Rept. Bk. No. 63/135
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DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

REGIONAL SURVEYS DIVISION

GEOLOGY OF THE CULTANA
1:63,360 MAP AREA

by

A.R. Crawford
Geologist

and

B.G. Forbes
Senior Geologist
REGIONAL MAPPING SECTION

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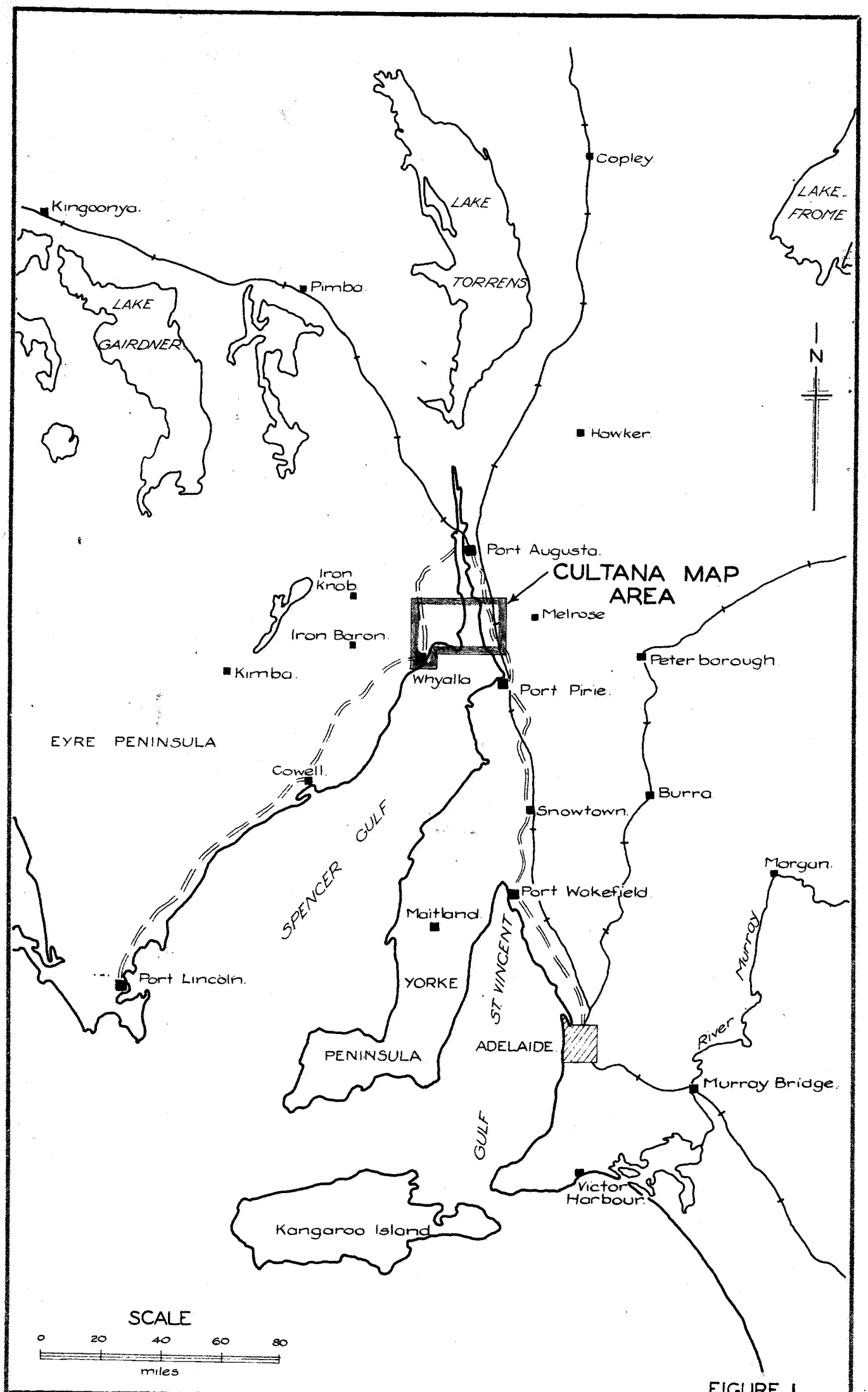
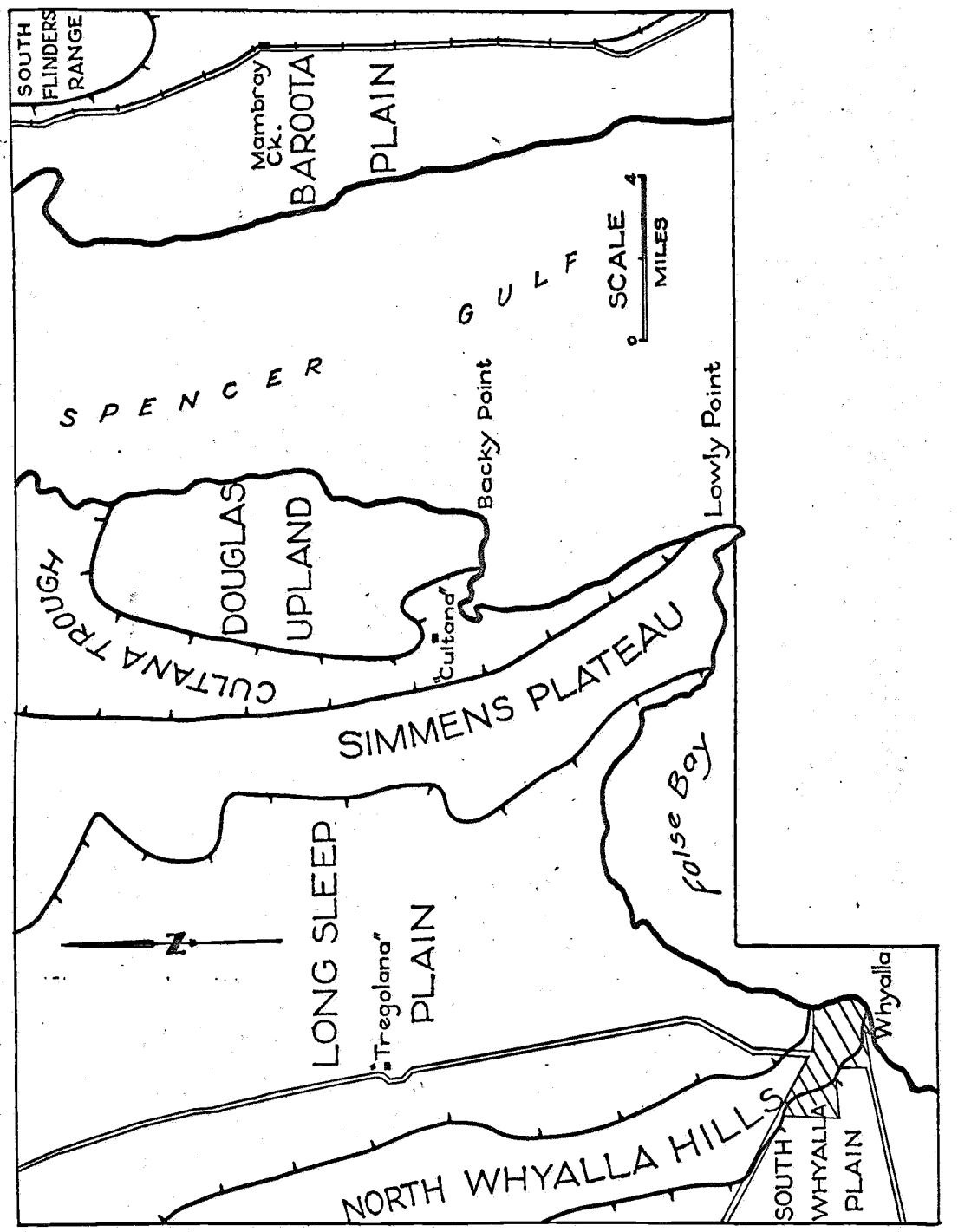


FIGURE 1

DEPARTMENT OF MINES — SOUTH AUSTRALIA

	Drn B.G.F	LOCATION OF CULTANA MAP AREA	SCALE : 1" = 40 miles
	Tcd A.M.C.D		S 5481 DE.
	Ckd. L.V.W.		
	Exd.		



Additional figure to accompany report by A.R. Crawford, B.G. Forbes Jan 1967

DEPARTMENT OF MINES — SOUTH AUSTRALIA

	Drn. BGF	GEOMORPHIC UNITS IN THE CULTANA 1:63,360 MAP AREA	SCALE: 4 miles to 1 inch
	Tcd. GM		S5666 DE
	Ckd. L.V.W.		
	Exd.		DATE: 7.2.67

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept. Bk. No. 63/135
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GEOLOGY OF THE CULTANA

1:63,360 MAP AREA

~~Hd. Cultana~~

ABSTRACT

The Cultana map area lies about 150 miles north-northeast of Adelaide and straddles the narrow northern arm of Spencer Gulf, South Australia. Along the western side of the area, which includes the industrial town of Whyalla, are exposures of steeply-folded dark sandstone of the Moonabie Formation (pre-Adelaide System lower Precambrian) overlain by the Pandurra Formation, reddish sandstone of possible Willouran (lower Adelaide System) age. These rocks are exposed again along the western shore of Spencer Gulf, where the Moonabie Formation is intruded by the Cultana Granite. Lavas considered to be equivalent to the Roopena Lava (about 1,450 million years old) are here interbedded with the Pandurra Formation.

Flat-lying quartzite of the Tent Hill Formation, which forms a prominent mesa west of Spencer Gulf, ~~are~~ is probably of Marinoan (upper Adelaide System) age and overlies the poorly-outcropping Tregolana Shale. These little-disturbed beds of the Stuart Stable Shelf contrast with their equivalent geosynclinal facies which appears as steeply-dipping quartzites and shales of the Wilpena and Umberatana Groups of the Adelaide System in the western edge of the Flinders Ranges, northeast corner of the map area. Much of the map area is covered by outwash, sand and swamp deposits.

INTRODUCTION

The Cultana one-mile sheet covers an area between Whyalla and Port Augusta, mostly lying west of the northern part of Spencer Gulf (Fig. 1). The city of Whyalla lies just beyond the southwest corner of the sheet and the area mapped has been extended to include the whole of the city. Much of the sheet is occupied by the shallow waters of Spencer Gulf. Part of the coastal plain east of the Gulf is included, with a smaller area of the southern Flinders Ranges.

Mapping has been done on Lands Department air photographs scale 1:47,320; M.N. Hiern mapped the area east of Spencer Gulf. The writer*, who mapped the western part of the area, is indebted to Major D.J. Galvin, Commander, Royal Engineers, Central Command for assistance in the field in June 1962 and for other help. Acknowledgement is also due to Messrs. J.E. Johnson and R.P. Coats who accompanied the writer on visits, and to Mr. P. Sweeney of Australian Mineral Development Laboratories for petrographic descriptions. Drafting was the work of Mr. Graham Willoughby. Photographs are by the author.

These notes are based largely on an original report produced in 1963 (Crawford, 1963c).

GEOGRAPHICAL INFORMATION

Topography

The land area is of varied relief but is divided into distinct regions. Of these, the most prominent is a tableland (Simmens Plateau) extending from north to south along the middle of the map. This varies in width but averages two to three miles, narrowing to a saddle in the centre of the map. Its flat upper surface is at about 900 feet above sea level in the north and over much of the Davenport sheet to the north on which Simmens Hill (912 feet) lies. Its upper surface is at about 600 feet in the centre, at 350-400 feet west of Cultana H.S., and declines almost to sea level towards Point Lowly at its southern extremity.

To the west of the Simmens plateau lies an extensive plain (Long Sleep Plain) to which it slopes very abruptly. Outwash fans and accumulated sand break the abruptness of the slope. This plain drains south to False Bay between Whyalla and Point Lowly.

The Whyalla-Port Augusta road traverses the plain. To the west lies low undulating country, the North Whyalla Hills.

FIG. 2 Mt. Laura summit composed of sandstone and conglomerate of the Pandurra Formation unconformably overlying steeply-dipping dark feldspathic quartzite of the Moonabie Formation, quarry face.

FIG. 3 Douglas Hills seen from the Simmens Plateau about 1½ miles west-southwest of Cultana H.S.

(substitute photo.)

Fig. 2. RANDELL 16181

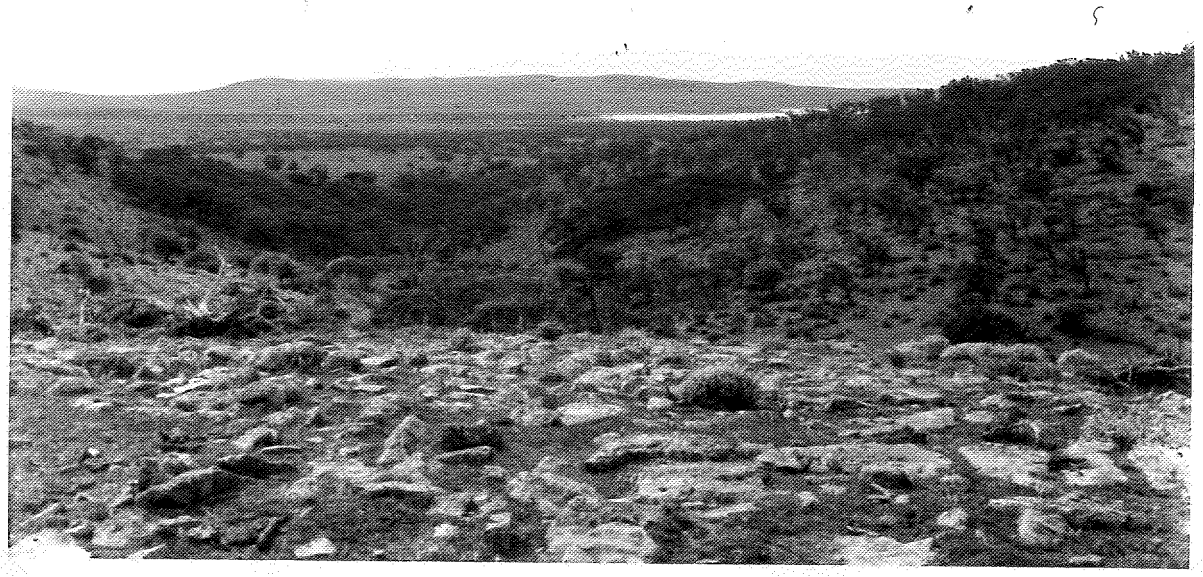

Fig. 3. CO YORK 16183

These extend south to Mount Laura (379 feet) (Fig. 2). Whyalla is built on a ridge which includes (from west to east) New Water Tank Hill, Old Water Tank Hill and Hummock Hill. A smaller hill lies north of Old Water Tank Hill, between the Iron Knob and Port Augusta roads.

South of Whyalla is another plain (South Whyalla Plain) which extends far beyond the boundaries of the sheet.

To the east of the Simmons Plateau, Cultana H.S. lies at the southern end of a lowland (The Cultana Trough) east of which is the Douglas Upland, an area of irregular hills which reach 630 feet in the north and 300-400 feet in the south (Fig. 3). The upland extends north from Fitzgerald Bay only for 8 miles, so that in the north the Cultana Trough widens out to a plain of less than 100 feet elevation, and a cliff gives way to a flat one.

East of Spencer Gulf the coastal plain (Baroota Plain) lies mostly below 100 feet, rising gradually from a low swampy coast to the outwash fans of the south Flinders Ranges, which form north-south ridges hereabouts.

The geomorphic units can therefore be listed, from west to east:

South Whyalla Plain (mostly off the map)
Whyalla Ridge
North Whyalla Hills
Long Sleep Plain
Simmons Plateau
Cultana Trough
Douglas Upland
(Spencer Gulf)
Baroota Plain
Southern Flinders Ranges

Climate

The climate of the area west of Spencer Gulf is semi-arid Average recorded rainfall varies between about 9 and 11 inches. Information for the east side of the Gulf is scanty but rainfall at Port Germein(1 mile south of the S.E. corner of the sheet) has averaged just over 12 inches.

Vegetation

The South Whyalla Plain and the western part of Long Sleep Plain is covered by a tree-steppe association, with myall, sandalwood and patches of mallee. Bluebush and saltbush are widespread. Mallee is dominant on the sandier country in the eastern part of Long Sleep Plain. Spinifex becomes dominant in the North Whyalla Hills and Douglas Upland. The Simmons Plateau is grassland.

The whole area excluding Whyalla and its industrial zone and the coastal swamps is used for sheep grazing, which has modified the natural vegetation.

Samphire and mangrove dominate the coastal flats east of Spencer Gulf, succeeded to the east by mallee and grassland on the sandy alluvium. The Flinders Ranges have wooded valleys with gums in the creeks. Spinifex is dominant on the bare slopes.

Human Geography

Excluding Whyalla the whole land area is sparsely inhabited, essentially by graziers. The area east of the Gulf has the closest settlement, on Barcoota Plain, with the very small townships of Barcoota and Nambray Creek and regularly scattered homesteads.

West of the Gulf four sheep stations only control

several hundred square miles and the head stations of two of these (Tregolana and Cultana) lie within the sheet boundaries. The other two, Lincoln Park and Koopena, lie beyond to the north and west respectively.

Whyalla is a new and rapidly expanding town. It owes its settlement as a port for the export of iron ore brought from Iron Knob by a railway constructed in 1901, at which time it was known as Hummock (or Hummocky) Hill. The subsequent building of an iron works and a shipyard on the low ground to the north of Hummock Hill led to further growth, particularly during and after the second World War. The construction of a steelworks and other expansion now in progress means inevitable further physical expansion of the industrial area north and northwest, and of the residential area westwards and southwestwards. The estimate of population for 1964 is approximately 18,000. The city has a direct air service with Adelaide and lies on the main Adelaide-Port Lincoln road, but no connection to the State railway system yet exists.

PREVIOUS GEOLOGICAL WORK

No previous geological work has been done in the area as a whole and scarcely any published information exists for the greater part of it.

Area west of Spencer Gulf

Lockhart Jack (1914) noted a boulder bed on the seaward side of Hummock Hill and correlated it with the rocks forming Mount Young (8 miles southwest) and the Moonabie Range (30 miles southwest). He raised the question of this being a tillite. His attitude to the rocks of the main mass of Hummock Hill is un-

certain, but he recognised the existence of definite Precambrian rocks further west.

L.K. Ward visited Whyalla with Professor Sir Edgeworth David in 1921 and compared the 'conglomerates of Hummock Hill' (i.e. the boulder bed of Jack) with those of Mount Young and Corunna (35 miles northwest), following Jack in regarding them all as part of the Tent Hill formation (unpublished notebooks of Ward).

R.W. Segnit (1939) briefly described Mount Laura and Hummock Hill, correctly separating the coarse boulder bed at the latter locality from the much less conglomeratic rocks of the main hill mass by an unconformity. It is evident from his notebooks that he first regarded the boulder bed as tillitic but in his published account he firmly disagrees with such an interpretation.

K.R. Miles (1955) and others mapped four one-mile sheets covering the Middleback Ranges and extended the mapping eastward, on the four-mile scale, to include Whyalla and a strip northward to Lincoln Gap. Brief reference is made in the text to the geology of the Mt. Laura-Whyalla area. The boulder bed at Hummock Hill is not mentioned. Miles regarded the main mass of Hummock Hill, the Whyalla ridge and the lower part of Mount Laura as Proterozoic. The capping of Mount Laura and of New Water Tank Hill he regarded as Cambrian, and equivalent in age to the rocks of the Simmens Plateau.

Area east of Spencer Gulf

No study has been made of the lowland area apart from short unpublished reports by R.K. Johns (1962a, 1962b, 1962c).

The geology of the small area of the southern Flinders Ranges which lies within the sheet boundaries is also poorly known, with no published information.

STRATIGRAPHY

Sedimentary Sequence

The outcropping sedimentary rocks of the area are divisible into four major time-rock units. Older Precambrian rocks may occur at relatively shallow depth. The four units are:

4 Quaternary

3 Tertiary

(angular unconformity)

2 Precambrian-Adelaide System

(angular unconformity)

1 Pre-Adelaide System: Moonabie Formation

The rocks of unit 3 are not mappable west of Spencer Gulf. They are rocks of older units altered by deep surface weathering processes during the Tertiary era, so that a thin capping should strictly be regarded as of that age. In this particular area these cappings are so rarely exposed that it is impracticable to represent them on the one-mile scale. The immediately underlying material is however important economically.

Oldest Precambrian Rocks

Oldest known Precambrian rocks do not outcrop on the Cultana sheet. Those outcropping extensively elsewhere in the Whyalla-Iron Knob-Cowell district probably occur at relatively shallow depth at least in the west. The oldest Precambrian rocks of Eyre Peninsula are divided into two main Groups. One, the Middleback Group (equivalent to the Hutchison Series of Johns,

1961) consists essentially of banded iron formations, quartzites, dolomites and schists. The other is a gneiss complex. These Eyre Peninsula Gneisses (equivalent to Johns's Flinders Gneiss) are older but not known to be separated by any angular unconformity from the Middleback Group. On structural grounds it is probable that any very old rocks underlying the area of the Cultana sheet are likely to be Eyre Peninsula Gneisses. Boulders and pebbles of rocks lithologically identical with those of the Middleback Group do however occur in the Moonabie Formation in the western part of the sheet.

Moonabie Formation

The Moonabie Formation forms part of the Whyalla Ridge and the lower part of Mount Laura. Outcrops do not exist in the central part of the sheet but the formation appears again in the Douglas Upland, where it is widely altered by thermal metamorphism and associated processes due to the intrusion of the Cultana Granite. No such large intrusion is known in the western outcrops but some feldspathization has occurred along the bedding. It should be noted that six miles west of the northwest corner of the sheet intrusions of Gawler Range Porphyry and a porphyritic granite into the Moonabie Formation rocks are known on the Koopena 1-mile sheet (Miles, Johns and Solomon, 1952).

The Moonabie Formation is commonly steeply dipping. It is arenaceous or argillaceous, indurated and dense, usually dark bluish grey in colour. It is characterised (more especially in the west) by the presence of pebbles and boulders of very varied sizes and provenance which are too common to be described as rare but are too few to form gravel layers indicating bedding. This feature in the past led to misidentification of the rocks

FIG. 4 Dark, fine-grained lithic sandstone of the Moonabie Formation in Hummock Hill quarry, Whyalla.

FIG. 5 Moonabie Formation lithic sandstone, partly manganiferous, in entrance to adit, Hummock Hill, Whyalla.

Fig. 4. RANDELL 16184

Fig. 5. RANDELL 16185

as tillites. It should be noted that further west, beyond the limits of the sheet, the pebble and boulder content increases so that they become largely or entirely rudaceous.

Of the western outcrops, the best exposures are at the quarries on the west slopes of Mount Laura, in the quarry on the east side of Hummock Hill, and in a quarry north of the railway and west of the Port Augusta road.

Dense dark grey arkosic quartzites are exposed at Mount Laura which in the main quarry (Fig. 2) are folded into an anticline along an east-west axis. Immediately southwards the beds are vertical or slightly overturned and here injection of feldspar along the bedding was noted. These beds rise into more massive and more gritty arkoses and lithic sandstones.

Half a mile east, similar rocks occur in a narrow disused kaolin quarry at the head of a gully on the south slope (described by Segnit, 1939, pp. 167-169) and are steeply dipping. The kaolin occurs as a weathered dyke intruded along the line of a fault. Slightly further east the rocks can be seen striking at 290°; they are vertical and can be followed along strike for half a mile.

At Hummock Hill a quarry in the upper part of the hill, above the B.H.P. railway siding, shows dense dark grey fine-grained lithic sandstone (Fig. 4). The attitude of this massive rock would be difficult to detect but for a prominent shale band in the eastern part of the quarry which shows a dip of 60-70° east. The rock of the western part of the quarry contains pale reddish pebbles, often with 'tails', which are of siltstone. No feldspathization was noted in this quarry but a smaller quarry 100 yards east shows a narrow feldspathic intrusion.

Similar rock can be seen at the top of the hill and on the northeast side in two adits, where it contains rare pebbles of siltstone and of igneous rocks. In the easternmost of these adits the rock has a strike of 300° and dips at 55° north. The rock

FIG. 6 Thermally metamorphosed Moonabie Formation, east side of Crag Point Trig.

FIG. 7 Amygdaloidal lava, Roopena Lava equivalent, Two Hummock Point.

Fig. 6. CULTANA. 16186

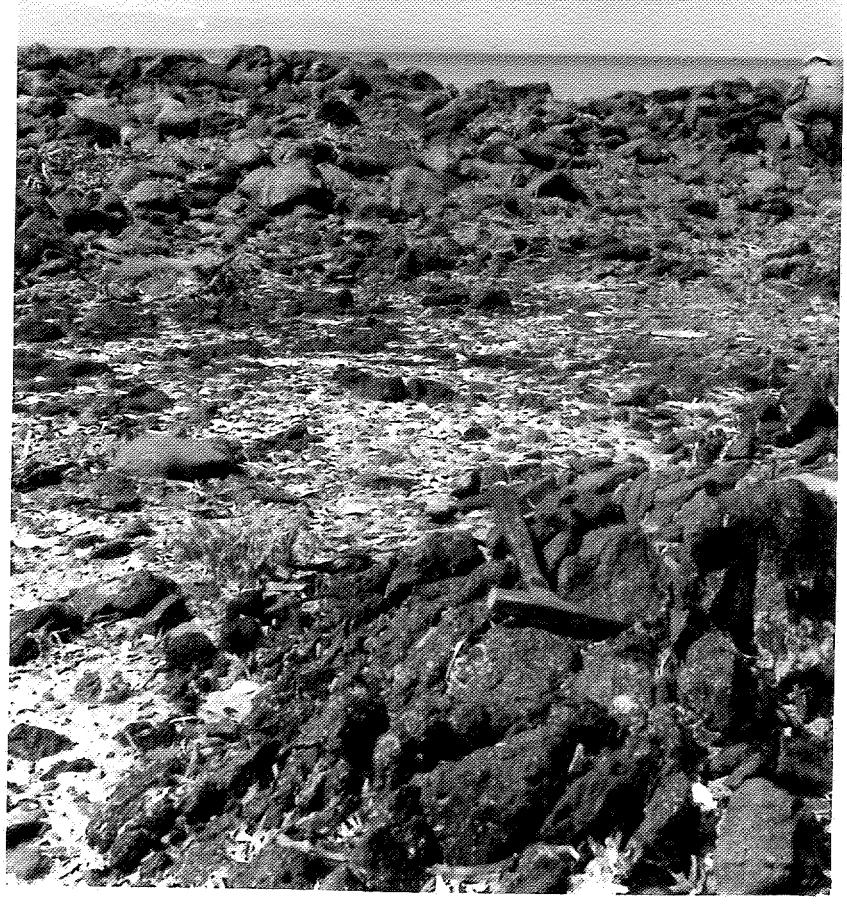

Fig. 7. ~~RANDELL~~ JENKINS 16187

is grey and with a 'dusty' appearance on breaking, suggestive of a partly tuffaceous character. Manganese oxide is common (Fig. 5).

In the quarry in the hill north of the railway and west of the Port Augusta road, the rocks are in general paler, rather finer-grained and in part less arkosic. A prominent friable gritty purple arkosic band one foot thick occurs, which owes its colour to numerous clay inclusions which are compressed mud balls. Here the strike is northwesterly with a southwest dip of 25°-30°.

Another occurrence is in New Water Tank Hill. This hill shows three distinct formations. The Moonabie Formation rocks are confined to the southern slopes and the crest except for a younger capping of unconformably overlying conglomerate. The strike is approximately northwesterly. The rocks are vertical, and are dense heavy-mineral banded current-bedded dark grey arkose, with rare rounded pebbles.

In the Douglas Upland very dense chloritized rocks occur along the coast west and north of Backy Point, and cover the eastern part of the southern group of hills (Fig. 6). They are baked by thermal metamorphism and appear to be domed over the Cultana Granite which 200 yards west of Backy Point occurs at sea level but which rises northwards and reaches an elevation of 651 feet at Monument Hill.

Only the southeastern quadrant of this dome is preserved, the sediments having been completely stripped off elsewhere by erosion.

No rocks of the Moonabie Formation are known on the Cultana sheet east of Spencer Gulf, but on structural grounds they might be expected to occur under Baroota Plain, in a concealed occurrence probably equivalent to an outcrop near Wilkatana H.S. (Drummschweiler, 1956).

Adelaide System Rocks West of Spencer Gulf

General

Adelaide System rocks outcrop very widely, forming

the Simmens Plateau. They form most of the outcrop in the northern part of North Whyalla Hills and occur in the middle part of the Whyalla Ridge and cap Mount Laura. Similar rocks occur in the Douglas Upland mostly on the east coast.

These rocks are essentially flat-lying arenaceous sediments. Most are pale or reddish or reddish brown in colour. It is important to realise that they are commonly bleached by Tertiary duricrusting and eminences show silicification. The lower beds are often purplish in colour due to presence of material derived from lavas at the base of the sequence.

A feature of the rocks is the presence of angular fragments up to a few inches in size scattered along the bedding planes of well-bedded medium-grained gritty sandstones. These occur mostly near bedrock composed of the Moonabie Formation. The rocks are also locally conglomeratic, especially those lapped around the domed Moonabie Formation and the Gultana Granite of the Douglas Upland. These sandstones of variable grainsize and content pass up into a persistent shaly facies and that to a persistent fine-grained flaggy sandstone facies. Thus a division can be made as follows:

	Approx. thickness
Tent Hill Formation, Simmens Member	300 feet
Corraberra Member	400 feet
Tregolana Shale	300 feet
Pandurra Formation	400 feet
Roopena Lavas	up to 100 feet ?

This division applies to the major outcrop (and concealed outcrop) of the west and centre of the sheet and the lowest formation (Roopena Lavas) lies off the sheet to the west at Old Roopena H.S. The rocks around the Douglas Upland are less certainly correlatable in detail as the sequence is very thin, and includes representatives probably equivalent to both the basal and uppermost formations with an absence of any shale facies.

Roopena Lava

These rocks are Woolitana-type (Crawford, 1963) amygdaloidal trachytes, with a dark purple ground mass and pink amygdales. The type area lies off the sheet five miles west of the northwest corner, the lavas outcropping north and south of Old Roopena H.S. in an area of low relief east of the meridional Roopena Fault.

It is possible that these lavas, which at Roopena appear to have flowed into and filled up depressions in an eroded surface of Moonabie Formation rocks, underlie younger Adelaide System sediments in the western part of the Oultana sheet. This is not to be assumed, as they are, like all lavas, of limited extent and their occurrence at Roopena may be due to effusion along the Roopena Fault. It may however be due to effusion wholly or partly along an older lineament at 285° which crosses the Oultana sheet and passes through Crag Point so that the area where lavas might be most likely to occur would be about four miles northwest of Tregolana H.S.

Identical lavas, underlying the Pandurra Formation, occur in the map area at Two Hummock Point (Fig. 7). They strike north-south and are found as float on low hills to the northwest. Further south they occur along the coastal slope north of Douglas Point but are much altered and weathered in this area of structural mobility. Lavas, apparently unaltered, occur also ½ mile west of Backy Point where they are copper-bearing. These are poorly exposed and the occurrence is regarded as an eroded dyke-like feeder, most of the extrusive rock having been eroded.

The Roopena Lavas near Old Roopena H.S. have been dated by the rubidium/strontium method (Compston, 1966, p. 247) at about 1450 M.Y.

Pandurra Formation

The Pandurra Formation consists for the most part of current-bedded gritty medium-grained quartzitic sandstones which

FIG. 8 Red and white, well-bedded coarse quartzitic sandstone of the Pandurra Formation, New Water Tank quarry.

FIG. 9 Well-jointed quartzite of the Simmens Member, Tent Hill Formation, ¼ mile east of Black Point.

Fig. 8. RANDELL 16188

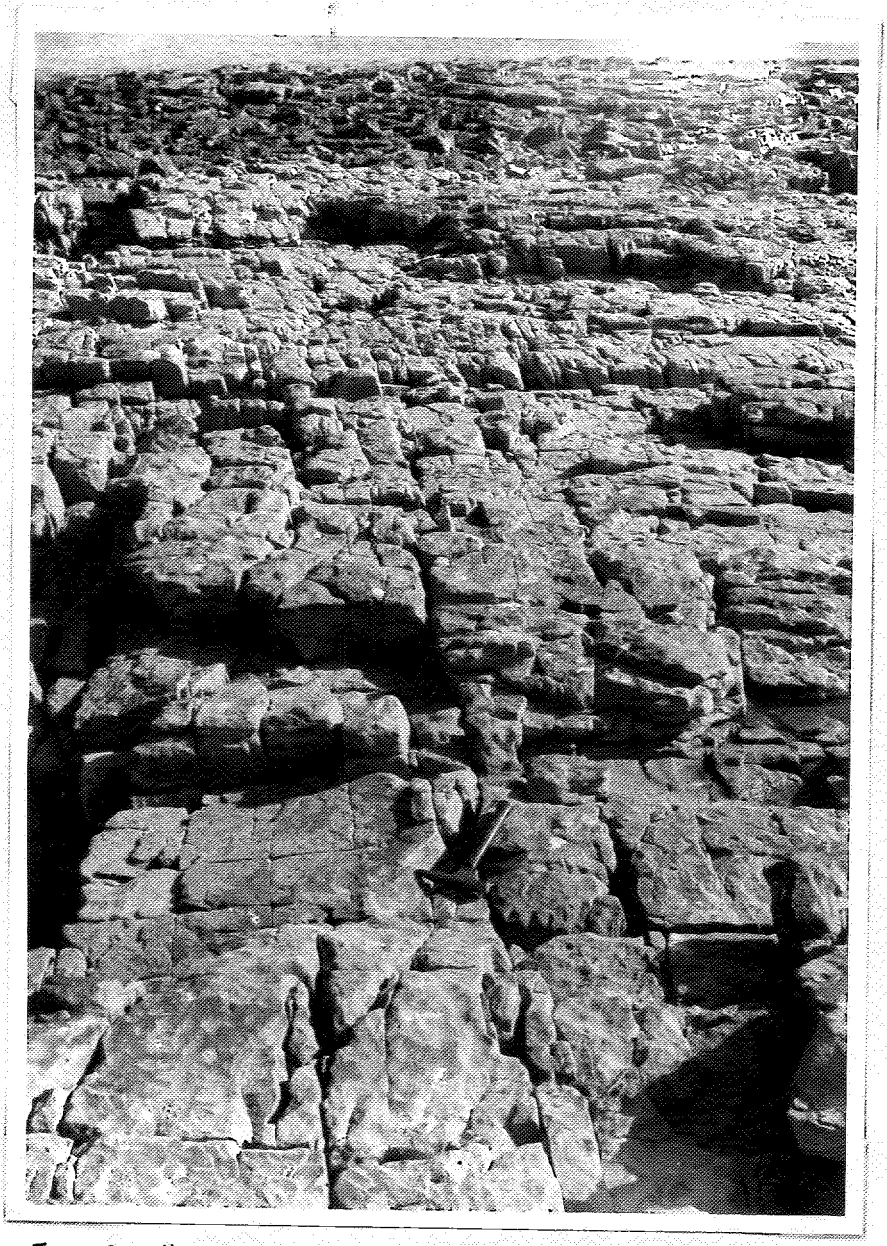

Fig. 9. CULTANA 16189

are usually red from iron oxide staining. They are however very commonly bleached due to duricrusting, the duricrust itself having relatively recently been stripped off most of the outcrop. Near the base they are more purple in colour due to the presence of volcanic detritus. Exposed knobs are sometimes silicified and the true and current bedding largely destroyed.

The northern part of the North Whyalla hills is almost entirely Pandurra Formation, the outcrop of which extends westward on to the Roopena sheet, where it forms much of the eastern part of the upland between Mount Whyalla and Roopena H.S. and all the upland northeast of Roopena H.S. Much of this outcrop is bleached by duricrusting.

At Mount Laura the capping of sandstone and conglomerate of the top 100 feet of the hill is Pandurra Formation. East of Mount Laura the Pandurra Formation occupies an area just north of the railway and similar rocks exist in the quarries on the north side of New Water Tank Hill, Whyalla, and extend along the Whyalla Ridge towards Hummock Hill, where they presumably thin out against the Moonabie Formation. They are best seen in the New Water Tank quarries, where red and white regularly bedded gritty quartzitic sandstones strike at 300° and dip at 20° to the northeast (Fig.8). These beds show scarcely any current bedding. Sun-cracked surfaces are visible. Angular boulders and smaller fragments are common, aligned along the bedding planes.

Further north these beds can be seen in the railway cutting. Still further north, west of the golf course, a quarry in a low rise exposes pale strongly current-bedded gritty sandstones which are bleached. In a second quarry on the north side unbleached equivalents are to be seen adjacent to the Moonabie Formation.

At Myalla on the east side of Hummock Hill there occurs a cemented boulder bed showing no internal dip but plastered on to the steep coastal slope, and outcropping from below the railway siding to beach level. This is composed mostly of sub-rounded boulders of Moonabie Formation metasediment of Hummock Hill. The boulders are mostly from three inches to one foot in diameter and are closely packed, such matrix as exists being arenaceous. Some very large boulders occur, up to 10 feet long. This is the boulder bed seen by Lockhart Jack (1914), Ward and Edgeworth David (unpub. obs., field notebooks of Ward) and Segnit (1939). The boulder bed is not however a tillite but appears to be a cemented scree. At beach level it overlies Moonabie Formation bedrock. Its dip is original.

In Quaternary time the lower part of this formation was undercut by high sea level marine erosion so that a line of emerged sea caves exists. The upper part has been further cemented by subaerial processes.

Similar boulder beds were recorded by Segnit (1939) on the south flanks of Mount Laura but have not been seen by the writer.

On the top of New Water Tank Hill a massive boulder bed, consisting of rounded pebbles very strongly cemented together, overlies unconformably the vertical Moonabie Formation rocks, the surface of unconformity being very irregular. At one point the conglomerate plunges into a widened joint in the underlying rocks, so that a 'conglomerate dyke' occurs.

The presence of comparable conglomerates on the top of Mount Laura, interbedded with quartzites, suggests that these may be of the same age. This capping at Mount Laura is identical with a similar capping on a small hill ('Solution Hill') in the Cultana Trough, unconformable on Cultana Granite.

At Two Hummock Point arenaceous rocks of the Pandurra Formation outcrop on the beach. Woolteana-type amygdaloidal lavas, considered to be equivalent to the Roopena Lava, are interbedded

with these rocks, which strike in a southerly direction, and dip east at 30°. In the two hummocks the gritty sandstones show heavy mineral banding in places but are mostly conglomeratic. On the top of South Hummock a boulder of Oultana-type granite was noted in these beds.

Further south, along the hilly coast near and north of Douglas Point there are numerous shore and low cliff outcrops of similar rocks. Immediately south of Douglas Point these dip east at 25° and though the contact is mostly faulted, at one point they can be seen to overlie Oultana Granite (which here abouts has the texture of a porphyry). Though cut by numerous quartz veinlets and one prominent east-trending feldspar vein 1 foot wide, they are not metamorphosed and are clearly unconformable on the granite. Locally they are extremely conglomeratic but most are current bedded reddish brown gritty sandstones. In beach outcrops are locally very much altered by intense ferruginization, some of the rocks being almost entirely changed to haematite boxwork. There is also evidence of volcanic extrusion but the exposed rocks are very altered by both these and recent marine processes. White and pale pink pegmatite intrusions occur. It should be noted that the lower part of the cliff outcrops appears to have been submerged during former high sea levels. The extreme ferruginization and the vulcanism here are apparently related to structural weaknesses along the coast (the alignment of which is strongly influenced by structures).

No Adelaide System rocks have been detected in the main part of the Douglas Upland (which is entirely Oultana Granite and its variants) but on the west side a hill ½ mile north of Oultana H.S. shows outcrops considered to be a basal conglomerate of the Pandurra Formation. The structure is best seen in the section in the creek on the west slope, immediately east of the dam just

north of the M.S. In the lower part of the valley an irregular surface of Oultana Granite is exposed, on which is a very coarse conglomerate composed of blocks of weathered granite and Moonabie Formation metasediment in a matrix largely of granite grush. This forms also the steeper slopes higher up the valley. The upper part of the hill is deeply weathered conglomerate and the bevelled top is littered with boulders of Moonabie Formation metasediment half-buried in granite detritus and soil derived from it. This is probably downfaulted with respect to the Oultana Granite area to the east. A small but lower area on the opposite (west) side of the Oultana Creek also shows conglomerate on granite.

The thickness of the Pandurra Formation in the west is variable but reaches 400 feet.

Tregolana Shale

Immediately east of the North Whyalla Hills the low ground, though strewn with detritus of Quaternary age, is underlain by Tregolana Shale, which extends under Quaternary cover over all Long Sleep Plain and under the sandstones of the Simmens Plateau as far as the limiting faults on the east side. It is very poorly exposed. Only two good exposures are known, very close to each other. One is in an old quarry cut into a hillock at Cocky's Dam which shows 24 feet of kaolinized shales and shaly sandstones, folded gently anticlinally on a northwest to southeast axis. A pit (Broken Hill Pty. Ltd.) 1½ miles southeast, about 25 feet deep, exposed flat-lying white or pale purple kaolinized shales under thin Quaternary.

The presence of definite duricrust at the first of these localities indicates that the whiteness of the Tregolana Shale is not an original feature but is due to its being the pallid zone of a duricrust profile. It is therefore to be noted that any Tregolana Shale met with in boring through substantial cover of younger Adelaide System rocks (e.g. on the Simmens Plateau) will probably

be much darker in colour and not immediately recognizable as this formation. The colour will probably be red or pale brown.

The thickness of the Tregolana Shale is uncertain but of the order of 400 feet.

Tent Hill Formation

The lower Corraberra Member of this formation is composed of dark reddish brown or dark brown micaceous shales and shaly sandstones which outcrop extensively in the lower slopes of the Simmens Plateau but are commonly obscured by talus and outwash fans Outcrops are rare on the Cultana sheet and the formation is named from good outcrops near Corraberra H.S., 8 miles west-northwest of Port Augusta. (The formation is also well exposed on the saddle south of the Sisters and on the lower slopes of Observation Point ½ ml. southwest of El Alamein Camp). The formation is thin-bedded and breaks up into small easily breakable slabs, which on flat outcrops almost entirely lack vegetation. The thickness of the Corraberra Member is approximately 400 feet.

The caprock of the Simmens Plateau in its major development in the northern part of the Cultana Sheet and beyond on the Davenport and Augusta sheets forms the upper part of the Simmens Member and is a dense current bedded flaggy or semi-massive quartzite, often silicified and intensely hard, giving a ringing tone when hammered. This has less massive beds associated with it, and is underlain widely by intraformational breccias formed of similar material.

The Simmens Member is the upper part of that described as 'Lincoln Gap Flags' by Miles (1955). It is named from Simmens Hill north of the map area, where the Member outcrops typically. It is poorly exposed, except along the steep scarps, in the Plateau proper, but restricted horizons are very well exposed in the low cliffs and shore outcrops west and north of Point Lowly. (Fig. 9). The thickness of the Simmens Member is approximately 300 feet.

Mt. Gullet is an isolated, but significant, exposure of the Simmens Member east of Spencer Gulf.

Ages of Adelaide System Rocks West of Spencer Gulf

The apparently conformable relationship of the Pandurra Formation and the Roopena Lava, the absolute age of which is about 1450 M.Y., and the presence of interbedded lavas and grits on the coast at Two Hummock Point, containing boulders of Gultana Granite, suggests that the lower part of the sequence should be correlated with the Callanna Beds.

The uppermost part of the sequence, viz. the Simmens Member of the Tent Hill Formation, is lithologically identical with rocks of Marinoan age only a few miles east in the southern Flinders Ranges.

No angular unconformity exists between these parts of the sequence, and no significant disconformity has been detected. Paraconformities probably exist which are undetectable palaeontologically. The presence of edgewise conglomerates, intraformational breccias and sun-cracked beds suggests that periods of continental-type deposition involving much non-deposition and erosion occurred. The whole sequence is therefore provisionally regarded as a thin equivalent of the Willouran, Torrensian, Sturtian and Marinoan rocks of the Adelaide System, excluding perhaps only the lowest Willouran and uppermost Marinoan.

Adelaide System Rocks East of Spencer Gulf

Adelaide System rocks forming part of the southern Flinders Ranges outcrop over only a small part of the Gultana map area in the extreme northeast. They have been examined in detail by M.N. Hiern, who has supplied the information below.

FIG. 10 Steeply-dipping A.B.C. Range Quartzite, north of Mambray Creek.

Fig. 10. WINNINOWIE

16190

The edge of the ranges north of Nambruy Creek is composed of synclinally folded white cross-bedded quartzites of the A.B.C. Range Quartzite (Fig. 10) which forms two prominent ridges; the quartzites are over 1000 feet thick. The Morgan-Whyalla pipe-line runs between the ridges near the axis of the syncline, which is cut by northerly-trending high-angle faults. The Brachina Formation, chocolate and purple shales, outcrops further east and is the basal formation of the Wilpena Group; it is about 700 feet thick. Underlying this to the east is the Elatina Formation, about 400 feet thick, the uppermost unit of the Umberatana Group. The Elatina Formation probably represents a glacial environment and contains pebbly purple siltstone and sandstones. At the eastern edge of the map area is the Willochra Formation, made up of grey and chocolate quartzites, shales, siltstones and gritty limestone. The base of this sequence is not exposed but it is at least 1500 feet thick.

Because of similarity of constituent rocks it seems probable that the Tent Hill Formation and A.B.C. Range Quartzite-Brachina Formation are co-extensive.

Tertiary Rocks

General

Tertiary rocks as mappable units do not exist in the map area west of Spencer Gulf. The presence of Tertiary limestones in the area 30 miles southwest of Whyalla, flanking Tertiary-Quaternary fault scarps (Miles, 1955) does suggest that comparable rocks may exist under Quaternary cover near Whyalla. Thus Tertiary rocks might be met in bores on the South Whyalla Plain. They are unlikely to be present elsewhere except possibly under thick cover on the eastern side of Long Sleep Plain near the western scarp of the Simmons Plateau.

Duricrust

Rocks which suffered profound changes in Tertiary time and which developed surface crusts are known, but are poorly exposed. The best known exposure is in a small disused kaolin quarry one mile west of the Whyalla - Port Augusta road 17 miles north of Whyalla. The quarry is dug into the northeast side of a small hill. The section shows

5.	Soil with iron oxide coated pebbles	6 ins. to 9 ins.
4.	Kunkar skin and occasional nodules 'wrapped over' 3.	approx. 6 ins.
3.	Duricrust. Dense light or pale yellowish-brown sub-conchoidally-fracturing rock containing angular and rounded quartz and amorphous fragments mostly 1/32" - 1/8" in size. Stub-like occurrence	2 ft.
2.	White or pale purple kaolinized shales and shaly sandstone	12 ft.
1.	White or very pale purplish kaolinized shaly sandstone	12 ft.

Formations 1-3 inclusive are regarded as a duricrust profile, and by analogy with well-exposed and well-studied sequences in the Great Artesian Basin, regarded as Oligocene. Formations 1 and 2 are a pallid zone developed on Precambrian argillites.

Laterite

A lateritic capping existed on many hills especially those in the west, but this is largely stripped and in fact

fragments of it are rare except as pebbles in the Quaternary alluvium (e.g. formation 5 of Section above). Large blocks of massive compact boxwork laterite were seen 7 miles north-north-west of Tregolana H.S.

There is no real evidence of lateritization of the Simmens Plateau (though plenty of evidence of silicification) but a well-exposed mottled zone of a laterite profile exists just off the Quilana sheet on the Davenport sheet. The age of this laterite is probably late Pliocene or early Pleistocene.

East of Spencer Gulf

On the eastern side of the Gulf, in the valley through which the Morgan-Whyalla pipeline runs, are small masses of yellow brown silicified sedimentary breccia, and sandstone. These rocks dip to the south-west at low angles and are underlain by kaolinised shales of the Brachina Formation.

The Pirie Torrens Basin underlies the Barcoota Plain and continues to the north and south on adjoining sheets. Chebotarev (1958), in describing the hydrology of the Basin, assigned a Tertiary Age to fine-grained sandy sediments intersected by bores in the lower part of the Basin. These sediments are unfossiliferous (except for some carbonaceous matter) but display lithological similarities with early Tertiary material from other parts of the State. They form the aquifer for the pressure waters which occur in the basin.

Quaternary Rocks

General

A varied suite of Quaternary deposits exists, covering the greater part of the sheet. These have been mapped in

FIG. 11 Conglomerate remnant of emerged beach, 3 miles north of Point Lowly.

FIG. 12 Quaternary sedimentary breccia, possibly an old cliff talus, Black Point.

Fig. 11. CULTANA 16191

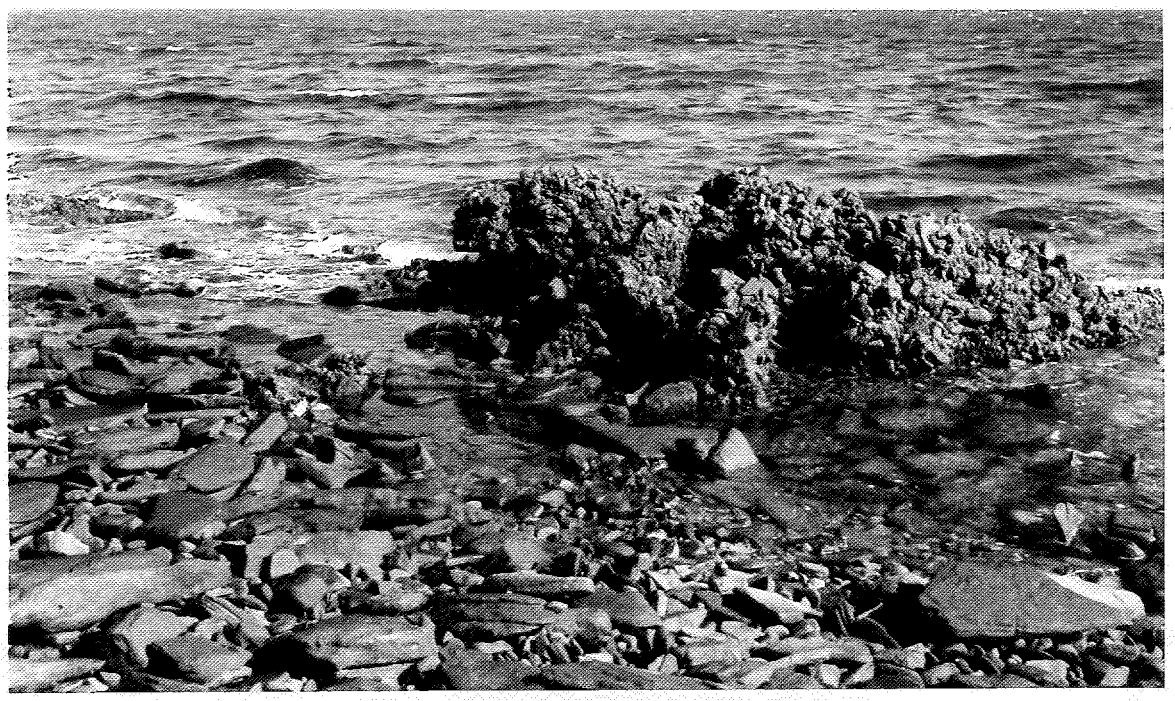

Fig. 12. CULTANA 16192

seven categories which cannot entirely be placed in a satisfactory time sequence, though some are obviously older than others.

They comprise

Symbol on map	Brief Description
Qa	Modern fluviatile, estuarine and littoral alluvium.
Ql	Salt lagoons, littoral lagoons, samphire flats, mangrove swamps.
Qb	Modern beach sand and sand dunes.
Qw	Older alluvium and low angle slope deposits partly derived from talus and partly from reworking of wind-deposited desert sand, according to location. Including thin gypsiferous crusts below.
Qt	Talus and high angle slope deposits, locally incorporating some desert dune material.
Qs	Desert soif dunes and associated sand accumulations, with kunkar developed as a B-zone in a soil profile.
Qe	Emerged beach gravels, emerged offshore bars, sedimentary breccias and gravel accumulations.

Category Qe - Emerged beach gravels, emerged offshore bars, sedimentary breccias and boulder beds

These form a varied suite in themselves. Emerged beach gravels are common along the east coast of the Point Lowly Peninsula, where they lie unconformably upon the Precambrian sandstones. The best exposure seen is 3 miles north of Point Lowly (adjacent to an old bus used as a fishing shack) where a coarse conglomerate about 3 feet thick, dipping at about 10° seawards is being eroded by the present tides (Fig. 11). This deposit shows white Quaternary shells and shell fragments in the

predominantly reddish matrix. It rises to a low cliff where it is topped by a shell bed thinly covered with Recent downwash. Adjacent to the north there is an accumulation of less well-consolidated material.

Similar conglomerate exists in thin patches further south and has often a more limy matrix, suggesting cementation after emergence as a kunkarised gravel.

Half a mile south semi-cemented pebble and boulder beds form some coastal cliffs.

At Stony Point 1½ miles west-northwest of Point Lowly a remarkable deposit exists (Crawford, 1963). This backs the present beach, the upper part of which, derived from flat-lying flaggy sandstones which outcrop seaward of it, consists of a gentle slope of loose slabs. The deposit has a steeper (but still gentle) seaward slope, has a flat top approximately 6 feet wide, and a very steep landward slope, backed by a dried-up lagoon. It is built of loose and very large slabs of sandstone and it is inconceivable that such a deposit could have been emplaced on land by the activity of present-day seas, which are known to be rarely, and then only mildly, rough. A similar deposit exists ½ mile east of Black Point, at the mouth of a small creek.

These deposits are regarded as emerged offshore bars related to relative high sea levels, but the structural mobility of the area makes it equally possible that the emergence is tectonic or eustatic.

At Black Point and westwards of it there exists equally remarkable sedimentary breccias and conglomerates. Small stacks of these lie on the lower part of the beach (the upper part having at one point larger stacks of the bedrock of Simmens Member conglomeratic sandstone) and are being eroded by the sea (Fig. 12).

The coarseness and complete lack of sorting and indeed of a continuous matrix in these extraordinarily jumbled rocks suggests that they are sedimentary breccias accumulated at the foot of either old coastal cliffs or old fault scarps. (The two could be the same).

Category Qs - Desert seif dunes and associated sand spreads with kunker developed as a B-zone in a soil profile

Much of the west-central part of the sheet is occupied by wind blown desert sand, in part piled up against the west face of the Simmons Plateau. Some of this extensive spread is in the form of seif (i.e. long straight narrow) dunes, all of which are aligned north-northwest due to control of deposition by the dominant wind directions at the the of the deposition.

Dunes are particularly well developed north and south of the un-named salt pan which lies four miles east-northeast of Tregolana H.S. Sand accumulation is also well seen on the road from Whyalla to Cultana as the Plateau is approached from the west.

The sand has developed a mallee vegetation on poor solonized soils which contain white kunkar limestone as nodules or discontinuous thin sheets. Occasionally the upper part of this soil profile has been stripped by erosion, baring the kunkar.

However, as the sand has been the result of repeated accumulations, some is sufficiently young not to have had time to develop any significant soil profile.

Much of the pile-up against the western edge of the Plateau has since been either covered by or become incorporated with talus and downwash from the Plateau and this is dealt with below. Sharp boundaries do not usually exist between the talus, the reworked material, and the sand; nor between these and more recent alluvium.

Category Qt - Talus and high-angle slope deposits, locally incorporating some desert sand

Talus exists principally around the edges of the Simmens Plateau. Because of the slabby or flaggy nature of the rocks of the Plateau the talus is very coarse and essentially a loose conglomerate of sandstone. Its content of interstitial material increases downslope and it merges with category Qw, or on the west side, with Qs.

Scarcely any talus exists around the hills of the Douglas Upland, the slopes of which are less abrupt. Little exists around the still gentler North Whyalla Hills, most being around the rather higher Mount Laura group. Thin talus occurs on the slopes of the Whyalla ridge.

The sharply emergent scarps of the Flinders Ranges have thick talus slopes at the foot.

Talus accumulates continuously so that in some places it overlies and in others underlies other Quaternary deposits. Much of the upper part of the beaches of the Point Lowly peninsula (for example) consists of slab talus accumulating at the present day and effectively undisturbed by the sea. A gradual downward creep of much of the coarser hill talus takes place. On much of the Simmons Plateau, especially in the south, the Precambrian bedrock is masked by a low-angle talus-cum-soil which is creeping downslope. This is a category which has not been mapped and merges with category 4.

Category Qw - Older Alluvium and low angle slope deposits partly derived from talus and partly from reworking of desert sand, according to location. Including gypsiferous crusts below

It is apparent from examination of creek sections east and west of the Plateau that an older alluvium exists which is being dissected by the present-day drainage.

A typical section can be seen 1½ miles northwest of Oultana.

	ft.	ins.
Light orange-brown limy alluvium	3	0
Arched crusts of gypsum, partly earthy	2	6
Very pale greenish grey rotted, granitoid rock	4 (seen)	0

The average thickness of this type of deposit is probably less than 10 feet, but locally, as for example at the old dam 2 miles north of Oultana, over 12 feet exists in repeated layers of gravelly sand (Plate 21).

The deposits of the western part of the sheet which have been placed in this category are of comparable thickness, but are commonly richer in reworked desert sand, especially those which are horizontal or very nearly so.

Category Qb - Modern beach sand and sand dunes

West of the Gulf these deposits are of very limited extent. White sand dunes up to 30 feet high occur near Point Lowly and Stony Point. Elsewhere dunes are very narrow and low, except for dune ridges at the head of Fitzgerald Bay.

East of the Gulf deposits are extensive but the dunes are low and ill-defined, merging with the coastal plain. They are widest west of Barcoota township.

Category Ql - Salt lagoons, littoral lagoons, samphire flats and mangrove swamps

West of the Gulf small salt pans occur in association with the desert sand areas. An extensive littoral lagoon exists behind the swamps at the head of False Bay, and separated from them by fragments of ancient beach dunes. The western end of this lagoon is artificially controlled and used for salt production by evaporation.

East of the Gulf narrow littoral lagoons lie between the youngest of the parallel beach dunes.

Samphire flats and mangrove swamps are most extensive at the head of False Bay and of Yatala Harbour.

Category Qa - Modern fluviatile and littoral alluvium

Deposits of this type are most extensive in the west along braided ephemeral stream courses, which drain to Long Sleep Plain and False Bay. Narrow belts of modern alluvium extend along some creeks in the Cultana trough and which drain south to Fitzgerald Bay, and as wider spreads along the northerly-draining streams.

Much of the Baroota coastal plain is covered with such alluvium, which is gradually spreading westwards over the previously deposited aeolian sand of desert origin.

Subsurface Quaternary

Beneath the Baroota Plain water bores have disclosed two units overlying the Tertiary sands previously discussed. The upper is a red-brown to brown sandy and gravelly clay with frequent lenticular sand and gravel beds. It has a thickness of 228 feet in a bore in Section 46 Hd. Baroota (about 3 miles south-southeast of Mt. Maubray), but elsewhere is generally less than 100ft. thick. The beds are typical of an alluvial deposit built up by coalescing outwash fans from the ranges.

The lower unit consists of up to 100 feet of red and grey mottled clay and sandy clay to which a Pleistocene age is tentatively assigned.

IGNEOUS ROCKS

General

Igneous rocks are known only in the Douglas Upland and the Cultana Trough. The former unit is the topographic expression of the Cultana Granite, regarded as a laccolith. The only other known igneous rocks are volcanic lavas of Woolteana-type, known outcrops of which are of very small extent, and confined to the coast.

Cultana Granite

The Cultana Granite outcrop extends about ten miles from north to south and about six miles from east to west. In the centre it rises to over 630 feet at Monument Hill, and over 550 feet in the hills to the southwest. The Cultana Granite has not been examined in detail but it is evident that much variation of rock type exists within the outcrop, and the name 'granite' is used in a loose sense, much of the rock being a porphyry, especially along the steep eastern slope near Douglas Point. Just north of Cultana H.S. it is a pink porphyritic granite, and similar rock exists in the northwestern part of the outcrop. This rock has the appearance of a true magmatic granite but the more porphyritic rock of the east (which is often associated with fine-grained pale purple variants) is commonly rich in very rounded quartz crystals and may be strongly contaminated. In the hills between Cultana and Douglas Point large tourmaline clots are a characteristic feature. In the extreme west, in the Cultana Trough, creek outcrops show rotted rock and nearby are occurrences of fine-grained pale purple variants comparable with those of the eastern side.

This distribution of types, together with the shape of the body, and the evidence of thermal metamorphism of fine-grained

Moonabie Formation rocks near Crag Point Trig, suggests that the granite is a laccolith, elliptical in plan, and perhaps faulted along its eastern margin. The fine-grained variants are regarded as chilled margins of the body. Metamorphosed Moonabie Formation rocks can be seen resting on Oultana Granite at sea level immediately west of Backy Point, though the rocks are badly affected by marine action.

The Granite may extend northwards under Quaternary cover since rotted igneous rock, possibly originally Oultana Granite, exists at the laterite locality on the Davenport sheet.

Volcanic Lavas

Reference has already been made to Woolteana-type amygdaloidal lavas at Two Hummock Point and near Douglas Point. Another occurrence is ¼ mile west of Backy Point where the presence of copper in the lavas led to some prospecting. All these lavas closely resemble those of Old Roopena on the Roopena sheet. Those at Two Hummock Point are thought to be interbedded with the sediments there, but near Douglas Point there is such brecciation and ferruginization of the outcrops that the relationships are less certain. At Backy Point the outcrop is poor and the occurrence is thought to be an eroded feeder along a fault.

The close association of the lavas with the Oultana Granite is thought to be meaningful, the lavas being a later product of the activity which originally led to the emplacement of the laccolith, effusion being along fractures possibly formed by the renewed activity.

STRUCTURE

West of Spencer Gulf is the Stuart Stable Shelf, the flat-lying Adelaide System rocks of which contrast strongly with the folded rocks of the Adelaide Geosyncline northeast of Mt. Gullet The whole of the area is in a zone of structural mobility, and is divided into fault blocks. Folding is unimportant in the west and present to any significant degree only in the Moonabie Formation rocks. Where these are exposed at the Mount Laura quarries they are strongly folded and the ubiquitous steep dips elsewhere suggest that such folding is characteristic of the ~~Group~~ formation.

The faulting shows strong northerly, north-northwesterly and northwesterly trends, though northeastern trending faults affect the Douglas Upland and Cultana Trough, which is the most mobile and most fractured area. The major faults have a meridional tendency. The area forms part of a wider zone extending from west of Iron Knob eastwards into the Southern Flinders Ranges, in which meridional faulting has repeated the Adelaide System successions in north-south belts. Because of the uneven surface on which the Adelaide System rocks were deposited, the irregular distribution of Quaternary rocks, and the obscured sea area, this pattern is not immediately obvious either in the field or on the map.

A fundamental but concealed structure probably extends in an east-southeasterly direction across the sheet through the Douglas Upland. The existence of the Cultana Granite is attributed to a weakness at the point where this crosses a particularly mobile north-south zone. The existence of this structure is inferred from evidence in the area to the west.

In the Whyalla area faulting is probably responsible for the existence of the Whyalla Ridge, which is regarded as a horst. In the writer's opinion the topography over the area as a whole owes itself largely to Quaternary structural features, many, if not

most, being rejuvenated old structures.

In the North Whyalla Hills north-northwesterly trending lineaments are dominant and this together with the slight easterly dip of the Adelaide System rocks is reflected in the present very subdued cuesta-topography. Again, Quaternary movement is responsible for abrupt features such as Wild Dog Hill. But as in the Whyalla Ridge and at Mount Laura, the unwen eroded Precambrian surface of the Whyalla Group rocks still affects the topography to a minor degree.

The Simmens Plateau is bounded by faults on its east side and possibly on its west side also. Talus usually obscures the trace of these faults but it is possible to observe the fault which bounds the east side of the Point Lowly peninsula. For example, in a creek section 1½ miles southwest of Cultana H.S. outcrop of the Simmens Member of the Tent Hill Formation is abruptly terminated against brecciated shales. Thirty yards upstream a tight anticline in the Member is silicified and the bedding almost obscured. Further north on the Davenport sheet the horizontal quartzite beds of the Simmens Member on the plateau are succeeded immediately to the east by sharply tilted quartzite (of identical lithology) forming small hills at the foot of the main scarp. Repetition of this topography further east suggests that this meridional (but slightly arcuate) faulting is repeated. (It is noteworthy that the coast itself in that area is almost exactly parallel to the main scarp and may have been influenced by a fault).

In the area covered by the central and northern part of the Cultana sheet however, the structural picture is complicated by the existence of the Cultana Granite. The Cultana Trough and Douglas Upland lie between the Plateau and the coast. Because of the considerable spread of talus and slope deposits the relationship of the Plateau to the laccolith is difficult to establish.

Faults mapped within the Gultana Granite outcrop are probably of small throw and are essentially linear fractures associated with continued movement of the laccolithic body.

The coast of the Douglas Upland is strongly influenced by faults, as is shown by the brecciated and altered condition of the coastal outcrops. The existence of volcanic lavas at Two Hummock Point, Douglas Point and west of Backy Point is probably related to these faults.

The inferred deeper structure aligned east-southeast passes through the narrowest part of the Simmens Plateau - which is thought to be not coincidental. It seems possible that the change in trend of the faults bounding the plateau from this point southwards, and the repeated relatively sudden and step-like southward diminutions in its elevation are related to movements of the granitic body.

East of Spencer Gulf low hills along the coast (Mt. Gullett and Mt. Membray) are thought to be separated from the Adelaide System rocks of the Southern Flinders Ranges by at least one major fault. The rocks of these hills are lithologically identical with the Simmens Member and are horizontal or nearly so. Rocks of the Flinders Ranges differ in lithology and attitude. As however the Douglas Upland is formed (for the most part) of older rocks, it is possible that another structure along the Gulf between the Upland and the eastern shore may exist. All these meridional structures between the Simmens Plateau and the Flinders Ranges are parallel to the major Torrens Lineament.

GEOLOGICAL HISTORY

In older Precambrian time an upland existed to the west. In Moonabie Formation time the upland was eroded and volcanic

activity ~~was active~~ occured along major, and mainly meridional lineaments. This led to the deposition in the area west of Whyalla of coarse- and fine-grained sediments and interbedded lavas and pyroclastics, with a gradual falling-off of the volcanism and dominance of sedimentation. Thus the Cultana sheet area, at least west of the present Gulf, became covered with sediments largely composed of volcanic detritus. These decreased in grainsize eastwards, having been derived from the west and southwest.

After consolidation of these sediments a period of folding took place, along west-northwesterly axes, possibly associated with a major weakness of the same alignment. By this time a major meridional weakness existed as a zone approximately along the line of the present northernmost part of the Gulf (but wider in extent) and the particular weakness where these major lineaments crossed led to the emplacement in that area of the Cultana Granite laccolith at a time when the vast spread of volcanics of the Gawler Ranges was being most actively effused.

Erosion of the Moonabie Formation rocks, and removal of the cover of the laccolith, took place early in Willouran time, with the deposition of coarse conglomerates followed by sandstones. Some movement along the meridional structures and the associated deeper structure led to fracturing of the laccolith and effusion of Woolltana-type lavas along th fractures.

Following this, the arenaceous and argillaceous sediments of the Adelaide System were formed in very shallow margins of the geosynclinal sea to the east, with much continental deposition at times of regression of the sea. (Further east the Flinders Ranges area was a deeper sea).

Between the end of Adelaide System time and the Tertiary Era there is no evidence of the history of the area.

In early Tertiary time a continental surface existed probably over the whole area but shallow seas may have invaded

it from the south. The area was later subject to chemical alteration which led to the formation of siliceous duricrust, followed (if not accompanied) by lateritization in warm humid conditions, during which much of the present topography was formed. Subsequently, generally arid conditions affected the area and led to a widespread cover of desert sand, which in slightly more humid conditions was later in part removed and spread as alluvium. Faulting, often along older structures, assisted in establishing the present topography and some of the Quaternary deposits. The age of the Gulf is uncertain but in its present form it post-dates the arid period.

MINERAL RESOURCES

No major metalliferous mineral resources are known but the non-metallic resources are considerable.

No marked mineralization in the Moonabie Formation has been noted. Small amounts of manganese minerals have been seen in the lithic sandstones of Hummock Hill quarry. The durierusted Moonabie Formation has been quarried for road metal north of Whyalla and the fresh rock at Hummock Hill. Active quarries now exist only at Mount Laura, in fresh rock. There are ample reserves here and in the vicinity.

The Cultana Granite has not been examined in detail and might repay such examination, as it is strongly tourmalinized in places. It would provide good monumental stone.

The Pandurra Formation is the host rock for barite veins in the area ½ mile east of Mt. Laura, comparable with the larger occurrence a few miles to the northwest on the Roopena sheet. The formation itself has been quarried for building stone at New Water Tank Hill and also ¾ mile north but these quarries are now inactive. The copper mineralization in the Rocky Point lavas and the wide-

spread strong ferruginization along the coast near Douglas Point are of mainly academic interest.

The Tregolana Shale is dug for kaolinitic clay by Broken Hill Pty. Ltd. 17 miles north of Whyalla. Ample reserves should exist, though not necessarily consistent in quality.

Modern beach dune sand is carted from Point Lowly for use at the Whyalla ironworks.

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ARC:BGF:SMA
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