DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
REGIONAL SURVEYS DIVISION

# EXPLANATORY NOTES FOR THE LINDSAY 1:250 000 GEOLOGICAL MAP

by

R.B. MAJOR
ASSISTANT SENIOR GEOLOGIST
REGIONAL MAPPING SECTION

Rept.Bk.No.72/161
G.S. No. 4927
DM. No.432/72

21st August, 1972

CONTENTS

PAGE

CONTENTS

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept.Bk.No. 72/161
G.S. No. 4927
DM. No. 432/72

# EXPLANATORY NOTES FOR THE LINDSAY 1:250 000 GEOLOGICAL MAP


## ABSTRACT

The LINDSAY 1:250 000 sheet area occupies portion of the southern part of the Musgrave Block and the northern part of the Officer Basin in the North West Province of South Australia. It is entirely contained by the Great Victoria Desert. The oldest rocks are gneisses of the amphibolite and granulite facies which have resulted from the high grade regional metamorphism of acid igneous rocks and sedimentary rocks during the ?late Carpentarian-?early Adelaidean. These gneisses have been intruded by granites (usually allanite-bearing) and basic dyke rocks. Clastic sediments of Adelaidean age have been equated with the Burra Group and the Pound Quartzite of the Wilpena Group. Clastic sediments of late Marinoan or early Cambrian age outcrop very poorly. A sandstone of probable Cambro-Ordovician age outcrops towards the eastern side of the area and this is overlain by Palaeozoic-Mesozoic sandstones. A lacustrine limestone of Tertiary-Quaternary age is found blanketing parts of the crystalline basement and older sedimentary rocks. Other Quaternary units include a red clay sandy soil, aeolian gypsum deposit, extensive sand dunes and sand spreads, minor amounts of alluvium and talus, and gypseous and clayey lake deposits. Most of the area is covered by sand dunes amongst which are widely separated outcrops of rock.


## INTRODUCTION

The LINDSAY sheet area covers about 16 300 square kilometres between Lat. 27° and 28° south, Long. 130°30' and 132°00' east. It occupies the southeast quarter of the North West Aboriginal Reserve (Fig. 1). There are no permanent settlements on LINDSAY but the Reserve is administered from "Amata" (formerly Musgrave Park, on WOODROFFE) by the South Australian

Department of Social Welfare and Aboriginal Affairs. Entry into the Reserve is restricted and permits to enter are required from that Department.

Access onto LINDSAY can be gained from the west by the road between Piltardi (in the Mann Range) and Cheesman Peak (on BIRKSGATE) and from the east, by using the track along the Officer Creek going south from Fregon to Mount Bonybonninna. Access from the east is also possible along tracks from EVERARD (see Fig. 1).

The country is semi-arid with an average rainfall less than 200 millimetres, with the heaviest falls from thunderstorms during the summer months. However, the amount of rain which falls in any particular month varies considerably from year to year. The average rate of evaporation may be in the order of 300 centimetres per year.

During the winter months of June to August the temperatures are mild (probably 18°-21°C) during the day but with cold nights which may result in radiation frosts in the early mornings before sunrise. These conditions contrast markedly with the very hot summer months (November to March) with day temperatures of perhaps 32°-38°C but which may exceed 43°C in the shade. Sun temperatures may be as high as 69°C, with 49°C in the shade (Nettleton, 1970). In all seasons there is usually a large diurnal variation in temperature due to sunny days and clear cloudless nights.

The following geological sheets in the North West Province of South Australia have been published by the South Australian Department of Mines - MANN (1:250 000), WOODROFFE (1:250 000), ALBERGA (1:253 440), and BIRKSGATE (1:250 000). The EVERARD 1:250 000 sheet is in preparation for publication by the S.A.D.M.

Dyeline copies of NOORINYA, WELLS and GILES are available from the S.A.D.M. These areas have been mapped by interpretation of air-photographs and then by ground and helicopter reconnaissance surveys.

The aeromagnetic contour maps of the following 1:63 360 sheet areas are available as dyeline copies from the S.A.D.M.

1. on LINDSAY - Illillinna and Purndu
2. on WOODROFFE - McNamara, Woodroffe, Eunyarinna and Wintiginna.
3. on ALBERGA - all 1:63 360 sheet areas.

The aeromagnetic contour maps of Eterinna, Moolalpinna, Perdinna and Polkari (on LINDSAY), the top six 1:63 360 sheet areas on BIRKSGATE, all of MANN and the 8 western sheets of WOODROFFE will be available as dyeline copies from the S.A.D.M. in 1973.

Bouguer gravity and aeromagnetic contour maps of all of South Australia at 1:1 000 000 scale will be available from S.A.D.M. by the end of 1972 and early 1973 respectively. LINDSAY has been covered by black and white air photos at 1:79 000 scale (available from S.A. Lands Dept.) and these were used for the field mapping and compilation of the map.

The Department of National Development (Division of National Mapping) has published topographic maps of all the 1:250 000 sheet areas shown on Fig. 1.

NOTE: in these notes the following method is used to signify the scales of various sheet areas.

A 1:250 000 sheet area is designated e.g. LINDSAY

A 1:63 360 sheet area is designated e.g. Eterinna

## HISTORICAL AND PREVIOUS INVESTIGATIONS

The LINDSAY area has long been occupied by the aboriginal people of the Yangkuntjatjara and Ngalea tribes. (see map in Tindale, 1940). Their interest in the rocks of the area was confined to the practical uses and to the mythical explanations of the origins of some of the physical features. However, they recognise that dolerite dykes cut through the other rocks. The chalcedony of the Mangatitja Limestone is used for cutting and scraping tools. They have almost no specific names for different rock types which, generally, seem to be described by their colour or use. Nowadays, the people are aware of the possible monetary value of minerals due mainly to the activities of the South Australian Department of Mines.

Because of the general inhospitability and lack of permanent water supplies LINDSAY is now uninhabited by aborigines except for brief incursions for tribal religious reasons or to hunt dingos for scalps. The people have gone to Ernabella, Fregon or Amata (See Fig. 1). Ernabella and Fregon are mission stations established by the Presbyterian Church in 1936 and 1961 respectively (Hilliard, 1968).

The first white men to visit the area were Tietkins and Young in 1875. They were with an exploring party, led by Ernest Giles, which was travelling from Beltana to Perth. They left the main party at Ooldabinna (approximately 150 kilometres north, $20^{o}$ west from Ooldea) and headed north towards the Musgrave Ranges on their camels to approx. Lat. $27^{o}42'$S, Long. $131^{o}19'$E (Giles, 1889, Vol. 2, p.177) i.e. northeast part of <u>Murrakai</u> and then returned to the main party. They saw nothing except sand dunes and mulga and consequently left no geographical names in these areas to record their visit.

The second group of white men to enter the area was probably the Elder Scientific Exploring Expedition in 1891, whose leader was David Lindsay (Lindsay, 1893) and geologist was Victor Streich (Streich, 1893). Lindsay discovered and named the Purndu Saltpan. These men were followed by John Carruthers, a South Australian Government Surveyor, who made a trigonometrical survey of the area between 1891 and 1892 (Carruthers, 1892). He probably named most of the hills on LINDSAY but this cannot be confirmed by the present author.

The fourth man to visit LINDSAY appears to have been Hubbe who was the leader of a South Australian Government party trying to find a stock route between South and Western Australia via the Musgrave, Mann and Tomkinson Ranges. While his camp was in the Musgrave Ranges he visited the Purndu Saltpans to examine an "extinct mound spring" which had been reported by Lindsay and Streich. (Hubbe, 1897). This mound spring has not been seen by the present author.

In 1914, R. Lockhart Jack travelled south down the Officer Creek on the eastern side of Illillinna and noted outcrops of biotite schist and pegmatite on the banks of the creek (Jack, 1915).

In 1955, T.A. Barnes, while Deputy Director of Mines conducted a reconnaissance geological survey with L. Beadell (Surveyor, Department of Supply) across the southeast corner of LINDSAY and collected samples of what is now known as the Boongar Sandstone (personal communication, T.A. Barnes, 1970, S.A.D.M. Descriptions of rocks in the area from Barnes' unpublished field note books are available in Ludbrook, 1966). This reconnaissance was made during the preparation for the atomic tests at Emu and Maralinga (see Beadell, 1965, 1967 and 1971).

After the atomic tests, parts of the formerly restricted areas were released for oil exploration and in 1958 McKenzie (1959) made a geological reconnaissance of much of the Officer and Eucla Basins in South Australia, including all of LINDSAY.

In 1960, J.E. Johnson (1963) mapped on Pindyin and in 1965, W. Johnson (1965) and R. Grasso (1965 a and b) made ground and photogeological surveys on LINDSAY on behalf of Exoil Pty. Ltd. and Continental Oil Company of Australia Ltd.

The Geological Survey of South Australia mapped parts of LINDSAY on the ground in 1960, 1966 and 1967. Officers involved in these were R.B. Major, J.A. Teluk, C.R. Dalgarno, G.W. Krieg and J.E. Johnson. In 1968 Major sampled rocks from the more inaccessible parts by using a helicopter and mapped remaining unvisited areas by airphoto interpretation. A number of gravity, aeromagnetic, ground magnetic and air-borne radiometric surveys have been conducted on and over LINDSAY. These are detailed under the section entitled "Geophysical Surveys".

LINDSAY has been covered in whole or part by three licence areas for petroleum exploration. The first was Oil Exploration Licence 19 issued to Oil Drilling and Exploration Ltd. in January, 1959. The area of O.E.L. 19 was reduced by about one-third and issued to Exoil Pty. Ltd. as O.E.L.28 in October, 1962. Since then the area of O.E.L. 28 has been successively reduced by surrendering less promising areas and Exoil Pty. Ltd. have farmed-out their interest in the area to Continental Oil Company of Australia Ltd. This company has conducted aeromagnetic, seismic, gravity and helicopter-geological surveys over the area, drilled two stratigraphic wells, Birksgate No. 1 and Munyarai No. 1 and a third, Officer No. 1, was drilled by S.A.D.M. for Continental. At present the southeast part of LINDSAY is covered by Petroleum Exploration Licence 12 issued to Exoil N.L. and Transoil N.L. in February, 1971 (S.A.D.M. Annual Reports and P.E.L. information).

## PHYSIOGRAPHY

LINDSAY is entirely contained in the Great Victoria Desert (Giles, 1889, Vol. 2 p.202) and is almost completely occupied by longitudinal sand dunes and sand spreads which, in the eastern parts, are covered by thick mulga scrub (Acacia aneura) but elsewhere by spinifex (Triodia sp.), acacias and eucalypts. The dunes trend southeast to east-west. The Desert is confined within the 6 inch to 8 inch isohyets (150-200 millimetres) but with the abundance of vegetation it might be more properly called an "arid zone".

In the northern half of the area occur scattered inselbergs and small outcrops of acid and basic rocks of the crystalline basement and extensive areas of the low-lying Mangatitja Limestone (T-Q) (Major, 1972g). The southern half of the area contains scattered low outcrops of ridges of sedimentary rocks.

The only water course of any significance is that of the Officer Creek which runs along the eastern side of Illillinna. Its headwaters are in Brown's Pass in the Musgrave Ranges on WOODROFFE (see Major et al., 1967) and it ends in an area of sand, alluvium and clay pans on Munyarai (south-west EVERARD). It is usually dry along its entire length and this author does not know when water last flowed on Illillinna. However, in March 1967 water reached as far south as Fregon, which is about 40 kilometres south of the Ranges and 27 kilometres north of Illillinna (personal communication, W.H. Edwards, Ernabella Mission, 1971). The course of the Officer Creek appears to be controlled by regional slope. It seems to truncate the sand dunes, and has well-developed meanders which have incised into the substrate of the unconsolidated Quaternary units. This substrate is variously crystalline basement rocks, Mangatitja Limestone or silcrete (the last is only on EVERARD).

## VEGETATION

Although LINDSAY is confined wholly within the Great Victoria Desert it is almost covered completely by vegetation, particularly after a heavy rain. The only areas on which plants were not seen to grow were smooth rock faces. There seems to be two main groups of plants: the long lived species which can survive in the hot dry conditions (Mulga trees, Witchetty shrubs and "spinifex") and the ephemerals which grow quickly from the bare soil after heavy rains, flower for a few weeks, seed and then die. When they flower, square miles of country can be covered by a patchwork of yellow, purple or white.

Plant specimens have been collected by the author from many parts of the North-West Province but only from Eterinna, Moolalpinna, Illillinna and Purndu on LINDSAY. The eucalypts have been identified by Mr. C.D. Boomsma, of the South Australian Woods and Forests Department, and the other plants, by the staff at the State Herbarium of South Australia. Voucher specimens are held in the herbarium of the S.A.D.W.F. (eucalypts) and the State Herbarium (AD) (others).

The author appreciates the help, encouragement and supply of collecting equipment by both Dr. Hj. Eichler, of the State Herbarium and Mr. Boomsma and the reading of this part of the Notes by Dr. Eichler, Mr. W.K. Harris and Mr. Boomsma.

The collection of 30 different species was far from complete and only the prominent ones in flower were collected. It should not be inferred that the species would necessarily be restricted to the geological substrate which is indicated. Some eucalypts were identified (but not collected) by the author from a pictorial key provided by Mr. Boomsma (they are marked "det. R.B.M.").

The following part of this section is a description of the vegetation of the various geological units. The common names of the plants are in brackets and most were obtained from Black and Rogers (1960), Black (1963), Black (1952), Black and Robertson (1957), Boomsma (1972) and Morcombe and Morcombe (1970). Some common names were suggested by Mr. Boomsma. The most common plants in the area: *Triodia* sp. (Spinifex, Porcupine Grass), *Acacia aneura* (Mulga tree), *Acacia kempeana* (Witchetty shrub) and *Eucalyptus* spp. (various mallees and gum trees) of the sand flats and dunes. Most of the other plants named are ephemerals.

1. Granitic gneiss and dolerite: *Triodia* sp. ("Spinifex")
2. Dolerite:- *Lepidium oxytrichum*

3. Palaeozoic - Mesozoic sediments on southeast Purndu: Eucalpytus concinna (Victoria Desert Mallee, det. R.B.M.), Casuarina trees.

4. Mangatitja Limestone. Triodia irritans ("Spinifex"), Eucalyptus oleosa (Red Mallee), Casuarina sp. (Desert Oak) and grasses.

5. Calcrete

5a. calcrete on weathered and crystalline basement rocks: Casuarina cristata (Black Oak), Eucalyptus oleosa (Red Mallee), Eucalyptus ewartiana (Ewart's Mallee), Atriplex sp. (Saltbush), Cassia nemophila var. platypoda, Kochia georgei, Dodonaea microzyga (a species of Hop Bush) and Stipa scabra (Spear-Grass). The latter two plants were only seen west of Lindsay's Pile but the others were generally common throughout the sampled area.

5b. Calcrete on Palaeozoic - Mesozoic sediments: Triodia sp. ("Spinifex").

5c. Calcrete on calcareous Palaeozoic - Mesozoic sediments: Triodia sp. ("Spinifex"), Eucalyptus oleosa (Red Mallee), and Causuarina sp. (Desert Oak).

5d. Calcrete on Mangatitja Limestone: Triodia sp. ("Spinifex") and Eucalypt spp. (Mallees).

6. Red clay sandy soil: Acacia aneura (Mulga), Acacia kempeana (Witchetty, det. R.B.M.), Cassia sp. Bassia sp. (Bindy-eye). Eremophila sp. On a red clay sandy soil area south of Piltardi in the Mann Ranges (north-east MANN) a great number of ephemerals grow and flower amongst the Mulga trees after heavy rains. These probably extend onto LINDSAY and are listed as follows:

Actinobole uliginosum, Cassia phyllodinea, Erodium crinitum, Helichrysum cassinianum (aneverlasting), Helipterum floribundum, Helipterum stipitatum, Helipterum tietkensii (white and yellow everlasting) Menkea sphaerocarpa, Menkea villosula, Minuria leptophylla, Ptilotus helipteroides, Senecio gregorii (yellow-top) and Swainsona phacoides.

7. Sand dunes and interdune areas with thick Mulga and Witchetty: Aristida browniana (wire grass), Brunonia australis (Blue Pincushion), Enneapogon polyphyllus, Eragrostis laniflora (Lovegrass), Helipterum stipitatum (yellow everlasting) Sida corrugata, Sida trichopoda, Triodia lanigera ("Spinifex").

8. Sand dunes and interdune areas with scattered mulga and witchetty: Brachychiton gregorii (Desert Kurrajong, det. R.B.M.), Dodonaea cuneata, Eucalyptus pyriformis subsp. youngiana (Ooldea Mallee, det. R.B.M.), Eucalyptus ewartiana (Ewarts Mallee, det. R.B.M.), Hakea spp. (det. R.B.M.), Helipterum cassinianum (pink everlasting), Helipterum stipitatum (pink and yellow everlasting), Olearia subspicata, Podolepis canescens, Triodia sp., Waitzia citrina.

9. Sandy rise against a granitic gneiss outcrop. Calandrinia remota (Round-leaved Parakeelya).

10. Purndu Saltpan

    10a. around the edge of the gypsum floor but not on the gypsum: Arthrocnemum halocnemoides (Samphire).

    10b. on alluvial flats and away from the samphire: Atriplex vesicaria (Bladder Saltbush), Bassia uniflora (Bindy-eye), Senecio gregorii (Yellow Top, Groundsel).

11. On gypsum, east side of Purndu Saltpan: Eucalyptus oleosa (Red Mallee) and Zygophyllum sp. (aff. Z. aurantiacum).

12. Talus slope of Moolalpinna Hill: Menkea sphaerocarpa.

13. Near the Officer Creek

13a. on the flats between calcrete and the creek channel: Atriplex sp. (Saltbush)

13b. along the banks and in the creek channel: Eucalyptus camaldulensis (River Red Gum, det. R.B.M.)

A list of the genera and species, the herbaria where the specimens are stored and their field sample numbers are in the Appendix.

## STRATIGRAPHY

The oldest rocks on LINDSAY are granitic gneisses which have been intruded by granites and basic dykes. Nonconformably overlying these rocks is a sequence of Precambrian sandstones, an oolitic chert, an Ordovician "worm-burrow" sandstone and various Palaeozoic-Mesozoic sandstones. These have been silcreted in places (Tertiary) and then a widespread chalcedonic limestone of Tertiary - Quaternary age was deposited. The youngest deposits are various Quaternary units, mainly a red clay sandy soil and sand.

The Phanerozoic and Precambrian stratigraphy and tectonic sequences are summarised in Tables 1 and 2.

## PRECAMBRIAN

### 1. Crystalline Basement

The relationships of most of the Precambrian crystalline basement rocks on LINDSAY are not seen in the field because of the sparse and scattered outcrops. Most are found in the northern three 1:63 360 scale sheet areas i.e. Eterinna, Moolalpinna and Illillinna. Since many of the gneisses of various origins look similar in outcrop and hand specimen, the following grouping of these rocks is somewhat subjective. The different rock types will be described in an order which may approximate to their relative ages (i.e. oldest rocks first). Most of the foliations in these rocks have a general northeasterly strike although there are variations from northerly to easterly.

(1) Rocks of amphibolite-granulite transition facies

These are seen at Tarleecartagun Hill (southern Perdinna) and in the northeast part of Eterinna. The petrological information from Tarleecartagun Hill was supplied by B. Collins (Amdel Report MP 3158-70) and from Eterinna by G. Lowder (Amdel Report MP 3467-72).

Tarleecartagun Hill is composed of a grey, granular, sometimes foliated, porous quartzite with very minor accessory amounts of a pale green clinopyroxene. This quartzite is interpreted by the petrologist as being a metamorphosed sandstone containing detrital pyroxene. Small masses of goethite and cryptomelane ($K_{\cdot}Mn_8O_{16}$, Mathieson and Wadsley, 1950) are found in the quartzite. This goethite material has high nickel and chromium values (Amdel Report An 3159/70) and may have been derived by the weathering of ultra-basic rock.

In a dry creek channel extending from the southeast corner of Tarleecartagun Hill is a series of rocks, outcropping over a length of about 220 metres, none of which were found in contact with any other. These rocks include hornblende-diopside granulites, amphibole-rock and a garnet-clinopyroxene-plagioclase-quartz rock of lower granulite facies and are probably metasediments (some may be basic meta-igneous rocks). A silicified dolomitic rock has high nickel and chromium values (Amdel Report An 3466/72) and may be due to the alteration of an ultrabasic rock (personal communication, L.C. Barnes, S.A.D.M., 1972). A light brown very fine-grained equigranular biotite adamellite is unmetamorphosed and assumed to be a later intrusion. A pinkish coloured argillaceous grit occurs at the base of the quartzite outcrop (and at a higher level than the other rocks) and is assumed to be the remnant of a sedimentary deposit of presumed Tertiary-Quaternary age.

In the northeast part of Eterinna the granulite-facies rocks are granitic gneisses containing variously, orthopyroxene, clinopyroxene, amphibole and biotite. They belong to the lower granulite to upper amphibolite facies of regional metamorphism (G. Lowder, Amdel Report MP 3467/72). On ALBERGA granulite-facies rocks have been dated at 1 380 ± 120 million years by the Rb/Sr method (Arriens and Lambert, 1969).

(2) Amphibolite-facies acid gneisses

These biotite-bearing rocks may be co-metamorphic with the amphibolite-granulite transition-facies rocks. They may be equivalent to the Wataru Gneiss on BIRKSGATE (Major et al., 1971).

The precursors are unknown and so it is possible that some of these gneisses may be the same as the amphibolite-facies acid gneisses of meta-igneous origin.

The amphibolite-facies gneisses mainly occur in scattered outcrops in a band between the Gilby Hill, Moolalpinna Hill and Cartumooninna Hill areas. At Gilby Hill the gneiss contains a few amphibolite lenses which may have been basic dykes intruded into the precursor of the gneiss and altered to amphibolite during the amphibolite-grade metamorphism.

(3) Amphibolite-facies acid gneisses of meta-igneous origin

These rocks presumably intruded those of (1) and (2) and show evidence of igneous origin both in the field and in thin sections. Dark xenoliths are seen at Oonmooninna Hill and thin section examinations show their metamorphic nature but elsewhere it is the interpretation of some of the textures e.g. at Mount Bonybonimna, which points to an igneous origin. They are generally dark biotite and hornblende-bearing rocks but an allanite-bearing gneiss on northern Perdinna is light coloured. Here the allanite is presumed to be of igneous origin.

In the northwest corner of Perdinna this rock has been intruded by a meta-igneous leucocratic granite gneiss which also contains allanite.

(4) Amphibolites

These are seen at Gilby Hill and in northern Purndu. A thin section examination of a specimen from the latter locality indicates that it is an altered basic igneous rock. It occurs as a dyke with a northwest trend. This dyke is not reported as having been cut by pegmatites. Some of these amphibolites represent basic dykes which were intruded into gneisses of (2) and igneous acid rocks of (3) before a period of metamorphism.

(5) Minor pegmatites intrude the gneisses of (2) and (3) at Yelooginna Hill, east of Cartumooninna Hill and on northern Purndu.

(6) Igneous gneisses

Only two examples of such rock are known on LINDSAY (i.e. at Mingeemealinna Hill and in northern Pindyin) and the origin of both were determined from thin section examination. It is possible that, in the absence of thin section descriptions on all specimens collected, there may actually be more representatives of these igneous gneisses than is presently known. The origin of these biotite gneisses is not known except that those at Mingeemealinna Hill may be related to the intrusion of the Ampeinna Granite although the common occurrence of accessory allanite in the granite and its apparent absence in the gneiss might rule against this relationship.

(7) Biotite-granites

This grouping includes various pale grey or pale pink medium-grained biotite-bearing rocks whose mutual relationships are unknown but the relationships of some of the members with older and younger rocks are known. They were seen just west of the North Pindyin Hills and, on the north-western part of LINDSAY, in a north-northwest trending line between Tarlee-cartagun Hill, northwest Perdinna (allanite-bearing) and the western side of Eterinna (fluorite-bearing).

(8) Leucoadamellite and leucogranite

These various pale pink biotite-poor rocks are seen in a band across the northern part of Polkari and in northwest Perdinna where they intrude an allanite-bearing biotite granite. Their pink colour and generally low amounts of dark minerals are distinctive.

(9) Ampeinna granite (equivalent to the Illbillie Adamellite on EVERARD)

This light coloured porphyritic biotite-allanite granite forms the highest inselbergs on LINDSAY i.e. Ampeinna Hills, Oompeinna Hill, Mount Illillinna and Umberdidinna Hill. It contains dark dioritic xenoliths at the first two localities but none were reported from the latter two. The rock is massive-the idiomorphic microcline phenocrysts and xenoliths do not have any preferred orientation. This granite is equated with the Illbillie Adamellite on EVERARD (See Krieg, 1968a, Thomson, 1969, p. 41 and Krieg et al., 1972) which is dated at 1 139 million years by the Rb/Sr method (A.W. Webb, Amdel Project 1/1/123, Progress Report No. 9). It is also equated with the Permano Adamellite on BIRKSGATE (Major et al., 1971) which has been dated at 1 141 m.y. by the Rb/Sr method (Webb, op.cit.). Slightly younger ages (1 100 m.y.) have been determined for other porphyritic granites on ALBERGA.

(10) Basic dykes

There are five dyke trends, northwest, north-northwest, west-northwest east-northeast and north-south, and at least three (and possibly four) different times of intrusion. The relationships of only two of these trends are known (at Cartumdoninna Hill). The main dyke trend is north-westerly as seen in the northwest quadrant of LINDSAY. The rock is mainly gabbro with olivine and orthopyroxene, but with some norite (1 mile north-northeast of Kulinja Soak) and a gabbroic troctolite at Mingeemealinna Hill. The basic dykes are fresh and unstrained.

At Cartumooninna Hill a north-northwest trending series of dolerite dykes (without olivine and orthopyroxene) is cut by an east-north-east trending dolerite dyke (with olivine and minor iron sulphides).

A dolerite dyke (?with olivine) trends northeasterly from Yelooginna Hill (where three different dyke directions intersect) but its relationship to northwesterly dykes at this Hill is not known from ground observation. However, photointerpretation suggests that the order of intrusion was west-northwest (oldest) then north-northwest and finally northeast (youngest). The west-northwest dyke may contain olivine but samples were not collected from the other two dykes.

2. Sedimentary Rocks

The Precambrian sedimentary rocks on LINDSAY are of two general widely separated age groups viz. pre-Sturtian and late Marinoan. No contacts between these rocks have been seen.

(1) Pre-Sturtian Sediments

(i) Pindyin Beds (Pbp) (Major, 1972a)

Elsewhere this unit has been called the Pindyin Sandstone because that is the only rock type which is generally seen in outcrop. (Thomson, 1969, p.55, Major et al., 1971). However, in the type area of the North Pindyin Hills (east dipping) the sandstone is overlain by white siltstone and also possibly by weathered and calcreted ?arkose (or ?granitic rock). Since it is not known whether these latter two units are the lower units of the overlying Wright Hill Beds (whose lower units have not been seen in outcrop in its type area) the more general term Pindyin Beds will be used instead of Pindyin Sandstone.

On Pindyin, the Pindyin Beds begin with a basal pebble conglomerate up to 15 centimetres thick overlying weathered acid crystalline basement. This conglomerate is overlain by about 3 metres of coarse-grained to granule sized feldspathic sandstone containing some very thin beds of quartz pebbles. Overlying these rocks are about 200 metres of a medium- to coarse-grained flaggy sandstone and quartzite. These weather pale brown but are generally white when fresh. This may be feldspathic, pebbly or have rare clay pebbles in some horizons. It commonly has large-scale tabular planar cross-bedding. Some irregular "mudcrack" casts may have sedimentary-diagenetic origins similar to those ascribed for Rhysonetron structures (Hoffman, 1971, p.36). Shrinkage cracks develop in a thin layer of mud. This is covered by sand and the crack infilled. Subsequent compaction elongates the infilling sand cast, squeezes out the muddy layer and results in a distorted sand cast of the original mud crack.

The lower 6 metres of this sandstone show abundant evidence of current activity: cross-bedding, ripple marks, bedding plane lineation and clay pebbles. On the evidence of eight measurements, it can be inferred that currents transporting sediments composing the lower part of the Pindyin Beds came from the northeastern or southwestern quadrants.

Overlying this sandstone in the type area is a maximum of 200 metres of white shale which weathers very pale green. It has lenticular chert beds near the base and some thin beds of limestone and dolomite near the exposed top. Sedimentation appears to have been continuous from the sandstone into the shale with about 1 metre of shale/sandstone transition beds between the two. Further east of the North Pindyin Hills are low outcrops of a calcreted weathered ?arkose or ?granitic rock.

The Pindyin Beds are the lowermost unit of the unmetamorphosed Precambrian sediments on LINDSAY and are correlated with the Heavitree Quartzite (in the Amadeus Basin)(Thomson, 1970, p.212) which is believed to be equivalent to units in the Burra Group of the Adelaide Geosyncline (Glaessner, et al., 1969). It is also correlated by Thomson (1970, p.212) and Lowry et al. (1971) with the Townsend Quartzite of the Officer Basin in Western Australia. The Townsend Quartzite is thought to unconformably overly volcanic rocks which include volcanics of the Tollu area now formalised as the Smoke Hill Volcanics (Daniels, 1969) and dated at 1 060$\pm$ 140 million years (Compston and Nesbitt, 1967). This would suggest a probable Torrensian age or older and probable equation with the Burra Group for the Townsend Quartzite and Pindyin Beds. The white shale which overlies the sandstone of the Pindyin Beds is probably equivalent to the Brown Range Siltstone (personal communication, M.J. Jackson, B.M.R., 1972) which was included with, and conformable with, the Townsend Quartzite (Daniels, 1969, p.14). However, Lowry et al., (1971, p.7) named this siltstone the Lefroy Beds.

(ii) Wright Hill Beds (Pbg) (Major, 1972b)

This unit has previously been called the Wright Hill Formation (Thomson, 1969, p.56, Major et al., 1971) but the term "Beds" is preferable because it is too poorly exposed for complete description.

The type section of these Beds is about 4 kilometres west of Wright Hill. Most of the Beds do not outcrop because of the covering veneer of sand. Ridges of quartzite and sandstone protrude through this sand and scattered patches of siltstone, calcareous material and black oolitic chert (i.e. a silicified oolitic limestone) are found amongst the mulga. Presumably most of the Wright Hill Beds consists of soft rock, such as siltstone or shale. The known thickness is 3 400 metres but neither the top nor the bottom are known and so its relationship to the underlying Pindyin Beds and overlying Punkerri Sandstone are not seen directly. West of the Purndu Hills photo-interpretation suggests that the unit transgressively overlaps the Pindyin Beds and crystalline basement. The Wright Hill Beds appear to be structurally conformable with both the Pindyin Beds and the Punkerri Sandstone.

The black oolitic chert, near the top of the Wright Hill Beds, is the most characteristic lithological feature of the unit. This type of chert is found as erratics in the Sturtian Chambers Bluff Tillite (Wilson, 1952, Major, 1972c) on northeast EVERARD (Krieg et al., 1972), which is about 220 kilometres east-northeast of the type area of the Beds. The extent of outcropping Wright Hill Beds in Sturtian times is not known but photo-interpretation suggests that outcrops occur west of Purndu Hills and the Beds probably extend further east beneath the Munyarai Trough of the Officer Basin (see Krieg, 1972a).

Providing that the correlation of the Pindyin Beds with the Heavitree Quartzite and Townsend Quartzite is correct then the Wright Hill Beds belong to the Burra Group. They have only a few similarities to published descriptions of the predominantly limestone Bitter Springs Formation (Wells et al., 1967) which overlies the Heavitree Quartzite in the Amadeus Basin.

(2) Late Marinoan Sediments

(i) Punkerri Sandstone (Pwk) (Major, 1972d)

The type area is the Punkerri Hills on BIRKSGATE where it is equated with Upper Marinoan Pound Quartzite of the Flinders Ranges on both fossil evidence (see Glaessner, 1966, p.44) and lithological grounds. Specimens collected by W. Johnson, B. Griffith and J. Johnson in 1964 were found to contain animal impressions similar to those of the Ediacara fauna e.g. *Rangea* sp., *Charnia* sp., *Tribrachidium heraldicium* Glaessner, possible *Charniodiscus* Ford, and a "double-spiral" (unpublished report, B. Daily, University of Adelaide, 1964).

The Punkerri Sandstone has a lower red member and an upper white member as does the Pound Quartzite (see Forbes, 1971).

On LINDSAY the Sandstone is best exposed at Wright Hill and just west of the Purndu Hills. It is a reddish coloured sequence of sandstone, quartzite and shale with abundant evidence of active shallow water currents (cross-bedding, ripple-marks, shale pebbles, load structures and various sole-markings). Vague impressions resembling trilobite tracks and halite casts have been seen. The predominant red colour of this sequence suggests that, on LINDSAY, it is mainly the lower unit of the Punkerri Sandstone which is present and that the upper unit is thin and represented by the occasional beds of light coloured sandstone which are present.

The Punkerri Sandstone and the Wright Hill Beds are generally structurally conformable but, apart from the Sturtian to Marinoan time gap which separates them, the only known field evidence of an erosional break between them is a thin conglomerate containing black oolitic chert pebbles, which was found in the Punkerri Sandstone at the Punkerri Hills (J.E. Johnson, S.A.D.M. field notes, unpublished).

3. <u>?Upper Marinoan - ?Lower Cambrian Sediments</u>

(1) <u>Wirrildar Beds</u> (Ɇi) (Major, 1972e)

This unit has previously been termed a Formation (Major et al., 1971) but since it is too poorly exposed for complete description the term "Beds" is preferable.

The type area is on BIRKSGATE where it consists of very poorly outcropping arkosic sandstone, micaceous sandstone and rare thin dolomite beds. It is thought to be either early Cambrian or latest Marinoan in age. It has not been seen in contact with the Punkerri Sandstone because its lowest beds are covered by sand. On LINDSAY, just south of Wright Hill, is a very poorly outcropping shale (personal communication, B. Daily, University of Adelaide, 1968) which is equated with the Wirrildar Beds because of its stratigraphic position. 21 kilometres southwest of Wright Hill is a sequence of poorly outcropping red siltstone, pink feldspathic sandstone and a silicified conglomerate (or ?silcrete) which is tentatively correlated with the Wirrildar Beds.

Due to lack of information about the upper and lower contacts of the Wirrildar Beds the age is in doubt. It may be latest Marinoan or early Cambrian ie.possible time equivalents of the Uratana Formation in the Flinders Ranges (see Daily, 1972).

The relationship of the Wirrildar Beds and the middle to late Cambrian Observatory Hill Beds (Wopfner, 1969) on GILES (and near Mount Johns on EVERARD) is not known. Their lithologies are broadly similar except that no cherts have, as yet, been seen in the Wirrildar Beds. The latter are folded on a close style similar to that of the Adelaide System sedimentary rocks (see BIRKSGATE map sheet) and therefore presumably folded at the same time, whereas the Observatory Hill Beds are flat lying on GILES and only gently folded on EVERARD where they overlie tightly folded Adelaidean rocks and are themselves overlain by the Cambro-Ordovician Mount Chandler Sandstone. On the bases of this stratigraphic relationship and the different fold styles, it is inferred that the times of deposition of the Wirrildar and Observatory Hill Beds were separated by a ?middle Cambrian episode of folding.

## PHANEROZOIC ROCKS

### 1. Palaeozoic - Mesozoic

#### (1) Mount Chandler Sandstone (Omc)

This is well exposed at the Purndu Hills and forms the most westerly known outcrop limit of the Munyarai Trough of the Officer

Basin (see Krieg, 1972a). The east-dipping sandstones contain abundant animal burrows of the Skolithos and Diplocraterion or Rhyzocorallium types. Because of these it is equated with the Pacoota Sandstone (Cambro-Ordovician, Wells et al., 1970, p.66) of the Amadeus Basin. An Ordovician age was inferred for the Mount Chandler Sandstone of the Indulkana Range (on northeast EVERARD) by Brown (1905) by correlation with similar rocks in the Northern Territory on the basis of similar trace fossil content.

This formation was informally named "Mount Chandler Quartzite" by Wilson (1952) after he had seen it in the Indulkana Range.

(2) Undifferentiated Palaeozoic - Mesozoic Sediments (P-M)

The southern and southeastern parts of LINDSAY, have low outcrops of white medium-grained sandstone and kaolinized feldspathic sandstone amongst the sand dunes and forming low cliffs on northwest Tanana. These sandstones dip at low angles ($0^{\circ}$-$10^{\circ}$). They are not seen in contact with any other rocks but the feldspathic sandstone southeast of the Purndu Hills has faint trend lines parallel to those of the Mount Chandler Sandstone of the Purndu Hills (photo-interpretation) and therefore are structurally conformable with them. They may also be stratigraphically conformable with them in which case they would probably be older than the sandstones on the southern three 1:63 360 sheet areas.

Trend lines of these sandstones on Murrakai, Wright and Tanana strike both parallel to, and perpendicular to, the Purndu Hills trend. This effect may be due to the (horizontal) sandstones overlapping the Mount Chandler Sandstone and then being gently warped. On the middle northern area of Murrakai and the southwestern area of Wright are strings of P-M outcrops oriented north-south approximately. These may indicate gentle north-south trending folds in the P-M sandstones in these areas.

These Palaeozoic-Mesozoic sandstones may correlate with the Wanna Beds, of the Officer Basin in Western Australia, which are described by van de Graaf (1971).

A sedimentary trough, the Munyarai Trough (Krieg, 1972a), trends northeast from the Purndu Hills (its position is shown by the negative gravity anomaly on EVERARD, see Fig. 4). The oldest outcropping formation on LINDSAY which was deposited in this trough is the Cambro-Ordovician Mount Chandler Sandstone. This is overlain by the undifferentiated Palaeozoic-Mesozoic sediments. The well, Munyarai No. 1, was drilled into the Munyarai Trough to a depth of 9 510 feet (2 900 metres) just east of Mulduri (Continental Oil Company of Australia Ltd., 1969). It apparently did not intersect the Mount Chandler Sandstone but penetrated sandstone and shale no older than Silurian but probably of Devonian age or younger (see Harris and Gilbert-Tomlinson, in Continental Oil Company of Australia Ltd., 1969). This sandstone and shale cannot be correlated with any of the surface rocks on LINDSAY (perhaps due to poor outcrops) but might suggest that the undifferentiated Palaeozoic-Mesozoic sediments might be, in part, of early Palaeozoic age.

(3) Boongar Sandstone (PMb) (Major, 1972f)

This rock is characteristically a clean, orange-coloured friable sandstone which is flat-bedded, at least 3 metres thick, and composed of fine to medium grained subrounded quartz grains. It commonly has horizontal and vertical hollow tubes which resemble worm burrows and trails but may be due to a solution effect. The origin of these tubes has not yet been determined satisfactorily.

The orange colour is probably a superficial weathering effect which has coated the grains with red iron-oxide. In thin sections this coating is not found in many of the grain contact areas suggesting that it was due to post depositional effects e.g. intermittent humidity in a desert environment (see Glennie, 1970, p.179). Cuttings from seismic shot holes along the Mount Davies to Emu track on WELLS are composed of similar looking sand except that it is white and may be unweathered sub-surface equivalents of the Boongar Sandstone. The type area is on the track on Boongar (Major, 1972f). Similar rocks were collected in 1955 by T.A. Barnes (see Ludbrook, 1966) on southeast Tanana. The outcrops shown on southwest Tanana and Murrakai have been taken to be Boongar Sandstone by photo-interpretation.

The sandstone was not seen in contact with any other rock-type. Being horizontal it is thought to be younger than the gently folded undifferentiated P-M sediments.

The presence of both unstrained and strained quartz grains as well as zircon and tourmaline suggests that there were two sources of sediment.

2. Tertiary

(1) Silcrete (Tsi)

No examples of solid silcrete has been seen on LINDSAY and no silcrete-capped buttes, mesas and plateaux are there although these landforms are well developed further east on EVERARD, ALBERGA, ABMINGA and WINTINNA. On LINDSAY the silcrete layer has been broken down to pebbles and cobbles which are seen capping low rises, underlain by very weathered acid basement rocks on northwest Perdinna.

(2) Ferruginous silcrete (Tfe/Tsi)

Elsewhere on LINDSAY the silcrete pebbles and cobbles have been ferruginized and are seen capping low rises, covered by mulga trees and witchetty shrubs (both Acacia sp.) amd underlain by weathered crystalline basement rocks and sediments. The origin of the dark red coloration which affects the outer parts of the pebbles, may be similar to desert varnish (see Glennie, 1970, p.19), or perhaps due to some other post-silcrete ferruginization process.

(3) Ferruginous granules and pebbles

These dark rounded pebbles are seen as veneers on sand flats and rises. They are composed of hematite, magnetite, quartz and possibly maghemite and have been derived from the weathering of fine-grained sedimentary rocks (Whitehead, 1970, Amdel Report MP3158-70). Areas covered by these pebbles are most commonly found in the southern parts of LINDSAY where the undifferentiated Palaeozoic-Mesozoic sediments outcrop. They have presumably been derived by the weathering of these sediments e.g. by ?Tertiary ferruginization. However, no weathering profiles have been seen in these sediments and the stratigraphic relationship of the ferruginous pebbles to other Tertiary-Quaternary units is not seen on LINDSAY.

3. Tertiary - Pleistocene

(1) Granule conglomerate

Underlying calcrete, on the western side of the Officer Creek, 20 kilometres north-northeast of Mount Bonyboninna, is a kaolinized granule arkosic conglomerate about 2/3 metre thick in a sequence as follows:

| thickness (metres) | |
|---|---|
| 0.6 | calcrete |
| 0.6 | granule conglomerate |
| 0.3 | lateritic material |
| | weathered acid crystalline basement. |

The extent of the calcrete in this area suggests that it has been derived from Mangatitja Limestone.

The conglomerate may have been deposited in sequence with, and just prior to, the deposition of the Limestone. The conglomerate was seen in one low scarp only and has not been represented on the map.

(2) Mangatitja Limestone (Major, 1972g)

On LINDSAY this is a sequence of limestone ?conformably underlain by clay and granule conglomerate. The limestone is hard, cream-coloured or rarely pink, chalcedonic and sometimes oolitic. It is widespread on LINDSAY, particularly in areas underlain by crystalline basement rocks.

On the edge of a claypan, 4.8 kilometres east-southeast of Gilby Hill (on Eterinna), 5 metres of limestone overlie weathered granitic basement rock. On the western side of Purndu Saltpan 1.6 metres of limestone overlie mottled green and red clay which may be a Pleistocene alluvial unit (personal communication, J.B. Firman, S.A.D.M., 1972). The top of the limestone is 12.5 metres above the floor of the Saltpan. Here, as well as having white chalcedony at the top, it also contains some small light brown granules of ?chalcedonic material.

Around the boundaries of Eterinna, Moolalpinna, Perdinna and Polkari a large area of limestone has northerly trending ridges. A ground reconnaissance did not reveal the causes of these ridges. They were a metre or so above the general sand level and the areas between the ridges were generally covered by sand and spinifex (*Triodia* sp.). In both ridges and valleys the limestone appeared to be the identical and one did not appear to be harder than the other.

The fossil content (stoneworts, ostracodes and gastropods) of similar limestone from MANN suggests that it was deposited in fresh or brackish water possibly in widespread shallow lakes (Ludbrook, 1965). Other than indicating a Cainozoic age, the fossils are not of biostratigraphic value. The origin of the chalcedony is not known - it may be primary or secondary (see Major, 1972g). Field evidence shows that the rock is younger than silcrete and laterite but older than the sand dunes. The deposition of a granule conglomerate may have preceeded the deposition of the limestone in some areas (see above).

The Mangatitja Limestone may have been deposited in shallow, widespread fresh or brackish water lakes during the late Tertiary to Pleistocene (Major, 1972g).

The Mangatitja Limestone is probably equivalent to the Mount Willoughby Limestone (Nichol, 1971) and to the Alberga Limestone on OODNADATTA (Freytag, et al., 1967). The Alberga Limestone is probably equivalent, at least in part, to the Etadunna Formation (personal communication, H. Wopfner, S.A.D.M., 1972. See Wopfner and Twidale, 1967, p.128). The age of the Etadunna Formation is not certain but it may be early Miocene (R.H. Tedford, DM.1430/70) or Miocene or younger (see Wopfner and Twidale, 1967, p.128).

4. Quaternary

(1) Calcrete

This usually consists of cream or light brown coloured rubbly calcareous material associated with the Mangatitja Limestone or with weathered acid basement rock. In the western parts of LINDSAY patches of grey calcrete are often seen with normal cream calcrete. Sometimes the cream calcrete consists of pebbles of cream calcrete recemented by cream calcrete as if there has been some reworking of the material (a similar situation is seen with the grey calcrete). The origin of the grey colour in the grey calcrete is not known. Analyses of samples of both types of calcrete (Amdel Report MP 3137/72) reveal only very small differences in their amounts of iron, carbonaceous carbon and manganese which would probably be the most likely elements to cause colour. On the eastern bank of the Officer Creek, 16 kilometres north-northeast of Mt. Bonyboninna, is a cliff 5 metres high composed of porous broken calcrete containing cobbles of pink calcrete. It is probably some form of reworked, recemented calcrete. Similar material is found further downstream on the banks of the Officer Creek on Cartoberinna (i.e. on EVERARD). The top of both these areas is flat (?due to sheet erosion by wind and/or water) and the sand dunes rest directly on this surface in these areas.

(2) Red clay sandy soil (Qrm) (Major, 1972h)

This is an unconsolidated red clay sandy soil which is homogeneous, with no known development of layering. It is composed of iron stained subrounded poorly-sorted quartz grains with opaques (magnetite) up to 5%, accessory feldspar, and rare accessories are tourmaline, zircon and carbonates. Clay (kaolinite and montmorillonite) occurs in accessory amounts as angular grains. Although all the grains are stained, no goethite or limonite were detected by X-ray diffraction (Stevenson, 1972, Amdel Report MP 3137/72) which suggests that they are probably amorphous.

In auger holes this material varies in depth from 4 metres to about 1 metre and is seen to overlie calcareous and ferruginous material which in turn may overlie weathered crystalline basement. It is not known whether the development of the calcareous and ferruginous material is related to the formation of the red soil or whether it is due to some other process either before or after the soil development.

The pH of the soil profile from the auger holes was determined using a wet dye technique devised by the C.S.I.R.O. Division of Soils in Adelaide (see Raupach and Tucker, 1959).

The pH of the surface is about 5.5 - 6.0 with a range between 4.5 to 6.0. If the hole bottomed in calcrete or soil containing calcrete pebbles the pH is 9.0 - 9.5 at the bottom. The pH of the intervening red soil varies from 5.5 to 7.0.

In the field Qrm is sufficiently compacted to walk on or drive over when dry. It is characterised by thick stands of mulga trees (*Acacia aneura*) growing on it and is typically developed on flat, gently undulating or gently sloping areas. In undulating areas the mulga trees grow in rows (between which is sparser vegetation) which follow the contours of the slopes and give a characteristic arcuate pattern on air-photographs (see Perry et al., 1962, Plate 7, Fig. 1). In areas of regular longitudinal sand dunes Qrm occupies the interdune areas and probably underlies most of the sand areas (Qrs) but where this covers Qrm to a depth of more than about 2 centimetres spinifex (*Triodia sp.*) becomes the dominant vegetation. The presence of dominant mulga on Qrm is probably related to availability of water. The poorly, sorted red clay sandy soil is better compacted (and would retain more water) than the loose sand of the sand spreads and dunes which are covered by spinifex which appears to be more tolerant to a drier substrate.

The genesis of Qrm is not known with any certainty. The unit may be a mantle of slightly clayey alluvial or residual sand, derived from underlying crystalline basement and sedimentary rocks. The red colour is due to iron oxides which probably originated from the weathering of amphiboles, micas, feldspars and magnetite from the basement rocks. Areas occupied by Qrm are shown on sheet 10 of the Atlas of Australian Soils (Northcote et al., 1968) are shown as being red earths (Gn 2.12) and red earthy sands (Uc 5.21) (see also Stace et al., 1968).

(3) Gypsum (Qrg)

This unit was seen in only one part of LINDSAY i.e. on the eastern side of the Purndu Saltpan where it forns a flat bed overlying the same green and red mottled clay as beneath the Mangatitja Limestone on the western side of the Saltpan. The salts in the saltpan are mainly gypsum and the Qrg is probably due to removal of this saltpan gypsum by westerly winds.

(4) Sand dunes and sand spreads (Qrs)

This is the most extensively developed surface Quaternary unit on LINDSAY and covers at least 80% of the map area. The dunes are longitudinal and can be up to 16 kilometres long, 6 metres high and 1.6 kilometres between crests. However, most of the dunes are shorter and closer than this and consist of several dunes of various lengths which join one another at various points along their lengths. These junctions point towards the downwind direction (Folk, 1971) (southeast or east) of the causal wind regime. The dunes and sand spreads are fixed by vegetation, mainly spinifex (Triodia sp.) and mulga (Acacia aneura), except for the crests which are often mobile. Most of the dunes are fairly symmetrical in cross-section but the mobile crests develop a steep northern avalanche face suggesting that the present prevailing winds come from a more southerly direction than those which formed the dunes.

LINDSAY can be divided into two areas each with dunes trending in a direction different from the other. The northern area has dunes trending southeast (and has a substrate of crystalline basement rocks) but the southern area has dunes trending easterly (and a substrate of sedimentary rocks). A similar situation is seen on BIRKSGATE and EVERARD but on MANN (Thomson et al., 1962) and WOODROFFE (Major et al., 1967), where the substrate is all crystalline basement the dunes trend southeast. The junction of the northwest and westerly causal wind regimes corresponds approximately with the junction between the Musgrave Block and the Officer Basin. This effect may be due to the disturbance and deflection of prevailing westerly winds by the mountain ranges and inselbergs of the Musgrave Block whereas the very low outcrops in the Officer Basin caused little disturbance to the winds.

The topography of the southern half of LINDSAY is gently undulating. From air-photographs and a low level aerial reconnaissance in 1966, it can be seen that the dunes on the crests of the undulations tend to be bigger, straighter and more widely separated than those in the troughs. This is assumed to be due to the wind being faster and having a more even flow over the crests than in the troughs.

The youngest deposits are the present-day alluvium, low angle slope deposits and the playa deposits.

(5) Alluvium (Qra)

Because of the almost total lack of drainage lines on LINDSAY most alluvium is found as sand in the bed of the Officer Creek and around saltpans and claypans which have more definite drainage lines into them.

(6) Low angle slope deposits (Qrt) are found around the more prominent outcrops, particularly those of the crystalline basement. The deposits are mainly coarse sand - granule size angular grains of quartz and feldspar.

(7) Playa deposits (Qrl) are the gypsum and halite of the Purndu Saltpan and the clay in other smaller claypans. The Purndu Saltpan has gypsum in it since probably before the development of the sand dunes because these are thought to overlie the gypsum unit (Qrg) which is seen on the eastern side of the Saltpan. This gypsum (Qrg) is thought to be due to wind removal of the gypsum in the Saltpan.

## STRUCTURE

The structures on LINDSAY appear to be fairly simple, due possibly to poor and scattered outcrops. Better exposure might have revealed more complex structure e.g. isoclinal folding, several periods of folding etc. The direction of strike of the layering of the crystalline basement is generally northeasterly which is the same as that seen over the rest of the Musgrave Block south of the Tomkinson-Mann-Musgrave Ranges (see Thomson, 1969, p.40). In the Lindsay Pile-Cartumooninna Hill area the strike is east-west.

At the Pindyin Hills the Pindyin Formation occupies the flanks of two eroded domes underlain by crystalline basement. In the North Pindyin Hills only the east flank of a north-northwest trending structure remains. The South Pindyin Hills are the northern half of an eroded dome which was probably circular in plan view. The structural conformity of the Pindyin Formation, Wright Hill Formation and the Punkerri Sandstone in the Pindyin Hills, Coffin Hill and Punkerri Hills areas (the latter two on Punkerri, BIRKSGATE) suggests that they were all folded at the same time by the up-doming of the basement (?faulting) in these areas. The ?Lower Cambrian Wirrildar Formation at Wright Hill appears to be structurally conformable with the Punkerri Sandstone there.

This suggests that this basement movement occurred in the middle to upper Cambrian. Its youngest time limit is probably determined by the flat-lying Kulyong Volcanics (Kulyong on BIRKSGATE) of Lower Ordovician age (Major and Teluk, 1967).

The Purndu Hills are composed of the Cambro-Ordovician Mount Chandler Sandstone. They are the westernmost known outcrop limit of the northeast trending Munyarai Trough of the Officer Basin (see Krieg, 1972b, Fig. 5). The trough is asymmetric with a steep northern flank (?faulted) and a gently sloping southern flank. It is thought to range in age from late Cambrian to Devonian (Wopfner, 1969a). Its depth exceeds 2 900 metres (9 510 feet) which was the total depth of the Munyarai No. 1 well which spudded into ?mid-Silurian to Permian sandstones and bottomed in Devonian sediments (Continental Oil Company of Australia, Ltd., 1969) apparently without having penetrated the Mount Chandler Sandstone. The general aeromagnetic depth to crystalline basement below the axis of the trough is approximately 4 500 metres (15 000 feet).

Munyarai No. 1 was drilled into the Munyarai structure (Krieg, 1972b) which is an east-west trending anticline on a horst block which is faulted along its northern and southern flanks. It is approximately 12 miles (19.2 kilometres) east-west and 5 miles (8.0 kilometres) north-south with a depth to seismic basement of 16 148 feet (4 926 metres) below surface. The western third of the structure is found on LINDSAY (Raitt and Bowman, 1967). The western known outcrop limit of the Munyarai Trough is the Mount Chandler Sandstone (at the Purndu Hills) which is overlain by undifferentiated Palaeozoic-Mesozoic sandstones and kaolinized feldspathic sandstone. (The Palaeozoic-Mesozoic rocks trend parallel to the Sandstone (i.e. north-easterly) but probably overlap them). On <u>Tanana</u> and northeast <u>Murrakai</u> trend lines swing from northeast to southeast suggesting a closure of the Trough in this area. However, the sediments here do not appear to be very different (photo interpretation) from those on southern <u>Murrakai</u> and <u>Tanana</u> which strike northeast. These may be younger Palaeozoic-Mesozoic sediments which overlap the main sedimentary fill of the Munyarai Trough.

At the northern end of the Purndu Hills, faulting has disrupted the Mount Chandler Sandstone. Because of the apparent shallow depth of cryptalline basement in this area (see Fig. 2), this disruption probably reflects faulting in the basement on the southern edge of the Musgrave Block in this area. The time of the faulting is unknown from direct evidence, but may be Devonian to Carboniferous. This age is based on the assumption that it is associated with the basement movements which resulted in the deposition of the feldspathic wackes and conglomerate of the Officer No. 1 Stratigraphic Well (see Fig. 1 and Krieg, 1967) and the Waitoona Beds (Krieg et al., 1972). The sediments in Officer No. 1 Well could not be dated but are probably younger than the Devonian sediments of Munyarai No. 1 Well. The Waitoona Beds are possibly lower Carboniferous.

## GEOLOGICAL HISTORY

The earliest geological history of LINDSAY is obscure due to widely scattered outcrops of acid gneisses and the lack of isotopic age determinations. The oldest rocks may be those of the amphibolite-granulite transition facies, and the amphibolite facies acid gneisses which include amphibolites (?originally basic dykes). Some of these were originally igneous rocks, others sedimentary while the precursors of others are unknown. This period of intrusion and metamorphism may have occurred in early Adelaidean time and the metamorphism impressed a general northeasterly strike onto the layered rocks. After this metamorphism the LINDSAY area was intruded by various granitic rocks the most important of which was the Ampeinna granite which may have solidified approximately 1 140 million years ago. The last known igneous intrusions were a series of basic dykes.

During Torrensian times the crystalline basement was uplifted eroded, weathered and submerged. This submergence resulted in the deposition of a sandstone/shale sequence (the Pindyin Beds) on the weathered basement. The Pindyin Beds were followed by the deposition of a ?siltstone, quartzite, oolitic limestone sequence (the Wright Hill Beds) which may have overlapped the Pindyin Beds onto basement. After the Wright Hill Beds there is no record of sedimentation for approximately 150 million years (all of the

Sturtian and most of Marinoan time) before the deposition of the latest Precambrian Punkerri Sandstone which has the impressions of soft-bodies marine animals. During the 150 million years hiatus there is evidence (on EVERARD) of Sturtian glaciation and deposition of sediments of the Umberatana Group.

The Punkerri Sandstone was followed in the latest Marinoan or early Cambrian by the Wirrildar Beds, a sequence of poorly outcropping siltstone and feldspathic sandstones. Sedimentation was probably interrupted in the middle Cambrian by an episode of folding (?due to basement faulting) which affected all the Precambrian and lower Cambrian sedimentary rocks. Deposition recommenced in the late Cambrian or early Ordovician with the downfaulting of the area south of the Musgrave Block to form the Officer Basin. The first sediments into the Basin formed the Mount Chandler Sandstone (with animal burrows) which appears to have been generally confined to a narrow trough, the Munyarai Trough, on LINDSAY and EVERARD. Other Palaeozoic - Mesozoic sediments (including Devonian shales) filled this trough and overlapped it to the west and southwest. Sedimentation was interrupted by a period of gentle folding. This was followed by further deposition (the Boongar Sandstone) which ceased with the advent of gentle uplift of an unknown (but probably pre-silcrete) age.

Long continued crustal stability in the Tertiary resulted in deep weathering and the development of silcrete. This has been broken up by further gentle uplift and by weathering in an arid climate which resulted in the coating of the silcrete with dark iron oxides.

In the late Tertiary to Pleistocene, slight crustal downwarping and a wetter climate resulted in widespread fresh or brackish water lakes in which were deposited mottled clays and arkose which were capped by a limestone which overlapped these clastics onto weathered crystalline basement. This sequence of clay, arkose and limestone is the Mangatitja Limestone.

Further gentle uplift resulted in the draining of these lakes and the incision of a drainage system (now relict) into the Limestone. The subsequent Quaternary deposits resulted from alternately wetter and drier climates. The red clay sandy soil may have been an alluvial or residual blanket deposit. It was followed by an arid windy period during which alluvium (derived from the Musgrave Block and Officer Basin during the previous wetter climates) and the red clay sandy soil was blown southeast and east to form the sand spreads and longitudinal dunes which cover so much of the area today. A somewhat wetter period in the Recent allowed the growth of vegetation, which has fixed the dunes, except for the mobile crests. The Officer Creek probably incised its present channel at this time. However, it is not known whether this was a new channel or a rejuvenated one which may have been first incised at the same time as the now relict drainage systems in the Mangatitja Limestone. Recent and present day deposits are minor alluvium, low angle slope deposits adjacent to outcrop and gypsum and clay in saltpans and claypans.

## ECONOMIC GEOLOGY

There are no known deposits of any economic mineral on LINDSAY. The only outcrop of any interest is Tarleecartagun Hill (southern <u>Perdinna</u>) where a glassy granular quartzite is found in association with basic and ?ultrabasic rocks of the granulite-facies. Some of these rocks have high nickel and chromium values. This association is similar to that found on <u>Kenmore</u> (ALBERGA) where S.A.D.M. is conducting a programme of nickel exploration (Barnes et al., 1971). So far only some copper and molybdenum mineralization has been located in diamond drill holes in intermediate and basic granulites on <u>Kenmore</u>.

In 1968 the Munyarai No. 1 well was drilled into the Munyarai Trough about 0.8 kilometres east of the eastern boundary of <u>Mulduri</u> (i.e. on <u>Munyarai</u>, EVERARD). This hole was dry but its total depth of 9 510 feet (2 900 metres) ended in possible Devonian sediments and provided useful sub-surface stratigraphic data (Continental Oil Company of Australia Ltd., 1969).

## GEOPHYSICAL SURVEYS

### 1. <u>Aeromagnetic Surveys</u>

The first aeromagnetic survey over LINDSAY was conducted by the Bureau of Mineral Resources in 1954 (Quilty and Goodeve, 1958). This survey was very much of a reconnaissance nature and no name was given to the area north of the Eucla Basin (this area is now known as the Officer Basin) where depths to magnetic basement of greater than 2 000 feet (600 metres) below surface were estimated. Between October 1964 and April 1965 Adastra Hunting Geophysics Pty. Ltd. flew an aeromagnetic survey for Exoil Pty. Ltd. over the Officer Basin area and covered the southern part of LINDSAY. (Steenland, 1965). The spacing of the flight lines (in groups of 3, with each group 16 kilometres apart) lends itself only to general interpretation but shows clearly a steep monocline (or fault) along the southern margin of the Musgrave Block. Figure 2 shows contours of depths to magnetic basement derived from this survey. Depths to magnetic basement of 16 000 feet (5 000 metres) below sea level are indicated in the south-west part of LINDSAY. Ground level in this area is about 400 metres a.s.l.

At the request of the S.A.D.M., the B.M.R. carried out two regional aeromagnetic surveys (1967 and 1969) which included the top six 1:63 360 sheet areas of LINDSAY (Fig. 2) i.e. were confined mainly to the Musgrave Block (Waller, 1968, Shelley and Downie, 1971). The trend lines in Fig. 2 have been interpreted by these authors from the aeromagnetic profiles. In these surveys the line spacing was 1.6 kilometres. The results have been reduced by S.A.D.M. to contour maps which show a general east-west magnetic trend but lesser development of a northeast trend which is the dominant structural trend on LINDSAY (and over the southern part of the Musgrave Block). The flight line spacing was too wide and some of the outcrops of basic dykes were missed. However, most of the main dykes have aeromagnetic anomalies associated with them which indicate that they extend further each way along strike than their present outcrop extent. Fig. 3 shows aeromagnetic trend lines interpreted from these contours by this author. The general trend is east-west and some trends on Fig. 3 are not indicated on Fig. 2. These differences in interpretation cannot be checked in the field due to the widely scattered nature of the outcrops and the intervening sand cover. In both cases the east-west trend lines may be due, in part, to the north-south flight lines which tend to introduce east-west bias into interpretations (personal communication, D. McPharlin, S.A.D.M., 1972).

The basic dyke at Moolalpinna Hill is well marked on both Fig. 2 and 3 by a negative anomaly, probably due to reversed magnetization (personal communication, Professor D. Boyd, University of Adelaide, 1972). The trend of the dyke at Cartumooninna Hill continued (with some interruptions) to the northeast and crosses into southeast WOODROFFE. On Fig. 3 a prominent east-west trend extends about 50 kilometres from west of Lindsay's Pile and continues south of Ampeinna Hills and on to northeast Eterinna. No rocks outcrop along this line and so its cause is not known - it may be a basic dyke or possibly a fault.

Lindsay Lineament

The trend of the basic dyke at Oonmooninna Hill continues to the northwest and to the southeast beyond the outcrop limits. The northwest trending gabbro dyke at Turner Hill does not appear to have any significant effect on the northeast orientated magnetic trends in that area.

2. Seismic Surveys

The first of these on LINDSAY was carried out in 1965-1966 for the Continental Oil Company of Australia Limited by Seismograph Service Limited using the vibroseis technique (Shorey, 1966) on NOORINNA, WELLS, BIRKSGATE and LINDSAY. The northern end of their No. 1 seismic track is found on southwest LINDSAY (see Fig. 1). The results show that the sediments in the northern part of the Officer Basin have steep southerly dips or are faulted. However, further south of the Block they are almost flat (Shorey, 1966, p.32-33).

In 1966, S.A.D.M. conducted a seismic and gravity survey for Exoil Pty. Ltd. north from Emu to the western side of Munyarai (EVERARD) near the Officer Creek (Moorcroft, 1967) (see also Fig. 1). This survey line (EO) did not go on to LINDSAY but was designed to cross a deep trough and an associated positive anomaly which was found on the Adastra Hunting Geophysics Pty. Ltd. aeromagnetic survey reported by Steenland, 1965. The trough and positive anomaly were confirmed by the S.A.D.M. survey which indicated a sedimentary section perhaps in excess of 19 000 feet (5 700 metres) in the trough (Moorcroft, 1967, p.63).

In 1967 Namco Geophysical Company conducted a combined seismic and gravity survey over this anomaly (the Munyarai structure, Krieg, 1972b) for the Continental Oil Co. of Aust. Ltd. The results indicated that the structure is an east-west trending anticline with a minimum area under closure of 40 square miles (104 square kilometres) and with a closure of approximately 2 000 feet (620 metres) (Raitt and Bowman, 1967). This structure extends westward onto LINDSAY (see Fig. 4). In 1968, a well, (Munyarai No. 1) was drilled by Continental Oil Co. of Aust. Ltd. into the Munyarai structure but did not find oil or gas (Continental Oil Company of Australia Ltd., 1969).

3. Gravity Surveys

The first gravity (and ground magnetometer) survey which included part of LINDSAY was conducted by S.A.D.M. in 1960 for Exoil Pty. Ltd. between Fisher (on the Transcontinental Railway Line) and Mount Davies (on MANN) (Mumme, 1963) (see Fig. 1). This survey confirmed the presence of a sedimentary basin between the Eucla Basin and the Musgrave Block. The presence of this basin (the Officer Basin) was suspected after the B.M.R. aeromagnetic survey in 1954 (Quilty and Goodeve, 1958).

Gravity profiles over the Munyarai structure in 1967 by Namco Geophysical Company agreed well with the seismic profiles of that survey to define the structure (Raitt and Bowman, 1967).

In 1970 a helicopter gravity survey was carried out for Murumba Oil N.L. in the North West Province and included the southern two-thirds of LINDSAY. In 1970 the remaining parts of LINDSAY were covered during a helicopter survey carried out for the Bureau of Mineral Resources and S.A.D.M. (Pettifer, 1971). Figure 4 is a modified version of part of a Bouguer gravity contour map of South Australia compiled by members of S.A.D.M. Seismic and Geophysical Sections (S.A.D.M. plan numbers 71-684 994.2 A, B, C and D) from the following: Nettleton (1970), Pettifer (1971), and S.A.D.M. plans 71-401 and 71-405. The main features of Figure 4 are the elongated gravity high areas of the Musgrave Block on the northern three 1:250 000 sheet areas (due, in part, to the basic rocks of the Giles Complex), the southern edge of the Musgrave Block along the northern parts of the three central sheet areas and the gravity lows of the northern Officer Basin on these three middle sheets. The approximate position of the Munyarai Trough is indicated by the negative anomaly on EVERARD (see Krieg, 1972a). The anomaly on which the Munyarai No. 1 well was drilled is well marked. The deepest parts of the area to the south of the Musgrave Block, and occupied, at least in part, by the Officer Basin, occur just to the south of the southern edge of the Block. This is indicated by gravity data (Mumme, 1963, Nettleton, 1970), aeromagnetic data (Steenland, 1965) and seismic data (Raitt and Bowman, 1967, Moorcroft, 1967). Depths (below sea level) in the order of 15 000 to 20 000 feet (4 600 to 6 000 metres) are indicated for troughs in this area by a regional aeromagnetic survey (Steenland, 1965, Sheet 1 and 3).

R.B. MAJOR
ASSISTANT SENIOR GEOLOGIST
REGIONAL MAPPING SECTION

RBM:FdeA
21.8.72

# BIBLIOGRAPHY

Arriens, P.A. and Lambert, I.B., 1969. On the age and strontium isotope geochemistry of granulite-facies rocks from the Fraser Range, Western Australia, and the Musgrave Ranges, Central Australia. Spec. Publs. Geol. Soc. Aust., 2:377-388.

Barnes, L.C., Conor, C.H. and Pain, A.M., 1971. Progress Report Nickel Exploration, Kenmore, ALBERGA. S.Aust. Dept. Mines RB.71/183 (unpublished).

Beadell, L., 1965. Too Long in the Bush. Rigby, Adelaide.

Beadell, L., 1967. Blast the Bush, Rigby, Adelaide.

Beadell, L., 1971. Bush Bashers, Rigby, Adelaide.

Black, J.M. and Rogers, R.S., 1960. Flora of South Australia, Part 1 (Second Edition). Government Printer, Adelaide.

Black, J.M., 1963. Flora of South Australia, Part 2 (Second Edition). Government Printer, Adelaide.

Black, J.M., 1952. Flora of South Australia, Part 3 (Second Edition). Government Printer, Adelaide.

Black, J.M. and Robertson, Enid, L., 1957. Flora of South Australia, Part 4 (Second Edition). Government Printer, Adelaide.

Boomsma, C.D., 1972. Native Trees of South Australia. Bull. S. Aust. Dept. Woods and Forests, No. 19.

Brown, H.Y.L., 1905. Report on Geological Explorations in the West and North-West of South Australia. Parl. Pap. S.Aust. No. 71.

Carruthers, J., 1892. Triangulation of North-West Portion of South Australia. Parl. Pap. S.Aust. No. 179.

Compston, W. and Nesbitt, R.W., 1967. Isotopic Age of the Tollu Volcanics, W.A. J. Geol. Soc. Aust., 14(2): 235-238.

Continental Oil Company of Australia Ltd., 1969. Munyarai No. 1, South Australia Stratigraphic Drilling Project. Well Completion Report (S.Aust. Dept. Mines open file Env. 979 - unpublished).

Daily, B., 1972. Discovery and Significance of Basal Cambrian Uratana Formation, Mount Scott Range, Flinders Ranges, South Australia. Search (in press).

Daniels, J.L., 1969. Explanatory Notes on the TALBOT 1:250 000 Geological Sheet, W.A. Record, Geol. Surv. W.Aust., No. 1969/14 (unpublished).

Eichler, Hj., 1965. Supplement to J.M. Blacks Flora of South Australia. Government Printer, Adelaide.

Folk, Robert L., 1971. Longitudinal dunes of the Northwestern Edge of the Simpson Desert, Northern Territory, Australia. 1. Geomorphology and grain size relationships. Sedimentology, 16(1/2): 5-54.

Forbes, B.G., 1969. Helicopter Geological Survey in the Officer and Eucla Basins: Preliminary Report, S.Aust. Dept. Mines RB.68/107 (unpublished).

Forbes, B.G., 1971. Stratigraphic Subdivision of the Pound Quartzite (Late Precambrian, South Australia). Trans. R. Soc. S.Aust. 95(4): 219-225.

Giles, E., 1874. Mr. E. Giles' Explorations, 1873-4. Parl. Pap. S. Aust. No. 215.

Giles, E., 1889. Australia Twice Traversed. London: Sampson Low, Worston, Searle and Rivington. Two Volumes. (Australiana Facsimile Edition No. 13, Libraries Board of South Australia).

Glaessner, M.F., 1966. Pre Cambrian Palaeontology. Earth - Science Reviews, 1(1): 29-50.

Glaessner, Martin F., Preiss, Wolfgang V., and Walter, Malcolm R., 1969. Precambrian Columnar Stromatolites in Australia: Morphological and Stratigraphic Analysis. Science, 164: 1056-1058.

Glennie, K.W., 1970. Desert Sedimentary Environments. Developments in Sedimentology, Volume 14. Elsevier Publishing Company, Amsterdam, 222 pp.

Graaf, van de, W.J.E., 1971. The Wanna Beds - an Analogue of Recent North Sea Sediments. Ann. Rept. Geol. Surv. W. Aust., 1971 (in press).

Grasso, R., 1965a. The photogeology of part of the O.E.L. 28 area. Fitzpatrick, Johnson and Associates for Exoil Pty. Ltd. (S. Aust. Dept. Mines open file Env. 453 - unpublished).

Grasso, R., 1965b. Reconnaissance Geological Survey of part of O.E.L. 28 area. Fitzpatrick, Johnson and Associates for Exoil Pty.Ltd. and Continental Oil Company of Australia Ltd. (S.Aust. Dept. Mines close file Env. 1290 - unpublished).

Henderson, S.W. and Tauer, R.W., 1967. Birksgate No. 1 Well, South Australia. Stratigraphic Drilling Project. Well Completion Report. Continental Oil Company of Australia Ltd. (S. Aust. Dept. Mines open file, Env. 768 - unpublished).

Hilliard, Winifred, M., 1968. The People In Between - the Pitjantjatjara People of Ernabella. Hodder and Stoughton Ltd., 253 pp.

Hoffman, H.J., 1971. Precambrian Fossils, Pseudofossils and Problematica in Canada. Bull. Geol. Surv. Canada, No. 189.

Hubbe, S.G., 1897. Stock Route Expedition from South to West Australia. Parl. Pap. S.Aust., No. 51.

Jack, R.Lockhart, 1915. The Geology and Prospects of the Region to the south of the Musgrave Ranges, and the Geology of the Western Portion of the Great Australian Artesian Basin. Bull. Geol. Surv. S.Aust., No. 5.

Johnson, J.E., 1963. Basal Sediments of the North side of the Officer Basin. Quart. Geol. Notes, Geol. Surv. S.Aust., No. 7.

Johnson, W., 1965. Geological Reconnaissance of the Officer Basin (O.E.L. 28). Fitzpatrick, Johnson and Associates for Exoil Pty. Ltd. (unpublished).

Krieg, G.W., 1966. Report on Officer Basin Geological Reconnaissance S.Aust. Dept. Mines, RB.63/61 (unpublished).

Krieg, G.W., 1967. Continental Stratigraphic Well, Officer No. 1 Well Completion Summary for Continental Oil Company of Australia Ltd. S. Aust. Dept. Mines, RB.744 (unpublished).

Krieg, G.W., 1968a. Progress Report on the Geology of the EVERARD 1:250 000 sheet area. Part I, Post-Adelaide System. Geol. Surv. S.Aust. RB.66/92 (unpublished).

Krieg, G.W., 1968b. Progress Report on the Geology of the EVERARD 1:250 000 sheet area. Part II, Precambrian. South Aust. Dept. Mines, RB.67/37 (unpublished).

Krieg, G.W., 1969. Geological Developments in the Eastern Officer Basin of South Australia. The APEA Journal 1969, 9(3): 8-13.

Krieg, G.W., 1971. Comments on NOORINNA, WYOLA, MAURICE 1:250 000 Geological Sheets. S.Aust. Dept. Mines, RB.71/4 (unpublished).

Krieg, G.W., 1972a. The Ammaroodinna Inlier. Quart. Geol. Notes, Geol. Surv. S.Aust., No. 41.

Krieg, G.W., 1972b. Explanatory Notes for the EVERARD 1:250 000 Geological Map. S. Aust. Dept. Mines, RB.72/121 (unpublished).

Krieg, G.W. and Major, R.B., 1972. EVERARD map sheet, Geological Atlas of South Australia, 1:250 000 series, Geol. Surv. S.Aust.

Lindsay, D., 1893. Journal of the Elder Scientific Exploring Expedition 1891-92. Govt. Printer, Adelaide.

Lowry, D.C., Jackson, M.J., van de Graaf, W.J.E., and Kennewell, P.J., Preliminary results of Geological Mapping in the Officer Basin, Western Australia, 1971. Annual Rept., Geol. Surv. W.Aust., 1971 (in press).

Ludbrook, N.H., 1965. S.Aust. Dept. Mines, Pal. Rept. F67/65 (unpublished).

Ludbrook, N.H., 1966. Rock Specimens from the Officer Basin, South Australia, west of Longitude 133°30'. S. Aust. Dept. Mines, Rept. Bk. No. 62/87 (unpublished).

Major, R.B., 1968. Preliminary Notes on the Geology of the BIRKSGATE 1:250 000 sheet area, S.Aust. Dept. Mines, RB.66/122 (unpublished).

Major, R.B., 1971. Explanatory Notes for the WOODROFFE 1:250 000 Geological Map. S.Aust. Dept. Mines, RB.71/80 (unpublished).

Major, R.B., 1972a. The Pindyin Beds. Quart. Geol. Notes, Geol. Surv. S.Aust. (in preparation).

Major, R.B., 1972b. The Wright Hill Beds. Quart. Geol. Notes, Geol. Surv. S.Aust. (in preparation).

Major, R.B., 1972c. The Chambers Bluff Tillite. Quart. Geol. Notes, Geol. Surv. S.Aust. (in preparation).

Major, R.B., 1972d. The Punkerri Sandstone. Quart. Geol. Notes, Geol. Surv. S.Aust. (in preparation).

Major, R.B., 1972e. The Wirrildar Beds. Quart. Geol. Notes, Geol. Surv. S.Aust. (in preparation).

Major, R.B., 1972f. The Boongar Sandstone. Quart. Geol. Notes, Geol. Surv. S.Aust. (in preparation).

Major, R.B., 1972g. The Mangatitja Limestone. Quart. Geol. Notes, Geol. Surv. S.Aust. (in preparation).

Major, R.B., 1972h. Red Sandy Soils, North West Province. Quart. Geol. Notes, Geol. Surv. S.Aust. (in preparation).

Major, R.B., 1973. Explanatory Notes for the BIRKSGATE 1:250 000 Geological Map. S.Aust. Dept. Mines (in preparation).

Major, R.B., Johnson, J.E., Leeson, B. and Mirams, R.C., 1967. WOODROFFE map sheet, Geological Atlas of South Australia, 1:250 000 series, Geol. Surv. S.Aust.

Major, R.B., Johnson, J.E. and Teluk, J.A., 1971. BIRKSGATE map sheet, Geological Atlas of South Australia, 1:250 000 series, Geol. Surv. S.Aust.

Major, R.B. and Teluk, J.A., 1967. The Kulyong Volcanics Quart. Geol. Notes, Geol. Surv. S.Aust., No. 22: 8-11.

Major, R.B. and Teluk, J.A., 1973. LINDSAY map sheet, Geological Atlas of South Australia, 1:250 000 series, Geol. Surv. S.Aust. (in preparation).

Mathieson, A.McL. and Wadsley, A.D., 1950. The crystal structure of cryptomelane, Am. Miner., 35 (1 & 2): 99-101.

McKenzie, K.G., 1959. A Geological Reconnaissance of the Woomera - Maralinga area. Exoil Pty. Ltd. (unpublished).

Milton, B.E. and Thornton, R.C.N., 1970. Discovery of a dense lower to middle Palaeozoic dolomite in the north-west Arckaringa Basin. Quart. Geol. Notes, Geol. Surv. S.Aust., 36: 10-15.

Moorcroft, E., 1967. Seismic Reflection, Refraction and Gravity Survey, Eastern Officer Basin, 1966. Min. Rev., Adelaide, 126: 58-66.

Morcombe, Michael and Morcombe, Irene, 1970. Wildflowers of the North and Centre. Periwinkle Books.

Mumme, I.A., 1963. Geophysical Survey of the Officer Basin, South Australia. Trans. R. Soc. S.Aust., 87: 119-122.

Nettleton, L.L., 1970. Eastern Officer Basin Helicopter Gravity Survey P.E.L. 10 and 11, South Australia by Geophysical Associates Pty. Ltd., for Murumba Oil N.L. (S.Aust. Dept. Mines open file 1196-unpublished).

Nichol, D., 1971. The Mount Willoughby Limestone. Quart. Geol. Notes, Geol. Surv. S.Aust., No. 39: 1-2.

Northcote, K.H., Isbell, R.F., Webb, A.A., Murtha, G.G., Churchwood, H.M. and Bettenay, E., 1968. Atlas of Australian Soils. C.S.I.R.O. and M.U.P., Melbourne.

Packham, G.H. and Webby, B.D., 1969. The geology of the Officer Basin in the EVERARD 1:250 000 map area. Murumba Oil N.L. (unpublished).

Perry, R.A., et al., 1962. General Report on Lands of the Alice Springs Area, Northern Territory, 1956-57. Comm. Sci. Ind. Res. Org. Aust., Land Research Series No. 6.

Pettifer, G., 1971. Preliminary Results from 1970 Gravity Survey, Area A, South Australia. Rec. Bur. Miner. Resour. Geol. Geophys. Aust. (in preparation).

Quilty, J.H. and Goodeve, P.E., 1958. Reconnaissance Airborne Magnetic Survey of the Eucla Basin, South Australia. Rec. Bur. Miner. Resour. Geol. Geophys. Aust. No. 1958/87.

Raitt, J.S. and Bowman, H.E., 1967. Final Report on the Eastern Officer Basin Seismic and Gravity Survey, O.E.L. 28, South Australia by Continental Oil Company of Australia Ltd. and Namco Geophysical Company. (S.Aust. Dept. Mines open file Env. 829 - unpublished).

Raupach, M. and Tucker, B.M., 1959. The field determination of soil reaction. J. Aust. Inst. Agric. Sci., 25(2): 129-133.

Shelley, E.P. and Downie, D.N., 1971. The MANN - WOODROFFE Aeromagnetic Survey, South Australia, 1969. Rec. Bur. Miner. Resour. Geol. Geophys. Aust., No. 1971/19.

Shiels, O.J., 1960. Report on a Geological Reconnaissance of the South Australian portion of The Officer Basin. Exoil Pty. Ltd. (S. Aust. Dept. Mines open file Env. 58 - unpublished).

Shiels, O.J., 1961. Report on the Petroleum Prospects of The Officer Basin in South Australia and Western Australia. Exoil Pty. Ltd. (S.Aust. Dept. Mines open file Env. 57 - unpublished).

Shorey, D.J., 1966. Serpentine Lakes Reconnaissance Seismic Survey by Seismograph Service Limited for Continental Oil Company of Australia Ltd. (S.Aust. Dept. Mines close file Env. 603 - unpublished).

Sprigg, R.C., Wilson, B. and Coats, R.P., 1959. ALBERGA map sheet, Geological Atlas of South Australia, 1:253 440 series, Geol. Surv. S.Aust.

Stace, H.C.T. et al., 1968. A Handbook of Australian Soils. Comm. Sci. Ind. Res. Org. Aust., 435 pp.

Steenland, N.C., 1965. Eastern Officer Basin O.E.L. 28, South Australia Aeromagnetic Survey by Adastra Hunting Geophysics Pty. Ltd. and Geophysical Associates Pty. Ltd. for Exoil Pty. Ltd. (S.Aust. Dept. Mines, open file Env. 527 - unpublished).

Streich, V., 1893. Geological Observations taken on the Sir Thomas Elder Expedition, 1891. Trans. R. Soc. S.Aust., 16(2): 74-115.

Terry, Michael, 1933. Untold Miles, London, 288 pp.

Thomson, B.P., 1967. Outline of geology on Southeast Musgrave Block, South Australia. Pre-aeromagnetic Survey Report. S.Aust. Dept. Mines, RB.64/120 (unpublished).

Thomson, B.P., 1969. Chapter 1: Precambrian Crystalline Basement. Chapter 2: Precambrian Basement Cover. The Adelaide System. In: L.W. Parkin (Editor), Handbook of South Australian Geology. Geological Survey of South Australia, Adelaide, 268 pp.

Thomson, B.P., 1970. A Review of the Precambrian and Lower Palaeozoic Tectonics of South Australia. Trans. R. Soc. S.Aust., 94: 193-221.

Thomson, B.P. and Major, R.B., 1968. Outline of geology of Western Musgrave Block, South Australia. Pre-aeromagnetic Survey Report. S.Aust. Dept. Mines, RB.66/124 (unpublished).

Thomson, B.P., Mirams, R.C. and Johnson, J.E., 1962. MANN map sheet, Geological Atlas of South Australia, 1:250 000 series, Geol. Surv. S.Aust.

Tindale, Norman B., 1940. Results of the Harvard-Adelaide Universities Anthropological Expedition, 1938-1939. Distribution of Australian Aboriginal Tribes: A Field Survey. Trans. R. Soc. S.Aust., 64(1): 140-231.

Waller, D.R., 1968. Musgrave Block Airborne Magnetic and Radiometric Survey South Australia, 1967. Rec. Bur. Miner. Resour. Geol. Geophys. Aust., No. 1968/51.

Walter, M.R., 1970. Stromatolites and the Biostratigraphy of the Australian Precambrian. Ph.D. Thesis, University of Adelaide (unpublished).

Wells, A.T., Forman, D.J., Ranford, L.C. and Cook, P.J., 1970. Geology of the Amadeus Basin, Central Australia. Bull. Bur. Miner. Resour. Geol. Geophys. Aust. No. 100.

Wilson, Allan F., 1952. Precambrian Tillites east of the Everard Ranges, North-Western, South Australia. Trans. R. Soc. S.Aust. 75: 160-163.

Wopfner, H., 1967. Some Observations on Cainozoic Land Surfaces in the Officer Basin. Quart. Geol. Notes, Geol. Surv. S.Aust., No.23.

Wopfner, H., 1969a. Depositional History and Tectonics of South Australian Sedimentary Basins. ECAFE Document I & NR/PR. 4/57. Also, Mineral Resour. Rev., S.Aust., 133: 32-50 (1972).

Wopfner, H., 1969b. Lithology and distribution of the Observatory Hill Beds, Eastern Officer Basin. Trans. R. Soc. S.Aust., 93: 169-185.

Wopfner, H. and Twidale, C.R., 1967. Geomorphological History of the Lake Eyre Basin. In: J.N. Jennings and J.A. Mabbutt (Editors), Landform Studies from Australia and New Guinea. A.N.U. Press, Canberra.

# APPENDIX I

## List of plants collected

| Names with Authors | Identified by | Herbarium | R.B. Major Field specimen number |
|---|---|---|---|
| *Acacia aneura* FvM.ex. Benth | AD | AD | R.B.M.94/66/Z4/605 |
| *Acacia kempeana* FvM.FvM. | R.B.M. | - | No specimen: field ident. |
| *Actinobole uliginosum* (Gray) Eichler | AD | AD | R.B.M.119/66 |
| *Aristida browniana* HENR | " | " | R.B.M.154/67/Z4/636 |
| *Arthrocnemum halocnemoides* NEES | " | " | R.B.M.102/66/Z4/65 |
| *Atriplex vesicaria* HEWARD ex. BENTH. | " | " | R.B.M.95/66/Z4/605 |
| " " " " | " | " | R.B.M.99/66/Z4/615 |
| *Bassia uniflora* (R.Br.) FvM. | " | " | R.B.M.100/66/Z4/615 |
| *Brachychiton gregorii* FvM. | R.B.M. | - | No specimen: field ident. |
| *Brunonia australis* SM | AD | AD | R.B.M.156/67/Z4/636 |
| *Calandrinia remota* BLACK | " | " | R.B.M.78/55/Z4/603 |
| *Cassia nemophila var platypoda* (R.Br.) BENTH | " | " | R.B.M.88/66/Z4/604 |
| *Cassia phyllodinea* R.Br. | " | " | R.B.M.108/66 |
| *Casuarina cristata* MIQ | " | " | R.B.M.93/66/Z4/605 |
| *Dodonaea cuneata* RUDGE | " | " | R.B.M.77/66/Z4/603 |
| *Dodonaea microzyga* FvM. | " | " | R.B.M.73/66/Z4/603 |
| " " " | " | " | R.B.M.90/66/Z4/604 |
| *Enneapogon polyphyllus* (DOMIN) BURBRIDGE | " | " | R.B.M.164/67/Z4/636 |
| *Eragrostis laniflora* BENTH. | " | " | R.B.M.161/67/Z4/636 |
| *Erodium crinitum* CAROLIN | " | " | R.B.M.120/66 |
| *Eucalyptus camaldulensis* DENHARDT | R.B.M. | - | No specimen: field indent; |

| | | | |
|---|---|---|---|
| *Eucalyptus concinna* MAID. & BLAKELY | R.B.M. | - | No specimen: field ident. |
| *Eucalyptus ewartiana* MAID. | " | - | No specimen: field ident. |
| *Eucalyptus oleosa* FvM. | C.D.E. | S.A.D.W.F. | R.B.M.79/66/Z4/604 |
| " " " | " | " | R.B.M.87/66/Z4/604 |
| " " " | " | " | R.B.M.97/66/Z4/615 |
| *Eucalyptus pyriformis* subsp. *youngiana* (FvM) C. BOOM. | R.B.M. | - | No specimen: field ident. |
| *Helichrysum cassinianum* GAUDICH | AD | AD | R.B.M.109/66 |
| *Helipterum cassinianum* GAUDICH. | " | " | R.B.M.76/66/Z4/603 |
| *Helipterum floribundum* A. CUNN. ex DC. | " | " | R.B.M.116/66 |
| *Helipterum stipitatum* (FvM) FvM. ex. BENTH | " | " | R.B.M.86/66/Z4/604 |
| " " " " " | " | " | R.B.M.113/66 |
| " " " " " | " | " | R.B.M.157/67/Z4/636 |
| *Helipterum tietkensii* FvM. | " | " | R.B.M.110/66 |
| *Kochia georgei* DIELS | " | " | R.B.M.96/66/Z4/605 |
| *Lepidium oxytrichum* SPRAGUE. | " | " | R.B.M.92/66/Z4/605 |
| *Menkea sphaerocarpa* FvM. | " | " | R.B.M.82/66/Z4/604 |
| " " " | " | " | R.B.M.107/66 |
| " " " | " | " | R.B.M.122/66 |
| *Menkea villosula* (FvM ex TATE) BLACK | " | " | R.B.M.118/66 |
| *Minuria leptophylla* DC. | " | " | R.B.M.112/66 |
| " " " | " | " | R.B.M.117/66 |
| " " " | " | " | R.B.M.121/66 |
| *Olearia subspicata* (HOOK.) BENTH. | " | " | R.B.M.85/66/Z4/604 |
| *Podolepis canescens* A. CUNN ex. DC. | AD | AD | R.B.M.75/66/Z4/603 |
| " " " | " | " | R.B.M.83/66/Z4/604 |
| *Ptilotus helipteroides* (FvM.) FvM. | " | " | R.B.M.111/66 |

| | | | |
|---|---|---|---|
| Senecio gregorii FvM. | AD | AD | R.B.M.101/66/Z4/615 |
| " " " | " | " | R.B.M.114/66 |
| Sida corrugata ) LINDL. var. angustifolia) BENTH. | " | " | R.B.M.158/67/Z4/636 |
| Sida trichopoda FvM. | " | " | R.B.M.159/67/Z4/636 |
| Stipa scabra LINDL. | " | " | R.B.M.91/66/Z4/604 |
| Swainsonia phacoides BENTH. | " | " | R.B.M.115/66 |
| " " | " | " | R.B.M.123/66 |
| Triodia irritans R.Br. | " | " | R.B.M.103/66/Z4/615 |
| " " " | " | " | R.B.M.150/66/Z4/602 |
| Triodia lanigera DOMIN | " | " | R.B.M.155/67/Z4/636 |
| Waitzia citrina (BENTH.) STEETZ | " | " | R.B.M.84/66/Z4/604 |
| Zygophyllum sp. )(LINDL) aff. Z.aurantiacum) (FvM.) | " | " | R.B.M.98/66/Z4/615 |

Abbreviations used in Appendix I.

| | |
|---|---|
| A. CUNN. | A. Cunningham |
| AD | State Herbarium of South Australia, Adelaide. |
| BENTH. | Bentham, G. |
| C. BOOM | C.D. Boomsma |
| C.D.B. | C.D. Boomsma |
| DC | de Candolle, A.P. |
| DOMIN | Domin, K. |
| FvM | F. von Mueller, Baron |
| GAUDICH | Gaudichaud, C. |
| HENR. | Henrard, J. Th. |
| HOOK. | Hooker, Sir W.J. |
| LINDL. | Lindley, J. |
| MAID. | Maiden, J.H. |
| MIQ | Miquel, F.A.W. |
| R.B.M. | R.B. Major |
| R.Br | Robert Brown |
| S.A.D.W.F. | South Australian Department of Woods and Forests |
| SM. | Smith, Sir, J.E. |

## TABLE 1. PHANEIOZOIC STRATIGRAPHY AND TECTONIC SEQUENCE

(a)

| AGE | | ROCK UNIT | LETTER SYMBOL | THICK-NESS(m) | MINERALOGY AND LITHOLOGY | REMARKS |
|---|---|---|---|---|---|---|
| CAINOZOIC | RECENT | Playa deposits | Qrl | >0·6 | Gypsum and clay with subsurface saline water in Purndu Saltpan. Elsewhere claypans covered by clay and silt. | Salt deposits in the Purndu Saltpan have probably been there since before the development of the sand dunes. |
| | | Alluvium | Qra | | Sand | Mainly loose sand confined to the channel of the Officer Creek. |
| | | Very low angle slope deposits | Qrt | | Sand — to granule-sized angular grains of quartz and feldspar. | Around bases of acid crystalline basement outcrops and more prominent sedimentary outcrops. Due to both gravitational movement and sheet wash of fresh detritus. May include some alluvium. |
| | PLEISTOCENE TO RECENT | Sand dunes and sand spreads | Qrs | | Pale yellow to pale orange aeolian sand. Quartz, minor goethite, kaolinite and illite. | South-east and east-west trending longitudinal dunes. Fixed by vegetation. |
| | | Gypsum | Qrg | | Gypsum powder. | Soft gypsum powder with a hard gypsum capping which is found on the top of a ridge on the eastern side of Purndu Saltpan. Probably blown from Saltpan. Ridge is 12·5 metres above floor of Saltpan. Overlies green and red mottled clay. Probably overlain by sand dunes. |
| | | Red clay sandy soil | Qrm | >4·0 ⩽1·0 | Subrounded iron stained quartz, with magnetite. Accessory feldspar, clay, tourmaline, zircon and carbonate. | Usually has thick stands of mulga growing on it. Maximum and minimum depths and average thickness are not known. Overlies calcrete and ferruginous material whose relation to Qrm is not known. |

## TABLE 1. (continued)

(b)

| AGE | ROCK UNIT | LETTER SYMBOL | THICKNESS(m) | MINERALOGY AND LITHOLOGY | REMARKS |
|---|---|---|---|---|---|
| CAINOZOIC — PLEISTOCENE TO RECENT | Calcrete | Qca | | Rubbly calcareous material. | Occurs in two main situations 1) associated with MANGATITJA LIMESTONE and probably due to weathering of the limestone. 2) a veneer on subcropping weathered acid crystalline basement and WRIGHT HILL FORMATION. |
| | Gentle Upwarping | | | | |
| CAINOZOIC — TERTIARY TO PLEISTOCENE | MANGATITJA LIMESTONE | T–Q | ?0·6–?5·0 | Hard, cream coloured limestone which may be dolomitic, fossiliferous chalcedonized and oolitic. Includes conformably underlying sandy and clayey sediments. | Flat lying. Often capped by a layer of white chalcedony. Fossils of <u>Chara</u>, ostracodes and gastropods seen elsewhere in the carbonate. |
| | Gentle Downwarping | | | | |
| CAINOZOIC — TERTIARY | Ferruginous granules and pebbles | | Veneer on surface | Haematite, magnetite, ? maghaemite Altered mica, quartz and feldspar. | Found on sand flats and rises associated with ferruginized, weathered sedimentary rocks. Derived from fine-grained sedimentary rocks. |
| CAINOZOIC — TERTIARY | Ferruginized silcrete | Tfe/Tsi | Thick veneer | | Generally seen as a thick veneer of dark red brown pebbles on low rises (which are probably underlain by ? Palaeozoic — ? Mesozoic sediments). Derived from the breakdown and ferruginization of silcrete eg. ? desert varnish |
| | Upwarping | | | | |
| CAINOZOIC — TERTIARY | Silcrete pebbles and cobbles | Tsi | Thick veneer | | Generally seen as a thick veneer capping rises and overlying crystalline basement rock on north-west <u>Perdinna</u>. Broken down silcrete horizon. No buttes, mesas or plateaux. |
| | Deep weathering | | | | |

## TABLE 1. (continued)

(c)

| AGE | ROCK UNIT | LETTER SYMBOL | THICKNESS(m) | MINERALOGY AND LITHOLOGY | REMARKS |
|---|---|---|---|---|---|
| PALAEOZOIC — MESOZOIC | BOONGAR SANDSTONE | PMb | ≥3 | Clean orange coloured friable sandstone. Fine to medium grained subrounded quartz grains with coating of iron oxide. Minor zircon and tourmaline. Most quartz grains unstrained but some are strained. | Flat lying, thin bedded, minor cross-bedding. At least 3 metres thick. Rock breaks into slabs from 7–15 cm. thick. Characteristic vertical and horizontal tubes which resemble worm burrows. Probably due to ?solution effects related to silcrete or siliceous case hardening. |
| | Folding and unconformity | | | | |
| | | PM | | White medium grained kaolinized (?feldspathic) sandstone. | Shallow dipping, very thin bedded and flaggy. Generally very low outcrops amongst sand dunes. Forms cliffs 6 metres high in north-east Murrakai. |
| | ? Unconformity | | | | |
| | | | | Kaolinized feldspathic sandstone. | On the eastern sides of Purndu and Mulduri. Feldspathic sandstone may be conformable or paraconformable with the MOUNT CHANDLER SANDSTONE. |
| | ? Unconformity | | | | |
| | MOUNT CHANDLER SANDSTONE | Omc | ?>290 | White fine-grained sandstone or quartzite. | Thin bedded, cross bedded, some ripple marks. Lower third of sequence is characterized by infilled animal tubes both parallel to, and perpendicular to the bedding. The perpendicular tubes have both straight and U-shaped types. Top and bottom units not seen. |
| | Folding and unconformity | | | | |
| ?LATE MARINOAN-?EARLY CAMBRIAN | WIRRILDAR BEDS | €i | | Red brown siltstone, pink fine-grained feldspathic sandstone, silicified conglomerate (?silcrete). | Very poor and minor outcrops. Overlies PUNKERRI SANDSTONE but contact not seen. |
| | ? Conformable or ?paraconformable | | | | |

# TABLE 2. PRECAMBRIAN STRATIGRAPHY AND TECTONIC SEQUENCE

(a)

| AGE | ROCK UNIT | LETTER SYMBOL | THICKNESS(m) | MINERALOGY AND LITHOLOGY | REMARKS |
|---|---|---|---|---|---|
| ADELAIDEAN — MARINOAN | PUNKERRI SANDSTONE | Ewk | 400 | Mainly pink fine to medium-grained feldspathic (kaolinized) sandstone and quartzite with interbedded red brown micaceous shale. | Thin to very thin bedded, flaggy. Cross-bedding (some overfolded foresets), ripple marks, casts of shale pebbles, load structures due to heavy mineral laminae, various sole markings, ?trilobite marks, ?halite casts. Top and bottom units not seen. Equivalent to the POUND QUARTZITE. |
| | Unconformity | | | | |
| ADELAIDEAN — TORRENSIAN | WRIGHT HILL BEDS | Ebg | >3400 | Siltstone, quartzite, sandstone, ?limestone, black oolitic chert. | Most of sequence does not outcrop and is therefore assumed to be a soft sediment such as siltstone or shale. Quartzites outcrop as ridges—may have feldspar, cross-bedding, bedding lineation, ripple marks or bedding planes covered by well rounded quartz granules. Top and bottom units not seen. Type section at Wright Hill. Contact with PINDYIN BEDS not seen. |
| ADELAIDEAN — TORRENSIAN | PINDYIN BEDS | Ebp | ?>430 | >230m – ??arkose. White or very pale green kaolinized shale with minor chert, limestone and dolomite (?all lenticular). 200m – medium to coarse-grained sandstone and quartzite (± feldspar). Basal pebble conglomerate. | Top not seen. Kaolinized shale may belong to base of WRIGHT HILL FORMATION. Sandstone : thin bedded, cross-bedded, ripple marked, bedding lineation, rare shale pebbles, ? "mud cracks" on bedding planes. Nonconformably overlies weathered biotite granitic rock and pegmatite. |
| | Uplift of crystalline basement emergence, weathering, submergence. | | | | |
| | Basic dykes | | | Gabbro, micro-gabbro (dolerite), norite and troctolitic rock. Most contain olivine. Main minerals : labradorite (or bytownite) + clinopyroxene (augite ± pigeonite) | Intrude all other rocks of the crystalline basement but not the sedimentary rocks. Main dyke trends are NW, NNW, WNW, ENE and NS. At least three different ages of intrusion but age relations generally unknown |

TABLE 2. (continued)

(b)

| AGE | ROCK UNIT | LETTER SYMBOL | THICK-NESS(m) | MINERALOGY AND LITHOLOGY | REMARKS |
|---|---|---|---|---|---|
| | Basic dykes (continued) | | | ± orthopyroxene ± olivine (forsterite) + opaque (magnetite, pyrite). Minor minerals: ± hornblende ± biotite ± orthoclase ± quartz ± apatite. | except at Cartumooninna Hill where the ENE dyke intrudes the NNW dyke. Troctolite seen only at Mingeemealinna Hill. |
| ?1140my | AMPEINNA GRANITE | | | Main minerals: microcline + quartz + oligoclase + brown biotite + green hornblende. Accessory minerals: opaque + zircon + apatite + allanite ± muscovite ± sphene. | Equivalent to the ILLBILLIE ADAMELLITE on EVERARD. Light coloured medium to very-coarse grained massive porphyritic biotite granite with allanite as a characteristic accessory mineral. Euhedral microcline phenocrysts up to 5 cm. long. Outcrops at and around Ampeinna Hills and Oompeinna Hill have rounded xenoliths of a dark biotite dioritic rock. Relationships to other acid basement rocks not seen. |
| | Leuco adamellite and granite | | | Main minerals: microcline (or orthoclase) + oligoclase + quartz + biotite ± muscovite. Accessory minerals: apatite + zircon + opaque + epidote ± sphene. | Pale pink coloured medium-grained equi-granular massive or slightly foliated adamellite or granite. Generally have only minor amounts of dark minerals. Relationships to other acid basement rocks not seen. |
| | Biotite granites | | | Various granitic rocks. Main minerals: microcline + oligoclase + quartz + biotite ± muscovite ± opaques. Accessory minerals: ± allanite ± epidote ± apatite ± sphene ± zircon ± calcite ± fluorite. | Various fine to medium-grained pale grey granitic rocks. whose mutual relations are unknown. One allanite granite intruded by a meta-igneous leucocratic granitic gneiss. A light grey fine to medium-grained biotite adamellite intrudes granulite-facies rocks at Tarleecartagun Hill. Relationships to other acid basement rocks not seen. |
| | Igneous gneisses | | | Adamellitic. Main minerals: quartz + andesine (or oligoclase) + microcline + green-brown biotite. | Medium-grained light coloured biotite adamellitic gneisses. Layering is due to thin laminae of biotite in a groundmass of felsic |

## TABLE 2. (continued)

(c)

| AGE | ROCK UNIT | LETTER SYMBOL | THICK-NESS(m) | MINERALOGY AND LITHOLOGY | REMARKS |
|---|---|---|---|---|---|
| ?LATE CARPENTARIAN — EARLY ADELAIDEAN | Igneous gneisses (continued) | | | Accessory minerals: opaque+apatite +zircon±sphene±green hornblende | minerals. Petrographic examination suggests igneous nature of these rocks. |
| | Pegmatites<br>Amphibolite | | | Quartz and potassium feldspar.<br>Plagioclase and amphibole. | Minor intrusions into acid gneisses.<br>Probably metamorphosed basic dykes.eg at Gilby Hill and northern Purndu. |
| | Amphibolite-facies acid gneisses of meta-igneous origin. | | | Granitic and adamellitic.<br>Main minerals: microcline+quartz+ oligoclase+green-brown biotite± brown-green hornblende± muscovite+opaques.<br>Accessory minerals: ±apatite± zircon±epidote±sphene±allanite. | Generally medium-grained, dark coloured gneisses. Layering due to concentration of dark and light coloured minerals into separate laminae. May have feldspar porphyroblasts. Contains dark coloured xenoliths at Oonmooninna Hill. The allanite-bearing gneiss in northern Perdinna is light coloured as is the granofels in northern Purndu. Minor dark amphibolite layers. Contain both fresh and metamorphosed dolerite (amphibolite). |
| | Amphibolite-facies acid gneiss | | | Adamellitic and granitic.<br>Main minerals: microcline (some orthoclase)+oligoclase or andesine +quartz+brown biotite±hornblende ±muscovite.<br>Accessory minerals: opaques± apatite±zircon±sphene±epidote ±monazite±tourmaline±garnet ±clinopyroxene (relict) | Generally fine to medium-grained light coloured equigranular rocks although feldspar tends to be porphyritic in some outcrops. Layering is due to thin laminae of dark minerals in a groundmass of light minerals. Layering is generally straight but there is some ptygmatic folding. May be massive in a few small areas. Metamorphic rocks. Precursors unknown. Include some amphibolite lenses (eg. at Gilby Hill) which may have been basic dykes. Gneisses may be cometamorphic with the granulite-facies rocks. Some may be same as the amphibolite-facies gneisses of meta-igneous origin. Possible equivalent of the WATARU GNEISS (on BIRKSGATE) |

TABLE 2. (continued)

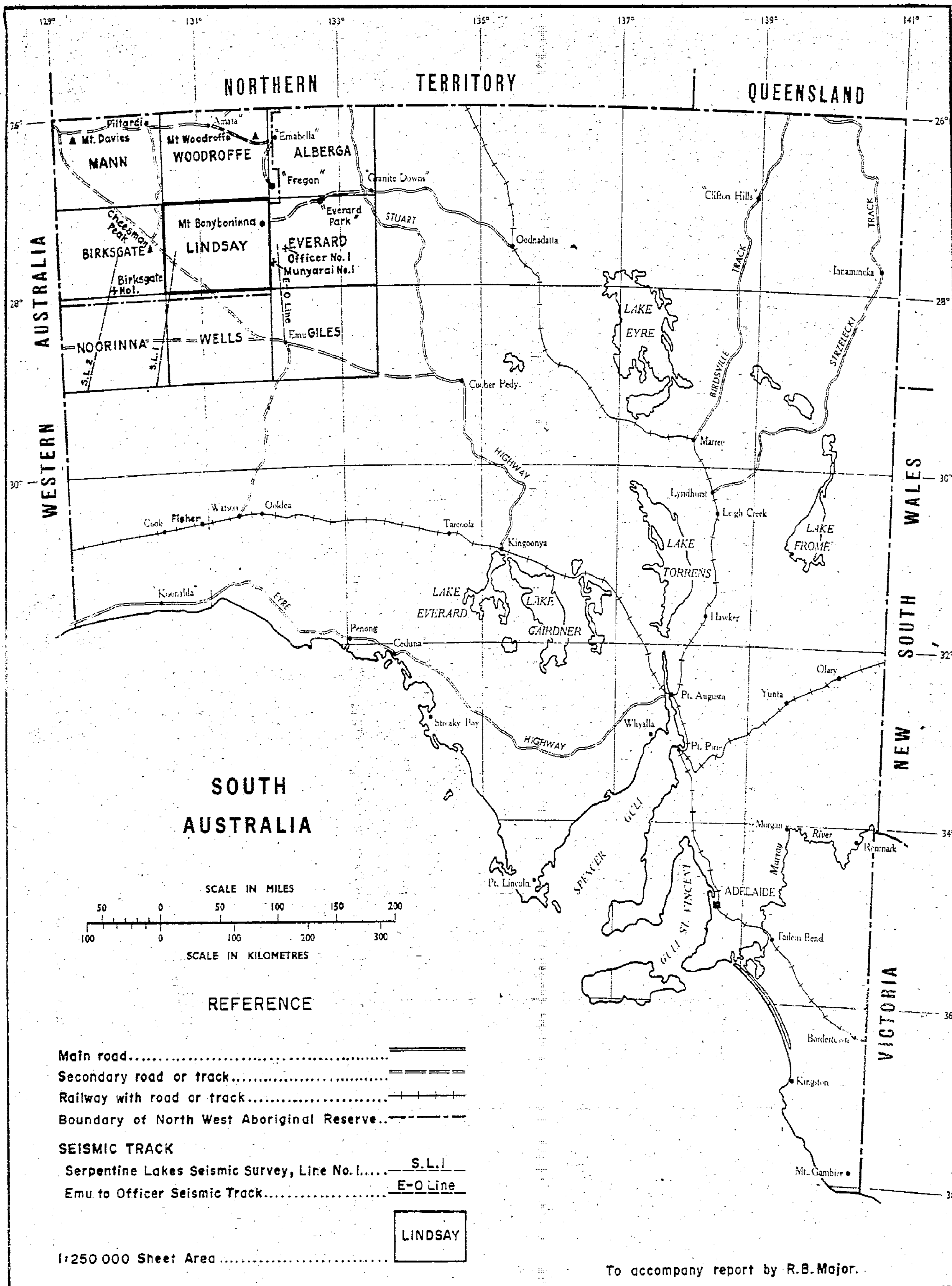
(b)

| AGE | ROCK UNIT | LETTER SYMBOL | THICK-NESS(m) | MINERALOGY AND LITHOLOGY | REMARKS |
|---|---|---|---|---|---|
| | Basic dykes (continued) | | | ± orthopyroxene ± olivine (forsterite) + opaque (magnetite, pyrite). Minor minerals: ± hornblende ± biotite ± orthoclase ± quartz ± apatite. | except at Cartumooninna Hill where the ENE dyke intrudes the NNW dyke. Troctolite seen only at Mingeemealinna Hill. |
| ?1140my | AMPEINNA GRANITE | | | Main minerals: microcline + quartz + oligoclase + brown biotite + green hornblende. Accessory minerals: opaque + zircon + apatite + allanite ± muscovite ± sphene. | Equivalent to the ILLBILLIE ADAMELLITE on EVERARD. Light coloured medium to very-coarse grained massive porphyritic biotite granite with allanite as a characteristic accessory mineral. Euhedral microcline phenocrysts up to 5 cm. long. Outcrops at and around Ampeinna Hills and Oompeinna Hill have rounded xenoliths of a dark biotite dioritic rock. Relationships to other acid basement rocks not seen. |
| | Leuco adamellite and granite | | | Main minerals: microcline (or orthoclase) + oligoclase + quartz + biotite ± muscovite. Accessory minerals: apatite + zircon + opaque + epidote ± sphene. | Pale pink coloured medium-grained equi-granular massive or slightly foliated adamellite or granite. Generally have only minor amounts of dark minerals. Relationships to other acid basement rocks not seen. |
| | Biotite granites | | | Various granitic rocks. Main minerals: microcline + oligoclase + quartz + biotite ± muscovite ± opaques. Accessory minerals: ± allanite ± epidote ± apatite ± sphene ± zircon ± calcite ± fluorite. | Various fine to medium-grained pale grey granitic rocks. whose mutual relations are unknown. One allanite granite intruded by a meta-igneous leucocratic granitic gneiss. A light grey fine to medium-grained biotite adamellite intrudes granulite-facies rocks at Tarleecartagun Hill. Relationships to other acid basement rocks not seen. |
| | Igneous gneisses | | | Adamellitic. Main minerals: quartz + andesine (or oligoclase) + microcline + green-brown biotite. | Medium-grained light coloured biotite adamellitic gneisses. Layering is due to thin laminae of biotite in a groundmass of felsic |

## TABLE 2. (continued)

(d)

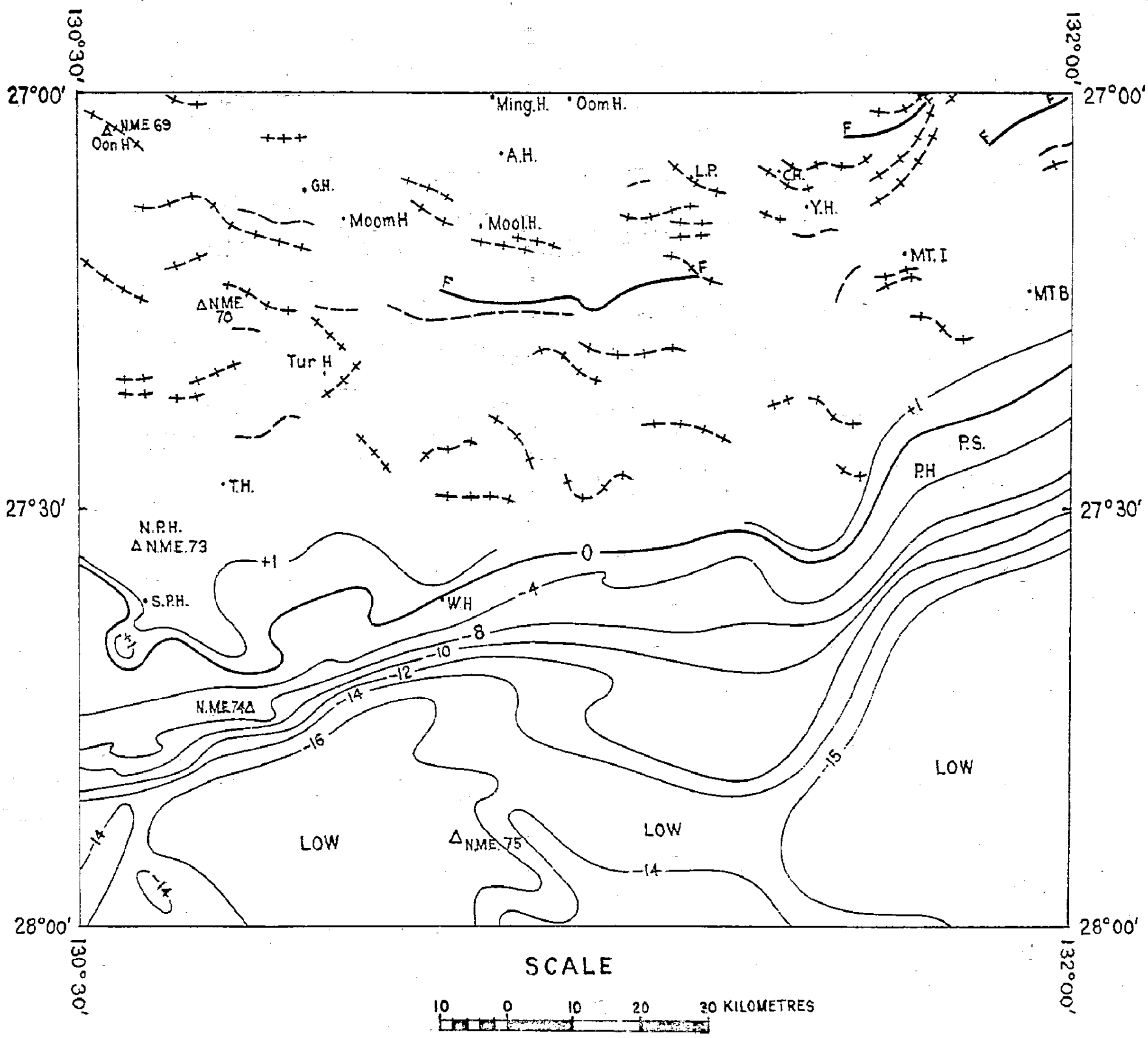
| AGE | ROCK UNIT | LETTER SYMBOL | THICK-NESS(m) | MINERALOGY AND LITHOLOGY | REMARKS |
|---|---|---|---|---|---|
| | | | | | None of these rocks are seen in contact with any other. |
| | Amphibolite/granulite transition facies. | | | Metasediments and basic ?meta-igneous rocks. Includes quartzite with clinopyroxene, hornblende-diopside granulite, amphibole-quartz rock, garnet-pyroxene-plagioclase-quartz rock, ?secondarily derived dolomitic and siliceous rocks. | Tarleecartagun Hill-composed of quartzite (metasediment) with the other rocks seen on the south-east margin. These other rocks are metasediments and mafic ?meta-igneous rocks. The dolomitic and siliceous rocks may be due to weathering of ?ultra-basic rocks. High nickel and chromium values obtained. Green hornblende, lack of orthopyroxene, and presence of sphene suggests upper amphibolite to ?lower granulite facies. |
| | | | | Granitic and adamellitic gneiss. Main minerals: orthoclase or microcline + plagioclase + quartz ± orthopyroxene ± clinopyroxene + opaques ± biotite ± amphibole. Accessory minerals: apatite + monazite ± allanite ± monazite. | Seen in the north-east of Eterinna. Amphibolite/granulite transition facies. Due to high grade metamorphism of acid igneous rocks. |




DEPARTMENT OF MINES —— SOUTH AUSTRALIA

| | | |
|---|---|---|
| Compiled. R.B.M. | LINDSAY 1:250 000<br>Explanatory Notes<br>LOCALITY MAP<br>FIG. 1 | Date: 20-4-72 |
| Drn. W.F.J. Ckd. | | Drg. No. S 9769 Aa+d |

F.F. No. 55850 994.2




NORTHERN AREA

Trend lines interpolated from aeromagnetic profile traces by Waller (1968, plate 6) and Shelley and Downie (1971, plate 5)

Magnetic trend positive.... + + +

Magnetic trend negative.... – – –

Interpreted fault............ F——F

SOUTHERN AREA

Contours of depth to magnetic basement drawn at the following values :-

| | | |
|---|---|---|
| +1 × 1000 feet | | |
| 0 | (Mean sea level) | |
| −4 " " " | | |
| −8 " " " | −14 × 1000 feet | |
| −10 " " " | −15 " " " | |
| −12 " " " | −16 " " " | |

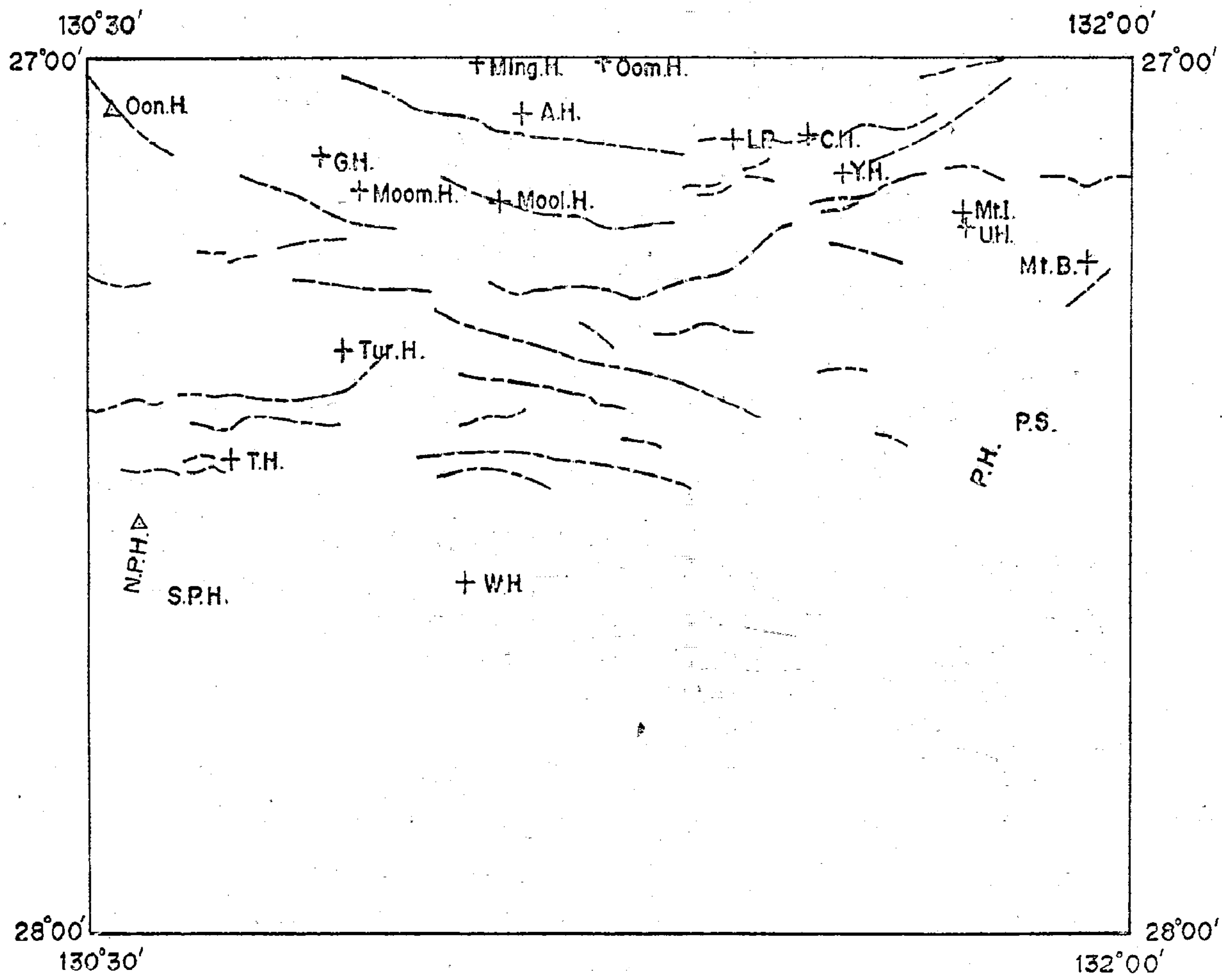
Ground level along Lat. S. 27°30' is approx 1300–1600 ft. above sea level

Reference - Steenland (1965)

To accompany report by R. B. Major.

| | | |
|---|---|---|
| | DEPARTMENT OF MINES – SOUTH AUSTRALIA | Scale: 1:1000 000 |
| Compiled: R.B.M. | LINDSAY 1:250 000<br>Explanatory Notes<br>GENERALISED AEROMAGNETIC DATA MAP<br>FIG. 2 | Date: 7-4-72 |
| Drn: A.S.F. \| Ckd. | | Drg. No. S 9756 Aa+d |

1M–2.70 A1810




Scale

Kilometres 10 0 10 20 30 Kilometres

| | |
|---|---|
| A.H.___ Ampeinna Hills | Oom. H.___ Oompeinna Hill |
| C.H.___ Cartumooninna Hill | Oon. H.___ Oonmooninna Hill |
| G.H.___ Gilby Hill | P. H.___ Purndu Hills |
| L.P.___ Lindsay Pile | P. S.___ Purndu Saltpan |
| Ming. H.__Mingoomoalinna Hill | S. P. H.___ South Pindyin Hills |
| Mool. H.__Moolalpinna Hill | T. H.___ Tarleecartagun Hill |
| Moom. H.__Moombunya Hill | Tur. H.___ Turner Hill |
| Mt. B.___ Mount Bonyboninna | U. H.___ Umberdidinna Hill |
| Mt. I.___ Mount Illillinna | W. H.___ Wright Hill |
| N.P. H.___ North Pindyin Hills | Y. H.___ Yelooginna Hill |

To accompany report by R. B. Major

DEPARTMENT OF MINES – SOUTH AUSTRALIA

Scale: 1:1000 000

Compiled: R.B.M.

LINDSAY 1:250000
Explanatory Notes
Trend lines derived from aeromagnetic contour maps compiled by S.A.D.M.
Fig. 3

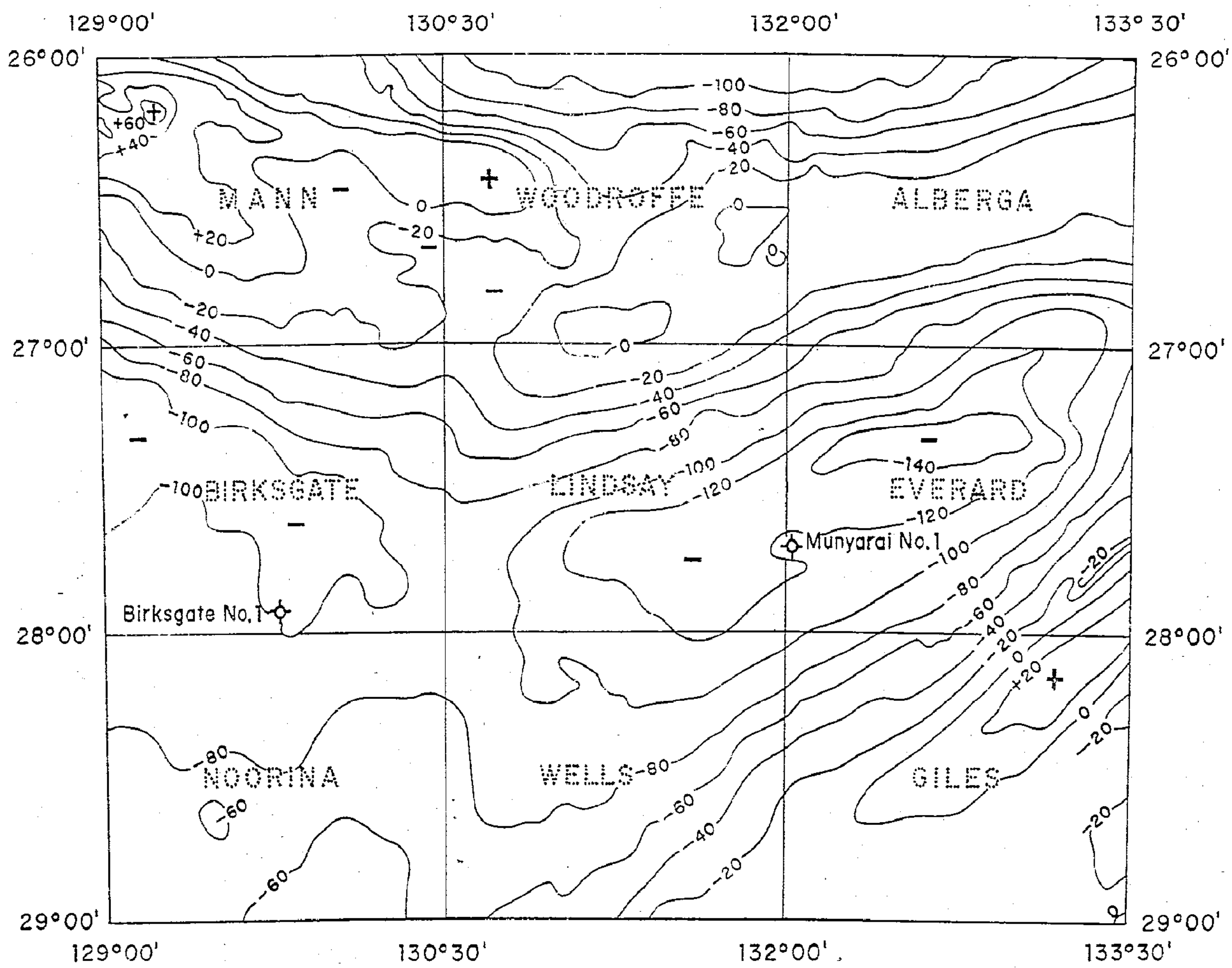
Date: 14 · 4 · 72

Drn. J.A.A. Ckd.

Drg. No. S 9766

Aa+d

1H–2.70 A1810




SCALE

KILOMETRES 50 0 50 100 150 KILOMETRES

REFERENCE

Bouguer Gravity Contours (Interval 20 milligals)
Position of maximum positive or negative gravity values ........ + −
Petroleum Exploration Well— Dry and abandoned

Modified from S.A.D.M. plan 71-684D, 994·2.

To accompany report by R.B. Major.

| | | |
|---|---|---|
| | DEPARTMENT OF MINES — SOUTH AUSTRALIA | Scale: 1:3,000,000 |
| Compiled: R.B.M. | LINDSAY 1:250,000 | Date: 25-5-72 |
| Drn. W.M. Ckd. | Explanatory Notes<br>Bouguer Gravity Contours<br>Fig.4 | Drg. No. S 9765<br>Aa+d |

1M–2.70 A1810