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REPORT:

GEOLOGY OF THE CRAFERS - STIRLING AREA.

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INTRODUCTION:

During August - September, eight days were spent on detailed geological mapping in this area. The area examined comprises some four square miles; the northern boundary is approximately one mile south of the Mount Lofty trig station and the boundary trends east-west. Mapping extended to one half-mile south of the Mount Lofty railway station.

The country is deeply dissected throughout, and the rugged topography has been enhanced by deeper weathering of the argillites in the central portion.

Owing to the deep weathering, outcrops are few in number, and mapping was limited almost entirely to road cuttings. Recent (Jan. 1959) air photos were used in this survey; the scale was approximately 410 feet to one inch.

PREVIOUS WORK:

The area was included in Sprigg's reconnaissance geological survey of the Adelaide Hills in 1945-46, and his report is available. Much of the district was remapped by Whittle (1947) as a part of the field work for his M.Sc. thesis. This was the most westerly extension of his mapping.

GENERAL GEOLOGY:

The area examined comprises series of Lower Proterozoic* arenites and argillites. Mapping has indicated a number of open folds and there is considerable drag-folding. At least one major fault and several minor faults offset the strata; this faulting has associations with the extensive block-faulting which is characteristic of the South Mount Lofty Ranges. As a direct result of this faulting, a tongue of Archean metamorphics is exposed in the eastern portion of the area.

The post-Archean rocks of the area (the Torrensian Series) have the fresh and unaltered appearance which is typical of the Adelaide Proterozoic sequence. It is noted that this is most unusual for rocks of similar age in other parts of the world.

Stratigraphy

After the mapping and subsequent geological interpretation of the district, the following Stratigraphic Table has been prepared. Faulting has produced a break in the succession.

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* Opinion of the South Australian Mines Department

STRATIGRAPHIC TABLE °

Member		Thickness	Index No.
Upper Phyllites	Siltstones	220'	1
Stonyfell Quartzite		900'	2
Lower Phyllites		?	
? ?		?	
Aldgate Sandstone	Quartzite	800'	3
	Siltstones	150'	4
	Sandy Siltstones	300'	5
	Sandstone	1000'	6
	Sandy Siltstones	950'	7
UNCONFORMITY			
Archean	gneisses	650'	8

Rock Types

Index No.

1. Upper Phyllites   Specimen W   (220')

This Member consists of well-bedded claystones and siltstones. The rock has a pale grey-green colour and a very fresh, unaltered appearance in hand specimen. Colour-banding is common, with darker and lighter strata up to several inches in thickness. A number of slump structures were observed; their form indicated localised free slumping in the sediments.

No mica flakes could be seen with a hand lens, although cleavage is very well developed.

There is a transition zone near the contact with the underlying Stonyfell Quartzite, with beds of sandstone up to eight inches in thickness. These have been channels of deep oxidation into the siltstone.

2. Stonyfell Quartzite Specimens, A, B.   (900')

A massive well-sorted medium-grained, quartzite. The rock is well-indurated and has a low "fines" content; felspar is a minor constituent. On exposed walls, the quartzite shows a pronounced slabbing which parallels the bedding. Individual slabs average 30 inches in thickness.

Specimen C illustrates a platy parting developed by grain elongation - this elongation is equivalent to a foliation and is Sander's bc plane.

Lower Phyllites

Near the north-eastern extremity of the mapping there is a contact between quartzite and siltstone. This is tentatively considered to be the local base of the Stonyfell Quartzite, and would be underlain by the Lower Phyllites.

° The names of lithologic members (e.g. Upper Phyllites) are those applied by the South Australian Mines Department.

Aldgate Sandstone

3. Quartzite Specimen C. (800')

This is not so well-sorted as the Stonyfell Quartzite and in part tends to a massive sandstone; some of the rock is quite friable. Grainsize varies from fine- to medium-grained - the basal section has a coarser grainsize. The rock has a general pale buff color, which is probably related to the large percentage of "fines"; felspar is more abundant than in the Stonyfell Quartzite.

The most easterly exposures show prominent grain elongation.

4. Siltstone (150')

A well-banded grey-green siltstone underlies the quartzite; there is no marked transition zone. The most easterly exposures of this rock-type have extensive slump structures. The rock shows complicated "fold" structures, and there are several examples of thin (6-9") competent beds, such as coarse sands, which were truncated during the movements. There is much evidence of free-slumping.

5. Sandy Siltstone (300')

This unit comprises well banded and finely bedded siltstones, sandy siltstones and fine-grained sandstones. Slump structures are less common than in the overlying bed, and are poorly developed. However, there are many excellent examples of small-scale cross-bedding.

6. Sandstone (1000')

There is a gradual downward transition into this unit, a thick succession of massive, fine-to medium-grained sandstones and silty sandstones. The rock-type is characterised by poorly developed bedding traces; bedding attitudes are usually obtained only with difficulty.

7. Sandy Siltstone. (950')

This is probably the lowest unit of the Torrensian Series and comprises thick sandy siltstones interbedded with minor sandstone and siltstone strata. There is little lithologic variation throughout the whole of this unit. Indeed, this has been a feature of the area.

Immediately above the unconformity there is a massive medium-grained quartzite with cross-bedded structures, and bands of heavy minerals.

8. Archean rocks. Specimens H, I, J, K, N, R, S, T. (650')

The Archean is exposed in few places only. Siliceous sericite gneisses are the general rock-type, and although the gneissosity is strongly developed and/the rock has undergone shearing, bedding traces are often preserved. There is a general content of hematite amounting to some few percent. The iron oxides are probably a product of metamorphic reactions.

e.g. Biotite + Kyanite = Felspar + Sillimanite + FeO

These gneisses are considered to represent original essentially sandy sediments.

In the eastern portion of the district, outcrops of phyllites, shales and some weathered poorly-sorted rockshave been assigned to this Age. The phyllite is a typical low grade metamorphic rock and has prominent platy partings. There is a three foot thickness of black shale in the eastern zone. The rock sandy siltstones at several localities during the survey. Examples were found only in units of the Aldgate Sandstone.

Archean.

The outcrop of the Archean comprises dark-grey phyllites and siliceous sericite gneisses. At the present, thin sections of these rocks are not available, but it is generally accepted that the gneisses are retrograde metamorphics. They therefore indicate a rather high-grade metamorphism.

Pegmatite veins are common throughout the whole of the Archean main road outcrop. It is not certain whether they are of igneous or metamorphic origin. Individual veins are broken and the pieces separated - this evidence from the form of their occurrence indicates that deformation and recrystallisation took place subsequent to their emplacement.

The Unconformity (Archean - Proterozoic)

The unconformity is exposed at one location only - near the southern end of the main road Archean section. Here strongly-sheared Archean gneisses are overlain by approximately twelve feet of extremely-weathered, poorly-sorted unconsolidated material with a high felspar content. The material has a large proportion of clay, and also contains several rounded pebbles up to two inches across; one of the pebbles has a granitic appearance and contains subhedral felspar crystals up to 5 mm x 3 mm in size. Overlying this loose material is a medium - grained, semi-indurated quartzite with bands of heavy minerals. There is some cross-bedding.

Sprigg (1946) stated that this unconsolidated material represents an Archean erosion surface. It is the most likely interpretation and I am in agreement with him. However, such an erosion surface would be a zone of weakness in the rock mass, and it is certain that release of stress occurred along this feature during deformation. The strongly-sheared nature of the nearby rock is further evidence of local movement.

The Proterozoic "quartzite" at the unconformity is somewhat friable, and would break-up during movement. It is suggested that this feature is an erosion surface along which movements have taken place. The unsorted weathered rock debris is derived in part from the erosion surface, and in part represents fault gouge.

STATISTICAL ANALYSIS OF THE STRUCTURES.

General

A statistical analysis of the bedding, bedding-cleavage relationships and cleavage in the area mapped was undertaken. The appropriate data were plotted on a stereographic projection, and the results have been analysed; the relevant projections are contained in Appendix B.

Bedding attitudes from the Archean rocks were too few in number to yield results of any value.

a. Bedding

Plots of strike-dip readings indicated north-south axial trends and rather flat south plunges for the folds - both in the area to the north of the major fault, and to the south. The stereograph also illustrated that folding was open, and overturning absent.

has been sheared and shows highly polished surfaces, suggesting that the shales are graphitic. A similar black shale is exposed in the main road Archean section.

Structure

a. Folding

The whole of the Proterozoic sequence in this area has been folded about N-S trending axes. The geological interpretation shows large-scale open-folding with a considerable amount of minor drag-folding. Five small drag-folds (several feet in dimensions) were found during the mapping; all of these plunge in a southerly direction at 10-15°. Deformation has produced extremely complex folds in the incompetent siltstones of the Aldgate Sandstones.

A dome structure, causing pitch reversal is believed to exist in the north-west corner of the area mapped. Bedding attitudes suggest this, and lineations in the Upper Phyllites near the northern margin of the map plunge flatly north, that is, they are opposed to the regional plunge of the folding.

Earlier folding is present in the Archean rocks. The evidence from this mapping is not conclusive, but suggests an axial trend rather west of south.

Fold axes in the north and south of the area covered by the present survey, are opposed - this supports stratigraphic evidence of a major fault located centrally in the district. Opposed structural trends in the south-eastern portion infer the existence of another fault there.

b. Faulting

Only one system of faults has been established; these trend approximately N45°E. The attitude of the fault-plane in three dimensions is uncertain. This fault-system is genetically related to the extensive block-faulting so typical of the South Mount Lofty Ranges. A simple calculation from the published Stratigraphic Table of the Torrensian Series indicates that the relative movement across the fault, was equivalent to some 6000 feet in the vertical plane, and was north-block-down. Bedding trends south of the main fault suggest that there was a horizontal component in the movement - in this example north-block-west. This direction is supported by evidence from the (?) fault in the south-eastern sector.

At the northern end of the Archean section along the main road there is a distance of about thirty feet without exposures; to the north of this break, typical Torrensian rocks (siltstones, quartzite) outcrop. That is to say, the main fault may be accurately positioned in this section.

The existence of the two northernmost of the three minor faults, is factual - the extension of these structures to the north-east and south-west is interpretation. Evidence for the southernmost minor fault has been mentioned before.

Metamorphism

Proterozoic. The Torrensian Series has undergone little metamorphism. This is characteristic of the whole of the rocks of the Proterozoic Era in the Adelaide region. Scattered flakes of sericite were found in siltstones and

b. <u>Cleavage</u>

The stereographic plot of cleavage readings had a rather disperse form, suggesting that there has been some minor folding since the development of the cleavage. No further evidence for this (?) second stage of folding has been found.

c. <u>Bedding - Cleavage relationships</u>

Stereographs of this relationship have the most direct application in geological interpretation; the following results were obtained (results are expressed to the nearest five degrees, both for azimuth and plunge):

Fold structures North of the major fault

Axial trend N-S Plunge 20°S

Fold structures south of the major fault

Axial trend N-S Plunge 35°S

A pitch reversal in the north-western portion of the area of the survey involves a plunge of 15° northerly on a bearing of N5°W.

GEOLOGICAL HISTORY:

During the Lower Proterozoic, an erosion surface on Archean metamorphics was submerged and overlain by a succession of sands, clays and silt. With diagenesis, thick rock units were developed; there are only minor lithologic variations within individual units.

These rocks, known as the Torrensian Series comprise well-indurated quartzites, sandstones, silty sandstones and siltstones. The Torrensian is unconformably underlain by Archean phyllites and gneisses.

The rock sequence has been folded, with the development of open folds; drag folding, although common, has produced only simple structures in the area studied. Extensive block-faulting has taken place in the South Mount Lofty Ranges. Geological mapping has indicated one major fault in the Crafers - Stirling district and there are several associated minor faults.

The History is represented diagrammatically on the following Table -

Index	EVENT	
5	Erosion	
4	Block-faulting and elevation	
3	Folding	
2	Sedimentation	(?) Lower Proterozoic
	Unconformity	
1	Archean metamorphics.	

ECONOMIC GEOLOGY:

Quarrying

Although there is little activity at the moment, a considerable amount of quarrying has been carried out locally in the past. Both the Stirling Council and private companies own quarries in the district, in quartzites of the Torrensian Series. There is some potential for future medium-scale operations, but an early resumption is unlikely, as there are more-favourable sites in the Adelaide Hills.

Hydrology

The Archean rocks are not considered promising aquifers and any prospective drilling should be in the Stonyfell Quartzite or the Aldgate Sandstone, which yield supplies of good quality water, usually less than 30 grains per gallon. Highest yields have been from bores penetrating fractured sandstone and quartzite strata; few bores produce more than 1500 g.p.h., the largest supplies being obtained from topographically favourable sites, where recharge is at a maximum. The bores in fault zones have particularly high yields.

Records indicate that pumping over a long period has caused some recession of the water table, despite the high annual rainfall (av. 47 inches per annum). It may be possible to counter this by the construction of deeper bores with correspondingly greater catchment areas and better possibilities for recharge.

Notes on the Geological Plan

In the absence of accurate contour information, the interpretation has been made as on an imaginary horizontal plane - the fact mapping has been projected vertically onto this plane. That is to say, the complication of topography has been removed, and the trace of lithologic boundaries simplified. A result of this is that there may be minor errors in stratigraphic thicknesses presented in this report. It is probable that these errors are of the order of ten percent.

The plan position of the unconformity to the east from the main road is interpreted and is based on trend lines in the overlying Torrensian Series.

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APPENDIX A

List of rock specimens:

INDEX	LITHOLOGIC MEMBER	ROCK TYPE
A	Stonyfell Quartzite	quartzite
B	" "	"
C	Aldgate Sandstone	"
D	Proterozoic	"
H	Archean	sericite gneiss
I	"	"
J	"	"
K	"	"
N	Archean	phyllite
R	Archean	dark grey phyllite
S	"	black shale
T	"	?
W	Upper Phyllite	siltstone

APPENDIX B.

Rock thin section descriptions

A. Stonyfell Quartzite

A sedimentary quartzite with remarkably even grain-size. Individual grains average 0.3 mm mean diameter and have corroded margins - there has been some recrystallisation. The quartz exhibits undulose extinction indicating that the rock has been considerably stressed and in addition many grains are cracked and broken.

Accessory minerals include detrital iron oxides, zircon and apatite.

A feature of this slide is the presence of small (av. 0.4 mm x 0.4 mm) areas of iron-stained material, probably clay minerals. The minerals could represent altered felspar grains and would precipitate iron from circulating groundwater.

B. Aldgate Sandstone (this specimen : quartzite).

A poorly-sorted sedimentary quartzite with grains to 1.5 mm x 0.8 mm, while the majority are smaller with an average mean diameter of 0.3 mm. The grain boundaries are corroded and there is abundant evidence of recrystallisation. Some grains show undulose extinction. Felspar comprises some 10% of the rock and the individual grains are generally within the Oligoclase range (Ab 70-90) range of composition.

There is a general development of very-fine-grained sericite between grain boundaries - it is not certain whether this developed from the breakdown of felspar, or from introduced material.

Accessory minerals are iron oxides, zircon and (?) apatite.

H. Archean. A sericite-hematite gneiss.

Quartz, felspar and hematite (pseudomorphing magnetite) occur in a very fine-grained matrix of sericite.

Quartz 20%. This mineral is evenly distributed throughout the section and is found in a wide range of grainsize (av. mean diameter 0.4mm). Individual grains are broken, and several show undulose extinction.

Felspar 5%. The felspar is altering to (?) sericite and only vestiges of the grains remain. Grains are considerably larger (av. mean diam. 0.8mm) than those of quartz; the most common felspar is microline, which has altered most rapidly along cleavage planes.

Hematite. 5-6% (incl. titaniferous magnetite) The iron oxide pseudomorphs titaniferous magnetite; individual grains are corroded and broken. Internal alteration has taken place and commonly parallels the grain boundaries. Some of the titanium - bearing magnetite remains unaltered and is distinguishable from the hematite under reflected light. This magnetite is commonly surrounded by an alteration rim of leucoxene and (?) chlorite.

Sericite ca 70%. The mica occurs as a very, fine grained mat and forms the "groundmass" for the thin section. The flakes have an imperfect alignment and mica "trains" are bent around the other minerals.

K. Archean Sericite gneiss.

Very similar to slide H, but this section has less of the titaniferous magnetite. However, there is an equivalent amount of leucoxene and chlorite. Several lath shaped crystals of tourmaline were noted in this thin section; the mineral is probably schorlite, an iron tourmaline.

N. Archean Phyllite

The section consists of abundant magnetite "dust" in a micro-grainsize matrix having a numerically large (30-50%)sericite content. The remainder of the groundmass is indeterminate, but probably contains quartz and felspar (inferred from appraisal of hand specimen).

The mica flakes have a good general alignment; in hand specimen the rock has a poorly - developed parting.

W. Upper Phyllite Siltstone

An extremely fine-grained sedimentary rock determined siltstone in hand specimen. The rock exhibits a rather well developed cleavage, but there is no other macroscopic evidence of post-diagenetic alteration.

In thin section the specimen consists of a felted mat of particularly fine-grained muscovite and chlorite; quartz and (?) felspars are also present.

Muscovite 30-40% This mineral is the major identified component and occurs in characteristic lath-shaped flakes - these have nearly parallel extinction. Individual laths show a poorly developed alignment which is sub-parallel to the bedding.

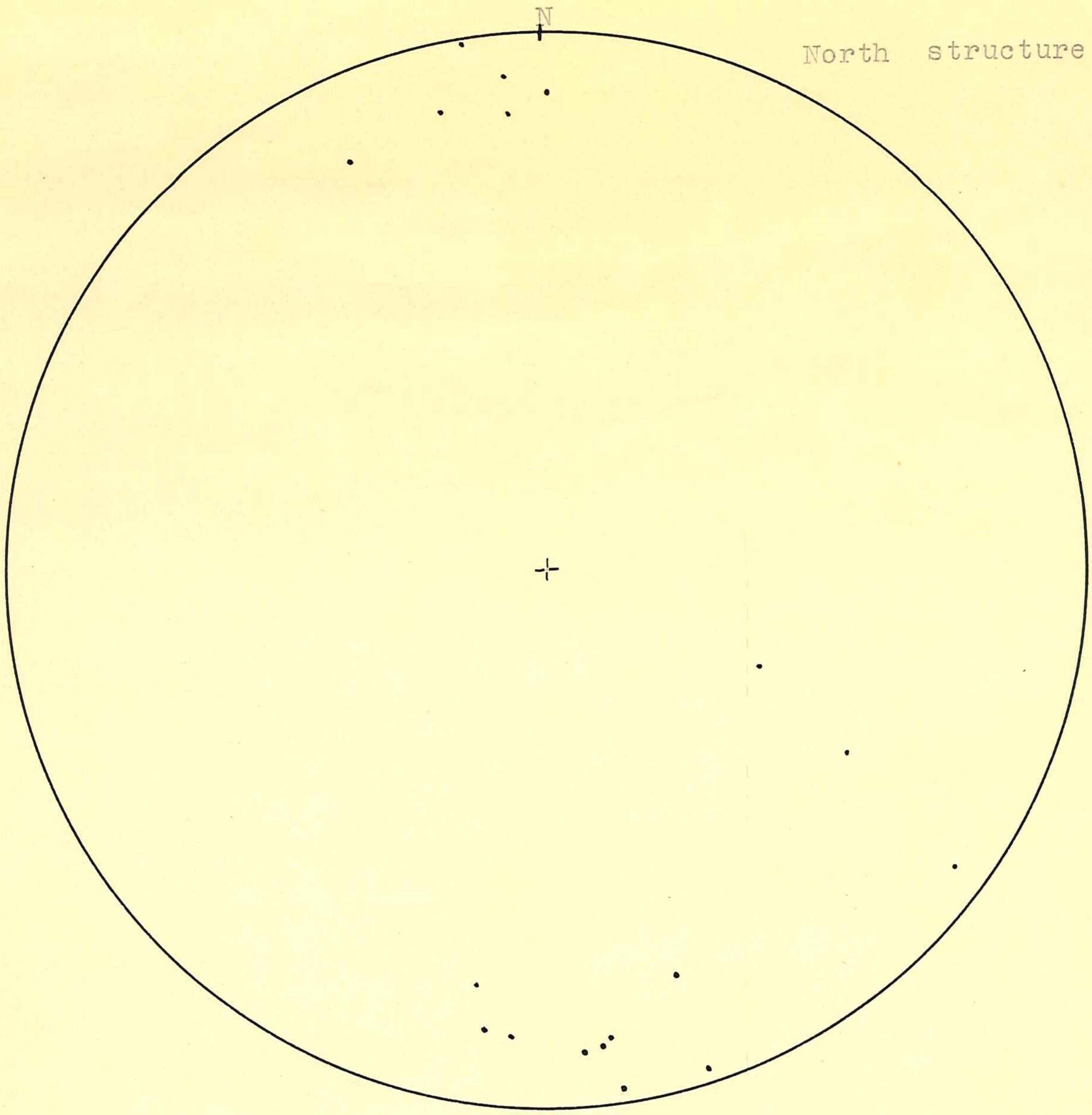
Chlorite ca 5% occurs as small, well separated flakes which are strongly pleochroic, dark-green to citrine.

Quartz Some fine-grained quartz was observed.

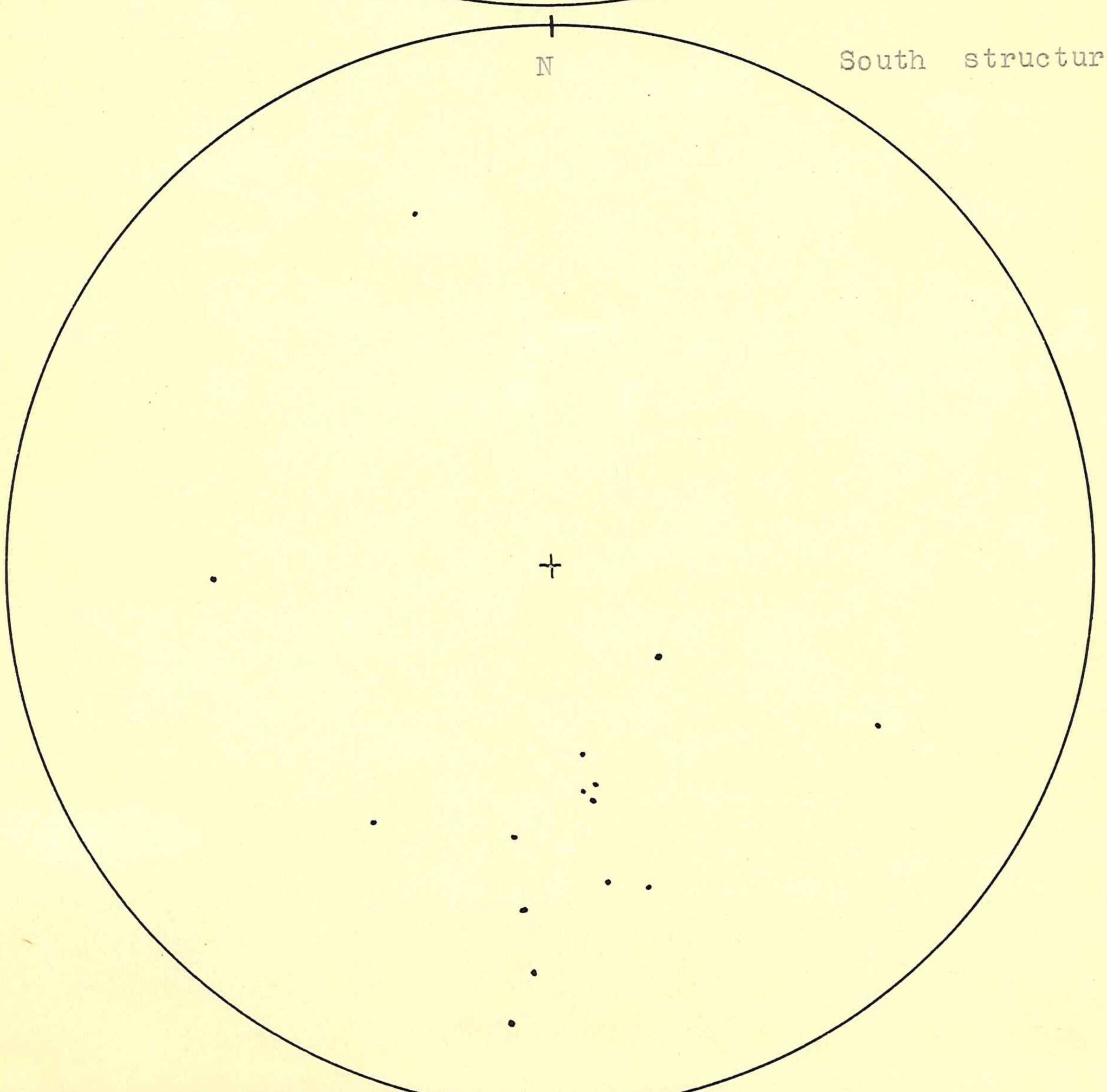
The slide is marred by numerous small sub-rounded pieces of burnt Lakeside "70", the adhesive compound.

Bedding-cleavage Relationships

North structure



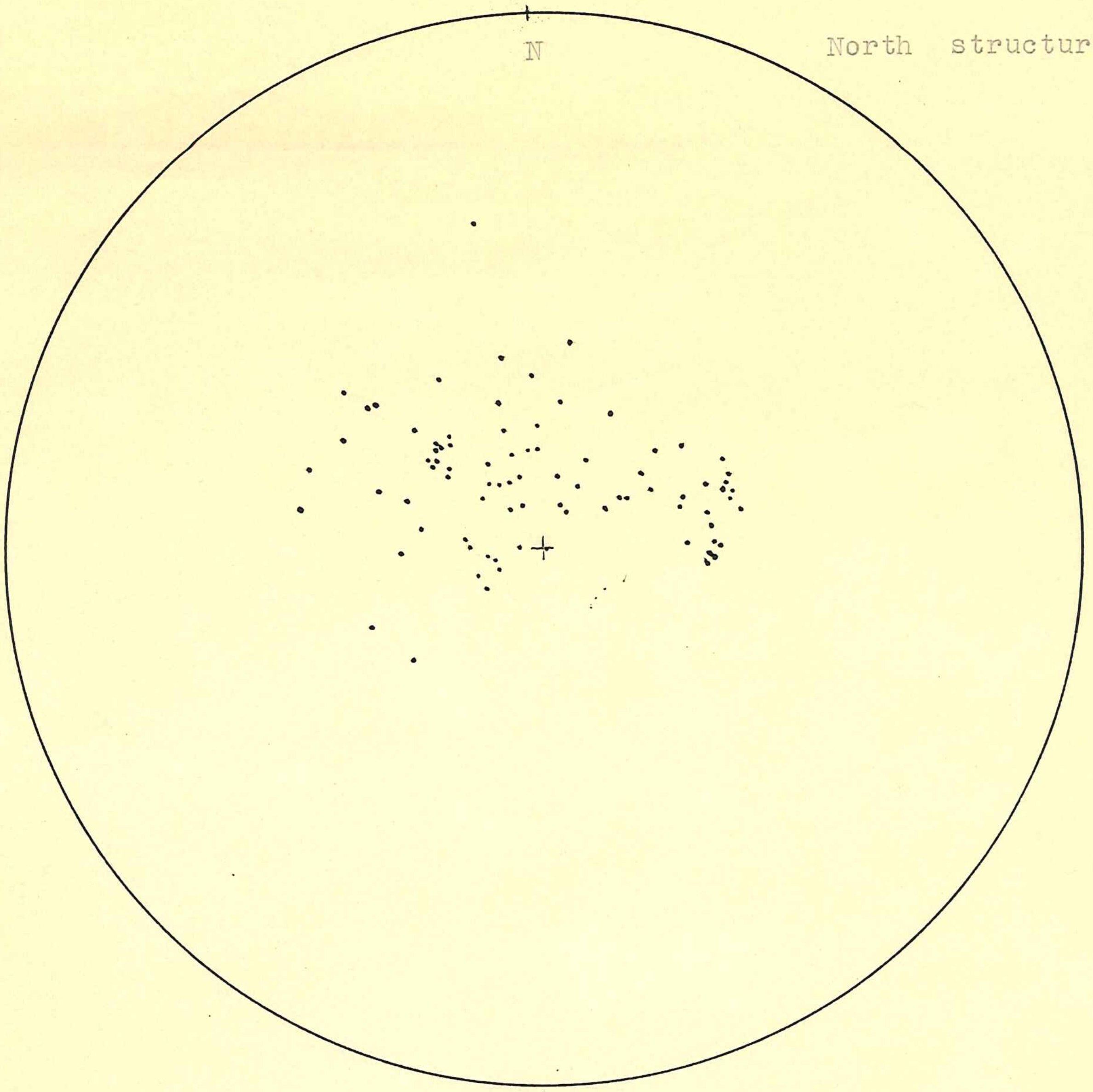
South structure



APPENDIX C

Bedding plane plot

North structure



South structure

Cleavage