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GEOLOGICAL SURVEY

THE LOWER BOUNDARY OF THE ADELAIDE SYSTEM AND OLDER BASEMENT RELATIONSHIPS IN SOUTH AUSTRALIA

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DEPARTMENT OF MINES
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THE LOWER BOUNDARY OF THE ADELAIDE SYSTEM AND OLDER BASEMENT RELATIONSHIPS IN SOUTH AUSTRALIA*

ABSTRACT

The stratigraphic problem of defining the lower boundary of the Adelaide System is discussed in relation to the geology of several critical areas in the Adelaide Geosyncline and adjacent shelf-platform.

The Precambrian stratigraphic succession and geological history is outlined with the aid of Rb/Sr age-determinations made by W. Compston of Australian National University.

It is concluded that the lower boundary of the Adelaide System is related to the collapse of older basement positive areas on which had developed a regional erosional surface. The surface is defined by the Callanna Beds, the oldest deposits of Willouran age. Willouran sedimentation began sometime between 1340 m. and 1490 m. years. Erosion of the basement rocks probably occupied a major earlier part of this time interval.

INTRODUCTION

Since the initial definition of the Adelaide System (Mawson and Sprigg, 1950) systematic regional mapping by officers of the Geological Survey of South Australia has been extended over most of the Adelaide Geosyncline and bordering provinces. The data now available has made it possible (Thomson et al. 1964) to classify the rock units of the Precambrian sediments in the central area of the Geosyncline into four major parts viz. Wilpena Group, Umberatana Group, Burra Group and Callanna Beds. The Series terms Marinoan, Sturtian, Torrensian and Willouran have been retained as time terms, to describe this part of the Proterozoic geological history of South Australia. The older Precambrian basement rocks have previously been called Archaean owing to their generally higher metamorphic grade than the Adelaide System. Table 1 outlines the nomenclature which has now been adopted in the Adelaide Geosyncline by the Geological Survey.

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*Published with the consent of the Hon. Minister for Mines for South Australia.

Table 1

Time & Rock Terminology

ADELAIDE GEOSYNCLINE (General, 1964)	MT. LOFTY RANGES (Mawson and Sprigg, 1950)	Time Terms	
Parachilna Formation etc.	Cambrian sediments	CAMBRIAN	
Wilpena Group	"Marinoan Series"	MARINOAN	ADELAIDE SYSTEM
Umberatana Group			
	"Sturtian Series"	STURTIAN	
Burra Group	"Torrensian Series"	TORRENSIAN	
Duff Creek Formation, Callanna Beds, River Wakefield group	"Willouran Series" (Sprigg 1952)	WILLOURAN	
UNCONFORMITY			
Peake Metamorphics, Mt. Painter Complex, Willyama Complex.	Barossa Complex	OLDER PRECAMBRIAN	

Study of the earliest Willouran sediments and their relationship with basement is made difficult by:-

(i) Limited exposures of basement within the geosyncline.

(ii) Internal unconformities and overlap of the younger sequences in the Adelaide System.

(iii) Lower Palaeozoic tectonics, intrusives and metamorphism in some key areas.

(iv) Proterozoic and later diapiric activity and decollement folding.

Extensive regional and detailed mapping and recognition of distinctive lithologies are overcoming these difficulties to some degree.

Following the establishment of a Geochronology Laboratory at Australian National University, Department of Geophysics, a project to date the Adelaide System was proposed to the S.A. Mines

Dept. by the Bureau of Mineral Resources Geology and Geophysics in March 1961. A sampling programme was arranged by officers of S.A. Mines Dept., B. P. Walpole of the Bureau of Mineral Resources and W. Compston of the Australian National University.

By mid 1961 about fifty rock samples had been collected by S.A. Mines Department personnel from within the geosyncline and adjacent basement areas ranging in age from older Precambrian to Lower Proterozoic. Additional samples have since been collected.

The Rb/Sr age determinations have been made by A.N.U. under the direction of Compston. More than 30 rock samples have been investigated, both mineral concentrate and total-rock techniques have been used for many of these samples. An important stage in the project was reached when Compston announced recently (ANZAAS Congress, Geochronology Symposium, Jan. 1964) that his evidence showed that the Adelaide System had an age of at least 1300 m. years. The investigations are continuing.

Liaison has been maintained at all stages of the project between Compston and officers of the Geological Survey who are engaged on the 1:250,000 scale mapping programme.

Preliminary age determinations stimulated critical appraisal of rock relationships to ensure that interpretation of the age-determinations referred to reliable geological and petrographical data. The petrology has been investigated for the S.A. Mines Department by Australian Mineral Development Laboratories. A number of chemical analyses of rock samples have also been made.

A separate paper by Compston (this journal) presents a complete account of the age-determinations available to date and details of his interpretations of the isotope data.

The age-determinations have been made available to the writer for preparation of this paper as also has the work of his colleagues in the Survey. This contribution will stress the early history of sedimentation in the Adelaide Geosyncline. Since sedimentation and tectonics are interrelated, an outline of the major tectonic features is given preliminary to examining the problem in detail.

SOUTH AUSTRALIAN PRECAMBRIAN TECTONIC UNITS (FIG. 1)

During Upper Proterozoic and Lower Cambrian time the following tectonic features were evident in South Australia.

Platform and Shelf Zones

The Gawler Platform (fig. 1) is defined by the large area of dominantly metamorphic and igneous rocks west of the Adelaide Geosyncline. It has apparently not been deformed, apart from block uplift, since before Adelaide System time. In Marinoan and Lower Cambrian time, continental and marine sediments were deposited on the platform forming the Stuart Shelf, a cratonic cover of unknown original extent. Similar unfolded shelf deposits flank the northern margin of the Gawler Platform and occur on the Giles Shelf to the north west.

Mobile Basement Blocks and Inliers

Small mobile inliers of the Mt. Lofty Ranges to the east of Adelaide, the Mt. Painter Region and the large Willyama Block extending into N.S.W. are associated with fault and shear systems which were active during Adelaide System time so that these tectonic units were repeatedly transgressed and eroded. The large Musgrave Block which is composed of igneous rocks and highly metamorphosed sediments probably of Archaean age, was possibly a positive area in Upper Proterozoic time.

The Adelaide Geosyncline (Sprigg, 1952)

This feature comprises a mobile fold belt of thick sediments ranging in age from Proterozoic to Middle Cambrian.

The Adelaide System is defined by the Precambrian sedimentary record in this geosyncline. Regional mapping shows the geosyncline to be a complex of trough zones reflecting basement block movements.

In Willouran time a thick sequence was deposited towards the west of the belt. This is confirmed by exposed sections and the zone of diapirs (Coats, 1964, fig. 11) containing these sediments. This trough zone is believed to continue to the north with probable branches to the west.

The source areas for the Adelaide System were the Gawler Platform and associated early shelf deposits, mobile basement blocks and associated contemporaneous covering sediments and intrusive diapir breccia masses.

<u>Kanmantoo Trough</u>

This feature and adjacent mobile basement zone in the Mt. Lofty Ranges area terminates the southern extension of the Adelaide Geosyncline.

The zone was very active during Lower Cambrian time and facies changes in Adelaide System sediments indicate that similar activity probably occurred in late Upper Proterozoic time. The tectonic role of this trough zone in early Willouran time is not known.

EVIDENCE FOR THE LOWER BOUNDARY OF THE ADELAIDE SYSTEM

<u>Mt. Painter Area, Northern Flinders Ranges</u> (Fig. 2)

Excellent exposures showing Adelaide System and basement relationships occur in this region. The unconformity between the two units was first recognized by Mawson (1923). The region and details of the unconformity were mapped by the Geological Survey between 1954 and 1960. (Geological Atlas, 1:63,360 sheets, <u>Umberatana</u>, <u>Gardiner</u>, <u>Paralana</u>, <u>Moolawatana</u>, published 1961). An outline of the geology was given by Campana (1958) who however did not recognize the Willouran sequence as subsequently shown on the published sheets compiled by R. P. Coats.

The Adelaide System overlies a basement (Mt. Painter Complex) containing metaquartzites with pebble horizons intertonguing with "rapakivi" potassic granite, schists, and ?felspathized metasediments. The igneous rocks include an older granitic suite which is pre Adelaide System, and a younger intrusive granite suite within the Mt. Painter Complex, which is now dated as Lower Palaeozoic (Compston this journal). Soda-rich granite plugs intrude the Adelaide System to the southwest of the area (Mawson & Dallwitz, 1954). The Adelaide System sediments in the vicinity of the older

Precambrian inlier show the effects of thermal metamorphism and of metasomatism, also presumably Lower Palaeozoic in age.

The basal unit of the Callanna Beds is a ferruginous lenticular conglomerate overlain by quartzite which is succeeded by phyllites, actinolitic marbles and calcareous phyllites. Intruding the lower units are plug-like bodies of basic igneous rock. Interbedded with and overlying the marbles are lenticular basic lava flows (Wooltana Volcanics) associated with tuffs and altered red shales.

The Wooltana Volcanics were first mapped in detail along the southern margin of the Mt. Painter Complex by W. Woodmansee and J. Johnson (S.A. Mines Dept. Unpub. Report R.B. 41/134, 1956). Crawford (1963) later extended the mapped area southwards to cover in detail the type Wooltana area previously investigated by Mawson (1923, 1926) and Woolnough (1926). Crawford's map shows that the Callanna Beds including volcanics have a maximum thickness of about 7,000 feet in this area. Blissett (S.A. Mines Dept. Unpub. Report R.B. 59/160, 1964) located the volcanics (shown on fig. 2) in the Callanna Beds north of Mt. Painter.

The Wooltana Volcanics are of stratigraphic significance as they occur low in the Willouran sequence. Samples from the Wooltana area have consequently been closely investigated by Compston. He obtained two sets of age results. The first set indicated that the Wooltana Volcanics and consequently the Willouran sequence there may have an age as great as 1,300 m. years, while the second set of results indicated a Lower Palaeozoic age.

This age is thought to reflect the tectonism and metamorphism of that time. Rb/Sr isotope study of illite in shales, stratigraphically close to the volcanics gave ages comparable to the older set.

The Callanna Beds are overlain by the Burra Group of Torrensian age. Both sequences are overlain with marked regional unconformity to the north by the Umberatana Group, here of Sturtian age. This is the type area for this Group (see Coats in Thomson, et al. 1964).

The lower part of the Group here reaches a maximum thickness of about 20,000 feet. This is the result of sedimentation controlled by contemporaneous faulting (Coats, 1962).

The Willouran Ranges

The type area of the Callanna Beds (Thomson et al. 1964, pp. 3-5) is in the Willouran Ranges about 100 miles west of Mt. Painter. This sequence corresponds with the Willouran Series (Mawson, 1927). Precise definition of the rock units of the Callanna Beds awaits further mapping in the area. The Callanna Beds underlie the Burra Group and are represented by 7,000 feet of metamorphosed flaggy sandstone, dolomitic and carbonaceous slates. This succession passes downward into a diapiric zone of Callanna Beds of unknown thickness including carbonates and sandstones with halite casts. Associated with these units in the diapir are basic lavas of the Wooltana type. If these lavas are correlated with the Wooltana Volcanics it follows that the deep trough of the Adelaide Geosyncline in Willouran time was located in the vicinity of the present Willouran Ranges.

Nilpinna Area, Peake and Denison Ranges (Fig. 3)

The Peake and Denison Ranges about 150 miles northwest of the Willouran Ranges are composed of Adelaide System and older Precambrian rocks surrounded and in part mantled by Permian or younger sediments. The thickest known sequence of Willouran sediments occurs below Burra Group sediments southeast of Nilpinna Homestead. (Geological Atlas 1:63,360 sheets Boorthanna and Conway). These sediments have been described as the Duff Creek Formation (Reyner, 1955) and were equated with the "Willouran Series;" Coats, (in Thomson et al. 1964), has recognized in the succession, units that are lithologically identical with units in the type area of the Callanna Beds. He has measured a section in sequence amounting to 12,000 feet in thickness. Lower units of the succession were considered to occur out of sequence in an adjacent diapir. Subsequent field work has lead the writer to believe that the lower units represent a succession about 6,000 feet in thickness. Although some diapiric activity has occurred the order of succession is retained and the lowest units rest with the unconformity on the older basement on the margins of the central core of the domal structure (fig. 3). Traces of a basal? gritty quartzite are present near the contact with basement. The quartzite is followed closely by silicified flaggy dolomites associated with stromatolites. Higher units are shales, siltstones, lenticular dolomites and sandstone. At this level, several bodies of basic igneous rock occur. These are overlain in turn by shales and sandstone, apparently to the lower limit of the section measured by Coats. The basic igneous rocks probably include intrusive altered dolerite (see analysis IX, Table 2) and extrusive amygdaloidal basic lavas showing flow banding, confirmed by petrological examination (P. Sweeney, 1964, unpub. rpt. A.M.D.L.). Similar amygdaloidal lavas presumably of Willouran age were recognised in the Douglas Well area to the south east of the Nilpinna area, (H.Wopfner & R. Heath, pers. comm.). Chemical analyses of these rocks are given in Table 2, item VIII.

The older Precambrian basement is composed largely of the Peake Metamorphics (formerly Peake Series, Reyner, 1955). This rock suite in the Nilpinna area comprises granite gneiss alternating with flaggy sericitic and partly felspathized metaquartzite. The relict bedding planes strike ENE and dip steeply north. The writer believes that the unconformity marking the base of the lower Willouran sediments is preserved on the margins of a mobile basement block. The block is bounded by fault and shear zones associated with a zone of flowage in the less competent Willouran sediments (Fig. 3, cross section). No age-determinations have yet been made on the rocks in the Peake and Denison Ranges.

Sequences of Willouran Age in other Localities in the Geosynclinal Environment

At Depot Creek near Wilkatana homestead, 25 miles NNE of Port Augusta, the Emeroo Quartzite (Mawson, 1947) which there marks the base of the Burra Group, unconformably overlies basic amygdaloidal volcanics (Brunnschweiler, 1956). These volcanics closely resemble the Wooltana Volcanics. Preliminary investigation indicates that age-determination results have been obscured by subsequent tectonism.

The volcanics are underlain by red dolomitic siltstones, dolomites and cross bedded heavy mineral sandstones, all of which are referred to the Callanna Beds (Coats, pers. comm.). Older basement rocks are not exposed. About 50 miles south of Port Augusta, again on the western flank of the Geosyncline, Mirams, (Burra 1:250,000 sheet, 1964), has mapped the Wirrabara Formation, underlying the Burra Group. It comprises clastics, dolomite, shale, sandstone with halite pseudomorphs which are referred to the Callanna Beds. Conformably underlying the Wirrabara Formation is the Nelshaby Sandstone, a pink felspathic sandstone, at least 6,000 feet thick. Basement is not exposed.

About 70 miles north of Adelaide near Clare in the northern Mt. Lofty Ranges, Forbes (1964) has mapped and described a sequence of dolomites, shales and sandstones below the Burra Group. These are part of the River Wakefield Group of Wilson (1952), lithologically they show similarities with the Callanna Beds. Older basement is not exposed. In the Mt. Lofty Ranges, near Adelaide, the Burra Group (Torrensian Series of Mawson and Sprigg, 1950) rests with marked unconformity on older basement, the Barossa Complex.

In the northern Barrier Ranges, N.S.W., 25 miles east of the South Australian border, Sturtian tillites overlie with disconformity, amygdaloidal basalts. The lavas with dolomites and clastics rest with marked unconformity (King and Thomson, p. 547, 1953) on the older Precambrian Willyama Complex. The volcanics (Crawford 1963 (b)) and associated sediments (Thomson, 1964) are correlated with the Wooltana Volcanics and Callanna Beds.

Chemical Composition of Willouran and Related Basic Igneous Rocks

Because the Willouran basic lavas are considered to occur also on the marginal shelf zone and are of critical importance in stratigraphic correlation their chemical characteristics are of great interest. Chemical analyses have been made of more than 20 igneous rocks which on geological evidence are of Willouran age. Many of these rocks are extrusive lavas, others are apparently dyke and plug feeders to the lavas. Table 2 summarizes available analytical data for normal rock types.

Analyses I and II of Table 2 are from the Wooltana Volcanics and V and VI are from lavas occurring as blocks in diapirs within the geosyncline and which are correlated with the Wooltana Volcanics. A similar correlation is made with the lava (with excess Fe_2O_3) represented by analysis VII. This volcanic rock is from Two Hummock Point in the western shelf area.

These are all basic igneous rocks, of approximately basaltic composition, (Mawson, op. cit., Wooltana; Spry, 1952, Worumba area; Coats, 1964, Blinman). They are characterized by SiO_2 percentage between 45% and 49%, high Fe_2O_3 and MgO/CaO ratio exceeding unity. The Willouran basic rocks from the Peake and Denison Ranges (Analyses VIII and IX) are also comparable except that the MgO/CaO ratio is less than 1. The low-silica Sturtian basalt from the Chambers Bluff area in the far northwest is of interest in that it provides further evidence of the association of Adelaide System sediments with basic volcanic rocks.

Crawford (1963 a & b) and Fander (1963) considered that the Wooltana Volcanics were cognetic with the Gawler Range Volcanics, evidence was adduced in the Merinjina Creek area near Wooltana where it was believed that a "bomb porphyry" and other "Pyroclastics" occurred in sequence above massive Willouran lava. The "bomb porphyry" was correlated with Gawler Range Volcanics. Subsequent observations by Mirams (1964) have shown that the contact between the massive Willouran lava and the "bomb porphyry" and "tuffs" is a glacial pavement and that these latter rocks are tillites of Sturtian age, containing erratics of the Gawler Range Volcanic type. Other erratics in the tillites appear to be of western provenance. It is of interest to note that Woolnough (1926) recognised erratics of Gawler Range Porphyry type in the tillites of the Wooltana area.

The Gawler Range Volcanics are dominantly of rhyolitic composition (68% to 72% SiO_2, Fig. 5), in marked contrast to the Willouran basic igneous rocks. The writer has excluded the Gawler Range Volcanics and associated Corunna Conglomerate from the Adelaide System largely on the basis of contrasting chemical composition of the two igneous suites.

TABLE 2 Analyses of Willouran and related Basic Igneous Rocks

	I	II	III	IV	V	VI	VII	VIII	IX	X
SiO_2	47.10	48.46	47.75	45.52	47.20	48.0	37.4	48.3	48.8	41.3
Al_2O_3	14.30	18.76	12.77	14.39	14.65	13.8	13.1	13.2	13.8	14.1
Fe_2O_3	7.41	6.38	7.22	5.21	11.55	12.1	26.2	12.1	6.85	6.40
FeO	3.72	3.01	4.38	6.79	3.71	2.80	7.30	3.14	5.35	7.10
MgO	9.95	6.94	9.92	12.68	6.61	6.54	2.90	5.18	7.60	4.50
CaO	4.01	5.00	5.79	6.22	5.39	4.80	0.28	6.32	9.40	8.00
Na_2O	1.84	3.44	3.46	1.68	3.43	4.60	0.13	3.57	1.96	3.25
K_2O	3.50	1.89	0.81	1.38	2.76	1.18	6.10	2.36	1.03	1.32
H_2O+	4.17	3.55	3.38	3.91	3.46	2.60	4.10	2.28	3.09	4.15
H_2O-	0.23	0.01	0.43	0.88	0.49	0.14	0.30	0.43	0.09	0.10
Co_2	1.44	0.26	1.98	0.00	0.08	1.19	0.05	0.85	0.15	5.95
TiO_2	1.54	1.53	1.65	1.46	1.80	1.83	1.45	1.81	1.58	2.85
P_2O_5	0.12	0.28	0.19	0.13	0.37	0.21	0.20	0.17	0.17	0.44
MnO	0.45		0.28	0.22	0.04	0.07	0.18	0.13		0.17
BaO		0.05			0.04	0.02		0.16	0.035	0.21
S								0.04		0.01
C								0.01		
FeS_2		0.04								
	99.78	99.68	100.19	100.47	100.54	99.79	99.7	99.9	99.9	99.9

I Wooltana Volcanics (A3821, 2, 3, 5, 6/62) Arkaroola Creek Area. Wooltana (Average of 5 analyses) A.M.D.L.

II Melaphyre, Woodnamoka Well, Wooltana (Mawson, 1926).

III Olivine Diabase, Woodnamoka Well, Wooltana (Mawson, 1926).

IV Ophitic Olivine Diabase, 2 mi. N. Wooltana H.S. (Mawson,1926)

V Malaphyre, Teatree Springs, Oraparinna 1 mi-sheet.(Mawson, 1926).

VI Non-amygdaloidal Melaphyre, Blinman (Coats, 1964, A.M.D.L.)

VII Amygdaloidal lava A3833/62. Two Hummock Pt. (Roopena Volcanic equivalent) Cultana 1 mi-sheet. (A.M.D.L.)

VIII Basic rocks including amygdaloidal lavas (average of 5 analyses A550-554/62 A.M.D.L.) ¼ mi. N.E. Douglas Well, Cadlareena Sheet (H. Wopfner (pers.comm.)

IX Altered dolerite 2 mile NNE Last Chance Mines, Nilpinna area, Boorthanna Sheet (A3376/64, A.M.D.L.), R.P. Coats, (pers. comm.)

X Sturtian amygdaloidal basalt (Coats, 1963) A549/62, ¾ mile SW Chambers Bluff, Chandler 1 mi-Sheet (A.M.D.L.)

<u>North Eastern Eyre Peninsula</u> (Fig. 4)

(a) General

This area comprises portion of the Gawler Platform, Stuart Shelf and western margin of the Adelaide Geosyncline. The figure has been compiled from five published sheets of the Geological Atlas 1 mile Series and current mapping by officers of the Geological Survey.

Pioneer mapping in Eyre Peninsula and the shelf area was carried out by Jack (1914, 1917, 1922) followed by Segnit (1939). Systematic mapping for the 1 mile series was done by Miles <u>et al.</u> from 1948 to 1951, in the Middleback Range region.

Johns (1961) mapped southern and central Eyre Peninsula between 1950 and 1957. Johns <u>et al.</u> subsequently mapped the area north of Eyre Peninsula (Torrens 1:250,000 sheet, 1964) and Andamooka 1:250,000 sheet (in preparation). Crawford and Hiern mapped the Cultana 1 mile sheet (1964). Mapping and revision of the Port Augusta and Whyalla 1:250,000 sheets is in progress.

The geology of the major iron ore deposits of the Middleback Ranges has been studied by geologists of the Broken Hill Proprietary Co. Ltd., Rudd in (Rudd and Miles, 1953) and Owen (1964). Corresponding investigations have been made by officers of the Geological Survey in this area and elsewhere, Miles (1954) and Whitten (1964).

Since the area permits study of relationships between Adelaide System and the older Precambrian, numerous age-determinations have been made since 1961 by Compston using samples collected by members of the Survey from both Adelaide System and older rocks. A particular problem has been the age of the Corunna Conglomerate, and Gawler Range Volcanics which on geological evidence post-date the older basement rocks. Mawson (1947) correlated the Corunna Conglomerate with the Emeroo Quartzite to the east which is Torrensian in age. Miles (1954) correlated the Conglomerate with the Pound Quartzite of the Adelaide Geosyncline at that time (apart from Segnit, 1939) considered to be Cambrian. The Pound Quartzite is now generally regarded on faunal evidence to be Marinoan in age, (Glaessner and Daily, 1959) and to be the uppermost rock unit in the Adelaide System. No positive geological field evidence has yet been found that clearly resolves the age relationship of the Corunna Conglomerate to the Adelaide System. Age-determinations by Compston have now however established that it and the Gawler Range Volcanics are older than any rocks yet dated within the Adelaide System, and younger than the granites that intrude the Older Precambrian basement in this region.

(b) Moonabie Range Area

The following table (III) summarizes the current geological information in this area. The petrology is being studied in detail by P. Sweeney and D. Smale of Australian Mineral Development Laboratories.

TABLE III

ROCK RELATIONSHIPS
MOONABIE RANGE AREA

1. Local silicification and epidotization of 2.
2. CORUNNA CONGLOMERATE, includes conglomerates, sandstone, red shale and sedimentary breccia members.
3. Unconformity, obscured by shearing. (2 overlies 5 and 6, relationship of 2 and 4 uncertain).
4. CHARLESTON GRANITE (intrudes 5).
5. MOONABIE PORPHYRY (porphyritic rhyolite, intrudes 6, occurs as pebbles in 2).

6. MOONABIE FORMATION (VOLCANICLASTIC PHASE)
(Restricted to Moonabie Range area. It is interbedded with rhyolite, early (?) phase of 5, and contains pebbles of penecontemporaneous or earlier rhyolites). 6 occurs as pebbles in 2.

The Moonabie Range is the type area of the "Moonabie Grit" (Miles, 1954). It is here proposed to rename this rock unit, the Moonabie Formation (Volcaniclastic Phase), since subsequent petrological work has shown that it contains abundant reworked rhyolite fragments. It is a dense cross-bedded siliceous metasediment interbedded with or intruded by thin rhyolite layers. Miles tentatively referred this unit to the Adelaide System and consequently assumed that it was separated from the older rocks by an unconformity.

The relationship of the unit to Middleback "Group" and "Gneiss" Complex is not known in the Moonabie Range area. The writer considers that the Moonabie Formation is best considered as a unit of the basement as it is separated from the Corunna Conglomerate by a major unconformity. Catley (1963, p.102) and Owen (1964, p.50) report an association of Middleback Group with volcanic rocks of various types. The Moonabie Porphyry is a dark grey rhyolitic rock intrusive into the volcaniclastic Moonabie Formation. At the contact it has the character of a dolerite-amphibolite (Miles 1954, p.35). The main rock type has a lower silica content than the generally red coloured Gawler Range Volcanics (see fig. 5). The Porphyry is in turn intruded by the acid Charleston Granite, dated by Compston (this journal) at 1590 ± 30 million years. The Moonabie Formation (Volcaniclastic Phase) and Moonabie Porphyry must consequently be of greater age.

The Corunna Conglomerate in its lower members contains boulders of Moonabie Porphyry, some altered pebbles of ?Moonabie Formation (J.E. Johnson, pers. comm.), abundant pebbles of the Middleback 'Group' iron formations, and occasional boulders of quartzose conglomerate.

The local silicification and epidotization of the conglomerate is possibly related to some effect of the Gawler Range Volcanics. An outcrop of this unit occurs several miles to the north.

(c) Corunna Range, North Middleback, Whyalla areas

The Middleback "Group," which includes shale, schist, dolomite, quartzite and iron formations is considered by Miles (1954) and subsequent work of the Survey to pass laterally, as the result of granitisation, into units of the "Gneiss" Complex. It is represented by the Flinders "Group" of Johns (1961) in Southern Eyre Peninsula. A "Middle Precambrian" or late Archaean age is given to the Middleback "Group" by Miles.

The possibility is not excluded that there are other parts of the "Gneiss" Complex of considerably greater age than the Middleback "Group."

The Burkitt Granite ("tor" granite of Miles) intrudes the "Gneiss" Complex and is overlain with marked unconformity by the Corunna Conglomerate, four miles west of Tassie Creek Reservoir. Chemical composition of the granite is shown in fig. 5.

The Moonabie Formation (Quartzitic Phase), a facies of the "Moonabie Grit" of Miles (1954), is a dense cross-bedded quartzite with heavy mineral bands and lithified sandstone members of variable grain size. It is generally poorly stratified, blocky and jointed and has some lithological features in common with the metaquartzites of the Mt. Painter Complex and Peake Metamorphic. Petrological evidence shows that this unit is generally recrystallized and has undergone some potash metasomatism and tourmalinization. The rock contains occasional pebbles and fragments of volcanic rocks, chert, siltstone and quartzite. None of these can be identified with certainty with the Middleback "Group" or "Gneiss" Complex. Boulders of the Moonabie Formation (Quartzitic Phase) occur in the Corunna Conglomerate. The unit is best seen in the Whyalla area where at Mt. Laura it is overlain with spectacular unconformity by the Corunna Conglomerate (Miles op. cit. p.25). To the east it is overlain by the Pandurra Formation, a red felspathic sandstone which is correlated with the Adelaide System (Crawford, 1964, Cultana 1 mile sheet). Because of poor outcrops, the contacts between Moonabie Formation (Quartzitic Phase) and "Gneiss" Complex have not yet been closely studied.

The type area of the Corunna Conglomerate is at Tassie Creek

Reservoir (Miles, op cit. p.27). The rock unit has a minimum thickness of 420 feet and includes a variety of members (table IV), one of these is a green illitic sandstone. Age-determinations of the illite and total rock are given by Compston (this journal).

Jack (1917) described the Gawler Range "Porphyry" at the eastern end of the Gawler Range (N.W. portion of fig. 4) -"as resting upon the Precambrian gneisses." He also suggested that "taken as a whole .... that here it is effusive rather than intrusive. No estimate of its age can be given." The volcanic character of these rocks is supported by Crawford 1963 (a) from reconnaissance field observations and by the unpublished petrological evidence of H. W. Fander of Australian Mineral Development Laboratories, obtained during the sampling by the Survey for the age-determination project. The rocks are dominantly rhyolitic in character. Chemical compositions (fig. 5) given by Jack (1917) and also from current analyses agree with this classification. The rock unit has consequently been renamed the Gawler Range Volcanics. The thickness of this unit is unknown but may be considerable. Compston has dated samples from the main mass in the Gawler Ranges.

Systematic mapping of these rocks is being carried out to the northwest. Johns and Solomon (1953) have previously demonstrated that in places the Gawler Range Volcanics clearly intrude the Corunna Conglomerate. At one of these localities, the Wartaka area 7 miles NNE of Tassie Creek Reservoir, an intrusive rhyolitic plug has been dated by Compston.

Another intrusive mass of this unit is the rhyolitic breccia 2 miles west of the reservoir which has also been dated by Compston. Boulders of Gawler Range type volcanics in the basal members of the Corunna Conglomerate in this area show that some of the volcanics in this suite were probably extruded onto an older basement erosion surface prior to deposition of the Conglomerate.

The following table summarizes the rock relationships in the area.

TABLE IV

ROCK RELATIONSHIPS IN CORUNNA RANGE, NORTH MIDDLEBACK AND WHYALLA AREAS.

1. GAWLER RANGE VOLCANICS acid intrusives and flows associated with local metamorphism of 2.

2. CORUNNA CONGLOMERATE. Conglomerate facies associated with dolomite, quartzite, sandstone, volcaniclastic arkose, red shale members and unnamed illitic sandstone member.

3. VOLCANICS. Rhyolites identical with 1, occur as boulders in 2 and veins in 5. Relationship to 6 is uncertain but probably intrusive.

4. Unconformity (established by 2 on 5 and 6, structure and pebble composition).

5. BURKITT ("Tor") GRANITE. (Probably intrudes 8, occurs as pebbles in 2, intruded by 1 and/or 3. Relationship to 6 not known).

6. MOONABIE FORMATION (QUARTZITIC PHASE) (Probably is a unit of 7 or 8 or a younger Older Precambrian unit. Occurs as pebbles in 2. Contains pebbles of volcanics, clay galls, etc.).

7. Metamorphism and Metasomatism of 8, producing "GNEISS" COMPLEX which occurs as pebbles in 2. (5 may be contemporaneous with metamorphism 7).

8. MIDDLEBACK "GROUP." (Occurs also as pebbles in 2).

(d) Area between Old Roopena Homestead and Spencer Gulf.

Webb & Crawford (1961, Mines Dept. unpub. Rept. R.B. 53/24) and Crawford (1963, Mines Dept. unpub. Rept. R.B. 56/17) recognized basic lavas (Roopena Volcanics) of the Wooltana type at Old Roopena Homestead and Two Hummock Point. Compston has dated the lava at Old Roopena Homestead at 1340 $\pm$ 20 m. years. This is a critical age-determination for indicating the duration of the Adelaide System. Age determinations (Compston this journal) show that the Gawler Range Volcanics, Corunna Conglomerate, Charleston and Burkitt Granites are older than Roopena Lava.

The overlying red felspathic sandstone (The Pandurra Formation) about 400 feet thick formerly mapped in this area as Corunna Conglomerate by Miles et al. wasprovisionally assigned to the Willouran by Crawford. He considered that similar grits and conglomerates at Two Hummock Point were interbedded with the Roopena Volcanics and were consequently of Willouran age. The field evidence in this locality is uncertain. At Old Roopena Homestead, reworked pebbles of Roopena Volcanics occur in a basal conglomerate member of the Pandurra Formation, indicating an erosional interval between the two units.

Johns (1963) equated the clastic sediments (Pandurra Formation) between Whyalla and Pandurra Homestead with the upper glacial units of the Adelaide System, Umberatana Group, (now considered Marinoan in age). Johns considers that the upper glacial sediments of the Umberatana Group are represented in the region west of Lake Torrens (Torrens 1:250,000 sheet, 1964) by the Pernatty Grit, a dominantly clastic sequence at least 1200 feet thick. Coarse grained members of this formation resemble the Pandurra Formation.

Erratics of rocks lithologically similar to an upper member of the Pernatty Grit occur however in the Sturtian tillites at several localities in the Flinders Ranges (pers. comm. R.P. Coats & J. E. Johnson) thus suggesting a pre-Sturtian age for the Pernatty Grit and possibly the Pandurra Formation.

The Pandurra Formation has not been recognized with certainty in sequence in the Adelaide Geosyncline to the East. West of Spencer Gulf the Formation is overlain with apparent conformity by the Tregolana Shale and Tent Hill Formation which from detailed lithological and mapping evidence undoubtedly represent units of the Wilpena Group of Marinoan age. In view of the lack of positive evidence the age of the Pandurra Formation has consequently not yet been fixed with certainty within late Willouran to early Marinoan time range.

At Depot Creek in the western Flinders Ranges (Brunschweiler, 1954) volcanics of the Wooltana and Roopena type overlie typical Callanna Beds. West of Spencer Gulf however the contact between Roopena Volcanics and older rocks is not exposed. It appears likely that there the volcanics were extruded onto a basement of Moonabie Formation subsequent to an erosional interval during which the earliest Callanna Beds were being deposited in the geosyncline to the east.

The Cultana Granite (Crawford 1964, Cultana 1:63,360 sheet) pre-dates the Pandurra Formation in age and post-dates Moonabie Formation (Quartzitic Phase). The igneous body is complex and includes porphyritic granite and porphyry with minor dacite, rhyolite and granophyre. It is provisionally equated with the Moonta Porphyry and Gawler Range Volcanics. Although preliminare age determinations of the Cultana Granite give an age approximating to that of the Roopena Volcanics, satisfactory total rock values have not yet been obtained (W. Compston pers. comm.).

A summary of rock relationships in the area is given below.

TABLE V

ROCK RELATIONSHIPS

AREA BETWEEN OLD ROOPENA HOMESTEAD AND SPENCER GULF

1. TENT HILL FORMATION (Marinoan) — Simmons Quartzite Member; Corraberra Sandstone Member
2. TREGOLANA SHALE (Marinoan)
3. disconformity? (inferred)
4. PANDURRA FORMATION
5. Disconformity or unconformity (established in Old Roopena H.S. area).
6. ROOPENA VOLCANICS
   Localities Old Roopena H.S. Two Hummock Pt., Backy Pt.
   Occur as pebbles at base of 4 at Old Roopena H.S.
7. Unconformity inferred, contact between 6 and 8 or 9 not yet seen.
8. CULTANA GRANITE shows acid volcanic affinities, intrudes 11, occurs as boulders in 4 in Cultana area.
9. GAWLER RANGE VOLCANICS. Occur as intrusive bodies in this area. Intrude 11, occur as pebbles in 4 at Old Roopena H.S.
10. Unconformity inferred; probably destroyed by erosion.
11. MOONABIE FORMATION (QUARTZITIC PHASE).
12. "GNEISS" COMPLEX. Relationship to 11 uncertain in this area, together with MIDDLEBACK GROUP occurs as pebbles in 4 at Old Roopena H.S.

(e) Chemical Compositions of Some Igneous Rocks from Northern Eyre Peninsula and Adjacent Areas (Fig. 4).

Chemical analyses of five rock samples of Gawler Range Volcanics are available from the following localities. Kundery Hill (67.8% SiO_2), Corunna Range (68.9, 69.0% SiO_2), Paney Bluff (red variety, 71.48% SiO_2) Paney Bluff (dark grey variety, 72.22% SiO_2). The variation diagram shows clearly that the K_2O, Na_2O and CaO trends intersect those of the Charleston Granite massif analyses. It is suggested that the two rock units are related to different igneous suites.

Supporting this interpretation the age-determination results indicate that the Charleston Granite is about 60 million years older than the Gawler Range Volcanics.

The Moonta Porphyry composition indicate correlation with the Gawler Range Volcanics, particularly with CaO and Na_2O trend of the two analyses available.

The Moonabie Porphyry analysis (65.86% SiO_2) also falls on the extrapolated Gawler Range Volcanics alkali curves although field relations indicate that it is pre-Charleston granite and is consequently not related in time to the Gawler Range volcanic igneous suite. Age-determination results on the other hand suggest it is Gawler Range Volcanic in age (Compston this journal). The single analysis of Burkitt Granite (65.59% SiO_2) with high Al_2O_3 (16.14%) indicates that it is a contaminated rock.

Only one analysis is available from Northern Eyre Peninsula of amygdaloidal basic lava of the Wooltana type, this is from Two Hummock Point (analyses VII, Table 2). The high Fe_2O_3 content (26.2%) is due to excess hematite. Correction for this shows that the rock probably had an original composition within the range of 45% to 48% SiO_2, typical of the Willouran lavas, and an MgO/CaO ratio greater than unity.

PRECAMBRIAN CORRELATIONS

The "Older Precambrian" Basement

Miles (1954) assigned a "Middle Precambrian" or "late Archaean" age to the Middleback "Group." He noted (p.126) the lithological similarities of the iron formations with the Archaean jaspilites of the West Australian goldfields. So far, age-determinations in South Australia neither confirm nor deny such a correlation, as they give the age of youngest granite or migmatisation. The Eyre Peninsula metasediments have been described as "typical Grenvillean complexes," (Dickenson & Sprigg, 1953, p.427). The age of the sediments comprising the Willyama Complex is likewise conjectural. The sediments are of greater age than the davidite lodes at Crocker's Well, 1660 m. years and at Radium Hill, 1540 m. years (Wilson et al. 1960).

An important link in the Precambrian stratigraphy of W.A. and S.A. is provided by the Precambrian units in the Musgrave Block and in the so-called Officer Basin, a large concealed area to the north of the Gawler Platform. The original sediments constituting the Musgrave Block are represented by the Musgrave-Mann Metamorphics of the granulite metamorphic facies (Davies, 1:63,360 sheet, in press). Wilson et al., (1960, p. 188) pointed out that age-determinations indicated that in the Musgrave Ranges these rocks are of unknown Precambrian age and have been subjected to repeated metamorphisms. Geological evidence in the Indulkana Range area (Coats, 1963) indicates that the igneous rocks intruding the Musgrave Block basement are at least pre-Sturtian in age. In this area a belt of unmetamorphosed Adelaide System sediments, possibly including some of Willouran age trends southwest into the Officer Basin.

A clastic sequence occurs farther west near the W.A. border (Johnson, 1963). This unit was provisionally assigned to the Marinoan and rests unconformably on granite basement at Belundina Hill (Birksgate 1:250,000 sheet). It resembles the Pandurra Formation and likewise may be as old as Willouran or in part as young as Ordovician (Sprigg et al. 1958, p.85). Johnson considers this sequence forms the northern flank of the Officer Basin and extends northwest for about 150 miles into Western Australia to the Warburton Range area where it is underlain by two volcanic and sedimentary sequences (Horwitz & Sofoulis, 1962). In the Skirmish Hill area, nearer the South Australian border, the clastic unit, according to J. E. Johnson (pers. comm.) rests on a thick complex volcanic sequence at the base of which a conglomerate marks a major unconformity with a granulite basement of the Musgrave-Mann Metamorphics.

The writer considers that the volcanics of Skirmish Hill and those underlying the "Townsend Range Series" (Talbot & Clarke, 1917) are best correlated with the Fortescue Group (Daniels, 1964) and equivalents in northwestern West Australia. This correlation has previously been made in general terms by Sofoulis (1961).

The Fortescue Group is the lowest Proterozoic unit in the remarkable Nullagine basin recently described by Daniels (op. cit.). The group is about 22,000 feet maximum thickness, is dominantly basaltic in the type area, it exceeds 2,100 m. years (Leggo et al. 1964) and rests unconformably on an older Archaean basement. It is overlain by the Hamersley Group containing the economically important iron formations (MacLeod, 1964) dated at about 2,100 m. years (Leggo et al. op.cit.). If the volcanics of Skirmish Hill are correlated with the Fortescue Group, then the Musgrave - Mann Metamorphics are Archaean in age.

The following table shows the relationships and lithology on the southwestern flank of the Musgrave Block.

TABLE VI

South West of Musgrave Block

Previous Correlation	Warburton Ra. Area(W.A.)	Skirmish Hill Area (W.A.)	Proposed Correlation
Marinoan (Horwitz & Sofoulis, 1962)	silts, shale, limestone "Townsend quartzite" UNCONFORMITY (Horwitz & Sofoulis, 1962)	shale, oolitic cherty limestone quartzite UNCONFORMITY (Johnson, 1963)	Adelaide System?
	basalt of "Townsend Series," 3000 feet approx. UNCONFORMITY, (Talbot & Clarke, 1917)		hiatus?
Lower Proterozoic (Sofoulis, 1961)	17000ft.approx. of doleritic and basaltic lava, tuff, dolomite and chert, intruded by porphyry, granite(?) and minor basic dykes and sills	17000ft.approx. of basalt, andesite, rhyolite, granophyre, porphyry with minor basic dykes. Basal conglomerate UNCONFORMITY	Lower Proterozoic
		Granulites etc. of Musgrave-Mann Metamorphics	Archaean

Within basement areas, correlation of metasediments depends on regional and detailed field stratigraphic studies supported by reliable age-determinations from contemporaneous rock such as interbedded volcanic flows. Until such data are available time subdivision into Middle and Lower Proterozoic and Archaean for the southern basement areas of South Australia does not appear to be possible. The general term "Older Precambrian" is now provisionally used for basement rocks. The end of this general time interval appears to be marked by the intrusion of late or post-orogenic granitic rocks (Burkett, Charleston, Pepegoona Porphyry and younger granites of the Olary Province) dated at about 1600 m. years.

The Gawler Range Volcanics and Corunna Conglomerate

These rock units lie between the Adelaide System and Older Precambrian sequences and are probably "Middle Proterozoic" in age.

The Adelaide System

Prolonged erosion during the Middle Proterozoic terminated with the collapse of the "Older Precambrian" basement east of the Gawler Platform. The Willouran time interval is taken as having commenced with the sedimentation in the resultant trough zone believed to represent the earliest phase of the Adelaide Geosyncline. This event is assumed to have begun at about 1400 m. years. Four major cycles of sedimentation followed before the Cambrian.

The beginning of the second (Burra Group) and third cycle (Umberatana Group) marked the beginning of the Torrensian and Sturtian time intervals, respectively. Two widespread glaciations represented in the Umberatana Group occurred in early Sturtian and in early Marinoan time. The base of the Umberatana Group is defined in many areas by an unconformity with the Burra Group (Thomson et al. 1964, p.8).

The four time intervals associated with the Adelaide System are of great practical value in South Australian geology because detailed lithological features in the sequences can be recognised over great areas and extend even beyond the State boundaries. Sufficient age-determinations are not yet available in South Australia to date the time intervals precisely. Until the question of fixing the Middle and Upper Proterozoic boundary is resolved throughout Australia and elsewhere, the Adelaide System is provisionally regarded as "Upper Proterozoic." Present evidence is that the Adelaide System includes Upper Proterozoic and part of Middle Proterozoic time-subdivisions as proposed for Canada by Stockwell (1962, p.9). Figure 6 illustrates diagrammatically the Precambrian time-rock relationships in South Australia. The time scale is adopted from age-determinations provided by Compston. The ages of Willouran, Sturtian and Marinoan boundaries represented on the diagram have been assumed. The numerous disconformities and internal unconformities observed within the major cycles are not shown on the diagram.

A great advance will be made when the sediments of the Nullagine Basin and Adelaide Geosyncline are accurately correlated. According to Daniels (op. cit.), the uppermost unit, the Bangemall Group of shales, dolomites and clastics is of the order of 900 m. years in age and overlies the Bresnahan Group, a thick clastic sequence. Both groups have lithological features in common with the Adelaide System sequences on the margins of the Gawler Platform and Musgrave Block.

<u>Summary of Precambrian and Lower Palaeozoic Geological History</u>

a. Deposition of Middleback "Group" and related sediments on buried older basement. Associated vulcanism. Moonabie Formation (?).

b. Folding of sediments, metamorphism and granitisation of the site of future Gawler Platform and Adelaide Geosyncline.

c. Intrusion of late or post-orogenic granites (approximately 1600 m. years) marking final phase of evolution of "Older Precambrian" basement.

d. Intermittent block uplift, erosion and peneplanation of Gawler Platform. Acid extrusives (Gawler Range Volcanics) with local areas of sedimentation (Corunna Conglomerate). Probable continued erosion of basement areas to east.

e. Collapse of eastern basement area, beginning of Adelaide System (Willouran) sedimentation ?1400 m. years in early trough of

Adelaide Geosyncline. Willouran basic volcanics (1340 m. years) within and flanking the Adelaide Geosyncline trough.

f. Intermittent sedimentation in Adelaide Geosyncline controlled by block tectonics and associated diapiric movements of Willouran sediments. Torrensian and Sturtian transgressions following erosional intervals over large ageas. Sturtian and Marinoan glaciations and glacio-marine sedimentation.

g. Post-glacial widespread Marinoan transgression on to Gawler Platform. Change to continental or lagoonal environments. Termination of Adelaide System sedimentation.

h. Cambrian marine transgression. Widespread carbonate shelf deposits extending over Adelaide Geosyncline and part of the Gawler Platform, minor volcanic activity and collapse of Kanmantoo Trough in south with associated geosynclinal sedimentation. Change to continental environment.

i. Orogeny, metamorphism, intrusion of south eastern margin of Adelaide Geosyncline by Ordovician granite.

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BPT:EMD
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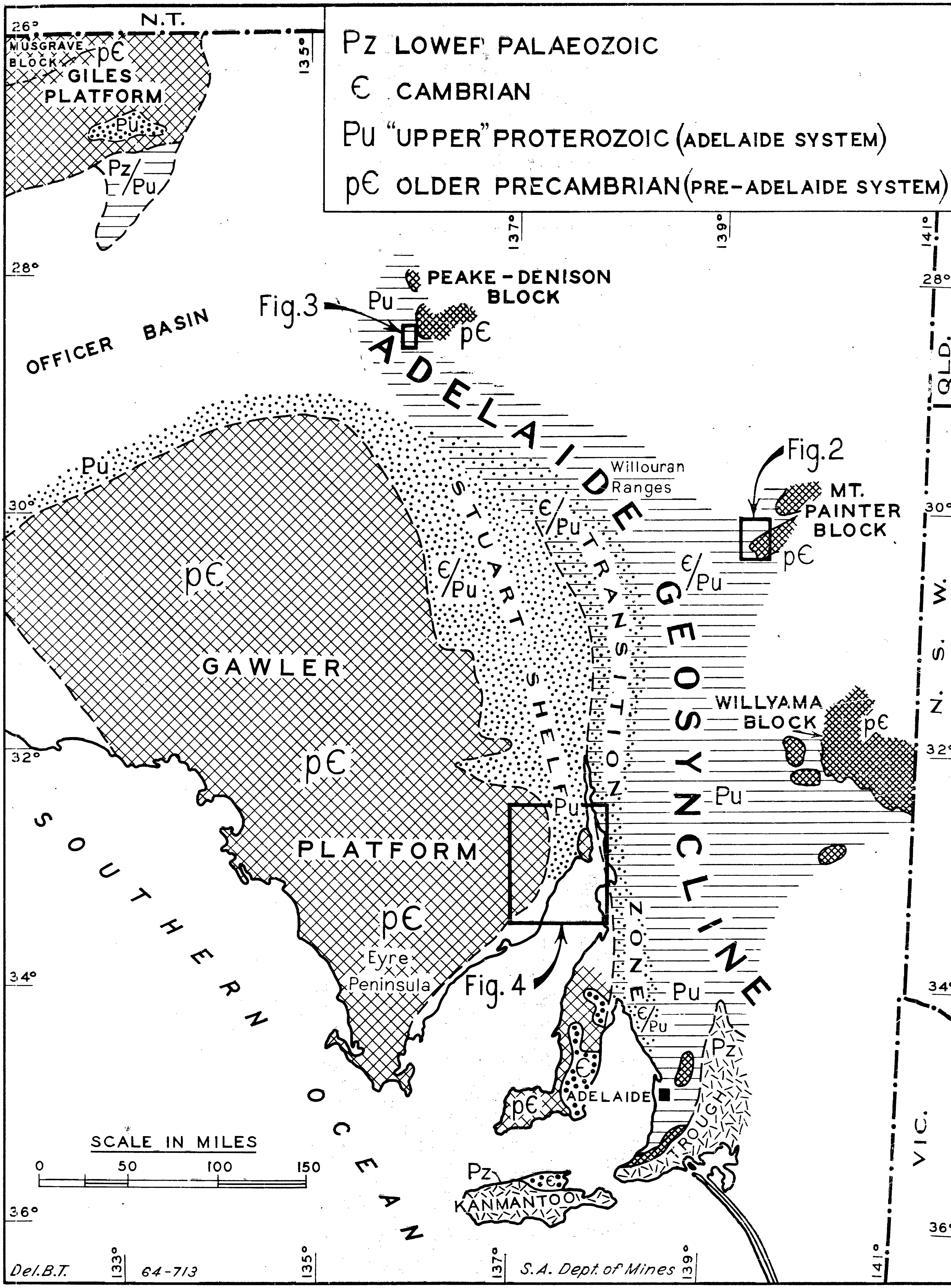
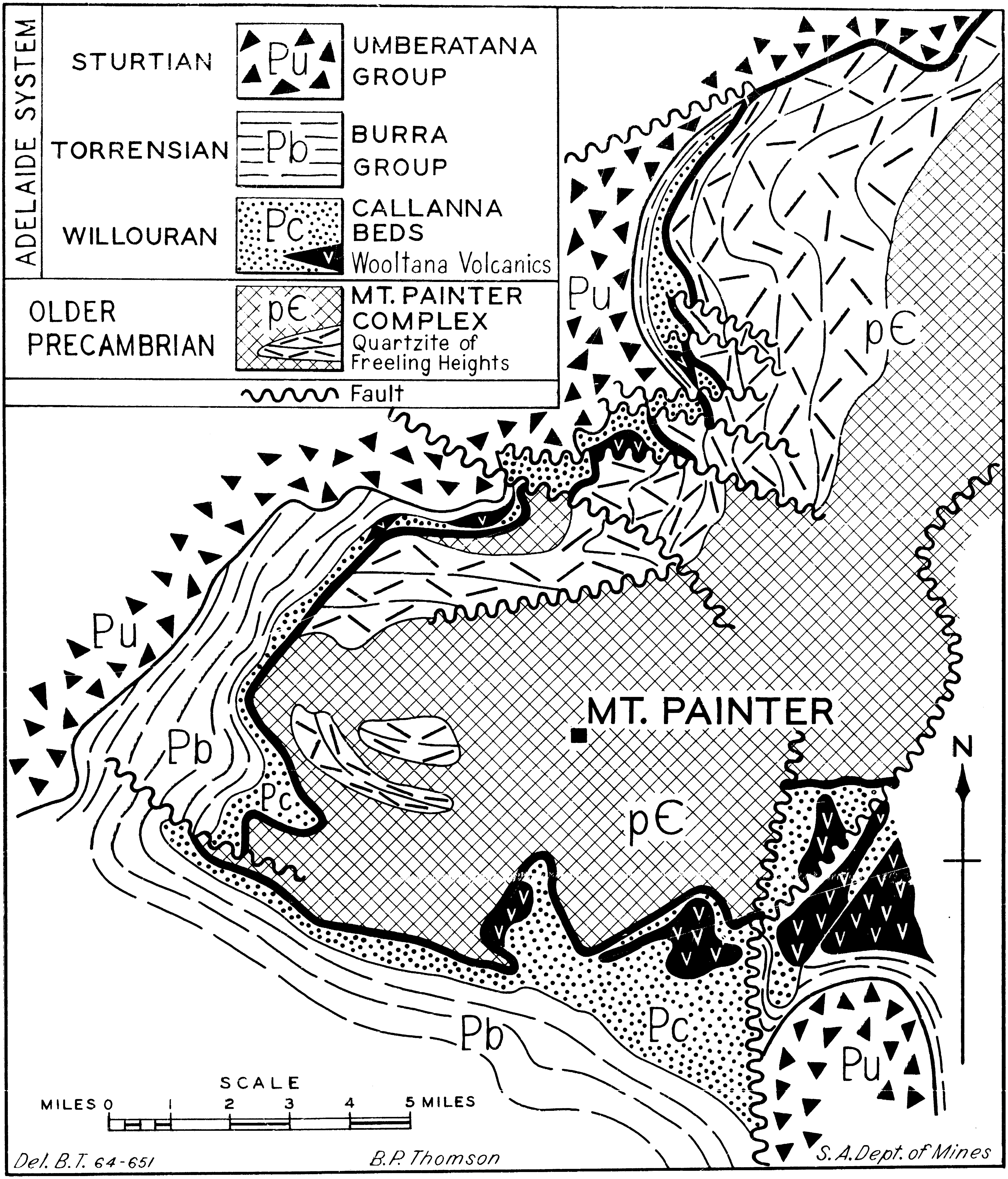
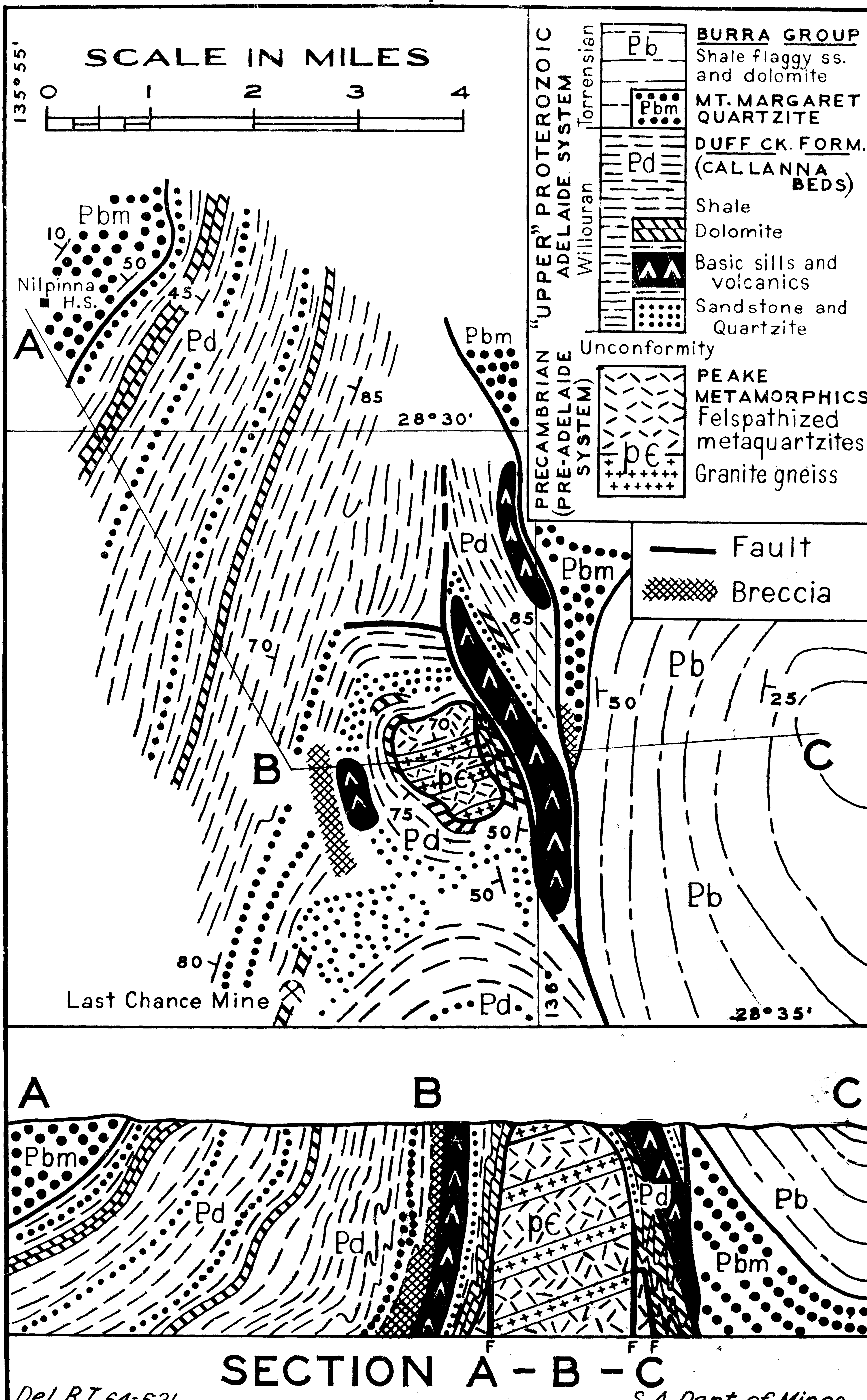

N.T.
Pz LOWER PALAEOZOIC
Є CAMBRIAN
Pu "UPPER" PROTEROZOIC (ADELAIDE SYSTEM)
pЄ OLDER PRECAMBRIAN (PRE-ADELAIDE SYSTEM)
MUSGRAVE BLOCK
GILES PLATFORM
PEAKE-DENISON BLOCK
Fig.3
OFFICER BASIN
ADELAIDE GEOSYNCLINE
Willouran Ranges
Fig.2
MT. PAINTER BLOCK
STUART SHELF
TRANSITION ZONE
GAWLER PLATFORM
WILLYAMA BLOCK
SOUTHERN OCEAN
Eyre Peninsula
Fig. 4
ADELAIDE
TROUGH
KANMANTOO
QLD.
N.S.W.
VIC.
SCALE IN MILES
0 50 100 150
Del.B.T.
64-713
S.A. Dept. of Mines


ADELAIDE SYSTEM
STURTIAN
Pu
UMBERATANA GROUP
TORRENSIAN
Pb
BURRA GROUP
WILLOURAN
Pc
CALLANNA BEDS
Wooltana Volcanics
OLDER PRECAMBRIAN
pЄ
MT. PAINTER COMPLEX
Quartzite of Freeling Heights
Fault
Pu
Pu
Pb
Pc
pЄ
MT. PAINTER
pЄ
Pc
Pb
Pu
N
SCALE
MILES 0 1 2 3 4 5 MILES
Del. B.T. 64-651
B.P. Thomson
S.A. Dept. of Mines



SCALE IN MILES
0 1 2 3 4
135°55'
"UPPER" PROTEROZOIC ADELAIDE SYSTEM
Torrensian
Willouran
Pb
BURRA GROUP
Shale flaggy ss. and dolomite
Pbm
MT. MARGARET QUARTZITE
Pd
DUFF CK. FORM. (CALLANNA BEDS)
Shale
Dolomite
Basic sills and volcanics
Sandstone and Quartzite
Unconformity
PRECAMBRIAN (PRE-ADELAIDE SYSTEM)
pЄ
PEAKE METAMORPHICS
Felspathized metaquartzites
Granite gneiss
Fault
Breccia
Nilpinna H.S.
A
B
C
28°30'
28°35'
136°
Last Chance Mine
SECTION A - B - C
F
F F
Del. B.T. 64-621
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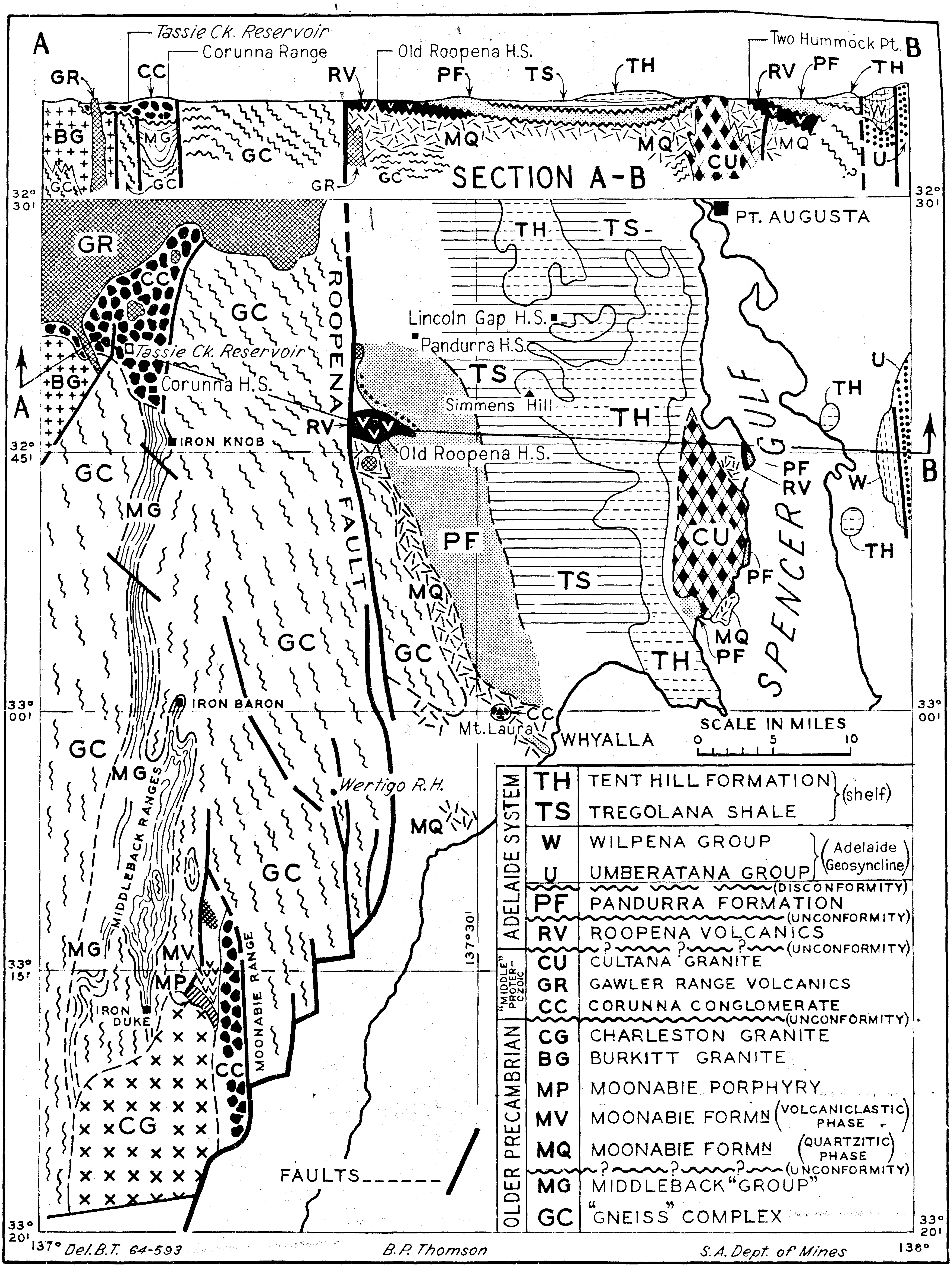
A
B
Tassie Ck. Reservoir
Corunna Range
Old Roopena H.S.
Two Hummock Pt.
SECTION A-B
PT. AUGUSTA
Lincoln Gap H.S.
Pandurra H.S.
Corunna H.S.
Simmens Hill
IRON KNOB
Old Roopena H.S.
ROOPENA FAULT
SPENCER GULF
IRON BARON
Mt. Laura
WHYALLA
Wertigo R.H.
MIDDLEBACK RANGES
MOONABIE RANGE
IRON DUKE
SCALE IN MILES
0 5 10
137°30'
32° 30'
32° 45'
33° 00'
33° 15'
33° 20'
137°
138°
FAULTS
ADELAIDE SYSTEM
TH TENT HILL FORMATION (shelf)
TS TREGOLANA SHALE
W WILPENA GROUP (Adelaide Geosyncline)
U UMBERATANA GROUP
(DISCONFORMITY)
PF PANDURRA FORMATION
(UNCONFORMITY)
RV ROOPENA VOLCANICS
? ? ? (UNCONFORMITY)
"MIDDLE" PROTEROZOIC
CU CULTANA GRANITE
GR GAWLER RANGE VOLCANICS
CC CORUNNA CONGLOMERATE
(UNCONFORMITY)
OLDER PRECAMBRIAN
CG CHARLESTON GRANITE
BG BURKITT GRANITE
MP MOONABIE PORPHYRY
MV MOONABIE FORMN (VOLCANICLASTIC PHASE)
MQ MOONABIE FORMN (QUARTZITIC PHASE)
? ? ? (UNCONFORMITY)
MG MIDDLEBACK "GROUP"
GC "GNEISS" COMPLEX
Del. B.T. 64-593
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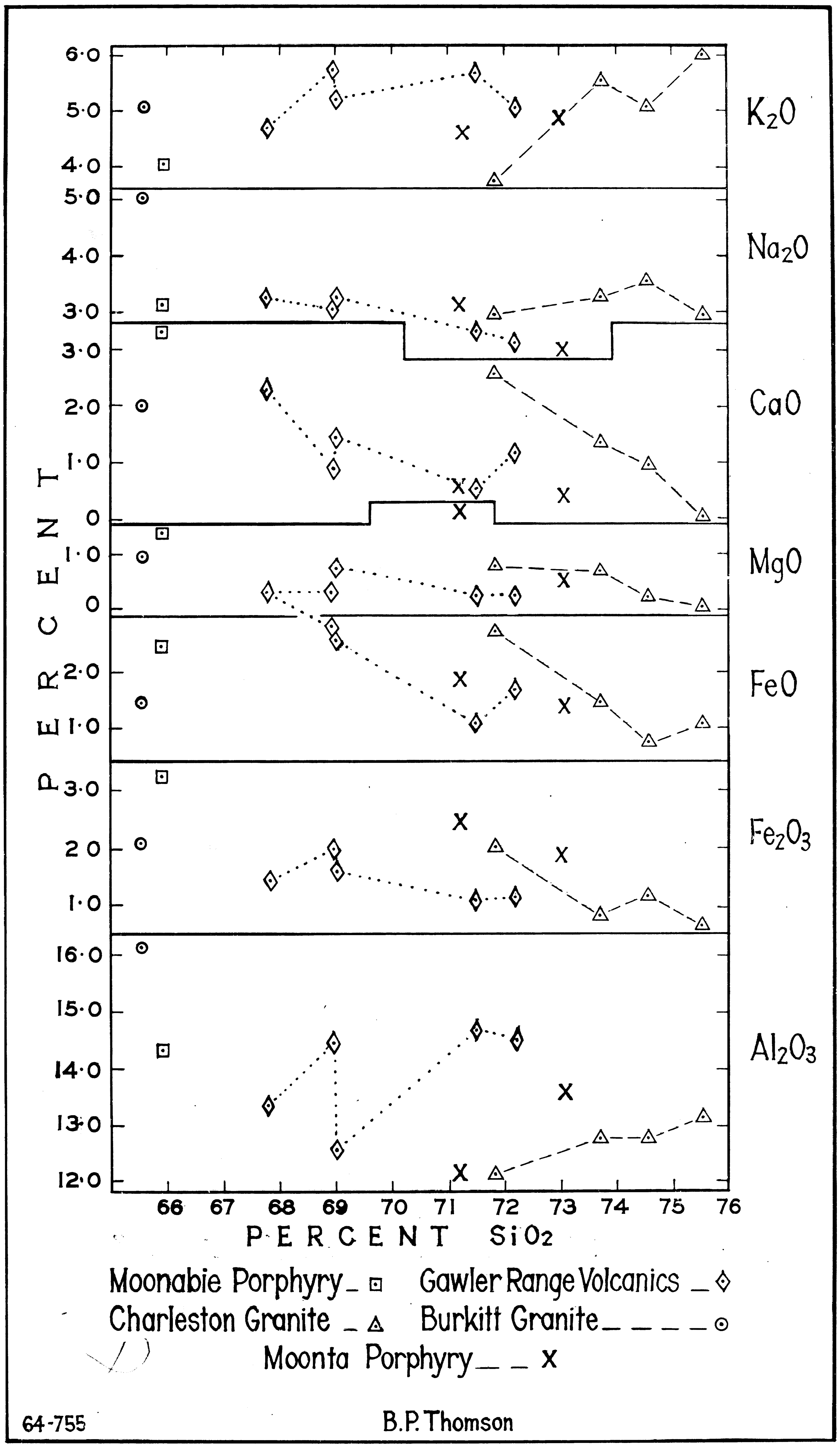

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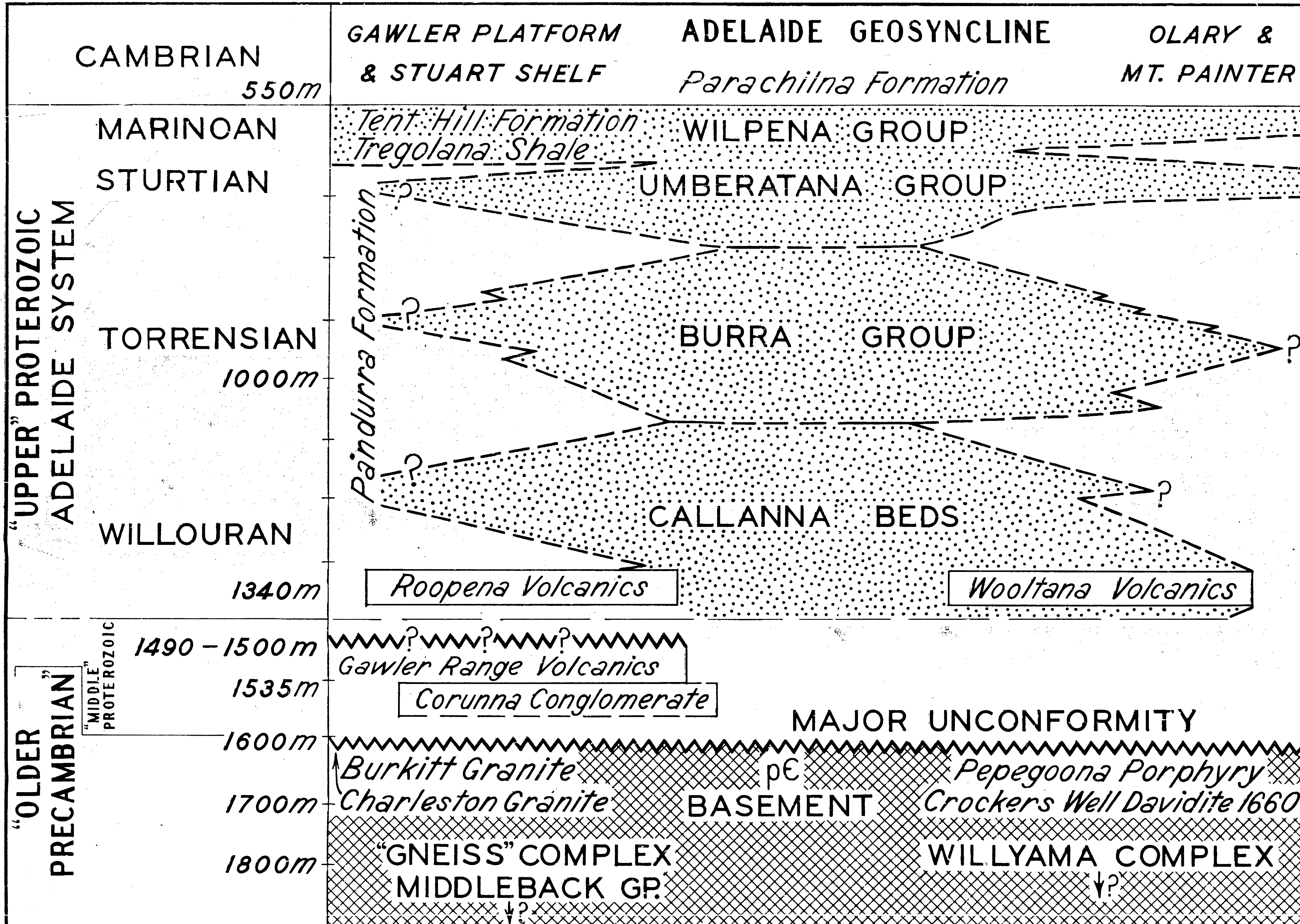
FIG. 5 VARIATION DIAGRAMS OF SOME NORTHERN EYRE PENINSULA ROCKS

No.	Amendment	Exd.	Date	Approved	Passed	Drn. F.B. / Tcd. / Ckd. / Exd.	Scale: 64-755 DE
				Director			Date 14·9·64



TIME-ROCK DIAGRAM

Del. B.T. 64-758

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