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THE GEOLOGY OF YUENDUMU NATIVE RESERVE, NORTHERN TERRITORY

by

P.J. Cook

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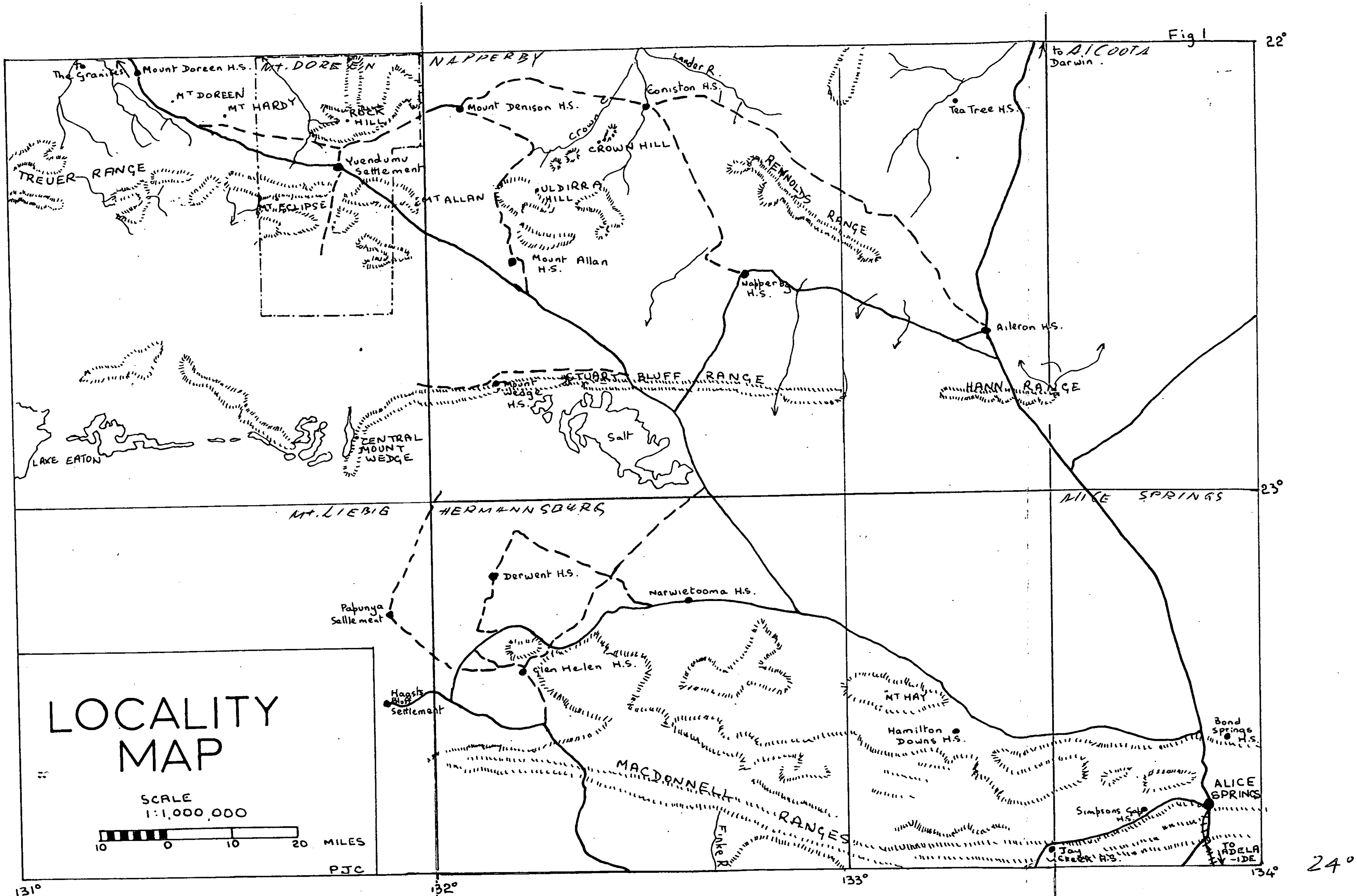

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F53/5

THE GEOLOGY OF YUENDUMU NATIVE RESERVE,

NORTHERN TERRITORY

SUMMARY

This report is the result of geological mapping undertaken to assist in the search for water at Yuendumu Native Reserve, Northern Territory but has a wider significance than this, as it is the first systematic description of the sediments of the Ngalia Trough which has been attempted. A total of 11,000 feet of sediments is exposed on Yuendumu Reserve and their age ranges from probable Upper Proterozoic to Upper Palaeozoic. The sediments are sandstones, limestones, and siltstones, which unconformably overlie a basement of Precambrian metamorphic and igneous rocks. The hydrology of the area is the subject of a previous report but brief mention is made of it here. The "nitrate problem" is discussed in the light of new information.

INTRODUCTION

General

The field work for this report was carried out over a period of five weeks during the months of February and March, 1962, as part of a programme to locate new supplies of groundwater on Yuendumu Native Reserve.

Location

The Yuendumu Native Reserve covers an area of 850 square miles and lies 180 miles north-west of Alice Springs, the nearest town. A formed earth road links Yuendumu with The Stuart Highway and Alice Springs, whilst numerous graded tracks provide links with the surrounding cattle stations (see Fig.(i)). A weekly plane service operates from Alice Springs to the settlement.

Climate

The area covered by Yuendumu Native Reserve has a typical semi-arid climate with the annual rainfall seldom exceeding 10 inches per year. Due to its situation north of the Macdonnell Ranges the area is prone to summer thunderstorms. Whilst mapping was being carried out in March, 1962 a rainfall of 6 inches in 36 hours was experienced.

Temperatures are high in summer, often exceeding 100° F, and moderate in winter with frosts occasionally occurring.

Field Methods

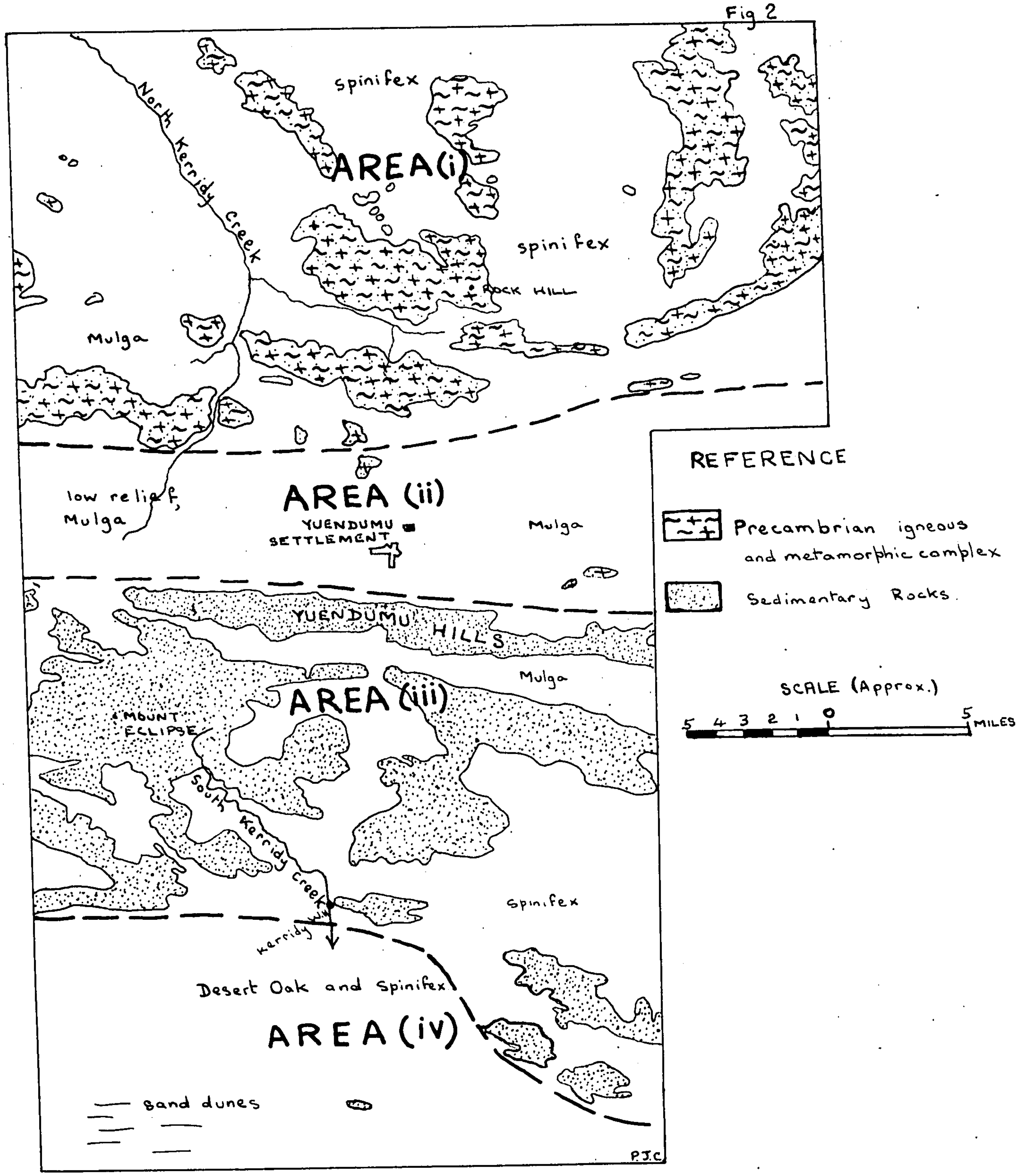
The geology was plotted on to aerial photographs in the field and then transferred to a base map prepared from an uncontrolled photo-mosaic having a photo-scale of approximately 1.25 inches to 1 mile. This was later reduced to a scale of two miles to one inch.

PREVIOUS GEOLOGICAL INVESTIGATIONS

The first geological studies in the area of Yuendumu Reserve were made in 1931 by Tindale who carried out a geological reconnaissance of the Cockatoo Creek area. (Tindale, 1933).

The next recorded visit to the area was made by Madigan (1937) who briefly mentions the granite and gneiss of the Rock Hill area. He was visiting some of the mineral deposits in the Mount Doreen area at the request of W.W. Braithling who discovered the deposits in 1935.

Fig 2



Physiographic Divisions

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The metal deposits were again examined by the north Australia Survey (Kiek 1941) and he too, briefly mentions the granite of Rock Hill.

Hossfold paid a short visit to the area in 1953 to examine a copper deposit on Yuendumu Native Reserve.

Since that time, geologists of the Bureau of Mineral Resources have made numerous visits to Yuendumu Native Reserve either in connection with the Nobagalang copper deposit (Ryan, 1956,unpub.) or for the siting of water bores (Jones and Quinlan,1958, unpub. Quinlan,1958,a, unpub., Quinlan,1958, b, unpub). In this latter connection,geophysical work was carried out in the environs of Yuendumu Native Settlement (Wiebenga,Goodchild and Bankers, 1959).

Prior to the present investigation, the most recent work was done in 1960 by Woolley (pers comm) who examined some of the sedimentary rocks to the south of Yuendumu Settlement.

PHYSIOGRAPHY

Yuendumu Native Reserve lies between the main mass of the Treuer Range and the Buxton - Reynolds Range, on a broad saddle of moderate to low relief, with residuals of sedimentary, igneous and metamorphic rocks standing above the Quaternary plain.

The general east - west strike of the rocks is reflected in four main physiographic areas which lie in east - west belts across the reserve. (See Fig. ii).

These areas are:

(i) The most northerly area is one of moderate to high relief, the highest peak being Rock Hill (also known locally as Woculbar) which rises to about 700 feet above the surrounding spinifex-covered plains.

This area is entirely underlain by igneous and metamorphic rocks. Many of the surfaces of the hills show the typical rounding due to exfoliation, so that rugged outlines are almost entirely absent.

The main creek, North Kerridy Creek, flows to the north as also do all the other more minor creeks of the area.

The present drainage has been superimposed on the Quaternary alluvium, which blankets any pre-Quaternary drainage pattern.

(ii) The Second physiographic area lies to the east and west of the settlement and is between the north and south water-sheds. Its northerly limit is marked by a low range of schistose hills, and its southerly limit by the east trending Yuendumu Hills.

It is an area of low relief with few outcrops. The whole area is probably underlain by igneous and metamorphic rocks under a Quaternary cover of 100 feet maximum thickness.

The drainage pattern is indefinite, with no major creeks in the area.

(iii) The Third physiographic area is of moderate relief with only small areas overlain by Quaternary deposits.

The northern margin is marked by the well defined northern scarp of the Yuendumu Hills. The southern margin is more irregular and less clearly defined.

The area is underlain by sedimentary rocks, which in many areas form steep-sided ranges rising to 200 feet above the plain. The highest hill in this area, Mount Eclipse, reaches a height of approximately 400 feet above the surrounding plain.

There are several small, well-defined creeks in the area, but they are generally of little extent and flood out on leaving the ranges. The main creek is South Kerridy Creek which flows into Kerridy Waterhole on the southern margin of Area (iii). The overall drainage is to the south, but locally the creeks often flow easterly or westerly in the east - west trending strike valleys.

(iv) The most southerly area is of low relief with no creeks whatsoever. The few exposures are of sandstone, and it is likely that the whole area is underlain by Palaeozoic sandstones. The major part of the area is covered by sand, but sand dunes, trending easterly, are only to be found in the south-west corner of the area. The only vegetation is Desert Oak and spinifex, which indicates the arid, sandy nature of the soil.

DESCRIPTION OF ROCK UNITS

General

The rocks which crop out on Yuendumu Reserve are extremely varied, ranging from Pre-cambrian metamorphic and igneous rocks, to Upper Proterozoic and Palaeozoic sedimentary rocks. Quaternary deposits overlie much of the area.

The area is thought to be situated on the margin of the Ngalia Trough (Tindale 1933, Bureau of Mineral Resources 1960), with the exposed sediments representing the neritic deposits of the trough, whilst the igneous and metamorphic rocks are representative of a stable block area.

PRECAMBRIAN

General

Precambrian rocks crop out over much of the northern half of Yuendumu Native Reserve. As in other metamorphic areas of Central Australia, the mapping of these rocks is made extremely difficult by the lack of any marker bands.

The metamorphic rocks have been divided into schist, gneiss, quartzite and undifferentiated Precambrian. This last division generally represents schist, gneiss and granitic gneiss, which are so intimately associated as to be impossible to distinguish except by detailed mapping. The metamorphic rocks have been intruded by five granitic bodies which may be distinguished on textural or mineralogical grounds. Whilst these "granites" show signs of having been subjected to some movement, it was of much less intensity than that undergone by the metamorphic rocks.

Intrusive rocks are represented by quartz veins and dolerite and lamprophyre dykes. Pre-diastrophism dykes may be represented by amphibolites.

Metamorphic Rocks

The most common metamorphic rock of the area, is a normal mica schist composed of quartz, feldspar, muscovite and biotite, but gneiss is also common. The schists often show a well-developed flexuring and foliation. The dip of the beds or of the schistocity is generally vertical whilst the strike of the schist is approximately east to south-east though in the north-east corner of the Reserve the strike is due north.

At no locality can a sharp boundary be observed between the schist and gneiss but rather there is a gradual change or possibly an "interleafing" of the schist and gneiss at the contact.

The gneiss is generally coarse grained and of variable lithology, with streaky segregation bands of irregular outline occurring throughout. Foliation is typically developed. Morgan (1962) (unpub.) petrologically examined two specimens of gneiss and determined them to be biotite-plagioclase-microcline-quartz gneiss and sillimanite-plagioclase-biotite-quartz gneiss.

Granite gneiss is fairly common, especially on the margins of granitic bodies.

Augen gneiss only crops out in a small area north east of Yuendumu Settlement and even here it is rather poorly developed.

Granulite is relatively rare and only crops out at one locality on the Yuendumu Reserve - Mount Doreen Station boundary, where it covers such a small area that it has been mapped as undifferentiated Precambrian.

There are 3 main developments of quartzite within the metamorphic rocks:

(a) North-west of the Settlement, a quartzite forms an extremely prominent ridge, rising to about 100 feet above the surrounding mulga-covered flats. It maintains a constant lithology and mode of outcrop over at least three miles, and from the aerial photographs it seems likely to continue for several miles more to the west, keeping an east-west strike for the whole of its length.

This quartzite is extremely fine grained, pale brown or white, and well jointed and cleaved so that a dip is difficult to obtain, though it is thought to be vertical.

Interbedded with the quartzite are beds or bands of slate and mica schist. The schist and slate crop out mainly in the centre of the quartzite, between the two thick marginal beds. At the widest point a thickness of 1000 feet was measured in the quartzite but it is uncertain whether this represents a true thickness, for the quartzite may be isoclinally folded.

(b) A second quartzite crops out to the north of Rock Hill and 12 miles due north of Yuendumu Settlement. It is somewhat darker and coarser-grained than the other and forms no prominent ridge nor is of any great lateral extent. This quartzite also has interbeds of slate and phyllitic slate, but none of mica schist. The strike is generally east-west but ranges from 70° to 105°.

On the southern margin of the quartzite an extremely sharp contact dipping at 80° to 85° to the south is exposed between the quartzite and mafic gneissose country rock.

(c) South and south-east of Yuendumu Settlement, three prominent quartzite ridges crop out with a strike varying from east to north-east. This quartzite is white and green in colour and differs from the two previously described quartzites in that it has no slaty interbeds. The quartzite is cut by many small veins of pink quartz.

The lateral extent of this quartzite is uncertain; it is at least 5 miles, and may be considerably more.

Quartz Veining is widespread in the Precambrian rocks (especially in the gneissose rocks). In some cases there is evidence that the veins occur on faults or shears, the injection of such veins taking place during movement. The veins are coarse grained and books of mica and large crystals of tourmaline are common.

Dolerite and lamprophyre dykes occur sporadically throughout the Precambrian rocks but at no locality were they observed to penetrate any of the granites. The number of dykes is small and generally they are of small lateral extent. They trend mainly parallel to the strike of the country rock, but at some localities are inclined at angles of up to 20° to it.

An early phase of dyke injection is possibly represented by somewhat 'patchy' outcrops of amphibolites with very little lateral extent and variable strike.

Igneous Rocks

The largest "granite" cropping out in Yuendumu Reserve is the Rock Hill Granite (strictly a diorite) first referred to by Kick (1941).

It is an elongate body, 15 miles in length and 2 miles in width, trending north-west, across the westerly strike of the country rock. The diorite crops out in typical "Whale-backs", showing well developed exfoliation surfaces.

It is a coarse grained, granulated biotite quartz-diorite with large phenocrysts of feldspar up to 3 inches across. Xenoliths commonly occur within the Rock Hill Granite, especially in the southern half and are round or ovoid in shape, dark in colour and rich in biotite and quartz. They are thought to be fragments of the country rock rather than cognate xenoliths (Morgan, 1962 unpub.). Foliation is generally absent from the diorite, but some alignment of xenoliths and phenocrysts occurs. Joint and shear planes have a north-west trend, but are rare.

There are no contacts exposed between the Rock Hill Granite and surrounding country rock but it is evident in the field that the contact must be relatively sharp with little or no metamorphism or granitization of the country rock having accompanied enplacement. Kick (1941) was of the opinion that the contacts of the "granite" may be gently dipping but the present author found no evidence to support this view.

A small body of "granite" with an exposed area of two square miles, crops out about six miles north-east of the Settlement. It is a porphyritic rock similar to the nearby Rock Hill Granite, but the phenocrysts of feldspar are only sporadically developed. Further distinguishing features are the development of foliation and the large number of coarse grained quartz-biotite-tourmaline pegmatites and large books of mica, but xenoliths are absent.

Morgan (1962 unpub.) describes a hand specimen from this granite as a "granulated recrystallized and greisenized muscovite-biotite granite", though in the north western part of the body, the rock is described as a "sheared and recrystallised biotite adamellite" indicating that the body is not of uniform composition.

Contacts between this small body of granite and the country rock are not exposed but on the eastern margin it is considered likely that there is a gradation from granite to gneiss with no sharp boundary.

A poorly exposed granitic body crops out as a series of small exposures over an area of approximately two square miles to the north-west of Yuendumu Settlement.

Morgan (1962 unpub.) considers the rock to be a "hornblende-biotite adamellite, showing gneissic foliation".

Quartz veining and foliation are common but phenocrysts and xenoliths are completely absent. The adamellite crops out as well developed "whale-backs" and "devils marbles" but because of poor exposure, there is no indication of the mode of contact between the adamellite and country rock.

The main area of a fourth granite body is on Mount Doreen Station, but it crops out over approximately four square miles of the reserve, 13 miles west of Yuendumu Settlement. Morgan (pers comm) describes this body as a muscovite-biotite trondhjamite. It is readily distinguishable from the other igneous rocks by a uniform fine grained texture. Phenocrysts and xenoliths are absent whilst pegmatites and quartz veins occur only rarely; foliation though rare becomes more common on the margin of the trondhjamite.

There is a fifth granitic body situated three miles south-east of Yuendumu Settlement, which is unconformably overlain by sedimentary rocks. It is only represented by a few small exposures, so that it is uncertain whether or not these are part of a much larger body.

It is a pink, coarse-grained, mica "granite" but unlike the other "granites" in the area, biotite is subsidiary to muscovite and the percentage of quartz is higher. Xenoliths and phenocrysts are rare but foliation is common. There are some lenses of extremely fine-grained rock within the main coarse granite which may represent an earlier formed fraction or differentiate.

The granite weathers extremely easily and is soft and crumbly at outcrop.

Morgan (1962 unpub.) considers that all mica "granites" examined by him "show signs of granulation followed by some recrystallization of the granulated material. These suggest movement followed by reheating".

SEDIMENTARY ROCKS

General

Owing to the limited state of knowledge of the sedimentary rocks of the Ngalia Trough, it is considered inadvisable, at this stage, to give any of the rock units formal names in accordance with the Australian Code of Stratigraphic Nomenclature (1958). The units are therefore designated A,B,C etc. in order to facilitate discussion. What few names existed before this report are due either to Tindale (1933) or Kiek (1941). Tindale (1933) uses the name, "Hann Range - Uldirra Hill - Crown Hill series" for the unmetamorphosed sediments, but such a name pre-supposes a correlation between the sediments of the Hann Range and the Uldirra Hill Range. This correlation is not possible at present. It is however possible to follow beds along their strike from the Yuendumu Hills to the Uldirra Hill area.

Fossils are extremely rare, only one having been found, (in Unit 'F') and outside Yuendumu Reserve, fossils have only been found at one other locality in the Ngalia Trough. These were located in 1962 by a road-gang working just north of the Stuart Bluff Range near the Yuendumu - Alice Springs road and are of Ordovician age (Quinlan, pers comm). The occurrence has not been confirmed by a geologist.

Tindale (1933) refers to a Giles Range Series, assigns these beds an Older Proterozoic age and distinguishes them from the younger sedimentary sequence by their lower degree of metamorphis and their less intense folding and faulting. No such distinction can be drawn between the sediments in the Yuendumu Reserve area, and the Giles Range Series is probably not represented.

The total thickness of the sedimentary sequence is estimated to be in the order of 11,000 feet with the highest unit (Unit G) contributing the major part of this thickness. This estimate of 11,000 feet for the total thickness of sediments agrees with Catley (unpublished note, Resident Geologists Office, Alice Springs, 1955), who suggested a thickness of not less than 10,000 feet for the complete sedimentary sequence in the Ngalia Trough.

The sediments are comprised of rudites, arenites and limestones and other carbonate sediments. All these beds generally have an easterly strike and a southerly dip. Exposure is good in the northern part of the area so that sections may be measured. Lack of time prevented the author from undertaking this, but Woolley (pers comm) measured several sections in 1960, (see fig. iii).

Sedimentary Sequence

Unit A is here used to denote a sequence of quartzite and sandstone which rests unconformably on Precambrian granite and which is overlain conformably by the Unit B. An Upper Proterozoic age is assigned to the sequence.

Unit A is best exposed at a prominent hill on the eastern end of the Yuendumu Hills, three miles south-east of the settlement. A section was not measured, but the thickness of the unit is estimated to be from 400 feet to 500 feet.

Unit A ranges from a true sedimentary quartzite, to a soft quartz sandstone which has undergone superficial silicification. It is generally white in colour but can become reddish-brown or pale brown on weathering; well-jointed and hard and resistant forming a prominent escarpment. The dip of the beds varies from 20° to 70° to the south. Unit A is medium-grained and well-sorted throughout most of its thickness, but there are occasional pebbly bands, and a thin conglomeratic bed occurs a few feet above the basal unconformity. The source of the pebbles appears to be exclusively the Precambrian igneous and metamorphic rocks.

The unconformity between Unit A and the underlying Precambrian granite is not exposed, because of 15 feet of scree-covered slope between the highest exposure of granite and the lowest exposed quartzite. On the northern margin of outcrop Unit A is faulted against a Precambrian quartzite by a fault of unknown displacement.

Unit B lies conformably between units A and C and is thought to be Upper Proterozoic in age.

A section was measured through Unit B approximately one mile north-west of White Point Bore by Woolley (see fig. iii) through a total thickness of almost 900 feet. The lithology of the unit is mainly arenitic, but occasionally ruditic. It is composed of quartz sandstones and feldspathic sandstones of medium to coarse grain, with subsidiary arkose, quartzites, pebble bands and pebbly conglomerates. Woolley considers that arkose forms a major part of the unit (see fig. iii). The unit is red, brown or white in colour, medium bedded, and with some thin-bedded intervals which have a high percentage of mica (mainly muscovite). Features such as false bedding, ripple marks and mud-pellet markings are common, indicating deposition in a shallow-water environment. The conglomeratic sandstones are more common near the base of the formation, but there is no basal conglomerate exposed and the lowest-exposed bed (cropping out in the gap to the north of White Point Bore) is a coarse silicified sandstone. These lowest beds have been injected with quartz veins and flow structures are common.

The greatest dips are recorded in the lower beds, dips of 80 - 85° to the south being common, but in the stratigraphically higher beds lying to the south, the maximum dip is 20°.

Along most of its strike the formation is faulted against Precambrian rocks, but in a small area to the south east of the settlement, it overlies Unit A. The actual contact is not exposed but it is thought to be probably conformable. There may be a slight angular unconformity, but outcrop is insufficiently widespread to establish any loss of section.

Unit C is the sequence of limestone, dolomite, arenite and minor rudite lying between Unit B and probably Unit D. It is thought to be Upper Proterozoic in age. A section was measured by Woolley in the area to the north-west of White Point Bore and a total exposed thickness of 673 feet was recorded (see fig. iii). The maximum thickness of the unit is approximately 900 feet.

This unit is made up of limestone, dolomitic limestone, dolomite, calcareous sandstone, quartz sandstone and breccia. The limstone and dolomitic limestone predominates, but some of the sandstones attain a considerable thickness and one such sandstone, which crops out about 200 feet above the base, has a thickness of approximately 60 feet, which is maintained for a considerable distance along strike.

The limestone units are generally thin-bedded but occasionally attain a thickness of ten feet. The colour can be brown, pink, grey or black on fresh surfaces, but weathered surfaces have a yellow or buff colour. The detrital content of some of the limestones is moderately high, the commonest detrital material being medium to fine grained, poorly rounded, quartz grains.

The interbedded sandstones are red or brown in colour, medium to coarse grained and generally thin-bedded. They are indistinguishable from many of the beds in Unit B. They occur throughout Unit C but are mainly concentrated in the lower half so that there is a transitional zone between the mainly arenitic Unit B and the predominantly carbonate Unit C.

The base of the Unit C is taken as being where the lithology becomes one with appreciable carbonate content. North of White Point Bore this is a limestone breccia which occurs just below the first true limestone.

Breccias occur throughout the unit but some of these may be post-depositional in origin, resulting from weathering of the original limestone. The only certain pene-contemporaneous breccia is the lowest one exposed, which consists mainly of angular fragments of red sandstone up to six inches diameter in a calcareous matrix. This breccia may be the basal breccia but there is about ten feet of scree-covered slope between this, the lowest exposure of the Unit C and the highest exposed bed of Unit B. The contact may be unconformable but it would be a maximum of five degrees and is somewhat difficult to detect in the field.

Unit D consists of the arenitic beds lying below Unit E and possibly above Unit C. A section has not been measured but the unit has an estimated maximum thickness of 500 feet, best exposed 7 miles south-west of Yuendumu Settlement, in the gap south of White Point Bore. An Upper Proterozoic age has been assigned to the unit.

Unit D is a white, medium to coarse-grained extremely friable sandstone, with well-rounded quartz grains, thin bedded to very finely laminate, with muscovite on the bedding planes. Superficial silicification occurs but never continues to more than two or three inches below the surface. Features such as false bedding or current bedding are absent, but rare and indistinct ripple marks and a few small pebbles can be found in the section just south of the White Point Bore. Along the entire length of its exposure the unit has a dip of 50° to 60° to the south.

The stratigraphic position of Unit D is uncertain. It is apparently stratigraphically higher than Unit C but the position is complicated by a concealed pre-Palaeozoic strike fault of unknown throw along the boundary between the two units. The exposures available could also be explained by an abutment unconformity between the two units.

Unit E is the sequence of arenites which overlies Unit D and which is unconformably overlain by Unit G and probably also by Unit F. This unit is thought to have an Upper Proterozoic age. A section has not been measured and the full thickness is uncertain but it is estimated from aerial photos to be at least 1000 feet.

Lithologically, the lower beds of this unit are similar to the underlying Unit D but are distinguished by their colour. The unit is a brown, (with few white beds) coarse grained, medium bedded sandstone (with subsidiary arkose and some probable greywackes); moderately sorted in the lower beds of the formation, but pebbly and poorly-sorted in the higher beds. Ripple marks and cross-bedding are common, especially higher in the unit. To the south, Unit E is lithologically very similar to Unit G and it is difficult to distinguish between them. The contact between Unit E and the underlying Unit D has not been seen, as there is a gap of approximately 10 feet with no exposure between the two formations along almost the entire length of the White Point Ridge. It is thought that the contact is conformable. Unit E is overlain throughout the major part of its outcrop area by Unit G, with an angular unconformity. In one small area, 3 miles west of White Point Bore, it is apparently overlain unconformably by Unit F, but outcrop at this locality is poor and the relationship between Units E, F and G are rather obscure.

Unit F is a predominantly arenaceous unit. A section (see fig.iii) was measured by Woolley at a locality four miles due west of White Point Bore, and a total exposed thickness of 344 feet was recorded. Unit F rests unconformably on Upper Proterozoic sediments and is overlain with slight angular unconformity by Unit G. It is of Lower Palaeozoic age.

The unit is composed of well-bedded, gently dipping medium grained reddish-brown or purple sandstone and greywacke, with some interbeds of red, green and grey shaly sandstone and siltstone. Many of the sandstone beds are highly micaceous, which gives rise to a marked fissility of the rock. Ripple marks are common, but false-bedding and current bedding are absent.

This is the only sedimentary unit in which a fossil has been found.

This has been identified by A.A. Öpik (pers comm) as a Protichnites, probably produced by a large trilobite such as an asaphid and likely to be of Lower Palaeozoic age.

No contact has been observed between the base of Unit F and underlying units, due to paucity of outcrops in critical areas. It can be seen, however, to overlie Units C and D, and may also overlie Unit E, indicating a strong transgression over the lower units. Its stratigraphic position above Unit E is confirmed by its position below Unit G, which in some areas directly overlies Unit E with an angular unconformity.

Unit G is a thick series of arenites and rudites which unconformably overlie Unit F. A section was not measured, but the unit has an estimated thickness of 7000 feet. The unit may be Upper Palaeozoic in age.

Unit G is composed of sandstone which is red brown and white, poorly sorted, medium to coarse-grained, soft, friable, and feldspathic in places. Many of these sandstones are conglomeratic with cobbles up to 6 inches in diameter. Generally the sandstone is thickly bedded but thin-bedding and false-bedding are fairly common. Ripple markings are rare.

The most distinctive of the conglomeratic sandstones is the lowest exposed bed of Unit G which is a white, slightly feldspathic sandstone, showing false bedding in places and forming a prominent escarpment about 15 feet in height. Throughout the 15 feet there are numerous large cobbles all of which are perfectly rounded, the majority being of quartzite or vein quartz.

Unit G rests with slight angular unconformity on Unit F but it also transgresses onto Unit E, Unit D and probably Unit C. Due to its lithological similarity to Unit E it is difficult to map the boundary between these two units.

Two beds crop out only over an extremely small area to the south-west of the settlement and due south of Mount Eclipse. Because of their limited extent none of the rocks are named and are here referred to as the Quartzite and the Breccia. Due to their small area of outcrop these two beds are not shown on the map.

The Quartzite has a thickness of 60 feet and is unconformably overlain by Unit G and the Breccia. The beds underlying the Quartzite are not exposed. The age of the Quartzite could be anywhere between Upper Proterozoic to Upper Palaeozoic.

The Quartzite is white or pale brown, fine grained, hard and well jointed. It crops out in the centre of a sharp anticline forming a prominent ridge. At the base of the Quartzite are some interbeds of hard shale or siltstone. The thickest shaly development at the base is 15 feet of red and brown papery shales.

The Breccia lies between the Quartzite and Unit G and has an exposed thickness of 15 feet. Its age is within the range Upper Proterozoic to Upper Palaeozoic.

The bed is a coarse breccia composed of large angular blocks up to 3 feet across, with a soft red sandstone matrix. The majority of the blocks are of pink quartzite, but some are of hard sandstone.

The Breccia crops out at only one locality and here it rests unconformably on the Quartzite. It is seen to be faulted against sandstones of Unit G on the south side of the exposure, but it is not thought to be a fault breccia. Jones and Quinlan (1958 unpub.) refer to a report by Hossfeld that probable glacial beds occur in the lower half of the sedimentary succession to the west of Yuendumu Reserve, but it is unlikely that this breccia is of glacial origin.

Tertiary Deep weathering.

Little evidence of Tertiary weathering is to be seen on Yuendumu Reserve and most of the deep weathering profile is though to have been removed by subsequent erosion. Patchy lateritic developments do occur in some of the iron-rich rocks where lateritization would probably have continued to a considerable depth e.g. in the mica schists. Jones and Quinlan (1958 unpub.) estimate that the deep weathering profile attained a maximum thickness of 100 feet in this area, but that little of this now remains.

Quaternary

Quinlan (1962) recognises four divisions of this age in the Alice Springs area. Two of those were recognised and mapped in the Yuendumu Reserve area.
Aeolian Sand. covers quite large areas especially in the south. The deposits are mainly redistributed aeolian sands, but there are some east-west trending dunes in the south west corner of the reserve.

Kunkar, Calcrete and Alluvium of Quaternary age crop out only over very small areas in Yuendumu Reserve and are mainly confined to the northern areas.

Recent

There are two mapped divisions of Recent Age.

The Red earth soils cover wide areas of the reserve. They are predominantly the areas in which mulga flourishes.

Alluvium is of limited extent and is confined to the immediate vicinity of creeks and to the areas around large outcrops and inselbergs, where pediment alluvial deposits form a thin veneer over the thicker Quaternary deposits.

STRUCTURE

General

The tectonic structures of the area show a marked east-west trend throughout the whole of Yuendumu Reserve. These structures are readily recognisable in the sedimentary rocks and can be accurately delineated, but are much more indefinite in the Precambrian igneous and metamorphic rocks and are often only inferred or postulated.

Faulting

It is likely that faulting is fairly common in the Precambrian rocks and that many of the quartz reefs mark the position of faults. This is supported in some areas (e.g. to the north-east of the settlement), where the line of a quartz reef corresponds to the line about which a change in strike takes place. It is only in such cases that quartz reefs have been mapped as faults. In some localities within the metamorphic area, fault breccias are exposed but they are of little lateral extent and probably have only a small displacement. There is no evidence of faulting at the margins of the "granites".

The fault likely to have the greatest displacement lies two miles to the south of Yuendumu Settlement and faults Precambrian metamorphic and igneous rocks against Upper Proterozoic sedimentary rocks. It may mark the margin of the stable Precambrian block and the Ngalia Trough. Two miles to the south of this fault, a second and parallel fault is thought to fault Unit C against Unit D. The displacement of this fault is also unknown because the thickness of strata between Units C and D is not known. The other possibility is that in fact there is not a fault but an abutment unconformity. If it is a fault however, it is pre-Unit F and is of Upper Proterozoic to Lower Palaeozoic in age, for Unit F is unaffected by the faulting. The dip of the strata is found to steepen considerably both near this fault and the previously-discussed northern marginal fault. Quartz veining in the basal beds of the Unit B indicate that some mineralization accompanied movement along the marginal fault, but no such mineralization accompanied the more southerly of the two faults.

The only other proved fault in the sedimentary rocks is that which faults the previously-mentioned Breccia, against sandstones of Unit G, but it would appear to be of small displacement and is of little lateral extent.

Folding

In the metamorphic zones, folding has been severe and the area has undoubtedly been subjected to more than one period of tectonic disturbance. This has resulted in a complex structural picture which is impossible to solve within the limited scope of this survey.

The sedimentary rocks have been subjected to much less severe, earth movements and a simpler pattern of folding has resulted. The main feature is the series of synclines and anticlines with approximately east-west axes, all showing plunge either to the east or the west, and arranged in an indistinct en-echelon pattern. The folds follow a definite pattern of broad, concentric synclines with shallow dips and narrow anticlines with steep dips, a pattern of folding also observed in the sediments of the Amadeus Basin.

The mechanics of such a pattern of folding is uncertain, but it is possible that the present exposed folding represents originally parallel (or concentric) folding which has been later eroded to a low stratigraphic level.

Earth movement took place during Upper Proterozoic and Lower Palaeozoic times, as indicated by the presence of unconformities. These were possibly not of major significance, being only the result of minor fluctuations in the land level at the margins of the Ngalia Trough. Such movement may have taken place along a marginal parallel fault system such as the one to the south of the settlement and may not have had folding associated with it.
There is in fact no definite evidence of folding of major significance in the sediments prior to the post-Unit G folding, apart from that accompanying the marginal fault.

GEOLOGICAL HISTORY

The oldest sediments are represented by the Precambrian rocks, with the gneisses possibly representing the oldest phase of igneous activity.

After an unknown lapse of time, following the main diastrophism in the Precambrian, a period of igneous activity occurred during which the igneous bodies of the area were intruded, accompanied by mineralization represented by pegmatites and the copper deposits of Yuendumu and surrounding areas. Re-heating, possibly accompanied by further movement, took place following the intrusion of the granitic bodies as shown by evidence of remobilization of some of the "granites" about their margins. The absence of any evidence of folding or lineation in the Rock Hill Granite may indicate that this was the latest igneous body to be intruded.

During Proterozoic times, vertical movements, leading to the development of a sunkland, took place within the Precambrian basement. Into the resulting trough were subsequently deposited the Upper Proterozoic and Palaeozoic sediments. The lithology of the sediments i.e. arenites and limestones, suggests deposition in fairly shallow water. This is supported by the various breaks which are thought to have taken place in sedimentation. Throughout this period of Upper Proterozoic sedimentation, movement was probably taking place along the marginal faults and some of this movement was accompanied by localized mineralization (e.g. quartz veining in the Unit B).

The absence of any major period of uplift is suggested by lack of coarse rudite deposits. It is likely that in the Yuendumu area there were long periods of non-deposition or long periods of erosion as the thickness of sediments here is considerably less than in the Amadeus Trough. Some of this decrease in thickness may be attributable to the smaller area from which the sediments were derived, accompanied by less uplift in the areas adjacent to the Ngalia Trough compared to those adjacent to the Amadeus Trough.

In Lower Palaeozoic times, a major transgression took place with Unit F transgressing over the lower units. There was however, little difference in the environments of Upper Proterozoic and Lower Palaeozoic times. From the Protichnites, Öpik (pers comm) concludes that the sediments of Unit F are marine and the preservation suggests a tidal flat environment with fairly rapid sedimentation. The period of Unit F sedimentation was followed by a period of some earth movement as is shown by the angular unconformity between Units F and G.

The Tectonic Map Committee (1962) suggest that prior to the deposition of the Pertnjara Formation, (Prichard and Quinlan, 1962), the shield area was affected by the Tabberabberan Orogeny which resulted in sharp vertical movements of the basement, and gave the considerable thickness of coarse rudites and arenites of the Pertnjara Formation in the Amadeus Trough. It is likely that the areas bordering on the Ngalia Trough would also have been affected by this orogeny and the resultant sediments are the 7000 feet of rudites and arenites of Unit G. Thus, in age (upper Lower Palaeozoic to Upper Palaeozoic) and in lithology, it is considered that Unit G may be correlated with the Pertnjara Formation of the Amadeus Trough. The latter formation is coarser than Unit G which would indicate less severe uplift in the Ngalia Trough area than in the Amadeus Trough area .

Following the deposition of Unit G the sediments were folded; according to the Tectonic Map Committee (1962) the folding of the Amadeus Trough following the deposition of the Pertnjara Formation is though to reflect the Kanimblan orogeny, and it is likely that the sediments of the Ngalia Trough were also affected by Kanimblan movement.

The geological history of the area is somewhat obscure during Mesozoic, Tertiary and Quaternary times. The lack of post-Palaeozoic sediments would suggest that the area was stable during much of this time. The only evidence of post-Palaeozoic conditions is provided by the Tertiary deep weathering, followed by a period of erosion and redeposition in the lower-lying valleys.

ECONOMIC GEOLOGY

Metallic Deposits

The only metallic deposit worthy of note, and actually within Yuendumu Reserve is the copper prospect to the north-west of Yuendumu Settlement (see fig. iv), referred to as the Nobagalang copper deposit by Hossfeld (1953, unpub. note).

The deposit has been mentioned by various authors including Madigan (1937, unpub. report), Kick (1941), Hossfeld (op cit) and Ryan (1956 unpub.), but of these, only Ryan and Hossfeld considers the deposit in any detail. The others give brief mention of the Nobagalang deposit whilst discussing the Mount Hardy - Mount Doreen mineral area.

The deposit, is on a low ridge of mica schist and crops out over about one third of a mile as an irregular lode. Ryan (1956) reports that the ore is secondary malachite with some cuprite. When assayed, the percentage of copper ranged from 3.22% to 53.76%, and it was considered that on Yuendumu Reserve, were 127 tons of low grade ore and 8 tons of high grade ore. On present day prices this would be worth about £2,500.

Hossfeld (op cit) recommends the deposit as a gougers' show and suggests that the deposit could be tested by means of an adit.

The Welfare Branch of the Northern Territory Administration have recently been considering the possibility of working the deposit, but it is unlikely that it could be worked economically due to the high cost of transporting the ore from Yuendumu. It might however be possible to work it economically if the whole of the Mount Doreen copper field were worked and a treatment plant were set up on the field, but this is only likely if there is a considerable increase in the price of copper.

HYDROLOGY

Results of Previous Investigations

The results of previous drilling have been discussed by Quinlan (1958a unpub.), Quinlan (1958b unpub.), Jones and Quinlan (1958 unpub.), Wiebenga et al (1959 unpub.), and Cook (1962, unpub.).

These reports are mainly concerned with the availability of ground-water in the immediate vicinity of the Settlement. Here they were unable to find a satisfactory aquifer, either within the Quaternary sediments or within the metamorphic rocks, a total of eight unsuccessful bores being drilled. Six of these were sited on a basis of the report of Jones and Quinlan (1958), whilst two others were based on the geophysical report of Wiebenga et al (1959). This lack of success was because the piezometric surface was below the base of the alluvium and also because of the difficulty of finding fracture or sheer zones within the metamorphic rocks. From this previous work it is recommended that no further drilling be undertaken in areas underlain by schist or gneiss.

It is unlikely that geophysical work would locate pre-Quaternary river channels which could contain saturated alluvium. The geophysical work by Wiebenga (1958) was concerned with the finding of such a feature, using electrical and magnetic prospecting. Their work failed to locate any well - defined channels. Areas of low resistivity were thought to represent regions of deeper alluvium and a bore was drilled in a low resistivity area, $\frac{3}{4}$ mile, south-west of the Settlement. The bore entered weathered schist at 15 feet, and a moderate supply of water (400 gallons per hour) was struck at 96 feet, but high nitrate content (130 ppm) precludes the use of this bore for a domestic supply. Thus, on the grounds of nitrate content alone, it is considered inadvisable to recommend any further bore sites in the immediate vicinity of Yuendumu Settlement. The nearest aquifer to the Settlement likely to yield an adequate supply of good quality water would appear to be within the sedimentary rocks of upper Proterozoic to Lower Palaeozoic age. The nearest of these rocks crops out two miles to the south of the settlement. It was here that a bore was sited by N.O. Jones in 1960, to test for an aquifer in Unit B. A depth of 400 feet was reached without any supply of water being located, and because the lithology is fairly uniform, it would seem that there is little likelihood of a good aquifer being located anywhere within Unit B.

Few stock bores have been sited on Yuendumu, the only two producing stock bores being White Point Bore and Penhalls (or Four Mile) Bore which lie to the south of the settlement.

A site was drilled on the west bank of Kerridy Creek, nine miles north-west of the settlement on a site proposed by Quinlan (1958). This bore reached a depth of 160 feet, a supply of only 150 g.p.h. being obtained from weathered schist.

The Availability of Ground-water

Few determinations of the porosity and permeability of the various rocks of the Yuendumu region have been made and thus any discussion on the hydrological properties of these rocks is only based on field observations.

Mica Schist and Gneiss

Schist and gneiss are very unlikely to yield a good supply of water owing to their extremely low porosity and permeability. This is due to the mica-rich layers which occur throughout the schist and gneiss and the 'tight' nature of the rock. Therefore, the only possible aquifer within schist and gneiss is a fracture or fault zone which would be susceptible to weathering. It is thought that this type of aquifer may have been penetrated at Settlement Bores 1 and 2.

Quartzite

Quartzites are likely to yield a moderate supply of water, their highly jointed nature making the rock pervious. The quartzites are also sufficiently hard for joints and fissures to stay open to a depth below the piezometric surface.

"Granite"

Five igneous bodies have been mapped, of these only the Rock Hill Granite is likely to be a reasonable aquifer, for its coarse grained, porphyritic texture will make it more susceptible to weathering than the others, which are finer grained. The depth of weathering of the Rock Hill Granite is unlikely to be greater than 150 feet and therefore wherever possible, bore-sites should be positioned so as to intersect shear zones and joint planes within the zone of weathering.

Proterozoic to Palaeozoic Sediments

Unit A

This unit is well jointed and likely to be a good aquifer. Much of the surface is silicified but this may only be a superficial feature. Bands of friable quartz sandstone, interbedded with silicified sandstone may yield some aquifers.

Unit B

This unit is unlikely to be a good aquifer because it consists of a poorly sorted 'tight' sandstone with the intergranular spaces filled with matrix and cement. This poor potentiality is supported by the lack of success on the previous hole sited in this unit.

Unit C

This unit is a reasonable aquifer; both the Penhalls and White Point Bores use it as an aquifer.

Unit D

This unit is likely to be a good aquifer on account of its well sorted lithology and lack of an intergranular cement. However, the bed is steeply dipping (50° to the S) and may be a somewhat difficult target to intersect.

Unit E

Unit E is unlikely to be a good aquifer; the rock commonly has a fairly high percentage of matrix, though the upper half is fairly well sorted, the percentage of matrix less, and the permeability moderate.

Unit F

This unit is unlikely to be a good aquifer because of its fairly high mica content and because it contains interbeds of shale. This latter condition does not of course necessarily make for a poor aquifer but merely for a confined one; however, it is unlikely that there would be a sufficient thickness of strata in which to obtain a large enough number of these confined aquifers to give an adequate supply.

Unit G

This unit, because of its poor sorting and high percentage of matrix is unlikely to be a good aquifer. In lithology Unit G is very similar to the Pertnjara Formation which has consistently proved to be a poor aquifer in the Missionary Plains area. It is however possible that certain units within Unit G e.g. a sandstone exposed at Kerridy Waterhole, will act as fairly good aquifers either because of their well-sorted and friable nature or because they are hard, and well jointed.

Quartzite

In lithology and hydrology this quartzite is very similar to the metamorphic quartzites.

It is sufficiently well jointed to contain useful quantities of water, however, its steep dip (60 - 70°) and hardness are likely to make it somewhat difficult to drill.

Breccia

The Breccia is likely to be a poor aquifer because it is poorly sorted, and the paucity of outcrop makes it a difficult target. Thus the Breccia has no potentialities as a source of water.

The "Nitrate Problem"

This problem was first discussed by Jones and Quinlan (1958). They showed that the nitrate content of the Settlement water supply had increased between 1955 and 1958 from 57 to 130 parts per million.

At that time, the results of analyses by the Animal Industry Branch of the Northern Territory Administration suggested that the sources of the nitrate was not organic, but Quinlan (op cit), felt that the source was in fact organic and resulted from pollution.

Chemical analyses carried out since 1958 support the view of Quinlan, for both nitrate and free ammonia have been detected in the water. Hem (1959) states that a major source of nitrate in underground water is by additions promoted by man himself e.g. excrement, but also cites the legumes as a possible source of nitrate concentration. There is, in fact a large area around the settlement where the main vegetation is leguminous (mulga).

Jackson (1957), does not record any high nitrate content in the soils of Yuendumu, but analyses by Animal Industry Branch in February 1959, gave the nitrate content of dry soil near the Settlement as .017% or 170 parts per million. This would correspond very closely to the normal maximum nitrate content of water from No. 2 Settlement Bore (maximum nitrate content of 140 - 180 parts per million) and it would seem likely that the vegetation of the region is a factor in the high nitrate content. This is supported by bore F52/12-51 (Resident Geologists Office, Alice Springs Bore Reference Number) which was sited on a geophysical anomaly, about ¾ mile south of the settlement. When analysed in 1960, the water from this bore was found to have a nitrate content of 130 parts per million. It is unlikely that pollution from the settlement would reach as far as ¾ mile from the source.

It has so far proved difficult to correlate climatic changes with variation in the nitrate content, though it was thought that in periods of drought the total dissolved salt content of the water tended to gradually increase whilst the total amount of nitrate increased correspondingly. When there was a fall in the total dissolved salt content then there was a corresponding fall in the total amount of nitrate. However, after a period of exceptionally heavy rain in March 1962, it was found that the total dissolved salt content of water in No.2 Bore had fallen from 1682 parts per million prior to the rain to 1434 parts per million after the rain whilst the amount of nitrate had risen in the same period from 172 parts per million to 224 parts per million. Thus, whilst a dilution of total dissolved salts has occurred, a concentration in the nitrate content has taken place.

This would seem to suggest that the nitrate ion and the other salts come from two different sources, the majority of the salts being derived from the metamorphic and igneous bed-rock, whilst the nitrate is derived mainly from elsewhere. The most likely zone of nitrate concentration is on the surface. Heavy rain would wash and leach this nitrate (derived from legumes or sewerage) from the soil or the top layer of the Quaternary sediments. This nitrate-rich meteoric water, would then permeate down to the aquifer to add its high nitrate content to the water already in the aquifer. The overall salt content of the rainwater however will be low, so that dilution would take place in the total dissolved salts of the water already in the aquifer.

Such a hypothesis could only be adequately proved by a systematic programme of water analysis. This would show whether or not changes in nitrate content can definitely be correlated with climatic changes, and whether any other salts follow or reflect in any way the changes in nitrate content. It would also supply further evidence on the main source of the nitrate pollution.

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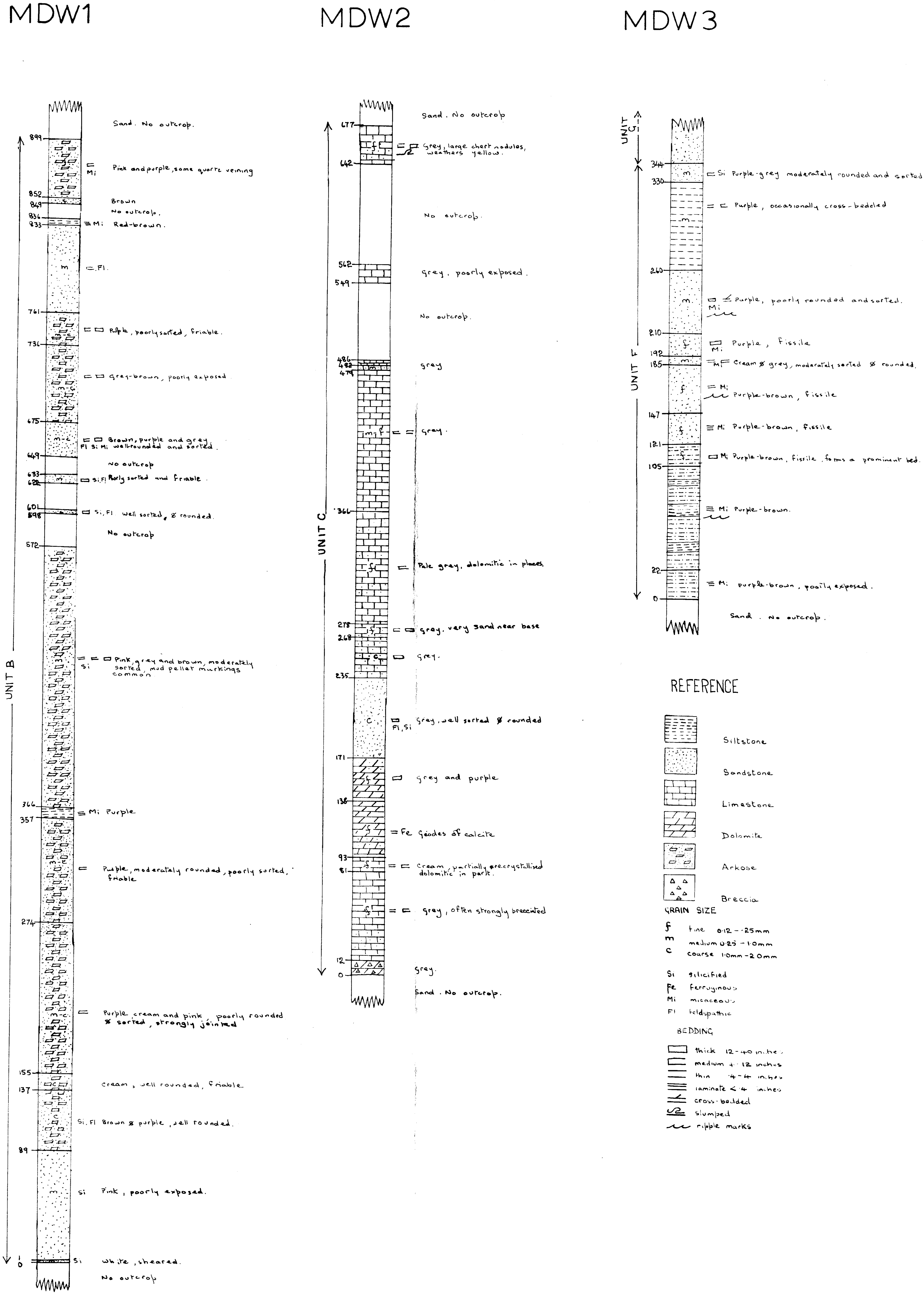
Fig 3

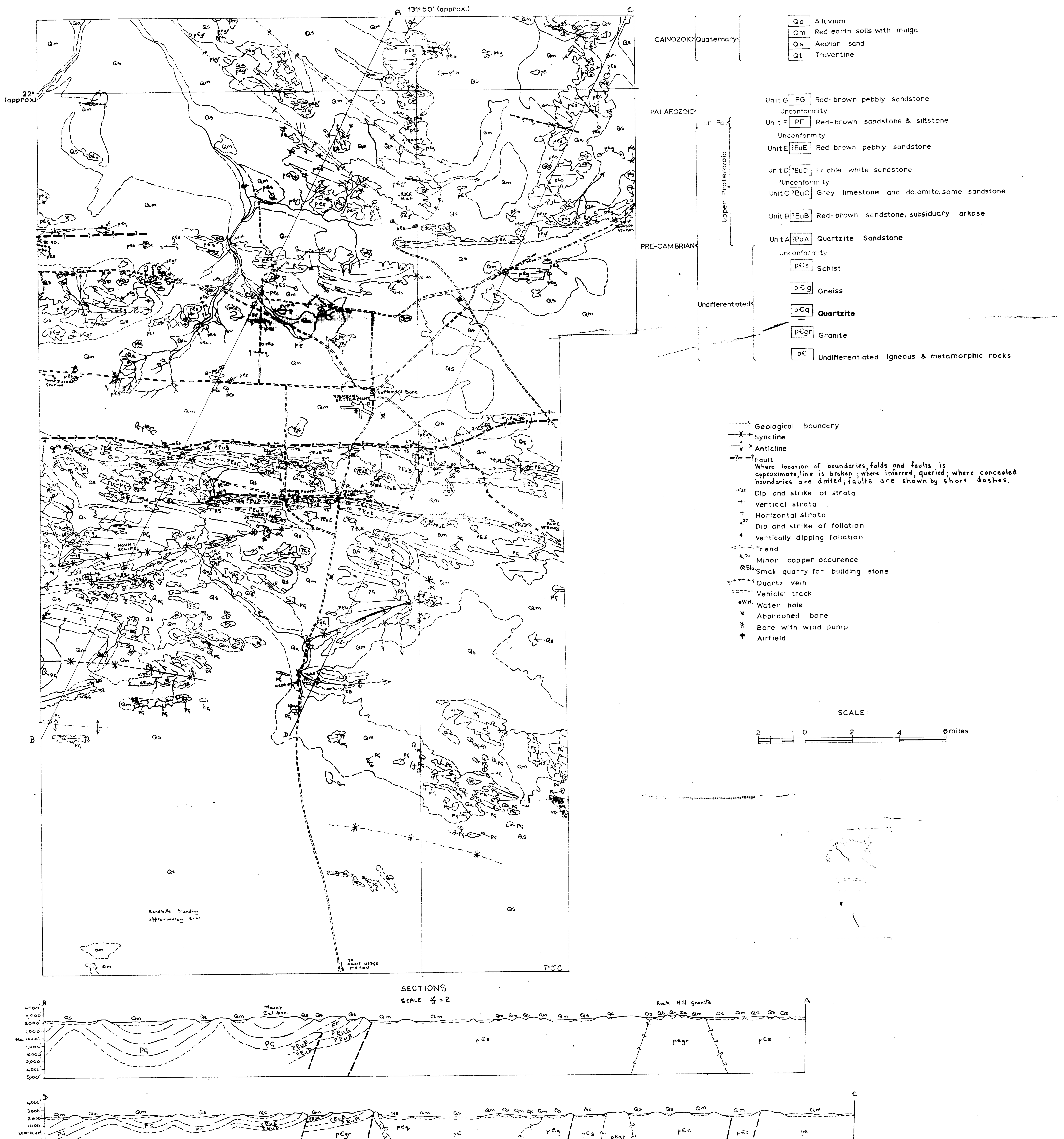


Bureau of Mineral Resources, Geology and Geophysics. Jan 1963. to accompany Record 1963/37

P.J.C.

F52/12/1

GEOLOGICAL MAP
YUENDUMU NATIVE RESERVE
NORTHERN TERRITORY



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F52/12/2