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Record 1973/171

GEOLOGY OF THE GRANITES AND PRECAMBRIAN PARTS OF BILLILUNA, LUCAS AND STANSMORE 1:250 000 SHEET AREAS, NORTHERN TERRITORY AND WESTERN AUSTRALIA

by

D.H. Blake, I.M. Hodgson, and P.C. Muhling

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SUMMARY

The area described is part of the Granites-Tanami region, situated between the mainly Precambrian Kimberley, Victoria River, and Arunta regions to the northwest, north, and south, respectively, and the Phanerozoic Wiso and Canning Basins to the east and west.

The oldest rocks exposed are steeply dipping and tightly folded sedimentary and minor volcanic rocks belonging to the Archaean or Lower Proterozoic Tanami complex and Halls Creek Group. They have been regionally metamorphosed to lower greenschist facies, and consist of schistose to phyllitic greywacke, lithic sandstone, siltstone and mudstone, banded chert, quartzite, basalt, and acid porphyry. The Tanami complex is intruded by granite, and overlain unconformably by Pargee Sandstone, both of which are probably Lower Proterozoic. These rocks together make up the Granites-Tanami Block, which continues south-eastwards into the Arunta Block.

The Lower Proterozoic and possibly Archaean rocks are overlain by Carpentarian and Adelaidean rocks. Most of these were deposited in the Birrindudu Basin, and belong to the Carpentarian Birrindudu Group and the unconformably overlying Carpentarian or Adelaidean Redcliff Pound Group. The Birrindudu Group comprises the Gardiner Sandstone, the Talbot Well Formation, which contains stromatolitic chert, and the Coomarie Sandstone. It is tentatively correlated with the Mount Parker Sandstone and the Bungle Bungle Dolomite of the Kimberley Region and the Limbunya Group of the Victoria River region. Glauconite from the Gardiner Sandstone has been dated at 1550-1620 m.y. The Redcliff Pound Group, tentatively correlated with the Wattie Group of the Victoria River region, comprises the Lewis Range and Muriel Range Sandstones, the Murraba Formation, which is characterized by chert granule conglomerate, and the Erica Sandstone. Several other units have been mapped which, because of inadequate information cannot be confidently assigned to either the Birrindudu or Redcliff Pound Groups.

The Precambrian rocks are overlain by flat-lying basalt of the Antrim Plateau Volcanics and by probably Palaeozoic unfossiliferous sandstone and mudstone of the Lucas Formation and clayey sandstone of the Pedestal Beds. There are also minor cappings of probably Cretaceous terrestrial sediments and extensive Tertiary and Quaternary superficial deposits: laterite, silcrete, calcrete, alluvial and aeolian sediments, and evaporites.

The area was involved in four major periods of tectonic activity, each marked by a major unconformity, between the deposition of the Tanami complex and the end of the Precambrian; it has been relatively stable since, and Phanerozoic rocks occupy shallow depressions that may be either tectonic or erosional.

Gold has been obtained from four localities within the Tanami complex, the main occurrence being at The Granites. Also within the Tanami complex, minor traces of copper have been found, and gossans are common locally, but are not known to have any significant mineralization associated with them. Uranium and associated rare earth mineralization is present at the base of the Carpentarian Gardiner Sandstone in the Killi Killi Hills, and some of the granite in the area shows appreciable radioactive anomalies.

Logs of 38 shallow stratigraphic holes drilled in 1972 are given in the appendix.

INTRODUCTION

The Granites and the Precambrian parts of Billiluna, Lucas and Stansmore 1:250 000 Sheet areas were mapped in 1972 by D.H. Blake (Party Leader), I.M.Hodgson, and P.C. Muhling (GSWA) as the second part of a program of reconnaissance mapping of the Granites-Tanami region. The first part was the mapping of the Tanami and Birrindudu 1:250 000 Sheet areas in 1971, and the third and final part will be the mapping of Webb and Highland Rocks 1:250 000 Sheet areas in 1973.

The Granites-Tanami region, an area of mainly Precambrian rocks, is bounded to the northwest, north, and south by the mainly Precambrian Kimberley, Victoria River, and Arunta regions respectively, and to the east and west by the Phanerozoic Wiso and Canning Basins (Fig. 1).

The area mapped in 1972 straddles the WA/NT border between latitudes 19° and 22°S. Access is by a track which goes from Alice Springs, 500 km to the southeast, to Halls Creek, 100 km to the north. Other tracks within the area are shown on Fig. 2; These tracks are suitable only for four-wheel-drive vehicles. There are no towns and habitation is almost entirely restricted to Billiluna, Carranya, and Sturt Creek homesteads in the Billiluna Sheet area, Mongrel Downs in The Granites Sheet area, and Balgo Mission in the Lucas Sheet area. The Stansmore Sheet area is uninhabited. Beef-cattle raising is carried out on the homestead properties and at Balgo Mission. At Rabbit Flat, 60 km northwest of The Granites, a motel caters for tourist coaches that run from Alice Springs to Halls Creek between May and September. Billiluna, Sturt Creek, and Mongrel Downs homesteads, Balgo Mission and Rabit Flat each have an airstrip suitable for light aircraft. Halls Creek is served by regular flights from Derby, Kununurra, and Alice Springs.

Climate and vegetation

The area is mainly semi-desert and has a mean annual rainfall of less than 380 mm.

Temperature data for Halls Creek indicate that maximum temperatures of over 38°C can be expected in October, November, and December, and also in March. Mean minimum temperatures of less than 10°C occur during June, July, and August, when frosts are common, especially in the south.

The vegetation consists mainly of desert shrubland with scattered low trees, commonly of snappy gum (*Eucalyptus brevifolia*). Spinifex is common throughout the area.

Survey methods

The field work was planned from the first edition geological maps of Billiluna, Lucas, and Stansmore Sheet areas, at 1 inch to 4 mile scale, and from a 1:250 000 photo-geological map of The Granites prepared by C.J. Simpson in 1971.

Billiluna, The Granites, and the northern part of Lucas Sheet areas were mapped mostly by ground traverses using Landrovers. The southern part of Lucas and all of Stansmore Sheet areas had to be mapped by helicopter, as ground access was virtually impossible because of many east trending longitudinal sand dunes. The helicopter was also used to visit the least accessible parts of the other sheet areas.

A BMR drilling team put down 24 shallow stratigraphic holes in parts of Lucas and The Granites Sheet areas where bedrock is obscured by Cainozoic superficial deposits. The sites of the holes are shown on the accompanying maps, and drill logs are summarized in the Appendix.

Observation sites were recorded on vertical aerial photographs at a nominal scale of 1:80 000. The geological data were plotted on overlays on the aerial photographs, and later transferred to planimetric sheets compiled by the Division of National Mapping. These were at a nominal scale of 1:50 000 and had to be photographically reduced to 1:80 000 to be compatible with the aerial photograph overlays. The compilation sheets were photographically reduced to 1:250 000 scale and redrawn for the preliminary editions accompanying this report.

The aerial photographs used in the survey were flown in 1971. Copies of the photographs can be obtained from the Division of National Mapping, Canberra.

Previous geological investigations

Between 1898 and 1900, A.A. Davidson (1905) led an expedition for Central Australian Exploration Syndicate Ltd, and investigated areas in the southern part of the Gardiner Range and in the Lewis Range. He also discovered gold at The Granites.

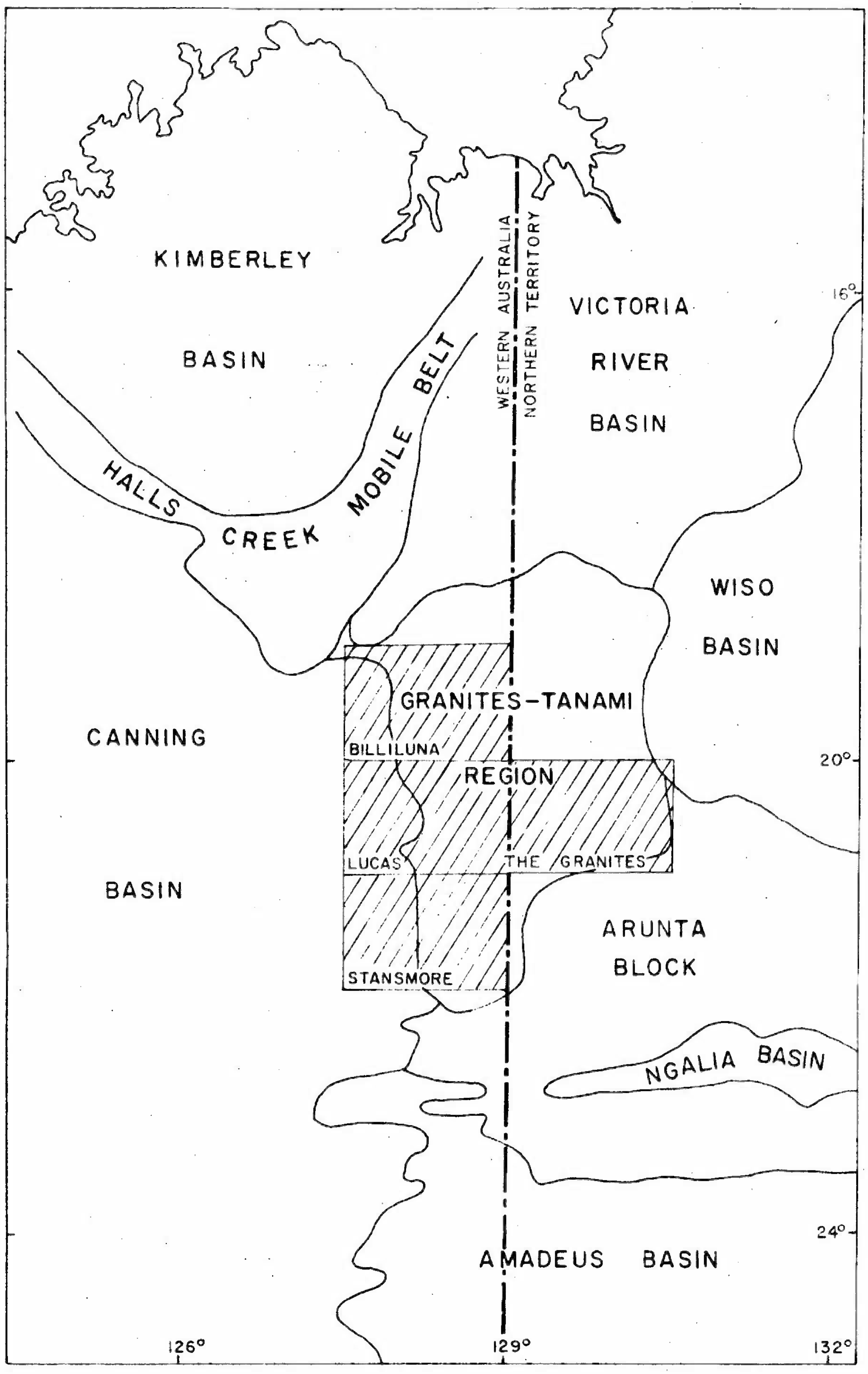

Fig.1 Tectonic Setting

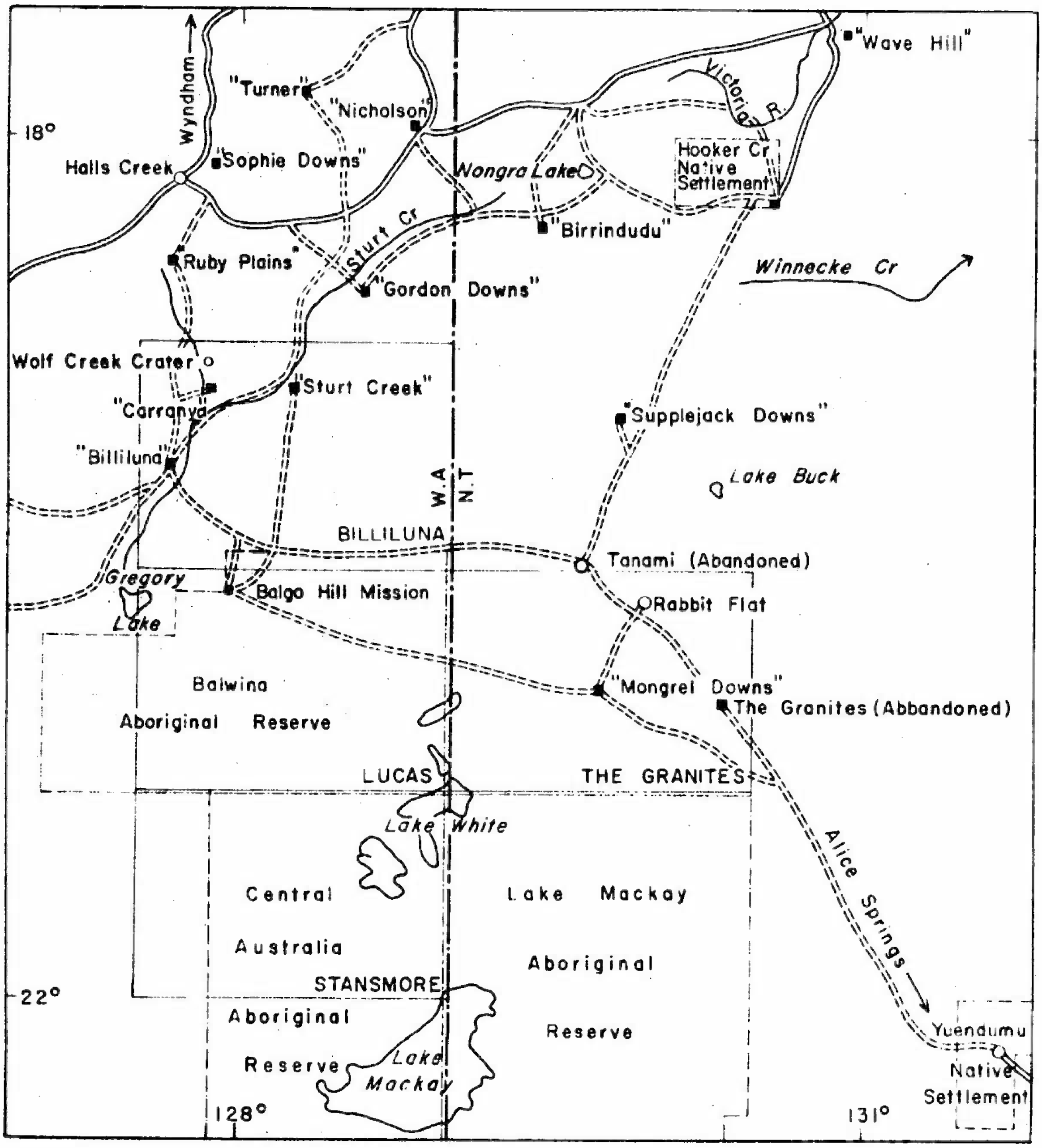

Fig. 2 Locality Map

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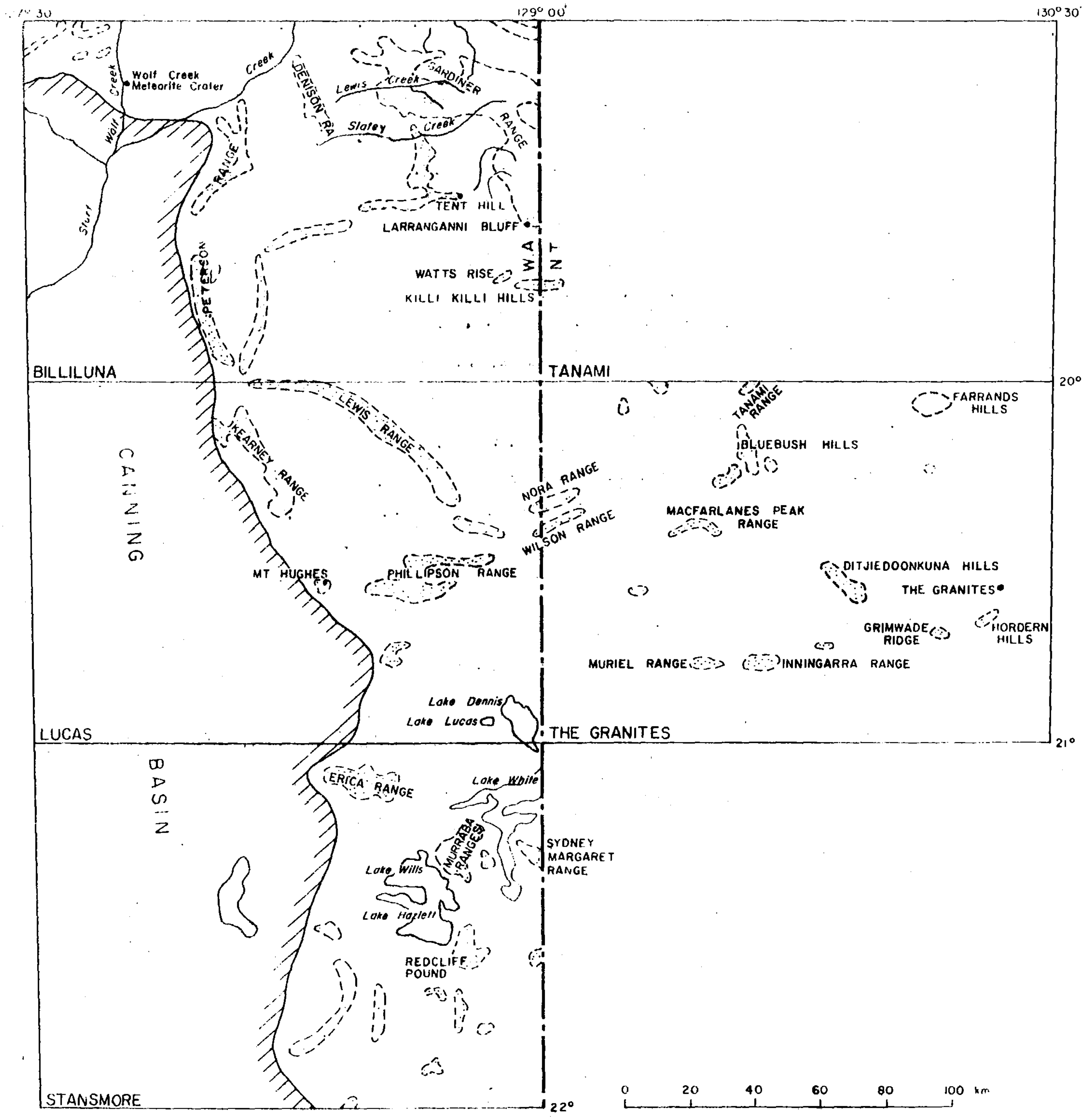

Fig 3 Topography and drainage

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In 1928, M. Terry (1930, 1934) led a prospecting expedition, which investigated the area around Larranganni Bluff, and in 1932 he led an expedition which covered much of the eastern part of the Stansmore Sheet area (Terry, 1937).

In 1955 Billiluna, Lucas, and Stansmore were mapped, at a scale of 1 inch to 4 miles during a geological survey of the Canning Basin (Casey & Wells, 1964; Veevers & Wells, 1961; Wells, 1962a, b, c). K.M. Phillips made a reconnaissance survey of The Granites Sheet area in 1959 (Phillips, 1959) and carried out more detailed surveys of part of the same sheet area in 1961 (Phillips, 1961).

The gold mining area in the vicinity of The Granites has been described by Gee (1911), Hossfeld (1940 a and b), Hall (1953) and Crohn (1961), and uranium occurrences in the Killi Killi Hills, Billiluna Sheet area, have been described by Clark & Blockley (1960) and Prichard et al. (1960).

Topography and drainage

The main topographic features are shown in Fig. 3. Most of the area is gently undulating sand plain with an altitude close to 350 m above sea level. The eastern part of The Granites Sheet area lies within the Tanami Desert, and Billiluna, Lucas, and Stansmore Sheet areas are on the eastern edge of the Great Sandy Desert. The plains are crossed by east trending longitudinal dunes which are most abundant in the south. Residual hills, plateaux, and strike ridges of resistant mainly Precambrian rocks rise above the sand plain. These are mostly less than 70 m high and are incised by drainage channels which pass outwards onto outwash fans and disappear on the surrounding plains.

There are no permanent water courses and few permanent water holes except along Sturt Creek in the northwest, which drains southwest into Lake Gregory. The only other water courses of any size are Slatey Creek and Lewis Creek in the Billiluna Sheet area. In the eastern sides of the Lucas and Stansmore Sheet areas most surface runoff is southwards towards a large system of salt lakes - Lakes Dennis, White, Wills, and Hazlett.

Wolf Creek Meteorite Crater, a prominent topographic feature in the northwest of the Billiluna Sheet area, is described by Casey & Wells (1964).

Rock nomenclature

In this report Precambrian sandstones are classified according to Pettijohn, Potter and Siever (1972) as follows: sandstone in which over 95 percent of the detrital grains are quartz is termed quartz arenite; that in which less than 95 percent but more than 75 percent of the detrital grains are quartz is sublithic arenite; the in which less than 75 percent of the detrital grains are quartz is lithic arenite. Sandstone having over 15 percent matrix is termed greywacke. The arenites characteristically have a cement of quartz that forms overgrowths in crystallographic and optical continuity with detrial quartz grains. Many of the so-called lithic grains in the arenites are probably altered feldspar: they are commonly white in hand specimen and consist of kaolinitic clay. Detrital grains still consisting of feldspar have been identified in only a few of the many sandstone specimens examined in thin section. Phanerozoic sandstones are termed quartzose if at least 75 percent of the detrital grains are quartz and lithic if over 25 percent of the detrital grains are not quartz.

Grain sizes of sandstones are: 0.125-0.25 mm, fine; 0.25-0.5 mm, medium; 0.5-1 mm, coarse; 1-2 mm, very coarse.

Bedding thicknesses used for sedimentary rocks are: 1 cm, laminated; 1-50 cm, thin-bedded; 50 cm - 2 m, medium-bedded; 2 m, thick-bedded.

For igneous rocks the classification of Hatch, Wells & Wells (1961) is used where practicable. However, because of the widespread alteration of fine-grained varieties and the lack of chemical analyses, general terms such as acid porphyry and acid lava are used instead of rhyolite or rhyodacite. Granitic rocks having an average grain size of less than 1 mm are described as fine; those of 1-5 mm, medium; those of 5 mm - 3 cm, coarse; those of over 3 cm, pegmatitic.

Terms describing metamorphic facies are as defined by Turner & Verhoogen (1960). Phyllite is distinguished from shale and mudstone in having fine-grained white mica developed along cleavage planes. Schist is characterized by the development of coarser grained mica.

Introduction to stratigraphy

Major problems in the reconnaissance geological mapping of the Granites-Tanami region have been the occurrence of extensive Cainozoic superficial deposits between widely scattered outcrops, the fact that most of the rocks exposed are quartz-rich sandstones which are difficult to tell apart, a general absence of useful marker beds, and the common occurrence of abrupt local changes in dip and strike. As a result, correlations between outcrops are often difficult. Deep and intense weathering, which has affected most rocks in the region that do not consist almost entirely of quartz, has not been such a major problem although, as it involves ferruginization, lateritization, and silicification, it hinders rock identification both in the field and in the laboratory. The region has been subject to subaerial denudation probably since at least the end of the Cretaceous, and rocks most susceptible to weathering tend to form topographic depressions and to be concealed beneath superficial deposits.

The stratigraphy is summarized in Table 1. The oldest rocks in the region are those of the Tanami complex and Halls Creek Group, which are Archaean or Lower Proterozoic. The Tanami complex is intruded by granite and overlain unconformably by Pargee Sandstone, both of which are probably Lower Proterozoic. The Tanami complex and the Lower Proterozoic units together make up the Granites-Tanami Block, which is overlain unconformably by sedimentary rocks of the Birrindudu Basin. These sedimentary rocks make up the Carpentarian Birrindudu Group and the Carpentarian or Adelaidean Redcliff Pound Group.

In the northwest corner of the Billiluna Sheet area part of the east Kimberley succession is exposed. Here the Olympio Formation of the Halls Creek Group is overlain unconformably by Mount Parker Sandstone which, with the overlying Bungle Bungle Dolomite, is probably correlated with the Birrindudu Group.

Carpentarian or Adelaidean rocks that cannot be confidently assigned to either the Birrindudu or Redcliff Pound Groups crop out in the northwest part of the Granites-Tanami region, between outcrops of these groups to the east and the Precambrian East Kimberley region and Phanerozoic Canning Basin to the northwest and west. These rocks have been mapped as beds rather than formations because their relationships to one another are also uncertain.

In the south, in the Stansmore Sheet area, the Redcliff Pound Group is underlain by the Munyu Sandstone, which may be correlated with the basal units of either the Birrindudu or Redcliff Pound Groups, and is overlain by the Hidden Basin Beds, which may represent the youngest sediments of the Birrindudu Basin.

Palaeozoic, Mesozoic, and Cainozoic units overlie Precambrian rocks both within the Granites-Tanami region and to the west, on the eastern edge of the Canning Basin. On the eastern edge of The Granites Sheet area sediments of probably Cambrian age belonging to the Wiso Basin succession, overlap westwards onto Precambrian rocks.

Correlations of the Precambrian rocks within the Granites-Tanami region and with the adjacent Kimberley and Victoria River regions are summarized in Figure 4.

ARCHAEAN OR LOWER PROTEROZOIC

Rocks of Archaean or Lower Proterozoic age form the basement in the area mapped. They comprise the Halls Creek Group, which is confined to the northwest, and the Tanami complex in the rest of the area. The two units are probably stratigraphic equivalents but are in different tectonic provinces, the Halls Creek Group being confined to the East Kimberley region and the Tanami complex to the Granites-Tanami block.

HALLS CREEK GROUP

Olympio Formation

Rocks of the Olympio Formation extend southwards from the Gordon Downs Sheet area into the northwest corner of the Billiluna Sheet area. They crop out extensively in the East Kimberley region, where they have been described by Dow & Gemuts (1969) and Gemuts & Smith (1968). The Olympio Formation is the only formation of the Halls Creek Group that crops out in the area mapped in 1972.

In the Billiluna Sheet area the outcrop area of the Olympio Formation is mostly flat to gently undulating, and is largely covered by superficial deposits. Hence the unit is generally poorly exposed. It consists of interbedded greyish to brownish iron-stained greywacke, siltstone, and shale which have been regionally metamorphosed to schistose greywacke, fine schist, and phyllite of low grade greenschist facies. Also present are minor quartzite and local calcareous lenses. The rocks have a near vertical cleavage or foliation generally parallel to bedding and are commonly cut by quartz veins. The formation is described by Dow & Gemuts (1969, p. 15) as 'a monotonous turbidite sequence of great extent and uniformity which probably once covered the whole of the East Kimberley region'.

TABLE 1. SUMMARY OF STRATIGRAPHY

AGE	Rock units & map symbol	Maximum thickness (m)	Lithology	Stratigraphic relationships	Remarks
CAINOZOIC – QUATERNARY	Qa	?	Sand, silt, clay	Superficial veneer on older units	Alluvial and lacustrine deposits
CAINOZOIC – QUATERNARY	Qe	?	Halite, gypsum	Superficial veneer on older units	Evaporite deposits in salt lakes
CAINOZOIC – QUATERNARY	Qm	?	Sand, and silt	Superficial veneer on older units	Alluvial and aeolian deposits in drainage depressions
CAINOZOIC – QUATERNARY	Qs	?	Sand, minor gravel	Superficial veneer on older units	Mainly aeolian, but includes sand and gravel on piedmont slopes flanking residual hills
CAINOZOIC – QUATERNARY	Qb	?	Grey clay	Superficial veneer on Cla	The Granites Sheet area
CAINOZOIC	Cak, Tt	?	Calcrete, partly silicified to chert	Unconformable on older units	Tt on The Granites Sheet
CAINOZOIC	Czs, Ts		Silcrete	Unconformable on older units	Ts on The Granites Sheet
CAINOZOIC	Stipple	?	Laterite	Veneer on pre-Tertiary units	Capping on topographic rises
MESOZOIC	Undivided possible Mesozoic M?	?	Porous quartzose sandstone	Inferred to be unconformable on Proterozoic rocks	Southeastern part of Lucas Sheet area. No fossils found
MESOZOIC – CRETACEOUS	Larranganni Beds Kl	10	Quartzose sandstone, conglomerate; commonly silicified	Unconformable on Killi Killi Beds and Gardiner Sandstone	Billiluna and The Granites Sheet areas. Terrestrial waterlaid deposits. Unfossiliferous
MESOZOIC – CRETACEOUS	Haslett Beds Kh	10	Quartzose sandstone, siltstone, claystone	Unconformable on Redcliff Pound Group	Stansmore Sheet area. Probable Cretaceous age indicated by Foraminifera cf. <u>Cenosphaera</u>
PALAEOZOIC	Chuall Beds Pzc	150	Quartzose sandstone, lithic sandstone; pelletal, friable	Inferred to be unconformable on Proterozoic rocks	Billiluna Sheet area, southeast of Sturt Creek homestead. No fossils found
PALAEOZOIC	Pedestal Beds Pzs	40	Clayey quartzose sandstone; minor conglomerate, shale, siltstone	Unconformable on Mount Charles Beds and unnamed granite. Inferred to be unconformable on Lucas Formation, Redcliff Pound Group and Antrim Plateau Volcanics	Not present in Billiluna Sheet area. Locally capped by laterite and silcrete. No fossils found
PALAEOZOIC	Lucas Formation Pzl	1000	Friable calcareous and non-calcareous sandstone, siltstone, mudstone; minor limestone and dolomite	Unconformable on Redcliff Pound Group	Not present in Billiluna Sheet area. Only fossils are a possible unidentifiable spore and some minute spheres of uncertain affinities
PALAEOZOIC – CAMBRIAN	Unnamed Cambrian Є	30	Thin bedded micaceous shale, siltstone, lithic sandstone quartzose sandstone	Inferred strongly unconformable on Tanami complex	Northeast corner of The Granites Sheet area. Capped by 2 m pisolitic laterite
PALAEOZOIC – CAMBRIAN	Antrim Plateau Volcanics Єla	?	Amygdaloidal basalt, fine quartzose sandstone, stromatolitic chert	Unconformable on Proterozoic units; overlain unconformably by Pedestal Beds	The Granites Sheet area. Extensive laterite cappings
ADELAIDEAN – EAST KIMBERLEY SUCCESSION – ALBERT EDWARD GROUP	Flat Rock Formation Baf?	?	Sublithic arenite, siltstone, shale	Conformable on Timperley Shale	Northwest part of Billiluna Sheet area
ADELAIDEAN – EAST KIMBERLEY SUCCESSION – ALBERT EDWARD GROUP	Timperley Shale Baj	100+	Micaceous shale, siltstone; minor lithic arenite	Conformable on Elvire Formation	" " "
ADELAIDEAN – EAST KIMBERLEY SUCCESSION – ALBERT EDWARD GROUP	Elvire Formation Bae	390	Siltstone, shale, lithic arenite, quartz arenite	Conformable on Mount Forster Sandstone	" " "
ADELAIDEAN – EAST KIMBERLEY SUCCESSION – ALBERT EDWARD GROUP	Mount Forster Sandstone Bao	200	Sublithic arenite, quartz arenite, conglomerate	Unconformable on Ranford Formation	" " "
ADELAIDEAN – EAST KIMBERLEY SUCCESSION – DUERDIN GROUP	Ranford Formation Bos	10	Micaceous shale, flaggy sublithic arenite	Conformable on Redbank Yard Conglomerate	Northwest part of Billiluna Sheet area
ADELAIDEAN – EAST KIMBERLEY SUCCESSION – DUERDIN GROUP	Redbank Yard Conglomerate Bor	330	Conglomerate, sublithic arenite; minor dolomite	Unconformable on Wade Creek Sandstone	Northwest part of Billiluna Sheet area. Correlated with Moonlight Tillite

Age	Group	Unit	Thickness	Lithology	Relationships	Remarks
CARPENTARIAN OR ADELAIDEAN	EAST KIMBERLEY SUCCESSION	Wade Creek Sandstone Bsw	800+	Sublithic arenite; minor siltstone	Unconformable on Bungle Bungle Dolomite	Northwest Billiluna Sheet area; contacts not exposed here
		Bungle Bungle Dolomite Bsb	300	Banded and brecciated chert, silicified oolite, cherty ironstone, minor lithic arenite. Chert is commonly stromatolitic	Conformable on Mount Parker Sandstone	Northwest part of Billiluna Sheet area. Tentatively correlated with Talbot Well Formation of Birrindudu Group
		Mount Parker Sandstone Bsp	300	Quartz arenite, sublithic arenite; minor conglomerate, siltstone	Strongly unconformable on Halls Creek Group	Northwest part of Billiluna Sheet area. Tentatively correlated with Gardiner Sandstone of Birrindudu Group
CARPENTARIAN OR ADELAIDEAN		Meteorite Crater Beds Bum	1000+	Sublithic arenite, quartz arenite; minor conglomerate		Billiluna Sheet area. No exposed contacts with other units. Could be correlated with either Birrindudu or Redcliff Pound Group
		Boes Beds Bub	350	Sublithic arenite, conglomerate	Probably conformable on Jawilga Beds	Billiluna Sheet area. Possibly correlated with Erica Sandstone
		Jawilga Beds Buj		Lithic and sublithic arenite, chert granule and pebble conglomerate	Probably conformable on Denison Beds	Billiluna Sheet area. Possibly correlated with Murraba Formation
		Denison Beds Bud	28+	Quartz arenite, abundant ripple marks above basal 10 m	Probably unconformable on Pindar Beds	Billiluna Sheet area. Possibly correlated with Lewis Range Sandstone
		Pindar Beds Bur	?	Quartz arenite, lithic and sublithic arenite, pelletal	Conformable on Lake Willson Beds	Billiluna Sheet area. Possibly correlated with Stake Range Sandstone of Birrindudu Group
		Lake Willson Beds Buw	?	Stromatolitic chert, sublithic arenite		Billiluna Sheet area only. Possibly correlated with Talbot Well Formation of Birrindudu Group
		Peterson Beds Bup	1000	Sublithic arenite, quartz arenite, lithic arenite, greywacke, conglomerate, siltstone, dolomitic shaly mudstone	Overlain unconformably by Palaeozoic rocks	Billiluna Sheet area. Separated by inferred fault from Proterozoic rocks to east
		Hidden Basin Beds Buh	3000+	Quartz arenite, sublithic arenite, shale, siltstone	Possibly conformable on Erica Sandstone	Central part of Stansmore Sheet
	REDCLIFF POUND GROUP	Erica Sandstone Bre	700	Sublithic arenite, quartz arenite, siltstone, shale; rare glauconitic sublithic arenite	Conformable on Murraba Formation. In Lucas Sheet area overlain unconformably by Lucas Formation and Pedestal Beds, and by possible Mesozoic. In Stansmore Sheet area overlain possibly conformably by Hidden Basin Beds and by Pedestal Beds. Unconformably overlain by Haslett Beds	Not The Granites Sheet area
		Murraba Formation Brb	800	Chert granule conglomerate, sublithic arenite, quartz arenite, siltstone, shale, dolomite	Inferred to be conformable on Lewis Range Sandstone. Unconformably overlain by Haslett Beds, Lucas Formation and Pedestal Beds	Eastern parts of Lucas and Stansmore Sheet areas
		Lewis Range Sandstone Brl	1000	Quartz arenite, sublithic arenite, conglomerate; minor siltstone	Unconformable on Killi Killi Beds, Lewis Granite, unnamed granite, and Gardiner Sandstone	Billiluna and Lucas Sheet areas. Correlated with Muriel Range Sandstone
		Muriel Range Sandstone Brm	450	Sublithic arenite, quartz arenite, siltstone, shale, conglomerate, breccia	Unconformable on Tanami complex and granite. Inferred to be unconformably overlain by Lucas Formation and Pedestal Beds	Eastern part of Lucas and The Granites Sheet areas. Correlated with Lewis Range Sandstone
		Munyu Sandstone Buu	400	Quartz arenite, locally conglomeratic; limestone lenses	Unconformable on Tanami complex and unnamed granite. Overlain, possibly conformably, by Redcliff Pound Group	Southeast part of Stansmore Sheet area. Possibly correlated with Gardiner Sandstone or with Lewis Range and Muriel Range Sandstones

CARPENTARIAN	BIRRINDUDU GROUP	Stake Range Sandstone Bdk		Lithic arenite	Conformable on Talbot Well Formation	One occurrence only, on Billiluna Sheet area
		Talbot Well Formation Bdt		Stromatolitic chert, sublithic arenite, siltstone, limestone	Conformable on Gardiner Sandstone	Billiluna and The Granites Sheet areas. Laterite or silcrete capping in places
		Gardiner Sandstone Bdg		Sublithic arenite, quartz arenite, siltstone, shale, conglomerate, glauconitic arenite	Unconformable on Tanami complex, Pargee Sandstone and unnamed granite. Overlain unconformably by Lewis Range Sandstone and Larranganni Beds	K-Ar minimum age 1550-1600 m.y. Possibly correlates with Mount Parker Sandstone
LOWER PROTEROZOIC		Unnamed granite Bg	-	Porphyritic and non porphyritic adamellite and granodiorite; veins of pegmatite and aplite	Intrudes Tanami complex. Overlain unconformably by Upper Proterozoic, Palaeozoic? and Mesozoic? sandstone	Locally sheared and foliated. Some lit-par-lit injection zones
		Lewis Granite Bgl	-	Mostly porphyritic adamellite; some granodiorite. Veins of pegmatite and aplite	Intrudes Killi Killi Beds. Overlain unconformably by Lewis Range Sandstone and Gardiner Sandstone	North and east of Lewis Range, Lucas Sheet area. Some lit-par-lit injection zones
		Pargee Sandstone Blg	1500	Sublithic arenite, greywacke, quartz arenite, conglomerate	Unconformable on Tanami complex. Overlain unconformably by Gardiner Sandstone and Muriel Range Sandstone	Billiluna and The Granites Sheet areas. Tentatively correlated with Mount Winnecke Formation and Supplejack Downs Sandstone of Tanami and Birrindudu Sheet areas
ARCHAEAN OR LOWER PROTEROZOIC	TANAMI COMPLEX	Undivided Tanami Complex At	?	Metaquartzite, sublithic arenite; schistose micaceous greywacke, siltstone, mudstone; amphibolite, quartz-ironstone, quartz schist, hematitic schist	Intruded by granite	
		Mount Charles Beds Atc	?	Low grade regionally metamorphosed rocks; banded chert and siltstone, quartzite, phyllitic to schistose greywacke and siltstone, gossanous ironstone, basic volcanics, jaspilite, acid porphyry	Intruded by unnamed granite. Overlain unconformably by Pargee Sandstone, Gardiner Sandstone, Muriel Range Sandstone, Pedestal Beds, Antrim Plateau Volcanics	Correlated with Killi Killi Beds
		Killi Killi Beds Atk		Schistose to phyllitic greywacke, lithic arenite, siltstone, mudstone; regionally metamorphosed to lower greenschist facies. Metaquartzite, banded chert, basalt	Intruded by Lewis Granite and unnamed granite. Overlain unconformably by Pargee Sandstone, Gardiner Sandstone, Lewis Range Sandstone, Muriel Range Sandstone	Correlated with Mount Charles Beds and probably with Halls Creek Group, East Kimberley region
	HALLS CREEK GROUP	Olympio Formation Aho	?	Schistose greywacke, schist and phyllite; minor quartzite, and calcareous lenses	Overlain unconformably by Mount Parker Sandstone	Northwest corner of Billiluna Sheet area only. Probably correlated with Killi Killi Beds

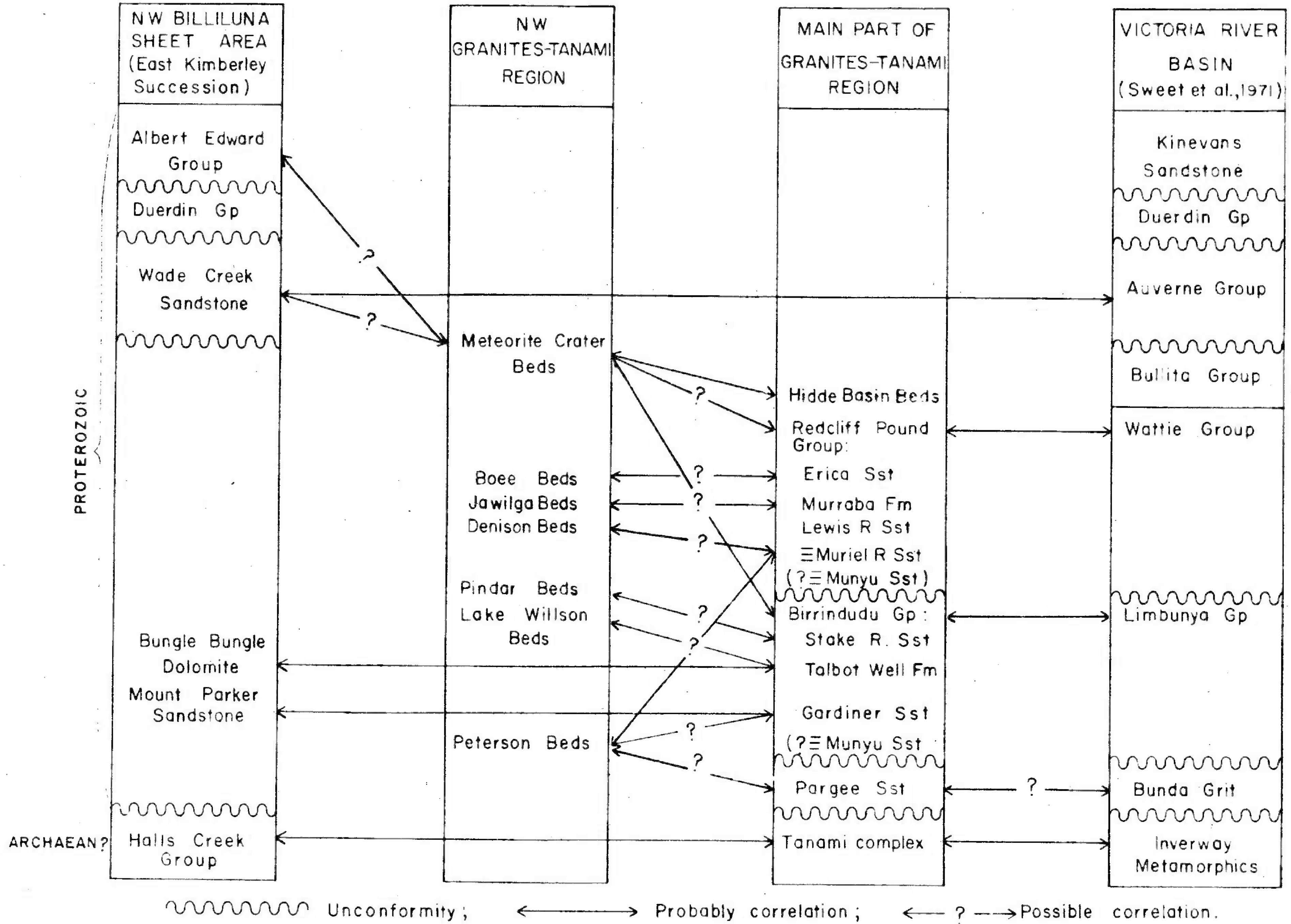

Fig. 4 Correlation chart for the Precambrian rocks of the Granites-Tanami area.

To accompany Record 1973/171

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The only prominent topographic feature formed by the unit in the Billiluna Sheet area is an east-trending ridge at 19°02'50"S, 127°32'30"E. It is about 100 m wide and consists of quartz-veined and brecciated white to pale pink fine quartzite. At the base of the south slope there are exposures of medium to thick-bedded greywacke and associated calcareous lenses a few centimetres thick. The greywackes dip 80° north, and graded bedding shows that they are right way up.

The Olympio Formation is steeply dipping and probably tightly folded, and its thickness is unknown. It is overlain unconformably to the east by gently dipping Mount Parker Sandstone which is probably Carpentarian. This relationship is exposed in a gully on the west side of a sandstone ridge, at 19°05'30"S, 127°31'20"E. The age of the Olympio Formation is uncertain. The Halls Creek Group (Dow & Gemuts, 1969; Gellatly, 1971) is known to be older that 1961 ± 27 m.y., the date given by the Rb/Sr method on metamorphosed equivalents of the group, and is intruded by pegmatite which has been dated less reliably at 2700 m.y. Hence the group could be either Archaean or Lower Proterozoic.

The Olympio Formation can probably be correlated with the Killi Killi Beds of the Tanami complex, as both units are similar in lithology, regional metamorphism, and deformation.

TANAMI COMPLEX

The oldest rocks in the Granites-Tanami region are those of the Tanami complex, named after the abandoned gold mining settlement of Tanami, in the Tanami Sheet area. These rocks were informally named the Tanami Group by Blake et al. (1972). The name has been changed to Tanami complex, because insufficient is known about the relationships between constituent rock units for these units to have the status of formal formations and a formally named group must consist wholly of divisions defined as formations, according to the Australian Code of Stratigraphic Nomenclature (Anon, 1964).

Two units of the Tanami complex crop out in the area mapped in 1972. These are the Killi Killi Beds in the west and Mount Charles Beds in the east. There are also outcrops mapped as undivided Tanami complex.

The Tanami complex consists of mainly low grade regionally metamorphosed sedimentary and volcanic rocks, of which the sedimentary rocks greatly predominate. No thick sequences within the complex have been established, because of tight folding, faulting, and generally poor exposures. However, the complex probably involves a stratigraphic succession several thousands of metres thick.

In many sand covered areas, wavy to contorted trends of rocks of the Tanami complex are visible on aerial photographs. They are indicated by lines of vegetation (dark) and bare vein quartz gravel (very pale), and show that in such areas the sand cover is very thin.

The complex is intruded and thermally metamorphosed by Lewis Granite and unnamed granite, and is unconformably overlain by Lower Proterozoic Pargee Sandstone, Carpentarian Gardiner Sandstone, Carpentarian or Adelaidean Lewis Range Sandstone and Muriel Range Sandstone, and by Lower Cambrian Antrim Plateau Volcanics and younger units.

Rocks of the Tanami complex near Tanami were previously termed the Tanami Metamorphics Series by Jensen (1915), who described them as 'highly metamorphic (probably Pre-Cambrian) mineral-bearing rocks ...... over a wide area around Tanami' consisting largely of metamorphosed and metasomatized volcanic rocks with laminated quartzite, jasper, jasperoid schist and slate. These rocks are now mapped as Mount Charles Beds.

The Tanami complex is probably the stratigraphic equivalent of the Halls Creek Group of the East Kimberley region (Dow & Gemuts, 1969), and is Archaean or Lower Proterozoic.

Killi Killi Beds (Atk)

Low grade regionally metamorphosed rocks mapped as Killi Killi Beds form much of the western part of the Granites-Tanami Block. They crop out in the eastern part of the Billiluna Sheet area, in the Lucas Sheet area north and east of the Lewis Range and northeast and southwest of the Kearney Range, and in the northwest part of The Granites Sheet area, as well as in the western part of the Tanami Sheet area. The Western Australian outcrops were previously mapped as undivided Halls Creek Metamorphics (Casey & Wells, 1964, Wells 1962a and b) and undifferentiated (=undivided) Halls Creek Group (Gemuts & Smith, 1968). The outcrops in Tanami Sheet area are described by Blake et al. (1972), who informally named the unit 'Killi Killi Formation'. This name has been changed to Killi Killi Beds as there is insufficient information available, according to the Australian Code of Stratigraphic Nomenclature (Anon, 1964), to give the unit formation status; neither the top nor bottom are exposed, and relationships to possibly contiguous rock units are uncertain.

The beds are named after the Killi Killi Hills, which straddle the NT/WA border at 19°45'S, in the Billiluna and Tanami Sheet areas. The reference area for the unit is 5 km south of Mount Stubbins, at 19°13'30"S, 128°54'30"E, in the central part of the Gardiner Range, Billiluna Sheet area. Here the main rock types of the Killi Killi Beds - schistose greywacke, lithic sandstone, siltstone, shale, and mudstone - are well displayed in steep hilly terrain.

Most of the outcrop area of the Killi Killi Beds consists of gently undulating and largely sand-covered plain on which there are isolated rocky hills and ridges mainly less than 15 m high. The beds also form foothills over 30 m high around the edges of the Gardiner Range, and this is where they are best exposed: south and east of Mount Stubbins, including the reference area; southeast of Mount Brophy; south and west of Larranganni Bluff; and south and west of Mount Mansbridge.

On aerial photographs the outcrops have variable tones. Around the Gardiner Range they are generally darker than adjacent Carpentarian sandstone, and irregular small folds can be identified. Elsewhere trends are commonly indicated by a fine wavy pattern of light and dark bands, the light bands being due to vein quartz rubble. Most outcrops are poorly defined, as they merge into surrounding sand plain.

The Killi Killi Beds are tightly folded and generally steeply dipping. Some of the folding is probably isoclinal. Complex contortions occur in fold noses, and irregular minor folds are common. Because of the folding, generally poor exposures, and a lack of marker horizons, the thickness of the beds is unknown. A minimum thickness of several thousands of metres has been estimated from aerial photographs.

Lithology

The Killi Killi Beds consist predominantly of interbedded greywacke, lithic arenite, siltstone, mudstone, and shale. These rocks have been regionally metamorphosed to lower greenschist facies, and are now schistose to phyllitic, secondary mica giving a foliation generally parallel to bedding. A fracture cleavage oblique to bedding is also commonly developed (Fig. 5), especially in greywacke and lithic sandstone. Other rock types locally present in subordinate amounts are metaquartzite, banded chert, basalt, dolerite and gabbro. No acid volcanics of the type described from the Tanami Sheet area (Blake et al., 1972) were found in 1972. Thin quartz veins (less than 1 m thick) abound at most exposures, and prominant ridge-forming quartz veins, in places over 5 m thick, are present at a few localities, mainly in the southern part of the Billiluna Sheet area, where they may mark fault lines. Most of the veins are of milky quartz, but there are also some thin veins of bluish-grey quartz, expecially on the northwest side of the Willsons Hills.

Greywacke is mainly medium to fine-grained, but is locally coarse-grained. It is grey to greenish-grey or iron-stained to maroon or yellowish-brown, and generally forms beds 1-2 m thick, some of which show graded bedding. With decreasing matrix greywacke grades into lithic arenite, which is mostly coarser grained and commonly current bedded, and with decreasing grain size is grades into siltstone, mudstone and shale. Some of the siltstone is laminated and shows small scale low-angle cross-bedding. The finer grained beds are generally less than 1 m thick. These five main rock types are present at almost all outcrops of Killi Killi Beds, and are especially abundant in the central and southern parts of the Billiluna Sheet area.

Other rock types within the Killi Killi Beds are relatively rare. Massive fine quartzite, invariably breccia-veined by quartz, is associated with some of the thick quartz veins in the Billiluna Sheet area. Banded chert recrystallized to fine quartzite is present interbedded in the greywacke sequence at a few localities, as south and west of Larranganni Bluff. The chert is similar to that of the Mount Charles Beds.

Basalt is exposed at a few outcrops. One such outcrop is north of the eastern end of the Lewis Range, at 20°24'00"S, 128°52'00"E, where basalt is associated with greywacke, lithic arenite, and phyllitic mudstone, which are cut by granite veins. The basalt here shows pillow-like structures, consisting of dark very fine-grained skins about 1 cm

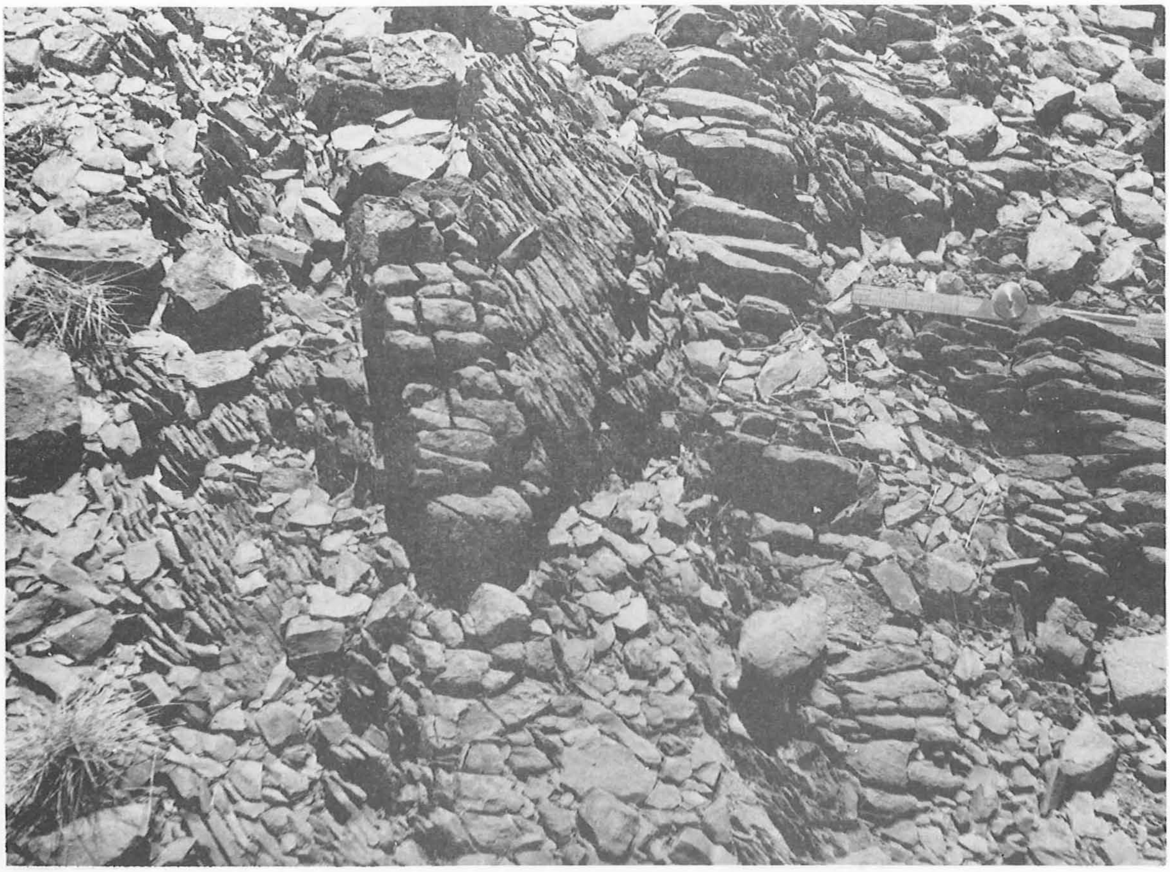


Fig. 5. Thin-bedded schistose greywacke and siltstone of the Killi Killi Beds, showing cleavage oblique to bedding. Northwest part of The Granites Sheet area. Neg. No. M1404/36

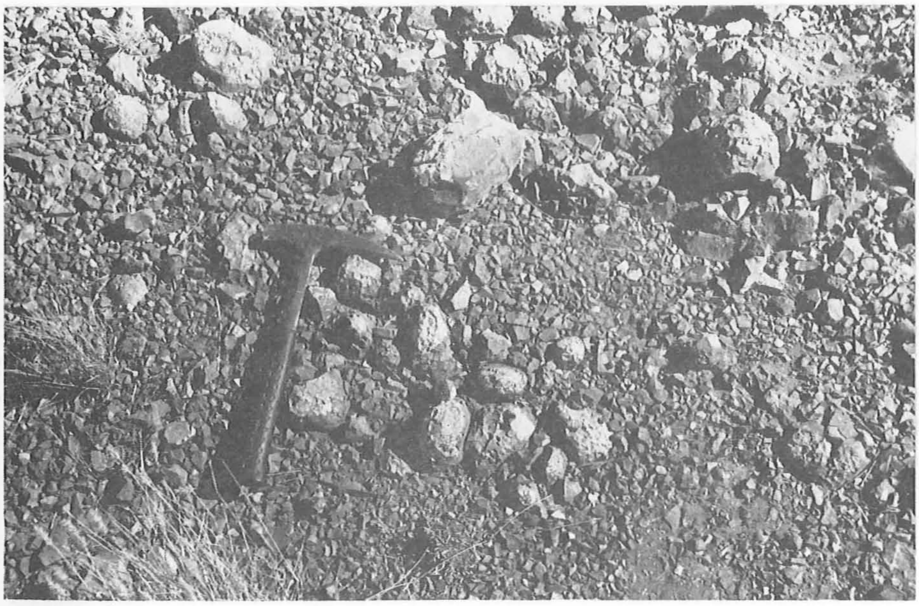


Fig. 6. Basalt of the Killi Killi Beds showing 'popcorn' weathering, 8 km northwest of Bloodwood Bore, Lucas Sheet area. Neg. No. M1356/36

thick enclosing apparently vesicular interiors; some of the basalt shows scaly 'popcorn' weathering (Fig. 6). Altered dolerite and gabbro, consisting of plagioclase and hornblende, are exposed locally, mainly in the southern part of the Billiluna Sheet area, where they probably form sills. They are dark brown to red when weathered. Relict ophitic textures are commonly visible on weathered surfaces. Some dolerite shows onion-skin weathering.

At some localities strongly weathered bedded sedimentary rocks of the Killi Killi Beds are replaced by iron oxide and now consist of lateritic ironstone, forming false gossans. One such gossan forms a small conical hill at 20°16'00"S, 129°08'00" E, east of Nora Range in The Granites Sheet area.

Most of the Killi Killi Beds are in the lower greenschist facies of regional metamorphism. Possible higher grade regional metamorphism may be indicated by the presence of fibrolite, a variety of sillimanite, in some schist. However the fibrolite may be a thermal metamorphic mineral associated with granite intrusions.

Relationships and age

The Killi Killi Beds may be the stratigraphically equivalent to the Mount Charles Beds. However, in The Granites Sheet area the relationship between the two units is uncertain because of complex folding and poor exposures in the contact zone. Both units are part of the Tanami complex, and are made up of similar rock types, though in different proportions; they have suffered comparable regional metamorphism and folding, and have similar relationships to granite and younger units.

The Killi Killi Beds are intruded and thermally metamorphosed by Lewis Granite and unnamed granite. Lit-par-lit injection zones are common at granite contacts; in these zones sheets of granite several metres thick are intercalated within the greywacke-shale sequence, and the sedimentary rocks are metamorphosed to a quartzitic or micaceous hornfels. A lit-par-lit injection zone is particularly well displayed 5 km northeast of Point Nelligan, on the north side of the Lewis Range, Lucas Sheet area.

The beds are unconformably overlain by Pargee Sandstone, which is probably Lower Proterozoic, and by Gardiner Sandstone of the Carpentarian Birrindudu Group and Lewis Range and Muriel Range Sandstones of the Carpentarian or Adelaidean Redcliff Pound Group.

An angular unconformity between the Pargee Sandstone and underlying the Killi Killi Beds is exposed in the northeast part of The Granites Sheet area. An unconformable relationship between steeply dipping and tightly folded Killi Killi Beds and overlying gently dipping Gardiner Sandstone is well exposed around the margins of the Gardiner Range (Figs. 7 and 10) and on the south side of the Killi Killi Hills. A similar relationship with Lewis Range Sandstone is exposed at Tent Hill and to the northwest, and also on the north side of the Lewis Range, and the unconformity with the Muriel Range Sandstone can be seen on the west side of the Wilson Range (Fig. 8).

The Killi Killi Beds can probably be correlated with the Olympio Formation of the Halls Creek Group of the East Kimberleys, and hence may be either Archaean or Lower Proterozoic (Dow & Gemuts, 1969). The two units have similar lithologies, show a similar style of deformation, and both are regionally metamorphosed to lower greenschist facies.

Mount Charles Beds (Atc)

Outcrops of Mount Charles Beds are confined to the northern and central parts of The Granites Sheet area, mapped in 1972, and the southern part of the Tanami Sheet area, mapped in 1971.

The beds are named after Mount Charles, which is also the reference area, situated 22 km northeast of Tanami in the Tanami Sheet area. They were informally named Mount Charles Formation by Blake et al. (1972).

Mount Charles Beds are generally steeply dipping and tightly to probably isoclinally folded. No marker beds have been recognised. Because of these factors, and the widely scattered outcrops, the thickness of the beds is not known, although it is thought to be in the order of several thousands of metres.

Outcrops range from barely perceptible rises to low rounded hills and ridges. Exposures commonly consist of ribs and blocks of rock projecting through rubble or a thin soil cover. On aerial photographs the outcrops have similar patterns and tones to the Killi Killi Beds.

From an economic viewpoint, the Mount Charles Beds are especially important, as they contain all the lodes that have been worked for gold in the Granites-Tanami region. The gold lodes in The Granites Sheet area are described in the section on economic geology.

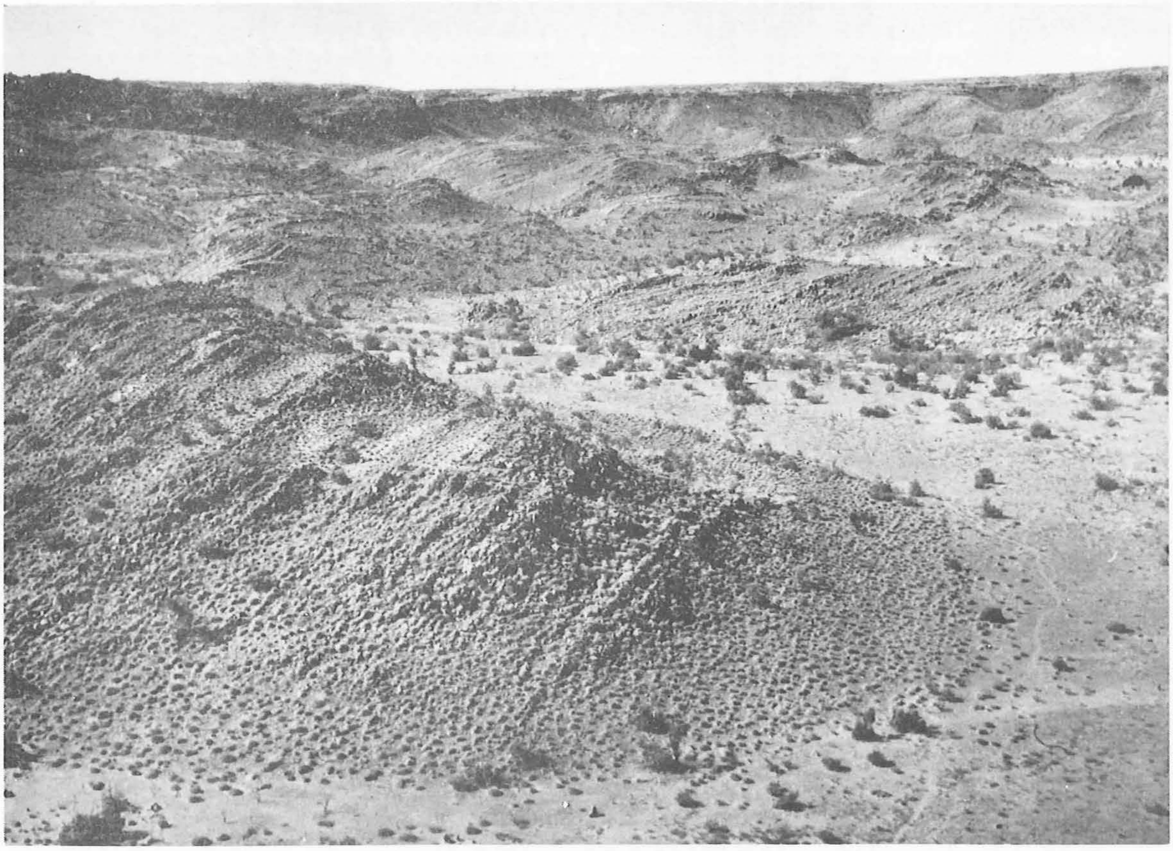


Fig. 7. Tightly folded Killi Killi Beds overlain to northeast (left) and east (right) by gently dipping Gardiner Sandstone. Gardiner Range northeast of Tent Hill, Billiluna Sheet area. Neg. No. GA/7996.

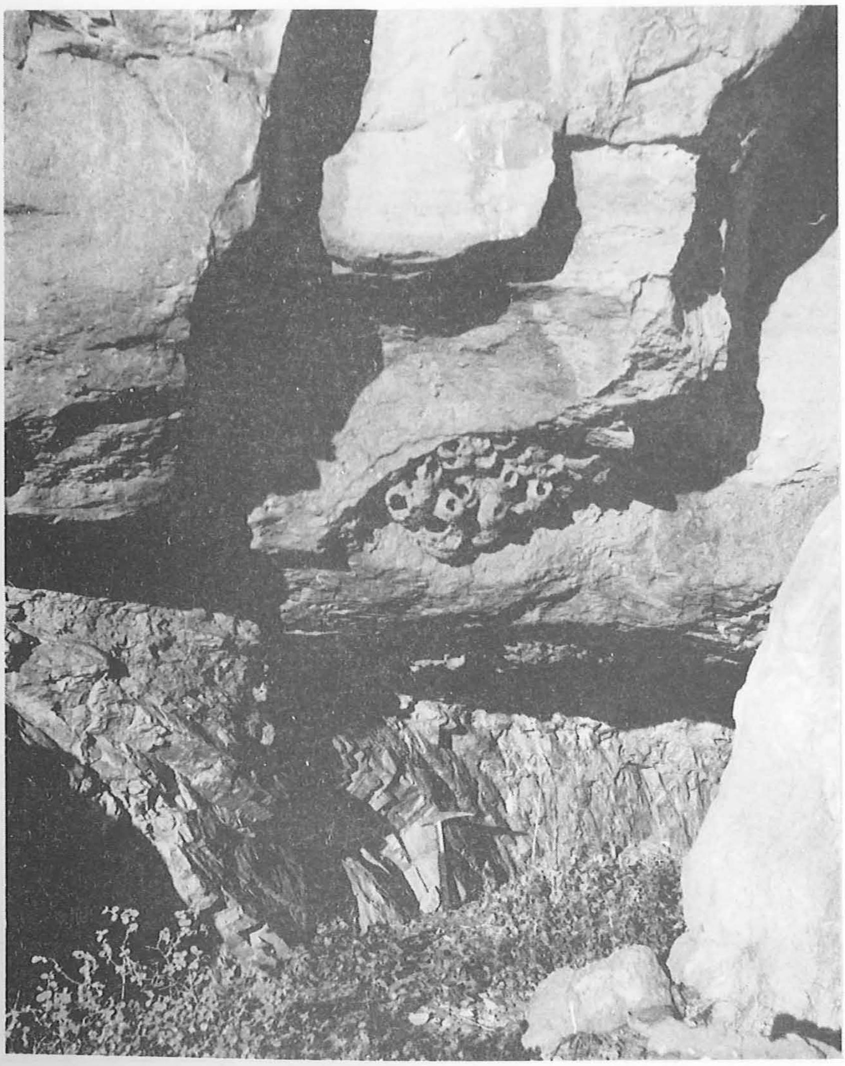


Fig. 8. Steeply dipping Killi Killi Beds overlain by gently dipping Muriel Range Sandstone. Wilson Range, east edge of The Granites Sheet area. Neg. No. M1353/6A.

Lithology

Mount Charles Beds comprise low grade regionally metamorphosed rocks. These are mainly thin-bedded banded chert and siltstone, fine quartzite, phyllitic to schistose greywacke and siltstone, and gossanous ironstone. Basic volcanics are present locally, as also is jaspilite, and acid porphyry is exposed at one locality, 7 km north of Macfarlanes Peak bore. The three main lithological units mapped within Mount Charles Beds in Tanami Sheet area by Roberts (1968) and Blake et al. (1972) have also been recognised in The Granites Sheet area. The three units are characterized respectively by thin-banded chert and siltstone, greywacke-siltstone, and basic volcanics. The distribution of these units is shown on the geological map of The Granites Sheet area. All three units are cut by white and less common blue-grey quartz veins. In places dyke-like masses of fine quartzite breccia-veined by milky quartz form prominent topographic ridges, especially in the east, as at Hordern Hills, Approach Hill, Quartz Ridge, and 12 km north of The Granites airstrip. The regional metamorphic grade is low greenschist facies.

The chert-siltstone unit (Atc), easily the most widespread, consists predominantly of thin banded to laminated chert and silicified siltstone and interbedded phyllitic siltstone. They show complex tight contortions, individual folds commonly being about 1 m across. At many localities the chert and siltstone are recrystallized to quartzite, some of which has a glassy appearance. The recrystallization may be partly a regional metamorphic effect, but some is due to thermal metamorphism associated with granite intrusions. Some chert may be silicified carbonate beds and some may be silicified clayey sediments. Evidence for the latter is the occurrence at some localities (e.g., 13 km northeast of Rabbit Flat) of medium-grained kaolinite bands up to 8 cm thick that pass along strike into chert. The kaolinite was identified, using X-ray diffraction methods, by G.H. Berryman. In many outcrops other rock types are present in mainly subordinate amounts. These are schistose greywacke, gossanous quartz-ironstone, jaspilite, breccia-veined massive quartzite, and amphibolite. The latter rock type is present in the Muriel Range-Officer Hill and Grimswade Ridge areas and also on the wouthwest side of the Farrands Hills. Smears of the copperbearing minerals were found at two localities.

The greywacke-siltstone unit (Atc_1) consists of mainly medium to thin-bedded phyllitic to schistose rocks, with little or no associated chert or quartzite bands, and is similar lithologically to Killi Killi Beds. North of Macfarlanes Peak Range this unit also includes minor amphibolite and acid porphyry.

Outcrops of the third unit, basic volcanics (Atc_2), are large enough to be shown on the 1:250 000 geological map at two localities only, northeast of Rabbit Flat and at Officer Hill, where they have been thermally metamorphosed to amphibolite.

Schistosity, where present, is mainly parallel to bedding. Some beds also show a fracture cleavage oblique to bedding.

Stratigraphic relationships

Mount Charles Beds are intruded by unnamed granite and are overlain unconformably by Lower Proterozoic and younger sedimentary rock units.

Unnamed granite intrudes Mount Charles Beds at several localities: Apertawoonga Ridge, Farrands Hills, northeast of Macfarlanes Peak Range, west of Mount Ptilotus, The Granites goldfield, Ditjiedoonkuna-Grimwade Ridge area, and Muriel Range-Officer Hill area. The granite forms crosscutting veins and dykes and also large batholithic masses around which are metamorphic aureoles several kilometres wide. Within the aureoles Mount Charles Beds are thermally metamorphosed to commonly glassy quartzite, dark fine-grained hornfels, muscovite and muscovite-hematite schist, and amphibolite. Needle-like porphyroblasts of andalusite pseudomorphed by sericitic chiastolite are common in the hornfels and schist, as also are equant iron oxide pseudomorphs which are probably after garnet. Most chiastolite porphyroblasts are less than 1 cm long and 1 mm across. Unaltered garnet has been found only below the zone of weathering at mines in The Granites goldfield.

Mount Charles Beds are seen to be overlain unconformably by Lower Proterozoic Pargee Sandstone west of the Tanami Range, at 20°00'00"S, 129°18'30"E.

Unconformable contacts between Mount Charles Beds and Carpentarian Gardiner Sandstone are exposed in the Bluebush Hills-Tanami Range area and on the east and west sides of the Farrands Hills. A similar relationship between Mount Charles Beds and Carpentarian or

Adelaidean Muriel Range Sandstone in the Muriel Range-Officer Hill area is obscured by faulting. On the north side of Macfarlanes Peak Range the beds are overlain unconformably by sandstone of the Palaeozoic Pedestal Beds, and in the Cave Hill-Smoke Hills area they are overlain by weathered basalt of the Lower Cambrian Antrim Plateau Volcanics.

Correlations and age

The Mount Charles Beds are correlated with the Killi Killi Beds to the west. Both are mapped as part of the Tanami complex, and consist of similar rock types, though in different proportions. They have similar relationships to granite, Pargee Sandstone, and younger rock units, and have undergone comparable deformation and regional metamorphism. Therefore Mount Charles Beds can probably be correlated with the Halls Creek Group of the East Kimberly region, and are either Archaean or Lower Proterozoic.

Undivided Tanami complex (At)

Small scattered outcrops of undivided Tanami complex are present in the northeast and southeast parts of The Granites Sheet area, and in the northeast corner of the Billiluna Sheet area.

In The Granites Sheet area, the northeastern outcrops mainly form ridges of fine-grained metaquartzite, and less commonly partly recrystallized sublithic arenite. The rocks are brecciated and veined by quartz. The quartz veins are locally contorted. The quartzitic rocks are commonly sheared, and are intruded by unnamed granite. Some low lateritic rises in this area may be formed on metamorphic rocks. An example of such a capping was seen east of The Granites Sheet area, at 20°06'00"S, 130°31'30"E. Here schistose micaceous greywacke, siltstone, and mudstone, and associated amphibolite, intruded by granite veins, are exposed in a breakaway capped by pisolitic laterite.

Schistose micaceous greywacke, associated with spotted fine schist and quartzitic breccia, is also exposed 25 km east of Mount Ptilotus.

In the southeast, thin to very thin-bedded metaquartzite and quartz-ironstone crop out 26 km west-southwest of Sangsters Bore; the quartzite is cleaved and has a prominent lineation, so that it breaks into striated rod-like fragments. South-southeast of Sangsters Bore, thin-bedded quartzite, quartz schist, ironstone, hematitic schist, and amphibolite are cut by veins of granite and granite pegmatite.

These rocks are mapped as part of the Tanami complex as they are regionally metamorphosed to quartzite and schist, and are intruded by granite.

In the northeast corner of the Billiluna Sheet area, in the southwest part of the Browns Range dome, a sequence of steeply dipping hornfelsic sublithic arenite crops out. It contains scattered pebbles up to 10 cm long, and is cut by quartz and quartz-tourmaline veins. The sequence is overlain by southwesterly dipping Gardiner Sandstone. To the north and east, in the Gordon Downs and Tanami Sheet areas respectively, there are outcrops of schist and quartzite that are probably part of the same sequence (Gemuts & Smith, 1968; Blake et al., 1972).

LOWER PROTEROZOIC

Pargee Sandstone (Ꝑgl)

Outcrops of Pargee Sandstone were mapped in The Granites and Billiluna Sheet areas. The formation is named after the Pargee Range, and the type area is in the West Pargee Range, in the Tanami Sheet area (Blake et al., 1972). It was previously mapped as part of the informally named Tanami Group, now named the Tanami complex, but has since been found to overlie the complex unconformably.

The Pargee Sandstone is steeply dipping to overturned, and forms prominent strike ridges, some over 20 m high. It has a maximum exposed thickness of about 1500 m in The Granites Sheet area and about 1250 m in the Billiluna Sheet area.

Lithology

The formation consists of sublithic arenite, greywacke, quartz arenite, and conglomerate. It is mostly medium bedded, but bedding is not always well defined. Cross-cutting quartz veins are very common. Some outcrops have patchy cappings of silcrete.

Sublithic arenite, the main rock type, is typically poorly sorted and medium to coarse or very coarse-grained. It has a quartz overgrowth cement and a generally sparse sericitic matrix. Current bedding is common. Many beds contain scattered pebbles of chert, jasper, vein quartz, and other rock types from the Tanami complex. Bands of gritty and pebbly sandstone occur locally, mainly near the base of the formation. Clasts are mostly angular to subangular, rarely well rounded.

Medium to coarse-grained micaceous greywacke and quartz arenite are locally interbedded with sublithic arenite west of the Tanami Range in The Granites Sheet area, and polymictic conglomerate is common near the base of the formation. The conglomerate is made up of pebbles derived from rocks of the Tanami complex.

Stratigraphic relationships, correlations, and age

The Pargee Sandstone unconformably overlies Killi Killi and Mount Charles Beds of the Archaean or Lower Proterozoic Tanami complex, and is unconformably overlain by both Carpentarian Gardiner Sandstone and Carpentarian or Adelaidean Muriel Range Sandstone. The unconformable contact on Killi Killi Beds is exposed at two localities in The Granites Sheet area, at 20°01'00"S, 129°14'00"E and 20°04'30"S 129°08'00"E. A similar contact with Mount Charles Beds can be seen at 20°00'00"S, 129°18'30"E, west of the Tanami Range. The unconformity between the Pargee Sandstone and the younger Gardiner Sandstone can be seen at the northwest end of the Gardiner Range, 19°02'S, 128°28'E, in the Billiluna Sheet area. Muriel Range Sandstone overlaps on to steeply dipping Pargee Sandstone in the Wilson Range at 20°22'30"S, 129°02'45"E.

The relationship of Pargee Sandstone to granite is not known, as the two rock units are not seen in contact with each other.

The stratigraphic relationships show that the Pargee Sandstone is younger than the Tanami complex and older than the Gardiner Sandstone. Hence the Pargee Sandstone is probably Lower Proterozoic, and it is mapped as part of the Granites-Tanami Block. It is tentatively correlated with the Mount Winnecke Formation and the Supplejack Downs Sandstone that crop out in the Tanami and Birrindudu Sheet areas (Blake et al., 1972).

Lewis Granite (Egl)

Casey & Wells (1964) and Wells (1962 a and b) mapped the granite cropping out in the Billiluna and Lucas Sheet areas as a single rock unit, which they named 'Lewis Granite'. However, this name is restricted by the present authors to granite cropping out north and east of the Lewis Range, in the Lucas Sheet area, because all the granite here, but not elsewhere, probably belongs to part of the same intrusive mass. Granite elsewhere in the area mapped in 1972 is unnamed: it is exposed in widely separated outcrops and probably belongs to several separate intrusions which may or may not be related to the Lewis Granite.

Casey & Wells (1964) selected the Lewis Range as the type locality. As this range covers an extensive area, we have chosen a more precise locality as the type area - a hill about 40 m high, situated 1 km northwest of Point Nelligan, at 20°11'30"S, 128°38'00"E, where the main rock types of the Lewis Granite are well exposed.

The Lewis Granite crops out on scarp faces up to 80 m high along the north and east sides of the Lewis Range, where it is unconformably overlain by Lewis Range Sandstone. Along the scarp the sandstone dips very gently south and east and forms cappings generally less than 5 m thick on the granite (Fig. 14). In many places the granite is partly or completely obscured by fallen blocks of sandstone or banked-up windblown sand. On the sides of the hill in the type area, large slabs of sandstone, remnants of a boulder scree, rest on small pedestals of weathered granite (Fig. 18). The granite immediately below the sandstone is friable and kaolinized, but becomes more coherent and generally less weathered several metres below the unconformity. At these outcrops along the scarp the granite commonly forms convex surfaces many metres across.

North and east of the Lewis Range scarps the granite forms tors of rounded to angular blocks and boulders, low mounds with rubbly surfaces, flat-topped hills capped laterite.

On aerial photographs the granite has a range of grey tones which are generally lighter than those of adjacent sedimentary and metamorphic rocks. Characteristically, the granite exposures are surrounded by gently sloping aprons of coarse granitic sand which shows up as pale grey to white tones on aerial photographs.

Northeast of Point Nelligan the granite is well exposed in a lit-par-lit injection zone. Layers of granite alternate with layers of greywacke, mapped as Killi Killi Beds, that have been thermally metamorphosed to a micaceous hornfels. The layers of granite and hornfels are up to 30 m thick and dip 40° east. The hornfels layers are also intruded by some cross cutting veins of granite.

Lithology

The Lewis Granite is mainly a pink sh to pale grey muscovite adamellite or muscovite-biotite adamellite. However, the most western outcrops consist of biotite adamellite and granodiorite (these may be better mapped as unnamed granite), and some biotite adamellite is also present north of Point Nelligan. The adamellite is medium to coarse-grained and at most exposures is porphyritic, containing abundant white phenocrysts of feldspar over 1 cm long. Close to the granite margins the phenocrysts show a well defined flow alignment parallel to the contacts. Away from the contacts the flow alignment varies from poorly to well defined and is irregular. Consistent flat-lying orientations of phenocrysts in the granite immediately below Lewis Range Sandstone along Lewis Range indicate that the top of the granite exposures here may be close to the original roof of the intrusion.

Gently and steeply dipping cross-cutting sheets of pegmatite and aplite, generally less than 0.5 m thick, are common within the Lewis Granite, and quartz veins, sparse dark fine-grained biotite-rich xenoliths, and rare slickensided surfaces are also present. The pegmatites consist of quartz and pale pink feldspar crystals several centimetres across and subordinate books of muscovite up to 5 cm across; graphic intergrowths of quartz and alkali feldspar are common.

Several specimens have been examined in thin section. In some of these the quartz is strained and partly granulated. Plagioclase and alkali feldspar are present in about equal proportions. Most of the plagioclase is probably oligoclase as it has refractive indices slightly less than those of quartz. It is weakly zoned and forms subhedral crystals which show alteration, especially in the cores, to sericite, muscovite, clay minerals, and in some cases, epidote, calcite, and zeolite. Alkali feldspar forms both anhedral crystals and subhedral to euhedral phenocrysts. These are generally of microcline, less commonly orthoclase, and are variably turbid owing to patchy alteration to clay minerals. Muscovite appears quite fresh, but biotite, which is brown and has pleochroic haloes, is commonly partly altered to chlorite and epidote. Apatite, fluorite, metamict minerals and zircon are common accessories, and some specimens also contain tourmaline.

Relationships and age

The Lewis Granite intrudes Killi Killi Beds, which are Archaean or Lower Proterozoic, and is overlain unconformably by Carpentarian or Adelaidean Lewis Range Sandstone along the Lewis Range. It is also overlain unconformably by Carpentarian Gardiner Sandstone on the north side of the Nora Range. Here aplitic Lewis Granite intrudes quartzitic hornfels of the Killi Killi Beds and is overlain by southerly dipping Gardiner Sandstone.

Samples of Lewis Granite collected in 1972 are being dated by R.W. Page using the Rb-Sr method, but no results are available at present. The granite is considered to be similar in age to the other granites in the Granites-Tanami area, and hence is probably late Lower Proterozoic.

Unnamed Granite (Ɛg)

Outcrops of unnamed granite are present in each of the sheet areas mapped. The granite intrudes metamorphic rocks of the Archaean or Lower Proterozoic Tanami complex and is overlain unconformably by Carpentarian and younger units. The granite at all the outcrops is believed to be of similar age - Lower Carpentarian. Several samples are being isotopically dated by R.W. Page using the Rb/Sr method.

The granite exposures mainly consist of friable weathered rock underlying scarp-forming sandstone, and isolated tors and rounded boulders of unweathered granite surrounded by granitic sand. On aerial photographs weathered granite shows up as pale grey tones, but tors have dark tones and are surrounded by the very pale tones of granitic sand.

Billiluna Sheet area

Outcrops of unnamed granite are confined to the southeast part of the Sheet area, where they were previously mapped as Lewis Granite (Wells, 1962a; Casey & Wells, 1964). The granite intrudes Killi Killi Beds and is overlain unconformably by Carpentarian Gardiner Sandstone and Carpentarian or Adelaidean Lewis Range Sandstone. The most extensive exposures underlie Lewis Range Sandstone which forms a prominent scarp north and west of Tent Hill. The granite forming the lower part of the scarp faces is generally friable and much weathered.

Away from the scarp isolated tors and boulders are composed of mainly unweathered granite. The weathered granite is white owing to the alteration of feldspar to kaolin.

About 75 km east-southeast of Billiluna homestead medium to fine, even grained muscovite granite contains tourmaline. This granite forms a lit-par-lit injection zone with hornfelsed greywacke of the Killi Killi Beds. Kaolinized muscovite granite crops out 25 km to the southwest, 8 km east of Errols Bore.

Granite underlying Lewis Range Sandstone west and north of Tent Hill, and at Tent Hill itself is mostly medium-grained and non porphyritic, although some feldspar phenocrysts are present locally. It is cut by veins of muscovite granite pegmatite and aplite (muscovite microadamellite), and locally is weakly foliated and sheared. In places it forms a lit-par-lit injection zone with schistose Killi Killi Beds. The main granite types are pale muscovite adamellite, and biotite-muscovite adamellite, petrographically similar to the adamellites or the Lewis Granite. In places, quartz and alkali feldspar form graphic intergrowths.

At exposures some 45 km southwest of Tent Hill two types of granite are present, biotite adamellite and biotite granodiorite. Both are grey, medium to fine-grained, and contain dark fine-grained xenoliths. The adamellite and granodiorite consist of quartz, some of which is strained; sodic plagioclase partly altered to white mica and clay minerals; alkali feldspar, mainly microcline, which is subordinate to plagioclase in the granodiorite; brown biotite partly altered to epidote and chlorite; and accessory apatite, metamict minerals, muscovite, opaques, sphene, and zircon.

Lucas Sheet area

Unnamed granite crops out near Mount Hughes and on the west and possibly northeast sides of the Kearney Range. At these outcrops the granite, previously mapped as Lewis Granite (Wells, 1962b) is generally deeply weathered and poorly exposed. It is a mostly porphyritic adamellite within which there are quartz-feldspar-muscovite-tourmaline pegmatites. On the west side of Kearney Range a strong foliation in the granite, defined by biotite and quartz, is parallel to fault lines in the adjacent Lewis Range Sandstone.

Stansmore Sheet area

Granite has been seen at one locality only, 40 km south-southeast of Redcliff Pound. Here weathered granite, cut by veins of pegmatite, underlies about 2 m of flat-lying silicified sandstone and associated silcrete mapped as Cretaceous Hazlett Beds. The granite is medium-grained and consists of quartz, altered feldspar, muscovite, and minor tourmaline. A pebble of granite was found in calcrete bordering a creek draining westwards into Lake Wills, on the west side of the Murraba Range.

The Granites Sheet area

Granite crops out in the following parts of this Sheet area.

1. Near the western margin, 20 km north-northeast of Wilsons Cave Bore, where medium to fine-grained friable strongly weathered granite is unconformably overlain to the south by gently dipping Gardiner Sandstone.

2. North and east of Macfarlanes Peak Range, where medium to fine-grained partly porphyritic and locally sheared and foliated granite intrudes Mount Charles Beds. In places the contact consists of a lit-par-lit injection zone. Both the granite and intruded rocks are cut by veins of quartz, pegmatite, and aplite, and are overlain unconformably to the south by flat-lying to gently dipping sandstone of the Palaeozoic Pedestal Beds.

3. Northwest of Murdoch Cliffs, south-southeast of Mongrel Downs. Here much weathered medium-grained non-porphyritic biotite granite forms low exposures north of southerly dipping Carpentarian or Adelaidean Muriel Range Sandstone.

4. South of Sangsters Bore, in the southeast corner of the Sheet area. Here metamorphic rocks mapped as undivided Tanami complex are cut by granite veins, some of which are concordant with the foliation of the intruded rocks. Pegmatite veins containing tourmaline are associated with the granite. Rounded boulders of weakly foliated granite are exposed to the south, just inside the Highland Rocks Sheet area.

5. Northeast corner of the Sheet area, where much weathered pink medium-grained granite has intruded quartzite of the Tanami complex.

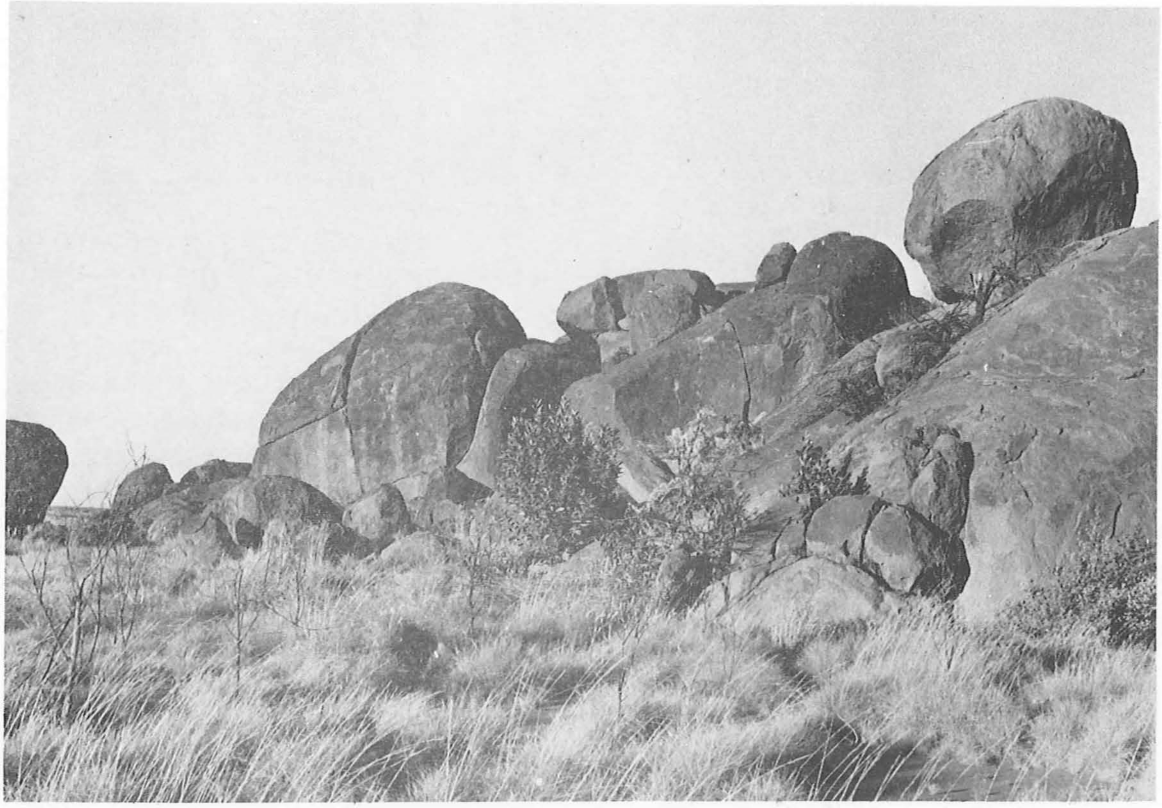


Fig. 9. Unnamed granite exposed 5 km southeast of Approach Hill, east of The Granites Sheet area. Neg. No. M1402/30.

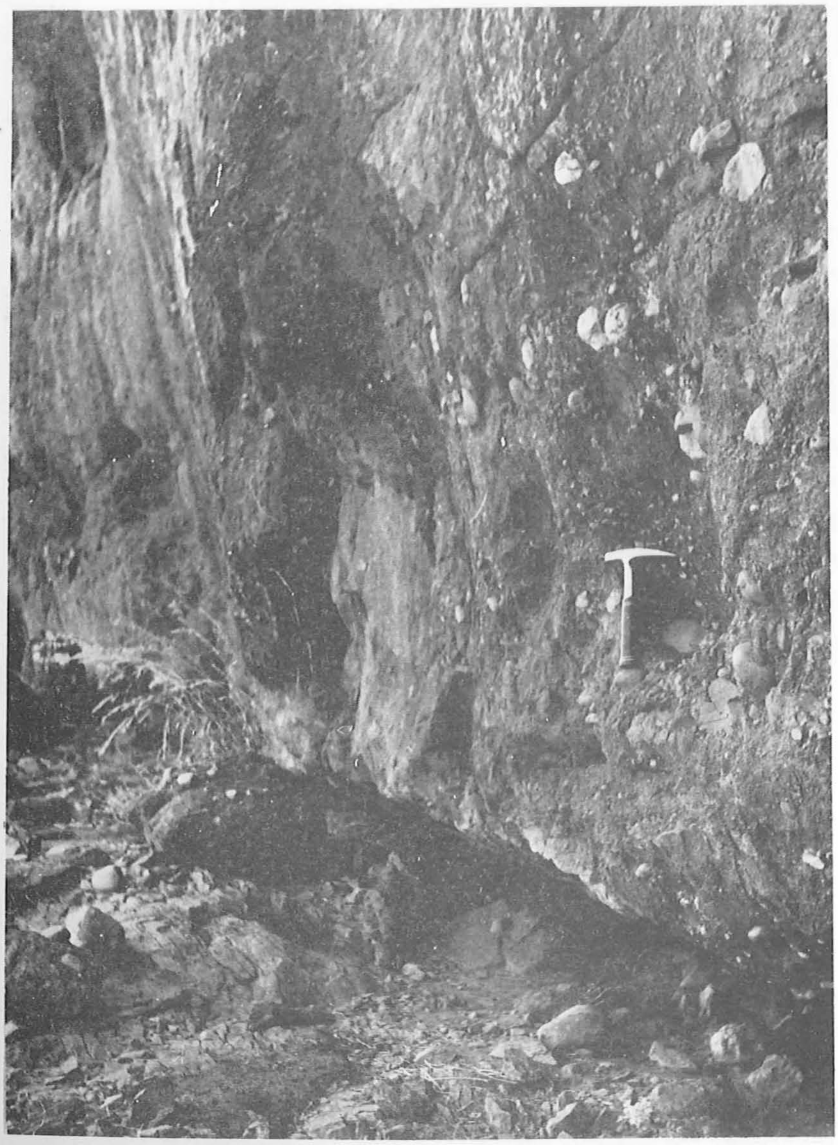


Fig. 10. Conglomeratic sandstone at the base of the Gardiner Sandstone unconformable on cleaved Killi Killi Beds. Gardiner Range northeast of Tent Hill. Billiluna Sheet area. Neg. No. M1352/23.

6. Southeast part of Farrands Hills, northeast of Rabbit Flat. Deeply weathered medium-grained biotite granite exposed in a creek bed is overlain unconformably by Gardiner Sandstone. The granite has 3X background radioactivity.

7. On the north side of the Muriel and Inningarra Ranges, southwest of Mongrel Downs. Granite here forms spheroidal boulders and tors where fresh, and more angular blocky and rubbly outcrops where weathered. It intrudes the Mount Charles Beds, and both units are cut by pegmatite, aplite and quartz veins. The granite is cheared at a faulted contact to the south with southerly dipping Muriel Range Sandstone, and is incorporated in a fault breccia 10 km south of Wild Potato Bore. The granite has up to 4X background radioactivity.

8. Northwest of Dr Abbotts Bore, 25 km southeast of Mongrel Downs. Here deeply weathered medium-grained granite forms isolated hilly outcrops.

9. East-northeast of Dr Abbotts Bore, 7 km east of Blackwood Bluff, where medium-grained leucocratic weathered granite is exposed in a small claypan. Blackwood Bluff itself is formed of flat-lying Muriel Range Sandstone, the basal beds of which consist of coarse sandy granitic detritus.

10. Southwest of the Hordern Hills, 20 km southwest of The Granites. Tors at this locality are formed of both rounded blocks and spheroidal boulders of unweathered grey granite and angular blocks and rubble of weathered pink granite. In the west, dykes and veins of granite containing pyrite intrude Mount Charles Beds.

11. The Granites. Here unweathered granite forms prominent tors, and also rounded blocks partly concealed by overlying sand. Soft and disaggregated weathered granite is exposed in some shallow gullies. The granite has intruded and thermally metamorphosed Mount Charles Beds, and at some of the mine workings the meatmorphic rocks are cut by veins of granite. The intrusive relationship was reported first by Madigan (in Kleeman, 1934) and later by Hossfeld (1940 a and b).

12. Southeast of Approach Hill, on the eastern margin of the Sheet area. Granite crops out 2 km southeast of this hill and more extensively as tors and spheroidal boulders a further 3 km southeast, just inside the Mount Solitaire Sheet area (Fig. 9).

Petrography

Samples of granite from localities 4, 7, 10, 11, and 12 have been examined in thin section, and a specimen from The Granites was previously described petrographically by Kleeman (1934). All the samples are of grey medium to fine-grained biotite adamellite which commonly contains poikilitic alkali feldspar phenocrysts over 1 cm across, and dark fine-grained xenoliths, some over 1 m long. Fine-grained adamellite at The Granites also contains biotite and quartz phenocrysts.

Quartz is generally strained and locally granulated. Plagioclase and alkali feldspar are present in about equal proportions. Plagioclase forms subhedral crystals mostly of oligoclase composition, though in some specimens the crystals have cores of andesine (An content up to 40%); the plagioclase shows weak normal zoning and is partly altered, especially in the cores, to sericite, muscovite, epidote, clay minerals, and in a few cases sparse calcite. Some myrmekitic intergrowths with quartz are present in some specimens. The alkali feldspar is microcline, which is mainly anhedral, slightly perthitic, and shows little or no alteration. Biotite is brown or greenish-brown and has pleochroic haloes around inclusions; it is patchily altered to chlorite, epidote and white mica. Accessory minerals in the granites include apatite, zircon, and allanite, primary epidote, fluorite, metamict minerals, opaque minerals, and sphene.

Kleeman (1934) gives the following chemical and modal analyses of adamellite from The Granites.

Chemical analysis	(wt %)
SiO_2	71.55
TiO_2	0.39
Al_2O_3	15.00
Fe_2O_3	0.56
FeO	2.13
MnO	0.04
MgO	0.14
CaO	2.18
Na_2O	3.92
K_2O	3.68
H_2O-	0.05

Modal analysis	(volume %)
Quartz	34.4
Microcline	26.0
Plagioclase	32.6
Biotite	6.5
Sphene	0.5

Chemical analysis	(wt%)
H_2O+	0.43
P_2O_5	0.19
ZrO	0.04
S	0.06
Total	100.36

CARPENTARIAN

BIRRINDUDU GROUP

The Birrindudu Group comprises the Gardiner Sandstone, Talbot Well Formation, and the Coomarie Sandstone. Rocks of the group form the Gardiner Range and Killi Killi Hills in the Billiluna Sheet area, and also crops out, but less extensively, in The Granites, Lucas and possibly Stansmore Sheet areas. Widespread outcrops in the adjoining Tanami and Birrindudu Sheet areas were described by Blake et al. (1972). The constituent units are grouped together because they form a conformable sequence with unconformities at the top and bottom. The group consists predominantly of sublithic arenite and is thickest in the Gardiner Range, where about 2500 metres is exposed.

The Birrindudu Group rests with strong angular unconformity on the Archaean or Lower Proterozoic Tanami complex, on Lower Proterozoic Pargee Sandstone and on unnamed granite. It is overlain unconformably by the Lewis Range Sandstone, the basal member of the Carpentarian or Adelaidean Redcliff Pound Group, by flat-lying Cambrian Antrim Plateau Volcanics and by probably Cretaceous Larranganni Beds. Glauconite from near the top of the Gardiner Sandstone has been dated at 1550-1620 m.y., indicating that the Birrindudu Group is Carpentarian.

Gardiner Sandstone (Ɛdg)

The Gardiner Sandstone, the oldest formation of the Carpentarian Birrindudu Group, crops out extensively in the Billiluna Sheet area where it forms the prominent Gardiner Range and also Killi Killi Hills. It also crops out in The Granites Sheet area where it forms the Bluebush Hills, Farrands Hills, Nora Range, and Tanami Range. On the border of the Lucas and Stansmore Sheet areas, some low, northwest-trending strike ridges of sublithic arenite have been mapped as possible Gardiner Sandstone. Two narrow fault-bounded bands of quartz arenite north of the Lewis Range, Lucas Sheet area, are also mapped as possible Gardiner Sandstone.

The formation was mapped as Gardiner Beds and named after the Gardiner Range by Casey & Wells (1964), who described a type section 320 feet thick (about 97 metres) at Larranganni Bluff, on the eastern margin of the Billiluna Sheet area. The maximum exposed thickness of the formation is about 200 m, in the Gardiner Range northwest from Mount Stubbins.

In the area mapped, the Gardiner Sandstone has a medium to light tone on aerial photographs and bedding traces and joint patterns are clearly visible.

In most places the Gardiner Sandstone has low dips, and it commonly forms plateaux bounded by scarps up to 100 m high. Where the sandstone dips at 10° or more, as in the Nora Range and Farrands Hills it forms strike ridges up to about 30 m high. In the central part of the Gardiner Range the formation has been folded gently into an east-trending elongate shallow basin. In The Granites Sheet area the main outcrops of Gardiner Sandstone are widely spaced and do not appear to constitute any major structural unit.

Lithology

The Gardiner Sandstone consists predominantly of sublithic arenite. Quartz arenite, conglomerate, and shale with thinly interbedded siltstone and fine arenite are present in minor proportions. Glauconite occurs in sublithic arenite and quartz arenite near the top of the formation.

The sublithic arenite and quartz arenite are mostly medium-grained but range from coarse to fine. They are invariably cross-bedded and in places ripple marks are common. Locally they contain scattered pebbles about 5 cm across and also lenses of conglomerate. Bedding ranges in thickness from a few centimetres to a metre or more. Near the base of the formation sublithic arenite is in places micaceous.

Conglomerate is best developed near the base of the formation, above the unconformable contact with the underlying Tanami complex. Here it is up to about 12 m thick and is composed of poorly sorted rounded to angular pebbles mainly of vein quartz, greywacke, phyllite, and quartzite. Boulders up to about 30 cm across are present locally. The basalt conglomerate is well exposed on the south and west sides of the Gardiner Range and near Mount Mansbridge. At 19°11'S, 128°53'20"E, northeast Gardiner Range, many boulders of conglomerate of the type typical of the Pargee Sandstone litter the ground, having been weathered out of the Gardiner Sandstone conglomerate. In The Granites Sheet area, west of the northern part of Bluebush Hills, at 20°11'30"S, 129°35'06"E, conglomerate is well exposed in a rise where it dips at about 35° toward Bluebush Hills. At the Killi Killi Hills the basal conglomerate of the Gardiner Sandstone contains concentrations of uranium and rare earths (See section on economic geology). Small lenses and thin bands of conglomerate are also present scattered throughout the formation.

Shale is best exposed in gullies at the base of sandstone scarps, as at Larranganni Bluff, and along the west side of Bluebush Hills. These exposures, and also a thick sequence of shale exposed in Farrands Hills, are near the base of Gardiner Sandstone. The shale is mostly maroon and greenish, and includes thin interbeds of siltstone and fine sublithic arenite.

Glauconitic sublithic arenite and quartz arenite occur within 500 m of the top of the formation and form useful marker horizons. In the northwest part of the Gardiner Range and in the Farrands Hills two glauconitic bands were identified. Samples of glauconitic sandstone have been isotopically dated using the K-Ar method (see below).

The type section at Larranganni Bluff is described by Casey & Wells (1964) as, in descending order:

60 feet (18 m)	Sandstone; hard silicified medium-grained, strongly jointed, current and wave ripple-marked, with thin beds containing moulds of clay pellets.
100 feet (30 m)	Sandstone; flaggy with minor interbedded micaceous shale; much clay pellet conglomerate.
120 feet (36 m)	Sandstone; light brown to yellow brown, rarely green, laminated, micaceous in beds up to two inches thick alternating with shale; chocolate brown, micaceous, in beds up to one foot thick.

40 feet (12 m)	Conglomerate; boulders up to 1 foot of slate, quartz greywacke, and quartz from underlying metamorphics. Fragments irregular, subrounded to subangular, average diameter 1 inch. Quartz greywacke fragments generally ellipsoidal and subrounded; quartz pebbles subangular and irregular. Quartz grains of matrix average 1.5 mm in diameter.

Unconformity

Lower Proterozoic Halls Creek Metamorphics (Killi Killi Beds); quartz greywacke, slate, and subgreywacke intruded by quartz and quartz-hematite veins.

At the base of Larranganni Bluff, at 19°33'S, 128°57'E, the lowest beds exposed are 10 m of thinly interbedded micaceous sublithic arenite, quartz arenite and flaggy dolomitic arenite.

In the Gardiner Range northwest from Mount Stubbins the following sequence is exposed in descending order:

Talbot Well Formation: Chert

40 m	Medium to coarse-grained quartz arenite and sublithic arenite, medium to thin-bedded. Upper few metres; medium-grained sublithic arenite and laminated sublithic arenite and siltstone.
10 m	Glauconitic sublithic arenite, medium-grained.
1100 m	Well sorted, mainly medium-grained quartz arenite; low-angle cross-bedding and ripple marks; some scattered well rounded pebbles and cobbles; medium to thick-bedded; some pebble rich bands and gritty layers. Near top flaggy and thin-bedded, low angle cross-bedding.
30 m	Flaggy sublithic arenite.
20 m	Thin-bedded micaceous siltstone, shale and fine sublithic arenite.
800 m	Medium to coarse-grained, variably sorted sublithic arenite and quartz arenite, cross-bedded, locally gritty with some pellety bedding planes; some thinly interbedded flaggy fine sublithic arenite and micaceous siltstone.
200 m	Cross-bedded medium to coarse-grained sublithic arenite with some pebble and conglomerate bands.

Unconformity

Killi Killi Beds

In the Nora Range, on the western edge of The Granites Sheet area, the Gardiner Sandstone is much thinner, the following sequence is present, in descending order:

	Talbot Well Formation; stromatolitic chert.
70m	Medium to coarse-grained quartz arenite and sublithic arenite, mainly thin-bedded.
10m	Variably glauconitic sublithic arenite and quartz arenite, medium to thin-bedded.
400m	Medium to coarse-grained sublithic arenite and quartz arenite; medium to thin-bedded, cross-bedded, some ripple marks and pelletal and pebbly horizons; minor interbeds of laminated siltstone.
0-4m	Conglomerate.
	Unconformity
	Granite and Killi Killi Beds.

In the Farrands Hills, in the northeast part of The Granites Sheet area the top of the Gardiner Sandstone is not exposed. Here the sequence is, in descending order:

250m	Medium to thin-bedded and flaggy medium-grained quartz arenite and sublithic arenite, ripple marked.
10m	Medium to coarse-grained glauconitic sublithic arenite.
150m	Medium-grained, medium to thin-bedded sublithic arenite, low-angle cross-bedding, some pelletal bedding planes.
10m	Variably glauconitic medium-grained quartz arenite, thin-bedded and flaggy, also pelletal.
500m	Medium to thin-bedded, medium to coarse-grained quartz arenite and sublithic arenite, cross-bedded, some pelletal bedding planes; minor thin-bedded to laminated siltstone and fine sublithic arenite.
10m	Coarse conglomerate, forms rounded strike ridge.
200m	Thinly interbedded shale, siltstone, and fine sublithic arenite, micaceous.

100m Mainly thin-bedded medium to coarse-grained quartz arenite and sublithic arenite, some ripple marks, low-angle cross-bedding. Conglomerate developed locally.

Unconformity

Granite and Mount Charles Beds.

Stratigraphic relationships

The Gardiner Sandstone is the basal member of the Carpentarian Birrindudu Group. It is unconformable on the Killi Killi Beds and the Mount Charles Beds of the Tanami complex, and Lower Proterozoic Pargee Sandstone and unnamed granite. The unconformable relationship with the Killi Killi Beds is well exposed around the scarp bounding the south and west edges of the Gardiner Range (Figs. 7 and 10) that with Mount Charles Beds is exposed on the margins of the Bluebush and Farrands Hills, and that with the Pargee Sandstone can be seen northwest of Mount Mansbridge. The contact with the unnamed granite is exposed in The Granites Sheet area on the north side of the Nora Range and on the southeast side of Farrands Hills. In the northeast corner of the Billiluna Sheet area the Gardiner Sandstone is also seen to be unconformable on undivided Tanami complex.

The Gardiner Sandstone is overlain conformably in the Gardiner and Nora Ranges by the Talbot Well Formation, and it is overlain unconformably in the Gardiner Range by the Lewis Range Sandstone of the Redcliff Pound Group (Fig. 11) and also by Larranganni Beds.

Age

Seven samples of glauconitic sandstone have been dated by AMDL (AMDL Report 3473/73) using the K-Ar method. The samples come from within a few hundred metres of the top of the Gardiner Sandstone, and are quartz and sublithic arenites. They have an average grainsize of about 0.5 mm and are cemented by authigenic overgrowths of quartz. Sorting varies from poor to good. Mild deformation is indicated by slight undulose extinction in both detrital and authigenic quartz. Glauconite is mostly a minor constituent though it is abundant in one sample (no. 72491135)

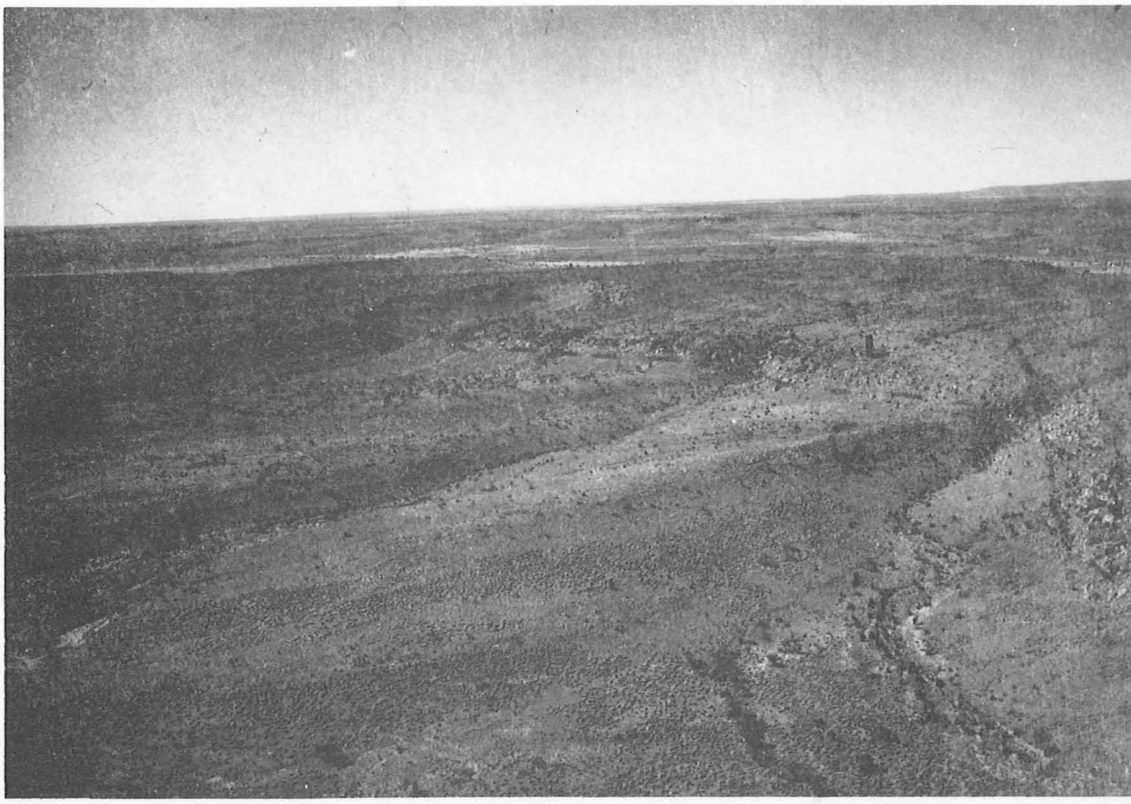


Fig. 11. Gently dipping Gardiner Sandstone (G) unconformably overlain by flat-lying Lewis Range Sandstone (L) in the west part of the Gardiner Range, Billiluna Sheet area. Neg. No. GA/8014.

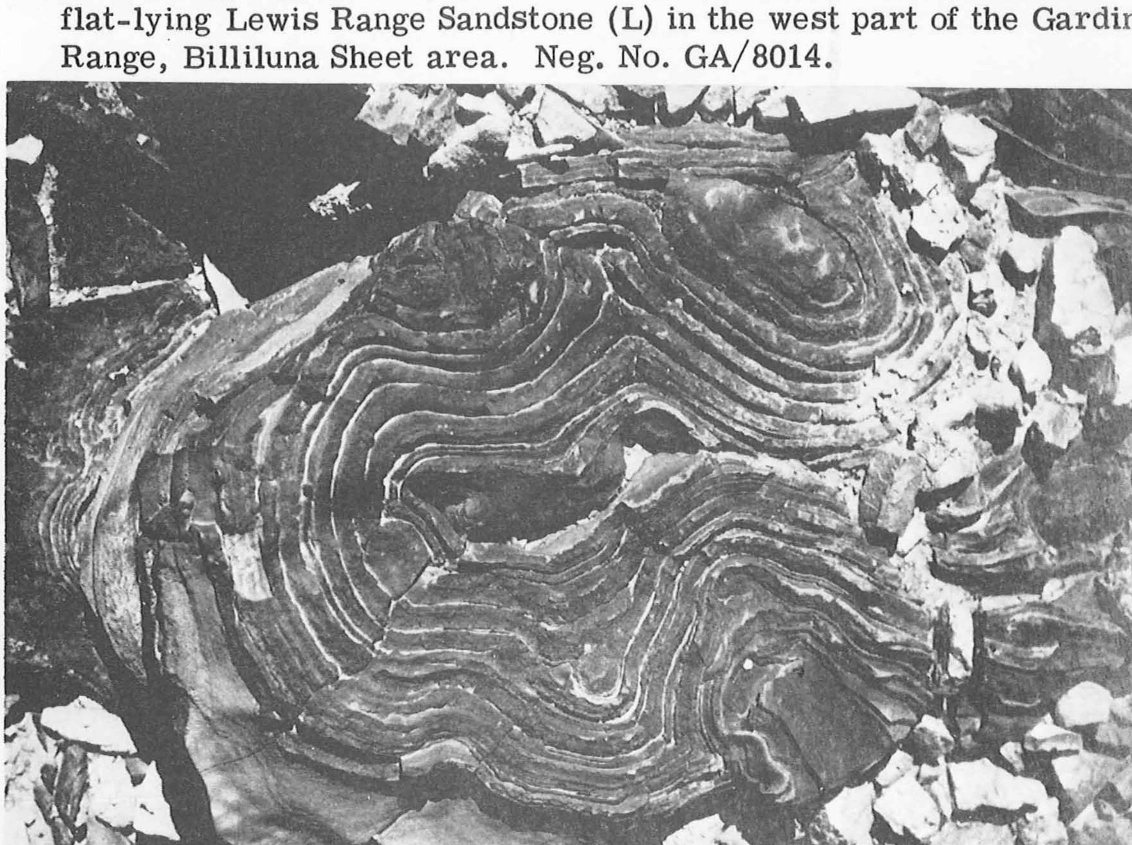


Fig. 12. Stromatolitic limestone of the Talbot Well Formation north-northeast of Mount Mansbridge, Billiluna Sheet area. Neg. No. GA/7958.

TABLE 2. K-Ar AGES OF GLAUCONITE FROM THE GARDINER SANDSTONE

Sample No.	% K	% Atmospheric A40	Radiogenic A40/K40	Age (m.y.)	Locality	Sheet area
72490087B	6.168 6.144	0.2	0.14120	1556 ± 20	12 km NNE Bloodwood Bore, Nora Range	Lucas
72490476A	5.759 5.791	0.2	0.15108	1628 ± 20	"	"
72490764	4.511 4.526	0.6	0.14265	1566 ± 20	21 km NE Rabbit Flat, Farrands Hills	The Granites
72491127	5.821 5.844	0.4	0.12942	1465 ± 20	Gardiner Range (19°07'18"S, 128°39'54"E)	Billiluna
72491135	6.563 6.575	0.3	0.14221	1563 ± 20	Gardiner Range (19°12'18"S, 128°40'24"E)	"
72491500	6.607 6.594	0.4	0.13643	1519 ± 20	Coomarie Spring	Tanami
72495021	4.735 4.753 4.800	0.8 0.9	0.13513 0.13583	1509 1515 ± 30	" "	" "

K^{40} = 0.0119 atom %; = 4.72×10^{-10}/yr; = 0.584×10^{-10}/yr.

in which there is also some patchy glauconite cement. Other minor constituents include feldspar, lithic fragments, clay and tourmaline.

The results of the dating are shown in Table 2. hese are interpreted by AMDL as follows: 'The K-Ar dates on five of the glauconite samples group closely in the range 1500 to 1560 million years. Some of this scatter could be due to greater than normal experimental error as some of the samples were difficult to separate and contained up to 10% impurities'.

'The remaining two samples had K-Ar ages of 1465 and 1628 million years. The older date suggests that perhaps most of the samples have lost radiogenic argon and that the correct age of the Gardiner Formation is older than 1630 million years, i.e. early Carpentarian. 1550 to 1600 million years is a minimum age for this Formation'.

Correlations

The Gardiner Sandstone is tentatively correlated with Mount Parker Sandstone of the East Kimberley region (Dow & Gemuts, 1969). Both formations unconformably overlie Archaean or Lower Proterozoic metamorphics and both are overlain conformably by stromatolitic dolomite which is commonly silicified. The Gardiner Sandstone may also be correlated with the Limbunya Group of the Victoria River region (Sweet et al., 1971).

Talbot Well Formation (Bdt)

In the Billiluna Sheet area the Talbot Well Formation crops out in the Gardiner Range in the centre of a shallow structural basin and also in the centre of a small basin northeast of Mount Mansbridge. In The Granites Sheet area the formation is exposed on the southeast side of the Nora Range.

The formation is named after Talbot Well in the Tanami Sheet area, and a type section has been described by Blake et al. (1972) on the west side of the Supplejack Range, west-northwest of Supplejack Downs homestead in the Tanami Sheet area.

The Talbot Well Formation is mostly flat-lying except near faults. Most outcrops have very little relief.

Lithology

The characteristic lithology is chert but the formation also includes thin-bedded sublithic arenite and laminated siltstone, and stromatolitic limestone crops out in the small basin northeast of Mount Mansbridge (Fig. 12). The chert is also stromatolitic in places, indicating that it is silicified limestone or dolomite, and some is banded or brecciated.

In the Gardiner Range, the Talbot Well Formation is up to 250 m thick.

At some localities the chert has a capping of laterite and, at others, silcrete.

Stratigraphic relationships and age

The Talbot Well Formation is a unit of the Carpentarian Birrindudu Group. Its conformable relationship with underlying Gardiner Sandstone is exposed in the Gardiner and Nora Ranges, and that with the overlying Coomarie Sandstone is exposed north-northeast of Mount Mansbridge.

Coomarie Sandstone (Ꞓdk)

A single outcrop only has been mapped as Coomarie Sandstone; it is an east-trending ridge east-northeast of Mount Mansbridge in the Billiluna Sheet area. The formation is named after Coomarie Spring and the Coomarie Range in the Tanami Sheet area. It was informally named the Stake Range Beds by Blake et al. (1972), who selected the type section 75 km northwest of Coomarie Spring.

Coomarie Sandstone in the Billiluna Sheet area is a medium to fine grained pale grey and maroon sublithic arenite. It contains pellets and balls, up to 1 cm across, of red and greenish siltstone, and shows cross-bedding and ripple marks. The exposed thickness is about 100 m.

The Coomarie Sandstone is the youngest unit of the Carpentarian Birrindudu Group and is conformable on the Talbot Well Formation.

CARPENTARIAN OR ADELAIDEAN

Munyu Sandstone (Ꞓuu)
(new name)

The Munyu Sandstone is named after Munyu Hills, 21°47'S, 129°08'E, in the Highland Rocks Sheet area. It crops out in the southeast part of the

Stansmore Sheet area, where it was previously mapped as the Gardiner Beds (Wells, 1962a), and in the west part of the Highland Rocks Sheet area to the east.

The sandstone forms isolated scarps and strike ridges up to 40 m high trending east to north-northeast, and dips 5 to 50° north to west-northwest. The type section is a strike ridge at 21°55'00"S, 128°55'00"E, in the Stansmore Sheet area, where the maximum thickness of the formation, 400 m, is exposed, dipping 45° north.

Lithology

The dominant rock type, some 400 m thick in the type section, is poorly sorted, medium to very coarse and gritty quartz arenite that is mostly medium bedded. It has a quartz overgrowth cement and generally some sericitic matrix. Quartz clasts greatly predominate, accompanied by minor quartzite and chert clasts and subordinate tourmaline, zircon, and muscovite. Locally the sandstone is pebbly and conglomeratic, especially near the base, and some basal sandstone contains abundant mica and feldspar derived from nearby granite. Low angle cross-bedding is common throughout.

Limestone lenses a few metres thick, consisting of an iron-stained medium-grained calcite mosaic, are associated with quartz arenite that is better sorted than normal at 21°59'30"S, 128°46'00"E, the only locality where the Munyu Sandstone is seen to be tightly folded.

Stratigraphic relationships, correlations, and age

The Munyu Sandstone is unconformable on unnamed granite and regionally metamorphosed rocks of the Tanami complex at False Mount Russell, in the Highland Rocks Sheet area, and it overlies unnamed granite in the southeast corner of the Stansmore Sheet area, although here the actual contact is not exposed. To the north and west the formation is overlain, possibly conformably, by the Redcliff Pound Group, but the contact relationships are uncertain, being concealed by Quaternary sand.

The Munyu Sandstone is the oldest unit in the southern part of the Birrindudu Basin. It may be correlated with the Carpentarian Gardiner Sandstone of the Birrindudu Group or with Carpentarian or Adelaidean Lewis Range and Muriel Range Sandstones at the base of the Redcliff Pound Group.

REDCLIFF POUND GROUP (new name)

The Redcliff Pound Group, named after Redcliff Pound (21°35'S, 128°45'E) in the eastern part of the Stansmore Sheet area, crops out in the Billiluna, Lucas, Stansmore, and The Granites Sheet areas. It has four constituent formations, namely Muriel Range Sandstone, Lewis Range Sandstone, Murraba Formation, and Erica Sandstone, all of which consist predominantly of quartz-rich sandstone classified as sublithic arenite and quartz arenite.

The basal formations of the group, Lewis Range Sandstone and its lateral equivalent, the Muriel Range Sandstone are unconformable on the Archaean or Lower Proterozoic Tanami complex, on Lewis Granite and unnamed granite which are probably Lower Proterozoic, and on Gardiner Sandstone, the basal formation of the Carpentarian Birrindudu Group. The Lewis Range Sandstone is overlain by the Murraba Formation, which is characterized by chert granule conglomerate, and the Erica Sandstone.

The maximum exposed thickness of the Redcliff Pound Group is about 1300 m, in the Redcliff Pound area, but here only Murraba Formation and Erica Sandstone crop out. The aggregate maximum thickness exposed of the constituent formations is about 2000 m, but the true maximum thickness may be greater, as an unknown amount is concealed under sand plain.

The Redcliff Pound Group is not affected by either regional or thermal metamorphism, but it has been folded into a series of anticlinal and synclinal structures, mainly in the south, and has been displaced along several faults, mainly in the north. Dips are mostly gentle but range from flat-lying to vertical.

In the Stansmore Sheet area the Redcliff Pound Group is overlain to the west, possibly conformably, by sandstone mapped as Hidden Basin Beds. If the contact is conformable, the Hidden Basin Beds would be considered part of the Redcliff Pound Group. In the same sheet area, to the southeast, the Redcliff Pound Group overlies, possibly conformably, Munyu Sandstone, but the nature of the contact is unknown. The relationship in the north between the group and the Kearney Beds, Peterson Beds, and units of the Peterson Range-Denison Range area are also unknown. The contacts between the Redcliff Pound Group and the above units are concealed beneath sand plains.

In the Lucas, Stansmore, and The Granites Sheet areas the group is unconformably overlain by Palaeozoic and Cretaceous units.

The group is mapped as Carpentarian or Adelaidean. Its age is uncertain, as it is unfossiliferous and no isotopic dates are available. Major unconformities separate the group from the underlying Birrindudu Group, dated as Carpentarian, and from overlying Palaeozoic units. A tentative correlation is made with the Wattie Group of the Victoria River Basin (Sweet et al., 1971), also mapped as Carpentarian or Adelaidean. The Wattie Group is unconformable on the Limbunya Group, which is correlated with the Birrindudu Group, and it includes Neave Sandstone, which contains chert granule conglomerate similar to that of the Murraba Formation.

Muriel Range Sandstone (Ērm)
(new name)

The Muriel Range Sandstone crops out in The Granites and eastern part of the Lucas Sheet areas. It is named after the Muriel Range, 20°46'S, 129°30'E. The formation is mostly gently dipping, and forms cuestas up to 20 m high. The highest scarps are those of the Wilson, Muriel, and Inningarra Ranges, Murdoch Cliffs, and Blackwood Bluff. Steep dips were found 8 km north of the Muriel Range, where the sandstone forms steep-sided hogsback ridges, and immediately adjacent to a fault on the north side of the Muriel Range.

The type section is across the Inningarra Range, southwest of the Mongrel Downs homestead, where the maximum known thickness of the formation, about 450 m, is exposed dipping gently south. It extends from 20°45'10"S, 129°38'45"E, where Muriel Range Sandstone is faulted against Mount Charles Beds to the north.

Lithology

The formation consists predominantly of sublithic and quartz arenite, but also includes siltstone and shale interbeds and local arkosic sandstone, conglomerate, and breccia.

The sublithic and quartz arenite are mostly pale pinkish to greyish, thin to very thin bedded (Fig. 13), and medium to fine-grained, with a quartz overgrowth cement and commonly some sericitic matrix. They are generally well sorted, although some beds contain coarse-grained to gritty lenses and some contain scattered pebbles. Ripple marks are very common and low angle cross bedding is widespread. In the Wilson Range, swirl structures in the basal 2 m of the formation indicate disturbances, possibly by slumping, of original bedding. Bedding planes are generally well defined, and are commonly crowded with shale pellets. Many show minor undulations. In the upper part of the formation, exposed in the main scarps of the Muriel and Inningarra Ranges, at Murdoch Cliffs and near Dr Abbots Bore, individual beds are generally thicker, averaging about 1 metre, pellety bedding planes and ripple marks are less common, and some bedding planes are poorly defined.

Minor micaceous siltstone and maroon shale are thinly interbedded with sublithic and quartz arenite at several localities, but are poorly exposed, generally forming depressions and flats between successive sandstone scarps. Friable arkosic sandstone about 10 m thick is exposed at Blackwood Bluff, underlying 3 m of thin bedded lithic sandstone; it is medium to coarse and consists of feldspar, mica, and quartz derived from nearby granite. Conglomerate beds less than 1 m thick are present locally at the base of the formation; they contain pebbles of rocks from the underlying Tanami complex. Breccia up to 1 m thick, formed of rock fragments from the Killi Killi Beds, is overlain by conglomerate at the base of the Muriel Range Sandstone in the Wilson Range, at 20°23'45"S, 129°00'3"E (Fig. 8).

In the type section, across the Inningarra Range, about 300 m of thin to very thin-bedded sandstone is overlain to the south by about 150 m of medium-bedded sandstone. The thin-bedded sandstone forms a series of cuestas generally less than 3 m high. It ranges from sublithic to quartz arenite, and is characterized by pellety bedding planes. The medium-bedded sandstone to the south forms a stepped scarp face about 15 m high. It is generally fine-grained and appears better sorted than the thin-bedded sandstone.

Stratigraphic relationships, correlations and age

Muriel Range Sandstone is strongly unconformable on steeply dipping Killi Killi Beds (Fig. 8) and Pargee Sandstone in the Wilson Range, and on granite at Murdoch Cliffs. It has a similar relationship to Mount Charles Beds and granite both on the north side of the Muriel and Inningarra Ranges, where the unconformity is obscured by a fault down thrown to the south, and in the Blackwood Bluff area, where the unconformity is concealed under superficial deposits.

Fig. 13. Thin-bedded sublithic and quartz arenita near the base of the Muriel Range Sandstone, Nora Range, The Granites Sheet area. Neg. No. M1353/15A.

Fig. 14. View west along the cuestas of the eastern part of the Lewis Range, Lucas Sheet area. The scarp faces are up to 280 m high and are formed from Lewis Granite capped by up to 10 m of southerly dipping Lewis Range Sandstone. Neg. No. GA/7989.

The formation is overlain by Palaeozoic Lucas Formation and Pedestal Beds. The contact is nowhere exposed, but is inferred to be unconformable.

The Muriel Range Sandstone is correlated with the Lewis Range Sandstone to the west, the two units being the basal formations of the Redcliff Pound Group. In the eastern part of the Lucas Sheet area, outcrops of the two sandstone formations are separated along strike by a gap of only 6 km. Both form northward facing cuestas, dip gently south, and unconformably overlie Killi Killi Beds and granite. They dip less steeply and are generally finer-grained and less silicified than Gardiner Sandstone of the Nora Range, and do not contain beds of glauconitic sandstone. The Muriel Range Sandstone is distinguished from the Lewis Range Sandstone in being mainly thin to very thin-bedded, more commonly pellety, and generally more variable in grain size.

Lewis Range Sandstone (Erl)
(new name)

The Lewis Range Sandstone forms the northwesterly-trending line of cuestas that make up the Lewis Range, after which the formation is named, in the northeast part of the Lucas Sheet area. Cuestas of Lewis Range Sandstone continue north and east from Lewis Range to Tent Hill and north to the southern edge of the western Gardiner Range, in the Billiluna Sheet area. The cuestas have scarp faces up to 80 m high, consisting mainly of granite, but capped by the sandstone, which is generally less than 10 m thick (Fig. 14). The capping sandstone locally forms two or three benches, as west of Tent Hill. Further north, outcrops of Lewis Range Sandstone form plateau areas in the western Gardiner Range, and outcrops mapped as possible Lewis Range Sandstone (Prl?) are present in the northeast corner of the Billiluna Sheet area.

The sandstone ridges of the Kearney Range, west of the Lewis Range, are also mapped as Lewis Range Sandstone, as also are the sandstone outcrops to the south, near Mount Hughes. The latter outcrops consist of narrow steep-sided ridges oblique to the strike of the bedding, indicating that they are probably bounded by faults, the traces of which are concealed beneath Quaternary sand.

The formation was previously mapped as part of the Phillipson Beds and Kearney Beds (Wells, 1962a, b; Casey & Wells, 1964). It is generally gently dipping, mostly at less than 5°, and is well jointed. Close vertical jointing on scarp edges is a characteristic feature which is visible on aerial photographs. Steep dips occur only in the Kearney Range and near faults at the northwest end of the Lewis Range, in the Lucas and Billiluna Sheet areas, where much of the sandstone is sheared, silicified, and cut by quartz veins. Small patches of surface silcrete are present in places.

The maximum known thickness of the sandstone in the Lewis Range is in the southeast where a sequence about 400 m thick is exposed, dipping gently south. A thickness of about 1000 m is present in the northern part of the Kearney Range.

The type section is the steep side of a cuesta 1.5 km southwest of Point Nelligan, in the Lewis Range, at 20°13'00"S, 128°38'00"E. Here a sandstone sequence about 20 m thick is exposed, unconformably overlying Lewis Granite.

Lithology

The Lewis Range Sandstone consists of friable, well sorted, medium to fine quartz arenite and, mainly at the base of the formation, conglomerate, poorly sorted sublithic arenite, quartz arenite, and minor siltstone.

The well sorted quartz arenite that forms most of the formation is generally brownish to maroon, due to iron-staining. It has a clayey matrix, is medium to thin-bedded, and commonly has low angle cross-bedding. High angle planar cross-bedding is present locally (Fig. 17). Ripple marks are widespread. Preferential erosion along bedding and current bedding planes and vertical joints results in characteristic flaggy tor-like exposures (Fig. 15). Bedding planes with shale pellets are present locally, but are generally uncommon. Near the base of the formation the arenite is less well sorted, and contains scattered quartz pebbles and grit grains which in places are concentrated in thin layers and lenses generally less than 15 m thick. In places the arenite is strongly silicified, white, and has a quartz cement.

Conglomerate is commonly present at the base of the Lewis Range Sandstone, overlying granite and metamorphic rocks of the Tanami complex. It forms beds and lenses up to 3 m thick and consists of pebbles mainly less than 10 cm across in a poorly sorted sandy matrix (Fig. 16). The pebbles

Fig. 15. Medium-bedded Lewis Range Sandstone showing low-angle cross-bedding. Lewis Range, west of Bloodwood Bore, Lucas Sheet area. Neg. No. M1356/32.

Fig. 16. Medium to thin-bedded sandstone and conglomerate of the Lewis Range Sandstone overlying granite west of Tent Hill, Billiluna Sheet area.
Neg. No. GA/7957.

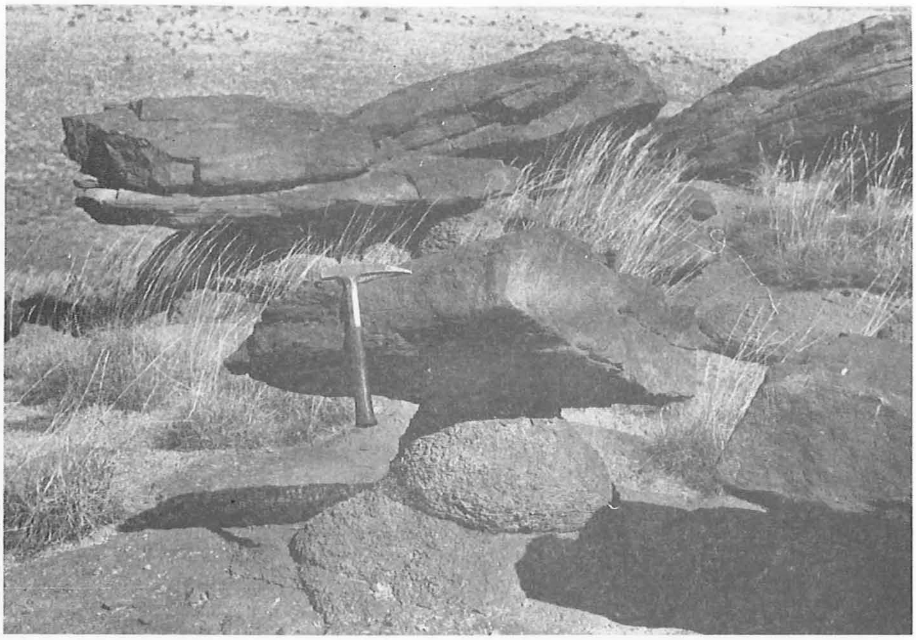


Fig. 17. Planar cross-bedding in Lewis Range Sandstone west of Tent Hill, Billiluna Sheet area. Neg. No. 7953.

Fig. 18. Blocks of Lewis Range Sandstone perched on Lewis Granite near Point Nelligan. Lewis Range, Lucas Sheet area. Neg. No. M1356/26.

are subangular to angular and are mainly of quartz, although pebbles of quartz-tourmaline aggregates, banded and unbanded chert, jasper, greywacke, muscovite schist and other rock types from the Tanami complex and less commonly pebbles of granite are present locally. The pebbles are subangular to rounded, mainly less than 10 cm long, and commonly have coatings of kaolinitic material. The conglomerate commonly shows low angle cross-bedding and is associated with layers and lenses up to 20 cm thick of mostly poorly sorted sublithic and quartz arenite, some of which is micaceous, and minor siltstone. Conglomerate is not present where the Lewis Range Sandstone overlies Gardiner Sandstone.

In the type area, 1.5 km southwest of Point Nelligan, friable weathered Lewis Granite is overlain by about 3 m of poorly sorted, fine to coarse-grained quartz arenite, minor sublithic arenite and associated grit and conglomerate lenses. These sediments are overlain by about 17 m of well sorted, medium bedded, medium-grained quartz arenite.

At the outcrops mapped as possible Lewis Range Sandstone in the northeast corner of the Billiluna Sheet area, a sequence about 60 m thick is exposed. The lower part consists of very poorly sorted conglomerate and lenses of coarse to fine sandstone; the upper part, exposed in the northwest, is coarse sandstone with conglomerate layers and lenses up to 2 m thick. Some very large scale cross-bedding is apparent in places. The conglomerate contains angular to rounded clasts, some over 30 cm across, of quartz, quartzite, chert, various types of sandstone, and kaolin (probably altered feldspar) enclosed in a poorly sorted sandy matrix. The clasts are derived from the Gardiner Sandstone and either or both the Tanami complex and Halls Creek Group. The beds are thought to be probably fluvial deposits. They are faulted against Gardiner Sandstone to the southwest and possibly to the north east, although here they may be unconformable on Gardiner Sandstone. They continue northwest into the Gordon Downs Sheet area, where they were mapped as part of the Gardiner Beds (Gemuts & Smith, 1968).

Stratigraphic relationships, correlations and age

The Lewis Range Sandstone is unconformable on Killi Killi Beds, which are part of the Archaean or Lower Proterozoic Tanami complex, on Lewis Granite and unnamed granite, which are probably Lower Proterozoic, and on Gardiner Sandstone, the basal unit of the Carpentarian Birrindudu Group. It is overlain conformably by Murraba Formation, and is separated by an inferred major fault from Peterson Beds.

The unconformable relationship with granite and Killi Killi Beds is exposed along the scarps of the cuestas extending from the Lewis Range to the Gardiner Range. These scarps are formed of friable weathered granite or less commonly metamorphic rocks, overlain by a few metres of Lewis Range Sandstone (Figs. 14 and 18). The rocks underlying the sandstone are partly to completely concealed by sandstone scree. Killi Killi Beds are also overlain unconformably by Lewis Range Sandstone at Mount Mansbridge, northwest Gardiner Range. Similar relationships are present in the Kearney Range, and the unconformity on granite is also exposed at Mount Hughes.

Gently dipping Gardiner Sandstone is overlain by flat-lying Lewis Range Sandstone in the western part of the Gardiner Range, mainly north of Lewis Creek. The overlapping unconformity is visible both on aerial photographs and on the ground, as the Lewis Range Sand stone forms distinctive cliff-bounded plateaux, but the actual unconformity surface is concealed by scree deposits.

In the Lucas Sheet area, south of the Lewis Range, the Lewis Range Sandstone dips gently south and is inferred to be overlain conformably by Murraba Formation, which is conformably overlain in turn by Erica Sandstone, also dipping gently south, along the northern edge of the Phillipson Range. The contact between Murraba Formation and Lewis Range Sandstone is concealed under Quaternary sand.

The Lewis Range Sandstone is correlated with the Muriel Range Sandstone, which forms the Wilson Range, a continuation to the east of the Lewis Range. The main differences between the two formations are that Lewis Range Sandstone is mainly medium bedded quartz arenite, whereas the Muriel Range Sandstone is mainly thin to very thin bedded sublithic arenite and quartz arenite, and the Lewis Range Sandstone does not commonly have bedding planes crowded with shale pellets. The two formations are at the base of the Redcliff Pound Group, and are Carpentarian or Adelaidean.

The Lewis Range Sandstone may also be correlated with the Denison Beds, which crop out in the northern part of the Billiluna Sheet area, and with the Munyu Sandstone of the Stansmore Sheet area.

Murraba Formation (Erb)
(new name)

The Murraba Formation is named after the Murraba Ranges in the northeast part of the Stansmore Sheet area (21°15'S, 128°45'E). It crops out in the eastern parts of the Lucas and Stansmore Sheet areas, where it is conformably overlain by Erica Sandstone (Fig. 21).

The formation consists mostly of thinly interbedded sandstone and conglomerate and is generally less resistant to erosion than the overlying Erica Sandstone, cropping out as mainly subdued strike ridges and low cuestas. It has been folded into open and tight anticlinal and synclinal folds, and dips range from gentle to vertical.

The maximum thickness exposes is about 800 m, at Redcliff Point, but north of the Phillipson Range the apparent thickness is only about 20 m. About 350 m is exposed dipping 20-30° west in the type section, on the east side of Redcliff Pound, at 21°36'30"S, 128°46'30"E.

Lithology

The characteristic rock type is chert granule conglomerate, which is interbedded with sublithic and quartz arenite. Also present are siltstone, shale, pebble conglomerate, and dolomite. The beds are mostly thin to very thin or laminated, but some are medium to thick. Some sequences of sublithic arenite within the formation are over 5 metres thick.

Conglomerate forms beds, generally less than 50 cm thick, consisting of rounded to subangular granules and less commonly pebbles, predominantly of chert, enclosed in medium grained sublithic to quartz arenite. It has a quartz overgrowth cement and little or no clay matrix. Some cross-bedding is discernible in places.

Sublithic arenite is mainly medium to fine or very fine-grained, but locally includes coarse grained and gritty bands. Some beds are micaceous and some contain scattered granules of quartz and chert. Low angle cross-bedding, ripple-marks, and pellety bedding planes, are typical of the sediments. Mudcracks observed at a few localities indicate very shallow water deposition. Sublithic arenite has a sparse to abundant kaolinitic matrix, and is slightly to highly friable where not silicified. With decreasing content of lithic clasts, it grades into quartz arenite. Friable siltstone and shale are locally interbedded with sublithic arenite.

Dolomite has been found within the Murraba Formation only in the Stansmore Sheet area, where pinkish to purple laminated dolomite was recorded by Casey & Wells (1964) near Brookman Waters and on the east side of Redcliff Pound. Banded grey dolomite was found during 1972, underlying sublithic arenite at the base of an easterly facing scarp, 8 km east of Redcliff Pound. Other dolomite bands may be concealed beneath Quaternary deposits.

In the type section, on the east side of Redcliff point, the lowest beds exposed are 160 m of flaggy, thin-bedded to laminated, fine-grained sublithic arenite showing small scale low-angle cross-bedding. These beds are succeeded successively by about 110 m of thin bedded pelletal medium to fine sublithic arenite, 10 m of medium-bedded quartz arenite, and 70 m of ripple-marked, thin bedded to laminated sublithic arenite and interbedded chert granule conglomerate. The sequence is overlain conformably to the west by sublithic arenite of the Erica Sandstone.

Stratigraphic relationships and age

The Murraba Formation is part of the Redcliff Pound Group, and is overlain conformably by Erica Sandstone. The contact, which is taken at the top of the highest bed of chert conglomerate, is exposed on the north and west sides of the Phillipson Range, on the south side of Lake Jeavons, and in the Redcliff Pound area. North of the Phillipson Range the formation is inferred to lie conformably on Lewis Range Sandstone, but the contact is concealed by Quaternary sand. The formation is Carpentarian or Adelaidean.

The Palaeozoic Lucas Formation and possibly also the Pedestal Beds are presumed to lie unconformably on Murraba Formation, but contacts are not exposed. The Cretaceous Hazlett Beds are seen to be unconformable on the formation in the Redcliff Pound area.

Shale, sandstone, and conglomerate that may be correlated with Murraba Formation were intersected in stratigraphic hole EB8, drilled by Esso Australia Ltd in 1972 in the southern part of the Billiluna Sheet area (see Appendix). These rocks are inferred to overlie Lewis Range Sandstone and may underlie possible Erica Sandstone mapped to the southwest. To the north, in the same sheet area, the Jawilga Beds are regarded as being possible stratigraphic equivalents of the Murraba Formation.

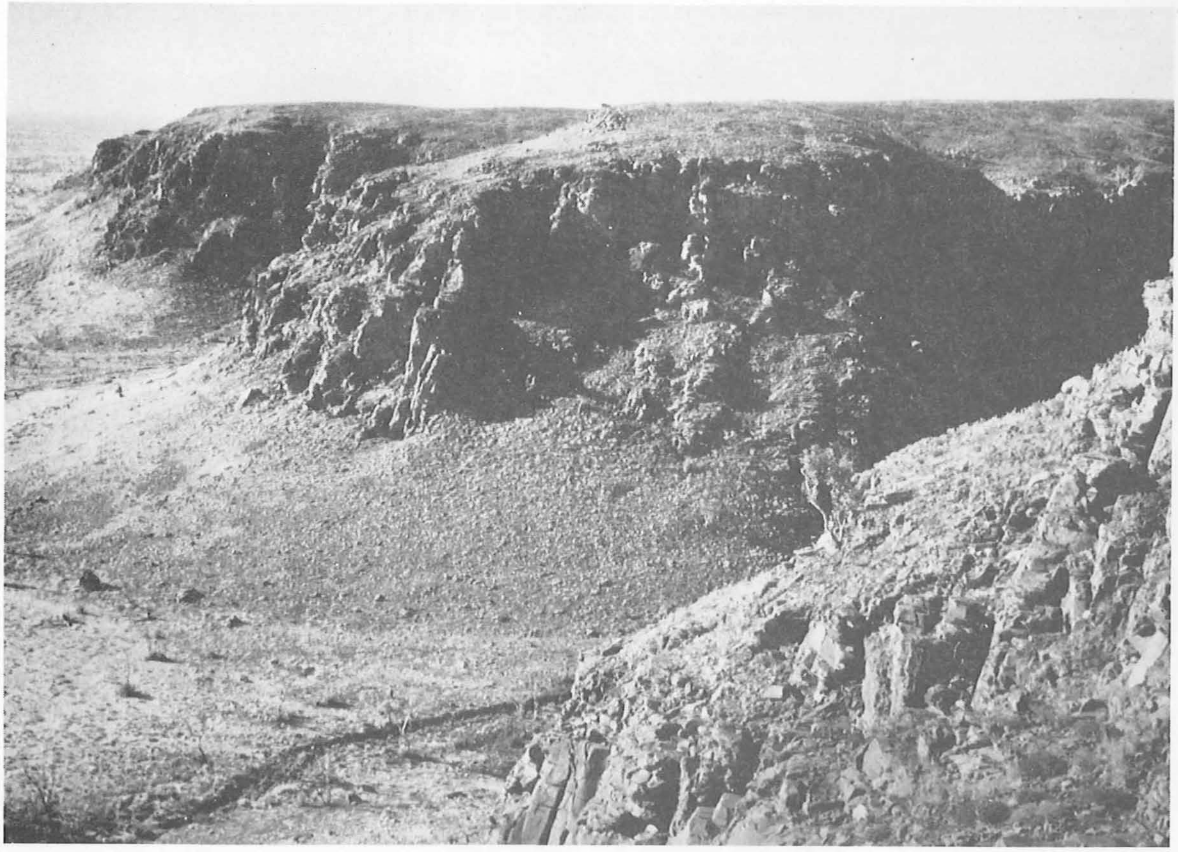


Fig. 19. North-facing sandstone scarp, the lower part of the Erica Range type section. Erica Range, Stansmore Sheet area. Neg. No. GA/7993.

Fig. 20. Large scale cross-bedding in flat-lying Erica Sandstone, western Erica Range, Stansmore Sheet area. M1355/12.

Fig. 21. Southern part of the Murraba Ranges, looking northwest to Lake Wills. The higher part of the range, to the left, is formed of steeply dipping Erica Sandstone, and the more subdued strike ridges to the right are formed of relatively resistant beds within the Murraba Formation. Stansmore Sheet area. Neg. No. M1404/25.

Fig. 22. Stromatolitic chert of the Lake Willson Beds, west of the Denison Range. Billiluna Sheet area. Neg. No. GA/7952.

Erica Sandstone (Ere)
(new name)

Erica Sandstone crops out extensively in the southeast part of the Lucas and the east part of the Stansmore Sheet areas, and extends eastwards into the Highland Rocks Sheet area. Outcrops have also been mapped as possible Erica Sandstone in the southern part of the Billiluna Sheet area and in the western part of the Stansmore Sheet area. The formation is named after the Erica Range, 21°05'S, 129°30'E. Outcrops consist of cuestas, plateaux, strike ridges, and hills up to 60 m high separated by sand plains with dunes and salt lakes. The formation was previously mapped as Phillipson Beds and Gardiner Beds (Wells, 1962b and c; Casey & Wells, 1964).

The type section is across a northeasterly facing cuesta in the Erica Range (Fig. 19), from 21°05'50"S, 128°30'00"E, to 21°07'00"S, 128°29'00"E, where a sequence about 400 m thick dips 5 to 10° southwest. The maximum thickness exposed is about 700 m, southeast of Redcliff Pound.

The formation has been folded to form a series of mainly broad anticlines, synclines, monoclines, domes, and basins, and dips are generally shallow. However, tight folds with steep dips occur locally, as on the west side of Redcliff Pound and in the southern part of the Murraba Ranges (Fig. 21).

Lithology

The predominant rock type is a well sorted, medium to fine-grained friable sublithic arenite that has a clayey matrix. It consists of over 80 percent quartz and minor chert clasts, up to 10 percent siltstone and mudstone clasts, and less than 10 percent matrix; some quartz overgrowth cement is also present, and tourmaline and minor zircon are present as heavy minerals. Most of the arenite is medium-bedded, but beds range from thick to thin. It is white or iron-stained to pink, purple, brown, and maroon. Cross-bedding is almost ubiquitous, and is generally low angle, most sets being less than 1 m thick, although larger sets are present locally, as in the western part of the Erica Range (Fig. 20). Ripple marks are common, as also are bedding planes with flattened clay pellets. Scattered clay clasts, grit-sized quartz clasts and well rounded pebbles up to 5 cm across of quartz and chert are presen in places, mainly in the lower part of the formation.

Other rock types locally present are: well to poorly sorted, medium-grained quartz arenite containing little or no matrix; thin-bedded to laminated fine micaceous sublithic arenite, siltstone, and shale, mainly near the base of the formation; rare beds of gritty and pebbly arenite; and glauconitic sublithic arenite, near the base of the formation 20 km west-southwest of Bloodwood bore in the Lucas Sheet area, and east of Lake Wills in the Stansmore Sheet area.

Local minor faulting, as on the south side of Erica Range, has resulted in some close jointing, breccia zones and slickensided surfaces.

Surface silicification is widespread, and silcrete cappings are common. Laterite cappings are developed locally on unsilicified clayey sandstone.

In the type section in the Erica Range, about 400 m of medium to fine-grained, current bedded, sublithic arenite is exposed. This is where Casey & Wells (1964) mapped a possible boundary between Gardiner Beds and apparently conformably overlying Phillipson Beds. The sandstones on either side of the boundary, although showing different patterns on aerial photographs, are similar lithologically, and show similar amounts of silicification. The only difference found was that the upper sandstone, unlike the lower sandstone, generally splits smoothly along bedding planes. As no unconformity or significant lithological difference can be demonstrated, the sandstone on both sides of the previously mapped boundary is considered to form part of the same formation, the Erica Sandstone.

The thickest sequence exposed in the Phillipson Range is about 200 m, in the northwest, from 20°32'30"S, 129°30'30"E, to 20°35'45"S, 129°35'00"E. The lower 100 m, conformably overlying conglomerate of the Murraba Formation, consists mainly of medium-grained sublithic arenite, some of which contains sparse pebbles, but interbeds of shale are also present near the base. The upper 100 m was measured and described by Casey & Wells (1964): it consists of about 15 m of sandstone overlain by 6 m of shale with interbedded sandstone, 15 m of flaggy to laminated medium-grained sandstone and over 60 m of cross-bedded and ripple marked medium-grained sandstone.

Stratigraphic relationships and age

The Erica Sandstone is the highest unit of the Redcliff Pound Group, and conformably overlies the Murraba Formation, the boundary between the two units being taken as the top of the highest bed of chert granule conglomerate. In the Lucas Sheet area Erica Sandstone is unconformably overlain by Lucas Formation and Pedestal Beds, which are considered to be Palaeozoic, and in the west by sandstone mapped as possibly Cretaceous. In the Stansmore Sheet area it is overlain in the southwest, possibly unconformably, by Hidden Valley Beds, and in the south it is inferred to be overlain unconformably by sandstone of the Palaeozoic Pedestal Beds. It is also overlain unconformably by Cretaceous Hazlett Beds in the Redcliff Pound area. The relationship between the Erica Sandstone and Hidden Valley Beds is uncertain because contacts are concealed by Quaternary sand. Contacts with Pedestal Beds are not exposed.

In the Billiluna Sheet area, sandstone mapped as possible Erica Sandstone is inferred to overlie Lewis Range Sandstone and to be separated by a postulated fault from Peterson Beds to the northwest. Shale, sandstone, and conglomerate possibly representing the Murraba Formation in this area were intersected in stratigraphic hole EB8 (see Appendix). Further north in the Billiluna Sheet area the Boee Beds are considered to be possibly equivalent to the Erica Sandstone.

Isolated outcrops mapped as possible Erica Sandstone in the western part of the Stansmore Sheet area show folding of the type present in the Redcliff Pound area to the east, and are overlapped by flat-lying Permian rocks of the Canning Basin succession.

CARPENTARIAN OR ADELAIDEAN BEDS

Hidden Basin Beds (Euh)
(new name)

Outcrops of Hidden Basin Beds are restricted to the central part of the Stansmore Sheet area west of the main outcrops of Erica Sandstone. Hidden Basin is the broad depression containing Lake Wills and Lake Hazlett (Terry, 1934). Exposures of the beds, previously mapped as part of the Gardiner Beds (Wells, 1962c, Casey & Wells, 1964), consist mainly of quartz arenite and sublithic arenite. These rocks form long parallel strike ridges, between which are broad sand plains presumably developed on rocks less resistant to erosion.

The Hidden Basin Beds range from gently to steeply dipping, and have been folded into anticlines and synclines, the trends of which swing northwards from northeast to northwest. They have also been displaced along faults, in the vicinity of which they are closely jointed, and locally brecciated and cut by quartz veins.

The maximum known thickness is about 3000 m, estimated from aerial photographs, but the true thickness is probably somewhat greater, as much of the unit is concealed beneath superficial deposits. Over 2000 m is exposed in the reference area, 23 km southwest of Lake Hazlett, at 21°40'S, 128°25'E.

Lithology

The main rock types seen are quartz arenite and sublithic arenite. However, thin-bedded to laminated shale, siltstone and fine sandstone are exposed in some creek cuttings, as at 21°40'00"S, 128°24'30"E, in the reference area, and similar beds may underlie many of the sand plains between sandstone ridges. The beds are white to pale grey or iron-stained to brownish or maroon.

Both types of sandstone are mainly well sorted, medium to fine-grained and show low angle cross bedding and locally ripple bedding. They commonly have a sparse white clayey matrix. Quartz arenite ranges from medium to very thin bedded. It is commonly silicified, and has a characteristic glassy appearance. Locally quartz arenite is poorly sorted coarse-grained to gritty and contains scattered quartz pebbles. Sublithic arenite is interbedded with quartz arenite, and all gradations between the two types are present. Sublithic sandstone is mainly medium-bedded, some is micaceous and some has bedding planes crowded with shale pellets.

In the reference area, about 1800 m of westward dipping medium bedded medium to fine-grained quartz arenite and sublithic arenite form a prominent strike ridge. This is separated from a lower strike ridge to the west, formed by medium-bedded glassy quartz arenite about 150 m thick, by a flat area developed on thin-bedded to laminated shale, siltstone, and fine sandstone about 280 m thick.

Stratigraphic relationships, correlations and age

The Hidden Basin Beds are faulted against the Erica Sandstone 10 km south-southwest of Lake Hazlett. Other contacts with Proterozoic rocks units are concealed by superficial deposits. However, the regional structure indicates that the Hidden Basin Beds overlie the Erica Sandstone. The contact between the two units may be conformable, as the Hidden Basin Beds contain sublithic arenite similar to that of the Erica Sandstone, and the upper part of the latter unit includes some quartz arenite similar to that found in the Hidden Basin Beds. The Hidden Basin Beds may therefore be the youngest exposed unit of the Carpentarian or Adelaidean Redcliff Pound Group.

Peterson Beds (Bup)
(new name)

The Peterson Beds form the Peterson Range, after which they are named. They are confined to the Billiluna Sheet area, where they form a Y-shaped outcrop south-southwest of Sturt Creek homestead. They extend south, to the southern edge of the Sheet area, as a belt of scattered and discontinuous outcrops, up to about 10 km wide. On aerial photographs bedding traces are clearly visible because of slight colour variations between beds. In the north the beds are folded into several tight anticlines and synclines with subparallel northwest trending axes, and they are separated from beds of the Denison Range area to the east by an inferred major fault. In the south dips are mainly very steep; facing is rarely determinable because of shearing and close jointing associated with local faulting and probably tight folding. An inferred fault separates this area of outcrop from Lewis Range Sandstone and possibly Erica Sandstone to the east and southeast.

Lithology

The Peterson Beds consist mainly of interbedded medium to fine-grained maroon, grey, and pink quartz arenite and sublithic arenite, some of which contains shale pellets. Beds are mostly 1-30 cm thick but may be up to 1 m. They are commonly cross-bedded and ripple-marked, and are closely jointed. Generally the arenite is silicified, but in places it is friable. In the southern part of the area some greywacke and lithic arenite bands up to 15 m thick are interbedded with the quartz arenite and sublithic arenite, and on either side of the Billiluna-Tanami road pebbly to conglomeratic sublithic arenite contains rounded clasts up to 5 cm across of quartzite, chert, quartz, greywacke, and jasper derived from the Tanami complex. The youngest rocks of the Peterson Beds exposed are laminated siltstone, seen 18 km southwest of Sturt Creek homestead, and thin-bedded kaolinitic and dolomitic shaly mudstone, poorly exposed at the foot of the Peterson Range 23 km south-southwest of Sturt Creek homestead.

The reference area is in the Peterson Range, between 19°22'12"S, 128°08'12"E and 19°22'40"S, 128°07'30"E, where a thickness of about 1000 m is exposed, consisting mainly of medium to fine-grained, medium to thin-bedded, cross-bedded mostly silicified quartz arenite and lithic arenite. In places the arenite has scattered coarse quartz grains, in places it is pebbly. The highest beds exposed are kaolinitic and dolomitic shaly mudstone.

Stratigraphic relationships, correlation, and age

The Peterson Beds are unconformably overlain to the west by Palaeozoic rocks of the Canning Basin and are separated by inferred faults from Proterozoic rocks to the east. In the south, they appear to be overalin by sandstone mapped as Lewis Range Sandstone.

How the Peterson Beds are correlated with other units in the area is uncertain. They are generally similar in lithology to the Gardiner Sandstone, except that glauconitic sandstone appears to be absent, and the thin-bedded dolomitic mudstone at the top of the unit in the north may be equivalent to the Talbot Well Formation. However, it is also possible that the Peterson Beds are equivalent to Lower Proterozoic Pargee Sandstone; both units have similar lithologies and have been folded into comparable structures. For the present the beds are mapped as Carpentarian or Adelaidean.

Meteorite Crater Beds (Ƥum)
(new name)

A group of low strike ridges of mainly silicified sandstone north of Carranya homestead, in the northwest part of Billiluna Sheet area, are mapped as Meteorite Crater Beds, after Wolf Creek Meteorite Crater (19°10'S, 127°46'E). They were previously mapped as part of the Kearney Beds (Wells, 1962a; Casey & Wells, 1964), and as Gardiner Beds where they extend northwards into the Gordon Downs Sheet area (Gemuts & Smith, 1968; Dow & Gemuts, 1969).

The beds are gently to steeply dipping, mainly southeast to east. Local shearing probably related to faults is indicated by brecciation, quartz-veining and slickensided surfaces.

The reference area for the unit is 10 km north-northeast of Wolf Creek Meteorite Crater, where a sandstone sequence about 450 m thick is exposed, dipping southeast. The thickest sequence at one outcrop is about 1000 m, 3 km southwest of Redbank yard. The maximum thickness of the unit is unknown because individual outcrops are separated from one another by sand plains which probably conceal faults, and neither the top nor bottom of the unit are exposed.

Lithology

Rock types exposed are white to pale pink or maroon silicified sublithic arenite and minor conglomerate, which predominate in the eastern outcrops, and quartz arenite which predominates in the west. Sublithic arenite and quartz arenite are mostly medium to coarse-grained, and medium to thin-bedded. They commonly have a sparse clayey matrix. Very coarse to gritty lenses and bands are present in places and most beds show cross-bedding. Sublithic arenite commonly contains scattered pebbles and some beds have pelletal bedding planes. Minor interbeds and lenses of pebbly sandstone and pebble conglomerate are common east of Wolf Creek. The pebbles are mostly well rounded, up to 7 cm across, and consist of quartz, quartzite, chert, sandstone, and shale.

The succession exposed in the reference area consists mainly of cross-bedded, medium to thin-bedded, medium-grained sublithic arenite, but also includes interbeds and lenses of pebble conglomerate less than 1 m thick.

At Wolf Creek Meteorite Crater the beds are generally unsilicified, in contrast to other outcrops. Here the dominant rock type is a slightly friable whitish medium to coarse-grained sublithic arenite which has a sparse clayey matrix. Some beds show cross-bedding, several gritty lenses are present, and thin interbeds of flaggy micaceous sandstone are exposed on the north side of the crater.

Relationships and age

The relationships of the Meterorite Crater Beds to other pre-Tertiary units are unknown, as contacts are concealed beneath Quaternary sand. The outcrop area is probably bounded by a concealed fault to the northwest, separating the beds from named formations of the east Kimberley succession. The other sides of the outcrop area are bordered by broad sand plains. Because of their commonly steep dips, lithology, and local shearing and quartz-veining, the beds are considered to be either Carpentarian or Adelaidean, and may be correlated with either the Birrindudu or Redcliff Pound Groups.

DENISON RANGE AREA

In the northern central part of the Billiluna Sheet area between the Denison Range in the east and the Peterson Range in the west, several units are exposed whose interrelations are obscure because of insufficient outcrop and faulting. Outcrops are mostly strike ridges isolated from each other by sand plain. The individual units are mapped as Beds because of the information available is insufficient to enable them to be mapped as formations. They were previously mapped as Gardiner and Kearney Beds, (Wells 1962a, Casey & Wells 1964).

Dips of bedding indicate that there is an anticlinal axis trending south-southeast from Sturt Creek homestead. To the west the units are separated from the Peterson Beds of the Peterson Range by a postulated fault. To the east they are bounded by the sand plain east of the Denison Range. As well as the broad anticline another major structural feature is a fault belt trending north-northwest along the Denison Range. Within this belt gentle northwest trending synclines and anticlines have been sliced by a number of faults. At Mount Weekes in the northern part of the Denison Range the faults seem to be mostly low angle thrusts, the evidence being slickensides on bedding planes, parallel to the direction of dip. Field evidence of faulting further south is given also by fine quartz veining and zones of brecciation.

Lake Willson Beds (Euw)

The Lake Willson Beds, named after Lake Willson (19°23'S, 128°16'E) are the oldest unit in the Denison Range area, and are exposed in the core of the major anticline. Exposures consist mostly of flat-lying stromatolitic chert, (Fig. 22) but 20 km south of Sturt Creek homestead, on the track to Balgo, a sequence of chert and sublithic arenite about 150 m thick dips northwest at 70°. The sublithic arenite is medium to coarse-grained and cross-bedded. This locality is chosen as the reference area. The steep dips here and elsewhere are probably related to local faulting. The northern outcrops of the beds are largely covered by laterite. The beds are correlated tentatively with the Talbot Well Formation of the Birrindudu Group.

Pindar Beds (Eur)
(new name)

The Pindar Beds, named after Pindar Yard, beside Jawilga Pool on Sturt Creek, overlie the Lake Willson Beds. Outcrops consist of low strike ridges and rubble on sandplains. The beds dip steeply and are locally overturned in the east. Rock types exposed are medium to coarse-grained quartz arenite and sublithic arenite which are cross-bedded and locally pelletal. Quartz veins and slickensided surfaces are common. The beds are about 300 m thick 2 km southwest of the northern Palm Springs in the Denison Range, and this is chosen as the reference area. The beds are tentatively correlated with Coomarie Sandstone of the Birrindudu Group, as they may be conformable on the Lake Willson Beds.

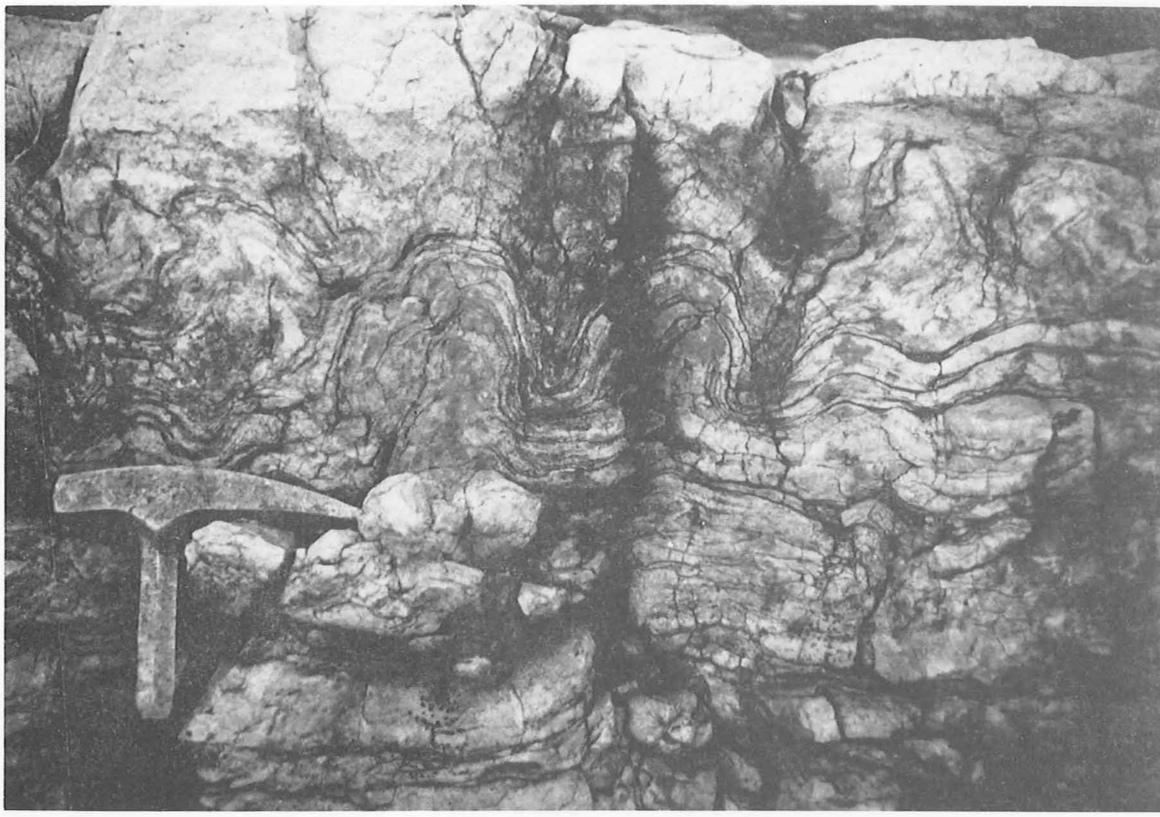


Fig. 23. Convolute laminations in sandstone of the Denison Beds, Denison Range, Billiluna Sheet area. Neg. No. GA/7951.

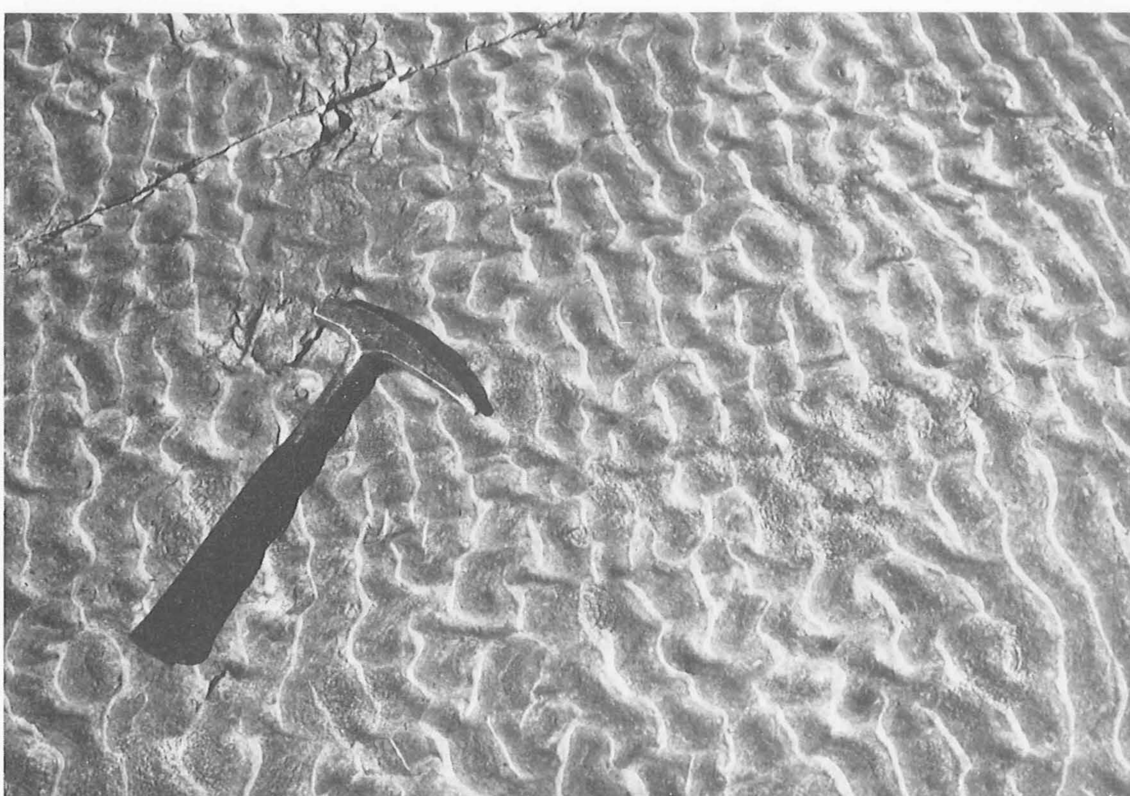


Fig. 24. Asymmetrical ripple marks in sandstone of the Denison Beds, 8 km east-northeast of Pyramid Hill, Billiluna Sheet area. Neg. No. GA/7955.

Denison Beds (Pud)
(new name)

The Denison Beds form the northwest trending Denison Range, after which they are named. They are not exposed on the west side of the major anticline. The reference area is the part of the Denison Range south of Pyramid Hill where the beds are about 30 metres thick. Here they consist of a lower unit, about 10 m thick, of thick-bedded quartz arenite which shows disturbed cross-bedding. This is overlain by pale pinkish quartz arenite, about 15 m thick, which is mostly medium grained and forms beds from 1 cm to 1 m thick. Cross-bedding is common, ripple marked surfaces are abundant, (Fig. 24) and one bed, about 0.5 m thick, shows convolute lamination, (Fig. 23). Above this is a few metres of thin bedded sublithic arenite containing abundant shale pellets. At the base of Pyramid Hill and at other localities along the west side of the Denison Range, maroon shale or siltstone and fine shaly sandstone are poorly exposed underlying the basal sandstone, and mostly obscured by scree.

The Denison Beds overlie the Pindar Beds, probably unconformably, and they are tentatively correlated with the lithologically similar Lewis Range Sandstone of the Redcliff Pound Group.

Jawilga Beds (Puj)
(new name)

The Jawilga Beds, named after a pool on Sturt Creek, crop out on both sides of the major anticline west of the Denison Range. To the west the beds form a narrow, very low, strike ridge 1.5 km west of the outcrop of Pindar Beds, and separated from the Peterson Beds by a postulated fault. They consist here of conglomerate, about 5 m thick, containing well rounded chert clasts up to 3 cm across. On the east side of the anticline, exposures of Jawilga Beds consist mainly of creamy grey to pale maroon, medium to fine-grained sublithic arenite that is medium to thin-bedded and shows cross-bedding and ripple marks. Also present are thin beds of chert granule conglomerate which is similar to that characteristic of the Murraba Formation of the Redcliff Pound Group. The beds here are confined to a narrow fault bounded slice, the reference area for the unit, where they are about 130 m thick.

Because of the presence of chert conglomerate the Jawilga Beds are tentatively correlated with the Murraba Formation.

Boee Beds (Eub)
(new name)

The Boee Beds, which are named after a pool on Sturt Creek, crop out east of the Peterson Range, between latitudes 19°23' and 19°30'S, as narrow strike ridges. At the northern end of the outcrop they are folded into a shallow basin 2-3 km across; south of this they dip at about 12° northwest. The maximum exposed thickness is about 350 m, measured north-northeast from 19°29'40"S, 128°02'25"E and this locality is chosen as the reference area.

The dominant lithology is medium to fine grained sublithic arenite, which is brown to maroon or cream. Individual beds range in thickness from about 30 cm to over 1 m. Some show low angle cross-bedding and some have layers with shale or clay pellets. Some conglomerate is present locally. In the reference area the basal 120 m consists of even-grained sublithic arenite. This is separated by sand plain, a few hundred metres wide, from overlying conglomeratic arenite that passes up into coarse very poorly sorted conglomerate containing boulders of quartzite up to about 30 cm across. Contacts between the Boee Beds and other units are not exposed. However, in the north the beds appear to overlie Jawilga Beds indicating that they may be equivalent to the lithologically similar Erica Sandstone of the Redcliff Pound Group.

CARPENTARIAN AND ADELAIDEAN EAST KIMBERLEY SUCCESSION

In the northwest corner of the Billiluna Sheet area, rocks mapped as Kearney Beds by Casey & Wells (1964) are correlated with Proterozoic rocks of the Gordon Downs Sheet area to the north (Gemuts & Smith, 1968; Dow & Gemuts, 1969). The exposed Proterozoic succession here is unconformable on the Olympio Formation of the Archaean or Lower Proterozoic Halls Creek Group to the west, and consists of the following formations: Mount Parker Sandstone; Bungle Bungle Dolomite; Wade Creek Sandstone; Redbank Yard Conglomerate (the stratigraphic equivalent of the Moonlight Valley Tillite) and Ranford Formation, both formations of the Duerdin Group; and Mount Forster Sandstone, Elvire Formation, Timperley Shale, and Flat Rock Formation, formations of the Albert Edward Group. All but Redbank Yard Conglomerate, a new formation, are defined by Dow & Gemuts (1969).

The East Kimberley succession in the Billiluna Sheet area is irregularly folded and is displaced by numerous minor faults. It is probably separated from Meteorite Crater Beds to the southeast by a postulated concealed major fault which is taken to mark a major structural discontinuity between Kimberley rocks and Granites-Tanami rocks. Correlations between successions on either side of the fault are tentative at present, as they are based on lithologic and stratigraphic similarities, not on isotopic age dating, and have to be made over large distances.

Mount Parker Sandstone (Ɇsp)

The Mount Parker Sandstone is about 300 m thick in the Billiluna Sheet area, where it dips 30-40° east to south-southeast, forming a discontinuous strike ridge. The main rock types are well sorted, medium-grained quartz arenite and, in the lower part of the formation, medium to coarse-grained sublithic arenite with minor interbedded pebbly arenite and conglomerate. In the northern outcrops some siltstone beds are also present. Individual beds are commonly less than 1 m thick; cross-bedded and some have pelletal bedding planes. Brecciation and quartz veining are common, being associated with local faulting.

The Mount Parker Sandstone is tentatively correlated with the Gardiner Sandstone, as it is strongly unconformable on metamorphic rocks of the Halls Creek Group, which is equivalent to the Tanami complex, and is conformably overlain by the Bungle Bungle Dolomite, which may be correlated with the Talbot Well Formation. Hence the formation may be Carpentarian.

Bungle Bungle Dolomite (Ɇsb)

In the Billiluna Sheet area the Bungle Bungle Dolomite is silicified, at least at the surface, to chert. It appears to be about 300 m thick, and is poorly exposed, mainly on low rises. Rock types present are banded chert, brecciated chert, silicified oolite, bouldery cherty ironstone (Fig. 25) showing swirl structures, and minor greywacke or lithic arenite. Micaceous greywacke, siltstone, shale, and lithic arenite that overlie Mount Parker Sandstone in the north may also belong to the formation.

The Bungle Bungle Dolomite is conformable on Mount Parker Sandstone, and like the Talbot Well Formation, with which it may be correlated, it is commonly stromatolitic (Dow & Gemuts 1969).

Wade Creek Sandstone (Ɇsw)

A prominent range of sandstone hills east of the strike ridge of Mount Parker Sandstone extends north into the Gordon Downs Sheet area, where it is mapped as Mount Parker Sandstone (Gemuts & Dow, 1968).

However, in the Billiluna Sheet area Bungle Bungle Dolomite underlies the sandstone, which is therefore mapped as Wade Creek Sandstone.

The formation has a regional dip to the east and has been involved in concertina-type folding. The axes of the folds plunge east.

The Wade Creek Sandstone is over 800 m thick in the Billiluna Sheet area, where it consists mainly of pale grey well sorted sublithic arenite. Minor bands of siltstone are also present and some coarse-grained lenses and beds were seen near the base of the unit. Beds are mostly about 1 m thick.

The contacts between the Wade Creek Sandstone and both the underlying Bungle Bungle Dolomite and overlying Redbank Yard Conglomerate are not exposed in the Billiluna Sheet area, being concealed beneath superficial deposits, but in the north the sandstone is known to rest unconformably on Bungle Bungle Dolomite and to grade into Helicopter Sandstone, which is unconformably overlain by the Duerdin Group (Dow & Gemuts, 1969).

The Wade Creek Sandstone may be correlated with the Auvergne Group of the Victoria River Region (Sweet, pers. comm.).

DUERDIN GROUP

Redbank Yard Conglomerate (Ᵽor)
(new name)

The Redbank Yard Conglomerate forms a group of isolated strike ridges east of the Wade Creek Sandstone, in the northeast of the Billiluna Sheet area. It is named after Redbank Yard on Wolf Creek, at 19°04'00"S, 127°47'00"E. The formation has been folded into easterly plunging open folds in the north and into tighter folds with east-trending axes in the south. The maximum thickness exposed is 330 m, in the type section 15 km west-southwest of Redbank Yard.

Lithology

Rock types exposed are conglomerate, medium-bedded sublithic arenite, and minor dolomite. The conglomerate is a poorly sorted deposit consisting of well rounded to angular fragments mainly of quartz, various types of sandstone, and chert; many of the fragments are more than 10 cm across. It forms thick beds and also thin bands and lenses interbedded with medium to coarse-grained and commonly pebbly sublithic arenite.

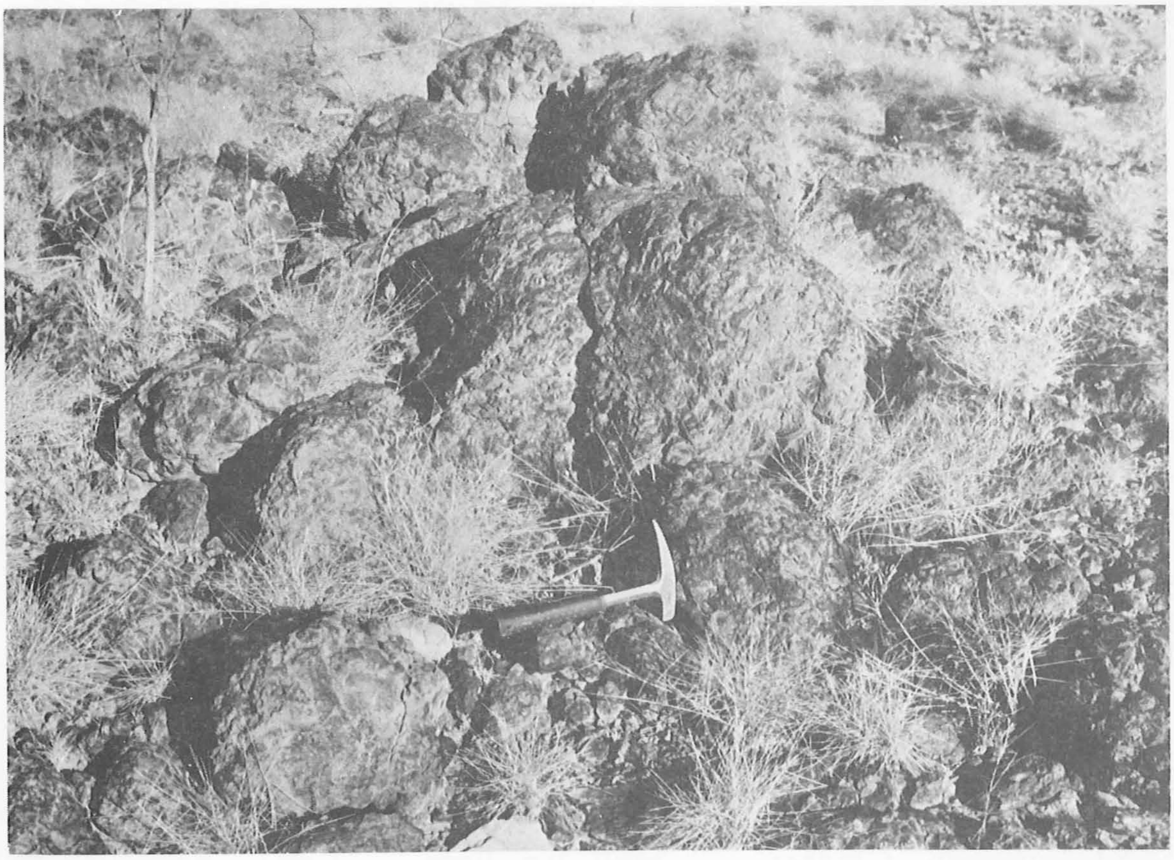


Fig. 25. Bouldery exposure of cherty ironstone developed on Bungle Bungle Dolomite, 16 km west-northwest of Wolf Creek Meteorite Crater, Billiluna Sheet area, Neg. No. GA/7992.

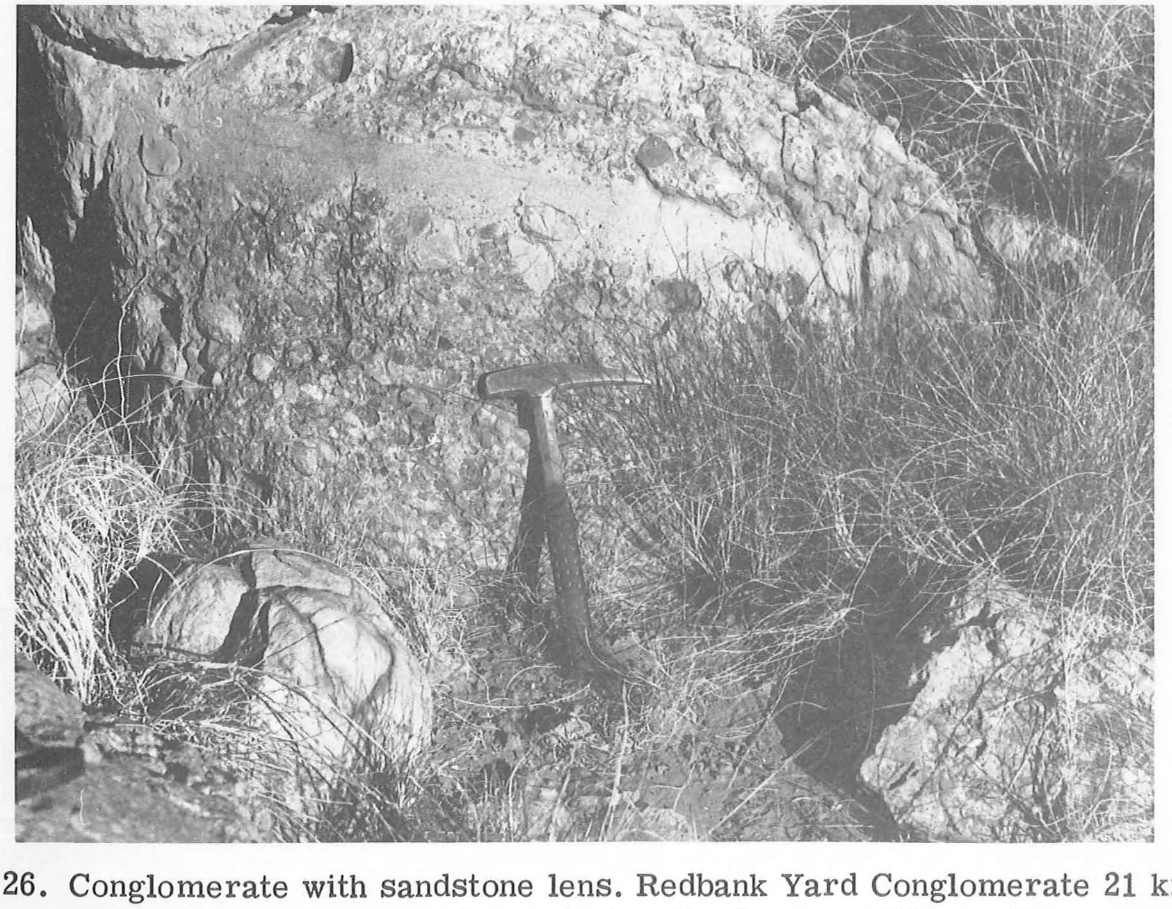


Fig. 26. Conglomerate with sandstone lens. Redbank Yard Conglomerate 21 km west-northwest of Wolf Creek Meteorite Crater, Billiluna Sheet area. Neg. No. M1353/20A.

Conglomerate predominates in the southern outcrops but sublithic arenite is the main rock type in the northern exposures. A lense of grey dolomite about 1 m thick is interbedded with sublithic arenite 14 km west-northwest of Redbank Yard.

In the type section a sequence about 330 m thick dips south at 20°. It consists of 200 m of thick to medium-bedded polymictic conglomerate with thin sandstone lenses (Fig. 26), overlain by 130 m of medium to very coarse-grained sublithic arenite.

The Redbank Yard Conglomerate was laid down in water, and is interpreted as an outwash deposit of sand and gravel derived from glacial moraines.

Stratigraphic relationships, correlations and age

The Redbank Yard Conglomerate overlies Wade Creek Sandstone to the west and is overlain by Ranford Formation to the east, but its contacts with these formations are not exposed. It is considered to be the stratigraphic equivalent of the Moonlight Valley Tillite, which occupies a similar position in the Gordon Downs Sheet area. The Redbank Yard Conglomerate is therefore mapped as part of the Adelaidean Duerdin Group, and is inferred to be unconformable on Wade Creek Sandstone and conformably overlain by Ranford Formation.

Ranford Formation (Ꝑos)

The Ranford Formation is exposed in gullies along the lower part of a prominent west-facing scarp formed mainly of Mount Forster Sandstone, west of the Billiluna-Halls Creek road. Rock types seen are thin-bedded to laminated micaceous shale and flaggy fine-grained well-sorted sublithic arenite. The maximum thickness exposed is about 10 m.

The contact with the overlying Mount Forster Sandstone is concealed by colluvial deposits, but is reported to be an angular unconformity in the Gordon Downs Sheet area (Gemuts & Smith, 1968).

ALBERT EDWARD GROUP

Mount Forster Sandstone (Ꝑao)

In the Billiluna Sheet area the Mount Forster Sandstone is about 200 m thick, and crops out as a prominent hogback and strike ridge west of Wolf Creek. The basal 15 m of the formation exposed consists of generally iron-stained, poorly sorted, medium-grained sublithic arenite that is partly pebbly and conglomeratic. This is overlain by interbedded mostly medium-grained white quartz arenite and pale grey sublithic arenite, some of which is pebbly. Cross bedding is common, and some beds show ripple marks.

The Mount Forster Sandstone overlies Ranford Formation, the contact being an angular unconformity in the Gordon Downs Sheet area, and it is overlain conformably by Elvire Formation.

Elvire Formation (Ꞓae)

This unit crops out on the east side of the hogback of the Mount Forster Sandstone, and extends northwards into the Gordon Downs Sheet area (in the southernmost part of this sheet area the Elvire Formation and younger formations of the Albert Edward Group are not distinguished from the Mount Forster Sandstone). The Elvire Formation is about 390 m thick in the Billiluna Sheet area, where the following sequence is exposed along a creek 12 km northwest of Redbank Yard:

Top, conformably overlain by Timperley Shale.

30 m, thin-bedded ripple-marked medium-grained lithic arenite.

150 m, poorly exposed thin-bedded siltstone and shale with a bed 3 m thick of pelletal white medium-grained quartz arenite near the top.

30 m, ripple-marked medium to fine-grained lithic arenite.

150 m, very thin bedded to laminated, flaggy micaceous siltstone, shale, and fine-grained lithic arenite.

30 m, very thin-bedded ripple marked fine-grained lithic arenite.

Base of formation, conformable on Mount Forster Sandstone.

Timperley Shale (Ꞓaj)

The Boonall Dolomite, present between the Elvire Formation and Timperley Shale in the Gordon Downs Sheet area, does not appear to be represented in the Billiluna Sheet area, as here the Elvire Formation is succeeded by over 100 m of mainly maroon micaceous shale, siltstone, and minor thin lithic arenite interbeds, mapped as Timperley Shale. To the east the upper part of the Timperley Shale is concealed beneath laterite capping and Quaternary sand.

Flat Rock Formation? (Ꞓaf?)

Isolated outcrops of mainly sandstone on either side of Wolf Creek (east branch), on the northern edge of the Billiluna Sheet area, are mapped as possibly Flat Rock Formation. Rock types exposed are medium bedded sublithic arenite that is medium to very coarse-grained and pebbly; thin bedded mauve micaceous siltstone and shale; and thin bedded to laminated siltstone and ripple marked fine-grained sublithic arenite. They are capped by laterite to the east. The rock types are similar to those of the Flat Rock Formation, the youngest unit of the Adelaidean Albert Edward Group in the Gordon Downs Sheet area, and they crop out down dip from, and hence are probably younger than, the Timperley Shale. The Nyuless Sandstone, which separates the Flat Rock Formation from the underlying Timperley Shale in the Gordon Downs Sheet area, has not been recognised in the Billiluna Sheet area.

CAMBRIAN

Antrim Plateau Volcanics (Ꞓla)

Basalt and associated rocks of the Antrim Plateau Volcanics were traced from the Victoria River area to the southern edge of the Tanami Sheet area in 1971 (Blake et al.,1972), and have now been traced farther southwards as a partly laterite-capped tongue, up to 20 km wide, that extends to the centre of The Granites Sheet area. A small outcrop of partly lateritized basalt also occurs 40 km east of Rabbit Flat, near the eastern edge of The Granites area. The basalt mostly forms broad rises partly bounded by break-aways, but west of Mongrel Downs homestead it also forms a plain on which a grey clay soil is developed.

On aerial photographs the volcanics generally have a dark tone, owing to the laterite capping. Where the capping is absent the outcrops are pale to medium toned.

The Antrim Plateau Volcanics are well exposed in Conglomerate Creek, about 15 km west of Rabbit Flat. On the north side of the creek lateritized basalt crops out, and on the south side flat-lying chert and fine sandstone are exposed. Some chert forms mounds where it overlies weathered ferruginised quartzose sandstone, and contains possible algal structures. Spheroidal weathered amygdaloidal basalt is exposed underlying chert and fine sandstone in the banks of Conglomerate Creek at 20°10'40"S, 129°53'42"E. The basalt here is strongly weathered, reddish brown and purple, and has white amygdales.

West of Mongrel Downs homestead there are several outcrops a few metres high of altered but relatively unweathered porphyritic basalt (Fig. 27). The phenocrysts, less than 1 cm long, are of feldspar. The exposed basalt is irregularly and closely jointed. No extrusive or intrusive features were seen.

The grey clay soil plain west of Mongrel Downs homestead is littered with fragments of porphyritic basalt, but elsewhere the basalt is capped by laterite, and exposures are found only in gullies and breakaways.

At most places the volcanics overlie Mount Charles Beds. Seventeen kilometres west of Cave Hill they overlie probable Gardiner Sandstone.

From stratigraphic evidence in the East Kimberley and Victoria River Regions, the Antrim Plateau Volcanics are considered to be probably Lower Cambrian (Sweet et al., 1971). Their distribution in The Granites Sheet area is presumed to be restricted to what were topographic depressions in the Precambrian land surface. West of Mongrel Downs, basalt outcrops are topographically lower than nearby flat-lying sandstone of the Pedestal Beds, indicating that they are probably overlain by the sandstone.

Unnamed Cambrian

In the northeast corner of The Granites Sheet area, laterite forming low rises is mapped as capping unnamed Cambrian rocks. The low rises extend eastwards into the adjoining Mount Solitaire Sheet area to a breakaway about 30 m high, at 20°09'S, 130°33'E. This breakaway consists of 2 m of pisolitic laterite overlying a flat-lying sequence of thin to very thin-bedded maroon micaceous shale, siltstone and fine grained lithic and white quartzose sandstone. The beds, which appear to be unfossiliferous, are less indurated than Precambrian rocks of similar type in the area, and are inferred to rest with strong angular unconformity on metamorphic rocks of the Tanami Complex as these are exposed a few kilometres to the north. The beds are tentatively correlated with unnamed Cambrian cropping out in the southeastern part of the Tanami Sheet area (Blake et al., 1972), and presumably represent the oldest sediments deposited on the southwestern edge of the Wiso Basin.

Fig. 27. Porphyritic basalt of the Antrim Plateau Volcanics 18 km west of Mongrel Downs homestead, The Granites Sheet area. Neg. No. GA/8017.

Fig. 28. Type section of the Lucas Formation, on the northeast side of Lake Dennis, Lucas Sheet area. Neg. No. GA/7990.

Fig. 29. Trends of bedding, joints, and minor faults of the Lucas Formation in Lake Dennis, Lucas Sheet area. Neg. No. GA/8015.

Fig. 30. Flat depressions with thin white salt crusts separated by sparsely vegetated low rises on the bed of Lake Dennis, Lucas Sheet area. Neg. No. GA/7994.

PALAEOZOIC?

Lucas Formation (Pzl)

The Lucas Beds, named and defined by Casey & Wells (1964), have been upgraded to formation status as the top as well as the base of unit is now defined. The formation, named after Lake Lucas, 20°56'S, 128°50'E, consists of partly calcareous sandstone and mudstone. It crops out in the southeast part of Lucas, southwest part of The Granites, northeast part of Stansmore and northwest part of Highland Rocks Sheet areas.

Exposures are generally poor, as over most of its outcrop area the Lucas Formation is covered by laterite, which is developed on low rises, calcrete, sand dunes, and alluvium. Good exposures are restricted to low breakaways bordering laterite rises and to cliffs present locally around lakes. The formation is best exposed in cliffs up to 15 m high along the east side of Lake Dennis, and it is at one of these cliffs, at 20°53'30"S, 28°56'00"E, Lucas Sheet area, that the type section has been selected (Fig. 28). Casey & Wells (1964) selected the bed of Lake Dennis (='the northern arm of Lake White') as the 'nominate' exposure, but here the Lucas Formation is covered by a thin layer of salt and alluvium even though bedding trends, joints, and small faults are very prominent on aerial photographs (Fig. 29).

The Lucas Formation was intersected in stratigraphic holes 1 to 5 in The Granites Sheet area. These were drilled during 1972, and several metres of unweathered rock was cored and collected.

Bedding trends, joints, and faults in the outcrop area of the Lucas Formation are commonly visible on aerial photographs as lines crossing areas of very pale toned calcrete, and also as alternating thin dark and pale bands reflecting interbedded sandstone and mudstone underlying alluvium in the beds of several lakes, in particular Lakes Dennis and Lucas in the Lucas Sheet area, and Lake Sarah and Bullock Head Lake in The Granites Sheet area.

The Lucas Formation is gently dipping to flat-lying, and dips are rarely over 5°. It appears to be thickest in the Lake Lucas-Lake Dennis areas, where a thickness of 1000 m has been calculated on the assumption that here the beds have an average dip of 2-3°, there is no repetition of beds owing to folding or faulting, and the beds do not overlap one another to the east.

Lithology

The Lucas Formation consists of friable calcareous and non calcareous sandstone, siltstone, and mudstone, and minor limestone, and dolomite.

The calcareous sandstone is purplish to grey, mostly medium to fine-grained, and is highly lithic. It has a calcite cement, and some beds show lustre mottling of fontainebleu type. Exposures are commonly criss-crossed by calcrete, which fills joints and cracks. This is well displayed on low rises and mounds in The Granites Sheet area south and east of Hommies Knob. The non-calcareous sandstone (lithic and sublithic arenite) is greyish or brownish to maroon, and mostly medium to coarse grained. It locally has a quartz overgrowth cement. Both types of sandstone are medium to thin bedded and flaggy, commonly micaceous, and many beds contain mudstone pellets. Cross-bedding is common and ripple marks are present locally. The sandstones are interbedded with thin-bedded to laminated, grey to greenish-grey and maroon, locally micaceous siltstone and mudstone, some of which is calcareous. The finer-grained rocks also show cross-bedding and ripple marks. They are friable, poorly exposed, and commonly form scree slopes below cappings of resistant sandstone.

Limestone is locally present as thin beds of pale pinkish calcilutite, and pink sandy dolomite was recorded by Casey & Wells (1964) northeast of Yam Hill. The same authors also noted a line of barytes pebbles, probably representing a lens or bed in the Lucas Formation, on the east side of Lake Dennis.

At the type section, a cliff on the east side of Lake Dennis, the following sequence is exposed, dipping at about 2° east:

Top of cliff	2.5 m Calcrete.
"	3 m Mudstone, calcareous, banded pale greenish-grey and maroon, contains some thin sandstone, laminae.
"	2 m Sandstone, calcareous, current-bedded and ripple-marked, greyish pelletal, medium-grained, shows lustre-mottling.
"	2 m Mudstone, as above.
	0.25 m Sandstone, as above.

Top of cliff	2 m Mudstone, as above.
"	1.5 m Sandstone, as above.
"	1 m Mudstone, as above.

Lake floor

10 km west of the type section a cliff exposure consists of 3 m of calcrete capping 1 m of maroon calcareous mudstone overlying 0.5 m of pale pinkish to maroon calcilutite, and, at the base, 2 m of brownish cross-bedded medium-grained calcareous sandstone containing pellets and laminae of mudstone.

The alternating dark and white bands visible on the floor of Lake Dennis are due to a microrelief of less than 1 m (Fig. 29). This consists of unvegetated flat depressions with a thin salt crust (white bands) separated by slightly hummocky rises with no salt crust (dark bands). Auger drilling indicated that the depressions are developed on mudstone, which is overlain by about 30 cm of mud, and the rises are on sandstone underlying 25-30 cm of mud.

About 5 m of flat-lying Lucas Formation is exposed at Pommies Knob, in The Granites Sheet area. This prominent hill is formed of thin-bedded, lithic sandstone and maroon and grey banded mudstone. The sandstone is coarse to fine-grained, poorly sorted and contains abundant mudstone pellets.

Laminated grey micaceous, non calcareous fine-grained sandstone, siltstone, and shale were intersected in several stratigraphic holes drilled in 1972 in The Granites and Lucas Sheet areas (see Appendix).

Stratigraphic relationships, age, and possible correlations

The Lucas Formation is unconformable on the Redcliff Pound Group, but the unconformity is not exposed. The formation is overlain, probably unconformably by sandstone of the Pedestal Beds. The contact between the Lucas Formation and Pedestal Beds is exposed at Yam Hill, in the Lucas Sheet area, and at Mount Tracey, in The Granites Sheet area, but is concealed east of Mount Tracey. It is inferred to be a low angle unconformity, as the Pedestal Beds appear to overlap westwards onto increasingly older beds of the Lucas Formation.

At Yam Hill, the basal beds exposed are thin-bedded greyish calcareous sandstone, 2 m thick, of the Lucas Formation. This sandstone is overlain by about 10 m of pale yellowish to white clayey quartz sandstone mapped as Pedestal Beds. Both the Lucas Formation and Pedestal Beds are flat-lying. At Mount Tracey about 3 m of Pedestal Beds sandstone overlies about 35 m of the Lucas Formation which consists of pale grey to maroon micaceous mudstone and siltstone, about 5 m thick, on 30 m of greenish-grey thin-bedded fine-grained sandstone with minor thin interbeds of mudstone.

The age of the Lucas Formation remains uncertain. Outcrop samples and drill core specimens failed to yield any fossils other than a possible unidentifiable spore and some minute spheres of uncertain affinities. However, these indicate that the formation is probably Phanerozoic and it is mapped as Palaeozoic. A Phanerozoic age is supported by the probable unconformable relationship of the Pedestal Beds on basalt mapped as part of the Lower Cambrian Antrim Plateau Volcanics in The Granites Sheet area, and by the soft and friable nature of the sandstone and mudstone of the Lucas Formation, especially compared with the Proterozoic rocks in the area. The lack of marine fossils indicates that the formation may be non marine.

The Lucas Formation may be stratigraphically equivalent to one or more of the Palaeozoic formations of the Canning Basin, from which it is separated by a structural 'high' formed of the Proterozoic Redcliff Pound Group. A correlation with the Permian Noonkanbah Formation of the Canning Basin was suggested by Casey & Wells (1964) on the grounds of similarities in lithology, photopattern, and structural expression. However the Lucas Formation, unlike the Noonkanbah Formation, does not contain marine fossils, and if it is non marine, similarities in lithology etc., may be fortuitous.

Pedestal Beds (Pzs)
(new name)

The Pedestal Beds consist predominantly of flat-lying to gently dipping clayey quartzose sandstone. They form cuestas, mesas, hillocks, mounds, hummocky terrain, and rocky pinnacles, all less than 10 m high. Outcrops are widely scattered in the southeast parts of Lucas and Stansmore Sheet area, where they were previously mapped as unnamed

Permian and Palaeozoic sediments respectively (Casey & Wells, 1964; Wells, 1962b, c) and in the eastern part of The Granites Sheet area. The main topographic features formed by the unit are the Pedestal Hills, 20°35'S, 129°17'E, after which the beds are named, and Macfarlanes Peak Range, both in The Granites Sheet area.

The beds are locally capped by laterite and silcrete, and surface silicification is common. Where not silicified, the beds are friable, and weathered surfaces are generally rough and pitted. Iron-staining is common, and the beds range from white to pale yellow, mauve, and maroon.

The maximum thickness exposed is about 40 m, in the Macfarlanes Peak Range. The reference area is 5 km east of Macfarlanes Peak Bore, at 20°22'10"S, 129°29'00"E.

Lithology

Rock types exposed are sandstone and minor conglomerate, shale, and siltstone. The sandstone (sublithic arenite) is quartzose, mostly medium to fine-grained, and has a generally abundant clayey matrix. Coarse-grained and micaceous varieties are also present, and some of the sandstone contains scattered well rounded pebbles up to 5 cm across. The micaceous sandstone is highly friable and has a well developed flaggy to almost shaly parting. Individual beds range from thick to thin, but are mostly about 1 m thick; they are locally poorly defined. Most beds show medium to large scale, low angle cross bedding (Fig. 31), and ripple marks and bedding planes with shale pellets are common. Conglomeratic sandstone about 1 m thick is present at the base of the unit in the Macfarlanes Peak Range area, unconformably overlying Mount Charles Beds and unnamed granite.

Conglomerate consisting of well rounded pebbles and cobbles is interbedded with sandstone in the southernmost part of The Granites Sheet area and in the adjoining Highland Rocks Sheet area. The pebbles and cobbles are of Proterozoic sublithic and quartz arenite, quartzite, milky vein quartz, and banded chert. They are enclosed in a sparse clayey sandstone matrix.

In the reference area, east of Macfarlanes Peak Bore, a sequence about 20 m thick dips 10-15° south. The basal 5 m exposed consists of medium-grained ripple marked quartzose clayey sandstone with micaceous partings. It is overlain by about 5 m of flaggy sandstone with thin interbeds of maroon siltstone, which in turn is overlain by 10 m of thick bedded sandstone showing large scale cross bedding.

Up to 10 m of flat-lying sandstone is exposed at the Pedestal Hills. The sandstone is medium-grained, mostly medium-bedded, patchily micaceous, and some bedding surfaces show moulds of clay pellets, cross-bedding is well developed (Fig. 31).

Stratigraphic relationships

Contacts between Pedestal Beds and underlying units are generally concealed beneath superficial deposits. However, the Pedestal Beds are seen to be unconformable on Mount Charles Beds and unnamed granite in the Macfarlanes Peak Range area, and to overlie Lucas Formation on Yam Hill and Mount Tracey, in the Lucas and The Granites Sheet areas respectively. They are inferred to overlie the Redcliff Pound Group and Antrim Plateau Volcanics.

At Yam Hill, 10 m of pale yellowish to white cross-bedded and ripple-marked clayey quartzose sandstone of the Pedestal Beds overlies 2 m of calcareous sandstone of the Lucas Formation. On Mount Tracey similar Pedestal Beds sandstone overlies 35 m of sandstone and mudstone belonging to the Lucas Formation. The Pedestal Beds at these two localities and farther east appear to overlie different stratigraphic levels of the Lucas Formation, and the contact between the two units is inferred to be an unconformity.

An unconformable relationship between Pedestal Beds and underlying rocks of the Redcliff Pound Group is inferred in the southeast part of the Stansmore Sheet area. Here the Redcliff Pound Group has been folded into a series of anticlines and synclines, and sandstone of the Pedestal Beds crops out in the core areas of two of the synclines. These are presumed to have been topographic depressions when the Pedestal Beds were deposited.

East of the Macfarlanes Peak Range, in The Granites Sheet area, outcrops of flat-lying sandstone of the Pedestal Beds are close to topographically lower outcrops of basalt mapped as part of the Antrim Plateau Volcanics, and the inference is made that the Pedestal Beds overlie the basalt.

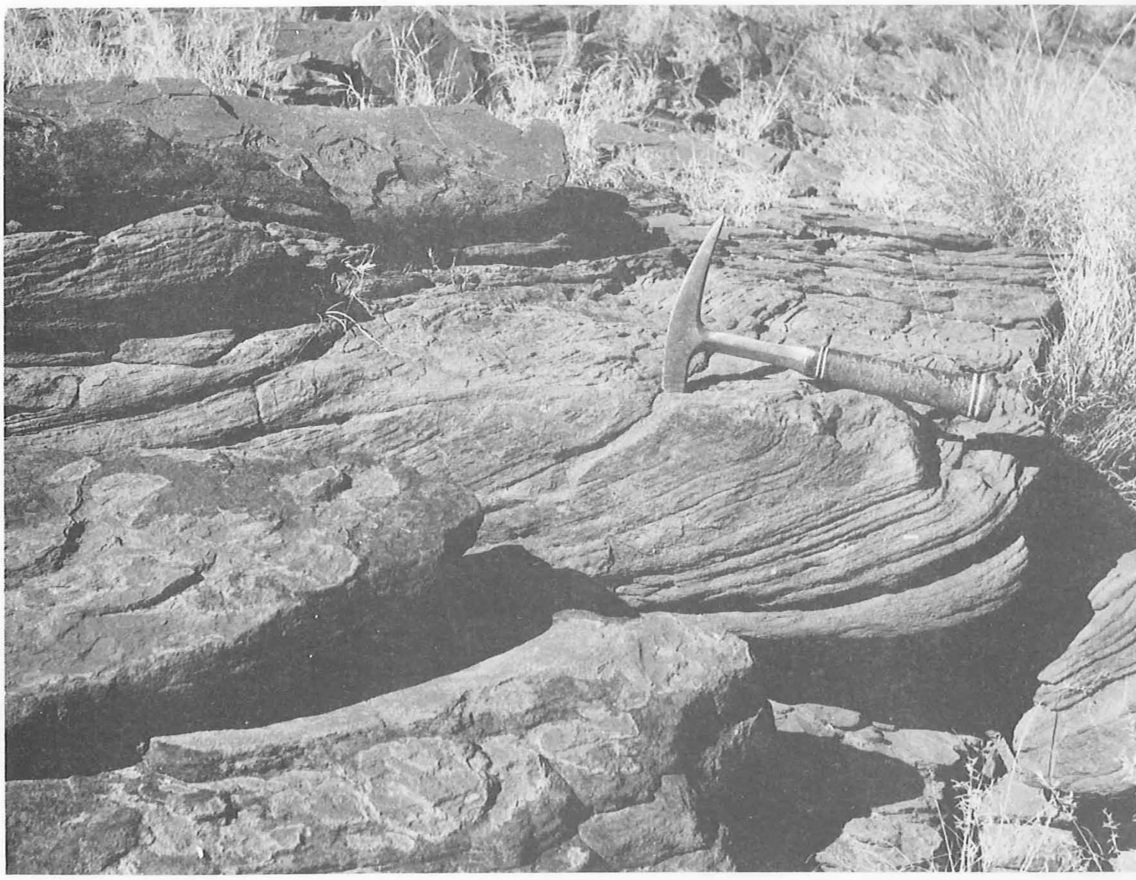


Fig. 31. Cross-bedded sandstone of the Pedestal Beds. Pedestal Hill, The Granites Sheet area. Neg. No. M1402/26.

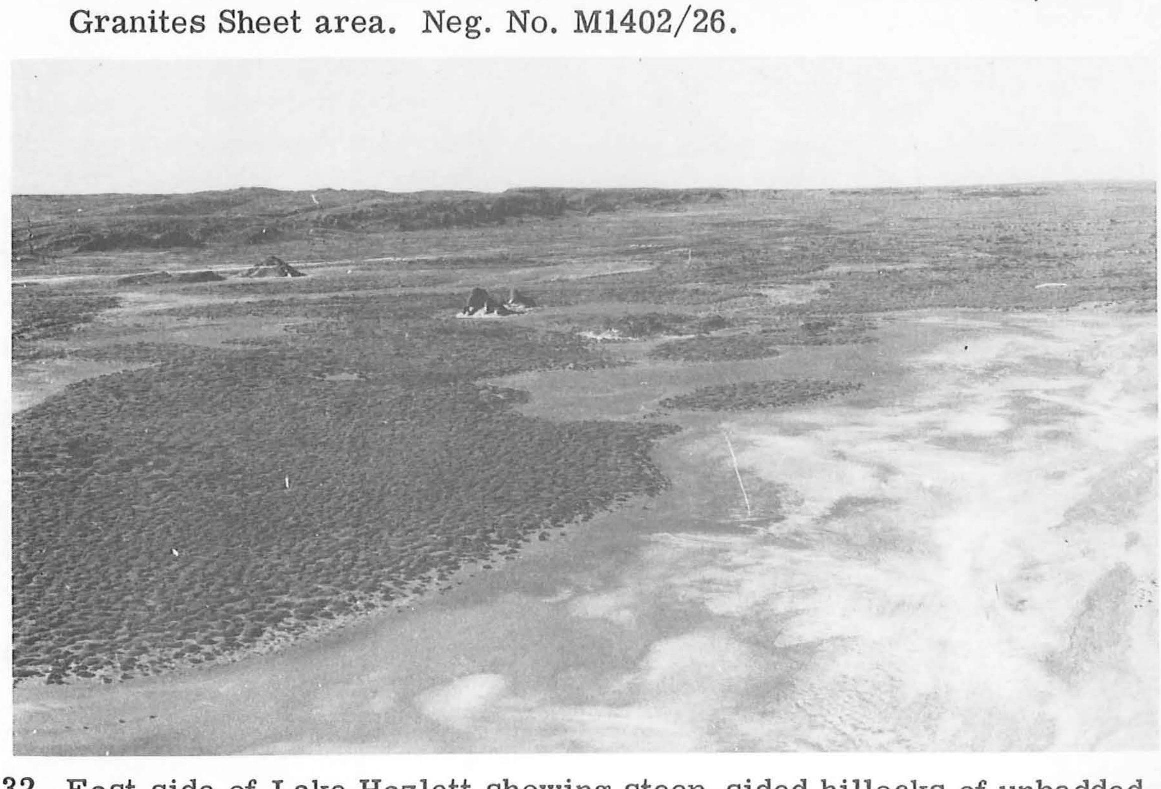


Fig. 32. East side of Lake Hazlett showing steep-sided hillocks of unbedded sandstone mapped as Hazlett Beds in front of the sandstone ridges of Redcliff Pound, Stansmore Sheet area. Neg. No. M1404/9.

Age and possible correlations

The age of the Pedestal Beds is uncertain, as the unit appears to be unfossiliferous. The lack of fossils may indicate that the beds are non-marine. The Pedestal Beds are probably post Lower Cambrian, as they are inferred to be unconformable on the Lower Cambrian Antrim Plateau Volcanics and the probably Palaeozoic Lucas Formation. They are probably pre-Tertiary, as they are affected by Tertiary laterization and their distribution is not related to Cainozoic drainage lines. Lithologically, the sandstone of the Pedestal Beds is strikingly similar to some of the Devonian Knobby Sandstone, and is unlike the sandstone of the Cretaceous Hazlett Beds and their probable stratigraphic equivalent, the Larranganni Beds. Hence the Pedestal Beds are tentatively regarded as Palaeozoic. They may be the stratigraphical equivalent of the Permian Condron Sandstone, which overlies the Noonkambah Formation, possible stratigraphic equivalent of the Lucas Formation, in the Canning Basin (Casey & Wells, 1964; Yeates et al., 1973).

Chuall Beds (Pzc)
(new name)

The Chuall Beds crop out southeast of Sturt Creek homestead in the Billiluna Sheet area. The reference area is 4 km southeast of the homestead. The Beds are named after nearby Chuall Pool in Sturt Creek and form low hills and cuesta up to 8 m high. They consist of flat-lying clayey and micaceous friable sandstone (sublithic arenite) which is about 140 m thick in the reference area.

The sandstone is quartzose to lithic and mostly fine to medium-grained, though there are many pelletal and gritty bands. It forms mainly thin beds, some of which show low angle cross bedded.

Chuall Beds are not seen in contact with other units. Because of their low dips they are inferred to be unconformable on adjacent Precambrian rock units of the Denison Range area. Their lithology and friable nature resembles that of Ordovician and Devonian sandstones to the southwest, and consequently the Chuall Beds are mapped as possibly Palaeozoic.

PALAEOZOIC CANNING BASIN SUCCESSION: RELATIONSHIPS WITH THE PRECAMBRIAN ROCKS

The part of the Canning Basin that is covered by the western parts of the Billiluna, Lucas, and Stansmore Sheet areas was mapped in 1972 by the East Canning Basin Party. The oldest rocks of the Canning Basin succession exposed here are sandstone and conglomerate containing Ordovician fossils. These rocks, named the Carranya Formation, are seen to overlap onto Proterozoic Peterson Beds southeast of Billiluna homestead, where the conglomerate contains mostly well rounded pebbles and boulders up to 50 cm across of various types of sandstone, vein quartz, quartzite, phyllite, and greywacke, enclosed in a poorly sorted clayey sandstone matrix. Sandstone of the same formation in this area is fine to medium-grained, contains scattered pebbles, and is cross-bedded and locally ripply marked. Northeast of Billiluna homestead the Carranya Formation is inferred to be unconformable on Adelaidean Redbank Yard Conglomerate.

The Carranya Formation is overlain unconformably by Upper Devonian Knobby Sandstone, which consists of cross-bedded medium to coarse sandstone and minor conglomerate and siltstone. The Knobby Sandstone rests unconformably on Peterson Beds northeast of Billiluna homestead and on Carpentarian or Adelaidean Kearney Beds and Lower Proterozoic unnamed granite west of the Kearney Range in the Lucas Sheet area, and it is overlain unconformably by Permian formations. The Permian formations do not extend eastwards onto the Precambrian rocks in the Billiluna and Lucas Sheet areas, but are seen to lie unconformably on rocks that probably belong to the Carpentarian or Adelaidean Erica Sandstone in the Stansmore Sheet area, south of the Stansmore Range.

CRETACEOUS

Hazlett Beds (Kh)

The Hazlett Beds, named and defined by Veevers & Wells (1961), crop out in the eastern part of the Stansmore Sheet area. They generally consist of medium-bedded quartzose sandstone (sublithic arenite to quartz greywacke), siltstone, and soft white claystone, and mainly form cappings up to 10 m thick on mesas and plateau surfaces. Between Redcliff Pound and Brookman Waters they also form small steep-sided hillocks, up to 10 m high, of unbedded white quartzose sandstone (Fig. 32). The sandstone is fine to medium-grained and has pitted weathered surfaces. Some is friable and some is silicified to silcrete.

The Hazlett Beds are generally flat-lying, and lie with marked angular unconformity on rocks of the Precambrian Redcliff Pound Group. Radiolaria from claystone east of Brookman Waters have been identified by Dr Crespin as cf. Cenosphaera, indicating that the Hazlett Beds are probably Cretaceous (Veevers & Wells, 1961).

Larranganni Beds (Kl)

The Larranganni Beds consist mainly of flat-lying quartzose sandstone. In the Billiluna Sheet area they form a series of mesas in front of the scarp marking the southwest edge of the Gardiner Range. They also crop out at 19°12'24"S, 128°50'30"E and 19°08'36"S, 128°47'54"E in the Gardiner Range, on the southwest side of the Killi Killi Hills, and on the north side of Tent Hill in the Billiluna Sheet area, and 5 km south of the Tanami Range and 14 km northwest of Sangsters Bore in The Granites Sheet area. The Larranganni Beds were first defined and named (Blake et al., 1972) in the Birrindudu and Tanami Sheet areas. The reference area is 0.5 km south of Larranganni Bluff, after which the unit is named, on the WA/NT border. The maximum thickness of the unit is about 10 m.

Lithology

The main rock type is medium-grained quartzose sandstone (quartz and sublithic arenite to quartz greywacke) which is commonly silicified and resembles silcrete, or else it is porous. Beds are generally less than 1 m thick and are flat-lying. West of the Gardiner Range some mesas of Larranganni Beds include cappings of silicified conglomerate containing angular blocks of Gardiner Sandstone. East of the Mount Brophy scarp about 10 m of similar conglomerate mapped as Larranganni Beds overlies Gardiner Sandstone. Several outcrops have cappings of silcrete.

On the north side of Tent Hill the Larranganni Beds form low-lying outcrops only a few metres high. They consist of poorly sorted clayey quartzose sandstone made up of mostly subangular quartz grains in an abundant kaolinitic matrix. The sandstone is presumably derived mainly from the granite which forms Tent Hill immediately to the south.

South of the Tanami Range silicified medium-grained sandstone containing angular to subangular quartz pebbles and with a silcrete type of matrix has been mapped as Larranganni Beds. The sandstone is gently dipping and has some ripple marks. It forms a low hill that is capped by pisolitic laterite.

Stratigraphic relationships and age

West of the Gardiner Range the Larranganni Beds can be seen to overlie the Killi Killi Beds, in the Gardiner Range they overlie Gardiner Sandstone. Cappings of silcrete occur in places and these indicate a pre-Tertiary age at least. The Larranganni Beds now occur as topographic highs and indicate that a considerable amount of erosion has occurred since they were deposited. The beds are tentatively correlated with the Cretaceous Hazlett Beds of similar lithology in the Stansmore Sheet area.

UNDIVIDED POSSIBLE MESOZOIC (M?)

Several small outcrop areas mapped as possible Mesozoic are present west of the Proterozoic outcrops in the southeastern part of the Lucas Sheet area and northeastern part of the Stansmore Sheet area. In these outcrop areas there are low mounds and tor-like masses of sandstone, generally less than 1 m high and 5 m across, rising out of the sand plain, and more extensive low rises of sandstone partly capped by laterite and silcrete. The sandstone exposed appears porous and less indurated and compact than Proterozoic sandstones, and commonly has pitted weathered surfaces. It is a pale yellowish or brownish to white, mostly medium to fine-grained quartzose sandstone (sublithic arenite) with over 10 percent opaline or silicified clayey matrix. Pebbly bands and thin layers of porcellanite are present locally. The pebbles are well rounded, up to 10 cm across, and are mainly of quartz sandstone, although chert and phyllite pebbles were also seen. Bedding planes tend to be poorly defined, and are flat to gently dipping. Cross bedding can be discerned at most exposures.

The sandstone is inferred to be unconformable on the Proterozoic rocks to the east, but no contacts are exposed. Although it closely resembles some of the Devonian Knobby Sandstone exposed adjacent to Proterozoic outcrops to the north in the Lucas and Billiluna Sheet areas, it is thought more likely to be Mesozoic, as sandstone of similar type is unconformable on Permian rocks in the Stansmore Range to the southwest, in the Stansmore Sheet area (Yeates et al., 1973).

CAINOZOIC

Over most of the area mapped the pre-Tertiary rocks are concealed beneath a cover of Cainozoic rocks. In many places this cover is less than a few metres thick and consists wholly of Quaternary deposits, mainly aeolian sand and alluvial sand, silt, and clay. In other parts the cover consists at least partly of Tertiary laterite, silcrete, and calcrete. Where the cover is very thin, the trends of bedding, joints, and faults in the underlying rocks are visible on aerial photographs. Good examples are bedding trends showing through Quaternary sand in the vicinity of many outcrops of the Tanami complex, and trends of bedding, joints, and minor faults in the Lucas Formation showing through alluvium and evaporites in Lake Dennis and through Tertiary calcrete and Quaternary aeolian sand in the area around Lake Dennis.

Locally the Cainozoic cover is relatively thick, as along most of the main present and former drainage lines, which are indicated on the geological maps by areas of Quaternary alluvium - Qa, Qs and Qe - and associated Tertiary calcrete - Tt and Czk (Fig. 35). There are also at least two Cainozoic sedimentary basins. One of these basins is in the Lucas Sheet area, between the Kearney and Lewis Ranges, and another lies between the Peterson Range and cuestas of the Lewis Range Sandstone to the east in the Billiluna Sheet area . Stratigraphic drilling was carried out in both these basins during 1972 (see Appendix) and further drilling is planned during 1973. Cainozoic sediments are probably at least 100 m thick in the basin east of the Kearney Range and at least 94 m in the basin east of the Peterson Range, and they consist mainly of Tertiary clay and associated chert. The clay is commonly calcareous and gypsiferous, and is overlain in places by calcrete up to 15 m thick.

A further Cainozoic sedimentary basin may be present in the Hidden Basin, a major topographic depression in the eastern part of the Stansmore Sheet area that includes Lake Wills and Lake Hazlett.

Laterite

Laterite is widespread in the areas mapped in 1972. It occurs on topographic highs which have smooth to gently undulating tops and sides that are gently sloping except where they are bounded by breakaways. Shallow gullies are commonly developed on the sides. On aerial photographs laterite shows up as dark tones.

The laterite is present as cappings on rocks ranging in age from Archaean or Lower Proterozoic to Cainozoic, and is best developed on rocks relatively low in silica, such as basalt, some of the regionally metamorphosed rocks of the Tanami complex, and sedimentary rocks of the Lucas Formation. Complete laterite profiles are commonly present on such rocks, consisting of an upper pisolitic layer up to 2 m thick, a central mottled zone, and a lower pallid zone. The upper layer is commonly cemented to pisolitic ironstone on the edges of the lateritic rises. The central and lower zones show a wide range in thickness and locally appear to be absent.

The laterite cappings are remnants of a flat to gently undulating surface, most of which has been removed by subsequent erosion. The amount of erosion is such that the laterite is regarded as probably Tertiary, and the surface on which it is developed is correlated with the Tennant Creek erosion surface of Hays (1967).

Silcrete (Czs, Ts)

Patches of silcrete are common in many parts of the area, but are mostly too small to be mapped at 1:250 000 scale. They have smooth pale tones on aerial photographs.

Fig. 33. Sand dunes near Lake White, northeastern part of the Stansmore Sheet area. Neg. No. GA/8013.

Fig. 34. Claypans and sand dunes south of the Muriel Range, The Granites Sheet area. Neg. No. M1402/6.

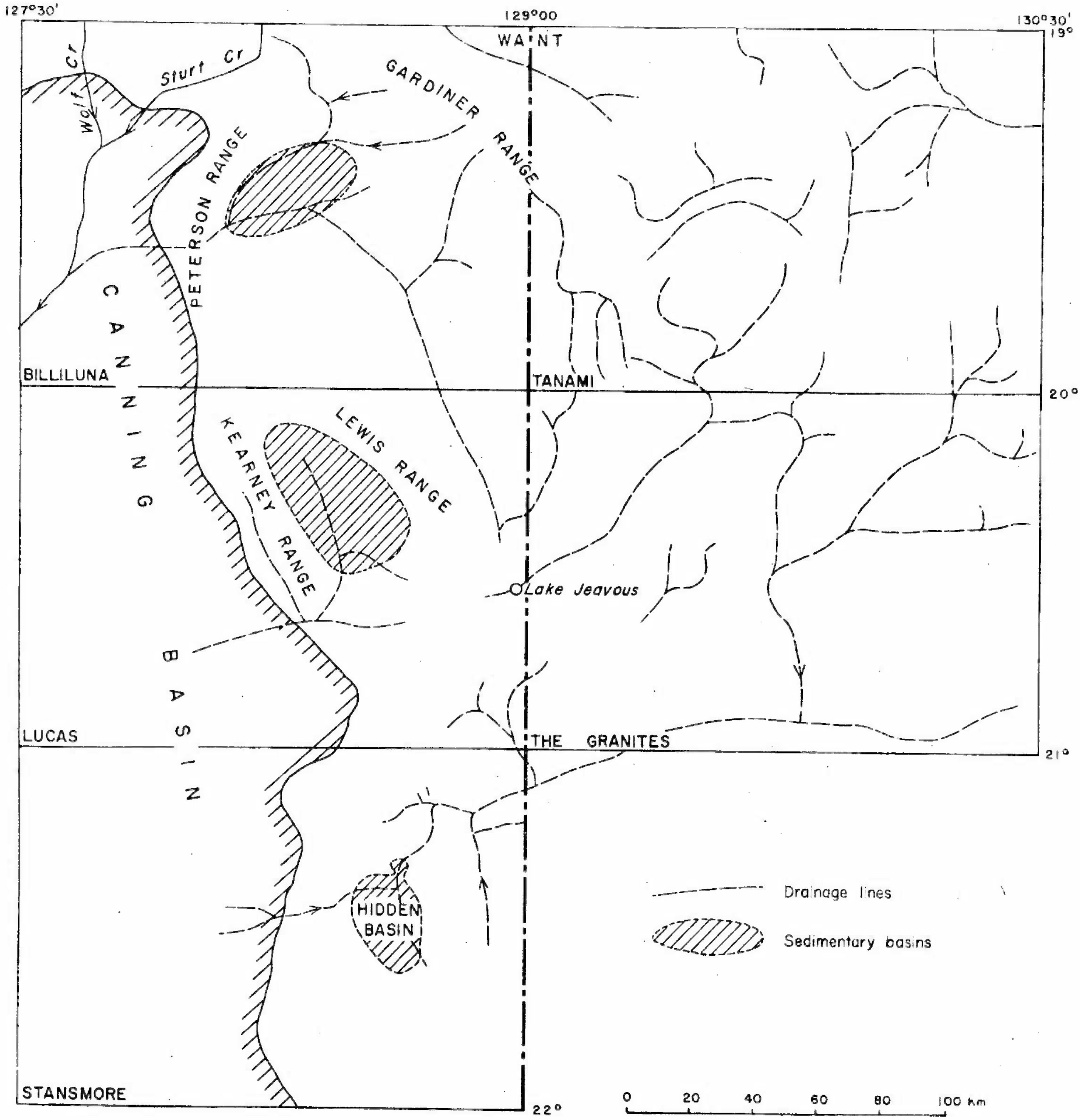


Fig. 35 Cainozoic drainage lines and sedimentary basins.

The silcrete is pale buff to grey, and consists of unsorted angular fragments, mainly of quartz, in a very fine-grained to amorphous siliceous matrix. It is mainly developed as cappings on rocks relatively rich in silica, especially quartz-rich sandstone. In places it is closely associated with laterite, as on possibly Mesozoic sandstone on the west side of the Phillipson Range, in the Lucas Sheet area.

Silcrete is not forming at the present time, and is regarded as probably Tertiary.

Calcrete

Tt (The Granites Sheet area), Czk (other Sheet areas)

Calcrete is present in the Billiluna, Lucas, and Stansmore Sheet areas, where it was previously mapped as travertine and tuff (Casey & Wells, 1964; Wells, 1962a, b, c), but it is most extensive in The Granites Sheet area. It crops out as local low rises in broad topographic depressions that represent old drainage lines. In the east these rises are up to 5 m above adjacent Quaternary superficial deposits, and consist of undulating rocky terrain with sink holes, but they decrease in relative relief to the south and west, and merge with aeolian and alluvial deposits in the Lake Wills-Lake Hazlett area. Locally a grey soil with fragments of chalcedony and limestone is developed on the calcrete.

On aerial photographs the calcrete shows up as very pale to white areas, many of which have a cerebriform texture.

The calcrete consists of white to pale grey inorganic limestone and associated chert. It is generally hard and vuggy, but some is soft and powdery, as on the margins of Lakes Wills and Hazlett. Sand grains and rock fragments are commonly visible in the calcrete, and at one locality, on the southwest side of the Murraba Ranges east of Lake Wills, calcrete contains fragments of granite several centimetres across. The source of this granite is not known, as there are no known granite outcrops within the Murraba Ranges.

The greatest known thicknesses of calcrete in the area are 15 m in drill hole EL4, Billiluna Sheet area, and 12 m in drill hole 11, Lucas Sheet area (see Appendix).

In the Lake Dennis area and east to the Pedestal Hills, calcrete 2 to 3 m thick is developed on calcareous rocks of probably Palaeozoic Lucas Formation and is overlain by Quaternary sand dunes. On the east side of Lake Dennis the calcrete is exposed on the tops of cliffs up to 15 m above the lake floor. On a low rise southeast of Lake Jeavons, near the eastern edge of the Lucas Sheet area, calcrete on Lucas Formation is overlain by pisolitic laterite.

The calcrete is a chemically precipitated terrestrial deposit associated with former drainage channels and possibly lakes, and was deposited by ground water in topographic depressions. As it now forms local topographic highs with up to 5 m relief, a considerable amount of erosion must have taken place since its deposition, probably more than can be accounted for during the Quaternary. Hence most of the calcrete is considered to be Tertiary. Further evidence supporting a pre-Quaternary age for most of the calcrete is the occurrence of laterite on calcrete on a low rise near Lake Jeavons, and the presence of granite fragments in calcrete east of Lake Wills: granite does not crop out upstream from the calcrete, and the fragments could not have been transported to this site by streams of the present drainage system. However, some of the low-lying and locally powdery calcrete in the southwest could be Quaternary and some may even be forming at the present time.

The calcrete in The Granites Sheet area is mapped as Tertiary (Tt) and that in the other Sheet areas is mapped as Cainozoic (Czk).

Vein quartz rubble (Czq)

In many parts of the area a thin veneer of vein quartz rubble with aeolian sand is present on rocks of the Tanami complex, generally showing up as a wavy pattern on aerial photographs. This pattern is due to alternating bare and vegetated patches which reflects trends in the underlying bedrock. The vein quartz rubble is a residual product, the result of prolonged weathering during the Cainozoic of quartz-veined metamorphic rocks. In places there are low exposures of vein quartz in situ, projecting through the rubble, but exposures and even loose fragments of bedrock are rare or absent.

QUATERNARY

The unconsolidated superficial deposits that cover most of the area mapped are grouped into the following five Quaternary units.

Alluvial and lacustrine sand, silt, and clay (Qa)

This unit comprises water-laid sediments localized along floodplains of major drainage channels and in lakes and clay pans. Sand and silt predominate on floodplains, and clay, commonly associated with gypsum and other evaporites, predominate in lakes and clay pans.

Evaporites (Qe)

Evaporites have been mapped in salt lakes and salt pans in the southern and western parts of the area. They show up wholly or partly white on aerial photographs (Figs 21, 39 and 31), owing to the presence of a thin salt crust that is developed on gypsiferous and saline clay. The salt crust consists mainly of halite and is generally less than a few millimetres thick.

Aeolian and alluvial sand and silt (Qs)

Detrital sand and silt deposited by sheet wash, rather than by rivers, and mixed with aeolian deposits are mapped as Qs. This unit is restricted to generally broad, barely perceptible topographic depressions, and is not normally associated with major drainage channels. In the south, mainly in the Stansmore Sheet area, many of the broad depressions mapped as Qs are crossed by sand dunes and contain many salt and clay pans too small to be mapped individually (Fig. 34).

Aeolian sand and minor piedmont gravel (Qz)

The most widespread of the Quaternary deposits in the area is aeolian sand, which forms both sand plains and dune fields that are topographically higher than adjacent Quaternary units. The dune fields consist of east trending, longitudinal (seif) dunes (Figs 33 and 34), mostly less than 5 m high, which show a considerable range in length, density, and complexity. The dunes have a sparse vegetation and are stationary.

The unit also includes minor gravel and sand deposited on gentle piedmont slopes flank ng residual hills and ridges.

Grey clay (Qb)

Grey clay is present on a grass-covered plain west of Mongrel Downs homestead, in The Granites Sheet area. It is formed on basalt of the Antrim Plateau Volcanics, fragments of which are scattered on the surface. It is a heavy clay that cracks widely and deeply after each wet period, and is similar to the clay that is widespread to the north, as in the Birrindudu Sheet area (Blake et al., 1972).

STRUCTURE

The Granites-Tanami area was involved in four main periods of tectonic activity between the deposition of the Archaean or Lower Proterozoic sedimentary rocks of the Tanami complex and the end of the Precambrian, but it has been relatively stable during the Phanerozoic, when probably only gentle flexuring and some faulting have taken place. The main structural features are shown in Fig. 38.

The oldest rocks, those of the Tanami complex, are tightly folded and cleaved. Most of the folds observed in the field and on aerial photographs are relatively small, the limbs of folds generally being less than 1 km long, and minor folds, with amplitudes of less than 1 metre, can be seen at many exposures. The folding was associated with low grade regional metamorphism and the development of a cleavage. It took place during the first period of tectonic activity and before the deposition of the Lower Proterozoic Pargee Sandstone and the emplacement of granite intrusions. The Pargee Sandstone is also tightly folded, but forms larger structures than those of the Tanami complex, fold limbs being several kilometres long. This folding took place during the second period of tectonism. The Tanami complex, Pargee Sandstone and granite intrusions together make up the Granites-Tanami Block, which forms the basement on which the sediments of the Birrindudu Basin were deposited.

Fig. 36. View north along the axis of a syncline on the west side of Redcliff Pound, Stansmore Sheet area. Neg. No. GA/7995.

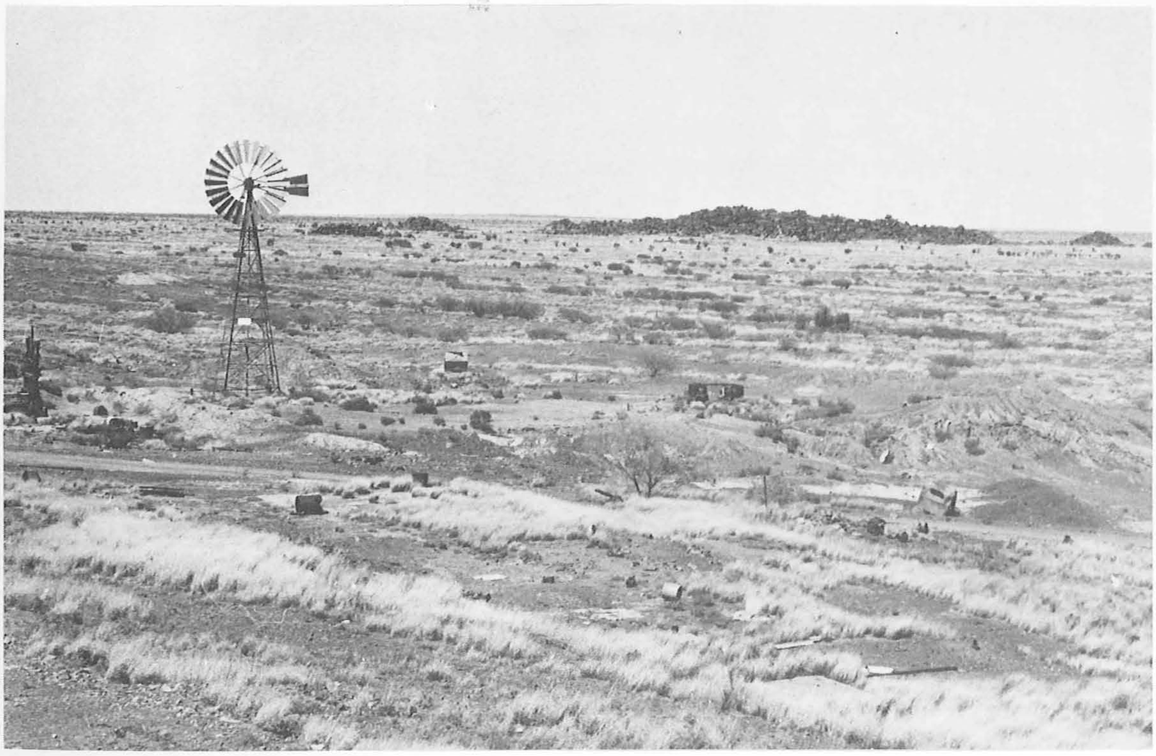


Fig. 37. The derelict gold mining settlement of The Granites. The exposures in the background are of unnamed granite. Neg. No. M1402/34.

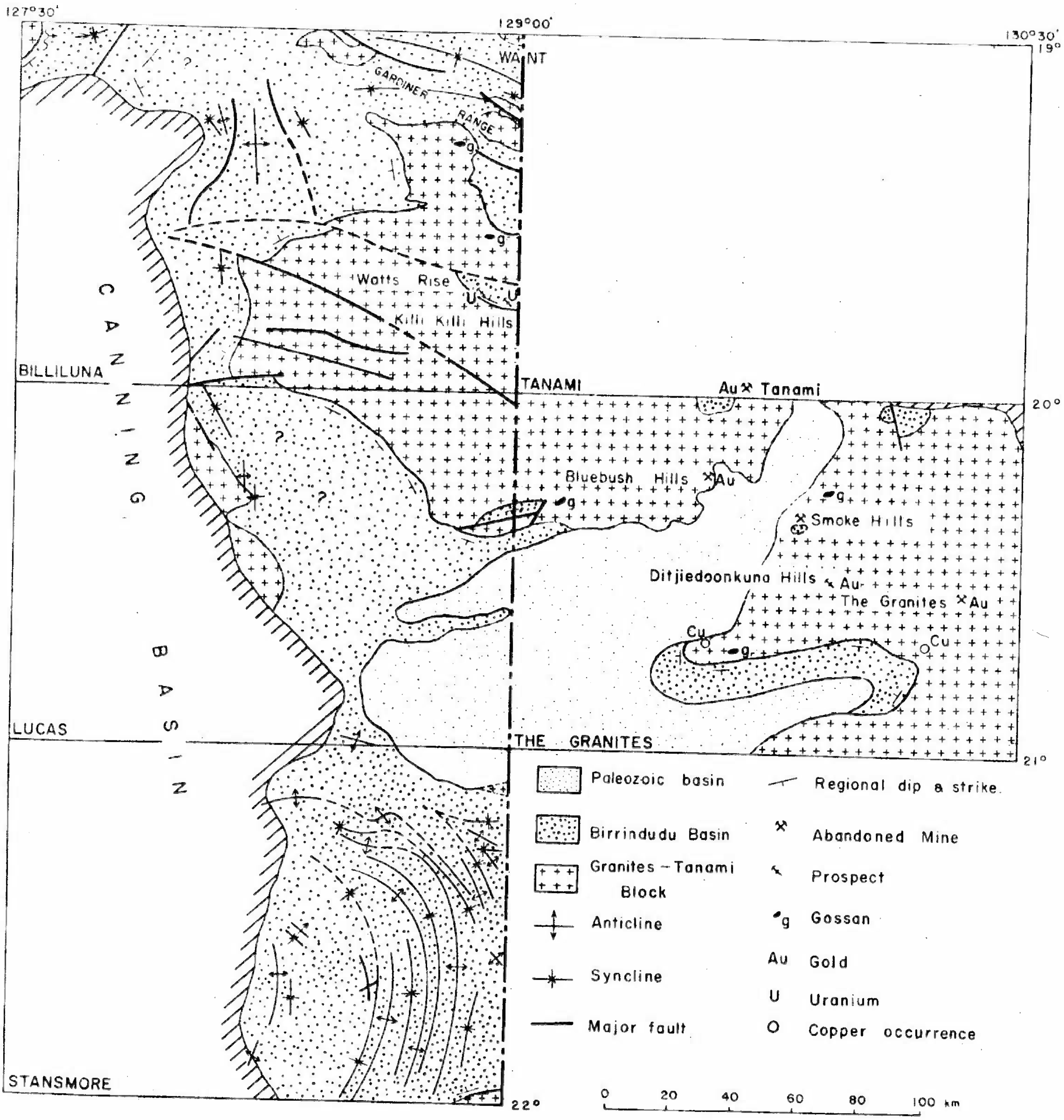


Fig. 38 Structural elements and occurrences of economic minerals.

To accompany Record 1973/171

The Carpentarian Birrindudu Group, at the base of the Birrindudu Basin succession, lies with strong angular unconformity on the Granites-Tanami Block. It was folded during a third period of tectonic activity into mainly broad anticlinal and synclinal structures over 10 km long. The most prominent of these structures is the synclinal basin in the northwestern part of the Gardiner Range, in the Billiluna Sheet area. The Birrindudu Group is overlain unconformably by the Redcliff Pound Group which is Carpentarian or Adelaidean. This latter group is flat-lying in the Gardiner Range, but to the south, in the Stansmore Sheet area, and possibly also west of the Gardiner Range, it was folded during the fourth period of tectonic activity into a series of open to tight anticlines and synclines that can be traced for many kilometers (Fig. 36).

Most of the main faults mapped in the area are probably related to the fourth period of tectonic activity, as several displace the Redcliff Pound Group as well as older units. Other major faults may be concealed beneath the widespread superficial deposits.

The complex structural pattern of the rocks of the Granites Tanami Block and to a lesser extent those of the Birrindudu Basin can be attributed to refolding and faulting that took place during the successive periods of tectonic activity.

Palaeozoic rocks occupy a broad and probably shallow irregular basin in the central part of the area, Lower Cambrian Antrim Plateau Volcanics being present in the northeast part of the basin and Lucas Formation and Pedestal Beds in the south and west. These rocks are generally gently dipping to flat-lying and have not been involved in major folding. However, they have been displaced by several minor faults, as can be seen at Lake Dennis, and local steep dips can probably be attributed to such faulting. Cainozoic rocks occupy more restricted shallow basins (Fig. 35) situated along regional drainage lines. These Phanerozoic sedimentary basins are probably erosional rather than tectonic in origin.

ECONOMIC GEOLOGY

Occurrences of gold, copper, and uranium and associated rare earths are known in the area mapped in 1972. Gold and traces of copper have been found in rocks of the Archaean or Lower Proterozoic Tanami complex, and uranium is present at the base of the Gardiner Sandstone, the lowest unit of the Carpentarian Birrindudu Group. Gossans are common locally within the Tanami complex, but are not known to have any significant mineralization associated with them. The gold, copper, uranium, and gossan occurrences are shown in Fig. 38. Brief notes are given on water supply and evaporite deposits.

GOLD

Several gold occurrences are known in The Granites Sheet area. The most important are those of The Granites goldfield, in the vicinity of the now abandoned mining centre of The Granites, and these are described in the following section. Three other occurrences have been reported: just west of the Bluebush Hills, in the Smoke Hills/Cave Hill area, and in the Ditjiedoonkuna Hills area. All these occurrences are in rocks mapped as Mount Charles Beds, as also is the gold at Tanami, in the Tanami Sheet area (Blake et al., 1972).

The occurrence west of the Bluebush Hills is at lat. 20°11'45"S, long. 129°34'30"E, where in 1905 the first gold in the Granites-Tanami area was mined, the gold occurring in quartz veins cutting shale and greywacke (Phillips, 1961). This may be the locality described by Gee (1911) as a reef being worked south-wouthwest of Tanami, the gold being present in quartz and ironstone. The workings were visited during the 1972 survey, and specks of gold were found with hematite in quartz veinlets cutting fine-grained greywacke and phyllite that dip southeast to south at 20°. The phyllite contains porphyroblasts pseudomorphed by iron oxide. The workings consist of three shafts probably about 15 m deep and several costeans.

Gee reported in 1911 that fine gold had been found in reefs 40 km (25 miles) south-southeast of Tanami in the Smoke Hills area, southwest of Rabbit Flat. These reefs were not found during 1972.

The third gold occurrence is near Dead Bullock Soak, in the Ditjiedoonkuna Hills (Gee, 1911; Phillips, 1961). At this locality, lat. 20°31'25"S, long. 129°56'30"E, which was searched for, but not found during the 1972 survey, Phillips reported 8-10 dwt gold per ton in quartz veins that cut thinly interbedded shale, chert and quartzite. These rocks are steeply dipping, and show minor contortions.

The Granites goldfield

The Granites goldfield has been described by Hossfeld (1940 a & b), Hall (1953), and Crohn (1961), and the following account is based on these reports supplemented by field observations made in 1972.

Gold was discovered in the area by A. Davidson in 1900 (Davidson, 1905), close to granite outcrops. By 1910 small quantities of alluvial gold was being obtained by 'dry-blowing' methods, and lode gold had been found in narrow quartz veins (Gee, 1911). The track from Alice Springs to Tanami, which passes through The Granites, was constructed in 1929, and shortly afterwards, in 1932, a small area of rich alluvial gold was found. This resulted in a 'rush' to the area, but the boom was shortlived because of relatively little gold recovered, acute water shortage, and transport difficulties. However, gold mining continued on a small scale up to 1960, by which time about 470 kg of gold had been produced, over half of this amount being recovered during the period 1945-1951 (Crohn, 1961). The goldfield is now deserted (Fig. 37).

The area was mapped during 1937-8 by the Aerial Geological and Geophysical Survey of Northern Australia (Hossfeld, 1940 a & b), which also carried out a geophysical survey in 1939 (by R.F. Thyer, J.M. Rayner and P.B. Nye; results were summarized by Daly, 1962). Between 1938 and 1948 Anglo Queensland Mining Pty Ltd, a subsidiary of Mount Isa Mines, examined the goldfield, and put down 20 diamond drill holes (Hall, 1953). Part of the goldfield was resurveyed in 1960 by P.W. Crohn (1961), and an aeromagnetic survey covering the area was carried out by the Bureau of Mineral Resources in 1962 (Spence, 1964).

The mine workings in the goldfield were divided into three main groups by Crohn (1961), as follows:

1. Bunkers Hill - Chapmans Hill workings in the south;
2. Golden Shoe - Bullakitchie workings, about 5 km west-northwest of Bunkers Hill;
3. Ivy workings, about 1.5 km west-southwest of the Golden Shoe.

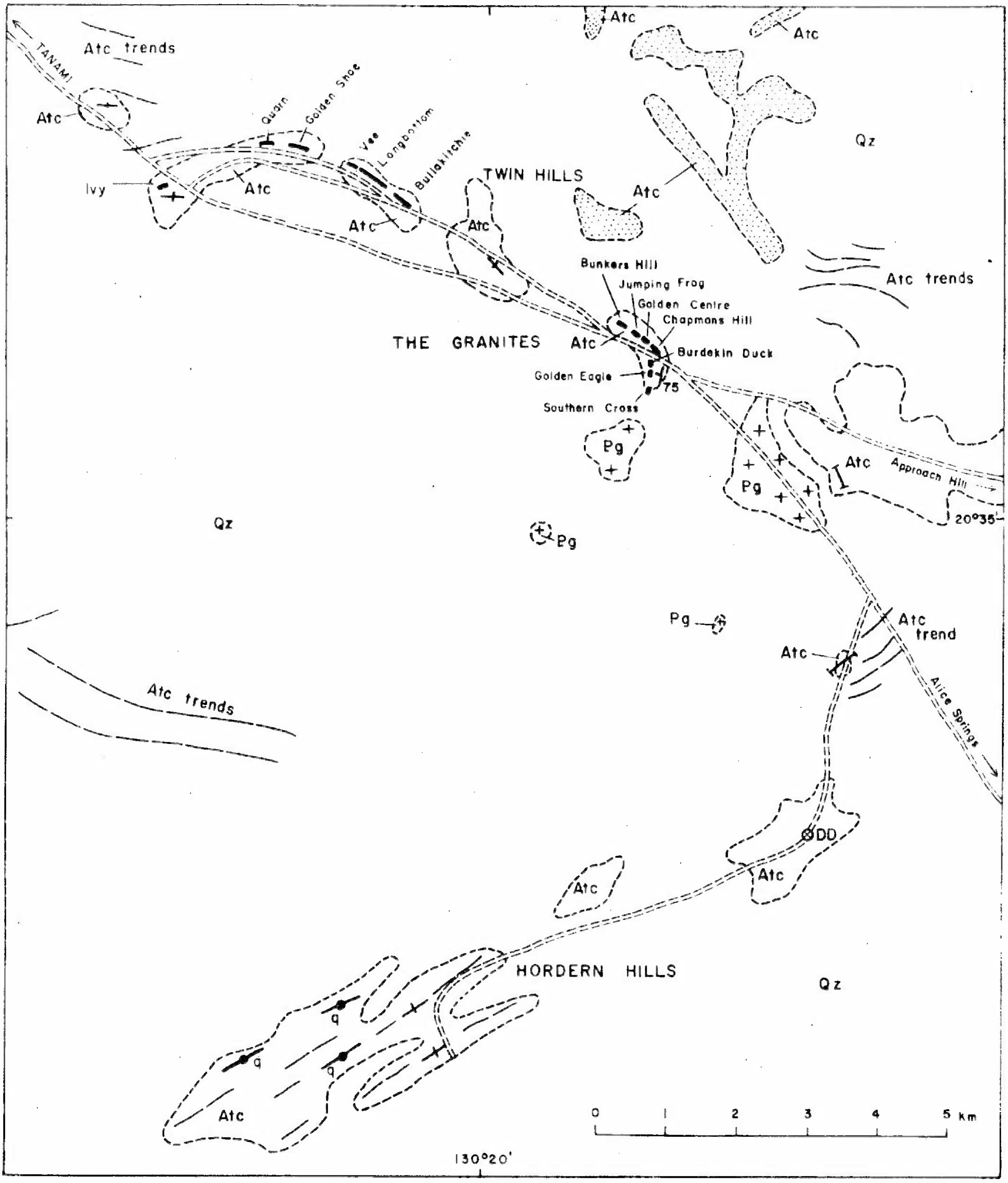
These same groupings are used in this report (Fig. 39).

General geology

The area lies about 430 m above sea level, and consists of a gently undulating sand-covered plain from which rise low hills and ridges mainly less than 15 m high. Rocks exposed are regionally metamorphosed sedimentary rocks, mapped as Archaean or Lower Proterozoic Mount Charles Beds, and unmetamorphosed granite which is probably Lower Proterozoic (Fig. 39). The metamorphic rocks are strongly weathered and impregnated with iron oxides. The weathered zone persists to depths of about 36 m (Hall, 1953), and within this zone some beds are selectively replaced by iron oxide to form ironstone. Gold lodes are confined to Mount Charles Beds, which are intruded and thermally metamorphosed by the granite.

The Mount Charles Beds in the goldfield consist of schist and quartzite which are cut by innumerable quartz veins and minor granite veins. The schist is medium to fine-grained and is mainly, if not entirely, regionally metamorphosed greywacke, siltstone, and shale in which a bedding-plane schistosity has been developed. However, some schist contains abundant microcline and may be either schistose feldspathic greywacke or granite. When strongly weathered the schist commonly appears more like phyllite or shale than normal schist. The regional metamorphic grade is low greenschist facies. Local thermal metamorphism and metasomatism due to the intruding granite is indicated by the presence of porphyroblastic andalusite which is generally altered to sericitic chiastolite, garnet which is replaced by iron oxide in weathered rocks, and tourmaline.

The quartzite is coarsely to finely crystalline, and is mostly thin-banded and glassy. It is probably made up of metamorphosed siliceous siltstone, fine sandstone, and chert. The banded quartzite is typically highly contorted, and shows tight rheomorphic minor folds (Hills, 1963), with thickening at rounded crests and troughs and marked thinning of limbs. Banded quartzite is present at all mine workings, where it is presumed to correspond to the 'Blue Quartzite Marker Bed' of Hall (1953).



Qz	Aeolian sand.
	Laterite capping.
+Pg+	Lower Proterozoic: Granite.
Atc	Archaean or Lower Proterozoic: Mount Charles Beds.
	Geological boundary.
75	Strike and dip of beds.
	Vertical beds.
	Trend line.
	Vertical cleavage.
q	Quartz vein.
⊗ DD	Diamond drill hole.
	Gold workings.

Fig. 39 Geological Map of The Granites area.

Some quartzite is massive rather than thin-bedded. This type, which forms low ridges and knolls such as Approach Hill, is so intensely veined by quartz that it has the appearance of a breccia.

Mount Charles Beds are also exposed in the Hordern Hills, a low range 10 km south of The Granites. Here they consist of thin-banded fine glassy quartzite, much of which is probably recrystallized chert, and more massive ridge-forming quartz-veined quartzite. Some of the quartzite contains small needle-like porphyroblasts, possibly of 'chiastolite', now pseudomorphed by iron oxide. The thin quartzite bands form very tight to isoclinal minor folds, many of which have nearly vertical fold axes and very gentle to flat plunges. The rocks are cut by both milky and bluish-grey quartz veins. Some exploratory costeaning and drilling has been carried out here, but no results of this work are available.

Northeast of the Hordern Hills, about 1 km south of the nearest granite outcrop, fine-grained mica schist is exposed near the main road.

Similar schist mapped as Mount Charles Beds crops out eastwards as a low broad ridge extending from the main road for over 10 miles to Approach Hill and into the adjacent Mount Solitaire Sheet area. At the western end of this ridge the schist is medium to thin-bedded, and many beds contain abundant small porphyroblasts of chiastolite, now generally altered to sericite. To the east, along the ridge,scattered exposures of medium- to fine-grained schistose greywacke project through rubble consisting of vein-quartz and ironstone. Approach Hill itself is formed of breccia-veined fine quartzite, which crops out to the south of mica schist and phyllite. At the exposures examined the schists are steeply dipping, show irregular minor folds, and are cut by quartz veins; some quartz-tourmaline veins were also seen north of Approach Hill. Granite crops out 1.5 km southeast of this hill, and forms prominent tors 1 km further southeast, just inside Mount Solitaire Sheet area.

The main granite outcrops at The Granites are west and southwest of the Chapmans Hill workings. They consist of large rounded blocks and boulders forming prominent tors.

The mine workings are confined to outcrops of Mount Charles Beds, which form a broken line of low ridges, the trends of which swing from west-southwest in the south to southeast, east, and east-northeast (Fig. 39). General bedding tmrends are approximately parallel to the ridges, but in detail the beds are complexly folded, and irregular tight to isoclinal minor folds can be seen at most exposures.

At the southern group of workings, south of the main road, the main rock types are quartz schist, mica schist, thinly interbedded fine quartzite, dark grey fine schist containing small chiastolite porphyroblasts, and densely spotted iron-stained fine schist. On the north side of the road the main rock types exposed are thinly interbedded fine quartzite and fine schist, some of which has iron-stained spots, possibly after garnet. The next outcrop to the northwest is at the Twin Hills, where similar quartzite and schist, some with chiastolite porphyroblasts, crop out. Farther to the northwest, at the Golden Shoe group of workings, are extensive mine dumps on which the main rock types are quartzite, vein-quartz, phyllitic schist, and mica schist. Some green schist consisting mainly of fine-grained amphibole, probably tremolite-actinolite, and garnet porphyroblasts, is also present, presumably derived from below the weathered zone. At the Ivy workings, thin-banded phyllitic schist, schist, and thin to medium-bedded quartzite are exposed.

Northwest of the mines, fine to medium-grained mica schist, cut by veins of quartz and granite, are exposed along the road. West of the road barely perceptible rises consist of quartz-veined and strongly iron-stained banded rocks capped by lateritic ironstone. Quartz Ridge, 7 km northwest of the Ivy workings, is formed of breccia-veined quartzite. Sporadic exposures of mica schist continue along the road for about 2 km to the northwest. Some of this schist contains porphyroblastic tourmaline.

The main regional structure of the mineralized area appears to be an asymmetrical anticline mainly trending northwest to west-northwest. The axial plane of this fold generally dips steeply southwest, and the ore deposits are on the partly overturned northeast limb (Hall, 1953). In the south the structuke is more complex than originally suggested by Hossfeld (1940b), who postulated a major syncline plunging east. No signs of such a structure were found by Crohn (1961). The relationships of the minor folds to the major structure are not known.

Lode deposits

Two main types of lodes have been worked for gold. These are short, narrow quartz veinlets that carry about 150 g gold per tonne but which do not appear to persist at depth, and wider zones of quartz and calcite veinlets carrying up to 17 g gold per tonne. These zones have been proved by drilling to extend to depths of at least 120 m (Hall, 1953). Both types of lodes are steeply dipping, and are generally concordant or nearly so with the bedding of the host rocks, which are schist and thin-banded quartzite. They appear to be restricted to about the same stratigraphic level within Mount Charles Beds.

The gold is present in quartz veins and also in the country rock, the highest values apparently being found associated with iron-stained quartz (Crohn, 1961). As described by Hall (1953), the gold occurs free, commonly in coarse particles, and it averages 900 fine; sulphides, mainly pyrite but also minor arsenopyrite (and pyrrhotite according to Crohn, 1961), make up less than 4 percent of the ore; iron carbonates form bands in the host rock below the base of oxidation.

The mineralization is epigenetic, as it occurs in cross-cutting quartz veins, but its source is uncertain. It may be related to the nearby granite as suggested by Hossfeld, or possibly to the pre-granite regional metamorphism. The granite itself appears to be unmineralized.

Mine workings

The three groups of mine workings were surveyed in 1938 (Hossfeld, 1940b), and the southern group was resurveyed in 1960 by Crohn (1961). Assay reports on samples collected from the workings are given by Hossfeld (1940b) and Hall (1953). No reliable production figures are available for either individual or groups of workings.

1. Bunkers Hill - Chapmans Hill group of workings

The lodes at these workings are mainly vertical, and most are roughly parallel to the general strike of the country rocks. Assays on samples collected in 1938 ranged up to 54 g gold per tonne (Hossfeld, 1940b). From north to south the workings are: Bunkers Hill, consisting of shafts and small open cuts following small lodes, as well as an adit which was driven for 35 m into the side of the hill without intersecting payable ore; the lode in this adit carries 2 g gold per tonne over a width of 15 m (Hall, 1953); Jumping Frog, pits and costeans; carries 1.7 g gold per tonne over 23 m (Hall, 1953); Golden Centre, shafts and open stopes to depth of about 10 m; the main producer between 1940 and 1960; Chapmans Hill, shafts, and open cuts on cross-cutting quartz veins; Burdekin Duck, shafts and stopes to depths of over 25 m; the main producer prior to 1940; Golden Eagle and Southern Cross, shafts and open cuts generally less than 10 m deep. Alluvial workings on the west side of Chapmans Hill are mainly down-slope of the Burdekin Duck.

2. Golden Shoe - Bullakitchie group of workings

In contrast to the southern group of workings, here there is a single main mineralized zone that can be traced for nearly 2 km. This zone is over 20 m wide in places, and swings from west-north-west in the east to east-northeast in the west. It dips 70-90° north, and is conformable to the general bedding of the country rocks. Within the zone there are several shafts over 30 m deep, and about 200 m of drives within 30 m of the surface. There has also been some selective stoping. On the north side of the workings 20 diamond drill holes inclined to the south were put down between 1941 and 1948 (Hall, 1953; Crohn, 1961). These reached vertical depths between 55 m and 120 m, and involved drilling about 2300 m (7600 ft) altogether. Ore was intersected in twelve of the holes, and assays ranged up to 54 g gold per tonne. The results indicated the presence of 250 000 tonnes of 11.5 g gold per tonne within 120 m of the surface: the downward limit was not proved. From east to west the workings here are Bullakitchie, Longbottom, Vee, Golden Shoe, and Quorn. Assays on samples collected in 1938 from these workings range from 0 to 185 g gold per tonne (Hossfeld, 1940b).

3. Ivy group of workings

These consist of a shaft and costeans which may be on the same lode as that at the Golden Shoe.

Geophysical investigations

A report on the AGGSNA geophysical survey of The Granites goldfield in 1939 was prepared by Thyer, Rayner, and Nye but was not published. However, a summary of the results was issued as a BMR Record (Daly, 1962). Four methods were tested for the survey. Of these, the self potential method showed no anomalies so was not used; the electromagnetic method showed up several anomalies, but was not used as these anomalies were located more precisely by the potential-ratio method, which also located anomalies caused by zones of high resistivity, and so was used for surveying part of the goldfield; the whole field was surveyed using the magnetic method.

The potential-ratio survey indicated some anomalies which may be related to the zone of quartz veinlets from which most of the gold production has come. The magnetic survey found several strong anomalies which indicated that a strongly magnetic bed is closely associated with the known mineralization, and hence is an important feature of the goldfield. However, except for ironstone rubble, samples of exposed rocks were found to be generally non-magnetic, and the nature of the magnetic bed remains unknown. It was recommended that the magnetic anomalies be tested by drilling, and that some of the potential-ratio anomalies be tested by trenching.

The airborne magnetic and radiometric survey carried out in 1962 (Spence, 1964) delineated several magnetic anomalies in the goldfields area. One anomaly was recorded at about 700 gammas, and its source was estimated to be about 150 m below the surface. Radioactivity was found to be low and fairly uniform, and no anomalies were found in the mineralized area.

URANIUM

In 1960 radioactivity due to uranium was discovered by Clarke & Blockley (1960) at the Killi Killi Hills, in Billiluna Sheet area. No other prospects have been found in the area mapped, although Lewis Granite on the north side of Lewis Range, in Lucas Sheet area, shows appreciable radioactive anomalies locally, with values of over four times background being recorded on an airborne spectrometer. The other granites in the area were tested using the same instrument but generally gave values less than twice background. Many other rocks were tested in outcrop, including conglomerates, but of these only some greywacke in the Killi Killi Beds was locally anomalous, again with values mostly less than twice background. Some radioactive anomalies have also been reported, but not confirmed, from calcrete in The Granites Sheet area.

The Killi Killi Hills uranium prospects were described by Prichard, Dallwitz, & Roberts (1960), and were re-examined during the present survey. Two prospects are present: Killi Killi No. 1, just on the Western Australian side of the WA/NT border, at 19°47'S, 128°58'E; and Killi Killi No. 2, 11 km to the WNW, on the southwest side of Watts Rise (Fig. 40). At both prospects radioactive anomalies of four to more than eight times background values are confined to the basal 6 m of the Carpentarian Gardiner Sandstone. This formation dips gently north and northeast, and lies unconformably on steeply dipping slightly schistose greywacke and siltstone of Lower Proterozoic Killi Killi Beds. The basal part of Gardiner Sandstone consists of lens-like beds of coarse sublithic arenite, pebbly arenite, conglomerate, and thin-bedded micaceous siltstone and fine lithic arenite. The conglomerate and pebbly arenite contain pebbles and cobbles up to 0.25 m across of various rock types, including vein quartz, sublithic and lithic arenite, greywacke, siltstone, chert, and quartzite. The basal beds are overlain by a thick succession of mostly current-bedded fine to coarse sublithic arenite which in parts is conglomeratic, pebbly and pelletal, and locally shows ripple marks and mud cracks. This is the main unit of the Gardiner Sandstone that forms the Killi Killi Hills and Watts Rise. No radioactive anomalies are present in this part of the succession.

At Killi Killi No. 1 the radioactive anomalies persist for about 1340 m along strike. At the eastern end two pits and two prospecting shafts, of maximum depth about 7 m, have been sunk, and at the western end are a pit and two trenches. Specimens selected in 1960 for maximum radioactivity assayed at 0.18 and 0.23 percent U_3O_8 (Prichard et al., 1960). In the east, the basal conglomeratic unit of Gardiner Sandstone is also exposed about 100 m south of the prospect, from which it is separated by a fault with downthrow to the south; this southern outcrop does not have a radioactive anomaly.

At Killi Killi No. 2, the unconformable contact of the Gardiner Sandstone on the Killi Killi Beds is concealed. The lowest beds exposed are conglomerate and conglomeratic arenite, in which the radioactive anomaly is situated. The anomaly extends for about 30 m along strike. Specimens collected in 1960 from spots reading about four times background radioactivity assayed 0.01 percent U_3O_8 (Prichard et al., 1960).

Similar conglomerate and sandstone, giving readings in 1972 of up to six times background values, form very low exposures midway between the two prospects.

Thin sections have been examined of specimens collected in 1960 and 1972 from the anomalies. The specimens are of conglomerate containing rounded pebbles enclosed in a matrix of coarse to fine silicified sandstone that contains xenotime and a mineral tentatively identified as florencite. The radioactivity in the specimens is due to uranium contained in the xenotime. 'Florencite' forms aggregates of anhedral to more commonly euhedral pseudo-cubic crystals up to 0.2 mm across, and is generally associated with abundant small granules of xenotime. Most of the 'florencite' crystals have anhedral to euhedral centres

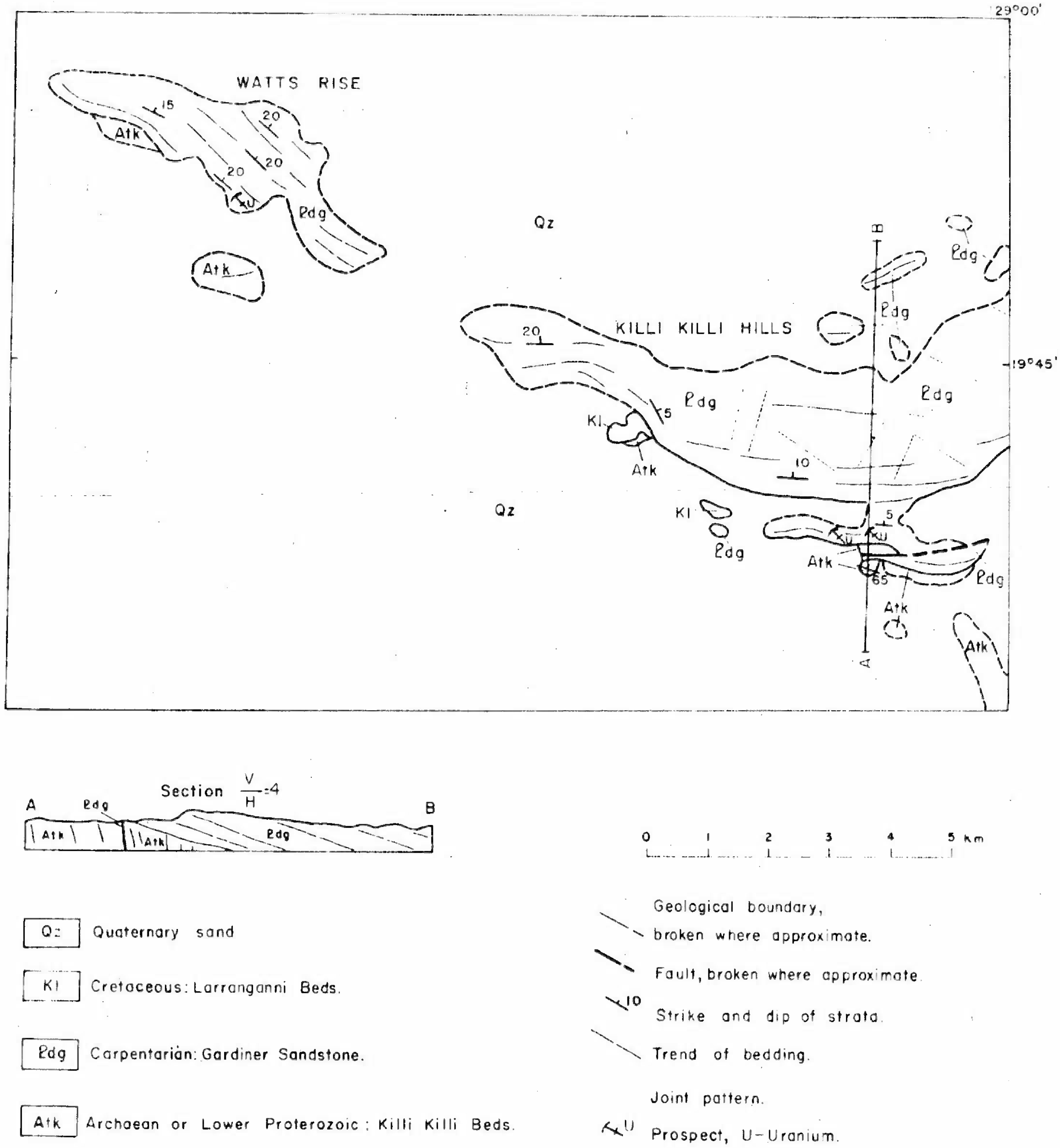


Fig. 40 Geological map, Killi Killi Hills area, W.A.

darkened by specks that are probably iron oxide. Both 'florencite' and xenotime are concentrated in what were presumably voids between grains, mainly quartz, in the matrix of the conglomerate and also in the matrix of some included sandstone pebbles, but they are also present in quartz overgrowth cement that is in optical continuity with host quartz grains; strings of fine xenotime grains also occur along bedding in pebbles of shale. Dallwitz and Roberts (in Prichard et al., 1960) recorded a vein of florencite cutting across part of a siltstone fragment.

The presence of patches formed almost exclusively of florencite and xenotime in the matrix of both the conglomerate and some constituent pebbles, the euhedral shapes of florencite crystals, the presence of florencite and xenotime in quartz overgrowths, and the cross-cutting vein of florencite in one specimen indicate that both the florencite and xenotime are probably epigenetic. They may have been introduced when the fault to the south of Killi Killi No. 1 was active. This is probably a strike fault that may well extend to Killi Killi No. 2. Perhaps it is significant that south of the fault basal Gardiner Sandstone comparable to that at the prospects and only 100 m from Killi Killi No. 1 does not have a radioactive anomaly.

The mineral thought to be florencite or a variety of that mineral has a refractive index of 1.660-1.670 (Dallwitz, in Prichard et al., 1960), and a birefringence slightly less than that of quartz. The crystals have a pseudo-cubic or squarish rhombohedral habit. The X-ray diffraction pattern closely resembles that of florencite (G.H. Berryman, pers. comm.). It may be a variety of florencite containing a small amount of sulphate, as some sulphate was detected by A.D. Haldane in the aqueous extract from a sodium carbonate fusion carried out on a rock specimen in 1960. This could explain the refractive indices, which are slightly lower than those reported for florencite, but higher than those of the related minerals goyazite, svanbergite, and woodhouseite. A specimen made up of quartz, xenotime and 'florencite' was partly analysed on the Direct Reader Optical Spectrograph and showed 0.3 percent Pb, 1 percent Fe, less than 0.5 percent Ca, over 0.3 percent Sr, 0.2 percent Ba, over 1 percent Y, and 0.1 percent La. In some specimens rare earths are reported to make up more than 5 percent of the total rock (D. Semple, pers. comm.).

COPPER

Very thin smears of the secondary copper minerals malachite and azurite have been found at two localities within the Tanami complex in The Granites Sheet area. The copper minerals occur mainly in amphibolite within Mount Charles Beds, close to intrusive veins of granite.

GOSSANS

Gossanous bands cap rocks of the Tanami complex at several localities. They are generally more resistant to erosion than the surrounding beds, and stand out as low strike ridges and cone-shaped pinnacles, but they are not as prominant topographically as the gossan ridges of the Black Hills, northeast of Tanami in the Tanami Sheet area (Blake et al., 1972).

The gossans are strongly leached, now consisting of iron oxides, quartz, and kaolinite, and do not contain visible base metal minerals or gold. However, they have yet to be tested chemically or by drilling. The gossans form bands that are cellular, but do not have identifiable boxworks. Individual bands are mostly less than 10 cm thick, but they are commonly present in groups, each of which has an aggregate thickness of several metres. The bands are conformable with the bedding of adjacent rocks, and may be developed on thin-bedded rocks containing pyrite and possibly other sulphide minerals, like the gossans of the Black Hills.

WATER SUPPLY

Permanent surface water is restricted to pools along Sturt Creek and small waterholes in the Gardiner Range, in the Billiluna Sheet area. For a few months in most years, several claypans in The Granites Sheet area contain surface water suitable for cattle.

Underground water supplies have yet to be evaluated. Numerous water bores have been sunk in all but the Stansmore Sheet area, and many of these bores produce water suitable for human or animal consumption. Others have been abandoned because the water obtained is too salty even for cattle. Most of the best water in the area is obtained at shallow depth (less than 15 m) from within calcrete.

EVAPORITES

Evaporite minerals are present in salt lakes mainly in the eastern part of the Stansmore Sheet area, where Lakes Wills and Hazlett are situated. The salt lakes, which are dry for at least most of the year, have a surface layer up to about 5 cm thick of halite and in some cases gypsum and calcareous material. This layer is underlain by soft sand, silt, and clay saturated with brine.

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APPENDIX

Stratigraphic drilling 1972

In 1972, 38 shallow stratigraphic holes were drilled in the area surveyed. These comprise 12 each in The Granites and Lucas Sheet areas, drilled by a BMR team under A. Zoska, using a mobile Fox drilling rig, and 14, 6 in Lucas and 8 in Billiluna Sheet areas, by Metals Department of Esso Australia Ltd. During the drilling of the BMR holes, cuttings were taken at 10 foot (3 m) intervals, and cores were collected from the bottoms of most holes.

The drilling was undertaken to:

1. determine the pre-Tertiary bedrock underlying Cainozoic superficial deposits,
2. determine the thickness of the Cainozoic cover,
3. collect unweathered bedrock for petrographic examination,
4. collect unweathered material which may contain fossils,
5. collect material for future geochemical analysis.

Summary of the drill logs are given below. The sites of the stratigraphic holes are shown on the geological maps accompanying this report. All the holes are located close to existing tracks.

LUCAS 1:250 000 SHEET AREA

BMR Stratigraphic Holes

1	0-3 m	cuttings,	laterite and calcrete
	3-32.3 mm	cuttings	pale grey and brown clay
	32.3-35.8 m	core	grey mudstone. Tertiary
2	0-3 m	cuttings,	sand, chert and calcrete
	3-6 m	"	calcrete
	6-8 m	"	calcrete and chert
	8-14 m	"	iron-stained friable sandstone
	14-15.2 m	"	silicified medium-grained sublithic arenite
	15.2-15.3 m	core	flat-lying, silicified, poorly sorted medium-grained sublithic arenite. Lewis Range Sandstone, Carpentarian or Adelaidean

3	0-3 m	cuttings,	reddish-brown sand
	3-4.9 m	"	weathered friable granite
	4.9-5.3 m	core	medium to fine-grained granite. Unnamed granite, Lower Proterozoic
4	0-3 m	cuttings,	red sand and schistose greywacke
	3-4.6 m	"	schistose greywacke
	4.606.1 m	core	brownish schistose fine-grained greywacke. Killi Killi Beds, Archaean or Lower Proterozoic
5	0-3 m	cuttings,	red sand
	3-33 m	"	yellowish to brownish clayey sand
	33-45.7 m	"	weathered granite
	45.7-46.1 m	core	medium-grained muscovite granite, with pink altered feldspar. Unnamed granite, Lower Proterozoic.
6	0-3 m	cuttings,	red sand
	3-27 m	"	friable brownish sandstone
	27-39.8 m	"	white to pale grey clayey sandstone
	39.8-43.8 m	core	pale grey, silicified, porous, medium-grained quartz arenite. Lewis Range Sandstone Carpentarian or Adelaidean.
7	0-6 m	cuttings,	pale grey and yellow fine sandstone
	6-47 m	"	grey micaceous siltstone and shale. Lucas Formation, Palaeozoic.
8	0-3 m	cuttings,	lateritic sand
	3-12 m	"	yellowish grey sandy clay with gypsum
	12-21 m	"	grey to brown sandy clay
	21-30 m	"	pale brown to grey clay
	30-49 m	"	grey clay. Probably Tertiary
9	0-3 m	cuttings,	lateritic sand and calcrete
	3-9 m	"	calcrete. Probably Tertiary
	9-37 m	"	white to pale brown calcareous clay. Tertiary
10	0-1 m	cuttings,	red sand
	1-15 m	"	white to pale grey clay, some gypsum
	15-18 m	"	white calcareous clay
	18-37 m	"	white calcareous clay, some dark grey chert
	37-58 m	"	dark grey chert, some calcareous clay
	58-61 m	"	dark grey chert. Tertiary

11	0-12 m	cuttings,	calcrete
	1-15 m	"	iron-stained sand
	15-24.4 m	"	white sandy mudstone
	24.4-24.5 m	"	pale grey chert. Tertiary
12	0-6 m	cuttings,	red sand
	6-9 m	"	pale grey sandy clay
	9-24 m	"	yellowish to reddish clayey sandstone with poorly sorted, angular grains. Cainozoic?

<u>Esso Stratigraphic Holes</u>

EL 1	0-6 m	cuttings,	laterite
	6-24 m	"	sandstone, some gypsum
	24-30 m	"	ferruginous quartz sandstone
	30-34 m	"	fine-grained quartz sandstone, some shaly bands
	34-43 m	"	fine-grained quartz sandstone. Carpentarian or Adelaidean
	43-76 m	"	grey to black slate. Killi Killi Beds? Archaean or Lower Proterozoic
EL 2	0-6 m	cuttings,	laterite
	6-15 m	"	lateritic sandstone
	15-18 m	"	pale to black cherty shale
	18-27 m	"	silicified 'calcrete', some shale and chert
	27-30 m	"	fine-grained sandstone
	30-37 m	"	banded buff shale and black chert
	37-40 m	"	siliceous shale and quartzite bands
	40-53 m	"	black chert or quartzite, some calcite: may be silicified grey shale or limestone. Tertiary?
EL 3	0-6 m	cuttings,	laterite
	6-12 m	"	pale brown claystone
	12-21 m	"	brown sandstone
	21-30 m	"	pale brown quartz sandstone, cemented
	30-46 m	"	white shale with chert and sandstone bands
	46-64 m	"	black banded chert with shale bands
	64-82 m	"	grey shale with minor calcareous fragments
	82-101 m	"	grey shale, chert and sandstone. Tertiary?

EL 4	0-3 m	cuttings,	laterite and calcrete
	3-9 m	"	calcrete
	9-15 m	"	calcrete and gritty claystone
	15-18 m	"	chert (silicified calcrete?). Tertiary
EL 5	0-15 m	cuttings,	gypsiferous clay
	15-18 m	"	gypsiferous clay and chert
	18-37 m	"	chert
	37-50 m	"	chert with intercalated shale. Tertiary.
EL 6	0-3 m	cuttings,	lateritic ironstone
	3-12 m	"	shale with ironstone and chert
	12-18 m	"	sandstone (and shale?)
	18-45 m	"	pale brown shale. Tertiary?

THE GRANITES 1:250 000 SHEET AREA

BMR Stratigraphic Holes

1	0-6 m	cuttings,	lateritic sand
	6-9 m	"	white to yellow clayey sandstone
	9-15 m	"	mottled clay. Tertiary
2	0-3 m	cuttings,	brownish-grey shale siltstone to fine sandstone
	3-25.6 m	"	grey siltstone and fine sandstone
	25.6-27.4 m	core	laminated pale grey micaceous siltstone, fine sandstone and white claystone; flat-lying, Lucas Formation, Palaeozoic
3	0-3 m	cuttings,	weathered mudstone
	3-21.3 m	"	brownish grey mudstone
	21.3-22.6 m	"	grey, micaceous, laminated fine sandstone, siltstone and mudstone; flat-lying. Lucas Formation, Palaeozoic.

4	0-18 m	cuttings,	laterite profile
	18-24 m	"	iron-stained fine sandstone and siltstone
	24-30.5 m	"	grey fine sandstone and siltstone
	30.5-30.8 m	core	grey laminated miacaeous siltstone and mudstone; flat-lying. Lucas Formation, Palaeozoic
5	0-12 m	cuttings,	grey fine-grained sandstone and siltstone, some iron-staining
	12-30 m	"	grey siltstone and mudstone. Lucas Formation, Palaeozoic.
6	0-9 m	cuttings,	weathered basalt
	9-17.4 m	"	grey basalt
	17.4-17.7 m	core	greyish maroon basalt containing phenocrysts of white altered feldspar. Antrim Plateau Volcanics, Lower Cambrian
7	0-4.9 m	cuttings,	laterite
	4.9-5.2 m	core	lateritic breccia with fragments of lateritized 'basalt'. Tertiary
8	0-9 m	cuttings,	laterite
	9-24.4 m	"	reddish-brown lateritized basalt
	24.4-24.7 m	"	weathered yellowish-brown basalt. Antrim Plateau Volcanics, Lower Cambrian
9	0-24 m	cuttings,	friable weathered reddish-brown phyllitic siltstone. Mount Charles Beds, Archaean or Lower Proterozoic
10	0-6 m	cuttings,	pale yellowish granitic sand
	6-9.1 m	"	reddish granitic sand
	9.1-9.6 m	core	weathered medium-grained granite containing pink altered feldspar and abundant altered biotite. Unnamed granite, Lower Proterozoic.
11	0-12 m	cuttings,	weathered phyllitic micaceous greywacke
	12-15 m	"	friable, dark maroon, medium to fine-grained phyllitic greywacke. Mount Charles Beds, Lower Proterozoic

12	0-3 m	cuttings,	laterite
	3-21.3 m	"	weathered reddish-brown granite
	21.5-22.9 m	core	friable pink medium-grained granite. Unnamed granite, Lower Proterozoic.

BILLILUNA 1:250 000 SHEET AREA

Esso Stratigraphic Holes

EB 1	0-34 m	cuttings,	slightly fissile brown siltstone
	34-58 m	"	blue-grey graphitic shale. Proterozoic.
EB 2	0-3 m	cuttings,	laterite
	3-24 m	"	white equigranular sugary sandstone
	24-30 m	"	pink-white sandstone
	30-40 m	"	sandstone and shale decomposed to clay
	40-49 m	"	sandstone and red micaceous siltstone and shale
	49-64 m	"	red micaceous shale, siliceous in part. Proterozoic.
EB 3	0-9 m	cuttings,	weathered brown silty shale, some clay and gypsum
	9-37 m	"	silty shale
	37-64 m	"	fissile grey and bluish grey shale. Proterozoic
EB 4	0-9 m	cuttings,	gypsiferous clay
	9-24 m	"	brown and grey clay, some sandstone, minor gypsum
	24-40 m	"	grey to brown sandstone, minor claystone
	40-52 m	"	maroon to brown shale and mudstone
	52-55 m	"	claystone with some gypsum
	55-70 m	"	gravel, Tertiary
	70-77 m	"	interbedded grey shale and black chert. Proterozoic?
EB 5	0-3 m	cuttings,	brown claystone
	3-40 m	"	pale brown gypsiferous clay
	40-46 m	"	calcareous clay, minor gypsum
	46-52 m	"	clay and sand
	52-66 m	"	interbedded sandstone and shale. Tertiary?

EB 6	0-3 m	cuttings,	calcrete
	3-55 m	"	pale brown clay with gypsum
	55-94 m	"	brown to grey clay and purple to grey shale. Tertiary
	94-101 m	"	grey shale and black chert. Proterozoic?
EB 7	0-3 m	cuttings,	laterite
	3-21 m	"	calcrete, Tertiary
	21-30 m	"	ironstone, medium-grained sandstone, minor gypsum
	30-40 m	"	very fine-grained ferruginous sandstone
	40-76 m	"	ferruginous calcareous sandstone. Lewis Range Sandstone? Carpentarian or Adelaidean
EB 8	0-3 m	cuttings,	laterite
	3-9 m	"	sandstone
	9-30 m	"	fine-grained ferruginous sandstone
	30-40 m	"	calcareous sandstone
	40-47 m	"	calcareous siliceous shale
	47-55 m	"	banded chert and shale
	55-70 m	"	conglomerate and sandstone. Murraba Formation? Carpentarian or Adelaidean.

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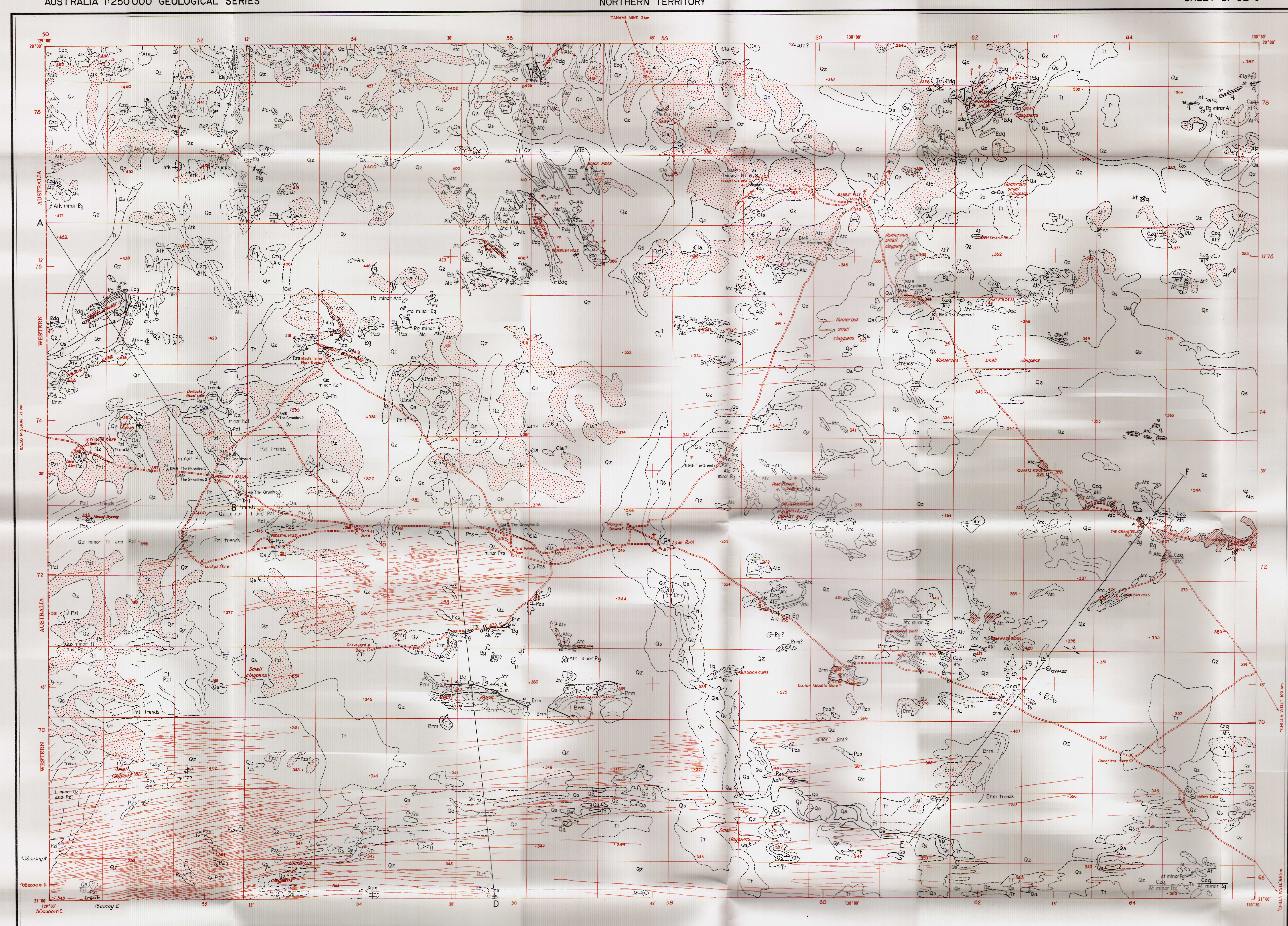
THE GRANITES

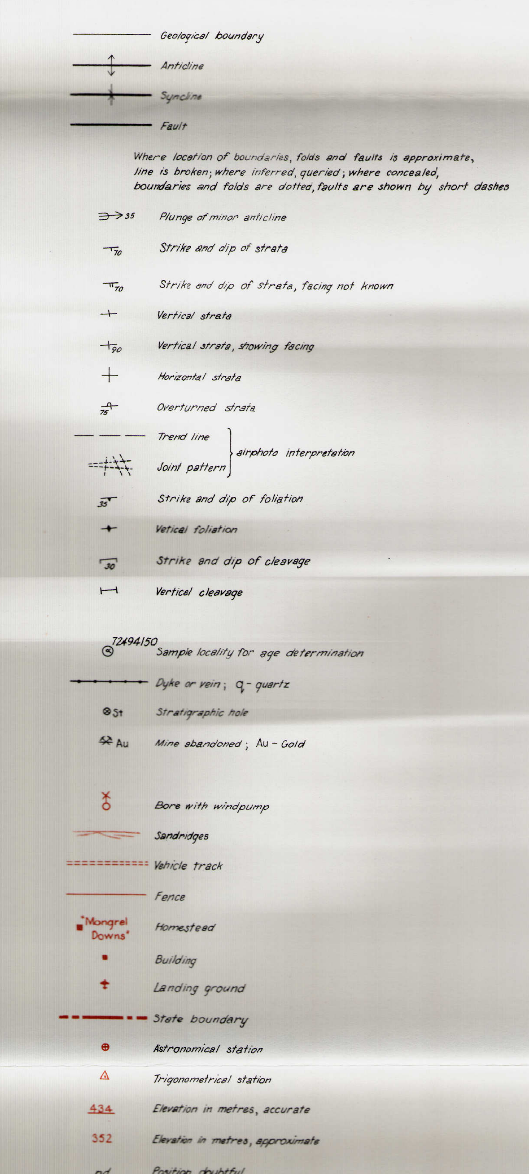
NORTHERN TERRITORY

SHEET SF 52-3



Reference

CAINOZOIC	QUATERNARY		Qa	Sand, silt, clay : alluvial and lacustrine
			Qe	Halite, gypsum : evaporitic
			Qs	Sand, silt : alluvial and aeolian
			Qz	Sand, minor gravel : aeolian and minor piedmont
			Qb	Grey clay soil
			Czq	Vein quartz rubble
	TERTIARY		Tt	Calcrete, partly silicified
			Ts	Silcrete
				Laterite capping
MESOZOIC ?	CRETACEOUS ?	Larranganni Beds	Kl	Quartzose sandstone
PALAEOZOIC		Pedestal Beds	Pzs	Quartzose sandstone; minor conglomerate, siltstone, shale
		Lucas Formation	Pzl	Calcereous and non-calcareous sandstone, siltstone and mudstone; minor limestone
	CAMBRIAN ?		€	Micaceous shale, fine lithic and quartzose sandstone
	LOWER CAMBRIAN	Antrim Plateau Volcanics	€la	Porphyritic and non porphyritic basalt; minor quartzose sandstone and stromatolitic chert
PROTEROZOIC	CARPENTARIAN OR ADELAIDEAN	Redcliff Pound Group Muriel Range Sandstone	Ꝑrm	Sublithic arenite, quartz arenite; minor siltstone, shale and conglomerate
	CARPENTARIAN	Birrindudu Group: Talbot Well Formation	Ꝑdt	Stromatolitic chert
		Birrindudu Group: Gardiner Sandstone	Ꝑdg	Quartz arenite, conglomerate, siltstone shale; Glauconitic, sublithic and quartz arenite
	LOWER PROTEROZOIC		Ꝑg	Porphyritic and non-porphyritic biotite granite; minor pegmatite and aplite
		Pargee Sandstone	Ꝑlg	Sublithic, lithic and quartz arenite, conglomerate, lithic greywacke
ARCHAEAN	ARCHAEAN OR LOWER PROTEROZOIC	Tanami complex	At	Quartzite, schist, amphibolite, ironstone
		Tanami complex: Mount Charles Beds	Atc	Banded chert, silicified siltstone, quartzite, phyllitic sandstone; minor schistose, lithic greywacke, amphibolite, jaspilite, gossanous ironstone
			Atc_1	Schistose to phyllitic greywacke, lithic arenite, siltstone, shale; minor banded chert
			Atc_2	Amphibolite
		Tanami complex: Killi Killi Beds	Atk	Schistose to phyllitic greywacke, lithic arenite, siltstone, mudstone, shale; minor quartzite, banded chert, basalt



NOTE ON GRID COORDINATES

Brown lines with black italic numbers (numbers shown only at SW corner of map and change of zone), indicate the 10,000 yard grid, Zone 4 (Australia Series), CLARKE 1858 SPHEROID. Transverse Mercator Projection

Brown numbered ticks (with larger upright numbers), inside the neatline are 20,000 metre intervals of the superimposed Australian Map Grid, Zone 52 AUSTRALIAN NATIONAL SPHEROID. Transverse Mercator Projection

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of Minerals and Energy. Issued under the authority of the Hon. R.F.X. Connor M.P., Minister for Minerals and Energy. Base map compiled by the Division of National Mapping from aerial photography at 1:50 000 scale

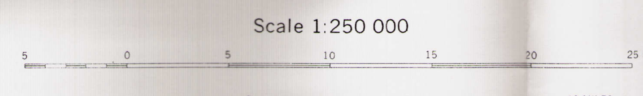
Transverse Mercator Projection

INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1970

MOUNT RAMSAY SE 52-9	GORDON DOWNS SE 52-10	BIRRINDUDU SE 52-11	WINNECKE CREEK SE 52-12	SOUTH LAKE WOODS SE 53-9
MOUNT BANNERMAN SE 52-13	BILLILUNA SE 52-14	TANAMI SE 52-15	TANAMI EAST SE 52-16	GREEN SWAMP WELL SE 53-13
CORNISH SF 52-1	LUCAS SF 52-2	THE GRANITES SF 52-3	MOUNT SOLITAIRE SF 52-4	LANDER RIVER SF 53-1
HELENA SF 52-5	STANSMORE SF 52-6	HIGHLAND ROCKS SF 52-7	MOUNT THEO SF 52-8	MOUNT PEAKE SF 53-5
WILSON SF 52-9	WEBB SF 52-10	LAKE MACKAY SF 52-11	MOUNT DOREEN SF 52-12	NAPPERBY SF 53-9

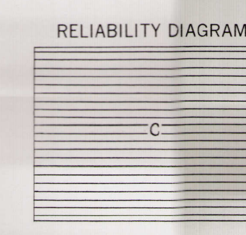
Scale 1:250 000



Sections

Cainozoic sediments omitted

Depths in metres



RELIABILITY DIAGRAM

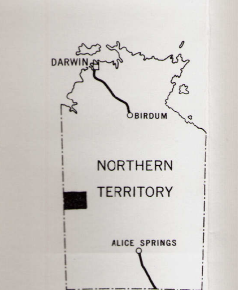
Geology C General reconnaissance: many traverses, and airphoto interpretation

Geology 1972 by D.H.Blake, I.M.Hodgson (BMR); P.C.Muhling (GSWA)

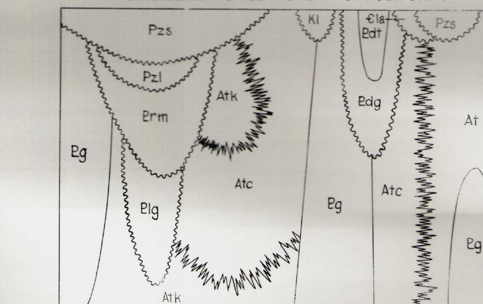
Compiled 1972 by D.H.Blake, I.M.Hodgson, D.G.Walton (BMR); P.C.Muhling (GSWA)

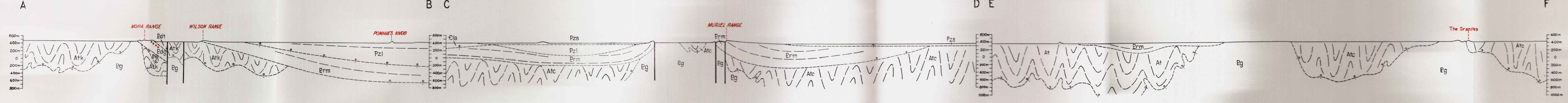
Cartography by Geological Branch, BMR

Drawn 1973 by D.G.Walton



DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS





THE GRANITES

SHEET SF 52-3

PRELIMINARY EDITION 1973

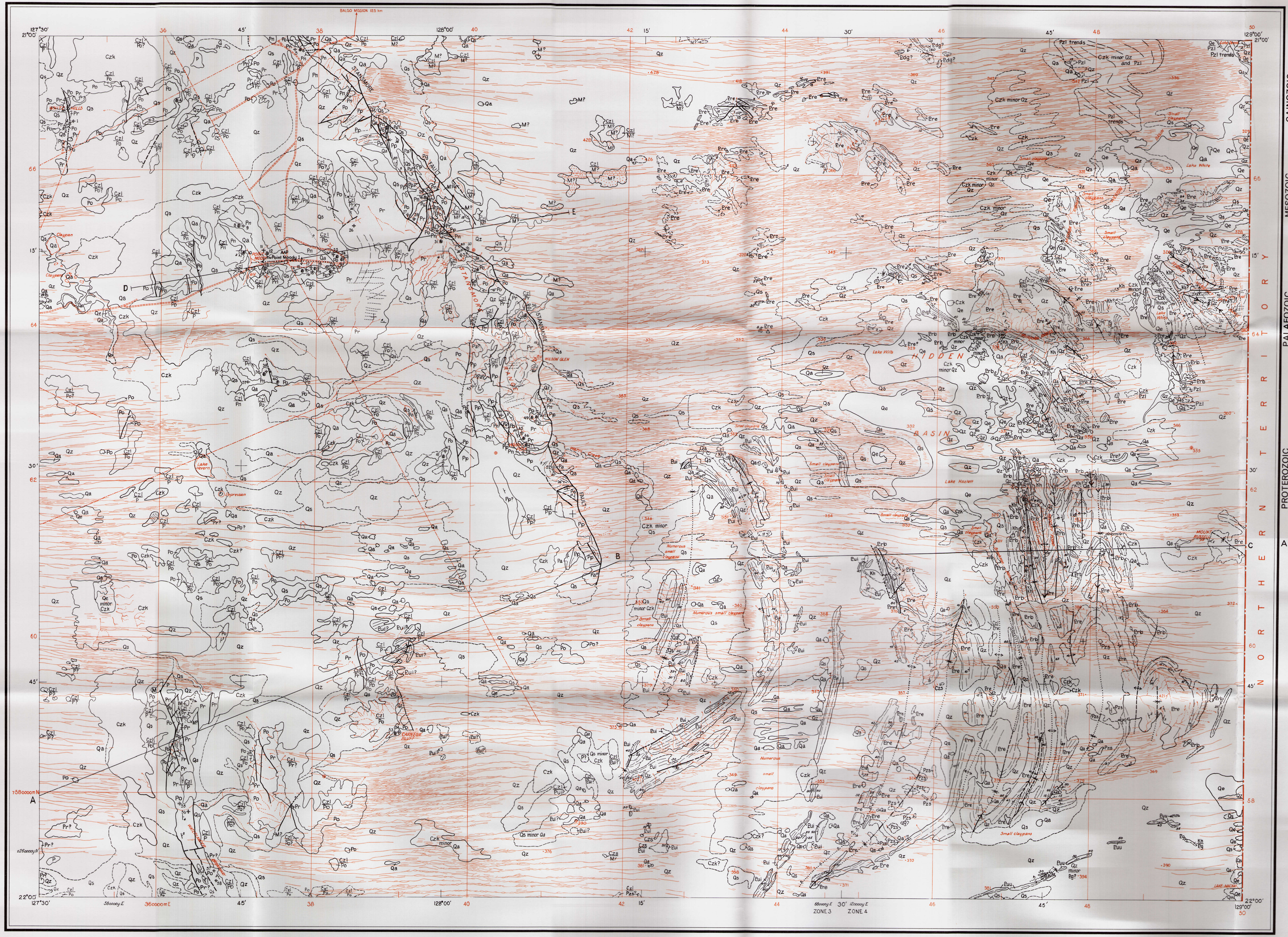
SUBJECT TO AMENDMENT

AUSTRALIA 1:250,000 GEOLOGICAL SERIES

STANSMORE

WESTERN AUSTRALIA

SHEET SF 52-6



Reference

CAINOZOIC	QUATERNARY		Qa	Sand, silt, clay: alluvial and lacustrine
			Qe	Halite, gypsum; sand, silt and clay: evaporitic and lacustrine
			Qm	Sand, gypsum, halite, calcrete: aeolian and evaporitic
			Qs	Sand, silt: alluvial and aeolian in depressions
			Qz	Sand, minor gravel: aeolian and minor piedmont
			Czk	Calcrete, chalcedony
			Czs	Silcrete
			Czl	Laterite capping, pisolitic or massive
			(stippled)	Chemically altered and texturally modified weathered rock
MESOZOIC			M	Sandstone, siltstone, claystone; poorly sorted
	CRETACEOUS	Hazlett Beds	Kh	Quartzose sandstone, siltstone, claystone
PALAEOZOIC		Pedestal Beds	Pzs	Quartzose sandstone; minor siltstone, shale
		Lucas Formation	Pzl	Calcareous and non-calcareous sandstone, siltstone, and mudstone; minor limestone
	PERMIAN		P	Sandstone, siltstone
		Liveringa Formation: Condren Sandstone Member	Pr	Fine quartzose sandstone, siltstone, thin bedded to laminated; minor claystone, conglomerate; plant-bearing: fluvial
		Liveringa Formation: Balgo Member	Po	Siltstone, micaceous sandstone, quartzose sandstone, thin to medium bedded; shale; concretionary siltstone near base; ferruginized clay pellet conglomerate; fossiliferous: shallow marine
		Noonkanbah Formation	Pn	Calcareous and non-calcareous siltstone and shale; minor limestone; fossiliferous: marine
		Poole Sandstone	Pp	Fine quartzose sandstone interbedded with micaceous siltstone: probably terrestrial
		Nura Nura Member	Pa	Shale, siltstone, calcareous sandstone; thin bedded: marine
		Grant Formation	Pg	Tillite
	CARBONIFEROUS	Anderson Formation	C	Sandstone, siltstone, shale
	DEVONIAN		D	Undivided sedimentary rocks; section only
	ORDOVICIAN		O	Undivided sedimentary rocks
PROTEROZOIC	CARPENTARIAN OR ADELAIDEAN	Hidden Basin Beds	Pui	Quartz arenite, sublithic arenite, shale, siltstone
		Redcliff Pound Group: Erica Sandstone	Pre	Sublithic arenite; minor quartz arenite, siltstone, shale, glauconitic sandstone
		Redcliff Pound Group: Murraba Formation	Prb	Chert granule conglomerate, sublithic arenite, quartz arenite, siltstone, shale, dolomite
		Redcliff Pound Group: Munyu Sandstone	Puu	Quartz arenite, in part conglomeratic, minor limestone lenses
	CARPENTARIAN	Birrindudu Group: Gardiner Sandstone	Pdg	Sublithic arenite, quartz arenite
	LOWER PROTEROZOIC		Pg	Muscovite granite
ARCHAEAN ?			A	Metamorphic rocks. Section only

Geological boundary

Anticline, showing plunge

Syncline, showing plunge

Fault

Normal fault, triangle indicates direction of dip

Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes

45 Strike and dip of strata

Strike and dip of strata, unmeasured

85 Strike and dip of strata, facing not known

Vertical strata

90 Vertical strata, showing facing

Horizontal strata

Dip < 15° } airphoto interpretation

Trend line } airphoto interpretation

Joint pattern } airphoto interpretation

4 Macrofossil locality } with reference number

2 Plant fossil locality } with reference number

55 Trace fossil locality } with reference number

Well dry abandoned

Abandoned bore

WH Waterhole

RH Rockhole

Claypan

Sand dunes

State boundary

Vehicle track

Seismic traverse line

Astronomical station

·376 Elevation in metres, approximate

pa Position approximate

NOTE ON GRID COORDINATES

Brown ticks with black italic numbers (numbers shown only at SW corner of map and change of zone), indicate the 20,000 yard intervals of the Australian National Grid, Zones 3 and 4 (Australian Series), CLARKE 1858 SPHEROID, Transverse Mercator Projection

Brown numbered lines (with larger upright numbers), indicate the 20,000 metre intervals of the superimposed Australian Map Grid Zone 52, AUSTRALIAN NATIONAL SPHEROID, Transverse Mercator Projection

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of Minerals and Energy. Issued under the authority of the Hon. R.F.X. Connor M.P., Minister for Minerals and Energy. Base map compiled by the Division of National Mapping from aerial photography at 1:50,000 scale. Transverse Mercator Projection

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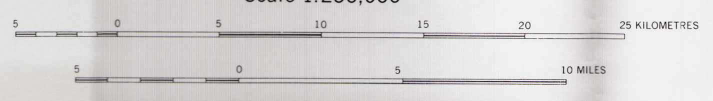
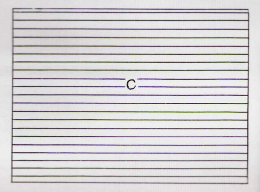
MORRIS SF 51-16	RYAN SF 52-13	MACDONALD SF 52-14	MOUNT RENNIE SF 52-15	MOUNT LIEBIG SF 52-16

Scale 1:250,000



RELIABILITY DIAGRAM



Geology C General reconnaissance: many traverses and airphoto interpretation

Geology 1955 by J.N. Casey, A.T. Wells (BMR)
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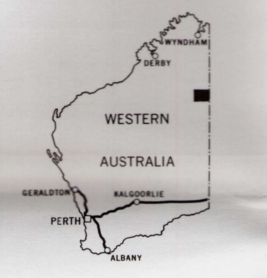
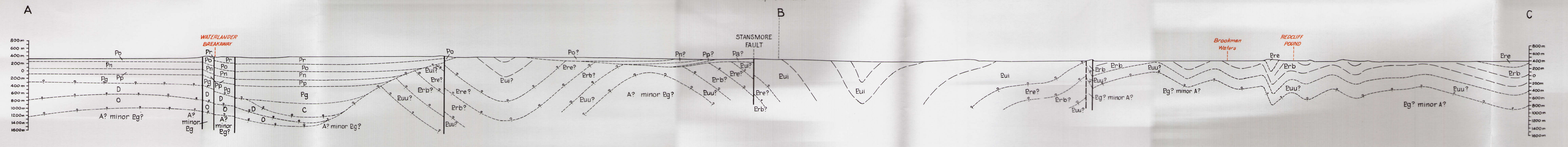


Sections

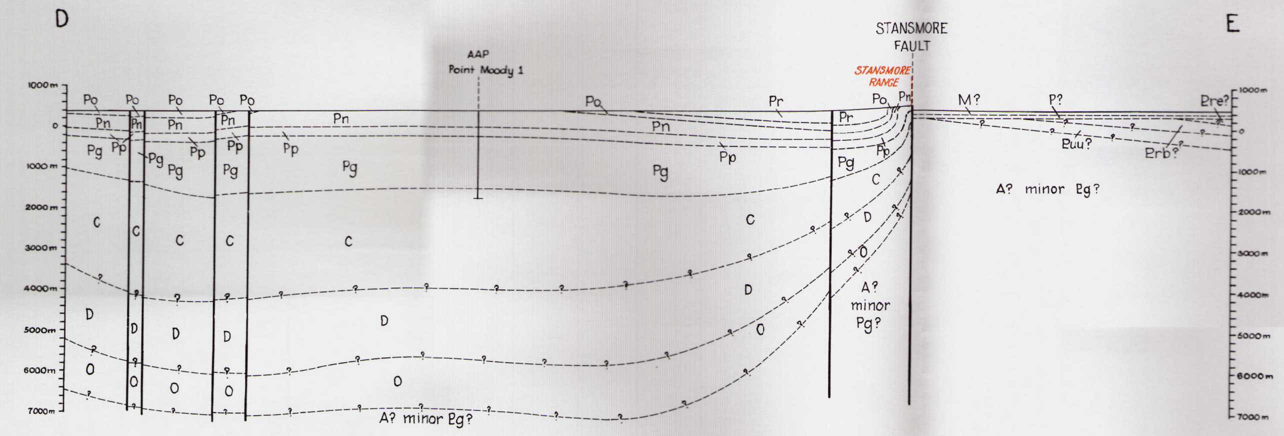
Cainozoic sediments omitted

Scale: $\frac{V}{H} = 4$

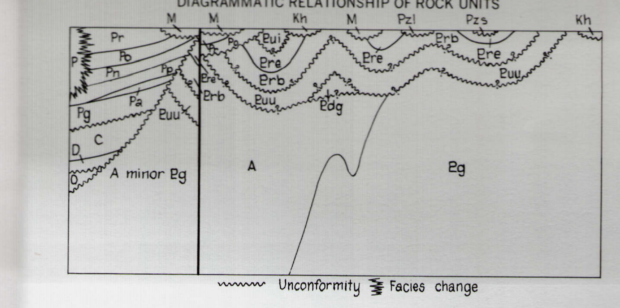
Depths in metres



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



DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



PRELIMINARY TO SECOND EDITION 1974

SUBJECT TO AMENDMENT

STANSMORE

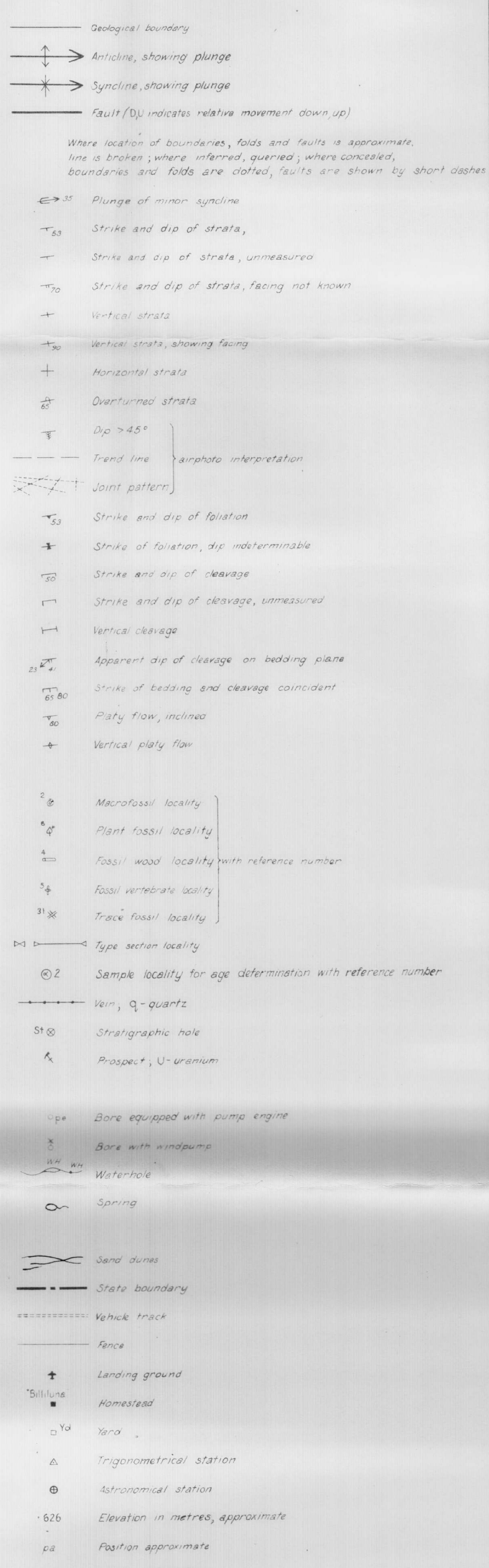
SHEET SF 52-6

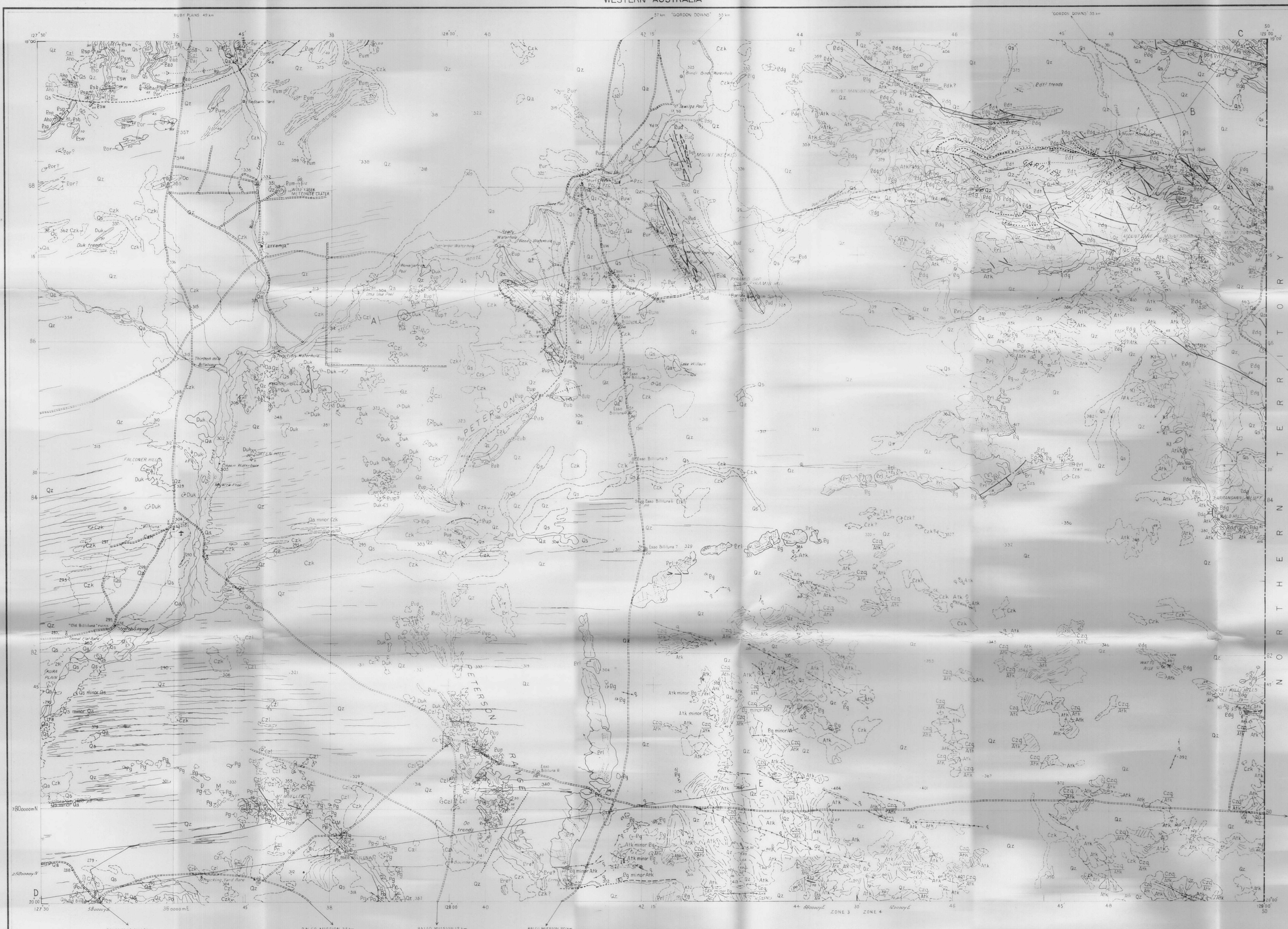
AUSTRALIA 1:250,000 GEOLOGICAL SERIES

BILLILUNA

WESTERN AUSTRALIA

SHEET SE 52-14





Reference

CAINOZOIC	QUATERNARY		Qa	Sand, silt, clay : alluvial and lacustrine
			Qs	Sand, silt : alluvial and aeolian in depressions
			Qz	Sand, minor gravel : aeolian, minor piedmont
			Czq	Vein quartz rubble
			Czk	Calcrete, chalcedony
			Czs	Silcrete
			Czl	Laterite capping, pisolitic or massive
MESOZOIC ?			M	Sandstone, siltstone
MESOZOIC	CRETACEOUS	Larranganni Beds	Kl	Quartzose sandstone ; minor conglomerate
PALAEOZOIC		Chuall Beds	Pzc	Clayey and micaceous quartzose sandstone
	PERMIAN	Liveringa Formation: Condren Sandstone Member	Pr	Quartzose sandstone, thin bedded ; minor siltstone, claystone, conglomerate ; plant fossils : fluvial
		Liveringa Formation: Balgo Member	Po	Micaceous siltstone, sandstone, shale, thin bedded, ferruginous siltstone ; fossiliferous : shallow marine
		Noonkanbah Formation	Pn	Calcareous and non-calcareous siltstone and shale ; minor limestone ; fossiliferous : marine
		Poole Sandstone	Pp	Fine quartzose sandstone, siltstone, shale, thin bedded ; plant fossils : terrestrial
		Grant Formation	Pg	Quartzose sandstone, thin to thick bedded, cross bedded ; minor siltstone and conglomerate ; plant fossils : fluvial
	UPPER DEVONIAN	Knobby Sandstone*	Duk	Medium to coarse quartzose sandstone, medium to thick bedded ; minor conglomerate ; fish plates and plant fossils : fluvial
	LOWER ORDOVICIAN	Carranya Formation*	Oc	Fine to medium quartzose sandstone, thin bedded ; conglomerate ; fossiliferous : marine
PROTEROZOIC	ADELAIDEAN	Albert Edward Group: Flat Rock Formation	Eaf	Sublithic arenite, micaceous siltstone and shale
		Albert Edward Group: Timperley Shale	Eaj	Micaceous shale, siltstone ; minor lithic arenite
		Albert Edward Group: Elvire Formation	Eae	Siltstone, shale, lithic arenite, quartz arenite
		Albert Edward Group: Mount Forster Sandstone	Eao	Sublithic arenite, quartz arenite ; minor conglomerate
		Duerdin Group: Ranford Formation	Eos	Micaceous shale, sublithic arenite
		Duerdin Group: Redbank Yard Conglomerate	Eor	Conglomerate, sublithic arenite ; minor dolomite
	CARPENTARIAN OR ADELAIDEAN	Wade Creek Sandstone	Esw	Sublithic arenite ; minor siltstone
		Bungle Bungle Dolomite	Esb	Stromatolitic chert, silicified oolite ; minor lithic arenite
		Mount Parker Sandstone	Esp	Quartz arenite, sublithic arenite ; minor conglomerate, siltstone
		Redcliff Pound Group: Erica Sandstone	Ere	Sublithic arenite ; minor quartz arenite
		Redcliff Pound Group: Murraba Formation	Erb	Chert granule conglomerate, sublithic arenite, shale. Section only
		Redcliff Pound Group: Lewis Range Sandstone	Erl	Quartz arenite ; minor sublithic arenite, conglomerate, siltstone
		Meteorite Crater Beds	Eum	Sublithic arenite, quartz arenite ; minor conglomerate
		Boee Beds	Eub	Sublithic arenite, minor conglomerate
		Jawilga Beds	Euj	Sublithic arenite, chert conglomerate
		Denison Beds	Eud	Quartz arenite, minor sublithic arenite
		Pindar Beds	Eur	Quartz arenite, sublithic arenite
		Lake Willson Beds	Euw	Stromatolitic chert, sublithic arenite
		Peterson Beds	Eup	Sublithic arenite, quartz arenite ; minor lithic arenite greywacke, conglomerate, siltstone, dolomitic mudstone
	CARPENTARIAN	Birrindudu Group: Coomarie Sandstone	Edk	Sublithic arenite
		Birrindudu Group: Talbot Well Formation	Edt	Stromatolitic chert, sublithic arenite, siltstone, limestone
		Birrindudu Group: Gardiner Sandstone	Edg	Glauconitic sandstone; Sublithic arenite, quartz arenite, siltstone, shale, conglomerate
	LOWER PROTEROZOIC		Eg	Porphyritic and non-porphyritic muscovite and biotite adamellite ; minor biotite granodiorite
		Pargee Sandstone	Elg	Sublithic arenite, quartz arenite, lithic arenite, conglomerate
ARCHAEAN ?		Tanami complex	At	Hornfelsic sublithic arenite
		Tanami complex: Killi Killi Beds	Atk	Schistose to phyllitic greywacke, lithic arenite, siltstone and shale ; minor quartzite, banded chert, basalt, acid porphyry
		Halls Creek Group: Olympio Formation	Aho	Schistose greywacke and siltstone, phyllite ; minor quartzite, calc-silicate lenses

*Name not yet approved

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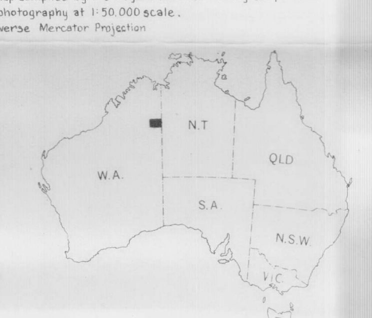
Base map compiled by the Royal Australian Survey Corps from aerial photography at 1:50,000 scale.
Transverse Mercator Projection



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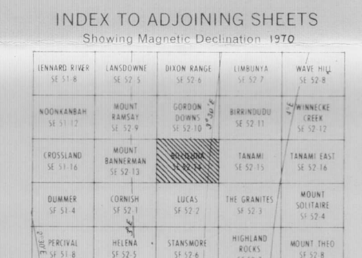
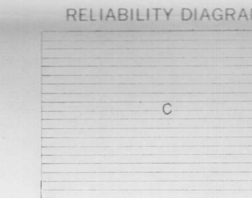


Scale 1:250,000

RELIABILITY DIAGRAM



Geology 1959 by J.N. Casey, A.T. Wells
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P.C. Muhling, R.W.A. Crowe (GSWA)
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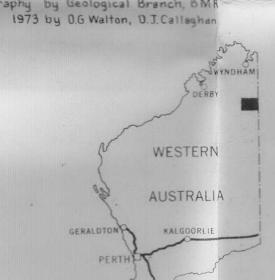
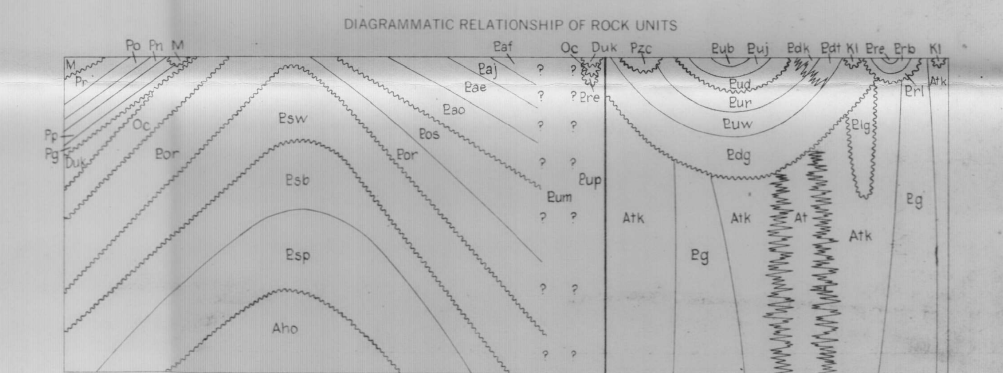
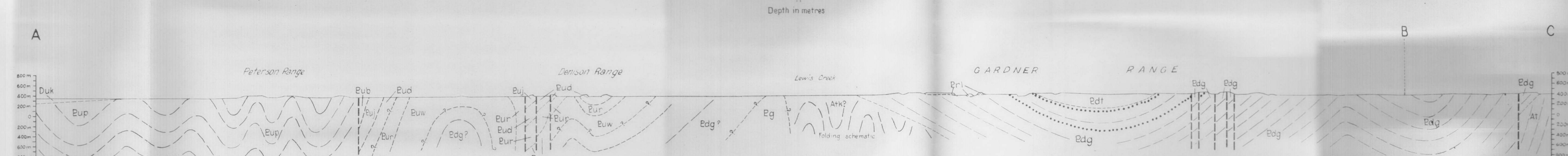


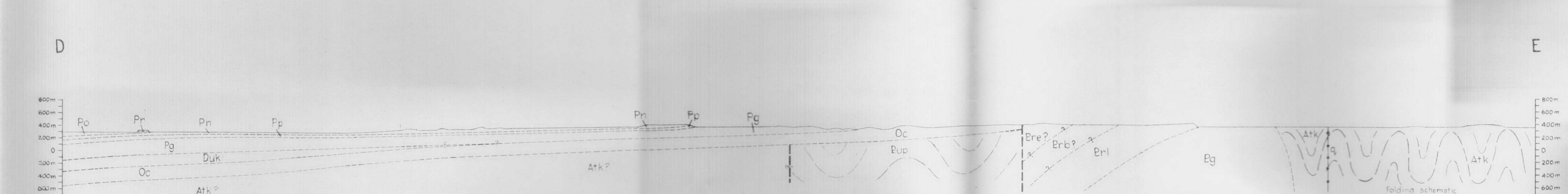
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity
Facies change

Sections





PRELIMINARY TO SECOND EDITION, 1974

SUBJECT TO AMENDMENT

BILLILUNA

SHEET SE 52-14

AUSTRALIA 1:250 000 GEOLOGICAL SERIES

LUCAS

WESTERN AUSTRALIA

SHEET SF 52-2

Reference

Geological boundary

Facies boundary

Anticline, showing plunge

Syncline

Fault

Normal fault, triangle indicates direction of dip

High-angle reverse fault, triangle indicates direction of dip

Low-angle thrust fault (⊢ indicates upper plate)

Inclined fault

Where location of boundaries, folds and faults is approximate line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes

Strike and dip of strata

Strike and dip of strata, unmeasured

Strike and dip of strata, facing not known

Vertical strata

Vertical strata, showing facing

Horizontal strata

Dip <15° (airphoto interpretation)

Generalised strike and dip of undulating strata (airphoto interpretation)

Trend line (airphoto interpretation)

Joint pattern (airphoto interpretation)

Lineament (airphoto interpretation)

Strike and dip of foliation

Vertical foliation

Strike and dip of foliation, dip indeterminable

Strike and dip of cleavage

Vertical cleavage

Direction and plunge of lineation

Platy flow, inclined

Vertical platy flow

Horizontal platy flow

Platy flow, dip not determined

10 Macrofossil locality (with reference number)

12 Microfossil locality (with reference number)

4 Plant fossil locality (with reference number)

54 Wood fossil locality (with reference number)

57 Palynomorph locality (with reference number)

Measured section

3 Sample locality for age determination

Dyke or vein, q-quartz

St Stratigraphic hole

Bore with windpump

Abandoned bore

Well

Dam

WH Waterhole

RH Rockhole

Spring

Sand dunes

State boundary

Vehicle track

Seismic traverse line

Fence

"Balgo" Homestead

Building

Landing ground

Yard

Astronomical station

Trigonometrical station

·285 Elevation in metres, approximate

pa Position approximate

pd Position doubtful

* Name not yet approved by State Authority

NOTE ON GRID COORDINATES

Brown ticks with black italic numbers (numbers shown only at SW corner of map and change of zone), indicate the 20,000 yard intervals of the Australian National Grid, Zones 3,4 (Australian Series), CLARKE 1858 SPHEROID, Transverse Mercator Projection

Brown numbered lines (with larger upright numbers), indicate the 20,000 metre intervals of the superimposed Australian Map Grid Zone 52, AUSTRALIAN NATIONAL SPHEROID Transverse Mercator Projection

Reference

CAINOZOIC	QUATERNARY		Qa	Sand, silt, clay: alluvial and lacustrine
			Qe	Halite gypsum, clay, silt and sand: evaporitic and alluvial
			Qs	Sand, silt: alluvial and aeolian in depression
			Qz	Sand, minor gravel: aeolian and minor piedmont
			Czq	Vein quartz rubble
			Czk	Calcrete, chalcedony
			Czs	Silcrete
			Czl	Laterite capping, pisolitic or massive
				Chemically altered and texturally modified weathered rock
MESOZOIC			M	Sandstone, siltstone, claystone; poorly sorted
			M_2	Sandstone, siltstone, pebble conglomerate; cross and graded bedding; immature: fluviatile
			M_1	Siltstone, fine sandstone, basal conglomerate; thin bedded bioturbated: probably paralic
	TRIASSIC	Erskine Sandstone	Ꞩe	Micaceous sandstone, clay matrix; minor siltstone: probably fluviatile
		Blina Shale	Ꞩb	Siltstone, claystone, sandstone; thin bedded and bioturbated: probably paralic
		Culvida Sandstone	Ꞩc	Fine sandstone, well-sorted, well-bedded; siltstone, minor conglomerate: probably continental
PALAEOZOIC		Pedestal Beds	Pzs	Quartzose sandstone; minor conglomerate, siltstone, shale
		Lucas Formation	Pzl	Calcareous and non-calcareous sandstone, siltstone and mudstone; minor limestone and dolomite
	PERMIAN		P	Sandstone, siltstone
		Liveringa Formation: Condren Sandstone Member	Pr	Fine quartzose sandstone, thin bedded; siltstone, minor claystone, conglomerate; plant bearing: probably continental
		Liveringa Formation: Balgo Member	Po	Siltstone, sandstone, thin bedded; shale; concretionary near base; ferruginized clay pellet conglomerate; fossiliferous: shallow marine
		Noonkanbah Formation	Pn	Calcareous and non-calcareous siltstone and shale; minor limestone; fossiliferous: marine
		Poole Sandstone	Pp	Fine quartzose sandstone, thin bedded; siltstone, in part carbonaceous: probably continental and marine
		Grant Formation	Pg	Quartzose sandstone, thin to thick bedded, cross bedded; minor siltstone and conglomerate: probably fluviatile
	UPPER DEVONIAN	Knobby Sandstone*	Duk	Quartzose sandstone, medium to thick bedded; siltstone, minor conglomerate: probably fluviatile
	DEVONIAN		D	Undivided sedimentary rocks (Section only)
	ORDOVICIAN		O	Undivided sedimentary rocks (Section only)
PROTEROZOIC	CARPENTARIAN OR ADELAIDEAN	Redcliff Pound Group: Erica Sandstone	Ꞓre	Sublithic arenite, minor quartz arenite, siltstone, shale, glauconitic sandstone
		Redcliff Pound Group: Murraba Formation	Ꞓrb	Chert granule conglomerate, sublithic arenite, quartz arenite, siltstone, shale, dolomite
		Redcliff Pound Group: Lewis Range Sandstone	Ꞓrl	Quartz arenite; minor sublithic arenite, conglomerate, siltstone
		Redcliff Pound Group: Muriel Range Sandstone	Ꞓrm	Sublithic arenite, quartz arenite; minor siltstone, shale, conglomerate
	CARPENTARIAN	Birrindudu Group: Gardiner Sandstone	Ꞓdg	Glauconitic sandstone; Sublithic arenite, quartz arenite, siltstone, shale, conglomerate
	LOWER PROTEROZOIC	Lewis Granite	Ꞓg	Porphyritic and non-porphyritic muscovite and biotitic adamellite
			Ꞓgl	Muscovite and biotite adamellite, biotite granodiorite, pegmatite, aplite
			$Ꞓgl_e$	Non-porphyritic adamellite
			$Ꞓgl_p$	Porphyritic adamellite
ARCHAEAN OR LOWER PROTEROZOIC		Tanami complex: Killi Killi Beds	Atk	Schistose to phyllitic greywacke, lithic arenite, siltstone and shale; minor quartzite, banded chert, basalt

*Name not yet approved

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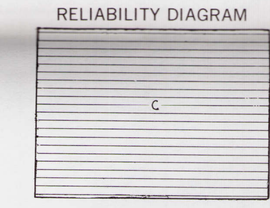
Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

RELIABILITY DIAGRAM



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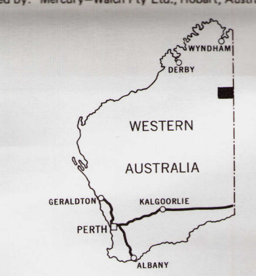

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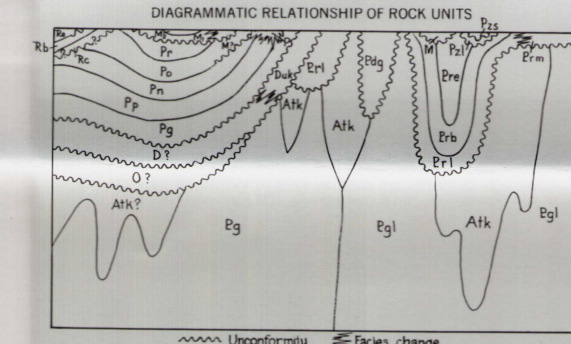
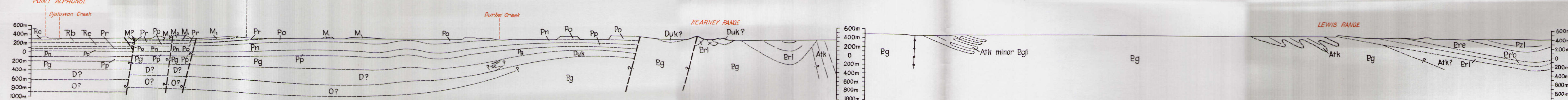


Sections

Cainozoic sediments omitted

Scale: $\frac{V}{H} = 4$

Depth in metres



PRELIMINARY TO SECOND EDITION, 1974

SUBJECT TO AMENDMENT

LUCAS

SHEET SF 52-2