonly light grey to white and subvitreous to vitreous, and overlies quartzofeldspathic rocks; angular medium-grained quartz grains are common where it overlies granite.

Exposed regolith

Deep and intense weathering has resulted in numerous areas where saprolitic residuum is recognizable, but original rock types are not known. These have been coded X_w.

Economic geology

The discovery of gold at Coolgardie and Kalgoorlie in the early 1890s prompted many explorers to head farther afield, ultimately to the north Eastern Goldfields region. The increased exploration led to the establishment of gold mining centres at Wiluna, Kathleen Valley, Sir Samuel, Lawlers, Darlot, and Duketon between 1896 and 1900 (Ferguson, 1998; Wright et al., 2000). As with the rest of the Eastern Goldfields region, production peaked in the early 1900s followed by a steady decline in the 1920s, a resurgence in the 1930s, and another decline in the 1960s. Interest was renewed in the 1980s and 1990s. The Yandal greenstone belt, where production was very low prior to the 1980s, has been a focus of recent exploration activity that has discovered major deposits at Darlot, Bronzewing, and Jundee.

The nickel boom of the late 1960s and 1970s, sparked by the discovery of high-grade nickel sulfide ore at Kambalda, resulted in intense exploration, particularly of the Agnew–Wiluna greenstone belt. Large komatiite-hosted nickel deposits were discovered at Mount Keith and in the Honeymoon Well and Perseverance areas, all in the Agnew–Wiluna greenstone belt.

Minor base metal prospects have been identified in the Agnew–Wiluna and Duketon greenstone belts and in the Proterozoic basins, but production from the north Eastern Goldfields region has been limited. Several calcrete-related uranium deposits, associated with valley-fill sediments of the palaeodrainage system, have been identified at

Yeelirrie, Lake Maitland, and Lake Way amongst others. Although the deposits may be economically significant (Keats, 1990), none has been exploited.

As outlined in the summary of data themes in the database, the themes MINOCC, MINEDEX, and TENGRAPH provide locality, resource, and tenement information respectively for the database area. The data in these layers are voluminous because of the large number of both historical and current mine sites, and the continuous prospecting activity. However, these data are simply an index to details of exploration activities that are recorded in open-file statutory, annual and completion, mineral exploration reports now stored in the Western Australian mineral exploration database (WAMEX) and accessible at the Perth and Kalgoorlie offices of DME. Resource and production statistics are provided by the MINEDEX database and annual publications such as the DME Statistics Digest. The most recent exploration and development statistics are provided by Flint and Abeysinghe (2001). The Explanatory Notes for the map sheets provide brief overviews of the mine localities and some production statistics for major mines. Among the great number of manuscripts addressing the many aspects of mineralization, some recent references for nickel include Elias et al. (1981), Marston (1984), Barnes et al. (1988a,b, 1995), and Hill et al. (1990, 1995). Recent references for gold include Witt (1993a,b,c,d), Witt et al. (1997), Witt and Vanderhor (1998), Groves (1993), Groves et al. (1995, 1998), Cassidy et al. (1998), Yeats et al. (1999), and Phillips and Zhou (1999). Base metals and other commodities have been less well documented because of their relative insignificance, but overviews are provided in Witt et al. (1998), Tyler et al (1998), and Hocking and Preston (1998).

Brief overviews of the commodities that are present and have been exploited in the north Eastern Goldfields region are presented below. More detailed descriptions of the various types of mineralization of the north Eastern Goldfields region are provided by Ferguson (1998), Phillips and Anand (2000), Liu (in press), and the Explanatory Notes for 1:100 000 map sheets collated in this database (Table 1). Recent detailed descriptions of individual mining centres and deposits in the region are available in Hughes (1990) and Berkman and Mackenzie (1998).

Gold

Most gold deposits in the north Eastern Goldfields region are fracture controlled, with gold present either within quartz-vein sets or in surrounding alteration zones. The continuum model of Groves (1993) and Solomon and Groves (1994), that interprets gold deposits of varying characteristics as formed throughout the middle to upper crust adjacent to crustal-scale plumbing systems in response to a massive fluid flux, was largely adopted for the bulk of gold mineralization in the Eastern Goldfields region. Recently, gold deposits of the Eastern Goldfields region have been described using the terms ‘late-orogenic structurally controlled’ (Witt and Vanderhor, 1998) and ‘orogenic’ (Groves et al., 1998). The major deposits in the area include Wiluna, Bronzewing, Jundee–Nimary, Mount McClure, Darlot, Centenary, Bellevue, and Rosemont. The combined identified resources at publication date are estimated to contain more than 17 million ounces of gold (Phillips and Anand, 2000; Witt et al., 1998).

The timing of gold mineralization in the north Eastern Goldfields region was considered largely contemporaneous with mineralization elsewhere in the Eastern Goldfields region, that is, there was a regional gold mineralizing event at 2.65 – 2.63 Ga (Solomon and Groves, 1994; Yeats and McNaughton, 1997). Recent dating from the Yandal greenstone belt, however, indicates that at least some gold mineralization occurred after 2.68 Ga and before 2.66 Ga (Yeats et al., 2000). Field studies support both cases: an early, syn-D_1 origin for the Christmas Well orebody on DUKETON (1:100 000) was suggested on structural grounds by Harris et al., (1997), whereas d’Ercole (1992) identified gold as a late infilling in lode veins at the Genesis deposit in the southern Wiluna–Agnew greenstone belt.

Lateritic gold deposits incorporate those deposits where mineralization has been concentrated or enhanced by supergene processes. In several cases, only the laterite ore has been exploited because grades in underlying fresh rock were not economic (Ferguson, 1998). Several primary deposits have exploitable lateritic deposits above them, including Gourdis and Bronzewing, whereas only the lateritic deposit has been exploited at Empire in the Yandal greenstone belt and at The Patch in the Duketon greenstone belt.

The discoveries of numerous gold deposits in the north Eastern Goldfields region, particularly those of the Yandal greenstone belt, are largely the result of advances in remote sensing and regolith sampling and analysis. Rotherham (2000) noted that at the Mount Joel prospect in the Yandal greenstone belt, transported material that overlies the deposit is typically barren whereas residual material retains or indeed concentrates gold grades present in underlying fresh rock. This highlights the importance of distinguishing regolith type (e.g. Phang and Anand, 2000) in gold exploration, particularly in a deeply weathered region like the north Eastern Goldfields.

Placer gold deposits are rare — those that have been recognized are commonly eluvial deposits adjacent to known primary or lateritic gold mineralization. Placer deposits that have been exploited include The Patch and Famous Blue in the Duketon greenstone belt, and deposits in the Darlot mining centre in the Yandal greenstone belt.

Nickel

Known komatiite- and dunite-associated nickel sulfide mineralization in the north Eastern Goldfields region is restricted to the Agnew–Wiluna greenstone belt. Hill et al. (1990, 1996) described the two types of orebodies. Type 1 deposits are thin high-grade orebodies hosted by komatiite, and include Perseverance and Rockys Reward at Leinster. Type 2 deposits are larger, lower grade orebodies hosted by dunitic subvolcanic feeder zones or lava pathways, and include the Mount Keith deposits, Six

Mile Well at Yakabindie, and most of the Honeymoon Well deposits. The Perseverance and Rockys Reward mineralization is the world's largest Type 1 deposit, and has yielded more than 14 million tons of ore at grades exceeding 2% nickel (De-Vitry et al., 1998; Libby et al., 1998). The Mount Keith deposit is a good example of the large-tonnage, low-grade disseminated-sulfide Type 2 ore deposit with in excess of 400 Mt (million tonnes) of ore at a grade of 0.6% nickel (Hopf and Head, 1998). Although some primary characteristics are recognizable in all the nickel sulfide deposits, the host rocks are completely serpentinized and variably carbonatized.

Laterite nickel(–cobalt) resources are presently being exploited at Murrin Murrin, Cawse, and Bulong in the Eastern Goldfields region. Considering the degree of regolith development in the northern region, this style of nickel mineralization seems likely, particularly in the Agnew–Wiluna and Duketon greenstone belts where ultramafic rocks are more common.

Copper, zinc, and lead

The only economic volcanic-hosted massive sulfide (VHMS) mineralization discovered to date in the Eastern Goldfields region is the 2.5 Mt copper–zinc deposit at Teutonic Bore, 45 km south of the database area, near the southern limit of the Yandal greenstone belt. Minor mineralization at Tuff Hill and Mason Hill in the Duketon greenstone belt are predominantly sphaleritic, with subordinate galena, pyrite, and chalcopyrite, and substantial concentrations of silver and gold (Ferguson, 1998). Trace element signatures of felsic volcanic sequences in the Eastern Goldfields region and base metal-rich Canadian Abitibi greenstones reveal that the Kalgoorlie terrane (including the Agnew–Wiluna and Yandal greenstone belts; Messenger, 2000) is not prospective (Witt et al., 1996). Felsic volcanic sequences east of the Kalgoorlie terrane were found to be more prospective, and occupy a setting analogous to the Duketon greenstone belt.

Copper mineralization in the Kathleen Valley area was mined between 1909 and 1967, yielding 420 t of copper from pyrite–chalcopyrite–quartz veins (Liu et al., 1998). The copper mineralization, commonly with some associated gold and silver, is spatially related to north-northwesterly trending shear zones in the Kathleen Valley Gabbro and Mount Goode Basalt (Bunting and Williams 1979).

The Proterozoic Earaheedy Group, in particular the Yelma Formation, hosts Mississippi Valley-type (MVT) zinc–lead mineralization on NABBERU (Pirajno and Jones, in prep.; Tyler et al., 1998), north of the area covered by the database. In addition, an outlier of the Yelma Formation hosts the unusual Magellan lead deposit on MEREWETHER, west of the area covered by the database. This deposit is completely oxidized, with cerussite ($PbCO_3$) and anglesite ($PbSO_4$) as the major ore minerals, and represents extensive supergene modification of MVT-style mineralization (McQuitty and Pascoe, 1998). Carbonate units in the Yelma Formation on BALLIMORE and DE LA POER are, therefore, prospective for MVT-style zinc–lead mineralization (Pirajno and Preston, 1998).

Iron

The Frere Formation of the Earaheedy Basin contains abundant granular iron-formation and ferruginous shale. Quartz – iron oxide – manganese oxide veins and stratiform iron- and manganese-oxide bands are present in the Chiall and Wongawol Formations respectively (Pirajno and Adamides, 2000). Iron enrichment is a local result of either hydrothermal alteration proximal to fault zones or chemical weathering processes (Hocking and Jones, in prep.). The Frere Formation is exposed on BALLIMORE and DE LA POER and extends northward at depth beneath the stratigraphically higher units of the Earaheedy Basin.

Uranium

There are calcrete-hosted uranium prospects in the Tertiary palaeodrainage systems of the north Eastern Goldfields region. Carnotite ($K_2(UO_2)_2(VO_4)_2.1–3H_2O$) is present as coatings and fillings within the calcrete (Langford, 1974). Most of the deposits are on WILUNA (Lake Way, Hinkler Well, Abercromby Well), but the Lake Maitland deposit is on WANGGANNOO and the Yeelirrie deposit lies just west of the area covered by the database. None of these deposits has been exploited.

Tin

There is a minor tin occurrence southwest of the Kathleen Valley townsite. The cassiterite-bearing pegmatite was worked between 1945 and 1953 (Bunting and Williams, 1979).

Diamonds

Stockdale Prospecting explored for diamonds in the northern Yilgarn Craton and southern Yerrida and Earaheedy Basins from 1989 to 1997. Several kimberlite dykes and stringers were located and several diamonds were recovered (Adamides et al., 2000).

References

ADAMIDES, N. G., FARRELL, T., and PIRAJNO, F., 1998, Cunyu, W.A. Sheet 2945 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

ADAMIDES, N. G., FARRELL, T., and PIRAJNO, F., 1999, Geology of the Cunyu 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 21p.

ADAMIDES, N. G., PIRAJNO, F., and HOCKING, R. M., 2000, Geology of the Fairbairn 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 53p.

ALLCHURCH, P. D., and BUNTING, J. A., 1976, The Kaluweerie Conglomerate: a Proterozoic fluviatile sediment from the Yilgarn Block: Western Australian Geological Survey, Annual Report 1975, p. 83–87.

ANAND, R. R., 2000, Regolith and geochemical synthesis of the Yandal greenstone belt, *in* Yandal Greenstone Belt: regolith, geology and mineralization, *edited by* G. N. PHILLIPS and R. R. ANAND: Australian Institute of Geoscientists, Bulletin, no. 32, p. 79–111.

ARNDT, H. T., and JENNER, G. A., 1986, Crustally contaminated komatiites and basalts from Kambalda, Western Australia: Chemical Geology, v. 56, p. 229–255.

BAGAS, L., and SMITHIES, R. H., 1998, Geology of the Connaughton 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 38p.

BARLEY, M. E., 1986, Incompatible-element enrichment in Archean basalts: a consequence of contamination by older sialic crust rather than mantle heterogeneity: Geology, v. 14, p. 947–950.

BARLEY, M. E., EISENLOHR, B. N., GROVES, D. I., PERRING, C. S., and VEARNCOMBE, J. R., 1989, Late Archean convergent margin tectonics and gold mineralization: a new look at the Norseman–Wiluna belt, Western Australia: Geology, v. 17, p. 826–829.

BARNES, S. J., GOLE, M. J., and HILL, R. E. T., 1988a, The Agnew nickel deposit: Part I. Structure and stratigraphy: Economic Geology, v. 83, p. 524–536.

BARNES, S. J., GOLE, M. J., and HILL, R. E. T., 1988b, The Agnew nickel deposit: Part II. Sulphide geochemistry with an emphasis on the platinum-group elements: Economic Geology, v. 83, p. 537–550.

BARNES, S. J., LESHER, C. M., and KEAYS, R. R., 1995, Geochemistry of mineralized and barren komatiites from the Perseverance nickel deposit, Western Australia: Lithos, v. 34, p. 209–234.

BERKMAN, D. A., and MACKENZIE, D. H., (*editors*), 1998, Geology of Australian and Papua New Guinean mineral deposits: Australasian Institute of Mining and Metallurgy, Monograph 22, 901p.

BLAKE, D., and WHITAKER, A. J., 1996a, Ballimore, W.A. Sheet 3145 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

BLAKE, D., and WHITAKER, A. J., 1996b, Sandalwood, W.A. Sheet 3144 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

BUNTING, J. A., and WILLIAMS, S. J., 1977, Sir Samuel, W.A. Sheet SG 51-13 (1st edition): Western Australia Geological Survey, 1:250 000 Geological Series.

BUNTING, J. A., and WILLIAMS, S. J., 1979, Sir Samuel, W.A. (1st edition): Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes, 40p.

CASSIDY, K. F., GROVES, D. I., and MCNAUGHTON, N. J., 1998, Late-Archean granitoid-hosted lode-gold deposits, Yilgarn Craton, Western Australia: Ore Geology Reviews, v. 13, p. 65–102.

CHAMPION, D. C., 1996, Tate, W.A. Sheet 3243 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

CHAMPION, D. C., 1997, Granitoids in the Eastern Goldfields, *in* Kalgoorlie '97 — an international conference on crustal evolution, metallogeny and exploration of the Yilgarn Craton — an update, Extended abstracts *compiled by* K. F. CASSIDY, A. J. WHITAKER, and S. F. LIU: Australian Geological Survey Organisation, Record 1997/41, p. 71–76.

CHAMPION, D. C., and SHERATON, J. W., 1997, Geochemistry and Nd isotope systematics of Archaean granites of the Eastern Goldfields, Yilgarn Craton, Australia: implications for crustal growth processes: Precambrian Research, v. 83, p. 109–132.

CHAMPION, D. C., and STEWART, A. J., 1996, Urarey, W.A. Sheet 3343 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

CHAMPION, D. C., and STEWART, A. J., 1998, Yeelirrie, W.A. Sheet 2943 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

CHEN, S. F., 1998, Strike-slip-induced local compression deformation in the Edjudina and Laverton area, eastern Yilgarn Craton, Western Australia: Western Australia Geological Survey, Annual Review 1997–98, p. 99–103.

CHEN, S. F., WITT, W., and LIU, S. F., 2001, Transpressional and restraining jogs in the northeastern Yilgarn Craton, Western Australia: Precambrian Research, 106, p. 309–328.

COMPSTON, W., WILLIAMS, I. S., CAMPBELL, I. H., and GRESHAM, J. J., 1986, Zircon xenocrysts from the Kambalda volcanics: age constraints and direct evidence for older continental crust below the Kambalda–Norseman greenstones: Earth and Planetary Sciences Letters, v. 76, p. 299–311.

COOPER, J. A., and DONG, Y. B., 1983, Zircon age data from a greenstone of the Archaean Yilgarn Block: Mid Proterozoic heating or uplift?: Contributions to Mineralogy and Petrology, v. 82, p. 397–402.

DE-VITRY, C., LIBBY, J. W., and LANGWORTHY, P. J., 1998, Rocky's Reward nickel deposit, *in* Geology of Australian and Papua New Guinean mineral deposits *edited by* D. A. BERKMAN and D. H. MACKENZIE: Australasian Institute of Mining and Metallurgy, Monograph 22, p. 315–320.

D'ERCOLE, C., 1992, Nature of Archaean lode-gold mineralisation in metasedimentary rocks of the Genesis mines, Lawlers, Western Australia: University of Western Australia, BSc Honours thesis (unpublished).

EISENLOHR, B. N., 1989, The structural development and controls on mineralization of the northern sector of the Norseman–Wiluna belt, Western Australia: Minerals and Energy Research Institute of Western Australia, Report no. 47, 189p.

EISENLOHR, B. N., 1992, Contrasting deformation styles in superimposed greenstone belts in the northern sector of the Norseman–Wiluna belt, Western Australia, *in* The Archaean: terrains, processes and metallogeny *edited by* J. E. GLOVER and S. E. HO: University of Western Australia, Geology Department and University Extension, Publication no. 22, p. 191–202.

ELIAS, M., DONALDSON, M. J., and GIORGETTA, N., 1981, Geology, mineralogy and chemistry of lateritic nickel–cobalt deposits near Kalgoorlie, Western Australia: Economic Geology, v. 76, p. 1775–1783.

FARRELL, T. R., 1997, Structural and metamorphic geology of the northern part of the Eastern Goldfields, *in* Kalgoorlie '97 — An international conference on crustal evolution, metallogeny and exploration of the Yilgarn Craton — an update, Extended abstracts *edited by* K. F. CASSIDY, A. J. WHITAKER, and S. F. LIU: Australian Geological Survey Organisation, Record 1997/41, p. 55–57.

FARRELL, T. R., 1999, Wiluna, W.A. Sheet SG 51-9 (2nd edition): Western Australia Geological Survey, 1:250 000 Geological Series.

FARRELL, T. R., and GRIFFIN, T. J., 1997, Banjawarn, W.A. Sheet 3242 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

FARRELL, T. R., and LANGFORD, R. L., 1996, Duketon, W.A. Sheet 3342 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

FARRELL, T. R., and WYCHE, S., 1997, Millrose, W.A. Sheet 3045 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

FARRELL, T. R., and WYCHE, S., 1999, Geology of the Millrose 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 29p.

FERGUSON, K. M., 1998, Mineral occurrences and exploration potential of the north Eastern Goldfields: Western Australia Geological Survey, Report 63, 40p.

FERGUSON, K. M., FARRELL, T. R., and HICKMAN, A. H., 1998, Mineralization and geology of the north Eastern Goldfields (1:500 000 scale), *in* Mineral occurrences and exploration potential of the north Eastern Goldfields *by* K. M. FERGUSON: Western Australia Geological Survey, Report 63, 40p.

FLINT, D. J., and ABEYSINGHE, P. B., 2001, Western Australia mineral exploration and development for 1999 and 2000: Western Australia Geological Survey, 35p.

GEE, R. D., and GREY, K., 1993, Proterozoic rocks of the Glengarry 1:250 000 sheet — stratigraphy, structure, and stromatolite biostratigraphy: Western Australia Geological Survey, Report 41, 30p.

GEE, R. D., BAXTER, J. L., WILDE, S. A., and WILLIAMS, I. R., 1981, Crustal development in the Archaean Yilgarn Block, Western Australia, *in* Archaean geology *edited by* J. E. GLOVER and D. I. GROVES: Geological Society of Australia; 2nd International Archaean Symposium, Perth, W.A., 1980; Special Publication, no. 7, p. 43–56.

GILES, C. W., 1980, A comparative study of Archaean and Proterozoic felsic volcanic associations in southern Australia: South Australia, University of Adelaide, PhD thesis (unpublished).

GILES, C. W., 1982, The geology and geochemistry of the Archaean Spring Well felsic volcanic complex, Western Australia: Geological Society of Australia, Journal, v. 29, p. 205–220.

GOLE, M. J., and HILL, R. E. T., 1990, The refinement of extrusive models for the genesis of nickel deposits: implications from case studies at Honeymoon Well and the Walter Williams Formation: Minerals and Energy Research Institute of Western Australia, Report 68, 176p.

GREY, K., 1994, Stromatolites from the Palaeoproterozoic Earaheedy Group, Earaheedy Basin, Western Australia: *Alcheringa*, v. 18, p. 187–218.

GRIFFIN, T. J., 1990, Eastern Goldfields Province, *in* Geology and mineral resources of Western Australia: Western Australia Geological Survey, Memoir 3, p. 77–119.

GRIFFIN, T. J., and FARRELL, T., 1998, Cosmo Newbery, W.A. Sheet 3442 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

GROENEWALD, P. B., PAINTER, M. G. M., ROBERTS, F. I., McCABE, M., and FOX, A., 2000, East Yilgarn Geoscience Database, 1:100 000 geology Menzies to Norseman — an explanatory note: Western Australia Geological Survey, Report 78, 53p.

GROVES, D. I., 1993, The crustal continuum model for late-Archaean lode-gold deposits of the Yilgarn Block, Western Australia: Mineralium Deposita, v. 28, p. 366–374.

GROVES, D. I., GOLDFARB, R. J., GEBRE-MARIAM, M., HAGEMANN, S. G., and ROBERT, F., 1998, Orogenic gold deposits: a proposed classification in the context of their crustal distribution and relationship to other gold deposit types: Ore Geology Reviews, v. 13, p. 1–27.

GROVES, D. I., RIDLEY, J. R., BLOEM, E. M. J., GEBRE-MARIAM, M., HAGEMANN, S. G., HRONSKY, J. M. A., KNIGHT, J. T., McNAUGHTON, N. J., OJALA, J., VIELREICHER, R. M., McCUAIG, T. C., and HOLYLAND, P. W., 1995, Lode-gold deposits of the Yilgarn block: products of Late Archaean crustal-scale overpressured hydrothermal systems, *in* Early Precambrian processes *edited by* M. P. COWARD and A. C. RIES: London, The Geological Society, Special Publication, no. 95, p. 155–172.

HAGEMANN, S. G., GROVES, D. I., RIDLEY, J. R., and VEARNCOMBE, J. R., 1992, The Archean lode gold deposits at Wiluna, Western Australia: high-level brittle-style mineralization in a strike-slip regime: Economic Geology, v. 87, p. 1022–1053.

HALL, W. D. M., GOODE, A. D. T., BUNTING, J. A., and COMMANDER, D. P., 1977, Stratigraphic terminology of the Earaheedy Group, Nabberu Basin: Western Australia Geological Survey, Annual Report 1976, p. 40–43.

HALLBERG, J. A., 1987, Postcratonization mafic and ultramafic dykes of the Yilgarn Block: Australian Journal of Earth Sciences, v. 34, p. 135–149.

HARRIS, D. H. M., WILLIAMS, P. R., NEWTON-SMITH, J., and FITZGERALD, L. G., 1997, Tectonic fabric development and mineralisation of the Duketon greenstone belt, Western Australia: Australian Journal of Earth Sciences, v. 44, p. 503–508.

HILL, R. E. T., BARNES, S. J., GOLE, M. J., and DOWLING, S. E., 1990, Physical volcanology of komatiites: a field guide to the komatiites of the Norseman–Wiluna Greenstone Belt, Eastern Goldfields Province, Yilgarn Block, Western Australia: Geological Society of Australia (W.A. Division), Excursion guide book no. 1, 100p.

HILL, R. E. T., BARNES, S. J., GOLE, M. J., and DOWLING, S. J., 1995, The volcanology of komatiites as deduced from field relationships in the Norseman–Wiluna greenstone belt, Western Australia: Lithos, v. 34, p. 159–188.

HILL, R. E. T., BARNES, S. J., and PERRING, C. S., 1996, Komatiite volcanology and the volcanogenic setting of associated nickel deposits, *in* Nickel '96 — mineral to market *edited by* E. J. GRIMSBY and I. NUESS: Australasian Institute of Mining and Metallurgy, Publication Series, no. 6/96, p. 91–95.

HOCKING, R. M., and JONES, J. A., in prep., Geology of the Methwin 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes.

HOCKING, R. M., JONES, J. A., PIRAJNO, F., and GREY, K, 2000, Revised lithostratigraphy for Proterozoic rocks in the Earaheedy Basin and nearby areas: Western Australia Geological Survey, Record 2000/16, 22p.

HOCKING, R. M., LANGFORD, R. L., THORNE, A. M., SANDERS, A. J., MORRIS, P. A., STRONG, C. A., and GOZZARD, J. R., 2001, A classification system for the regolith in Western Australia; Western Australia Geological Survey, Record 2001/4, 22p.

HOCKING, R. M., and PRESTON, W. A., 1998, Western Australia: Phanerozoic geology and mineral resources: Australian Geological Survey Organisation, Journal of Australian Geology and Geophysics, v. 7(3), p. 245–260.

HOPF, S., and HEAD, D. L., 1998, Mount Keith nickel deposit, *in* Geology of Australian and Papua New Guinean mineral deposits *edited by* D. A. BERKMAN and D. H. MACKENZIE: Australasian Institute of Mining and Metallurgy, Monograph 22, p. 307–314.

HUGHES, F. E., (*editor*), 1990, Geology of the mineral deposits of Australia and Papua New Guinea, Volume I: Australasian Institute of Mining and Metallurgy, Monograph 14, 978p.

JAGODZINSKI, E., STEWART, A. J., and CHAMPION, D. C., 1999, Geology, structure, and mineral resources of the Mount Keith 1:100 000 sheet (3043), Western Australia: Australian Geological Survey Organisation, Record 1999/37, 31p.

JAGODZINSKI, E., STEWART, A. J., and LIU, S. F., 1997, Mount Keith, W.A. Sheet 3043 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

JOHNSON, G. I., 1991, The petrology, geochemistry and geochronology of the felsic alkaline suite of the eastern Yilgarn Block, Western Australia: South Australia, University of Adelaide, PhD thesis (unpublished).

JONES, J. A., PIRAJNO, F., and HOCKING, R. M., 2000a, A revised stratigraphic framework for the Earaheedy Group: implications for the tectonic evolution and mineral potential of the Earaheedy Basin: Western Australia Geological Survey, Annual Review 1999–2000, p. 57–64.

JONES, J. A., PIRAJNO, F., and HOCKING, R. M., 2000b, Stratigraphy, tectonic evolution, and mineral potential of the Earaheedy Basin: Western Australia Geological Survey, Record 2000/8, p. 11–13.

KEATS, W., 1990, Uranium, *in* Geology and mineral resources of Western Australia: Western Australia Geological Survey, Memoir 3, p. 728–731.

KENT, A. J. R., and HAGEMANN, S. G., 1996, Constraints on the timing of lode-gold mineralization in the Wiluna greenstone belt, Yilgarn Craton, Western Australia: Australian Journal of Earth Sciences, v. 443, p. 573–588.

KRAPEZ, B., BROWN, S. J. A., HAND, J., BARLEY, M. E., and CAS, R. A. F., 2000, Age constraints on recycled crustal and supracrustal sources of Archaean metasedimentary sequences, Eastern Goldfields Province, Western Australia: evidence from SHRIMP zircon dating: Tectonophysics, v. 322, p. 89–133.

LANGFORD, F. F., 1974, A supergene origin for vein-type uranium ores in the light of the Western Australian calcrete–carnotite deposits: Economic Geology, v. 69, p. 516–526.

LANGFORD, R. L., and FARRELL, T. R., 1998, Geology of the Duketon 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 27p.

LANGFORD, R. L., and LIU, S. F., 1997, Wiluna, W.A. Sheet 2944 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

LANGFORD, R. L., WYCHE, S., and LIU, S. F., 2000, Geology of the Wiluna 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 26p.

LESHER, C. M., and ARNDT, N. T., 1995, REE and Nd isotope geochemistry, petrogenesis and volcanic evolution of contaminated komatiites at Kambalda, Western Australia: Lithos, v. 34, p. 127–157.

LIBBY, J. W., STOCKMAN, P. R., CERVOJ, K. M., MUIR, M. R. K., WHITTLE, M., and LANGWORTHY, P. J., 1998, Perseverance nickel deposit, *in* Geology of Australian and Papua New Guinean mineral deposits *edited by* D. A. BERKMAN and D. H. MACKENZIE: Australasian Institute of Mining and Metallurgy, Monograph 22, p. 321–328.

LIBBY, J. W., STOCKMAN, P. R., and LANGWORTHY, P. J., 1997, Nickel mineralization and geology of the Perseverance – Mount Keith segment of the Agnew–Wiluna greenstone belt, *in* Kalgoorlie ’97 — An international conference on crustal evolution, metallogeny and exploration of the Yilgarn Craton — an update, Extended abstracts *compiled by* K. F. CASSIDY, A. J. WHITAKER, and S. F. LIU: Australian Geological Survey Organisation, Record 1997/41, p. 97–101.

LIU, S. F., 1997, Jones Creek Conglomerate, *in* Archaean geology and mineralization of the northern part of the Eastern Goldfields province, Yilgarn Craton, Western Australia — a field guide, Kalgoorlie ’97 *compiled by* S. WYCHE: Western Australia Geological Survey, Record 1997/7, p. 39–43.

LIU, S. F., 2000, Sir Samuel, W.A. Sheet SG 51-13 (2nd edition): Australian Geological Survey Organisation, 1:250 000 Geological Series.

LIU, S. F., in press, Geology of the Sir Samuel 1:250 000 sheet area, Western Australia: Australian Geological Survey Organisation, 1:250 000 Geological Series Explanatory Notes.

LIU, S. F., and CHEN, S. F., 1998a, Structural framework of the northern Yilgarn Craton and implications for hydrothermal gold mineralization: Australian Geological Survey Organisation, Research Newsletter, v. 29, p. 21–23.

LIU, S. F., and CHEN, S. F., 1998b, Structural framework of the northern Yilgarn Craton from recent geological and geophysical mapping: Geological Society of Australia; The 14th Australian Geological Convention, Townsville, Queensland, 1998; Abstracts, v. 49, p. 278.

LIU, S. F., GRIFFIN, T., WYCHE, S., and WESTAWAY, J., 1996, Sir Samuel, W.A. Sheet 3042 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

LIU, S. F., GRIFFIN, T., WYCHE, S., WESTAWAY, J., and FERGUSON, K. M., 1998, Geology of the Sir Samuel 1:100 000 Sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 25p.

LIU, S. F., HICKMAN, A. H., and LANGFORD, R. L., 1995, Stratigraphic correlations in the Wiluna greenstone belt: Western Australia Geological Survey, Annual Review 1994–95, p. 81–88.

LYONS, P., STEWART, A. J., JAGODZINSKI, E. A., and CHAMPION, D. C., 1996, Wanggannoo, W.A. Sheet 3143 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

MARSTON, R. J., 1984, Nickel mineralization in Western Australia: Western Australia Geological Survey, Mineral Resources Bulletin 14, 271p.

MARSTON, R. J., and TRAVIS, G. A., 1976, Stratigraphic implications of the heterogeneous deformation in the Jones Creek Conglomerate (Archaean), Kathleen Valley, Western Australia: Geological Society of Australia, Journal, v. 23, p. 141–156.

MESSENGER, P. R., 2000, Igneous geochemistry and base metal potential of the Yandal belt, *in* Yandal greenstone belt: regolith, geology and mineralization *edited by* G. N. PHILLIPS and R. R. ANAND: Australian Institute of Geoscientists, Bulletin, no. 32, p. 69–71.

McQUITTY, B. M., and PASCOE, D. J., 1998, Magellan lead deposit, *in* Geology of Australian and Papua New Guinean mineral deposits *edited by* D. A. BERKMAN and D. H. MACKENZIE: Australasian Institute of Mining and Metallurgy, Monograph 22, p. 293–296.

MORRIS, P. A, and WITT, W. K., 1997, Geochemistry and tectonic setting of two contrasting Archaean felsic volcanic associations in the Eastern Goldfields, Western Australia: Precambrian Research, v. 83, p. 83–107.

MYERS, J. S., 1997, Preface: Archaean geology of the Eastern Goldfields of Western Australia — a regional overview: Precambrian Research, v. 83, p. 1–10.

NALDRETT, A. J., and TURNER, A. R., 1977, The geology and petrogenesis of a greenstone belt and related nickel sulfide mineralization at Yakabindie, Western Australia: Precambrian Research, v. 5, p. 43–103.

NELSON, D. R., 1997a, Compilation of SHRIMP U–Pb zircon geochronology data, 1996: Western Australia Geological Survey, Record 1997/2, 189p.

NELSON, D. R., 1997b, Evolution of the Archaean granite–greenstone terranes of the Eastern Goldfields, Western Australia: SHRIMP U–Pb zircon constraints: Precambrian Research, v. 83, p. 57–81.

NELSON, D. R., 1998, Compilation of SHRIMP U–Pb zircon geochronology data, 1997: Western Australia Geological Survey, Record 1998/2, 242p.

NELSON, D. R., 1999, Compilation of SHRIMP U–Pb zircon geochronology data, 1998: Western Australia Geological Survey, Record 1999/2, 222p.

NELSON, D. R., 2000, Compilation of geochronology data, 1999: Western Australia Geological Survey, Record 2000/2, 251 p.

NEMCHIN, A. A., and PIDGEON, R. T., 1998, Precise conventional and SHRIMP baddeleyite U–Pb age for the Binneringie dyke, near Narrogin, Western Australia: Australian Journal of Earth Sciences, v. 45, p. 673–675.

PHANG, C., and ANAND, R. R., 2000, Distinguishing transported and residual regolith material, *in* Yandal greenstone belt: regolith, geology and mineralization *edited by* G. N. PHILLIPS and R. R. ANAND: Australian Institute of Geoscientists, Bulletin, no. 32, p. 125–133.

PHILLIPS, G. N., and ANAND, R. R., (*editors*), 2000, Yandal greenstone belt: regolith, geology and mineralization: Australian Institute of Geoscientists, Bulletin, no. 32, 400p.

PHILLIPS, G. N., VEARNCOMBE, J. R., BLUCHER, I., and RAK, D., 1998, Bronzewing gold deposit, *in* Geology of Australian and Papua New Guinean mineral deposits *edited by* D. A. BERKMAN and D. H. MACKENZIE: Australasian Institute of Mining and Metallurgy, Monograph 22, p. 127–136.

PHILLIPS, N., and ZHOU, T., 1999, Gold-only deposits and Archean granite: Society of Economic Geologists, Newsletter no. 37, p. 1–13.

PIDGEON, R. T., and HALLBERG, J. A., 2000, Age relationships in supracrustal sequences in the northern part of the Murchison Terrane, Archaean Yilgarn Craton, Western Australia: a combined field and zircon U–Pb study: Australian Journal of Earth Sciences, v. 47, p. 153–165.

PIDGEON, R. T., and WILDE, S. A., 1990, The distribution of 3.0 and 2.7 Ga volcanic episodes in the Yilgarn Craton of Western Australia: Precambrian Research, v. 48, p. 309–325.

PIRAJNO, F., and ADAMIDES, N. G., 2000, Iron–manganese oxides and glauconite-bearing rocks of the Earaheedy Group: implications for the base metal potential of the Earaheedy Basin: Western Australia Geological Survey, Annual Review 1999–2000, p. 81–87.

PIRAJNO, F., BAGAS, L., SWAGER, C. P., OCCHIPINTI, S. A., and ADAMIDES, N. G., 1996, A reappraisal of the stratigraphy of the Glengarry Basin, Western Australia: Western Australia Geological Survey, Annual Review 1995–96, p. 81–87.

PIRAJNO, F., and JONES, J. A., in prep., Geology of the Nabberu and Granite Peak 1:100 000 sheets: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes.

PIRAJNO, F., OCCHIPINTI, S. A., and SWAGER, C. P., 1998, The geology and tectonic evolution of the Palaeoproterozoic Bryah, Padbury and Yerrida Basins (formerly Glengarry Basin), Western Australia: Precambrian Research, v. 90, p. 119–140.

PIRAJNO, F., and PRESTON, W. A., 1998, Mineral deposits of the Padbury, Bryah and Yerrida basins, *in* Geology of Australian and Papua New Guinean mineral deposits, *edited by* D. A. BERKMAN and D. H. MACKENZIE: Australasian Institute of Mining and Metallurgy, Monograph 22, p. 63–70.

PLATT, J. P., ALLCHURCH, P. D., and RUTLAND, R. R., 1978, Archaean tectonics in the Agnew supracrustal belt, Western Australia: Precambrian Research, v. 7, p. 3–30.

ROTHERHAM, J. F., 2000, Gold mineralization in the oxide–transition zone — Mt Joel prospect, Yandal greenstone belt, *in* Yandal Greenstone Belt: regolith, geology and mineralization *edited by* G. N. PHILLIPS and R. R. ANAND: Australian Institute of Geoscientists, Bulletin, no. 32, p. 273–282.

SOFOULIS, J., 1966, Widgiemooltha, W.A.: Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes, 26p.

SOLOMON, M., and GROVES, D. I., 1994, The geology and origin of Australia's mineral deposits: Oxford, Monographs in Geology and Geophysics, v. 24, 951p.

STEWART, A. J., 1996, De La Poer, W.A. Sheet 3443 (preliminary edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

STEWART, A. J., 1997, Archaean geology of the Lake Violet 1:100 000 sheet area, Yandal greenstone belt, Eastern Goldfields Province, Western Australia: Australian Geological Survey Organisation, Research Newsletter 27, p. 11–13.

STEWART, A. J., 1999, Geology of the De La Poer (3443) and Urarey (3343) 1:100 000 sheet areas, Yilgarn Block, Western Australia: Australian Geological Survey Organisation Record 1999/33, 14p.

STEWART, A. J., and BASTRAKOVA, I., 1997, Lake Violet, W.A. Sheet 3044 (1st edition): Australian Geological Survey Organisation, 1:100 000 Geological Series.

SWAGER, C. P., 1995, Geology of the greenstone terranes in the Kurnalpi–Edjudina region, southeastern Yilgarn Craton: Western Australia Geological Survey, Report 47, 31p.

SWAGER, C. P., 1997, Tectono-stratigraphy of late Archaean greenstone terranes in the southern Eastern Goldfields, Western Australia: Precambrian Research, v. 83, p. 11–42.

SWAGER, C. P., GOLEBY, B. R., DRUMMOND, B. J., RATTENBURY, M. S., and WILLIAMS, P. R., 1997, Crustal structure of the granite–greenstone terranes in the Eastern Goldfields, Yilgarn Craton, as revealed by seismic reflection profiling: Precambrian Research, v. 83, p. 43–56.

SWAGER, C. P., GRIFFIN, T. J., WITT, W. K., WYCHE, S., AHMAT, A. L., HUNTER, W. M., and McGOLDRICK, P. J., 1990, Geology of the Archaean Kalgoorlie Terrane — an explanatory note: Western Australia Geological Survey, Record 1990/12, 55p.

SWAGER, C. P., GRIFFIN, T. J., WITT, W. K., WYCHE, S., AHMAT, A. L., HUNTER, W. M., and McGOLDRICK, P. J., 1995, Geology of the Archaean Kalgoorlie Terrane — an explanatory note: Western Australia Geological Survey, Report 48 (reprint of Record 1990/12), 26p.

TYLER, I. M., PIRAJNO, F., BAGAS, L., MYERS, J. S., and PRESTON, W. A., 1998, The geology and mineral deposits of the Proterozoic in Western Australia: AGSO Journal of Australian Geology and Geophysics, v. 17(3), p. 223–244

VEARNCOMBE, J. R., 1998, Shear zones, fault networks and Archaean gold: Geology, v. 26, p. 855–858.

VEARNCOMBE, J. R., KOHLER, E., MEYERS, J., PHILLIPS, G. N., ROTHERY, E., and RYAN, D., 2000, Regional, structural and exploration geology in a terrain with minimal outcrop — the Yandal Belt, *in* Yandal greenstone belt: regolith, geology and mineralization *edited by* G. N. PHILLIPS and R. R. ANAND: Australian Institute of Geoscientists, Bulletin, no. 32, p. 17–39.

WESTAWAY, J. M., and WYCHE, S., 1998, Geology of the Darlot 1:100 000 sheet: Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes, 24p.

WHITAKER, A. J., BLAKE, D. H., and STEWART, A. J., 2000, Geology and geophysics of the Ballimore and Sandalwood 1:100 000 sheet areas (3145 and 3144), Western Australia: Australian Geological Survey Organisation, Record 2000/2, 20p.

WILLIAMS, I. R., 1974, Structural subdivision of the Eastern Goldfields Province, Yilgarn Block: Western Australia Geological Survey, Annual Report 1973, p. 53–59.

WINGATE, M. T. D., CAMPBELL, I. H., and HARRIS, L. B., 2000, SHRIMP baddeleyite age for the Fraser Dyke Swarm, southeast Yilgarn Craton, Western Australia: Australian Journal of Earth Sciences, v. 47, p. 309–313.

WITT, W. K., 1993a, Gold deposits of the Menzies and Broad Arrow areas, Western Australia: Western Australia Geological Survey, Record 1992/13, 156p.

WITT, W. K., 1993b, Gold deposits of the Mt Pleasant – Ora Banda areas, Western Australia: Western Australia Geological Survey, Record 1992/14, 104p.

WITT, W. K., 1993c, Gold deposits of the Kalgoorlie – Kambalda – St Ives areas, Western Australia: Western Australia Geological Survey, Record 1992/15, 108p.

WITT, W. K., 1993d, Lithological and structural controls on gold mineralization in the Archaean Menzies–Kambalda area, Western Australia: Australian Journal of Earth Sciences, v. 40, p. 65–86.

WITT, W. K., HICKMAN, A. H., TOWNSEND, D. B., and PRESTON, W. A., 1998, Mineral potential of the Archaean Pilbara and Yilgarn Cratons, Western Australia: Australian Geological Survey Organisation, Journal of Australian Geology and Geophysics, v. 17(3), p. 201–221.

WITT, W. K., KNIGHT, J. T., and MIKUCKI, E. J., 1997, A syn-metamorphic lateral fluid flow model for gold mineralization in the Archean southern Kalgoorlie and Norseman Terranes, Western Australia: Economic Geology, v. 92, p. 407–437.

WITT, W. K., MORRIS, P. A., WYCHE, S., and KNIGHT, J. T., 1996, The Gindalbie Terrane as a target for VMS-style mineralization in the Eastern Goldfields Province of the Yilgarn Craton: Western Australian Geological Survey, Annual Review 1995–96, p. 41–55.

WITT, W. K., and VANDERHOR, F., 1998, Diversity within a unified model for Archaean gold mineralization in the Yilgarn Craton of Western Australia: an overview of the late-orogenic, structurally controlled gold deposits: Ore Geology Reviews, v. 13, p. 29–64.

WOODHEAD, J. D., and HERGT, J. M., 1997, Application of the 'double spike' technique to Pb-isotope geochronology: Chemical Geology, v. 138(3–4), p. 311–321.

WRIGHT., J., PHILLIPS, G. N., and HERBISON, I., 2000, History of exploration in the Yandal greenstone belt, *in* Yandal greenstone belt: regolith, geology and mineralization *edited by* G. N. PHILLIPS and R. R. ANAND: Australian Institute of Geoscientists, Bulletin, no. 32, p. 187–198.

WYBORN, L. A. I., 1993, Constraints on interpretations of lower crustal structure, tectonic setting and metallogeny of the Eastern Goldfields and Southern Cross Provinces provided by granite geochemistry: Ore Geology Reviews, v. 8, p. 125–140.

WYCHE, S., and FARRELL, T., 2000, Regional geological setting of the Yandal greenstone belt, northeast Yilgarn Craton, *in* Yandal Greenstone Belt: regolith, geology and mineralization *edited by* G. N. PHILLIPS and R. R. ANAND: Australian Institute of Geoscientists, Bulletin, no. 32, p. 41–49.

WYCHE, S., and WESTAWAY, J. M., 1996, Darlot, W.A. Sheet 3142 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

WYCHE, S., and GRIFFIN, T., 1998, Depot Springs, W.A. Sheet 2942 (1st edition): Western Australia Geological Survey, 1:100 000 Geological Series.

YEATS, C. J., and McNAUGHTON, N. J., 1997, Significance of SHRIMP II U–Pb geochronology on lode-gold deposits of the Yilgarn Craton; *in* Kalgoorlie '97 — an international conference on crustal evolution, metallogeny and exploration of the Yilgarn craton — an update, Extended abstracts *compiled by* K. F. CASSIDY, A. J. WHITAKER, and S. F. LIU: Australian Geological Survey Organisation, Record 1997/41, p. 125–130.

YEATS, C. J., McNAUGHTON, N. J., RUETTGER, D., BATEMAN, R., GROVES, D. I., HARRIS, J. L., and KOHLER, E., 1999, Evidence for Archean lode gold mineralization in the Yilgarn Craton, Western Australia: a SHRIMP U–Pb study of intrusive rocks: Economic Geology, v. 94, p. 1259–1276.

YEATS, C. J., GROVES, D. I., McNAUGHTON, N. J., DUNPHY, J. M., KOHLER, E., GEBRE-MARIAM, M., and VIELREICHER, N. M., 2000, Constraints on the age of gold mineralization in the Yandal belt, *in* Yandal greenstone belt: regolith, geology and mineralization *edited by* G. N. PHILLIPS and R. R. ANAND: Australian Institute of Geoscientists, Bulletin, no. 32, p. 215–217.

Appendix 1

Rock units of the north Eastern Goldfields Province

Ultramafic rocks

Au Ultramafic rock, undivided; includes talc–chlorite(–carbonate) and tremolite–chlorite schists

Aub Interleaved ultramafic and mafic schist

Auc Talc–carbonate(–serpentine) rock; commonly schistose

Aud Dunite; massive serpentinite with preserved olivine-cumulate microstructures

Auk Komatiite; olivine spinifex texture; tremolite–chlorite, serpentinite, carbonate assemblages; silicified or weathered

Aup Peridotite, commonly serpentinized; relict olivine-cumulate texture; locally rodingitized or silicified

Aur Tremolite(–chlorite–talc–carbonate) schist; locally serpentinized; derived from komatiitic basalt or pyroxenite

Aus Serpentinite, commonly massive

Aut Talc–chlorite(–carbonate) schist; minor tremolite–chlorite schist

Aux Pyroxenite; commonly associated with peridotite in minor layered sills; variably tremolitized, locally schistose

Mafic extrusive rocks

Ab Fine to very fine grained mafic rock, undivided

Aba Amphibolite, fine to medium grained; commonly weakly foliated or massive

Abf Foliated fine-grained mafic rock; locally hornfelsed or epidotized

Abg Mafic rock interleaved with minor foliated granitoid rock

Abi Basaltic andesite or andesite; amygdaloidal; locally feldspar phyric

Abie Basaltic andesite and andesite; epidotized; foliated

Abip Basaltic andesite with plagioclase phenocrysts; variably foliated

Abm Komatiitic basalt; pyroxene spinifex common; variolitic, pillowed locally

Abmg MOUNT GOODE BASALT: tholeiitic basalt

Abmgp MOUNT GOODE BASALT: tholeiitic basalt, plagioclase phyric; phenocrysts up to 20 cm long

Abml Pillowed komatiitic basalt; variolitic texture and local pyroxene-spinifex texture

Abo Basalt, dolerite, and gabbro; thin interleaved units (probably differentiated flows)

Abp Porphyritic basalt, medium- to coarse-grained plagioclase phenocrysts; local intense epidotization

Abs Fine-grained schist derived from basalt; amphibole–chlorite assemblages locally strongly metasomatized

Abv Basalt, undivided; includes feldspar–hornblende or chlorite schist; locally porphyritic; doleritic in parts

Abvc Basalt, extensively carbonatized; includes massive carbonate lenses

Abve Epidotized basalt

Abvh Hornfelsed basalt

Abvi Basalt with interlayers of sedimentary rock

Aby Amygdaloidal basalt

Felsic extrusive rocks

Af Felsic volcanic and volcaniclastic rocks, undivided; includes tuff; commonly deeply weathered and kaolinized

Afd Dacite; commonly tuffaceous; locally brecciated

Afdp Felsic intrusive porphyry; porphyritic dacite (to rhyodacite); predominantly feldspar phenocrysts

Afi Felsic rocks of intermediate composition; dacite to basaltic andesite; locally amygdaloidal

Afip Porphyritic andesite, volcanic or subvolcanic; numerous plagioclase phenocrysts; variably foliated

Afp Feldspar–quartz porphyry; dacite to rhyodacite; volcanic, subvolcanic, or intrusive; locally schistose

Afr Rhyolite lava flows, quartz phyric, locally tuffaceous; weak to schistose foliation

Afrd Rhyodacite; porphyritic; rarely spherulitic

Afs Schistose quartzofeldspathic micaceous rock derived from felsic volcanic or volcaniclastic protolith

Afsv Bedded felsic volcaniclastic rocks with minor felsic volcanic rock

Aft Felsic tuffaceous rock; finely banded; foliated; fine to medium grained; quartz and feldspar phenocrysts

Aftl Felsic lapilli tuff

Afv Felsic volcanic and volcaniclastic rocks; quartz and/or feldspar phenocrysts; includes fragmental rock and finely layered tuff; variably foliated

Afx Felsic fragmental rock, coarse grained; volcanic or volcaniclastic derivation

Afy Trachyandesite

Clastic sedimentary rocks

As Sedimentary rock, undivided; includes sandstone, siltstone, shale, and chert; may have volcaniclastic component

Asc Conglomerate with subordinate sandstone; pebbles and boulders include granitoid, chert, felsic porphyry, and mafic rocks; matrix or clast supported

Ascb Conglomerate and subordinate pebbly sandstone with abundant clasts; clasts are gabbro and basalt

Ascf Oligomictic conglomerate with clasts mainly of felsic volcanic rock; subordinate sandstone; psammitic matrix

Ascq Oligomictic conglomerate with clasts mainly of quartz, quartzite, and chert

Asf Volcaniclastic, tuffaceous, and other felsic sedimentary rocks; foliated; commonly deeply weathered and kaolinized

Ash Shale–slate, in part chert; minor siltstone and sandstone; foliated; commonly silicified

Ashc Grey to black slate and interlayered quartzo-feldspathic schist with chert layers and lenses; locally ferruginous and/or pyritic

Ashg Graphitic black shale or slate

Ashk Carbonatized fine-grained metasedimentary rock (subsurface only)

Ashq Shale and siltstone; local quartz phenocrysts

Asjc JONES CREEK CONGLOMERATE: conglomerate and sandstone; dominantly granitoid clasts in quartzofeldspathic matrix

Asjcb JONES CREEK CONGLOMERATE: conglomerate and sandstone with dominantly mafic matrix

Asjct JONES CREEK CONGLOMERATE: arkosic sandstone, fine to medium grained; rare pebbles

Asq Medium-grained quartzite; locally quartz siltstone, and quartz–muscovite schist

Ass Sandstone to siltstone, locally partly conglomerate

Chemical sedimentary rocks

Ac Chert and banded chert; locally includes silicified (black) shale, slate, or exhalite

Aci Banded iron-formation, oxide facies; finely interleaved magnetite- and quartz-rich chert and/or siliceous slate

Acis Banded iron-formation, silicate facies; quartz–magnetite(–grunerite–hornblende) rock

Acj Jaspilite

Askd Dolomite

Askl Limestone

Mafic intrusive rocks

Ao Mafic intrusive rock, undivided

Aod Dolerite

Aodp Porphyritic dolerite, with feldspar phenocrysts

Aog Gabbro; minor pyroxenite or quartz gabbro components

Aogf Strongly foliated gabbro

Aogl Leucogabbro; locally magnetite rich

Aogp Porphyritic gabbro with plagioclase phenocrysts

Aogq Quartz-bearing gabbro and quartz gabbro

Aogt Epidotized metagabbro

Aogv Olivine gabbro

Aogx Pyroxenitic gabbro

Kathleen Valley Intrusion

AaKVa Anorthositic gabbro and anorthosite

AaKVo Gabbro

AaKVox Pyroxene-rich gabbro

AaKVq Quartz-bearing gabbro and quartz gabbro

AaKVqt Quartz gabbro and tonalite

AaKVr	Gabbro with rhythmic layering (2–10 cm) due to varying proportions of amphibole and plagioclase

Granitoid rock types

Ag	Granitoid rock, undivided
Aga	Fine-grained granitoid rock; deeply weathered
Agb	Foliated granitoid rock interleaved with subordinate mafic rock; gneissic banding locally developed
Agc	Coarse-grained granitoid rock
Agd	Diorite to quartz monzodiorite; with hornblende, clinopyroxene, and/or biotite; small dykes and stocks
Agdp	Porphyritic diorite or monzodiorite; plagioclase phenocrysts, K-feldspar megacrysts; locally quartz phyric
Agdq	Quartz diorite and quartz monzodiorite
Agem	Medium-grained, equigranular granitoid rock
Agf	Strongly foliated granitoid; locally gneissose; includes amphibolite lenses
Agg	Granodiorite; microgranitoid enclaves locally
Aggp	Granodiorite, porphyritic (subsurface only)
Aggwe	WEEBO GRANODIORITE: granodiorite, coarse-grained phase
Aggwea	WEEBO GRANODIORITE: granodiorite, fine-grained phase
Agl	Leucocratic granitoid and microgranitoid rocks
Agln	Gneissic leucocratic granitoid rock; locally quartzitic
Agm	Monzogranite; biotite bearing, local hornblende; commonly medium to coarse grained; minor granodiorite
Agma	Fine-grained biotite monzogranite
Agmf	Strongly foliated biotite monzogranite, medium to coarse grained; minor granodiorite and pegmatite dykes
Agmh	Hornblende monzogranite (subsurface only)
Agmp	Porphyritic monzogranite
Agn	Gneissic granitoid rock
Agnq	Granitoid rock and quartzofeldspathic gneiss
Agp	Porphyritic granitoid, undivided
Ags	Syenite and quartz syenite; numerous mafic schlieren and xenoliths; porphyritic locally
Agt	Tonalite
Agz	Monzonite
Agzq	Quartz monzonite; commonly porphyritic
Agzwa	WADARRAH QUARTZ MONZONITE: quartz monzonite; hornblende rich; local platy alignment

Dykes and veins

a	Aplite dyke
d	Dolerite dyke or sill
dyy	Granophyric dyke
e	Epidosite, epidote rock
g	Granite dyke
gg	Granodiorite dyke
gt	Tonalite dyke
lp	Lamprophyre dyke
p	Pegmatite dyke or pod
q	Quartz vein or pod; quartzolite; massive, crystalline or brecciated
qi	Goethite–quartz and quartz–goethite veins
qix	Goethite(or hematite)–quartz breccia

Metamorphic rocks

Low to moderate grade

Ala	Amphibolite; schistose; clinopyroxene, cummingtonite, and/or garnet present locally; protolith unknown
Alan	Banded amphibolite
Alb	Biotite schist (subsurface only)
Ald	Quartz–aluminosilicate rock within felsic volcanic sequences; highly poikilitic andalusite; minor kyanite locally
Alk	Felsic schist with kyanite; locally andalusite and/or chloritoid present; quartz clasts preserved locally
All	Chlorite schist
Alqb	Quartz–biotite(–feldspar–muscovite) schist
Alqf	Quartz–feldspar(–muscovite) schist; schistose to massive; locally deeply weathered
Alql	Quartz–chlorite schist; chlorite–magnetite –feldspar, and chlorite schist; locally deeply weathered
Alqm	Quartz–muscovite(–feldspar) schist

High grade

Ahbx Pyroxene hornfels

Gneissic rocks

An Banded to agmatitic felsic gneiss; minor calc-silicate and mafic components

Ang Quartzofeldspathic or banded granitoid gneiss; locally migmatitic; mafic bands

Angb Interlayered quartzofeldspathic gneiss, monzonite, and metamorphosed mafic rock

Angk Quartz–K-feldspar gneiss

Ank Calc-silicate gneiss

Anq Quartzitic gneiss; typically local unit within felsic gneisses

Proterozoic dykes

P_dy Mafic and ultramafic dykes; locally known as the Widgiemooltha dyke swarm

Rocks of the Yerrida Group

P_Yj JUDERINA FORMATION, Windplain Subgroup: quartz sandstone; local sandstone, chert breccia, and conglomerate

P_Yjb JUDERINA FORMATION, Bubble Well Member: laminated stromatolitic chert, stromatolitic carbonate beds, and dolostone

P_Yjf JUDERINA FORMATION, Finlayson Member: quartz arenite; planar bedded or cross-stratified minor pebble conglomerate and intercalated siltstone

P_Yjs JUDERINA FORMATION: shale and siltstone

P_Yk KILLARA FORMATION, Mooloogool Subgroup: undifferentiated mafic intrusive and extrusive rocks, and intercalated thin chertified volcaniclastic rocks

P_Ykb KILLARA FORMATION: tholeiitic basalt; locally amygdaloidal; minor nontronite layers

P_Ykc KILLARA FORMATION, Bartle Member: chert, chert breccia, laminated chert, and chertified sedimentary rock; locally with pseudomorphs of anhydrite crystals and nodules; minor basalt

P_Ykd KILLARA FORMATION: dolerite and gabbro, mainly in sills; minor disseminated sulfides (hypabyssal equivalent of *P_Yk*)

Rocks of the Earaheedy Group

P_Eck CHIALL FORMATION, Karri Karri Member: shaly siltstone

P_Ecw CHIALL FORMATION, Wandiwarra Member: sandstone and shale

P_Ed WINDIDDA FORMATION: limestone and shale

P_Ef FRERE FORMATION: peloidal chert, granular iron-formation, granular siliceous iron-formation, siltstone, and sandstone; variably ferruginous

P_Efg FRERE FORMATION: granular iron-formation and peloidal chert; minor siltstone and shale

P_Efs FRERE FORMATION: shaly siltstone; minor chert and fine-grained sandstone

P_Ey YELMA FORMATION: sandstone, arkose, shale, siltstone, conglomerate, and stromatolitic dolomite; minor chert breccia

P_Eya YELMA FORMATION: fine- to medium-grained sandstone with pebble lags towards base

P_Eyc YELMA FORMATION: carbonate, locally stromatolitic, with shale

Proterozoic sedimentary rocks of fluvial origin

P_kc KALUWEERIE CONGLOMERATE: polymictic conglomerate

P_ks KALUWEERIE CONGLOMERATE: arkosic sandstone and mudstone

P_s Unassigned conglomerate, quartz-rich sandstone, arkosic sandstone, and microbial laminates; commonly silicified and brecciated

Permian rocks

Pac PATERSON FORMATION: conglomerate, with sandstone and siltstone; probably of glacigene origin

Pah PATERSON FORMATION: claystone and siltstone; probably of lacustrine origin

Pas PATERSON FORMATION: sandstone, with pebbly to bouldery siltstone, conglomerate, and mudstone; probably of fluviatile origin

Psc Unassigned conglomerate; polymictic, poorly sorted; fluvioglacial deposit

Psh Unassigned claystone and siltstone

Regolith

Alluvial deposits

Apc Clay and silt in claypans

Ad — Clay, silt, sand, and gravel in channels and floodplains

Ak — Calcrete in active fluvial channels

Colluvial deposits

Cd — Gravel and sand as proximal sheetwash and talus

Cf — Ferruginous gravel or reworked ferruginous duricrust

Cfc_i — Detritus and talus adjacent to ridges of banded iron-formation

Cq — Quartz-vein debris

Czu — Rubble derived from silcrete on ultramafic rock

Sheetwash deposits

W — Clay, silt, and sand as extensive fans; locally ferruginous and/or gravelly

Wf — Ferruginous buckshot gravel flats and small tree-rimmed claypans

Sandplain deposits

S — Yellow sand with minor silt and clay; limonitic pisoliths near base; low, vegetated dunes locally common; pebbles of ferruginous duricrust

S_v — Unconsolidated sand and minor silt and clay, restricted to old valley systems

Sgp — Quartzofeldspathic sand and gravel over and adjacent to granitic rock

Lacustrine deposits

L_d — Sand, silt, and gypsum in stabilized dunes adjacent to playa lakes

L_de_g — Kopi — lithified gypsum and clay in mounds and dunes adjacent to playa lakes

L_g — Silt, sand, and gravel in halophyte flats adjacent to playas

L_l — Saline and gypsiferous evaporites, clay, silt, and sand in playa lakes

L_m — Mixed playa and sandplain terrain, commonly palaeodrainages

Residual deposits

R — Residual regolith and reworked products, undivided; mainly ferruginous and carbonate duricrust; minor silcrete and calcrete

Rf — Ferruginous duricrust and/or ferricrete; massive to rubbly; locally reworked

Rfi — Massive ironstone as ridge and capping

Rk — Calcrete

Rz — Silcrete

Rzp_g — Silcrete and/or kaolinized granitoid rock

Rzu — Siliceous caprock over ultramafic rock; locally includes chalcedony and chrysoprase

Exposed regolith

X_w — Weathered rock; protolith unrecognizable

Appendix 2

MINEDEX commodity groups, mineralization types, and reference abbreviations

Commodity groups and minerals

Note: Mineral order represents the sequence of relative importance within the specific commodity group. Contaminant or gangue minerals in potential products have an order of 500 or greater.

Commodity group	*Order*	*Mineral*	*Mineral abbrev.*
Alunite	10	Alunite	ALUM
	20	Potash	K_2O
	30	Gypsum	$CaSO_4$
Andalusite	10	Andalusite	AND
Antimony	10	Antimony	Sb
Arsenic	10	Arsenic	As
Asbestos	10	Asbestos	ASB
Barite	10	Barite	$BaSO_4$
Bauxite–alumina	10	Alumina (available)	ABEA
	20	Bauxite	BAUX
	500	Reactive silica	$RESIO_2$
Bismuth	10	Bismuth	Bi
Chromite–platinoids	10	Chromite	Cr_2O_3
	20	Platinum	Pt
	25	Palladium	Pd
	31	Rhodium	Rh
	40	PGE	PGE
	50	PGE + gold	PGEAu
	55	Gold	Au
	60	Nickel	Ni
	70	Copper	Cu
	100	Iron	Fe
Clays	10	Attapulgite	ATTAP
	20	Bentonite	BENT
	30	Kaolin	KAOLIN
	35	Saponite	SAPON
	40	Cement clay	C.CLAY
	60	White clay	W.CLAY
Coal	10	Coal	COAL
	20	Lignite	LIGN
Construction materials	10	Aggregate	AGGREG
	20	Gravel	GRAVEL
	30	Sand	SAND
	40	Rock	ROCK
	50	Soil	SOIL
	300	Vanadium	V_2O_5
	310	Titanium dioxide	TiO_2
	320	Iron	Fe
Copper–lead–zinc	10	Zinc	Zn
	20	Copper	Cu
	30	Lead	Pb
	40	Silver	Ag
	50	Gold	Au
	60	Molybdenum	Mo
	65	Cobalt	Co
	70	Barium	Ba
	80	Cadmium	Cd
	90	Tungsten	WO_3
Diamonds	10	Diamond	DIAM
Diatomite	10	Diatomite	DIATOM
Dimension stone	10	Dimension stone	DIM.ST
	20	Sandstone	SST
	30	Quartzite	QZTE
	40	Limestone	LST
	50	Black granite	B.GRAN
	55	Granite	GRAN
	60	Marble	MARBLE
	70	Dolerite	DOLER
	80	Slate	SLATE
	90	Spongolite	SPONG
Dolomite	10	Dolomite	DOLOM
Fluorite	10	Fluorite	CaF_2
Gem, semi-precious and ornamental stones	10	Amethyst	AMETH
	20	Emerald	EMER
	30	Opal	OPAL
	32	Tourmaline	TOURM
	35	Chrysoprase	CHRYSP
	37	Malachite	MALACH
	40	Tiger eye	T.EYE
	45	Jasper	JASPER
	50	Zebra rock	ZEBRA
	60	Chert (green)	CHERT
Gold	10	Gold	Au
	20	Silver	Ag
	30	Copper	Cu
	40	Nickel	Ni
	50	Cobalt	Co
	54	Lead	Pb
	55	Zinc	Zn
	60	Tungsten	WO_3
	70	Molybdenum	Mo
	500	Antimony	Sb
	510	Arsenic	As
Graphite	10	Graphite	GRAPH
	20	Carbon (fixed)	C
Gypsum	10	Gypsum	$CaSO_4$
	30	Alunite	ALUM
	500	Salt	SALT
Heavy mineral sands	10	Heavy minerals	HM
	20	Ilmenite	ILM
	30	Leucoxene	LEUCO
	50	Rutile	RUTILE
	60	Zircon	ZIRCON
	70	Monazite	MONAZ
	80	Xenotime	XENO
	90	Garnet	GARNET
	100	Kyanite	KYAN
	130	Synthetic rutile	SYN.R
	510	Slimes	SLIMES
	520	Titanium dioxide	TiO_2
	530	Zirconia	ZrO_2
Industrial pegmatite minerals	10	Mica	MICA
	20	Beryl	BERYL
	30	Feldspar	FELDS
	35	Alkalis	K+Na
	37	Alumina	Al_2O_3

Commodity groups and minerals (continued)

Commodity group	*Order*	*Mineral*	*Mineral abbrev.*
	40	Quartz	QUARTZ
	505	Ferric oxide	Fe_2O_3
Iron ore	10	Iron	Fe
	20	Manganese	Mn
	500	Phosphorus	P
	510	Alumina	Al_2O_3
	520	Silica	SiO_2
	525	Sulfur	S
	530	Loss on ignition	LOI
Limestone–limesand	10	Calcium carbonate	$CaCO_3$
	20	Limestone–limesand	LIME
	50	Shell grit	SHELL
	70	Chalk	CHALK
	100	Lime	CaO
	200	Magnesite	$MgCO_3$
	501	Silica	SiO_2
Magnesite	10	Magnesite	$MgCO_3$
	10	Manganese	Mn
	100	Iron	Fe
	510	Silica	SiO_2
	520	Alumina	Al_2O_3
	530	Phosphorus	P
Nickel	10	Nickel	Ni
	20	Copper	Cu
	25	Cobalt	Co
	30	Nickel + copper	Ni+Cu
	35	Nickel equivalent	Ni EQU
	40	Gold	Au
	50	Platinum	Pt
	55	Palladium	Pd
	70	Chromite	Cr_2O_3
	80	Silver	Ag
	90	Magnesia	MgO
	500	Silica	SiO_2
Other	10	Gold	Au
Peat	10	Peat	PEAT
Phosphate	10	Phosphate	P_2O_5
Pigments	10	Ochre	OCHRE
	20	Hematite pigment	HEM
Potash	10	Potash	K_2O
	10	Sulfur	S
	20	Iron	Fe
	30	Zinc	Zn
	40	Copper	Cu

Commodity group	*Order*	*Mineral*	*Mineral abbrev.*
	50	Lead	Pb
Rare earths	10	Rare earth oxides	REO
	20	Yttrium	Y_2O_3
	25	Lanthanides	LnO
	30	Tantalite	Ta_2O_5
	40	Columbite	Nb_2O_5
	50	Tin (cassiterite)	SnO_2
	60	Xenotime	XENO
	70	Gallium	Ga
	80	Zirconia	ZrO_2
	90	Hafnium	HfO_2
	100	Beryl	BERYL
	510	Alumina	Al_2O_3
Salt	10	Salt	SALT
	20	Gypsum	$CaSO_4$
Silica – silica sand	10	Silica	SiO_2
	20	Sand	SAND
	30	Quartzite	QZTE
	510	Ferric oxide	Fe_2O_3
	520	Titanium dioxide	TiO_2
	530	Alumina	Al_2O_3
	540	Heavy minerals	HM
Talc	10	Talc	TALC
Tin–tantalum–lithium	10	Tin (cassiterite)	SnO_2
	20	Tantalite	Ta_2O_5
	30	Columbite	Nb_2O_5
	40	Spodumene	Li_2O
	50	Kaolin	KAOLIN
	510	Ferric oxide	Fe_2O_3
Tungsten–molybdenum	10	Tungsten	WO_3
	20	Molybdenum	Mo
	30	Copper	Cu
	40	Antimony	Sb
	50	Vanadium	V_2O_5
	60	Gold	Au
Uranium	10	Uranium	U_3O_8
	20	Vanadium	V_2O_5
	30	Copper	Cu
Vanadium–titanium	10	Vanadium	V_2O_5
	20	Titanium dioxide	TiO_2
	30	Iron	Fe
	40	Gold	Au
Vermiculite	10	Vermiculite	VERMIC

Mineralization types

Abbreviation	*Mineralization type*
ALLAKE	Alunite in lake sediments
ANDSED	Andalusite in metasedimentary rocks
ASBAMP	Metasomatic asbestos deposits in amphibolites
ASBBIF	Asbestos deposits in banded iron-formations
ASBDLM	Asbestos deposits in dolomite intruded by dolerite
ASBSER	Asbestos deposits in serpentinites
ASBUM	Asbestos veins in ultramafic rocks
ASMASS	Stratiform massive arsenopyrite in metasediments
ASQTZV	Arsenic associated with auriferous quartz veins
AUALL	Alluvial–eluvial gold deposits
AUBIF	Gold in banded iron-formation and related sediments
AUCONG	Gold in conglomerate within greenstones
AUEPI	Epigenetic gold deposits in Precambrian terrains
AUFVOL	Felsic volcanic rocks and/or volcanogenic sediments containing auriferous quartz veins and/or shear zones
AUGRAN	Gold deposits along granite–greenstone contacts and in granitoid rocks
AULAT	Lateritic gold deposits
AUPLAC	Precambrian placer gold deposits
AUPOR	Gold associated with felsic porphyry within greenstones
AUSHER	Basalt and/or dolerite containing auriferous quartz veins along faults or shear zones
AUSTOK	Dolerite or gabbro containing auriferous quartz stockworks or veins
AUSYN	Syngenetic gold deposits in Precambrian terrains
AUUM	Gold deposits in ultramafic rocks
BABED	Stratabound bedded barite deposits
BACAV	Vein and cavity-fill deposits
BAPEGM	Pegmatite-hosted barite deposits
BAUKAR	Karstic bauxite deposits
BAULAT	Lateritic bauxite deposits
BIPEGM	Bismuth in quartz-rich pegmatites
BIQTZV	Bismuth associated with gold mineralization
BMMASS	Volcanogenic Cu–Zn deposits
BMMISS	Mississippi Valley-type Pb–Zn deposits
BMPOR	Porphyry Cu–Mo deposits
BMSED	Sedimentary Cu–Pb–Zn deposits
BMSHER	Base metal deposits in quartz veins and/or shear zones
CADUNE	Limesand in coastal dune sands
CALAKE	Calcareous material in lake sediments
CALIME	Limestone deposits
CASEA	Offshore limesand deposits
CLBED	Bedded sedimentary clay deposits
CLRES	Residual clay deposits
CLTRAN	Transported clay deposits
COJSBT	Jurassic sub-bituminous coal
COLIGN	Eocene lignite deposits
COPBIT	Permian bituminous coal
COPSBT	Permian sub-bituminous coal
CRLAT	Lateritic chromium deposits
CRPGLY	Platinum group elements and/or chromium in layered mafic–ultramafic intrusions
CRPGUM	Platinum group elements and/or chromium in metamorphosed mafic–ultramafic rocks
DIAALL	Alluvial–eluvial diamond deposits
DIALAM	Lamproitic diamond deposits
DLMBED	Dolomite deposits in sedimentary sequences
DLMKAN	Residual kankar (dolomite) deposits
DLMLAK	Dolomite deposits associated with lake sediments
DLMSOM	Metasomatic dolomite deposits
DTMLAK	Diatomaceous lake deposits
FEBIF	Primary banded iron-formation deposits
FEBR	Iron ore deposits in the Brockman Iron Formation
FEGGT	Iron ore deposits in granite–greenstone terrains
FEMM	Iron ore deposits in the Marra Mamba Iron Formation
FEPIS	Pisolitic iron-ore deposits
FESCRE	Scree and detrital iron-ore deposits
FESED	Sedimentary basin iron-ore deposits
FGRAN	Fluorite deposits associated with granitic rocks
FPEGM	Pegmatite-hosted fluorite deposits
FVEIN	Vein fluorite deposits
GEMMET	Gem and/or semi-precious stones in high-grade metamorphic rocks
GEMPEG	Pegmatite-hosted gem and/or semi-precious stones
GEMSED	Sediment-hosted gem and/or semi-precious stones
GEMUM	Ultramafic-hosted gem and/or semi-precious stones
GEMVOL	Gem and/or semi-precious stones in volcanic rocks
GRMETA	Graphite deposits in metamorphic rocks
GRPEG	Pegmatite-hosted graphite deposits
GRQTZV	Graphite deposits in quartz veins
GRUM	Graphite as segregations in ultramafic rocks
GYBBAS	Gypsum in coastal barred-basin deposits
GYDUNE	Dunal gypsum deposits
GYLAKE	Gypsum in lake sediments
HMSCAP	Heavy mineral deposits in the Capel shoreline
HMSDON	Heavy mineral deposits in the Donnelly shoreline
HMSDUN	Heavy mineral deposits in the Quindalup shoreline
HMSEN	Heavy mineral deposits in the Eneabba shoreline
HMSGIN	Heavy mineral deposits in the Gingin shoreline
HMSHV	Heavy mineral deposits in the Happy Valley shoreline
HMSMES	Heavy mineral deposits in Mesozoic formations
HMSMIL	Heavy mineral deposits in the Milyeaanup shoreline
HMSMIS	Heavy mineral deposits — miscellaneous
HMSMUN	Heavy mineral deposits in the Munbinea shoreline
HMSWAR	Heavy mineral deposits in the Warren shoreline
HMSWRN	Heavy mineral deposits in the Waroona shoreline
HMSYOG	Heavy mineral deposits in the Yoganup shoreline
KBRINE	Potash deposits in brines and surface evaporites
KEVAP	Potash deposits in buried evaporite sequences
KGLAUC	Potash in glauconitic sediments
KLAKE	Potash associated with lake sediments
MGUM	Mafic–ultramafic rocks
MNCAV	Joint–cavity-fill manganese deposits
MNRES	Residual manganese deposits
MNSED	Sedimentary manganese deposits
MNSUPR	Precambrian supergene enrichment of manganiferous sediments
MOPOR	Porphyry Cu–Mo deposits
NABRIN	Salt in brines and surface evaporites
NAVAP	Salt deposits in buried evaporite sequences
NIINTR	Nickel in dunite phase of thick komatiite flows
NILAT	Lateritic nickel deposits
NISED	Nickel deposits in metasedimentary rocks
NITHOL	Nickel deposits in the gabbroic phase of layered tholeiites
NIVEIN	Vein-type nickel deposits
NIVOLC	Nickel associated with volcanic peridotites
PCARB	Carbonatite-hosted phosphate deposits
PEGPEG	Pegmatite-hosted industrial minerals

Mineralization types (continued)

Abbreviation	*Mineralization type*
PGALL	Alluvial–eluvial platinoid deposits
PGUANO	Quaternary guano (phosphate) deposits
PIGHEM	Specular hematite pigment
PNOD	Seafloor (nodular) phosphate deposits
PSED	Phosphate deposits in Phanerozoic sediments
PVEIN	Vein phosphate deposits
REALL	Alluvial–eluvial rare earth deposits
RECARB	Carbonatite-hosted rare earth deposits
REFELS	Felsic volcanic-hosted rare earth deposits
REHMS	Rare earths in heavy mineral sands
REPPEG	Pegmatite-hosted rare earth deposits
RESST	Xenotime in sandstones
SBQTZV	Antimony associated with auriferous quartz veins
SIDUNE	Mesozoic dune and bedded silica sands
SIQTZ	Silica in vein quartz
SIQZTE	Silica in quartzite or chert or both
SMASS	Sulfur in massive sulfides
SNALL	Alluvial–eluvial tin–tantalum deposits
SNGREI	Tin–tantalum deposits in greisen zones
SNPEGM	Pegmatite tin–tantalum–lithium deposits
SNVEIN	Vein tin–tantalum deposits
SSEDQZ	Sulfur in sediments and/or quartz veins
TALDLM	Talc deposits associated with dolomite
TALUM	Talc deposits in ultramafic rocks
UCALC	Calcrete-related uranium deposits
UCAV	Secondary (cavity-fill) vein-like uranium deposits
UCONG	Conglomerate-hosted deposits
ULIGN	Lignite-hosted uranium deposits
UPEG	Pegmatite-hosted uranium deposits
USST	Sandstone-hosted uranium deposits
UUNCF	Unconformity-related uranium deposits
UVEIN	Uranium in veins associated with base metals
VCALC	Calcrete-related vanadium deposits
VERUM	Vermiculite deposits associated with weathered mafic and ultramafic bodies
VTIALL	Alluvial–eluvial vanadium–titanium deposits
VTILAT	Lateritic vanadium–titanium deposits
VTIMAG	Titaniferous magnetite deposits
VTIVN	Vanadium–titanium vein deposits associated with base metals
WMOGRE	Tungsten–molybdenum deposits in greisen zones
WMOPEG	Pegmatite tungsten–molybdenum deposits
WSKARN	Tungsten–molybdenum skarn deposits

Abbreviations of source references

Source	Full title
02208/93	Department of Minerals and Energy (DME) mines file number
?	Unknown source
A_______	Accession number of open-file statutory mineral exploration report in DME library
AIMM PRO	Australasian Institute of Mining and Metallurgy Proceedings
AMH	Australian Mining Handbook
AMIQ	Australian Mineral Industries Quarterly
AR(CO)	Annual Report to Shareholders (abbreviated company name)
ASX(CO)	Report to Shareholders (abbreviated company name)
AUSIMM	Australasian Institute of Mining and Metallurgy Report
AUSIMM14	Australasian Institute of Mining and Metallurgy Bulletin and number
BHP	BHP correspondence
BMR	Bureau of Mineral Resources Report
BMR RR 1	Bureau of Mineral Resources Resource Report and number
BMR59/24	Bureau of Mineral Resources Record and number
BULL(NO)	Geological Survey of Western Australia (GSWA) Mineral Resource Bulletin (and number)
CO CORR/REP	Company report to shareholders
CO(CO)	Company report to shareholders (abbreviated company name)
CSIROPUB	CSIRO publication
DN	Daily News newspaper
EMP(NO)	Environmental management report (and number)
ER	Open-file statutory mineral exploration report in DME library
ERMP	Environmental Review and Management Program
F.NOTE	DME file note

Source	Full title
FR	Financial Review newspaper
GG	Gold Gazette
GS BULL	GSWA Bulletin
GS REP	GSWA Report
GSWA AR	GSWA Annual Report
HI CORR/REP	Hamersley Iron correspondence or report
HOGAN	Hogan and Partners Investor's Sharewatch
HOMESWES	Homeswest report
HY(CO)	Half year report to shareholders (abbreviated company name)
I(NO)	Item number of open-file statutory mineral exploration report in DME library
IND MIN	Industrial Minerals magazine
KAL MIN	Kalgoorlie Miner newspaper
M(NO)	M number of open-file statutory mineral exploration report in DME library
MB SYMP	Metals Bulletin Symposium
MEM 3	GSWA Memoir and number
MG	Metals Gazette
MINER	Miner
MINMET	MINMET report
MJ	Mining Journal
MM	Mining Monthly
MRR(NO)	GSWA Mineral Resources Report (number)
NOI(NO)	Notice of Intent to mine (number)
PAYD	Paydirt
PER	Public Environmental Review
PERS COM	Personal communication
PRO(CO)	Company prospectus (abbreviated company name)
QR(CO)	Quarterly report to shareholders (abbreviated company name)
REC(NO)	GSWA Record (number)
REP 33	GSWA Report (number)
ROY REP	DME Royalty Report
STAT DEC	Statutory Declaration submitted to DME
WEST A	The West Australian newspaper