

Revised & for preparation for publication  
(1955)

N.B. field notebook missing

POST - ARCHAEOAN SEDIMENTARY SUCCESSION,

HINDMARSH - INMAN VALLEY REGION

THESIS PRESENTED FOR HONOURS DEGREE B.Sc.

UNIVERSITY OF ADELAIDE

1952.

B. G. F O R B E S

Forbes, BG 1952. Honours thesis  
Supervisor: Professor Sir Douglas Mawson

## C O N T E N T S

INTRODUCTION	1
LOCALITY PLAN	2
GEOGRAPHY	3
PHOTOGRAPHS	5A
STRUCTURAL GEOLOGY	6
GEOLOGICAL PLANS	7
PETROLOGY AND STRATIGRAPHY	
1. Archaean Complex	11
2. Quartzite Formations	12
Photographs	17
3. Subgreywacke Formation	18
Photographs	20
4. Arkose Formation	21
Triangular Composition diagram	22
5. Post Arkose Beds	23
Geologic Sections	23A
6. Stratigraphic Interpretation	23
7. Intrusive Rocks	24
8. Metamorphism	25
MICRO DRAWINGS	26
HISTORICAL RESUME	28
LIST OF MATERIAL ACCOMPANYING THESIS	
APENDIX - PETROGRAPHIC DESCRIPTIONS	

### SUMMARY

Between Grey Spur in the Hundred of Encounter Bay and Brown Hill in the Hundred of Goolwa is a faulted and folded sedimentary sequence with a possible stratigraphic thickness of 29,000 feet. The succession overlies an Archaean inlier along a faulted unconformity. To the west of the inlier near Myponga Hill similar sediments are overthrust.

In the main area investigated the succession dips steeply in a direction about 130 degrees east of north. There are distinguished three main formations named merely for convenience quartzite, subgreywacke and arkose formations. These are overlain conformably by greywackes and slates. The quartzite formation is considered to indicate stable shelf conditions, the arkose sharp differential uplift with neighbouring slow subsidence, the greywacke rapid uplift and rapid deposition below wave-base.

The structural position is not clear, but the most simple hypothesis is assumed viz. that there is no major disturbance.

## INTRODUCTION

On the western scarp of the Mount Lofty Ranges and in the Flinders Ranges rocks of Proterozoic age have been extensively investigated. Knowledge of the sedimentary succession to the east of the Archaean inliers is not as advanced; this ~~thesis~~<sup>paper</sup> is presented as a contribution to that knowledge.

The area investigated occurs mainly in the Hundred of Encounter Bay, partly in the Hundred of Goolwa, County Hindmarsh. Spring Mount, the centre of field operations, is about 38 miles almost due south of Adelaide. The area is of about forty square miles and extends from a little west of Spring Mount to about two miles north west of Port Elliot. In respect to the one inch military sheets, the area lies mainly on the Milang Sheet, <sup>and</sup> partly on the Encounter Bay and Yankalilla Sheets.

The main purpose of the investigation is stratigraphic. By studying lithology and succession it was hoped some light might be thrown on Post-Archaean sediments on the eastern scarp of the Mount Lofty Ranges, particularly in regard to their stratigraphic relationship with the better known Adelaide System to the west and with other sedimentary rocks being studied on the eastern scarp.

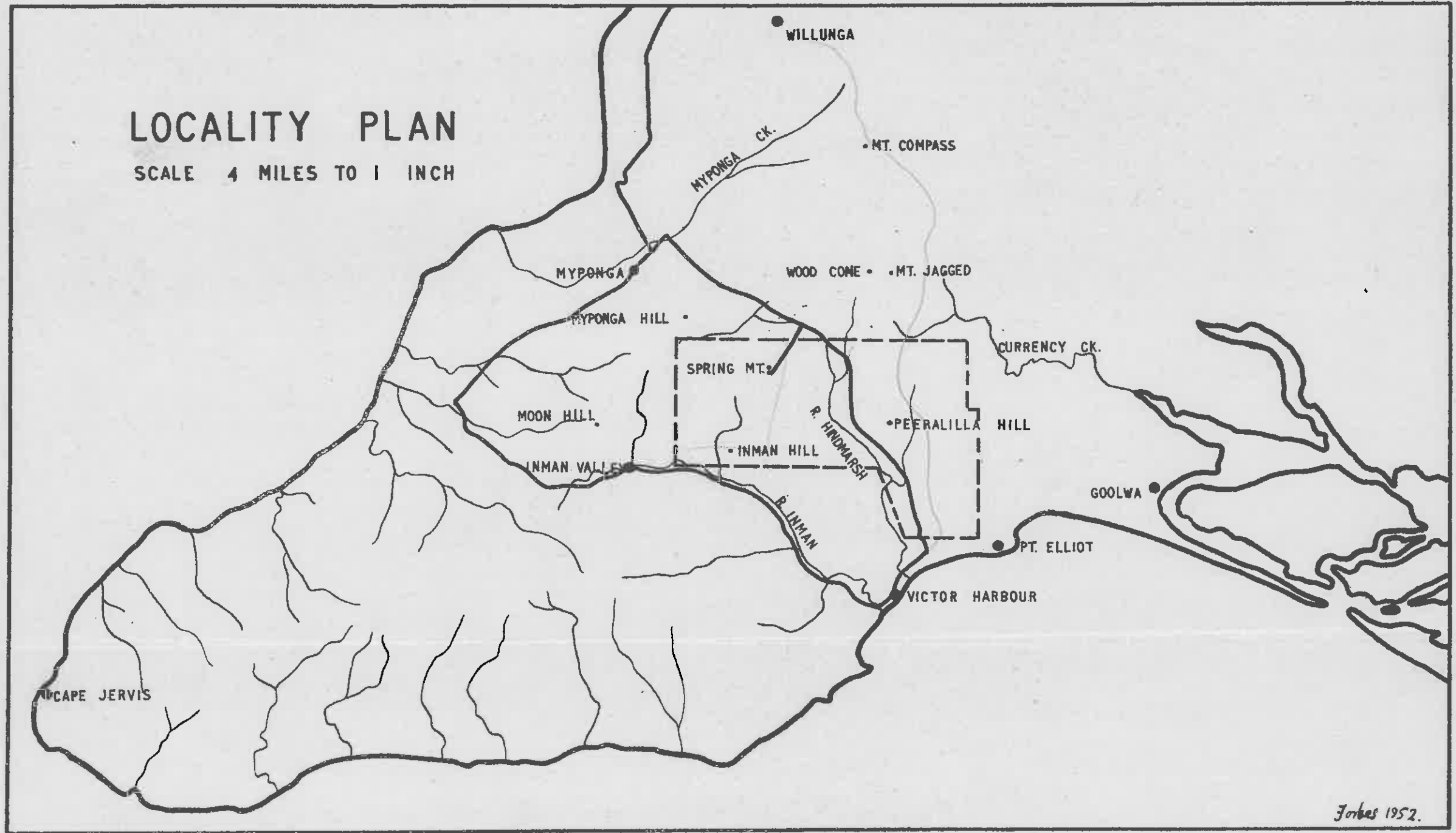
Forty days' field mapping was carried out with the aid of aerial photographs obtained on loan from the Lands Department.

The region has been investigated previously by a number of workers including Howchin, Mawson, King and Guppy.

The writer has carried out the investigation during the tenure of a Junior Research Scholarship, and is indebted to Sir Douglas Mawson for suggesting the problem and for assistance during the year's work. Acknowledgment is due also to senior students and members of the Geology Department staff for assistance and advice. The work has been greatly facilitated by S.A. Hardwoods Limited who provided accommodation and assistance at Spring Mount, through their Supervisor, Mr. Camac.

# LOCALITY PLAN

SCALE 4 MILES TO 1 INCH



Forbes 1952.

GEOGRAPHY

Perhaps the chief topographic feature is the broad, mature valley of the River Inman which trends S.E. Along the northern margin of this lower country is a range of hills dominated by such points as Spring Mount (1358 feet), Inman Hill (897 feet), Mount Billy and Peeralilla Hill (each about 900 feet) and Brown Hill (827 feet, about four miles N.W. of Port Elliot). (The heights were read from the 1:253,440 military sheet). The Hindmarsh River originates in a small basin with a S.E. trend to the north of Spring Mount, then cuts through the range and for the final section of its course flows through the Inman glacial terrain.

The three main factors influencing the geography of the region are the distribution of bed-rock types, the late Palaeozoic glaciation and the Tertiary block-uplifts.

The River Inman has long been held to occupy a fossil glacial valley. *which is still flooded in part & which contains a few glacial boulders.* The chief evidence for glaciation is the widespread occurrence of erratics, chiefly in the valley and the low lying neighbourhood. In addition to the large granite erratics of the Inman, however, patches of small rounded pebbles occur in the higher country to the north. The remnant of glaciofluvial material sometimes gives a soil of a very variable and patchy nature, causing embarrassment during cultivation.

Swamps are most commonly a feature of the upper reaches of streams where they are due to a low gradient possibly combined with the effects of glaciofluvial sediments. Examples of such swamps are at the western end of the Upper Hindmarsh basin (Edinburgh Swamp) and at the head of some creeks S.S.W. of Spring Mount.

The Upper Hindmarsh basin itself may be a glacial feature. Through it the Hindmarsh follows a meandering course. This meandering of streams is typical of parts where there is a remnant of the glaciofluvial mantle. Streams therefore meander most commonly in their lower courses for nearly a mile south of the Hindmarsh Falls, however, the River Hindmarsh meanders within the arkose formation with an amplitude as great as the meanders of the Inman. These Hindmarsh meanders are incised and controlled by the structure of the arkoses. On reaching the lower country a little further south the Hindmarsh changes its course towards the south east.

This lower Hindmarsh still meanders but with no evident geological control and a much reduced amplitude.

The glacial features amount<sup>ng</sup>~~ing~~ to the positive landscape elements may be distinguished with even less confidence. The long, rounded ridge of Inman Hill may be one such element. It is composed of resistant arkose with a thin soil supporting only a sparse, stunted vegetation and constitutes a prominent landmark. Flanking both sides of the ridge are deposits of glaciofluvial clays and sands embedded in which are some erratics varying in size from pebbles to granite boulders of more than ten feet diameter. There is also a residual patch of till on top of the ridge at its north eastern end. Southwest of Inman Hill on the north bank of the River Inman is a small hill of arkose. The hill is in an unusual position and in view of its rounded profile and plan may be a *roche moutonnee*. The house nearby is significantly named "Glacial Hill". The scarp running north east parallel to the Sawpit Gully road has a steepness possibly attributable to glaciation. The streams cutting the scarp drop rapidly in a series of waterfalls to the mature country below. There is also the possibility however, that this is a fault-scarp.

The geographic effects of basement rock type distribution have been greatly modified by the other two main factors. In the resistant Archaean gneisses and schists the topography is mature, and the drainage pattern is radial. The change from a low scrub vegetation to high forest in passing from the Archaean to the marginal conglomerate is abrupt and well marked in some localities, particularly on the northern margin of the Hindmarsh basin. This change occurs, but is less evident, between Edinburgh Swamp and Grey Spur. The quartzite and schist with an average strike of forty degrees gives a trellis drainage pattern. Some valleys confined to schist are deeply incised. Flow at right angles to the strike corresponds to a joint direction. Where sufficient soil has developed, as in the neighbourhood of Spring Mount, the quartzite, subgreywacke and arkose formations will alike carry a high forest vegetation. The ruggedness of the topography between Inman Hill and Peeralilla Hill along the north

side of the Inman-Hindmarsh lower country is due to the arkose formation. This formation does not normally support forest and often <sup>results in</sup> gives stony patches difficult to cultivate. The change in rock type from resistant arkose to softer interbedded slates and greywackes is evident on the eastern slope of Peeralilla Hill. The smooth, cultivated hills stretching south east to Port Elliot are a contrast to the scrub-covered ruggedness of Peeralilla Hill.

The Hindmarsh Falls and two other notable waterfalls are on a line bearing forty degrees. This parallels the strike of arkose outcropping at the falls and ~~is~~ therefore suggests that this series of falls coincides with a particularly resistant bed. At each exposure, however, the arkose is disturbed and a contributing factor may therefore be faulting. A waterfall also attributable to local faulting is that north west of the Tower of Babel.

A note on soils and vegetation may be added here. (Boomsma, 1948, Ecological Studies (Thesis, M.Sc.) University of Adelaide) Most of the soils are podsol, save in the vicinity of Spring Mount where there is a residual lateritic soil. According to Boomsma most of the uplands podsol have probably developed from bedrock while those of the lowlands are more likely to have developed from transported material including glaciofluvial sediments. In the vicinity of Spring Mount the residual lateritic soil supports *Eucalyptus obliqua* (stringy bark) high forest. This also is the most common eucalypt in a zone east and west of Spring Mount outside the high forest area. Prominent in the understory is the Black Boy bush, *Xanthorrhoea semiplana*. On stony patches of arkose a low scrub of *E. Cosmophylla* (scrub gum) occurs locally. Distinguishing a zone paralleling the Inman and commencing about two miles north of the river, the common tree eucalypt is *fasciculosa* (pink gum). On a poor soil such as that of Inman Hill *E. Fasciculosa* is stunted and occurs with *E. cosmophylla*, *casuarina stricta* (sheoak) and *Xanthorrhoea semiplana*. The dominant trees near the rivers are *E. Camaldulensis* and *E. leucoxylon* (red gum and blue gum, respectively).





Mature landscape in  
laterised Archaean,  
two miles W.N.W.  
of Spring Mount.



Narrow valley cut in  
arkose. Looking  
toward Inman Valley  
from waterfalls  
west of Tower of  
Babel.



Lower Hindmarsh Valley.  
Rugged Peeralilla Hill  
extreme left;  
smoother Port Elliot  
hills in distance.



steep scarp  
flanking N.W. side  
of Sawpit Gully.

## STRUCTURAL GEOLOGY

### 1. Archaean - Proterozoic Boundary

Both on the west (near Myponga Hill) and on the east margin the Archaean inlier is faulted. Reverse faulting to the west and faulting on the east have structurally modified the marginal conglomerate and Archaean gneisses to produce convergent augen gneiss and schists.

Outcrops near Myponga Hill are poor in the zone of overthrusting, but the sequence unmodified Proterozoic slates and quartzites, augen gneiss (modified conglomerate) and schists, unmodified Archaean pegmatite, gneiss and calc-silicate hornfels may be traced. The slates dip beneath the Archaean gneisses approximately parallel to the schistosity conferred by overthrusting. The schistosity has the attitude: strike 50 degrees E. of N., dip 50 degrees S.

Grey Spur provides the best exposures of the eastern margin faulting. In the upper coarse arkose phase of the conglomerate quartz and feldspar phenoclasts are stretched most in the bedding-plane parallel to the dip-trace. The intensity of dynamic metamorphism, as indicated by elongation of cobbles within the conglomerate, increases as the faulted Archaean contact is neared. The pink granitic gneiss F57<sub>2</sub> occurs about forty feet from recognizable strongly sheared conglomerate in which some cobbles have dimensions  $1\frac{1}{2}$  x 20 inches, 1 x 15 inches. Between stretched conglomerate and Archaean gneiss is a sericitic gritty schist.

The basal stretched conglomerate may be traced for a short distance as a narrow extension across the creek on the N.E. side of Grey Spur. The remainder of the marginal conglomerate is not represented on the N.E. side of the creek, but is replaced by a fine-grained schist (F64) and contorted fine-grained arkose. This may be attributed alternatively to faulting or non deposition. In a deep creek further N.E. where the conglomerate re-appears is a peculiar rock (F60) which is possibly a much stressed coarse arkose.

The Archaean block has therefore moved relatively to the flanking younger sediments, over-thrusting toward the north-west and possibly in turn being overthrust by younger sediments.

2. Quartzite, Subgreywacke and Arkose Formations

A central member of the quartzite formation has been tightly folded and from the accompanying map it would appear that the whole formation is a syncline pitching at a shallow angle to the north. If this is so there must exist between the quartzite and arkose formations either a major fault or unconformity, since the top of the subgreywacke - arkose succession lies to the south east.

The writer favours the alternative and not so spectacular interpretation that the tightly folded quartzite marks the anticlinal portion of a large drag-fold possessing a shallow pitch to the south west, paralleled by a synclinal axis a short distance west. Reasons for this are:-

- (1) there is no symmetry about the axis of folding,
- (2) about one mile N.N.E. of Spring Mount the quartzite formation appears to young to the east,
- (3) a small (drag?) fold about half a mile N.W. of Spring Mount simulates the mode of folding favoured.

There is a disturbed zone about one mile south-west of Spring Mount but paucity of outcrops renders comment highly interpretative. The thin flexed quartzite and the elongate hill of quartzite may be a reflection of the folding revealed more clearly further south-west in the arkose formation.

The westernmost synclinal axis and truncating fault within the lower arkose are undoubted; the anticlinal axis a little further east may be accompanied or replaced by faulting. An undoubted minor fault within the quartzite formation occurs about  $1\frac{1}{2}$  miles N.N.W. of Spring Mount.

3. Post Arkose - Greywacke and Slate

Within the greywacke-slate succession there is a marked cleavage trending about 45 degrees east of north and dipping at a steep angle. The average strike and dip of bedding planes which are rarely seen in a single outcrop are 35 degrees east of north and 70 degrees east, respectively.

Undoubted anticlinal folding occurs west of Brown Hill with pitch (about 30 degrees?) to the north-west. In view of the fact that near Hindmarsh Valley the dip is again to the east, drag-folding is assumed with an intermediate synclinal axis as indicated on the map.

PETROLOGY AND STRATIGRAPHY

1. The Archaean Complex

Gneisses and schists of Archaean age occur west of the marginal conglomerate and have been investigated for a short distance from the conglomerate. The common rock types are gneisses of a granitic character interspersed with simple microcline-quartz pegmatites and in one locality, a calc-silicate hornfels. At least part of the complex is of sedimentary origin, therefore. Where the mineral association is diagnostic, the albite-epidote amphibolite facies of metamorphism is indicated. Superimposed on this in some cases is a more recent retrograde metamorphism of the biotite chlorite subfacies.

At the sheared base of the marginal conglomerate retrograde metamorphism is of course more evident. At Grey Spur one of the Archaean rock types is a granitic gneiss in which has developed secondary sericite. It is a medium to coarse grained quartz-microcline-albite<sup>rock</sup> with accessory zircon.

A solitary outcrop of calc-silicate hornfels veined with black tourmaline occurs about 1½ miles N.N.E. of Grey Spur. This outcrop is remarkably like that of a sedimentary rock, and possesses a granoblastic texture. The minerals are oligoclase, microcline, diopside, epidote, calcite, sphene, garnet, iron ore and apatite.

Exposed in Gum Tree Gully and the creek south of it are granitic gneisses of varying granularity and biotite-richness. Such types as biotite-sericite schist (mainly near the base of the conglomerate), quartz and feldspar augen-gneiss, coarse white microcline-quartz, graphic pegmatite and crenulated quartz-sericite-biotite gneiss are common. Microscopically, two examples may be cited. One is a medium-grained quartz-andesine-biotite-gneiss. It has a poeciloblastic texture and is composed of quartz, andesine crowded with epidote inclusions, biotite, apatite and iron ore. The other example is the only gneiss found to contain garnet. This is a grey, fine-grained rock composed of porphyroblastic garnet and

quartz in an eighty per cent ground mass of sericite with some biotite. At least part of the mica is an alteration product of garnet.

Near the conglomerate, marginal faulting has obliterated the original foliation of the Archaean rocks, schistosity here being parallel to the attitude of the conglomerate. Further from the conglomerate schistosity may still be the same, but in many cases is at an angle approaching a right angle.

On the Myponga side of the Archaean inlier the calc-silicate hornfels has been located in several places. This is a distinctive rock and may prove to be a useful marker when the inlier is given a full structural and petrological investigation, which is beyond the scope of this thesis.

## 2. The Quartzite Formation

Although alternating quartzite and schist characterize this formation, conglomerate and arkose are included. The westernmost and stratigraphically lower boundary is marked by the faulted junction of Archaean gneisses and schists with a marginal conglomerate. The conglomerate is best known at Grey Spur, from where it stretches north east with only one break to Edinburgh Swamp. The thickness of individual units and that of the whole formation increases gradually toward the north. The formation more than doubles its thickness for the three miles mapped along the strike. In the centre of the part mapped the formation has an outcrop width of about one mile with a possible stratigraphic thickness in the neighbourhood of 3000 feet.

The following constitutes a section through the Quartzite Formation, the data being derived from field sheets of air-photograph scale, and not from actual measurements. The section is at right angles to the average strike and is from a point one mile southwest of the road leading west from Spring Mount to Myponga, assuming an average dip of 70 degrees.

Structural duplication, other than the obvious instance of Unit 13, is not allowed for:-

Unit 1	marginal conglomerate	210 feet
2	schist	160
3	quartzite (arkose at Grey Spur)	210
4	schist	75
5	quartzite	200
6	slate and schist with interbedded thin quartzite	178
7	a. marble grading into b. quartzite	25 280
8	schist	160
9	quartzite	75
10	slate and schist with interbedded quartzite	100
11	quartzite	90
12	schist	365
13	quartzite, folded with schist	320
12	schist	450
14	quartzite	} 206
15	schist	
16	quartzite	
17	schist	1000
18	quartzite	94
19	schist	330
20	quartzite	500
21	schist	188
22	quartzite	94

Total thickness perpendicular to strata:  
5250 feet.

Schist : quartzite thickness = 1.8:1

The thicknesses are correct to about the nearest fifty feet and serve therefore as a qualitative indication of relative thicknesses in the formation. The usefulness of a section is severely limited by structural uncertainty and thickness variation along the strike.

The marginal conglomerate outcrops well only in a few places along its strike. The best locality for examination is on the north-east side of Grey Spur. However, it may be followed readily even where there is no outcrop, because of the distinctive rounded cobbles lying on the surface.

It is composed of a 70 per cent or more coarse, angular sandy matrix of quartz, feldspar (about 30 per cent of matrix) finer material and secondary sericite and muscovite. Bands of ilmenite sometimes occur up to one inch thick. In this matrix are cobbles of various sizes, these near the base having an average diameter of about four inches. The largest cobble noted has dimensions 10 x 10 x 4 inches and is disc shaped. Near the top of the bed large cobbles are rare and the average grain size is finer than that at the base. About 60 per cent of the cobbles are quartzite, perhaps 10 per cent quartz and the remainder fine grained gneiss with some graphic pegmatite. Feldspar fragments frequently reach a diameter of one inch. There occur also occasional rounded pebbles of ilmenite. The sphericities of the two typical cobbles weathered out from the matrix were determined and gave values of 0.78 and 0.59. From inspection the roundness of cobbles is about 0.8 (Krumbein & Sloss - Sedimentation and Stratigraphy).

The upper part of the bed is an arkose (Rock No. F56) and is probably representative of the conglomerate matrix as a whole. Feldspar constitutes 30 per cent and occurs mainly with quartz hornfels as phenoclasts. Both microcline and acid plagioclase are present. The matrix is recrystallized quartz with chlorite, sericite, and accessories ilmenite, tourmaline, zircon and apatite. A preferred orientation, more evident in the micas, extends also



to tourmaline prisms. The arkose exhibits cross-bedding, indicating that younging is to the south east.

The matrix material of the conglomerate could have been derived from nearby Archaean rock-types. No quartzite beds have been seen in the Archaean mapped and a provenance for quartzite cobbles can not therefore be given. The degree of rounding of these cobbles is at any rate suggestive of a longer distance of transport than the immediate locality would afford.

Schists with some slates comprise nearly two thirds of the formation's thickness. They are commonly fine-grained grey rocks. The schistosity planes sparkle with mica, which is mainly biotite. Besides quartz the schists contain a little feldspar and sericite with accessory tourmaline. Biotite shows a marked preferred orientation. In one locality a grey pyritic slate was noted.

These beds are poorly outcropping.

The equivalent of units two to five near Grey Spur is a series of alternating bands of arkose, schist and fine-grained greywacke, arkose being predominant. The arkose may be massive or banded and cross bedded, of a pale grey to white colour. It is a compact hard recrystallized fine-grained rock composed of quartz, about thirty per cent feldspar and a little accessory sericite, tourmaline, pyrites and apatite. The associated greywacke is finer grained, richer in biotite and of a dark grey colour. From these beds, due to thickening further north, there emerges the sequence which appears on the section.

About half the quartzite typifying the formation are ortho-quartzites, the remainder being feldspathic quartzites. They are all compact, light-coloured recrystallized rocks, the feldspar content ranging from almost nil to about ten per cent. Grain-size is chiefly fine, but individual rounded grains of quartz and feldspar may reach a diameter of 1m.m. Tourmaline, zircon and pyrites are occasional accessories. In the quartzites possessing a 'fused' appearance recrystallization has been more

intense. This may be due either to faulting or intense folding. The quartzites, including the fused variety, show occasional cross-bedding, though generally not clearly enough to establish the facing of the beds.

One calcareous horizon was observed, and that in only one place - the bottom of a narrow deep valley about one mile north east of Grey Spur. Here a siliceous marble grades upward into quartzite. The colour of <sup>the</sup> rock is pale grey when fresh and darker brownish-black on the weathered surface. Quartz granules stand out on the bedding planes. The purer marble in addition to recrystallized calcite ~~the rock~~ contains 10 per cent small angular grains of quartz, some feldspar and plentiful pyrites. This last probably causes the darker colour of the weathered surface. The calcareous quartzite of intermediate composition contains a higher proportion of quartz and feldspar grains of about 0.09 m.m. diameter and also about 30 per cent of angular quartz and feldspar fragments of an average 0.28 m.m.

The overlying quartzite into which the marble grades is feldspathic quartzite containing about 10 per cent microcline which has an average diameter of half a millimetre. Cross-bedding indicates (not conclusively) that the series still youngs to the east. On the ridges outcrops are laterised to a soft red-brown powdery grit<sup>1</sup> normal weathering produces a soft pale brown argillaceous grit. Thin slabs may be weathered into unusual patterns resembling compound ripple-marks and concentric circular undulations.



Marginal conglomerate,  $1\frac{1}{2}$  miles WNW  
of Spring Mount. Largest pebble  
measures 4 inches.



Looking along strike of unit  
7 quartzite, near road W. of  
Spring Mount.



Spheroidal weathering, unit 7  
quartzite.

### 3. The Subgreywacke Formation

The southernmost extension of this formation is composed of about 1,200 feet of blue-gray slate overlain by 2,800 feet of subgreywacke, some schist and rare beds richer in quartz. The upper limit is marked by alternating arkose and greywacke passing conformably upward into the arkose formation. This boundary may be mapped and its approximate position appears on the accompanying plan. The lower limit, save in the south, is poorly exposed, and in view of the folding, truncation and recrystallization of the quartzite unit 23 of the underlying formation, is at least in part faulted.

The poorly outcropping equivalents of this formation forming part of the range to the south of the upper Hindmarsh Valley are subgreywacke and spotted schists with interbedded quartzite.

The rock termed subgreywacke is <sup>a</sup> grey, fine-grained, slightly schistose quartz-biotite rock of subgreywacke composition. The average grain diameter of 0.09m.m. is on the border of sand and silt. The massive outcrops possess a smooth, dark grey surface. Variations due to change in grain size or proportions of constituents give rise to interbedded quartzite, schists and spotted schists.

In a restricted area near the eastern end of the swamp, 1½ miles S.S.W. of Spring Mount, subgreywacke contains occasional inclusions of recrystallized quartz hornfels. There are rounded pebbles of about two to four inches diameter. Microscopically the pebbles are very similar to the nearby recrystallized quartzites save that they contain biotite. They are only a localized feature due probably to a temporary vicissitude in sedimentation.

Schist variants are more common than quartzite. The spotted schist F66 occurring about two miles S.S.W. of Spring Mount may serve as an example. This is a quartz-biotite-sericite rock of finer grain than the subgreywacke and containing a greater proportion of biotite.

The biotite is oriented preferentially save within the centres of incipient mineralization represented by rounded spots. The spots are of about one to two millimetres in size and differ from the rest of the rock in a greater percentage of micas and the different orientation. The growth of spots has been most evident in the direction at right angles to schistosity where micas are seen to be forced aside and bent around the spots.

Interbedded quartzite is more prominent to the north, possibly indicating a slight change in facies.



Smooth, massive subgreywacke  
near swamp  $1\frac{1}{2}$  miles S.S.W.  
of Spring Mount.



Inclusions in subgreywacke,  
same locality.

#### The Arkose Formation

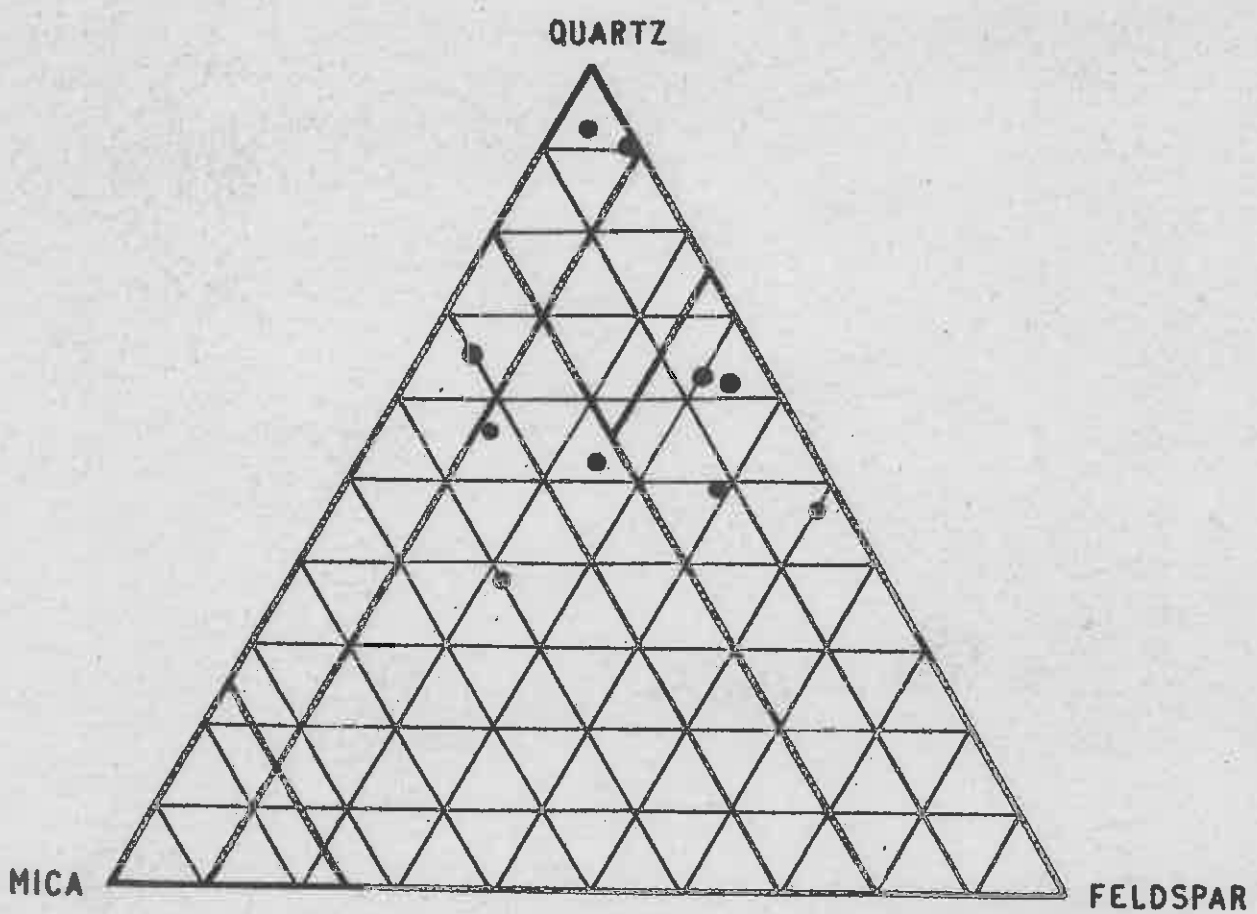
Arkose predominates in this formation, but minor thicknesses of greywacke also occur with<sup>in</sup> it. The outcrop width is just over three miles and the formation extends from the River Inman southwest of Inman Hill to a line bearing about 30 degrees just east of Peeralilla Hill. Further east the characteristic rock-type is greywacke.

In view of a variation in dip from 25 degrees to vertical the calculated thickness is only approximate. The thickness of the formation based on an average dip of 50 degrees is 14,300 feet.

The arkose is similar macroscopically to the average quartzite. The massive variety is a hard, compact light grey to light brown rock. When streaked with thin biotite-rich bands the composition is still that of an arkose but may grade into greywacke by an increase in the proportion of micas.

In thin section these rocks are seen to be largely recrystallized, perhaps with the exception of feldspar and some accessory minerals. Average grain diameter varies from about 0.13 to 0.23 m.m. The measured feldspar content, acid plagioclase and microcline, ranges from 33 to 50 per cent by volume. There is no significant stratigraphic variation in feldspar content. Biotite and sericite show a preferred orientation. Accessories are the common iron ore, apatite, zircon and tourmaline.

The banded arkoses exhibit a variety of structures contemporaneous or penecontemporaneous with deposition. The most useful is cross-bedding, all observations on which indicate that the top of the formation is to the east. These observations are in the writer's opinion sufficiently widespread to indicate that there is little if any, repetition by folding within the formation. Another common structure is minor folding which simulates nappe structures. These overturned folds generally have an amplitude of six to twelve inches but in one instance more than five feet was measured. They are attributable to slumping which in most cases appears to have come from the north, the projection of overturning being to the south. Truncated slump structures serve to confirm the conclusions from cross-bedding. Small scale penecontemporaneous faulting also occurs within the formation.



### COMPOSITION OF SEDIMENTS

EXPRESSED AS RELATIVE  
 PERCENTAGES OF QUARTZ,  
 FELDSPAR AND MICA.

ROCK NUMBER	FORMATION	COMPOSITION		
		Q	F	M
F7	QUARTZITE	93	3	4
F27	..	91	9	0
F56	..	63	30	7
F5	SUBGREYWACKE	66	4	30
F33	ARKOSE	62	33	5
F34	..	49	39	12
F49	..	47	50	3
F46	..	38	22	40
F52	..	57	11	32
F80	POST-ARKOSE	52	25	23

Forbes 1952.



### 5. Post Arkose Beds

Conformably overlying the arkose formation are beds, predominantly greywacke, of about 7000 feet thickness, overlain in turn by slates. (Total thickness of greywacke and interbedded slate perpendicular to bedding is 8300 feet This ignores folding).

The greywackes vary from light to dark grey and possess a strongly developed schistosity. Granularity also varies, but is chiefly fine. Microscopically the greywacke F.83 is made up of lens-shaped grains of quartz with longer axes parallel. Interstitial to the quartz and some feldspar are micas with a parallel orientation. Accessory minerals are epidote, zircon, tourmaline, apatite and iron ore.

Both the interbedded and overlying slates are chiefly dark-coloured. The upper boundary of the greywacke beds has been indicated only tentatively on the map.

### 6. Stratigraphic Interpretation

The rock-types described represent three phases of sedimentation:-

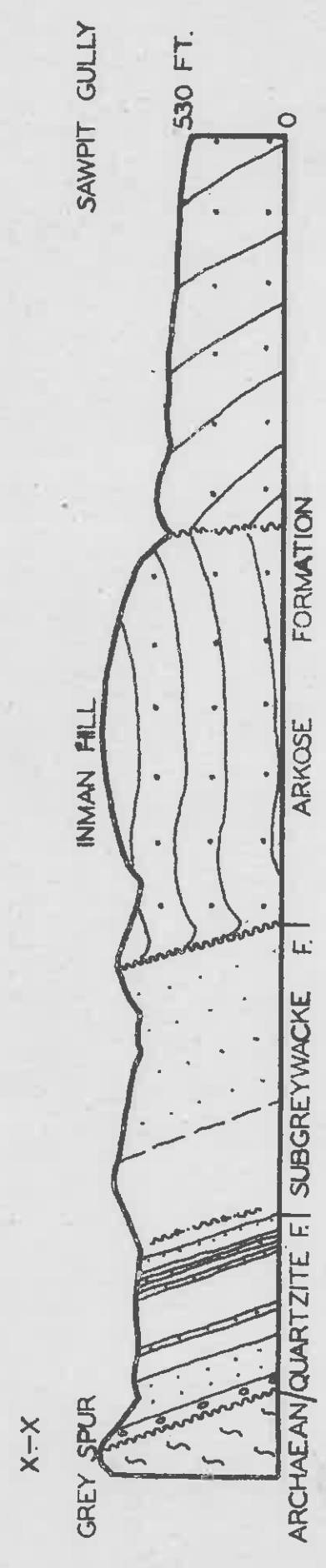
- (1) stable shelf
- (2) sharp uplift with corresponding slow subsidence of the basin of deposition
- (3) sharp uplift with corresponding rapid subsidence.

Evidence of condition (1) is supplied by the quartzite formation. The cobble-component of the marginal conglomerate is oligomictic in character, while the arkose-component is presumably a 'basal' arkose. The formation represents marine transgression over the stable continental shelf accompanied by slight fluctuations in level. The source area, in view of the well-sorted nature of the deposits, possessed probably a mature or senile topography. This sequence is the one which most resembles the Adelaide system.

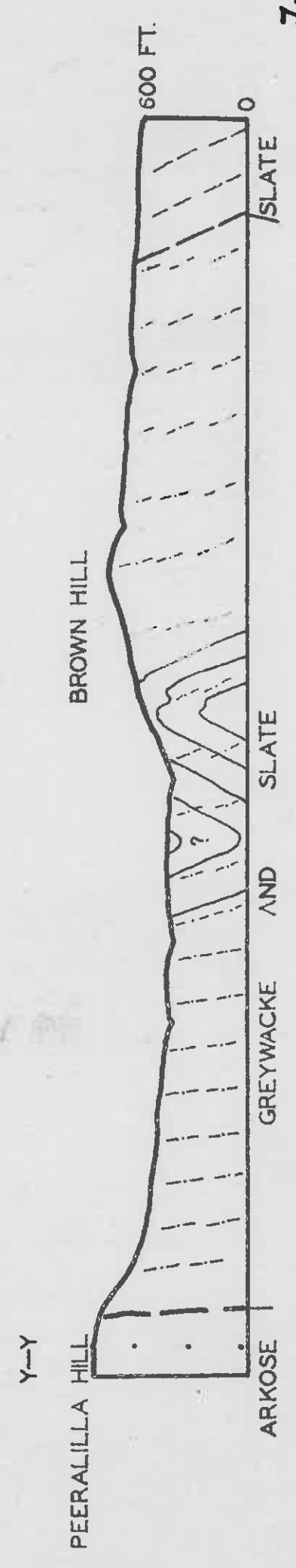
The subgreywacke formation possibly represents condition transitional between (1) and (2).

The arkose formation is considered to be a tectonic arkose, reflecting rapid uplift of a neighbouring granitic area (the

# GEOLOGIC SECTIONS



HOR. SCALE 2 INS. TO 1 MILE, VERT. SCALE 3X.  
 TOPOGRAPHY ESTIMATED.



Forbes 1952

Archaean inlier). The frequent cross-bedding encountered in this formation suggests shallow water accumulation, hence a slowly subsiding area of deposition is postulated. Slumping from the north indicates also a slight tilt to the South.

The post arkose interbedded greywackes and slates represent original muddy sandstones and dark muds deposited rapidly below wave-base. They therefore represent geosynclinal or unstable shelf conditions (3).

The shape of the area investigated allows very little enquiry into facies change. However, the rapid south-westerly thinning of the quartzite formation is considered to be due to a depth decrease in the environment of deposition.

Such time markers as tillite or fossils are not present in the sequence, hence an age cannot be assigned. It may nevertheless safely be assumed that the quartzite formation is Proterozoic in age.

#### 7. Intrusive Rocks

Indicated on the map are three occurrences of altered dolerite.

1. Near the unconformity and where the marginal conglomerate has been severely attenuated due to faulting is a five feet wide dolerite sill which was traced for about fifty feet. The specimen, F59, is a green-black medium-grained rock speckled with white feldspar. The sill intrudes Archaean gneisses and appears to have an attitude similar to that of nearby Proterozoic quartzites.
2. About half a mile from the above is another sill of similar dimensions and attitude occurring near the base of quartzite (unit 11). This dolerite (F21), is more coarsely crystalline than F59 and has been converted to schist along its western margin.
3. Near the top of the marginal conglomerate south of Edinburgh Swamp and just north of the Myponga road is a small weathered exposure of coarse dolerite similar to F21. The outcrop is only a few square feet in area.

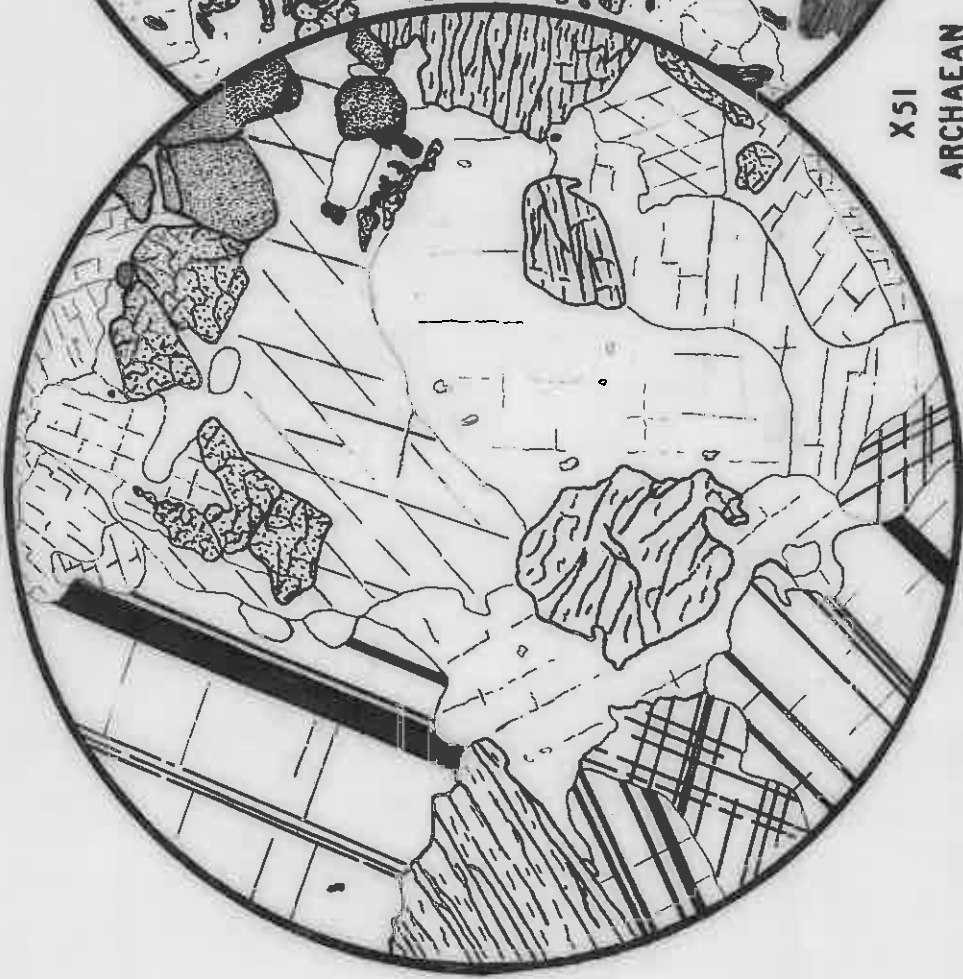
The dolerites, as described in the Appendix, are all unalitized and considerably altered, but show relict ophitic texture under the microscope.

8. Metamorphism

The petrologic terms applied to rocks of the post-Archaeon succession are sedimentary, in view of the fact that this study is primarily stratigraphic. Nevertheless, the rocks are low-grade metamorphic, the subfacies of metamorphism being the biotite-chlorite subfacies of the greenschist facies.

The general metamorphism is dynamo-thermal with in some localities a marked stress factor. Within the subgreywacke formation certain spotted schists (e.g. F66), may represent deficient stress.

Conversion of meta-dolerite (F21) to the biotite-hornblende schist (F20) indicates that strong regional metamorphism post dated the intrusion.



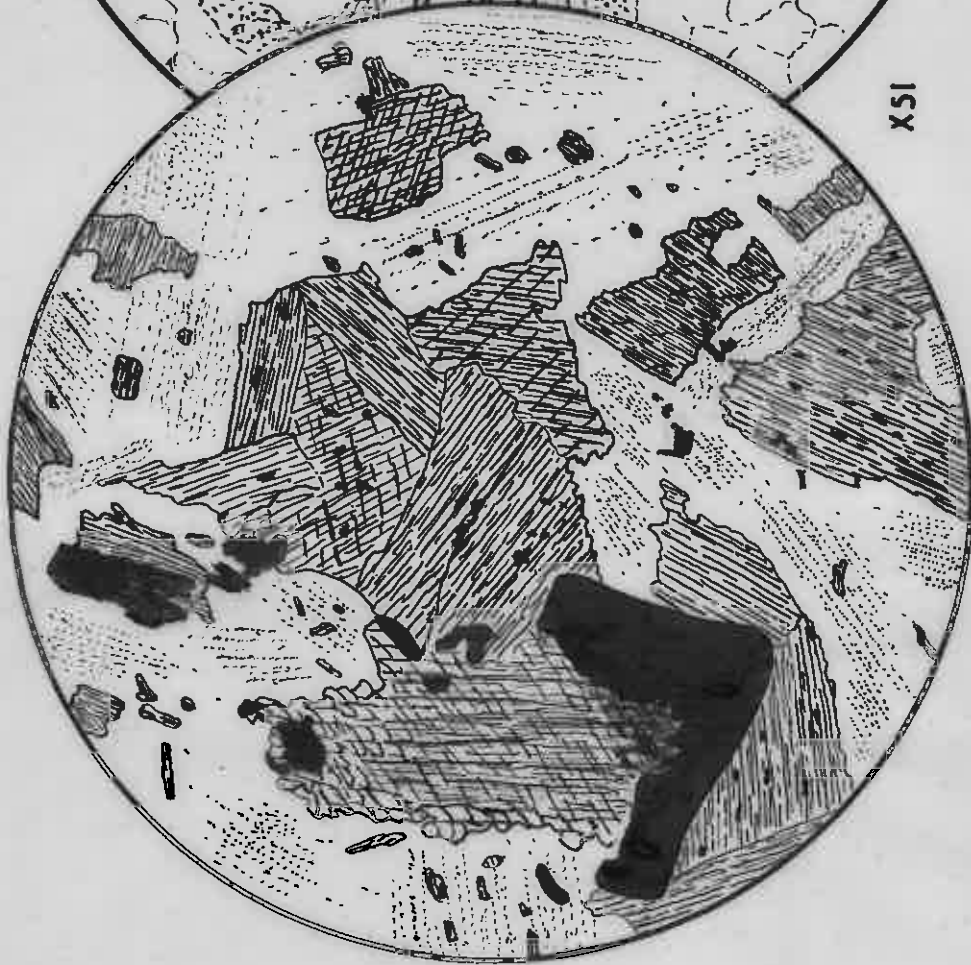
F11 CALC-SILICATE HORNFELS:  
 OLIGOCLEASE, MICROCLINE,  
 CALCITE, DIOPSIDE,  
 EPIDOTE, GARNET.



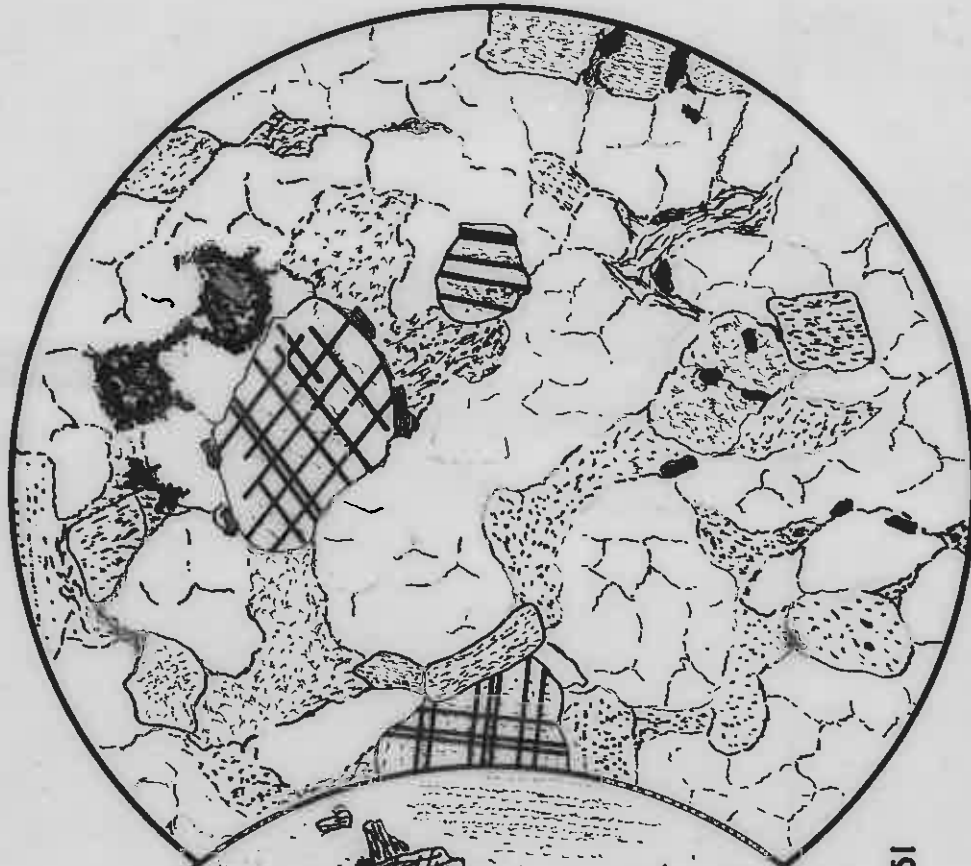
F42 GNEISS:  
 QUARTZ, ANDESINE,  
 BIOTITE, EPIDOTE,  
 IRON ORE.

X51  
 ARCHAIC

Forbes 1952.



**F21 URALITISED DOLERITE  
INTRUSIVE  
HORNBLLENDE, ANDESINE,  
IRON ORE.**



**F49 ARKOSE  
ARKOSE FORMATION  
QUARTZ, MICROCLINE,  
ALBITE, MICAS,  
IRON ORE.**

X51

### HISTORICAL RESUME

During Archaean time a sedimentary series represented now by fine-grained biotite gneisses and calc silicate hornfels was folded and intruded by coarse granitic pegmatite. Over the Archaean basement there passed a marine transgression with consequent slow accumulation of alternating sand and mud beds. In the littoral zone the washed soil provided a marginal arkose and conglomerate. Then followed the sequence of events indicated in the stratigraphic interpretation.

Sedimentation may have continued into early Palaeozoic time when the geosynclinal sediments were folded and faulted. Possibly accompanying the folding, and before the conclusion of regional metamorphism, dolerite sills were intruded. At the end of the period of regional metamorphism the Encounter Bay granites (unstressed) were intruded into the succession and later themselves intruded by dolerite dykes.

In late Palaeozoic time glaciation occurred, modifying the topography and leaving a mantle of debris. During the Mesozoic this mantle was partly removed from the higher parts and concentrated in the valleys.

Early Tertiary time saw another marine transgression which further re-worked the glaciofluvial mantle. Coal and limestone accumulated within certain areas including the Myponga and Upper Hindmarsh basins. In later Tertiary time uplift of the area occurred, causing rejuvenation of streams and possibly incising of the Middle Hindmarsh meanders. Laterite may be pre or post Kosciuszian.

LIST OF MATERIAL ACCOMPANYING THESIS

1. Three 4 ins. to 1 mile maps of field observations and specimen locations.
2. Field note-book (containing specimen index).
3. Hand-specimens numbered F1 to F87.
4. Thin sections of the following:  
F5,7,11,16-21,23,23A,25,27,28,30,32-34,42,45,46,49-53,  
56,57,59,60,64,74.



APPENDIX == PETROGRAPHIC DESCRIPTIONS

INDEX

<u>Number</u>	<u>Name</u>	<u>Text Reference Page</u>
F5	subgreywacke	18, 22.
F11	calc-silicate hornfels	11, 26.
F17	granitic gneiss	11.
F21	uralitized dolerite	24, 27.
F33	arkose	21,22.
F42	quartz-andesine-biotite gneiss	11, 26.
F46	banded greywacke	21, 22.
F49	arkose	21, 22, 27.
F56	arkose	14, 22.
F57	granitic gneiss	11.
F59	uralitized dolerite	24.
F60	albite-quartz-biotite schist	6.
F74	sericite-biotite-garnet gneiss	11.
F83	greywacke	23.

ROCK NUMBER F5

MACROSCOPIC A grey, fine-grained arenaceous rock in which may be distinguished tiny flakes of black biotite and white grains of quartz.

MICROSCOPIC The average grain size is 0.09 m.m., and the texture granoblastic but modified by a preferred orientation as evidenced in biotite. The minerals are listed below in order of abundance.

Quartz(66%) is clear, colourless, xenoblastic and of low relief. Although the grains are recrystallized the general shapes indicate an original angularity.

Biotite(30%) appears as brown pleochroic rods or flakes of moderate relief. The pleochroism is X pale yellow-brown, Y brown, Z very dark brown.

Birefringence is masked by these colours.

Albite(4%) in ordinary light may be identical in appearance with quartz, but often shows a cleavage or alteration. The refractive index is approximately the same as balsam (less than quartz). Between crossed nicols albite twin lamellae frequently appear, the maximum extinction angle in the symmetrical zone being 10 degrees. This indicates a composition of Ab90 (albite-oligoclase). The interference figure is biaxial positive with a high 2V. In view of the difficulty of distinguishing between quartz and some untwinned or unaltered feldspar, the above percentage is probably an understatement. A powdery or sericitic alteration product sometimes occupies the central part of feldspar grains.

Sericite occurs as occasional clear colourless flakes. It attains a size greater than the average biotite. Birefringence is strong. Some sericitic mica is faintly pleochroic\_- this may be altered biotite.

apatite and other accessory minerals may be located easily in reflec

easily in reflected light. It appears as clear, colourless rounded grains of high relief and low birefringence.

Zircon occurs in smaller grains than apatite, is of higher relief and strong birefringence.

Tourmaline is seen occasionally as grey pleochroic grains of high relief.

The volume percentages given for quartz, micas and feldspar were determined with the integration stage. As seen from the triangular plot, the composition is that of a subgreywacke. The original quartz grains and the finer matrix material have suffered recrystallization, the latter as far as the biotite-chlorite subfacies of regional metamorphism.

ROCK NUMBER F11

MACROSCOPIC A medium-grained greenish-grey banded rock in which may be distinguished white calcite and plagioclase, dark green diopside, yellow-green epidote and brown garnet and sphene. The banding is controlled by varying abundance of coloured minerals.

MICROSCOPIC A medium-grained rock of granoblastic texture, composed of the following minerals:-

Oligoclase (50%) appears as abundant clear colourless equidimensional sections of low relief. Most grains have a refractive index notably greater than balsam, but occasionally in a particular orientation, the refractive index is less than balsam. On several sections the plagioclase cleavages are well shown. Birefringence is low and the interference figure biaxial negative with a fairly high 2V. Albite twin lamellae possess a maximum extinction angle in the symmetrical zone of 10 degrees (positive). This indicates a composition Ab 75. Oligoclase contains calcite intergrowths and also alters slightly to a faint powdery brown material or micaceous flakes.

Microcline (5%) is clear, colourless and xenoblastic. Relief is low, the refractive index being less than balsam. The cross-hatched twinning is frequently exhibited. Microcline is biaxial negative with a high 2V and low birefringence.

Diopside (25%) occurs as green rounded to subidioblastic sections of high relief. The two main cleavages when present together are irregular, but are at an angle of approximately 90 degrees. Birefringence is strong and the interference figure (as recognised in sections perpendicular to the optic axis) biaxial positive with a high 2V.

ROCK NUMBER F11

(continued)

Epidote (8%) is seen in irregular scattered yellow-green pleochroic masses of high relief. The grains show numerous irregular fractures. The pleochroism is X = very pale yellow green, Y = greenish yellow, Z = yellow-green. The interference figure is biaxial n negative with a high 2V. Birefringence is strong.

Calcite (6%) occurs as clear, colourless xenoblastic sections showing the rhombic cleavage. Relief typically changes with rotation.

Sphene (4%) is in pale brown faintly pleochroic rounded grains of high relief. Birefringence is strong and the interference figure biaxial positive with a low 2V.

Garnet occurs in large brown grains similar in appearance to sphene but non-pleochroic and isotropic.

Iron ore is black, opaque and appears sporadically in small angular grains.

Apatite, clear, colourless and of high relief is in rare rounded grains. Birefringence is low and the interference figure uniaxial negative.

The composition of the rock is unusual in that quartz is absent and nearly all the constituent minerals are calc-silicates. The texture is that of a metamorphic rock in the formation of which the stress factor was absent, possibly to be explained by a richness in calcite. The subfacies of regional metamorphism is probably chloritoid-almandine, indicated by the association epidote-garnet-calcite-diopside. Calc-silicate hornfels is a suitable name.

ROCK NUMBER F17

MACROSCOPIC

Medium grained pink microcline, white quartz and plagioclase and dark micas combine to give the rock a light pinkish grey colour. The arrangement of sericitic mica along certain planes is indicative of shearing. Iron ore reacts to the magnet as readily as magnetite.

MICROSCOPIC

The average grain-size is about 2 m.m. and the general texture granoblastic. Into this micas, particularly sericite, introduce a minor directed element.

Microcline (30%) is much altered to sericite, but the unaltered portions of grains are clear, colourless and of low relief. The refractive index is less than balsam. Some microcline contains small rounded blebs of quartz. The cross-hatching is frequently seen between crossed nicols. Birefringence is low and the interference figure negative with a high 2V.

Albite (20%) does not form such large crystals as microcline, but suffers as much alteration. Grains are of the same general appearance but show a better cleavage and between crossed nicols the albite twin lamellae. On these the maximum symmetrical extinction angle is about 14 degrees indicating the composition Ab95. The refractive index is less than to approximately equal that of balsam.

Quartz (30%) is clear, colourless, xenoblastic and relatively free from inclusions. Some of the finest quartz is probably recrystallized.

Biotite (7%) occurs as wellformed brown pleochroic flakes associated with iron ore and recrystallized sericite and quartz.

Muscovite (8%) is seen sometimes in clear, colourless well-formed flakes but is more common as the variety sericite. This is an abundant alteration

product of feldspars, occurring as fine flakes within crystals or better developed between the grains.

Iron ore is probably all magnetite and appears in irregular black opaque aggregates.

Zircon is seen as occasional rounded or oval yellowish brown grains of high relief and strong birefringence. Some grains have a furry appearance. The interference figure is uniaxial positive

Apatite occurs as rare clear colourless grains of high relief and low birefringence.

In this, as with most of the Archaean rocks near the marginal conglomerate, there has been a second low-grade metamorphism superimposed on the original fairly high-grade metamorphism. The minerals taken to represent the first metamorphism are quartz, feldspars, magnetite, zircon, apatite. Original mica, if present, has recrystallized. Representing retrograde metamorphism is some quartz, biotite and muscovite, indicative of the biotite-chlorite subfacies. A suitable name is granitic gneiss.



ROCK NUMBER F21

MACROSCOPIC A hard, dense, dark greenish-grey medium grained rock in which dark green hornblende is recognizable.

MICROSCOPIC The grain size varies from about 0.01 to 2 m.m., averaging about 1 m.m. Texture is that of an altered igneous rock. Laths of plagioclase may be seen occasionally partly enclosed in hornblende. This constitutes a relict ophitic texture. On examination of the powdered rock in oils of known refractive index, plagioclase is found to correspond more to andesine than the normal labradorite of dolerites. The refractive indices lie between about 1.55 and 1.56. Andesine (50%) occurs as large clear, colourless euhedral laths of low relief. These contain numerous inclusions, chiefly hornblende and a powdery grey alteration product. Carlsbad, pericline and albite twin lamellae are exhibited, the latter possessing a maximum symmetrical extinction angle of 27 degrees. The composition indicated is Ab 50, midway between andesine and labradorite. The interference figure is biaxial positive with a high 2V. Hornblende (40%) is the normal green variety derived from original pyroxene. It is in large subhedral sections showing generally one or both amphibole cleavages. Pleochroism is X pale yellow green, Y yellow-green, Z dark blue-green. Iron ore (5%) occurs in irregular black opaque fragments possessing a metallic lustre in reflected light. Biotite in small brown pleochroic flakes is a scattered secondary product occurring in minor amount. Zoisite appears in clear colourless idiomorphic rods of high relief. Extinction is parallel and birefringence low. The crystals are length fast with a biaxial positive interference figure and a moderate 2V. A

cross-fracture and less prominent longitudinal cleavage are exhibited.

Quartz is sometimes intergrown with biotite occupying the centre of some plagioclase crystals.

Epidote is of rare occurrence as an aggregate of small grains possessing a high relief and strong birefringence.

There is also present some yellowish limonitic material.

The original composition and texture of this rock approximate that of a dolerite, hence the most useful name is uralitized dolerite. The occurrence of secondary quartz and biotite is suggestive of the general regional metamorphism.

ROCK NUMBER F33 (F33)

MACROSCOPIC A light-grey, fine grained hard siliceous rock.

MICROSCOPIC Average grain size is about 0.13 m.m. and the texture granoblastic, being dominated by recrystallized quartz and plagioclase.

Quartz(62%) is clear, colourless and of low relief.

Feldspar(33%) occurs in clear colourless xenoblastic sections distinguished from quartz by a slight alteration to very fine sericite. Birefringence and relief are low. There are present at least two varieties:

Oligoclase frequently shows albite twin lamellae, the maximum extinction angle in the symmetrical zone being 15 degrees. This indicates a composition Ab70. The refractive index of plagioclase ranges from a little less than balsam to greater than quartz. This, coupled with the fact that both biaxial positive and negative interference figures are present, suggests the presence of more sodic plagioclase also. Microcline showing the typical cross-hatching is present in small amount.

Biotite pleochroic from pale to dark brown occurs in small irregular shreds and patches. Flakes are commonly almost equidimensional.

Sericite appears as clear, colourless elongate flakes up to 0.19 m.m. in length. Some sericitic mica shows a very pale brown pleochroism, possibly a transition to biotite.

Chlorite is in small green faintly pleochroic fragments.

Iron ore, apatite and zircon are also present.

The volume percentages of quartz, feldspar and micaceous minerals classify this rock as an arkose in composition. Metamorphism is to the biotite-chlorite subfacies.

ROCK NUMBER F42

MACROSCOPIC A medium- to fine-grained grey rock of gneissic texture. Pale pinkish-brown streaks richer in quartz and feldspar are set in a dark grey biotite-rich background.

MICROSCOPIC The texture is poeciloblastic.

Quartz (30%) appears as clear, colourless xenoblastic aggregates of low relief. Save for a little biotite and iron ore it is almost free from inclusions. Some quartz shows undulose extinction.

Andesine (30%) is clear, colourless and generally crowded with inclusions of chiefly epidote. This confers the poeciloblastic texture. Relief is low and the refractive index greater than quartz. Those grains showing albite twin lamellae are partly cleared of inclusions. The maximum extinction angle in the symmetrical zone of albite twins is 27 degrees, indicating the composition Ab50. Some grains show also pericline twinning. Birefringence is low and the interference figure biaxial positive with a 2V near 90 degrees.

Biotite (25%) occurs in elongate brown pleochroic flakes of moderate relief. The pleochroism is normal, X pale straw yellow, Y brown, Z very dark brown (parallel to polarizer). Birefringence is strong and the interference figure uniaxial negative.

Epidote (10%) is seen as colourless to very pale yellow-green subidioblastic granules of high relief. The grains form irregular clusters most commonly associated with andesine. Red-shaped grains show oblique extinction, and occasionally, twinning. The interference figure is biaxial negative with a high 2V and strong birefringence.

Apatite is a fairly common accessory, appearing in clear, colourless rounded grains of high relief and low birefringence. The figure is uniaxial negative.

Iron ore occurs in black opaque irregular grains, in  
in reflected light possessing a silvery metallic lustre.  
Chlorite of a very pale greenish-yellow colour and low  
relief is a rare inclusion in andesine. Birefringence  
is almost nil.

The mineral association andesine, epidote suggests that regional  
metamorphism has advanced to one of the lower subfacies of the  
albite-epidote amphibolite facies. Quartz-andesine-biotite gneiss  
is a suitable name.

ROCK NUMBER F46

MACROSCOPIC A dark grey fine grained rock composed of alternating light and dark grey bands averaging 2 and 1 m.m. thickness respectively. The rock fractures most easily along the darker layers due to a richness in biotite.

MICROSCOPIC The rock is fine grained, the average grain size being about 0.13 m.m. The general texture is granoblastic but an evident preferred orientation of biotite in the darker bands introduces a schistose element. In the section this parallelism is at an angle of about 25 degrees to the palimpsest sedimentary layers.

The following are the mineral constituents in order of abundance:-

Biotite (39%) occurs as small flakes of a yellow-brown to dark brownish-black colour. Average dimensions are 0.02 x 0.12 m.m. Relief is moderate, the refractive index being greater than balsam. Strong pleochroism  $X =$  pale yellow-brown,  $Y =$  grey-brown,  $Z =$  brownish-black (almost opaque) is shown. The 001 cleavage appears on some flakes. A satisfactory interference figure was not obtained. Birefringence is strong.

Quartz (38%) appears as clear, colourless xenoblastic grains of low relief. The thin section was intended for petrofabric work and some quartz sections therefore show first order orange-red between crossed nicols.

Feldspar (22%) is distinguished from quartz by its alteration to sericite or a fine powdery grey material. Some twinned plagioclase fragments are clear however. Relief is low, the refractive index of all feldspar examined being intermediate between

ROCK NUMBER F46 that of quartz and balsam. The extinction angles  
(continued)

of ten fragments showing albite twinning in the symmetrical zone gave a maximum value of 15 degrees. In view of the refractive index the composition is probably albite-oligoclase Ab 90 approximately. The interference figures obtained from untwinned feldspar were poor, but indicated them to be biaxial positive with a high  $2V$ .

Accessory minerals, as under, amount to about one or two per cent.

Apatite occurs as clear colourless rounded granules of high relief and low birefringence. The interference figure is uniaxial negative.

Muscovite may be seen as occasional clear colourless bent flakes, generally of about twice the size of biotite. Relief is fairly high and refractive index greater than quartz. With rotation relief changes markedly. The 001 cleavage is generally apparent. Birefringence is strong and the flakes length slow.

Tourmaline appears as occasional rounded or elongate brownish pleochroic fragments of high relief. One elongate fragment exhibits transverse fractures. Pleochroism is = dark greenish grey (when length perpendicular to polarizer), = pale brown. Birefringence is moderate, the interference figure being uniaxial negative with several coloured rings.

Zircon is present in small pale yellowish rounded wheat-shaped grains of high relief and strong birefringence.

The volume percentages given for biotite, quartz and feldspar were determined with the integration stage. This composition when plotted on the triangular diagram falls into the field commonly ascribed to greywacke. The rock is therefore a regionally metamorphosed grey-

ROCK NUMBER F46

(continued)

wacke. The extent of metamorphism is not great, the main effects being recrystallization of quartz and muscovite together with the formation of biotite from micaceous material occurring in bands and interstitial between quartz and feldspar grains. The rock may be assigned to the biotite chlorite subfacies of metamorphism. Notwithstanding this, the most useful name appears to be banded greywacke.



ROCK NUMBER F49

MACROSCOPIC The rock is massive, light-brown and fine-grained.

MICROSCOPIC The average diameter of feldspar grains is 0.28 m.m. the value for the rock in general being somewhat less than this. The texture is granoblastic, the rock comprising largely an intergrowth of feldspar and quartz.

Feldspars (50%) are distinguished from quartz by a slight cloudy alteration. They occur as roughly equidimensional xenoblastic clear colourless grains of low relief. At least two varieties are present.

Microcline comprises about half the feldspar. It commonly shows the microcline cross-hatching between crossed nicols and has a refractive index less than balsam.

Albite possesses a refractive index less than quartz and may show albite twinning. The maximum symmetrical extinction angle on twin lamellae of 15 degrees indicates a composition nearly pure albite.

Quartz (47%) occurs as a clear colourless mosaic of low relief.

Biotite is the normal brown pleochroic variety occurring in minor amount interstitially. Some biotite contains small needles, probably rutile. Biotite is uniaxial negative. There is also present some green mica, other than colour possessing similar properties to biotite.

Sericite is of sporadic occurrence as an irregular aggregate of small clear colourless ragged flakes.

Iron ore, black and opaque, is scattered in small granules.

Zircon is in rare, well rounded, clear colourless grains of high relief and strong birefringence.

Tourmaline appears occasionally in greenish-grey pleochroic fragments of high relief. The interference figure is uniaxial negative.

ROCK NUMBER F49

Edipote in small well formed rods, and apatite,  
are also present.

This rock is different from the other arkoses described in its greater average grain-diameter and greater proportion of feldspar. Volume percentages were determined by integration stage and plotted on the triangular diagram.

ROCK NUMBER F56

MACROSCOPIC A light brown clastic rock composed of a matrix of medium grain size in which are occasional rock and mineral phenocrasts. The matrix is largely quartz and feldspar with some ilmenite grains, this last mineral being sometimes concentrated in 1-2 m.m.-thick bands. Ilmenite responds readily to the magnet. The phenocrasts are rounded quartz, pink feldspar, quartz-hornfels and rare shale fragments. These range in size from about one to two cm.

MICROSCOPIC The texture is that of a clastic rock somewhat modified by regional metamorphism. The mineral and rock fragments are angular to subrounded or lenticular in shape, with irregular boundaries due to recrystallization. Average grain size is 2 m.m. The parallelism of sericite flakes in therecrystallized groundmass imparts a minor directed texture.

(1) Rock fragments:

A fine grained quartz-hornfels was the only variety of rock fragment in section. The total quartz in the rock is 63% by volume.

(2) Mineral fragments:

Quartz occurs less frequently as separate grains.

Microcline constitutes more than half the feldspar content of the rock in which the total volume per cent of feldspar is 30. It appears as large equidimensional grains which are clear and colourless save for a cloudy alteration outlining the twinning. Relief is low and the refractive index less than balsam. Microcline frequently exhibits its characteristic twinning.

Untwinned feldspar has the properties of, and is probably microcline.

Acid plagioclase occurs as clear, colourless, often bent grains, slightly altered to fine flakes of sericite.

Refractive index is intermediate between that of balsam and quartz, while the maximum extinction angle in the symmetrical zone of albite twins is 18 degrees. These properties are the same as those of albite-oligoclase in F57, indicating a similar composition.

(3) Accessory minerals:

Ilmenite is the most common accessory, appearing as black opaque granules with a metallic lustre.

Tourmaline occurs commonly as small prismatic crystals, pleochroic from pale to dark grey-brown. In the groundmass it has a tendency to align itself parallel to sericite.

Apatite and zircon appear as small rounded grains of high relief.

(4) Recrystallized matrix:

This represents the original interstitial cement, and is composed largely of fine sericite flakes together with chlorite and quartz.

Sericite constitutes about 4% by volume of the whole rock. It occurs as clear, colourless shreds which show a marked change in relief on rotation. Birefringence is strong.

Chlorite is colourless to pale yellow-green, of low relief and birefringence.

Quartz is in small xenoblastic grains.

(Feldspar was not detected.)

The volume composition quartz 63%, feldspar 30%, mica 7% was determined with the integration stage. When plotted on the triangular diagram this composition is seen to fall within the field assigned to arkose.

ROCK NUMBER F57

MACROSCOPIC A light pale coloured coarse-grained rock composed of pink microcline, pale greyish quartz, and plagioclase, pale greenish grey sericite and dark biotite. The mica lies along curved slickenside-like planes of movement. Powdered plagioclase was examined for its refractive index by the oil immersion method. The values for twinned feldspar were  $\alpha$  1.534,  $\gamma$  1.542 corresponding to albite-oligoclase of about Ab90-85.

MICROSCOPIC: The rock is medium to coarse grained, the general texture being granoblastic.

Quartz (40%) occurs in clear colourless xenoblastic aggregates of low relief and birefringence.

Microcline (30%) is seen as large clear colourless but often somewhat altered xenoblastic sections of low relief. The refractive index is less than balsam. Some large crystals show the crosshatching between crossed nicols. Microcline alters to numerous small flakes of sericite.

Acid plagioclase (20%) is in clear colourless equidimensional subidioblastic sections of low relief. The refractive index is intermediate between that of quartz and balsam. Albite twin lamellae are generally shown. On these the maximum extinction angle measured in the symmetrical zone is about 17 degrees, which does not well accord with the refractive index data above. This latter is more liable to be correct, hence the composition may be taken to be about Ab90-85. Plagioclase alters extensively to sericite.

Zircon as a solitary pale brown rounded grain of high relief may be noted in the section. It is strongly birefringent and uniaxial positive.

Iron ore is very rare, but may be seen as an occasional small black opaque grain.

Sericite is the most common secondary mineral. Although occurring as an alteration product within crystals, it is most plentiful along fractures and on certain parts of

ROCK NUMBER F57  
(continued)

the periphery of grains. It occurs as clear colourless flakes, strongly birefringent and changing markedly in relief on rotation. A few flakes of a yellow-brown pleochroic mineral, possibly biotite, and yellowish limonitic material also occur.

The coarse grained assemblage quartz-microcline-albite is that of a high grade metamorphic or a meta-igneous rock, conveniently termed a granite gneiss. Sericite, typical of a low grade of metamorphism gives evidence of a second retrograde metamorphism in which stress was predominant.

ROCK NUMBER F59

This is a uralitized dolerite similar to F21. It differs from F21 only in that (1) grain-size is a little less;

(2) hornblende and epidote are more plentiful;

(3) plagioclase is more acid andesine as indicated by extinction angles.

ROCK NUMBER F60

MACROSCOPIC: A dark grey medium grained massive rock in which may be noted dark lustrous mica and feldspar grains, which are both pink and white. Two parallel planes of movement occur in the specimen.

MICROSCOPIC: The rock is medium grained and the texture markedly blastoporphyritic. Most of the large feldspar grains are equidimensional, but some quartz and feldspar is eyeshaped. Between the grains twine long trains of mica and chlorite.

Albite (50%) occurs as large clear colourless but somewhat altered sections of low relief. The refractive index is intermediate between that of quartz and balsam. Many sections exhibit albite twin lamellae, the maximum symmetrical angle of extinction being 15 degrees. In view of the refractive index, the composition is therefore in the neighbourhood of Ab90. Untwinned feldspar has the above refractive index and may be assumed to be of the same composition. The interference figure is biaxial positive. Alteration is to tiny flakes of sericite or larger flakes of biotite and sericite which outline the twin lamellae and cleavages. No optical strain effects are shown.

Quartz (15%) appears in both large grains of quartz hornfels and in the smaller xenoblastic grains. It is clear, colourless and little altered (probably recrystallized).

Biotite (15%) occurs in greatest amount interstitially as brown pleochroic flakes. It shows a preferred orientation in the same general direction as trains of sericite and chlorite.

Sericite (10%) is also concentrated interstitially in aggregates of long thin flakes showing marked change in relief on rotation. Certain patches show a brownish pleochroism, possibly a transition between sericite and biotite. Birefringence is strong.



ROCK NUMBER F60  
(continued)

Chlorite is clear colourless or of a very pale green and occurs in association with sericite. Birefringence is low.

Apatite is scattered in clear colourless rounded grains of high relief and low birefringence.

Iron ore (ilmenite) occurs plentifully in widespread black opaque granules of irregular shape. Some grains have been shattered and drawn out along the sericite bands.

From a consideration of its field occurrence, mineral composition and texture, the most likely explanation of the rock's nature is that it is a sheared arkose. A suitable petrographical name is albite-quartz-biotite schist. The biotite is most likely the latest mineral development.

ROCK NUMBER F74

MACROSCOPIC: A grey, fine-grained gneissic rock in which the schistosity planes are defined by sericite and biotite. Brownish garnet and quartz may also be distinguished in small amount.

MICROSCOPIC: Porphyroblastic garnet and quartz occur in a fine grained schistose groundmass largely sericite with some biotite. Trains of sericite and biotite pass around quartz grains giving an augen like structure. Sericite (75%) varies in habit from a very fine grained aggregate to well-formed flakes. It is clear, colourless and shows a strong birefringence. At least in part, sericite together with biotite is an alteration product of garnet.

Biotite (8%) is the normal brown pleochroic variety, and occurs in well-formed flakes or small shreds.

Quartz (10%) occurs as large clear colourless porphyroblastic fragments occasionally showing undulose extinction.

Garnet (5%) appears as large, considerably altered porphyroblastic crystals of high relief. The isotropic garnet alters along cracks to sericite and biotite flakes, the original crystal often occurring as scattered fragments in a groundmass of micas.

Iron ore is seen in small amount as irregular black opaque fragments and small grains. In reflected light these possess a silvery metallic lustre.

Zircon is present as several small rounded grains of high relief. Birefringence is strong.

As indicated by the alteration of garnet, the rock has suffered considerable retrograde metamorphism from a facies at least as high as the chloritoid almandine subfacies. The rock may be named sericite-biotite-garnet gneiss.

ROCK NUMBER F83

MACROSCOPIC A fine-grained grey compact rock which cleaves readily parallel to one plane. These planes are richer in mica, whereas in a section at right angles, small dark angular grains of quartz and white flecks of feldspar may be distinguished.

MICROSCOPIC The rock is made up of <sup>of</sup> largely of lens-shaped grains of quartz with longer axes parallel.

Interstitial to the quartz and some feldspar are micas with a parallel orientation.

Average dimensions of the lenses are 0.16 x 0.48 m.m.

Quartz (50%) is clear, colourless and little-altered. It frequently contains inclusions of biotite, zircon or hair-like black crystals (rutile?) and small liquid inclusions carrying bubbles of gas. Some inclusions are square in section and may be Halite. The section is thick, hence birefringence is not normal. Feldspar (20%) may be distinguished from quartz by its alteration, which is to sericite and a kaolinitic material. Some feldspar, presumably acid plagioclase, shows also one good cleavage. Such grains have a refractive index greater than balsam. Albite twinning is exhibited occasionally.

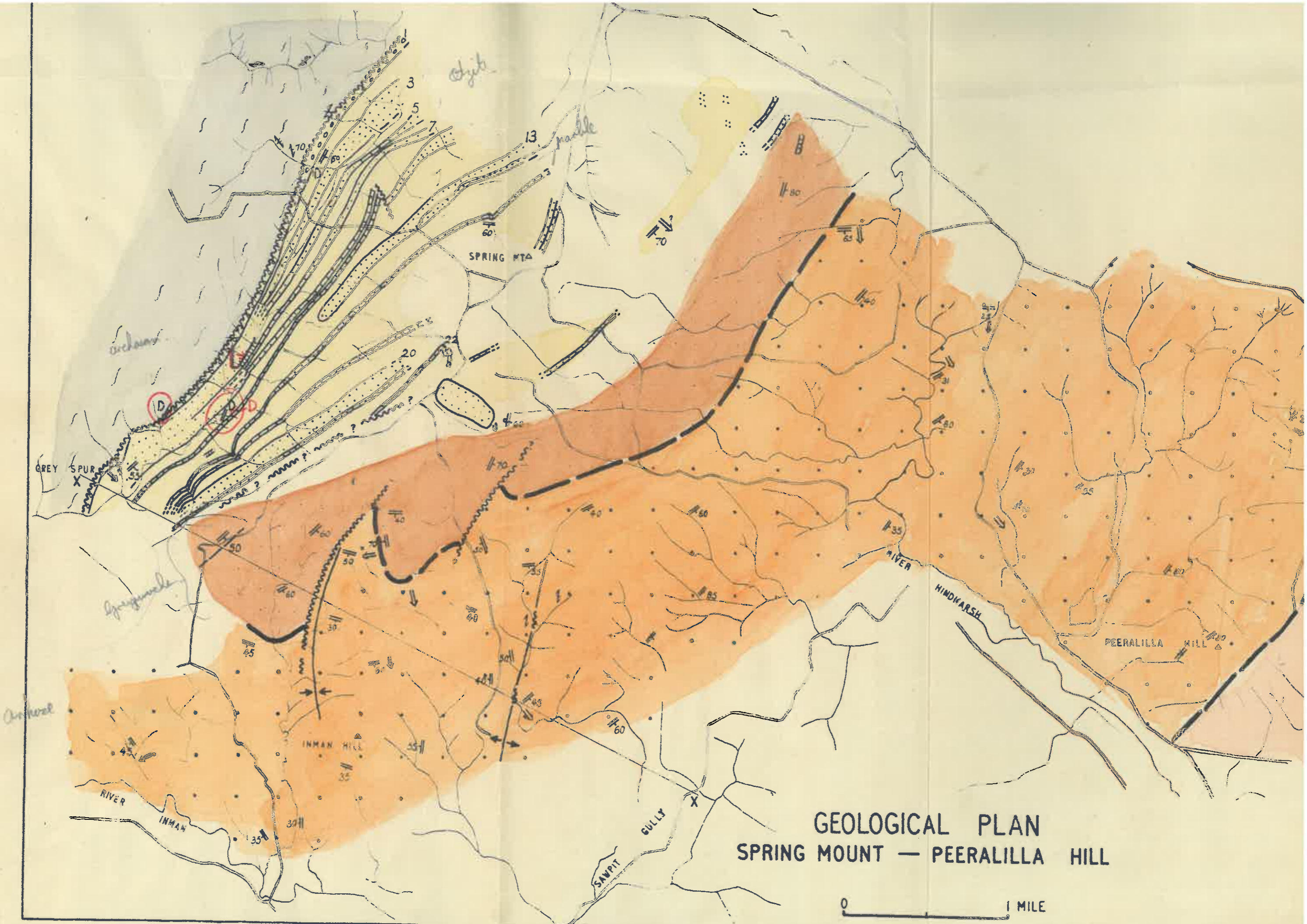
Biotite (15%) is the normal dark brown pleochroic variety and occurs as irregular shreds or less commonly as well formed flakes interstitially to quartz and feldspar. It may often be seen as a thin envelope surrounding larger grains. A green variety is also present.

Sericite (10%) is similar in occurrence to biotite and may form separate colourless flakes of strong birefringence. It is concentrated in the fine-grained ground mass.

Epidote, zircon, tourmaline and apatite are all present in small amount as rounded grains save for tourmaline, which occurs as prismatic crystals. Epidote is pleochroic from colourless to pale yellow-green and is probably detrital. Zircon is colourless and well-rounded. Tourmaline is pleochroic from pale grey to darker brown. Apatite is colourless and of low birefringence.

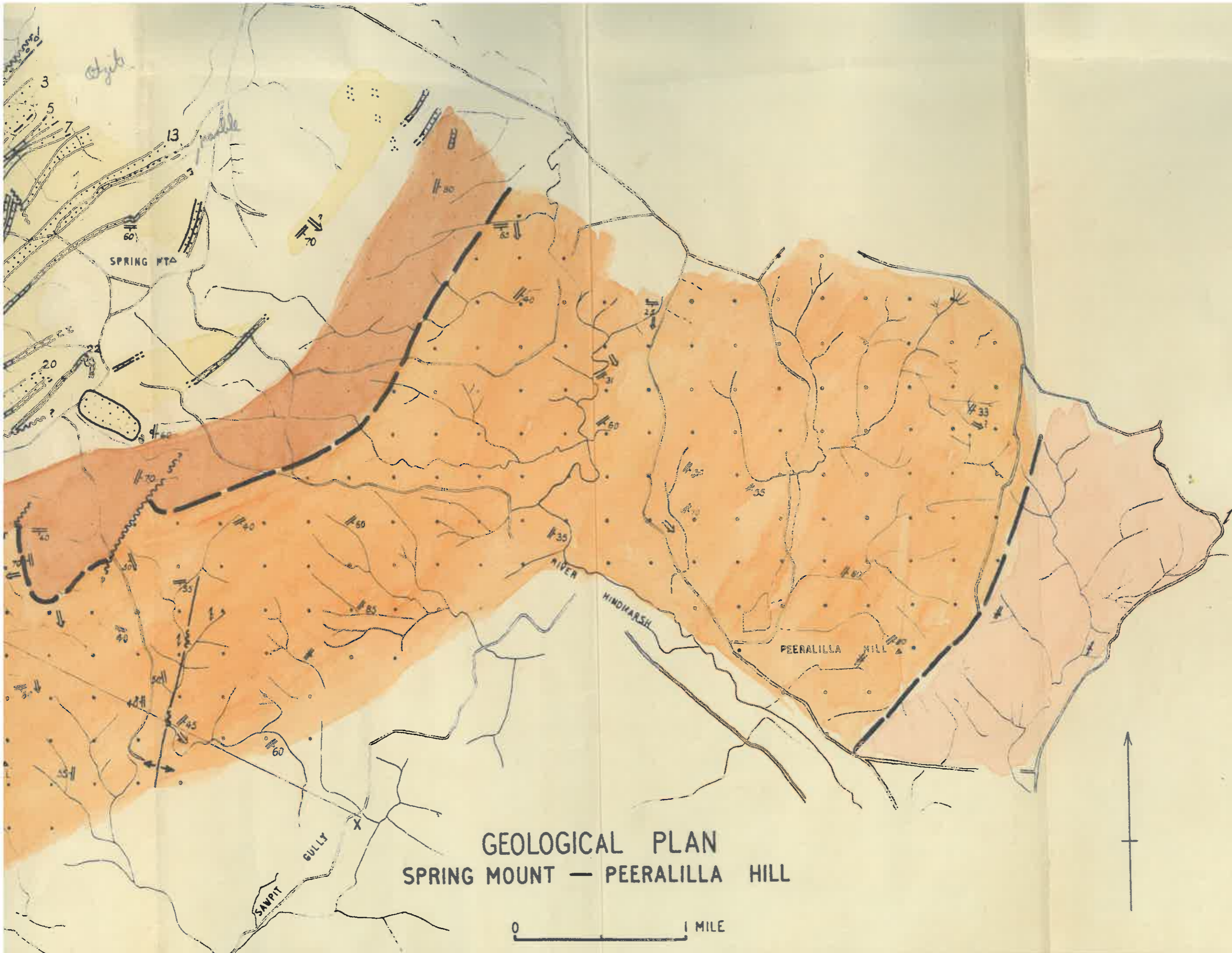
Iron ore is in sporadic and irregular black opaque grains. One larger grain resembles chromite, but the semi-transparent core is probably limonite.

In composition this rock is a greywacke but has suffered regional metamorphism in which the stress-factor has locally been high.



**GEOLOGICAL PLAN  
 SPRING MOUNT — PEERALILLA HILL**

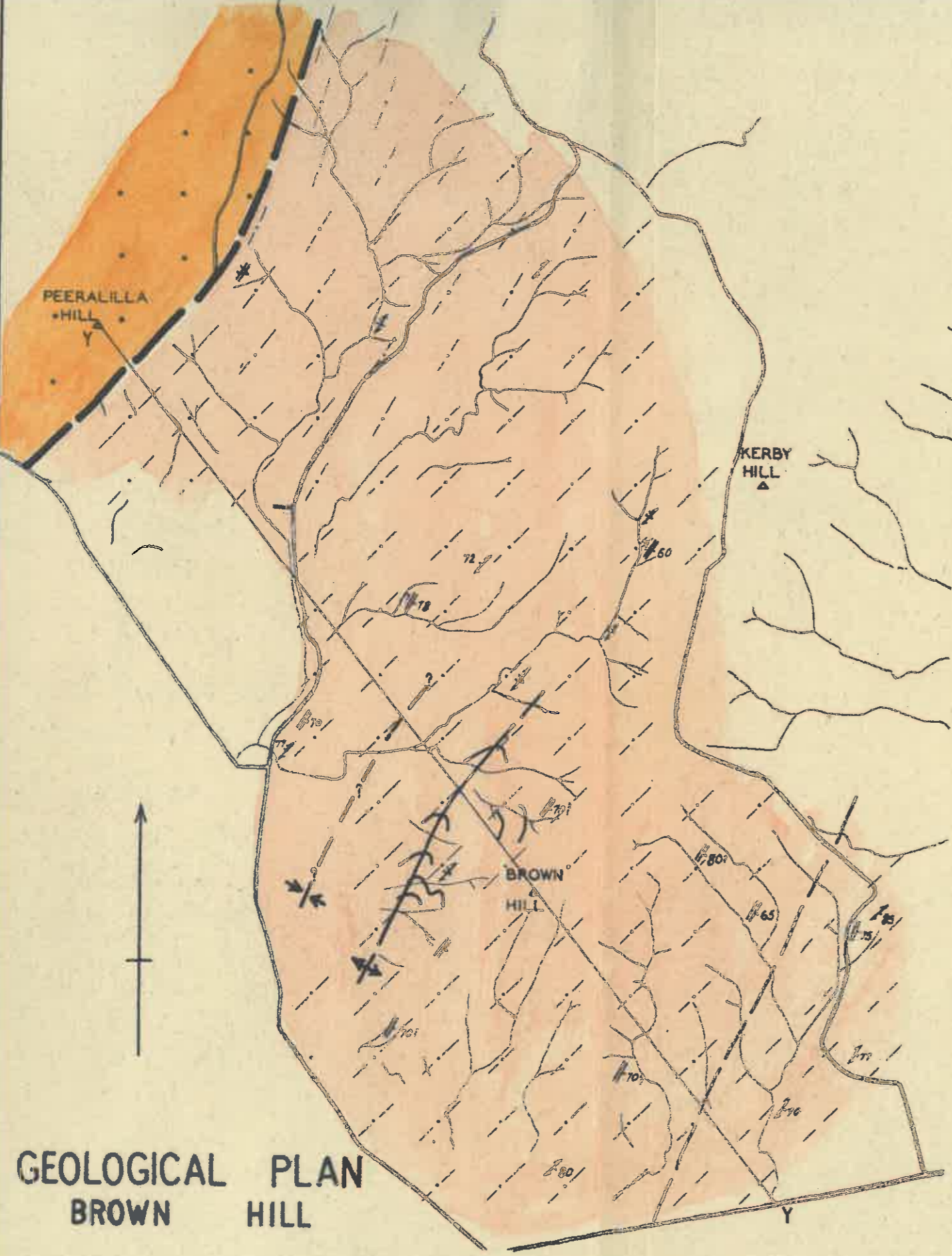
0 ————— 1 MILE



GEOLOGICAL PLAN  
SPRING MOUNT — PEERALILLA HILL

0 1 MILE

Forbes 1952



**GEOLOGICAL PLAN**  
**BROWN HILL**

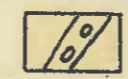
0 1 MILE

### LEGEND

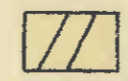
#### ARCHAEAN



#### QUARTZITE FORMATION



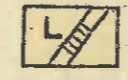
CONGLOMERATE



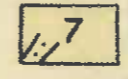
SLATE, SCHIST



QUARTZITE



MARBLE



UNIT NUMBER

#### SUBGREYWACKE FORMATION



#### ARKOSE FORMATION



BOUNDARIES



#### POST-ARKOSE

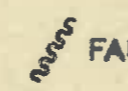
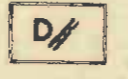


GREYWACKE

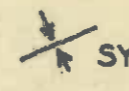


SLATE

#### INTRUSIVE



FAULT



SYNCLINAL AXIS



FACING



ANTICLINAL AXIS



TREND-LINES

#### ATTITUDE :



BEDDING



SCHISTOSITY