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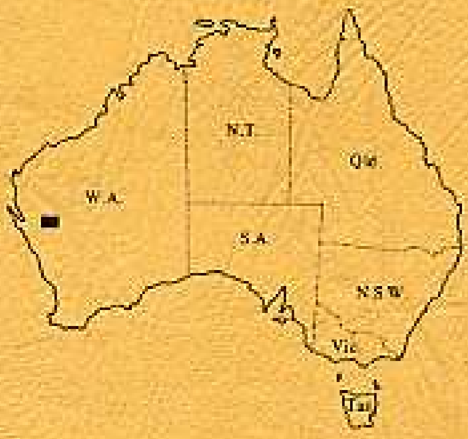
BYRO

WESTERN AUSTRALIA



SHEET SG50-10 INTERNATIONAL INDEX

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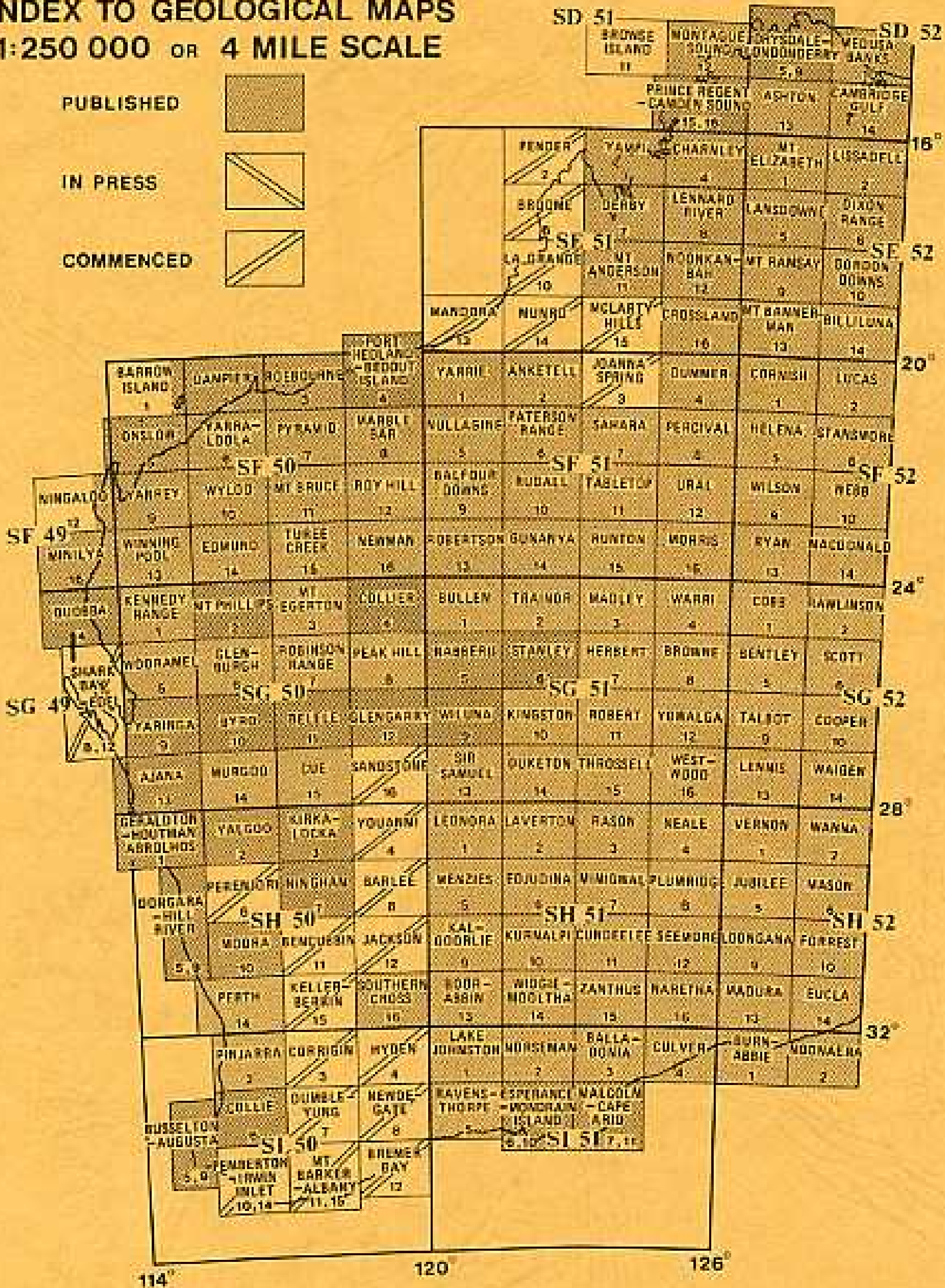

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

BYRO

WESTERN AUSTRALIA

SHEET SG50-10 INTERNATIONAL INDEX

COMPILED BY I. R. WILLIAMS, I. M. WALKER, R. M. HOCKING, AND S. J. WILLIAMS

PERTH, WESTERN AUSTRALIA 1983

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Explanatory Notes on the Byro Geological Sheet

Compiled by I. R. Williams, I. W. Walker, R. M. Hocking and S. J. Williams

INTRODUCTION

The BYRO* 1:250 000 Sheet, SG 50-10 of the International Series, is bordered by latitudes 26°00'S and 27°00'S and longitudes 115°30'E and 117°00'E. BYRO takes its name from a pastoral station situated along its northwestern margin.

There are no towns in the area, and the small resident population relates to ten pastoral leases (mainly sheep) and the Murchison Shire Office, located 8 km north of Meeberrie Homestead. The station homesteads are linked by unsealed roads to Gascoyne Junction in the north, Mullewa and Yalgoo in the south, and Cue to the southeast. Weekly mail services are maintained from Mullewa, Yalgoo and Cue to the pastoral stations. Station tracks afford reasonable access to most areas except hilly country around Meegea Hill and in the Weiragoo and Tching Ranges.

The climate is semi-arid; summers are hot and winters mild. The annual rainfall is generally less than 200 mm, and the annual evaporation rate is greater than 2 400 mm. Rainfall is derived from scattered summer thunderstorms, remnants of tropical cyclones, and southeast-moving winter frontal systems.

Extensive open woodlands of mulga (*Acacia aneura*) dominate the vegetation, particularly on the broad washes and pediplains. A mixed acacia scrub covers the low hills and is the main vegetation along the western margin of BYRO. Vegetation density decreases northeasterly in response to diminishing rainfall.

Eucalyptus sp. is mainly restricted to the large drainages such as the Murchison River. More saline drainages, such as the extensive salt-pan and dune terrain west of Curbur Homestead, are covered with mixed acacia scrub, together with herbs, grasses, saltbush and samphire communities. Open grasslands cover the Byro Plains.

Geological data were plotted on aerial photographs (approximate scale 1:80 000) flown in 1972.

PREVIOUS INVESTIGATIONS

The earliest descriptions of the country are found in journals and records of the explorers who traversed the Murchison River valley: R. Austin in 1854, F. T. Gregory in 1858 and J. Forrest in 1874. Maitland (1898), on a trip from Northampton to Peak Hill commented on the gneisses along the Murchison River valley and the quartzites at Mount Narryer. He also discovered a small, high-grade iron-ore deposit (weathered banded iron-formation) just west of Mount Narryer. Maitland and Montgomery (1924) summarized the early geological work, and Talbot (1926) included the region in a geological sketch map of the area between the Ashburton and Murchison Rivers.

From the 1920s attention was focused on the potential oil bearing Phanerozoic sedimentary rocks lying in the western half of BYRO (Raggatt, 1936). The Bureau of Mineral Resources (BMR) included these rocks in geological and geophysical

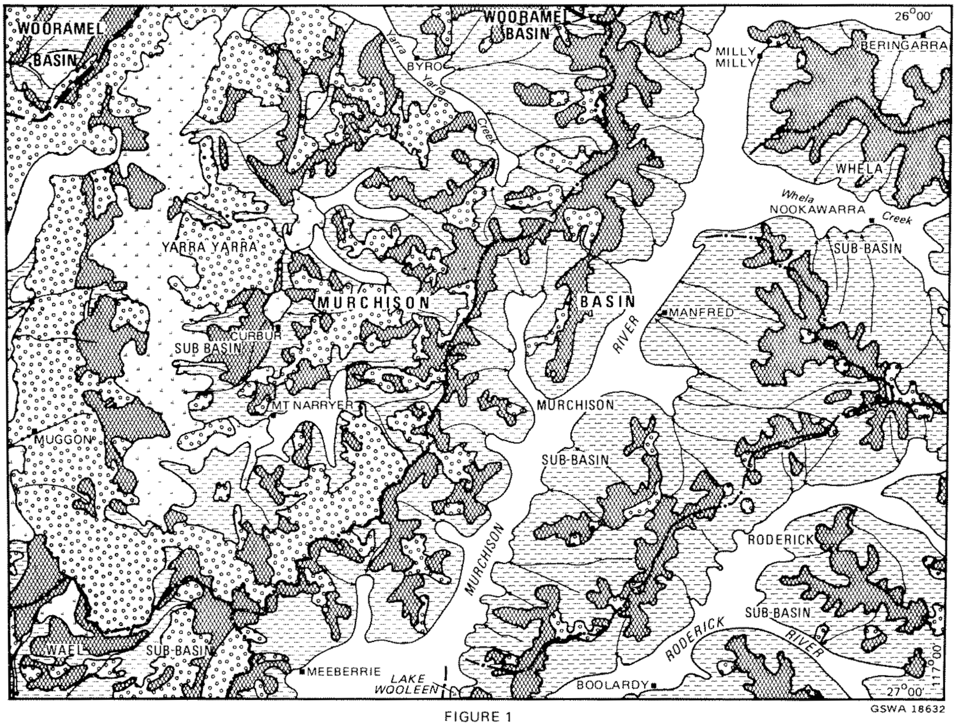
*Sheet names are printed in upper case letters to avoid confusion with like-named localities.

investigations of the Carnarvon Basin in the mid-1950s (Konecki and others, 1958, Condon, 1967). Perry and Dickens (1960) investigated the Proterozoic sediments of the Badgeradda Group in the southwest corner of BYRO. Reconnaissance mapping of the eastern (Precambrian) half of BYRO was carried out by the Geological Survey between 1946 and 1948 (Johnson, 1950).

Total magnetic intensity and Bouguer anomaly maps of BYRO were published by the BMR in 1974.

PHYSIOGRAPHY

The dichotomic division between Phanerozoic and Precambrian terrains is reflected in the topography. The gradual increase in elevation across BYRO from 250 m above sea level (ASL) on the western margin to over 400 m in the southeastern corner is broken by the remarkably linear Murchison River drainage. The eastern extent of Phanerozoic rocks (Byro Sub-basin) roughly corresponds to the 300 m contour.



GSWA 18632

FIGURE 1

PHYSIOGRAPHY AND DRAINAGE

BYRO SHEET SG 50–10

0 10 20 30 km

REFERENCE

Main drainage, floodplains, alluvium

Dune and playa terrain, alluvium and eolian, saline

Pediment plains, sheet wash alluvium and colluvium

Remnant duricrust surface, sand plain

Bedrock outcrop

Drainage basin boundary

Drainage sub-basin boundary

Watercourse

Homestead

Whereas the surface expression of the Phanerozoic rocks is monotonous and flat (relief less than 70 m) the Precambrian terrain is undulating and has varied topography with local relief greater than 200 m. The distribution of the main physiographic units is given in Figure 1.

The landscape over Phanerozoic rocks is marked by scattered, low rocky hills and isolated mesas of duricrust (laterite and silcrete) surrounded, and overlain, by monotonous sand plains. An extensive terrain of dunes and playas occupies a broad palaeodrainage west of Byro and Curbur Homesteads. This valley is part of the south-flowing Yarra Yarra Creek system (Williams and others, 1980).

Topographic highs and lows are closely related to the Phanerozoic bedrock structure. The Ballythanna Hill Anticline is topographically high whereas the Byro Plains and palaeodrainage west of Byro Homestead occupy regional synclines.

The Precambrian terrain is characterized by broad alluvial valleys that pass laterally to gently rising, sheet-wash pediplains. These, in turn, rise to low rocky hills in bedrock, or breakaways in deeply weathered duricrust-covered bedrock. Some bedrock hills, as in the Weiragoo and Tching Ranges, which occur along drainage divides, are capped by mesas of duricrust. Extensive areas of lateritic duricrust and sandplain lie west of the Murchison River. In contrast, east of the Murchison River, isolated remnants of duricrust are preserved along the drainage divides (Fig. 1). The duricrust surface may be equivalent to the old high-level peneplain surface of Jutson (1950).

The highest hills and ranges, such as Mount Narryer (510 m ASL), Mount Murchison (520 m ASL) and the Jack Hills (>500 m ASL), consist of resistant quartzite and banded iron-formation.

The drainage on BYRO is exorheic and, except for two small areas along the northern boundary which drain to the Wooramel River, belongs to the Murchison drainage basin (Fig. 1). All streams are ephemeral, although the Murchison River may flow for a long period after heavy rain.

The Murchison River follows, for most of its length, an unusually linear course (trend 040°). The river, in this section is a subsequent stream, almost certainly fault controlled (the Manfred Lineament). This feature is further emphasized by the unusual junction between the Murchison and the Roderick Rivers, 25 km east of Meeberrie Homestead. The Roderick River flows northwards to meet head on the south-flowing Murchison River. At this point a gorge, 10-15 m deep, runs southwest (the normal consequent direction) through semi-consolidated hardpan and old river deposits "Murchison cement"). It is suggested that, at some earlier period, a fault with a west-block-up movement dammed the Roderick and Murchison Rivers, forming Lake Wooleen on the MURGOO 1:250 000 Sheet (Baxter, 1974). The river later broke through this barrier 4 km south of Meeberrie Pool.

The region is known to be seismically active as shown by recently recorded earthquakes and the discovery of degraded fault scarps near Mount Narryer (Williams, 1979).

All west-flowing tributaries of the Murchison River, plus the Murchison River north of Milly Milly Homestead and east of Meeberrie Homestead, Yarra Yarra Creek, and short streams emptying into the dune and playa terrain west of Curbur Homestead, are consequent streams. However, the southern continuation of the Yarra Yarra Creek drainage system is a subsequent stream. West of Muggon Homestead, it is confined to a major palaeodrainage valley which is controlled by the Darling and Woodrarrung Faults.

The short, east-flowing tributaries of the Murchison River are obsequent streams. These have removed the duricrust cover with the result that there are excellent bedrock exposures in the hills west of the Murchison River.

TECTONIC SETTING

YILGARN BLOCK

The eastern three-quarters of BYRO is occupied by rocks of the Archaean Yilgarn Block. Three types of Archaean terrain are present. They are a medium- to high-grade gneiss and migmatite, the low- to medium-grade Jack Hills Greenstone Belt, and the Yilgarn cratonic granitoids of the Murchison Province. The latter intrude both the gneiss and the greenstone belt. The age relationship between the Jack Hills Greenstone Belt and the gneiss-migmatite terrain is unclear due to subsequent shearing and disruption by the later intrusive granitoids.

PROTEROZOIC ROCKS

The predominantly shallow-water arenaceous Badgeradda Group occupies the southwest corner of BYRO. The group is essentially unmetamorphosed and only gently folded. It occupies an intra-cratonic basin, unconformably overlying Archaean gneiss-migmatite, and underlies at least part of the Byro Sub-basin.

CARNARVON BASIN

Sedimentary rocks of the Phanerozoic Byro Sub-basin of the Carnarvon Basin occupy most of the western quarter of BYRO. Permian and Permo-Carboniferous sediments, ranging from Upper Carboniferous to Sakmarian fluvioglacial, marine-glacial and marine deposits to Artinskian marine and deltaic deposits, occupy the sub-basin. These rocks are unmetamorphosed, but are gently folded and faulted.

YILGARN BLOCK

GNEISS-MIGMATITE TERRAIN

The Archaean gneiss-migmatite terrain occupies most of the region between the Meeberrie Fault System (eastern margin of the Byro Sub-basin) (van de Graaff and others, 1977) and the Murchison River (Manfred Lineament) as well as the area north of Whela Creek. East and south of these regions the gneiss-migmatite is extensively intruded by later (2 600 m.y.) granitoids. The proportion of migmatite to gneiss increases southwards and eastwards across BYRO.

Rock types

Quartzo-feldspathic gneiss and migmatite: Banded quartz-microcline-oligoclase-biotite gneiss (*Anb*) is the dominant rock type. The gneiss may be banded grey, cream or pink, fine to coarse grained, and ranges from tonalite to granite in composition. Minor muscovite, hornblende and garnet, secondary sericite, chlorite and epidote, and accessory sphene, zircon, apatite and opaques are present.

The banding is either a continuous layering defined by quartz-feldspar-rich layers up to 10 mm wide, separated by biotite films (laminae), or layers up to 1 m wide in which leucocratic quartz-feldspar bands alternate with mesocratic biotite-rich quartz-feldspar bands. Grain size may vary from band to band, and feldspar augen may be present in some bands. This type of banding has been traced continously for over 100 m along strike, and the continuity contrasts with the discontinuous, lensoid banding found in the more homogeneous gneissic granitoids or orthogneiss (*Agla*, *Agbs*).

Good exposures of banded gneiss occur 8 km southeast of Milly Milly Homestead, 7 km northwest of Mount Dugel, and along the drainage divide east of Stone Hut Well.

A leucocratic, faintly banded, medium-grained quartz-microcline-oligoclase-muscovite-biotite-magnetite gneiss (*Anf*) is common west and south of Byro Homestead. It has an adamellite to granite composition and is commonly strongly lineated. Its association with quartzite, quartz-magnetite rock and calc-silicate gneiss suggests that it may be derived from impure sandstone or arkose.

Minor quartz-biotite (-chlorite)-muscovite-feldspar-garnet paragneiss and schist (*Anl*) occurs in the Meegea Hill, Mount Dugel and Deep Well areas.

In the field, the banded gneiss can be traced through incipient migmatization to migmatite, a change that reflects increasing degrees of melting. The symbol (*Amb*) is only used where 30 per cent or more of the outcrop is anatectic granitoid.

An example of the gradual development of migmatite from banded gneiss occurs between Milly Milly Homestead and Jack Hills. Simple banded gneiss around Milly Milly passes southeastwards into a banded gneiss with leucosome veins. Most of the leucosomes have biotite selvages and appear to have formed *in situ* from the gneiss. At Sharpe Bore, the migmatite (*Amb*) consists of banded gneiss with patches of newly generated granitoid. The banded gneiss passes transitionally into the granitoid phase by way of a nebulous zone of vague banding and biotite schlieren. The new granitoid phase eventually dominates and the migmatite passes to a nebulitic homogeneous granitoid (*Agbs, Agla*).

Most migmatite and anatectic granitoid have strong gneissic foliation although some rocks have granoblastic texture.

Other extensive areas of migmatite occur northeast and southwest of Coobbooroo Well, west and north of the Weiragoo Range, and in a linear zone extending from near East Noola Well southwest to Coondawa Well. Lenses of calc-silicate gneiss and amphibolite occur in the linear zone.

Amphibolite: Lenses and small pods of banded amphibolite (*Ana*) are scattered throughout the banded quartzo-feldspathic gneiss (*Anb*). They are foliated, fine- to coarse-grained, dark-green nematoblastic or granoblastic rocks. Assemblages consist of brown-green hornblende, plagioclase (mainly andesine), minor (diopsidic) clinopyroxene, secondary tremolite-actinolite and epidote, and accessory sphene, apatite and opaques. Quartz and biotite may be present. Amphibolites of this type are considered to be of mafic igneous origin.

Assemblages with higher quartz and biotite and lesser hornblende content are possibly metamorphosed mafic sediments.

Calc-silicate gneiss: Scattered pods of calc-silicate gneiss (*Anc*) occur within the banded quartzo-feldspathic gneiss (*Anf, Anb*). They are granoblastic assemblages of green hornblende, quartz, plagioclase, biotite, tremolite-actinolite, epidote, and lesser clinopyroxene, garnet and sphene. A prominent outcrop of green- and white-banded calc-silicate gneiss, in leucocratic banded gneiss (*Anf*) is exposed 6 km west of Byro Homestead.

Carbonate-rich rocks have not been found with the calc-silicate gneiss on BYRO. Many assemblages appear transitional in composition to amphibolite.

Quartzite and meta-conglomerate: Quartzite and micaceous quartzite (*Anq*) form prominent strike ridges in the banded-gneiss terrain. They are mainly granoblastic, coarse-grained quartz-rich rocks with minor muscovite (also green fuchsite) and accessory sphene, zircon (some rounded) and opaques. Biotite, hornblende, chlorite, garnet and sillimanite may also be present.

A remarkable high-grade quartzite (sillimanite-garnet-quartz rock) is exposed at Mount Narryer, where it is interlayered with meta-conglomerate, sillimanite-garnet-cordierite paragneiss and quartz magnetite rock. These rocks extend 35 km north to Mount Dugel, where the quartzite has been strongly sheared and finely recrystallized. This sequence may be part of an even larger metasedimentary belt which can be traced discontinuously across shear zones, from east of Coondawa Well in the south to 12 km northeast of Far Cargarra Well in the north, a distance of over 100 km. This belt includes the quartzite of Mount Murchison.

Two kilometres north of Mount Narryer there is a polymictic conglomerate (*Anqc*) containing large (up to 0.4 m) clasts of banded quartz-magnetite rock, banded recrystallized chert, and quartzite set in a matrix of quartz, garnet, minor amphibole, opaques and occasional zircon. Small lenses of quartz-pebble conglomerate also occur in the region. The arenaceous sequence, together with extensive cordierite-sillimanite-garnet-bearing gneiss, has been called the Narryer Metamorphic Belt. Prominent quartzites also crop out between Maradagee Woolshed Bore (Byro) and Iniagi Well, south of Dallah Creek, and 5 km northwest of the Murchsion Shire Office.

Banded quartz magnetite rock: Banded quartz magnetite rock (*Ani*), which is a metamorphic derivative of banded iron-formation, occurs throughout the banded gneiss terrain although the frequency of occurrence diminishes southwards across BYRO. It is most abundant in the Meegea Hill area.

They are medium- to coarse-grained granoblastic rocks in which quartz-rich bands alternate with bands of magnetite and ferroan silicates on the scale of millimetres. Associated metamorphic minerals include hypersthene, clinopyroxene (ferrohedenbergite), grunerite, hornblende, actinolite, and minor garnet, biotite, plagioclase and sphene.

Pelitic granofels and related rocks: Pelitic granofels are medium- to coarse-grained, dark-grey to pink, xenoblastic granular rocks which may be banded and gneissic. They contain patchy veins of a leucogranitoid carrying garnet and biotite clots. The assemblages contain varying proportions of quartz, perthitic microcline, oligoclase, red-brown biotite, cordierite (some pinitized), sillimanite (some fibrolite), almandine garnet, minor hypersthene, and accessory sphene, zircon and opaques.

Such amphibolite-granulite rocks are thought to have originally been sedimentary.

A belt of pelitic granofels, paragneiss and minor mafic granofels extends for 30 km south-southwest of Mount Narryer, with the best exposures 3 km southwest of Dingo Well. These rocks are included in the Narryer Metamorphic Belt.

Similar rocks have been found in the Taccabba Well area where semi-pelitic granofels (quartz, biotite, plagioclase, hypersthene) occurs adjacent to a large body of mafic granofels.

Small bodies of sillimanite-cordierite granofels are scattered throughout the banded-gneiss terrain; the more important are 3 km east of Thoolmugga Well and 5 km south east of Wandarrie Well.

Mafic granofels: The mafic granofels (*Ano*) are upper-amphibolite to lower-granulite metamorphic rocks, derived mainly from mafic-ultramafic igneous bodies. Gross igneous layering and primary igneous texture are preserved in places. Other rocks are higher grade equivalents of the amphibolites. Most rocks are partly sheared and show various degrees of retrograde metamorphism mainly to amphibolite facies.

Assemblages consist of plagioclase (andesine to bytownite composition), brown and olive-green hornblende, hypersthene, clinopyroxene (diopside and augite) biotite, and minor olivine with accessory hercynite, zircon, sphene and opaques. Secondary minerals include talc, serpentine, chlorite, sericite and tremolite-actinolite.

Metamorphosed, layered mafic-ultramafic bodies occur 3 km east of Thoolmugga Well, around Iniagi Well, and near Taccabba Well (recovered in drill cores). The last two localities contain segregated chromite lenses. Original rock types include peridotite, lherzolite, norite, gabbro, anorthositic gabbro and anorthosite.

A metamorphosed, layered gabbroic body, with a hypersthene-plagioclase-clinopyroxene-amphibole-olivine-hercynite assemblage, and well-preserved igneous texture crops out 10 km north-northeast of Mount Narryer in high-grade gneiss.

Ultramafic bodies in gneiss: Discrete ultramafic bodies (*Anu*) are scattered through the gneiss-migmatite terrain. The rocks are generally schistose and all primary texture has been destroyed. They consist of fine- to coarse-grained talc, serpentine, chlorite, tremolite-actinolite, minor anthophyllite, carbonate and opaques.

The discrete ultramafic bodies are unrelated to the layered mafic-ultramafic bodies as they appear to post date the period of migmatization in the banded gneiss.

Most bodies are concentrated in the area between Meegea Hill and Melun Bore and between No. 13 Bore and the Weiragoo Range.

Gneissic granitoids: The gneissic granitoid (orthogneiss) of the gneiss-migmatite terrain is the final anatectic product of a migmatization event which predates emplacement of the Yilgarn cratonic granitoids. They are medium- to coarse-grained gneissic or granoblastic rocks in which the igneous textures have been largely destroyed. They have both sharp and transitional contacts with the banded gneiss. The moderate-grade metamorphism, which produced the gneissic fabric and discontinuous lensic banding, was followed by low-grade retrograde metamorphism. This latter event is possibly related to the emplacement of the Yilgarn cratonic granitoids.

Medium- to coarse-grained biotite adamellite to granodiorite gneiss (*Agla*) containing large microcline (more rarely plagioclase) augen is common north of Sharpe Bore. It also forms a mobilizate phase in the migmatite (*Amb*) in this region. A number of small bodies of augen orthogneiss (*Agla*) intrude banded gneiss in the Stone Hut Well area. A large pendant of augen gneiss (with folded gneissosity) occurs in the marginal facies (*Agx*) of the Yilgarn cratonic granitoids, 2 km north of Joorong No. 5 Bore.

Grey to pinkish-grey medium- to coarse-grained biotite (-ferrohastingsite-muscovite) adamellite gneiss (*Agbs*) with lesser granite and granodiorite gneiss are associated with migmatite (*Amb*) between No. 15 and Muckeringa Wells and the Bilga Rock area. The plagioclase is oligoclase or sodic andesine; allanite is a common accessory. Where ferrohastingsite is present, minor fluorite has been found in thin section.

Two bodies of grey, medium- to coarse-grained quartz syenite (*Ags*) intrude the gneiss-migmatite terrain. A hornblende-diopside-bearing quartz syenite with prominent sphene occurs 4.5 km northwest of Dallah Bore. It is petrologically similar to the Katrine Syenite described from gneisses near Northam (Wilde and Low, 1978). The second body lies 2 km northwest of No. 13 Bore. It is a strongly recrystallized amphibole-microcline-albite-quartz syenite. Contact with surrounding gneiss-migmatite is transitional.

Metamorphism

The earliest metamorphism, identified in the gneiss-migmatite terrain, is medium to high grade. It is characterized by the development of scattered, discrete areas of granulite facies surrounded by middle- to upper-amphibolite facies. The juxtaposition of granulite and migmatite (with anatectic granitoids) is attributed to the same metamorphic event. The granulites (hypersthene zones) probably represent areas where the water pressure was low or non-existent in a high-temperature, moderate-to-high-pressure regime.

Granulite facies is identified in fifteen localities. The largest belt extends from Mount Narryer southwards 30 km to near Christmas Well. Other granulite areas occur in the vicinity of Milly Milly, Iniagi Well, Meegea Hill, Mount Dugel and Middado Well.

Primary pelitic assemblages on BYRO diagnostic of granulite facies, with minerals listed in decreasing order of abundance, are:

Milly Milly: quartz-biotite-plagioclase-orthopyroxene

Meegea Hill: quartz-cordierite-biotite-oligoclase-sillimanite-microcline (-garnet)

Mount Narryer: quartz-cordierite-sillimanite-almandine-biotite

Dingo Well-Christmas Well:

(a) quartz-microcline-biotite-cordierite-plagioclase-sillimanite

(b) quartz-sillimanite-garnet-cordierite-biotite-hypersthene

Co-existing garnet and cordierite from Mount Narryer were analyzed and a pressure-temperature estimate of 510 MPa at 785°C was calculated (D. Blight, 1979, pers. comm.). This would be equivalent to crustal depths of around 17 km. The presence of sillimanite and K-feldspar, and lack of andalusite and muscovite suggests temperature in excess of 680°C and pressure greater than 420 MPa (Hess, 1969). The abundant cordierite in the pelitic assemblages suggests pressures less than 650 MPa.

Mafic granulite is recorded from Iniagi Well, Milly Milly, Mount Dugel, Middado Well and Dingo Well areas. All assemblages are various combinations of the following:

Plagioclase (labradorite-bytownite)-hornblende (olive-brown to olive-green)-hypersthene-clinopyroxene-hercynite-biotite(-olivine).

A very high-grade anhydrous assemblage of bytownite, hypersthene and augite occurs 3 km northwest of Mount Dugel.

Primary amphibolite facies assemblages for the banded gneiss terrain are:

Mafic assemblage (hornblende (green to olive green)-plagioclase (andesine)-clinopyroxene-quartz);
Calc-silicate assemblage (quartz-hornblende-clinopyroxene-plagioclase-epidote).

The plagioclase of the quartzo-feldspathic gneiss is either oligoclase or sodic andesine. Biotite and microcline are nearly always present; muscovite, garnet and hornblende are minor components.

The generation of anatectic granitoids from banded gneiss has been discussed by Williams, S. J. and others (1980).

Many rocks have assemblages indicative of a late Archaean retrograde metamorphism. However, retrogressed assemblages in narrow zones of high strain (shear zones), which occur in the northern half of BYRO (*see: Structure*), are believed to be Proterozoic.

An upper-amphibolite retrograde metamorphism is evident in some granulite terrains, for example at Iniagi Well. The orthopyroxene and to a lesser extent the clinopyroxene may be rimmed or replaced by green or blue-green hornblende, and sometimes colourless ?cummingtonite. These rocks are mildly sheared.

Secondary muscovite has been observed in some cordierite-bearing gneisses.

The anatectic granitoids (*Agla, Agbs*) and migmatite (*Amb*) have a weak to strong gneissic fabric and mineral assemblages that are stable in the amphibolite facies. Whether this amphibolite-facies event represents the maintenance of the primary prograde medium- to high-grade event which generated the anatectic granitoids or is a separate metamorphic event after the granitoid generation is not clear.

Patchy greenschist-facies retrograde metamorphism occurs throughout the gneiss-migmatite terrain particularly in the eastern half of BYRO where this terrain is extensively intruded by the 2 600 m.y. Yilgarn cratonic granitoids.

Granulite-facies assemblages near Milly Milly show greenschist-facies retrograde metamorphism. The plagioclase is saussuritized; chlorite replaces biotite; clinopyroxene is replaced by fibrous amphibole; orthopyroxene is replaced by chlorite and serpentine; and hornblende by fibrous tremolite-actinolite. Fine-grained ragged textures are associated with retrograde metamorphism.

Structure

Structural trends, delineated by gneissic banding, foliations, and lithologic units in the gneiss-migmatite terrain, vary between a northerly and northeasterly direction and dip steeply east and west. The oldest recognizable structural surface in the gneiss is the compositional banding which parallels the strike of lithologic units such as quartzite. This possibly represents a composite surface resulting from both primary layering and deformation.

A strong gneissic fabric roughly parallels the banding and is axial planar to intrafolial and very tight isoclinal folds developed by this surface. Large-scale folds are probably present but, because of later superposed folding, they are difficult to recognize.

The gneissic banding has been refolded by a second generation of isoclinal folds which also have a strong axial-planar fabric. This deformation is thought to be syntectonic to the development of the anatectic granitoids (*Agla, Agbs*). The gneissic fabric in both these granitoids and the neosomes of the migmatite is the product of the second deformation.

The south-plunging Mount Narryer synform, outlined by high-grade quartzites, may be a second-generation fold. At least two fold periods can be seen in banded gneiss 5 km southwest of Duffies Well.

A third generation of open, generally south-plunging folds is evident in the gneissic granitoids. The relationship of these folds, which must have also affected the gneiss-migmatite terrain, to the deformation of the Jack Hills Greenstone Belt is not known. However, the later fold generations are probably related to the progressive emplacement of the voluminous Yilgarn cratonic granitoids to the southeast.

North of Mount Narryer several strongly defined shear zones, containing prominent quartz ridges, cut across all Archaean structures including the Yilgarn cratonic granitoids. East of the Murchison River, discrete shear zones, up to 1 km wide, trend west-southwest. Although deformation within the shear zone is heterogeneous there is overall a strong dextral (north-block-east) movement. The Cargarra and Nookawarra Shears are the main zones.

West of the Murchison River, the discrete zones split up into a series of parallel shears, which northwest of No. 15 Well becomes a zone 11 km wide of discontinuous shears and laminated mylonite zones. Refolding of mylonitic laminae into tight asymmetric folds (Z vergence) point to a long history of dextral movement in this region.

The progressive change from discrete quartz-filled shear zones in the east to a wide zone of parallel shears and mylonite zones in the west may represent a change from a more brittle 'shallow' level environment to a 'deeper' level ductile environment.

These shear zones are believed to be Proterozoic and to represent the final imprint of tectonic events that were generated in the Gascoyne Province, which lies about 35 km to the north.

The western extent of exposed Archaean gneiss-migmatite terrain is controlled by the Meeberrie Fault System (van de Graaff and others, 1977). This system has a large downthrow to the west. It is also the eastern edge of the Byro Sub-basin.

The fault system has been active periodically over a long time interval. It controlled deposition of the Phanerozoic Byro Sub-basin sediments and possibly also the Proterozoic Badgeradda Group.

About 40 km to the east of this fault system, particularly in the southern half of BYRO, there is a roughly parallel zone of faults, with downthrow to the east. This is a currently active seismic zone, the Meeberrie-Onslow Zone (Denham, 1976). It includes the recently active Mount Narryer faults (Williams, 1979), the Manfred Lineament (which controls the linear course of the Murchison River) and the White Hill Fault. It is the site (northeast of Meeberrie Homestead) of the largest earthquake on the Australian mainland, the Meeberrie earthquake of 1941 (Denham, 1976).

The west-block-down displacement on the Meeberrie Fault system and east-block-down displacement on the Mount Narryer faults etc. define horst-like structure for this region.

Recent faulting of the Quaternary in the Frazer Well area further to the north also indicates an east-block-down movement.

A structural sketch map of BYRO is given in Figure 2.

JACK HILLS GREENSTONE BELT

The Jack Hills Greenstone Belt extends from the eastern boundary of BYRO to 7 km west-northwest of Nookawarra Homestead. In this region it is a narrow, northeasterly trending, curvilinear belt of prominent strike ridges which resembles other Archaean greenstone belts in structural style and metamorphic grade.

However the large volumes of volcanic material, typical of other greenstone belts, are lacking, and the Jack Hills Belt is largely a metasedimentary sequence. The regional setting of this belt within a high-grade gneiss and migmatite terrain also sets it apart from the granite-greenstone terrain more typical of the Yilgarn Block.

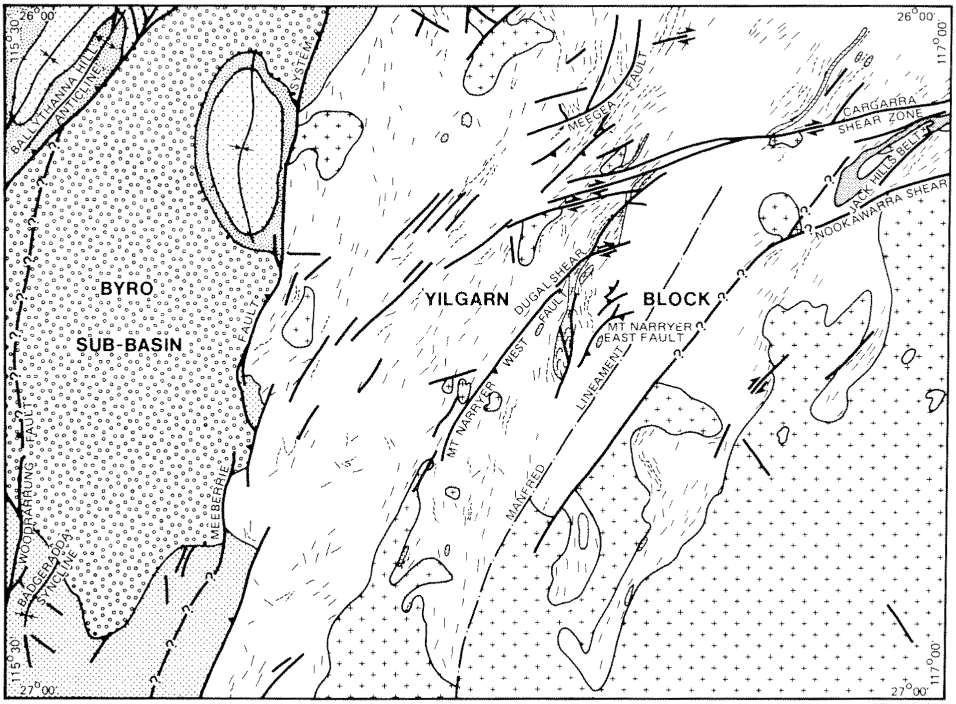


FIGURE 2

STRUCTURAL INTERPRETATION

BYRO SHEET SG 50–10

0 10 20 30 km

REFERENCE

PALAEOZOIC: Byro Group; Wooramel Group; Lyons Formation

PROTEROZOIC: Badgeradda Group

ARCHAEAN: Granitoid; Greenstone belt; Gneiss and migmatite; Banded quartz-magnetite rock; Quartzite

Geological boundary

Shear zone or fault

Sense of movement of shear zone

Sense of movement of normal fault

Inferred fault

Syncline

Anticline

Regional foliation, banding in gneiss

The tectonic setting and lithologic content are similar to a metasedimentary greenstone belt described for the Tallering Peaks area over 260 km to the south (Baxter, 1971; Muhling and Low, 1977).

Additional descriptions of the Jack Hills Belt are given in the BELELE (Elias, in press) and ROBINSON RANGE explanatory notes (Elias and Williams, 1977) where it has been called the Mount Taylor Belt.

Layered sequence

The metamorphosed layered sequence consists of banded iron-formation, quartzite, and minor quartz-pebble conglomerate separated by a variety of pelitic schists and phyllite.

Two types of banded iron-formation are recognized. These are a finely recrystallized banded quartz-magnetite (hematite) rock (*Aiw*) which is common east of Erawondoo Hill and a finely banded dark-grey quartz-amphibole (pale hornblende or grunerite)-garnet rock (*Aim*) which is more common southwest of Noonie Hill. Small, enriched pods of massive hematite are associated with the iron-formations.

The pelitic schists and phyllite (*Alm*) consist of quartz-chlorite-muscovite-biotite-garnet assemblages.

Quartzite and micaceous quartzite (*Asq*) (with minor fuchsite) form a prominent ridge through Noonie Hill. A quartz-pebble conglomerate (*Asc*) with a schistose matrix occurs 3 km east-northeast of Erawondoo Hill. Thin quartz-pebble horizons in quartzite were also found 2 km north of Racecourse Well.

The sequence has been intruded by concordant metamorphosed dolerite (*Ada*), serpentinized peridotite (*Aup*), and metapyroxenite (*Aux*) bodies. Narrow low-grade metamorphosed ultramafic dykes found in the adjacent gneiss and gneissic granitoid terrain are possible feeder dykes for the ultramafic bodies in the Jack Hills Greenstone Belt.

The belt is also intruded by lenses of fine- to medium-grained biotite adamellite (*Age*) and a coarse-grained biotite (-muscovite) adamellite (*Agb*). Both granitoids are similar to the widespread homogeneous Yilgarn cratonic granitoids south of Whela Creek.

Structure and Metamorphism

No major structure can be outlined within the Jack Hills Geenstone Belt on BYRO. The belt appears to be a moderately steep, north-dipping sequence which is concave southwards. At least two periods of folding are indicated in the pelitic schists which have the main foliation strongly crenulated. The gentle bowing of the belt northwards is possibly related to the forceful emplacement of the large granitoid mass south of Whela Creek.

The structural relationship between the Jack Hills Greenstone Belt and the adjacent gneiss-migmatite terrain is unclear. Strong shearing is present along the contacts. This would have destroyed pre-existing definitive evidence for intrusive or unconformable relationships. However, it is possible that the sedimentary rocks of the Jack Hills were deposited originally in a fault-controlled basin within the gneiss-migmatite terrain. Shearing, roughly parallel to the Jack Hills trend, persisted into the Proterozoic (*see: Structure*).

The Jack Hills Greenstone Belt on BYRO is a prograded metamorphic sequence which attains upper-greenschist to lower-amphibolite facies. Elias (in press) pointed out on adjoining BELELE that there is a pattern of increasing metamorphism from low to moderate grade, westwards along this belt.

Metamorphic assemblages on BYRO are:

(i) Pelitic rocks; garnet (-chlorite)-biotite-muscovite-quartz (biotite is commonly retrograded to chorite)

(ii) Metamorphosed banded iron-formation; garnet-biotite-amphibole(-hornblende or grunerite)-magnetite-quartz.

The low to moderate prograde metamorphic sequence of the greenstone belt contrasts with the moderate to high-grade assemblages in the adjoining gneiss-migmatite terrain.

The difference in metamorphic grade between the two terrains suggests that the metamorphic peak was reached independently. The low-grade retrograde metamorphism present in some gneisses may correspond to the prograde metamorphism of the Jack Hills Greenstone Belt.

YILGARN CRATONIC GRANITOIDS

The Yilgarn cratonic granitoids are the voluminous granitoids that record Rb-Sr isotopic ages of around 2.6 to 2.7 b.y., an event which led to the eventual stabilization of the Yilgarn Block. On BYRO these granitoids occupy most of the region east of the Murchision River and south of Whela Creek. A number of small, discrete plutons with weak foliation and partly recrystallized igneous textures that intrude the banded-gneiss-migmatite terrain and Jack Hills Greenstone Belt, and a large elongate granitic body emplaced in high-grade gneiss between Meeberrie shearing shed and the Murchision River (Manfred Lineament), are also bracketed with the Yilgarn cratonic granitoids.

The granitoids include the western extension of the large, nebulitically banded, domal batholith described on BELELE (Elias, in press), and the internal and marginal facies granitoids of adjoining MURGOO (Baxter, 1974).

The granitoids show a wide variety of composition, texture, superimposed or primary fabrics, and homogeneity or heterogeneity. The least altered types, with allotriomorphic or hypidiomorphic textures, are medium- to coarse-, even-grained biotite adamellite, granite and minor granodiorite with occasional microcline phenocrysts (*Agb*). Porphyritic (some seriate phases) adamellite (*Agl*), and small bodies of fine- to medium-grained equigranular biotite adamellite (*Age*) are less common. All assemblages consist of varying amounts of quartz, microcline, oligoclase, biotite, and accessory sphene, zircon, apatite and opaques. They are found in the Weiragoo and Tching Ranges and Balloo Hill area. Small plutons also intrude the banded-gneiss—migmatite terrain.

Spherodial textured (now ?recrystallized) biotite adamellite and granodiorite (*Ago*) crops out 7 km west of Mount Murchison.

More heterogeneous in outcrop are medium- to coarse-grained hornblende (-biotite) granodiorite and adamellite (*Agh*) together with porphyritic variants containing microcline phenocrysts (*Aghl*). They occupy the area around Geigies Well and south of Joorong No. 5 Bore.

Small bodies of medium- to coarse-grained biotite (-hornblende) tonalite and granodiorite (*Agt*) intrude the banded-gneiss terrain in the Meegea Hill area.

In some outcrops several granitic types may be present. Where they cannot be distinguished at map scale the symbol (*Agm*) is used.

In all cases the presence of a strong foliation or shearing is indicated on the map by an overprint.

Most granitoids show some degree of recrystallization and alteration suggestive of very low-grade metamorphism, for example incipient saussuritization of feldspar and chloritization of biotite. A porphyritic biotite granodiorite (*Agl*), emplaced in banded gneiss 6 km northwest of Melun Bore, contains pumpellyite and polygonized quartz, which are indicative of very low-grade metamorphism.

Banded granitoids, with igneous textures, are common in some marginal areas of the Yilgarn cratonic granitoids. The banding (up to 1 m wide) is regular and may be defined either by biotite content, which occurs as entrained books and not as metamorphic foliae, or by the size and frequency of microcline crystals. Good examples of banded porphyritic adamellite (*Agl*) occur 2.5 km northwest of Mooninew Well. Possible origin and significance of this banding has been discussed in detail by Elias (in press).

The relationship between the Yilgarn cratonic granitoids and the gneiss-migmatite terrain is complex, and no single or simple relationship can be established. The gross regional shape of the contact is given in Figure 2.

Long, narrow tongues of banded-gneiss-migmatite can be traced well into the granitoid terrain and bulbous appendages of granitoid protrude into the gneiss-migmatite terrain. Complex mixed granitoids, including schlieric, nebulitic, banded, and foliated varieties together with enclosed lenses, pendants, and xenoliths of banded gneiss in various stages of assimilation occur adjacent to the gneiss-migmatite terrain. This unit has been mapped as a marginal facies (*Agx*).

The gneiss-migmatite appears, in some places, to pass transitionally into the nebulitically banded granitoids of the marginal facies. Examples occur between Coondawa South Well and Dickons Well and west of Mount Murchison. Tectonized contacts and 'lit-par-lit' intrusions also exist between the banded gneiss and the more homogeneous granitoids of the marginal facies. Examples occur in the Weiragoo and Scrubby Range areas. An agmatite at Meroula Pool consists of large blocks of dismembered, disoriented banded gneiss, with pegmatoid leucosomes (earlier incipient migmatization) surrounded by a neosome of unfoliated pegmatoid leucogranite.

The time relationship between the migmatite that is marginal, in places, to the Yilgarn cratonic granitoids and the banded gneiss-migmatite that anatectically produced the gneissic granitoids (*Agla, Agbs*) is uncertain.

It is possible that the former migmatite represents a younger and separate event and formed part of the generative zone of the Yilgarn cratonic granitoids.

The Manfred Lineament may be significant. If the interpretation of a horst structure to the west of this lineament is correct then the banded-gneiss - migmatite - granulite terrain in this region represents a lower crustal profile than the gneiss-migmatite-granitoid terrain east of the lineament (*see: Structure*).

Further discussion on the gneiss-granitoid contact can be found in Elias (in press).

PROTEROZOIC ROCKS

BADGERADDA GROUP

Coarse- to fine-grained arenaceous sediments of probable late Proterozoic age are mainly confined to the southwest corner of BYRO. Small outcrops also extend in a narrow zone from Mount Rebecca, 15.5 km west of Byro Homestead, north to the sheet boundary. They also occur around Mowry Hill northwest of Mount Narryer Homestead.

The group was initially described as the "Badgeradda Beds" (Konecki and others, 1958). A detailed study by Perry and Dickins (1960) later led to the defining of four formations: the basal Bililly Formation, followed by the Woodrarrung, Coomberarie, and Yarrawolya Formations. A fifth formation, the Errabiddy Sandstone, was thought to be a correlate of the lower part of the Woodrarrung Sandstone. These formations comprised the Badgeradda Group. Except for the basal Bililly Formation, all formations crop out on BYRO.

Stratigraphy

Woodrarrung Sandstone: The Woodrarrung Sandstone (*ꞒAw*) (Perry and Dickins, 1960) is a grey-white, medium- to coarse-grained, massive, quartz sandstone, feldspathic in part. It crops out south of Mongolia Bore in the extreme southwest of BYRO and 6 km southeast of Moogla Well. Cross-bedding is rare, although some examples occur near Moogla Well.

Errabiddy Sandstone: The Errabiddy Sandstone (*ꞒAe*) (Perry and Dickins, 1960) is exposed in the Errabiddy Hills 16 km northwest of Meeberrie Homestead. The sandstone is shallow dipping, pale brown to grey-white, medium grained and often feldspathic. Thin, pebble conglomerate bands occur within the sandstone. Macroscale cross-beds up to 10 m thick are exposed in the north-facing scarp of the Errabiddy Hills. Asymmetric ripple marks and current lineations are also present.

Fine- to medium-grained feldspathic sandstone, cropping out around Mowry Hill and Mount Rebecca, is considered to be equivalent to the Errabiddy Sandstone.

Perry and Dickins (1960) suggested that the Errabiddy Sandstone was equivalent to the lower part of the Woodrarrung Sandstone. However, the present survey has found that the Errabiddy Sandstone conformably overlies Woodrarrung Sandstone 6 km southeast of Moogla Well. Nevertheless, the Errabiddy Sandstone may possibly by a coarse-grained facies equivalent of the Woodrarrung Formation that developed along the eastern margin of the Proterozoic depositional basin.

Coomberarie Formation: The Coomberarie Formation (*ꞒAc*) (Perry and Dickins, 1960) is a thick sequence of shallow-dipping, light fawn-brown and reddish-white, thin-bedded siltstone and fine-grained sandstone. Good flaggy exposures crop out in a prominent ridge north of Coombrarri Well. Small-scale cross-bedding is common. The relationship between the Coomberarie Formation and the underlying Woodrarrung Sandstone is unclear on BYRO. Although they are apparently conformable the contact is not exposed.

Yarrawolya Formation: Perry and Dickins (1960) divide the Yarrawolya Formation (*ꞒAy*) into two units, an upper fine-grained hematitic sandstone and a lower siltstone. For purposes of this compilation, they have been combined. The dark purple-grey sediments crop out north and south of Yarrawolya Pool where they conformably overlie the Coomberarie Formation. Small-scale cross-beds, current lineations and drop pebbles are common.

The Permian Lyons Formation unconformably overlies the Yarrawolya Formation east of Come Back Well.

Structure and Metamorphism

An asymmetric shallow north-northeasterly plunging syncline, in Coomberarie and Yarrawolya Formations, occurs 5 km southeast of Yarrawolya Pool. This is the core of the Badgeradda Syncline as defined by Perry and Dickins (1960). The western limb of this structure is disrupted by transcurrent faulting which has juxtaposed Woodrarrung Formation against the Coomberarie and Yarrawolya Formations. The significance of the intense transcurrent faulting and dynamically metamorphosed Badgeradda Group of the Woodrarrung Range and areas westwards has been discussed by van de Graaff and others (1980).

South of Twelve Mile Well, shearing subparallel to the axial surface of the Badgeradda Syncline has developed a fracture cleavage at a high angle to the bedding. However, small contorted folds in the same area are slumps and are not related to the regional folding.

The eastern contact between the Errabiddy Sandstone and the Archaean gneiss is controlled by the complex Meeberrie Fault system (van de Graaff and others, 1977) which has a large downthrow to the west. However, east of Mount Rebecca the nature of the poorly exposed contact is uncertain and an unconformity between the Errabiddy Sandstone and Archaean gneiss can not be ruled out.

Post-depositional alteration of the Badgeradda Group on BYRO, unlike that of the dynamically metamorphosed equivalents on the adjoining YARINGA Sheet (van de Graaf and others, 1980) is regarded as diagenetic rather than metamorphic.

MAFIC DYKES

A series of unmetamorphosed mafic dykes trend east-northeast across BYRO. They are thought to be Proterozoic as they intrude homogeneous Yilgarn cratonic granitoids, particularly in the Weiragoo Range area. Several small, weathered dolerite dykes were also found in the proterozoic Badgeradda Group.

CARNARVON BASIN

STRATIGRAPHY

Rocks assigned to the Carnarvon Basin on BYRO consist of Late Carboniferous Lower Permian and Tertiary sediments. The stratigraphy of these is summarized on Table 1.

Late Carboniferous-Permian

The Lyons Formation (*Pl)* is a fluvioglacial and marine glacial sequence which rests unconformably on Precambrian rocks. It is exposed mostly as boulder fields of weathered-out glacial erratics of numerous Precambrian rock types; and as scattered low ridges of poorly sorted, feldspathic sandstone and siltstone. Konecki and others

TABLE 1. CARNARVON BASIN—STRATIGRAPHY IN THE BYRO SHEET AREA

Age				*Symbol and rock unit*	*Maximum Thickness (m)*	*Lithology*	*Stratigraphic relationships*	*Remarks*
	?MIOCENE			*Tp* Pindilya Formation	5	Sandstone, conglomerate, minor siltstone; commonly silcreted	Unconformably overlies older unit	?fluviatile environment; age by inference; greatest thickness in solution pipes in underlying bedrock.
PALAEOZOIC	PERMIAN	ARTINSKIAN	BYRO GROUP	*Py* Coyrie Formation	68	Generally bioturbated siltstone to fine-grained sandstone; commonly exposed as ferruginized scree and gibber	Conformably overlies older units	Basal unit of Byro Group; quiet shelf environment; thickness in Deep Bore, Byro Station
PALAEOZOIC	PERMIAN	ARTINSKIAN	WOORAMEL GROUP	*Pk* Keogh Formation	?80	Siltsone, sandstone, minor claystone and carbonaceous shales; some herringbone cross-lamination	Conformably overlies Moogooloo Sandstone, boundary gradational	Thickness estimated from dip measurements; subtidal environment
PALAEOZOIC	PERMIAN	ARTINSKIAN	WOORAMEL GROUP	*Pm* Moogooloo Sandstone	?350	Quartzose to felspathic sandstone, siltstone, minor claystone and carbonaceous shale; some herringbone cross-bedding	Disconformably overlies older rocks	Thickness estimated from dip measurements; cool to cold deltaic to subtidal environments; Wooramel Group 310 m thick in Deep Bore, Byro Station
PALAEOZOIC	PERMIAN	SAKMARIAN		*Pr* Carrandibby Formation	?100	Micaceous claystone, siltstone, sandstone; thin to medium-bedded; fossiliferous and calcareous in the type area	Conformably overlies Lyons Formation	Thickness estimated from dip measurement; partly eroded prior to Moogooloo Sandstone deposition; local facies variant of Lyons or Callytharra Formations; cold shallow-marine deposition
PALAEOZOIC	LATE CARBON-IFEROUS			*Pl* Lyons Formation	1200	Immature sandstone, siltstone, shale and phyllite; contains numerous glacial erratics	Disconformably overlies Badgeradda Beds or older Precambrian	?glaciolacustrine, ?fluvioglacial and marine glacial environments; poor exposure—as boulder fields and scattered boulders, minor sandstone ridges

(1958) estimated the thickness of the Lyons Formation south of Byro Station to be of the order of 1 200 m; that estimate has not been altered by later geophysical data (Stanley and Stilley, 1965; Stanley, 1967). Marine fossils and plant fossils from areas to the north indicate that the Lyons Formation is largely of Sakmarian age (Dickins, 1956, 1957, 1963; Dickins and Thomas, 1959), although it is probably Late Carboniferous at the base (Hocking and others, 1980).

The Carrandibby Formation (*Pr*) is a marine, fine-grained unit which is transitional between the Lyons and Callytharra Formations. On BYRO, mapped Carrandibby Formation is unfossiliferous, and it is unconformably overlain by Moogooloo Sandstone. Dickins (1963) dated the formation in the type area as Sakmarian.

The Wooramel Group is a transgressive, sandy and silty sequence which, on BYRO, consists of the Moogooloo Sandstone and Keogh Formation. Scarce marine fossils from areas to the north indicate an Artinskian age (Condon, 1967). The Moogooloo Sandstone (*Pm*) was deposited on the Callytharra, Carrandibby and Lyons Formations after an erosional break, which in some areas removed all of the Callytharra and Carrandibby Formations. The Moogooloo Sandstone is a high-energy, deltaic to subtidal unit, which on BYRO was mapped by Konecki and others (1958) as 'Curbur Formation', but this name was dropped by van de Graaff and others (1977). South of Mintahalla Bore, the thickness of the Moogooloo Sandstone, calculated from dips, is about 350 m. The section measured by Konecki and others (1958) as the type section of the 'Curbur Formation' is 96 m thick, but it is incomplete because of faulting. The Keogh Formation (*Pk*) conformably overlies the Moogooloo Sandstone and was deposited in a quieter, subtidal environment. Thicknesses calculated from dips indicated the formation is 50 to 80 m thick near Mintahalla Bore.

The Coyrie Formation is the only unit of the Byro Group exposed on BYRO. It is of Artinskian age (Condon, 1967), and in most places it is exposed as ferruginized siltstone scree. Hocking and others (1980) simplified the Byro Group Stratigraphy and abandoned the name 'Madeline Formation'.

Tertiary

The Pindilya Formation (*Tp*) is an extensively silcreted ?fluviatile sandstone and conglomerate unconformably overlying Permian rocks. A revised type section of this unit, 3 km southwest of Swelt Bore, was proposed by van de Graaff and others (1977). The Pindilya Formation is probably of Miocene age (van de Graaff and others, 1980) and was laid down on a subdued land surface. Some silcrete, laterite and exhumed pre-Pindilya erosion surfaces were not differentiated from the Pindilya Formation in mapping, because their respective air-photo patterns are indistinguishable.

STRUCTURE

The Byro Sub-basin of the Carnarvon Basin is a down-faulted synclinal zone, which on BYRO is stratigraphically continuous with the Merlinleigh Sub-basin and the Coolcalalaya Sub-basin of the Perth Basin. In the east, the Byro Sub-basin is bounded by the Meeberrie Fault System, and only small outliers of Lyons Formation occur east of the fault. In the southwest the sub-basin is bounded by the Darling Fault, a subsidiary fault which may continue as the large west-block-down fault immediately east of the Ballythanna Hill Anticline. The Woodrarrung Fault, which may also join this fault, has little effect on the Permian sequence.

Two large, gentle synclines, separated by the Ballythanna Hill Anticline, are mapped in the area.

GEOLOGICAL HISTORY

The first Phanerozoic event recorded is the Late Carboniferous-Early Permian glaciation. During the Sakmarian, the climate was frigid, and a cold climate persisted during much of the Artinskian. The regional disconformity at the base of the Artinskian probably reflects isostatic uplift after melting of most of the ice sheet in the late Sakmarian. A widespread transgression followed, during which the Wooramel and Byro Groups were deposited. Normal faulting in the ?Late Permian and ?Triassic shaped the Byro Sub-basin as a separate structural unit. In the early Teriary, fluviatile deposition occurred on a subdued land surface, followed by, and ?contemporaneous with, lateritic weathering.

SUPERFICIAL DEPOSITS

Superficial Cainozoic units are separated into older cemented lithified, or semi-consolated fluviatile, residual or eolian deposits ranging from Tertiary to Quaternary age, prefixed (*Cz*), and younger Quaternary, unconsolidated alluvial, colluvial and eolian surficial deposits prefixed (*Q*).

Remnants of a once extensive duricrust surface, now represented by silcrete (*Czb*), laterite (*Czl*), ferruginous jasperoidal cappings on weathered ultramafic rocks (*Czj*) and deep weathered bedrock, are preserved as mesas and scattered remnants bordered by breakaways, along the major drainage divides east of the Murchison River. The duricrust surface is more extensive west of the Murchison River where it intersects and coincides more closely with the present erosion surface.

An older eolianite (*Czs*) forms low rises on top of some breakaways overlying Permian rocks. It is a moderately indurated reddish sandstone with unbiquitous soil structures such as root casts, and probably correlates with the ?early Pleistocene Peron Sandstone of the Shark Bay area.

Calcrete (*Czk*), which is largely a chemical precipitate from groundwater of calcium and magnesium carbonates, crops out discontinuously along the Murchison and Roderick Rivers and Yarra Yarra, Whela and Karbar Creeks. Although they are trunk valley calcretes, their partly dissected nature would place them in the dissected calcrete category of Butt and others (1977). Deltaic, partly buried calcretes occur in the Mount Narryer and Curbur Homesteads area. These calcretes occupy fan-shaped regions adjacent to saline dune and playa terrain (*Ql*).

The position of these calcretes appears to be related to the linear, ?fault-controlled contact between Permian and Precambrian rocks. A similar deltaic calcrete lies just north of Coolyun Hill on the eastern margin of a broad dune and playa terrain. Calcrete also occurs in the palaeodrainage valley northwest of Muggon Homestead.

Partly dissected hardpan (*Czc*) is found in all main drainages, particularly the Murchison River and marginal to the dune and playa terrain occupying the palaeodrainage valley west of Curbur Homestead. It is commonly covered by thin sheet wash (*Qw*) in areas adjacent to the main drainage. The hardpan (*Czc*) is a mixed alluvial-colluvial unit of fluviatile origin. It consists of red-brown poorly bedded clay, silt, and very fine to coarse sand with scattered pebbles and conglomerate lenses. The Murchison River, down-stream from the junction with the

Roderick River has cut a shallow gorge 10-15 m deep in this material. This unit includes the 'Murchison cement' which, on the adjacent Murgoo Sheet, near Billabalong, has yielded Aboriginal artifacts and bone fragments of extinct Holocene Marsupials (Merrilees, 1968).

The recent surficial deposits include large claypans (fresh) and playas (saline) (*Ql*), gypsiferous dunes (*Qe*) marginal to the larger playas and a dune and playa terrain (*Qle*) in which individual playas are too small and numerous to distinguish on the map. All these units are concentrated in a broad palaeodrainage system, an extension of Yarra Yarra Creek, over Permian bedrock west of Mount Narryer and Cubur Homesteads. Some of the eolian material is derived from the surface of the pans and lakes but the bulk is probably derived from the reworking of the adjacent sandplain unit (*Qs*). The playa-dune unit (*Qle*) has a very characteristic stippled photo-pattern. A similar unit has been mapped along the Murchsion and Roderick River drainages in areas of very low gradient.

The playa-dune unit (*Qle*) also resembles, and grades into, a mixed eolian-colluvium wash unit (*Qw*) which lies adjacent to the main drainage lines. However, the wash (*Qn*), which consists of sinuous clay and silt pans separated by low anastomosing banks of sand, is a low-slope unit. The photo-pattern is mottled and striped rather than stippled, as for the playa-dune unit (*Qle*).

The wash (*Qw*) passes to unconsolidated alluvial silt, sand and gravel (*Qa*) in the main drainage channels or upslope to colluvial scree deposits (*Qc*) adjacent to bedrock outcrop. The (*Qc*) generally has a quartz, ironstone-pebble, or rock veneer.

The sandplain unit (*Qs*) is probably reworked from a pre-existing older sandplain overlying the duricrust surface. It is extensively developed over Permian rocks, but is rare east of the Murchison River.

ECONOMIC GEOLOGY

MINERAL DEPOSITS

Gold

Gold has been reported from high-grade gneiss near Mount Dugel (Johnson, 1950). However, the present survey was unable to locate any workings in this area.

Copper

A very small copper prospect, a quartz reef containing malachite-stained, limonitic gossan, has been pitted 2 km north of Byro Homestead in a banded granitic gneiss. Malachite-stained gossanous material has also been found in a laterite-covered and weathered ultramafic lens 5 km north-east of Melun Bore (Byro Prospect).

Nickel

At least twelve small ultramafic bodies, mainly chlorite-tremolite-talc-serpentine assemblages after peridotite, occur in banded gneiss and gneissic granitoid terrain northwest and west of Meegea Hill. Exploration of these bodies in the late 1960's and early 1970's located several nickeliferous gossans, all of which proved to be uneconomic. Ultramafic bodies, in banded gneiss terrain, 8 km southwest of Mount Dugel, 4 km northwest of Partnership Bore, and 2 km north of Deep Well have also been investigated without success.

A large, differentiated ultramafic body, now mainly a chlorite-amphibole-serpentine (-talc) assemblage, has been unsuccessfully prospected near Noonie Hill, in the Jack Hills Greenstone Belt.

A cluster of talc-carbonate-chlorite-serpentine bodies in banded gneiss and migmatite adjacent to homogeneous granite in the region roughly 18 km southwest of Nookawarra Homestead, between No. 13 and No. 20 Bores have been unsuccessfully explored.

Chromite

Eluvial chromite has been recorded from residual soils overlying a largely concealed layered mafic-ultramafic complex in the Iniagi Well (Imagi Well; Baxter 1978, p 171) area. This northeasterly facing layered body contains slivers of paragneiss within it, suggesting that more than one intrusion may be involved. It has been metamorphosed to an upper-amphibolite to lower-granulite facies assemblage.

Recent exploration of this body (Western Mining Corporation Ltd, 1978) has shown that small chromite lenses are associated with the ultramafic portion of the western side of the body. Iron-rich chromite layers also occur with a meta-norite higher in the body near Iniagi Well. However, the generally poor quality of the chromite and limited tonnage make the deposit uneconomic.

A similar, concealed, metamorphosed mafic-ultramafic body, within granulite facies terrain, has been investigated 2 km north of Milly Milly Homestead in the Taccabba Well area. Drilling has located a magnetite-chromite band 1.5 km long marginal to a meta-lherzolite. Traces of pyrite and chalcopyrite were also noted (Horseley, 1974).

Iron Ore

Maitland (1898) noted small bodies of hematitic iron ore ($<$10 kt), just west of Mount Narryer, in banded iron-formation. The hematite deposits of the Jack Hills are confined to the adjacent BELELE Sheet (Elias, in press).

Corundum

Several eluvial corundum occurrences were found overlying high-grade (upper-amphibolite to lower-granulite facies) banded gneiss, calc-silicate gneiss and mafic granofels (after layered mafic bodies). However, the source rock for the corundum could not be established in the field. The largest deposit, which covers about 0.5 ha, lies 4 km east of Thoolmugga Well north of the Byro-Milly Milly road. Corundum float has also been found 1 km north of this position and 4.5 km north-northeast of Thoolmugga Well.

The corundum crysals are up to 80 mm long, have a bronze chatoyance and are strongly zoned. Many are rimmed by hercynite (iron-aluminium spinel). Weak magnetism, exhibited by the crystals, is attributed to minute inclusions of ilmenite and magnetite crystals within the hercynite margin. Hercynite is an accessory mineral in the mafic granofels. It is possible this rock is the source of the corundum, possibly as xenoliths caught up in the layered mafic body (now mafic granofels). Read (1931) has described similar occurances of corundum-spinel xenoliths from norite in Scotland.

Twinned, blue-grey corundum in colluvium overlying granitic gneiss has also been found 5.5 km north-northeast of Byro Homestead.

Gemstones

Simpson (1904, 1952) describes the occurrence of tiger-eye and cats-eye opal, discovered in 1899, from somewhere along Yarra Yarra Creek. The locality, known as the Bulgarro (or Bulgaroo) Opal Mine, is probably the same one from which 54.4 kg of tiger-eye opal was produced in 1960. This prospect lies 6 km south-southeast of Coontrabillily Well on the southern side of Tathire Creek, a major tributary of Yarra Yarra Creek. The material is derived from an opalized silica capping on deeply weathered ultramafic rock.

Small amounts of potentially gem-quality opaline silica have been found north of Meegea Hill and near Iniagi Well. All are found in jasperoidal silica cappings on ultramafic rocks.

Barite

A number of thin barite veins have been prospected over a length of 300 m, 2.5 km north-northwest of Badgeradda Claypan. The barite veins lie in a fracture cleavage, which dips vertically to 80° west and strikes 360°. The host rock is a shallow, east-dipping (less than 5°) laminated to thin-bedded, khaki-green micaceous siltstone belonging to the Yarrawolya Formation of the Proterozoic Badgeradda Group. Although a number of veins are present the deposit is very small.

Building stone

Perry and Dickins (1960) record the use of flaggy fine-grained sandstone of the Yarrawolya Formation as a building and flagging stone at Muggon Homestead. This material has been quarried from a site 1.5 km south of Yarrawolya Pool.

Locally quarried gneiss and gneissic granite have been used in buildings at Meeberrie, Mount Narryer and Boolardy Homesteads.

Economic potential of Phanerozoic rocks

No significant mineralization is recorded from the Phanerozoic sediments. Potential targets for coal exploration are the Keogh Formation and Moogooloo Sandstone, but the sublittoral environment of deposition interpreted for most of these two units (where exposed) makes the sequence a poor prospect. Initial exploration in the early 1970s indicated only very minor shaly coal within mudstones, and low-grade, sub-bituminous coal flakes within sandstone. The area has, however, seen a recent upsurge in interest, primarily for steaming coal.

The Byro Group, Carrandibby Formation and Callytharra Formation are potential petroleum source rocks. Seismic work has shown the Ballythanna Hill Anticline to persist at depth (Stanley, 1967) but no potential reservoirs remain unbreached, and no other potential structures are known. As well, the low rank of coal flakes suggests that maturation was too low for petroleum generation.

Very recently, a diamond search has been carried out in the Muggon Homestead area. The search was concentrated along deep-seated faults which are known to occur in this area, in Proterozoic and Phanerozoic sediments.

Water

A total of 418 wells and bores, supplying domestic and stock water, were tested for water quality. These ranged from 157 mg/L to over 10 000 mg/L TDS. However, 67% of tested wells and bores contain water with less than 2 000 mg/L whilst 24% contain less than 1 000 mg/L TDS.

Overall BYRO has extensive areas of reasonable quality groundwater (<2 000 mg/L) in the drainage divide areas (see Fig. 1), but there is a marked salinity increase towards the major drainages. In Precambrian bedrock areas the more saline groundwater is restricted to narrow zones along the Murchison River and Whela Creek, and to a lesser extent along the Roderick River, particularly the lower reaches. All these drainages tap the saline hinterland to the east.

Although the Murchison and Roderick Rivers flow freshwater after heavy rains, the Murchison River, in particular, rapidly becomes saline with decreasing flow. Salinity measurements taken in May 1978, at the beginning of winter rains registered 6 240 mg/L at Minnawarra Crossing and 12 474 mg/L at Nine Mile Crossing. A further reading, obtained in August after the winter rains still registered 9 180 mg/L at Mindle Well Crossing west of Manfred Homestead. Although groundwater along the Roderick River is fairly saline (ranging up to 7 000 mg/L) the short duration surface flow measured in August registered only 1 600 mg/L.

Permanent pools are probably restricted to the Murchison River, which during the present survey, flowed intermittently south from the Manfred Homestead area. Large semi-permanent pools occur along the Roderick River and Whela and Yarra Yarra Creeks. Ephemeral fresh water lies for months in some large claypans in the Curbur and Mount Narryer Homestead areas.

Yarra Yarra Creek (mainly downstream from Byro Homestead), the broad dune and playa terrain west of Curbur Homestead, most of the Wael sub-drainage basin (Fig. 1), and the palaeo-drainage system of Muggon Homestead all contain fairly saline groundwater (>2 000 mg/L) although most is suitable for stock.

Although most of the above-mentioned areas overlie Phanerozoic rocks of the Byro Sub-basin, reasonable quality groundwater can be obtained from these rocks in the northwest corner of BYRO and from narrow drainage divides.

Stock-quality water is obtained from the Moogooloo Sandstone and Lyons Formation. The former produced large quantities of potable water. Supplies from the Lyons Formation vary in both quantity and quality. The Byro Group is too fine-grained and impermeable to provide a good aquifer.

Cainozoic calcrete provides moderate quantities of potable water for domestic supplies at Mount Narryer, Curbur, Byro, Meeberrie and Nookawarra Homesteads.

APPENDIX I
LOCALITIES MENTIONED IN TEXT

Place Name	Latitude	Longitude
Badgeradda Claypan	26°52′45″	115°32′54″
Balloo Hill	26°46′28″	116°48′40″
Ballythanna Hill	26°03′30″	115°39′50″
Bilga Rock	26°57′54″	115°56′40″
Boolardy Homestead	26°58′50″	116°31′39″
Bulgarro Opal Mine	26°07″26′	116°20′18″
Byro Homestead	26°04′50″	116°09′15″
Byro Plains	26°03′00″	115°34′00″
Christmas Well	26°44′00″	116°16′12″
Come Back Well	26°54′46″	115°36′10″
Coobbooroo Well	26°35′33″	116°04′38″
Coondawa Well	26°50′48″	116°29′50″
Coondawa South Well	26°54′38″	116°27′54″
Coolyun Hill	26°11′50″	115°48′42″
Coombrarri Well	26°57′00″	115°36′11″
Contrabillily Well	26°06′08″	116°17′12″
Curbur Homestead	26°28′00″	115°56′06″
Dallah Bore	26°12′14″	116°36′35″
Deep Well	26°42′54″	116°13′56″
Dickons Well	26°47′12″	116°34′18″
Dingo Well	26°40′10″	116°18′04″
Duffies Well	26°31′25″	116°16′06″
East Noola Well	26°45′34″	116°34′38″
Erawondoo Hill	26°11′07″	116°56′32″
Errabiddy Hills	26°55′30″	115°49′20″
Frazer Well	26°15′08″	116°21′23″
Geigies Well	26°56′02″	116°43′28″
Iniagi Well	26°12′19″	116°12′15″
Jack Hills	26°10′00″	116°57′00″
Joorong No. 5 Bore	26°38′37″	116°43′48″
Manfred Homestead	26°26′48″	116°32′24″
Maradagee Woolshed Bore	26°09′39″	116°14′36″
Meeberrie Homestead	26°57′30″	115°58′22″
Meeberrie Pool	26°54′22″	116°14′00″
Meeberrie Woolshed	26°50′39″	116°03′43″
Meegea Hill	26°07′30″	116°26′50″
Melun Bore	26°03′22″	116°20′12″
Meroula Pool	26°17′14″	116°58′28″
Middado Well	26°25′37″	116°08′05″
Milly Milly Homestead	26°04′29″	116°41′27″
Mindle Well	26°28′37″	116°26′53″
Minnawarra Crossing	26°47′56″	116°16′15″
Mintahalla Bore	26°13′22″	115°57′23″
Mongolia Bore	26°50′52″	115°30′45″
Moogla Well	26°57′14″	115°45′36″
Mooninew Well	26°56′43″	116°22′30″
Mount Dugel	26°20′04″	116°27′09″
Mount Murchison	26°45′33″	116°25′18″
Mount Narryer	26°31′18″	116°22′44″
Mount Narryer Homestead	26°35′00″	115°55′23″
Mount Rebecca	26°05′36″	116°00′02″
Mowry Hill	26°31′39″	115°52′25″
Muckeringa Well	26°40′02″	115°56′55″
Muggon Homestead	26°36′55″	115°32′42″
Murchison Shire Office	26°33′31″	115°57′16″
Nine Mile Crossing	26°33′17″	116°24′37″
Nookawarra Homestead	26°18′07″	116°52′25″
Noonie Hill	26°12′23″	116°53′10″
No. 13 Bore	26°22′56″	116°46′32″
No. 15 Well	26°23′16″	116°18′52″

APPENDIX I

LOCALITIES MENTIONED IN TEXT—*continued*

Place Name	Latitude	Longitude
No. 20 Bore	26°26′11″	116°39′55″
Partnership Bore	26°14′29″	116°32′15″
Scrubby Range	26°43′06″	116°30′58″
Sharpe Bore	26°08′06″	116°51′38″
Stone Hut Well	26°27′04″	116°13′28″
Swelt Bore	26°22′39″	115°47′24″
Taccabba Well	26°05′16″	116°37′53″
Tching Range	26°34′00″	116°54′00″
Thoolmugga Well	26°09′58″	116°21′32″
Twelve Mile Well	26°54′13″	115°32′24″
Wandarrie Well	26°26′13″	115°59′25″
Weiragoo Range	26°29′00″	116°47′00″
White Hill	26°43′48″	116°22′53″
Yarrawolya Pool	26°47′55″	115°32′42″

APPENDIX II

SELECTED DENSITY CALCULATIONS OF GRANITE AND GNEISS

GSWA Sample No.	Rock Type	Latitude	Longitude	Density (t/m^3)	
57293	Biotite granite	26°38′00″	116°52′45″	2.68	Yilgarn cratonic granitoids
60103	Porphyritic biotite-muscovite adamellite	26°28′30″	116°48′30″	2.65	
57241	Biotite adamellite gneiss	26°39′15″	115°58′15″	2.63	older gneiss terrain
57221	Banded adamellite gneiss	26°00′15″	116°27′30″	2.63	
57238	Biotite-hornblende adamellite gneiss	26°42′45″	115°55′45″	2.73	
57268	Cordierite-biotite-microcline gneiss	26°40′30″	116°15′45″	2.73	
57265	Hornblende-olivine granulite	26°39′30″	116°16′15″	3.29	

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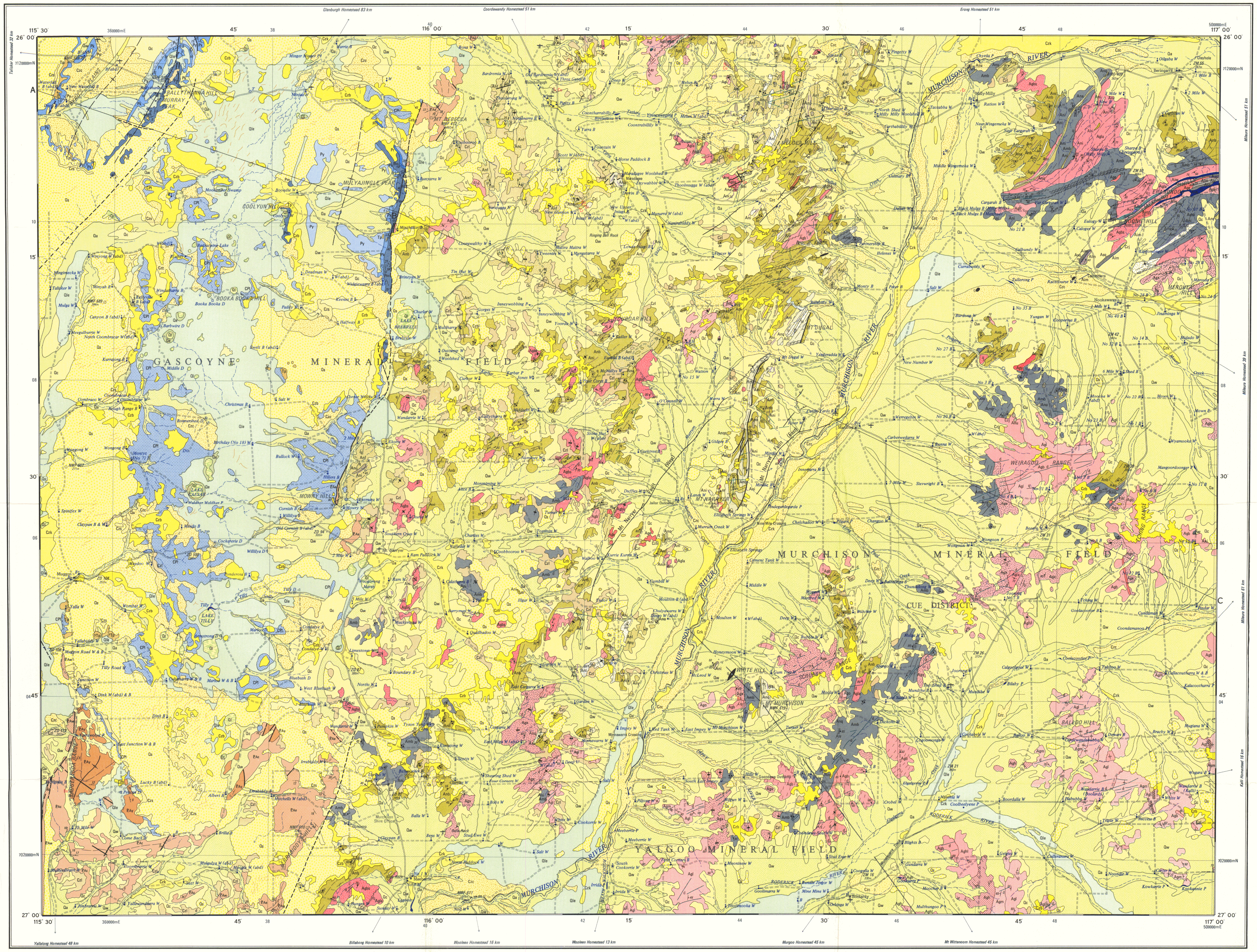
AUSTRALIA 1:250 000 GEOLOGICAL SERIES

BYRO

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET SG 50 - 10



SYMBOLS

- Geological boundary
- Fault
  - established
  - inferred or concealed
  - normal, tick on downthrow block
  - recent, tick on downthrow block
- Shear zone, may be quartz filled
- Fold
  - axial trace of anticline, showing plunge
  - axial trace of syncline, showing plunge
  - axial trace of synform
  - plunge of minor fold, early phase
  - plunge of minor fold, late phase
  - parasitic fold showing plunge, early phase
  - parasitic fold showing plunge, late phase
- Bedding, facing not implied in Archaean Rocks
  - inclined
  - vertical
  - horizontal
  - top of bed
  - palaeocurrent from cross-bedding or cross-lamination
- Air photo lineaments
  - bedding, gneissic banding or metamorphic foliation
  - undetermined
- Strongly foliated, lineated or sheared
- Gneissic banding or early metamorphic foliation
  - inclined
  - vertical
- Metamorphic foliation
  - inclined
  - vertical
  - dip not determined
- Igneous banding
  - inclined
  - vertical
  - dip not determined
- Lineation
  - mineral elongation
  - intersection or crenulation
- Fossil locality
- Isotopic age determination site
- Type locality

- Mineral field boundary
- Formed road
- Track
- Homestead — Muggon
- Locality — Calcatharra
- Building
- Landing ground
- Horizontal control, minor
- Benchmark, height accurate — ZD 104 257m
- Sand dune

- Watercourse, intermittent
- Pool — P
- Well — W
- Bore — B
- Windpump
- Dam — D
- Tank — T
- Rockhole — RH
- Abandoned — (abd)

- Prospect
- Mineral occurrence
  - Barite — Ba
  - Beryl — Be
  - Chromium — Cr
  - Copper — Cu
  - Corundum — Cn
  - Gemstones — Gs
  - Hematite — He
  - Nickel — Ni

REFERENCE

CAINOZOIC — QUATERNARY

Ql Alluvium – clay, silt, sand, grit, pebbles in playa lakes; saline, gypsiferous and/or calcareous
Qle Mixed playa-dune terrain; saline in part; alluvium and eolian
Qe Gypsiferous eolian sand in lunette dunes
Qa Alluvium – unconsolidated silt, sand, gravel; associated with drainage lines
Qw Alluvium – unconsolidated silt, sand in sheetwash and on piedmont plains, also overlies Tertiary hardpan; often with banks of windblown sand
Qc Colluvium – unconsolidated silt, sand, gravel and rubble; including scree and talus slopes
Qs Eolian and residual sand

Czc Hardpan – consolidated and semi-consolidated colluvium and alluvium, silt, sand, gravel; commonly dissected includes "Murchison cement"
Czk Calcrete
Czs Older eolian and residual sand; semi-consolidated
Czl Laterite and ferruginous deposits
Czb Silcrete, "Billy", includes some silicified bedrock
Czj Opaline silica, jasperoidal chalcedony, ferruginized deposits over ultramafic rocks

TERTIARY

Tp **PINDILYA FORMATION** : sandstone, conglomerate, minor siltstone; commonly silcreted

PALAEOZOIC — PERMIAN

ARTINSKIAN — Wooramel Group, Byro Group

Py **COYRIE FORMATION** : bioturbated siltstone, fine-grained sandstone
Pk **KEOGH FORMATION** : siltstone, sandstone, minor claystone, carbonaceous shale
Pm **MOOGOOLOO SANDSTONE** : quartzose or feldspathic sandstone, siltstone, minor claystone and carbonaceous shale

SAKMARIAN

Pr **CARRANDIBBY FORMATION** : micaceous claystone, siltstone, shale, sandstone
CPl **LYONS FORMATION** : immature sandstone, siltstone, shale, tillite; contains numerous glacial erratics. Lower part of formation may be of Late Carboniferous age

LATE PROTEROZOIC

q Quartz vein
d Dolerite dyke, may be weakly metamorphosed, age variable

Badgeradda Group

PAy **YARRAWOLYA FORMATION** : siltstone, silty sandstone
PAc **COOMBERAIE FORMATION** : silty sandstone
PAe **ERRABIDDY SANDSTONE** : feldspathic sandstone, minor pebble conglomerate lenses
PAw **WOODRARRUNG FORMATION** : thin bedded feldspathic and quartzose sandstone

ARCHAEAN

Age Fine to medium-grained equigranular biotite adamellite in small bodies
Ago Spheroidal textured granodiorite and adamellite in dykes and small bodies
Agb Medium to coarse-grained biotite adamellite and granite, minor granodiorite, some microcline megacrysts
Agl Medium to coarse-grained, seriate to porphyritic biotite adamellite, granite, microcline megacrysts
Agh Medium-grained hornblende (-biotite) granodiorite and adamellite, even-grained
Aghl Medium to coarse-grained, seriate to porphyritic hornblende (-biotite) adamellite, granodiorite and tonalite, microcline megacrysts
Agt Foliated, medium to coarse-grained biotite-hornblende granodiorite and tonalite, in dykes and small bodies
Agm Mixed granitoid rocks; combinations of above symbols, not separated at map scale
Agx Marginal facies; complex of granitoid units, large rafts etc. of older migmatite and banded gneiss

Jack Hills Greenstone Belt

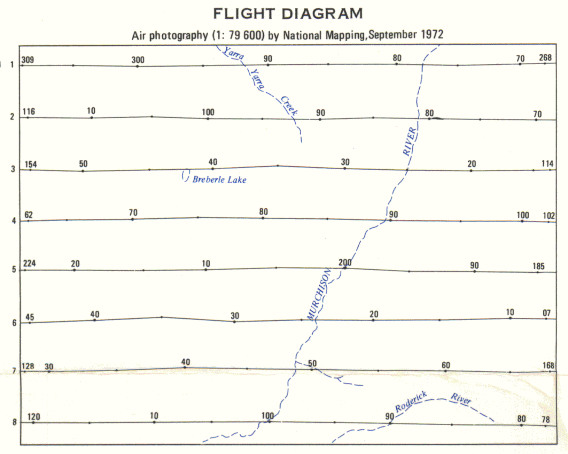
Aiw Banded iron-formation, black and white banded, may be recrystallized to a fine granular texture
Aim Amphibole-bearing banded iron-formation
Asq Quartzite and micaceous quartzite, fine to medium-grained quartz wacke
Asc Quartz pebble conglomerate; schistose matrix
Alm Quartz-mica schist, contains garnet and andalusite in places; pelitic metasediments
Ada Amphibolite; fine to medium-grained, schistose with growth of amphibole in foliation; metamorphosed dolerite
Aux Meta-pyroxenite
Aup Serpentinized peridotite, cumulate olivine texture preserved

Agla Gneissic biotite (- ferrohastingsite) granite, adamellite and granodiorite; coarse to medium-grained, porphyritic, seriate and even-grained phases, generally microcline augen and/or laths
Agbs Gneissic biotite (- ferrohastingsite - muscovite) granodiorite, adamellite and granite; coarse to fine-grained
Agy Gneissic quartz syenite, microcline-hornblende-diopside assemblage

Amb Migmatite with banded microcline-plagioclase-quartz-biotite gneiss and 30% or more anatectic biotite adamellite or granite

Anb Banded microcline-plagioclase-quartz-biotite gneiss; coarse to fine-grained, migmatitic in part
Anf Banded microcline-plagioclase-quartz-biotite-muscovite-magnetite gneiss; medium-grained, migmatitic in part
Anl Quartz-feldspar-biotite-muscovite (- chlorite) - garnet paragneiss and schist
Anc Hornblende-tremolite-actinolite-quartz-plagioclase-epidote (- clinopyroxene-garnet) compositionally layered assemblages; calc-silicate gneiss
Ana Hornblende-plagioclase (- actinolite-epidote-clinopyroxene) amphibolite; banded
Anq Quartzite, micaceous quartzite; minor fuchsite, garnet, sillimanite, cordierite
Anqc Garnet-bearing meta-conglomerate
Ani Quartz-magnetite (- amphibole-garnet-clinopyroxene) rock; metamorphosed banded iron-formation
Any Pelitic and semi-pelitic granofels; quartz-microcline-biotite-cordierite-sillimanite-garnet-plagioclase-hyperthene assemblages; granulite; includes minor mafic granofels
Ano Mafic granofels; plagioclase (- labradorite-bytownite) - hornblende-clinopyroxene-orthopyroxene granofels; mafic granulite
Anu Serpentine-amphibole-talc-chlorite; (- olivine); ultramafic assemblages in gneissic terrain

FLIGHT DIAGRAM



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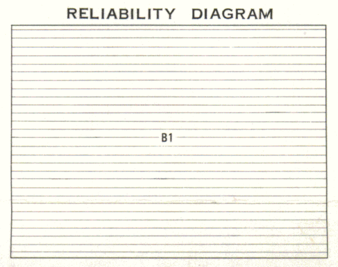
Copies of this map may be obtained from the Geological Survey of Western Australia, 66 Adelaide Tce., Perth.

Printed by the Government Printing Office, Perth.

RELIABILITY DIAGRAM



B1 Numerous traverses with air photo interprretation

HON. P. DOWDING, M.L.C.
MINISTER FOR MINES
A.F. TRENDALL, DIRECTOR, GEOLOGICAL SURVEY

SCALE 1:250 000

TRANSVERSE MERCATOR PROJECTION
ZONE 1 AUSTRALIA SERIES
Grid represents 10000 metre superimposed Australian Map Grid

INDEX TO ADJOINING SHEETS

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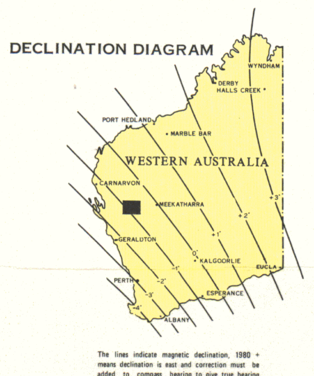
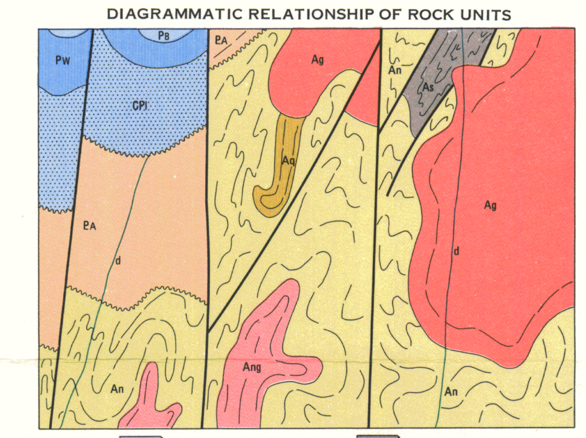
YARINGA SG 50 - 9	BYRO SG 50 - 10	BELELE SG 50 - 11
AJANA SG 50 - 13	MURGOO SG 50 - 14	CUE SG 50 - 15

Geology: Phanerozoic – R.M. Hocking and W.J.E. van de Graaff, 1976
Precambrian – I.R. Williams, I.W. Walker and S.J. Williams, 1978

DECLINATION DIAGRAM



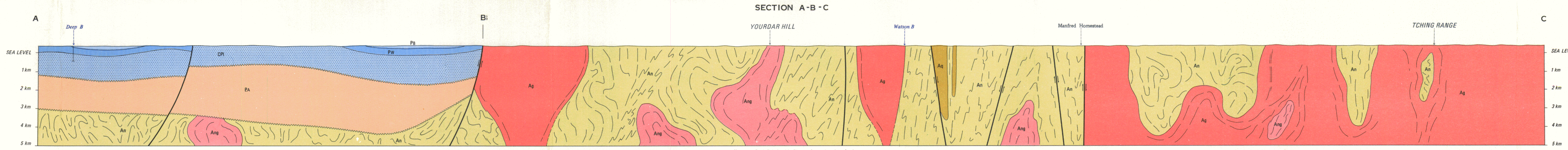
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



PB Byro Group
PW Wooramel Group
CPl Lyons, Carrandibby and Callytharra Formations
PA Badgeradda Group
Ag Yilgarn cratonic granitoids
As Jack Hills Greenstone Belt
Ang Gneissic granitoids
Aq Quartzite
An Gneiss and migmatite
Unconformity
Shear zone or fault
Foliation trends

DIAGRAMMATIC SECTION

SECTION A - B - C



Note: see Rock Relationship Diagram for explanation of units

BYRO
SHEET SG 50 -10

FIRST EDITION 1983