NT SF 53-14 Alice Springs

WHITE HILL DAM GOLD PROSPECT

EXPLORATION LICENCES NO'S 4463 AND 4528

This Geological report covers the exploration work carried out from commencement to the end of November 1986 on Exploration Licences No's 4463 and 4528.

Report January 1987 by
Ken I Nielsen, Geologist
MAIMM MGSA MASEG MMICA MAIG
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SUMMARY

The White Hill Dam Gold Prospect is located in the Harts Range in the Northern Territory, approximately 100 km northeast from Alice Springs. Two exploration licences, No's 4463 and 4528, were granted to Kinex in May 1984; they now comprise 58 square kilometres.

Geologically, the area is part of the Arunta Block, Early Proterozoic, with highly metamorphosed rocks, including amphibolites and granulites. Structurally, the rocks have been deformed during several metamorphic episodes, and folds, isoclinal to open, of greatly varying scale and plunge are common.

In earlier exploration, a 900 m by 1 m gold mineralisation, say three grams gold per tonne, was discovered even though the area is not known as a gold province. In the later exploration, an anomalous zone has been delineated by geological mapping, interpretation of aeromagnetic data and geochemical C-horizon exploration using bulk cyanide leaching assay techniques.

The origin and distribution of the gold mineralisation are not known, but the exploration methods applied in the latest exploration have proved effective and it is recommended that the exploration until now be considered an orientation survey and that exploration be continued using these methods.
INTRODUCTION

Kinex and Kinex personnel have been associated with exploration in the Harts Range in the Northern Territory since 1971, with early exploration carried out as employees of Russgar Minerals. In regional geochemical exploration, rock samples from the White Hill Dam area yielded high gold assay values, and Kinex, late in 1983, applied for exploration licences to cover the area now referred to as the White Hill Dam Gold Prospect. The licences were granted to Kinex in May 1984, and this report discusses the exploration and exploration results for the period of the licences.

LOCATION, ACCESS AND TENURE

The centre of the White Hill Dam Gold Prospect is 102 km on bearing 52 degrees from Alice Springs. Access is by four-wheel-drive vehicles, and water supplies, a few bores and dams, are not reliable, see report in appendix D for further access details.
WHITE HILL DAM GOLD PROSPECT

EXPLORATION LICENCES

1:250,000
REF: SF 53-14

KINEX PTY LTD
APRIL 1986

Dwg No: 1032
The two exploration licences originally applied for and granted on the 31st May 1984, for a term of six years, pending renewal, Exploration Licence No's 4463 and 4528, comprised 36 EL blocks, where a block is one minute squared. The area was reduces by 50% when the licence renewal applications were submitted on the 30th April 1986, and EL 4463 now covers 12 blocks and EL 4528 covers 6 blocks, see map page 4, a total of 58 square kilometres.

Kinex has made an arrangement with Balmoral Resources NL such that Kinex is to transfer all its interests in the licences to Balmoral. The arrangement has now been formalized.

EXPLORATION

In the early 1970's, the exploration was regional and the target mainly copper mineralisation; in all some 2,600 square kilometres were explored. The main components of the regional work were prospecting and geological mapping combined with rock geochemical sampling. An aeromagnetic survey was also completed. The Oonagalabi Copper Zinc Prospect, to the east from White Hill Dam, was found as a result of the regional work, and the gold mineralisation at the Copper Queen (in the present area) was also found at that time.

In the ensuing years, a number of substantial surveys were completed on the Oonagalabi Prospect, and only in 1984 was the White Hill Dam area again examined. The rock
geochemical data (Cu, Pb, Zn, Ni) was replotted and analysed, and the geology reinterpreted (colour aerial photographs) and redrafted. Field surveys were carried out to check the regional mapping, and a detailed mapping and sampling programme completed on the Copper Queen mineralisation. The exploration and the results are discussed in the report in appendix D.
The exploration in the 1984/85 year was carried out exclusively by Messrs I R F MacCulloch and K I Nielsen of Kinex, whereas in the 1985/86 year, the exploration work was done in part by MacCulloch and Nielsen, and in part by Dr E Leitch (geological mapping and sampling) and in part by Mr J Slade (aeromagnetic interpretation). The aeromagnetic data (flown by Geophysical Resources Development Company in 1970) was matched to the 1:23,500 (aerial photo scale) geological map, see Early Regional Geology, Rock Geochemical Values and Aeromagnetic Contours map in appendix E, to test for correlations, in the first instance, and the aeromagnetic data was then interpreted by Mr J Slade, see report in appendix C. The geology was again revised, partly in the office and partly in field surveys, and a combined mapping and sampling programme, see report in appendix B, was completed, as was a C-horizon power auger drilling programme with 30 holes drilled in four drill hole lines. The C-horizon samples were assayed for gold by fire assay, 100 grams buttons (Australian Laboratory Services). The geology, sample locations and drill lines are shown on the Geology and Sample Locations map in appendix E.

The Exploration expenditure for the period from the 31st May 1984 till now amounts to $47,724.00.

GEOLOGY AND MINERALISATION

The Harts Range Area, and thus the White Hill Dam Area, is part of the Arunta Complex or Arunta Block which extends over an area of some 400,000 square kilometres. The rocks of the Arunta Block are Early Proterozoic, high grade regional metamorphic rocks, amphibolite and granulite
regimes, after five or more metamorphic episodes with three of these being major orogenies.

Mount Schaeber

In the latest mapping, the rocks have been subdivided into five groups, namely (1) Ongeva Creek Granulite, (2) Blackfellows Bones Granulite, (3) Cadney Gneiss, (4) Irindina Gneiss and (5) Gough Dam Schist. Small intrusives associated occur within the rocks of these groups, and a large intrusion, the Mount Schaeber Granite, occurs in the southwest corner of the prospect area. Structurally, the early deformation probably consisted of east-west trending isoclinal folding with two later periods then refolding these folds and any remaining lithological structures into folds with widely varying closures and plunges - a number of domains can now be recognized. The geology is shown on the
map Geology and Sample Locations in appendix E, and on the 
map on page 8, and the geology is discussed in detail in the 
reports in appendices B and D.

In the early exploration, a 900 m long east-west striking 
conformable garnet-pyroxene unit in the Cadney Gneiss with 
gold and copper mineralisation was examined in some detail. 
The orthogonal thickness of the mineralisation is about one 
metre and the grade of the order of three grams gold per 
tonne and one to three percent copper. There is no 
correlation between gold and copper (oxidised) values, and 
sulphide mineralisation has not been observed (but at 
Oonagalabi, 20 km to the east, zinc, iron and copper 
sulphide mineralisation has been encountered at depth, and 
at the surface in marble).

In the recent exploration, the targets were extensions to 
and other zones of Copper Queen type mineralisations. The 
aeromagnetic data was again examined (see report in appendix 
C, and magnetic susceptibility data in appendix A), a large 
part of the area was re-mapped, and an orientation 
geochemical survey completed. The geological mapping and 
the aeromagnetic interpretation independently suggest a 
three to four square kilometres anomalous zone - zone of 
potential mineralisation - in the centre of the area, see 
map in appendix E and map on page 8.

The values for 33 geochemical rock chip samples, see 
appendix A, range from <0.01 to 0.08 ppm Au and may weakly 
indicate a concordent pegmatitic veins gold association. 
Further data is needed. The C-horizon geochemical 
orientation survey (drilling, then bulk cyanide leaching) 
yielded assays from <0.05 to 1.90 ppb Au in thirty samples, 
see appendix A. If the background value is taken as about
0.45 ppb Au, then the results for the 12 holes in drill line 4 are: 4 results just above background, 4 results twice background, 2 results thrice background and 2 results four times background - rather anomalous compared to the other three drill lines.

Western Limit, Copper Queen

CONCLUSION

The exploration until now of the White Hill Dam Gold Prospect has established that gold mineralisation occurs in an area not previously considered a gold province, and a 900 metre by 1 metre, say three grams gold per tonne, mineralisation has been located, plus a rather large anomalous zone. Superficially, the gold may appear to be
associated with copper, but it is more likely that the copper mineralisation is indigenous and the gold mineralisation much younger – very fine grained gold mineralisation.

The combination of re-mapping and aeromagnetic interpretation has been useful in the delineation of a anomalous zone, and the C-horizon geochemical survey, using bulk cyanide leaching assay techniques, has been shown to be an adequate technique in an area where the origin and type of the gold mineralisation is not as yet known.

It is suggested that further exploration is warranted, and that such exploration should include further and slightly more detailed geological mapping, rock chip geochemical sampling (bulk cyanide leach assaying) coupled with further C-horizon sampling in areas of Quaternary eluvium. The use of both aerial and ground magnetometer surveys should be considered.
APPENDIX A
CHIP SAMPLING  SAMPLING LOG

HR 4) Cadney Gneiss
HR 5) Veins associated with mylonitic pegmatites
HR 3) Cadney Gneiss - late - stage quartz-epidote segregation vein
HR 2) Cadney Gneiss
HR 21) Late-stage cross-cutting quartz veins
HR 19) Cadney Gneiss - veins associated with copper-stained gneiss
HR 34) Ongeva Granulite - Concordant quartz veins
HR 23) Blackfellow's Bore Granulite
HR 25) Broadly concordant, commonly pegmatite associated veins
HR 36)
HR 37)
HR 38)
HR 9) Irindina Gneiss
HR 10) Quartz veins associated with cupriferous gneiss
HR 11)
HR 13)
HR 15) Irindina Gneiss
HR 42) Early metamorphic segregation veins
HR 17) Irindina Gneiss - Pegmatite - associated veins
HR 14) Irindina Gneiss - Late-stage discordant veins
HR 24) Gough Dam Schist (northern zone)
HR 39) Concordant veins
HR 41)
HR 32) Gough Dam Schist - Pegmatite related veins
HR 6) Gough Dam Schist (southern zone)
HR 7) Concordant veins, some pegmatite related
HR 8)
HR 27)
HR 28)
HR 29)
HR 30)
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WHITE HILL DAM GOLD PROSPECT

DRILL HOLE SAMPLE DESCRIPTION

LINE 1

Hole 1 - sample 1/1.
30m from tree on bearing 345°T. Top of calcrete = 1.7m. Lithologies: quartz/biotite schist. Sample from 1m below top of calcrete.

Hole 2 - sample 2/1.
Top of calcrete at 1.8m. Lithologies: quartz and biotite metamorphics and feldspar fragments. Sample from 1m below top of calcrete.

Hole 3 - sample 3/1.
Gravel encountered at 1m (drilling aborted) - sample at this stage (3/1). Noticeable amphibolite chips.

Hole 4 - sample 4/1.
Bedrock (? or large rock) at 1.4m - micaceous schist. Lot of mica in sand (also a lot of outcrop nearby). Sample taken at this level.

Hole 5 - sample 5/1.
Located between two stream courses - gravel encountered at 2.3m, with chips of quartz-biotite schist.

Hole 6 - sample 6/1.
Gravel encountered at 2m (chips of amphibolite and quartz, biotite, feldspar). Cut through, and encountered gravelly sand (muscovite flakes and quartz chips - some calcrete and mica schist). Definite calcrete encountered at 2.8m, and sample taken at 3.8m (ie 1m below top of calcrete).

Hole 7 - sample 7/1.
Last on this line. Gravel at 2.3m (chips of quartz, mica schist, amphibolite). Calcrete at 2.8m - sample taken at 1m below this in a buff coloured gravelly sand.

LINE 2

Hole 1 - sample 1/2.
Gravel at 2m - drill stopped. Sample taken.

Hole 2 - sample 2/2.
50m from hole 1 on bearing 225°T. Calcrete at 1.2m. Material is a fine-grained grey-brown silty sand with mica schist chips. Sample at 1.9m as drilling aborted.
Hole 3 - sample 3/2.
Poor penetration, as o/c approximately 10m away. Max penetration only 0.5m (sample taken) comprising friable sand with rare (?amphibolite) chips.

Hole 4 - sample 4/2.
Lot of o/c nearby. 1m - minor calcrete (and rare chips of amphibolite + 1 piece of calc-silicate) in an grey-brown sandy silt. Maximum penetration is 1m (sample taken).

Hole 5 - sample 5/2.
No visible o/c. At 1.5m, bottomed on mica schist (sand has noticeable mica flakes) - sample at this level.

Hole 6 - sample 6/2.
No visible outcrop nearby. At 0.8m, penetrated a weathered brown rock, with cemented grains of quartz and mica. Determined as a ferricrete. Sample taken at this level.

Hole 7 - sample 7/2.
No visible outcrop. Ferricrete at 0.5m, penetrated at 0.8m (ie 30cm thick). Weathered mica schist encountered at 1.8m - sample at this level.

Hole 8 - sample 8/2.
No visible outcrop. Mica schist and amphibolite fragments at 2.8m - drilling easier here. Drill stops at 3.2m (too hard) - some fragments of quartzite, mica schist and amphibolite. Sample taken at 3.2m.

Hole 9 - sample 9/2.
Last of this line located approximately 20m from blazed tree. Ferricrete at 0.7m - drilled through it. Very few rock fragments - alluvium seems thick here. Some ferricrete fragments. Drill stopped at 3m (sample).

LINE 4 (Line towards Copper Queen)

The first two holes were drilled on Friday 27th June. 100m spacings on a line bearing 165T from track junction to a blazed tree (approx 500m) then a bearing of 175T to the end.

Hole 1 - sample 1/4.
Calcrite at 2m. Sample taken approx. 0.2m below this.

Hole 2 - sample 2/4.
Calcrite at 2.75m. Sample taken approximately 0.2m below this (?).
Hole 3 - sample 3/4.
Conspicuous amphibolite and quartz schist fragments at 1.6m. Colour change to lighter sand here (calcrete). Sample taken 1m below this at 2.6m.

Hole 4 - sample 4/4.
Amphibolite and quartz schist chips at 1.7m, with minor calcrete. Rare feldspar fragments (?pegmatite). Sample at 2.7m.

Hole 5 - sample 5/4.
Gravel at 1.8m (? calcrete). Rock hit at 2.4m. Sample taken here.

Hole 6 - sample 6/4.
First hole after change in bearing to 175°. Calcrete-cemented gravel at 3m. - drill impeded and sample taken at this level.

Hole 7 - sample 7/4.
Calcrete (grey with amphibolite and quartz schist chips) at 1m then 2m of poorly-cemented calcrete - sample taken at 3m.

Hole 8 - sample 8/4.
Calcrete gravel (slight colour change) at 1.6m. Sample taken at 2.6m.

Hole 9 - sample 9/4.
Pebbly sand for first 1m. Calcrete chips at 0.8m, which are finer than before. Sample at 1.8m.

Hole 10 - sample 10/4.
Calcrete at 1.8m. Large rock at 2.4m - sample taken at this level.

Great thickness of stream alluvium here as only 2m from stream bed At 4.3m, hit rock - sample at this level.

Hole 12 - sample 12/4.
Calcrete cemented gravel at 0.8m - drill impeded at 1.2m - sample taken here.

LINE 5

Hole 1 - sample 1/5.
Located 30m from blazed tree in direction 170°. Gravel at 3.2m comprising chips of quartz, feldspar micaeous metamorphics, and amphibolite. Quartz and feldspar chips resemble pegmatites. Possible calc-silicate fragments. Chips up to 2.5cm long. Subangular and occasionally fractured. More chips here than previous holes, including large mica flakes. Sample taken at 3.8m.
Hole 2 - sample 2/5.
Located 150m on bearing 170T from Hole 1. Gravel at 3.7m - chips of quartz, feldspar, mica flakes. Is a course sand - pebbly sand. Occasional micaceous schist chips. Sample taken at 4.4m.
### Laboratory Report

**Client:** KINEX PROPRIETARY LIMITED  
**Address:** P.O. BOX 167  
GORDON  
N.S.W.  
2072

**Contact:** MR. I. MacCulloch

**Order No.:** LETTER (FAX)  
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NT SF 53-14 Alice Springs

APPENDIX B

GEOLOGICAL REPORT

WHITE HILL DAM PROSPECT

EL 4528 and EL 4463

HARTS RANGE, NORTHERN TERRITORY

SEPTEMBER 1986

Report by
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M Sc Ph D FGS

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INTRODUCTION

Work presented in this report was carried out under instruction from I.R.P. MacCulloch of Kinex Pty Limited. Eleven days were spent in the field in the Barts Range, mainly in a regional appraisal involving major revision of then-current company mapping, reconnaissance structural investigations, appraisal of areas of known mineralization and hard rock (mainly quartz vein) and alluvial sampling for anomalous gold values. Approximately 500 in situ magnetic susceptibility measurements were made in order to aid interpretation of aeromagnetic data.

This report presents only field data; rock determinations are based only on hard specimen examination. However a representative set of lithologies were collected and are at present being prepared for microscopic study. They may form the basis for a later report.

LOCATION, ACCESS AND TENURE

These aspects were dealt with in detail in the Kinex report of July 1984 by MacCulloch and Nielsen. The material below is an updated version of that report. I have no direct knowledge of the present tenure of the exploration licences.

EL 4463 and EL 4528 informally referred to as the White Hill Dam Prospect, are situated in the Barts Range district in the southeastern part of the Northern Territory. The centre of the licence area is 102 km on a bearing of 52 degrees from Alice Springs. From Alice Springs the area is reached by driving north 68 km on the Stuart Highway and then east for 96 km on the Plenty Highway to the Blackfellow's Bones Bore track turn off (immediately east of the Highway crossing of Ongeva Creek). The Blackfellow's Bones Bore track is followed southeast for about 20 km to the western limit of EL 4528. The track runs approximately west to east across
the White Hill Dam Prospect area and continues further east to Oonagalabi. The Blackfellow's Bones Bore track is dirt and best negotiated in a four-wheel drive vehicle. The route from Alice Springs to Ongeva Creek is bitumen.

Exploration Licences 4463 and 4528 were granted to Kinex Pty Ltd on the 31st May 1984 for a term of six years. The licences together comprise 36 EL Blocks, where a block is one minute square. EL 4463 encompasses 24 blocks and EL 4528 12 blocks. The total area of the licences is 116 square kilometres.

GEOLOGY

Except for areas of Quaternary alluvium, rocks exposed in the White Hill Dam Prospect comprise high-grade regional metamorphic lithologies of Early Proterozoic age and small associated intrusions. Descriptions of the geology of the prospect are included in a number of regional accounts of the rocks of the Harts Range. Joklik (1955) described the geology of about 2,000 square miles of the central Harts Range in a monograph that covered the regional geology, petrology and mica deposits. More recently Shaw adn Wells (1983) and Shaw, Stewart and Rickard (1984) have produced regional maps and brief summaries. Warren (1980) gave a short description of some mineral deposits on the Alice Springs 1:250,000 sheet, and Stewart and Warren (1977) mention some White Rock Dam prospect locations in their review of the mineral potential of the Arunta Block. MacCulloch and Nielsen (1984) reported on aspects of the area for Kinex, as also did Leitch in a preliminary account of the present work for Kinex (Leitch, July 1986).

ROCK UNITS

Various divisions of the metamorphic rocks of the Harts Range have
been proposed by previous workers (eg Joklik, 1955; Shaw and Wells, 1983; Shaw, Stewart and Rickard, 1984). In this report five major groups of these rocks are distinguished, defined mainly on the range of rock types found associated and their relative abundances. While some of these groupings may be stratigraphically significant, they are not based on any inferred stratigraphic principles, the application of which would require much more detailed study than that of the present study. Within the groups, areas in which a single rock type, or closely related rock types, predominate, can often be recognized. These, as well as the primary divisions are shown on the accompanying geological map. Boundaries on the map are the result of the present field observations, colour air photograph interpretation and the interpretation of earlier maps.

ONGEVA CREEK GRANULITE

Granulite facies rocks in the southeast corner of KL 4529 surround the Mount Schaeber Granite and are collectively referred to as Ongeva Creek Granulite. This grouping encompasses closely associated mafic, felsic and silicic granulites that are veined by aplite and pegmatite. Fluidal structures and intrusive relationships indicate a migmatitic character for some of these rocks. Prominent well foliated metaquartzite occurs close to the Mount Schaeber Granite. No calc-silicate rocks were recognized in this unit, which may originally have been a pile of diverse volcanic flows. The presence of cordierite in some rocks suggests high temperature but relatively low pressure metamorphism. Although air photo interpretation suggests that the rocks are cut by several sets of faults no evidence of retrogression was noted. The Ongeva Creek Granulite is bounded to the northeast by the southern zone of Gough Dam Schists with an inferred faulted contact. Shaw, Stewart and Rickard (1985) mapped out distinct zones of mafic and felsic granulite within the Granulite but this did not prove possible during the present survey.
BLACKFELLOWS BONES GRANULITE

The Blackfellows Bones Granulite consists of two major lithologies that can usually be readily separated even during reconnaissance mapping. Mafic granulites are mostly rather equigranular aggregates of plagioclase and pyroxene often with accompanying garnet and/or hornblende. These granulites form dark coloured outcrops, usually of lensoidal or ovoid shape. They are mostly massive, but in a few outcrops show a layered structure, resulting from variations in plagioclase content, or a foliation defined by the alignment of prominent crystallographic directions. By contrast felsic granulites comprise aggregates of quartz, feldspar and biotite with the accessory phases cordierite and garnet. The most quartzose of the rocks are appropriately termed biotite quartzites which grade, with increasing feldspar content, into quartzose gneiss and quartzofeldspathic gneiss. Felsic granulites have a similar range of fabric types to the mafic granulites but typically form yellow or orange weathering outcrops, resistant to erosion and with little vegetation. Felsic granulites are more common than those of mafic character in the Blackfellows Bones granulite.

In the east-central part of EL 4528 the granulite has a migmatitic structure and is host for a number of small granitic bodies. Pegmatites occur widely throughout the unit. As with the Ongeva Granulite mineral assemblages indicate high temperature/low pressure regional metamorphism. The shape of many of the mafic granulite bodies suggests they were once small basic intrusions, perhaps into a sequence of fairly mature sedimentary rocks, the latter now represented by the felsic granulites.

The Blackfellows Bones Granulite is separated from the Ongeva Granulite by the southern zone of Gough Dam Schist, and its relationship to this Granulite is unknown. Both contain a similar range of rock types but felsic granulites are more common in the
Blackfellow's Bones Unit. A zone of Gough Dam Schist also separates the latter unit from the Irindina Gneiss. The lower metamorphic grade of the Gneiss suggests the Blackfellow's Bones Granulite may have been uplifted along this northern zone. In the east the Granulite is in contact with the Cadney Gneiss. This contact appears conformable and the amphibolite facies of the Cadney Gneiss suggests it lay structurally above the Granulite during regional metamorphism.

CADNEY GNEISS

Calcsilicate rocks are the most characteristic lithology of the Cadney Gneiss. They comprise rocks consisting of varying proportions of brown (grossular) garnet, epidote, diopside, amphibole and calcite that are commonly thinly banded but show little foliation. Locally the rocks have recrystallized, seemingly under hydrostatic conditions, with the production of coarse quartz-epidote-(garnet)-(ilmenite) rocks.

With increase in carbonate content the calc-silicates pass into coarse equigranular marble, which forms elongate lenses in the Copper Queen area. Increase in amphibole leads to the production of dark coloured amphibolites that outcrop in irregular masses within the Cadney Gneiss. Biotite gneiss is a significant member of the Cadney in the area around Fannikin Dam and further east. These rocks are generally well foliated types which while dominated by biotite, quartz and feldspar also contain pink (almandine) garnet and sillimanite. Lenses of quartzofeldspathic and quartzose gneiss occur throughout the Cadney Gneiss. They are readily recognized by their orange coloured outcrops that are often more resistant to erosion than surrounding lithologies. These rocks, the principal variation in which are the result of differing quartz to feldspar ratios, are often well foliated with layering defined by aligned biotite flakes.
Most of the Cadney Gneiss occurs between the southern Gough Dam Schist zone and the eastern extension of the northern Gough Dam Schist zone. However, an area predominantly of calcsilicate rocks in the northeast of EL 4463 previously mapped as Irindina Gneiss (Shaw, Stewart and Rickard, 1984) is also included in this unit. This occupies an antiformal culmination which, if the interpretation is correct, shows that the Cadney lies structurally below the Irindina Gneiss. Although this contact has been previously interpreted as an unconformity no convincing evidence for such a relationship was noted during this survey.

The Cadney Gneiss comprises a lithologically diverse sequence, probably of relatively shallow-water limestone, calcareous sandstone, sandstone and shale, that has been highly deformed and metamorphosed under amphibolite facies conditions. Pegmatites are widespread throughout the Cadney Gneiss but no migmatitic structures have been recognised nor any minor silicic intrusive bodies.

**IRINDINA GNEISS**

Layered gneisses that outcrop boldly in the northern part of EL 4463 consist mainly of amphibolite, biotite gneiss and quartzofeldspathic gneiss. These rocks comprise the Irindina Gneiss. Amphibolite is the major rock type and consists of plagioclosehornblende aggregates most of which contain smaller amounts of garnet or pyroxene. Many of the amphibolites are layered and foliated. Biotite gneiss shows the assemblage quartz-feldspar-biotite-(garnet)-(sillimanite) and is also strongly foliated and lineated, the latter structure being especially prominent in sillimanite-bearing rocks. With increase in the abundance of quartz and feldspar, biotite gneiss. The latter rock type is typically more massive than other members of the Irindina Gneiss.
Interlayering of the main lithologies in the Gneiss occurs on a range of scales. Some amphibolite layers are in excess of 200 m thick but more often layers are 0.5 to 10 m thick with mapped units being characterised by the abundance of a particular rock type rather than its exclusive occurrence.

Locally quartzite, garnet quartzite, marble and calc-silicate rocks occur within the Irindina Gneiss.

Metamorphism of the Gneiss occurred under amphibolite conditions. The nature of the protolith is uncertain. The strongly layered character of the unit indicates the rocks were stratified but it is unclear if the rocks are all of sedimentary parentage or whether at least the amphibolites had igneous progenitors. As indicated previously the Irindina Gneiss probably lies structurally above the Cadney Gneiss. Shaw, Stewart and Rickard (1985) considered there was a difference in structural complexity between these two units and certainly the Irindina Gneiss forms more planar and more continuous layers. However, on a mesoscopic scale the two units show a comparable structural history.

Pegmatites occur widely within the Irindina Gneiss.

GOUGH DAM SCHIST

Rock units that have suffered significant amounts of retrograde metamorphism are collectively grouped in the Gough Dam Schist. The most characteristic rock is a micaceous schist, notably more finely foliated than the gneisses of the White Hill Dam Prospect, and containing notably amounts of muscovite. Associated with the schists are amphibolites, some epidote bearing, as well as epidote rich calc-silicate rocks, marble, biotite schist and quartzofeldspathic rocks.
Gough Dam Schist outcrops in two zones, one trending east and then southeast from the northwestern corner of EL 4528, and the other running east-southeast across the southern part of this EL and along the southern edge of EL 4463. The northern zone separates Blackfellow's Bones Granulite from Irindina Gneiss. It includes many calc-silicate rocks and marble lenses suggesting correlation with the rocks of the Cadney Gneiss. The wider and more continuous southern zone reveals a variety of lithologies outcropping in blocks that are interpreted as fault-bounded. Individual blocks are dominated by calc-silicate, quartzofeldspathic and micaceous rocks suggesting they collectively comprise slices of retrogressed Blackfellow's Bones Granulite and Cadney Gneiss.

Like the surrounding units, the Gough Dam Schist contains abundant pegmatites. However quartz veining is no more common than in other rocks and despite the mineralogical evidence for retrogression the rocks are no more structurally complex than unaltered gneiss and granulite. Overall Gough Dam Schist appears to be the product of crystallization under conditions of relatively high water pressures similar to those found elsewhere in the White Hill Dam Prospect.

MOUNT SCHAEBER GRANITE

A small elliptical granite pluton has been emplaced within the Ongeva Granulite in the southwest corner of EL 4528. This intrusion is termed the Mount Schaebier Granite. It ranges in composition from at least tonalite to granodiorite, consisting mainly of quartz plagioclase, alkali feldspar and biotite. The rocks are strained and show a weak foliation. An amphibolite dyke, 1m wide, was noted on the northern edge of the pluton but neither pegmatite nor aplite dykes were observed in the body or in immediately surrounding rocks. Evidence of thermal metamorphism in the surrounding rocks is also absent, and there is no sign of hydrothermal alteration.
associated with the emplacement of the body. Collectively these observations suggest granite emplacement during regional metamorphism. Rare mafic schlieren occur within the pluton.

QUATERNARY ALLUVIUM

Sandy and gravelly alluvium is associated with the more prominent west-flowing creeks in EL 4528. Alluvium mantles valley floors for up to 500 m from present day creek courses but drilling indicates such material rarely attains a thickness greater than 4 metres.

STRUCTURAL GEOLOGY

All of the metamorphic units show the same deformation history on outcrop scale. The earliest recognised structural event produced tight to isoclinal folds in lithological layering, folds that now plunge at widely varying angles to the west, north or east. A later event refolded these structures and lithological layering, into open to close structures, the axial surfaces of which strike east-west. Folds of this generation plunge at low to moderate angles east or west. Even folds of the later generation from the same outcrop show a wide range of orientations, suggesting rather unconstrained fluidal flow, probably near the peak of metamorphic temperatures. Axial surface structures are rare, indicating an absence of a highly anisotropic stress field.

Small-scale structures are most common in the thinly layered rocks of the Cadney Gneiss but are also widespread in the Irindina Gneiss and the Gough Dam Schist. Although the same pattern occurs in the granulites their massive character commonly masks their structure, while migmatitic rocks mostly yield a confused structural geometry.

On the macroscopic scale the White Hill Dam Prospect can be
divided into 4 structural domains. Domain 1 comprises the rocks north of the northern zone of the Gough Dam Schist and the inferred fault that continues east from the tapering end of this zone. The domain is occupied mainly by the Irindina Gneiss that has an overall east-west trend, well defined by mapped lithological layers despite numerous small-scale folds. A major synform occurs in the south-east of this domain, with east-west axial trace and steeply inclined axial plane. A similarly oriented antiform is responsible for the emergence of an elongate inlier of the Cadney Gneiss about a kilometre north of the synformal trace, and a further synformal fold is probably marked by the hinge in a disrupted layer of quartzfeldspathic gneiss close to the northern boundary of EL 4463.

Domain 2 encompasses the northern zone of the Gough Dam Schist. This is a region of widespread small-scale folding in which the foliation strikes approximately parallel to the overall trend of the zone.

Domain 3 encompasses the outcrop area of Blackfellow's Bones Granulite and Cadney Gneiss lying between the northern and southern Gough Dam Schist zones (and their eastward extension). A major synformal structure is postulated within the Blackfellow's Bones Granulite, the axial trace of which is slightly sinuous but trends approximately east-southeast from the unnamed dam on the western boundary of EL 4528. This structure has also affected the contact of the Granulite with the Cadney Gneiss but has not been traced into the latter unit.

An antiformal structure is believed to fold the Cadney Gneiss further south, with an axial trace directed about east-north east and lying a little to the north of the North Copper Queen. The existence of this fold is inferred from both structural data and from the aeromagnetic pattern in this area, and causes rocks along strike from the western end of the Copper Queen mineralization to
be bent north and disappear beneath the extensive area of alluvium northwest of the Copper Queen. The combined affect of these structures may be to fold the cupriferous gneiss horizon of the North Copper Queen such that it links with the similar gneisses exposed in the coastal just south of the Copper Queen track junction with the Blackfellow's Bones Bore-Gonagalabi track.

Further east in the Cadney Gneiss large-scale folds are indicated by the outcrop pattern of quartzofeldspathic gneiss south and southeast of Pannikin Dam. The seemingly abrupt termination of these layers against biotite gneiss in the Pannikin Dam area has been interpreted as indicating a fault (Shaw, Stewart and Rickard 1985) but little evidence for this structure can be seen in the field. Large mesoscopic folds mark the boundary where it is cut by the Cadney Creek.

Domain 4 comprises the southern Gough Dam Schist Zone and the area of granulite and granite in the southwest corner of EL 4528. The structure of this domain is of fault-bounded blocks and slivers that show an overall west-northwest - east-southeast elongation. Rocks that occur within the domain are similar to those further north in lithology. No zones of brecciation or slickensiding have been recognised, and it is inferred that the movements which produced the distinctive structure of the domain occurred under elevated temperatures, probably just below those which stabilise muscovite rather than sillimanite plus potash feldspar.

The rocks of the White Hill Dam Prospect are noteworthy for the absence of signs of post-metamorphic faulting. No breccia zones have been recognized, nor prominent fracture systems, nor zones of intense jointing. The relatively young pegmatites and associated veins probably lie along fractures, possibly the products of tensile stresses operating late in the history of the region.
MINERALIZATION

Two styles of mineralization have been recognised in the White Hill Dam Prospect: copper mineralization in biotite gneiss and copper-gold mineralization associated with calc-silicate rocks and marble. These are discussed in turn below, followed by a discussion of various quartz vein types which were sampled in an attempt to establish whether gold was introduced in a separate event from that responsible for the copper in the area of copper-gold mineralization.

CUPRIFEROUS GNEISS

The most extensive area of cupriferous gneiss is that of the Copper Queen North (Macculloch and Nielsen, 1984). Here small malachite-stained lenses of biotite-sillimanite-(garnet) gneiss are concentrated in a discontinuous zone up to about 1.5 m thick and several hundred metres long. Individual lenses, and the zone they collectively define, trend parallel to the foliation in the rocks. Apart from the presence of malachite, seldom in other than minor concentrations, the rocks in the lenses are similar to adjacent unmineralized gneiss. No sulphides were observed in fresh gneiss from this area and it is possible that the malachite has been produced by the breakdown during weathering of a copper-bearing silicate mineral. The North Copper Queen mineralization occurs within the Cadney Gneiss, the unit in which this style of mineralization is most common. Cupriferous biotite-sillimanite-garnet gneiss of the Cadney Gneiss exposed in a costean at the intersection of the Copper Queen track with the Blackfellow's Bones Bore - Oonagalabi track are of very similar characters to those of the North Copper Queen, and the possibility that these two areas are linked has already been discussed. Other occurrences of malachite-stained gneiss are about 0.75 km south of Pannikin Dam (Cadney Gneiss), within the southern Gough Dam Schist Zone (in rocks believed derived from Cadney Gneiss) and in a discont-
inuous zone west from the Virginia Prospect which is located immediately east of EL 4463 adjacent to the Oonagalabi track. The last zone is developed within rocks mapped as Irindina Gneiss lying just north of the anticlinal inlier of Cadney Gneiss. Again the host-rock is biotite-sillimanite-garnet gneiss, the mineralization is restricted to small lenses concentrated in a strike-parallel zone, and only secondary copper minerals have been identified.

COPPER QUEEN MINERALIZATION

The Copper Queen mineralization has been discussed in detail by MacCulloch and Nielsen (1984). Copper mineralization here is concentrated in a discontinuous layer of garnet-clinopyroxene-epidote rock closely associated with other calc-silicate lithologies and marble. The mineralized zone is generally less than a metre thick, parallels layering in adjacent metamorphic rocks, and becomes increasingly discontinuous westward. To the east the zone terminates in a series of small late-stage mesoscopic folds. Only secondary copper minerals, mainly malachite, have been recognized at the Copper Queen and the primary phase carrying the copper is not known. The abundance of copper minerals is highly variable along the zone with concomittant variation in copper grades.

Although the host-rock mineralogy is that expected in a skarn, the geological setting is inappropriate for skarn-type mineralization. There is no nearby evidence for an adjacent unexposed pluton; the rocks show regional rather than contact metamorphic charaters and there is no need to postulate metasomatism to account for their composition.

Of particular note in some assayed Copper Queen samples described by MacCulloch and Nielsen are anomalously high gold values. Not all Copper Queen samples show high values and there is no close
relationship between gold and copper abundance so the relationship between the introduction of the two metals into the rocks is unclear.

QUARTZ VEINS

As indicated in the preceding section the origin of the gold from some Copper Queen samples is obscure. Although there are no cross-cutting veins at the Copper Queen, the sporadic distribution of high gold values raises the possibility that this metal was introduced separately from the copper. Elsewhere in the Arunta Block, gold mineralization is associated with quartz veins. In the White Hill Dam Prospect quartz veins of a range of structural settings and implied ages have been sampled in an attempt to determine if gold was mobilised at any stage during the formation of the veins.

Sampled veins include:

Cadney Gneiss
(a) veins associated with mylonitic pegmatites - HR 4, HR 5
(b) late-stage quartz-epidote segregation veins - HR 3
(c) late-stage cross-cutting quartz veins - HR 2, HR 21
(d) veins associated with copper-stained gneiss - HR 19

Ongeva Granulite
(e) Concordant quartz veins - HR 34

Blackfellow's Bones Bore Granulite
(f) Broadly concordant, commonly pegmatite associated veins - HR 23 HR 25, HR 36, HR 37.

Irindina Gneiss
(g) Quartz veins associated with cupriferous gneiss - HR 9, HR 10, HR 11, HR 13
(h) Early metamorphic segregation veins — HR 15, HR 42
(i) Pegmatite — associated veins HR 17
(j) Late-stage discordant veins HR 14

Gough Dam Schist (northern zone)
(k) Concordant veins — HR 24, HR 39, HR 41
(l) Pegmatite related veins — HR 32

Gough Dam Schist (southern zone)
(m) Concordant veins, some pegmatite related — HR 6, HR 7, HR 8, HR 27, HR 28, HR 29, HR 30, HR 31, HR 33.

The interpretation of assay values, not available at time of writing, will be discussed separately.

CONCLUSIONS

New geological mapping, allied with assay results should allow the refining of exploration targets substantially. The present survey suggests:

(1) The copper mineralization is of itself of no economic significance but the metal may serve as an indicator to anomalous gold values. Assay results should help to determine whether this is indeed the case.

(2) The Cadney Gneiss appears to be the most promising of the units mapped for mineralization.

(3) Exploration might be concentrated (a) in the area north from the Copper Queen to the Blackfellow's Bones Bore — Oonagalabi Track and (b) in the little known region between this area and west of a line joining Pannikin Dam and the White Lady Mica Mine.
(4) As the Gough Dam Schist Zones are probably areas of metasomatism involving the introduction of water and the introduction or remobilization of potassium, the assays from these rocks should be carefully assessed.

(5) Preliminary analysis of in situ magnetic susceptibility indicates high values are associated with some of the Copper Queen rocks. Ground magnetic traverses would probably allow more precise definition of any continuation of this zone to the north as suggested by structural and aeromagnetic data.

REFERENCES


WARREN, R.G., 1980: Summary descriptions of mineral deposits by commodities in the Alice Springs 1:250,000 Sheet area. Northern
APPENDIX C

INTERPRETATION OF THE AEROMAGNETIC DATA
OVER THE WHITE HILL DAM AREA,
HARTS RANGE, N.T.

ON BEHALF OF

KINEX PTY. LTD.
784 PACIFIC HIGHWAY,
GORDON, N.S.W.

BY

J. SLADE & ASSOCIATES PTY. LTD.
4TH. FLOOR,
39 EAST ESPLANADE,
MANLY, N.S.W.

DATE: MARCH 1986.
1 INTRODUCTION

The aeromagnetic data over EL's 4463 & 4528, known as White Hill Dam Area, Harts Range N.T., was interpreted by J. Slade & Associates Pty. Ltd., on behalf of Kinex Pty. Ltd. The data was supplied in the form of contours of total magnetic intensity at a scale of 1:23,500 (approximately). The data was recorded by G.R.D. in 1970. The type of magnetometer used was not specified. The survey was flown in a north south direction at an altitude of 100 metres with flight lines spaced at 440 metres.

The magnetic data has been merged with detail geological mapping of the area. The Proterozoic Irindina Formation, a sequence of quartz feldspar, porphyroblastic biotite garnet and calcsilicates, covers much of the area. Interbedded with this Formation are the Cadney Creek Formation, (calcsilicates and magnetite gneiss) and the Blackfellow Bones Formation, (quartz feldspars with magnetite gneiss). The magnetite gneisses in these formations will be the source of the intense magnetic activity associated with the area. The area to the north of the two EL's has been intruded by the Devonian Mt. Riddock Formation, a mafic unit of hornblende and amphibolites. The intrusions appear to be conformable with the Irindina Formation and have been tightly folded. The central and southern portions of both EL's have been intruded by the Devonian Mt. Brassy Formation which is similar to the Mt. Riddock Intrusions although the latter is more pervasive and intrudes most formations. The south west of the area is mapped as the Ongeva Creek Formation, a magnetite rich granulite.
2 INTERPRETATION

The magnetic data were interpreted and the results presented on a base map at the same scale as the geology, (see accompanying Interpretation Map). This map shows the principal magnetic trends depicted by the magnetic highs, and a number of regional zones which include a possible alteration zone in the centre of the area. A north striking fault or contact across the regional grain of the formations has been identified. The movement along the fault has been interpreted as right lateral or, alternatively, the eastern block has been displaced to the south. This is partially confirmed from the geological mapping which shows the Blackfellow Bones Formation displaced to the south. The east west faults, in the south of the area, are evident in the magnetic data. The interpreted location of these faults indicates that they are approximately 300 metres south of the surface expression and have a southerly dip.

The mineralised zones at Copper Queen and White Lady have been plotted to show the relationship between the known mineralisation and the interpretation.

The area can be divided into five zones which have characteristic responses.

Zone 1

This zone, which is located in the north of the area, is relatively non magnetic and correlates with the folded sequence of Irindina Formation intruded by the Mt. Riddock amphibolites. Two synclinal structures have been plotted and a possible anticlinal structure in the west of the area has been interpreted from the magnetic data, see Interpretation Map.
Zone 2

Zone 2 is located in the west of the area and correlates with a region of relatively magnetic linears. The region is bounded to the east by the northerly striking fault or contact. In certain places the magnetic linears are coincident with the mapped Mt. Bessy Formation which intrudes the Blackfellow Bones Formation. The magnetic pattern has been interpreted as a possible anticlinal structure. A small zone of possible alteration has been mapped on the northern contact.

Zone 3

Zone 3 is in the south west of the area and correlates with the Ongeva Formation. The magnetite rich granulites explain the above average, regional magnetic response. The area does not contain any extraordinary anomalies. The magnetic data indicates that this zone extends approximately 1000 metres to the north of the presently mapped boundary.

Zone 4

Zone 4 extends across the southern portion of the area and along the eastern boundary of EI4463. This region contains numerous minor linear magnetic anomalies with an easterly strike direction. These are related to the faulting in the area which would appear as a shear zone rather than discrete faults as mapped. As suggested earlier, the displacement of the magnetic response from the mapped surface expression of these faults indicates a dip to the south.
Central Alteration Zone

In the centre of the area there is an anomalous zone which can be recognised in the magnetic data as a series of magnetic lows. These form three linked closures as shown on the Interpretation Map. This zone generally correlates with a region of Cadney Creek Formation which has been intruded by the Mt. Brassy Formation. The regions of positive magnetism correlate with the intrusive. The two known mineral deposits in the area, Copper Queen and White Lady, are located on the southern contact of the alteration zone. The magnetic lows can be linked as closures which have been interpreted as an aureole surrounding a major intrusive. Magnetite in the host rock has been removed or altered to a non magnetic ferrous mineral.

Surface mapping has shown that the gold mineralisation is controlled by a structure which emanates from the Copper Queen, travels west and then north east to near White Hill Dam. The magnetic data shows this to be on the contact of the alteration zone. The mineralisation would extend approximately 2000 metres west of Copper Queen and then swing north east for 1000 metres. The mineralised zone may not be continuous in a north easterly direction, but a second zone striking north east, 500 metres south of White Hill Dam probably matches the geochemical results.

3 CONCLUSIONS AND RECOMMENDATIONS

The interpretation of the magnetic data has identified a zone of alteration associated with a recent intrusion. This is evident in the magnetic data as a circular or arcuate low. The two, known mineral deposits in the area are located on the contact between the alteration zone and the host formation. Ground investigations should be carried out
to sample the entire contact of the alteration zone, including the small area 3000 metres west of White Hill Dam.

Ground magnetic surveys would be the most suitable method of tracing possible extensions of the mineralisation. This interpretation should be reviewed when considering the geochemical results collected over the area.

The interpretation by J Slade and Associates is shown on the Geology and Sample Locations map in appendix E and on the Exploration and Simplified Geology map on page 8.
APPENDIX D

NT SF 53-14, Alice Springs

A GEOLOGICAL REPORT

WHITE HILL DAM PROSPECT
ALICE SPRINGS
NORTHERN TERRITORY
July 1984

Report by
Ian R F MacCulloch
Ken I Nielsen
Geologists, MMICA
AMAIMM, MAIG, MGSA
MASEG
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Appendix 1 ...................... Exploration Licences

Appendix 2

Map titled 'Preliminary Regional Geology and
Cu Pb Zn Ni Rock Geochemical Values' 1:23,500
[the scale is approximate - and the same scale
as the 1971 colour aerial phographs coverage].
SUMMARY

The White Hill Dam Prospect is located in the Harts Range in Northern Territory, and approximately 100 km northeast from Alice Springs. The prospect comprises a total area of 116 sq km covered by exploration licences No's 4463 and 4528 granted to Kinex on the 31st May 1984.

In regional exploration in 1971, Russgar Minerals NL had some samples from the Copper Queen, a narrow occurrence of copper mineralisation in the area, assayed for gold and the laboratory reported gold values ranging from 1.6 to 26.0 grammes gold per tonne.

Geologically, the White Hill Dam Area is part of the Arunta Block, an area of highly metamorphosed rocks, including gneisses, amphibolites and granulites, the results of several periods of deformation where a first period may date back to the Early Proterozoic.

In terms of mineralisation, other than the mica and the mica mining which ceased some 25 years ago, several copper occurrences were found in early prospecting and in the later geological mapping, prospecting and rock geochemical survey. The district and the area was not at any time considered a gold environment. The more comprehensive sampling in the vicinity of the Copper Queen confirms that gold occurs in the area. The Copper Queen mineralisation, three grammes gold per tonne and one to three percent copper over a width of one metre plus, does not represent an economic orebody. Tentatively, the mineralisation is thought of as hydrothermal and the host as metamorphic rocks which at some time have been subjected to metasomatism.

The White Hill Dam Area has not been explored for gold mineralisation and the several known copper mineralisations, except for one, in the area have not been checked for gold mineralisation. It is suggested that the potential fully justifies further exploration for gold.
INTRODUCTION

Russgar Minerals NL [with Messrs MacCulloch and Nielsen working for the company], in the early 1970's, carried out regional exploration in an area of some 2,600 square kilometres in the Harts Range in the Northern Territory, and in the course of this work, at the locality known as Copper Queen in the White Hill Dam Area, a few samples when assayed for gold yielded values of consequence. Kinex has now been granted exploration licences over 116 square kilometres surrounding the Copper Queen locality, and this report discusses the results of the earlier exploration and the exploration carried out by Kinex.

LOCATION, ACCESS AND TENURE

The White Hill Dam Prospect area is situated in the Harts Range Area in the Northern Territory, and the centre of the area is 102 km from Alice Springs, approximately, on bearing 52 degrees, see map page 5 for co-ordinates. From Alice Springs the area is reached by driving north on the Stuart Highway for 68 km, then northeast and east for 96 km on the Plenty River Highway to the Blackfellow Bones Bore track turn-off [just east of the Ongeva Creek crossing of the Highway] and then southeasterly on this track for 23 km, passing the Blackfellow Bones Bore 6 km from the turn-off. The last 30 km of the Plenty River Highway is good formed dirt road, whilst the Blackfellow Bones Bore track is best negotiated in a four-wheel-drive vehicle. The remainder is bitumen road.

Kinex applied for two exploration licences in the area some time ago, and the two licences were granted on the 31st May 1984 for a term of six years. The licences together comprise 36 EL blocks, where a block
**LEGEND**

- **Pzb** Na-Ca feldspar, hornblende amphibolites
- **PEq** Quartz, Na-feldspar, hornblende, minor biotite, quartz diorite
- **PCI** Quartz, feldspar, biotite, garnet, often porphyroblastic, & calcisilicates
- **PECf** Mainly quartzo-feldspathic with, minor biotite, garnet & magnetite gneiss
- **PECe** Interbedded calcisilicates & quartz, feldspar, biotite gneisses (with magnetite)
- **PECz** Granulites, hypersthene, quartz, phlogopite, diopside Ca-feldspar, magnetite

- Mine
- Fold with direction of plunge
- Mineralised Zone
- Fault, inferred
- Copper mineralisation
- Geological boundary
- Syncline
- Dam

**LOCALITY MAP**

**WHITE HILL DAM AREA**

**HARTS RANGE, ALICE SPRINGS - N.T.**

KINEX AUG. 84  REF. SF 53 - 14
is one minute squared, and cover an area of 116 square kilometres:

<table>
<thead>
<tr>
<th>Licence</th>
<th>Blocks</th>
<th>Area (sq km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL 4463</td>
<td>24</td>
<td>77</td>
</tr>
<tr>
<td>EL 4528</td>
<td>12</td>
<td>39</td>
</tr>
</tbody>
</table>

The combined exploration expenditure commitment for the two licence areas for the first year is $47,000. Copies of the licences may be found in appendix 1.

**GEOLOGY**

The Harts Range Area, and thus the White Hill Dam Area, is part of the Arunta Complex or Arunta Block which extends over an area of some 1,000 km east-west and 400 km north-south, and forms the basements of several basins. The geology of the Arunta Block is complex with at least five metamorphic episodes prior to the deposition of the rocks of the Amadeus Basin in Late Proterozoic with the main sedimentation period in the Basin being the Late Devonian [refer 1:250,000, second edition, geological series map and notes, Shaw & Wells 1983]. In the White Hill Dam Area, some 30 km to the north of the northern part of the Amadeus Basin, the rocks of the Arunta Block are metamorphosed to amphibolite, amphibolite-granulite and granulite regimes, and it is generally believed that these rocks, the 'Central Zone of the Arunta Block', have been subjected to three major periods of deformation:

1. The Arunta Orogeny - the Strangways Event - Nullaginian
2. The Petermann Ranges Orogeny and/or associated events - Adelaidian, and
3. The Alice Springs Orogeny - Carboniferous.

where the granulites of the Ongeva Creek Formation may represent the oldest rocks in the area, refer the Locality Map on page 5 and the Preliminary Regional Geology Map in appendix 2.

Lithologically, the rocks in the area have been subdivided into five groups, namely the Ongeva Creek Formation [granulite], the Cadney Creek Formation [calc-silicates and quartz-feldspar-biotite gneisses and marbles], Blackfellow Bones Formation [quartz-feldspathic, minor biotite and garnet, gneiss], and the ? younger Formations, Irindina [garnet-quartz-feldspar gneiss], and Mt Riddock and Mt Brassy [Na-Ca feldspar-hornblende amphibolites - possibly older than indicated on the map in appendix 2]. The Mt Schaeber Quartz Diorite, in the far southwestern corner of EL 4528, has been mapped as a granitoid with
age? Early Proterozoic. It is now suggested that it is a gneissic quartz diorite, see thin section notes, sample WH 45, and photograph looking west from Copper Queen and showing the quartz diorite outcrop in the background, below.

Structurally, the regional strike is east-west with dips variable but generally to the north. This general trend is very often disrupted, however, by faulting in the form of extensive thrust faults and many
normal and ? transcurrent faults. Folding is equally common and that with a sizeorder distribution from 10 cm to 10 km; tight to isoclinal folds are rather typical, as are folded fold hinges and closures with close to vertical plunges. The structural geology of the area is yet to be resolved, but some indications of the structures are included on the maps on pages 5 and 10 and in appendix 2.

On the 1:250,000 geological series map and in the accompanying notes, it is suggested that the area to the south of the Copper Queen is an area of retrograde amphibolite facies rocks. In the vicinity of the Copper Queen and to the south, however, there are several occurrences of pegmatites, both concordant and discordant, and in the latter case with foliation at an angle to the strike, and, noting the proximity of the Mt Schaeber Quartz Diorite, it could easily be that the effect of metasomatism, at least in part, has been identified as retrograde metamorphism.

MINERALISATION

The known mineralisation in the White Hill Dam Area may be subdivided into three groups, tentatively:

(1) The mica mines - for location, see map in appendix 2 - the White Lady Mica Mine and the Pannikin Dam Mica Mine. The mica mining in the Harts Range commenced before the turn of the century and only ceased some 25 years ago. Today, mica occurrences are of no interest in an economic sense.

(2) Scattered occurrences of copper mineralisation - indicated by Cu on the map in appendix 2 - where the mineralisation is generally copper stain, malachite and cryscolite, with rare chalcocite, assays ranging to 15% Cu, with no other mineralisation present in anomalous and economic amounts ???, and these occurrences ranging in size from a few metres length to three kilometres in length - eg the Virginia Occurrence with intermittent mineralisation in a thrust fault 60 cm wide and 3 km long.

(3) The Copper Queen Occurrence - for location, see map in appendix 2 - where the copper mineralisation is as mentioned above, but in addition, the occurrence also carries anomalous and economically significant gold values.

The anomalous gold values in early sampling in the vicinity of Copper
Queen caused the decision to apply for the area and thus facilitate further exploration. The values from the earlier exploration are:

Russgar Minerals NL, 1971; assays by Sample Analytical Laboratories; assays in ppm; sample width 15 cm except A394 60 cm.

<table>
<thead>
<tr>
<th>Spl No</th>
<th>Cu %</th>
<th>Pb</th>
<th>Zn</th>
<th>Au</th>
<th>Ag</th>
</tr>
</thead>
<tbody>
<tr>
<td>A391</td>
<td>1.0</td>
<td>45</td>
<td>45</td>
<td>1.6</td>
<td>2.5</td>
</tr>
<tr>
<td>A392</td>
<td>2.0</td>
<td>20</td>
<td>38</td>
<td>8.0</td>
<td>2.6</td>
</tr>
<tr>
<td>A393</td>
<td>6.1</td>
<td>15</td>
<td>31</td>
<td>5.0</td>
<td>4.2</td>
</tr>
<tr>
<td>A394</td>
<td>15.5</td>
<td>55</td>
<td>18</td>
<td>7.5</td>
<td>8.2</td>
</tr>
<tr>
<td>A395</td>
<td>6550</td>
<td>15</td>
<td>78</td>
<td>3.2</td>
<td>1.8</td>
</tr>
<tr>
<td>A396</td>
<td>8.7</td>
<td>45</td>
<td>10</td>
<td>26.0</td>
<td>6.8</td>
</tr>
<tr>
<td>A397</td>
<td>5100</td>
<td>15</td>
<td>47</td>
<td>3.2</td>
<td>1.3</td>
</tr>
<tr>
<td>A398</td>
<td>6000</td>
<td>35</td>
<td>42</td>
<td>0.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Geopeko Ltd, 1974/75; assays by ? Geopeko, Tennant Creek; assays in percent except for the gold values.

<table>
<thead>
<tr>
<th>Spl No</th>
<th>Cu</th>
<th>Au [ppm]</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>T01356</td>
<td>2.48</td>
<td>4.9</td>
<td>6.1</td>
</tr>
<tr>
<td>T01357</td>
<td>0.13</td>
<td>0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>T01358</td>
<td>0.27</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>T01359</td>
<td>1.38</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>T01360</td>
<td>0.05</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>T01361</td>
<td>0.05</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>

where samples A391 to A398, east-west, are from the area between the sample locations 15 to 10 shown on the map on page 10, and the first three geopeko samples are from the A392, and the last three from the A394 sample locations, as far as can be ascertained.

In the regional exploration, the combined prospecting and geological mapping resulted in the discovery of the various copper occurrences, and the gold copper mineralisation at the Copper Queen, whereas the results from the regional rock geochemical survey, with 196 samples assayed for copper, lead, zinc and nickel, considered in isolation, do not appear to indicate any zone or any trend of consequence. The sample locations and assays are shown on the 'Preliminary Regional Geology and Cu Pb Zn Ni Rock Geochemical Values' map in appendix 2.

In order to establish the geochemical background values for different formations in the area, the means for the four elements, excluding
TRACK TO THE BLACKFELLOW BONES BORE - OONAGALABI TRACK

To Onevo Creek

Amphibolite

Mostly the country rock is biotite (muscovite), plagioclase, quartz, garnet schist / gneiss

Calc-silicates ( & marble) units

Garnet calc-silicate

Epidote - garnet units

Garnet quartzite

Quartz, biotite, sillimanite gneiss

Calc-silicates ( & marble) units

SOUTH SIDE OF CREEK

Sample location

Fold closure

Fault

SCALE 1:10,000

Metres

WHITE HILL DAM AREA - N.T.
SAMPLE LOCATIONS IN THE VICINITY OF COPPER QUEEN

KINEX AUG.84 REF SF 53-14
obviously anomalous samples, have been calculated, as have the means for four groups in an arbitrary west-east grouping [to test for east-west zoning]:

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Formation</th>
<th>Group WW</th>
<th>W</th>
<th>E</th>
<th>EE</th>
</tr>
</thead>
<tbody>
<tr>
<td>number spl's</td>
<td>Mt Brassy</td>
<td>11</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Mt Riddock</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Irindina</td>
<td>22</td>
<td>17</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Blackfellow Bones</td>
<td>19</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Cadney Creek</td>
<td>0</td>
<td>8</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>mean Cu ppm</td>
<td>Mt Brassy</td>
<td>38.3</td>
<td>55.5</td>
<td>45.3</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>Mt Riddock</td>
<td>42.4</td>
<td>32.0</td>
<td>40.3</td>
<td>49.4</td>
</tr>
<tr>
<td></td>
<td>Irindina</td>
<td>31.3</td>
<td>37.8</td>
<td>40.7</td>
<td>38.5</td>
</tr>
<tr>
<td></td>
<td>Blackfellow Bones</td>
<td>6.9</td>
<td>5.5</td>
<td>19.5</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>Cadney Creek</td>
<td>29.6</td>
<td>10.5</td>
<td>19.1</td>
<td></td>
</tr>
<tr>
<td>mean Pb ppm</td>
<td>Mt Brassy</td>
<td>6.7</td>
<td>12.5</td>
<td>15.0</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>Mt Riddock</td>
<td>6.3</td>
<td>13.8</td>
<td>11.8</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>Irindina</td>
<td>9.5</td>
<td>24.7</td>
<td>14.9</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>Blackfellow Bones</td>
<td>7.7</td>
<td>11.7</td>
<td>15.0</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Cadney Creek</td>
<td>-</td>
<td>19.4</td>
<td>20.5</td>
<td>13.6</td>
</tr>
<tr>
<td>mean Zn ppm</td>
<td>Mt Brassy</td>
<td>23.8</td>
<td>32.5</td>
<td>82.3</td>
<td>72.0</td>
</tr>
<tr>
<td></td>
<td>Mt Riddock</td>
<td>24.1</td>
<td>49.0</td>
<td>35.5</td>
<td>38.0</td>
</tr>
<tr>
<td></td>
<td>Irindina</td>
<td>50.9</td>
<td>56.1</td>
<td>57.0</td>
<td>52.7</td>
</tr>
<tr>
<td></td>
<td>Blackfellow Bones</td>
<td>21.1</td>
<td>20.7</td>
<td>10.0</td>
<td>21.0</td>
</tr>
<tr>
<td></td>
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<td>-</td>
<td>48.0</td>
<td>24.0</td>
<td>44.0</td>
</tr>
<tr>
<td>mean Ni ppm</td>
<td>Mt Brassy</td>
<td>26.8</td>
<td>17.0</td>
<td>40.0</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td>Mt Riddock</td>
<td>29.3</td>
<td>27.5</td>
<td>32.3</td>
<td>22.5</td>
</tr>
<tr>
<td></td>
<td>Irindina</td>
<td>34.3</td>
<td>27.4</td>
<td>36.9</td>
<td>34.0</td>
</tr>
<tr>
<td></td>
<td>Blackfellow Bones</td>
<td>25.8</td>
<td>16.3</td>
<td>17.5</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>Cadney Creek</td>
<td>-</td>
<td>28.8</td>
<td>35.0</td>
<td>35.3</td>
</tr>
</tbody>
</table>

For the Area

| Spl's 18 | Mt Brassy | 38.8 | 9.4  | 39.9 | 29.9 |
|          | Mt Riddock | 42.6 | 10.6 | 35.5 | 28.0 |
|          | Irindina   | 36.8 | 15.5 | 53.9 | 33.3 |
|          | Blackfellow Bones | 7.8  | 8.9  | 20.2 | 22.6 |
|          | Cadney Creek | 21.7 | 17.5 | 41.5 | 32.5 |
The grouped data suggest that there are no larger area anomalies, i.e., areas with consistent anomalous high values for a number of adjacent sample locations, and the anomalies to be checked are limited to the several individual high copper assay sample locations. It is noted that the background copper values for the older formations, Cadney Creek and Blackfellow Bones, are relatively low—indeed, the values for the Blackfellow Bones Formation are low for all four elements—and the latter formation is the host to the Oonagalabi mineralisation further to the east whilst the Copper Queen mineralisation is located within the Cadney Creek Formation.

The more comprehensive sampling in the vicinity of the Copper Queen, see detailed sample and assay data in the table on pages 13, 14 and 15 and the map on page 10, shows that gold and copper mineralisation occurs in the same stratigraphic horizon over some 900 metres, with only minor discontinuities, at the Copper Queen, and similarly to the north from the Copper Queen, except that the mineralisation here only contains copper—the photograph on this page shows the mineralised quartz-biotite-sillimanite gneiss at sample location 5. The country
## TABLE OF SAMPLE DATA

The samples are all channel chip samples except as noted, and values are in ppm except as noted. The assays are AAS except for the Au fire assays and the assaying was done by the Pilbara Laboratory in Perth. The sample weights vary from 0.5 to 2.0 kg depending on sample length.

<table>
<thead>
<tr>
<th>Sample Description</th>
<th>Cu</th>
<th>Zn</th>
<th>Pb</th>
<th>Ag</th>
<th>Au Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spl Loc 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.035</td>
</tr>
<tr>
<td>WH 01 1m spl Cu stain in qtz mica schist</td>
<td>1.51%</td>
<td>116</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Spl Loc 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.041</td>
</tr>
<tr>
<td>WH 02 0.5m spl Cu stain in qtz-fel schist</td>
<td>2530</td>
<td>23</td>
<td>15</td>
<td>-</td>
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<tr>
<td>Spl Loc 16</td>
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<td></td>
<td>0.973</td>
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<tr>
<td>WH 03 0.6m spl in Cu in qtz-ga-bio-fel</td>
<td>3.41%</td>
<td>34</td>
<td>15</td>
<td>-</td>
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<td>Spl Loc 15</td>
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<tr>
<td>WH 04 0-0.8m* fels-qtz-bio gneiss</td>
<td></td>
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<tr>
<td>no mineralisation (visible)</td>
<td>690</td>
<td>15</td>
<td>-</td>
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<td>WH 05 4-7.3m Cu in garnet-pyroxene rock</td>
<td>1.38%</td>
<td>60</td>
<td>14</td>
<td>-</td>
<td>0.43</td>
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<tr>
<td>WH 06 7.3-10.6m as WH 05</td>
<td>1.82%</td>
<td>44</td>
<td>-</td>
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<td>0.37</td>
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<tr>
<td>WH 07 12.3-18.7m as WH 05 less Cu</td>
<td>0.66%</td>
<td>48</td>
<td>13</td>
<td>-</td>
<td>0.48</td>
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<tr>
<td>WH 08 18.7-23.3m ga-epi q'zite no min</td>
<td>420</td>
<td>52</td>
<td>10</td>
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</tr>
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<td>Spl Loc 14</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>WH 09 0-1m ga-diope-epi marble no min</td>
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<td></td>
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<td>0.012</td>
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<tr>
<td>WH 10 1.4-4m bio-qtz schist no min</td>
<td>211</td>
<td>103</td>
<td>7</td>
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<tr>
<td>WH 11 4-6.8m as WH 10 trace Cu</td>
<td>347</td>
<td>81</td>
<td>9</td>
<td>-</td>
<td>0.041</td>
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<tr>
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<td>1.25%</td>
<td>34</td>
<td>12</td>
<td>-</td>
<td>1.46</td>
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<tr>
<td>WH 13 7.8-8.4m band bio-epi gneiss no min</td>
<td>620</td>
<td>81</td>
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<td>-</td>
<td>0.064</td>
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<tr>
<td>WH 14 10.3-11.8m bio gneiss no vis min</td>
<td>123</td>
<td>51</td>
<td>-</td>
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<td>0.115</td>
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<td>Spl Loc 15</td>
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<td>WH 15 1.6m spl Cu in garnet-pyroxene rock</td>
<td>1.23%</td>
<td>70</td>
<td>8</td>
<td>-</td>
<td>3.19</td>
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<tr>
<td>WH 16 1m spl south from WH 15 - no vis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.300</td>
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<tr>
<td>min in epi-ga schist, some marble</td>
<td>610</td>
<td>21</td>
<td>14</td>
<td>-</td>
<td>0.069</td>
</tr>
<tr>
<td>Spl Loc 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WH 17 1m spl Cu in garnet-pyroxene rock</td>
<td>.53%</td>
<td>59</td>
<td>10</td>
<td>-</td>
<td>.37</td>
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<td></td>
<td></td>
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<td>.536</td>
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* sample width measures commence at northern point of a sample line.
### TABLE OF SAMPLE DATA CONTINUED

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<th>Cu</th>
<th>Zn</th>
<th>Pb</th>
<th>Ag</th>
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<th>Au3</th>
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<tr>
<td>WH 18 5.5m spl Cu stain in bio schist</td>
<td>0.45%</td>
<td>26</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.042</td>
</tr>
<tr>
<td>WH 19 13m spl south and as WH 18 no min</td>
<td>140</td>
<td>32</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.017</td>
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<tr>
<td>WH 20 4m spl little Cu in bio schist</td>
<td>780</td>
<td>30</td>
<td></td>
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<td>-</td>
<td>0.014</td>
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<td>Spl Loc 5</td>
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<tr>
<td>WH 21 0-3.7m Cu in qtz-bio-ga gneiss</td>
<td>0.32%</td>
<td>36</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.044</td>
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<tr>
<td>WH 22 6-9.8m as WH21 (3.7-6m scree)</td>
<td>2450</td>
<td>58</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
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<tr>
<td>WH 23 9.8 -12.8 as WH 21</td>
<td>1860</td>
<td>39</td>
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<td>-</td>
<td>-</td>
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<td>WH 24 picked rich from WH 21</td>
<td>9.25%</td>
<td>22</td>
<td>2</td>
<td>0.15</td>
<td>0.159</td>
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<td></td>
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<tr>
<td>WH 25 0-2.2m marble/calc unit no min</td>
<td>340</td>
<td>18</td>
<td>13</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.029</td>
</tr>
<tr>
<td>WH 26 2.2-5.6m garnet-pyroxene rock and also epi, also fel lenses, Cu min</td>
<td>0.83%</td>
<td>55</td>
<td>10</td>
<td>-</td>
<td>0.40</td>
<td>0.433</td>
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<tr>
<td>WH 27 5.6-9.2m ga-epi schist no min</td>
<td>1470</td>
<td>70</td>
<td>9</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.009</td>
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<td>Spl Loc 10</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WH 28 0.15m picked garnet-pyroxene rock</td>
<td>6.03%</td>
<td>77</td>
<td>4</td>
<td>2.30</td>
<td>2.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spl Loc 9</td>
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<td></td>
<td></td>
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<tr>
<td>WH 29 chip spl in qtz-mica pegm Cu min</td>
<td>0.65%</td>
<td>60</td>
<td>15</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.060</td>
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<tr>
<td>WH 30 picked spl from WH 29</td>
<td>0.51%</td>
<td>56</td>
<td>12</td>
<td>-</td>
<td>0.10</td>
<td>0.106</td>
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<td>Spl Loc 1</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WH 31 0-4.2m bio gneiss no vis min</td>
<td>262</td>
<td>42</td>
<td>9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.012</td>
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<tr>
<td>WH 32 4.2-9.2m bio gneiss little Cu min</td>
<td>2280</td>
<td>43</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.017</td>
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<tr>
<td>WH 33 9.2-15.6m bio gneiss trace Cu</td>
<td>1200</td>
<td>42</td>
<td>9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.017</td>
</tr>
<tr>
<td>WH 34 15.6-19.7 as WH 33</td>
<td>1450</td>
<td>33</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.015</td>
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<td>Spl Loc 2</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>WH 35 2m spl bio gneiss rich Cu min</td>
<td>2.79%</td>
<td>63</td>
<td>6</td>
<td>-</td>
<td>0.05</td>
<td>0.054</td>
<td></td>
</tr>
<tr>
<td>Spl Loc 6</td>
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<tr>
<td>WH 36 4m spl ga-qtz-bio gneiss Cu min</td>
<td>0.55%</td>
<td>42</td>
<td>10</td>
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<td>-</td>
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<td>0.042</td>
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TABLE OF SAMPLE DATA CONTINUED

<table>
<thead>
<tr>
<th>Sample Description</th>
<th>Cu</th>
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<th>Pb</th>
<th>Ag</th>
<th>Au</th>
<th>Auufire</th>
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<tbody>
<tr>
<td>Spl Loc at Copper Queen - Oonagalabi tracks junction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WH 37 4m spl west from costean Cu stain in bio schist, some ga some qtz</td>
<td>0.28%</td>
<td>64</td>
<td>11</td>
<td>-</td>
<td>0.10</td>
<td>0.121</td>
</tr>
<tr>
<td>WH 38 3m spl from costean as WH 37</td>
<td>0.35%</td>
<td>88</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>0.028</td>
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<tr>
<td>WH 39 2m spl 7m from and as WH 38</td>
<td>0.50%</td>
<td>64</td>
<td>12</td>
<td>-</td>
<td>0.05</td>
<td>0.086</td>
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<tr>
<td>Assays less than 1ppm Ag, 5ppm Pb and 0.05ppm Au are indicated by '-'</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

| WH 40                                        | not assayed |    |    |    |    |         |
| WH 41                                        | as sample WH 32 for petrological examination - identified as a weakly mineralised quartz-biotite-sillimanite gneiss. |      |    |    |    |    |         |
| WH 42                                        | as sample WH 15 for petrological examination - identified as a calc-silicate granulite/hornfels/skarn, the main constituents being calcium garnet (63%), clinopyroxene (20%) and quartz and epidote and microcline each 5%. |      |    |    |    |    |         |
| WH 43                                        | as sample WH 24 for petrological examination - identified as a mineralised quartz-biotite-garnet-sillimanite gneiss. |      |    |    |    |    |         |
| WH 44                                        | as sample WH 36 for petrological examination - identified as a garnet-quartz-biotite gneiss. |      |    |    |    |    |         |
| WH 45                                        | sample from the southwest corner of EL 4528 - the Mt Schaebor Hornblende Granite - identified as a gneissic tonalite. 'Despite development of gneissic fabric and strain phenomena (wavy extinction, curved twin lamellae) during deformation, an orginial medium-grained hypidiomorphic granular texture is still evident, indicating a plutonic igneous origin. The emplacement was apparently syn- or late-tectonic' ... from the TS-interpretation. |      |    |    |    |    |         |

Thin section petrology by N C N Stephenson, University of New England
At the Copper Queen, the mineralisation occurs in a rather massive garnet-pyroxene rock [see sample WH 42], conformable, with a 60 cm to 160 cm orthogonal thickness and length 900 m, and largely continuous over the length. The dip varies, say 60 degrees to the north, and the plunge is 70 degrees to the west. At the eastern end, at sample location 15, an 18.70 m non-orthogonal width is exposed and assayed, when sampled, just over 1 percent copper and 3/4 gramme/tonne gold. Elsewhere, the channel chip sampling resulted in assays ranging from 1.25% Cu and 3.0 ppm Au over 1.0 to 1.5 m to 0.83% Cu and 0.4 ppm Au over 3.4 m. The sampling also shows that the rocks adjacent to the garnet-pyroxene rock do not contain gold, except for a trace of gold in sample WH 14 [0.115 ppm Au].

At the Copper Queen North, the mineralisation is in a quartz-biotite-sillimanite [see sample 43] again conformable and again dipping to the north. The copper grade varies from 2.79% over 2 m at location 2 to 0.25% over 6.4 m at location 5 — and no gold mineralisation except for a trace of 0.15 ppm in a picked sample, WH 24 from location 5, with 9.25% Cu.

The remainder of the known copper mineralisations in the White Hill Dam Area have not been checked for gold mineralisation, except for the occurrence at the Copper Queen-Blackfellow Bones Bore-Onagalabi track junction where a sample yielded trace gold [0.121 ppm, WH 37].

Four of the samples from the Copper Queen vicinity, samples WH 12, WH 15, WH 28 and WH 36 were analysed for Ti, Tb, Sc, Dy, Hf, Y, Pr, La, Th, Sr, Ce, Ba, Mn, Fe, Cr, Na, K, Be, Eu, Re, Yb, Li, W, Zr, Al, Mg, Co, Ca, Mo, Ta, Ni, V, Tm, U, Nb and Gd. There does not appear to be
any anomalous values in this data, and neither the rare earth metals nor molybdenum (<5ppm) or tungsten (<20ppm) are therefore suitable as trace elements, it seems, in future geochemical exploration.

DISCUSSION

The latest, more comprehensive sampling and assaying in the vicinity of the Copper Queen confirm the existence of gold mineralisation in a district and a geological setting not previously considered a gold environment. Our knowledge of the geological history of the whole of the White Hill Dam Area, and thus the present geological setting, is incomplete and still to be resolved. The rocks at the Copper Queen may easily be skarn rocks, a fact which would favour metasomatism and not retrograde metamorphism, and the identification of quartz diorite and the pegmatite occurrences [with foliation] may suggest intrusions early in the geological history. The complex structures, folded fold hinges and associated various plunges etc, confirm that the area has been subject to more than one period of deformation.

The question of type of mineralisation is not resolved either. The presence of mineralisation in a skarn rock, i.e. the garnet-pyroxene rock, and not a trace of mineralisation whatsoever in adjacent skarn rocks, may suggest that the mineralisation is not directly associated with the metasomatism — perhaps ?? hydrothermal mineralisation. The lack of gold and copper values correlation may mean two periods of mineralisation, or the lack of correlation may simply be caused by different mobilities for different minerals under various metamorphic conditions — not to mention the different mobilities in an oxidising environment.

CONCLUSION

The exploration in the White Hill Dam Area, so far, has resulted in the location of several copper mineralisations, not as yet tested for gold, and a gold-copper mineralisation. Tentatively, the gold-copper mineralisation, known as the Copper Queen, in an area not previously considered a gold environment, is thought of as hydrothermal. It is obvious, that the three grammes gold per tonne over a width of one metre plus, at the Copper Queen, is not an economic mineralisation, not even with the addition of one to three percent copper. The area as a whole and the area near the Copper Queen, however, have not been
explored for gold, and it is suggested that such exploration is very much justified, and that, when carrying out the exploration, special attention should be given to the area of alluvium to the west of, and the rugged area to the east of the Copper Queen.

The apparent lack of copper-gold correlation and the apparent lack of associated mineralisation with the gold mineralisation rather limit the exploration options. The proposed forward exploration programme is essentially a programme of geological mapping [1:5,000, say] and prospecting combined with a substantial sampling programme [some 600 samples for the area, say] - a programme requiring about 100 man days and an approximate expenditure of $78,000 - and a programme which is obviously to be extended to include detailed mapping, geophysics and drilling as results to hand warrant.
NORTHERN TERRITORY OF AUSTRALIA

Mining Act 1980

EXPLORATION LICENCE

EL NO: 4463

KINEX PTY LIMITED is hereby licenced to explore that area of land delineated in red in the second schedule attached hereto in accordance with the provisions of the Mining Act 1980 and regulations thereunder and subject to the terms and conditions set out in the first schedule for a period of six years from the date hereof.

Secretary

Date 3.5.87

FIRST SCHEDULE

Terms and Conditions

1. The licensee shall ensure that a minimum amount of $31,000 is expended in carrying out exploration on the licence area during year one (1) of the licence.

2. The licensee shall comply with the provisions of and directions lawfully given under this Act and all other laws in force in the Territory in relation to his activities on the licence area.

EL 4463
JCC:CAH:149
4.4 NZ
NORTHERN TERRITORY OF AUSTRALIA

Mining Act 1980

EXPLORATION LICENCE

EL NO: 4528

KINEX PTY LIMITED is hereby licenced to explore that area of land delineated in red in the second schedule attached hereto in accordance with the provisions of the Mining Act 1980 and regulations thereunder and subject to the terms and conditions set out in the first schedule for a period of six years from the date hereof.

[Signature]
T C LOVEGROVE
Secretary 3

Date 31.5.84

FIRST SCHEDULE

Terms and Conditions

1. The licensee shall ensure that a minimum amount of $16,000 is expended in carrying out exploration on the licence area during year one (1) of the licence.

2. The licensee shall comply with the provisions of and directions lawfully given under this Act and all other laws in force in the Territory in relation to his activities on the licence area.

EL 4528
JCC:CAH:149
4.4 N3
THE ECONOMIC POTENTIAL

OF THE

WHITE HILL DAM PROSPECT

HARTS RANGE, NORTHERN TERRITORY

by

P.M. Nicholson B.Sc(Hons) A.M.A.I.M.I.

for

Balmoral Resources N.L.

Darwin
May, 1987

Alice Springs
1:250,000
CONTENTS

1 INTRODUCTION
2 SUMMARY
3 CONCLUSIONS
4 RECOMMENDATIONS
5 GEOLOGY
6 EXPLORATION METHODS

REFERENCES

APPENDIX I Geology and Mineralisation of the Jervois Range, N.T. by Ypma et al.

Appendix II Geology of the Green Parrot and Reward Silver-lead Deposits, Jervois Range, N.T. by A.M. Mackie.
1 INTRODUCTION

The White Hill Dam prospect is located in the Harts Range in the Northern Territory, approximately 100 kilometres north east from Alice Springs. It is accessible from Alice Springs by driving north 88 kilometres on the Stuart Highway, then east for 96 kilometres on the Plenty Highway to the Blackfellow Bones bore track. The prospect is then reached by driving 30km to the southeast on a bulldozed dirt track.

The prospect is covered by Exploration Licences 4463 and 4628, which were granted on 31st May, 1984. The licences now cover 58 square kilometres. The licences were originally granted to Kinex Pty Ltd, but have recently been transferred to Balmoral Resources N.L.

Previous exploration in the Harts Range area mainly occurred in the early 1970's and was targeted at copper mineralisation (Neilson, 1987). Work included regional geological mapping, rock geochemical sampling and aeromagnetic surveying. The Oonagalabi copper-zinc prospect to the east of the White Hill Dam area, and the gold mineralisation at Copper Queen (within the present area) were found at that time. In 1984 the Copper Queen area was re-examined through the re-interpretation of geochemical and geophysical data, and more detailed mapping and sampling in the immediate prospect area. A C-horizon auger drilling programme was completed over possible strike extensions to the Copper Queen mineralisation in 1985/86.

The author of this report has examined the reports on the prospect area by MacCulloch and Neilson (1984) and Neilson (1987), studied literature relevant to the regional geology by Shaw et al (1984), Ypma et al (1984) and Mackie (1984), and visited the Copper Queen area for one day. From this information an assessment has been made on the economic potential of the area. A course for future exploration has been proposed.
2 SUMMARY

The White Hill Dam area has undergone regional exploration including geological mapping, aeromagnetics and rock chip sampling. Prospect-scale work has been restricted to more detailed rock chip sampling at the Copper Queen prospect. This work has identified low grade, stratiform gold-copper mineralisation. Although the grade and dimensions of the mineralisation found to date are uneconomic, comparison of the Copper Queen mineralisation with deposits in the nearby Jervois Ranges indicates much thicker, potentially economic, mineralisation could occur down-dip or along-strike.
3 CONCLUSIONS

1 The mineralisation at the Copper Queen is similar to the base metal lodes in the Jervois Range area. In both areas the deposits are stratiform, hosted by garnet and calcisilicate-rich "lode" rocks and associated with sequences containing impure marble and garnet-calcisilicate beds. The comparison with the Jervois mineralisation suggests the mineralisation in the White Hill Dam area will be stratabound.

2 Rock chip sampling at Copper Queen indicates a 500 metre strike-length may average 1 to 2% Cu and up to 3 g/t Au over a one metre thickness. Although this is subeconomically, the poddiness of the mineralisation indicates significantly thicker mineralisation could occur down-dip or along-strike. Masses of similar mineralisation attain tonnages of 500,000 to 1,500,000 tonnes in the Jervois Range area.

3 No discrete drilling targets are currently obvious. Further exploration would consist of geological mapping and ground magnetic surveys and perhaps stream sediment geochemistry to identify the location of the host stratigraphy. Rock chip sampling and electrical geophysical methods would then be used to define detailed targets.
4 RECOMMENDATIONS

1 A visit to the Jervois deposits should be arranged if possible to better evaluate the prospectivity of this mineralisation style.

2 The areas of potential mineralisation recognised by Neilson (1987) should be gridded and geologically mapped. Calcsilicate-garnet lithologies should be rock chip sampled, all first order creeks stream sediment sampled and the grid covered by a ground magnetic survey. This work will elucidate the position and nature of the potentially mineralised horizon.

3 An orientation survey of electrical geophysical methods should be carried out over the Copper Queen Prospect. The most efficient method would then be used to explore for thicker pods of sulphide mineralisation.

4 Geophysical and geochemical anomalies would be followed up with drilling and/or costeaming.
5 GEOLOGY

The rocks of the White Hill Dam area are high grade metamorphics of the Early Proterozoic Arunta Complex (Shaw et al., 1984; Neilsen, 1987). The geology of the White Hill Dam area is described by Leitch (in Neilsen, 1987).

5.1 Stratigraphy

Various divisions of metamorphic rocks in the area have been made according to the range and relative abundance of lithologies. The following are a brief description of the subdivisions recognised by Leitch (op cit).

Ongeva Creek Granulite  This group is composed of closely associated mafic, felsic and silicic granulites veined by pegmatite and aplite. The group surrounds the Mount Schaeber Granite in the south-east corner of EL 4628.

Blackfellows Bones Granulite  Mafic and felsic granulites comprise this unit. The shape of many of the mafic bodies suggests they were once small basic intrusions, perhaps into a sequence of mature sedimentary rocks, now represented by the felsic granulites.

Cadney Gneiss  Calcsilicate rocks comprised of varying proportions of garnet, epidote, diopside, amphibole and calcite are characteristic of this group. Leases of biotite and quartzofeldspathic gneiss also form a significant proportion of the unit. A domal antiform of the Cadney Greiss occurs in the southern half of EL 4463. The Copper Queen mineralisation and a magnetic unit are contained within the outer (?upper) parts of this dome.

Irindina Gneiss  This unit is composed of interlayed amphibolite, biotite gneiss and quartz feldspathic gneiss. It is considered to structurally overlie the Cadney Gneiss.
Gough Dam Gneiss  Lithologies that have suffered significant amounts of retrograde metamorphism are grouped into this unit. In the White Hill Dam area they occur in two linear zones, which trend approximately East to south east.

Mount Schaeben Granite  A small elliptical granite pluton occurs in the south west corner of EL 4528. Weak foliation and a lack of contact effects suggest the granite was emplaced during regional metamorphism.

5.2 Structural Geology

All of the metamorphic units show the same deformation history on outcrop scale. The earliest recognised tight to isoclinal folds are refolded into open to closed structures with east-west striking axial surfaces. Fold axes of the second generation show a wide range of orientations.

Leitch op cit describes a number of structural domains separated by the linear, retrograde zones of Gough Dam Schist. A number of east to south-east trending folds can be recognised with wavelengths of one to three kilometres.

5.3 Mineralisation

Two styles of mineralisation can be recognised in the White Hill Dam area.

Cupriferous Gneiss zones consist of malachite-stained lenses of biotite-sillimanite-(garnet) gneiss. At the most significant occurrence of this mineralisation style, the Copper Queen North, a discontinuous zone is several hundred metres long and up to 2 metres wide. This mineralisation contains no known anomalous gold concentrations and does not appear to have any direct association with the more important calc-silicate-related mineralisation.
Calc-silicate-related mineralisation occurs at the Copper Queen prospect. The mineralisation is concentrated in a discontinuous layer of gossanous, garnet- clinopyroxene epidote rock closely associated with other calc silicate lithologies and marble. The mineralisation appears to be conformable with the surrounding metasediments. The mineralised zone is generally about one metre thick, although thinner, subparallel bands of "lode rock" may be concentrated over several metres. Channel chip samples taken by MacCulloch and Neilsen (1984) range from 1.6 m at 1.23% Cu and 3.3 g/t Au to 14.7 m at 1.03% Cu and 0.64 g/t Au.

In the Jervois Range area, which lies about 100 km to the east of the White Hill Dam area, Arunta Complex rocks including impure marbles, calc silicates and magnetite-quartzites host two types of stratabound base metal mineralisation (Ypma et al. 1984, Appendix I). Chalcopyrite-pyrite lodes hosted by magnetite-chlorite rocks vary in grade between 1.0 and 3.5% Cu and 20 to 60 g/t Ag, and occur in masses of 500,000 to 1,500,000 tonnes. Argentiferous galena and sphalerite are hosted by similar host rocks and also in manganese-rich calcisilicates. These orebodies attain grades of 8% Pb, 140 g/t Ag, and 2-4% Zn and occur in pods of 10,000 to 40,000 tonnes. Clusters of pods reach tonnages of 60,000 to 250,000 tonnes. The gold grades of these mineralisation types is not known.

The Copper Queen mineralisation has many similar features to the Jervois deposits. It is therefore inferred that Copper Queen-style mineralisation in the White Hill Dam area will be stratabound in distribution, poddy in nature and have the potential to obtain several hundred thousand tonnes. It is not unreasonable to expect the gold grade to improve in areas of thicker mineralisation.
EXPLORATION METHODS

The C-horizon/cyanide extraction survey (Neilsen, 1987) does not appear to be of much value. The highest values located appear to be mainly in calcrete or alluvium, and are not really significant anyway (0.002 g/t Au). Regional rock chip geochemistry is probably also of a limited use. Stratiform mineralisation will not necessarily be surrounded by an aureole with anomalous copper and/or gold content.

Combined geological mapping and aeromagnetics have been used by MacCulloch and Neilsen (1984) and Neilsen (1987) to recognise the extensions of the Copper Queen host stratigraphy. This could probably be refined by more detailed grid mapping and magnetics. Detailed stream sediment geochemistry and rock chip sampling of all potential host lithologies should occur in this zone. Analysis technique and size fraction selection for the stream sediment sampling could be determined after a brief orientation programme in the Copper Queen area.

The mineralisation may be susceptible to an electrical geophysical method. The exact method would depend on the amount and texture of the sulphide minerals, and would be determined by an orientation programme using several methods over the Copper Queen. The Copper Queen area and any other areas considered prospective would then be surveyed by the most successful method.

Drilling and/or costeaming would follow up geochemical and geophysical anomalies.
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APPENDIX I
GEOLOGY AND MINERALIZATION OF THE JERVOIS RANGE, N.T.

By
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EXTENDED ABSTRACT

The northern margin of the Arunta Block is characterized by a metasedimentary and volcanic sequence of lower metamorphic grade than that of the central Arunta Block. Whereas the Hart rangee have greenschist to lower amphibolite metamorphic grades, the northern margin only reached greenschist to lower amphibolite facies. Most of the high grade area of the central Arunta Block appears to be unprospective, but the lower grade marginal fringe contains most mineral prospects to name a few: Barrow Creek, Holyhill and the Jervois mine. Numerous smaller prospects occur in this marginal zone.

Four major lithostratigraphic units can be recognized in the Jervois mine area:
1. Gneissic Suite consisting of granitic and rhyolitic gneisses which are characterized by a distinct intersection lineation.
3. Mica Sequence, consisting of spotted schists with andalusite and cordierite, quartz-sericite-feldspar schists with distinct rhyolitic remnants and quartz-sericite-feldspar schists which contain the lode horizons:
   a. impure marble;
   b. magnetite-quartzite;
   c. chlorite-magnetite-quartzite with or without staurolite and garnet
   d. calc-silicate rocks.
4. Quartz-Chlorite Suite of quartz-chlorite schists and quartz-magnetite-chlorite schists.

All lithostratigraphic units contain banded iron formations, amphibolites, quartz-tourmaline rocks and calc-silicate rocks. The sequence of stratigraphic units as presented is probably in stratigraphic order, with rocks which reflect the oldest deformation most clearly (the Gneissic Suite) at the bottom, and the Lode Horizon stratigraphically above the Acid Volcanics.

The main base metal mineralization is associated with quartz-sericite-feldspar schists suggesting an acid volcanogenic source. Three types of mineralization occur:
1. chalcopyrite-pyrite lodes in magnetite-chlorite-garnet rocks;
2. argentiferous galena and sphalerite in similar host rock but also in manganese-rich calc-silicates, and
3. scheelite in marbles and calc-silicates.

All ores are stratabound, the copper and tungsten ores are stratiform as well. The quartz-tourmaline rocks and banded iron formations (BIF) are excellent stratigraphic markers. The BIF, magnetite-quartzites, and magnetite-garnet-chlorite-quartz rocks occur on the same stratigraphic horizon, and are occasionally grading into each other, probably reflection initial time, facies variations. The copper-silver ores vary in grade between 1.0 and 3.5% Cu and 20 to 65g Ag/t and occur in masses of 500,000 to 1,500,000 tonnes along the lode horizons. The lead-silver-zinc orebodies have higher grades: 8% Pb, 140g Ag/t and 2-4% Zn, but occur in smaller pods of 10,000 to 40,000 tonnes, constituting mineable ore clusters of 60,000 to 250,000 tonnes.

Lateral and vertical continuity of orebodies have been affected by deformation of the host rock: the copper-silver orebodies to a lesser extent than the lead-silver-zinc ores. Three phases of deformation have been recognized.
1. The oldest D₁ deformation produced a layer or bedding parallel schistosity (S₁). The folds (F₁) causing this schistosity are not obvious and are probably of large scale, and may have formed recumbent folds and nappes structures. The S₁ schistosity is most pronounced in the northern Gneissic Suite and adjoining Metasedimentary Suite.
2. The second deformation (D₂) produced locally a north-south schistosity (S₂) which has become the dominant schistosity in the Jervois Range. The D₂ event produced mineral segregation parallel to S₂ and extensive transposition of layering. Transposition has obscured many of the top-bottom criteria which are normally used for reconstructing stratigraphic sequences. The main regional metamorphic event of upper green-schist to lower amphibolite facies is probably coeval with D₂. This metamorphic event was

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Figure 1. Geological Sketch Map of the Jervois Range N.T.

followed by granite intrusion (whole rock dates of 1750 Ma) and thermal blastesis of late to post-kinematic cordierite and andalusite.

3. A younger crenulation folding (D3) affected the S2 schistosity leading to pencil cleavage, and could be coeval with mica ages of 1460 Ma. The formation of the prominent "J"-structure is due to this D3 event (see Figure 1).

Interference between S1 and S3 caused the linear gneiss textures of the northern Jarvols mine area. Refolding by F3 - principally a shear fold mechanism - caused curved F3 hinges, boudinage, attenuation of fold limbs and thickening of layering (including the ore shoots) in fold hinges.

Mineral and ore segregation during and after D3 was facilitated by fluid convection possibly due to granite emplacement. Fluid inclusion studies indicate a cooling hydrothermal event in a closed system: starting at a temperature of 390°C and 2 Kb pressure, the fluids segregated into a Cu-rich fluid and a brine of increasing salinity during regional cooling. The copper-silver mineralization was affected by the high temperature end of this cooling fluid (300-200°C); agate-lead-silicon followed in the 200-100°C domain and lead-silver-zinc mineralization was the last to be affected (150-90°C) by brines with salinities of up to 30% equivalent CaCl2. Notwithstanding this thermal and volatile-induced overprint, the mineralization as a whole is considered to be pre-D3, as zinc has been incorporated in metamorphic minerals like staurolite in the lode horizon, and manganese silicates (rhodonite) are characteristic for the ore zones.

Host rocks and ore lithologies show similarities (although at a lower metamorphic grade) with those of Broken Hill (N.S.W.); that is the dominance of acid and intermediate volcanogenic rocks, the presence of stratiform tourmaline and aegirite-lead-silicon formations and the manganese-lead-silver-zinc with skarn-type minerals.

This extended abstract is a resume of work done by students and staff of the University of Adelaide and the State University of Utrecht in the Netherlands. This cooperative programme has been generously supported by the Plenty River Mining Company N.L. (PRM Co). The authors wish to thank PM Co for authorization to publish these results.
APPENDIX II
GEOLOGY OF THE GREEN PARROT AND REWARD SILVER-LEAD DEPOSITS JERVOIS RANGE, NORTHERN TERRITORY

By
A. M. MACKIE

ABSTRACT

The Green Parrot and Reward stratiform silver-lead (copper-zinc) deposits are located in the eastern part of the Arunta Block. At Green Parrot, mineralisation is contained within a north-south striking lode horizon comprised of elongate lenses of massive garnet or calcisilicate-carbonate "lode rocks" with intercalated sericite-biotite schist and laminated biotite-feldspar schist. The "lode rocks" are increasingly calcareous to the west. The mineralisation is broadly zoned with an increase in lead content and decreases in copper and silver contents from east to west. The principal sulphide minerals are galena, sphalerite and bornite.

The Reward deposit lies adjacent to a lens of massive garnet "lode rock" which is contained within garnetiferous sericite-quartz schist. Primary mineralisation consists of galena, chalcopyrite, sphalerite and pyrite.

Both deposits are associated with a substantial thickening of the lode horizon which is narrow and discontinuous along strike from the Green Parrot and Reward deposits. The mineralisation and lode rocks are probably derived from volcanic exhalations. Deformation has caused brecciation of the ore zones and the associated massive garnet "lode rocks" plus minor remobilisation of galena into narrow cross-cutting veins.

INTRODUCTION

The Jerwois Mineral Field is located in the eastern part of the Arunta Block some 265 km northeast of Alice Springs (Fig. 1). Secondary copper and lead mineralisation was discovered in 1929 (Robertson, 1959). Between 1938 and 1956, intermittent gouging and small-scale, underground mining was undertaken on a number of prospects but production was small (Robertson, 1959).

Fig 1. - Location of mineral deposits in the Jerwois Area.

Systematic exploration of the area was carried out by New Consolidated Goldfields (Australasia) Pty Ltd, followed by Petrocar Exploration NL and Union Corporation (Australia) Pty Ltd in the period 1960 to 1975. In 1981, Plenty River Mining Co (NT) Ltd commenced open cut mining of the Green Parrot deposit after construction of a gravity-flotation mill. Approximately 40,000 tonnes of oxide ore was mined prior to the mine and treatment plant being placed on care and maintenance in December, 1983.

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GENERAL GEOLOGY

The host rocks to mineralisation at Jervois are Lower Proterozoic metapelites and metavolcanics which have been folded into a "J"-shaped structure. Dominant lithologies are cordierite, sericite, andalusite or chlorite schists with subordinate amphibolite, biotite-feldspar schist, calcisilicate rock, carbonate rock, magnetite quartzite, massive garnet rock, banded iron formation, and quartz-tourmaline rock.

The metamorphic grade ranges from upper greenschist to middle amphibolite facies (Dobos, 1978). Three separate deformations are recognised (Dobos, 1978; Ypea et al., this volume).

The schistose sequence is unconformably overlain to the west and northwest by Upper Proterozoic - Lower Cambrian Mapunga Group sediments which form the Jervois Range.

Three types of mineralisation are present.

1) Silver-lead (copper-zinc) mineralisation associated with lenticular bodies of garnetiferous and calcisilicate-rich rocks. The best examples are Green Parrot and Reward.

2) Stratiform copper mineralisation as chalcopyrite (plus pyrite) hosted by extensive, thin magnetite quartzite horizons (for example, Marshall and Bellbird).

3) Tungsten mineralisation as scheelite in calcisilicate rock and altered amphibolite (for example, Wards and Pioneer).

A detailed account of the regional geology is given by Ypea et al., (this volume).

GREEN PARROT DEPOSIT

The Green Parrot deposit is a resource of approximately 0.3 million tonnes averaging eight percent lead and 160 ppm silver.

The following observations and interpretations are based on detailed mapping of surface exposures and logging of drill core by the author as well as petrographic studies by J. Pontifex of Pontifex and Associates, Adelaide.

STRATIGRAPHY AND LITHOLOGIES

The vertically dipping mine sequence trends north-south. Three stratigraphic units are recognised from east to west namely, sericite schist, lode horizon and cordierite schist. The facing direction is not clear as sedimentary younging information is lacking in the mine sequence.

Sericite schist

The sericite schist unit consists predominantly of sericite-quartz-magnetite schist. Garnet and biotite may also be present. Subordinate to the schist are several 0.2-2.0 m thick horizons of magnetite quartzite which are weakly banded and contain minor garnet-rich laminae as well as sporadic secondary copper minerals. Also present within the sericite schist unit are minor 20mm - 0.1 m thick bands of laminated biotite-feldspar schist, a lithology characteristic of the lode horizon.

Lode horizon

The lode horizon hosting the mineralisation consists of numerous lenses of "lode rock" separated by biotite-rich schist (Fig. 2).

LEGEND

SERCITE SCHIST
CORDIERITE SCHIST
× HIGH C.ADE Pb-Ag-Zn-Cu MINERALISATION

GAR: T-CALC SILICATE
GAR: T-QUARTZ ROCK
CALC SILICATE, CARBONATE
BIOTITE-FELDSPAR SCHIST ; SERICITE-BIOTITE SCHIST

Fig 2. - Simplified geology of the Green Parrot deposit.

The thickness of the lode horizon is variable, reaching a maximum of 55 m in the centre of the Green Parrot deposit but thinning to three m of barren calcillicate-carbonate rock and biotite-feldspar schist to the south, before disappearing under surficial cover.

"Lode rocks" are defined as massive garnet and/or calcillicate-rich rocks which are spatially related to mineralisation. They are interpreted as having originally been chemical sediments, probably of exhalative origin and are divisible into three types on the basis of mineralogy.

1) Garnet-calcillicate rock consisting of 80 per cent, massive, granular, brown garnet with disseminated patches of calcillicate minerals, principally diopside with lesser epidote. The garnet is spessartine-rich with minor grossular garnet also present and typically contains magnesium oxide.

2) Garnet-quartz rock consisting of fine granular garnet with irregular lenses of quartz and minor, disseminated magnetite. This type is found only in the central part of the Green Parrot deposit and has a limited lateral extent. It is similar in appearance to the "garnet sandstone" at Broken Hill described by Barnes (1980).

3) Calcillicate rock is green in colour and consists of variable amounts of epidote, grossular garnet, vesuvianite, diopside and actinolite with minor calcite, quartz, apatite and sphene. This rock type forms a lens up to 15 m thick at the western edge of the lode horizon where it contains irregular pods of white marble and veins of calcite and fluorite.

Irregular patches of earthy to massive manganese oxides are present in the oxide zone associated with "lode rocks" and particularly with garnet-calcillicate rock. The manganese oxides have accumulated in open spaces and are probably derived from the weathering of spessartine garnet. Subhorizontal pegmatite veins up to one m thick are common in the lode horizon.

Schists within the lode horizon are of two types.

1) Sericite-biotite-quartz schist with finely disseminated magnetite and garnet is similar to the sericite schist unit to the east.

2) Laminated biotite-feldspar schist, with or without quartz and garnet, contains individual laminae 0.5 to 5mm thick which are rich in feldspar or biotite-quartz.

Both plagioclase and potash-feldspar are present as porphyroblasts up to three mm in diameter. Biotite defines a schistosity at a low angle to pervasive layering which is extremely regular and most likely bedding.

The mineral assemblage suggests that the original rock type was either a volcanioclastic sediment or an acidic tuff. The occurrence of biotite-feldspar schist as finely laminated and very thin but persistent horizons within sericite schist is more compatible with a tuffaceous than a sedimentary origin.

Cordierite schist

Cordierite schist consists of silvery grey, muscovite-quartz-biotite schist with ovoid poikiloblasts of cordierite plus disseminated magnetite. The cordierite schist contains minor, intercalated, biotite-feldspar schist and thin layers of epidote-rich calcillicate rock.

MINERALISATION

Patchy mineralisation is common within the lode horizon. However, economic grades and widths are confined to two zones.

One zone of lead-copper-zinc-silver ore is associated with the easternmost lens of "lode rock" which is a garnet rock with minor calcillicate minerals (Fig. 2). High grade mineralisation (greater than eight per cent lead) is restricted to the margins of the lens of garnet "lode rock" in contact with biotite-feldspar schist, although low grade, disseminated mineralisation is found within the garnet rock itself.

The high grade mineralisation in the sulphide zone consists of galena with bornite and sphalerite. In the oxide zone, which extends to a maximum depth of 25 m, cerussite, anglesite, hemimorphite, malachite, cuprite and distinctive blue-green chrysocolla (after which the deposit is named) are present.

Silver values in the high grade ore are typically 200-300 ppm. The silver occurs in minute inclusions of tetrahedrite (Ormsby, 1982) or as small, discrete silver sulphide grains. No silver has been detected in solid solution within galena.

Mineralisation near the southern end of this eastern zone contains a few patches of high grade copper oxide ore consisting of cuprite and malachite (up to 25 per cent copper). Patches of massive manganese oxides also lie along strike from the mineralisation. Lead and zinc values within the manganese oxides are due to the presence of coronadite and woodruffite. Both the garnet "lode rock" and associated mineralisation have been boudinaged into three discrete pods.

A zone of lead-zinc-silver ore occurs within a thick lens of calcillicate rock near the western boundary of the lode horizon (Fig. 2). Pods of massive galena are restricted to a zone ten m wide near the eastern margin of the calcillicate lens. The mineralisation has been strongly deformed into isolated boudins and minor, narrow, transgressive galena veins marginal to the boudins. The veins appear to result from stress-induced remobilisation of the galena. Sphalerite is commonly associated.

2 Electron microprobe analysis by ANBGL (0.1 per cent silver detection limit).

with the galena and in some pods the zinc to lead ratio is as high as one to one.

In contrast to mineralisation of the eastern zone, copper is only a minor constituent and is present as fine grained inclusions of bornite in galena. Silver values are erratic but on average are somewhat lower that in the first zone.

In addition to the lead-copper and lead-zinc mineralisations, minor patchy scheelite is present in a zone, one m wide in the calcisilicate lens along the western boundary of the lode horizon. The scheelite mineralisation is adjacent to but separate from the lead-zinc mineralisation. Patchy scheelite mineralisation is generally widespread in calcisilicate rock and amphibolite of the Jervois area, particularly within the cordierite schist unit. The scheelite occurrences, with the exception of Green Parrot, are at different stratigraphic horizons to the lead-copper-zinc and lead-zinc occurrences, suggesting they are genetically unrelated.

REWARD DEPOSIT

The Reward silver-lead deposit is located 1.1 km north of the Green Parrot deposit (Fig. 1) and contains 30,000 tonnes of 18 per cent lead and 250 ppm silver. The Reward deposit is inferred to be at a stratigraphic level 40-50 m east of the Green Parrot deposit.

The Reward deposit lies along the western edge of a major striking, subvertical lens of garnet-rich "lode rock" which consists of coarse, brown garnet with occasional patches of epidote, quartz and magnetite plus minor disseminated apatite. The "lode rock" and mineralisation are enclosed within sericite-quartz schist similar to the sericite schist unit at Green Parrot.

The sericite-quartz schist east of the garnet "lode rock" has abundant, disseminated magnetite and garnet and contains thin layers of magnetite-biotite-quartzite, biotite-feldspar schist and andalusite-biotite-garnet schist. The sericite schist to the west contains abundant mesoscopic laminae of garnet-quartz rock ("garnet sandstone"). The lithologic layering defined by alternating sericite schist and garnet-quartz rock forms an angle of 30° to the schistosity. The sericite schist passes westwards into a chalcopyrite-pyrite-magnetite quartzite horizon which is a northerly extension of the Marshall copper orebody. The stratigraphic interval between the copper orebody and Reward silver-lead orebody is approximately ten m.

The silver-lead mineralisation consists of massive galena with minor to trace amounts of sphalerite, pyrite and chalcopyrite. Gangue minerals are garnet, quartz and minor fluorite. The mineralisation reaches a maximum thickness of eight m at a point which also corresponds with the maximum development of the garnet "lode rock" (12 m thick). Subsequent information for the Reward silver-lead deposit is derived from five diamond and 17 percussion drill holes. In individual drill holes, there is a good correlation between the thickness of the ore intersection and the thickness of the associated garnet "lode rock". This implies that similar depositional controls existed for both the "lode rock" and the ore.

The contact between the ore and "lode rock" is gradational with the thinning in the thickness of galena over about 0.5 m whereas the contact between the ore and sericite schist is sharp. The eastern margin of the garnet "lode rock" is sheared and brecciated by faulting. Sulphides, dominantly chalcopyrite and pyrite, are present in the breccia matrix.

CONCLUSIONS

Strataloud silver-lead (copper-zinc) mineralisation at Jervois is spatially related to lenticular bodies of garnet- and calcisilicate-rich "lode rocks". Laminated biotite-feldspar schists, with or without quartz and garnet, are common in the lode horizon at Green Parrot and are interpreted to be tuffaceous in origin.

Both the Green Parrot and Reward deposits are associated with a thinning of the lode horizon. This feature may be interpreted as being either of primary, sedimentary origin or the result of structural thickening. The Reward ore zone is associated with a corresponding increase in the thickness of a single lens of garnet "lode rock", whereas the mineralisation of Green Parrot is related to increases in both the number of lenses of "lode rock" and thicknesses of individual lenses.

Individual lenses of "lode rock" at Green Parrot differ markedly in mineralogy, ranging from garnet-rich to calcisilicate- and/or carbonate-rich lithologies. There are also differences between the mineralisation of the westernmost zone, which is relatively rich in copper and silver, compared with that of the eastern zone which is richer in lead and zinc. These characteristics indicate that thickening of the lode horizon is unlikely to be due to repetition by folding of one or two layers of "lode rock" and mineralisation but is probably a original, depositional feature. High grade mineralisation at Reward and Green Parrot generally occurs along lithologic boundaries in contact with "lode rocks" which are interpreted to be metamorphosed chemical sediments. It is envisaged that the "lode rocks" and mineralisation were derived from exhalations which accumulated on the sea floor in small basins during breaks in sedimentation, with individual pulses being rich in one or more of manganese, calcium and base metals.
Deformation has resulted in brecciation of the competent "lode rocks" and associated mineralisation, along with minor re-mineralisation of galena-rich mineralisation into narrow, transgressive veins.

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