P-05-144

Oskarshamn site investigation

Geophysical borehole logging in boreholes KLX05 and HLX32

Uffe Torben Nielsen, Jørgen Ringgaard, Jesper Fris Dahl
RAMBØLL

June 2005

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

ISSN 1651-4416
SKB P-05-144

Oskarshamn site investigation

Geophysical borehole logging in boreholes KLX05 and HLX32

Uffe Torben Nielsen, Jørgen Ringgaard, Jesper Fris Dahl
RAMBØLL

June 2005

Keywords: Geophysical logging.

Abstract

Geophysical borehole logging has been performed in borehole KLX05 and HLX32 both situated in Laxemar in Oskarshamn, Sweden.

The objective of the survey is to determine the physical properties of the rock mass around the borehole, e.g. to determine rock types and quantify the fracture frequency and localise deformation zones in the rock. Geophysical borehole logging was used to measure changes in physical properties in the borehole fluid and the bedrock surrounding the boreholes.

The logging in KLX05 was recorded from 15 m to 1,000.5 m and in HLX32 from 12.3 m to 162.6 m.

The present report comprises a description of the applied equipment and the performed logging program, the fieldwork, data delivery and a presentation and discussion of the results.

Composite sheets of all the processed logs are included in Appendix 1 and 2.

Sammanfattning

Geofysisk borrhålsloggning har genomförts i borrhålen KLX05 och i HLX32 i delområde Laxemar, Oskarshamn.

Syftet med geofysisk borrhålsloggning är att bestämma bergets fysikaliska egenskaper för att bestämma bergartsfördelningen i det genomborrade bergpartiet samt att kvantifiera sprickfrekvensen och att lokalisera deformationszoner. Med geofysisk borrhålsloggning mäts bergets och borrhålsvattnets fysikaliska egenskaper i borrhålet och omgivande berg.

Den geofysiska borrhålsloggningen genomfördes i KLX05 från 15 m till 1 000,5 m och i HLX32 från 12,3 m till 162,6 m.

Rapporten beskriver använd utrustning, genomfört loggningsprogram, fältarbete, leverans av data och en diskussion av resultatet.

Processerade loggar presenteras i Appendix 1 och 2.

Contents

1 Introduction 7

2 Objective and scope 9

3 Equipment 11

4 Execution 13
4.1 General 13
4.2 Nonconformities 13

5 Results 15
5.1 Presentation 15
5.2 Orientation, alignment and stretch of logs 16
5.2.1 Orientation of images 16
5.2.2 Overlapping data 16
5.2.3 Alignment of data 16
5.2.4 Stretch of logs 16
5.2.5 Removing of data 16
5.2.6 Repicking of sonic log 16
5.3 Calculated log curves 16
5.3.1 Calculation of coordinates 17
5.4 Borehole KLX05 18
5.5 Borehole HLX32 19

6 Data delivery 21

Appendix 1 Borehole KLX05, drawing no 1.1, borehole logs 23

Appendix 2 Borehole HLX32, drawing no 2.1, borehole logs 37

1 Introduction

This document reports the results gained by the geophysical borehole logging in boreholes KLX05 and HLX32, which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with activity plan AP PS 400-05-005 (SKB internal controlling document). In Table 1-1 controlling documents for performing this activity are listed.

All measurements were conducted by RAMBØLL during the period April 6 to 8, 2005 and May 2, 2005. The borehole was recorded from Top Of Casing (TOC) to the bottom of the borehole. The technical data from the borehole is shown in Table 1-2. The location of the boreholes is shown in Figure 1-1.

The delivered raw and processed data have been inserted in the database of SKB (SICADA) and data are traceable by the activity plan number.

Table 1-1. Controlling documents for the performance of the activity (SKB internal controlling documents).

Activity plan	Number	Version
Geofysisk borrhålsloggning i KLX05	AP PS 400-05-005	1.0
Tillägg till AP PS 400-05-005 avseende HLX32		
Method descriptions	**Number**	**Version**
Metodbeskrivning för geofysisk borrhålsloggning	SKB MD 221.002	1.0
Metodbeskrivning för krökningsmätning av hammar- och kärnborrhål	SKB MD 224.001	1.0

Table 1-2. Technical data from core borehole KLX05.

Boreholes parameter	KLX05	HLX32
Co-ordinates (RT90)	X: 6365633.343 Y: 1548909.414	X: 6365725.793 Y: 1546734.363
Elevation (RHB70)	Z: 17.627	Z: 10.844
Inclination (from horizontal)	–65.1197°	–58.669°
Azimuth	189.721°	28.590°
Length	1,000.50 m	162.60 m
Borehole diameter	Ø 343 mm (0.00–12.6 m) Ø 250 mm (12.6–15.0 m) Ø 195 mm (15.0–75.1 m) Ø 76 mm (75.1–1,000.5 m)	Ø 191 mm (0.00–12.3 m) Ø 140 mm (12.3–162.6 m)
Casing	Ø 323/310 mm casing (0–12.6 m) Ø 208/200 mm casing (12.6–15.0 m) Cone from 73–108.35 (Ø 100/Ø 77 mm).	Ø 168/160 mm casing (0–12.21 m) Ø 168/147 mm casing (12.21–12.30 m)
Cleaning level	Level 2	Level 2

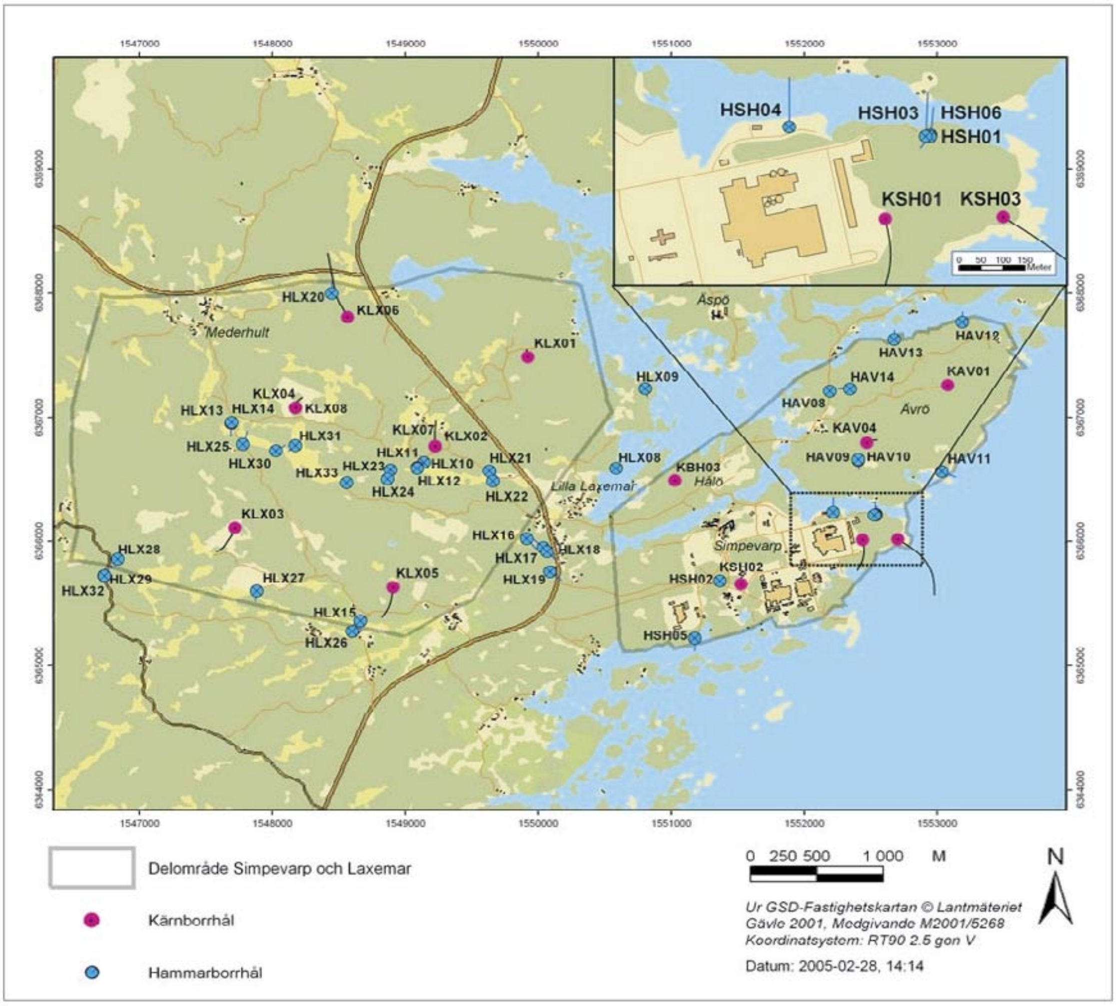


Figure 1-1. *General overview over the Simpevarp and Laxemar subareas with the location of boreholes KLX05 and HLX32.*

2 Objective and scope

The objective of the survey is to both receive information of the borehole itself, and from the rock mass around the borehole. Geophysical borehole logging was used to measure changes in physical properties in the borehole fluid and the bedrock surrounding the boreholes. Acoustic televiewer was used for determination of the deviation of the borehole (azimuth and inclination) as well as to determine the length marks in the core-drilled borehole, KLX05.

This field report describes the equipment used as well as the measurement procedures. Geophysical borehole logging data is presented in graphs as a function of depth in drawing no 1.1 for borehole KLX05 in Appendix 1 and drawing no 2.1 for borehole HLX32 in Appendix 2.

3 Equipment

The geophysical borehole logging program in all boreholes was performed with 7 multi tool probes and resulted in a suite of 19 log types, listed in Table 5-1. The tools and recorded logs are listed in Table 3-1.

Table 3-1. Logging tools and logs recorded in KLX05.

Tool	Recorded logs	Dimension	Source detector spacing and type	Tool position in borehole
Century 8044 Normal resistivity.	Normal resistivity (16 and 64 inch), lateral, single point resistance and natural gamma.	237×5.3 cm		
Century 8622 Magnetic susceptibility.	Magnetic susceptibility and natural gamma.	203×4.1 cm		
Century 9030 Gamma density.	Gamma density, natural gamma, 140 cm focused guard log resistivity, 10 cm 1-arm caliper.	307×5.6 cm	20.3 cm 125 mCi Cs137	Sidewall. Gamma source focused.
Century 9042 Fluid temperature and fluid resistivity	Fluid temperature, fluid resistivity and natural gamma.	137×4.1 cm		
Century 9072 3 m focused guard.	3 m focused guard log resistivity and natural gamma.	310×6.4 cm		
Century 9310 Sonic.	Full wave form travel-time providing P- and S-wave velocity picking, compensated P-wave travel-time and natural gamma.	283.2×5.1 cm	Near 2 ft. Far 3 ft.	Centralized.
RG 25 112 000 HiRAT. Acoustic televiewer.	Full waveform acoustic amplitude and travel-time, 360° orientated acoustic image, 360° very high resolution caliper, borehole azimuth and dip and natural gamma.	246·4 cm		Centralized.

4 Execution

4.1 General

In general the measurement procedures follow the SKB method description (MD 221.002, SKB internal controlling document). The logging program was executed in the period April 6 to 8, 2005 and on May 2, 2005. All relevant logging events are described in the daily report sheets delivered to SICADA and are traceable by the activity plan number.

The fluid resistivity and temperature logs are recorded in downward direction, as the first log run. All other log types are recorded running the tool in upward direction in the borehole.

The applied logging equipment was calibrated and cleaned before arriving at the site according to SKB cleaning level 2 (SKB internal controlling document SKB MD 600.004). Furthermore, all equipment was wiped with alcohol before it was lowered into the borehole.

A function test of the deviation measurements in the HiRAT tool was performed before arriving at the site, following SKB internal controlling document SKB MD 224.001.

For control, each log run is normally recorded both in down and in upward direction using the down run as a repeat section. For logging tool 9030 recording a repeat section in upward direction controls the data. The depth of the probe in the borehole is shown on both the recording computer and the winch. On the winch the tension of the cable is also shown. The winch will automatically stop, if the tension changes rapidly. The tension was recorded on all log runs using Century equipment, except tool 9310.

All data was recorded with max.10 cm sample interval. The speed of the logging tools was in general 10 m/min for the used log runs.

4.2 Nonconformities

The 8044 probe has been recorded with an old calibration file. Due to this all logs recorded with the 8044, have been recalibrated with the calibration file made on April 5, 2005. The Normal 64" and Lateral curves have not been included in the presentation and data delivery of KLX05.

Due to disturbance of the cone between 73 and 108.35 m data has been skipped in that part.

The co-ordinates from HLX32 have not been calculated.

5 Results

5.1 Presentation

All relevant logging events were described in the daily report sheets, which was delivered separately.

Logs presented in drawing no 1.1 in Appendix 1 and in drawing no 2.1 in Appendix 2 are presented in Table 5-1.

Table 5-1. Logs presented in drawings no 1.1 in Appendix 1 and drawing no 2.1 in Appendix 2.

Log	Log name short	Unit	Tool
Fluid temperature	TEMP(FL)	deg C	9042
Fluid resistivity	RES(FL)	ohm-m	9042
Normal resistivity 16 inch	RES(16N)	ohm-m	8044
Normal resistivity 64 inch	RES(64N)	ohm-m	8044
Lateral resistivity	LATERAL	ohm-m	8044
Single point resistance	SPR	Ohm	8044
Magnetic susceptibility	MAGSUSCEP	$SI*10^{-5}$	8622
Caliper, 1-arm	CALIPER1	mm	9030
Gamma-gamma density	DENSITY	kg/m^3	9030
Focused guard log resistivity, 140 cm	RES(MG)	ohm-m	9030
Natural gamma	GAM(NAT)	μR/h	9030
Focused guard log resistivity, 300 cm	RES(DG)	ohm-m	9072
P-wave velocity	P-VEL	m/s	9310
Full wave form, near receiver	AMP(N)	μs	9310
Full wave form, far receiver	AMP(F)	μs	9310
Caliper, high resolution. 360°	CALIPER 3D	Mm	HiRAT
High resolution 1D Caliper	CALIPER MEAN	Mm	HiRAT
Borehole azimuth magnetic north	AZIMUTH MN	Deg	HiRAT
Borehole Inclination from horizontal	DIP	Deg	HiRAT
360° orientated acoustic travel time	TRAVEL TIME	100 ns	HiRAT
360° orientated acoustic travel time	AMPLITUDE	–	HiRAT

5.2 Orientation, alignment and stretch of logs

5.2.1 Orientation of images

The orientation of the results from the HiRAT Acoustic tool, are done after recording. The orientation is done using the raw data from the magnetometers and accelerometers, where spikes and disturbed data are deleted or filtered away.

5.2.2 Overlapping data

If the log data from one probe have been recorded in more than one file, the files are merged using events in both files. Overlapping in data is always used from the topmost-recorded file (overlapping data are never the mean value from two log runs).

5.2.3 Alignment of data

In order to obtain an exact depth calibration, the track marks made while drilling are used. In boreholes without track marks, gamma events in the top and the bottom of the borehole are used. The connection between the track marks and the logs is obtained from the HiRAT Acoustic tool. The depths from the track marks and from the HiRAT tool are used to make a new depth scale in WellCAD. All log files are shifted using the new depth scale.

5.2.4 Stretch of logs

There is a minor difference in the depth registration between up- and down runs for the used winch. The size of the defect is about 1.5 m/km. To compensate for this the logs are stretched using another new depth scale for each tool. The depth scale is made by using gamma events from the tool compared with the same gamma events from the HiRAT tool. The events in both files are matched, and the new depth scale is made and added to the log.

5.2.5 Removing of data

The processing of the data includes removing of spikes, negative and unrealistic values and data in the casing.

5.2.6 Repicking of sonic log

The sonic velocity is normally calculated using an automatic picking routine in the sonic tool, 9310. In inclined boreholes the routine is often picking the wrong arrivals, due to so-called “road noise”. Therefore all sonic logs have been manually repicked in WellCAD using the full wave signal.

5.3 Calculated log curves

The different logs are calculated as described in Table 5-2.

Table 5-2. Calculated log curves.

Log	Description of log calculation
Caliper, 1-arm	The Caliper was converted from (cm) to (mm) units by multiplying (cm) with 10.
Gamma-gamma density	The gamma-gamma was converted from (g/cm3) to (kg/m^3) units by multiplying with 1,000.
Focused guard log resistivity, 140 cm	–
Natural gamma	The natural gamma log was converted from CPS to μR/h by multiplying with the constant 0.077. This constant was computed from the logs previously performed in borehole KLX02 located in Oskarshamn.
Fluid temperature	–
Fluid resistivity	–
Normal resistivity 16 inch	–
Normal resistivity 64 inch	–
Lateral resistivity	–
Single point resistance	–
Self-potential	–
Focused guard log resistivity, 300 cm	–
P-wave velocity	The P-VEL velocity is calculated using the difference in distance between the far and near receiver divided by the difference between the first arrival from the far and near signal. (121.9 cm–91.4 cm)/(Time(far)–Time(near)).
Full wave form, near receiver	–
Full wave form, far receiver	–
Magnetic susceptibility	The magnetic susceptibility was converted for CGS units to SI units by multiplying the CGS value by 4π.
Caliper, high resolution. 360° CALIPER 3D	The Caliper 3D is calculated using the acoustic travel time and the velocity in the borehole fluid. The velocity in the fluid is calculated using the fluid temperature and fluid conductivity.
High resolution 1D Caliper CALIPER MEAN	The Caliper mean is calculated using the mean travel time from the acoustic televiewer, the fluid temperature, fluid velocity and the internal travel time in the acoustic televiewer.
Borehole azimuth magnetic north	See 5.3.1
Borehole Inclination from lateral	See 5.3.1
360° orientated acoustic travel time	–
360° orientated acoustic travel time	–

5.3.1 Calculation of coordinates

To convert the measured azimuth and inclination to grid-coordinates, one needs to take into account the magnetic declination at the site at the time of data acquisition. The actual declination was found by means of the current International Geomagnetic Reference Field (IGRF). The actual values can be found below. Disturbances from solar storms etc were not taken into account. By means of the "Radius Of Curvature" method implemented in WellCad, the azimuth and inclination were converted to northing, easting and TVD coordinates relative to the top of the borehole. In the same calculation, the magnetic declination was added. Finally, the relative coordinates were added to the given coordinate in RT90 for the top of the borehole.

Declination = 3.461° changing by 0.139°/year
Inclination = 71.315° changing by 0.006°/year

5.4 Borehole KLX05

In order to obtain an exact depth calibration in borehole KLX05, the reference track marks made while drilling are used. The correlation between the track marks and the logs is obtained from the HiRAT Acoustic tool.

The reference track marks in the borehole and the recorded track marks from the HiRAT are observed in the following depths, Table 5-3.

To compensate for the difference between the reference track marks and the recorded track marks the logs are stretched. The result from the stretching is a new depth scale. The new depth scale is applied to the HiRAT file. In this way a perfect match between given depths of the reference marks and the recorded data is obtained. By means of alignment of the observed gamma events in KLX05, between all logruns, the obtained reference mark correlation is transferred to the other logs.

The complete log suite for borehole KLX05 is presented as composite log sheets in drawing no 1.1 in Appendix 1. The logs presented in drawing no 1.1 are listed in Table 5-1.

Table 5-3. The reference track marks in the borehole and the recorded track marks form the HiRAT in borehole KLX05.

Reference mark	HIRAT recorded
110.00	110
150.00	150
200.00	200.17
250.00	250.41
300.00	300.41
350.00	350.54
400.00	400.66
450.00	450.76
500.00	500.89
550.00	551.05
600.00	601.1
650.00	651.25
700.00	701.43
750.00	751.44
800.00	801.55
850.00	851.69
900.00	901.76

5.5 Borehole HLX32

Using the bottom of the casing and the natural gamma from the HiRAT as reference, the natural gamma logs from the other probes are aligned to the same depth. A new depth scale is added to each log and afterwards the logs are stretched using the events shown in Table 5-4.

The complete log suite for borehole HLX32 is presented as composite log sheet in drawing no 2.1 in Appendix 2. The logs presented in drawing no 2.1 are listed in Table 5-1.

Table 5-4. Gamma events in borehole HLX32.

Events	Depths
Top event	25.62
Bottom event	139.63

6 Data delivery

Geophysical logging data from the measurements, recorded in Century and Robertson format, were delivered directly after the termination of the field activities. The recorded data files used in the processing have also been delivered in WellCAD format, Table 6-1.

The delivered data have been inserted in the database (SICADA) of SKB and are traceable by the activity plan number.

The processed files shown on the drawings have been delivered in WellCAD, Table 6-2, and as excel files (one for each borehole) in SICADA format, Table 6-3.

Table 6-1. Recorded log files in Century or Robertson format used for processing.

Borehole	Probe	Log direction	WellCAD File	Description
KLX05	8044	Down	KLX05_04-07-05_09-09_8044C_.02_71.54_997.00_ORIG.log	Start Depth: 71.54 m. End Depth: 997 m.
KLX05	8622	Up	KLX05_04-07-05_13-45_8622C_.02_3.43_996.87_ORIG.log	Start Depth: 996.87 m. End Depth: 3.43 m
KLX05	9030	Up	KLX05_05-02-05_17-18_9030CA_.02_-0.80_995.28_ORIG.log	Start Depth: 995.28 m. End Depth: 0.80 m.
KLX05	9042	Down	KLX05_04-06-05_17-14_9042C_.02_14.75_995.60_ORIG.log	Start Depth: 14.75 m. End Depth: 995.6 m.
KLX05	9072	Up	KLX05_04-07-05_11-40_9072C_.02_3.70_998.66_ORIG.log	Start Depth: 998.66 m. End Depth: 3.7 m.
KLX05	9310	Up	KLX05_04-06-05_20-48_9310C2_.10_52.00_717.10_ORIG.log	Start Depth: 717.1 m. End Depth: 52 m.
KLX05	9310	Up	KLX05_04-06-05_20-12_9310C2_.10_709.60_996.60_ORIG.log	Start Depth: 996.6 m. End Depth: 709.6 m.
KLX05	HiRAT	Up	KLX05_Hirat_90_up2.HED	Start Depth: 995 m. End Depth: 0 m.
HLX32	8044	Down	HLX32_04-08-05_08-47_8044C_.02_0.28_162.46_ORIG.log	Start Depth: 0.28 m. End Depth: 162.46 m
HLX32	8622	Up	HLX32_04-07-05_19-51_8622C_.02_3.01_161.73_ORIG.log	Start Depth: 161.73 m. End Depth: 3.01 m.
HLX32	9030	Up	HLX32_05-02-05_20-18_9030CA_.02_0.03_162.11_ORIG.log	Start Depth: 162.11 m. End Depth: 0.03 m.
HLX32	9042	Down	HLX32_04-07-05_18-50_9042C_.02_0.22_162.64_ORIG.log	Start Depth: 0.22 m. End Depth: 162.64 m.
HLX32	9072	Up	HLX32_04-07-05_19-25_9072C_.02_3.30_162.15_ORIG.log	Start Depth: 162.15 m. End Depth: 3.3 m.
HLX32	9310	Up	HLX32_04-08-05_10-07_9310C2_.10_3.30_161.00_ORIG.log	Start Depth: 161 m. End Depth: 3.3 m.
HLX32	HiRAT	Up	HLX32_Hirat_90_up2.HED	Start Depth: 160 m. End Depth: 2 m.

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KLX05	1.1	KLX05_Presentation.WCL
HLX32	2.1	HLX32_Presentation.WCL

Table 6-3. Data files in SICADA format.

Sheet	Comment
“Borehole”_GP040 - Caliper logging.xls	
“Borehole”_GP041 - 3-D caliper.xls	
“Borehole”_GP060 - Fluid temperature and resistivity logging.xls	
“Borehole”_GP090 - Density logging.xls	
“Borehole”_GP110 - Magnetic susceptibility logging.xls	
“Borehole”_GP120 - Natural gamma logging.xls	
“Borehole”_GP150 - Single point resistance logging.xls	
“Borehole”_GP160 - Resistivity, normal 1.6 m (64 in).xls	Not included for borehole KLX05
“Borehole”_GP161 - Resistivity, focused 140 cm.xls	
“Borehole”_GP162 - Resistivity, focused 300 cm.xls	
“Borehole”_GP163 - Resistivity, lateral 1.6-0.1 m.xls	Not included for borehole KLX05
“Borehole”_GP164 - Resistivity, normal 0.4 m (16 in).xls	
“Borehole”_GP175 - Fullwave sonic.xls	
“Borehole”_GP830 - Acoustic televiewer.xls	Co-ordinates not included for borehole HLX32

Appendix 1

Borehole KLX05, drawing no 1.1, borehole logs

Co-ordinates in RT90 2,5 gon V 0:-15

Northing: 6365633,343 Easting: 1548909,414 Elevation: 17,627

Diameter:	76 mm
Reaming Diameter:	195 mm
Outer Casing:	208 mm
Inner Casing:	200 mm
Borehole Length:	1000,50 m
Cone:	73 - 108,35 m
Inclination at ground surface:	-65,1197 deg
Azimuth:	189,721 deg
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9030	mm
DENSITY	Gamma-gamma density	9030	kg/m³
RES(MG)	Focused guard log resistivity, 140cm	9030	ohm-m
GAM(NAT)	Natural gamma	9030	μR/h
TEMP(FL)	Fluid temperature	9042	deg C
RES(FL)	Fluid resistivity	9042	ohm-m
RES(DG)	Focused guard log resistivity, 300cm	9072	ohm-m
P-VEL	P-wave velocity	9310	m/s
AMP(N)	Full wave form, near receiver	9310	μs
AMP(F)	Full wave form, far receiver	9310	μs
MAGSUSCEP	Magnetic susceptibility	8622	SI*10-5
CALIPER 3D	Caliper, high resolution 360 degrees	HiRAT	mm
CALIPER MEAN	High resolution 1D caliper	HiRAT	mm
AZIMUTH MN	Borehole azimuth magnetic north	HiRAT	deg
DIP	Borehole inclination from horizontal	HiRAT	deg
TRAVEL TIME	360 degrees orientated acoustic travel time	HiRAT	100 ns
AMPLITUDE	360 degrees orientated acoustic amplitude	HiRAT	-
THORIUM	Spectral gamma, Thorium component	9080	PPM
URANIUM	Spectral gamma, Uranium component	9080	PPM
POTASSIUM	Spectral gamma, Potassium component	9080	percent
RES(16N)	Normal resistivity 16 inch	8044	ohm-m
RES(64N)	Normal resistivity 64 inch	8044	ohm-m
LATERAL	Lateral resistivity	8044	ohm-m
SPR	Single point resistivity	8044	ohm
SP	Self Potential	8044	mV

Rev.	Date	Drawn by	Control	Approved
0	2005-05-13	JRI	UTN	UTN

Job	Scale
547310A	1:500

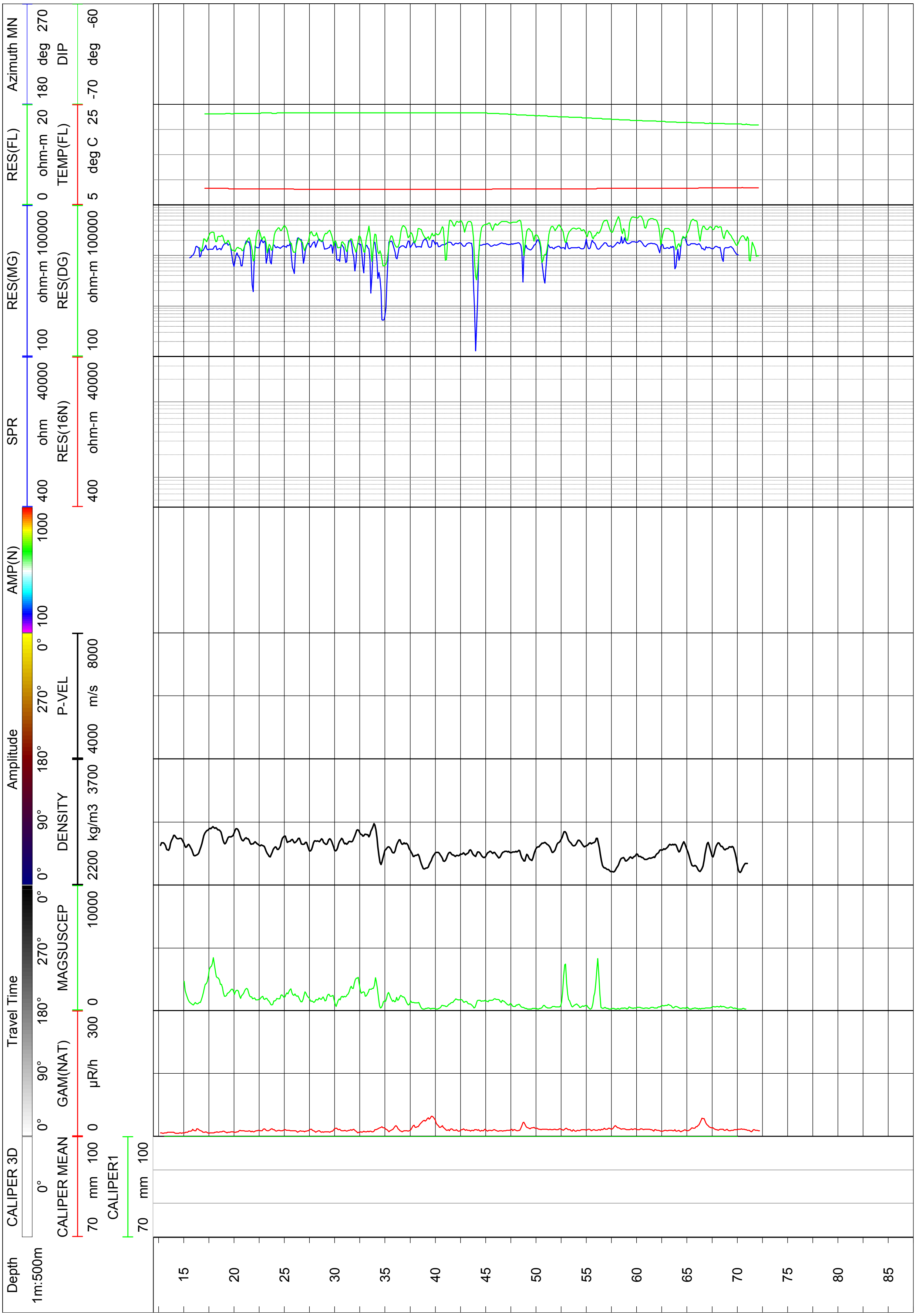
RAMBØLL
Rambøll. Bredevej 2, DK-2830 Virum
Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

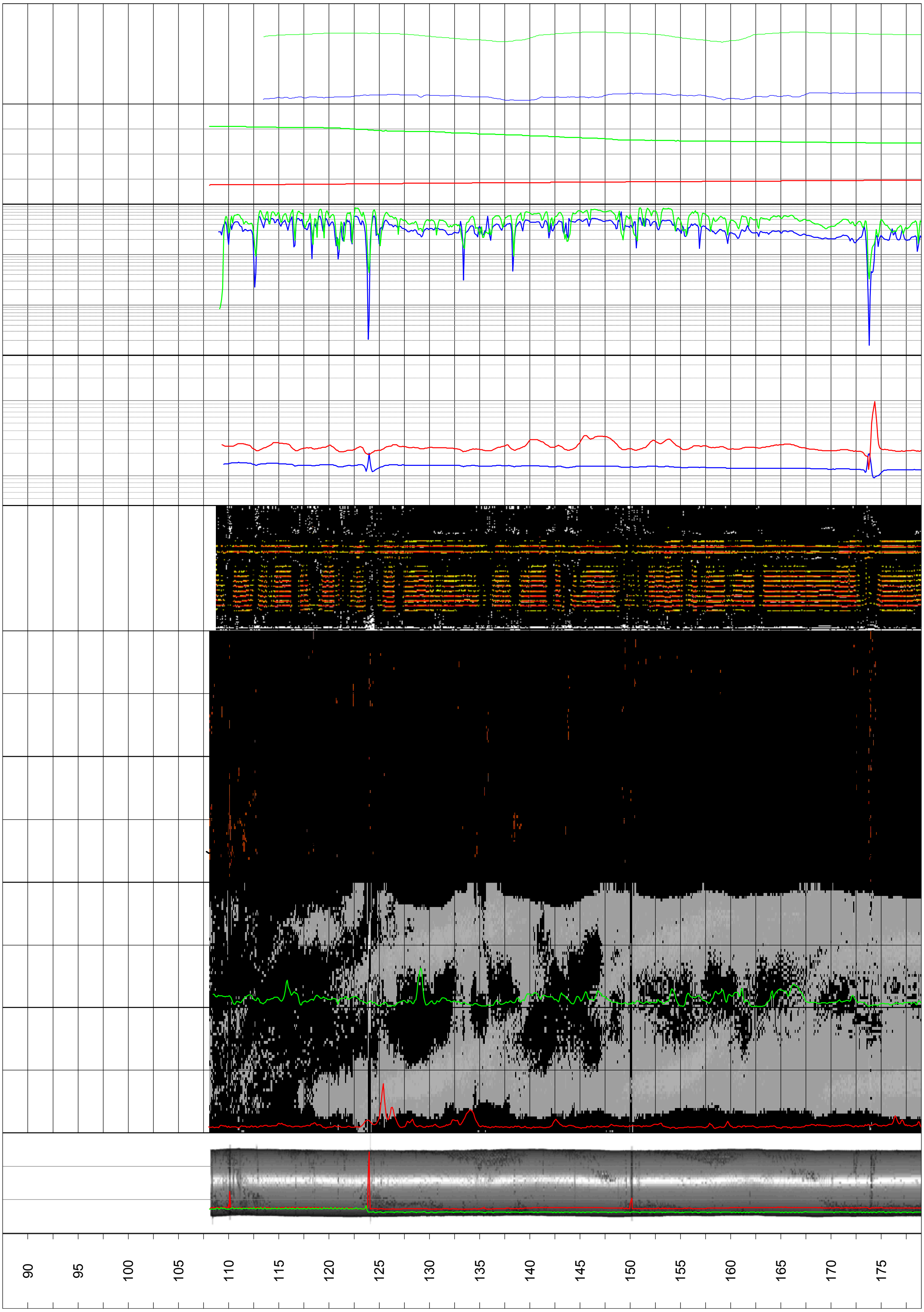
SKB geophysical borehole logging
Borehole KLX05

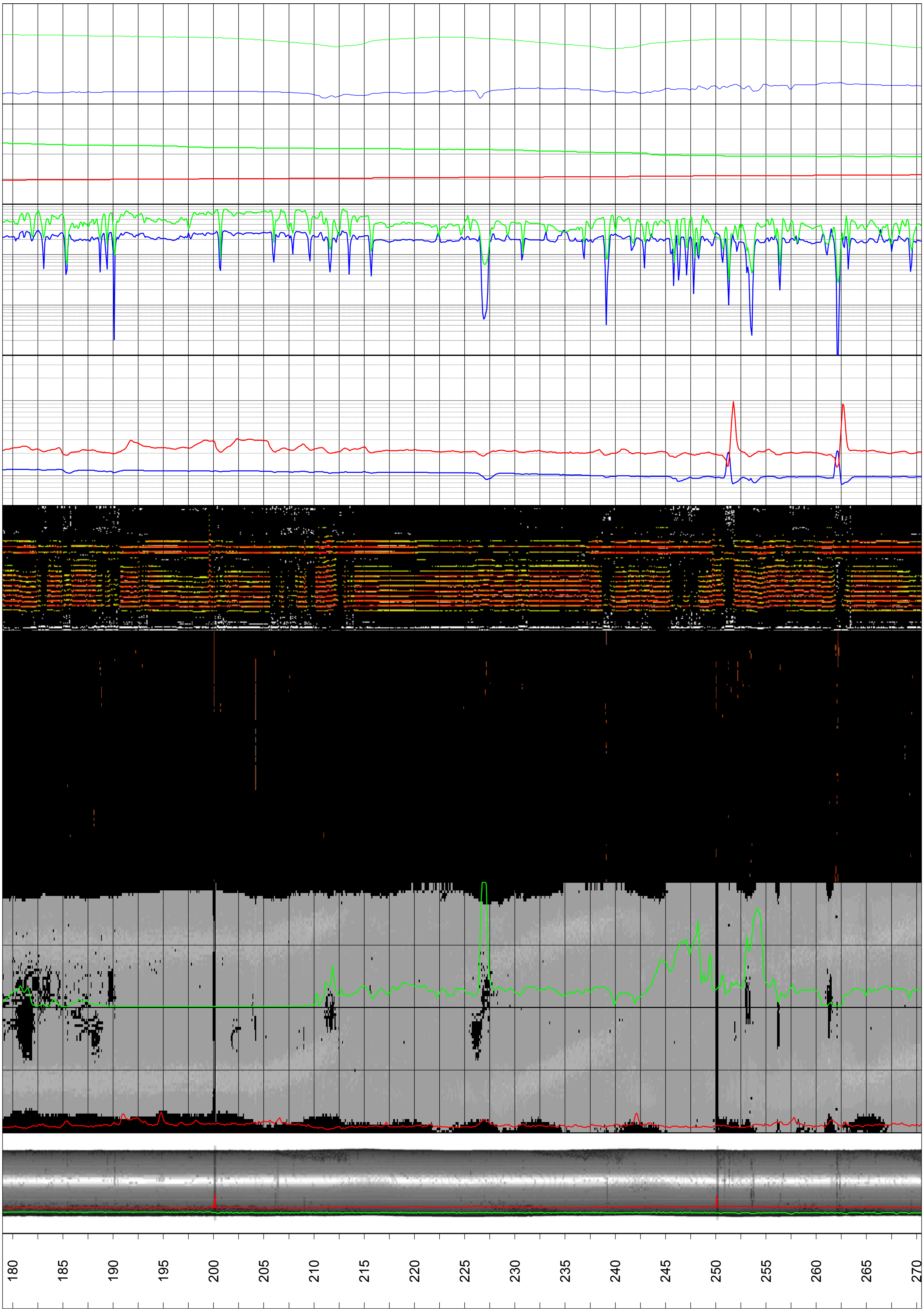
Presentation

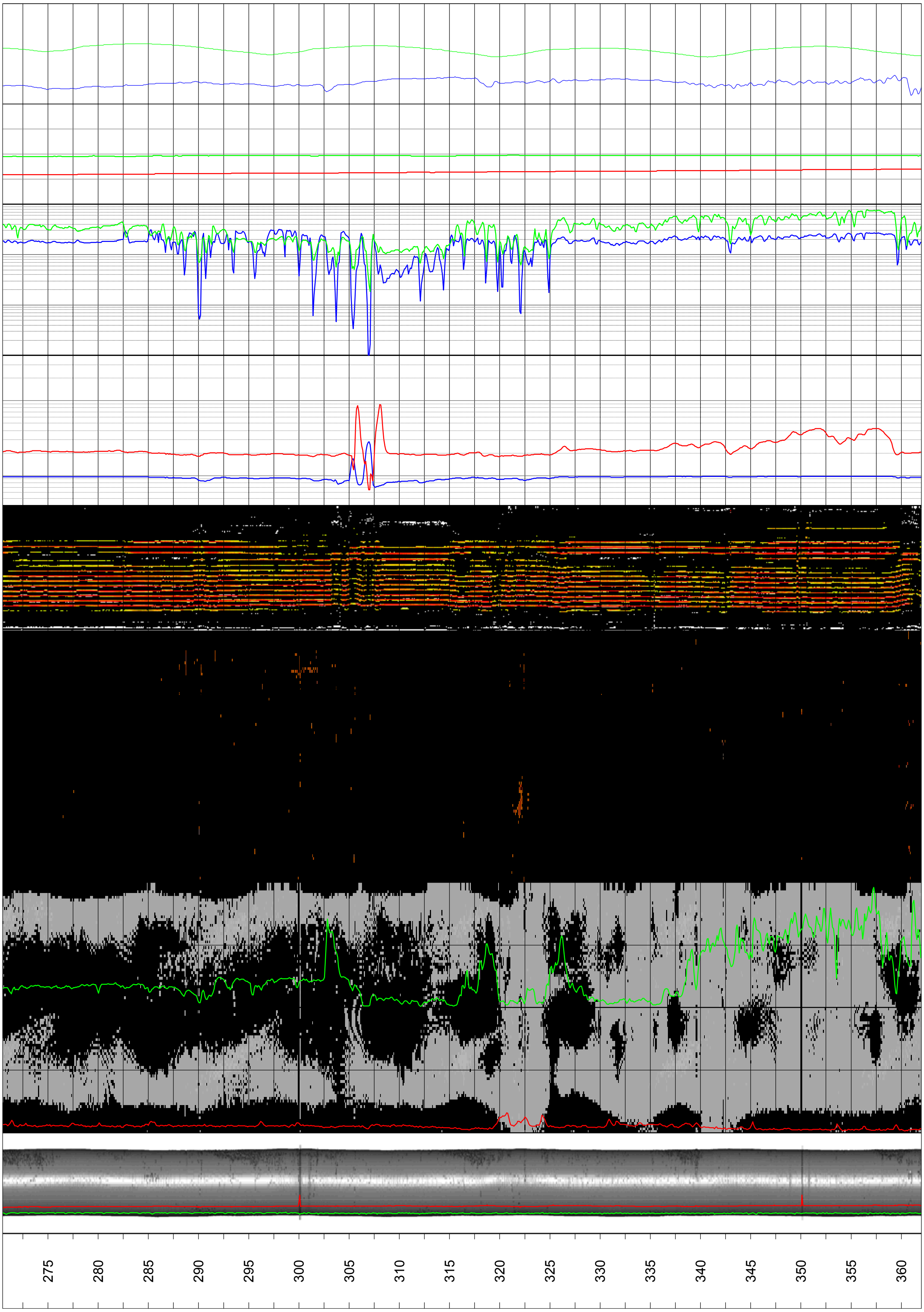
Filename:
KLX05_Presentation.wcl

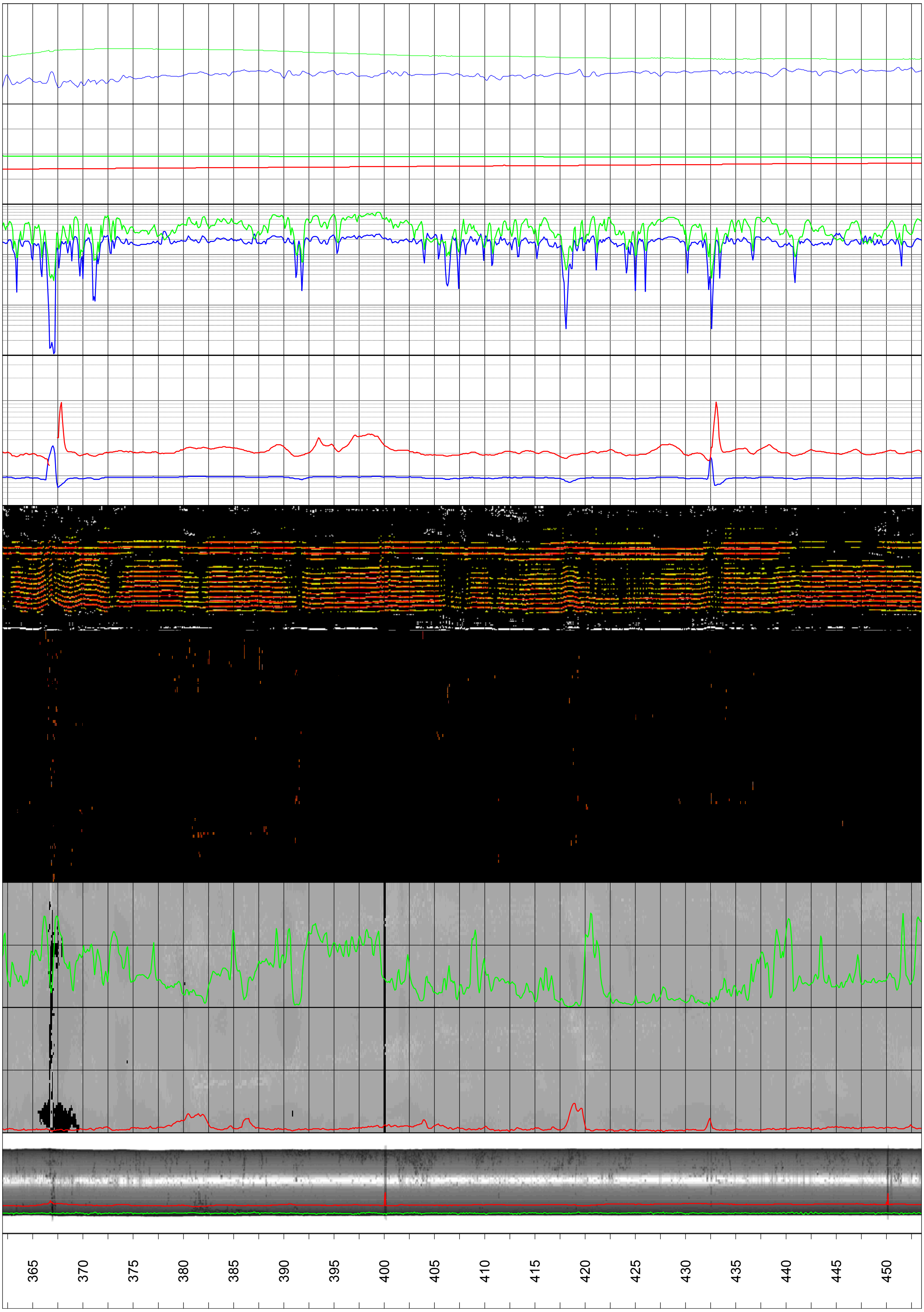
Drawing no.:
1.1

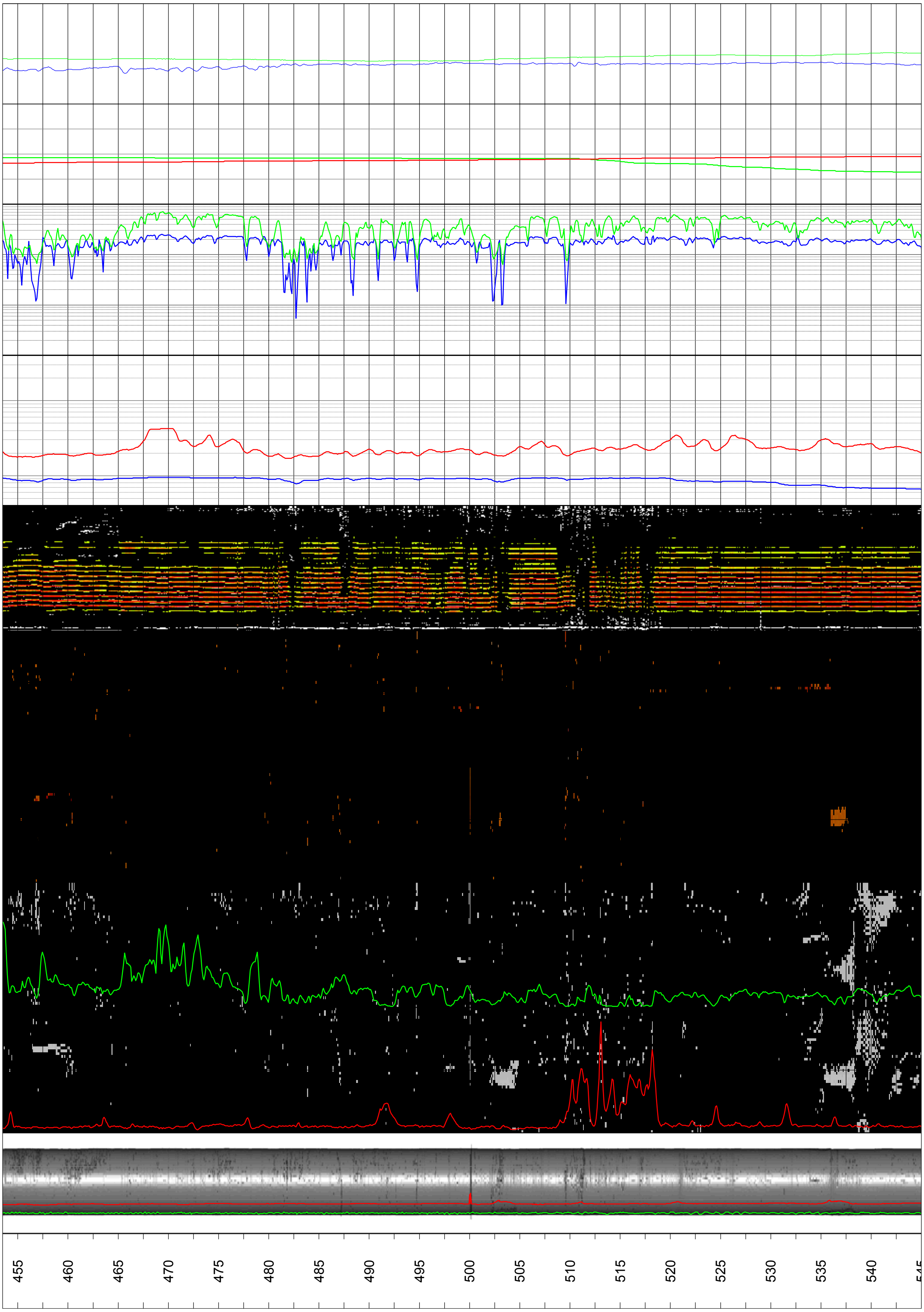

Depth
1m:500m
CALIPER 3D
0°
CALIPER MEAN
70 mm 100
CALIPER1
70 mm 100
Travel Time
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 300
MAGSUSCEP
0 10000
Amplitude
0° 90° 180° 270° 0°
DENSITY
2200 kg/m3 3700
P-VEL
4000 m/s 8000
AMP(N)
100 1000
SPR
400 ohm 40000
RES(16N)
400 ohm-m 40000
RES(MG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(FL)
0 ohm-m 20
TEMP(FL)
5 deg C 25
Azimuth MN
180 deg 270
DIP
-70 deg -60
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85

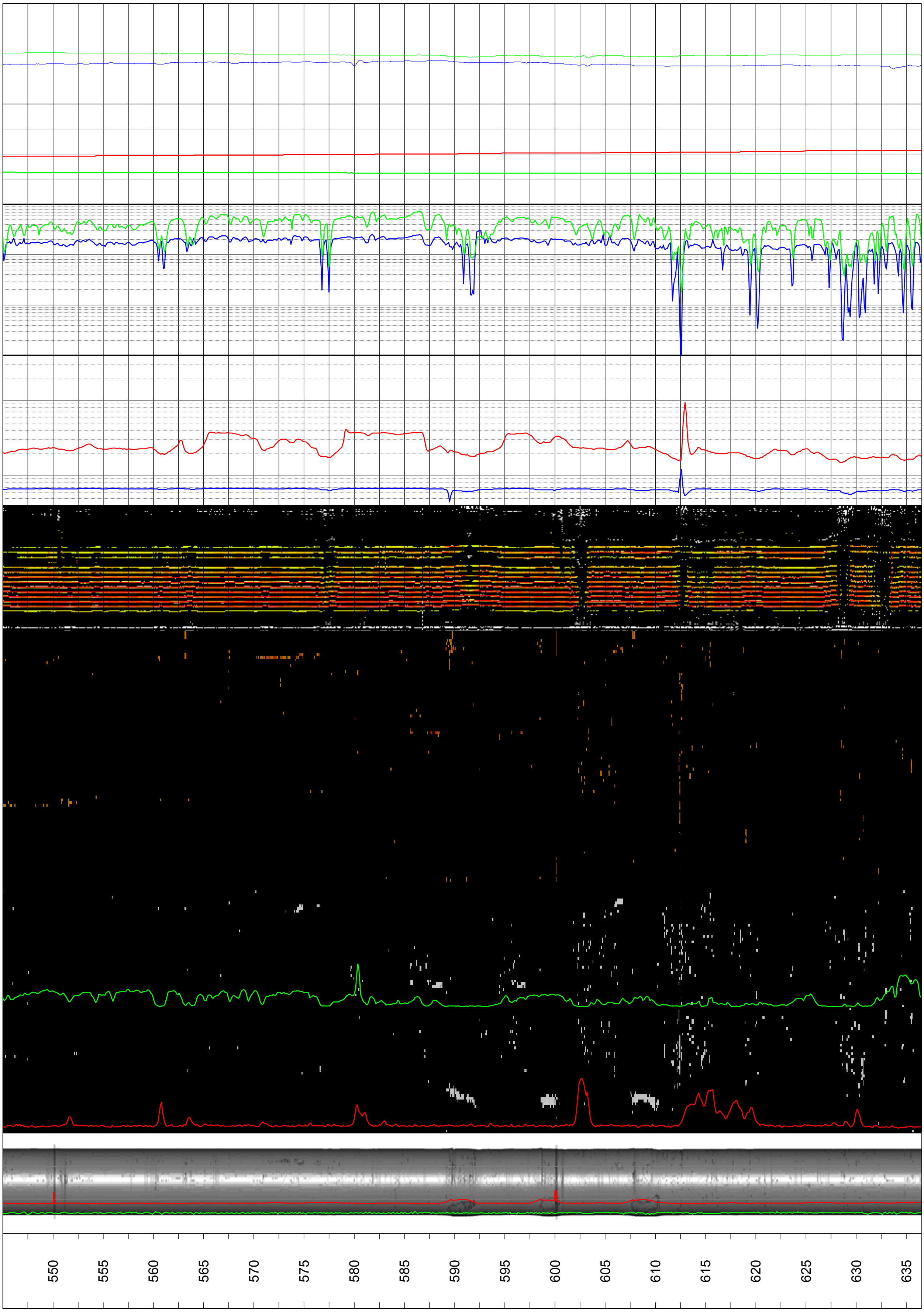

90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175

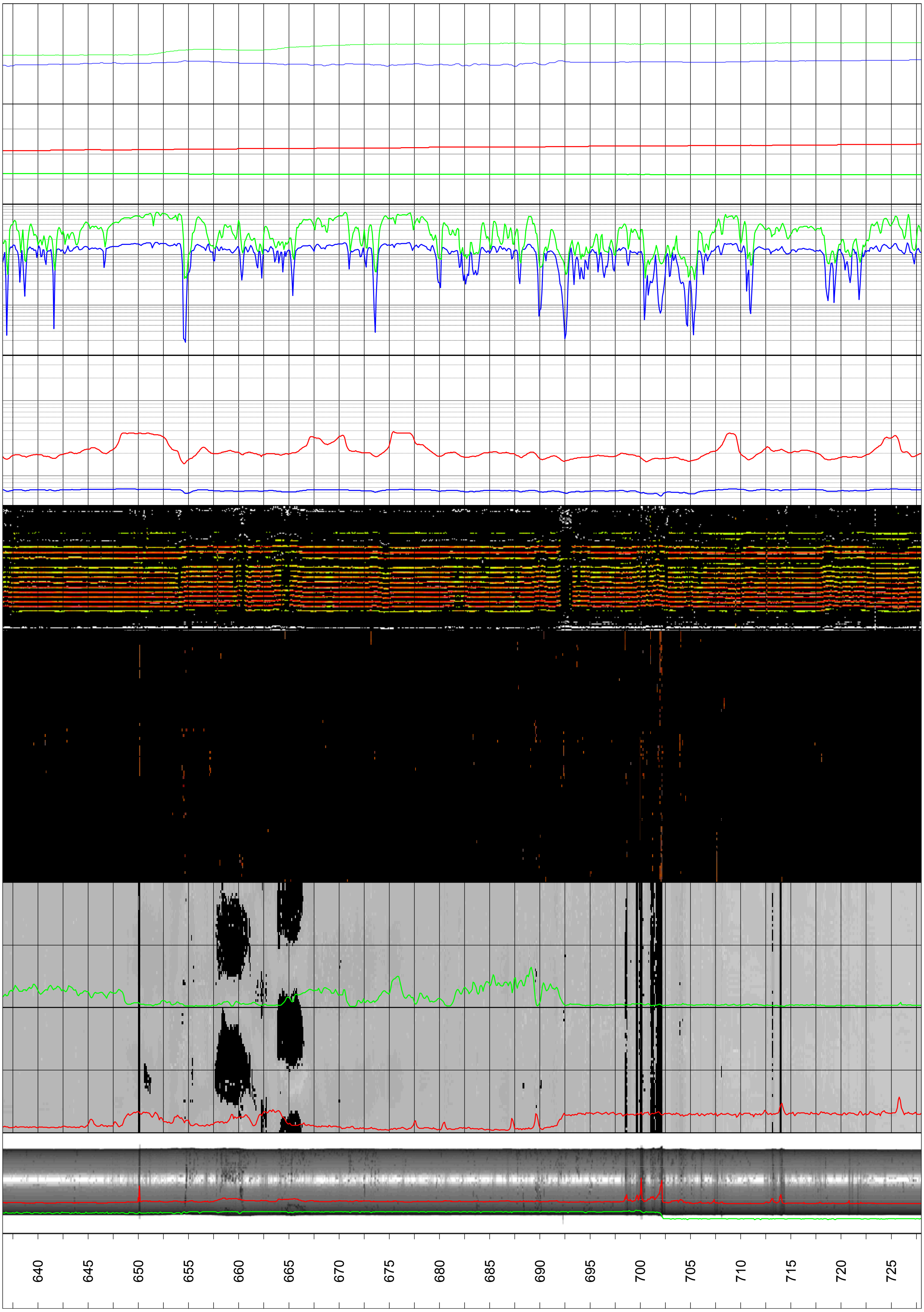

180
185
190
195
200
205
210
215
220
225
230
235
240
245
250
255
260
265
270

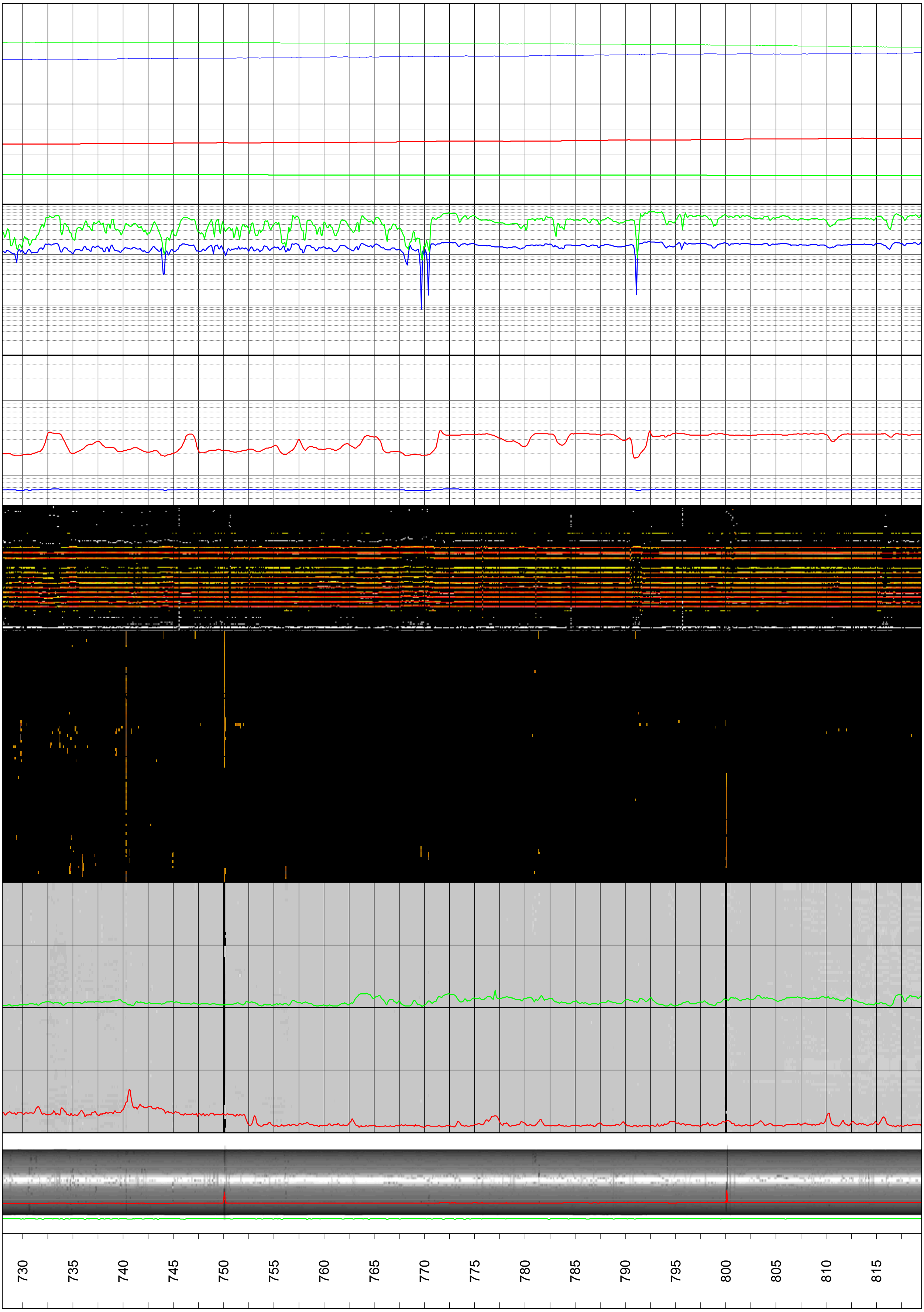

275
280
285
290
295
300
305
310
315
320
325
330
335
340
345
350
355
360

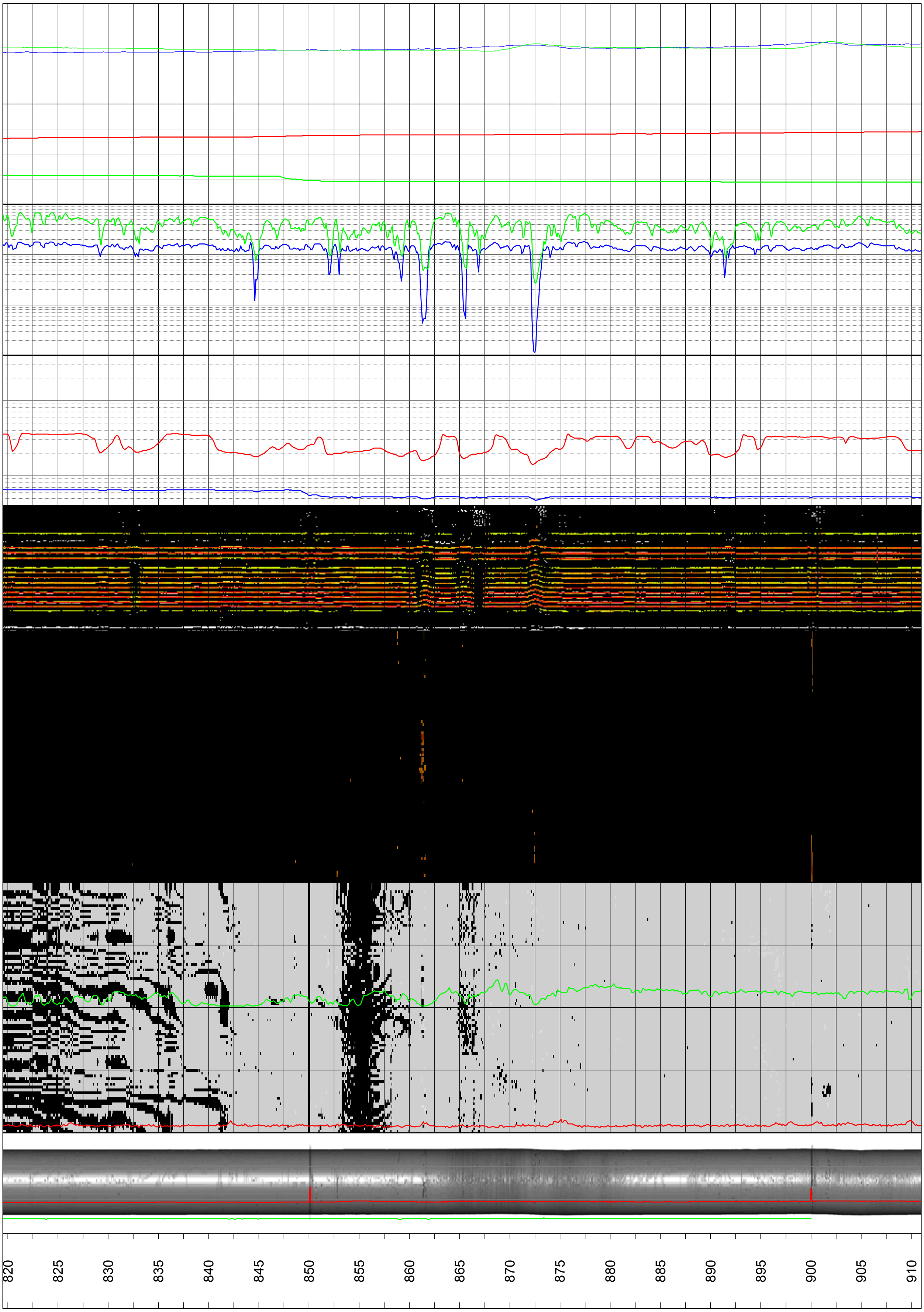

365
370
375
380
385
390
395
400
405
410
415
420
425
430
435
440
445
450

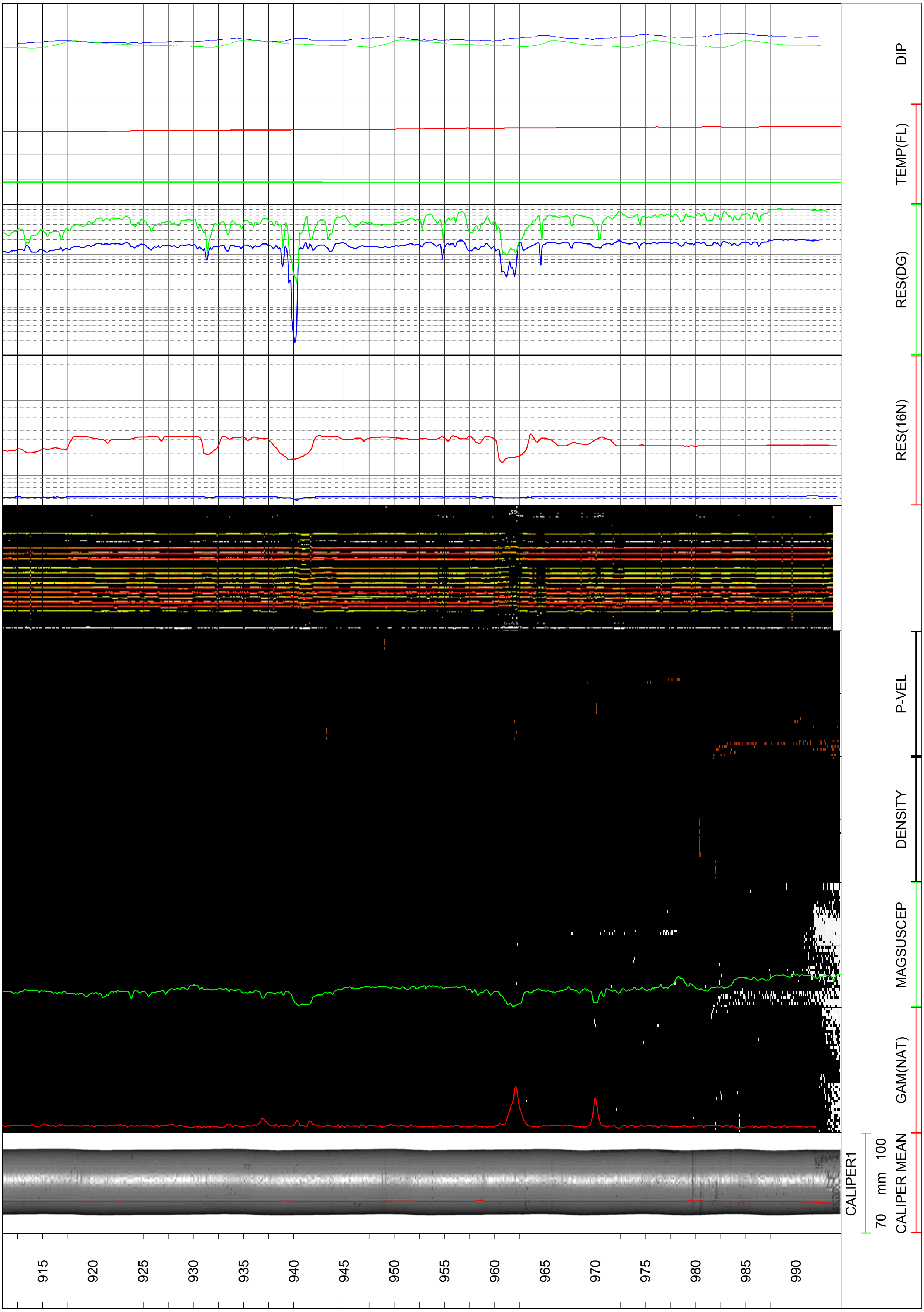

455
460
465
470
475
480
485
490
495
500
505
510
515
520
525
530
535
540

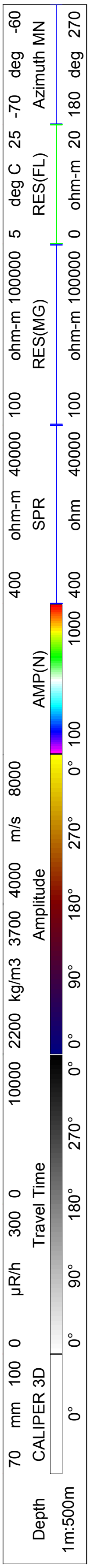

550
555
560
565
570
575
580
585
590
595
600
605
610
615
620
625
630
635


640
645
650
655
660
665
670
675
680
685
690
695
700
705
710
715
720
725


730
735
740
745
750
755
760
765
770
775
780
785
790
795
800
805
810
815


820
825
830
835
840
845
850
855
860
865
870
875
880
885
890
895
900
905
910


DIP
TEMP(FL)
RES(DG)
RES(16N)
P-VEL
DENSITY
MAGSUSCEP
GAM(NAT)
CALIPER1
70 mm 100
CALIPER MEAN
915
920
925
930
935
940
945
950
955
960
965
970
975
980
985
990


70 mm 100 0 µR/h 300 0 10000 2200 kg/m3 3700 4000 m/s 8000 400 ohm-m 40000 100 ohm-m 100000 5 deg C 25 -70 deg -60
Depth
CALIPER 3D
Travel Time
Amplitude
AMP(N)
SPR
RES(MG)
RES(FL)
Azimuth MN
1m:500m 0° 0° 90° 180° 270° 0° 0° 90° 180° 270° 0° 100 1000 400 ohm 40000 100 ohm-m 100000 0 ohm-m 20 180 deg 270

Appendix 2

Borehole HLX32, drawing no 2.1, borehole logs

Co-ordinates in RT90 2,5 gon V 0:-15

Northing: 6365725,793 Easting: 1546734,363 Elevation: 10,844

Diameter:	140 mm
Reaming Diameter:	
Outer Casing:	168 mm
Inner Casing:	160 mm
Borehole Length:	162,60 m
Cone:	
Inclination at ground surface:	-58,669 deg
Azimuth:	28,590 deg
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9030	mm
DENSITY	Gamma-gamma density	9030	kg/m³
RES(MG)	Focused guard log resistivity, 140cm	9030	ohm-m
GAM(NAT)	Natural gamma	9030	µR/h
TEMP(FL)	Fluid temperature	9042	deg C
RES(FL)	Fluid resistivity	9042	ohm-m
RES(DG)	Focused guard log resistivity, 300cm	9072	ohm-m
P-VEL	P-wave velocity	9310	m/s
AMP(N)	Full wave form, near receiver	9310	µs
AMP(F)	Full wave form, far receiver	9310	µs
MAGSUSCEP	Magnetic susceptibility	8622	SI*10-5
CALIPER 3D	Caliper, high resolution 360 degrees	HiRAT	mm
CALIPER MEAN	High resolution 1D caliper	HiRAT	mm
AZIMUTH MN	Borehole azimuth magnetic north	HiRAT	deg
DIP	Borehole inclination from horizontal	HiRAT	deg
TRAVEL TIME	360 degrees orientated acoustic travel time	HiRAT	100 ns
AMPLITUDE	360 degrees orientated acoustic amplitude	HiRAT	-
THORIUM	Spectral gamma, Thorium component	9080	PPM
URANIUM	Spectral gamma, Uranium component	9080	PPM
POTASSIUM	Spectral gamma, Potassium component	9080	percent
RES(16N)	Normal resistivity 16 inch	8044	ohm-m
RES(64N)	Normal resistivity 64 inch	8044	ohm-m
LATERAL	Lateral resistivity	8044	ohm-m
SPR	Single point resistivity	8044	ohm
SP	Self Potential	8044	mV

Rev.	Date	Drawn by	Control	Approved
0	2005-05-31	JIJ	UTN	UTN

Job	Scale
547310A	1:500

RAMBØLL

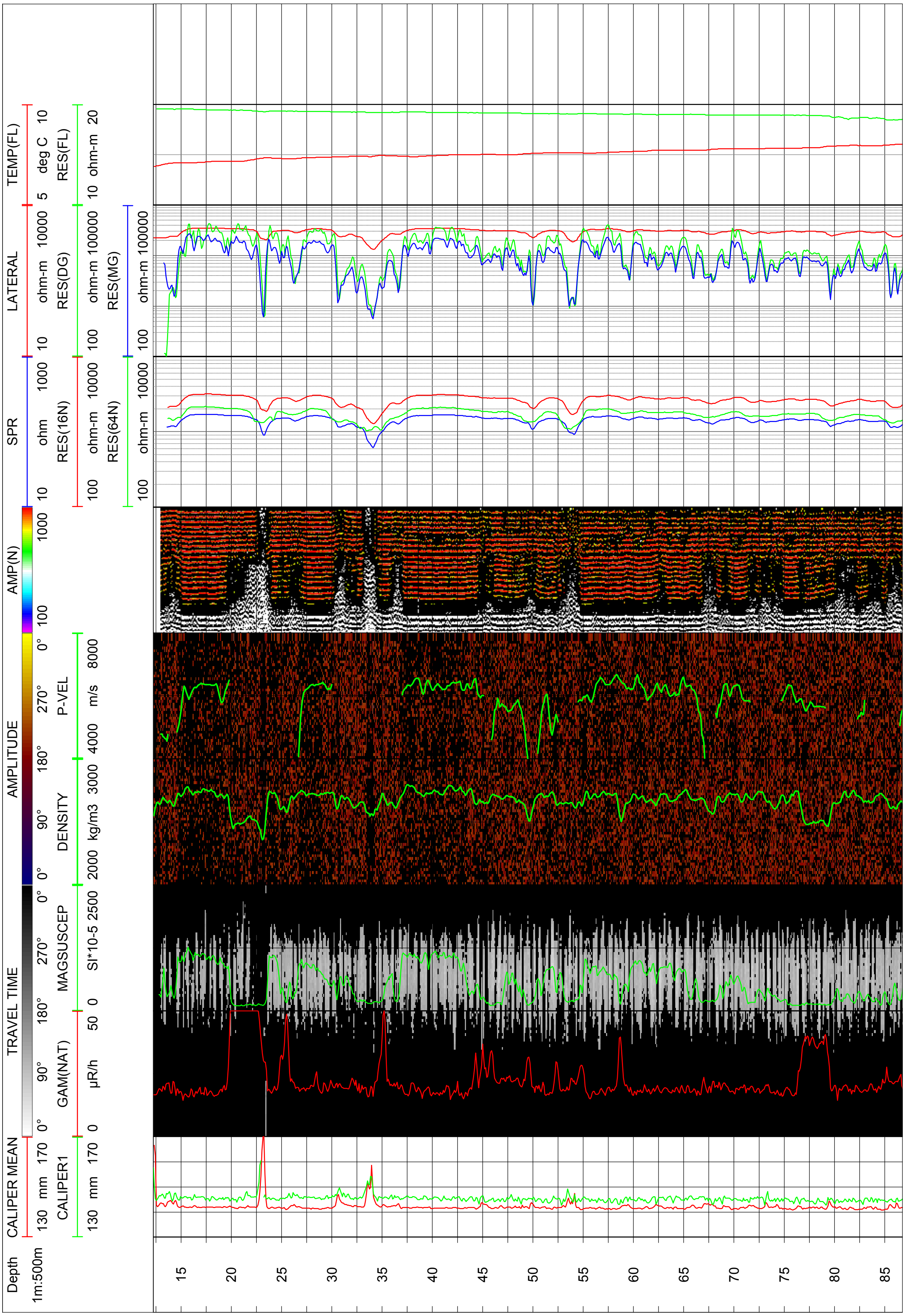
Rambøll. Bredevej 2, DK-2830 Virum
Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

SKB geophysical borehole logging
Borehole HLX32

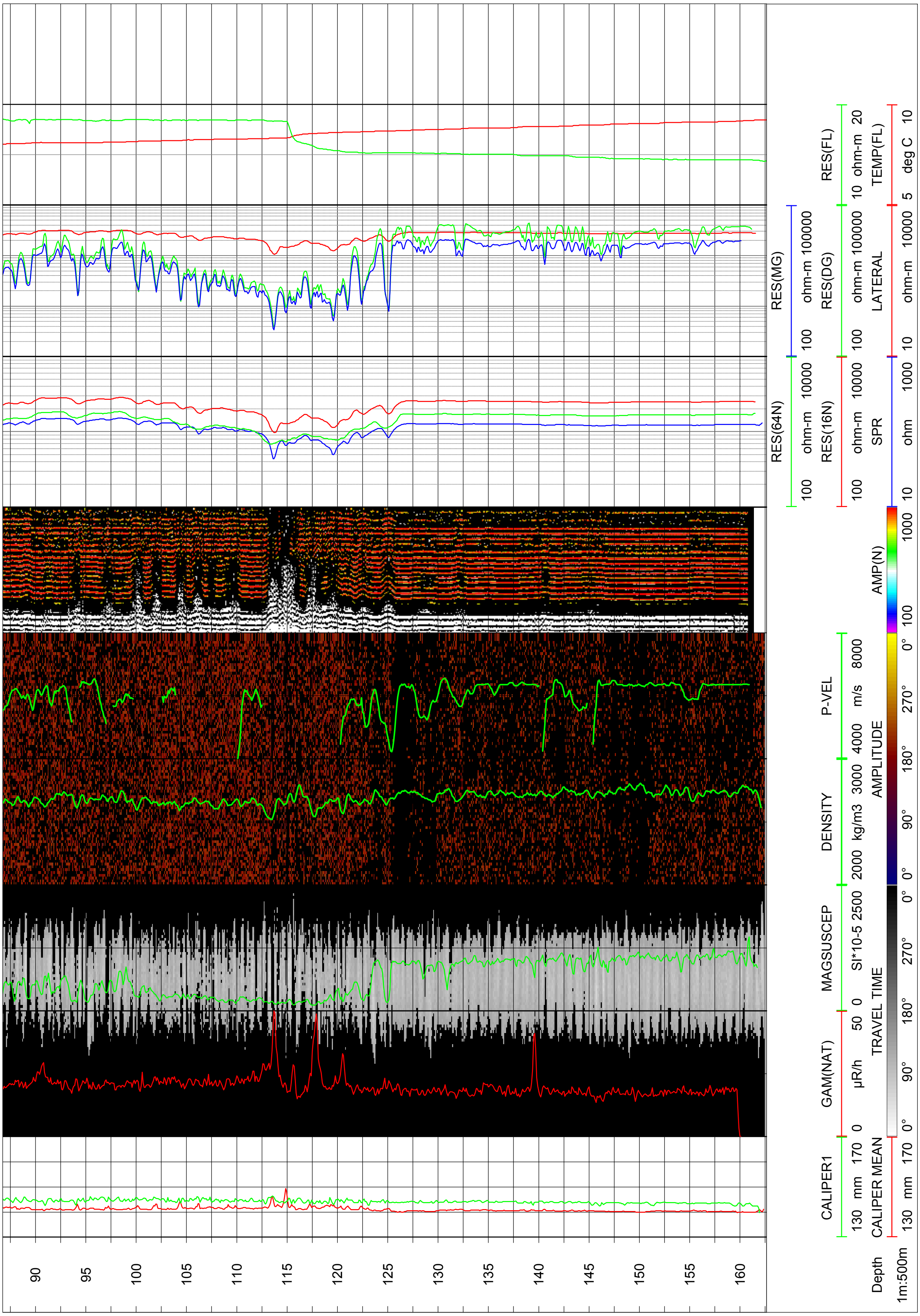
Presentation

Filename:
KLX05_Presentation.wcl

Drawing no.:
2.1



Depth
1m:500m
CALIPER MEAN
130 mm 170
CALIPER1
130 mm 170
TRAVEL TIME
0° 90° 180° 270° 0°
GAM(NAT)
0 μR/h 50
MAGSUSCEP
0 SI*10-5 2500
AMPLITUDE
0° 90° 180° 270° 0°
DENSITY
2000 kg/m3 3000
P-VEL
4000 m/s 8000
AMP(N)
100 1000
SPR
10 ohm 1000
RES(16N)
100 ohm-m 10000
RES(64N)
100 ohm-m 10000
LATERAL
10 ohm-m 10000
RES(DG)
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
TEMP(FL)
5 deg C 10
RES(FL)
10 ohm-m 20
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85


Depth
1m:500m
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
CALIPER1
130 mm 170
CALIPER MEAN
130 mm 170
GAM(NAT)
0 µR/h 50
TRAVEL TIME
0° 90° 180° 270° 0°
MAGSUSCEP
0 SI*10-5 2500
DENSITY
2000 kg/m3 3000
AMPLITUDE
0° 90° 180° 270° 0°
P-VEL
4000 m/s 8000
AMP(N)
100 1000
RES(64N)
100 ohm-m 10000
RES(16N)
100 ohm-m 10000
SPR
10 ohm 1000
RES(MG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
LATERAL
10 ohm-m 10000
RES(FL)
10 ohm-m 20
TEMP(FL)
5 deg C 10