

**EXPLANATORY  
NOTES**



# **GEOLOGY OF THE GUNANYA 1:100 000 SHEET**

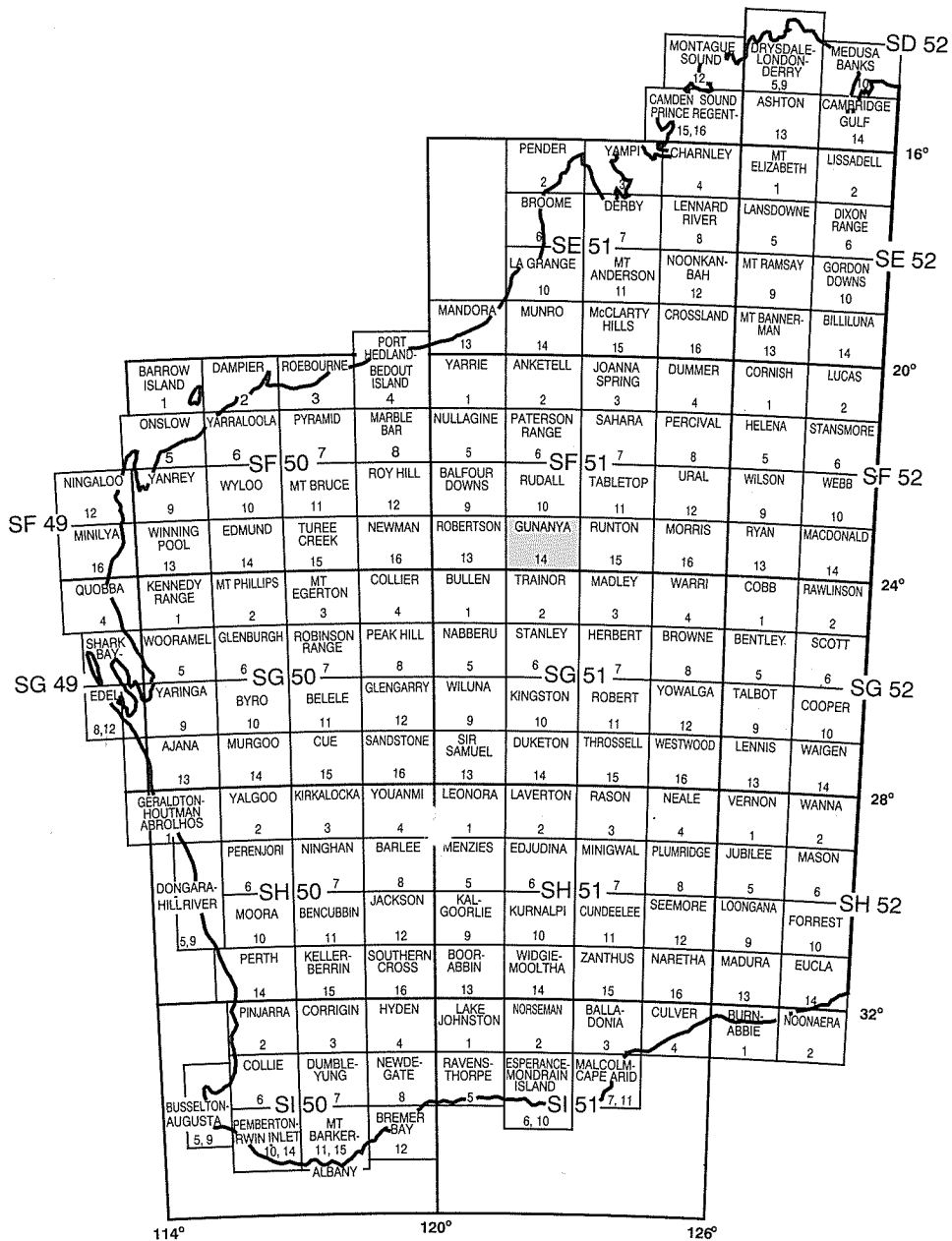
**by L. Bagas**

**1:100 000 GEOLOGICAL SERIES**



**GEOLOGICAL SURVEY OF WESTERN AUSTRALIA  
DEPARTMENT OF MINERALS AND ENERGY**





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**GEOLOGICAL SURVEY OF WESTERN AUSTRALIA**

# **GEOLOGY OF THE GUNANYA 1:100 000 SHEET**

**by  
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**Perth 1998**

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**Cover photograph:**

**Outcrop of the Gunanya Sandstone forming the McKay Range, in the northwestern part of the GUNANYA 1:100 000 map sheet**



# Contents

Introduction .....	1
Previous investigations .....	1
Physiography .....	1
Tertiary land surface .....	1
Recent land surface .....	4
Erosional surface .....	4
Depositional surface .....	4
Precambrian geology .....	4
Rudall Complex .....	4
Connaughton Terrane .....	5
Medium-grained, non-garnetiferous amphibolite ( <i>ERam</i> ) .....	5
Metamorphosed banded iron-formation ( <i>ERi</i> ) .....	5
Metamorphosed chert and banded iron-formation ( <i>ERic</i> ) .....	5
Orthoquartzite ( <i>ERq</i> ) and micaceous quartzite ( <i>ERqm</i> ) .....	5
Talbot Terrane .....	5
Micaceous quartzite ( <i>ERqm</i> ) .....	5
Quartz–mica schist ( <i>ERm</i> ) .....	5
Orthogneiss .....	5
K-feldspar augen orthogneiss ( <i>ERga</i> ) .....	5
Quartzofeldspathic gneiss and schist of uncertain protolith .....	5
Mylonite ( <i>ERns</i> ) .....	5
Fine-grained biotite gneiss ( <i>ERnb</i> ) .....	5
Late intrusive rocks .....	5
Dolerite ( <i>Ed</i> ) .....	5
Massive to weakly foliated granitoids ( <i>Egm, Egl</i> ) .....	6
Amygdaloidal basalt ( <i>Eb</i> ) .....	6
Yeneena Supergroup .....	6
Throssell Group .....	6
Taliwanya Formation ( <i>ETi</i> ) .....	6
Pungkuli Formation ( <i>ETp, ETpk</i> ) .....	6
Tarcunyah Group .....	6
Gunanya Sandstone ( <i>EUu, EUup</i> ) .....	6
Unassigned units ( <i>EUss, EUs</i> ) .....	7
Minor intrusive rocks and quartz veins ( <i>d, q</i> ) .....	7
Cainozoic geology .....	7
Quaternary deposits .....	7
Structure .....	8
Yapungku Orogeny ( $D_{1-2}$ ) .....	8
Miles Orogeny ( $D_{3-4}$ ) .....	8
Paterson Orogeny ( $D_6$ ) .....	8
Metamorphism .....	8
Economic geology .....	9
Mineral occurrences .....	9
Mineral potential .....	9
Water resources .....	9
Acknowledgements .....	9
References .....	10

# Figures

1. Regional geological setting of GUNANYA .....	2
2. Physiography and main access on GUNANYA .....	3





# Geology of the Gunanya 1:100 000 sheet

by

L. Bagas

## Introduction

The GUNANYA\* 1:100 000 map sheet covers the northeastern part of the GUNANYA 1:250 000 map sheet, between latitudes 23°00' and 23°30'S and longitudes 122°30' and 123°00'E (Fig. 1). This area is within the eastern part of the Paterson Orogen (Williams and Myers, 1990). It lies along the northeastern margin of the Little Sandy Desert (Beard, 1970) and includes the northern half of Lake Disappointment (Fig. 2).

GUNANYA is situated in the Eastern Land Division and forms part of the Marble Bar District of the Pilbara Mineral Field. The map sheet is named after Gunanya Spring in the eastern part of the McKay Range.

There is no permanent habitation on GUNANYA. The nearest habitation is Telfer, which is about 150 km north-northwest of the map sheet. The Talawana Track is a good-quality, four-wheel drive track connecting the northern part of GUNANYA to Newman, through the Balfour Downs Homestead and the Ethel Creek – Jigalong road. A rough four-wheel drive track follows the disused Canning Stock Route around the western edge of Lake Disappointment.

## Previous investigations

The first report on the region was by Rudall (1897) who searched unsuccessfully for lost members of the Calvert scientific and exploring expedition in 1896. In 1889 F. H. Hann discovered the northwestern corner of Lake Disappointment while searching for grazing land and prospecting for gold.

The first geological observations of the region were made in 1908–09 by H. W. B. Talbot, who accompanied A. W. Canning's well-sinking party along the Canning Stock Route (Talbot, 1910; 1920). Talbot produced geological reports and maps of the region in which he described gneiss (Rudall Complex), the 'Nullagine Series'

(Proterozoic sedimentary rocks younger than the Rudall Complex), and the 'Paterson Range Series' (Paterson Formation). Kidson (1921) carried out a magnetic survey along the Canning Stock Route.

The Geological Survey of Western Australia (GSWA) mapped the GUNANYA 1:250 000 sheet in 1975 as part of the systematic 1:250 000 geological mapping of Western Australia (Crowe and Chin, 1979; Yeates and Chin, 1979; Williams and Williams, 1980; Chin et al., 1980).

In 1989 GSWA began a program of detailed 1:100 000 geological mapping of the Rudall Complex. By 1994, BROADHURST (Clarke, 1991; Hickman and Clarke, 1994), RUDALL (Hickman et al., 1994; Hickman and Bagas, in prep.), THROSSSELL (Williams and Bagas, in prep.a), CONNAUGHTON (Bagas and Smithies, in prep.), POISONBUSH (Williams and Bagas, in prep.b), and GUNANYA had been mapped.

This report and the accompanying 1:100 000 geological map are the result of detailed regional mapping during 1994. Geophysical data supplied by CRA Exploration and PNC Exploration were used to interpret structures and lithologies hidden by Cainozoic cover.

The geology of the southeastern portion of GUNANYA has been reinterpreted from field data collected by I. R. Williams in 1988 (Williams, 1992), and I. R. Williams, R. J. Chin, and S. J. Williams in 1979 (Crowe and Chin, 1979; Williams and Williams, 1980).

## Physiography

The physiography of GUNANYA (Fig. 2) is the product of several distinct erosional and depositional events, the most important of which have been Tertiary peneplanation and the recent erosion and deposition.

## Tertiary land surface

The calcrete deposits throughout GUNANYA pre-date the sandplains and may relate to channels and lakes that were active during the Tertiary. These deposits form low

\* Capitalized names refer to 1:100 000 and 1:250 000 map sheets.

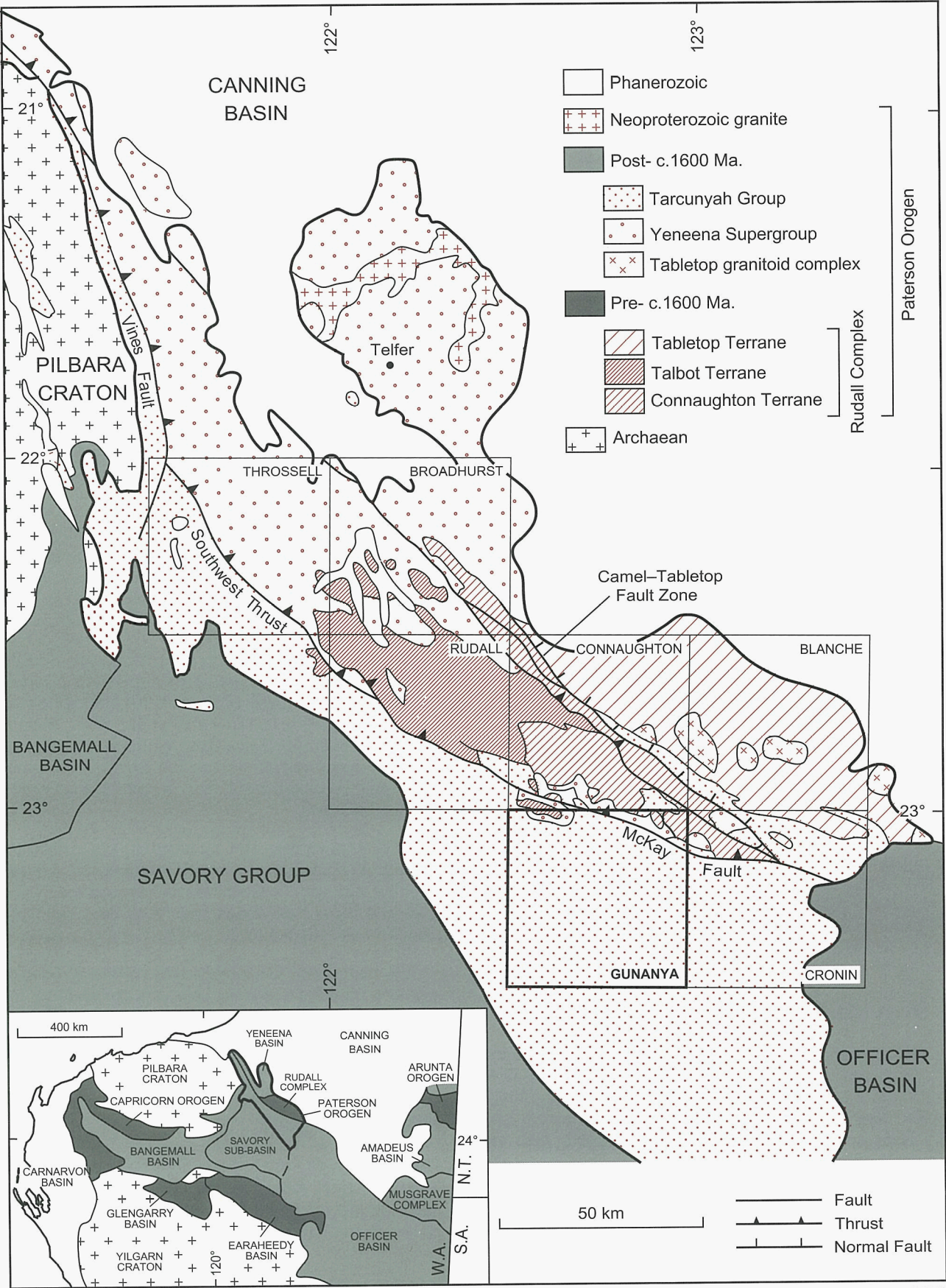


Figure 1. Regional geological setting of Gunanya



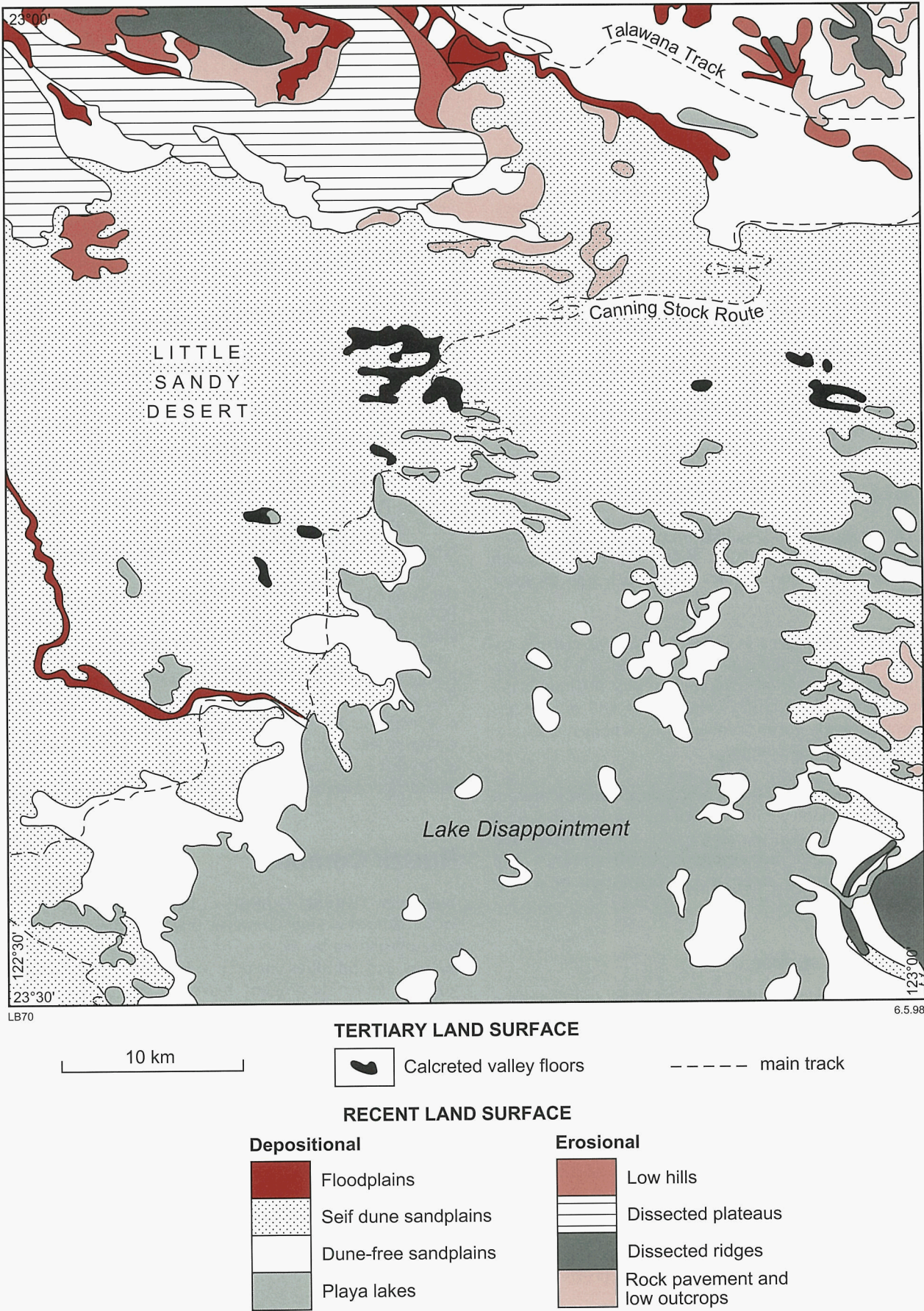


Figure 2. Physiography and main access on GUNANYA

mounds in low-lying areas and are composed of massive, nodular, and vuggy limestone locally replaced by chalcedony.

## Recent land surface

The recent land surface can be subdivided into erosional and depositional-dominated surfaces (Fig 2). The erosional surface is subdivided into dissected plateaus, dissected ridges, low hills, and rock pavements and low outcrops, whereas the depositional surface comprises seif dune and dune-free sandplains, floodplains, and playa lake deposits.

### Erosional surface

Within the recent erosional surface, dissected plateaus are the least eroded areas and are preserved in areas underlain by sandstones of the Tarcunyah Group. The plateaus are cut by short narrow gorges and ravines, and are usually separated from the more subdued landscape of the adjoining areas by well-defined cliff lines.

The dissected areas include, in part, sinuous quartzite ridges rising to about 450 m above sea level, although characteristically they are bevelled to a height of about 400 m.

The low hills area is subject to active erosion by headwater systems and constitutes a dissected, low-lying pediplain. The underlying rock types influence the morphology of the hills; orthogneiss and paragneiss characteristically form rounded hills, whereas quartzite forms more rugged country.

Rock pavements and low outcrops are mainly present in sandplain country, but also occupy small areas within the low hills division. Erosion results mainly from wind action and water movement in small streams, and represents the last stage in the formation of a new pediplain.

### Depositional surface

Sandplains are sub-divided into seif dune and dune-free sandplains. The seif dune sandplains consist of seif dunes that reach a maximum height of 30 m. The dunes are many kilometres long and spaced up to 3 km apart. In longitudinal profile, their steep southern slopes and tuning-fork shapes are consistent with a prevailing wind direction from the east-southeast (Crowe, 1975). The dune-free sandplains are present in areas subjected to periodic flooding, and on the leeward side of hills.

The floodplains often flank sandplains and represent locally derived clastic detritus deposited from streams and channels draining hilly and plateau regions. The present drainage system dissects some of these deposits.

The playa lake subdivision includes salt and playa lakes, lunette dunes, and gypsum deposits. Williams and Williams (1980) observed that Lake Disappointment has

migrated eastward, as suggested by the presence of extensive gypsum deposits and sand-buried lake deposits fringing its western margin.

## Precambrian geology

GUNANYA occupies part of the Paterson Orogen (Williams and Myers, 1990), which was previously referred to as the Paterson Province (Daniels and Horwitz, 1969; Blockley and de la Hunty, 1975). The term Paterson Orogen is applied to a northwesterly trending belt of folded and metamorphosed sedimentary and igneous rocks, ranging in age from Palaeoproterozoic to Neoproterozoic, that have a common tectonic history (Williams and Myers, 1990). The orogen is flanked to the west and southwest by Archaean rocks of the Pilbara and Yilgarn Cratons respectively, and is unconformably overlain by Neoproterozoic to Phanerozoic rocks of the Canning and Officer Basins to the north and east respectively (Fig. 1).

The Paterson Orogen on GUNANYA is subdivided into the Rudall Complex, Yeneena Supergroup, and Tarcunyah Group (Williams and Bagas, in prep.a). The Rudall Complex is in the centre of the Paterson Orogen between the West Australian Craton (composed of the Yilgarn and Pilbara Cratons) and the unexposed North Australian Craton to the east (Myers et al., 1996). The sedimentary rocks of the Yeneena Supergroup and the Tarcunyah, Earraheedy, Bangemall, and Savory Groups obscure the basement rocks between the Rudall Complex and these cratons (Fig. 1). The relationship between the Rudall Complex and the Precambrian North Australian Craton to the east is obscured by cover sequences of the Canning and Officer Basins (Fig. 1).

## Rudall Complex

The term 'Rudall Complex' is applied to Palaeoproterozoic rocks on GUNANYA that were deformed and metamorphosed by the c. 1780 Ma 'Yapungku Orogeny' (Bagas and Smithies, in prep.). Igneous rocks that are younger than this orogeny but older than the Yeneena Supergroup are not assigned to a group.

The Rudall Complex (Williams, 1990) outcrops along the northern margin of GUNANYA. The complex is divided into two tectonically juxtaposed, lithologically distinct packages of rocks: the Connaughton and Talbot Terranes (Bagas and Smithies, in prep.).

The Connaughton Terrane comprises metamorphosed mafic volcanic or intrusive rocks (or both), banded iron-formation, pelite, chert, felsic gneiss (including augen orthogneiss), and quartzite. These rocks are metamorphosed to the amphibolite-granulite transitional facies (Smithies and Bagas, 1997). The Talbot Terrane comprises mainly siliciclastic sedimentary rocks and granitoids, metamorphosed to amphibolite facies. Both terranes contain augen orthogneiss.



Most rocks of the Rudall Complex have undergone retrogressive metamorphism to greenschist facies and are characterized by the following mineral assemblage: epidote, actinolite, albite, quartz, chlorite, sericite, and calcite. To avoid lengthy petrographic descriptions, only the higher grade mineral assemblages and important retrogressive assemblages will be discussed.

## Connaughton Terrane

The Connaughton Terrane outcrops north of the McKay Fault, in the northeastern corner of GUNANYA.

### **Medium-grained, non-garnetiferous amphibolite (ERam)**

Medium-grained amphibolite (ERam) is intercalated with augen orthogneiss. The rock is well foliated, and locally shows distinct centimetre-scale layering due to metamorphic segregation of amphibole-rich and amphibole-poor layers. Plagioclase (andesine) and hornblende are the main constituents. Quartz comprises less than 20% of the rock and may be partly the product of extensive retrogressive alteration of plagioclase to epidote. Accessory minerals include titanite, apatite, magnetite (or leucoxene), rutile, biotite, and zircon.

### **Metamorphosed banded iron-formation (ERi)**

Banded iron-formation (ERi) is fine to medium grained and finely laminated. It consists of recrystallized quartz, aligned magnetite, accessory amounts of muscovite and apatite, and rare light-green amphibole, relict garnet, and epidote. The laminations define a pervasive early foliation, and primary surfaces have not survived recrystallization.

### **Metamorphosed chert and banded iron-formation (ERic)**

Quartzite (after chert) and lesser amounts of banded iron-formation (ERic) form prominent outcrops, and are interlayered and folded with augen orthogneiss. The unit ranges from pure chert to quartz-magnetite rock, although the dominant rock type is a ferruginous chert. The chert consists of quartz, magnetite, garnet, diopside, grunerite, and apatite.

### **Orthoquartzite (ERq) and micaceous quartzite (ERqm)**

Orthoquartzite (ERq) consists of a fine-grained, recrystallized quartz mosaic. The protolith was either a chert or a quartz arenite. Micaceous quartzite (ERqm) consists of fine-grained recrystallized quartz and muscovite, with variable amounts of sericite and opaque minerals.

## Talbot Terrane

The Talbot Terrane outcrops in the centre of the McKay Antiform, in the northwestern part of GUNANYA.

### **Micaceous quartzite (ERqm)**

Micaceous quartzite (ERqm) consists of interlayered quartz-mica schist and quartzite. The quartzite consists of fine- to medium-grained recrystallized quartz outlining a pervasive ( $S_2$ ) foliation; sericite, muscovite, opaque minerals, and rutile are accessory phases. The protolith of the quartzite was a sandstone with subordinate argillaceous siltstone.

### **Quartz-mica schist (ERm)**

Quartz-mica schist (ERm) is fine grained and interlayered with thin quartzite. The schist consists of quartz-biotite-muscovite(-Fe-oxide-tourmaline-garnet-K-feldspar) and its protolith was an argillaceous metasedimentary rock.

## Orthogneiss

### **K-feldspar augen orthogneiss (ERga)**

The K-feldspar augen orthogneiss (ERga) is present in both the Connaughton and Talbot Terranes. It is a microcline-quartz-plagioclase-biotite gneiss containing numerous augen (deformed megacrysts) of K-feldspar. Minor and accessory minerals include zircon, garnet, titanite, allanite, apatite, and opaque minerals. The gneiss commonly shows a strong foliation defined by the alignment of mica and microcline augens. These are stretched out within the foliation plane. The strong mineral fabrics are the result of early deformation ( $D_2$  event).

The protoliths to the augen orthogneiss were mainly porphyritic biotite monzogranite and biotite granite.

### **Quartzofeldspathic gneiss and schist of uncertain protolith**

### **Mylonite (ERns)**

Early fabrics of the mylonitic quartz-sericite(-K-feldspar-muscovite-biotite) schist (ERns) were destroyed by intense cataclasis, which has granulated the quartz and sericitized feldspar and biotite.

### **Fine-grained biotite gneiss (ERnb)**

Fine-grained quartz-feldspar-biotite(-muscovite) gneiss (ERnb) is interlayered with quartzite units in the Connaughton and Talbot Terranes. The proportion of quartz decreases as shearing increases towards the contacts with augen orthogneiss (ERga). The more highly sheared rocks are muscovite-rich whereas biotite becomes the dominant mica in less sheared rocks. The gneiss may be a sheared orthogneiss and marks an early ( $D_2$ ) tectonic boundary between quartzite and orthogneiss.

## Late intrusive rocks

### **Dolerite (Ed)**

Small pods of dolerite (Ed) intrude the Rudall Complex in the core of the McKay Antiform. The dolerite is

present as pods in a major fault that is unconformably overlain by the Throssell Group. This relationship indicates that the dolerite is older than the Throssell Group.

### Massive to weakly foliated granitoids (*Egm*, *Egl*)

Massive to weakly foliated, leucocratic granitoids are present as equigranular (*Egl*) or megacrystic (*Egm*) rocks. Igneous textures are preserved, although these rocks show some signs of recrystallization, particularly of quartz. The rocks are metamorphosed to greenschist facies, and the equigranular granitoid rocks cross-cut  $D_2$  fabrics.

### Amygdaloidal basalt (*Pb*)

Fine-grained amygdaloidal basalt (*Pb*) outcrops in the Connaughton Terrane. The basalt unconformably overlies the Rudall Complex and is overlain by the Tarcunyah Group. On CONNAUGHTON the equivalent basalt is overlain by the Taliwanya Formation (Bagas and Smithies, in prep.).

The basalt is a dark-green, non-foliated rock that consists of altered clinopyroxene, saussuritized plagioclase, accessory magnetite, and minor amounts of altered orthopyroxene, olivine, and secondary amphibole.

### Yeneena Supergroup

The Yeneena Supergroup comprises the Throssell and Lamil Groups (Williams and Bagas, in prep.a). Only the Throssell Group outcrops on GUNANYA.

In the absence of continuous outcrop, the Taliwanya Formation and the conformably overlying Pungkuli Formation are tentatively included in the Throssell Group. This correlation is based on similar rock types, lithological successions, and interpreted environments of deposition and deformation history when compared with the Throssell Group on CONNAUGHTON (Bagas and Smithies, in prep.).

### Throssell Group

#### Taliwanya Formation (*ETt*)

The Taliwanya Formation (*ETt*) is the basal formation of the Throssell Group in the northern part of GUNANYA, and is present on both sides of the McKay Fault. It is possible that the formation is a correlative of the Coolbro Sandstone (Hickman and Clarke, 1994), although it is much thinner than the Coolbro Sandstone on BROADHURST (Hickman and Clarke, 1994) and RUDALL (Hickman and Bagas, in prep.).

The Taliwanya Formation is up to 170 m thick, and principally composed of a basal lenticular polymictic conglomerate and arkosic sandstone with rare heavy-mineral bands. The formation also contains rare, thin interbeds of fine-grained lithic wacke, siltstone, and shale, which become abundant towards a transitional contact with the overlying Pungkuli Formation. The

conglomerate contains pebbles, cobbles, and boulders of quartzite, vein quartz, orthogneiss, and rare angular clasts of ironstone. The clasts are commonly rounded or subrounded and supported by an arkosic matrix. Locally, there is an upward decrease in clast size into the overlying arkosic sandstone. The conglomerate is interpreted as a channel-fill deposit. Cross-bedding and asymmetrical ripple marks are locally preserved in the sandstone.

#### Pungkuli Formation (*ETp*, *ETpk*)

The Pungkuli Formation (*ETp*), in the northwestern part of GUNANYA, is about 900 m thick and consists of interbedded, laminated, slightly micaceous, grey to dark-brown-black shale, locally carbonaceous shale and siltstone, thin units of sulfidic shale and sandstone, and minor amounts of carbonate and chert. Lenticular bedding and rare wave-ripple marks indicate deposition in a quiet shallow-water environment. The formation closely resembles the Broadhurst Formation on RUDALL, of which it may be a correlative.

Light-pink, grey, to cream recrystallized dolostone, interbedded with light-grey chert, calcareous shale, siltstone, and minor amounts of black sulfidic and carbonaceous shale and sandstone (*ETpk*), is well exposed at the base of the Pungkuli Formation in the McKay Range (e.g. at AMG 645545\*). Individual beds are less than 0.3 m thick. Fine-scale cross-bedding and flute marks are locally preserved in the interbedded sandstone.

### Tarcunyah Group

The Tarcunyah Group unconformably or disconformably overlies the Throssell Group. Palaeontological evidence from stromatolites and acritarchs, found in the Tarcunyah Group throughout the Paterson Orogen, indicates an age of c. 800 Ma (Bagas et al., 1995). This implies that the Tarcunyah Group is part of Supersequence 1 of the Centralian Superbasin (Walter et al., 1995), and a correlative of the basal part of the Savory Basin (Williams, 1992).

The Tarcunyah Group on GUNANYA includes the Gunanya Sandstone in the north and the unassigned units of shale, siltstone, sandstone, and conglomerate in the southeast. These rocks lack the penetrative foliation ( $S_4$ ) and greenschist facies metamorphism observed in rocks of the underlying Throssell Group.

### Gunanya Sandstone (*Eu*, *Euup*)

The Gunanya Sandstone (*Eu*) consists of medium- to coarse-grained, characteristically light-pink to purple, arkosic sandstone interbedded with thin beds of feldspathic granule- to pebble-conglomerate. Abundant trough cross-beds and asymmetrical ripple marks indicate

\* Localities are specified by the Australian Map Grid (AMG) standard six-figure reference system whereby the first group of three figures (eastings) and the second group (northings) together uniquely define position, on this sheet, to within 100 m.



that the sandstone was deposited by southwesterly directed currents in what was presumably a fluvial to deltaic environment.

Outliers of sandstone in the northeastern part of GUNANYA, which are lithologically similar to the Gunanya Sandstone in McKay Range and the Karara Formation on BLANCHE and CRONIN, have been labelled ?*BUu*. Conglomerate (?*BUup*) at the base of this sandstone is matrix supported and contains well-sorted, rounded pebbles of vein quartz. The conglomerate is less than 10 m thick, lenticular, and shows an upward-fining clast-size distribution.

### Unassigned units (*BUss*, *BUs*)

The unassigned units of the Tarcunyah Group in the southeastern part of GUNANYA are composed of cyclical sequences of sandstone, siltstone, and shale (Crowe and Chin, 1979). Sandstone (*BUss*) forms the basal part of the sequence and is massive, medium to coarse grained, cross-bedded, and ripple marked. The sandstone commonly contains clay balls and is interbedded with minor amounts of granular conglomerate containing intraformational mudstone clasts. Mudstone laminae define bedding planes, and have asymmetrical and symmetrical shallow-water ripple marks (Crowe and Chin, 1979).

The sequence fines upward through a 100-m interval to interbedded, flaggy siltstone, shale, and minor amounts of thin, fine-grained, micaceous sandstone (*BUs*).

### Minor intrusive rocks and quartz veins (*d*, *q*)

Northerly trending dolerite dykes (*d*) intrude the Rudall Complex in the northeastern part of GUNANYA. Aeromagnetic maps of the region show that the dolerite clearly post-dates early structures that affect the Throssell and Tarcunyah Groups, although no intrusive contact with these rocks has been observed in the field. The dolerite dyke in amphibolite and mylonite at AMG 973562 is lenticular, has a chilled margin, and is about 10 m wide. It consists of microphenocrysts of plagioclase in an granular matrix of augite, plagioclase, and opaque minerals.

Quartz (*q*) veins are widespread and commonly located in faults and shear zones. Some of the veins are limonitic, particularly along their margins, indicating wallrock sulfidation. Other veins contain limonite and goethite in late fractures, suggesting sulfide precipitation from groundwater during Cainozoic lateritization. Some veins contain tourmaline or rutile.

## Cainozoic geology

Areas of recent and active sedimentation are mapped as Quaternary (*Q*) deposits. Older and significantly dissected sediments are mapped as Cainozoic (*Cz*) deposits.

Most Precambrian outcrops on GUNANYA show some evidence of ferruginization, leaching, or silicification typical of lateritic profiles. Gently undulating duricrust caps, including ferricrete or ironstone deposits (*Czl*) and silcrete deposits (*Czz*), have been eroded during recent times to expose underlying bedrock. The ferricrete grades downward into deeply weathered rock that has been leached and kaolinized. These sediments are probably Tertiary in age and may be part of the Tertiary continent-wide weathering event (Idnurm and Senior, 1978).

Dissected colluvium, sheetwash, fan deposits, and talus (*Czc*) are composed of red-brown, ferruginous gravel, sand, and silt, and are locally derived from a variety of sources.

Calcrete (*Czk*), consisting of massive, vuggy, or nodular sandy limestone, is only a few metres thick and present in old drainage channels (e.g. north of Lake Disappointment). Secondary silicification locally results in incomplete replacement by a vuggy, opaline silica caprock. The calcrete to the north of Lake Disappointment is in an old major drainage course, which has subsequently been transgressed and overlain by seif dunes.

In the northeastern part of GUNANYA, sand containing laterite granules and ironstone pebbles (*Czf*) stands out on aerial photographs with a characteristically dark photo-pattern. This unit is a mixture of partly residual and partly transported ferricrete granules, pebbles, and eolian sand, and commonly overlies shale, pelitic schist, or nodular laterite. The residual component indicates a ferruginous bedrock.

### Quaternary deposits

Locally derived colluvial silt, sand, and gravel (*Qc*) form gently sloping scree and outwash fans. The colluvium is weakly incised by watercourses. Extensive colluvial fans locally grade downstream into alluvium.

Flat to undulating sandplains (*Qs*) cover most of GUNANYA. The sandplains and seif (longitudinal) dunes comprise dark-red eolian sand and clayey sand (Crowe, 1975). The sand is composed of iron-stained quartz grains up to 0.5 mm in diameter. The dunes reach a maximum height of 30 m, are many kilometres long, and have a pronounced east to southeast orientation. Sand movement is confined to the dune crests, and their sides are stabilized by a cover of spinifex and small bushy eucalypts. Some dunes terminate on the eastern sides of outcrops, or where cut by drainage channels. The depth of the sand between dunes is commonly less than 2–3 m, as revealed by exposed pediments.

Poorly developed red, silty clay (*Qw*) is present in the northeastern part of GUNANYA. This unit is covered with dense mulga, which has grown in a distinctive striped pattern. The soils have formed over mature, deeply weathered plains or after mature alluvium, and contain varying amounts of ferricrete granules and, in places, calcareous soils.

The present day drainage courses and associated floodplains contain alluvium (*Qa*), which consists of unconsolidated clay, silt, sand, and gravel. The floodplain deposits also contain sand and clay mixed with eolian sands. Drainage courses originating in hilly areas eventually terminate in floodplains underlain by eolian sands.

Playa lake deposits (*Ql*, *Qle*, *Qlg*) occupy about a third of the map sheet area, with Lake Disappointment being the largest area with these units. The lacustrine deposits (*Ql*) consist of clay, silt, and evaporite minerals. They are present in low-lying areas or at the termination of creeks against sand dunes. Underlying the dry lake surface of Lake Disappointment is a mixture of black to brown mud, evaporite minerals, and sand. The dry lake surfaces are not vegetated, except for seasonal grasses and scattered eucalypts in some terminal lakes. The gypsum deposits (*Qle*) are present as kopi (impure gypsum) dunes along the western sides of dry lakes, whereas reworked eolian deposits (*Qlg*) are present on the western side of Lake Disappointment. Mixed lacustrine (*Ql*) and eolian (*Qs*) deposits that cannot be subdivided are labelled as *Qd* on the map sheet.

## Structure

The structural evolution of the Paterson Orogen on GUNANYA is discussed within the general framework outlined by Bagas and Smithies (in prep.), who defined the Yapungku Orogeny as the  $D_{1-2}$  deformation events, the Miles Orogeny as the  $D_{3-4}$  deformation events, and the Paterson Orogeny as the  $D_6$  deformation event. The  $D_1$ ,  $D_3$ , and  $D_5$  events have not been recognized on GUNANYA.

### Yapungku Orogeny ( $D_{1-2}$ )

The Rudall Complex was intensely deformed and metamorphosed between about 2000 and 1760 Ma, during two deformation events ( $D_1$  and  $D_2$ ) collectively referred to as the Yapungku Orogeny.

Large-scale isoclinal  $F_2$  folds are present in the northwestern part of GUNANYA, where they are cut by layer-parallel  $D_2$  faults. The  $F_2$  folds are overturned to the southwest.

The rocks in the northeastern part of GUNANYA are complexly folded and faulted. The  $F_2$  folds are tight to isoclinal and trend in a northwesterly-southeasterly direction. At least three generations of faults have been recognized in this area. The early ( $D_2$ ) faults are layer parallel and have affected the contact between gneiss and quartzite. The later faults ( $D_4$  and  $D_6$ ) are subparallel and cross-cut the earlier structures.

### Miles Orogeny ( $D_{3-4}$ )

The Miles Orogeny covers the  $D_3$  and  $D_4$  events. However,  $D_3$  structures have not been recognized on

GUNANYA. The age of the Miles Orogeny is poorly constrained between 1300 and 800 Ma (Bagas et al., 1995).

$F_4$  folds in the northern parts of RUDALL, BROADHURST, and CONNAUGHTON are commonly overturned to the southwest. The McKay Antiform, on the northwestern part of GUNANYA, plunges about  $40^\circ$  east-southeast, instead of the more common southeasterly direction. It has a steep northern limb and a shallower southern limb, indicating overturning towards the east-northeast. The difference in fold style may relate to a back-thrusting or local drag along the  $D_6$  McKay Fault. Alternatively, the McKay Antiform may be a younger structure formed during the Paterson Orogeny ( $D_6$ ).

### Paterson Orogeny ( $D_6$ )

The Paterson Orogeny ( $D_6$ ) was the last major structural event to affect the Paterson Orogen, and is probably related to the Petermann Orogeny of central Australia. It occurred at about 550 Ma (Bagas et al., 1995).

Major  $D_6$  structures on GUNANYA consist of open folds with an associated spaced  $S_6$  cleavage, and a conjugate set of northwesterly and north-northeasterly striking faults and shear zones. The overturning of the McKay Antiform towards the east-northeast may relate to back-thrusting or local drag along the  $D_6$  McKay Fault.

The  $D_6$  faults clearly post-date  $D_4$  folds and faults, although they may follow pre-existing structures. In addition to significant vertical movement, west-northwesterly trending  $D_6$  faults, such as the McKay Fault, show a marked sinistral component of movement and have displaced  $D_2$  and  $D_4$  faults.

In the southwestern part of CONNAUGHTON the Gunanya Sandstone is extensively silicified, brecciated, and veined by quartz and hematite along the McKay Fault. This structure is a major south-southwesterly dipping high-angle fault along the northeastern edge of the McKay Range. Here it is associated with southwesterly trending sinistral splay faults that extend onto the northern part of GUNANYA. The McKay Fault has truncated both the northern limb of the McKay Antiform to the south, and the contact between the Connaughton and Talbot Terranes of the Rudall Complex to the north.

The Tarcunyah Group in the southeastern part of GUNANYA is open-folded about west-northwesterly trending axes.

The late-stage dolerite dykes (*d*) trend north-northwesterly and fill fracture zones that may relate to extensional structures associated with the  $D_6$  event.

## Metamorphism

The dominant structural and metamorphic features of the Paterson Orogen were produced by the  $D_4$  event. However, there is abundant evidence that the Rudall Complex was metamorphosed to amphibolite-granulite

facies in the Connaughton Terrane, and to amphibolite facies in the Talbot Terrane during  $D_2$ , before deposition of the Yeneena Supergroup and the Tarcunyah Group (Bagas and Smithies, in prep.).

Evidence for  $M_1$  metamorphism (Bagas and Smithies, in prep.) is extremely scarce, due to the intensity of subsequent tectonism and metamorphic recrystallization. The only constraint on the timing of  $M_1$  metamorphism is that it occurred before emplacement of the post- $D_1$  K-feldspar augen orthogneiss (*PRga*), and is therefore older than 1790 Ma (Bagas and Smithies, in prep.). The  $M_2$  metamorphism (Bagas and Smithies, in prep.) relates directly to  $D_2$ , which deformed the augen orthogneiss. Intrusion of the protolith to the augen orthogneiss and the  $D_2$  event occurred between 1790 and 1765 Ma (Nelson, 1995).

Greenschist facies metamorphism ( $M_4$ ), associated with the  $D_4$  event, affected both the Rudall Complex and the Throssell Group, but some greenschist assemblages in the Rudall Complex may represent late- $M_2$  retrogression. Peak  $M_4$  metamorphism occurred between c. 1300 and 800 Ma (Bagas and Smithies, in prep.).

The effects of  $M_4$  metamorphism are seen in pelite and carbonate of the Pungkuli Formation, but not in the sandstone and shale of the Tarcunyah Group. The metamorphic expression in the Pungkuli Formation is sericite–muscovite growth parallel to  $S_4$  schistosity, silica overgrowth of rounded to subrounded quartz grains in the pelite, and calcite veining parallel to and cross-cutting  $S_4$  in carbonate rocks.

## Economic geology

### Mineral occurrences

No detailed information has been published about mineralization on GUNANYA.

Since the late 1960s, the Rudall Complex has been explored without success for copper, nickel, gold, and platinum. A number of kimberlitic indicators and microdiamonds have been detected by CRA Exploration within the region, although no kimberlite pipes have been found. It is thought that these kimberlitic indicators and microdiamonds probably originated from Permian glaciogenic sedimentary rocks, with a provenance to the south. Gypsum deposits around the salt lake systems are too remote to be of economic interest.

### Mineral potential

The mineral potential of the Paterson Orogen became apparent with the discovery of the Telfer Dome gold deposit on PATERSON in 1971, the Nifty copper deposit

on LAMIL in 1983, and the Kintyre uranium deposit on BROADHURST in 1985. Through comparisons of the Rudall Complex, the East Alligator River region of the Northern Territory, and the Athabasca region of Canada, it was considered that the potential for discovering further unconformity vein-style uranium deposits in the Paterson Orogen was high. The Rudall Complex was also considered a potential source for Palaeoproterozoic-style stratiform and stratabound base-metal and gold deposits, and for ultramafic-related platinum-group element (PGE) mineralization.

During the last twenty years of exploration, numerous stratabound and fault-controlled vein-type mineral deposits (including gold, base metals, uranium, and PGE) have been found throughout the Paterson Orogen. Many of the deposits in the Rudall Complex are found in carbonaceous or sulfidic schist, are hydrothermal in origin, formed late in the history of the complex, and are supergene-enriched to varying degrees (Hickman et al., 1994).

The little-explored Pungkuli Formation of the Tarcunyah Group in the northern part of GUNANYA contains locally sulfidic or gossanous shale and carbonate, which could be prospective for Mississippi Valley-type and Mount Isa-type base-metal deposits, and gold mineralization.

## Water resources

Permanent and semi-permanent pools are found along major watercourses where alluvium is sufficiently thick and extensive to hold groundwater resources. Areas of calcrete may contain large, although possibly saline, groundwater supplies. Groundwater in the Rudall Complex is likely to be restricted to shear and fault zones. Significant groundwater supplies may be found in the fractured and sheared Gunanya Sandstone.

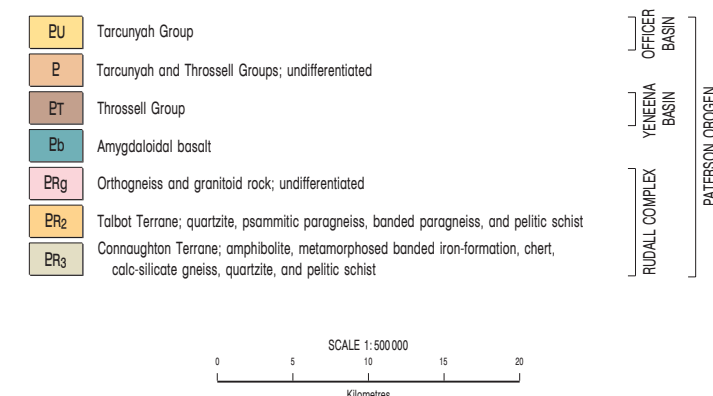
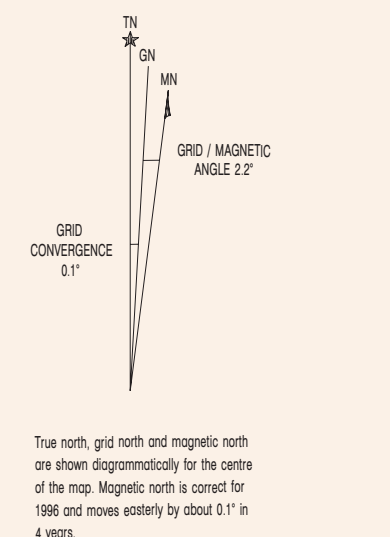
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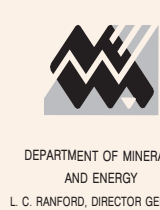
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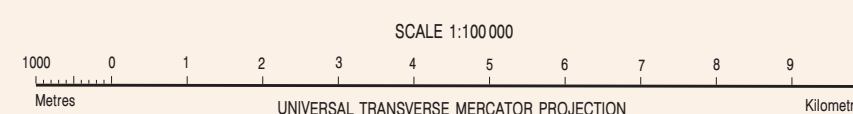
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	RUDALL			TABLETOP	
POSBOROUGH 352	SF 51-10 REAL	CONWRIGHT 362	SLAVICK 362	SF 51-11 DICKER	MUNZING 392
STONY 357	WUZZARD 367	GUNNAR 367	CHOWN 381	SUPPES 381	WORME 391
	GUNNAY			RLNTON	
KIGHT 326	SF 51-14 DORA	DEANSPORT 365	AUSTON 358	SF 51-15 LEBARD	SEAR 359




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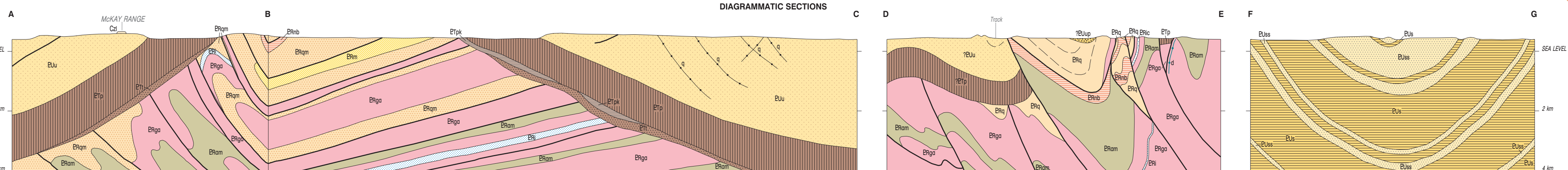
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