P-04-202

Oskarshamn site investigation

Geophysical borehole logging in borehole KAV04A, KAV04B, HLX13 and HLX15

Uffe Torben Nielsen, Jørgen Ringgaard
RAMBØLL

July 2004

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

ISSN 1651-4416
SKB P-04-202

Oskarshamn site investigation

Geophysical borehole logging in borehole KAV04A, KAV04B, HLX13 and HLX15

Uffe Torben Nielsen, Jørgen Ringgaard
RAMBØLL

July 2004

Keywords: Geophysical logging.

Abstract

Geophysical borehole logging has been performed in borehole KAV04A, KAV04B, HLX13 and HLX15 situated in Simpevarp and Laxemar in Oskarshamn, Sweden.

The objective of the surveys is to determine 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 KAV04A was recorded from 100 to 1,000 m, KAV04B was recorded from 0 to 100 m, HLX13 was recorded from 0 to 200 m and HLX15 was recorded from 0 to 150 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 borrhål KAV04A, KAV04B, HLX13 och HLX15 i delområde Simpevarp och 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 KAV04A från 100 till 1 000 m, KAV04B mättes från 0 till 100 m, HLX13 mättes från 0 till 200 m och HLX15 mättes från 0 till 150 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 borehole KAV04A, KAV04B, HLX13 and HLX15, 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 400-04-047 (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 June 1–3, 2004. All boreholes were recorded from ground level 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 KAV04A, KAV04B, HLX13 and HLX15.	AP PS 400-04-047	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 KAV04A and KAV04B and hammer boreholes HLX13 and HLX15.

Boreholes parameter	KAV04A	KAV04B	HLX13	HLX15
Co-ordinates	6366795.764 N	6366795.641 N	6366953.000 N	6365361.975 N
(RT90)	1552474.999 E	1552474.469 E	1547690.420 E	1548664.018 E
Elevation RHB70)	10.353 m	10.352 m	17.391 m	4.807 m
Azimuth	77.032°	134.269°	184.18°	184.65°
Inclination (from horizontal)	–84.9052°	–89.8422°	–58.07°	–58.37°
Length	1,004.0 m	101.03 m	200.02 m	151.90 m
Casing	0–100.2 m 208/200 mm	0–11.52 m 89/77 mm	0–11.85 m 168/160 mm	0–11.53 m 168/160 mm
Cone	96.35 m–100.95 m 100/ 77 mm			
Borehole diameter	76 mm 100.95–1,004.0 m	76 mm	190 mm (0–12.00 m) 140 mm (12.00–200.02 m)	190 mm (0–12.24 m) 140 mm (12.24–151.90 m)
Cleaning level	Level 2	Level 2	Level 1	Level 1

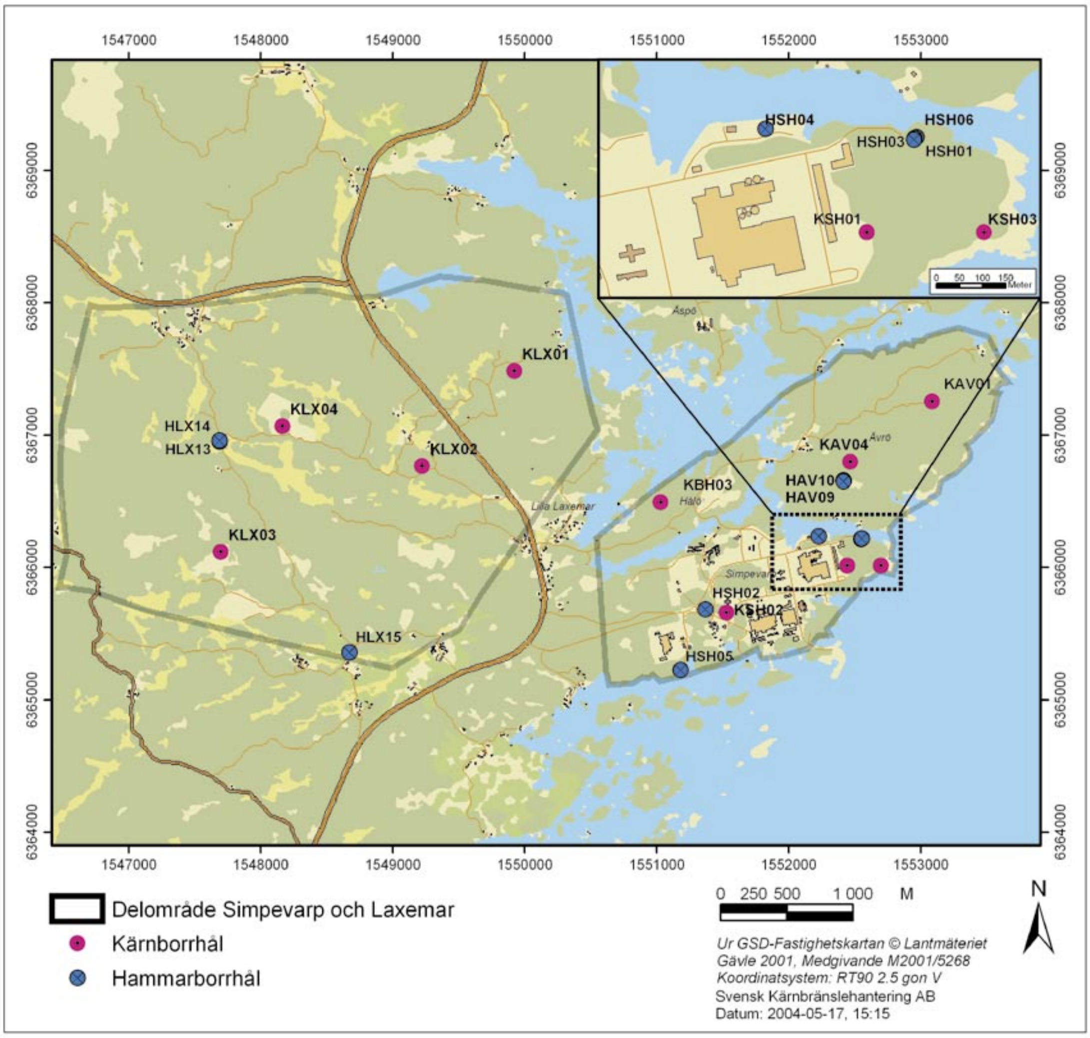


Figure 1-1. *General overview over the Simpevarp and Laxemar subareas.*

2 Objective and scope

The objective of the surveys 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, KAV04A.

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 KAV04A in Appendix 1, drawing no 2.1 for borehole KAV04B in Appendix 2, drawing no 3.1 for borehole HLX13 in Appendix 3 and drawing no 4.1 for borehole HLX15 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 KAV04A, KAV04B, HLX13 and HLX15.

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 documents). The logging program in borehole KAV04A and KAV04B was executed in the period June 1–2, 2004 and in borehole HLX13 and HLX15 in the period June 2–3, 2004.

All relevant logging events were described in the daily report sheets included in Enclosure A.

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 cleaned 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 to the boreholes.

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

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

4.2 Nonconformities

There were no nonconformities according to the Activity plan.

5 Results

5.1 Presentation

All relevant logging events were described in the daily report sheet which was delivered separately. A function test of the deviations measurements in the HiRAT tool was performed before arriving at the site, following SKB internal controlling document SKB MD 224.001.

The logs have not been filtered during logging or presentation. 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.

The logs have not been filtered during logging or presentation.

Table 5-1. 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.

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/m3	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 Orientations, 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 used winch between up- and down runs in the depth registration. The size of the defect is about 1.5 m/km. To compensate for this the logs are stretched using another new depth scale for each tool. The depth scale is made by using gamma events from the tool compared with the same gamma events from the HiRAT tool. The events in both files are matched, and the new depth scale is made and added to the log.

5.2.5 Removing of data

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

5.2.6 Repicking of sonic log

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

5.3 Calculated log curves

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

Table 5-2. Calculated log curves.

Log	Description of log calculation
Caliper, 1-arm	The Caliper was converted from [cm] to [mm] units by multiplying [cm] with 10.
Gamma-gamma density	The Gamma-gamma was converted from [g/cm3] to [kg/m3] 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	–
Borehole Inclination from lateral	–
360° orientated acoustic travel time	–
360° orientated acoustic travel time	–

5.4 Borehole KAV04A

In order to obtain an exact depth calibration in borehole KAV04A, the track marks made while drilling are used. The connection between the track marks and the logs is obtained from the HiRAT Acoustic tool.

To obtain a common depth reference point, the track mark at 108.65 m in the HiRAT file is used as the marker at depth 110 m. The HiRAT tool is therefore shifted 1.35 m down. The same correction value is used for the whole boring.

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

Table 5-3. The reference mark made in the borehole, the recorded track marks form the HiRAT and the corrected depth.

Reference mark	HIRAT recorded	HIRAT after shift
110.00	108.65	108.650
150.00	148.69	148.690
200.00	198.72	198.720
250.00	248.72	248.720
300.00	298.77	298.770
350.00	348.8	348.800
400.00	398.82	398.820
451.00	449.88	449.880
500.00	498.9	498.900
550.00	548.92	548.920
600.00	598.98	598.980
650.00	649.01	649.010
700.00	699.08	699.080
750.00	749.12	749.120
800.00	799.18	799.180
846.00	845.24	845.240
900.00	899.3	899.300
950.00	949.31	949.310

A new depth scale is made using the corrected depth shown in Table 5-3. 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 Table 5-4, between all logruns, the obtained reference mark correlation is transferred to the other logs.

The complete log suite for borehole KAV04A is presented as composite log sheets in drawing no 1.1 in Appendix 1. The logs presented in drawing no 1.1 are listed in Table 5-1.

Table 5-4. Gamma events in borehole KAV04A.

Events	Depths
Top event	115.98
Mid event	531.91
Bottom event	991.06

5.5 Borehole KAV04B

Using the bottom of the casing and the natural gamma from the HiRAT as reference, he 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 KAV04B 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 5-5. Gamma events in borehole KAV04B.

Events	Depths
Top event	15.14
Bottom event	87.17

5.6 Borehole HLX13

Using the bottom of the casing and the natural gamma from the HiRAT as reference, the natural gamma logs from the other probes are aligned to the same depth. A new depth scale is added to each log and afterwards the logs are stretched using the events shown in Table 5-6.

The complete log suite for borehole HLX13 is presented as composite log sheet in drawing no 3.1. The logs presented in drawing no 3.1 are listed in Table 5-1.

Table 5-6. Gamma events in borehole HLX13.

Events	Depths
Top event	28.45
Bottom event	193.6

5.7 Borehole HLX15

Using 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 5-7.

The complete log suite for borehole HLX15 is presented as composite log sheet in drawing no 4.1. The logs presented in drawing no 4.1 are listed in Table 5-1.

Table 5-7. Gamma events in borehole HLX15.

Events	Depths
Top event	16.87
Bottom event	140.67

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 note no 372.

The processed files shown on the drawings have been delivered in both WellCAD, Table 6-2, and as excel files in SICADA format, Table 6-3. The different excel sheets (one for each log) in SICADA format are listed in Table 6-4.

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

Borehole	Probe	Log direction	WellCAD File	Description
KAV04A	8044	Down	KAV04A_06-02-04_08-04_8044C_.02_0.28_ 998.18_ORIG.log	Start Depth: 0.28 m. End Depth: 998.18 m.
KAV04A	8622	Up	KAV04A_06-01-04_18-47_8622C_.02_4.46_ 1002.26_ORIG.log	Start Depth: 1,002.26 m. End Depth: 4.46 m.
KAV04A	9030	Up	KAV04A_06-01-04_16-27_9030CA_.02_4.96_ 1003.24_ORIG.log	Start Depth: 1,003.24 m. End Depth: 4.96 m.
KAV04A	9072	Up	KAV04A_06-01-04_11-36_9072C_.10_-0.10_ 1002.90_ORIG.log	Start Depth: 1,002.9 m. End Depth: –0.1 m.
KAV04A	9310	Up	KAV04A_06-02-04_11-46_9310C2_.10_-3.40_ 1001.80_ORIG.log	Start Depth: 1,001.8 m. End Depth: –3.4 m.
KAV04A	HiRAT	Up	KAV04A_HiRAT_90_pixels_up_run1.HED	Start Depth: 1,000 m. End Depth: 0 m.
KAV04B	8044	Down	KAV04B_06-02-04_13-44_8044C_.02_0.28_ 99.48_ORIG.log	Start Depth: 0.28 m. End Depth: 99.48 m.
KAV04B	8622	Up	KAV04B_06-02-04_15-00_8622C_.10_-0.30_ 99.40_ORIG.log	Start Depth: 99.4 m. End Depth: –0.3 m.
KAV04B	9030	Up	KAV04B_06-02-04_15-45_9030CA_.10_0.10_ 100.10_ORIG.log	Start Depth: 100.1 m. End Depth: 0.1 m.
KAV04B	9072	Up	KAV04B_06-02-04_14-35_9072C_.10_0.00_ 100.00_ORIG.log	Start Depth: 1 m. End Depth: 0 m.
KAV04B	9310	Up	KAV04B_06-02-04_14-17_9310C2_.10_-0.30_ 98.80_ORIG.log	Start Depth: 98.8 m. End Depth: –0.3 m.
KAV04B	HiRAT	Up	KAV04B_HiRAT_90_pixels_up_run2.HED	Start Depth: 98 m. End Depth: 0 m.
HLX13	8044	Down	HLX13_06-03-04_08-50_8044C_.02_0.28_ 198.40_ORIG.log	Start Depth: 0.28 m. End Depth: 198.4 m.
HLX13	8622	Up	HLX13_06-03-04_12-21_8622C_.02_0.36_ 198.74_ORIG.log	Start Depth: 198.74 m. End Depth: 0.36 m.
HLX13	9030	Up	HLX13_06-03-04_10-58_9030CA_.10_-0.30_ 199.00_ORIG.log	Start Depth: 199 m. *End Depth: –0.3 m.
HLX13	9072	Up	HLX13_06-03-04_10-15_9072C_.10_-0.40_ 199.10_ORIG.log	Start Depth: 199.1 m. End Depth: –0.4 m.
HLX13	9310	Up	HLX13_06-03-04_09-37_9310C2_.10_-0.70_ 198.00_ORIG.log	Start Depth: 198 m. End Depth: –0.7 m.

Borehole	Probe	Log direction	WellCAD File	Description
HLX13	HiRAT	Up	HLX13_HiRAT_90_pixels_up_run2.HED	Start Depth: 196.74 m. End Depth: 0 m.
HLX15	8044	Down	HLX15_06-02-04_16-41_8044C_.02_0.38_ 150.92_ORIG.log	Start Depth: 0.38 m. End Depth: 150.92 m.
HLX15	8622	Up	HLX15_06-02-04_19-39_8622C_.10_-0.40_ 151.10_ORIG.log	Start Depth: 151.1 m. End Depth: –0.4 m.
HLX15	9030	Up	HLX15_06-02-04_18-08_9030CA_.02_0.64_ 151.36_ORIG.log	Start Depth: 151.36 m. End Depth: 0.64 m.
HLX15	9072	Up	HLX15_06-02-04_17-30_9072C_.02_0.14_ 151.04_ORIG.log	Start Depth: 151.04 m. End Depth: 0.14 m.
HLX15	9310	Up	HLX15_06-02-04_19-12_9310C2_.10_-0.30_ 150.30_ORIG.log	Start Depth: 150.3 m. End Depth: –0.3 m.
HLX15	HiRAT	Down	HLX15_HiRAT_90_pixels_UP_run2.HED	Start Depth: 147 m. End Depth: 0 m.

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KAV04A	1.1	KAV04A_Presentation.WCL
KAV04B	2.1	KAV04B_Presentation.WCL
HLX13	3.1	HLX13_Presentation.WCL
HLX15	4.1	HLX15_Presentation.WCL

Table 6-3. Data files in excel, in SICADA format.

Borehole	Excel file
KAV04A	KAV04A_data.xls
KAV04B	KAV04B_data.xls
HLX13	HLX13_data.xls
HLX15	HLX15_data.xls

Table 6-4. Sheets included in the excel files, in SICADA format.

Sheet	Other
Acoustic televiewer	
Focused resistivity 140 cm	
Focused resistivity 300 cm	
Fullwave sonic	column: v_velocity (shear wave), not interpreted from the recorded data
Caliper1	
Caliper Mean	Calculated using Fluid resistivity and Acoustic televiewer
Fluid resistivity	
Fluid Temperature	
Density	
Resistivity	
Natural gamma	
Self potential	
Single point resistivity	
Magnetic susceptibility	

Borehole KAV04A, drawing no 1.1, borehole logs

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

Northing: 6366795.76 m Easting: 1552474.99 m Elevation: 10.353 m, RHB70

Diameter:	76 mm
Reaming Diameter:	
Outer Casing:	208 mm
Inner Casing:	200 mm
Borehole Length:	1004.0 m
Cone:	96.35 - 100.95 m
Inclination at ground surface:	-84.90°
Azimuth:	77.03°
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

Rev.	Date	Drawn by	Control	Approved
0	2004-06-09	JRI	FDH	UTN

Job	Scale
360210A	1:500

DGE Dansk Geo-servEx a/s — RAMBØLL

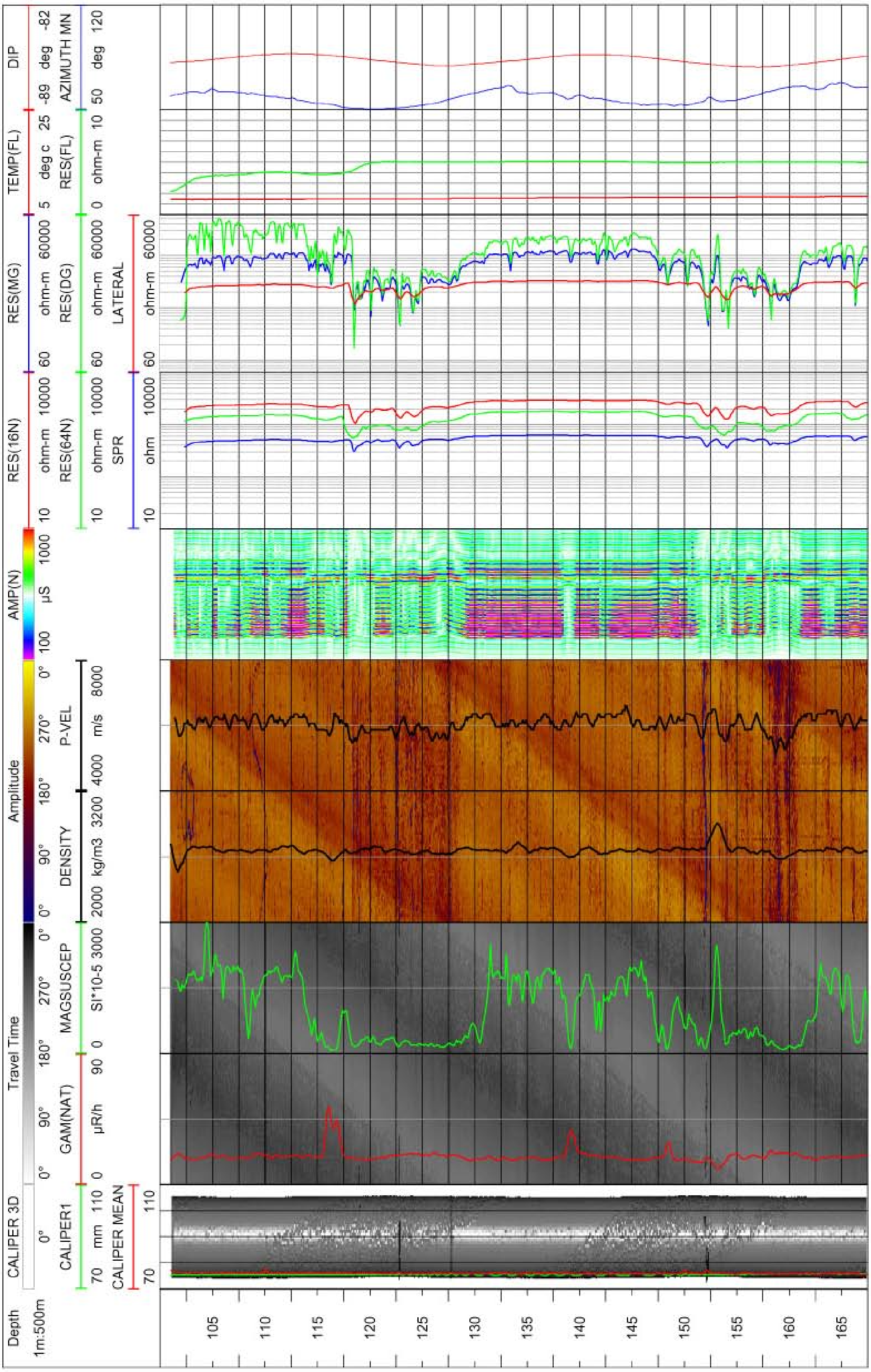
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

SKB geophysical borehole logging
Borehole KAV04A, Ävrö

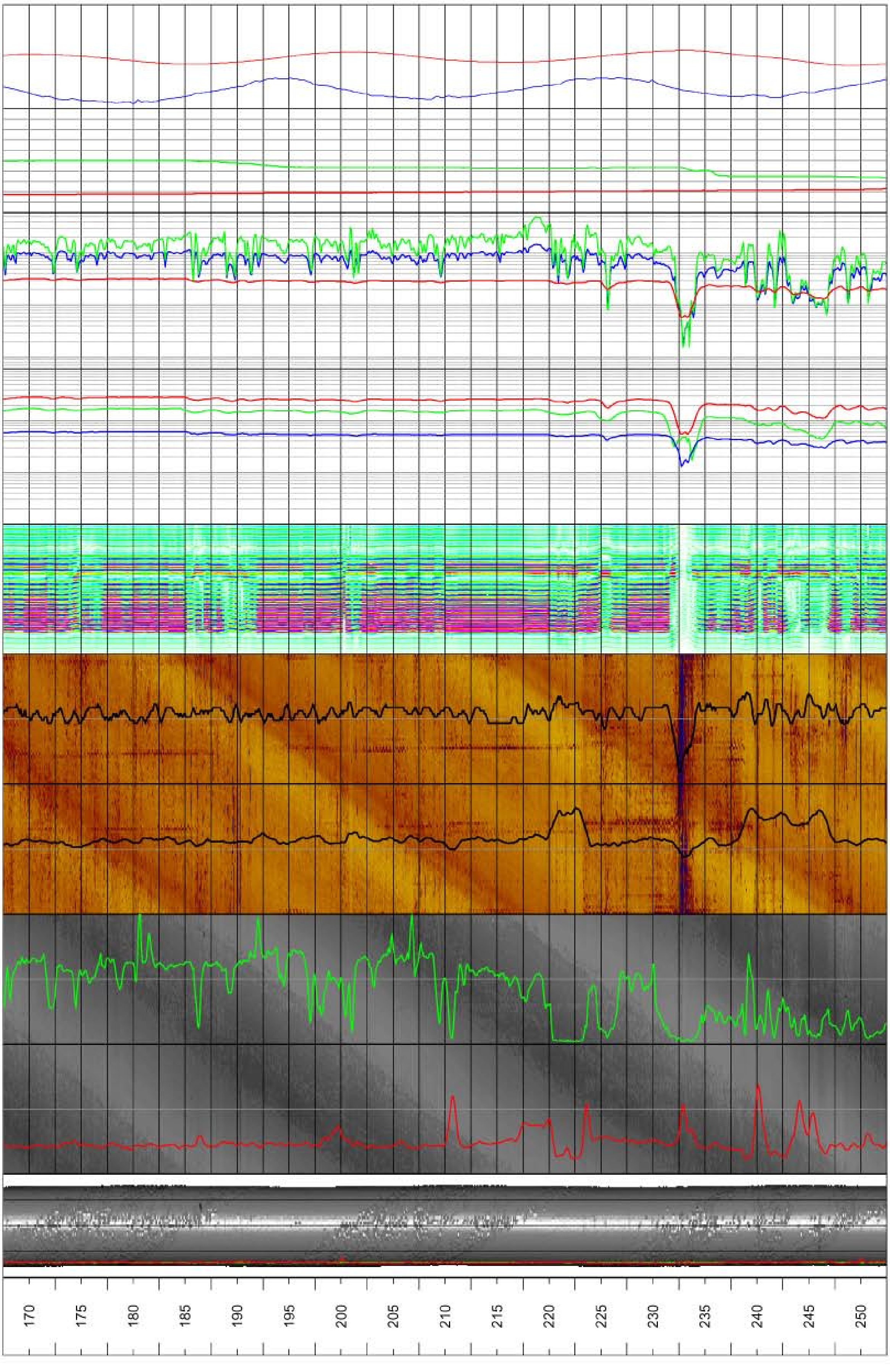
Presentation

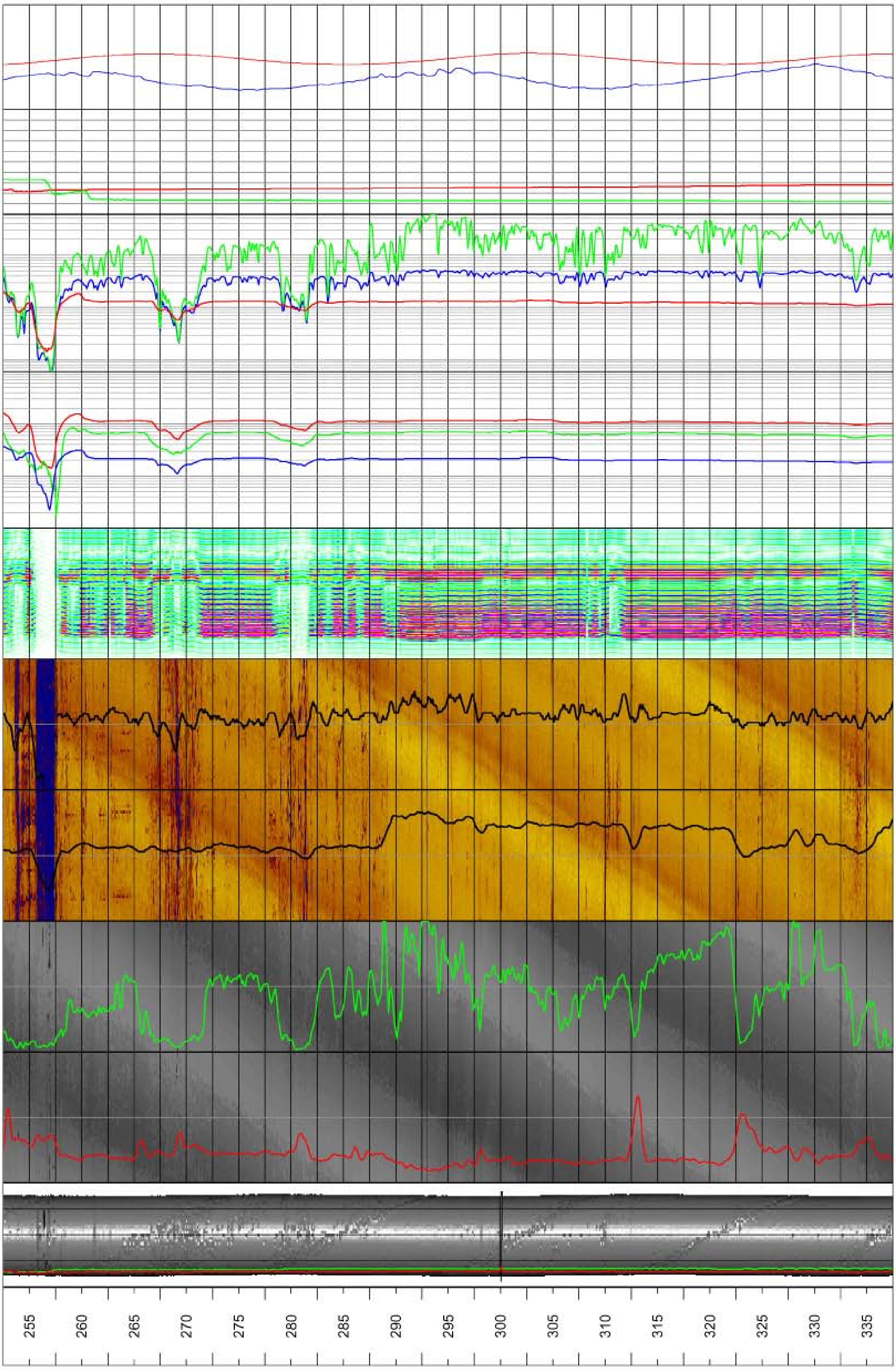
Filename:
KAV04A_Presentation.wcl

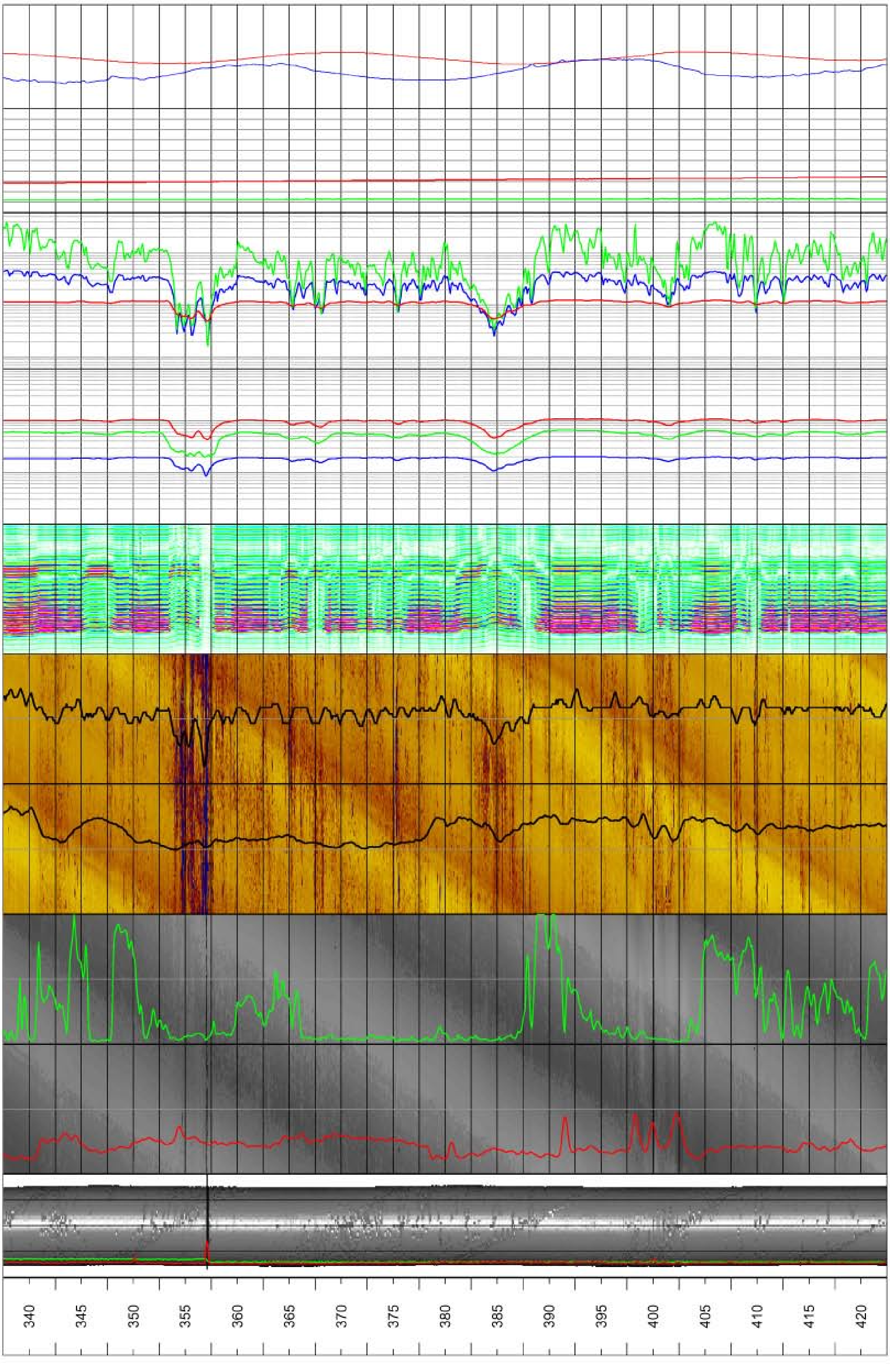
Drawing no.:
1.1

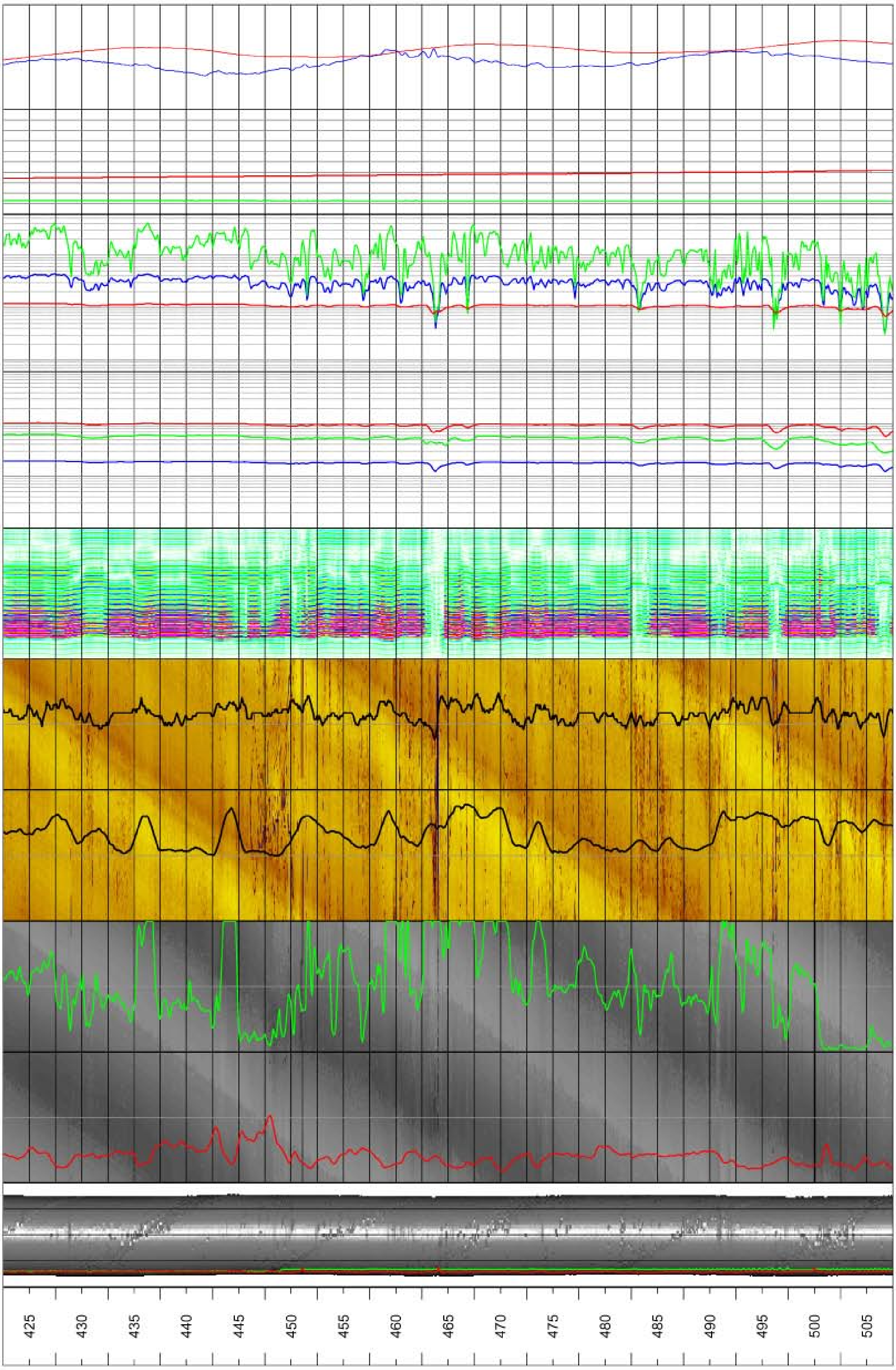


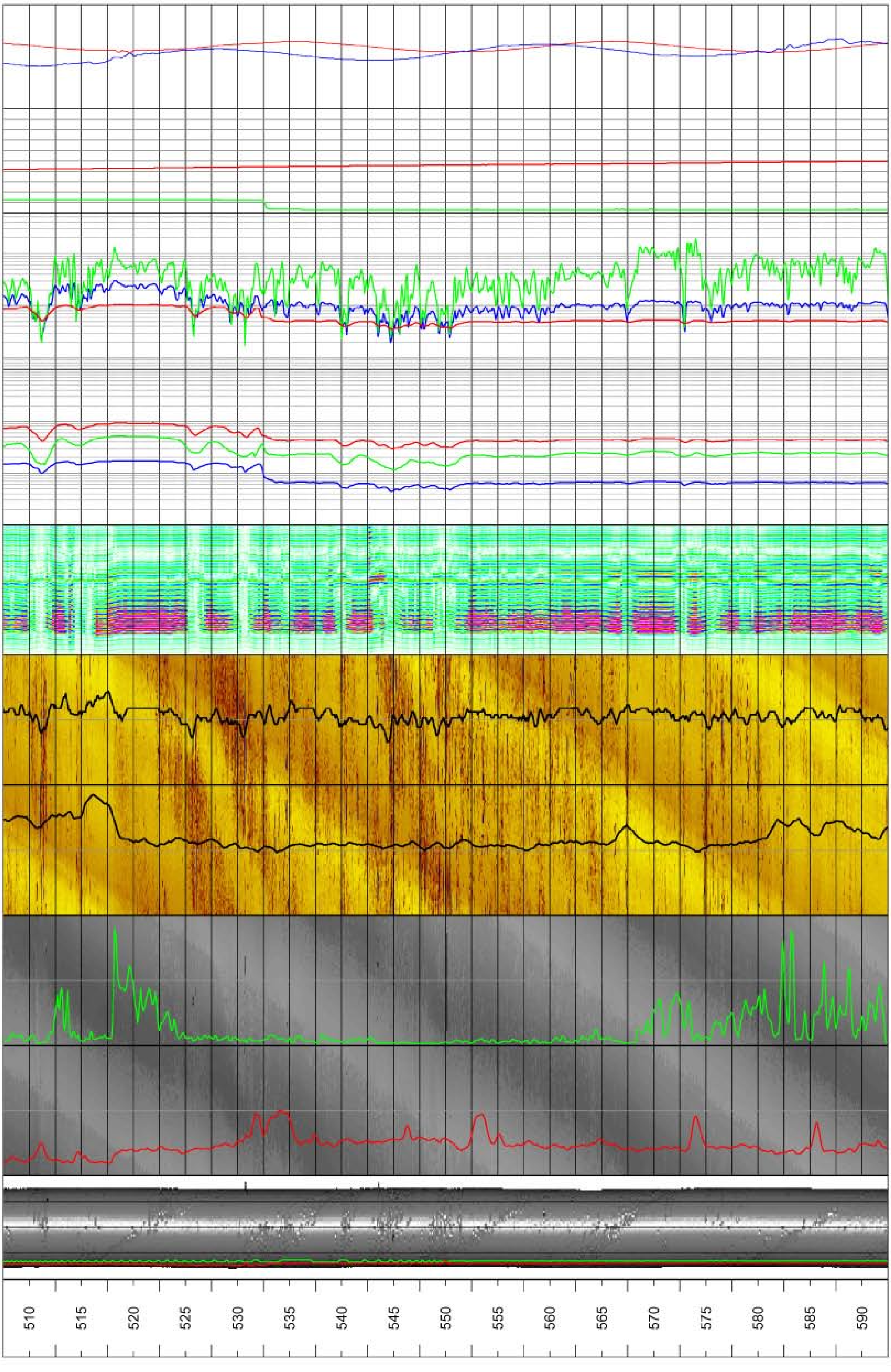
Depth
1m:500m
CALIPER 3D
CALIPER1
70 mm 110
CALIPER MEAN
70 110
Travel Time
GAM(NAT)
0 µR/h 90
MAGSUSCEP
0 SI*10-5 3000
Amplitude
DENSITY
2000 kg/m3 3200
P-VEL
4000 m/s 8000
AMP(N)
100 µS 1000
RES(16N)
10 ohm-m 10000
RES(64N)
10 ohm-m 10000
SPR
10 ohm 10000
RES(MG)
60 ohm-m 60000
RES(DG)
60 ohm-m 60000
LATERAL
60 ohm-m 60000
TEMP(FL)
5 deg c 25
RES(FL)
0 ohm-m 10
DIP
-89 deg -82
AZIMUTH MN
50 deg 120
105
110
115
120
125
130
135
140
145
150
155
160
165

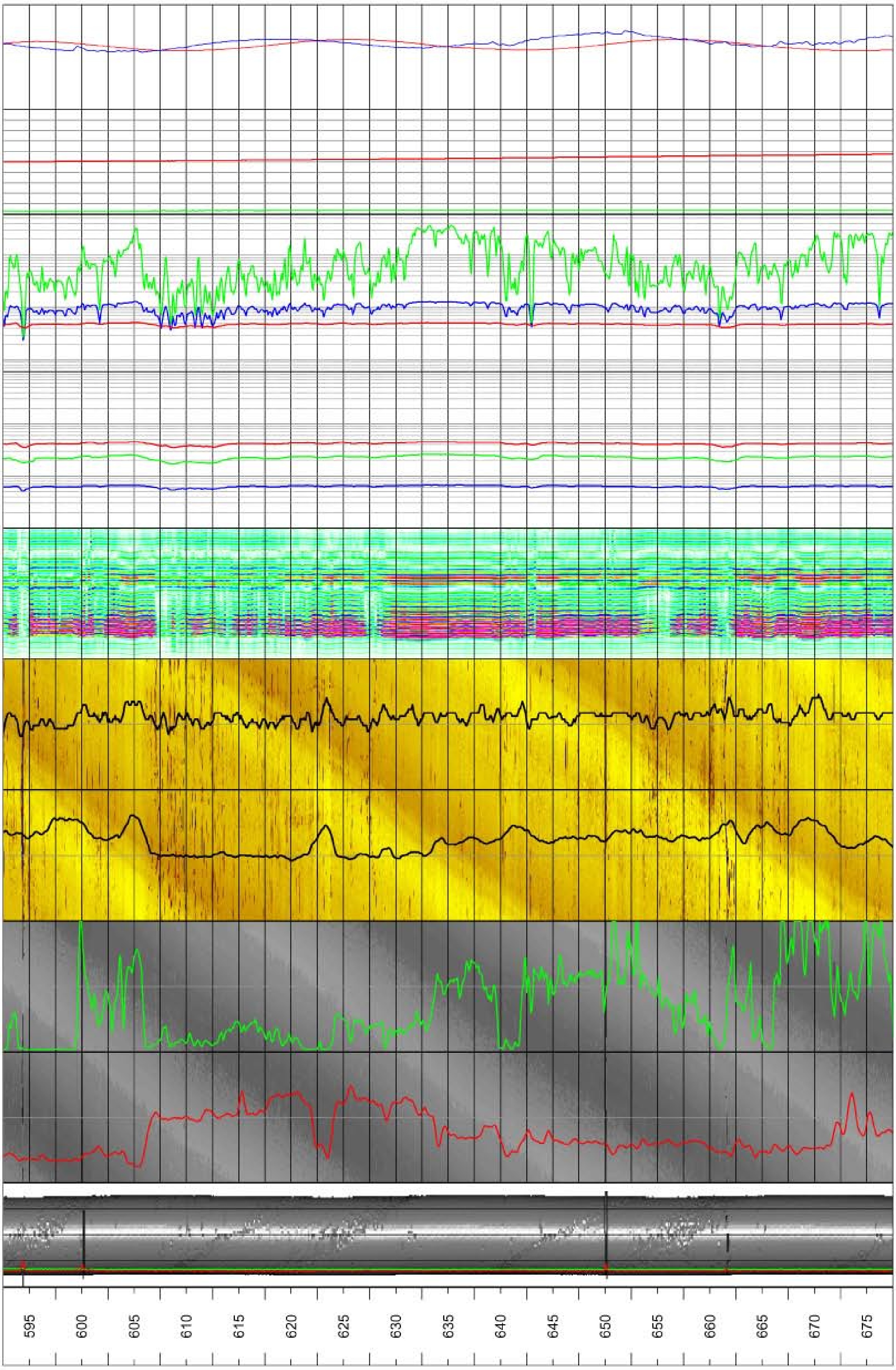

170
175
180
185
190
195
200
205
210
215
220
225
230
235
240
245
250

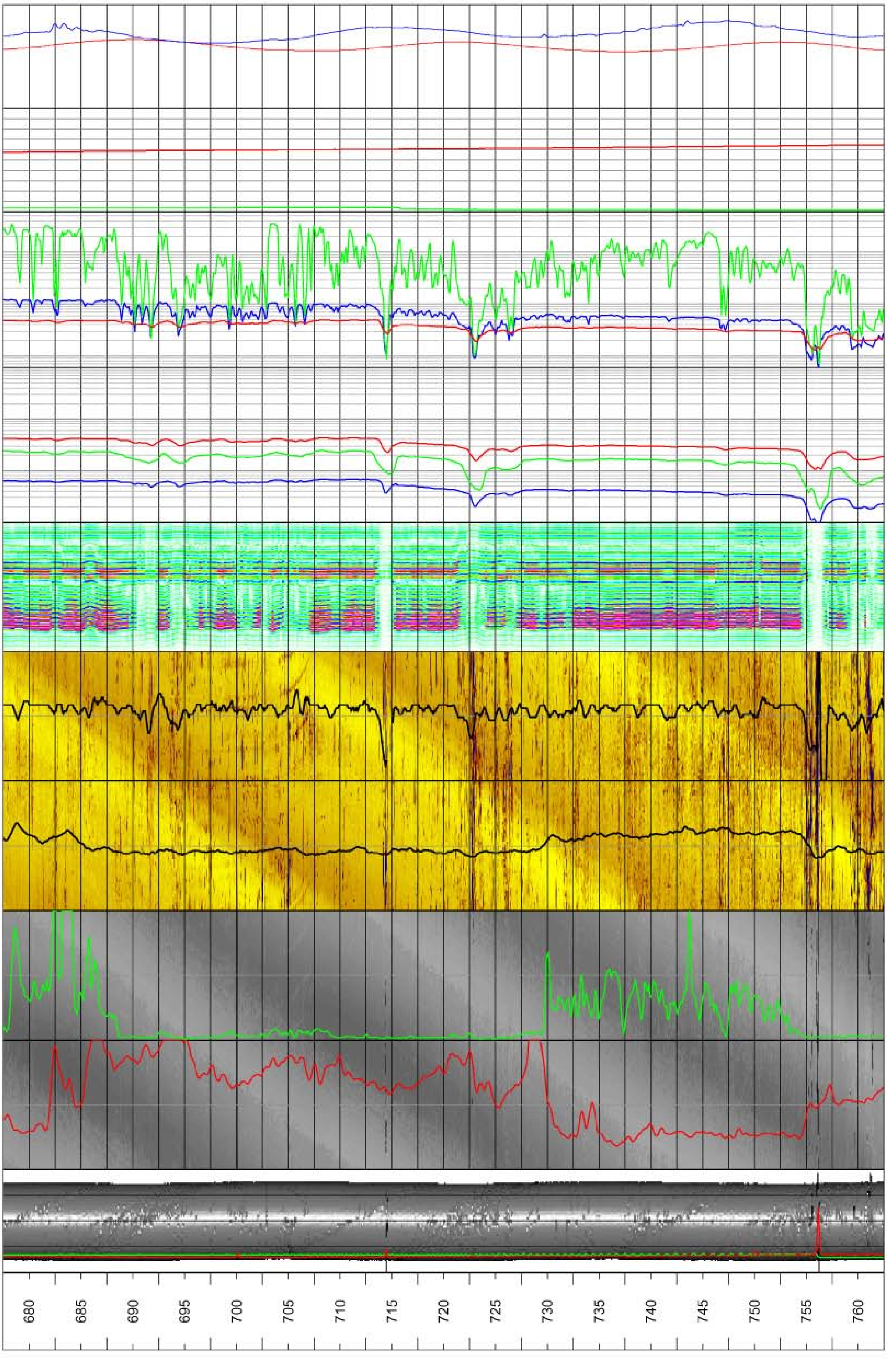

255
260
265
270
275
280
285
290
295
300
305
310
315
320
325
330
335

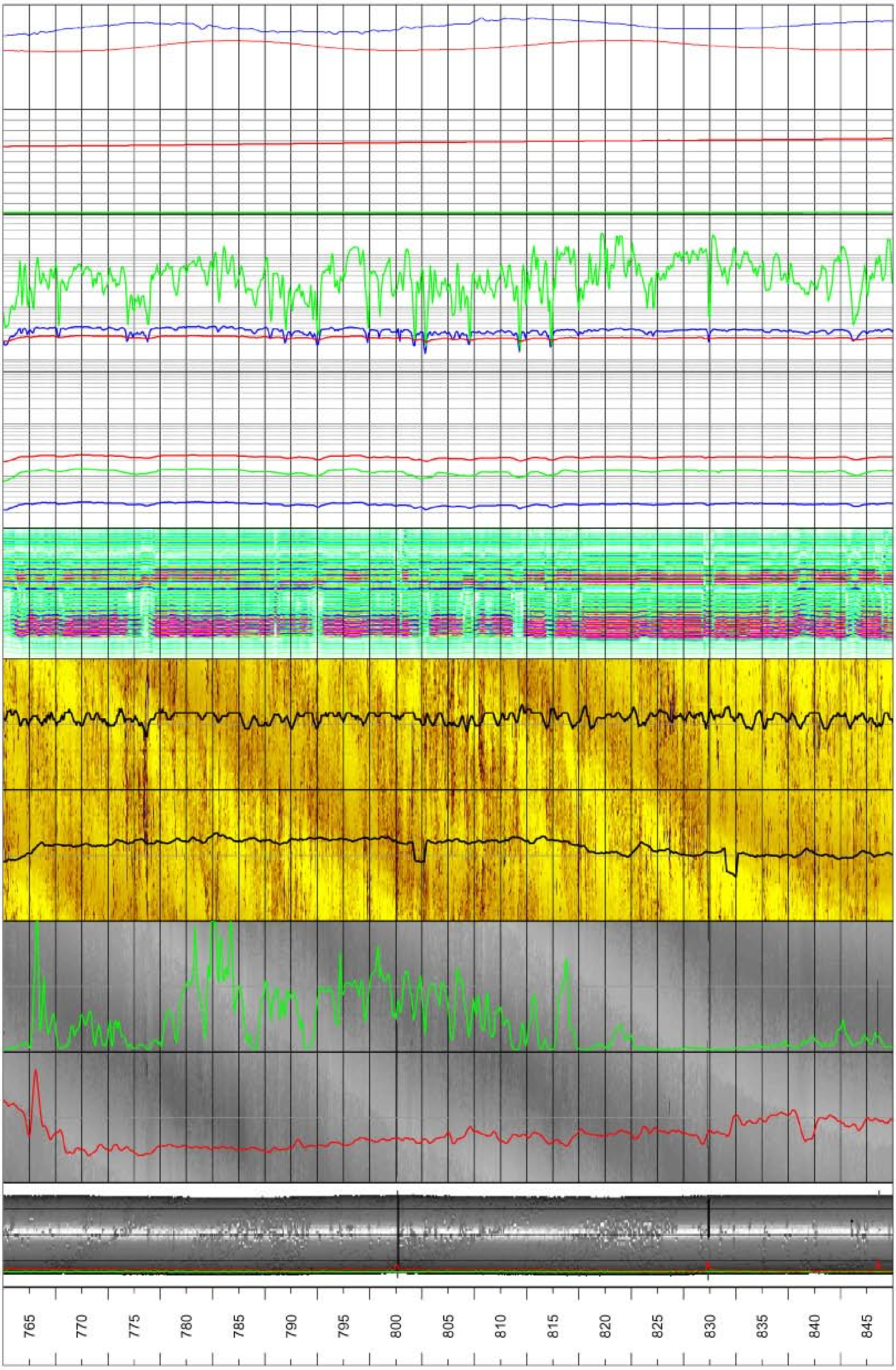

340
345
350
355
360
365
370
375
380
385
390
395
400
405
410
415
420

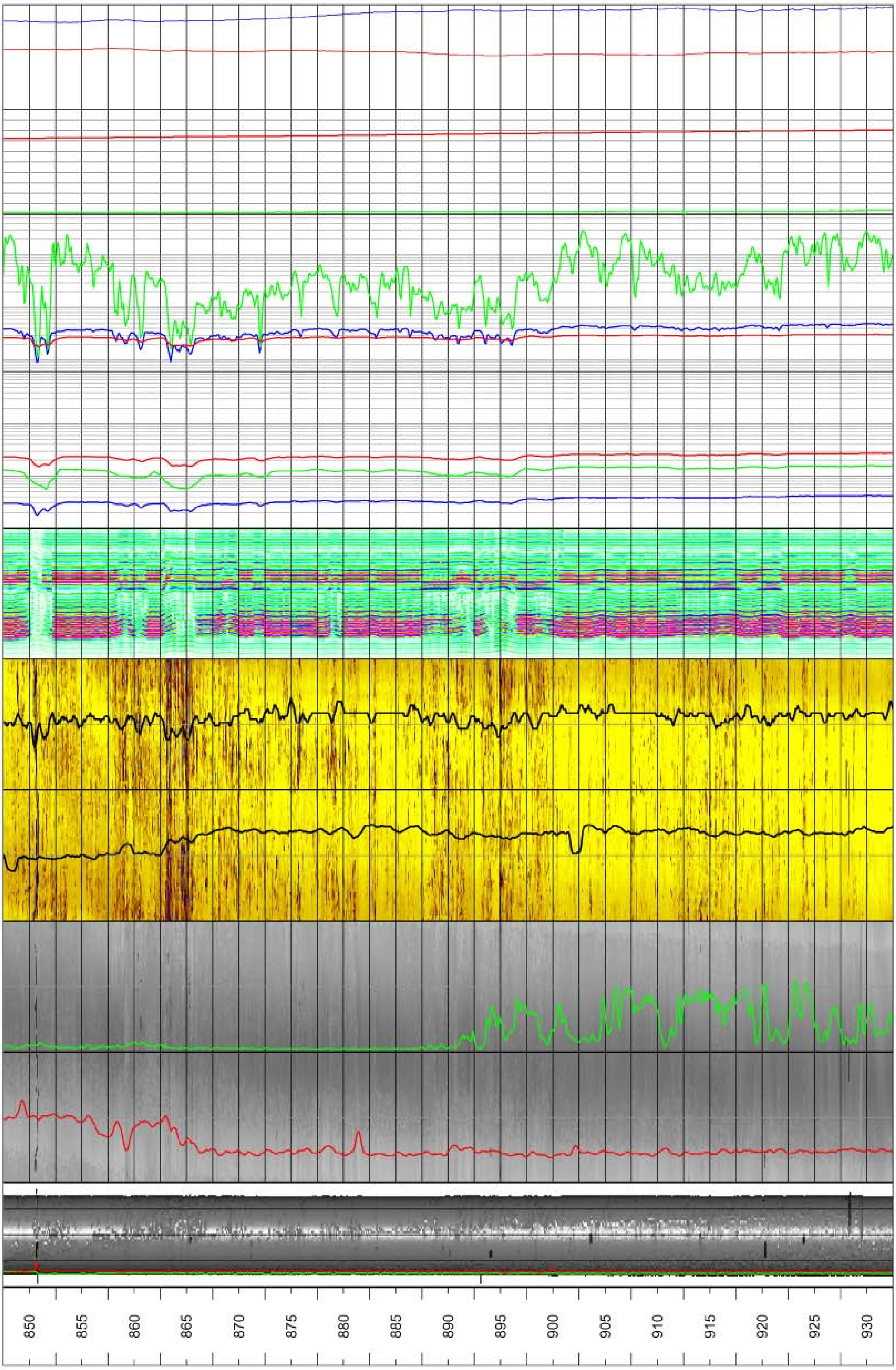

425
430
435
440
445
450
455
460
465
470
475
480
485
490
495
500
505

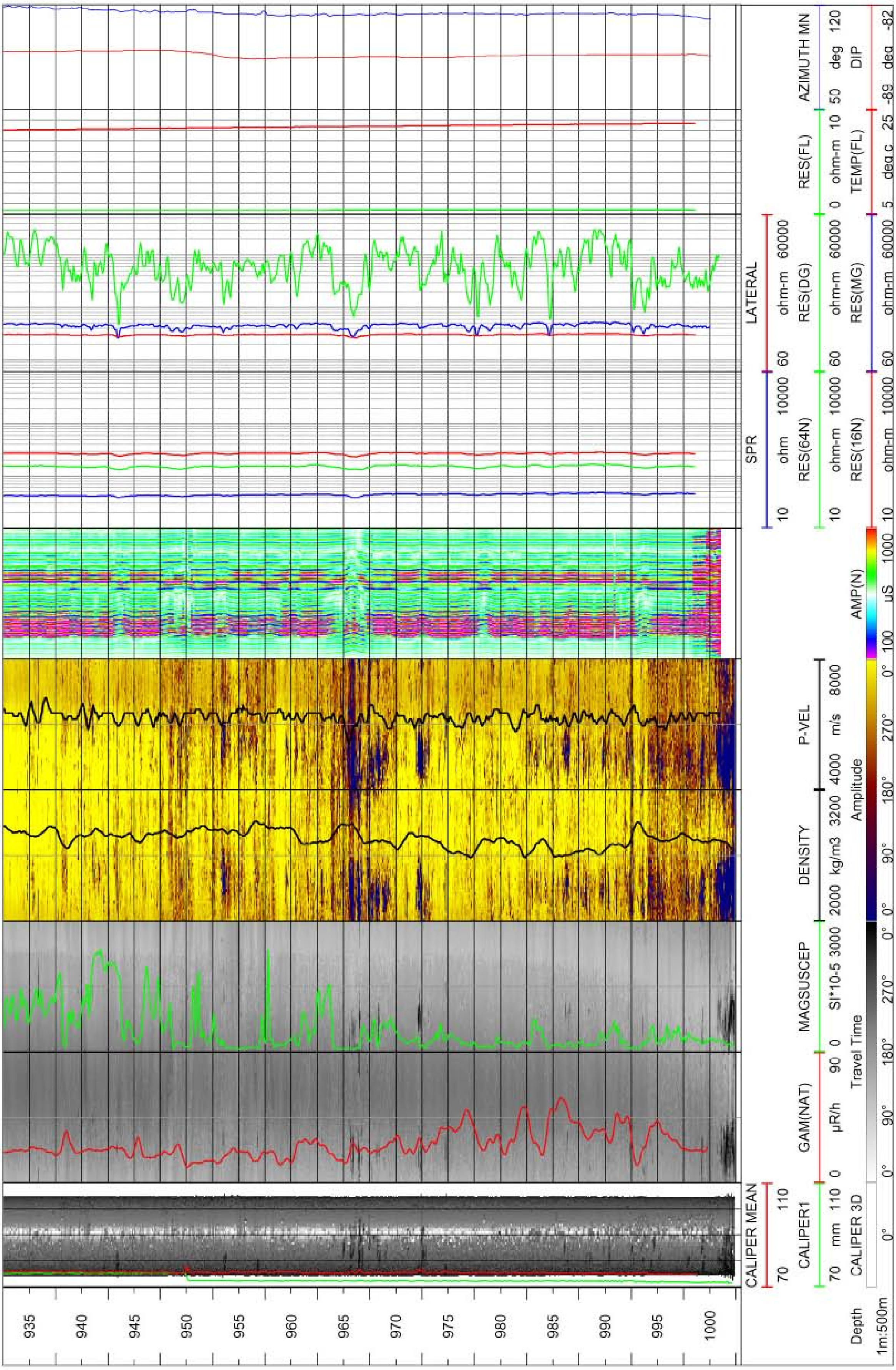

510
515
520
525
530
535
540
545
550
555
560
565
570
575
580
585
590


595
600
605
610
615
620
625
630
635
640
645
650
655
660
665
670
675


680
685
690
695
700
705
710
715
720
725
730
735
740
745
750
755
760


765
770
775
780
785
790
795
800
805
810
815
820
825
830
835
840
845


850
855
860
865
870
875
880
885
890
895
900
905
910
915
920
925
930


Depth
1m:500m
935
940
945
950
955
960
965
970
975
980
985
990
995
1000
CALIPER MEAN
70 110
CALIPER1
70 mm 110
CALIPER 3D
0°
GAM(NAT)
0 µR/h 90
MAGSUSCEP
0 SI*10-5 3000
Travel Time
0° 90° 180° 270° 0°
DENSITY
2000 kg/m3 3200
P-VEL
4000 m/s 8000
Amplitude
0° 90° 180° 270° 0°
AMP(N)
100 uS 1000
SPR
10 ohm 10000
RES(64N)
10 ohm-m 10000
RES(16N)
10 ohm-m 10000
LATERAL
60 ohm-m 60000
RES(DG)
60 ohm-m 60000
RES(MG)
60 ohm-m 60000
RES(FL)
0 ohm-m 10
TEMP(FL)
5 deg c 25
AZIMUTH MN
50 deg 120
DIP
-89 deg -82

Appendix 2

Borehole KAV04B, drawing no 2.1, borehole logs

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

Northing: 6366795.64 m Easting: 1552474.47 m Elevation: 10.352 m, RHB70

Diameter:	76 mm
Reaming Diameter:	
Outer Casing:	89 mm
Inner Casing:	77 mm
Borehole Length:	101.03 m
Cone:	-
Inclination at ground surface:	-89.84°
Azimuth:	134.269°
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

Rev.	Date	Drawn by	Control	Approved
0	2004-06-15	JRI	FDH	UTN

Job	Scale
360210A	1:500

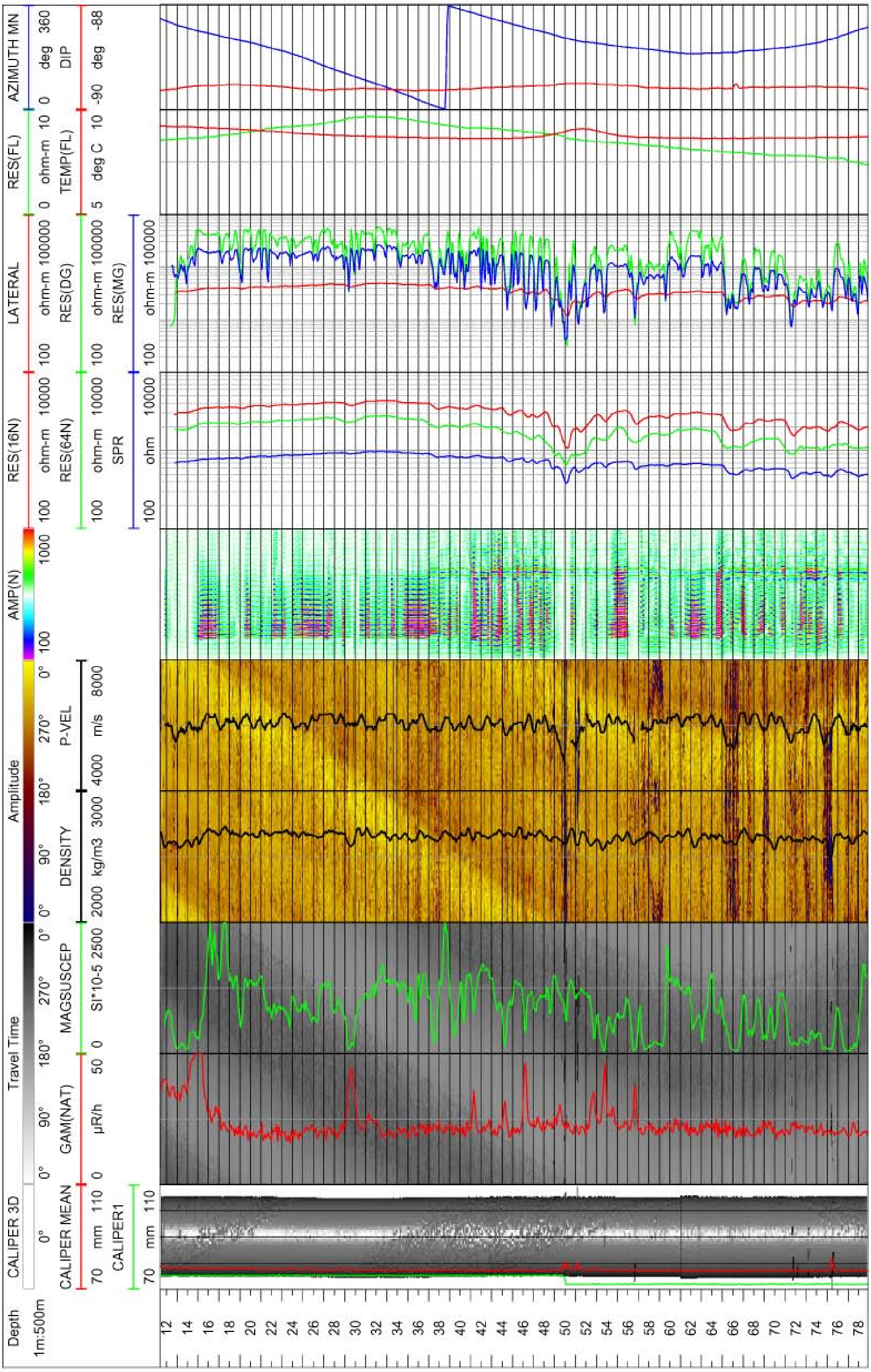
DGE Dansk Geo-servEx a/s
RAMBØLL
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

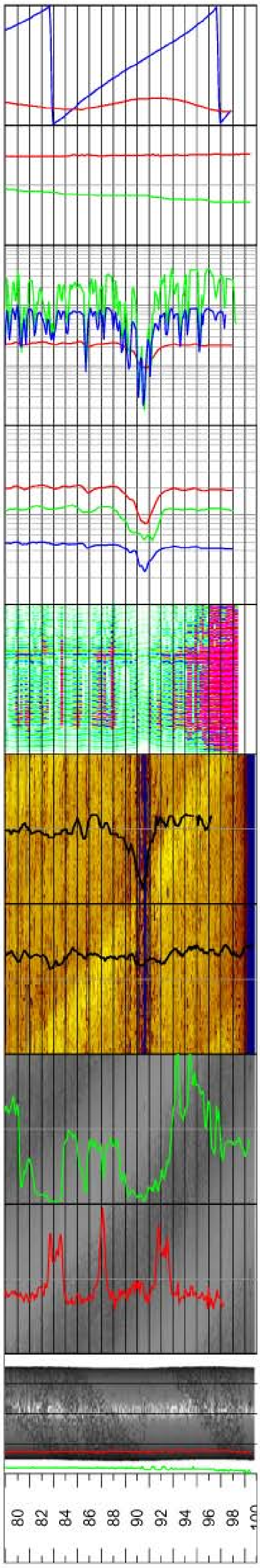
SKB geophysical borehole logging
Borehole KAV04B, Ävrö

Presentation

Filename:
KAV04A_Presentation.wcl

Drawing no.:
2.1


Depth
1m:500m
CALIPER 3D
CALIPER MEAN
CALIPER1
mm
Travel Time
GAM(NAT)
µR/h
MAGSUSCEP
SI*10-5
Amplitude
DENSITY
kg/m3
P-VEL
m/s
AMP(N)
RES(16N)
RES(64N)
SPR
ohm
LATERAL
RES(DG)
RES(MG)
ohm-m
RES(FL)
TEMP(FL)
deg C
AZIMUTH MN
DIP
deg


80
82
84
86
88
90
92
94
96
98
100

Appendix 3

Borehole HLX13, drawing no 3.1, borehole logs

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

Northing: 6366953 m Easting: 1547690.42 m Elevation: 17.391 m

Diameter:	140 mm
Reaming Diameter:	
Outer Casing:	168 mm
Inner Casing:	160 mm
Borehole Length:	200.02 m
Cone:	
Inclination at ground surface:	-57.07°
Azimuth:	184.18°
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	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

Rev.	Date	Drawn by	Control	Approved
0	2004-07-04	FDH	UTN	UTN

Job	Scale
360210A	1:500

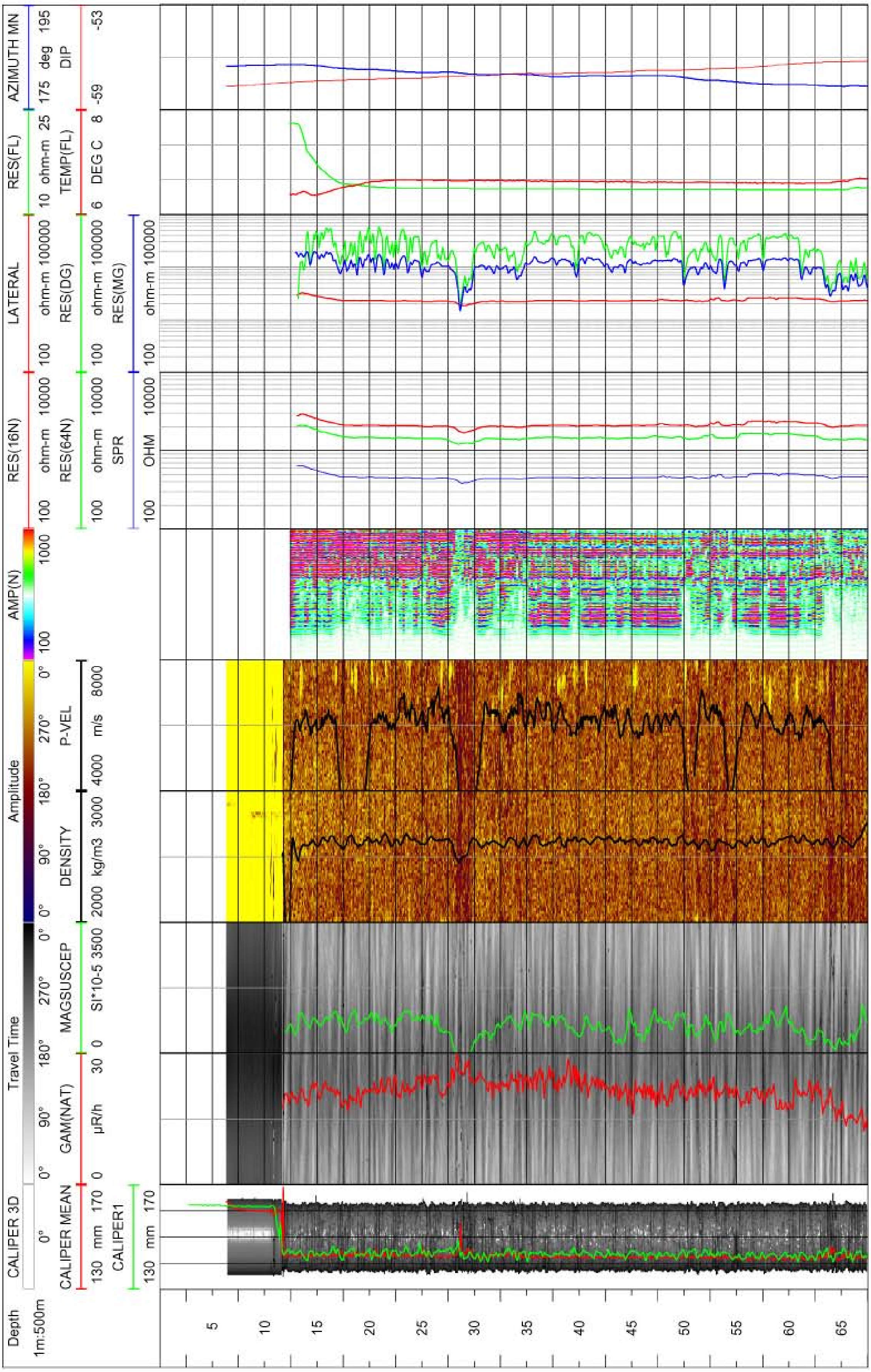
Dansk Geo-servEx a/s
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

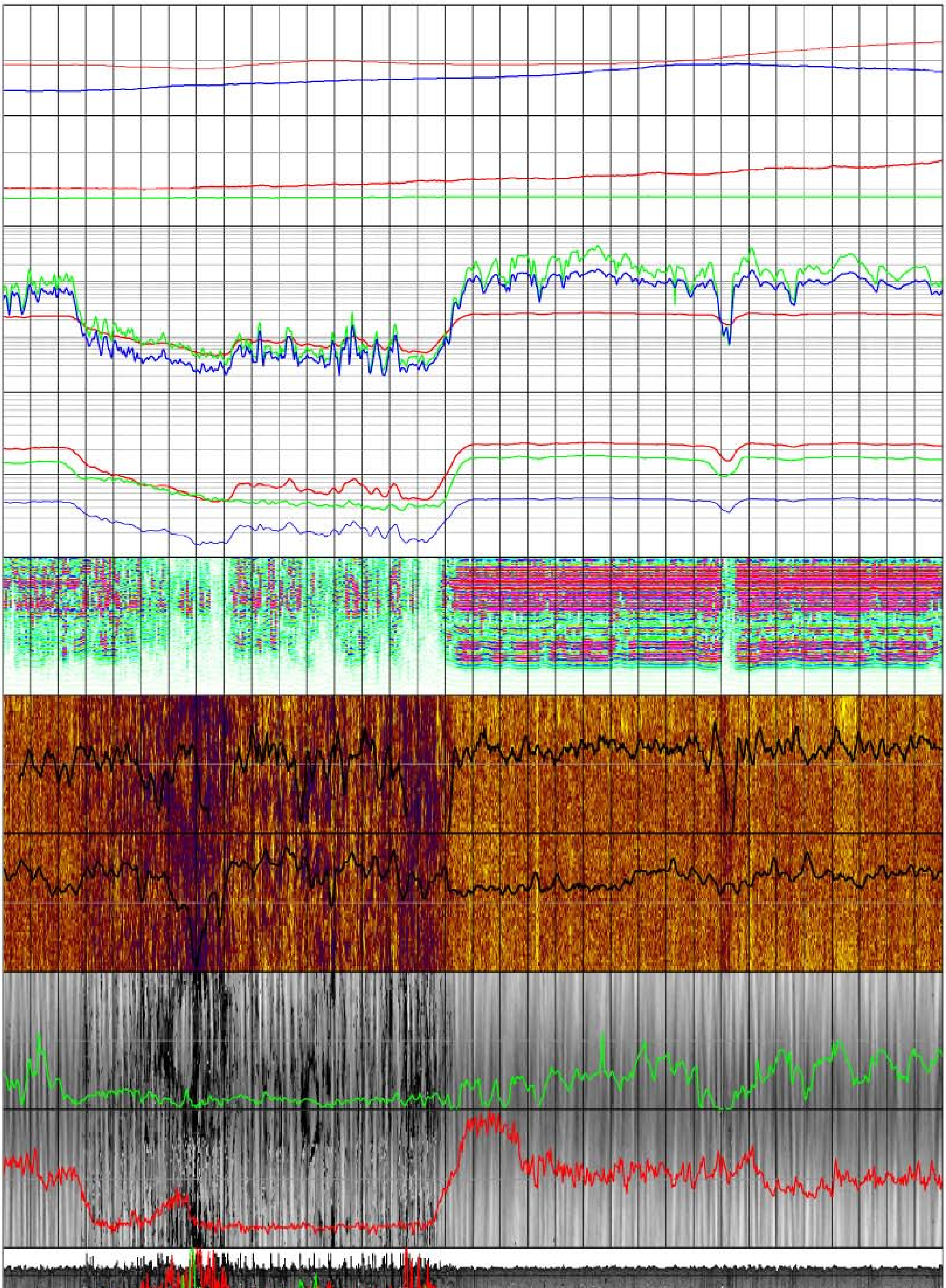
SKB geophysical borehole logging
Borehole HLX13

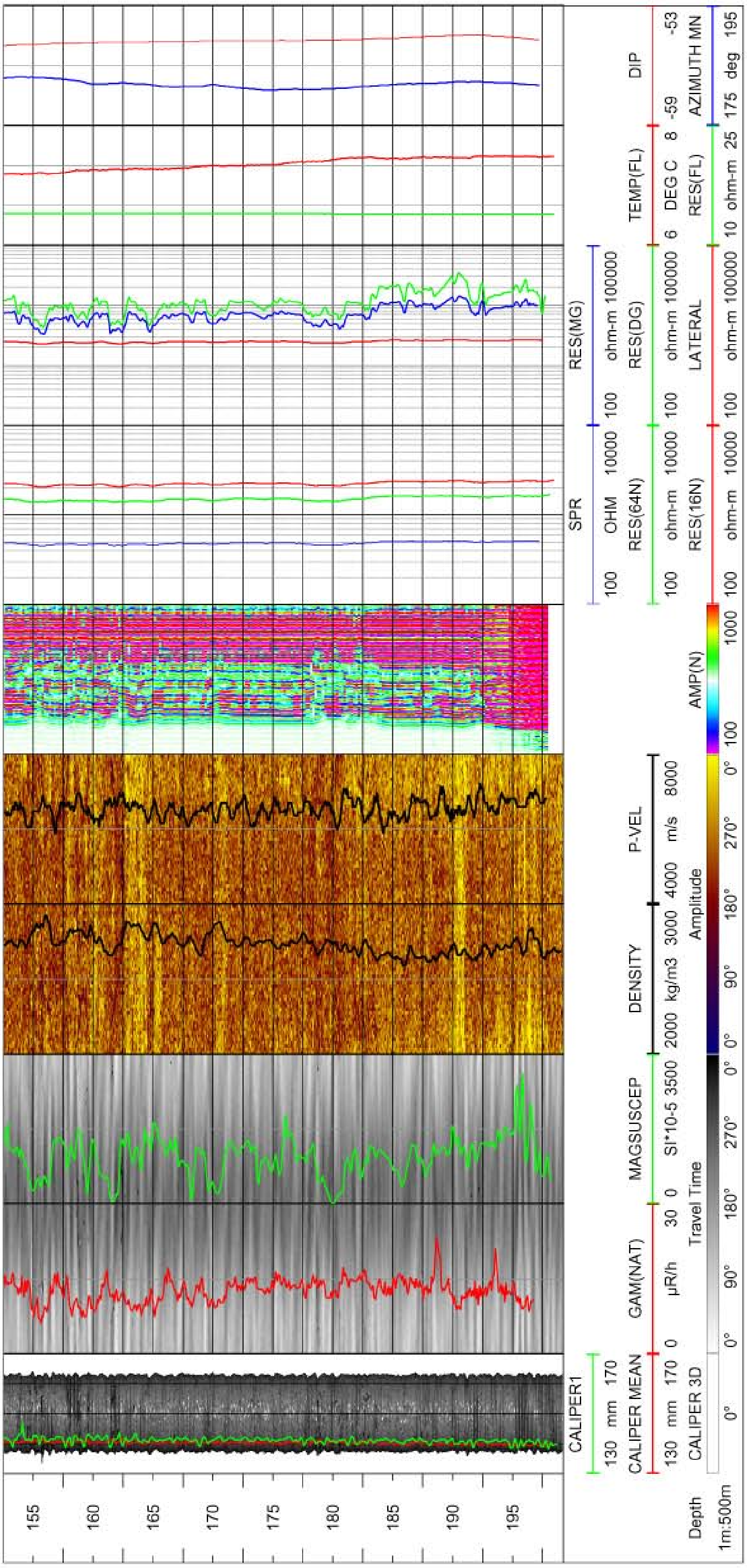
Presentation

Filename:
HLX13_Presentation.wcl

Drawing no.:
3.1


Depth
1m:500m
CALIPER 3D
CALIPER MEAN
130 mm 170
CALIPER1
130 mm 170
Travel Time
GAM(NAT)
0 µR/h 30
MAGSUSCEP
0 SI*10-5 3500
Amplitude
DENSITY
2000 kg/m3 3000
P-VEL
4000 m/s 8000
AMP(N)
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
RES(FL)
10 ohm-m 25
TEMP(FL)
6 DEG C 8
AZIMUTH MN
175 deg 195
DIP
-59 -53
5
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


Depth
1m:500m
155
160
165
170
175
180
185
190
195
CALIPER1
130 mm 170
CALIPER MEAN
130 mm 170
CALIPER 3D
0°
GAM(NAT)
0 µR/h 30
MAGSUSCEP
0 SI*10-5 3500
Travel Time
0° 90° 180° 270° 0°
DENSITY
2000 kg/m3 3000
P-VEL
4000 m/s 8000
Amplitude
0° 90° 180° 270° 0°
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
TEMP(FL)
6 DEG C 8
RES(FL)
10 ohm-m 25
DIP
-59 -53
AZIMUTH MN
175 deg 195

Appendix 4

Borehole HLX15, drawing no 4.1, borehole logs

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

Northing: 6365362 m Easting: 1548664 m Elevation: 4.807 m

Diameter:	137 mm
Reaming Diameter:	
Outer Casing:	168 mm
Inner Casing:	160 mm
Borehole Length:	151.90 m
Cone:	
Inclination at ground surface:	-58.37 °
Azimuth:	184.65°
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

Rev.	Date	Drawn by	Control	Approved
0	2004-07-05	FDH	UTN	UTN

Job	Scale
360210A	1:500

DGE Dansk Geo-servEx a/s RAMBØLL

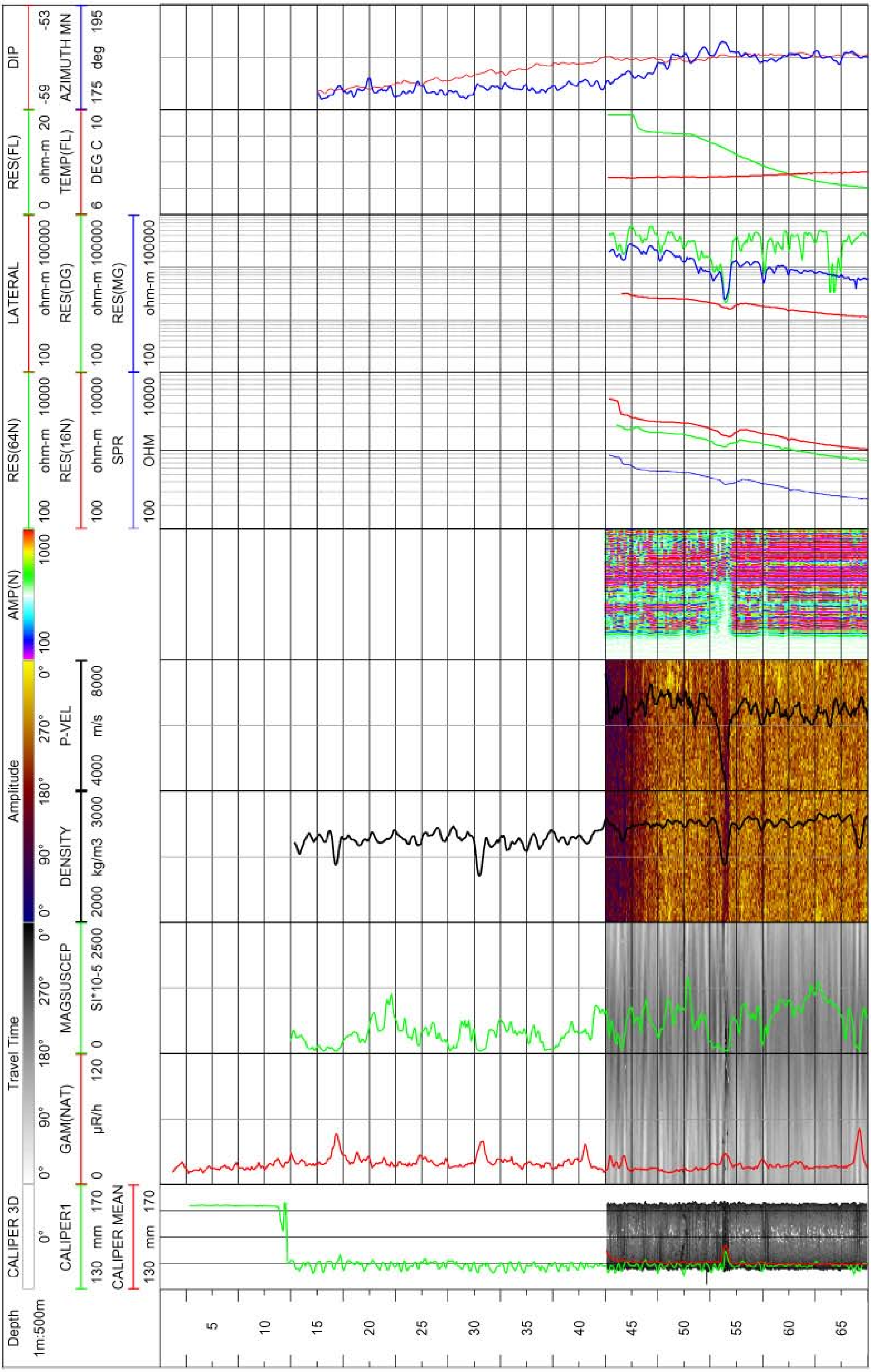
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

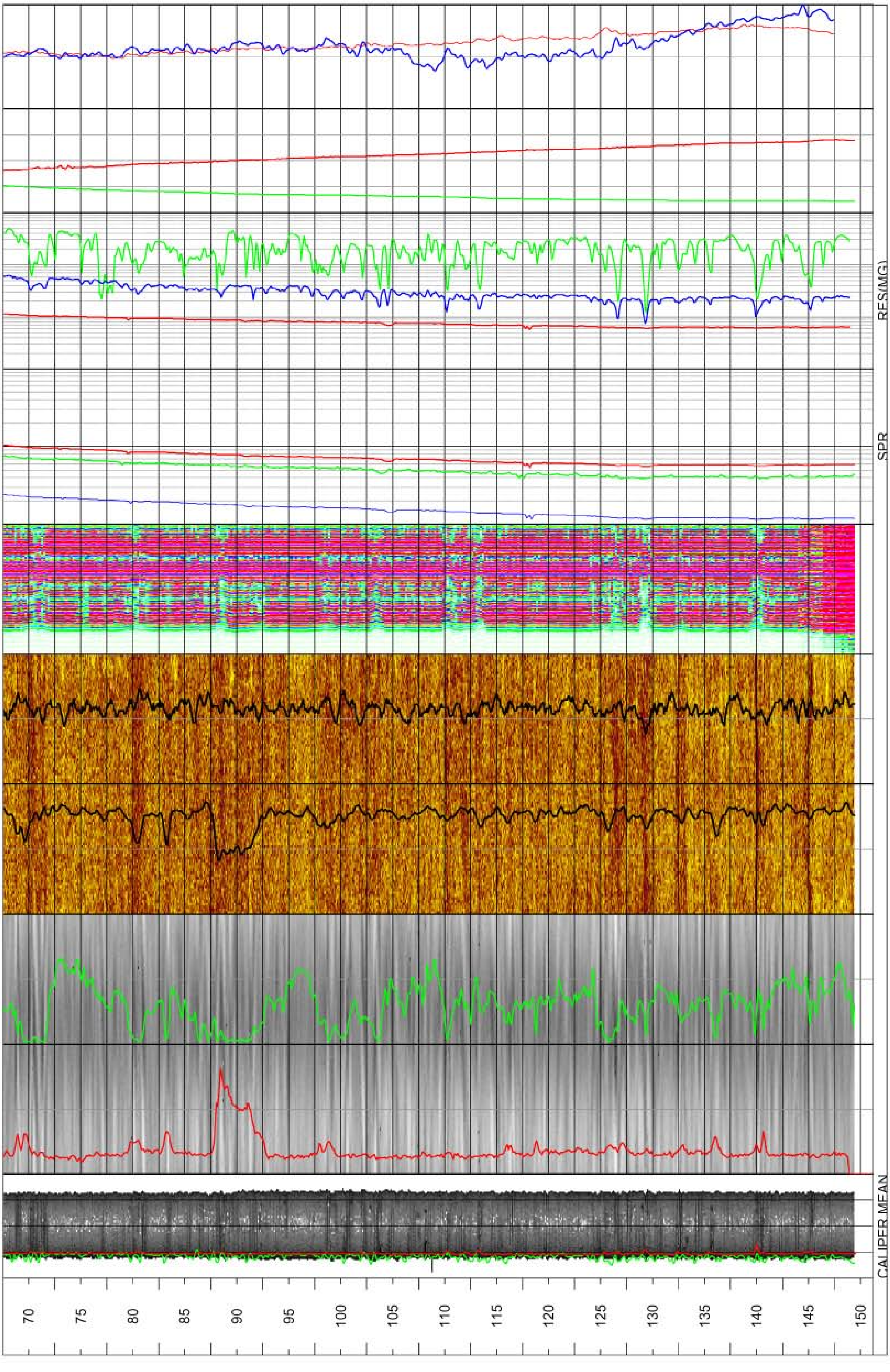
SKB geophysical borehole logging
Borehole HLX15

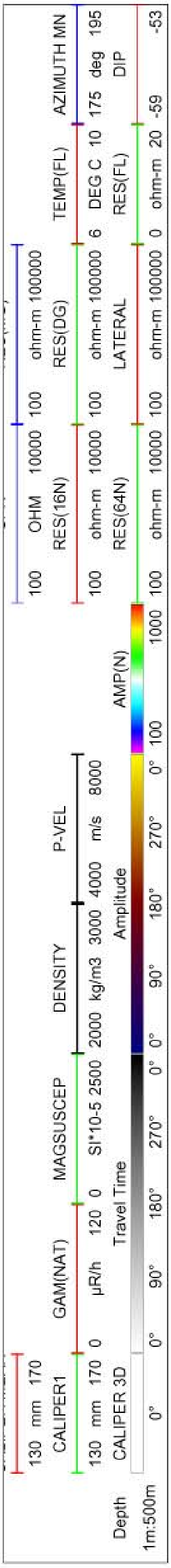
Presentation

Filename:
HLX15_Presentation.wcl

Drawing no.:
4.1


Depth
1m:500m
CALIPER 3D
CALIPER1
130 mm 170
CALIPER MEAN
130 mm 170
Travel Time
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 120
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
RES(64N)
100 ohm-m 10000
RES(16N)
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
RES(FL)
0 ohm-m 20
TEMP(FL)
6 DEG C 10
DIP
-59 -53
AZIMUTH MN
175 deg 195
5 10 15 20 25 30 35 40 45 50 55 60 65


RES(MG)
SPR
CALIPER MEAN
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150


130 mm 170
100 OHM 10000
100 ohm-m 100000
Depth
1m:500m
CALIPER1
130 mm 170
CALIPER 3D
GAM(NAT)
0 µR/h 120
MAGSUSCEP
0 SI*10-5 2500
Travel Time
DENSITY
2000 kg/m3 3000
P-VEL
4000 m/s 8000
Amplitude
AMP(N)
100 1000
RES(16N)
100 ohm-m 10000
RES(64N)
100 ohm-m 10000
RES(DG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
TEMP(FL)
6 DEG C 10
RES(FL)
0 ohm-m 20
AZIMUTH MN
175 deg 195
DIP
-59 -53