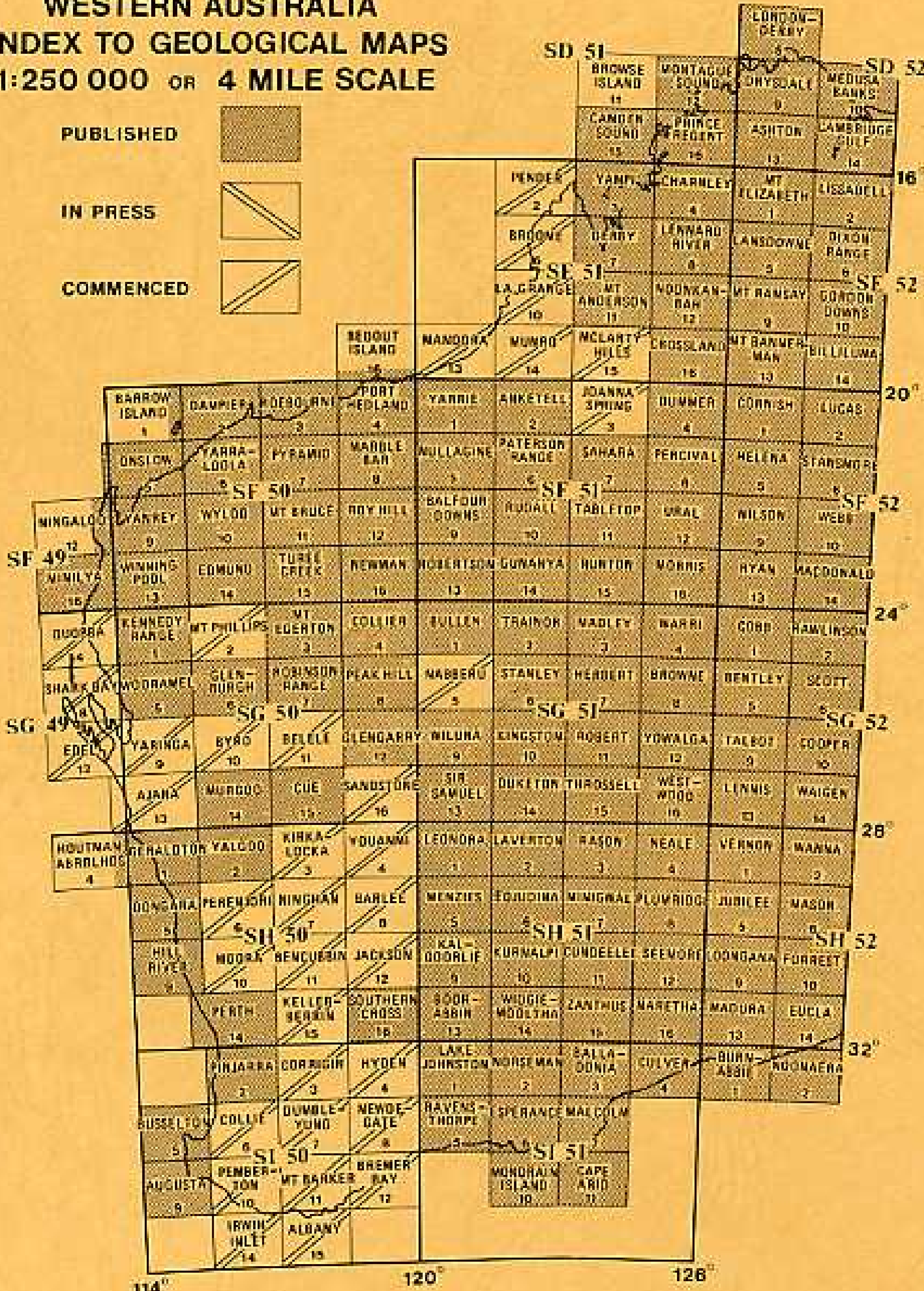
1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

STANLEY

WESTERN AUSTRALIA

SHEET SG 51-6 INTERNATIONAL INDEX

WESTERN AUSTRALIA
INDEX TO GEOLOGICAL MAPS
1:250 000 OR 4 MILE SCALE



GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

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STANLEY

WESTERN AUSTRALIA

SHEET SG 51-6 INTERNATIONAL INDEX

COMPILED BY D. P. COMMANDER, P. C. MUHLING
AND J. A. BUNTING

PERTH, WESTERN AUSTRALIA 1982

18023—1

DEPARTMENT OF MINES, WESTERN AUSTRALIA
Minister: The Hon. P. V. Jones, M.L.A.
Under-Secretary: D. R. Kelly

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
Director: A. F. Trendall

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EXPLANATORY NOTES ON THE STANLEY GEOLOGICAL SHEET

Compiled by
D. P. Commander, P. C. Muhling and J. A. Bunting

INTRODUCTION

The STANLEY* 1: 250 000 Geological Sheet, reference SG/51-6 of the International Series, is bounded by latitudes 25°00'S and 26°00'S and by longitudes 121°30'E and 123°00'E. The sheet takes its name from Stanley Bluff near Glenayle homestead (*see* Appendix for co-ordinates of localities).

The permanent population is engaged in the pastoral industry. Three pastoral station homesteads are located on STANLEY. Earaheedy, established in 1903, is stocked with sheep; Carnegie (1921) and Glenayle (1938), with cattle. Part of Wongawol (cattle) also lies within the area. A small transient population is engaged in kangaroo shooting, vermin control, and sandalwood cutting. Access is by a graded road from Wiluna, which serves the pastoral homesteads. There are also a limited number of station tracks. The Canning Stock Route passes through the northwest corner of the area, and the Gunbarrel Highway runs eastwards from Carnegie homestead to Giles Meteorological Station and Warburton Mission, well to the east of STANLEY.

During the period of field mapping, April to July 1976, virtually no rain fell, and the whole of the area was accessible to four wheel drive vehicles.

The climate is one of hot summers and cool to mild winters. The mean annual rainfall is about 240 mm, most of which falls in the summer months, January to March. It is unreliable, and the area is subject to both drought and localized short-term floods. Annual potential evaporation is of the order of 3 000 mm. January, the hottest month, has a mean maximum temperature of about 38° C and a minimum of about 23° C; June and July, the coldest months, have a mean maximum temperature of about 20° C and a minimum of about 6° C.

PREVIOUS INVESTIGATIONS

STANLEY was traversed by the explorers, John Forrest (1874) and L. A. Wells (1896-7). The first geological reconnaissance was by H.W.B. Talbot during the construction of the Canning stock route in 1908 (Talbot, 1910). Subsequent reconnaissance traverses were made during 1912-13 (Talbot, 1920, 1926). Talbot recognized that the sediments in the south of the area unconformably overlie granite. The unconformity at the base of the Middle Proterozoic sequences was correctly recognized, but an unconformity was postulated between the flat-lying and folded Lower Proterozoic rocks. This interpretation remained on state geological maps up to and including the 1957 edition. Horwitz and Daniels (1967) assigned all the Proterozoic rocks in the area to the Middle Proterozoic Bangemall Basin.

Hall and Goode (1975) distinguished the Lower Proterozoic rocks of the Nabberu Basin from the Middle Proterozoic Bangemall Basin, and proposed stratigraphic subdivisions. These were modified slightly and formally defined by Hall and others (1977). Horwitz (1975a and b) also recognized the presence of an Early Proterozoic basin.

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* Names of 1:250 000 sheets are given in upper case, to distinguish them from localities of the same name.

The water resources of the area, in particular the calcrete aquifers were assessed by Sanders and Harley (1971) after a brief reconnaissance survey.

Adjoining 1:250 000 sheets which have been published are HERBERT (Kennewell, 1974), KINGSTON (Bunting, 1977), NABBERU (Bunting and others, 1979) and TRAINOR (Brakel and Leech, 1979).

The present survey of STANLEY commenced in 1975 with a helicopter reconnaissance in the northeast corner by I. R. Williams and R. E. J. Leech. In 1976, the remainder of the sheet was mapped on ground traverses by J. A. Bunting and D. P. Commander (Early Proterozoic) and P. C. Muhling and A. T. Brakel (Middle Proterozoic).

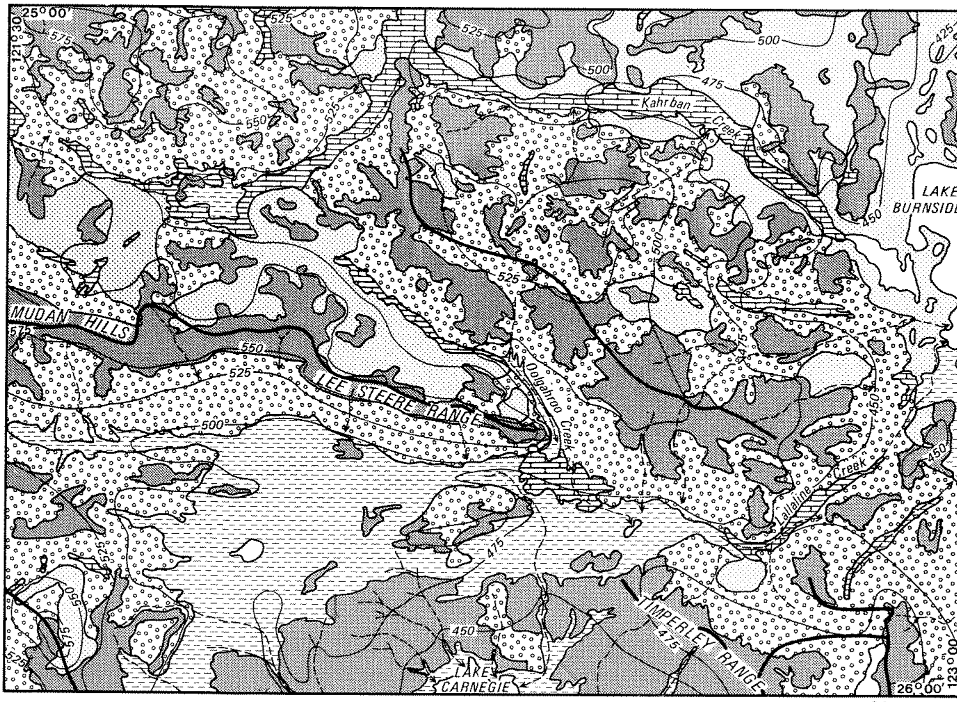


FIGURE 1 GSWA 17587

PHYSIOGRAPHY AND DRAINAGE

STANLEY SHEET SG 51-6

0 10 20 30 km

REFERENCE

DEGRADATIONAL AREAS

1 Upland areas, low hills, cuestas, duricrust-capped mesas and associated pediments

INTERMEDIATE AREAS (material derived from 1)

2a Flat sheetwash plains and valley floors consisting of colluvium and alluvium

2b Eolian sandplain, with patchy cover of longitudinal dunes

AGGRADATIONAL AREAS (material derived from 1 and 2)

3a Flat, bare salt-lake surface

3b Dunes and sheets of eolian and alluvial material marginal to salt-lakes and in major valley floors

3c Calcrete filled valley floors, low-lying with hummocky surface

---→ Ephemeral drainage

—— Drainage divide

—450— Topographic contour in metres

PHYSIOGRAPHY AND VEGETATION

The main physiographic features, presented in Figure 1, are divided into degradational areas (mainly bedrock and talus slopes), intermediate areas (colluvium, alluvium and eolian sand plain), and aggradational areas (salt lakes, associated marginal dunes, and valley calcrete).

The land surface is characterized by generally low relief; the elevation rises from less than 450 m above sea level in the east to over 550 m in the west. Several ranges of hills stand above the general level. The Mudan Hills-Lee Steere Range belt is the most prominent: its spine-like parallel ridges rise steeply above the plain. In the east, Bangemall Group sandstones form a number of flat-topped ranges with steep sides. Permian sediments form a flat, dissected plateau surface, now expressed as mesas and breakaways. Remnants of the early Tertiary laterite surface occur throughout STANLEY commonly forming small breakaways up to 10 m high.

All streams and lakes in the area are ephemeral and flow only after heavy rain. A major drainage basin south of the Mudan Hills-Lee Steere Range contains a large area of alluvium, sheet wash and small eolian dunes. Formerly, this drained through Lalline Creek into Lake Burnside and was part of an extensive palaeodrainage system in which surface flow ceased in the Middle Miocene van de Graaff and others, 1977). Rejuvenation of southward-flowing streams has caused diversion of this drainage southwards through youthful creeks into Lake Carnegie. Another example of drainage diversion occurs west of Glenayle homestead, where the upper part of the southeast-flowing Oolgahroo Creek has been diverted eastwards into the Kahrban Creek-Lake Burnside drainage system.

The extreme northeast and east portions of STANLEY are part of the Little Sandy Desert, and are characterized by longitudinal and chain dunes which trend predominantly west-southwest, though there is some variation around the lakes.

Vegetation assemblages mapped by Beard (1974) correspond largely with the physiographic units. Areas of colluvium and outcrop are covered by open mulga (*Acacia aneura*) woodland, or soft spinifex (*Plectrachene melvillei*) and wattle (*Acacia* sp.). Sand plain areas are covered by spinifex (*Triodia* sp.) and scattered mallee (*Eucalyptus* sp.) Areas marginal to salt lakes support halophytes such as samphire (*Arthrocnemum* sp.), saltbush (*Atriplex* sp.) and bluebush (*Kochia* sp.) with *Casuarina* sp. in alluvial channels. Major watercourses are commonly lined with tall river gums (*E. camaldulensis*) and have an understory of *Eremophila* sp.

SUMMARY OF GEOLOGY

STANLEY is occupied by parts of four sedimentary basins and a small inlier of granitoid basement.

1. The Nabberu Basin, here comprising the Earaheedy Group and the underlying Troy Creek Beds, is Early Proterozoic and extends across the southern half of the sheet. The Stanley Fold Belt affects the northern part of the basin, whereas the southern part is relatively undeformed.

2. The Scorpion Group represents a basin which is intermediate in age between the Nabberu and Bangemall Basins and which may extend under the Bangemall Group to the northeast. On STANLEY, the Scorpion Group is faulted against the Bangemall Group to the north and the Troy Creek Beds to the south.

18023—2

3. Unconformably overlying the Nabberu Basin to the northeast is the southeastern extremity of the Middle Proterozoic Bangemall Basin, which has undergone only mild deformation.
4. The Officer Basin extends onto the eastern edge of the sheet and is represented by glacigene rocks of Permian age. Cretaceous sediments occur a few kilometres east of the sheet boundary (Kennewell, 1974).

MALMAC DOME

North of the Lee Steere Range, various granitoids crop out in a basement inlier called the Malmac Dome (Horwitz, 1976). The dome forms a structural high in the Stanley Fold Belt and covers an area of about 200 km^2. The granitoid is unconformably overlain by basal sediments of the Earaheedy Group, and is, therefore, older than the presumed age of about 1 700 m.y. for the Earaheedy Group.

The granitoid is poorly exposed, mostly covered by eolian sand, deeply weathered, and in places difficult to distinguish from arkose in the overlying Yelma Formation; it ranges from medium, even grained, to coarse and porphyritic. Rarely, it is strongly foliated.

PROTEROZOIC STRATIGRAPHY

NABBERU BASIN

Troy Creek Beds

Below the lowest continuous quartz arenite of the Yelma Formation is a diverse group of rocks, the age and relationships of which are not clear. They occur in a 15 km wide belt to the north of the Mudan Hills. Rock types include shale, phyllite, quartz sandstone, chert, and felsic volcanics. The unit cuts out against the Malmac Dome to the east, and this contact, which is not exposed, could be either an unconformity or an intrusive contact. To the north, the Troy Creek Beds are faulted against the Scorpion Group, and are also in part unconformably overlain by the Bangemall Group.

The nature of the southern contact with the Yelma Formation is not clear. There is some evidence of an unconformity (Bunting and others, 1978), but poor outcrop, structural complexity, and similarity of some rock types preclude a conclusive answer.

The most common rock is a brown, maroon, or purple pelite, which may be either a cleaved shale or phyllite. The main cleavage trends between 070° and 090°, has a moderately steep northerly dip, and is parallel to that in the Earaheedy Group. A later crenulation cleavage is common. Twenty kilometres northeast of Sydney Heads Pass, below the unconformity with the Bangemall Group, a quartz-mica schist contains weathered porphyroblasts (possibly after garnet) which have been slightly rotated during the later crenulation event.

North of Imbin Rock Hole is a thick unit of quartz arenite and interbedded shale. The arenite is quartz-rich, contains minor feldspar and clay, and is thick-bedded to massive. Tight parasitic folds, a regional fold closure to the west, bedding-cleavage relationships, and grading bedding, all indicate that the arenite lies in the core of an overturned, west-plunging anticline.

About 15 km north of Sydney Heads Pass, felsic volcanic rocks are interbedded with the shale and phyllite. The felsic rock contains quartz phenocrysts, which are commonly embayed and occasionally have rounded bypyramidal terminations. In places, the rock is a crystal tuff, which, in addition to the phenocrysts, contains fragments of fine-grained felsic and shaley material set in a quartz-mica or quartz-clay matrix; the fragments are up to several centimetres across. All the felsic volcanic rocks are deeply weathered to varying degrees, and exposure is poor.

On stratigraphic and lithological grounds, the Troy Creek Beds probably correlate with rocks in the axial sequence of the Glengarry Sub-basin (Bunting and others, 1977).

Earaheedy Group

The Earaheedy Group (Hall and others, 1977) is a shallow-water sequence of shale, sandstone, limestone, and granular iron-formation about 6 000 m thick. Isotopic ages of 1 590 to 1 710 m.y. have been obtained from glauconite in the Yelma Formation in the southeast Nabberu Basin (Preiss and others, 1975), and an age of 1 685 m.y. has been reported from the Wandiwarra Formation on KINGSTON (Horwitz, 1975b).

Yelma Formation: The Yelma Formation is the basal unit of the Earaheedy Group, and forms the northern edge of the Mudan Hills and Lee Steere Range. The formation consists mainly of quartz arenite, shale, and minor arkose, carbonate and conglomerate. The unconformity with the granitoid rocks in the Malmac Dome is well exposed in places.

The lowest unit is variously shale, arkose and quartz-pebble conglomerate. Further west, the contact with the underlying Troy Creek Beds is poorly exposed and problematical.

On the side of the Malmac Dome, the formation is about 500 m thick, and is predominantly shale with thin quartz arenite bands. In this area, Horwitz (1976) used the term 'Malmac Formation' for this unit. The quartz arenite bands thicken to the west, and the formation reaches a thickness of possibly 1 000 m near Sydney Heads Pass. In the Mudan Hills, two quartz arenite units stand out as parallel ridges. The lower unit, about 200 m thick, is a ferruginous quartz arenite containing variable amounts of fine-grained octahedral magnetite. The upper unit, about 500 m thick at Mount Evelyn, is predominantly a medium-grained, clean quartz arenite with rare ferruginous bands. Cross-bedding is abundant in some layers, and indicates facing to the south. About 150 m from the top of the upper arenite is a band, 1 to 5 m thick, of very coarse sandstone containing granules of quartz and pink chert. Between the two arenite units is a poorly exposed, cleaved shale with a few thin carbonate bands. The main cleavage development was accompanied by growth of white mica. This early cleavage strikes between 070° and 090°, and is cut by a later crenulation cleavage which may or may not be visible in hand specimen.

Frere Formation: The Frere Formation, about 1 300 m thick, is a sequence of dominantly ferruginous chemical sediments, fine-grained clastics, and minor carbonate. The formation forms a series of parallel ridges in the Mudan Hills and Lee Steere Range, and also crops out in the vicinity of Coonabildie Bluff.

The most distinctive association (*ŁEf*) consists of alternate beds of hematitic shale and granular iron-formation. The iron-formation:shale ratio varies considerably. Individual beds attain a thickness of 1 m, but are generally between 50 and 300 m thick. Wavy, lenticular bedding is common. The iron-formation varies from virtually iron-free greyish-green chert, through ferruginous chert, to red jasperoidal iron-formation containing specular hematite. The granular texture is usually peloidal, rarely oolitic or brecciated. The peloids are rounded, sub-spherical grains of chert containing variable amounts of red hematite dust (jasper). In the more iron-rich rocks, the peloids contain specular hematite. Ooliths are less well developed than on the southern side of the Nabberu Basin; and, generally, only a vague concentric layering is present. Both peloids and ooliths range in size from 1 to 2 mm, and are enclosed in a matrix of chert. Such textures are comparable with the Superior-type iron-formation of North America (Gross, 1965; Dimroth and Chauvel, 1973) and indicate a shallow, probably turbulent, marine environment (Goode and Hall, 1976).

Banded iron-formation (*ȒEf(i)*) is not common, but is significant as an indicator of an increase in water depth. It occurs intermittently near the top of the formation, notably west of Mount Royal and on the south side of the Lee Steere Range. Alternate iron-rich and cherty mesobands range in thickness from 10 to 100 m. The chert mesobands are white, iron-free and internally massive. The iron-rich mesobands contain microbands on a millimetre scale, although this is often obscured by alteration of the hematite to limonite. At the southern end of Sydney Heads Pass, banded iron-formation near the base of the formation displays a highly disrupted form of wavy bedding, possibly resulting from sedimentary boudinage and load deformation.

The iron-formation and shale association occurs in at least three major units within the Frere Formation. Between these units, and accounting for over half the total thickness, are shale units (*ȒEf(s)*), which are poorly exposed in valleys between the main iron-formation ridges. The shales are micaceous, strongly cleaved, and in some places, display a later crenulation. The shale unit between the top arenite of the Yelma Formation and the lowest iron-formation is included in the Frere Formation by definition (Hall and others, 1977). Thin carbonate bands occur rarely within this lowest shale unit, in a similar stratigraphic position to limestones on the south side of the Nabberu Basin (Bunting, 1977; Bunting and others, 1979).

The easternmost occurrence of the formation is at Coonabildie Bluff, where about 10 m of magnetite-hematite siltstone, stromatolitic carbonate, and dark-grey chert with quartz-filled anastomosing cracks, forms a small inlier. Aeromagnetic evidence suggests that the proximity of this inlier to units near the top of the Earaheedy Group may be due to a northwest-trending pre-Bangemall fault.

Windidda Formation: The Windidda Formation in the type area on KINGSTON conformably overlies the Frere Formation, and is a 1 200 m thick succession of carbonate and shale (Hall and others, 1977). Rocks succeeding the Frere Formation on STANLEY are predominantly shale, and have not been distinguished from the overlying Wandiwarra Formation. Only one exposure of carbonate in this stratigraphic position is known, and it has been mapped as Windidda Formation (lat. 25°38′, long. 122°15′). The carbonate and chert sequence at Coonabildie Bluff may mark the transition from the Frere to the Windidda Formation.

Wandiwarra Formation: Over most of its outcrop on STANLEY, the Frere Formation is conformably overlain by a thick sequence of shale, siltstone, and sandstone. All this has been included in the Wandiwarra Formation, although the lower half may be a facies variant of the Windidda Formation, which is a major unit on the south side of the basin. The disconformity which separates the Windidda and Wandiwarra Formations on the south side is not apparent on STANLEY.

Shale is dominant, especially in the lower part of the formation where it crops out as low breakaways. It is maroon to purple, occasionally buff to pink, and is generally deeply weathered. Cleavage is moderate, but becomes stronger northwards where there are numerous small thrust faults.

Sandstone forms isolated, rubbly hills within large areas of sheet-wash. It is typically a dark-gray quartz arenite, in which medium to coarse, sub-angular to rounded quartz grains are set in a siliceous or ferruginous cement. Small, clay or siltstone intraclasts are common, and there are a few thin chert beds and jasper intraclasts.

In the southwest corner of STANLEY, the formation is represented by fine-grained immature sandstone, quartz arenite, and finely laminated shale, all of which display abundant ripple marks.

Princess Ranges Quartzite: The Princess Ranges Quartzite lies conformably between the Wandiwarra and Wongawol Formations, and consists of about 250 m of medium- to coarse-grained, extremely well-sorted, quartz-cemented orthoquartzite and interbedded micaceous sandstone and siltstone. The quartzite in the southwest corner of the sheet is medium- or thick-bedded with a faint lamination, and commonly displays trough cross-bedding. Ripple marks and mud pellets are common. In places, the quartzite has a speckled or blotchy appearance because of brown, ferruginous spots, up to 40 mm across, which are probably weathered rhombs of calcite cement. Within the fold belt to the north, recrystallization has obscured much of the bedding and sedimentary textures.

In southwest STANLEY the resistant quartzite forms cuestas; elsewhere, isolated rubble-strewn hills rise steeply; above the sheet-wash plains.

Wongawol Formation: The Wongawol Formation is a thick succession of fine-grained sandstone, siltstone, and subordinate carbonate rocks. The type section extends northwards along the Wiluna-Carnegie road from south of Wongawol homestead (on KINGSTON) to the base of the Kulele Limestone near Thurraguddy Bore.

The lower part of the formation is a monotonous sequence of grey to pinkish-brown, finely laminated, fine-grained arkosic sandstone and siltstone. Abundant sedimentary structures include small-scale festoon cross-bedding, ripple marks, small scour channels, load casts, ball and pillow structures, and rare mudcracks. The flaggy sandstone commonly shows current lineation.

In the upper part—named the Sholl Creek Member by Hall and others (1977)—thin, lenticular beds of carbonate and carbonate breccia are interbedded with the sandstone. Increasing proportions of carbonate and micaceous maroon and chocolate shale over fine-grained sandstone in this part of the formation mark a transition towards carbonate sedimentation.

The formation forms low, rubbly exposures and occasional low breakaways over large areas of the southern part of STANLEY, and typically supports a very sparse vegetation. Total thickness is probably between 1 500 and 2 000 m, but shallow dips and gentle folds make precise calculations difficult.

Kulele Limestone: The Kulele Limestone consists of limestone interbedded with pink or pale grey micaceous mudstone. The limestone units, which range from a few centimetres to about 5 m thick, are internally complex, and consist of several limestone types, including oolite, intraclastic breccia, cross-bedded calcarenite, stromatolite limestone and laminated micrite.

Stromatolites in the thicker limestone layers form slightly elongate domes which can be up to 2 m high and several metres long. They are consistently oriented in a direction of $330 \pm 10°$. The interdomal areas are filled with ooliths and intraclasts. In the thinner layers, stromatolites form smaller elongate domes, up to 0.5 m long and a few centimetres high. These are commonly oriented about 080°.

The limestone and mudstone alternations reflect a crudely cyclic sedimentation. Towards the top of the formation, fine-grained sandstone becomes common in the clastic layers, and the proportion of carbonate decreases.

The formation is 300 m thick in its type area in southeast Kingston. However, the best exposures, particularly of the large domal stromatolites, are in an outlier east of Thurraguddy Bore.

Mulgarra Sandstone: The Mulgarra sandstone is a transgressive sandstone overlying the Kulele Limestone with a sharp, possibly disconformable contact. The formation is limited to the Timperley Range area, where about 100 m is exposed. The top of the formation is obscured by Bangemall Group and Permian rocks.

The basal quartz arenite forms the prominent scarp of the Timperley Range. The dominant rock type is a medium-grained, grey to red-brown ferruginous quartz arenite containing minor glauconite. Sedimentary structures include small cross-beds, shale pellets, slumps and load casts. Carbonate and shale beds occur near the top of the formation.

SYDNEY HEADS PASS CONGLOMERATE

A single outcrop of conglomerate and sandstone, measuring about 1 100 m by 400 m by about 40 m thick, occurs at Sydney Heads Pass. Faulting and folding have resulted in dips up to 40° (Fig. 2). It lies unconformably over steeply dipping Yelma Formation arenite and Frere Formation shale. The conglomerate forms a plateau, about 20 m above the alluvium-filled valley, but it is topographically below ridges of Yelma arenite.

The basal beds, west of the road, are ferruginous quartz arenite, occasionally with cross-bedding, and are similar in composition to the underlying Yelma Formation. East of the road, the lowermost exposed beds are 15 m of conglomerate and interbedded lenticular arenite. Individual beds of conglomerate are up to 2.6 m thick. The matrix is composed of finely laminated iron-rich and quartz-rich layers. Secondary iron enrichment has partly replaced some quartz grains. The pebbles, up to 70 mm diameter, are rounded and composed of vein quartz, white quartzite, ferruginous arenite, hematitic shale, and granular iron-formation. The pebbles are not in contact with each other and are aligned along bedding planes. A slight imbrication implies a southerly current movement.

Above the conglomerate are several pisolite beds, up to 0.3 m thick, which contain ferruginous pisoliths (10 mm in diameter) in a quartz–iron oxide matrix. The pisoliths are ovoid, and contain a core of material similar to the matrix. Some mixed rocks contain pebbles and pisoliths.

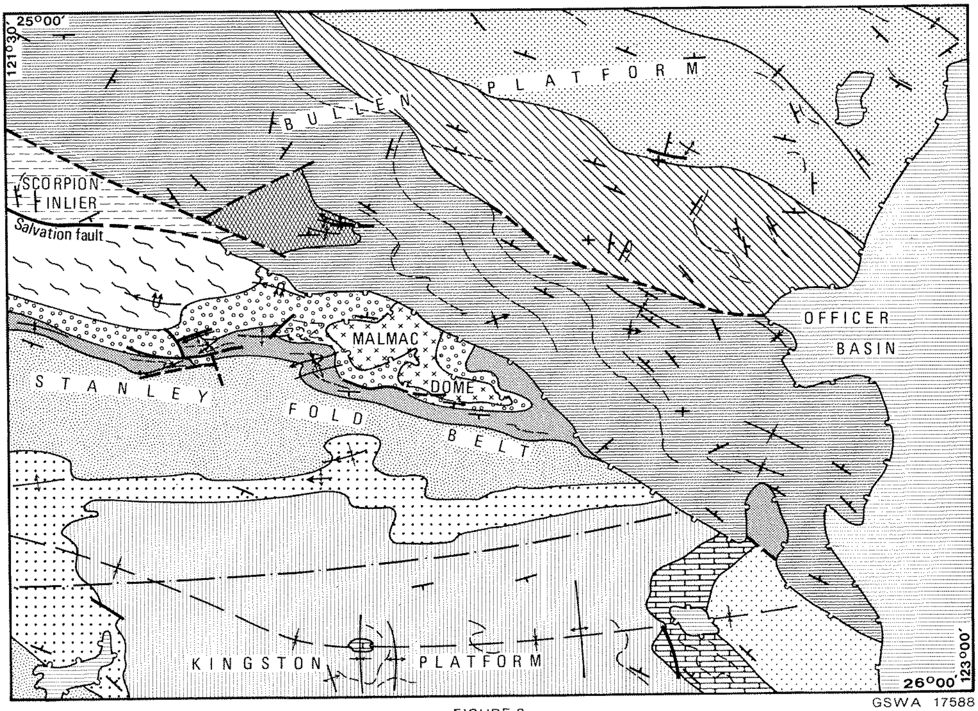
The topmost beds are poorly exposed, but consist mainly of medium-grained quartz arenite, quartzite and shale, and are not ferruginous.

The age of the deposit is uncertain. It post-dates folding, uplift and erosion of the Earaheedy Group, but is itself folded and faulted. Some of the movement has taken place on pre-existing faults, and suggests that the area was still tectonically active at the time of deposition. The conglomerate is probably the remnant of a more extensive intermontane deposit of early Middle Proterozoic age. It is possibly an ancient analogue of the Tertiary Robe Pisolite of the Hamersley Basin.

SCORPION GROUP

The stratigraphic position of the Scorpion Group is not known with certainty. The following points indicate that it is probably younger than the Earaheedy Group, that it lies unconformably beneath the Bangemall Group, and is, therefore, probably of Middle Proterozoic Age.

1. Conglomerate in the Scorpion Group, adjacent to the Salvation Fault, is probably unconformable on the Earaheedy Group as it contains clasts of peloidal iron-formation that can be matched with the Frere Formation.



GSWA 17588

FIGURE 2

SOLID GEOLOGY AND STRUCTURE

STANLEY SHEET SG 51-6

0 10 20 30 km

REFERENCE

OFFICER BASIN

PERMIAN — PATERSON FORMATION

BANGEMALL BASIN

MIDDLE PROTEROZOIC:
- CALYIE SANDSTONE (BANGEMALL GROUP)
- MARLOOYANOO FORMATION (BANGEMALL GROUP)
- COONABILDIE FORMATION (BANGEMALL GROUP)
- Unassigned (BANGEMALL GROUP)
- SCORPION GROUP

NABBERU BASIN

LOWER PROTEROZOIC:
- MULGARRA SANDSTONE (EARAHEEDY GROUP)
- KULELE LIMESTONE (EARAHEEDY GROUP)
- WONGAWOL FORMATION (EARAHEEDY GROUP)
- PRINCESS RANGES QUARTZITE (EARAHEEDY GROUP)
- WANDIWARRA FORMATION (EARAHEEDY GROUP)
- FRERE FORMATION (EARAHEEDY GROUP)
- YELMA FORMATION (EARAHEEDY GROUP)
- TROY CREEK BEDS

MALMAC DOME

ARCHAEAN OR PROTEROZOIC — Granitic rocks

- Geological boundary
- Unconformable boundary between tectonic units
- Fold belt/platform boundary
- Fault
- Fault inferred
- Synclinorial axis
- Anticline with plunge
- Syncline
- Anticline overturned
- Syncline overturned
- Dip and strike of bedding
- Horizontal bedding
- Bedding trend

2. The total thickness of the Scorpion Group on NABBERU and STANLEY is at least 10 000 m (Bunting and others, 1979). The Bangemall Group on STANLEY is about 4 000 m thick. The rapid change in thickness required for one group to be a facies equivalent of the other is unlikely in such mature, shelf-type sediments. The Scorpion Group is therefore not equivalent to the Bangemall Group.
3. The Salvation Fault, a major structure, forms the southern boundary to the Scorpion Group, but 30 km to the southeast it has not affected the basal contact of the Bangemall Group with the Earaheedy Group. This suggests that the Bangemall Group is younger than the Salvation Fault and the Scorpion Group.

The northern boundary of the Scorpion Group is inferred to be a major fault because it is difficult to accommodate the thickness of the group between the base (on NABBERU), and the nearest Bangemall Group rocks to the northeast. Northwesterly trending minor faults, adjacent to the northern boundary of the Scorpion Group, are thought to be parallel to the major fault. The Scorpion Group may correlate with the Cornelia Inlier on TRAINOR (Brakel and Leech 1979) or the Yeneena Group (Williams and others, 1976), and may be part of a major sedimentary basin which underlies the eastern Bangemall Basin. Alternatively the Scorpion Group may not be directly linked to the other groups, but instead it may represent a fault-bound, local deposit in a zone (related to the Stanley Fold Belt) in which tectonism persisted into the Middle Proterozoic.

The upper part of the Scorpion Group is exposed on STANLEY. Medium- and fine-grained sandstone with subordinate conglomerate and shale (*Ɇo(a)*) are the main rocks. The sandstone is pink to grey, weathering to maroon. It is moderately to poorly sorted and contains lithic grains and scattered pebbles. Muscovite is common in the less well-sorted varieties. Detrital feldspar is scarce, except near the top of the sequence, where it may attain up to 20 per cent of the rock. Conglomerate forms single pebble horizons, a few beds reaching 0.8 m thick. The pebbles and cobbles are sub-rounded and include sandstone, quartzite, slate and vein quartz. Close to the Salvation Fault, conglomerate (*Ɇo(l)*) is more plentiful, and in a few places is the dominant rock. Such a distribution indicates that movement on the Salvation Fault started just before or during sedimentation. The conglomerate contains pebbles, cobbles, and a few boulders of vein quartz, quartzite, and peloidal iron-formation derived from the Earaheedy Group. The matrix of the conglomerate is poorly or moderately sorted sandstone. In the upper part of the arenaceous sequence, brown shale and silty shale, commonly with abundant mica, are interbedded with sandstone containing intraclast moulds. The shale also contains lenses of fine-grained sandstone.

UNASSIGNED ROCKS

Five kilometres southwest of Glenayle Homestead is a sequence of medium-grained, red-brown quartz arenite with scattered granules and laminae of coarse-grained arenite. Bedding planes are 20 to 50 mm apart. Cross-bedding is well developed; there are numerous planar and tangential units, as well as a few trough cross-beds. Ripple marks are also present. The arenite has been deformed into upright folds that vary from open to tight. Accompanying the tight folds are a weak axial-plane cleavage, quartz veins, and faults subparallel to the axial zones of the folds. The relation of this arenite to the Bangemall Group is not known. It appears to conformably overlie the basal part of the Coonabildie Formation, but contains no siltstone. However, the locally intense deformation in the arenite, in contrast to that in the gently dipping Bangemall Group, suggests these unassigned rocks lie unconformably beneath the Coonabildie Formation, and may be part of the Scorpion Group.

BANGEMALL GROUP

The Bangemall Group on STANLEY is a gently deformed sequence of siltstone, shale and sandstone, which dips northward off the Earaheedy Group. The Permian Paterson Formation unconformably overlies all units of the Bangemall Group.

Coonabildie Formation

The lowest unit in the Bangemall Group, the Coonabildie Formation, consists of interbedded siltstone and quartz arenite overlying a distinctively laminated and bedded basal chert. Good exposures of the formation are in the area east of Mount Moore. Quartz arenite forms cuestas and ridges; it probably constitutes less than 30 per cent of the lower part of the formation, but increases towards the top. The arenite is pale grey, medium-grained, and has plentiful siltstone pellet moulds. Most of the arenite is well sorted and contains less than 5 per cent of clay and feldspar. There are a few beds of moderately sorted, green lithic sandstone. Arenite bands in the lower part of the formation contain laminae of coarse-grained arenite and granule conglomerate. Ripples, flute casts and cross-beds are locally abundant.

The siltstone is typically micaceous, and purple where fresh, but most is weathered to yellow. Discontinuous laminae of fine-grained sandstone and thin interbeds of shale are common. Thin beds of fine- and medium-grained limestone, dark-green siltstone and shale crop out near Stanley Bluff.

The basal unit of laminated and banded white chert contains some jasper as well as white and grey cherty rocks, which are probably silicified mudstone. These contain moulds which may be after gypsum crystals.

The Coonabildie Formation probably rests unconformably on the Earaheedy and Scorpion Groups. It is a gently dipping sequence, which trends across the complex structure of the Earaheedy Group and its associated aeromagnetic anomalies, which extend in the sub-surface beneath Mount Moore. The contact with the overlying Marlooyanoo Formation is not exposed. Sections across the contact zone indicate that the Coonabildie Formation may be either older or younger than the Marlooyanoo Formation. The Coonabildie Formation is thought to be older because:

1. In the less deformed areas, the Coonabildie Formation dips under the Marlooyanoo Formation.
2. The Marlooyanoo Formation does not appear between the basal Coonabildie Formation and the underlying Earaheedy Group.

In the southeast, there must be a fault between the two formations if, as argued above, the Coonabildie is older. To the northwest, the nature of the boundary is less clear, because of an apparent convergence of strike near the contact. Therefore the contact may be either:

1. a continuation of the fault from the southeast; or
2. a low angle unconformity between the two formations; or
3. a conformable contact in which the apparent convergence is interpreted as a series of northeasterly trending folds which die out rapidly in the gently dipping and poorly exposed rocks near the contact.

The preferred interpretation is that the formations are conformable.

Marlooyanoo Formation

The Marlooyanoo Formation consists mostly of laminated micaceous siltstone and shale with variable proportions of sandstone and small amounts of carbonate. The formation contains a series of cycles, each with a basal laminated shale, which grades upward into laminated siltstone and finally fine- and medium-grained sandstone. A good exposure of this sequence is 9 km east of Lyn Bore. The siltstone is purple where fresh, but mostly weathers to yellow and pink. The shale is greenish-grey to white. Both rocks show a regular, even lamination with a few small scours and slumps.

The proportion of sandstone in the formation is high in the southeast, but decreases to the northwest where bands are less than 3 metres thick. There are good exposures 4 km northeast from Yarra Bore. The sandstone weathers to yellow brown, but is green where fresh. It is a well-sorted, medium- and fine-grained, laminated arenite with 5-15 per cent feldspar and a little clay matrix. Planar and trough cross-beds are well developed; units are about 1 metre thick in the medium-grained arenite. Ripples are the only structures in the fine-grained arenite.

The Marlooyanoo Formation appears to dip under the Calyie Formation. The boundary is not exposed. The distribution of the Calyie Formation suggests it is regionally transgressive over the Marlooyanoo Formation. The formations have a similar structural style, and are intruded by the same suite of dolerite sills and dykes; therefore, the contact may be only a disconformity, with local faults.

Calyie Formation

Most outcrop of the Calyie Formation is north of Kahrban Creek, and is not readily accessible. The formation comprises medium- and fine-grained blue-grey to purple arenite and small amounts of siltstone. The arenite is moderately to well sorted, contains about 5 per cent clay matrix, and a lesser amount of feldspar and mica. Intraclasts of siltstone are common. Bedding planes are about 150 mm apart, though there are few laminated zones. Planar cross-beds are widespread.

The Calyie Formation is unconformable on the Cornelia Sandstone to the northeast (Brakel and Leech, 1979).

BASIC INTRUSIVE ROCKS

Sills

Dolerite and gabbro sills intrude all formations of the Bangemall Group, the Scorpion Group, the unassigned rocks, and the Kulele Limestone and Mulgarra Sandstone of the Earaheedy Group. The sills are concordant or slightly discordant. The dolerite consists of altered plagioclase, subophitically intergrown with pyroxene. Magnetite is a common accessory, although dolerite at Digby Hill contains up to 5 per cent pyrite. Most sills show little textural or mineralogical variation except for marginal chilling. The thickest sill (minimum 850 m) is in the southeast of the Parker Ranges, and it displays features such as primary alignment of feldspars, primary layering, and granophyre veins, which are unusual for sills of this suite. All sills have been folded with the Bangemall Group. Similar dolerites on ROBERT have been dated, by Rb/Sr methods, at 1 050 ± 50 m.y. (Compston, 1974.)

Dykes

Dolerite dykes were intruded after the folding of the Bangemall Group. They trend from northwest to northeast. Many are deeply weathered and unconformably overlain by the Permian Paterson Formation.

PROTEROZOIC STRUCTURE

The structure of the Precambrian rocks is shown in Figure 2. Summaries of the regional structure are given by Bunting and others (1977), Hall and Goode (1978), and Muhling and Brakel (in prep.).

KINGSTON PLATFORM

The Kingston Platform is characterized by shallow dips and gentle folds which lack a penetrative cleavage. It includes the axis of the broad synclinorium where the youngest rocks of the Earaheedy Group are preserved. The main period of folding took place along approximately east-trending sub-horizontal axes. The folds are gentle, open, occasionally with a steeper southern limb, and become tighter northwards towards the Stanley Fold Belt. A later set of very gentle cross-folds with a northerly trend has produced an elongate dome and basin interference pattern. One of these shallow basin structures contains the outlier of Kulele Limestone at Thurraguddy Well.

STANLEY FOLD BELT

The transition from platform to fold belt is taken at the first appearance of a slaty cleavage, and this probably represents the change from a stable to a more active basement.

Between Mount Evelyn and the Lee Steere Range, the sub-parallel bands of Yelma and Frere Formation outline large parasitic folds with Z-asymmetry. Axial surfaces dip steeply north, and axes plunge west at 10 to 20°. The longer limbs are steeply dipping and commonly overturned, while the short limbs dip north at 20 to 30°. Between Mount Evelyn and the western sheet boundary, the folds trend west-northwest and have horizontal axes. In adjacent NABBERU, the folds have S-asymmetry and plunge east. This change in trend and plunge is due to a broad synclinal cross fold. Small north-dipping thrusts and reverse faults associated with the asymmetrical folds indicate shortening and hence compression from the north, possibly as a result of movement of the granitic basement. In the Lee Steere Range, such a fault has brought Yelma Formation quartzite into contact with ferruginous chert of the Frere Formation. Over the Malmac Dome, the Earaheedy Group is only mildy deformed, in contrast to the steeply dipping and folded rocks flanking the dome. The dome probably moved upwards and southwards during deformation.

Metamorphic grade in the northern part of the Stanley Fold Belt reaches lower greenschist facies, as shown by the development of muscovite (and, rarely, garnet in the Troy Creek Beds northeast of Sydney Heads Pass). Two cleavages are apparent in some phyllites of the Troy Creek Beds, but only one is present in the Earaheedy Group. A later crenulation or kink banding is common in both sequences. Quartz veining is locally common in the Troy Creek Beds and Yelma Formation, and ptygmatic quartz veins occur in the Wandiwarra Formation.

SCORPION INLIER

The Scorpion Inlier is the structural unit containing the Scorpion Group. Most of the sequence is moderately dipping, and steep dips occur only near the Salvation Fault. The Scorpion Group on STANLEY forms a basin, truncated on the south and north sides by faults. The Salvation Fault, on the south side, is probably a normal fault, dipping to the north. This is indicated by the orientation of shear planes adjacent to the fault and the sense of drag in the Scorpion Group.

BULLEN PLATFORM

The Bullen Platform (Muhling and Brakel, in prep.) is an area in the eastern part of the Bangemall Basin, in which gently deformed sediments overlie a stable basement. The sediments on STANLEY lie on the southeast edge of the Bullen Platform and form a regional synclinorium between the Malmac Dome and Scorpion Inlier to the south and the Cornelia Inlier (Brakel and Leech, 1979) to the north on TRAINOR. Most of the Bangemall sequence dips north towards the axial zone of the synclinorium on the northeast corner of STANLEY. The Coonabildie and Marlooyanoo Formations do not occur on the north side of the synclinorium, and have been interpreted as deltaic deposits (Muhling and Brakel, in prep.) which wedge out to the north.

The main folds within the synclinorium trend northwest, and most are developed in the Coonabildie Formation. They are open, upright, roughly concentric folds with no axial-plane cleavage. The folds are very open where the Bangemall Group overlies the Earaheedy Group, but become tighter in the zone between the Coonabildie Range and the Minyan Hills. Dips in this zone decrease to the northwest. Subsidiary northeasterly trends have interacted with the main northwesterly trends producing folds at Yallum Hill, flexures in the Coonabildie Formation and Calyie Formation and domes in the Marlooyanoo Formation.

PERMIAN

Flat-lying glacial and fluvioglacial deposits, which are unconformable on the Proterozoic rocks, are correlated with the Paterson Formation, of early Permian age, which extends throughout the Canning and Officer Basins (Lowry and others, 1972). The formation can be subdivided into three lithofacies types: unbedded, poorly sorted sediments, from boulder conglomerate to clayey siltstone with pebbles (*Pag*); cross-bedded conglomeratic sandstone (*Paf*); and siltstone (*Pal*). These are interpreted as tillite, fluvioglacial and lacustrine sediments respectively. Cross-beds in the fluviatile sediments in the southwest corner of STANLEY show a consistent north to north-northeast palaeocurrent direction. This is the same as the direction of ice movement inferred from the distribution of erratics on KINGSTON (Bunting, 1977).

The Permian sediments are deeply weathered and in places are completely silicified to form a silcrete capping. Much of the colluvium in the southeast part of the sheet has large rounded boulders of granite and various Proterozoic rocks including the distinctive Frere Formation. It is probably the residue from erosion of Permian tillite.

CAINOZOIC

Mapping of Cainozoic units is based on lithology and morphological expression. The boundary between many units is transitional. A distinction is made between older Cainozoic units, which are deep-weathering features dating back to the early Tertiary, and Quaternary units which are unconsolidated sediments, some of which are still being deposited.

OLDER CAINOZOIC

Laterite (*Czl*) is a ferruginous pisolitic duricrust, which formed as a soil horizon, commonly over iron-rich shale, fine sandstone and dolerite. It occurs as an undulating plateau surface which has been dissected in places to reveal the underlying pallid zone of weathered bedrock.

Silcrete (*Czb*) is a hard, siliceous duricrust formed over bedrock, and consists of angular quartz grains in a silica cement. It occurs mainly over Permian sediments and granite.

Calcrete (*Czk*) is a carbonate and opaline silica rock restricted to infilled Tertiary drainage systems. It formed by the *in situ* replacement of alluvium in the valley floors, and can range in thickness from 15 m to 50 m. Calcrete can occur several metres above adjacent present day alluvial channels, and is now being eroded.

QUATERNARY

Colluvium (*Qc*), consisting of angular to rounded rock and quartz fragments in loam, occurs marginal to rock outcrops as a scree or thin cover over fresh and weathered rock. It grades downslope into coalesced alluvial fans and broad sheetwash areas covered with clay and loam with small pebbles (*Qd*). In many areas the colluvium (*Qc*) unit passes downward into an iron-cemented colluvium or hardpan.

Alluvial deposits in confined drainage channels (sand and gravel) and in broad drainages (clay and loam) are grouped as a single unit (*Qa*).

Lake deposits (*Ql*) can consist of clay/loam or salt and clay. The deposits form flat, bare, salt-lake surfaces, and are covered with water only after heavy rain. Low-lying areas of samphire and saltbush flats with low mulga-covered sand dunes oriented along the direction of water flow, or parallel to lake shorelines, are included in a marginal unit (*Qg*). This unit reflects eolian reworking of water-borne material.

Eolian deposits of red-brown sand (*Qs*) form extensive areas of gently undulating sand plain, characteristically vegetated by spinifex, and broken by occasional longitudinal dunes. Wind-blown sand mixed with ferruginous pebbles, mapped as *Qp*, occurs mainly in the north of the sheet, where it overlies the Bangemall Group.

MINERAL POTENTIAL

IRON ORE

The iron-ore potential of the Frere Formation has only recently (1973) been recognized. Temporary reserves covering parts of the Mudan Hills and the Lee Steere Range were granted in late 1976, but at the time of writing, no significant finds have been reported. Zones of iron enrichment occur in the Frere Formation in the Mudan Hills and at Mount Ooloongathoo, but these zones are of highly variable quality and limited extent.

URANIUM

Outside STANLEY, uranium is known to occur at the Proterozoic-Archaean unconformity, and in valley calcretes downslope from granitic catchment areas. Horwitz and Mann (1975) detected up to 55 ppm uranium in Proterozoic sediments over the Malmac Dome. However, most of this uranium is in detrital zircon according to J. F. Lovering (pers. comm.) cited by Butt and others (1977, p. 7). No exploration other than sampling of bore water is known to have been carried out on calcrete adjacent to the granite.

MANGANESE

West of Earaheedy homestead, bands of superficial manganese enrichment occur in shale of the Wandiwarra Formation. The bands are probably controlled by joints in the steeply dipping sediments, but occur as isolated outcrops surrounded by a thin veneer of colluvium. The deposits are too small to be of economic interest; the largest has a maximum thickness of about 10 m and a strike length of some 80 m. Four pooled samples, taken at 2 m intervals across strike, assayed at 27 per cent Mn, 2.3 per cent Fe and 36.8 per cent SiO_2.

BASE METALS

No base-metal mineralization has been recorded from STANLEY, but in view of exploration developments elsewhere in Australia, two environments would seem to offer some potential. One of these is the stromatolitic carbonate of the Kulele Limestone, although the associated shale, on surface evidence, does not appear to be pyritic. Secondly the felsic volcanic rocks in the Troy Creek Beds north of Sydney Heads Pass could possibly host volcanogenic base-metal deposits.

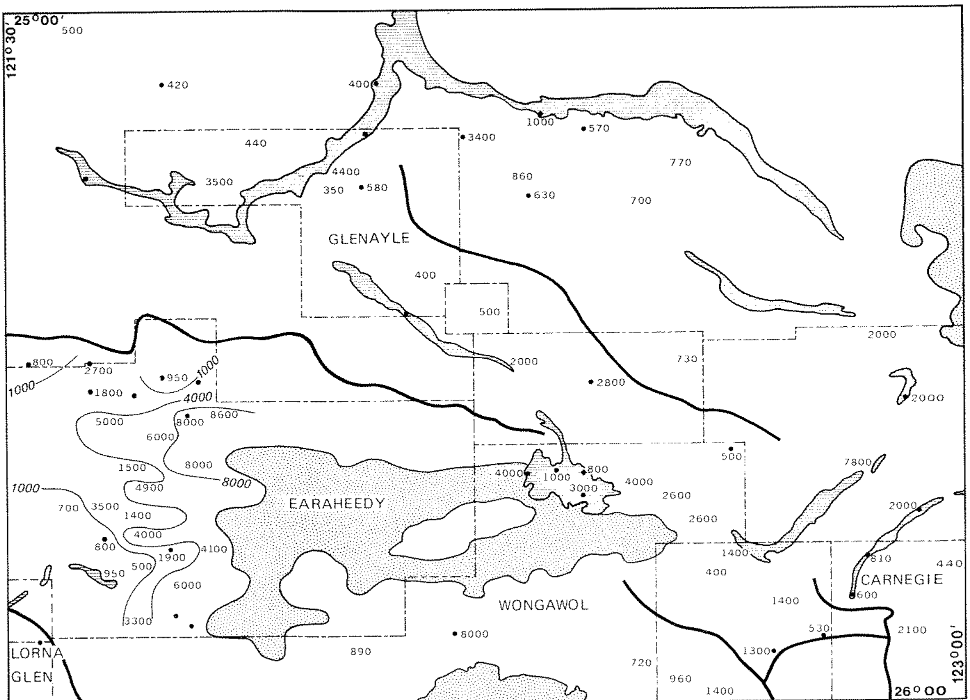
GROUNDWATER

There are about 106 bores and wells, most of which are equipped with windmills for stock supply. Figure 3 shows the distribution of aquifer types and the locations and salinities of the bores and wells. Half are located in colluvium and weathered bedrock, one fifth each in alluvium and calcrete and one tenth in fractured Proterozoic aquifers. Permian sediments are not a prospective source.

Areas of bedrock and colluvium away from the trunk drainages tend to have fresh to brackish groundwater in the salinity range 400-4 000 mg/l. Bores are usually located near small creeks. Water of lowest salinity occurs in the Parker Ranges, where the bedrock is sandstone and dolerite. Water of higher salinity occurs in colluvium over deeply weathered shale near Earaheedy homestead, and in colluvium flanking sheetwash areas. Depths to water range from 5 to 20 m. Yields are variable but are generally sufficient to supply 10 to 50 m^3 day.

Salinities tend to rise downstream, and towards the centres of the drainages, to over 10 000 mg/l in the alluvium/sheetwash and salt lake areas. An area of calcrete at Aqua Spring (a native well) contains groundwater of less than 1 000 mg/l, in contrast to higher salinity further up the drainage indicating a local recharge from surface water or rainfall. Generally, salinity in calcrete increases rapidly away from the intake. Depth to water in calcrete is in the range 1 to 5 m, and up to 10 m in alluvium. Potential yields for bores and wells in calcrete are very high, over 1 000 m^3 day.

Sanders and Harley (1971) estimate the total annual recharge to five areas of calcrete and alluvium to be 6.5 x $10^6 m^3$, in the 400-8 000 mg/l range. Usage of groundwater in the area is estimated to be less than $10^5 m^3$ per year, a small figure compared with both recharge and storage. Most recharge takes place during the infrequent heavy rains. It is not considered that drought has a significant effect on aquifers in the area.



GSWA 17589

FIGURE 3

HYDROGEOLOGY

STANLEY SHEET SG 51-6

0 10 20 30 km

REFERENCE

Calcrete

Alluvium or lake deposit (saline)

• 4000 Bore or well : salinity in mg/l

–1000– Groundwater salinity contour

Drainage divide

Pastoral Lease boundary

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APPENDIX: Co-ordinates of localities mentioned in text.

	Latitude			Longitude		
	°	′	″	°	′	″
Aqua Spring	25	41	30	122	24	00
Carnegie Homestead	25	48	00	122	58	30
Coonabildie Bluff	25	46	00	122	41	00
Digby Hill	25	11	30	121	53	45
Earaheedy Homestead	25	35	30	121	35	00
Glenayle Homestead	25	16	00	122	02	45
Imbin Rockhole	25	26	30	121	44	15
Kahrban Creek	25	15	00	122	45	00
Lake Burnside	25	17	00	122	58	00
Lake Carnegie	25	59	00	122	15	00
Lee Steere Range	25	34	30	122	09	30
Lyn Bore	25	16	00	122	19	30
Mount Evelyn	25	30	15	121	44	45
Mount Moore	25	37	30	122	28	30
Mount Ooloongathoo	25	43	00	121	33	45
Mount Royal	25	31	00	121	45	30
Mount Throssell	25	59	45	122	40	00
Mudan Hills	25	29	00	121	38	00
Oolgahroo Creek	25	33	30	122	20	30
Parker Ranges	25	22	45	122	12	30
Stanley Bluff	25	17	30	122	04	15
Sydney Heads Pass	25	30	30	121	46	45
Thurraguddy Bore	25	56	00	122	01	45
Timperley Range	25	55	30	122	38	00
Yarra Bore	25	16	45	122	28	45

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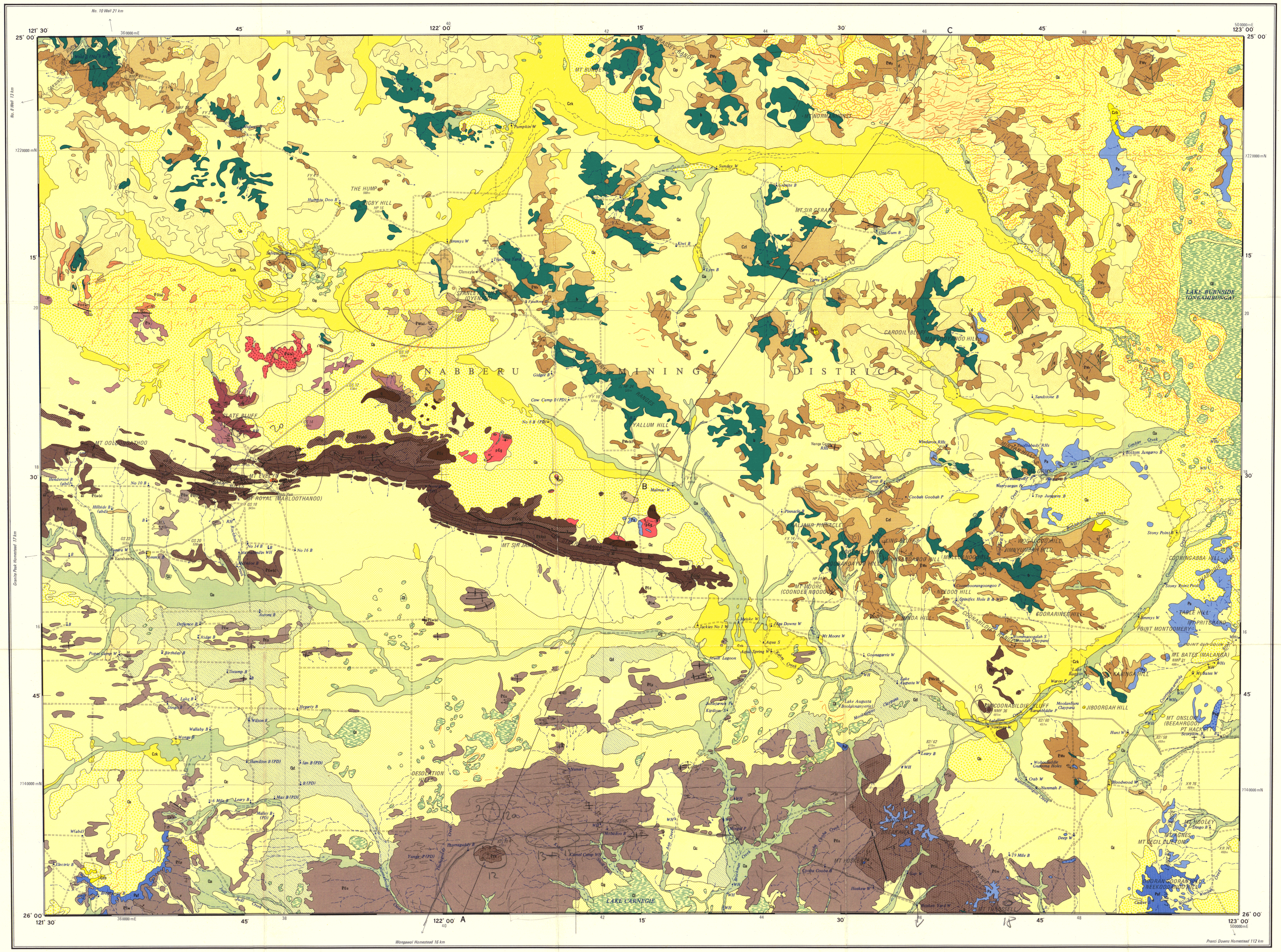
STANLEY

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA



SYMBOLS

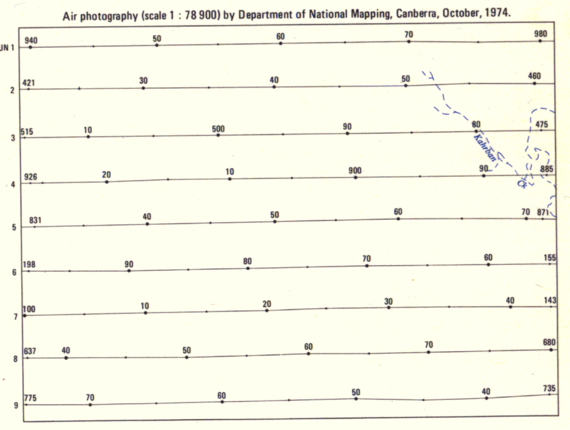
Geological boundary
Fault
Accurate
Inferred
Fold
Anticline, accurate, with plunge
Anticline, approximate or inferred
Anticline, overturned
Syncline, accurate, with plunge
Syncline, approximate or inferred
Syncline, overturned
Minor anticline, with plunge
Minor syncline
Bedding
Inclined
Horizontal
Vertical
Overturned
Air photo interpretation, dip 5–15
Trend line
Fold plunge on bedding trend
Cleavage
Inclined
Vertical
Foliation
Inclined
Vertical
Mineral orientation in igneous rocks, inclined
Air photo lineament
Stromatolite locality

Goldfield boundary
Formed road
Track
Homestead
Landing ground
Horizontal control, major
Bench mark, height accurate
Sand dune

Watercourse, intermittent
Bore
Well
Pool
Waterhole
Rockhole
Spring
Windpump
Abandoned
Position doubtful

FLIGHT DIAGRAM

Air photography (scale 1 : 78 900) by Department of National Mapping, Canberra, October, 1974.



REFERENCE

CAINOZOIC — QUATERNARY

Qs Eolian sand
Qp Ferruginous pebbles and eolian sand
Qc Colluvium – colluvial fans, quartz and rock fragments in loam, commonly contains hardpan
Qd Sheetwash – alluvium, colluvium, in low lying areas flanking Qg and Ql
Qa Alluvium – poorly sorted clay to pebble deposits in drainage lines and adjacent floodplains
Qg Mixed alluvium and lake deposits with sand dunes, marginal to salt lakes, gypsiferous in parts
Ql Lake sediments – clay, silt and sand, saline and gypsiferous

Czk Calcrete – massive, nodular and sheet carbonate with minor chalcedony
Czb Silcrete – sub-vitreous siliceous duricrust with angular quartz grains
Czl Laterite – massive and pisolitic ferruginous duricrust

PALAEOZOIC — EARLY PERMIAN

Pa **PATERSON FORMATION**: poorly sorted sandstone, siltstone, claystone, and conglomerate
Pal Claystone and siltstone; lacustrine
Paf Poorly sorted sandstone, conglomerate, minor siltstone, fluviatile
Pag Conglomerate, minor sandstone; glacigene

PROTEROZOIC — MIDDLE PROTEROZOIC

d Dolerite dyke
b Dolerite sill, minor granophyre

Bangemall Group (ꝒM)

ꝒMy **CALYIE SANDSTONE**: quartz sandstone, cross-bedded, with intraclasts, fine-grained sandstone, siltstone
ꝒMr **MARLOOYANOO FORMATION**: laminated siltstone and shale with minor to major feldspathic sandstone, minor carbonate
ꝒMx **COONABILDIE FORMATION**: siltstone; cross-bedded quartz arenite, with intraclasts and local granules; minor shale, conglomerate, carbonate
ꝒMx(c) Chert and shale unit
ꝒM(a) Sandstone, unassigned

Scorpion Group (ꝒO)

ꝒO(l) Lithic, silty sandstone, coarse polymictic conglomerate, quartz sandstone, shale
ꝒO(a) Quartz sandstone, and siltstone
Ꝓr Conglomerate, ferruginous arenite, arenite, pisolite; restricted to Sydney Heads Pass area

EARLY PROTEROZOIC

Earaheedy Group (ꝒE)

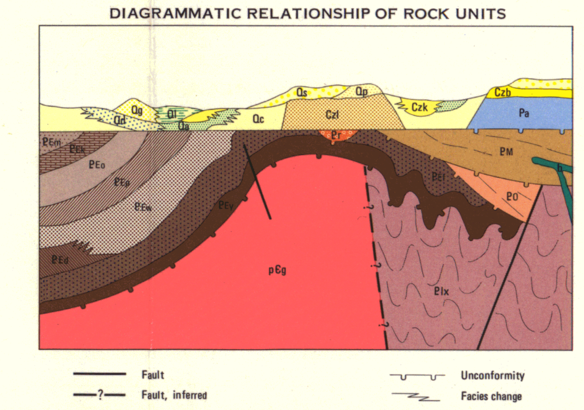
ꝒEm **MULGARRA SANDSTONE**: fine to medium-grained quartz sandstone, locally glauconitic, minor carbonate bands
ꝒEk **KULELE LIMESTONE**: stromatolitic limestone, calcarenite and mudstone; minor sandstone in upper part
ꝒEo **WONGAWOL FORMATION**: fine arkosic sandstone and shale grading upwards into mudstone, sandstone and carbonate
ꝒEp **PRINCESS RANGES QUARTZITE**: clean white quartz arenite, minor clayey sandstone and siltstone
ꝒEw **WANDIWARRA FORMATION**: fine to coarse-grained quartz sandstone and shale, locally glauconitic
ꝒEw(a) Fine to coarse-grained sandstone
ꝒEw(s) Shale, siltstone
ꝒEd **WINDIDDA FORMATION**: carbonate, calcilutite, mudstone
ꝒEf **FRERE FORMATION**: granular and banded iron-formation, hematite shale, chert, shale, minor carbonate
ꝒEf(i) Banded iron-formation
ꝒEf(s) Shale, siltstone, minor carbonate
ꝒEf(l) Grey carbonate and intraclastic carbonate breccia
ꝒEy **YELMA FORMATION**: quartz arenite, arkose, shale
ꝒEy(a) Quartz arenite, ferruginous in part
Shale, siltstone

Ꝓlx **TROY CREEK BEDS**: shale, phyllite, minor sandstone, chert
Ꝓlx(a) Quartz arenite and interbedded shale
Ꝓlx(v) Felsic porphyry and interbedded phyllite

ARCHAEAN OR EARLY PROTEROZOIC

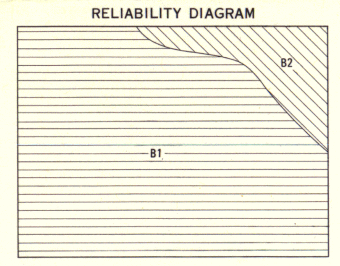
q Quartz dykes
p€g Granitic rock

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Compiled and published by the Geological Survey of Western Australia. Cartography by the Geological Mapping Section, Department of Mines. Topographic base from compilations by the National Mapping, Canberra, A.C.T.
Copies of this map may be obtained from the Geological Survey of Western Australia, 66 Adelaide Tce., Perth.

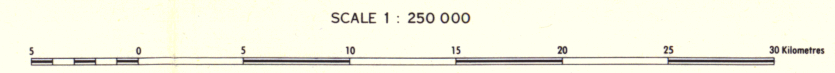
RELIABILITY DIAGRAM



B1 Ground traverses with air photo interpretation
B2 Helicopter traverses with air photo interpretation

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

SCALE 1 : 250 000



TRANSVERSE MERCATOR PROJECTION
ZONE 51 AUSTRALIAN MAP GRID

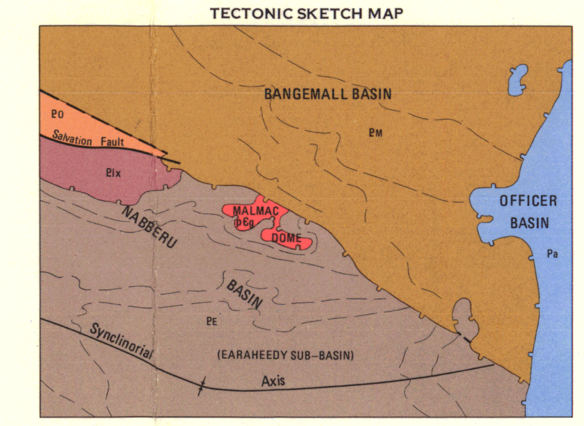
INDEX TO ADJOINING SHEETS

BULLEN SG 51-1	TRAINOR SG 51-2	MADLEY SG 51-3
NABBERU SG 51-5	STANLEY SG 51-6	HERBERT SG 51-7
WILUNA SG 51-9	KINGSTON SG 51-10	ROBERT SG 51-11

Geology by: I.R. Williams, R.E.J. Leech 1975, J.A. Bunting, D.P. Commander, P.C. Muhling, A.T. Brakel 1976.

DECLINATION DIAGRAM

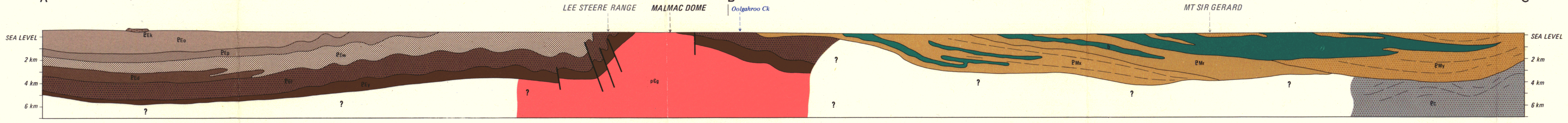
TECTONIC SKETCH MAP



DIAGRAMMATIC SECTION

NATURAL SCALE

SECTION A - B - C



Ꝓc Cornelia Sandstone (extrapolated from Trainor Sheet)

STANLEY
SHEET SG 51-6

FIRST EDITION 1981