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Oskarshamn site investigation

Geophysical borehole logging in boreholes KLX07A, KLX07B, HLX20, HLX34 and HLX35

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September 2005

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Abstract

Geophysical borehole logging has been performed in boreholes KLX07A, KLX07B, HLX20, HLX34 and HLX35 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 KLX07A was recorded from 12 m to 844 m, KLX07B was recorded from 9 m to 200 m, HLX20 was recorded from 9 m to 202 m, HLX34 was recorded from 9 m to 151 m and HLX35 from 6 m to 151 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 5.

Sammanfattning

Geofysisk borrhålsloggning har genomförts i borrhålen KLX07A, KLX07B, HLX20, HLX34 och i HLX35 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 KLX07A från 12 m till 844 m, i KLX07B från 9 m till 200 m, i HLX20 från 9 m till 202 m, i HLX34 från 9 m till 151 m och i HLX35 från 6 m till 151 m.

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

Processerade loggar presenteras i Appendix 1 till 5.

Contents

1 Introduction

This document reports the results gained by the geophysical borehole logging in boreholes KLX07A, KLX07B, HLX20, HLX34 and HLX35, 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 400-05-051 (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 July 4 to July 8, 2005. 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.

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

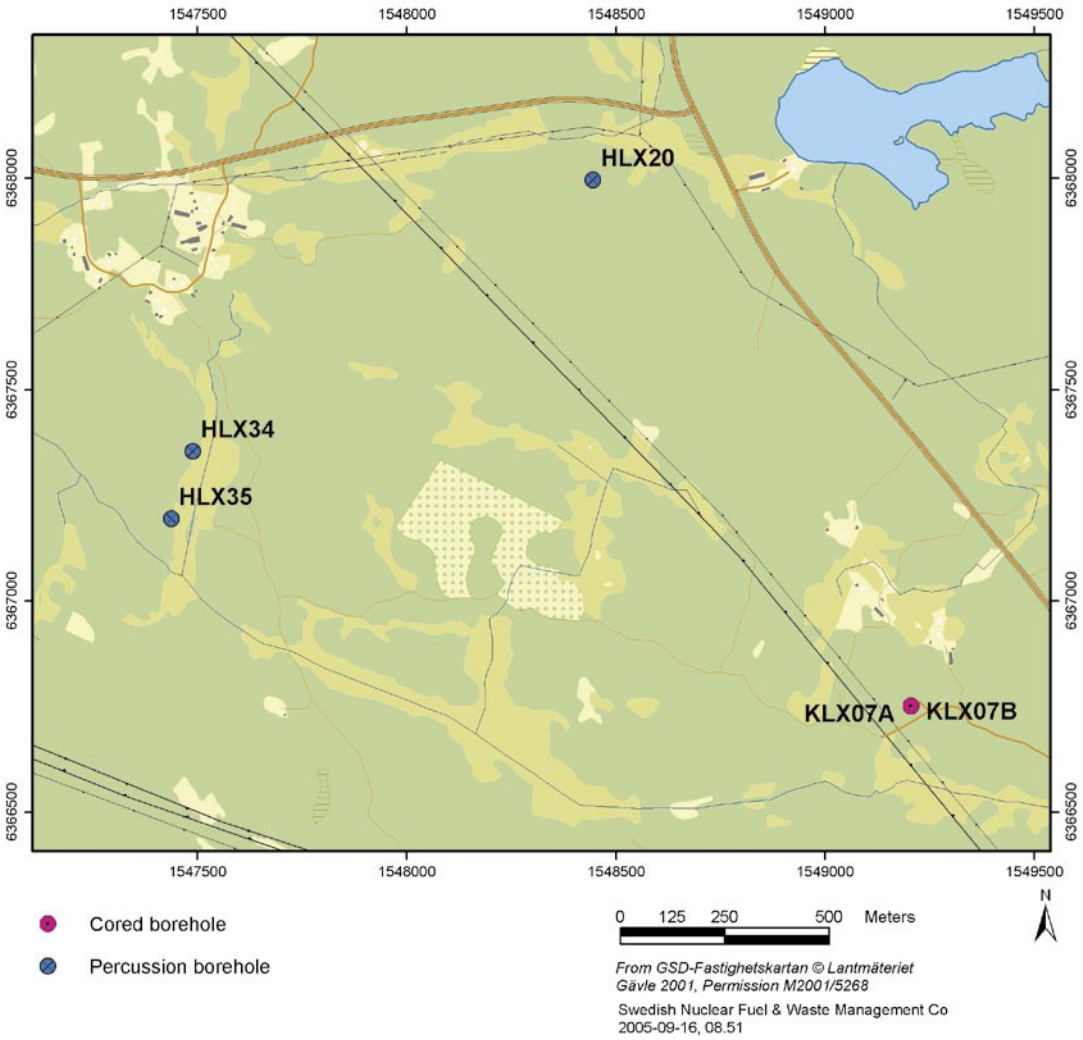

Figure 1-1. *Overview over location of boreholes KLX07A, KLX07B, HLX20, HLX34 and HLX35 in the Laxemar subarea.*

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

Activity plan	Number	Version
Geofysisk borrhålsloggning i KLX07A, KLX07B, HLX34 och HLX35	AP PS 400-05-051	1.0
Tillägg till AP PS 400-05-005 avseende HLX20	AP PS 400-05-005	Tillägg
Method descriptions	**Number**	**Version**
Metodbeskrivning för geofysisk borrhålsloggning	SKB MD 221.002	2.0

Table 1-2. Technical data for the boreholes.

Borehole parameter	KLX07A	KLX07B	HLX20	HLX34	HLX35
Co-ordinates (RT90)	X: 6366752.094 Y: 1549206.855	X: 6366753.135 Y: 1549206.758	X: 6367996.256 Y: 1548446.085	X: 6367355.125 Y: 1547489.558	X: 6367194.788 Y: 1547437.792
Elevation (RHB70)	Z: 18.470	Z: 18.380	Z: 11.179	Z: 14.290	Z: 14.444
Inclination (from horizontal)	–60.0375°	–85.0023°	–60.384°	–59.7274°	–59.8774°
Azimuth	174.1792°	174.3295°	0.405°	101.0683°	102.2160°
Length	844.73 m	200.13 m	202.20 m	151.80 m	151.80 m
Borehole diameter	∅ 343 mm (0.00–8.9 m) ∅ 252 mm (8.9–11.8 m) ∅ 198 mm (11.8–100.3 m) ∅ 165 mm (100.3–100.4 m) ∅ 86 mm (100.46–100.98 m) ∅ 76 mm (100.98–844.73 m)	∅ 96 mm (0.00–9.64 m) ∅ 76 mm (9.64–200.13 m)	∅ 190 mm (0.00–9.12 m) ∅ 137 mm (9.12–202.2 m)	∅ 190 mm (0.00–9.1 m) ∅ 137 mm (9.1–151.8 m)	∅ 190 mm (0.30–6.1 m) ∅ 140 mm (6.1–151.8 m)
Casing	∅ 323/310 mm casing (0–8.9 m) ∅ 208/200 mm casing (8.9–11.8 m) Cone from 97.33–100.98 (∅ 100/∅ 77 mm)	∅ 89/77 mm casing (0–9.64 m)	∅ 168/160 mm casing (0–8.94 m) ∅ 168/147 mm casing (8.94–9.03 m)	∅ 168/160 mm casing (0–8.94 m) ∅ 168/147 mm casing (8.94–9.03 m)	∅ 168/160 mm casing (0–5.94 m) ∅ 168/147 mm casing (5.94–6.03 m)
Cleaning level	Level 2	Level 2	Level 1	Level 1	Level 1

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 to determine the length marks in the core-drilled borehole, KLX07A.

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 KLX07A in Appendix 1, drawing no. 2.1 for borehole KLX07B in Appendix 2, drawing no. 3.1 for borehole HLX20 in Appendix 3, drawing no. 4.1 for borehole HLX34 in Appendix 4 and drawing no. 5.1 for borehole HLX35 in Appendix 5.

3 Equipment

The geophysical borehole logging program in KLX07A was performed with 7 multi tool probes and resulted in a suite of 19 log types, listed in Table 5-1. The geophysical borehole logging program in KLX07B, HLX20, HLX34 and HLX35 was performed with 6 multi tool probes and resulted in a suite of 13 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, fluid temperature and fluid resistivity.	Normal resistivity (16 & 64 inch), single point resistance, fluid resistivity, fluid temperature and natural gamma.	237×5.3 cm			All boreholes
Century 8622 Magnetic susceptibility.	Magnetic susceptibility, natural gamma.	203×4.1 cm			All boreholes
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.	All boreholes
Century 9042 Fluid temperatur and fluid resistivity.	Fluid temperature, fluid resistivity and natural gamma.	137×4.1 cm			All boreholes (for QA, not reported)
Century 9072 3 m focused guard.	3 m focused guard log resistivity and natural gamma.	310×6.4 cm			All boreholes
Century 9310 Sonic.	Full wave form travel-time providing P & S-wave velocity picking, compensated P-wave travel-time and natural gamma.	283.2×5.1 cm	Near 2 ft. Far 3 ft.	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	KLX07A

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 July 4 to 8, 2005. All relevant logging events are described in the daily report sheets delivered to SICADA and are traceable by the activity 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.

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 for the 9030 tool was 5 m/min, for the 8622 tool 20 m/min and for all other tools 10 m/min.

4.2 Nonconformities

For borehole HLX34 the down run from the 9310 tool has been used in the processing.

For borehole KLX07A due to disturbance of the cone between 97.33 and 100.98 and bad data in the wider part of the borehole (198 mm) between 11.8 and 100.4 m data has been skipped in that part.

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. 1.1–5.1 are presented in Table 5-1.

Table 5-1. Logs presented in drawings no. 1.1 through. 5.1 in Appendices 1 to 5.

Log	Log name short	Unit	Tool
Fluid temperature	TEMP(FL)	deg C	8144
Fluid resistivity	RES(FL)	ohm-m	8144
Normal resistivity 16 inch	RES(16N)	ohm-m	8144
Normal resistivity 64 inch	RES(64N)	ohm-m	8144
Lateral resistivity	LATERAL	ohm-m	8144
Single point resistance	SPR	Ohm	8144
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
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 processed in the tool while recording, using the magnetometers and accelerometers in the tool.

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. The bottom of the borehole is considered in stretching the logs in case 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.

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 acoustic televiewer, the fluid temperature, fluid velocity and the internal travel time in the acoustic televiewer.
360° orientated acoustic travel time	–
360° orientated acoustic travel time	–

5.4 Borehole KLX07A

In order to obtain an exact depth calibration in borehole KLX07A, 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 KLX07A.

Reference mark	HIRAT recorded
110.00	110
150.00	150.06
200.00	200.11
250.00	250.15
300.00	300.2
349.00	349.27
400.00	400.3
450.00	450.36
500.00	500.375
550.00	550.43
600.00	600.49
650.00	650.53
700.00	700.59
750.00	750.66
800.00	800.73

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 KLX07A, between all log runs, the obtained reference mark correlation is transferred to the other logs.

The complete log suite for borehole KLX07A 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 KLX07B

Using the bottom of the casing and the natural gamma from the 9030 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 54.

Table 5-4. Gamma events in borehole KLX07B.

Events	Depths
Top event	9.42
Bottom event	191.4

The complete log suite for borehole KLX07B 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 HLX20

Using the natural gamma from the 8144 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 HLX20.

Events	Depths
Top event	46.44
Bottom event	193.46

The complete log suite for borehole HLX20 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 HLX34

Using the natural gamma from the 8144 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 5-6.

Table 5-6. Gamma events in borehole HLX34.

Events	Depths
Top event	21.6
Bottom event	122.55

The complete log suite for borehole HLX34 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.

5.8 Borehole HLX35

Using the natural gamma from the 8144 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 5-7.

Table 5-7. Gamma events in borehole HLX35.

Events	Depths
Top event	33.45
Bottom event	144.75

The complete log suite for borehole HLX35 is presented as composite log sheet in drawing no. 5.1 in Appendix 5. The logs presented in drawing no. 5.1 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 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
KLX07A	8144	Down	KLX07A_07-04-05_15-45_8144C_.02_6.27_838.59_ORIG.log	Start Depth: 6.27 m. End Depth: 838.59 m
KLX07A	8622	Up	KLX07A_07-06-05_12-01_8622C_.02_-2.37_832.82_ORIG.log	Start Depth: 832.82 m. End Depth: –2.37 m
KLX07A	9030	Up	KLX07A_07-05-05_14-33_9030CA_.02_266.15_834.79_ORIG.log	Start Depth: 834.79 m. End Depth: 266.15 m
KLX07A	9030	Up	KLX07A_07-05-05_16-58_9030CA_.02_90.80_375.33_ORIG.log	Start Depth: 375.33 m. End Depth: 90.8 m
KLX07A	9072	Up	KLX07A_07-05-05_11-59_9072C_.02_-1.77_834.39_ORIG.log	Start Depth: 834.39 m. End Depth: –1.77 m
KLX07A	9310	Up	KLX07A_07-06-05_09-00_9310C2_.10_90.10_835.10_ORIG.log	Start Depth: 835.1 m. End Depth: 90.1 m
KLX07A	HiRAT	Up	KLX07A_Hirat_90_up_run2.HED	Start Depth: 844 m. End Depth: 0 m
KLX07B	8144	Down	KLX07B_07-04-05_18-54_8144C_.02_0.54_201.48_ORIG.log	Start Depth: 0.54 m. End Depth: 201.48 m
KLX07B	8622	Up	KLX07B_07-06-05_12-57_8622C_.02_0.04_199.50_ORIG.log	Start Depth: 199.5 m. End Depth: 0.04 m
KLX07B	9030	Up	KLX07B_07-05-05_18-48_9030CA_.02_0.70_199.78_ORIG.log	Start Depth: 0.7 m. End Depth: 199.78 m
KLX07B	9072	Up	KLX07B_07-05-05_13-36_9072C_.02_0.50_199.66_ORIG.log	Start Depth: 199.66 m. End Depth: 0.5 m
KLX07B	9310	Up	KLX07B_07-06-05_11-09_9310C2_.10_0.40_198.70_ORIG.log	Start Depth: 198.7 m. End Depth: 0.4 m
HLX20	8144	Down	HLX20_07-06-05_16-20_8144C_.02_0.28_197.80_ORIG.log	Start Depth: 0.28 m. End Depth: 197.8 m
HLX20	8622	Up	HLX20_07-06-05_18-04_8622C_.02_0.28_197.79_ORIG.log	Start Depth: 197.79 m. End Depth: 0.28 m
HLX20	9030	Up	HLX20_07-06-05_19-34_9030CA_.02_0.44_199.56_ORIG.log	Start Depth: 199.56 m. End Depth: 0.44 m
HLX20	9030	Up	HLX20_07-06-05_21-18_9030CA_.10_0.10_197.00_ORIG.log	Start Depth: 197 m. End Depth: 0.1 m
HLX20	9072	Up	HLX20_07-06-05_18-34_9072C_.02_0.30_198.20_ORIG.log	Start Depth: 198.2 m. End Depth: 0.3 m
HLX20	9310	Up	HLX20_07-06-05_20-43_9310C2_.10_0.10_197.20_ORIG.log	Start Depth: 197.2 m. End Depth: 0.1 m

Borehole	Probe	Log direction	WellCAD File	Description
HLX34	8144	Down	HLX34_07-07-05_09-06_8144C_.02_0.28_ 151.06_ORIG.log	Start Depth: 0.28 m. End Depth: 151.06 m
HLX34	8622	Up	HLX34_07-07-05_10-58_8622C_.02_-0.28_ 150.60_ORIG.log	Start Depth: 150.6 m. End Depth: –0.28 m
HLX34	9030	Up	HLX34_07-07-05_12-36_9030CA_.10_0.10_ 150.50_ORIG.log	Start Depth: 150.5 m. End Depth: 0.1 m
HLX34	9072	Up	HLX34_07-07-05_10-23_9072C_.02_-0.34_ 150.74_ORIG.log	Start Depth: 150.74 m. End Depth: –0.34 m
HLX34	9310	Down	HLX34_07-07-05_11-14_9310C2_.10_0.20_ 150.00_ORIG.log	Start Depth: 0.2 m. End Depth: 150 m
HLX35	8144	Down	HLX35_07-07-05_13-45_8144C_.10_0.30_ 150.90_ORIG.log	Start Depth: 2.7 m. End Depth: 150.4 m
HLX35	8622	Up	HLX35_07-07-05_14-58_8622C_.10_2.70_ 150.40_ORIG.log	Start Depth: 150.4 m. End Depth: 2.7 m
HLX35	9030	Up	HLX35_07-07-05_16-54_9030CA_.02_1.12_ 151.00_ORIG.log	Start Depth: 151 m. End Depth: 1.12 m
HLX35	9072	Up	HLX35_07-07-05_15-27_9072C_.02_2.84_ 150.32_ORIG.log	Start Depth: 150.32 m. End Depth: 2.84 m
HLX35	9310	Up	HLX35_07-07-05_16-00_9310C2_.10_3.50_ 149.80_ORIG.log	Start Depth: 149.8 m. End Depth: 3.5 m

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KLX07A	1.1	KLX07A_Presentation.WCL
KLX07B	2.1	KLX07B_Presentation.WCL
HLX20	3.1	HLX20_Presentation.WCL
HLX34	4.1	HLX34_Presentation.WCL
HLX35	5.1	HLX35_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	Only included for borehole KLX07A
“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	

Borehole No. KLX07A

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

Northing: 6366752.09m Easting: 1549206.86m Elevation: 18.47m, RHB70

Diameter:	76mm
Reaming Diameter:	
Outer Casing:	
Inner Casing:	
Borehole Length:	844.73m
Cone:	
Inclination at ground surface:	-60.04°
Azimuth:	174,18°
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	8144	deg C
RES(FL)	Fluid resistivity	8144	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

Rev.	Date	Drawn by	Control	Approved
0	2005-08-04	JRI	UTN	UTN

Job: 547310A

Scale: 1:500

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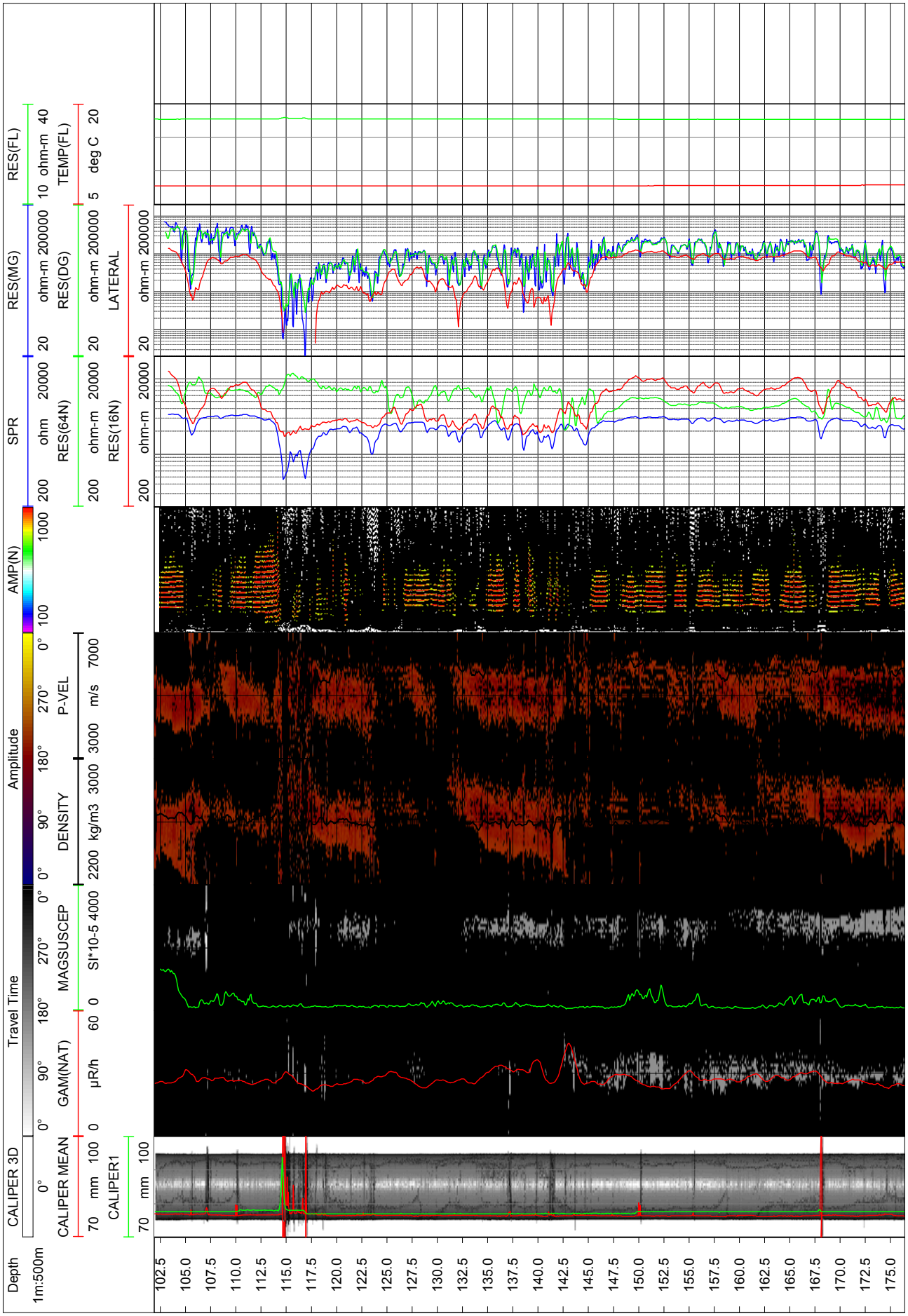
SKB geophysical borehole logging
Borehole KLX07A

Presentation

Filename: KLX07A_Presentation.wcl

Drawing no.: **1.1**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CALIPER 3D
Travel Time
Amplitude
AMP(N)
SPR
RES(MG)
RES(FL)
CALIPER MEAN
GAM(NAT)
MAGSUSCEP
DENSITY
P-VEL
RES(64N)
RES(DG)
TEMP(FL)
CALIPER1
RES(16N)
LATERAL
102.5
105.0
107.5
110.0
112.5
115.0
117.5
120.0
122.5
125.0
127.5
130.0
132.5
135.0
137.5
140.0
142.5
145.0
147.5
150.0
152.5
155.0
157.5
160.0
162.5
165.0
167.5
170.0
172.5
175.0


177.5
180.0
182.5
185.0
187.5
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192.5
195.0
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232.5
235.0
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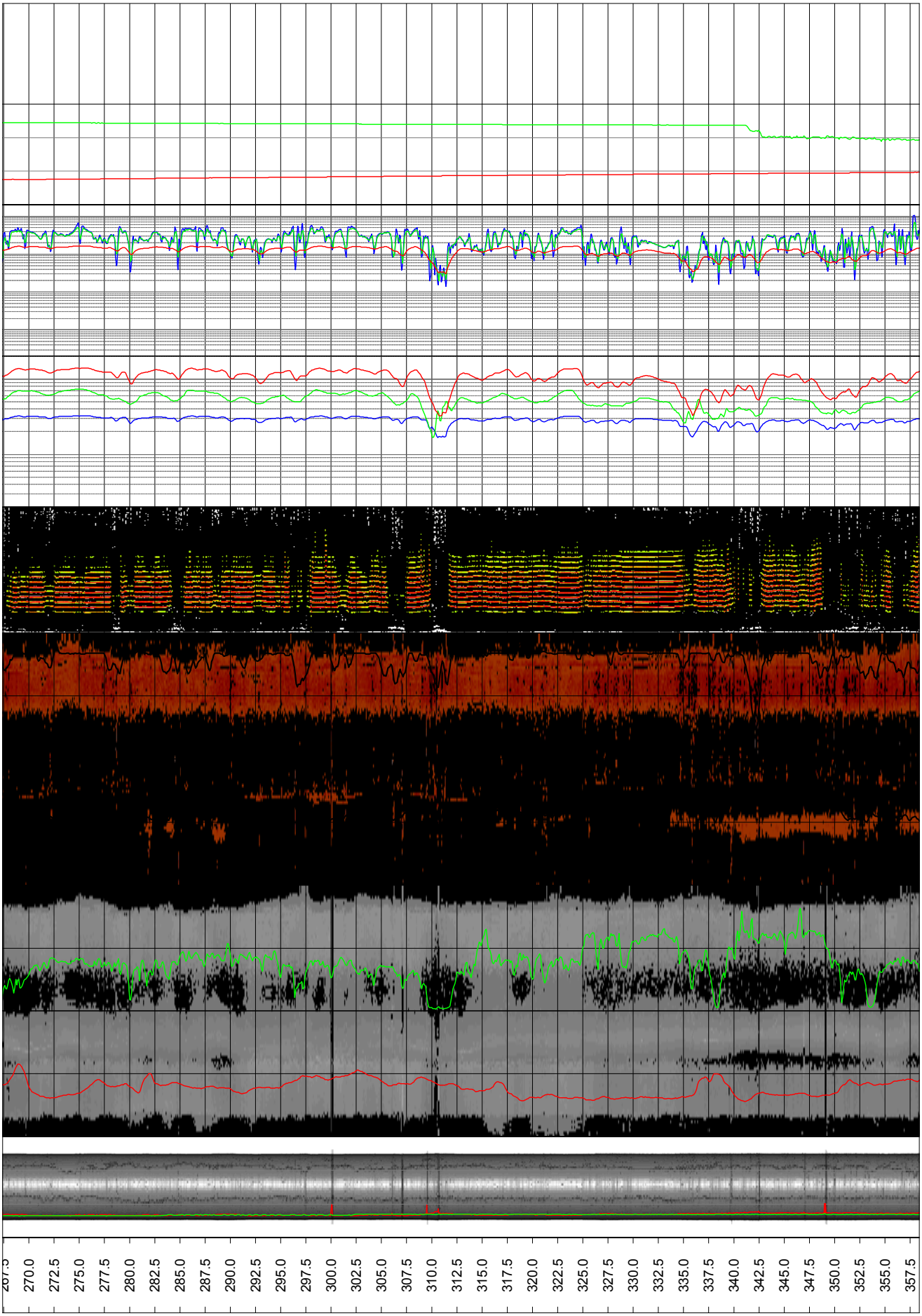
265.0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307.5
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312.5
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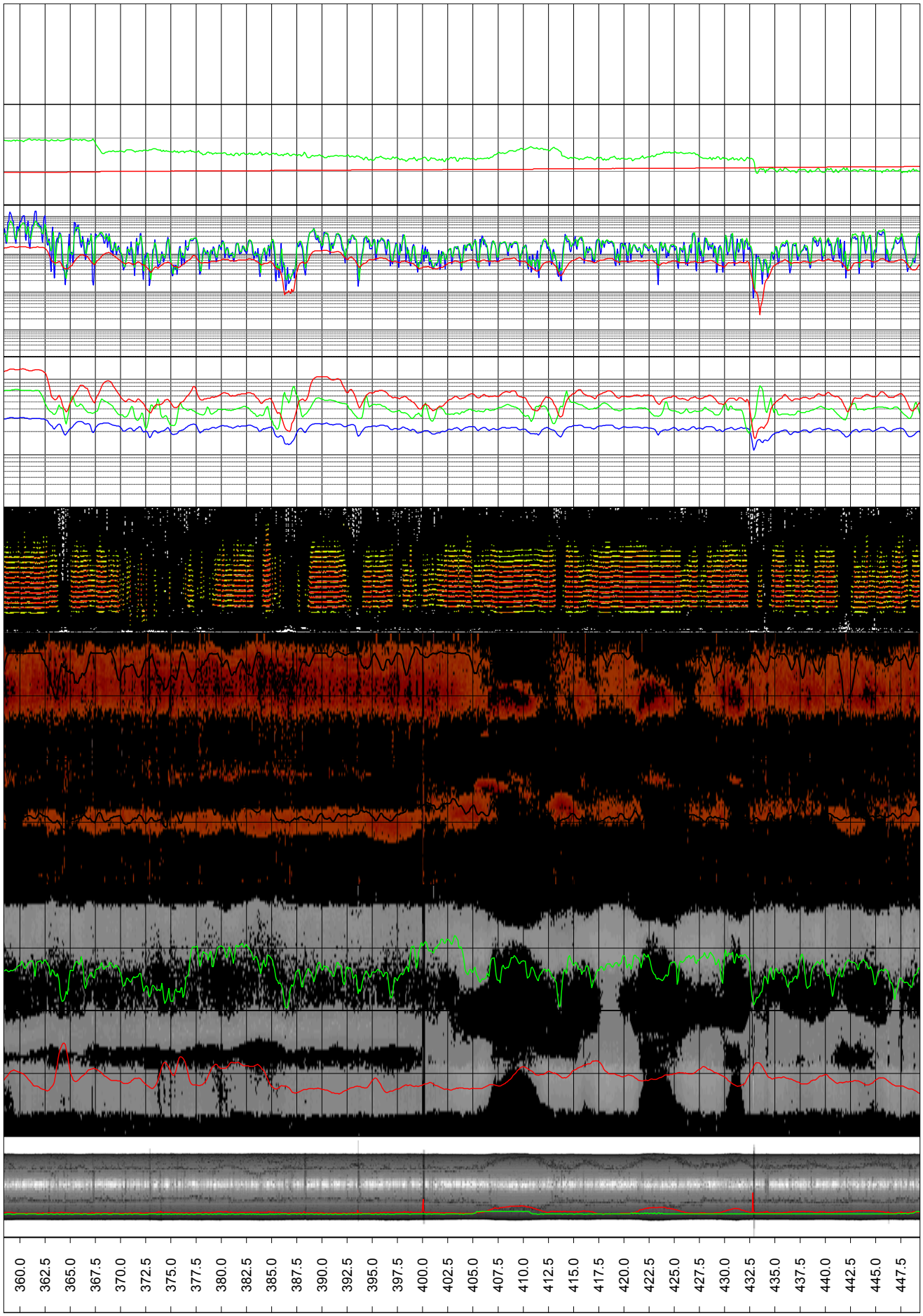
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410.0
412.5
415.0
417.5
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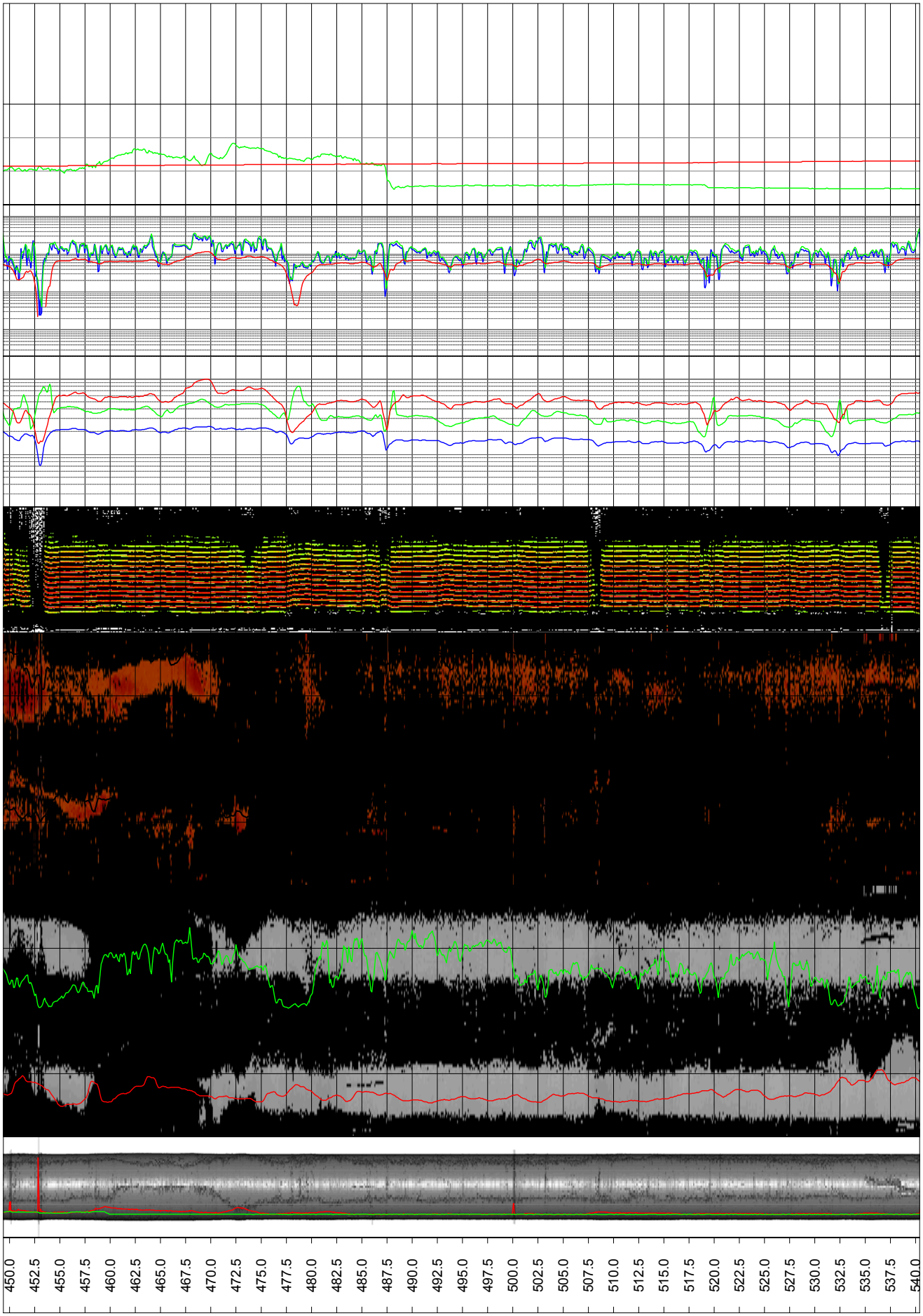
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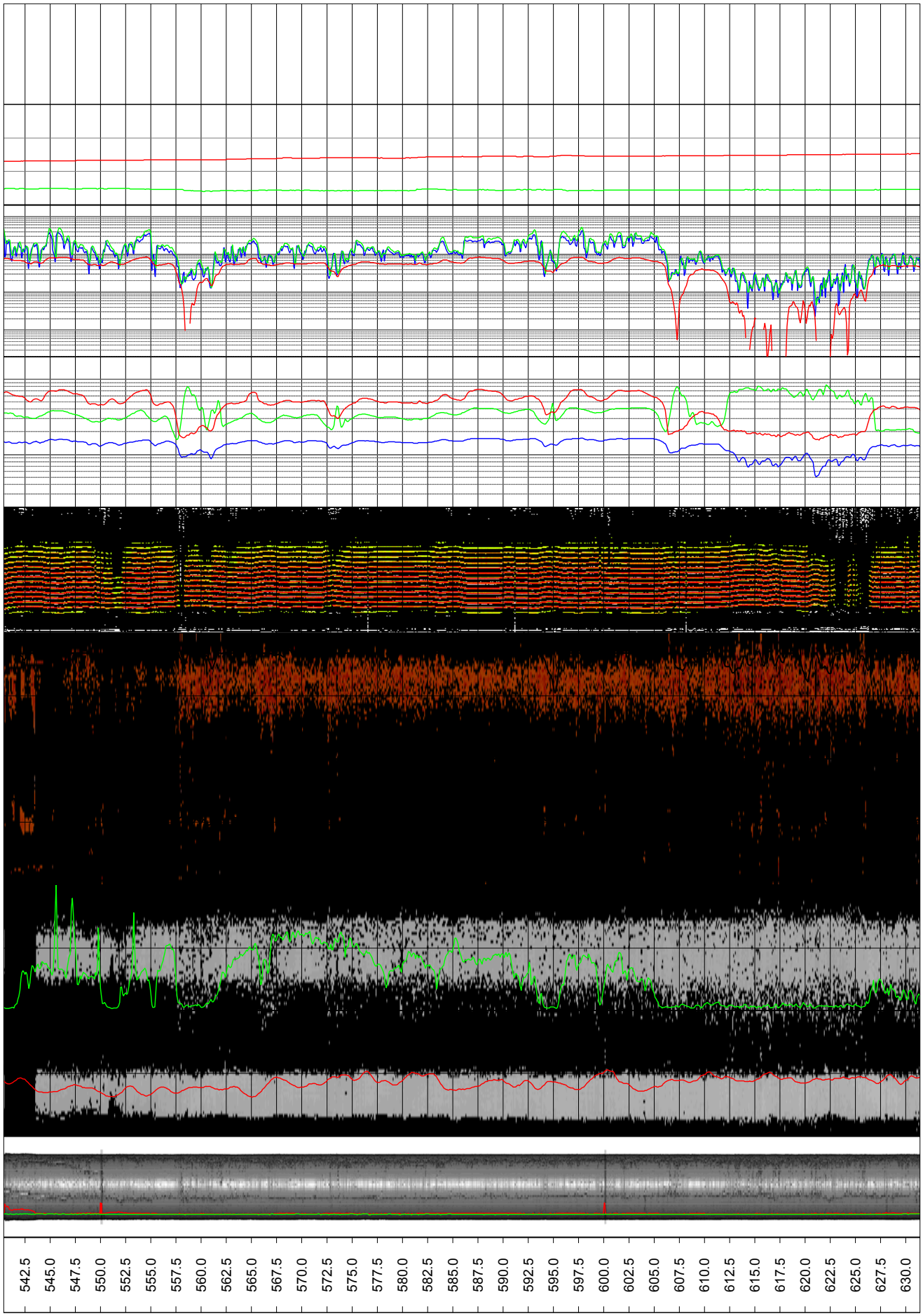
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582.5
585.0
587.5
590.0
592.5
595.0
597.5
600.0
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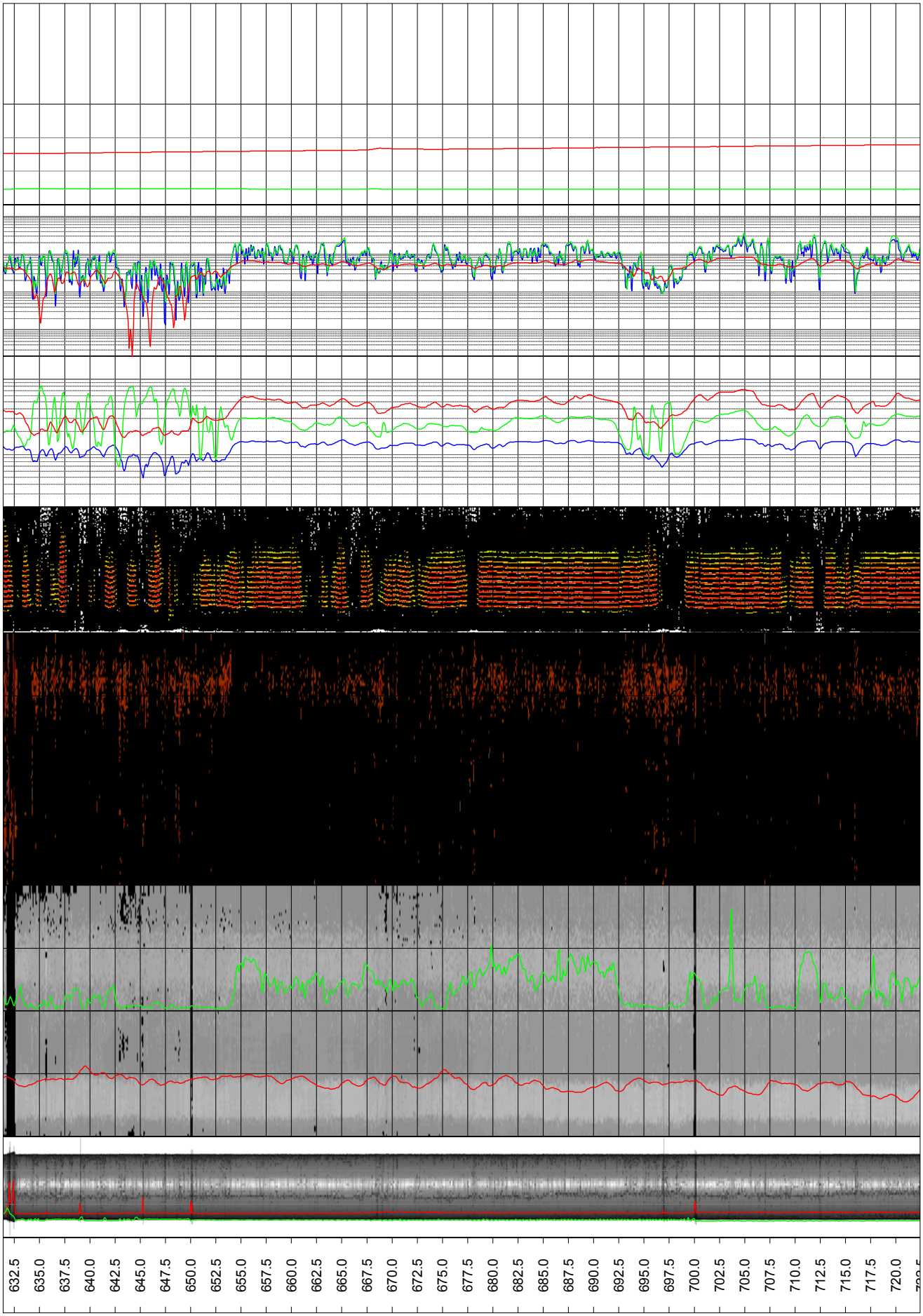
630.0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677.5
680.0
682.5
685.0
687.5
690.0
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710.0
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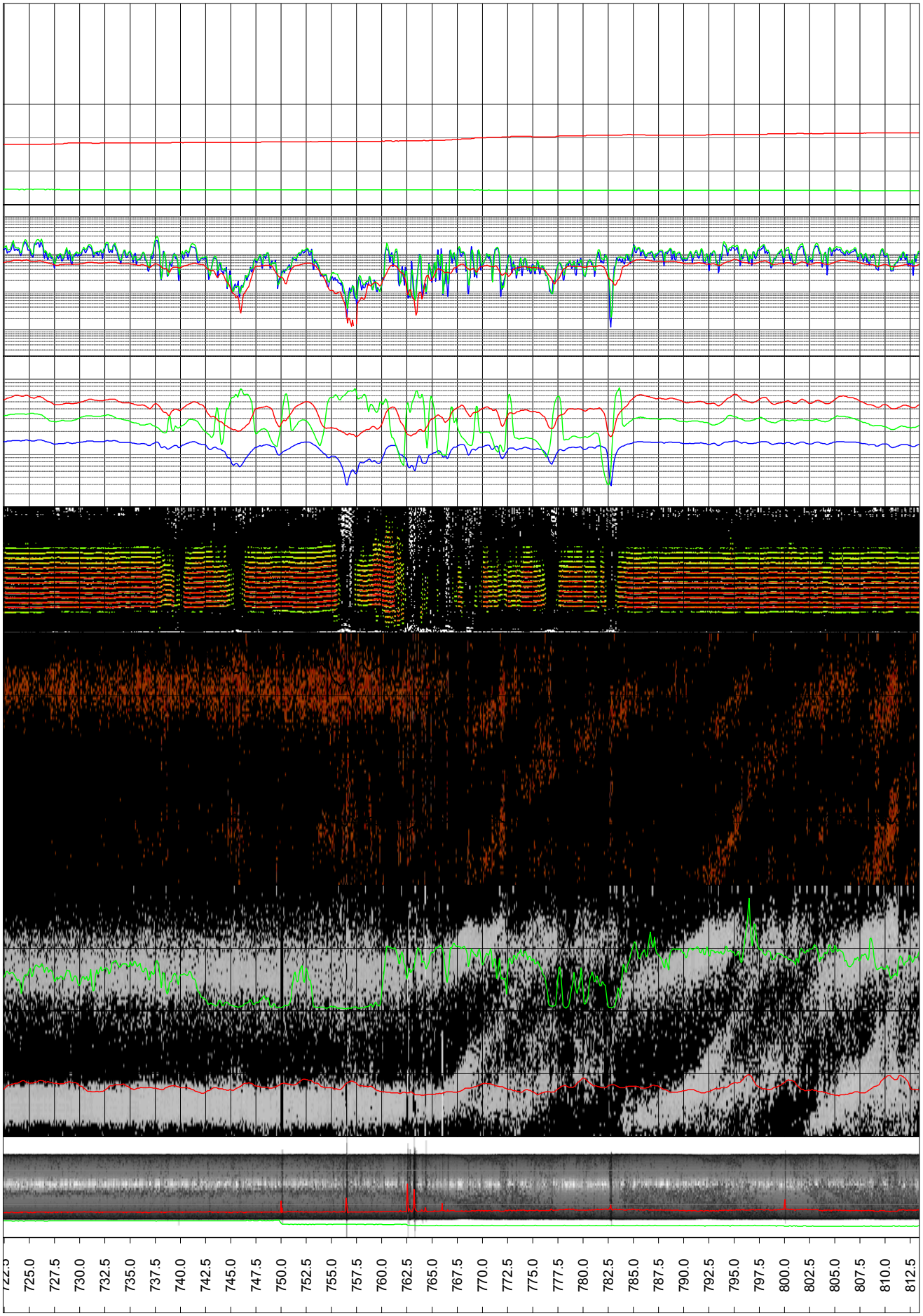
715.0
717.5
720.0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747.5
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755.0
757.5
760.0
762.5
765.0
767.5
770.0
772.5
775.0
777.5
780.0
782.5
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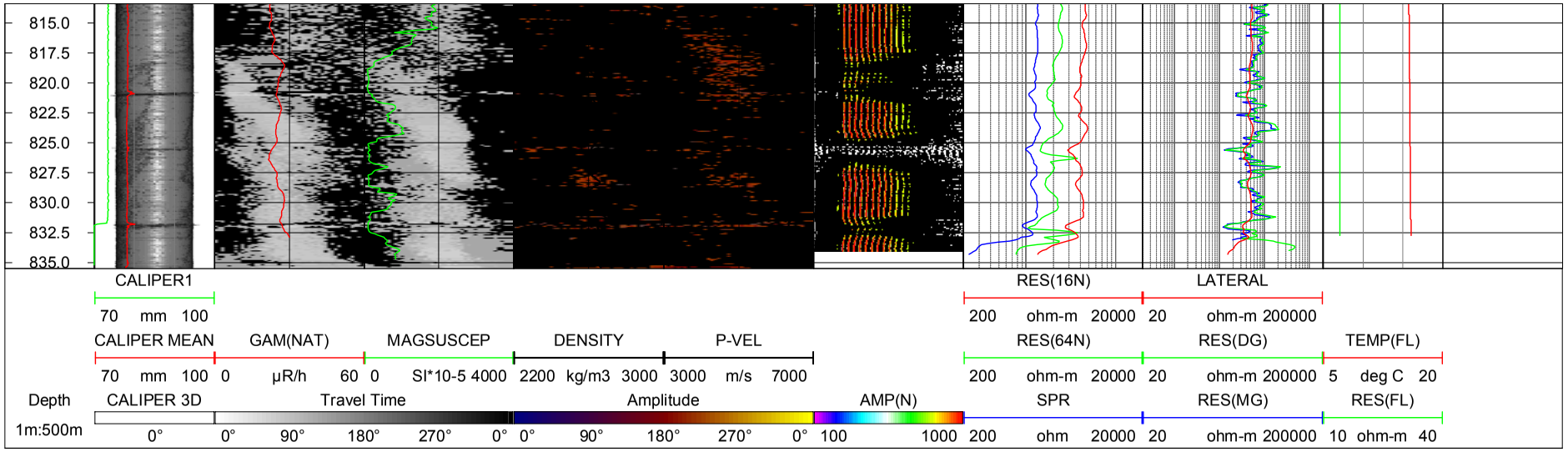
815.0
817.5
820.0
822.5
825.0
827.5
830.0
832.5
835.0
CALIPER1
70 mm 100
RES(16N)
LATERAL
200 ohm-m 20000
20 ohm-m 200000
CALIPER MEAN
GAM(NAT)
MAGSUSCEP
DENSITY
P-VEL
RES(64N)
RES(DG)
TEMP(FL)
70 mm 100
0 µR/h 60
0 SI*10-5 4000
2200 kg/m3 3000
3000 m/s 7000
200 ohm-m 20000
20 ohm-m 200000
5 deg C 20
Depth
CALIPER 3D
Travel Time
Amplitude
AMP(N)
SPR
RES(MG)
RES(FL)
1m:500m
0°
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°
100 1000
200 ohm 20000
20 ohm-m 200000
10 ohm-m 40

Borehole No. KLX07B

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

Northing: 6366753.135m Easting: 1549206.758m Elevation:18.380m, RHB70

Diameter:	76mm
Reaming Diameter:	
Outer Casing:	89mm
Inner Casing:	77mm
Borehole Length:	200.13m
Cone:	
Inclination at ground surface:	-85.0°
Azimuth:	174.33°
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	8144	deg C
RES(FL)	Fluid resistivity	8144	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

Rev.	Date	Drawn by	Control	Approved
1	2005-09-13	JRI	UTN	UTN

Job: 547310A

Scale: 1:500

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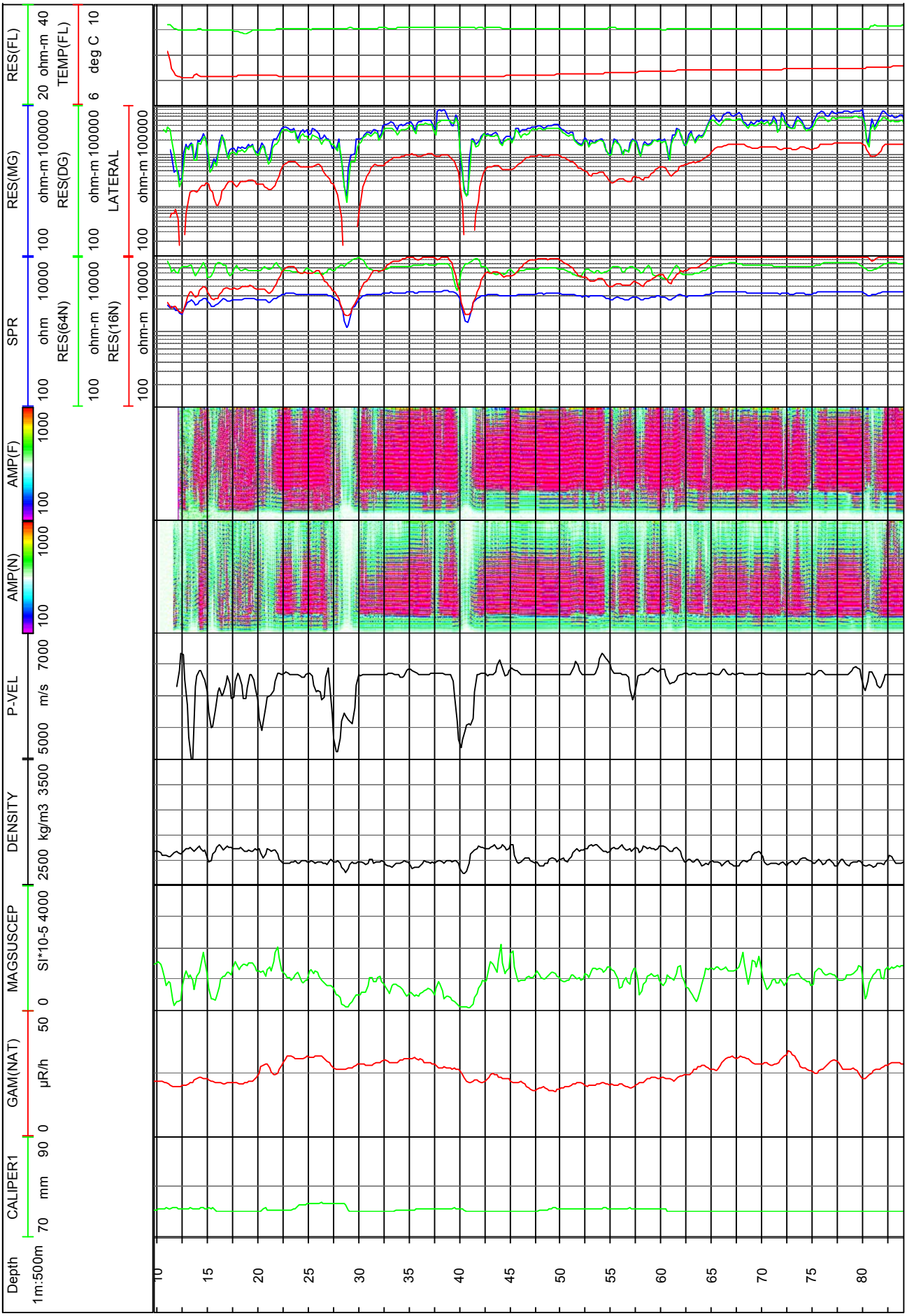
SKB geophysical borehole logging

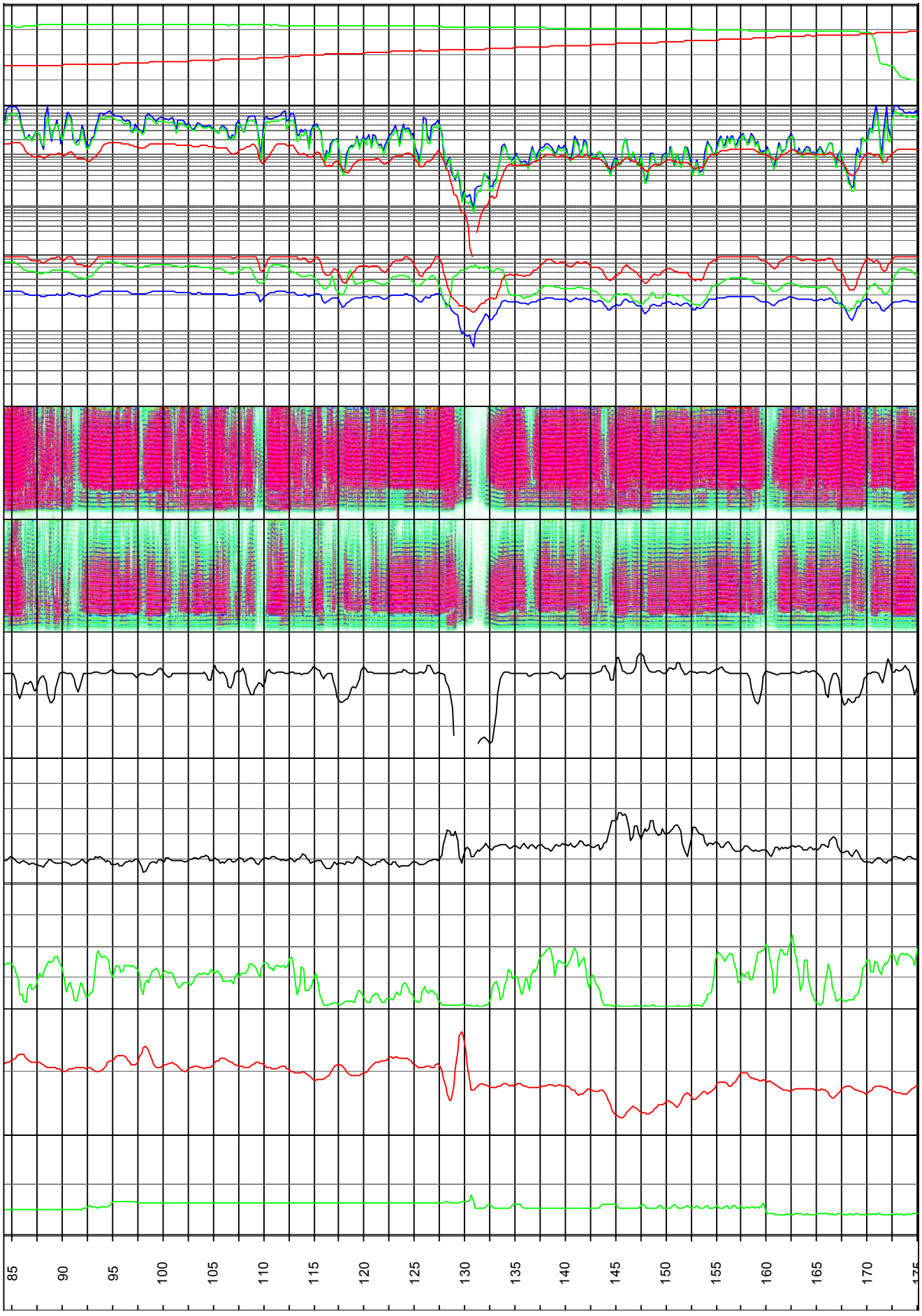
Borehole KLX07B, Laxemar

Presentation

Filename: KLX07B_Presentation.wcl

Drawing no.: **2.1**


Depth
1m:500m
CALIPER1
70 mm 90
GAM(NAT)
0 µR/h 50
MAGSUSCEP
0 SI*10-5 4000
DENSITY
2500 kg/m3 3500
P-VEL
5000 m/s 7000
AMP(N)
100 1000
AMP(F)
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)
20 ohm-m 40
TEMP(FL)
6 deg C 10
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80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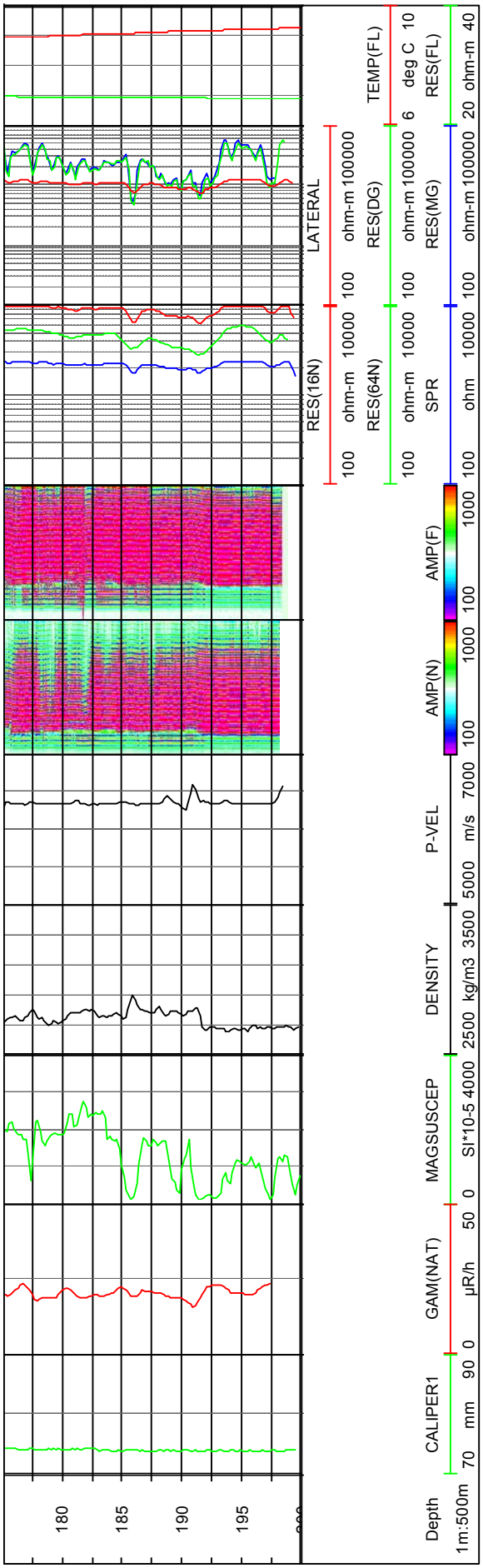
Depth
1m:500m
CALIPER1
70 mm 90
GAM(NAT)
0 µR/h 50
MAGSUSCEP
0 SI*10-5 4000
DENSITY
2500 kg/m3 3500
P-VEL
5000 m/s 7000
AMP(N)
100 1000
AMP(F)
100 1000
RES(16N)
100 ohm-m 10000
RES(64N)
100 ohm-m 10000
SPR
100 ohm 10000
LATERAL
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
TEMP(FL)
6 deg C 10
RES(FL)
20 ohm-m 40
180
185
190
195

Borehole No. HLX20

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

Northing: 6367996.256 Easting: 1548446.085 Elevation:11.179

Diameter:	138 mm
Reaming Diameter:	
Outer Casing:	
Inner Casing:	
Borehole Length:	202.20 m
Cone:	
Inclination at ground surface:	-60.384
Azimuth:	0.405
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	8144	deg C
RES(FL)	Fluid resistivity	8144	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

Rev.	Date	Drawn by	Control	Approved
0	2005-08-03	JIJ	UTN	UTN

Job 547310A

Scale 1:500

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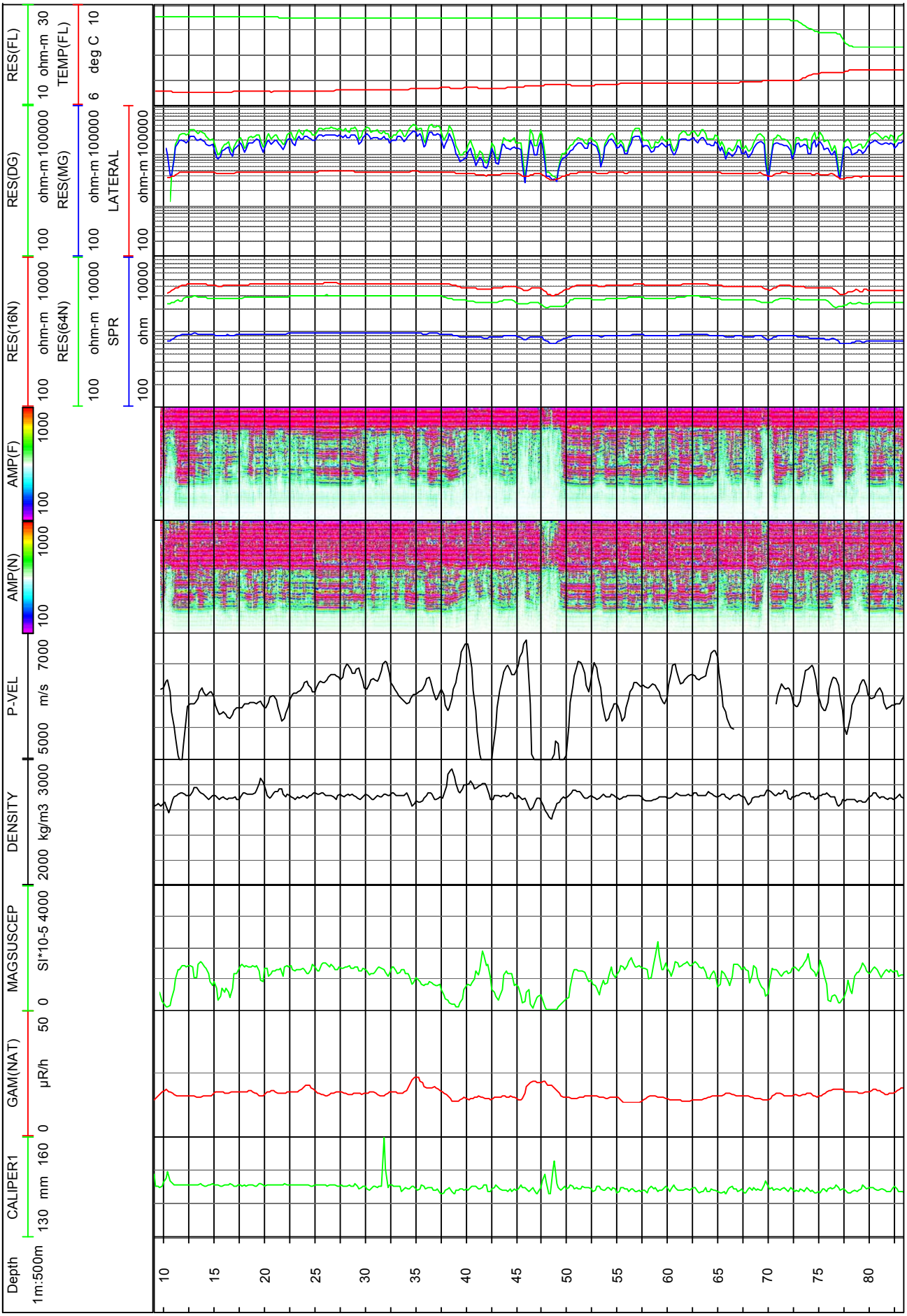
SKB geophysical borehole logging
Borehole HLX20

Presentation

Filename: HLX20_presentation.wcl

Drawing no.: **3.1**


Depth
1m:500m
CALIPER1
130 mm 160
GAM(NAT)
0 µR/h 50
MAGSUSCEP
0 SI*10-5 4000
DENSITY
2000 kg/m3 3000
P-VEL
5000 m/s 7000
AMP(N)
100 1000
AMP(F)
100 1000
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(MG)
100 ohm-m 100000
TEMP(FL)
6 deg C 10
RES(FL)
10 ohm-m 30
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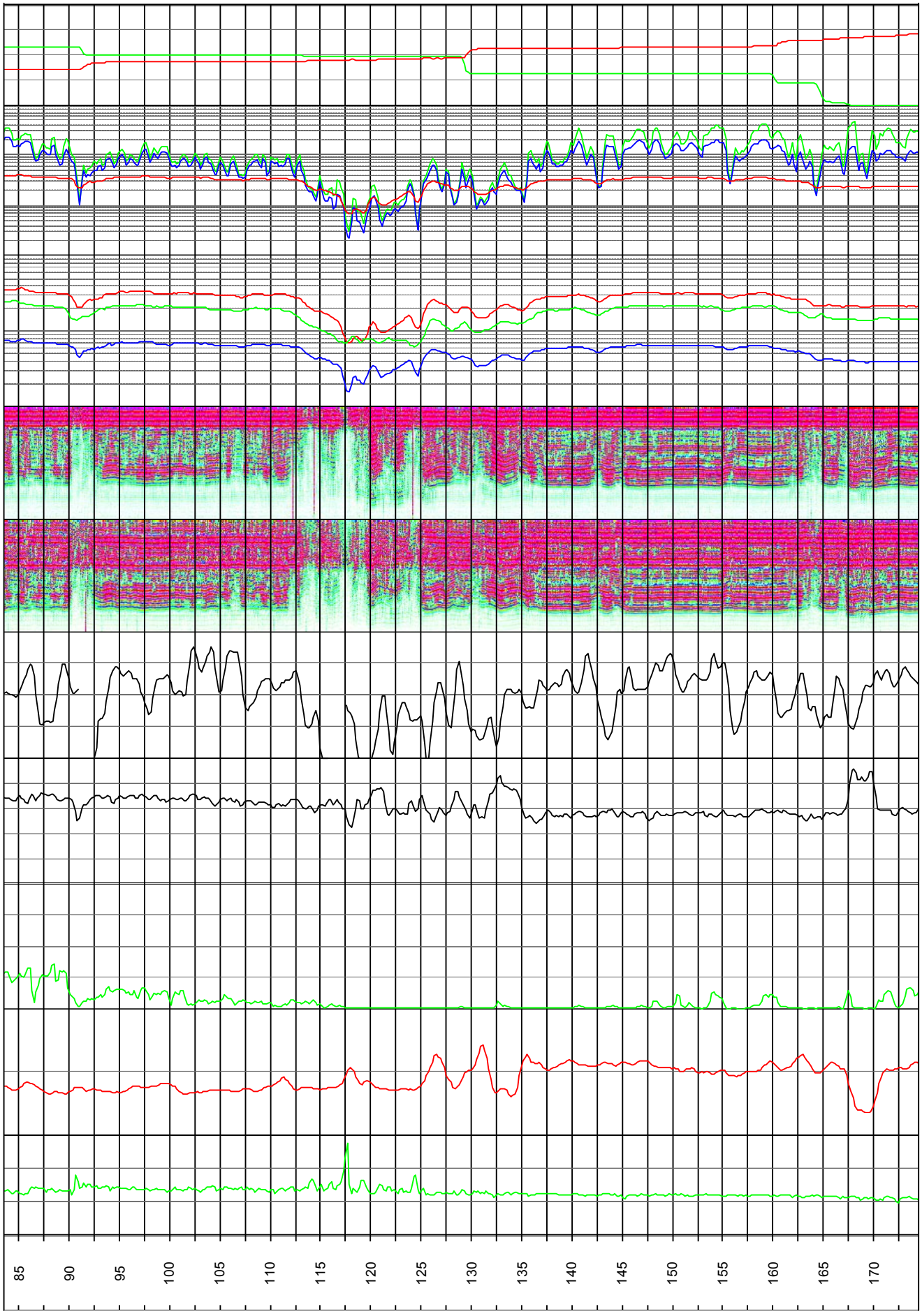
35
40
45
50
55
60
65
70
75
80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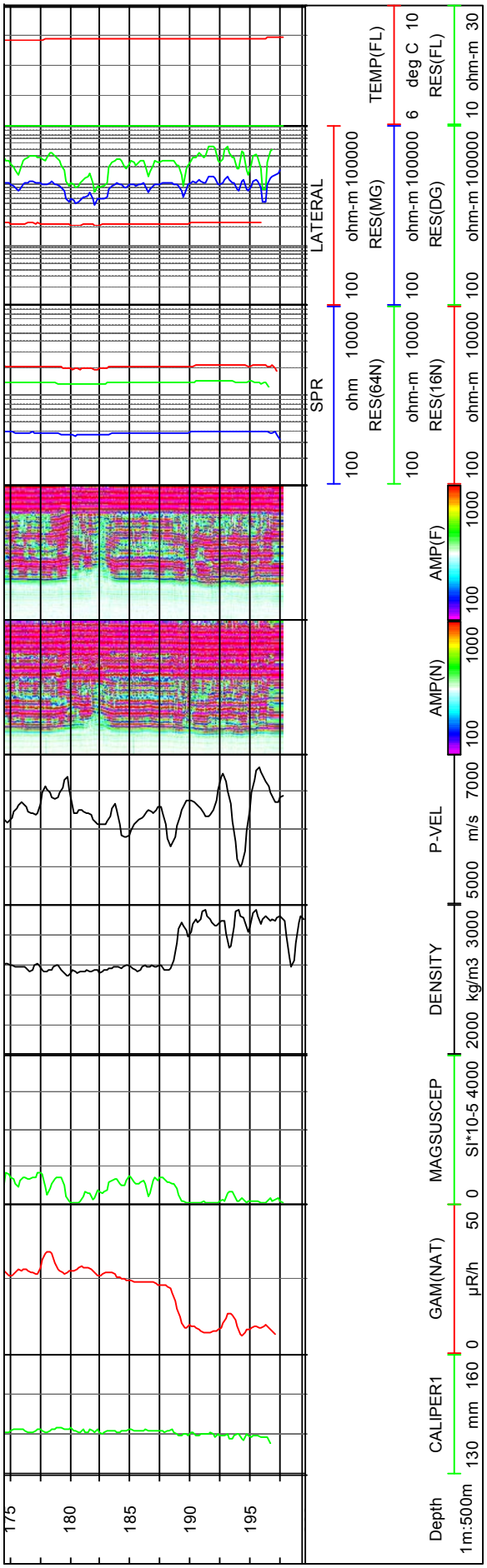
Depth
1m:500m
CALIPER1
130 mm 160
GAM(NAT)
0 µR/h 50
MAGSUSCEP
0 SI*10-5 4000
DENSITY
2000 kg/m3 3000
P-VEL
5000 m/s 7000
AMP(N)
100 1000
AMP(F)
100 1000
RES(16N)
100 ohm-m 10000
RES(DG)
100 ohm-m 100000
RES(64N)
100 ohm 10000
RES(MG)
100 ohm-m 100000
SPR
LATERAL
100 ohm-m 100000
TEMP(FL)
6 deg C 10
RES(FL)
10 ohm-m 30
175
180
185
190
195

Borehole No. HLX34

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

Northing: 6367355.125 m Easting: 1547489.558 m Elevation:14.29 m, RHB70

Diameter:	137 mm
Reaming Diameter:	
Outer Casing:	
Inner Casing:	
Borehole Length:	151.80 m
Cone:	
Inclination at ground surface:	-59.7274°
Azimuth:	101.0683°
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	8144	deg C
RES(FL)	Fluid resistivity	8144	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

Rev.	Date	Drawn by	Control	Approved
0	2005-09-05	UTN	JRI	UTN

Job 547310A

Scale 1:500

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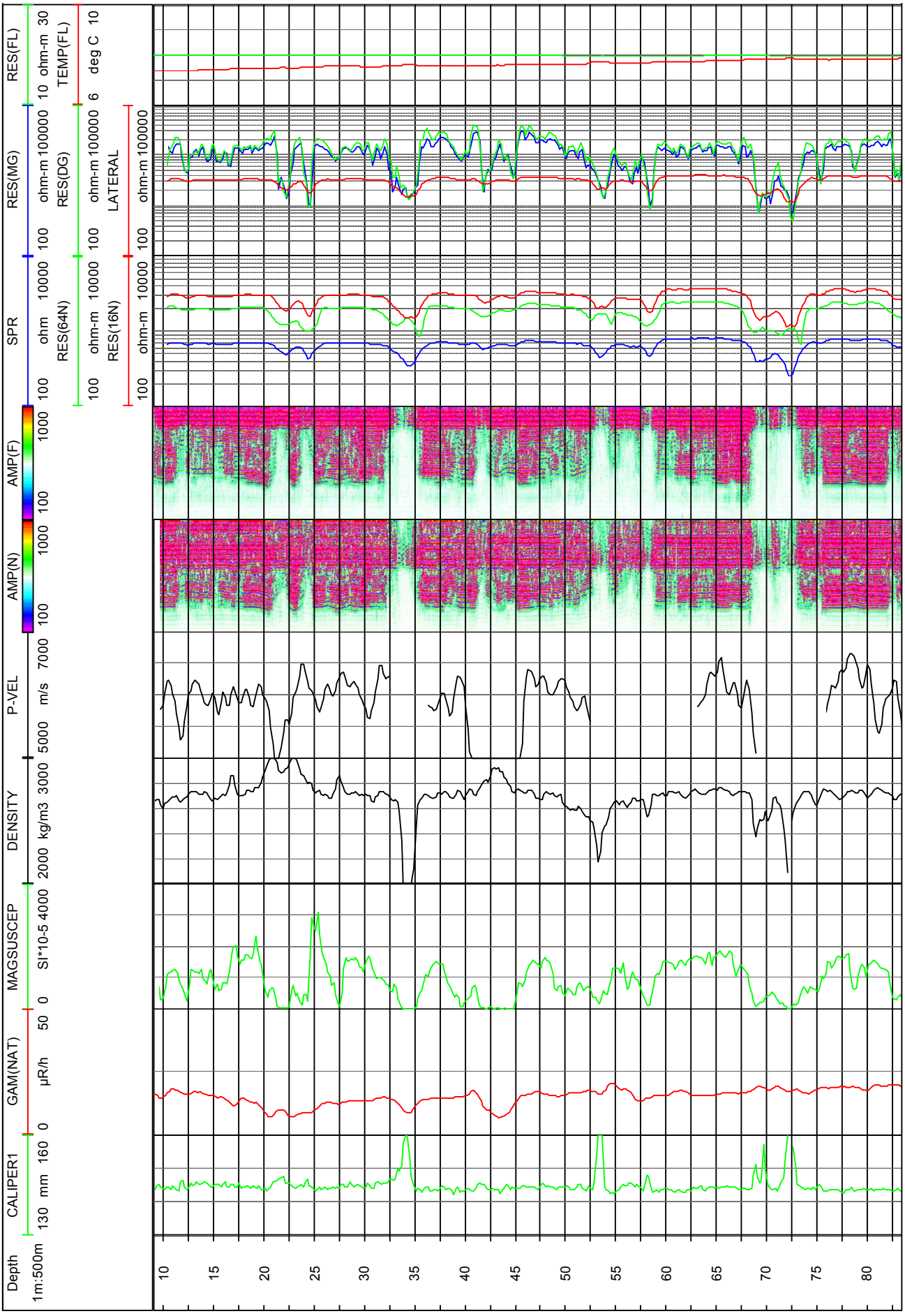
SKB geophysical borehole logging
Borehole HLX34

Presentation

Filename: HLX34_Presentation.wcl

Drawing no.: **4.1**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1m:500m
CALIPER1
130 mm 160
GAM(NAT)
0 µR/h 50
MAGSUSCEP
0 SI*10-5 4000
DENSITY
2000 kg/m3 3000
P-VEL
5000 m/s 7000
AMP(N)
100 1000
AMP(F)
100 1000
SPR
100 ohm 10000
RES(64N)
100 ohm-m 10000
RES(16N)
100 ohm-m 10000
LATERAL
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
TEMP(FL)
6 deg C 10
RES(FL)
10 ohm-m 30
10
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20
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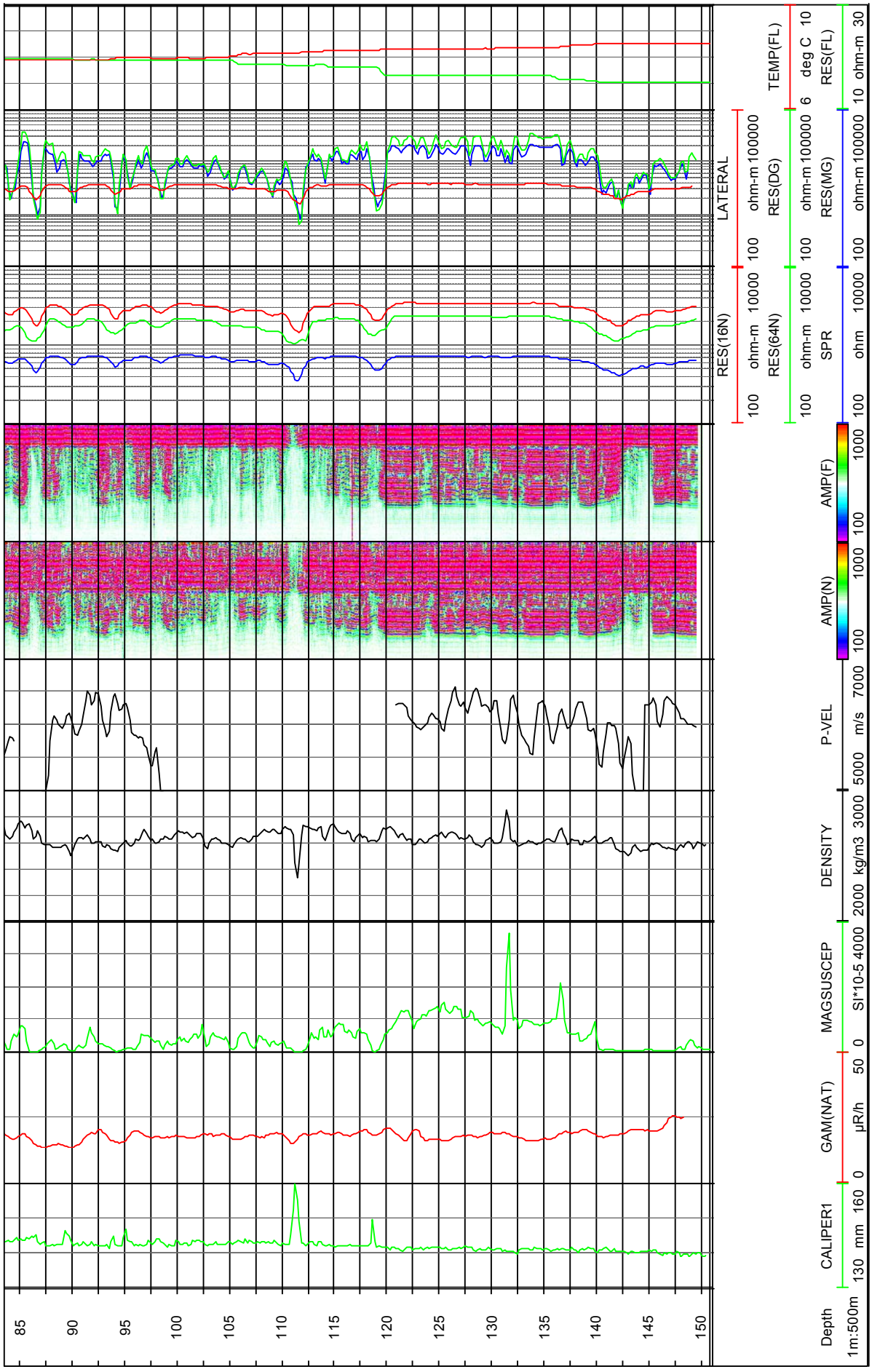
30
35
40
45
50
55
60
65
70
75
80


Depth
1m:500m
CALIPER1
130 mm 160
GAM(NAT)
0 µR/h 50
MAGSUSCEP
0 SI*10-5 4000
DENSITY
2000 kg/m3 3000
P-VEL
5000 m/s 7000
AMP(N)
100 1000
AMP(F)
100 1000
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(MG)
100 ohm-m 100000
TEMP(FL)
6 deg C 10
RES(FL)
10 ohm-m 30
85
90
95
100
105
110
115
120
125
130
135
140
145
150

Borehole No. HLX35

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

Northing: 6367194.788 Easting: 1547437.792 Elevation:14.44, RHB70

Diameter:	140 mm
Reaming Diameter:	
Outer Casing:	
Inner Casing:	
Borehole Length:	151.80 m
Cone:	
Inclination at ground surface:	-59.8774°
Azimuth:	102.2160°
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	8144	deg C
RES(FL)	Fluid resistivity	8144	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

Rev.	Date	Drawn by	Control	Approved
0	2005-09-07	UTN	JRI	UTN

Job 547310A

Scale 1:500

RAMBØLL

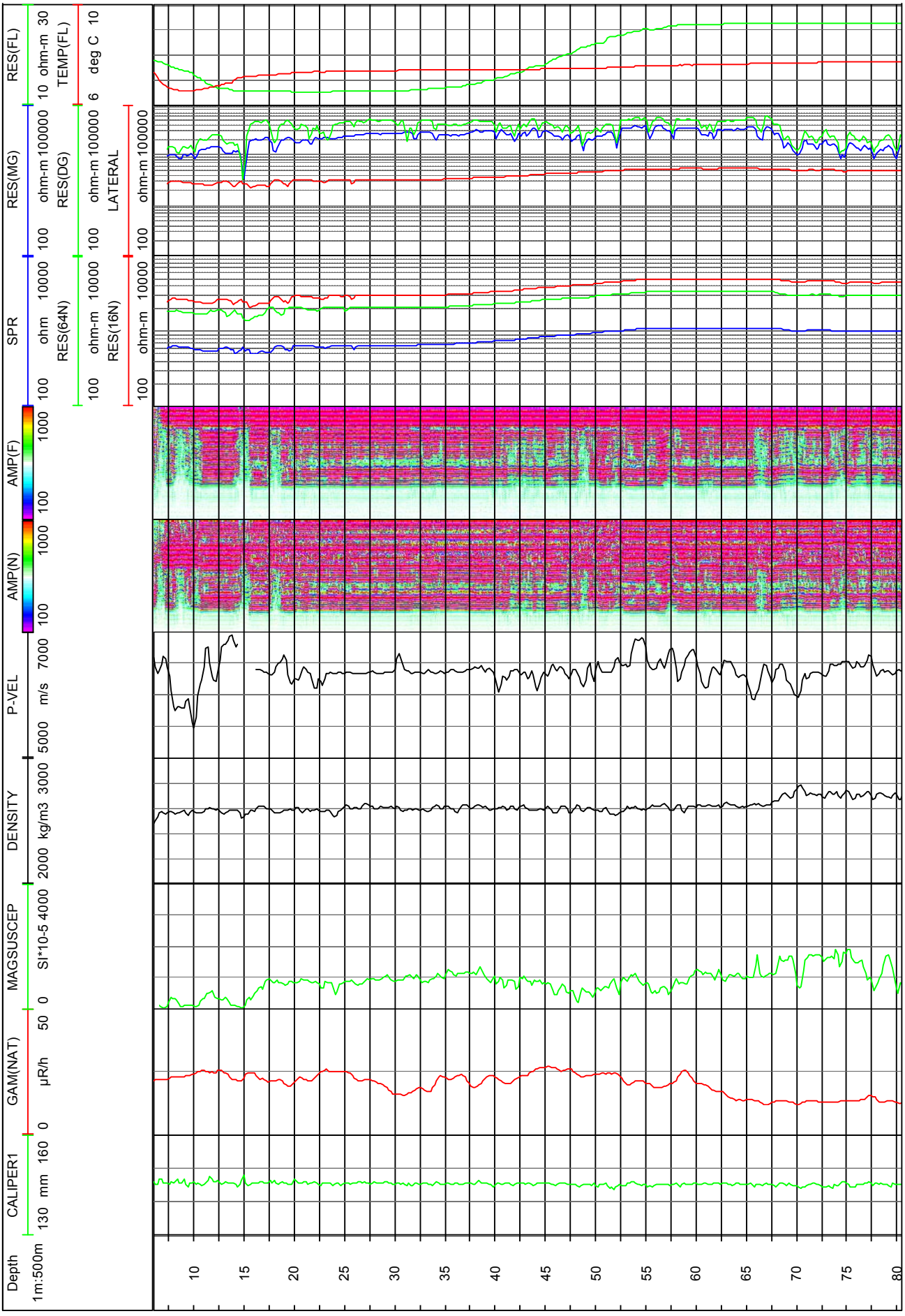
Rambøll. Bredevej 2, DK-2830 Virum
Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

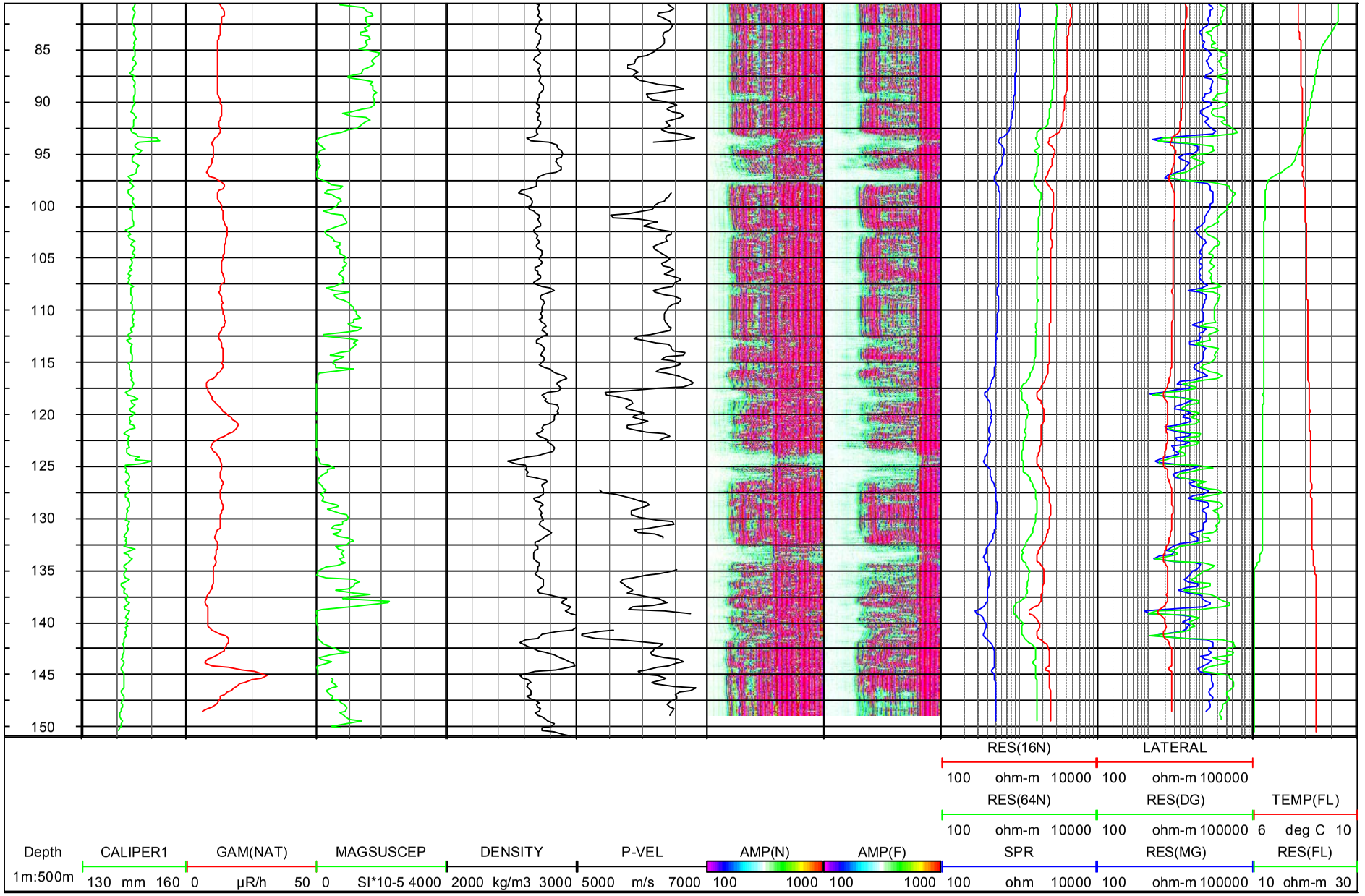
SKB geophysical borehole logging
Borehole HLX35

Presentation

Filename: HLX35_Presentation.wcl

Drawing no.: **5.1**


Depth
1m:500m
CALIPER1
130 mm 160
GAM(NAT)
0 µR/h 50
MAGSUSCEP
0 SI*10-5 4000
DENSITY
2000 kg/m3 3000
P-VEL
5000 m/s 7000
AMP(N)
100 1000
AMP(F)
100 1000
SPR
100 ohm-m 10000
RES(64N)
100 ohm-m 10000
RES(16N)
100 ohm-m 10000
LATERAL
100 ohm-m 100000
RES(MG)
10 ohm-m 100000
RES(DG)
10 ohm-m 100000
TEMP(FL)
6 deg C 10
RES(FL)
10 ohm-m 30
10
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
RES(16N)
LATERAL
100 ohm-m 10000 100 ohm-m 100000
RES(64N)
RES(DG)
TEMP(FL)
100 ohm-m 10000 100 ohm-m 100000 6 deg C 10
Depth
1m:500m
CALIPER1
130 mm 160
GAM(NAT)
0 µR/h 50
MAGSUSCEP
0 SI*10-5 4000
DENSITY
2000 kg/m3 3000
P-VEL
5000 m/s 7000
AMP(N)
100 1000
AMP(F)
100 1000
SPR
100 ohm 10000
RES(MG)
100 ohm-m 100000
RES(FL)
10 ohm-m 30