Bergvesenet

Postboks 3021, N-7441 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
BV 4834	06/00131-15			**Fortrolig**
Kommer fra ..arkiv	**Ekstern rapport nr**	**Oversendt fra**	**Fortrolig pga**	**Fortrolig fra dato:**
		Sulfidmalm a.s.	Muting	

Tittel

Vinter Ground Geophysical Surveying, Vakkerlien project

Forfatter	Dato / År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Langridge, Rob	May 2006	Sulfidmalm A/S Lamontagne Geophysics LTD

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Kvikne	Hedmark		15123	Mandal

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Geofysikk		Vakkerlien
Råstoffgruppe	**Råstofftype**	
Malm/metall	Ni	

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

CD ligger vedlagt: 2006 UTEM Survey 0611, 2006 Data and Logistics Report

2006 Winter Ground Geophysical Surveying, Vakkerlien Project,

Hedemark County, Norway

2006 Winter Ground Geophysical Surveying,
Vakkerlien Project,
Hedemark County, Norway

Summary and Conclusions

The attached report by Lamontagne Geophysics Ltd. gives the details of UTEM geophysical surveying carried out on the Vakkerlien project in the winter of 2006.

The project is located approximately 300km north of Oslo and 90km south of Trondheim in central Norway and is an option and joint venture between Sulfidmalm A/S (Norway), a wholly-owned subsidiary of Xstrata PLC (formerly Falconbridge Limited), and Blackstone Ventures Inc. (Canada). Exploration programs are carried out by Falconbridge Limited on behalf of Sulfidmalm.

The Vakkerlien project area is underlain by Gula group supracrustal and intrusive rocks within the central Norwegian Caledonides. This region hosts the Vakkerlien nickel deposit (400,000 tonnes grading 1.0% Ni & 0.4% Cu) as well as the Olkar and Kaltberget nickel occurrences.

Surface UTEM surveying during the fall of 2005 identified a two-line UTEM response flanking the west side of the hook-shaped magnetic feature which is situated immediately east of the Vakkerlien deposit. In-house modeling by A. Watts outlined a UTEM plate with a conductance of 2000 siemens, a strike extent of 300m, a dip extent of 400m and a 53° east dip. The modeled plate represented a potential drill target. However, further verification of this target was strongly recommended as the data from the 2005 UTEM survey was negatively impacted by 1) the effects of a powerline transecting the northwestern corner of the survey area and 2) the very resistive nature of the terrain surveyed.

Based on follow-up recommendations, 2.575 line km of out-of-loop UTEM surveying was carried between March 15 and March 19th, 2006 in order to follow-up the previously identified UTEM anomaly. Data was collected at 25m station intervals on lines spaced 50m apart with 12.5m stations in anomalous areas. The loop position was optimized and improvements were made to the surveying methodology including the use of thicker loop wire, longer stacking times and higher pre-whitening settings. This resulted in better quality data but, unfortunately, also eliminated the previously interpreted anomaly as no distinct response was obtained in the 2006 survey. Due to the lack of a well defined drill target, no further work is recommended in this immediate area.

P. Tirschmann
Xstrata Plc (formerly Falconbridge Limited)
For Sulfidmalm A/S

October 23, 2006

-Logistics Report-
2006 UTEM Survey
Vakkerlien
Norway
for
A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

May, 2006

Rob Langridge, M.Sc.

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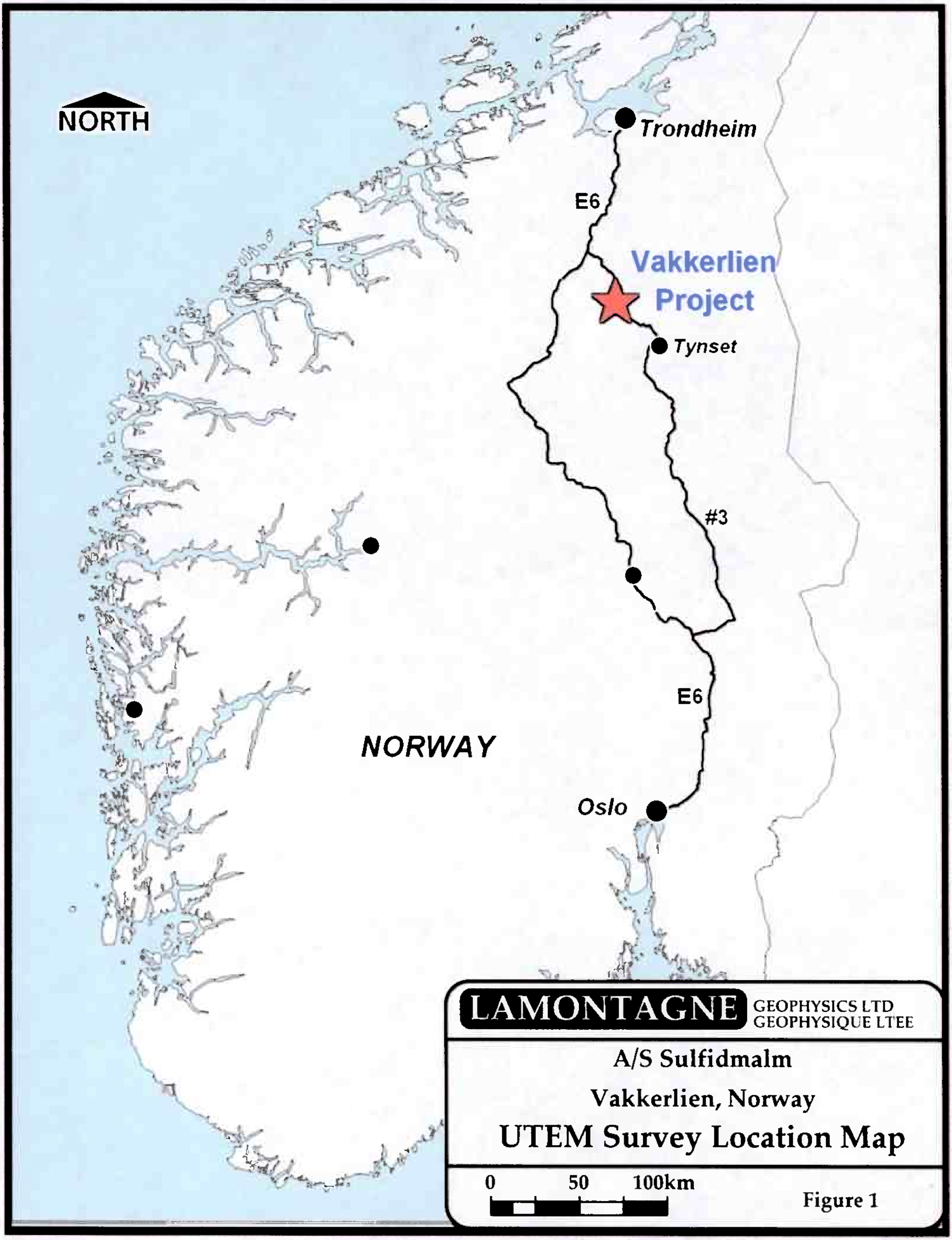
INTRODUCTION

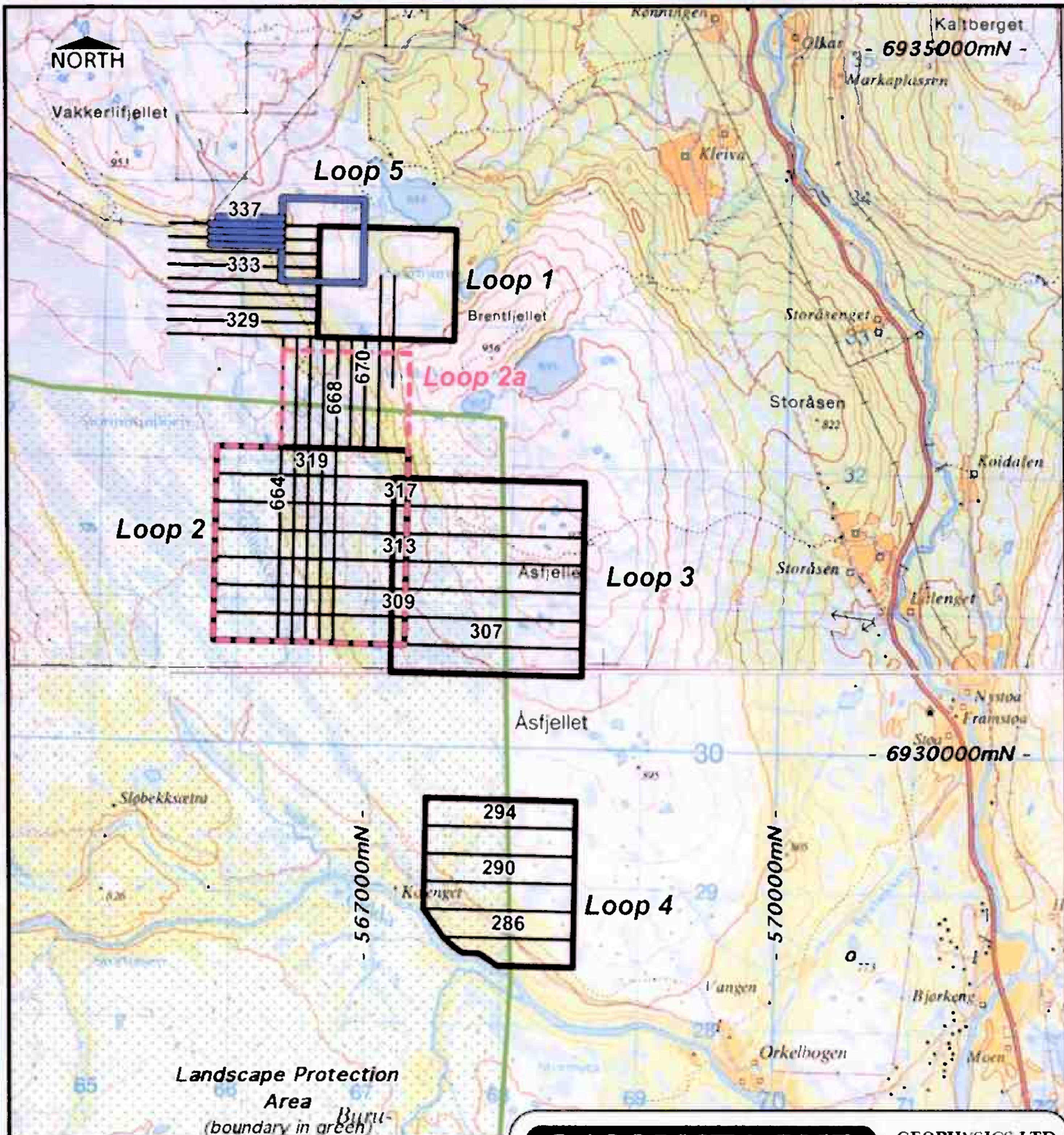
During the period of March 15th 2006 through March 19th 2006 a UTEM survey was carried out by Lamontagne Geophysics Limited personnel for A/S Sulfidmalm in the area of Vakkerlien, Norway (Figure 1). The location of the property is shown in Figures 1 and 2. Areas of interest were identified from the results of an airborne survey and the results of previous work in the area. The survey was carried out to locate conductors in the immediate grid area with the intention of outlining targets for future work.

A total of 2.575km of surface UTEM data was collected using 1 transmitter loop (Loop 5). All lines were surveyed measuring the vertical component, Hz. A station spacing of 25m or 50m and a line spacing of 50m was employed. The receiver operated in 10-channel mode at a transmitter frequency of 3.251Hz.

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

- List of Personnel/Production Diary (Appendix B)
- an outline of the UTEM System (Appendix C)
- Note on sources of anomalous Ch1 (Appendix D)
- Note on 4Hz UTEM Data (Appendix E)


NORTH
Trondheim
E6
Vakkerlien Project
Tynset
#3
E6
NORWAY
Oslo
LAMONTAGNE
GEOPHYSICS LTD
GEOPHYSIQUE LTEE
A/S Sulfidmalm
Vakkerlien, Norway
UTEM Survey Location Map
0 50 100km
Figure 1



Notes:
-Local grid coordinates are:
(grideast, gridnorth)=(UTM easting-560000, UTM northing-6900000)
-Loop 5 (in bloe) was added to detail a response in the area covered by the survey lines (blue).

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A/S Sulfidmalm

Vakkerlien, Norway

Idealized Grid Map - Loop 5

0 1000m

Figure 2

SURVEY DESIGN

This UTEM survey is part of a nickel exploration program in the Vakkerlien area. Historically mining of Ni-bearing massive sulfide deposits has been carried out in the area. The UTEM survey was planned and carried out to outline and allow better definition of a response detected during previous work in November 2005.

The grid and loop layout was designed by A/S Sulfidmalm/Falconbridge Ltd. personnel to allow efficient coverage of the area. Loop size and grid location were selected to provide good coupling with the expected target and to minimize noise problems that affected the earlier survey. The base frequency was lowered from the international standard ~26Hz to 3.251Hz to eliminate the response of many "moderate" conductors - these responses will have decayed away by Ch1 time. Any remaining Ch1 responses are then considered to be representative of conductors of an appreciably higher conductivity.

The survey parameters employed:

- outside-the-loop coverage with 2 receivers
- variable transmitter loop size - to fit the area to be covered and the relief
- 1.70mm diameter (~2mm^2 ~14-gauge) copper wire - DAMID PE GR 2
- line spacing of 50m
- station interval of 25m reduced to 12.5m in anomalous areas.
- Hz (vertical component measurements)
- 10-channel data at a frequency of 3.251Hz
- minimum 256 stacking (512 half-cycles) increased where noise levels dictate

In nickel exploration non-decaying Channel 1 (Ch1) conductors are indicative of highly conductive mineralization. Any non-decaying anomalous Ch1 features are therefore of interest. Non-decaying channel UTEM anomalies can reflect:

i) the presence of conductive 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 standpoint magnetic anomalies and geometric control should be considered and evaluated as a mandatory part of any interpretation. From a field standpoint 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.

For this survey GPS data was collected using handheld GPS units. The grid was located using the handhelds. Once the grid was located a baseline was set up @6275E - the eastern extremity of all the survey lines. The five survey lines were chained in and turned off. Line 3370E was chained out 125m and a cross line was turned off and chained in as a reference. After that all lines were secant chained. The accuracy obtained using this method is quite acceptable - the work was set up to outline/detail features with responses that do not continue through to Ch1. Note that the area has relatively gentle topography - no topographic corrections were applied.

SURVEY LOGISTICS

A Lamontagne Geophysics crew mobilized from Canada on February 15th and arrived in Oslo on February 16th. The crew, consisting of Rob Langridge (geophysicist/crew chief), Ryan Land (operator) and Bud Evans (looper) worked on another project in Norway. On March 16th the crew packed the requisite equipment for a short survey and traveled to the Vakkerlien area along with client representative Yannick Beaudoin. The base of operations for the survey the Kvikne Fjellhotell. We met up with the local guide/snuscooter operator (Knute) and equipment was moved out into the field the same day.

The following day the crew mobilized to the field site with the remaining equipment and began laying wire/establishing a grid. Once the loop was complete and several lines were established one crew began surveying. Four lines were chained and surveyed over the course of the day. Little response was detected but it was decided to complete the fifth line and to then recover the pickets and the loop wire. This was accomplished on March 18th - all equipment was brought in from the field and packed and Knute's snuscooter/sleighs were also returned to his home. The gear was packed and the crew departed the following morning for Espedalen to continue work. Details of the daily production and personnel are included in the Production Diary (Appendix B) along with a summary of production.

One transmitter loop was used during the surface UTEM survey for a total survey coverage of 2.575km. Figure 2 shows the loop location and grid layout. Access to the Vakkerlien project was by pick-up truck via farm access roads and then by snuscooter. The grid/loop positions were demarcated by bamboo wands and flagging and were established by hand-held GPS and compass/chaining. Access to the grid was on foot and snuscooter.

The field equipment included the new generator -NORGESAGGREGATET 2200B. The generator will run for ~10 hours with a UTEM loop as the load - eliminating the need to refill the generator every 4 hours as in previous surveys. Electrical connection to the generator was made through an LGL isolation-transformer/Variac combination rewired to conform with the sockets (standard 2-pin/side-clip ground european) on the generator.

The survey equipment consisted of two UTEM 3 receivers and one UTEM 3 transmitter as well as all necessary accessories, support equipment and backup equipment. Data was reduced on a field computer (Macintosh) and UTEM profiles and digital data were made available/emailed to the client's personnel on a daily basis. Boots and then snowshoes were used during the survey.

Care was taken during the survey not to leave anything on the site. The weather/snow conditions were generally good for surveying.

SURVEY RESULTS

The results of the survey are summarized and presented as UTEM profiles in Appendix A. The final grid and Loop Location are presented in Figure 2. Overall the data quality is good. Little evidence of conductors and/or conductive features are evident. Although every effort was taken to shelter the receiver coil minor wind noise may be evident in some profiles.

Surface profiles are listed by Loop number and presented as 3-axis profiles in the following order:

Hz	**continuous norm**	***Ch1 reduced***	**(blue separator)**
Hz	**point normalized**	***Ch1 reduced***	**(pink separator)**

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

Outline of surface profile types

Hz continuous norm ***Ch1 reduced*** **(blue separator)**

Continuous normalization is useful for detection of the presence of anomalies at any position on a profile. The anomaly shape is distorted by the normalization to the local field. As the field gets very big near the wire the continuously normalized Ch1 tends towards zero.

top axis - Ch5-10
middle axis - Ch2-5
bottom axis - Ch1
bottom axis - topography - no vertical exaggeration

Hz point normalized ***Ch1 reduced*** **(pink separator)**

normalization point: all data~300m out from the loop-front centre

Point normalized data is useful for interpretation purposes. Anomaly shape is preserved as is the amplitude if the normalization point is local to the anomaly.

All data has been point normalized to a the field at a point ~300m out from the centre of the loop front. Note that this field value is intermediate and it was chosen because the survey was roughly half inside-the-loop and half off-loop. Normalizing to an intermediate point allows the interpretation of responses along the entire line. The amplitude of responses close to (**further from**) the loop front will be blown up (**muted**).
Note: Typically the normalization point for off-loop profiles is 4-500m out from the centre of the loop front and for inside-the-loop profiles it is the loop centre.

The disadvantage of point normalization is that small errors in location near the wire and in current tend to appear as large errors in Ch1. If the loop/station locations and the current are accurately known then point normalized Ch1 (in the absence of a local conductor) will tend to be continuous approaching the wire - unlike the continuously normalized Ch1 which, as described above, will dip to zero.

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

Discussion of Results

The area surveyed is very resistive - little response is seen at even the earliest time-channels. In this instance topographic corrections were not applied - the area has relatively gentle topography and the previous work did not indicate a Ch1 response. As a result there is some character in Ch1 that topographic corrections would remove.

During the previous UTEM work in the area - November 2005 - noise levels proved to be high and in places, along certain geologic structures, extremely high. This was particularly true in the area covered by this survey. The off-loop data from Loop 1 is noisy-to-very-noisy in places once the distance to the loop front exceeds 500-600m. As a result the loop front for Loop 5 was moved forward - placing the area of interest well within 500-600m of the loop front.

The issue of noisy data when surveying in areas of very-resistive country rock is discussed in detail in the following section.

Discussion of noise issue in very resistive terrains

From the standpoint of data collection during a UTEM survey there are a number of different sources of "noise" - natural, cultural, coil motion, instrumental and geological. For the purpose of this discussion the following distinction is made:

- "true" noise - results in poor repeatability and is due to:
    - a noise field composed of: power line fields, sferic fields due to thunderstorm activity worldwide, other natural EM sources (micropulsations, etc), or
    - coil motion due to the effect of wind either: moving the the coil directly, causing movement in the ground near trees or undulating the ice surface of a large frozen lake.

  In the case of poor repeatability increased stacking time will improve things.
- geological noise - in resistive areas profiles show scatter but features are repeatable. The scatter in the data is due to short-wavelength geological responses which are spatially undersampled. In this case increased stacking time will not improve things. Repeat readings that are in agreement, however, serve to confirm that the scatter represents geological noise.
  Note that if the features are of interest a finer station spacing may resolve them.

So repeated readings should tell whether noisy-looking data is due to poor repeatability or short-wavelength geological responses.

UTEM surveys carried out at Vakkerlien in the fall of 2005 and on projects in southern Norway in early 2006 were carried out over very resistive terrain and ran into very noisy conditions. The following is a discussion of the noise issue as it affects these surveys and the strategies/changes that have been employed/made to combat it.

Overall the high noise issue as it affects UTEM surveys carried out over very resistive terrain - including the 2005/2006 Vakkerlien UTEM survey and the 2006 southern Norway surveys - can be resolved into three factors:

- surveying in/over very resistive terrain
- the nature of the target(?) conductor(s) in very resistive terrain
- the combination of the response of a powerline and the noise associated with a powerline

A look at each of these factors follows. Note that there is some overlap between the three factors.

Surveying in/over very resistive terrain

When conductive overburden or a typically conductive country rock is present very little of the natural sferic field penetrates to the geological conductors. The noise field at the earth's surface is ~horizontally-polarized. In terms of how this affects a typical UTEM survey it means that:

- when measuring Hz - the vertical component and the component most often measured - noise levels are typically lower and stacking times are chosen to allow accurate measurement of the smaller secondary field in the presence of the (typically) stronger primary field.
- when measuring Hx/Hy - horizontal components - noise levels are typically higher and stacking times are chosen to allow accurate measurement of the small secondary field in the presence of higher noise levels. In relatively flat terrain the horizontal component of the primary field is typically weak.

Over very resistive terrain the noise field becomes somewhat less horizontally-polarized. A significant component of the noise field penetrates to the geological conductors. The result is a tilted noise field - more noise is in the vertical component.

In addition over very resistive terrain there is an increase in geological noise due to induced current channeling in discrete faults and overburden channels. The vertical noise field in particular is amplified by current channeling anomalies.

Result: stacking times for Hz measurements must be increased to allow accurate measurement of the secondary field in the presence of higher noise levels. Increased stacking time will not affect scatter in the data that represents geological noise. Repeat readings will serve to confirm if the scatter represents geological noise.

The nature of the target(?) conductor(s) in very resistive terrain

The presence of a good, consistent conductive feature will make UTEM data look very clean - secondary currents flow in a "well organized" fashion and give a good response. A larger response forces the use of a coarser plotting scale - visually "suppressing" noise even further.

In very resistive areas there is little or no background response present. If there are no local features of appreciable size present to give rise to a response then virtually all you see on a profile is a combination of "true" noise and geological noise. In this instance plotting scales are often blown up in an attempt to reveal whether subtle responses are present - and noise is visually "amplified".

Weakly-conductive features - especially those that are broken up and vary in character/orientation along strike - produce geological noise on a profile. In very resistive terrain even very weakly-conductive features will channel current. The overall result can be line-to-line variable, "scattered" responses that give the profiles the appearance of an increase in noise in general. These weakly-conductive variable features also affect the noise field. The vertical noise field in particular is amplified by current channeling anomalies in very resistive terrain.

Very long geological conductors tilt the natural (for our purposes noise) field in their vicinity giving rise to cross-over tilt angle anomalies - more noise in the vertical component. Since the natural fields are very large scale and the conductors very long the response of very long geological conductors is much greater in proportion than what the UTEM data would lead us to believe.

The net affect on an off-loop UTEM survey appears in one of two fashions:

- locally high noise levels at one or more stations near the "geologically-noisy" feature.

  Result: stacking times for Hz measurements must be increased at the noisy stations to allow accurate measurement of the secondary field but stacking times can be reduced again once the noisy section is passed. If there is an indication that the noise is geological then repeat readings should be taken.

- high noise levels that start abruptly at the "geologically noisy" feature and persist beyond it.

  Result: stacking times for Hz measurements must be increased abruptly at the "geologically noisy" feature and increased stacking must be continued at all stations beyond (further from the loop). If there is an indication that the noise is geological then repeat readings should be taken.

Note that in the field it may take a while for an operator to determine the correct procedure to follow. Abruptly increasing the stacking time and doing repeat readings can add significantly to the survey time. For reference at 3.251Hz approximate reading times are as follows for single readings and to cover 100m (4 stations):

	single	100m @25m
512 stack	~2min 50secs	~11min 20secs
x2 = 1K stack	~5min 40secs	~22min 30secs
x2 = 2K stack	~11min 10secs	~44min 50secs
x2 = 4K stack	~22min 20secs	~89min 25secs
x2 = 8K stack	~44min 40secs	~178min 40secs

As an example increasing from a 512 stack to a 1K stack and doing a repeat reading will take the stacking time from ~2min 50secs (~11min 20secs/100m) to ~~11min 20secs (~44min 50secs/100m). Note also that to the operator in the field abruptly noisy data looks very much like an instrument problem. In checking for instrumental problems some additional delay will occur.

The combination of the response of a powerline and the powerline noise

A typical UTEM survey is affected by the presence of a powerline in two distinct ways:

- There will be a response due to the powerline. The response will be coincident with the powerline and can serve to mask other conductive features. The nature of a powerline response varies depending on the powerline's: characteristics, location with-respect-to the transmitter loop and geological setting. Note that in resistive terrain all power line return currents are concentrated in long geological conductors rather than being dispersed throughout the conductive earth.
  The option of "stripping" the powerline response exists - this can reveal the presence of any masked conductive features. Data used in "stripping" the response is typically collected on a more detailed traverse across the powerline.

  Result: surveying time will be increased somewhat because of the increased stacking required to collect data accurate enough to allow "stripping" to reveal any masked features. In some cases a few additional stations will be surveyed.

- There will be EM noise present due to any operating powerline. Noise levels increase as the powerline is approached. Power line noise normally is strongest on the vertical component near a power line and becomes more horizontal at a distance because of induction in the earth. This rotation towards the horizontal occurs much farther away from the power line in resistive terrain than in a conductive area. In very resistive terrain powerline noise in the vertical component will persist to a considerably distance.
  For some powerlines the noise levels will be high enough to force the data to be collected at a lowered signal gain. For many larger powerlines noise levels very close to the powerline are high enough that data cannot be collected at all at a few stations.

  Result: surveying time will be increased because of the increased stacking required to overcome the higher noise levels. Some coverage in the immediate vicinity of the powerline may be missed due to very high noise levels.

Strategies/changes that have been employed/made to combat the noise issue

In order to overcome the noise a number of strategies/changes have been employed/made:

- stacking increased
  improves data quality when dealing with "true" noise but @3.251Hz readings can become quite long
- readings repeated where there are indications that the noise is geological
  repeat readings that are in agreement serve to confirm that scatter in the data represents geological noise.
- increased station spacing at some chosen distance from the loop front
  a trade off between improved data quality and station sampling when readings @3.251Hz become quite long - see above.
- higher pre-whitening levels used where possible
  improves noise rejection but the UTEM 3 transmitter is required to run close to the rise-time limit - transmitter operation can be finicky at this level, especially if there are powerlines in the vicinity.
- the use of heavier gauge wire
  larger wire = allows higher current = improves signal-to-noise ratio
  Improved signal-to-noise ratio means that less stacking is required for the same level of data quality.
- where possible a switch to in-loop surveying
  in-loop = considerably stronger applied field = improved signal-to-noise ratio
  Note: in-loop surveying is less sensitive to small, steeply-dipping conductors.

CONCLUSIONS AND RECOMMENDATIONS

The results of the survey are summarized and presented as UTEM profiles in Appendix A. Overall the data quality is good . The final Grid and the Loop Location are presented in Figure 2. The area surveyed is very resistive - little response is seen at even the earliest time-channels.

The profiles presented in Appendix A have been reduced with a grid corrected as well as possible using available information. For this survey the grid was located using the handheld GPS units. Once the grid was located a baseline was set up @6275E and the five survey lines were turned off and secant chained in. The accuracy obtained using this method is quite acceptable - the work was set up to outline/detail features with responses that do not continue through to Ch1. Note that the area has relatively gentle topography - no topographic corrections were applied. As a result there is some character in Ch1 that topographic corrections would remove.

In terms of logistics the survey ran very smoothly and the crew supplied by Falconbridge was excellent and is thanked for their efforts.

Appendix A

0611 UTEM Profiles

UTEM 3 Survey

Vakkerlien
Norway

for

A/S Sulfidmalm

Presentation

The results of the survey are summarized and presented as UTEM profiles in Appendix A. The final grid and Loop Location are presented in Figures 2. Overall the data quality is good. Few conductive features are evident. A description of the standard plotting formats used and of the UTEM System is presented in Appendix C.

The profiles are listed by Loop number and presented as 3-axis profiles in the order:

Hz continuous norm ***Ch1 reduced*** **(blue separator)**
Hz point normalized ***Ch1 reduced*** **(pink separator)**

Outline of surface profile types

Hz continuous norm ***Ch1 reduced*** **(blue separator)**

Continuous normalization is useful for detection of the presence anomalies at any position on a profile. The anomaly shape is distorted by the normalization to the local field. As the field gets very big near the wire the continuously normalized Ch1 tends towards zero.

top axis - Ch5-10
middle axis - Ch2-5
bottom axis - Ch1
bottom axis - topography - no vertical exaggeration

Hz point normalized ***Ch1 reduced*** **(pink separator)**

normalization point: all data ~300m out from the loop-front centre

Point normalized data is useful for interpretation of responses. Anomaly shape is preserved as is the amplitude if the normalization point is local to the anomaly.

All data has been point normalized to a the field at a point ~300m out from the centre of the loop front. Note that this field value is intermediate and it was chosen for agreement with the 2005 survey. Normalizing to an intermediate point allows the interpretation of responses along the entire line. The amplitude of responses close to (**further from**) the loop front will be blown up (**muted**).
Note: Typically the normalization point for off-loop profiles is 4-500m out from the centre of the loop front and for inside-the-loop profiles it is the loop centre.

The disadvantage of point normalization is that small errors in location near the wire and in current tend to appear as large errors in Ch1. If the loop/station locations and the current are accurately known then point normalized Ch1 (in the absence of a local conductor) will tend to be continuous approaching the wire - unlike the continuously normalized Ch1 which, as described above, will dip to zero.

top axis - Ch5-10
middle axis - Ch2-5
bottom axis - Ch1
bottom axis - topography - no vertical exaggeration

List of Data Collected and Plotted

Vakkerlien 2006 Grid

Surface coverage - @ 3.251 Hertz

	Line		coverage		
Loop 05	Line	3355E	5750E	- 6275E	525m
	Line	3360E	5750E	- 6275E	525m
	Line	3365E	5750E	- 6275E	525m
	Line	3370E	5750E	- 6275E	525m
	Line	3375E	5800E	- 6275E	475m
		Vakkerlien	Loop 05 Total		2575m
		Vakkerlien	**2006 Total**		**2.575m**

Vakkerlien

Loop 5

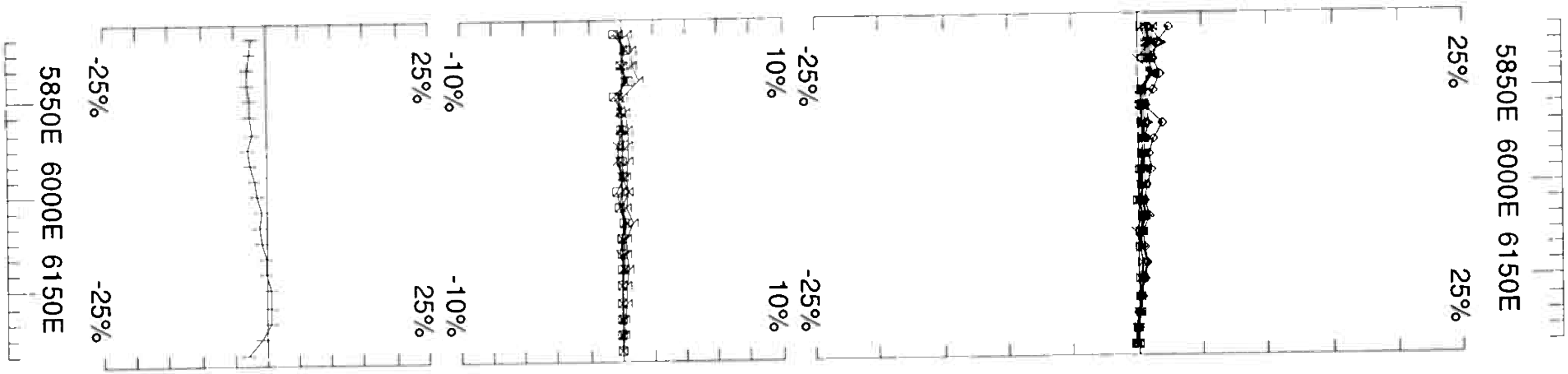
Hz
@3.251 Hz frequency

continuous norm

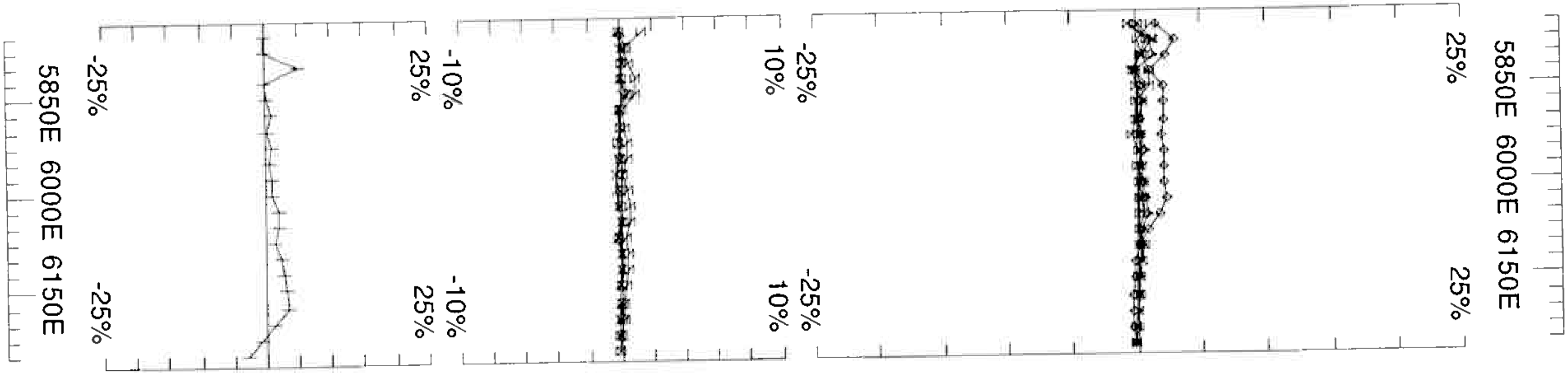
Ch1 reduced

Loop 05	Line	3355E	5750E - 6275E	525m
	Line	3360E	5750E - 6275E	525m
	Line	3365E	5750E - 6275E	525m
	Line	3370E	5750E - 6275E	525m
	Line	3375E	5800E - 6275E	475m
		Vakkerlien	Loop 05 Total	2575m

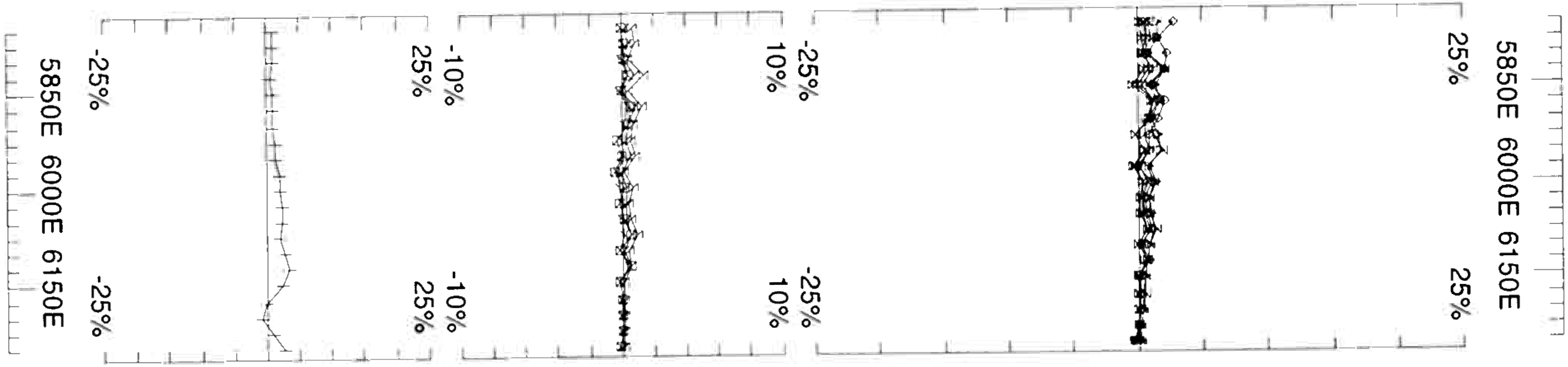
Loop 5 - continuous norm



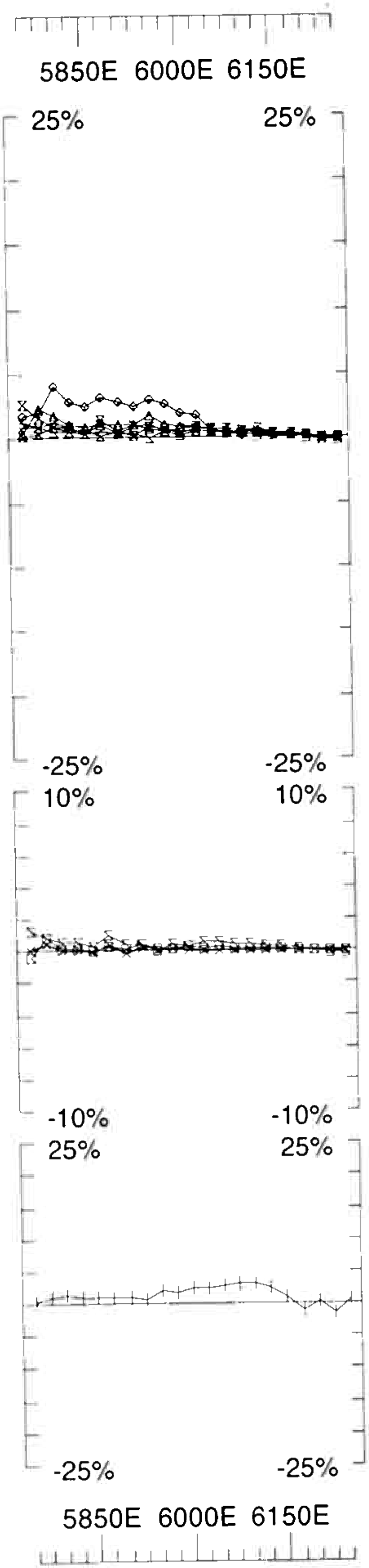
Loop: 05	Secondary, (Chn - Ch1)/IHpl	UTEM Survey at: Vakkerlien
Line: 3355N	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0611 — Surveyed : 18/3/6 Reduced : 18/3/6 Plotted : 1/6/6



Loop: 05 Line: 3360N Compt: Hz	Secondary, (Chn - Ch1)/lHpl Contin. Norm at depth of 0 m Base Freq. 3.251 Hz	UTEM Survey at: Vakkerlien For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD / GEOPHYSIQUE LTEE Job 0611 Surveyed : 17/3/6 Reduced : 18/3/6 Plotted : 1/6/6



Loop: 05 Line: 3365N Compt: Hz	Secondary, (Chn - Ch1)/IHpI Contin. Norm at depth of 0 m Base Freq. 3.251 Hz	UTEM Survey at: Vakkerlien For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0611 Surveyed : 17/3/6 Reduced : 18/3/6 Plotted : 1/6/6



UTEM Survey at: Vakkerlien
For: A/S Sulfidmalm

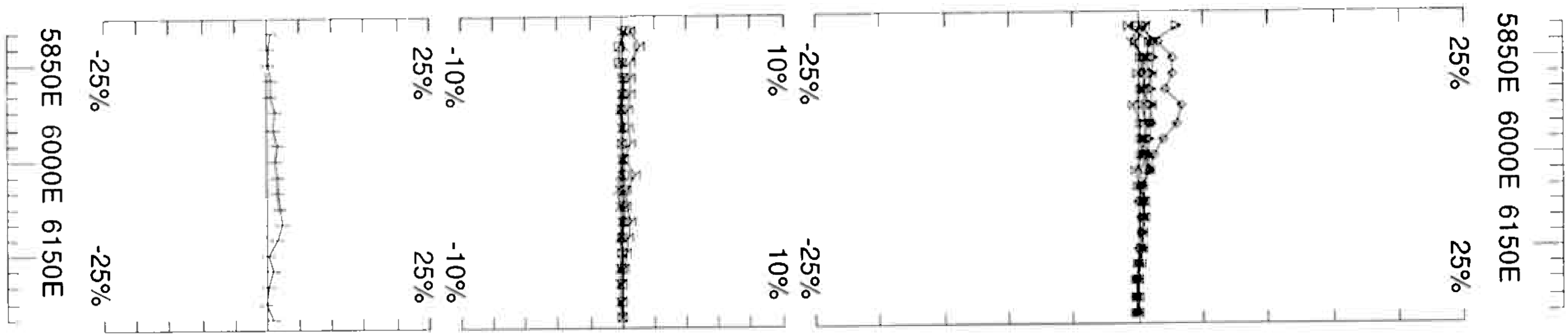
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0611

Surveyed: 17/3/6
Reduced: 18/3/6
Plotted: 1/6/6

Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

Loop: 05
Line: 3370N
Compt: Hz



Loop: 05	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Vakkerlien
Line: 3375N	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0611 — Surveyed : 17/3/6 Reduced : 18/3/6 Plotted : 1/6/6

Vakkerlien

Loop 5

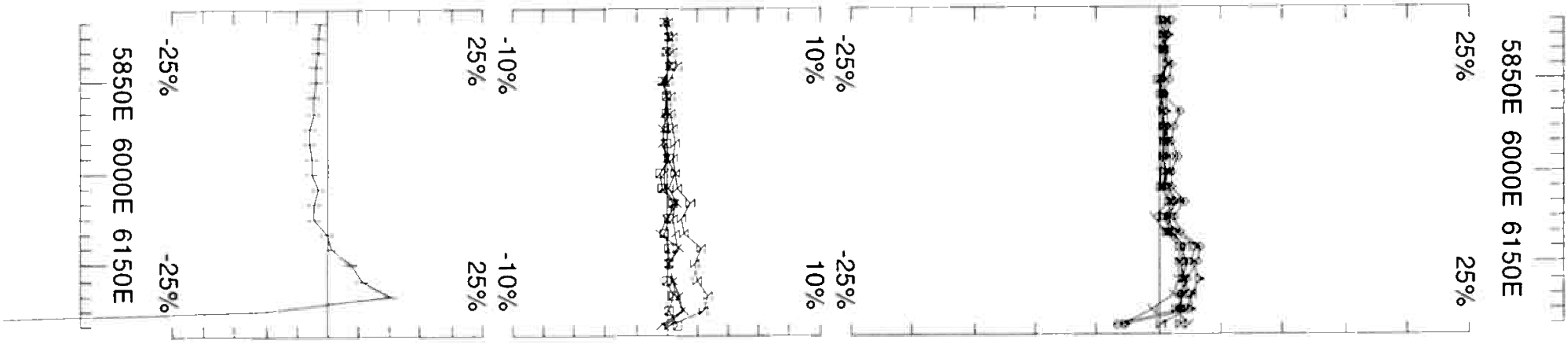
Hz
@3.251 Hz frequency

point norm
@
(x,y,z) = (5975E,33600N, 860 m.a.s.l.)

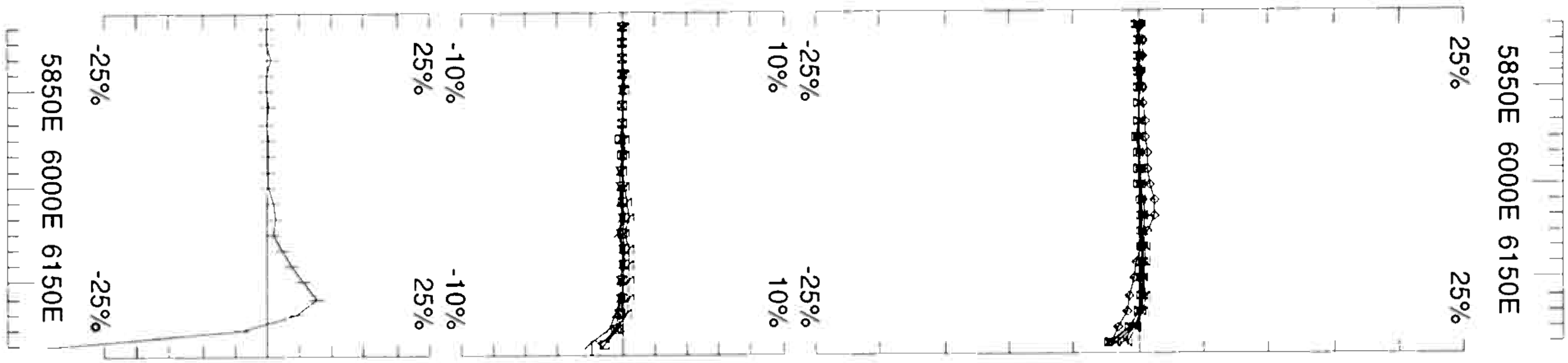
Ch1 reduced

Loop 05	Line	3355E	5750E	- 6275E	525m
	Line	3360E	5750E	- 6275E	525m
	Line	3365E	5750E	- 6275E	525m
	Line	3370E	5750E	- 6275E	525m
	Line	3375E	5800E	- 6275E	475m
		Vakkerlien	Loop 05 Total		2575m

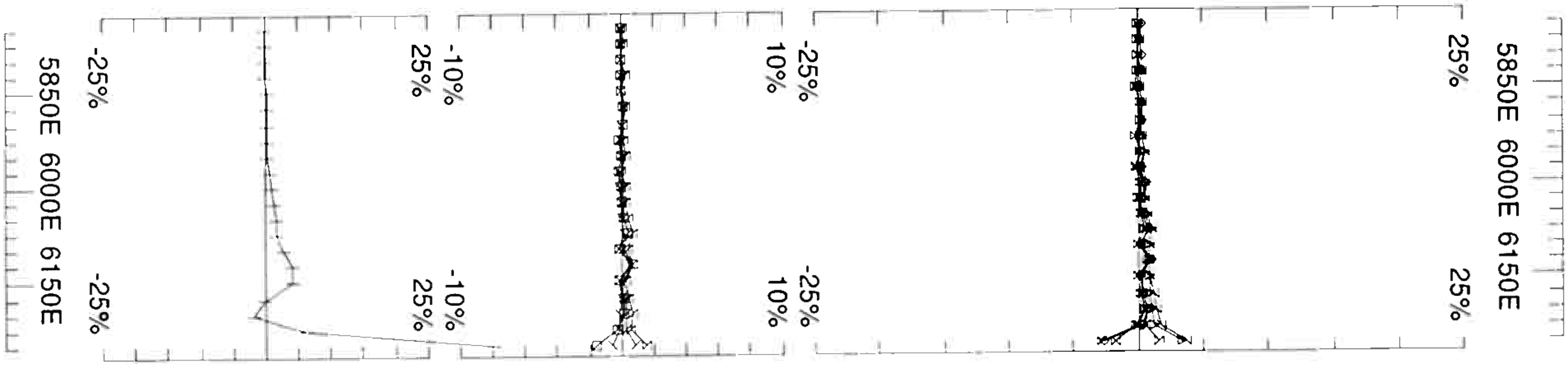
Loop 5 - point norm



Loop: 05 Line: 3355N Compt: Hz	Secondary, (Chn - Ch1)/lHpl Point Norm.at x,y,z (5975,33900,860) Base Freq. 3.251 Hz	UTEM Survey at: Vakkerlien For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0611 Surveyed : 18/3/6 Reduced : 18/3/6 Plotted : 1/6/6



Loop: 05 Line: 3360N Compt: Hz	Secondary, (Chn - Ch1)/lHpl Point Norm.at x,y,z (6150,33300,860) Base Freq. 3.251 Hz	UTEM Survey at: Vakkerlien For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0611 Surveyed : 17/3/6 Reduced : 18/3/6 Plotted : 1/6/6



Loop: 05
Line: 3365N
Compt: Hz

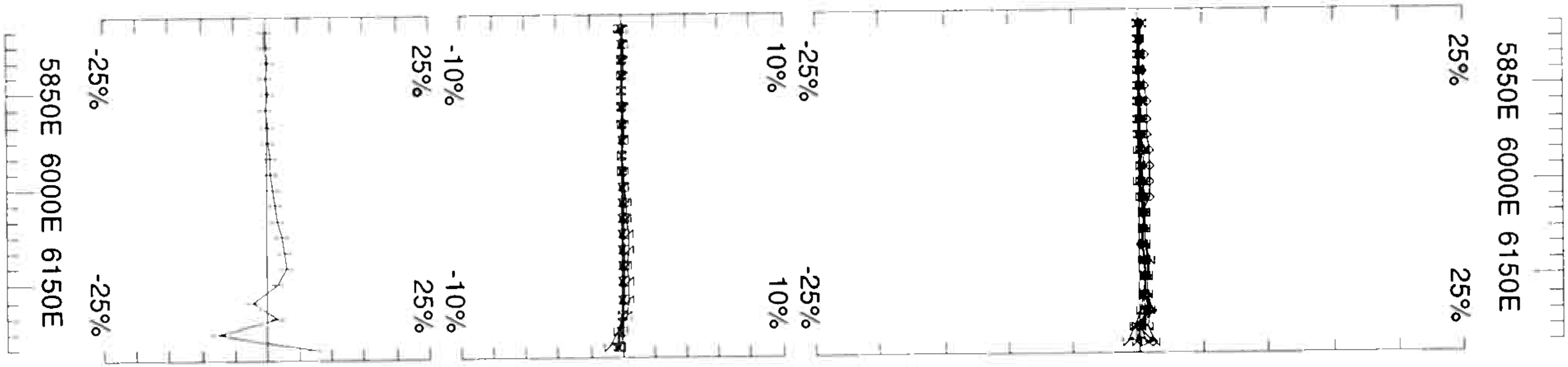
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(6150,33300,860)
Base Freq. 3.251 Hz

UTEM Survey at: Vakkerlien
For: A/S Sulfidmalm

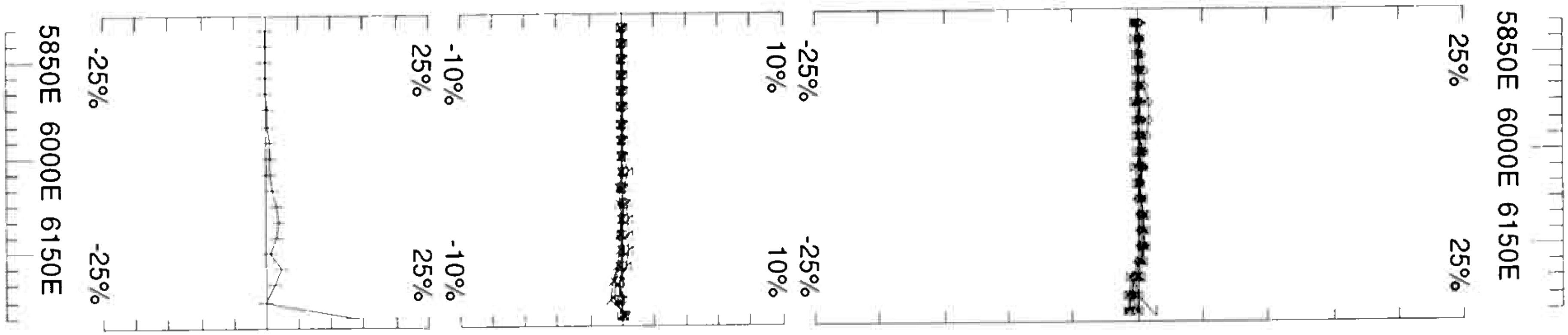
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job
0611

Surveyed : 17/3/6
Reduced : 18/3/6
Plotted : 1/6/6



Loop: 05 Line: 3370N Compt: Hz	Secondary, (Chn - Ch1)/IHpl Point Norm.at x,y,z (6150,33300,860) Base Freq. 3.251 Hz	UTEM Survey at: Vakkerlien For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD / GEOPHYSIQUE LTEE	Job 0611 Surveyed : 17/3/6 Reduced : 18/3/6 Plotted : 1/6/6



Loop: 05 Line: 3375N Compt: Hz	Secondary, (Chn - Ch1)/lHpl Point Norm.at x,y,z (6150,33300,860) Base Freq. 3.251 Hz	UTEM Survey at: Vakkerlien For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0611 Surveyed : 17/3/6 Reduced : 18/3/6 Plotted : 1/6/6

Appendix B

0611 Production Diary

UTEM 3 Surface Survey

Vakkerlien Grid
Norway

for

A/S Sulfidmalm

Production Log (0611)
UTEM Survey - Vakkerlien
Norway
A/S Sulfidmalm

Date	Rate	Production	Comments
up to March 15		-	Mobilization of crew and equipment to Norway and work on another project.
March 16	**L(2)-3**		Pack gear and get on road by 10:00. Drive to Kvikne for work on the Vakkerlien project. Arrive ~15:30. Unpack and meet up with Knute - the local snuscooter owner who is providing transport. Head out to the grid with Yannick and move gear in/establish corners and points. Crew back in camp ~18:30. Crew:R.Langridge,R.Land,W.Evans
March 17	**P(2)-3**	2050m	Put in Loop 05. Establish chaining points and chain/survey 4 lines. Crew back in camp ~17:30 **Loop V05** **Line 3365E 5750E - 6275E Hz Rx16** **Line 3360E 5750E - 6275E Hz Rx15** **Line 3370E 5750E - 6275E Hz Rx16** **Line 3375E 5800E - 6275E Hz Rx16** Crew:R.Langridge,R.Land,W.Evans Vakkerlien Total to date: 2.050km
March 18	**P(2)-3**	525m	Out Loop 05 with Knute - windy and warm. Chain/survey the remaining line. Pick up all pickets and the loop. Transport all equipment out and back to the hotel. Drive Knute's car home. Plot data and pack. Crew back in camp ~14:00 **Loop V05** **Line 3355E 5750E - 6275E Hz Rx16** Crew:R.Langridge,R.Land,W.Evans Vakkerlien Total to date: 2.575km
March 19	**0.5 L(2)-3**		Gear packed and on the road by 09:00. Drive back to Espedalen. Leaving Kvikne the conditions were very windy with lots of blowing snow but conditions improved as we drove south of Dombas. Back in Espedalen ~13:30. The 2006 hole 53 was expected to be ready to read on Monday so we left the borehole gear in place and picked up 6 lines of pickets and set up the transmitter site for the remaining 2004/05 holes. Crew back in camp ~16:10. Crew:R.Langridge,R.Land,W.Evans
March 20 and later			Continue work on another project in Norway.

Date	Rate	Production	Comments

LEGEND

P(n)-x	Surface Production (# of receivers) - # of personnel
L(n)-x	Looping (# 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.

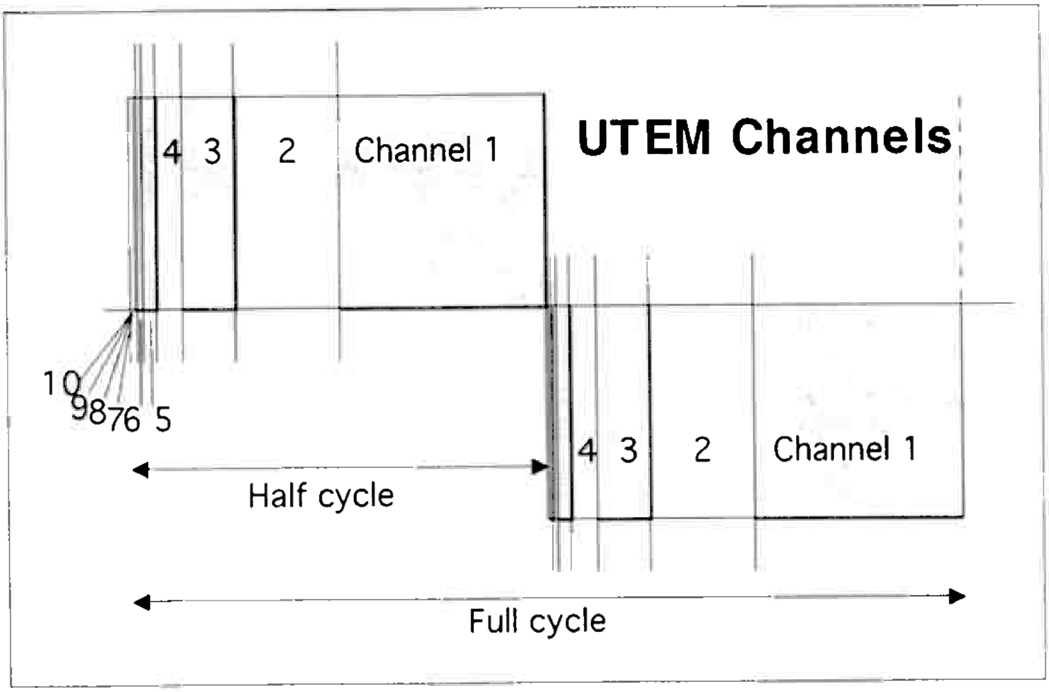
Measurements are routinely taken to a distance of 1.5 to twice the loop dimensions, depending on the local noise levels, and can be continued further. Lines are typically surveyed out from the edge of the loop but may also be read across the loop wire and through the centre of the loop, a configuration 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 **decay time** 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:

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

$\mathbf{R1_j}$ is the result plotted for the latest-time UTEM channel, channel 1,

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

$\mathbf{Ch1_j}$ is the raw component sensor value for channel 1 at station j,

$\mathbf{H^P{}_j}$ is the computed primary field component in the sensor direction

$|\mathbf{H^P}|$ 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	Σ
6	0.378	◭
7	0.189	7
8	0.095	X
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

Note on 4 Hz UTEM data: The effect of the presence of a 60-cycle powerline.

Note

While this Appendix uses data collected in the presence of a 60Hz powerline the issue dealt with applies equally to UTEM data collected in the presence of a 50Hz powerline.

Note: The standard presentation in Appendix A has Ch2-5 plotted on the middle axis. An alternative presentation - with Ch2 and Ch3 on the middle axis - is sometimes chosen when a powerline cuts through the surveyed area. This Appendix is a brief discussion of why the alternative presentation is chosen.

Note on 4 Hz UTEM data:The effect of the presence of a 60-cycle powerline.

This appendix outlines and discusses the effect of the presence of a 60-cycle powerline on ~4Hz (3.872Hz) UTEM data. This line is from a series of loops with a powerline cutting across the survey area. The UTEM data is affected by the presence of the powerline.

example data:

Figure E1(a) is the example data as presented in Appendix A - an alternative presentation with Ch2 and Ch3 on the middle axis. The standard presentation is shown in Figure E1(b) - with Ch2-5 plotted on the middle axis. The alternative presentation was chosen for a series of loops (including this loop) with a powerline cutting through the surveyed area. Figure E1(c) shows why - Ch4 and Ch5 show a pattern where when one is up the other is down and vice versa. The amplitude of the pattern decreases with distance away from the powerline. It was felt that this pattern obscured the information in Ch2 and 3 and the alternative presentation was chosen.

explanation:

Figure E2a) shows the UTEM waveform at ~4Hz with a 60Hz waveform superimposed on it. Roughly 16 cycles of the 60-cycle waveform fit into the full UTEM waveform. On a channel-by-channel basis:

~4 cycles fit into Ch1
~2 cycles fit into Ch2
~1 cycle fits into Ch3.

The multiple cycles tend to cancel out. Earlier channels are narrower - only part of a cycle wide. In particular Ch4 is ~half a cycle wide and Ch5 falls in the opposite halfcycle. The result is the pattern shown in Figure 1(c): Ch4 and Ch5 tending to diverge from one another - more strongly near the powerline.

other presentations:

Figures E3(a) and (b) show the example data in two other presentations where several channels are combined to give fewer, cleaner channels:

Figure E3(a): In this presentation Ch4 and 5 are combined to give a combined Ch"4" that is ~1.5 times as wide as the original Ch4. The Ch"4" is cleaner than the original. The original Ch5-10 are shown on the upper axis.

Figure E3(b): In this presentation Ch4-10 are combined to give a combined Ch"4" that is 2x as wide as the original Ch4 (equal in width to the original Ch3). The Ch"4" is as clean as the original Ch3. Note that Ch10 is added in twice to make the 2x factor exact. The original Ch5-10 are shown on the upper axis.

Discussion:

Several elements of UTEM survey design and procedure will have an affect on the number of useful channels in the final data set. These would include:

- careful positioning of the transmitter loops relative to the powerline(s)
- increasing the transmitter current (and the signal-to-noise ratio)
- care in the selection of gains during surveying. Near a source of coherent noise (eg powerline) the signal gain should be selected to minimize data rejections.

Consideration should also be given to increasing the station spacing in the vicinity of the powerline. This allows additional stacking to be done (at fewer stations) without much of an increase in surveying time.

Several other ways to increase the number of channels free of the powerline affects are:

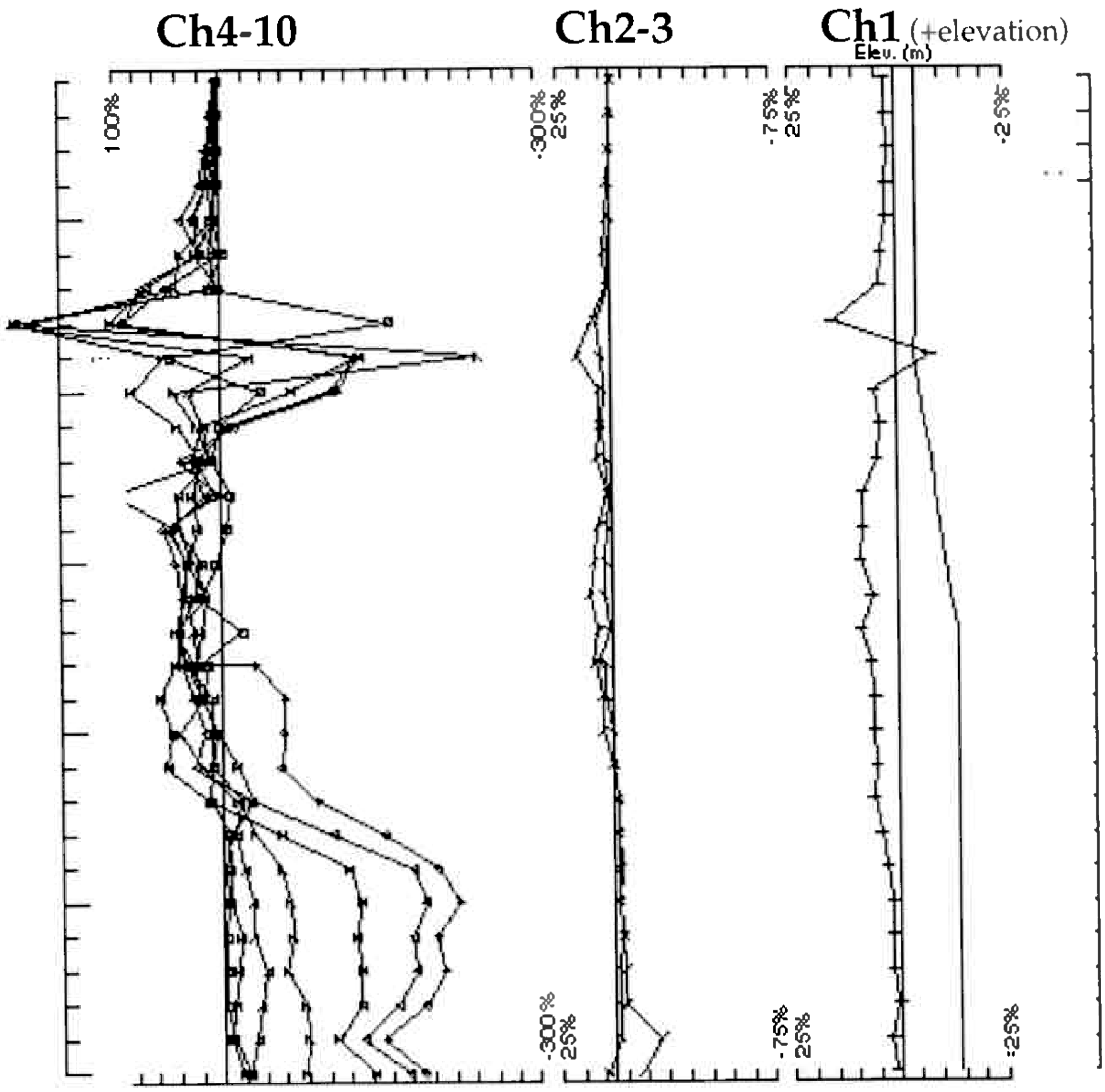
- lowering the frequency: each factor of two lower in frequency would add a channel relatively free of the affects of the powerline. The cost would be increased stacking time at each station.

- taking multiple readings: each reading starts at a different (random) point on the 60-cycle waveform. The sum of several readings will tend to better average out any affect.

- alternative channel sampling: Figure E2b) shows the standard UTEM 3 Boxcar channel sampling. An alternative - tapered channel sampling - is available (and often used) with UTEM 4. In this case if tapered sampling had been available it would likely have been used. The result would have been:

  - a slightly noisier Ch3
  - a considerably improved Ch4
  - an improved Ch5

  The choice of which sampling to use on a UTEM 4 survey depends on the frequency of the survey, the proximity and the frequency of any local powerline and the type of decay seen.



Loop	Secondary, (Chn-Ch1 / Hpl	
Line	Contin. Norm at a depth of 0m	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Compt: Hz	Base Freq. 3.872Hz	

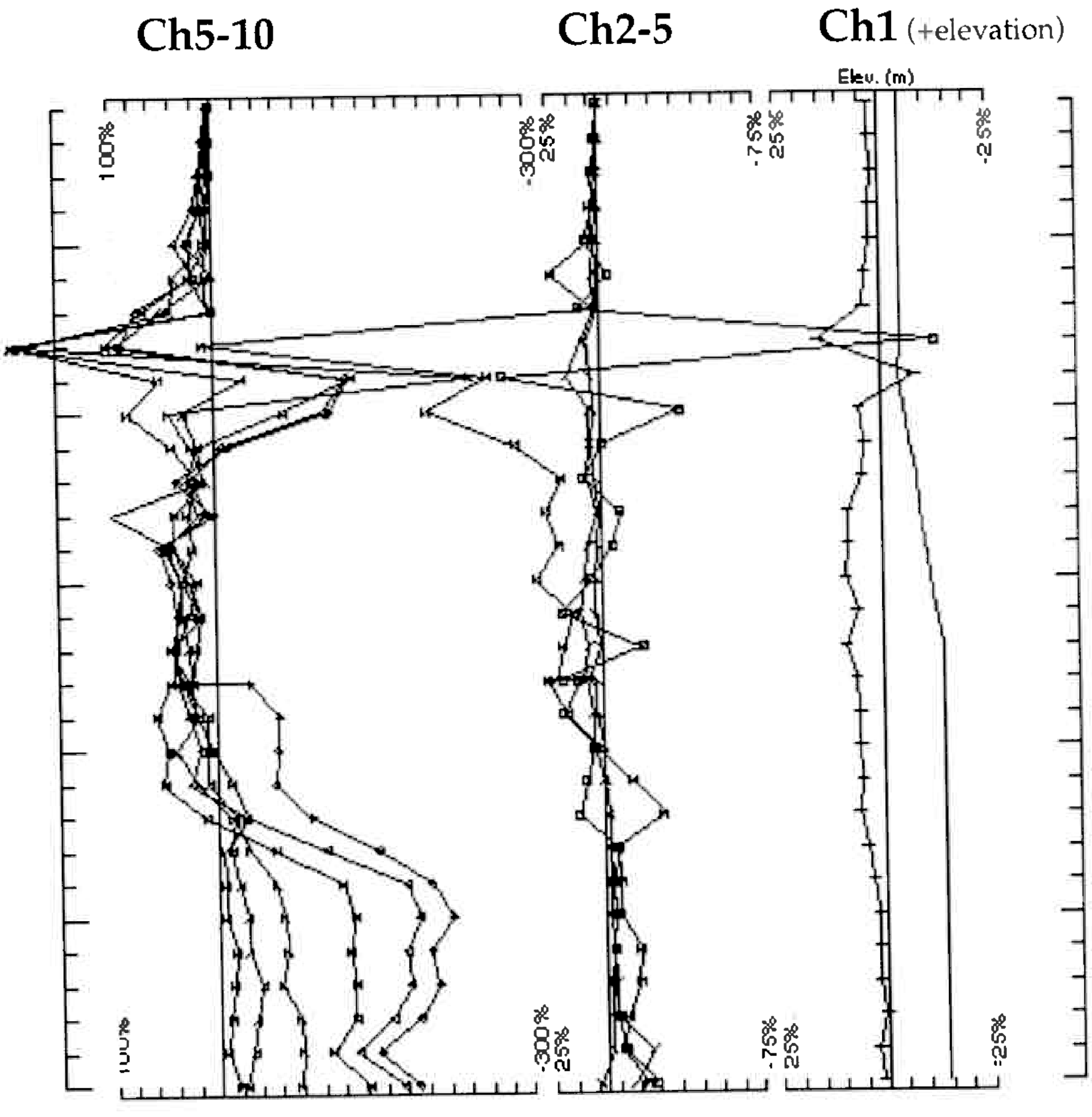
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Appendix E

Figure E1(a)

Original 4Hz data: alternative format

Figure E1a



Loop	Secondary, (Chn-Ch1/Hp)
Line	Contin. Norm at a depth of 0m
Compt: Hz	Base Freq. 3.872Hz

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

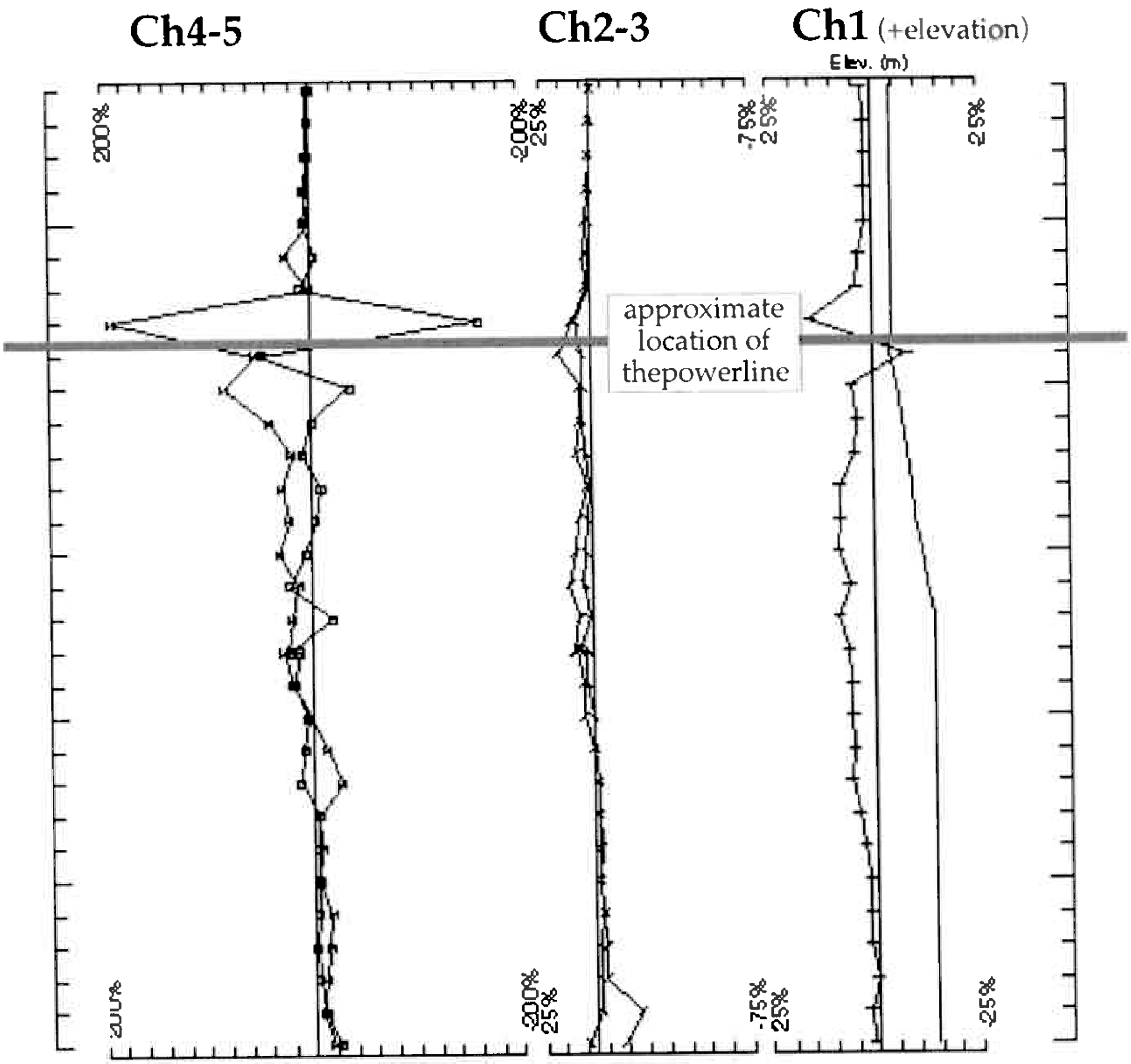
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Appendix E

Figure E1(b)

Original 4Hz data: standard format

Figure E1b



Loop	Secondary, (Chn-Ch1/Hp)	
Line	Contin. Norm at a depth of 0m	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Compt: Hz	Base Freq. 3.872Hz	

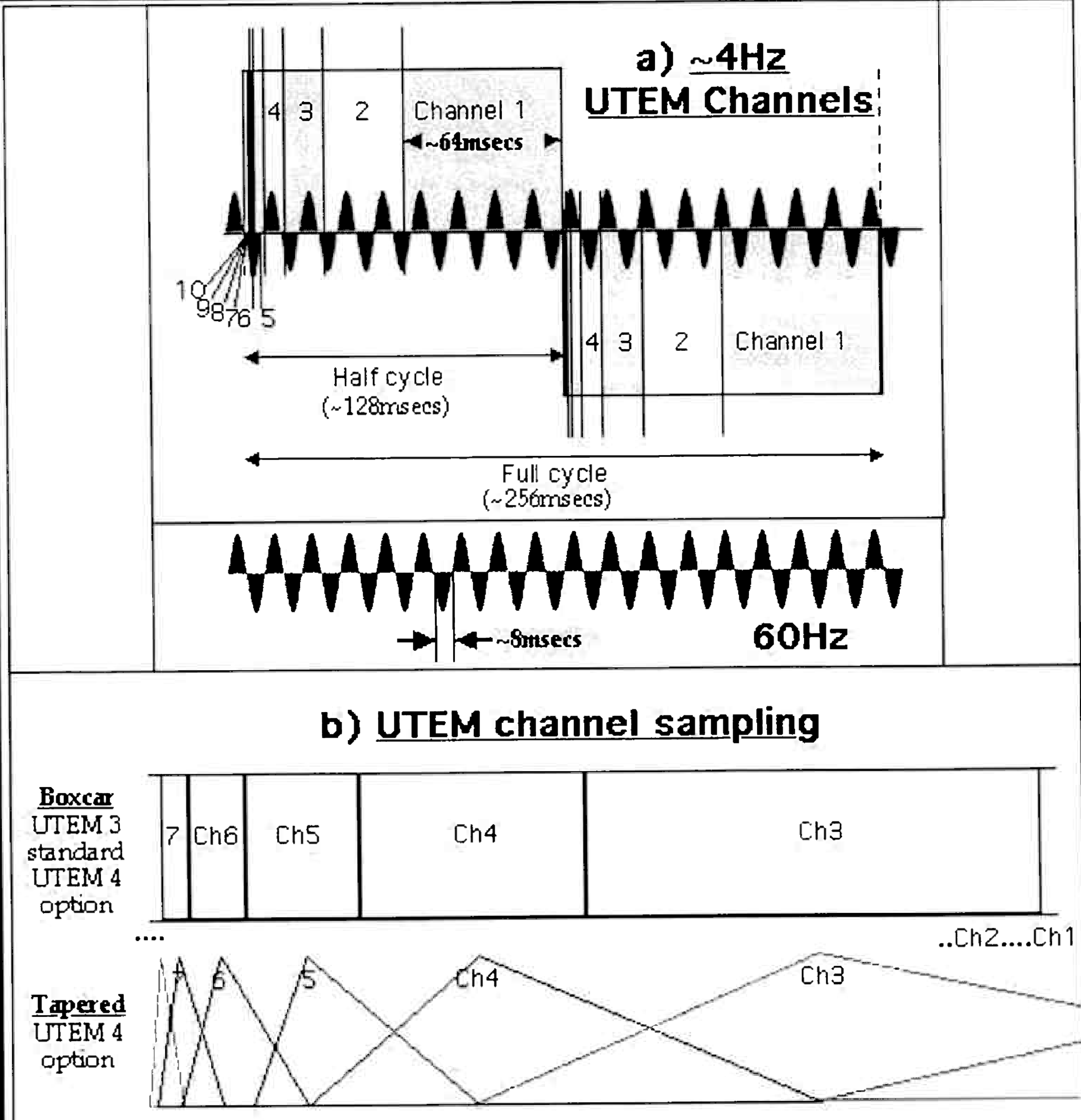
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Appendix E

Figure E1(c)

Original 4Hz data: Ch4/5 detail

Figure E1c



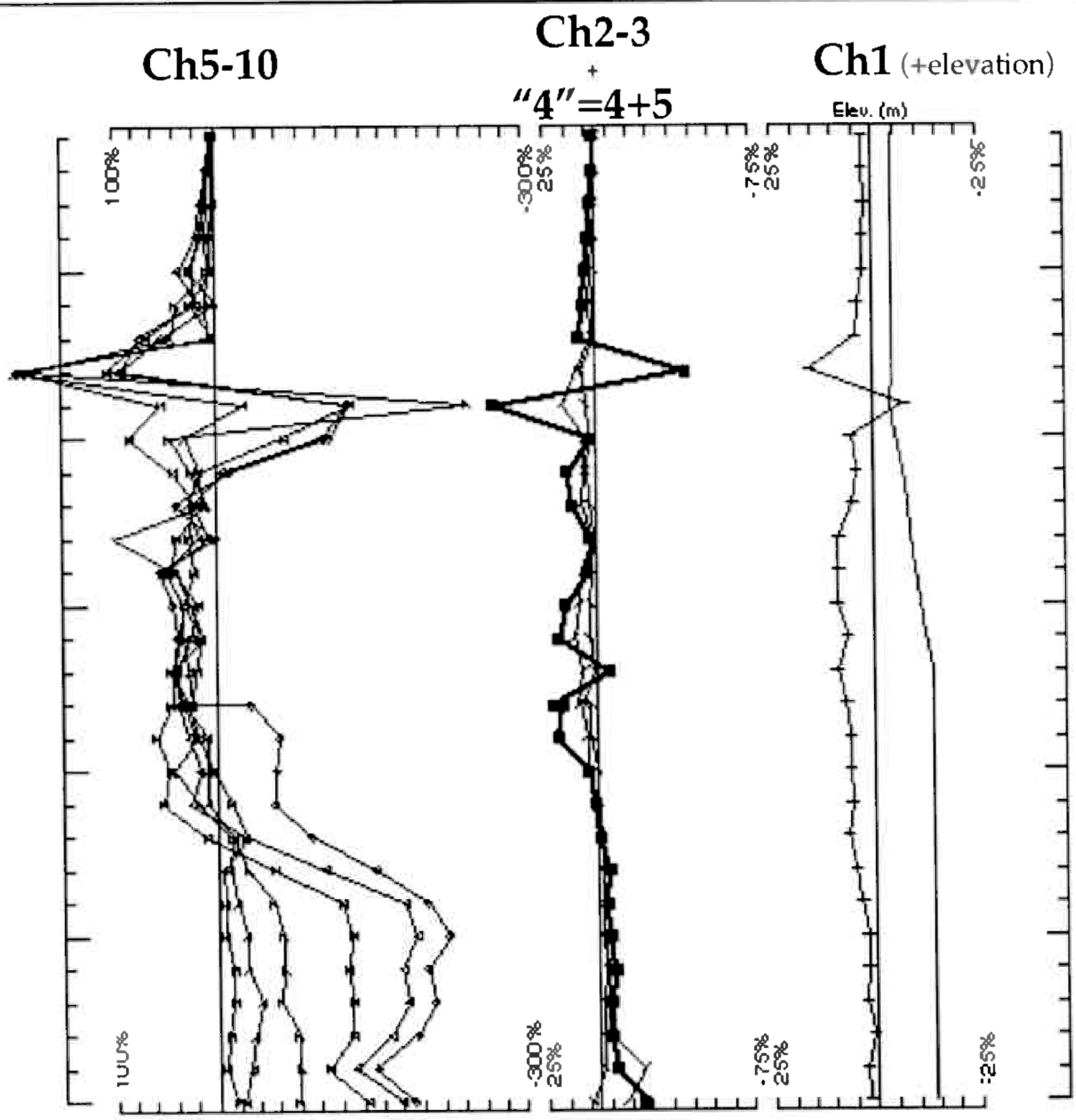
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Appendix E

Figure E2

a) ~4Hz UTEM Channels with 60Hz signal
b) UTEM Channel sampling options

Figure E2



Loop:	Secondary, (Chn-Ch1/Hpl
Line	Contin. Norm at a depth of 0m
Compt: Hz	Base Freq. 3.872Hz

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"modified" Ch4
=
2/3(Ch4+1/2Ch5)

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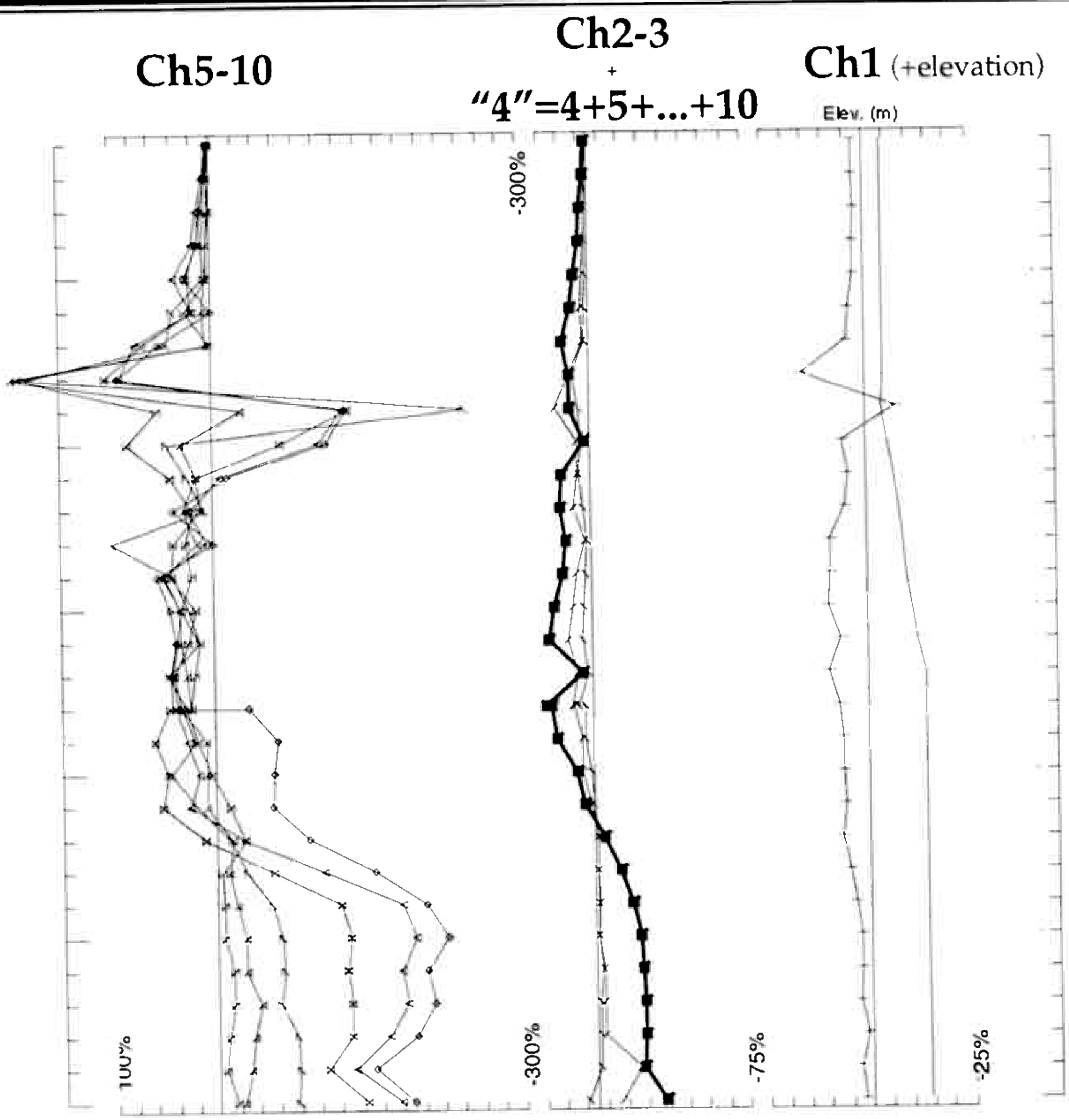
Appendix E

Figure E3(a)

Modified 4Hz data: Ch4/5 combined

Figure E3a



Loop:	Secondary, (Chn-Ch1/Hpl	
Line	Contin. Norm at a depth of 0m	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Compt: Hz	Base Freq. 3.872Hz	

"modified" Ch4
=
1/2Ch4+1/4Ch5+1/8Ch6+1/16Ch7)+
1/32Ch8+1/64Ch9+1/128Ch10+
1/128Ch10
Note: extra 1/128Ch10 to ~complete "modified" Ch4

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Appendix E

Figure E3(b)

Modified 4Hz data: Ch4-10 combined

Figure E3b