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DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

IRON EXPLORATION SECTION

GEOLOGICAL REPORT NO. 2 ON BRENNAND ANOMALY

Hundred Koppio, Southern Eyre Peninsula

Cummins 1-Mile Sheet

by

W.B. Robinson,
Geologist

21st September, 1965

D.M. 157/65

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ABSTRACT

Regionally metamorphosed Precambrian jaspilites and amphibolites, thickened by dragfolding and with an associated aeromagnetic anomaly, were tested by diamond drilling.

BD1 drilled 549', intersected 150' of jaspilite estimated to contain 5-10% iron oxides. Only minor bands of magnetite-jaspilite were encountered.

Petrographic, specific gravity, susceptibility and suspended magnet determinations were made on the core.

INTRODUCTION

As part of its policy in the search for magnetic iron ore deposits, the South Australian Department of Mines is systematically mapping and drilling jaspilites in the Lincoln Uplands of Southern Eyre Peninsula. Previous work includes the regional mapping by Johns (1961) and aeromagnetic surveys at 1500' (Webb 1957) and 300' (Webb 1962). Detailed mapping and drilling has been carried out at Greenpatch (Shackleton 1963, 1964a; Whitten 1964 a & b), Koppio (Shackleton 1964b, Robinson 1964), Oolanta (Robinson 1965 b & c) and Rock Valley (Robinson 1965 d).

Wide outcrops (400') of weathered jaspilite (?) associated with an aeromagnetic anomaly were found on secs. 74, 44, 40 and 114, hundred of Koppio during an inspection with the Senior Geologist G.F. Whitten. Subsequently detailed mapping,

dip needle traversing and surface sampling was carried out (Robinson 1965a).

Two diamond drill holes BD1 and BD2 were recommended but BD2, was not drilled.

The iron oxide content of the drill core was estimated visually. Specific gravity, susceptibility and suspended magnet determinations were made. Petrographic descriptions of selected drill core and surface specimens were supplied by officers of Australian Mineral Development Laboratories. The drill-core has been retained whole.

This report finalises the investigation of Brennand Anomaly.

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LOCATION

Brennand's Anomaly is approximately 30 road miles north of Port Lincoln, the principal port of southern Eyre Peninsula. The nearest port is Tumby Bay which is 20 miles to the east.

The surrounding districts are used for grazing and cropping and are served by good sealed and unsealed roads. Access is not difficult. The area is on the Cummins 1-mile sheet (Johns 1958).

TITLE

The mineral rights of Sections 40, 44, 74 and 111 belong to the Crown and of Section 114 to the owners of the freehold.

Sections 40, 44 and 111 Hundred of Koppio, have been reserved from operations of the Mining Act. (Gazetted 25.2.65).

REGIONAL GEOLOGY

Johns (1961) referred to the jaspilite beds as hematite quartzites and placed them at or near the base of the Hutchison Group. The Hutchison Group comprises schists, amphibolites,

quartzites, jaspilites, marbles and minor gneisses. It overlies the Flinders Group which has mainly gneisses with minor amphibolites, schists, dolomites and quartzites. Recent work in the Lincoln Uplands has revealed more extensive jaspilite outcrops than mapped in 1961. Inspection of the Lincoln-4-mile aeromagnetic map (Webb 1963) and the Lincoln 4-mile geological map (Johns and Thatcher 1958) suggest the following sequence which is incomplete because of lack of outcrop.

Flinders Gneiss

Coarse grained gneiss with minor amphibolites etc.

These rocks outcrop along the east coast of Eyre Peninsula and form a prominent ridge of rounded hills which run parallel to the coast. The rocks are associated with a generally moderate level of magnetic activity (1400 gammas with randomly oriented peaks up to 1700 gammas).

Hutchison Group

1. Amphibolites and schists with associated jaspilites, marbles and dolomites.

General magnetic activity in the Hutchison Group approximates 1000 gammas. A series of longitudinal aeromagnetic anomalies with values up to 2,5000 gammas (e.g. at Greenpatch) and having steep gradients run parallel to, and west of the Hutchison - Flinders Group boundary. Drilling at Greenpatch (Shackleton 1963, 1964a; Whitten 1964a, b) to the south, and Port Neill (Whitten 1964c) to the northeast revealed marbles associated with magnetite jaspilites. Jaspilites with marbles and dolomites were found outcropping northeast of the Tod Reservoir. These beds occur 1 to 2 miles west of the western boundary of the Flinders gneiss and are all associated with a semi-continuous zone of aeromagnetic anomalies. This suggests that they belong to the same stratigraphic horizon.

2. Jaspilites associated with amphibolites.

A series of longitudinal anomalies with peaks up to 2000 gammas and having steep gradients, trend approximately parallel

to and west of the anomalies mentioned above. These anomalies are associated with jaspilite beds which outcrop semi-continuously northwards from near Bald Hill to just south of Nyllow Hill. The jaspilite beds at Brennand, Koppio and Oolanta are part of this more westerly sequence.

3. Other rocks.

Approximately 6 and 12 miles respectively to the west of the upper jaspilites (2) are two series of northeast trending anomalies. These anomalies seem to be partly associated with quartzites but no detailed mapping has been carried out in the area. Further west, there are no significant anomalies almost to the western edge of Eyre Peninsula and aeromagnetic intensities range from 600 to 1000 gammas. Trending northwards along the western margin of Eyre Peninsula there is an anomalous zone with peak values of 2000 gammas in the Coffins Bay area. Due to lack of outcrop it is difficult to correlate the beds of western Eyre Peninsula with those to the east.

The interpretation of the sequence containing the jaspilites is similar to that described by Miles (1954) for the Middleback Range area. There is evidence from the mapping of Johns (1959) and Miles (1954) that the jaspilites of the Lincoln Uplands trend north towards the Middleback Ranges. The age of the jaspilites may be middle Precambrian as suggested by Miles.

DETAILED GEOLOGY

The ares is one of youthful topography with small intermittently flowing streams, some having steep sides gullies. The main area of outcrop has an elevation of over 300 feet above the general stream level.

An area approximately 1000' x 3000' has been mapped using aerial photographs enlarged to a scale of approximately 1" = 400' or a plane table. Detailed profiles over proposed drillhole lines have been plane tabled at 1" = 100'.

Rock Types

The outcropping rocks are jaspilites and amphibolites which are generally weathered and oxidised. The jaspilites are more resistant than the amphibolites and form ridges. Surficial deposits of canga, sandy laterites and coarse quartz conglomerate with a ferruginous cement occur.

The jaspilites consist of alternating bands of quartz (sometimes cherty, sometimes granular) and iron minerals generally hematite or limonite. The bands vary from 1/16 to ½ inch thick but are generally about ⅛ of an inch. The jaspilites grade in places to quartzites or metacherts with only a few scattered grains of iron oxide. One small outcrop of massive crystalline martitised magnetite with hematite was found (for pet. description see Appendix).

There are 5 to 7 bands of jaspilite which vary between 10 and 90 feet thick but are generally 10 to 30 feet. A series of samples (see Plan S4028) taken over 260' of outcropping jaspilite average 42.2% acid soluble iron, the highest value being 48.0% and the lowest 38.9% .

The laminated unweathered amphibolites (see Appendix), consist of darker laminae with abundant green hornblende alternating with lighter laminae of plagioclase and quartz grains. When weathered the felspars and amphiboles decompose to kaolin and chlorite. Often, the amphibolites are heavily iron stained at the surface, and it is difficult to distinguish them from oxidised jaspilites. Rocks composed of soft earthy yellow limonitic material have been mapped as weathered amphibolite while rocks containing red-brown martite-hematite (?) bands or hard brown laminated bands have been mapped as jaspilite. The amphibolites are generally weathered and tend to form basin like "cirques" when in contact with the more resistant jaspilites.

Minor coarse grained quartzites have been found as float.

Structure

The structure in the area is difficult to determine because of creep.

The jaspilite beds can be traced from the eastern edge of the Koppio structure in an easterly direction gradually trending to the northeast. The jaspilites mainly dip to the north and northwest from 30° to 90°. Some southeasterly dips observed on the northwest sides of hills are thought to be due to creep. To the northeast the beds are covered with canga and laterite.

The most westerly beds of the main outcrop on Profile F'-F-F'' (see plan 65-93), dip to the southeast at an angle of about 45°. Between F'-F the beds gradually steepen in dip until at F, they dip vertically or slightly to the northwest. Southeast of F, the beds dip consistently at 45° to the northwest. Point F is on the crest of a hill and it is thought that soil creep may have affected the beds downslope on both flanks of the hill. Drilling indicates that the beds dip at 70° northwest, not to the southeast as indicated on the northwest flank and flatly northwest as indicated on the southeast flank.

The structure is interpreted to be a dragfold (see plan) which tends to thicken the jaspilite beds. The plunges of the minor folds in the area generally tend to be vertical where it is reasonably certain that the beds have not been affected by creep. If these plunges are correct, the jaspilites continue in depth.

GEOPHYSICS

Aeromagnetic surveys have been carried out over the area at 1500' (Webb, 1957) and at 300' (Webb, 1962). A number of dip needle traverses have been read in an effort to find the likely areas of magnetite concentration and to delineate the structure in areas of no outcrop. The dip needle traverses at Koppio (Robinson, 1964) show close agreement with the ground magnetometer traverses over the same lines.

Aeromagnetics

Two profiles have been drawn along flight lines which pass over the area which has been mapped. These profiles have been drawn from information obtained from the low level aeromagnetic survey (Webb, 1962).

The line through points 8640, 8655, and 8571 (Plan I65-1) passes obliquely over the main exposures of jaspilite. This profile shows a "high" of 2,500 gammas above background to the west of the main outcrop of jaspilites. There is also a slight "kick" in the profile just west of the most easterly outcropping jaspilite beds. This tends to confirm a general westerly dip of the beds. The "high" could possibly result from the nose of the western element of the dragfold proposed to explain the structure. The "high" in this area is slightly greater than the "high" 500 feet to the north of the diamond drillhole KD 4 Koppio. In this hole a band of 140 feet of unweathered magnetite jaspilite was first intersected 160 feet below the surface.

The flight line which is 1200 feet south of the above line, (through points 8022, 8069, 8050) shows an anomaly which is 1500 gammas above background. The lower anomaly may indicate that the jaspilites have been oxidised to a greater depth than those to the north, or that the beds are thinner and contain less magnetite. This "high" occurs to the west of the outcropping jaspilites and again supports a general westerly dip of the beds.

Dip Needle Traverses

At Koppio, the highest dip needle reading was 211°. This occurred in the traverse over diamond drillhole KD 4, the hole which intersected 140 feet of unoxidised magnetite jaspilite. Over KD 3 which intersected mainly low-grade oxidised jaspilites the maximum value was 199°. The results obtained at Brennand will be discussed with these readings in mind. The locations of the traverses are shown on Plan I65-1 and the profiles on Plans

65-2, 65-63 and S-4037.

Profile M'-M.

On this most northerly profile the most easterly outcropping jaspilite beds give a value of 195°. Readings rise to a peak of 199° between the eastern and western outcrops. No higher values were recorded west of the western outcrops. This suggests that the westerly beds are dipping approximately vertically. The outcrops indicate an easterly dip and it is probable that creep has been active. The most westerly beds along M'-M are the probable equivalents of the most westerly beds exposed along F'-F''. The reduced width of outcrop along M'-M may be due to the non-exposure of beds or more likely to a thinning of beds to the north of the folded area. Comparing the dip needle values with those at Koppio they indicate that the jaspilites may be oxidised, thinner or lower grade,

Profile N'-N

Rises to a peak of 198° at the main outcrops of jaspilite. There is a small "kick" in the profile west of the most easterly beds indicating a westerly dip in the jaspilites. The peak above the main outcrops of jaspilite may indicate near vertical dipping beds. Variation in values to the west is probably caused by deposits of canga, which give erratic readings.

Profile F'-F''

Shows a maximum reading of 202°. This occurs near F'' and on canga which is presumed to overlie the most easterly jaspilite beds. This peak occurs slightly to the west of the inferred position of the jaspilite and may indicate a westerly dip. Over the main outcropping jaspilite beds there is a broad anomaly with maximum values of 200°. Readings diminish to the east and west of the outcrop jaspilite. This probably indicates vertically dipping beds. There is also a small peak rising to 196 further to the west . This occurs above heavily lateritised amphibolite

(?) and is also in the area of the western element of the inferred dragfold.

The drillhole was drilled south easterly along line F'-F". The jaspilites were generally oxidised. Only minor bands of magnetic material were intersected. Similar results were obtained from Koppio KD3.

Profile P'-P

Gives a maximum value of 204° to the west of the main outcropping jaspilite and west of the axis of the western element of the proposed dragfold. The "high", east of here, may result from the eastern element of the dragfold. If these results are not affected by surface canga then they seem to indicate that the jaspilites may be less weathered than those to the north. The values also place some credence in the proposition for a dragfold.

Profile Q'-Q

Shows a maximum value of 207° and a minimum value of 164°. These values are over canga. A maximum value of 199° is recorded over the main outcrops of jaspilite at the nose of the eastern element of the dragfold. There is also a peak in the profil to the west of the most easterly outcrop beds indicating a dip to the west. The value of 199° may indicate oxidation.

Profile R'-R

Shows maximum values of 203° over areas of no outcrop. These values occur over the eastern limb of the western element of the proposed dragfold. The peak is broad and may indicate thick jaspilites with oxidation to a moderate depth. Erratic values occur over outcrops of canga and the poorly outcropping westerly beds exhibit low values.

Profile V-U

Shows a peak of 199° in an area of no outcrop, This peak could be due to concealed beds in the nose of the eastern element of the inferred dragfold. Profile U-T shows a peak of 195°

shows a peak of 195° over the west of outcropping jaspilites Profile T-S has a peak of 200° in an area of no outcrop. This is to the west of the westerly outcrops of jaspilite and may indicate a westerly dip.

The aerial magnetometer and the ground dip needle surveys indicate an anomalous zone over and to the west of the exposed jaspilites.

The highest aeromagnetic values of approximately 2,500 gammas above background occur to the west of the main outcrops of jaspilite and approximately in the position of the nose of the western element of the dragfold. Comparison with the aeromagnetic survey and results from diamond drillhole KD 4 at Koppio may indicate magnetite jaspilites at moderate depth in the vicinity of the anomaly.

Dip needle values over the main outcrops of jaspilite indicate that oxidation has affected the jaspilites. The aero magnetic and dip needle surveys are interpreted to indicate a steep westerly dip for the beds. Drilling along line F'-F" confirms the oxidised nature of the jaspilites and their steep westerly dips. Creep is thought to be responsible for the general easterly dip of the beds on the western flank of the main outcropping jaspilites.

DRILLING RESULTS

Techniques

One diamond drill hole was drilled south easterly at 40° for 549' using a Mines Department Mindrill F25 rig. The hole was maintained at N-size to 381' and at B-size for the remainder. The highly weathered nature of the jaspilites and amphibolites in the upper part of the hole, necessitated cementing and the use of drilling mid to maintain the hole. Core recovery (see plan S4684) was poor in the upper part of the hole.

The angle of the hole was measured every 100', by etching glass test tubes with diluted hydrofluoric acid. See Plan 65-63).

Results

BD 1

Collar F-480' Direction F'-F (approx. south-east)

Angle - 40° Depth 549' Plans L65-1 65-63

Summary L BD 1

0	-	77'	Amphibolite. Deeply weathered to kaolinitic materia. Iron stained.
77	-	191'	Amphibolite interbedded with jaspilite. Deeply weathered. Approximately 88' of jaspilite 5-10% FeOx. Manganese staining in places. Minor pyrite and chalcopyrite.
191	-	288	Banded hornblende-quartz-felspar amphibolite with minor garnet occurrences. Deeply weathered at first, minor pyrite.
288	-	305	Banded quartz-hornblende-magnetite jaspilite. Weathered with some limonite. 5-10% FeOx.
305	-	346	Banded quartz-felspar-hornblende amphibolite, weathered.
346		358.1	Banded quartz-hornblende-magnetic-jaspilite, interbedded with hornblende-quartz-felspar amphibolite.
358.1	-	469.1	Amphibolite-mainly hornblende-quartz-felspar with minor diopside, wollastonite cummingtonite, garnet augite (?) and apatite. Disseminated magnetite occurs $\leq$ 5% FeOx.
497.5	-	549.0	Coarse grained hornblende-plagioclase amphibolite.

END OF HOLE.

The hole intersected approximately 150' of jaspilite estimated to contain 5-10% iron oxide of this 88' (betwen 77' and 191') was deeply weathered and consisted mainly of goethite with minor martite and magnetite. The deep weathering made it difficult to distinguish the jaspilite from weathered and ironstained amphibolite. In thin section the presence of magnetite and martite confirms its jaspilitic origin. Minor pyrite and chalcopyrite occur. The remainder of the jaspilite occurred as narrow bands with uneconomic amounts of magnetite. The richest of those bands occurred from 469.1' - 497.5' and is estimated to average 10-15% iron oxide. Minor magnetite occurs mainly as disseminated grains in amphibolite from 358.1' - 469.1'. Some of this rock has been identified by AMDEL as being granadioritic in composition and texture, probably indicating thermal metamorphism. The greater temperatures required may have caused dissemination of the magnetite.

The beds intersected in the drill hole correlate well with those mapped on the surface. (see plan 65-63). At the surface the jaspilites are weathered - the magnetite oxidising to martite and goethite. The amphibolites are only rarely seen in outcrop and most of the areas of no outcrop are thought to represent amphibolites. The beds in the lower part of the hole dip mainly at 70-80° to the N.W. In the upper part they dip to the S.E. - indicating that surface creep has been active.

Petrographic examination of selected specimens indicates that generally the rocks have attained low-grade almandine-amphibolite facies of regional metamorphism.

Thermal metamorphism is indicated by coarse-grained rocks with a grandioritic composition (See Appendix 2). This metamorphism may be responsible for the dissemination of the magnetite in this portion of the core (346'-469').

The original rocks were probably siltstones and shales with developments of jaspilite and carbonate sediments.

Developments of garnet, cummingtonite, augite, wollastonite and diopside occur.

Specific gravity values (see plan S4684) reflect the weathering of the core and to a certain extent the iron oxide content. The values from 90' - 190' correlate well with the weathered jaspilitic material. The low values either side of this peak correlate with weathered amphibolitic material. The high values from 290' - 360' correspond to a magnetite-jaspilite band. The richest magnetite-jaspilite band from 469.1' - 497.5' doesn't appear as a peak.

Bulk susceptibility readings were taken where possible, at two feet intervals, to 486'. Volume percent of magnetite was calculated (see plan S4684) using the formula from Bath (1962).

$$K \text{ (susceptibility)} = .001116\ V^{1.39}$$

where V is colume % of magnetite.

No significant values were read between 0' and 380' because of the oxidation of the magnetite in the jaspilitic sections of the core. The highest readings were from 468' - 486', where a maximum of 19% of magnetite was recorded. This is consistent with the visual estimates of grade.

CONCLUSIONS

Detailed mapping, aeromagnetic and dip-needle surveys and subsequent drilling indicate that the jaspilites investigated are too low grade and oxidised to be of economic interest. Aeromagnetic evidence suggests that higher grade magnetite-jaspilites may occur to the west of the area drilled but there are no outcrops.

Petrological examination of selected specimens indicates that the rocks have generally attained the almandine-amphibolite facie of regional metamorphism. Some thermal metamorphism is suggested by the granadioritic composition and texture of some rocks.

No further work is proposed for this anomaly.

21.9.65
WBR:AWK

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APPENDIX I

PETROLOGY OF SURFACE SPECIMENS

(D. AYRES, AMDEL).

P517/64: B:A Amphibolite: TS14937: PS8486

This is a laminated, medium-grained amphibolite. Darker laminae contain abundant green hornblende whilst the lighter laminae contain anhedral plagioclase and quartz grains. Occasional laminae contain partly altered clinopyroxene as a prominent constituent.

Hornblende is present as elongate, subhedral laths, pleochroic from yellow-green to dark green. Plagioclase grains are commonly twinned and are of andesine composition. In some laminae the grains are sericitised. Clinopyroxene is colourless and appears to be of diopsidic composition. Some is altered to pale blue-green tremolite actinolite. Accessory minerals are sphene, apatite and ilmenite.

P518/64: B:A Magnetite: PS8485

This is a medium to coarse grained aggregate of martitised magnetite grains. The individual grains range in size from 0.25 to 4.0 mm. More than 50 per cent of the original magnetite has altered to hematite although the hand specimen is still noticeably magnetic.

APPENDIX 2.

PETROLOGY OF DRILL CORE SPECIMENS FROM BO1 (A.R. TURNER, AMDEL).

TABLE MINERAL ASSEMBLAGES DEVELOPED IN DIAMOND DRILL HOLE BD_1

116.6 to 116.8 ft	quartz-magnetite-martite-geothite
120.0 to 120.2 ft	quartz-magnetite-pyrite-chalcopyrite-rutile-marcasite-goethite
121.2 to 121.5 ft	quartz-goethite-martite-hornblende-magnetite-apatite
394.1 to 394.3 ft	hornblende-cummingtonite-diopside-quartz-wollastonite
402.5 to 402.7 ft	quartz-plagioclase-hornblende-clinopyroxene-apatite
463.6 to 463.7 ft	quartz-hornblende-plagioclase-sphene-carbonate
524.8 to 525.0 ft	hornblende-plagioclase-epidote-quartz.

The textures and mineral assemblages developed in this sequence suggest that the rocks have been subjected to regional metamorphism. There is an apparent increase in the degree of metamorphism with depth until approximately 395 feet is attained at which point there appears to be a decrease in the grade of metamorphism with depth. No adequate explanation for this phenomena is readily available from the specimens provided, however it it possible that the middle zone of the core has been subjected to thermal metamorphism and mobile solutions (?anatexis). This is supported in part by the formation of a rock of granitic composition and texture.

The metajaspilite sequence appears to have had two modes of formation. The near surface sequence was probably deposited as mixed cherts, iron-oxides and iron carbonate with possibly rare layers of calcium phosphate. Below a surface zone of oxidation, hydration, and leaching the banded iron formation rocks contain silicate minerals and in places sulphides. All rocks have been altered by regional metamorphism as indicated by texture and extinction displayed by the quartz grains. There is no evidence to suggest any appreciable migration of iron in the jaspilite during low-grade metamorphism. Banding is due almost entirely to variations in the proportion of magnetite or martite. These rocks were probably formed originally as a sedimentary deposit although whether this was chemical or mechanical cannot be determined. Nearer the metamorphosed calc-silicate rocks it is likely, although by no means definite, that the iron-ore formations have developed by leaching followed by metamorphism. The products of leaching could possibly have formed a chemical deposit at the surface.

The metamorphic grade of the sequence is probably low-grade almandine-amphibolite facies.

P183/65: BD_1: 116.6 - 116.8 ft: TS16070: PS8844

This specimen is an irregularly banded meta-jaspilite,

similar to others in this suite, except that there is an increase in the quartz contant at the expense of the opaque material.

The layers of quartz are somewhat more regular and frequent in their distribution. The quartz occurs in layers approximately 5 mm deep composed of compound irregularly shaped grains of quartz which have crystallized under the influence of an unidirectional stress system. The stress laminae in the quartz have sub-parallel orientation. The quartz contains minute idiomorphic magnetite inclusions and parallel orientated laths of a green pleochroic ?biotite. The quartz laminations are frequently fractured and geothite has infilled these. The areas in which opaque concentrations are relatively high still contain abundant quartz. This occurs as numerous, single, isolated grains set in a matrix of quartz and goethite. The quartz defines a poorly developed laminated texture, within the opaque layers, and exhibits properties similar to that in the quartz-rich layers.

A study of the opaque minerals showed that martite is predominant and may form up to 50% of a particular horizon. The discrete material rarely exceeds a size of 0.1 mm and has been substantially altered to goethite (refer to figure 9).

P184/65: BD_1: 120 - 120.2 ft: TS16071: PS8843

This specimen is an irregularly banded meta-jaspilite composed of a mass of apparently structureless opaque minerals and geothite which is traversed by irregularly spaced, subparallel layers of recrystallized quartz.

Randomly distributed throughout the iron-rich layers are numerous irregularly shaped quartz grains which have a size distribution in the range 0.2 to 0.05 mm. Generally they are inclusion free but occasionally contain finely disseminated iron-oxides. The quartz-rich layers are composed of compound recrystallized quartz grains included with abundant, finely disseminated iron-oxides, the inclusions tend to be crowded into minute subparallel layers running approximately perpendicular to the direction defined by layered texture of the rock and perpendicular to strain lamallae which have developed in the quartz. The grains are frequently fractured; the fractures being infilled with geothite. The contact between the iron-rich and quartz-rich layers is sometimes sharp and sometimes gradational.

A study of the opaque minerals disclosed that magnetite is dominant in layers as subhedral usually interlocking material with most grains less than 0.1 mm. The bands, which average 0.75 mm in width, contain up to 50% magnetite. Pyrite is locally abundant in the non-magnetite layers. Euhedral, cubic crystals are common with a maximum diameter of 0.2 mm. Associated with the pyrite, but nearly always separate, is a smaller quantity of chalcopyrite of a fixed grain-size (maximum 0.02 mm). Both sulphides appear to be later than the gangue. Rare pyrite and chalcopyrite grains occur in the magnetite layers, the later apparently associated with rutile, there is one composite Cu/Fe sulphide particle of which parts appear to be ?late marcasite.

P185/65: BD_1: 121.2 - 121.5 ft:

TS16072: PS8845

This specimen is a meta-jaspilite. The rock is composed

essentially of an irregular banded mass of quartz, magnetite and geothite. The quartz is present as very angular, isolated grains set in a matrix of geothite and also as large interlocking grains. The large grains have a size distribution in the range 2 to 0.15 mm and form clearly defined laminations throughout the ferruginous material. The grains are frequently compound, interlocking and exhibit a pronounced undulose extinction. The extinction laminae are usually orientated in a direction perpendicular to the laminations. The quartz is included with numerous minute elongated grains of a green pleochroic amphibole (?hornblende). These inclusions have an orientation subparallel to the laminations in the rock. Other inclusions in the quartz include minute idiomorphic magnetite grains, finely disseminated opaque minerals and rare apatite. On occasions the grains are separated by a fine veneer of geothite. Other layers in the rock are similar except that there is a marked decrease in grain-size and content of quartz and a corresponding increase in the content of geothite. The grains tend to be isolated, are extremely irregular in shape, often embayed, and have been subjected to recrystallization. The geothite forms a fretwork structure about the quartz grains. The remainder of the rock is composed wholly of goethite throughout which are distributed irregular laminations of magnetite.

The laminations in the rock alternate at approximately every 5-20 mm. Goethite is the dominant opaque mineral forming up to 100% of some layers. Martite is present in limited quantities in the centre of the thicker non-gangue layers, where it remains as rims to geothite cores. Otherwise much of the geothite appears to be matrix infilling (refer to figure 10).

P186/65: BD_1: 394.1 - 394.3 ft: TS16073

This specimen is an amphibole-wollastonite-diopside-quartz rock which exhibits moderately well defined segregation banding.

Two amphiboles are present in this specimen: hornblende and a mineral having the optical properties of cummingtonite. The amphiboles together with a clino-pyroxene (?diopside) form broad bands alternating with quartz rich layers. The hornblende is pleochroic from deep blue-green to a yellowish-green and occurs as short, stumpy prisms which have ragged terminations. The ?cummingtonite has a similar habit to the hornblende but displays a well defined, simple, lamellar twinning parallel to (100). The cummingtonite is colourless to pale green in thin section and is frequently found partially replacing hornblende crystals as well as anhedral grains. The diopside tends to be concentrated into veinlets, parallel to the banding, within the amphibole rich layers. Frequently associated with the diopside are grains of wollastonite. The grains of diopside and wollastonite are idiomorphic and have been altered along cleavage traces and parting fractures to opaque minerals and incipiently developed spinel. They have been partially replaced around their margins by hornblende. Opaque mineral grains (?magnetite) are randomly distributed in interstitial positions throughout the amphibole layers and in a finely disseminated state throughout the hornblende and rarely in the cummingtonite. Rare metamict ?allanite inclusions are found in the amphibole. Numerous apatite grains occur in discontinuous trains at irregular intervals throughout the amphibole. The quartz forms relatively large, irregularly shaped, compound grains, which have recrystallized under the influence of a stress system, as indicated by the well developed undulose extinction. The grains are included with ubiquitous minute, laths of amphibole (?cummingtonite) which have a sub-parallel orientation, rods of apatite and rare laths of muscovite together with

finely disseminated opaque mineral grains.

The rock has a typical granoblastic texture. The grain size distribution is in the range $4\frac{1}{2}$ to 0.1 mm of which the coarser fraction is composed of quartz. The bulk of the grains are approximately 0.35 to 0.2 mm in diameter (refer to figures 11 and 12).

P187/65: BD$_1$: 402.5 - 402.7 ft: TS16074: TS16075

This specimen is a rock of granodioritic composition being composed of an xenomorphic granular mass of quartz, plagioclase, hornblende, clinopyroxene with accessory apatite, epidote, and minor opaque minerals. The rock may more correctly be termed a trondhjemite because of the complete suppression of alkali-feldspar.

The amphibole-hornblende, pleochroic from blue-green to yellowish-green occurs in large euhedral to subhedral grains which are occasionally twineed and contain minute inclusions of quartz and a brown biotite-like mineral. The amphibole appears to have crystallized in aggregates as an early phase and is now often completely surrounded, or nearly so, by large, anhedral, plagioclase crystals. Quartz occupies remaining interstitial positions. The plagioclase is well twineed according to the albite law and has a composition in the range An_{20} - An_{30} (calcic obligoclase). It has been subjected to incipient alteration along cleavage traces, parting fractures and particularly along zones in contact with the amphibole to sericite and minor epidote. Clinopyroxene (?augite) is comparatively rare and appears to be forming as an alteration product of the amphibole. It is found rimming crystals and frequently contains inclusions of the amphibole. The quartz is fresh but contains numerous subparallel orientated trains of dusty opaque minerals as inclusions. A distinctive feature of the rock is the abundance of apatite which occurs in comparatively large six sided and anhedral crystals. It is commonly found as inclusions in the plagioclase but is also found rarely in the amphibole. A carbonate mineral (?siderite) has crystallized along minute fractures which are found in the rock.

The [illegible]-grained nature of this rock together with the mineral assemblage suggests it is an intrusion which has possibly effected contact metamorphism of surrounding sediments (refer to figures 13 and 14).

P188½65: BD$_1$: 463.7 ft: TS16076

This specimen is a quartz-hornblende-plagioclase amphibolite. The amphibolitic structure is moderately well developed with an incipient schistosity being imparted to the rock by parallel orientated amphibole laths. There is no evidence for foliation. The laths of hornblende are numerous and occur as loosely packed, short, fibrous prisms. They are pleochroic from greenish-yellow to bluish-green. They are fresh, showing no signs of alteration and rarely enclose poikiloblastically, round quartz grains. The majority of the hornblende laths typically have a size of approximately 0.25 x 0.06 mm. Occupying interstitial positions between the amphibole laths are grains of plagioclase and recrystallized quartz grains which have a size

distribution in the range 0.15 to 0.04 mm. The quartz grains are virtually free of inclusions except for rare minute apatite and opaque mineral grains. There appears to be two generations of plagioclase. The first, and prably primary phase, is extensively altered to sericite and occasionally muscovite to the extent that its composition cannot be determined accurately, the second generation, probably formed concurrently with the amphibole, is fresh and has a composition of approximately An_{30} (calcic oligoclase). It is poorly twinned according to the pericline law. Other minerals present in accessory amounts include sphene, and carbonate, the later being a product of alteration probably of primary plagioclase. Accessory opaque minerals grains (?magnetite) are randonly distributed throughout the rock with an orientation sub-parallel to that of the amphibole laths (refer to figure 15).

P189/65: BD_1: 524.8 - 525.0 ft: TS16077

This specimen is a moderately coarse-grained, crystalline hornblende-plagioclase amphibolite.

The hornblende is pleochroic from yellow-green-olive-green-blue-green and occurs in prisms with ragged terminations and included with minute, rounded, untwinned plagioclase grains and rare opaque minerals. The amphibole and plagioclase tend to be equally abundant. The plagioclase ranges in composition from An_{30} - AN_{40} (sodic andesine) and occurs in equant xenoblastic grains, either untwinned or showing a few lamellae of either the albite or the pericline type. Accessory epidote, frequently accompanied by opaque minerals, is randomly distributed throughout the rock. It is either colourless or very pale yellow but nevertheless highly birefringent. Rare needles of apatite and grains of pleochroic yellowish-green tourmaline are found included within the plagioclase.

The rock exhibits a granoblastic texture traversed by planes in which there is a marked parallellism of component minerals. The grain-size distribution of the rock is in the range 1.8 to 0.1 mm with the hornblende generally representing the coarser fraction. There tends to be a preferred orientation for the amphibole laths, in thin section, however this is not well-defined and, in general the amphibolitic structure is poorly developed. (Refer to figure 16).

Figure 9: TS16070: PPL X40 (App. 2, p. 2)

Magnetite (black) and goethite forming a matrix filling interstitial to quartz grains. Note recrystallisation of goethite along fracture in quartz.

Figure 10: TS16072: PPL X25: (App. 2, p. 2)

Martite (black) altering to goethite (light grey) within laminations of recrystallised quartz.

Figure 11: TS16073: XN X100: (App. 2, p. 4)

Cummingtonite twinned parallel to (100)

Figure 12: TS16073: XN X100: (App. 2, p. 4)

Inclusions of finely disseminated opaque minerals, amphibole (?cummingtonite) laths, rods of apatite and muscovite in a fractured recrystallised quartz grain.

Fig. 9.

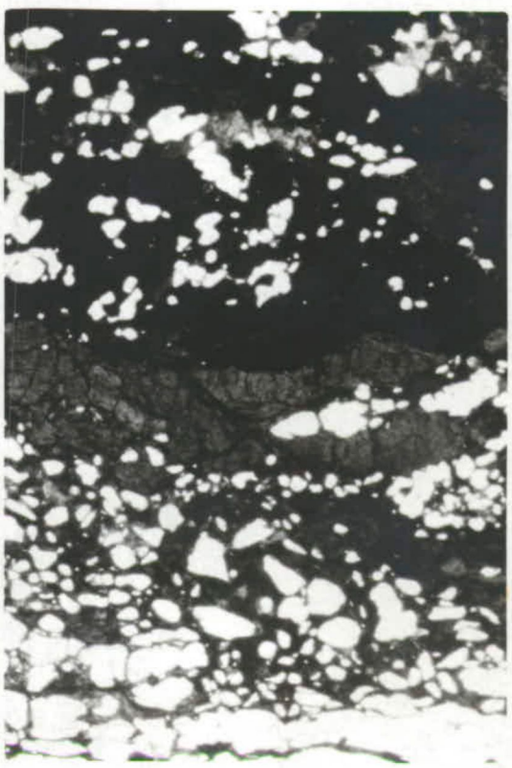


Fig. 10.

Fig. 11

Fig. 12.

Figure 13: TS16075: XN X 25 (App. 2, p. 4)

Plagioclase (An_{20} - A_{30}), quartz, amphibole (hornblende) and clinopyroxene (?augite) in a granodioritic rock. (Inclusion of apatite in plagioclase).

Figure 14: TS16075: XN X25 (App. 2, p. 4)

Relatively large, euhedral to subhedral, apatite crystals included in grains of quartz.

Figure 15: TS16076: XN X40 (App. 2, p. 5)

Hornblende-plagioclase amphibolite. Note the development of a structural lineation.

Figure 16: TS16077: XN X25 (App. 2, p. 5)

Hornblende-plagioclase-amphibolite exhibiting granoblastic texture. Plagioclase twinned according to the pericline law. Hornblende with poikiloblastic inclusions of quartz.

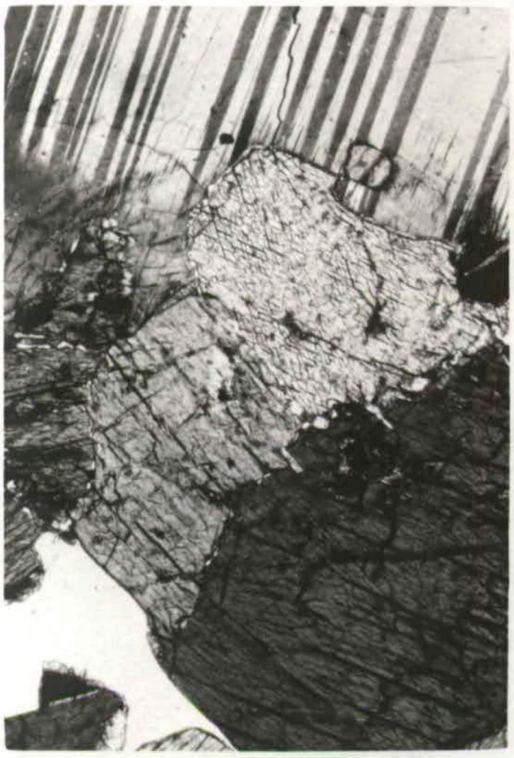


Fig. 13

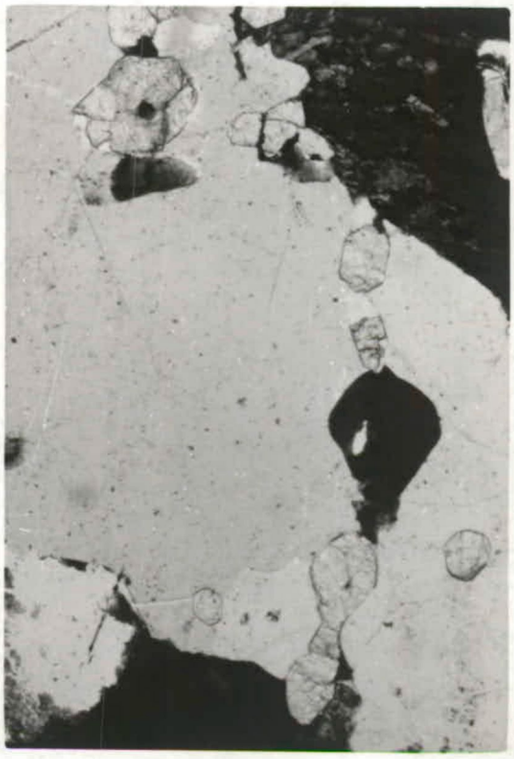
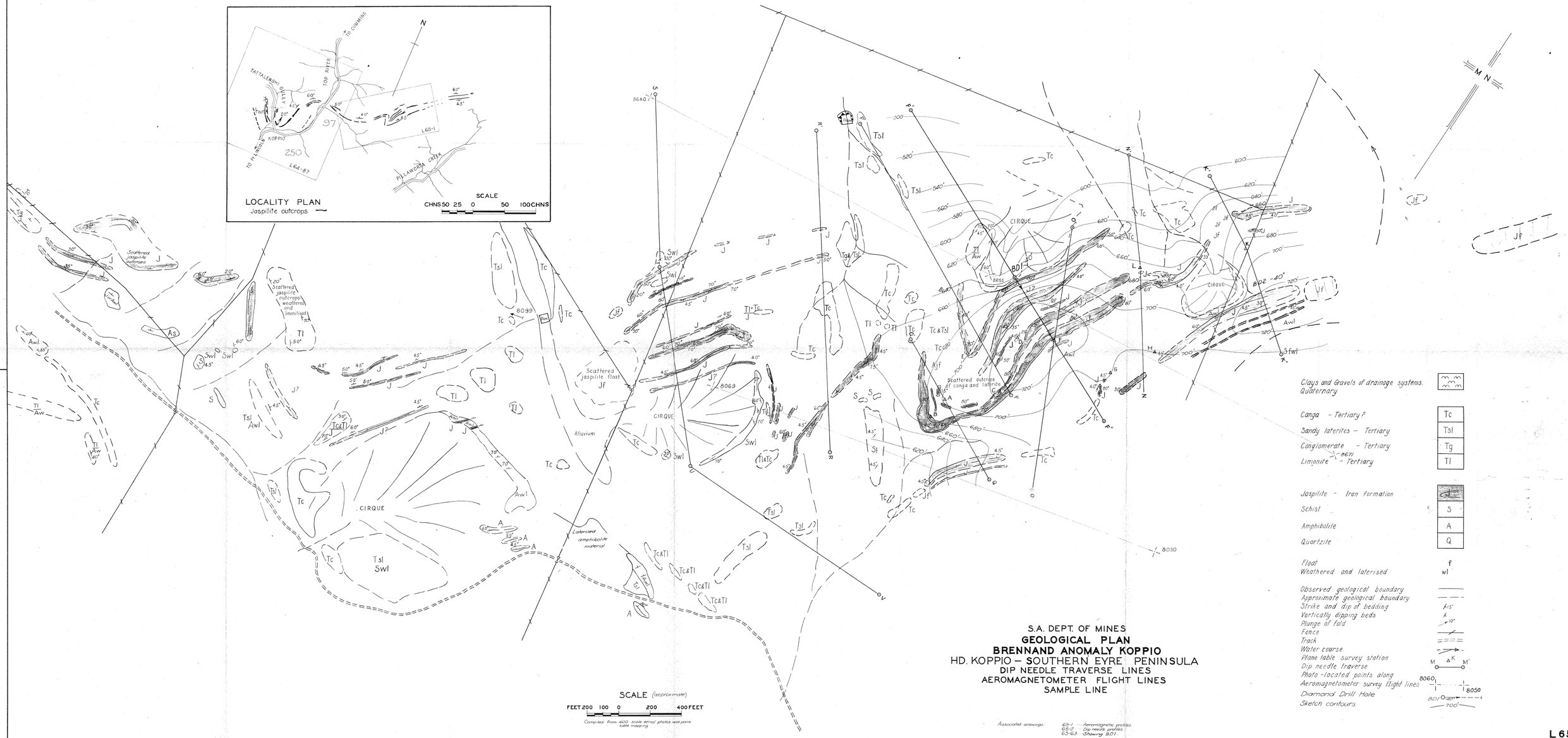


Fig. 14

Fig. 15

Fig. 16

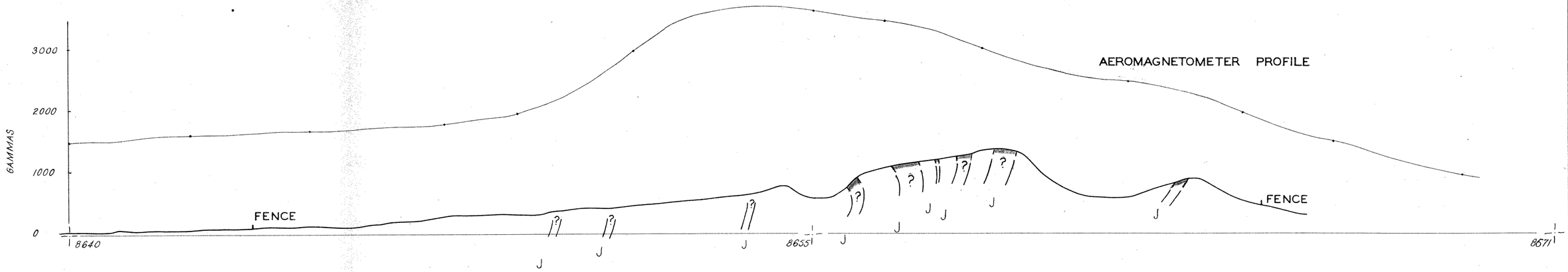


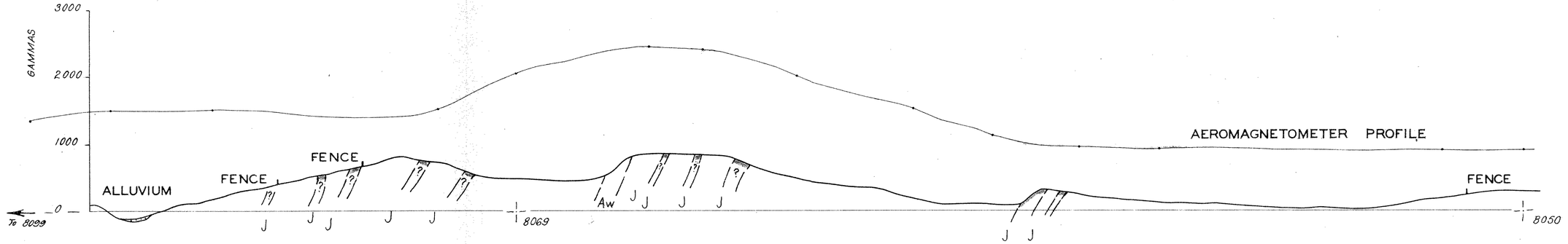
S.A. DEPT. OF MINES

GEOLOGICAL PLAN
BRENNAND ANOMALY KOPPIO
HD. KOPPIO — SOUTHERN EYRE PENINSULA
DIP NEEDLE TRAVERSE LINES
AEROMAGNETOMETER FLIGHT LINES
SAMPLE LINE

L65-1
Dn7

To accompany report by W.B. Robinson.





Scale : 200 feet to 1 inch.

S.A. DEPT. OF MINES

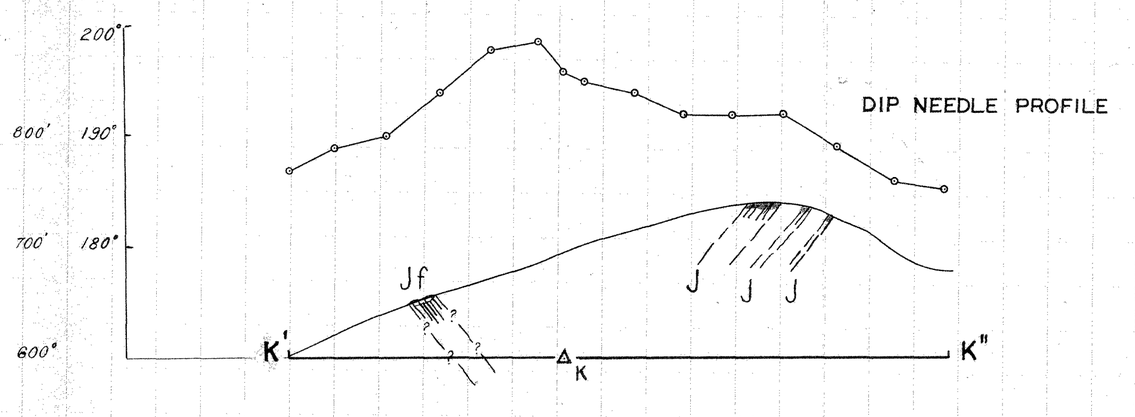
BRENNAND ANOMALY, KOPPIO

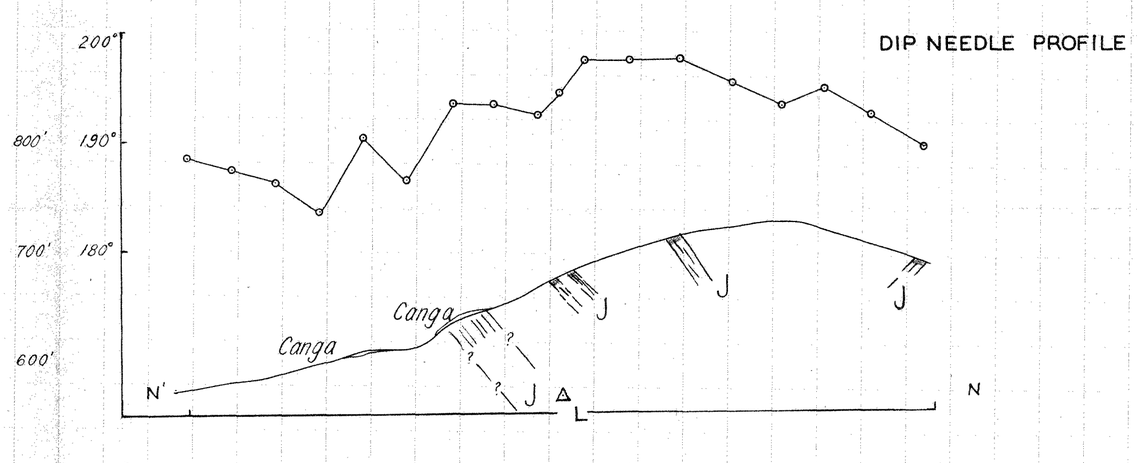
AEROMAGNETOMETER PROFILES WITH SKETCH SECTIONS

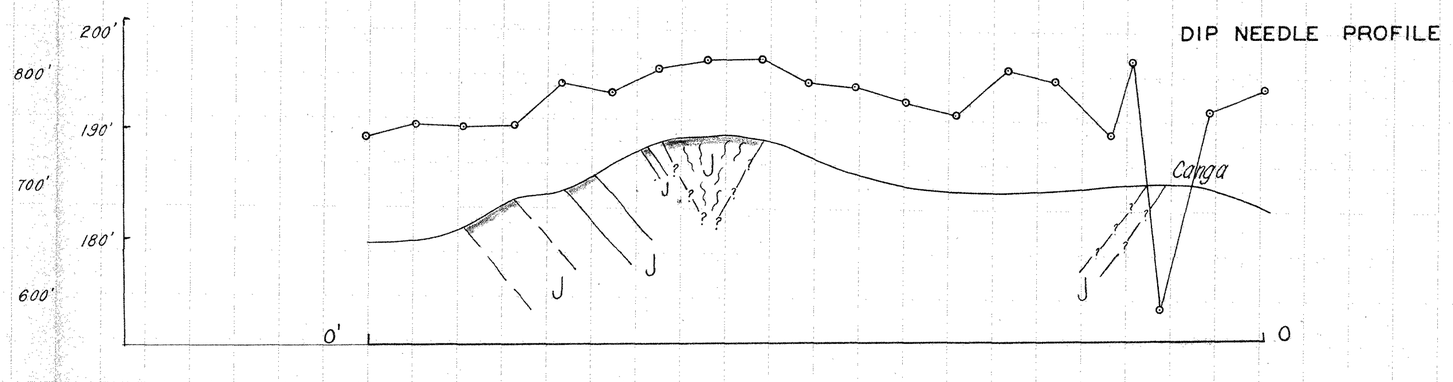
For location of flight lines see plan L 65-1.

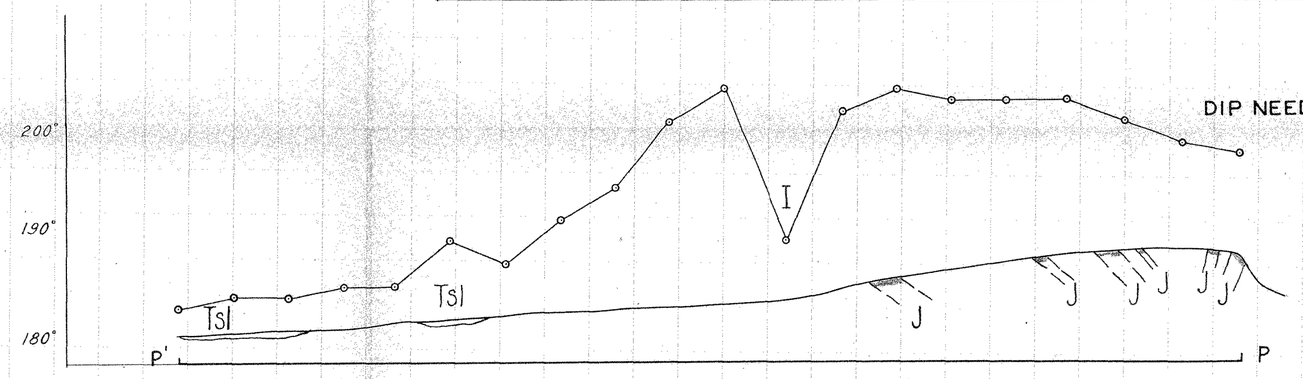
65-1
Dn 7

To accompany report by W.B. Robinson









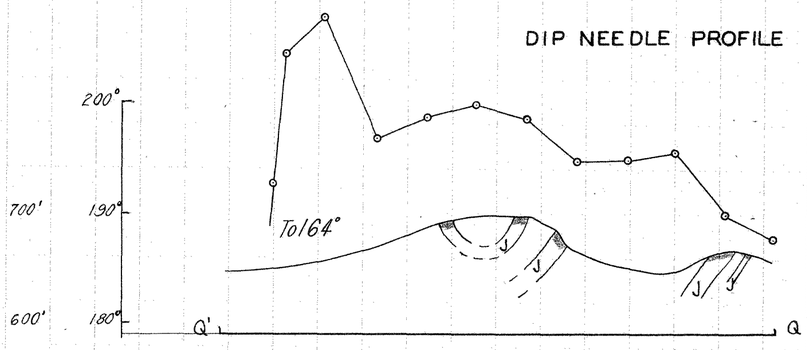
S.A. DEPT. OF MINES

BRENNAND ANOMALY KOPPIO

DIP NEEDLE PROFILES & SECTIONS

To accompany report by W.B. Robinson

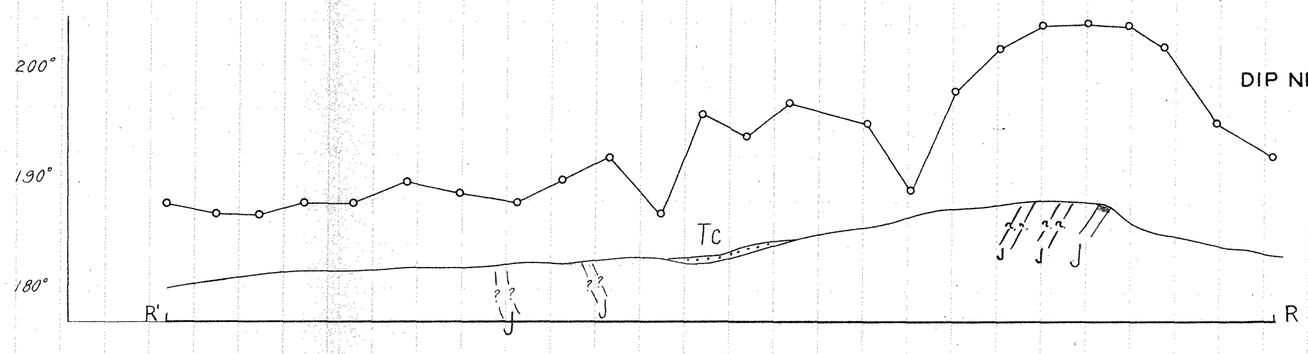
65-2
Dn7

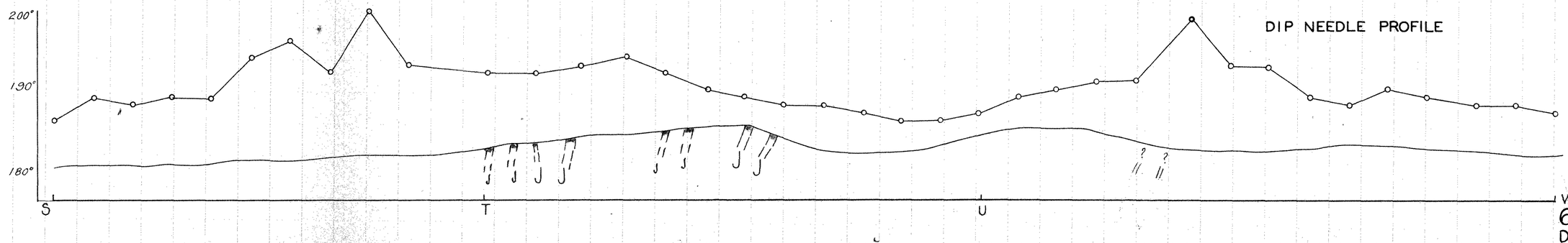


For location of traverses see plan L65-1.

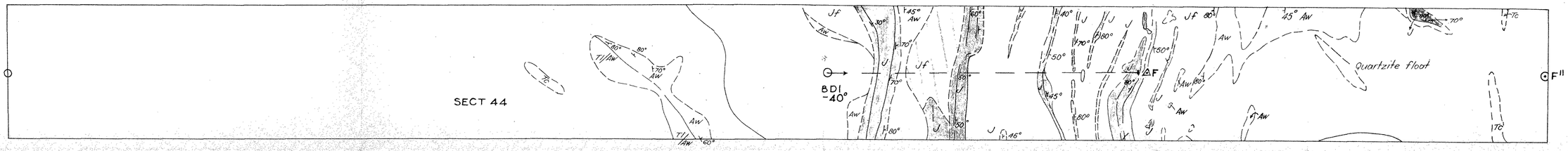
For traverse F-F see plan 65-63.

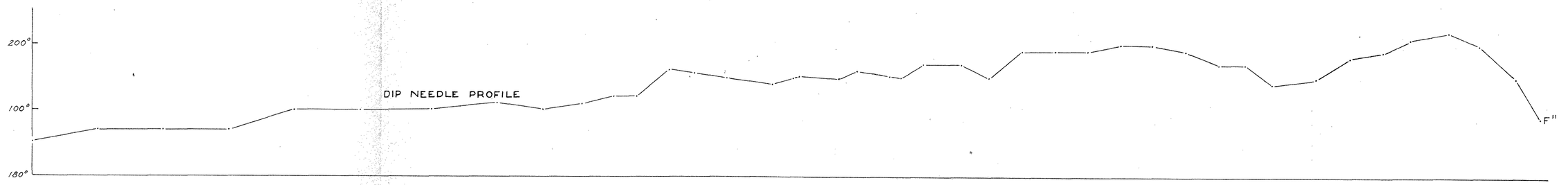
Scale: Horizontal 200ft. to 1in.
Vertical 100ft. to 1in.

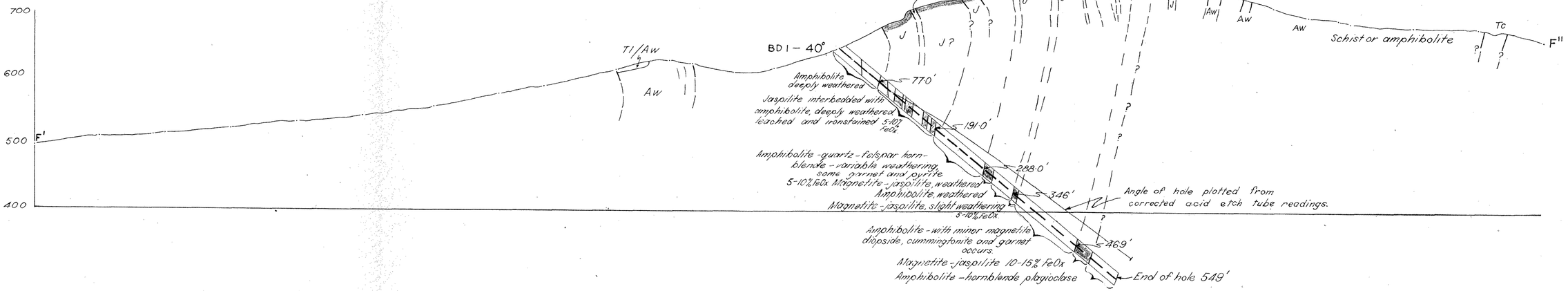




65-2
Dn7







To accompany report by W.B. Robinson

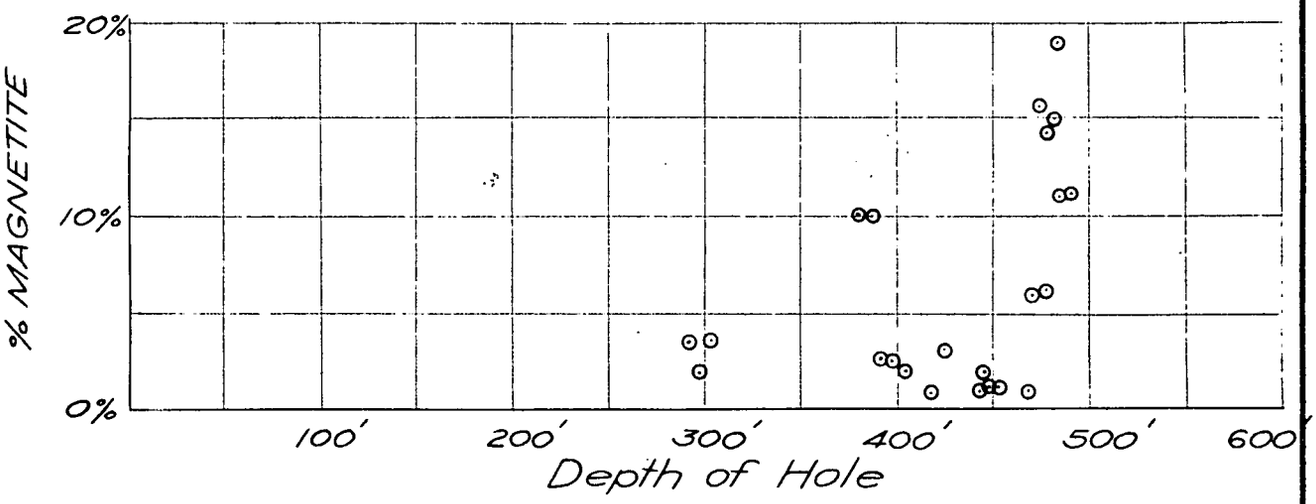
S.A. DEPT. OF MINES

BRENNAND ANOMALY
SHOWING DIAMOND DRILL HOLE BD1
PLAN, SECTION and DIP NEEDLE PROFILE
ASSOCIATED PLAN L 65-1

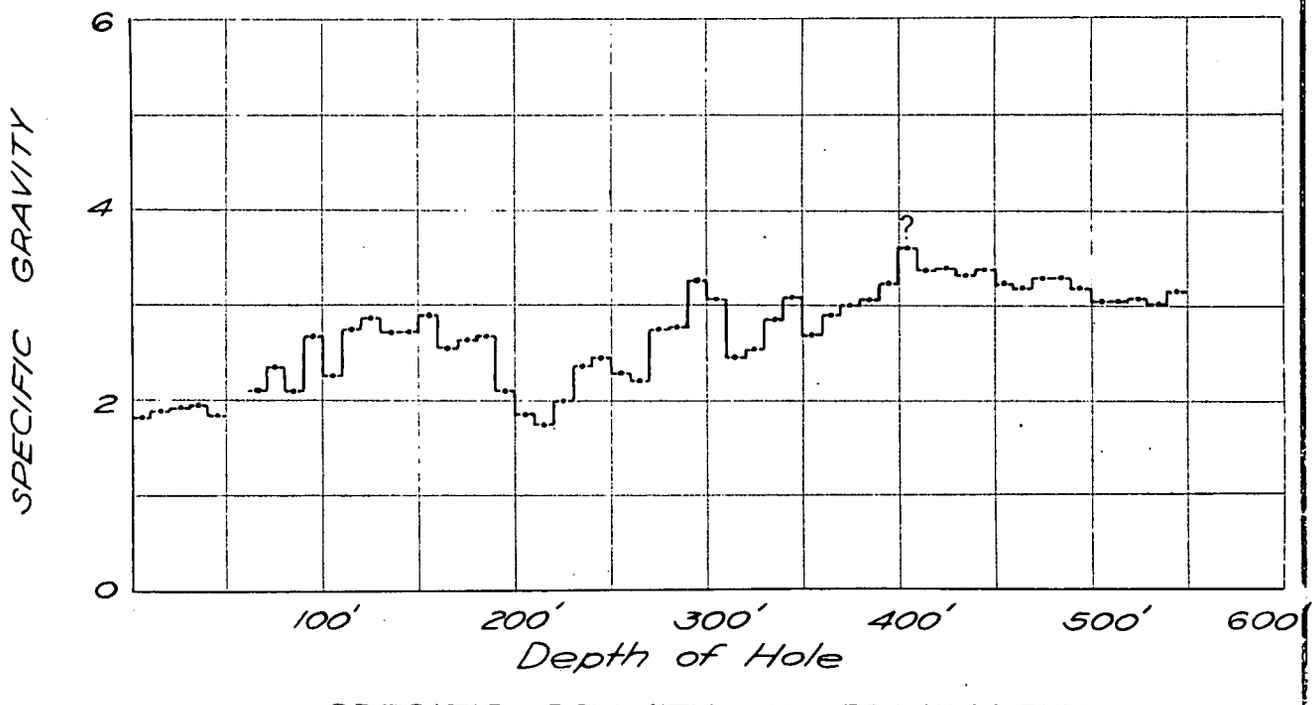
Associated Drawing	No.	No.	Amendment	Exd.	Date

Req. No.
D.M.
Compiled from

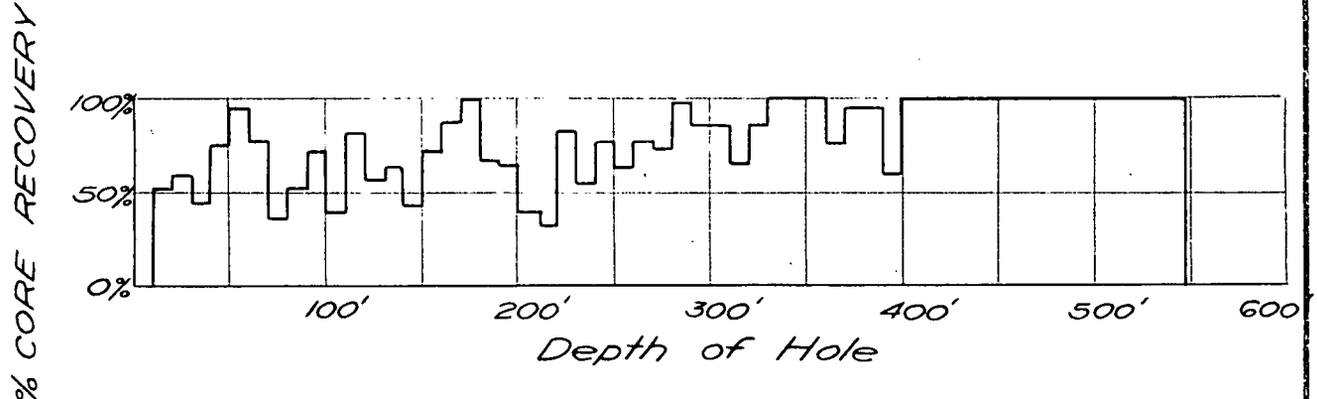
Approved	Passed		Scale: 100ft to 1 in.
		Drn.	65-63/6
		Tcd. G.M.	Dn 7
Director of Mines		Ckd.	
		Exd.	Date 9.2.65



% MAGNETITE DERIVED
FROM SUSCEPTIBILITY READINGS.



SPECIFIC GRAVITY DETERMINATION



PERCENTAGE RECOVERY OF CORE

DEPARTMENT OF MINES — SOUTH AUSTRALIA

	Drn. W.B.R Tcd. T.P.S Ckd. L.V.W Exd.	BRENNAND ANOMALY PERCENTAGE MAGNETITE, SPECIFIC GRAVITY AND CORE RECOVERY GRAPHS BD1	SCALE: S 4684 Dn7 DATE: