DEPARTMENT OF MINES
SOUTH AUSTRALIA
GEOLOGICAL SURVEY

THE GEOLOGY OF THE QUORN MILITARY SHEET

(Explanation of the Geological Map)

by

R. G. SHEPHERD, B.Sc., Assistant Geologist

and

D. THATCHER, B.Sc., Assistant Geologist.

REPORT OF INVESTIGATIONS No. 13

Issued under the Authority of
The Hon. Sir A. Lyell McEwin, K.B.E., M.L.C., Minister of Mines

1959

PUBLICATIONS OF THE SOUTH AUSTRALIAN DEPARTMENT OF MINES AND GEOLOGICAL SURVEY

ANNUAL REPORTS OF THE DIRECTOR OF MINES AND GOVERNMENT GEOLOGIST

WARD, L. KEITH—
Annual Reports, 1912-1943 (issued as Parliamentary Papers).

DICKINSON, S. B.—
Annual Reports, 1944-1955 (issued as Parliamentary Papers).

GEOLOGICAL MAPS

Geological Map of South Australia, coloured ; scale, 32 miles to 1 inch. 1953.
Structural Geological Map of South Australia, coloured : scale, 32 miles to 1 inch. 1953.
Regional Geological Maps (Military Sheets), coloured—
Scale 1 mile to 1 inch: Adelaide, Alexandrina, Algebuckina, Angepena, Anna, Arno, Ballara, Boorthanna, Cadlareena, Chandler, Conway, Copley, Corunna, Coulta, Cowell, Cummins, Darke, Echunga, Ernabella, Farina, Gambier-Northumberland, Gawler, Giles, Glenorchy, Glynn, Indulkana, Jervis, Kalabity, Kapunda, Kiana, Kingston, Lincoln, Lyndhurst, Mannum, McGregor, Middleback, Myrtle, Neill, Nilpinna, Olary, Plumbago, Quorn, Robe, Roopena, Rudall, Serle, Sleaford, Tumby, Umbum, Verran, Yankalilla, Yeelanna, Wangary.
Scale, 4 miles to 1 inch : Kingscote, Penola, Lincoln, Upper Eyre Peninsula.
All maps, price 2s. 6d. each.

REPORTS OF THE GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

1. WARD, L. KEITH, and JACK, R. LOCKHART—
The Yelta and Paramatta Mines (with plans). 22nd March, 1912. Price, 3s. 6d.

2. JACK, R. LOCKHART—
The Mount Grainger Goldfield (with map). 25th June, 1913. Price, 3s. 6d.

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The Yudnamutana Mining Field (with plans and map). 8th December, 1915. Price 3s. 6d.

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2. WARD, L. KEITH—
The Possibilities of the Discovery of Petroleum on Kangaroo Island and the Western Coast of Eyre's Peninsula (with maps). 24th January, 1913. (*Out of print*).

3. JACK, R. LOCKHART—
The Geology of the County of Jervois, and of portions of the Counties of Buxton and York, with special reference to Underground Water Supplies (with maps). 31st January, 1914. (*Out of print*).

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The Supposed Oil-bearing Areas of South Australia (with maps). 24th February, 1915. (*Out of print*).

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The Geology and Prospects of the Region to the South of the Musgrave Ranges, and the Geology of the Western Portion of the Great Australian Artesian Basin (with maps).
Also Appendices on " The Flora of the Country between Oodnadatta and the Musgrave and Everard Ranges ", by Captain S. A. WHITE : and on " Results of Magnetic and Astronomical Observations", by G. F. DODWELL. 6th September, 1915. (*Out of print*)

6. JACK, R. LOCKHART—
The Geology of the Moonta and Wallaroo Mining District (with maps). 22nd May, 1917, (*Out of print*)

7. JACK, R. LOCKHART—
The Phosphate Deposits of South Australia. 19th May, 1919. (*Out of print*).

8. JACK, R. LOCKHART—
The Salt and Gypsum Resources of South Australia. 1st December, 1920. (*Out of print*).

9. JACK, R. LOCKHART—
The Iron Ore Resources of South Australia (with maps). 6th February, 1922. (*Out of print*).

10. JACK, R. LOCKHART—
The Building Stones of South Australia. 12th March, 1923. Price 5s.

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Some Developments in Shallow Water Areas in the North-East of South Australia (with maps). 15th December, 1924. (*Out of print*).

12. JACK, R. LOCKHART—
Clay and Cement in South Australia. 17th May, 1926. (*Out of print*).

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Pigment Minerals in South Australia. 26th March, 1928. Price 5s.

14. JACK, R. LOCKHART—
Geological Structure and other Factors in Relation to Underground Water Supply in Portions of South Australia (with maps). 13th May, 1930. (*Out of print*).

15. JACK, R. LOCKHART—
Report on the Geology of the Region to the North and North-West of Tarcoola (with map). 2nd February, 1931. (*Out of print*).

16. SEGNIT, RALPH W.—
Geology of the Northern Part, Hundred of Macclesfield, with special reference to its Economic Aspects (with map). 10th March, 1937. Price 5s.

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Geology and Development of Ground Water in the Robinson Fresh Water Basin, Eyre's Peninsula (with map). 30th November, 1937. Price 5s.

18. SEGNIT, RALPH W.—
The Pre-Cambrian—Cambrian Succession. The General and Economic Geology of these systems in portions of South Australia (with maps). 26th October, 1938. Price 7s. 6d.

19. WARD, L. KEITH—
The Underground Water of the South-Eastern Part of South Australia (with maps). 28th December, 1940. Price 5s.

[*Continued on page* 3 *of cover*.

Geological Survey of South Australia.

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R. G. SHEPHERD, B. Sc.

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(ASSISTANT GEOLOGISTS)

The geological map of the Quorn Military Sheet, which this report describes, was published in 1956. Further copies of the map are available at a cost of 2/6 each from the Department of Mines, 169 Rundle St., Adelaide.

Letter of Transmittal.

Geological Survey Office,
Department of Mines,
Adelaide. S.A.

15th December, 1958.

Sir,

I have the honour to submit herewith for publication a report by R. G. Shepherd and D. Thatcher, Assistant Geologists on the geology of the Quorn Military Sheet.

The mapping which this report describes was done following the re-routing of the northern railway by-passing Quorn; and its purpose was to survey the potential economic mineral wealth of the district. The groundwater resources of the Willochra Basin, which lies on the western half of the sheet, have been described in an earlier report. While the survey did not locate any significant new mineral deposits, much valuable geological information has been compiled, having an important bearing on future geological investigations elsewhere in the State.

Following the publication of the geological map, and after the present survey had been completed, a small concealed sedimentary basin was discovered near Booleunda. The presence of coal in the basin opened up possibilities of economic deposits in the district, and recent Mines Department work has been aimed at testing this and one other small basin in the district. The east Boolcunda basin has been briefly described by W. Johnson, Senior Geologist, in an appendix to this report.

I have etc.

T. A. BARNES

Government Geologist

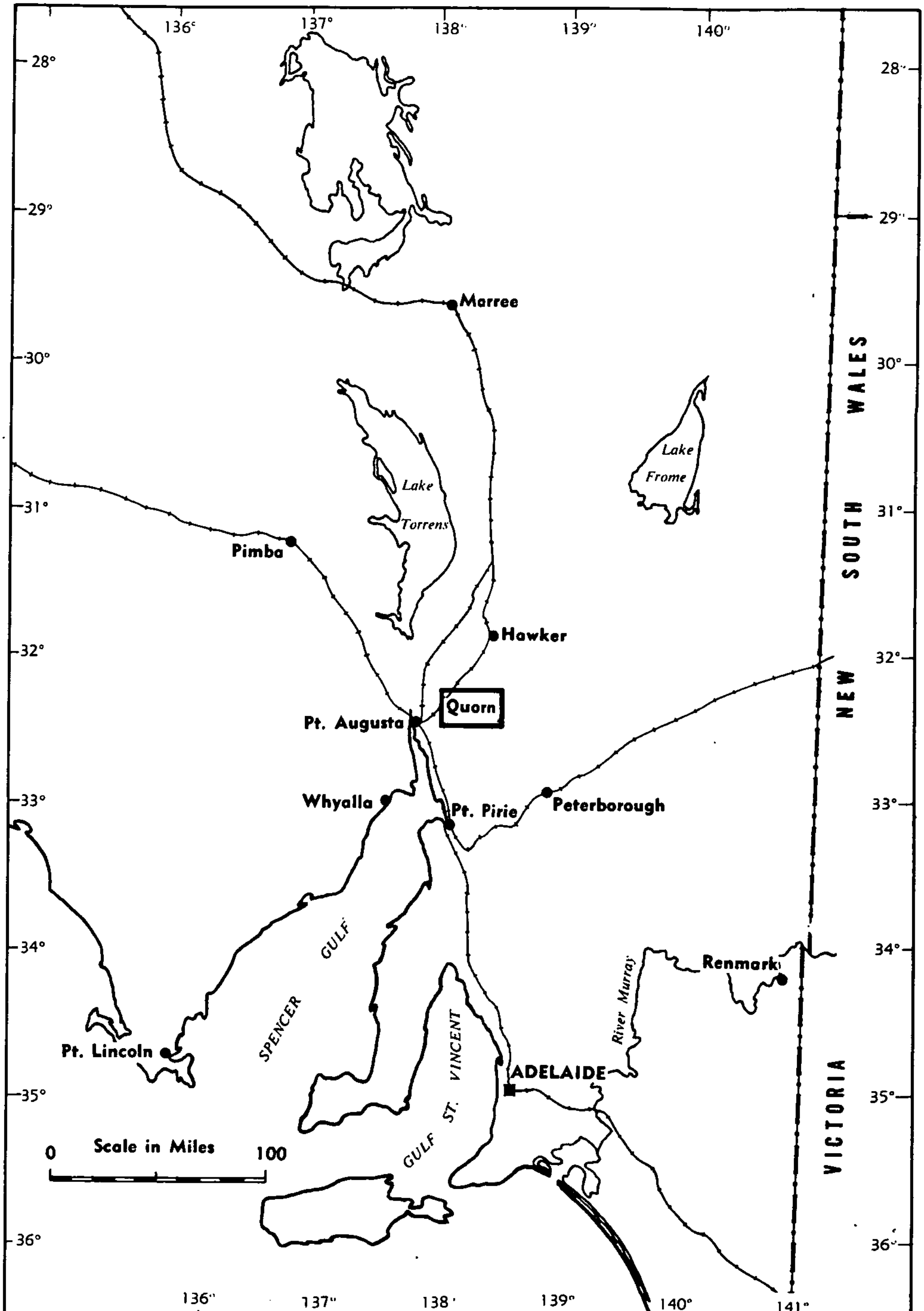
To the Hon. Sir A. Lyell McEwen, K.B.E., M.L.C.
Minister of Mines.

Submitted for approval to print as a Report of Investigation of the Geological Survey.

Approved.

A. LYELL McEWIN

Minister of Mines



LOCALITY PLAN

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Illustrations.

Introduction

The area covered by the Quorn military sheet lies in the mid-north of South Australia, between longitudes 138 deg. 00 min. and 138 deg. 30 min. and latitudes 32 deg. 15 min. and 32 deg. 30 min. The chief town is Quorn with a population of approximately 2000 people. Climatically the area is semi-arid; the mean annual rainfall of 12.99 inches at Quorn decreases eastwards to 11.94 inches at Carrieton (Trumble-1948). Mallee scrub with native pine clothes the higher ground while salt-bush is well developed on the plain, larger eucalypts grow along the main water courses. Clearing of the natural vegetation has accelerated soil erosion, such that deep gutters have been cut in the lower slopes of the hills by surface run-off following the infrequent, but often heavy, rains.

Quorn has been an important junction on the northern railway which in recent years has handled the coal produced at Leigh Creek. However a line has now been constructed which by-passes Quorn and links Port Augusta with the existing railway at Brachina - approximately 75 miles north-northeast of Quorn. This new route deprives Quorn of its principal function and the survey of the military sheet was undertaken with the object of finding economic minerals which might provide an alternative industry.

The Quorn one mile military sheet has been mapped by R. G. Shepherd, I. R. Campbell and D. Thatcher, under the direction of Dr. K. R. Miles. Field work was commenced in November 1953 and completed by July 1954. The base map used in this work was prepared on a scale of two inches to one mile from aerial photographs.

The geological map for publication has been prepared by the Drafting Section of the South Australian Department of Mines, using the Quorn one mile Military Sheet as a base.

General Physiography

Two distinct physiographic units occur in the area: centrally is the Willochra plain, which is bordered to the east and west by the hills of the Flinders Ranges.

The Willochra plain is an intermontane flat 10 - 15 miles wide, sloping gently from its margins towards the Willochra Creek, which is the main drainage channel of the area. This creek has a very low gradient and flows northwards by a meandering course towards Lake Torrens.

The ranges possess a diverse physiography due to a variety of rock types and structures, intermittently exposed to erosion since the early Palaeozoic, although the present erosion cycle is relatively young.

The most prominent land marks of the eastern ranges are Moockra Tower (2,550 feet above sea level) and Mt. Helen. These are parts of the Horseshoe Range; a bold outcrop of quartzite folded in a large pound structure. East of the Horseshoe Range the outcrop of argillaceous rocks gives rise to a lower and more gently undulating topography. This country is drained by the Pekina and Coonatto Creeks, the valley of the latter being followed by the Wilmington - Carrieton road. In the southeastern part of the Quorn sheet, tillitic rocks form a marked ridge trending north-eastwards. Ridge and vale topography continues eastwards over alternate bands of quartzite and dolomitic shales.

North of the Horseshoe Range the shallow southern pitch of an anticlinal fold gives rise to scarp and dip slope landforms (e.g. the Bluff) in the more resistant horizons. On the western limb of the anticline a band of quartzite rises to a steep hog-backed ridge (see Plate 11, fig. 2), faulted on its western margin against tillite. Approximately six miles to the west tillite forms the prominent feature of Round Hill. The country between is an area of low relief with shaley and silty rocks outcropping.

The most prominent landmarks of the western ranges are Mt. Brown (3,152 feet above sea level), the Devil's Peak and the Dutchman's Stern (see Plate 1, figs. 1 and 2). All lie just beyond the limits of the Quorn military sheet.

Mt. Brown is at the nose of an elongate northerly pitching syncline, with quartzite forming a rim of bold outcrops (see Plate 1, fig. 3). Younger rocks nearer the fold axis are obscured by alluvium in the valley of the Capowie Creek, which slopes gently northwards to Quorn. West of the syncline is the faulted and dissected area of the Devil's Peak. The Peak is a steep ridge of quartzite (see Plate 1, fig. 2).

North of Quorn is a high ridge of quartzite lying along the keel of the synclinal fold. Approximately 4,000 feet to the east is a less prominent ridge of quartzite. To the west the land surface is low and gently undulating over softer argillaceous beds, while further west the ground rises sharply to the rugged Dutchman's Stern Range and the Bluff, which are just beyond the boundaries of the Quorn sheet, to the west and north respectively.

Stratigraphy

Cainozoic

The youngest sediments of the Quorn area are the alluvial deposits of the creek channels.

In the smaller creek beds red silty clay with sand occurs. Bedding is usually absent. Locally, where the slopes are steeper than normal and a suitable source rock is nearby, these deposits may be intermixed with ill-sorted and sub-angular quartzite pebbles, exhibiting a crude bedding. In the deeper stream beds this alluvium may be exposed to a depth of eight feet.

In the larger creek beds a crude bedding is frequently visible in lenticular sandy and pebbly sediments. The alluvium is generally better sorted and the pebbles less angular than in the smaller stream beds. In places coarse conglomerates are cemented by a calcareous matrix, the maximum observed thickness is 15 feet. Such sections occur in Coonatto Creek.

Beneath the Willochra plain is a sequence of young sediments which are not exposed at the surface. The cores from three recent

View from the western side of the Willochra Basin near Acacia Creek looking southwest towards Mount Brown. In the right background is the Devil's Peak.

Fig. 1.

The scarp slope of the Devil's Peak (Pound Quartzite) viewed from the northeast. The upper shales lie below the flat foreground.

Fig. 2.

A view of the Waukarie Creek cutting across the massive current bedded quartzite on the western limb of the Quorn syncline. The axis of the fold lies in the middle distance and the quartzite of the eastern limb on the horizon.

Fig. 3.

PLATE I

hydrology test bores have been examined palaeontologically by Ludbrook (1954) and petrologically by Whittle (1954). Bore logs form Plate VIII of these notes. The sediments are chiefly mottled clays, sandy clays and clayey sands. The sediments thicken southwards from 400 feet in Bore No.1 to 525 feet in Bore No.3. Bore No.3 passed through brown carbonaceous silt and sand at 475 feet from the surface. Examination of this material by Pike (1955) has disclosed the presence of very numerous pollen grains, most of which are identified as nothofagus, indicating that the horizon is post-Eocene but pre-Pliocene.

The Willochra Basin sediments were evidently deposited in an intermontane piedmont environment. Most of the sediments penetrated by the test bores are fine in texture which is to be expected in the centre of the sedimentary basin furthest away from the upland source areas. That local forests bordering swamps developed early in the cycle is indicated by the carbonaceous sediments cut by Bore No.3.

Palaeozoic

Cambrian System

North of Quorn is a prominent quartzite which underlies the fossiliferous Archaeocyatha Limestone (outcropping 16 miles north of Quorn). Because of its lithology and position in the stratigraphic column it is correlated with the Pound Quartzite as described by Mawson from Wilpena Pound and elsewhere (Mawson 1938). In the Quorn sheet area this formation consists of a compact well cemented, fine to medium grained, white quartzite frequently interbedded with thin shale bands. In places it is felspathic and elsewhere ferruginous. Near the base the formation becomes coarser and sometimes conglomeratic.

Besides outcropping north of Quorn the Pound Quartzite is well exposed in the steep ridge of the Devil's Peak, five and a half miles southwest of Quorn (Mawson 1947). The horizon does not outcrop in the eastern ranges within the Quorn sheet area. Faulting prevents the full thickness of the formation being seen, but the quartzite reaches 1,000 feet north of Quorn.

Proterozoic

The placing of the boundary between the Adelaide and the Cambrian Systems has been discussed by Howchin (1922), Mawson (1939) and other workers. Following recent convention the base of the Pound Quartzite is taken as the base of the Cambrian succession. No evidence of unconformity has been found here or lower in the sequence.

The Adelaide System is represented in the Quorn area by up to 29,000 feet of sediments representing, it is believed, the equivalent of the type succession from the Marinoan to the Torrensian Series, although the base of the System is not exposed. Correlation with the type section of the system is considered as well established.

Marinoan Series

Upper shales

Below the Pound Quartzite is a sequence of multicoloured shales with interbedded thin calcareous and dolomitic rocks passing downwards to mottled shales. All of these are included under the designation upper shales which, north of Quorn, reach a thickness of 3,500 feet. In the western ranges the thickness of the mottled shales is about 400 feet, increasing four fold within the Horseshoe Range.

Massive current bedded quartzite

The lithology and stratigraphic position of the quartzite forming the prominent scarp feature in the two synclinal structures of the Quorn sheet suggest correlation with the quartzites described by Mawson from the A.B.C. Ranges (1939). The quartzite is a white, medium grained, compact rock, felspathic or kaolinitic in places. Interbedded shales are conspicuous in the middle and lower parts, but the higher horizons are massive quartzites exhibiting only current bedding. In the western ranges the thickness of the quartzite is approximately 3,600 feet decreasing to half this thickness on the eastern side of the Willochra plain.

Chocolate shales

A dominantly silty to argillaceous sequence with some sandstone horizons is grouped here as the chocolate shales formation.

The upper beds are predominantly grey siltstones and shales which in places are dolomitic. Chocolate shales are best developed in the western ranges at a horizon just below the massive current bedded quartzite. The more arenaceous rocks tend towards greywackes. Large scale mud cracks are found in this greywacke type just off the northern margin of the Quorn sheet in the western ranges.

Two sandstone horizons can be traced for considerable distances on both sides of the Willochra plain. Generally they do not give rise to prominent steps in the topography but their outcrop is indicated by areas of higher relief and also surface floaters of sandstone. They are light coloured rocks, fine to medium grained with occasional coarser layers.

In the lower beds the chief rock type is a chocolate to purplish shale frequently showing ripple marked bedding planes. Associated with these chocolate shales are numerous grey shales and also silty and sandy layers.

The total thickness of the chocolate shales is of the order of 11,500 feet in the eastern ranges, compared with 3,500 feet in the western.

An exposure in the Mt. Brown Creek, two and a half miles south-west of Forster Dam, shows numerous narrow, cord-like structures lying along bedding planes. The structures seen in situ (Plate lV, fig.1) lie along the troughs of ripple marks while those on a fallen block (Plate lV, fig.2) follow the crests. The structures are sinuous, describing regular arcuate curves and occasionally branching.

They are semicircular in cross section and are filled with siltstone similar to the remainder of the rock. The chocolate shales examples closely resemble American types illustrated in a paper by Wheeler and Quinlan (1951) who considered the structures to be of mud crack origin. An earlier worker, Faul, tentatively interpreted similar examples as the trails or burrows of some unknown type of organism (1948, 1949, 1950). In the present case, the regularity of the structures and their relation to the ripple marks would seem to suggest an inorganic origin.

also in flat-top qtes. N. of Pt Augusta

Disc-like structures (Plate V, fig. 2) have been found in the chocolate shales from one small exposure in a gutter one and a half miles south of the large bend in the Boolcunda Creek, five miles east of Boolcunda East homestead. The rock is a micaceous fine siltstone with thin laminae of coarser sediment. From the fine siltstone 12 specimens were collected which show circular, and in one case oval, structures lying along the bedding planes. The shape of the oval examples (Plate V, fig. 1) is probably due to distortion as the largest diameters are parallel to a shear direction seen on the other side of the hand specimen. The structures consist of an inner area, generally containing one or more ridges which radiate outwards and in one specimen continue into the surrounding rock. The inner area is bounded by a prominent band, which in weathered examples stands out as a ridge. In the best preserved specimen the ridge is seen to be slightly darker in colour than the surrounding material. The oval specimens show the prominent band surrounded by a smooth apron, the external margin of which is not preserved. Organic material appears to be absent. The structures may be the result of mineral segregation in which material has been concentrated in rings around some type of nucleus. On the other hand they may represent the external moulds of some primitive soft bodied organism. At present the oldest definite organic remains are impressions of "jellyfish" found by Sprigg in the Cambrian Pound Quartzite at Ediacara (Sprigg 1947 and 1949).

Sturtian Series

This series is dominantly argillaceous with calcareous and dolomitic phases, especially near the top. A glacial and fluvioglacial group occurs near the base. The Sturtian Series has been sub-divided into the following members:

Dolomitic and calcareous shales

This is the top member and represents essentially a continuation of the earlier argillaceous sedimentation. The horizon is approximately 100 feet thick with a fine grained facies more dolomitic and calcareous than the underlying shales. The dolomitic and calcareous shales have a facies and a stratigraphic position similar to the Brighton Limestone as defined near Adelaide.

In the northwestern part of the Quorn sheet the horizon outcrops as a ridge. The rock is dolomitic and in places has a brecciated appearance, interpreted as an intra-formational breccia or a pseudo-breccia caused by metasomatic changes in the dolomite - calcite content of the rock. Scattered silicification is an associated feature. South of Quorn, on the eastern limb of the major syncline,

Fig. 1.

View from the northern end of the Horseshoe Range looking northwest over hills built of chocolate shale and Sturtian Series rocks. The immediate foreground is massive current bedded quartzite. In the far distance is the Willochra plain, with the western ranges on the horizon.

Fig. 2.

The steep hog-back ridge of massive current bedded quartzite north of the Boolcunda Creek, viewed from the east. In the foreground chocolate shales outcrop.

PLATE II

the outcrop is less prominent. Lithologically the rock is less dolomitic than in the north and there is a more gradual transition to the underlying shales.

On the eastern half of the Quorn sheet the horizon is not prominent. Its lower boundary is indefinite. The upper boundary is better defined and can be traced more precisely, except in low lying areas where exposures are few and surface float sparse.

Laminated shales

The Tapley Hill Slates of the type area near Adelaide are thought to be represented on the Quorn sheet by a thick succession of grey calcareous shales. A ubiquitous feature of the rocks is the fine bedding lamination in which purplish bands alternate with greenish grey layers. The laminae show little variation in grain size. The colouration may be due to mineral salts, probably manganiferous, present in varying states of oxidation. Typically a plane of easy parting follows the bedding and perpendicular joints are well developed. The formation shows a remarkably constant lithology throughout a thickness which varies from 3,700 feet in the east to 1,500 feet, west of Quorn.

Boulder tillite with interglacial shales and sandstones

Tillitic rocks are important marker beds in the Quorn area; they are placed in the Sturtian Series of the type area, south of Adelaide, to which they are lithologically comparable (Mawson & Sprigg 1950) Boulder tillites are well developed, the rocks usually having an argillaceous matrix containing erratics varying in size up to two feet in diameter. The larger erratics are chiefly sub-angular though some are fairly well rounded; the smaller fragments are angular. White current bedded quartzite erratics are the most abundant while granite, granite gneiss, schist and shale erratics are much less common. Much of the tillite was evidently derived from sedimentary terrains by the erosion of quartzitic and argillaceous rocks, perhaps of the underlying Torrensian Series. The presence of erratics of gneissic and schistose rocks indicates that materials were also derived from a metamorphic terrain.

The tillite occurs in discrete bands often only two or three feet thick, separated by layers of shale, siltstone and sandstone which are well sorted and show current bedding, frequently with eroded topset beds. These intertillitic beds were evidently laid down in shallow water where currents washed and reworked the materials. They are in striking contrast to the tillite with its wide and unsorted range of grain sizes. The sedimentary environment was evidently one of shallow water with intermittent dumping of glacial material when the sorting action of water was at a minimum. The conformable character of the tillite layers and their alternation with shallow water sediments suggest deposition from floating ice.

The tillite also outcrops in the southeastern and eastern margins of the Quorn sheet, reaching a thickness of 1,000 feet. The boundaries with the overlying laminated shales and the underlying Torrensian Series are well defined. Between bands of tillite are bedded sandy siltstones and shales, some of which are dolomitic.

Fig. 1.

Sedimentary structures, probably resulting from slumping, within thin bedded dolomitic rocks of the Sturtian interglacial beds. Location: 1 mile south of Boolcunda East, in the eastern ranges.

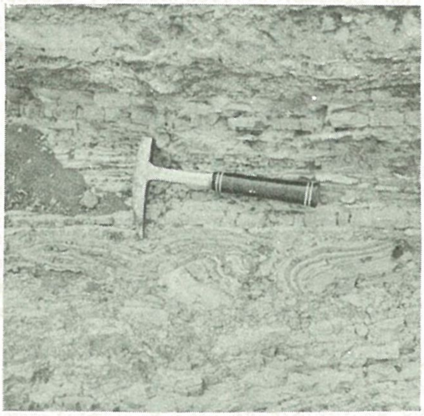

Fig. 2.

Conglomerate with quartzite boulders, from the upper shales 4 miles north of Mt. Brown.

PLATE III

On the western side of the eastern ranges the tillite and intertillitic sediments are similar to those described above. However they are separated into an upper and lower horizon by interglacial beds approximately 900 feet thick giving a total of about 2,700 feet. The interglacial beds are chiefly well sorted calcareous and dolomitic shales, siltstones and coarse felspathic grits. The rocks are current bedded and show rapid changes of facies. Slump structures have also been noted (see Plate 111, fig. 1). The interglacial beds appear to represent a period of glacial retreat during which sedimentation was dominantly in shallow water. However, the occasional presence of ice is indicated by rare and thin layers of tillite. The absence of decomposition of the felspar grains in many of the grit bands may be due to the low temperatures prevailing under such peri-glacial conditions.

Boulder tillite outcrops also along the eastern margin of the western ranges. Four miles east of Quorn the tillite is about 950 feet thick and is underlain by a series of sandstones, quartzites, siltstones and shales, with bands of tillite, considered to be equivalent to the interglacial beds of the eastern ranges.

Two miles west of Quorn tillite outcrops again, separated from the laminated shales by a coarse grit; the grit and the tillite are each approximately 100 feet thick, and neither horizon has been located more than one and a half miles to the north. West of Quorn the tillite is seen overlying a coarse to medium grained kaolinitic sandstone, quartzitic near the top, which has an observed minimum thickness of about 4,000 feet. The eastern margin is faulted. The small thickness of the boulder tillite and its disappearance northwards suggest that the horizon may be represented in part by the kaolinitic sandstone, part of which may also be equivalent in age to the interglacial beds.

Torrensian Series

In the south-eastern corner of the Quorn sheet is a sequence of dolomitic limestones, dolomitic shales, sandstones and quartzites, which as it underlies the tillite is referred to the Torrensian Series. The quartzites give rise to high ridges in contrast to the shale outcrops. The dolomitic beds are fine grained, well bedded, dense, light grey rocks. The lower margin of the Series is not seen, but a thickness of approximately 11,500 feet is reached within the Quorn sheet.

Torrensian Series rocks are also exposed on the western side of the eastern ranges, in the region of No-Where-Else Dam and at a locality seven miles to the north. The dolomites and quartzites exposed are similar to those in the southeast of the sheet. The lower margin is obscured by the sediments of the Willochra Basin.

Stratigraphic Columns

The stratigraphic columns which accompany these notes (see plate V111) have been drawn to illustrate the variations in thickness and facies of the rocks within the Quorn sheet. The greatest variation is seen when beds are compared with their equivalent horizons on the other side of the Willochra plain. There are fewer changes from north to south. In the eastern ranges sedimentary rocks

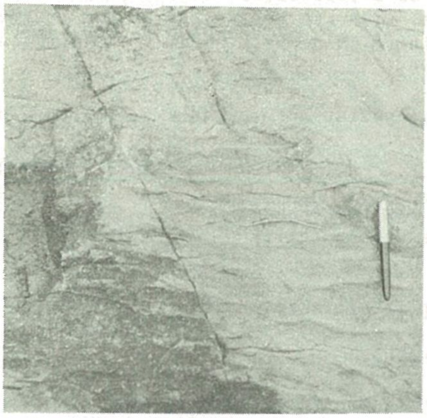

Fig. 1.
Ripple marked bedding plane in siltstone of the chocolate shales, Mount Brown Creek. Corded structures lie along the troughs between ripples.

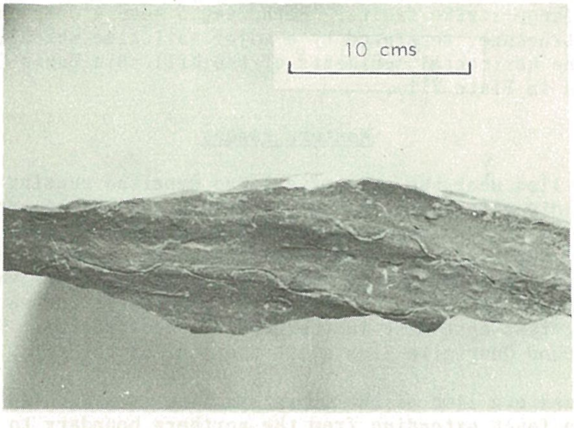

Fig. 2.
Ripple marked bedding plane in siltstones of the chocolate shales. Block found near face in plate IV, fig. 1, but not seen in situ. Corded structures follow the crests of the ripples.

PLATE IV

reach a thickness of 29,000 feet. Sedimentation was evidently on a geosynclinal scale, with the depression of the sedimentary floor in delicate equilibrium with deposition as the sediments are dominantly shallow water types.

The thickness variations across the Willochra plain are:-

	Western ranges	Eastern ranges
Mottled shales of the upper shales	400'	1,600'
Massive current bedded quartzite	3,600'	1,700'
Chocolate shales	3,500'	11,600'
Laminated shales	1,500'	3,700'
Tillite (including interglacial beds)	0 - 100'	2,700'-1,000'
Kaolinitic sandstone (base unseen)	4,000'	

The thinning of the formations in the western ranges indicates proximity to the margins of the original sedimentary trough. Adelaide System rocks continue to thin westwards until in the Middleback Ranges they are overlapped by the Cambrian, which rests directly upon the Archaean basement.

Structure.

Introduction

The eastern and western ranges in the area described show Adelaide System rocks disposed in broad regular folds, complicated by several large strike faults. Both ranges have a dominantly synclinal structure, separated by a major anticline which is entirely masked by the horizontal sediments of the Willochra Basin (see geological sections in Plate V11).

Western ranges

Quorn lies near the axis of a large syncline running in a nearly north-south direction with an easterly deviation in the north. The fold, named the Quorn Syncline, pitches northwards so that synclinal entrances of successively younger horizons occur from south to north. The high land around Mt. Brown, whose summit is just off the southern margin of the Quorn sheet, occurs where the massive current bedded quartzite strikes east-west in the nose of the syncline. North of Quorn the Pound Quartzite lies along the keel of the fold.

The western limb of the Quorn syncline is truncated by a large strike fault extending from the northern boundary to the southwestern corner of the Quorn sheet, a distance of thirteen miles. The fault, named the Quorn Fault, brings the Quorn syncline into a position adjacent to an anticline to the west which has been named the Pinkerton Creek Anticline and which has an axial trend to the south-southwest. The magnitude of the Quorn fault is shown in Stony Gully, two and a half miles north-northwest of Quorn, where Sturtian kaolinitic sandstone in the core of the Pinkerton Creek Anticline is in contact with the Pound Quartzite in the keel of the Quorn Syncline.

Two and a half miles southwest of Quorn the Quorn Fault bifurcates to produce a splinter in which the Pound Quartzite and the upper shales outcrop. The splinter is faulted against the massive tillites overlain by laminated shales. The western limb is truncated by faulting which runs southeastwards across the trend of the anticline, bringing lower and lower horizons into contact with the chocolate shales to the west. The southern portion of the anticline appears to have been upfaulted with the cutting out of the tillite; at the surface the sub-tillite beds rest next to the chocolate shale rocks.

Eastern ranges

The dominant structure in the eastern ranges is a large pound whose axis lies near Mt. Helen and has a northeast to southwest trend. This major structure has been named the Bellaratta Syncline. The structure is clearly shown by the very prominent outcrop of the massive current bedded quartzite. There is a change of pitch across the middle of the syncline, so that in the northern portion there is an axial pitch southwards and in the southern a northerly pitch. In the south the pound is cut by a fault named the Bellaratta Fault whose trend is parallel to the fold axis. The fault has lowered the southeastern flank of the syncline so that the massive current bedded quartzite outcrop is displaced four and a half miles to the south. The quartzite outcrop shows terminal bending on both sides of the fault.

On the western flank of the Bellaratta Syncline there is an anticlinal and a synclinal fold. The two fold axes parallel the trend of the major folding. The axial flexure which affected the Bellaratta Syncline crosses the anticlinal and synclinal fold axes in the region three and a half miles south-southeast of Round Hill. Further south the pitch is very shallow and as a result the outcrop of the Sturtian Series is wide.

In the northwest, Round Hill lies near the axis of an anticline trending northeast to southwest and swinging north-south near the northern margin of the sheet. On the southeastern flank of the anticline the laminated shales outcrop in a syncline faulted on the southern and eastern sides.

Lying approximately seven miles east of Round Hill is the axis of a broad anticline, pitching at about 20 deg. towards the southwest. The eastern limb of this fold is the western limb of the Bellaratta Syncline. The western limb of the anticline is truncated by a large strike fault, named the Boolcunda Fault. The fault trends unevenly in a general northeast to southwesterly direction, the displacement decreasing southwards. The fault uplifts the northwestern side relative to the southeastern. The fault is well exposed where the Boolcunda Creek turns northwards, four and a half miles east of Boolcunda East. Here, the massive current bedded quartzite is separated from Sturtian tillite by a fault zone approximately 300 feet wide. In the fault zone argillaceous beds, with some tillite, lie in a highly disturbed state. In the centre of the zone stress was chiefly relieved by plastic flow. Towards the margins of the zone fractures and breccias are more evident. In the massive current bedded quartzite near the fault zone there is a syncline, interpreted as a dependent drag fold.

The Sturtian Tillite on the western side of the Boolcunda fault forms the core of an anticline whose axis swings away from the fault into an east-west direction. On the southern limb of the anticline, the junction of the laminated shales with the underlying Sturtian Tillite is strongly disturbed by numerous, irregular folds and faults.

An anticlinal axis enters the area of the Quorn sheet just south of the northeastern corner. The axis swings southwards and then southeastwards. In the locality of the Yanyarrie Creek, Sturtian Tillite lies in the core of the anticline, pitching in a northwesterly direction. The anticlinal axis changes pitch in the latitude of Yanyarrie; to the north the axial pitch is southwards at a low angle to the horizontal.

Willochra Basin

The sediments of the Willochra Basin are poorly consolidated rocks, in marked contrast to the Proterozoic Series of the eastern and western ranges. There is no evidence of folding and the sediments appear to rest in an undisturbed, horizontal position. It is concluded that the folding of the Proterozoic occurred prior to the deposition of the Basin sediments.

Structurally, the Willochra Basin lies over a large north-south trending anticline in the Proterozoic basement. Apparently, erosion produced inversion of relief and the eroded anticline was filled with Basin sediments, which rest unconformably on, and overlap the underlying Proterozoic. There is no evidence to suggest that the Willochra Basin has a graben structure.

Orogenic and Physiographic Evolution

The folding seen in the eastern and western ranges took place after the lower Cambrian and prior to the deposition of the Willochra Basin sediments. The long stratigraphic break prevents a more precise dating from local evidence. However it may be assumed that the major tectonic disturbances were part of the orogeny which occurred throughout the Mt. Lofty - Flinders Ranges geosyncline and is dated as pre-Permian in the Fleurieu Peninsula. The Quorn area may also have been affected by movements in the Triassic, observed at Leigh Creek, and in the Tertiary, recorded from the Fleurieu Peninsula.

The absence of deposits between the lower Cambrian and the Willochra Basin sediments indicates that there was no major sedimentation in the region, which probably stood as a land mass and must have passed through many cycles of erosion. Following uplift of the last peneplanated surface the Willochra Basin was eroded out along a major anticline in the Proterozoic basement. The recent hydrology test bores show that the bottom of the basin is approximately 300 feet above the present sea level and slopes northwards, which must therefore have been the direction of drainage. Erosion was succeeded by sedimentation, so that today the basin is filled to a minimum level of approximately 700 feet above sea level.

The present topography with its maximum elevation of over 3,000 feet and minimum of 700 feet above sea level indicates the scale of the last uplift. The uplift appears to have occurred by a process

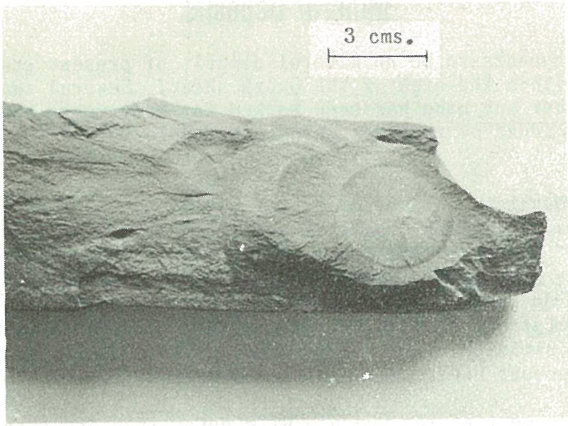

Fig. 1.

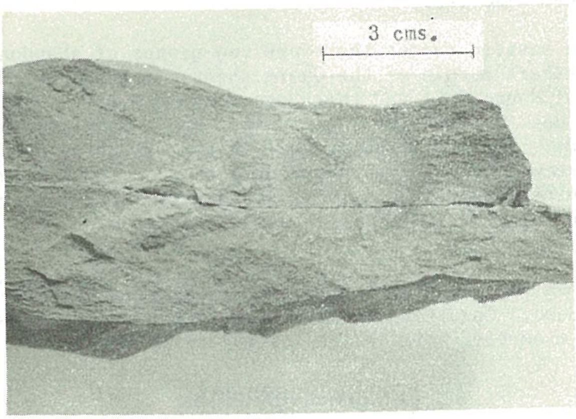

Fig. 2.

Disc-like structures from the chocolate shales in the eastern ranges. (see text).

PLATE V

of broad warping rather than by block faulting as faulting is not evident along the western margin of the Flinders Ranges east of Port Augusta.

Mineral Deposits.

There appears to be no mineral deposit of present economic importance within the area of the Quorn sheet. Several small groups of shafts occur but none has been worked for many years and no evidence was found of reserves which would make further development profitable.

Three quarters of a mile west of the Quorn - Wilmington road there are disused shafts a quarter of a mile south and also one mile north of the Mt. Brown Creek. The northerly workings are over the axis of a southerly pitching anticline. Both groups of workings are situated on the outcrop of the dolomitic and calcareous shales. No lode structure is visible from the surface. Minerals scattered about in the vicinity of the shafts include in order of abundance, barytes, micaceous hematite, calcite and malachite.

One mile west of the Quorn - Wilmington road and three quarters of a mile north of the Mt. Brown Creek is a disused barytes mine consisting of a shaft and several trenches. The mine is in the chocolate shale rocks near the axis of a synclinal fold. The barytes lode is six to seven feet wide, strikes 45^{0} and dips at 75^{0} to the north-west. The footwall appears to be a brecciated ferruginous sandstone. The only mineral seen in association with the barytes is finely divided hematite.

In the eastern ranges there are two groups of abandoned workings near the northern margin of the Quorn sheet. A manganese mine seven miles east of Round Hill and three quarters of a mile south of the Boolcunda Creek, consists of a sixty foot shaft and a twelve foot deep open cut. The ore is botryoidal, black manganese oxide and occurs in brecciated material apparently as a cavity filling deposit. Associated minerals include calcite and quartz. The country rock is a horizon near the base of the chocolate shales.

Two and a half miles east of Boolcunda East several shallow pits have been dug along a vein which cuts Sturtian Tillite in an anticlinal core. Calcite, siderite, hematite and quartz are the more common minerals, while traces of malachite occur.

Acknowledgements.

Appreciation for frequent and valuable help is extended to the officers of the Hydrological Section of the Geological Survey of South Australia, who commenced a hydrological survey of the Willochra Basin before the regional mapping of the Quorn sheet began.

Grateful acknowledgement is made of important stratigraphic information provided by Dr. A. W. Kleeman, Geology Department, University of Adelaide, who located the Archaeocyatha Limestone north of the Quorn sheet.

The Photographic Section of the Department of Mines provided the illustrations which accompany these notes and the Drafting Section of the geological survey prepared the geological sections and stratigraphic columns. (5/4/56).

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Addendum
to the
Geology of the Quorn Military Sheet.

Stratigraphy

Triassic

Subsequent to the publication of the Quorn sheet of the one mile Geological Series, coal was discovered during water boring operations on the property of E. Hilder at East Boolcunda, at long. 138° 19' E. and lat. 32° 15' S. Further examination showed the presence of a small basin of sediments with a number of impure coal seams, none of which outcrop. Samples from the coal seams were examined palynologically by Mr. B.E. Balme of the University of Western Australia and determined to be of Triassic age.

The Triassic sediments are mostly soil covered. Near the southern boundary a few feet of purple and grey coarse grained current bedded sandstone underlain by grey gypsiferous argillites outcrop. At the eastern boundary conglomerate can be observed in contact with weathered Proterozoic slates. In the discovery borehole, and others drilled subsequently, white sandstones and clays were penetrated but their position in the succession is obscure.

The Triassic sediments are markedly folded and lie unconformably on the Proterozoic slates. The current bedded sandstones show dips as great as 30° and while the structure is obscure there is sufficient evidence to show that the dips are due to folding and not dragging along faults.

At least two coal seams were penetrated during drilling operations. They are low grade sub-bituminous coals with high ash and water content. The total depth of sediments in the basin has not been penetrated in boreholes. It may amount to several hundreds of feet.

The basin shows marked similarities to the Triassic basins in the Leigh Creek area and the Springfield Basin on the Willochra sheet some 10 miles north-northeast.

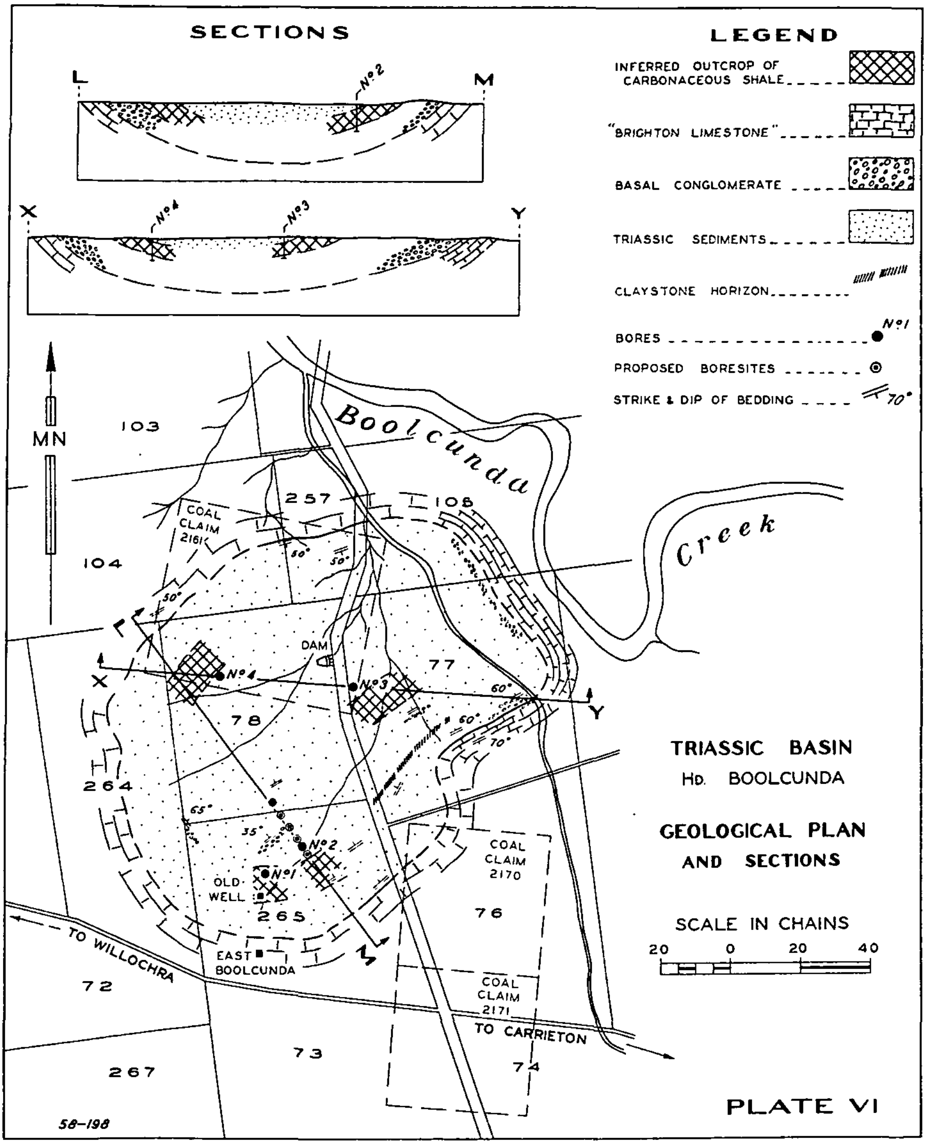
The attached plan Plate VI shows the basin and its relation to the surrounding Proterozoic rocks. It is not shown on the Quorn sheet since this was printed prior to the discovery of the basin.

Mineral Deposits.

Coal has been penetrated in thin seams in a Triassic basin at East Boolcunda. This coal is impure and not of economic grade. A proximate analysis of samples from a borehole were as follows:-

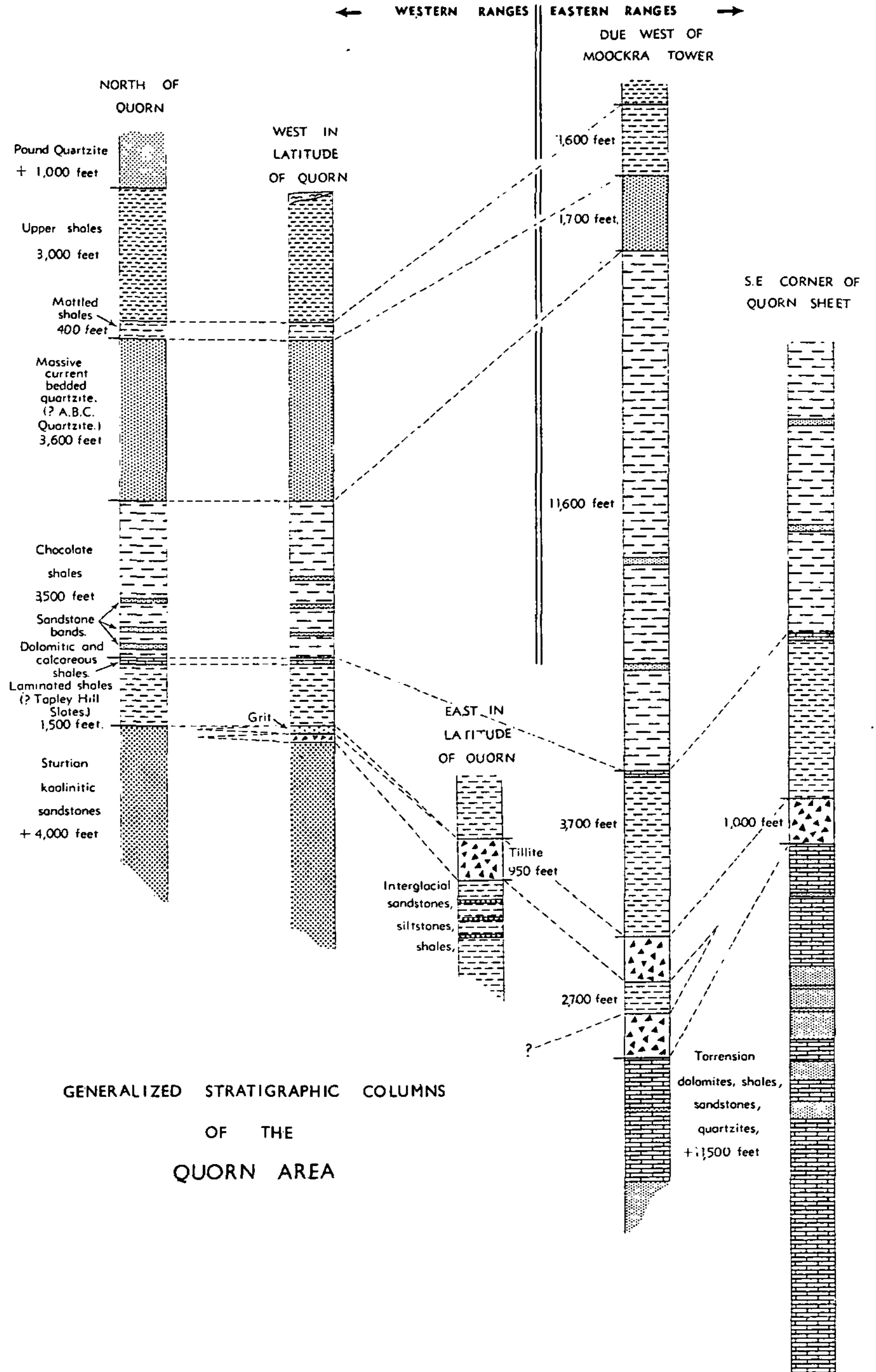
	Moisture	Volatile matter	Fixed Carbon	Ash
1	7.41 %	14.64 %	9.28 %	68.67 %
2	14.88	30.21	23.68	31.22
3	24.96	42.29	25.96	6.79

The basin is at present being investigated by the Mines Department. (June 1958)



SECTIONS
L
M
Nº2
X
Y
Nº4
Nº3
LEGEND
INFERRED OUTCROP OF CARBONACEOUS SHALE
"BRIGHTON LIMESTONE"
BASAL CONGLOMERATE
TRIASSIC SEDIMENTS
CLAYSTONE HORIZON
BORES
Nº1
PROPOSED BORESITES
STRIKE & DIP OF BEDDING
70°
MN
Boolcunda
Creek
103
104
257
108
COAL CLAIM 2161
DAM
77
78
264
265
OLD WELL
EAST BOOLCUNDA
COAL CLAIM 2170
76
COAL CLAIM 2171
TO WILLOCHRA
TO CARRIETON
72
73
74
267
TRIASSIC BASIN
HD. BOOLCUNDA
GEOLOGICAL PLAN AND SECTIONS
SCALE IN CHAINS
20 0 20 40
PLATE VI
58-198

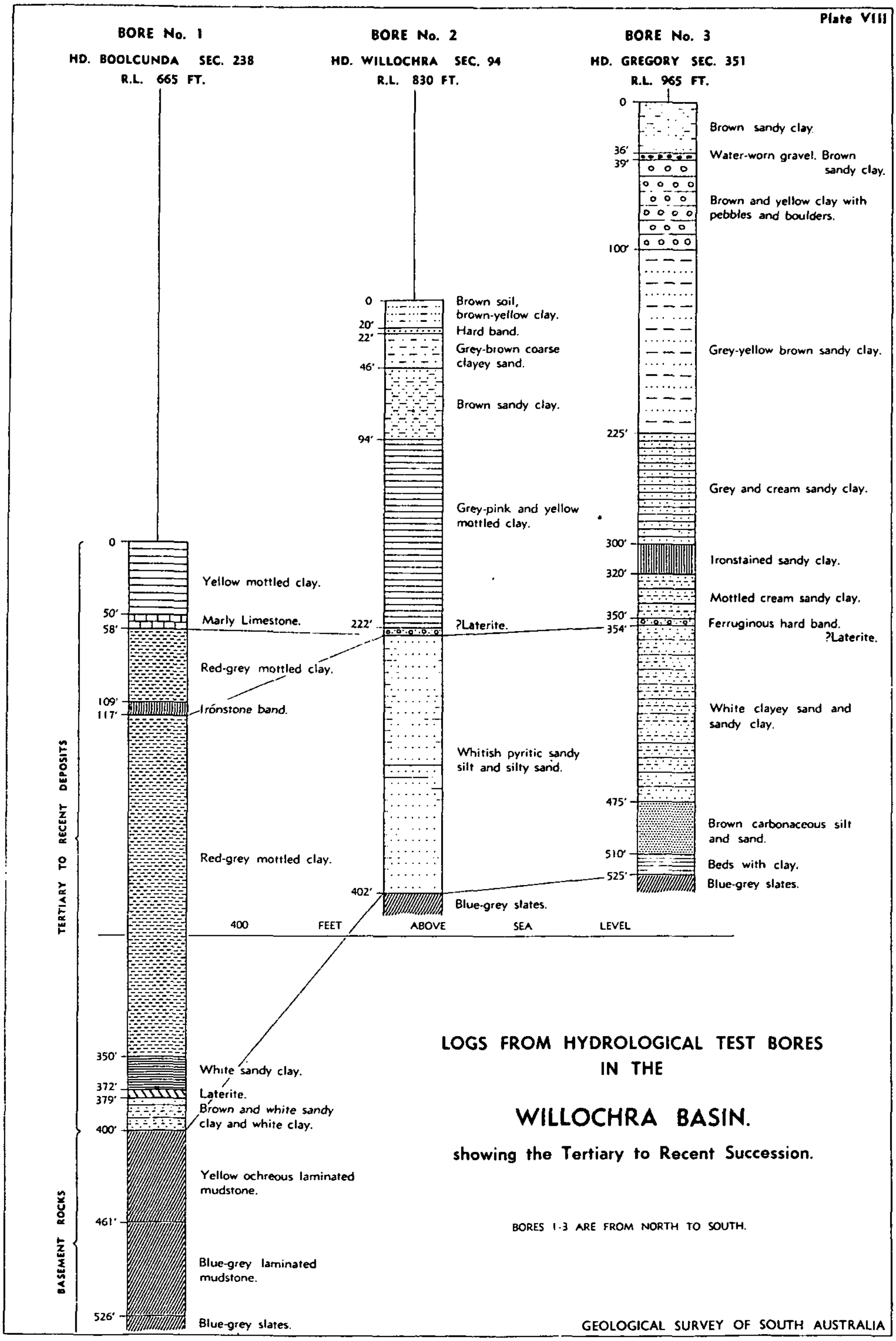
Plate VII



GENERALIZED STRATIGRAPHIC COLUMNS OF THE QUORN AREA

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

Plate VIII



LOGS FROM HYDROLOGICAL TEST BORES IN THE

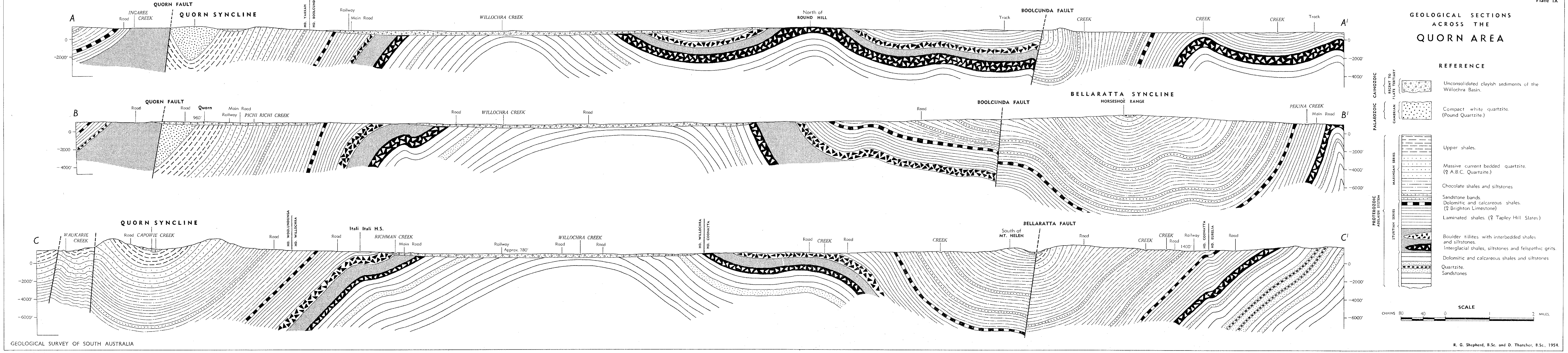
WILLOCHRA BASIN.

showing the Tertiary to Recent Succession.

BORES 1-3 ARE FROM NORTH TO SOUTH.

GEOLOGICAL SURVEY OF SOUTH AUSTRALIA

Plate IX



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