P-06-197

Oskarshamn site investigation

Geophysical borehole logging in boreholes KLX11A, HLX36 and HLX37

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RAMBØLL

August 2006

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ISSN 1651-4416
SKB P-06-197

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Keywords: Geophysical logging.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

A pdf version of this document can be downloaded from www.skb.se

Abstract

Geophysical borehole logging has been performed in boreholes KLX11A, HLX36 and HLX37 all 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 KLX11A was recorded from 12 m to 992 m, HLX36 was recorded from 0 m to 200 m and HLX37 from 0 m to 200 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 to 3.

Sammanfattning

Geofysisk borrhålsloggning har genomförts i borrhålen KLX11A, HLX36 och i HLX37 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 spricko-frekvensen och att lokalisera deformationszoner. Med geofysisk borrhålsloggning mäts bergets och borrhålsvattnets fysikaliska egenskaper i borrhålet och omgivande berg.

Den geofysiska borrhålsloggningen genomfördes i KLX11A från 12 m till 992 m, i HLX36 från 0 m till 200 m och i HLX37 från 0 m till 200 m.

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

Processerade loggar presenteras i Appendix 1 till 3.

Contents

1 Introduction

This document reports the results gained by the geophysical borehole logging in boreholes KLX11A, HLX36 and HLX37, 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 400-06-030 (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 March 6, 17 and 23 to 24, 2006. The borehole was recorded from Top Of Casing (TOC) to the bottom of the borehole. The technical data from the boreholes is shown in Table 1-2. The location of the boreholes is shown in Figure 1-1.

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

Activity plan	Number	Version
Geofysisk borrhålsloggning i KLX11A, HLX36 och HLX37	AP PS 400-06-030	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för geofysisk borrhålsloggning	SKB MD 221.002	2.0

Table 1-2. Technical data for the boreholes.

Borehole parameter	KLX11A	HLX36	HLX37
Co-ordinates	X: 6366339.716	Y: 1546608.490	X: 6366172.935
(RT90)	Y: 1546558.452	X: 6366183.660	Y: 1546406.214
Elevation			
(RHB70)	Z: 27.143	Z: 15.558	Z: 15.188
Inclination (from horizontal)	–76.434°	–59.301°	–59.246°
Azimuth	89.840°	270.608°	86.182°
Length	992.29 m	199.80 m	199.80 m
Borehole diameter	Ø 343 mm (0.43–9.6 m)	Ø 190 mm (0.00–6.1 m)	Ø 190 mm (0.00–12.1 m)
	Ø 248 mm (9.6–12.05 m)	Ø 140 mm (6.1–199.8 m)	Ø 140 mm (12.1–121.5 m)
	Ø 195 mm (12.05–99.96 m)		Ø 139 mm (121.5–199.8 m)
	Ø 160 mm (99.96–100.06 m)		
	Ø 86 mm (100.06–101.53 m)		
	Ø 76 mm (101.53–992.29 m)		
Casing	Ø 323/310 mm casing (0.43–9.6 m)	Ø 168/160 mm casing (0–5.94 m)	Ø 168/160 mm casing (0–11.94 m)
	Ø 210/200 mm casing (0.0–12.05 m)	Ø 168/142 mm casing (5.94–6.03 m)	Ø 168/142 mm casing (11.94–12.03 m)
	Cone from 96.08–100.85 m (Ø100/ Ø 80 mm)		
Cleaning level	Level 1	Level 1	Level 1

Figure 1-1. *Overview over borehole KLX11A, HLX36 and HLX37 in the left part of the Laxemar subarea.*

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

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 360° caliper and to determine the length marks in the core-drilled borehole KLX11A.

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 KLX11A in Appendix 1, drawing no. 2.1 for borehole HLX36 in Appendix 2 and drawing no. 3.1 for borehole HLX37 in Appendix 3.

3 Equipment

The geophysical borehole logging program in KLX11A was performed with up to 7 multi tool probes and resulted in a suite of 16 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.

Tool	Recorded logs	Dimension	Source detector spacing and type	Tool position in borehole	Tool used in borehole
Century 8144 Normal resistivity	Normal resistivity (16 and 64 inch), single point resistance, self potential and natural gamma.	237×5.3 cm			All boreholes
Century 8622 Magnetic susceptibility	Magnetic susceptibility, natural gamma.	203×4.1 cm			All boreholes
Century 9042 Fluid temperature and fluid resistivity	Fluid temperature, fluid resistivity and natural gamma.	137×4.1 cm			All boreholes
Century 9072 3 m focused guard	3 m focused guard log resistivity and natural gamma.	310×6.4 cm			All boreholes
Century 9139 Compensated gamma density	Compensated gamma density, natural gamma, 140 cm focused guard log resistivity, 1-arm caliper.	280.3×5.6 cm	20.3 cm 200 mCi Cs137	Sidewall. Gamma source focused.	All boreholes
Century 9310 Sonic	Full wave form travel-time providing P and S-wave velocity picking, compensated P-wave travel-time and natural gamma.	300×6.0 cm	Near 91.4 cm Far 121.9 cm	Centralized.	All boreholes
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	KLX11A, HLX36

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 March 6, 17 and 23 to 24, 2006. 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 1 (SKB internal controlling document SKB MD 600.004).

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 density tool 9139 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 for the 9139 tool was 5 m/min, for the 8622 tool 20 m/min and for all other tools 10 m/min.

4.2 Nonconformities

The logging has been performed in accordance with the activity plan AP PS 400-06-030. No nonconformities occurred.

5 Results

5.1 Presentation

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

Logs presented in drawings no. 1.1–3.1 are presented in Table 5-1.

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 processed in the tool while recording, using the magnetometers and accelerometers in the tool.

Table 5-1. Logs presented in drawings no. 1.1 through. 3.1 in Appendices 1 to 3.

Log	Log name short	Unit	Tool	Recorded/ calculated in borehole
Fluid temperature	TEMP(FL)	deg C	9042	All
Fluid resistivity	RES(FL)	ohm-m	9042	All
Natural gamma	GAM(NAT)	μR/h	9042	All
Normal resistivity 16 inch	RES(16N)	ohm-m	8144	All
Normal resistivity 64 inch	RES(64N)	ohm-m	8144	All
Lateral resistivity	LATERAL	ohm-m	8144	All
Single point resistance	SPR	Ohm	8144	All
Self potential	SP	V	8144	KLX11A
Magnetic susceptibility	MAGSUSCEP	SI*10^{-5}	8622	All
Caliper, 1-arm	CALIPER1	mm	9139	All
Gamma-gamma density	DENSITY	kg/m^3	9139	All
Focused guard log resistivity, 127 cm	RES(SG)	ohm-m	9139	All
Focused guard log resistivity, 300 cm	RES(DG)	ohm-m	9072	All
P-wave velocity	P-VEL	m/s	9310	All
Full wave form, near receiver	AMP(N)	μs	9310	All
Full wave form, far receiver	AMP(F)	μs	9310	All
Caliper, high resolution. 360°	CALIPER 3D	mm	HiRAT	KLX11A, HLX36
High resolution 1D Caliper	CALIPER MEAN	mm	HiRAT	KLX11A, HLX36

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 length 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 length scale in WellCAD. All log files are shifted using the new length scale.

5.2.4 Stretch of logs

There is a minor difference in the length 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 length scale for each tool. The length 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 length scale is made and added to the log. The bottom of the borehole is considered in stretching the logs so that no data will occur below the bottom of the borehole.

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.

5.4 Borehole KLX11A

In order to obtain an exact length calibration in borehole KLX11A, 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 length scale. The new length 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 KLX11A, between all logruns, the obtained reference mark correlation is transferred to the other logs.

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/cm^3] 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 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	The SP value was converted from [mV] to [V] by dividing with 1,000.
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 time 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.

Table 5-3. The reference track marks in the borehole and the recorded track marks form the HiRAT in borehole KLX11A.

Reference mark	HIRAT recorded
110	108.332
150	148.41
200	198.578
250	248.818
300	298.929
350	349.116
400	399.267
450	449.411
500	499.467
550	549.717
600	599.899
650	650.084
700	700.179
750	750.386
800	800.531
850	850.713
900	900.818
944	945.027
972	975.122

The complete log suite for borehole KLX11A is presented as composite log sheets in drawing 1.1 in Appendix 1. The logs presented in drawing no. 1.1 are listed in Table 5-1.

5.5 Borehole HLX36

Using the natural gamma from the 9042 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 HLX36 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 event in borehole HLX36.

Events	Depths
Mid event	43.2

5.6 Borehole HLX37

Using the natural gamma from the 9042 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 5-5.

The complete log suite for borehole HLX37 is presented as composite log sheet in drawing 3.1 in Appendix 3. The logs presented in drawing no. 3.1 are listed in Table 5-1.

Table 5-5. Gamma event in borehole HLX37.

Events	Depths
Mid event	104.2

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
KLX11A	8144	Up	KLX11A_03-24-06_13-33_8144C_.10_5.10_991.80_ORIG.log	Start Depth: 991.8 m. End Depth: 5.1 m
KLX11A	8622	Up	KLX11A_03-23-06_12-44_8622C_.10_–1.10_991.70_ORIG.log	Start Depth: 991.7 m. End Depth: –1.1 m
KLX11A	9042	Down	KLX11A_03-23-06_09-24_9042C_.10_0.20_992.20_ORIG.log	Start Depth: 0.2 m. End Depth: 992.2 m
KLX11A	9072	Up	KLX11A_03-23-06_18-41_9072C_.10_871.00_991.60_ORIG.log	Start Depth: 991.6 m. End Depth: 871 m
KLX11A	9072	Up	KLX11A_03-23-06_18-56_9072C_.10_887.00_896.70_ORIG.log	Start Depth: 896.7 m. End Depth: 887 m
KLX11A	9072	Up	KLX11A_03-23-06_18-58_9072C_.10_603.70_889.60_ORIG.log	Start Depth: 889.6 m. End Depth: 603.7 m
KLX11A	9072	Up	KLX11A_03-23-06_19-29_9072C_.10_632.70_641.80_ORIG.log	Start Depth: 641.8 m. End Depth: 632.7 m
KLX11A	9072	Up	KLX11A_03-23-06_19-31_9072C_.10_86.60_635.30_ORIG.log	Start Depth: 635.3 m. End Depth: 86.6 m
KLX11A	9072	Up	KLX11A_03-23-06_20-26_9072C_.10_1.50_89.10_ORIG.log	Start Depth: 89.1 m. End Depth: 1.5 m
KLX11A	9139	Up	KLX11A_03-23-06_14-41_9139A_.10_–0.50_992.30_ORIG.log	Start Depth: 992.3 m. End Depth: –0.5 m
KLX11A	9310	Up	KLX11A_03-24-06_08-41_9310C2_.10_–0.90_991.30_ORIG.log	Start Depth: 991.3 m. End Depth: –0.9 m
KLX11A	HiRAT	Up	KLX11A_HiRat_90pixels_up_run2.HED	Start Depth: 990 m.
HLX36	8144	Up	HLX36_03-17-06_10-02_8144C_.1_0.80_199.20_ORIG.log	Start Depth: 199.2 m. End Depth: 0.8 m
HLX36	8622	Up	HLX36_03-17-06_11-27_8622C_.1_0.10_199.20_ORIG.log	Start Depth: 199.2 m. End Depth: 0.1 m
HLX36	9042	Down	HLX36_03-17-06_09-01_9042C_.1_4.20_112.80_ORIG.log	Start Depth: 4.2 m. End Depth: 112.8 m
HLX36	9072	Up	HLX36_03-17-06_10-43_9072C_.1_–0.30_199.20_ORIG.log	Start Depth: 199.2 m. End Depth: –0.3 m
HLX36	9139	Up	HLX36_03-17-06_13-11_9139A_.10_–0.60_198.40_ORIG.log	Start Depth: 198.4 m. End Depth: –0.6 m
HLX36	9310	Up	HLX36_03-17-06_11-59_9310C2_.10_–0.10_198.50_ORIG.log	Start Depth: 198.5 m. End Depth: –0.1 m
HLX36	HiRAT	Up	HLX36_90pixels_up_run2.HED	Start Depth: 199 m. End Depth: 0 m

Borehole	Probe	Log direction	WellCAD file	Description
HLX37	8144	Down	HLX37_03-06-06_16-43_8144C_.02_0.28_199.40_ORIG.log	Start Depth: 0.28 m. End Depth: 199.4 m
HLX37	8622	Up	HLX37_03-06-06_20-11_8622C_.10_0.20_199.00_ORIG.log	Start Depth: 199 m. End Depth: 0.2 m
HLX37	9042	Down	HLX37_03-06-06_16-01_9042C_.02_0.22_199.02_ORIG.log	Start Depth: 0.22 m. End Depth: 199.02 m
HLX37	9072	Up	HLX37_03-06-06_17-31_9072C_.02_0.04_198.92_ORIG.log	Start Depth: 198.92 m. End Depth: 0.04 m
HLX37	9139	Up	HLX37_03-06-06_18-20_9139A_.02_0.32_199.18_ORIG.log	Start Depth: 199.18 m. End Depth: 0.32 m
HLX37	9310	Up	HLX37_03-06-06_19-33_9310C2_.10_0.40_198.30_ORIG.log	Start Depth: 198.3 m. End Depth: 0.4 m

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KLX11A	1.1	KLX11A_Presentation.WCL
HLX36	2.1	HLX36_Presentation.WCL
HLX37	3.1	HLX37_Presentation.WCL

Table 6-3. Data files in SICADA format.

Sheet	Comment
“Borehole”_CALIPER1_GP040 - Caliper logging.xls	
“Borehole”_CALIPER MEAN_GP041 - 3-D caliper.xls	KLX11A, HLX36
“Borehole”_TEMP(FL)_RES(FL)_GP060 – Fluid temperature and resistivity logging.xls	
“Borehole”_DENSITY_GP090 – Density logging.xls	
“Borehole”_MAGSUSCEP_GP110 - Magnetic susceptibility logging.xls	
“Borehole”_GAM(NAT)_GP120 - Natural gamma logging.xls	
“Borehole”_SPR_GP150 - Single point resistance logging.xls	
“Borehole”_RES(64N)_GP160 - Resistivity, normal 1.6 m (64 in).xls	
“Borehole”_RES(MG)_GP161 - Resistivity, focused 140 cm.xls	
“Borehole”_RES(DG)_GP162 - Resistivity, focused 300 cm.xls	
“Borehole”_LATERAL_GP163 - Resistivity, lateral 1.6–0.1 m.xls	
“Borehole”_RES(16N)_GP164 - Resistivity, normal 0.4 m (16 in).xls	
“Borehole”_P-VEL_GP175 - Fullwave sonic.xls	
KLX11A_SP_GP180 - Self potential logging.xls	Only KLX11A

Borehole KLX11A. Drawing no. 1.1. Borehole logs

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

Northing: 6366339,716 Easting: 1546608,490 Elevation: 27,143

Diameter:	76 mm
Reaming Diameter:	
Outer Casing:	
Inner Casing:	
Borehole Length:	992,29
Cone:	
Inclination at ground surface:	-76,434
Azimuth:	89,840
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9030/9139	mm
DENSITY	Gamma-gamma density	9030/9139	kg/m³
RES(MG)	Focused guard log resistivity, 140cm	9030	ohm-m
GAM(NAT)	Natural gamma	9072	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	8144	ohm-m
RES(64N)	Normal resistivity 64 inch	8144	ohm-m
LATERAL	Lateral resistivity	8144	ohm-m
SPR	Single point resistivity	8144	ohm
SP	Self Potential	8144	mV
RES(SG)	Focused guard log resistivity, 128 cm	9139	ohm-m

Rev.	Date	Drawn by	Control	Approved
0	2006-04-12	UTN	JIJ	UTN

Job: 547310A

Scale: 1:500

RAMBØLL

Rambøll, Bredevej 2, DK-2830 Virum
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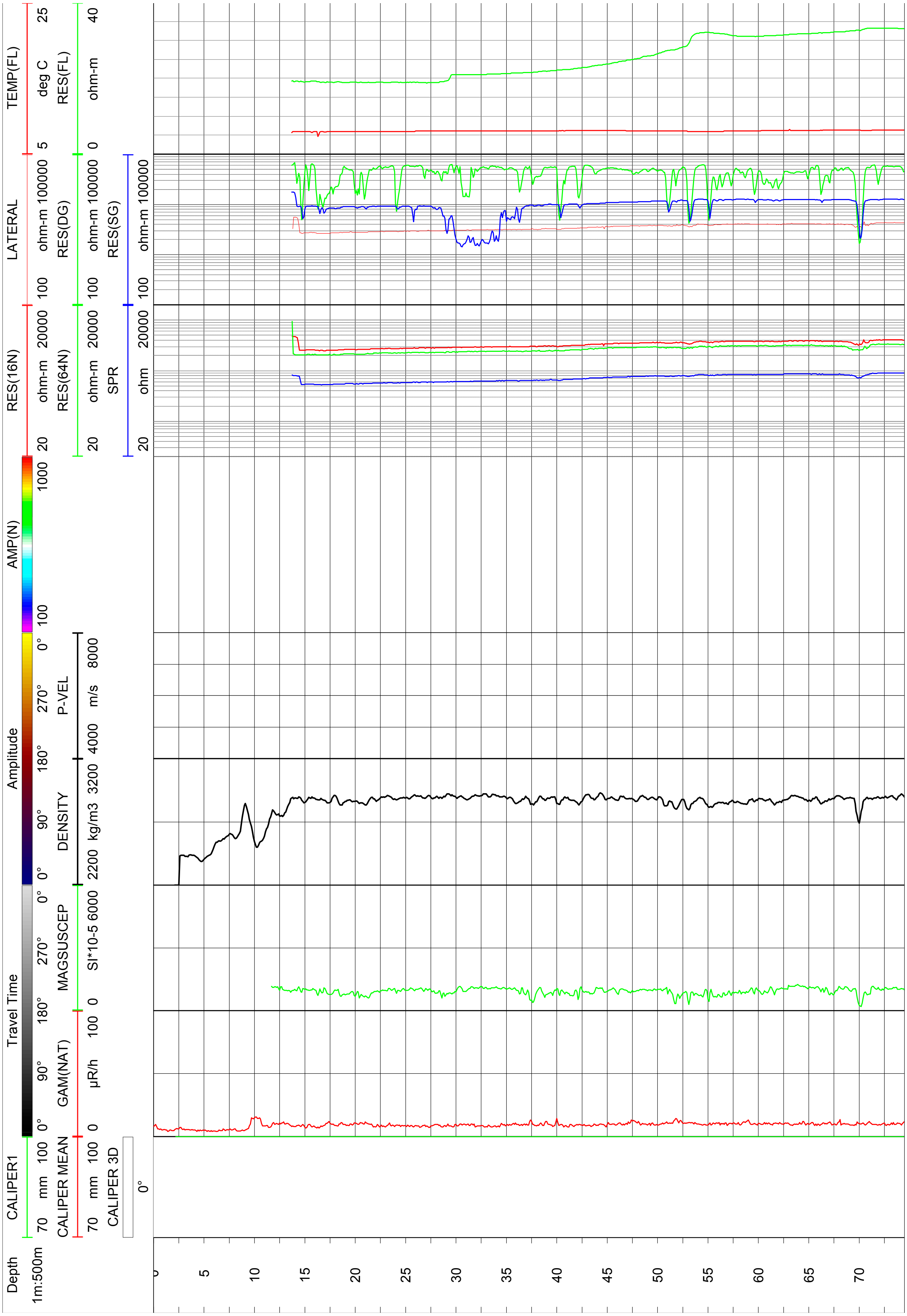
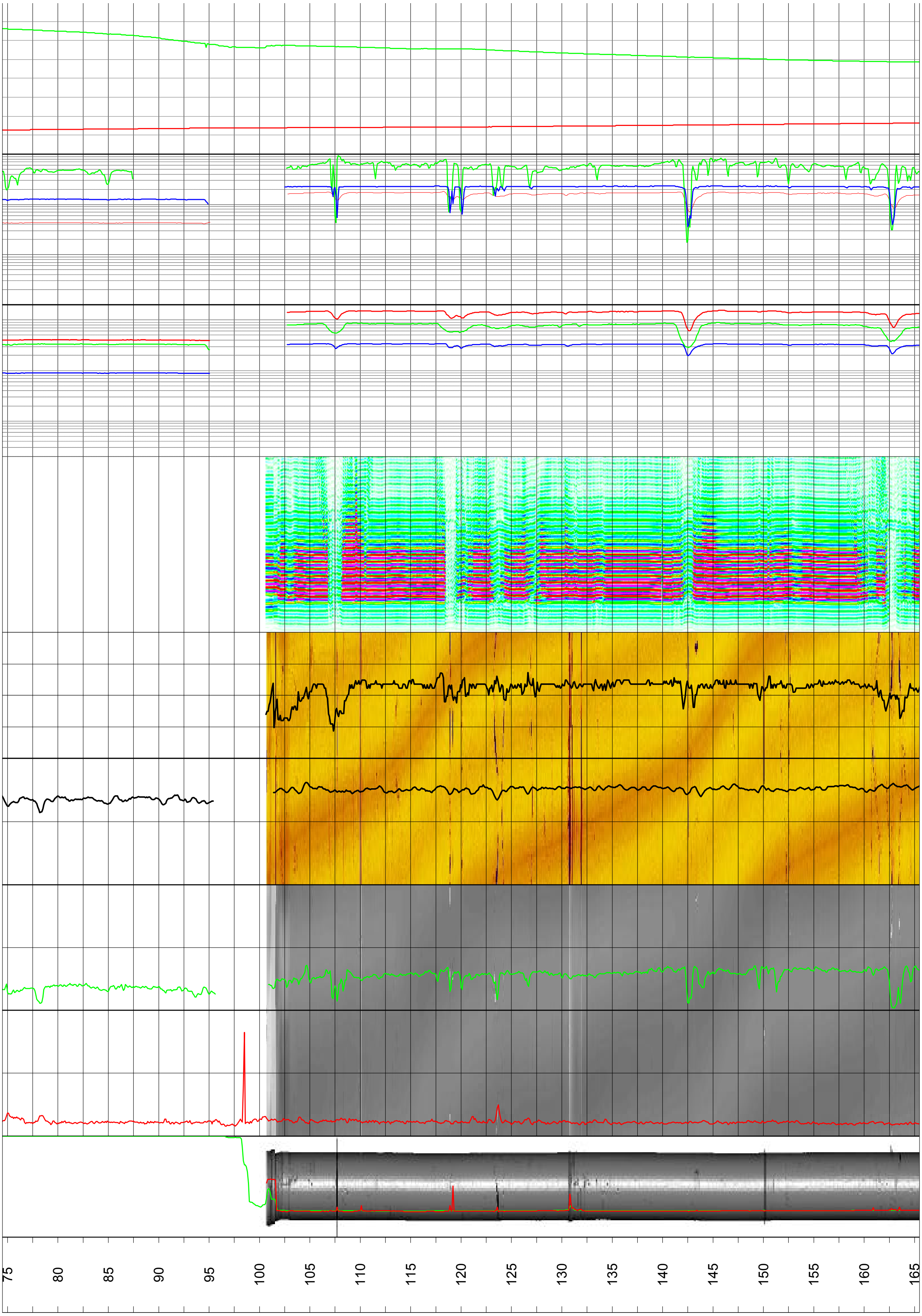
SKB geophysical borehole logging
Borehole KLX11A

Presentation

Filename:
KLX11A_Presentation.wcl

Drawing no.:
1.1


Depth
1m:500m
CALIPER1
70 mm 100
CALIPER MEAN
70 mm 100
CALIPER 3D
0°
Travel Time
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 100
MAGSUSCEP
0 SI*10-5 6000
Amplitude
0° 90° 180° 270° 0°
DENSITY
2200 kg/m3 3200
P-VEL
4000 m/s 8000
AMP(N)
100 1000
RES(16N)
20 ohm-m 20000
RES(64N)
20 ohm-m 20000
SPR
20 ohm 20000
LATERAL
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(SG)
100 ohm-m 100000
TEMP(FL)
5 deg C 25
RES(FL)
0 ohm-m 40
5
10
15
20
25
30
35
40
45
50
55
60
65
70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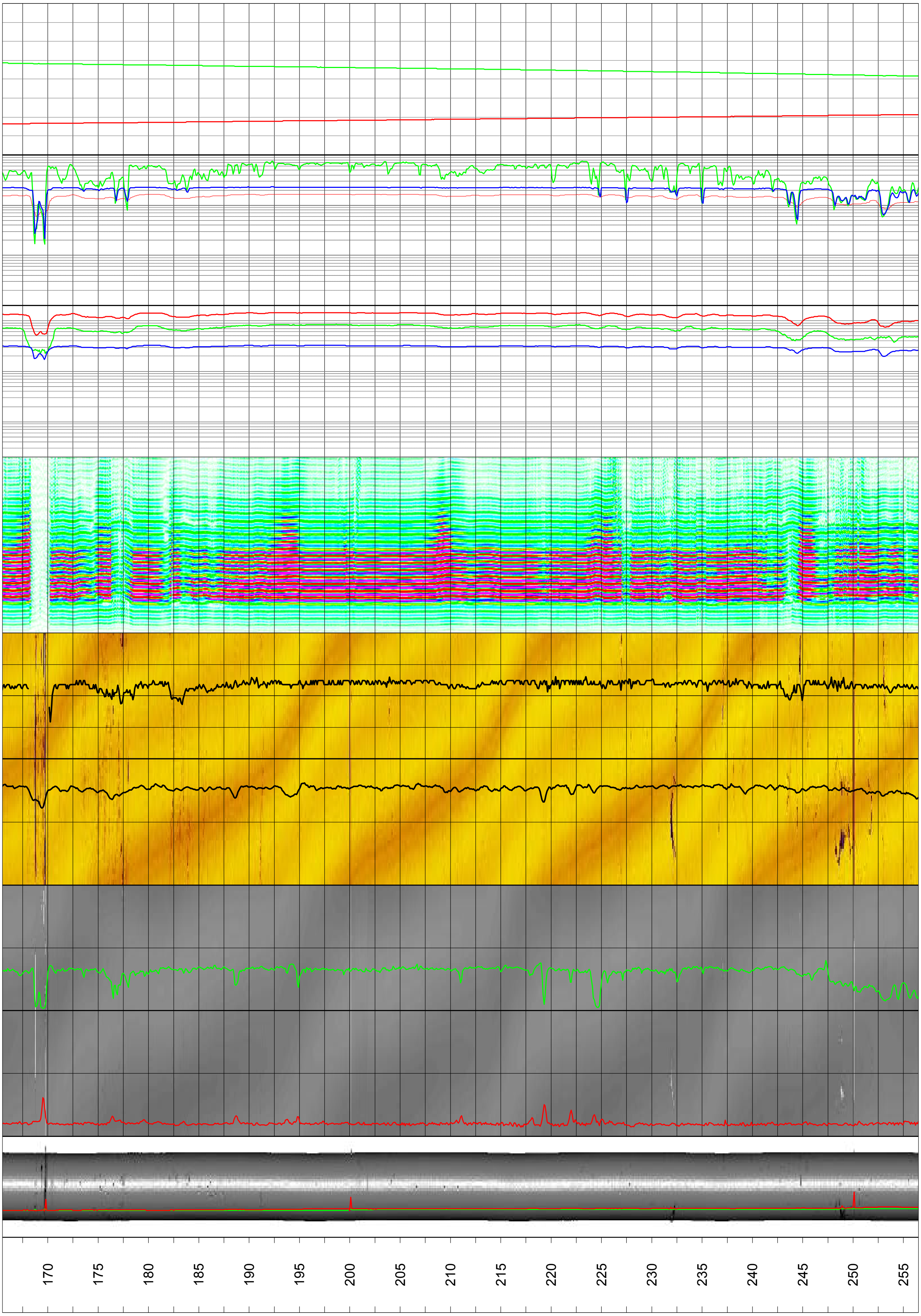
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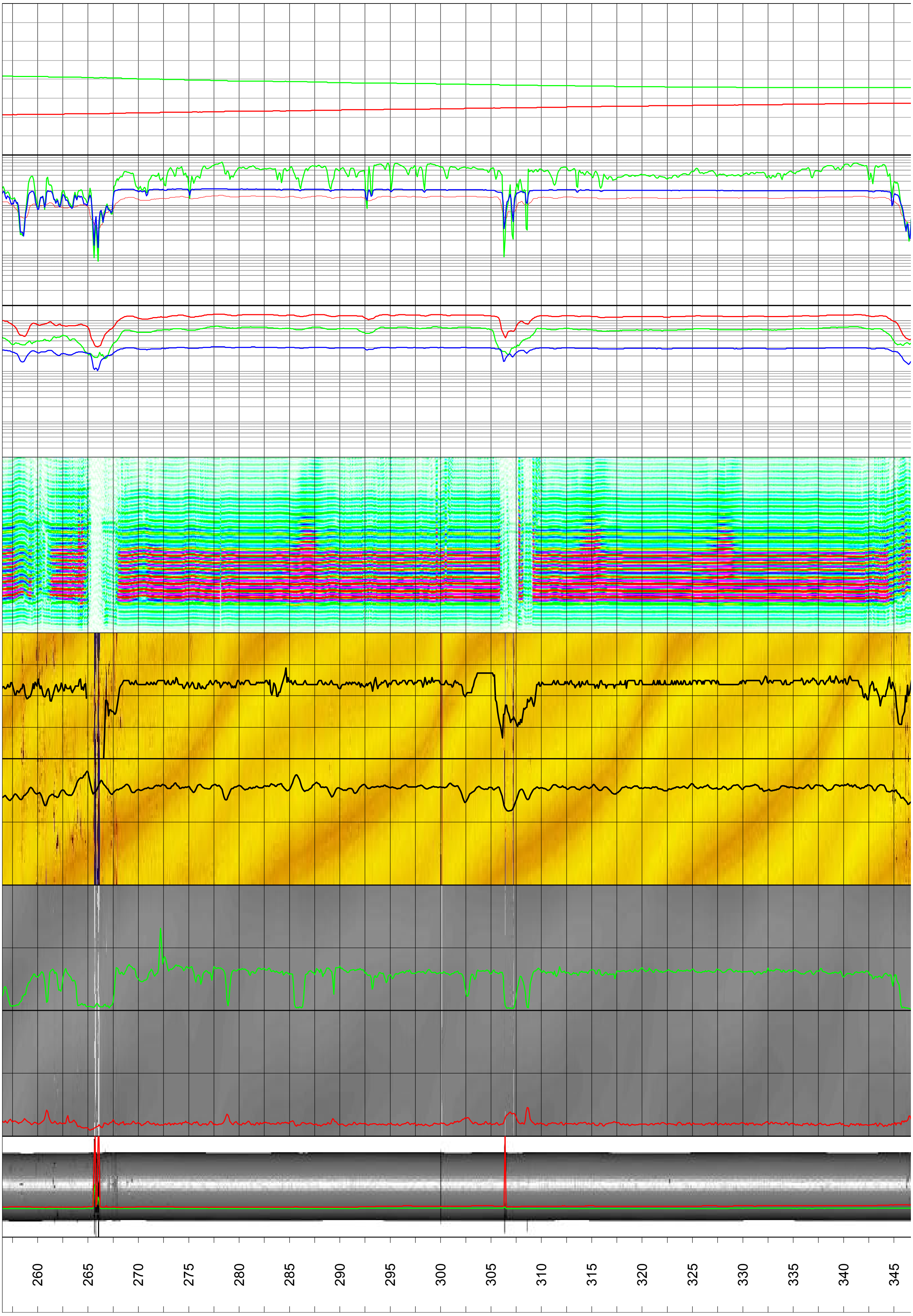
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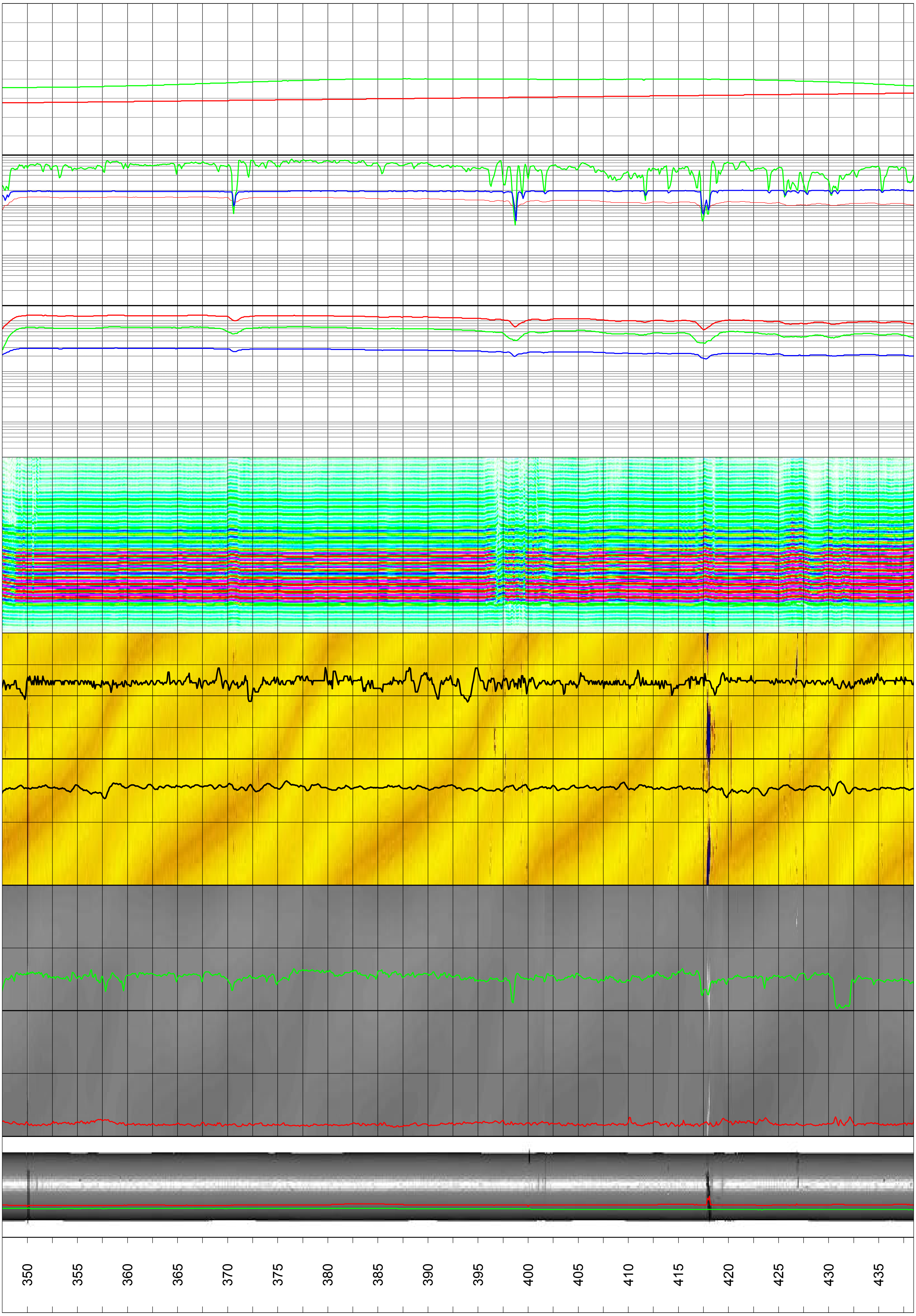
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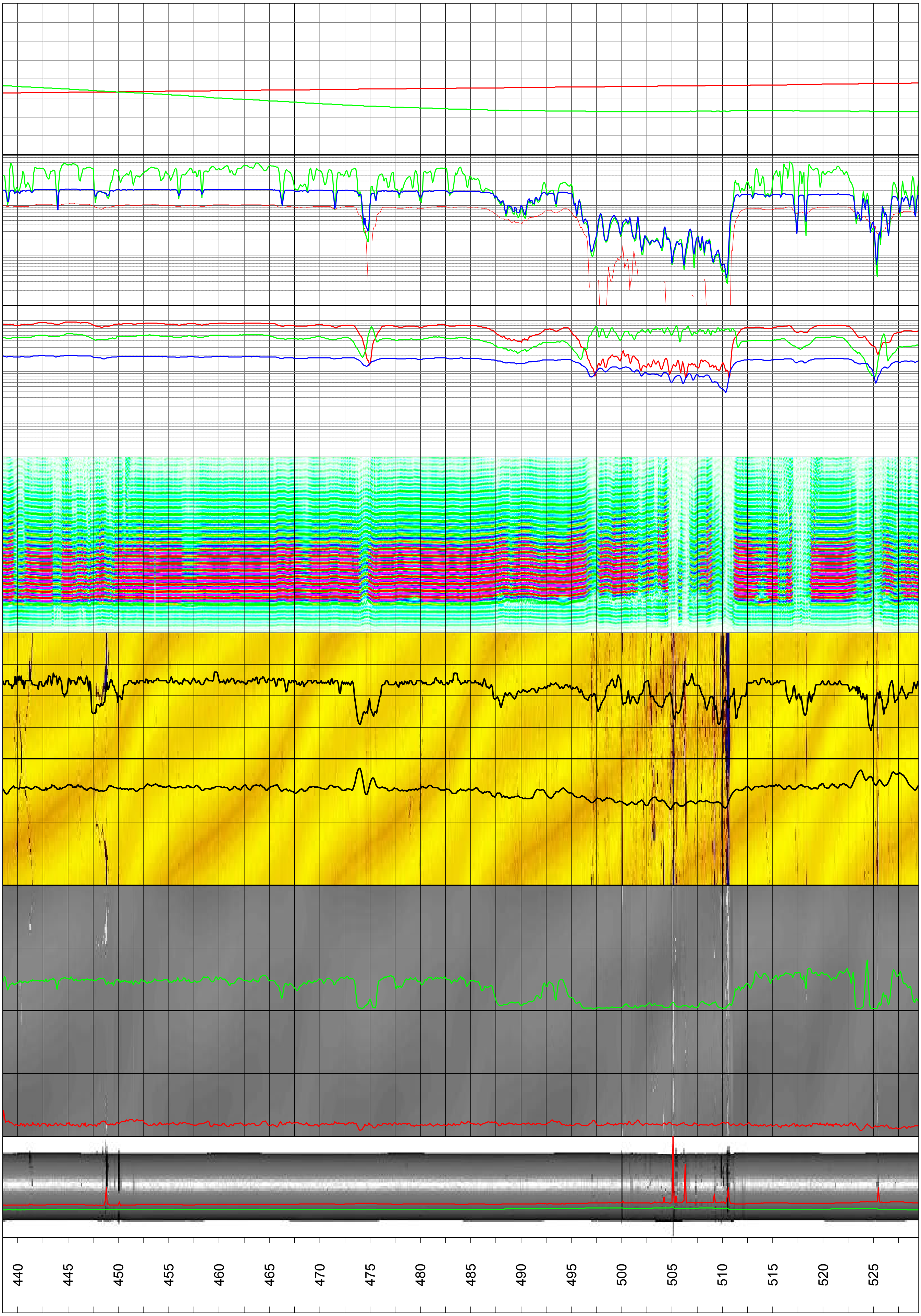
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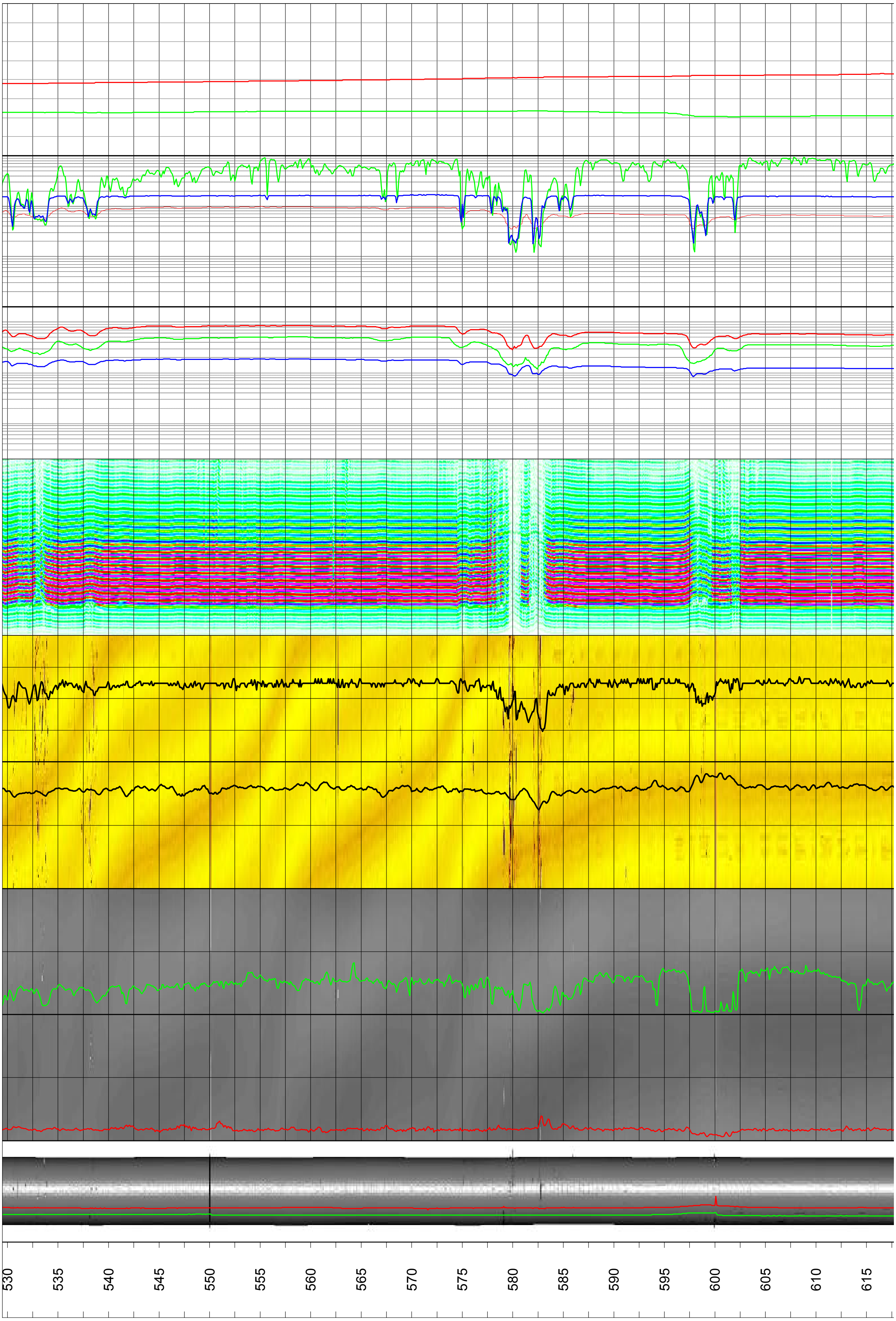
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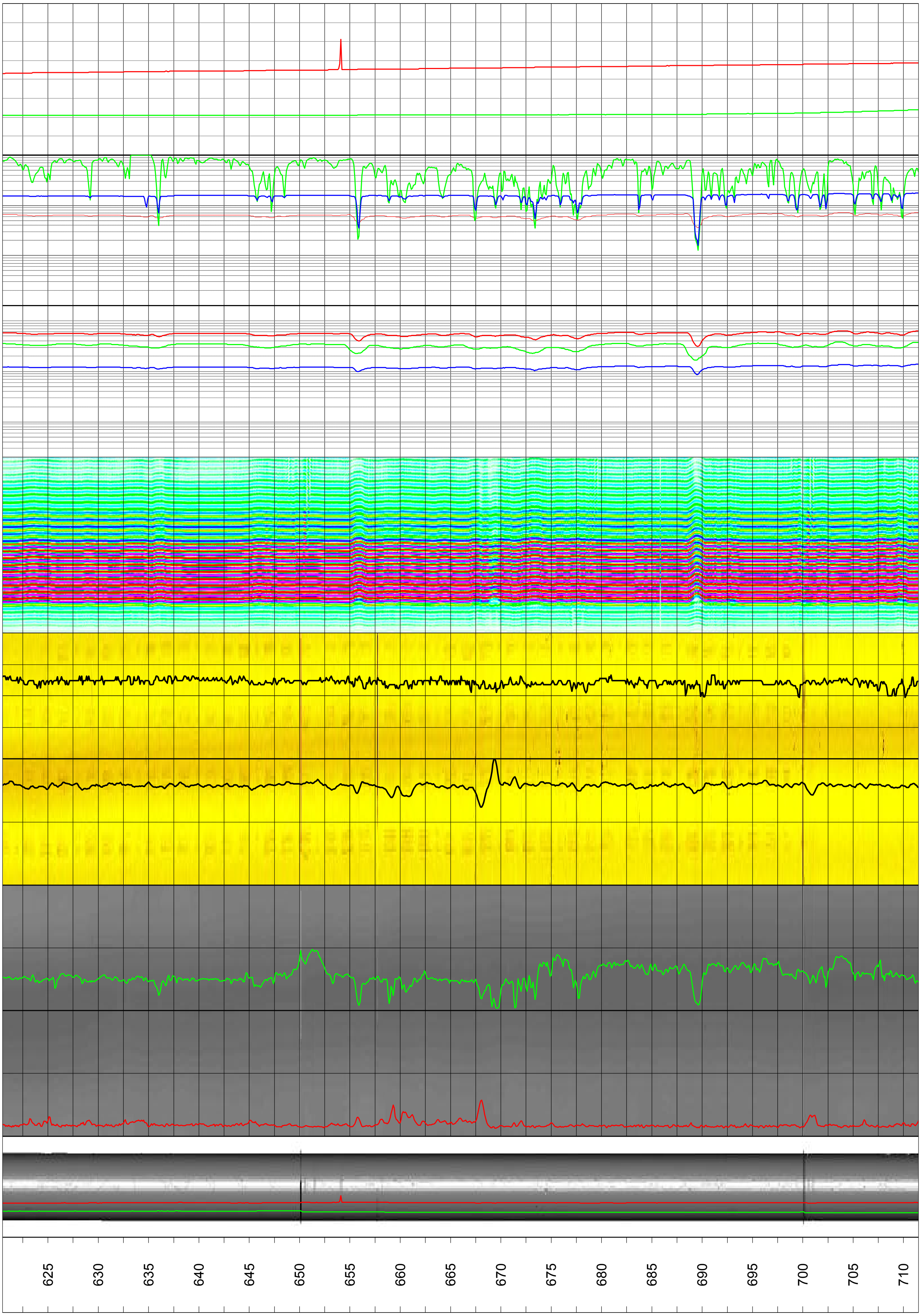
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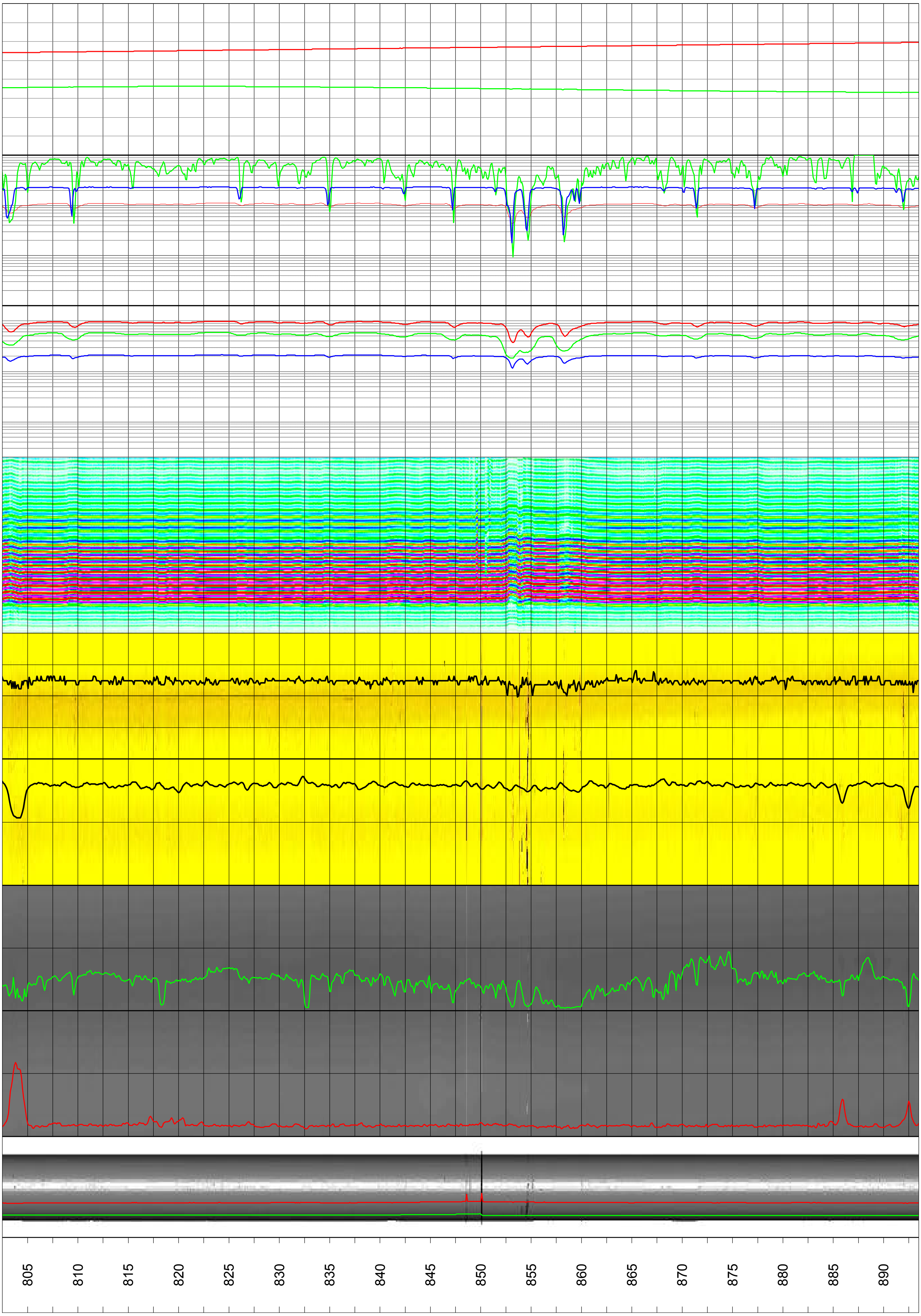
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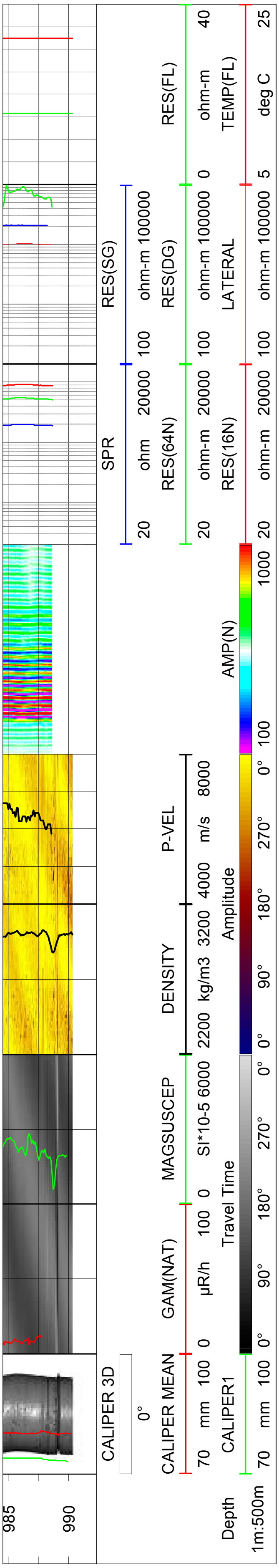
980


Depth
1m:500m
985
990
CALIPER 3D
0°
CALIPER MEAN
70 mm 100
CALIPER1
70 mm 100
GAM(NAT)
0 µR/h 100
MAGSUSCEP
0 SI*10-5 6000
Travel Time
0° 90° 180° 270° 0°
DENSITY
2200 kg/m3 3200
P-VEL
4000 m/s 8000
Amplitude
0° 90° 180° 270° 0°
AMP(N)
100 1000
SPR
20 ohm 20000
RES(64N)
20 ohm-m 20000
RES(16N)
20 ohm-m 20000
RES(SG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
RES(FL)
0 ohm-m 40
TEMP(FL)
5 deg C 25

Appendix 2

Borehole HLX36. Drawing no. 2.1. Borehole logs

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

Northing: 6366172.935m Easting: 1546558.452m Elevation: 15.558m, RHB70

Diameter:	140mm
Reaming Diameter:	190mm
Outer Casing:	168mm
Inner Casing:	160mm
Casing Length:	6.03m
Borehole Length:	199.80m
Cone:	
Inclination at ground surface:	-59.30°
Azimuth:	270.61°
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9139	mm
DENSITY	Gamma-gamma density	9139	kg/m³
RES(SG)	Focused guard log resistivity, 128 cm	9139	ohm-m
GAM(NAT)	Natural gamma	9072	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
RADIUS	360 degrees orientated acoustic radius	HiRAT	mm
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	8144	ohm-m
RES(64N)	Normal resistivity 64 inch	8144	ohm-m
LATERAL	Lateral resistivity	8144	ohm-m
SPR	Single point resistivity	8144	ohm
SP	Self Potential	8144	V

Rev.	Date	Drawn by	Control	Approved
0	2006-07-18	JRI	UTN	UTN

Job 547310A **Scale** 1:500

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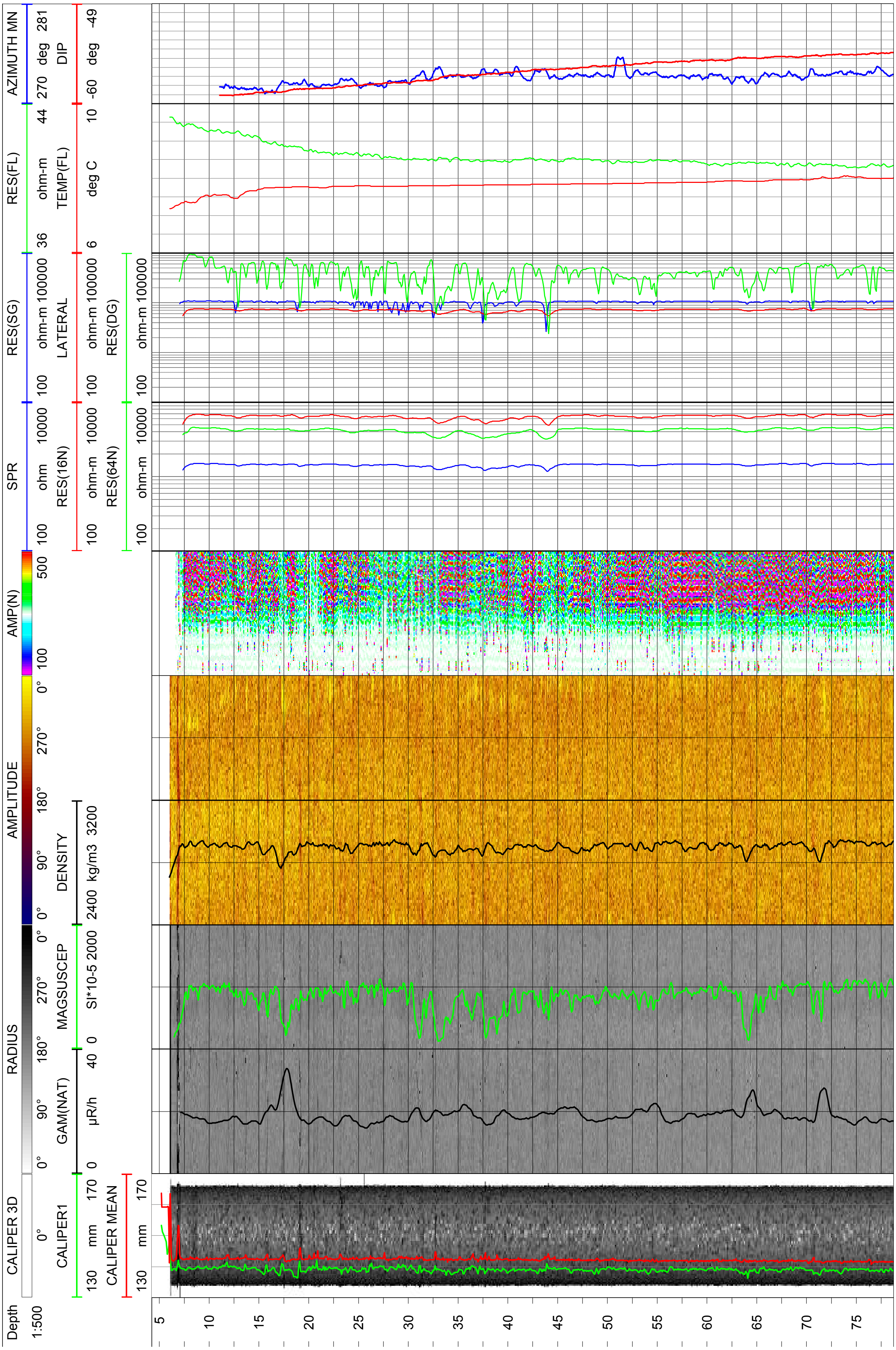
SKB geophysical borehole logging
Borehole HLX36

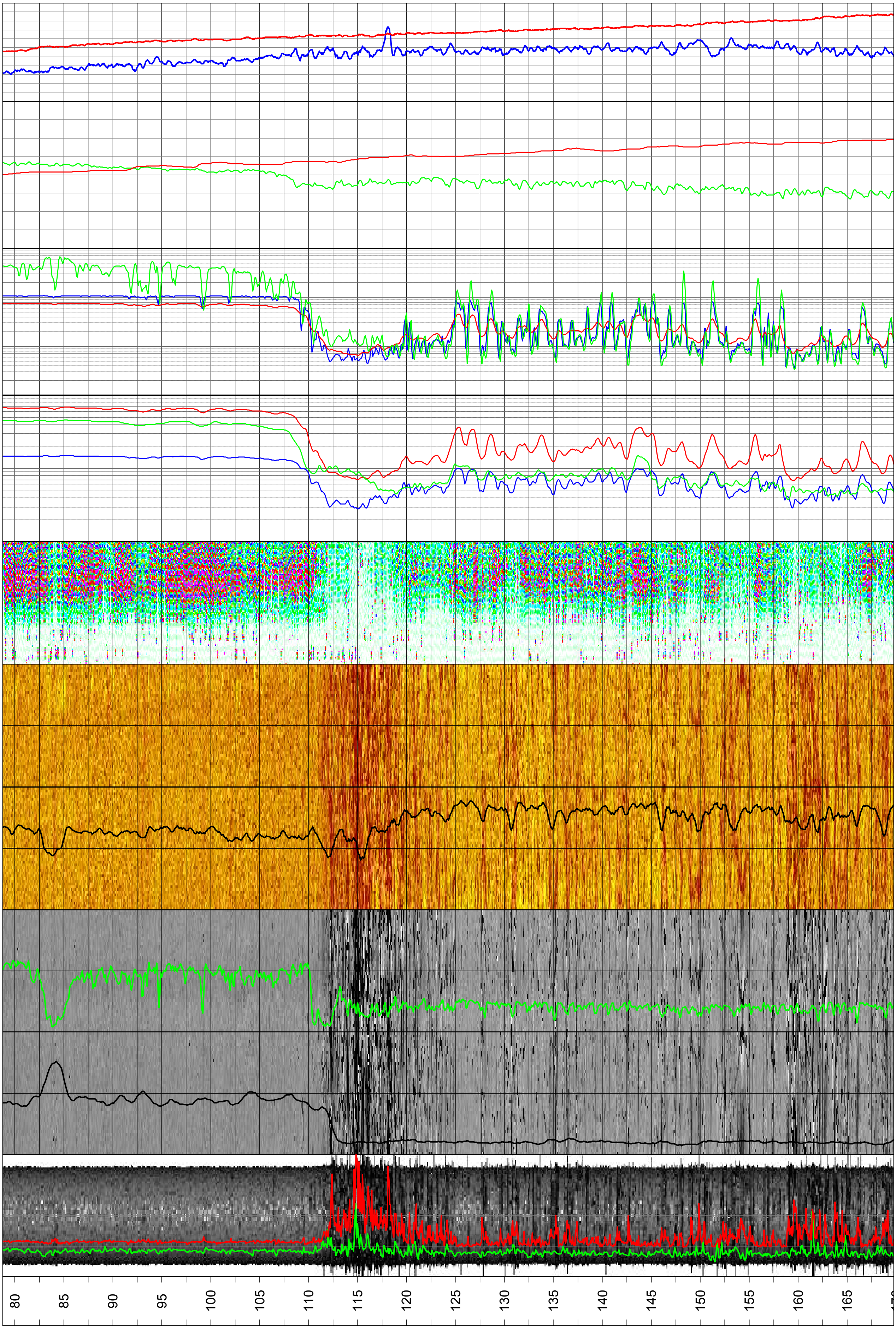
Presentation

Filename:
HLX36_Presentation.wcl

Drawing no.:
2.1



Depth
1:500
CALIPER 3D
0°
CALIPER1
130 mm 170
CALIPER MEAN
130 mm 170
RADIUS
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 40
MAGSUSCEP
0 SI*10-5 2000
AMPLITUDE
0° 90° 180° 270° 0°
DENSITY
2400 kg/m3 3200
AMP(N)
100 500
SPR
100 ohm 10000
RES(16N)
100 ohm-m 10000
RES(64N)
100 ohm-m 10000
RES(SG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(FL)
36 ohm-m 44
TEMP(FL)
6 deg C 10
AZIMUTH MN
270 deg 281
DIP
-60 deg -49
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75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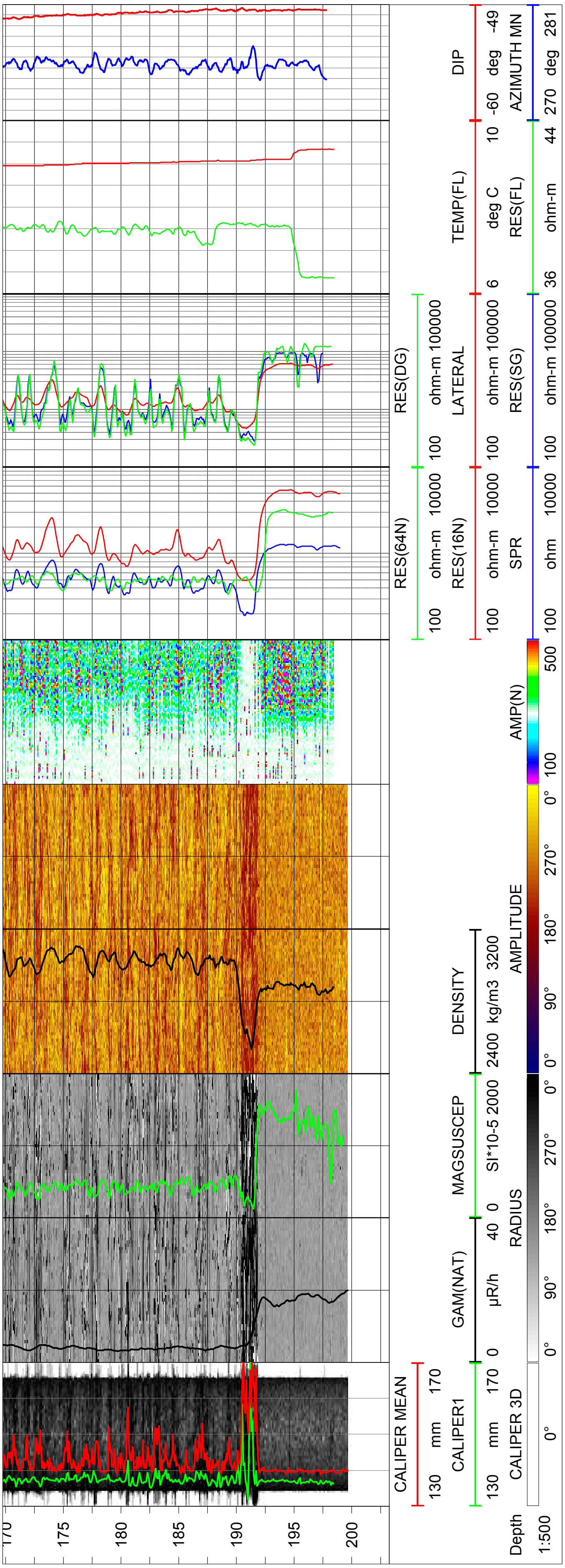
Depth
1:500
170
175
180
185
190
195
200
CALIPER MEAN 130 mm 170
CALIPER1 130 mm 170
CALIPER 3D 0°
GAM(NAT) 0 µR/h 40
RADIUS 0° 90° 180° 270° 0°
MAGSUSCEP 0 SI*10-5 2000
DENSITY 2400 kg/m3 3200
AMPLITUDE 0° 90° 180° 270° 0°
AMP(N) 100 500
RES(64N) 100 ohm-m 10000
RES(16N) 100 ohm-m 10000
SPR 100 ohm 10000
RES(DG) 100 ohm-m 100000
LATERAL 100 ohm-m 100000
RES(SG) 100 ohm-m 100000
TEMP(FL) 6 deg C 10
RES(FL) 36 ohm-m 44
DIP -60 deg -49
AZIMUTH MN 270 deg 281

Appendix 3

Borehole HLX37. Drawing no. 3.1. Borehole logs

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

Northing: 6366183.660m Easting: 1546406.214m Elevation: 15.188m

Diameter:	140mm
Reaming Diameter:	190mm
Outer Casing:	168mm
Inner Casing:	160mm
Borehole Length:	199.8m
Cone:	
Inclination at ground surface:	-59.246°
Azimuth:	86.182°
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9030/9139	mm
DENSITY	Gamma-gamma density	9030/9139	kg/m³
RES(MG)	Focused guard log resistivity, 140cm	9030	ohm-m
GAM(NAT)	Natural gamma	9072	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	8144	ohm-m
RES(64N)	Normal resistivity 64 inch	8144	ohm-m
LATERAL	Lateral resistivity	8144	ohm-m
SPR	Single point resistivity	8144	ohm
SP	Self Potential	8144	mV
RES(SG)	Focused guard log resistivity, 128 cm	9139	ohm-m

Rev.	Date	Drawn by	Control	Approved
0	2006-03-30	JRI	UTN	UTN

Job 547310A **Scale** 1:500

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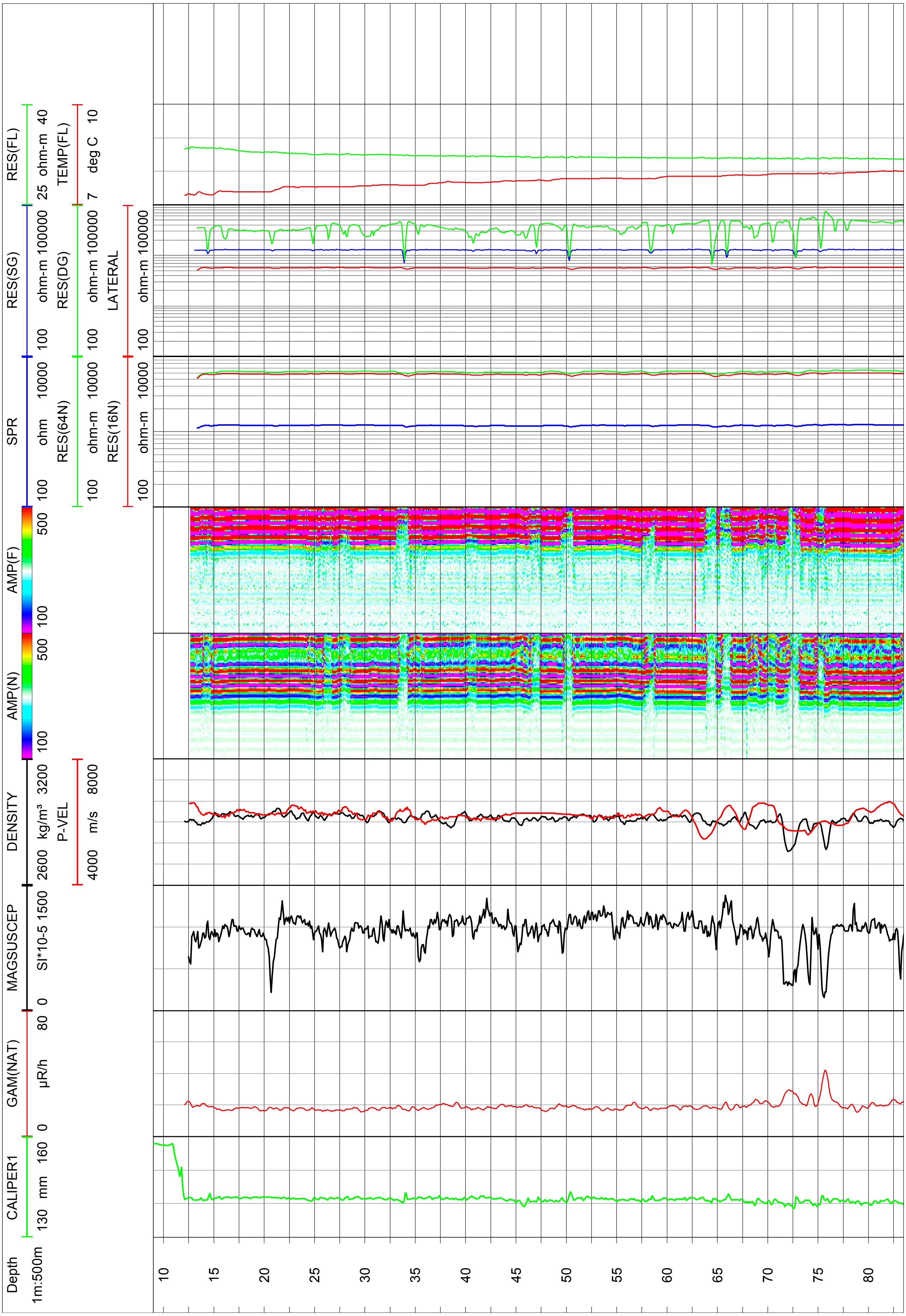
SKB geophysical borehole logging
Borehole HLX37

Presentation

Filename: HLX37_Presentation.wcl

Drawing no.: **3.1**


Depth
1m:500m
CALIPER1
130 mm 160
GAM(NAT)
0 µR/h 80
MAGSUSCEP
0 SI*10-5 1500
DENSITY
2600 kg/m³ 3200
P-VEL
4000 m/s 8000
AMP(N)
100 500
AMP(F)
100 500
SPR
100 ohm 10000
RES(64N)
100 ohm-m 10000
RES(16N)
100 ohm-m 10000
RES(SG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
RES(FL)
25 ohm-m 40
TEMP(FL)
7 deg C 10
10
15
20
25
30
35
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45
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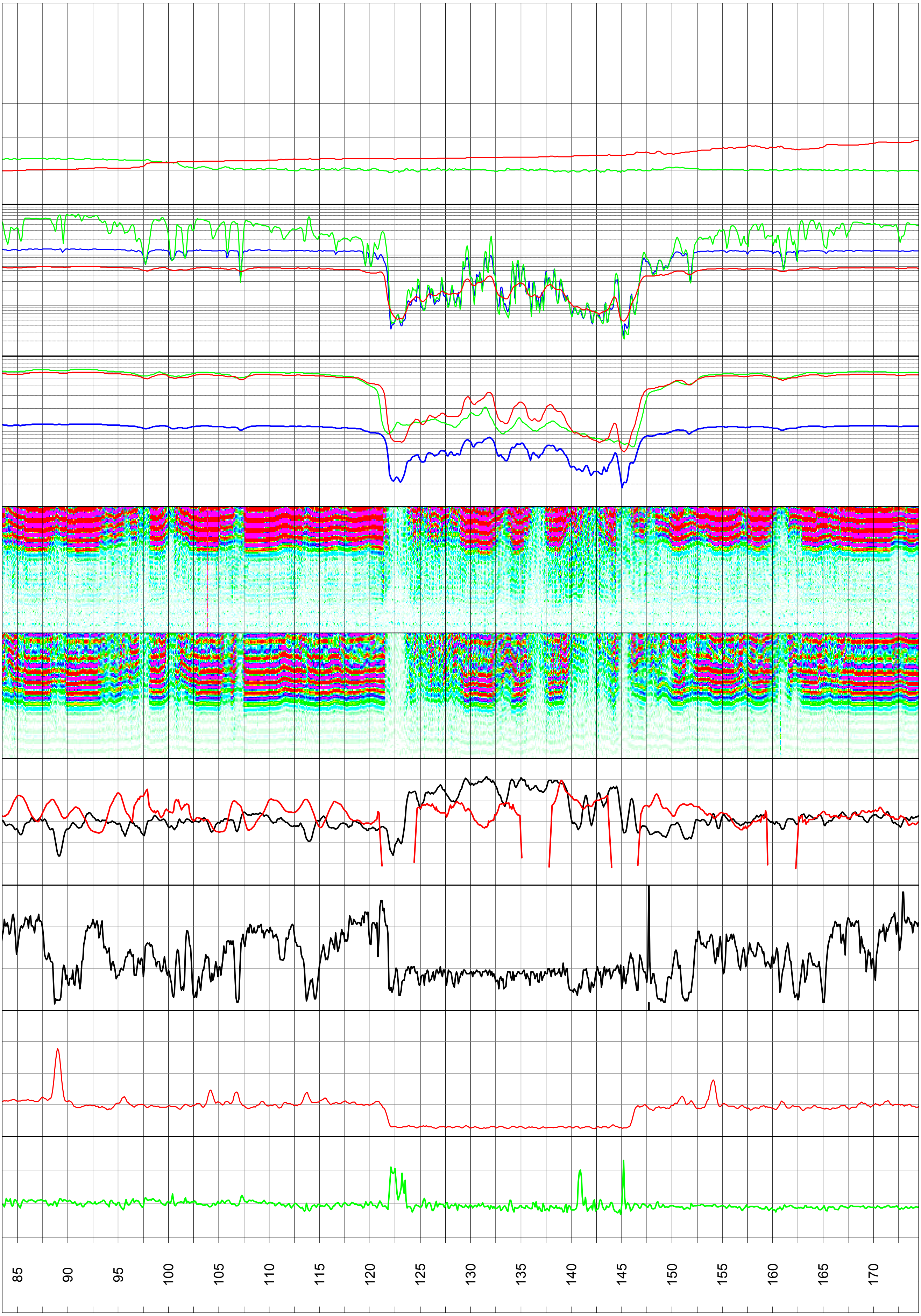
60
65
70
75
80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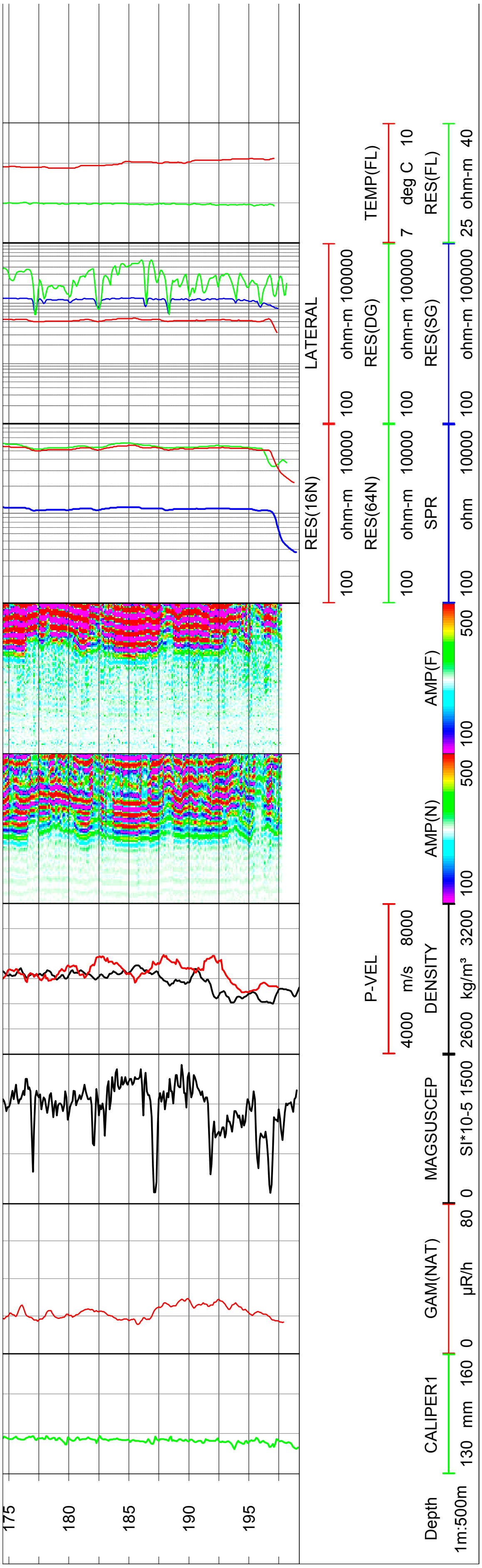
Depth
1m:500m
175
180
185
190
195
CALIPER1
130 mm 160
GAM(NAT)
0 µR/h 80
MAGSUSCEP
0 SI*10-5 1500
P-VEL
4000 m/s 8000
DENSITY
2600 kg/m³ 3200
AMP(N)
100 500
AMP(F)
100 500
RES(16N)
100 ohm-m 10000
RES(64N)
100 ohm-m 10000
SPR
100 ohm 10000
LATERAL
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(SG)
100 ohm-m 100000
TEMP(FL)
7 deg C 10
RES(FL)
25 ohm-m 40