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2004-2005 Drilling Programs, Espedalen Prosject
Logistic report 2005 BHUTEM 3 Survey-2, Espedalen, Med CD
Appendix F til rapport BV 4823

Forfatter	Dato År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
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Råstoffgruppe	Råstofftype
Malm/metall	Cu Ni

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Inneholder appendix F til rapport BV 4823

Med CD: BHUTEM 3 Survey-2005-2

APPENDIX F

LAMONTAGNE

GEOPHYSICS LTD.
GEOPHYSIQUE LTEE.

-Logistics Report-
2005 BHUTEM 3 Survey-2
Espedalen
Norway
for
A/S Sulfidmalm

appendix F

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

May, 2005

Rob Langridge, M.Sc.

CONTENTS

Figures

Appendices

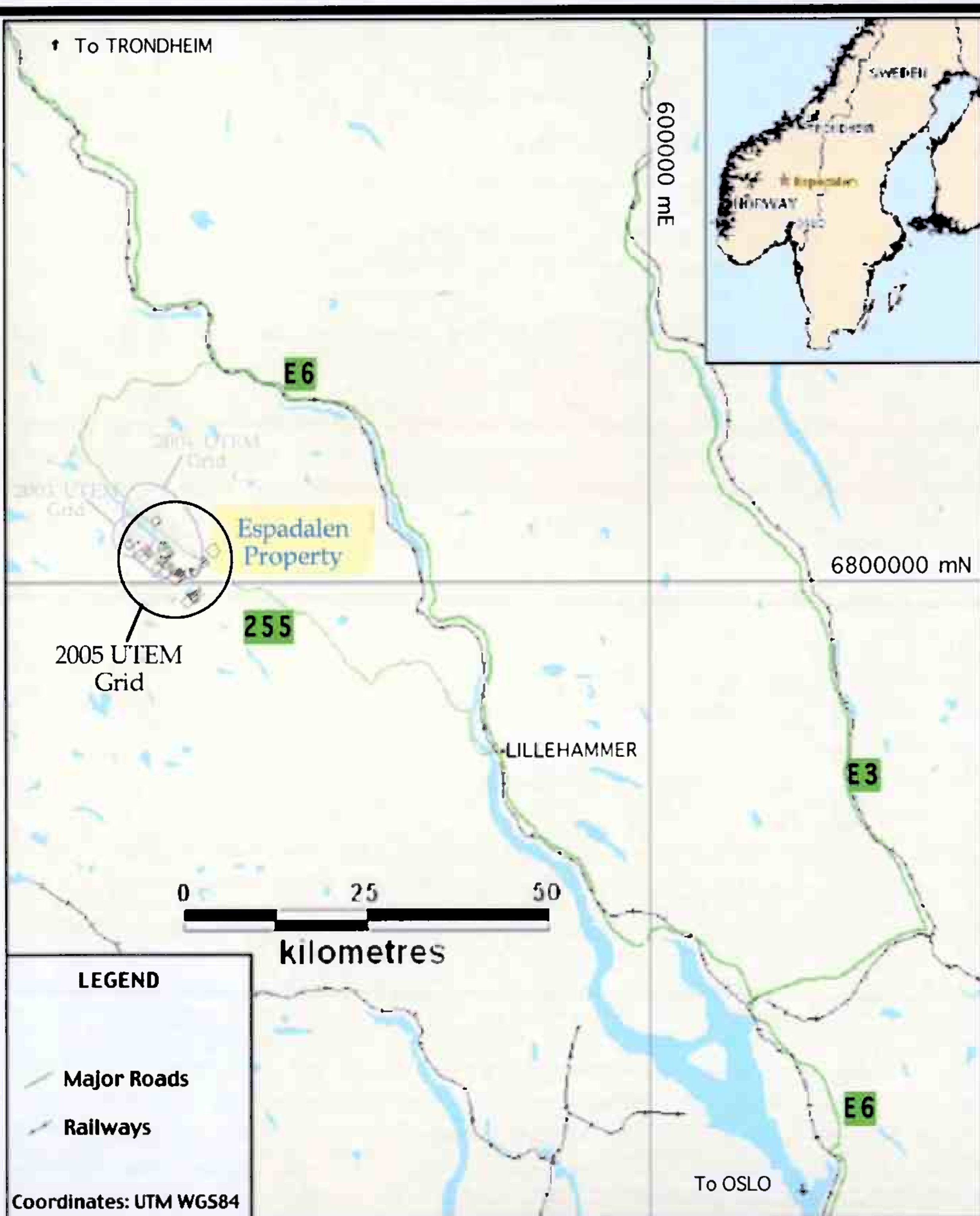
INTRODUCTION

During the period of May 17th 2005 through May 23th 2005 a UTEM/BHUTEM-3 survey was carried out by Lamontagne Geophysics Limited personnel for A/S Sulfidmalm in the area of Espedalen, Norway (Figure 1). This survey continues on from 2003/2004/2005 UTEM 3 surveys. The location of the property is shown in Figures 1 and 2. The survey was carried out to locate/detail conductors in the Stormyra area (Loop 20a) with the intention of outlining targets for future work and for drilling.

A total of 12 holes were surveyed with BHUTEM-3 from one transmitter loop - Loop 20a - a slight modification of Loop 20. All 12 holes were drilled in 2005. In addition a short surface survey was carried out (400m total) to detail a feature in the vicinity of Line 12200E ~3300N using the BH probe as a coil. For all work - both surface and BHUTEM-3 - the receiver operated in 10-channel mode at a transmitter frequency of 3.251Hz.

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

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



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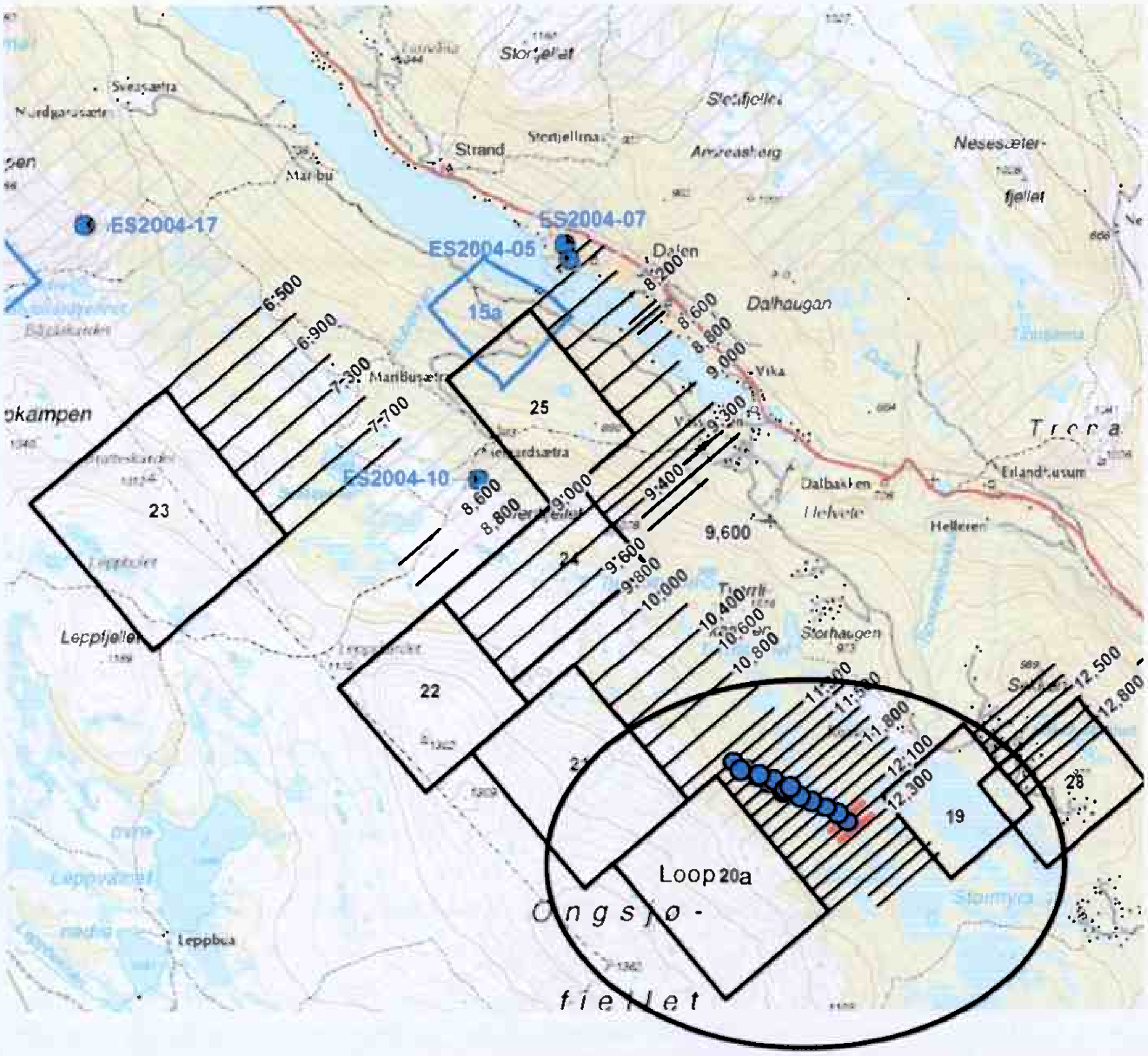
A/S Sulfidmalm

Espedalen, Norway

UTEM Survey Location Map

Figure 1



Loop 20a notes:

- locations of boreholes ( ) and "surface lines ( )are approximate

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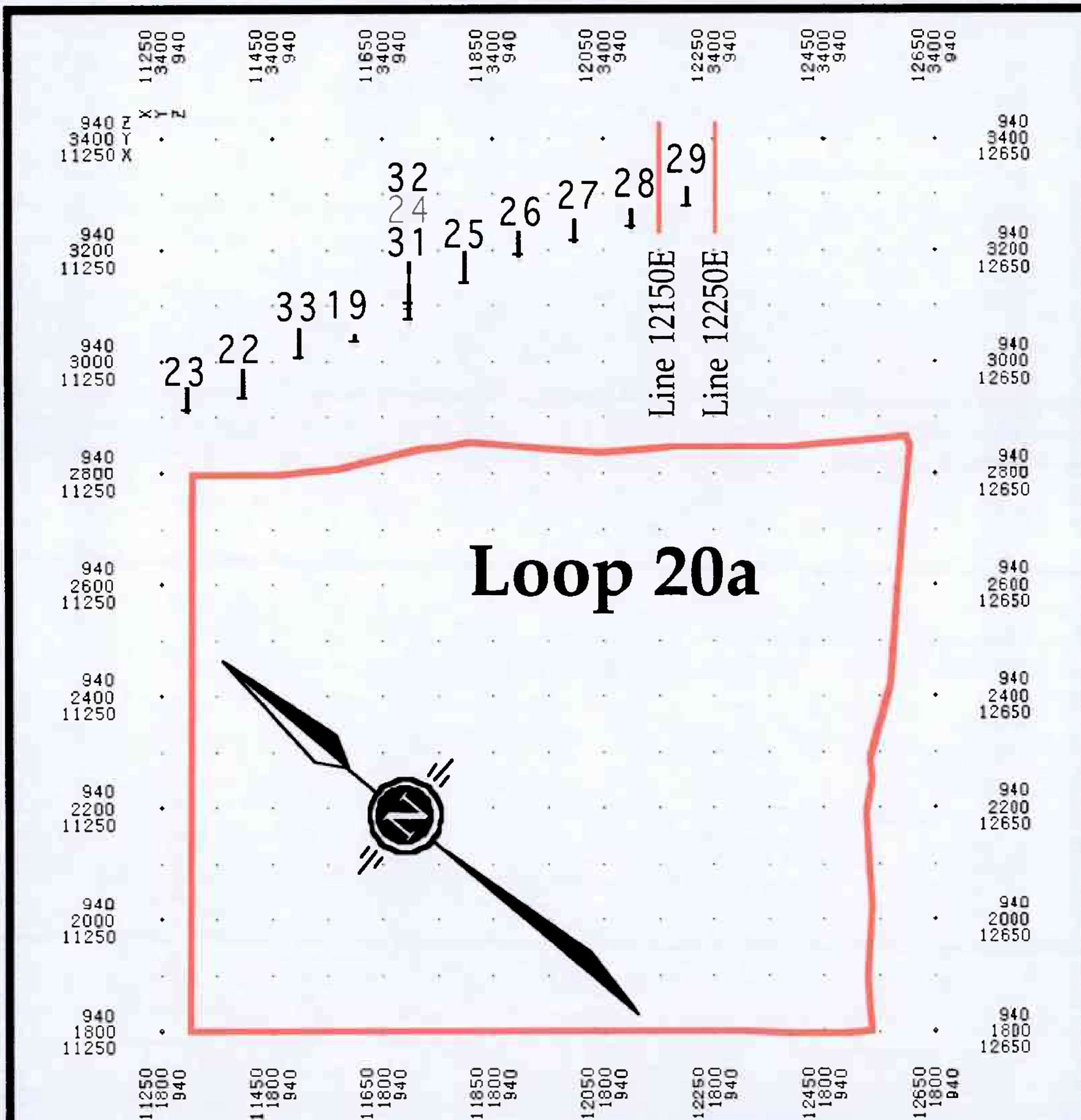
A/S Sulfidmalm

Espedalen, Norway

BHUTEM Loop 20a Location Map

0 500 2500m

Figure 2



Loop 20a notes:
- all borehole numbers are prefaced by ES2005-
- local grid coordinates shown

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

A/S Sulfidmalm

Espedalen, Norway

BHUTEM Loop 20a details

0 100 500m

Figure 3

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:

- variable transmitter loop size - to fit the area to be covered and the relief
- 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
- BHUTEM-3 coverage of selected boreholes @5m, 4/2/1m in zones of interest
- outside-the-loop coverage with 1 receiver and the BHUTEM probe as a coil
- station interval of 25m.
- Hz (vertical component measurements)
- 10-channel data at a frequency of 3.251Hz
- minimum 256 stacking (512 half-cycles) increased where noise levels dictate

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

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

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

For this survey GPS data was collected 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. GPS data collection for UTEM reduction should be most 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 of the loop as well as the loop/line intersection points.

SURVEY LOGISTICS

A Lamontagne Geophysics crew mobilized from Helsinki and arrived in Oslo on May 5th. The crew met client representative Finn Hansen the following morning and picked up a vehicle and the equipment. The crew and Finn Hansen then drove to the base of operations for the Espedalen survey - Strand Fjellstue (Figure 1 - www.strand-fjellstue.no). A stop was made enroute to purchase groceries for the survey. The survey began the following morning.

The transmitter loop - Loop 20a, a slight modification of Loop 20 - had been laid out by Falconbridge personnel prior to their decampment. The loop was good and surveying commenced after the equipment was shuttled into the field. The equipment performed well and Finn Hansen was informed he would not be required for the remainder of the survey.

Access to the grid was road and then by snowmobile along a series of pre-existing trails used by skiers/hikers etc. to access the area. Worries about snow conditions led to the crew getting up early (04:00) and working longer days than normal. As the holes had recently been gyroed we decided not to dummy all the holes - just the ones where bad ground had been reported by the drillers. Dummying is strongly recommended but in this case we felt we could pass on it. We logged all holes going down-hole and lowered the probe very carefully.

The snow conditions held and the surveying was completed on May 10th - including a short section of surface work carried out using the BHUTEM probe as a coil (no UTEM3 coil was available). The loop was collected on May 11th and the equipment was packed and labeled. The crew demobilized to Oslo the following morning (departure 03:00) and rendezvoused with Finn Hansen at Gardermoen. The equipment was delivered and the crew departed Norway.

The survey equipment consisted of the requisite BHUTEM-3 equipment 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. The weather conditions were generally good for surveying - cool nights and warm days. The snow conditions were generally good - helped by a couple of fresh snowfalls.

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.

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

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

BHUTEM3 profiles follow in order of Hole number . The following plots are presented for a borehole:

3-axis plot
total field plot
plan vectorplot
gridnorth-south section vectorplot

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

Outline of surface profile types

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

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

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

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

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

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

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

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

Note: In areas near powerlines channels 4 and higher (earlier times) are quite noisy. In this instance - Loop 29 for instance on this survey - the axis are presented as follows:

top axis - Ch4-10
middle axis - Ch2-3
bottom axis - Ch1
bottom axis - topography - no vertical exaggeration

<u>Outline of BHUTEM-3 plot types</u>

3-axis plot - **secondary field**
total field plot - **total field**

Both continuously normalized secondary and total field plots are presented for each borehole surveyed. Note that for reference the primary field is plotted on all BHUTEM profiles. The axes on the **3-axis plot** contain:

top axis - Ch5-10
middle axis - Ch2-5
bottom axis - Ch1 + primary field

The axis on the **total field plot** contains:

axis - Ch1-10 + primary field

plan and gridnorth-south section vectorplots

Plan and gridnorth-south section vectorplots are included for each borehole surveyed. Vectorplots are useful in both planning loop locations and in evaluating profiles - particularly in areas of high relief. Vectorplots show the primary field local to the borehole - allowing the coupling to be evaluated.

Appendix A

0511-2 UTEM Profiles
0511-2 BHUTEM 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 and a number of conductors and/or conductive features are evident. Moderate-to-severe noise levels to the gridnorth of lines surveyed from Loops 05 through 12 reflect the presence of a regional powerline beyond the end of the lines. A description of the standard plotting formats used and of the UTEM System is presented in Appendix C.

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

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

BHUTEM3 profiles follow in order of Hole number by area. The following plots are presented for a borehole:

3-axis plot
total field plot
plan vectorplot
gridnorth-south section vectorplot

Outline of surface profile types

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

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

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

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

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

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

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

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

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

Note: In areas near powerlines channels 4 and higher (earlier times) are quite noisy. In this instance - Loop 29 for instance on this survey - the axis are presented as follows:

top axis - Ch4-10
middle axis - Ch2-3
bottom axis - Ch1
bottom axis - topography - no vertical exaggeration

Outline of BHUTEM-3 plot types

3-axis plot - **secondary field**
total field plot - **total field**

Both continuously normalized secondary and total field plots are presented for each borehole surveyed. Note that for reference the primary field is plotted on all BHUTEM profiles. The axes on the **3-axis plot** contain:

top axis - Ch5-10
middle axis - Ch2-5
bottom axis - Ch1 + primary field

The axis on the **total field plot** contains:

axis - Ch1-10 + primary field

plan and gridnorth-south section vectorplots

Plan and gridnorth-south section vectorplots are included for each borehole surveyed. Vectorplots are useful in both planning loop locations and in evaluating profiles - particularly in areas of high relief. Vectorplots show the primary field local to the borehole - allowing the coupling to be evaluated.

Notes on Survey and Presentation/plotting details

- An effort has been to keep the scales consistent. The horizontal scale is 1cm:100m. For BHUTEM plots it is 1cm:10m.

List of Data Collected and Plotted

Espedalen 2005 Grid

Surface coverage - @ 3.251 Hertz

	Line	coverage	
Loop 20a	Line 12150E	3225N - 3425N	200m
	Line 12250E	3225N - 3425N	200m
	Espedalen	Loop 20a Total	400m

List of Borehole Data Collected and Plotted

Area	Borehole Name	Survey Depth	Dummy Depth	Loop Number	Frequency
Listed by hole number:					
Stormyra:	ES2005-19	122m	125m	Loop 20a	3.251Hz
	ES2005-22	75m	78m	Loop 20a	3.251Hz
	ES2005-23	60m	61m	Loop 20a	3.251Hz
	ES2005-24	132m	135m	Loop 20a	3.251Hz
	ES2005-25	135m	138m	Loop 20a	3.251Hz
	ES2005-26	128m	131m	Loop 20a	3.251Hz
	ES2005-27	130m	134m	Loop 20a	3.251Hz
	ES2005-28	104m	106m	Loop 20a	3.251Hz
	ES2005-29	84m	88m	Loop 20a	3.251Hz
	ES2005-30		blocked	Loop 20a	3.251Hz
	ES2005-31	130m	132m	Loop 20a	3.251Hz
	ES2005-32	152m	155m	Loop 20a	3.251Hz
	ES2005-33	125m	128m	Loop 20a	3.251Hz

0511-2

Surface UTEM Profiles

Espedalen

Loop 20a

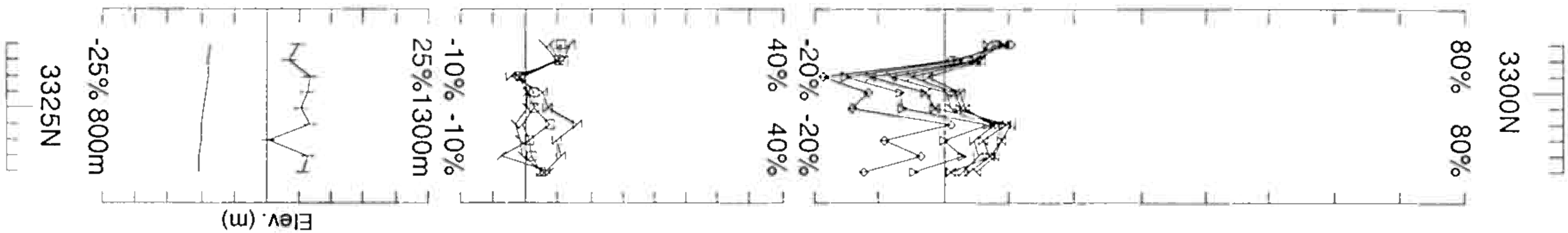
Hz
@3.251 Hz frequency

continuous norm

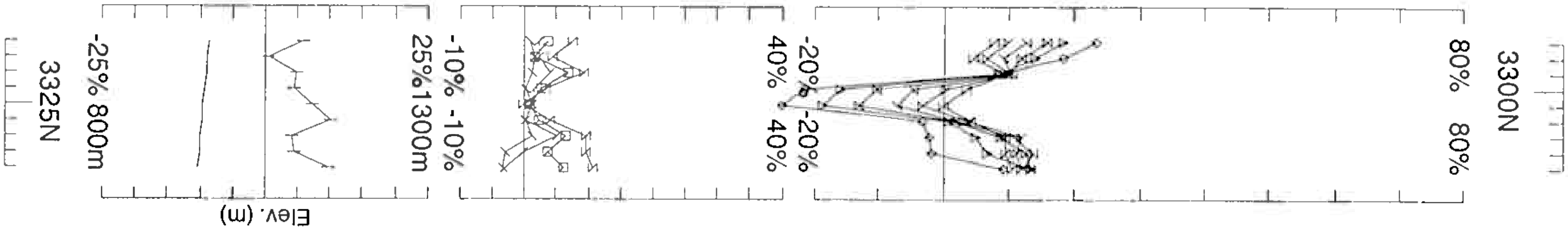
Ch1 reduced

Loop 20a	Line 12150E	3225N - 3425N	200m
	Line 12250E	3225N - 3425N	200m
	Espedalen	Loop 20a Total	400m

Loop 20a - continuous norm



Loop: 20a	Secondary, (Chn - Ch1)/lHpl	UTEM Survey at: Espedalen
Line: 12150E	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Hz	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 10/5/5 Reduced : 10/5/5 Plotted : 17/5/5



Loop: 20a Line: 12250E Compt: Hz	Secondary, (Chn - Ch1)/lHpl 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 0511 Surveyed : 10/5/5 Reduced : 10/5/5 Plotted : 17/5/5

Espedalen

Loop 20a

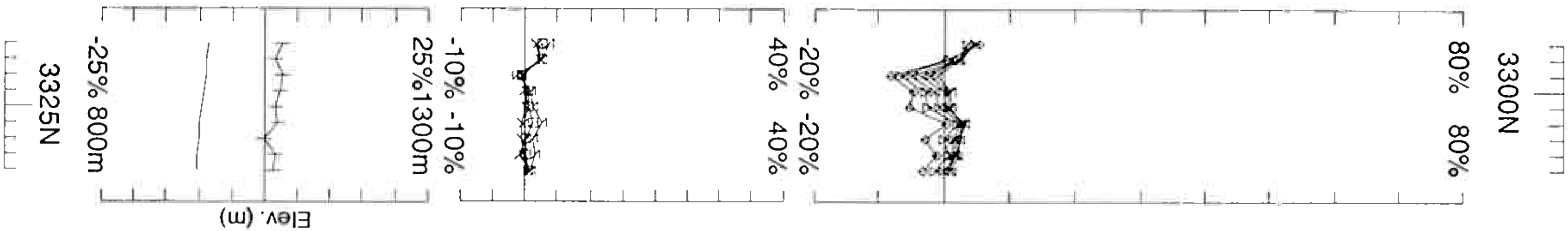
Hz
@3.251 Hz frequency

point norm
@
(x,y,z) = (11950E,3100N, 975 m.a.s.l.)

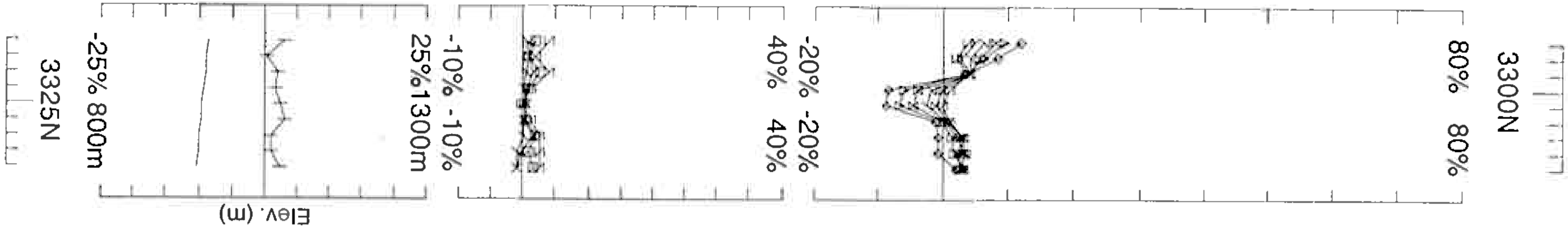
Ch1 reduced

Loop 20a	Line 12150E	3225N - 3425N	200m
	Line 12250E	3225N - 3425N	200m
	Espedalen	Loop 20a Total	400m

Loop 20a - point norm



Loop: 20a Line: 12150E Compt: Hz	Secondary, (Chn - Ch1)/|Hp| Point Norm.at x,y,z (11950,3100,975) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE	Job 0511 Surveyed : 10/5/5 Reduced : 10/5/5 Plotted : 17/5/5



Loop: 20a Line: 12250E Compt: Hz	Secondary, (Chn - Ch1)/lHpl Point Norm.at x,y,z (11950,3100,975) Base Freq. 3.251 Hz	UTEM Survey at: Espedalen For: A/S Sulfidmalm LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 10/5/5 Reduced : 10/5/5 Plotted : 17/5/5

0511-2

BHUTEM 3 Profiles with vectorplots

Stormyra

Loop 20a - BH UTEM-3

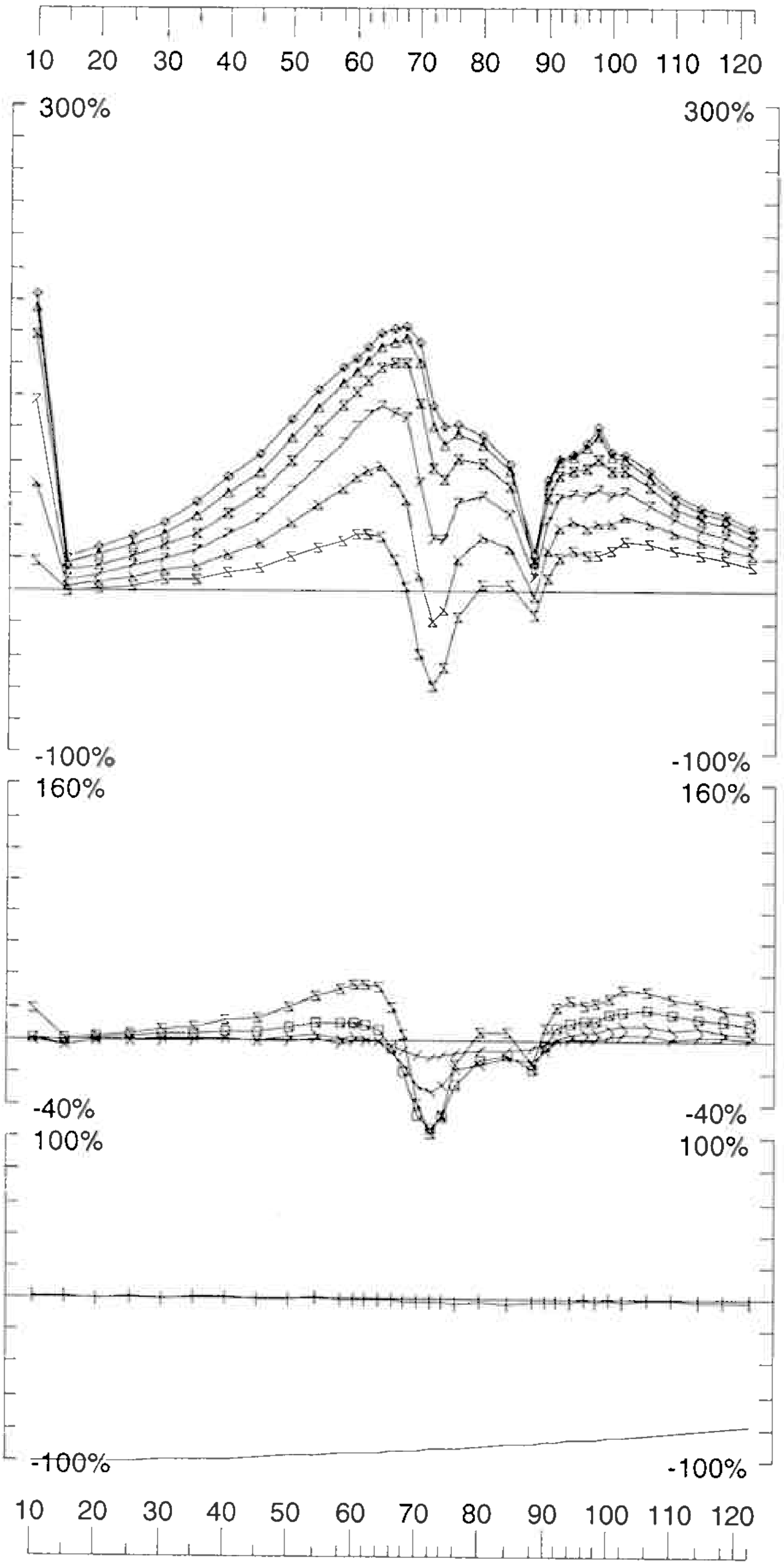
@3.251 Hz frequency

Ch1 reduced

3-axis plot
total field plot
plan vectorplot
gridnorth-south section vectorplot

Stormyra:	ES2005-19	122m	125m	Loop	20a
	ES2005-22	75m	78m	Loop	20a
	ES2005-23	60m	61m	Loop	20a
	ES2005-24	132m	135m	Loop	20a
	ES2005-25	135m	138m	Loop	20a
	ES2005-26	128m	131m	Loop	20a
	ES2005-27	130m	134m	Loop	20a
	ES2005-28	104m	106m	Loop	20a
	ES2005-29	84m	88m	Loop	20a
	ES2005-31	130m	132m	Loop	20a
	ES2005-32	152m	155m	Loop	20a
	ES2005-33	125m	128m	Loop	20a

Loop 20a BHUTEM-3 data



BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

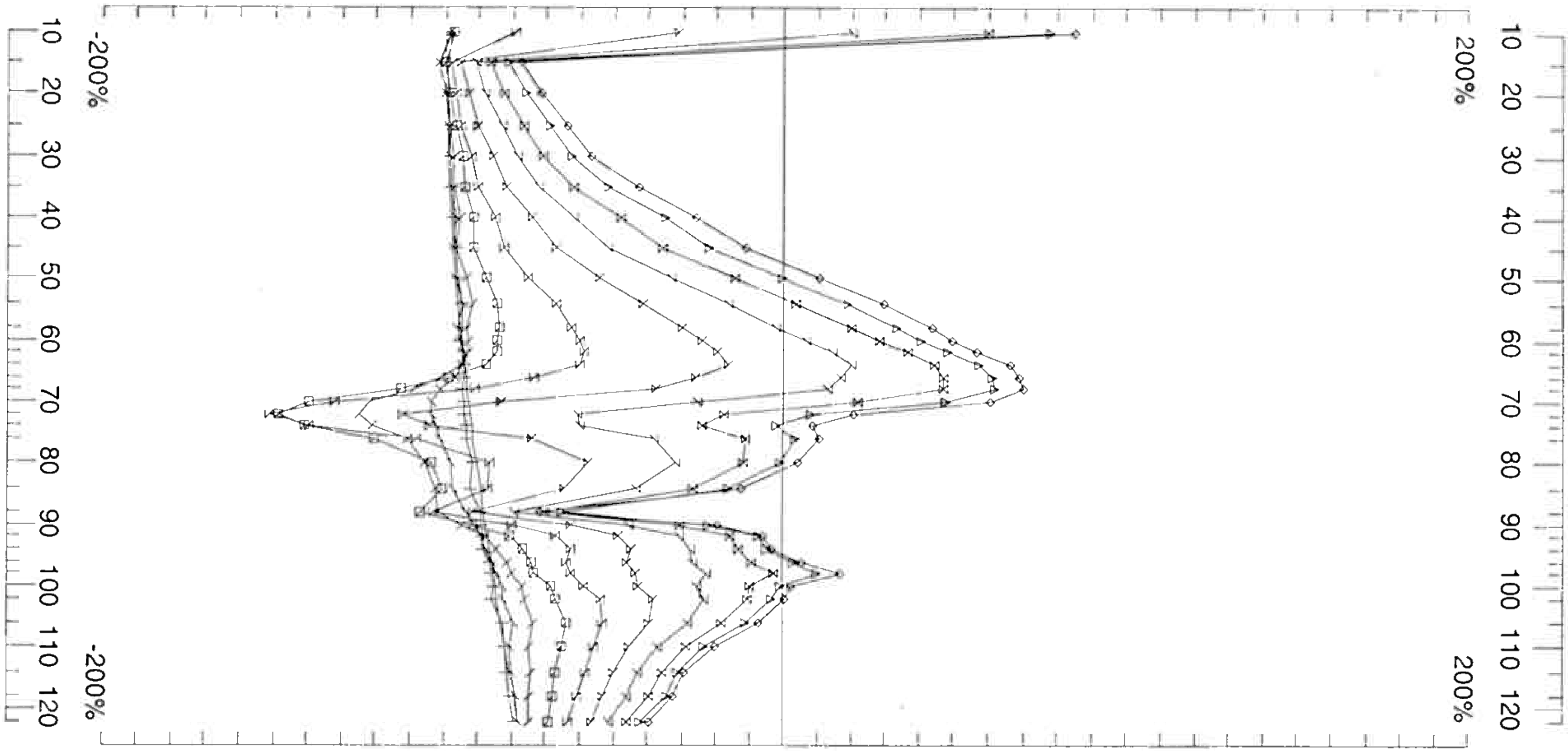
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0511

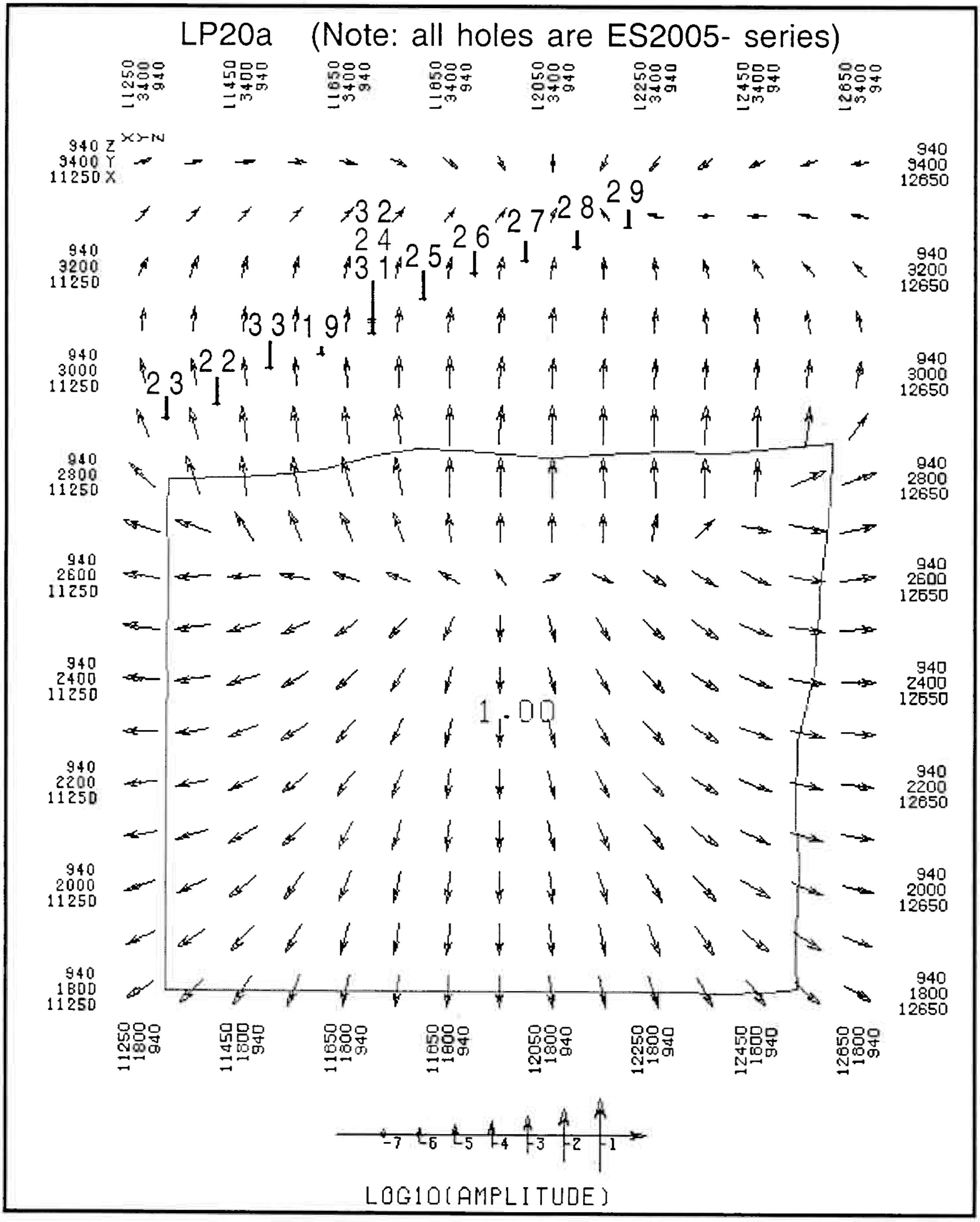
Surveyed : 9/5/5
Reduced : 9/5/5
Plotted : 17/5/5

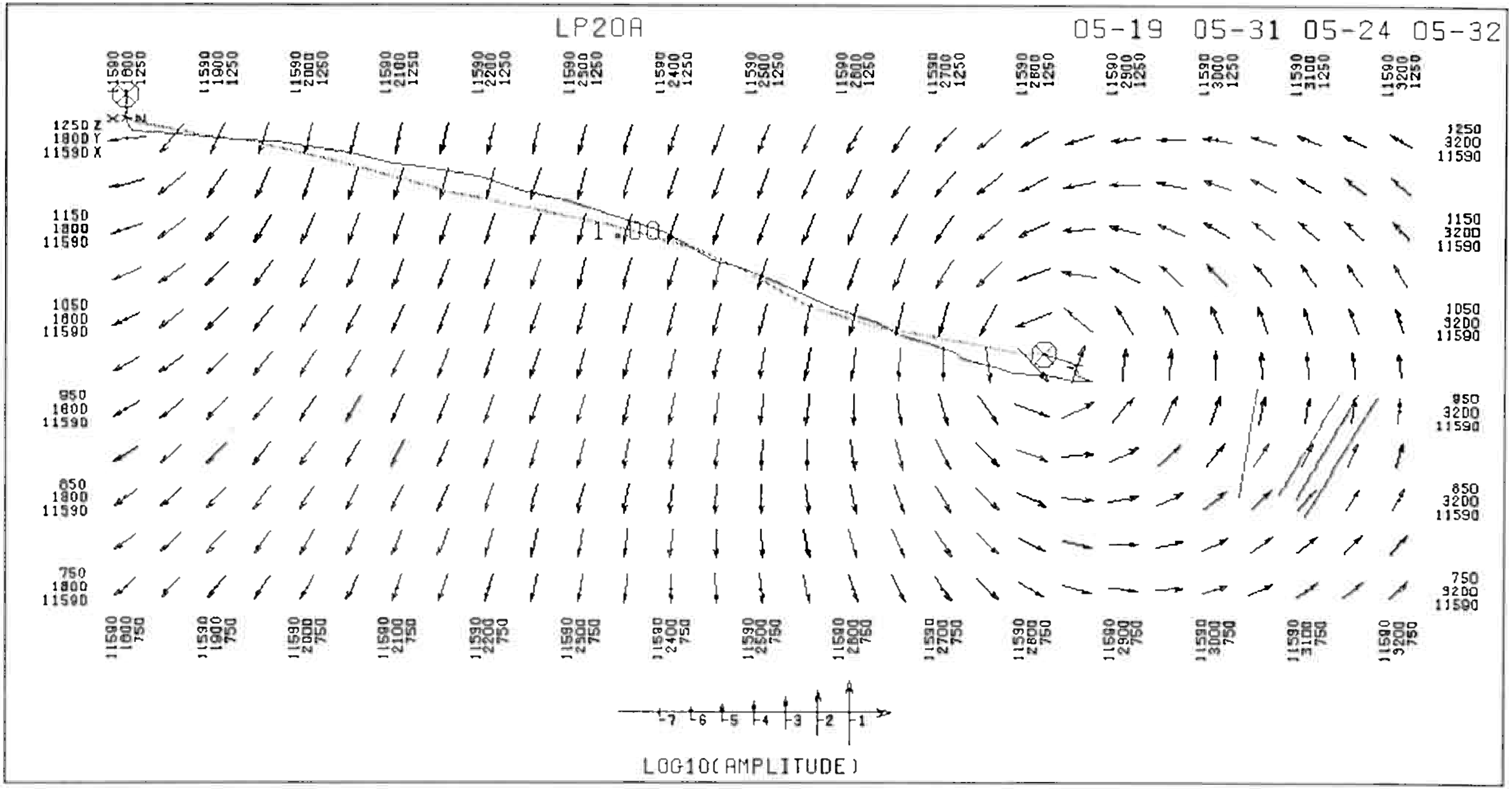
Loop: 20a
Hole: ES-2005-19
Compt: Axial

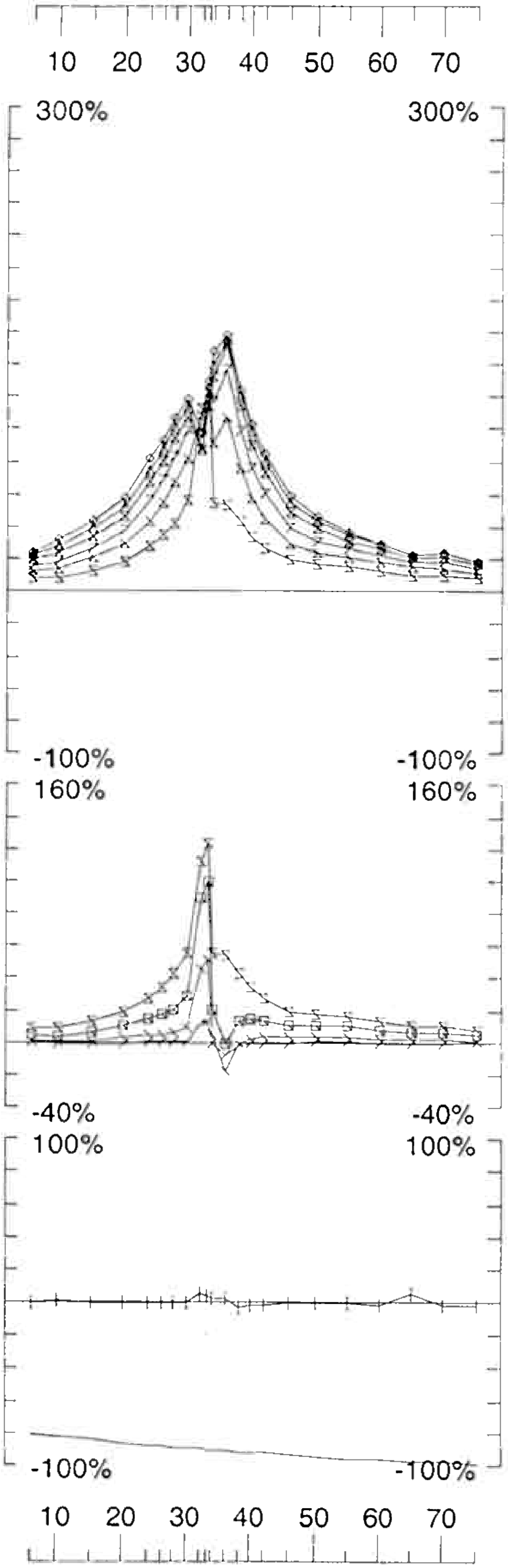
Secondary, (Chn - Ch1)/IHpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz



Loop: 20a	Total, Chn/IHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-19	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed: 9/5/5 Reduced: 9/5/5 Plotted: 17/5/5


LP20a (Note: all holes are ES2005- series)
1.00
LOG10(AMPLITUDE)
23
22
33
19
31
24
32
25
26
27
28
29


LP20A
05-19 05-31 05-24 05-32
1250 Z
1800 Y
11590 X
1.00
-7 -6 -5 -4 -3 -2 -1
LOG10(AMPLITUDE)



BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

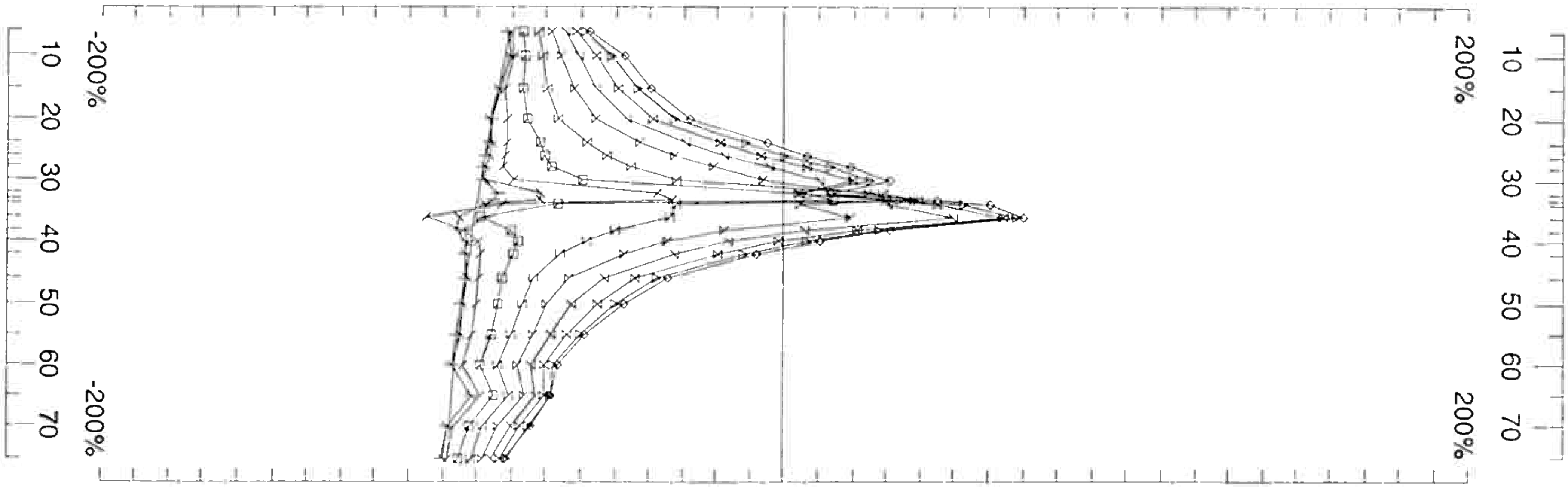
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0511

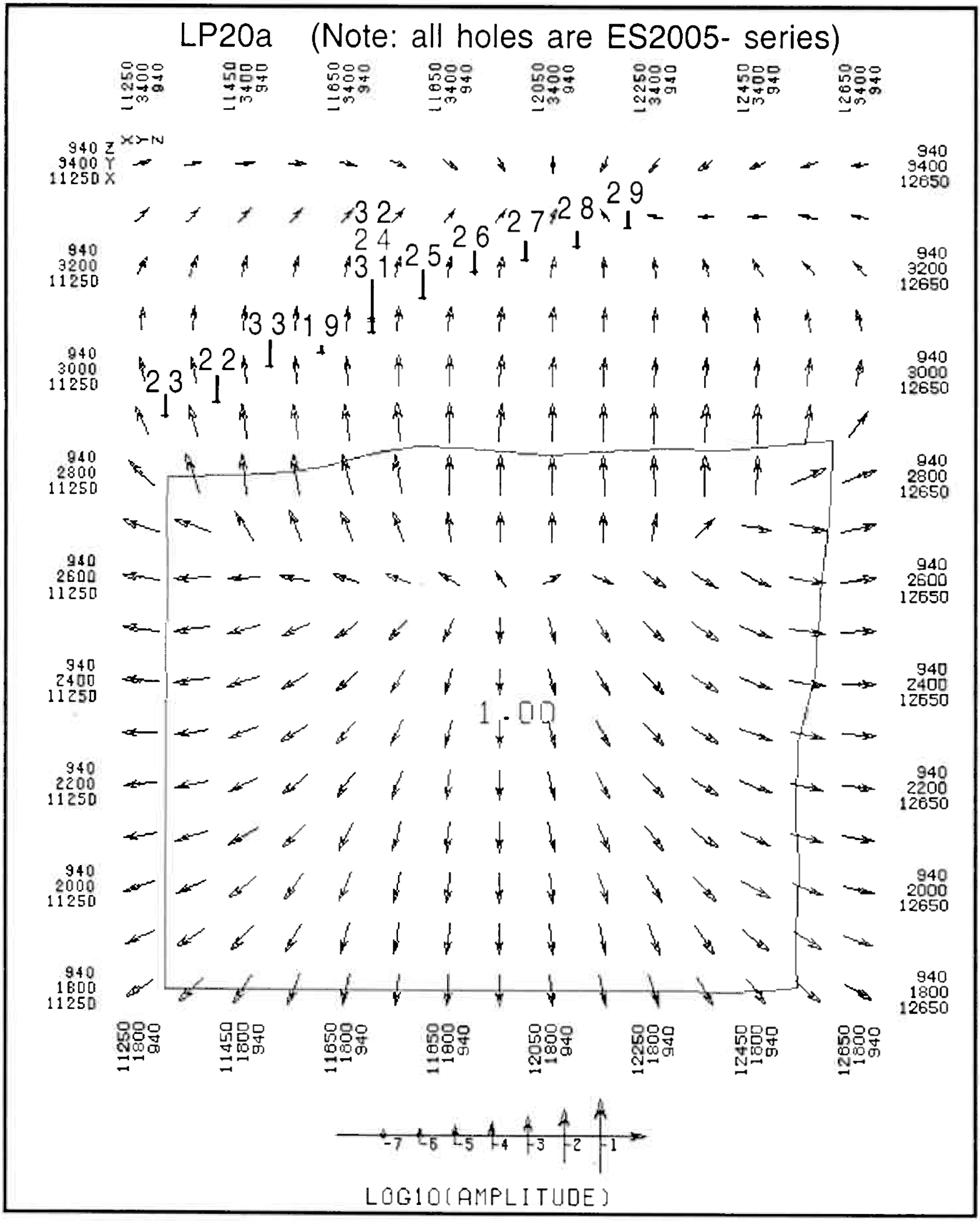
Surveyed : 10/5/5
Reduced : 10/5/5
Plotted : 17/5/5

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

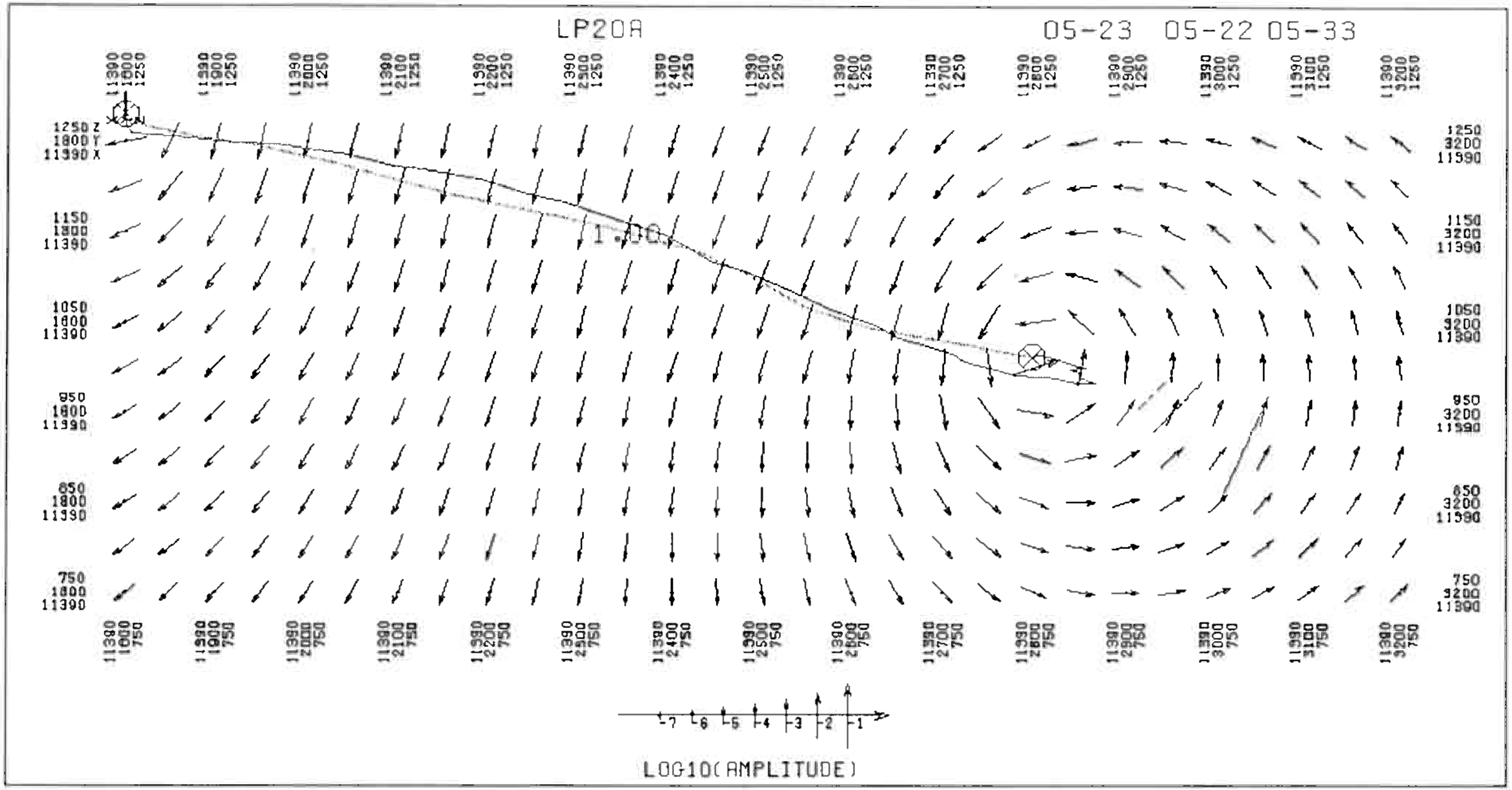
Loop: 20a
Hole: ES-2005-22
Compt: Axial



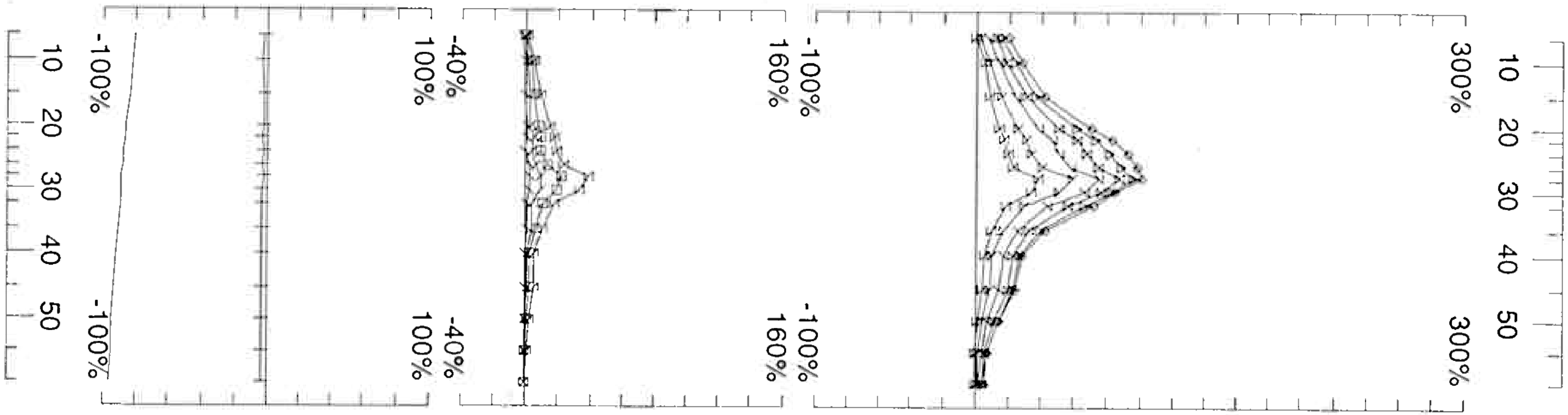
Loop: 20a	Total, Chn/lHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-22	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 10/5/5 Reduced : 10/5/5 Plotted : 17/5/5



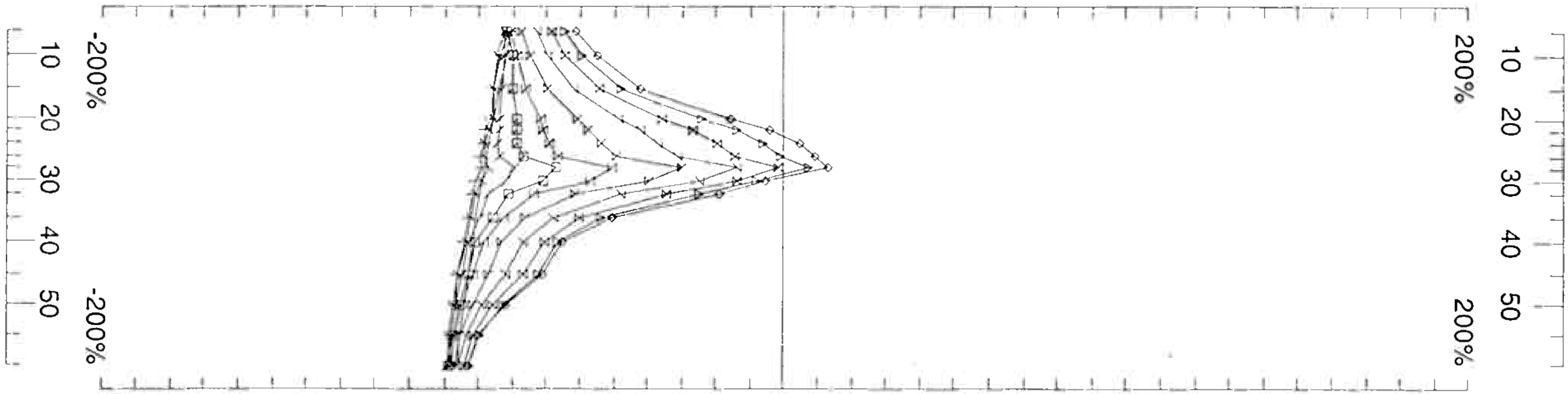
LP20a (Note: all holes are ES2005- series)
LOG10(AMPLITUDE)
1.00



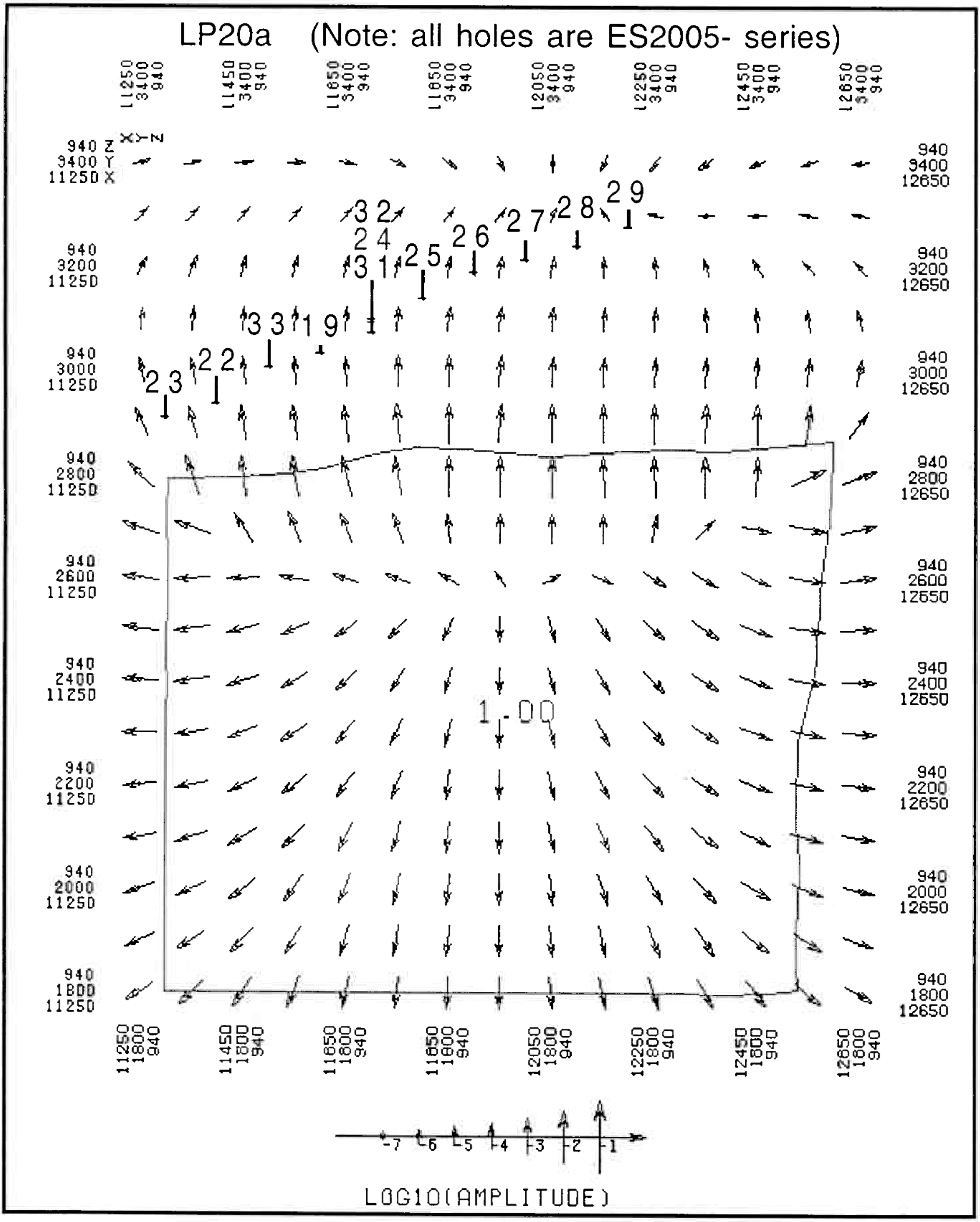
LP20A
05-23 05-22 05-33
1250 Z
1800 Y
11390 X
1.00
-7 -6 -5 -4 -3 -2 -1
LOG10(AMPLITUDE)

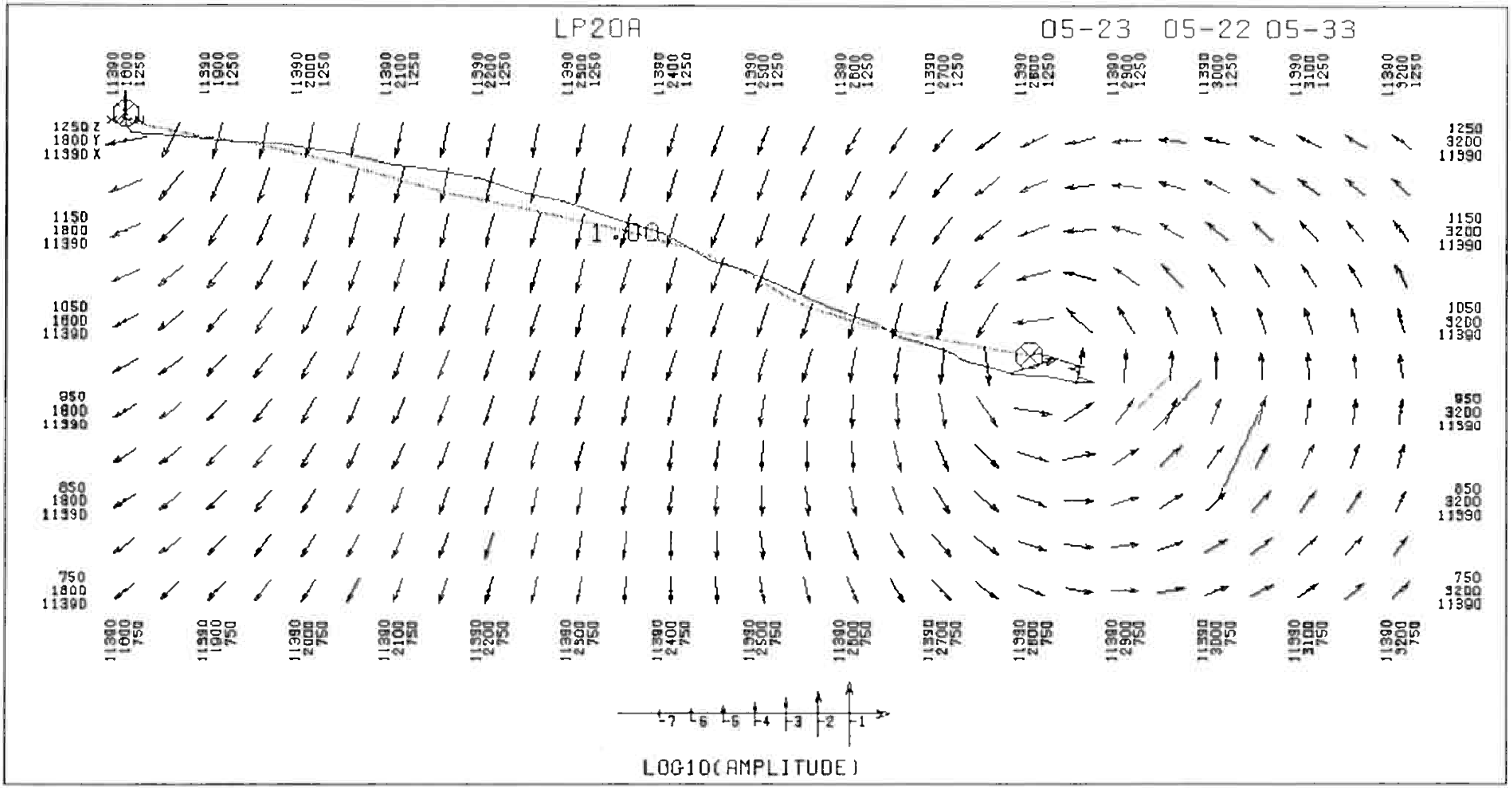


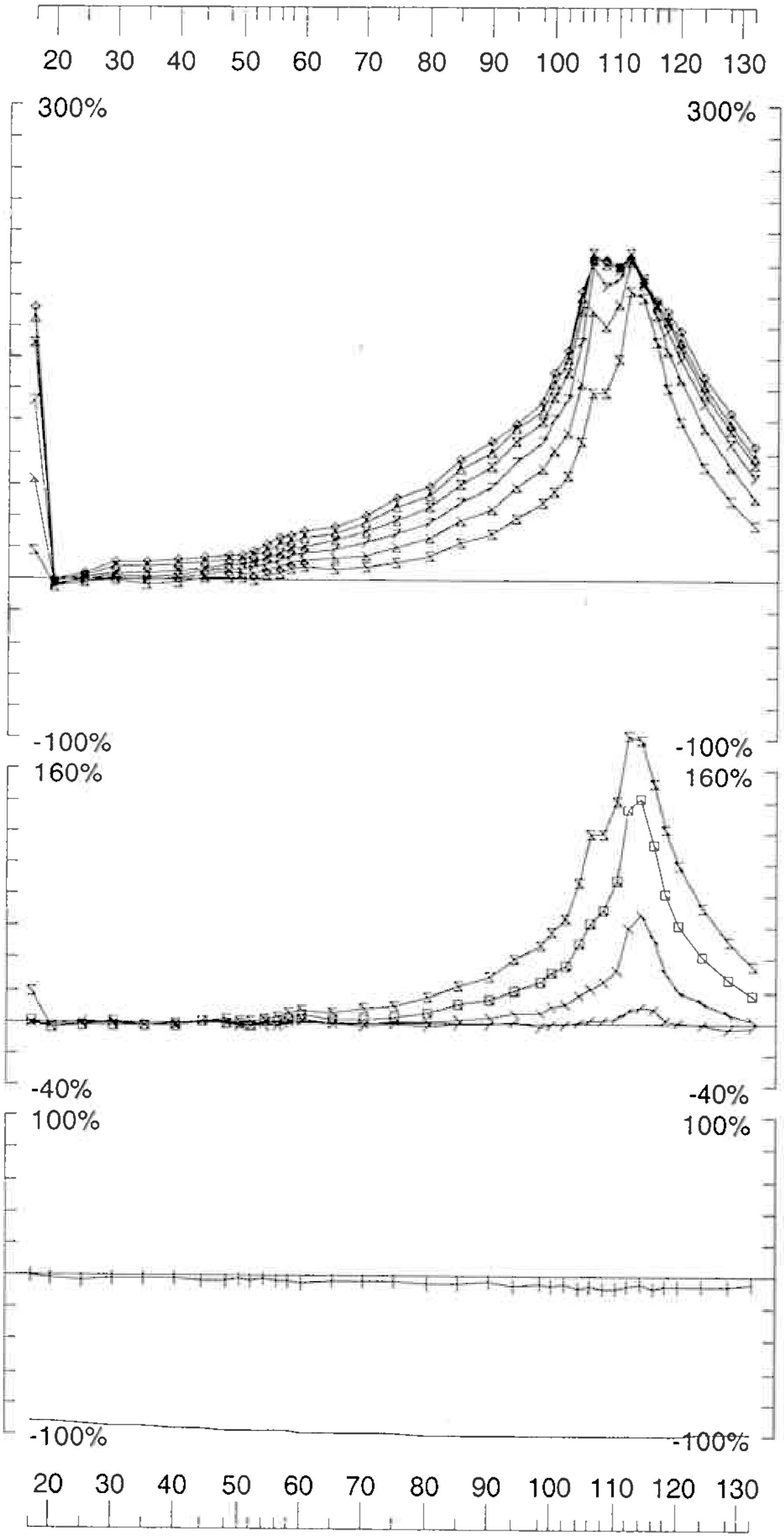
Loop: 20a	Secondary, (Chn - Ch1)/IHpI	BHUTEM Survey at: Espedalen
Hole: ES-2005-23	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 10/5/5 Reduced : 10/5/5 Plotted : 17/5/5



Loop: 20a	Total, Chn/lHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-23	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 10/5/5 Reduced : 10/5/5 Plotted : 17/5/5


LP20a (Note: all holes are ES2005- series)
X Y Z
23
22
33
19
31
24
32
25
26
27
28
29
1.00
LOG10(AMPLITUDE)
-7
-6
-5
-4
-3
-2
-1


LP20A
05-23 05-22 05-33
1.00
-7 -6 -5 -4 -3 -2 -1
LOG10(AMPLITUDE)



Loop: 20a
Hole: ES-2005-24
Compt: Axial

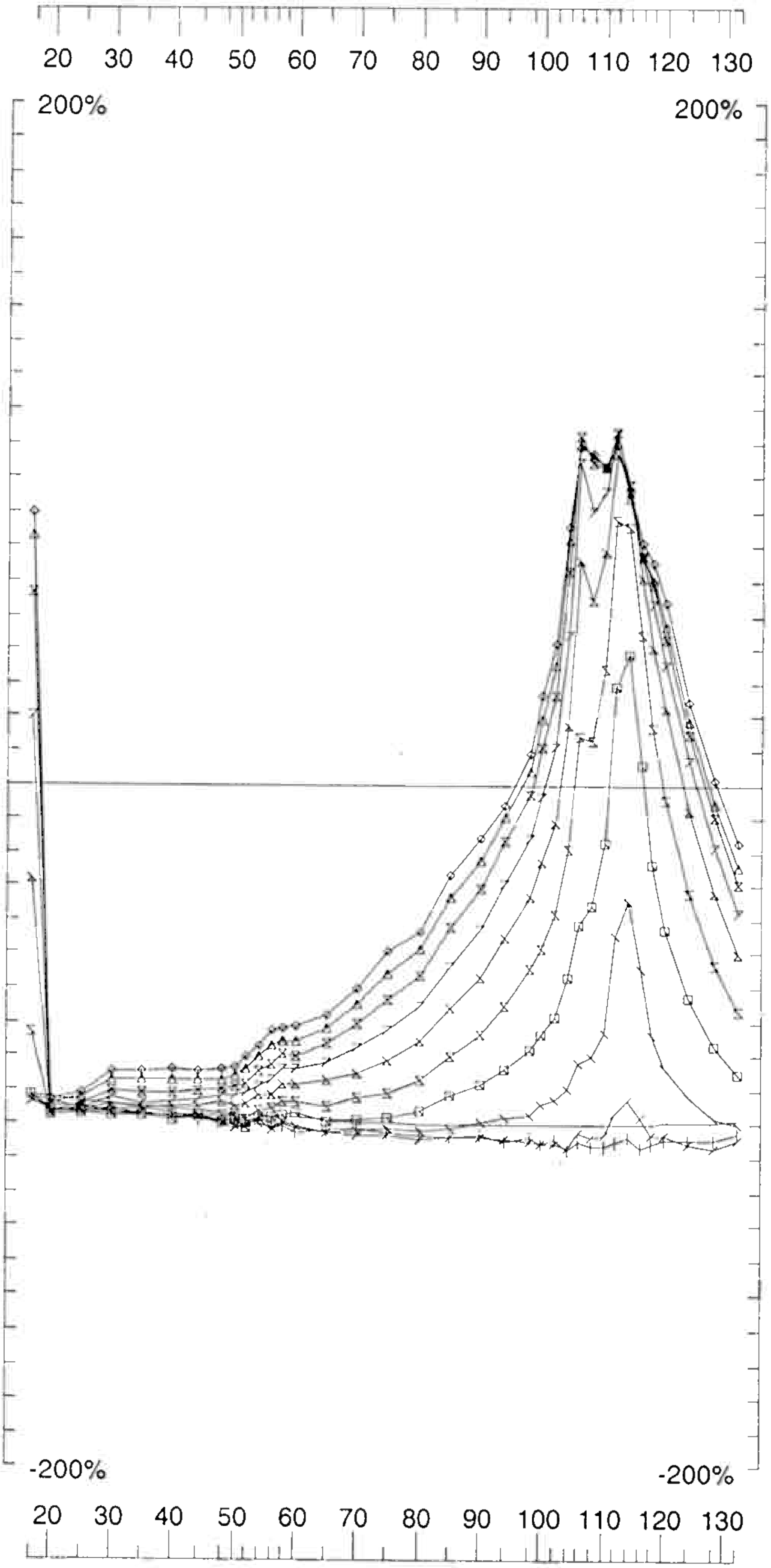
Secondary, (Chn - Ch1)/IHpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0511

Surveyed : 9/5/5
Reduced : 9/5/5
Plotted : 17/5/5



BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

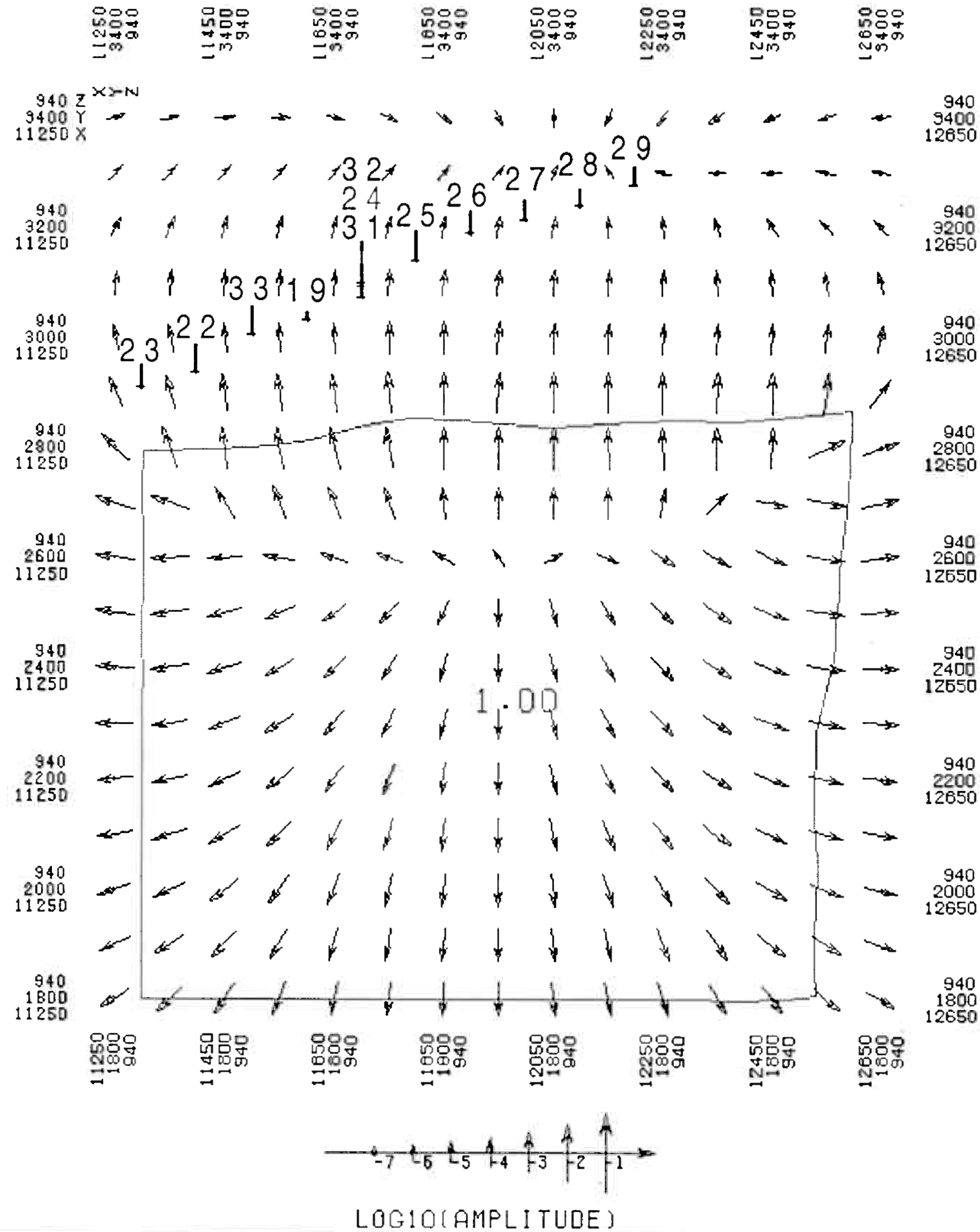
Job 0511

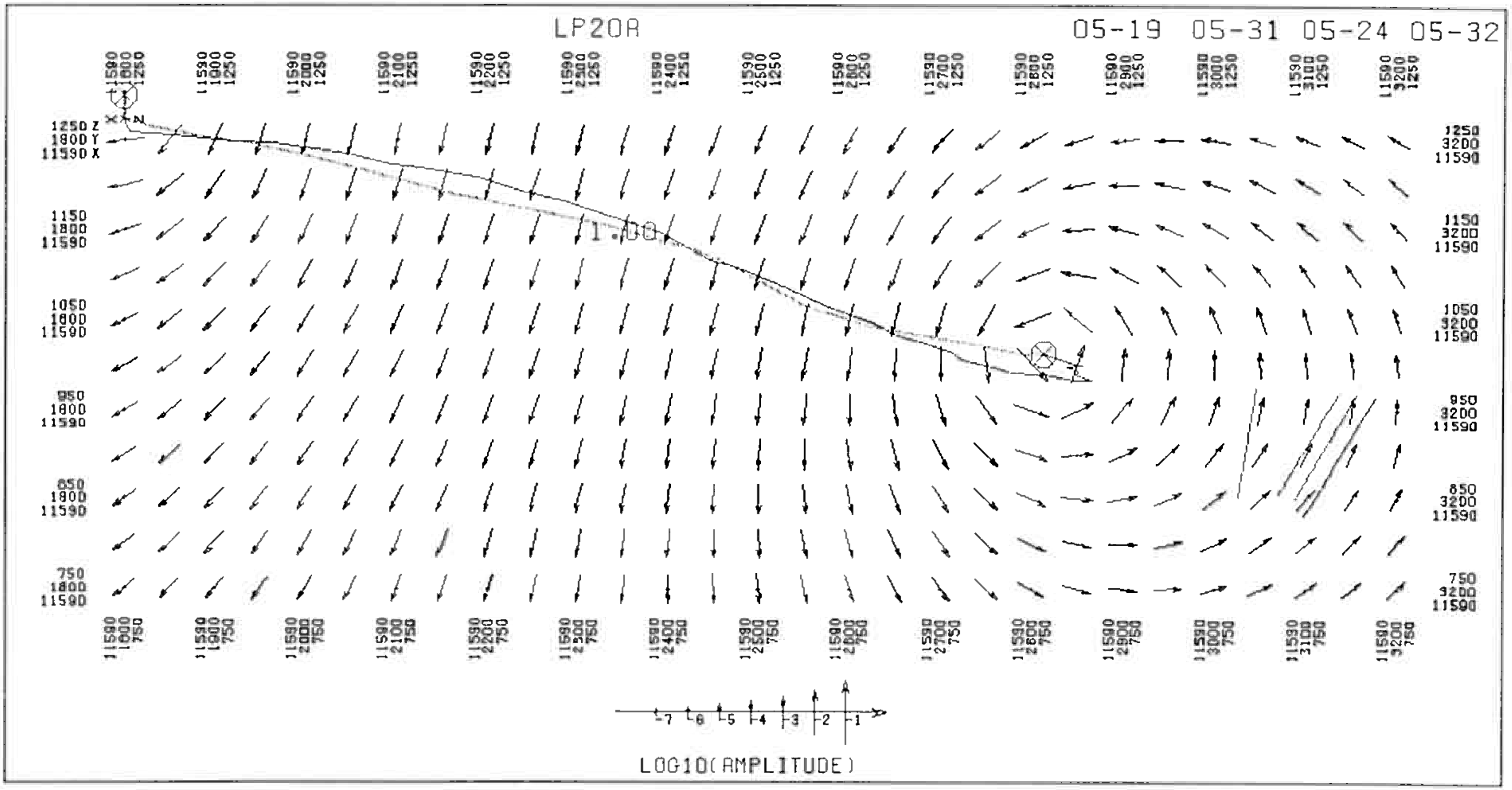
Surveyed : 9/5/5
Reduced : 9/5/5
Plotted : 17/5/5

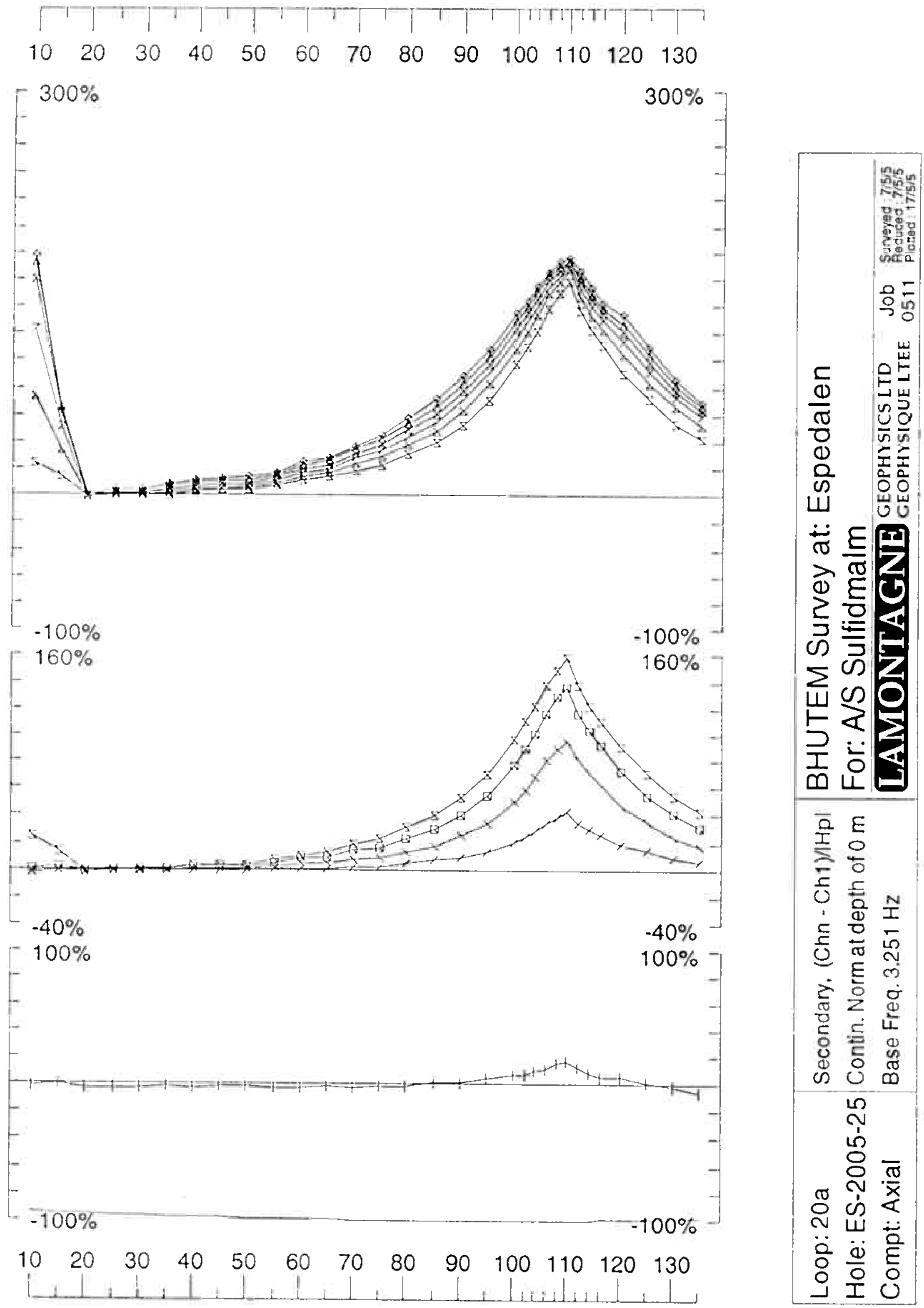
Loop: 20a
Hole: ES-2005-24
Compt: Axial

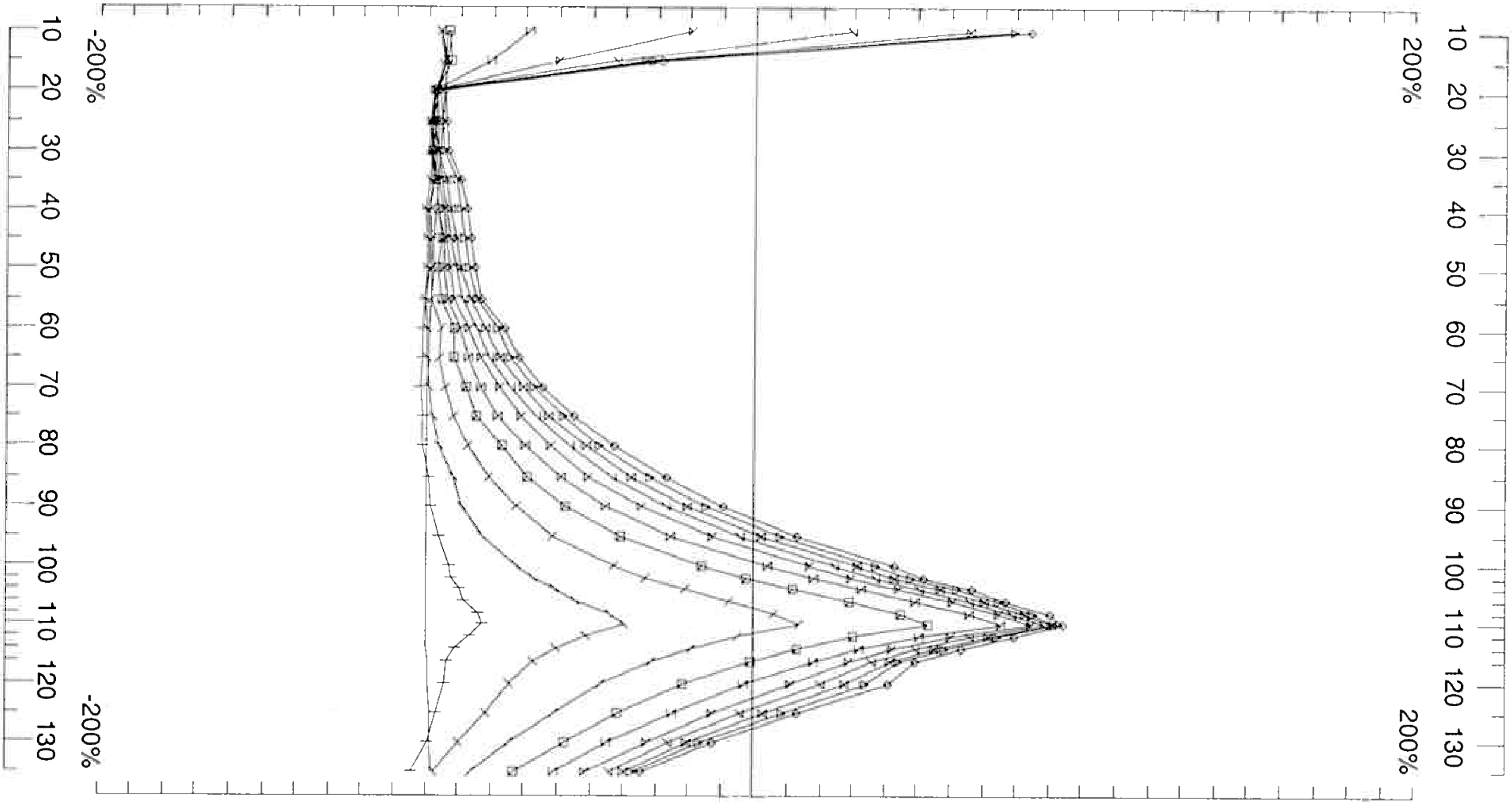
Total, Chn/IHpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

LP20a (Note: all holes are ES2005- series)



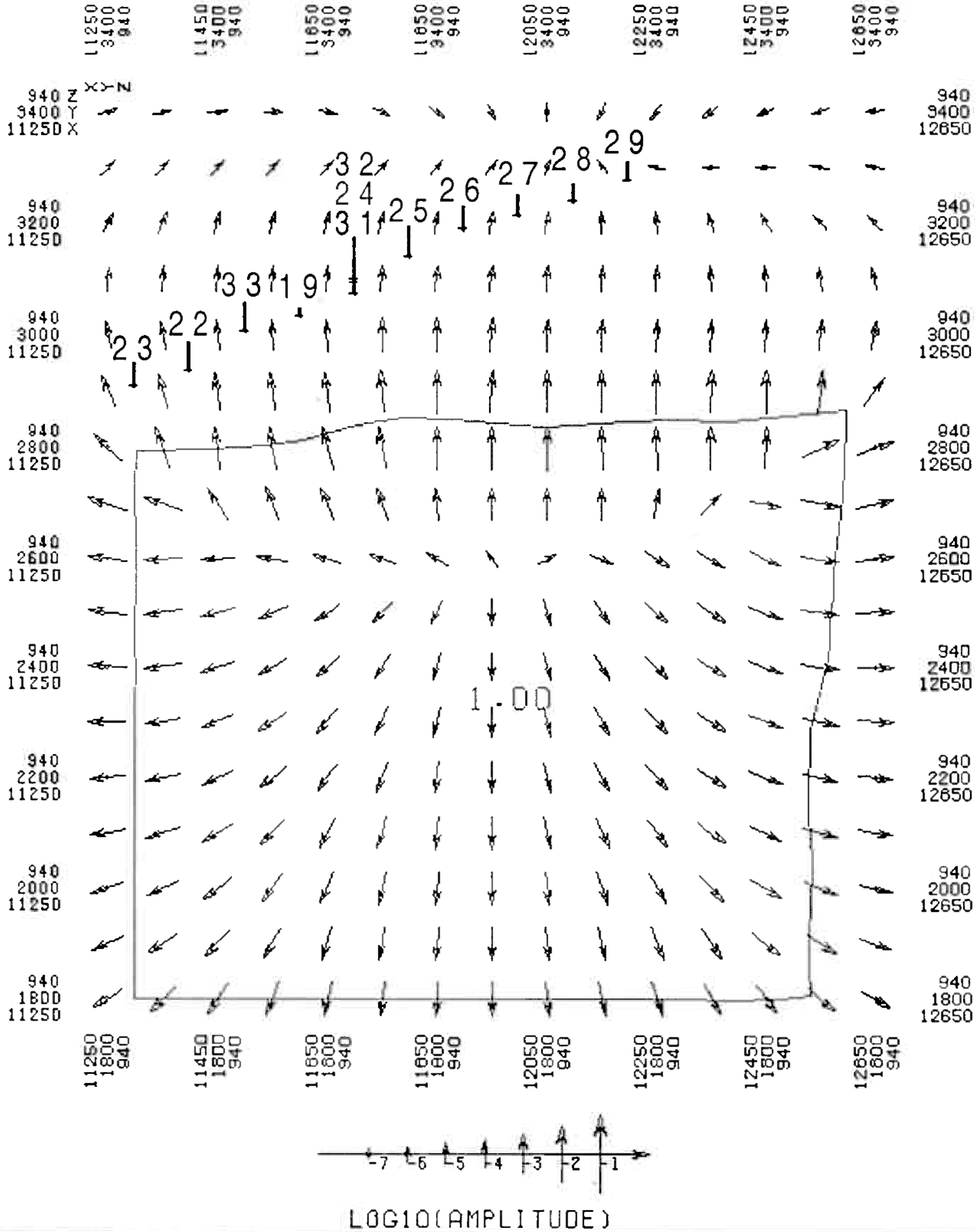

LP20A
05-19 05-31 05-24 05-32
1250 Z
1800 Y
11590 X
1.00
LOG10(AMPLITUDE)

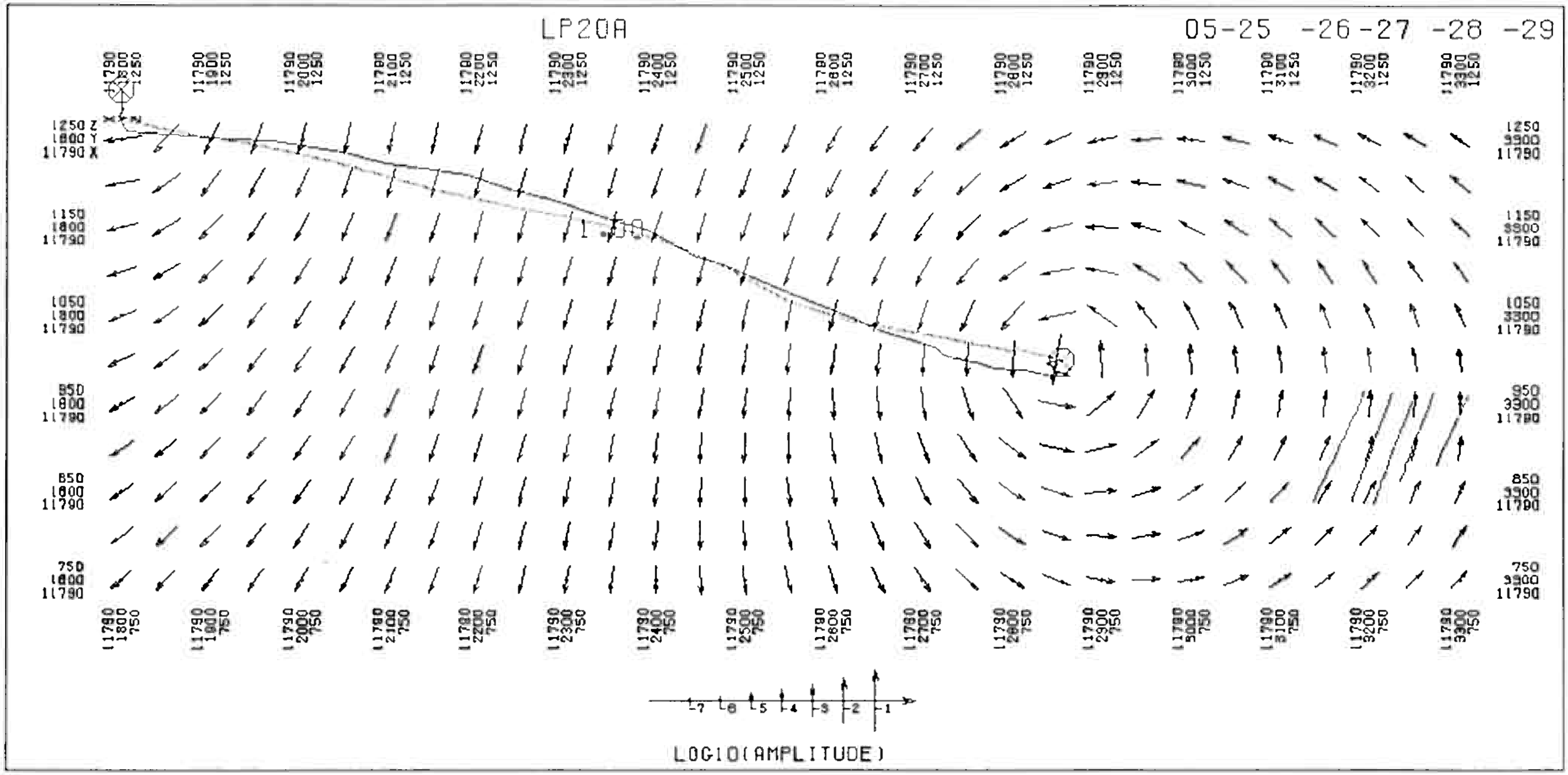

10 20 30 40 50 60 70 80 90 100 110 120 130
300%
-100%
160%
-40%
100%
-100%
BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0511
Surveyed: 7/5/5
Reduced: 7/5/5
Plotted: 17/5/5
Loop: 20a
Hole: ES-2005-25
Compt: Axial
Secondary, (Chn - Ch1)/Hpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

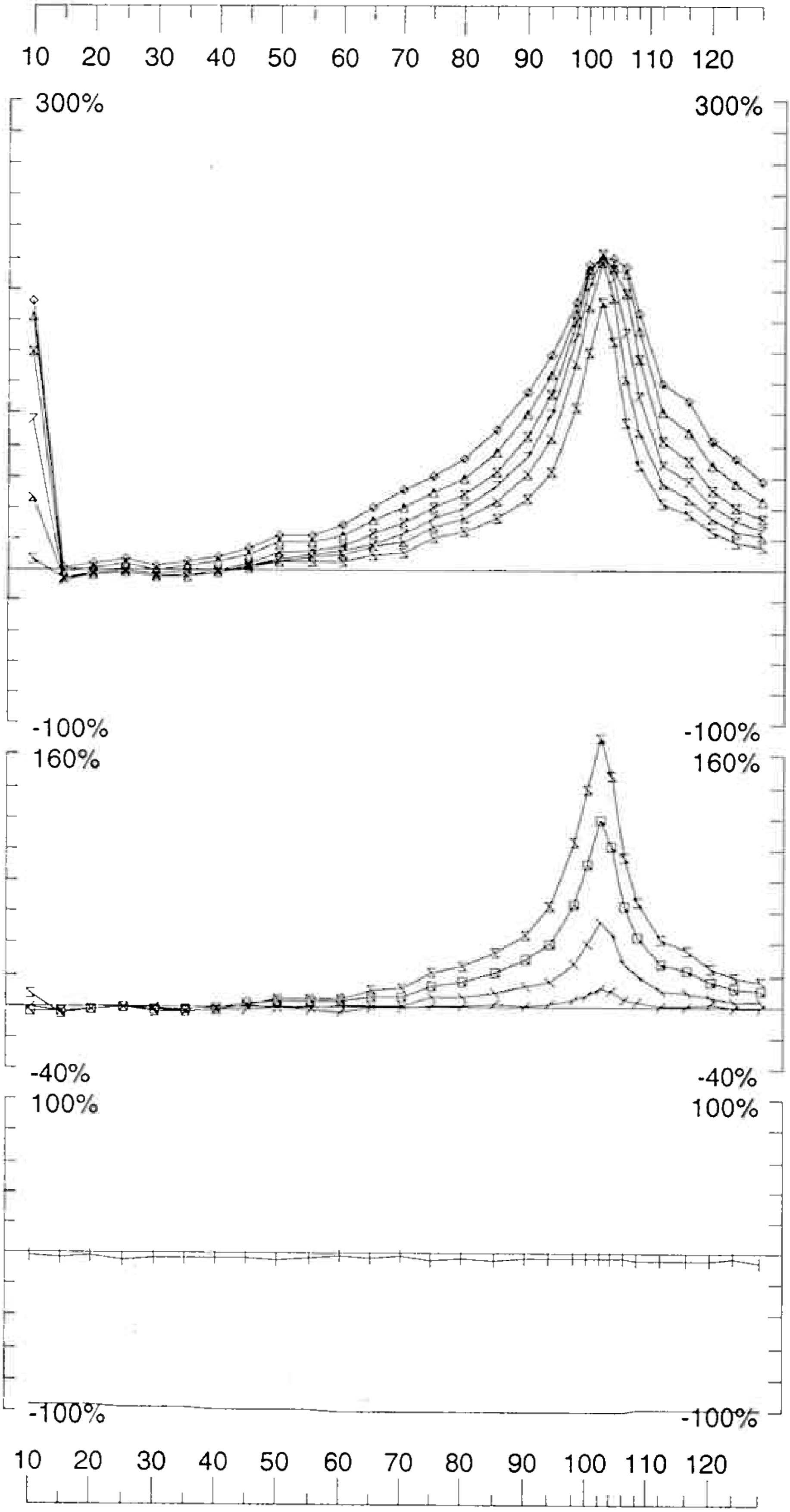


Loop: 20a	Total, Chn/lHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-25	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed: 7/5/5 Reduced: 7/5/5 Plotted: 17/5/5

LP20a (Note: all holes are ES2005- series)




LP20A
05-25 -26-27 -28 -29
LOG10(AMPLITUDE)



BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

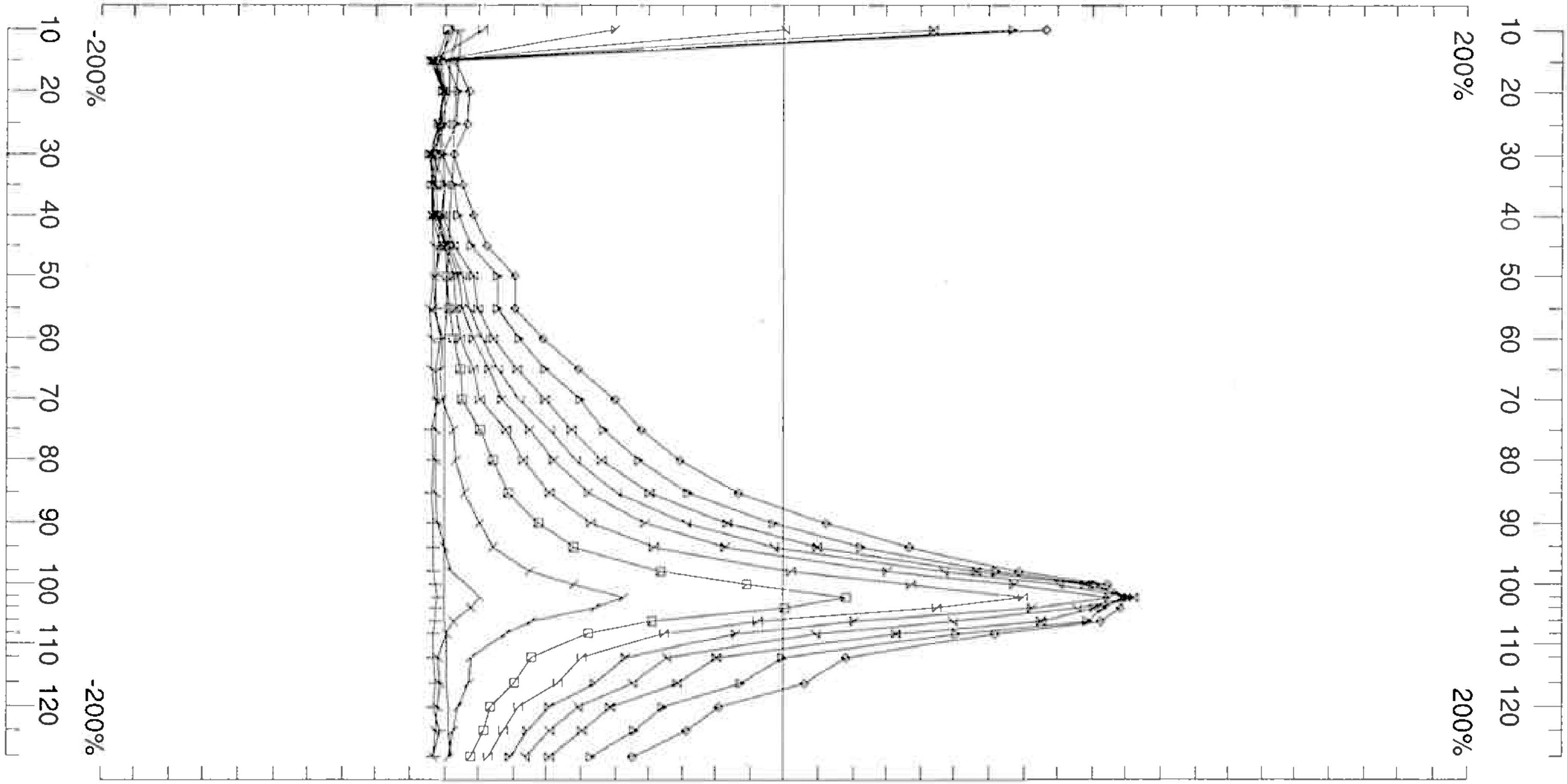
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0511

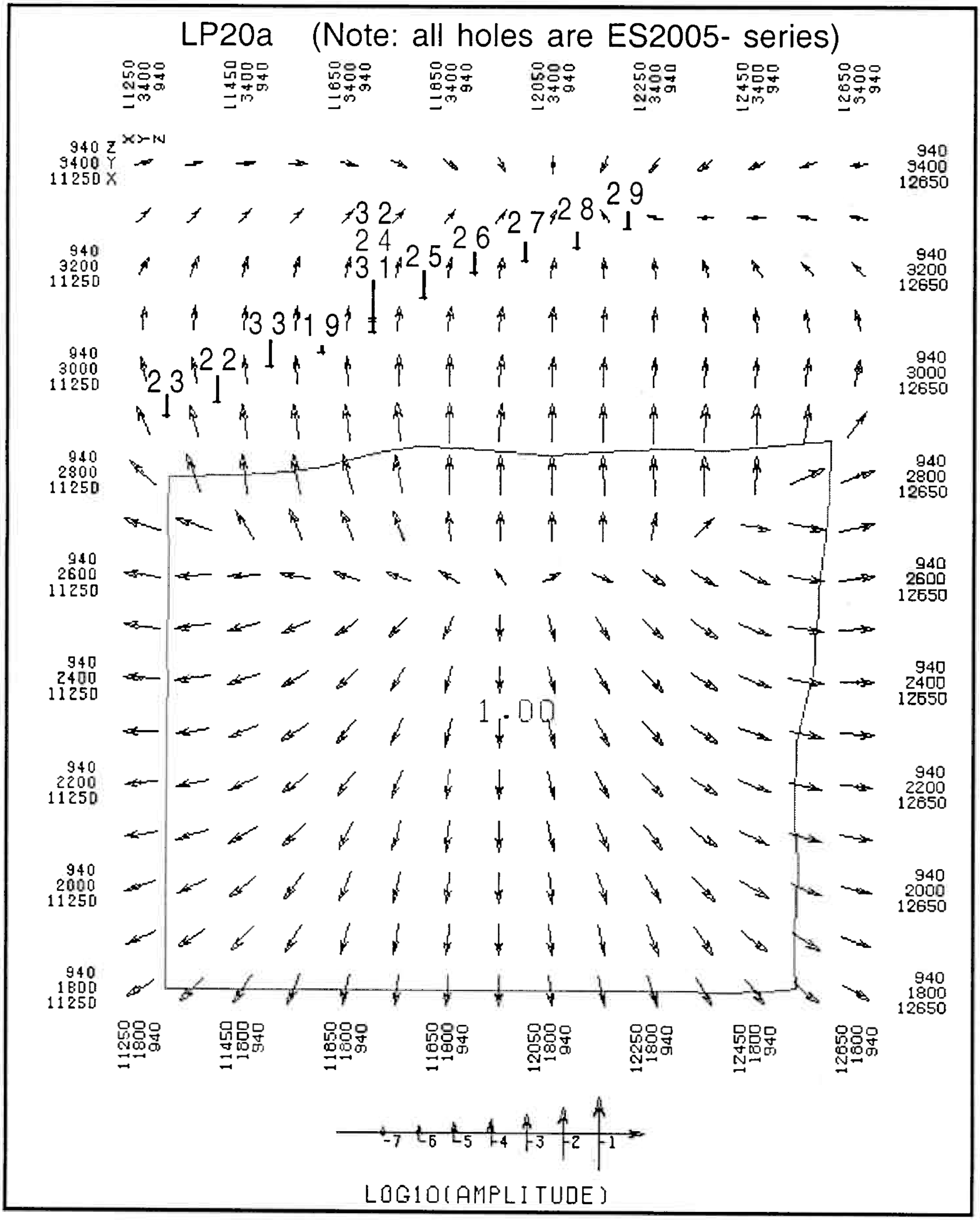
Surveyed : 7/5/5
Reduced : 7/5/5
Plotted : 17/5/5

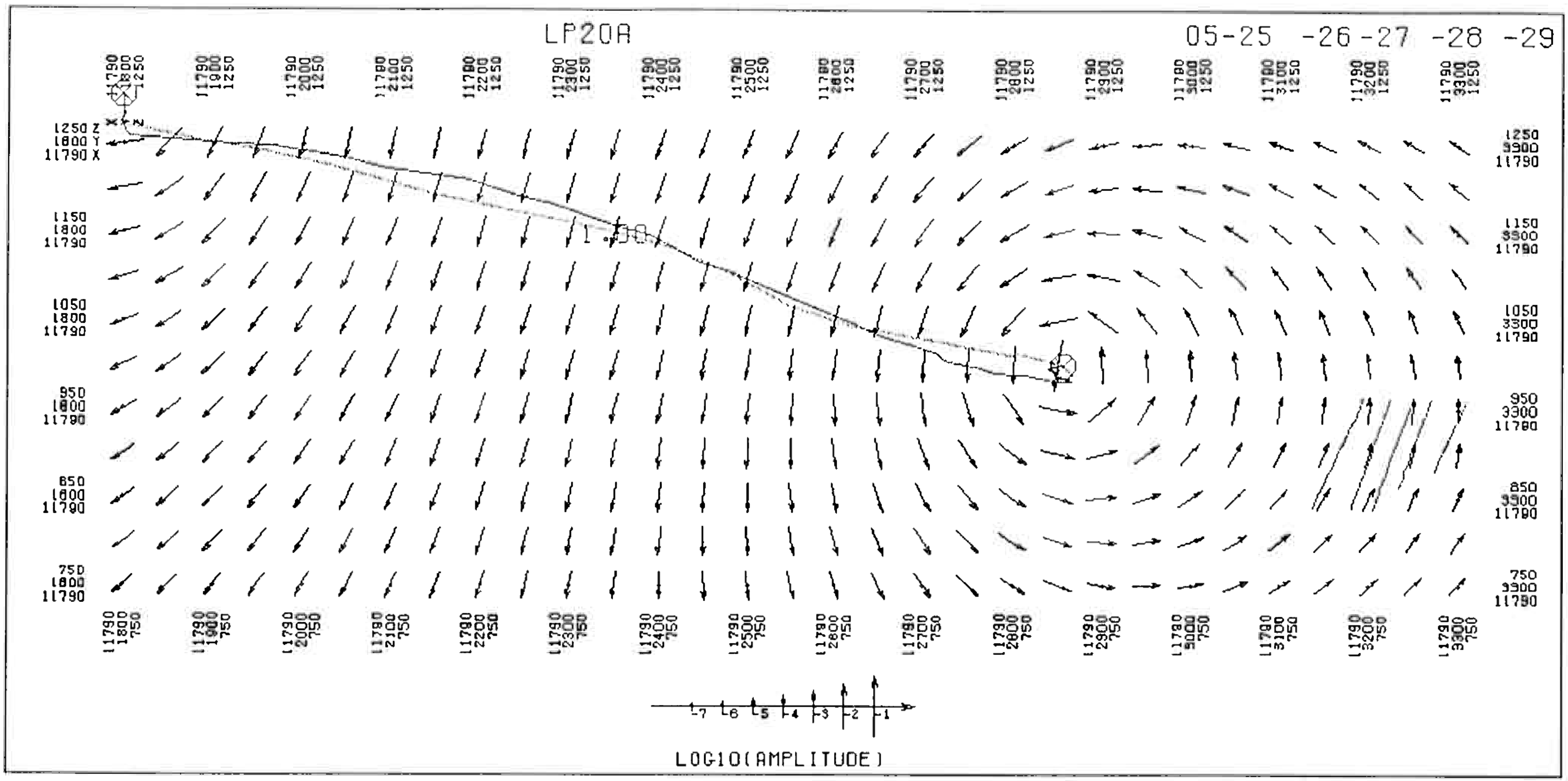
Secondary, (Chn - Ch1)/IHpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

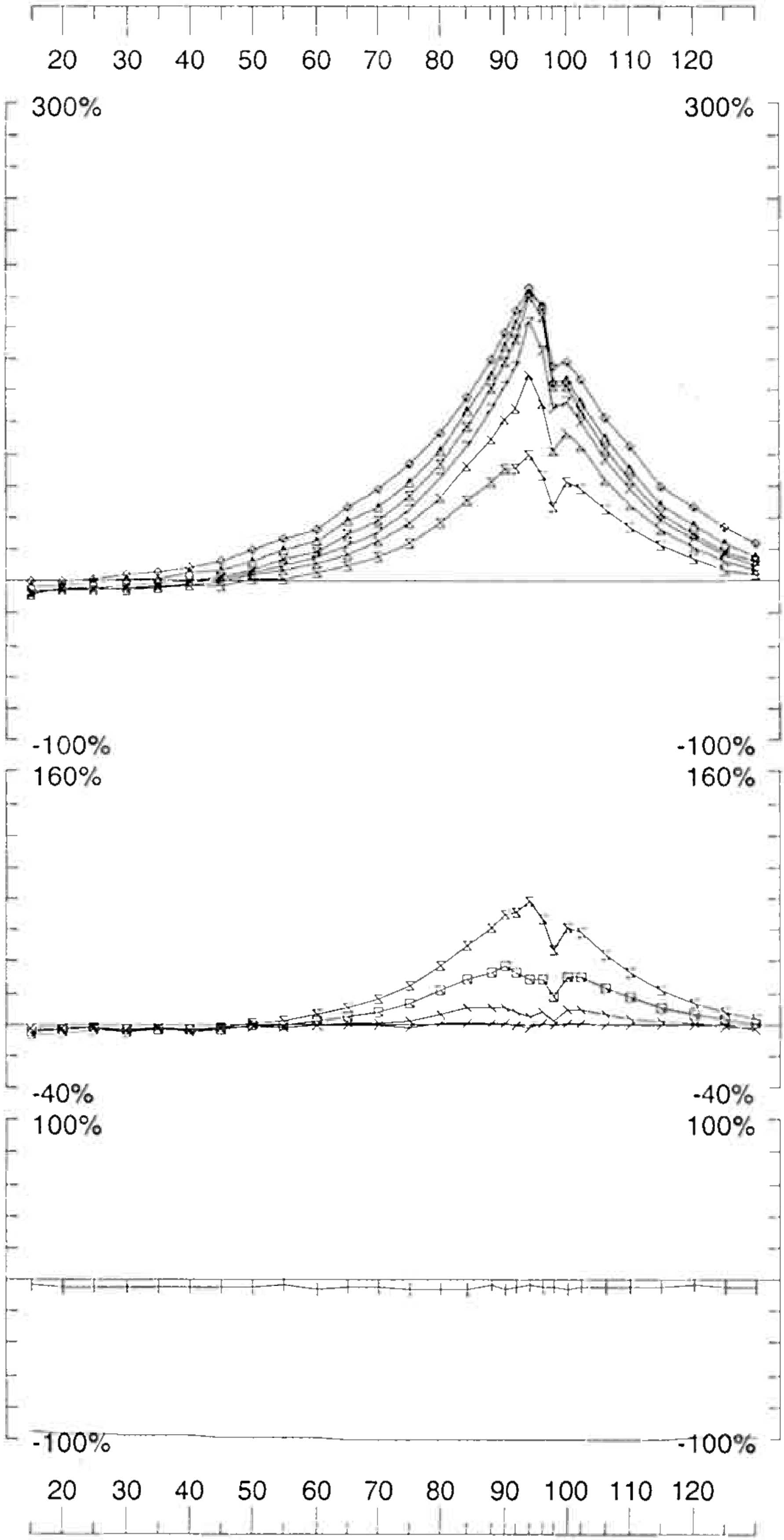
Loop: 20a
Hole: ES-2005-26
Compt: Axial



Loop: 20a	Total, Chn/lHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-26	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 7/5/5 Reduced : 7/5/5 Plotted : 17/5/5


LP20a (Note: all holes are ES2005- series)
XYZ
940 Z
3400 Y
11250 X
23
22
33
19
31
24
32
25
26
27
28
29
1.00
-7
-6
-5
-4
-3
-2
-1
LOG10(AMPLITUDE)


LP20A
05-25 -26 -27 -28 -29
LOG10(AMPLITUDE)
-7 -6 -5 -4 -3 -2 -1
1.00
X Y Z



BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

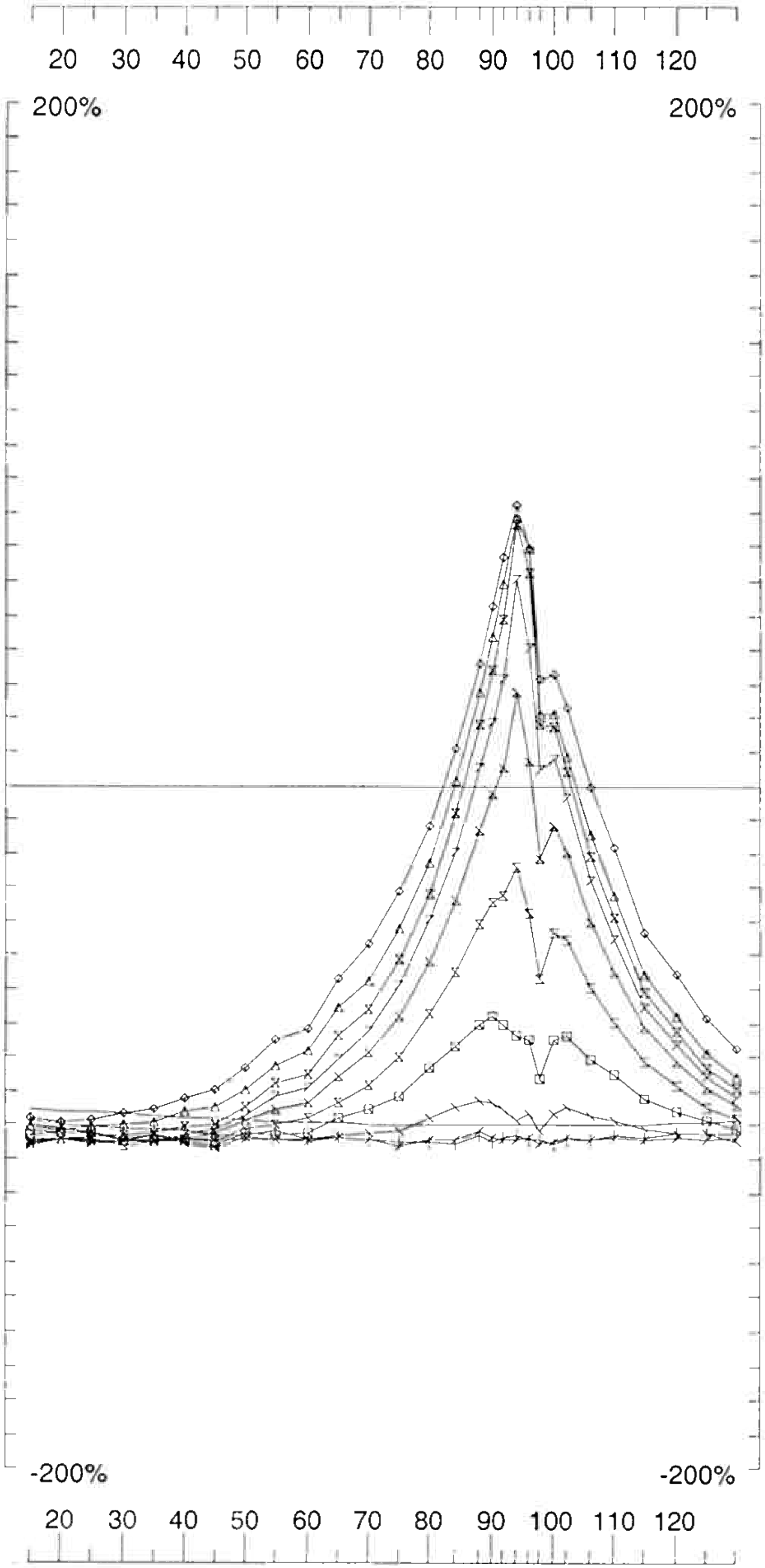
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0511

Surveyed : 8/5/5
Reduced : 8/5/5
Plotted : 17/5/5

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

Loop: 20a
Hole: ES-2005-27
Compt: Axial



BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

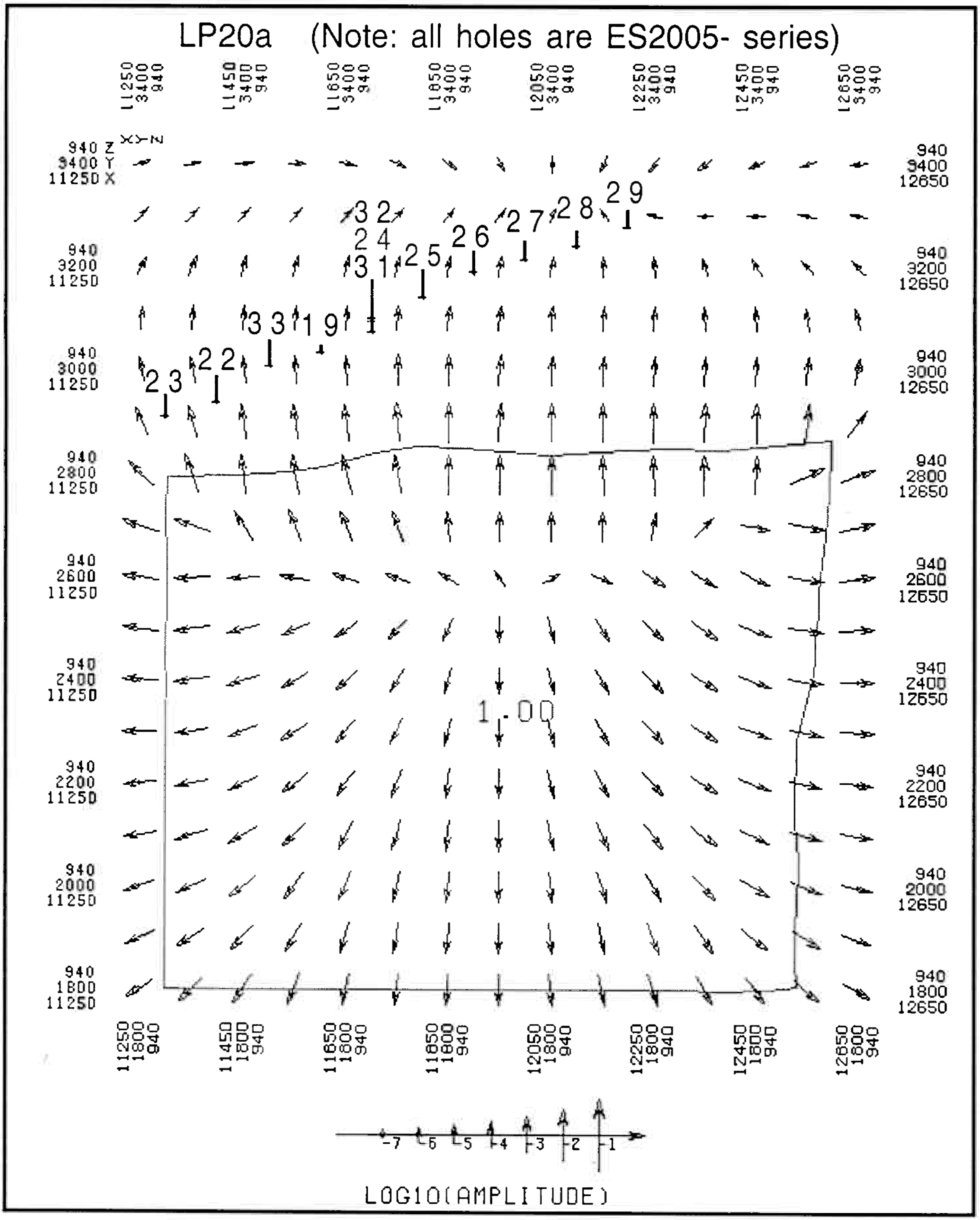
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

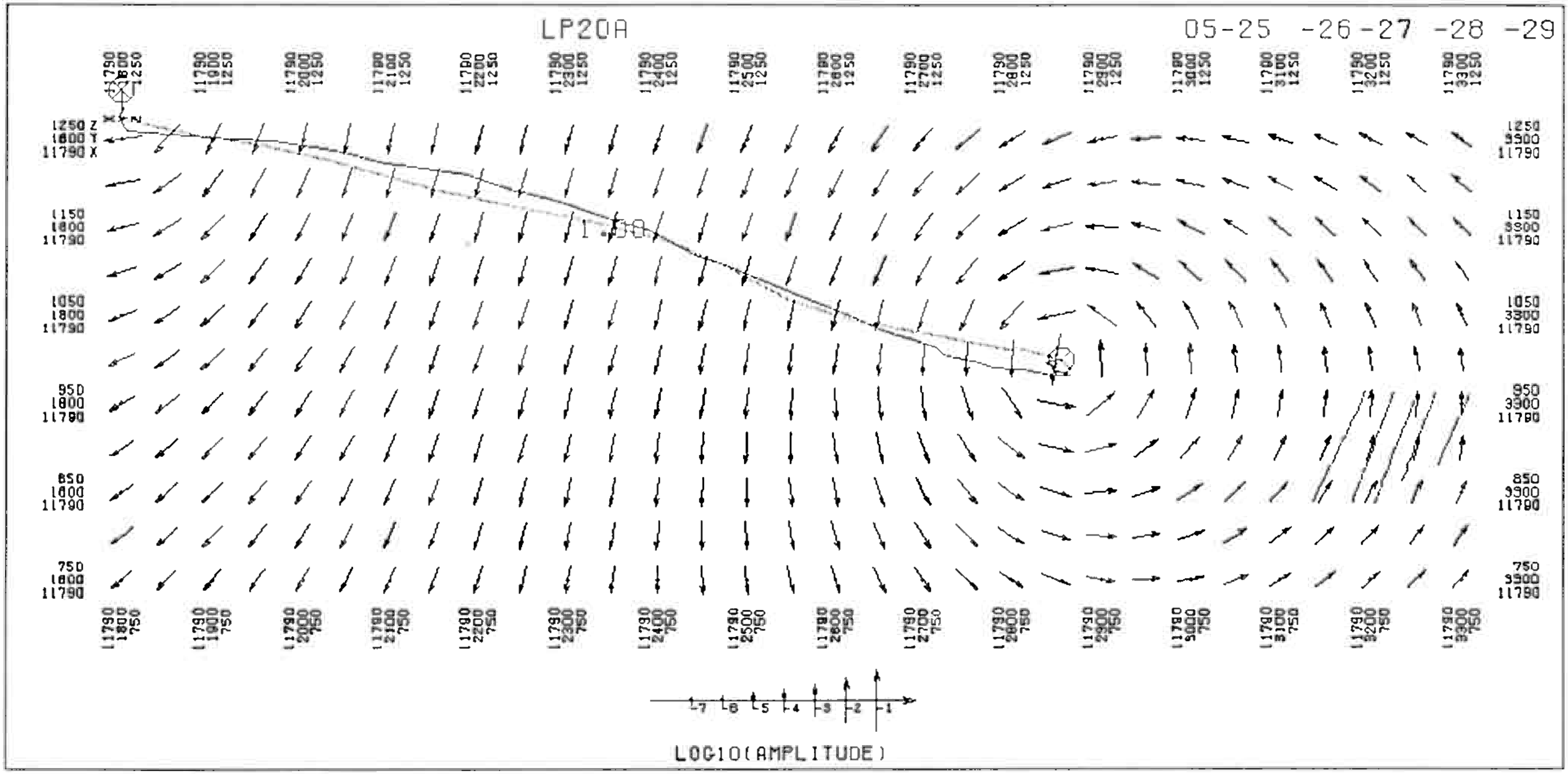
Job 0511

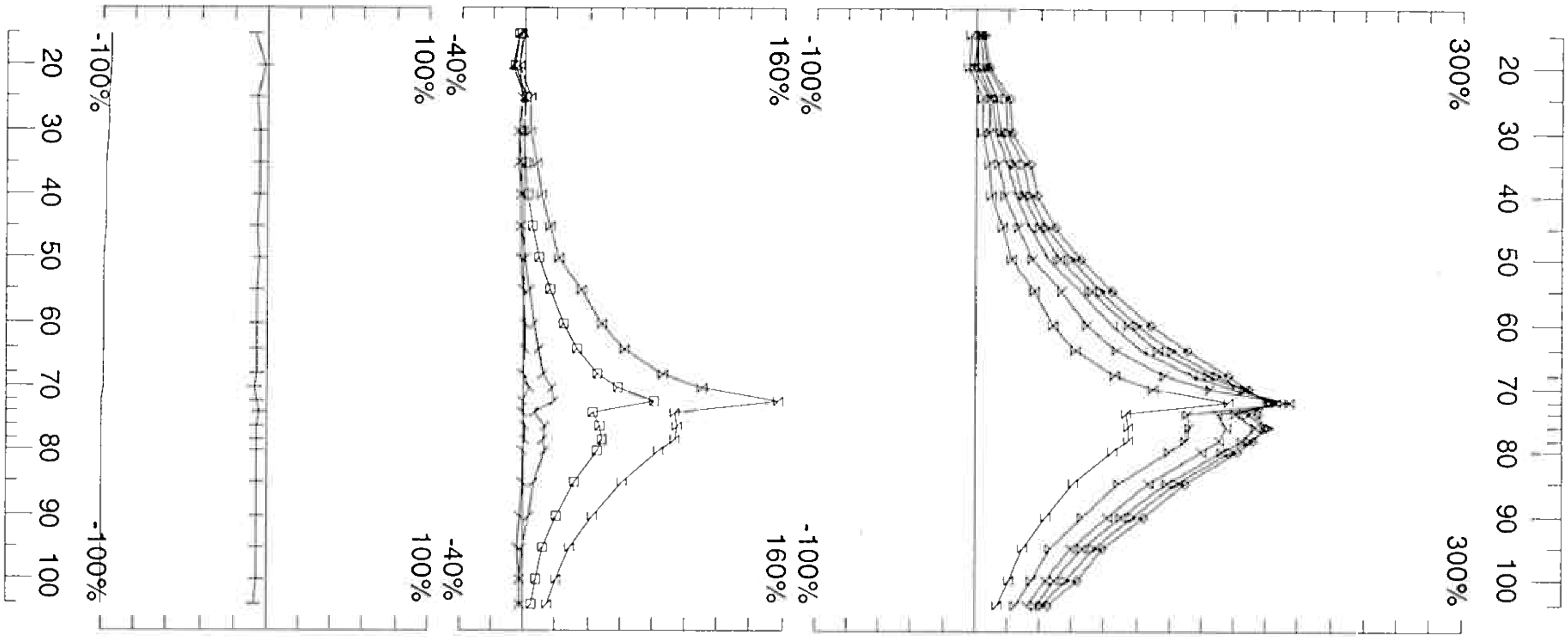
Surveyed: 8/5/5
Reduced: 8/5/5
Plotted: 17/5/5

Loop: 20a
Hole: ES-2005-27
Compt: Axial

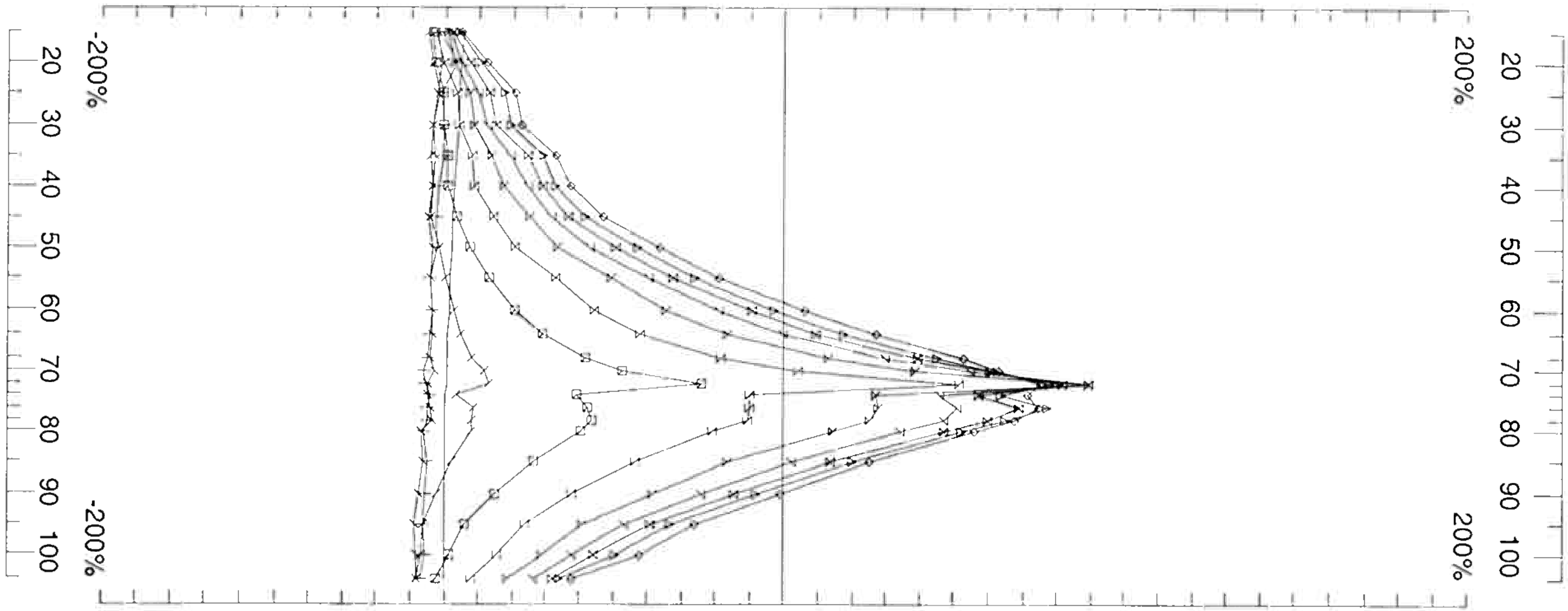
Total, Chn/IHpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz


LP20a (Note: all holes are ES2005- series)
23
22
33
19
31
24
32
25
26
27
28
29
1.00
LOG10(AMPLITUDE)
940 3400 11250
940 3200 11250
940 3000 11250
940 2800 11250
940 2600 11250
940 2400 11250
940 2200 11250
940 2000 11250
940 1800 11250
940 3400 12650
940 3200 12650
940 3000 12650
940 2800 12650
940 2600 12650
940 2400 12650
940 2200 12650
940 2000 12650
940 1800 12650
11250 3400 940
11450 3400 940
11650 3400 940
11850 3400 940
12050 3400 940
12250 3400 940
12450 3400 940
12650 3400 940
11250 1800 940
11450 1800 940
11650 1800 940
11850 1800 940
12050 1800 940
12250 1800 940
12450 1800 940
12650 1800 940
-7 -6 -5 -4 -3 -2 -1

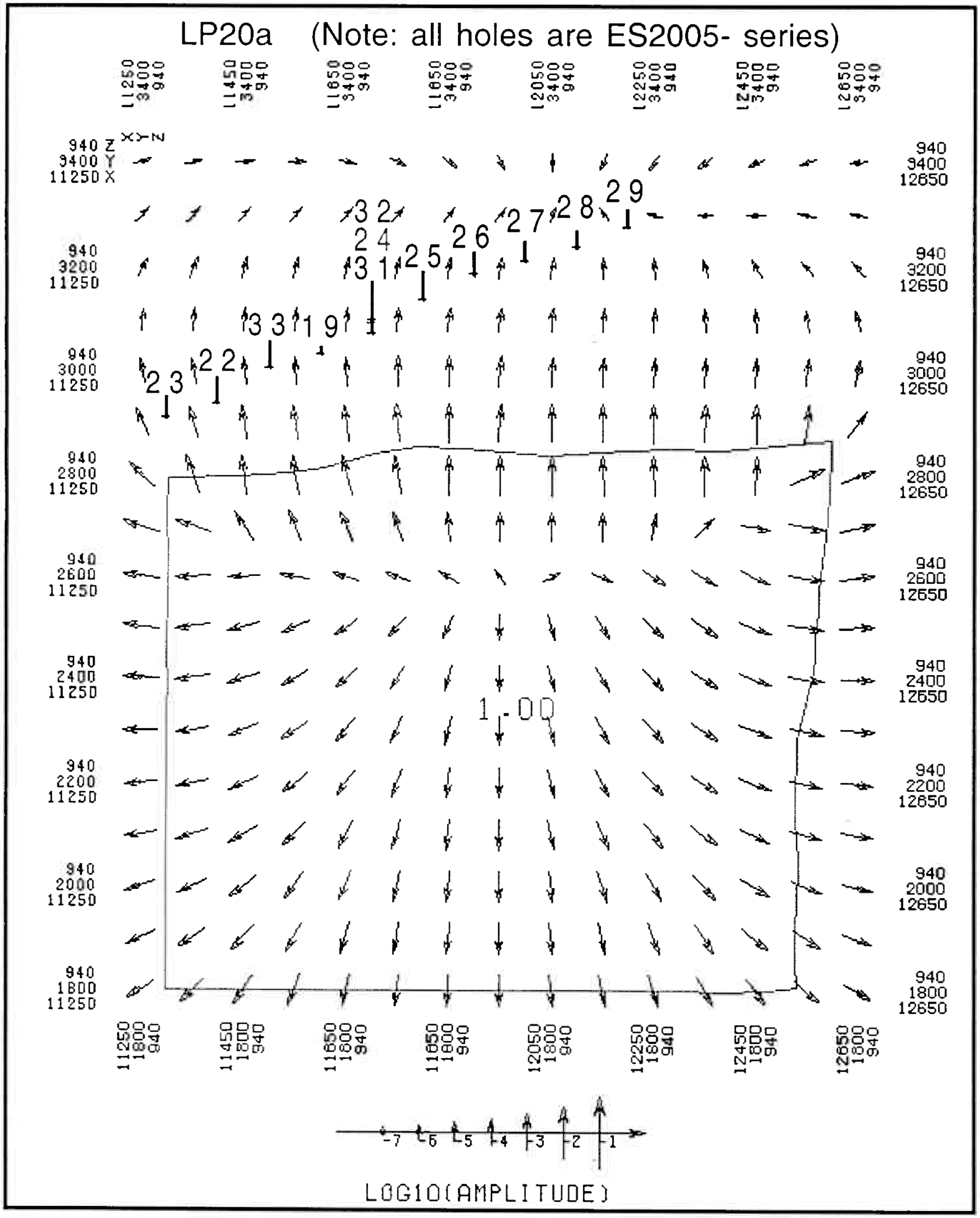

LP20A
05-25 -26-27 -28 -29
1.00
LOG10(AMPLITUDE)
-7 -6 -5 -4 -3 -2 -1
1250 Z
1800 Y
11790 X
1250 3300 11790
1150 1800 11790
1150 3300 11790
1050 1800 11790
1050 3300 11790
950 1800 11790
950 3300 11790
850 1800 11790
850 3300 11790
750 1800 11790
750 3300 11790



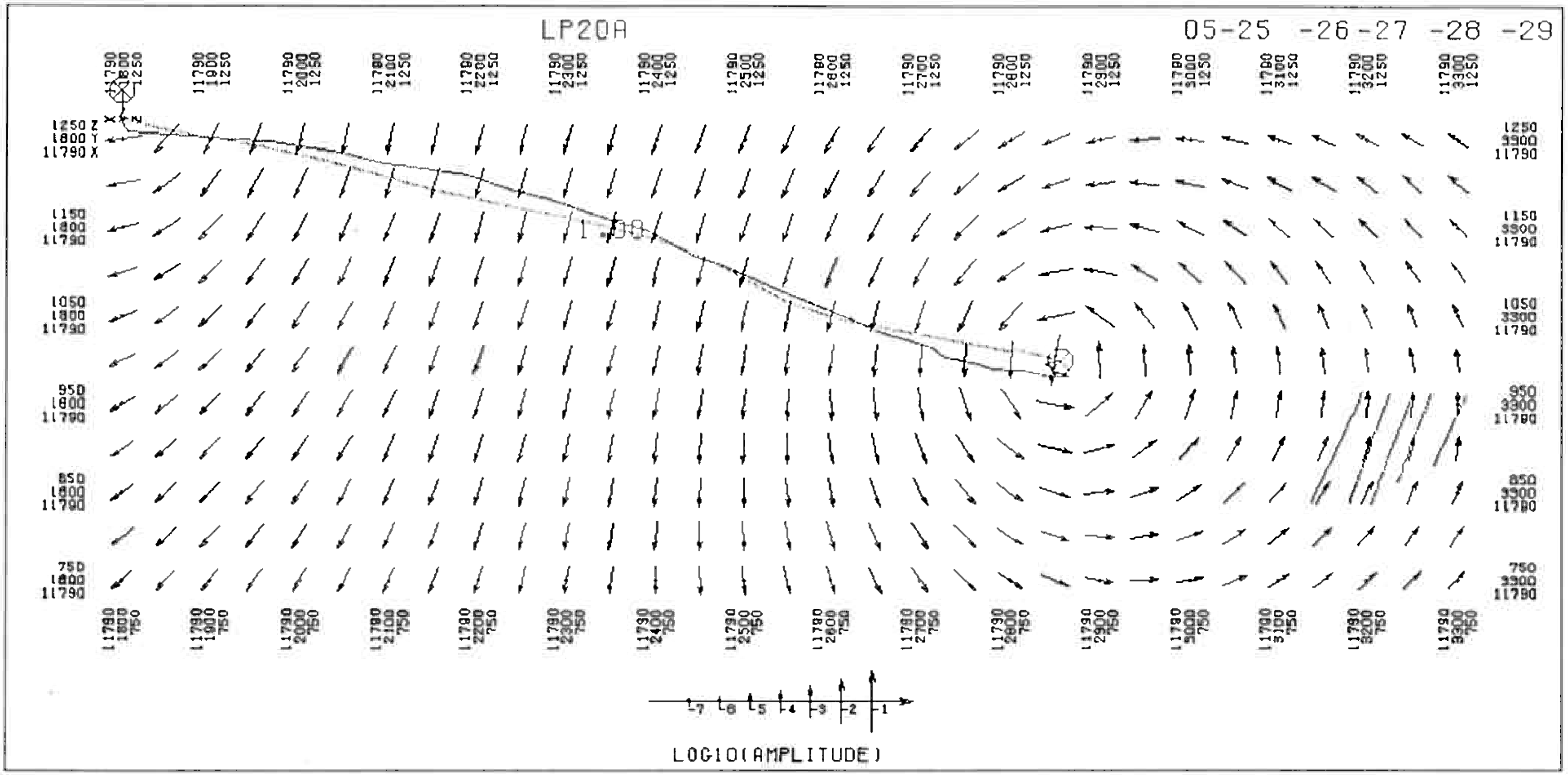
Loop: 20a	Secondary, (Chn - Ch1)/IHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-28	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed: 8/5/5 Reduced: 8/5/5 Plotted: 17/5/5

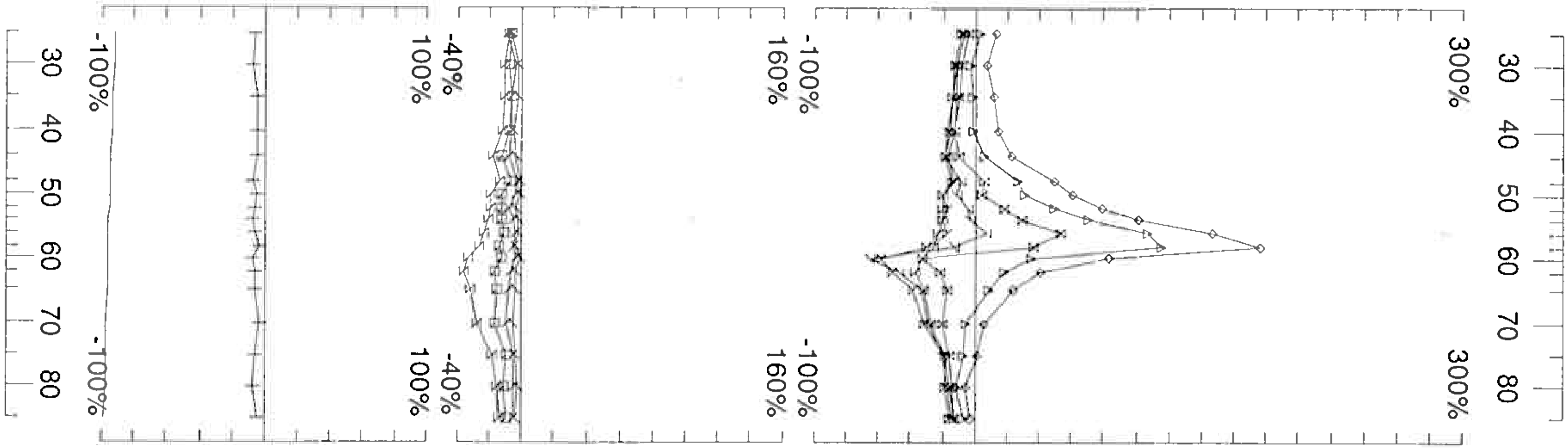


Loop: 20a	Total, Chn/IHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-28	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 8/5/5 Reduced : 8/5/5 Plotted : 17/5/5

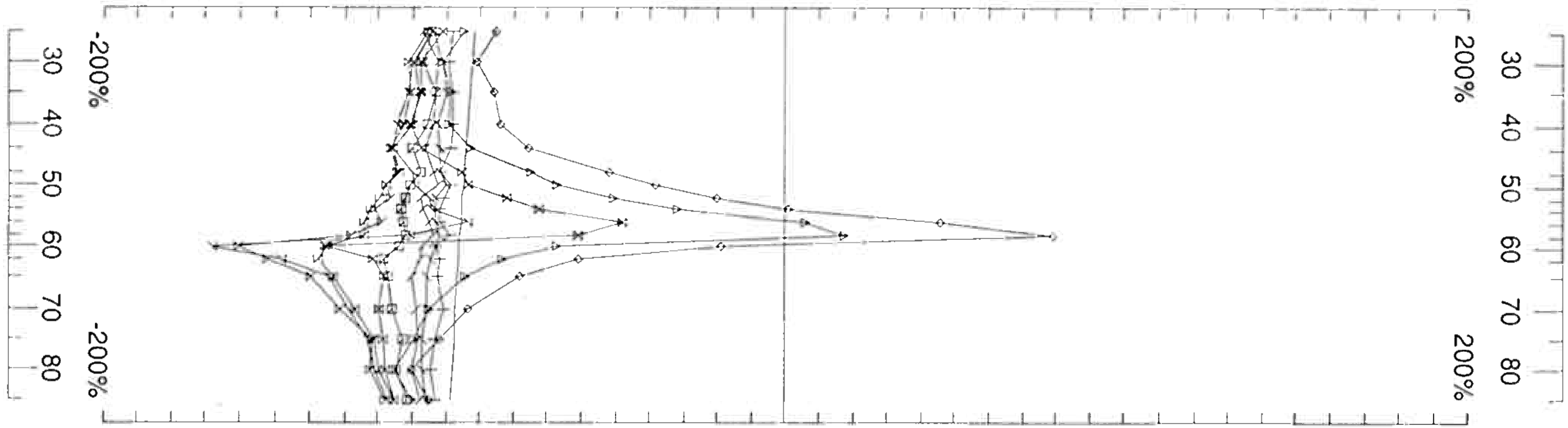


LP20a (Note: all holes are ES2005- series)
32
24
31
25
26
27
28
29
33
19
22
23
1.00
LOG10(AMPLITUDE)

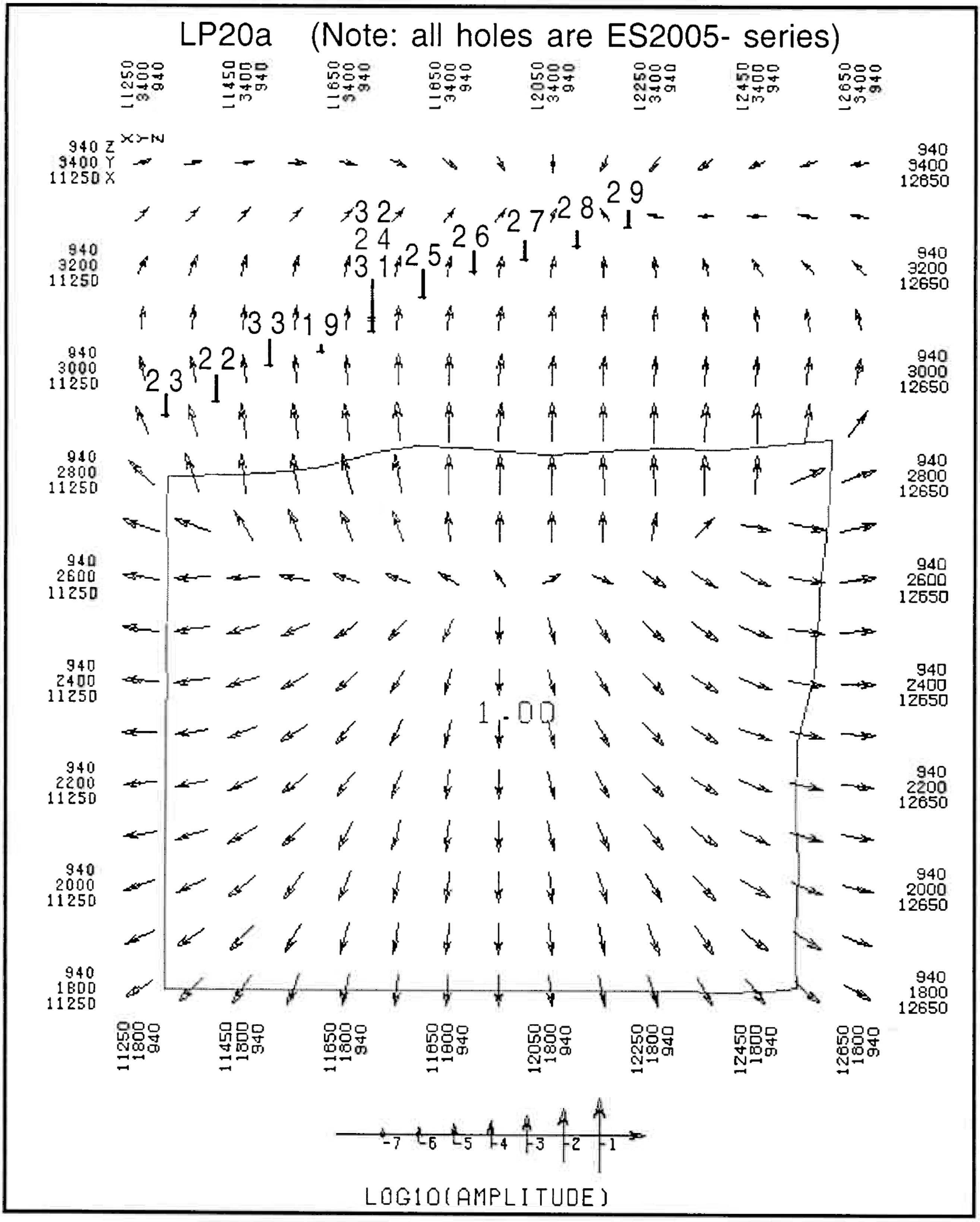

LP20A
05-25 -26-27 -28 -29
LOG10(AMPLITUDE)

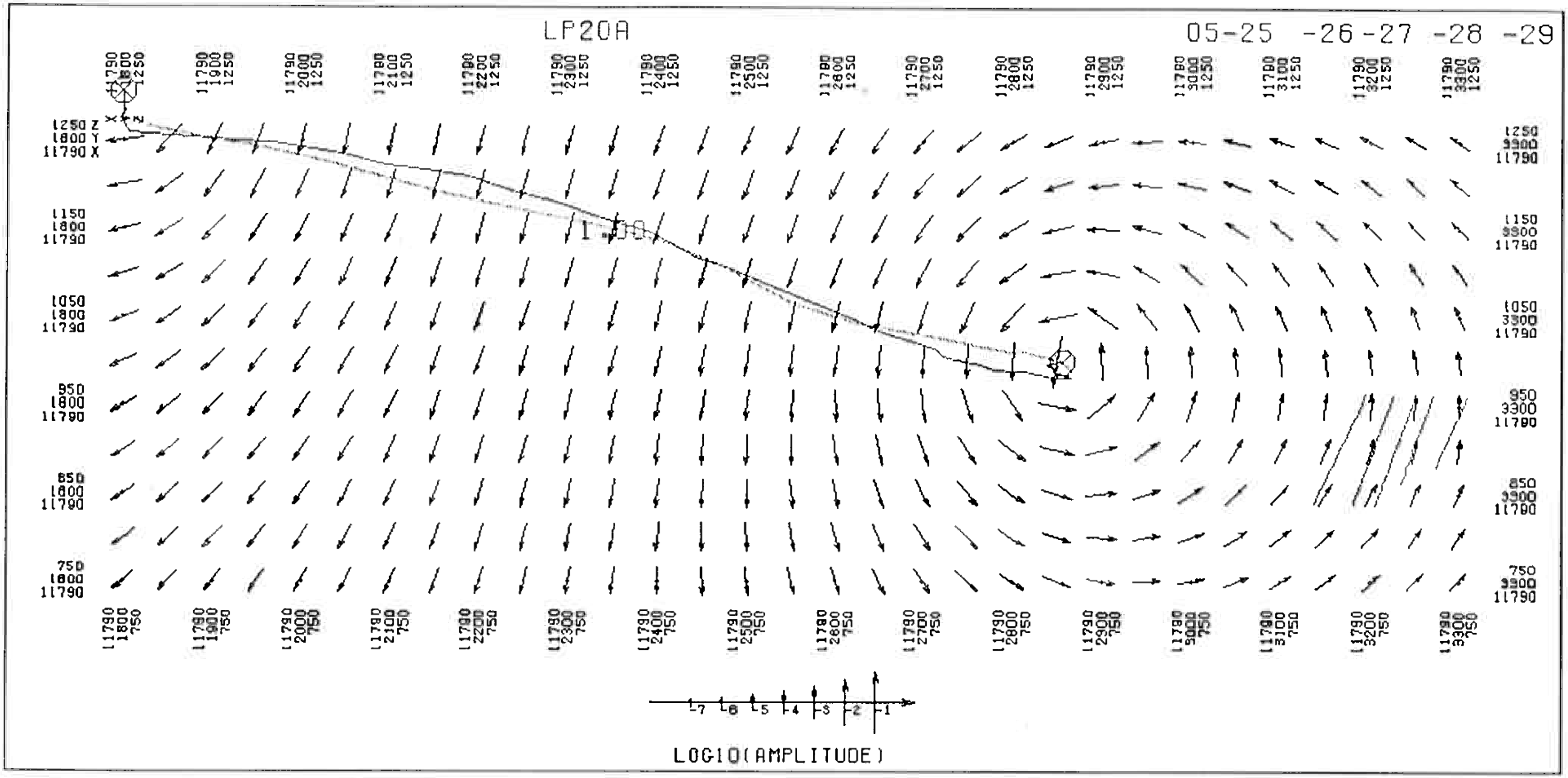


Loop: 20a	Secondary, (Chn - Ch1)/IHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-29	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 8/5/5 Reduced : 8/5/5 Plotted : 17/5/5

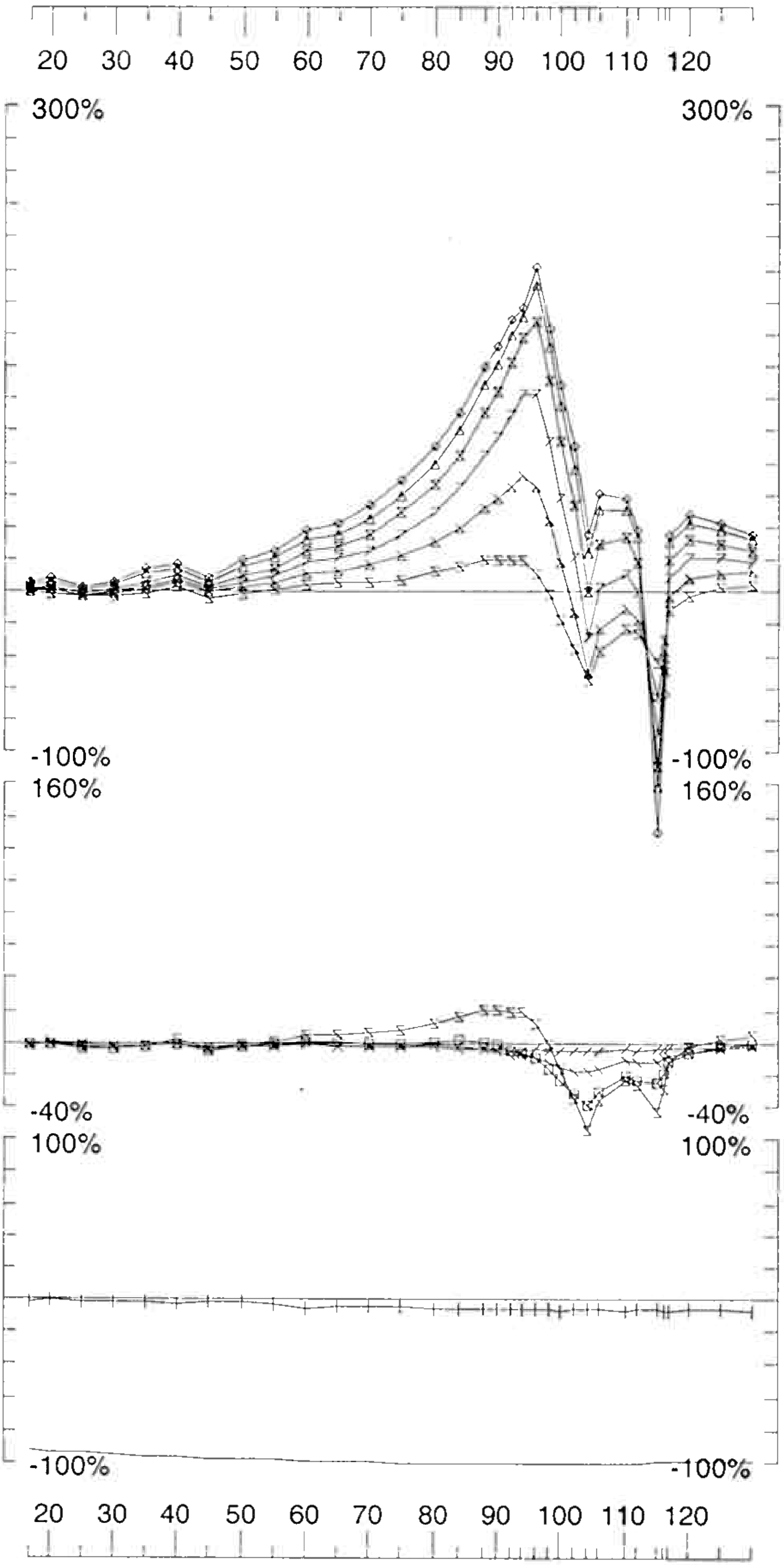


Loop: 20a	Total, Chn/IHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-29	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE — Job 0511 — Surveyed : 8/5/5 Reduced : 8/5/5 Plotted : 17/5/5


LP20a (Note: all holes are ES2005- series)
X Y Z
940 Z
3400 Y
11250 X
940
9400
12650
32
24
31
25
26
27
28
29
33
19
22
23
1.00
LOG10(AMPLITUDE)
-7
-6
-5
-4
-3
-2
-1



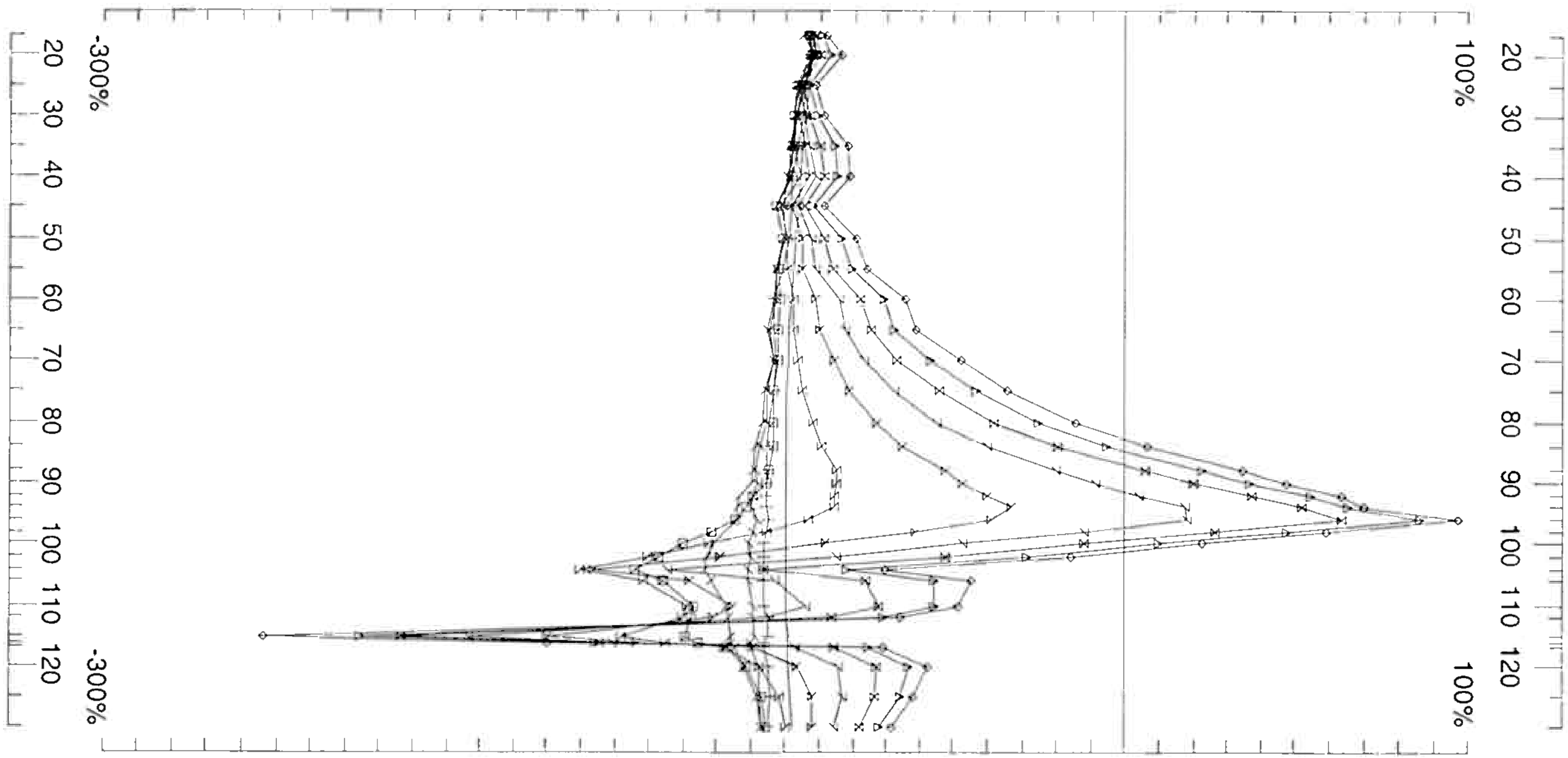
LF20A
05-25 -26 -27 -28 -29
LOG10(AMPLITUDE)



BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE
Job 0511
Surveyed: 9/5/5 Reduced: 9/5/5 Plotted: 17/5/5

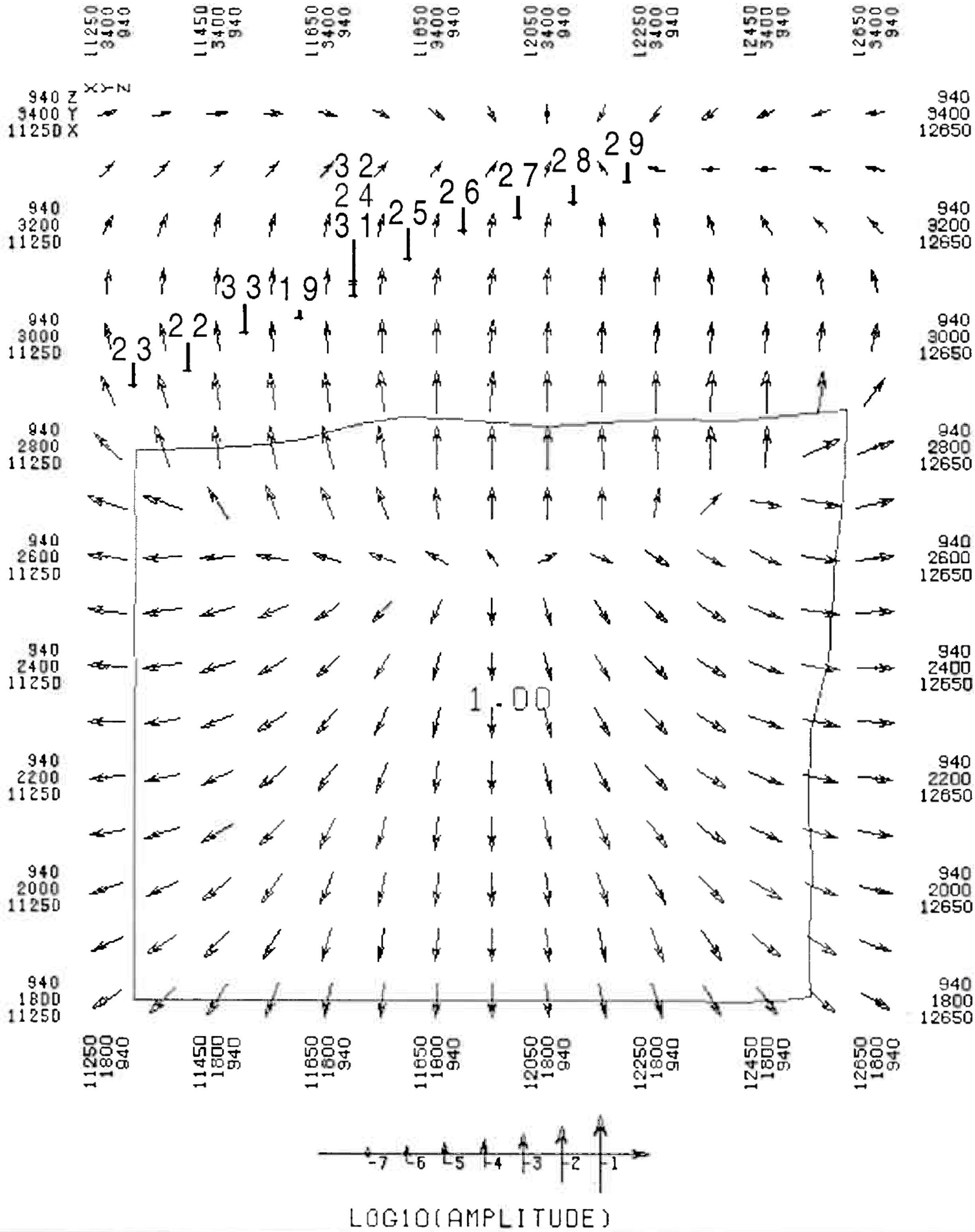
Secondary, (Chn - Ch1)/Hpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

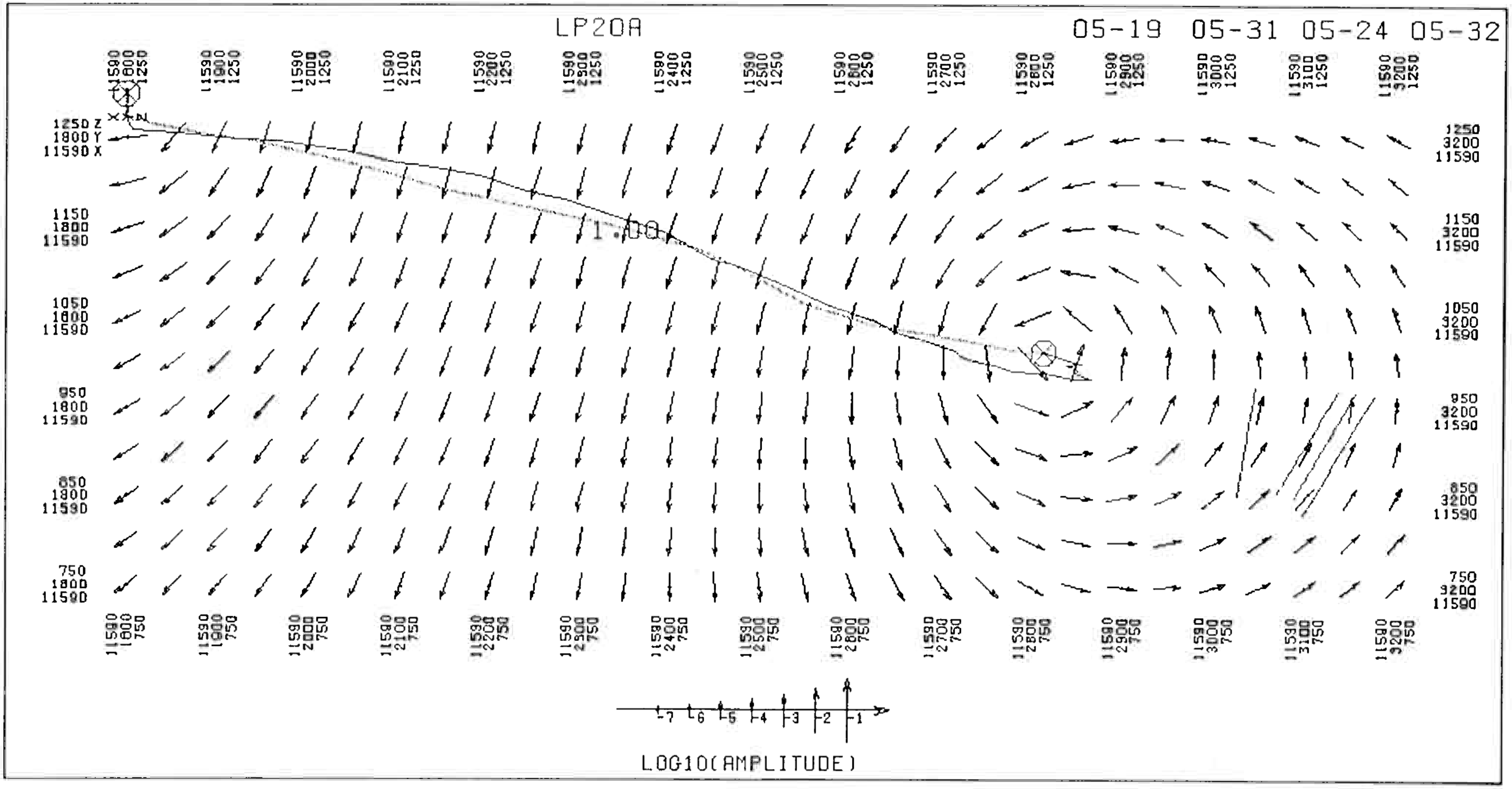
Loop: 20a
Hole: ES-2005-31
Compt: Axial

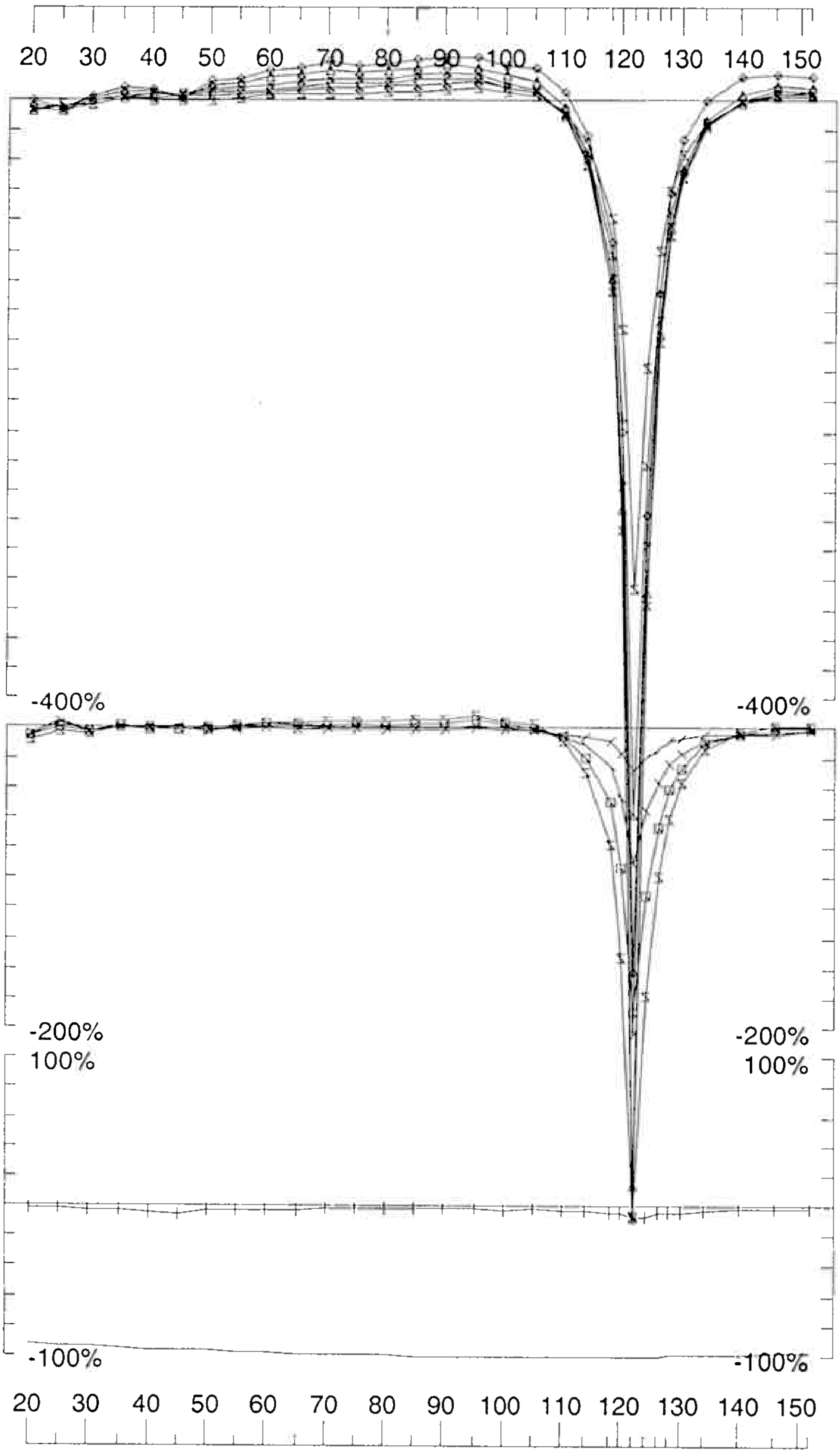


Loop: 20a	Total, Chn/IHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-31	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 9/5/5 Reduced : 9/5/5 Plotted : 17/5/5

LP20a (Note: all holes are ES2005- series)




LP20A
05-19 05-31 05-24 05-32
1250 Z
1800 Y
11590 X
1.00
LOG10(AMPLITUDE)



BHUTEM Survey at: Espedalen

For: A/S Sulfidmalm

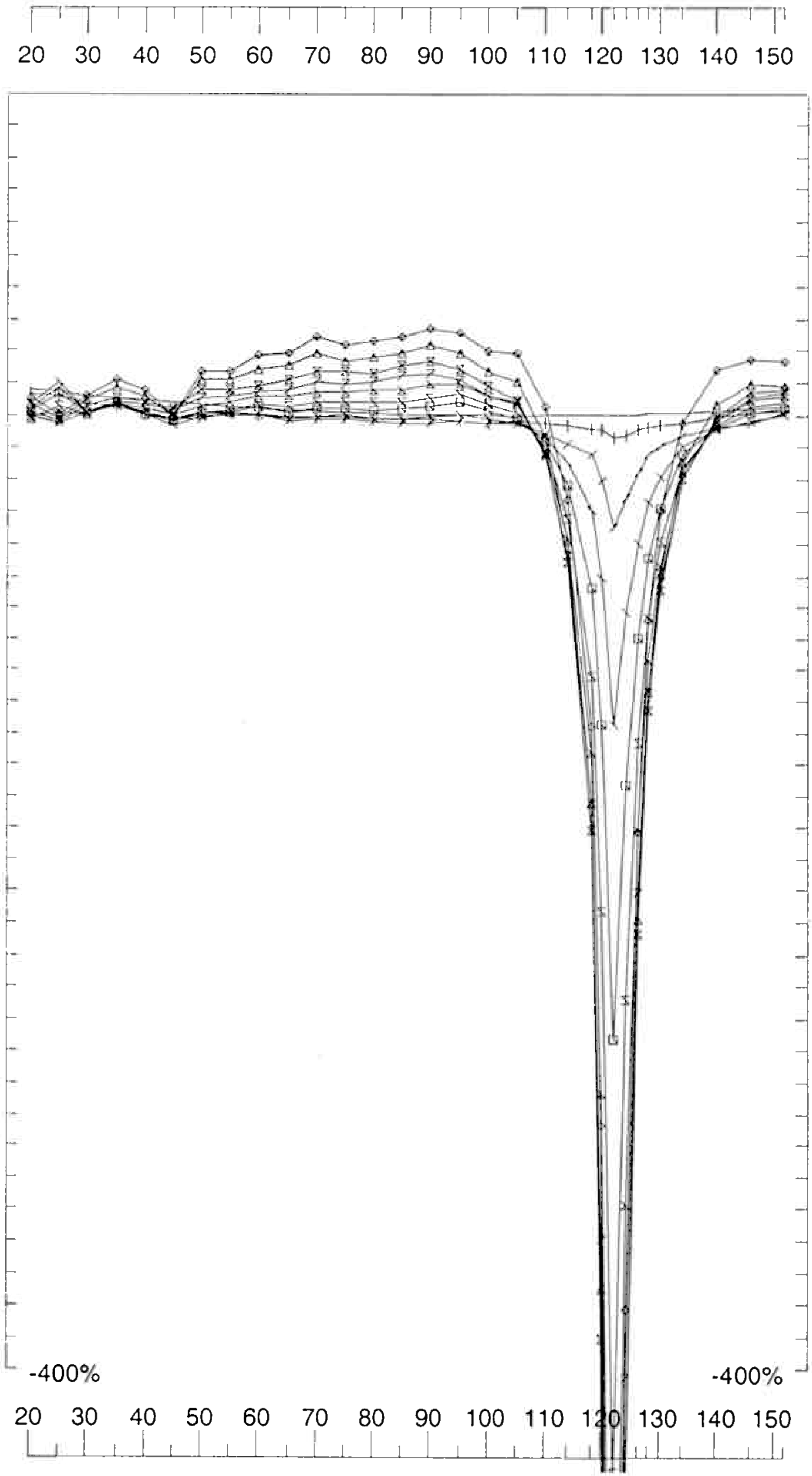
LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0511

Surveyed : 9/5/5
Reduced : 9/5/5
Plotted : 17/5/5

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

Loop: 20a
Hole: ES-2005-32
Compt: Axial



Loop: 20a
Hole: ES-2005-32
Compt: Axial

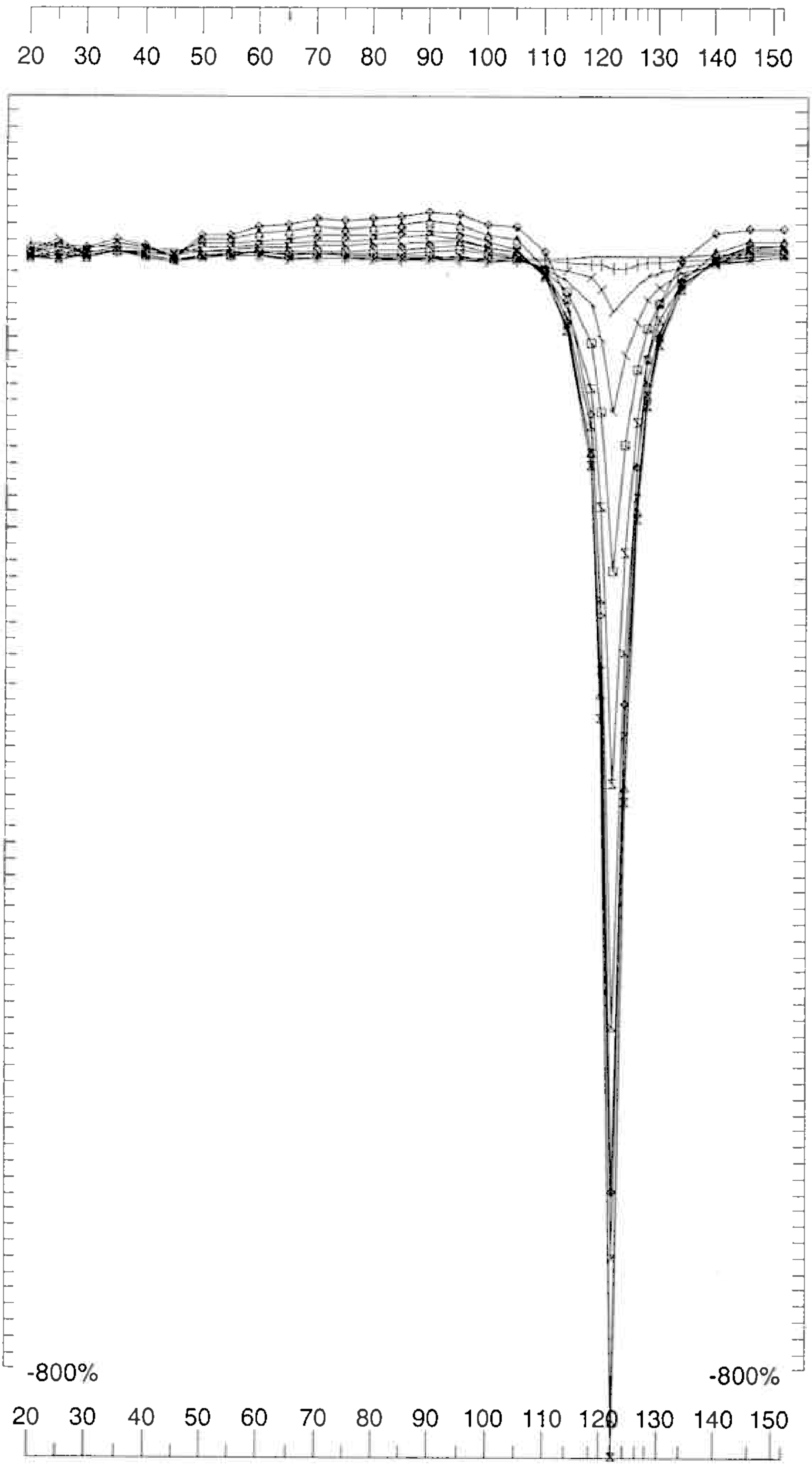
Total, Chn/IHpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

LAMONTAGNE GEOPHYSICS LTD
GEOPHYSIQUE LTEE

Job 0511

Surveyed : 9/5/5
Reduced : 9/5/5
Plotted : 17/5/5



Loop: 20a
Hole: ES-2005-32
Compt: Axial

Total, Chn/IHpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

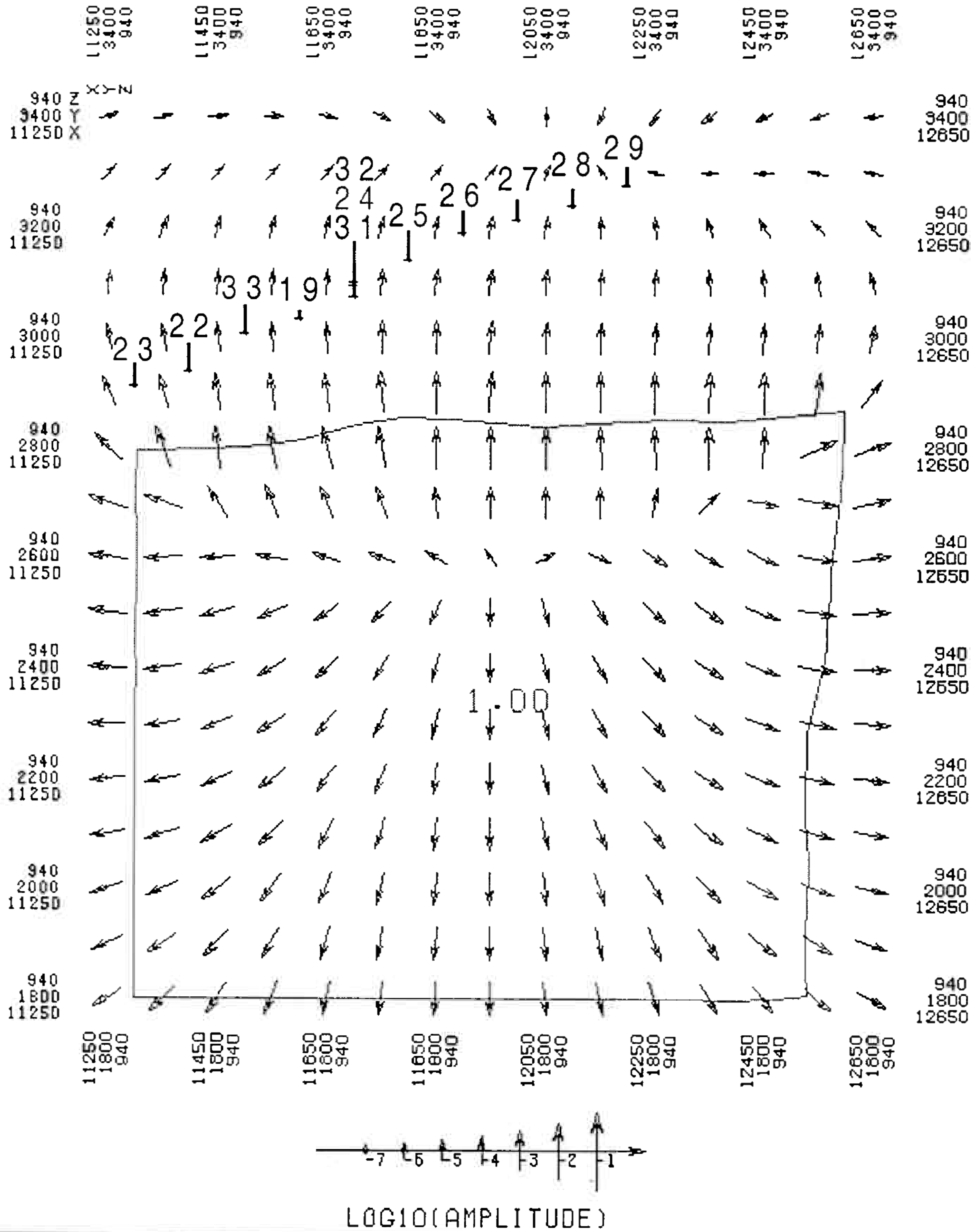
BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

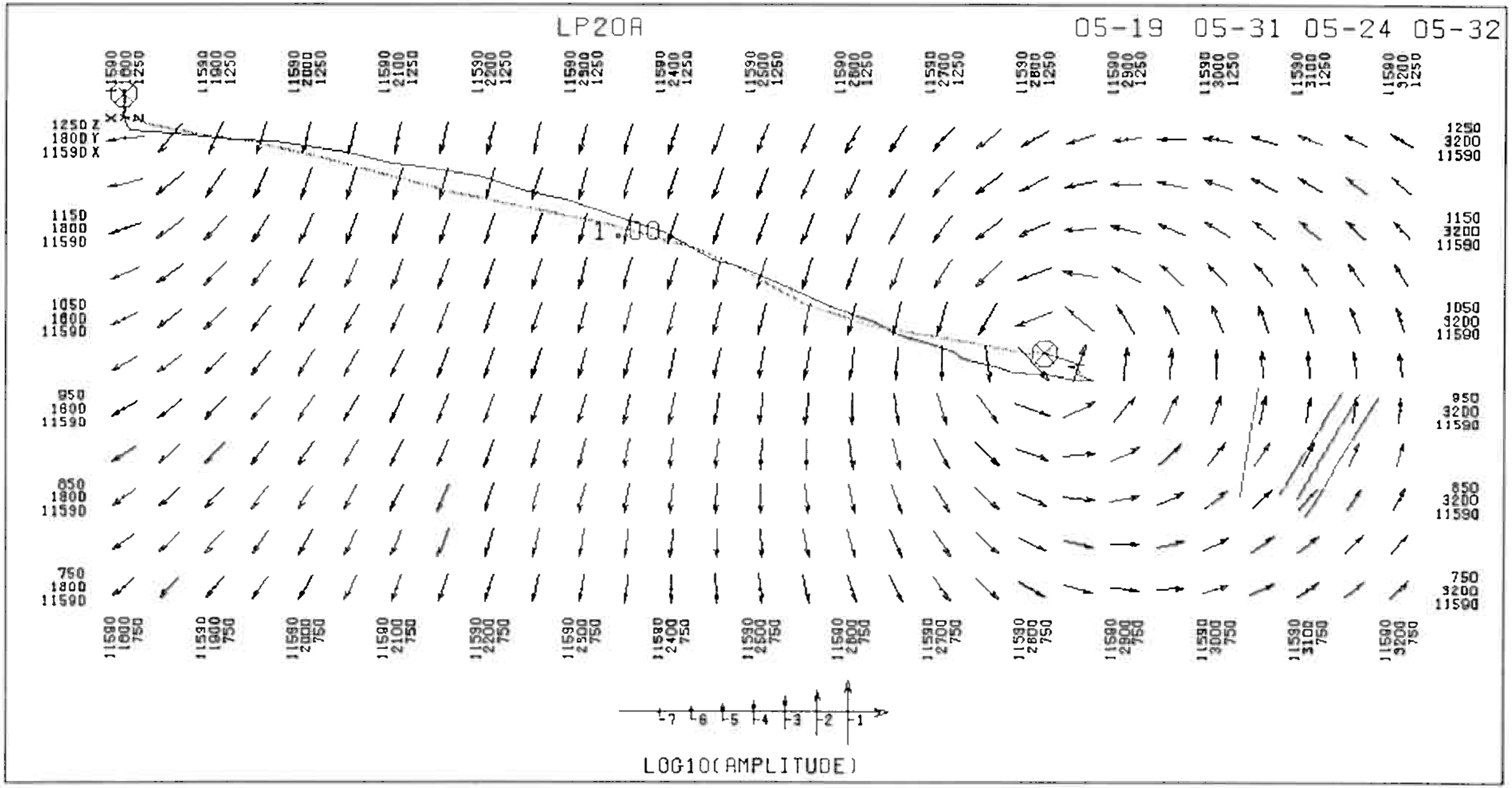
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Job 0511

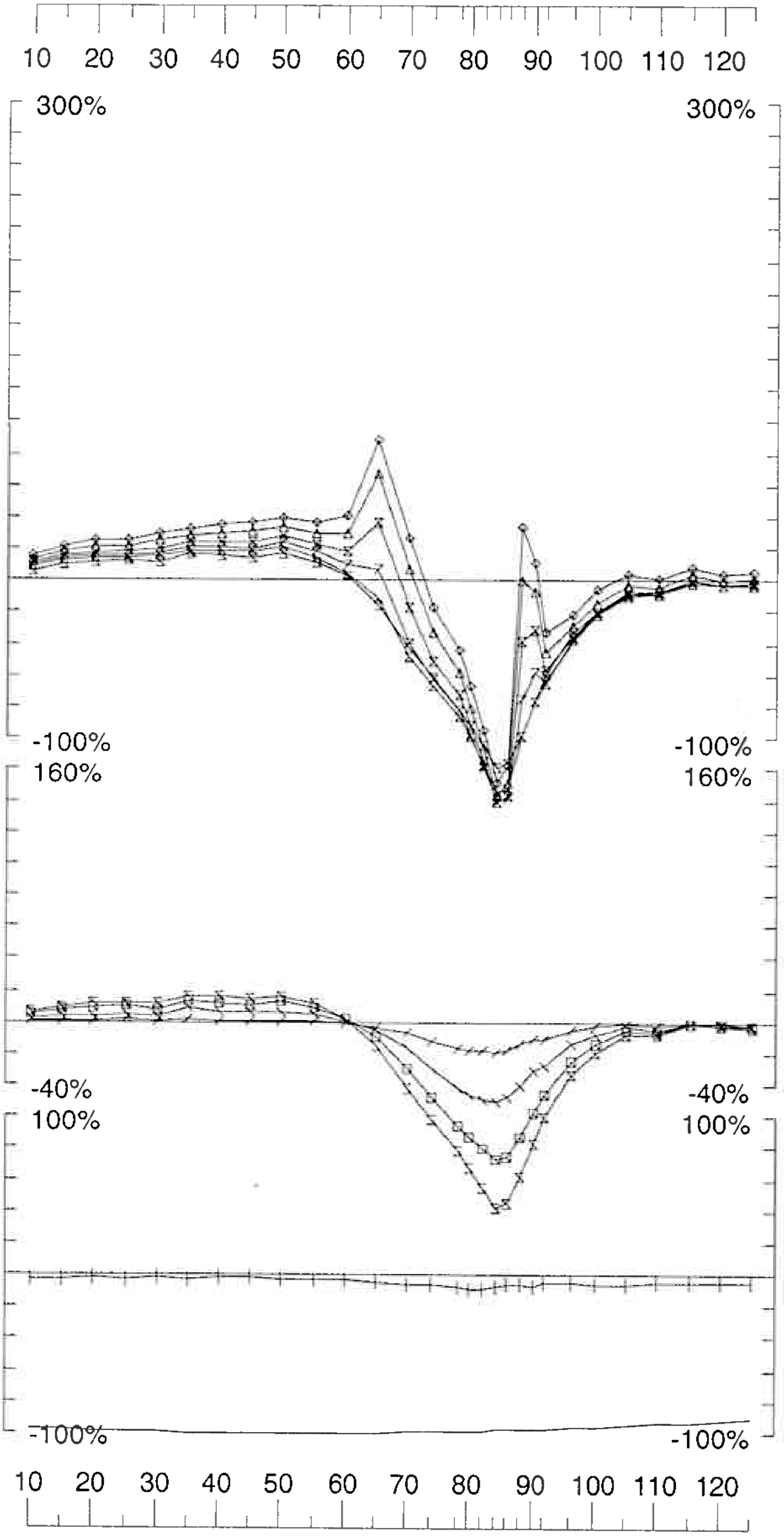
Surveyed: 9/5/5
Reduced: 9/5/5
Plotted: 17/5/5

LP20a (Note: all holes are ES2005- series)





LP20A
05-19 05-31 05-24 05-32
1250 Z
1800 Y
11590 X
1.00
-7 -6 -5 -4 -3 -2 -1
LOG10(AMPLITUDE)



Loop: 20a
Hole: ES-2005-33
Compt: Axial

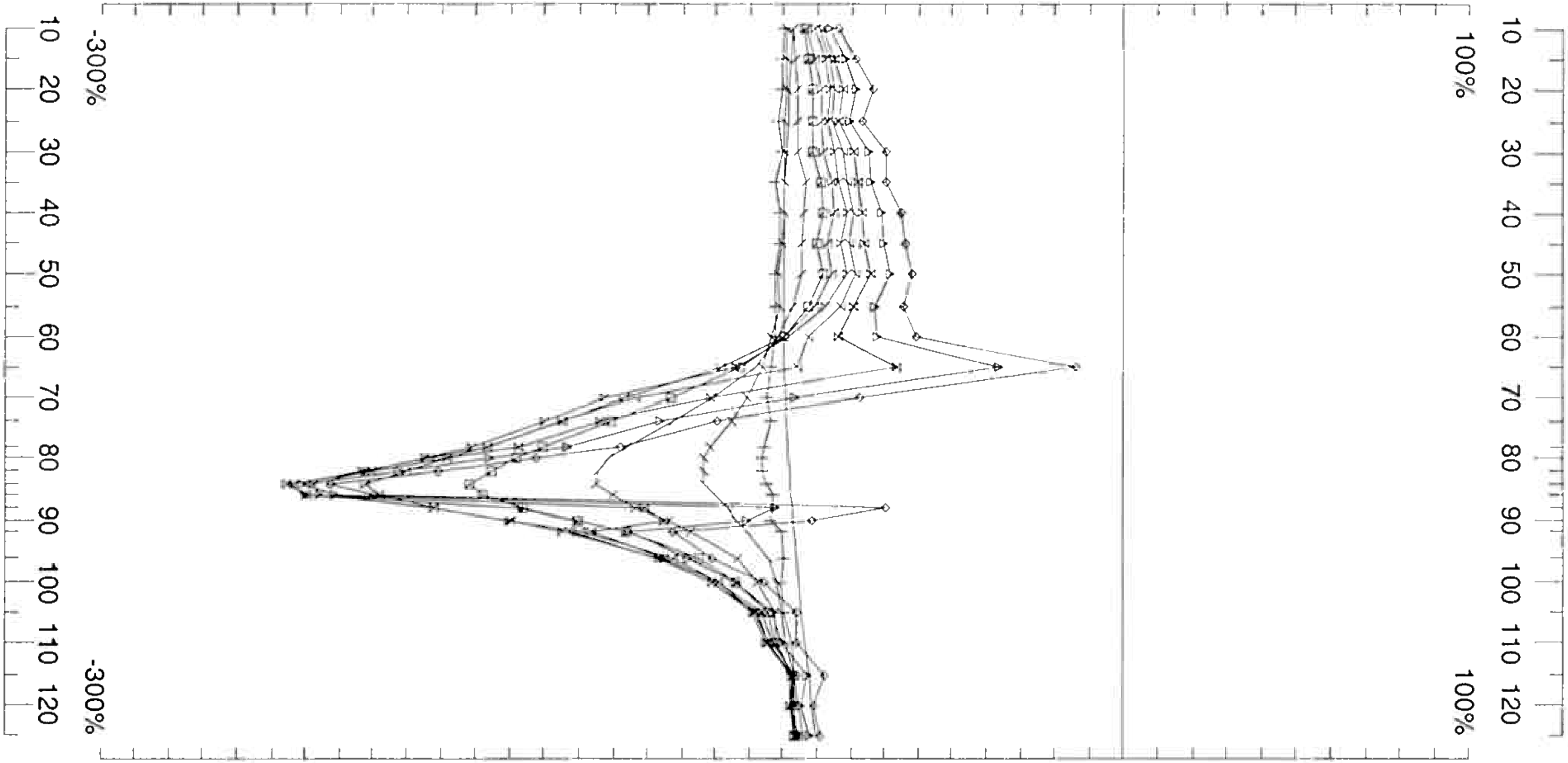
Secondary, (Chn - Ch1)/IHpl
Contin. Norm at depth of 0 m
Base Freq. 3.251 Hz

BHUTEM Survey at: Espedalen
For: A/S Sulfidmalm

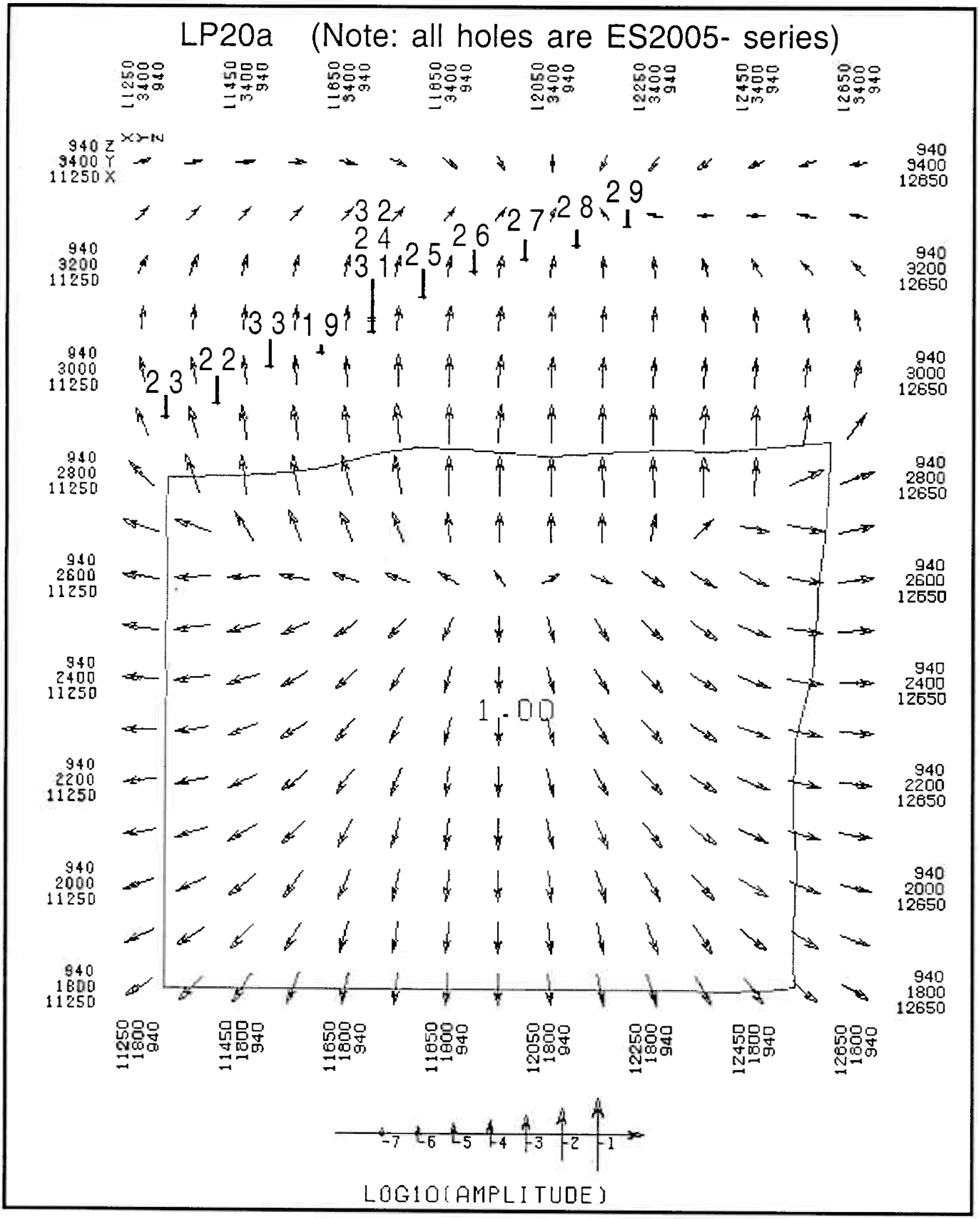
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

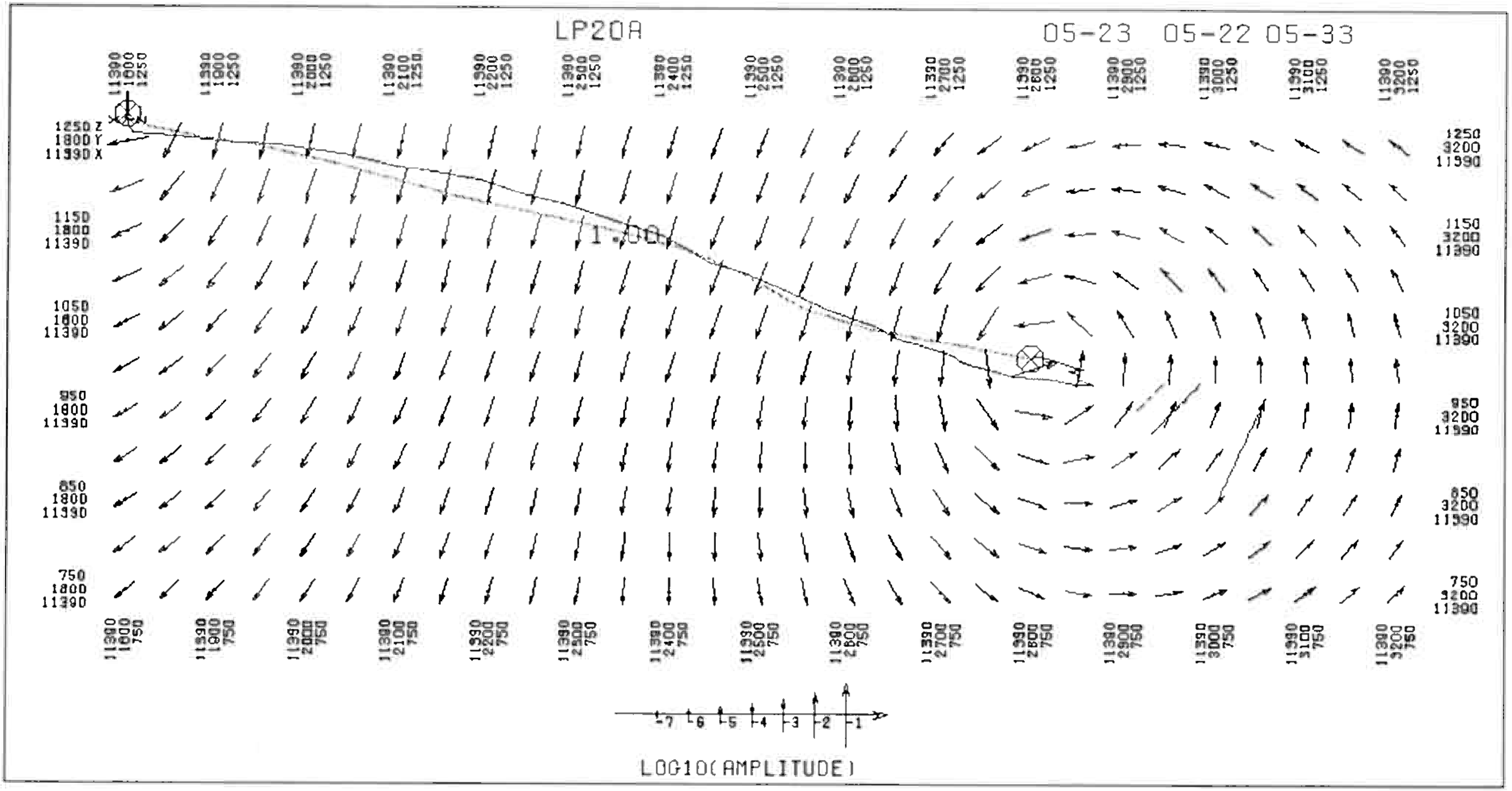
Job 0511

Surveyed: 10/5/5
Reduced: 10/5/5
Plotted: 17/5/5



Loop: 20a	Total, Chn/IHpl	BHUTEM Survey at: Espedalen
Hole: ES-2005-33	Contin. Norm at depth of 0 m	For: A/S Sulfidmalm
Compt: Axial	Base Freq. 3.251 Hz	LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE Job 0511 Surveyed : 10/5/5 Reduced : 10/5/5 Plotted : 17/5/5


LP20a (Note: all holes are ES2005- series)
LOG10(AMPLITUDE)
-7 -6 -5 -4 -3 -2 -1
1.00
23 22 33 19 31 25 24 32 26 27 28 29
940 Z 3400 Y 11250 X
940 9400 12650
940 3200 11250
940 3200 12650
940 3000 11250
940 3000 12650
940 2800 11250
940 2800 12650
940 2600 11250
940 2600 12650
940 2400 11250
940 2400 12650
940 2200 11250
940 2200 12650
940 2000 11250
940 2000 12650
940 1800 11250
940 1800 12650
11250 3400 940
11450 3400 940
11650 3400 940
11850 3400 940
12050 3400 940
12250 3400 940
12450 3400 940
12650 3400 940
11250 1800 940
11450 1800 940
11650 1800 940
11850 1800 940
12050 1800 940
12250 1800 940
12450 1800 940
12650 1800 940


LP20A
05-23 05-22 05-33
1.00
LOG10(AMPLITUDE)
1250 Z
1800 Y
11390 X
1150
1050
950
850
750
3200
11390

Appendix B

0511-2 Production Diary

BHUTEM 3 Survey

Espedalen Grid
Norway

for

A/S Sulfidmalm

Production Log (0511-2)
BHUTEM 3 Survey - Espedalen
Norway
A/S Sulfidmalm

Date	Rate	Production	Comments
up to April 28		-	Discussions, signing of the contract, assembly of crew and equipment. Falconbridge personnel in Espedalen lay out wire for Loop 20a.
April 29	Mob	(equip)	Equipment packed up and labelled. Picked up from Kingston. Shipping address is: Yusen Air & Sea Services (Canada) Inc. 905.458.9622 261 Parkhurst Square, Brampton, ON, L6T 5H5
	and then		Wilhelmsen Agencies AS Gardermoen Postboks 14 Gardermoveien 209 No-2061 Gardermoen Norway attn:Lisbeth W.Kjoenstad
April 30-May 3	Mob	(equip)	Equipment in transit to Oslo. Some problems occur.
May 04	Mob	-	The LGL crew -Rob Langridge and Tom de Kok complete work on a job in Finland. They standby in Helsinki for word on when the shipment will be available in Oslo. By mid-day it is clear that the equipment will arrive in Oslo during the night of May4-5 but that because Noweigian customs will be closed on May 5 (Ascension Day) they will not be able to collect the gear till Friday morning (May 6). They book travel to Oslo on May 5.
May 05	Mob	-	The LGL crew -Rob Langridge and Tom de Kok - travel from Helsinki (HEL)-->Oslo (OSL). They contact Finn Hansen and discuss the arrangements for the survey.
May 06	Mob	-	Meet with Finn Hansen and obtain the customs paperwork and retrieve the Falconbridge vehicle from the airport carpark. The crew and equipment is then collected and transported to Lillehammer (lunch and shopping) and then on to Espedalen (arrive ~15:30 local time). Unpack gear and prepare for survey. Gas up the truck and get fuel for the generator. Set-up for surveying.
May 07	**PB(1)-2**	BH 135m BH 128m	Out to Loop 20a. Set up and read two boreholes - ES2005-25 and -26. Back in camp ~19:00. Crew: R.Langridge, T.de Kok

Date	Rate	Production	Comments
May 08	PB(1)-2	BH 130m BH 104m BH 84m	Up at 05:00. Out to Loop 20a. Set up and read three boreholes - ES2005-27, -28 and -29. Back in camp ~15:00. Crew: R.Langridge, T.de Kok
May 09	1.25PB(1)-2	BH 130m BH 132m BH 152m BH 122m	Up at 04:00. Out to Loop 20a. Set up and read four boreholes - ES2005-31, -24, -32 and -19. Back in camp ~17:00. Crew: R.Langridge, T.de Kok
May 10	1.25PB(1)-2	400m BH 125m BH 75m BH 60m	Up at 04:00. Out to Loop 20a. Set up and read three boreholes - ES2005-33, -22 and -23. Then read two 200m detail lines using a handheld GPS and the BH probe as a surface coil at the request of Tony Watts. Packed up most of the gear and headed home to process the data. Back in camp ~17:00. **Loop 20a** **Line 12150E 3225N - 3425N Hz Rx11** **Line 12800E 3225N - 3425N Hz Rx11** Crew: R.Langridge, T.de Kok
May 11	L(2)-2		Up at 05:00. Out to pick up the loop and retrieve the generator. Packed gear for transport to Gardemoen in the morning. Arranged flights and backed up data. Crew: R.Langridge, T.de Kok
May 12	demob		Up at 03:00. Gear and crew to Gardemoen. Met with Finn Hansen. Arranged for shipping of gear back to Canada. Gear shipped and crew flys home.
May 13 ->May 17	equipment	-	Equipment in transit.
May 18			Equipment picked up and transported to Kingston.

LEGEND

P(n)-x	Surface Production (# of receivers) - # of personnel
PB(n)-x	BHUTEM3 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
DB(n)-x	Down BHUTEM3 (# of receivers) - # of personnel

Appendix C

The UTEM SYSTEM

The UTEM System

UTEM Data Reduction and Plotting Conventions

Data Presentation

The UTEM SYSTEM

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

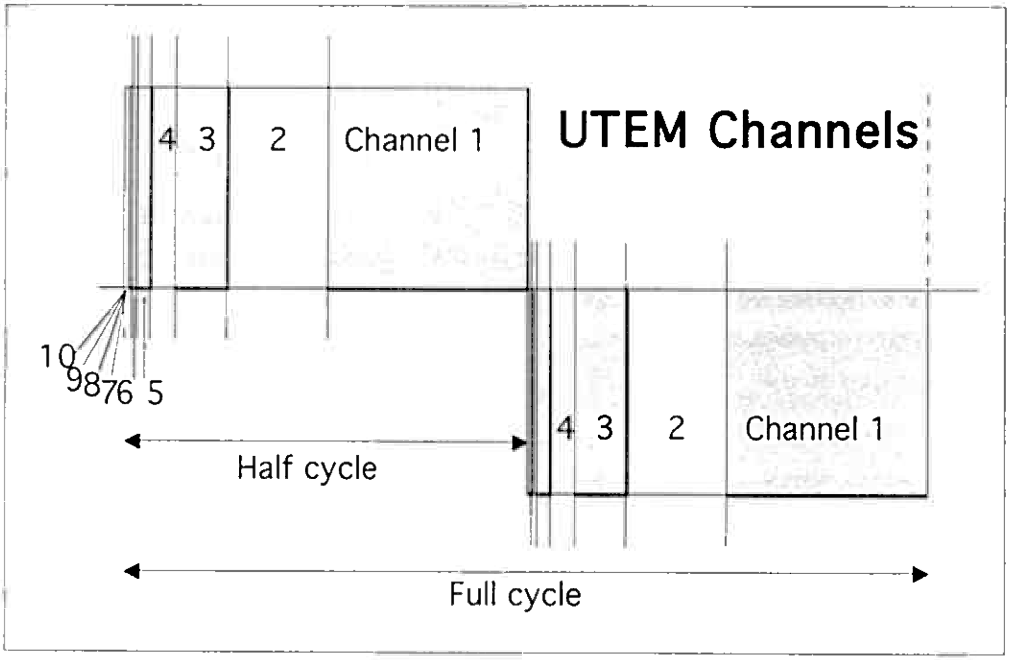
Measurements are routinely taken to a distance of 1.5 to twice the loop dimensions, depending on the local noise levels, and can be continued further. Lines are typically surveyed out from the edge of the loop but may also be read across the loop wire and through the centre of the loop, a configuration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

System Waveform

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

System Sampling

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



System Configurations

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

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

The EM Induction Process

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

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

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

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

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

UTEM DATA REDUCTION and PLOTTING CONVENTIONS

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

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

NORMALIZATION

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

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

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

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

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

FIELD TYPE

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

UTEM Results as Secondary Fields

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

1) UTEM Channel 1

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

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

2) Calculated primary field

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

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

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

Mathematical Formulations

In the following expressions:

Rn$_j$ is the result plotted for the n^{th} UTEM channel,

R1$_j$ is the result plotted for the latest-time UTEM channel, channel 1,

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

Ch1$_j$ is the raw component sensor value for channel 1 at station j,

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

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

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

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

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

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

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

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

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

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

UTEM Results as a Total Field

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

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

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

DATA PRESENTATION

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

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

UTEM System Mean Delay Times

10 Channel Mode @ 31 hz.(approx.)

(base freq: 30.974 hertz)

Channel #	Delay time (ms)	Plot Symbol
1	12.11	|
2	6.053	\
3	3.027	/
4	1.513	□
5	0.757	Σ
6	0.378	∡
7	0.189	7
8	0.095	×
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.

Appendix E

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

Note

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

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

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

This appendix outlines and discusses the effect of the presence of a 60-cycle powerline on ~4Hz (3.872Hz) UTEM data. The example data is from Loop 12 Line 280S. This line is from a series of loops with a powerline cutting across the survey area. The Loop 12 Line 280S UTEM data is affected by the presence of the powerline.

example data:

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

explanation:

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

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

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

other presentations:

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

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

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

Discussion:

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

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

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

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

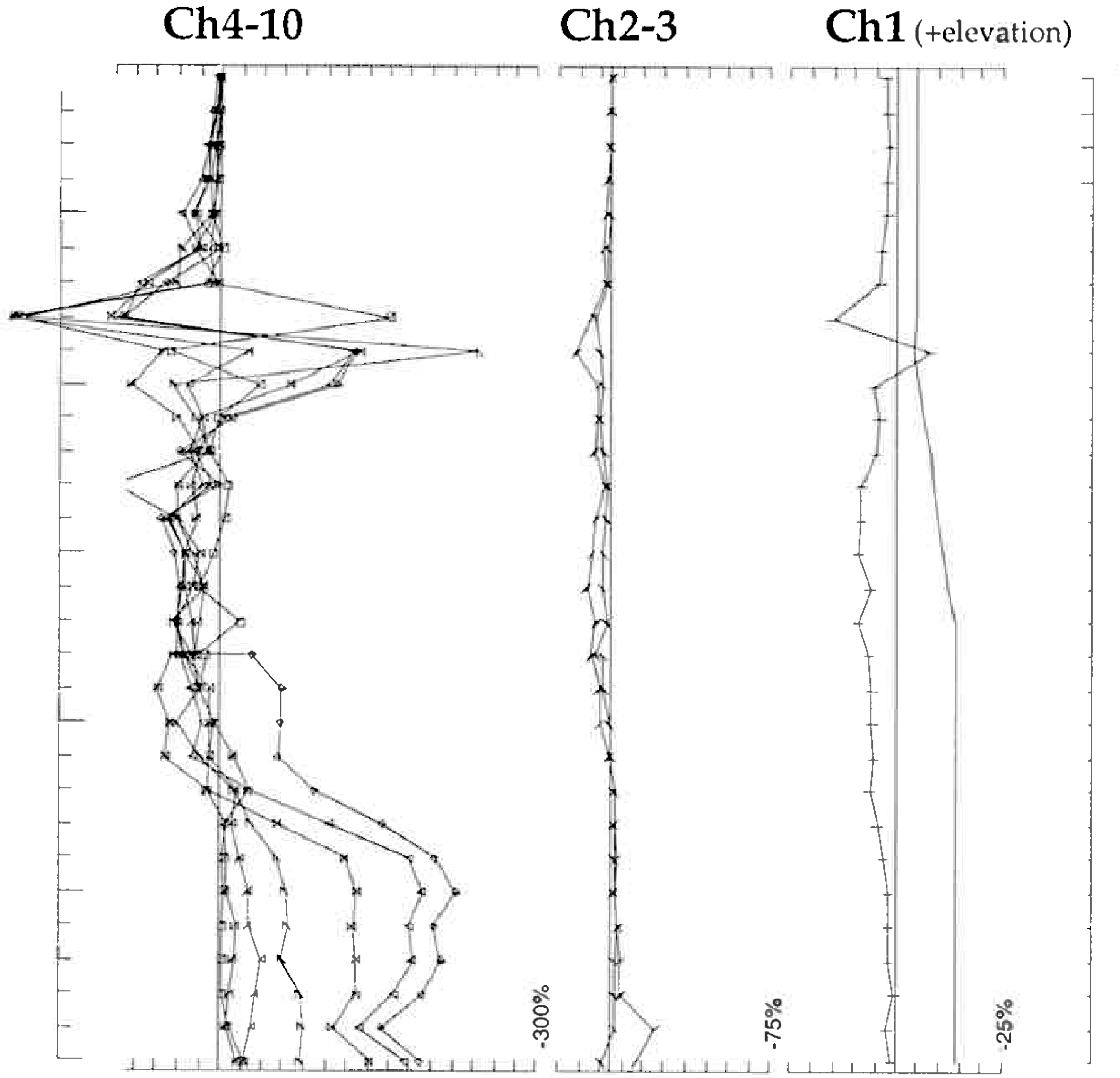
- <u>lowering the frequency</u>: each factor of two lower in frequency would add a channel relatively free of the affects of the powerline. The cost would be increased stacking time at each station.

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

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

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

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



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

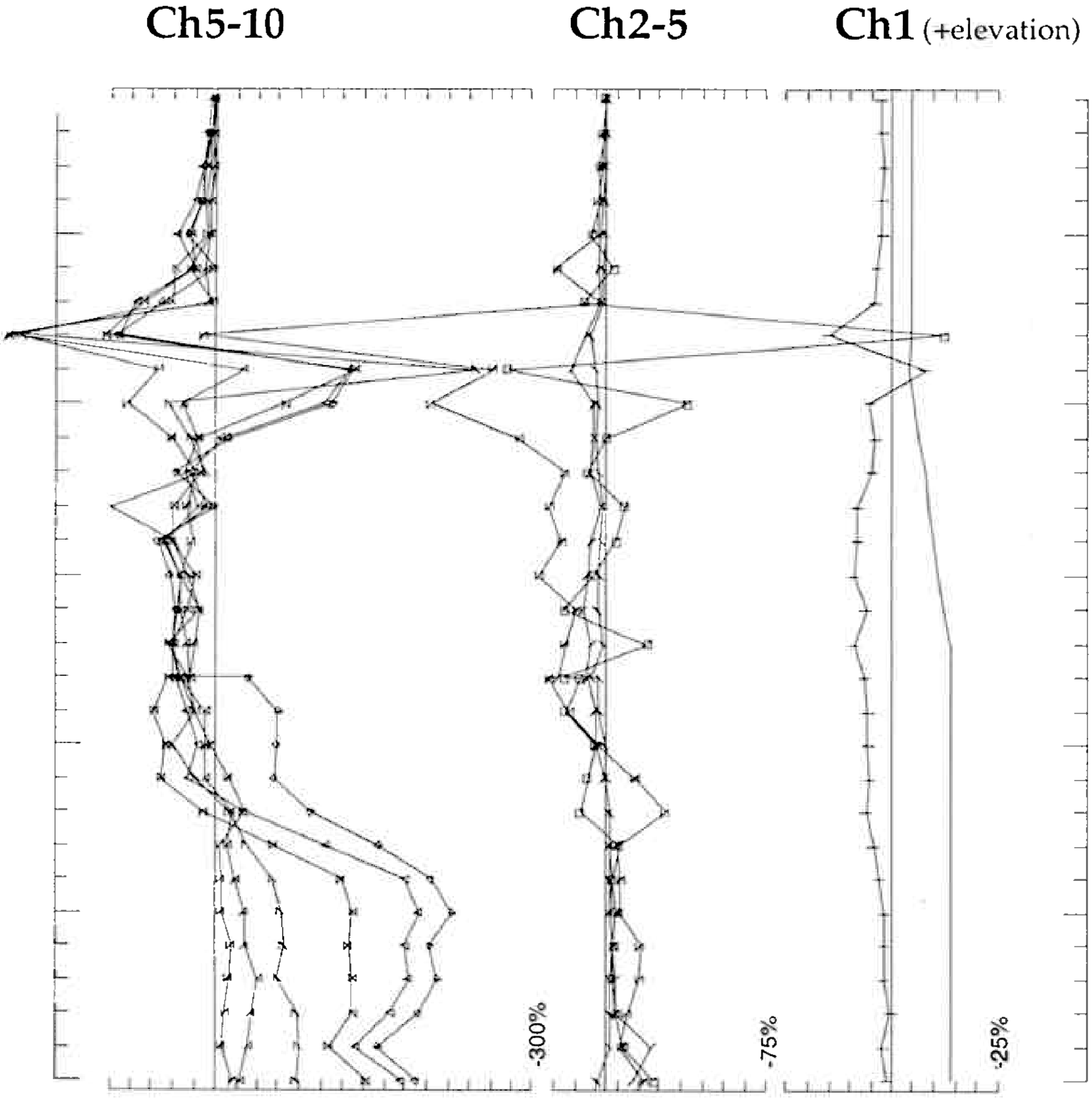
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Appendix E

Figure E1(a)

Original 4Hz data: alternative format

Figure E1a



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

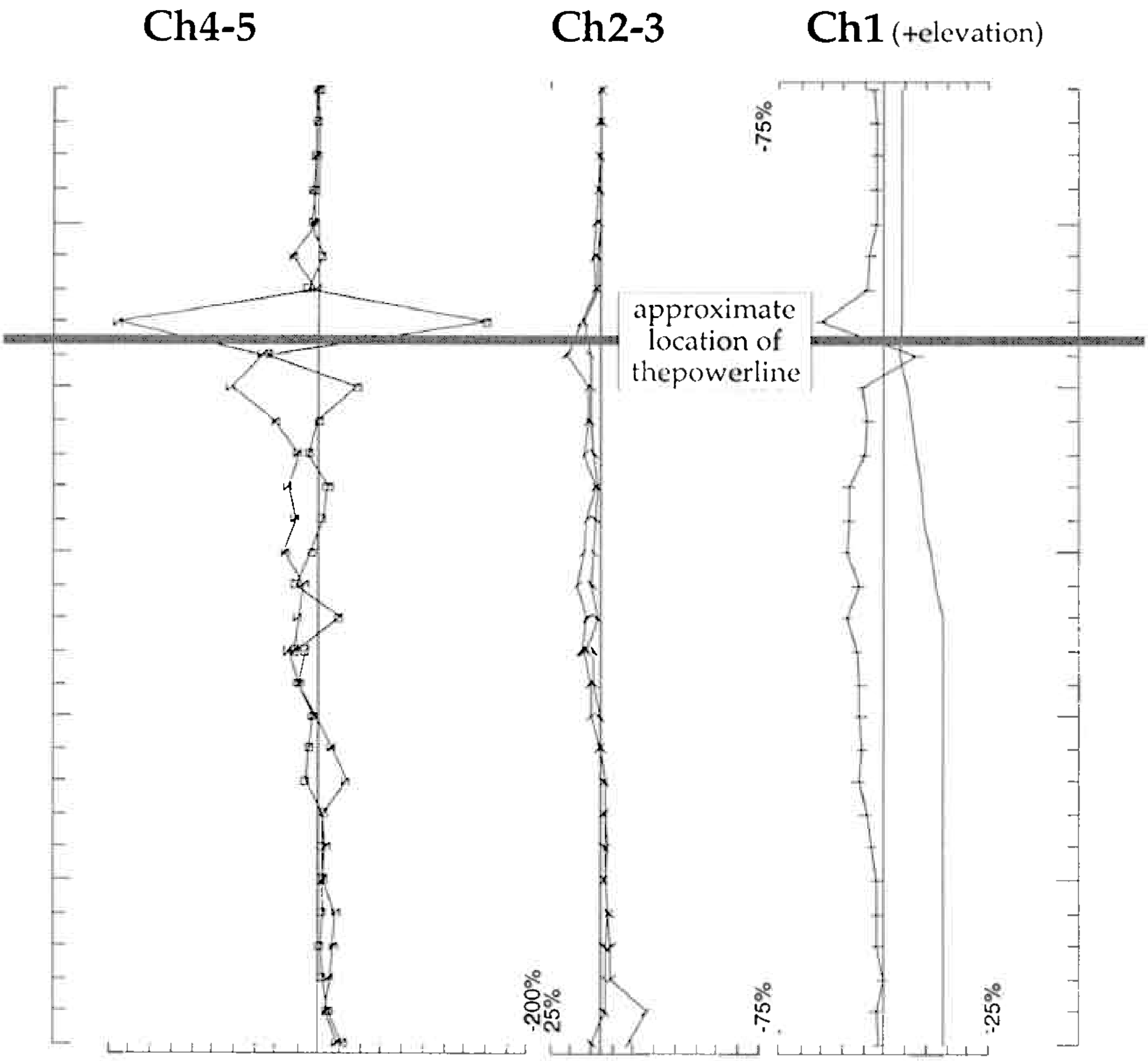
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Appendix E

Figure E1(b)

Original 4Hz data: standard format

Figure E1b



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

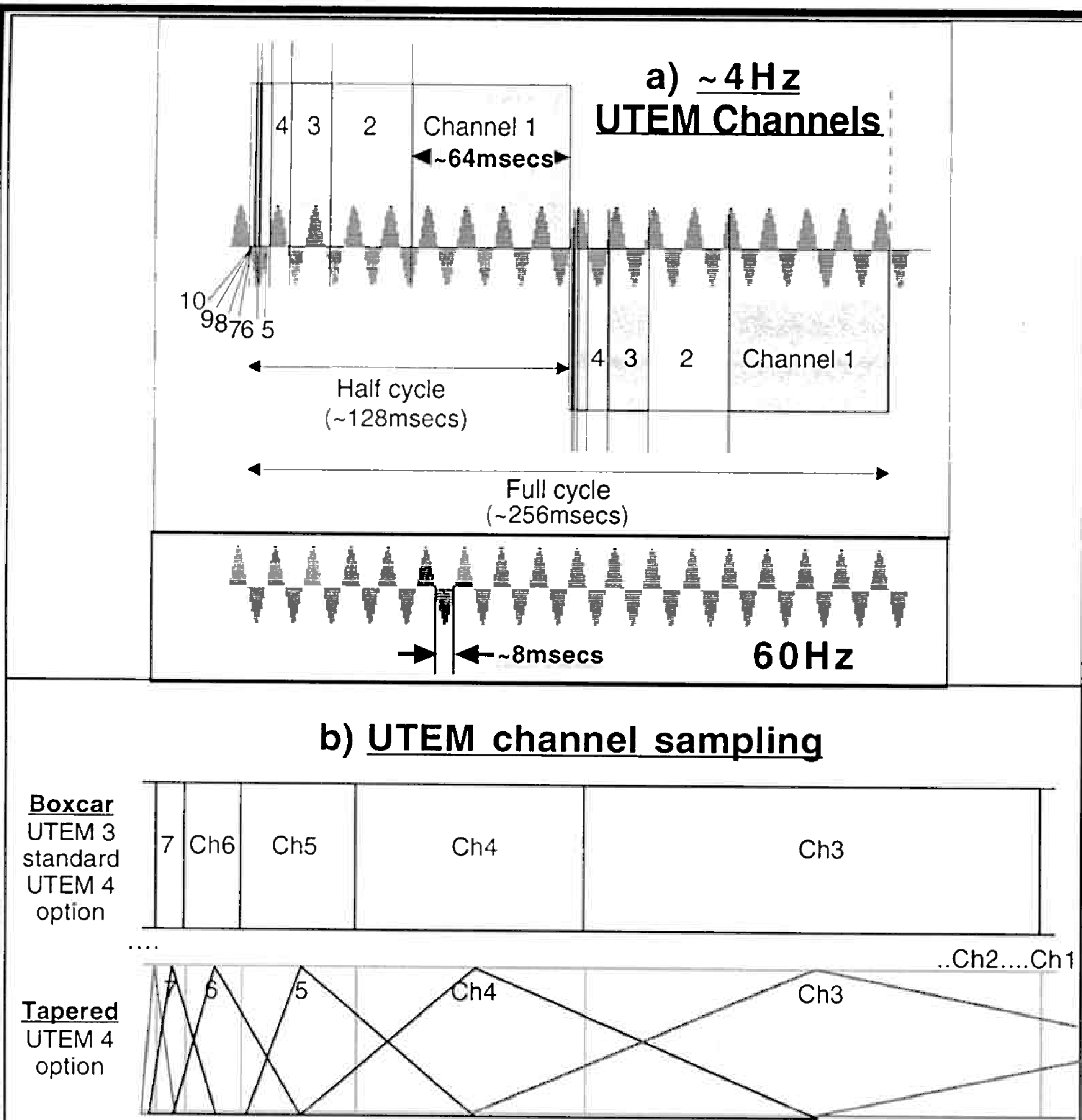
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Appendix E

Figure E1(c)

Original 4Hz data: Ch4/5 detail

Figure E1c



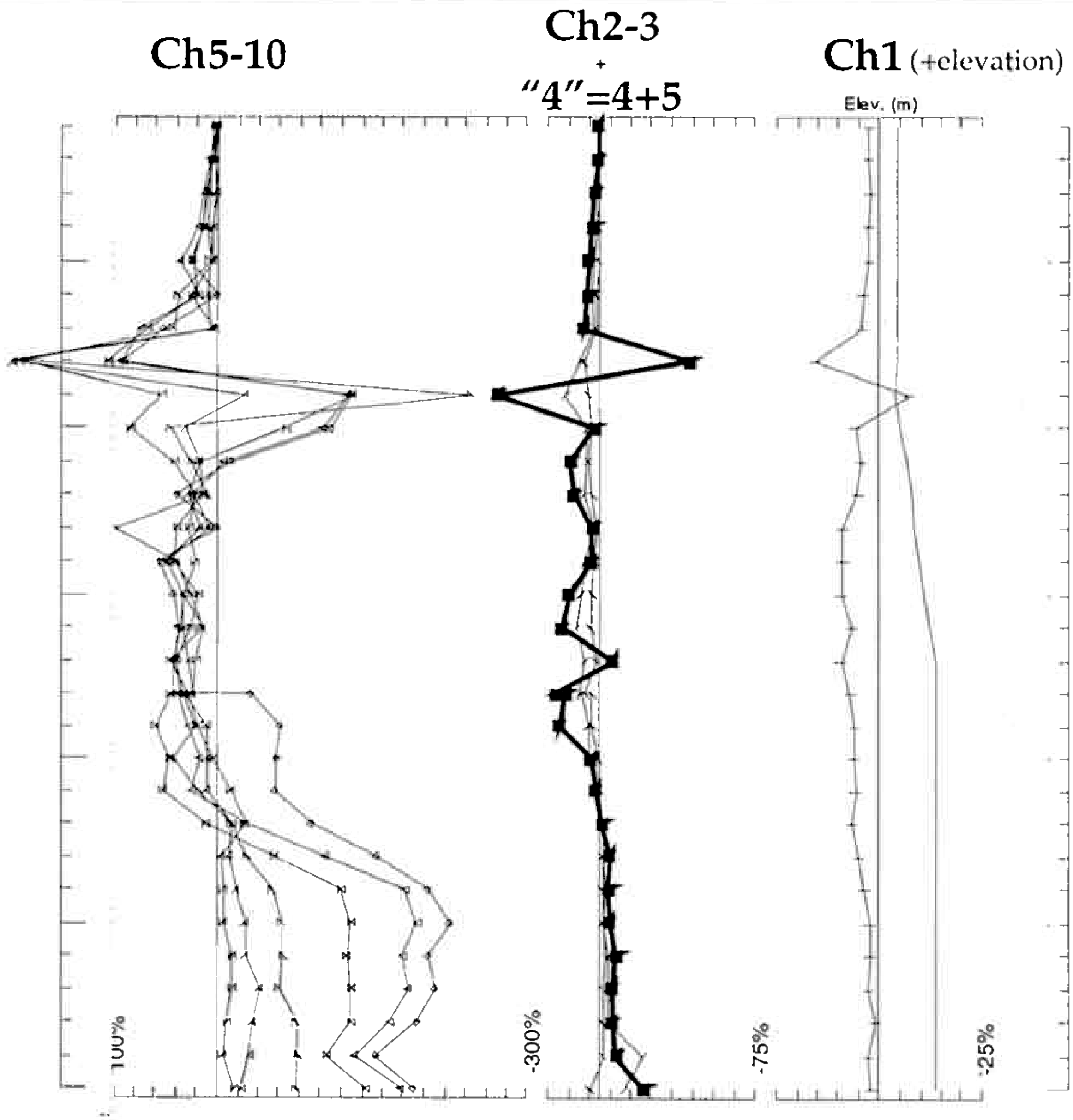
LAMONTAGNE GEOPHYSICS LTD GEOPHYSIQUE LTEE

Appendix E

Figure E2

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

Figure E2



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

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

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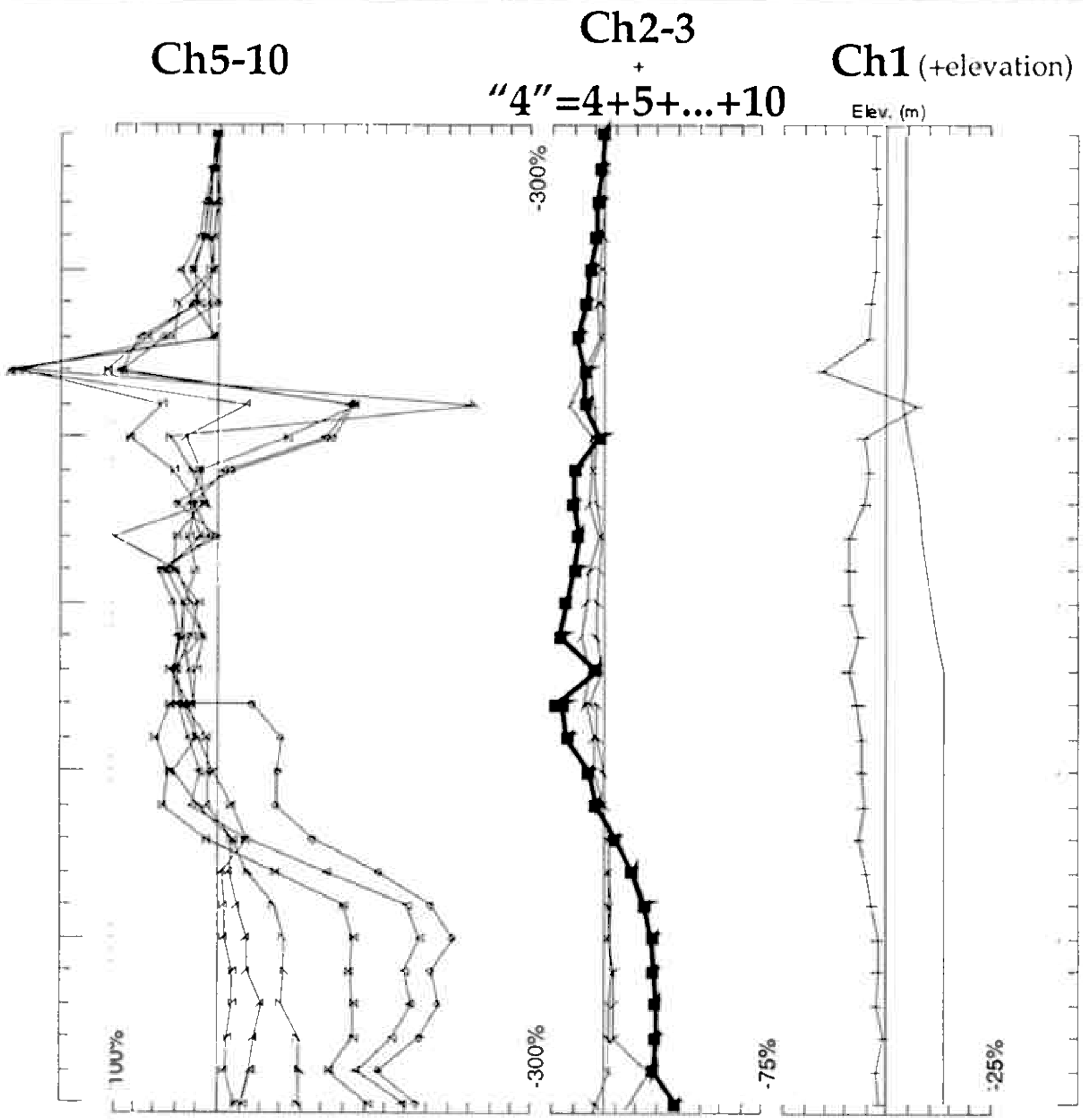
Appendix E

Figure E3(a)

Modified 4Hz data: Ch4/5 combined

Figure E3a



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

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

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Appendix E

Figure E3(b)

Modified 4Hz data: Ch4-10 combined

Figure E3b