A REPORT ON
THE GEOPHYSICAL ASPECTS OF
RAPID RECONNAISSANCE
MAGNETIC INDUCED POLARIZATION SURVEYS
OVER THE HUNTER CREEK AND WILLIERAY BLOCKS
NEAR RENNER SPRINGS, NORTHERN TERRITORY
ON BEHALF OF
CLIFFORD MINERALS LIMITED
IN ASSOCIATION WITH
TECHNOMIN AUSTRALIA N.L.

OPEN FILE

NORTHERN TERRITORY
GEological SURVEY.
CR84/257
A REPORT ON
THE GEOPHYSICAL ASPECTS OF
RAPID RECONNAISSANCE
MAGNETIC INDUCED POLARIZATION SURVEYS
OVER THE HUNTER CREEK AND WILLIERAY BLOCKS
NEAR RENNER SPRINGS, NORTHERN TERRITORY
ON BEHALF OF
CLIFFORD MINERALS LIMITED
IN ASSOCIATION WITH
TECHNOMIN AUSTRALIA N.L.

BY

A.W. HOWLAND-ROSE
MSc,DIC,PIMM,MAusIMM,FAIG,FGS,CEng.
GEOPHYSICIST

SYDNEY, N.S.W.  AUGUST, 1984
NT-034R
CONTENTS

Summary

Introduction

Hunter Creek Block

Reconnaissance Phase

Detailing Phase

Conclusions and Recommendations

Willieray - Northern Area

Discussion

Conclusions and Recommendations

Willieray - Southern Area

Discussion

Conclusions and Recommendations

Final Comment

Appendices: Data Acquisition and Presentation

Brief Description of Method and Meaning of Parameters

MIP Method

Plates:

Plates 1 - 7  RPS, MMR and Interpretation Plans - Hunter Block Area

Plates 8 - 14  RPS, MMR and Interpretation Plans - Willieray North Grid

Plates 15 - 21  RPS, MMR and Interpretation Plans - Willieray South Grid
SUMMARY

Rapid reconnaissance magnetic induced polarization surveys have been carried out over one block in the Hunter Creek prospect and two blocks in the Willieray area. Significant moderate areas of polarization have been located in the Hunter Creek block which are recommended for further ground follow-up and perhaps drilling. At Willieray the northern block contains some anomalous responses of interest, but on the southern block, most anomalous responses located on the reconnaissance survey were downgraded.
INTRODUCTION

At the request of Mr. P. Ho, Director of Clifford Minerals Limited, and under direction of Mr. D. Ward, Consulting Geologist of D. Ward & Associates, Scintrex Pty. Ltd. executed a series of RRMIP arrays over two areas known as Hunter Creek and Willieray, near Renner Springs, Northern Territory. The work was carried out in two phases, both under the control of Mr. P. Brown, BSc, party leader.

The reconnaissance work involved a crew of up to seven, including four line peggers and three instrument readers. The reconnaissance work took place between about 7th June and 16th July, 1984. The detailing phase was undertaken by a 3-4 man crew between 6th and 22nd August, 1984. Mr. D. Ward visited the crew during both phases of the field work.

Details of data presentation and comments on the method are appended to this report.

It is understood that Mr. D. Ward will present a report to accompany these comments outlining the geology in the anomalous areas, and comment on these results.
DISCUSSION OF DATA

The area was covered in a series of five 2500 metre arrays, one 2200 metre array (5) and one small section by a 1400 metre array (7W). Readings were taken along 150 metre spaced lines at 50 metre intervals. The results are presented in MMR and RPS contour format at the scale of 1:5000, and also in standard printergraph format.

North of 5000N the MMR data displays a number of distinct regions. The extreme western section has a distinct 'formational' appearance. A sharp conductor axis was defined extending from 4300E/6500N across line 7700N at 4450E (where MMR reaches 110%) and thence across line 8450N at 4512E to cross line 8900N at 4700E (+120%) to exit the area at 4750E/9200N, at which point MMR values of over +200% were recorded.

Between this western conductor axis to about 5900E(±) where a fairly sharp rock type change was noted, a fairly uniform MMR background was recorded of about normal ±10%. At a few locations (4700E/7400N, 4850E/7400N, 5150E/7400N, 5650E/7400N, 4950E/7100N, 5500E/9200N and 4750E/8300N), strong, local 100%(±) MMR conductors were recorded.
To the east of the abovementioned rock type change, the resistivities show much greater variation from +80% to -60%, often on a wave length of 200 metres. Thus a major change to the sequence is suggested east of the contact at 5900E(±).

Below 5000N changes in MMR akin to the easternmost portion of the northern section (i.e. east of 5900E±) were recorded.

The salient features of the MMR data have been summarised on the interpretation diagram and are best viewed in that form.

**Induced Polarization Data**

The 'background' observed ranges from about +0.5° to +1.0° at the 3Hz energising frequency. Each of the significant areas or linear polarization features is briefly discussed below.

**Zone 1**

Two sub-parallel linears of significance were defined on the western edges of arrays 3E and 5E. These have been designated W (west) and E (east) respectively.

The Zone 1W line extends in a series of discontinuous maxima, most of which occur just west of the grid. The most northerly response was centred on line 9050N at 4575E with extensions to the north and south. The amplitude is about +0.4° above background and the source is associated with sharply
increased resistivities. The source therefore is disseminated in origin. Source depths look to be 100(+) metres. West of 4500E/8700N a strong 1.5° RPS response was recorded, again with sharply increased resistivities. West of the ends of lines 8150N to 8450N (i.e. west of 4400E), +0.7° RPS maxima were observed which again are associated with resistive rocks. At 4300E± on lines 7250N, 7400N, 7550N and 7700N +0.6°, +0.6°, +0.9° and +0.8° RPS were defined from a resistive source.

Zone 1E was seen as two en echelon, moderate chargeability responses extending from 4650E/8600N to 4550E/8000N with a maximum of +1.2° PS centred at 4600E/8450N. At this site a single sharp increase in RPS is located within a broader resistivity low. The source, disseminated sulphides (± graphite), has a resistive host. Depths are difficult to gauge from the data, but 100± metres seems possible. The second anomaly can be traced between 4650E/7850N and 4450E/7250N, and overall reaches about +0.5°(+) above background. On line 7550N at 4600E the response is +0.4° above background and the form suggests an east dip to the source. (However, detail is required to confirm this). The current source depth is great (150+ metres) but the source, if wide, could be much shallower than this. The MMR is depressed over this anomaly, indicating a resistive host, however, not as resistive as seen in 1W. Any investigation of the response should be undertaken first on line 7750N at 4600E.

Zone 2

A series of three responses was located in the north-east of the area on array 5E. The anomaly centres and amplitudes above background are as
follows: 5600E/8750N (+0.7°), 5500E/8300N (+0.7°) and 5625E/8450N (+1.0°). For the most part all are associated with slightly higher resistivities. The depth to current centres look to be well over 100 metres. Further anomalies seen on the array overlap line, 8000N, at 5600E and 5650E, are no doubt responses associated with the same group of axes. The mis-match between arrays is due to source dip, but the direction is obscure. (Detailing would be required to clarify the nature of this source). All are considered to be due to disseminated sources in rocks having slightly higher resistivities.

Zone 3

A large zone of anomalous polarization was recorded between 5600N and 6350N and 4300E to 5900E, and between lines 5000N and 5750N between coordinates 5500E and 7000E. This zone contrasts with the areas to the north and south thereof in showing a large number of significant +0.5° to +1.5° RPS responses above background. The form and shape of this area is difficult to envisage from the 150 metre line spacing as the wavelength of the anomaly is for the most part 100± metres, and the strike length for most features not greater than 200± metres. Some individual features within this large anomalous area are discussed in more detail.

3W This is an amorphous +1.4° RPS feature which terminates sharply to the north between lines 6200N and 6350N (perhaps by a fault?) and has two anomaly centres at 4500E and 4650E on 6200N, the latter with an extension across lines 6050N and 5900N at about 4650E and 4550E respectively. Overall the anomalous area shows no sharp changes in MMR, indicating a wholly
disseminated sulphide (+ graphite) origin. (An electrical sounding was carried out in this vicinity and is discussed below).

3N A moderate to strong internal polarization anomaly was defined on the north-eastern edge of array 1E extending from about 5700E/6350N (+1.0°) across line 6200N at 5700E (+1.3°) and line 6050N at 5600E (+0.6°). To the south the zone may pass into zone 3C described below. No significant changes in MMR were noted over the anomaly, which points to a disseminated source, while depths to current centre appear to lie about 100 metres. (A reconnaissance array whose current axis was parallel to the west-north-west(±) orientation of the boundary of the whole zone 3 partly covered this anomaly and is discussed below.)

3C An area of high internal polarization was defined at 5700E/5750N ±100 metres east west and ±200 metres north south. Unfortunately it lies on an area of array overlap, but appears to be +1.5°(±) above the general level of chargeability in the vicinity. Slightly higher bulk resistivities accompany the polarization, indicating a disseminated chargeable source.

3E A curvilinear north south trending series of responses was recorded between 6175E/5300N and 6250E/5900N, with a maximum amplitude of +1.3° RPS above background being recorded at 6150E/5600N. The response is accompanied by moderately lower resistivities, indicating a resistive host to the chargeable source. The maximum depth to source looks to be less than 100 metres, but detail would be required to clarify this. This too is considered a significant RRMIP anomaly.
3S Twin maxima of about +0.7° to +1.0° above background were recorded on lines 5150N, 5300N and 5450N at 5950E and 6050E±. Overall the zone is accompanied by markedly lower MMR values, indicating a highly resistive source, particularly on line 5150N. The maximum depths to source look to be 100 to 150 metres, but again detailing would be required to clarify this.

Zone 4

This is a series of significant induced polarization responses of up to +1.3° RPS above background and was defined on, or slightly off grid at 4300E on lines 4250N to 5750N, a strike length of over 1500 metres. These anomalies are again accompanied by a distinct increase in resistivity, and therefore the sources are disseminated in origin and contained within a resistive host. This response has been subject to a detailed array centred at 4300E/4625N and is described further below.

Zone 5

A series of grid north south (±20°) striking linear chargeability anomalies were defined between lines 3650N and 4250N (see interpretation map). These may represent a faulted block. Perhaps the most significant feature was defined on lines 3950N and 4100N at 5150E and 5125E from a disseminated source which is of the order of 100 to 150 metres deep (subject to detailing). Other responses within the 'wedge' are considered less significant.
Zone 6

On the extreme eastern edge of lines 2000N to 3800N a series of significant linear responses were recorded. These represent significant linear anomalies and should receive careful ground study over their axes. A typical response would be seen at 5600E/2450N where a +0.6° RPS above background anomaly emanates from a resistive source. In both cases the depth to source is estimated to lie in the range 125 to 150 metres (subject to detailing).

DETAILING PHASE

As a result of conferences held between Mr. P. Ho (Clifford Minerals Limited), Mr. D. Ward (D. Ward & Associates, Geological Consultants) and Mr. I. Shulman (Technomin Australia N.L.) and the author, the programme outlined in the letter appended to this report was decided on. The author later cut the mutually perpendicular soundings to single soundings due to the time required to carry out each sounding.

An angled array (8N) was set up to investigate a possible west-north-west trending structure. The anomaly was centred at 5700E/6500N. The MMR data shows no west-north-west structure, while the trend of the RPS data merely confirms the general north south strike. No additional material information was gained from this array.
Zone 4

This zone was detailed using an 850 metres dipole centred at 4300E/4625N. In the east of the array at 4488E the conductor axis for the detailed array was displaced very slightly west, indicating a steep east dip in the north, becoming gradually shallower to the south (e.g. on line 4400N). The MMR over the anomalous area gave considerably more detail than seen on the reconnaissance array, with the internal polarization axis of +0.4° RPS above background being coincident with a very narrow, small conductor axis within a broad resistor. Thus in part, the chargeable material shows conduction within the source. The axis of the chargeability shows a small westerly displacement which indicates a steep east dip to the source. The maximum depth at 4275E/4625N is about 100 metres. This represents an excellent geophysical target.

Sounding at 6100N/4650E over Zone 3W

Over this site 6100N/4650E near to zone 3W, surface resistivities of 120 ohm-metres were noted to 40± metres, and resistivity to 10% of this below that level. (These lower resistivities are somewhat of a surprise.) At depth (100+ metres), apparent resistivities climb to over 600 ohm-metres (actual 2000+ ohm-metres), which is more akin to those expected. The chargeability data is 'noisy' due to geological sources, and also is low (maximum value 7 millivolts/volt). The surface layer is a low 1 to 3 millivolts/volt with higher values at depths of 100± metres. However, the data does not confirm the presence of a highly chargeable source at depth, and perhaps, the middle conductive layer may preclude this. It is true,
however, that chargeabilities at depth are greater than within 60 metres of surface.

Sounding at 5750N/5750E over zone 3C

This site shows near surface resistivities of 700 to 800 ohm-metres, with increasing resistivities at 100 metres. Again the chargeability data is low and noisy, but the higher chargeabilities also appear to increase from 100 metres down, assuming a bulk chargeability of about 2 millivolts/volt for the first 100 metres. The RFS data in the vicinity of zone 3C also implies source depths of this order. Thus a stratigraphic hole at this site would appear warranted, although as for zone 3W, the absolute levels of the chargeability implied by the data cannot be confirmed to be high.

Sounding at 2150N/5100E west of Zone 6

This site gives a similar picture to site 3C with the near surface layer of 200± ohm-metres (above 5± metres) with a sharp contact at about 50 metres depth where resistivities of 1000+ ohm-metres and low chargeabilities of 1 to 2 millivolts/volt were observed. Higher chargeabilities were recorded below this level. However, the level of chargeability is not shown to be high. The conclusions are similar to those at 3W and 3C except that any investigation by drilling should take place on the RRMIP anomaly at 5600E/2450N rather than at the sounding site.
CONCLUSIONS AND RECOMMENDATIONS

General

The area shows both single linear and areas of linear internal polarization anomalies of interest. For the most part the significant anomalies are accompanied by a moderate to marked increase in the accompanying resistivities. This indicates the source is either disseminated and silicified, or if massive to semi-massive, must be discontinuous and perhaps silicified also. Some Mississippi Valley type deposits have been recorded which have this signature.

The low absolute level of chargeability observed on the electrical soundings is worrying, as higher amplitudes would have been expected.

As with all geophysical anomalies, the geological context is important, and it is recommended that drilling decisions not be based wholly on the geophysical results.

Detailed

Zone 1W  A discontinuous series of moderate internal polarization responses were recorded from 4575E/9050N to 4300E/7250N. The source is inferred as being due to disseminated sulphides (± graphite?) within a resistive host. Detail would be required to ascertain depth, but 100± metres is the initial guesstimate.
Zone 1E Two en echelon responses each about 600 to 700 metres long were centred at 4600E/8450N and at 4600E/7550N. At the latter site the anomaly is some +0.4° above background associated with a moderate resistivity increase and is interpreted as disseminated sulphides (+graphite?) within a host somewhat more resistive than the enclosing rocks. The depth to source is considered to be less than the current centre which is 150 metres. The form suggests an east dip.

Zone 2 Four responses centred at 5600E/8750N, 5500E/8300N, 5625E/8450N and 5600E-5650E/8000N have +0.8°± RPS above background associated with very slight increases in resistivity. The disseminated sources are at depths of 100+ metres. Detailing would be required prior to drilling.

Zone 3 A large area of individual internal polarization anomalies was defined having a very general west-north-west trend from about 6350N/4300E to 5300N/6200E. The zone has an irregular shape which might be faulted (see interpretation diagram) and is 600 to 800 metres wide in the north south direction. The area contrasts with the 'quieter' appearance of the RPS data seen to the north and south. Several distinct anomalies within this large area are singled out for discussion. 3W centred at 4650E/6200N extends west and south-south-west. The response is sharply terminated to the north (by an east west fault?) and reaches about +1.0° to +1.5° RPS above local background, but with no appreciable change in MMR. The source therefore is disseminated. 3N by contrast, is a linear feature extending from 5750E/6350N to 5600E/5900N with a maximum value of +1.5° RPS(±) being centred at 5700E/6200N. The centre of current is 100+ metres, while a
slight increase in resistivity is noted over the source. This is a significant response. 3E A 600 metre linear one having chargeabilities of +1.2°± along its length and accompanied by increased resistivity, was centred at 6150E/5600N where a +1.3° RPS maximum has a current centre depth of 100 metres. This is considered an important RRMIP anomaly and worthy of careful ground investigation. 3E is centred at 6000E/5150N and is seen as a resistive chargeable source whose maximum depth is 100 to 150 metres (subject to detailing). The anomaly essentially consists of two parallel linear sources each 300+ metres in strike length.

Zone 4 was seen at 4300E, or west thereof, for over 1500 metres between lines 4250N and 5750N. The maximum values of +1.3° come from within a resistive host and were subject to detail by an 850 metre array centred t 4300E/4625N. The detail shows limited conduction within a narrow section of the source; a steep east dip; and a maximum depth to source of about 100 metres at 4275E/4625N. This is a recommended target providing the geological/structural and geochemical data support it as a zone of potential economic interest.

Zone 5 A wedge shaped zone of higher north south (+20°) striking linear zones between coordinates 4300E/3500N, 5700E/3800N, 4300E/4250N and 5700E/4250N may represent an up-faulted block. No specific recommendations are made pending geological evaluation of this feature.

Zone 6 An important series of linear chargeability axes, generally from resistive sources, was defined in the eastern section of array 6E and 2E. Individual axes merit close ground follow-up.
Sounding at the site of zone 3W  Increased resistivities and chargeabilities are seen below 100 metres. It is suggested that while the chargeabilities seen are not abnormally high, a stratigraphic hole to intersect the source of zone 3W may be warranted, particularly if the geological/geochemical evidence supports this.

Sounding at the site of Zone 3C  The site 5750N/5750E showed more resistive and higher chargeabilities at depths of about 100 metres, but the absolute levels inferred for the latter are not high. Bulk chargeabilities for the first 100+ metres are a low 1 to 2 millivolts/volt, but normal for carbonate and silica rich rocks, as well as for rocks subject to intense oxidation. Providing the geology supports this site, a drill hole could be carried out here.

Sounding at 2150N/5100E west of Zone 6  The data shows a resistive, chargeable layer at 50 metres, but the amplitude of the chargeability does not appear high. The conclusions as far as 3W and 3C, save that any drilling on the anomaly 6 should be carried out at 5600E/2450N rather than at the sounding site.
WILLIERAY - NORTHERN AREA

DISCUSSION

The Willieray surveys were performed over two separate areas. The most northerly involved five x 1500 metre arrays (1 to 5) within coordinates 25900N/2000E, 25900N/5000E, 25000N/5000E, 25000N/4000E, 24100N/4000E to 24100N/2000E.

This area showed a series of broad MMR conductors and resistors ranging from +70% to -40%. The strike varies sinuously from grid 340° to grid 005°. Most features have strike lengths of over 600 to 800 metres, and the general form of the MMR data is of different appearance to Hunter Creek. The salient features are summarised in the interpretation diagram.

The RPS data shows backgrounds between about +0.3° and +0.5° for the most part, with large areas of low amplitude responses. There are three areas of possible interest, and one linear feature of interest.

Zone A

This zone is located on the edges of arrays 3E and 4W where both join array 1E. Three linear features make up the zone. The most westerly, AW, extends from about 2850E/24850N to 2900E/25150N reaching up to +0.8° above background. This anomaly lies close to a distinct resistor axis. A smaller zone, AN, is inferred between arrays 3E and 4W from about 3000E/25600N to 3000E/25300N. This response reaches up to +0.4° RPS above background and
lies close to a distinct resistivity low. The major response was defined running grid 035\(^\circ\) from 3250E on line 25300N across line 25150N at 3100E to 3000E on line 24850N. The anomaly is best seen on lines 25150N and 25300N, and on the latter at 3250E the anomaly is some +0.6\(^\circ\) above background and allied to a resistivity low. The source of all three responses is disseminated chargeable material within a resistive host. Depth to current centres appear less than 100 metres, even on the 1500 metre array.

Detailed array 11E was centred at 3000E on line 25150N and confirms the general form of the MMR data seen on the reconnaissance array. In the west the anomaly axes are coincident, implying a near vertical dip, while in the east the detailed resistor axis is slightly displaced to the west, implying that the causative resistor dips steeply to the east. While not negating the reconnaissance array data, the detailed array did not assist in the evaluation of the chargeability responses, showing only a small variation in RPS from +0.1\(^\circ\) to +0.3\(^\circ\), perhaps due to the entire array being contained within the chargeable area. Two mutually perpendicular soundings were located at 25150N/3025E. Both show broadly similar vertical profiles. Surface resistivities of 120 ohm-metres to 3 to 5 metres are underlain by 30 to 50 ohm-metre material to a depth of about 100 metres by resistivities approaching 1000 ohm-metres. In both cases the chargeabilities of the first 60+ metres are less than 2 millivolts/volt. The chargeability appears to increase after 40 metres, but the absolute levels remain a low 6 to 10 millivolts/volt.
The electrical soundings and detailed arrays have not been able to confirm the interest of Zone A as a whole. Zone AE, however, remains of interest, and any investigation by drilling should be on that target only (unless otherwise indicated by geology).

Zone B

A significant increase in internal polarization was noted within the central section of array 5W. The zone is made up of some four individual anomalies. The most significant, B4, was defined from 4800E/25600N where the response reaches +1.3° RPS, some +1.0° above background, to 4700E/25300N where the response is but +0.3° above background. A small single +0.4° response, B1, at 4550E/25600N is seen only on that line. B3 was a broad +0.4° response above background and was seen from 4650E/25300N to 4550E/25150N. B1 occurs on a marked change in apparent resistivity, while B2-4 occur associated with a broad resister. The detailed array (10E) centred at 4900E/25375N confirms the resistivity pattern, implying a vertical to steep east in the east. The RPS gave only minor responses which were not able to confirm the significance of anomaly B4, although it implied a steep west dip on line 25450N. A sounding was centred at 25225N/4575E along the strike of B3. This showed a very shallow irregular surface layer of 4± metres, having resistivities well over 1000 ohm-metres. (This is perhaps the surface disseminated layer) with resistivities of 30± ohm-metres being seen down to 30 metres (±10 metres), thereafter resistivity increases progressively. The chargeability in the first 40 metres is less than 2 millivolts/volt, but increases to over 8 to 9 millivolts/volt at 60 metres depth. Again the chargeabilities at depth are not seen to be substantial.
Zone C

One of the better anomalies defined was zone C which was logged between 4950E/25600N and 4850E/25150N. The best response was seen on lines 25300N and 25450N at 4900E. The MMR data shows this marked response which reaches +0.8° above background to lie on a change in resistivity (contact?). The current centre looks to lie in the range 70 to 100 metres below surface. The inferred current axis to the immediate east has an implied steep east dip when the detailed and reconnaissance array MMR data is compared. The RPS data gives only extremely small responses which may reflect the zone. If so, the source is again inferred to dip steep east. The source depth is 100+ metres, while the source material may be disseminated sulphides on, or close to a rock type change.

CONCLUSIONS AND RECOMMENDATIONS

General

1 The general strike of the northern Willieray block lies within ±20° of grid north south and shows a series of broad resistors and conductors of moderate amplitude. The RPS anomalies are much less widespread than in the Hunter block, and of lower amplitude.

2 Only three anomalous areas of interest were detected and again most are associated with resistor axes. Only the single axis of zone C was associated with a contact.
3 In general the follow-up soundings and detailed arrays did not provide diagnostic support for the anomalies located in the reconnaissance survey. The author would have expected higher absolute chargeability values in the soundings, for while oxidation to 50 to 100 metres in implied, the lower 'surface' resistivities at Willieray are not sufficiently low to produce masking effects.

4 Support from other geodata will be expected to change the priorities allotted to anomalies which are based on amplitude only.

**Detailed**

**Zone A** Three moderate internal polarization responses were defined whose best sections were seen at 2900E/25150N (AW), 3025E/25450N (AN), and the most substantial (AE) seen from 3025E/25000N to 3250E/25300N with significant centres at 3250E/25300N and 3100E/25150N. The detailed array implies a vertical dip in the west and a steep east dip in the east. The detailed array did not resolve the chargeability axes, nor did the sounding indicate substantial polarization at depth, although an increase was indicated at 60 to 100 metres, with a major increase in resistivity at about 100 metres. Only zone AE should be investigated further by drilling, preferably at 3250E/25300N, providing always that geological data does not negate this target.

**Zone B** was situated in the central east of array 5W and is made up of a number of individual linear responses, three of which are associated with a broad resistor axis. B4 is the most significant and was logged between
4700E/25300N to 4800E/25600N at which site it reaches +1.0° above background. The source is disseminated sulphides within a resistive host; has a steep dip, perhaps west. The detail shows a weak response only, so a source depth of 100 metres is inferred. The broad low amplitude anomaly B3 was subjected to an electrical sounding at 25225N/4575E which showed surprisingly low bulk resistivities of 30 ohm-metres to 30 to 40 metres depth, and higher (but not substantial) chargeability of 10+ milli-volts/volt at depths greater than 60 metres. Of the two targets, B4 is favoured.

**Zone C** was seen as a distinct response over 500 to 600 metres, but is best seen as a +0.8° RPS anomaly on lines 25300N and 25450N at 4900E with source depths of 100± metres. The detailed array hardly shows the response at all. The source is interpreted as of disseminated origin located on or near a rock type contact, with the conductor to the immediate east showing a steep east dip. This represents a possible geophysical target.
WILLIERAY - SOUTHERN AREA

DISCUSSION

Two arrays (6E and 7E) were completed on this area, both using 1500 metre current dipoles. The area was located between grid coordinates 3750E and 4750E and between 14100N and 15900N.

The MMR data shows only moderate amplitude changes from +60% to -40%. The main feature seen is a broad resistor axis extending from 4450E/15900N to 4500E/15000N and from 4425E/15000N to 4350E/14100N. The resistor strike sinuously grid north south. To the west thereof, only minor variations were observed, but to the east, a moderate conductor axis increasing from a weak zone at 4650E/15000N to a moderate zone at 4450E/14100N of +60% was recorded. No major dislocations are visible from the MMR data.

The background RPS is a high +0.9°(±) with significant axes rising only +0.5° to +1.0° above this level. Zone D was recorded running about grid north south from 3950E/14100N to 4050E/14850N with a maximum value of +1.5° RPS at 4050E/14700N, although by contrast, the better anomalies were seen on lines 14550N and 14400N. The accompanying resistivity shows no significant changes, thus the source must be disseminated in origin. A detailed array (8W) was centred at 4050E/14700N which showed the chargeable axes to be very slightly more resistive than background. However, to the author's great surprise, the RPS data shows the axis seen previously as a weak to moderate anomaly, as a very weak but definite low, with a high
displaced to the east (of 4200E±). The explanation could be that the zone has a shallow west dip - but that would require a crescent shaped anomaly on the reconnaissance array which was not seen. A further possibility is that the source of the response is deep, but the current axis of the detailed array RPS data is some 80 to 100 metres, well within the range of the reconnaissance array. The explanation must lie in the source lying deeper than the current centre depth indicates. However, it is difficult to drill an anomaly of moderate to low amplitude at say 150 to 200 metres without contribution from other geodata.

Zone E

A high plateau was noted centred at 4650E/15225N of about +1.4° RPS, some +0.6° above background. A sounding was centred at 15225N/4575E to investigate this source. The first 2 to 3 metres has resistivities of 200 to 250 ohm-metres (the dessicated zone) underlain by resistivities of the order of 30 ohm-metres to 30 to 40 metres, thereafter resistivities increase. No significant increase in resistivity with depth was noted, with absolute chargeabilities remaining a low 2 millivolts/volt. Thus no recommendation for drilling is made at this site.

Zone F

A strong internal polarization response was implied east of lines 14700N to 15300N of over +1.7° RPS. This covered both the extreme north-east corner of 6E and the south-east corner of 7E. The accompanying MMR values were seen not to show any significant variations. A detailed array centred
at 4750E/15100N shows no significant response over this feature, which may indicate that we have 'wire effect' caused by the conductor just off the line. The MMR data clearly shows a strong conductor axis centred at 4725E/15300N (+70%) weakening towards 4700E/15000N where the response is minimal (+20%). This feature must dip east as no signature was observed on the reconnaissance array. Certainly no significant internal polarization response was recorded on the detail, thus no further work is recommended at this site.

CONCLUSIONS AND RECOMMENDATIONS

1 Moderate, broad MMR conductors and resistors characterise the MMR data, with a 'marker' resistor being present at 4450E ±50 metres over the whole strike length.

2 RPS anomalies are of generally low amplitude varying about 0.8° above the +0.9° background (except in the far north-east).

3 Comments on individual anomalies follow:

Zone D  A low amplitude +0.4° to +0.5° RPS axis was noted from 3950E/14100N to 4050E/14850N. Current centre depths are of the order of 100 metres. A detailed array has revealed the axis lies along a weak resistor (which the reconnaissance array did not resolve). However, the detailed array showed a weak internal polarization low associated with the axis. No interpretation other than a deep source
to the anomaly can be given, and it is not recommended that the source be drilled without confirmation from other data.

Zone E A +0.6° RPS 'plateau' centred at 4650E/15225N within an area showing no appreciable MMR change, was investigated by a sounding. This showed no anomalous polarization to be present at depth, merely backgrounds of 2 millivolts/volt typical of limestones or high silica rocks. No further work is recommended at this site.

Zone F Strong internal polarization was noted on the eastern extremities of lines 14700N to 15300N, implying a source to the east thereof. A detailed array located a conductor axis to 70% just off grid to the east of the reconnaissance array, but no associated internal polarization. It is concluded that the source was wire effect caused by a strong conductor axis off grid to the east. No further work is recommended at this site.
FINAL COMMENT

1. In spite of the experienced crew employed, and some pre-knowledge of the area, much of the terrain proved extremely slow going, in spite of the assistance in the western areas of a bulldozer to clear the thick bush. This was a disrupting aspect of both the reconnaissance and detailed work.

2. On the whole the detailed follow-up work was not able to assist generally in the selection of targets for drilling, particularly on the Willieray grid. On the negative side, Zone E was seen to be subject to wire effect due to a conductor, and on the positive side, Zone 4 on Hunter Creek was seen to represent a fine geophysical target. In this case geological evaluation of the targets will be much more important than usual, as the amplitude of most responses, while clear against background, are not great in absolute terms.

Respectfully submitted on behalf of:

SCINTREX PTY. LTD.

P.P.

A.W. Howland-Rose, MSc, DIC, FIMM, MAusIMM, FAIG, FGS, CEng.

Geophysicist
18th July, 1984 Sydney

Mr. P. Ho Clifford Minerals
Mr. D. Ward * Consultant Geologist
Mr. I. Shulman Technomin
Mr. P. Brown * Scintrex Party Leader
(* set of annotated maps enclosed. Due to time problems, I will send sets
to Peter and Ike at a later date if requested to do so.)

Re: Hunter Creek Area, Helen Springs

Following meetings held at Technomin's office, the following decisions were
taken with respect to detailing within the Hunter Creek area. Both
additional RRMIP and electrical soundings (two at each site – mutually
perpendicular) are to be run. 'a' spacings in the latter are to be from 10
metres to 750± metres. We will have to ship additional 2 x IPR-10 and
porous pots (plus perhaps radios) to the crew to carry out these surveys.

Should Don or Peter require additional work on the area (or require any
changes), get in touch with myself, or in my absence, Duncan Webb, or in
his absence, Linda Kichno.

The Detailed Work

1  A detailed 850metres(±) current dipole to be centred at 4300E/4625E
(North-west section of array 2E). From this set-up, run some 7 x 75
metres spaced lines 200 metres either side of the current line with 25
metre readings in the central section and 50 metres on the outside
section of each line.

   Time estimate: 1½ days

2  With a current centre at 6500N/5750E, put in a 1500 metre current
dipole oriented grid 296°(±). From this run eight 150 metre spaced
lines for 300 metres either side of the current dipole, with readings
intervals of 50 metres.
   Line length  8 x 600 metres = 4.8 kilometres
   Number of readings = 96
   Pegging  1-1½ days
   Reading  1 day

   Time estimate: 2-2½ days

3A Two mutually perpendicular Schlumberger electrical soundings centred
   within the circle (see map) at about 6100N/4650E

3B Two mutually perpendicular Schlumberger electrical soundings centred
   within the circle (see map) at about 5750N/5700E.

3C Two mutually perpendicular Schlumberger electrical soundings centred
   within the circle (see map) at about 2150N/5100E.

   Time estimate: maximum of 1 day per site.
Total Time Estimate

5 - 7 days for a two operator, three/four man crew (i.e. smaller crew than used on reconnaissance phase)

Please confirm that the arrangements are according to your wishes and instructions.

Best personal regards,

A.W. Howland-Rose
Managing Director
28th July, 1984     Sydney

Mr. P. Ho        Clifford Minerals
Mr. D. Ward*    Consultant Geologist
Mr. I. Shulman  Technomin
Mr. P. Brown*    Scintrex Party Leader

(* Set of annotated maps enclosed)

Re: Willieray Area, Helen Springs

Following discussions held on Friday 27th July, the following detail work is suggested.

3 detail arrays as follows:

600 metre current dipole
five lines 400 metres in length
25 metre reading interval over centre 300 metre section, with 50 metre readings on the ends of lines
75 metre line spacing

Centres at:  15150N/4750E
            14700N/4050E
            25375N/4900E

and perhaps (?) a fourth at 25150N/3000E

Four mutually perpendicular soundings as follows:

15225N/4575E (±)  oriented ±040°
25600N/4750E (±)  "          N-S
25225N/4575E (±)  "          ±040°
25150N/3025E (±)  "          N-S

At this stage I suggest that only 2/3rd of the above recommended work be done, but the final choice I will leave to Peter Ho and Don Ward. Could you please advise Linda soonest, so that the instructions can be passed on to Phil Brown.

 Regards,

A.W. Howland-Rose
APPENDIX

DATA ACQUISITION AND PRESENTATION
DATA ACQUISITION AND PRESENTATION

Data Recorded:

The following parameters were recorded:

- $H_p$, the incident magnetic field due to the current flow in the current dipole.
- RPS, the magnetic induced polarization effect at each station by reference to the Relative Phase Shift of the primary and third harmonic.
- PFE, the magnetic induced polarization effect by reference to the Percent Frequency Effect observed from the relative amplitudes of the first and third harmonic.
- The offsets for RPS and PFE for each array.
- The energising current ($I$) and the frequency of energisation.
- The total magnetic field

Data Processing:

The data has been computed and the following parameters have been calculated for each station.

- MMR Magnetometric resistivity
- HN Normalised horizontal magnetic field
- Hu Geometric factor
- RPS Relative Phase Shift (in °)
- PFE Percent Frequency Effect (in %)
- HSQ/I Secondary field (derived from RPS)
- HSP/I Secondary field (derived from PFE)
- PFE/RPS ratio, an indication of the presence of coupling.
Data Presentation:

The data has been displayed in table form with the selected parameters of MMR, RPS and HSQ/I being shown in computer printergraph format by array.

In addition MMR and RPS have been contoured and presented at the scale of 1:5000. The Hunter Block grid is presented in two sheets. Interpretation plans have been prepared for the three areas.

The contour plans show the array numbers. The centres of the arrays are shown with a circle, while the suffix to the array number denotes the position of the electrode wire with respect to the array. The size of the current dipole is given in hundreds of metres by the figure below the array number.
APPENDIX

BRIEF DESCRIPTION OF METHOD AND MEANING OF PARAMETERS
METHOD

A brief and simple description of the method is given below for those unfamiliar with the basic principles behind the Rapid Reconnaissance Magnetic Induced Polarization (RRMIP) method. However, it is strongly recommended that the enclosed appendix be studied in detail for a more complete description of the method, and for those who are to make a geophysical assessment of the data, it is recommended that the papers referred to in the appendix be read also. The references therein give the current major papers dealing with MMR and MIP methods by various authors.

There are two significant electrical properties of rocks and ore bodies which are of great assistance in identifying zones of potential economic interest. The first is resistivity. This can be described as the resistance of a rock to the passage of electric current through it. Obviously those sections which are less resistive will allow greater quantities of current to flow than those which are more resistive. Massive 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 RRMIP, the measurement of resistivity is made with a very sensitive horizontal field magnetometer. This senses the volume of current flowing in the section below 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 magnetometer is proportional to the current flowing through the volume of overburden and rock below the sensor. This measurement is called Magnetometric Resistivity (MMR). Positive values define areas of relative
conductivity, and negative values areas which are relatively resistive. This property can be used as a method for tracing rocks having different resistivities beneath conductive overburden, as well as to define conductors which may of themselves be of potential economic interest.

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 sulphide (or graphite) grains, and the water contained between grain boundaries in rocks and ore bodies. If a pulsed current is used, the sulphide (or graphite) zones will charge during periods of current flow, and discharge during periods 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 reason for a magnetic sensor being used rather than simple electrical contact with the surface of the ground is that the conductive surface areas effectively mask the major changes in resistivity (MMR) beneath the conductive surface layer, and invariably either completely short out the induced polarization effect, or render it unrecognisable against background noise. The current is injected into the ground through current electrodes placed from 1 to 3 kilometres apart. These large current electrodes enable current to penetrate
the weathering into the fresh rocks below that hold the sulphides which are the subject of our exploration search.

THE PHYSICAL MEANING OF RRMIP PARAMETERS

A summary of the main characteristics of each of the features highlighted in the interpretation map follow in order that the reader can fully appreciate the geological implications of the data.

Conductor Axes

These represent the axes of the MMR conductor. To be significant they must have (i) a significant cross-sectional area conductivity contrast with the immediate enclosing rocks, and (ii) a significant strike length with respect to the current dipole used to energise the array. A diminution of either (i) or (ii) with respect to background resistivity of the rocks, or current dipole respectively, will result in a diminution of the observed response.

One further consideration with respect to the magnitude of the response is that should the current dipole be 'small' and the conductivity width of the overburden 'great', then a diminution of response will occur also. (For details see MIP appendix, page 12, fig. 7.)

One major point to bear in mind is that horizontal layering will not be observed on the MMR, while lateral changes will be emphasised.
Resistor Axes

These represent the axes of the significant MMR resistors, which in turn represent the area of the most resistive rock units. All the remarks above for conductors apply to the resistor axes.

Contacts

Where significant gradients are observed in the MMR data, a line has been drawn along the inflexion point (or approximately so, allowing for various 'local' distortions). This line will, for vertical dipping bodies show the approximate location, and certainly the strike length of major rock type changes.

Dislocations

These are located on the interpretation maps to emphasise a significant along strike discontinuity in both MMR and RPS features. They represent faults, flexures in strike direction or perhaps lensing of significant resistors and conductors.

Internal Polarization Axes

These represent above background zones of anomalous internal polarization. They are caused by segregations of sulphides, graphite and more rarely, by serpentine, mafic mineral content and magnetite.

These features can be distorted by electromagnetic coupling, by current channelling, particularly when MMR curves show a steep (25° to 30°) angle with the energising current, and by wire effects should the energising frequency be excessive with respect to the conductivity width of the overburden.
On the flanks of arrays, the precise location of the axes may not necessarily be mapped, but can be inferred. In such cases additional limited detailed work is required. Where this is done, the axes can be identified.

Significance of the Three RRMIP Parameters, MMR, RPS and HSQ/I

As discussed elsewhere, the positive MMR values denote the relative bulk conductors, while the negative values denote relative bulk resistors. The positive RPS values emphasise internal polarization within low current density areas. (Please refer to the papers for further explanation.)
CLIFFORD MINERALS LIMITED
IN ASSOCIATION WITH TECHNO MIN

WILLIERAY
NR. RENNER SPRINGS, N.T.

RRMIP SURVEY
MMR CONTOURS

Surveyed and Compiled by
SCINTREX

NORTHERN TERRITORY GEOLOGICAL SURVEY

CR 84/257

PLATE 10
CLIFFORD MINERALS LIMITED
IN ASSOCIATION WITH TECHNOMIN

WILLIERAY
NR. RENNER SPRINGS, N.T.

RRMIP SURVEY
RPS CONTOURS

Surveyed and Compiled by
SCINTREX

NORTHERN TERRITORY GEOLOGICAL SURVEY

CR84/257

AUGUST, 1984
SCALE 1:50,000
Job No. NT-034R

PLATE 11
CLIFFORD MINERALS LIMITED
IN ASSOCIATION WITH TECHNOMIN

WILLIERAY
NR. RENNER SPRINGS, N.T.

RRMIP SURVEY
RPS CONTOURS
Surveyed and Compiled by
SCINTREX

NORTHERN TERRITORY
GEOLOGICAL SURVEY

CR 84/257

AUGUST, 1984
SCALE 1:5000m
Job No. NT-0344

PLATE 13
CLIFFORD MINERALS LIMITED
IN ASSOCIATION WITH TECHNOMIN

WILLIERAY
NR. RENNER SPRINGS, N.T.

RRMIP SURVEY
RPS CONTOURS

Surveyed and Compiled by
SCINTREX

NORTHERN TERRITORY
GEOLOGICAL SURVEY

CR84/257

AUGUST, 1984
SCALE 1:5000m
Job No. NT-0348
PLATE 18
CLIFFORD MINERALS LIMITED
IN ASSOCIATION WITH TECHNOMIN

WILLIERAY
NR. RENNER SPRINGS, N.T.

RRMIP SURVEY
MMR CONTOURS

Surveyed and Compiled by
SCINTREX

NORTHERN TERRITORY
GEOLOGICAL SURVEY

CR84/257

AUGUST, 1984
SCALE 1:5000m
Job No. NT-034R
CLIFFORD MINERALS LIMITED
IN ASSOCIATION WITH TECHNOMIN

WILLIERAY
NR. RENNER SPRINGS, N.T.

RRMIP SURVEY
RPS CONTOURS

Surveyed and Compiled by
SCINTREX

NORTHERN TERRITORY
GEOLOGICAL SURVEY

CR 84/257

PLATE 20