Rept. Bk. No. 55/62
G.S. No. 2436
D.M. 765/61

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

REGIONAL SURVEYS

Report

on

THE GEOLOGY OF

the

MT. BARKER - CALLINGTON AREA

by

R.C. Mirams
Asst. Senior Geologist

30th August, 1962

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ABSTRACT

The Cambrian sediments in the vicinity of the Mt. Barker Creek and about the Callington-Kanmantoo mines have been studied. Evidence is produced to show there is rapid thickening of members above the Inman Hill Formation north of Mt. Barker Creek. The metamorphic grade is uniform over the area mapped, the presence of andalusite being due to a difference in composition in the original sediment. The base of the Cambrian has been identified at the base of an arkosic member near the bridge at Mt. Barker Springs. Some comments on a probable origin for the copper mineralization are included.

INTRODUCTION

This report records the progress of a closer study of the Cambrian rocks in the Mt. Barker - Callington Area.

The scope of the investigation includes

(a) A detailed examination of a thick section of the Cambrian succession

(b) To relate the stratigraphic position of the beds in which mines are found to this column.

(c) Genesis of the mineral deposits.

While the mapping was in progress Mines Exploration Pty. Ltd. initiated geophysical investigation in the area, and this department began investigating an aeromagnetic anomaly near Dawesley. As these projects are directly related to the study as outlined, the necessary liaison with the company and the Geophysical Section has been handled by the writer.

It should be noted when referring to the map and this report that the investigation is restricted to the Cambrian or older rocks, their deposition and their diagenesis. Superficial deposits have been ignored and examined only to add information of use to the interpretation of the older rocks.

The area east of the Bremer fault has not yet been mapped.

LOCATION, CLIMATE, TITLE

The area to be studied, 31½ miles by 17¼ miles extends from near Mt. Barker in the northwest to a point nine miles southeast of Callington, incorporating the Bremer Valley immediately north of Callington.

The area is traversed by the Adelaide Melbourne Railway and the Princes Highway, both affording many good exposures in cuttings.

The rainfall ranges from approximately 20 inches in the western portion of the area mapped to 14 inches in the Callington district. The land is used mainly for sheep grazing with some feed crops being sown in the drier eastern portion.

All the significant mineral occurrences are found on land with minerals alienated from the Crown. The exploitation of some areas is further complicated by the mineral rights being vested in a defunct company.

PREVIOUS WORK AND ACKNOWLEDGMENTS

The Mt. Barker - Callington area lies across the boundary of the Echunga 1 mile Geological Sheet (Sprigg & Wilson) and the Mobileng 1 mile geological Sheet (Johns 1960).

The area has been investigated as a whole by Dickinson (1942) before aerial photography was available. Portions of the area have been examined in detail by many authors and these works are referred to in the text and bibliography.

Systematic geochemical sampling was commenced in the area in 1960. The Nairne Pyrite member was remapped on 1" = 20 chain Lands Department base maps by D. Ker and B. Thomson. The northern and southern extension of this member and associated sediments was mapped on this scale by R. Dalgarno. A regional geochemical traverse of the Cambrian along Barker Creek was mapped by B.P. Thomson and R.C. Mirams. This mapping was extended to the north over the area described in this report as a result of

the interest shown in the district by Mines Exploration Pty. Ltd.

REGIONAL GEOLOGY

Initially this study commenced as an investigation of the Kanmantoo Group and the mines contained in that group near Kanmantoo and Callington. As the mapping proceeded the area was extended along strike to incorporate less disturbed rocks and west to include the base of the Cambrian.

The Cambrian System rests on slates and quartzites of the Adelaide System. While an unconformity cannot be proved, a sudden change to arkosic rocks and varying nature of the beds immediately below the first arkosic band suggest a break in deposition (Horwitz, Thomson & Webb). The underlying beds consist of grey slates, calc silicates, and "clay-gall" quartzites. The slates show incipient development of scapolite. This is in contrast with the Cambrian sediments which, due to a compositional difference, are characterised by the formation of andalusite.

The lowest Cambrian beds are arkosic sandstones with some local cubic casts after halite(?) or rhombic? after calcite? These are overlain by further felspathic sandstones and quartzites in all less than 200 feet. This unit is followed by regularly bedded alternating greywacke (calcareous?) and andalusite biotite schist. The beds are one to two feet thick and the bedding is noticably more regular than higher in the sequence. This suggests a preliminary rhythmic deposition of the two major rock types of the Cambrian in the area.

The regular beds are followed by a massive greywacke-sandstone with strong cross-bedding. This in turn is followed by further regularly banded greywacke and andalusite biotite schist. The regular appearance diminishes higher in the column with the development of some cross bedding in the greywacke beds.

The next unit is the Mt. Barker Quartzite which varies from an arkosic sandstone to a quartzite and a calc-silicate. The unit is a good marker on the map and forms the base of the Inman Arkose. There follows a thick sequence of medium grained pale coloured arkosic sandstones. These in turn are overlain by a group of pyrite beds including the Nairne Pyrite. The pyrite beds occur in a greywacke sequence, the column from the Nairne upwards containing 50% or more of greywacke with the units selected according to the nature of the more conspicuous beds within the monotonous greywacke. Above the Nairne Pyrite there are recognizable units with andalusite, then pyrite, then andalusite, until a greywacke unit with no interbedded material is recognized. This is overlain by a further pyrite group and finally a thick greywacke the top of which is not reached in the area mapped.

The units described above have for convenience been given the names:-

	Brown Hill Greywacke
	Aclare Pyrite Beds
	Bremer Greywacke
Brukunga Formation	Paringa Andalusite Beds
	Dawesley Pyrite Beds
	Dawesley Andalusite Beds (Kleeman & Skinner)
	Nairne Pyrite Beds
Inman Hill Formation	Inman Arkose
	Mt. Barker Quartzite
	Lower Andalusite Beds
	Transition Beds
	Upper Proterozoic Marinean

The beds above the Inman Arkose show rapid thickening from south to north, north of Mt. Barker Creek. Fig. is a diagrammatic section across the zone of thickening.

A detailed examination of the lower beds, i.e. below the Nairne Pyrite has not been made at this stage. There follows a description of the units of greater interest to this study.

Nairne Pyrite Beds

The Nairne Pyrite beds that are being exploited and those adjacent have been adequately described. The upper beds incorporated in this unit include greywacke with argillaceous bands, some pyritic, and a bleached (kaolin?) bed 2 ft. thick. The beds then gradually become more siliceous until they approach quartzite in composition. How much of the silica is due to secondary silicification is not known at this stage. There follows a coarse greywacke with soft biotite rich bands or beds, the biotite follows the bedding but may be segregated into biotite rich bands. These beds grade into thick "slate" beds. These are well parted on the bedding rather than the cleavage so could probably be better described as flags. These flags are exposed in a quarry used mostly for a railway embankment but subsequently stone has been taken for masonry.

This unit traverses the map from north to south without any significant change in thickness.

Dawesley Andalusite Beds (Kleeman & Skinner 1958)

This name was given by Kleeman and Skinner to the Andalusite schist outcropping in the road cutting on the Princes Highway leading down into Native Valley. The lower beds in the unit are flaggy greywackes with andalusite and biotite rich bands forming the partings. The partings become more diffuse and the andalusite more evenly distributed near the middle of the unit - this is approximately the stratigraphic level appearing in the roadside cutting mentioned above. Surface outcrop of this unit is rare and certainly not representative as the andalusite exposures are restricted to fresh or deeply incised creeks or cuttings. The surface exposures usually show prominent greywacke beds protruding through the soil cover with the softer biotite andalusite bands obscured. The occurrence of the andalusite will be discussed later when considering the metamorphic history.

The Dawesley Andalusite beds thicken from 700 feet on

Mt. Barker Creek to 3500 feet on the northern edge of the map.

Dawesley Pyrite Beds

The beds begin with two thin pyrite beds, the upper of which carries much free quartz in the form of veins and blows. These two beds run from the vicinity of Allambi to the northern edge of the sheet; to the north of Allambi further pyrite beds are mapped higher in the unit. Where the unit crosses Mt. Barker Creek it consists only of greywacke. The pyrite beds are characterised by a bleached outcrop and can be readily identified on air photos.

Paringa Andalusite Beds

The Paringa Andalusite beds show the most prominent development of andalusite. They appear to have much less biotite than the andalusite beds lower in the column. The andalusite locally is much coarser, up to 1" crystals, and the sedimentary structure is far more obscure. The mapping of this unit is incomplete, 20 chain mapping was abandoned and 500' - 1" enlargments have been obtained.

This coarse andalusite rock is that to which Woolnough gave the name Paringite.

The beds are less than 500 feet thick where they are exposed on Mt. Barker Creek reaching an estimated 3,000 feet in the vicinity of the Kanmantoo mines and then may be thinning again near the northern boundary of the map.

The copper mines with the exception of the Bremer Mine occur in, or marginal to, the Paringa Andalusite beds.

Bremer Greywacke

This is a lenticular unit rapidly thickening to the north from the Aclare Mine. The lower beds are massive greywacke with little sedimentary structure. Towards the top a black banding becomes evident, current bedding is evident. This is overlain by a graphitic slate. Where this unit has been mapped it is tightly folded and extensively disrupted by faulting,

making thickness estimates highly speculative.

Aclare Pyrite

These pyrite beds are probably the next in persistence to the Nairne Beds. They can be traced south of the Mt. Barker Creek to where they are only 3,000 feet stratigraphically above the Nairne beds. To the north they enter the faulted area northeast of the Aclare Mine and have been traced into the axis of the syncline and lost beneath alluvium near the Pioneer Mine. On a section through the Kanmantoo Mine the beds between the Nairne and Aclare Pyrite Beds have increased their apparent thickness to more than 14,000 feet.

Brownhill Greywacke

The unit as a whole has been described elsewhere (Forbes 1957, Thomson). The lower portion occurring within the area mapped consists of massive greywacke with lenses of pyritic schist in the lower part.

THE CAMBRIAN PRECAMBRIAN BOUNDARY

This problem formed the subject of a paper by Horwitz, Thomson and Webb (1958). In this paper the whole problem along the eastern Mt. Lofty ranges is dealt with. The results of the present detailed mapping have necessitated a local change in the position of the interpretation of the base.

The present author would place the base at the bottom of a coarse arkose which outcrops on the east bank of the Mt. Barker Creek near the bridge at Mt. Barker Springs. There is a marked change in the sedimentation at this point.

The beds immediately under the arkose are thin quartzites, clay slates, calc silicates and greywackes. These beds have been scapolitized during metamorphism. The quartzite has clay inclusions and voids after clay flakes and galls a feature typical of the upper most Marinoan. This feature is

interpreted as representing a period of very slow or intermittent deposition. The beds are thin here but elsewhere they reach great thicknesses. It would not be unreasonable to correlate these beds with those occurring at the close of the Marinoan near Kulpara, Lochiel and even the Flinders Ranges.

The arkosic bed overlying the Proterozoic is typical basal Cambrian arkose similar lithologically to the material from this unit at Kulpara, Lochiel and Central Flinders Ranges. Secondly this unit marks the beginning of what has been termed the "Kanmantoo Facies".

The characteristic coarse andalusite of the Cambrian in the area mapped occurs in the first micaceous rocks above this arkose. In every area examined there has been evidence for a marked change in sedimentation at the base of this arkose and in most an unconformity has been indicated. Here an unconformity can not be proved but the proximity of the upper tillite to the contact suggests absence of much of the Marinoan.

REGIONAL STRUCTURE

A major hinge-line (Thomson G.S. 2049, DM 765/61) runs from Drukunga through to the Kanmantoo Mines and shows as a series of NNW SSE shears and breccia zones. This hinge line approximately coincides with the edge of the zone of thickening in the Cambrian sediments; it is therefore suggested from the evidence in this area that movement occurred along this line after the deposition of the Inman arkose, (further north earlier movement has been detected).

North of the Aclare Mine a major fault has been mapped running from east to west and curving to the southwest. The hinge line shears and this fault controls the direction of the fracture pattern which has been examined in detail in the mine areas.

The regional folding has been illustrated by Johns (1960, 1961) and the western portion of his Mobilong tectonic sketch has been incorporated in the tectonic sketch bound herein (S). This sketch shows a broad syncline with an undulating plunge to the south-south-east. This plunge would average 25° to 30°. The cleavage is well developed and indicates the axes to be inclined to the west. The west limb shows pronounced crumpling of incompetent beds some of which is due to slumping and most of which may be pre-consolidation. What slump rolls that have been examined indicate a movement from the west which is in harmony with the slopes that would form during subsidence of the east block along the hinge line.

In computing thicknesses in the area mapped it is known that there is considerable structural thickening in the folding, but as the observations have been taken on the limb of a fold the structural thickening is considered subordinate except where the word "apparent" has been used.

REGIONAL METAMORPHISM

The regional metamorphic grade indicated by McCarthy for a number of specimens shows little variation from high in the greenschist facies to almandine-amphibolite facies.

It has been suggested by Kleeman and Skinner that the metamorphic grade is uniform and the degree of alteration various beds have undergone is purely dependent on their original composition. This is in contrast to Dickinson who postulated metamorphic highs associated with the andalusite concentrations.

The present investigations support Kleeman and Skinner as rocks which would be classified as paringite have been mapped down to the base of the Cambrian and followed several miles to the south into what were previously considered lower grade areas. The present mapping does not support these author§' contention that the andalusite schists grade to mica schists. This may occur locally due to variation in sediment deposited but the

decrease in relative proportions of paringite to greywacke on the stable platform to the south has been shown to be due to the wedging out of these units to the south.

The underlying Adelaide System rocks have similar metamorphic grade with the development of calcsilicates and scapolite.

White (1956) considers there is a regional gradient falling from sillimanite-staurolite near Harrogate to staurolite-andalusite round the mines and absence of andalusite further to the west. For the area mapped the grade can be considered uniform, the absence of andalusite to the west is probably due to composition of the sediments, either arkose of the Inman Hill Formation or Adelaide System sediments.

DETAILED STUDY OF KANMANTOO-CALLINGTON MINERALIZATION

In addition to the 20 chain mapping of the Mt. Barker Callington Area mapping at 500 feet to 1 inch on enlarged aerial photographs has been done in the mineralized areanear Callington. It was found necessary to use the larger scale to depict the fracture pattern and smaller scale folding.

The mapping showed the copper mines to occur in lower beds than the silver lead. The major copper lodes are associated with the Paringa Andalusite beds (paringite). The lodes are found either in a marginal to the paringite, a notable exception being the Bremer which is found in the Bremer greywacke above the Paringa Andalusite unit.

The lodes occur as tabular or pipelike bodies in north-south shear zones. The attitude of the shears is 70° - 80° east. The pipes are controlled by the intersection of the shears with east-west fractures generally dipping 80° to the north, the resultant is a pipe plunging about 75° to the northeast.

About the lodes there has been an increase in the metamorphic grade resulting in the formation of garnet, magnetite in places, and staurolite. This is thought to be due to frictional

high temperatures developed during stress. The ore minerals occur, in the primary zone, as chalcopyrite, cuprite, magnetite and pyrite. Secondary chalcocite enrichment is known at the base of the oxidized zone.

All the worked ore bodies occur on north-south shears, only isolated instances are known of the early miners opening out on an east-west lode channel. Most of the numerous shafts have been sunk on an intersection of north-south and east-west shears, showing the Cornishmen were aware of the importance of these fractures. In many instances they have sunk 20 or 30 feet in barren ground on these intersections.

The detailed mapping has shown some north-south shears, many will have been missed as they are extremely hard to find where they closely follow the cleavage. Numerous east-west fractures have been detected and these have proved most interesting.

There are five variations in the type of east-west fractures mapped.

(1) Joints

(2) Joints with quartz infilling and a ferruginous halo in the adjacent strata.

(3) Joints with ferruginous infilling and silicification of adjacent strata.

(4) Joints infilled with milky quartz.

(5) Joints with quartz and tourmaline.

These joints may or may not have movement on them.

While this classification may be artificial it is of use in predicting mineralized bodies. Types 2 and 3 are those which attracted the Cornish Miners, where they intersect north-south "lode" shears is where the prospecting shafts are found.

These shears may have been the feeders for the lodes. There are numerous quartz blows as offshoots in the cleavage direction from these channels, and the ferruginous and siliceous haloes indicate they were carrying mineral in solution. Whether

the copper was carried in this solution or precipitated by it cannot be stated with certainty but it surely contributed to the present location of the ore bodies.

ORIGIN OF THE COPPER OREBODIES

Dickinson, who has investigated the mines, postulates an igneous source for the ore bodies. Kleeman and Skinner agree, as does this author, with his structural control but differ on his thoughts on "metamorphic highs". Metamorphic highs associated with the ore bodies do exist but they are restricted to the proximity of the north-south shears and are thought to be thermal effects caused by shear movement. Considering the possibility of a modified sedimentary origin discussed by B.P. Thomson (G.S, 2049, DM1765/61) the original sediments that contained the copper minerals could be the pyritic beds or more probably the per-aluminous clay deposits from which andalusite biotite schists developed. It is a plausible concept to consider the adsorption of copper ions in clay minerals, and their "distillation" during the metamorphism which drove off silica and iron and converted the clays to biotite and andalusite. This concept is more probable than a similar removal of copper from the pyrite beds where the pyrite remains relatively unaffected, it still is found in the dispersed state.

The mineral bearing solutions would then have travelled along the east-west fractures and have been deposited in the north-south shears. As the metamorphic grade is so even over the area studied it has not been possible to examine any "andalusite schist" in a lower metamorphic state.

The location of the copper mineralization is limited to the edge of the sinking trough. This explains the absence of mineralization in lithologically similar beds along the strike and lower in the column. The hinge line thickening is not evident below the Inman Hill Formation in the area mapped, but, where it does affect the lower beds to the north,

mineralisation is known. The quartz veins, blows, and lodes can all be formed in the above manner and the presence of quartz filled tension gashes in greywacke shows evidence pointing to lateral secretion. The quartz tourmaline veins are the only suggestion of outside or "igneous" rocks in the area mapped in detail. Microdiorite dykes are known in the vicinity of the hinge line near Brukunga and one has been mapped in the north of the 20 chain map intersecting the upper Nairne beds but none have been located near the mines.

ECONOMIC GEOLOGY

One object of this investigation was to assess the possibility of extraction of further copper from the mine area and adjacent areas.

Shortly after the field work began, Mines Exploration sought prospecting rights over the old Section 2001, Hd. Kanmantoo originally taken out by the South Australian Company. Mines Exploration ran more than 50 miles of Induced Polarisation traverses over the section and a composite map has been prepared with the author's geology and the geophysical results. The department is to receive a copy of this map, but at this stage the results are still under consideration. Several anomalies worthy of drilling have been located but legal technicalities are holding up further work.

On geological observations concentration of workings, and drillhole intersections the area round the Kanmantoo working was selected as the best for close investigation in conjunction with the Bremer Mine. These two areas were to be mapped in detail and drilling targets predicted on the basis of the intersecting fractures forming ore pipes. The detailed assessments of the mines was deferred when the prospecting company took out their lease.

It is interesting to note that excellent conductivities were recorded near the Emily Workings, the logical place,

geologically, to continue the investigation started by Austral Development in 1937-8.

It is interesting to note the features recorded at Dawesley which are similar to those found near the mines. There is a major north south breccia zone, dipping steeply to the east, and there is an adjacent andalusite schist (paringite) in a zone where the latter is thickening rapidly to the north. The anomaly lies on the west limb of a south plunging syncline towards the axis. The hinge line intersects the syncline and paringite beds at a similar position in the syncline. There is an unknown metallic conductor at moderate depth with an orientation parallel to the shear.

The programme (as with the investigation of the Dawesley Anomaly DM 2221/61) is static pending a clarification of the legal position as to mineral title especially as to those areas held by the South Australian Company.

The silver lead zinc mineralization is on a minor scale only. With one notable exception it is associated with pyrite beds, the Aclare pyrite beds in particular. The Wheal Margaret probably bears a similar relationship to the Ding Dong Copper mine and the Dawesley Anomaly. A series of spectrographic profiles were taken to be used in identification of the individual pyrite beds. The profiles in the lowest pyrite bed of the Aclare beds showed the lead content to be of most interest; there is a trend to higher lead values in the top sample of most profiles.

CONCLUSION

The field work on this project has been temporarily suspended pending clarification of the mineral title and will be resumed when drilling commences.

On resumption of operations it is proposed to initiate a detailed study of the paringite to determine the nature of the somewhat irregular contortions and folds. It may be found th-

there is considerable crumpling that originated before consolidation.

The 20 chain map will be completed. Both these tasks can be handled in conjunction with the supervision of the drilling. The drill core will be invaluable in interpretation of the structures in the Paringa Andalusite Beds.

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REGIONAL SURVEYS

RCM:AGK
30/8/62

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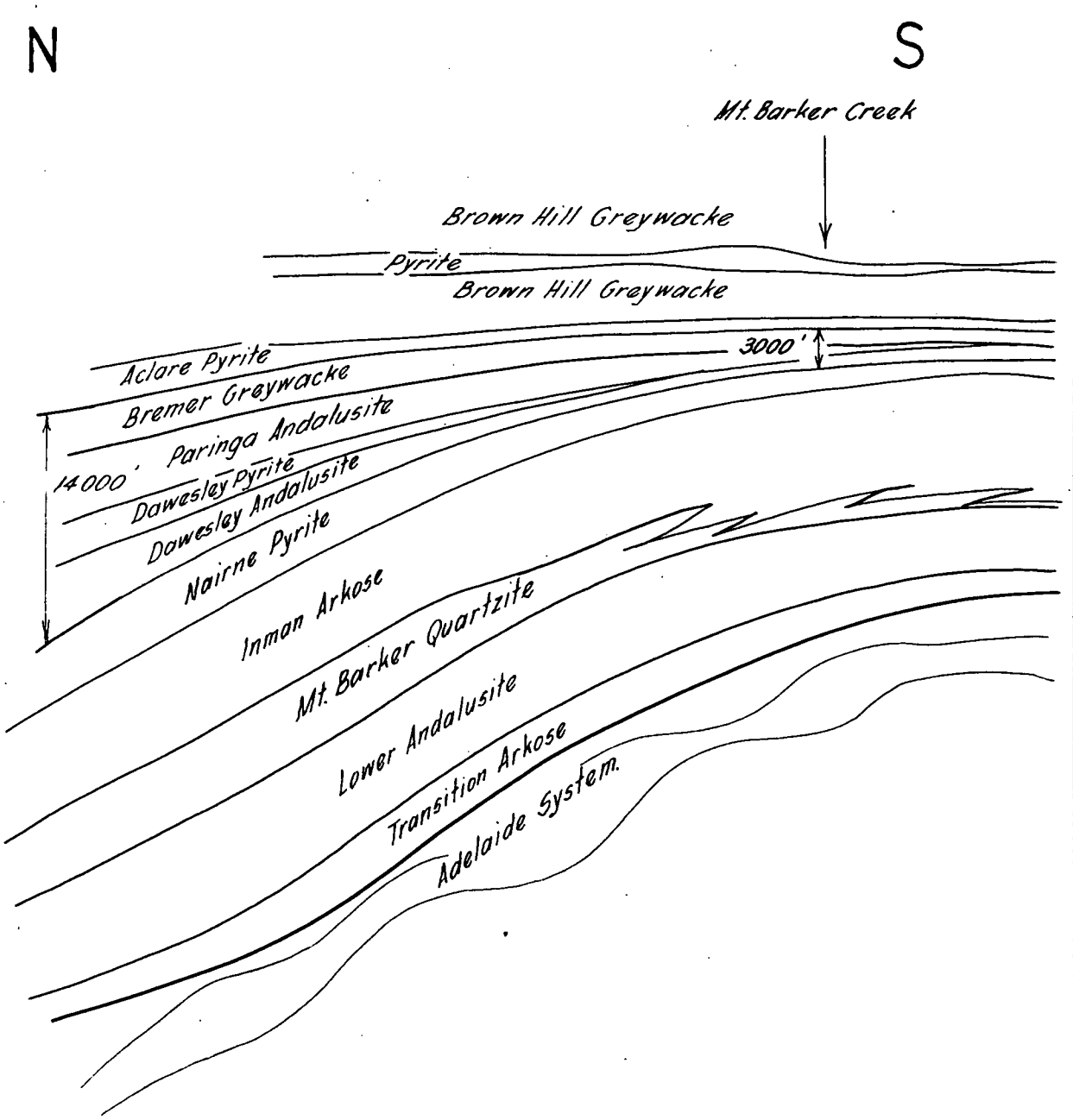

To accompany report by R.C. Mirams.

S.A. DEPARTMENT OF MINES

Approved	Passed	Drn.	SKETCH SECTION Showing THICKENING OF CAMBRIAN BEDS NORTH OF Mt BARKER CREEK Fig 1	D.M.	Scale
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		Ckd.			
Director		Exd.			Date 7·9·62.

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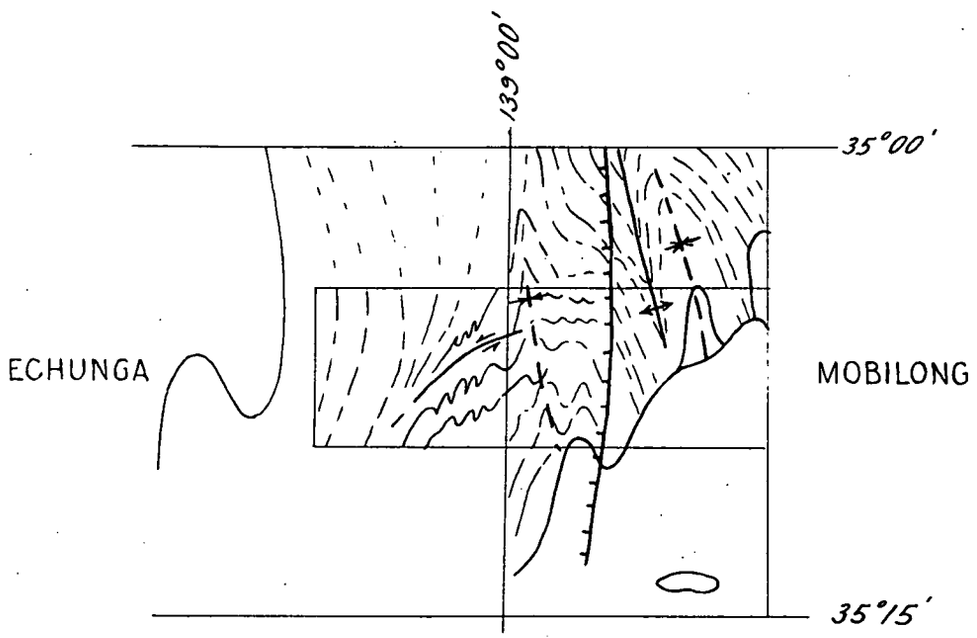

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S.A. DEPARTMENT OF MINES

Approved	Passed	Drn.		D.M.	Scale 7 Miles to 1 Inch
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		Ckd.	TECTONIC SKETCH		H66
Director		Exd.	Fig 2		Date 5·9·62

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