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THE GEOLOGY OF THE SOUTH-EASTERN PART OF THE AMADEUS BASIN

by

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THE GEOLOGY OF THE SOUTH-EASTERN PART OF THE AMADEUS BASIN

SUMMARY

The geological mapping covered the north-east corner of the Ayers Rock Sheet area, the southern quarter of the Henbury Sheet area and the whole of the Kulgera and Finke Sheet areas. The Sheet areas cover the south-eastern part of the Amadeus Basin and part of the western edge of the Great Artesian Basin. The geology of the whole of the Henbury Sheet area is discussed by Ranford and Cook (1964).

The early geological history of the area is not well known because the relationship between the Amadeus Basin sediments and and the basement rocks at the southern margin is not exposed. Geophysical surveys indicate a depression with low density rocks trending east-west on the southern half of the Kulgera Sheet area, separated, by a possible large basement uplift, from a shelf area with thin sediments of the Great Artesian Basin on the Finke Sheet area. To the north the depression is separated from the area underlain by a large wedge of sediments of the Amadeus Basin by a poorly defined ridge probably composed of near surface basement rocks. There is no surface indication of this ridge except that it probably divides the area of thick Palaeozoic and Proterozoic sediments to the north from a thick Precambrian sequence to the south.

The oldest observed rocks are Precambrian granite, gneiss and dolerite in the southern part of the area. Similar rocks may form part of the basement to younger rocks deposited to the north. Steep gravity gradients occur over the granitic and basic rocks on the south east part of the Kulgera Sheet area, and over similar rocks further south, in South Australia. This suggests that these rocks may be overthrust over the less dense rocks in the depression to the north. Precambrian granitised sediments underly the area outlined by the westward part of the large gravity depression on the Ayers Rock and Petermann Range Sheet areas. The part of the depression on the area mapped, probably contains a thick development of similar sediments.

The northern parts of the Kulgera and Ayers Rock Sheets and the north-west part of the Finke Sheet were the site of thick Upper Proterozoic sedimentation which totalled about 12,000 feet of dolomite, siltstone, sandstone and beds of probable glacial origin. These sediments were derived principally from large uplifted masses of Upper Proterozoic and older Precambrian rocks to the south and south-west. The source areas probably also included uplifted parts of the sediments in the large depression indicated by geophysics on the southern half of the

Kulgera Sheet. A major period of folding and faulting followed the deposition of the Upper Proterozoic rocks and was succeeded by an extensive period of erosion. The possible thrusting of basement over the now concealed Precambrian rocks may have been initiated during this orogenic period.

The shore-line of the Cambrian sea was along the northern part of the area mapped and coarse clastics, including boulder conglomerates, were deposited near shore and finer clastics and dolomite were deposited off shore. A period of erosion followed and the Ordovician sea then transgressed the Cambrian shore-line and the Larapinta Group sediments rest directly on Upper Proterozoic rocks. Many of the present higher ridges of Upper Proterozoic rocks were probably islands or peninsulas in the Ordovician sea because some of the younger sediments, of probable Ordovician and Devonian age, locally overlap the Larapinta Group to rest unconformably on the Upper Proterozoic rocks.

The deposition of the Larapinta Group was followed conformably by a sand, the Mereenie Sandstone, formed probably by aeolian reworking and deposition in a shallow sea probably in the Upper Ordovician. This was followed by the thin deposits of the Pertnjara Formation possibly in the Devonian. Lateral equivalents of the Pertnjara Formation extend to the south-east onto the Finke Sheet area and have been mapped as part of the Finke Group. Folding of the Amadeus Basin succession was probably synchronous in part with the Pertnjara sedimentation. Fold axes trend roughly east-west and in places the sediments are overturned to the south. The total thickness of the Palaeozoic sediments in the south-east Amadeus Basin probably does not exceed 2,000 feet.

The sediments of the Finke Group transgressed the older Palaeozoic rocks to the south and the coarse basal conglomerate rests on Precambrian igneous rocks. Faulting along the Mount Kingstone-Black Hill range which uplifted a large block of Upper Proterozoic rocks and deformed the overlying Finke Group probably preceded deposition of the Permian rocks. Thin Permian glacial sediments unconformably overly the Finke Group and are followed unconformably by Mesozoic sediments. The sediments of the Finke Group and the Permian and Mesozoic rocks, whose total thickness is about 3,000 feet, are considered to be part of the Great Artesian Basin succession. Some of the Mesozoic sediments transgressed the Permian rocks and those of the Finke Group and extended westwards where they were deposited unconformably on formations of the Amadeus Basin succession.

Some thin Tertiary sandstone, siltstone and limestone were deposited, probably in freshwater lakes, near the centre of the Kulgera Sheet area.

INTRODUCTION

General

During the 1963 field season, from late May to early October, A.T. Wells, A.J. Stewart and S.K. Skwarko, geologists of the Bureau of Mineral Resources, mapped the 1:250,000 Sheet areas of Kulgera (G53-5) and Finke (G53-6); (the name of this Sheet was changed from Charlotte Waters in December 1963 by the Division of National Mapping). In addition, the north-eastern third of the Ayers Rock Sheet area (G52-8) and the southern quarter of the Henbury Sheet area (G53-1) were mapped, and a number of localities on the Rodinga and Hale River Sheet areas were visited by helicopter. The geology of the whole of the Henbury Sheet is discussed in Ranford and Cook (1964), and the geology of the south-western two-thirds of the Ayers Rock Sheet area in Forman and Hancock (1964).

This mapping continued the work done by Wells, Forman and Ranford (1961, 1962), Wells, Ranford and Cook (1963), and Forman (1963), and formed part of the Bureau's programme of mapping the Amadeus Basin at 1:250,000 scale.

Palaeontologists J. Gilbert-Tomlinson and C.G. Gatehouse worked with the party for one week, and the draftsman was A. Mikolajczak.

Location and Access

The area mapped is in the Northern Territory immediately north of the border with South Australia, and lies between latitudes 24°45'S. and 26°00'S. and longitudes 131°30'E. and 135°00'E. (Fig.1). There are several homesteads in the area, and graded roads connect these with Alice Springs, the nearest town. Communications between the party and the Royal Flying Doctor base at Alice Springs were by Traeger TM2 portable transceivers.

Climate

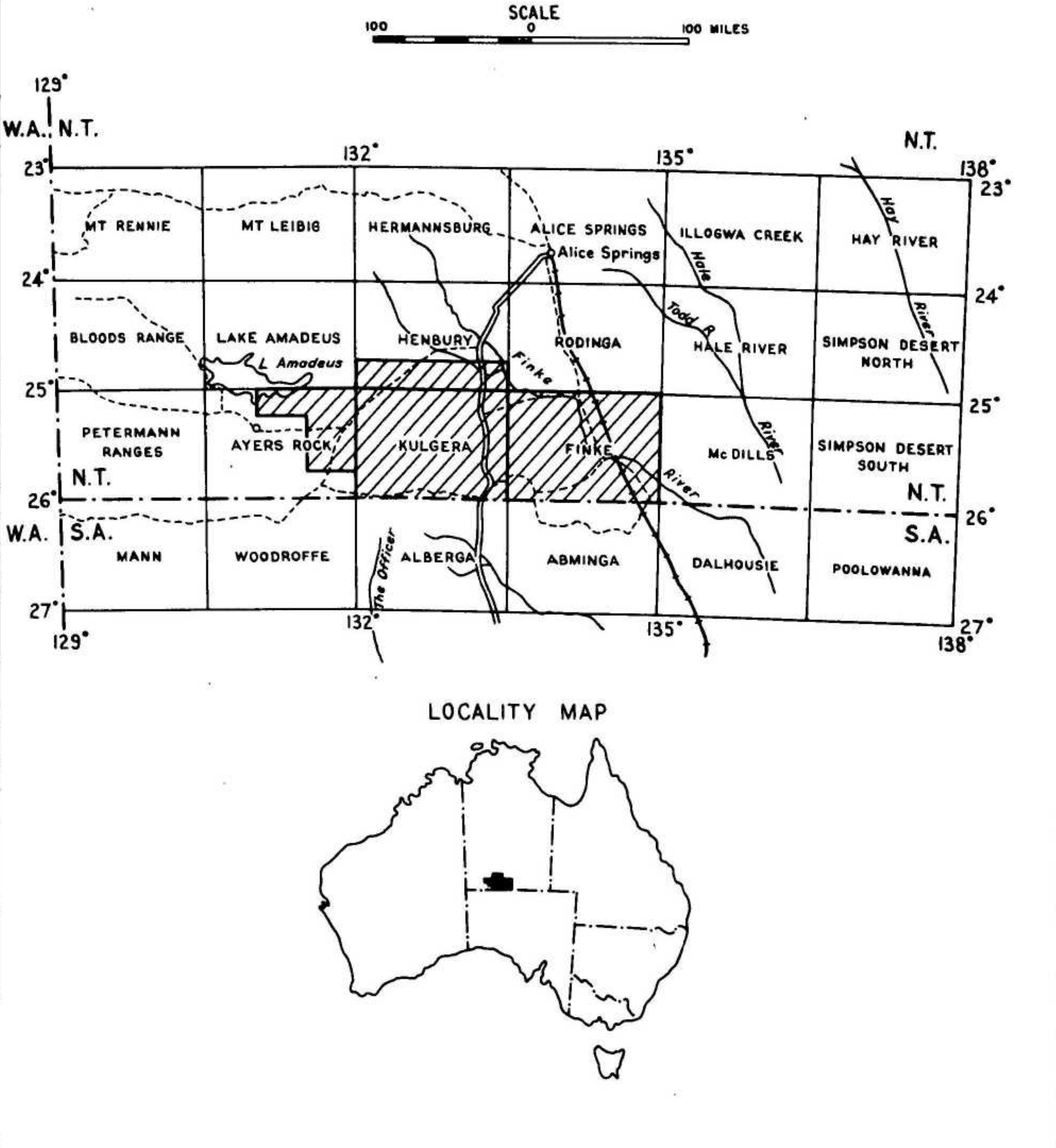
The area lies almost entirely between the 8 inch and 5 inch isohyets, and most of the rain falls during the summer. Summer temperatures are high, with the normal daily maximum in January between 95°F and 100°F and the minimum between 70°F and 75°F. In July the normal daily maximum is between 65°F and 70°F, and the minimum around 40°F. The prevailing wind is from the south east.

Development

Beef cattle are raised in the area, and a total of about 330 bores and wells have been sunk, though many of these have been unsuccessful. Bore information appears in Appendix I.

Fig 1

POSITION OF AREA MAPPED AND REFERENCE TO AUSTRALIAN 1:250,000 AND 1:253,440 MAP SERIES



Survey Method

Most of the mapping was done by Land Rover reconnaissance traverses, but a total of 30 hours' flying time was spent making helicopter traverses, mainly on the Finke Sheet area. Stratigraphic sections were measured either with a 300 foot steel tape or with a 100 foot linen tape and Abney Level, and the position of these sections appears in Fig.3.

PREVIOUS INVESTIGATIONS

The first white man in the area was John McDouall Stuart (1865). After three preparatory journeys in South Australia, he left Chambers Creek, near Port Augusta in March 1860 on his first attempt to accomplish the north-south crossing of Australia. He travelled due north, and discovered and named the Finke River, Mt. Daniel, and Mount Beddome (all on the Finke Sheet area). He then continued along the Finke to the MacDonnell Ranges, naming Chambers Pillar on the way. He planted the British flag in the centre of the continent, and eventually reached Attack Creek, north of Tennant Creek. From here he had to return south. For his second attempt on the north-south crossing, he left on January 1st, 1861, and passed along the same route, reaching Newcastle Waters, north of Attack Creek, but was again forced to return. He immediately left Adelaide (in October 1861) for his third attempt, again over the same route, and this time accompanied by the naturalist Waterhouse. At last he was successful, reaching the Indian Ocean at Van Dieman's Gulf on 24th July 1862, where he 'washed his face and hands in the sea'. He arrived back in Adelaide in January 1863.

Stuart was followed by Ernest Giles (1889) in 1872-74 and 1876. Giles travelled mostly in the region west of the Kulgera and Finke Sheet areas, but on his second expedition he passed through the Ayers Range, and towards the end of his fifth expedition visited Mount Conner. Gosse (1874) also worked mainly to the west of the area, discovering and naming Ayers Rock and Mount Conner.

An early geological report was that of East (1889). At Cunningham's Gap, near Crown Point on the Finke Sheet area, he observed 'large boulders of red granite' in the bed of the stream, and at Polly Spring he noted a 'ridge of argillaceous and hornblendic schists, having a central core of red granite'. This was the Black Hill Range, now mapped as Winnall Beds. His 'core of red granite' must be a mistaken interpretation of granite boulders derived from the Polly Conglomerate, as no intrusive granite was found there during this field season's mapping. Flanking the ridge he also observed the flat-lying clays and sand grits which are now mapped as part of the Finke Group.

The Horn Expedition (Tate and Watt, 1896, 1897; Winnecke 1897) started and finished at Charlotte Waters Telegraph Station, and most of the major landmarks of the Finke Sheet area were named, including the Newland Ranges, Mount Magarey, Mount Hopetoun, Jenkins Bluff, Mount Kingstone and Mount Watt, where 'Lower Silurian' fossils were collected. Physiographic notes of the whole area were also published. On the same expedition, Tate (1897) noted striated boulders at Yellow Cliff on the Finke River, and at first ascribed the striations to bedding, but after discussion with David he believed them to be of true glacial origin. David himself (1898) described a number of these striated and grooved boulders from the same locality, and considered them to be of Permo-Carboniferous age. However, the Australasian Association for the Advancement of Science Committee (of which David was secretary) would only allow a Late Palaeozoic or Mesozoic age, because of insufficient stratigraphic evidence. They were actually mapped as Tertiary by Tate and Watt (1896). Years later, David and Howchin (1924) visited Yellow Cliff and Crown Point, and described the stratigraphy. They noted many grooved, striated, facetted, and soled boulders, and also observed strongly contorted beds in the sequence, with intense puckering and locally very steep dips developed. They found that these glacial beds dipped beneath the Cretaceous sediments of the area, and considered the glacials to be conformable with the Finke River sandstones of Chewings (1914), which, according to this author, unconformably overlay post-Ordovician sandstones north of Idracowra Homestead. On the basis of these relationships, and the great lithological similarity of the beds with the glacials at Bacchus Marsh in Victoria, David and Howchin had no hesitation in assigning a Carboniferous or Permo-Carboniferous age to the glacials of Yellow Cliff and Crown Point. They refer to the red-shale at Horseshoe Bend as Horseshoe Bend 'series', although on their geological section it is referred to as Horseshoe Bend 'Beds'.

Basedow (1905) accompanied the South Australian Government North-West Prospecting Expedition of 1903, and in his report gave brief notes on the Ayers Range, Mount Conner, and Mount Kingston. He noted the even-grained granites and the east-west 'diorite' dykes of the Ayers Range, and also the gneiss east of the range, with a west-dipping foliation. At Mount Conner he observed the bands of conglomerate in the upper part of the sequence, and commented on the highly ferruginous quartzite of Mount Kingston. He believed Mount Olga and Ayers Rock to be Ordovician, and noted that Mount Olga was composed of a metamorphic conglomerate and Ayers Rock of a metamorphic grit or arkose. In 1926 he travelled with the MacKay Exploring Expedition (Basedow 1929a, 1929b), and again visited the Ayers Range before departing for the Petermann Ranges.

The 'Finke River sandstones' (now part of the Finke Group) in the part of the Finke Sheet area between Mount Daniel and Idracowra Homestead were described by Chewings (1914). He noted the shales underlying the sandstone between Horseshoe Bend and Idracowra, and considered the Crown Point glacials to be a river conglomerate of non-glacial origin. He included this conglomerate in the Finke River sandstone, and assigned both sandstone and underlying shale to the (?)Jurassic. In 1928 he still considered them to be Jurassic (Chewings, 1928). Chewings (1935) discussed the 'Pertatataka Series' of the older part of the Amadeus Basin sequence, and regarded Mount Olga, Ayers Rock, and Mount Conner as 'Newer Proterozoic'. He also thought that the Erldunda, Basedow, and Kernot Ranges were 'Larapinta residues', and outliers of the 'Marena' red sandstone (i.e. Mereenie Sandstone) of the Levi and George Gill Range. These ranges are now mapped as Winnall Beds.

The 'Finke Series of Sediments' were again described, by Ward (1925). At Polly Spring he noted the 'coarse pebbly grits (now Polly Conglomerate and Langra Formation) .... resting unconformably upon the old Palaeozoic sandstone and quartzite (now Winnall Beds) .... probably above this came white and red shales ... (and) greenish-grey shales (now Horseshoe Bend Shale), overlain by 100 feet of cross-bedded variegated sandstone and grit' (now De Souza Sandstone). The tillite of Yellow Cliff he thought to be stratigraphically closely related to the cross-bedded sandstone, and regarded them both as Permo-Carboniferous. He regarded the 800+ feet of Jurassic sands (now De Souza Sandstone) in the old Charlotte Waters Bore as being directly on top of the sandstones of the 'Finke Series' and the 494 feet of his Lower Cretaceous 'Rolling Downs Formation' resting on the Jurassic in this bore is now mapped as the Rumbalara Shale. Madigan (1932) correlated the 'Finke River sandstone' with the Pertnjara Formation (as is done in this present report), and considered them both as Permo-Carboniferous.

In 1930, Terry (1931) conducted a purely exploratory trip from Horseshoe Bend, travelling west to Erldunda, Mount Conner, Ayers Rock and on to the Schwerin Mural Crescent in Western Australia. He returned by way of the Kernot, Basedow and Erldunda Ranges, and concluded that 'no evidence of any mineral of commercial value exists in this area'. Ellis (1937) accompanied a private expedition to the Robert Range (in Western

Australia), and in passing thought Mount Olga, Ayers Rock and Mount Conner were all Upper Proterozoic in age.

Wilson (1947, 1950, 1952a 1960) has carried out detailed petrological investigations of the pyroxene-bearing granites of the Musgrave Ranges, including some from the Ayers Range, and has also discussed other aspects of the rocks of this area (Wilson, 1948, 1952b, 1953, 1954, 1959). Robinson (1949) described two thin sections from specimens collected by Basedow in 1903 from the Ayers Range.

The first publication by the Bureau of Mineral Resources concerning this area was by Sullivan and Öpik (1951). They investigated the ochre mine north-east of Rumbalara, in connection with the use of the ochre in camouflage paint for military purposes. In this report they proposed the formal names Rumbalara Shale (marine, Lower Cretaceous) and De Souza Sandstone (then of unknown age, possibly Ordovician or possibly Permo-Carboniferous). They demonstrated the unconformity at the base of the Rumbalara Shale (the base of the yellow ochre bed), and showed that the ochre was a true sedimentary bed in the sequence. Öpik suggested that the iron content of the ochre bed had possibly been precipitated by bacteria.

Hossfeld (1954), in describing the stratigraphy of the Northern Territory, regarded the 'Finke Series' as Palaeozoic and possibly Permian. He considered the lower members to be glacial tills and sands, overlain by 2000 feet of porous sandstone. He regarded the sands overlying the glacial beds at Yellow Cliff as possibly Jurassic. He also briefly described the Musgrave Block, noting that the oldest rocks were gneiss, subsequently intruded by basic rocks, then by granite batholiths, and lastly by dolerite and gabbro. Similar relationships were found in the Umbeara area.

The Frome-Broken Hill Company then took an interest in the oil prospects of the Amadeus Basin, and Thomas (1956) reviewed the literature and discussed the physiography and general geology of the basin as an introduction to the company's subsequent reconnaissance work. Weegar (1959) produced a photogeological map of the basin for use by the field parties. Gillespie (1959) investigated the south-west part of the basin, and regarded Mount Conner as Upper Proterozoic to Lower Palaeozoic. Leslie (1960) worked in the southern part of the basin, and recognised the glacial beds in his Pioneer Formation (now mapped as Inindia Beds and Areyonga Formation). He regarded this formation as generally conformable beneath the Pertatataka Formation (now mapped as Winnall Beds in the area covered by this record). He noted the angular unconformity at the base of the

Stairway Sandstone, and laid some emphasis on the several unconformities in the succession of this southern area of the Amadeus Basin. He also considered that, on a regional scale, time horizons were crossed by the sedimentary units. Wulff (1960) carried out a reconnaissance of the south-eastern part of the basin. He regarded the whole of the 'Finke River Beds' as glacial, though he only noted the Horseshoe Bend Shale ('varved micaceous siltstones') and Idracowra Sandstone of the present Finke Group. He considered the De Souza Sandstone as being closely associated with the glacials, and regarded them all as Permian. Taylor (1959) examined the fossils collected by the field parties and discussed correlations, concluding that the rock units could not be regarded as time-rock units, as they varied in age from place to place. He considered the sediments of the Mount Kingston Range as part of the Pertatataka Formation, and on the basis of a trilobite trail (Protichnites) from the Mereenie Sandstone at Angas Downs, ascribed an Ordovician age to this unit. Indeterminate plant stems were found in the 'Finke River Beds' at Rumbalara, and he regarded these beds as Permian.

Ollier and Tuddenham (1961) described the geomorphology of Mount Conner, Ayers Rock, and Mount Olga, and for each inselberg presented a theory on its erosional development. At Mount Conner, they found that weathering took place mainly by blocky disintegration of the quartzite boulders, due to thermal expansion and contraction. The slopes on the side of the mountain consisted of 300 feet of a joint-controlled vertical free face (of quartzite), beneath which was a rock-cut waning slope (35^{o}) in the softer siltstones, passing down imperceptibly into a pediment. Slope retreat was parallel.

In 1960-61 the Institute Francais du Petrole carried out an air-photo interpretation of the Amadeus Basin for the Bureau of Mineral Resources, and prepared photogeological maps of the whole basin at 1:250,000 scale, for the subsequent use by the Bureau of Mineral Resources field parties (Scanvic, 1961). The first detailed reconnaissance work in the Bureau of Mineral Resources search for oil in the Amadeus Basin was that of Prichard and Quinlan (1962). They mapped the southern half of the Hermannsburg Sheet area, measured the section at Ellery Creek, and established the basic succession of the sediments of the Amadeus Basin, formally defining rock-units where necessary.

Since Prichard and Quinlan's work, the Bureau of Mineral Resources has been steadily mapping the Amadeus Basin at 1:250,000 scale. The results have appeared as published but uncoloured provisional geological maps and the reports of each season's findings in unpublished records (Wells, Forman and Ranford, 1961, 1962; Wells, Ranford, and Cook, 1963; Forman, 1963). These records are at present being edited for publication by the Bureau of Mineral Resources as Reports.

The Bureau of Mineral Resources geophysical section has completed a regional gravity survey of the Basin (Langron, 1962; Lonsdale and Flavelle, 1963).

Subsequent to Frome-Broken Hill's work, other company geologists have been active in the area since 1960 (Hopkins, 1962; Stelck and Hopkins, 1962; Hartman 1963), and Sprigg (1963) has discussed the geology of the Simpson Desert and its surroundings directly east and south-east of the Amadeus Basin. He mentions a number of localities on the Finke Sheet area, including Umbeara, stating that here isoclinal folds with north-east trending axes are present in the basement gneiss. Tillitic beds are mentioned as being present in the Proterozoic sediments of the Black Hill Range, and he correlates the fossiliferous sandstone on top of Mount Watt (Ordovician Stairway Sandstone) with the 'pipe rock' reported by Sullivan and Öpik (1951) at Rumbalara (now known to be Jurassic De Souza Sandstone).

Cook (1963) wrote a short account of the discovery of phosphorites in the Amadeus Basin by the Bureau of Mineral Resources field parties. He described the rocks and proposed an origin for the phosphate by a mixing of incoming oxygenated and detrital-laden water with phosphate-rich marine bottom waters, causing the precipitation of the phosphate as crypto-crystalline apatite. This season's mapping has extended the known occurrences of phosphorite.

Rochow (1963) carried out rapid reconnaissance mapping of the Charlotte Waters Sheet area (now Finke Sheet area), and recognised and described (but did not name) the four units of the 'Finke Series' (now formally named the Finke Group). He also included the overlying Crown Point glacials and De Souza Sandstone in this 'Series', but in this record they have been established as separate units. He correlated the fossiliferous sandstone capping Mt. Watt with the Stairway Sandstone, and regarded the Crown Point glacials as being unconformable on the underlying units.

PHYSIOGRAPHY

The south-eastern part of the Amadeus Basin has been divided into eight broad physiographic divisions (Fig. 2). These are -

High mountain ranges and hills; low ranges and hills with intervening sand dunes and sand plain; sand plain with many sand dunes and some low outcrops; sand plain with dunes; salt lakes; gibber or alluvial plains with mesas and low hills; alluvial flood plains with some clay plans; mesas and buttes with intervening sand or alluvium.

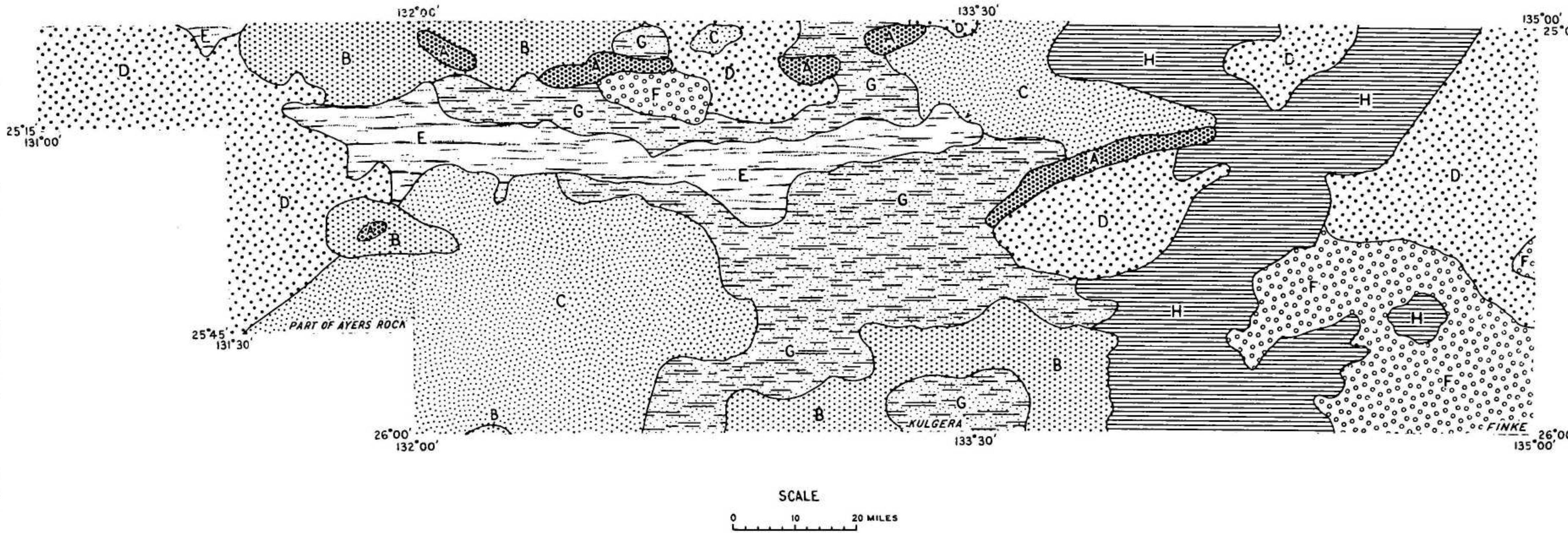
High mountain ranges and hills of sandstone are found at Mt. Conner on the Ayers Rock Sheet area, in the northern part of the Kulgera Sheet area at the Kernot, Basedow, Erlunda, and Mt. Sunday Ranges, and at the Mt. Kingston-Black Hill Range on the Finke Sheet area. Mt. Conner is about 1,000 feet above the plain and forms a large flat-topped mesa with a sheer vertical wall on the north-west side rising from a smooth talus slope. The mountain has been discussed in detail by Ollier and Tuddenham (1961). The other ranges are much lower, rising 300-500 feet above the plain, and except for the Mt. Sunday Range have prominent escarpments on their northern sides due to the general southerly dip and vertical jointing developed in the sandstones. All these ranges are of Winnall Beds. The Mt. Sunday Range is an eroded anticline of Palaeozoic sediments, so that the range shows steeply dipping parallel strike ridges particularly on its northern flank; Mt. Sunday itself is another flat-topped mesa, situated at the turnover of the anticline.

Low ranges and hills occur in three areas: (i) north of Curtin Springs and easterly from there to Angas Downs; (ii) around Mt. Conner; (iii) the granite area from Victory Downs to Umbeara. The first two areas contain strike ridges, in places up to 200 feet high but generally less than 100 feet above the plain, formed from gently dipping Lower Palaeozoic rocks or from sandstone units in the Inindia Beds. Intervening sand dunes are poorly developed. The southerly area of granite exposures shows rounded inselbergs (or bornhardts) rising sharply out of the alluvial plain. South-east of Umbeara there is rather more exposure of bedrock between the inselbergs, as the area here forms a local divide between south-flowing and east-flowing creeks, and the alluvium cover is thinner.

Sand plain with many sand dunes and some low outcrops covers the south-western part of the Kulgera Sheet area, extending on to the Ayers Rock Sheet area, and also forms a large part of the Finke Sheet area, from the Mt. Sunday Range to the Black Hill

PHYSIOGRAPHIC DIVISIONS

Fig. 2



A High mountain ranges and hills
B Low ranges and hills with intervening sand dunes and sand plain
C Sand plain with many sand dunes and some low outcrops
D Sand plain with dunes
E Salt lakes
F Gibber or alluvial plains with mesas or low hills
G Alluvial flood plains with some clay pans
H Mesas and buttes with intervening sand and/or alluvium

Range. A third smaller area occurs north-east of the Basedow Range on the northern margin of the Kulgera Sheet area. Rock exposures are small and few in the first area, and the sand dunes are long, straight, and covered in mulga scrub. In the other areas the dunes are of the short and curved type and mulga is absent.

Sand plain with dunes occurs in five parts of the area mapped, and is distinguished from the division of sand plain with many dunes mainly on the lack of solid exposures. In the area north-west to south-west of Curtin Springs the dunes are of the short and curved type, and in the southern part of this area the inter-dune areas have been flooded with alluvium. In the area between the Basedow and Erldunda Ranges the dunes are also short and curved, while south of the Black Hill Range they tend towards a more longitudinal braided form. North-east of Horseshoe Bend and in the large area east of Rumbalara, on the fringe of the Simpson Desert, the dunes are longitudinal, trend approximately north-south, and individual dunes extend for many miles.

Salt lakes (salinas) occur in an east-west belt extending across the Kulgera Sheet area, forming a continuation of the salt lake country of Lake Amadeus to the north-west. Water is found in the lakes only occasionally, but the lake bed sediments beneath the surface are always damp. The lakes are covered with a layer of powdery salt a fraction of an inch thick. The lakes diminish in size towards the eastern end of the belt.

Gibber or alluvial plains with mesas and low hills occupy the south-east corner of the Finke Sheet area. Some patches of sand dunes occur, and watercourses of some size are present, heading east to the Finke River.

Alluvial flood plains with some clay pans are present mainly on the Kulgera Sheet area, on each side of the belt of salt lake country. Large areas underlain by Quaternary and Tertiary limestone occur here, and the country is flat and monotonous. Creeks are not prominent.

Mesas and buttes, with intervening sand and alluvium, cover the greater part of the Finke Sheet area, where the flat-lying Upper Palaeozoic and Mesozoic sediments occur. The mesas are up to 200 feet above the plain, steepsided, in places showing a compound step-like appearance due to differential weathering. They have a close dendritic drainage pattern with steep-sided gullies. The edges of the gullies produce a minutely sutured pattern in plan. The major watercourses of the area are found in this division, but they only flow for a short time after heavy rain, although some pools remain in the Finke

River for several weeks longer; these are often salty.

The most important factors that have governed the formation of the landscape have been the internal drainage and the very low rainfall. No geomorphological study of the area has been made, but clearly the landscape shows several forms typical of the desert cycle of erosion, and presumably the area has undergone the process of desert-levelling.

It is not certain when the last period of weathering and erosion started, but in the central part of the Kulgera Sheet area it was possibly in the upper part of the Tertiary, after the deposition of the non-marine sediments containing Tertiary molluscs. Elsewhere, exposure to the atmosphere may have begun rather earlier, though not earlier than the time of uplift of the Cretaceous Rumbalara Shale.

At some stage following the deposition of the Tertiary sediments, silicification of the topmost beds of this formation took place, and this was probably contemporaneous with the formation of billy on the Mesozoic rocks to the east. The capping of the hills has since been considerably eroded, resulting in the formation of 'breakaways'.

When the latest period of aridity began is also not known, but the nature of the Kulgera-Finke area indicates that it was a considerable time ago. As indicated by the lack of watercourses entering the salt lakes, surface run-off is slight. Slopes are long, gentle, and unbroken for miles. Hills and ranges are few, low, and isolated. Dust storms are fairly common around the cattle stations where the plant cover has been eaten out, and during these storms there is considerable horizontal transport of sand near the ground. Some deflation is therefore taking place. Large parts of the area are covered in sand dunes, which were once migrating but are now mostly fixed. Other areas are gibber plains, and inselbergs are well developed in the southern part of the area. All these forms indicate that the landscape is in the state of old age, and so the initiation of the desert cycle probably began well before Quaternary time.

STRATIGRAPHY

General

The oldest Precambrian rocks mapped in the area are granite, gneiss, quartzite and schist at the southern margin of the Amadeus Basin. The earliest sediment of the Amadeus Basin succession exposed is the Upper Proterozoic dolomite of the Bitter Springs Limestone. It is succeeded disconformably by thick sediments which are in part glacial and are overlain with an angular unconformity by thick siltstone and sandstone. The Palaeozoic rocks succeed these sediments with a pronounced angular unconformity. Cambrian conglomerate, sandstone, siltstone and minor dolomite is disconformably overlain by the Ordovician sediments of the Larapinta Group. Only the upper two formations of the Larapinta Group, as known elsewhere in the basin, were deposited. They are followed conformably by thin sequences of undifferentiated Palaeozoic sediments. Part of these sediments are continuous with the Finke Group of the Great Artesian Basin. The Finke Group, the glacials of the Permian Crown Point Formation and Mesozoic De Souza Sandstone are separated by unconformities and the Cretaceous Rumbalara Shale rests probably unconformably on the De Souza Sandstone. Thin remnants of Tertiary sediments have been mapped as well as superficial Quaternary deposits.

The relationships of the Amadeus Basin sediments are shown diagrammatically in Fig.4, and details of the stratigraphy are shown in Table I. The location of measured sections and phosphorites is shown in Fig. 3.

All new stratigraphic names used in this report have been approved by the Stratigraphic Nomenclature Committee of the Territories Division.

Specimen localities and reference points shown on the geological maps and referred to in the text are prefixed by the letters AR for Ayers Rock, K for Kulgera and CW for Finke.

UNDIFFERENTIATED PRECAMBRIAN

Undifferentiated Precambrian rocks of the Musgrave Block crop out along the southern margin of the Kulgera Sheet area, and in the south-eastern corner of the Finke Sheet area. Most of the exposures occur as inselbergs with a more or less rounded profile, rising abruptly out of the surrounding alluvium. The inselbergs range up to about 400 feet above the plain. Surface run-off on the inselbergs follows the jointing, and has incised steep-sided gullies up to 100 feet deep. In the Umbeara area, on the Finke Sheet area, the alluvium cover is

TABLE I.

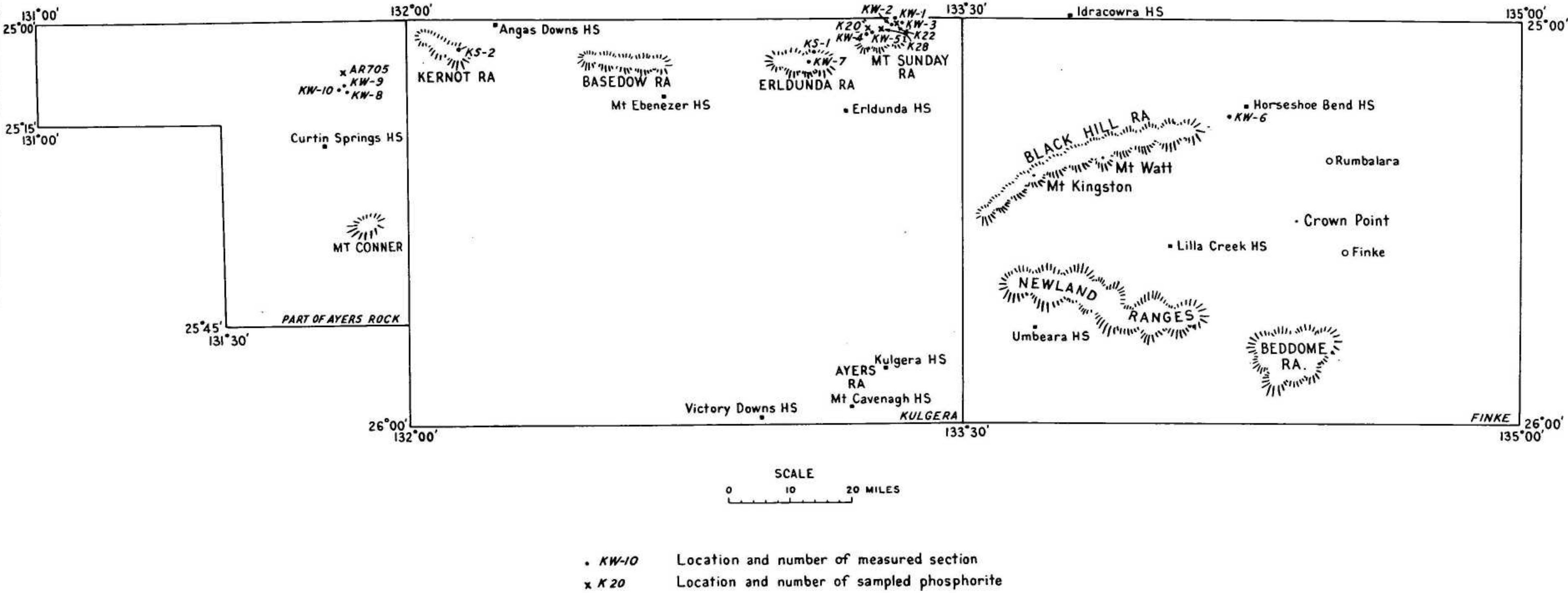
STRATIGRAPHY OF THE KULGERA, FINKE, AND PART OF THE AYERS ROCK SHEET AREAS.

AGE	FORMATION	MAP SYMBOL	THICKNESS	CORRELATION	LITHOLOGY	REMARKS
QUATERNARY		Qa	-	-	Alluvial gravel, sand, clay and red earth plains.	
		Qs	-	-	Aeolian sand	
		Qt	-	-	Salt lake evaporites	
		Ql	-	-	Travertine	
		Qg	-	-	Earthy gypsum	
TERTIARY		Tb	-	-	Grey "billy"	
		Tc	-	-	Conglomerate and breccia	
		Tl	-	-	Lacustrine limestone, calcareous siltstone, siltstone and sandstone.	One outcrop of fossiliferous siltstone on the Kulgera Sheet area.
MESOZOIC: LOWER CRETACEOUS	Rumbalara Shale	Klr	900' Area S. of Charlotte Waters Bore	-	Shale, siltstone and some porcellanite. Lenses of glauconitic sandstone.	Contains marine macro-and micro-fossils of Aptian age. Base of formation is ochreous at Rumbalara.
MESOZOIC: UNDIFFERENTIATED	De Souza Sandstone	Md	300'+ (possibly 850'+) Charlotte Waters Bore.		Sandstone and pebbly sandstone, medium to coarse, coarsely cross-bedded with bands and lenses of claystone and siltstone. Some pipe-rock.	Contains poorly preserved plant fossils. Plant fossils from similar sequence at Anna Hill in South Australia are Upper Jurassic - Lower Cretaceous.
	Undifferentiated	M			Kaolinitic sandstone and siltstone.	
PALAEOZOIC: ?PERMIAN	Crown Point Formation	Pzr	150' at Crown Point 200' W.N.W. of Rumbalara Railway Siding.		Poorly sorted sandstone, boulder beds, tillite, and inter-bedded siltstone and claystone. Striated and facetted erratics. Large slump structures.	Artinskian spores in Malcolm Bore, McDills Sheet area from similar sediments beneath Cretaceous rocks.
PALAEOZOIC: UNDIFFERENTIATED (Finke Group)	Idracowra Sandstone	Pzi	500' in bore G53/6-87.	Possibly equivalent wholly or in part to the Pertnjara Formation.	Fine and medium, white, kaolinitic sandstone, conglomeratic and cross-bedded near base.	
	Horseshoe Bend Shale	Pzh	300' at Horseshoe Bend.		Red-brown and green, biotitic, calcareous and gypsiferous shale, and some fine to medium sandstone interbeds.	
	Langra Formation	Pzn	400-500' estimated at Horseshoe Bend.		Fine and coarse, yellow sandstone, beds of conglomerate with pebbles and cobbles of granitic and metamorphic rocks and large fragments of fossiliferous Stairway Sandstone. Interbeds of red-brown siltstone.	
	Polly Congloomerate	Pzo	200' N. flank of Black Hill Range.		Pebbles, cobbles and boulders mainly of granitic and metamorphic rocks and large fragments of Winnall Beds. Matrix of coarse, poorly sorted sand.	

			Pertnjara Formation	Pzp	700' Mount Sunday Range		Fine and medium, silty, red-brown and fawn sandstone, overlying red-brown, micaceous siltstone with minor sandstone.	Red-brown sandstone is interbedded with white kaolinitic sandstone (? Idracowra Sandstone) on the south-east part of the Henbury Sheet area. Placoderm fish plates, cf. <u>Bothriolepis</u> or <u>Remigolepis</u> occur in the formation in the north flank of the Mereenie Anticline, Mt. Liebig Sheet area. They indicate a late Middle or Upper Devonian age.
			Mereenie Sandstone	Pzm	340' Mount Sunday Range		White and red-brown, medium kaolinitic sandstone with interbedded gypsiferous, red and yellow siltstone near base.	Formation is noticeably coarser grained on the south-east part of the Henbury Sheet area.
PALAEOZOIC	ORDOVICIAN	Larapinta Group Ꞓ - O1	Stokes Formation	Ot	50' Mount Sunday Range 400'+ N.E. Curtin Springs Homestead.		Variegated siltstone and shale with halite pseudomorphs. Grey-green, medium-bedded dolomite and sandy dolomite with abundant worm trails.	Poorly preserved fossils, chiefly pelecypods.
			Stairway Sandstone	Os	150' N.E. Curtin Springs Homstead. 350' Mount Sunday Range.		White, thin bedded, medium and fine sandstone, minor conglomerate and siltstone. Thin lensing beds with phosphatic pellets. Basal part of formation is a coarse sandstone.	Only upper part of formation deposited. Richly fossiliferous.
	CAMBRIAN		Pertaoorrta Formation	Ꞓp	370' Erldunda Range		Silty sandstone, siltstone, boulder conglomerate, arkose, greywacke, and thin beds of fine, grey dolomite.	Fragmentary brachiopods in dolomite at western end of unnamed range, south of Seymour Range on Henbury Sheet area .
UPPER PROTEROZOIC			Winnall Beds	Buw	2000' + Ippia Hill	Pertatataka Formation	Silicified white and purple-brown, thin to thick bedded sandstone, dark brown siltstone and glauconitic siltstone. Abundant flow casts, cut and fill structures, silt pellets and ripple marks.	
			Inindia Beds	Bun	About 7000' 1700' measured N.E. of Curtin Springs Homestead.	In part equivalent to the Areyonga Formation.	Bedded chert, chert breccia, red-brown and grey siltstone, haematitic and manganiferous breccia in lower part of Beds. Coarse cross-bedded sandstone, medium, silicified sandstone, siltstone, fine, pink and yellow dolomite, conglomerate with chert pebbles and siltstone with tillitic texture in upper part of Beds.	Siltstone in upper part of formation contains striated and facetted erratics.
			Bitter Springs Limestone	Bub			Dark grey and pink, fine to medium dolomite, recrystallized in part with interbedded siltstone and minor sandstone. Secondary chert, abundant. Numerous stromatolites in places .	Thin interval of sandstone at top of formation at Ippia Hill has halite pseudomorphs.
PRECAMBRIAN				pꞒg			Granite	Complex sequence of granitic intrusions with dykes of dolerite, pegmatite, and aplite.
				pꞒn			Gneiss and minor amphibolite.	Confined to the southern part of the Kulgera Sheet area and south-west part of the Finke Sheet area.
				pꞒ			Quartzite and schist.	

Figure 3

LOCATION OF MEASURED SECTIONS AND PHOSPHORITES



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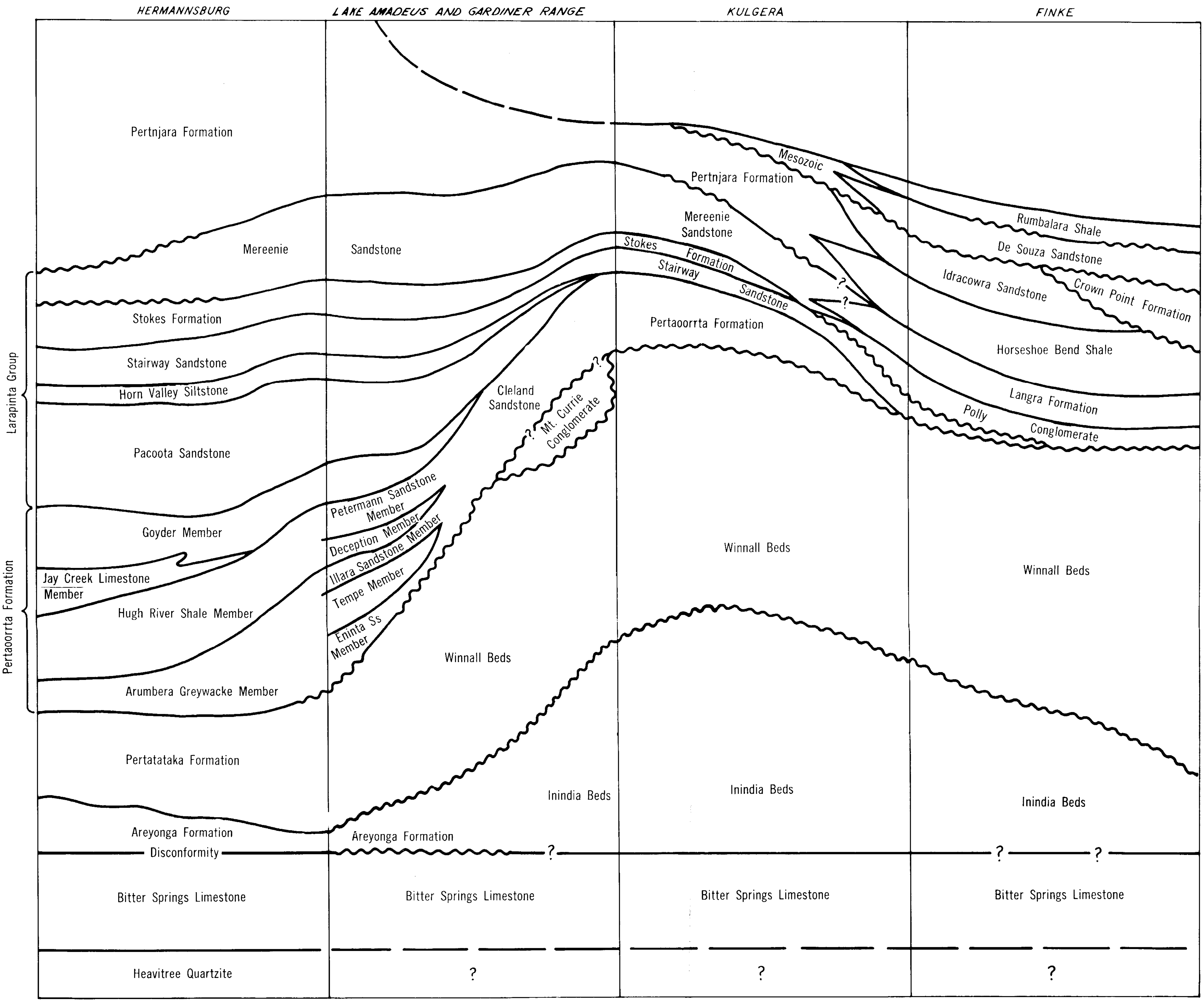
CORRELATION OF ROCK UNITS



more sparse, and large areas of rock are exposed between the inselbergs.

On the 1:250,000 maps accompanying this record, the Undifferentiated Precambrian has been divided into five rock units. These are schists (pS) (Kulgera Sheet only), gneiss (pGn), granite and gneiss (pGg), dolerite (do), and amphibolite (amph) (Finke Sheet only). Fig. 5 is a more detailed map of the Victory Downs-Umbeara area, and shows the distribution of the various types of gneiss and granite found there. Outcrops described below in the section on gneiss are those indicated by the symbols pGg^1, pGg^{1a}, pGg^3, pGg^{14}, and also the amphibolites (amph). The section on granite and gneiss includes the outcrops indicated by the symbols pGg^2, and pGg^4 to pGg^{15} inclusive. The absence of exposures of contacts between the various bodies of granites has prevented the determination of the relative ages of the granites, and so no order of intrusion is implied in the use of numerals with the letter symbols. The symbols indicate different rock types only.

Schists

Precambrian schists are exposed in the south-west corner of the Kulgera Sheet area. At K144 (visited only by helicopter), the rocks form a few very low hills, and consist of interbedded schist and quartzite. There are two main types of schist, (i) a pale greenish-grey to dark grey, micaceous, friable schist, very easily split into thin sheets, and (ii) a pale grey to pale reddish-grey or pale greenish-grey, tough, quartzose schist, not easily cleaved. Over the whole exposure the schistosity strikes 080°M and dips 70°S. In the first, very schistose type, a faint, vertical lineation is visible on the schistosity surfaces, and in the second, less schistose type, a horizontal east-west lineation is very well developed in addition to the vertical lineation. This horizontal lineation is formed by the intersection of an earlier S-surface with the plane of a later schistosity. This earlier S-surface may have been original bedding lamination, or a schistosity imposed by shearing movements acting before those which produced the second, steeply south-dipping, schistosity. The original attitude of the earlier S-surface is unknown, as it has since been deformed into small puckers and microfolds, with an east-west strike and horizontal plunge. The axes of these puckers (following the usage of Nevin, 1949, p.41; and Billings, 1954, p.34) are parallel to the horizontal lineation. The horizontal lineation itself is formed by the lines of intersection of the plicated earlier S-surface with the steeply south-dipping planes of the later schistosity. At this stage it is not clear how the plications in the earlier S-surface

Fig. 5.

GEOLOGICAL MAP OF
VICTORY DOWNS-MT CAVENAGH-KULGERA-UMBEARA AREA

R E F E R E N C E

CAINOZOIC	Quaternary		Qa	Alluvium
			Qs	Sand
			Ql	Travertine
	Tertiary		Tl	Limestone
MESOZOIC	Undifferentiated		M	Mainly white sandstone
	Rumbalara Shale		Klr	White and yellow kaolinitic shale; fossiliferous
	De Souza Sandstone		Md	Red and brown, medium to coarse-grained sandstone
PALAEOZOIC	Finke Group	Horseshoe Bend Shale	Pzh	Red and green biotite shale
		Langra Sandstone	Pzn	Fine to medium-grained sandstone with some interbedded shale
		Polly Conglomerate	Pzo	Conglomerate, with rounded phenoclasts of granite and metamorphic rocks
PRECAMBRIAN			do	Dolerite; also occurs as dykes do
			peg	Pegmatite
			p€g	Undifferentiated granite or gneiss
			p€g15	Medium-grained leucocratic pegmatitic granite; also occurs as dykes p€g15
			p€g14	Fine-grained granite with planar orientation of biotite flakes
			p€g13	Porphyritic microgranite
			p€g12	Porphyritic biotite granite
			p€g11	Microgranite; also occurs as dykes p€g11
			p€g10	Leucogranite, slightly foliated
			p€g9	Clinopyroxene adamellite
			p€g8	Fine-grained leucogranite
			p€g7	Hornblende granite and biotite granite
			p€g6	Biotite granite and biotite-muscovite granite
			p€g5	Coarse-grained porphyritic granite
			p€g4	Coarse-grained hornblende granite
			p€g3	Medium-grained granite gneiss
			p€g2	Hornblende granite and adamellite
			amph	Gneissic amphibolite bodies in p€g1
			p€g1a	'Lenticle gneiss', strongly foliated body in p€g1
			p€g1	Coarsely foliated gneiss

	Geological boundary approximate
	Geological boundary inferred
	Fault approximate
	Fault inferred
	Horizontal strata
	Inferred direction of fracture
	Strike and dip of foliation
50	Measured
	Vertical
	Horizontal
	Dip indeterminable
	Anticlinal foliation axis
	Synclinal foliation axis
	Trend of foliation
15	Direction and plunge of lineation
	Horizontal lineation
	Platy flow, inclined
	Platy flow, vertical
	Dip < 15° (air photo interpretation)
	Joint pattern (air photo interpretation)
XCW67	Specimen locality
Run No / Photo No	Air photo centre point
	Air photo wing point
	Bore
	Bore with windpump
	Well with wind pump
RH	Rock hole
	Spring
	Position approximate
	Roads
	Fence
	Creek
	Dam or yard (indicated)
	Astro station
•1612	Spot height
A/D	Aerodrome
W/T	Wireless transceiver

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G53/A6/5

formed. They may represent true folds, which arose in response to a compressive stress-field, probably directed north-south and close to the horizontal. In this case the steeply south-dipping schistosity is analogous to an axial-plane cleavage in these plications or microfolds. On the other hand, the plications may be shear-folds (Hills, 1953, p.91; de Sitter, 1956, p.182), produced in the earlier S-surface by differential movements, along closely spaced shearing planes (i.e. the planes of the steeply south-dipping schistosity), in response to a stress-field directed almost vertically and producing simple shear, accompanied by only a relatively slight amount of horizontal compression. From the appearance of the hand specimens of the rocks themselves, and also from the nature of the outcrops of the schists in the field, it is clear that the dominant characteristic of the rock is the steep south-dipping schistosity, not the microfolding. Hence it is considered that the second possible process (i.e. plication of the earlier S-surface by shear-folding) is the more likely of the two.

The vertical lineation mentioned previously has developed in the plane of the steeply south-dipping schistosity, and is seen to be of the slickenside type, If the plicated form of the earlier S-surface has been caused by shear-folding, then the vertical lineation (or slickensiding) is an a- lineation, parallel to the direction of the steeply south-dipping shearing movements. It has been suggested (D.J. Forman, B.M.R., pers.comm.) that this vertical lineation is a lineation (either a or b) originally present in the earlier S-surface, and since folded with this surface. One could then expect the vertical lineation to be best developed (i.e. least damaged) in the rocks least deformed by the shear-folding, and weakest or quite obliterated in those rocks most deformed. In the field it was found that the vertical lineation was present only on the steeply south-dipping planes of schistosity, not on the plicated S-surface, and also that the lineation reached its strongest development in the most thoroughly schistose rocks, and so it is felt that this vertical lineation is a product of the shear-folding (with the steeply south-dipping planes of schistosity), and not a relict structure present in the earlier S-surface.

The amplitude of the puckers and microfolds developed in the earlier S-surface is small, about $\frac{1}{4}$ inch, and as the apical plane for any one folia (i.e., the plane tangential to any one plicated folia of this S-surface) has a shallow north dip, it seems reasonable to postulate a similar shallow north dip for the attitude of the earlier S-surface before the shear-folding.

One thin section of the schist has been cut (R16670), and shows a fine-grained sutured mass of equant unaligned quartz crystals, thin bands of small green flakes of biotite, colourless flakes of muscovite, showing schistose alignment, and larger pale grey-brown slightly turbid grains of garnet, occurring mostly in biotite-rich laminae. Relict beds of different grain sizes are present.

The quartzites are pale grey, dark grey, and black, fine-grained, laminated to thin bedded, very tough, with a sub-conchoidal fracture and vitreous lustre. Lineation and schistosity are poorly developed, and then only in the more sericitic varieties. One thin section (R16671) shows a mosaic of sutured quartz grains occurring in bands of different grain sizes, and showing a preferred orientation parallel to this relict bedding. Small flakes of muscovite are present, and the rock is crowded with minute rounded grains of opaque iron ore.

One specimen of green epidosite was collected, and this has the same south-dipping schistosity as the other rocks. Its exact time and spatial relationships with the other rocks are not known.

The exposure south of the Victory Downs-Mulga Park road was not visited.

Gneiss ($p\mathrm{Gg}^{1}$, $p\mathrm{Gg}^{1a}$, $p\mathrm{Gg}^{3}$, $p\mathrm{Gg}^{1+}$, amph.)

Precambrian gneiss has been mapped in three areas, (i) east of Mt. Cavenagh Homestead (ii) north-east of Kulgera Homestead, and (iii) a large area south-east and east of Umbeara Homestead, on the Finke Sheet area. The gneiss of the first area is probably a primary igneous gneiss, whereas the rocks of the other two areas are true metamorphites of sedimentary origin.

Area 1, gneiss east of Mt. Cavenagh Homestead ($p\mathrm{Gg}^{3}$).

Like the granites to the west of Mt. Cavenagh Homestead, the gneiss of this area ($p\mathrm{Gg}^{3}$ in Fig.5) forms rounded inselbergs, up to 100 feet high. In the southern part of the area, the rock is a medium-grained, strongly foliated granite, with foliae (about $\frac{1}{8}$ inch thick) rich in biotite interleaved with layers of quartz and feldspar. Individual foliae can be traced for distances of up to 12 inches or more. Xenoliths and phenocrysts are absent, and no lineation could be observed in the plane of the foliation. In thin section (K122; R16641) the rock is a biotite leucogranite, and consists of quartz, microcline, biotite, and accessory opaque iron ore; plagioclase is lacking. The quartz and microcline crystals are anhedral, and the quartz grains are elongate and oriented in one direction. The biotite flakes are subhedral and similarly aligned. The quartz crystals are cracked, but show only slight strain shadows, and the microcline has well developed cross-hatched twinning. There is no real granulation, or evidence of shearing movements in the solid granite. The evidence suggests viscous flow of a magmatic crystal and liquid mush. At K123 (R16641), one mile farther north, the granite is similar, but oligoclase and hornblende are present and biotite occurs in smaller amounts.

Farther north again, about due east of Mt. Cavenagh Homestead, the foliae are thicker, shorter, and wavy in shape. Lenticular patches of slightly coarser material occur, and long veins, 6 to 12 inches thick, of coarse-grained porphyritic granite are found, carrying angular phenocrysts of potash-feldspar. These veins are parallel with the foliation of the host granite, and their margins are slightly undulatory. At K124, half a mile north of Mt. Cavenagh Homestead, the granite is also strongly foliated and porphyritic, with phenocrysts of potash-feldspar aligned in the foliation. A number of large sharply-bounded xenoliths of schistose rock are also present, and the foliae in the granite flow around these xenoliths, parallel to their margins. On the western side of the exposure is a band of augen gneiss. The thin section of this rock (R16644) shows the augen to be of microcline, containing large inclusions of equant, anhedral and 'corroded-looking' crystals of quartz, plagioclase, and biotite. The groundmass around the augen is a medium-grained, granitic-textured aggregate of quartz, microcline, rare oligoclase, biotite, and a little muscovite. The inclusions in the augen appear exactly similar to the components in the groundmass, and this, together with the replaced appearance of the borders of these inclusions, suggests a metasomatic origin for the microcline augen. In the hand specimen, the foliae of the groundmass are seen to flow around the lenticular augen. Apparently the gneiss has been a mushy magma for at least part of the time, movements of which continued after some potash metasomatism had occurred.

North-east of Mt. Cavenagh Homestead, the granite is fine to medium-grained, and the foliae are only an inch or so long. Consequently the rock possesses a platy flow structure, formed by the drawn-out clots of biotite-rich material. Xenoliths are rare and phenocrysts absent, but elongate bodies of coarse-grained leucogranite are present, and a few melanocratic schlieren, some yards long, also occur.

Three miles north of Mt. Cavenagh Homestead, at K125 (R16645) the rock is similar to that at K122, and is a biotite leucogranite with a preferred orientation of the biotite flakes, and at K126 (R16646), 2 miles east of K125, the rock is a medium-grained aplitic granite, with biotite present only as an accessory. Pegmatitic bodies in the granite are persistently, though not commonly found.

Throughout the area of outcrop of this gneiss (or gneissic granite) the foliation has a consistent north-south strike and a moderate to steep west dip. The true shape of the whole body, its relative age, and relationships, are unknown, as contacts with other rocks are concealed by alluvium. However, its strongly foliated nature suggests that it was formed under conditions of greater pressure, and so possibly earlier, than the weakly foliated granites west of Mt. Cavenagh Homestead. The texture and structure of this gneissic granite, both in the field and in thin section, the purely granitic mineral composition, and the sharply bounded margins of the xenoliths all indicate a rock that passed through a magmatic stage during its history. The amount of actual liquid which formed was probably not great, but enough to impart mechanical mobility to the mass.

Area 2, gneiss north east of Kulgera Homestead ($p\mathfrak{C}g^1$)

The gneiss of this area ($p\mathfrak{C}g^1$ in Fig.5) forms rocky scrub-covered hills up to 50 feet high. The appearance on air-photographs is different from that of the hills of granite close by to the north-west, and those east of Mt. Cavenagh Homestead. Thin sections have been cut from five localities.

At locality K131 (R16652), a small exposure of the gneiss is strongly and coarsely foliated, and has the composition of a medium-grained hornblende-biotite trondhjemite; potash-feldspar is almost totally absent. At K136 the gneiss is fine to medium-grained and medium to coarsely foliated, with alternating dark and light foliae up to $\frac{3}{4}$ inch thick, but generally about $\frac{1}{4}$ inch thick. Contortions and plications are common, but the overall dip is around 30°west. No large crystals are present. The only thin section cut (R16657)is of a sillimanite-cordierite-biotite gneiss; the rock consists predominantly of quartz and microcline, accompanied by many clear and colourless euhedral prisms of sillimanite, their long axes aligned parallel to the gneissic foliation. These occur in a few well-defined bands, and are included in large, clear, colourless, very irregular crystals of cordierite, showing small areas of spindle-shaped twin lamellae, and with a very slight turbid appearance quite distinct from the adjacent water-clear quartz. Small rounded orange grains of isotropic altered cordierite also occur throughout the slide away from the sillimanite-bearing areas. Other bands have concentrations of red-brown, aligned, biotite flakes, and of hematite in very irregular grains; isotropic green spinel and biotite are associated with the hematite. At this same locality, a prominent south-dipping dyke of porphyritic microgranite cuts sharply through the gneiss, and is described below in the section on pGg[11].

At locality K140, the gneisses are similar to those at K136, with medium to coarse foliae, in places strongly plicated, but mostly with a regular and gentle west dip. The leucocratic layers are medium to coarse-grained, and the melanocratic layers are medium to fine-grained. Specimens from a band of very tough, fresh, dark-coloured gneisses have been sectioned, and show a variety of rock types.

K140a (R16661) is a metamorphosed igneous rock, consisting of large poikiloblasts of quartz enclosing anhedral grains of very calcic labradorite (with much secondary sericite), crystals of uralitised clinopyroxene, and large irregular grains of ilmenite, with leucoxene. Small fine-grained areas of clinozoisite are present in the quartz crystals, and a few large poikiloblasts of hornblende have formed after pyroxene. The separate grains of labradorite in the quartz crystals show a common optical orientation. The rock is a gabbro which has been largely replaced by quartz.

K140b(R16662) is a sillimanite-biotite-cordierite gneiss, very similar to K136a. The rock consists mainly of quartz and microcline, but in the melanocratic bands red-brown biotite occurs in large flakes oriented parallel with the foliation. Considerable amounts of cordierite are present, forming large, clear, anhedral and commonly elongate crystals, with small areas of polysynthetic twinning and a few yellow pleochroic haloes. Included in the cordierite are bands of many colourless sillimanite prisms. Large poikiloblasts of opaque iron ore,with rare green spinel, are also common.

K140c (R16663) is another metagabbro similar to K140a, and largely replaced by quartz. Remnants of labradorite and altered clinopyroxene are enclosed in poikiloblasts of quartz. Green hornblende is a major constituent of the rock, and has also undergone replacement by the quartz. The hornblende seems to have been a component of the original gabbro. Anhedral grains of ilmenite are common, and rare clinozoisite is also present.

K140d (R16664)is another cordierite gneiss, and in the hand specimen the cordierite is clearly visible as dark purplish crystals with a resinous lustre. The rock is composed of quartz, microcline, cordierite, opaque iron ore, and biotite. The edges of the cordierite grains are altered to yellow pinite, and one large cordierite crystal cut parallel to (001) shows the characteristic penetration twinning. No sillimanite is present.

K140e is a grey speckled rock with fine laminations, and in thin section (R16665) is found to be a norite, largely replaced by poikiloblastic quartz, as in K140a and K140c. Large green poikiloblasts of hornblende are also present. Hypersthene occurs in good quantity, and is pleochroic from reddish-brown to very pale green. Calcic labradorite, ilmenite, a little red-brown biotite, and clinozoisite make up the rest of the rock.

At locality K141, the gneiss is coarsely foliated (the foliae are up to 2 inches thick) and strongly contorted, with an appearance approaching ptygmatic folding in places. In thin section (R16666) the rock is fine-grained and consists of quartz, andesine, red-brown biotite, and opaque iron ore, with small amounts of potash-feldspar and green hornblende. The rock is a gneissic granodiorite.

At locality K117, five miles north-west of Mt. Cavenagh Homestead, a small inselberg of hornblende granite (described below under $p\mathcal{G}g^2$) contains a band of gneiss striking east-south-east through the outcrop. The relationships of the granite with the gneiss are not at all clear. In thin section, the rocks include a fine-grained diopside gneiss (K117a, R16633), composed of quartz, microperthite, diopside, hornblende, iron ore, and rare biotite. K117c (R16635) is a diopside-biotite gneiss, consisting predominantly of equant grains of these minerals, plus andesine, some quartz, iron ore, rare epidote, and chlorite.

Only a few measurements of the attitude of the foliation of the gneiss have been made in this area. The strikes and dips suggest a synform, with an axis plunging gently north-west (Fig.5). How much this reflects the structure of the original unmetamorphosed rocks is not known.

Area 3, gneiss south-east and east of Umbeara Homestead ($p\mathcal{G}g^1$, $p\mathcal{G}g^{1a}$, $p\mathcal{G}g^{14}$, amph.)

The gneiss of this area is reasonably well exposed, but almost everywhere very weathered, so that fresh specimens are difficult to obtain. There are at least four main rock-types in the gneiss shown as $p\mathcal{G}n$ on the Finke Sheet, and these have been delineated on the detailed map of the area, Fig.5. These rock types are:- (i) the normal coarsely foliated, medium-grained gneiss (pGg^1), (ii) a fine-grained granitic variant of this, with no true foliation, but with a strong planar alignment of the mica flakes (pGg^{14}), (iii) a very strongly foliated variant, called a 'lenticle gneiss' (pGg^{1a}), (iv) bodies of amphibolitic rocks (amph).

(i) Coarsely foliated, medium-grained gneiss (pGg^1)

This is the most abundant rock in the area, and is similar to the gneiss of area (2.), north-east of Kulgera Homestead. Typically, the rock has a black and white, sharply banded appearance with individual foliae up to 4 inches wide and commonly with sharp boundaries. The leucocratic layers are medium to coarse-grained, and the melanocratic layers medium to fine-grained. The dark mineral in most of the dark layers is biotite, but numerous hornblende gneisses also occur, generally forming bands a few yards wide in the biotite gneisses. The foliation is generally regular and even, but in places is contorted, and even ptygmatic. Single foliae can be traced for many yards.

Augen gneisses are not common, but one band occurs at locality CW63, 3 miles south-west of Umbeara Homestead. Here, potash feldspar crystals, of all sizes up to 2 inches long, and with well-formed crystal faces on the sides and oval to lenticular ends, are set in a fine-grained gneissic groundmass. The foliation of this groundmass wraps around the feldspar crystals, suggesting that movement of the gneiss continued during and possibly after the formation of the feldspars.

In one area 9 miles south-east of Umbeara Homestead, the melanocratic layers have small, ill-defined, paler areas in them, suggestive of feldspar augen forming. The gneiss is intimately mixed with medium to coarse-grained massive granite, and in some places the gneiss has sharp contacts with the granite; in others the rocks are transitional into one another. It seems that some mobilization of the gneiss has occurred. In other areas, particularly about 6 miles south of Umbeara Homestead, many lenticles and pods of pegmatite occur, and where these are not so common individual crystals of potash feldspar are present in large numbers throughout the gneiss. This suggests that potash metasomatism has taken place, possibly connected with the mobilization of the gneiss.

In some places the gneiss is more leucocratic, and the melanocratic foliae are narrower, less than 1 inch thick. Thin veinlets of epidosite are common in some areas, and cut across the foliation.

Because of the lack of fresh material, only two thin sections were available at the time of writing. CW57a (i) (R16682) is cut from a melanocratic layer, and shows a hornblende-biotite gneiss composed of these minerals plus quartz, oligoclase, rare microcline and abundant sphene, forming thick rims around large anhedral ilmenite grains. The rock has the composition of a granodiorite. CW57a (ii) (R16690) is from a coarse-grained leucocratic layer, and has the composition of a leucocratic biotite granodiorite, consisting essentially of quartz, oligoclase, some microcline, brownish-green altered biotite, with accessory hematite.

(ii) fine-grained granitic variant ($p\mathcal{G}g^{14}$)

This rock occurs as isolated areas in the typical gneiss ($p\mathcal{G}g^{1}$) throughout the whole of this Umbeara area, but at only a very few localities were contacts observed between the two rock-types. Accordingly, almost all the dashed boundaries delineating the areas of $p\mathcal{G}g^{14}$ in Fig.5 are entirely hypothetical, and are only shown in order to emphasise the very local distribution of this rock-type.

In the field, this rock is everywhere rotten and friable from weathering, and for this reason no thin sections have been cut. The rock is a pink to brownish-yellow, fine-grained, leucocratic, biotite granite with a planar orientation of the biotite flakes but no segregation of light minerals from dark to give a banding or foliation. Lenticular patches of pegmatite occur in the granite. At one locality, 2 miles east of Umbeara Well the fine-grained granite is transitional into areas of hornblende gneiss, suggesting that the granite ($p\mathcal{G}g^{14}$) is possibly a fine-grained phase of the gneiss ($p\mathcal{G}g^{1}$). However, 2 miles north-north-west of Umbeara Well, the granite contains definite xenoliths of gneiss. At two other localities, the first 2½ miles north-west of Umbeara Well, and the second 2 miles south-south-west of Umbeara Homestead (on the east side of the road to Umbeara Well), fine-grained granite was observed intruding the gneiss. Unless these three occurrences have been confused with weathered $p\mathcal{G}g^{11}$ (a microgranite definitely intrusive into the gneiss, and described below), it is possible that the fine-grained granite ($p\mathcal{G}g^{14}$) is a younger intrusive into the gneiss ($p\mathcal{G}g^{1}$).

(iii) lenticle gneiss ($p\mathcal{G}g^{1a}$)

This variant of $p\mathcal{G}g^{1}$ occupies three separate areas 2 to 3 miles south of Umbeara Homestead and shown as $p\mathcal{G}g^{1a}$ on Fig.5. The rock consists of quartz and feldspar concentrated into lenticles up to 2 inches long and ½ inch thick, separated from each other by thin films of biotite. Aplite and pegmatite are generally rare. At a few localities the rock is a 'pencil gneiss', with the leucocratic minerals forming elongate rod-shaped masses up to several inches long and ¼ to ½ inch in diameter. The 'lenticle gneiss' has an east-west strike similar to that of the foliation in the surrounding gneiss ($p\mathcal{G}g^1$), and the lineation of the 'pencil gneiss' has the same east-west trend and a subhorizontal to horizontal plunge.

The rock is far too weathered for thin sectioning, but from field relationships the 'lenticle gneiss' is a phase of the typical gneiss ($p\mathcal{G}g^1$) and presumably developed where pressure was more intense. The 'pencil gneiss' is the result of the most extreme drawing-out of the lenticles, and its attitude indicates horizontal movements, at least during the end stages of the metamorphism.

(iv) amphibolitic rocks (amph)

Bodies of amphibolite and diorite occur in numerous places through this area. Most are too small to map but the larger ones are shown on the Finke Sheet and in Fig.5, with the symbol amph. In the field they are only slightly weathered, and occur as black, or black speckled with white, fine to medium to coarse-grained, dense, very tough, gneissic rocks, forming elongate areas in the typical gneiss ($p\mathcal{G}g^1$). The strike and dip of the foliation in the amphibolites is everywhere parallel with that in the surrounding gneiss. At locality CW58, 1 mile north-west of Umbeara Homestead, the amphibolite forms three very narrow bodies, 2 to 3 yards wide, up to 70 yards long and about 25 yards apart.

Several thin sections have been cut from these rocks. CW54a (R16674) and CW54c (R16676) are amphibolites consisting of about 75% of green hornblende, accompanied by altered andesine (sericitised and ferruginised) microcline, epidote, and accessory apatite. CW54b (R16675) is a gneissic quartz diorite, composed of green hornblende (about 40%) and andesine, with some quartz and potash-feldspar. CW57b (R16683) is from a xenolith contained in a later intrusion ($p\mathcal{G}g^{12}$), and consists of about equal proportions of hornblende and andesine, with a little potash-feldspar. Opaque iron ore is rare in all these rocks. CW58 (R16685) is a gabbro, with about 40% of hornblende and 15 to 20% of clinopyroxene, plus labradorite and some ilmenite. CW60 (R16687) is a coarse-grained hornblende diorite.

Whether these bodies are ortho or para-amphibolites is not known as yet. Their occurrence as small discrete masses in the typical gneiss suggests that they are of igneous origin, intruded before the metamorphism which resulted in the formation of the gneiss of the area.

At each locality where gneiss was observed, the strike and dip of the foliation was determined. The measurements appear both on the 1:250,000 sheets and in Fig.5. Throughout the area the strike of the foliation maintains an east-west trend, and the dip directions indicate a number of antiforms and synforms. The limbs dip at about 45° and the axes trend east-west. This conflicts with the statement of Sprigg (1963) that isoclinal folds with north-easterly trending axes are developed in the Umbeara area. Whether the east-west axes correspond to the original folds in the sediments has not been proved at this stage, but it may be shown in the future to be the case.

The mineral assemblages of the gneisses of the whole area belong to the low-pressure end of the almandine-amphibolite facies of regional metamorphism, grading into the hornblende-hornfels facies of contact metamorphism (this is indicated by the presence of the cordierite and epidote). Most of the rocks have an assemblage belonging to the staurolite-almandine subfacies of regional metamorphism, corresponding to temperatures around 600°C and pressures of about 3000 to 4000 bars (Turner and Verhoogen, 1960, p.553).

Granite and Gneiss ($p\epsilon g^2$, $p\epsilon g^4$ to $p\epsilon g^{15}$, incl.)

This division includes all the known exposures of granite and also any unvisited exposures of granite or gneiss. Several varieties of granite are present in the area, and are shown in Fig.5.

(i) hornblende granite and adamellite ($p\epsilon g^2$)

This rock outcrops over a small area about 4 miles north-west of Mt. Cavenagh Homestead, on the Kulgera Sheet area. The isolated inselberg at locality K145, 8 miles north-north-west of Victory Downs Homestead, is also included in this unit. The rock is generally a hornblende granite, but in places is a hornblende adamellite. It is medium-grained, and has a well developed platy flow structure, striking approximately east-west. Xenoliths are found at all exposures, both equant and lenticular shapes being represented. In places the granite carries ¼ inch phenocrysts of oligoclase.

In thin section (K116a, R16631; K118, R16637; K120, R16690) the rock is unevenly grained, and consists of large anhedral crystals of oligoclase in a groundmass of quartz, orthoclase microperthite, oligoclase, hornblende, ilmenite (partially rimmed with sphene) and rare biotite. Some very weathered remnants of clinopyroxene are also present, associated with the hornblende. All these minerals are anhedral.

At locality K117, the granite is associated with a band of gneiss, and itself has been epidotised. In K117b (R16634) the large crystals of plagioclase have been extensively sericitised, hornblende is associated with epidote, the microperthite has become crowded with a mass of minute brown specks of (presumably) a clay mineral, and some of the ilmenite is replaced by leucoxene. In K117d (R16636) a vein of epidotite cuts through the rock, and granular epidote has formed in the cores of the adjacent plagioclase crystals. This rock is an adamellite, and also contains stilpnomelane and numerous grains of hypersthene, partially altered. Hornblende is lacking, now being represented by aggregates of epidote.

The granite from locality K145 is coarser-grained than the first body, and is a sphene-bearing hornblende adamellite, with some biotite and epidote.

At localities K117 and K145, there is some evidence for potash metasomatism before the epidotisation. As in the granite $p\mathrm{Gg}^4$ (described below), a number of oligoclase crystals are enclosed in, and being replaced by, microperthite. The grains of quartz are anhedral and appear to have formed at a number of points throughout the rock, without regard to the existence of the minerals previously crystallised. This gives the whole rock a distinctly metamorphic appearance in thin section.

(ii) granite (including a clinopyroxene-bearing type) ($p\mathrm{Gg}^4$)

This is the most extensive granite body mapped, and occupies an area from west of Victory Downs Homestead to Mt. Cavenagh Homestead, a distance of about 30 miles. Two small exposures very close to Kulgera Homestead are also placed in this division. The extent of the granite is unknown owing to the lack of exposures of contacts with other rocks.

The granite is coarse-grained, grey, with the mafic minerals aggregated together in large black clots. These are drawn out and show a weak to well developed platy flow structure. A few subhedral to euhedral phenocrysts of plagioclase, and more of potash feldspar, are generally present. Xenoliths are rare, but where present their long axes are parallel with the platy flow structure. Dykes of pegmatite and microgranite, mostly less than 1 foot wide, cut the granite. At a few localities veins of tachylytic dolerite have been injected along fracture zones in the granite, and here epidotisation of the granite has taken place.

In thin section, the rock is found to vary slightly from place to place over its outcrop, and it is possible that this unit could be subdivided. As mapped at present, it includes three main rock types.

The first type, various clinopyroxene-hornblende granites, has been sampled from three localities. At K109 (R16622) the rock is a clinopyroxene-hornblende granodiorite, with a small amount of red-brown biotite and opaque iron ore. The potash-feldspar is orthoclase microperthite, and myrmekite is common. At K111a (R16624) microperthite exceeds oligoclase in amount, clinopyroxene and iron ore are present in considerable quantities, biotite is almost absent, and several very large zircons are conspicuous. The oligoclase crystals have 'corroded' margins, and in several places are completely enclosed in, and apparently being replaced by, the microperthite. The rock is a clinopyroxene hornblende granite. At K113 (R16628) the rock is very similar to that at K111, but here potash metasomatism has not proceeded so far and the rock is a clinopyroxene-hornblende adamellite. This is the Ayers Ranges Adamellite of Wilson (1960, p.53). To sum up, the first rock-type is apparently a potash-metasomatised granodiorite the degree of metasomatism being different from place to place.

The second rock-type is a hornblende-biotite granite, lacking pyroxene. At locality K115 (R16630), the rock is composed predominantly of orthoclase microperthite, everywhere containing small unreplaced remnants of oligoclase crystals. Myrmekite is particularly well developed, and is found between the crystals of potash-feldspar. K116b (R16632) is similar, but potash-metasomatism has not proceeded as far as at K115. At K119 (R16638) both orthoclase microperthite and microcline are present, and the former appears to be replacing, or recrystallising from, the latter.

The third type, collected at K121 (R16640), is a hornblende-clinopyroxene-biotite granodiorite. Small areas of myrmekite are well developed, but little, if any, clear replacement of plagioclase by potash-feldspar is discernible.

Specimens from the two exposures at Kulgera Homestead have not been sectioned, but a description of the eastern exposure appears in Wilson (1960, p.54). He identified the rock as a hornblende-biotite adamellite and named it the Kulgera Adamellite. Potash-metasomatism of the plagioclase has taken place.

Where possible, measurements of the strike and dip of the platy flow structure in the granite have been taken. Almost all have a steep dip and a northerly or north-westerly strike Fig.5.

(iii) coarse-grained porphyritic granite ($p\Theta g^5$)

This is a hornblende-biotite granite containing many large crystals of potash-feldspar, up to 2 inches across. Both oval-shaped and angular crystals are present together, and the rock has an appearance suggestive of rapakivi texture. The rock was found at only two localities, both 2 miles east of Victory Downs Homestead and just south of the road to Mt. Cavenagh Homestead. At the easternmost locality there is one small exposure of this 'rapakivi' granite ($p\Theta g^5$) cutting off the platy flow structure in the coarse-grained granite ($p\Theta g^4$), and at this same locality $p\Theta g^5$ contains three large xenoliths of $p\Theta g^4$, indicating that the 'rapakivi' granite ($p\Theta g^5$) is younger than $p\Theta g^4$. No thin section of $p\Theta g^5$ has been cut.

(iv) biotite and biotite-muscovite granite ($p\Theta g^6$)

This rock-type has been mapped at only three localities. Four miles north-west of Victory Downs Homestead, at locality K110 (R16623), the rock is a medium-grained, foliated, biotite granite, consisting of quartz, microcline, calcic oligoclase, biotite, ilmenite, and sphene. Several pegmatite dykes cut the granite, and these carry magnetite in addition to quartz and microcline.

At K143, 18 miles west-north-west of Victory Downs Homestead a small isolated group of low inselbergs are composed of a medium-grained biotite-muscovite granite, consisting of quartz, microcline, oligoclase, clear and colourless muscovite, and brown biotite with many pleochroic haloes. Some replacement of oligoclase by orthoclase microperthite has taken place. Many pegmatite dykes cut through the granite and are composed of orthoclase, quartz and muscovite; quartz generally occupies a zone in the centre of the dykes.

The third locality is on the Finke Sheet area, 6 miles south-east of Umbeara Homestead and ½ mile west of Mt. Hopetoun. The exposure is a prominent hill composed of a medium-grained biotite granite, even-grained, with a strong primary foliation of biotite schlieren up to 12 inches long, striking north-easterly and dipping 40°S.E. No thin section has been cut.

(v) hornblende granite and biotite granite ($p\Theta g^7$)

These rocks outcrop 2 to 4 miles north and north-east of Kulgera Homestead and are medium to coarse-grained hornblende granite and biotite granite. Phenocrysts are absent, but xenoliths of several varieties are reasonably common, with their long axes lying parallel with the weak to moderate platy flow structure developed in the granite. The granite itself is homogeneous overall, except for the existence of a few patches of leucocratic granite.

Hornblende granite occurs in the northern part of the area of outcrop. At K133 (R16654) the rock is coarse-grained, and consists of quartz, microcline, oligoclase, hornblende, biotite, and rare muscovite. The granite also contains large crystals of brownish-yellow sphene. At K134 (R16655), the rock is a medium-grained biotite-hornblende granite, containing a much higher content of ferromagnesian minerals and ilmenite than K133. It is s similar rock to pGg^2.

In the southern part of this area are biotite granites. At K135 (R16656) is a coarse-grained sphene-bearing hornblende-biotite granite, with a fair amount of ilmenite, and K137 is similar to K134, but with more biotite than hornblende.

All the granites show some degree of replacement of oligoclase by potash-feldspar.

(vi) fine-grained leucogranite (pGg^8)

This rock-type was observed at three well separated localities in the south-east part of the Kulgera Sheet area, and at one locality on the Finke Sheet area. On the Kulgera Sheet area, the southernmost exposure, 5 miles east of Mt. Cavenagh Homestead is composed of a pale cream, fine to medium-grained, sheared leucogranite. The crystals of quartz have been drawn out and granulated into lenticles, and the small amount of biotite is present as short, very thin laminae. Lenticular patches of coarser-grained pegmatitic granite are abundant, but feldspar phenocrysts and xenoliths are absent.

At the locality on Outounya Creek, 8 miles east-north-east of Mt. Cavenagh Homestead, and at the third locality, 2 miles to the north-east, the granite is fine-grained and leucocratic, but instead of a schistosity, it possesses a strong platy flow structure, formed by the concentration of the biotite into laminae. The quartz and feldspar grains show no sign of a cataclastic texture. Phenocrysts and xenoliths are absent. Lenticular bodies of pegmatite are present in the north-east locality, and at this same locality, the platy flow structure seems to lose its north-east dip in places, and becomes a horizontal north-westerly lineation.

The considerable distance between these localities suggests that the granite may be a large body, largely covered by alluvium. The rock was too weathered for thin-sectioning.

On the Finke Sheet area, a small mass of pGg^8 has been mapped 5 miles south of Umbeara Homestead. Here it is a medium-grained, foliated, biotite leucogranite. The foliae are several feet in length, and it is possible that the rock is a leucocratic phase in the surrounding gneiss (pGg^1), though the strike of the foliation of the leucogranite is at an angle to that of the gneiss.

(vii) clinopyroxene adamellite (pGg^9)

This rock was found at only one locality, K128, 6 miles south-east of Kulgera Homestead. It forms a steep, elongate inselberg, composed of a very tough, greyish-cream speckled with green, medium-grained granite. In places it is leucocratic. In thin section (R16648), the rock has both an unusual texture and composition. The feldspars are anhedral, oligoclase has been replaced by microcline with embayments of one feldspar in the other, and the quartz everywhere forms a micrographic intergrowth with the microcline. All these interlocking crystals probably account for the very tough nature of the rock. The only ferro-magnesian mineral present is a bright green, subhedral clino-pyroxene, either an augite or an aegerine-augite (but not diopside). A little ilmenite is present, encrusted with sphene, and larger solitary crystals of sphene also occur. The rock is a clinopyroxene adamellite.

(viii) leucogranite (pGg^{10})

This is a small body of medium to fine-grained, rather aplitic leucogranite, exposed 4 miles north of Kulgera Homestead on the western side of the road to Alice Springs. The granite has a well developed platy flow structure, which in many places is a primary foliation. The biotite laminae are constantly and regularly spaced, and show swirls and undulations. The overall strike is approximately east-west and the dip is probably steep to the north. Thin irregular masses of pegmatite are common in the leucogranite. No phenocrysts or xenoliths were seen.

In thin section (R16649), the rock consists of quartz, orthoclase microperthite, and microcline, together with a little sodic plagioclase (commonly myrmekitic), rare yellow-brown biotite, and accessory hornblende and iron ore. The larger crystals of plagioclase are not myrmekitic, but occur as 'corroded' remnants in the microcline. Potash-metasomatism of the plagioclase has occurred, and there are also replacement textures between the microcline and the microperthite.

(ix) microgranite (pGg[11])

This rock-type is found almost exclusively on the Finke Sheet area, intruding the gneiss (pGg[1]) at many localities south-east of Umbeara Homestead. It includes a number of mineralogical types. Three small exposures of the rock occur on the Kulgera Sheet area, at localities K130, K131, and K136.

The microgranite is conspicuous in the field, as at nearly every locality where it occurs, it forms a discrete body 50 to 100 yards across, and of any length up to a mile. Each outcrop forms a small hill of large, smooth, spheroidal core stones (or tors) of unweathered rock, rising abruptly out of the surrounding area of gneiss like a small inselberg. The core stones are a bright blue-grey, and can be recognised from some distance. The hand specimen is a tough, blue to bluish-grey, pale rock, speckled with black biotite flakes, fine-grained, mostly even-grained, and generally massive. In places a cream or pinkish-cream colour is found instead of grey. Phenocrysts of feldspar occur at a few localities, and xenoliths of gneiss are fairly common.

In thin section, the microgranite shows some variation from place to place. At K130a (4 miles north-north-west of Kulgera Homestead) R16650 is a hornblende-biotite microgranite, consisting of quartz, microcline, oligoclase, biotite, hornblende, and ilmenite coated with sphene. K130b (R16651) is similar, but lacks hornblende and contains more plagioclase, making it a biotite microadamellite. K136b (R16658) is one of the rare porphyritic varieties, and has euhedral phenocrysts of orthoclase microperthite, 1 to 1½ inches long, in an adamellitic groundmass of quartz, microcline, oligoclase, biotite, iron ore, and rare muscovite. Twenty miles east of these localities, at CW59 (R16686) and CW61 (R16688), near Umbeara Homestead, the rock is a muscovite-biotite microgranite.

At some localities, a planar parallelism of the biotite flakes is faintly developed, and very rarely some dark schlieren are found. Where a contact with older rock is exposed, the planar arrangement of the biotites is usually parallel to this. However, at a few places the strike of the platy flow structure is almost at right angles to the long axis of the microgranite body, suggesting the possibility of some dilatational movements of the country rock before final solidification of the micro-granite.

Looking at the whole outcrop pattern of the microgranite bodies in the area south-east of Umbeara Homestead, it is clear that they t[illegible] to occur along lines, trending in two main directions ([illegible] 5). The larger bodies are elongated in these same direction. In the area between Mt. Hopetoun, Mt. Falconer, and Umbeara Well these directions trend north-north-west and north-north-east, whereas south of Umbeara Homestead the trends are closer to north-west and north-east. Clearly the injection of the microgranite has been controlled by a joint or fracture system in the country rock gneiss.

(x) biotite granite (pGg^{12})

This is a single small body outcropping one mile north of Umbeara Homestead. The rock (CW57c) is a medium-grained, pink and green, slightly porphyritic biotite granite, with a weak platy flow structure of the tablet-shaped potash-feldspar crystals, striking approximately east-west and steeply dipping. In thin section (R16684), the rock consists of quartz, microcline (with Carlsbad-twinning in addition to polysynthetic albite and pericline-twinning), rare plagioclase, biotite, and iron ore. Large xenoliths of the country rock gneiss (pGg^{1}) are common, including one of amphibolite. Pegmatite veins carrying biotite are also present.

(xi) porphyritic microgranite (pGg^{13})

Two isolated inselbergs, 11 miles west-south-west of Umbeara Homestead, are composed of a porphyritic microgranite, which is fresh and tough. The hand specimen (CW53) shows very pale brownish-cream phenocrysts of feldspar, ¼ inch across, set in a fine-grained 'salt-and-pepper' groundmass. In thin section (R16673) the phenocrysts are found to be of microcline (Carlsbad-twinned), and the groundmass is composed of quartz, microcline, oligoclase, biotite, sphene (abundant), ilmenite, and rare muscovite.

The rock has a weakly to moderately well developed platy flow structure, striking east-west and of indeterminate dip. Xenoliths of gneiss up to 4 feet across are present, and many thin dykes of pegmatite (about 2 inches wide) cut through the granite. Several dykes of non-porphyritic microgranite, from 4 to 10 feet wide, also occur.

(xii) leucogranite dykes (pGg^{15})

Intruded into the coarsely foliated gneiss (pGg^{1}), in the area north of an east-west line through Umbeara Homestead are many dykes and sheets, 5 to 10 feet wide, of a tough, pink to cream, fine to medium to coarse-grained leucogranite. In places the sheets form the tops of small hills, so presenting an outcrop large enough to appear on Fig.5. Six miles east of Umbeara

Homestead are two larger bodies of this rock-type. The hand specimen of the rock has an unusual appearance, and in many localities the rock is composed almost entirely of feldspar. Elsewhere there is sufficient quartz to give a pegmatitic aspect, though with finer grain-size. The rock is closely jointed, and erodes into angular blocks, 6 to 12 inches across.

At CW54 (R16677, R16678) and CW55 (R16679), the rock is fine-grained and consists mostly of microcline, accompanied by quartz, weathered plagioclase, and chloritised biotite. The leucogranite at CW56 (R16680, R16681) is coarse-grained and is also composed chiefly of microcline, with quartz, olicclase, and muscovite.

(xiii) aplite, pegmatite, and reef quartz.

Though nowhere extensive enough to form mappable bodies (except at Mt. Hopetoun) these rocks occur throughout the area as thin dykes and veins injected into the older rocks. They are particularly common in the gneiss ($p\mathrm{G}g^{1}$) of the Finke Sheet area and here they have a preferred strike direction trending north-north-east. This is coincident with one of the two strike directions favoured by the microgranite intrusions ($p\mathrm{G}g^{11}$) in the same area. Many pegmatites reach 5 feet in width, and are very coarse-grained, some of the potash-feldspar crystals measuring 12 inches long. Books of muscovite, 4 inches across, occur usually in discrete patches a few feet wide in the pegmatite. Magnetite and tourmaline (in crystals 4 inches long) are found in the pegmatite at CW61, 2½ miles west of Umbeara Homestead.

At Mt. Hopetoun, a larger body of kaolinised pegmatite is found.

Dolerite

Large numbers of olivine dolerite dykes occur throughout the granite and gneiss of the Kulgera and Finke Sheet areas. They represent the last igneous activity in the area.

The dykes are composed of fresh, very tough, fine to medium-grained, dark grey rocks. The thicker dykes show columnar jointing in several localities. In thin section (K40; K123b, R16643; K127, R16647; K139, R16660; K141b, R16667; Cw62, R16689) the dolerites are typical, consisting of an inter-granular mass of labradorite laths, clinopyroxene, olivine, and magnetite. The coarser-grained types contain areas of subophitic to (rarely) ophitic texture.

At K111, the olivine dolerite has metamorphosed and infiltrated into the granite country rock. The process of metamorphism has been described by Wilson (1952b) from another locality, near Kulgera Homestead. At locality K111, the crystalline fabric of the granite has started to break down. Stringers and veinlets of dolerite have intruded into the granite as metamorphism proceeded, and the dolerite of the main part of the dyke carries corroded and altered xenocrysts of quartz and feldspar derived from the granite.

At a number of other localities, the dolerite has been injected along fracture zones in the granite, and here the texture of the dolerite becomes tachylytic. An example occurs at K114, 5 miles west-south-west of Mt. Cavenagh Homestead. Here thin veins and stringers of tachylyte, a fraction of an inch wide, have been injected into the fractures in the granite. In thin section (R16629), the tachylyte is seen to contain broken xenocrysts of feldspar from the granite, and in one small area in the slide, numerous small crystals of leucite are present. They are quite isotropic, show the characteristic polygonal outline, and contain tiny regularly arranged inclusions, generally forming a circle in each leucite crystal. The leucites occur both in the tachylyte, and in the xenocrysts of feldspar. Their manner of formation is unexplained at this stage; they may be the product of some reaction between the granite and tachylyte.

In the Victory Downs-Mt. Cavenagh-Kulgera area the dolerite dykes have a general southerly dip, about 40° at Victory Downs, decreasing to 20° or less at Kulgera. The strike directions form a notably arcuate pattern, changing from west-north-west at Victory Downs to north-east at Kulgera. In the Umbeara area, the strike is north-north-east (parallel to the pegmatite and aplite dykes, and to one of the preferred directions of the microgranite intrusions, pGg^{11}), and the dips of the dykes are steeper. However, in this area there also occur undulatory sheets of dolerite, with shallow and variable dips. These are found south-west of Umbeara Homestead.

Because of the short time available for mapping this area of granite and gneiss, and for describing the thin sections, it has only been possible to give a very introductory account of the rock-types present, their natures, and distributions. However it is clear that this small part of the Musgrave Block contains a number of interesting rocks, and several equally interesting problems. An understanding of the formation of the gneiss, and the subsequent emplacement of the granites, awaits a detailed petrological and structural study, as far as the scanty nature of the exposures will allow.

UPPER PROTEROZOIC

Bitter Springs Limestone

The Bitter Springs Limestone was defined by Joklik (1955) in the following terms:- 'The Heavitree Quartzite is in most places overlain by a thick formation of limestone which is here named after the excellent exposures in Bitter Springs Gorge'. The type locality is Bitter Springs Gorge. The Bitter Springs Limestone occurs in a few small outcrops on the Ayers Rock, Kulgera and Finke Sheet areas. The identification of the outcrops of dolomite in the south-eastern part of the Amadeus Basin is based on their lithology and stratigraphic position beneath the Inindia Beds. The Inindia Beds are correlated with the Areyonga Formation. In the MacDonnell Range the Bitter Springs Limestone lies between the Heavitree Quartzite below and the Areyonga Formation above.

No lower contacts of the formation are visible in the area studied and it is disconformably overlain by the Inindia Beds or unconformably overlain by the Ordovician Stairway Sandstone, the Cambrian Pertaoorrta Formation and the Palaeozoic Langra Formation. Outcrops of the Bitter Springs Limestone are poor and are generally in the form of low hills or mounds.

The Bitter Springs Limestone crops out in the core of an overturned anticline, 23 miles north-north-east of Curtin Springs Homestead, where it is unconformably overlain by the Stairway Sandstone. Several isolated outcrops of the formation are exposed on the alluvial plain north of the Kernot Range but show no contacts with younger formations.

The outcrop of Stairway Sandstone, in an east-west trending ridge, 3 miles south of Angas Downs Homestead, dips to the south unconformably off several small outcrops of Bitter Springs Limestone. In these small outcrops the formation is intricately folded with, and disconformably overlain by, the Inindia Beds.

The best exposure of the Bitter Springs Limestone are in two outcrops in the core of the Erldunda Range. At this locality the formation is disconformably overlain by the Inindia Beds and overlain by conglomerate and greywacke of the Pertaoorrta Formation with an angular unconformity.

One small poorly exposed outcrop of Bitter Springs Limestone in the Black Hill Range in the Finke Sheet area occurs near outcrops of the Inindia Beds and is unconformably overlain by the Palaeozoic Langra Formation.

The Bitter Springs Limestone consists predominantly of dolomite with a few interbeds of calcareous dolomite and limestone. The dolomite is commonly dark blue-grey, with red, pink, maroon and purple-brown varieties and mostly fine-grained and some medium and coarse-grained. Oolitic dolomite is found at some localities. Some of the dolomite contains abundant coarse sand grains and most specimens have some blebs or thin laminae of fine sand grains. The beds are laminated or thin and there are interbeds of grey thin-bedded siltstone and medium, friable sandstone in the Erldunda Range. A small thickness of thin-bedded, silty, fine, silicified, dark purple-brown sandstone with pseudomorphs after halite occurs above the dolomite in the western exposure in the Erldunda Range. This sandstone sequence is tentatively placed in the Bitter Springs Limestone. In nearby areas the dolomite of the formation is overlain by chert and sandstone of the Inindia Beds, suggesting erosion of the top of the Bitter Springs Limestone. Irregular chert bands,laminae,and lenses are common in most outcrops of the formation. Possible stromatolites are present in the Erldunda Range and well preserved stromatolites are present in the outcrop in the Black Hill Range.

A thin section of a sample from the Bitter Springs Limestone from a locality north of the Kernot Range shows a fine grained dolomite, partly recrystallised and partly replaced by chert. Fine subangular quartz up to 1 mm. across is present and the rock is in part oolitic with the oolites set in a coarser, recrystallised, dolomitic matrix.

A thin section of the dolomite from Ippia Hill shows small masses of fine carbonate surrounded by coarser crystalline dolomite. The slide shows unevenly distributed fine sand and silt in irregular pods. The coarser carbonate and quartz may be introduced void filling materials. Iron staining is common and is probably the cause of the red colouration of the rock.

The thickness of the Bitter Springs Limestone in this part of the Amadeus Basin cannot be estimated from the incomplete exposures. The formation is a shallow marine deposit on a stable epicontinental shelf. The mapped outcrops indicate deposition over the whole of the Amadeus Basin and there are indications, mainly from exposures outside the Amadeus Basin, that the formation was probably deposited well beyond the present limits of the Basin. The Bitter Springs Limestone is thought to be Upper Proterozoic in age as it is overlain by both several thousand feet of sediments also thought to be Precambrian in age, and by Cambrian rocks with a pronounced angular unconformity. The only fossils found are stromatolites.

Inindia Beds

The Inindia Beds, as defined by Wells, Ranford, and Cook (1963) is 'the sequence of siltstone, sandstone, chert, chert breccia, and thin beds of dolomite which disconformably overlies the Bitter Springs Limestone and is overlain, probably unconformably by the Winnall Beds'. The name is derived from Inindia Bore in the south-east corner of the Lake Amadeus Sheet area and 25 miles east of Angas Downs. There is no type section, and the true maximum thickness is unknown.

The Inindia Beds are exposed discontinuously from about 20 miles north-west of Curtin Springs on the Ayers Rock Sheet area, across the northern part of the Kulgera Sheet area to Black Hill, 4 miles north-east of Mt. Watt on the Finke Sheet area. The most southerly exposures are around Mt. Conner and at Mt. Kingston. Most of the outcrops are poor, and are mostly mounds of chert and jasper fragments with low ridges of sandstone. Other mounds consist of pale silicified siltstones. Some better exposures do occur, notably at the prominent ridge 12 miles north-east of Curtin Springs, the circular strike ridges around Mt. Conner, and at the isolated ridges 4 miles west of Pulcura Well near the middle of the Kulgera Sheet area.

Stratigraphically, there is no conclusive evidence on the relationship of the Inindia Beds with the underlying Bitter Springs Limestone. In the few places where the two have been seen in contact, i.e. in the Erldunda Range and 12 miles south-east of Angas Downs, the units are apparently conformable. However, at a number of localities a tillite horizon is exposed in the Inindia Beds, and in this tillite numerous small erratics have been found in situ, consisting of silicified brown dolomite, chert, and siltstone, all of which can be correlated with rock types in the Bitter Springs Limestone. Therefore, as there is no angular discordance between the Inindia Beds and the Bitter Springs Limestone, the contact of the two is probably disconformable. At one locality 7 miles west of Angas Downs, a sandstone ridge in the Inindia Beds dips south at 30°, apparently taking it beneath a large mass of Bitter Springs Limestone immediately to the south. However this locality is in the core of an anticline, and there may have been local overturning.

At only one locality, at the eastern end of the Basedow Range, are the Inindia Beds seen close to the next overlying unit, the Winnall Beds. Here, a small exposure of coarse, white, kaolinitic sandstone and siltstone of the Inindia Beds underlies the closely jointed, dark-brown, blocky siltstone of the lower part of the Winnall Beds. The two formations strike parallel to each other, but no dip is determinable in the Winnall Beds, so that evidence for an angular concordance or discordance is lacking. At several other localities, notably along the north side of the Basedow Range, the exposures of Inindia Beds have a dip and strike close to that of the overlying Winnall Beds to the south, and along the north side of the Kernot Range, the strike and dip of the two formations is the same. However close by on the neighbouring Henbury Sheet area, on the northern side of the Liddle Hills near the western end, an outcrop of kaolinitic sandstones and siltstones of the Inindia Beds strikes at 140° while a few yards to the south the Winnall Beds strike 110°. Along the southern side of the Liddle Hills, the Inindia Beds strike at an angle to the Winnall Beds, while at the eastern end of the Liddle Hills, the two formations have parallel strikes but different dips. Definite unconformities therefore do exist between the two formations, and it seems that the Inindia Beds are in places apparently conformable beneath the Winnall Beds, while in other places they are unconformable.

At the Angas Downs aerodrome on the Henbury Sheet area, in a small area 24 miles north-east of Mt. Ebenezer Homestead, and in the Erldunda Range, the Inindia Beds are unconformably overlain by the conglomerate of the Pertaoorrta Formation. At many other localities, mostly on the Ayers Rock Sheet area, the Inindia Beds are found unconformably beneath the Stairway Sandstone, and this relationship extends well on to the Kulgera Sheet area, as far east as the eastern end of the Basedow Range. Actual exposures of the unconformity surface are few, but the very different natures of the lithologies of the two units enables the position of the unconformity to be located within a few feet.

The Inindia Beds have a mixed lithology, but sandstones and siltstones are the most common rock types, with small amounts of chert, dolomite, and tillite. In the whole sequence of Inindia Beds, as deduced from several localities (Table 2), there are at least eight sandstone intervals of different thicknesses but usually less than 100'. These sandstones are white to yellow-brown, slightly kaolinitic, generally medium to coarse-grained but with some fine-grained beds, medium-bedded and blocky, moderately tough to friable. One of the thicker friable sandstones near the middle of the sequence possesses well-developed pseudo-pebbles, where patchy silicification has formed spheroidal concretions up to one inch across. The two sandstone units highest in the sequence form the outer and inner concentric strike ridges around Mt. Conner. The inner ridge is coarse-grained, friable, strongly cross-bedded and contains some angular granules of chert. In thin section the sandstones are mostly orthoquartzites (Pettijohn, 1957, p.295), composed of grains of quartz and chert, in places with a small amount of siliceous cement. Some subgreywacke also occurs.

The lowest observed sandstone near the base of the Inindia Beds is conglomeratic in places, with granules and pebbles of chert, reef quartz, and jasper, both well rounded and poorly rounded in the one bed. In some exposures the amount of angular pebbles becomes great enough to form a chert breccia. The sandstone matrix is often manganiferous and blue-black, while in other places a certain content of oolitic hematite is found.

The siltstones are mostly white and pale cream, yellow, pink, and yellow-brown. The rocks are laminated to thin-bedded, kaolinitic, in places micaceous, moderately tough, often with a sub-conchoidal fracture. Claystone occurs commonly with the siltstone, and the thin sections show laminae with siltstone grading into claystone. Other siltstones are poorly sorted and sandy. Some shales also occur with the siltstones, but are not common.

Most of the cherts in the Inindia Beds occur in the middle of the sequence, but some thin alternating beds of chert and sandstone occur near the base. The chert is vari.-coloured and the commonest varieties are red, green and yellow, irregularly laminated and splintery; massive, cloudy, blue-white, fractured; white, oolitic; black, oolitic commonly with quartz geodes; and a pale grey and white, thin-bedded type.

Dolomite was found <u>in situ</u> in the Inindia Beds at only two localities. At the prominent ridge 12 miles north-east of Curtin Springs, the dolomite occurs at the top of the exposed sequence as a pale pinkish-brown, tough, laminated rock, interbedded with yellow-brown siltstones. The other locality is at the prominent strike ridge 4 miles west of Pulcura Well, where the dolomite is overlain by a white sandstone and then by tillite. This sandstone is correlated with the outer arcuate ridge around Mt. Conner.

The tillite is well exposed at three localities. Four miles west of Pulcura Well, and beneath the scarp of the inner sandstone ridge on the north-eastern side of Mt. Conner, the tillite consists of non-bedded, poorly sorted, yellow-brown, tough siltstone, with angular quartz grains up to half-an-inch across in the matrix and containing numbers of erratics <u>in situ</u> of quartzite, black oolitic chert, red jasper, siltstone (with striations), and banded chert. Many rounded erratics are broken. Beneath the same scarp on the north-western side of Mt. Conner, erratics include pieces of yellow-brown, silicified dolomite containing replacement black chert. In the Erldunda Range the tillite is similar, but in places lacks erratics and is very clayey.

About 1700 feet of Inindia Beds was measured in a section (KW-9, Plate 1) 12 miles north-east of Curtin Springs. In this section the sediments above the dolomite are eroded. An air-photo estimation of the thickness of the sandstones and siltstones around Mt. Conner gives a figure of about 4,500 feet, and this with an estimated thickness of 500 feet for the red-brown siltstones below the measured section makes a total possible thickness of about 7,000 feet for the Inindia Beds. The known sequence of the Inindia Beds is shown in Table 2.

The greater part of the Inindia Beds are probably marine sediments, in view of the considerable thicknesses of sandstone and siltstone with no cross-bedding, and the existence of chert and dolomite in the sequence. The actual environment of deposition is not known, but the water may have been of an intermediate depth on a shelf area. Towards the end of deposition of the Inindia Beds sequence, glacial conditions prevailed, on the evidence of the tillite. The overlying thick, cross-bedded, coarse-grained sandstone may indicate deposition under continental conditions. Unfortunately the rocks directly below the tillite are exposed only at the locality 4 miles west of Pulcura Well: the tillite here is underlain by about 200' of white, medium-grained, kaolinitic sandstone which becomes coarser, more poorly sorted and contains some angular chert fragments towards the top. It is thus similar, though without the cross-bedding, to the inner sandstone ring above the tillite at Mt. Connor, but whether it is a continental sandstone is not certain. A detailed study of rock types and their occurrence is necessary before more precise ideas on the origin of the Inindia Beds can be given.

No fossils have been found in the Inindia Beds, but from their unconformable relation with the overlying Winnall Beds and their probably disconformable junction with the underlying Bitter Springs Limestone, the Inindia Beds are placed in the Upper Proterozoic. They are correlated with the Areyonga Formation in the northern part of the Amadeus Basin mainly on the existence of the tillite horizon.

Table II

Sequence in the Inindia Beds

Thickness	Lithology	Remarks
Top of sequence		
ca. 1,000'	Sandstone, white, red-brown, and orange, laminated to thin bedded, cross-bedded, coarse to medium-grained, poorly sorted, well rounded to poorly rounded, friable, kaolinitic, porous, with lenticles of quartz and chert granules.	Forms inner strike ridge around Mt. Conner.
ca. 75'	Tillite, yellow to off-white, non-bedded, coarse to fine-grained, poorly sorted to unsorted, poorly rounded, tough, irregularly jointed, clayey, with erratics, some striated.	Exposed directly below inner sandstone ridge around Mt. Conner, in Erldunda Range, and 4 miles west of Pulcura Well.
ca. 3,000'	Covered interval.	
ca. 650'	Sandstone, white, laminated, fine-grained platy, clean, silicified. Higher in section, rock becomes thin bedded, poorly rounded and kaolinitic. Near the top of the ridge, rock is medium-grained, poorly sorted, clean, blocky, and friable.	Forms outer partial strike ridge around Mt. Conner.
27'	Siltstone, cream, yellow, and brown with thin beds of yellow and purple, fine-grained, medium bedded dolomite near top.	Occurs at top of KW-9 section 12 miles NE. of Curtin Springs, and below sandstone ridge, 4 miles west of Pulcura Well.
163'	Covered interval	
76'	Sandstone, medium-grained, poorly medium bedded, with large clay pellets.	
76'	Siltstone, white and grey, gypsiferous.	
114'	Covered interval.	

Thickness	Lithology	Remarks
22'	Sandstone, white, fine-grained, poorly sorted, with coarse sand streaks and siltstone fragments.	
92'	Covered interval.	
11'	Chert, golden-brown	
182'	Siltstone, weathered, limonitic with irregular patches of chert.	
22'	Sandstone, yellow, fine-grained, medium bedded.	
39'	Shale, grey laminated.	
226'	Covered interval.	
88'	Sandstone, pale brown to white, medium-grained, with pseudo-pebbles.	
148'	Sandstone, pale brown, thin bedded, medium-grained, platy in middle section; medium bedded and kaolinitic near top.	
68'	Siltstone, yellow and white, thin bedded, with a few beds of ferruginous sandstone and of fawn, poorly sorted, medium-grained sandstone.	
312'	Chert and sandstone, interbedded, and some siltstone. Mostly covered.	Interpolated into section KW-9.
25'	Sandstone, grey and purple-brown, in places manganiferous.	In places contains many chert pebbles, angular or rounded.
ca. 500'	Siltstone, red-brown.	Occurs below bottom of section KW-9.

Base of sequence.

Winnall Beds

Most of the prominent topographic features in the area, i.e. Mount Conner, Kernot, Basedow, and Erldunda Ranges (Fig.9) Mount Kingston, and Black Hill Ranges are made up of the Winnall Beds. The Beds were defined by Wells, Ranford and Cook (1963) as "the sequence of siltstone, sandstone and pebbly sandstone which lies unconformably above the Inindia Beds and unconformably below the Pertaoorrta Formation, Cleland Sandstone, and Larapinta Group". In the south-east part of the Amadeus Basin the Beds show the same stratigraphic relationships except that at one locality at the eastern end of the Kernot Range the Beds are overlain unconformably by the Mereenie Sandstone and in the Black Hill Range are unconformably overlain by the Palaeozoic Polly Conglomerate and Langra Formation. The Cleland Sandstone is not present in the south-east Amadeus Basin. The unconformities between the Winnall Beds and younger units are well marked and may be traced for considerable distances. The unconformity between the Stairway Sandstone and the Winnall Beds in the Basedow Range can be traced continuously for nearly fifteen miles.

The sandstone units of the Beds are relatively resistant and form high strike ridges. The siltstone units of the Beds are easily weathered and either crop out on hill slopes beneath the sandstone ridges or as rubble on low rises. As well as the localities mentioned above, the Winnall Beds occur in a ridge on the north-east corner of the Ayers Rock Sheet area, and in a small downfaulted block in an unnamed group of hills seventeen miles south of Mount Ebenezer, and four miles west of Pulcura Well.

Wells et al (1963) described three units in the Winnall Beds; upper and lower siltstone units, and a middle sandstone unit. Only the two basal units are present in outcrops in the south-east part of the Amadeus Basin. A fourth unit of the Winnall Beds, a younger sandstone unit, has been mapped in the Liddle Hills in the south-west part of the Henbury Sheet area but does not crop out farther south.

The lower siltstone unit is well exposed on the flanks of Mount Conner. It is made up of dark purple-brown, thin bedded, friable, siltstone and fine, silty sandstone followed by slightly calcareous, dark purple-brown, black, fine sandy, siltstone which is poorly, thin and medium bedded and contains some clay and rock fragments.

The middle sandstone unit of the Winnall Beds forms the prominent cliffs of Mount Conner. The sandstone is separated from the lower siltstone unit by about 15-20 feet of conglomerate which consists of rounded and subrounded pebbles of silicified sandstone and black and white chert set in a poorly sorted matrix of sand. The conglomerate occurs in beds four to five feet thick with interbeds of sandstone. The overlying middle sandstone unit is pink, silicified, poorly thick bedded, in places cross-bedded, medium-grained, with a few slump structures and some subrounded pebbles and thin beds with weathered-out pellets. The sandstone capping Mount Conner is white, silicified and poorly sorted. It contains some flat ellipsoidal clay pellets.

The basal siltstone of the Winnall Beds occurs in a small downfaulted block between outcrops of the Inindia Beds 17 miles south of Mount Ebenezer. The sediments consist of thin bedded, dark brown, silty sandstone which is in part calcareous, and interbedded dark brown, silty, thin bedded sandstone and siltstone. There is some fine, white and yellow-brown, tough sandstone inter-bedded with the dark brown variety. The dark brown sandstone splits into rhomboidal joint blocks, about three inches across.

The middle sandstone unit is well exposed in the large ranges. Two divisions of the sandstone are apparent in the more complete exposures. The lower unit is a thick bedded, cross-bedded, pink, medium sandstone with convolute laminations, a few heavy mineral laminae and current lineations. These beds are overlain by a thinner section of finer grained, thin bedded to laminated, white sandstone with abundant ripple marks and numerous bedding plane markings.

In many places, particularly near the top of the sandstone unit, casts of sand with a tubular shape, usually flattened, and gently tapering at either end, cover the bedding planes (Fig.7). The casts have irregular branches and one cast may cut across the path of another. Several casts show signs of a small meridi-onal groove or depression. The casts are from two to four millimetres across and gently curved or sinuous. There is a clear cut boundary with the underlying sediment, and there appears to be no penetration into the underlying substrata. Similar markings have been described from the Winnall Beds on the Lake Amadeus Sheet area and were compared with "synaeresis" cracks which have been described by White (1961). They are attributed to fissures that develop in a suspension where water is expelled from the clay - water system by internal forces. They resemble mud cracks in the sediments. Frarey and McClaren (1963) describe fossil relics, as internal casts with tubes, which occur on a ripple marked surface of a fine arkose of Huronian age (Lower Proterozoic) from the Canadian Shield. Frarey and McClaren discount the hypothesis of a dessication crack origin because of the absence of clay or

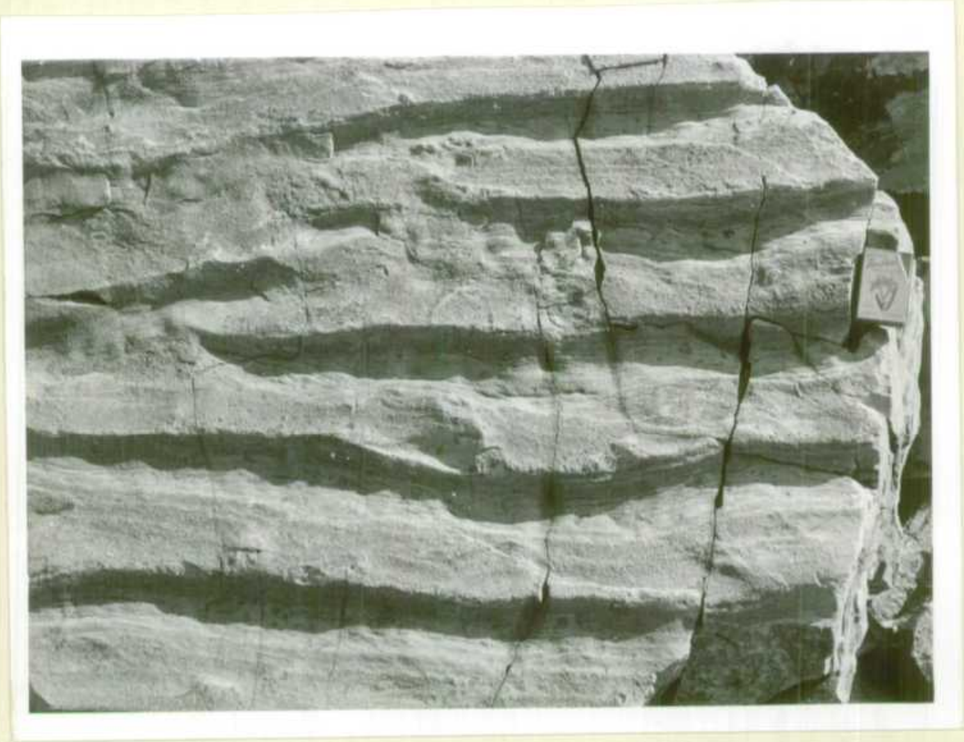


Fig.6. Cut and fill structures in sandstone of the Winnall Beds, Basedow Range.
Neg.No.M331-11.

Fig.7. Possible organic trails in ripple marked, silicified sandstone of the Winnall Beds, Basedow Range.
Neg.No.M331-19.

argillaceous material in the beds, the clear separation of cast and substratum, the flattened form with a longitudinal groove, the consistent diemnsions of the rods, and the overlap of one cast by another without any mutual deformation. Similar considerations apply to the markings in the Winnall Beds and although they cannot be definitely attributed to worm casts or feeding burrows they appear to be fossil remains.

The upper part of the lower sandstone unit of the Winnall Beds has many types of depositional features including cut and fill structures (Fig.6), flow casts, current lineation, ripple marking, and convolute lamination. In places the lower siltstone unit of the Winnall Beds may be absent and the sandstone/rests with an angular unconformity on the Inindia Beds.

In the Mount Kingston, Black Hill Range area the Winnall Beds crop out in strike ridges nearly fifty miles long. There is considerable change in the lithology of the sediments along this ridge. In the western part of the outcrop near Mount Kingston the sandstone is light coloured, medium and thin bedded with silt pellets and minor interbeds of siltstone. In the Black Hill Range area and at Horseshoe Bend the proportion of shale has increased greatly to become the dominant lithology. The shale and interbedded siltstone are grey, grey-brown, purple-brown and green, and both, together with some interbeds of fine, dark sandstone, contain abundant grains of bright green glauconite. The glauconite grains may be arranged either in thin laminae or rarely in small clotlike masses. The sediments in this area bear a close resemblance to the siltstone of the Pertatataka Formation. The beds show abundant flow casts and clay pellets.

By stratigraphic position the Winnall Beds are correlated with the Pertatataka Formation and are probably Upper Proterozoic in age. The decrease in grain size of the sediments to the north and east suggests derivation of the sediments from areas in the south and west, probably mainly from provinces on the southern parts of the Kulgera and Ayers Rock Sheet areas. The sedimentary structures preserved indicate rapid deposition and strong current action.

A thickness of over 2,000 feet was measured, mainly in the middle sandstone unit, at Ippia Hill (KW-7, Plate 1). The thickness is approximate because of the large variation in dips, particularly in the lower part of the unit where siltstone is interbedded with sandstone.

CAMBRIAN

Pertaoorrta Formation

The Pertaoorrta Formation (Wells et al. 1963) was redefined from the term Pertaoorrta Group (Prichard and Quinlan 1962). This redefinition was considered desirable because although the Group was recognisable away from the type locality the formations were not, and instead of defining new groups at each new locality it was thought preferrable to change the nomenclature from a group to a formation and define new constituent members where necessary. The Pertaoorrta Formation is defined by Wells et al. (1963) as - "the sequence of interbedded siltstone, sandstone, dolomitic limestone, shale and quartz greywacke which lies conformably beneath the Pacoota Sandstone and both conformably and unconformably above the Pertatataka Formation. The type locality of the Pertaoorrta Formation is in the MacDonnell Ranges near Ellery Creek and the unit includes both the 'Pertaoorrta Group'/and Arumbera Greywacke' of Prichard and Quinlan (1962)".

In the south-eastern part of the Amadeus Basin the rocks identified with the Pertaoorrta Formation have changed considerably in lithology, and the main rock types present are conglomerate, coarse sandstone, greywacke, siltstone and dolomite. The formation is identified by its stratigraphic position. None of the rocks is fossiliferous.

In the Kulgera Sheet area the Pertaoorrta Formation overlies the Bitter Springs Limestone, the Inindia Beds and the Winnall Beds with an angular unconformity and is overlain with a regional unconformity by the Ordovician Stairway Sandstone. Although in several sections the Pertaoorrta Formation and the overlying Larapinta Group rocks have a similar attitude it is apparent that an erosional interval separates the two units and in most places there is a conglomerate at the base of the Stairway Sandstone.

Outcrops of the Pertaoorrta Formation are poor. It is exposed in small mounds and hills north and east of the Basedow Range, and in the Erldunda and Mount Sunday Ranges. One small outcrop of pebble conglomerate doubtfully referred to the Pertaoorrta Formation is present on the north-east corner of the Ayers Rock Sheet area.

The outcrops of the Pertaoorrta Formation in areas near Angas Downs and to the east as far as the Erldunda Range are predominantly conglomerate, quartz greywacke, silty sandstone and some clayey siltstone; the sediments are mostly poorly sorted and contain abundant rock fragments, clay pellets and lenses. The conglomerate contains pebbles, cobbles and boulders made up predominantly of silicified sandstone. Some boulders are five feet across. The phenoclasts are well rounded to rounded, poorly sorted and enclosed in a matrix of extremely poorly sorted, coarse, kaolinitic, purple-brown greywacke. The phenoclasts of silicified, white and red-brown sandstone in the conglomerate are derived from the Winnall Beds. Many chert fragments, lithologically similar to the chert in the Inindia Beds, are also present.

The greywacke is purple-brown, poorly sorted, coarse and medium, with small angular rock fragments and angular grains, abundant silt and clay matrix, and with subrounded to rounded pebbles. Friable, red-brown and purple-brown siltstone is present as interbeds in the sequence.

In places the sandstone of the formation is thin bedded, finely kaolinitic, purple-brown or white, silicified or friable, with clay pellets. The sandstone is mostly moderately well to poorly sorted, medium to coarse-grained with small cross-beds, and small angular clay and rock fragments. In many of the outcrops visited the sandstone is in sharp contact with the overlying conglomerate (Fig.8).

The conglomerate, greywacke, sandstone and siltstone are exposed in small outcrops in the area between the north-east of the Ayers Rock Sheet area and the Erldunda Range. However, in the Mount Sunday Range the sediments are predominantly red-brown, chocolate, green, grey, purple-brown and grey-brown siltstone and grey-green siltstone, with thin interbeds of grey and white, fine-grained, slightly calcareous dolomite. The siltstone shows some bedding plane markings. The dolomite contains some secondary chert. It is mostly laminated to thin bedded but weathers medium bedded. In the eastern part of the Mount Sunday Range there is a thin sequence of poorly sorted, silty, orange and brown sandstone, arkose, and pebble beds above the section of siltstone and interbedded dolomite. The phenoclasts in the pebble conglomerate are up to 6 inches across and made of granite, mica schist, pegmatite, quartzite, quartz, and some purplish dolomite. The arkose has abundant angular pink feldspar, and clear quartz grains.

An incomplete section measured in the sandstone, siltstone and dolomite of the Pertaoorrta Formation at Mount Sunday gave a thickness of about 260 feet. A section measured in the conglomerate sandstone and siltstone in the Erldunda Range gave a

Fig. 8. Conglomerate and underlying sandstone of the Pertaoorrta Formation in the eastern part of the Erldunda Range. Neg.No.G/6276

Fig. 9. View looking north-east over the Erldunda Range from Ippia Hill. Winnall Beds in foreground.
Neg.No.G/6304

complete thickness of 370 feet between the Bitter Springs Limestone below and the Stairway Sandstone above.

The type of sediments and their changes laterally suggest that this area was the margin of Cambrian marine sedimentation with deposition predominantly of coarser near-shore clastics. The transition from shore-line type of deposits to marine sedimentation is probably marked by the change from coarse clastics in the Erldunda Range to dolomite and fine clastics in the Mount Sunday Range.

The age of the sediments can only be deduced from their stratigraphic position and they are assigned a Cambrian age. The units cannot be correlated with any certainty with the described members of the Pertaoorrta Formation from neighbouring areas. The lack of any fossils in the sediments also precludes any precise age determination. Conglomerate at the base of the Cambrian sequence is present on the Henbury Sheet area but there is no evidence to suggest that it is the same age as the Cambrian conglomerate at the southern margin of the basin. The marginal conglomerate may represent a late transgressive stage and could be Upper Cambrian in age. In a similar fashion the siltstone and dolomite in the Mount Sunday Range area can be correlated lithologically with the basal part of the Jay Creek Limestone Member on the Henbury Sheet but it is not necessarily the same age. The arkose and conglomerate overlying the siltstone and dolomite could be part of the interfingering shore-line and marine zone as already mentioned.

ORDOVICIAN

LARAPINTA GROUP

The Larapinta Group as formerly defined by Prichard and Quinlan (1962) is made up of four formations which are, in ascending order, the Pacoota Sandstone, Horn Valley Formation, Stairway Greywacke and Stokes Formation. The name Stairway Greywacke was revised to Stairway Sandstone by Wells, Forman and Ranford (1962) and the Horn Valley Formation to Horn Valley Siltstone by Wells, Ranford and Cook (1963). Of these Larapinta Formations only the Stairway Sandstone and Stokes Formation are present in the south-east part of the Amadeus Basin.

Stairway Sandstone

Prichard and Quinlan (1962) state 'The formation of quartz greywacke and quartz sandstone which at Ellery Creek conformably overlies the Horn Valley Formation, and is there followed unconformably by the Mereenie Sandstone, does not appear to have been formally named, although Chewings (1935) referred to it in a Table as 'Stairway Quartzite'. It is here named the Stairway Greywacke'. The formation was redefined as Stairway Sandstone by Wells et al. (1962).

In the south-east part of the Amadeus Basin the Stairway Sandstone unconformably overlies the Bitter Springs Limestone, the Inindia Beds and the Winnall Beds and lies disconformably on the Cambrian Pertaoorrta Formation. It is overlain conformably by the Stokes Formation or in places unconformably overlain by Mesozoic deposits. The exposures of the lower unconformity are well defined structural features and on the air-photos are prominent lineaments which can be traced for several miles.

The formation crops out in the Curtin Springs area in the west and as far east as Mt. Watt. The most southerly outcrops are those small exposures 17 miles south of the Basedow Range and on the south side of Mt. Kingston. The formation crops out mostly as low strike ridges and small hills, with one exception in the north-east part of the Kulgera Sheet where the Stairway Sandstone forms the high ridges and hills of the Mt. Sunday Range.

The Stairway Sandstone comprises medium and fine, white, thin and medium bedded sandstone, coarse, cross-bedded, orange, yellow and white sandstone and minor interbeds of kaolinitic, fine sandstone, siltstone and conglomerate. Pellet phosphate occurs in lensing bodies in parts of the formation and large phosphate pellets occur in the basal conglomerate in the Mt. Sunday Range.

The lower part of the formation, at most localities in the south-east part of the Amadeus Basin, is made up of yellow, orange and white sandstone, and is coarse-grained, in places bimodal, poorly sorted and bedded, with large cross-beds and thin beds of coarse, angular sand. Where the formation unconformably overlies Upper Proterozoic rocks a thin basal conglomerate, 2-3 feet thick, has angular fragments from the underlying beds. The fragments are mostly 3"-4" across, and some up to 6", and consist commonly of chert, silicified sandstone and some siltstone. The matrix is a siliceous, poorly sorted, coarse sand. In many places near the unconformity with Upper Proterozoic formations the Stairway Sandstone is slickensided and quartz veined. The disconformable contact with the Pertaoorrta Formation is marked by a thin basal conglomerate, 1-2' thick, made up mainly of angular, white quartz and quartzite averaging ½" across and a few pink feldspar fragments and black biotite flakes in a coarse, angular, sand matrix. The conglomerate is well exposed in the Mt. Sunday Range and in several places contains dark-grey, and some smaller brown, phosphate pellets up to 3" across of flattened ovoid shape or irregular outline. Some of the beds in the basal sandstone contain abundant worm burrows, "pipe-rock" and some bedding planes are covered with a multitude of invertebrate tracks including Cruziana (Fig.10). Some of the vertical U-shaped burrows can be referred to Diplocraterion. A similar coarse basal part of the Stairway Sandstone on the south-east part of the Lake Amadeus Sheet area was doubtfully referred to the Pacoota Sandstone (Wells et al., 1963) but it is now apparent that the Pacoota Sandstone is absent in these sections and the Stairway Sandstone rests unconformably on older Precambrian units. At many localities the basal few feet of the Stairway Sandstone is deeply silicified and the rock breaks with a conchoidal fracture. This rock has been used in several places by aborigines for the manufacture of tools.

The medium and fine sandstone overlying the basal coarser sandstone is richly fossiliferous and also has abundant bedding plane markings including "dingo-paws" (Fig.11) and Cruziana. This sandstone has some interbeds of kaolinitic and some ferruginous, fine sandstone and coarser sandstone (in places phosphatic) and siltstone. The sandstones have clay pellets in some thin beds. Most of the sandstone is silicified to varying degrees. The marine fossils include pelecypods, brachiopods, nautiloids and trilobites.

Pseudomorphs of fine sand after halite were found in a fine, poorly thin bedded, silicified, white sandstone 4 miles south-west of Mt. Ebenezer. The sandstone has abundant tracks and trails on bedding planes.

A small outcrop of Stairway Sandstone, about 40 feet thick, overlies the Winnall Beds with an angular unconformity at Mt. Watt. The highest beds are fossiliferous, silicified, tough sandstone, overlying friable, white and orange-brown, fine sandstone. The lowermost beds are coarse, rounded sandstone with a thin conglomerate, containing subrounded to subangular pebbles of white quartz up to about 2 inches across, at the unconformity. On the south side of the Mt. Kingston Range silicified and fractured beds of the Stairway Sandstone crop out in a small strike ridge, and the beds are overturned to the north.

Several sections were measured through the Stairway Sandstone. It is 350 feet thick in KW-1 in the Mt. Sunday Range and 220 feet thick in KS-1 in the Erldunda Range. Two sections were measured in the formation 12 miles north-east of Curtin Springs Homestead. 150 feet of the formation was measured in KW-10 where there is a good upper contact with a sandy dolomite of the Stokes Formation. At KW-8 the upper limit of the formation is poorly defined and an accurate thickness is not possible. About 170 feet of the formation is exposed. Measured

Fig.10. Cruziana and other tracks and trails in the basal part of the Stairway Sandstone, western end of the Basedow Range.
Neg.No.G/6301

Fig.11. "Dingo-paws" in the Stairway Sandstone, north of Curtin Springs Homestead.
Neg.No.G/6308

sections KW1, KW8, KW10 and KS1 are shown on Plate 3.

The abundant fossils in the Stairway Sandstone indicate an Ordovician age. They also indicate that only the upper part of the formation was deposited in the south-east part of the Amadeus Basin (Joyce Gilbert-Tomlinson, pers.comm.). The fossil assemblage from Mt. Watt is considered by Joyce Gilbert-Tomlinson (pers.comm.). to be anomalous. The earliest possible age of this fauna is early middle Ordovician.

The abundance of fossils and the presence of halite pseudomorphs indicate deposition in a shallow marine, stable shelf environment. The increased coarseness of the sediments and the fact that only the upper part of the formation was deposited indicates a transgressive shoreline deposit with sediments probably derived from a terrain of Upper Proterozoic and Precambrian rocks which lay to the south. Parts of the basal conglomerate of the formation indicate derivation from a not too distant granitic terrain.

Stokes Formation

The Stokes Formation (Prichard and Quinlan, 1962) is "the formation of siltstone and fine-grained, silty greywacke which conformably overlies the Stairway Greywacke and is disconformably succeeded by the Mereenie Sandstone and is the top formation of the Larapinta Group". In the south-east Amadeus Basin the upper and lower boundaries of the Stokes Formation are not well exposed. There is a sharp contact between the sandy dolomite at the base of the Stokes Formation and the siliceous, fine sandstone of the Stairway Sandstone twelve miles north-east of Curtin Springs Homestead. The contact with the Mereenie Sandstone is in most areas apparently conformable and gradational in that at the base of the Mereenie Sandstone there is interbedded siltstone and sandstone. The top of the Stokes Formation is arbitrarily taken as the base of the first prominent bed of sandstone. This sandstone bed forms a small scarp or ridge at most exposures and may be succeeded by thin siltstone beds and then by the main body of sandstone of the Mereenie Sandstone.

The sediments of the formation are easily weathered and usually underly alluvium in small strike valleys. In places it is exposed on hill slopes beneath ridges of the Mereenie Sandstone or rarely as rubbly outcrop on alluvial flats. The dolomite beds are more resistant and may form low strike ridges. Poor exposures of these formations are present on the northern part of the Kulgera Sheet area, north of Curtin Springs Homestead and in one outcrop eighteen miles south of the Basedow Range.

The Stokes Formation consists of variegated, thin bedded and laminated siltstone, interbedded minor fine sandstone and calcareous sandstone, and thin beds of silty and sandy dolomite. The calcareous part of the formation is usually towards the base. Most outcrops of the siltstone show pseudomorphs of the enclosing sediment after halite.

Marine macrofossils, mainly pelecypods, were collected from a sandy dolomite at the base of the formation north-east of Curtin Springs and from a green siltstone in the Mount Sunday Range.

The most complete measured section through the formation is twelve miles north-east of Curtin Springs Homestead. This section is 400 feet thick and is shown in KW8 (Plate 3). The base of the formation in this section is not exposed. The total thickness of the Stokes Formation here may be up to 490 feet if the base of the formation is in the same relative position as in section KW10 nearby (Plate 3). A thin bed of fossiliferous sandy dolomite marks the base of the formation at this locality. In the outcrop 18 miles south of the Basedow Range the sediments are interbedded pale blue-grey and pale red, laminated siltstone and thin and medium beds of pink and purple-brown, silty dolomite. The dolomite has abundant worm markings but no macrofossils were found. The Stairway Sandstone at this locality is overlain by a siltstone of the Stokes Formation. The siltstone has abundant pseudomorphs after halite. A thin sequence of Stokes Formation in the Mount Sunday Range consists of thin bedded, light grey, silty dolomite interbeds in a variegated siltstone. Both have halite pseudomorphs. The dolomite contains abundant small pelecypods. A chocolate, poorly bedded, haematitic siltstone at the top of the formation is conformably overlain by the Mereenie Sandstone.

The thickness of Stokes Formation measured in KW1 (Plate 3) is about 50 feet. In other exposures of the formation in the Mount Sunday Range the formation is much less than 50 feet thick and is represented by a few thin beds of silty red-brown and grey, fine-grained, medium bedded sandstone and some interbeds of siltstone.

The Stokes Formation is a shallow marine deposit of Upper Ordovician age. The thickness variations of the formation at different localities indicate that the limit of deposition of the Stokes Formation probably lay just south of the Mount Sunday Range but probably transgressed a good deal further south in the central part of the Kulgera Sheet area.

UNDIFFERENTIATED PALAEOZOIC

Mereenie Sandstone

The Mereenie Sandstone was originally defined by Madigan (1932, p.702) in these terms; 'Above the upper quartzites in the Larapintine lie 900 feet of bright-red, fine-grained sandstone, a freestone. It contains few of the impression-like holes of the lower quartzites and shows little stream-bedding below, but this is very marked towards the top, indicating a shallowing. Boulders of it are found in the Pertnjara conglomerate above. This important, conspicuous, and widespread formation is here given the name Mareenie sandstone'. The 'upper quartzites in the Larapintine' refer to the beds of Stairway Sandstone at Ellery Creek, the Stokes Formation not being present at this section (Prichard and Quinlan 1962, p.21), so that here the Mereenie Sandstone directly overlies the Stairway Sandstone. The spelling has been changed from 'Mareenie' to 'Mereenie' in accordance with the usage of the Division of National Mapping. A revised definition of the Mereenie Sandstone was published by Prichard and Quinlan (1962, p.22); 'A quartz sandstone formation overlies the Larapinta Group with a regional unconformity, and is succeeded, again with a regional unconformity, by the Pertnjara Formation'. The type section is in the MacDonnell Ranges 4½ miles west of Ellery Creek on the Hermannsburg Sheet area.

The Mereenie Sandstone is well exposed in the north-east corner of the Ayers Rock Sheet area, and continues intermittently across the northern part of the Kulgera Sheet area as far as the Mt. Sunday Range. The formation is not found on the Finke Sheet area, and most probably is not present there. Generally the rock occurs as strike ridges up to 50 feet high, but where the dip flattens, steep escarpments rising to 150 feet are formed. On the north side of the Mt. Sunday Range the steep strike ridges are up to 200 feet high.

The unit which underlies the Mereenie Sandstone, the Stokes Formation, is easily eroded and so is consistently represented by an alluviated valley immediately next to the strike ridges of Mereenie Sandstone. These two formation are in conformable contact throughout the area. The contact between the Mereenie Sandstone and the overlying Pertnjara Formation is nowhere exposed, but at the unnamed range south of the Seymour Range on the Henbury Sheet area, the Mereenie Sandstone is regarded as being unconformable beneath the Pertnjara Formation, for although the two units have the same strike and direction of dip, the magnitudes of the dips are very different. A cross-section through this range appears in Ranford and Cook (1964).

The lithology of the Mereenie Sandstone is generally uniform over the area. At well exposed localities, mainly on the Ayers Rock Sheet area, there is 20 to 30 feet of red-brown to purple-brown, poorly bedded, gypsiferous, micaceous, 'chopped-up' siltstone at the base, with a small content of prominent, poorly rounded to well-rounded quartz grains. In places these are plentiful enough to make the rock a sandy siltstone. In a number of places a 5 to 10 foot bed of sandstone occurs near the middle of the siltstone interval. Above this is about 70 feet of white to cream (in places slightly greenish) sandstone which is medium-grained, laminated to thin bedded, cross-bedded, poorly sorted, poorly rounded, porous, flaggy to blocky, friable, and kaolinitic. Overlying this white sandstone is about 100 feet of orange-brown to red-brown, fine to medium-grained sandstone, laminated and cross-laminated, moderately well sorted, poorly rounded, porous, moderately friable, platy to flaggy, ripple marked, slightly kaolinitic, and ferruginous. In the lower part of this sandstone are interbeds of dark brown, slightly sandy, gypsiferous siltstone, in places slightly micaceous. The total thickness of Mereenie Sandstone on the Ayers Rock Sheet area is estimated at around 200 feet.

Exposures on the Kulgera Sheet area are usually poor, as the Mereenie Sandstone is thinner and rarely forms prominent scarps. However the lithology remains similar to that found on the Ayers Rock Sheet area, and in general the rocks are pinkish-brown, cross-bedded, kaolinitic sandstone, with in places some red-brown, slightly micaceous, sandy siltstone exposed at the base. At the Mt. Sunday Range about 340 feet of Mereenie Sandstone is well exposed along the northern side of the range (section KW1 - Plate 3), and has a similar lithology to that described above except that some of the sandstone interbeds are coarse-grained.

The 340 feet of Mereenie Sandstone measured in the Mt. Sunday Range is the maximum thickness recorded. The other thicknesses mentioned above are rough estimates.

On the Lake Amadeus Sheet area, the Mereenie Sandstone has been divided into two units; the lower unit, Pzm (1) is a 'red-brown, well rounded, moderately to poorly sorted, - micaceous in places, - thickly bedded, cross laminated ripple marked - ' sandstone; the upper unit, Pzm (2), is a 'white or pale brown, - fine grained, moderately rounded, well sorted, medium to thickly bedded, and cross-laminated - ' sandstone (Wells, Ranford and Cook, 1963, p.37). This division can be recognised on the northern part of the Henbury Sheet area (Ranford, B.M.R., pers. comm.), but the Mereenie Sandstone on the Ayers Rock and Kulgera Sheet areas and on the southern quarter of the Henbury Sheet area cannot be exactly correlated with either of these units, because of the differences in lithologies. Accordingly the Mereenie Sandstone on the Ayers Rock and Kulgera Sheet areas has not been divided, although it almost certainly corresponds to Pzm (1). At the unnamed range south of the Seymour Range in the Henbury Sheet area, there is a definite physiographical and lithological division of the Mereenie Sandstone into two units (though still conformable). The lower unit is very similar to the sandstone of the Ayers Rock Sheet area, and has been mapped as Pzm (1), but the upper unit is quite different, and shows more resemblance to the sandstone unit of the overlying Pertnjara Formation than to the normal Mereenie Sandstone lithology. This upper unit is a red-brown to orange-brown sandstone which is medium and coarse-grained, thin to medium bedded, cross-bedded, very poorly sorted, well rounded to poorly rounded (as the grain size decreases), friable, kaolinitic, dirty and ferruginous. It is thus quite unlike normal Pzm (2), but in the unnamed range it has been mapped as Pzm (2), because of its position and the strong possibility of its being a lateral equivalent of the more normal type of Pzm (2).

One fossil locality in the Mereenie Sandstone was found in the mapped area. At the north-western end of the unnamed range south of the Seymour Range, probable worm tubes are present in the lower unit, Pzm (1). The tubes are perpendicular to the bedding, measure approximately 1 inch long by $\frac{1}{8}$th inch in diameter, are slightly irregular and full of silty material, finer grained than the host sandstone. Similar tubes are found in the Mereenie Sandstone in other parts of the Henbury Sheet area (L.C. Ranford, pers.comm.).

The origin and environment of deposition of the Mereenie Sandstone is not fully understood. The evidence of suspected pseudomorphs after halite in two localities (Wells, et al., 1963, p.38), the presence of worm tubes, the occurrence of Cruziana in the south-east corner of the Lake Amadeus Sheet area (Wells, et al., 1963, p.38), the large-scale cross-bedding, the thinness of the unit compared to its development farther north, and the generally (but not exclusively) conformable relationship with the underlying marine Stokes Formation, indicate that the Mereenie Sandstone was probably deposited in a shallow marine environment at the edge of the basin. Oldershaw (pers.comm. in Wells, et al., 1963, p.37) stated that three samples of sandstone he examined from the Alice Springs area had been deposited in a deltaic environment in or near a desert, and that a fourth sample was an aeolian sandstone. The occurrence of possible halite pseudomorphs also supports the suggestion of arid conditions. Taylor (1959, p.15) regarded the Mereenie Sandstone as being formed in either a paralic or terrestrial environment. The few fossils found occur only in the lower unit (Pzm (1)), and as the underlying Stokes Formation contains silty dolomites and halite pseudomorphs, again indicating warm and shallow marine conditions, it is possible that the lower unit of the Mereenie Sandstone was formed by the erosion of an aeolian desert sand, which was then carried away by rivers and deposited in a very shallow warm sea, shallow enough in places for the sand to be exposed at low tide. Perhaps some of the sand was blown off shore instead of being carried down in rivers, and deposited in the sea with the aeolian pitting and frosting of the grains still preserved. The upper part of the Mereenie Sandstone, which except in the area around the unnamed range, is a white, well-sorted, and strongly cross-bedded sandstone, may be a true terrestrial aeolian sand. The source of the great volumes of quartz grains forming the Mereenie Sandstone was presumably the large areas of granite and quartzose schist and gneiss forming the margins of the Amadeus Basin. No systematic study of the cross-bedding to determine directions of transport has yet been carried out.

The age of the Mereenie Sandstone is thought to be Upper Ordovician, as it follows conformably upon the Stokes Formation, and contains Cruziana and a few worm tubes.

Pertnjara Formation

The Pertnjara Formation was originally described by Tate and Watt (1896), and first named by Chewings (1931) as 'Pertnjara (Series) - the Post-Ordovician Conglomeratic Sandstone Formation'. Prichard and Quinlan (1962, p.24) defined the Pertnjara Formation as 'the sequence of sandstone, quartz greywacke, and conglomerate that overlies the Mereenie Sandstone with a regional unconformity .... Its upper limit is not known': The type section is at Ellery Creek on the Hermannsburg Sheet.

The Pertnjara Formation is not exposed on the Finke Sheet area, and few exposures are present on the Kulgera and Ayers Rock Sheet areas. One small patch of siltstone and another of sandstone are found on the north side of the Erldunda Range, and a larger area of very poorly exposed siltstone occurs north-west of the Mt. Sunday Range. A low strike ridge of sandstone is situated on the north side of the eastern end of the same range. The best exposures of the Pertnjara Formation are found at the unnamed range south of the Seymour Range on the Henbury Sheet area where the unit forms two discontinuous strike ridges on the north and south sides of the range, up to 60 feet high. These exposures are described in Ranford and Cook (1964).

In the north-east corner of the Ayers Rock Sheet area, the flat-lying Tertiary limestone overlies very poorly exposed, red-brown siltstone. These exposures occur in the axial regions of synclines in the Mereenie Sandstone and Larapinta Group, and are regarded as belonging to the Pertnjara Formation.

The stratigraphic relations of the Pertnjara Formation with the underlying Mereenie Sandstone are not clearly shown on the Kulgera Sheet area. One exposure of siltstone immediately overlying the Mereenie Sandstone on the north side of the Mt. Sunday Range (at the top of measured section KW-1) has a strike and dip parallel to that of the Mereenie Sandstone. However the exposure is too small to have much regional significance. The small sandstone ridge on the north side of the Erldunda Range dips 10° north-west in contrast to the steep north to overturned south dip of the Larapinta Group half a mile to the south. This unconformable relationship is also seen in the unnamed range south of the Seymour Range, as discussed in the section on Mereenie Sandstone. The Pertnjara Formation is unconformably overlain by flat-lying Mesozoic deposits in the Erldunda Range, at the western end of the Mt. Sunday Range, and on the southern side of the unnamed range, but contacts are obscured.

In the extreme south-east corner of the Henbury Sheet area, the nearly flat-lying red-brown sandstone of the Pertnjara Formation is interbedded with two intervals of white kaolinitic sandstone, each about 30 feet thick and about 30 feet apart. This white sandstone is very similar to the Idracowra Sandstone of the Finke Group. The red-brown, biotite-bearing shale and siltstone of the Pertnjara Formation underlying the sandstone sequence is similar to the Horseshoe Bend Shale of the Finke Group. Hence it is thought that there is an intertonguing relationship between the Pertnjara Formation of the Henbury Sheet area and the Finke Group of the Finke and Rodinga Sheet areas.

The Pertnjara Formation can be lithologically divided into two main units. The lower unit, which is exposed on the north side of the Mt. Sunday Range, is a red-brown to pink and rarely green, laminated to thin-bedded, well sorted, biotite-bearing siltstone, with a few interbeds of thin-bedded, micaceous sandstone. The thickness of this unit is estimated from the air-photos to be about 650 feet. The siltstone in the unnamed range south of the Seymour Range is very similar and estimated at 1,000 feet thick; some pseudomorphs after halite occur here.

The siltstone beneath the Tertiary limestone on the Ayers Rock Sheet is red-brown to pinkish-brown, well sorted, finely fragmented, and contains patches of biotite flakes on the bedding planes. The thickness here is unknown.

The upper unit of the Pertnjara Formation, an orange-brown to red-brown sandstone, is medium to coarse-grained (though in a few places fine-grained), thin to medium to thick-bedded, cross-bedded, poorly sorted to moderately well sorted, poorly rounded to well rounded, porous, kaolinitic and ferruginous. In places 2 inch to 3 inch bands of clay pellets are present. The thickness of this unit is estimated at 50-60 feet.

A third type of lithology, consisting of thick continental conglomerates and interbedded sandstones (totalling about 10,000 feet thick), is developed in the northern part of the Amadeus Basin, to the exclusion of the sandstone and siltstone units described above. However no conglomerate occurs in the Pertnjara Formation of the mapped area, nor on the Henbury or Lake Amadeus Sheet areas, though isolated pebbles and cobbles are present near the top of the sandstone unit in the north-east part of the Henbury Sheet area (Ranford, pers. comm.).

The total thickness of the Pertnjara Formation on the Kulgera and Ayers Rock Sheet areas is not known, but it could be around 700-800 feet. No stratigraphic sections were measured through the unit.

The Pertnjara Formation has a number of points in common with rocks of the post-orogenic (or molasse) facies. Chief among these are the great thicknesses of conglomerate in the north part of the Amadeus Basin, the change from conglomerate to sandstone and siltstone from north to south, and the marked thinning of the formation in the same direction. A source of the sediments in the north is therefore indicated. The phenoclasts of the conglomerates are derived from all the underlying units (Prichard and Quinlan, 1962, p.24), including the basement Arunta Complex, and this, together with the considerable thickness of the unit and its unconformable relationship with the underlying units, suggests that the Pertnjara Formation was derived during and after a particularly strong phase of the tectonism affecting the margin and northern part of the Amadeus Basin. However the steep dips in the Pertnjara Formation in this northern area show that the major movement took place after the deposition of this unit.

Only one diagnostic fossil has been found in the Pertnjara Formation, by R.M. Hopkins of Magellan Petroleum. This is a placoderm fish plate from a sandstone bed in the lowest siltstone unit, on the northern flank of the Mereenie Anticline on the Mt. Liebig Sheet area. Though not yet described, the plate is probably referable to Bothriolepis or Remigolepis (N.E.A. Johnson, B.M.R., pers. comm.), indicating a late Middle or Upper Devonian age for the Pertnjara Formation.

On the basis of the similarity in lithologies of the Pertnjara siltstone unit to the Horseshoe Bend Shale, and the intertonguing of the Pertnjara sandstone with the Idracowra Sandstone, the Pertnjara Formation is correlated with the Finke Group of the Finke Sheet area.

FINKE GROUP

The term 'Finke River Sandstone formation or series' was used by Chewings (1914) for the beds exposed from the Goyder River to a point a little north of Idracowra Homestead. He regarded the beds as being Jurassic(?) in age. The term 'Finke River sandstone' as used by Chewings therefore includes the Mesozoic De Souza Sandstone (Sullivan & Öpik, 1951), the ?Permian Crown Point Formation (as defined in this report) and the Finke Group, a new term introduced and defined in this report.

The Finke Group, as here defined, consists of four formations which are essentially conformable and are in part equivalent to the Pertnjara Formation. They are the Polly Conglomerate, Langra Formation, Horseshoe Bend Shale and Idracowra Sandstone, in order of decreasing age. The maximum exposed thickness of the Group is 1,500 feet.

The youngest formation, Idracowra Sandstone, interfingers with the top sandstone member of the Pertnjara Formation. The Pertnjara Formation crops out extensively to the north-west of the Finke Sheet area. The preceeding older unit of the Finke Group, the Horseshoe Bend Shale was observed to grade laterally into the lower siltstone member of the Pertnjara Formation. As the age of Pertnjara Formation is regarded as possibly Devonian, the age of the Finke Group may be the same.

Polly Conglomerate

The name Polly Conglomerate is here proposed for the conglomerate with rounded pebbles, cobbles and boulders of granite, metamorphic rocks, and sedimentary rocks which overlies much older strata with unconformity and which in turn is overlain, apparently conformably, by the Langra Formation - the next younger unit of the Finke Group.

The known distribution of the Polly Conglomerate is not great and limited almost entirely to the Finke Sheet area. The conglomerate crops out at Polly Corner, Horseshoe Bend (Fig. 12) and on both flanks of the Black Hill Range; it probably underlies the Langra Formation and Horseshoe Bend Shale just north of Lilla Creek. The granite pebble and cobble conglomerate which crops out to the north-west and west of Umbeara Homestead was also mapped as Polly Conglomerate; in this area some of the Conglomerate extends across the Sheet boundary into the Kulgera Sheet area.

The composition of the Polly Conglomerate varies from place to place. In the Umbeara area, where it crops out near, or overlies, the large granitic mass, its composition is almost entirely well rounded granite with a few angular cobbles of vein quartz. Away from the granite the percentage of quartz and quartzite and metamorphic constituents increases; nearer the outcrops of Winnall Beds the angular siltstone and sandstone fragments become more common (Fig. 12).

On the south side of the Black Hill Range, at CW17, the Polly Conglomerate is vertical where it has been faulted against the Winnall Beds. About 20 yards to the south of this outcrop the Langra Formation crops out and dips at about 15° to the south. The Conglomerate contains phenoclasts up to about 8" across and pebbles and cobbles of pink granite, pegmatite, some quartz and a few boulders of dolomite. The dolomite is pink to reddish, medium grained and is lithologically similar to the Bitter Springs Limestone.

The Polly Conglomerate does not form prominent outcrops as its resistance to erosion is no greater than that of the overlying sandstone of the Langra Formation. In most outcrops (except at Umbeara) it forms the lowest few feet of scarp under a thicker layer of Langra Sandstone. Rochow (1963) gives the maximum thickness of the Polly Conglomerate as 200 feet which he estimated on the northern flank of the Black Hill Range, where the formation overlies Winnall Beds. About 80' of the formation was measured in KW-6 (Plate 4) at Horseshoe Bend.

The age of the Polly Conglomerate is not precisely known. It is post-Proterozoic as shown by its unconformable contact with the Winnall Beds and probably post-Ordovician as the conformably overlying Langra Formation contains pebbles of Stairway Sandstone. The Polly Conglomerate is pre-Permian because the Finke Group is unconformably overlain by probable Permian beds of the Crown Point Formation. A possible Devonian age is suggested from the intertongueing of part of the Finke Group with the Pertnjara Formation.

Fig.12. Polly Conglomerate at Horseshoe Bend, Finke River. Pebbles and cobbles of sandstone from the Winnall Beds, quartzite, and many varieties of igneous and metamorphic rocks in a poorly sorted matrix.

Neg.No.G/6303

Langra Formation

The Langra Formation, a new name, is here defined as beds of fine to medium-grained, coarsely cross-bedded sandstone with isolated pebbles and cobbles, and conglomerate interbeds with granitic and metamorphic rocks (Fig.13) overlain by greenish or reddish shale which in turn is overlain by medium to fine grained sandstone.

The passage from the underlying Polly Conglomerate to Langra Formation is regarded as conformable and consists of a transition over a few feet from conglomerate to pebbly and cobbly sandstone to sandstone. The passage from Langra Formation to the overlying Horseshoe Bend Shale is also conformable (Fig. 18) and transitional.

The reference area of the Langra Formation is between Polly Corner and Horseshoe Bend Homestead. The distribution of the Formation is more extensive than that of the Polly Conglomerate: apart from the reference area it was found near Langra Well; between Jenkins Bluff and Corella Creek; it is thought to underlie Quaternary sediments between the Upper Corella Creek and Outside Creek - a northern tributary of Spring Creek; finally small outcrops of Langra Formation occur scattered between Mt. Watt and Lilla Creek Homestead. Subsurface information from bores indicates a much wider distribution of this unit (Rochow, 1963). All these sites are on the Finke Sheet area, but the Formation, according to Rochow is much more extensive, extending to the west as far as the salt lakes on the Kulgera Sheet and lensing out on Lower Palaeozoic rocks south of Maryvale.

The age of the Langra Formation is not accurately known. It may be Devonian by correlation of part of the Finke Group with the Pertnjara Formation.

The Langra Formation is made up of sandstone, siltstone and beds of conglomerate. The sandstone is yellow and white, poorly-sorted, with rare clay pellets, friable, with some limonitic laminae, coarsely cross-bedded, medium and coarse grained, with scattered pebbles mostly of granitic and metamorphic rocks as well as interbeds 5-10 feet thick of cobble conglomerate and thin interbeds of red-brown siltstone. The sandstone shows slump structures and cut and fill structures with large eroded channels filled with conglomeratic sandstone (Fig.14). Many of the outcrops of sandstone are overlain by a scree of rounded pebbles and cobbles of granite, porphyry, quartzite, white quartz, several varieties of metamorphic rocks and large sub-angular pieces of Stairway Sandstone.

Fig.13. Conglomerate of granite pebbles in cross-bedded sandstone of the Langra Formation. Horseshoe Bend, Finke River.

Neg.No.M332-10.

Fig.14. Cut and fill structure in the Langra Formation. Conglomerate and coarse sand filling depression eroded in banded sandstone. Horseshoe Bend, Finke River.

Neg.No.M332-14

Penecontemporaneous brecciation of the red-brown siltstone (Fig.16) has been caused by the rapid deposition of overlying coarse cobble beds or in places angular silt fragments have been incorporated into the sandstone above.

The red-brown siltstone occurs both in the upper and lower part of the Langra Formation (Fig.16). It is micaceous, (biotite and muscovite) thin bedded and laminated, and partly calcareous.

The thickness of the Langra Formation is estimated by Rochow (1963) to be 400-450 feet at Horseshoe Bend. Section KW-6 (Plate 4) is an incomplete section through about 250 feet of the Langra Formation exposed at Horseshoe Bend.

The sequence in the Langra Formation at Horseshoe Bend with approximate thicknesses is -

Horseshoe Bend Shale - Shale and siltstone, red-brown.

Langra Formation

50 feet - Sandstone, yellow and white, thin to medium bedded, weathers thick bedded, poorly sorted, subrounded quartz grains up to 2 mm., with conglomerate at top, and scree with white quartz pebbles. Large mica flakes in upper part. Few thin interbeds of red-brown siltstone and silty sandstone. Sandstone cross-bedded, near base kaolinitic, few white clay and kaolin pellets, friable. Grades into siltstone below. A few pebbles.

50 feet - Siltstone, red-brown, micaceous in part with muscovite and biotite, poorly thin bedded to laminated. Some dark red limonitic parts.

175 feet - Sandstone, yellow-grey and white, medium and coarse and very coarse, poorly sorted, cross-bedded, medium to thick bedded, friable, interbeds of red-brown sandstone and siltstone, scattered pebbles, and pebble and boulder beds 5-10 feet thick with rounded and well rounded phenoclasts of granitic, porphyry and metamorphic rocks and large fragments (up to about 15" across) of Stairway Sandstone in scree from the conglomerate. Slump structures and cut and fill structures common.

225 feet - Sandstone and interbeds of siltstone. Sandstone yellow, red-brown, fawn, poorly sorted and bedded, angular grains,

Fig.15. Red-brown shale and overlying kaolinitic sandstone of the Langra Formation near Horseshoe Bend Homestead.
Neg.No.G/6277

Fig.16. Langra Formation, Horseshoe Bend. Penecontemporaneous brecciation of banded sandstone by overlying mass of coarse sandstone and conglomerate. Horseshoe Bend, Finke River.
Neg.No.M332-8

micaceous in part, few white subangular quartz pebbles, white kaolinitic flecks in places, friable, cross-bedded, thin pebble interbeds with phenoclasts of quartz, metamorphics and banded chert. Siltstone, red-brown, thin bedded, with some interbeds of fine sandstone. Interbeds are from 5-10 feet thick.

Polly Conglomerate - Conglomerate, polymictic.

Horseshoe Bend Shale

The red shale and siltstone at Horseshoe Bend was referred to as 'Horseshoe Bend Series' and 'Horseshoe Bend Beds' by David and Howchin (1924) but they were not certain of its stratigraphic position.

The Horseshoe Bend Shale is here defined as the red and green, biotitic shale with thin interbeds of fine sandstone which overlies the Langra Formation apparently conformably and is in turn overlain with a disconformity by the Idracowra Sandstone (Fig.17). The shale is distributed widely over the central portions of the Finke and Kulgera Sheet areas. The reference area for the formation is at Horseshoe Bend.

In composition the Horseshoe Bend Shale varies little over its area of outcrop. It is red and green in outcrop but reputedly grey in bores (Rochow, 1963) usually richly biotitic and gypsiferous; it contains pseudomorphs after halite, ripple marks, mud cracks and inclusions of gypsum and calcite. Its grain size is uniformly fine, but small lenses and bands of fine sand are not uncommon. Just north of the north-western corner of Finke Sheet area the Horseshoe Bend Shale becomes progressively coarser laterally and grades into medium-grained, red siltstone of the Pertnjara Formation.

The Horseshoe Bend Shale overlies the Langra Formation apparently conformably (Fig.18) and the passage from sandstone to shale is a distinct marker separating the two. The contact between the shale and the overlying Idracowra Sandstone is probably disconformable. In several places the top of the Finke Group was eroded before the Permian, and the Crown Point Formation unconformably overlies the Horseshoe Bend Shale. The greatest thickness of shale measured in a section - at the reference area at the Horseshoe Bend - was about 300 feet. In a bore section about 20 miles west from the Horseshoe Bend the thickness is about the same (Rochow 1963).

Fig.17. Horseshoe Bend Shale, exposed in gully in foreground and low benches near base of mesas, overlain by the Idracowra Sandstone, Mount Musgrave.
Neg.No.G/6306

Fig.18. Contact (at top of hammer handle) of Horseshoe Bend Shale with underlying conglomerate and sandstone of the Langra Formation , near Polly Spring, Finke River.
Neg.No.G/6305

On the Finke Sheet area the Horseshoe Bend Shale crops out in mesas or in low rolling billy-covered hills from near Impadna Dam eastwards to Horseshoe Bend; and from Horseshoe Bend south to near Echidna Retreat and west-south-west almost as far as Mount Falconer.

There are few mappable outcrops of Horseshoe Bend Shale on the Kulgera Sheet area. However the distribution of this unit is extensive in this Sheet area although it is masked by the travertine which forms on top of it by upward migration of lime. The distribution of shale is similar therefore to that of travertine i.e. it extends east-west across the sheet into the Ayers Rock Sheet area.

Idracowra Sandstone

The Idracowra Sandstone is the name proposed for a medium-grained, kaolinitic quartz sandstone which crops out mainly in the northern portion of the Finke Sheet area where it overlies the Horseshoe Bend Shale apparently conformably or with local disconformities. In some outcrops it may be in turn unconformably overlain by the De Souza Sandstone but usually is uncovered with a silicified erosion surface giving rise to mesa topography. In places it is probably unconformably overlain by the Crown Point Formation but the contacts are not well exposed.

On the Finke Sheet area the Idracowra Sandstone crops out extensively eastwards from near the north-western corner of the Sheet area as far as the Rumbalara Ochre Mine, and east-south-east to near the Rumbalara railway siding. Small and scattered outcrops were mapped near Langra Well; eight miles north-north-west of Lilla Creek; along a line joining Mt. Humphries and Echidna Retreat and in scattered outcrops within 12 miles south of this line. On the Kulgera Sheet area only two small outcrops of this sandstone were mapped: both are situated close to the Sheet's eastern boundary.

The Idracowra Sandstone consists of white and yellow, thin-bedded or in places massive, medium-grained to fine-grained, kaolinitic quartz sandstone with pebbles of clay and rare pebbles of quartz and quartzite. In one or two sections a basal conglomerate was observed. In outcrop the sandstone is seldom more than 200 feet thick. Where its base is visible the top is an erosion surface. Rochow (1963) records 500 feet of this sandstone from a bore (G53/6-87, 3½ miles north-east of Rumbalara Siding.)

In the reference area, which includes the northern-most mesas due south of Idracowra Homestead, the sandstone is found overlying apparently conformably the Horseshoe Bend Shale and its top is a strongly silicified erosion surface. The section is -

8' grey billy with solution tubing and mottled staining in grey and brick red.

50' Idracowra Sandstone: white, with pinkish outside layer near top of section, yellowish towards the base; kaolinitic towards the base, porous near the top; mostly medium-grained but also of somewhat irregular grain-size; laminated and poorly broadly cross-bedded.

40' Horseshoe Bend Shale: red-brown and greenish, gypsiferous, biotitic, with earthy platy ?calcite; with admixture of quartz grains in small lenses. Base not visible.

In other portions of the Finke Sheet area, the following variations in composition and thickness were observed:

At Mt. Casuarina in the northern central portion of the Sheet over 250' of Idracowra Sandstone is exposed. Here it is harder than in the reference area and cross-bedding is better developed. The contact between it and the underlying Horseshoe Bend Shale seems to be conformable.

Near Mt. Kingston, the top 50 feet of the Idracowra Sandstone has a one foot billy capping and is very hard, laminated, and has a shattered appearance. The lower 70 feet in this section is similar in composition to that in the reference area but contains pebbles of quartz and one inch bands of richly red-brown, fine, micaceous sandstone and siltstone near the base.

Near Point Eremophila, about 160 feet of Idracowra Sandstone is clearly laminated with laminae of quartz grains alternating with laminae of kaolin. The overlying two feet of quartz pebble conglomerate probably belongs to the bottom layers of the De Souza Sandstone.

The De Souza Sandstone was also observed unconformably overlying the Idracowra Sandstone near the Rumbalara Claypan Dam, at Colsons Pinnacle, and in other places.

At Mount Musgrave (Fig. 17) the transition zone between some 180 feet of closely alternating red and green layers of Horseshoe Bend Shale and the white, kaolinitic Idracowra Sandstone consists of yellow and pinkish sandy shale.

Where preserved as the top-most bed, the Idracowra Sandstone, by virtue of its flat disposition gives rise to mesa-type topography. This is particularly true in the northern portion of the Finke Sheet area.

Just north of the north-western corner of Finke Sheet area the Idracowra Sandstone was found to interfinger with the upper sandstone member of the Pertnjara Formation. Since the age of the Pertnjara Formation is thought to be possibly Devonian, that is also the possible age of the Idracowra Sandstone.

?PERMIAN

Crown Point Formation

The sediments at Crown Point were referred to by Ward (1925) as the Corwn Point 'Series' (although the distinction of first recognising the beds as being possibly glacial in origin rests with Tate & Watt (1896). Tate (1897) suggested that the beds were Permian in age. David & Howchin (1924) give further details of the Crown Point series at Yellow Cliff.

The name Crown Point Formation is the revised name which is applied exclusively to sandstone, tillite and conglomerate regarded to be Permian. Formerly these sediments were included by Chewings (1914) in his 'Finke River Sandstone'. However, this name is too broad to be useful as it was applied to sediments exposed along the Finke River from Horseshoe Bend to Idracowra Homestead and from Goyder Well to Francis Well, i.e. to sediments which are presently grouped in Polly Conglomerate, Langra Formation, Horseshoe Bend Shale, Idracowra Sandstone, De Souza Sandstone and the Crown Point Formation.

Sediments of the Crown Point Formation are limited in their distribution to the central and north-eastern portions of the Finke Sheet area. They crop out at and north of Lilla Creek Homestead, along the track leading to the Rumbalara Ochre Mine, and at the reference area at Crown Point. They are also exposed between Echidna Retreat and the Rumbalara railway siding and between Echidna Retreat and Mt. Squire.

The main lithological types encountered in the Crown Point Formation are sandstone, siltstone, tillite and conglomerate.

At Colsons Pinnacle the top of the Crown Point Formation sequence is occupied by about one hundred feet of uniform, medium and fine-grained, richly kaolinitic sandstone which is predominantly white but is stained yellow and pink near the top. Here the top of the formation is an erosion surface. This sequence is underlain by slumped tillite of similar composition but with pebbles and cobbles of quartz and quartzite.

About 3 miles west-north-west from Rumbalara railway siding about 200 feet of tillite crops out in mesas. The rocks here consists of well sorted, yellow-brown, medium-grained sandstone, but with solitary pebbles, cobbles and boulders scattered throughout the sequence.

At One Tree Point (close to the Crown Point) the sequence is approximately:

50' De Souza Sandstone
150' Crown Point Formation; poorly sorted, fine sandstone with angular rock fragments set in white rock flour cement. Rounded pebbles of quartzite up to 6" across. Silty, medium sandstone with pebbles at base.

Heaps of round boulders of predominantly quartz and quartzitic composition were noted at Cunninghams Gap and near Echidna Retreat. Very few boulders had striations on them (Fig.20).

The lower contacts of the Crown Point Formation were observed at only a few points. Between Crown Point and Echidna Retreat the glacial conglomerate overlies the Horseshoe Bend Shale unconformably and is secondarily indurated with lime derived from the underlying formation. At Mount Squire the Idracowra Sandstone, which crops out extensively to the north-east and the north-west, dips gently to the south and eventually outcrops are obscured by the glacials.

The upper contact of the Crown Point Formation was seen in the reference area where the glacials are overlain unconformably by the De Souza Sandstone. Contacts between these two units can also be seen north and south of the track leading to the Rumbalara Ochre Mine, and also at Colsons Pinnacle.

The age of the Crown Point Formation is regarded as Permian. At Malcolms Bore at Andado Station, approximately 40 miles east of the Rumbalara Ochre Mine, Artinskian spores were identified by Balme (in Sprigg et al. 1960) from a depth of 1350 feet in sandy, grey shale which is regarded as belonging to the Crown Point Formation. The thickness of Permian sediments in the bore may be up to 1200 feet (Rochow, 1963).

UNDIFFERENTIATED MESOZOIC

De Souza Sandstone

The De Souza Sandstone was originally defined by Sullivan & Öpik (1951) from the north-eastern corner of Finke Sheet area. Sullivan and Öpik say "On the surface the De Souza Sandstone is dark brown because it is covered by a thick crust rich in limonite. In fresh outcrops the sandstone is soft, white to

Fig. 19. Light coloured Rumbalara Shale, with some thin interbeds of sandstone forming benches, overlying the De Souza Sandstone at the Rumbalara Ochre Mine.
Neg.G/6272

Fig. 20. Glacial striae on a quartzite boulder from the Crown Point Formation. Three miles west of Crown Point.
Neg.No.G/6300

reddish, and is generally cross-bedded and micaceous. In many places the sandstone is interbedded with grits and conglomerate showing current bedding; most of the pebbles are of quartz. Ripple marks are rare". Its type locality is at Mt. De Souza, near the Yellow King Ochre Mine which is popularly referred to as the Rumbalara Ochre Mine. It crops out fairly widely in the southern portion of the Northern Territory between Alice Springs and the South Australian Border, and probably extends southward into South Australia. Quinlan (1962) showed its possible lateral extent on his 1:1,000,000 map, "Geology of the Alice Springs Area", and later Rochow (1963) mapped and described it in some detail. Sprigg (1963) discussed it briefly and showed its distribution.

Characteristically, the De Souza Sandstone is a friable, reddish or brown, medium to coarse-grained, steeply cross-bedded sandstone. Such sandstone crops out in the reference area. At Colsons Pinnacle, the generalised section is as follows:

- 15' Strongly silicified, sandy shale with some grey billy near top.
- 110' Rumbalara Shale: soft, white, yellow, or purplish shale with rare fragmental pelecypods.
- 110' De Souza Sandstone: separated from Rumbalara Shale by a strongly ferruginized layer (2-3'); strongly and steeply cross-bedded near the top and bottom but tends to be massive in the middle. Free of kaolin, coarse to medium-grained. Separated from the underlying strata by another iron-rich band.
- 130' Crown Point Formation: the top 100 feet is medium-grained and fine-grained, uniform in composition and rich in kaolin; the lower 30 feet strongly contorted and slumped but of similar composition.

Away from the reference area, however, the composition of the De Souza Sandstone may be extremely variable in some outcrops. Thus in places it is massive and may be extremely rich in kaolin; it may contain lenses and layers of siltstone, shale and conglomerate (predominantly of pebbles and cobbles of quartz and quartzite). This is particularly true in the south-western portion of the Finke Sheet area where the De Souza Sandstone wedges out on to the granite masses. In bores the thickness of De Souza Sandstone varies between 50 and 300 feet (Rochow, 1963).

In many outcrops the De Souza sandstone is overlain with or without an angular unconformity by the Rumbalara Shale. In some places, where there is no angular discordance, contacts have an appearance of being conformable - this is particularly true where beds and layers of claystone near the top of the De Souza Sandstone are interbedded with layers of sandstone. However at a number of outcrops there is evidence of erosion of the top of the De Souza Sandstone before the deposition of the Rumbalara Shale. Cut-and-fill structures were observed as were also angular contacts, and the relationship between the two units is regarded as unconformable. In places the Rumbalara Shale has been removed by erosion leaving the De Souza Sandstone exposed at the surface.

The base of the De Souza Sandstone was examined at a number of sections. It was found to overlie the Crown Point Formation as well as the Idracowra Sandstone: these contacts are everywhere unconformable.

The age of the De Souza Sandstone is not known with certainty. As it overlies the Crown Point Formation with unconformity, and is in turn overlain unconformably by the Rumbalara Shale, its age must be somewhere between Permian and Cretaceous. The only fossils found in the sandstone are plant remains which are few in number and indeterminate. The age of De Souza Sandstone may be Jurassic.

Sandstone of similar lithology has been described by Wopfner and Heath (1963) from Mt. Anna in the Peake and Denison Range, South Australia. This sandstone is overlain by bleached silty shales of presumed Cretaceous age and rests unconformably on Upper Proterozoic rocks. The top few feet of the sandstone is completely impregnated by limonite, a feature which is also characteristic of the De Souza Sandstone. Well preserved plant fossils in the sandstone have been dated as Upper Jurassic to Lower Cretaceous.

LOWER CRETACEOUS

Rumbalara Shale

The cretaceous shale which crops out widely over the south-eastern portion of the Northern Territory was named Rumbalara Shale by Sullivan & Öpik (1951) from the type locality at the Rumbalara Ochre Mine (Fig. 19) north-east of the Rumbalara railway siding (north-eastern portion of the Finke Sheet) about 120 miles south of Alice Springs. At the type locality the sequence is as follows (after Sullivan & Öpik, 1951):

- 10' siliceous laterite
- 14' ferruginous sandstone
- 76' soft, white, kaolinitic rock with hard bands of porcellanite: most pelecypods which were found came from this horizon.

8' relatively hard sandy bed. Sponge horizon.
28' soft, white, kaolinitic rock with hard bands of porcellanite.
Radiolaria and fragmental Pelecypoda were found here.
1.5 - 4' Yellow ochre, probably of bacterial origin.
1.5 - 4' hard limonite with quartz boulders.
140'+ red and grey, cross-bedded sandstone with some conglomerate.

The lower boundary of the Rumbalara Shale was placed at the base of the ochre layer, and the hard limonitic layer and the underlying beds were included in the De Souza Sandstone. The boundary between Rumbalara Shale and the De Souza Sandstone is regarded as unconformable. Rochow (1963) gives the thickness of the Rumbalara Shale as 900 feet in the area south of Charlotte Waters Bore, which is in the south-eastern portion of the Finke Sheet area, but the thickness of this unit decreases westwards towards what must have been an old shore line in the Lower Cretaceous. In outcrops the top of Rumbalara Shale is invariably an erosion surface.

On the Finke Sheet area the best outcrops of Rumbalara Shale are south-west of the Rumbalara Ochre Mine. The Shale crops out extensively in the southern and south-eastern portion of this Sheet area, but the exposures are poor; the low hills of Shale are in most places obscured by cobbles and boulders of grey billy. On the Kulgera Sheet area, the Rumbalara Shale was mapped in the eastern and north-eastern portion, but it is not extensive and only small thicknesses are exposed. The composition of Rumbalara Shale is remarkably persistent over large areas.

During the helicopter survey, several large outcrops of flat lying sediments near the centre of the Hale River Sheet area were visited. These were found to be fine grained sediments of the Rumbalara Shale. A few poorly preserved fossils were collected.

Öpik (in Sullivan & Öpik 1951) identified eleven fossils from the Rumbalara Shale and these enabled him to date it as Lower Cretaceous. Later, this dating was narrowed down to Aptian through the correlation of the Rumbalara Shale with the Lower Wilgunya Formation of the Great Artesian Basin on the Queensland side of the Border (Skwarko, 1962). Terpstra & Evans (1963) reached the same conclusion regarding the age and correlation of Rumbalara Shale through the study of microfossils which they identified from Birthday Bore 10 miles north of Andado (new homestead), about 45 miles east-south-east of the Rumbalara Ochre Mines. It can be definitely stated that the Rumbalara Shale was deposited in the western extension of the Great Artesian Basin in the Aptian.

TERTIARY

The following sediments which are thought to be of Tertiary age were mapped on the Finke and the Kulgera Sheet areas: grey billy, conglomerate and limestone, all of which will now be discussed in turn.

Grey Billy

Grey billy occurs as a continuous and coherent layer of siliceous duricrust which caps mesas and cuestas, or it may take on the form of a rubble layer with cobbles and boulders of silica impregnated rock that blankets rolling hills of underlying fresher but softer rock. These cobbles and boulders are obviously disintigration products of duricrust layers.

On silicification not all types of surface rock, however, give rise to grey billy. The final product of progressive silicification of the flat Tertiary limestone cappings is chalcedony, examples of which, as well as intermediate stages of its formation, were observed in different portions of both the Finke and Kulgera Sheet areas. Similarily, silicified conglomerate is not a grey billy in the strict sense.

Grey billy has formed on the formations of the Finke Group and the Mesozoic sediments where they have lain exposed for a long time. Sandy siltstone or silty sandstone seems to have been the best, or at least the commonest, medium for the precipitation of silica, and layers of billy up to 12 feet thick were found capping the De Souza Sandstone while in at least one locality the Idracowra Sandstone was seen to be capped by about 20 feet of solid billy.

Although in its appearance, and up to a point in its composition, grey billy was found to vary in texture, colour and grain size, from outcrop to outcrop, and almost all attempts to classify its characteristics according to the rock on which it has formed, have failed. It was observed, however, that billy which had a mottled brick-red and grey colour almost invariably formed on the Idracowra Sandstone. Some specimens of grey billy showed a weathered surface with circular markings about 2 inches across made up of irregular, poorly defined concentric, arcuate of circular laminae. The origin of these structures is not known.

Quaternary sediments were found to be free of the grey billy. Since it covers Cretaceous and earlier rocks, its time of origin must clearly be post-Cretaceous. Furthermore, at one locality on the Kulgera Sheet area strongly silicified limestone was found overlying a 30 foot section of sandstone and shale with non-marine Tertiary gastropods. Since, it is not known from which part of the Tertiary column these fossils come, it is not possible to tell the time at which silicification took place in the area under discussion. The main period of silicification in the Northern Territory is regarded as sometime in the middle Tertiary.

Conglomerate

Deposits of gravel and poorly consolidated conglomerate are found surrounding Mt. Conner in the Ayers Rock Sheet area, at the Kernot and Erldunda Ranges on the Kulgera Sheet, and at the Mt. Kingston-Black Hill Range on the Finke Sheet. The sediments generally consist of angular to poorly rounded pebbles, cobbles and a few boulders of sandstone from the Winnall Beds in a dark brown, silty and sandy matrix. No bedding is visible but the upper surfaces of the deposits slope gently away from the adjacent ranges to be eventually covered by the surrounding alluvium or sand.

On the northern (or scarp) sides of the Kernot and Basedow Ranges, erosion of the conglomerate has formed a deep gully trending parallel to the range, with a steep scarp up to 50 feet high facing south towards each range. Shorter steep-sided gullies at right angles to the ranges dissect these longer gullies. Short gullies have also been cut by creeks flowing away from the southern flanks of the ranges, but these are not as deeply incised as those on the northern sides owing to the shallower gradient of the streams. Because of the roughly circular shape of Mt. Conner, the main gully occurs around the mountain and is bounded by a scarp 70-100 feet high. Shorter gullies trend radially away from the mountain.

Although mapped as Tertiary, because they are consolidated and deeply dissected, the upper layers of the conglomerate may include some Pleistocene and Recent deposits, as scree and rubble.

Limestone

A number of outcrops of highly silicified limestone were mapped on the central and eastern portions of the Kulgera Sheet area and a few just north of the Black Hill Range on the Finke Sheet area.

This limestone, or its final conversion product, chalcedony, is regarded as Tertiary in age as it is younger than the Rumbalara Shale and predates the silicification phase.

As already mentioned above, at one small outcrop on the Kulgera Sheet area, chalcedonised limestone was found overlying a small thickness of sandstone and siltstone with gastropods which are reputedly non-marine in origin and Tertiary in age.

QUATERNARY

The Quaternary sediments were classified and mapped under the following headings: alluvium, aeolian sand, evaporites travertine and gypsum. All these sedimentary types, some of which cover large portions of the Kulgera and Finke Sheet areas will be discussed in turn.

Alluvium

Sediments which were laid down in the post-Tertiary times by the rivers and streams along watercourses and on flood plains bordering rivers, were mapped as alluvium. In addition deposits mapped as alluvium include areas away from the entrenched channelways and dry water courses. These occupy extensive plains and even between sand-dunes, in fact, anywhere where repeated surface runoff occurs. Alluvium covers very large parts on the Kulgera Sheet area, but its distribution on the Finke Sheet area is more limited.

Aeolian Sand

Accumulations of sand, which were built up into mounds or dunes of different shapes and sizes by the action of wind, were mapped as aeolian sand. Two main types of sand-dunes are present in the area covered by the Finke and Kulgera Sheet areas, these are the seifs and the dendritic (or braided) sand-dunes.

Seifs are fundamentally linear structures, which may be several miles long, and are aligned parallel or subparallel to each other. They occur over large areas in the eastern portion of Finke Sheet area where they mark the western margin of the Simpson Desert. Here their alignment is approximately north-south or north-north-west to south-south-east. In the eastern portion of this Sheet area they are less well developed and are shorter and less regular in shape and their orientation is less uniform. They cover the south-western quarter of the Kulgera Sheet area, where they are aligned in the north-east direction.

The dendritic dunes are best developed in the northern portion of the Kulgera Sheet area and on the Ayers Rock Sheet area. As their name implies they form a dendritic or braided pattern and mostly occur in areas that are topographically low.

Evaporites

A chain of salt lakes, which is a continuation of the Amadeus Salt Lakes complex, stretches east-west across the northern portion of the Kulgera Sheet area into the north-western portion of the Finke Sheet area. For most of the time the floors of these lakes are dry and covered by successive layers of evaporite deposits, such as gypsum and salt, alternating with thin layers of fine sediment brought in during the brief periods of rain. Where the floors of lakes are clayey and hard, they are mapped as claypans with alluvium.

Travertine

Two types of Quaternary limestone are recognised. These are the yellow-brown, sandy and layered, hard limestone, which is by far the most common, and the blueish soft limestone which gives off a characteristic foetid odour when struck with a hammer.

On the aerial photos travertine can be readily separated from other Quaternary deposits because of the hummocky relief surface bounded by low scarps as well as the impressed dendritic drainage pattern.

Travertine was mapped over large areas in the central portion of the Kulgera Sheet area where its distribution indicates connection with the presence of salt-lakes. In addition it almost invariably occurs overlying the Horseshoe Bend Shale where it becomes concentrated by an upward migration of lime. This is probably the result of the seasonal migration of the water table following the heavy rainfall which occurs every few years in the area. This rain brings about the rather uncommon presence of water in the salt lakes. On the Finke Sheet area the distribution of travertine is also connected with the distribution of Horseshoe Bend Shale. Where conglomerate of the Crown Point Formation overlies the Horseshoe Bend Shale, lime from the Shale migrates through the coarse sediment resulting in secondary cementation with travertine.

The young age of travertine is inferred from the fact that it escaped the process of silicification, which has affected all the older rocks and which is usually regarded as having taken place some time in the Tertiary. In many places it was difficult to distinguish travertine from Tertiary limestone especially where the silicified part of the Tertiary deposits was partly stripped.

Gypsum

Gypsum is present mainly in the Ayers Rock Sheet area, and occurs in two ways. Near Curtin Springs Homestead, it occurs in the silts forming the beds of the salt lakes (salinas), beneath the thin crust of evaporites. Groundwater moving down slope to the belt of salt lakes from the ranges in the north, carries calcium sulphate in solution. This is derived from the weathering of the several gypsum-bearing formations in the Amadeus Basin succession, e.g. the Pertaoorrta Formation, the Stokes Formation, and the basal parts of the Mereenie Sandstone and Pertnjara Formation. On reaching the salt lakes, the calcium sulphate crystallizes out from the groundwater, once the concentration becomes high enough. This forms the gypsum in the silts of the lake beds.

About 30 miles north-west of Curtin Springs Homestead, near the northern margin of the Ayers Rock Sheet area, 'outcrops' of gypsum are found. Here, the gypsum occurs as lumps and masses in a white, powdery, earthy form, intimately associated with sand dunes that have built up around numerous small salt lakes near the eastern end of Lake Amadeus. The very finely divided nature of this gypsum indicates that it has crystallized fairly rapidly, and so it probably formed as a result of the evaporation of groundwater which moved up to the surface from the shallow water table through the sand surrounding the salt lakes.

Although salt lakes occupy a band across the Kulgera Sheet area, gypsum is only rarely found at the lake margins. Instead, the lakes are commonly surrounded by Tertiary and Quaternary limestone. Whether this results directly from a difference in the salt content of the groundwater compared with the area farther west, or from some other phenomenon, is not known.

STRUCTURE

Gravity Survey

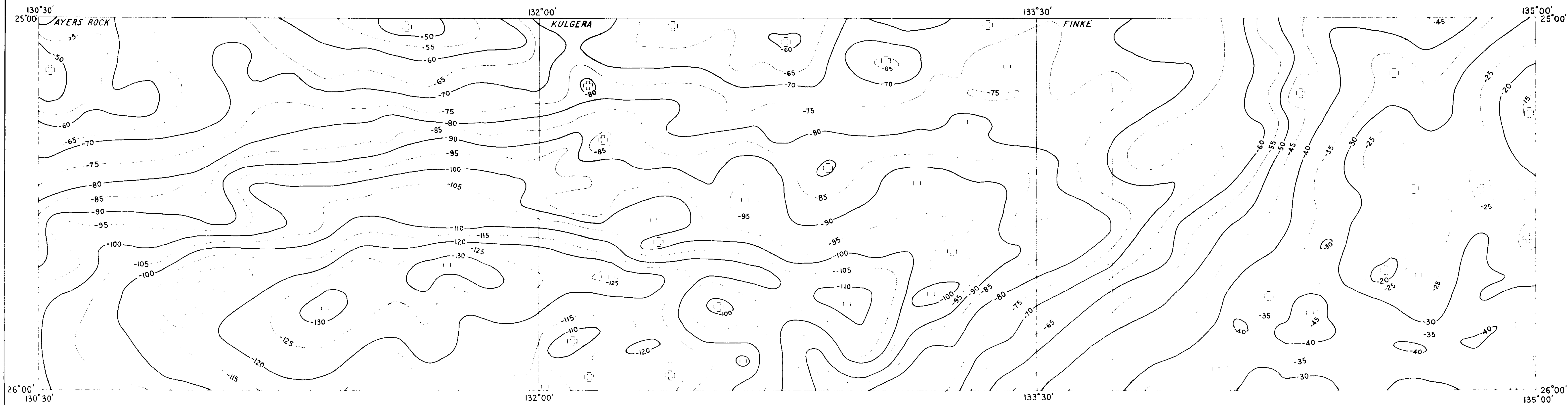
The area mapped was included in a reconnaissance gravity survey using helicopters carried out by the Bureau of Mineral Resources in 1962. Regional Bougner anomalies are shown in Fig. 21. The results of this reconnaissance are recorded by Lonsdale & Flavelle (1963). Parts of four gravity units have been distinguished in the area. They are the Angas Downs Gravity Ridge, the Ayers Rock Gravity Depression, the McDills Gravity Platform and the Amadeus Gravity Depression. These gravity features are shown in Fig.22.

The deep gravity low of the Ayers Rock Gravity Depression on the southern part of the Ayers Rock Sheet and extending eastward onto the Kulgera Sheet, is named the Musgrave Gravity Trough. The Mount Liebig Gravity Trough is the main feature of the Amadeus Gravity Depression and represents the thick pile of sediments of the Amadeus Basin (Langron, 1962).

The Angas Downs Gravity Ridge separates the Mount Liebig

Figure 21

BOUGUER ANOMALIES



Isogals from preliminary Bouguer Anomaly Maps prepared by Geophysical Branch, B.M.R.

SCALE

10 0 10 20 30 MILES

Isogals, values in milligals

High anomaly

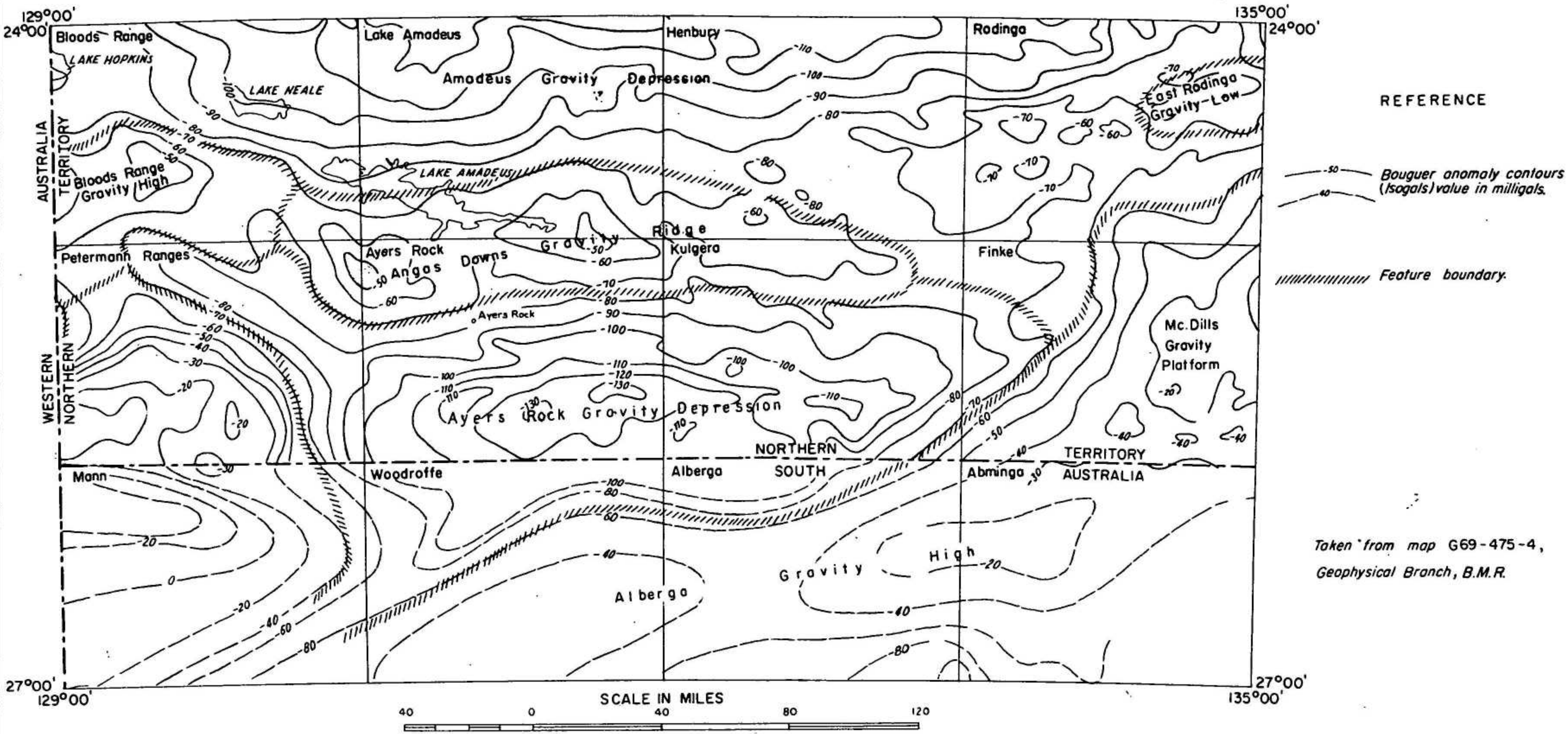
Low anomaly

Bureau of Mineral Resource, Geology and Geophysics. March 1964 To accompany Record No 1964/35

NT/A/64

REGIONAL BOUGUER ANOMALIES AND GRAVITY FEATURES

Fig. 22



Bureau of Mineral Resources, Geology and Geophysics. *To accompany Record No. 1964/35*

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Gravity Trough from the Ayers Rock Gravity Depression. The Angas Downs Gravity Ridge indicates near surface Precambrian basement rocks possibly similar to those present on the south-east Rawlinson Sheet area. The Angas Downs Gravity Ridge is possibly related to the Bloods Range Gravity High and therefore the rocks underlying the two areas may be similar. Upper Proterozoic sediments with a thin veneer of Palaeozoic sediments crop out in the area of the Angas Downs Gravity Ridge. Positive culminations occur along this Gravity High centred near the outcrop of the Bitter Springs Limestone on the Ayers Rocks Sheet area and another culmination is centred on the outcrops of the Bitter Springs Limestone in the core of the Erldunda Range. The gradient on the north side of the gravity ridge is not steep which indicates a gradual thinning of the Amadeus Basin sediments (mostly the Palaeozoic rocks) to the south towards this ridge. The geology of the area covered by the Ayers Rock Gravity Depression is obscured by superficial deposits. The magnitude of the Musgrave Gravity Trough suggests a large thickness of sediments or a thickening of acidic igneous rocks in this area. The depression continues in a narrow branch north-westerly into the Petermann Range Sheet area. Here the area outlined by the depression is underlain by mainly granitised sediments and granitic rocks and similar rocks may underly the area of the Ayers Rock Gravity Depression. On the south-west part of the Kulgera Sheet and the south-east of the Finke Sheet steep gravity gradients, becoming more positive to the south, occur over outcrops of granite and gneiss with abundant dolerite dykes. Some of these rock types also crop out in the southern part of the area of the Musgrave Gravity Trough and the structure here may be analogous to that postulated on the north side of the Amadeus Basin. This involves basement rocks thrust over a sedimentary pile so that the Musgrave Gravity Trough could be filled mainly with less dense sediments and this would explain the steep gradient to the south of Kulgera.

A stratigraphic bore in the area of the gravity depression on the southern part of the Kulgera Sheet would help to elucidate the structural configuration of the south-eastern part of the Amadeus Basin.

Part of the McDills Gravity Platform covers a large area of the Finke Sheet and indicates a moderate thickness of sediments from the Great Artesian Basin on a shelf area. The basement rocks of the shelf may be similar to those exposed on the south-west part of the Finke Sheet. A positive gravity lobe, trending south-south-west from more positive gravity features of the McDills Gravity Platform to the east, overlies the Upper

Proterozoic rocks of the Black Hill Range.

Aeromagnetic Survey

An aeromagnetic survey of part of the area was carried out in 1963 by Aero Service Limited for Exoil (N.S.W.) Pty Ltd. Part of the survey covered the northern part of the Kulgera Sheet, all the Finke Sheet, and a small part of the north-east margin of the Ayers Rock Sheet. Interpretations of depths to magnetic basement below sea level were made at several localities and contours and structural interpretations were compiled from these figures (Fig.23).

The greatest thickness of sediments interpreted from this survey occur between Mount Sunday and Basedow Ranges where depth to magnetic basement is estimated to be greater than 10,000 feet and contours on the map are drawn showing basement depths of 17,000 feet. The large embayment with contours to magnetic basement below 13,000 feet occurs north of Mount Conner, and trends south-easterly onto the Kulgera Sheet as far as Murrathurra Well. The estimated depths to magnetic basement decrease to the south until the contours are intersected by a interpreted fault line. The fault trace occurs about fifteen miles north of Kulgera and trends east-north-east onto the Finke Sheet and swings to the north-east roughly parallel to the Finke River. Several smaller faults have been interpreted on the north-east corner of the Finke Sheet. On the western end of the fault the throw is several thousand feet.

To the south-east of this fault the estimated depths to basement are generally between one thousand and three thousand feet with the exception of the area of steep magnetic gradients over outcrops of Precambrian rocks. On the south-east corner of the Finke Sheet area estimated depth to magnetic basement increase to over seven thousand feet in the area near Charlotte Waters Bore.

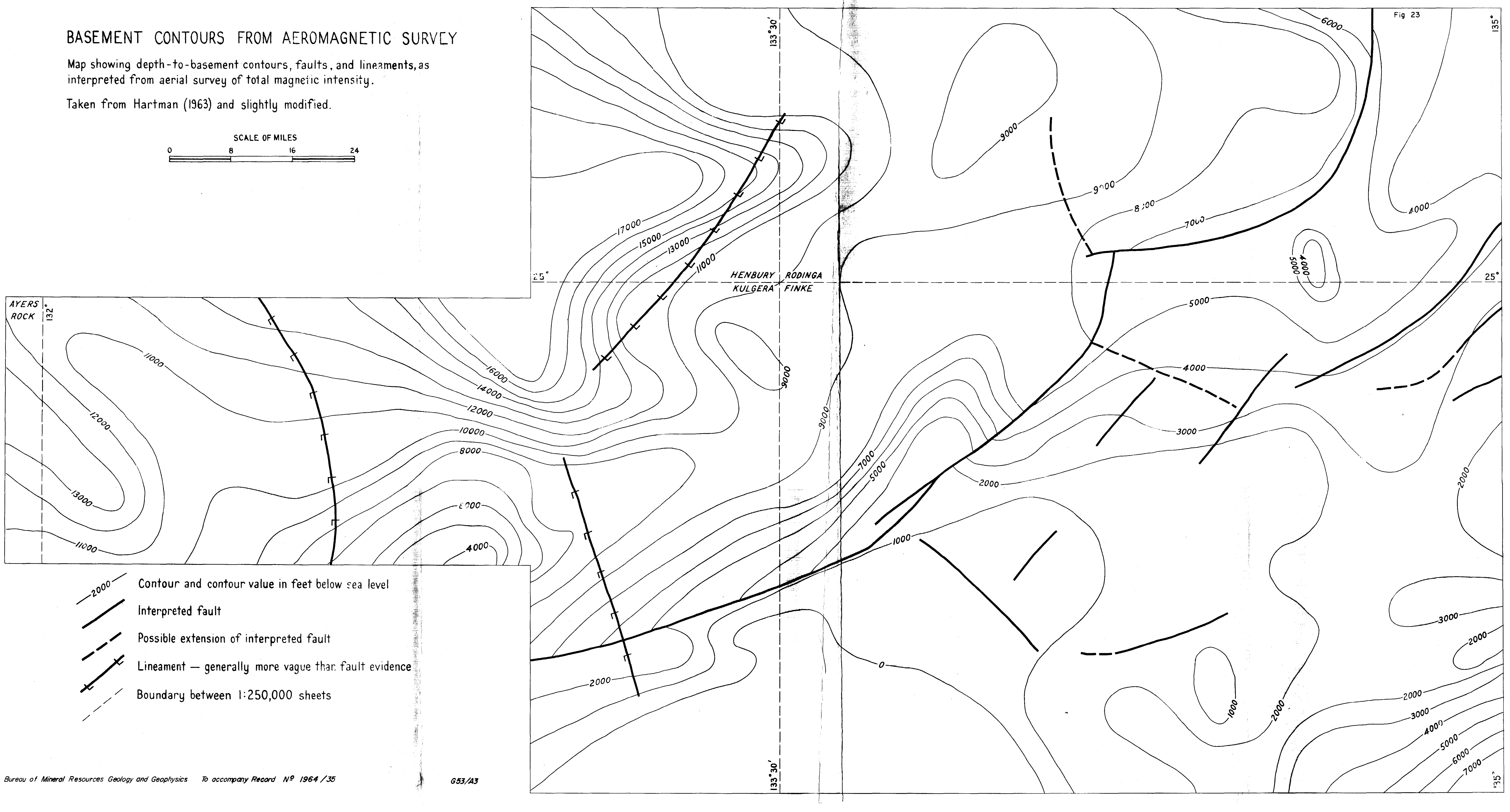
There is general agreement between gravity values and aeromagnetic interpretation on the eastern side of the area. The large fault on the Finke Sheet area corresponds closely to the trend of the gravity high over the Mt. Kingston - Black Hill Ranges. The trend of the fault inferred from the aeromagnetic contours roughly parallels trends in the outcrop of Upper Proterozoic rocks in the Black Hill Range. This fault may be related to the major uplift of the Mount Kingston - Black Hill Range block. The thick sediments on the north-west corner of the Finke Sheet lie in the area of the Amadeus Gravity Depression. On the Kulgera Sheet there is little correspondence between the aero-

Fig 23

BASEMENT CONTOURS FROM AEROMAGNETIC SURVEY

Map showing depth-to-basement contours, faults, and lineaments, as interpreted from aerial survey of total magnetic intensity.

Taken from Hartman (1963) and slightly modified.



magnetic anomalies and the gravity gradients which outline the area of the Angas Downs Gravity Ridge. This implies that the rocks causing the gravity ridge may be comparatively dense but are not magnetically susceptible. The decrease in estimated depth to magnetic basement in the eastern side of the Kulgera Sheet is probably related to near surface granitic and basic rocks.

The Horseshoe Bend seismic traverse crosses the large fault interpreted from the aeromagnetic data. The seismic refractors occur to depths of 8,000 feet with a poor refractor at 15,000 feet. The interpreted depths to magnetic basement are 4 to 5,000 feet on the south side of the fault. The refractors on the Black Hill traverse are in an area where aeromagnetic basement was interpreted at 3 to 4,000 feet. This corresponds very closely with the refractor depths. The anomalous high amplitude alignment with a crest at about 4,000 feet shown in cross-section (Langron, 1962) is most likely associated with the uplifted block of Proterozoic rocks in the Black Hill Range area.

Seismic Surveys

Short seismic traverses were made by the Bureau of Mineral Resources at four places on the Finke Sheet area. They are designated Horseshoe Bend, Black Hills, Lilla Creek and Lilla Creek South traverses.

The Horseshoe Bend Seismic traverse has good refractors to a depth of about 8,000 feet and a poor refractor at about 15,000 feet. The refractors in the seismic cross section dip to the north and their dip increases with depth.

The Black Hills seismic traverse shows refractors to a depth of about 6,000 feet and all have a northerly dip.

Gravity measurements along these traverses were made by Langron in 1961 (Langron 1962). On the Black Hills traverse there is a relatively high gravity anomaly which correlates with the deep seated feature shown on the seismic cross section.

At Lilla Creek, refraction results indicated a refractor with a velocity of 18,900 ft/sec at a depth of about 580 feet. This velocity is similar to that recorded for granite at Lilla Creek South (19,400 ft/sec at a depth of 500 feet) and it presumably indicate a shallow granite basement in the area.

Surface Structures

A structural interpretation of part of the area mapped is shown in Fig.24. The Upper Proterozoic and older rocks were subjected to air orogeny in the Upper Proterozoic or early Cambrian. In this period they were tightly folded, mostly into

STRUCTURAL INTERPRETATION

chevron type folds with sharp axial crests and troughs, or rarely into broad basin structures such as Mount Conner. This period of folding is probably the same as the Lake Neale folding of Forman (1963). The Upper Proterozoic rocks were then eroded and the Palaeozoic sediments deposited unconformably over them. This unconformity is a prominent feature on the northern part of the area mapped. In several cases the unconformity is a linear feature which can be traced for several miles. The striking linearity of the contact suggests that there may have been major faulting in the Upper Proterozoic rocks with the Palaeozoic sediments deposited against uplifted blocks. However, no direct evidence of major faulting in the Upper Proterozoic rocks has been seen. A structure of this kind is present in the Erldunda Range where the Bitter Springs Limestone is unconformably overlain by the Palaeozoic rocks, and where Palaeozoic rocks overly Upper Proterozoic sediments in the Basedow and Kernot Ranges, and hills twelve miles north-east of Curtin Springs.

This first major period of folding in the Upper Proterozoic or Cambrian probably affected the whole of the area which now lies along the southern margin of the Amadeus Basin. The strongest effects of the orogeny were centred in this zone and folding of the Amadeus sediments decreased gradually in intensity to the north. The orogeny produced large recumbent folds in the Petermann Range, Bloods Range and Ayers Rock Sheet areas. Movements occurring in the same period may have been responsible for the postulated major thrusting in the south-east part of the Amadeus Basin. In this area thrusting or overfolding of basement rocks over younger sediments is inferred chiefly from the gravity data.

The folding of the Palaeozoic rocks (Amadeus Basin folding of Forman, 1963) produced broad folds whose axes trend east-west, roughly parallel to those in the Proterozoic rocks. There are some minor cross folds. Some of the dips in the Palaeozoic sediments were probably initial depositional dips particularly those near higher ranges of Upper Proterozoic rocks. There is some local overturning of the sediments to the south particularly in the north-east corner of the Ayers Rock Sheet area. The Pertnjara Formation is a syn-orogenic deposit which had its greatest development next to the uplifted orogenic zone. Only thin finer grained equivalents of the Formation were deposited to the south of the orogenic zone.

The effects of the second major period of folding in the Upper Palaeozoic were intensified along the northern margin of the Amadeus Basin. In this area there was also recumbent folding and possible overfolding of a large part of the basement over the

Amadeus Basin Succession (Langron, 196?).

The contact of the Upper Proterozoic rocks with the Ordovician Larapinta sediments is very irregular and in several places the Stairway Sandstone is in-folded on a small scale into the Inindia Beds.

Major late Palaeozoic faulting was probably responsible for the uplift of the Mount Kingston-Black Hill Range block. The major fault inferred from aeromagnetics is roughly aligned parallel to this uplifted block and depths to magnetic basement indicate that the area to the south of the range has been upthrown several thousand feet.

The formation of the Mount Kingston-Black Hill Range block occurred by renewed movements along the faults initiated during the late Palaeozoic orogeny. In places the Finke Group sediments are vertical next to the uplifted block.

The Mesozoic rocks of the Great Artesian Basin have been subject to only minor tilting and faulting.

GEOLOGICAL HISTORY

The early Precambrian history of the area is largely unknown and must be deduced from neighbouring areas and interpreted from geophysical data. The sequence of geological events may be summarized as follows -

1. The inferred deposition of a thick sequence of Precambrian sediments in an east-west trending depression on the southern part of the area on an unknown basement. The gneissic and granitic rocks of the Kulgera and Finke Sheets may be an integral part of the basement rock.

2. The early history of the Upper Proterozoic rocks of the Amadeus Basin is unknown. The earliest known deposit is marine dolomite of the Bitter Springs Limestone deposited on a stable epicontinental shelf.

3. Thick deposits of waterlaid and in part glacial sandstone, siltstone, chert and tillitic siltstone of the Inindia Beds were laid down disconformably on the Bitter Springs Limestone. There was probably contemporaneous erosion of some exposed areas of Bitter Springs Limestone possible caused by prior minor localised warping.

4. Slight tilting and folding of the Inindia Beds.

5. Uplift of Precambrian rocks from (1).

6. Deposition of thick sandstone and siltstone of the Winnall Beds, with source areas in Precambrian rocks to the south.

7. Major folding and uplift of Upper Proterozoic and older rocks followed by an extensive period of erosion. The possible thrusting of basement rocks over the Precambrian rocks from (1) was probably initiated during this orogenic period. A decollement may have developed at the top of the Bitter Springs Limestone during this orogeny.

8. Erosion of newly raised Cambrian land-surface and deposition of coarse clastics of the Pertaoorrta Group along a shore line on the northern part of the area. Some carbonates were deposited on the seaward side of the shoreline.

9. Period of erosion.

10. Marine transgression in the Upper Ordovician and deposition of the Stairway Sandstone and Stokes Formation of the Larapinta Group disconformably on the Pertaoorrta Formation in a shallow water stable shelf environment. The sea transgressed the Cambrian shoreline and the Ordovician sediments were deposited unconformably on Upper Proterozoic sediments. Some of the resistant Upper Proterozoic rocks were probably islands or peninsulas in the Ordovician sea.

11. Deposition of the Mereenie Sandstone probably in part by aeolian reworking of older rocks and shallow marine deposition. In the Kernot Range the formation transgressed the Larapinta Group to rest unconformably on the Upper Proterozoic rocks.

12. Slight tilting of the Lower Palaeozoic sediments before deposition of the Pertnjara Formation in a shallow marine and transitional environment. Only the finer -grained development of the formation was deposited on the tectonically stable south side of the basin. Initial minor folding of the Amadeus Basin sediments was probably in part contemporaneous with the deposition of the Pertnjara Formation.

13. Completion of folding after the deposition of the Pertnjara Formation. Locally the Palaeozoic sediments were overturned to the south. The incompetent folding in the Bitter Springs Limestone and the possible decollement at the top of the formation may have been further accentuated during this period.

14. Deposition of the Finke Group for the most part contemporaneous with the Pertnjara Formation. The sediments of the group transgressed over a wide area and overly basement rocks on the south-western part of the Finke Sheet area.

15. Uplift of the Black Hill Range-Mount Kingston block and tilting and faulting of the Finke Group sediments near the range.

16. Period of erosion and removal of a large part of the Finke Group before deposition of the Crown Point Formation. The formation was probably derived from material eroded by continental glaciation in the Permian.

17. Further erosion followed by deposition of Mesozoic rocks. The De Souza Sandstone was deposited in a marginal facies, possibly deltaic, with some of the material derived from the Crown Point Formation. This was followed by a marine incursion with deposition of the Rumbalara Shale. The Mesozoic rocks overlapped the Finke Group and Crown Point Formation and transgressed to the west where they were deposited unconformably on the Amadeus succession.

18. Deposition of Tertiary limestone, siltstone and sandstone probably in freshwater lakes, and conglomerate next to the higher ranges.

19. Period of deep weathering with formation of "billy" mostly on the kaolinitic sediments of the Finke Group and Mesozoic rocks. Silicifation of the Amadeus Basin rocks occurred in the same period.

20. Initiation of the present cycle of erosion with deposition of evaporites and gypsiferous silt in salt lakes and formation of travertine. Dunes were formed in an arid period which was followed by an amelioration of the climate with fixing of large areas of the dunes by sparse vegetation, and deposition of alluvium.

ECONOMIC GEOLOGY

Petroleum Prospects

In the south-east part of the Amadeus Basin the only rocks regarded as being likely sources of petroleum are the Cambrian and Ordovician sediments and possibly the Upper Proterozoic Bitter Springs Limestone. Potential cap rocks and reservoirs are present through the section. The Palaeozoic and Mesozoic sediments of the Great Artesian Basin succession may conceal older Palaeozoic source rocks in parts of the Finke Sheet area or in some areas may include concealed thick marine facies of some of the formations that are more prospective.

On the Ayers Rock, Kulgera and Finke Sheet areas a large part of the section of marine Ordovician rocks was not deposited and only the Stokes Formation and the upper part of the Stairway Sandstone are present. The sediments are thin and do not occur in any demonstrable closed structures. Similar considerations apply to the Cambrian rocks. They consist of thin deposits of coarse continental conglomerate, silty sandstone and siltstone and some thin sequences of marine dolomite and siltstone. The sandy facies of the Cambrian Pertaoorrta Formation could be a reservoir for petroleum migrating up dip from possible concealed thick sections of marine sediments. The Upper Proterozoic Bitter Springs Limestone is present over large parts of the area but the petroleum potential of this formation is unknown.

The flatlying Cretaceous, Mesozoic and Palaeozoic rocks of the Great Artesian Basin succession crop out over a large part of the Finke Sheet area and exposures indicate a total thickness of about 3000 feet of sandstone, conglomerate and siltstone deposited in a transitional environment followed by beds of Mesozoic marine shale. The Finke Group and Permian and Mesozoic rocks would provide reservoirs and cap rocks for petroleum migrating from any concealed Lower Palaeozoic source beds. Any concealed marine facies of the Permian sediments could be possible source beds for petroleum.

The exposed anticlines on the northern part of the Kulgera Sheet area and the north-east part of the Ayers Rock Sheet area are breached into the Upper Proterozoic rocks. The Mt. Sunday Range is the only exception. Thin sequences of Cambrian dolomite, siltstone and sandstone are exposed in the core of the anticline. A small reversal of plunge on the axis of the anticline produces a small area of closure on its western end. There is apparently no surface closure on the eastern end of the anticline.

Geophysical surveys over the south-east Amadeus Basin have outlined areas where thick sediments may be preserved. The large gravity depression on the southern part of the Kulgera Sheet is probably caused by thick Upper Proterozoic and older Precambrian rocks. These rocks are overlain by a thin discontinuous veneer of Mesozoic and Palaeozoic rocks. Until the composition of the Precambrian rocks is known, the petroleum prospects of the area cannot be highly rated.

Over parts of the northern area of the Kulgera Sheet and north-east of Ayers Rock Sheet the aeromagnetic survey indicates a depth to magnetic basement of greater than 10,000 feet and on the north-east part of the Kulgera Sheet depths greater than 10,000 feet, possibly up to 17,000 feet, to magnetic basement are indicated. In these areas the outcropping Palaeozoic rocks would account for only a fraction of this inferred thickness of sediments so that the bulk of the rocks are probably Upper Proterozoic and undifferentiated Precambrian. The thickness of the Winnall Beds, Inindia Beds and Bitter Springs Limestone could easily account for this thickness of sediments and the possibility of petroleum would depend on the potential of the Bitter Springs Limestone and its occurrence in suitable confining structures. It would appear, then, that further exploration for petroleum is justified in this area.

Two areas of possible thick sediments which warrant further prospecting are the area north of the Black Hill Range and on the south-east corner of the Finke Sheet area. In the first area geophysical surveys indicate a thickness of sediments possibly exceeding 10,000 feet. The area is covered by flat lying sediments of the Finke Group. The north-dipping Upper Proterozoic Winnall Beds may form a broad synclinal structure but the age and thickness of any overlying Lower Palaeozoic sediments is not known. Ordovician sediments reached as far south as Mt. Watt where a thin remnant of the Stairway Sandstone overlies the Upper Proterozoic Winnall Beds. Thick Ordovician and possibly Cambrian sediments could be preserved below the veneer of Finke Group sediments to the north.

On the south-east corner of the Finke Sheet area there are outcrops of flat lying Cretaceous and Mesozoic rocks. The petroleum possibilities of this area are indicated by the estimate of 7,000 feet to magnetic basement from aeromagnetic surveys. The nature of the sediments below the Mesozoic rocks and underlying possible Permian and Finke Group sediments is not known but they could consist of older prospective Palaeozoic sediments or include a thick marine facies of say the Permian rocks. Areas further east in the Great Artesian Basin may contain more prospective thicker marine equivalents. Generally only the marginal facies (possibly deltaic, and fluviatile) of the succession is visible in outcrops in the Finke Sheet area.

Phosphate Deposits

Phosphate deposits have been described previously from the Amadeus Basin (Wells et al. 1962 and 1963, and Cook, 1963). The richest pellet phosphate deposits occur in the sediments of the Larapinta Group and in particular the Stairway Sandstone. Many outcrops of the Stairway Sandstone are present on the south-eastern part of the Amadeus Basin and pellet phosphate was found in outcrops twelve miles north-east of Curtin Springs Homestead, and at several localities in the Mount Sunday Range. The phosphate pellets usually occur in coarse, poorly sorted sandstone but in the Mount Sunday Range large pellets are present in a thin conglomerate that forms the basal 2-3 feet of the Stairway Sandstone.

In the outcrops of Stairway Sandstone twelve miles north-east of Curtin Springs Homestead the phosphate occurs as grey pellets up to 1 inch across in a coarse sandstone bed, 1 foot thick, and one hundred and thirty five feet above the base of the formation. The total thickness of the formation is one hundred and fifty two feet. A bed rich in phosphatic brachiopods and some white phosphatic pellets occurs ninety feet from the base of the formation. The pellets probably occur in lenses in the Stairway Sandstone because they could not be traced laterally for any great distance.

The mode of occurrence of phosphate in the Mount Sunday Range is similar. It occurs as both grey and brown pellets in lensing bodies up to one foot thick in a coarse sandstone. The phosphate bed is about two hundred and thirty feet above the base of the formation. The formation is three hundred and fifty feet thick in section KW-1, at the eastern end of the Mt. Sunday Range. No phosphate was intersected in the measured section although the coarse sandstone, which in places contains phosphate pellets, can be identified. Large grey phosphate pellets of flattened ovoid or irregular form and up to four inches across occur in the poorly sorted, subangular conglomerate at the base of the Stairway Sandstone in the Mount Sunday Range. The pellets were found only in the basal conglomerate in the western end of the Mount Sunday Range. This type of occurrence is unique in the Amadeus Basin in that no phosphate has been recorded previously in a basal conglomerate or from rocks of such coarse grain size. The pellets are also probably the largest found so far.

Analyses of several samples of Stairway Sandstone for phosphate gave -

K28A Mount Sunday Range 4.9% P_2O_5 (= 11.6% Apatite)
K28B Mount Sunday Range 4.6% P_2O_5
K28C Mount Sunday Range 4.4% P_2O_5
K20A Mount Sunday Range 0.8% P_2O_5
K22 Mount Sunday Range $<$0.5% P_2O_5
AR705 North-East Ayers Rock Sheet area $<$0.5% P_2O_5

(Analyses were carried out colorimetrically using the molybdo-vanadate procedure).

Several samples of phosphate were collected from the Stairway Sandstone in the south-east corner of the Lake Amadeus Sheet area about six miles east-north-east of Inindia Bore.

Analyses of these samples gave -

LA701B Coarse sandstone 16% P_2O_5
LA701C Grey phosphate pellet 27% P_2O_5
LA701D Coarse sandstone 17.8% P_2O_5 (= 42.3% Apatite)

A sample (LA701A), from this area, contained an apparently amorphous green mineral which was identified as Corkite by X-ray diffraction (S.G. Goadby, B.M.R.). This is the first recorded occurrence of corkite in Australia. The mineral is probably of secondary origin formed by the interaction of phosphate and other original constituents of the rock. Corkite was also found in phosphatic rocks of the Stairway Sandstone in the unnamed range in the south-eastern part of the Henbury Sheet area, south of the Seymour Range. Several other phosphatic beds in the Stairway Sandstone occur on the southern part of the Henbury Sheet area in outcrops south of the Liddle Hills, in the Mill Ridges and surrounding hills, and near Briscoe Tent Hill. The analyses of these rocks and the types of occurrences are discussed in Ranford and Cook (1964).

The formation of the phosphate pellets, their localisation in the Stairway Sandstone and their lensing nature are only partly understood. The hypothesis put forward by Kazakov in 1931 is widely accepted as a satisfactory explanation of the formation of phosphate deposits. The work of Kazakov is briefly reviewed by Sauchelli (1962). The main results of Kazakov's work indicate that phosphate is a marine chemical deposit formed by the replacement of calcium carbonate nodules in water which may be from one hundred and fifty to six thousand feet deep. The phosphate originates in deep ocean basins and the phosphate-rich waters from these basins welled up on to shelves or platforms where replacement of calcium nodules took place. The precipitation of phosphate is related to the partial pressure of carbon dioxide in the sea water. The calcite nodules were formed by accretion on the shelves under the influence of marine currents and were replaced by phosphate in situ. The available evidence in the Amadeus Basin suggests that most of the phosphate transportation took place in shallow water. The evidence supporting this theory is -

1. The general coarse grain size of the enclosing sediments.
2. The presence of the large pellets in a basal conglomerate. The conglomerate is made up of angular fragments of quartz and some feldspar averaging about one quarter of an inch across.

3. The presence of phosphate in areas where the total thickness of Stairway Sandstone is comparatively small. There has been no phosphate found in the Stairway Sandstone in the

MacDonnell Range where the formation is thickest and generally contains a high proportion of finer grained clastics. It is presumed that in this area the formation was deposited in deeper water.

The localisation of the phosphate formation may be related to the bottom floor topography at the time of deposition of the Stairway Sandstone. Thus deposition of phosphate may be controlled by the presence of submerged ridges and hills where there would be more agitated seawater, a good supply of phosphate rich water, coarser sediments and a favourable area for the formation of calcite nodules. The phosphate nodules could be subsequently concentrated into lensing bodies by long-shore currents in these areas.

In 1963 four bores (AP1 - AP4) were drilled by the Bureau of Mineral Resources to evaluate the phosphate deposits in the Stairway Sandstone. Continuous core was obtained.

The details of bores AP1 - AP4 drilled in the Stairway Sandstone are reported by Barrie (1964). A detailed lithological analysis of cores obtained from these bores has been undertaken by Crook and Cook (1964). The most promising results were obtained from AP4 which penetrated the Stairway Sandstone near Inindia Bore. AP4 was 338'8" deep and intersected 170 feet of Stairway Sandstone. In this area the Stairway Sandstone overlies the Winnall Beds with an angular unconformity and the strike ridge of these Upper Proterozoic rocks was probably a large submarine ridge during deposition of the Stairway Sandstone in the Upper Ordovician. The results of the estimation of phosphate in selected core samples from AP4 are -

Depth	Per cent P_2O_5	Depth	Per cent P_2O_5
246'9½" - 247'3"	2.4	253'11" - 254'2"	2.2
248'4" - 249'2½"	2.2	254'2" - 255'	1.8
249'2½" - 249'7½"	2.4	255' - 255'5"	1.8
249'7½" - 250'1"	5.0	255'5" - 255'8"	0.6
250'1" - 251'	2.0	255'8" - 255'10"	7.4
251' - 251'6"	6.6	255'10" - 257	0.4
251'6" - 252'1"	5.0	257' - 257'9"	1.0
252'1" - 252'3"	6.0	257'9" - 258'11"	3.2
252'3" - 252'7"	6.9	258'11" - 259'1½"	11.4
252'7" - 253'6"	2.2	259'1½" - 259'4½"	2.2
253'6" - 253'11"	5.0	274'7" - 274'11"	12.0

Prospecting for phosphate deposits in the Amadeus Basin will require detailed stratigraphic studies from surface and subsurface information. Further drilling could well be directed towards areas which have a structure similar to that near Inindia Bore. No economic deposits have been proved to date.

Water Supply

The area covered by the Ayers Rock, Kulgera and Finke Sheet areas is leased by several stations for cattle raising, and as there is no surface water of any significance the water supplies are derived from bores and some earth dams.

Underground Water

Insufficient information is available to plot on the geological maps all the bores shown in the Tables. The details of bores drilled in the Sheet areas mentioned above are shown in Appendix I. In the areas on the north-eastern part of the Ayers Rock Sheet area and the northern part of the Kulgera Sheet area the best aquifer is the clean porous sand of the Mereenie Sandstone. Most bores in this formation yield good supplies of potable water. Good water supplies are also being obtained from sand in the Winnall Beds. Some of the sandstone beds in the Stairway Sandstone and Inindia Beds could also be good aquifers but require further evaluation.

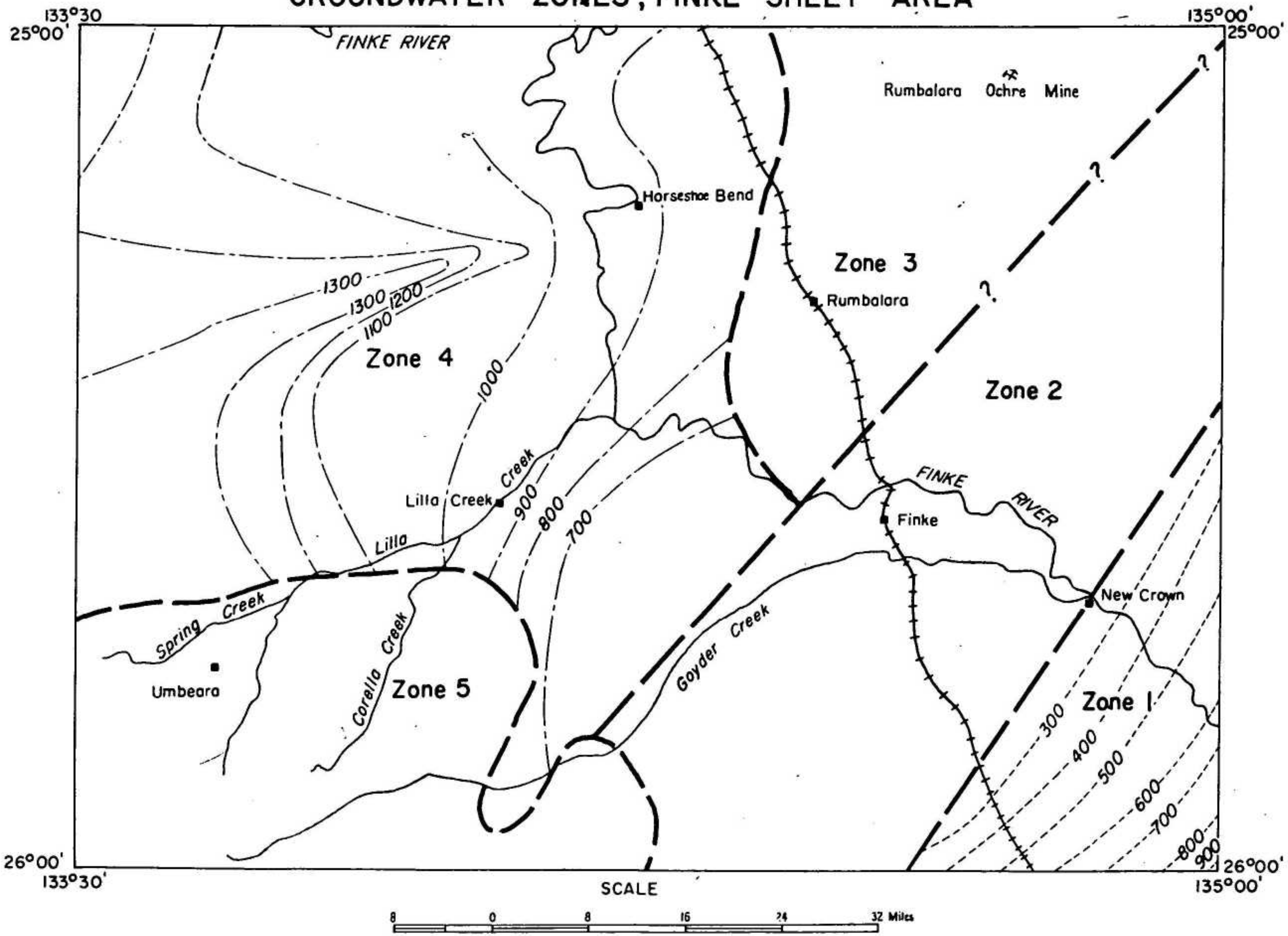
Several bores have been sunk in the area of the chain of salt lakes which continues from Lake Amadeus across the south-eastern part of the Amadeus Basin. The quality and supply of water from these areas is unreliable. Many of the bores are extremely saline and unsuitable both for human consumption and for cattle. Many were sunk in the red-brown shale of the Horseshoe Bend Shale or salt water sands in alluvium near the salt lakes. Several shallow bores on the Kulgera Sheet area are obtaining good quality water from alluvial deposits and areas of travertine away from the salt lake areas.

An appraisal of the water supplies on the Finke Sheet area is given by Rochow (1963). The main aquifers are the De Souza Sandstone, the Idracowra Sandstone and Langra Formation. Rochow has divided the area into five zones (Fig.25) based on the conditions of occurrence of ground water. The main features of these zones are -

Zone 1: the aquifer is the De Souza Sandstone and the piezometric surface is 470 feet above sea level. Groundwater occurs a few feet below the base of the Rumbalara Shale.

GROUNDWATER ZONES, FINKE SHEET AREA

Fig. 25



REFERENCE

Groundwater zone boundary -700---- Contours on piezometric surface with depth in feet -300-- Contours on surface at which water is struck. Dephth in feet. ▪ Homestead

++++++ Railway line

After Rochow (1963) map G/53-6-2A, Resident Geologists Office, Alice Springs

Bureau of Mineral Resources, Geology and Geophysics.

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G53/A6/6

LK

Zone 2: the aquifer is again the De Souza Sandstone and the piezometric surface is about 470 to 500 feet above sea level. The salinity of the water rarely exceeds 1,000 ppm. The depth at which water is struck is about 500 feet below the ground surface.

Zone 3: the aquifer is the Idracowra Sandstone with water supplies mainly from the lower sandstone of the formation. The piezometric surface is 700-800 feet above sea level and the depth at which water is struck is variable.

Zone 4: Ground water is highly saline. The Langra Sandstone is the main aquifer. The only likely fresh water areas are those with local recharge. Some successful bores have been sunk on or near/which areas are topographically high. Upper Proterozoic rocks have saline aquifers. The depth at which water is struck is variable.

Zone 5: No aquifer of regional extent. Local aquifers in granite, sediments of the Finke Group, and alluvium along the large water courses. The piezometric surface is usually shallow, about 50 ± 30 feet.

The Rumbalara Shale yields salty water from local aquifers. The Horseshoe Bend Shale does not possess any suitable aquifers and bores in this formation yield salt water. Salt water is known in the Finke River in areas outside the outcrop of the Langra Formation so there may be a combination of recharge into and outflow from, outcrops of the Langra Formation depending on the position of the piezometric surface. The Polly Conglomerate would probably also have salt water unless there was sufficient recharge in certain areas. No water bores have penetrated this formation.

Surface Water

Natural surface waters are limited to pools present in the larger watercourses, small springs and a few rock holes. Surface water is also stored in several artificial earth dams.

Salt water obtained from alluvium in the Finke River and in waterholes in the stream bed is, in most cases, derived from outflow of ground-water from the Langra Formation. A salt spring is present in a creek cutting through the Black Hill Range west of Horseshoe Bend. The salt water is issuing from the Langra Formation. A sample (CW14) of salts from the stream bed was analysed by I. Francis (A.M.D.L.) and showed -

		%
Chloride	-	30.1
Sulphate	-	13.7
Nitrate	-	nil

Sodium	- 19.5
Potassium	- 0.40
Calcium	- 0.75
Magnesium	- 0.90
Water insolubles	- 18.9
Carbon dioxide	- 0.04

Rock holes with fresh water are present in the Polly Conglomerate at Horseshoe Bend and several rock holes are present in the granitic rocks on the southern and south-eastern part of the Kulgera Sheet area. Springs are known in these parts of the Kulgera Sheet as well as a few in the area of the salt lake chain in the central part of the Sheet. Several wells and bores have been sunk on the sites of the springs.

Artificial earth dams have been constructed on several of the cattle stations, particularly those in the Finke Sheet area. Most of the dams were dry, because of the prolonged period of low rainfall. The dam walls and intake channelways are subject to gullying and erosion with consequent siltation of the dam. This problem was most noticeable in newly made dams where the constructing materials are fine friable sands and as yet uncompacted. However earth dams are probably the surest and most economical method of obtaining water, particularly in areas where the aquifers yield poor supplies or salty water.

<u>Yellow Ochre</u>

Yellow ochre deposits occur in the base of the Rumbalara Shale north-east of the Rumbalara Railway Siding and have been mined at the Rumbalara Ochre Mines (Yellow Queen and Yellow King) near Mt. De Souza. The following summary of the features of this deposit is taken largely from Sullivan and Öpik, (1951).

The ochre occurs in a band 1½ - 4 feet thick and averages 2½ feet thick. The golden-yellow ochre contains 45-55% Fe_2O_3 and apart from F_2O_3 consists mainly of kaolin with a few fine grains of quartz and a few flakes of muscovite. It has a specific gravity of 3.33. It is underlain by a bed of limonite 1-1½' thick which has 60-70% Fe_2O_3.

The deposit was under a mining lease to the Australian United Paint Co. Ltd who took the entire output. Production of ochre from the mine to December 1949 was 7,456 long tons valued at £28,239. The total production was 7,875 tons up to the time of the closing of the mine in 1951. It is estimated that the possible reserves are 25,000-30,000 tons of ochre if the band maintains its thickness through the mesa. Other deposits of unknown extent occur 12 miles south-west of those at the Rumbalara Ochre Mines.

A.A. Öpik (in Sullivan & Öpik, 1951) says the ochre has the features of a sediment. It is the basal bed of the marine Cretaceous and is a sedimentary iron ore. The ochre is probably a bacterial sediment formed by Cretaceous micro-organisms comparable to the recent Leptotrix ochracea.

Evaporites

Thin deposits of evaporites are present in the long chain of salt lakes which stretch from the north-east corner of the Ayers Rock Sheet area and trend east-west across the central part of the Kulgera Sheet area. The lakes terminate near the eastern edge of the Kulgera Sheet area about sixteen miles south-east of the Mount Sunday Range. These salt lakes are an off-shoot from Lake Amadeus on the Lake Amadeus Sheet area.

The evaporites in the lakes are predominantly halite. The halite from some of the salt lakes near Curtin Springs is mined at odd intervals and sold in Alice Springs. The percentage of salts in the lakes is highest in the western parts of the lake chain. The lakes near Erldunda Homestead are filled mainly with silt and clay with minor amounts of evaporites.

Two samples of evaporites, K8A and K30, from the crust of salt lakes on the Kulgera Sheet area were analysed. K8A is located near Pulcura Well and K30 near Migura Well, about 5 miles east of K8A. Radicals detected by flame photometer in K8A and K30 were mainly sodium, and also potassium, calcium, magnesium and strontium. Ions detected chemically in samples K8A were abundant sulphate, minor chloride and less than 1 p.p.m. borate. In sample K30, abundant chloride, minor sulphate, and less than 1 p.p.m. boratewere detected chemically.

The analyses of component fractions of these samples are -

K8A

Component fractions	Wt.%	Minerals found by X-ray and petrology	Probable mineral equivalents
Soluble in H_2O	48.12	Na_2SO_4(90%) Thenardite	Thenardite or mirabilite
		NaCl(10%) Halite	Halite.
Soluble in HCl	1.46	$CaSO_4$ Anhydrite	Anhydrite or gypsum
Insoluble	50.41	Quartz-sand, clay limonite.	-
K30			
Soluble in H_2O	70.45	NaCl. Halite	Halite
Soluble in HCl	4.11	$CaSO_4$ Anhydrite	Anhydrite or gypsum
Insoluble	25.50	Sand, clay, limonite.	

Analyses were carried out in the B.M.R. Laboratory by I.R. Pontifex, S. Baker and N. Le Roux.

Evaporites also occur in some salt pools in the Finke River and some small creeks that drain into this stream. Most of the salts in the rivers and creeks are derived from springs issuing from the Langra Formation. A small stream that drains southerly through the Black Hill Range has encrustations of white salts which consist mostly of sodium chloride and sodium sulphate.

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REFERENCES

BARRIE, J., 1964 - Phosphate drilling, Amadeus Basin. Bur.Min.Resour.Aust.Rec. 1964/ (in preparation)

BASEDOW, H., 1905 - Geological report on the country traversed by the South Australian Government north-west prospecting expedition, 1903. Trans.roy.Soc. S.Aust., 29, 57-102.

BASEDOW, H., 1929a - Geological report on the Petermann Ranges, Central Australia. In Mackay, D., - The Mackay exploring expedition, Central Australia, 1926. Geog.J. 73, 258-265.

BASEDOW, H., 1929b - Notes to accompany the 'Map of the Mackay exploring expedition in Central Australia, 1926'. Proc.roy.Geogr.Soc. Aust'asia S.Aust.Br., 29, 171-176.

BILLINGS, M.P., 1954 - STRUCTURAL GEOLOGY. New Jersey: Prentice Hall, 2nd ed.

BROWN, H.Y.L., 1897 - Reports on Arltunga Goldfield, etc., 1896. S.Aust.Parl.Pap. 127.

CHEWINGS, C., 1914 - Notes on the stratigraphy of Central Australia. Trans.roy.Soc.S.Aust., 38, 41-52.

CHEWINGS, C., 1928 - Further notes on the stratigraphy of Central Australia. Trans.roy.Soc. S.Aust., 52, 62-81.

CHEWINGS, C., 1931 - A delineation of the Precambrian plateau in Central and North Australia with notes on the impingent sedimentary formations. Trans.roy.Soc.S.Aust., 55, 1-11.

CHEWINGS, C., 1935 - The Pertatataka Series in Central Australia, with notes on the Amadeus Sunkland. Trans.roy.Soc.S.Aust., 59, 141-163.

COATS, R.P., 1962 - Geology of the Alberga Four-mile Military Sheet. Geol.Surv.S.Aust. Rep. 22.

COOK, P.J., 1963 - Phosphorites in the Amadeus Basin of Central Australia. Aust.J.Sci., 26, (2), 55-56.

CROOK, K.A.W., and COOK, P.J., 1964 - Sedimentological studies of the Ordovician Stairway Sandstone. Bur.Min.Resour.Aust.Rec. 1964/ (in preparation).

DAVID, T.W.E., 1898 - Report on occurrence of glacial boulders at Yellow Cliff, Crown Point Station, Finke Valley, Central Australia. Rep.Aust.Ass.Adv.Sci., 3.

DAVID, T.W.E., and HOWCHIN, W., 1924 - Glacial research on deposits at Yellow Cliff, Central Australia, and in the vicinity. Rep. Aust.Ass.Adv.Sci., 16, 74-94.

DE SITTER, L.U., 1956 -- STRUCTURAL GEOLOGY. N.Y.; McGraw-Hill.

EAST, J.J., 1889 - Geological structure and physical features of Central Australia. Trans. roy.Soc.S.Aust., 12, 31-53.

ELLIS, H.A., 1937 - Report on some observations made on a journey from Alice Springs to the country north of the Rawlinson Ranges in W.A., via the Musgrave and Petermann Ranges in 1936 (with plans). Ann. Prog.Rep.Geol.Surv.W.A. for 1936

FORMAN, D.J., 1963 - Regional geology of the Bloods Range Sheet, south-west Amadeus Basin. Bur.Min.Resour.Aust.Rec. 1963/47 (unpubl.).

FORMAN, D.J. and HANCOCK, P.M., 1964 - Regional geology of the southern margin, Amadeus Basin, Rawlinson Range to Mulga Park Station. Bur.Min.Resour.Aust.Rec. 1964/41.

FRAREY, M.J., and McCLAREN, D.J., 1963 - Possible Metazoans from the early Proterozoic of the Canadian Shield. Nature, 200, 4905, 461-462.

GILES, E., 1889 - AUSTRALIA TWICE TRAVERSED. London: Sampson Low, Marston, Searle and Rivington. Two Vol's.

GILLESPIE, I., 1959 - The southwest Amadeus Basin geological reconnaissance survey. Frome-Broken Hill Co. Rep 4300-G-23. (unpubl.).

GOSSE, W.C., 1874 - Report and diary of Mr. W.C.Gosse's central and western exploring expedition, 1873. S.Aust.Parl.Pap.48.

GRASSO, R., 1963 - The photogeology of the OP.72 Area. Finke Oil Co.Pty Ltd., confidential report by Minoil Services, Adelaide, S.A. (unpubl.).

HARTMAN, R.R., 1963 - Airborne magnetometer survey over Oil Permit No.72 and portion of Oil Permit No.78 (Amadeus Trough, N.T.). Report by Aeroservice Ltd for Exoil (N.S.W.) Pty Ltd. (unpubl.).

HILLS, E.S., 1953 - OUTLINES OF STRUCTURAL GEOLOGY. London; Methuen, 3rd ed.

HOPKINS, R.M., 1962 - Stratigraphic measurements, Amadeus Basin, permit 46, N.T. Report for Magellan Petroleum Corporation. (unpubl)

HOSSFELD, P.S., 1954 - Stratigraphy and structure of the Northern Territory. Trans.roy.Soc. S.Aust., 77, 103-161.

JOKLIK, G.F., 1955 - The geology and mica-fields of the Harts Range, Central Australia. Bur. Min.Resour.Aust.Bull. 26.

LANGRON, W.J., 1962 - Amadeus Basin reconnaissance gravity survey using helicopters, N.T., 1961. Bur.Min.Resour.Aust.Rec. 1962/24 (unpubl.).

LESLIE, R.B., 1960 - The geology of the southern part of the Amadeus Basin, Northern Territory. Frome-Broken Hill Co. Rep. 4300-G-28. (unpubl.).

LONSDALE, G., and FLAVELLE, A., 1963 - Amadeus Basin and South Canning Basin. Results of reconnaissance gravity survey using helicopters, N.T. and W.A., 1962. Bur.Min.Resour. Aust.Geophys.Prog.Rep. 1963/4 (unpubl.).

MADIGAN, C.T., 1932 - The geology of the western MacDonnell Ranges, Central Australia. Quart.J.geol.Soc.Lond., 88(4), 672-711.

MOSS, F.J., 1962 - Amadeus Basin (southern margin) seismic survey, Northern Territory, 1961. Bur.Min.Resour.Aust.Rec. 1962/167.

NEVIN, C.M., 1949 - PRINCIPLES OF STRUCTURAL GEOLOGY. N.Y.; Wiley.

OLLIER, C.D., and TUDDENHAM, W.G., 1961 - Inselbergs of Central Australia. Z.Geomorph. Bd.5, Hft.4, 257-276.

PETTIJOHN, F.J., 1957 - SEDIMENTARY ROCKS. New York; Harper & Bros. 2nd ed.

PRICHARD, C.E., and QUINLAN, T., 1962 - The geology of the southern half of the Hermannsburg 1:250,000 Sheet. Bur.Min.Resour.Aust. Rep. 61.

QUINLAN, T., 1962 An outline of the geology of the Alice Springs area. In General report on lands of the Alice Springs area, Northern Territory, 1956-57. Sci.ind. Res.Org.Melb., Land Res.Ser. 6.

RANFORD, L.C., and COOK, P.J., 1964 - The geology of the Henbury 1:250,000 Sheet area, Amadeus Basin, Northern Territory. Bur.Min.Resour. Aust.Rec. 1964/40.

ROBINSON, E.S., 1950 - The petrological nature of some rocks from the Mann, Tomkinson and Ayers Ranges of Central Australia. Trans.roy.Soc.S.Aust., 73,(1), 29-39.

ROCHOW, K., 1963 - The geology and occurrence of ground water on the Charlotte Waters four-mile Sheet, N.T. Bur.Min.Resour. Aust. MS.

SAUCHELLI, V., 1962 - The origin and processing of phosphate rock, with particular reference to beneficiation. The Fertiliser Soc., 70.

SCANVIC, J.Y., 1961 - Report on photo-interpretation of the Amadeus Basin. Rep.for Bur.Min. Resour.Aust. by Institute Francais du Petrole. AUS./31 (unpubl.).

SKWARKO, S.K., 1962 - Notes on Australian Lower Cretaceous palaeogeography. Bur.Min.Resour. Aust.Rec. 1962/11 (unpubl.).

SPRIGG, R.C., 1963 - Geology and petroleum prospects of the Simpson Desert. Trans.roy.Soc. S.Aust., 86, 35-65.

SPRIGG, R.C., JOHNSON, J., and AUDLEY-CHARLES, M., 1960 - Petroleum possibilities of the Simpson Desert area, Central Australia. Geosurveys of Aust.Ltd., Rep. (unpubl.).

STELCK, C.R., and HOPKINS, R.M., 1962 - Early sequence of interesting shelf deposits, Central Australia. J.Alberta Soc.Pet. Geologists. 10,1,1-12.

STUART, J., McD., 1865 - Explorations in Australia; the Journals of John McDouall Stuart during the years 1858-1862, etc. London; Saunders, Otley & Co. 2nd edit.

SULLIVAN, C.J., and ÖPIK, A.A., 1951 - Ochre deposits, Rumbalara, Northern Territory. Bur.Min.Resour. Aust. Bull. 8.

TATE, R., 1897 - On evidences of glaciation in Central Australia. Trans.roy.Soc. S.Aust. 21, 68.

TATE, R., and WATT, J.A., 1896 - General geology. In Report on the work of the Horn Scientific Expedition to Central Australia, part III. London & Melbourne.

TATE, R., and WATT, J.A., 1897 - Report of the physical geography of Central Australia. In Winnecke, C., Journal of the Horn Scientific expedition, 1894. S.Aust.Govt Printer, Adelaide.

TAYLOR, D.J., 1959 - Palaeontological report on the southern Amadeus region, N.T. Frome-Broken Hill Co. Rep. 4300-G-27. (unpubl.).

TERPSTRA, G.R.J., and EVANS, P.R., 1963 - Cretaceous microfossils from Andado Station, Northern Territory. Bur.Min.Resour.Aust.Rec. 1963/108.

TERRY, M., 1931 - Two journeys westward from Horseshoe Bend and Oodnadatta, Central Australia. Geogr.J.,78, 341-346.

THOMAS, Nancy M., 1956 - Review of the geology of the Amadeus Basin. Frome-Broken Hill Co. Rep. 4300-G-11. (unpubl.).

TOMLINSON, Joyce GILBERT-, 1963 - Cambrian and Ordovician fossils from the areas of Hermannsburg and Lake Amadeus Sheet areas, N.T. Appendix I in Wells, Ranford & Cook, Bur.Min.Resour.Aust.Rec. 1963/51 (unpubl.).

TOMLINSON, Joyce GILBERT-, 1964 - Palaeozoic fossils from the Amadeus Basin, 1963. Bur.Min.Resour. Aust.Rec., 1964/ (in preparation).

TURNER, F.J., and VERHOOGEN, J., 1960 - IGNEOUS AND METAMORPHIC PETROLOGY. N.Y.; McGraw-Hill 2nd ed.

WARD, L.K., 1925 - Notes on the geological structure of Central Australia. Trans.roy.Soc. S.Aust., 49, 61-84.

WEEGAR, A.A., 1959 - Interim report on the geology of the southern part of the Amadeus Basin, N.T. Frome-Broken Hill Co. Rep. 4300-G-25. (unpubl.).

WELLS, A.T., FORMAN, D.J., and RANFORD, L.C., 1961 - Geological reconnaissance of the Rawlinson-Macdonald area, W.A. Bur.Min.Resour. Aust.Rec. 1961/59 (unpubl.).

WELLS, A.T., FORMAN, D.J., and RANFORD, L.C., 1962 - Geological reconnaissance of the north-west Amadeus Basin. Bur.Min.Resour.Aust. Rec. 1962/63 (unpubl.).

WELLS, A.T., RANFORD, L.C., and COOK, P.J., 1963 - The geology of the Lake Amadeus 1:250,000 Sheet area, N.T. Bur.Min.Resour.Aust.Rec. 1963/51 (unpubl.).

WHITE, W.A., 1961 - Colloid phenomena in the sedimentation of argillaceous rocks. J.Sed.Pet. 31, 560-570.

WILSON, A.F., 1947 - The charnockitic and associated rocks of north-western South Australia, Pt. I: The Musgrave Ranges - an introductory account. Trans.roy.Soc. S.Aust., 71 (2), 195-211.

WILSON, A.F., 1948 - The charnockitic and associated rocks of north-western South Australia, Pt. II: Dolerites from the Musgrave and Everard Ranges. Trans.roy.Soc.S. Aust. 72,(1), 178-200.

WILSON, A.F., 1950 - Some unusual alkali-feldspars in the Central Australian charnockitic rocks. Miner.Mag., 29, 215-224.

WILSON, A.F., 1952a The charnockite problem in Australia. Sir D. Mawson Anniv.Vol.Univ.Adelaide. 203-224.

WILSON, A.F., 1952b - Metamorphism of granite rocks by olivine dolerite in Central Australia. Geol. Mag., 89, 73-86.

WILSON, A.F., 1953 - The significance of lineation in Central Australia. Aust.J.Sci., 16, 47-50.

WILSON, A.F., 1954 - The significance of lineation in Central Australia. A reply. Aust.J. Sci., 16, 242-243.

WILSON, A.F., 1959 - Notes on the fabric of some charnockitic rocks from Central Australia. J.roy.Soc.W.Aust., 42, 56-64.

WILSON, A.F., 1960 - The charnockitic granites and associated granites of Central Australia. Trans.roy.Soc.S.Aust., 83, 37-76.

WINNECKE, C., 1897 - Journal of the Horn Scientific Exploring Expedition to Central Australia. S.Aust.Parl.Pap. 19.

WOPFNER, H., and HEATH, G.R., 1963 - New observations on the basal Creta-Jurassic Sandstone in the Mt. Anna Region, South Australia. Aust.J. Sci., 26, (2), 57-59.

WULFF, G.E., 1960 - Geology of the south-eastern part of the Amadeus Basin. Frome-Broken Hill Co. Rep. 4300-G-29. (unpubl.).

RECORDS 1964/35.

THE GEOLOGY OF THE SOUTH-EASTERN PART OF THE AMADEUS BASIN.

APPENDIX I.

B O R E   D A T A

AYERS ROCK, KULGERA, and FINKE SHEET AREAS.

APPENDIX I - TO RECORDS 1964/35.

BORE DATA

Information on bores and wells in the Ayers Rock, Kulgera, and Finke 1:250,000 Sheet areas, collected from Water Resources Branch, Northern Territory Administration, and Resident Geologist's Office, Bureau of Mineral Resources, Alice Springs, is listed in this Appendix.

The order of listing is (a) by map sheets, and (b) numerically by the reference numbers allocated to the bores and wells by the Resident Geologist, Alice Springs.

Abbreviations used in this Appendix are listed on page 3, but these have not been used universally throughout the Appendix. To save repetition of column headings, the columns in the body of the Appendix are lettered A to J: a specimen sheet giving the full headings and the appropriate letter is given on page 4.

ABBREVIATIONS

Bk.	black
Blk.	black
Bl.	blue
Bld.	boulder
Bldr.	boulder
Br.	brown
Bn.	brown
Brn.	brown
C.	coarse
c.	coarse
Cs.	coarse
Ca.	about
Choc.	chocolate
Ck.	creek
Cl.	clay
cl.	clay
cls.	clays
col.	coloured
Cong.	conglomerate
Cr.	cream
Dk.	dark
dk.	dark
E.	east
e.	east
F.	fine
f.	Fine
frag.	fragments
fragmnts.	fragments
G.	grained
gr.	grained
Gn.	green
Gr.	granite
grdmass.	groundmass
Gvl.	gravel
Gy.	grey
Gyp.	gypsum
Hd.	hard
H/S	homestead
Ironst.	Ironstone
Junct.	Junction
Lst.	Limestone
Lt.	light
m.	medium
Med.	medium
med.	medium
mat'ial.	material
Mxd.	mixed
N.	north
n.	north.
P.cl.	pipe clay
Pk.	pink
qty.	quantity
Qtz.	quartz
qtz.	quartz
Rbl.	rubble
Rd.	red
Rk.	rock
rk.	rock
Rtn.	rotten
S.	south
s.	south.
Sh.	shale
Si.	silt
Sst.	sandstone
Stk.	stock
Sts.	stones
Su.	surface
Sy.	sandy
traver.	travertine
V.	very
v.	very
W.	with } Column J only
w.	with } Column J only
W.	west } Column D only
w.	west } Column D only
Wd.	weathered
Wh.	white
wh.	white
Y.	yellow

BORE NAME	REFERENCE NUMBER	LEASE	LOCATION	TOTAL DEPTH	DEPTH TO FIRST AQUIFER	S.W.L.	SUPPLY G.P.H.	T.D.S.	STRATA AND REMARKS
A.	B.	C.	D.	E.	F.	G.	H.	I	J

APPENDIX I - TO RECORDS 1964/35.

PART I

AYERS ROCK - BORE LOGS

Pages 7 to 12.

A	B	C	D	E	F	G	H	I		J
MT CONNER WELL	G52/8-1	Curtin Springs	Run 10,ph.5074	14	-	-	1400	-		Slightly brackish
Parrara Well	" 2	Curtin Springs	-	12	-	10	900	1538	-	-
Homestead Well	" 3	"	Run 6, ph.5030	18	-	14	900	2574 2724	-	Two analyses
Spring Well	" 4	"	Run 6, ph.5034	9	-	7'3"	100	4955	-	-
Garden Well	" 5	"	Run 6, ph.5030	16	-	-	-	-	-	-
Amory Well	" 6	"	E.Key,ph. 5133	18'9"	-	12	small	6503	-	-
No.1(Dud) Bore	" 7	"	-	596	-	42	unlim.	-	0'- 15' Red loam -596' Blue clay	Salt taste
Mallee Well	" 8	"	Run 5,ph. 5164	8	-	-	1400	-	-	Near salt lake
Tuits	" 9	Ayers Rock Reserve	Run 6,ph. 5013	117	-	57	80-100	1295 1021	Travertine overlying clays? and then sandstone	
Reserve Board [illegible]. No.1 Try	" 10	"	Run 6,ph. 5013 5.4"E.,3.7"N.	400	-	60	40	-	0'-10' Top soil -15' Sandstone boulders -48' Clay -52' Boulders in clay -66' Limestone -105' White Clay -163' White clay -205' Limestone -293' White clay -305' Sandstone -400' Quartzite Hard drilling at bottom of hole.	

A	B	C	D	E	F	G	H	I	J
Old Station Well	G52/8-11	Mulga Park	-	-	-	55	-	2524	In gneiss —
Alice Springs Tours	" 12	Ayers Rock Reserve	-	ca.130	-	Ca.80	-	-	Red ferrugineous silt in bore drain, some sand but not much. May be small thickness of travertine at top of hole. Water appeared after driller left site.
Mt Olga No.2	" 13	Reserves Board	Run 4, ph. 5122 4"E., 2.5"N.	?130	-	53	-	811	Creek alluvium over Mt Olga Conglomerate (Mt Currie Conglomerate)
Mt Olga No.1	" 14	Reserves Board	Run 4, ph. 5122 3.5"E., 0.5"N.	165	-	[illegible]	200	1171	0'- 11' Top soil - 80' Limestone - 84' Gravel -125' Boulders & clay -165' Quartzite
Ayers Rock Camping Reserve No.2 Try	" 15	Reserves Board	Run 6, ph. 5013 4.3"E., 3.4"N.	250	-	153	600	1509 1686 1577	0'- 22' Red-brown sandy soil slightly clayey - 33' Cream, grey, & brown travertine - 46' Slightly clayey creamy-grey sand, f. to v.c. Fragments of quartz, feldspar & arkose, up to ¼" -140' Stiff, white sandy clay -163' - -167' Red, silty sand m. to c. -250' Soft red clay
Tuits No.1 Try	" 16	Ayers Rock Reserve	-	93	-	-	Nil	-	0'- 7' Soil - 85' Clay - 92' Sandstone

A	B	C	D	E	F	G	H	I	J
Tuits No.2 Try	G52/8-17	Ayers Rock Reserve	-	240	-	211	1000	1267 633	0'- 7' Soil -163' Clay '-167' Silty sand -240' White clay Two analyses
No.1 Bore	"	18 Mulga Park	-	80	-	55	1400	1685	- -
No.2 Bore	"	19 " "	-	90	-	60	700	1199	- -
No.3 Bore	"	20 " "	-	95	-	60	1400	2547	- -
No.4 Bore	"	21 " "	-	105	-	60	300	1209	- -
Stock Well	"	22 Curtin Springs	-	16	-	15	3000	1531	- -
No. 9 Bore	"	23 Mulga Park	-	70	-	65	400	5045	- -
No.2(Dud) Bore	"	24 Curtin Springs	-	170	-	90	unlim.	-	0'- 15' Red loam '-170' Blue clay Salty taste
No.5 Bore	"	25 Mulga Park	-	100	-	50	1000	1219	- Sample two weeks old when analysed.
No.6 Bore	"	26 " "	-	50	-	30	1250	2448	0'- 30' Very hard clay '- 50' White clay
Dud Bore	"	27 " "	-	-	-	75'8"	-	3967	- -

A	B	C	D	E	F	G	H	I	J
No.10	G52/8-28	Mulga Park	-	90	-	75	1200	3521	0'- 34' Dark grey mic. quartz mica schist - 49' Black quartz schist - 53' Strongly weathered schist - 61' Quartz schist - 70' Quartz, feldspar mica, ferromagnesium gneiss (or schist?) - 90' Quartz feldspar mica schist
Dud Bore	" 29	"	-	95	-	47	v.small	609	0'- 30' Fragments of granite - 65' Fine-gr. black basic igneous rocks -?dolerite - 70' Fine-gr. black basic igneous rocks -? dolerite - 92' Ditto
No.1 Dud Bore	" 30	"	-	205	-	42	"	-	7'-100' Weathered; quartz fragments with some red clay -180' Ditto, some fragments of slate -187' Lt gn. & yellow mudstone -205' Fragments of quartz & iron oxide in quartzitic groundmass
No.7 Bore	" 31	"	-	-	-	-	-	2022	- -
Dud Bore	" 32	"	-	90	-	-	-	-	0'- 40' Fine qtz w.cl. - 60' Ditto - 63' Silicified shale - 90' Granite chips
Dud Bore	" 33	"	-	-	-	-	-	6409	In metamorphics -
No.8 Bore	" 41	"	-	-	-	-32	-	6721	- -

A	B	C	D	E	F	G	H	I	J
No.4 (Dud) Bore	G52/8-42	Curtin Springs	-	575	-	315	-	-	0'- 12' Sur. soil -575' Blue clay salt taste
No.11, at 5th attempt	" 43	Mulga Park	-	56	-	56	1500	-	Probably alluvium over metamorphics -
No.12, 4th attempt	" 44	" "	-	101	-	-	7950	-	" " " "
No.13, 1st attempt	" 45	" "	-	104	-	-	7800	-	Probably in alluvium -
Salt Bore	" 46	Curtin Springs	-	80	-	30	-	41,062	0'- 20' White travertine - 30' Red silty cl.w. traver.fragmnts - 40' Pale gn.calcareous cl.W.traver. frag. - 50' Pale gn.gypsiferous cl. - 80' Fine to coarse qtz. sand.W.calcareous cement
Stockyard Bore	" 47	"	-	35	-	18	2000	3764	0'- 10' Off-white lime-stone,W.appearance of cl.replaced by limestone - 18' As above - 30' Very pale green silty clay - 35' As above.
House Bore	" 48	"	-	45	-	21	1800	4066	0- 15' Off-white limestone - 30' Off-wh.limestone W.veinlets of patch-like qtz - 40' cream calcareous cl.W.med.to c. quartz sand - 45' Red-brown and cr. fine to c.fairly clean sand

A	B	C	D	E	F	G	H	I	J
No.16 Bore	G52/8-49	Mulga Park	-	100'	-	80	-	6652	- -
Karee No.2(Dud)	" -50	"		108	-	-	v.small	-	0'- 25' Red Soil - 40' Broken granite -108' Solid granite
Karee No.2	" -51	"	-	115	-	-	-	-	Successful.
Dud	" -52	Curtin Springs	E.Key,ph.5129 6.5"N.,4"E.	130	-	33	Ca.200	-	0'-115' Laminated choc.-Br.siltstone -160' Choc.-Br/W.streaks [siltstone] of pale grey siltstone. ?Pertnjara siltstone. Water very salty.
Dud	" -53	"	E.Key,ph.5129 2.5"N.,5.5"E.	202	-	33	200	-	0'-130' Choc.-Br. siltstone. -140' Mottled choc.-Br.& pale Gy. siltstone. -200' Mottled Choc.-Br., Gy.& yellow clayey siltstone Salt taste
Amery Bore	" -54	"	-	75	-	8	320	10,821	- -
Tuits Bore	" -55		-	170	-	55	50	-	- Fair quality; high fluoride
			-						
Wineyard Bore	" -57	"	-	60	-	-	-	-	0'- 6' Limestone - 20' Red clay - 25' Limestone - 60' Rd Cl. & stone. Bad quality

APPENDIX I - TO RECORDS 1964/35.

PART II

KULGERA - BORE LOGS.

Pages 14 to 31

A	B	C	D	E	F	G	H	I	J
Mt.Ebenezer	G53/5- 1	Mt.Eben-ezer	Run 3,ph.5015, 5.05"E.,6.3"N.	-	-	190	300	1441	- -
No.1	" - 2	"	-	275	-	100	1000	-	0'- 20' Limestone - 80' Blue clay 0'-275' Sandstone & limestone
D.R.No.2 try	" - 3	"	Run 2,ph.5064 2.6"E.,4.4"N.	300	-	187	200	5315	0'- 12' Top soil -120' Wh.Sst. -130' Shale & Cl. -145' Br.shale & Cl. 0'-162' Y.Cl. & gravel -173' Grey clay -187' Y.Cl. & gravel -300' Shale
D.R.No.2 try	" - 4	"	Run 2,ph.5064 2.6"E.,4.4"N.	240	-	180	2	9062	0'- 8' Red sand -125' Wh.sandstone 0'-240' Br.& Gn.shale
Packhorse	" - 5	Idracowra	Run 2,ph.5047 1.5"E.,3.7"N.	300	-	250	600	6213 6332	0'-200' Lst.& Clay -230' Sandstone 0'-270' Clay -285' Sandstone
D.R.No.1 try	" -6	"	Run 1,ph.5126 5.65"E.,4.77"N.	225	225	200	large	10,297 17,274	0'- 65' Thin Su.soil then Lst. - 85' Clean Qtz.Sst. -145' Lst.or marl 0'-215' Red shale -220' Red siltstone -225' White quartzite
Dud	" - 7	Govt Stock Route	Run 12,ph.5005 ?3.1"E.,6.4"N.	375	-	-	Nil	-	- Black stinking mud came out when column was pulled. Bore reached the ?Mesozoic conglomerate
Dud	" - 8	Kulgera	Run 13,ph.5207 7.2"E.,6.6"N.	-	-	-	Nil	-	- -
Dud - well	" - 9	"	Run 13,ph.5027 ?5.8"E.,4.75"N.	-	-	-	Dry	-	- -
Dawkins Well	" -10	"	Run 13,ph.5207 7.37"E.,3.55"N.	55+	-	25	-	-	- Abandoned

A	B	C	D	E	F	G	H	I	J
Kangaroo Bore	G53/5-11	Kulgera	Run 12,ph.5013 4.1"E.,3.2"N.	100	-	-	2200- -600	1088	100' hard going. Jan.57. Supply fell off to 320 gph but was brought back to 800 gph with gelly.
At Kangaroo Bore	" -12	"	Run 12,ph.5013 4.1"E.,3.2"N.	220	-	-	450	-	Drilling soft - went in on Lst.blow. -
Top Well	" -13	"	Run 13,ph.5204 4.75"E.,5.42"N.	60	-	-	400	1438	L. Maconville states safe yield is approx. 200 gph.
Lyndock Well	" -14	Mt.Cave- nagh	Run 14,ph.5113 0.9"E.,3.5"N.	? 75	-	50-55	small	-	Spoil of a quartz biotite gneiss - metamorphic within the Gr. Water level is supposed to rise to 30' when mill is not pumping.
Stock Yard Well	" -15	"	Run 15 EC.ph5061 6.65"E.,4.63"N.	-	-	43	-	3460 2402 3600	Alluvium. Well sunk at the base of a travertine rise,at level of alluvium.
Homestead Well	" -16	"	Run 15EC,ph.5061 7.07"E.,0.85"N.	-	-	52	100 gpday	1905 842	Spoil of fine to medium G.gneissic Bl.Gr. Well sunk near the edge of a travertine rise.
Calamity No.2	" -17	Mt.Cave- nagh	Run 15EC,ph.5065 4.78"E.,3.9"N.	143	-	-	300	-	0'- 3' Red loam - 10' Y.gravelly Cl. - 42' Broken Wh. Rk. - 48' " Rk. - 59' Schist - 61' V. Hd.Rk. - 70' Hd.schist '- 73' Hd Rk. - 76' Broken Rk. - 80' " " - 990' " Granite - 92' Hd.black Rk. - 103' Broken Granite - 143' Hd. Granite
Calamity No.1	" -18	Mt.Cave- nagh	Run 15EC,ph.5065 4.78"E.,3.95"N.	105'	68	-	4000	606 692	0'- 45' ? '- 62' Rtn.Rk.(Mxd.) - 68' Porous Rk. - 80' Hd.Rk. '- 85' Blue schist - 96' Hd.schist,grey -100' Porous Rk. - 105' Hd.Rk.

A	B	C	D	E	F	G	H	I	J
No.7 Goyder	G53/5-19	Goyder Stockroute	-	208	-	60	1800	2322	0'- 6' Limestone - 72' Br.shale -110' Sandy shale -120' Sandy clay -194' Fine-grained Sst. -208' Coarse sand
Engine Well	" -20	Kulgera	-	20	-	Dry	-	-	This well has a rat hole into the drive from well G53/5-21
Mill Well	" -21	"	-	-	-	52	-	1567 1582	Spoil of soft traver-tine & kaolin material W.s ome fragments of a Wd.Gr.,medium-G.leuco-cratic variety.
Dud(Homestead)	" -22	"	-	74	-	-	small	-	Hard gneiss. 5/5/60. Bore has been filled in.
Dud	" -23	Wilkinson's Store	Kulgera town-ship	175	-	? 30	-	-	Decomposed Gr. 9/4/59. Hole apparently now filled in.
Ironwood No.2 Engine Hole	" -24	Kulgera	Run 14,ph.5113 4.5"E.,6.0"N.	67	-	? 23	1400	-	- -
Ironwood No.1 Mill Hole	" -25	"	Run 14,ph.5113 4.[illegible]"E.,6.0"N.	75	29	23	1400	1083	0'- 10' Hd.baked Cl. & sand - 20' Gneiss - 29' Hd seams - 38' Gneiss W.Hd. seams - 37'6" V.Hd.seam - 73' Coarse sand - 75' Dolerite
Mulga Bore	" -26	"	Run 14,ph.5121 4.97"E.,5.85"N.	180	-	-	-	-	White silt Gn.silty Cl. Washed gravel.
? Dud	" -27	"	-	-	-	-	-	-	31/8/56 at 200' in sticky clay, advised by N.O. Jones to continue.

A	B	C	D	E	F	G	H	I	J
Dud	G53/5-28	Kulgera	Run 12,ph.5015 12.25"E,5.75"N.	75	-	-	-	30,000	- -
Greenwood's Mill	" -29	"	-	111	-	34'6"	50	1361 1393	Precambrian schists; Granite at 111' - Bore sunk for Wilkinson's Store on a site picked by a diviner
D.R.No.1 Bore	" -30	Curtin Springs	Run 8,ph.5016	140	-	60	2000	1622 1614	Travertine but partly covered by sandhills. Out-cropping Palaeozoic 3 miles to S.W.
Doug's Well	" -31	Mt.Cave-nagh	-	-	-	-	-	1358	- -
Sundown Well	" -32	"	-	-	-	-	-	1724	- -
Branson's Well	" -33	"	-	-	-	-	-	924	- -
Holy Water Well	" -34	"	-	-	-	-	-	2516	- -
Ooleara	" -35	"	-	-	-	-	-	1086	- -
East	" -36	"	-	-	-	-	-	896	- - -
Kooyong Well	" -37	"	Run 15,ph.5113	67	-	44	-	1368	0'- 30' Alternating traver-tine,silt & chal-cedony - 73' Wd.gneiss & Gr.
Homestead	" -38	Kulgera	-	-	-	-	-	2200 2108	- -
D.R.No.1 try	" -39	"	-	212	-	100	800	7013	0'- 50' Rd.Cl. -212' Br.sandstone.

A	B	C	D	E	F	G	H	I	J
Dud	G53/5-40	Erldunda	-	273	-	65	50	13,425	0'- 10' Top s oil -180' Cl.& gravel -250' Shale -270' Broken Sh.& gravel -273' Gravel and sand. Mesozoic sands and clays.
No.2 D.R.Try	" -41	"	Run 10,ph.5109	200	-	65	1500	2541	0'- 5' Top soil - 17' Broken Lst. -105' Br.Cl.& gravel -185' Br.& Wh.Sst. -190' Broken Sst. -200' Sst.
Paddy's	" -42	Mt. Ebenezer	-	180	-	100	2500	1479	- -
D.R.No.1	" -43	Victory Downs	Run 15A,ph.5073	266	-	35	200	776	Qtz.,[illegible] & musco-vite in bore drain.
Murray	" -44	Palmer Valley	-	223	-	163	1000	9458 8367	0'- 12' [illegible] - 50' Cl.& loose Sts. -100' Variegated Cls.-[illegible] -170' Rd.Cl.W.Sst. floaters -180' Cl.heavy Gvl., Sst.floaters -200' Sandy pipe clay -206' Cong.Sst.bar -214' P.Cl.& sand,light Gvl. -220' Sst.cong.bar -223' Wh.Pipe clay
Plumbush	" -45	Kulgera	-	-	-	-	-	-	- -
D.R.No.3A Try	" -46	Mt. Ebenezer	-	300	220	165	200	1441	0'- 10' [illegible] Cl. - 80' Various col.Cls & [illegible] -130' Hd.bars of Sst. -190' Rd.& Bl.Cl. -200' Hd.Sst. -220' Gvl. & Cl. -250' Rd.Cl. & shale -300' Red shale D.R. Bore No.3 Try (G53/5-1) redrilled.
New Bore No.2 Site	" -47	Mt.Cave-nagh	Run 14,ph.5117	132	-	70'-80	1200	33,256	- -

A	B	C	D	E	F	G	H	I	J	
D.R. No.2	G53/5-48	Victory Downs	Run 15A, ph.5073	250	-	45	200	739	-	-
D.R.No.4 Try	" -49	Mt. Ebenezer	-	209	-	165	2000	1957	0'- 5' Top soil - 30' Rd.Cl.& Gvl. - 39' Sst. -180' Rd.Sst.	-190' Sand & Gvl. -209' Red shale
Lucky Bore	" -50	Palmer Valley	-	52	35	34	850	1881	0'- 8' Rd.Cl.& Loose stone - 14' Loose Cl.&sand - 16' White sand - 20' Conglomerate of sandstone	- 35' Travertine - 40' Cong.Sst. - 53' White quartz grit on top of red clay
No.12	" -51	Victory Downs	-	-	-	-	-	-	-	-
D.R. No.3	" -52	"	-	180	-	125	2000	1350	Mesozoic sands and clays.	
No.9	" -53	"	-	-	-	-	-	-	-	
Double Creek No.6	" -54	Goyder Stk route	-	49	-	-	-	-	0'- 49' Granite This was the sixth attempt in the Umbeara, Kulgera, Eldunda triangle - country undrillable.	
Callamonta (Dud)	"- 55	"	-	-	-	-	-	-	0'-283' Sandstone and clay. Very salty.	
Dud	" -56	"	-	700	-	300	-	-	Cut off very bad water at 300' ; proceeded to 378' Water improved. Finished bore unfit for stock.	

A	B	C	D	E	F	G	H	I	J
No.3	G53/5-57	Victory Downs	-	-	-	-	-	-	-
No.4	" 58	"	-	-	-	-	-	-	-
No.5	" 59	"	-	-	-	-	-	-	-
No.6	" 60	"	-	-	-	-	-	-	-
No.7	" 61	"	-	-	-	-	-	-	-
Greenwood's No.2	" 62	-	-	105	40	31	?60-300	6587	0'-25' - -35' Hd.seam -40' Gy.Cl. --46' - -52' Hd seam -57' Soft -59' Tight -64' Purple Hd.mica -66' Hd.mica schist -70' Hd mica Sch. -73' - -74' Quartz stone -75' Tight -77' Firm limestone -80' Green soapy -81' Good going -83' Firm fine grey -86' Harder sandstone -91' Creek water stone -92' Firm -93' Quartz Rk. -94' Creek bed -95' Firm -96' Fine sand -97' Firm -99' Tight -100' Sand -102' Tight, brown
D.R.No.2	" 63	Kulgera	-	347	-	110	-	1781	0'- 4' Br.soil -80' Red clayey soil -88' ? Billy -110' Clayey sand -150' Med.G.Wh.V. clayey sand -223' ?Part of a deep weathering profile. -275' ?Laterite -310' Red-Br.fine to med.G.samd -340' Red-Br.med.G.Sand -347' Med.G.sand and fr angular feldspar granite fragments Probably very clo to bed-rock

A	B	C	D	E	F	G	H	I	J
New Bore	G53/5-64	Erldunda	-	-	-	-	-	9647	- -
No.8	" -65	Victory Downs	-	-	-	-	-	-	- -
Station	" -66	Erldunda	-	660	-	-	1000	3048 3444	- -
Homestead Dud	" -67	Kulgera	-	100	-	37	-	-	Bore drain of grey medium to coarse quartz feldspar mica schist. 5/5/60 Dry at 12' depth from W.S.
No.1 Try	" -68	Police Station	Kulgera township	180	-	35'	120	1094 1055	0'- 20' Top soil - 50' Y.Cl. & sand - 80' Wh. Cl. -168' Decomposed granite -170' Granite
No.2 Try	" -69	Police Station	"	100	-	33	-	1305	0'- 20' Top soil - 55' Y. Cl. - 95' White clay -100' Schist
No.3 Try	" -70	"	"	95	-	35	80	1403	0'- 5' Br.soil & sand - 30' Y.Clay - 40' Y.Cl.& Gvl. - 50' Red Cl.& sand - 65' Grey clay - 75' Gy.cl. and sand - 80' Decomposed Granite - 95' Granite
No.4 Try	" -71	"	"	155	-	33	400	1278 1208 1283	0'- 10' Bn.sandy soil - 40' Y.sandy Cl. - 65' Gy.sandy Cl. '-100' Khaki sandy clay - 155' Granite
Homestead	" -72	Victory Downs	-	85	?52	52	300	-	52' Water washed clear quartz 85' Granite Quartz-feldspar granite fragments in bore drain
Coolata Springs	" -73	Erldunda	-	-	-	-	-	1744 1615	- -
Pulcura Well	" -74	"	-	10'9"	-	6'7"	-	3713	- -

A	B	C	D	E	F	G	H	I	J
Murrathurra Well	G53/5-75	Erldunda	-	4'10"	-	3'6"	-	5727	- -
Pug Box Well	" -76	Mt.Eben-ezer	-	200	-	160	700	5203 4293	90' of Cl. No.gvl. soft all the way
Greenwood No.3	" -77	Kulgera	-	175	-	34'5"	100	2071	Schist
Mallee Bore	" -78	Mt.Eben-ezer	-	180'	-	140	800	2515	- -
Station Well	" -79	Mt.Eben-ezer	-	30	-	30	-	1255 1182	Cl.& soft Sh. Only a soakage, pumped three times daily for average of 250 gallons ea.time.
D.R.No.3 Try	" -80	Kulgera	-	248	-	70	600	1530	0'- 60' Bn.sandy Cl. -110' Bn.sandy Cl. & clayey sand -125' Feldspar/Qtz Gy.sand -130' Reddish sand -160' Red-Br.coarser sand -22[illegible] Coarse brownish sand -247' Red clayey sand -248' Reddish-Br.[illegible].sand, very coarse
D.R.No.1 Try	" -81	Mt.Eben-ezer	-	233	231	130	700	5319 5045	0'- 6' Travertine - 78' Bn.siltstone - 90' Fine Wh.[illegible]o Khaki Sst. -103' Dk.Choc.-Bn. Siltstone & C[illegible] -2[illegible] Choc.calcareous shaley siltstone & some gy. fine calcareous Sst. -233' Choc.laminated to thin bedded calcareous siltstone.
D.R.No.2 Try	" -82	"	-	257	255	?40	1500+	5233 2659	0'- 31' Billy & fragments of ironst. - 40' Sandy Cl.some fragments of dolomite - 61' Soft Wh.soapy Material - 74' Clay -140' Deep choc.-Bn.Clayey siltstone -258' Shaley siltstone, some grey clay -257' Thin bedded and laminated calcareous siltstone.

A	B	C	D	E	F	G	H	I	J	
Bogga Bogga Well	G53/5-83	Erldunda	-	17'3"	-	16'7"	-	2835	-	-
Old Miningera Well	" -84	"	-	11'6"	-	4'	-	6143	-	-
No.2 Well	" -85	"	-	40'8"	-	24'	-	6901	?	-
Rinebra Spring	" -86	-	-	-	-	-	-	3262	-	-
Mallee Well	" -87	-	-	31'3"	-	29'8"	-	7085	-	-
Acacia Well	" -88	-	-	30'7"	-	29'7"	-	1726	-	-
D.R.No.1 Try	" -89	Idracowra	-	325	-	-	-	-	0'- 4' Top soil	'-320' Brown siltstone W. fragments of gypsum Dry hole.
No.10 Well	" -90	Victory Downs	-	-	-	-	-	-	-	-
Corkwood Bore	" -91	Erldunda	-	-	-	-	-	2430	-	-
Sandhill Bore	" -92	"	-	-	-	-	-	898	-	-
Western Bore	" -93	Palmer Valley	-	297	-	260	1000	2157 2359	0'- 6' Top soil	-297' Wh.& Pk.Lst. & P.cl.
Boundary Bore	" -94	Erldunda	-	-	-	-	-	3452	-	-
Myguire Bore	" -95	"	-	-	-	-	-	4470	-	-
Beefwood Bore	" -96	"	-	-	-	-	-	2692	-	-
New Bore	" -97	"	-	47'5"	-	24'6"	-	2738	-	-
Birthday Bore	" -98	Palmer Valley	-	-	-	-	-	5126	-	-

A	B	C	D	E	F	G	H	I	J
Candy Bore	G53/5-99	Erldunda	-	-	-	-	-	2686	- -
No.8 Dud	" 100	Palmer Valley	-	110	105	105	-	20,530	0'- 10' Brn.top soil -105' Bn.clay -110' Brown gravel. Salt
No.9 Dud Bore	"-101	"	-	95	85	85	-	29,457	0'- 10' Lst.gvl. - 35' Dk.bn.cl. - 85' Light Brn.cl. - 95' Brown gravel. Salt
No.[illegible] Dud	"-102	"	-	115	105	-	-	-	0' -10' Lst.& bldrs. - 30' Red clay -75' Bn.Cl. -105' Light Brown clay, Light -115' Brown clay. Salt
No.19 Dud	"-103	"	-	60	-	-	190	190	0'- 2' Top soil - 7' Bn.Cl. - 45' Wh.Sst. - 60' Cl.(Wh.,Bn. & Y.)
Lucky (Engine Bore)	"-104	"	-	60	-	-	650	-	0'- 2' Bn.topsoil - 7' Bn.cl. - 50 Limestone - 60' Yellow clay
No.21 Dud	"-105	"	-	112	65	-	-	-	0'- 30' Bn.Sst. - 65' Lst. - 75' Limestone -112' Brown clay
No.20 Dud	"-106	"	-	260	135	-	Small	1½ oz. per gall.	0'- 4' Red sand - 65' Bn.Sst. - 93' Lst. -135' Bn.Sst. -158' Lst. -205' Brown clay -21[illegible]' Coarse & fine sand -230' Clay -257' Red & yellow sand -260' Brown clay
Gap Bore	"-107	"	-	215	200	190	350	755	0'- 3' Red sand -142' Bn.Sst. -200' Wh.Lst. -212' Sand and rubble -215' Limestone Quality - ¼ oz. salt per gallon.

A	B	C	D	E	F	G	H	I	J
Stoney Bore	G53/5-108	Palmer Valley	-	170	-	-	-	960	- -
No.13 Dud	"-109	"	-	126	112	-	-	-	0'- 3' Bn.topsoil - 65' Lt.bn.cl. - 68' Bn.Sst. - 90' Bn.Sst. & clay -112' Brown clay -126' Light bn.Sst. 3¼ oz. salt per gallon.
No.12 Dud	"-110	"	-	125	-	115	-	-	0'- 6' Lst.rubble - 35' Bn.clay - 55' Lt.bn.Sst.& Cl. - 75' Lt.bn.Sst. - 80' Wh.Sst. - 95' Red clay -100' Brown sandstone & Cl. -105' Bn.sandstone -125' Bn.sandstone & cl. Quality - 3½ oz.salt per gallon.
No.11 Dud	"-111	"	-	83	78	-	-	-	0'- 3' Bn.topsoil - 8' Bn.sandstone - 44' Gy.Cl.& multi-col.Wh.,Pk., cr.& Blk.Cl. - 58' White Sst. - 65' Light bn.rock. - 70' Wh.Sst. - 78' Yellow clay - 83' White clay
No.17 Dud	"-112	"	-	50	-	-	400	-	0'- 6' Limestone - 40' Bn.Sst. - 45' White sandstone - 50' Red clay Quality - 3¼ oz.salt per gallon.
No.16 Dud	"-113	"	-	200	195	-	-	-	0'- 6' Lst. - 40' Bn.Cl. -106' Bn.cl.& st. -115' Lt.bn.rk.,hd -129' Bn.clay -133' Blue rock,hard -138' Brown clay -153' Lt.bn.stone -195' bn.clay -200' Lt.bn.clay Quality - 2½ oz.salt per gallon.

A	B	C	D	E	F	G	H	I	J
No.2 Dud	G53/5-114	Palmer Valley	-	-	-	-	-	-	0'- 3' Su.loam - 8' Red Cl.W. small qty.of red Gyp. - 12' Ditto above -25' Red clay -30' Red cl.W gvl. -36' Red cl.W.a little gvl. -45' Hard mudstone. A low draining a good catchment for fresh water.Tastes very salt.
No.1 Dud	"-115	"	-	?69	-	-	-	-	0'- 5' Su.loam -10' Cl.& Lst.rbl. - 20' Red streaky Cl. W. gvl. Taste very salt. - [illegible] Cong.desert Sst. - 52' Bright red Cl.W. heavy gvl. - 58' Ditto - 70' Red slate
No.2 Try D.R.	"-117	Idracowra	"	335	-	-	500	6789 7098	0'- 4' - - 12' Red silty sand - 20' Red Cl. ? Top of Tertiary - 45' Gy.fine cal-careous Sst. *-125' Red-Bn.Siltstn. -185' Red Cl. -188' Pale gy.& dk. purple fine sandy clay -195' Pale grey sandy clay -250' Red clay -255' Red clay and white fine gr.sandstone UNCONFORMITY - TOP OF ? PROTEROZOIC -314' Dark red-brown siltstone *-145' Red-bn Siltstone & fine Sst.
No.11 Bore	"-118	Victory Downs	-	-	-	-	-	-	-
Wilbia Well	"-119	Angas Downs	-	21	-	17'9"	-	2656	- Equipped with broken semi-rotary hand pump.
Well	"-120	"	-	50	-	44'9"	-	-	- -
Homestead Bore	"-121	"	-	-	-	-	-	2244 2355 2204	- -
Boundary Bore	"-122	Palmer Valley	-	215'	-	192	450	846	Clays to a water-bearing Lst.gvl.

A	B	C	D	E	F	G	H	I	J
Boundary Bore	G53/5-123	Palmer Valley	-	225	-	155	600	7582	Topsoil Clay Sandy clay Black clay River gravel
Corner Bore	"-124	Curtin Springs	-	42	-	30	3000	1946	0'- 8' Lt.red-Bn.silt - 30' Siliceous Lst. - 42' Qtz.replacing Cl. Light pink and off-white clayey Lst. W.thin veins of qtz.
No.2 Try D.R.	"-125	Victory Downs	-	121	-	-	Seep-age	-	0'- 8' Red-Bn.fine sandy Cl. - 18' Wh.& Lt.red-Bn.Cl. - 50' Lt.-Bn.fine sandy clay - 80' Off-white sericite, angular qtz. & mica - 95' As above. -121' Fresh qtz, feldspar, muscovite granite.
D.R.No.1 Try	"-126	Victory Downs	-	127	-	-	Nil	-	0'- 6' Red-Bn.sand - 29' Angular qtz.& feldspar W.some mica flakes - 40' Weathered & silicified granite - 80' Pink fine-grained weathered granite -125' As above. -127' Fresh pink fine-grained qtz., feldspar, muscovite granite.
No.13 Bore	"-127	"	-	-	-	-	-	-	- -
No.14 Bore	"-128	"	-	-	-	-	-	-	- -
No.15 Bore	"-129	"	-	-	-	-	-	-	- -
No.16 Bore	"-130	"	-	-	-	-	-	-	- Weathered granite fragments in bore drain.
-	"-131	Mt.Ebenezer	-	130	-	-	-	-	- -
Dud Bore	"-132	Victory Downs	-	70	-	-	Small	-	Samples from bore drain consisted of quartz & fresh & decomposed feldspar.

A	B	C	D	E	F	G	H	I	J
Dud Bore	G53/5-133	Victory Downs	-	28	-	—	Dry	-	Sample from bore drain contains fragments of fresh quartz-feldspar-granite,W.magnetic iron oxide & some mica.
Dud Bore	" -134	"	-	-	-	-	Dry	-	Sample from bore drain is a fairly fresh qtz.-feldspar Gr.W.magnetic iron oxides.
Dud Bore	"- 135	"	-	-	-	129	-	-	0'- 13' Ferruginised Cl. W.fragments of clear & milky Qtz. - 25' Bn.& Wh.silty clay,some fine white sandy Cl. - 70' Wh.cl.W.med.to coarse angular qtz. -100' Wh.fine to med.qtz. sandy cl. -117' - -119' Lt.bn.Sh.W.some mica on bedding planes. Also med.to coarse clayey qtz. sand. -129' - -131' Med.to V.coarse sand of rounded & angular granite fragments.
Dud Bore	"- 136	"	-	250	-	-	-	-	0'- 30' Brown clay - 95' Lt.orange cl. -220' Wh.qtz. & Cl. -250' Soft Sst. Small supplyof salt water.
East Boundary Gate Bore	"- 137	"	-	-	-	-	450	-	0'-125' Gy.rock. Sample from bore drain contained angular qtz.& a Wh.cl.Probably a weathered Gr.

A	B	C	D	E	F	G	H	I	J
Dud Bore	G53/5-138	Victory Downs	-	80	-	-	Dry	-	Sample from bore drain contains angular qtz., iron oxides & Wh.& bn. clayey mat'ial which may be decomposed feldspar. Abandoned at 80' because of crooked hole.
Dud Bore	"- 139	"	-	126	-	-	Dry	-	0'- 45' Lt.gy.sticky cl. W.fine sand - 55' Bright red cl.W. smooth red stones. -126' Wh.sandy clay changing to orange,red & bn.in bands.
Dud Bore	"- 140	"	-	60	-	-	Very small	-	Sample from bore drain contains fragments of a strongly weathered Gr. (qtz.-feldspar & magnetic oxides).
Dud Bore	"- 141	"	-	-	-	34	-	-	Sample from bore drain contains fragments of a weathered qtz.-feldspar Gr.(calcareous) Went dry on standing.
Dud Bore	"- 142	"	-	48	-	-	360	-	Fragments of qtz.-feldspar gr.and doler ite in bore drain. Equipped but pumped dry in 1960.
No.18 Bore	" -143	"	-	-	-	-	-	-	- -
Dud Bore	"- 144	"	-	62	-	-	Drilling supply	-	Qtz.-feldspar Gr.fragments in bore drain.

A	B	C	D	E	F	G	H	I	J
Dud Bore	G53/5-145	Victory Downs	-	40	-	Dry	-	-	Fragments of qtz.-feldspar Gr.in bore drain
Dud Bore	"- 146	"	-	67	-	-	Drilling supply	-	Fragmentsof Qtz.-feldspar Gr.in bore drain
Dud Bore	"- 147	"	-	32	-	Dry	-	-	Fragments of dolerite in bore drain.
Dud Bore	"- 148	"	-	49'6"	-	-	-	-	- Equipped but pumped dry in 1960.
Dud Bore	"- 149	"	-	68	-	Dry	-	-	Fragments of Qtz.-feldspar Gr.in bore drain.
Dud Bore	"- 150	Victory Downs	-	158	-	100	Very small	-	0' 20' Sy.Bn.Cl. -25' Bar of Wh.Qtz. -40' Bn.Sy.Cl. -50' Bar of Wh.Qtz. -80' Lt.orange Cl. -86' Bar of Wh.qtz. - 96' Lt.orange Cl.W. Qtz. and Gvl. - 98' Bar of Wh.qtz. -125' Gvl in Cl. -135' Bn.Cl.W.fairly firm Gvl -138' Gy.rock.
Dud Bore	"- 151	"	-	-	-	80	None	-	- -
Dud Bore	"- 152	"	-	28	-	Dry	-	-	0'- 28' Decomposed Gr. bottomed on Hd.Gr.
Adjacent No.14 Bore	"- 153	"	-	220	-	-	360	-	0'-142' Topsoil & Sy. Bn.Cl. -152' Soapy head -220' White Qtz.and Cl.
Dud Bore	"- 154	"	-	170	-	95	-	-	0'-105' Gy.stone 0'-170' Wh.qtz. and clay.

A	B	C	D	E	F	G	H	I	J
Dud Bore	G53/5-155	Victory Downs	—	190	-	88	100	-	0'- 98' Gy stone -190' Wh.Qtz.and Cl.
Dud Bore	"-156	Victory Downs	-	55	-	-	Very small	-	0'- 55' Decomposed Gr. bottomed on Hd.Gr.
Dud Bore	"-157	"	-	32	-	Dry	-	-	0'- 32' Granite
Dud Bore	"-158	"	-	105	-	-	Very small	-	0'-105' Fragments of Gr. and dolerite in bore drain. Water in clay at 40'
No.17 Bore	"-159	"	-	-	-	-	-	-	Fragments of gr.in bore drain. Equipped.
Dud Bore	"-160	"	-	150	-	85	120	-	0'-118' Sy.Bn.Cl. -120' Water washed Gvl. '-150' Lt.orange sand W.Qtz. and Cl.
Dud Bore	"-161	"	-	80	-	Dry	-	-	0'- 40' Sy.Bn.Cl. - 60' Decomposed Gr. '- 80' Harder rock.
Ironwood Bore	"-162	Mt.Eben-ezer	-	-	-	-	-	783	- -
rep.Kooyong Well	"-165	Mt.Cave-nagh	-	28'4"	-	Dry	-	-	Some travertine at Su. but hd.Gr.at shallow depth. Sited on travertine rise.

APPENDIX I - TO RECORDS 1964/35

PART III

FINKE - BORE LOGS

Pages 33 to 46.

A	B	C	D	E	F	G	H	I	J
Idracowra Drought Relief (2nd attempt)	1725 G53/6-1	Idracowra	?8 miles S.W. of Homestead	185	175	70	Large	8000	0'- 10' Lst. - 90' Clay [illegible]'-185' Sst. Salt water - abandoned.
Drought Relief No.1(1st att.)	1766 & 3335 G53/6-2	Lilla Creek	9 miles S.E. of homestead. 5 miles from Lilla Creek	562	510	340	150	5967 5836	0'-135' Bn.silty Cl. -170' Fine-med. gr. red sand. -180' Bn.silty Cl. -260' Wh.med.Grained sand W.minor silt [illegible]'-400' Bn.and bluish silt and clay -553' Wh.med.grained sand, some silt -558' Coarse sand -562' Fine sand(decomposed Granite) then Gr. Unsuccessful - abandoned.
Drought Relief 1st attempt	1767 G53/6-3	Mt.Cave- nagh	7 miles S.of Kulgera Dam, ¼ mile W.of Ck	98	75	65	Very small	-	0'- 10' Loam and Gvl. - 27' Lst. [illegible]'- 77' Gr.in various stages of decomposition -98' Solid granite. Dry - abandoned.
Drought Relief Mt.Cavenagh (2nd attempt)	1768 G53/6-4	Mt.Cave- nagh	1 mile N.of No.1 attempt	153	30	35	Ca. 80	5498	0'- 10' Rubbly Lst. - 50' Brittle Lst. -125' Coarse sand [illegible]'-127' Coarse sand & Bl.Cl. -155' Brittle Gr.then Hd.Gr. Insufficient supply - abandoned. Water unfit for human consumption.
Adnanta Well	2018 G52/6-5	Umbeara	E.bank of small creek 100 yds E.of H/S	50	-	12	7000- -8000	720 789	0'- 50' Well jointed Gr.
Well	2017 G53/6-6	"	W.bank of creek 8½ miles E.of Homestead	15	15	12	-	-	0'- 15' Alluvium. Water milky but seems O.K.
Angatheta Well (twin wells)	3332 and 1834 G53/6-7	Lilla Creek	N.bank Lilla Ck 9 miles S.W.of homestead	42	-	30'-40'	-	404	River alluvium.
Angatheta	3332 G53/6-7	" Lilla Ck	10 miles W.of homestead	30	-	26	550	404	0'- 30' Alluvium.

A	B	C	D	E	F	G	H	I	J
Bore at Angatheta Well	3333 G53/6-8	Lilla Creek	N.bank of Lilla Ck,9 miles s.w. of homestead	100	-	-	-	-	0'-100' Alluvium & Sst.
Boundary Bore	1835 G53/6-9	"	E.bank of Mangulina Ck,tributary of Lilla Ck,14 miles s. w. of H/S.	135	-	Shallow	-	3086	? Alluvium. A bit salty.
Umbeara Well	564 G53/6-10	Umbeara	38 miles w.of Bloodwood Bore, 13 miles S.E.of Umbeara H/S,N. bank of tributary to Goyder Creek	47	-	20	-	1972	0'- 47' Alluvium and ? weathered Gr.
Boundary Bore	2074 G53/6-11	Kulgera	26 miles E.N.E. of homestead	140	-	-	300	11,441	0'-140' Alluvium & gneiss.
20 yards N.of boundary bore	3337 G53/6-12	"	7½ miles S.W.of Umbeara H/S.	82	-	60'-80'	-	-	0'- 82' ? @ 82' Hard gneiss. Not equipped.
75 yards E. of Boundary Bore	3339 G53/6-13	"	7½ miles S.W.of Umbeara H/S.	82	-	-	-	-	- Not equipped.
20 yards S.of Boundary Bore	3338 G52/6-14	"	7½ miles S.W.of Umbeara H/S.	74	-	-	-	-	- Hole now caved in.
Sputnik Bore	3985 G53/6-15	Umbeara	4 miles w.& 2 miles N.along the road to Adnanta from the Finke Junct.	123	18	18	1000	-	0'- 20' Rubbly Lst. -120' Runs of 6' and then hd.seam,repeated many times. 37 bits used.

A	B	C	D	E	F	G	H	I	J
Mt.Cavenagh Dr. Relief (3rd attempt)	1789 G53/6-16	Mt.Cave-nagh	4/01/6.25"E., 11.0" N.	177	40	31	Small	10,703	0'- 10' Su.Cl.& Gvl.Lst. rubble & Cl. - 30' Soft Gr. - 70' Decayed Gr.& Cl. -110' Hd.bar Gr. -130' Decayed Gr. & Cl. -140' Med.Hd.Gr. -177' Soft Gr.& mica then hard granite. Abandoned.
Drought Relief (4th attempt)	1770 G53/6-17	"	100 yds N. of S. boundary between creek Junctions	121	70	57	950	4276	0'- 10' Su.silt deposits, red.Cl.& Gvl. - 95' Gn.Cl.& coarse sand. -116' Coarse gravel. -121' Gn.Cl. & coarse sand, then hard granite.
Taylor's Well M.S.Umbeara Well	3231 G53/6-18	Umbeara	-	60	-	20	Limi-ted	Poor quality	- -
Christmas Well	G53/6-19	"	between Umbeara well & Adnanta homestead	-	-	-	-	-	- -
Old Crown Point Well	4/20	W/S stock route	25 miles N.of Goyder Junct.	48	41	41	1250	-	- - Good domestic -
Old Crown Well	4/20	South Barkly Stk Route	12 miles N.of Finke Siding	-	-	32	800	-	- Used for stock & human consumption.
Old Crown Well	2012 912 507 963 G53/6-20	Lilla Creek	27 miles N.E.of H/S.25 miles N. of Goyder Junction Well	48	30	42	1000	2553	0'- 48' Alluvium.

A	B	C	D	E	F	G	H	I	J
Stockwell	4/?20 or 53	Old Crown Point	4/04,14.75" N.,3.25"E.from S.W.corner; 13½ chains from Finke R. bank	-	25	-	-	-	- -
New Mallee No. 2	563 G53/6-21	Goyder Stock Route	22 miles E.of Umbeara Well, 44 miles S.W.of Finke	600	470	460	960	836 1570	0'- 3' Su.soil - 7' River sand -215' Clay -225' Sy.clay -470' Sandstone -496' Coarse gravel, then -600' Sandstone. Replacement of collapsed bore.
Old well at Bloodwood Bore	G53/6-22	-	17 miles E.of Mallee Bore	-	-	-	-	-	- -
Bloodw ood No.1	G53/6-23	Goyder Stock Route	24 miles W.of Finke Siding	687	-	446	-	604 529	- -
Goyder 9-Mile Bore	G53/6-24	"	9 miles S.W.of Finke siding	450	450	365	600	1096 1436	0'- 85' Sst. -400' Drift sand -450' Bk.Gy.& choc.Cl.W. bars of Sst. -453' Drift sand. ~~12 hrs of pumping produced no sign of lowering.~~
Lilla Creek Homestead Well	3334 G53/6-25	Lilla Creek	4/05,14.0"N., 3.5"E.from S. W.corner.	50	-	48	100	1886	0'- 50' Creek alluvium. Gn.Sh.below 50'.
Indiadna Well	1838 G53/6-26	"	¾ mile S.W.of Homestead	-	-	30	600	5961	0'- 35' Alluvium,probably clayey bottom.
Coglin Bore	2014 G53/6-27	New Crown	4/03,10.5"N., 8.75"E. from S.W. corner	-	-	?230	1440	-	0'-305' Cl.& Sh. -371' Drift sand.

A	B	C	D	E	F	G	H	I	J
Claude Bore	2013 G53/6-28	New Crown	4/03,14.0"N., & 3.75"E.from S.W.corner	327	280	?280	1440		0'-308' Wh.Sst., clayey Sst. & thin beds of Wh.Cl. -327' Bn.& dk.Gy.Sh.
Old Mallee Well	G53/6-29	Umbeara	14/34/7.2"E., 5.2"N.	-	-	-	-	-	- -
Old Mallee Bore No.1	G53/6-30	"	14/34/7.2"E., 5.2 "N.	-	-	-	-	-	- -
Old Mallee Bore No.2	3989 G53/6-31	"	14/34/7.2"E., 5.2"N.	410	-	-	Dry	-	Granite at 410'
New Mallee Bore No.1	G53/6-32	"	4/02,8.75"N., & 7.25"E.from S.W.corner	527	464	464	200	-	- -
No.2 Bloodwood Bore	2021 G53/6-33	"	4/	570	462	?466	960	529	0'- 40' Red soil -260' Sst. -468' Clay -520' Sand -570' Clay
Etemia Bore	2020 G53/6-34	"	4/01,11.0"N. &12.75"E.from S.W.corner,N.W. of Umbeara Well	100	-	-	300	-	100' In metamorphics.
Corella Bore	2019 G53/6-35	"	6 miles N.E.of Umbeara Well	-	-	40	400	-	80' In metamorphics.
Umbeara Drought Relief (1st Attempt)	1848 G53/6-36	"	5 miles S.E.of Mallee Bore	320	-	-	dry	-	0'- 6' Red topsoil -270' Wh.Sst.W.small layers of Wh.Cl. -304' Fine Wh.sand, -320' Sand drift. Abandoned.

A	B	C	D	E	F	G	H	I	J
Umbeara Drought Relief (2nd attempt)	1849 G53/6-37	Umbeara	4/02	385	-	-	-	-	0'- 7' Hd.Sst. - 24' Clay -207' Sst. -374' Sand -385' Granite 6" casing left in hole.
Umbeara Drought Relief (3rd attempt	1850 G53/6-38	"	8 miles E.of Mallee Bore	369	-	-	dry	-	0'- 33' Mixed Cl.& S. -350' Sand -368' Weathered granite. Abandoned.
Eastern (old bore)	G53/6-39	Finke	4/04;12.25"N. & 4.50"E.of S.W. corner	305	-	-	-	-	- Not used or equipped.
Stock Inspector's House Tap.	4/39	Finke Town	3 miles N.of tower	-	-	-	-	-	- -
Finke New Bore or Finke Railway Bore	1794 2016 1793 G53/6-39	Finke	4/04;12.25"N. & 4.50"E.of S. W.corner	434	320	265	6500	725	0'-420' Sand -434' Boulders & Gvl.
Colson's Bore	3990 G53/6-40	Finke	9/83 /	468	-	-	-	-	0'- 6' Red Sy.soil - 36' Y.Sy.Cl. - 53' Wh.cl. - 56' Fine Wh.Sy.Cl. - 58' Pk.Sy.Cl. - 95' Drift Sand -102' Wh.Sy.Cl. -106' Sand -147' Sy.Cl. -150' Wh.Qtz.Sand -154' Wh.gravelly Cl. -175' Wh.kaolin -177' Sy.Cl. -183' Drift sand -190' Wh.sy.cl. -225' Fine drift sand -235' Wh.Cl. -468' Sand & Sy.Cl.
Dud	4/41	Lilla Creek	-	?200	-	-	-	-	- -

A	B	C	D	E	F	G	H	I	J
No.2 Bore	G53/6-41	Lilla Creek	4/05;11.25"N. & 8.75" E from S.W. corner	342	-	-	300	-	- -
No.1 Bore	1837 G53/6-42	"	4/05;13.75"N. & 3.75"E.of S. W. corner	545	335 and 516	?330	200	-	0'-330' Red Sy.Cl. -525' Wh.Sy.Cl. -545' Granite.
No.1 Area Drought Relief Bore(2nd attempt)	G53/6-43	Lilla Creek	4 miles S.W. of 9 mile bore	518	480	433	1000	-	- -
Charlotte Waters No.1	981 G53/6-44	South Barkly Stock Route	4/03;8.0"N. & 25.5"E. of S. W. corner	1474	614	140	1950	-	0'- 4' Red Sy.loam - 13' Gravel - 65' Wh.pipeclay -614' Bl.calcareous Sh. & Hd.bands -925' siliceous Sand -1116' Clayey sand -1233' Soft & Gy.micaceous rock. -1445' Wh.siliceous sand -1472' Soft siliceous & micaceous Sst. -1474' Wh.siliceous sand.
Charlotte Waters No.2	3510 G53/6-45	Charlotte Waters	-	645	615	141	1000	1250	0'-615' Blue shale - 645' Fine Qtz.Sand
Charlotte Waters No.3	G53/6-46	South Stock Route	28 miles N.of Blood Creek alongside No.1	640	626	141	Unlimited	-	- -
New Crown Homestead Bore	3230 G53/6-47	New Crown	4/04;6.0"N.& 21.0"E. of S.W.corner	-	-	180	-	2392	- -

A	B	C	D	E	F	G	H	I	J
Umbeara Drought Relief (4th attempt)	1851 G53/6-48	Umbeara	6 miles S.W. of Mallee Bore	542	340	334	20	1842	0'- 80' Bn.loam -154' Wh.fine med.Sand -180' Wh.fine Sy.Si. -250' Wh.Cl.W.Cs.Qtz. -340' Gn.Sy.Cl. -343' Cs.to fine Sand W. fine pebbles,water -366' Gn.Cs.to fine sand. -470' Gy.med.G.to silty Qtz.sand -487' Bn.Cs.to fine silty feldspar & Qtz.sand -535' Bn.med.G.silty Qtz.Sand -542' Weathered granite
Station Well	G53/6-49	Idracowra	100 yards W.of homestead	25	-	22	600	511	- -
Poona Well	1339 G53/6-50	"	14 miles S.of homestead	40	35	35	700	4727	0'- 40' Red & Gn.micaceous Shales W. fine Wh.Sst.at bottom.
Marianne Bore	2015 G53/6-51	New Crown	5 miles from homestead towards Charlotte Waters	480	615	195	1400	-	- -
Sandy Bore	3992 G53/6-52	"	11 miles W.of homestead	-	-	260	-	417	0'-100' Sst.& Cong. -300' Sand
John's Well	1840 G53/6-53	Lilla Creek	12 miles N.E. of homestead	42	-	-	-	-	0'- 40' Gn.micaceous sh.& fine Wh.Ss.
Homestead Wells Nos 1 and 2	G53/6-54	Horseshoe Bend	4/11;2.0"N.& 15"E. of S. W. corner	-	-	-	-	-	- Sand wells in Finke.
Mines Branch Bore - Rumbalara	3993 G53/6-55	-	20 chains E.of Rumbalara siding	432	412	390	600-1000	7000-8000	0'-101' Cl.& Sst. -432' Sandstone. Abandoned.

A	B	C	D	E	F	G	H	I	J
Rumbalara Rail- way Bore - Dud	3994 G53/6-56	-	Rumbalara siding	474	-	350	-	Stock water	0'-474' Sandstone -
Mulga No.1	G53/6-57	Goyder Stock Route	4/02;8.75"N. & 2.0"E.of S.W. corner	91	-	-	-	-	- All in granite
Mulga No.2	G53/6-58	"	17 miles N.W.of Umbeara	96	64	64	20	-	- - All in granite
Drought Relief No.2	1857 G53/6-59	Lilla Creek	8 miles W.of Old Crown Windmill	500	160	130	-	9274	0'-220' Clayey & silty fine S. -415' Bn.micaceous Cl.,mudstones 0'-455' Gy.,slightly clayey, V.fine Sst. -500' Fine Wh.Sst. Uns uitable water
Mulga No.3	G53/6-60	Goyder Stock Route	17 miles N.W. of Umbeara Well	80	-	63	-	-	- All in granite
New Bore (Wind- mill Hole)	G53/6-61	Umbeara	10 miles N.E. of homestead	-	-	-	-	-	- -
New Bore (Engine Hole)	3996 G53/6-62	"	1 0 miles N.E. of homestead	-	-	25	-	5101	Grey and brown fine to medium grained Sand.
Langra Well	1275 G53/6-63	Horseshoe Bend	4/08;10.75"N. & 4.75"E.of S.W. corner	60	-	About 25	-	8659	0'- 30' Gn.micaceous shale W.fine Wh.Sst.at bottom.
Goyder Junction Well	G53/6-64	North- South Stock Route	25 miles N.of Charlotte Waters	64'	58	-	4006	-	- -

A	B	C	D	E	F	G	H	I	J
Horseshoe Bend Soakage	G53/6-65	-	Southern Stock Route, bed of ~~Finke River~~	-	-	-	-	-	-
No.15 - Dud	3998 G53/6-66	Palmer Valley	5 miles E.of Mt.Kingston No.1	185	140 182	-	Very small	1900	0'- 3' Lst.rubble then Sst. & Cl.
No.14 Dud	3999 G53/6-67	"	5 miles W.of Mt.Kingston No.1 Dam	92	-	-	Dry	-	0'- 3' Bn.top soil - 15' Y. Sst. - 25' Wh.Sst. - 28' Pink Cl. '- 67' Lt.Bn.Sst. - 73' Rock - 89' Lt.Bn.Sst. - 92' Rock.
1961 Drought Relief, 2nd attempt	2774 G53/6-68	Horseshoe Bend	23 miles W.of homestead	239	230	88	1200	20,391	0'-230' Bn.micaceous clayey s ilt '-239' Clean Wh.fine Qtz.sand.
Deep Well	G53/6-69	"	-	108	-	100	-	-	-
No.1 Try - Drought Relief	2773 G53/6-70	"	28 miles E.N.E. of Homestead	580	300	300	Trickle	2945	0'-580' Siltstone and fine silty sandstone.
Polly's Spring	G53/6-71	"	4 miles W. of homestead	-	-	-	-	-	-
1961 Drought Relief, 3rd attempt	2775 G53/6-72	"	20 miles W.S.W. of homestead	300	-	127	Very small	10,381	0'- 40' Sandstone -260' Sand '-283' Shale, green micaceous
Jones Well	G53/6-73	South Stock Route	18 miles S.of Finke s iding	-	-	58	800	-	- Stock and human
Black Hill Well	4005 G53/6-74	Horseshoe Bend	11 miles W.of homestead	70	-	24	-	12,368	0'- 70' White sandstone.

A	B	C	D	E	F	G	H	I	J
No.1 Bore	2843 G53/6-75	Palmer Valley	7 miles N.E. of Kingston Dam	200	180	63	-	28,728	0'-180' Gn.gypsiferous Cl. -200' Sst. Abandoned
No.2 Dud Bore (Mt.Kingston)	G53/6-76	"	-	276	-	150	-	-	0'- 5' Su.soil -276' Choc.clay
No.3 Dud Bore (Mt.Kingston)	G53/6-77	"	-	293	-	-	Unlimited	-	0'- 9' Su.soil - 35' Blue Cl. - 73' Lst.& Y.Sst. -113' Wh.Sst. -165' Red Sst. -293' Y.Sst. Salt.
Dud Bore (Mt. Kingston)	G53/6-78	"	-	185	-	-	-	-	- Salt.
Clough's Advice or Clough's Bore Replacement	A24/1 3176 G53/6-79	Lilla Creek	4/08;3.25"N.& 2.75"E.of S.W. [illegible] corner	277	196	+1	-	100,181	0'- 15' Fine Wh.Sst. -188' Gn.& Bn.micaceous Cl. -203' Clean fine Wh.to med.sand -207' Choc.cl. -215' Wh.fine silty sand.
Bore	4009 G53/6-80	New Crown	6-7 miles N. of homestead	250	214	212	700	-	0'- 5' Top soil - 60' Sst.W.pebbles -250' Sand.
Bore	4010 G53/6-81	"	16 miles N.of homestead	250	244	240	-	-	0'-250' Sand
Camel Flat B ore	4011 G53/6-82	"	11 miles N.E. of homestead	230	207	186	1100	619	0'- 41' Gravelly Lst. - 61' Y.Cl. -198' Shale -207' Soft Sst. -230' Wh.Clay.
Centenary Bore	4012 G53/6-83	"	18 miles N.E. of homestead; 7 miles N.E.of Camel Flat Bore	252	231	180	1100	1461	0'- 12' Topsoil - 51' Sst.Congl. - 83' Y.Cl. -224' Bl.Sh. -231' Soft Sst.

A	B	C	D	E	F	G	H	I	J
Minga Bore	G53/6-84 4013	New Crown	6 miles E.N.E. of homestead	75	49	49	-	3492	0'- 75' Sandstone
Siberia Bore	4014 G53/6-85	"	12 miles N.N.W. of Centenary Bore	290	-	248	-	413	0'-290' Sandstone
Cindy No.1 Bore	4015 G53/6-86	"	11 miles N.W.of homestead.6-7 miles E.of Finke	304	266	260	1200	-	0'- 49' Hd.Sst.Cong. - 96' Softer Sst. -258' Cs.sand -264' Gravel -304' Sand
C/M Advice A40/1 or Cimbore	3542 G53/6-87	Horseshoe Bend	3½ miles N.E.of Rumbalara siding	503	449	444	600	3854	0'-361' Silty,F.to med. G.Sst. -449' F.sy.Cl. -500' Fine-grained sand with some clay.
Good Friday No. 1 Bore	G53/6-88	"	11 miles E.N.E. of Rumbalara	500	?400	-	small	-	Mainly fine white sand.
Nine Mile	2188 G53/6-89	New Crown	11 miles S. of homestead	423	381	154	650	-	0'-370' Cl. and Sh. -412' Wh.sand -423' Lt.Sy.Cl.
Willoughby Bore	2189 G53/6-90	"	15 miles W.S.W. of homestead	280	190	-	1000	-	0'278' Wh.Clayey S. -280' Cs.siliceous sand
1962 Advice Dual Bore (Golf stick)	G53/6-91	Horseshoe Bend	13 miles E. of H/S.2 miles S.W. of Mt.Squire Siding	572	400	398	150	-	0'- 10' Topsoil -540' Sandstone -572' Sst.W.layers of shale
No.2 Try 1962 Bore	G53/6-92	"	13 miles E.of H/S.2 miles S.W. of Mt.Squire Siding	600	-	-	-	-	Sand
Dud	4019 G53/6-93	Lilla Creek	5 miles N.N.W. of homestead	180	-	-	-	High	0'-180' Wh.F.to medium sand. Salt.

A	B	C	D	E	F	G	H	I	J	
Good Friday Bore No.2	G53/6-94	Horseshoe Bend	11 miles E.N.E. of Rumbalara	571	435	-	400	-		Sand W.s ome clay.
Dud Homestead	4021 G53/6-95	"	(at homestead)	70	Shal-low	-	-	22,956	0'- 70'	Fine Wh.Sst.
Finke Well	G53/6-96	North-South Stock route	-	32	-	-	good	-	-	-
Goyder Soak	G53/6-97	Southern Stk route	18 miles from old Crown Point Well	15	-	-	-	-	-	Dry after long drought.
Horseshoe Bend Well	G53/6-98	"	2 8 miles N.of Old Crown Well 1923	20	-	-	-	-	-	Old well in Finke River
Homestead No. 2 Bore	G53/6-99	Lilla Creek	½ mile E.of H/S across Finke R.	100	40	-	360	-	0'- 10' - 90'	Sy.loose topsoil '-100' Fine river sand. Sst.Gy.to Bl. as deepening
Garden Well	G53/6-100	Old Crown Point	4/04,15.5"N.& 26.5"E.of S.W. corner;2 chains from Finke R. bank	-	25	-	-	-	-	-
Dry Well	G53/6-101	"	8 miles S.E.of Station	-	-	-	-	-	-	- Uns uccessful.
Dick's Well	G53/6-102	Lilla Creek	4/05;6.5"N.& 6.0"E.of S.W. corner.	-	-	-	-	-	-	-

A	B	C	D	E	F	G	H	I		J
Homestead Well	G53/6-103	Lilla Creek	4/D5;4.5"N. & 3.5"E.of S.W. corner	-	-	-	-	-	-	-
Corella Creek 1st Attempt	G53/6-104	"	11/82/5.0"E., 5.8"N.	90	-	-	-	-		Cong.overlying fine sandstone and clayey sandstone probably equivalent of Unit 1 (Polly Conglomerate) of Finke Group
1963 Advice Bore (2nd attempt Corella Creek)	G53/6-105	"	11/82/4.3"E., 5.5"N.	150	150	-	-	-	-	-
Well	G53/6-106	Horseshoe Bend	2 miles N.W.of Horseshoe Bend	-	-	-	-	-	-	- Salt - us eless.
Depot Well	G53/6-107	Hugh River	-	-	46	-	-	1 oz/ gall.	-	-
Top Soak Well	G53/6-108	Horseshoe Bend	On Finke R.one mile E.of Idracowra boundary	-	-	-	-	-	-	- Washed out.
Davis Well	G53/6-109	"	17 miles N.along Finke R.from H/S	12	-	-	-	-	-	-
Mick's Soak Well Nos 1 and 2	G53/6-110	"	2 miles N.along Finke R. from homestead	-	-	-	-	-	- -	-
Musgrave's Well	G53/6-111	"	8 miles S.along Finke R.from homestead	12	-	-	-	-	-	-

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

THE GEOLOGY OF THE SOUTH-EASTERN PART OF THE AMADEUS BASIN.

BY

A. T. WELLS, A. J. STEWART and S. K. SKWARKO

RECORDS 1964/35

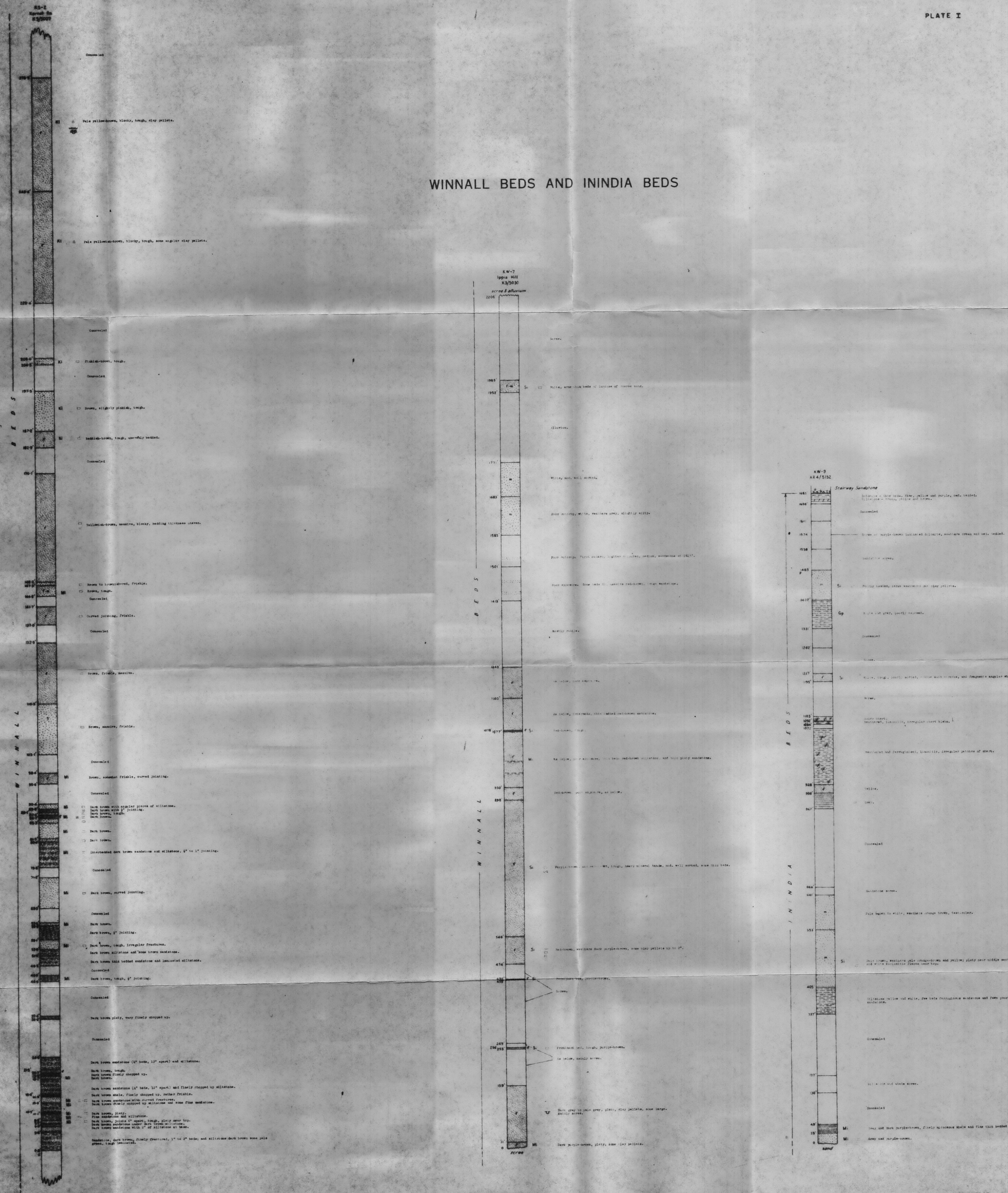
ENCLOSURES

Plates:

1. Sections KW7, KW9, and KS2 through the Inindia Beds and Winnall Beds.
2. Sections KW2, KW3, KW4, and KW5 through the Pertaoorrta Formation.
3. Sections KW1, KW8, KW10, and KS1 through the Pertaoorrta Formation, Larapinta Group, Mereenie Sandstone and Pertnjara Formation.
4. Section KW6 through the Polly Conglomerate and Langra Formation.
5. Reference for Columnar Sections.
6. Geological Map of the Ayers Rock 1 : 250,000 Sheet Area.
7. Geological Map of the Kulgera 1 : 250,000 Sheet Area.
8. Geological Map of the Finke 1 : 250,000 Sheet area.

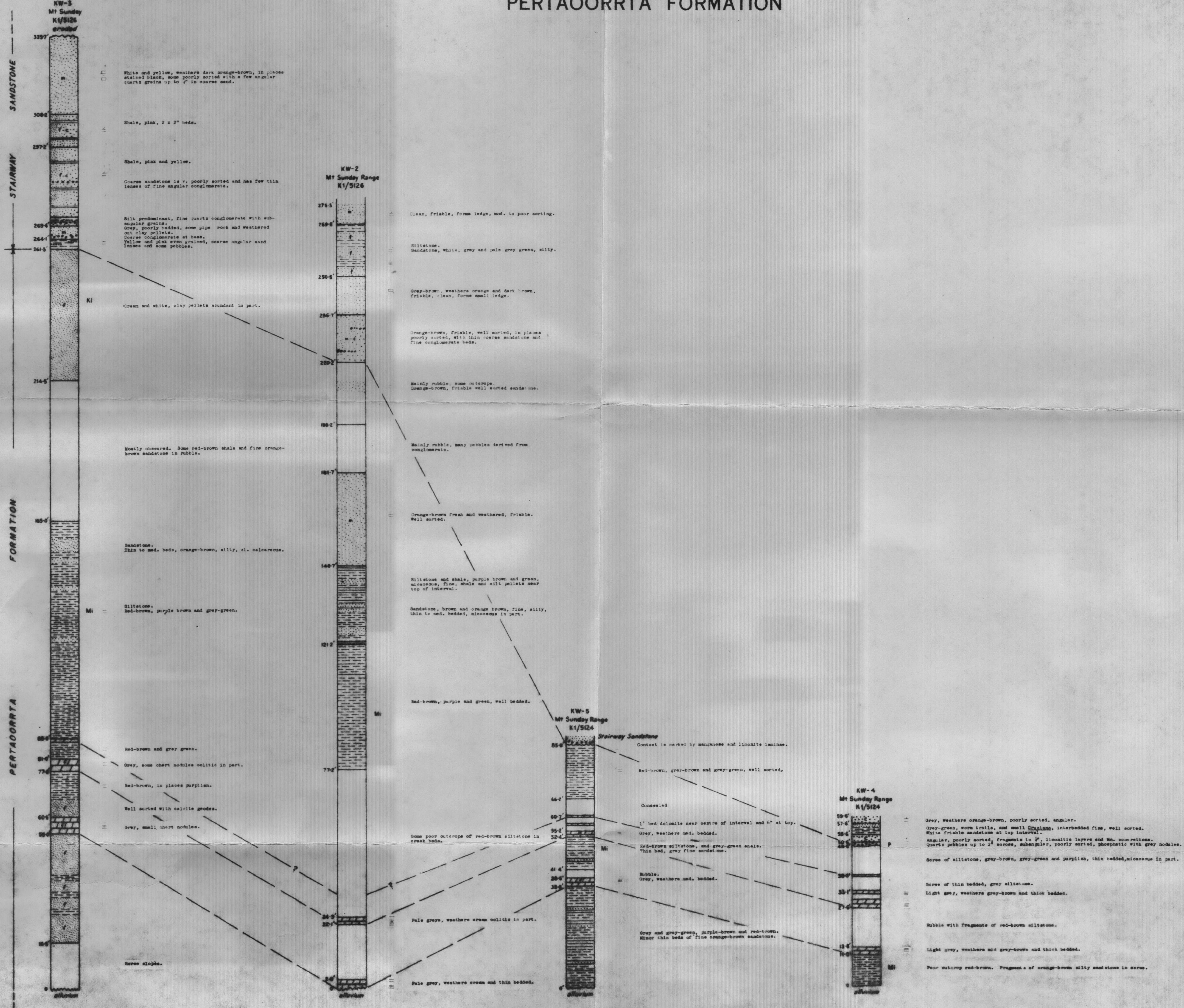
PLATE I

WINNALL BEDS AND ININDIA BEDS



655/A6/3

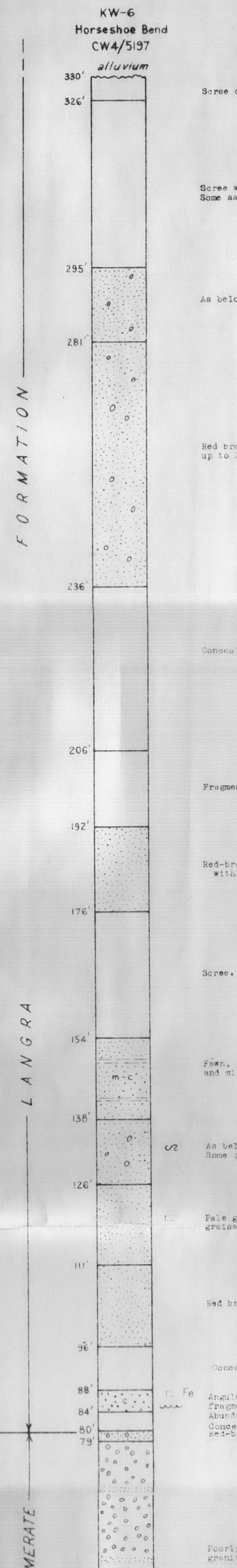
PERTAOORRTA FORMATION



PERTAOORRTA FORMATION, LARAPINTA GROUP, MEREENIE SANDSTONE AND PERTNJARA FORMATION

PLATE IV

LANGRA FORMATION AND POLLY CONGLOMERATE



Scree of Winnall Beds common, some sandstone as below.

Scree with subangular to rounded pebbles and boulders from ½" to 8" across. Some sandstone as below.

As below, fawn and yellow; scree with abundant chert, quartz and quartzite.

Red brown and fawn, poorly sorted angular fragments and subangular pebbles up to 2", silty, non-bedded.

Concealed

Fragments of red-brown siltstone.

Red-brown and fawn, silty, poorly sorted sandstone, poor outcrop, scree with rounded boulders of grey billy and banded chert.

Scree.

Fawn, poorly sorted and bedded, interbedded, poorly sorted silty sandstone and siltstone, scree with boulders and pebbles of quartz and metamorphics.

As below, in part finer grained and micaceous with biotite and muscovite. Some quartz pebbles.

Pale grey-brown, weathers fawn, v. poorly sorted and bedded, angular grains, quartz pebble scree on surface.

Red brown, v. poorly sorted and bedded, silty.

Concealed

Fe Angular, poorly sorted, pale orange-brown and dark brown, some angular fragments up to ¼". Poorly bedded, white kaolinitic flecks.
Abundant white subangular quartz pebbles up to 6".

Concealed

Red-brown, pebbly, quartz in red silty matrix.

Poorly sorted, angular to subangular, fragments of quartzite, quartz, granite and pegmatite. Small lenses yellow coarse sand.

Pebbles of quartz, metamorphics, granite, quartz-feldspar porphyry, v. poorly sorted, angular to subangular, fragments max. 1' across.

Concealed

Conglomerate and breccia coarse, (poorly sorted, angular granite, quartz, acid igneous rocks and Winnall Beds up to 6" across). Some interbedded coarse poorly [illegible] sand, and [illegible] med. [illegible] pale yellow med. sorted sandstone. Limonitic in part, pale yellow-brown, weathers orange-brown.

Bureau of Mineral Resources, Geology and Geophysics. March 1964 To accompany Record No 1964/35 G53/A6/2

REFERENCE FOR COLUMNAR SECTIONS

Shale

Siltstone

Sandstone

Coarse sandstone - Fine conglomerate

Conglomerate

Erratics

Chert

Limestone

Silty limestone

Sandy limestone

Dolomite

Breccia

Burrows

Scour and fill

Convolute

Load cast

Chewed up by organisms

Grain Size

f	- *fine*	*0·12 - 0·25 mm*
m	- *medium*	*0·25 - 1·0 mm.*
c	- *coarse*	*1·0 - 2·0 mm*
v.c	- *very coarse*	*2·0 - 4·0 mm*
Fine conglomerate		*4·0 - 16·0 mm.*
Pebble conglomerate		*3/4 - 2 1/2 inches*
Cobble conglomerate		*2 1/2 - 10 inches*
Boulder conglomerate		*> 10 inches*

Si	*Silicified*	Gl	*Glauconitic*
Fe	*Ferruginous*	Fl	*Feldspathic*
Mi	*Micaceous*	Ha	*Pseudomorphs of halite*
Ca	*Calcareous*	P	*Phosphatic*
Kl	*Kaolinitic*		
G	*Gypsum*		

Bedding

Very thick	> 40 inches
Thick	12 - 40 inches
Medium	4 - 12 inches
Thin	0·4 - 4 inches
Laminate	< 0·4 inches

Cross bedded

Cross laminated

Graded bedding

Undulate

Slumped

Ripple marks - wave

Ripple marks - current

Tracks and trails

Oolites

Macrofossil

M6/5556 *Sheet, run and photo number*

P.P. *Principal point of photograph*

Gaps in columnar sections are concealed areas

Bureau of Mineral Resources, Geology and Geophysics. March 1964 G52/4/12 GM

To accompany Record 1964/35

AUSTRALIA 1:250.000

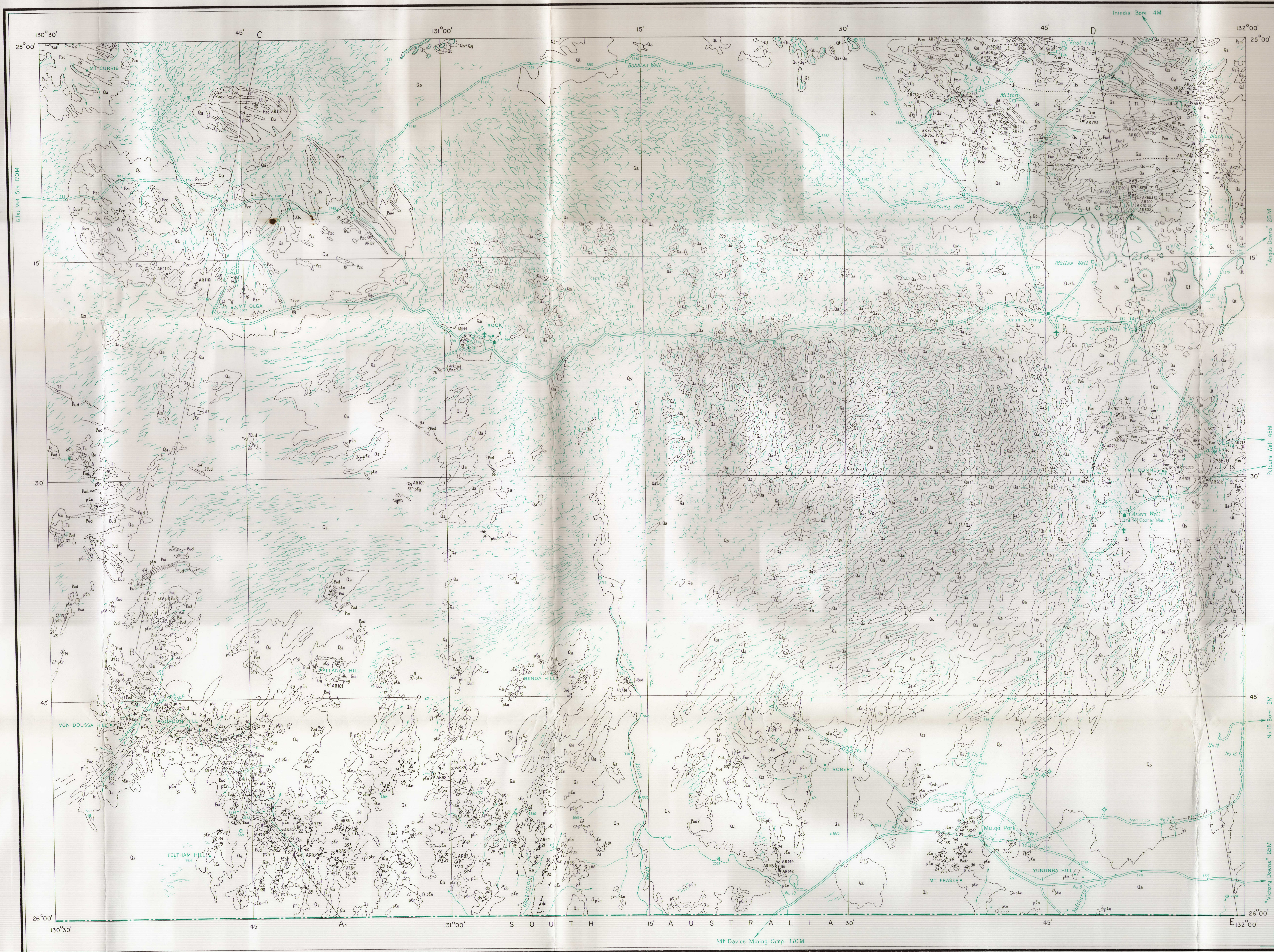
AYERS ROCK

NORTHERN TERRITORY

1:250.000 GEOLOGICAL SERIES SHEET SG 52-8

PRELIMINARY EDITION, 1964

SUBJECT TO AMENDMENT



Reference

CAINOZOIC	QUATERNARY		Qa	Alluvium
			Qs	Sand
			Qt	Evaporites
			Ql	Travertine
			Qg	Gypsum
	TERTIARY		Tc	Conglomerate
			Tl	Limestone
PALAEOZOIC	UNDIFFERENTIATED	Mereenie Sandstone	Pzm	Red-brown silty sandstone and white cross-bedded sandstone
	ORDOVICIAN	Stokes Formation	Ot	Shale and siltstone, some fossiliferous dolomite at base
		Stairway Sandstone	Os	White fine sandstone and kaolinitic sandstone, minor siltstone
	CAMBRIAN	Pertaoorrta Formation	Єp	Pebble conglomerate
	UNDIFFERENTIATED		Pzc	Conglomerate; arkose at Ayers Rock possible lithological variant
PRECAMBRIAN	UPPER PROTEROZOIC	Winnall Beds	Puw	Fine siliceous sandstone and dark brown siltstone, minor conglomerate
		Inindia Beds	Pun	Red-brown and white siltstone, chert, sandstone, pebbly siltstone, thin beds of dolomite
		Bitter Springs Limestone	Pub	Dark grey dolomite
		Pinyinna Beds	Pui	Grey phyllite and quartz-sericite schist
		Dean Quartzite	Pud	Schistose quartzite
	UNDIFFERENTIATED		pЄn	Gneiss with schist and amphibolite
			pЄg	Granite

Geological boundary	Bore
Anticline, showing plunge	Abandoned bore
Syncline, showing plunge	Well
Overturned anticline	Tank
Fault. Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes	Earth tank
Strike and dip of strata	Windpump
Horizontal strata	Spring
Overturned strata	Rockhole
Dip < 15° (air-photo interpretation)	Sand dunes
Dip 15° — 45° (air-photo interpretation)	Road
Dip > 45° (air-photo interpretation)	Vehicle track
Trend lines (air-photo interpretation)	State boundary
Joint pattern (air-photo interpretation)	Fence
Strike and dip of foliation	Homestead
Strike and dip of foliation, unmeasured	Landing ground
Vertical foliation	Yard
Horizontal foliation	Astronomical station
Strike and dip of bedding with trend of lineation	Trigonometrical station
Strike and dip of foliation with trend of lineation	Height in feet, instrument levelled (datum: mean sea level Port Augusta)
Trend of lineation	Height in feet, barometric (datum: mean sea level Port Augusta)
Macrofossil locality	
Specimen locality	
Measured section	
Dyke: do - dolerite	

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Base map compiled by the Division of National Mapping, Department of National Development. Aerial photography by the Royal Australian Air Force; complete vertical coverage at 1 : 46,500 scale.
Transverse Mercator Projection

Geology, 1963, by : D.J.Forman, P.M.Hancock, A.J.Stewart, A.T.Wells
Compilation by : D.J.Forman, A.T.Wells, A.S.Mikolajczak
Drawn, 1964, by : A.S.Mikolajczak

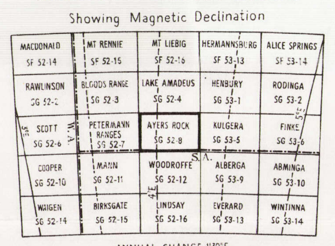
Scale 1 : 250,000

MILES 5 0 5 10 15

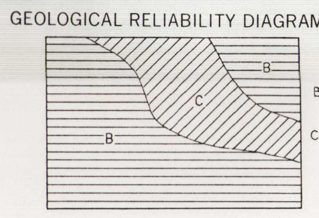
KILOMETRES 5 0 5 10 15 20

INDEX TO ADJOINING SHEETS

Showing Magnetic Declination



GEOLOGICAL RELIABILITY DIAGRAM



B Reconnaissance, traverses and air-photo interpretation

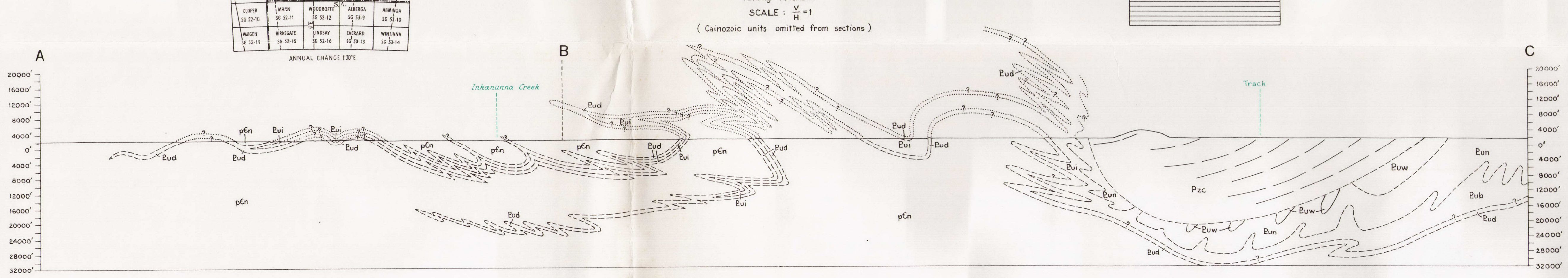
C Air-photo interpretation only

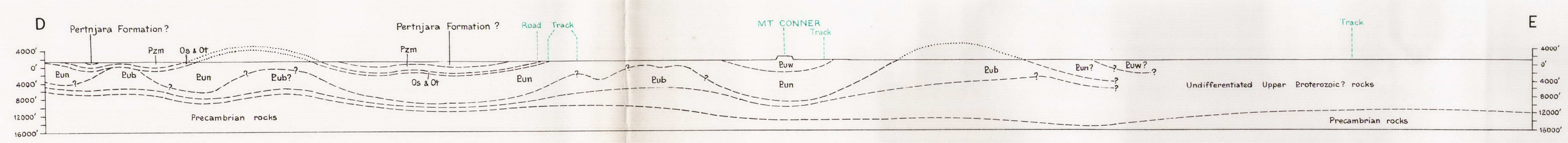
Sections

Folding schematic

SCALE : $\frac{V}{H} = 1$

(Cainozoic units omitted from sections)

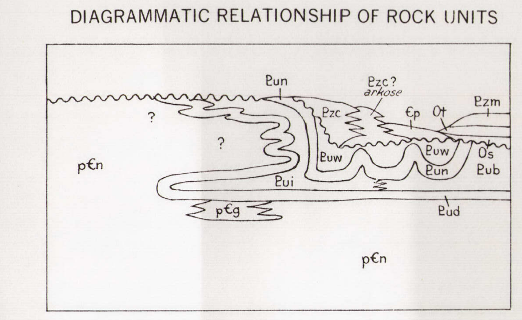




AYERS ROCK

SHEET SG 52-8

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



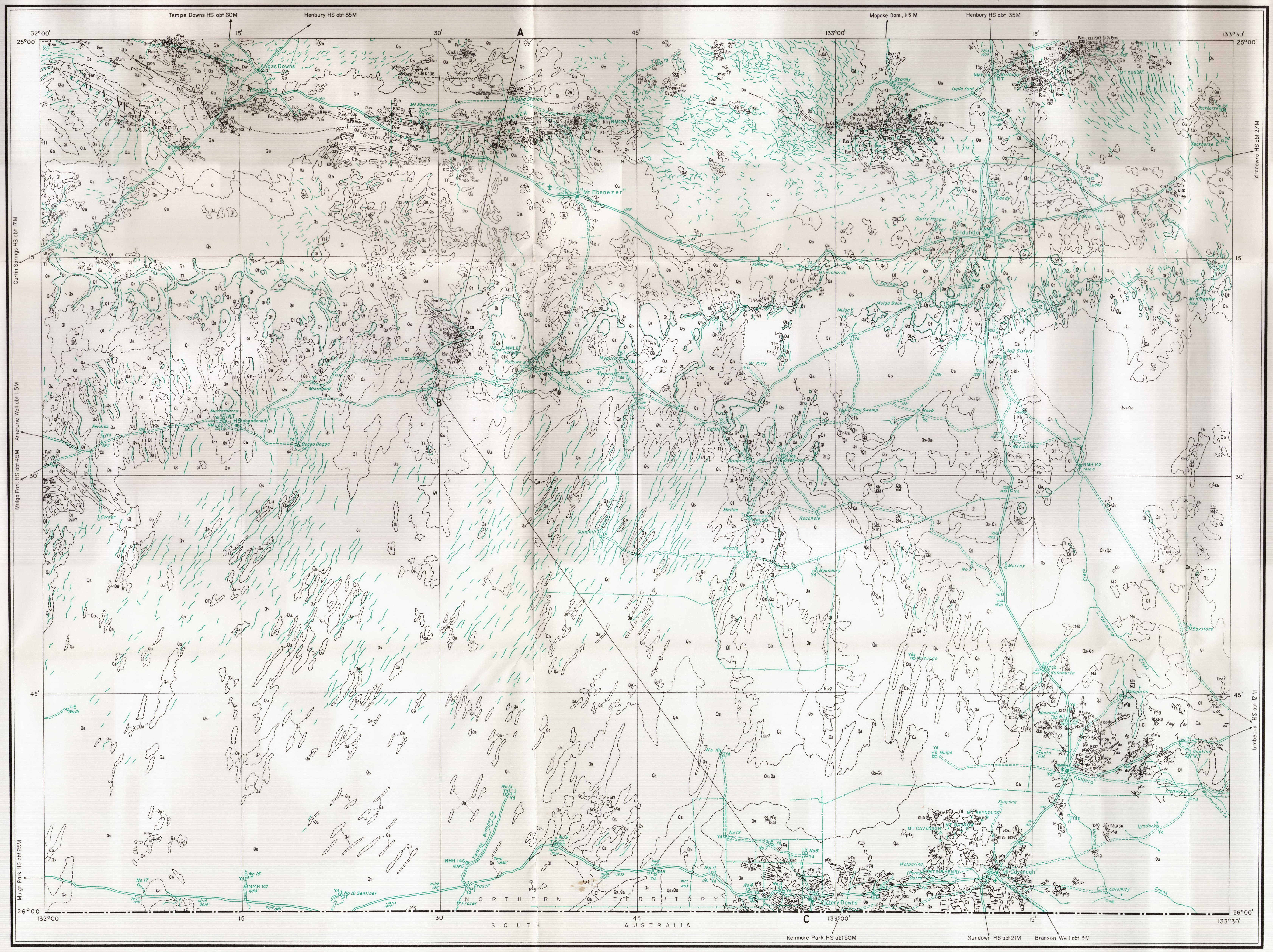
Unconformity

AUSTRALIA 1:250,000

KULGERA

NORTHERN TERRITORY

1:250,000 GEOLOGICAL SERIES SHEET SG 53-5



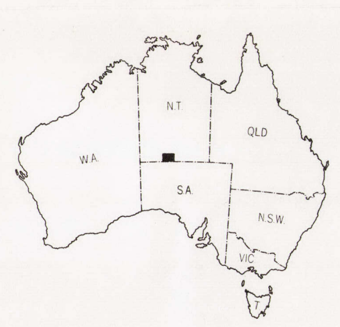
Reference

CAINOZOIC	QUATERNARY		Q	Undifferentiated (Section only)
			Qa	Alluvium, conglomerate
			Qs	Sand
			Ql	Travertine
			Qt	Evaporites
	TERTIARY		Tc	Conglomerate
			Tl	Limestone, calcareous siltstone, siltstone, sandstone
			Tb	"Grey billy", silicified sediments
MESOZOIC			M	Sandstone, siltstone
	LOWER CRETACEOUS	Rumbalara Shale	Klr	Fossiliferous shale and siltstone
	UNDIFFERENTIATED	De Souza Sandstone	Md	Sandstone, pebbly sandstone
PALAEOZOIC	UNDIFFERENTIATED	Finke Group: Idracowra Sandstone	Pzi	White kaolinitic sandstone
		Finke Group: Horseshoe Bend Shale	Pzh	Red-brown biotite shale, some fine sandstone
		Finke Group: Polly Conglomerate	Pzo	Conglomerate
		Pertnjara Formation	Pzp	Red-brown sandstone, siltstone
		Mereenie Sandstone	Pzm	Red-brown kaolinitic sandstone, siltstone
	ORDOVICIAN	Stokes Formation	Ot	Siltstone, silty dolomite
		Stairway Sandstone	Os	Fossiliferous sandstone, phosphorite, conglomerate
	CAMBRIAN	Pertaoorrta Formation	Єp	Sandstone, siltstone, conglomerate
PRECAMBRIAN	UPPER PROTEROZOIC	Winnall Beds	Puw	White and purple-brown sandstone, dark brown siltstone
		Inindia Beds	Pun	Bedded chert, chert breccia, siltstone, dolomite, sandstone, tillite
		Bitter Springs Limestone	Pub	Dolomite, sandstone, chert
			do	Dolerite
			pЄg	Granite, gneiss
			pЄn	Gneiss
			pЄ	Schist

Geological boundary
Anticline, showing plunge
Syncline, showing plunge
Overturned anticline
Fault
Where location of boundaries, folds and faults is approximate, line is broken; where inferred queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes.
Strike and dip of strata
Horizontal strata
Overturned strata
Dip < 15°
Dip 15° — 45°
Dip > 45°
Trend lines
Joint pattern
(air-photo interpretation)
Strike and dip of foliation
Vertical foliation
Strike and dip of platy flow structure
Vertical platy flow structure
Macrofossil locality
×K29 Specimen locality
KW-7 Measured section
do Dyke do, dolerite

Bore, with windpump
Abandoned bore
Well
Abandoned well
Spring
T Tank
E Earth tank
Dam on stream
R.H. Rockhole
Sand dunes
Road
Vehicle track
Fence
"Kulgera" Homestead
Landing ground
Yd Yard
Astronomical station
1672 Height in feet, barometric levelled. Datum, mean sea level. Port Augusta
74/12 Station number

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Photo scale compilation supplied by the Division of National Mapping, Department of National Development.
Aerial photography by R.A.A.F.; complete vertical coverage at 1:46,500 scale
Transverse Mercator Projection.



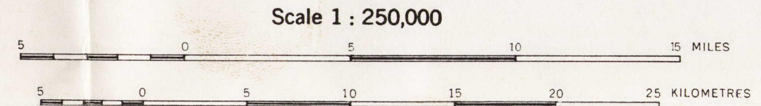
INDEX TO ADJOINING SHEETS

SHOWING MAGNETIC DECLINATION

MT RENNIE SF 52-15	MT LIEBIG SF 52-16	HERMANNSBURG SF 53-13	ALICE SPRINGS SF 53-14	ILLOGWA CREEK SF 53-15
BLOODS RANGE SG 52-3	LAKE AMADEUS SG 52-4	HENBURY SG 53-1	RODINGA SG 53-2	HALE RIVER SG 53-3
PETERMANN RANGES SG 52-7	AYERS ROCK SG 52-8	KULGERA SG 53-5	FINKE SG 53-6	MCDILLS SG 53-7
MANN SG 52-11	WOODROFFE SG 52-12	ALBERGA SG 53-9	ABMINGA SG 53-10	DALHOUSIE SG 53-11
BIRKSGATE SG 52-15	LINDSAY SG 52-16	EVERARD SG 53-13	WINTINNA SG 53-14	OODNADATTA SG 53-15

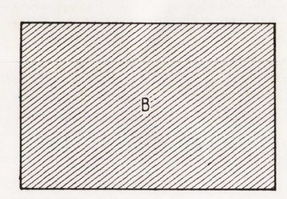
Annual Change 1°30′ E

Scale 1 : 250,000



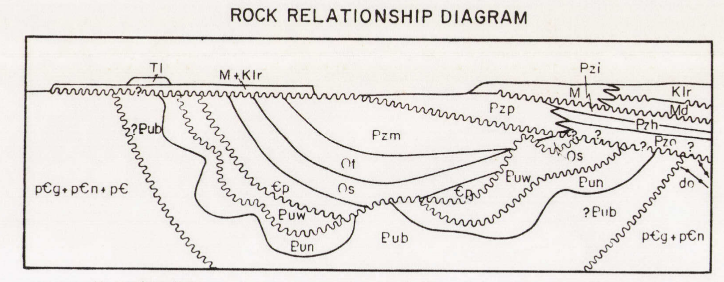
Geology and compilation, 1963, by: A. T. Wells, A. J. Stewart, S. K. Skwarko and A. Mikolajczak
Drawn, 1964, by: R. J. Molloy, J. Pasman and G. Matveev

GEOLOGICAL RELIABILITY DIAGRAM



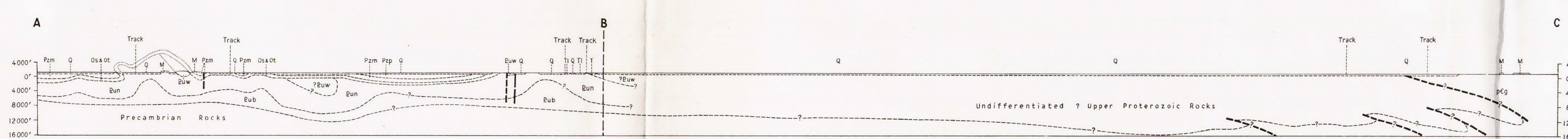
B *Detailed reconnaissance—numerous traverses, with air-photo interpretation*

ROCK RELATIONSHIP DIAGRAM



Section

Scale



KULGERA

SHEET SG 53-5

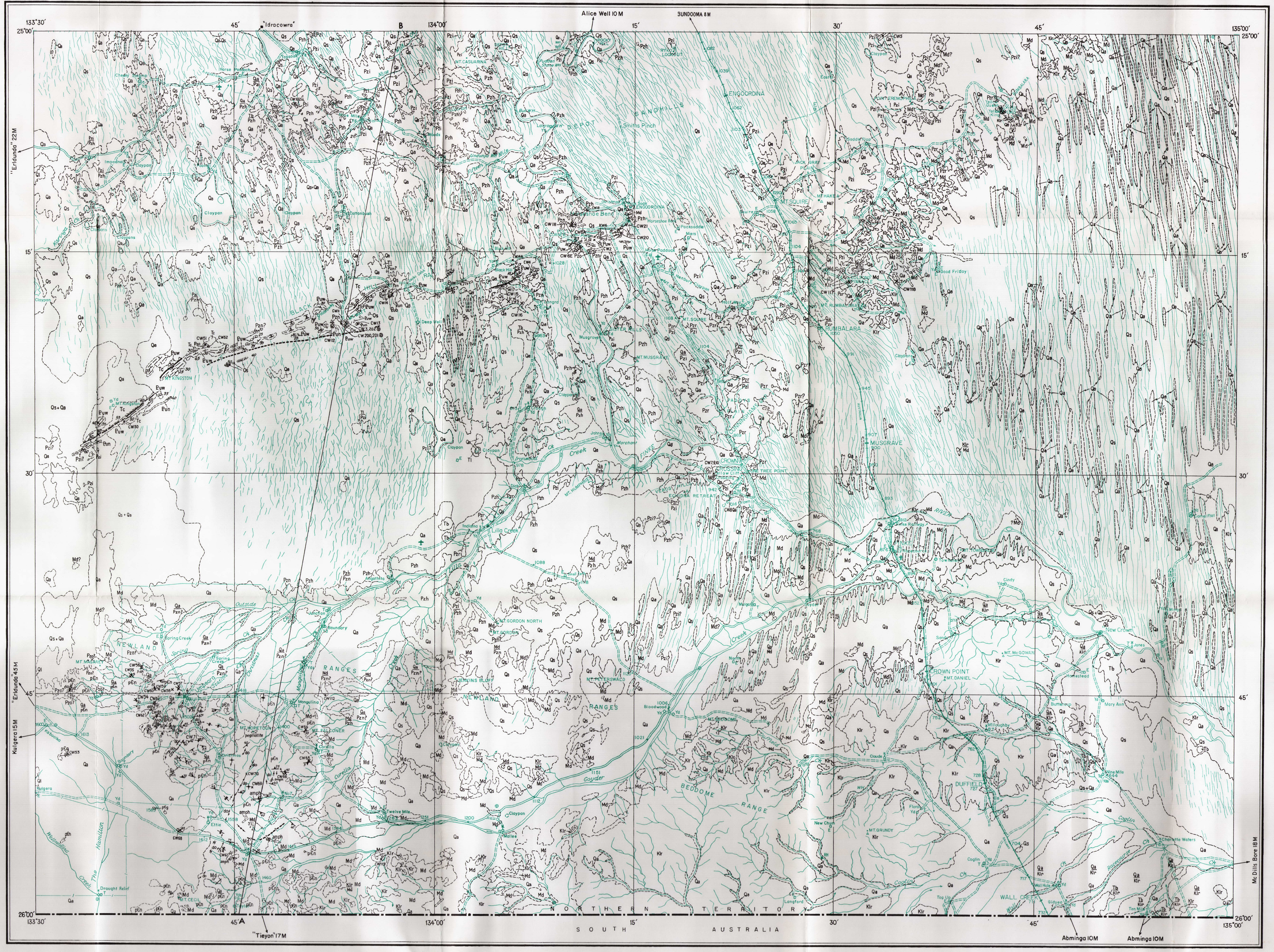
PRELIMINARY EDITION, 1964
SUBJECT TO AMENDMENT

AUSTRALIA 1:250,000

FINKE

NORTHERN TERRITORY

1:250,000 GEOLOGICAL SERIES SHEET SG 53-6



Reference

CAINOZOIC	QUATERNARY		Q	Undifferentiated (section only)
			Qa	Alluvium
			Qs	Sand
	TERTIARY		Tc	Conglomerate
			Tl	Limestone
			Tb	"Grey Billy"
MESOZOIC	LOWER CRETACEOUS	Rumbalara Shale	Klr	Fossiliferous shale and siltstone
	UNDIFFERENTIATED	De Souza Sandstone	Md	Sandstone, pebbly sandstone
PALAEOZOIC	? PERMIAN	Crown Point Formation	Pzr	Sandstone, conglomerate, siltstone
	UNDIFFERENTIATED (Finke Group)	Idracowra Sandstone	Pzi	White kaolinitic sandstone
		Horseshoe Bend Shale	Pzh	Red-brown biotite shale, some fine sandstone
		Langra Formation	Pzn	Yellow sandstone, conglomerate, red-brown siltstone
		Polly Conglomerate	Pzo	Conglomerate
	ORDOVICIAN	Stairway Sandstone	Os	Fossiliferous sandstone, conglomerate
PRECAMBRIAN	UPPER PROTEROZOIC	Winnall Beds	Puw	White and purple-brown sandstone, glauconitic siltstone
		Inindia Beds	Pun	Bedded chert, chert breccia, red-brown siltstone, sandstone, tillitic siltstone
		Bitter Springs Limestone	Pub	Grey-brown dolomite with stromatolites
	UNDIFFERENTIATED		do	Dolerite
			p€g	Granite
			p€n	Gneiss
			amph	Amphibolite

Geological boundary

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

Strike and dip of strata
Vertical strata
Horizontal strata
Overturned strata
Dip < 15°
Dip 15° - 45°
Dip > 45°
Trend lines
Joint pattern
(air-photo interpretation)
Strike and dip of foliation
Vertical foliation
Horizontal foliation
Foliation, dip indeterminable
Direction and plunge of lineation
Horizontal lineation
Inclined platy flow
Vertical platy flow

Macrofossil locality
×CW20 Specimen locality
KW-6 Measured section
do Dyke; do - dolerite

Mine, not being worked
•Oc Minor mineral occurrence; Oc - ochre

Bore
Abandoned bore
Well
Abandoned well
Windpump
T Tank
E Earth tank
Dam on stream
Spring
RH Rockhole
Sand dunes

Road
Vehicle track
Railway with siding
State boundary
Fence
Telegraph line
"Umbeara" Homestead
Landing ground
Yd Yard
Astronomical station
·717' Height in feet, barometric; datum: mean sea level
Trigonometrical station

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Photoscale compilation supplied by the Division of National Mapping, Department of National Development.
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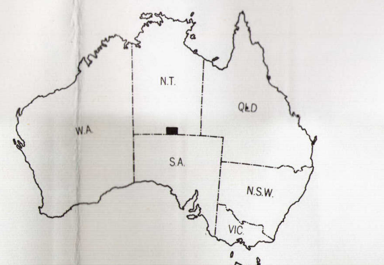

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SHOWING MAGNETIC DECLINATION

MT. LIEBIG SF 52-16	HERMANNSBURG SF 53-13	ALICE SPRINGS SF 53-14	ILLOGWA CREEK SF 53-15	HAY RIVER SF 53-16
LAKE AMADEUS SG 52-4	HENBURY SG 53-1	RODINGA SG 53-2	HALE RIVER SG 53-3	SIMPSON DESERT N. SG 53-4
AYERS ROCK SG 52-8	KULGERA SG 53-5	FINKE SG 53-6	MCDILLS SG 53-7	SIMPSON DESERT S. SG 53-8
WOODROFFE SG 52-12	ALBERGA SG 53-9	ABMINGA SG 53-10	DALHOUSIE SG 53-11	POOLOWANNA SG 53-12
LINDSAY SG 52-16	EVERARD SG 53-13	WINTINNA SG 53-14	OODNADATTA SG 53-15	NOOLYEANNA SG 53-16

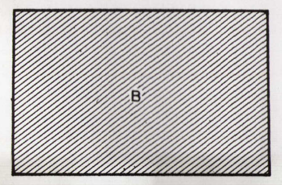
Annual change 1'30"E

Scale 1 : 250,000

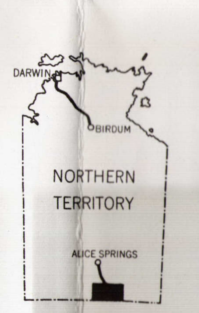
5 0 5 10 15 MILES

5 0 5 10 15 20 25 KILOMETRES

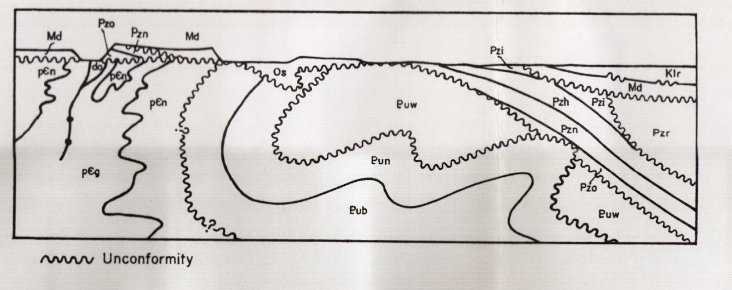
GEOLOGICAL RELIABILITY DIAGRAM



B Detailed reconnaissance - numerous traverses, with air-photo interpretation



DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Section

Scale: $\frac{V}{H}=1$