NORTHERN GOLD N.L.

COMBINED ANNUAL REPORT FOR


EXPLORATION LICENCES 4207, 4208
AND 4235 HOWLEY AREA,
NORTHERN TERRITORY.

Licences  - 4207 G.N. Kater
           4208 G.N. Kater
           4235 Talmina Trading

Operator  - Northern Gold N.L.
Licences  - EL's 4207, 4208, 4235
Location  - Pine Creek 1:250,000 5052-8
           Batchelor 1:100,000 5171
           Tipperary 1:100,000 5170

Period    - June 1983 - June 1984
Date Submitted - August 1984
Author    - B.R. Richardson.
TABLE OF CONTENTS.

1. INTRODUCTION.
   1.1 History and Production.
   1.2 Previous Exploration.

2. GEOLOGY.

3. EXPLORATION POTENTIAL.

4. WORK DONE.
   4.1 EL 4208
   4.2 EL 4235 and 4207

5. RESULTS.
   5.1 EL 4208
   5.2 EL 4235

6. CONCLUSIONS and RECOMMENDATIONS.
   6.1 EL 4207
   6.2 EL 4208
   6.3 EL 4235

FIGURES.

1. EL 4208 Geological Maps with RPS Contours RRMIP Survey.

APPENDICES.

2. RRMIP Technique.
SUMMARY.

Exploration Licences 4207, 4208 and 4235 occur approximately 140 kilometres south of Darwin and are three of the twenty-two operated by Northern Gold N.L. in the Howley area. The licences are prospective for gold mineralization associated with hardrock and alluvials shedding from the Howley and John Bull Lines. EL4235 is also prospective for tin associated with pegmatites emanating from the Mt. Shoobridge Granite. EL4207 occurs between the Howley and John Bull Lines, while EL 4208 covers part of the western limb of the Howley anticline. EL 4235 occurs to the west of the anticline and straddles part of an anticlinal axis paralleling the Howley Line.

During the year Northern Gold N.L. conducted an RMP survey over part of EL 4208 and a significant anomaly was defined along the eastern boundary. Only general prospecting was carried out over the other tenements.

The future programme involves geological mapping, costeering, and sampling with bulk testing of alluvials. The alluvial testing programme is underway at the time of writing this report.
1. INTRODUCTION.

Exploration Licences 4207, 4208 and 4235 are located in the Howley area, approximately 140 kilometres south of Darwin. Northern Gold N.L. are the operators of these three tenements along with nineteen others in the Howley area. (Fig. 1)

<table>
<thead>
<tr>
<th>TITLE</th>
<th>REGISTERED HOLDER</th>
<th>AREA</th>
<th>DATE OF GRANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL4207</td>
<td>G.W.Kater (in trust for Talmina)</td>
<td>1 block</td>
<td>27/5/83</td>
</tr>
<tr>
<td>EL4208</td>
<td>G.W.Kater (in trust for Talmina)</td>
<td>4 blocks</td>
<td>27/5/83</td>
</tr>
<tr>
<td>EL4235</td>
<td>Talmina Trading</td>
<td>2 blocks</td>
<td>17/6/83</td>
</tr>
</tbody>
</table>

The licences operated by Northern Gold N.L. contain large areas of the South Alligator Group of rocks which are hosts to gold mineralization in the Howley area and elsewhere. A number of significant old mines occur in the area, the most noted of which are the Cosmopolitan, Metropolitan (Big) and Chinese Howleys. These three occur on the Howley Anticline, a major structure in the Pine Creek Geosyncline. Gold mineralization can be traced along this fold axis, termed the Howley Line, from Cosmopolitan Howley northwards through the licence area.

The large number of small tenements held by Northern Gold N.L. in the Howley area makes it very difficult to carry out a systematic exploration programme and at the same time conduct work on each of the Exploration Licences. During the year, the company explored the most prospective areas along the Howley Anticline and initiated a programme to assess the alluvials shedding from this line. Part of EL4208 was explored during this programme but very little work was carried out on EL's 4207 and 4235. These areas will be explored more fully during
later phases of the overall programme when the ground away from the most prospective zone is assesed.

1.1 HISTORY AND PRODUCTION

Gold was first discovered in the Howley district in 1873 during the construction of the Overland Telegraph. Gold mining in the tenements was initiated by Chinese during the 1880's from both alluvials and reefs. The largest reef mine, the Metropolitan Howley (sometimes referred to as the Big Howley) operated between 1883 and 1903 and since that time there has been no significant production except for cyaniding of tailings. Officially recorded production from the Metropolitan Howley totals about 1,000 kilograms of gold; however old unofficial reports suggest production may have been considerably more. The workings consisted of an open cut, two three compartment shafts to depth of 52 and 58 metres and extensive underground workings. 1,300 metres to the southeast the Chinese Howley mine was operated between 1892 and 1896 with official recorded production about 360 kilograms (ore grade 28 g/t). By 1896, problems with sulphide ore treatment, underground water, periodic flooding and mine collapses were encountered in the Chinese Howley mine. During the 1890's medium grade gold ore was produced from dozens of pits along the Howley Line northwest of Metropolitan Howley, but few records are available. At Bridge Creek, a group of small but very rich leaders, ranging in width from 1 or 2 inches to about 18 inches, has been intermittently worked since 1873 (Perkes 1892). Five shafts were recorded from 50 to 70 feet deep in this area. The total recorded production is 1190 oz, but this is known to be incomplete. Since 1960 the only work carried out in the area has been the limited testing of the alluvials.

The Howley Line is semi-continuous from the Cosmopolitan Howley prospect and is marked by numerous shafts and pits. Several intermittent sub-parallel reef systems were worked on both sides of the Howley Line,
other significant lines of reefs were worked, the most prominent known as the John Bull and Britannia Lines. Production usually ceased at the water table. Below the water table gold was associated with strong sulphide mineralization causing treatment problems. The major producers along the John Bull Line were Zapopan (2146 kgs of gold) and the Brocks Creek mine where 40,000 tonnes of ore were crushed for a recovery of 682 kgs of gold (17.1 g. Au/tonne) and 18,326 tonnes of tailing were treated for 147 kgs of gold (8 g. Au/tonne).

Production from the large and intensely worked shallow alluvial fields is not recorded.

1.2 PREVIOUS EXPLORATION.

After the end of mining early this century and prior to 1976, only limited exploration was conducted over the Howley area. In the period 1976-1981 B.H.P. Co. Ltd. and Homestake Mining Ltd. carried out an extensive exploration programme covering the Cosmopolitan to Metropolitan Howley belt. They concluded that the resources outlined were too small for viable production rates. The tenure holdings, which of Gold Mining Leases and Mineral Claims over the three main deposits, were optioned to a joint venture between Peck-Wallsend and Anaconda Australia in 1982. Exploration by this joint venture is continuing at present and is concentrated at the Cosmo.

In 1980/81 Territory Mining Pty. Ltd. and Greenex conducted an alluvial testing programme, using a backhoe, over the Bridge Creek workings. The results were not encouraging enough to continue and the licence was relinquished.

In the area covered by the three tenements there is no reported exploration prior to the work carried out by Talmina Trading in 1982/83. During this period an auger drilling programme was conducted over the alluvials covering EL4207. (See Annual Report EL2450 1983). Thirteen holes returned visually estimated gold grades
of between 0.25 to 1.5 g/t. These results are regarded as significant and further work was programmed for this area. Only general prospecting was carried out over the other two tenements.

2. GEOLOGY.

The Howley area is located within the western part of the Pine Creek Geosyncline and contains rocks of Lower Proterozoic age. In the basin, granitic Archaean basement is successively overlain by: coarse clastics and carbonates of the Batchelor group; fluvial and shallow water platformal clastics of the Mount Partridge group; and a heterogenous sequence of carbonaceous mudstones, acid tuffs, bonded iron formations and siltstone/greywacke turbidites of the South Alligator Group and finally the flysch sequence of the Finnis River Group. The sediments were intruded by sills of the Zamu Dolerite prior to the major phase of regional deformation, which was accompanied by greenschist facies regional metamorphism. A second, broad, open phase of cross-folding is probably related to widespread granite intrusion, which occurred in the early Middle Proterozoic. Sediments of the South Alligator and Finnis River Group and intrusives of the Zamu Dolerite and Burnside Granite occur in the Howley area. The intrusion of the granite during the Middle Proterozoic was responsible for the formation of the major structure in the area, the Howley Anticline, which has a strike length of over 20 km.

The sediments are tightly folded with western limb dipping at 60 to 80 degrees while the eastern limb is steeply dipping to overturned. The axis runs in a north-westerly direction curving around to the north outside the tenement area. The plunge of the axis is variable, changing from 50 degrees W in the Cosmo Howley area, to 32 degrees NW at the Metro Howley and 50 degrees S at the Bridge Creek working.

The oldest rocks along the Howley Anticline are the carbonaceous shales, mudstones, iron formations and carbonates of the Kooldin Formation exposed at the
Cosmo Howley area. These are overlain by acid tuffs, mudstones and siltstones of the Gerowie Tuff. The Mt. Bonnie Formation is a transitional sequence between the Gerowie Tuff and the Burrell Creek Formations, and shows a gradual decrease in volcanic component and increase in clastic component. The Burrell Creek Formation is the basal unit of the Finnis River Group and is comprised of greywakes, siltstones, shales and minor conglomerates.

Sills of the Zamu Dolerite occur along the Howley Line area and are most common within the Koolpin Formation and basal Gerowie Tuff units.

Exploration Licence 4207 occurs to the east of the Howley Anticline and contains greywakes and silts of the Burrell Creek Formation and minor tuffaceous units of the Mt. Bonnie Formation in the north-east corner. The rocks crop out along low rises but the majority of the area is covered by alluvium.

Exploration Licence 4208, located west of the anticline contains parallel striking ridges along the eastern boundary. To the west of these ridges all units are covered by alluvium. The tuffaceous units of the Gerowie Tuff and the red silts and thin b.i.f. horizons of the Mt. Bonnie Formation are easily followed along the ridges and the boundary between these two formations is marked by a 2m. wide greywake. The gradual decrease in volcanic component and increase in greywake and silt component was noted going up sequence. This tenement contains an area of old alluvial diggings to the west of the highway and a carbonaceous shale horizon which was defined by the R.M.I.P. survey. (Fig ).

Exploration Licence 4205 covers part of an anticlinal axis that parallels the Howley Line. According to the J. Batchelor - Hayes Creek 1:100,000 map this axis runs through units of the Mt. Bonnie Formation with flanking units of the overlying Burrell Creek Formation. Limited mapping has indicated only siltstones and quartzites similar to Burrell Creek units found elsewhere. A number of conglomerates emanating from the nearby Mt. Shoobridge Granite intrude these sediments and parallel the regional strike.
EXPLORATION POTENTIAL.

The major gold mineralization within the Howley area is structurally controlled, restricted to the hinge line of the major anticlines and concentrated at the nose of tight folds, eg Como and Metro Howley. Alluvial workings cover large areas of the shed from the gold lines and palaeo-channels and can carry gold several kilometres from the reef zones. The two major targets of exploration in the Howley area are:

1) the gold mineralization within hard rock along the Howley Line.

2) gold bearing alluvials.

Northern Gold is concentrating at this stage on exploring the Howley Line with special emphasis on the Bridge Creek area and on the alluvials shedding from this line. Exploration Licence 4208 contains a reasonable area of gold bearing alluvials and also prospective units of the Gerovie and Mt. Bonnie Formations. Interpretation of Landsat Imagery by G. Kater has indicated that an anticlinal structure may occur parallel to the west of the Howley Line and cut through the tenement area. Work is already underway to test this in the adjoining EL 4238.

Exploration Licence 4207 is prospective for alluvial gold shedding from the John Bull line of reefs. The hardrock potential is regarded as minimal.

Exploration Licence 4205 straddles part of an anticlinal axis within the Mt. Bonnie Formation and this structure is the main target of exploration. This tenement is also prospective for tin mineralization associated with pegmatites related to the nearby Mt. Shobridge Granite.

4. UNK DONE.

4.1 EL 4200

In October 1983 Northern Gold N.L. contracted Scintrex Pty. Ltd. to execute a series of RAPID RECONNAISSANCE MAGNETIC INFUCED POLARIZATION (RMIP)
surveys over various prospects in the Howley area. The objective of these surveys was to locate and define segregations of sulphides as gold is known to be associated with pyrite - arsenopyrite in the Howley area.

The ARMIP method is a recently developed technique that has proved very successful in locating sulphide bodies beneath very conductive overburden. A brief and simple description is given below with a more complete description given in Appendix 2.

There are two significant properties of rocks and ore bodies which are of great assistance in identifying zones of potential economic interest. The first is resistivity which can be described as the resistance of a rock to the passage of electric current through it.

Resistive sulphide zones, fault zones, zones of deeper and more intense oxidation and graphite horizons are examples of units which will allow greater quantities of current to pass. In ARMIP, the measurement of resistivity is made with a very sensitive horizontal field magnometer. This by virtue of the fact that current is simply the number of electrons flowing, and each of these electrons carries a magnetic field with it as it moves. Thus the magnetic field observed by the magnometer is proportional to the current flowing through the volume of overburden and rock below the sensor. This measurement is called Magnometric Resistivity (MRR). Positive values define areas of relative conductors, and negative values, areas which are relatively resistant. This property can be used as a method for tracing rocks having different resistivities beneath conductive overburden, as well as to define specific conductors.

The second and more significant property is known as induced polarization. This phenomenon involves the storage of some of the electrical energy at the grain boundaries of sulphides (or graphite) grains, and the water contained between grain boundaries in rocks and ore bodies. If a pulse current is used, the sulphide or graphite zones will charge during periods of current flow, and discharge during the period when the current ceases to flow. It is this discharge of stored energy which is the induced polarization effect, and the magnetic sensor is sufficiently
sensitive to define these minute magnetic fields. The magnetic induced polarization effects are measured in terms of relative Phase shift (RPS). Positive values denote internal polarization from within sulphides or graphite, while negative values generally denote the discharge of the polarization effect external to the source. The field procedure involved the laying out of a 600 by 600m grid across the strike of the units of interest. Where possible a base line was run along the main zone of interest and cross lines taken off every 100m and extended 300m either side of the base line. Holes were dug for the electrodes, positioned 1200m apart on the base line, i.e. 300m north and south of the array. Readings were taken at 25m intervals but broadened to 50m towards the end of the survey. Two operators were used and one 600m by 600m could be read in a full day if all gridding was completed and electrode holes were dug.

The Bridge Creek area straddles the Howley Line north of the highway and is regarded as one of the most prospective areas held by Northern Gold N.L. Gold mineralization is clearly related to the hinge line and appears to be more common in the carbonaceous shales of the Koolpin Formation. The October R.MIP survey was designed to cover the hinge line and the flanking sediments. Three arrays were run across this zone with one array in DL 4208. A fourth array was later run to follow up an anomaly that was striking north from DL 4208 into DL4021.

It was hoped that the results of the survey would help define the hinge area, pick up any sulphide bearing horizons and give us some idea as to the depth of the conductive carbonaceous shales below the units of the Gerowie Lufa.

The surveyed corner peg of DL4238 was located and three arrays were run from this point, one to the west and two to the east. The peg was given the co-ordinate 11500N/9700E and the array covered a 600m by 600m area.

Two costeans were dug across areas of alluvium using a Komatsu Excavator and geological mapping was carried out along grid lines.
4.2 EL4235 and 4207.

In EL4235 one geological traverse was done just south of the old highway and across the possible hinge area. Three samples were collected for panning.

In 4207 only general prospecting was carried out during the exploration of the neighbouring tenements, EL's 2306 and 4206.

5. RESULTS.

5.1 EL 4208.

A summary of the results from the ARMIP survey is given in the following pages and shown on figures 2, 3, 4, 5.
DISCUSSION

Some four arrays were surveyed over these areas as set out below, with the data being set out on plates 4 and 5. The salient features are set out on plate 6 on the interpretation sheet.

array 2E  electrodes at 11200N and 12400N on 9400E  1200 metre dipole
array 3W  electrodes at 10900N and 12100N on 10000E  1200 metre dipole
array 4E  electrodes at 11200N and 12400N on 10600E  1200 metre dipole
array 10W electrodes at 11800N and 13000N on 9600E  1200 metre dipole

(Note: array 2 was read at 25 metre intervals while arrays 3, 4 and 10 were read at 33.3 metre intervals, both along 100 metre spaced lines.)

The MMR data shows a general grid north south strike, with significant relative conductor axes being noted in the south-western quadrant of the survey area within array 2E, with the rocks between about 9200E and 9600E (+) from 11500N to 12700N being generally more conductive. On array 10W a marked transition between relatively conductive rocks to the west and relatively resistive rocks to the east was defined at about 9660E. This is a major rock type change and is accompanied by high chargeabilities in the east where values to +4.0°(+) were defined from a major source often east of the survey grid. (As a mine shaft is indicated on the 1:100,000 geological map at about this coordinate just to the north, these chargeabilities are probably of prime potential economic interest. The source is disseminated sulphides within a relatively resistive host. The anomaly form is that previously
expected from deposits of the Big Howley and Chinese Howley type, and which has been observed over the Metro Howley deposit. While the marker axis lies just east of the grid on all lines to the north of 12300N (inclusive), the axis was recorded on line 12200N at 9933E where a +2.6° RPS was recorded from a current centre at less than 150 metres deep. (Note: this is not necessarily the top of the source, but a current centre within and down dip thereof.) On line 12100N the maximum of +1.6° RPS at 9866E represents the trace of that source on this line. However, higher readings east thereof indicate a source east of the line end at 9965E. The data shows multiple sources within this unit. Smaller arrays placed at about 9900E will be required to resolve the sources prior to the selection of specific drilling targets within this zone. Also, the data cannot indicate the source dip at this stage.

Within the western series of conductor axes between 9200E and 9500E, a series of internal polarization axes were defined between lines 11500N and 11900N (see interpretation map). These have quite distinct boundaries, apparently quite unrelated to the enclosing rock type as seen from the MNR. This could indicate their source to be disseminated overall. In detail some five axes can be interpreted as seen on the interpretation plate and the RPS contour map, however, west of 9475E the internal polarization effects cannot be accurately resolved. The precise geological implications of this chargeable area are difficult to resolve without some geological input. This series of anomalies is bounded by a distinct RPS response which can be identified clearly on all lines between 11500N to 11900N as follows:

11900N  +0.8° at 9525E
11800N  +0.95° at 9537E*
11700N  +0.8° at 9550E
11600N +0.7° at 9525E
11500N +0.7° at 9550E

In most cases the increased chargeability is accompanied by a local depression in the MMR, indicating that the increase in chargeability is accompanied by higher resistivities. Thus the source could be quartz with sulphides. The maximum depth to source could be of the order of 50 metres to 75 metres, but further detailed work would be required to define this, together with the dip which cannot be estimated from this data.

A distinct induced polarization axis was defined on the extreme eastern boundary of array 2E. While the amplitude may be slightly exaggerated by the presence of the wire to the east, the source nevertheless remains impressive. To the north the source becomes part of the major zone of interest defined on the eastern section of array 10W. The details of this anomaly are as follows:

line 12100N +2.3° east of 9750E -13% MMR
line 12000N +2.3° east of 9750E -15% MMR
line 11900N +1.5° east of 9700E -18% MMR
line 11800N* +2.1° at 9700E -12% MMR
line 11700N* +1.7° at 9700E -14% MMR
line 11600N no trace

The response, uniquely defined on lines 11800N and 11700N, is interpreted as a narrow, chargeable resistive source perhaps(?) dipping to the west.

While detailed array(s) would be required to define depth to source, the current centre within this source lies at depths of the order of 75 to 100 metres. This
anomaly is considered of prime interest as it is akin to the Big Howley/Chinese Howley model.

On array 3W a moderate conductor decreasing in amplitude from +50% to barely above background, was defined between 10000E on 11800N to 10033E on 11500N. On the eastern flank thereof a minor, but definite RPS response of about +0.3° above external polarization was defined from 10033E/11800N to 10066E on 11500N. The higher polarization lies on, or close to a rock contact, and is interpreted as being due to weakly disseminated sulphides whose maximum depth to current centre would appear to be only 50 metres to 75 metres.

The most easterly chargeable zone of interest was defined on the western boundary of array 4E and the easterly section of array 3W. An amorphous zone of internal polarization was recorded between about 10200E and 10325E +25 metres. The zone is open to both south and north, and north of 11800N is also open to the west. The accompanying MMR data indicates that the underlying rock types show relatively little contrast with the enclosing rocks, being but slightly more resistive. Depth to current source looks to be of the order of 50 metres+. The source is interpreted as being due to disseminated sulphides within a host having little electrical contrast with the enclosing rocks (i.e. type B).

CONCLUSIONS

1. The general strike of the area surveyed as seen from the MMR data is within +15% of grid north south. The most conductive rock units were observed to the west of 9660E. Here a series of en echelon relative conductor axes imply the presence of relatively conductive rock units. The RPS data does
not imply that this relative conduction is due to sulphides, but rather to the intrinsic rock properties themselves. To the east of 9660E the MMR contrasts observed were more subdued.

2 The most substantial area of sulphides was observed east of about 9700E. The maximum sulphide content is inferred to be present east of 9900E. A number of lesser axes are inferred from the data, but detailed arrays will be required to define these, and to indicate dip direction.

The combination of high chargeability and resistive sources gives this zone some interest as the signature is that seen over Metro Howley, and expected on Big Howley and Chinese Howley.

3 A triangular shaped series of five zones of higher polarization extending from approximately 9200E/11800N to 9550E/12000N to 9550E/11500N spans the series of multiple conductor axes observed in the west without apparently influencing their continuity. The western four zones are difficult to resolve from one another, but the most easterly zone defined at 9537E+ on lines 11500N to 11900N is quite distinct. Along its axis there is a minor, but distinct depression in the MMR, indicating the chargeable source to be resistive. The anomaly is best seen on line 11800N at 9537E where the resistive source has an inferred maximum depth of 50 to 75 metres into the current axis at that point.

4 A significant moderate response of +2.3° RPS was observed from a resistor axis at 9700E+ on lines 11700N to 12100N inclusive. On lines 11800N and 11900N the depth to current centre within the source is estimated at 75 metres to 100
metres, and the inferred dip is seen as to the west. However, detailed arrays will be required to confirm this.

5 A weak but definite induced polarization axis recorded between 10033E/11800N to 10066E/11500N lies on or in close proximity to a contact between more conductive rocks to the west and resistive rocks to the east. Current centre depths within the source look to be of the order of 50 to 75 metres. The source is likely to be weakly disseminated sulphides.

6 Between about 10200E and 10325E (+) from 11500N to 12100N(?), higher internal polarization of +0.3° to +0.6° from very slightly more resistive rocks is interpreted as being due to amorphous segregations of sulphides of low volume percent (1%). The current centres of this response look to be 50 metres to 75 metres.
The boundary between the cherts and minor siltstones of the Gerowie Tuff and the more conductive siltstones and greywackes of the overlying Mt. Bonnie Formation is clearly defined along 96°0E. The enchelon relative conductor axes west of 96°0E are possibly related to the b.i.f. units that occur in this area.

The most significant anomaly in EL4208 occurs along the eastern boundary and significantly, it corresponds to the only area of alluvial diggings away from the Bridge Creek valley. A carbonaceous shale was mapped in this area but the anomaly response is interpreted as a narrow, chargeable resistive source, i.e., sulphides in quartz veining. To the north this anomaly is masked by the carbonaceous horizons of the Koolpin Formation.

The costean (C30), intersected over 3 metres of coarse gravels below recent silts. If this area is carrying gold, the volume of alluvials within the Bridge Creek area will be significantly increased. At the present time a bulk testing plant is in operation but to date no samples have been taken from EL4208.

5.2 EL4235

The only rock types observed across EL4235 were purple weathering coarse to medium grained biotite-quartz siltstones, quartzites and minor shales. A number of pegmatites were observed, all striking parallel to the country rock. In the interpreted axis area a wide zone (70m) of quartz and pegmatite veining occurs but the three named samples showed no tin or gold in the concentrate. Outcrop was very poor but the rocks encountered suggests that units of the Burrell Creek Formation occur in the highway area and that the underlying Formations occur to the south east.
6. CONCLUSIONS AND RECOMMENDATIONS.

6.1 EL 4207.

Northern Gold N.L. is in the process of assessing the alluvial potential within the Howley area. The programme on EL 4207 will depend to a large extent on the results of this assessment. The estimated expenditure for 1984/85 is $9,000.

6.2 EL 4208.

The ARMIP survey clearly defined the boundary between the Gorowie Tuff and Mt. Bonnie Formations. A significant anomaly corresponding to an area of alluvial diggings was located and further work involving costeasing and sampling is required to test this zone.

The area west of the gridded area is mostly covered by recent alluvium but mapping and sampling where practicable will be carried out to test for a second anticlinal axis paralleling the Howley Line. This programme will be carried out in conjunction with work on the adjoining licences 4238 and 3009.

Testing of the alluvials within the Bridge Creek area is underway and results so far are encouraging. The alluvial areas of EL 4208 will be tested during this programme. The estimated expenditure during the 1984/85 period is $15,000, assuming the viability of the alluvials in the area. A Statement of Expenditure for 1984 is given in Appendix 1.

6.3 EL 4235.

Exploration Licence 4235 requires detailed mapping, geochemical sampling and costeasing to first define the area and then to assess it for gold mineralization. The tenement also is prospective for tin mineralization associated with pegmatites. Exploration across this area will be carried out in conjunction with the work done on EL 4196. The estimated expenditure is $7,000.
**APPENDIX 1.**

**STATEMENT OF EXPENDITURE 1983/1984**

<table>
<thead>
<tr>
<th>Item</th>
<th>4207</th>
<th>4208</th>
<th>2235</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries &amp; Salaries</td>
<td>300</td>
<td>3,300</td>
<td>300</td>
</tr>
<tr>
<td>RRMIF Survey</td>
<td>-</td>
<td>3,000</td>
<td>-</td>
</tr>
<tr>
<td>Excavator Hire</td>
<td>-</td>
<td>2,300</td>
<td>-</td>
</tr>
<tr>
<td>Dozer Hire</td>
<td>-</td>
<td>250</td>
<td>-</td>
</tr>
<tr>
<td>Proportion Construction cost Bridge Creek Camp</td>
<td>5,300</td>
<td>5,300</td>
<td>5,300</td>
</tr>
<tr>
<td>Logistic Support</td>
<td>2,400</td>
<td>2,400</td>
<td>2,400</td>
</tr>
<tr>
<td>Vehicle Expenses</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Airfares &amp; Accommodation</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Administration</td>
<td>500</td>
<td>700</td>
<td>500</td>
</tr>
</tbody>
</table>

$9,500 \hspace{1cm} 18,250 \hspace{1cm} 9,500$
THE PRESENT APPLICATION
OF THE MAGNETIC INDUCED POLARIZATION (MIP) METHOD
IN THE TIME AND FREQUENCY DOMAIN

INTRODUCTION

Since the Magnetic Induced Polarization (MIP) method was introduced into Australia some six years ago, very considerable field experience has been gained. The purpose of these comments is to discuss the application of the method, the form of the responses observed, and how the standard anomaly forms are generated. This is a simple non-mathematical description designed to enable the geologists to visualise just how the energising and induced polarization currents flow in the ground, and how to interpret these in a qualitative sense, for it is the geologist who is far better qualified to interpret this data in a structural context. It is the author's opinion that MIP data is more often than not, simpler and more diagnostic to interpret than EIP or EM data in the conductive conditions which exist over much of Australia's land mass.

The uniqueness of the MIP Method ......

It is essential to grasp the very basic differences between the magnetic mode of acquiring induced polarization data (MIP) and the more conventional electrical mode (EIP). As even geophysicists of some experience have had difficulty in appreciating the full significance of this method, it is necessary to state in simple terms some of the unique attributes of the method.

1 - Conventional EIP data monitors ONLY the current flow AT THE SURFACE, generated by the storage of charge (IP effect) WITHIN the body. With MIP both the current flow OUTSIDE, but more importantly INSIDE the chargeable
source, are **DIRECTLY MONITORED**. Thus the external (EIP) polarization from mineralisation **NEED NOT NECESSARILY COME TO THE SURFACE** for it to be monitored.

2 - In conventional EIP, the transfer of the induced polarization signal from the source mineralisation to the surface involves a considerable loss of energy by "friction" and "chemical reactions" en route, whereas for MIP, as the movements in current at depth are monitored from depth via their associated magnetic fields, very much less loss of energy is involved. Thus, the fall off in response with distance from a chargeable source is very much less as seen with MIP than that seen with EIP.

3 - With conventional EIP methods, the external induced polarization effect is monitored via two potential electrodes placed some distance apart (commonly 25 to 100 metres), effectively averaging the response over this distance. However, as the MIP sensor is about 60 centimetres in length only, in the MIP method it is essentially a point source measurement which improves resolution very considerably.

4 - Where conventional EIP techniques are applied to highly conductive overburden/oxidation regions, the multi-layering within this zone very considerably reduces or even eliminates the EIP signal en route to the surface. With MIP, both primary and secondary (IP) current flow within this zone has **NO MATERIAL INFLUENCE** on the data. Thus the problems of "masking" are eliminated with MIP.

5 - As the EIP induced polarization signal flows from source to surface, the medium through which it passes not only reduces its amplitude (see 2 above), but also modifies the form of the signal. Thus the decay form observed at the surface will tend to be that of the medium rather than the source. However, as the MIP monitors the magnetic field from the decay within the source itself, no such distortion in the **internal** polarization decay form can be expected.

6 - The EIP method is essentially a measurement of **absolute** levels of apparent resistivity and chargeability as observed at the surface. However, the MIP
method measures the relative properties of chargeability and resistivity, and is thus more sensitive to these differences.

7 - In the EIP method, the electric field is often severely distorted by local and often insignificant inhomogeneities in resistivity. However, as the primary (resistivity) and secondary (IP) magnetic field measurements are summed over a large volume of rock, they are not distorted or masked by local inhomogeneities.

A Definition of Terms ......

Before going into the detailed qualitative discussion of the principles of operation, it is best to define the terms used in the description.

Energisation: - The process by which current is introduced into the volume of rock which is the subject of the survey. Primary Current Flow: - The flow of current through this medium as a result of this energisation. Primary Magnetic Field (H_p): - The magnetic field generated by virtue of the primary current flow in the subsurface.

Induced Polarization Effect: - The "condenser like" storage of energy on an electronic/electrolytic boundary, for instance on sulphide/electrolyte boundaries. Internal Polarization: - The induced polarization effect within the body, which is the source of all induced polarization phenomenon, whose discharge is always in the OPPOSITE DIRECTION to the primary current flow which caused it.

External Polarization: - The induced polarization effect which flows outside or external to the causative source which is always of the same sign as it is in the same direction as the energising primary current. Secondary Magnetic Field (H_S): - This is the magnetic field caused by the flow of secondary currents within (internal) and outside (external) of the causative source.

Decay Form (LM): - This term describes the decay of the energy stored within the body. It may be more rapid than "normal" or slower than "normal". (A detailed description follows on Page 9).
Comparison of the Electrical and Magnetic Modes of Acquiring Induced Polarization Data

By far the most meaningful way in which to visualise the nature of MIP (and indeed EIP) data, is to consider the energy storage concept and to look at the primary current flow pattern and the resultant equipotential field caused by this energising current, and then the consequent secondary current flow pattern and its associated secondary potential field caused by the decay of the energy stored on electronic/electrolytic contact boundaries, which is known as induced polarization. As this is most easily visualised in the time domain, this description is confined to that domain.

**Energisation Process** ..... Normally current is applied to the volume to be sampled by means of two electrodes placed semi-parallel to the expected strike of the target mineralisation. In the diagram shown in Figure 1, the fine solid lines represent the current flow pattern so generated. The dashed faint lines represent the equipotential surfaces (lines in the section).

In the **electrical mode**, the two potential electrodes (see Figure 1) will measure the **resistivity** of a volume of material defined by the equipotential surfaces which are always at right angles to the current flow.

**Energy Storage Process** ..... The material through which the current passes will store some portion of the energy in a way determined by the properties of the storage material. The amount of energy stored will depend on the total area of the sulphides (or graphite etc.) presented to the current, and thus, the greater this surface area with respect to the volume of material, the greater will be the energy stored. Finely disseminated material will store substantially more energy than coarse grained material.

**The Discharge of Stored Energy** ..... On cessation of the energising current flow, the energy stored by the **chargeable source** will discharge internally within the source as shown by the solid arrows in Figure 2, and externally around the body in the medium surrounding the source as shown by the solid heavy lines in Figure 2. These currents are respectively known as **internal** and **external** current flow. The former is of **negative sign** as it is in the **opposite direction** to the original energising current, and the latter is of **positive sign** as it is in the **same**
SCINTREX

EIP & MIP ENERGIZATION

MIP Sensor

Magnetic field due to current flow

Current

EIP potential dipole

Current

Disseminated chargeable source

Sum of magnetic field due to whole current flow below

Primary Equipotential surface

Primary magnetic field

Primary current path

Fig. 1
SCINTREX

EIP & MIP
DISCHARGE OF INDUCED POLARIZATION

---

Fig 2.
direction as the energising current.

In the electrical mode, only the discharge external to the body is investigated. In Figure 2 the thick solid lines show this discharge together with the equipotential surfaces (thick broken lines) which this current imposes. As with the charging process these surfaces must be at right angles to the current lines which impose them. The potential electrodes will therefore measure the stored energy (chargeability) as seen via the secondary equipotential field. It is important to note that (i) this is NOT the same volume as the resistivity measurements and (ii) it is NOT the original IP signal as stored by the body, but a measurement distorted and processed by the environment through which it has passed.

In the magnetic mode a very sensitive magnetometer (Scintrex MFM-3) is used to "sense" the horizontal component of the magnetic field due to the current flow both inside and outside of the source material. This is possible because each electron which flows in the ground carries with it an associated magnetic field. This magnetic field will pass unhindered through the environment and thus both the discharge internally and externally to the source can be monitored on the surface.

The Form of MIP Anomalies ......

In the MIP method, the energising field is normalised with respect to the energising current electrodes. Details of this procedure are given later in this paper. In the description Figures 3 to 6, the magnetic field due to the primary passage of the energising field \( H_N \), can be regarded as "relative bulk conductivity" plotted upwards. In these figures, internal polarization (which is negative in sign because it flows in the opposite direction to the energising current), is plotted upwards, while external polarization (which flows in the same direction as the energising current and is therefore positive in sign) is plotted downwards.

The enclosed Figure 3 demonstrates the theoretical form of an MIP anomaly from a source which has no electrical contrast with the enclosing material, but has the property of retaining charge. (In nature such anomalies are in fact observed from the ilmenite fraction within heavy mineral deposits in beach sands.)
SCINTREX

TYPICAL M.I.P ANOMALY FORMS

THEORETICAL MODEL
CHARGEABLE SOURCE
NO RESISTIVITY CONTRAST

Relative conductivity

100%  

Geological cross section

NOTE:
+ External current flow into plane of paper
• Internal current flow out of plane of paper

Fig. 3
Energisation is along strike, into the plane of the paper. In all figures the current flow direction is represented by arrows, with dots representing current flow out of the plane of the paper, and crosses represent the current flow into the plane of the paper.

In Figure 3, over the source, the magnetometer will "see" a surplus of internal (negative) current flow, while on the flanks of the body, the external (positive) current flow will become predominant. The "head and shoulders" MIP anomaly shown is always seen over all sources. It is the distortions in shape, form and zero level that yield vital information as to conductivity of the source, conductivity of the environment above and about the source, the depth to the source and the nature of the mineralisation in and around the source.

TYPE 'A' (Figure 3) ..... shows the typical anomaly form over a chargeable source which is more resistive than the surrounding medium. In such cases the normal "head and shoulders" anomalies coincident with a depression in the $H_N$ are observed. An example of such an anomaly form is chalcopyrite/pyrite in quartz veins itself within a more resistive conductive rock unit.

TYPE 'B' (Figure 4) ..... In this case the chargeable source has no resistive contact with the enclosing material. This example is very similar to the theoretical model. An example of such an anomaly form would be over disseminated sulphides within a homogeneous rock unit.

TYPE 'C' (Figure 6) ..... In this case the source of the chargeable material is itself more conductive than the enclosing rock type. When the observed $H_N$ values are less than 180% - 200%, a normal "head and shoulders" anomaly is observed over the source. In practice, observed $H_N$ values rarely exceed 150% of normal.

TYPE 'D' (Figure 5) ..... In this most important anomaly form which invariably is associated with massive sulphides which are both conductive and electrically continuous, a massive sulphide must be surrounded by a disseminated halo within more resistive host rocks. In this case the disseminated sulphides will naturally store the induced polarization charge far more efficiently than the massive electrically continuous core. Thus, on completion of the energisation process,
SCINTREX  TYPICAL M.I.P. ANOMALY FORMS

TYPE B
CHARGEABLE SOURCE
HOMOGENEOUS

TYPE C
CHARGEABLE SOURCE
CONDUCTIVE

NOTE:
+ External current flow into plane of paper
- Internal current flow out of plane of paper

Fig. 4.
the charge stored within the disseminated halo will preferentially discharge through the conductive massive sulphide core. This effect has NEVER been observed where $H_N$ values have been less than 180% of normal. This anomaly form due to its high $H_N$ and coincident predominantly external (positive) current flow, is diagnostic when observed. An example of such a response is the Mt. Windarra pyrrhotite/nickel/copper deposits in Western Australia.

**TYPE 'E' (Figure 5)** .... A distorted MIP response curve is generated when a polarizable body is located on a contact between rocks of quite different resistivities. This is rather common in Western Australian nickel deposits. In such a case the return polarization current flow will be concentrated in the more highly conductive rock type instead of being symmetrically distributed on both sides of the body. The resultant MIP response is an asymmetric curve, with its internal (negative) maximum lying on the more resistive side of the body and the external (positive) current peak lying on the more conductive side. Sometimes the asymmetry is so large that the "crossover" is almost directly over the polarizable body. The $H_N$ peak is shifted over the conductive rock side of the polarizable body.

**Composite Anomalies .....**

As can readily be appreciated, the above examples 'A' to 'E', represent single simple bodies. In the field, more often than not, the sources vary in composition and therefore in chargeability and resistivity across strike, along strike and down dip. For example, while the form of Type 'C' and Type 'D' anomalies are very different in appearance, the geological situation which gives rise to them requires relatively little change in conductivity to materially change their form from 'C' to 'D'.

In the interpretation of MIP therefore, the electrical characteristics of known 'Type Deposits' similar to those being sought, together with local information as to the possible range of structure in the area, is of primary importance. In other words, geological input is often of greater importance than quantitative geophysical data.
TYPICAL M.I.P ANOMALY FORMS

TYPE D

CHARGEABLE SOURCE VERY CONDUCTIVE WITH DISSEMINATED HALO

TYPE E

CHARGEABLE SOURCE ON CONTACT BETWEEN TWO ROCK TYPES OF DIFFERING RESISTANCE

NOTE:

+ External current flow into plane of paper
- Internal current flow out of plane of paper

Fig. 5.