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Oskarshamn site investigation

Geophysical borehole logging in boreholes KLX04, HLX26, HLX27 and HLX28

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November 2004

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Abstract

Geophysical borehole logging has been performed in boreholes KLX04, HLX26, HLX27 and HLX28 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 KLX04 was recorded from 100 m to 1,000 m. HLX26 was recorded from 0 to 151 m, HLX27 was recorded from 0 to 164 m and HLX28 was recorded from 0 to 154 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 4.

Sammanfattning

Geofysisk borrhålsloggning har genomförts i borrhålen KLX04, HLX26, HLX27 och HLX28 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 KLX04 från 100 m till 1 000 m. HLX26 mättes från 0 till 151 m, HLX27 mättes från 0 till 164 m och HLX28 mättes från 0 till 154 m.

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

Processerade loggar presenteras i Appendix 1 till 4.

Contents

1 Introduction

This document reports the results gained by the geophysical borehole logging in boreholes KLX04, HLX26, HLX27 and HLX28, 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 400-04-061 (SKB internal controlling document) for borehole KLX04 and activity plan AP PS 400-04-097 for boreholes HLX26, HLX27 and HLX28. In Table 1-1 controlling documents for performing this activity are listed.

All measurements were conducted by RAMBØLL during the period October 20 to 22, 2004. All boreholes were recorded from Top Of Casing (TOC) to the bottom of the borehole. The technical data from the boreholes are shown in Table 1-2. The locations of the boreholes are 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 KLX04	AP PS 400-04-061	1.0
Geofysisk borrhålsloggning i HLX26, HLX27 and HLX28	AP PS 400-04-097	1.0
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 boreholes KLX04 and percussion drilled boreholes HLX26, HLX27 and HLX28.

Boreholes parameter	KLX04	HLX26	HLX27	HLX28
Co-ordinates (RT90)	X: 6367077.188 Y: 1548171.937	X: 6365278.707 Y: 1548600.525	X: 6365605.073 Y: 1547882.686	X: 6365861.704 Y: 1546834.473
Elevation (RHB70)	Z: 24.089	Z: 6.478	Z: 8.248	Z: 13.424
Inclination (from horizontal)	–84.6826°	–60.420°	–59.412°	–59.485°
Azimuth	0.109°	12.372°	190.999°	201.375°
Length	Ca 1,000 m	151.2 m	164.70 m	154.2 m
Borehole diameter	∅ 76 mm (100.30–ca 1,000 m)	∅ 190 mm (0–9.1 m)	∅ 190 mm (0–6.1 m)	∅ 190 mm (0–6.1 m)
		∅ 137 mm (9.1–151.2 m)	∅ 137 mm (6.1–164.70 m)	∅ 136 mm (6.1–154.2 m)
Casing	∅ 208/200 mm (0–12.240 m)	∅ 168/160 mm (0–8.94 m)	∅ 168/160 mm (0–5.94 m)	∅ 168/160 mm (0–5.94 m)
	∅ 196 mm (12.240–100.300 m) ∅ 76 mm (100.30–ca 1,000 m)	∅ 168/147 mm foderrör (8.94–9.03 m)	∅ 168/147 mm foderrör (5.94–6.03 m)	∅ 168/147 mm foderrör (5.94–6.03 m)
Cleaning level	Level 2	Level 1	Level 1	Level 1

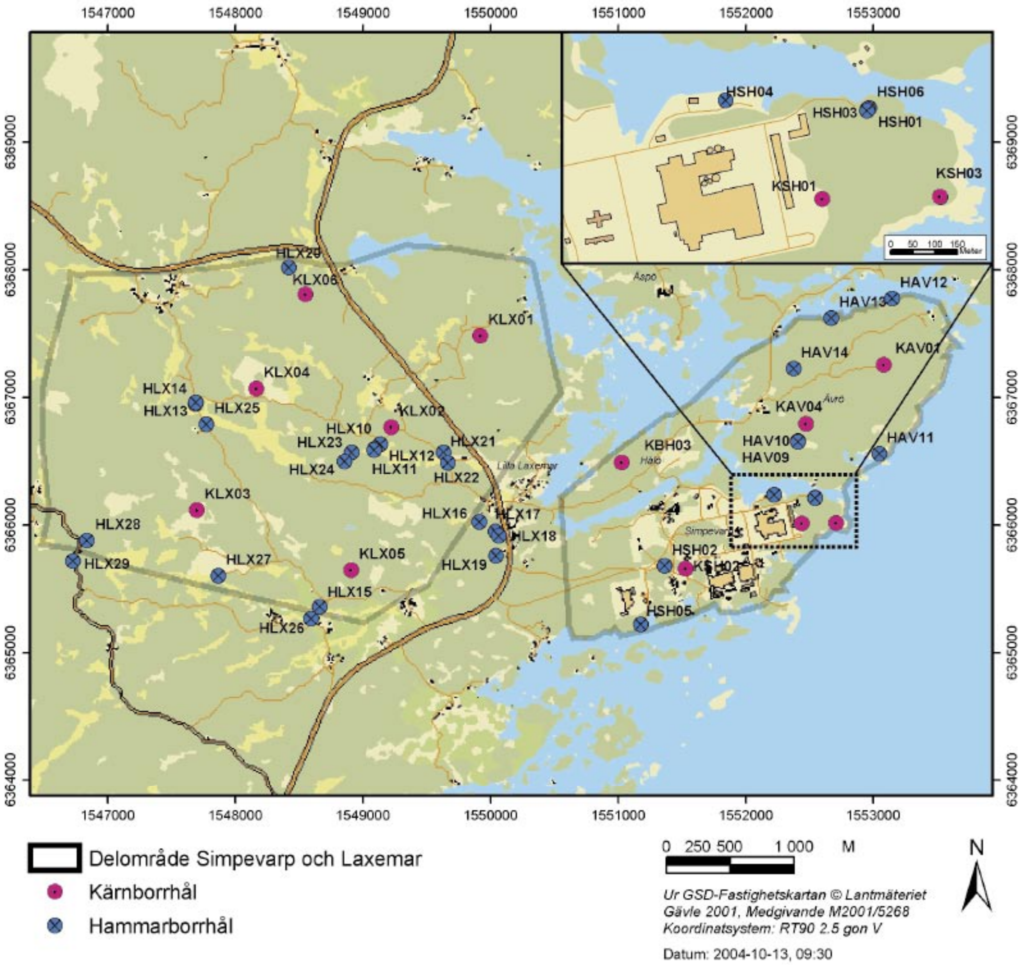

Figure 1-1. *General overview over the Simpevarp and Laxemar subareas.*

The delivered raw and processed data have been inserted in the database of SKB (SICADA). The SICADA field note reference to the present activity is presented in Table 1-3.

Table 1-3. Data references.

Subactivity	Database	Identity number
Geofysisk borrhålsloggning i KLX04	SICADA	Field note 430
Geofysisk borrhålsloggning i HLX26, HLX27, HLX28	SICADA	Field note 524

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, KLX04.

This field report describes the equipment used as well the measurement procedures. Geophysical borehole logging data is presented in graphs as a function of depth in drawing no 1.1 for borehole KLX04 in Appendix 1, drawing no 2.1 for borehole HLX26 in Appendix 2, drawing no 3.1 for borehole HLX27 in Appendix 3 and drawing no 4.1 for borehole HLX28 in Appendix 4.

3 Equipment

The geophysical borehole logging program in all boreholes was performed with 6 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 KLX04, HLX26, HLX27 and HLX28.

Tool	Recorded logs	Dimension	Source detector spacing and type	Tool position in borehole
Century 8044 Normal resistivity, fluid temperature and fluid resistivity.	Normal resistivity (16 and 64 inch), single point resistance, fluid resistivity, fluid temperature and natural gamma.	237·5.3 cm		
Century 8622 Magnetic susceptibility.	Magnetic susceptibility, natural gamma.	203·4.1 cm		
Century 9030 Gamma density.	Gamma density, natural gamma, 140 cm focused guard log resistivity, 10 cm 1-arm calliper.	307·5.6 cm	20.3 cm 125 mCi Cs137	Sidewall. Gamma source focused.
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.	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 October 20 to 22, 2004. All relevant logging events were described in the daily report sheets delivered to SICADA field notes no 430 and 524.

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. The cleaning was done according to SKB cleaning level 2 (SKB internal controlling document SKB MD 600.004) before arriving at the site. Furthermore, all equipment was wiped with alcohol before it was lowered into the boreholes.

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 maximum10 cm sample interval. The speed of the logging tools was in general 10 m/min for the used log runs.

4.2 Nonconformities

The calculated values for the Caliper Mean log were not reliable for HLX28. The Caliper Mean log and Caliper 3D is therefore not included in the presentation for this borehole.

5 Results

5.1 Presentation

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

Logs presented in drawings no 1.1 in Appendix 1, no 2.1 in Appendix 2, no 3.1 in Appendix 3 and in no 4.1 in Appendix 4 are presented in Table 5-1.

Table 5-1. Logs presented in drawings no 1.1–4.1 in Appendices 1 - 4.

Log	Log name short	Unit	Tool
Fluid temperature	TEMP(FL)	deg C	8044
Fluid resistivity	RES(FL)	ohm-m	8044
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/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	–
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 acoustical televiewer, the fluid temperature, fluid velocity and the internal travel time in the acoustical 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.

Latitude: 57 deg, 25 min, 04 sec
Longitude: 16 deg, 35 min, 57 sec
Elevation: 0.00 km
Date of Interest: 30/09/2004
Declination = 3° 15´ E

5.4 Borehole KLX04

In order to obtain an exact depth calibration in borehole KLX04, 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.

Table 5-3. The reference track marks in the borehole and the recorded track marks form the HiRAT in borehole KLX04.

Reference mark	HIRAT recorded
110.00	110
150.00	150.025
200.00	200.064
250.00	250.168
300.00	300.224
349.00	349.296
400.00	400.4
450.00	450.465
500.00	500.576
550.00	550.616
600.00	600.72
650.00	650.808
700.00	700.873
750.00	751
800.00	801.032
899.00	900.121
950	951.248

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 KLX04, between all logruns, the obtained reference mark correlation is transferred to the other logs.

The complete log suite for borehole KLX04 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.

5.5 Borehole HLX26

Using the bottom of the casing and the natural gamma from the 8044 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.

Table 5-4. Gamma events in borehole HLX26.

Events	Depths
Top event	35.8
Bottom event	145.8

The complete log suite for borehole HLX26 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.

5.6 Borehole HLX27

Using the bottom of the casing and the natural gamma from the 8044 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.

Table 5-5. Gamma events in borehole HLX27.

Events	Depths
Top event	24.54
Bottom event	133.96

The complete log suite for borehole HLX27 is presented as composite log sheet in drawing no 3.1 in Appendix 3. The logs presented in drawing no 3.1 are listed in Table 5-1.

5.7 Borehole HLX28

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, and the shift correction value for the other tools is found. These values are shown in Table 5-6.

Table 5-6. Shift correction value in borehole HLX28.

Tool	Shift correction value
8044	0.52
8622	0.30
9030	0.28
9072	0.32
9310	0.38
HiRAT	0

The complete log suite for borehole HLX28 is presented as composite log sheet in drawing no 4.1 in Appendix 4. The logs presented in drawing no 4.1 are listed in Table 5-1.

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. The SICADA reference to the present activity is field notes no 430 and 524.

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
KLX04	8044	Down	KLX04_10-20-04_13-19_8044C_.1_17.20_1001.30_ORIG.log	Start Depth: 17.2 m. End Depth: 1,001.3 m.
KLX04	8622	Up	KLX04_10-20-04_20-23_8622C_.1_54.80_993.10_ORIG.log	Start Depth: 993.1 m. End Depth: 54.8 m.
KLX04	9030	Up	KLX04_10-21-04_11-44_9030CA_.1_81.40_993.30_ORIG.log	Start Depth: 993.3 m. End Depth: 81.4 m.
KLX04	9072	Up	KLX04_10-20-04_18-26_9072C_.1_34.50_993.60_ORIG.log	Start Depth: 993.6 m. End Depth: 34.5 m.
KLX04	9310	Up	KLX04_10-21-04_14-55_9310C2_.10_83.70_989.60_ORIG.log	Start Depth: 989.6 m. End Depth: 83.7 m.
KLX04	HiRAT	Up	KLX04_HiRAT_90_pixels_up_run23.HED	Start Depth: 570 m. End Depth: 0 m.
KLX04	HiRAT	Up	KLX04_HiRAT_90_pixels_up_run22.HED	Start Depth: 990 m. End Depth: 560 m.
HLX26	8044	Down	HLX26_10-22-04_09-59_8044C_.10_0.10_150.80_ORIG.log	Start Depth: 0.1 m. End Depth: 150.8 m.
HLX26	8622	Up	HLX26_10-22-04_12-14_8622C_.10_-0.30_150.50_ORIG.log	Start Depth: 150.5 m. End Depth: –0.3 m.
HLX26	9030	Up	HLX26_10-22-04_12-45_9030CA_.10_0.10_150.60_ORIG.log	Start Depth: 150.6 m. End Depth: 0.1 m.
HLX26	9072	Up	HLX26_10-22-04_11-14_9072C_.10_0.20_151.50_ORIG.log	Start Depth: 151.5 m. End Depth: 0.2 m.
HLX26	9310	Up	HLX26_10-22-04_11-44_9310C2_.10_3.30_149.70_ORIG.log	Start Depth: 149.7 m. End Depth: 3.3 m.
HLX26	HiRAT	Up	HLX26_HiRAT_90_pixels_up_run2.HED	Start Depth: 151 m. End Depth: 0 m.
HLX27	8044	Down	HLX27_10-21-04_18-17_8044C_.10_0.10_162.90_ORIG.log	Start Depth: 0.1 m. End Depth: 162.9 m.
HLX27	8622	Up	HLX27_10-21-04_21-48_8622C_.10_-0.10_163.00_ORIG.log	Start Depth: 163 m. End Depth: –0.1 m.
HLX27	9030	Up	HLX27_10-21-04_20-41_9030CA_.10_1.80_162.30_ORIG.log	Start Depth: 162.3 m. End Depth: 1.8 m.
HLX27	9072	Up	HLX27_10-21-04_21-20_9072C_.10_2.20_162.50_ORIG.log	Start Depth: 162.5 m. End Depth: 2.2 m.
HLX27	9310	Up	HLX27_10-21-04_19-40_9310C2_.10_1.80_161.50_ORIG.log	Start Depth: 161.5 m. End Depth: 1.8 m.

Borehole	Probe	Log direction	WellCAD File	Description
HLX27	HiRAT	Up	HLX27_HiRAT_90_pixels_up_run2.HED	Start Depth: 162 m. End Depth: 0 m.
HLX28	8044	Down	HLX28_10-22-04_13-40_8044C_.10_0.10_147.70_ORIG.log	Start Depth: 0.1 m. End Depth: 147.7 m.
HLX28	8622	Up	HLX28_10-22-04_16-32_8622C_.10_-0.40_146.20_ORIG.log	Start Depth: 146.2 m. End Depth: –0.4 m.
HLX28	9030	Up	HLX28_10-22-04_15-37_9030CA_.10_0.30_145.60_ORIG.log	Start Depth: 145.6 m. End Depth: 0.3 m.
HLX28	9072	Up	HLX28_10-22-04_16-06_9072C_.10_0.10_146.50_ORIG.log	Start Depth: 146.5 m. End Depth: 0.1 m.
HLX28	9310	Up	HLX28_10-22-04_14-59_9310C2_.10_-0.40_144.60_ORIG.log	Start Depth: 144.6 m. End Depth: –0.4 m.
HLX28	HiRAT	Up	HLX28_HiRAT_90_pixels_up_run2.HED	Start Depth: 140 m. End Depth: 0 m.

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KLX04	1.1	KLX04_Presentation.WCL
HLX26	2.1	HLX26_Presentation.WCL
HLX27	3.1	HLX27_Presentation.WCL
HLX28	4.1	HLX28_Presentation.WCL

Table 6-3. Data files in excel for each borehole. Files in SICADA format.

Sheet	Comment
“Borehole”_GP040 – Caliper logging.xls	
“Borehole”_GP041 – 3-D caliper.xls	Not included for borehole HLX28
“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	
“Borehole”_GP161 – Resistivity, focused 140 cm.xls	
“Borehole”_GP162 – Resistivity, focused 300 cm.xls	
“Borehole”_GP163 – Resistivity, lateral 1.6–0.1 m.xls	
“Borehole”_GP164 – Resistivity, normal 0.4 m (16 in).xls	
“Borehole”_GP175 – Fullwave sonic.xls	
“Borehole”_GP830 – Acoustic televiewer.xls	

Appendix 1

Borehole KLX04, drawing no 1.1, borehole logs

Borehole No. KLX04

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

Northing: 6367077.188m Easting: 1548171.937m Elevation: 24.089m, RHB70

Diameter:	76 mm
Reaming Diameter:	210mm
Outer Casing:	208mm
Inner Casing:	200mm
Borehole Length:	1000m
Cone:	
Inclination at ground surface:	-84.6826°
Azimuth:	0.109°
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	8044	deg C
RES(FL)	Fluid resistivity	8044	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	2004-11-17	JRI	UTN	UTN

Job	Scale
360210A	1:500

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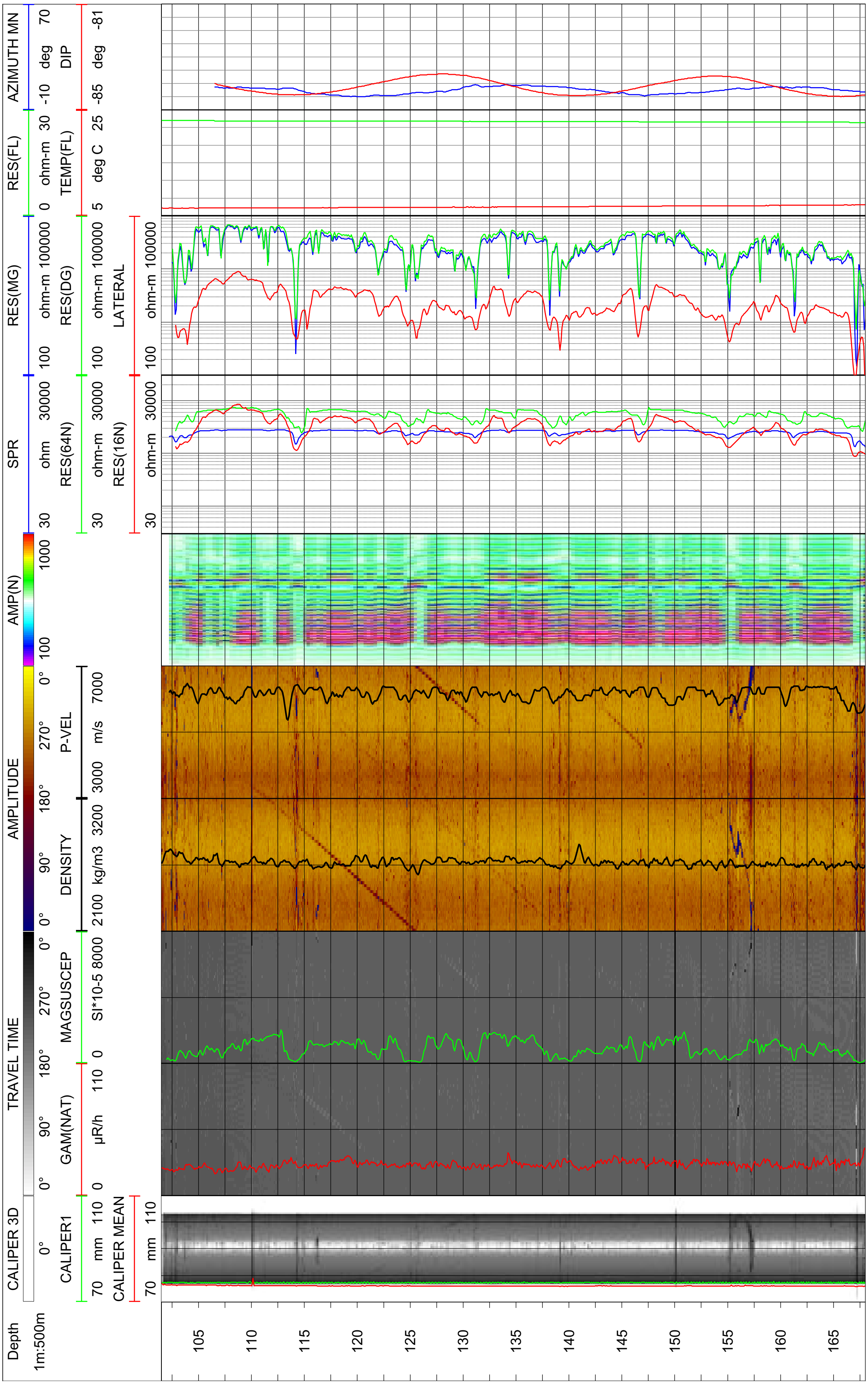
SKB geophysical borehole logging
Borehole KLX04

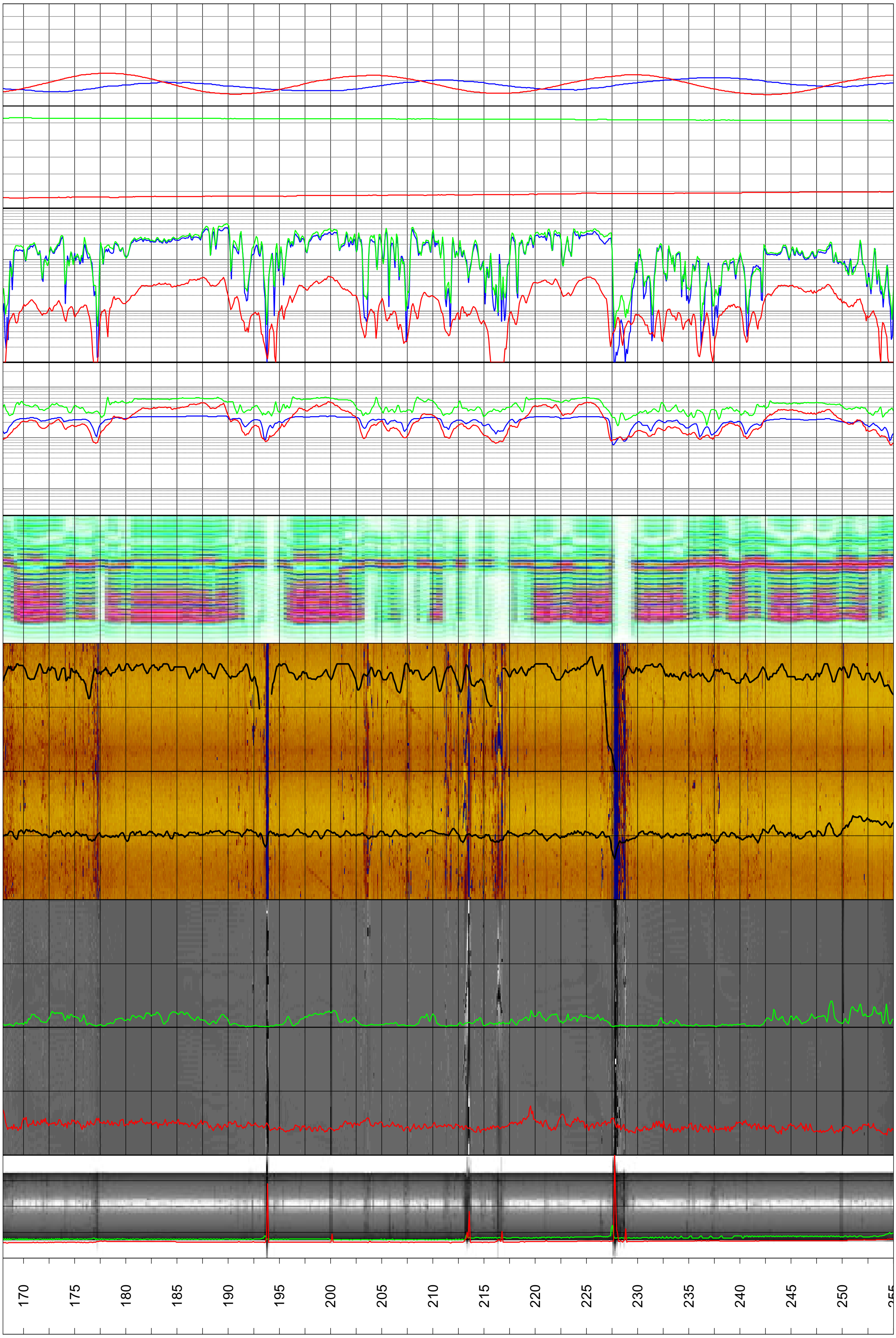
Presentation

Filename:
KLX04_Presentation.wcl

Drawing no.:
1.1



Depth
1m:500m
CALIPER 3D
0°
CALIPER1
70 mm 110
CALIPER MEAN
70 mm 110
TRAVEL TIME
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 110
MAGSUSCEP
0 SI*10-5 8000
AMPLITUDE
0° 90° 180° 270° 0°
DENSITY
2100 kg/m3 3200
P-VEL
3000 m/s 7000
AMP(N)
100 1000
SPR
30 ohm 30000
RES(64N)
30 ohm-m 30000
RES(16N)
30 ohm-m 30000
RES(MG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
RES(FL)
0 ohm-m 30
TEMP(FL)
5 deg C 25
AZIMUTH MN
-10 deg 70
DIP
-85 deg -81
105
110
115
120
125
130
135
140
145
150
155
160
165



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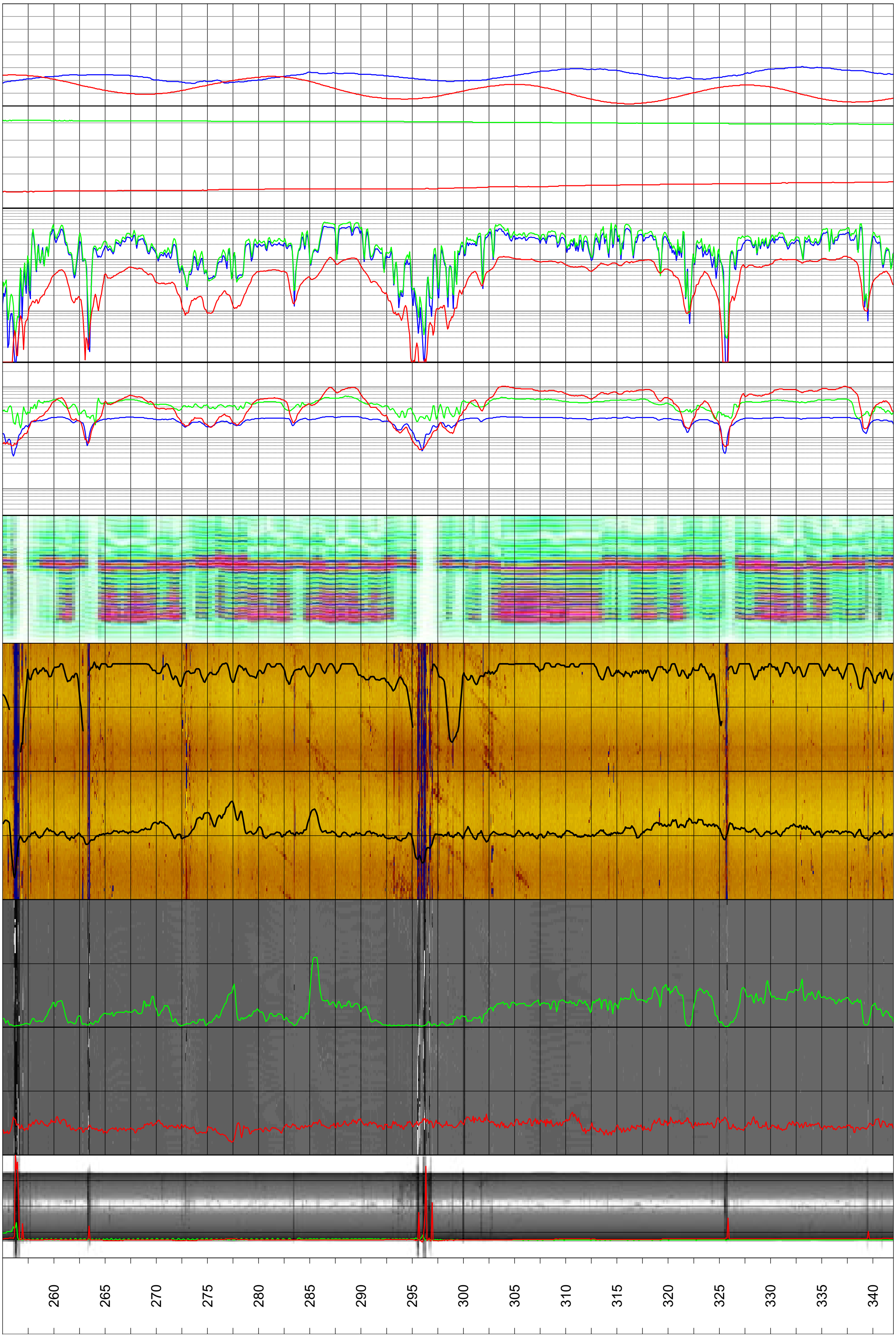
175
180
185
190
195
200
205
210
215
220
225
230
235
240
245
250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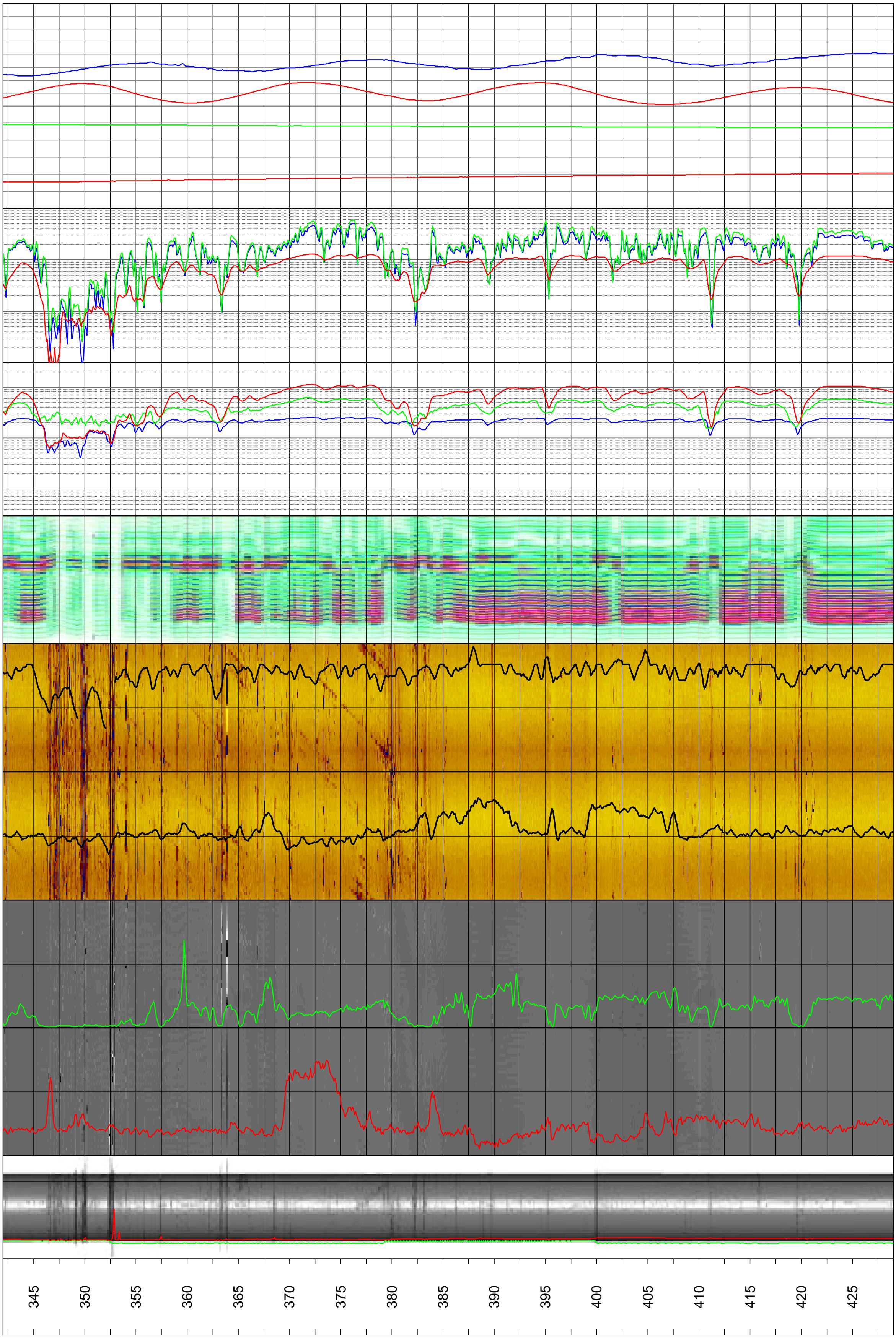
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420
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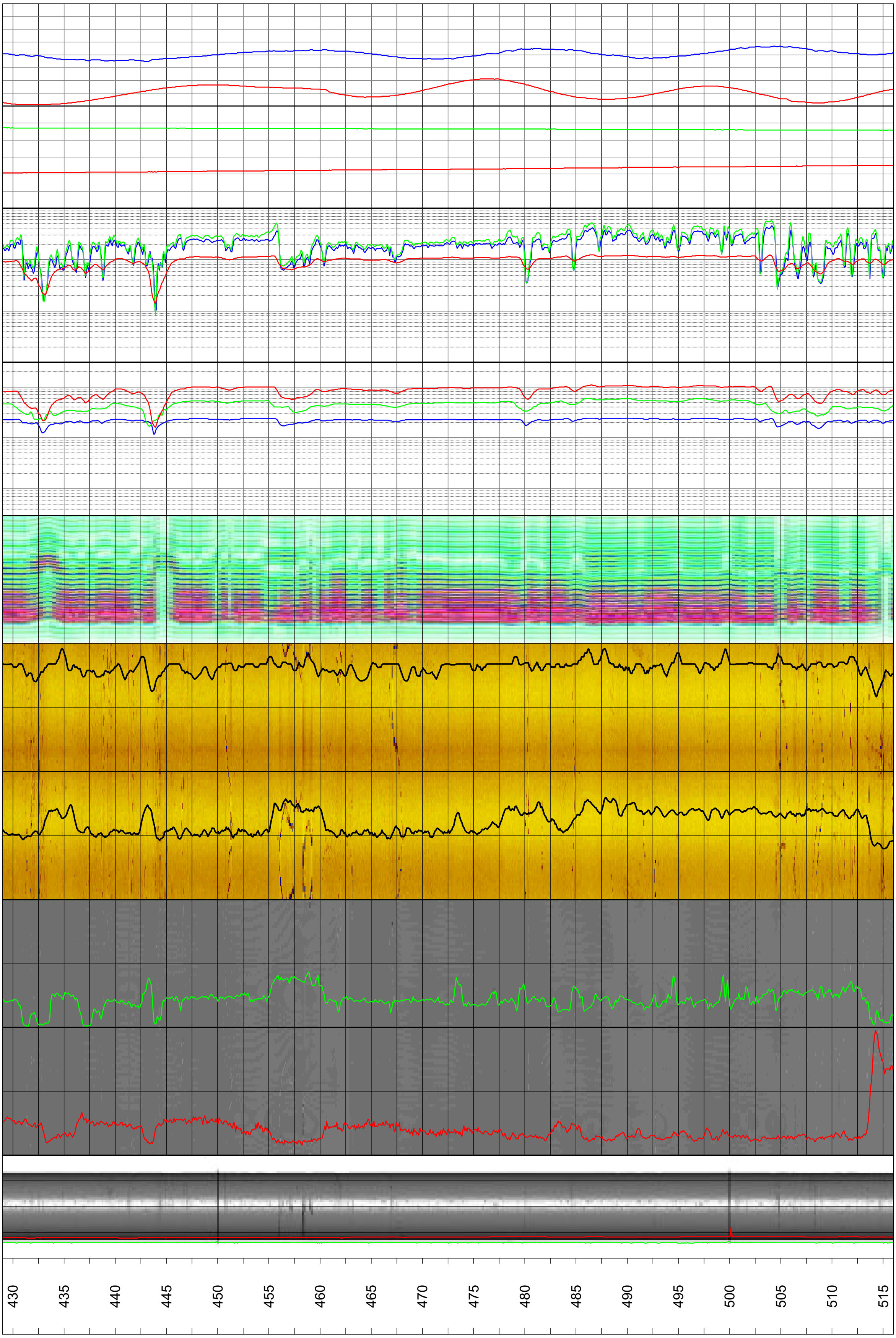
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445
450
455
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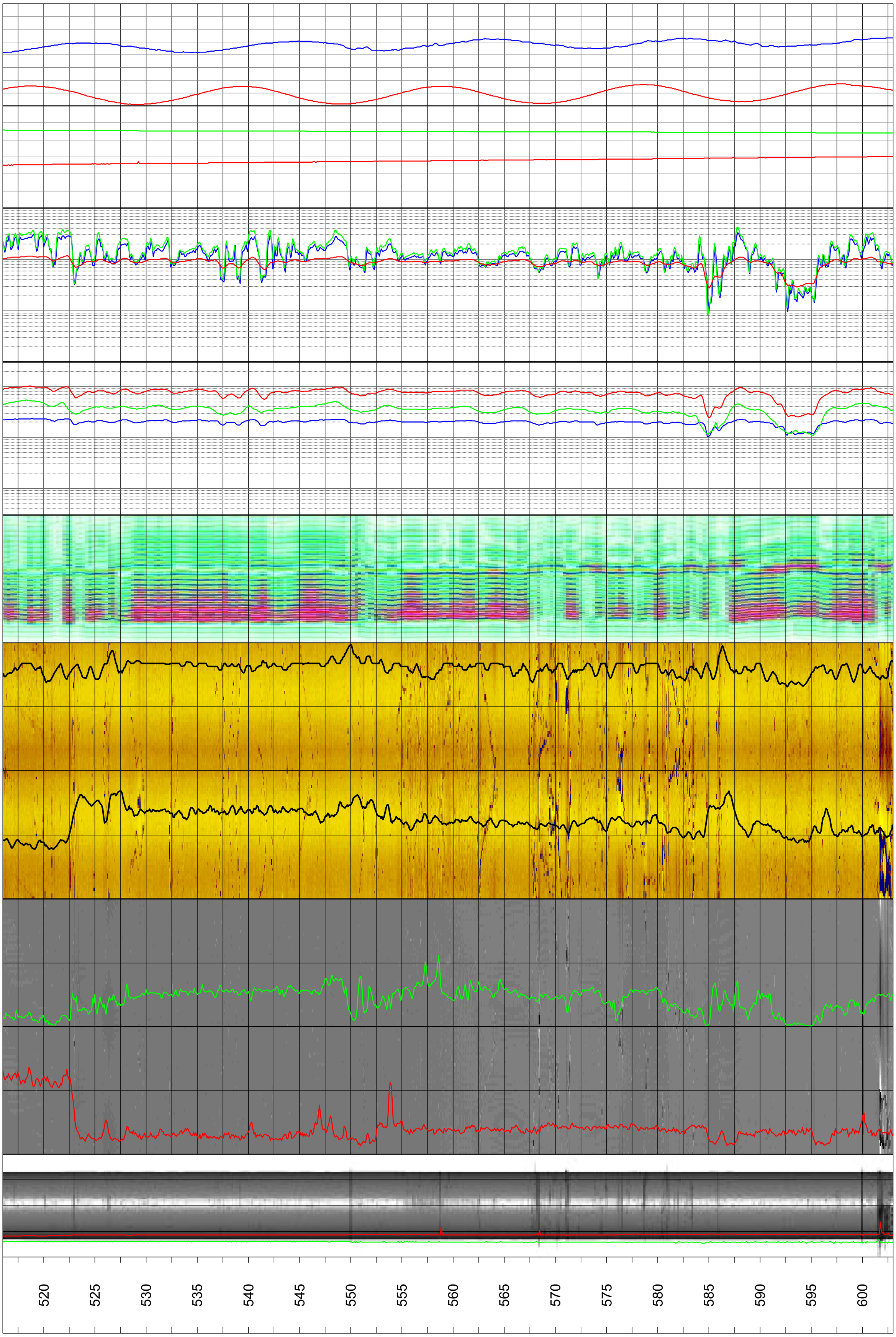
480
485
490
495
500
505
510
515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585
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595
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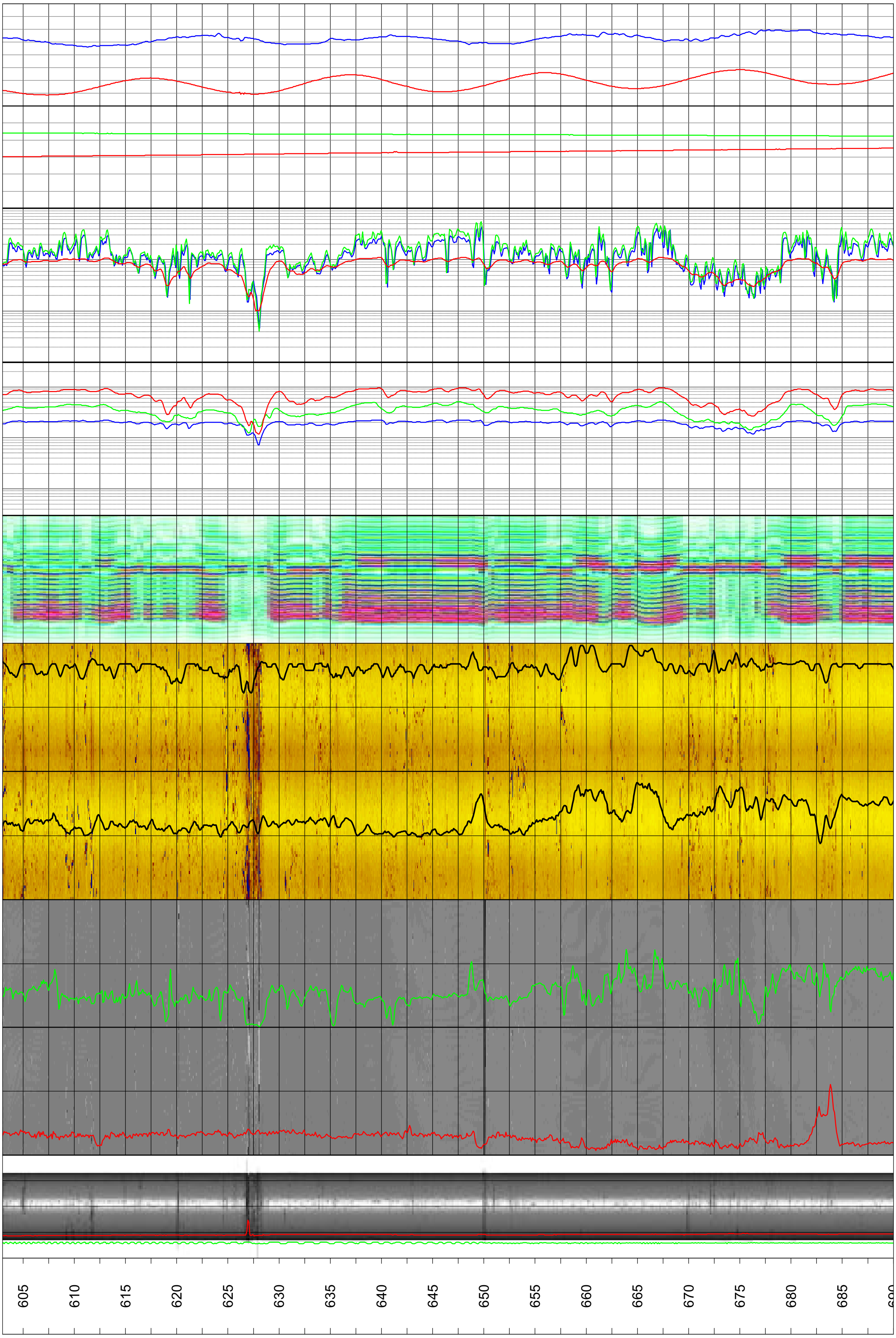
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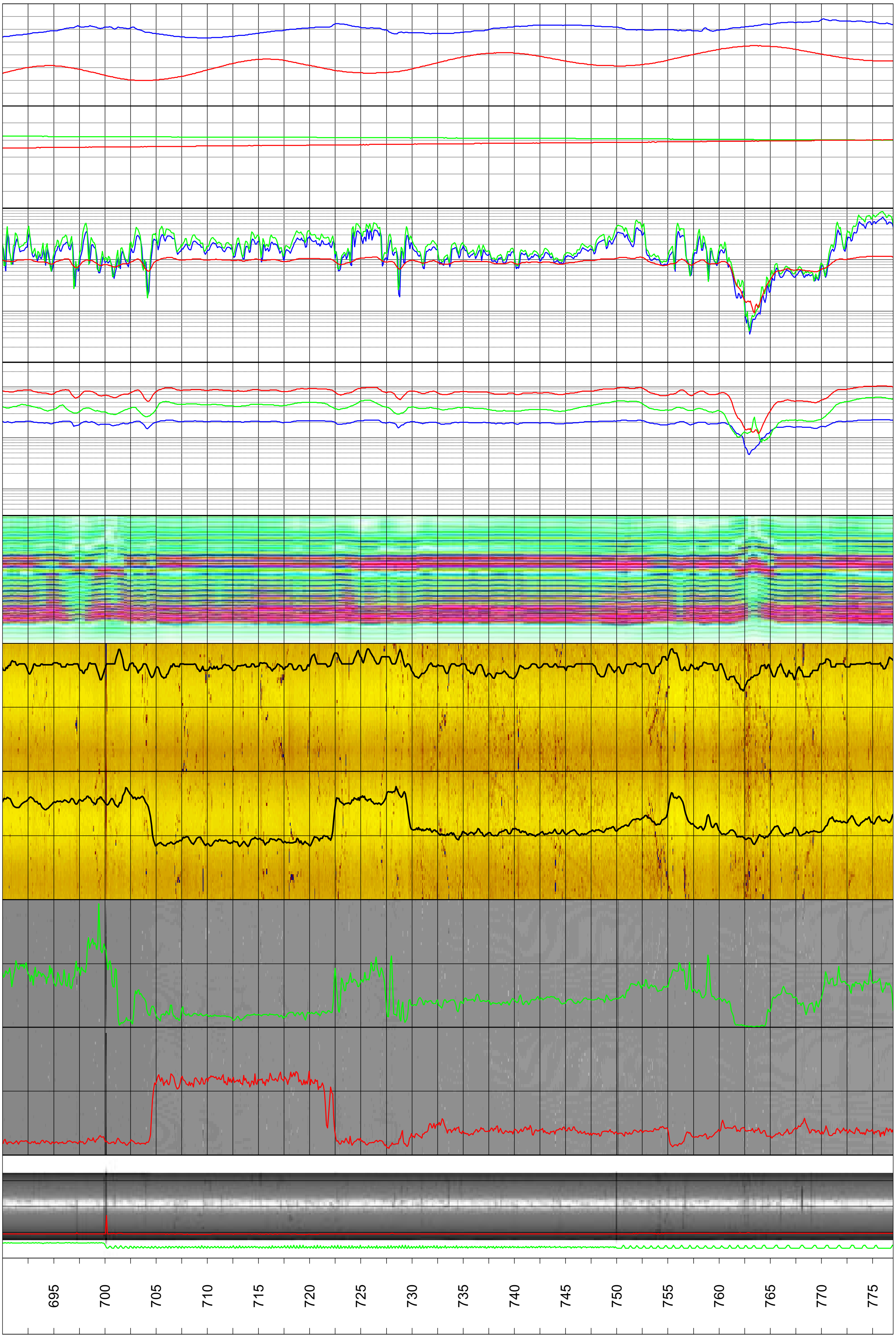
610
615
620
625
630
635
640
645
650
655
660
665
670
675
680
685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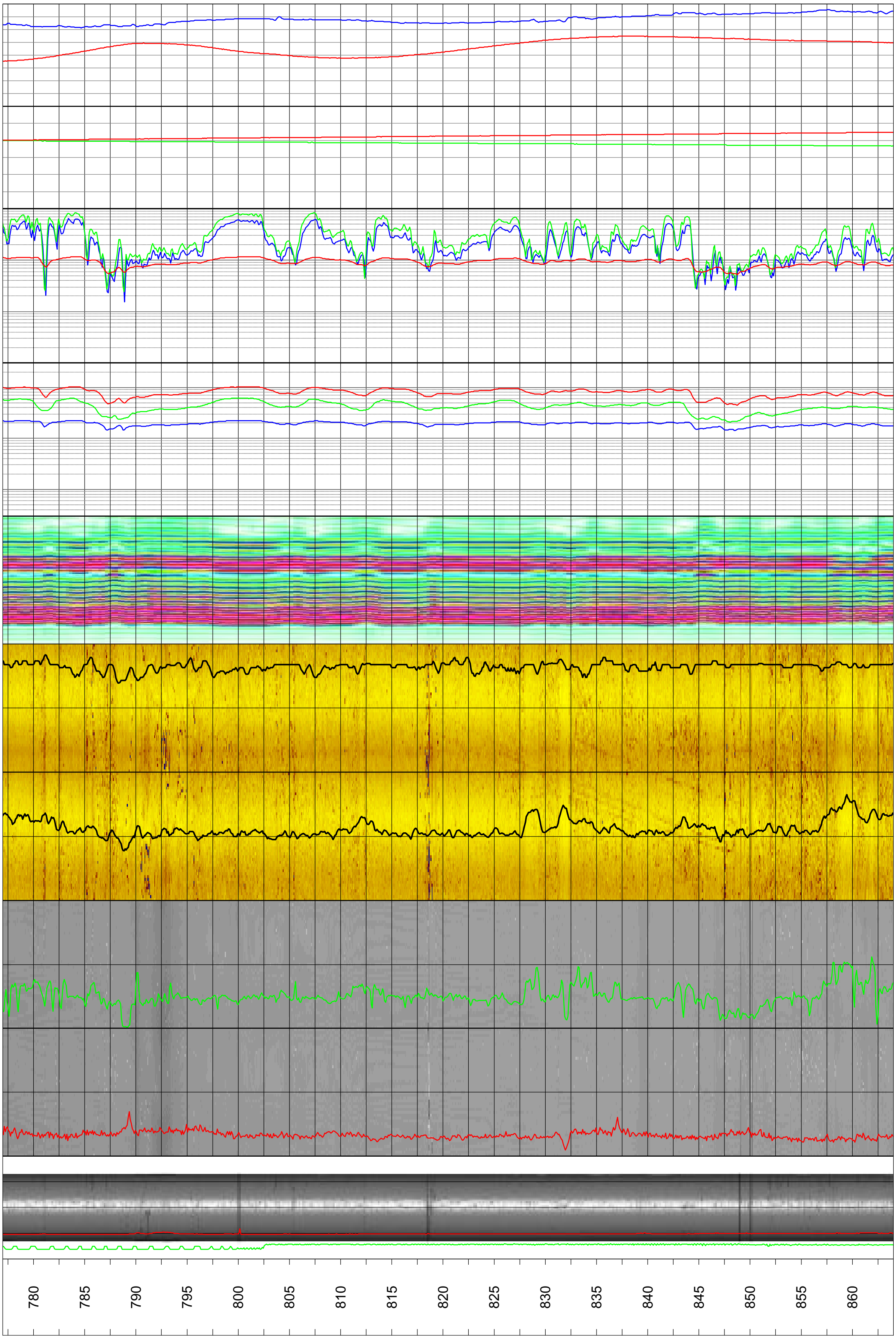
700
705
710
715
720
725
730
735
740
745
750
755
760
765
770
775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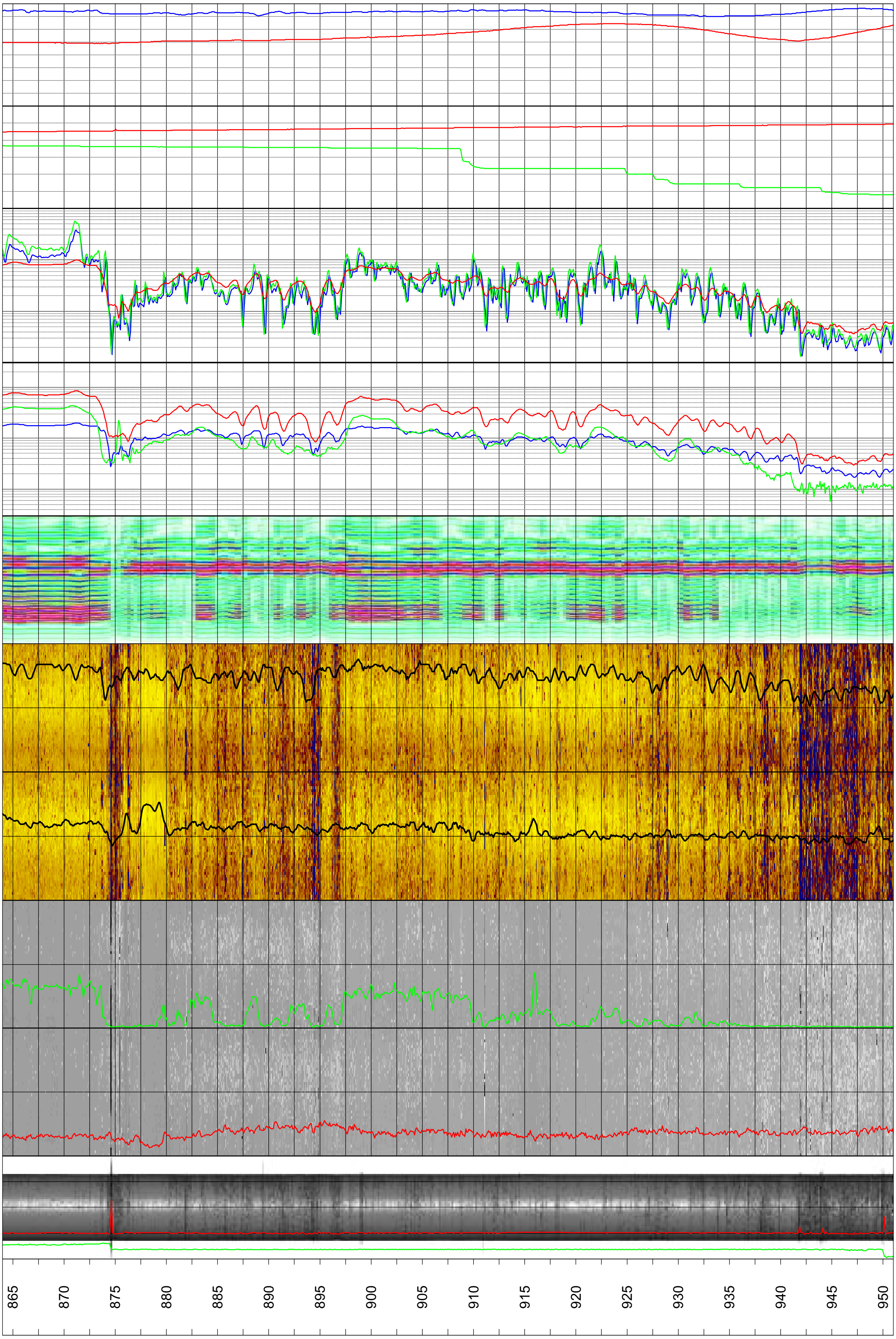
785
790
795
800
805
810
815
820
825
830
835
840
845
850
855
860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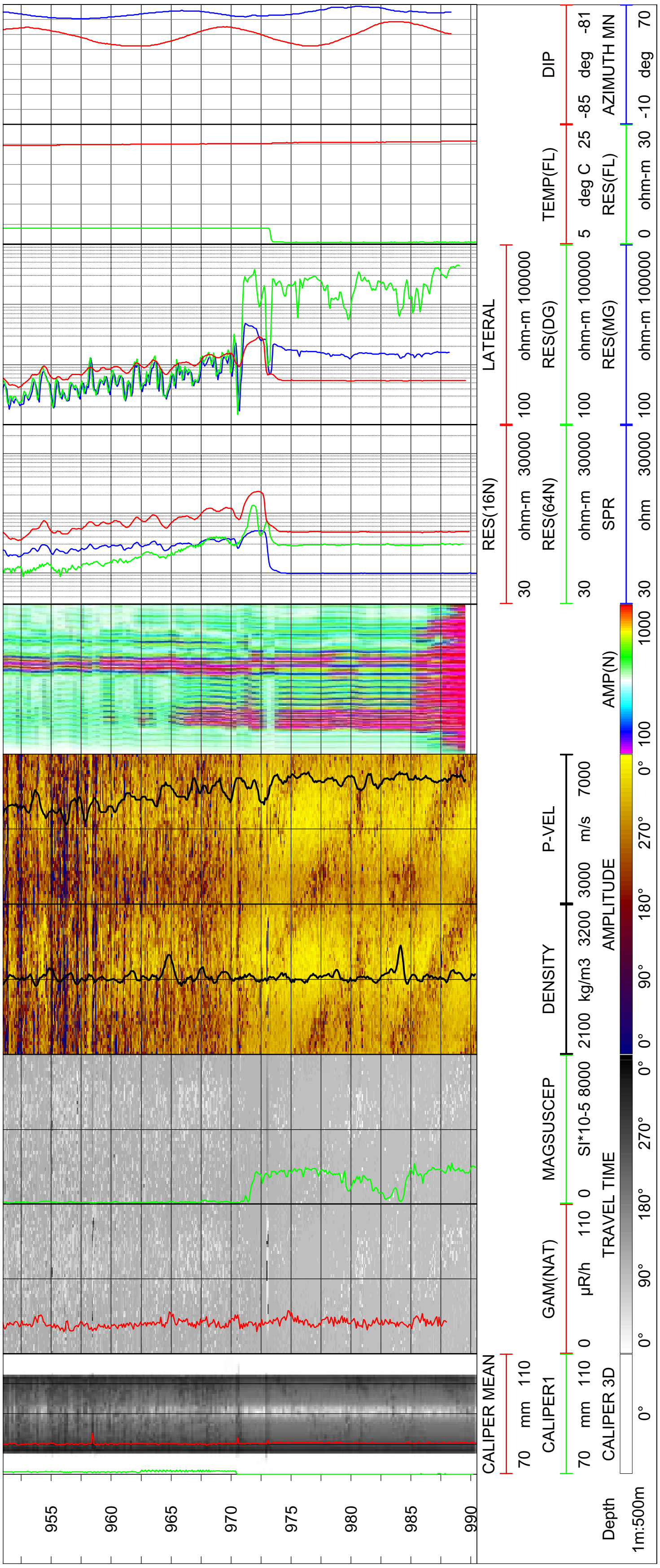
870
875
880
885
890
895
900
905
910
915
920
925
930
935
940
945
950



Depth
1m:500m
955
960
965
970
975
980
985
990
CALIPER MEAN
70 mm 110
CALIPER1
70 mm 110
CALIPER 3D
0°
GAM(NAT)
0 µR/h 110
MAGSUSCEP
0 SI*10-5 8000
TRAVEL TIME
0° 90° 180° 270° 0°
DENSITY
2100 kg/m3 3200
P-VEL
3000 m/s 7000
AMPLITUDE
0° 90° 180° 270° 0°
AMP(N)
100 1000
RES(16N)
30 ohm-m 30000
RES(64N)
30 ohm-m 30000
SPR
30 ohm 30000
LATERAL
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
TEMP(FL)
5 deg C 25
RES(FL)
0 ohm-m 30
DIP
-85 deg -81
AZIMUTH MN
-10 deg 70

Appendix 2

Borehole HLX26, drawing no 2.1, borehole logs

Borehole No. HLX26

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

Northing: 6365278.707m Easting: 1548600.525 Elevation: 6.478

Diameter: 137 mm
Reaming Diameter:
Outer Casing: 168 mm
Inner Casing: 160 mm
Borehole Length: 151.2 m
Cone:
Inclination at ground surface: -60.420
Azimuth: 12.372
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	8044	deg C
RES(FL)	Fluid resistivity	8044	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	2004-11-19	FDH	UTN	UTN

Job 360210A **Scale** 1:500

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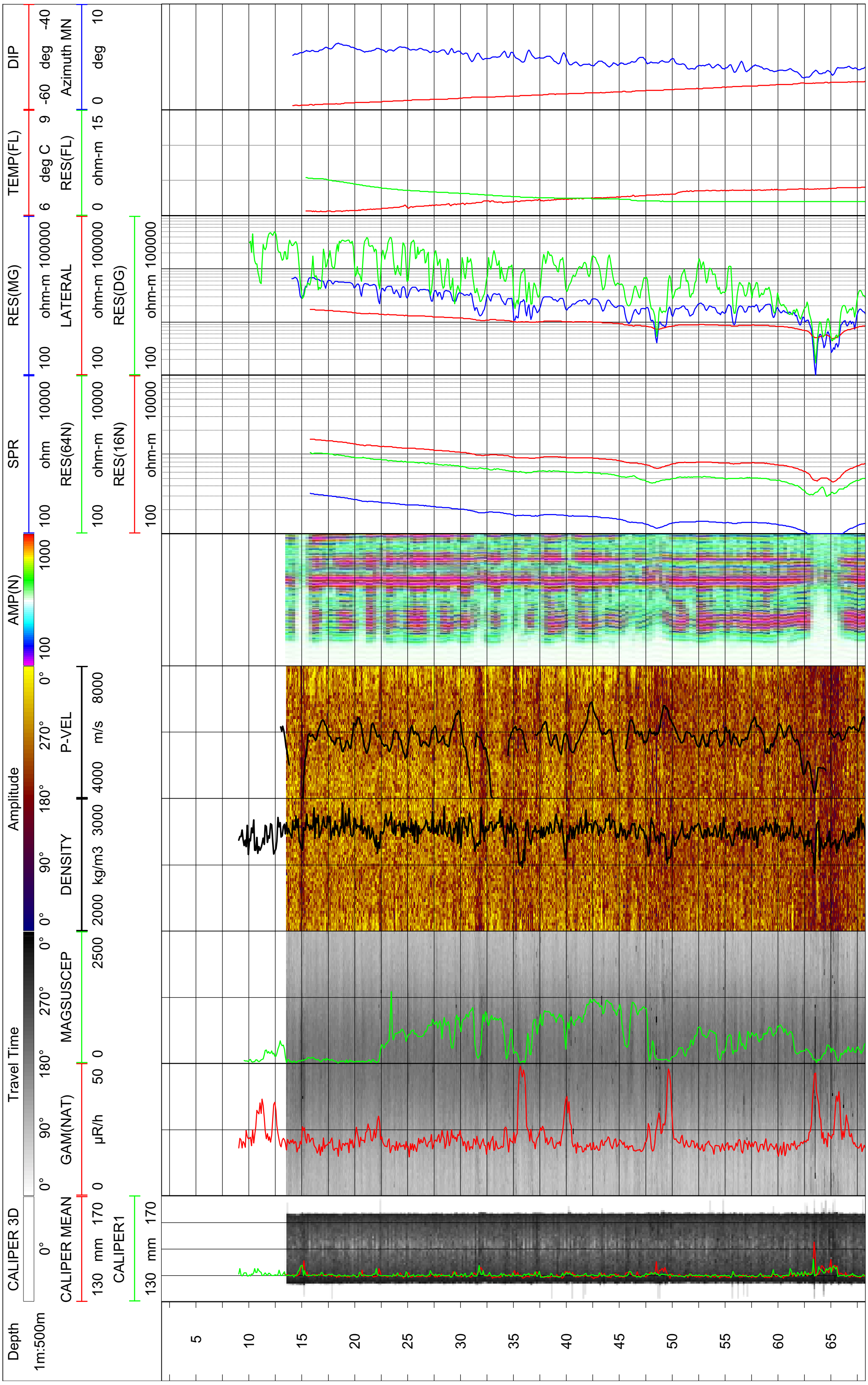
SKB geophysical borehole logging
Borehole HLX26. Laxemar

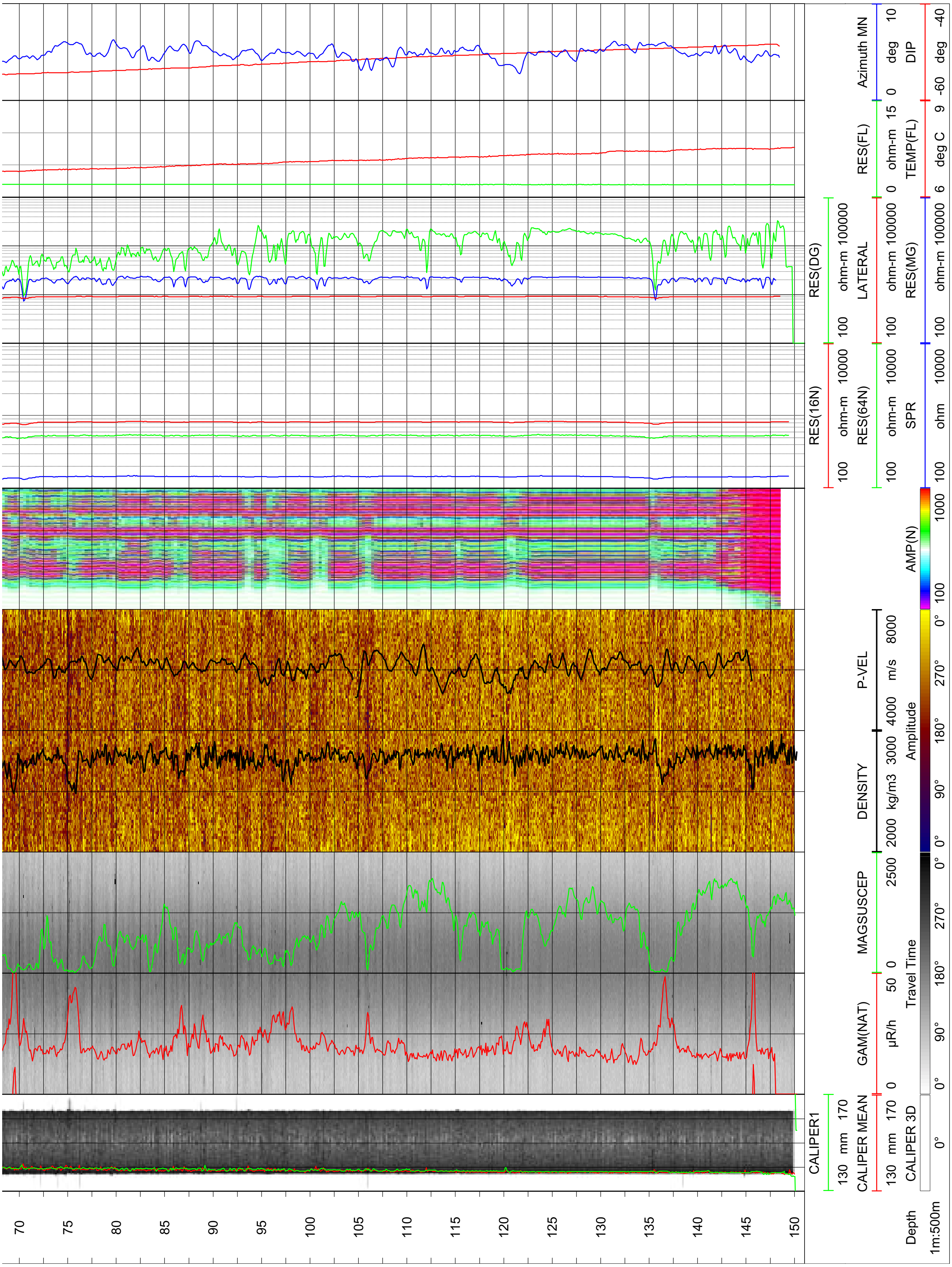
Presentation

Filename:
HLX26_presentation.wcl

Drawing no.:
2.1



DIP
-60 deg -40
Azimuth MN
0 deg 10
TEMP(FL)
6 deg C 9
RES(FL)
0 ohm-m 15
RES(MG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
SPR
100 ohm 10000
RES(64N)
100 ohm-m 10000
RES(16N)
100 ohm-m 10000
AMP(N)
100 1000
Amplitude
0° 90° 180° 270° 0°
DENSITY
2000 kg/m3 3000
P-VEL
4000 m/s 8000
Travel Time
0° 90° 180° 270° 0°
MAGSUSCEP
0 2500
GAM(NAT)
0 µR/h 50
CALIPER 3D
0°
CALIPER MEAN
130 mm 170
CALIPER1
130 mm 170
Depth
1m:500m
5
10
15
20
25
30
35
40
45
50
55
60
65



Azimuth MN 0 deg 10
DIP -60 deg -40
RES(FL) 0 ohm-m 15
TEMP(FL) 6 deg C 9
RES(DG) 100 ohm-m 100000
LATERAL 100 ohm-m 100000
RES(MG) 100 ohm-m 100000
RES(16N) 100 ohm-m 10000
RES(64N) 100 ohm-m 10000
SPR 100 ohm 10000
AMP(N) 100 1000
P-VEL 4000 m/s 8000
DENSITY 2000 kg/m3 3000
Amplitude 0° 90° 180° 270° 0°
MAGSUSCEP 0 2500
GAM(NAT) 0 µR/h 50
Travel Time 0° 90° 180° 270° 0°
CALIPER1 130 mm 170
CALIPER MEAN 130 mm 170
CALIPER 3D 0°
Depth 1m:500m
70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150

Borehole HLX27, drawing no 3.1, borehole logs

Borehole No. HLX27

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

Northing: 6365605.073 Easting: 1547882.686 Elevation: 8.248

Diameter:	137 mm
Reaming Diameter:	
Outer Casing:	168 mm
Inner Casing:	160 mm
Borehole Length:	164.7 m
Cone:	
Inclination at ground surface:	-59.412
Azimuth:	190.999
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	8044	deg C
RES(FL)	Fluid resistivity	8044	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	2004-11-19	FDH	JRI	UTN

Job 360210A

Scale 1:500

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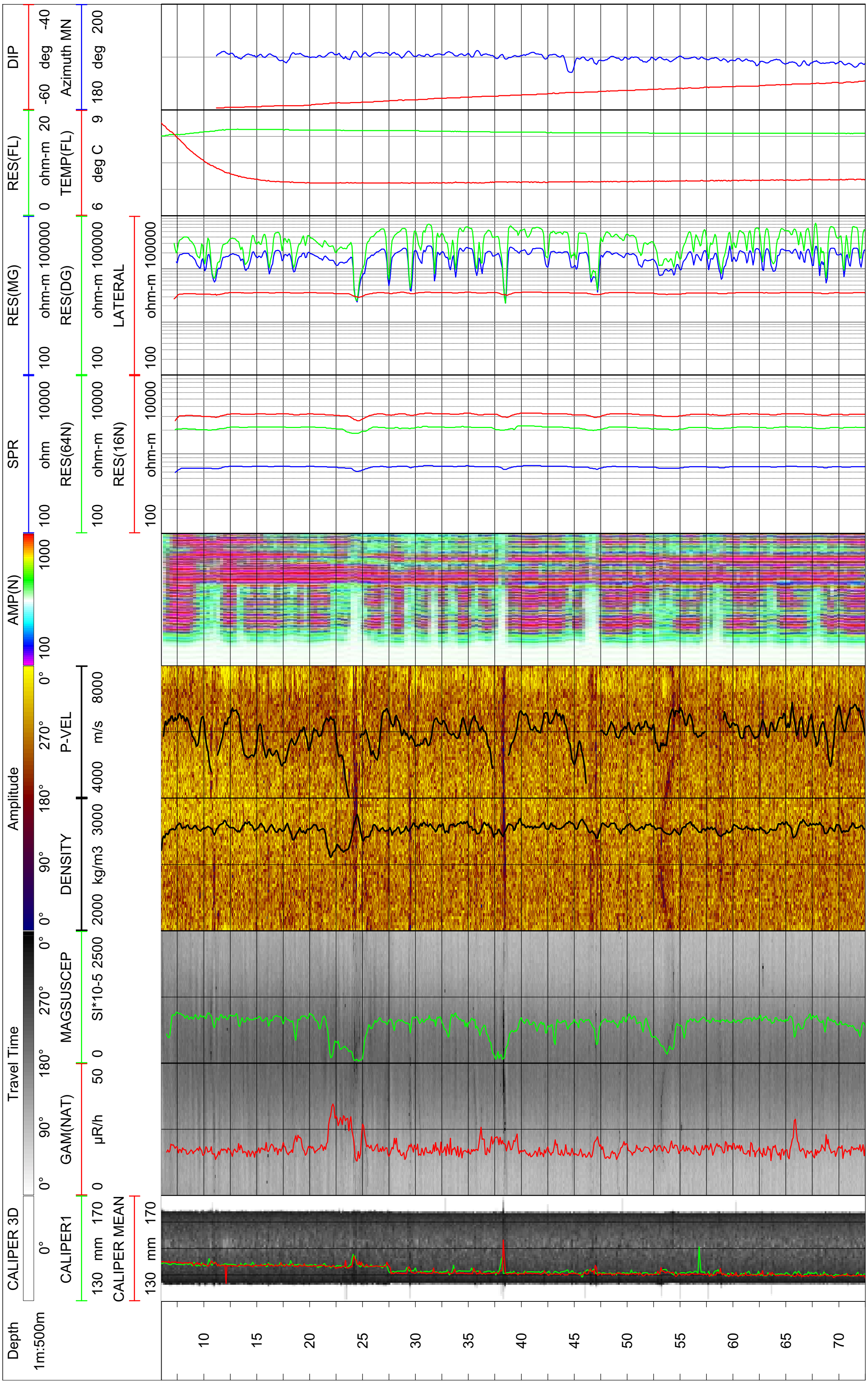
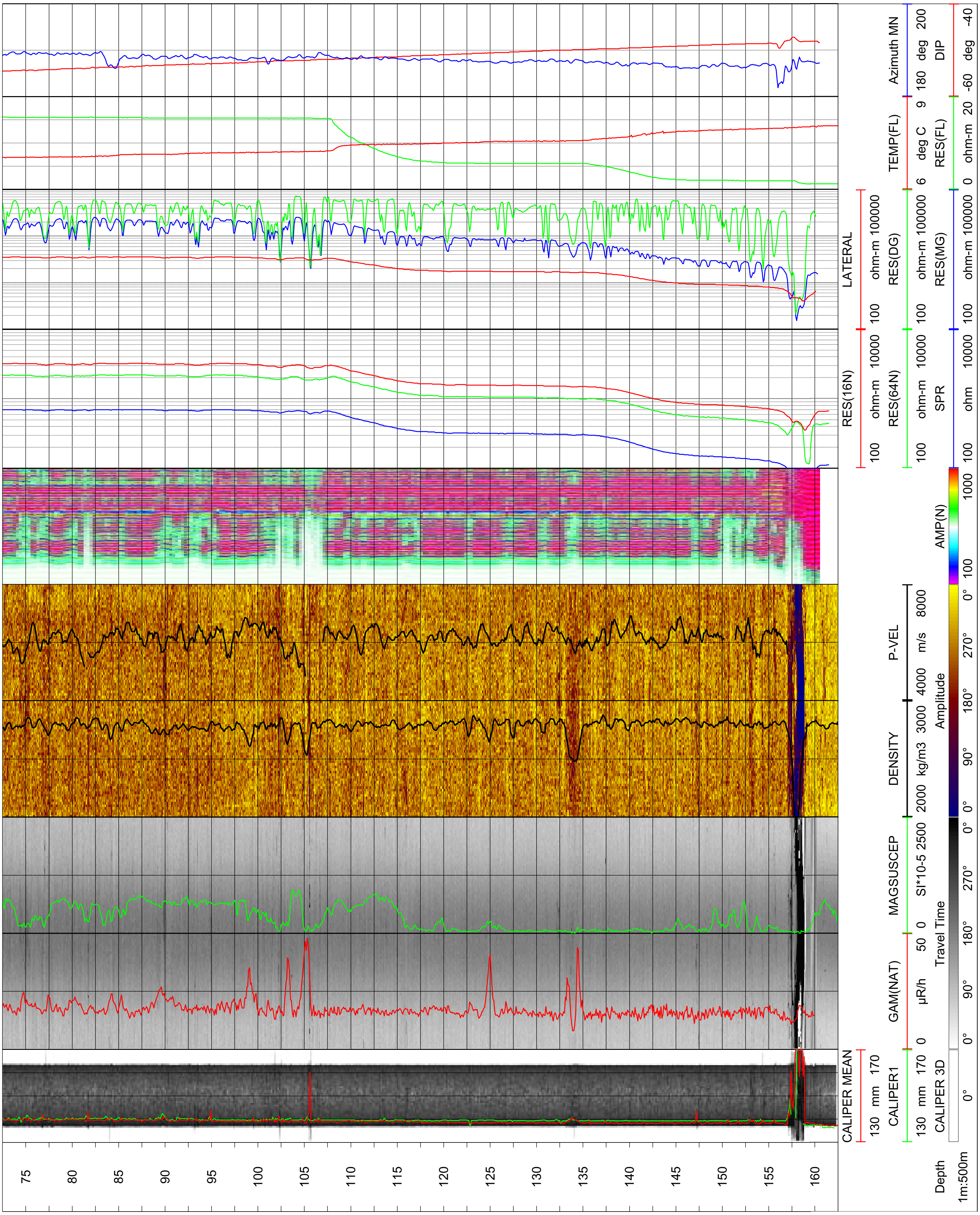
SKB geophysical borehole logging
Borehole HLX27. Laxemar

Presentation

Filename:
HLX27_presentation.wcl

Drawing no.:
3.1


Depth
1m:500m
CALIPER 3D
0°
CALIPER1
130 mm 170
CALIPER MEAN
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
100 ohm 10000
RES(64N)
100 ohm-m 10000
RES(16N)
100 ohm-m 10000
RES(MG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
RES(FL)
0 ohm-m 20
TEMP(FL)
6 deg C 9
DIP
-60 deg -40
Azimuth MN
180 deg 200
10
15
20
25
30
35
40
45
50
55
60
65
70


Azimuth MN
180 deg 200
DIP
-60 deg -40
TEMP(FL)
6 deg C 9
RES(FL)
0 ohm-m 20
LATERAL
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
RES(16N)
100 ohm-m 10000
RES(64N)
100 ohm-m 10000
SPR
100 ohm 10000
AMP(N)
100 1000
P-VEL
4000 m/s 8000
DENSITY
2000 kg/m3 3000
Amplitude
0° 90° 180° 270° 0°
MAGSUSCEP
0 SI*10-5 2500
GAM(NAT)
0 µR/h 50
Travel Time
0° 90° 180° 270° 0°
CALIPER MEAN
130 mm 170
CALIPER1
130 mm 170
CALIPER 3D
0°
Depth
1m:500m
75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160

Borehole HLX28, drawing no 4.1, borehole logs

Borehole No. HLX28

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

Northing: 6365861.704m Easting: 1546834.473m Elevation: 13.424m, RHB70

Diameter:	136mm
Reaming Diameter:	
Outer Casing:	168mm
Inner Casing:	160mm
Borehole Length:	154.2m
Cone:	
Inclination at ground surface:	-59.485°
Azimuth:	201.375°
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	8044	deg C
RES(FL)	Fluid resistivity	8044	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	2004-11-19	FDH	JRI	UTN

Job	Scale
360210A	1:500

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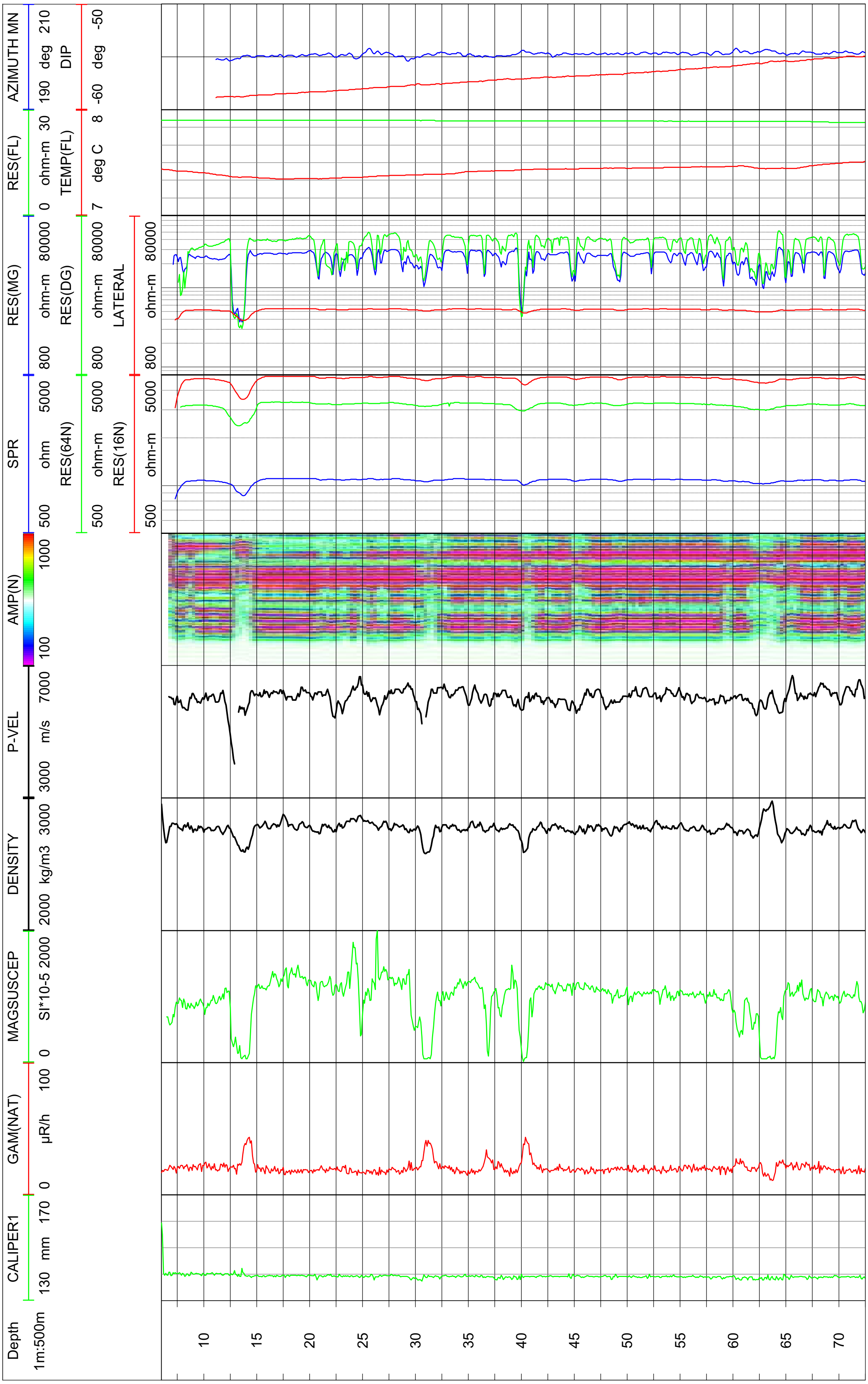
SKB geophysical borehole logging
Borehole HLX28. Laxemar

Presentation

Filename:
HLX28_presentation.wcl

Drawing no.:
4.1


AZIMUTH MN
190 deg 210
DIP
-60 deg -50
RES(FL)
0 ohm-m 30
TEMP(FL)
7 deg C 8
RES(MG)
800 ohm-m 80000
RES(DG)
800 ohm-m 80000
LATERAL
800 ohm-m 80000
SPR
500 ohm 5000
RES(64N)
500 ohm-m 5000
RES(16N)
500 ohm-m 5000
AMP(N)
100 1000
P-VEL
3000 m/s 7000
DENSITY
2000 kg/m3 3000
MAGSUSCEP
0 SI*10-5 2000
GAM(NAT)
0 µR/h 100
CALIPER1
130 mm 170
Depth
1m:500m
10
15
20
25
30
35
40
45
50
55
60
65
70

DIP
-60 deg -50
AZIMUTH MN
190 deg 210
TEMP(FL)
7 deg C 8
RES(FL)
0 ohm-m 30
LATERAL
800 ohm-m 80000
RES(DG)
800 ohm-m 80000
RES(MG)
800 ohm-m 80000
RES(16N)
500 ohm-m 5000
RES(64N)
500 ohm-m 5000
SPR
500 ohm 5000
AMP(N)
100
1000
P-VEL
3000 m/s 7000
DENSITY
2000 kg/m3 3000
MAGSUSCEP
0 SI*10-5 2000
GAM(NAT)
0 µR/h 100
CALIPER1
130 mm 170
Depth
1m:500m
75
80
85
90
95
100
105
110
115
120
125
130
135
140