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A total of 29.250m "outside-the-loop UTEM data was collected using 4 transmitter loops with the receiver operating in 10-channel mode

- Interpretation Report -
2003 UTEM Survey
Espedalen
Norway
for
A/S Sulfidmalm

Original

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

June, 2003

Rob Langridge, M.Sc.

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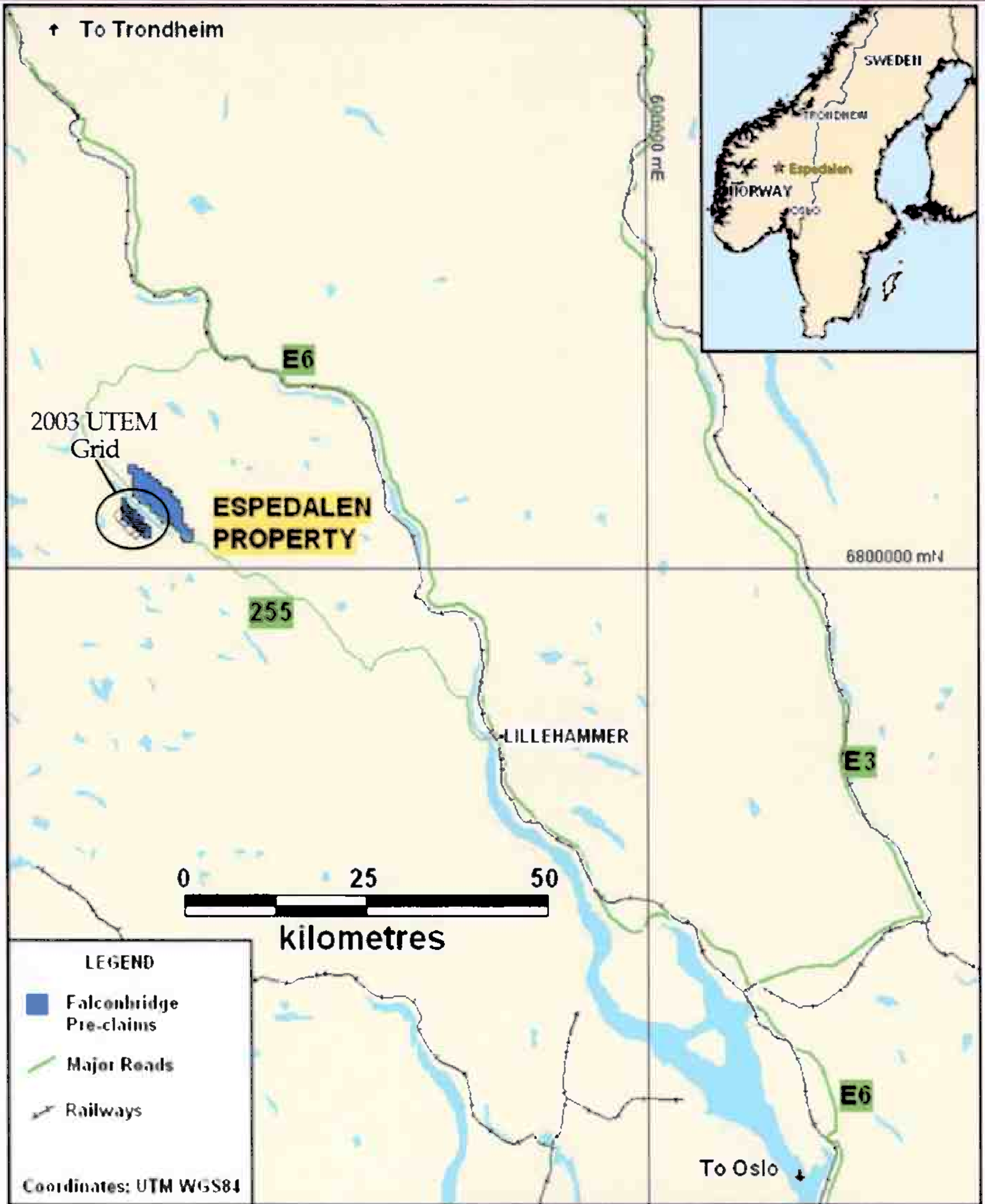
INTRODUCTION

During the period of April 2nd 2003 through April 16th 2003 a UTEM 3 survey was carried out by Lamontagne Geophysics Limited personnel for A/S Sulfidmalm in the area of Espedalen, Norway (Figure 1). The location of the property is shown in Figures 1 and 2. The survey was carried out to locate conductors in the immediate grid areas with the intention of outlining targets for future work.

A total of 29.250km of outside-the-loop UTEM data was collected using 4 transmitter loops with the receiver operating in 10-channel mode. A transmitter frequency of 3.251 Hz was used for all loops. All lines were surveyed measuring the vertical component, Hz. A station spacing of 25m and a line spacing of 200m was employed with detailing lines at 100m intervals as required.

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)



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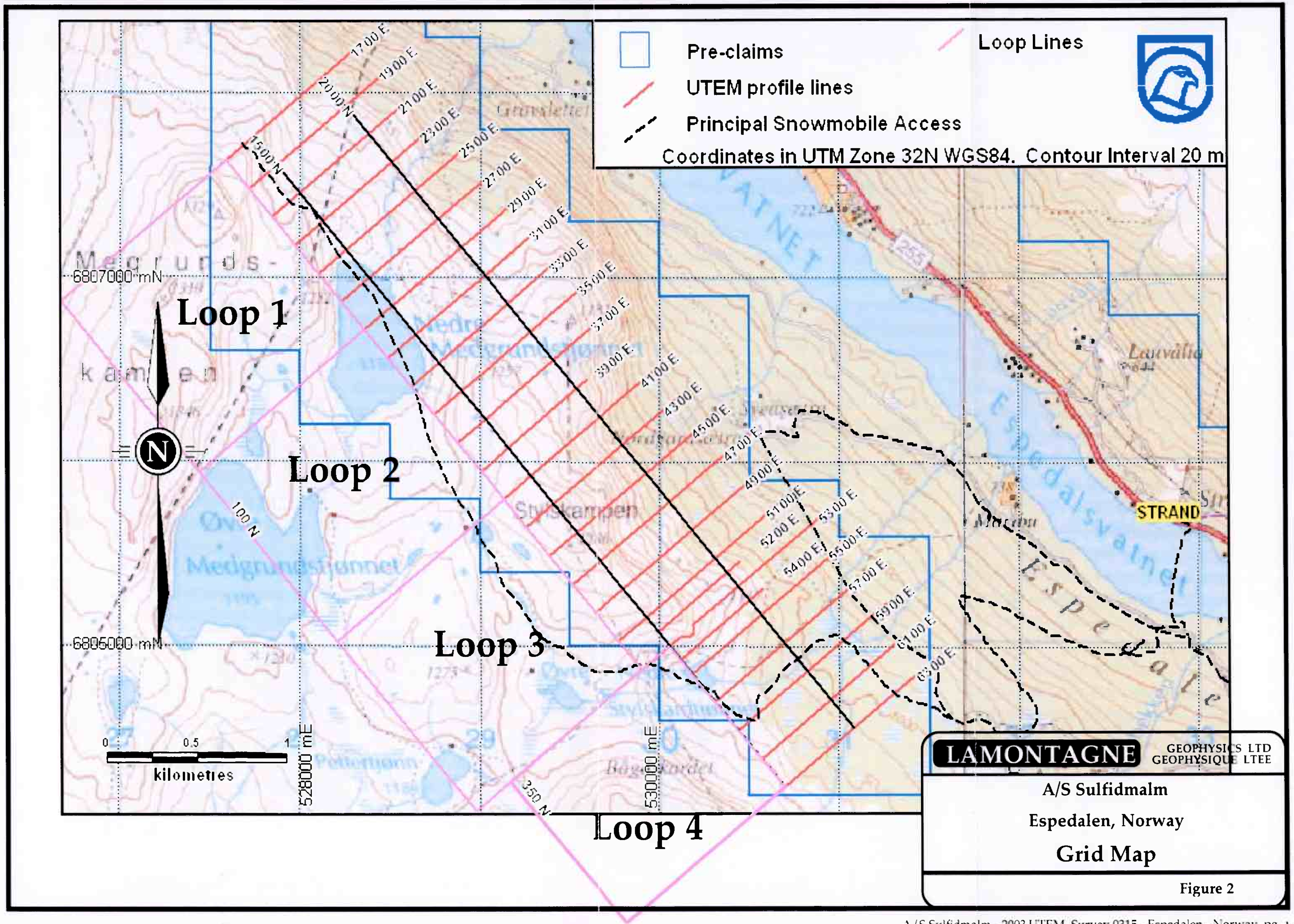
UTEM Survey Location Map

Figure 1



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Espedalen, Norway

Grid Map

Figure 2

SURVEY DESIGN

This UTEM survey is part of a nickel exploration program in the Espedalen 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 known conductors, to detect/outline new conductors and to detect/outline deeper features and depth continuations of known features.

The grid and loop layout was designed by A/S Sulfidmalm/Falconbridge Ltd. personnel to allow efficient coverage of the area. Loop size and locations were selected to provide good coupling with the expected targets and to allow efficient coverage of the grid area. 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 (or 1 receiver as available)
- approximately 2000x1200m transmitter loops
- 1.18mm (~1mm^2 ~17-gauge copper wire) doubled in places for increased current - more signal requires shorter stacking times and/or better quality data
- line spacing of 200m with detailing lines at 100m intervals as required
- 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 conductors are indicative of highly conductive mineralization. Any non-decaying anomalous channel 1 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 channel 1 conductors.

For this survey GPS data was collected by the client and made available for use in reducing the UTEM data. GPS data was collected for all survey points and at intervals around all transmitter loops. For reference future GPS collection for UTEM reduction should be more detailed along loop fronts - the most important portion of the loop from a UTEM reduction perspective. The goal along the loop front - and loop sides/back - is to recover the topographic shape loop as well as the loop/line intersection points.

SURVEY LOGISTICS

A Lamontagne Geophysics crew mobilized from Kingston on March 31st and arrived in Oslo on April 1st. The crew and equipment were picked up client representatives Jean Laforest and Dag Inge and driven to the base of operations for the Espedalen survey was Strand Fjellstue(Figure 1 - www.strand-fjellstue.no). The survey began the following morning.

Four transmitter loops were used during the UTEM survey for a total survey coverage of 29.250 km. Figure 2 shows the loop locations and grid layout. Access to the grid was by snowmobile along a series of pre-existing trails used for accessing the area by skiers/hikers etc. The grid/loop positions had been established by GPS and were demarcated by bamboo wands and flagging.

Surveying began with Loop 2. The wire for this loop was laid in advance by the client representatives. The generator (Honda 7500W) was already in position. 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. This worked well for the duration of the survey. The small-volume gas tank on the generator was the only drawback - it required filling 2-3 times a survey day.

In general surveying for all loops went well. Noise levels proved to be high and in places, along certain geologic structures, extremely high. This likely indicates channeling telluric currents along conductive features in the relatively-resistive host rock. In places individual stations were stacked for 4+ times the stacking used at neighbouring stations. In response to the noise levels stacking in general was increased and double wire was laid out. We had enough wire (~10km total) to double all sides on only one loop. The wire available coupled with the logistics of laying/picking up wire(s) in icy, steep terrain resulted in the doubling of the side-wires only - wires common to two loops. Comparison of the data from Loop 3 (two sides doubled) and Loop 2 (no sides doubled) shows that the Loop 3 data - more signal, more stacking - is less noisy (Appendix A).

Particular care was taken during the survey not to leave anything on the site. The very hard-packed snow on the northeast-facing slopes meant that protection was required on some survey lines. In practice the UTEM operators would work alone and Dag Inge, a qualified mountain guide, along with Jean Laforest would set up the protection. The protected portions would then be surveyed with a crew of two - operator plus coiler.

The final data was surveyed April 15th and all remaining wire was picked up April 16th along with a number of lines of pickets (all trace of the survey had to be removed after completion). The survey was declared completed and the equipment was packed for shipping. The equipment was transported to SAS cargo at Oslo Gardemoen Airport. The crew demobilized to Ontario, Canada. Details of the daily production and personnel are included in the Production Diary (Appendix B) along with a summary of production.

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. At the suggestion of the client snowshoes equipped with crampons were obtained for the survey - Dag Inge suggested that serrated frames would also have been useful. Given the conditions stiff boots - and insulated if possible - are recommended for kicking steps. Consideration should also be given to crampons/crampon-ready boots. Where required the protection involved a climbing harness. On future surveys crew could bring along a harness and even a climbing helmet if they have them available or are difficult to fit.

The weather conditions were generally good for surveying - cold nights and pleasant days. The snow conditions were generally good although towards the end of the survey the afternoon snow conditions were becoming pretty sticky. High winds stopped surveying for one day.

SURVEY RESULTS

The results of the survey are summarized and presented as UTEM profiles in Appendix A. The final grid and Loop Locations are presented in Figures 2. Overall the data quality is good - though in places it is noisy. A number 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.

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 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 tend towards zero.

top axis - Ch5-10
middle axis - Ch2-5
bottom axis - Ch1
bottom axis - ground magnetics - 48000 to 58000nT

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

normalization point: off-loop data ~400m out from the loop-front centre
inside-the-loop data @ the centre of the loop

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

The normalization point for off-loop surveys is typically 4-500m out from the centre of the loop front. The field at this point is intermediate (~1200m lines). 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**).

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

Discussion of the Grid

The profiles presented in Appendix A have been reduced with a grid produced from the GPS data and notes collected by the Lamontagne crew. The steps in this process are described above. The overall results of this process are quite good (Appendix A). Some of the character in Ch1 profiles is due to remaining errors in loop/line location - this is particularly true near the loop wire where errors in station/loop location/elevation have a larger effect (Appendix D). For reference future GPS collection for UTEM reduction should be more detailed along loop fronts - the most important portion of the loop from a UTEM reduction perspective. The goal along the loop front - and loop sides/back - is to recover the topographic shape loop as well as the loop/line intersection points.

It is also advisable to treat GPS data collection on grids for UTEM surveys as one would treat a land survey:

- surveying the loop front in a single pass and being sure to tie in all survey lines to the loop front (probably the most important factor)
- closing survey "loops"
- surveying BaseLines and survey Lines as single entities (where possible).

Discussion of Results

A number of responses of interest can be seen on the profiles. An interpretation is presented in two figures:

Figures 3 Interpreted Features
Figures 4 Interpretation

Features outlined are mainly contacts, shallow conductors and thin conductive zones - geological units and structural features. The best responses are in two areas :

Conductor A: Lines 5100E/5300E and infill Lines 5200E and 5400E ~1765N

- a sharp Ch2 anomaly at the southeastern tip of Stylskampen

Conductor B: Lines (2700E)/2900E/3100E/3300E/3500E ~1900-2100N

- a broad anomaly that correlates with known mineralization

Conductor A and **Conductor B** are discussed in detail in the Interpretation section.

Note that character on the Ch1 profiles may reflect one or a combination of (see Appendix D):

- local magnetics
- conductive features
- poor geometric control

Ch1 responses - spikes and broader features - should be checked against magnetics and rechecked against geometry. The character of the Ch1 profiles suggests that geometric control is quite good. Stations affected by poor geometry are close to the loop in locations where the loop shape is complicated by local topography.

A number of points can be said about the results in general:

- The pattern of responses outlined in Figure 3 generally fits with the map pattern of the geological mapping. Features are generally continuous over sections of the grid - some over the entire grid. Changes in strike/offsets occur coincide with breaks in topographic features and elevation changes. For example the map pattern of interpreted features (Figure 3) changes at the offset in the northeast-facing slope down to Espadalsvatnet between ~3800E and ~4200E. Line 3900E was stopped shorter than adjacent lines due to a sharp drop in elevation - the combination of the short line and the offset makes it more difficult to correlate features across this offset.

- Known mineralization on Lines 2900/3100/3300E and flanking lines shows a response (**Conductor B**) roughly midway along the survey lines. Extensions of these responses can be tracked across the grid. This indicates that the overall the grid locations were sufficiently accurate to cover the target geology.

- Responses reflect shallow features or features that have a shallow expression - possibly minor mineralization. Features outlined (Figures 3/4) are mainly contacts, shallow conductors and thin conductive zones - geological units and structural features.

- Overall the background response seen in the profiles indicates a resistive area.

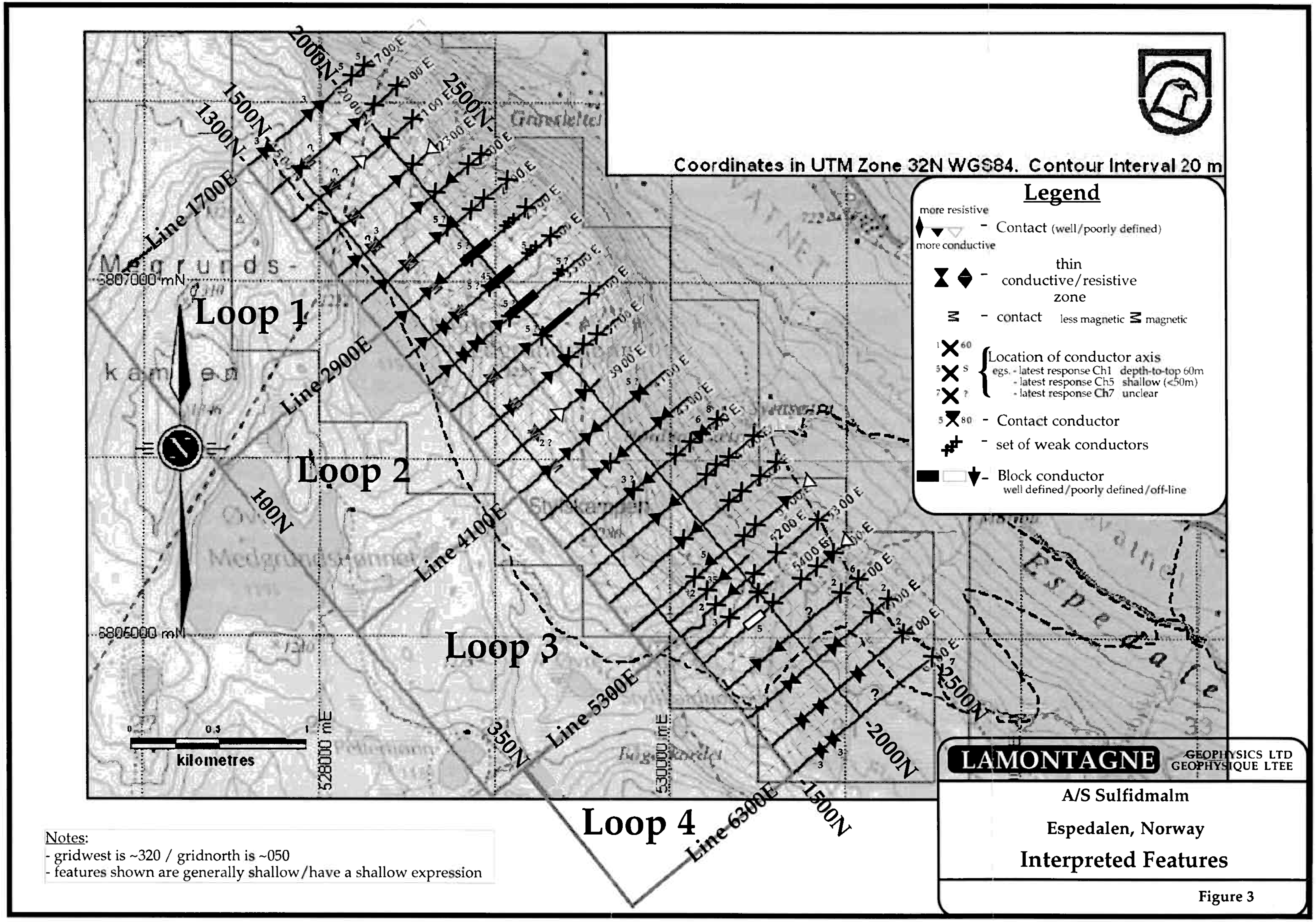
- In areas of steep terrain - where elevation changes markedly along survey lines - care should be exercised in interpreting responses. Responses are often "distorted". The situation is analogous to a borehole survey where the conductor is not necessarily beneath the survey - it may lie to the side or above.

- The profiles are in places fairly noisy - in particular the mid-to-late time channels. Some of this is wind noise but a good portion of it is geological noise - reflecting the character of the local mineralization - in places thin stringers of sulphides - and the lithology as evidenced by the spiky character of the ground magnetics. In this situation isolated stations are noisy - for example even though Line 2700E Station 1950N was stacked 4x as long (10 minutes vs 2.5 minutes) as the stacking used at flanking stations it appears noisy (Appendix A). Some stations were repeated doubling/tripling and in some cases using 4 times the stacking at specific stations on Lines 2100 E(1550, 1850 and 2025) and 2300E (1950, 2100). In general there is a noisy station that correlates to (Figure 3 - Line 2100E chosen for example):
  - a thin conductive zone ~1550E (Line 2100)
  - at the western edge of a magnetic feature ~1850E (Line 2100)
  - at the eastern edge of a magnetic feature ~2025E (Line 2100)

- There is generally a good correlation between the magnetic profiles plotted on the continuously normalized profiles (blue separators, Appendix A) and the Ch1 profiles - for example Loop 3 Line 4700E from 1950N-2300N. Note that the correlation is not expected to be exact (Appendix D).

- From ~Line 2100E through Line 3900E there is a weakly conductive feature that marks a change in lithology to a unit characterized by a more active/spiky magnetic signature - Line 2900E and 3100E are sharp examples. Stations coinciding with this transition are often noisy and required additional stacking. Grideast of Line 3900E this feature was not as noticeable - reflecting an offset or possibly deeper burial under Stylskampen.

- Lake Øvre Medgrundstjonnet is outlined by a series of weak contacts on Lines 2500-3300E @~1450N.


Coordinates in UTM Zone 32N WGS84. Contour Interval 20 m
Legend
more resistive
more conductive
- Contact (well/poorly defined)
thin conductive/resistive zone
- contact less magnetic magnetic
Location of conductor axis
egs. - latest response Ch1 depth-to-top 60m
- latest response Ch5 shallow (<50m)
- latest response Ch7 unclear
- Contact conductor
- set of weak conductors
- Block conductor
well defined/poorly defined/off-line
Loop 1
Loop 2
Loop 3
Loop 4
Line 1700E
Line 2900E
Line 4100E
Line 5300E
Line 6300E
1300N
1500N
2000N
2500N
100N
350N
-2000N
-1500N
6807000 mN
6806000 mN
528000 mE
530000 mE
0
0.5
1
kilometres
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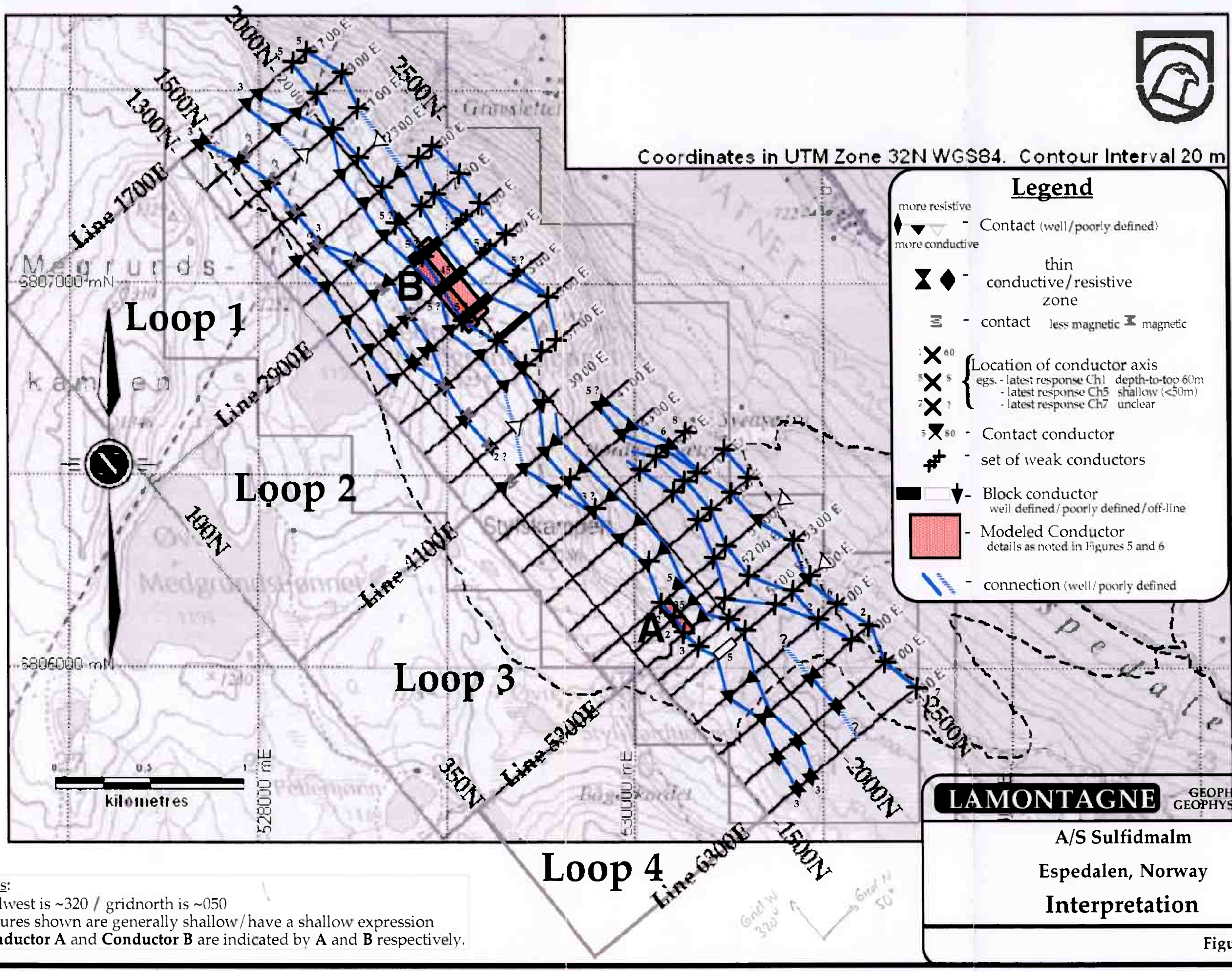
A/S Sulfidmalm
Espedalen, Norway
Interpreted Features
Figure 3
Notes:
- gridwest is ~320 / gridnorth is ~050
- features shown are generally shallow/have a shallow expression



Notes:
- gridwest is ~320 / gridnorth is ~050
- features shown are generally shallow / have a shallow expression
- **Conductor A** and **Conductor B** are indicated by **A** and **B** respectively.

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Espedalen, Norway

Interpretation

Figure 4

INTERPRETATION

An interpretation is presented in two figures:

Figures 3 Interpreted Features
Figures 4 Interpretation

Features outlined are mainly contacts, shallow conductors and thin conductive zones - geological units and structural features. These are discussed above. The best responses are two features along a trend that is interpreted (on the basis of this survey only) to be continuous across the extent of the area surveyed (Figure 4). This suggests that extending the survey along strike should be considered if the geology is favourable. The two best responses are:

Conductor A: Lines 5100E/5300E and infill Lines 5200E and 5400E ~1765N

- a sharp Ch2 anomaly at the southeastern tip of Stylskampen

Conductor B: Lines (2700E)/2900E/3100E/3300E/3500E ~1900-2100N

- a broad anomaly that correlates with known mineralization

An interpretation of these two features follows. Note: the Legend for Figures 3 and 4 is enlarged and presented as Figure 7.

<u>Conductor A</u> Lines 5100E/5300E and infill Lines 5200E and 5400E ~1765N

Conductor A was initially detected during surveying from Loop 3 as a feature strengthening to the grideast on across Lines 4900/5100/5300E. Note: when examining the profiles that Line 5300E just gridsouth of **Conductor A** was bent around a cliff - the southeastern tip of Stylskampen. Infill Lines 5200E and 5400E were set out and surveyed during the routine surveying of Loop 4. Line 5300E was repeated from Loop 4. The **Conductor A** response weakens to the grideast on Lines 5400/5500E. The overall best response detected was that on Loop 4 Line 5200E and this response was selected for MultiLoop modeling.

Modeling **Conductor A**: Loop 4 Line 5200E Figure 5

The modeling results for Loop 4 Line 5200E are shown in Figure 5. The overall background response was modeled using a laterally extensive conductive layer at a depth of 1100m. Details of the local response are modeled using a pair of conductors (pale blue in Figure 5). One of these is steeply-dipping (gridnorth) - the other is ~parallel to the conductor but laterally more extensive. **Conductor A** appears to be an enhancement along a conductive horizon. Details of **Conductor A** as modeled as listed in Figure 5 are:

centre of top 5200E, 1762N, 1105 m.a.s.l. (grid coords.)
local elevation ~1140 m.a.s.l. giving ~35m depth-to-top
strike/dip ~320/45° conductance 2000S
along strike/downdip 200m/85m

Conductor A is interpreted to be an excellent conductor - it should be evaluated in comparison with other known features in the local area. Primary field coupling is good but the feature is not maximum coupled as modeled suggesting that the conductance is a reasonable estimate - it could be higher. Increasing the strike length of the modeled body would act to lower the conductance somewhat.

Conductor B Lines (2700E)/2900E/3100E/3300E/3500E ~1900-2100N

The survey started with Lines 2900/3100E as surveyed from Loop 2 to cover **Conductor B**. Line 2900E was repeated from Loop 1. The **Conductor B** response changes character along strike and weakens gridwest of Line 2900E/grideast of Line 3500E. The response is generally that of a flat-lying conductor or a top anomaly. The main response is complicated by a set of noisy, weaker responses may indicate the presence of stringer mineralization. The overall best response detected was that on Loop 2 Line 3100E and this response was selected for MultiLoop modeling.

Modeling **Conductor B**: Loop 2 Line 3100E Figure 6

The modeling results for Loop 2 Line 3100E are shown in Figure 6. The overall background response was modeled using laterally extensive conductive layers at a depth of 1100m and 400m respectively. Details of the local response are modeled using a set of conductors (pale blue in Figure 6). Three of these are steeply-dipping (gridnorth) - the other is bracketed by two of the steeply-dipping conductors and is ~parallel to the **Conductor B** but is laterally more extensive. Like the case for **Conductor A, Conductor B** appears to be an enhancement along a conductive horizon. **Conductor B** has been modeled as a set of two similar plates offset slightly vertically and slightly overlapping. Details of **Conductor B** as modeled as listed in Figure 5 are:

centre of top gridsouth plate 3100E, 1940N, 1070 m.a.s.l. (grid coords.)
local elevation ~1110 m.a.s.l. giving ~40m depth-to-top
along strike/downdip 500m/80m
strike/dip ~320/10° conductance 175S

centre of top gridnorth plate 3100E, 2015N, 1050 m.a.s.l. (grid coords.)
local elevation ~1100 m.a.s.l. giving ~50m depth-to-top
along strike/downdip 500m/95m
strike/dip ~320/10° conductance 175S

Conductor B is interpreted to be a ~175S conductor - it should be evaluated in comparison with other known features in the local area. **Conductor B** is maximum coupled as modeled suggesting that the conductance is a reasonable but minimum estimate. The later channels are noisy coincident with **Conductor B** suggesting that sharp features - stringers of mineralization? - may be present.

It has been noted that **Conductors A** and **B** are interpreted to fall along the same trend (in this report on the basis of this survey). Perhaps not surprisingly the modeling results share several characteristics:

- the main conductive zone is modeled to be an enhancement along a conductive horizon that dips ~gently gridnorth.
- the main conductive zone is modeled to be ~bracketed by steeply grideast dipping features.

This suggests that what is known about **Conductor B** should be useful in evaluating **Conductor A**.

Espedalen Grid 2003 -Loop 4
Conductor A -Line 5200E Modeling

Conductor A as modeled

centre of top
(x,y,z)=5200E, 1762N, 1105 m.a.s.l.
(grid coords.)

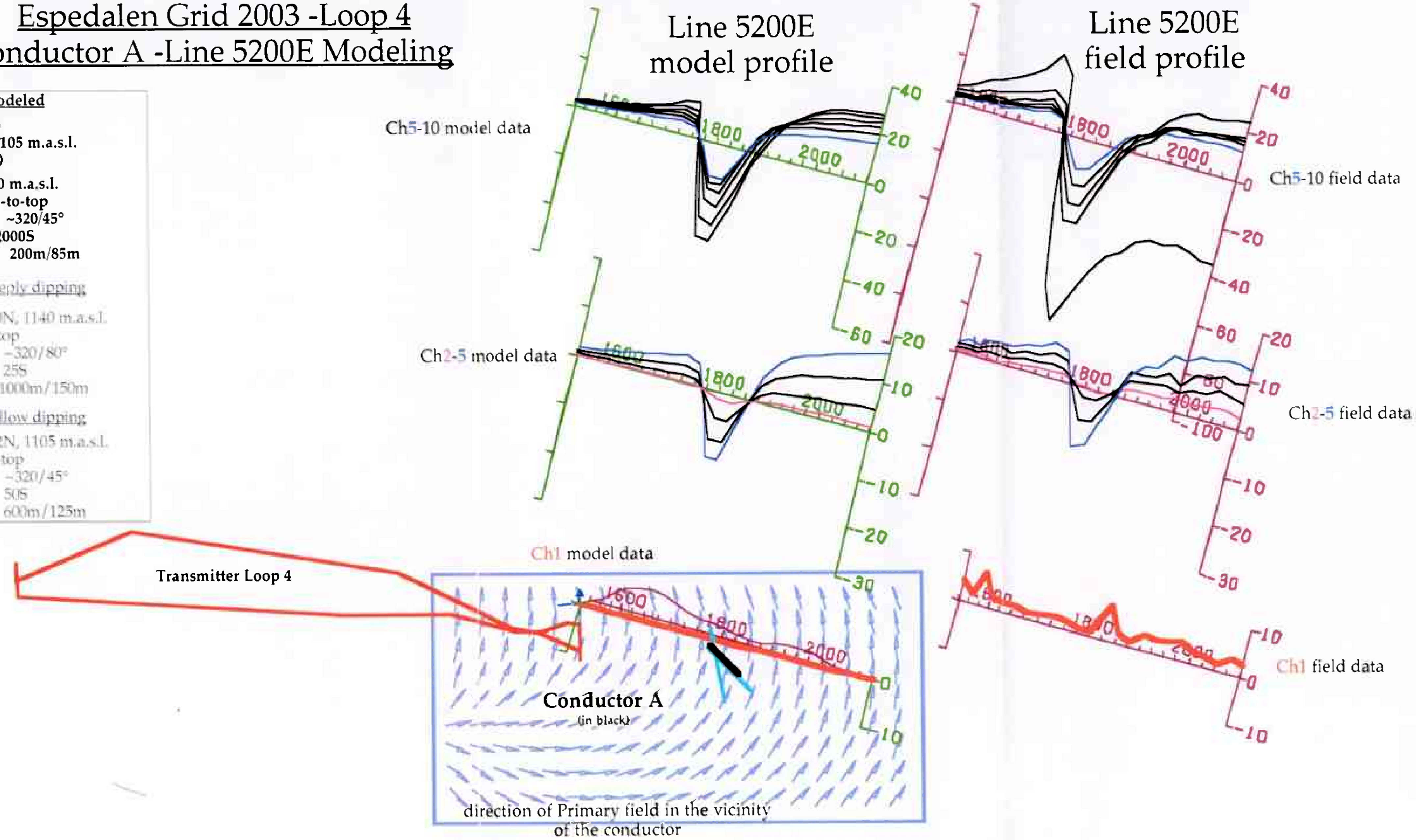
local elevation ~1140 m.a.s.l.
giving ~35m depth-to-top
strike/dip ~320/45°
conductance 2000S
along strike/downdip 200m/85m

light blue conductor - steeply dipping

centre of top 5200E, 1770N, 1140 m.a.s.l.
~2m depth-to-top
strike/dip ~320/80°
conductance 25S
along strike/downdip 1000m/150m

light blue conductor - shallow dipping

centre of top 5200E, 1762N, 1105 m.a.s.l.
~35m depth-to-top
strike/dip ~320/45°
conductance 50S
along strike/downdip 600m/125m



Notes:
- view is looking gridwest (~320)
- conductor as modeled is well-coupled but not maximum coupled.
- locations are listed in Grid coordinates - refer to GPS notes for UTM locations.
- conductors shown in light blue model the background/current channeling/local response in the vicinity of the conductor.
- conductor shown in pink (laterally extensive, centred under loop, ~1100m deep, 30S) models the overall background response.

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Conductor A - Modeling Line 52+00E

Espedalen 2003 Grid

0 100 500m

Figure 5

Espedalen Grid 2003 -Loop 2
Conductor B -Line 3100E Modeling

Conductors B as modeled - 2 plates

centre of top - gridsouth plate
(x,y,z)=3100E, 1940N, 1070 m.a.s.l.
~40m depth-to-centre
along strike / downdip 500m/80m

centre of top - gridnorth plate
(x,y,z)=3100E, 2015N, 1050 m.a.s.l.
~50m depth-to-centre
along strike / downdip 500m/95m

strike/dip (both) ~320/10°
conductance (both) 175S

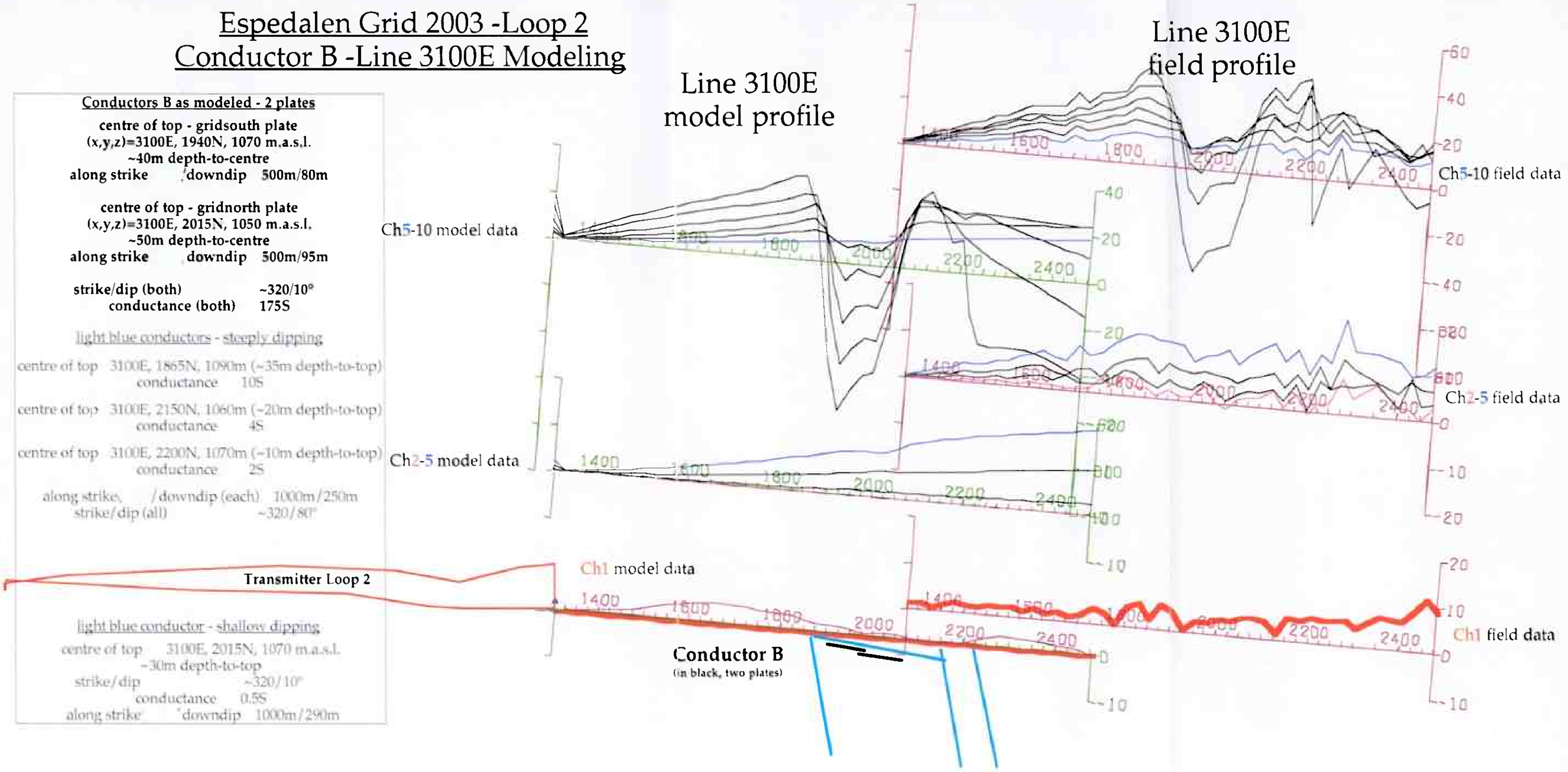
light blue conductors - steeply dipping

centre of top 3100E, 1865N, 1090m (~35m depth-to-top)
conductance 10S

centre of top 3100E, 2150N, 1060m (~20m depth-to-top)
conductance 4S

centre of top 3100E, 2200N, 1070m (~10m depth-to-top)
conductance 2S

along strike / downdip (each) 1000m/250m
strike/dip (all) ~320/80°



light blue conductor - shallow dipping

centre of top 3100E, 2015N, 1070 m.a.s.l.
~30m depth-to-top
strike/dip ~320/10°
conductance 0.5S
along strike / downdip 1000m/290m

400m depth, 2S

Notes:
- view is looking gridwest (~320)
- conductor as modeled is ~maximum coupled.
- locations are listed in Grid coordinates - refer to GPS notes for UTM locations.
- conductors shown in light blue model the background / current channeling / local response in the vicinity of the conductor.
- conductors shown in pink (laterally extensive, centred under loop, as labelled) model the overall background response.

1100m depth, 15S

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Conductor B - Modeling Line 31+00E

Espedalen 2003 Grid

0 100 500m

Figure 6

CONCLUSIONS AND RECOMMENDATIONS

The results of the survey are summarized and presented as UTEM profiles in Appendix A. Overall the data quality is good and a number of conductive features are evident. The final Grid and Loop Locations are presented in Figure 2 and an interpretation is presented in Figures 3 and 4. Features outlined are mainly contacts, shallow conductors and thin conductive zones - geological units and structural features. The pattern of responses outlined in Figures 3 and 4 fits the map pattern of the geological mapping and in general indicates that field location of the grids was sufficiently accurate to cover the target geology.

The best responses are two features along a trend that is interpreted on the basis of this survey only to be continuous across the extent of the area surveyed (Figure 4). This suggests that extending the survey along strike should be considered if the geology is favourable. The two best responses were selected for MultiLoop modeling:

Conductor A: Lines 5100E/5300E and infill Lines 5200E and 5400E ~1765N

- a sharp Ch2 anomaly at the southeastern tip of Stylskampen
- details of **Conductor A** as modeled with a single plate are (Figure 5):

centre of top 5200E, 1762N, 1105 m.a.s.l. (grid coords.)
local elevation ~1140 m.a.s.l. giving ~35m depth-to-top
along strike/downdip 200m/85m
strike/dip ~320/45° conductance 2000S

Conductor A is interpreted to be an excellent conductor - it should be evaluated in comparison with other known features in the local area.

Conductor B: Lines (2700E)/2900E/3100E/3300E/3500E ~1900-2100N

- a broad anomaly that correlates with known mineralization
- details of **Conductor b** as modeled with two plates are (Figure 6):

centre of top gridsouth plate 3100E, 1940N, 1070 m.a.s.l. (grid coords.)
local elevation ~1110 m.a.s.l. giving ~40m depth-to-top
along strike/downdip 500m/80m
strike/dip ~320/10° conductance 175S

centre of top gridnorth plate 3100E, 2015N, 1050 m.a.s.l. (grid coords.)
local elevation ~1100 m.a.s.l. giving ~50m depth-to-top
along strike/downdip 500m/95m
strike/dip ~320/10° conductance 175S

Conductor B is interpreted to be a ~175S conductor - it should be evaluated in comparison with other known features in the local area.

Conductors A and **B** are interpreted to fall along the same trend (in this report on the basis of this survey). Modeling results share several characteristics:

- the main conductive zone is modeled to be an enhancement along a conductive horizon that dips ~gently gridnorth.
- the main conductive zone is modeled to be ~bracketed by steeply grideast dipping features.

This suggests that what is known about **Conductor B** should be useful in evaluating **Conductor A**.

The profiles presented in Appendix A have been reduced with a grid corrected as well as possible using available information. The location of all survey points and loop locations were collected using a GPS system. For reference future GPS collection for UTEM reduction should be more detailed along loop fronts - the most important portion of the loop from a UTEM reduction perspective. The goal along the loop front - and loop sides/back - is to recover the topographic shape loop as well as the loop/line intersection points.

Noise levels during the survey proved to be high and in places, along certain geologic structures, extremely high. Doubling the loop wire or the use of a heavier gauge wire would allow higher transmitter currents - increasing the signal-to-noise ratio of the survey and improving data quality. In addition care should be taken to ensure that stacking is adjusted on a station-by-station basis to allow for noisy stations.

Legend

more resistive

– Contact (well/poorly defined)

more conductive

– thin conductive/resistive zone

– contact less magnetic magnetic

1 60

5 S

7 ?

Location of conductor axis

egs. - latest response Ch1 depth-to-top 60m

- latest response Ch5 shallow (<50m)

- latest response Ch7 unclear

5 80 – Contact conductor

– set of weak conductors

– Block conductor

well defined/poorly defined/off-line

– Modeled Conductor

details as noted in Figures 5 and 6

– connection (well/poorly defined

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

A/S Sulfidmalm

2003 Espedalen UTEM Survey

Interpretation Legend

Figure 7

Appendix A

0315 UTEM Profiles

UTEM 3 Survey

Espedalen
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 Locations are presented in Figures 2. Overall the data quality is good - though in places it is noisy. A number of conductors and/or 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 following order:

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

Outline of 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 tend towards zero.

top axis - Ch5-10
middle axis - Ch2-5
bottom axis - Ch1
bottom axis - ground magnetics - 48000 to 58000nT

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

normalization point: off-loop data ~400m out from the loop-front centre
inside-the-loop data @ the centre of the loop

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

The normalization point for off-loop surveys is typically 4-500m out from the centre of the loop front. The field at this point is intermediate (~1200m lines). 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)**.

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

<u>List of Data Collected and Plotted</u>

Espedalen 2003 Grid

Surface coverage - @ 3.251 Hertz

	Line	coverage	
Loop 1	Line 17+00E	13+00N-22+25N	925m
	Line 19+00E	13+00N-22+50N	950m
	Line 21+00E	13+00N-23+00N	1000m
	Line 23+00E	13+00N-22+25N	925m
	Line 25+00E	13+00N-24+50N	1150m
	Line 27+00E	13+00N-24+50N	1150m
	Line 29+00E	13+00N-25+00N	1200m
		Loop 1 Total	7300m
Loop 2	Line 29+00E	13+00N-25+00N	1200m
	Line 31+00E	13+00N-24+75N	1175m
	Line 33+00E	13+00N-23+75N	1075m
	Line 35+00E	13+00N-24+75N	1175m
	Line 37+00E	13+00N-23+75N	1075m
	Line 39+00E	13+00N-20+75N	775m
		Loop 2 Total	6475m
Loop 3	Line 41+00E	13+00N-24+00N	1100m
	Line 43+00E	13+00N-24+00N	1100m
	Line 45+00E	13+00N-24+75N	1175m
	Line 47+00E	13+00N-26+00N	1300m
	Line 49+00E	13+00N-25+75N	1275m
	Line 51+00E	13+00N-25+50N	1250m
	Line 53+00E	13+00N-26+00N	1300m
		Loop 3 Total	8500m
Loop 4	Line 52+00E	15+00N-21+00N	600m
	Line 53+00E	15+00N-20+00N	500m
	Line 54+00E	15+00N-21+00N	600m
	Line 55+00E	15+00N-26+00N	1100m
	Line 57+00E	15+00N-25+50N	1050m
	Line 59+00E	15+00N-25+75N	1075m
	Line 61+00E	15+00N-25+50N	1050m
	Line 63+00E	15+00N-25+00N	1000m
		Loop 4 Total	6975m

Espedalen Total **29.250km**

Espedalen

Loop 1

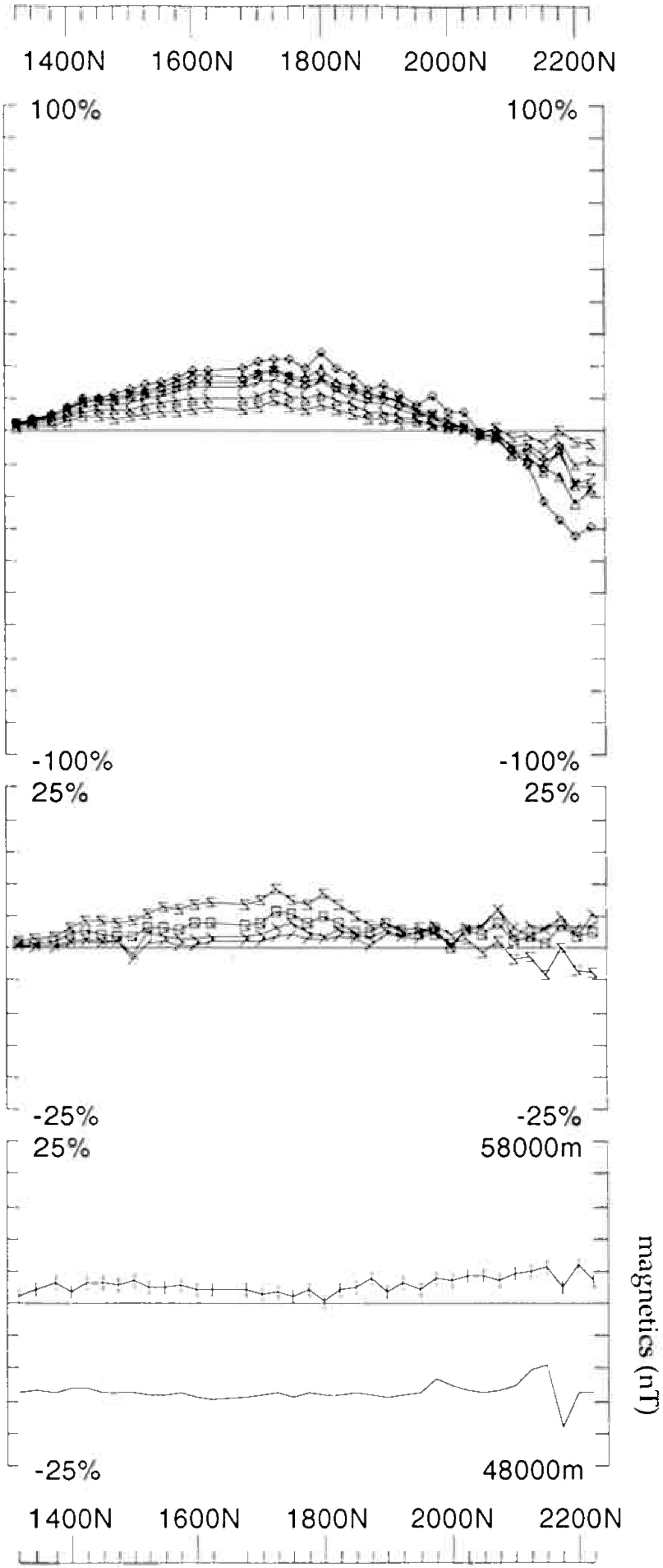
Hz
@3.251 Hz frequency

continuous norm

Ch1 reduced

Loop 1	Line 17+00E	13+00N-22+25N	925m
	Line 19+00E	13+00N-22+50N	950m
	Line 21+00E	13+00N-23+00N	1000m
	Line 23+00E	13+00N-22+25N	925m
	Line 25+00E	13+00N-24+50N	1150m
	Line 27+00E	13+00N-24+50N	1150m
	Line 29+00E	13+00N-25+00N	1200m
		Loop 1 Total	7300m

Loop 1 - continuous norm



Loop: 1
Line: 1700E
Compt: Hz

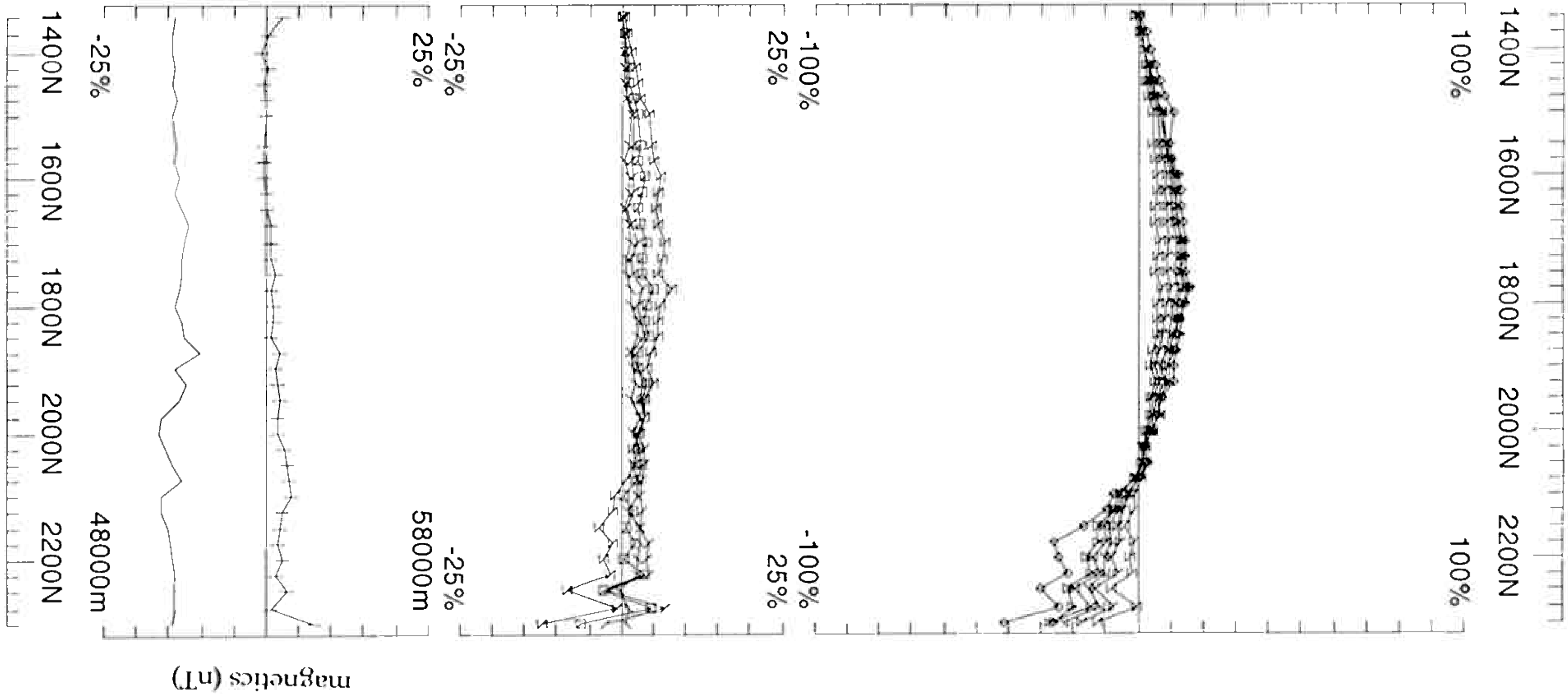
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

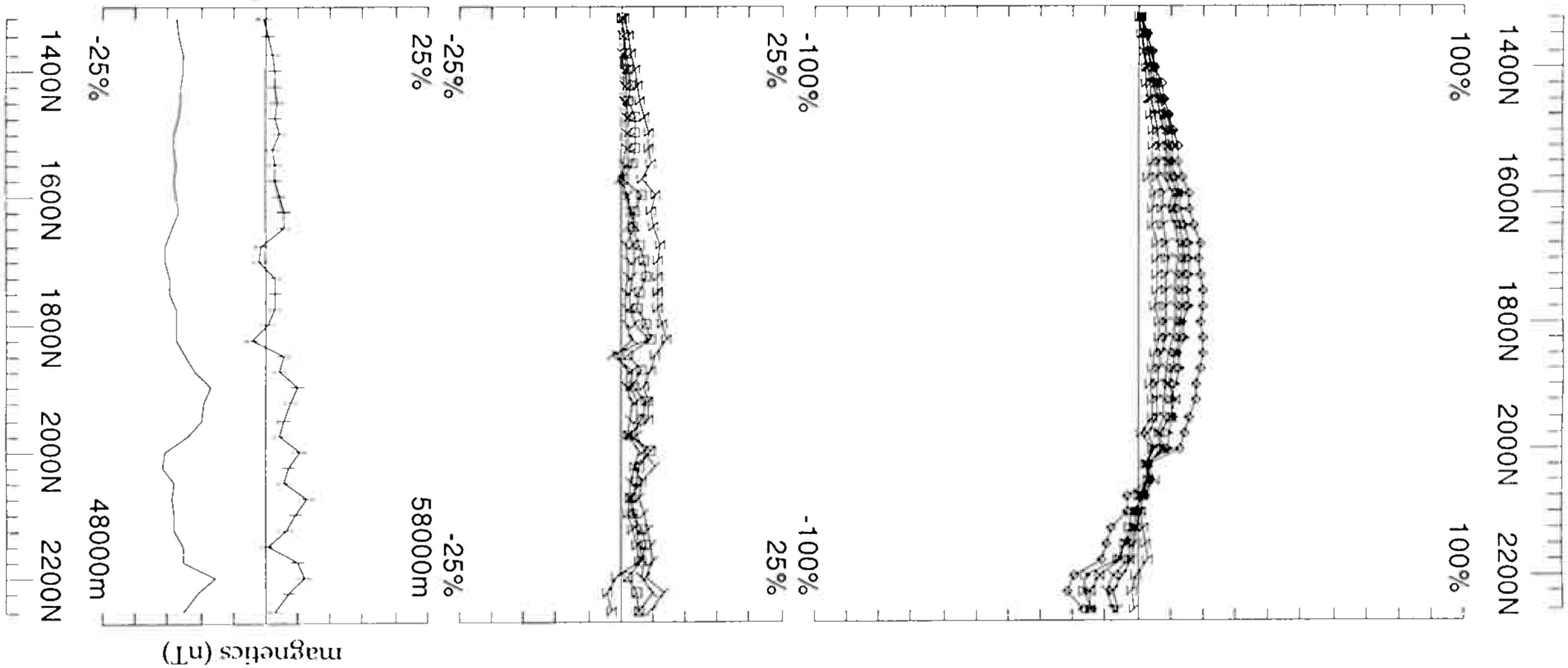
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0315

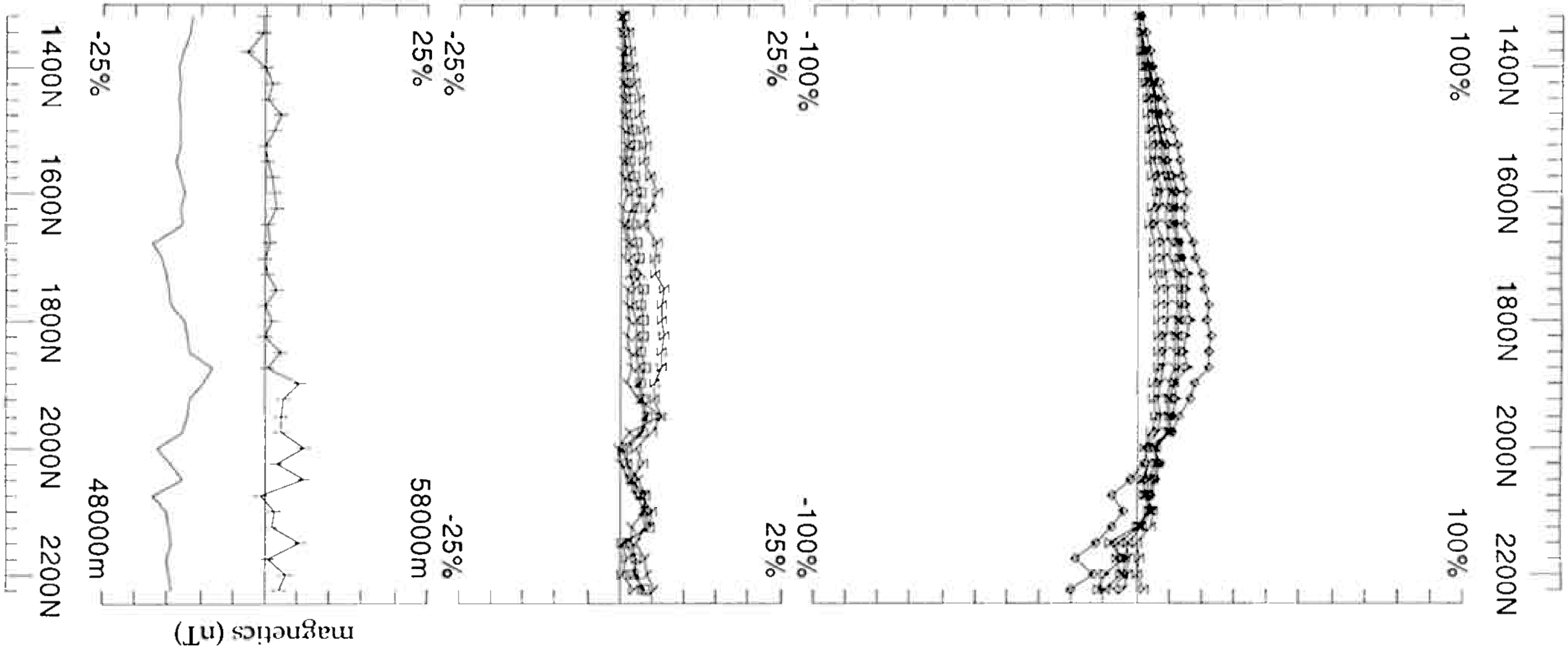
Surveyed : 20/2/48
Reduced : 23/4/3
Plotted : 24/4/3



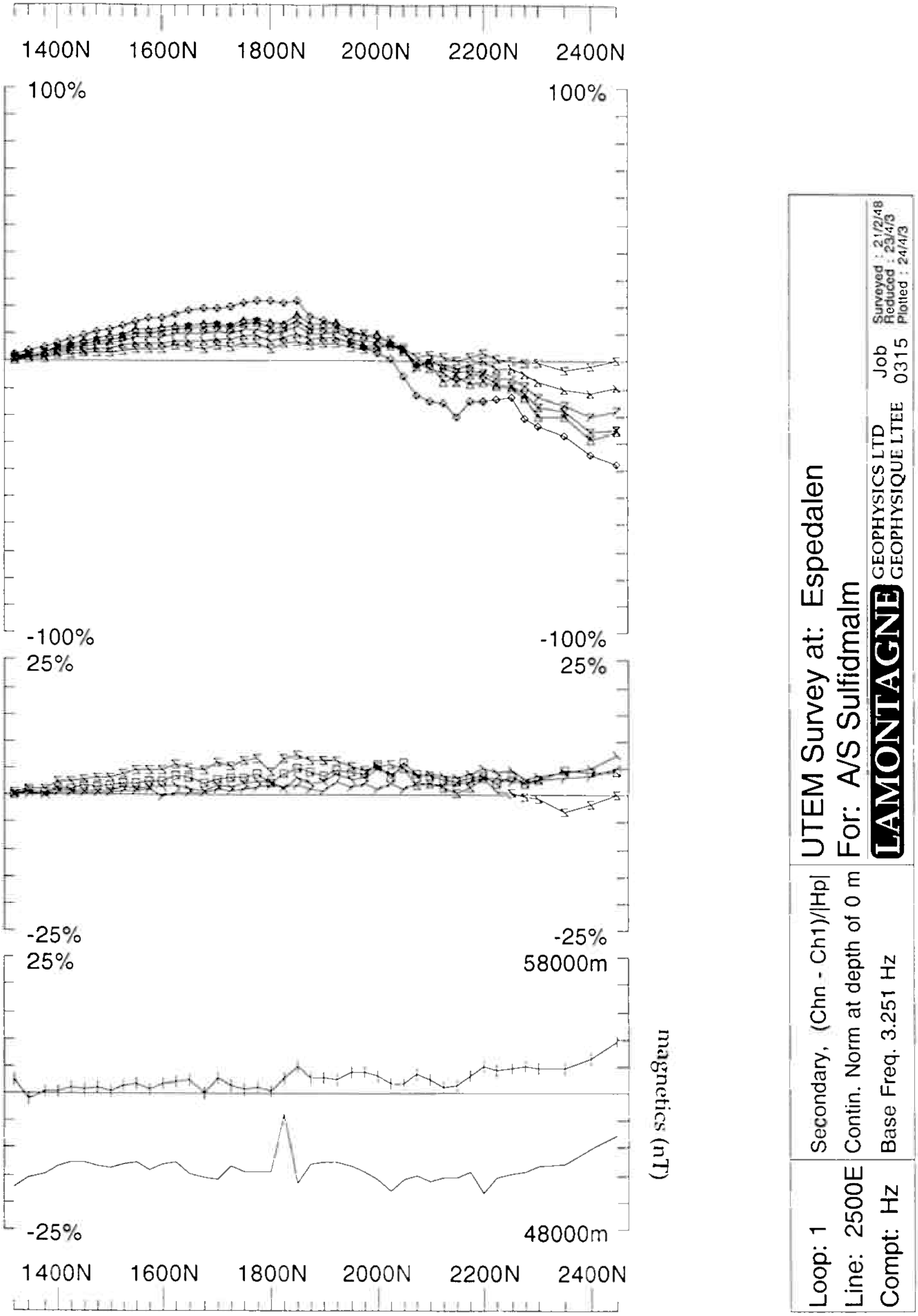
Loop: 1	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 1900E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Plotted : 24/4/3



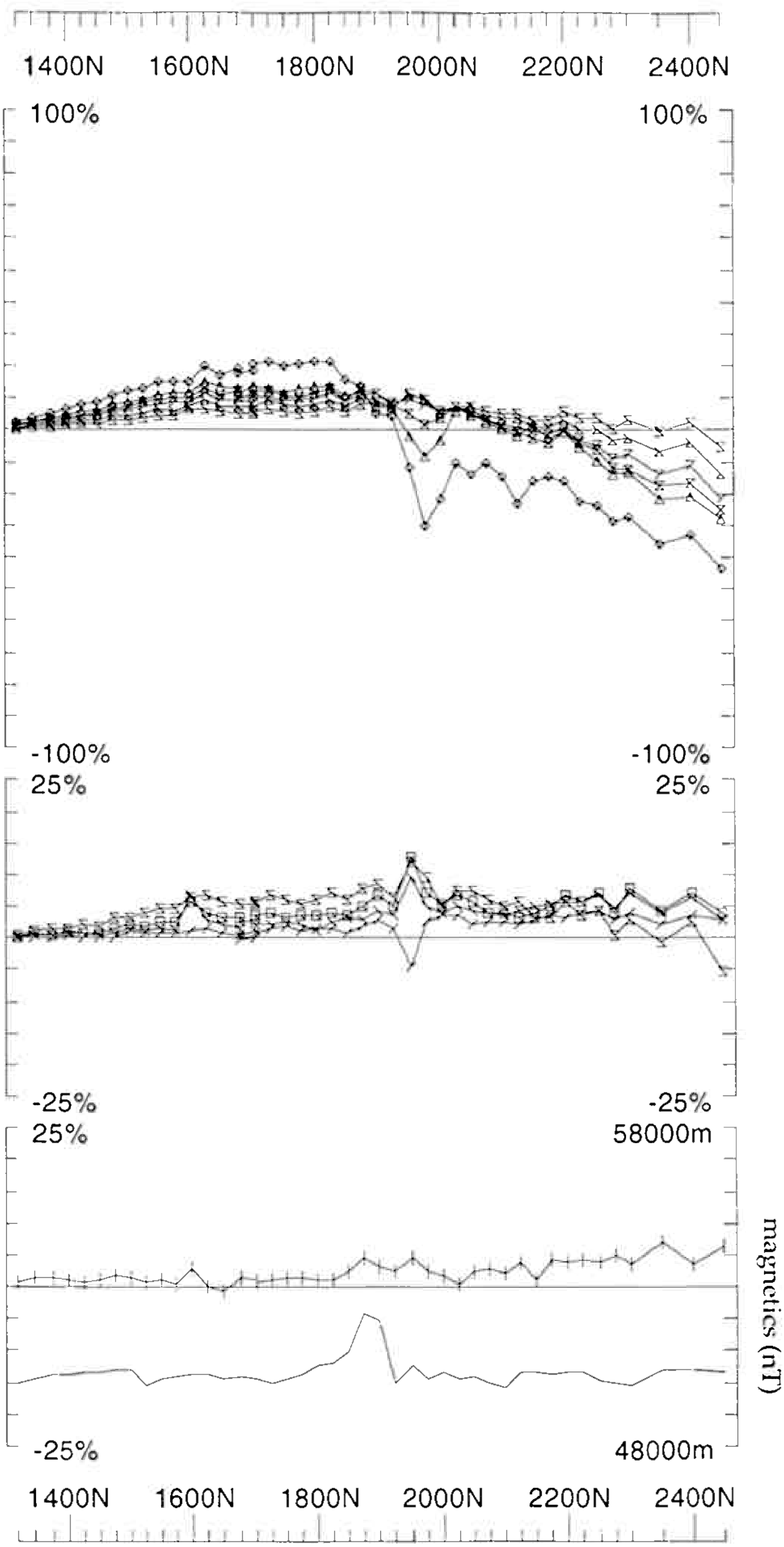
Loop: 1	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 2100E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 20/2/48 Reduced : 23/4/3 Plotted : 24/4/3



Loop: 1	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 2300E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 20/2/48 Reduced : 23/4/3 Plotted : 24/4/3



1400N
1600N
1800N
2000N
2200N
2400N
100%
100%
-100%
-100%
25%
25%
-25%
-25%
25%
58000m
magnetics (nT)
-25%
48000m
1400N
1600N
1800N
2000N
2200N
2400N
Loop: 1
Line: 2500E
Compt: Hz
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE
Job 0315
Surveyed : 21/2/48
Reduced : 23/4/3
Plotted : 24/4/3



Loop: 1
Line: 2700E
Compt: Hz

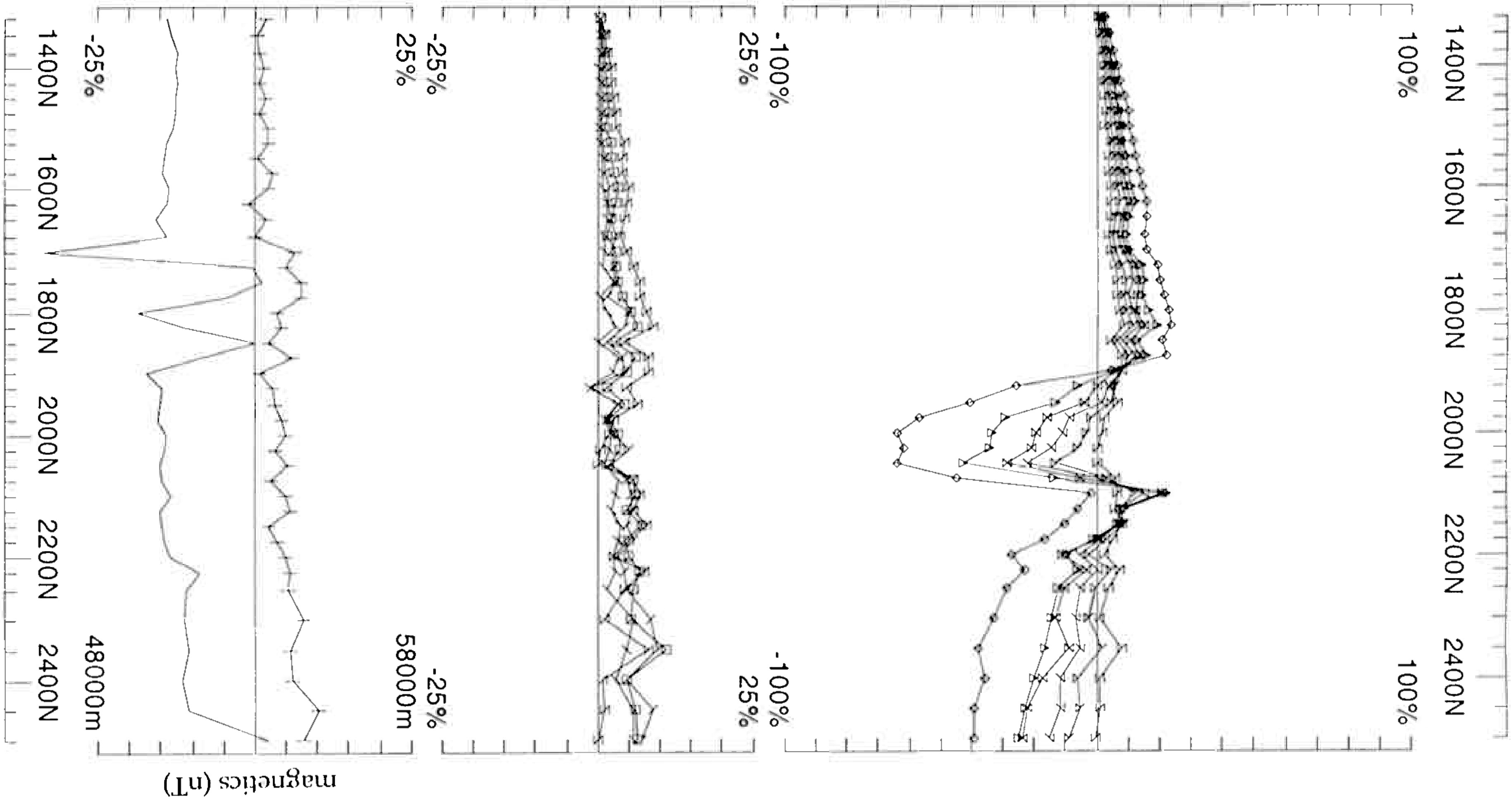
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

Plotted : 24/4/3



Loop: 1
Line: 2900E
Compt: Hz

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

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job
0315

Surveyed : 23/12/48
Reduced : 23/4/3
Plotted : 24/4/3

Espedalen

Loop 2

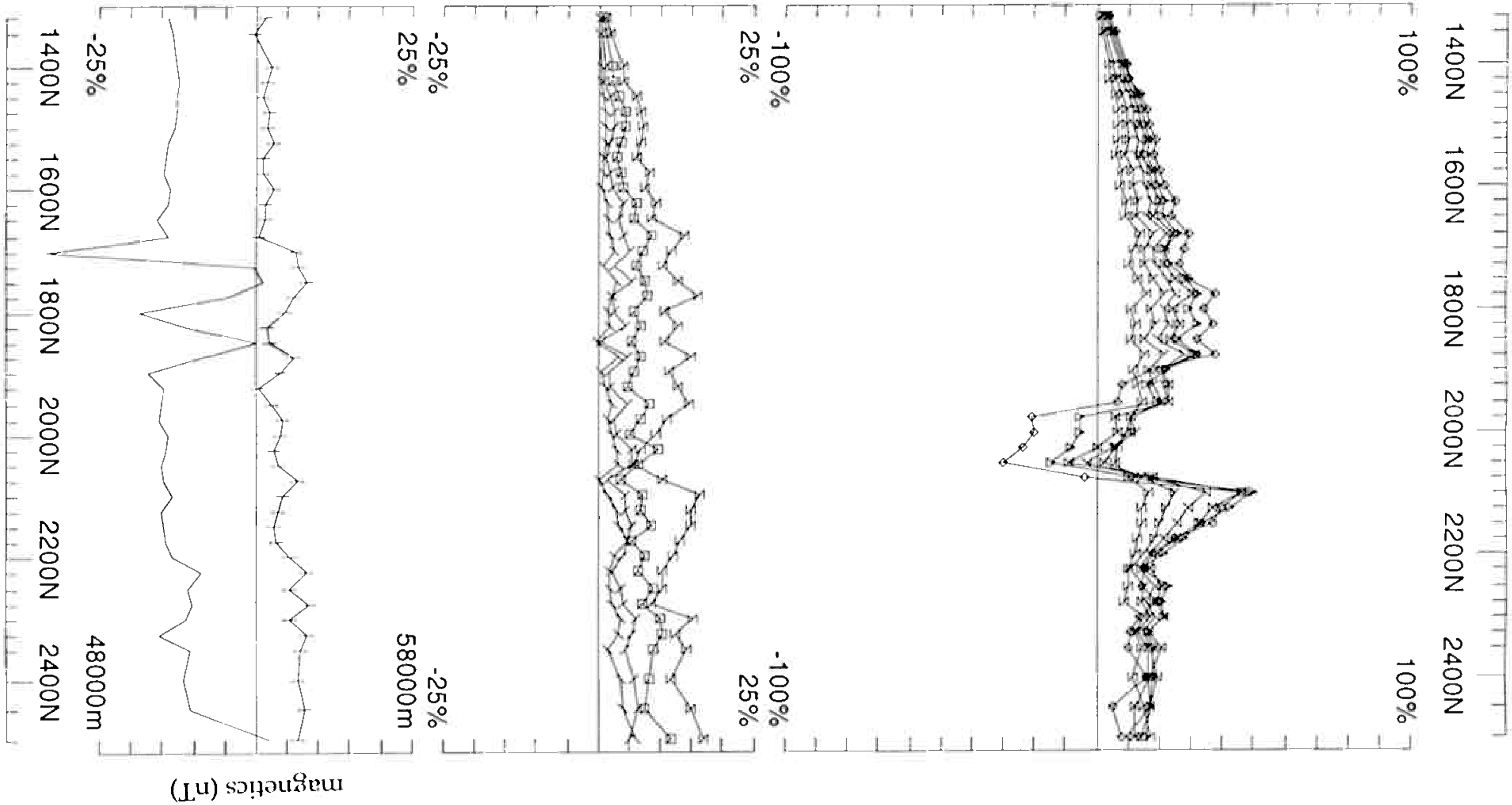
Hz
@3.251 Hz frequency

continuous norm

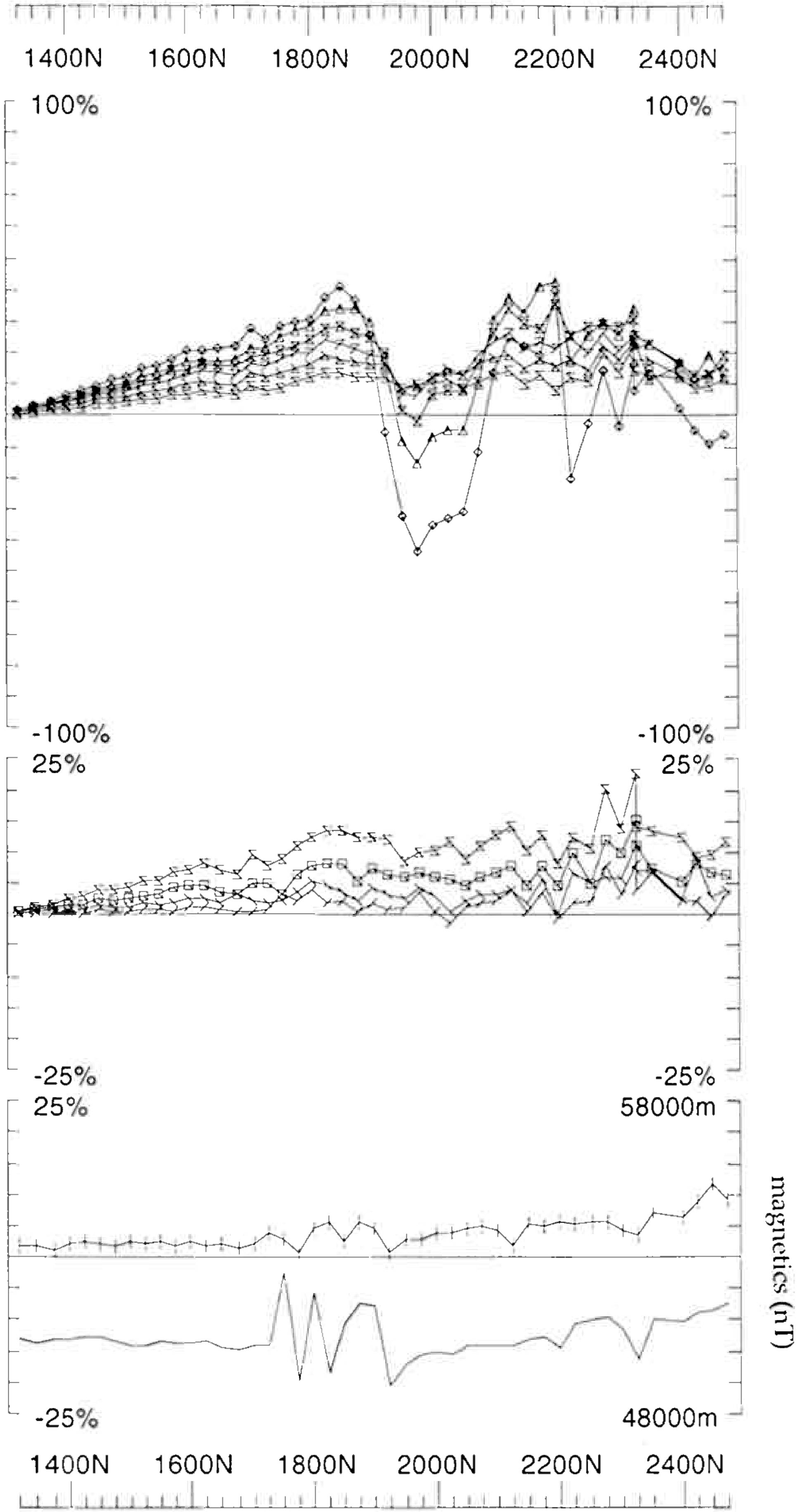
Ch1 reduced

Loop 2	Line 29+00E	13+00N-25+00N	1200m
	Line 31+00E	13+00N-24+75N	1175m
	Line 33+00E	13+00N-23+75N	1075m
	Line 35+00E	13+00N-24+75N	1175m
	Line 37+00E	13+00N-23+75N	1075m
	Line 39+00E	13+00N-20+75N	775m
		Loop 2 Total	6475m

Loop 2 - continuous norm



Loop: 2	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 2900E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0315 — Surveyed : 10/2/48 Reduced : 24/4/3 Plotted : 24/4/3



Loop: 2
Line: 3100E
Compt: Hz

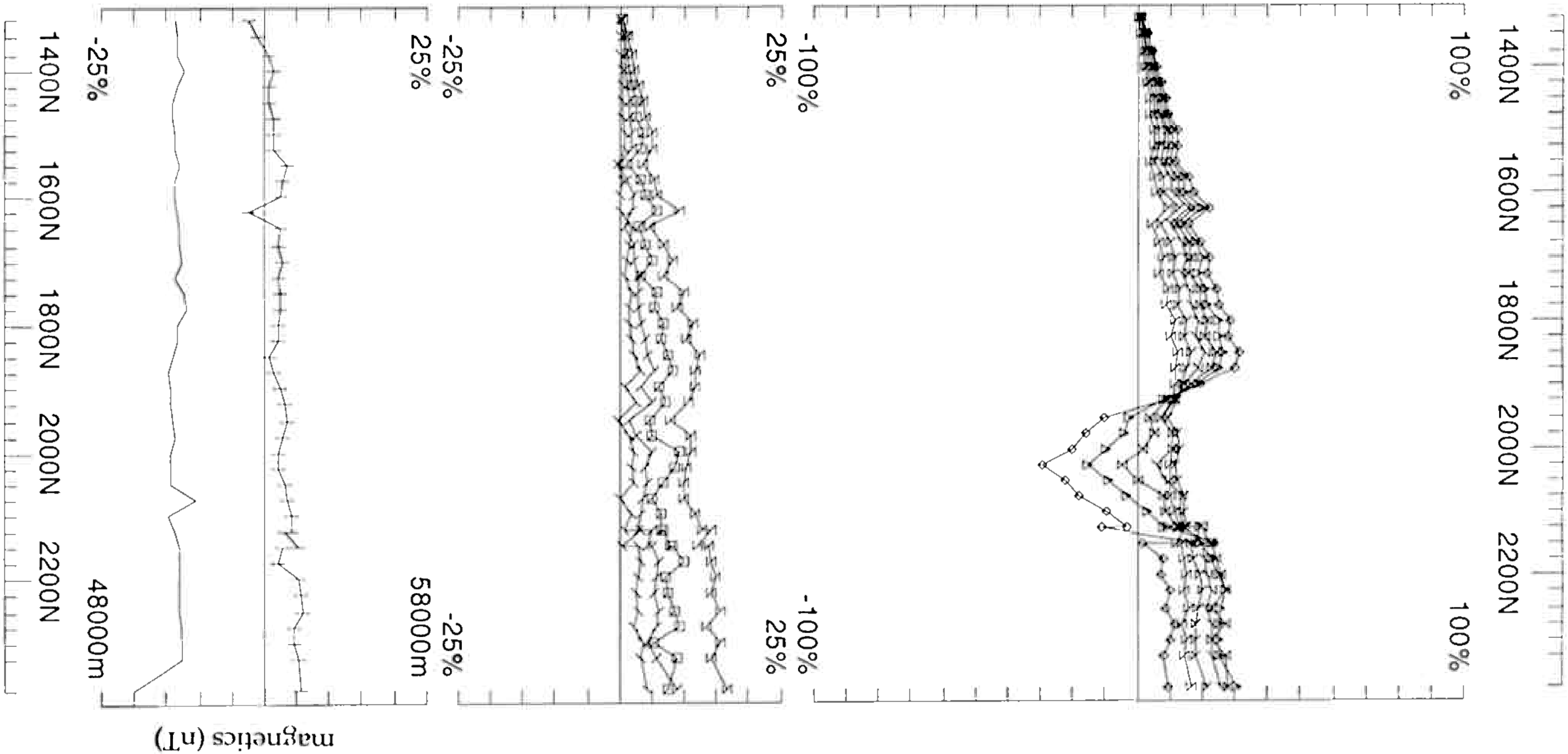
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

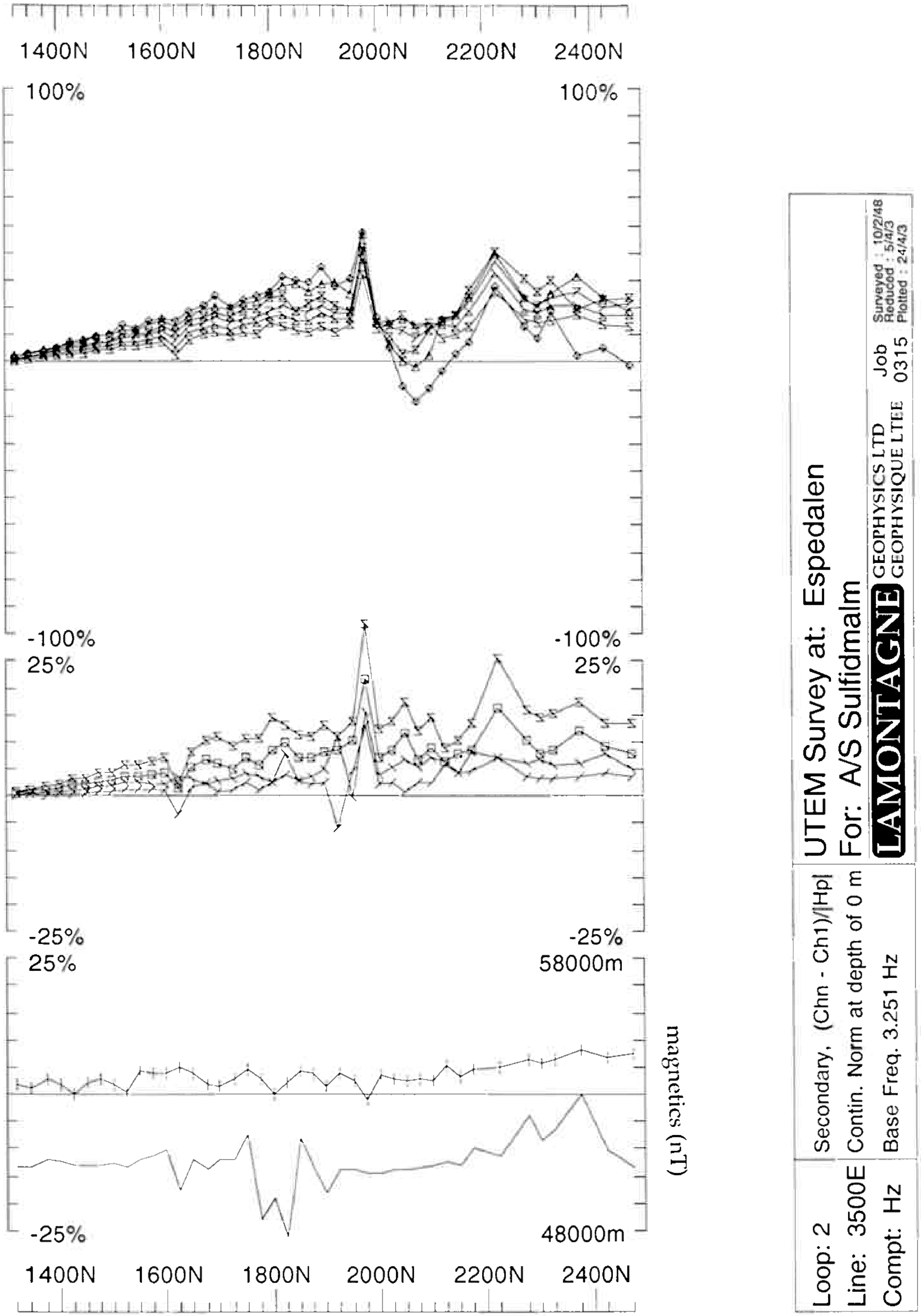
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

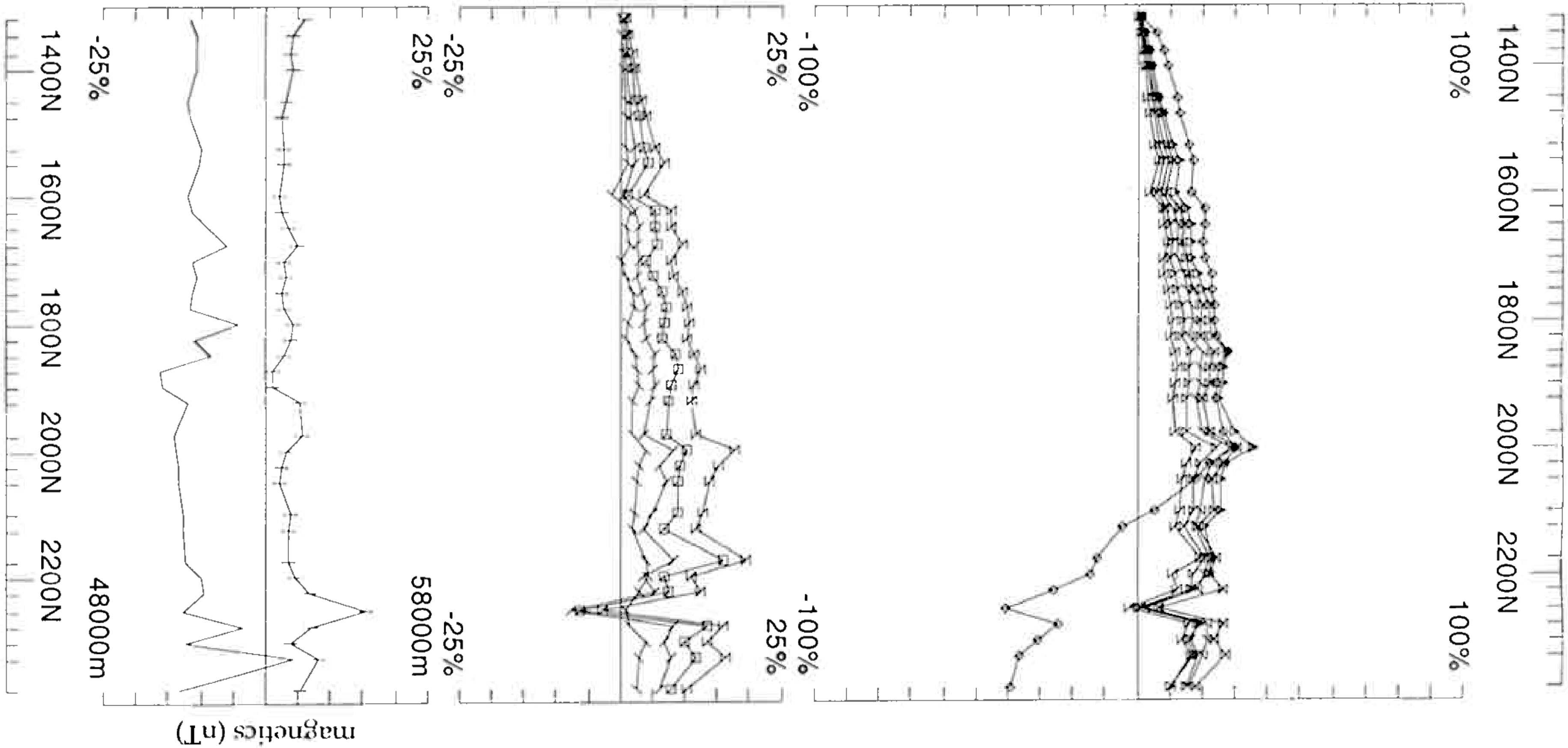
Job 0315

Surveyed : 14/12/47
Reduced : 24/4/3
Plotted : 24/4/3

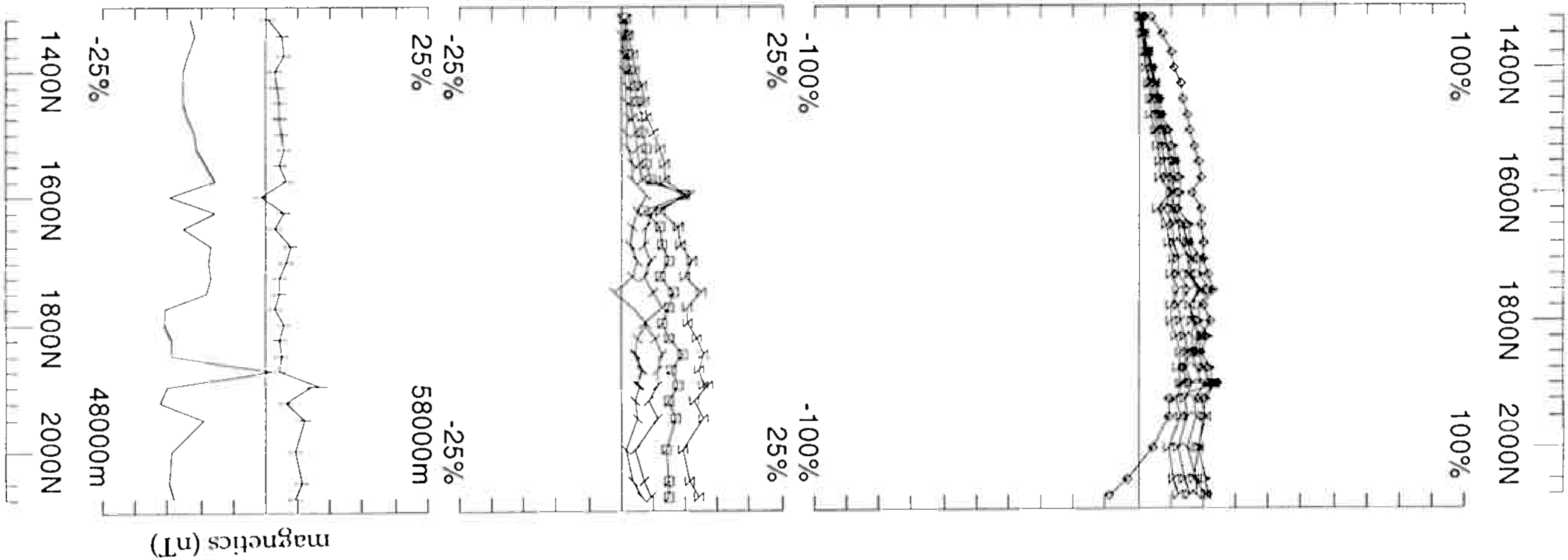


Loop: 2 Line: 3300E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Contin. Norm at depth of 0 m Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Plotted : 24/4/3


1400N
1600N
1800N
2000N
2200N
2400N
100%
100%
-100%
-100%
25%
25%
-25%
-25%
25%
58000m
-25%
48000m
magnetics (nT)
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Surveyed : 10/2/48
Reduced : 5/4/3
Plotted : 24/4/3
Loop: 2
Line: 3500E
Compt: Hz
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz



Loop: 2	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 3700E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 12/2/48 Reduced : 24/4/3 Plotted : 24/4/3



Loop: 2
Line: 3900E
Compt: Hz

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

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0315 Plotted : 24/4/3

Espedalen

Loop 3

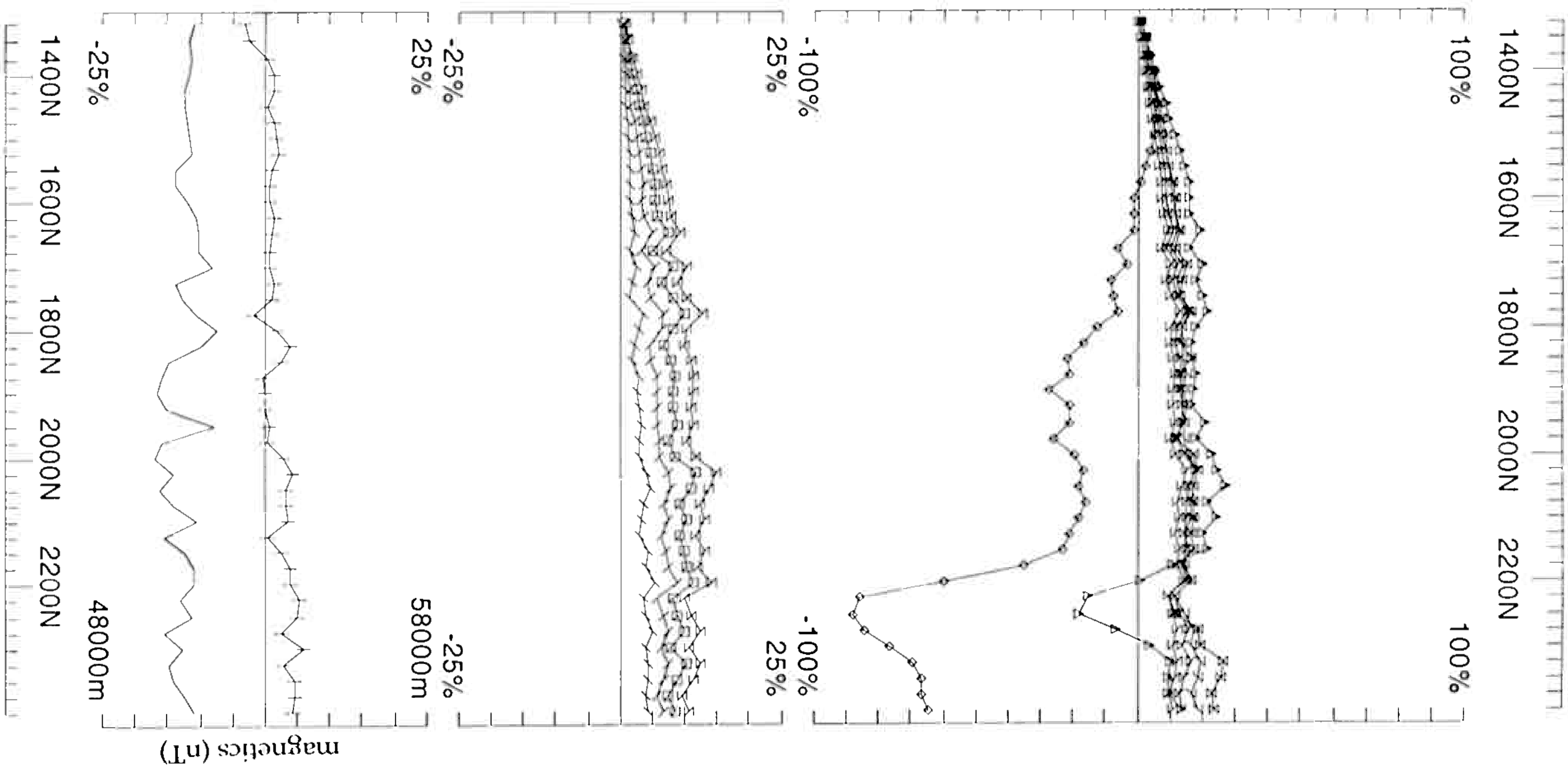
Hz
@3.251 Hz frequency

continuous norm

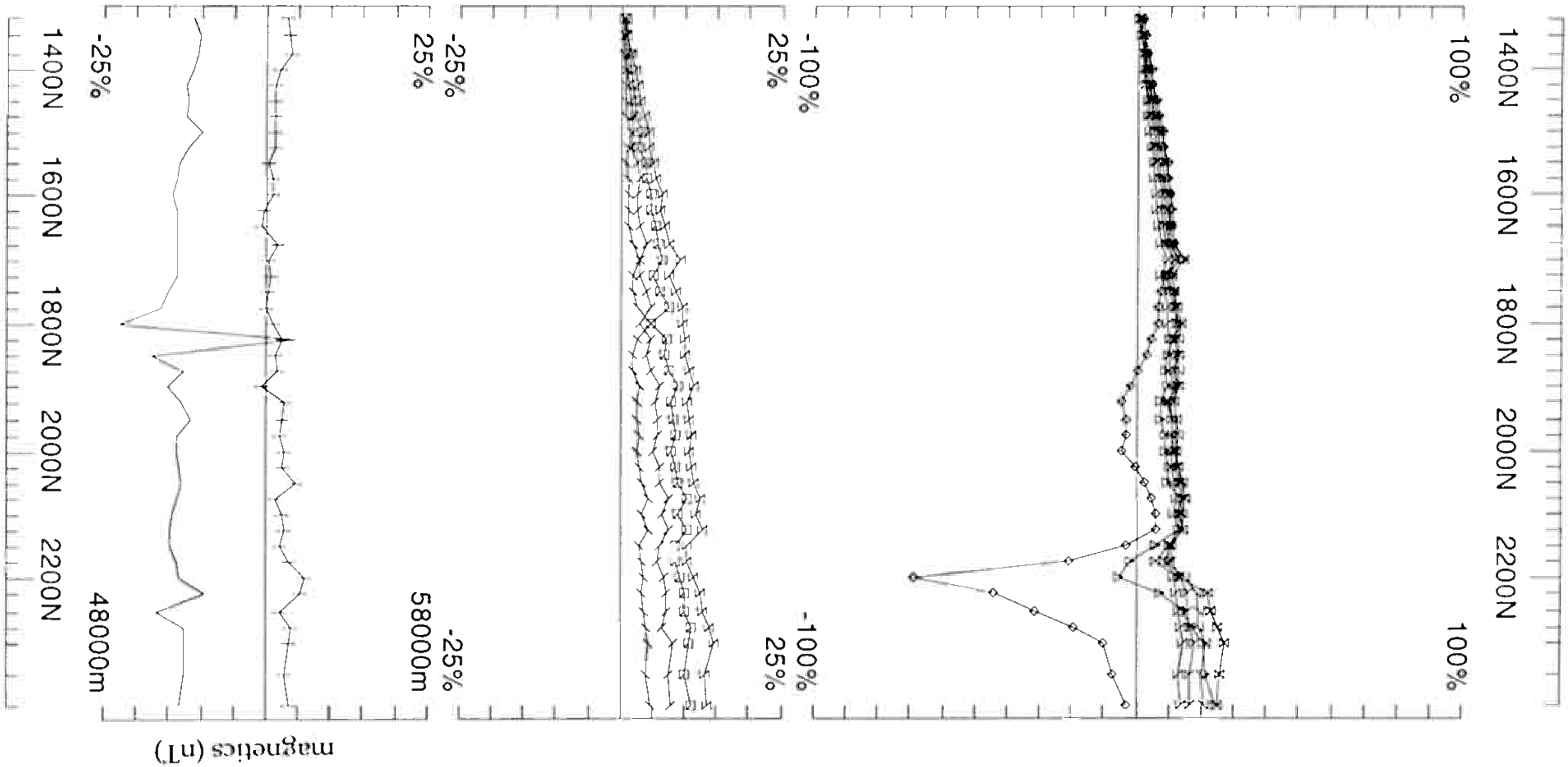
Ch1 reduced

Loop 3	Line 41+00E	13+00N-24+00N	1100m
	Line 43+00E	13+00N-24+00N	1100m
	Line 45+00E	13+00N-24+75N	1175m
	Line 47+00E	13+00N-26+00N	1300m
	Line 49+00E	13+00N-25+75N	1275m
	Line 51+00E	13+00N-25+50N	1250m
	Line 53+00E	13+00N-26+00N	1300m
		Loop 3 Total	8500m

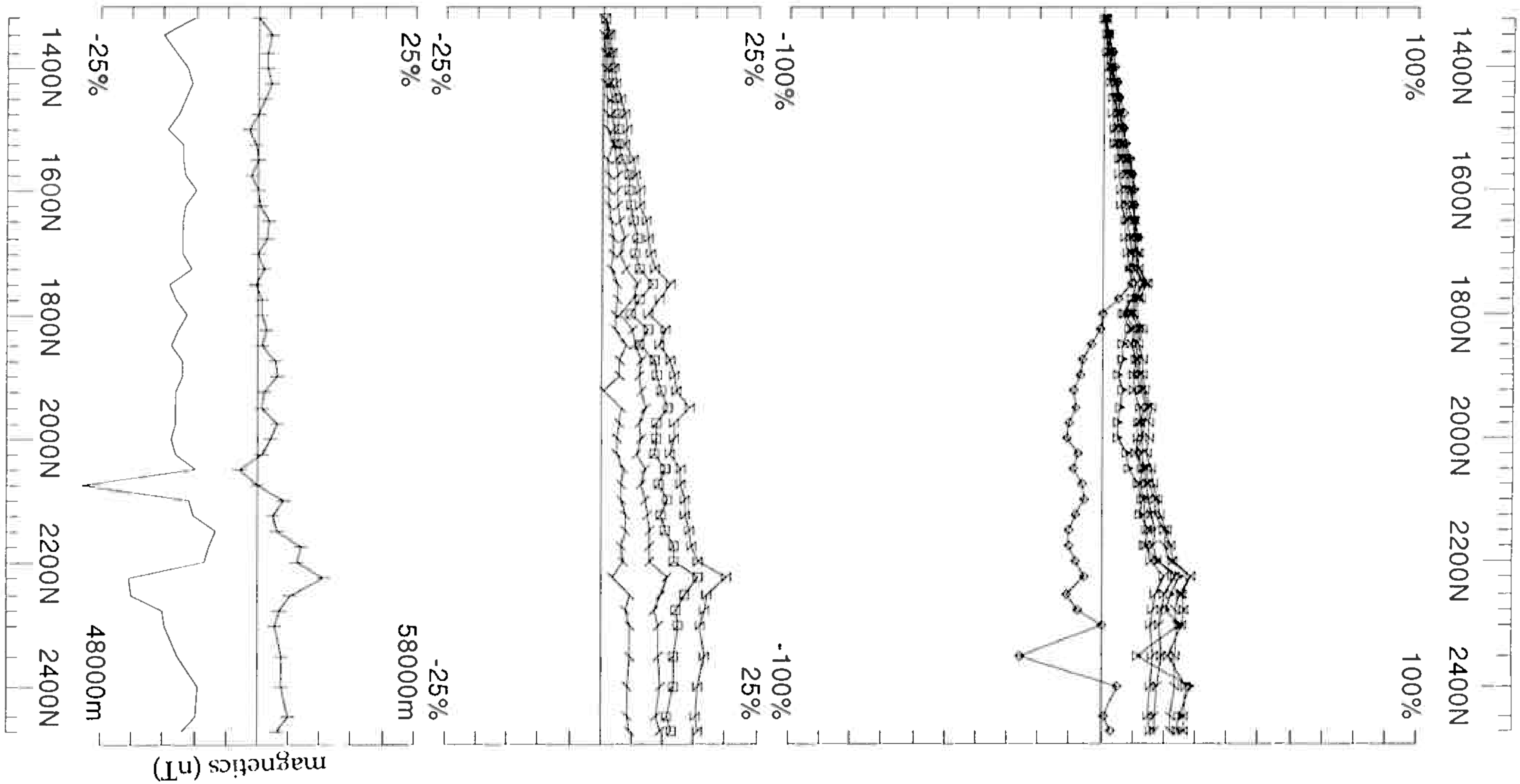
Loop 3 - continuous norm



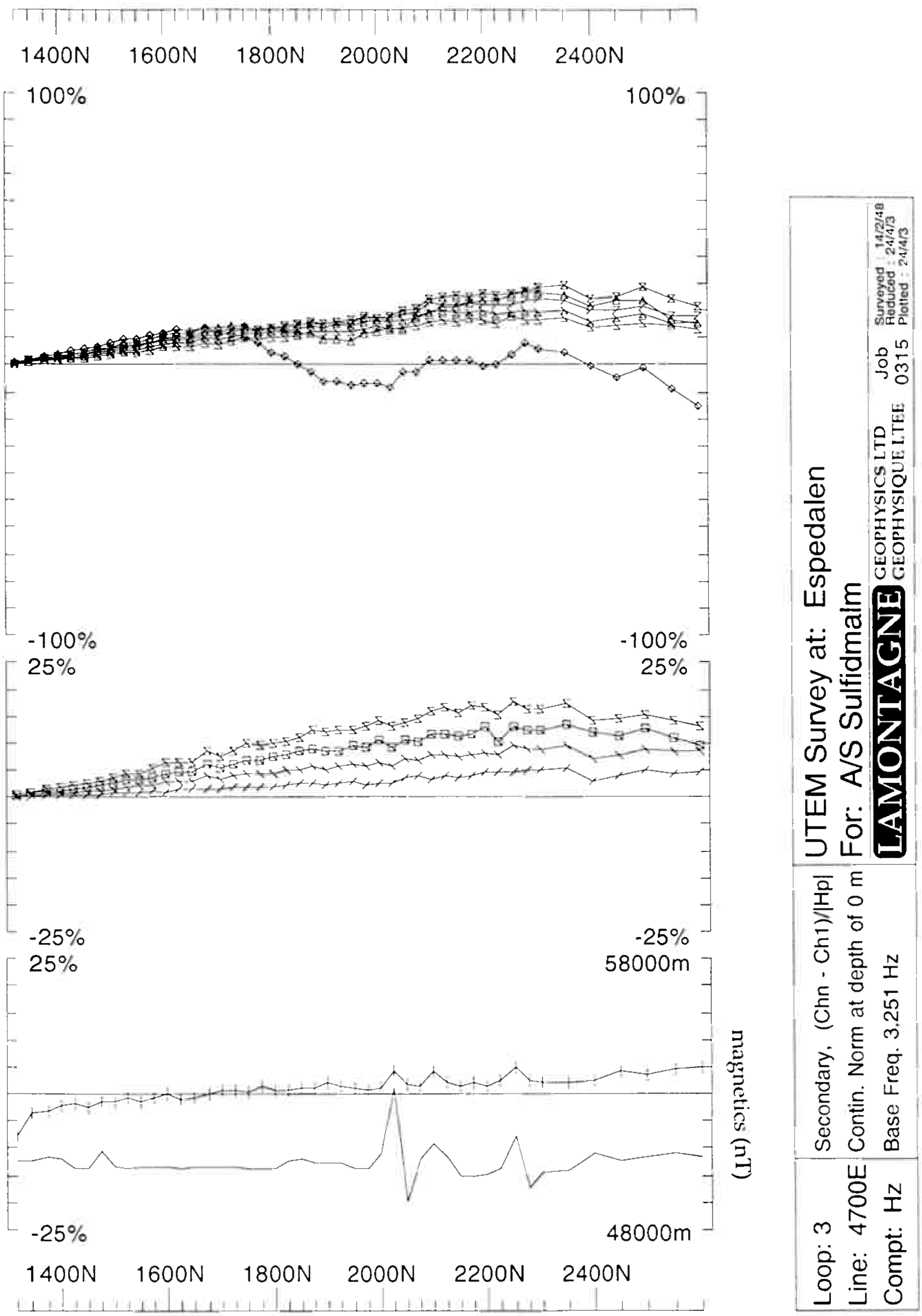
Loop: 3	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 4100E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0315 — Surveyed : 13/2/48 Reduced : 24/4/3 Plotted : 24/4/3



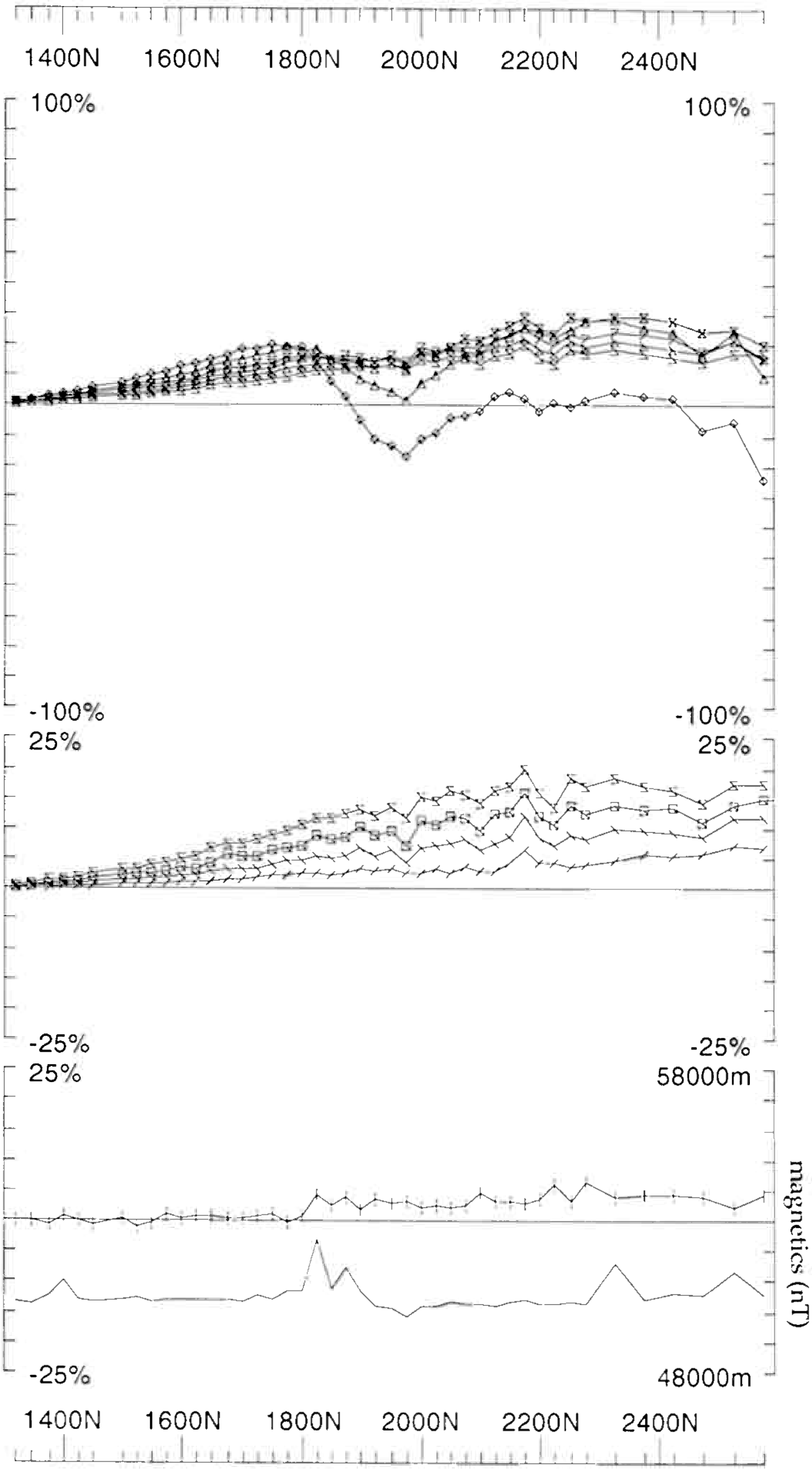
Loop: 3	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 4300E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0315 — Surveyed : 15/2/48 Reduced : 8/4/3 Plotted : 24/4/3



Loop: 3 Line: 4500E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Contin. Norm at depth of 0 m Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD / GEOPHYSIQUE LTEE Job 0315 Surveyed : 14/2/48 Reduced : 8/4/3 Plotted : 24/4/3



1400N
1600N
1800N
2000N
2200N
2400N
100%
100%
-100%
-100%
25%
25%
-25%
-25%
25%
58000m
-25%
48000m
magnetics (nT)
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Surveyed : 14/2/48
Reduced : 24/4/3
Plotted : 24/4/3
Loop: 3
Line: 4700E
Compt: Hz
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3,251 Hz



UTEM Survey at: Espedalen
For: A/S Sulfidmalm

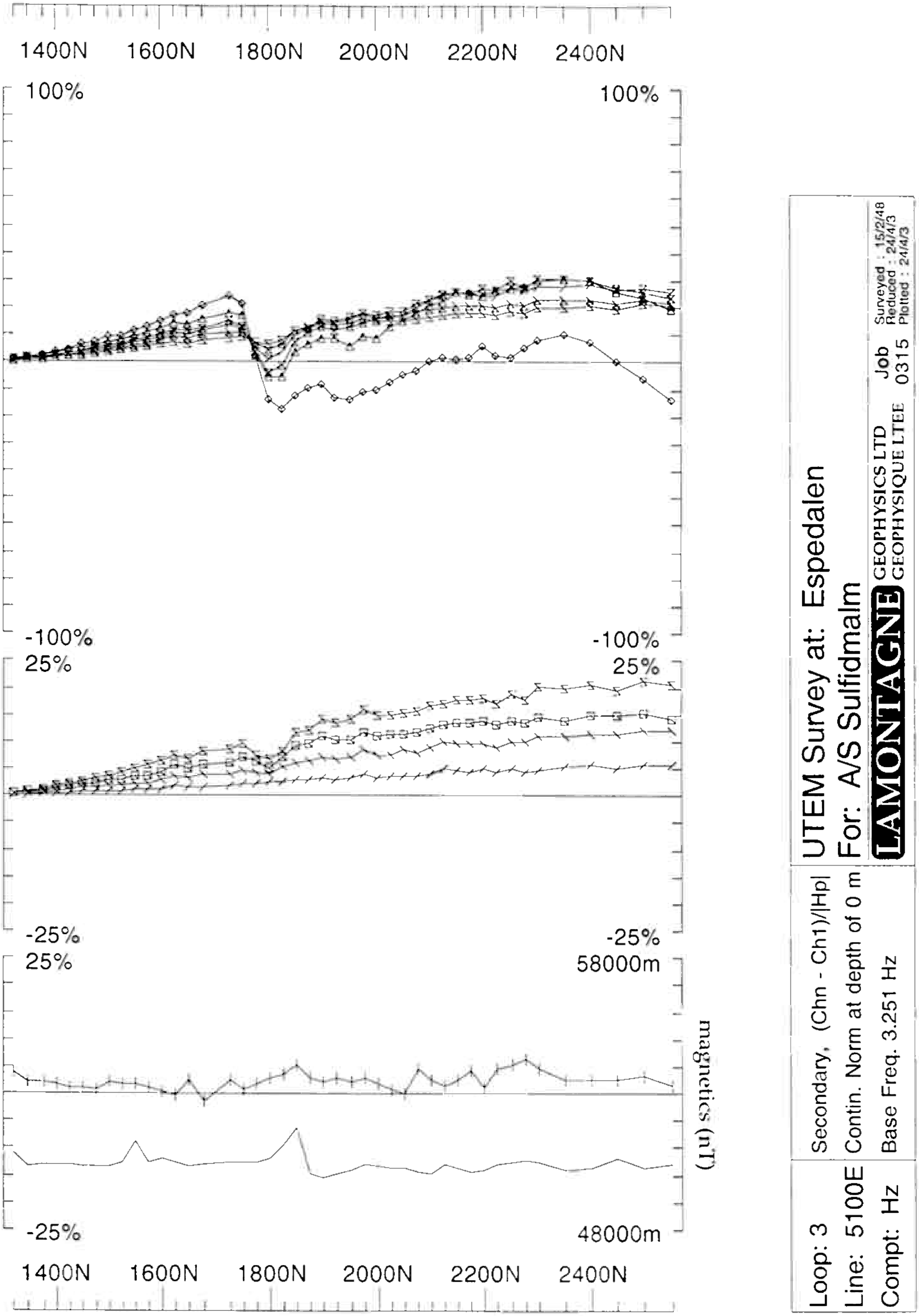
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

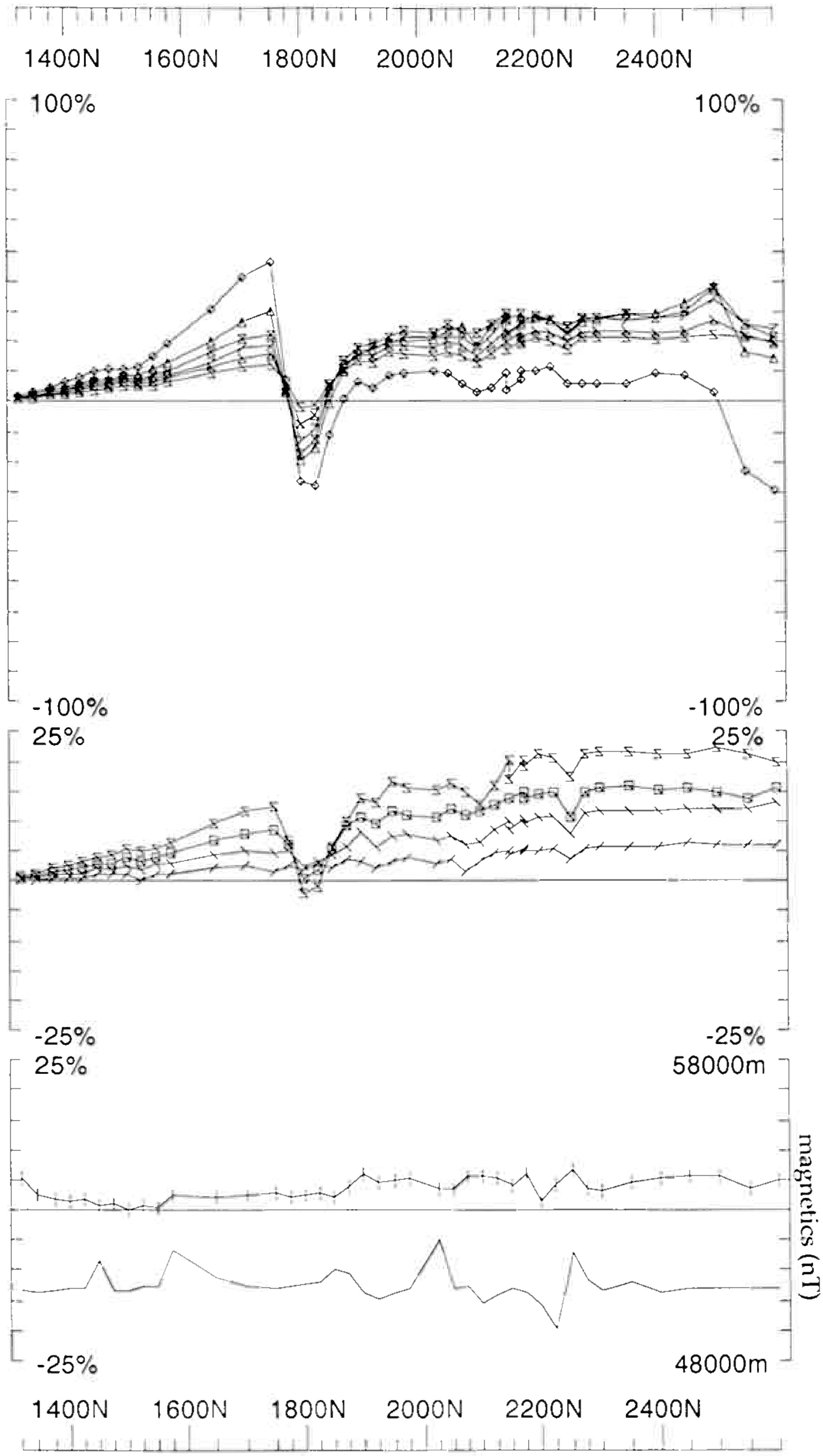
Job 0315

Surveyed : 15/2/48
Reduced : 10/4/3
Plotted : 24/4/3

Loop: 3
Line: 4900E
Compt: Hz

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


1400N
1600N
1800N
2000N
2200N
2400N
100%
100%
-100%
-100%
25%
25%
-25%
-25%
25%
58000m
magnetics (nT)
-25%
48000m
Loop: 3
Line: 5100E
Compt: Hz
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE
GEOPHYSICS LTD
GEOPHYSIQUE LTEE
Job
0315
Surveyed : 15/2/48
Reduced : 24/4/3
Plotted : 24/4/3



UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

Plotted : 24/4/3

Loop: 3
Line: 5300E
Compt: Hz

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

Espedalen

Loop 4

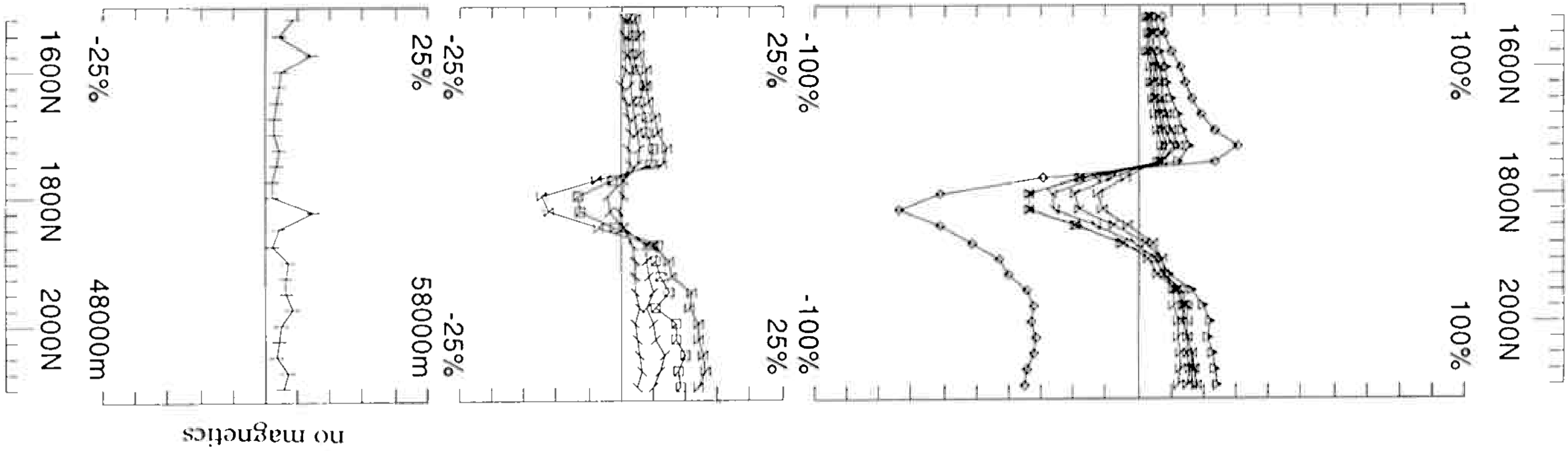
Hz
@3.251 Hz frequency

continuous norm

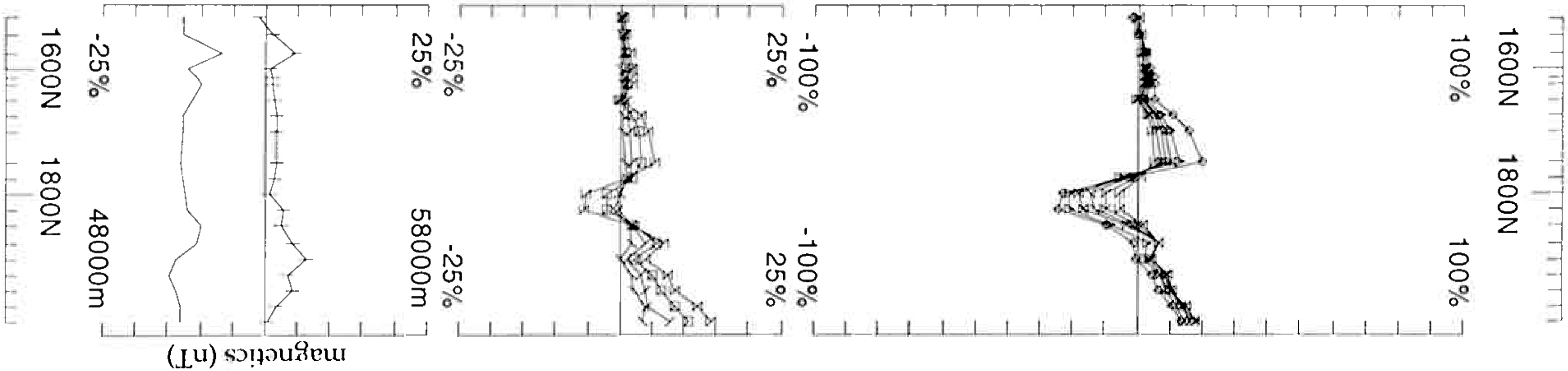
Ch1 reduced

Loop 4	Line 52+00E	15+00N-21+00N	600m
	Line 53+00E	15+00N-20+00N	500m
	Line 54+00E	15+00N-21+00N	600m
	Line 55+00E	15+00N-26+00N	1100m
	Line 57+00E	15+00N-25+50N	1050m
	Line 59+00E	15+00N-25+75N	1075m
	Line 61+00E	15+00N-25+50N	1050m
	Line 63+00E	15+00N-25+00N	1000m
		Loop 4 Total	6975m

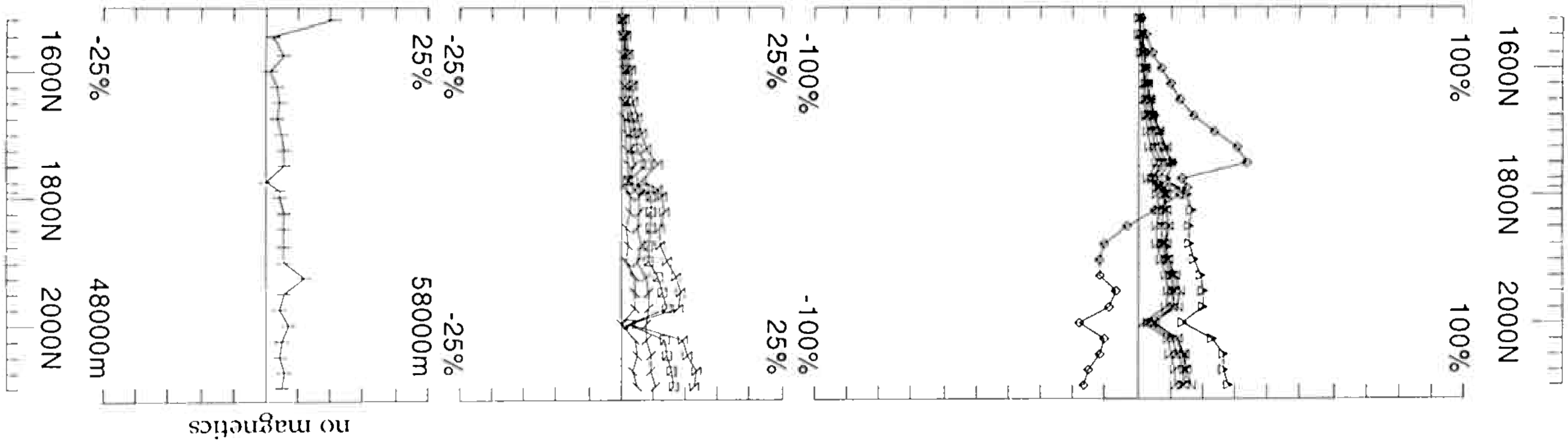
Loop 4 - continuous norm



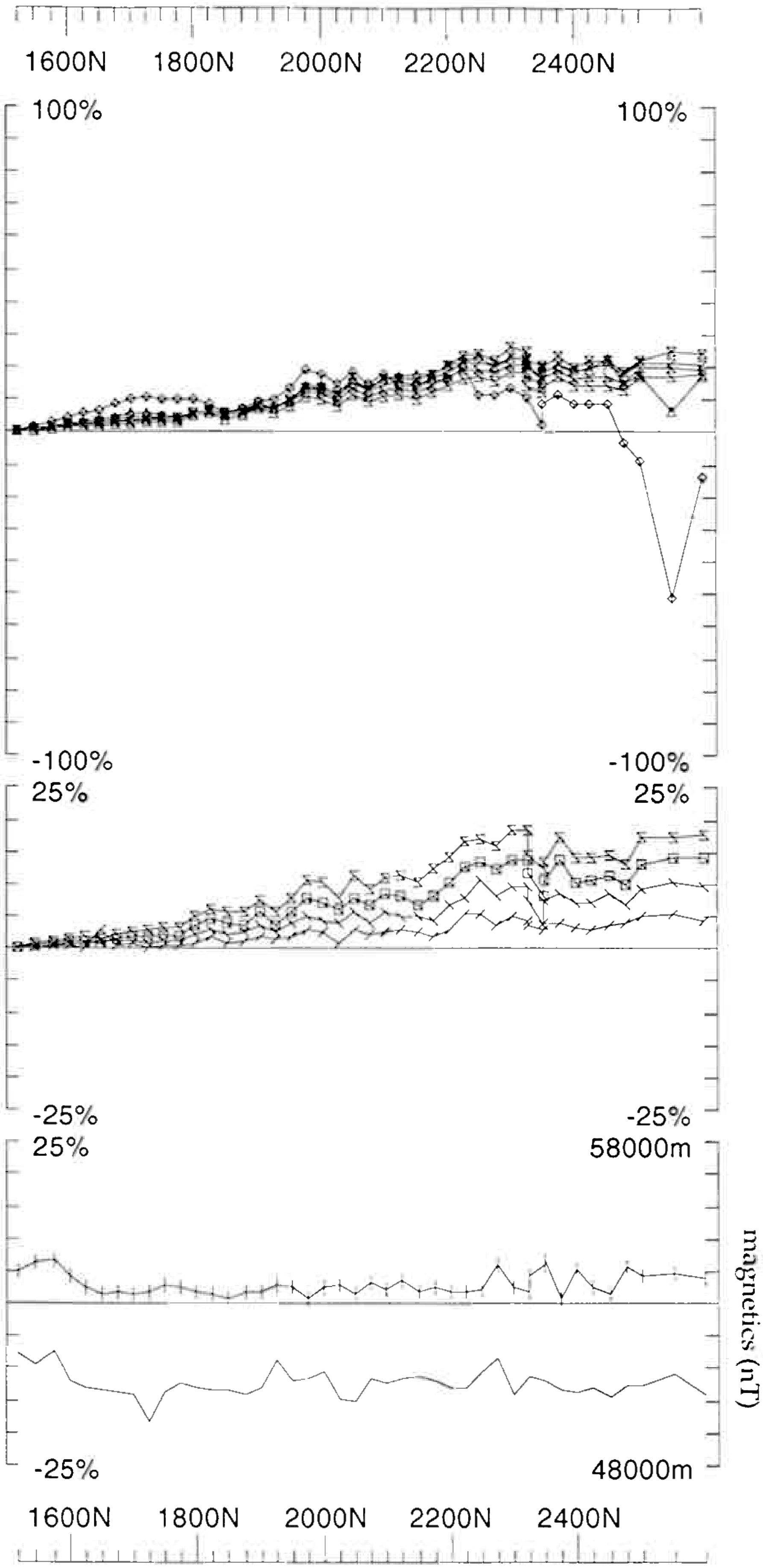
Loop: 4 Line: 5200E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Contin. Norm at depth of 0 m Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 18/2/48 Reduced : 11/4/3 Plotted : 24/4/3



Loop: 4 Line: 5300E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Contin. Norm at depth of 0 m Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 16/2/48 Reduced : 10/4/3 Plotted : 24/4/3



Loop: 4	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 5400E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0315 — Surveyed : 18/2/48 Reduced : 11/4/3 Plotted : 24/4/3



Loop: 4
Line: 5500E
Compt: Hz

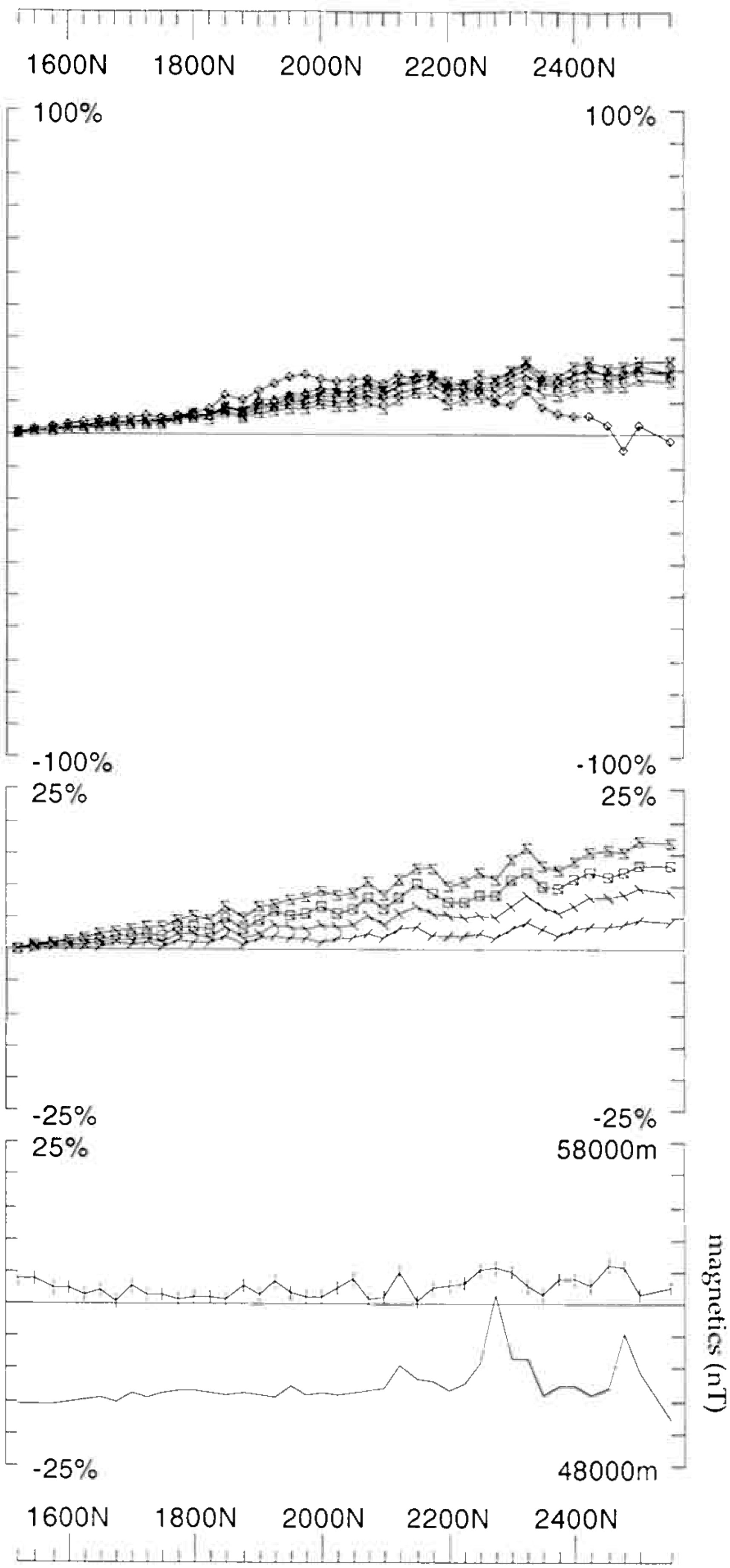
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

Plotted : 24/4/3



Loop: 4
Line: 5700E
Compt: Hz

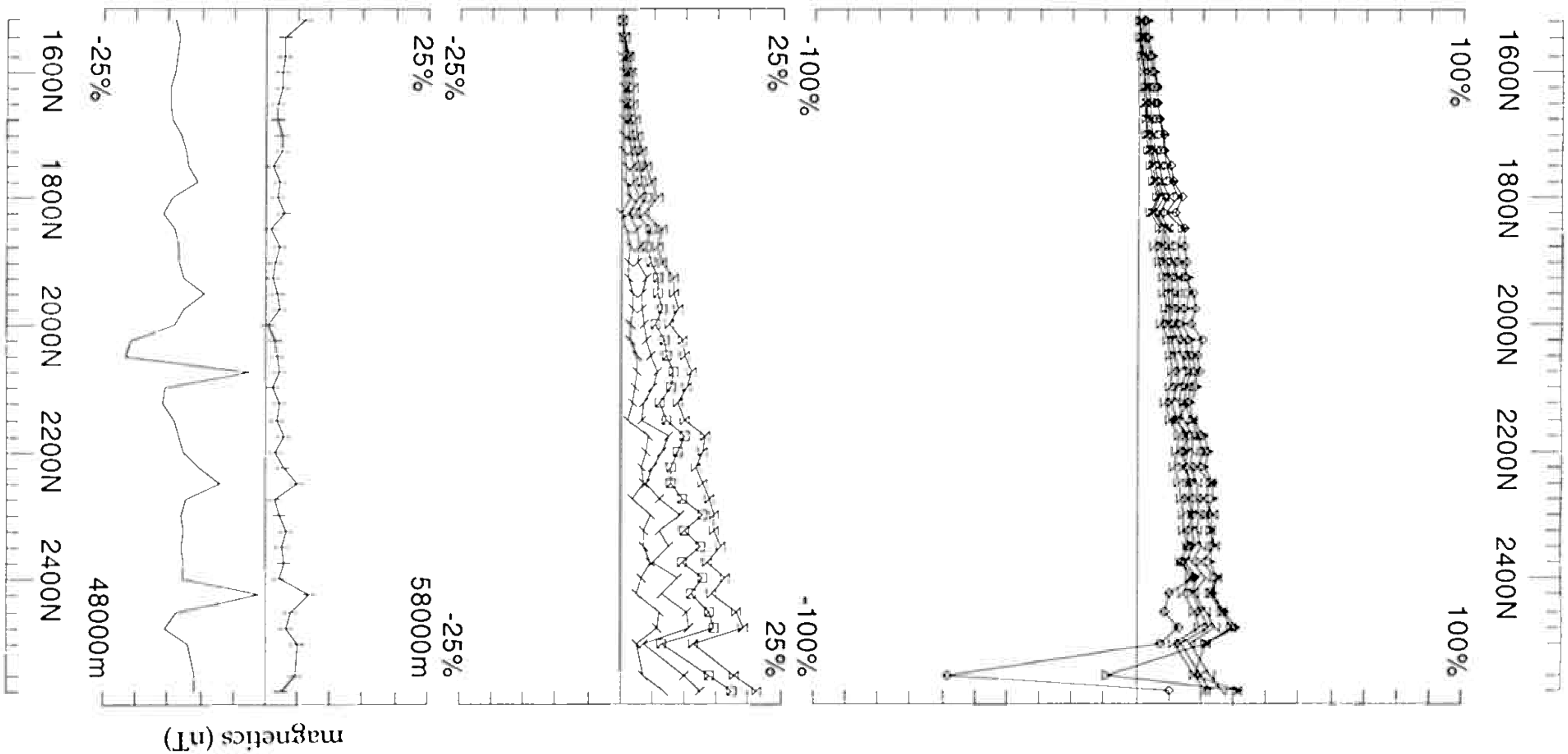
Secondary, (Chn - Ch1)/|Hp|
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

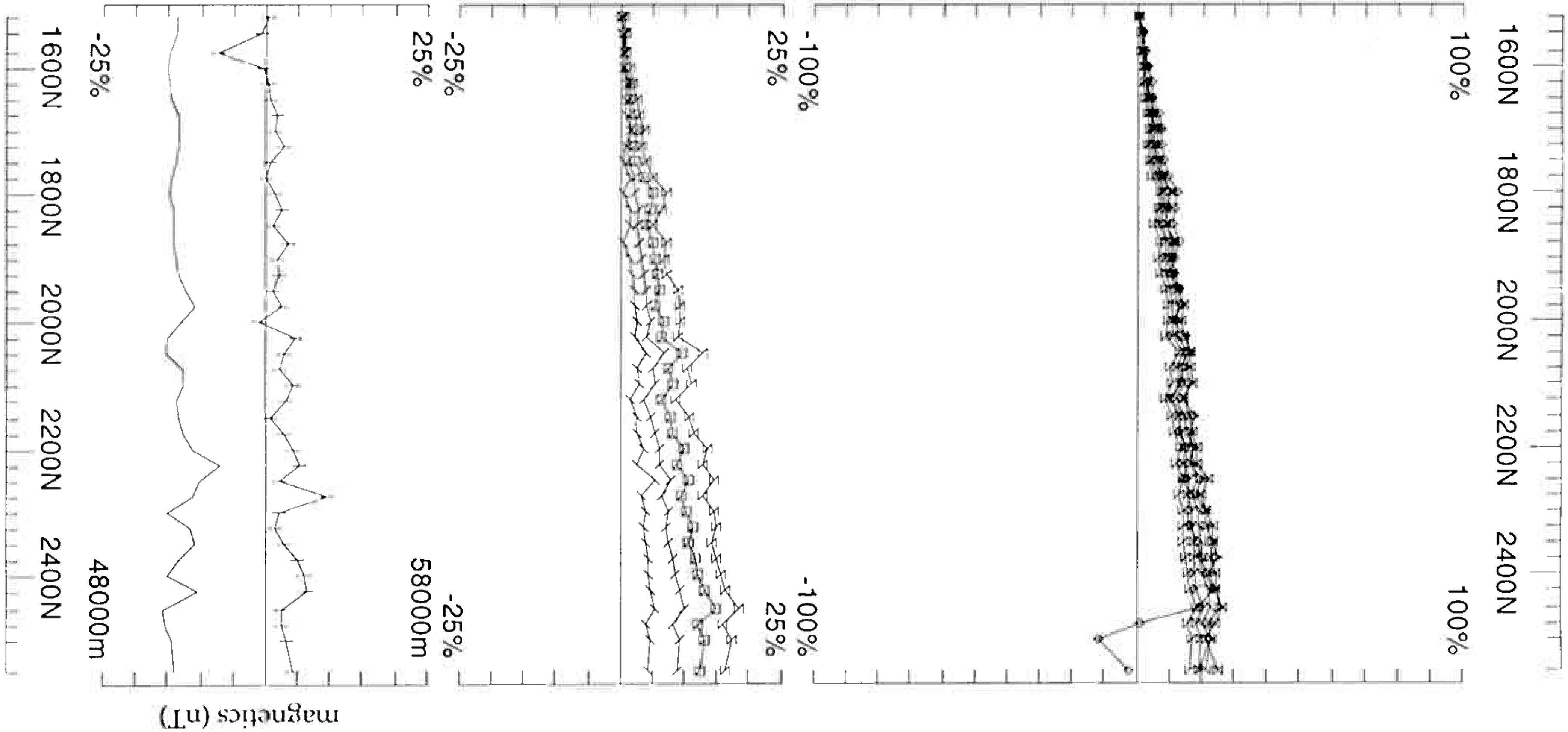
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

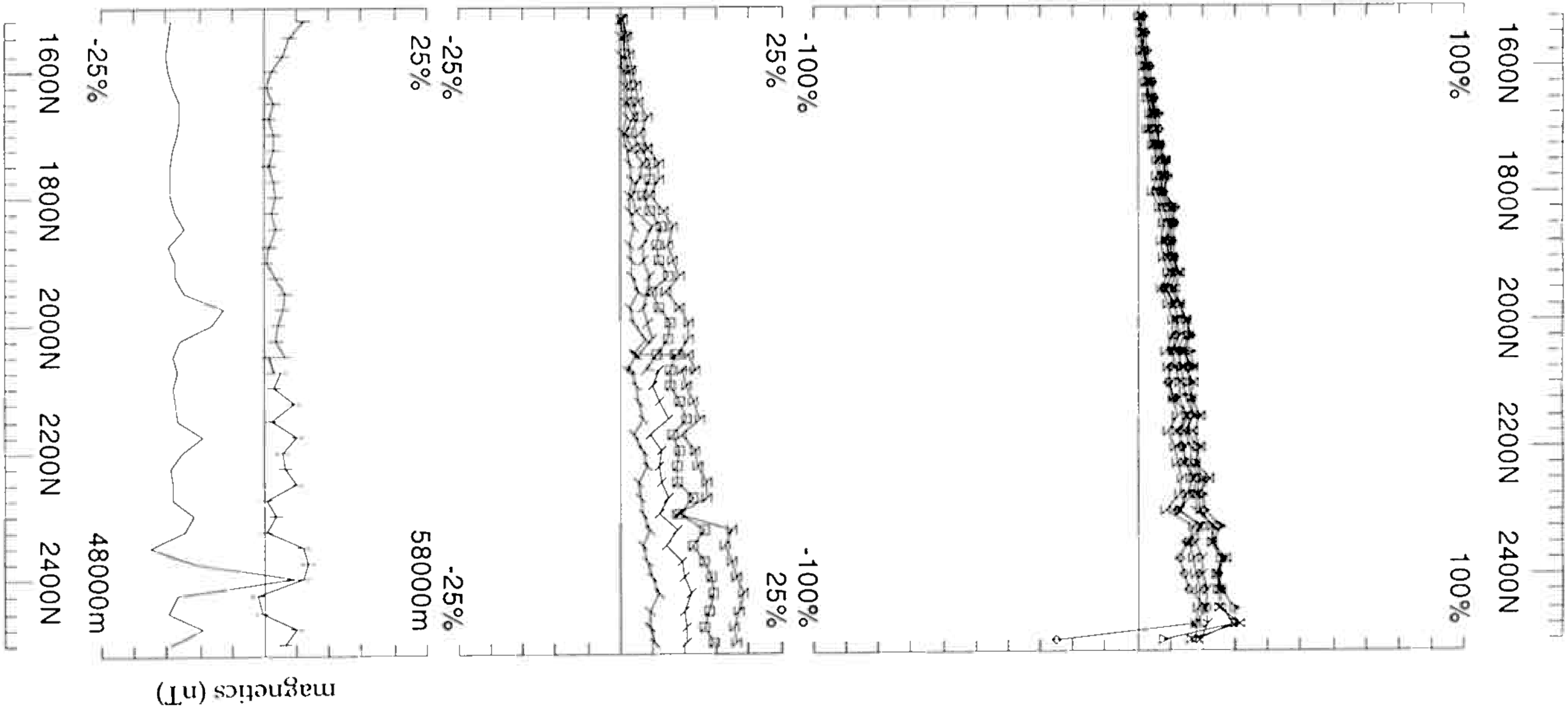
Surveyed : 16/2/48
Reduced : 9/4/3
Plotted : 24/4/3



Loop: 4	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 5900E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0315 — Surveyed : 17/2/48 Reduced : 10/4/3 Plotted : 24/4/3



Loop: 4 Line: 6100E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Contin. Norm at depth of 0 m Base Freq. 3,251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 17/2/48 Reduced : 10/4/3 Plotted : 24/4/3



Loop: 4	Secondary, (Chn - Ch1)/|Hp|	UTEM Survey at: Espedalen
Line: 6300E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Plotted : 24/4/3

Espedalen

Loop 1

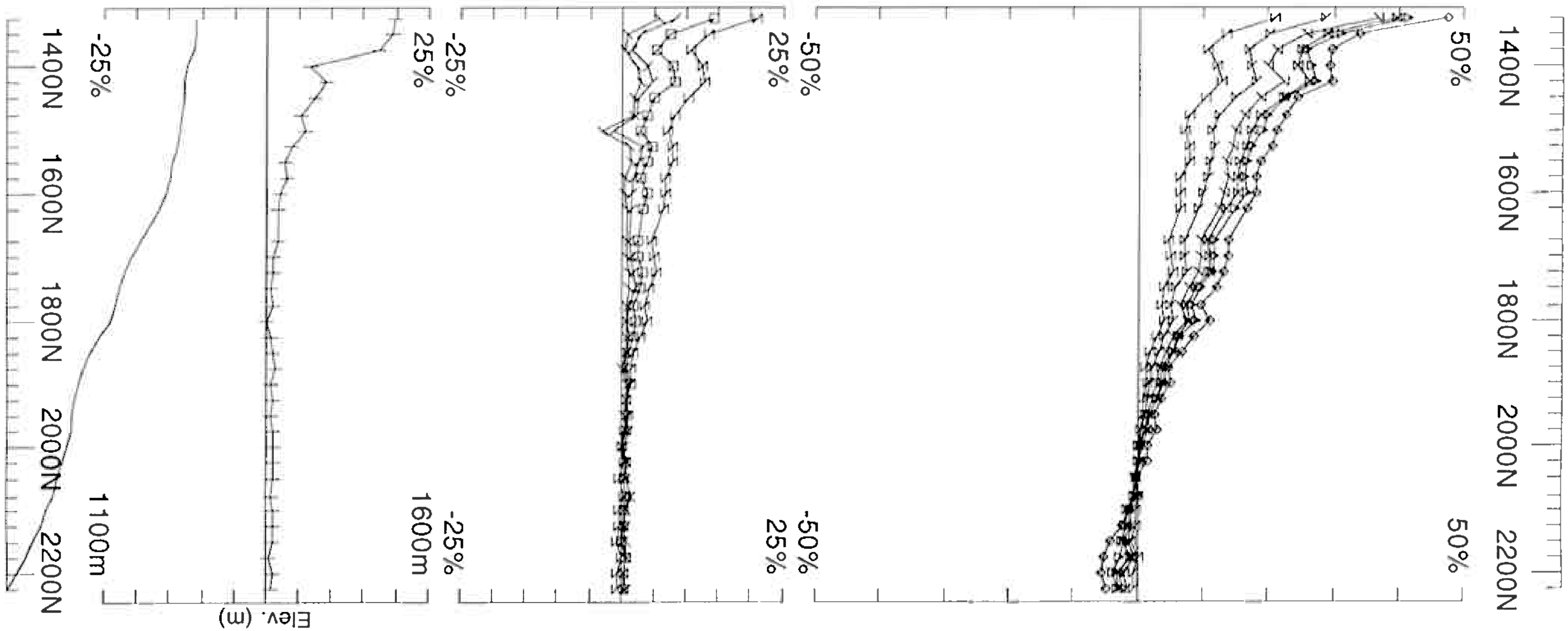
Hz
@3.251 Hz frequency

point norm
@
(x,y,z) = (2300E,1700N, 1150 m.a.s.l.)

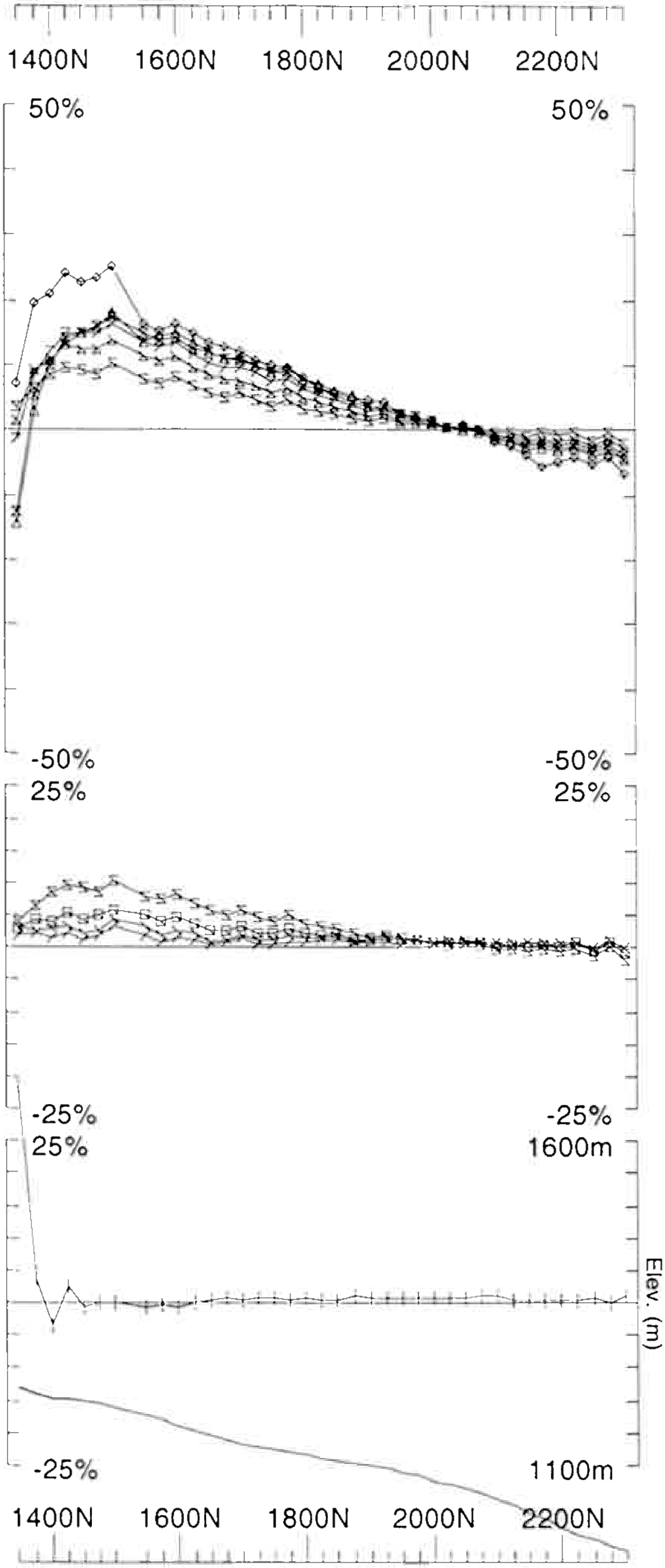
Ch1 reduced

Loop 1	Line 17+00E	13+00N-22+25N	925m
	Line 19+00E	13+00N-22+50N	950m
	Line 21+00E	13+00N-23+00N	1000m
	Line 23+00E	13+00N-22+25N	925m
	Line 25+00E	13+00N-24+50N	1150m
	Line 27+00E	13+00N-24+50N	1150m
	Line 29+00E	13+00N-25+00N	1200m
		Loop 1 Total	7300m

Loop 1 - point norm



Loop: 1 Line: 1700E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (2300,1700,1150) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 20/2/48 Reduced : 23/4/3 Plotted : 24/4/3



Loop: 1
Line: 1900E
Compt: Hz

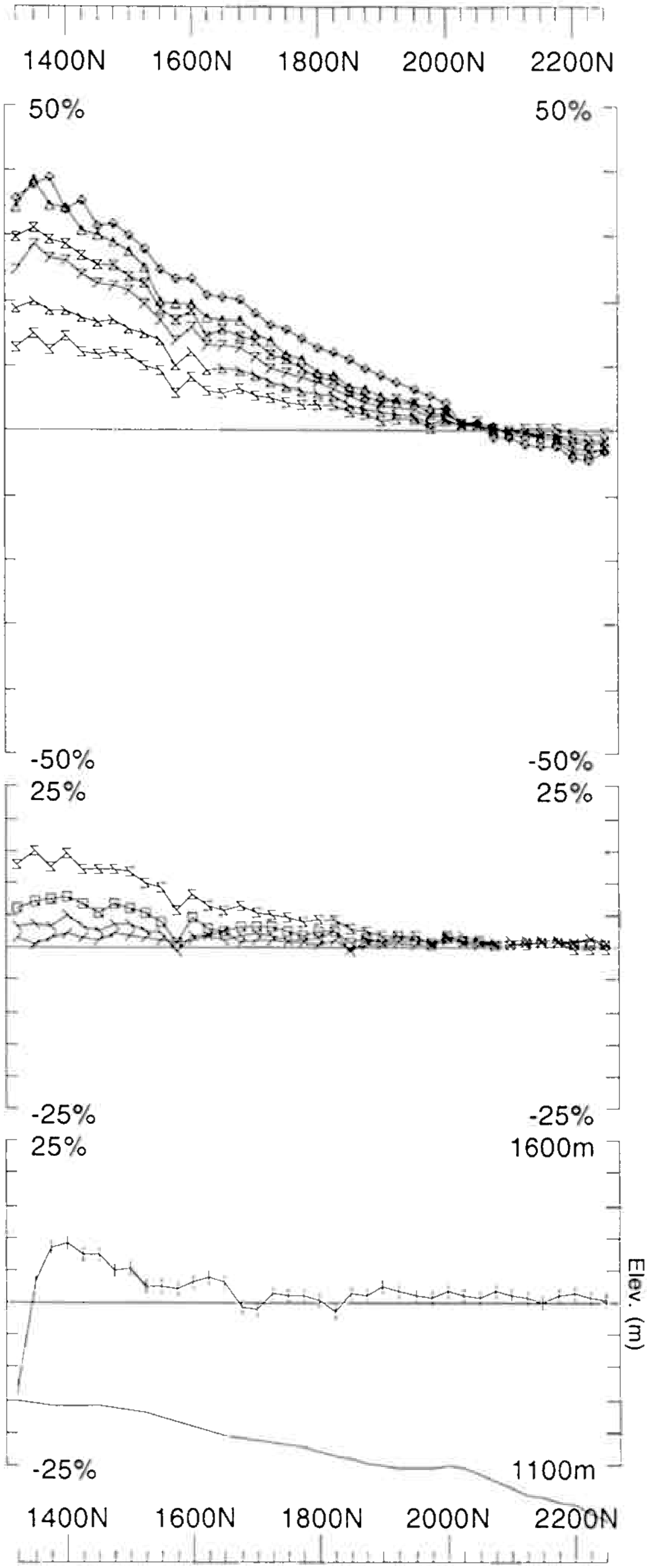
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(2300,1700,1150)
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

Plotted : 24/4/3



Loop: 1
Line: 2100E
Compt: Hz

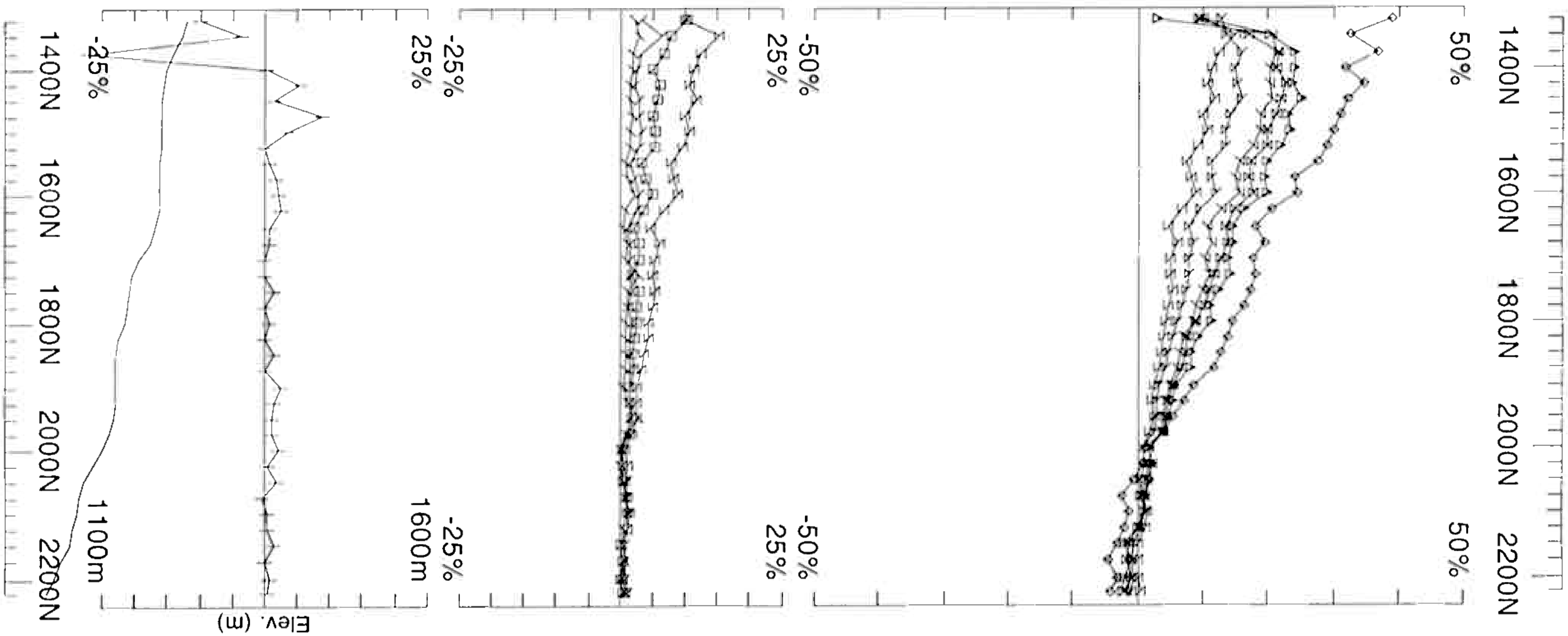
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(2300,1700,1150)
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

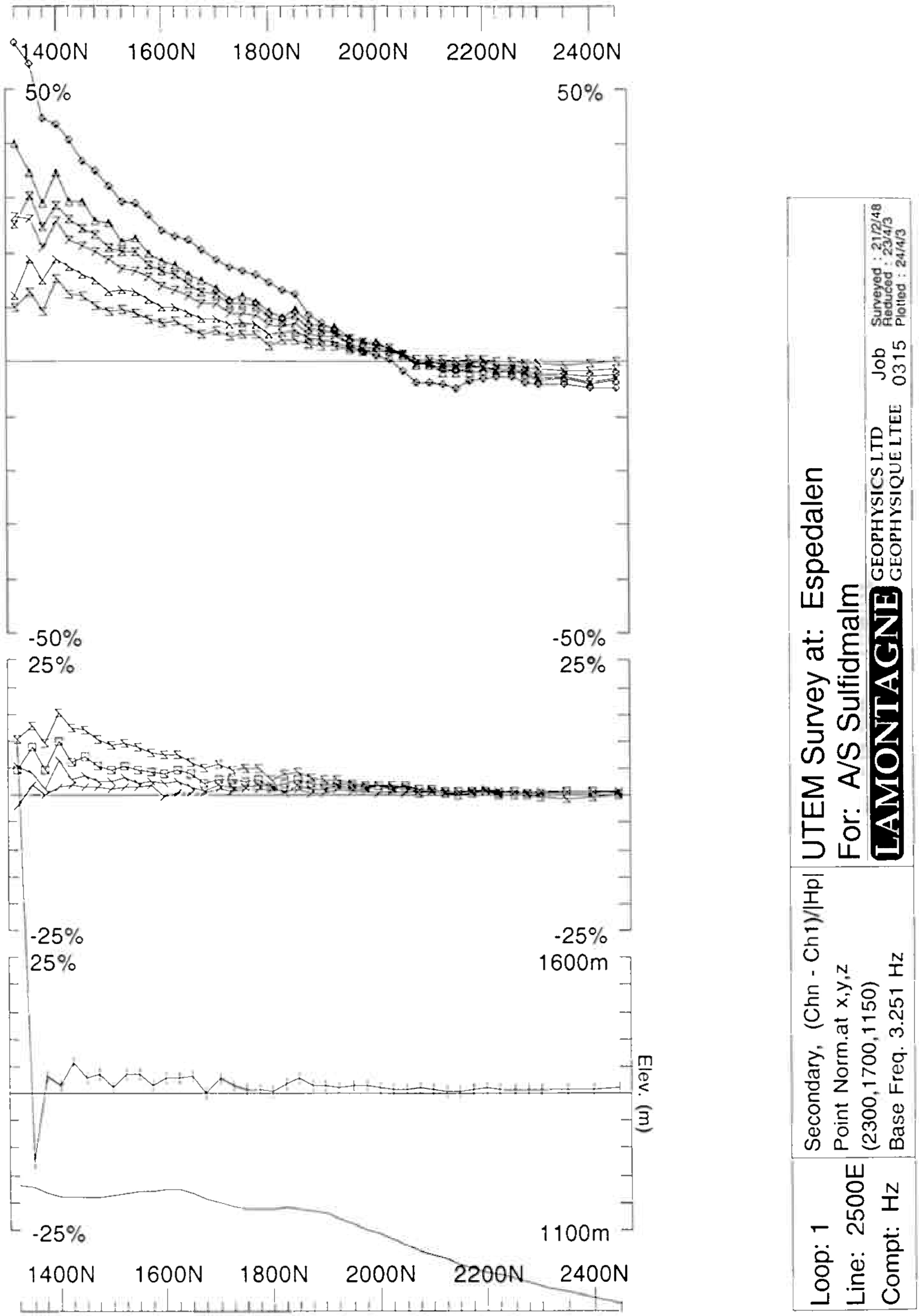
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job
0315

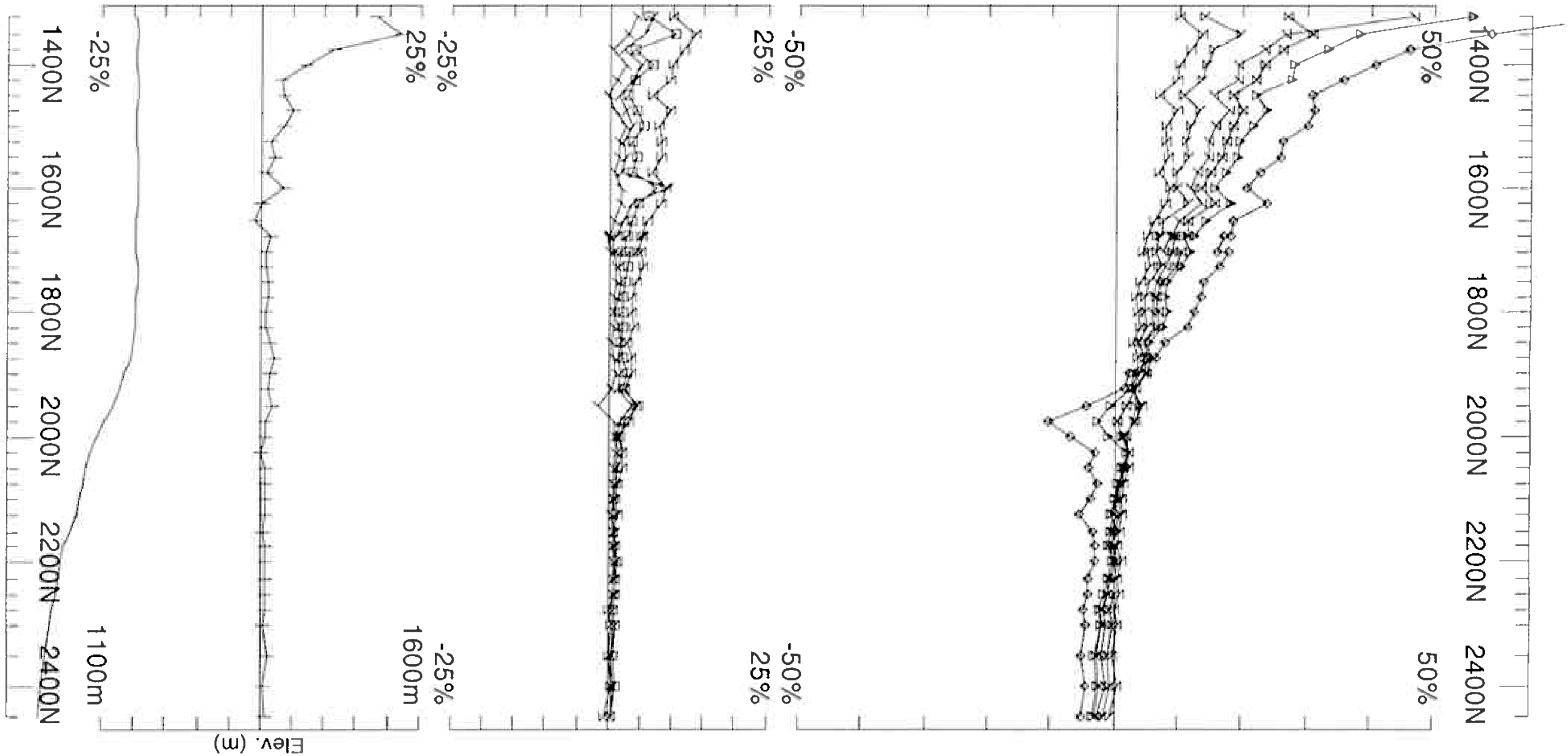
Surveyed : 20/2/48
Reduced : 23/4/3
Plotted : 24/4/3



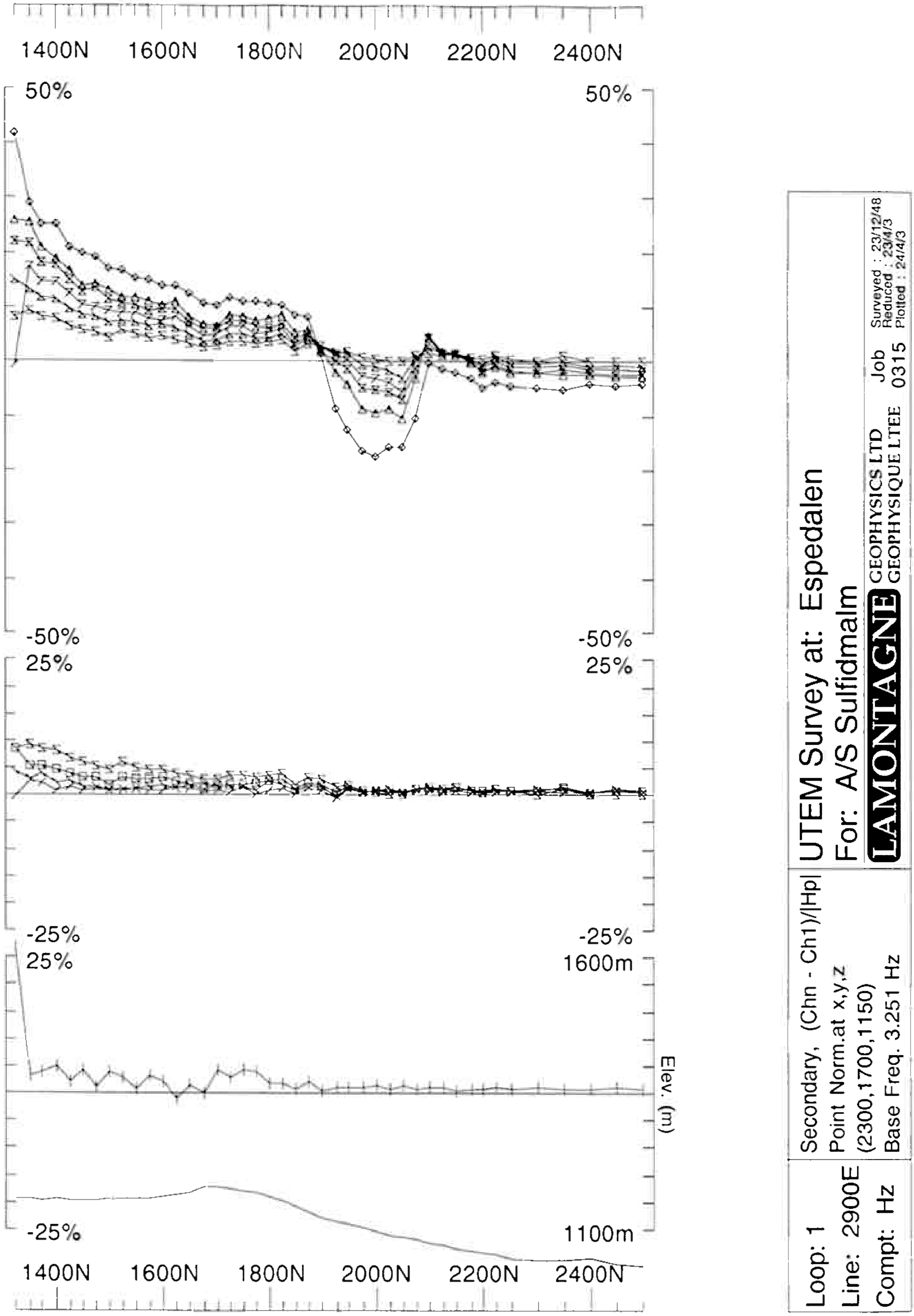
Loop: 1 Line: 2300E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (2300,1700,1150) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE	Job 0315 Surveyed : 20/2/48 Reduced : 23/4/3 Plotted : 24/4/3



1400N
1600N
1800N
2000N
2200N
2400N
50%
50%
-50%
-50%
25%
25%
-25%
-25%
25%
1600m
Elev. (m)
-25%
1100m
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Surveyed : 21/2/48
Reduced : 23/4/3
Plotted : 24/4/3
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(2300,1700,1150)
Base Freq. 3.251 Hz
Loop: 1
Line: 2500E
Compt: Hz



Loop: 1 Line: 2700E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (2300,1700,1150) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Plotted : 24/4/3


1400N
1600N
1800N
2000N
2200N
2400N
50%
50%
-50%
-50%
25%
25%
-25%
-25%
25%
1600m
Elev. (m)
-25%
1100m
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Surveyed : 23/12/48
Reduced : 23/4/3
Plotted : 24/4/3
Loop: 1
Line: 2900E
Compt: Hz
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(2300,1700,1150)
Base Freq. 3.251 Hz

Espedalen

Loop 2

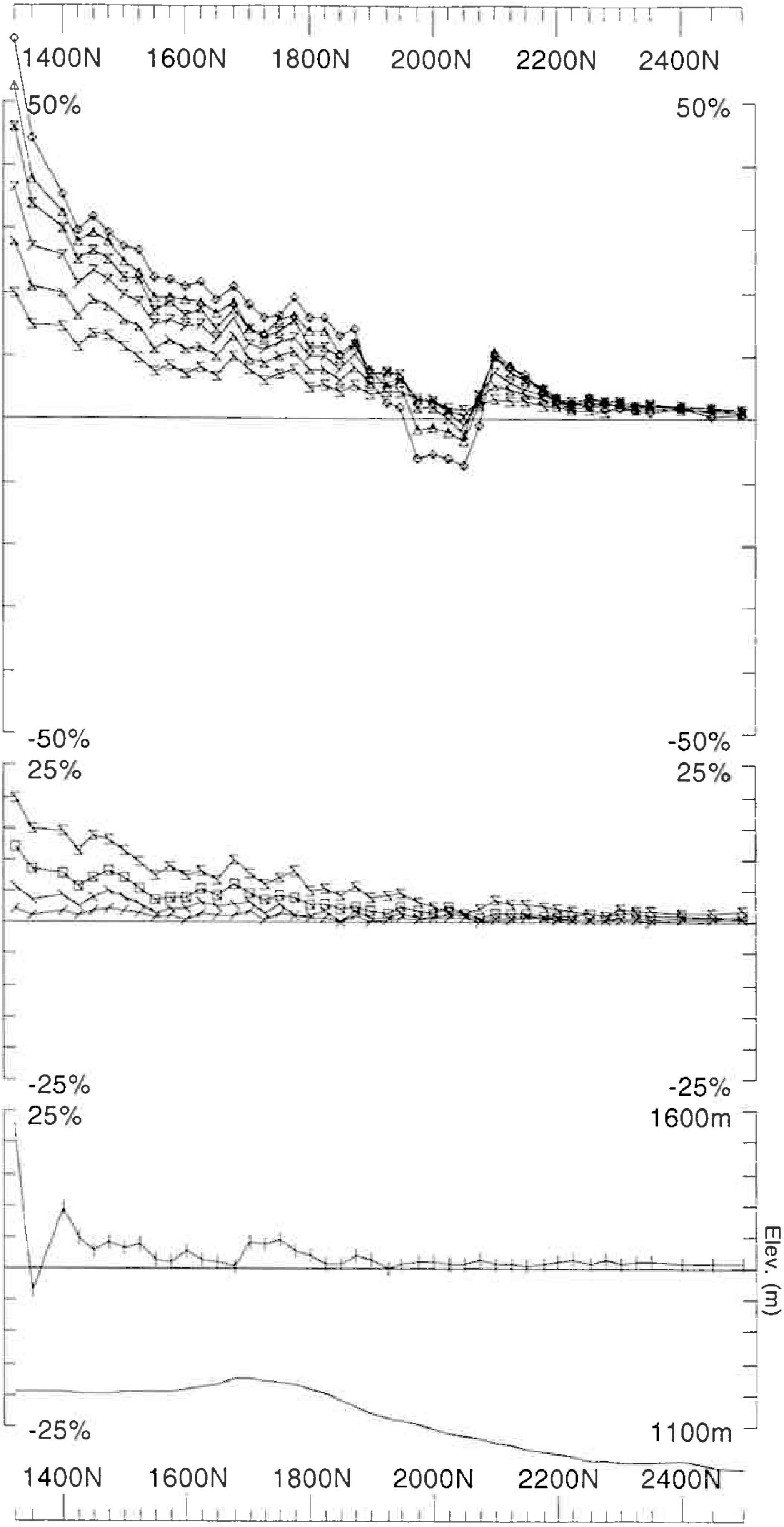
Hz
@3.251 Hz frequency

point norm
@
(x,y,z) = (3500E,1700N, 1150 m.a.s.l.)

Ch1 reduced

Loop 2	Line 29+00E	13+00N-25+00N	1200m
	Line 31+00E	13+00N-24+75N	1175m
	Line 33+00E	13+00N-23+75N	1075m
	Line 35+00E	13+00N-24+75N	1175m
	Line 37+00E	13+00N-23+75N	1075m
	Line 39+00E	13+00N-20+75N	775m
		Loop 2 Total	6475m

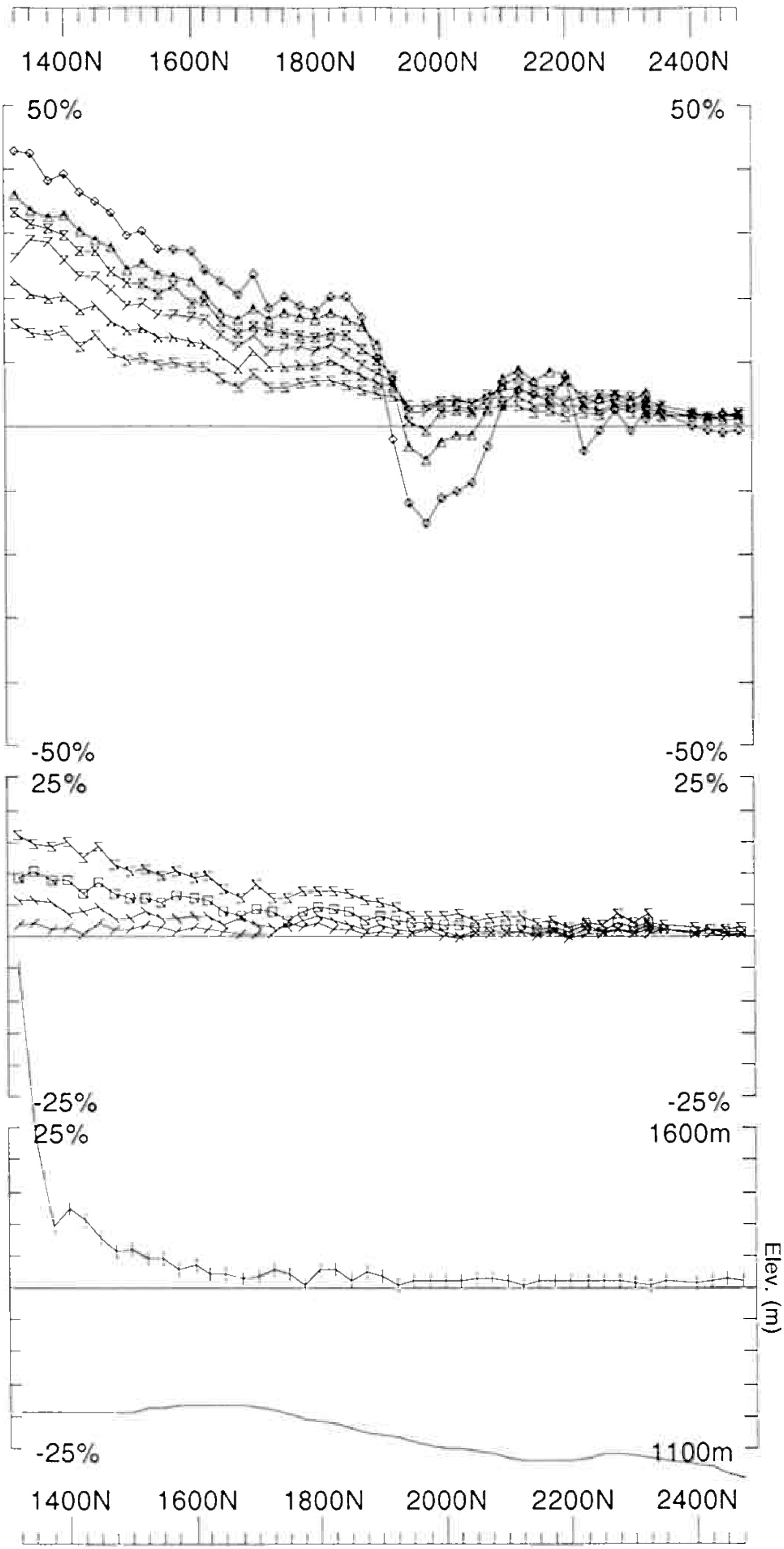
Loop 2 - point norm



UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Surveyed : 10/2/48
Reduced : 24/4/3
Plotted : 24/4/3

Loop: 2
Line: 2900E
Compt: Hz

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(3500,1700,1150)
Base Freq. 3.251 Hz



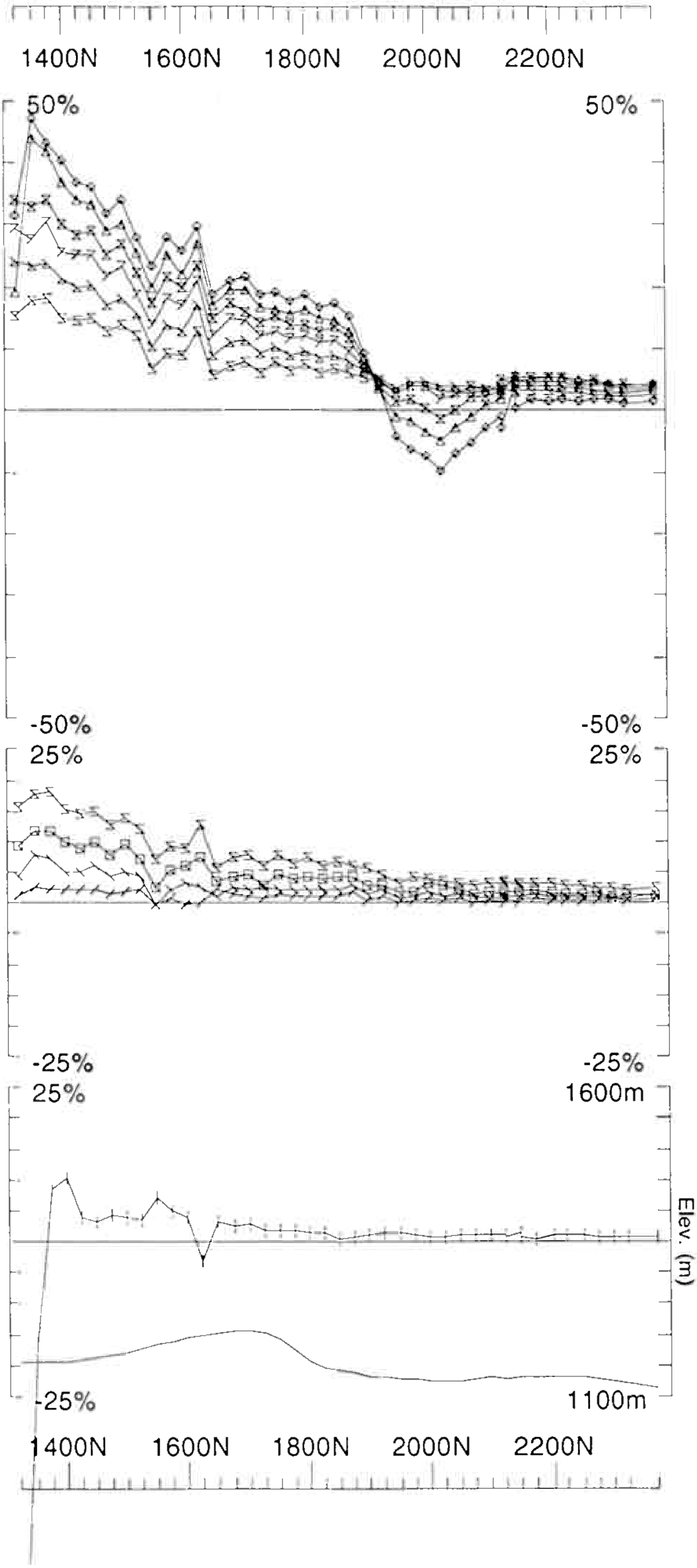
UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0315
Surveyed : 14/12/47
Reduced : 24/4/3
Plotted : 24/4/3

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(3500,1700,1150)
Base Freq. 3.251 Hz

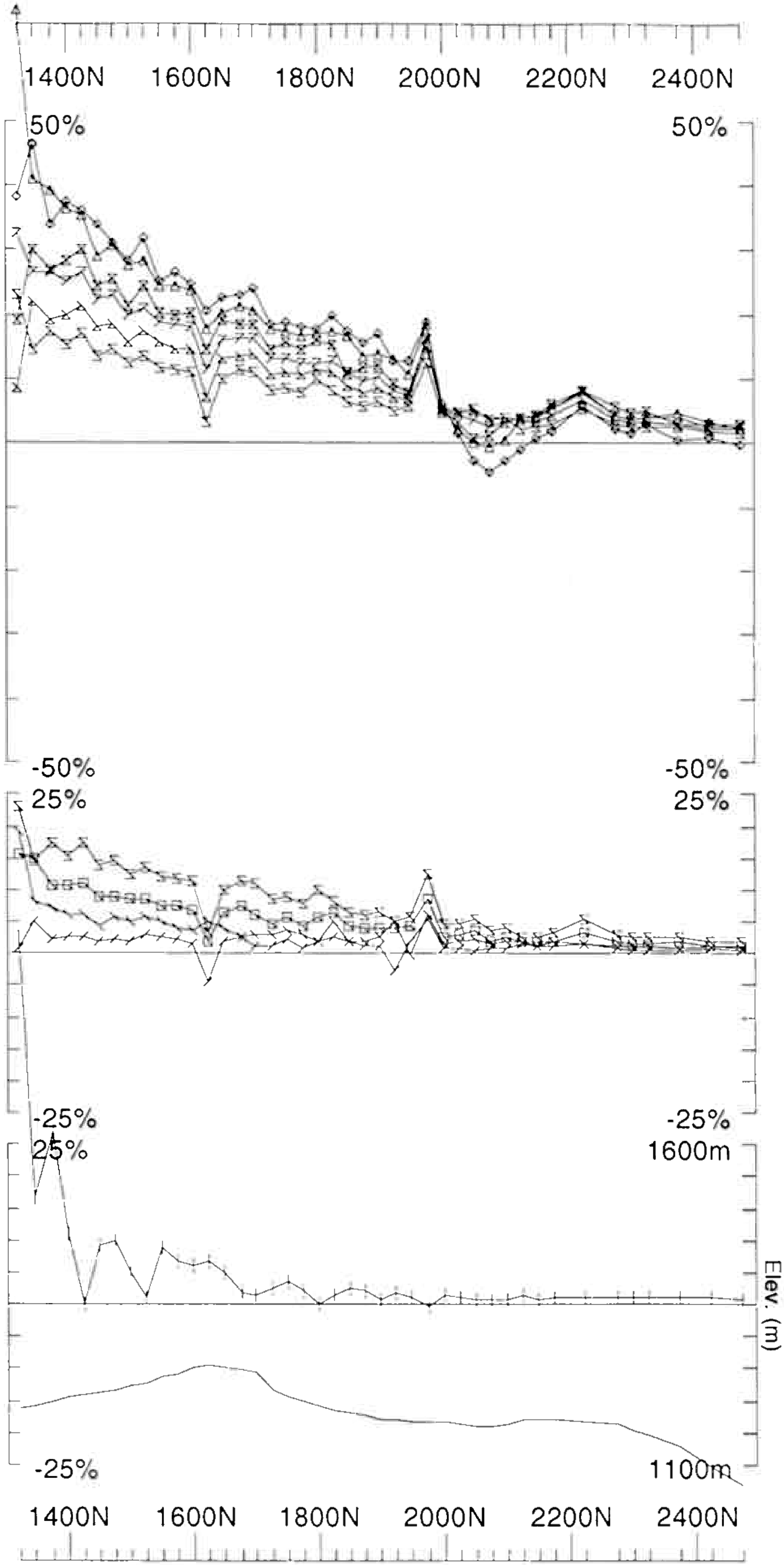
Loop: 2
Line: 3100E
Compt: Hz



UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Plotted : 24/4/3

Loop: 2
Line: 3300E
Compt: Hz

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(3500,1700,1150)
Base Freq. 3.251 Hz



Loop: 2
Line: 3500E
Compt: Hz

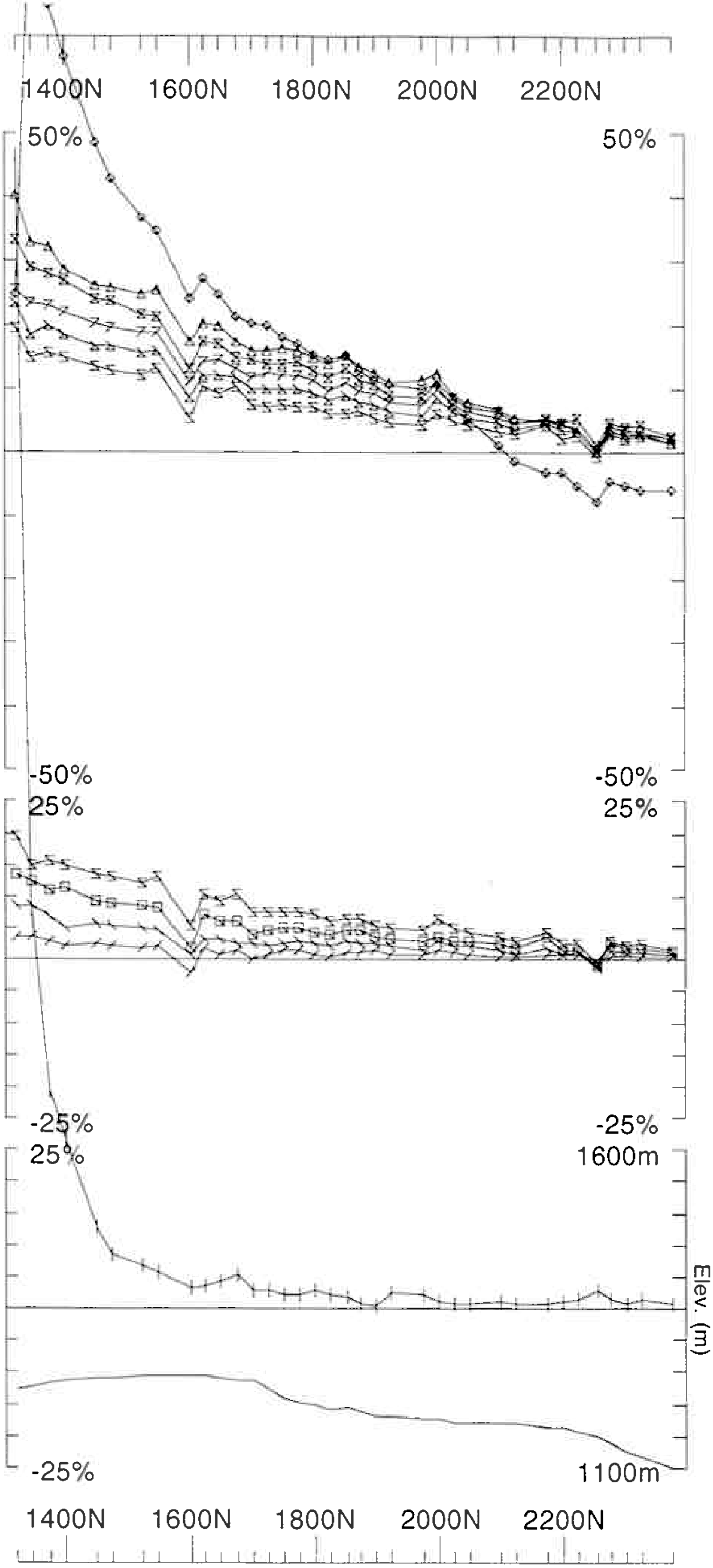
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(3500,1700,1150)
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

Surveyed : 10/2/48
Reduced : 5/4/3
Plotted : 24/4/3



UTEM Survey at: Espedalen

For: A/S Sulfidmalm

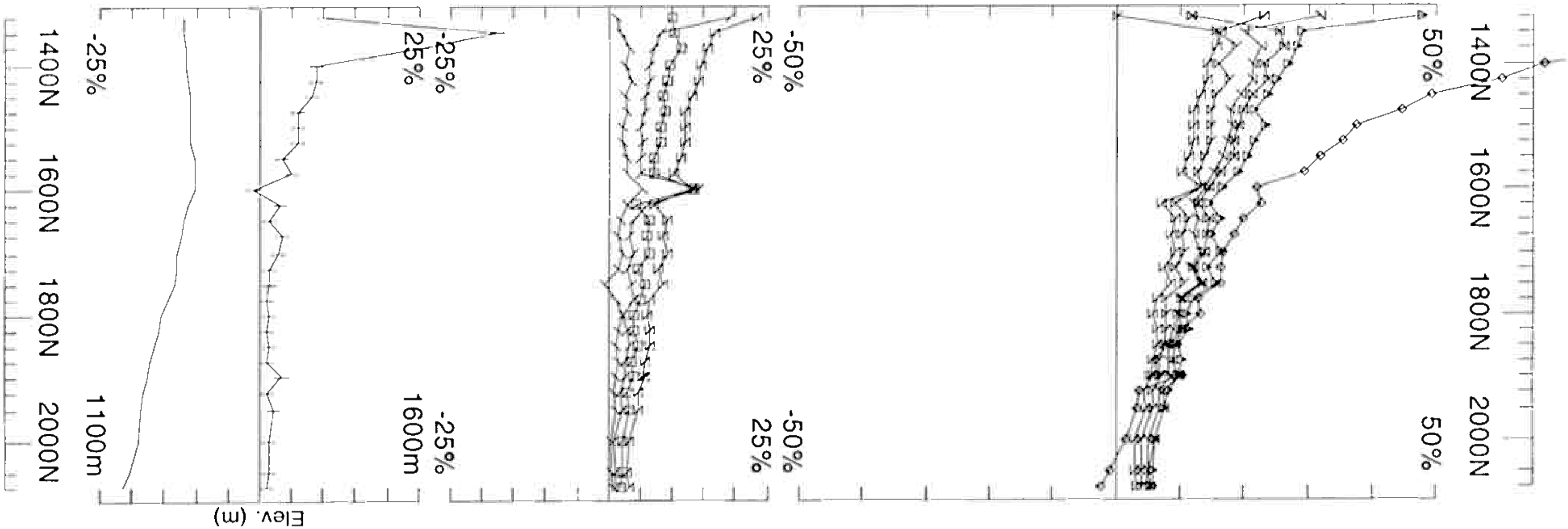
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

Surveyed : 12/2/48
Reduced : 24/4/3
Plotted : 24/4/3

Loop: 2
Line: 3700E
Compt: Hz

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(3500,1700,1150)
Base Freq. 3.251 Hz



Loop: 2 Line: 3900E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (3500,1700,1150) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Plotted : 24/4/3

Espedalen

Loop 3

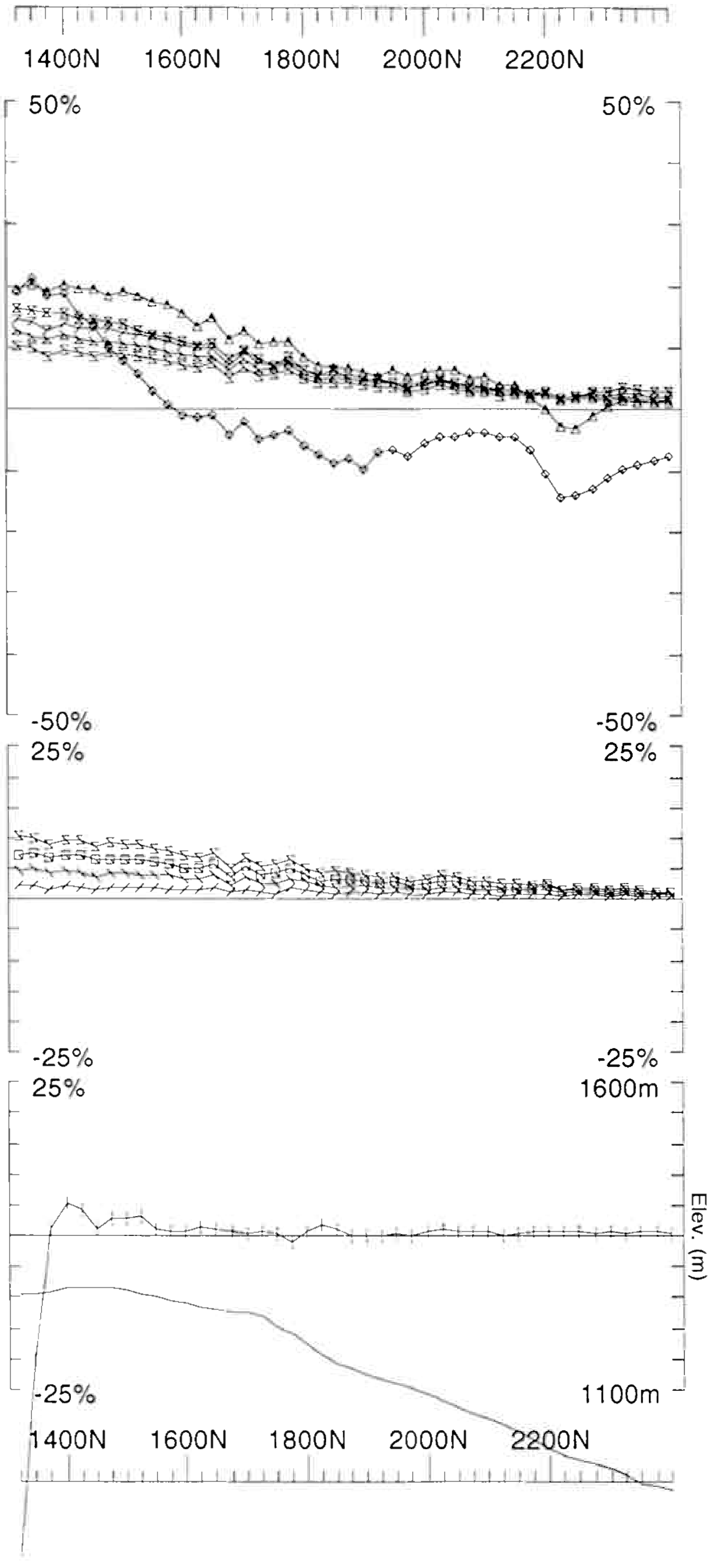
Hz
@3.251 Hz frequency

point norm
@
(x,y,z) = (4700E,1700N, 1150 m.a.s.l.)

Ch1 reduced

Loop 3	Line 41+00E	13+00N-24+00N	1100m
	Line 43+00E	13+00N-24+00N	1100m
	Line 45+00E	13+00N-24+75N	1175m
	Line 47+00E	13+00N-26+00N	1300m
	Line 49+00E	13+00N-25+75N	1275m
	Line 51+00E	13+00N-25+50N	1250m
	Line 53+00E	13+00N-26+00N	1300m
		Loop 3 Total	8500m

Loop 3 - point norm



UTEM Survey at: Espedalen
For: A/S Sulfidmalm

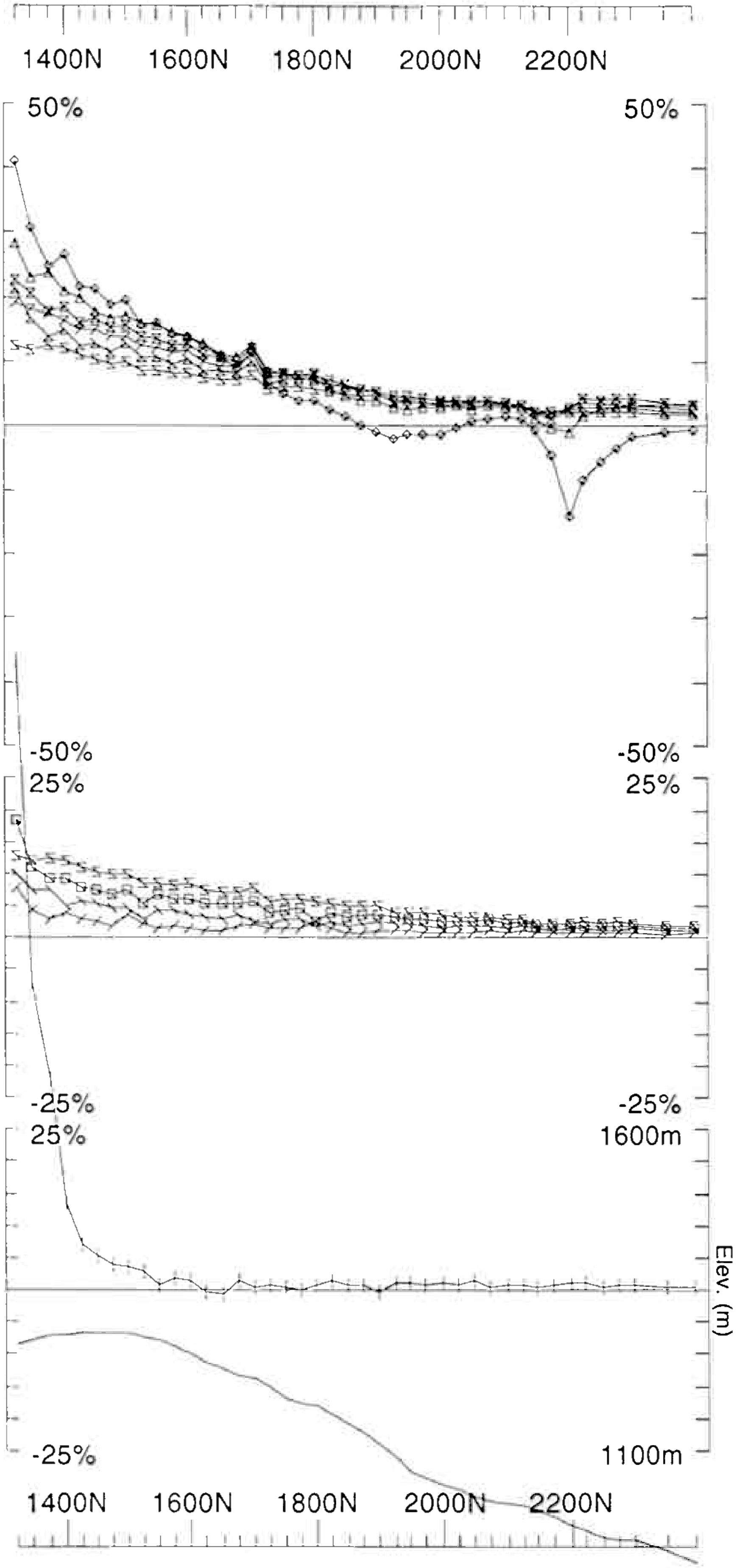
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

Surveyed : 13/2/48
Reduced : 24/4/3
Plotted : 24/4/3

Loop: 3
Line: 4100E
Compt: Hz

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(4700,1700,1150)
Base Freq. 3.251 Hz



Loop: 3
Line: 4300E
Compt: Hz

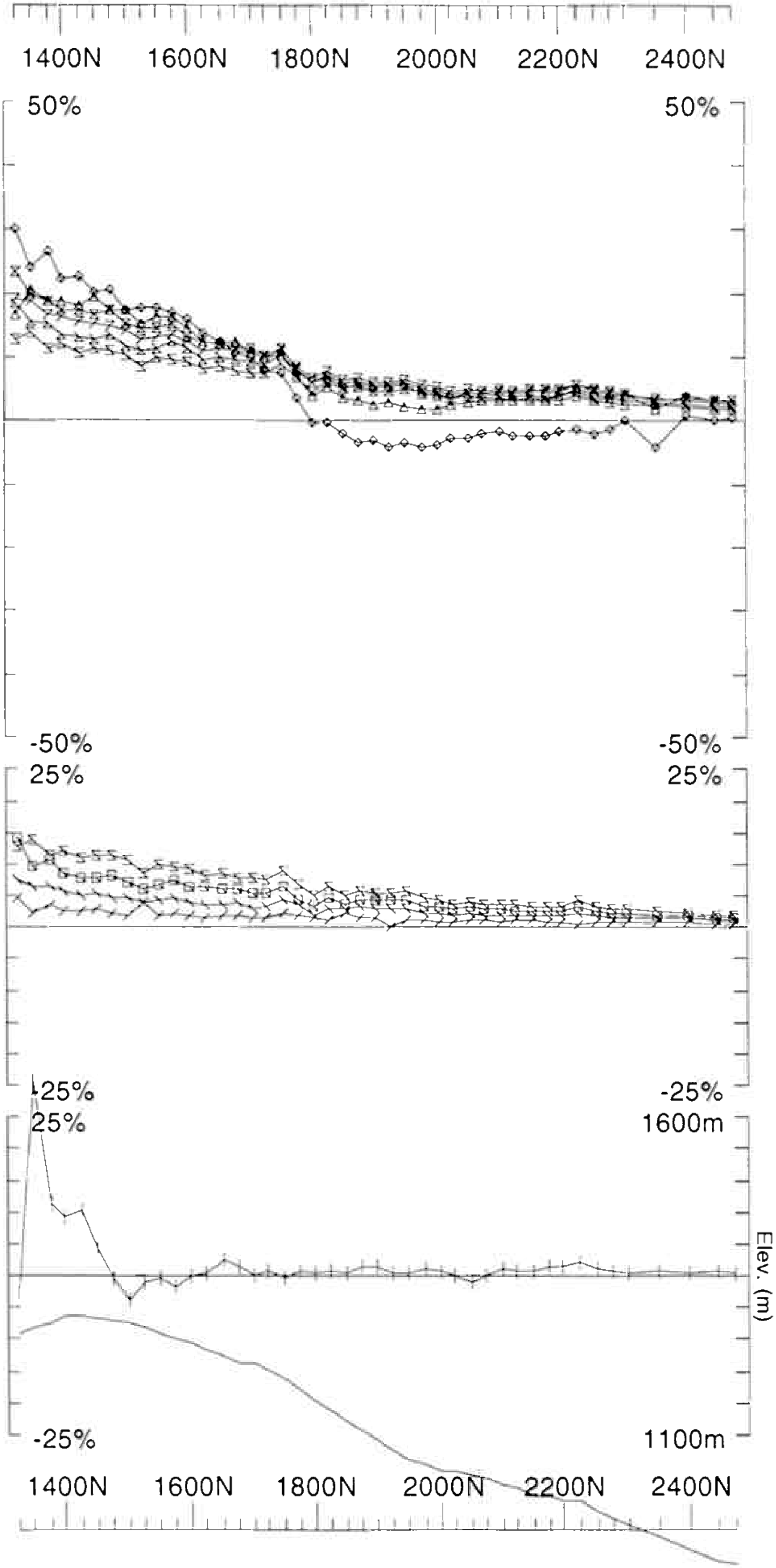
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(4700,1700,1150)
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0315

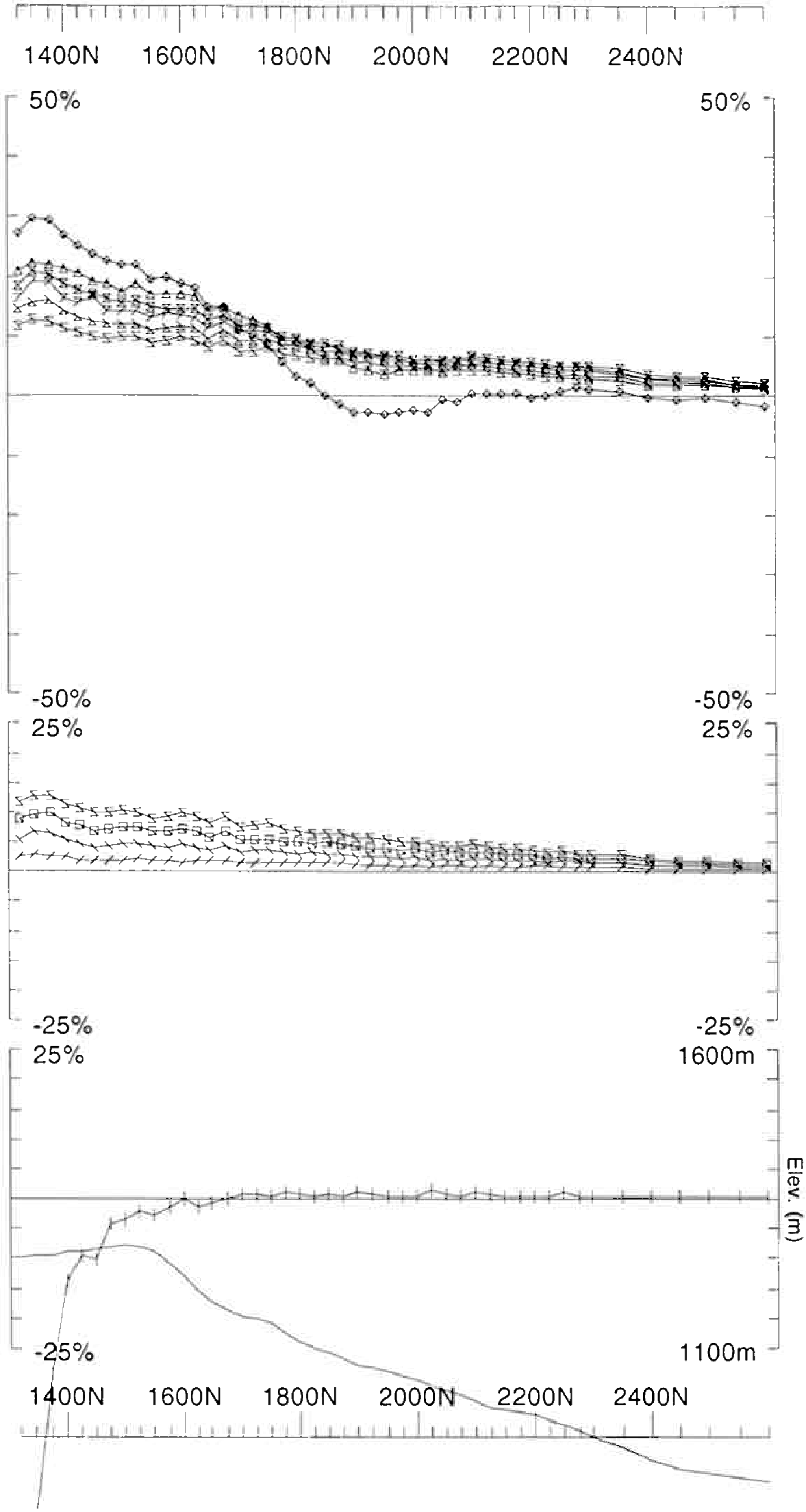
Surveyed : 15/2/48
Reduced : 8/4/3
Plotted : 24/4/3



UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD / GEOPHYSIQUE LTEE
Job 0315
Surveyed : 14/2/48
Reduced : 8/4/3
Plotted : 24/4/3

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(4700,1700,1150)
Base Freq. 3.251 Hz

Loop: 3
Line: 4500E
Compt: Hz



UTEM Survey at: Espedalen

For: A/S Sulfidmalm

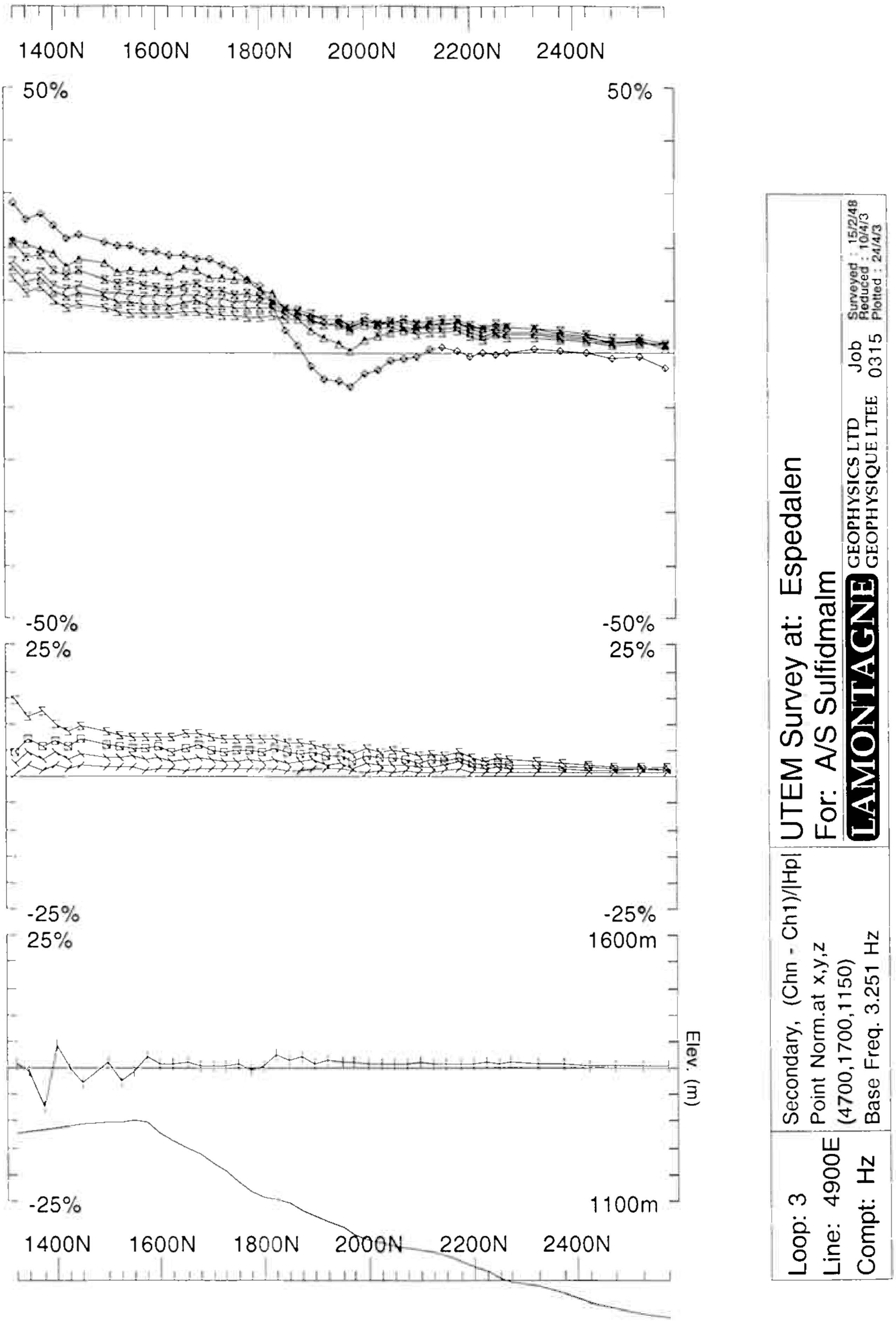
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

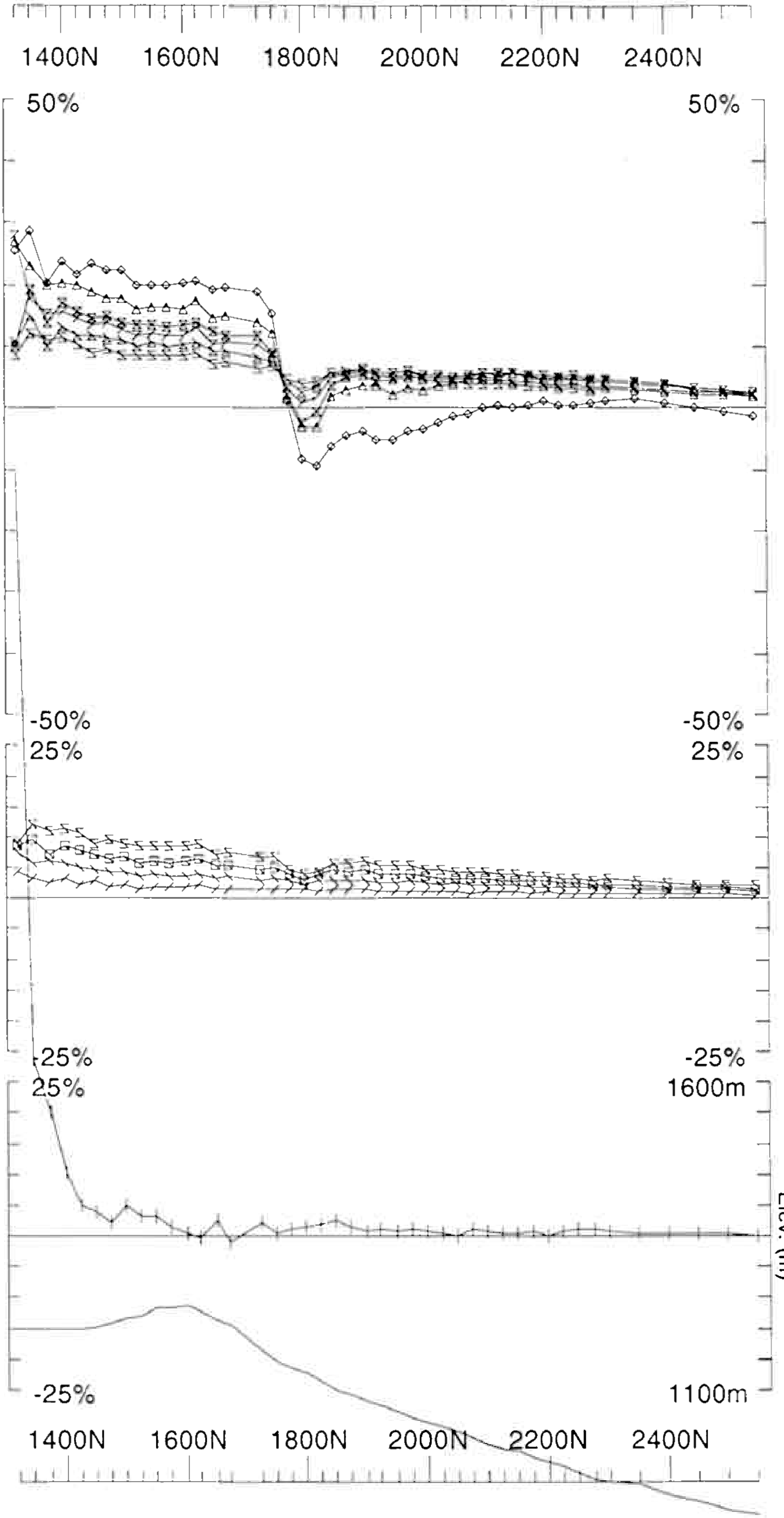
Job 0315

Surveyed : 14/2/48
Reduced : 24/4/3
Plotted : 24/4/3

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(4700,1700,1150)
Base Freq. 3.251 Hz

Loop: 3
Line: 4700E
Compt: Hz


1400N
1600N
1800N
2000N
2200N
2400N
50%
50%
-50%
-50%
25%
25%
-25%
-25%
25%
1600m
Elev. (m)
-25%
1100m
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Surveyed : 15/2/48
Reduced : 10/4/3
Plotted : 24/4/3
Loop: 3
Line: 4900E
Compt: Hz
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(4700,1700,1150)
Base Freq. 3.251 Hz



Loop: 3
Line: 5100E
Compt: Hz

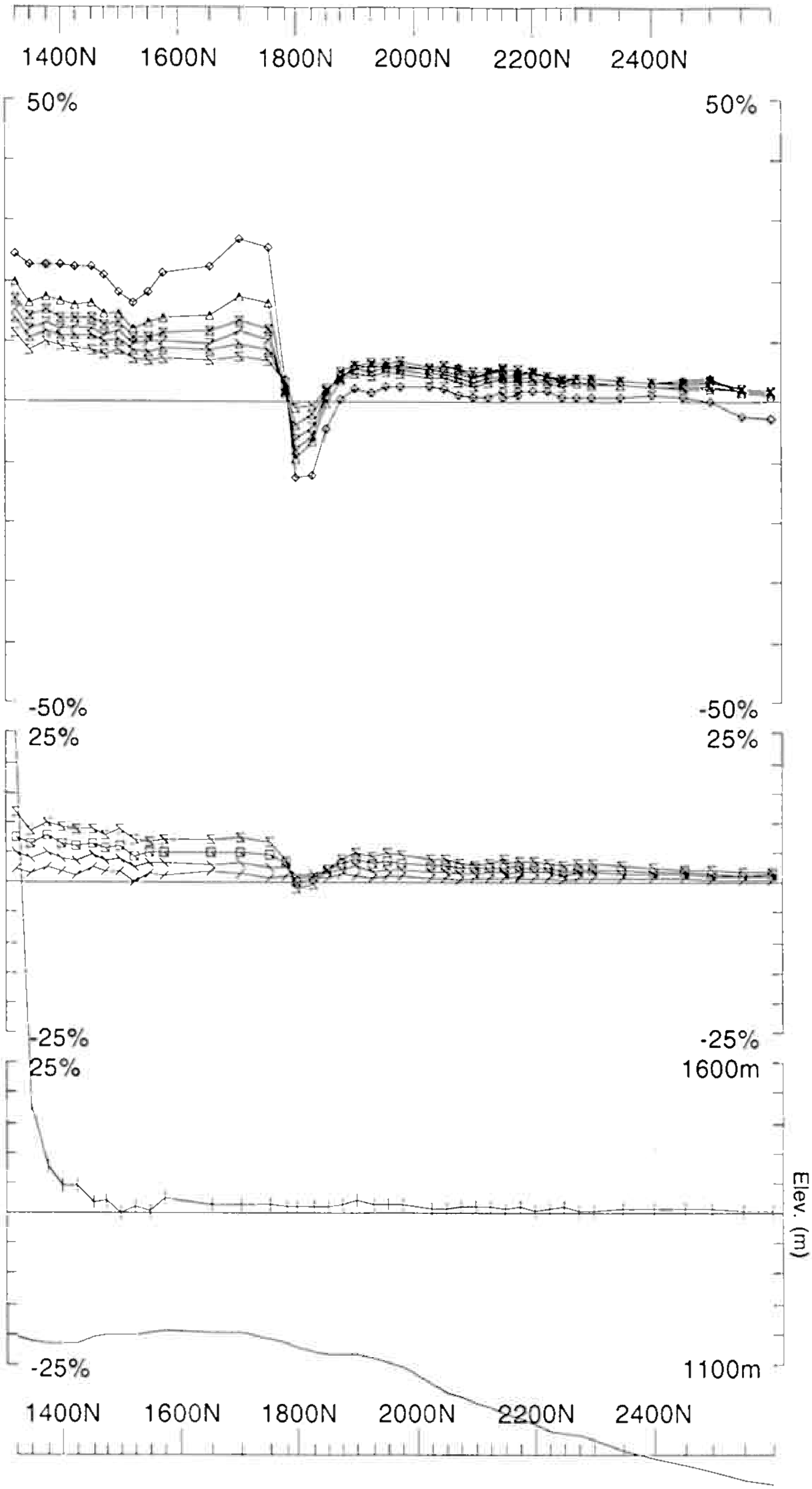
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(4700,1700,1150)
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0315

Surveyed : 15/2/48
Reduced : 24/4/3
Plotted : 24/4/3



Loop: 3
Line: 5300E
Compt: Hz

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(4700,1700,1150)
Base Freq. 3.251 Hz

UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job
0315
Plotted : 24/4/3

Espedalen

Loop 4

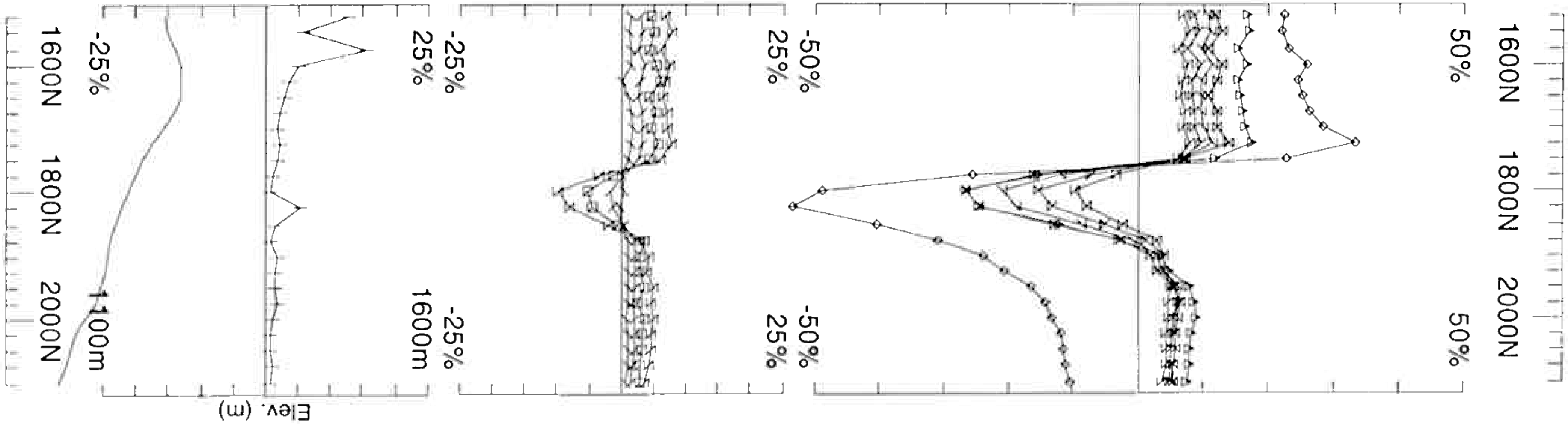
Hz
@3.251 Hz frequency

point norm
@
(x,y,z) = (5800E,1900N, 1150 m.a.s.l.)

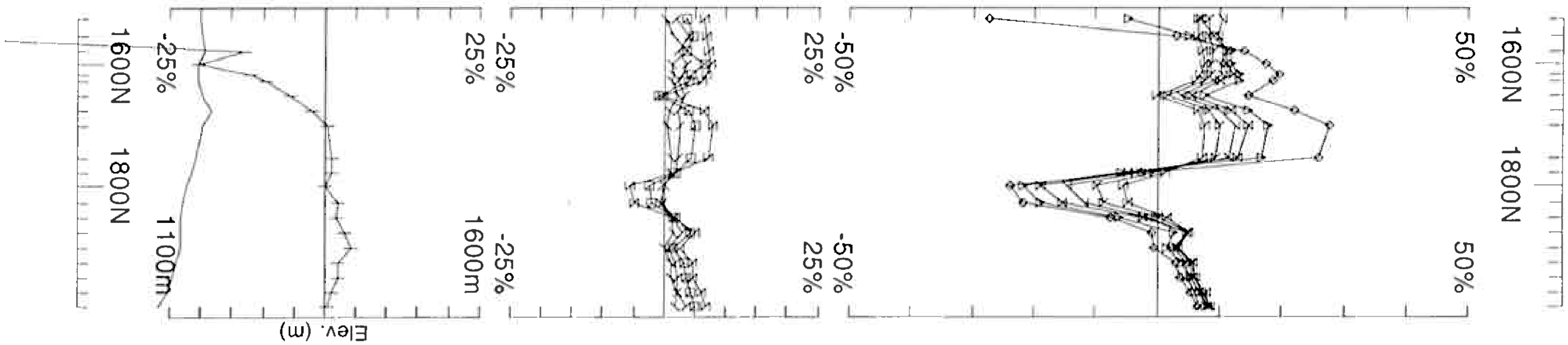
Ch1 reduced

Loop 4	Line 52+00E	15+00N-21+00N	600m
	Line 53+00E	15+00N-20+00N	500m
	Line 54+00E	15+00N-21+00N	600m
	Line 55+00E	15+00N-26+00N	1100m
	Line 57+00E	15+00N-25+50N	1050m
	Line 59+00E	15+00N-25+75N	1075m
	Line 61+00E	15+00N-25+50N	1050m
	Line 63+00E	15+00N-25+00N	1000m
		Loop 4 Total	6975m

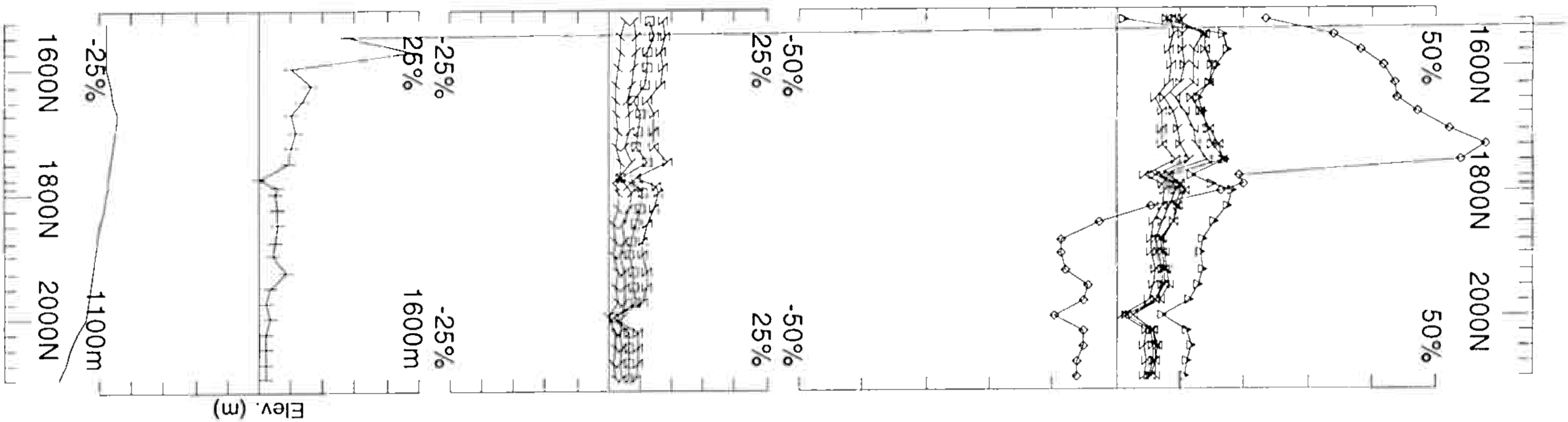
Loop 4 - point norm



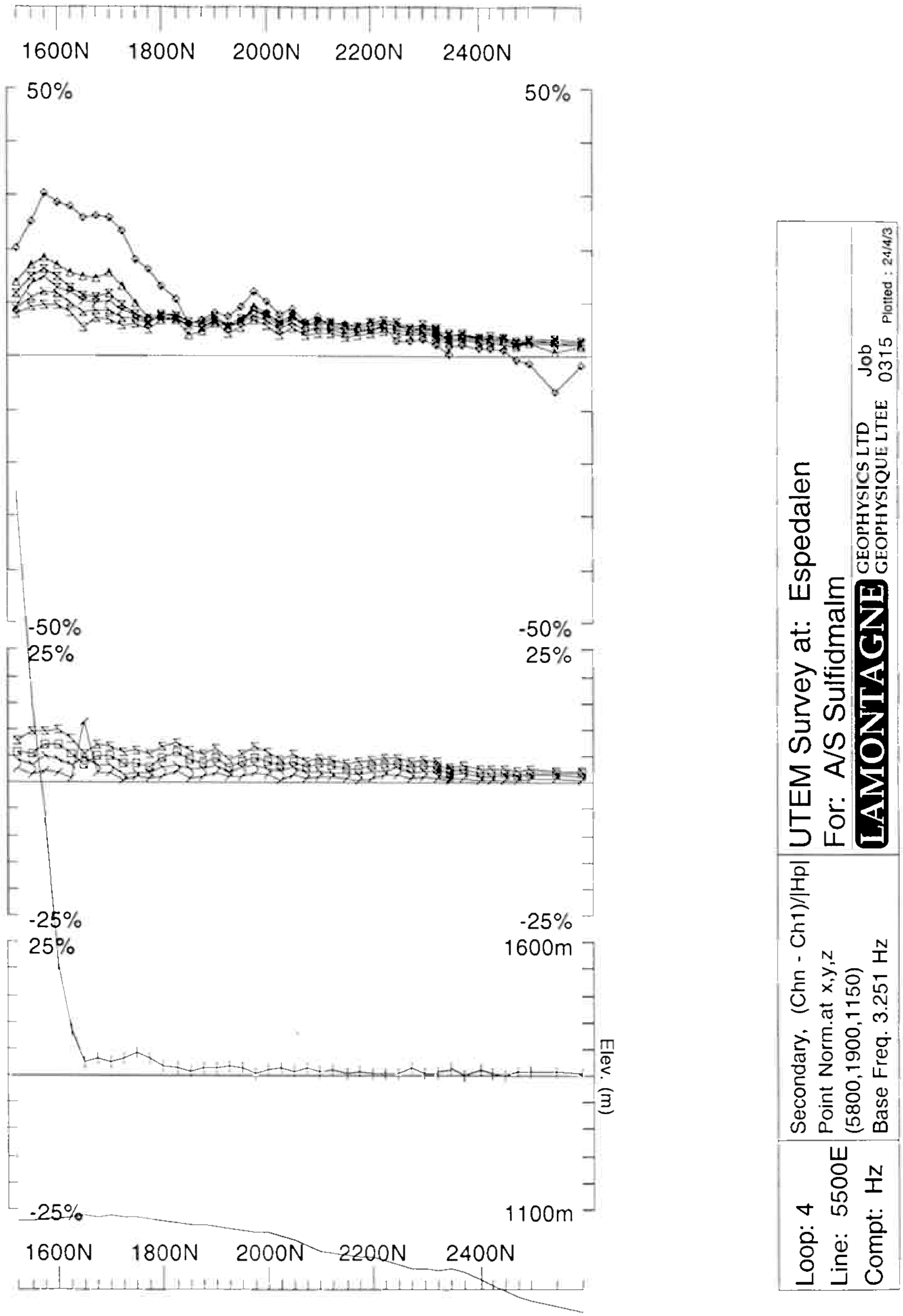
Loop: 4 Line: 5200E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (5800,1900,1150) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 18/2/48 Reduced : 11/4/3 Plotted : 24/4/3

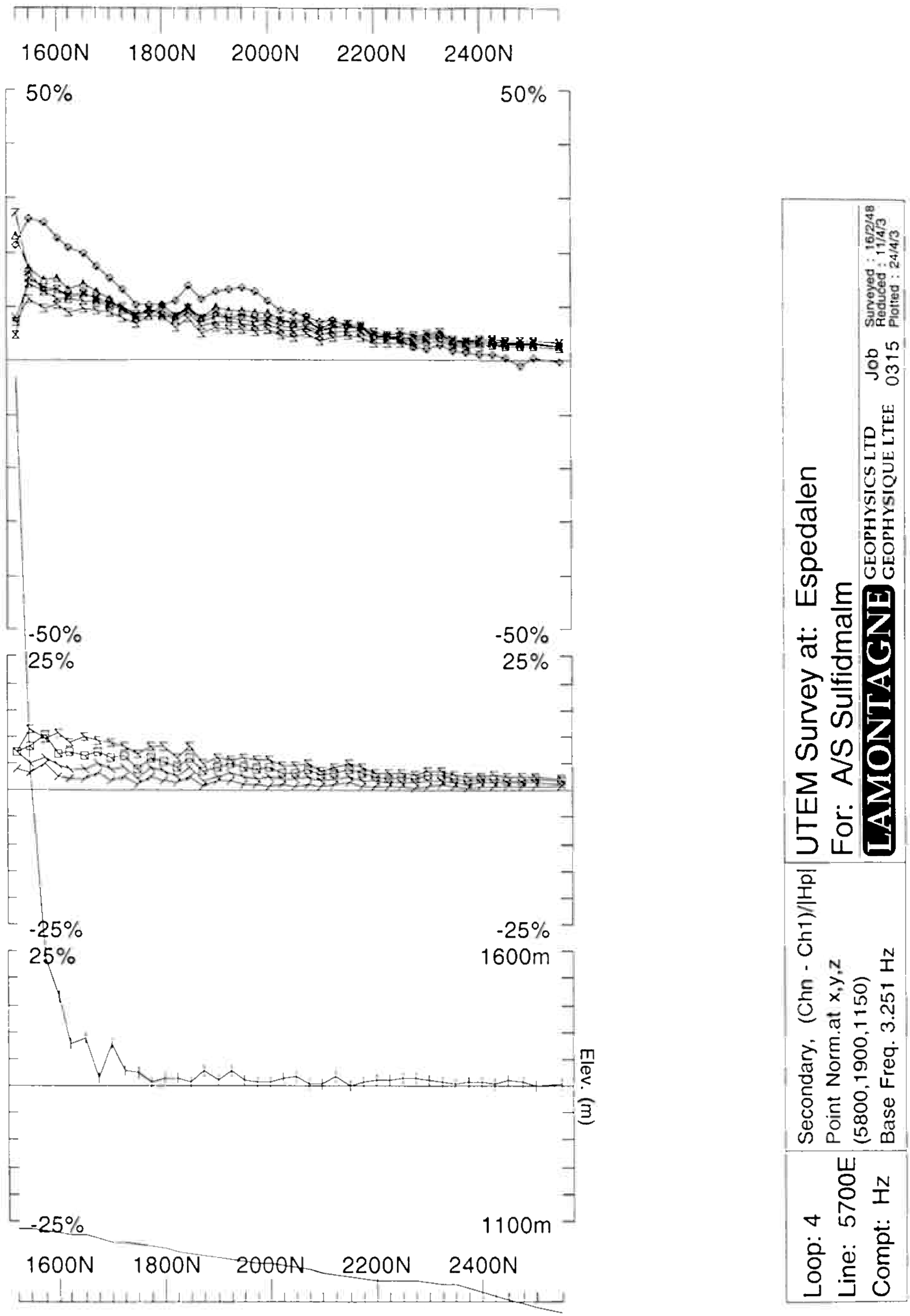


Loop: 4 Line: 5300E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (5800,1900,1150) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 16/2/48 Reduced : 11/4/3 Plotted : 24/4/3

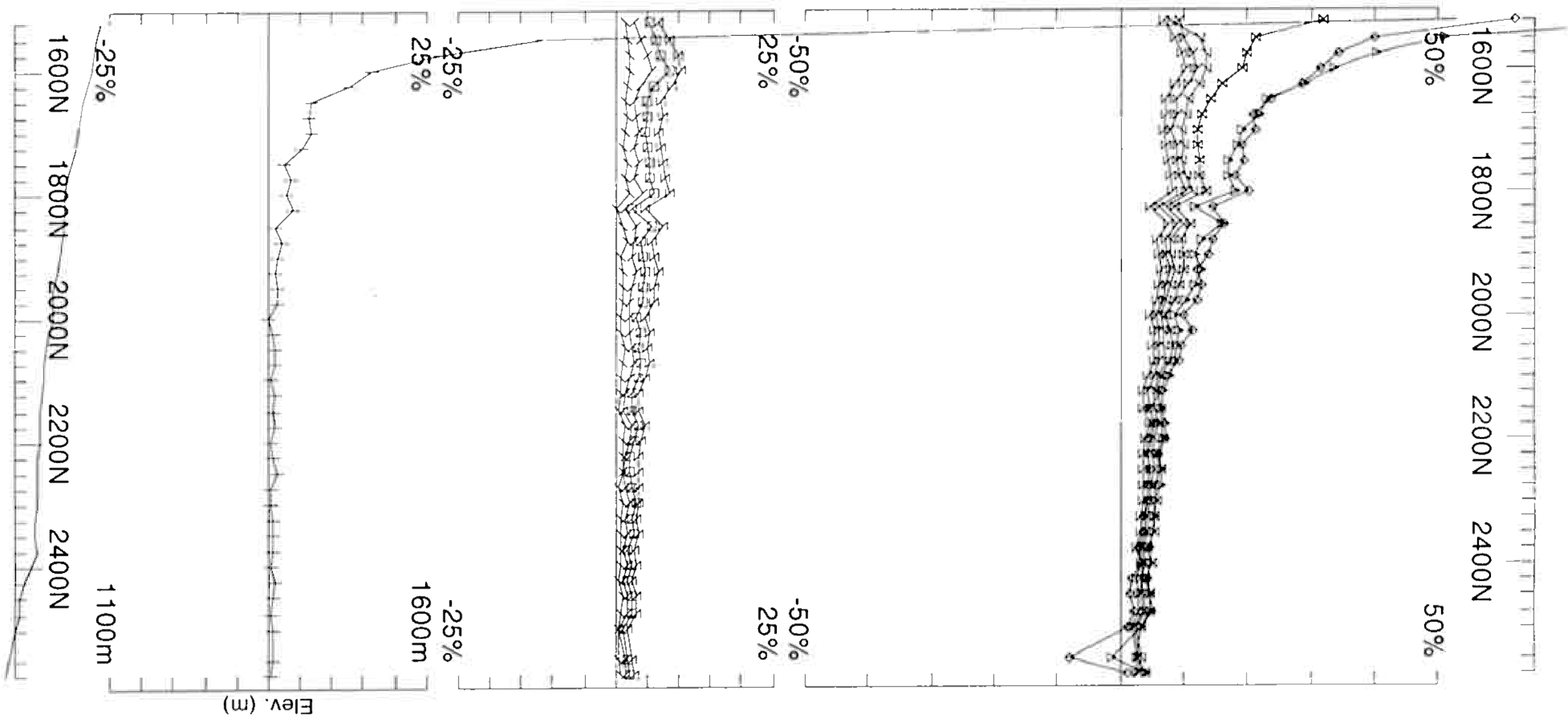


Loop: 4 Line: 5400E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (5800,1900,1150) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0315 Surveyed : 18/2/48 Reduced : 11/4/3 Plotted : 24/4/3

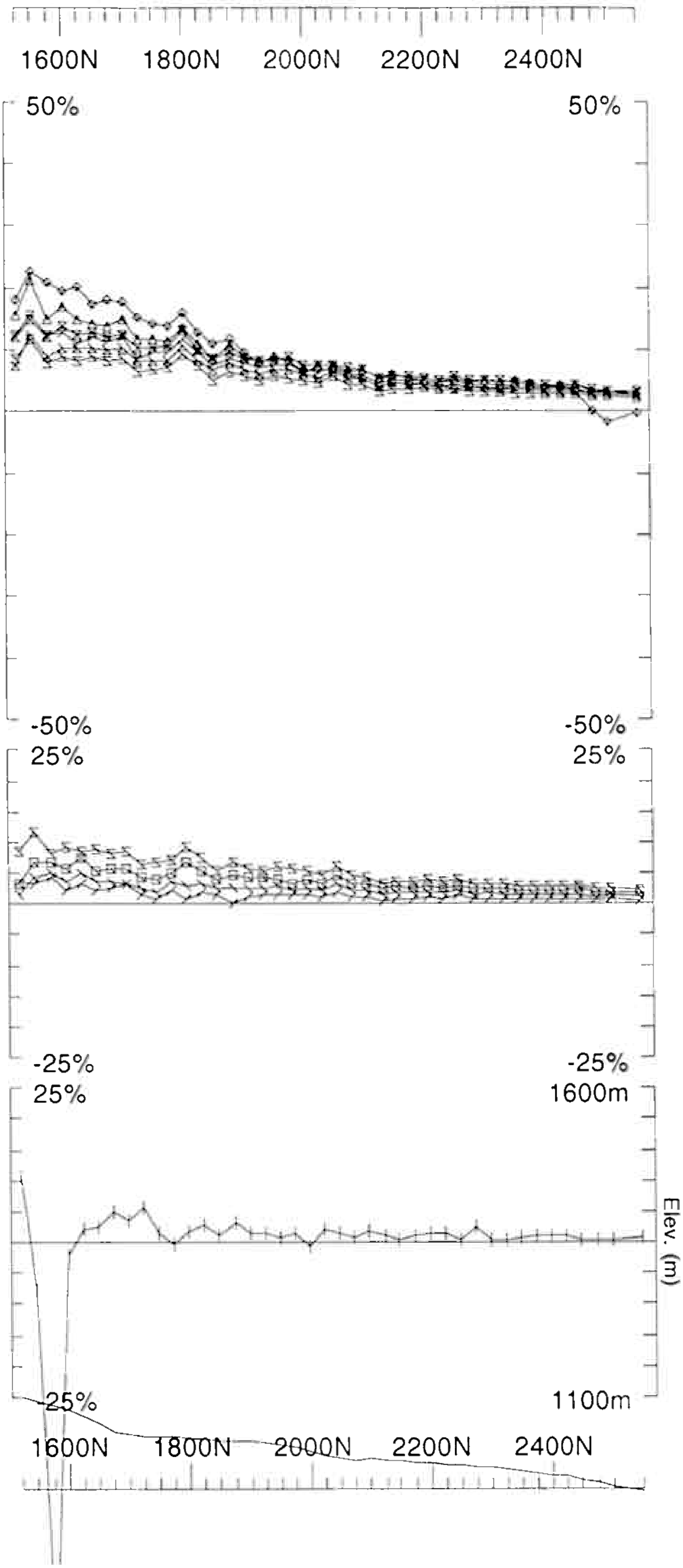

1600N
1800N
2000N
2200N
2400N
50%
50%
-50%
-50%
25%
25%
-25%
-25%
25%
1600m
Elev. (m)
-25%
1100m
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Plotted : 24/4/3
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(5800,1900,1150)
Base Freq. 3.251 Hz
Loop: 4
Line: 5500E
Compt: Hz



1600N
1800N
2000N
2200N
2400N
50%
50%
-50%
-50%
25%
25%
-25%
-25%
25%
1600m
Elev. (m)
-25%
1100m
1600N
1800N
2000N
2200N
2400N
UTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0315
Surveyed : 16/2/48
Reduced : 11/4/3
Plotted : 24/4/3
Loop: 4
Line: 5700E
Compt: Hz
Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(5800,1900,1150)
Base Freq. 3.251 Hz



Loop: 4 Line: 5900E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (5800,1900,1150) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD / GEOPHYSIQUE LTEE Job 0315 Surveyed : 17/2/48 Reduced : 11/4/3 Plotted : 24/4/3



UTEM Survey at: Espedalen

For: A/S Sulfidmalm

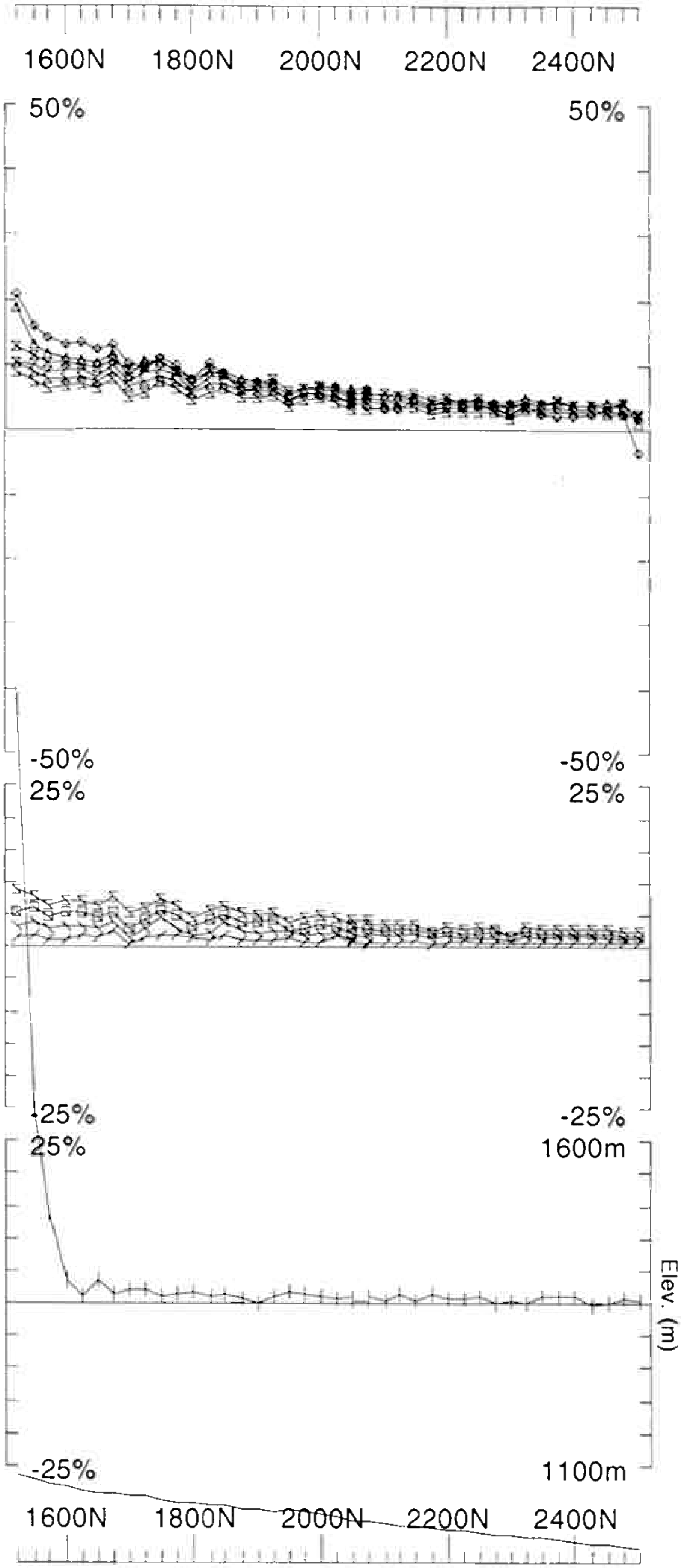
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0315

Surveyed : 17/2/48
Reduced : 11/4/3
Plotted : 24/4/3

Loop: 4
Line: 6100E
Compt: Hz

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(5800,1900,1150)
Base Freq. 3.251 Hz



UTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job
0315

Plotted : 24/4/3

Secondary, (Chn - Ch1)/|Hp|
Point Norm.at x,y,z
(5800,1900,1150)
Base Freq. 3.251 Hz

Loop: 4
Line: 6300E
Compt: Hz

Appendix B

0315 Production Diary

UTEM 3 Surface Survey

Espedalen Grid
Norway

for

A/S Sulfidmalm

Production Log (0315)
UTEM Survey - Espedalen
Norway
A/S Sulfidmalm

Date	Rate	Production	Comments
up to March 27		-	Discussions, signing of the contract, assembly of crew and equipment.
March 27	Mob	(equip)	Equipment packed up and labelled. Picked up in the afternoon. Shipping address is: A/S Sulfidmalm Strand Fjellstue 2658 Espedalen Norway ATTN: Svein Sørum phone (47) 38 10 14 40
March 31	Mob	-	The LGL crew -Rob Langridge and Ryan Land - travel from Kingston (YGK) and Halifax (YHZ) respectively to Toronto Pearson Airport and begin trip: Toronto (YYZ)->Frankfort (FRA)->Oslo (OSL) Equipment arrives Oslo. Falconbridge personnel in Espedalen lay out Loop 2.
April 01	Mob	-	Continuation of air travel. Crew arrives in Oslo and is collected by Falconbridge personnel. The gear has cleared customs and the crew and gear are transported to the hotel in Espedalen. Unpack gear and find coil collar yokes are missing. Arrange transport.
April 02	**P(1)-2**	1175m	Pack gear and travel out to Loop 2 Tx site. Get to the site and get the transmitter setup by just after 12:00. It is discovered that Rx1 was accidentally turned off in the morning. Ryan and Rob survey Line 3100E . Jean and Dag lay out three sides of Loop 3 and then limp the "Grizzly" snowmobile home. Back in camp ~18:20. **Loop 2** **Line 3100E 1300N - 2475N Hz** Crew: R.Langridge, R.Land Total to date: 1.175km
April 03	**P(2)-2**	3450m	Out to Loop 2 Tx site. Windy day in the hills. Back in camp ~18:20. **Loop 2** **Line 2900E 1300N - 2500N Hz** **Line 3300E 1300N - 2475N Hz** **Line 3500E 1300N - 2375N Hz** Crew: R.Langridge, R.Land Total to date: 4.625km.

Date	Rate	Production	Comments
April 04	**1/2P(2)-2 1/2 standby**	-	Out to Loop 2 Tx site. Very windy. Charged the car battery for the Tx for ~30mins. The wind seemed to have died down so we set up/out to read. On the ridge it was actually getting windier so we decided to pack it in for the day. Back in camp ~11:45. TV/radio crew arrived and interviewed/filmed the crew.
April 05	**P(2)-2**	1850m	Out to Loop 2 Tx site. Very windy day in the hills. Problems with one coil late in the day could not be fixed in the field. One loop break. **Loop 2** **Line 3700E 1300N - 2375N Hz** **Line 3900E 1300N - 2075N Hz** Crew: R.Langridge, R.Land Total to date: 6.475km.
April 06	**P(2)-2**	2200m	Out to Loop 2 Tx site. Moved gear to Loop 3 Tx site. Laid an additional wire along the east/west sides of Loop 3. Read two lines with fixed ropes on both. Back in camp ~18:00. **Loop 3** **Line 4100E 1300N - 2400N Hz** **Line 4300E 1300N - 2400N Hz** Crew: R.Langridge, R.Land Total to date: 8.675km.
April 07	**P(2)-2**	2475m	Out to Loop 3 Tx site. Picked up the gridsouth and gridnorth sides of Loop 2. Dag set out fixed ropes for the survey lines Read two lines with fixed ropes on both. Dag and Jean laid out all remaining wire on Loop 4 - it is missing ~300m. Back in camp ~18:15. **Loop 3** **Line 4500E 1300N - 2475N Hz** **Line 4700E 1300N - 2600N Hz** Crew: R.Langridge, R.Land Total to date: 11.150km.
April 08	**P(2)-2**	3825m	Out to Loop 3 Tx site. Fixed a loop break. Dag set out fixed ropes for the survey lines Read three lines with fixed ropes on all of them. Dag headed off to get a replacement skidoo. Back in camp ~19:00. **Loop 3** **Line 4900E 1300N - 2575N Hz** **Line 5100E 1300N - 2550N Hz** **Line 5300E 1300N - 2600N Hz** Crew: R.Langridge, R.Land Total to date: 14.975km.

Date	Rate	Production	Comments
April 09	P(2)-2	2650m	Out to Loop 3/4 Tx site. Picked up one of the double sides of loop 3 and then laid out the final sides of loop 4 and buried wire on ski trails. Dag set out fixed rope on 5300E again. Read three lines. Back in camp ~18:30. **Loop 4** **Line 5300E 1500N - 2000N Hz** **Line 5500E 1500N - 2600N Hz** **Line 5700E 1500N - 2550N Hz** Crew: R.Langridge, R.Land Total to date: 17.625km.
April 10	P(2)-2	3125m	Out to Loop 3/4 Tx site. Read three lines. Snow scooter problems. Back in camp ~16:45. Moved everything from the house to rooms. Snow started to fall ~18:00 **Loop 4** **Line 5900E 1500N - 2575N Hz** **Line 6100E 1500N - 2550N Hz** **Line 6300E 1500N - 2500N Hz** Crew: R.Langridge, R.Land Total to date: 20.750km.
April 11	P(2)-2	1200m	Out to Loop 3/4 Tx site. Dag waited for snow scooter repairman. Jean laid out detail Lines 5200/5400E with the GPS. Rob and Ryan attempted to lay out part of Loop 1 but near-whiteout condition prevented it. Read the detail lines and picked up the remainder of Loop 3. Back in camp ~16:00. **Loop 4** **Line 5200E 1500N - 2100N Hz** **Line 5400E 1500N - 2100N Hz** Crew: R.Langridge, R.Land Total to date: 21.950km.
April 12	P(2)-2	-	Out to Loop 3/4 Tx site and moved everything over to the Loop 1/2 Tx site. Laid in Loop 1. Finished ~13:30. Decided to do other work - changed oil.in generator, picked up Loop 4 and removed pickets from Lines 4900/4500E. Back in camp ~17:15.
April 13	P(2)-2	3800m	Out to Loop 1/2Tx site. Ryan and Rob read one line down with no coiler and one line up with coilers. Jean and Dag complete collecting the bamboo wands (pickets) off Lines 3900-4900E. Problems with Rx 5 recording slowed things down and with 1 station to go the Tx shut down. Back in camp ~19:00. **Loop 1** **Line 1700E 1300N - 2225N Hz** **Line 1900E 1300N - 2300N Hz** **Line 2100E 1300N - 2250N Hz** **Line 2300E 1300N - 2225N Hz** Crew: R.Langridge, R.Land Total to date: 25.750km.

Date	Rate	Production	Comments
April 14	**P(2)-2**	3500m	Out to Loop 1/2 Tx site. Ryan and Rob read three lines with coilers. Back in camp ~18:45. **Loop 1** **Line 2500E 1300N - 2450N Hz** **Line 2700E 1300N - 2450N Hz** **Line 2900E 1300N - 2500N Hz** Crew: R.Langridge, R.Land Total to date: 29.250km.
April 15	**L(2)-2**	-	Out to Loop 1/2 Tx site. Pick up Loop 1. Move equipment down the mountain and pick pickets up. Jean speaks to a local meeting late in the afternoon. Get the okay to leave. Transfer wire and pack.
April 16	**demob**	-	Finish packing. Geir drives crew and equipment to SAS Cargo at Gardemoen Airport.
April 17	**n/c**	-	Crew day off.
April 18	**demob**	-	Crew travels Oslo-Frankfurt-Toronto. Rob moves on to Kingston, Ryan to Port Hope..
April 19-23	**equipment**	-	Equipment in transit.
April 24	**equipment**	-	Equipment arrives in Kingston.

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.

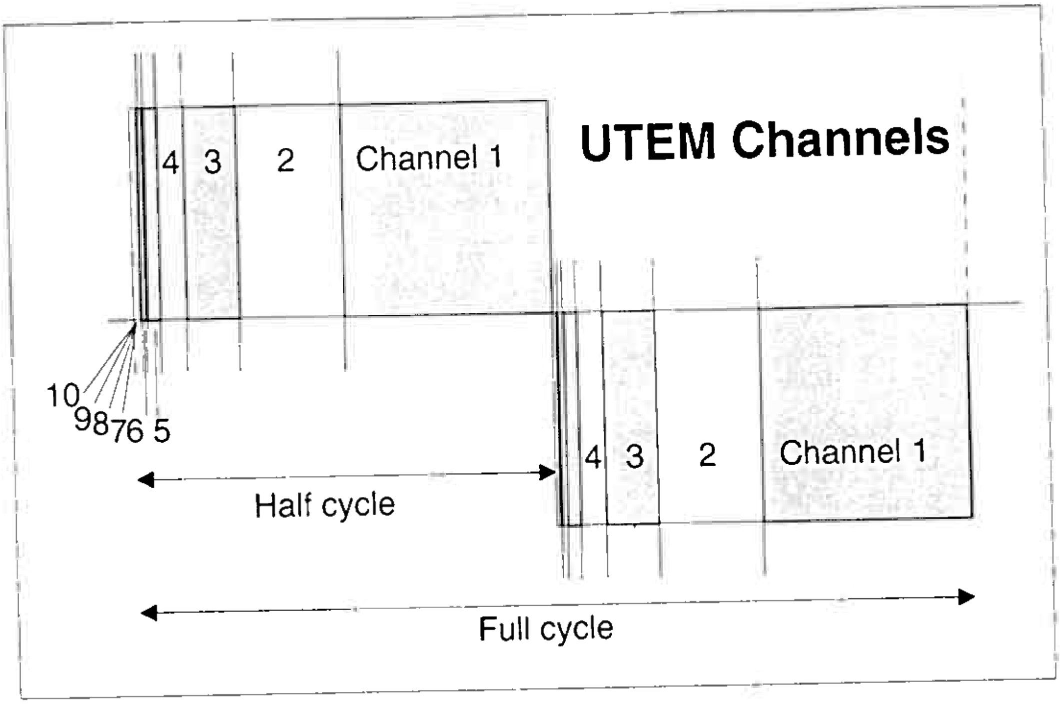
Measurements are routinely taken to a distance of 1.5 to twice the loop dimensions, depending on the local noise levels, and can be continued further. Lines are typically surveyed out from the edge of the loop but may also be read across the loop wire and through the centre of the loop, a configuration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

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	Σ
6	0.378	∆
7	0.189	7
8	0.095	X
9	0.047	△
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.