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## EL 1759

## NEUROODLA

## PROGRESS REPORTS TO LICENCE EXPIRY/SURRENDER FOR THE PERIOD 3/1/1992 TO 2/7/1995

Submitted by
NGM Pty Ltd
1992



**Enquiries:** Customer Services Branch
Minerals and Energy Resources
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101 Grenfell Street, Adelaide 5000

Telephone: (08) 8463 3000
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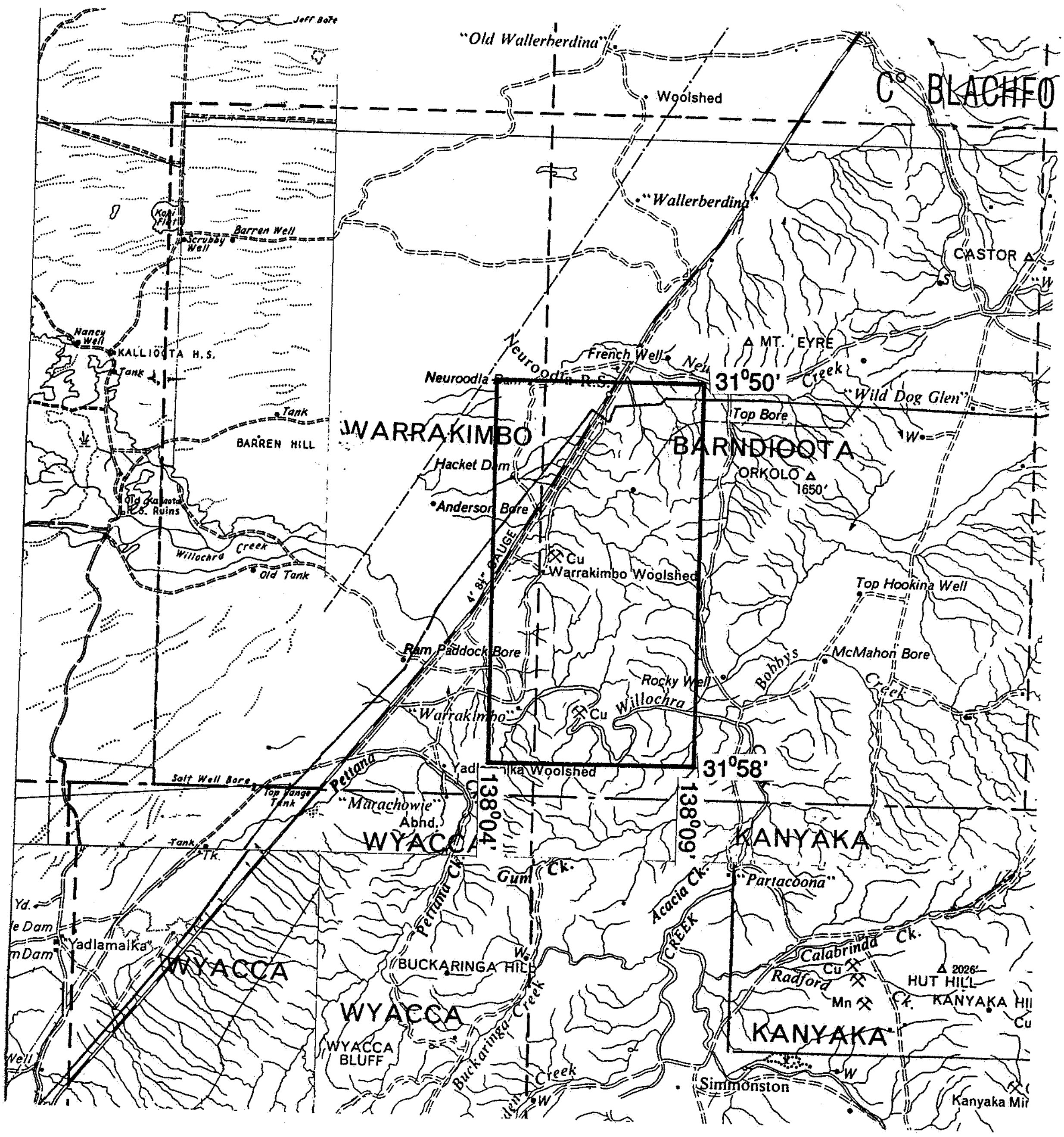
Government of South Australia
Primary Industries and Resources SA

# SCHEDULE A




EXPIRED

SCALE 1:250,000

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES

APPLICANT: NGM PTY. LTD.

DME 240/91

AREA: 116 square kilometres (approx.)

1:250000 PLANS: PARACHILNA

LOCALITY: NEUROODLA AREA – approx. 15 km west of Hawker

DATE GRANTED: 3·1·92

DATE EXPIRED: 2·1·93 ~~94~~ ~~95~~ 2·7·95

EL No: 1759 ✓

**AMF HOLDINGS LIMITED**

AMF Holdings Limited. A.C.N. 008 071 403
Registered Office:
Accounts & Administration
36 Bowyer Road, WINGFIELD. S.A. 5013

Telephone: (08) 268 8954
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29 July 1992

CONFIRMATION OF FACSIMILE

The Director General
SADME, P. O. Box 151
**Eastwood** SA 5063

Att: I. G. Faulks

Dear Sir

**Re: Warrakimbo EL 1759 SA**
**Technical Reporting: Quarters Ending 2nd April & July**

**1st Reporting Period**

During this period no field work was undertaken due to other commitments. Activity was therefore of an administrative nature.

**2nd Reporting Period**

During this period JLC Exploration Services was appointed to design and implement a field exploration programme. Company representatives Mr C. Adsett, Mr M. O'Neill and Mr J. L. Curtis (consultant geologist) also made a technical visit to Warrakimbo.

To date the programme and budget have been prepared and approved. The programme seeks to examine the potential for additional specularite resources within the title area by way of field examination and mapping.

Scaled aerial photography over the title area has been obtained and Aboriginal heritage contact persons have been identified courtesy of Tom Power, Archeologist - Department, National Parks and Wildlife (Port Augusta).

Unfortunately the area is subject to heritage claim by three Aboriginal Peoples. Development of a strategy regarding Aboriginal heritage matters and initiation of the field programme are anticipated during the next quarter.

Exploration costs brought to account during the period totalled $7,691.00 being essentially administrative in nature. A detailed expenditure statement is appended.

Yours faithfully
**AMF Holdings Ltd**

**Chris Adsett**
Director
mm:993

## SUMMARY OF EXPENSES 03/01/92 - 02/07/92

## WARRAKIMBO PROJECT

| | |
|---|---|
| Lease Expenses | $ 410.00 |
| Vehicle Expenses | $ 250.00 |
| Consultants - Land | $1,500.00 |
| - Exploration | $1,000.00 |
| Photography & Maps | $1,000.00 |
| Telephone | $ 76.00 |
| Taxies etc | $ 105.00 |
| Food & Accom | $ 170.00 |
| Wages & Salaries | $3,180.00 |
| Total | **$7,691.00** |

cha:mm:12a

# N.G.M. PROPRIETARY LIMITED

EXPLORATION REPORT 92/93

WARRAKIMBO SPECULAR HEMATITE PROJECT

EL No. 1759

SOUTH AUSTRALIA

NOVEMBER 1992

SADME 1
(MICROFILM)
COPY FIG 6 - UNCOLOURED

by

J.L. CURTIS



NOVEMBER, 1992

JLC EXPLORATION SERVICES

# ABSTRACT

Geological investigations into the nature and occurrence of specular hematite at Warrakimbo reveals that mineralisation occurs where favorable host calcarenite carbonate beds within the Neoproterozoic Etina Formation are affected by second and third order faulting to the Mount Stephen Thrust which is the locus of typical 'diapiric' Callana Group breccias at the toe of Mount Stephen and Warrakimbo Woolshed. The variously associated alteration forms of granular recrystall-isation of the host carbonate, brown ferroan dolomitisation, and jasperisation indicate strongly that the epigenetic mineralising fluids were similar to those circulating in the breccias.

Application of basic field observations in conjunction with photo-geological work confirmed the above model through the hands-on in-field recognition of massive specular hematite bodies at the Rainy Day Prospect hitherto un-reported and hence previously unknown to the title holders. Mapping at this location confirms that mineralisation is structurally related and warrants exploratory follow-up by way of costeaning and drilling.

# CONTENTS

# LIST OF FIGURES

# 1 INTRODUCTION

NGM Pty Ltd is a subsidiary of AMF Holdings Pty Ltd, a company with a mainstream interest in fertilizer production and a developing interest in industrial minerals.

Specular hematite with specific characteristics has a particular end use in high quality corrosion resistant paints. Specular hematite from Warrakimbo Mine has been metallurgically investigated and found to be capable of meeting stringent market place criteria.

NGM Pty Ltd's function is to maintain business arrangements with the registered lease holders of the mine and expedite its development. NGM Pty Ltd is pursuing an active marketing strategy and has initiated prolonged real time "live" trials of test paints.

Since assurance of product continuity and quality is important to potential product consumers NGM Pty Ltd has sought the assistance of JLC Exploration Services to evaluate the potential for additional resources of specular hematite in the general neighborhood of the existing deposit.

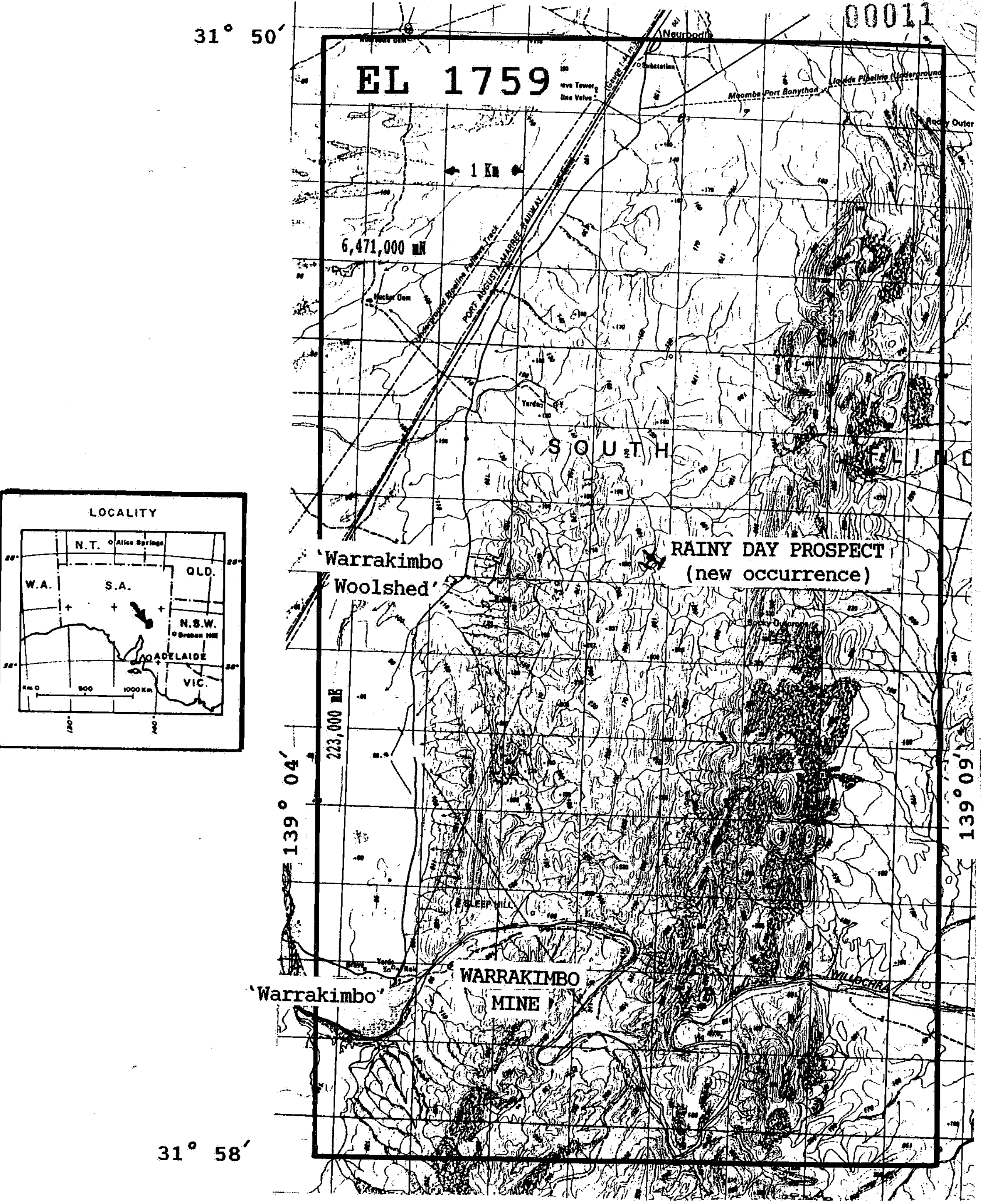
This report reviews aspects of previous investigations in the area (circa 1985-6) and provides details regarding the first year of exploration and documents the re-discovery of insitu massive specular hematite mineralisation 5.5 km N of the existing Warrakimbo mine.

# 2 LOCATION & ACCESS

EL 1759 is located 70 km NNE of Port Augusta on the adjacent 'hundreds' of Warrakimbo (west) and Barndioota (east). The locality is accessible by a dry weather bush road from Port Augusta to the south and the township of Hawker to the east which passes along the plains to the west of the prospective Southern Flinders Ranges.

Road travel times are approximately 1 hr & 40 mins respectively in optimum circumstances. The area is also traversed by the Port Augusta - Leigh Creek Coalfield standard gauge railway with Neuroodla Siding located in the NW portion of the area.

Both the railway and sub-adjacent Moomba - Port Bonython oil/gas pipeline form a corridor across the northwestern and northern portions of the title in areas of relatively poor outcrop and therefore offer little impediment to exploration activity at the present time. Road maintenance in support of these essential services for SA is ensured. (See figure 1)




**LOCATION MAP**

**EL 1759 WARRAKIMBO** **Figure 1**

8573-1


CENOZOIC

QUATERNARY – RECENT

| | |
|---|---|
| Qa | Gravel & sand in active drainage |

UNDIFFERENTIATED

| | |
|---|---|
| Cze | Eluvial soil & scree of local derivation |
| Cza | Alluvial soils |
| Czg | Alluvial gravels |

PALAEOZOIC

DELAMARIAN (Diapiric Fault Breccias)

| | |
|---|---|
| $PNd_2$ | MT. STEPHENS BRECCIA. Rafts of basic volcanics & dolerite, & brown dolomite in matrix of pink grey siltstone chips, minor masses of specular hematite. |
| $PNd_1$ | WARRAKIMBO BRECCIA. Rafts of vesicular basalt & brown dolomite in a grey siltstone chip matrix, accessory clasts of quartz & specular hematite, minor Cu oxides |

CAMBRIAN

HAWKER GROUP

MERN MERNA FORMATION (PARARA LIMESTONE)

| | |
|---|---|
| Ehr | Grey silty laminated limestone |

PHANEROZOIC

NEOPROTEROZOIC — WILPENA GROUP

UNDIFFERENTIATED

| | |
|---|---|
| PN | Pink-orange brown sandstones & grey siltstones, interbedded |

POUND SUBGROUP

| | |
|---|---|
| PNpr | RAWNSLEY QUARTZITE. Pale pink, white, orange brown sandstone & shaley interbeds, "Ediacaran Fauna Zone" |
| PNpb | BONNEY SANDSTONE. Orange brown soft sandstone |
| $PN_{ww}$ | WONOKA FORMATION. Grey-pink limey shales with interbeds of grey laminated dolomite, (dk-brown varnish) |
| PNwb | BUNYEROO FORMATION. Pink-Red brown shale/siltstone |

SANDISON SUBGROUP

| | |
|---|---|
| PNsa | ABC RANGE QUARTZITE. Massive bedded, white-pink sandstone with small scale crossbedding, minor silty interbeds. |
| PNsb | BRACHINA FORMATION. Massive laminated siltstone/shale. |
| PNsn | NUCCALEENA FORMATION. Pale pink dolomite beds in bright pink shales, minor 'ripup' clasts, exposures in drainage, elsewhere yellowish clays with solution craters. |

NEOPROTEROZOIC — UMBERATANA GROUP

WILLOCHRA SUBGROUP

| | |
|---|---|
| PNhl | ELATINA FORMATION. Massive, bedded siliceous sandstones with jasper granules at base, silty interbeds |
| PNhe ($m_5$, $m_4$, $m_3$, $m_2$, $m_1$) | ETINA FORMATION. Grey-pink weathering siltstone/shale with interbeds of fine sand grading upward into clastic/oolitic calc-arenite. $m_2$–$m_5$ are calcarenite beds at the top of shallow marine depositional cycles. $M_1$ is an arkosic bed. |
| PNhw | WILMINGTON FORMATION. Fine to very fine calcareous sandy beds in shale with minor siltstones. |
| PNha | ANGEPENA FORMATION. Transitional unit with basal clastic limestone progressing upward into limey sand and shale/siltstone. |

FARINA SUBGROUP

| | |
|---|---|
| PNfb | BRIGHTON LIMESTONE. Thin & thick (1-2m) beds of domal stromatolites with shale interbeds |
| PNft | TAPLEY HILL FORMATION. Grey laminated siltstones & minor shales. |

ROCK BOUNDARIES

- Outcrop boundary
- Stratigraphic Boundary
- Stratigraphic subunit Boundary
- Strike direction, subunit interpolation
- Dip/Strike indicator

STRUCTURE

- Major Fault
- Indicated Major Fault
- Inferred Major Fault
- "Lesser" Fault
- Indicated Fault
- Inferred Fault
- Fold - Syncline
- Fold - Anticline
- Hybrid Cross section, Fig 4 Geology

△ MT STEPHENS

→ EL Boundary Markers

DRAINAGE

- MAJOR STREAM
- minor stream.

OTHER

- WARRAKIMBO MINE
- RAINY DAY PROSPECT
- Photo-centre 005
- A...B Measured Stratigraphic section

CULTURE

- Road
- Track
- Railway
- Fence (II-Electric)
- Oil/Gas pipeline
- Power Line
- Building

AGRICULTURE

- Water Catch
- Turkeys Nest
- Water Tank
- Water Pipeline
- Windmill Pump

8573-1

NGM PTY. LTD.

EL 1759 SA

WARRAKIMBO

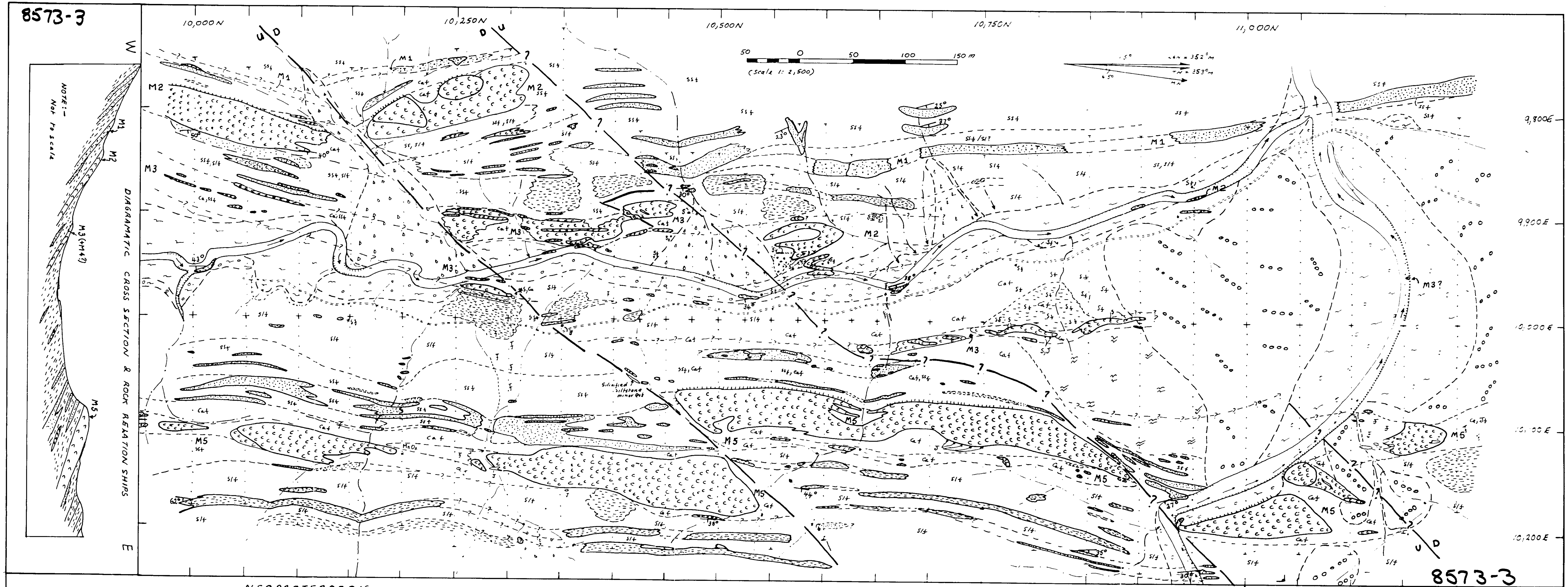
REGIONAL GEOLOGY

PHOTO-COMPILATION

| Prep. JLC Ex. Sv. | Date 28.2.93 | Figure No. 2 |
|---|---|---|

WARRAKIMBO ANTICLINE
THRUST
STEPHEN
MOUNT
HORSE'S HOE
FAULT
Willochra Creek
'Warrakimbo Mine'
CENOZOIC
QUATERNARY – RECENT
Qa Sands and gravels in active drainge
UNDIFFERENTIATED
Cze Eluvial soil & minor scree
Cza Alluvial soil
Czg2 Younger alluvial gravels
Czg1 Older cemented alluvial gravels
Czc Calcreted soil/gravel.
Czt Talus breccias
PHANEROZOIC
PALAEOZOIC
DELAMARIAN
PNd – Fault (breccia/alteration zones)
CAMBRIAN
HAWKER GROUP – MERNMERNA FORMATION (PARARA LIMESTONE)
Ehr – Light grey bedded limestone
POUND SUBGROUP
RAWNSLEY QUARTZITE
PNpr Pale pink – white – orangy brown sandstone shaley interbeds
BONNEY SANDSTONE
PNpb Orange-brown 'soft' sandstone.
WONOKA FORMATION.
PNww Grey-pink, minor green shales, dolomite interbeds with dk brown 'varnish'
BUNYEROO FORMATION.
PNwb Pink-red brown shale & siltstone.
GROUP
NEOPROTEROZOIC
WILPENA GROUP
SANDISON SUBGROUP
ABC RANGE QUARTZITE
PNsa Massive bedded yellow brown sandstone with basal white member, small scale xbeds, ripples
BRACHINA FORMATION
PNsb Massive red-brown laminated siltstone/shale
NUCCALEENA FORMATION
PNsn Pale pink dolomite beds in bright pink shale Frequently unexposed
WILLOCHRA SUBGROUP
ELATINA FORMATION
PNhl Massive yellow-brown sandstones, jasper granules present in basal portion.
ETINA FORMATION
PNhe Grey/pink-weathering siltstones & shales with interbeds of fine sandstone grading upward into calc-arenite, cyclically
M6 M5 M4 M3 M2 M1
M2–M6, calc-arenite beds, oolitic and clastic, light to dark brown.
M1 arkosic basal sandstone, easily mistaken for calc-arenite
UMBERATANA
WILLOCHRA SUBGROUP (cont'd)
WILMINGTON FORMATION.
PNhw Fine to medium grained calcareous sands & shales, interbedded, redweathering
FARINA SUBGROUP
?TAPLEY HILL FORMATION
?PNft medium grey bedded limestone and limestone conglomerate – uncertain stratigraphic position – possible Brighton Limestone
ROCK BOUNDARIES
Outcrop boundary/contact.
Stratigraphic boundary
Inferred stratigraphic boundary
Lithological contact/stratigraphic s'unit
Lithological "strike" trend
Dip/strike indicator
(Measurements – N. Rollings '86, loc. approx.)
STRUCTURE
MAJOR FAULT
fault
OTHER
Prospect pits/occurrence
Mine shaft
Mine Portal
Dump
C...D Measured Stratigraphic section
Lease marker.
Cu Copper
Sp Specular hematite.
CULTURAL FEATURES
Fence
Gate
Track
Water Pipline
Water Tank
Tunkey's Nest
NATURAL FEATURES
Major Stream
Water hole
Minor stream
Spring
Notes
Scale: Nominally 1:5000 without photogrametric correction
Photo: 4244/044
Grid: AMG, approximately located using Topographic base 6534-3. Accuracy estimated @ ±10m
Data: Compiled from field inspection stereographic examination & previous mapping
Specular Hematite occurrences
SP1 Stylolite
SP2 Clayton
SP3 Windy Ridge
TN
AMGN
MN
(Scale 1:5000)
100 50 0 100 200 300 400 500 m
8573-2
NGM PTY LTD
EL 1759 SA
WARRAKIMBO
WILLOCHRA GORGE
GEOLOGY MAP
Prep. JLC Ex,Sv.
Date 1.3.93
Figure No. 5

8573-3




QUATERNARY

?HOLOCENE

Alluvial Soil

Older alluvium with Quartzite gravel - ABC Range Quartzite

?PLEISTOCENE

"Fanglomerate," Alluvium overlying gravels - gilgai surface

"Scree Fans" Small talus of angular sandstone clasts

NEOPROTEROZOIC

Lithofacies

Fine to very fine grained sandstones, calcareous, brown varnish (ss+ = float)

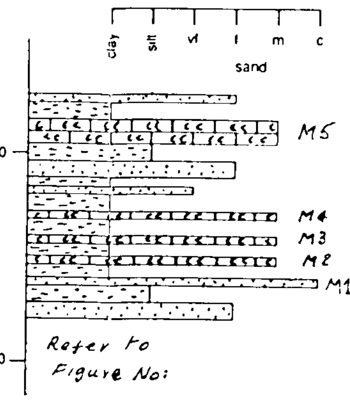
Siltstones, minor shales, Pale pink to brown weathering (sl+ = float)

Calcarenite, coarse to medium grained, grey-brown, oolitic (Ca+ = float)

Arkose, very coarse to medium grained, brown weathering, friable (bold outcrop infrequent, looks like ccc)

Stratigraphy

| | | | |
|---|---|---|---|
| UMBERATANA GROUP | WILLOCHRA SUBGROUP | Etina Formation | $C_4$ |
| | | | $C_3$ |
| | | Wilmington Formation | $C_2$ |




Mineralization - *

S Specular hematite

J Yellow-brown Jasper

Cu Copper-oxides

Sd Siderite

Ғ Jasper float

S+ Specular hematite float.

Boundaries

Outcrop

Subcrop

Indicated

Inferred.

Fault

" Indicated

" Inferred

Natural & Cultural Features

Water course

Main water course

Steep Slope

Lease corner peg

Fence & Track

Pit & spoil pile

Excavation

Grid: boundary, stations & Base line markers

NGM PTY LTD

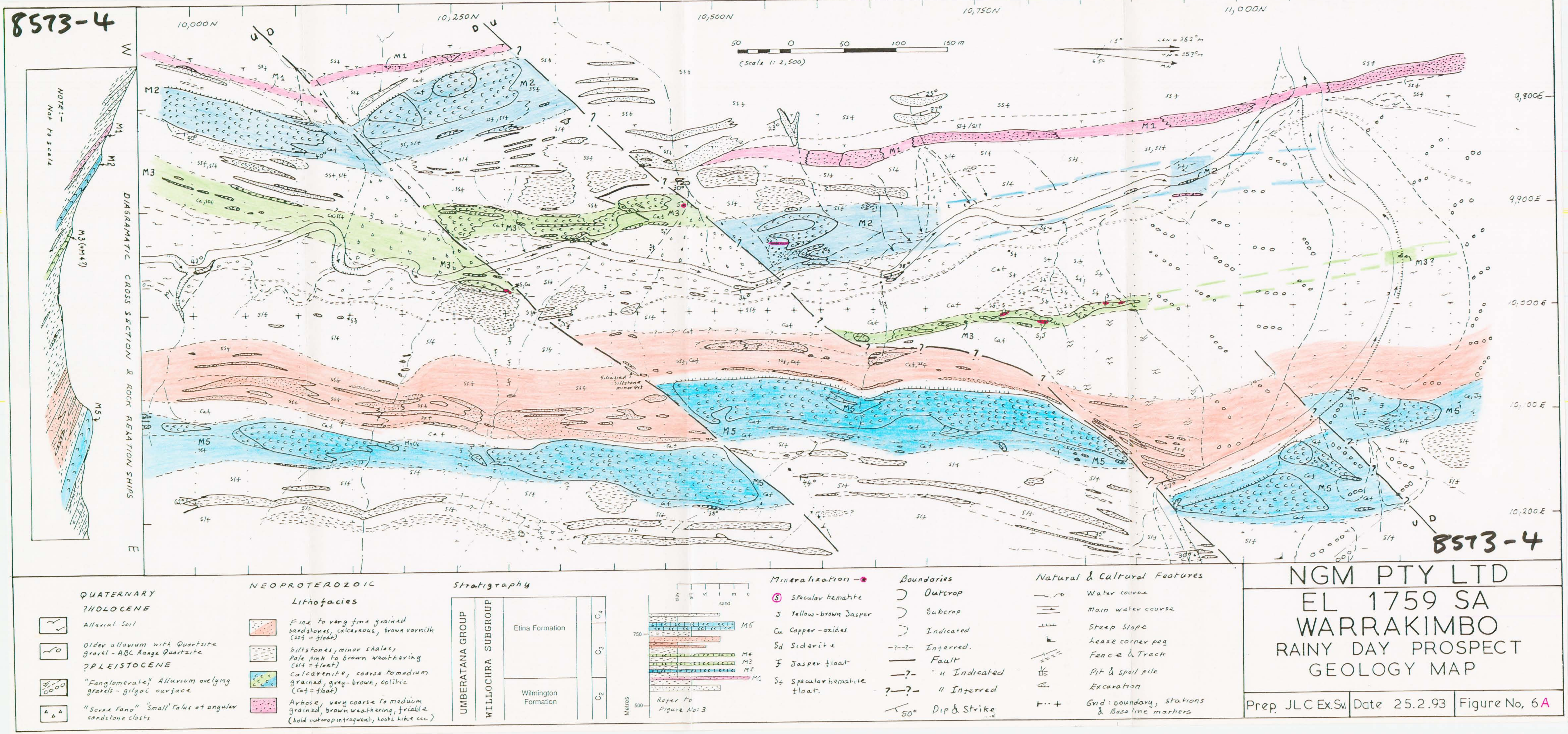
EL 1759 SA

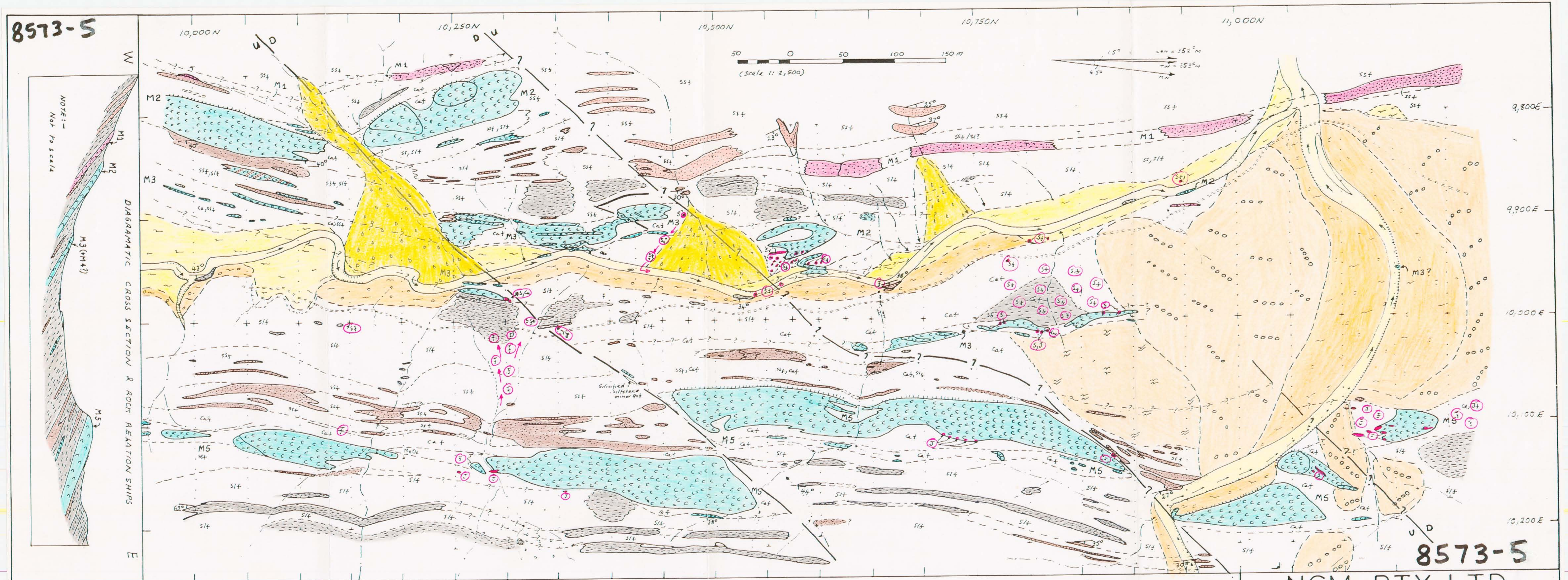
WARRAKIMBO

RAINY DAY PROSPECT

GEOLOGY MAP

| Prep. JLC Ex.Sv. | Date 25.2.93 | Figure No. 6 |
|---|---|---|


8573-4
10,000N
10,250N
10,500N
10,750N
11,000N
9,800E
9,900E
10,000E
10,100E
10,200E
(Scale 1: 2,500)
NOTE:- Not to scale
DIAGRAMATIC CROSS SECTION & ROCK RELATION SHIPS
W
E
M1
M2
M3
M3 (M4?)
M5
Silicified Siltstone mineral
8573-4
QUATERNARY
?HOLOCENE
Alluvial Soil
Older alluvium with Quartzite gravel - ABC Range Quartzite
?PLEISTOCENE
"Fanglomerate," Alluvium overlying gravels - gilgai ourface
"Scree Fans" 'Small' talus of angular sandstone clasts
NEOPROTEROZOIC
Lithofacies
Fine to very fine grained sandstones, calcareous, brown varnish (ssf = float)
Siltstones, minor shales, Pale pink to brown weathering (slf = float)
Calcarenite, coarse to medium grained, grey-brown, oolitic (Caf = float)
Arkose, very coarse to medium grained, brown weathering, friable (bold outcrop infrequent, looks like ccc)
Stratigraphy
UMBERATANA GROUP
WILLOCHRA SUBGROUP
Etina Formation
Wilmington Formation
C4
C3
C2
clay
silt
vf
f
m
c
sand
Metres
750
500
M5
M4
M3
M2
M1
Refer to Figure No: 3
Mineralization
S Specular hematite
J Yellow-brown Jasper
Cu Copper-oxides
Sd Siderite
F Jasper float
Sf Specular hematite float.
Boundaries
Outcrop
Subcrop
Indicated
Inferred.
Fault
" Indicated
" Inferred
50° Dip & Strike
Natural & Cultural Features
Water course
Main water course
Steep Slope
Lease corner peg
Fence & Track
Pit & spoil pile
Excavation
Grid: boundary, stations & Base line markers
NGM PTY LTD
EL 1759 SA
WARRAKIMBO
RAINY DAY PROSPECT
GEOLOGY MAP
Prep. JLC Ex.Sv.
Date 25.2.93
Figure No. 6A




| QUATERNARY | |
|---|---|
| ?HOLOCENE | |
| | Alluvial Soil |
| | Older alluvium with Quartzite gravel - ABC Range Quartzite |
| ?PLEISTOCENE | |
| | "Fanglomerate," Alluvium overlying gravels - gilgai surface |
| | "Scree Fans" Small talus of angular sandstone clasts |

**NEOPROTEROZOIC**

*Lithofacies*

- Fine to very fine grained sandstones, calcareous, brown varnish (sst = float)
- Siltstones, minor shales, pale pink to brown weathering (slt = float)
- Calcarenite, coarse to medium grained, grey-brown, oolitic (Cat = float)
- Arkose, very coarse to medium grained, brown weathering, friable (bold outcrop infrequent, looks like ccc)

**Stratigraphy**

| | | | |
|---|---|---|---|
| UMBERATANA GROUP | WILLOCHRA SUBGROUP | Etina Formation | C4 / C3 |
| | | Wilmington Formation | C2 |

Refer to Figure No: 3

**Mineralization**

- S Specular hematite
- J Yellow-brown Jasper
- Cu Copper-oxides
- Sd Siderite
- J Jasper float
- St Specular hematite float

**Boundaries**

- Outcrop
- Subcrop
- Indicated
- Inferred.
- Fault
- " Indicated
- " Inferred
- 50° Dip & Strike

**Natural & Cultural Features**

- Water course
- Main water course
- Steep Slope
- Lease corner peg
- Fence & Track
- Pit & spoil pile
- Excavation
- Grid: boundary, stations & Base line markers

# NGM PTY LTD
# EL 1759 SA
# WARRAKIMBO
## RAINY DAY PROSPECT
## GEOLOGY MAP

| Prep. JLC Ex.Sv. | Date 25.2.93 | Figure No. 6B |
|---|---|---|

The easterly hills tract of the title is accessible from the road via a bush track that follows the Willochra George in the south, a fence-line track from Hacket tank, and an access to an old abandoned well site in the north.

## 3 TENURE

EL 1759 was granted to NGM Pty Ltd on the 3 January 1992 for an initial term of 1 year and covers an area of 116 $km^2$. At the time of writing, application for an additional term has been lodged by NGM. (See figure 1)

The area is under freehold pastoral tenure which is managed by Mr. L. Dear from 'Partacoona'.

## 4 ABORIGINAL HERITAGE

Following recommendations from the SADME and in compliance with SA Heritage legislation advice concerning Aboriginal heritage interest groups was sought from the Port Augusta Office of the Aboriginal Section of the Department of Environment and Planning (DEP).

The advice received suggested that one or more of three Aboriginal clan/family groupings could have had heritage sites within the title as a result of uncertainties in the location of their respective common/overlapping lands. The resident DEP officers in Port Augusta contacted spokespersons of each of the ***"BARNGALAR", "ADNYMATHANHA" and "NUKUNU" PEOPLES*** and found each group believed the title lay within its' heritage jurisdiction.

As a result of this complex situation advice was sought from Mr. A. Turner, a recognised Aboriginal affairs consultant to the Exploration and Mining industry. Following his investigation a fourth Aboriginal group the ***"KUYANI" PEOPLE*** were identified as the correct heritage claimant and the matter was placed in the hands of Mr. J. Bannon who has established personal rapport with Mr. Mark M^c Kenzie, their spokesperson. The ***"KUYANI" PEOPLE*** are closely connected to the ***"VANGALA" PEOPLE (otherwise known as "BARNGALAR", "BANKGARLA" or "BUNGALA").***

The agreement provides for light Exploration activities to be undertaken freely until such time as track making, costeaning or drilling are being contemplated - consistent with existing Declared Equipment provisions of the SADME. Due respect of any Aboriginal sites or features either known or recognised during the course of investigations to be taken at all times.

# 5 PREVIOUS INVESTIGATIONS

Technical data at the Glenside Document Storage Centre was perused and brief summary of this information is included as appendix 1.0. The main sources of geological data are provided in the reference list at the end of the text.

## 5.1 History

Initial prospection of the area was carried out circa 1863 for copper when the Warrakimbo deposit was discovered and subsequently opened up in the early 1900's. The presence of occasional lumps of specular hematite pervaded by green copper carbonate minerals in the dumps suggests that an enrichment carapace may have been present. In any event the specular hematite was then considered gangue and proved to be a disappointing copper resource at depth.

While the specular hematite was recognised in 1908 serious investigation was not undertaken until after regional geological maps were compiled and published as the Parachilna 1:250,000 sheet (current edition).

Scott (1976) assisted by other Geological Survey officers mapped and reviewed the potential of the Warrakimbo Mine. Periodically samples were submitted to AMDEL laboratories for mineralogical examination and metallurgical test-work by Departmental Officers.

In 1985 N. M. Rollings finalised a university thesis that specifically examined genetic aspects of the Warrakimbo specular hematite mineralisation (Rollings, 1985).

In 1987 a review of the cumulated metallurgical reports and geological data was prepared by AMDEL for the Department of Mines (AMDEL, 1987).

In the same year the area was briefly explored for specular hematite by N. Rollings on behalf of RIMAC Holdings Pty. Ltd., as EL 1402. Various exploration techniques were employed but the results were not considered encouraging (Rollings, 1987).

In 1990/91 exploration for diamonds by Helix Resources N.L. as EL 2094 centred on the diapir at the abandoned Warrakimbo Woolshed and contributes an overview of an exotic xenolithic assemblage of clasts and mineralogical components in this mass (Slack-Smith, 1991).

## 5.2 Technical Significance

### Geology

Rollings work advanced the understanding of the local geology through the mapping of a restricted area about the Warrakimbo Mine. This remains the most substantial work to date. Although the general stratigraphic picture provided by existing Geological Survey mapping was confirmed by his work his thesis focusses on the mineralisation aspect of the area with a lesser degree of attention to the context of its geological setting. However, with hindsight from the perspective presented within this report, it would appear that this emphasis resulted in the mis-interpretation of field data obtained during exploration for RMIAC.

The subsequent release of a full review of the Neoproterozoic stratigraphy of the Adelaide geosyncline (Preiss, 1987) therefore requires that caution be exercised in accepting the stratigraphic boundaries as mapped by Rollings.

Since the broad regional deformational structure is not well understood at the present time, the interpretation provided by Rollings in respect of such a small restricted area of observations should also be treated with caution.

Rollings work does however highlight that all the potentially significant mineralisation occurs in oolitic carbonate units of the Etina Formation.

### Mineralisation

Rollings work clearly links the epigenetic, poddy, and massive specular hematite mineralisation to structurally induced porosity in a carbonate host rocks, which is consistent with other sites of significant mineralisation cited in the literature.

At a detailed level, specular hematite at Warrakimbo is associated with minor trace sulphides and was accompanied by multiple dolomite and calcite deposition. An envelope of ferroan dolomitisation is also commonly present and recrystallisation of the host carbonate may also have occurred without colour change. Silica mobilisation is also observed and siderite is sometimes present.

The mineralogy of all of the samples examined to date have to some extent been affected by weathering and oxidation due to the substantial relief relative to the water table level at the floor of Willochra Gorge. Much of the mineralogy suggests up to 5% primary pyrite may have been present, this now being represented by geothite which is sometimes pseudomorphic.

The oxidation of the pyrite would also have required dissolution of nearby carbonate and the generation of gypsum which has left the system in spite of the present day arid climate. The 'economic' copper mineralisation was therefore probably entirely a supergene accumulation from accessory chalcopyrite within the pyrite. While totally fresh material from beneath the water table is unavailable sulphides are occasionally observed in samples collected form underground workings.

The source of the iron in the specular hematite deposit is of little consequence given its general abundance in the host carbonates and semi-adjacent sequences, once fluids of suitable chemistry are mobilised. The real issue is the depositional mechanism. While this remains conjectural the circumstantial evidence is considered to favour a structurally controlled replacement mechanism.

The specular hematite at Warrakimbo commonly occurs in coarse bladed rosette cluster forms thought to have been inherited from a precursor carbonate mineral, possibly siderite or ferroan calcite. Low $P^H$ (acidic) conditions at substantial pressure are believed to favour specular hematite conversion/deposition.

Fluid inclusions in dolomite associated with massive vein type, coarse-bladed specular hematite suggest an early hydrothermal event at 145 ± 15 C with carbon dioxide rich fluids that accompanied wall rock alteration. A second event at 210 ±10 C with fluids of greater salinity appears to have been associated with the main period of hematite deposition.

The wide spatial distributed late/post Delamerian hydrothermal epigenetic willemite (zinc silicate) mineralisation and associated pervasive hematitic alteration in younger Cambrian carbonates, has similar mode of occurrence and emplacement temperature (Curtis, 1991). Correlation between the regional thermal event responsible for willemite deposits and the Warrakimbo specular hematite mineralisation is probable.

## Exploration

The emphasis on mineralisation in Rollings' thesis was not adequately complimented by field mapping with the consequence that the diapiric type breccia at Mount Stephen and the possible relevance of siliceous jaspers went un-recognised. Misinterpretation of exploration data was a consequence. (See section 6.3.1)

In particular :-

* Magnetic signatures at Mount Stephen saddle which were referred to dykes probably reflected rafts of volcanics in the breccia.

* Carbonate rafts were mis-identified as "Etina Formation out of stratigraphic position".

* The significance of free specular hematite clasts within the Mount Stephen breccia and their impact on heavy mineral stream sampling was unrecognised.

* The choice of Willochra Creek, a very high energy main drainage and locally affected by active mining, for stream sediment orientation was highly inappropriate.

# 6 EXPLORATION ACTIVITIES

## 6.1 Exploration Strategy

The small size of high quality industrial specular hematite deposits requires an exploration strategy that recognises the improbability of discriminating ore masses by applying many of the conventional exploration practices without carefully planned modifications.

The existing Warrakimbo deposit is in an optimum discovery setting. Being in the wall of a gorge, which is locally oriented parallel to strike, and has a slopes at close to the dip as well as the angle of rest for scree, the host horizon consequently is very well exposed providing excellent opportunity for its' discovery.

In other circumstances the 45 m strike of mineralisation could very nearly remain totally concealed and only be evident by float. This would be especially so if a weathered specular hematite mass was not bound by relatively strong gangue or secondary weathering products in a region of low relief. Added to the pinch and swell nature of the veining the 45 m strike exhibited by the surface body at Warrakimbo Mine may well be exceptional and much smaller expressions are possible.

This realisation clearly requires that small outcrops and/or patches of specular hematite float be systematically documented and examined in the context of their geological and geomorphological setting.

Remote sensing techniques, despite the massive improvement in satellite imagery since the initial work of Rollings still has a very low chance of successfully detecting the strong yellow brown alteration because of the very low target to pixel size ratio. For detection with this method a significant portion of one pixel (minimal size 30 x 30 m) must reflect a colour contrast.

The most likely possibility using this technology would be spectral scanning with an airborne platform which offers a wider spectral range and a massive improvement on pixel dimensions. Given the small size of the title, the likely costs of a ground based orientation and the airborne work this approach was considered unviable without better ground truth knowledge.

It was therefore concluded that photo-interpretation followed by systematic field examination of the Etina Formation package was the appropriate initial exploration activity. Field work was designed to ratify the existing mapping and seek indications of mineralisation by focussing on carbonate beds, particularly emphasis being placed of structural disturbance and/or dolomitic alteration as previously documented by Rollings.

## 6.2 Photo-geology

Colour Photography

Stereographic coverage of 1:40,000 scale Lands Department 1990 colour photography taken at an altitude of 6125 m (20,000 ft) supplemented by selected scaled 1:25,000 and 1:5,000 enlargements were acquired.

All of the lithologies and soils in the area are tones of brown. Consequently only rocks with strong contrast such as dark brown weathering varnish or white bleaching are easily traced, all other lithologies with weaker contrast tend to merge with one another and soil covers.

Field inspection demonstrates a clear visual colour signature for the dolomitic alteration associated with mineralisation. Regrettably however, the print emulsion of the colour photography is not adequately sensitive to display this contrast, presumably due to the minor siderite component of the oolites in the unaltered limestone beds of the Etina Formation.

Transparent overlays were prepared for the enlargements to provide a working base for the assembly of previous exploration information and a more detailed geological base map. Both photogeological data and field observations have been combined in Figures 2 & 5.

Scaled measurements between known points on the standard 1:50,000 map sheet confirmed a consistent uniform scale on the photo-maps and permitted the location of AMG coordinates at an acceptable degree of accuracy.

Stratigraphy

By comparison with aerial photography (1:5000) regional mapping (1:10,000 SADME plan 85-623) by Rollings is closer to a 'solid geology map' rather than an outcrop plan. The data is therefore interpretive rather than factual. (Plan view pinches and swells in outcrop patterns, corresponding respectively to drainage intersections and dipslope presentations, are smoothed out.)

While overall stratigraphic relationships mapped by Rollings are confirmed, detail within the Etina Formation package is not substantiated at 1:5,000 scale in the region of the mine.

It is clear from the photography that the breccias illustrated on Rollings plan are actually predominantly prominent scree deposits on a landscape which has a thin veneer of scree over much of its surface. The association of the breccias with the main thrust fault is solely a function of relief arising from the contrast in erosive resistance of juxtaposed units.

Stratigraphic units have been re-assigned photogeologically and warrant field confirmation before formal acceptance is contemplated.

Structure

The known structural features, the Sleep Hill Syncline, Mount Stephen Thrust and the western limb of the Rocky Point Syncline are quite evident on the photo-geology.

However, it is apparent that the many of the 'faults' identified by Rollings are not substantiated by recent aerial photography. These features (on his plan) are somewhat coincident with drainage and are often illustrated without any displacement. It is concluded that these features are mainly joints.

Furthermore the faulted axial plane and the cross fault on the nose of the Sleep Hill Syncline are not substantiated by the photography. There is also some doubt as to whether there is a strike bound spur thrust to the immediate west of Mount Stephen.

Complex faulting in the vicinity of the Clayton specular hematite occurrence is however confirmed although the structural detail presented by Rollings is difficult to substantiate. Photo-enlargement at 1:5,000 scale suggests that the Windy Ridge Fault has a dextral and/or SW-down displacement that is taken up by a single plane just south of the horse-shoe bend of Willochra Creek and several subsidiary planes at the Clayton Specular Hematite occurrence.

It is clear that the Clayton, Windy Ridge and other 'minor' specular hematite occurrences marked on the RIMAC plan are related to the Windy Ridge Fault.

Exploration Data

Dip and strike measurements were transferred from an enlargement of the regional geology map prepared by Rollings but unsubstantiated features have been omitted from the plans presented in this report.

Location of regional exploration data from RIMAC work was only partially successful because the 'insert' detailed drawings are not available and the 1:50,000 scale plan obtained from SADME archives appears to be distorted when enlarged fivefold to a matching scale.

When approximately located the work of Rollings indicates that specular hematite is being released into the drainage flowing north from the foot of Mount Stephen to the horseshoe bend of Willochra Creek and specular hematite was to be found in the headwaters region of the north flowing (sub-Parallel) creek on the east.

Similarly there appeared to be some evidence of specular hematite somewhere to the east of the former Warrakimbo Woolsheds.

## 6.3 Regional Geology

The regional geology is not re-described from literature (as is common practice) in this section due to the availability of the unmatchable account of this topic as provided by Bulletin 53 (Preiss, 1987). The title has been subdivided into several work areas and each is discussed separately in respect of both stratigraphy and mineralisation from the viewpoint of field based observations blended with information from literary sources.

Rapid systematic strike walking of the Etina Formation package throughout the title and structural features in the vicinity of Mount Stephen were conducted during two short field campaigns. Two further campaigns were focussed on mapping at the Rainy Day Prospect.

### 6.3.1 Mount Stephen

*Northwest Sector*

The WNW spur of Mount Stephen was traversed from west to east and thence northward down the face of spur just to the west of the saddle.

Massive white quartzites with pink hematitic siltstone interbeds are present. Along this interval the Pound Group quartzites appear to be quite silicified, particularly on the northern face of near the saddle where the bedding appeared to be locally flattened to nearly horizontal in contrast to the steep easterly dip a few tens of meters to the south.

On the south/west side of the saddle are some large blocks of altered dark brown dolomite and at least one large block of vertically layered greenstone (chloritised igneous rock). Small fragments of these lithologies formed a minor component of the abundant quartzite scree.

A few meters east/south the exotic lithologies disappear beneath thickening scree. On the north side of saddle the dip of the ABC Range Quartzite is much flattened.

The flattened dips in the Pound Quartzites and ABC Range Quartzite are consistent with fault drag corresponding to south/west side down and north/east side up on the main thrust that passes through the saddle.

A short traverse was then made northward along the frontal scarp of the western ridge of the ABC Range Quartzite. The flattened dips observed at the saddle are only sustained a few meters to the north. Minor strike parallel brecciation and shearing accompanied by silicification and brown iron oxide ?geothitic veining was intermittently observed along the west facing scarp.

A decent to the floor of the valley to west of the ridge and south to the foot of the Mount Stephen spur across the red siltstones of the Brachina Formation followed.

At the foot of the spur about midway between the spring and the saddle more blocks of dark brown dolomitic carbonate rock penetrate up through the scree.

Secondary carbonate and iron oxide deposits at the spring suggest that the groundwater is upwelling from the Mount Stephen Thrust.

*Northeast Sector*

The region on the eastern side of the Mount Stephen saddle was then inspected. The weakly incised drainage leading due east from the saddle exposes a meter or so of a thick sheet of calcrete. Nearby, on the almost tree-less slope to the south, are a few rounded black clasts of poor quality specular hematite measuring up to 15 cms in diameter.

On the north side of the drainage at the foot of the western ABC Range Quarzite ridge are a few masses of dark grey recrystallised limestone with layering that is disjunctive to the regional eastern dip.

A short distance northward down the main creek from this location and at the foot of the steep slope of the east dipping western ridge of ABC Range Quartzite, are flat to west dipping red brown siltstones clearly rotated through ≈90 . No facings were observed.

On the east side of the valley above the track is a minor excavation in a breccia composed of pink and light grey-green siltstone chips up to a few centimeters in diameter. Nearby higher upslope and slightly to the north are massive blocks of dark brown dolomitic carbonate surrounded by scree (from ABC Range Quartzite in the truncated nose of the Rocky Point syncline) and rubble that includes clasts of greenstone. A few meters to the south of the excavation large patches of subcropping greenstone with massive fine to coarse grained doleritic texture are present.

*Interpretation*

Collectively the exotic greenstone and dolomite lithologies associated with siltstone breccia are typical of basal Adelaidean Callana Group rocks that have been well documented from diapiric breccias masses elsewhere in the Finders Ranges. It is thus inferred that a substantial body of 'diapiric' breccia lies partially concealed by the scree along the northern flank of Mount Stephen within the thrust zone.

Study of a lithologically similar diapiric breccia just east of the former Warrakimbo Woolshed, also within the Mount Stephen Thrust, provides some insight into the likely character of the Mount Stephen Breccia. The Woolshed breccia contains relatively abundant specular hematite and traces of many exotic minerals that are affiliated with diamonds (Slack-Smith, 1991).

Here, the specular hematite is widely distributed in the soil cover from place to place and appears to be occurring within free breccia clasts as veining. There is a high probability that the hematite was deposited in a contiguous anastomosing lattice of veins that were subsequently disrupted by later translations within the breccia.

It is therefore inferred that contiguous masses of specular hematite of a commercial size are unlikely to be present in the Mount Stephen breccia. Also since there is a reasonable expectation of specular hematite occurring in the breccia to the east of the saddle, dispersion into the drainages on both sides of the saddle is anticipated, adequately explaining the origin of the stream anomalies detected by rollings in the western drainage.

Furthermore the greenstone masses probably retain traces of magnetite and are a reasonable source for the magnetic anomalies that were attributed to 'dykes'.

### 6.3.2 Warrakimbo Mine Area

In this area the geology of the east dipping succession between the Mount Stephen thrust and the Nuccaleena Formation was examined by systematic strike walking.

*Farina Subgroup*

Exposure of this lowermost stratigraphic unit is restricted to a small area located to the west of the mine and adjacent to the thrust. It is a relatively massive block of grey limestone and limestone conglomerate which is altered (silicification and ferrugenised) and brecciated along its western side where it is topographically prominent. It has been thrust faulted at a steep angle over younger Wonoka Formation to the west.

The lithology would be consistent with the Brighton Limestone although it does not have the massive stromatolitic textures /features observed elsewhere further north, to the east of the abandoned Warrakimbo Woolsheds, where the underlying Tapley Hill Formation is also present. At this latter locality the uppermost Tapley Hill Formation-Brighton Limestone transition has spectacular development of stomatolitic mounds varying from 10s of cm to several meters in height and width. Fragmental material from these limestones is also incorporated in the sequence and at the contact with the overlying Wilmington Formation but these features are absent to the west of Warrakimbo Mine.

Minor prospect shafts and scrapings for secondary copper associated with thin quartz veining are present but there is no evidence of accompanying specular hematite although some secondary ferrugenisation is associated with the thrust plane.

The actual contact with the overlying Wilmington Formation is unexposed and hence the block could be a wedge shaped fault sliver or a disconformable contact on a former basement high.

*Wilmington Formation*

The Wilmington Formation is best exposed in the floor and walls of Willochra Gorge. The stratigraphic base of the unit is either poorly exposed or more commonly it has been lost by truncation at the Mount Stephen Thrust.

Locally it is a reasonably robust sequence of red brown weathering siltstones and fine to very fine sand units which form a set of prominent bars that cross the floor of the gorge. It is at least 200 m thick and overlain conformably by the Etina Formation.

## *Etina Formation*

### Sedimentology

This formation consists of a number of depositional cycles capped by arenite beds. Each cycle, depending on the perspective taken, commences with the deposition of grey coloured fine silt and shale that progresses upward into fine medium brown sandstones which are commonly resistive to weathering and often have a dark brown 'varnish'. The fine sandstones gradationally contact and interfinger with conformably overlying massive coarse to medium grained calcarenite beds (sandy granular limestones).

As part of a regional stratigraphic study I. Dyson kindly measured a stratigraphic cross section C..D through the Etina Formation (Fig. 2) which has permitted systematic subdivision on the basis of macro deposition cycles C1.. and micro cycles that have given rise to each calcarenite bed M1.. which are designated on Figure 3.

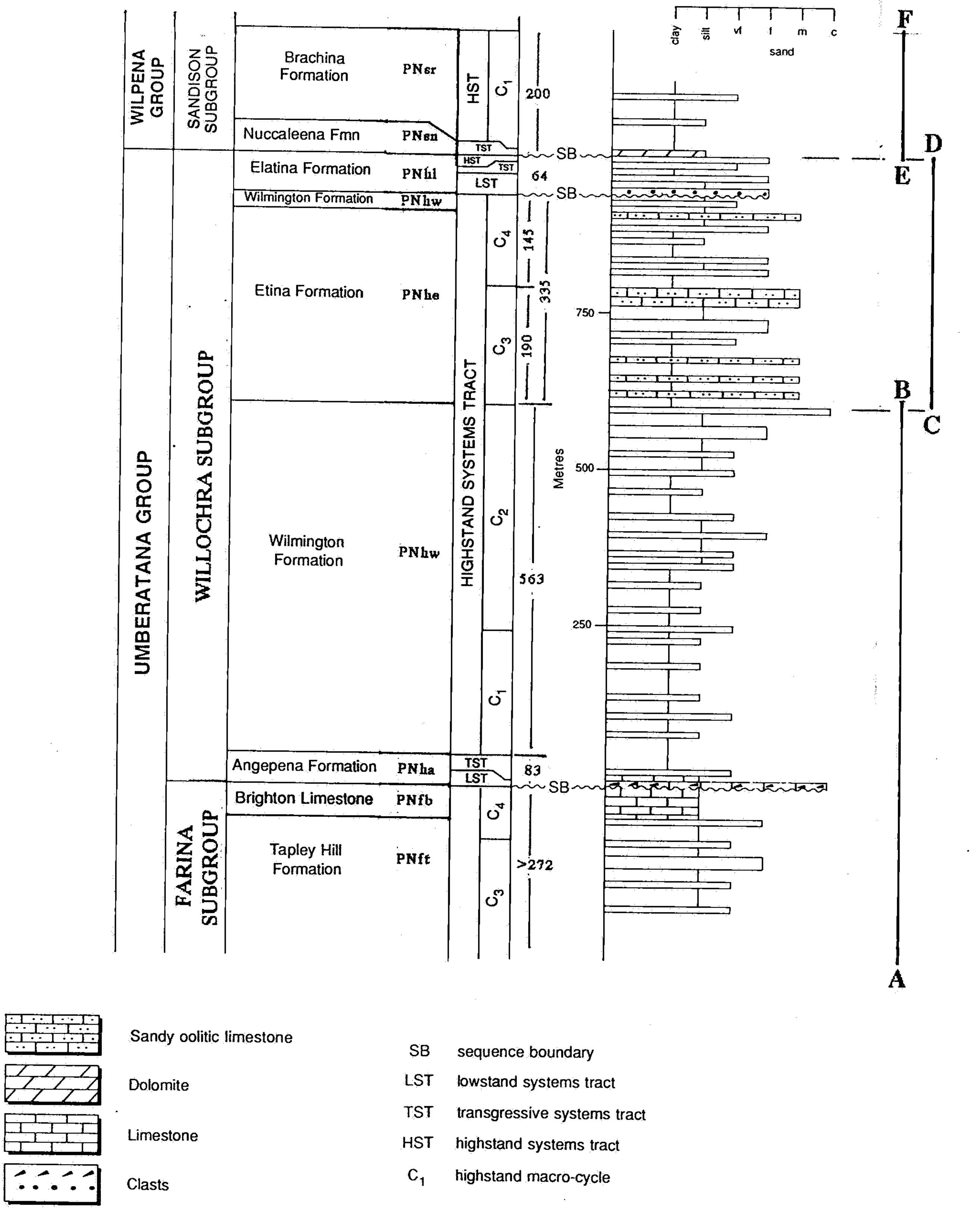
The base of the sequence is commonly marked by a an arkosic sandstone (M1) with some larger quartz granules that may superficially resemble calcarenite where physical attrition is the main degradational process as found in Warrakimbo Gorge. Elsewhere when chemical degradation has occurred the outcrop may be subdued to almost non-existent.

The grey silt and shale units have weak outcrop expression and have been view by Rollings and other workers to be Wilmington Formation.

The sandstone and calcarenite beds often form robust cuesta ridges commonly with the sandstone forming a minor scarp capped by a partly degraded cap of calcarenite. Both the sandstones and the calcarenite were deposited in an energetic environment and exhibit crossbedding. The depositional environment probably reflects a progressive influx of granular carbonate material rather than a change in overall marine conditions much as might be imagined occurs with migrating offshore bar systems.

The calcarenite samples examined petrologically by Rollings are clearly oolitic, but for the most part the fine structure of these distinctive grains is not in the least evident in the field save for their roundness which could easily be attributed to simple erosive abrasion. Indeed many of the grains in calcarenite beds appear to consist of sub-rounded grains and chips of preexisting limestone.

The limestone clasts are generally of very fine grained buff-pinkish muddy looking carbonate. In rare instances thin beds consisting of thin platy fragments of this material a few centimeters in diameter were observed. In one case similar material was observed in-situ as capping a local channel fill of




**WARRAKIMBO COMPOSITE STRATIGRAPHIC COLUMN** Figure 3 upward-fining calcarenite. It is thus inferred that this type of material is locally sourced and could be consolidated 'dust' from periods of high energy attrition of oolitic material that has settled out only to have been ripped up at the onset of more vigorous marine disturbance.

Each cycle (M1..) is indicative of an upward shallowing environment that probably resulted from sediment accumulation at and across the wave base transition in a near shore setting. Periodic elevations of sea level in the order of 30 m are probably responsible for the accumulation of each cycle.

In detail, the calcarenite caps (M1..) to each cycle vary from being absent to 10 m thick. Measurements conducted by I. Dyson in the clearly show that there are 10 or more major cycles of which 5 were capped by calcarenite ≥ 5 m thick. Thinner calcarenite beds are present indicating sub-cyclic events but demonstration of their lateral continuity appears to be limited.

The top of the formation is marked by a prominent siltstone unit which I. Dyson believes to be an incursion of Wilmington Formation which has arisen as a result of a substantial increase in water column height.

'Styolites'

The unaltered calcarenite beds, although now well indurated, were probably excellent aquifers and possibly retained a degree of permeability until the onset of tectonism when pore fluids were most likely to have been vigorously mobilised. There has been a debate between sedimentologists concerning the nature of low sinuosity 'styolites' that are frequently present in these units (I. Dyson, pers. comm.).

The field evidence observed by this author also leads to questioning of their presumed styolitic origin. The 'styolites' are commonly thick wavy bands ( 1-3 cm) which often weather with upstanding relief. The sinuosity is comparable to that observed with marine ripple forms and appear bedding constrained, sometimes with spatial regularity and patterns that mimic cross-bedding including forsett truncations.

This broad morphological similarity to sedimentary structures leads this author to the opinion that they are indeed a bedform inheritance feature. The most likely explanation is that they are former higher porosity zones which acted as pathways for migrating fluids and a focus for diagenetic/alteration processes including partial dissolution of the matrix ie.- styolitic type processes. The most probable origin is that they are the coarser grained toe zone of advancing ripple wave foresettes. Their morphology being a reflection of the underlying substrate whether it be wavy or planar corresponding to rippled or truncated crossbeds respectively.

Rollings advances a model regarding the origin of specular hematite in these 'styolites' at the Clayton prospect (M4) where he observes evidence of recrystallisation within them. It is self evident that the PT conditions for such processes have varied over the diagenetic history of the rocks, probably becoming identical to those under which classic high sinuosity pressure solution styolites are considered to occur, during Delamerian orogenesis. The existence of abundant styolites of the classic type in recrystallised Etina Formation, as seen in the floor of Willochra Gorge, on the west side of the horseshoe bend, supports this viewpoint.

Mineralisation & Alteration

Styolitic banding is quite common and is only rarely mineralised. Rollings work which examined styolitic mineralisation processes is not exhaustive because it does not adequately consider the broader context of over all field relationships.

The distribution of styolitic mineralisation and its close field association with crosscutting fault structure and pervasive dolomitic alteration of restricted extent, within the calcarenite beds is probably just as relevant as the microscopic detail.

Field inspection in the vicinity of the Clayton prospect shows that the intensity of brown dolomitic alteration appears to diminish northward along the calcarenite beds away from the Horseshoe Fault system and irregular patchy (non styolitic) specular hematite mineralisation is present in the calcarenite bed (?M3) below the 'styolitic' deposit.

Furthermore massive honey yellow, red and dark brown siliceous jasper masses within altered calcareinite both a short distance along strike (M4), south of the mineralisation and in the main fault plane on the north have hitherto been excluded from technical discussion. Similarly also, has the possible relevance of minor secondary copper mineralisation and thin quartz veining in slightly sheared siltstone/shale a few meters away from the main fault plane jasper vein, been unconsidered.

The jaspers appear to be replacement veins and masses within joints/fractures/faults. They could be dismissed as being entirely a secondary feature but this is regarded as being improbable by this author because a guided visit to the Upalinna diapir (courtesy of I. Dyson) revealed that nearly identical jasperisation is a common replacement alteration of the country rock along the north westerly contact rim of the Upalinna breccia and also locally associated with a nearby radial vein of massive/specular hematite and accessory siderite, in the rim rocks.

The distinctive yellow-brown dolomitic alteration described in detail by Rollings at the Warrakimbo Mine appears to have been preceded by recrystallisation of the calcarenite accompanied by the loss of much sedimentological detail. Recrystallisation of this type could be exclusively diagenetic but might also be attributable to applied stress.

The recrystallised limestone, (in the floor of Willochra George) with abundant styolites has been warped by right lateral drag on the Horseshoe Fault. It is of relatively uniform grey colour, massive and generally fine grained. Thin (< 1 cm ) veining by white calcite in several planar orientations has occurred before a late set of thin brown dolomite veins was introduced.

Northward down the Gorge the white calcite veins become less prevalent but sporadic occurrences of brown dolomitic veining continues with subtly increasing abundance and thickness over about 500 meters of strike. In the last 250 metres, south of the upper adit access track, the limestone forms the lower part of the wall of the Gorge where sporadic patches of brown dolomitic alteration penetrates up to 10 cm laterally from some joints. At the mine itself an irregular 200 m alteration zone was mapped by Rollings. Minor intermittent alteration was also traced northward beyond mapping and obliquely down section to the base of the host calacarenite bed.

<u>Please Note:</u> Rollings detailed 1:1,000 scale map of this area shows a southern termination of the alteration zone within the host limestone but this is potentially misleading because all outcrop virtually disappears at this point due to soil cover which extends from about the 130 m topographic contour beyond the explosives magazine site southward to the other side of the minor east flowing creek. The drawing is clearly interpretive.

Without detailed re-mapping there is a hint that the dolomitic alteration has a preferential bias to bedding oblique fractures oriented approximately SSE. In the mine adit (A) there is clear evidence of bedding parallel strain that was initially observed by Rollings who inferred that it had influenced the distribution of mineralisation. Two of the shears were mapped at surface by Rollings but there are at least four that can be recognised underground. The two additional shears occur in the portal shales and another one is present on the portal side of the vehicle turn-around bay. This latter shear seems to be slightly steeper than the bedding and might indicate that this could be a pattern exhibited by the other shears.

The main specular hematite mass exposed in the adit is irregularly shaped with minor late stage veins of white carbonate. At least two generations of white carbonate are present, the older being structurally dislocated and the pale brown footwall dolomite shows evidence of brecciation prior to specular hematite deposition. Samples taken from the mulloch dump show that chalcopyrite was probably introduced with the carbonate.

The evidence presented in the preceding discussion clearly implies brown dolomitic alteration was a relatively late event postdating major faulting which opened up permeable pathways in the semi-adjacent rocks. At a slightly later time the fluids deposited specular hematite or replaced a precursor carbonate mineral wherever permeability and adequate porosity permitted. It appears that minor tectonic disturbances may have maintained the fluid pathways. The jaspers may be a late depositional feature.

The free clasts of specular hematite in the diapiric breccias suggest that veining took place but subsequent tectonic mobilisation has resulted in fragmentation. The field relationships of similar veining at Upalinna strongly suggest that the fluids at Warrakimbo were sourced from a diapiric breccia which is concealed at depth along the Mount Stephen thrust fault in the mine area. (See Figure 4)

*Elatina Formation*

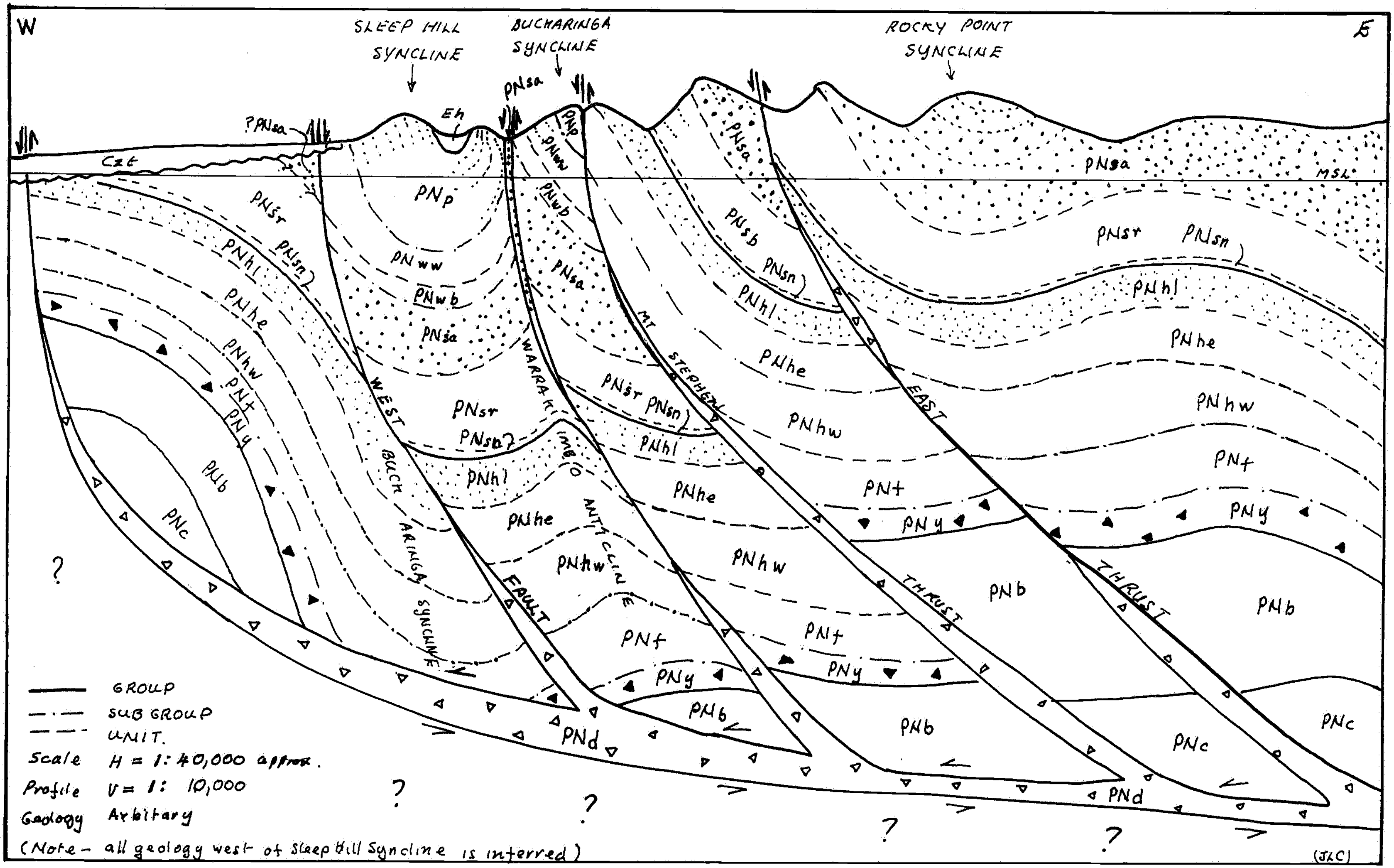
The Elatina Formation is a widespread and generally thick unit that occurs in the Northern Flinders Ranges. At Warrakimbo it is considerably thinner and comprised of massive sandstones. It is recognisable by its disconformable base upon the underlying sequence and the presence of small granules of red-brown chert within the basal few meters.

Locally distinct slump rolls and ballings (≤2 m in diameter) which are clearly a result of soft sediment tectonics related to the undulating disconformity surface, are exposed in the northern wall and visible in the stream bed of Warrakimbo Gorge north of the Mine. A modest palaeoslope associated with an unstable mass of rapidly deposited sediment, from Marinoan Glaciation melt waters, is probable.

*Nuccaleena Formation*

Fine red brown shales with up to two distinctive pale pink dolomite interbeds beds characterise this unit that conformably overlies the Elatina Formation. Local slump / mudflake type of breccia within the shales is rarely observed, one notable occurrence being just south of the access road ramp down to the floor of the Gorge about 0.5 km north of the mine.

The shales weather readily to a red soil similar to the adjacent overlying Brachina Formation and are much less diagnostic than the dolomite inter-beds when they are present. Elsewhere outside the




Eh — HAWKER GROUP

WILPENA GROUP

PNp- POUND SUBGROUP

PNw- — SUBGROUP

PNs- SANDISON SUBGROUP

UMBERATANA GROUP

PNh- WILLOCHRA SUBGROUP

PNt- FARINA SUBGROUP

PNy- YUDNAMUTANA SUBGROUP

PNb BURRA GROUP

PNc CALLANA GROUP

**WARRAKIMBO HYBRID CROSS SECTION — STRUCTURAL MODEL**

Figure 4

00029

mine area the Nuccaleena Formation does not have this surface expression. Instead a light coloured clayey soil with 'crab' holes (small solution collapse features) and poor vegetation cover is all that can be seen. This latter expression is however well recognised on colour photographs and is an important field mapping marker.

Minor oxide copper occurrences have been prospect pitted on the north side of Warrakimbo Gorge adjacent to Willochra Creek at the mouth of a local south flowing tributary drainage and on the east side of Willochra Creek, adjacent to the track opposite the Warrakimbo Mine.

Outcrops of dolomite located on the SE side of the horseshoe bend are the most southerly known field expression.

*Brachina Formation*

The Brachina Formation seems to be a monotonous chocolate red brown silty/shaley sequence. It was not studied in any detail.

*ABC Range Quartzite*

The ABC Range Quartzite is a massive thick bedded sandstone that is physically tough and gives rise to robust classic cuesta ridges which dominate the eastern skyline of the study area and the eastern wall of the Gorge opposite the Mine. It was not studied in detail.

*Superficial Units*

Observations of geomorphological features on the western margin of the Flinders Ranges in the vicinity of Moralana Creek and highway 83 to Leigh Creek (40 km north of EL1759) clearly demonstrate relatively recent uplift and rejuvenation of local drainages. This same shift in base level is manifest as a dissected valley step opposite the Warrakimbo mine and partially dissected indurated alluvial gravels on the inside bend of Willochra Creek 700 m north of the mine (Czg1, Fig. 5) and used by the access track.

A more recent base level is marked by a second tier of gravel deposits (Czg2. Fig. 5) and calcreted talus (Czc) along the toe of the northern wall of the Gorge (see C-D, Fig. 5) is also present about 2 m above the present stream base. A calcreted alluvial fan (breccia) that developed at the confluence of the south flowing tributary and Willochra Creek upon Nuccaleena Formation substrate is illustrated on Rollings' map but it appears to have been interpreted as a fault breccia.

### 6.3.3 Homestead

Given the proximity and probable genetic link of specular hematite mineralisation to the Mount Stephen Thrust south of Willochra Creek, the prospectivity of the region to the west of the thrust was also evaluated because carbonate horizons in the Wonoka Formation were possible host lithologies and major faulting is evident from mapping by Rollings.

In this area the Wonoka Formation lies conformably beneath the Pound Subgroup which is wedged off progressively northwards along the thrust from the vicinity of Mount Stephen to a point 600 m south of Willochra Creek where the Wonoka Formation comes into contact with the thrust.

*Pound Subgroup*

The Bonney Sandstone dominates the wedge-out against the thrust and forms round topped ridge of relatively soft orange brown sandstone. There is no evidence suggestive of specular hematite mineralisation.

*Wonoka Formation*

The Wonoka Formation consists of grey to pinkish shales with very fine grained grey laminated dolomite interbeds. Dolomite appears to be more abundant near the top of the unit and has a strong photo-signature due to dark brown weathering varnish and is relatively robust and forms the main skyline seen to the east of the Warrakimbo Homestead.

A traverse across this possible host unit provided no evidence of mineralisation and the fine grained nature of the rocks suggests a relatively impervious environment is present which is unsuited to the passage of epigenetic mineralising fluids,.

*Bunyeroo Formation*

The underlying Bunyeroo Formation, a fine grained red laminated shale is soft and recessive with poor exposure

*ABC Range Quartzite*

The slivers of massive fine grained silicified quartzite mapped by Rollings were examined and the facings near Willochra Creek confirmed as being west. Further south of the pipeline track where the quartzite is exposed in incised creeks it is very contorted and brecciated within a red silty matrix clearly indicating a major fault. There is little direct evidence as to whether the host siltstone is Brachina Formation or Bunyeroo Formation.

Given the observed contortion, the block with the observed facings could well be rotated and actually be facing the wrong way. Minor folding and sympathetic folding is evident in proximity to the main structure. The best fit interpretation is that the quartzite is pinched off blocks/slabs within the sheared out axial plane of a fold. Given the dynamics, the feature must continue along strike northwards to intersect the Mount Stephen Thrust north of Willochra Creek.

The only evidence of mineralising processes associated with the fault is a small showing of oxidised copper mineralisation hosted by red shales in the lee of the main quartzite blow near Willochra Creek just south of the mine access track, there being no indications of specular hematite.

### 6.3.4 North Warrakimbo

Systematic strike walking of the Etina Formation to the north of Warrakimbo Gorge was undertaken in three stages.

Traversing the southern ruggard area was mounted from the Gorge walking northward about 2 km along the upper M5 oolitic carbonate hori and returning south along the M2-4 horizons. The upper M6 hori was very thin and not examined in any detail. Each bed was quite similar. The rock is quite granular and did not appear to have suffered massive recrystallisation or have high sinuosity styolites. Wavy 'styolites' were however commonly present.

The limestone beds were ubiquitously straw-yellow to light-brown but without any evidence of massive pervasive alteration /recrystallisation or other indications of mineralisation.

### 6.3.5 Neuroodla

Traversing was then carried out north and south from the fence line accessed via Hacket Tank, to a position about 5 km north of Warrakimbo Gorge. The terraine has relatively little relief on the Etina Formation compared to the mine area, being largely a broad undulating valley between the low hills of Wilmington Formation in the west and the Brachina Formation/ABC-Range Quartzite cuesta ridge to the east.

The northward traverse examined the M5 hori, the M6 hori being absent or non-outcropping and the return southward was along the M2-4 hori. The carbonate beds were much harder to inspect because poorer intermittent exposure. Generally, as for elsewhere, evidence for mineralisation was scant except for two localities.

From about 1 km to 2.5 km north of the fence nearly all evidence of the carbonate beds disappear beneath surface rubble which is probably alluvial in part. North of the abandoned tanks, mill, and decaying fence the Etina Formation is covered by a flat lateritic plain. Low profile concretionary ironstone outcrops overlook the creek near the fence in the east in the inferred position of M5 hori. A former swampy environment, now undergoing active dissection, is probable.

### *Jasper Hill*

Jasper Hill which is located on M5 horizon, on the north side and adjacent to the fence, is a low east dipping strike ridge of limestone about 20 m high and about 200 m long. A prominent dark brown jaspery gibber scree lies on the western side and arises from irregular massive dark brown jasper 'veins' parallel to and along the western side of the hill.

On the gentle eastern dipslope discontinuous and poly-directional jasper veining occupies joints orthogonal to bedding. In one locality a nearly complete poylgon has formed in the central region of the hill. On the western side of this polygon the jasper veining is a re-sealed silicified breccia which includes a small irregular mass of specular hematite. This observation confirms a close temporal & genetic link between jasperisation and specular hematite mineralisation.

Sporadic jasper and minor manganese oxide occurrences continue to the north for a several hundred meters but no additional specular hematite was observed.

There is no strong yellow-brown ?sideritic alteration at Jasper Hill as recorded at Warrakimbo.

### *Neuroodla Turkey Nest*

In the north the M5 horizon disappears beneath soil cover, and the M2-4 horizons become difficult to trace due to oblique NNE faulting. Photo-interpretation and previous mapping indicates that this region is the exposed eastern portion of a north plunging anticline.

Field observations indicate considerable complexity due to the interaction of faulting and probable crumple folding of the Etina Formation. To the immediate south and east (<500 m) of the Neroodla Turkey Nest, dips in the Etina Formation appear to be steep southerly with an arcuate strike. To the immediate south and west (<500 m) where the NNE faults occur, the dips are gently east to virtually flat. Contrastingly, further south, (≈ 1 km) all the dips are uniformly easterly at about ?25-30

The fold 'nose' has also been cross-cut by a NW oriented fault which seems to be the northerly limit of stratigraphic continuity and simple structure, even though the displacement of this feature on the ABC Range Quartzite is fairly minor.

Indications of mineralisation are weak.

To the SE of the Turkeys Nest close to the fence is a region of next to no outcrop and yet it is strewn with small lumps and chips of siliceous altered lithologies not typical of local stratigraphic units. Occasionally adhering to a clast and commonly in the gritty soil are traces of fine ?specular hematite. While there is some possibility that the material is transported, there are no fluviatile characteristics such as rounding of clasts and an appropriate parental source environment is unknown. A 'diapiric' type breccia is therefore suspected and is displayed as such on figure 2. This interpretation also provides accommodation for the structural disparity between the Etina Formation and the ABC Range quartzite.

At one locality to the SW of the Turkeys Nest strong yellow-brown colouration of a limestone bed in the zone of NNE faulting was noted. This warrants a closer re-inspection to determine if it is typical of alteration associated with specular hematite elsewhere.

Given the structural complexity of the area and weak indications of mineralisation a more detailed field inspection of the Neureoodla Turkey Nest area is warranted. A back-hoe costean into the suspected 'diapiric' breccia should be considered.

### 6.3.6 East Woolshed

The southward traverse followed a similar pattern, once again strike walking the M5 horizon southwards about 3.5 km to co-join with the Warrakimbo North traverse and returning along the M2-4 hori. The terrain is subdued but more undulating compared to the northern side of the fence. Fairly abundant alluvial/elluvial talus fans and sheet deposits which occur along the valley slopes and floor commonly obscure the Etina Formation.

For the first km the M5 horizon is reasonably well exposed south of Jasper Hill. In this interval outcrop is reasonable to poor and jasper occurrences are sporadic and diminish southward. Further south for another 2 km the outcrop is quite poor. Evidence of weathered carbonate by way of secondary iron oxides, nodular manganese, and some calcrete with occasional relict clasts demonstrate stratigraphic continuity of the unit. The reasons for poor outcrop are unclear but a proneness to solution weathering is suspected. Apart from the jaspers there was no obvious alteration or other indication of mineralisation.

Demonstrating continuity along the strike of the M2-4 horizons on the return traverse could not be reliably achieved in the field. Along the southern-most 2.5 km, the M3/4 horizon is concealed by fluvial deposits in a drainage course and the M2 horizon being thin is obscured by scree along the western wall of the valley. Outcrop improved to the north but strike continuity is affected by oblique NE faulting about 1 km south of the fence line.

There are no strong outward signs of a mineralised environment along the M2-3 horizons such as yellow-brown alteration seen elsewhere or jaspery material as in the nearby northern portion of M5 horizon. Yet where the faults transect the M2 and M3/4 horizons there are veins of massive specular hematite. Minor amounts of free specular hematite were noted down the drainage northward toward the fence. It is now clear that this locality was previously inspected by Rollings who recorded the mobile specular hematite but did not record its presence in outcrop. This area was considered to warrant detailed investigation has been named the Rainy Day Prospect in reflection of the weather at the time of the current investigation.

*Rainy Day Prospect*

*Previous Workings*

An old shallow prospect pit sunk on a specular hematite vein with a trace of copper oxides probably dates from the time of the initial discovery of the Warrakimbo Mine. Large blocks of undisturbed black specular hematite adjacent to the pit are unmarked indicating that the target was visible green copper mineralisation.

The pit which occurs on the northern end of a small outcrop of M4 horizon was first observed by L. Dear about 1978 who nearly rode his motorbike into it because the spoil pile is small and restricted to the downslope to the adjacent creek channel in an otherwise relatively flat terraine.

The specular hematite dips shallowly to the east and appears to be roughly parallel to the dip of the host limestone. The vein appears to pinch down dip and extends only a few meters to the south of the pit.

*Massive Specularite*

Two outcrops of mineralisation are located to the north of the prospect pit and on the west side of the creek. The two exposures are more or less in-situ but the presumed limestone host rock, evident close by, is not in direct contact with either of the masses. The bedrock in the region between the two specular hematite masses (90 m) is concealed by a small talus fan possibly a meter or more thick. Continuity of limestone beds across the fan is not demonstrable and cross faulting is inferred.

Neither outcrop contains any sign of secondary copper minerals and until this programme no sampling of significance has ever occurred. Free clasts are present in the vicinity of the main outcrop and may have been taken previously in lieu of outcrop sampling.

The small south-westerly outcrop was found first. It consists of several small black masses, clustered in an area of about a square meter that barely break through the scree deposit. The largest mass is about 30 cm across and 25 cm. high. The distribution is suggestive of a partly dismembered mass almost totally buried by talus.

The second mass lies 90 m to the NE and is far more impressive being dominated by nearly vertical rounded mini-spire about 1.25 m high and 1.5 m long, oriented parallel to the strike of the nearby limestone. A 10 m trail of large and small clasts of specular hematite mark the northerly extent of the vein. Free clasts are dispersed to the east down slope to the adjacent creek.

The thickness of the vein is difficult to estimate but probably exceeds 30 cm and the plane of symmetry is nearly upright suggesting a dip that is oblique to the local stratigraphy. The prominent mass contains visible silica which has given it resistance to weathering processes. The remainder of the vein has poor exposure because it is either thin or degraded by weathering through lack of resistive silica.

The specular hematite is coarse bladed and easily flaked, being similar to that obtained at Warrakimbo Mine. No mineralogical investigations have been initiated at this time.

The re-discovery of this mineralisation at 26,800 mE, 67,300 mN AMG underlines the potential difficulty of recognising indications of specular hematite mineralisation in the field and suggests that even the smallest trace of specular hematite justifies follow-up. Recognition of both natural processes and human intervention in the re-distribution of the material is self-evidently important.

*Geology*

Following a field visit by principals of NGM Pty. Ltd. when further traces of mineralisation were noted by C. Adsett, a decision was taken to carry out detailed mapping the immediate vicinity of the mineralisation.

Photo-geology

Prior to undertaking field work additional photo-enlargements were obtained for the area of interest and a more thorough examination of this data was carried out. Faulting in the proximity of the mineralisation was confirmed and demonstrated to be the distal extremities of minor arcuate feather faulting to the Mount Stephen Thrust.

The fault traces are difficult to pinpoint precisely due to the fairly uniform bedding in the Wilmington Formation and soil/scree cover over the Etina Formation with the exception of the M5 horizon. The fault(s) are oriented roughly north at the Thrust and swing to the NE across the Wilmnington Formation and then seem to swing northward again sub-parallel to strike and die out agianst the Elatina Formation in the east (a sigmoidal signature) (see FIg. 2).

The fault traces are focussed in the region with indications of mineralisation --- selected for detailed mapping with the addition of Jasper Hill which lies less than 100 m further north. The M5 horizon dipslope has a distinctive dark brown colour tone on the photo over this interval. Jasper debris is not the cause since the scree slope on the west of Jasper Hill has no significant contrast and the abundance of jasper on the dipslopes is much too low. A weak alteration signature that is not immediately evident in the field is therefore a possibility. This colouration is not evident on the lower carbonate horizons, which are fairly difficult to recognise in the first place.

Mapping

A grid comprising a pegged baseline at 352 Mag (1.5 west of TN) was run parallel to strike about 100 m west of the M5 hori. Cross lines were laid in at 50 m intervals and flagged at 10 m intervals. The main zone of mineralisation was covered by cross lines at 25 m intervals. The resulting grid is 1.4 km x 0.45 km in area.

Field mapping sought to identify all features directly relevant to the occurrence of the mineralisation and establish the existence and relevance of dispersed specular hematite float clasts and traces. Attention was therefore directed to the distribution of Etina Formation carbonate units, and elucidating the location of faults as well as superficial Quaternary stream and talus deposits.

The results of the mapping programme are presented in figure 6. This drawing is designed to present both factual ground truth/superficial geology and underlying Proterozoic solid geology (interpretation with superficial units deleted) and can be coloured to present these features at will. The colour scheme of drawing (A) in the back pocket emphasises solid geology and the stratigraphy of the Etina Formation limestone horizons, and drawing (B) emphasises outcrop lithology and cover units.

Etina Formation

The lithologies are little different from the Warrakimbo Mine area.

The M1 horizon outcrops weakly and is commonly only recognisable at ground level as an off-white coarse grained granular sandstone with a friable silty matrix. It is only occasional sufficiently robust to form upstanding outcrops.

The M1-M2 interval is occupied by poorly out-cropping fine grained siltstones.

The M2 hori is about 2-3 m thick and is relatively well exposed south of 10,300 mN but north of 10,500 mN exposure is much weaker, possibly due to alluvial cover. Lithologically it is typical of elsewhere. A sandy zone occurs at the top of the hori between 10,000 and 10,150 mN and a thin coarse grained arkosic bed is present at the top of the unit at 10,950 mN where it is crossed by the access track. There is no discernable brown dolomitic alteration associated with the mineralisation at 10,550 mN.

The M2-M3/4 interval is occupied primarily by fine grained mauve to grey shaley siltstone but includes minor lensy beds of sandstone and carbonate.

The M3 (/4) horizon is less prominent due to internal heterogeneity that is reflected in outcrop presentation which commonly consists of several prominenet thin sub-adjacent carbonate beds of relatively short strike. The limestone is greyish brown and not particularly distinctive. Mineralisation at the old copper pit at 10,330 mN and at 10,475 mN is unaccompanied by dolomitic alteration.

However, north of 10,600 mN the outcrop consists of band of scrappy small exposures that follow a strike trend for 275 m before disappearing northwards below alluvial cover. It is here that a fourth zone of mineralisation was recognised by C. Adsett. Detailed mapping identified four small in-situ locii of trace specular hematite, one of which is accompanied by jasper and minor copper oxide mineralisation. The scatter of specular hematite float that lies down slope toward the stream from the northern 150 m of this horizon is clearly locally sourced.

The M3/4-M5 interval naturally subdivides into a lower zone of grey-mauve silty shales which outcrop very weakly. The best exposures being between 10,250 Mn and 10,350 mN. These shales have clearly been exploited by the drainage. The upper zone (?siltstone) generally has no outcrop expression except for irregular lenses of fine grained, finely crossbedded sandstone. Sandstone outcrops typically have a dark brown weathering varnish and are only semi-continuous. Thin carbonate interlayers are sometimes recognisable in the uppermost sandstone beds just beneath the M5 horizon.

The M5 horizon is about 4 m thick and locally forms a prominent ridge with a weak westerly breakaway. It is light brown and of massive texture. Bedding is present but not very prominent. The upper-most portion of the unit (≈0.5 m) is of more greyish colour, and physically weaker due to muddy films on some bedding planes with the result that the top of the horizon is often imprecisely known.

Above the M5 hori is a relatively monotonous package of fissile finely laminated siltstones which have minor variations in weathering resistance. Locally some more competent bands can be traced but reliable correlation over long strike lengths is doubtful.

Fine grained sandstones mapped between 10.800 mN and 10,900 mN may be correlates of the M6 horizon known from the vicinity of Warrakimbo Gorge. Narrow bedding parallel bands of white clayey soil often favoured by rabbit burrows may be weathered thin (≤1 m) limestone horizons since no chippings could be identified.

Superficial Units

As observed in Warrakimbo Gorge there are two distinct historic stream deposit regimes but the elevation difference is much smaller.

The older regime is characterised by fan deposits. The largest is an alluvial fan with its apex located at 10,150 mE , 10,950 mN which is now bisected by its parent stream. This fan is partially dismembered and is characterised by mature pebbly (ABC Range Quartzite) gilgai with a remnanat of its upper soil mantle remaining along its SE edge. Much smaller talus fans along the western side of the valley are probably contemporary. These talus fans which are composed primarily of angular clasts of red brown Wilmington Formation sandstone are being dissected by their parent streams.

The second regime is characterised by pebbly alluvium adjacent to the two major streams courses about 1m lower than the oldest regime and about 1.5 m above present stream base. Pebbles are well rounded ABC Range Quartzite. These deposits are clearly relict and are under attack by the present channel system.

The present day regime comprises sandy channels with fine silty over-bank flood deposits that have no pebbly fraction of significance.

The distribution of almost all the observed floaters of jasper and specular hematite are adequately explained by downslope creep from known bedrock sources and/or redistribution by one of the recognised stream regimes. The exceptions are two clasts, one close to basline peg 10,150 mN which has no geological affiliation and the second also on the baseline at 10,325 mN relatively close to the copper prospection pit. Both may be entirely the result of human influence. None of the floaters occurr in any pattern that might be directly attributed to old copper prospecting activities such as a camp or ore sorting site.

Structure

A small ground level patch of silicified sandstone with small quartz viens at 10,060 mE, 10,410 mN is only one location where there is any direct in-situ evidnce of faulting. The remaining evidence is derived from stratigraphic discontinuities that have been correlated using M5 as a marker horison.

The southerly fault clearly dispaces the M5 horizon by 50 m in plan, eqivalent to about 2-3 m vertical (visual eastimate). The dispacement of M2 is similar but the outcrop is distorted due to contrasts in elevation on the side of the hill. The photo-geolgical trace is quite easily recognised.

The northerly fault is most evident from the stratigraphy and is photo-geologically very faint. Correlation is based on the position of M1 and the distributtion of calcarenite beds. It is immediately apparent that the displacement is in the opposite sense and about the same magnude once due allowance has been made for elevation aspects.

It is also obvious from the mapping that the northern fault must dog-leg as shown on Figure 6. However the large alluvial fan and soil cover may obscure further structural complexity. For example a strike parallel fault might trend north of the dog-leg and link up with jasper veining along the western side of Jasper Hill about 300 m north of the map sheet at about 10,050E.

The old prospect pit is very close to the southern fault and the other three specular hematite occurrences are close to the inferred position of the nothern fault confirming the strong link between subtly expressed structures and mineralisation.

Overview

The mapping at Rainy Day firmly links specular hematite mineralisation to faulting and calcarenite members of the Etina Formation.

While the distribution of mineralisation indicators would suggest that the northern fault is the most promising locality for a commercial discovery the region to the north beneath the major alluval fan should not be discounted.

Since viable pockets of specular hematite are dimensionally small targets (eg. 2 x 10 m) detection is difficult and direct sampling methods remain the most realistic. Of drilling and costeaning the easiest to impliment and most cost effective approach is carry out costeaning first, since it should improve the quality of geological knowledge leading to the optimum siting of drill holes.

# 7 PROPOSED PROGRAMME

## 7.1 Rainy Day Prospect

Plan a back-hoe costening programme for Rainy Day.

Initiate a second round of Aboriginal Heritage consultation concerning Rainy Day.

Execute costeaning mapping and sampling programme.

Review results, plan and impliment drilling where warranted.

## 7.2 Warrakimbo Area

Carry out detailed mapping of the Etina Formation along the Horseshoe Bend Fault.

Consider carrying out a limited petrological study comparing recrystallisation and alteration signatures from the Warrakimbo and Rainy Day regions.

# 8 CONCLUSIONS and RECCOMEDATIONS

## 8.1 Conclusions

The Mount Stephen Thrust is host to a 'diapiric' type fault breccia at the foot of Mount Stephen.

Epigenetic specular hematite mineralisation is associated with a style of silicic alteration (japerisation) known from the Upallina Diapir rim rocks contact zone.

Epigenetic specular hematite mineralisation is associated with secondary/tertiary level structures of the Mount Stephen Thrust Fault system.

Epigenetic specular hematite mineralisation is therefore closely associated with late Delamarian deformation and diapiric breccia injection along major faults.

The Etina Formation carbonate members remain the most prospective host lithology.

## 8.2 Reccomendations

Undertake the proposed programme of work.

# REFERENCES

AMDEL, 1987. Information Review Warrakimbo Micaceous Hematite. AMDEL Report No, OD 6357-1/1/249, March '87. (Cross reference to South Australian Department of Mines and Energy Docket. DME 46/82. *In* Open File Envelope No. 4458).

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Preiss, W.V., (Compiler) 1987. The Adelaide Geosyncline-Late Proterozoic stratigraphy, sedimentation, palaeontology and tectonics. South Australia. Geological Survey. Bulletin 53.

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Slack-Smith J., 1991. EL 1692, Hawker SA., First and Final Report for the Period . December 1990 - March 1991. Helix Resources NL, Company Report No. Technical Report 2094 (unpub.). *In* South Australia. Department of Mines and Energy. Open File Envelope No. 8410

N.G.M. PROPRIETARY LIMITED

# WARRAKIMBO SPECULAR HEMATITE PROJECT

EL No. 1759

SOUTH AUSTRALIA

## APPENDIX 92/93 REPORT:

## A BIBLIOGRAPHY OF REFERENCES

SADME ARCHIVES -- GLENSIDE SA.

Data Summarised by J.L. Curtis.

*Reference:* Report Book 76/148, DME:952/74, Mineral Resources Review 145:P 48-45

*Author:* D.C. Scott, SADME Industrial Minerals Geologist

*Title:* Warrakimbo Micaceous Hematite Deposit, Sect. 109, Hd. Barndioota, Co. Blachford.

*Tenure:* Present mine lease noted as being former MC 579 (Nov '74) of 11.25 Ha. converted to ML 4521 23 March 1976 for 7 yrs. in name of L. Morellato.

*Main Topic:* History and summary of mapping undertaken by SADME staff including N. Hein and G. Oliver. It is stored independently of Envelope 4485.

*Commentary:* Brief but thorough report. Class B environmental area.Geological Notes: Stratigraphic context established, 7 samples used to characterise host rock, alteration and hematite mineralisation by analytical and microscopic investigations. Potential viability as a paint grade resource was recognised.

Hematite associations noted:---

0.1-1% Co present affiliated with Cu traces of Cr, Zr, & W
Mn present (<1%) but without mineral speciation (solid solution? with FeOx?- JLC)
Dolomitic envelope to lode.
Mineralising solutions seem to have been corrosive to primary detrital quartz and feldspar in the sedimentary host rock.
Hematite appears to be paragenetically late with respect to dolomitic halo.
Hematite appears to be associated with late calcite and minor quartz deposition, tourmaline and ?hornblende.
Quartz in associated veins is strained (clear link to syntectonic emplacement- JLC)
Sulphides as pyrite/chalcopyrite appear to have been primary constituents in both host and hematite ore. occurring independently and as aggregates.

Secondary development of supergene Cu mins such as covellite and malachite derived from the sulphide was the target of early prospectors.

Much of the hematite is reported microscopically to contain colloform/layered geothite or voids. (It is

*Reference:* Report Book 86/019, DME 16/85,
Reproduction of Hons. Thesis without modification.
(Mineral Resources Review 156: P110 - Abstract)

*Author:* N.M. Rollings

*Title:* Micaceous Hematite Mineralisation and Geology of the Warrakimbo George, South West Flinders Ranges, South Australia.

*Tenure:* none

*Main Topic:* Focussed on the detail of mineralisation - occurrence and geological setting.

*Commentary:* RB 16/85 includes maps which cover the immediate environs of the Hematite deposit. (Fault structures and formation interlayering within the host Etina/Wilmington Formations as presented do not match well with recent large scale detailed photographs. -JLC)

********************************

*Reference:* Envelope No. 4458: #1
DME: 46/82: AMDEL REPORT No. 1511

*Author:* Alan Webb

*Title:* A COMPARATIVE STUDY OF THE PHYSICAL AND CHEMICAL PROPERTIES OF THREE SAMPLES OF MICACEOUS ORE

*Tenure:* none

*Main Topic:* Metallurgical - Crystallography
Grain Size, Density, and Oil Adsorption properties were examined. Two samples were from Warrakimbo and the another was an "Austrian Standard".

*Commentary:* The samples were presumably the same as those referred to by Rollings since the SEM photographs in his report are from this work. The original SEM Photos are better quality of larger field and scale. Original prints are in the envelope.

Three size ranges are examined in detail although separation at +28,21,15,10,7, & -7 um was undertaken.

The ranges +28, & -10+7 um were examined in detail in both bulk and washed conditions. Both SEM (b&w) and colour x45 transmitted light photographs were taken.

*Reference:* Envelope No. 4458: #2
AMDEL: PR No. 1 OD 1/1/249 Sept '80
{DME 394/77 (ENV 3081)}

*Author:* F. Radke & P.G. Capps

*Title:* WARRAKIMBO MICACEOUS IRON OXIDE

*Tenure:* none

*Main Topic:* Work was undertaken to investigate the benefication potential for the hematite ore.

*Commentary:* The progress report indicates liberation of gangue and sulphides from the hematite was quite successful & recommends further work regarding separation.

Trace element chemistry was undertaken.

*Request:* R.L. Wildy

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*Reference:* Envelope No. 4458: #3
AMDEL: PR No. 2 OD 1/1/249 Apr '81
{DME 394/77 (ENV 3081)}

*Author:* J.K.W. Ellis

*Title:* WARRAKIMBO MICACEOUS IRON OXIDE

*Tenure:* none

*Main Topic:* Metallurgical investigations - magnetic and flotation testing.

*Commentary:* The work showed that the magnetic fraction was predominantly black . The non magnetic portion was of red brown colour and incorporated 20-30% of the samples Cu content. The magnetic fraction was then treated by flotation and 90% of the remaining sulphur (sulphide) was successfully removed.

Desliming improved the sulphide removal efficiency.

A recoverable? gold content was also identified! .065-.170 g/tonne being detected in the -75 & -212 um feeds.

*Request:* R.L. Wildy

*Reference:* Envelope No. 4458: #4
AMDEL: OD 1/1/308 JUL '85
{DME 46/82 }

*Author:* J.K.W. Ellis

*Title:* WARRAKIMBO MICACEOUS IRON OXIDE

*Tenure:* none

*Main Topic:* Communition and gravity separation testing.

*Commentary:* Rolls/Impact Crushing and Gravity Separation tests on two samples of high & low grade respectively. The tests indicate impact crushing followed screening and jigging of +500 um fraction was most effective.

*Request:* R.L. Wildy

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*Reference:* Envelope No. 4458: #5
AMDEL: GS 1/6/0 Apr '86
{DME ???? }

*Author:* Dr. A.W. Webb

*Title:* WARRAKIMBO MICACEOUS IRON OXIDE

*Tenure:* none

*Main Topic:* Sizing and chemical analysis of micaceous hematite.

*Commentary:* Sample EX 494

*Request:* J. Townsend

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*Reference:* Envelope No. 4458: #6
AMDEL: AC 1913/86 Nov '85
{DME ???? }

*Author:* D. Patterson

*Title:* WARRAKIMBO MICACEOUS IRON OXIDE

*Tenure:* none

*Main Topic:* Analyses for magnetic separation products.

*Commentary:* Sample Ex 438.

*Request:* R.K. Johns
*Reference:* Envelope No. 4458: #7
AMDEL: GS 6433/84 Feb '84
{DME 46/82}

*Author:* Dr. A. Webb.

*Title:* WARRAKIMBO MICACEOUS HEMATITE

*Tenure:* none

*Main Topic:* Evaluation of physical properties for comparison with previous samples.

*Commentary:* Sample Ex 107 was screened and reconstituted to provide size ranges that matched those studied in Amdel report 1511. The sample was investigated by SEM and a higher proportion of the sample reported to the -106+25 um range, smaller in the -25+13 um, and similar -13 um ranges.

The shapes were not materially or significantly different. Full page original SEM Photos are present.

*Request:* R.L.W. ..(Wildy)

**********************************

*Reference:* Envelope No. 4458: #8
AMDEL: OD 6357-1/1/249 Mar '87
{DME 46/82}

*Author:* Not listed on report.

*Title:* INFORMATION REVIEW

WARRAKIMBO MICACEOUS HEMATITE

*Tenure:* none

*Main Topic:* Coverage of all information sources.

*Commentary:* A brief abstract/summary of 22 technical/analytical reports and their origins, was prepared for databasing. Linking between reports where relevant has also been annotated.

An overview of each general area of investigation is also provided.

*Request:* SADME

*Reference:* Envelope No. 6866 #1
RIMAC HOLDINGS Pty. Ltd.

*Author:* N.M. Rollings.

*Title:* Ist. Qtly. Rept. 13/08/87

*Tenure:* EL 1402

*Main Topic:* Landsatt Imaging

*Commentary:* Somewhat unrealistic/academic attempt at application of Landsatt imagery to seeking very small target reflectance area with respect to detection pixel size. Alteration halo recognised as being more realistic but target/pixel ratio still about 1:3 even with higher precision Thematic Mapper / Spot systems. (Reasonable prospect of detection if targets were significantly larger than the Warrakimbo Deposit. Non-recognition of it is unlikely given the strong copper association and signature from past prospecting history - JLC)

Conventional exploration mooted.

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*Reference:* Envelope No. 6866 #2
RIMAC HOLDINGS Pty. Ltd.

*Author:* N.M. Rollings.

*Title:* 2nd. Qtly. Rept. 13/11/87

*Tenure:* EL 1402

*Main Topic:* Landsatt Imaging, but major emphasis on conventional exploration.

*Commentary:* Further consideration of Satellite Imagery to generate targets based on quasi-theoretical grounds. However regions defined very large and nebulous with respect to conventional methodologies such as aerial photography.

Reversion to more conventional exploration technologies of stream/rock geochemical sampling, geophysical and basic field observations followed.

Stream Orientation:

Hematite detected using Fe3+/Fe2+ ratio. A 300-400m lag in the main creek was noted. Sample spacing of 200m was recommended.

A Cu/Au/As association was noted.
(Samples with Specularite would be expected to report as HM accumulations to some extent but not strictly due to hydrodynamics of the flakes. Accumulation in drainage would be often controlled by these special hydrodynamic aspects and may not follow the pattern of HM or clay/silt/humate adsorption accumulators usually relevant to such sampling.

Conventional active high velocity tracts of the drainage may be unexpectedly poor sample sites for stream sampling the Fe 3/2+ ratio where full disaggregation and high fragmentation of the specular hematite has occurred. Results of the above programme did not address this and should be regarded with caution. The Cu/Au/As results should not be adversely affected by these aspect. In particular the value of Willochra Creek is quite doubtful due to its stream magnitude and an active mine contamination source.- JLC)

Field Follow up:

Stream results were followed up and a number of potentially relevant observations were made.

A sample of altered mafic rock "dolerite" (SN 16223) was found and analysed giving anomalous Au/Cu/As/Ag. The sample site is SE of the horseshoe bend Fig 6866-6 and probably related to SN 16224 (This correlation may indicate a link to the similar weak association for the Specular hematite. The well documented Mafic association and occasional occurrence of specular hematite in diapirs is hard to dismiss. - JLC)

Micaceous Hematite Sites: DRAWING 87-006

27500mE 68000mN

Two semi- adjacent ridges of Etina Limestone appear to shed specular hematite into ?adjacent ?creeks. Southern of two ridges has specular O/Cs &

considered to be more prospective. Ridges 800m apart: Sample Nos. 146228,-229, west of woolshed: see drawing 87-006/6866-6 (87-017A detail sketch appears to be missing, 017B, 017B are ground magnetic profiles without geological ground truth.

(Inferred to be EW oriented from description - perhaps related to major thrust plane? The location reference corresponds with jasper hill but the sketchy data does admittedly after the event fit some of the features concerning Rainy Day -JLC)

25000mE 60000mN
Specular hematite recognised in drainage on west side of Mt. Stephens Saddle and as joint paint on quartzite. Sample No. 146223 drawing 87-006/6866-6. (Probably being released from the concealed diapiric breccia in the Mount Stephen Thrust -JLC)

25000mE 58000mN
Etina Formation Limestone recognised out of stratigraphic sequence position at Mt. Stephen Saddle - old workings Cu & specular hematite in adjacent creeks: sample No 146235 & 236 drawing 87-006

(South of current title, not traced to source-could relate to above Specular hematite -meggabreccia?? in thrust fault?: samples are south of 146223 see above - how does the "west" fit?? Limestone is not Etina but dolomite blocks in Mount Stephen Thrust Breccia probable Callana Group - JLC).

Geophysics report refers to steep easterly dipping shallow to very shallow tabular magnetic sources (5) and the existence of dolerite?: 146223 reputed to contain magnetite

500?0mE 565500mN
Specular hematite recognised in creek with associated malachite (Cu geochemical results), dolomitised Etina formation nearby. Sample No: 146248, (not shown on drawing 87-006/6866-6).

(Unlabeled sample sites due west of "Partacoona" lat 32dg approx. is probable location, well south of current title but could warrant follow-up. -JLC)

Geophysical Surveys.
These are poorly reported against geology in all cases and difficult to assess because the mine

infrastructure/voids may have affected the orientation survey. Both micro-gravity and magnetic total field/gradient were employed and appeared to give some signature.

Localities tested: Mine, Windy Ridge, & Styolite

Interpretation appears to have been qualitative only. In a number of localities "dolerite dykes" were indicated/assumed as magnetic sources but no maps supporting such conclusions are provided. To some extent the interpretation appears to pre-empt later surveys. Follow-up surveys were planned.

(Dykes may be mafics in Mount Stephen Breccia.

***Appendix:*** Petrology report in appendix to sample No 146223 from Pontifex. Albite/Tremolite rock epidote, magnetite, carbonate-bladed Hematite veins, 10-5% each.

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***Reference:*** Envelope No. 6866 #3
RIMAC HOLDINGS Pty. Ltd.

***Author:*** N.M. Rollings.

***Title:*** 3rd. Qtly. Rept. 13/02/88

***Tenure:*** EL 1402

***Main Topic:*** No significant data.

********************************

***Reference:*** Envelope No. 6866 #4
RIMAC HOLDINGS Pty. Ltd.

***Author:*** N.M. Rollings.

***Title:*** 4th. Qtly. Rept. 13/05/88

***Tenure:*** EL 1402

***Main Topic:*** Gravity and magnetic data. Solo Geophysics : Field Operations Rept, Data printout and profiles.

***Commentary:*** No comprehensive modelling or geophysical interpretation is provided along with this latter data.

The title holder seems to have lost interest and dismissed the area as only likely to contain deposits that are too small to warrant commercial potential.

(It would seem that since the Warrakimbo deposit is potentially commercially significant and its surface expression would have originally been quite small and at some levels in the mine probably very small this does not hold up very well as an argument based solely on the nature of surface expression. -JLC)

*Reference:* Envelope 1492
Australian Hanna Ltd.

*Author:* M.D. Watts

*Title:* Geology and Geophysics Neuroodla Area SA.

*Tenure:* S.M.L. 478

*Main Topic:* Ground magnetics.

*Commentary:* Ground search for an aeromagnetic anomaly was unsuccessful, feature presumed to be instrumentation error. (Anomaly was originally inferred to be of diapiric origin).

However ground survey data shows weak 20-50 y anomaly with approx NS orientation straddling the creek (approx EW). Relative magnitude of airborne and ground anomalies appears consistent. Disparity may be due entirely due to base level definition differences.

(Report offers no significant contribution to the search for specular hematite.)

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*Reference:* Envelope No. 8410
Helix Resources NL (Myall Exploration NL)

*Author:* J. Slack-Smith.

*Title:* First and Final Report for the period December '90 - March '91.

*Tenure:* EL 1692

*Main Topic:* Diamond Exploration, Stream sampling and investigation of Warrakimbo Woolshed Diapiric breccia.

*Commentary:* Mineral assemblage of diapir well described includes reference to alteration and specular hematite - associated carbonate veining. Ultramafic component and exotic Cr-pyrope garnets identified. One micro-diamond (found near Rainy Day locality) only result from stream programme.