GM 61684

LOGISTICS REPORT ON A UTEM 3 SURVEY, MCLEOD GRID

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Énergie et Ressources naturelles
Québec

Logistics Report on a UTEM 3 Survey
McLeod Grid
Matagami, Québec
for
Noranda Inc.

Ressources naturelles et Faune, Québec
07 DEC. 2005
Service de la Géoinformation

GM 61684

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

January, 2005

Rob Langridge, M.Sc.,P.Geo.
Geoff Heminsley, P.Geo.
Michael Marchen

05178-022

noranda

memorandum

FALCONBRIDGE

Noranda Inc./ Falconbridge

To	Grant Arnold
From	Michel Allard
CC	Gilles Simard, Gilles Roy
Date	June 7, 2005
Regarding	Interprétation, conclusion et recommandation concernant le levé UTEM au dessus de Renaissance

REÇU AU MRNF
23 JUIN 2005
Direction du développement minéral

L'objectif du levé UTEM était de tenter de déceler la lentille Renaissance et de préciser sa géométrie et ses propriétés physiques le cas échéant. La figure 1 montre la localisation des lignes du levé par rapport aux conducteurs connus par les levés électromagnétiques en forage.

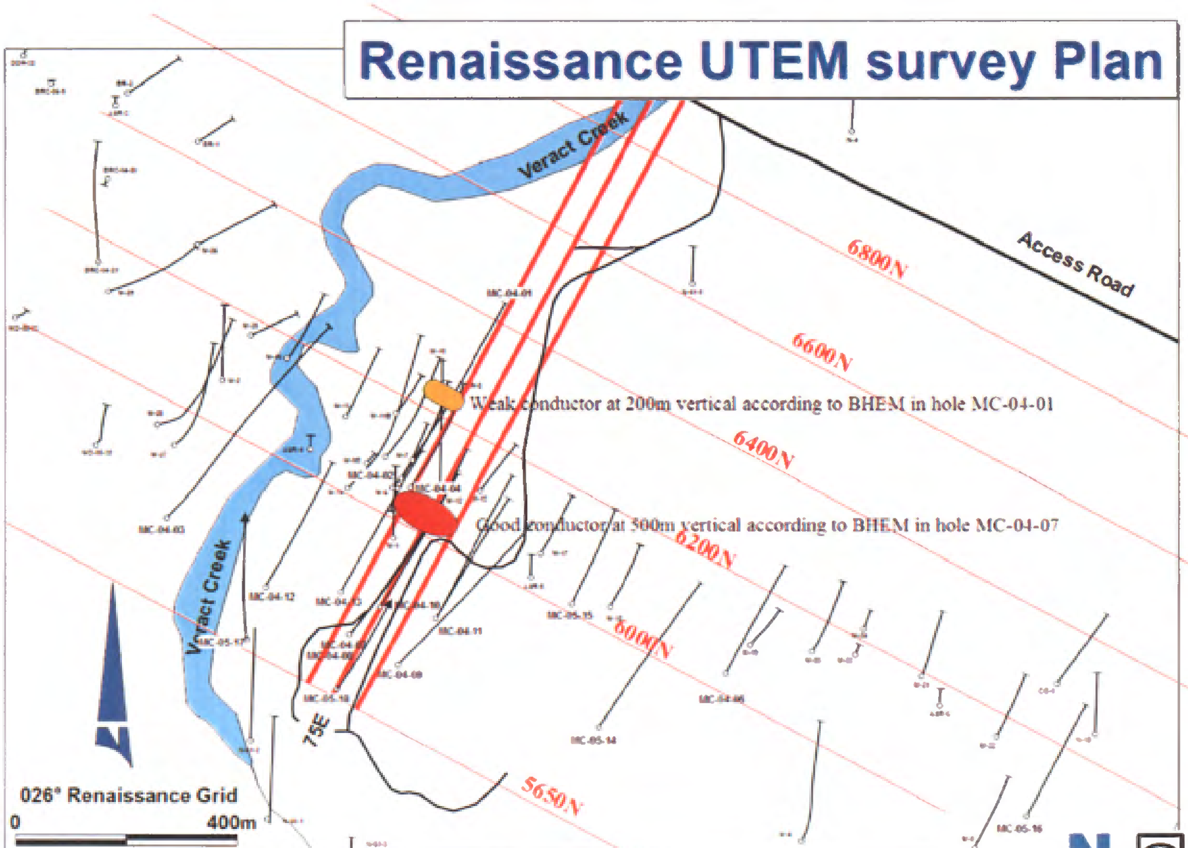


Figure 1 : Location des lignes de levés par rapport aux zones conductrices connues.

05178-022

Afin de vérifier si la détection était possible, une modélisation a d'abord été faite en utilisant les paramètres connus et probables de la lentille. Selon ce modèle, présenté à la figure 2, une faible anomalie d'environ 1 à 2% était envisageable en utilisant une boucle placée au sud de la zone.

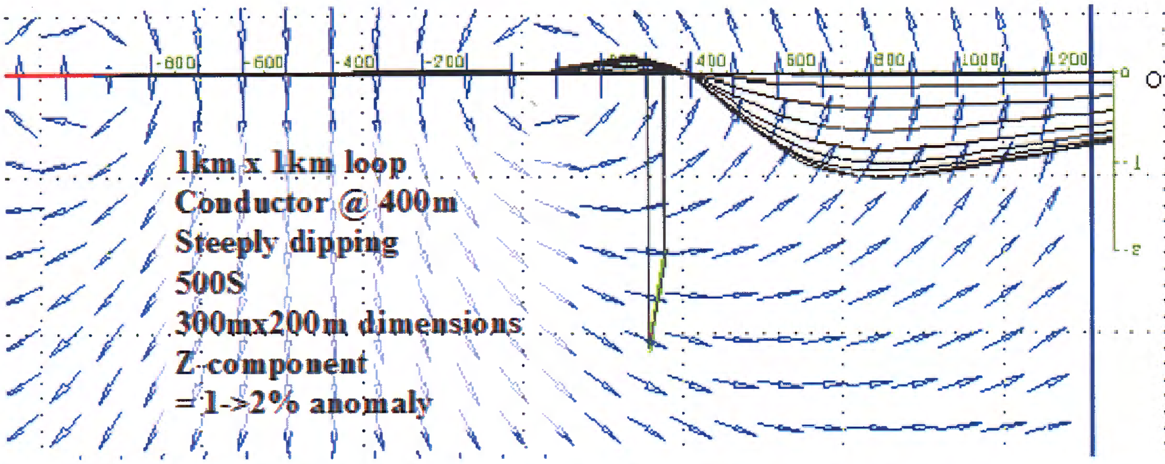


Figure 2 : Modélisation préliminaire montrant la possibilité de détecter la lentille Renaissance en utilisant une boucle de courant placée au sud.

L'observation des résultats obtenus sur les trois profils à la fréquence 31 Hz avec la boucle sud permet de constater deux phénomènes :

1) La partie nord du levé près de la rivière Veract est très fortement affectée par une réponse de grande longueur d'onde, de forte amplitude et décroissance rapide (voir figure 3). Cette réponse est très certainement causée par un épaississement local du mort-terrain conducteur. Les lectures prises avec la boucle nord qui n'ont pas été affectées de la même façon confirme cette hypothèse.
2) En filtrant l'effet du mort-terrain (figure 4) ou en observant les fenêtres moins affectées (figure 5), on observe une anomalie dans le secteur de la lentille Renaissance. L'amplitude de l'anomalie de la fenêtre 4 après filtrage est d'environ 2% ce qui correspond à peu près à ce qui avait été estimé avec la modélisation préliminaire. Les résultats de la fenêtre 8 sont beaucoup plus clairs et forts que ceux prévus. Ceci pourrait signifier que la réponse est causée par à un conducteur de moins bonne qualité, c'est-à-dire moins de 500S qui pourrait correspondre à l'enveloppe minéralisée qui inclurait les zones de veinules de sulfures
Bien qu'il soit qualitativement difficile d'affirmer avec certitude que la réponse anomale observés soit bel et bien celle causée par la lentille Renaissance, la coïncidence géographique ainsi que la forme de l'anomalie telle qu'elle apparaît sur les profils de la fenêtre 8 le laisse fortement penser. Seulement une modélisation quantitative plus poussée permettrait de s'en assurer.

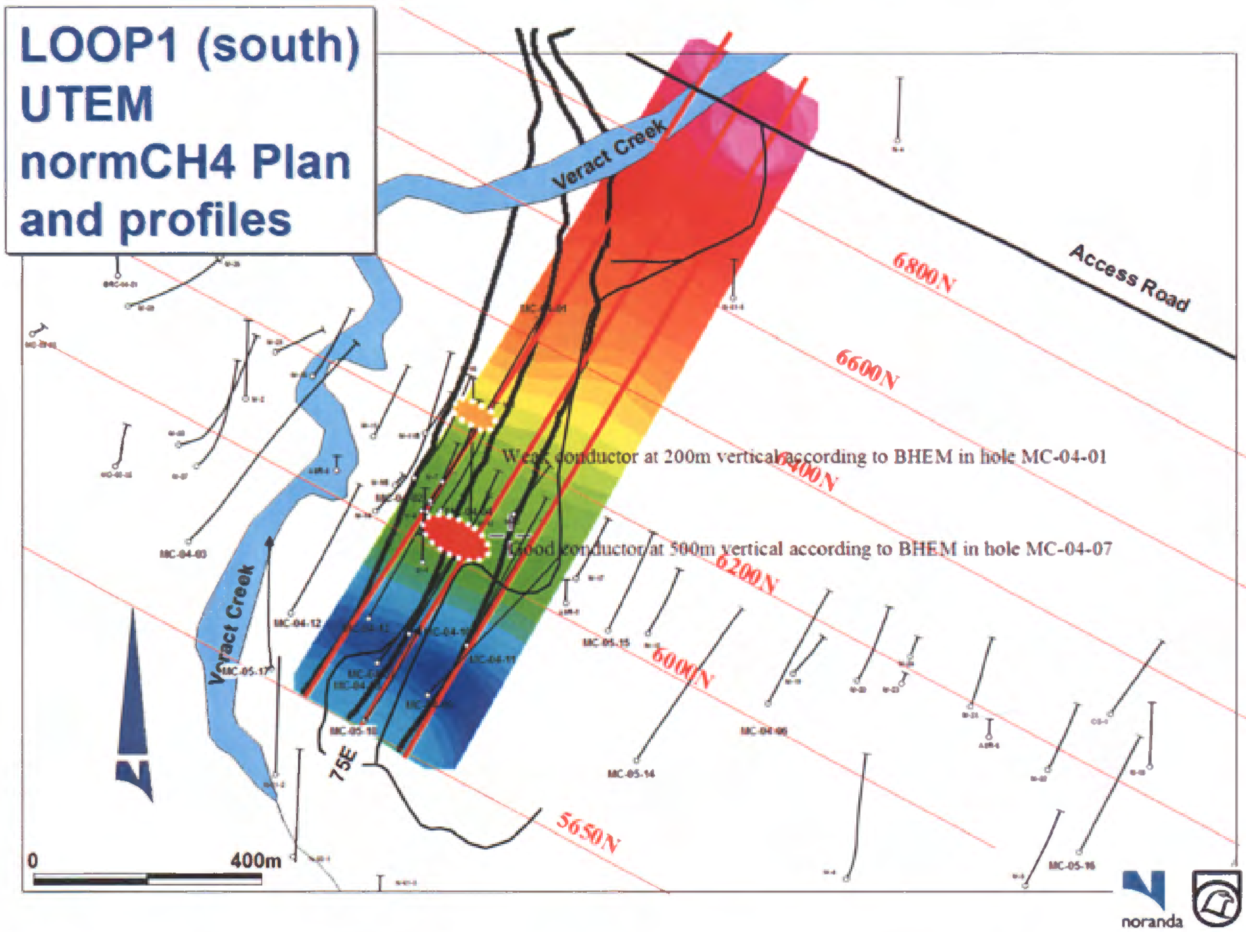


Figure 3 : Plan et profils des mesures de la fenêtre 4 (1.5ms) prises à 31 Hz avec la boucle 1 (sud)

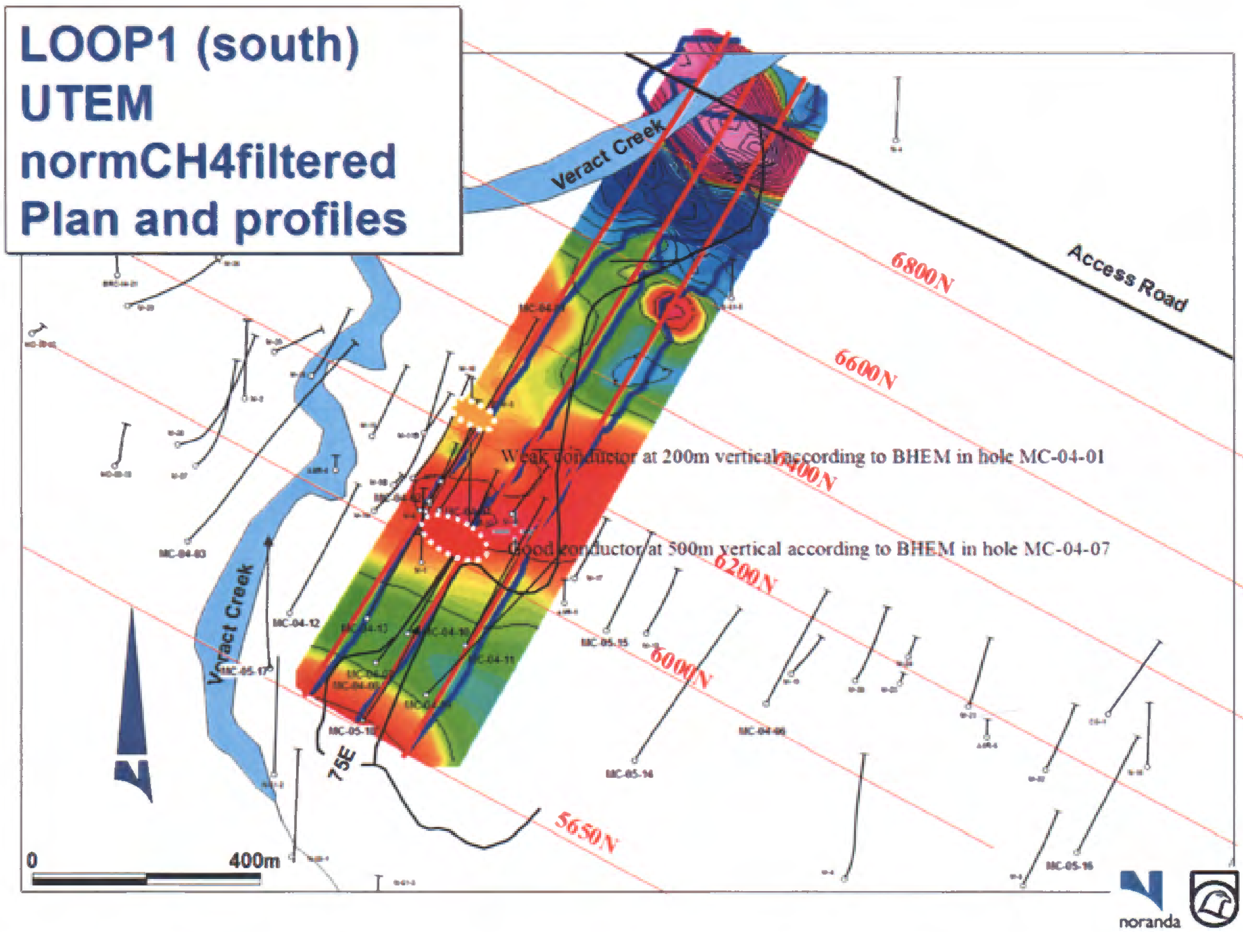


Figure 4 : Plan et profils des mesures de la fenêtre 4 (1.5ms) prises à 31 Hz avec la boucle 1 (sud) filtrés è l'aide d'un filtre passe-haut pour éliminer l'effet du mort-terrain.

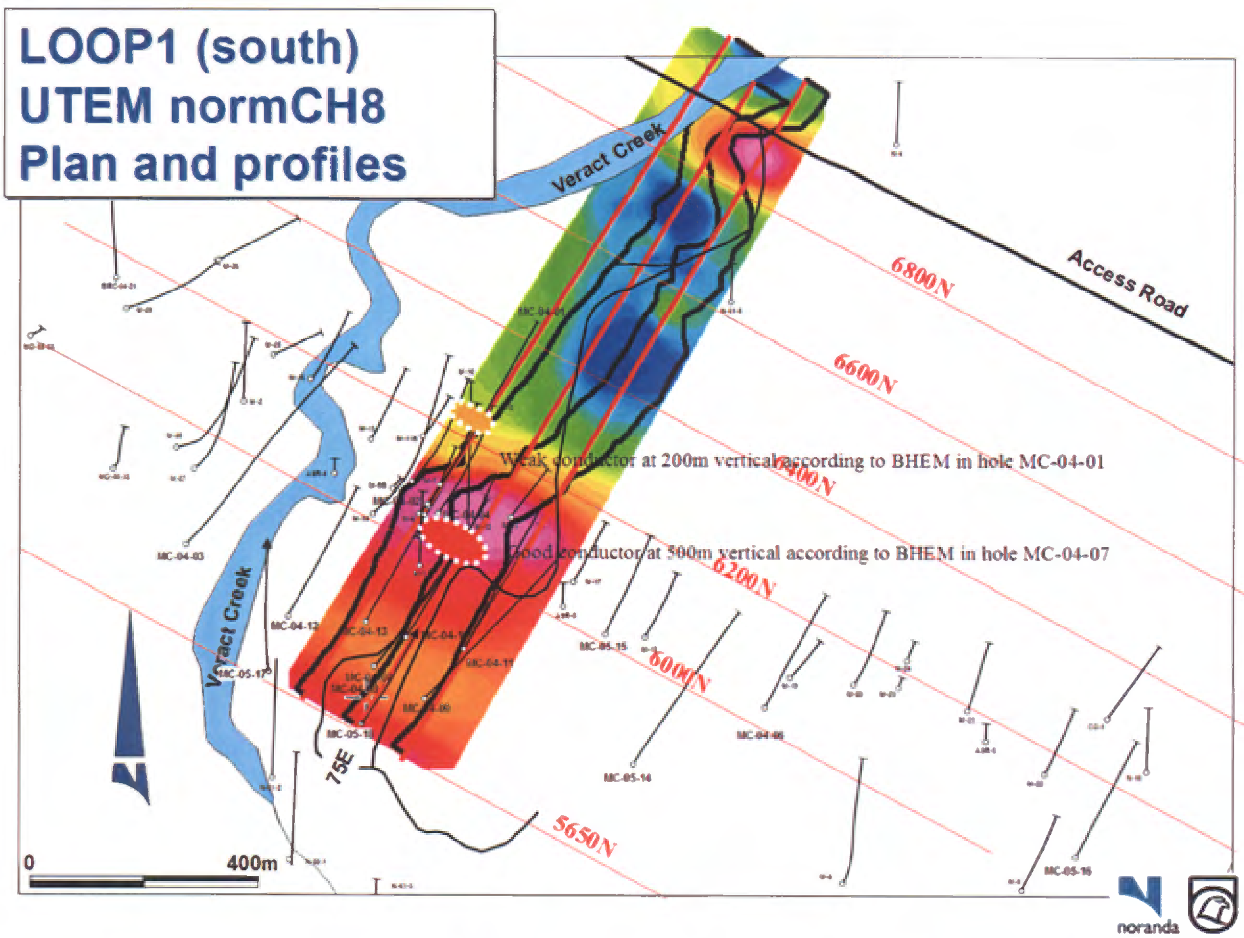
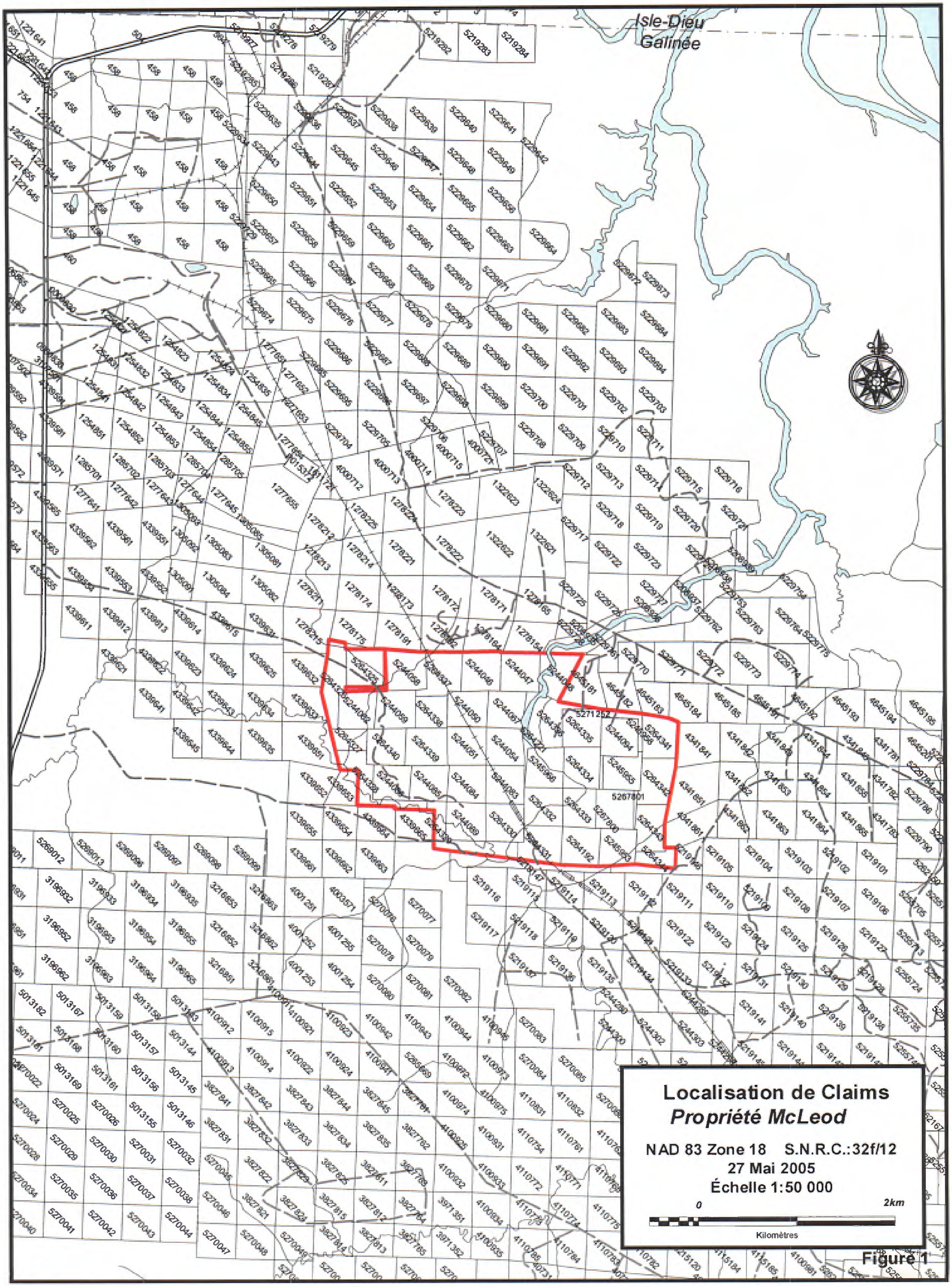
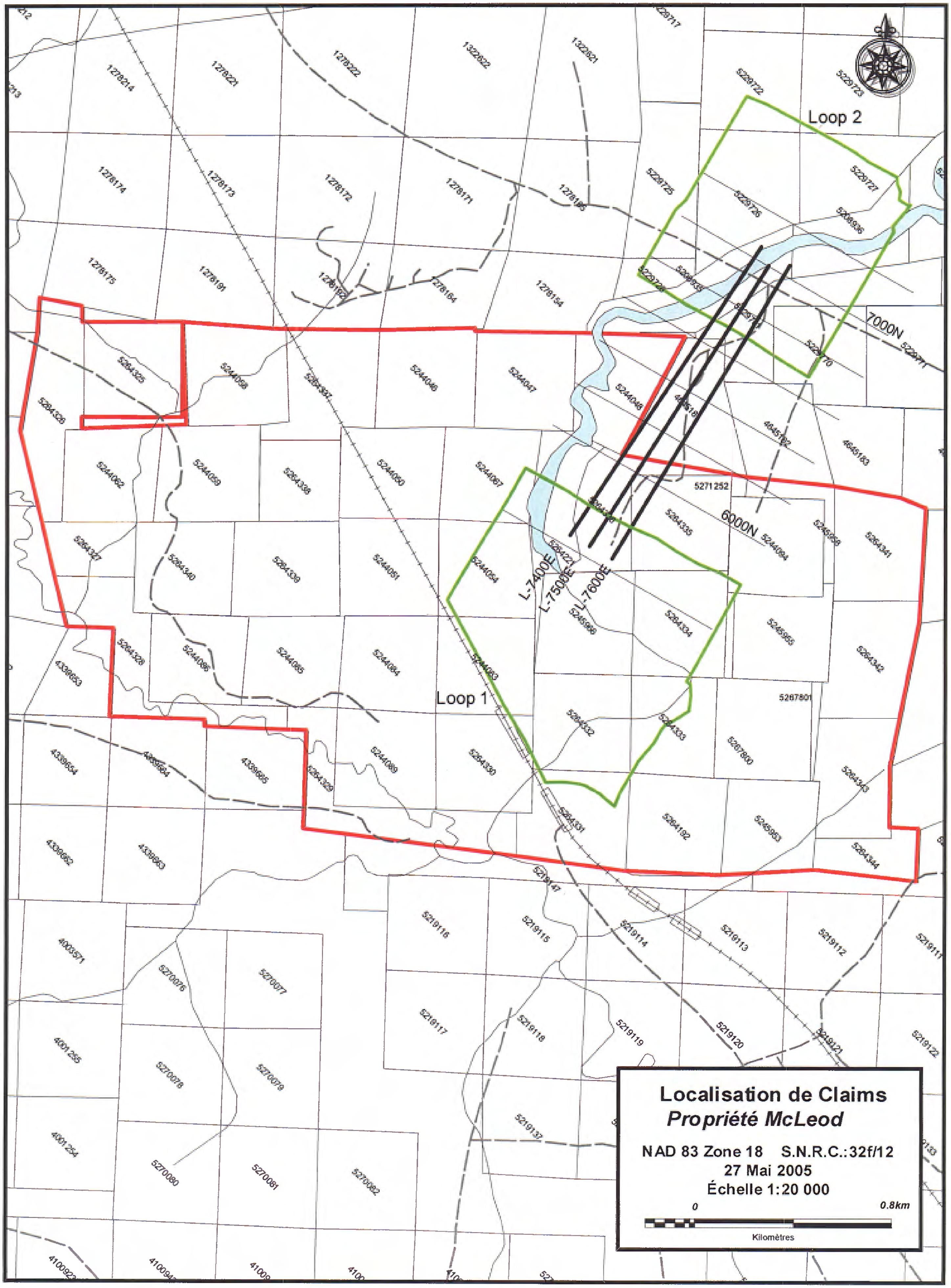


Figure 5 : Plan et profils des mesures de la fenêtre 8 (1.0ms) prises à 31 Hz avec la boucle 1 (sud)

Michel Allard, ing
Géophysicien principal


Isle-Dieu
Galinée
Localisation de Claims
Propriété McLeod
NAD 83 Zone 18 S.N.R.C.:32f/12
27 Mai 2005
Échelle 1:50 000
0
2km
Kilomètres
Figure 1



Loop 1
Loop 2
7000N
6000N
L-7400E
L-7500E
L-7600E
Localisation de Claims
Propriété McLeod
NAD 83 Zone 18 S.N.R.C.:32f/12
27 Mai 2005
Échelle 1:20 000
0
0.8km
Kilomètres

CONTENTS

Figures

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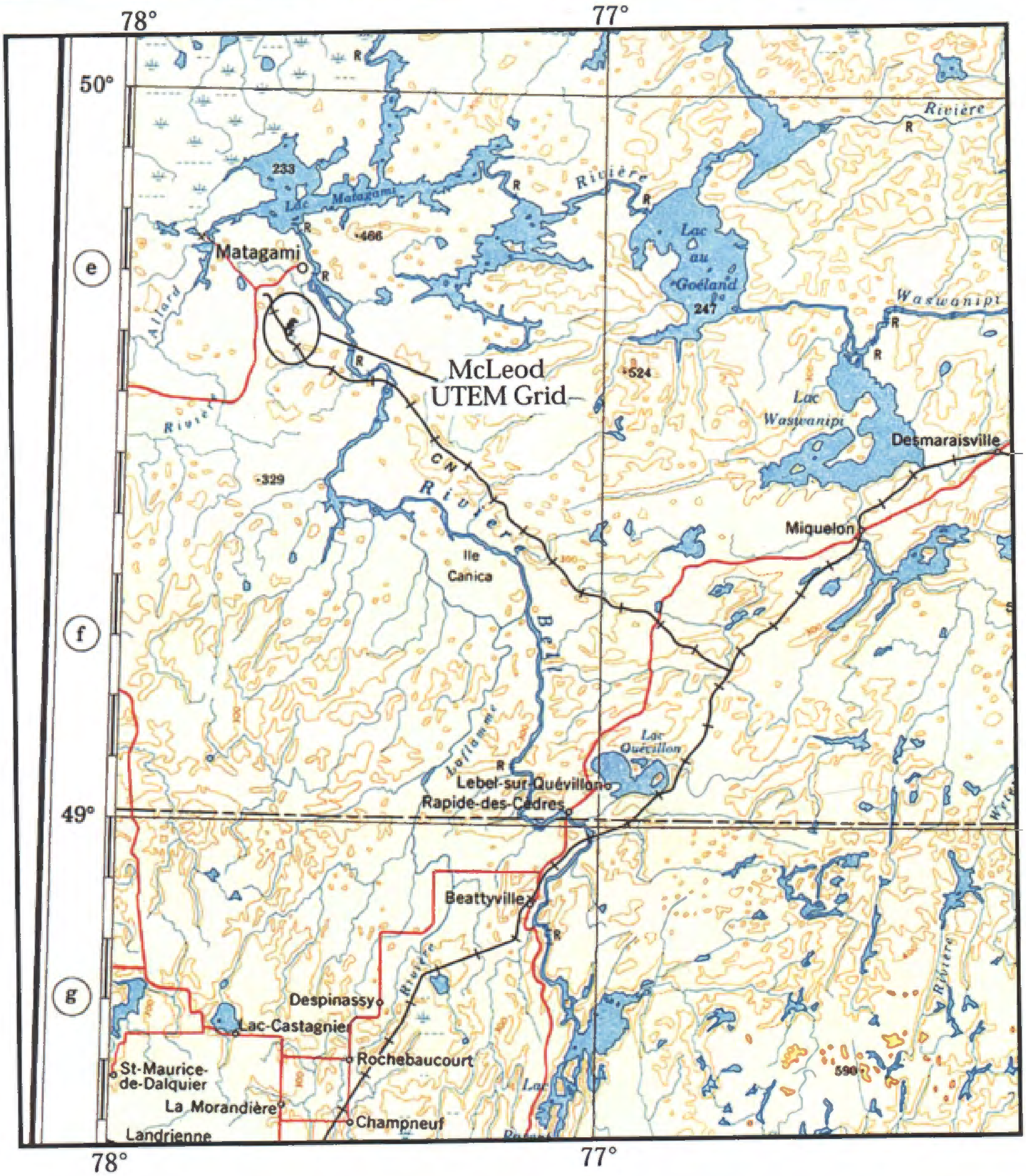
INTRODUCTION

A UTEM 3 surface survey was conducted on the McLeod Grid in the area of Matagami, Québec between October 31st and November 13th, 2004 (Figures 1 and 2). Personnel employed by Lamontagne Geophysics conducted the survey on behalf of the client - Noranda Inc. The survey was carried out to test for electromagnetic responses in the immediate survey area.

A total of 6.675 kilometres of UTEM data was collected - 5.345km @ a transmitter frequency of 30.574Hz and 1.175km @ 3.872Hz. A survey lines spacing of 100m and a nominal station spacing of 25m was used. Two transmitter loops were used - Loops 1 and 2. All lines were surveyed measuring the vertical (Hz) magnetic field.

This report documents the UTEM survey in terms of logistics, survey parameters and field personnel. Appendix A contains the complete data presented in profile form. Other appendices contain:

- The Production Log (Appendix B)
- An outline of the UTEM System (Appendix C)
- Notes on sources of anomalous Ch1 (Appendix D)



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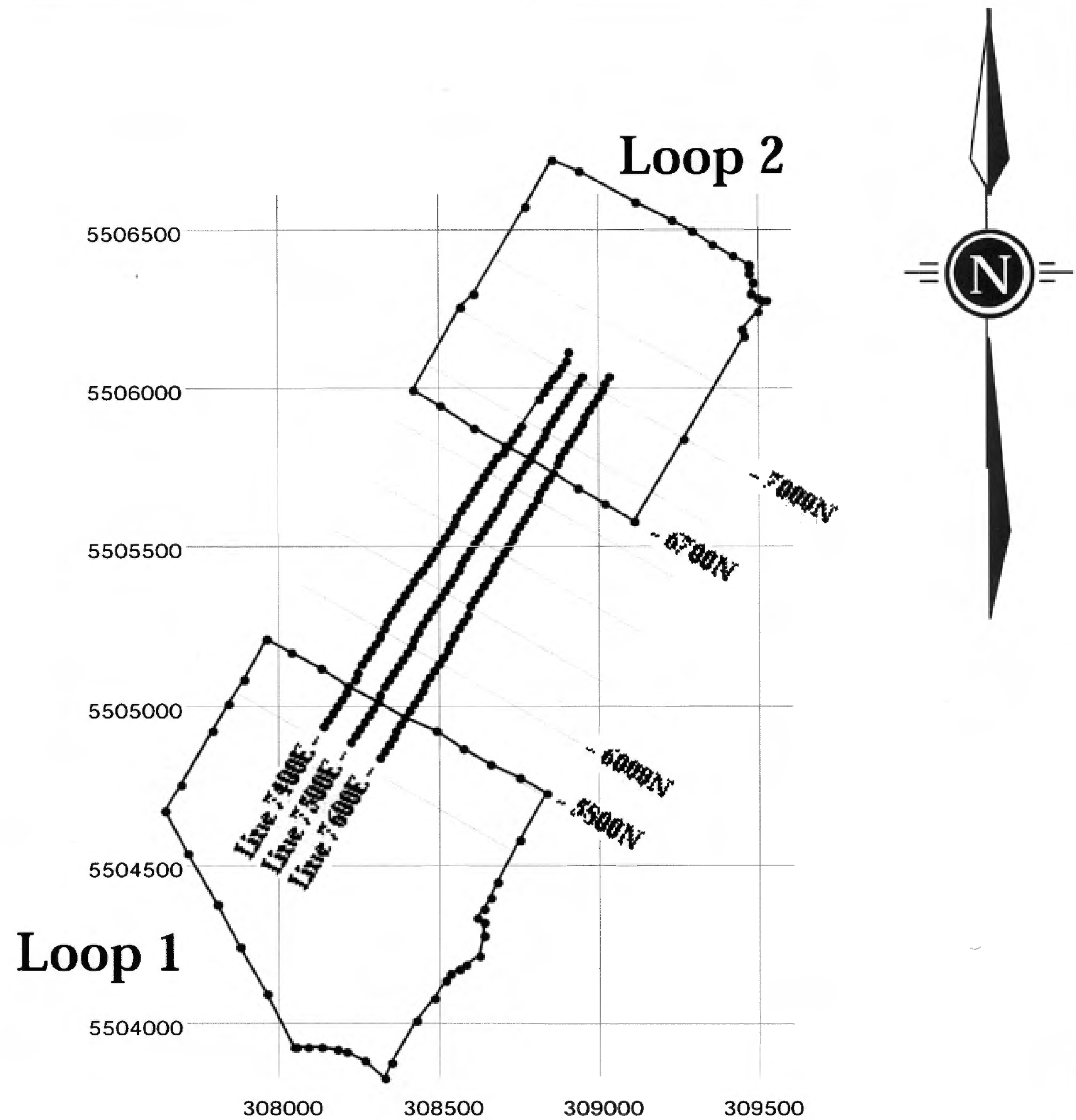
Noranda Inc.

McLeod Grid
UTEM Survey Location Map

0 10 50km

Figure 1

Notes:
- part of Sheet NM-18 Lac Chbougamau Edition 1



LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Noranda Inc.

McLeod Grid
UTEM Survey Location Map

0 200 1000m

Figure 2

Notes:
- full UTM coordinates as supplied by the client shown
- to reduce rounding errors in data reduction the coordinates were shifted by: (UTMeasting-308000, UTMnorthing-5504000)

SURVEY DESIGN

Noranda Inc. personnel designed the survey loops with the depth and orientation of the expected target in mind. The lines surveyed are cut at an azimuth of ~030.

The survey parameters are as follows:

- transmitter Loop 1 of ~1600x1600m
  Loop 2 of ~1250x 1250m
- nominal line spacing of 100 m
- station interval of 25 m
- Vertical (Hz) component measurements
- 10-channel data at a frequencies of 30.974 and 3.872Hz,
- one UTEM receiver
- minimum 1K stacking (1024 full-cycles/2048 half-cycles) increased where noise levels dictated to maintain data quality.

These parameters were selected to provide good coupling with targets located near or on the grid.

Non-decaying Ch1 conductors are often indicative of economic mineralization. Any non-decaying anomalous Ch1 features are therefore of interest. Non-decaying Ch1 UTEM anomalies can reflect:

i) the presence of mineralization
ii) the presence of a magnetic anomaly
iii) poor geometric control - either station location or loop location

These are outlined in more detail in Appendix D. From an interpretation point of view this means that magnetics and geometric control should be considered and evaluated as a part of any interpretation. From a field point of view it means that precise geometric control should be part of any UTEM survey where the target is non-decaying. Poor geometric control has the potential to both mask and invent Ch1 conductors.

The client provided GPS data used for geometric control of both transmitter loops. This information was used to produce the grid used in reducing the UTEM data presented in profile form in Appendix A.

FIELD WORK

The Lamontagne Geophysics crew carried out the survey over the period of October 31st to November 13th. Operations were based out of the Town of Matagami. The survey area was accessed by ATVs - rented out of Timmins.

Figures 2 shows the location and configuration of the McLeod grid. The Production Log in Appendix B outlines the day-to-day operations of the survey.

The Lamontagne crew consisted of P.Guimond (crew-chief) and S.Miramontes (operator and field assistant). Surveying began on November 2nd and all surveying was terminated by the client (G.Arnold) on November 11th. Loop 1 was retrieved on November 7th and Loop 2 was retrieved on November 11th and 12th.

The Survey equipment employed in the field consisted of:

-One UTEM 3 transmitter
-One UTEM 3 receiver and one coil
-All necessary spares

An iMac field computer was used to reduce and plot the data while on site.The preliminary results were delivered to Noranda Inc. on a timely basis.

SURVEY RESULTS

The results of the survey are summarized and presented as UTEM profiles in Appendix A. Overall the geometric control and data quality is good.

For each line the Hz continuosly-normalized data are presented as 3-axis profiles:

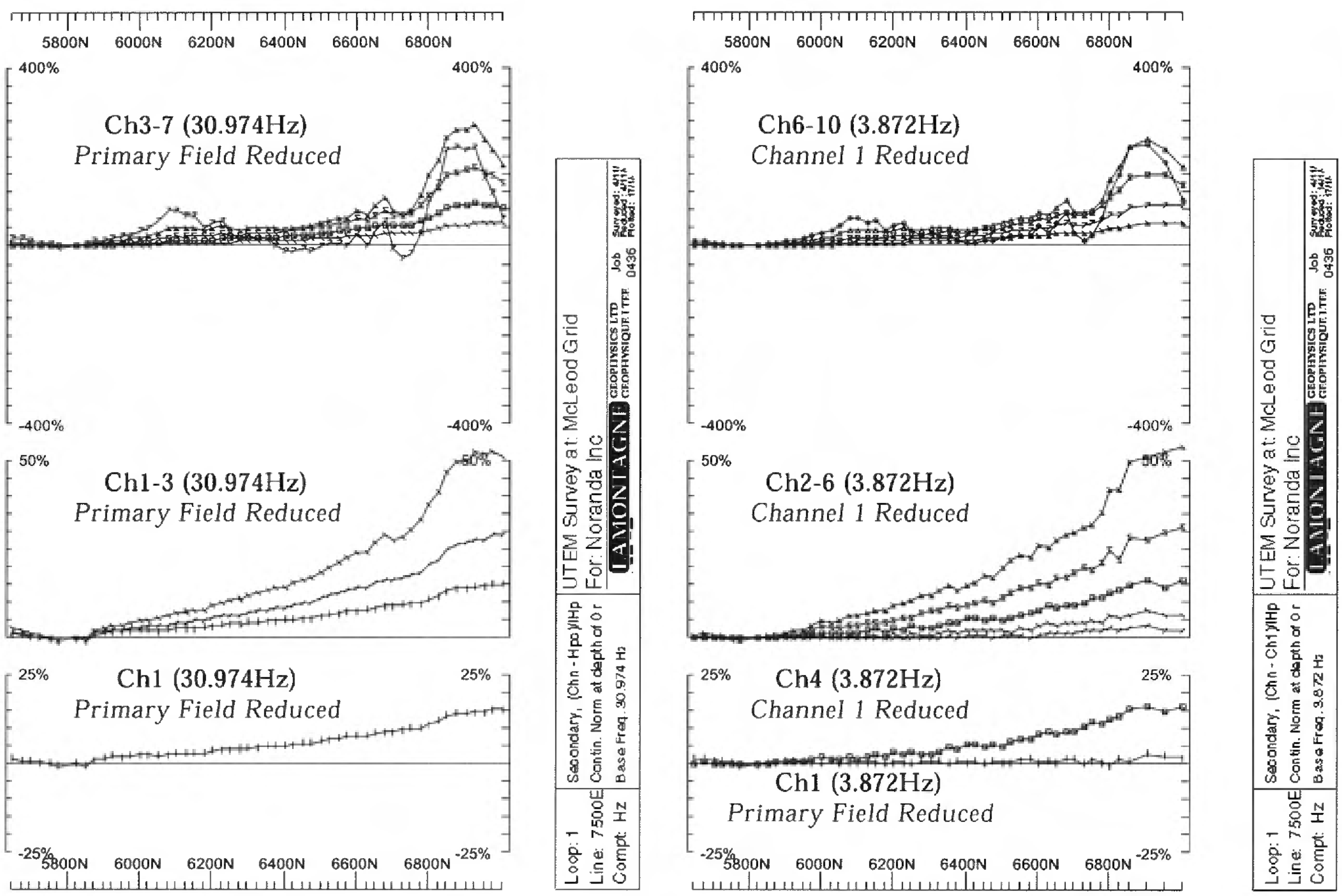
top axis	Ch 5-10	*Ch1 Reduced*
centre axis	Ch 2-5	*Ch1 Reduced*
bottom axis	Ch1	*Primary Field Reduced*

A description of the standard plotting formats used and of the UTEM System is presented in Appendix C.

Line 7500E was surveyed from Loop 1 @30.974Hz and then,to evaluate the remaining Ch1 response, the line was resurveyed @ exactly 1/8th of the original frequency - 3.872Hz. The choice of 3.872Hz makes Ch1(2,3...7) @30.974Hz equivalent to Ch4(5,6...10) @3.872Hz. To allow a direct comparison both Loop 1 Line 7500E profiles (@30.974Hz and @3.872Hz) are shown in Figure 3. The Ch1(2,3...7) @30.974Hz are quite comparable to the Ch4(5,6...10) @3.872Hz.

Loop 1 Line 7500E

@30.974Hz @ 3.872Hz



Note

Loop 1 Line 7500E was surveyed @30.974Hz and then,to evaluate the remaining Ch1 response, the line was resurveyed @ exactly 1/8th of the original frequency - 3.872Hz.
The choice of 3.872Hz makes Ch1(2,3...7) @30.974Hz equivalent to Ch4(5,6...10) @3.872Hz.

For comparison purposes both Loop 1 Line 7500E profiles (@30.974Hz and @3.872Hz) are shown in this figure.

Note that because of the response on the 30.974Hz Ch1 profile Ch2-10 are presented as *Primary Field Reduced.* The 3.872Hz Ch1 profile shows very little remaining Ch1 response and Ch2-10 are *Channel 1 Reduced.*

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Noranda Inc.

Comparison of 30.974/3.872Hz Loop 1 Line 7500E profiles

0 200 1000m

Figure 3

Appendix A

0436 UTEM Profiles

UTEM Survey

McLeod Grid
Matagami, Québec

2004

for

Noranda Inc.

Presentation

The results of the survey are summarized and presented as UTEM 3 profiles in Appendix A. Profiles are presented by transmitter loop in order. The survey went well and overall the data quality is good. An outline of profile types follows:

UTEM 3 Surface Survey

For each line surveyed the continuously normalized profiles for the vertical (Hz) component have been plotted (blue separators).

Hz continuous norm ***Ch1 reduced***

top axis - Ch5-10
middle axis - Ch2-5
bottom axis - Ch1

A description of the standard UTEM 3 plotting formats and of the UTEM System is presented in Appendix C.

List of Data Collected and Plotted

McLeod Grid
2004 Surface Survey

	Line	Coverage	
Loop 1	Line 7400E	5650N - 7050N	1400m
@30.974Hz	Line 7500E	5650N - 7000N	1350m
	Line 7600E	5650N - 7050N	1400m
		Loop 1 Total @30.974Hz	**4150m**
@3.872Hz	Line 7500E	5650N - 7000N	1350m
		Loop 1 Total @ 3.872Hz	**1350m**
		Loop 1 Total	**5500m**
Loop 2	Line 7500E	5675N - 6850N	1175m
@3.872Hz		**Loop 2 Total @ 3.872Hz**	**1175m**
	McLeod Grid	**Total Surveyed**	**6.675km**

McLeod Grid

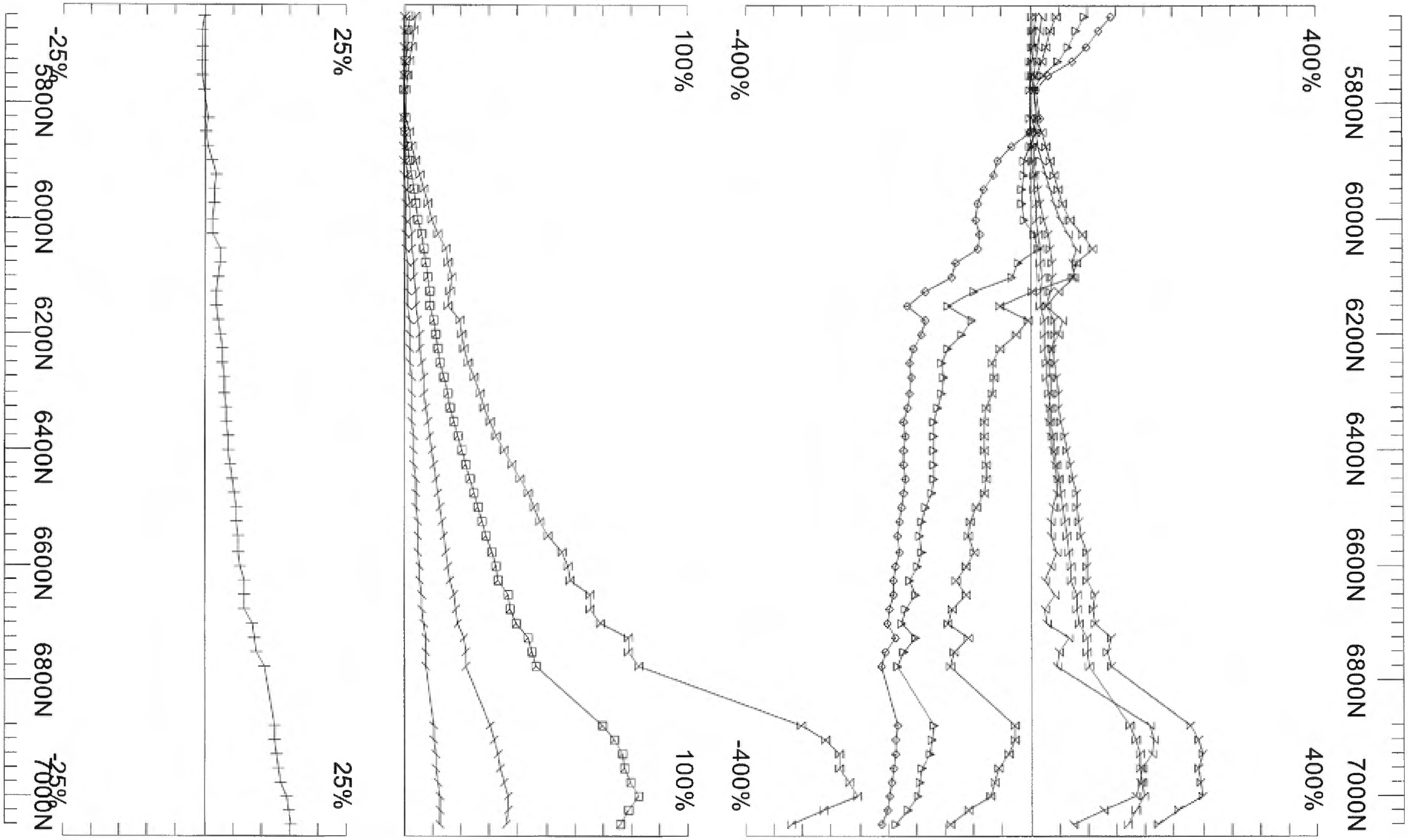
Loop 1

Hz Profiles
(continuous norm)

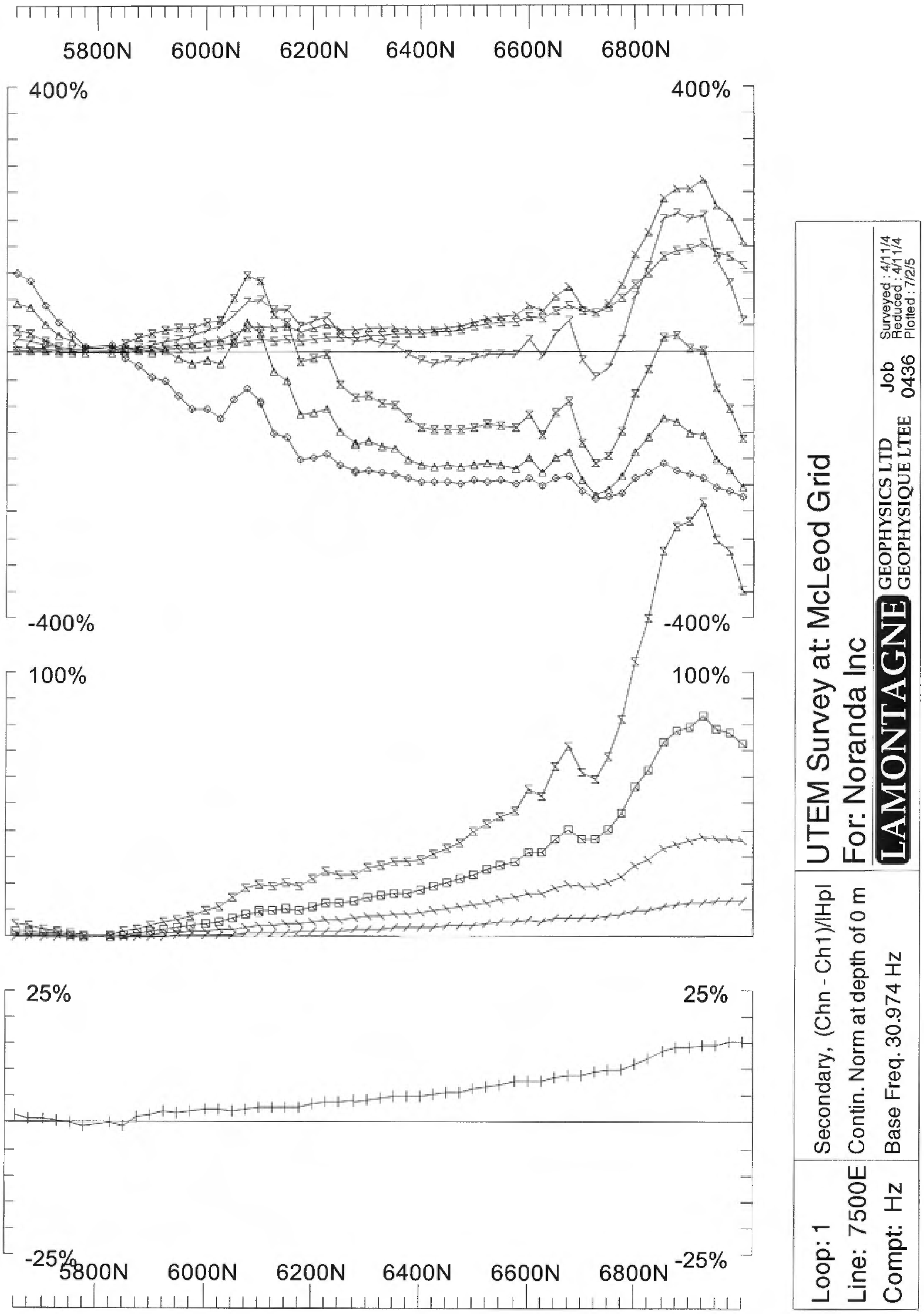
@ 30.974. Hz

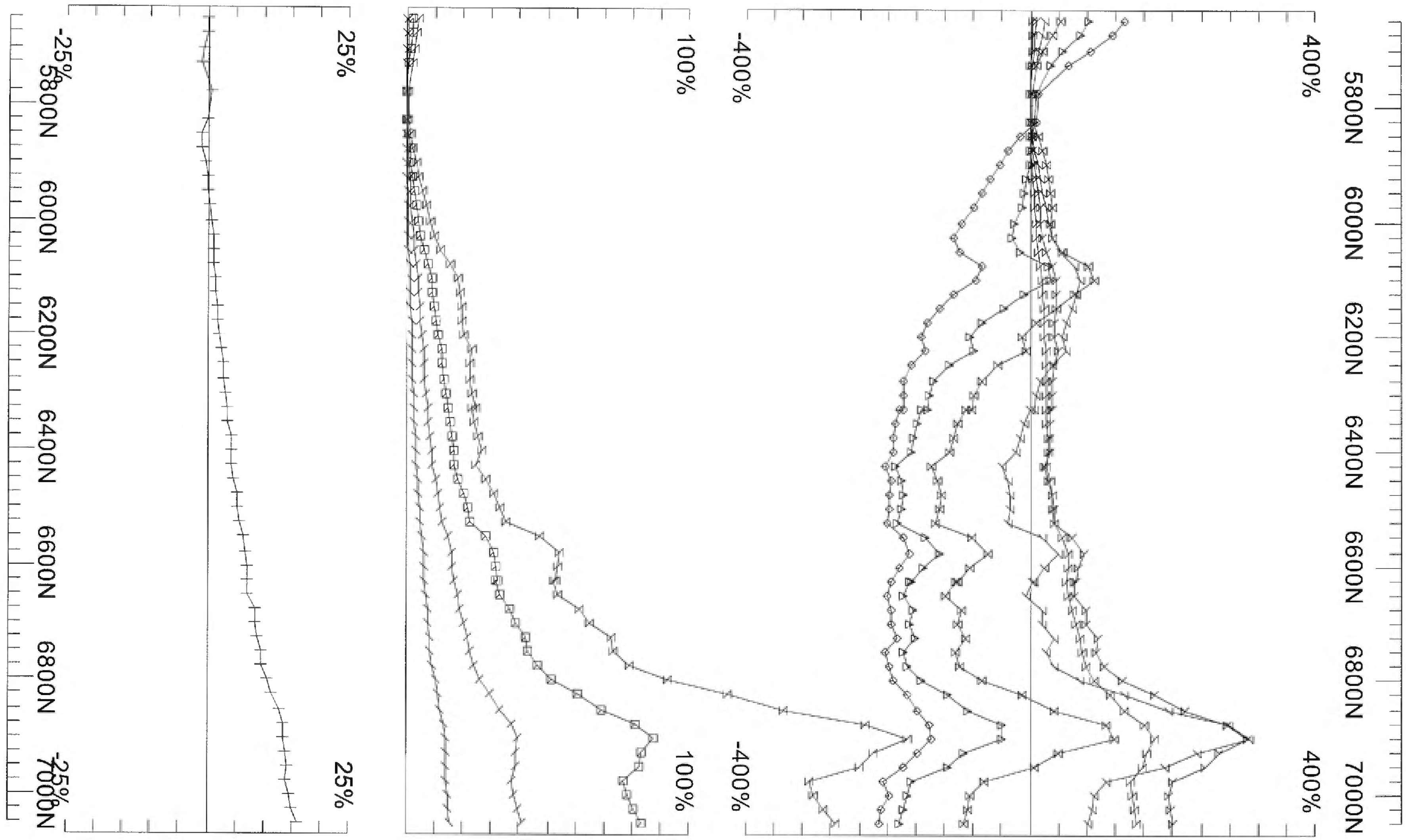
	Line	Coverage	
Loop 1	Line 7400E	5650N - 7050N	1400m
	Line 7500E	5650N - 7000N	1350m
	Line 7600E	5650N - 7050N	1400m
		Loop 1 Total @30.974Hz	**4150m**

Loop 1 - continuous norm @ 30.974Hz



Loop: 1	Secondary, (Chn - Ch1)/IHpl	UTEM Survey at: McLeod Grid
Line: 7400E	Contin. Norm at depth of 0 m	For: Noranda Inc
Compt: Hz	Base Freq. 30.974 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0436 Surveyed : 6/11/4 Reduced : 17/1/5 Plotted : 7/2/5


5800N
6000N
6200N
6400N
6600N
6800N
400%
400%
-400%
-400%
100%
100%
25%
25%
-25%
-25%
UTEM Survey at: McLeod Grid
For: Noranda Inc
LAMONTAGNE
GEOPHYSICS LTD
GEOPHYSIQUE LTEE
Job
0436
Surveyed : 4/11/4
Reduced : 4/11/4
Plotted : 7/2/5
Loop: 1
Line: 7500E
Compt: Hz
Secondary, (Chn - Ch1)/lHpl
Contin. Norm at depth of 0 m
Base Freq. 30.974 Hz



Loop: 1	Secondary, (Chn - Ch1)/IHpl	UTEM Survey at: McLeod Grid
Line: 7600E	Contin. Norm at depth of 0 m	For: Noranda Inc
Compt: Hz	Base Freq. 30.974 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0436 — Surveyed : 3/11/4 Reduced : 17/1/5 Plotted : 7/2/5

McLeod Grid

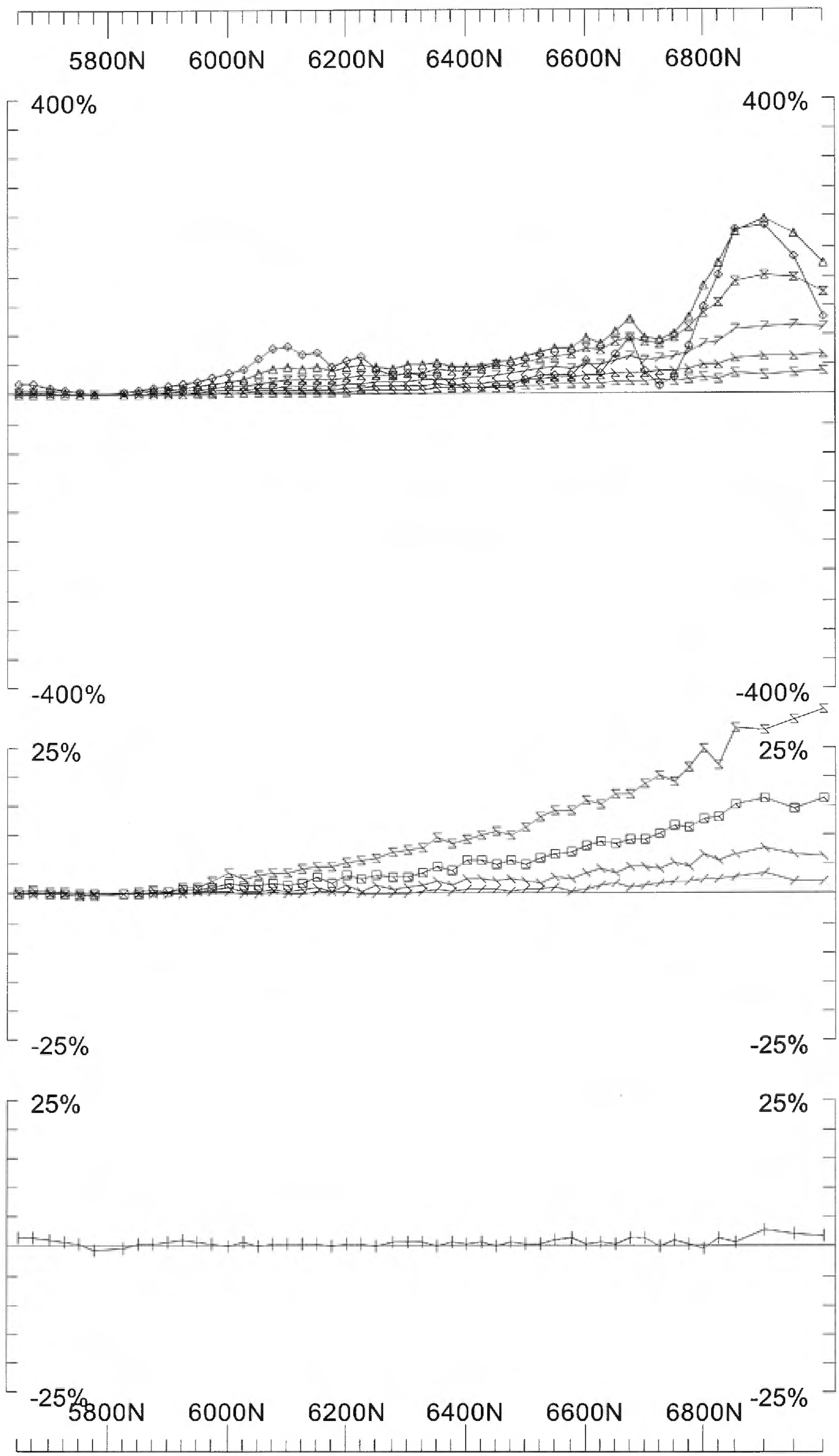
Loop 1

Hz Profiles
(continuous norm)

@ 3.872 Hz

	Line	Coverage	
Loop 1	Line 7500E	5650N - 7000N	1350m
		Loop 1 Total @ 3.872Hz	**1350m**

Loop 1 - continuous norm @ 3.872Hz



UTEM Survey at: McLeod Grid

For: Noranda Inc

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0436

Surveyed : 4/11/4
Reduced : 14/1/5
Plotted : 7/2/5

Loop: 1
Line: 7500E
Compt: Hz

Secondary, (Chn - Ch1)/IHpI
Contin. Norm at depth of 0 m
Base Freq. 3.872 Hz

McLeod Grid

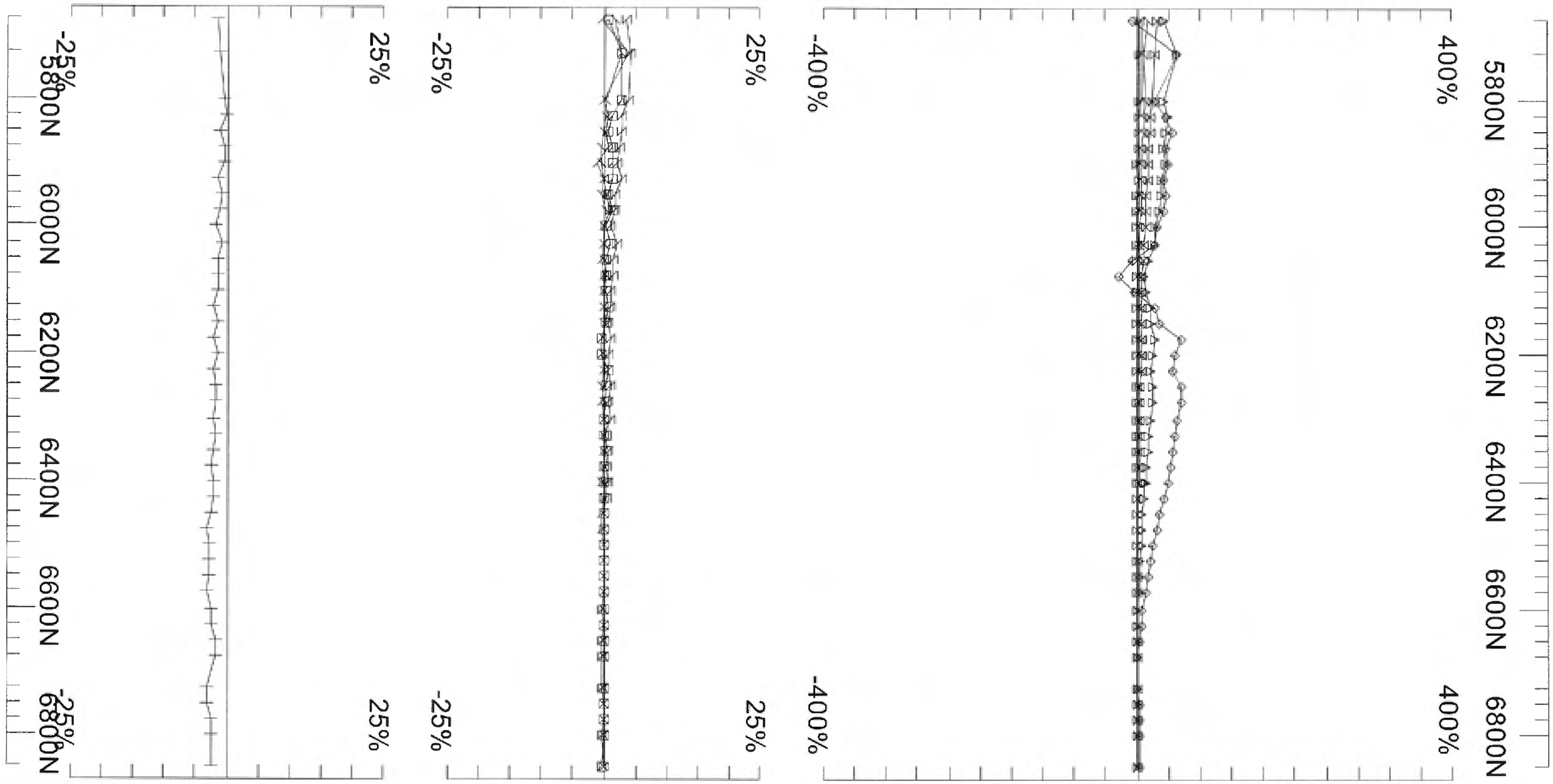
Loop 2

Hz Profiles
(continuous norm)

@ 3.872 Hz

	Line	Coverage	
Loop 2	Line 7500E	5675N - 6850N	1175m
		Loop 2 Total @ 3.872Hz	**1175m**

Loop 2 - continuous norm @ 3.872Hz



Loop: 2	Secondary, (Chn - Ch1)/IHpl	UTEM Survey at: McLeod Grid
Line: 7500E	Contin. Norm at depth of 0 m	For: Noranda Inc
Compt: Hz	Base Freq. 3.872 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0436 Surveyed : 10/11/4 Reduced : 17/1/5 Plotted : 7/2/5

Appendix B

0436 Production Log

UTEM 3 Survey

McLeod Grid
Matagami, Québec

2004

for

Noranda Inc.

Production Log (0436)
UTEM Survey of the McLeod Grid, Matagami, Québec
Noranda Inc.

Date	Rate - Production		Comments
October 31	Mob	-	P.Guimond and S.Miramontes depart Cochrane, Ontario from another job in the early afternoon and drive to Matagami, Québec.
November 1	L(1)-2		Meet with the client (Grant Arnold) in the morning to discuss the survey. Drive to the grid and check out access, Lay 3 sides of Loop 1 on the McLeod Grid. Crew: P.Guimond and S.Miramontes.
November 2	P(1)-2	475m	**Read: Loop 1 @ 30.974 Hz** **Line 75+00E 56+50N - 61+25N** To Date: .475km Drive to the exploration office to drop off the trailer and pick up GPS data for the grid. Back to town to buy fishing rod needed for river crossing. Finish laying the loop front and the river crossing by 14:30. Read part of Line 75+00E at 31Hz Crew: P.Guimond and S.Miramontes.
November 3	P(1)-2	2275m	**Read: Loop 1 @ 30.974 Hz** **Line 75+00E 61+25N - 70+00N** **Line 76+00E 56+50N - 70+50N** To Date: 2.750 km There was a loop break first thing in the morning (bulldozer) which was repaired. Finish reading Line 75+00E and all of Line 76+00E. Crew: P.Guimond and S.Miramontes.
November 4	P(1)-2	1350m	**Read: Loop 1 @ 3.872 Hz** **Line 75+00E 56+50N - 70+00N** To Date: 4.100 km Read all of L75E at 4 Hz. Slow going because of 25m stations and extra stacking. Crew: P.Guimond and S.Miramontes.
November 5	L(1)-2	-	Lay a second wire in parallel with Loop 1 to increase the current and improve the signal-to-noise ratio. Crew: P.Guimond and S.Miramontes.
November 6	P(1)-2	1400m	**Read: Loop 1 @ 30.974 Hz** **Line 74+00E 56+50N - 70+50N** To Date: 5.500 km Short delay in the morning syncing receiver. Read all of L74E at 31 Hz. Crew: P.Guimond and S.Miramontes.

Date	Rate - Production		Comments
November 7	L(1)-2)	-	Informed by client to abandon the south loop and lay a loop to the north. Pick up both wires of Loop 1 **Crew:** P.Guimond and S.Miramontes.
November 8	L(1)-2	-	Lay 1.5 sides and both river crossings of Loop 2. **Crew:** P.Guimond and S.Miramontes.
November 9	L(1)-2	-	Finish laying all of Loop 2. **Crew:** P.Guimond and S.Miramontes.
November 10	P(1)-2	1175m	**Read: Loop 2 @ 3.872 Hz** **Line 75+00E 56+75N - 68+50N** To Date: 6.675km Read Line 75E at 3.872 Hz from the north loop. Skipped stations 5775N and 5750N due to proximity to the drill. Drop the last few stations because of darkness. **Crew:** P.Guimond and S.Miramontes.
November 11	L(1)-2	-	Demob the ATVs from the field in the morning. Transfer them to one of the mine buildings to thaw out overnight. Meet Grant Arnold at noon to discuss the project. It is decided that no further surveying will be done. Spend the afternoon picking up 2.5 sides of Loop 2. **Crew:** P.Guimond and S.Miramontes.
November 12	L(1)-2)	-	Finish picking up Loop 2. Drive to Timmins in the afternoon to return the ATVs. **Crew:** P.Guimond and S.Miramontes.
November 13	Demob	-	Return the ATV's in the morning. Drive to Toronto to drop off P.Guimond, then onto Kingston. **Crew:** P.Guimond and S.Miramontes.

LEGEND

P(n)-x	Surface Production (# of receivers) - # of personnel
S(n)-x	Standby (# of receivers) - # of personnel
D(n)-x	Down (# of receivers) - # of personnel

Appendix C

The UTEM SYSTEM

The UTEM System

UTEM Data Reduction and Plotting Conventions

Data Presentation

The UTEM SYSTEM

UTEM uses a large, fixed, horizontal transmitter loop as its source. Loops range in size from 300m x 300m up to as large as 4km x 4km. Smaller loops are generally used over conductive terrain or for shallow sounding work. The larger loops are only used over resistive terrain. The UTEM receiver is typically syncronized with the transmitter at the beginning of a survey day and operates remotely after that point. The clocks employed - one in each of the receiver and transmitter - are sufficiently accurate to maintain synchronisation.

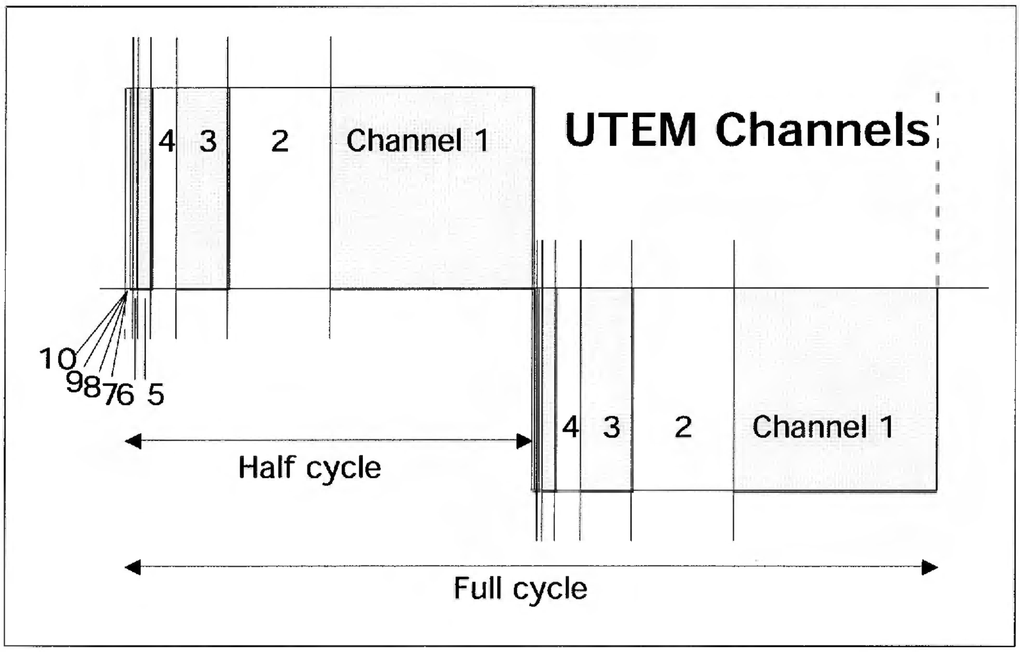
Measurements are routinely taken to a distance of 1.5 to twice the loop dimensions, depending on the local noise levels, and can be continued further. Lines are typically surveyed out from the edge of the loop but may also be read across the loop wire and through the centre of the loop, a configuration used mainly to detect horizontal conductors. BHUTEM - the borehole version of UTEM -surveys have been carried out to depths up to 3000+ metres.

System Waveform

The UTEM transmitter passes a low-frequency (4 Hz to 90 Hz) current of a precisely regulated triangular waveform through the transmitter loop. The frequency can be set to any value within the operating range of the transmitter, however, it is usually set at 31 Hz to minimise power line (60 Hz in North America) effects. Since a receiver coil responds to the time derivative of the magnetic field, the UTEM system really "sees" the step response of the ground. UTEM is the only time domain system which measures the step response of the ground. All other T.D.E.M. systems to date transmit a modified step current and "see" the (im)pulse response of the ground at the receiver. In practice, the transmitted UTEM waveform is tailored to optimize signal-to-noise. Deconvolution techniques are employed within the system to produce an equivalent to the conceptual "step response" at the receiver.

System Sampling

The UTEM receiver measures the time variation of the magnetic field in the direction of the receiver coil at 10 delay times (channels). UTEM channels are spaced in a binary, geometric progression across each half-cycle of the received waveform. Channel **10** is the earliest channel and it is $1/2^{10}$ of the half-cycle wide. Channel 1, the latest channel, is $1/2^{1}$ of the half-cycle wide (see Figure below). The measurements obtained for each of 10 channels are accumulated over many half-cycles. Each final channel value, as stored, is the average of the measurements for that time channel. The number of half-cycles averaged generally ranges between 2048 (1024 full-cycles - 1K in UTEM jargon) to 32768 (16K) depending on the level of ambient noise and the signal strength.



System Configurations

For surface work the receiver coil is mounted on a portable tripod and oriented. During a surface UTEM survey the vertical component of the magnetic field (Hz) of the transmitter loop is always measured. Horizontal in-line (Hx) and cross-line (Hy) components are also measured if more detailed information is required. The UTEM System is also capable of measuring the two horizontal components of the electric field, Ex and Ey. A dipole sensor comprised of two electrodes is used to measure the electric field components. This is generally used for outlining resistive features to which the magnetic field is not very sensitive.

BHUTEM surveys employ a receiver coil that is smaller in diameter than the surface coil. The borehole receiver coil forms part of a down-hole receiver package used to measure the axial (along-borehole) component of the magnetic field of the transmitter loop. Due to the distance between coil and receiver in borehole surveys the signal must be transmitted up to the receiver. In BHUTEM the signal is transmitted to surface digitally using a kevlar-reinforced fibre-optic cable as a data link. Using a fibre-optic link avoids signal degradation problems and allows surveying of boreholes to 3000+m. The cable is also very light - the specific gravity is nearly 1.0 - making the cable handling hardware quite portable.

The EM Induction Process

Any time-varying transmitted ("primary") field induces current flow in conductive regions of the ground below and around the transmitter loop (i.e. in the earth or "half-space"). This current flow produces a measurable EM field, the secondary field, which has an inherent "inertia" that resists the change in primary field direction. This "inertial" effect is called self-inductance; it limits the rate at which current can change and is only dependent on the shape and size of a conductive path.

It takes a certain amount of time for the transmitted current flow to be redirected (reversed) and reestablished to full amplitude after the rate-of-change of the primary field reverses direction. This measurable reversal time is characteristic for a given conductor. In general, for a good conductor this time is greater than that of a poor conductor. This is because in a good conductor the terminal current level is greater, whereas its rate of change is limited by the inductance of the current path. The time-varying current causes an Emf in the sensor proportional to the time derivative of the current. This Emf decays with time - it vanishes when the reversal is complete - and the characteristic time of the Emf decay as measured by the sensor is referred to as the **decaytime** of the conductor.

The large-scale current which is induced in the half-space by the primary field produces the half-space response as seen in typical UTEM profiles. This background response is influenced by the finite conductivity of the surrounding rock. Other currents may be induced in locally more conductive zones (conductors) that have longer decay times than the half-space response. The responses of these conductors are superimposed upon the background response. The result is that the UTEM receiver detects:

- the primary field waveform, a square-wave
- the half-space (background) response of the surrounding rock
- a slight-to-large response due to any conductors present.

The result is that in the presence of conductors the primary field waveform is substantially (and anomalously) distorted.

UTEM DATA REDUCTION and PLOTTING CONVENTIONS

The UTEM data as it appears in the data files is in total field, continuously normalized form. In this form, the magnetic field data collected by the receiver is expressed as a % of the calculated primary magnetic field vector magnitude at the station. These are total field values - the UTEM system measures during the "on-time" and as such samples both the primary and secondary fields.

For plotting purposes, the reduced magnetic field data (as it appears in the data file) are transformed to other formats as required. The following is provided as a description of the various plotting formats used for the display of UTEM data. A plotting format is defined by the choice of the *normalization* and *field type* parameters selected for display.

NORMALIZATION

UTEM results are always expressed as a % of a normalizing field at some point in space.

In **continuously normalized** form the normalizing factor (the denominator) is the magnitude of the computed local primary field vector. As the primary exciting field magnitude diminishes with increasing distance from the transmitter loop the response is continuously amplified as a function of offset from the loop. Although this type of normalization considerably distorts the response shape, it permits anomalies to be easily identified at a wide range of distances from the loop.

Note: An optional form of continuous normalization permits the interpreter to normalize the response to the magnitude of the primary field vector at a fixed depth below each station. This is useful for surface profiles which come very close to the loop. Without this adjustment option, the normalizing field is so strong near the loop that the secondary effects become too small in the presence of such a large primary component. In such circumstances interpretation is difficult, however; by "normalizing at some depth" the size of the normalizing field, near the loop in particular, is reduced and the resulting profile can be more effectively interpreted to a very close distance from the transmitter wire. The usual choice for the depth is the estimated target depth is used.

In **point normalized form** the normalizing factor is the magnitude of the computed primary field vector at a single point in space. When data is presented in this form, the point of normalization is displayed in the title block of the plot. Point normalized profiles show the non-distorted shape of the field profiles. Unfortunately, the very large range in magnitude of anomalies both near and far from the loop means that small anomalies, particularly those far from the loop, may be overlooked on this type of plot in favor of presenting larger amplitude anomalies.

Note: Selecting the correct plot scales is critical to the recognition of conductors over the entire length of a point normalized profile. Point normalized data is often used for interpretation where an analysis of the shape of a specific anomaly is required. Point normalized profiles are therefore plotted selectively as required during interpretation. An exception to this procedure occurs where surface data has been collected entirely inside a transmitter loop. The primary field does not vary greatly inside the loop, therefore, the benefits of continuous normalization are not required in the display of such results. In these cases data is often point normalized to a fixed point near the loop centre.

FIELD TYPE

The type of field may be either the **Total field** or the **Secondary field.** In general, it is the secondary field that is most useful for the recognition and interpretation of discrete conductors.

UTEM Results as Secondary Fields

Because the UTEM system measures during the transmitter on-time the determination of the secondary field requires that an estimate of the primary signal be subtracted from the observations. Two estimates of the primary signal are available:

1) UTEM Channel 1

One estimate of the primary signal is the value of the latest time channel observed by the UTEM System, channel 1. When Channel 1 is subtracted from the UTEM data the resulting data display is termed ***Channel 1 Reduced***. This reduction formula is used in situations where it can be assumed that all responses from any target bodies have decayed away by the latest time channel sampled. The Channel 1 value is then a reasonable estimate of the primary signal present during Channels 2....10.

In practice the ***Channel 1 Reduced*** form is most useful when the secondary response is very small at the latest delay time. In these cases channel 1 is indeed a good estimate of the primary field and using it avoids problems due to geometric errors or transmitter loop current/system sensitivity errors.

2) Calculated primary field

An alternate estimate of the primary field is obtained by computing the primary field from the known locations of the transmitter loop and the receiver stations. When the computed primary field is subtracted from the UTEM data the resulting data display is termed ***Primary Field Reduced***.

The calculated primary field will be in error if the geometry is in error - mislocation of the survey stations or the loop vertices - or if the transmitter loop current/system sensitivity is in error. Mislocation errors from loop/station geometry may give rise to very large secondary field errors depending on the accuracy of the loop and station location method used. Transmitter loop current/system sensitivity error is rarely greater than 2%. ***Primary Field Reduced*** is plotted in situations where a large Channel 1 response is observed. In this case the assumption that the Channel 1 value is a reasonable estimate of the primary field effect is not valid.

Note: When UTEM data is plotted in the ***Channel 1 Reduced*** form the secondary field data for Channel 1 itself are always presented in ***Primary Field Reduced*** form and are plotted on a separate axis. This plotting format serves to show any long time-constant responses, magnetostatic anomalies and/or geometric errors present in the data.

Mathematical Formulations

In the following expressions:

Rn_j is the result plotted for the n^{th} UTEM channel,

$R1_j$ is the result plotted for the latest-time UTEM channel, channel 1,

Chn_j is the raw component sensor value for the n^{th} channel at station j,

$Ch1_j$ is the raw component sensor value for channel 1 at station j,

H^P_j is the computed primary field component in the sensor direction

$|H^P|$ is the magnitude of the computed primary field at:

- a fixed station for the entire line (point normalized data)
- the local station of observation (continuously normalized data)
- a fixed depth below the station (continuously normalized at a depth).

Channel 1 Reduced Secondary Fields : Here, the latest time channel, Channel 1 is used as an "estimate" of the primary signal and channels 2-10 are expressed as:

$$Rn_j = (Chn_j - Ch1_j) / |H^P| \quad x\ 100\%$$

Channel 1 itself is reduced by subtracting a calculation of the primary field observed in the direction of the coil, H^P as follows:

$$R1_j = (Ch1_j - H^P{}_j) / |H^P| \quad x\ 100\%$$

Primary Field Reduced Secondary Fields : In this form all channels are reduced according to the equation used for channel 1 above:

$$Rn_j = (Chn_j - H^P{}_j) / |H^P| \quad x\ 100\%$$

This type of reduction is most often used in cases where very good geometric control is available (leading to low error in the calculated primary field, $H^P{}_j$) and where very slowly decaying responses result in significant secondary field effects remaining in channel 1 observations.

UTEM Results as a Total Field

In certain cases results are presented as a % of the **Total Field.** This display is particularly useful, in borehole surveys where the probe may actually pass through a very good conductor. In these cases the shielding effect of the conductor will cause the observed (total) field to become very small below the intersection point. This nullification due to shielding effects on the total field is much easier to see on a separate ***Total Field*** plot. In cases where the amplitude of the anomalies relative to the primary field is small, suggesting the presence of poorly conductive bodies, the ***Total Field*** plot is less useful.

The data contained in the UTEM reduced data files is in ***Total Field***, continuously normalized form if:

$$Rn_j = Chn_j / |H^P| \quad x\ 100\%$$

DATA PRESENTATION

All UTEM survey results are presented as profiles in an Appendix of this report. For BHUTEM surveys the requisite Vectorplots, presented as plan and section views showing the direction and magnitude of the calculated primary field vectors for each transmitter loop, are presented in a separate Appendix.

The symbols used to identify the channels on all plots as well as the mean delay time for each channel is shown in the table below.

UTEM System Mean Delay Times

10 Channel Mode @ 31 hz.(approx.)

(base freq: 30.974 hertz)

Channel #	Delay time (ms)	Plot Symbol
1	12.11	|
2	6.053	\
3	3.027	/
4	1.513	□
5	0.757	≤
6	0.378	∠
7	0.189	7
8	0.095	×
9	0.047	Δ
10	0.024	◇

Notes on Standard plotting formats:

10 channel data in ***Channel 1 Reduced*** form - The data are usually displayed on three separate axes. This permits scale expansion, allowing for accurate determination of signal decay rates. The standard configuration is:

Bottom axis - Channel 1 (latest time) is plotted alone in ***Primary Field Reduced*** form using the same scale as the center axis.

Center axis - The intermediate to late time channels, ch5 to ch2 are plotted on the center axis using a suitable scale.

Top axis - The early time channels, ch10 to ch6 and a repeat of ch5 for comparison are plotted on the top axis at a reduced scale. The earliest channels, ch8 to ch10, may not be plotted to avoid clutter.

10 channel data in ***Primary Field Reduced*** form: The data are displayed using a

single axis plot format. Secondary effects are plotted using a Y axis on each data plot with peak to peak values up to 200%.

BHUTEM data plotted as total field profiles: Data are expressed directly as a percentage of the ***Total Field*** value. The Y axis on each single axis data plot shows peak values of up to 100%. These departures are always relative to the measured total field value at the observation station.

BHUTEM data plotted as secondary field profiles: Check the title block of the plot to determine if the data is in ***Channel 1 Reduced*** form or in ***Primary Field Reduced*** form.

Note that on all BHUTEM plots the ratio between the axial component of the primary field of the loop and the magnitude of the total primary field strength **(dc)** is plotted as a profile without symbols. In UTEM jargon this is referred to as the "primary field" and it is plotted for use as a polarity reference tool.

Appendix D

Note on sources of anomalous Ch1

Note on sources of anomalous Ch1

This section outlines the possible sources of anomalous channel 1 which is not correlated to the Ch2-10 data plotted on the upper axes of a *channel 1 normalized* plot.

1) **Mislocation of the transmitter loop and/or survey stations**

Mislocating the transmitter loop and/or the survey stations results in an error in the calculated primary field at the station and appears as an anomalous Ch1 value not correlated to *channel 1 normalized* Ch2-10. The effect is amplified near the loop front. This can be seen in the profiles - the error in Ch1 generally increases approaching the loop. As a rule a 1% error in measurement of the distance from the loop will result in, for outside the loop surveys, an error in Ch1 of:

- 1% near the loop front (long-wire field varies as $1/r$)
- 3% at a distance from the loop front (dipolar field varies as $1/r^3$)
- 2% at intermediate distances (intermediate field varies as $\sim 1/r^2$)

Errors in elevation result in smaller errors but as they often affect the chainage they accumulate along the line.

The in-loop survey configuration generally diminishes geometric error since the field gradients are very low. At the centre of the loop the gradient in the vertical field is essentially zero so it is difficult to introduce geometric anomalies near the loop centre. Near the loop sides and at the closest approach of the lines to the wire mislocation of the loop and the station becomes more critical. Typically loop sides are designed to be >200m from any survey stations.

2) **Magnetostatic UTEM responses**

Magnetostatic UTEM responses arise over rocks which generate magnetic anomalies. Such magnetic materials will amplify the total (primary + secondary) field of the UTEM transmitter which is sensed by the receiver coil. The secondary field is generated by subtracting a computed primary which does not include magnetic effects. This can give rise to strong and abrupt channel 1 anomalies when the source of the magnetics is at surface. This is the case in a number of places on these grids. UTEM magnetostatic anomalies differ from DC magnetic anomalies in the following three major ways:

1) In the case of DC magnetics the field is dipping N and is very uniform over the scale of the survey area while the UTEM field inside the loop is vertical and it is stronger near the loop edges.
2) Most aeromagnetics are collected as total field while with UTEM we measure a given (in this case generally z,x) component.
3) DC magnetic instruments observe the total magnetization of the causative body which is due to its susceptibility as well as any remnant magnetization. An AC method such as UTEM will not respond to the remnant portion of the magnetization.

The larger amplitude of the UTEM Ch1 response is explained by the fact that the UTEM primary field is often more favourably coupled (magnetostatically speaking) to

magnetic mineralization as compared to the earths field. Another factor could be the presence of a reverse remnant component to the magnetization.
Note that positive magnetic anomalies will cause:

- positive Ch1 anomalies in data collected outside the loop
- negative Ch1 anomalies in data collected inside the loop

3) **Extremely good conductors**

An extremely good conductor will be characterized by a time constant much longer than the half-period (@ 30Hz >>16ms). This will give rise to an anomalous Ch1 which is not correlated to the Ch2-10 data plotted on the upper axes of a *channel 1 normalized* plot.

Appendix E

Qualifications Statement

Qualifications Statement

I, **Robert John Langridge** of 1-162 King Street East, Kingston, Ontario certify that:

1) I am a graduate of Queen's University
   Degree: B.Sc.(Hons) Geology and Physics received 1978.

2) I am a graduate of the University if Toronto
   Degree: M.Sc. Physics received 1982.

3) I have been practicing as a geophysicist since 1976. I am a member of the Professional Engineers and Geoscientists -PEG - of Newfoundland and Labrador.

4) I have no direct interest in the companies, leases or securities of Noranda Inc.

5) This report was prepared by me and is based on field work done by:
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Senior Associate
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2005.01.17
Date