

G E O L O G Y

of the

D E L A M E R E   A R E A

S O U T H   A U S T R A L I A

by

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## S U M M A R Y

In Stockyard Creek near Delamere there is a tilted sedimentary sequence with a stratigraphic thickness greater than 5500 feet. This is a portion of the sediments of the Adelaide Geosyncline.

The finding of Lower Cambrian fossils (hyolithids) in two formations of the Delamere Marble, has allowed relative dating of the sequence which is given as Upper Proterozoic and Lower Cambrian age. The base of the Cambrian has been taken as the lowest known occurrence of the hyolithids.

A description of the geology of the area and a detailed account of the lithology of the Stockyard Creek section is given, and where possible, by using lithological similarity and fossil evidence the sequence has been correlated with the type areas.

## CONTENTS

	page
Introduction	1
Physiography	2
Investigation Methods	3
Stratigraphy	4
Sturt Group	5
Marino Group	9
Mt. Terrible Formation	14
Cambrian Succession	15
Wangkonda Limestone	15
Sellick Hill Limestone	16
Fork Tree Limestone	17
Heatherdale Shale	18
Greywackes	20
Permian	21
Recent	22
Structure	23
Economic Geology	25
Acknowledgements	27
References	28
Illustrations	29

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## INTRODUCTION

The area investigated occurs on the Jervis Sheet (1:63,360 military survey). It is in the southern Mt. Lofty Ranges 65 miles by road south of Adelaide near the western extremity of the Fleurieu Peninsula. The area is of 7.5 square miles. The town of Delamere is in the area near the centre of the eastern boundary. The main Adelaide-Cape Jervis road passes through the town and runs in a north-easterly direction through the area.

The region has been investigated previously by a number of workers. Madigan (1925) published a sketch map and a description of the geology of the Fleurieu Peninsula. This was the earliest regional work in the district. Skinner studied the geology of the Rapid Bay and Delamere region with particular reference made to the limestones. Campana and Wilson (1955) mapped the Jervis Geological Sheet and came to the conclusion that the Delamere area was a recumbent anticline. This was done by correlating the limestone in the western side of the area with the Delamere Marble in the east. The most recent work has been done by Thomson and Horwitz in their investigations for the Barker Sheet 1/4 mile series (in print).

Detailed geological mapping in Stockyard Creek with careful study of the facings of the beds and the succession of lithological units, revealed that the area consisted of a tilted stratigraphic sequence of which the lowest boundary, in the west, has the Kanmantoo Group rocks thrust over the sequence, while in the east the succession is covered by recent deposits. The sequence has the Tapley Hill Slate equivalent at the base and greywacke rock type at the top. The greywacke has been correlated with the Carrickalinga Head formation.

Use is made of the terms Adelaide Supergroup, Sturt Group and Marino Group to replace the terms Adelaide System,



T.N.  
↑

# LOCALITY MAP DELAMERE AREA

GULF ST. VINCENT

Normanville

Yankalilla

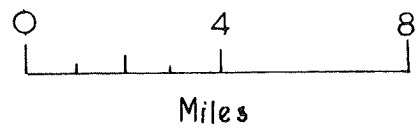
Second Valley

Fleurieu Peninsula

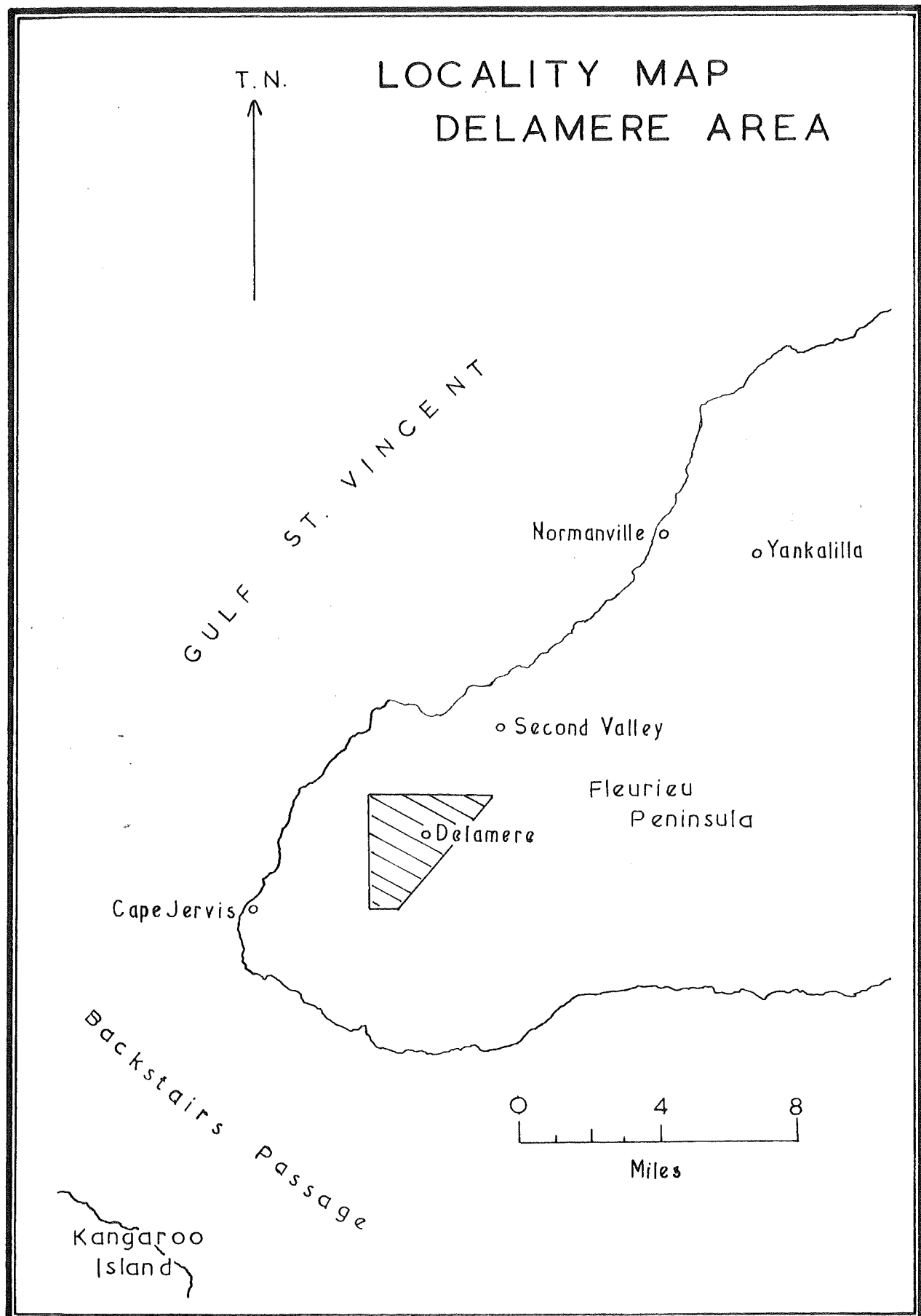
Delamere

Cape Jervis

Backstairs Passage



Kangaroo Island



Sturtian Series and Marinoan Series in conformance with the renaming by Dr B. Daily (in press).

The project has been done as part of a contribution by four postgraduate students of the Geology Department of the University of Adelaide to elucidate and reveal the structure and stratigraphy of the north-western district of the Fleurieu Peninsula.

### PHYSIOGRAPHY

The area is of semi-mature topography with rounded ridges intersected by deep steep-sided valleys. The ridges tend to be elongated in a N.N.E. direction parallel to the strike of the beds.

The rounded ridges are typical of a moderate rainfall region and generally have several feet of soil cover. A few of these are formed by thick quartzite beds which outcrop along the crests. Minor hills and spurs generally have 5 to 6 feet of soil cover and either show very sparse outcrop or no outcrop at all. The high plateau on the eastern margin of the area has an average height of 1000 feet above sea level. The hills and ridges of the remaining area have an average height of 800 feet.

Stockyard Creek, the main drainage, flows in a north-westerly direction through the northern end of the area. It has a steep sided valley which shows good and almost continuous outcrop. The tributary streams have a general flow direction parallel to Stockyard Creek, which is at right angles to the strike of the beds, or flow in a N.N.E. direction which is parallel to the strike. The south-west corner of the area mapped is drained by Salt Creek and Plough Creek. Several of the stream valleys have been filled with Permian and Recent deposits, which give them a broad U-shaped appearance and obscure the outcrop, while the remaining stream courses show good outcrop. Outcrop in the area is generally poor and forms about one quarter of the land surface.

Approximately 90% of the area has been cleared and cultivated for dairying and grazing purposes. The remainder is still covered with a scrubby natural vegetation.

The Delamere area lies in the 20 to 25 inch rainfall belt with most of the rain falling in the winter months. The prevailing winds are south-westerlies as indicated by the growth shape of many trees, particularly those on the crests of high ridges.

### INVESTIGATION METHODS

The area is photographed on 9" x 9" Aadastra air photos with an approximate scale of 1 inch = 1320 feet. A slotted template was made using these photos with Bullaparinga Hill and Black Bullock Hill as control points. The template was set to a scale of 4 inches = 1 mile and from this a base map was drawn on kodatrace.

#### (a) Field Procedure

Due to the poor outcrop the majority of the mapping was done by investigation of all water courses and road cuttings. Correlation of lithological units from creek to creek was then carried out. The harder bands which consist of quartzites, marbles and mottled limestones were followed along the strike as far as possible.

Structural elements such as bedding, foliation and lineation attitudes were recorded on the geological map. These have been studied and discussed under the Structural Geology of this paper.

#### (b) Laboratory Procedure

A fact map from the field data was compiled and from a careful study of the rock units various beds were correlated and the geological map was compiled.

Field samples were described and selected specimens were microscopically examined.

Chemical analysis of the Heatherdale Shale was done to determine the  $P_2O_5$  content of the nodules and the whole bed.

Statistical analysis of the Permian glacial sands was done to study the degree of sorting and other sedimentary features.

### STRATIGRAPHY

The most recent published work carried out in the Fleurieu Peninsula is by Campana and Wilson (1955) and they have compiled a section of the sediments of the Adelaide Geosyncline in the Second Valley area. The author of this paper has measured a section in Stockyard Creek and correlated the rocks with the Cambrian type section at Sellick Hill (Abele and McGowran 1959) and the Adelaide System Subdivision (Mawson and Sprigg 1950). The geological record indicates there was continuous sedimentation in the Adelaide Geosyncline in the Delamere Area.

The Proterozoic, Cambrian and Kanmantoo Group rocks are geosynclinal sediments and have been folded to form one limb of a large recumbent anticline. They have been slightly metamorphosed. The Upper Proterozoic beds are a monotonous sequence of quartzites, siltstones and phyllites found to be approximately 3500 feet thick in Stockyard Creek. The Lower Cambrian beds are about 1800 feet thick and are predominantly limestones with shales forming the upper formation. These beds extend from the north to the south on the eastern side of the area. The Kanmantoo Group is composed of meta-greywackes and meta-arkoses, and outcrops on both sides of the area studied. Part of this has been correlated with the Carrickalinga Head formation.

The low valleys of the area have been filled with Permian fluvio-glacial sediments, some of which appear to have been reworked to some degree.

The high plateau on the eastern side is the remnant of an old land surface which is indicated by a covering of lateritic material of recent age. Table 1 shows the stratigraphy of the Delamere area.

#### STURT GROUP

The Sturt Group rocks outcrop in the north-western corner of the area. A study of the lithology and the facings in this portion revealed the area is a straight stratigraphic sequence.

The Sturt Group consists of the following formations:-

- (1) Brighton Limestone
- (2) Tapley Hill Slate.

The lower boundary of the Sturt Group is a thrust fault with the Kanmantoo Group rocks being thrust from the west over this group.

#### TAPLEY HILL SLATE (A229/1)

Good exposures of this formation occur in Stockyard Creek but it is quickly faulted out to the south by a large thrust fault trending in a north-south direction.

The rock is a dark grey shaly siltstone which has been slightly metamorphosed to give a phyllitic appearance on the bedding plane. The phyllitic appearance is due to patches of finely recrystallized biotite which shows a marked lineation parallel to the other lineations found in the area to the south. The bedding is very poor and is only indicated by slight lithological changes from more phyllitic appearing layers to layers consisting of more granular quartzose material. These layers vary from 1 mm. to 5 mm. in thickness and in some portions indicate differential compaction about the harder more massive quartzose layers. Most of the fractures and bedding planes that have opened up have coatings of limonitic material. The phyllitic layers consist of fine grained

TABLE 1  
Stratigraphy of the Delamere Area

<u>AGE</u>	<u>ROCK UNITS</u>	<u>LITHOLOGY</u>	<u>FOSSILS</u>	
Quaternary	—	Laterite		
	UNCONFORMITY			
Permian	—	Fluvio-glacial clays sands and boulders		
	UNCONFORMITY			
Cambrian	Kannantoo / Carrickalinga Group / Head Greywacke	Greywacke		
	Heatherdale Shale	Carbonaceous Shale		
	Fork Tree Limestone (Marble Phase)	Upper Member  Lower Member	Mottled Limestone  Marble	
	Sellick Hill Limestone	Mottled Limestone	Hyolithids	
	Wankonda Formation	limestone member  hyolithes sandstone	Marble  Mottled Limestone and Sandstones	Hyolithids
Proterozoic	Mt. Terrible Formation	Calcareous Sandstone Siltstones and Phyllites		
	Marino Group	Phyllites, Siltstones and Quartzites		
	Sturt Group	Limestones, Dolomites Siltstones and Quartzites		

sericitic material and patches of biotite 1 to 2 cms. long and  $\frac{1}{2}$  to 1 cm. wide. The bedding parallels the trend of the other beds throughout the area. The rock shows a very poor cleavage and this may be a joint. It is a non-calcareous rock.

The upper boundary of this formation is not sharp but transitional and it grades into a flaggy limestone which is the lowest unit of the Brighton Limestone equivalent. An arbitrary boundary was picked by the author and the formation was measured to be 215 feet thick in Stockyard Creek.

### BRIGHTON LIMESTONE

This is a calcareous sequence which varies greatly between the boundaries. The author has divided the formation into five units in the Stockyard Creek section but does not recommend that they be used for correlation as the units change quickly along the strike. The sequence cannot be recognised in No Where Else Creek to the north.

The limestone subdivisions with their corresponding thickness found in Stockyard Creek are tabulated below.

Calcareous shale	10'
Calcareous shaly siltstone	105'
Dolomite	34'
Marble	50'
Flaggy to shaly limestone	220'

#### (a) Flaggy to shaly limestone (A229/2)

This unit is stratigraphically immediately above the Tapley Hill Slate and is a mid-grey coloured rock of fine grain size. The bedding is very poor and is only shown by slight changes of more granular limestone layers to layers containing more micaceous material. The rock shows a good bedding plane parting and this is the only good break exhibited. These partings occur in the micaceous layers and a good lineation, which parallels other lineations in the area, is shown on these partings. The bedding plane is

cut at right angles by tension gashes which are filled with calcite and siderite. The unit has been slightly metamorphosed and changes abruptly into a massive white marble.

(b) The marble unit (A229/3)

This is a massive white granular marble. The grain size is fairly constant of about 1 mm. in diameter. Practically no bedding is shown within the unit. A few fractures in the rock show alteration to siderite and within a few millimetres of these pseudomorphs of limonite after pyrites of about 1 mm. in diameter are present.

(c) Dolomite (A229/4)

Stratigraphically overlying the marble with a sharp contact is a dolomite unit. This is a massive bed of medium grey colour; small light coloured patches give it a weak mottled effect. It consists entirely of pure dolomitic material apart from small pseudomorphs of limonite after pyrites which are about  $\frac{1}{2}$  mm. in diameter. The grain size of the dolomite is indeterminable in the hand specimen. The rock weathers to a light buff colour on the surface.

(d) Calcareous shaly siltstone (A229/5)

Overlying the dolomite layer is a dark grey strongly calcareous shaly siltstone of fine grain size. This is a massive bed and shows a weak lineation on the shaly surface. The shaly parting is poor and micaceous material is present on the surfaces. Calcite veins up to 1 mm. thick cut across the rock and these are approximately at right angles to the shaly parting but their surfaces are irregular.

(e) Calcareous shale

Immediately above the calcareous siltstone is a thin bed of calcareous shale. This bed is very similar in lithology to the siltstone below it but the shaly nature is better developed and more marked. The top of this bed is the top



of the Brighton Limestone and also the top of the Sturt Group. It forms a sharp contact with the Marino Group.

The whole of the Sturt Group is rapidly faulted out to the south of Stockyard Creek and only the Dolomite and Marble units show outcrop on the hillsides.

MARINO GROUP

The author has divided the Marino Group into fourteen lithological units in the Stockyard Creek section and most of these can be identified in the area to the south. This has been done for the purpose of description and these can be grouped into six divisions which may be of use for regional correlation as they also extend into the area in the north. The subdivisions of the sequence with the thicknesses are tabulated below.

	<u>Thickness</u>	<u>Division</u>
Interbedded quartzites and phyllites	310'	6
Phyllite	1200'	5
Siltstone	27'	4
Calcareous siltstone	395'	
Quartzites	85'	3
Greywacke	40'	
Calcareous siltstone	20'	
Phyllites	75'	
Interbedded quartzites and shales	155'	
Shaly siltstone	55'	2
Calcareous siltstone	15'	
Marble	10'	
Calcareous siltstone	4'	
Interbedded quartzites and siltstones	485'	1

The beds are conformable throughout this group and most of the contacts in Stockyard Creek are well defined, however in the area to the south due to poor outcrop many of these contacts cannot be found but the six divisions are easily noticed.

(a) Division 1

The lowest division consists of interbedded quartzites and siltstones (A229/6). It is a dark grey rock predominantly of silt grain size. The silty material consists of quartz and micaceous material of which the main portion is biotite. Interbedded with the silty material are sandy and shaly layers. The sandy layers are a light buff colour consisting almost entirely of quartz and these form a gradational boundary with the silty layers. The small bands, up to 3 cms. thick, tend to lense out rapidly while the thicker bands are much more continuous. The shaly layers show good bedding by colour differences from light to dark grey. The shales have been slightly metamorphosed giving the rock a weak phyllitic appearance due to recrystallization of the micaceous minerals which consist predominantly of biotites and show a weak lineation. The shale layers cleave readily parallel to the bedding but the coarser grained layers tend to fracture irregularly. Open tension gashes occur at right angles to the bedding. Pseudomorphs of limonite after pyrites occur scattered throughout this unit.

(b) Division 2

The second division conformably overlies the first and it consists of a calcareous siltstone (A229/8) containing a prominent pale pink saccharoidal marble (A229/7) lense in the lower half. The marble has a massive texture and there is no evidence of the bedding. The siltstone is the same above and below the marble and is a dark grey colour consisting of muscovite biotite and quartz and is strongly calcareous. It shows poor thin bedding and breaks with an irregular fracture. The unit as a whole can be traced easily along

the strike, but in No Where Else Creek to the north-east the lithology has changed to an arkose. This is possibly equivalent to the Hallett Arkose (Dr B. Daily, personal communication).

(c) Division 3.

This is a clastic sequence containing rocks of medium to fine grain size. The lowest unit, a shaly siltstone shows poor outcrop and incomplete exposure in Stockyard Creek. It is a dark grey shaly rock and shows good bedding plane parting. It is slightly metamorphosed to give a weak phyllitic texture.

Overlying this unit is 155 feet of interbedded quartzites and shales (A229/9). The quartzites are a grey blue colour and show good bedding. In these, facings were found by use of current bedding. There is a good bedding plane parting giving a flaggy appearance. At right angles to the bedding are tension gashes of direction  $230^{\circ}$  and dipping  $65^{\circ}$  west; some are filled with siderite and calcite, others with biotite and chloritic material. The quartzites weather to a brown grey colour and in parts are stained with limonite. The shaly interbeds are phyllitic and are weathered to a light brown colour. The layer contains pseudomorphs of limonite after pyrites. Above this is 77 feet of blue grey phyllite which shows a marked lineation. Outcrop was only found in the creek and it is poor. It is a homogeneous unit throughout.

Conformably overlying the phyllites is 20 feet of calcareous siltstone (A229/10). This is a dark blue grey massive rock which has a concoidal fracture. The rock consists of quartz, biotite, calcite and small amounts of muscovite. It is of fine grain size and is equigranular. It has been recrystallized to a small extent and has a finely banded texture. The rock is hard and forms good outcrop and can be traced easily along the strike. This unit is overlain by 40 feet of greywacke which consists of interbedded grey shaly siltstones and dark grey quartzites. This is a soft rock and forms poor outcrop.

Stratigraphically above the dark fine grained sequence is a clean white quartzite (A229/11) which is the top of division 3. It is massive with an average grain size of 1 mm. Weak bedding is shown by a concentration of coarse grains and finer grains. The rock consists almost entirely of quartz, it is hard and forms good outcrop throughout the area. It outcrops in the western side of the area and forms the top of a prominent ridge. A mile south of Stockyard Creek it is overlain by Permian deposits as are other units of this division. The quartzite is 85 feet thick.

(d) Division 4.

This is predominantly a calcareous siltstone sequence apart from the top 27 feet which is non-calcareous. The lower calcareous unit (A229/12) is a mid-grey colour and consists of equal proportions of calcite, micas and quartz. Muscovite is the predominant mica and is associated with minor amounts of biotite. The quartz and calcite show no crystal form whereas the micas have a rectangular outline. The grain size is fine and the rock is weakly banded. In more phyllitic portions of the rock it is weakly lineated. This unit contains hard lenses which form good outcrop but the remainder is poor in outcrop.

The upper unit (A229/13) is non-calcareous and can be followed easily along the strike. It shows almost continuous outcrop and approximately a mile south of Stockyard Creek it is covered by Permian deposits. In Stockyard Creek it is displaced horizontally by about 100 feet by a fault striking at  $320^{\circ}$ . This unit is a lighter grey than the underlying unit and is massive in appearance; however in some specimens it does show weak banding. The rock is of fine grain size and consists of equal proportions of quartz and muscovite with minor amounts of biotite. The micas show a lepidoblastic texture and accessory amount of iron minerals are present.

(e) Division 5.

This is a monotonous sequence of phyllites (A229/14) measured to be 1200 feet thick in Stockyard Creek. It outcrops predominantly in the creek beds but there are several exposures on hillsides. South of Stockyard Creek it is covered by Permian sediments.

The rock is a medium to light grey colour composed mainly of sericite with biotite and quartz and accessory amounts of iron minerals. The sericite shows a lepidoblastic texture while the larger biotite grains show random orientation. The rock is of fine grain size and has a good phyllitic texture. The bottom 400 feet of this unit contains a high concentration of idiomorphic magnetite of about 1 mm. in diameter. Magnetite is present throughout the unit but the concentration falls off rapidly towards the top. The rock shows a good schistosity and this is parallel to the bedding and the rock has a marked lineation. The top half of this unit contains harder more quartzose bands some of which are clean white quartzites and show a boudinaged structure. The length of the boudins is parallel to the lineation. These quartzose bands have a maximum thickness of 4 inches.

(f) Division 6.

This unit consists of a sequence of interbedded quartzites and phyllites. The quartzites (A229/15) are massive and show poor bedding and some of these show ripple marks. In parts the quartzites are clean and white but in other parts they contain considerable iron minerals which have weathered to give the rock a red colour. Specularite is common on most of the joint planes. There are four quartzite bands in this sequence varying from 10 feet to 30 feet in thickness. They are hard and form continuous outcrop and to the south are covered by Permian deposits, and can be traced through the area to the north almost to Second Valley. This sequence is hard and forms a prominent ridge. The quartzites are strongly boudinaged and this is shown well in Stockyard Creek, with the length of the boudins parallel to the lineation.

The surrounding grey phyllitic material is fine grained and is relatively soft but it does contain thin hard silty grey bands. The phyllite is composed of quartz, muscovite, biotite and chlorite with the platy minerals exhibiting a lepidoblastic texture. The fine grained material only outcrops in the creek sections.

#### MT. TERRIBLE FORMATION

This is a clastic sequence composed of sandstones (A229/16A) and siltstone (A229/16B) and is slightly phyllitic in the lower portions. The formation is 160 feet thick and good outcrop is shown in Stockyard Creek; poor outcrop is shown elsewhere and at the northern boundary of the area gritty bands outcrop. The lower portion is a fine grained shaly siltstone which has a medium grey colour and lithologically it is very similar to the siltstones in division 6 of the Marino Group. This formation contains coarse gritty bands near the base which are arkosic. On going up the sequence it becomes slightly calcareous and about 30 feet from the top is a calcareous grit layer 8 to 10 feet thick. This layer is a red colour but weathers red due to the weathering of the iron minerals in the interstices. The top portion of the formation is sandy and is calcareous giving a limey sandstone. The top band is a coarse grained sandstone and is 10 feet thick, and near the top of this bed is a thin band about 3 feet thick which contains hyolithids. This is the oldest Cambrian fauna found in the area and the base of this layer is taken as the base of the Cambrian in the district (Dr B. Daily, in press).

The upper and lower boundaries are conformable with the contiguous beds. The base of the sandy layer containing hyolithids is a conformable contact and this shows continuous sedimentation across the Precambrian-Cambrian boundary. This formation shows very similar lithology to the sequence at Mt. Terrible where it was originally named, but its thickness is considerably less; however it does indicate similar environmental conditions of sedimentation.

THE CAMBRIAN SUCCESSION

WANGKONDA LIMESTONE (MARBLE PHASE)

This unit has been correlated with the lowest Cambrian limestone bed at Sellick Hill.

The formation is 270 feet thick with the lowest 40 feet consisting of blue argillaceous limestone showing a mottled appearance. The remaining 230 feet of the formation consists of marble of varying colours. 20 feet above the argillaceous limestone-marble contact is a light brown coloured sandy band (A229/17A), 10 feet thick. It is of medium grain size composed predominantly of quartz and with limonitic material in the interstices giving the bed a brown colour. The marble is of medium grain size (approximately 1 mm. diameter). Near the base below the sandy band it is a blue grey colour (A229/17B). Immediately above the sandy band it has a blue-grey and brown banded appearance (A229/17C), while at the top it is a homogeneous pink colour (A229/17D). South of Stockyard Creek it shows relatively good outcrop (Plate 1) except in the central portion of the area where no outcrop was found, and can be traced nearly to the southern boundary of the area where it is covered by recent soil and laterite. Both the top and the bottom boundaries are displaced 100 to 200 feet by minor faulting approximately at right angles to the strike of the bed.

Half a mile south of Stockyard Creek cross faulting has occurred moving the southern portion to the west bringing the Sellick Hill Limestone abutting with this formation. From this fault south only the upper pink coloured portion of the bed can be found, due to no outcrop of the lower portion. Above the sandy layer the formation is massive and all evidence of the original bedding has been destroyed by recrystallization due to effects of metamorphism.

SELLICK HILL LIMESTONE

This formation is stratigraphically above and in conformable contact with the Wangkonda Limestone. The rock is a mottled type limestone consisting of alternating bands of limestone and argillaceous material (A229/18). The limestone bands tend to be lenticular within the argillaceous bands (Plate 2). The argillaceous portion contains biotite muscovite and quartz in equal proportions with accessory amounts of iron mineralization. The micaceous minerals show a lepidoblastic texture and this gives the argillaceous portion a distinct phyllitic appearance. The calcareous faces consist of pure calcite, which is fine grained, and these show a distinct parallelism to the bedding which is also parallel to the schistosity of the argillaceous bands. Coarse grained veins of pure calcite about 1 mm. thick cut through these lenses and they too are parallel to the bedding plane.

The rock is a dark blue-grey colour but weathers to a buff colour which generally forms a thin veneer over the surface of the fresh rock. The formation is hard and forms fairly good outcrop from Stockyard Creek south; however to the north the outcrop is very sparse. To the south the unit is faulted by cross faults displacing it by 100 to 200 feet in both east and west directions. In the southern extremity of the area the formation is covered by recent soil and laterite. There are hard bands 2 to 4 feet thick within the unit which can be traced continuously (Plate 3). In parts the line is completely leached out leaving a non-calcareous shale which shows a coarse "sponge like" texture. In a small part of the area south of Stockyard Creek the holes have been completely closed up to give a pure shaly rock. The lowest 2 feet of the formation contains hyolithids which were found to be siliceous by X-ray methods. This portion contains thin sandy bands up to 3 inches in thickness. The formation was measured to be 440 feet thick in Stockyard Creek but was found to thin slightly to the south.



FORK TREE LIMESTONE

This formation has been lithologically correlated with the type section at Sellick Hill. The formation to the south of Delamere outcrops to the east of the main Cape Jervis road. The outcrop is poor at Delamere and here it crosses the main road. Just north of the town it is covered by Permian outwash deposits and recent alluvium. The formation consists of two members:

- (a) Upper member - mottled argillaceous limestone.
- (b) Lower member - massive banded marble.

(a) Lower member

This is a massive light coloured marble and is banded in parts. This formation conformably overlies the Sellick Hill Limestone and is variable within itself. The lowest portion is a massive white banded marble (A229/19A). This portion consists almost entirely of recrystallized calcite with minor amounts of interstitial quartz. The calcite is completely recrystallized with a maximum grain size of 1 mm. and an average grain size of 0.5 mm. diameter. On going up the sequence this member develops a banded appearance (plate 4) and near the top it is a coarsely crystalline grey and white banded marble (A229/19B) with sericitic layers parallel to the bedding planes. The sericite layers are strongly lineated. The banding has straight and sharp contacts and show a constant thickness; this is most probably remnant of the original bedding and the calcite grains are elongated parallel to this. In Stockyard Creek this member was measured to be 585 feet thick. In the southern portion of the area the upper boundary of this member is vague as there is no outcrop of the upper member.

(b) Upper member

This is a typical mottled argillaceous type limestone (Plate 5) with dark blue grey bands of limestone interbedded with grey brown bands of argillaceous material (A229/20).

The limestone bands compose upward of 70% of the rock and the calcite is fine grained. The argillaceous layers are composed predominantly of sericite with minor amounts of limonite.

The member was measured to be 40 feet thick in Stockyard Creek where it shows good outcrop on the valley sides. The member can be distinguished in the next three creeks to the south but further south it is not seen due to soil cover.

The Fork Tree Limestone is thinner in the south of the area and this is apparently caused by sedimentary effects.

The three Cambrian limestone formations previously discussed in this paper

- (1) Wangkonda Limestone
- (2) Sellick Hill Limestone
- (3) Fork Tree Limestone

represent the Delamere Marble as described by previous workers.

#### HEATHERDALE SHALE

This formation conformably overlies the Fork Tree Limestone and the lower boundary is transitional. The upper boundary is taken as the base of the overlying conformable greywackes.

This formation consists of grey carbonaceous shales (A229/21). The rock shows very poor bedding, there is no well defined cleavage and it breaks with an uneven fracture.

It is composed predominantly of quartz, biotite, muscovite and sericite with black carbonaceous material. The presence of sericite indicates low grade metamorphism, by recrystallization of the clays to sericite. No calcareous matter is present and no fossils have been found in the formation in this area.

Black earthy nodules are scattered throughout the formation and these show no preferred orientation and are not continuous along the strike. In Stockyard Creek there are very few nodules while in the creeks to the south they are abundant.

The nodules are composed of carbon, apatite  $\{Ca_4(CaO)(PO_4)_3\}$  and goyazite  $\{Ca_3Al_{10}P_2O_3 \cdot 9H_2O\}$  (determined by Dr B.J. Skinner). The nodules are roughly spherical and vary in size from  $\frac{1}{2}$  cm. diameter to 1 cm. diameter. Some of the nodules have muscovite and sericite coatings. The unit is homogeneous throughout.

The outcrop is very poor and is found only on steep hillsides and in deep creeks and in several of these it is weathered almost to a black soil. Most of the outcrop is deeply weathered and appears as a lighter grey colour than the fresh rock.

In Stockyard Creek a section was measured by pacing and a thickness of 320 feet was found.

It outcrops about  $\frac{1}{2}$  mile to the east of the main Cape Jervis road. In the northern end of the area it is covered by Permian sands and recent deposits; to the south by laterite.

Analyses for  $P_2O_5$  content have been carried out on many specimens from the formation. The results are listed in Table 2.

TABLE 2

<u>Location</u>	<u>Type of Sample Analysed</u>	<u>% P<sub>2</sub>O<sub>5</sub></u>
$\frac{1}{4}$ ml. south of Delamere	isolated nodule	1.47%
$\frac{1}{2}$ ml. south of Delamere	shales immediately adjacent to the nodules	0.05%
$\frac{1}{4}$ ml. north of Stockyard Creek	bulk sample taken across strike	0.19%
Stockyard Creek	"	0.19%
$\frac{1}{2}$ ml. north of Delamere	"	0.14%
$\frac{1}{2}$ ml. south of Delamere	"	0.312%

GREYWACKES

(a) Conformably overlying the Heatherdale Shale is a thick sequence of interbedded shales, siltstones and quartzites. The unit is seen only on the eastern side of the area and forms good outcrop to the north but to the south it is covered by laterites and can only be found on the valley sides.

The rock is composed of quartz, with an average grain size of 0.2 mm. although many grains are much smaller. Micaceous material of which biotite is most abundant, with muscovite and sericite is also present. The micas/are of smaller grain size than the quartz grains and show a distinct lepidoblastic texture. Accessory amounts of iron minerals

are present. Several grains of plagioclase felspar are present and these are assumed to be of detrital origin. The rock is a meta-greywacke (A229/22). The bedding is well shown by lithological differences and the rock breaks giving a smooth surface along these. The lepidoblastic nature of the micas has caused the developments of a schistosity plane which is parallel to the bedding and the unit has been correlated with the Carrickalinga Head greywacke.

(b) Outcropping to the west of the postulated thrust on the western side of the area is a grey silty rock but this rock appears more quartzose (A229/23) than the greywackes in the east of the area. Sedimentary banding is shown by concentration of quartzose rich layers giving them a light buff colour. The harder bands, which form good outcrop are siltstones consisting of a high percentage of quartz with minor amounts of biotite and muscovite, showing random orientation, and iron minerals. All the rocks of this unit contain accessory amounts of iron minerals. The softer bands are finer grained and contain equal proportions of micas and quartz. The micaceous minerals in these softer bands show a lepidoblastic texture, and the rock shows a weak schistosity in the south, but to the north becomes more marked and forms a plane along which the rock breaks readily. Some specimens contain enough felspar to allow the rock to be classified as a sub-arkose with orthoclase and plagioclase in equal proportions.

#### PERMIAN

The Permian deposits are predominantly glacial outwash deposits except for a small portion in the south-west corner of the area which is glacial till.

The outwash deposits which have been statistically analysed (Fig.1) are well sorted, and has the following sedimentary coefficients:-

GRAIN SIZE ANALYSIS OF PERMIAN SAND.

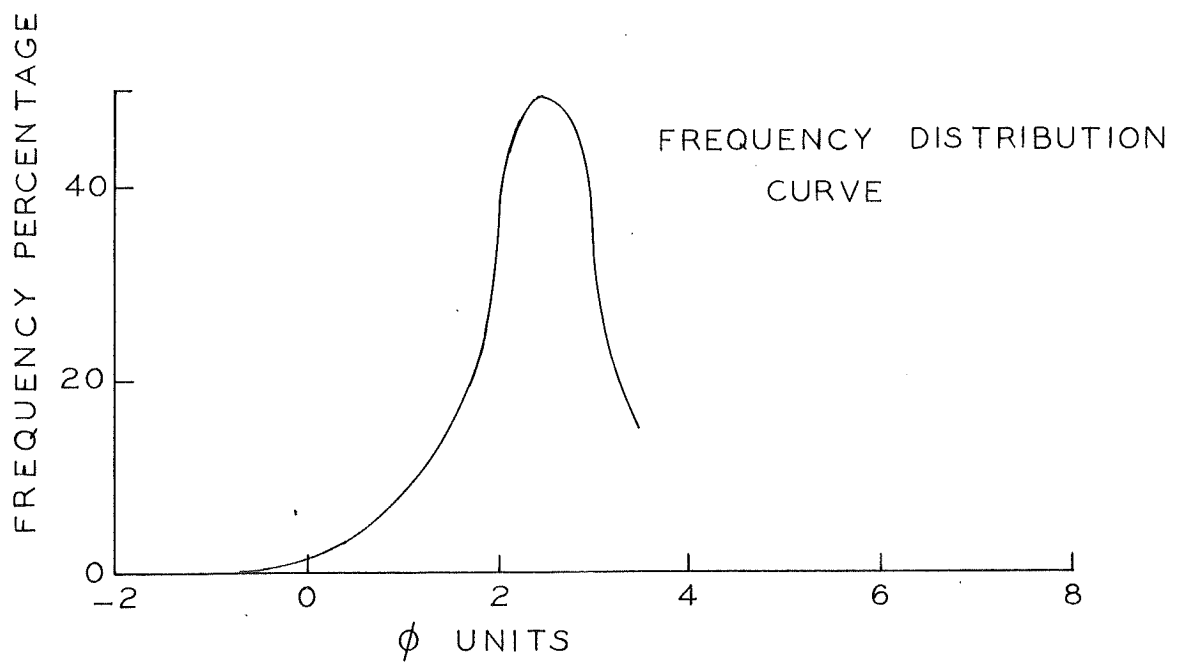
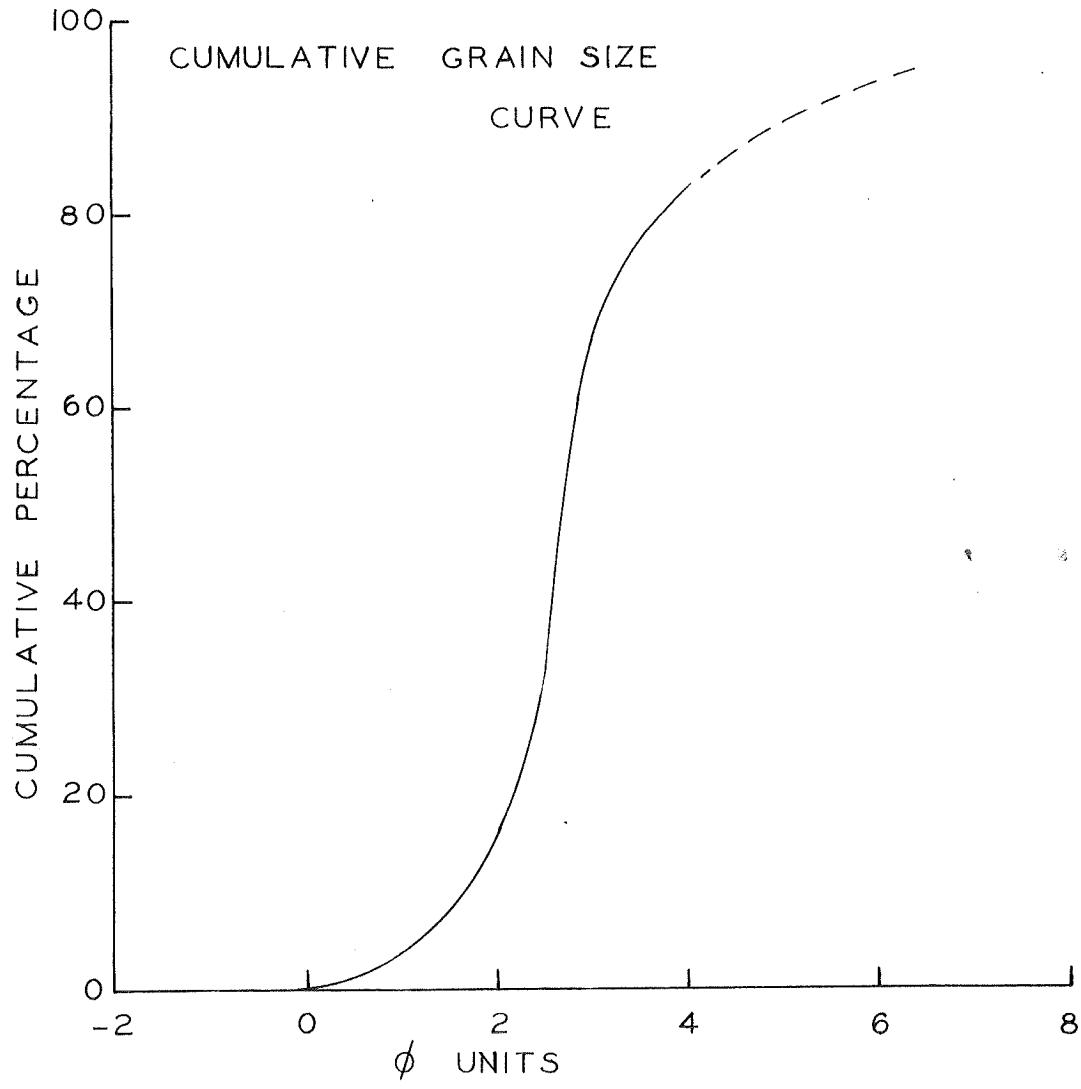


FIGURE I.

Sorting coefficient	1.262
Median	2.46 $\phi$ units
Skewness	1.197
Kurtosis	0.1924

Using these, the unit is classified as a well sorted fine sand with finer admixture exceeding coarser admixtures. It consists entirely of well rounded quartz grains showing a high sphericity with clayey material filling the interstices (A229/24), and in parts this has been stained by limonitic material. In parts the unit shows good layering and this coupled with the features exhibited by the quartz grains, is characteristic of a shore line deposit.

The glacial till (A229/25) is a layered deposit with bands of quartz grains and clayey bands. This unit contains large erratics of granite up to 2 feet in diameter and smaller erratics of greywacke. The finer material consists of well rounded quartz grains showing high sphericity with clay filling in the interstices. This is not as well sorted as the glacial outwash deposits.

Both units are unfossiliferous and good outcrop is shown in water courses which have cut deeply into these deposits. In most outcrops these units were saturated with water and are therefore possible aquifers.

#### RECENT (?)

#### Lateritic crust of the Uplift<sup>ed</sup> Plateau

This occurs on the high plateau to the east of the main road and forms a cap on the Greywackes and Heatherdale Shale.

It has a massive appearance and it is a reddish brown silty rock. Sub-angular to sub-rounded quartz constitutes about 20% of the rock. Minor amount of muscovite is present showing random orientation. Some portions appear metallic

while others are almost completely altered to limonite and haematite. The rock is moderately porous and the larger holes are lined with concretionary iron minerals showing botryoidal form.

This occupies the old peneplane that existed before the Tertiary Uplift.

### STRUCTURE

The elements of structure, bedding, foliation and lineation, have orientations remarkably constant throughout this area.

Previous investigations in the area interpreted the structure as being a large recumbent anticline with the axial plane direction approximately parallel to the strike of the beds.

Detailed stratigraphic work in Stockyard Creek showed no repetition of strata but a continuous sedimentary sequence. Several facings found in the quartzite beds above the Brighton Limestone showed no overturning.

East of the major thrust trending north-south on the western side of the area the beds show a constant attitude. The Cambrian sequence although recrystallized showed evidence of original bedding of strike  $205^{\circ}$  to  $220^{\circ}$  and dipping at  $25^{\circ}$  to  $40^{\circ}$  east.

The Proterozoic rocks show a higher grade of metamorphism and bedding is only visible in the non-phyllitic layers. The bedding attitude is parallel to the overlying Cambrian sequence.

Cleavage and foliation planes in the phyllites were found to have the same attitude and this may be parallel to the axial plane of some major structure controlling the attitude of the beds in this area. This attitude is the same as that of the bedding.



In the foliation planes of the phyllites, mica flakes showed a distinct parallelism giving a lineation of direction  $145^{\circ}$  and dip  $25^{\circ}$  south-east. This was found to be constant in all the Proterozoic phyllites.

The banded quartzite unit just below the base of the Cambrian is boudinaged and the attitude of these boudins, which is also constant in this unit, is parallel to the lineation in the phyllites.

Several small drag folds found in the Cambrian limestones have their fold axes parallel to the lineation in the phyllites and the length of the boudins in the quartzites. These structures are only about six inches across and <sup>are</sup> only shown by the compositional banding. Lineations are also shown on the bedding planes of the Massive Fork Tree Limestone. These are most prominent in the upper banded portions of this unit and their attitude is parallel to the other lineation. The Brighton Limestone is also lineated.

West of the major thrustfault, the Kanmantoo rocks have a strike of  $210^{\circ}$  to  $220^{\circ}$  and a dip in the southern portion of the area of  $35^{\circ}$  to  $50^{\circ}$  east. In the northern portion of the area this dip increased to  $65^{\circ}$  to  $80^{\circ}$  east.

At a distance of greater than 300 yards west of the thrust fault the phyllitic layers of the Kanmantoo rocks show cleavage and foliation parallel to the bedding of the more quartzose bands. On approaching the thrust from the western side the cleavage was found to turn and the direction to become almost normal to the direction of the thrust. The cleavage near the fault has a strike of  $250^{\circ}$  to  $260^{\circ}$  and dipping at  $30^{\circ}$  to  $40^{\circ}$  to the south.

Faulting occurs on both major and minor scales in the area.

To account for the contact phenomenon of the Kanmantoo with the Adelaide Supergroup in the western portion of the area a thrust fault dipping westward is postulated. To the

north the Brighton limestone equivalent is pinched out rapidly which indicates a tectonic effect. In the area examined there are no effects of faulting, such as brecciation and the actual position of the fault is rather obscure. There is no morphological feature associated with it. In the southernmost portion of the area near the Cape Jervis-Victor Harbor road junction there is an elongated area covered with quartz float which may bear some relation to the fault.

Several minor faults occur in the area. Four of these were noticed in the Cambrian Limestone sequence. These trend in a direction of  $280^{\circ}$  to  $310^{\circ}$ , that is approximately at  $90^{\circ}$  to the thrust fault.

These may be conjugate faults to the thrusting. No information about their dip could be found and were represented only by bedding contact displacements of about 100 feet to 200 feet. These faults fade out along their length and this may be due to a scissor action. In some small limestone quarries many smaller displacements of beds by 1 to 3 inches occur. These have a direction parallel to the minor faults and are vertical.

The Permian boundaries are not displaced by the faulting and the faulting may then be aged as occurring after the folding of the Cambrian and Precambrian rocks but before the deposition of the Permian fluvio-glacial sediments. This applies to the major thrust fault as well as the minor faults.

### ECONOMIC GEOLOGY

#### MINERALIZATION

The only evidence of mining is in the north-west corner of the area, 200 yards south of Stockyard Creek in the marble and dolomite subdivision of the Brighton Limestone. Spoil

from the diggings showed siderite rich and gossanous material but apart from this no mineralization was found.

The interbedded quartzites and phyllite above the Brighton Limestone contain pseudomorphs of limonite after pyrites and bands consisting entirely of pyrite boxworks, 3 to 4 inches wide have been found. The abundance of these pseudomorphs is low and do not indicate an underlying ore body.

The massive phyllite bed is very rich in magnetite in the lower 300 feet but again due to abundance this is not of any economic significance.

The Heatherdale Shale Formation contains black carbonaceous nodules with apatite and goyazite and this formation has been analysed for  $P_2O_5$  content.

Present mining and extraction methods could not win the phosphate minerals economically from this unit.

### INDUSTRIAL ROCKS

Many hard quartzite bands of Proterozoic age would be suitable for building purposes but there is poor access to them and reserves are not large.

The Cambrian Limestones contain thick bands of pure marble and would be suitable for fluxing material but access and transport would increase the cost of mining considerably.

The limestones and marbles are generally very hard and have been used locally for buildings and road material.

### HYDROLOGY AND WATER SUPPLY

The area is in the 25" to 30" rainfall region of the State.

Stockyard Creek is a permanent stream and in summer time the average flow is 16,000 gallons/hour and is the main drainage of the area.

The Permian sands throughout the area are saturated with water and when exposed in creeks discharge considerable quantities of water. No water seeps were found in the other rocks.

Water erosion is strong in the area with deep water courses cut into valleys; some hills and spurs have had the alluvium removed from them exposing the country rock.

#### ACKNOWLEDGEMENTS

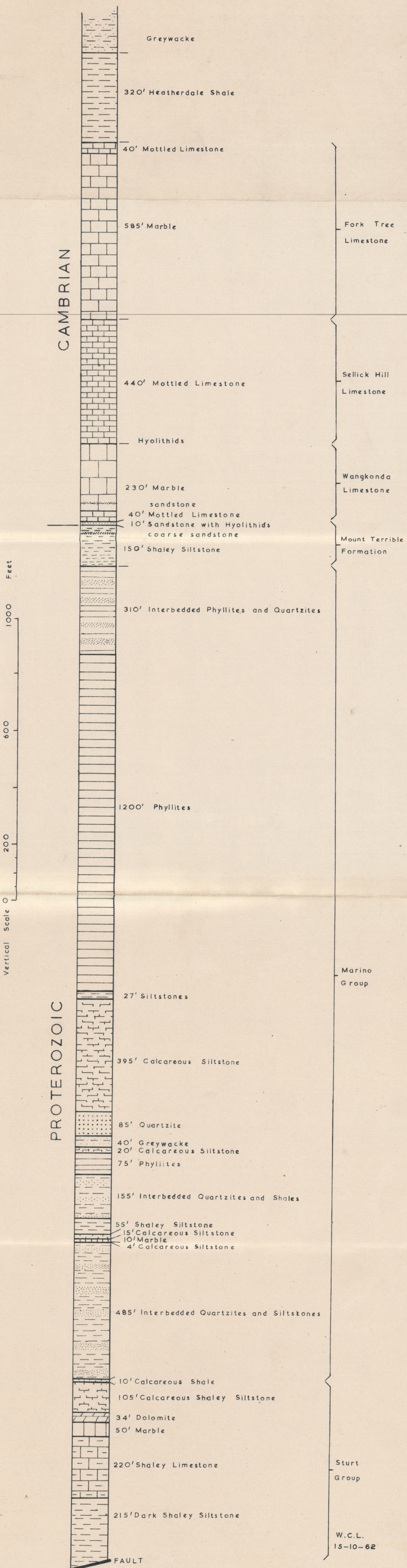
I would like to thank Mr J.L. Talbot for suggesting this project and for help on various aspects pertaining to the structural geology of the area. To Dr B. Daily I am particularly indebted for his constant help and discussions on various aspects of the project, particularly those related to stratigraphic problems and general field geology. I would also like to thank Mr R.D. Drayton, who worked in conjunction with me, several of the staff members and research students of the School of Geology of the University for helpful discussions and constructive criticisms on various aspects of geology and on the writing of this paper. I also extend my appreciation to Miss B.G. Storer who typed the manuscript and to Miss A.M.C. Swan and Mr W. Mitchell for advice on many of the drafting problems.

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# STOCKYARD CREEK SECTION DELAMERE



W.C.L.  
15-10-62





Plate 1.  
Outcrop of Wangkonda Limestone



Plate 2.  
Lenticular limestone bands within argillaceous bands  
of the Sellick Hill Limestone.



Plate 3.  
Hard bands within the Sellick Hill Limestone.



Plate 4.  
Banded portion of the lower member of the Fork Tree  
Limestone.





Plate 5.  
Argillaceous appearance of the upper member of the  
Fork Tree Limestone.