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COLLIER

WESTERN AUSTRALIA

SHEET SG50-4 INTERNATIONAL INDEX

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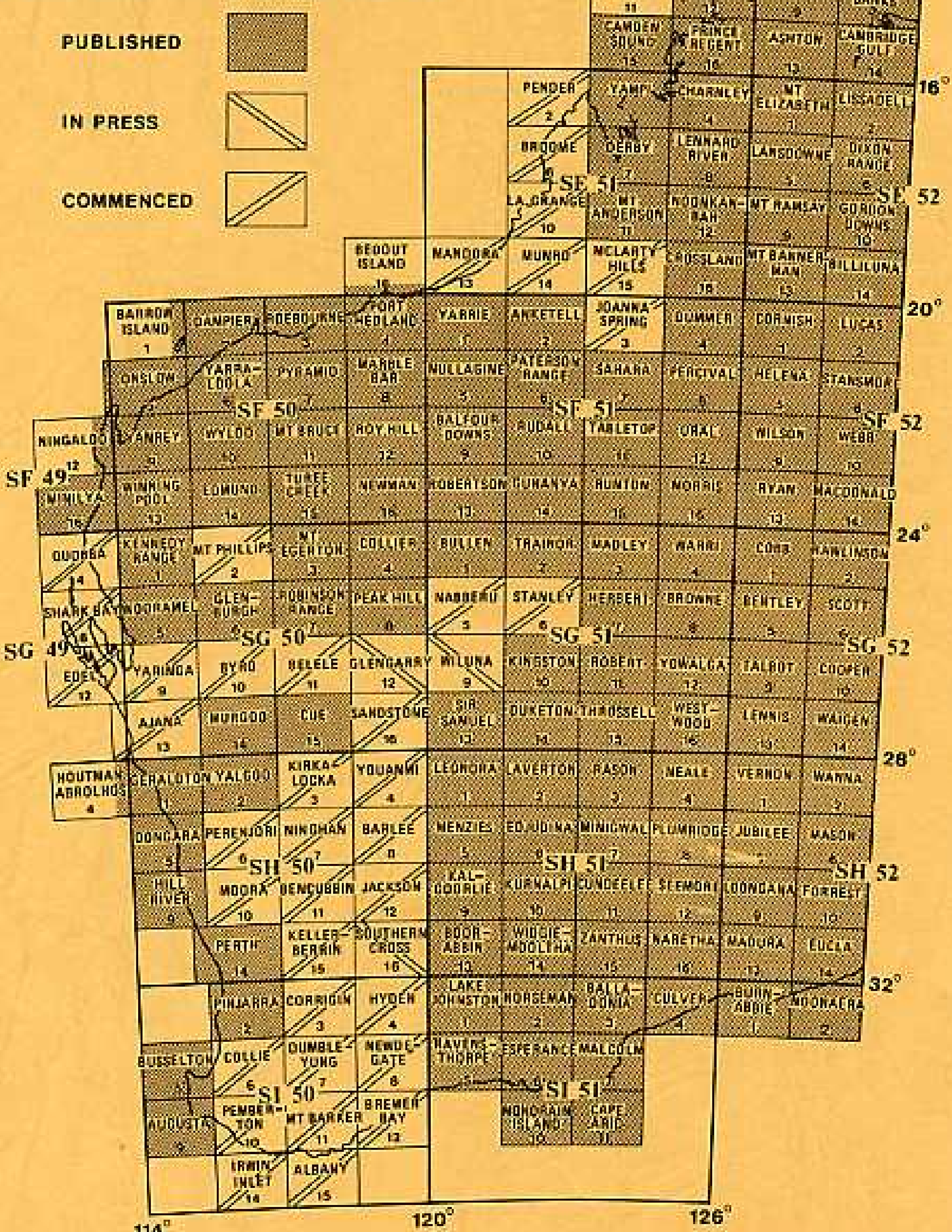

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

COLLIER

WESTERN AUSTRALIA

SHEET SG50-4 INTERNATIONAL INDEX

COMPILED BY A. T. BRAKEL, M. ELIAS, AND J. C. BARNETT

PERTH, WESTERN AUSTRALIA 1982

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Explanatory Notes on the Collier Geological Sheet

Compiled by A. T. Brakel, M. Elias, and J. C. Barnett

INTRODUCTION

The COLLIER* (SG50-4) 1:250 000 sheet area is bounded by latitudes 24° and 25°S and longitudes 118°30′ and 120°E. It lies in the North-West Division of Western Australia, and is located principally within the structure known as the Bangemall Basin. Most of the region is cattle grazing country. The great Northern Highway and the road to Mundiwindi cross the eastern half of the area, and a road linking Meekatharra and Onslow via the Ashburton Valley runs along the western boundary. Tracks provide access to most of the region, but some of the more rugged country is difficult to reach. The nearest towns are Newman, Meekatharra and Paraburdoo, all outside the area.

Mining for copper ore has taken place at Ilgarari and Kumarina, as well as at a number of small shows in the eastern half of the region, and a small lead deposit has been worked 16 km south of Bulloo Downs.

The climate is semi-arid with hot summers and mild winters. Rainfall is irregular, and is mostly contributed by cyclonic disturbances and scattered summer thunderstorms.

PREVIOUS INVESTIGATIONS

The region was first explored by Giles, who travelled along the Ashburton River and Brumby Creek, before heading east into the desert (Giles, 1889). Brief reference was made to the western part of COLLIER by Woodward (1912) in a search for artesian water.

More detailed observations and maps of the pysiography and geology of the area were made by Talbot (1914a, 1920, 1926, 1928), who had previously investigated the copper occurrences at Ilgarari and Kumarina (Talbot, 1914b, 1919). The latter were also commented on by Matheson (1941).

Bouguer anomaly gravity maps at scales of 1:250 000 and 1:500 000 have been published by the Bureau of Mineral Resources (Australian Department of Minerals and Energy). The region has been explored for base-metals, and some of this work is still continuing.

The present regional survey is the first systematic geological mapping to be undertaken, and occupied the 1974 field season and three weeks in 1975. The main personnel involved were A. T. Brakel (1974-5), M. Elias (1974) and J. C. Barnett (1974). P. C. Muhling spent one week in 1974 mapping the Batthewmurnarna Hill district. Petrographical work on rock samples was done by J. R. Drake.

PHYSIOGRAPHY

Physiographic features of COLLIER are shown in Figure 1. Much of the region consists of rugged upland areas of sedimentary rocks. In the more steeply dipping rocks of the western part of the sheet, resistant sandstone and chert beds form strike

*To avoid confusion with place names, sheet names are written in full capitals.

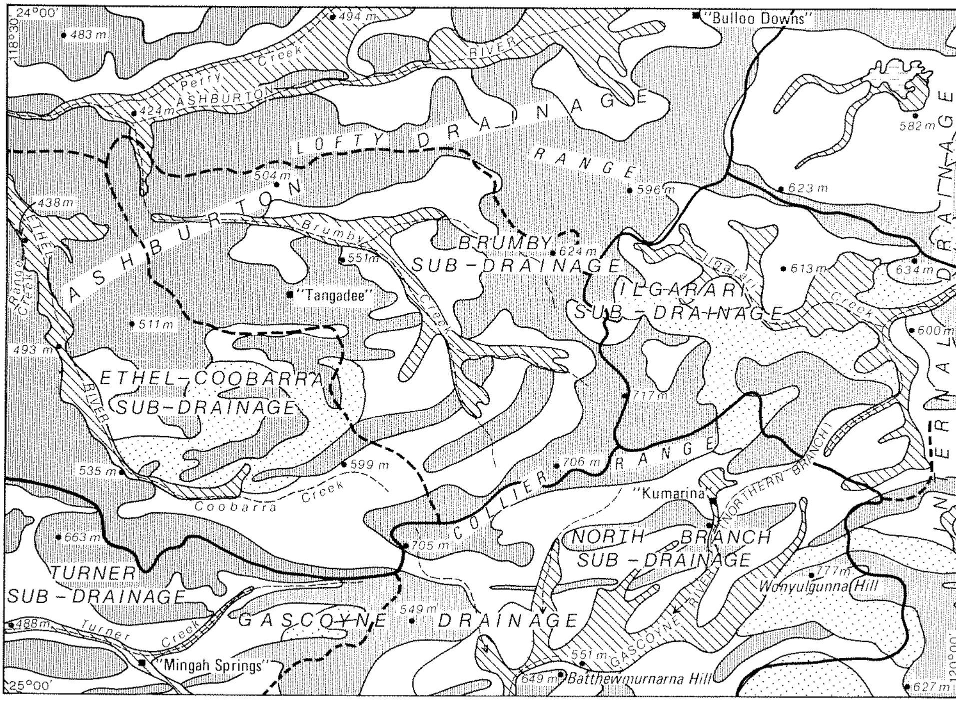
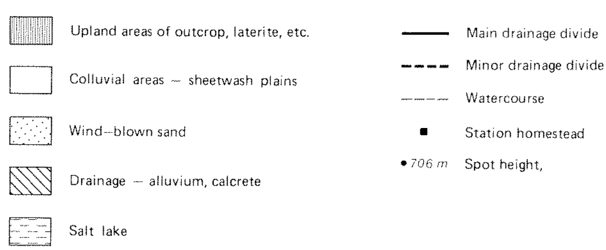


FIGURE 1

PHYSIOGRAPHY AND DRAINAGE

COLLIER SHEET SG 50–4

0 10 20 30 km



ridges separated by broad low areas of shaly units. In the eastern part of COLLIER, shallow dipping sandstone forms steep-sided broad tabular plateaux, exemplified by the Collier Range. Granitic rocks and schist in the southeastern corner form an area of low relief, contrasting with the prominent ridge to the north which culminates in Wonyulgunna Hill, the highest point on COLLIER.

Colluvial slopes surround the areas of outcrop, and particularly in the south, grade downslope into broad sheet wash plains adjacent to the main drainages such as the Gascoyne River and Turner Creek.

A major drainage divide separating the region of external drainage from the internal drainage system passes through the eastern part of COLLIER. The external drainage system comprises the Ashburton to the north and the Gascoyne to the south. The Ashburton drainage is typified by relatively narrow, incised channels in valleys containing extensive deposits of valley calcrete and hardpan. The Gascoyne drainage differs in that it consists of poorly defined channels in broad sheet flood areas. Valley calcrete also occurs in the Gascoyne drainage.

The internal drainage system consists of ephermeral and poorly defined water courses draining into dry saline lakes. One such lake occurs in the northeast corner of COLLIER, and to the south drainage is directed eastwards into saline lakes in the adjoining BULLEN sheet.

Plains covered in wind-blown sand in the eastern part of the sheet form the western edge of the Gibson Desert (the Little Sandy Desert of Beard, 1969). A smaller area of sandplain is developed in the west central part of COLLIER over a granitic inlier. Both areas contain northeast-trending longitudinal or seif dunes.

PRE-BANGEMALL GROUP ROCKS

Rocks older than the Bangemall Group occur in the southeast corner of COLLIER, in an elongated inlier at the western border, and in an outcrop of Bresnahan Group in the northwest corner. Table 1 is a stratigraphic column for COLLIER.

MARYMIA DOME

The Marymia Dome (Bunting and others, 1977) extends from PEAK HILL into the southeast corner, where it contains metamorphosed sedimentary rocks and granitic rocks.

Schists and related rocks

These are confined to south of Wonyulgunna Hill, some occurring as roof pendants and rafts in granite. The rock types are mainly quartz-muscovite and quartz-chlorite schists, with minor phyllite and quartzite. Quartz veins up to 3 m wide occur along the cleavage in places.

Also common are beds of resistant metamorphosed banded iron-formation. The banded iron-formation is well bedded and laminated, with contorted folding in some layers. Typically, magnetite-hematite bands are thicker and more numerous than the alternating quartz bands. In places the bands occur as a series of irregular, ragged lenses. Rare current lineation is known. Schist is interbedded with some units on a metre scale. Thin, irregular quartz veining common in some outcrops can be attributed to metamorphic remobilization of silica. At the unconformity between banded iron-formation and overlying Bangemall sandstone (lat. 24°48′45″S, long. 119°53′00″E), the iron-rich bands have been replace by cream-coloured silica while the quartz-rich bands appear as clear quartz, and a few clasts of this light coloured rock are present in the younger sandstone. Away from the contact, this silicification is not apparent. This phenomenon is interpreted to indicate a Proterozoic, pre-Bangemall period of silicification.

The metamorphics resemble the Peak Hill Beds described by MacLeod (1970), but the status of this formation is in doubt, and is currently believed to be equivalent to the axial sequence of the Glengarry Sub-basin sequence (Bunting and others, 1977).

TABLE 1. STRATIGRAPHIC COLUMN

	Age	Group	Map Symbol	Formation	Lithology	Thickness (m)	Remarks
CAINOZOIC	Quaternary		Ql		Salt lake deposits: sand, silt, clay, gypsum and halite		
			Qs		Reddish, wind-blown quartz sand		
			Qa		Alluvium: unconsolidated silt, sand and gravel deposited by streams		Good aquifer
			Qc		Colluvium: unconsolidated silt, sand, gravel and rubble deposited by sheet wash and as talus		
					UNCONFORMITY		
	Tertiary and/or Quaternary		Czk		Calcrete, in places replaced by chalcedony and opaline silica	20±	Includes Brumby Creek Beds. Good aquifer where not dissected
			Czc		Hardpan: consolidated colluvium and alluvium; minor silcrete	30±	Wiluna Hardpan
			Czl		Laterite: massive pisolitic and detrital iron oxide deposits, often overlying a leached zone	3—	
					UNCONFORMITY		
PROTEROZOIC	Middle Proterozoic	Bangemall	q		Quartz veins		Various ages
			d		Dolerite and basalt in dykes		At least two generations present
			b		Dolerite, gabbro and basalt in sills		
			Ꝑmz	Ilgarari Formation	Shale, siltstone, claystone, minor fine-grained sandstone	650+	
			Ꝑmy	Calyie Sandstone	Sandstone, minor shale and siltstone	1250	
			Ꝑmb	Backdoor Formation	Shale, siltstone, chert; minor sandstone, dolomite	3700	Equivalent to Fords Creek Shale-Jillawarra Formation interval
			Ꝑmw	Wonyulgunna Sandstone	Sandstone, minor conglomerate; local basal shale and siltstone	800+	
			Ꝑmq	Kurabuka Formation	Shale, minor chert	1400	Equivalent to Ilgarari Formation
			Ꝑmn	Mount Vernon Sandstone	Sandstone; minor shale and siltstone	630	Equivalent to Calyie Sandstone
			Ꝑms	Fords Creek Shale	Shale and siltstone; minor dolomite, sandstone, chert	650	
			Ꝑml	Ullawarra Formation	Shale, siltstone, Sandstone	1500	
			Ꝑmv	Devil Creek Formation	Dolomite, shale, minor siltstone	0-500	
			Ꝑmd	Discovery Chert	Chert, minor shale	0-70	Laminated rocks, hummocky bedding common
			Ꝑmj	Jillawarra Formation	Shale, siltstone, claystone, minor dolomite; rare chert and sandstone	1050	

TABLE 1—*continued*

	Age	Group	Map Symbol	Formation	Lithology	Thickness (m)	Remarks
PROTEROZOIC	Middle Proterozoic	Bangemall	Ᵽmk	Kiangi Creek	Sandstone, shale, siltstone, dolomite	1000	
PROTEROZOIC	Middle Proterozoic	Bangemall	Ᵽmo	Coobarra	Sandstone, conglomerate, minor shale and rhyolite	500	Basal lenticular formation
PROTEROZOIC	Middle Proterozoic	Bangemall	Ᵽmi	Irregully Formation	Dolomite and minor sandstone		
PROTEROZOIC	Middle Proterozoic	Bangemall	Ᵽmt	Top Camp Dolomite	Shale, dolomite, and sandstone	2500	Equivalent to all units below Fords Creek Shale
PROTEROZOIC	Middle Proterozoic	Bangemall	Ᵽmp	Prairie Downs Beds	Sandstone, conglomerate		
					UNCONFORMITY		
PROTEROZOIC	Early Proterozoic ?	Bresnahan	Ᵽbs	Kunderong Sandstone	Sandstone, conglomerate		
					PROBABLE UNCONFORMITY		
PROTEROZOIC	Early Proterozoic ?		Ᵽp		Sandstone, shale, dolomite		Equivalent to Nabberu Basin rocks
					POSSIBLE UNCONFORMITY		
UNASSIGNED PRECAMBRIAN	?Early Proterozoic		pЄg		Granitic rocks		Intrudes pЄl, pЄi and possibly Ᵽp
UNASSIGNED PRECAMBRIAN	?Early Proterozoic		pЄl		Quartz-mica and quartz chlorite schist, minor phyllite and quartzite		Probably equivalent to Peak Hill Beds (pre-Pradbury Group)
UNASSIGNED PRECAMBRIAN	?Early Proterozoic		pЄi		Banded iron formation, minor schist interbeds		Beds within pЄl

Granitic rocks

The granitic rocks are even grained, medium to fine grained, foliated or massive, and vary from leucoadamellite to biotite granite. Foliation ranges from strongly to poorly developed, and is expressed as elongate mineral alignment, or cleavage and parting planes; rarely, a gneissic texture is developed. A few outcrops have banding defined by quartz-feldspar, biotite, or quartz bands, and some aplitic and pegmatitic phases are present. Quartz veins usually follow the foliation. Fluorite interstitial to microcline has been noted.

The intrusive relationship of the igneous rocks to the metamorphics is best seen in two places. At lat. 24°54′15″S, long. 119°46′15″E, small steeply dipping banded iron-formation outcrops less than 1 m wide and up to several metres long occur with granitic outcrops only centimetres away on each side. These are interpreted as slab-like rafts caught up in an intruding granitic magma. This locality is at the eastern end of a ridge of banded iron-formation which has granite on each side. At lat. 24°58′45″S, long. 119°55′30″E, the granite contact cuts across the bedding of the country rock and there appears to be lit-par-lit relationship and contact metamorphism at one spot.

At least some of the granitic rock of the Marymia Dome is therefore Proterozoic in age. Its relationship to the Bangemall Group is best seen in the northeast corner of PEAK HILL at lat. 25°7′15″S, long. 119°55′00″E, where foliated granitic rock is non-conformably overlain by chert and minor arkose which displays no cleavage and no evidence of contact metamorphism. This establishes a pre-Bangemall age for the intrusive.

Structural features

Cleavage in the schist strikes parallel to bedding as a result of isoclinal folding along east to east-northeasterly trending axes. Meso-scale isoclinal folding on the same trend is present within some banded iron-formation beds.

A second deformation is indicated by crenulation of the cleavage, and by kink bands which are abundant near Wonyulgunna Hill and in the Copper Hills, where they show a sinistral displacement and an average trend of 310 degrees. The second deformation was probably the same as the one which affected the Bangemall Group.

WESTERN INLIER

A fault-bounded elongate inlier extends eastward from MOUNT EGERTON and passes south of Burgoynes Well. The sediments were regarded in previous mapping as part of the Bangemall Group, but a more complex deformational history has subsequently been recognized in the phyllitic varieties on MOUNT EGERTON, and an older age is indicated. The eastern end of the inlier, southwest of Tangadee homestead, is occupied by granitic rock, but the relationship of this to the older sediments is not known.

Sedimentary rocks (Ᵽp)

A resemblance between the older sediments and the Bangemall sediments makes their distinction difficult, and the northern and southern contacts of the inlier are extrapolated eastward from work on MOUNT EGERTON. Quartz arenite, which forms the major part of the older sediments, is fine to medium-grained, with a silica cement over-grown on quartz grains. Siltstone and shale, commonly ferruginous, are interbedded in the quartz arenite. Isolated lenses of pebble conglomerate with clasts of vein quartz, quartzite and chert occur. An isolated outcrop 4 km southwest of Burgoynes Well consists of shale and fine-grained dolomite passing upwards (to the north) into shale, siltstone, fine-grained quartz arenite and in part calcarenite.

The rocks are probably related to rocks in the western part of the Nabberu Basin, and may be equivalent to either the Padbury Group of ROBINSON RANGE (Elias and Williams, 1977), or the axial sequence of the Glengarry Sub-basin (Bunting, Commander and Gee, 1977).

Granitic rocks

Granitic rocks crop out in the western end of the inlier and probably underlie most of the sand plain in that area. They vary from leuco-adamellite to biotite granite, and are fine to coarse grained. In places they are sheared, and even gneissic. In thin section, thin veins of colourless fluorite have been observed. Pegmatitic phases, and veins of quartz and quartz-tourmaline occur in outcrop. Quartz in the veins is commonly brecciated, granulated or strained.

The age of the granitoid is speculative, but it more likely relates to the granitoids of the Gascoyne Province, rather than the ?Archaean gneiss of the Sylvania Dome.

BRESNAHAN GROUP

A small area of Kunderong Sandstone (*Ebs*) of the Bresnahan Group extends into the northwest corner of COLLIER from NEWMAN where it unconformably overlies the Wyloo Group and is in turn unconformably overlain by the Bangemall Group. The unit consists of clean, coarse-grained quartz sandstone with some granule conglomerate and beds with scattered quartz pebbles. Feldspar forms up to 20 per cent, and small black opaque grains are a common accessory. Grouped sets of tabular and asymptotic cross-bedding indicate a local transport direction from the northwest.

BANGEMALL BASIN

STRATIGRAPHY OF THE BANGEMALL GROUP

Facies variations

Transitions between three major facies provinces of the Bangemall Basin, each with distinctive lithostratigraphic assemblages, take place in COLLIER: these facies are termed the western, eastern and northern facies (Brakel and Muhling, 1976). The western facies has the most varied succession, and occupies most of MOUNT EGERTON. It is found on the western side of COLLIER where the change to the eastern facies is due to the lensing out of dolomite, chert and sandstone, and the persistence of shale and siltstone beds. The northern facies, in the Ashburton River region, is mostly in faulted contact with the other facies provinces, except east of Bulloo Downs, where the Fords Creek Shale is laterally equivalent to part of the Backdoor Formation of the eastern facies, and distinguishing between them becomes arbitrary.

Correlation of the formations of the facies provinces is shown in Table 2. Previously, doubt had been expressed about the correlation of the Mount Vernon and Calyie Sandstones (Brakel and Muhling, 1976), but subsequent field work in adjoining sheets has corroborated their equivalence.

This means that rapid facies changes must occur across the present region of the Lofty Range and Neds Gap Faults. The green shales and mudstones of the Fords Creek Shale north of the Lofty Range would correlate with the higher beds of the Backdoor Formation, where green mudrocks occur only in the centre of the Tangadee Syncline and 13 km west-northwest of Bunningunna Bluff, while grey, less fissile rocks predominate elsewhere. The Calyie Sandstone east of Neds Gap is thinner than the Mount Vernon Sandstone to the west, and has no corresponding fine-grained sandstone and coarse-grained siltstone at its base. The Kurabuka Formation is largely made up of greenish shale, mudstone and chert, whereas its correlative, the Ilgarari Formation, contains white and brownish shale, mudstone and fine-grained sandstone, but rarely any green rocks.

TABLE 2. CORRELATION OF FACIES PROVINCES OF THE BANGEMALL GROUP

<table>
<tr><th>Northern facies</th><th>Western facies</th><th>Eastern facies</th></tr>
<tr><td>Kurabuka Formation</td><td>Karabuka Formation</td><td>Ilgarari Formation</td></tr>
<tr><td>Mount Vernon Sandstone</td><td>Mount Vernon Sandstone</td><td>Calyie Sandstone</td></tr>
<tr><td>Fords Creek Shale</td><td>Fords Creek Shale</td><td rowspan="2">Backdoor Formation</td></tr>
<tr><td rowspan="2">Top Camp Dolomite</td><td>Ullawarra Formation
Devil Creek Formation
Discovery Chert
Jillawarra Formation</td></tr>
<tr><td>Kiangi Creek Formation</td><td>?Kiangi Creek Formation
Coobarra Formation</td></tr>
<tr><td>Prairie Downs Beds</td><td>Irregully Formation</td><td></td></tr>
</table>

Formal statigraphic nomenclature corresponding to the facies provinces will be defined in a future bulletin on the Bangemall Basin.

Coobarra Formation (Mo)

The Coobarra Formation is a wedge of sandstone and conglomerate unconformably overlying granite, and is analogous to the alluvial fan deposits of the Mount Augustus and Tringadee Formations in MOUNT PHILLIPS and MOUNT EGERTON. It is estimated to be at least 500 m thick. The unit is overlain conformably along its southern margin, at least in part and possibly wholly, by the Kiangi Creek Formation, where the boundary between the two is taken as the base of a 200 m thick siltstone-shale member which appears to persist for at least 10 km. Where this is absent, the base is the lowest dolomite. The Coobarra Formation is thought to be laterally equivalent westwards to the lower part of the Kiangi Creek Formation.

Coarse-grained sandstone is by far the most prevalent lithology, but medium and fine-grained varieties are interbedded. Near the base, it is pebbly with a small component of feldspar and tourmaline, but towards the top there are significantly more feldspar, chert and red jaspilite grains, which together constitute up to 25 per cent of the rock. Cross-bedded units, and siltstone and shale interbeds, form a minor proportion of the sequence.

Conglomerate makes up about half of the formation in its northwest extent, but in most places is much less.The rock contains well-rounded (but some angular to sub-rounded) pebbles, cobbles and boulders of vein quartz, with minor clasts of siliceous siltstone, sandstone, jaspilite-bearing conglomerate and, rarely, quartz-tourmaline rock.

Six rhyolite bodies occur about 60 m above the base of the formation at lat. 24°37′S, long. 118°47′E, and these have been described by Gee, de Laeter and Drake (1976). They form a line of plugs which were extruded as small viscous domes that grew upward and outward, as earlier extruded rhyolite was shouldered aside by later extrusions. They were then eroded before being covered by conglomerate. A Sr-Rb isochron obtained from these rocks indicates an age of 1 098 ± 42 million years.

Irregully Formation (Ḗmi)

Dolomite, which forms the oldest rocks of the western facies in COLLIER occurs in the Glen Ross Anticline west of the Ethel River. No basement is exposed here, and the correlation of the beds with the Irregully Formation instead of dolomite members of the Kiangi Creek Formation is equivocal. The rocks consist dominantly of fine-grained, laminated dolomite which weathers to pinkish-brown, yellow, white and buff. There are also interbeds of carbonate-cemented, medium to coarse-grained quartz sandstone.

Kiangi Creek Formation (Ḗmk)

The Kiangi Creek Formation consists of fine, medium and coarse-grained quartz sandstone, with siltstone, shale and dolomite members. Cross-bedding, mud clast molds, scattered quartz pebbles and a feldspar constituent are present in the sandstone.

Five kilometres northwest of Nicholl Spring is an unusual sequence of fine-grained, laminated to massive, fissile to medium-bedded, greenish to pinkish-grey sandstone and silty sandstone, with minor siltstone, coarser-grained quartz sandstone and laminite. These rocks are notable for variable amounts of mica, feldspar and lithic grains, and some have a dolomitic cement.

The Kiangi Creek Formation in the Ethel River district is quite varied, recording a complex array of changing sub-environments. Quartz and polymictic sandstones of various grain sizes are interlensed with green and grey mudstone, and shale, dolomite, and mixtures of dolomite with muddy and sandy clastics. Cross-bedding, including herringbone cross-bedding presumably resulting from tidal activity, and a few pyrite pseudomorphs are present in some members.

Jillawarra Formation (ḖMj)

This unit comprises grey, black, and rarely greenish shale and mudstone which weather to white, brown and maroon colours; minor chert, dolomite and fine-grained sandstone are also present. Rarely, small blebs of pyrite have been found in some fresh rock.

Good exposures exist in cliff outcrops along the Ethel River at Nicholl Spring, and in the nose of the Brumby Creek Anticline.

Discovery Chert (ḖMd)

The Discovery Chert is a distinctive marker horizon in the western facies province. Its most striking lithology is a black massive chert which can be non-banded, or contain diffuse, light-coloured laminae that are planar, wavy or contorted. Usually a streaky texture can be seen with a hand lens. The larger scale bedding units are 0.1 to 0.3 m thick and are commonly hummocky with irregular depressions and swells. The more massive chert is underlain and overlain by well-bedded, lighter coloured chert, which is fissile and splintery in places. Truncation of one group of laminae by others is common. Porous bands, which in fresh rock are crowded with white crystals usually less than 1 mm long, probably represent layers originally containing pyrrhotite or pyrite, or possibly gypsum. There are also a few cubic crystal molds after pyrite.

The formation varies from 70 m thick to zero as it lenses out eastward. It is only 16 m thick near the Bujundunna Fault. In the Brumby Creek Anticline a thickness of 53 m was measured, although another 37 m of white cherty rock overlies this which was not included with the formation because it is the silicified equivalent of a basal claystone of the Ullawarra Formation along strike.

Devil Creek Formation (ꝒMv)

This formation is characterized by thinly inter-bedded fine-grained dolomite and shale, shale generally being the more abundant. There is an upward decrease in the proportion of dolomite as the formation grades into the shaly Backdoor Formation. Dolomite is generally fine-grained, laminated and blue-grey to olive. In some places, laminated dolomite is replaced by silica to form a chert of identical appearance to the parent rock. Shale is laminated, and white, dark-brown, green or mauve in colour; in places it shows small-scale ripple cross-bedding.

Ullawarra Formation (ꝒMl)

This unit is laterally equivalent to part of the Backdoor Formation, and the distinction between them in this region is arbitrary. The present boundary near the western edge of COLLIER is largely an artefact of mapping progress, and on future maps of the Bangemall Basin it may be desirable to extend the Backdoor Formation on to MOUNT EGERTON to wherever there is an uninterrupted sequence of mudrocks from the Ullawarra Formation into the Fords Creek Shale.

The Ullawarra Formation consists of shale, argillaceous and quartzose siltstone, minor claystone and minor fine-grained sandstone. Along the Lofty Range Fault and farther west, there is a quartz sandstone member which may be equivalent to the Mount Vernon and Calyie Sandstones. Such a correlation implies that the underlying mudrock is a condensed sequence equivalent to the Devil Creek Formation-Fords Creek Shale interval elsewhere.

Fords Creek Shale (ꝒMs).

This is a thick, monotonous succession of green and dark-grey shale, weathering to khaki brown or grey, with minor mudstone and intercalations of dolomite. The green and khaki colours indicate a greater abundance of chlorite in the Fords Creek Shale compared with lower shale formations. The shale is commonly broken down into small plates about 1 cm across and a few millimetres thick.

Dolomite occurs as thin units at various levels in the Fords Creek Shale, such as at Ti-Tree Well and near Fork and Lever Bore. Only the larger areas of dolomite have been shown on the map (ꝑMs(d)). North of Fork and Lever Bore disc-shaped concretions of carbonate occur in shale, similar to those in the Backdoor Formation southwest of Tangadee. Simpson (1923) analyzed presumably similar carbonate concretions from the Fords Creek Shale 8 km northeast of Conical Hill, and found them to consist of calcrete, with minor kaolin, quartz and limonite.

The abundance of dolomite in the Fords Creek Shale appears to increase northwards into NEWMAN. Minor quartz sandstone is interbedded with the shale near the western edge of COLLIER.

Mount Vernon Sandstone (ꝑMn)

The Mount Vernon Sandstone is a prominent ridge-forming unit and a good marker formation in the northern part of COLLIER. It is a hard, medium- to fine-grained quartz sandstone with a low feldspar content. The rock varies from massive to flaggy and finely laminated. Some beds contain glauconite grains, and others have intraclasts up to 0.15 m long of siltstone and fine-grained sandstone. Groove marks, flute molds, possible swash zone ripples, and cross-bedding are present. Occurences of herringbone cross-bedding imply tidal activity.

The time-transgressive nature of the Mount Vernon Sandstone is well illustrated on the northern side of the Lofty Range, where the formation interfingers with the underlying Fords Creek Shale. In this area, individual sandstone beds can also be traced passing from the top of the formation to near the bottom. The interfingering of sandstone and green, micaceous shale produces a thick transition zone, in which the stratigraphic base of the Mount Vernon Sandstone is taken as the first major sandstone member. The transition zone also contains coarse-grained quartzose siltstone as an important rock type, as well as micaceous siltstone, white shale, and a small occurrence of diamictite consisting of coarse, well-rounded quartz grains dispersed in a matrix of finer sand, silt and clay.

Kurabuka Formation (ꝑMq)

The youngest formation of the Bangemall Group is a sequence of shale, siltstone, mudstone and chert, usually greenish-grey or green in colour weathering to brown or khaki. Pale-weathering chert and mud-rocks near the base produce a distinctive air photo pattern. The chert is laminated and displays detrital quartz and sericite in thin section.

Top Camp Dolomite (ꝑMt)

The name Top Camp Dolomite, introduced by Halligan and Daniels (1964) in TUREE CREEK, was replaced on EDMUND by several formations (Daniels, 1966). The Top Camp Dolomite continues from TUREE CREEK into MOUNT EGERTON, but its constituent units could not be correlated with formations south of the basin axis, and their stratigraphic formalization was not attempted. The same now applies for the extension of the Top Camp into COLLIER, although it seems likely that in future it will be re-established as a formation, and members defined in TUREE CREEK.

The Top Camp Dolomite, which is the basal part of the northern facies province, is equivalent to all formations below the Fords Creek Shale. It rests unconformably on the Bresnahan Group.

The basal member in northwest COLLIER is yellow-brown, pink or white fine-grained dolomite, varying from massive to faintly bedded. It is overlain by grey, pale-brown or olive shale and siltstone with some interbedded black cherty rock and minor lenses of sandstone. A dolomitic shale and dolomite similar to the basal member overlies, followed by a distinctive unit of fine-grained quartz sandstone which contains an abundance of flute molds, groove marks, current lineations, and some current ripples and shale fragments. At the top of the sequence is a massive to laminated dolomite locally with intraformational folding and hematite pseudomorphs of pyrite balls up to 10 mm in diameter.

The dolomite appears to be laterally equivalent to part of the Fords Creek Shale on NEWMAN, where there is rare, thin dolomite (Daniels and MacLeod, 1965). The Prairie Downs Beds on NEWMAN extend to just across the border with COLLIER, and form a sandstone and conglomerate wedge in the basal dolomite sequence. These outcrops have not been examined on the ground, but on NEWMAN, along the Bulloo Downs-Turee Creek road, the unit consists of quartz sandstone with local quartz pebbles and interbeds of shale, cherty rock and coarse-grained quartz siltstone.

Wonyulgunna Sandstone (ɆMw)

At the base of the Bangemall Group in southeastern COLLIER is the Wonyulgunna Sandstone, which forms a prominent easterly trending range. The unit appears to lens out rapidly southwest of Wonyulgunna Hill. It is predominantly a whitish, coarse-grained, moderately sorted, thickly bedded quartz sandstone with a feldspar content of 2 per cent or less. Cross-bedding and molds of fine-grained rock fragments are widespread but not abundant. Conglomerates are uncommon; the best examples are at lat. 24°48′15″S, long. 119°53′00″E, where pebble and granule conglomerate rests on the unconformity; and 5 m higher up, where there is a 10 m-thick cobble conglomerate. The clasts are vein quartz, quartzite and silicified iron formation. There is no basal conglormerate in most places on the actual unconformity.

Outliers of chert, siltstone and shale on the basement to the south are parts of more extensive units on BULLEN (Leech and Brakel, 1978). Where they underlie the main part of the Wonyulgunna Sandstone, the basal member is a black, bedded chert, which ranges from massive to laminated, and does not have a streaky texture like the Discovery Chert.

Backdoor Formation (ɆMb)

The Backdoor Formation is a shale and siltstone sequence with lesser chert, claystone, dolomite and sandstone. It overlies the Wonyulgunna Sandstone at Wonyulgunna Hill, but farther to the southwest it seems to lie directly on basement. In western COLLIER it may be conformable on the Coobarra Formation, but the contact is obscured by sand, and the Kiangi Creek Formation may lie between them. Generally in the transition area between the eastern and western facies provinces the Backdoor Formation is equivalent to the Ullawarra — Fords Creek interval, but where the Devil Creek Formation and the Discovery Chert lens out, the mud-rock sequence extends down to the base of the Jillawarra Formation.

The shale and siltstone are dark grey or black when fresh, weathering to brownish, yellow-brown, white and maroon colours. Green and olive-grey shales, similar to the Fords Creek Shale, occur in the centre of the Tangadee Syncline and about 15 km west of Bunningunna Bluff. Siltstones, both laminated and massive, are of two types: a soft, earthy rock similar to the shales; and a hard, grey-white, siliceous quartzitic type, which grades into fine-grained sandstone.

Some bands are dark-grey to black chert, while other types appear to be silicified shales. The rock can be massive or laminated with streaky texture. Some varieties are similar to the Discovery Chert, a good example being a chert near the top of the formation at the western end of the Calyie Syncline. Black, planar-bedded chert occurs near the top of the formation in the central part of COLLIER and is particularly well exposed at the western end of the Collier Range, where it is rhythmically interlaminated with shale. Another prominent chert member lies lower in the sequence at Beyondie Bluff.

Thin sandstone beds are present in several places, but are best developed in the Batthewmurnarna Hill region. A few thin bands of silty sandstone appear in the shale at the top of the formation in the western Collier Range, where a similar grey-brown wacke forms a persistent basal member of the Calyie Sandstone. Dolomite occurs at widely separated localities as lenses of fine-grained, laminated rock similar to the dolomite of the Devil Creek Formation, and containing rare, thin interbeds of limestone and calcareous sandstone.

Pyrite as balls and small, irregular patches, or its traces as weathered-out cubic molds up to 20 mm on edge, is present in all the rock types, but is plentiful only in siltstone in southwestern and northeastern COLLIER. Layers of alunite up to 80 mm thick occur in shales near Beyondie Bluff, and are probably the result of kaolin beds reacting with dilute sulphuric acid derived from the weathering of pyrite. The efflorescences of the secondary sulphates pickingite ($MgSO_4.Al_2(SO_4)_3.22H_2O$) and tamarugite ($Na_2SO_4.Al_2(SO_4)_3.12H_2O$) reported by Simpson (1923) probably are from the Backdoor Formation. Discoidal calcitic concretions up to 0.3 m in diameter and 0.2 m thick exist towards the base of the formation near the Budjundunna Fault. These contain cone-in-cone structure and goethite after cubic pyrite. Irregular slabs of limestone about 0.1 m thick, also with cone-in-cone structure, occur near the axis of the Tangadee Syncline south of Eight Mile Rockhole and may have a similar concretionary origin.

Calyie Sandstone (ȻMy)

Between the Backdoor and Ilgarari Formations lies the Calyie Sandstone, a resistant unit which forms ridges, plateaux and mesas.

The bulk of the rock is pale, siliceous quartz sandstone, which is laminated and cross-bedded in the eastern part of its extent. In western COLLIER it is dominantly massive and structureless, but this change may be due to the increase in surface silicification, which tends to destroy primary structures.

The sandstones are usually fine and medium-grained, with a feldspar content up to 5 per cent, and a silica cement. De-watering structures, consisting of irregular siliceous stringers leading up from particular beds, are common in the type section 7 km north of Mingah Springs homestead. Weathered-out molds of siltstone and shale fragments are sparse but widespread. These range up to 0.25 m long where they are more abundant. Pyrite, in cubes or formless masses 1 to 10 mm across, is sparsely distributed.

Pebbly and granule sandstone, conglomerate, siltstone and shale form a small proportion of the formation. Some silty sandstone occurs near the base in the Calyie Syncline and Collier Range. In the Kumarina district a glauconitic sandstone also occurs near the base; samples of this member from No. 35 Government Well were described by Chapman (1933) as containing Cretaceous microfossils, but his photographs are unconvincing.

Ilgarari Formation (*ꝒMz*)

This is the top unit of the eastern facies, and occurs only in the centres of structural basins. The chief rock types are thinly bedded siltstone, claystone and shale, which weather to whitish, brownish and yellowish colours. Some green laminae have been found in a new highway cutting near the Butcher Bird mine. Most siltstones are earthy and soft, but subordinate coarse-grained quartz siltstone is hard and siliceous and grades into fine-grained sandstone of similar appearance. Buff-brown, faintly laminated chert occurs near the base at Mardinidya Well.

BASIC INTRUSIONS

Dolerite sills have extensively intruded the Bangemall Group, particularly the Backdoor and Devil Creek Formations and the Fords Creek Shale. Sills range in thickness from less than 1 m to about 100 m. They are generally concordant, but in places transgress bedding, such as in the Fords Creek Shale southwest of O'Donnell Soak. A particularly extensive 60 m-thick sill, about 60 km long, has intruded just under the top of the Backdoor Formation between Collier Range and Lofty Range.

Dolerite dykes have intruded both contemporaneously with and after the sills. They generally trend north-northwesterly or east-northeasterly, trends which are related to regional late-tectonic lineament systems (see Structure of the Bangemall Group). The dykes are rarely more than 6 m wide. The largest, south of Mickey Spring, is 50 m wide and about 15 km long.

Dolerite from both sills and dykes is tholeiitic, fine to medium grained, and consists of plagioclase, augite, orthopyroxene and magnetite with a sub-ophitic texture. The rock is typically altered, perhaps deuterically. Bright yellow-green veins up to 120 mm thick associated with dolerite in central COLLIER consist of opal, nontronite and goethite. The best example of these veins occurs about 5 km west of Mulangulbungalla Spring. A sill in the Mount Vernon Sandstone northeast of Monkey Well contains a few aplite veins up to 20 mm wide. Coarse-grained gabbroic phases are present in some sills.

STRUCTURE OF THE BANGEMALL GROUP

Folds

Three structural regions are recognized on COLLIER: a northern gently tilted region, a western area of tight folds, and the remaining region of gently warped beds with open folds and structural basins in places (Brakel and Muhling, 1976).

The dominant structure in western COLLIER consists of easterly trending folds that are a direct continuation of those from MOUNT EGERTON (Muhling, Brakel and Davidson, 1976). The Coobarra Formation and the underlying granitic basement occupy the centre of a semi-dome bounded to the north by the Bujundunna Fault. These structures die out eastwards, where the sedimentary succession is only gently warped except for the abrupt tight fold of the Jaydinia Syncline. North of the Lofty Range Fault the succession forms a gentle southerly dipping homocline.

Most of the folds are concentric in style. The Brumby Creek Anticline, which has an axial zone of complex crumpling and thrusting, may be continuous with the Mulangulbungalla Anticline to the east, suggesting a major anticlinal zone 75 km long which is parallel to the Lofty Range Fault to the north. The Calyie and Tangadee Synclines display subsidiary cross-folding on northeasterly and northwesterly axes respectively. These fold directions are also evident in other parts of the region.

Lineaments

The boundary between the western and eastern structural provinces in marked by the Tangadee Lineament (Brakel and Muhling, 1976), which is expressed as a line of basement inliers and faults on COLLIER and MOUNT EGERTON. The most important of these faults are the Bujundunna and Neds Gap Faults.

Lineaments of unknown significance are represented on the geological map where they are visible on air photos. They could be joints, faults or dykes and are usually parallel to the northeasterly trending fold and fault directions. North-northwesterly trends are also common.

Faults

The largest fault is the 80 km-long Lofty Range Fault, which appears to be a steep south-dipping thrust. Thrusting from the south is inferred from the movement on minor thrusts in the centre of the Brumby Creek Anticline 4 km from the main fault. North of the Mulangulbungalla Anticline, the Kurabuka Formation adjacent to the fault has been deformed into ten-metre scale folds. The Lofty Range Fault terminates against the Neds Gap Fault to the east, and the western end curves southward and probably splays into the Mount Vernon Fault, which is also a major, south dipping thrust fault, extending into MOUNT EGERTON. The Mount Vernon Fault is inferred to lie along Brumby Creek between the Tangadee Syncline and Brumby Creek Anticline, and extend westwards south of Dingo Bore, where there is stratigraphic discontinuity. The main fault would pass under superficial cover north of Mount Sanford on MOUNT EGERTON, and there is probably a branch fault to the south. The Mount Vernon Fault and the Lofty Range Fault form a thrust system which is at least 160 km, and possibly 200 km long.

Another major east-west fault is the Bujundunna Fault which marks the northern outcrop limit of the Coobarra Formation. The strike ridges of the Backdoor Hills in the centre of the sheet also appear to be truncated by this fault, and the Backdoor Formation immediately north of the fault is folded. To the southwest, it probably links with the thrust on MOUNT EGERTON passing just south of Quartzite Well. Faults on east-northeasterly trends in the Tangadee Syncline and Glen Ross Anticline are probably also reverse faults, but their displacements are small.

Northeasterly faults, of which the Neds Gap Fault is an example, appear to be vertical with no significant lateral component. An east-northeasterly fault which juxtaposes granitic rocks against Bangemall Group in the southeast corner of COLLIER has a dextral component of unknown magnitude, as evidenced by the geometry of minor folds in immediately adjacent shales. This fault stands out as a silicified zone. The granitic rocks are cut by shear zones parallel to the fault and up to 5 km from it. Dykes have intruded along some faults.

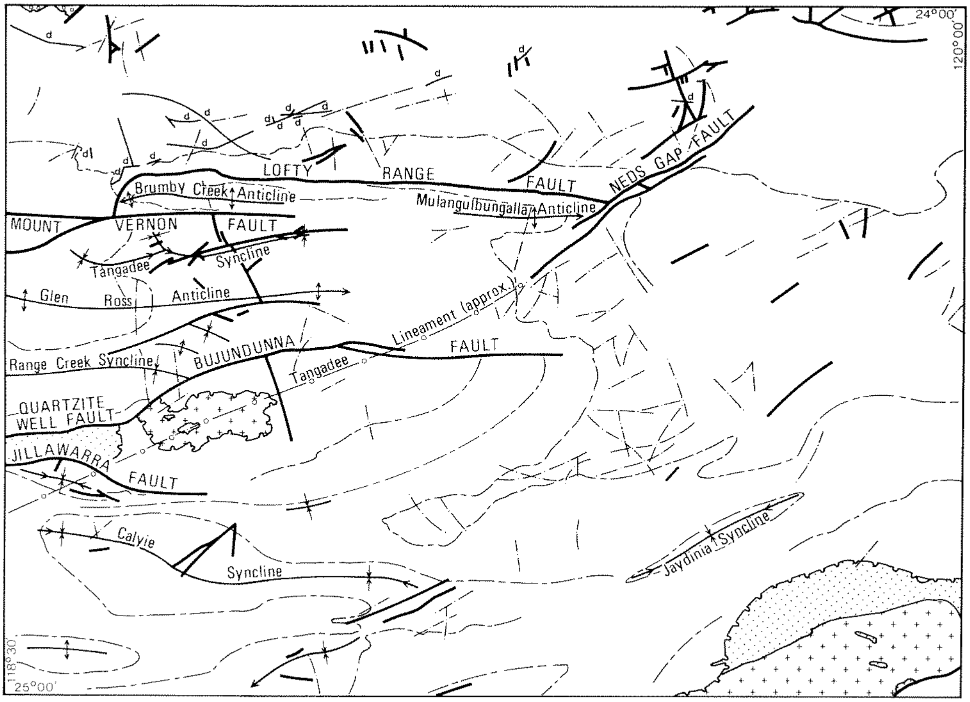
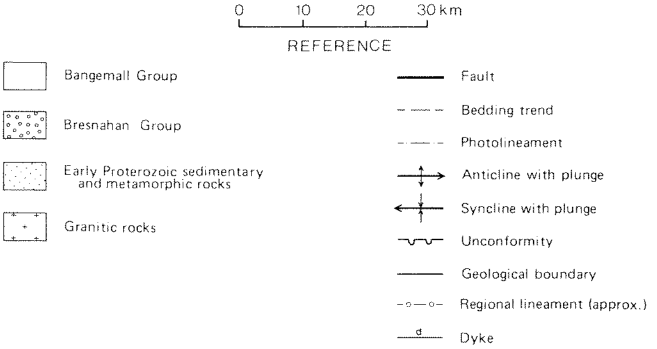


FIGURE 2

STRUCTURAL INTERPRETATION

COLLIER SHEET SG 50–4



CAINOZOIC GEOLOGY

The oldest, consolidated superficial sediments were deposited on a plateau surface of Tertiary age, which has since been dissected in the area of external drainage. Slow degradation is still proceeding, as the Ashburton and Gascoyne drainages encroach eastwards by headward erosion. Redistribution of the weathered products of this process is giving rise to the younger, unconsolidated sediments.

LATERITE (*Czl*)

Laterite consists of various ferruginous deposits. Massive or porous goethite, hematite and limonite in places overlies leached and deeply weathered bedrock. Nodular and pisolitic laterite composed of limonite and goethite grades down into earthy, structureless ferruginous material overlying a mottled and pallid zone of leached bedrock in which relict textures may be preserved. The pisolitic material has been used for road metal in places on the Great Northern Highway.

The laterite now remains as low knobs, mesas and breakaways. The age of lateritization is uncertain and there was probably more than one period of formation. Near Top Trough Well on Bulloo Downs Station, massive ironstone at the tops of hills overlies hardpan. However, this hardpan also contains pebbles of ironstone near its top, suggesting that the two deposits were forming side by side, sometimes the ironstone being eroded and contributing to the hardpan, and at other times lateritization encroaching on the hardpan area.

HARDPAN AND SILCRETE (*Czc*)

Most hardpan is partially consolidated older colluvium. The deposits occur as remnants of talus aprons on valley sides in the northwestern half of the Ashburton drainage and presently form vertical or overhanging cliffs. Elsewhere hardpan occurs in the banks of incised watercourses, and probably extends under much of the younger colluvium. The maximum estimated thickness is about 30 m.

The deposits are orange or reddish-brown, and consist of sand, pebbles and cobbles in a finer-grained, ferruginous clay matrix. In the banks of larger creeks hardpan is a cemented older alluvium of bedded, cross-bedded and imbricated gravel. Palaeocurrent directions agree with present stream directions.

Bettenay and Churchward (1974) called this unit the Wiluna Hardpan, and suggested a late Tertiary or Early Quaternary age. Brewer and others (1972) concluded it was formed from colluvium with a high proportion of lateritic detritus that had been eroded from an older laterite or hardpan. Field relationships on COLLIER suggest a penecontemporaneous age with calcrete.

Silcrete occurs mostly as sporadic outcrops and is considered to be a silica replacement of bedrock. Most silcrete outcrops are too small to show on the map. The rock is white to pale brown, and in the vicinity of sandstone contains quartz grains. Numerous angular fragments of underlying bedrock may be present, as for example 5 km west of Box Bluff, Collier Range, where beds of an underlying chert are bent upwards into silcrete breccia.

VALLEY CALCRETE (*Czk*)

Calcrete is a white limestone formed by the replacement of valley-fill sediment and soil by calcium carbonate. It generally occurs as thick deposits in the drainages of present-day or ancestral watercourses. At White Hill Spring it has replaced shale of the Backdoor Formation. The material forms low mounds of nodular or massive limestone, which contain small sink holes.

Along the Ethel River, Ashburton River and Brumby Creek, extensive sheets of calcrete capping hardpan have been dissected and stand up as cliffs. This calcrete was referred to as the Brumby Creek Beds by Talbot (1920). The relationship with the underlying hardpan is well exposed: stringers of earthy calcrete become more numerous upward, and over an interval of 2 m the hardpan becomes completely replaced by carbonate. The stringers are irregular, following surfaces of easiest infiltration, such as foresets of cross-bedding. Above the zone of earthy calcrete is the main, massive, microcrystalline calcrete bed, in which carbonate-cemented gravel lenses are recognizable in places. Within this massive layer, bands of the carbonate may themselves be replaced by chalcedonic and opaline silica. These bands may mark former levels of the water table. At a few localities, the entire thickness of calcrete has been replaced by silica.

Although calcrete usually overlies hardpan, the reverse is true directly north of Tangadee homestead where hardpan lies on an irregular calcrete surface, and a similar situation may prevail near Gununarra Pool. In other places, calcrete and hardpan appear to be laterally equivalent, apparently representing stream and valley flank deposits at about the same topographic level. Calcrete and hardpan formed at the same time, the calcrete recording environments favouring the replacement of sediment by carbonate. In view of the degree of dissection in the Ashburton catchment, a Tertiary age is most likely.

Calcrete along the course of Yanneri (Ilgarari) Creek has a fragmented texture of calcrete pebbles and quartz sand cemented by calcite. This points to erosion of calcrete and later re-cementation with the incorporation of wind-blown sand. This later period of calcrete formation may still be proceeding today.

Fossilized wood in earthy calcrete occurs at the base of the unit near the Ashburton River at lat. 24°07′45″S, long. 118°47′45″E, 2 km west of Mickey Spring. The material consists of calcified branches or roots.

COLLUVIUM (*Qc*)

Colluvium related to the present period of erosion consists of unconsolidated sand, silt, gravel and rubble on slopes and outwash plains. It is transported by sheet wash. The unit also includes eluvium, alluvium of small streams, and minor admixtures of wind-blown sand.

ALLUVIUM (*Qa*)

Alluvium is unconsolidated gravel, sand and silt transported in water-courses. The boundaries with colluvium are transitional and all areas showing evidence on air photos of stream action are regarded as alluvial.

WIND-BLOWN SAND (*Qs*)

Reddish, wind-blown quartz sand occurs as sheets and dunes in the desert region of the eastern part of COLLIER, and also in a smaller area to the west around the outcrops of the Coobarra Formation. The dunes originated during Late Pleistocene aridity, and have now been fixed by spinifex and other vegetation. The presence of a nearby non-silicified sandstone source appears to be a prerequisite for the formation of the sand.

SALT LAKE DEPOSITS (*Ql*)

The surface of the salt lake in the northeast corner of COLLIER is a mixture of small gypsum crystals and quartz sand. This becomes an orange-brown, fine, silty sand with dark mottling 0.15 m below the surface. Sand and gravel beaches and spits, with small gastropod shells, lie along the shoreline. Salt crystallizes out from pools in tributary arms otherwise filled with black, euxinic mud.

ECONOMIC GEOLOGY

COPPER

Copper mineralization occurs mainly in a north-south zone through Kumarina, within a variety of host rocks such as metamorphic rocks of the Marymia Dome, the Fords Creek, Ilgarari and Backdoor Formations of the Bangemall Group, and dolerite in the equivalent of the Top Camp dolomite. The Bangemall occurrences that have been worked are all supergene enrichments of sulphide-quartz veins along north-northeasterly to east-northeasterly trending fault zones, usually in or near dolerite intrusions. The common copper minerals are chrysocolla, malachite, azurite and chalcocite; minor tenorite, chalcopyrite, cuprite, chalcanthite and native copper have also been reported (Marston, 1979). Secondary gypsum occurs in the Neds Gap and Koode Magi prospects.

TABLE 3. REPORTED PRODUCTION OF COPPER AND LEAD, COLLIER SHEET AREA

Mine	Copper ore and concentrates (t)	Cupreous ore and concentrates (t)	Average grade (%)	Contained copper (t)
	Copper			
Bulloo Downs area	79.87		25.98	20.75
Butcher Bird	37.39		22.63	8.46
Koode Magi		13.72	12.73	1.75
Mountain Maid (Towers Find, Nounena or Cawse)	2.03		40.39	0.82
Ilgarari group	1 907.70		30.76	586.86
		1 252.81	16.19	202.82
Kumarina group	475.35		37.00	176.11
		2 302.62	17.51	403.19
TOTALS	2 502.34	3 569.15	23.1*	1 400.76

*Weighted average for copper and cupreous ore and concentrates combined

Mine	Concentrate (t)	Contained lead (t)	Contained silver (g)
	Lead		
Keep-it-dark	5.6	4.4	1 865

The two major producing centres are Ilgarari (which has yielded about 790 t of contained Cu to date) and Kumarina (580 t of contained Cu) (see Table 3). These figures compare with 20 100 t for Ravensthorpe, the State's largest copper producer. Mining at both COLLIER centres in recent years has been intermittent. The ore is used in the fertilizer industry. The deepest mining has been 61 m at Ilgarari in 1974, when 12 t of cupreous ore were produced. The other copper shows in the region have produced only very small amounts of hand-picked ore. Ilgarari and Kumarina, both discovered in 1913, have been reported on by Talbot (1914b, 1919), Matheson (1941), and Low (1963), while Marston (1979) describes the individual workings in detail.

The restriction of most occurrences to a narrow zone regardless of stratigraphy, their association with dolerite intrusions, and the structural control by a regional northeasterly fracture system suggest that the copper may have been remobilized from basement rocks by the intrusions.

Copper mineralization in basement rocks at Copper Hills occurs in small quartz veins along the schistosity, and as purple-weathering zones, less than 0.5 m wide, within quartz-muscovite and quartz-chlorite schist of the Marymia Dome. Chrysocolla, malachite, azurite, chalcocite, cuprite, hematite and limonite occur at the surface, and chalcopyrite is associated with pyrite at depth.

Green copper staining, similar to that on bedding and joint surfaces in the Glen Ross Shale Member in the Mount Vernon Syncline (MOUNT EGERTON), is present on some cliff outcrops of the Jillawarra Formation along Brumby Creek, south of the axis of the Brumby Creek Anticline. In the Mount Vernon Syncline, this type of mineralization was found by Westfield Minerals (W.A.) N.L. to decrease rapidly with depth.

LEAD

The only known lead occurrence is the Keep-it-dark mine, 16 km south of Bulloo Downs homestead, which produced a small tonnage of ore in 1949 (Table 3). The mineralization is in narrow lenses of quartz-filled breccia with galena, cerussite and manganese oxides in a north-northeasterly trending shear zone in the Fords Creek Shale. There is a dolerite dyke in the footwall, and a larger sill is nearby. The main workings extend for 30 m to a maximum depth of 5 m, and have been described by Blockley (1971).

MANGANESE

Manganese encrustation is common on outcrops of the Ilgarari Formation between the Ilgarari and Butcher Bird mines. Ordinarily, manganese oxides replace the underlying shale as lines of nodules, grading up to wholly replaced layers in which the original bedding is still recognizable. The manganese-enriched zone is up to 3 m thick. The largest deposit is near the Great Northern Highway just west of the Butcher Bird Mine, and it contains black asbestiform cryptomelane ($(K,H_2O)_2Mn_5o_{10}$) in places, in addition to the common manganese oxides.

HYDROGEOLOGY

SURFACE WATER

Rainfall can vary widely from year to year. The average annual rainfall is about 200 mm in the southwest of COLLIER and abour 250 mm in the northeast. Annual potential evaporation is about 2 500 mm. Rivers and creeks flow only briefly, after heavy rain. Most rainfall is lost by evaporation and runoff and only a small percentage infiltrates to the water table.

There are over 20 permanent pools, springs or soaks in creek or river beds, fed by underflow in alluvium and calcrete, or from groundwater in fractured bedrock. Most of them are in the Ashburton River catchment which is generally more dissected than the other drainage systems on COLLIER. All were fresh or slightly brackish when visited in 1974, except for Mulangulbungalla Spring, near the west boundary of Bulloo Downs pastoral lease, which had a measured salinity of 5 100 mg/L Total Dissolved Solids (October 1974), perhaps because of evaporation. The salinity of these pools and springs varies seasonally.

GROUNDWATER

One hundred and thirty-five bores and wells are recorded, most of which are still in use, providing stock and domestic water. Thirteen bores were sunk by the Main Roads Department in 1975 and 1977 to provide compaction water for upgrading and rerouting the Great Northern Highway. Groundwater information from bores, wells, springs and mineshafts is shown in Table 4. Complete groundwater analyses are listed in Table 5.

TABLE 4. BORES, WELLS AND SPRINGS

Pastoral lease	*Name of bore, well or spring*	*Total depth (m)*	*Water level (m)*	*Salinity mg/L TDS*	*Aquifer*	*Remarks*
Bulloo Downs	Bloodwood Well	14.3	12.0	390	Colluvium	
	Bluebush Bore			370	Calcrete	10 m from Bluebush Well
	Bluebush Well	10.1	9.5		Calcrete	
	Bottom Trough Bore	12.2		1 390	Calcrete	
	Boundary Bore	29.2		2 100	Shale	
	Bull Well	24.0	14.6	1 365	Shale	
	Bungarra Bore			600	Colluvium	
	Cadgie Well	6.1		4 300	Calcrete over shale	
	Charley No. 2 Bore	30.4	11.4	660	Calcrete and colluvium over shale	
	Charley Well	6.8	5.6	840	Calcrete	
	Claypan Bore			520	Alluvium	
	Copper Show Well				Shale with quartz veins	Collapsed, dry
	Corner Bore	28.8		420	Colluvium and alluvium	
	Crabholes Bore	24.3		660	Calcrete	
	Fig Tree Spring	—		300	Alluvium and fractured sandstone	
	Fork and Lever Bore	28.6		675	Shale	
	Government Well No. 37	6.6	4.9	455	Calcrete	Supply 200 m³/day
	Granny Well				Colluvium	Collapsed
	Homestead Bore	21.4		1 110	Shale	
	House Well	14.6	9.1	910	Shale	
	Ilgarari Mine	61.0		510	Shale	Mine shaft—water pumped from 61 m level
	Ilagarari Well	7.4	6.0	1 280	Calcrete	
	Koode Magi Well	8.5	6.5	625	Shale	
	Lager Bore			570	Shale	
	Letter Box Bore	21.4		390	Mudstone	
	Mardinidya Well	7.9	5.3	1 890	Shale	
	Monkey Well	11.9	8.4	875	Shale	
	Montharra Bore	15.4		665	Shale	
	Morowa Bore	21.5			?Colluvium	
	Morrisey Junction Well	6.7	4.8	710	Calcrete	Also known as ESR Well No. 4

TABLE 4. BORES, WELLS AND SPRINGS—*continued*

Pastoral lease	*Name of bore, well or spring*	*Total depth (m)*	*Water level (m)*	*Salinity mg/L TDS*	*Aquifer*	*Remarks*
Bulloo Downs —*continued*	Mulangulbungalla Spring			5 100	Alluvium	Also known as Big Spring
	Mungajerry Bore	9.6		1 340	Calcrete	
	New Granny Bore	14.6		2 300	Colluvium	
	Nuninga Spring			840	Jointed mudstone	Also known as Little Spring
	Old Ilgarari Well	6.1	4.5	920	Calcrete	
	Old well (unnamed)	1.4			Calcrete	1.3 km NW of Old Ilgarari Well. Was 28.8 m deep, now collapsed
	P.J. Bore	24.3		1 090	Colluvium	
	Richard's Bore	21.4		3 500	Colluvium	
	Scotty Well	9.1	7.8	2 600	Calcrete	Supply 130 m^3/day
	Sheepskin Well	17.8	16.0	820	Dolerite	
	Swamp Bore				Alluvium	Dry
	Ti-Tree Well	7.8	6.6	970	Calcrete	
	Top Trough Well	13.0	12.0	1 320	Shale	
	Yanneri Bore			1 390	Calcrete	
	Yanneri Well	7.6			Calcrete and alluvium	
	Woolbunna Bore	10.4	5.8	1 450	Calcrete	
Beyondie	Bongardner Well	24.9	17.3		Shale	Aban-doned
	Kulonoskis West Well	12.7	12.4		Alluvium	Aban-doned
	Limestone Well	12.3			Calcrete	Dry, aban-doned
	Nip and Gallon Soaks			790 & 1 070	Alluvium	Two springs in Creek bed
	Seven Mile Bore				Dolomite	Col-lapsed, aban-doned
Kumarina	Bald Hill Homestead Well	27.2	25.8	1 025	Shale	
	Boundary Bore	9.2		710	Alluvium	
	Browns Well	5.3	5.0	1 785	Siltstone and shale	
	Cabbage Gum Bore	12.8		630	Colluvium	
	Cardawan Homestead Well	16.6	15.8	495	Alluvium	
	Duff Bore				Weathered Shale	
	Flood Gum Bore				Alluvium	No infor-mation (not found)
	Gidgey Bore	12.2		1 005	Alluvium	
	Gidgy Bore				Alluvium	No infor-mation (not found)
	Jaydinia Bore			1 580	Siltstone and shale	
	Joe's Bore	39.6		1 125	Alluvium	
	Jonny's Pool Bore	19.8	13.7	880	Alluvium	
	Limestone Bore			530	Calcrete	
	Main Yard Bore			1 875	Shale	

TABLE 4. BORES, WELLS AND SPRINGS—*continued*

Pastoral lease	*Name of bore, well or spring*	*Total depth (m)*	*Water level (m)*	*Salinity mg/L TDS*	*Aquifer*	*Remarks*
Kumarina —*continued*	Marie's Bore	27.7			Sandy colluvium or alluvium	
	Mock Pool Bore			635	Shale	
	Monty's Well	14.1	13.9	1 200	Alluvium over sandstone	
	No Name Bore	24.6	13.2	755	Colluvium or Alluvium	Poor supply
	Number 34 Government Well	21.2	15.6	290	Alluvium	
	Number 35 Government Well	18.3	16.8		Shale and glauconitic sandstone	
	Number 36 Government Well	13.2	10.7	1 340	Weathered sandstone	Supply 1 200 m^3/day
	Rinaldi's Mineshaft	22.5	18.1	1 365	Brecciated shale and dolerite	
	Shepherds Well	20.1	16.3	450	Siltstone and shale	
	Six Mile Well	20.2	16.5	500	Alluvium	
	Snell Well	9.8	8.8	2 000	Silty shale	
	Stuart Peak Bore	16.5	5.5	360	Alluvium (possibly with calcrete)	Supply 220 m^3/day
	Three Corner Well	11.6	11.2	820	Calcreted alluvium	Possibly weathered dolerite at depth
	Woolbunna Bore	10.4	5.8	1 450	Calcrete	
	Yanneri Well	4.8	4.1	1 180	Calcrete	
Mingah Springs	Bore (abandoned)	16.3			Sand	Dry
	Berry Well	4.7	4.0	530	Calcrete	
	Bidulena Bore	45.0			Colluvium	Aban-doned, no supply
	Bubba Kail Kail Bore			855	Calcrete	
	Crooked Bill Well	6.5	6.4	470	Calcrete	
	Dead End Bore				Calcrete	
	Garden Well	12.4	8.2	1 390	Colluvium	
	Irrigation Well	7.5	4.3	570	Calcrete	
	Jam Tin Bore			2 050	Colluvium	
	Lane's Bore				Colluvium	
	Limestone Bore			2 650	Calcrete	
	Mingah Gap Spring			2 040	Calcrete	
	Mingah Homestead Bore	4.7	4.3	720	Calcrete	
	Nickem Bore			720	Calcrete	Also called Black Hill
	No Name Bore				Colluvium possibly over shale	
	Shamrock Bore				Shale	
	Spinifex Bore			930	Colluvium	
	Stoney Point Bore			1 115	Colluvium	
Mount Vernon	Bummers Well	8.2	4.6	790	Alluvium over calcrete	
	Bluff Well	8.7	4.5	600	Calcrete	Also called ESR Well No. 15

TABLE 4. BORES, WELLS AND SPRINGS—*continued*

Pastoral lease	*Name of bore, well or spring*	*Total depth (m)*	*Water level (m)*	*Salinity mg/L TDS*	*Aquifer*	*Remarks*
	Dingo Bore			710	Alluvium or colluvium	
	Dingo Spring			1 430	Alluvium, fissured dolerite	
	Eight Mile Rockhole			945	Alluvium overlying dolerite	Spring
	Mickey Spring			590	Sand over calcrete	
	O'Donnell Soak				Alluvium	
	Peterson Bore			1 590	Alluvium	
	Salt Water Well				Colluvium or alluvium	Abandoned
Mulgul	Bedford Bore			1 255	Dolomite	
	Burgoynes Well	16.5	3.6	520	Shale	Supply 8 m³/day. Also called ESR Well No. 14A
	Chalk Spring				Calcrete	
	Godsend Well	16.9	10.7	925	Shale and mudstone	Also called ESR Well No. 14
	Nicholl Spring			1 030	Alluvium	Also called Bamboo Spring
Tangadee	Bastard Bore	25.0	10.7	1 420	Shale	
	Black Magic Bore			650	Colluvium	
	Bujundunna Well	12.4	9.6	240	Alluvium	
	Chilibubba Pool			45	Alluvium over shale	
	Corner Bore				Siltstone	
	Gununarra Pool			680	Alluvium	
	Kelly Bore	11.2			Shale	
	Number 88 Well	10.1	10.1		Calcrete	
	Tangadee Homestead Bore 'A'	21.8	12.3	890	Shale	
	Tangadee Homestead Bore 'B'	17.1	6.9		Shale	
	Tangadee Homestead Well	10.4	8.3	930	Shale	
	Twelve Mile Bore				Calcrete	
	Wannangunna Spring			580-830	Alluvium and calcrete	Line of pools extending over several km of creek bed
	White Hill Spring			1 320	Alluvium	
Three Rivers	Beefwood Outcamp Well	6.5	5.0	830	Colluvium over shale	Supply 260 m³/day
	Bore Well	11.4	6.6	650	Calcrete	Also called Government Well No. 33. Supply 260 m³/day
	Cork Tree Well	16.4	10.2	410	Colluvium	
	Jubilee Well	7.6	7.0	2 230	Calcrete	

TABLE 4. BORES, WELLS AND SPRINGS—*continued*

Pastoral lease	*Name of bore, well or spring*	*Total depth (m)*	*Water level (m)*	*Salinity mg/L TDS*	*Aquifer*	*Remarks*
Three Rivers —*continued*	Nugglegunna Well	7.6	5.6	925	Alluvium and colluvium, some calcrete	
	Saltbush Well	19.9	18.6	1 100	Dolomite	
Weelarrana	Cornelis' Well	4.0			Calcrete	Abandoned, dry
	Government Well No. 38	8.5	6.9	690	Calcrete	
	Government Well No. 39	9.3	4.8	550	Shale	
	McKays Bore	6.0	5.6	1 030	Calcrete	
	Minnieritchie Bore	11.3	9.8	720	Colluvium	Abandoned
	Salt Well	5.6	4.5	5 800	Calcrete	
Main Roads Department 1975 drilling program	PB 10 Bore 1	37.1	9.8	Fresh	Calcrete over shale	Lat. 24°52′S Long. 119°28′E supply 100 m³/day
	PB 10 Bore 2	18.0				Same site as PB 10 Bore 1. Abandoned
	PB 10 Bore 3	33.0			Calcrete over ?dolomitic shale	Same site as PB 10 Bore 1. Supply 300 m³/day
	PB 11	24.0	4.6	Fresh	Calcrete, alluvium and fractured rock	Lat. 24°43′S, Long. 119°37′E. Supply 1800 m³/day
	PB 13 Bore 1	28.0			Calcrete over clay	Lat. 24°34′S, Long. 119°38′E. Supply 85 m³ day
	PB 14 Abandoned	16.7	5.4		Calcrete	Supply 15 m³/day. Lat. 24°28′S, Long. 119°42′E
	PB 14	19.0	6.0		Calcrete	Same site as PB14 abandoned Supply 750 m³/day
	PB 17	18.0	6.3		Calcrete	Supply 450 m³/day. Lat. 24°19′S, Long. 119°42′E
	Camp Bore	56.3				Dry, abandoned in clay. Lat. 24°49′S, Long. 119°36′E

TABLE 4. BORES, WELLS AND SPRINGS—*continued*

Pastoral lease	*Name of bore, well or spring*	*Total depth (m)*	*Water level (m)*	*Salinity mg/L TDS*	*Aquifer*	*Remarks*
1977 Drilling program	MRD No. 1	23.5	4.9		Calcrete	Supply 200 m^3/day. Lat. 24°18'S, Long. 119°42'E
	MRD No. 2	26.0	7.5		Slate	Supply3-400 m^3/day. Lat. 24°12'S, Long. 119°42'E
	MRD No. 3	24.0	6.3		Calcrete	Supply 130 m^3/day. Lat. 24°27'S, Long. 119°42'E
	MRD No. 4	20.0	13.5		Clay and sandstone	Supply 10 m^3/day. Lat. 24°03'S, Long. 119°44'E

TABLE 5. COLLIER—GROUNDWATER ANALYSES

Pastoral lease	*Tangadee*	*Kumarina*			
Bore or well	*Bastard Bore*	*Monty's Well*	*Six Mile Well*	*Sturt Pea Bore*	*Woolbunna Bore*
Specific conductance mS/m (25°C)		187	75	63	229
pH	7.1	8.5	7.9	7.2	7.4
TDS (by evaporation) (*a*)			500	360	1450
TDS (by conductivity x 6.4) (*a*)	1420	1200	480	410	1460
Total hardness (as $CaCo_3$) (*a*)	860		201	335	701
Total alkalinity (as $CaCo_3$) (*a*)	220		43	318	303
Calcium, Ca (*a*)	116		36	88	124
Magnesium, Mg (*a*)	110		27	28	95
Sodium, Na (*a*)			53	1	196
Potassium, K (*a*)			23	6	36
Carbonate, CO_3 (*a*)			Nil	Nil	Nil
Bicarbonate, HCO_3 (*a*)			52	387	369
Chloride, Cl (*a*)	212		159	13	383
Sulphate, $SO_{4\,(a)}$	830		44	5	255
Nitrate, NO_3 (*a*)			40	4	80
Iron, Fe (*a*)	18			<0.05	<0.05
Copper, Cu (*a*)	0.2				
Silica, SiO_2 (*a*)			69	4	6
Boron, B (*a*)			0.28		
Fluoride, F (*a*)			0.5		
NaCl (calculated from Cl) (*a*)		514		22	631

(*a*) mg/L

Most groundwater supplies are drawn from valley calcrete, alluvium and colluvium, although some of the deeper bores probably penetrate weathered or fractured bedrock. The calcrete and alluvium may be up to 25 m thick, and the maximum saturated thickness about 20 m. Colluvium may be up to 40 m thick, with a maximum saturated thickness of about 30 m.

Many bores also draw water from jointed shale or mudstone. Successful bores have been drilled without any deliberate selection of shale or mudstone as a potential aquifer.

Depth to water table depends on ground relief and ranges between 3 and 26 m below the natural surface; it is usually less than 15 m.

The salinity of the groundwater (Table 4) is generally less than 2 000 mg/L Total Dissolved Solids (TDS) and often less than 1 000 mg/L TDS (fresh water). The salinity depends on local variations in aquifer permeability, and a regional trend to slightly higher average salinities to the east is evident. Salinities also tend to be slightly higher in shale and mudstone, because of lower permeability.

There is little information on bore yields, but potential supplies from alluvium, colluvium and fractured rock probably range from 10-500 m^3/day. Supplies of as much as 5 000 m^3/day may be obtainable from calcrete.

When siting bores for domestic water, areas with large stands of vegetation should be avoided, as transpiration losses may locally increase the groundwater salinity.

Groundwater can also be obtained from fractured and jointed bedrock, where there is adequate catchment for rainwater intake. Shale or mudstone should be avoided when drilling for fresh water.

Two other potential aquifers, which are largely untested, are dolomite and sandstone. Dolomite can develop solution cavities in the weathered zone, and if such cavities are present below the water table large groundwater yields are possible. A sinkhole in dolomite southeast of Beyondie Bluff indicates some development of solution cavities in that area.

Groundwater supplies could also be obtained from beds of porous sandstone and grit, by drilling downdip from outcrops to intersect these beds below the water table.

APPENDIX Localities mentioned in text Collier sheet SG50-4

	Lat. (°S)	Long. (°E)
Backdoor Hills	24°37′	119°05′
Batthewmurnarna Hill	24°57′	119°23′
Box Bluff	24°45′	119°11′
Brumby Creek Anticline	24°17′	118°49′
Bujundunna Fault	24°34′	118°45′
Bulloo Downs homestead	24°00′	119°34′
Bunningunna Bluff	24°26′	119°23′
Burgoynes Well	24°36′	118°33′
Butcher Bird Mine	24°24′	119°44′
Calyie Syncline	24°48′	118°43′
Collier Range	24°41′	119°15′
Conical Hill	24°14′	119°56′
Copper Hills	24°54′	119°41′
Dingo Bore	24°16′	118°32′
Eight Mile Rockhole	24°21′	118°46′
Ethel River	24°20′	118°33′
Fork and Lever Bore	24°10′	119°21′
Glen Ross Anticline	24°25′	118°50′
Gununarra Pool	24°20′	119°03′
Ilgarari Outcamp	24°20′	119°34′
Jaydinia Syncline	24°46′	119°36′
Koode Magi prospect	24°10′	119°35′
Kumarina Hotel	24°42′	119°36′
Mardinidya Well	24°16′	119°30′
Mickey Spring	24°08′	119°49′
Mingah Springs homestead	24°57′	118°41′
Monkey Well	24°13′	119°19′
Mulangulbungalla Anticline	24°19′	119°19′
Neds Gap prospect	24°14′	119°33′
Nicholl Spring	24°30′	118°35′
No. 35 Government Well	24°38′	119°37′
Tangadee homestead	24°25′	118°56′
Tangadee Syncline	24°21′	118°49′
Ti-Tree Well	24°07′	119°33′
Top Trough Well	24°05′	119°36′
White Hill Spring	24°19′	119°58′
Wonyulgunna Hill	24°49′	119°44′
Yanneri Creek	24°26′	119°55′

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13926/8/81—1M—L3135

WILLIAM C. BROWN, Government Printer, Western Australia

COLLIER

AUSTRALIA 1 : 250 000 GEOLOGICAL SERIES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET SG 50-4

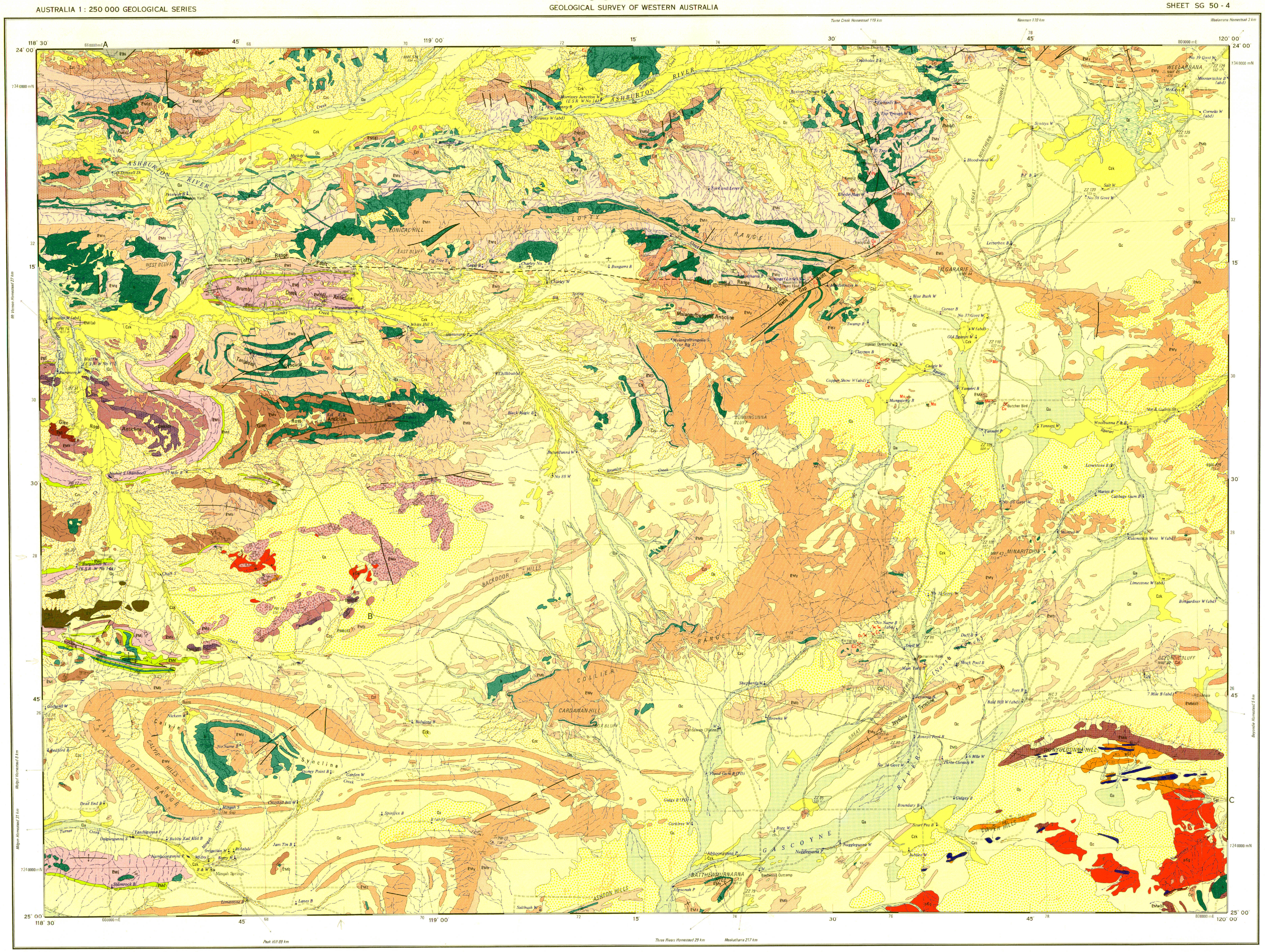
SYMBOLS

- Geological boundary
  - Facies change
- Fault
  - Accurate
  - Concealed
- Fold
  - Anticline, accurate, showing plunge
  - Plunge of minor anticline
  - Plunge of minor fold axis
  - Syncline, accurate
- Bedding
  - Inclined
  - Vertical
  - Horizontal
  - Overturned
  - Trend line
- Cleavage
  - Inclined
  - Vertical
- Foliation
  - Inclined
  - Vertical
- Mineral orientation in igneous rocks
  - Inclined
  - Undetermined
- Air photo lineament

- Highway with national route marker
- Road
- Track
- Landing ground
- Homestead — Tangadee
- Building
- Yard
- Horizontal control, major, minor
- Bench mark, height accurate — GE 30 526 m
- Sand dune

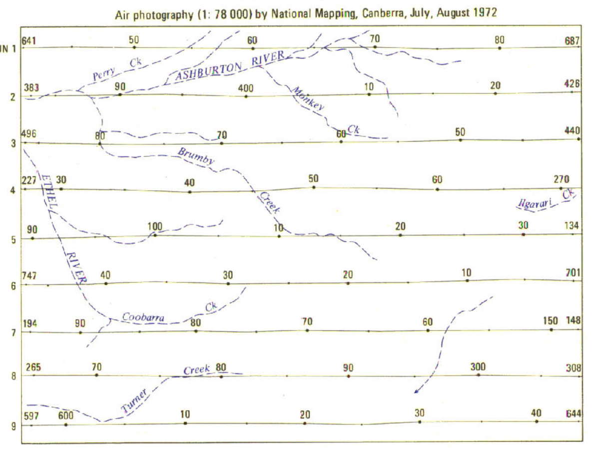
- Watercourse, intermittent
- Pool — P
- Well — W
- Bore — B
- Gnamma hole — GH
- Rockhole — RH
- Soak — Sk
- Spring — S
- Windpump
- Tank — T
- Abandoned — (abd)
- Position doubtful — (PD)

- Mine
- Prospect
- Prospect, not being worked
- Mineral occurrence
  - Copper — Cu
  - Manganese — Mn
  - Lead — Pb



FLIGHT DIAGRAM

Air photography (1 : 78 000) by National Mapping, Canberra, July, August 1972



REFERENCE

CAINOZOIC

QUATERNARY

Ql	Salt lake deposits — sand, silt, clay, gypsum and halite
Qs	Wind-blown sand
Qa	Alluvium — unconsolidated silt, sand and gravel associated with watercourses
Qc	Colluvium — unconsolidated silt, sand, gravel and rubble; minor alluvium
Czk	Calcrete — limestone in modern and ancient drainages, replaced by opaline silica in places; minor kankar
Czc	Hardpan — consolidated colluvium and alluvium: silt, sand, gravel and rubble; minor silcrete
Czl	Laterite — massive and pisolitic ferruginous deposits, frequently overlying a leached zone

q — Quartz vein (age variable)

b, d — Dolerite, gabbro and basalt sill (b) and dyke (d)

v — Rhyolite extrusive in Coobarra Formation

PROTEROZOIC

MIDDLE PROTEROZOIC

Bangemall Group

Ethel River – Lofty Range Area; Calyie Hills – Ilgarari Area

₽Mz	**ILGARARI BEDS:** white, grey and brown shale, siltstone, claystone and fine-grained sandstone
₽Mq	**KURABUKA FORMATION:** green, khaki and grey shale and chert
₽My	**CALYIE SANDSTONE:** quartz sandstone, usually medium-grained and moderately sorted, with minor shale and siltstone
₽Mn	**MT VERNON SANDSTONE:** quartz sandstone, usually medium-grained and well sorted, fine-grained towards base; minor shale and siltstone
₽Ms	**FORDS CREEK SHALE:** greenish-grey shale and siltstone; minor quartz sandstone and chert
₽Ms(d)	Dolomite unit
₽Ml	**ULLAWARRA FORMATION:** shale, siltstone (argillaceous and quartzose), minor fine-grained sandstone and claystone
₽Ml(a)	Sandstone unit
₽Mb	**BACKDOOR FORMATION:** shale and siltstone, minor chert and sandstone
₽Mb(d)	Dolomite unit
₽Mv	**DEVIL CREEK FORMATION:** dolomite and shale, minor siltstone
₽Md	**DISCOVERY CHERT:** chert, black to cream, massive to laminated and some wavy bedded varieties
₽Mj	**JILLAWARRA FORMATION:** shale, siltstone and claystone; rare chert and sandstone
₽Mj(d)	Dolomite unit
₽Mw	**WONYULGUNNA SANDSTONE:** coarse and medium-grained quartz sandstone with local conglomerate
₽Mw(s)	Shale and siltstone unit
₽Mo	**COOBARRA FORMATION:** sandstone and conglomerate; minor shale and rhyolite
₽Mk	**KIANGI CREEK FORMATION:** medium and fine-grained sandstone with subordinate shale and siltstone
₽Mk(d)	Dolomite and dolomitic sandstone units
₽Mi	**IRREGULLY FORMATION:** dolomite and minor dolomitic sandstone

₽M(a)	Sandstone
₽M(s)	Shale
₽M(d)	Dolomite
₽Mp	**Prairie Downs Beds:** sandstone and conglomerate

These units together are equivalent to **TOP CAMP DOLOMITE** (Turee Creek and Newman Sheets)

LOWER PROTEROZOIC

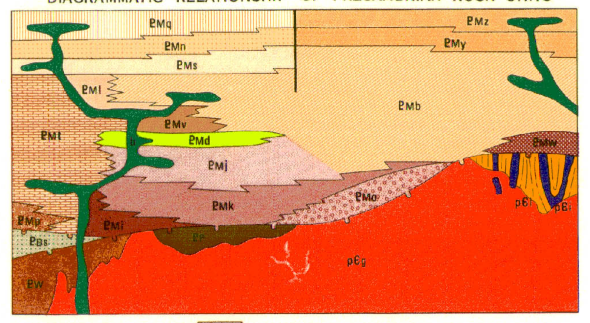
Bresnahan Group — ₽Bs — **KUNDERONG SANDSTONE:** coarse-grained sandstone with granule conglomerate

Probable Padbury Group — ₽P — Sandstone, shale and dolomite

UNASSIGNED PRECAMBRIAN

p€g	Granitic rocks, usually foliated; intrude metamorphic rocks in area south of Wonyulgunna Hill
p€l	Quartz-mica and quartz-chlorite schists; minor phyllite and quartzite
p€i	Banded iron-formation; some interbeds of schist

DIAGRAMMATIC RELATIONSHIP OF PRECAMBRIAN ROCK UNITS



₽Mt — Equivalent to **TOP CAMP DOLOMITE**

₽W — Wyloo Group (Newman Sheet)

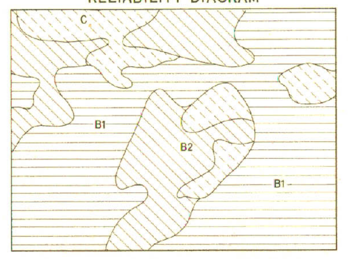
Unconformity

Geology by: A.T. Brakel 1974-5, M. Elias, J.C. Barnett and P.C. Muhling 1974

Compiled and published by the Geological Survey of Western Australia. Cartography by the Geological Mapping Section, Department of Mines. Topographic base from compilations by the Department of Lands and Surveys.

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

RELIABILITY DIAGRAM



B1 Numerous traverses with air photo interpretation

B2 Air photo interpretation with a few traverses

C Air photo interpretation

HON. P.V. JONES, M.L.A.
MINISTER FOR MINES
A.F. TRENDALL, DIRECTOR, GEOLOGICAL SURVEY

SCALE 1 : 250 000

TRANSVERSE MERCATOR PROJECTION
ZONE 50 AUSTRALIAN MAP GRID

INDEX TO ADJOINING SHEETS

TUREE CREEK SF 50-15	NEWMAN SF 50-16	ROBERTSON SF 51-13
MT EGERTON SG 50-3	COLLIER SG 50-4	BULLEN SG 51-1
ROBINSON RANGE SG 50-7	PEAK HILL SG 50-8	NABBERU SG 51-5

DECLINATION DIAGRAM

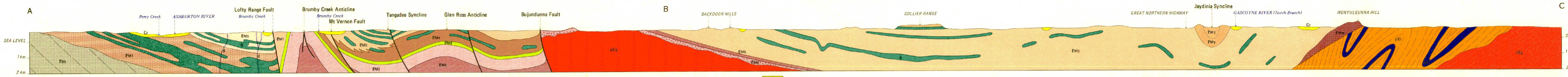
The lines indicate magnetic declination, 1970. + means declination is east and correction must be added to compass bearing to give true bearing. − means declination is west and correction must be subtracted from compass bearing to give true bearing.

Annual change is -1' westerly

DIAGRAMMATIC SECTION

SCALE $\frac{V}{H} = 2$

SECTION A - B - C



Cz — Undifferentiated Cainozoic

COLLIER
SHEET SG 50-4

FIRST EDITION, 1981