PROJECT: GEOPHYSICAL SURVEY
(Transient Electro-Magnetics)

AREA: ERL94, Redbank Copper Mine, NT

CLIENT: Redbank Mines Limited

PROJECT NO: AG-280

CLIENT P/O: Purchase Order (Email),
RBMO.2009-11-002 and
RBMO.2009-12-007
5th May 2009.
DRAFT REPORT
Geophysical Survey: Transient Electro-Magnetics on Portion of ERL94, Redbank Copper Mine, NT

For

Redbank Mines Limited
Level 1, Hay Street
Subiaco, WA 6008

Telephone: (08) 6389 6400
Facsimile: (08) 6389 6410

By

Alpha Geoscience Pty. Limited
ABN 14 080 819 209
Unit 1, 43 Stanley St
Peakhurst NSW 2210

Telephone: (02) 9584 7555
Facsimile: (02) 9584 7599

Authorised by:

Jamie Speer BSc. Geophys Hon Geophys / Geochem
Senior Geophysicist

Date: 29 June 2009
# TABLE OF CONTENTS

1. **INTRODUCTION** .................................................. 1
2. **AUTHORITY** .................................................. 1
3. **SURVEY RATIONALE** .......................................... 1
4. **STAFF** .......................................................... 2
5. **EQUIPMENT** .................................................. 2
   5.1 **Monash Geoscope terraTEM** .................................. 2
   5.2 **SkyTEM Receiver Coil** ..................................... 2
   5.3 **GPS and DGPS Positioning** ................................ 2
6. **SURVEY, DATA ACQUISITION AND PROCESSING** ........ 2
   6.1 **Initial Testing** ............................................ 2
   6.2 **Data Acquisition and Survey Parameters – ERL94** .... 6
   6.3 **Data Processing** ........................................... 7
   6.4 **Quality Assurance** ........................................ 7
7. **RESULTS** ...................................................... 7
   7.1 **Prince** ..................................................... 7
   7.2 **Redbank and Azurite** ..................................... 9
   7.3 **Punchbowl and San Manuel** ................................ 11
   7.4 **Roman Nose** ............................................... 12
   7.5 **Quartzite** .................................................. 13
   7.6 **Bluff** ........................................................ 14
   The anomaly associated with the Bluff Site appears to be centralised over one data loop, with an extent of 150 by 100m. The anomaly appears to be north of the major focus of previous exploration. ......................................................... 14
   7.7 **Gravity Anomalies** ........................................ 15
   7.8 **IP Anomalies** ............................................. 18
8. **COMMENTS ON RESULTS** ...................................... 23
   8.1 **IP Processing** ............................................. 24
9. **CONCLUSIONS** .................................................. 26
10. **LIMITATIONS OF REPORT** ..................................... 26
11. **APPENDIX 1 – Plot of TerraTEM Loop Centre Locations.** 28
12. **APPENDIX 2 – Plot of Transient EM Response Data, Originally Presented to Redbank Mines. Image From Redbank Mines ASX Media Release, Exploration Update, 7/7/2009** ... 29
13. **APPENDIX 3 – Plot of Transient EM Response Data, Channel 9 From 0.4Amp Data. Data Displayed is the Largest Area of Investigation, “Redbank” to “Bluff”** .......... 30
14. **APPENDIX 4 – Plot of Transient EM Response Data, Channel 13 From 1.7Amp Data. Data Displayed is the Largest Area of Investigation, “Redbank” to “Bluff”** .......... 31

© Alpha Geoscience Pty. Limited

"COPYRIGHT Alpha Geoscience Pty. Limited 2008. No part of this work may be reproduced or copied in any form or by any means (graphic, electronic or mechanical, including photocopying, recording of information and retrieval systems, including publication on the web) without prior permission of Alpha Geoscience Pty. Limited."
15. APPENDIX 5 –Comparative Plots: Average Late Time Amplitude between Channel 30-50 from 1.7Amp data (left) and Absolute Values of the Averaged Data (right).

16. APPENDIX 6: Comparative Plots of Relative Polarity Reversal Time (left) and Maximum Negative Value (right) from the 1.7A Dataset

17. APPENDIX 7: Comparative Plots of Relative Polarity Reversal Time (left) and Early Time Amplitude (CH 10), from the 1.7A Dataset

18. APPENDIX 8 - Alpha GeoScience - Curriculum Vitae

19. APPENDIX 9 - REFERENCES
1. INTRODUCTION

Alpha Geoscience Pty. Limited (Alpha), based in Sydney, NSW, was contracted by Redbank Mines Limited to undertake a geophysical survey acquiring Transient Electro-Magnetic (TEM) data at a number of sites near Redbank Copper Mine, NT, including; two grids, and two sets of profiles on ERL94. The locations of the TEM soundings are plotted for each of the areas in Appendix 1.

The field work component comprised of one visit. The data collection occurred between 20/5/2009 and 23/06/2009.

2. AUTHORITY

Bruce Morrin, Authorised Officer of Redbank Mines Limited provided the authority to proceed with the project by way of a Purchase Order (RBMO.2009-11-002), dated 5th May 2009 to Jamie Speer. A second Purchase Order (RBMO.2009-12-007) was supplied for an extension of field work.

3. SURVEY RATIONALE

The scope of the project was to carry out a Transient Electromagnetic (TEM) survey to confirm the presence of circular structures inferred from previous work on the ERL.

The primary targets were described as mineralised breccia pipes with sulphide cores. Two other target areas were investigated based on gravity anomalies identified from the gravity survey that was being undertaken during the same period.

The basic principle of the TEM method is that a current flowing in a transmitter loop sets up a magnetic field which when switched off induces eddy currents to flow in any good electrical conductor in the ground. These eddy currents set up a secondary magnetic field which can be detected by a receiver loop as a time-dependant decaying voltage (Henderson & Pippett 2006). Mineralised breccia pipes should be an ideal conductive target for TEM methods as the sulphide core should be a good conductor.

The recording of the ‘transients’ is a means of detecting conductors in the ground. The decaying transient can be described by a number of measurement channels recording the voltage at various delay times (see figure below) during the “quiet time” between current pulses. The character of this decay (duration, amplitude, etc.) depends on the conductivity, shape, size, depth and attitude of the conductor and its position with respect to the receiver loop and can be used to provide information on all these factors. A particular advantage of transient EM systems over continuous waves systems is the fact that the measurements are taken when the transmitted fields are switched off. This means that the sensitivity of the receiver can be a maximum to record the transient voltages only without having to cope with the much greater signal strength of the transmission field. It also means that a greater variety of loop configurations can be used including having the receiver loop (coincident loop) in the same place as the transmitter loop for maximum signal reception (Henderson & Pippett 2006).
4. STAFF

The Senior Geophysicist for the project was Jamie Speer. The Project Geophysicist for the survey was Jeremy Hill. Additional field assistance was provided by Kathleen McMahon and Michael Fitzgerald of Alpha Geoscience.

Data processing, interpretation and presentation were undertaken by Jamie Speer, Jeremy Hill and Michael Fitzgerald.

Reporting was undertaken by Jamie Speer, Jeremy Hill and Michael Fitzgerald.

5. EQUIPMENT

5.1 Monash Geoscope terraTEM

The terraTEM is a state of the art transient electromagnetic survey system designed and constructed in Australia. The unit features a 10 Amp transmitter and is powered by an external 24 V battery pack system allowing 3-8 hours of continuous operation (dependent on transmitter power settings and stacks acquired). It also contains a 15-inch colour LCD panel with a touch-screen; data storage in the form of an expandable 1 gigabyte solid-state memory with transfer using a USB flash memory stick. System parameters are stored automatically with each sounding for post survey quality assurance. The included data reduction and processing software can generate on-site standard profile and decay plots, apparent conductivity pseudo-sections, and contour plan maps. An optional 12-channel, built-in GPS receiver can be mounted on the front panel, allowing location information to be automatically recorded with soundings.

5.2 SkyTEM Receiver Coil

The SkyTEM Receiver Coil is a state of the art receiver coil designed in Denmark. The receiver coil has an effective loop area of 105 square metres.

5.3 GPS and DGPS Positioning

Positioning of loop locations was achieved by the use of 2 Garmin Map76 GPS units. Positioning of the Receiver Coil was recorded using a Trimble AG114 DGPS, utilising Omnistar Virtual Base Station corrections.

6. SURVEY, DATA ACQUISITION AND PROCESSING

6.1 Initial Testing

Initial testing near the suspected target at Bluff showed extremely fast decaying values followed by what appeared to be noise from an Alternating Current (AC) source, see Plot 1 for a decay plot of this data. Consequently, a series of experiments were performed to test whether the power generators at Redbank Mine and the Camp were the source(s) of the apparent noise. The experiments showed that the apparent noise was not caused by either of the generators.
The possibility of instrument noise was then tested at a site near Station Creek on Wollogorang Station where high quality data had been obtained nearby in a previous survey. The data obtained in the test is shown below in Plot 2. The resulting data was of very high quality and ruled out the possibility of instrument noise.

Further testing was undertaken at the lookout near Echo Gorge and near the old Redbank workings, the resulting data is presented in Plots 3 and 4 respectively. Comparison of the two plots shows a very similar fast decaying early time response although somewhat slower than that of the data collected at Bluff (Plot 1). Both of the curves become noisy after about 0.1 or 0.2 milliseconds, however, the noise is not consistent with an AC signal for either decay plot.
Plot 2: Decay Plot of data collected near Wollogorang station.

Plot 3: Decay Plot of data collected at the lookout above Echo Gorge.
Plot 4: Decay Plot of data collected near the old Redbank workings.

A north-south running line of data was then collected over the Bluff target; this is presented as Plot 5, below. The smooth variations of the early time data in the profile showed that the early time data was most likely the genuine TEM response of very resistive ground. The late time response of the data was typified by strong negative responses in certain areas as well as what looks like AC type noise in a few of the soundings.

The strong negative response in some of the late time data was consistent with what is known as the Induced Polarization effect (IP). It was concluded that the AC style noise was most likely the result of IP or related phenomena due to the geological setting of the site, and hence geophysical conditions rather than any external AC source. A quantifiable argument for such a conclusion is the fact that the absolute value of the amplitude of the apparent AC signal decreases with time. This indicates that the phenomena which causes the AC style signal is a direct result of excitation from the primary field and subsequently decays when the field is switched off, whereas the signal from an external AC source should not decay with time. Indeed the final survey confirmed the widespread presence of IP in the data, the possible causes of which will be discussed in the following sections.
6.2 Data Acquisition and Survey Parameters – ERL94

After extensive testing of numerous loop sizes and configurations, the loop configuration chosen was a 50m x 50m transmitter loop with a centrally positioned roving receiver coil (RVR). This configuration was chosen in preference to coincident loop and single loop configurations because of the presence of Super Parra-Magnetism (SPM) caused by the interaction of the primary field with iron minerals in the uppermost part of the regolith profile usually where laterite is present. The SPM effect is only present in the immediate vicinity of the transmitter loop and hence the centre loop configuration alleviated this problem. The Slingram configuration could also have been used. However, testing showed that the Slingram configuration did not improve the data or reduce the influence of the IP effect using the offsets available. Therefore central loop configuration was chosen as it maximises the signal to noise ratio and increases productivity.

Four transmitter loop currents were obtained by adding external resistance to the transmitter loop, these were; 0.4, 1.7, 2.4 and 7.0 Amps. The different currents were used to yield the highest quality data throughout as large a portion of the decay as possible. Smaller currents yield higher resolution in the early time data as the turn off time is faster. Whereas larger currents increase the signal to noise ratio and usually improve the quality of late time data. Thus a range of currents was used to gain the most information possible for each sounding location.

The number of stacks required was usually 1024 stacks and the optimum gain setting was 32. Higher gains either clipped or made no improvement to the data and lower gains decreased the signal to noise ratio resulting in a lower dynamic range for individual measurements.

Soundings were collected at 50m spacing; see Appendices 1 to 4 for location of soundings.
6.3 **Data Processing**

The following steps were taken in the data processing and imaging of the Transient Electro-Magnetic data collected:

- TEM data was exported from Templot software in TEM format. Soundings were assigned DGPS positions manually and re-imported to Templot.
- Decay plots were produced using Templot processing and visualisation software.
- Profile plots were produced using Templot processing and visualisation software.
- Contour maps of TEM data for a range of channels were produced using Templot processing and visualisation software.
- Contour maps of TEM data for a range of channels were overlaid onto 3D surfaces of DGPS elevation data collected during the survey using Surfer 8 plotting software.
- Contour maps of Sign reversal times were plotted.

6.4 **Quality Assurance**

The following steps were taken to ensure the delivery of a high quality data set.

- Extensive testing was conducted to ensure the optimal instrument and survey parameters were selected to suite the physical conditions of the site.
- Each sounding was checked for integrity in the field and reacquired if necessary.
- DGPS positioning for each sounding was averaged over 60 separate readings.
- The location of metallic objects was recorded using DGPS for comparison with anomaly locations.

7. **RESULTS**

A total of 969 stations, with 100 initial test soundings at 10 stations were acquired during the survey. The positions of the soundings are displayed in Appendix 1, below.

Plots of the data are either; Channel 9, from the 0.4Amp data set or of Channel 13, from the 1.7 Amp data set, except for the data displayed for the Gravity anomalies, various power ratings are displayed for this portion of the survey.

Plots of the data from the total survey and the largest portion, “Redbank” to “Bluff” are given in Appendices 2, 3 and 4.

The results from the site were plotted as smaller sections and are shown as individual plots and described below.

7.1 **Prince**

The plot below displays the data from the Prince Site. The plotting scale is the same scale as used for this data from other sites. There is a large linear zone of higher conductivity plotted in the southern section of the site. This may correspond to a paleochannel, or a zone of oxidised material.

The second plot of the site, shown in Plot 6, below, reveals a circular feature about 80 to 100m across within the region of higher conductivity. This plot uses data limits that are close
to the natural data limits for the site. Both the zone of higher conductivity and the central zone are up to 250m to the south of the pre-existing mine workings.

The feature plotted above is haloed by a Mid to Late Time IP Response. This response is only present along the edge of the higher amplitude response. See discussions below in Section 8.

Plot 6: Colour Infill Contour Plot Prince Site, Channel 13, 1.7 Amp Data From the prince Site, Data Limits Matching Those Employed for the Balance of the Presentations.
Plot 6: Colour Infill Contour Plot Prince Site, Channel 13, 1.7 Amp Data From the Prince Site, Wider Data Limits Applied.

7.2 Redbank and Azurite

The plots of Channel 9, from the 0.4 Amp data set, are shown below. A similar approach to that used with the above data set was taken to highlight the believed centre of the Azurite deposit. This is shown below in Plot 8.

The 2 lower conductivity regions to the north of Redbank and Azurite show good correlation with the waste dumps on the site. As these contain mineralised material it is assumed that these responses are a result of the mineralised waste and not mineral deposits.
Plot 7: Colour Infill Contour Plot Redbank and Azurite Sites, Channel 9, 0.4 Amp Data From the prince Site, Data Limits Matching Those Employed for the Balance of the Presentations.

Plot 8: Colour Infill Contour Plot Redbank and Azurite Sites, Channel 9, 0.4 Amp Data From the prince Site, Data Limits For This Plot Altered to Highlight the Central Feature of the Anomalies.
7.3 **Punchbowl and San Manuel**

Two localised zones of higher conductivity are present in the plot of this section of the ERL. See Plot 9, below.

Also present within this portion of the site is a localised area of low conductivity. This low conductivity area maps a section of the data displaying an IP response, see below for discussion of the IP sections in the data set.

![Plot 9: Colour Infill Contour Plot San Manuel and Punchbowl Sites, Channel 9, 0.4 Amp Data From the prince Site, Data Limits Matching Those Employed for the Balance of the Presentations.](image)
7.4 Roman Nose

The Roman Nose Site is characterised by a small semicircular feature. This appears to be associated with a region to the south that displays similar conductivity.

There is associated with the southern section a Mid to Late Time IP Response. see Section 7.8.2 below.

Plot 10: Colour Infill Contour Plot Roman Nose Site, Channel 9, 0.4 Amp Data From the prince Site, Data Limits Matching Those Employed for the Balance of the Presentations.
7.5 Quartzite

The plot of the data acquired across the site of the Quartzite exploration target is shown below. Of note is that the higher conductive zone is actually two closely spaced circular targets. Also of note on this site is the IP response in the later times. See the Sections 7.8.2, showing the IP results and Section 8, the discussion on the IP responses.

![Colour Infill Contour Plot Quartzite Site](image)

Plot 11: Colour Infill Contour Plot Quartzite Site, Channel 9, 0.4 Amp Data From the prince Site, Data Limits Matching Those Employed for the Balance of the Presentations.
7.6 Bluff

The anomaly associated with the Bluff Site appears to be centralised over one data loop, with an extent of 150 by 100m. The anomaly appears to be north of the major focus of previous exploration.

![Colour Infill Contour Plot of Transient EM Response at Channel 9 From 0.4 Amp Data Set](image)

*Plot 12: Colour Infill Contour Plot Bluff Site, Channel 9, 0.4 Amp Data From the prince Site, Data Limits Matching Those Employed for the Balance of the Presentations.*
7.7 Gravity Anomalies

Three anomalies were selected from the gravity survey. Data was acquired as 2 profiles across both the gravity anomalies. The results are plotted below, both as colour filled contour plots and as profiles.

The data from the Gravity High does not appear to reveal an anomaly in the early time data set, see Plot 13, below. There is a slight lift in the late time data over the centre of the profile. This lift is also flanked by IP responses in the late time data; see Profile, Plot 14, below.

The High / Low Gravity Anomaly displays a “pull down” in the mid to late time data. This pull down coincides with the portion of the profiles that falls between the Gravity High and Low Anomalies, see Plots 15 and 16 below.

The pull down in the TEM data may indicate a thin conductive body.
Plot 14: Gravity High: Profile Plot of the Transient EM Response, from the 1.7Amp Data set, for Line 8097750N

Plot 15: Gravity High Low: Profile Plot of the Transient EM Response, from the 7Amp Data set, for Line 8097000N
Plot 16: Gravity High Low: Profile Plot of the Transient EM Response, from the 7Amp Data set, for Line 8096950N
### 7.8 IP Anomalies

#### 7.8.1 Northern IP Anomaly

Below is plotted an example of the Early Time IP Response. There are 4 areas with this characteristic response. The signal rapidly falls to a negative value within the Early Time channels for all power settings used. The areas showing this response are shown in Appendices 5, 6 and 7, below. The IP response is plotted in blue.

See comments below for discussion, Section 8.

---

*Plot 17: Colour Infill Contour Plot At the Site of The Northern IP Anomaly, Channel 9, 0.4 Amp Data From the prince Site, Data Limits Matching Those Employed for the Balance of the Presentations.*
7.8.2 IP Anomaly Associated with Roman Nose data set.

The Mid to Late Channel data from the Roman Nose data set reveals an IP Response to the south of Roman Nose. The IP response is plotted in blue. This anomaly is present on a number of channels and on all power settings. Below are plotted the 1.7 and 2.4 Amp responses.

Of note is the presence of a more conductive zone in the Early Time Channels associated with this response.

See comments below for discussion.

Plot 18: Colour Infill Contour Plot at the Site of the IP Anomaly associated with the Roman Nose section of the site, Channel 37, 1.7 Amp Data.
Plot 19: Colour Infill Contour Plot at the Site of the IP Anomaly associated with the Roman Nose section of the site, Channel 34, 2.4 Amp Data.
7.8.3 IP Anomaly Associated with Quartzite data set.

The Mid to Late Time data from the Quartzite site displays an IP Response. The IP appears to be in 3 areas, see plots below. The response is present across a number of channels and is present on all power settings employed in this survey. See comments below for discussion.

Plot 20: Colour Infill Contour Plot at the Site of the IP Anomaly associated with the Quartzite site, Channel 37, 1.7 Amp Data.
Plot 21: Colour Infill Contour Plot at the Site of the IP Anomaly associated with the Quartzite site, Channel 37, 1.7 Amp Data.
8. COMMENTS ON RESULTS

Overall the TEM method appears to have been highly successful at locating circular features and other extensive zones with relatively high amplitude response in the early time channels. These anomalous features correspond very well to areas of both known mineralisation and exploration targets.

Most, if not all of the TEM data collected was affected by Induced Polarization (IP). For interpretation methods based on TEM theory, the IP affected portion of the decay is essentially lost information. Most of the data was affected by IP in the late time and some of the data was IP affected in the early and mid times as well.

The IP effect manifests in TEM data as a change in sign of the voltages measured by the receiver coil. Thus the presence of negative values indicates the presence of a polarisable conductor. In this case the polarisable conductor is most likely to be disseminated sulphide mineral grains, which were in abundance in some of the rock types present on site. Other possible polarisable conductors include parallel thin sheet conductors or clay interfaces; however the widespread presence of such conductors seems unlikely in a predominately volcanogenic geological model. Some success has been achieved in modelling mineral size and concentration in disseminated ore using IP affected TEM data, Flores & Peralta-Ortega (2009). However, no inversion code is commercially available for this process and the results did not show a high level of accuracy.

The problems associated with modelling of IP affected TEM data are numerous. One possible solution is to separate the decay curve into its TEM and IP components. Such a separation is theoretically possible using multiple loop sizes that vary in their susceptibility to IP effects, Descolteres et al (2000), or by using multiple loop configurations, Kaufman et al (1989). This would essentially double or triple the size and cost of a survey. However, the data already collected could be used as one of the different loop configurations for this purpose, if more TEM data is collected on site in future.

McNeill (1994) suggests using offset-loop soundings to attenuate the IP effect. However, our testing of the Slingram (offset-loop) showed no improvement at 40m offset. Offsets were limited by cable length and current output. Long offsets may prove useful in future surveys for deep targets. However, spatial resolution would be compromised by the Slingram method and the high currents required to increase the signal for such offsets would reduce data resolution in the early time. The use of the Slingram method would probably also at least half production.

Some of the soundings displayed positive late time data that mirrored the curve of some negative IP affected late time data, although no mention of IP displaying positive values is reported in the current literature. The occurrence of the “positive IP” was usually in areas with a large number of soundings with strong negative IP. Appendix 5 contains two plots, the first plot is the 1.7Amp late time data averaged between channels 30 and 50 and the second plot is the absolute value of the averaged data. Notice the circled clusters of high positive and negative late time averages in the first plot. This spatial relationship suggests that the “positive IP” is in fact related to the negative IP in some areas. When we plot the absolute values of the late time averages we see that the anomalies appear consolidated.

Metallic objects large enough to interfere with the results of the TEM survey were present in the survey area. The concentration of these objects was obviously higher in areas where previous drilling had occurred and for obvious reasons these areas corresponded to the location of targets. The objects ranged in size from steel drums and rolls of wire, to lost rod strings and old mining equipment. DGPS positions were collected for all metallic objects of reasonable size.
to ensure that noise from man-made metallic objects could not be confused with targets for exploration.

The location of metallic objects collected using DGPS did not correlate directly with the location of exploration targets. All exploration targets showed gradational changes in signal amplitude over distances much larger than the effects of metallic objects of the sizes encountered could be measured.

### 8.1 IP Processing

Kauffman et al (1989), suggests that in the late times, the ratio of the induction and polarization components of the field remain constant. With this in mind it was thought that plotting of amplitude of the late time data should give an indication of the relative strength of the IP and TEM responses, a plot of averaged late time amplitude is shown in Appendix 5. There are a number of negative IP anomalies visible in the late time data. However, as the source of the IP is, at the time of writing speculative, a review of the literature was conducted with the aim of assessing the possible causes of the IP anomalies and the validity of these anomalies as targets for drilling.

Listed below are some useful conclusions about the characteristics of IP affected central-loop TEM data as described by Descloiteres et al (2000) and others, which are consistent throughout the literature. These principles will form the basis of the discussion of IP affected data.

- The part of the TDEM response due to the IP effect is negative. In some situations, when the amplitude of the inductive part of the response becomes small enough, the IP signal dominates and leads to negative data. This occurs usually at late time.
- The more resistive the ground, the higher the amplitude of the IP effect. In general, it can be shown that the amplitude of negative peaks is roughly proportional to the square root of the resistivity.
- Larger DC resistivities result in earlier sign reversals, Flores and Peralta-Ortega (2009).
- When sign reversals are recorded, the time of occurrence and amplitude of the negative peak are strictly connected with the value of m, c and t. Flores and Peralta-Ortega (2009).

The literature describes the IP component of the TEM response using the Cole-Cole model (Cole and Cole, 1941). The model is expresses the ground conductivity as a dispersive (frequency dependent) conductivity $\sigma$.

$$\sigma = \sigma_0 \left( \frac{1 + (i\omega\tau)^c}{1 + (1 - m)(i\omega\tau)^c} \right)$$

Where $\sigma$ is the DC conductivity(S/m), $m$ the Cole–Cole chargeability, $c$ the frequency dependence, $t$ the Cole–Cole time constant, and $\omega$ the angular frequency (Hz).

Results from forward modelling, conducted by Flores and Peralta-Ortega (2009), using the Cole-Cole model are shown below in Figure 1. Figure 1 shows the effect of changing one of the four variables; $\sigma$ DC resistivity, $m$ the Cole–Cole chargeability, $t$ the Cole–Cole time constant and $c$ the frequency dependence.
Figure 1 (a) shows that increasing the DC resistivity of the medium increases the maximum amplitude of the IP decay and also results in earlier sign reversals. Figure 1 (b) shows that larger Cole-Cole chargeability also results in earlier sign reversal much like the effect of increasing DC resistivity although its effect on amplitude of the negative signal is much more pronounced. Figure 1 (c) and (d) show that increasing the frequency exponent results in slightly higher amplitude negative voltages with little effect on the time of sign reversal. Comparative Plots of Relative Polarity Reversal Time and Maximum Negative Value from the 1.7A Dataset are shown in Appendix 6. Notice that the plots are almost identical; this confirms that the relationships between the variables described above are true for this dataset.

When picking IP anomalies for exploration it would seem appropriate to exclude those anomalies where high DC resistivity is the determining factor, as this would probably indicate fresh bedrock. Conversely, IP anomalies where Cole-Cole chargeability is the determining factor are prime candidates for exploration as they may indicate a relatively high concentration of disseminated sulphides. It is therefore necessary to differentiate between IP anomalies where Cole-Cole chargeability is the determining variable and those where high DC resistivity is the determining variable.

A major difference in the effects of DC resistivity and Cole-Cole chargeability is apparent in the forward modelling; increased resistivity results in lower amplitude response in the early times as seen in Figure 1 (a). Whereas in Figure 1 (b) we see the opposite, increasing the Cole-Cole chargeability increases the early time amplitude. Figure 1 (c) shows that increasing the Cole-Cole time constant results in earlier sign reversal, however there is relatively small effect on early time amplitude. Figure 1 (d) shows that increasing the frequency exponent results in slightly higher amplitude negative voltages with little effect on the time of sign reversal.

![Figure 1](image_url)

**Fig. 1.** Amplitude (solid lines) and phase (dashed lines) spectra of the Cole–Cole relaxation model. a) Varying the dc resistivity, b) the chargeability, c) the time constant, and d) the frequency exponent of the reference model \([ \sigma = 100, m=0.5, t=0.01, c=0.5 \)].
Therefore, areas of relatively low positive early time amplitude and early sign reversal should correspond to areas of relatively high DC resistivity. Alternatively, areas with relatively high positive early time amplitude and early sign reversal should correspond to areas of high chargeability, inferring a high concentration of disseminated mineral grains. It should be noted that this is only proven true for homogenous polarisable half-space proximal to both the receiver and transmitter loops.

Comparative Plots of Relative Polarity Reversal Time and Early Time Amplitude (CH 10) from the 1.7A Dataset are shown in Appendix 7. From comparison of the plots we can see that the majority of the low amplitude early time responses (red) are coincident with early sign reversals (red), therefore we must conclude that for these IP anomalies the determining variable is most likely high DC resistivity and we do not recommend these anomalies as targets for drilling.

Only one stand alone IP anomaly is thought to be of note. The Mid to Late Time IP anomaly that is in evidence in the “Roman Nose” data set may be a target for further investigation. This anomaly is in evidence in an area of higher conductivity and may be the result of disseminated ore.

The IP Responses associated with the conductive Quartzite anomaly may indicate the presence of sulphide ore assemblages.

9. CONCLUSIONS

A geophysical survey was successfully undertaken using TEM at a number of sites on ERL94, Redbank Copper Mine, NT.

A number of circular features were mapped from the evidence in the TEM data.

Anomalies from the concurrent gravity survey were investigated. One of the anomalies displayed “pull downs” in the data that may indicate a thin conductor. This locality may warrant further investigation.

A large proportion of the data set displays an IP Response.

One IP anomaly has been presented as a possible target and may be worthy of further investigation.

10. LIMITATIONS OF REPORT

This report has been prepared for the use of Redbank Mines Limited in accordance with general accepted Consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. This report has not been prepared for the use by parties other than the client, the owner and their respective consulting advisors. It may not contain sufficient information for purposes of other parties or for other uses.

This report was prepared on completion of the field work and is based on conditions encountered and reviewed at the time of preparation. Alpha GeoScience disclaims responsibility for any changes that might have occurred after this time.

The interpreted locations and depths noted in this report should be taken as an indication only, and no decision should be based solely on these results.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.
Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, conditions on the site (including the depositing and removal of contamination) can change in a limited time. This should be borne in mind if the report is used after a protracted delay.
**Time Domain Electromagnetic Survey Extent:**

ERL94, Including MLN631, MLN632, MLN633, MLN634, MLN635, MLN636 and MLN1108.

Datum: MGA94, Zone: 53. Positioning by GPS
Date of Survey 20/5/2009 to 23/6/2009
Map Prepared by: J. Speer 1/7/2009

969 Data Points Collected: Using 50m X 50m Transmitter Loop with a Multi-turn Central Receiver Loop.

Total Data Plot from Transient Electromagnetic Survey, ERL94, 2009
APPENDIX 3 – Plot of Transient EM Response Data, Channel 9 From 0.4 Amp Data. Data Displayed is the Largest Area of Investigation, "Redbank" to "Bluff"
14. APPENDIX 4 – Plot of Transient EM Response Data, Channel 13 From 1.7Amp Data. Data Displayed is the Largest Area of Investigation, “Redbank” to “Bluff”
15. APPENDIX 5 – Comparative Plots: Average Late Time Amplitude between Channel 30-50 from 1.7Amp data (left) and Absolute Values of the Averaged Data (right).
Notice that the plots are almost identical; this confirms that the relationships between the variables as shown by forward modelling are true for this dataset. See Discussion on Results -IP Processing section of this report. These are not targets recommended for drilling.
From comparison of the plots we can see that the majority of the early sign reversals (circled on the left plot) are coincident with low amplitude early time responses (circled on the right plot), therefore we must conclude that for these IP anomalies the determining variable is most likely high DC resistivity and we do **not** recommend these anomalies as targets for drilling.
18. APPENDIX 8 - Alpha GeoScience - Curriculum Vitae

Alpha GeoScience was established in 1997 to offer high sensitivity geophysical tools and expertise as an alternative to intrusive investigations in the following areas:

- **Environmental Services** Including the mapping of buried structures, site assessments and the detection of chemical pollutants.

- **Ordnance Services** The location of buried unexploded ordnance (UXO), site assessments and sample surveys to determine extent of pollution. Alpha GeoScience is a member of the Defence UXO Panel.

- **Engineering Services** Assisting civil mining and construction engineers with subsurface investigations, especially where intrusive investigation is difficult and costly to undertake.

- **Forensic Geophysics** The location of buried gravesites and other buried objects for the police and other crime agencies.

- **Mining and Exploration** Assist mining and exploration companies with near surface investigations.

- **Training** Provides training courses in high-resolution magnetics, electro-magnetics, seismic refraction and ground-penetrating radar for clients who wish to undertake surveys themselves.

- **Project Management** Is an intricate part of all projects and Alpha GeoScience has expertise and experience in setting up, running and reporting on both major and minor projects worldwide.

- **Research and Development** Alpha GeoScience has been involved in running a number of research and development projects including the development of a multi-sensor geophysical instrumentation package for the horizon control of a coal-mining machine.

The types of techniques offered by Alpha GeoScience include high sensitivity magnetics, ground penetrating radar, time or frequency domain electro-magnetics, resistivity mapping and seismic refraction and reflection techniques. These services combined with the digital processing of the data to produce colour images of the site and the interpretation of the data gives high-resolution detail of the subsurface on the site. This data can be imported into Geographical Information Systems (GIS) for future reference and auditable documentation.

Alpha GeoScience also offers the services of processing and interpretation of data in Sydney with the data being downloaded from the field via the Internet.

Alpha GeoScience is based in Sydney Australia and is capable of mobilising to any part of the world with very short notice. We have experience in operations throughout Australia, North America, Europe and South East Asia.

Alpha GeoScience is offering its services and consultation so that the client obtains the best technology for the particular target being investigated. Whether it is ordnance items or environmental pollution plumes, it has the technical expertise to provide the right solution.
19. APPENDIX 9 - REFERENCES


