P-04-50

Oskarshamn site investigation

Geophysical borehole logging in borehole KSH03A, KSH03B, HAV09 and HAV10

Uffe Torben Nielsen, Jørgen Ringgaard
RAMBØLL

March 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-04-50

Oskarshamn site investigation

Geophysical borehole logging in borehole KSH03A, KSH03B, HAV09 and HAV10

Uffe Torben Nielsen, Jørgen Ringgaard
RAMBØLL

March 2004

Keywords: Geophysical logging.

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

Abstract

Geophysical borehole logging has been performed in borehole KSH03A, KSH03B, HAV09 and HAV10, situated in Simpevarp, 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 KSH03A was recorded from 100 m to 1000 m, KSH03B was recorded from 0 to 100 m, HAV09 was recorded from 0 to 200 m and HAV10 was recorded from 0 to 100 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 KSH03A, KSH03B, HAV09 och HAV10, i delområde Simpevarp, 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 KSH03A från 100 m till 1000 m, i KSH03B genomfördes mätningen mellan 0 och 100 m, i HAV09 genomfördes mätningen mellan 0 och 200 m respektive i HAV10 mellan 0 och 100 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 data gained in December 2003 at Simpevarp subarea in Oskarshamn. The geophysical borehole logging operations presented here include boreholes KSH03A, KSH03B, HAV09 and HAV10.

The logging program has been executed by RAMBØLL. RAMBØLL is acting as a subcontractor to DGE and ÅF-IPK.

All measurements were conducted by RAMBØLL during the period December 2–5 2003 in accordance with the instructions and guidelines from SKB (activity plan AP PS 400-03-082 and method description MD 221.002, SKB internal controlling documents) and under supervision of Leif Stenberg, SKB.

In borehole KSH03A logging data was recorded from 100 m to 1000 m. The borehole is cored with a diameter of 76 mm and a slight inclination of approximately –59º from the horizontal plan.

In borehole KSH03B the logs were performed from 0 m to 100 m. The borehole is cored with a diameter of 76 mm and a slight inclination of approximately –64.7º from the horizontal plan.

In borehole HAV09 the logs were performed from 0 m to 200 m and in borehole HAV10 the logs were performed from 0 m to 100 m. The boreholes HAV09 and HAV10 are drilled with a diameter of approximately 136 and 140 mm respectively with a slight inclination of approximately –68º from the horizontal plan.

The locations of the boreholes are shown in Figure 1-1.

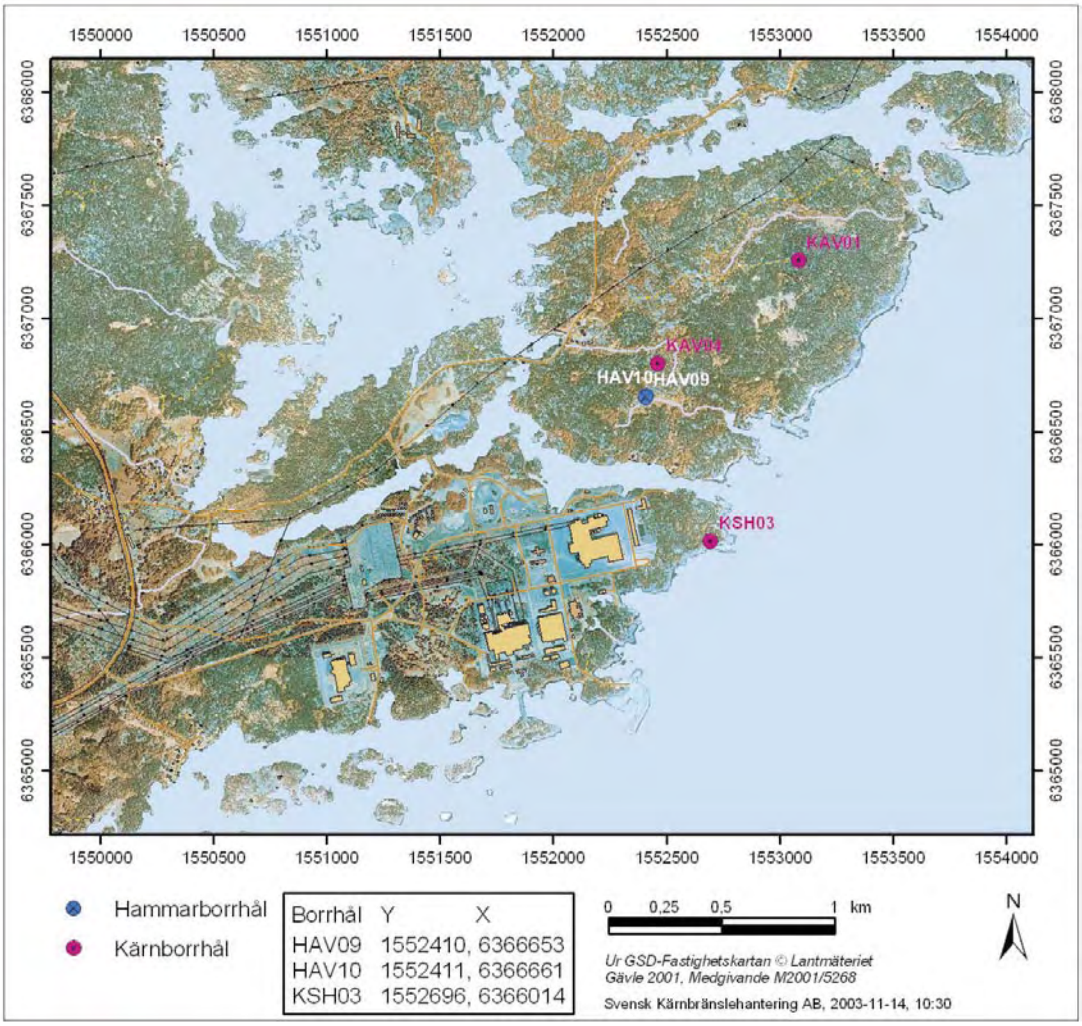


Figure 1-1. *General overview over the Simpevarp subarea in Oskarshamn with the location of the boreholes KSH03A and KSH03B (drilled close to each other at the location KSH03). The percussion- drilled boreholes HAV09 and HAV10 are located on the Ävrö island.*

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).

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 KSH03A in Appendix 1, drawing no. 2.1 for borehole KSH03B in Appendix 2, drawing no. 3.1 for borehole HAV09 in Appendix 3 and drawing no. 4.1 for borehole HAV10 in Appendix 4.

3 Equipment

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

Table 3-1. Logging tools and logs recorded in KSH03A, KSH03B, HAV09 and HAV10.

Tool	Recorded logs	Dimension	Source detector spacing and type	Tool position in borehole
Century 8622 Magnetic susceptibility	Magnetic susceptibility, natural gamma	203 x 4.1 cm		-
Century 9030 Gamma density	Gamma density, natural gamma, 140 cm focused guard log resistivity, 10 cm 1-arm calliper	307 x 5.6 cm	20.3 cm 125 mCi Cs137	Sidewall Gamma source focused
Century 9044 Normal resistivity and Single point resistance	Fluid conductivity, Fluid temperature, Normal resistivity (16 & 64 inch), single point resistance and natural gamma.	237 x 5.3 cm		-
Century 9072 3 m focused guard	3 m focused guard log resistivity and natural gamma	310 x 6.4 cm		-
Century 9310 Sonic	Full wave form travel-time providing P & S-wave velocity picking, compensated P-wave travel-time, and natural gamma	300 x 6.1 cm	Near 91.4 cm. Far 121.9 cm.	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 x 4 cm		Centralized

4 Execution

In general the measurement procedures follow the SKB method description (MD 221.002, SKB internal controlling document). The logging program in borehole KSH03A and KSH03B was executed in the period December 2–3, 2003 and in borehole HAV09 and HAV10 in the period December 4–5, 2003.

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 1 (SKB internal controlling document SKB MD 600.004) before arriving at the site.

The applied logging equipment was calibrated before arriving at the site. The procedures and calibration values were delivered separately.

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, except for the HiRAT Acoustic tool where the speed was 2.4 m/min.

In borehole KSH03A some tools have not been recorded to the bottom of the hole, due to problems with the tools got stocked in the borehole. Tool 9030 and 9310 had been recorded to a depth of 900 m and tool 8622 to at total depth of 920 m.

Due to a recording error, the sonic data was not recorded in borehole KSH03A in the depth interval from 203.5 m to 255 m. Due to pure data quality, the normal resistivity have been removed from top to 237.5 m.

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.

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
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
Fluid temperature	TEMP(FL)	deg C	9044
Fluid resistivity	RES(FL)	ohm-m	9044
Normal resistivity 16 inch	RES(16N)	ohm-m	9044
Normal resistivity 64 inch	RES(64N)	ohm-m	9044
Lateral resistivity	LATERAL	ohm-m	9044
Single point resistance	SPR	Ohm	9044
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 values and data in the casing. The caliper logs, azimuth and dip have not been removed 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 or 9320. In inclined borehole the routine is picking wrong first arrivals. Due to this problem 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 1000.
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	-
Focused guard log resistivity, 300 cm	-
P-wave velocity	The P-VEL 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)). See 5.3.2
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.

```
Model: IGRF2000
Latitude: 57 deg, 24 min, 59 sec
Longitude: 16 deg, 40 min, 56 sec
Elevation: 0.03 km
Date of Interest: 12/3/2003

D(+ East)    I (+ Down)
   (deg)         (deg)
 3 d  11 m    71 d  17 m
```

5.4 Borehole KSH03A

In order to obtain an exact depth calibration, as described in 5.2.3, the track marks are used. The connection between the track marks and the logs is obtained from the HiRAT Acoustic tool.

The HiRAT image logs are shifted 2.00 m down and the natural gamma 0.57 m down. To obtain a common depth reference point, the track mark at 107.51 m in the HiRAT file is used as the marker at depth 110 m. The HiRAT tool is therefore shifted 2.49 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	107,51	110,000
150,00	147,58	150,070
200,00	197,65	200,140
250,00	247,65	250,140
300,00	297,83	300,320
350,00	347,92	350,410
400,00	397,91	400,400
450,00	448,09	450,580
500,00	498,19	500,680
550,00	548,14	550,630
600,00	598,36	600,850
650,00	648,38	650,870
700,00	698,38	700,870
750,00	748,58	751,070
800,00	798,64	801,130
850,00	848,59	851,080
900,00	898,76	901,250
950,00	948,85	951,340

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 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.

Table 5-4. Gamma events in borehole KSH03A.

Events	Depths
Top event	107
Mid event	547,6
Bottom event	975
Bottom 8622	918

The complete log suite for borehole KSH03A 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 KSH03B

Using the natural gamma from the 9044 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 KSH03B.

Events	Depths
Top event	21,9
	25,85
	73,5
Bottom event	89,2

The complete log suite for borehole KSH03B 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 HAV09

Using the natural gamma from the 9044 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 HAV09.

Events	Depths
Top event	7,9
Bottom event	156,75

The complete log suite for borehole HAV09 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.

5.7 Borehole HAV10

Using the natural gamma from the 9044 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 HAV10.

Events	Depths
Top event	6,8
Bottom event	88,3

The complete log suite for borehole HAV10 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.

6 Data delivery

6.1 Delivery of logging data

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. 193.

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.

Borehole	Probe	Log direction	WellCAD File	Start and End Depth
KSH03A	8622	Up	KSH03A_12-03-03_18-40_8622C_.02_2.25_ 921.95_ORIG.log	Start Depth: 920 m. End Depth: –2.76 m
KSH03A	9030	Up	KSH03A_12-02-03_18-24_9030CA_.02_616.35_ 901.35_ORIG.log	Start Depth: 900 m. End Depth: 616 m
KSH03A	9030	Up	KSH03A_12-02-03_19-02_9030CA_.02_1.91_ 623.05_ORIG.log	Start Depth: 620 m. End Depth: –1.85 m
KSH03A	9044	Down	KSH03A_12-02-03_11-33_9044C_.02_3.14_ 997.07_ORIG.log	Start Depth: 997 m. End Depth: –2.16 m
KSH03A	9044	Down	KSH03A_12-02-03_09-08_9044C_.02_680_0_ PROC_B.LOG	Start Depth: 0 m. End Depth: 675 m
KSH03A	9072	Up	KSH03A_12-02-03_15-15_9072C_.02_3.06_ 1000.13_ORIG.log	Start Depth: 997 m. End Depth: –2.31 m
KSH03A	9310	Up	KSH03A_12-03-03_16-31_9310C2_.02_152.16_ 902.09_ORIG.log	Start Depth: 900 m. End Depth: –2.71 m
KSH03A	9310	Up	KSH03A_12-03-03_19-40_9310C2_.02_0.52_ 202.50_ORIG.log	Start Depth: 200.55 m. End Depth: –0.74 m
KSH03A	HiRAT	Yes	KFM06A_HiRAT_360pixels_up_run5.HED	Start Depth: 505 m. End Depth: –2.65 m
KSH03A	HiRAT	Yes	KFM06A_HiRAT_360pixels_up_run4.HED	Start Depth: 740 m. End Depth: 500 m
KSH03A	HiRAT	Yes	KFM06A_HiRAT_360pixels_up_run3.HED	Start Depth: 1000 m. End Depth: 739 m
KSH03B	8622	Up	KSH03B_12-02-03_15-13_8622C_.02_0.68_ 99.82_ORIG.log	Start Depth: 100 m. End Depth: 0 m
KSH03B	9030	Up	KSH03B_12-02-03_16-12_9030CA_.02_0.88_ 99.98_ORIG.log	Start Depth: 100 m. End Depth: 0 m
KSH03B	9044	Down	KSH03B_12-02-03_13-39_9044C_.02_0.28_ 100.65_ORIG.log	Start Depth: 0 m. End Depth: 98.4 m
KSH03B	9072	Up	KSH03B_12-03-03_19-24_9072C_.02_0.78_ 100.08_ORIG.log	Start Depth: 0 m. End Depth: 100 m
KSH03B	9310	Up	KSH03B_12-02-03_17-14_9310C2_.02_0.72_ 99.14_ORIG.log	Start Depth: 100 m. End Depth: 0 m
KSH03B	HiRAT	Up	KSH03B_HRAT_120_up_run2.HED	Start Depth: 100 m. End Depth: 0 m

Borehole	Probe	Log direction	WellCAD File	Start and End Depth
HAV09	8622	Up	HAV09_12-04-03_12-05_8622C_.02_0.44_ 57.35_ORIG.log	Start Depth: 55 m. End Depth: –0.05 m
HAV09	8622	Up	HAV09_12-04-03_11-55_8622C_.02_45.83_ 198.16_ORIG.log	Start Depth: 197 m. End Depth: 45 m
HAV09	9030	Up	HAV09_12-04-03_13-15_9030CA_.02_2.81_ 199.76_ORIG.log	Start Depth: 197 m. End Depth: 1.36 m
HAV09	9044	Down	HAV09_12-04-03_10-09_9044C_.02_0.28_ 201.13_ORIG.log	Start Depth: 0 m. End Depth: 200 m
HAV09	9072	Up	HAV09_12-04-03_10-55_9072C_.02_1.23_ 199.72_ORIG.log	Start Depth: 997 m. End Depth: –0.08 m
HAV09	9310	Up	HAV09_12-04-03_12-24_9310C2_.02_1.09_ 197.47_ORIG.log	Start Depth: 196 m. End Depth: –0.13 m
HAV09	HiRAT	Up	HAV09_HRAT_180_down_run6.HED	Start Depth: 0 m. End Depth: 197 m
HAV10	8622	Up	HAV10_12-04-03_20-45_8622C_.02_0.62_ 98.62_ORIG.log	Start Depth: 100 m. End Depth: 0 m
HAV10	9030	Up	HAV10_12-04-03_21-40_9030CA_.02_0.94_ 98.96_ORIG.log	Start Depth: 100 m. End Depth: 0 m
HAV10	9044	Down	HAV10_12-04-03_19-15_9044C_.02_0.28_ 98.68_ORIG.log	Start Depth: 0 m. End Depth: 100 m
HAV10	9072	Up	HAV10_12-04-03_23-04_9072C_.02_0.74_ 98.68_ORIG.log	Start Depth: 100 m. End Depth: –0.05 m
HAV10	9310	Up	HAV10_12-04-03_22-31_9310C2_.02_10.61_ 98.07_ORIG.log	Start Depth: 100 m. End Depth: –0.05 m
HAV10	HiRAT	Up	HAV10_HRAT_180_up_run2.HED	Start Depth: 100 m. End Depth: 0 m

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KSH03A	1.1	KSH03A_Presentation.WCL
KSH03A	1.2	KSH03A_Deviation.WCL
KSH03A	1.3	KSH03A_Deviation.WCL
KSH03B	2.1	KSH03B_Presentation.WCL
KSH03B	2.2	KSH03B_Deviation.WCL
KSH03B	2.3	KSH03B_Deviation.WCL
HAV09	3.1	HAV09_Presentation.WCL
HAV09	3.2	HAV09_Deviation.WCL
HAV09	3.3	HAV09_Deviation.WCL
HAV10	4.1	HAV10_Presentation.WCL
HAV10	4.2	HAV10_Deviation.WCL
HAV10	4.3	HAV10_Deviation.WCL

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

Borehole	Excel file
KSH03A	KSH03A _data.xls
KSH03B	KSH03B _data.xls
HAV09	HAV09 _data.xls
HAV10	HAV10 _data.xls

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

Sheet	Other
Acoustic televiewer	See description of "total magnetic field" and "magnetic inclination" below
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	
Single point resistivity	
Magnetic susceptibility	

6.2 Calculation of the total magnetic field

The data delivered in the "tot magn field" column, in the "Acoustic televiewer" sheet, was calculated as the square root of the sum of the 3 components, from the magnetometer in the HiRAT probe, squared.

6.3 Calculation of the magnetic inclination

The data delivered in the "magn_inclination" column, in the "Acoustic televiewer" sheet, was found by calculating the angle between the z component and the summarized vector of the x and y components from the magnetometer in the HiRAT probe.

Appendix 1

Borehole KSH03A. Drawing no. 1.1. Borehole logs

Borehole No. KSH03A

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

Northing: 6366018.64m Easting: 1552711.17m Elevation: 4.16m, RHB70

Diameter:	76mm
Reaming Diameter:	200mm
Outer Casing:	
Inner Casing:	200mm
Borehole Length:	1000.70m
Cone:	
Inclination at ground surface:	-59°
Azimuth:	126°
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9030	mm
DENSITY	Gamma-gamma density	9030	kg/m³
RES(MG)	Focused guard log resistivity, 140cm	9030	ohm-m
GAM(NAT)	Natural gamma	9030	μR/h
TEMP(FL)	Fluid temperature	9042/9044	deg C
RES(FL)	Fluid resistivity	9042/9044	ohm-m
RES(DG)	Focused guard log resistivity, 300cm	9072	ohm-m
P-VEL	P-wave velocity	9320	m/s
AMP(N)	Full wave form, near receiver	9320	μs
AMP(F)	Full wave form, far receiver	9320	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	9044	ohm-m
RES(64N)	Normal resistivity 64 inch	9044	ohm-m
LATERAL	Lateral resistivity	9044	ohm-m
SPR	Single point resistivity	9044	ohm

Rev.	Date	Drawn by	Control	Approved
0	2003-12-19	JRI	TVP	UTN

Job	Scale
360210A	1:500

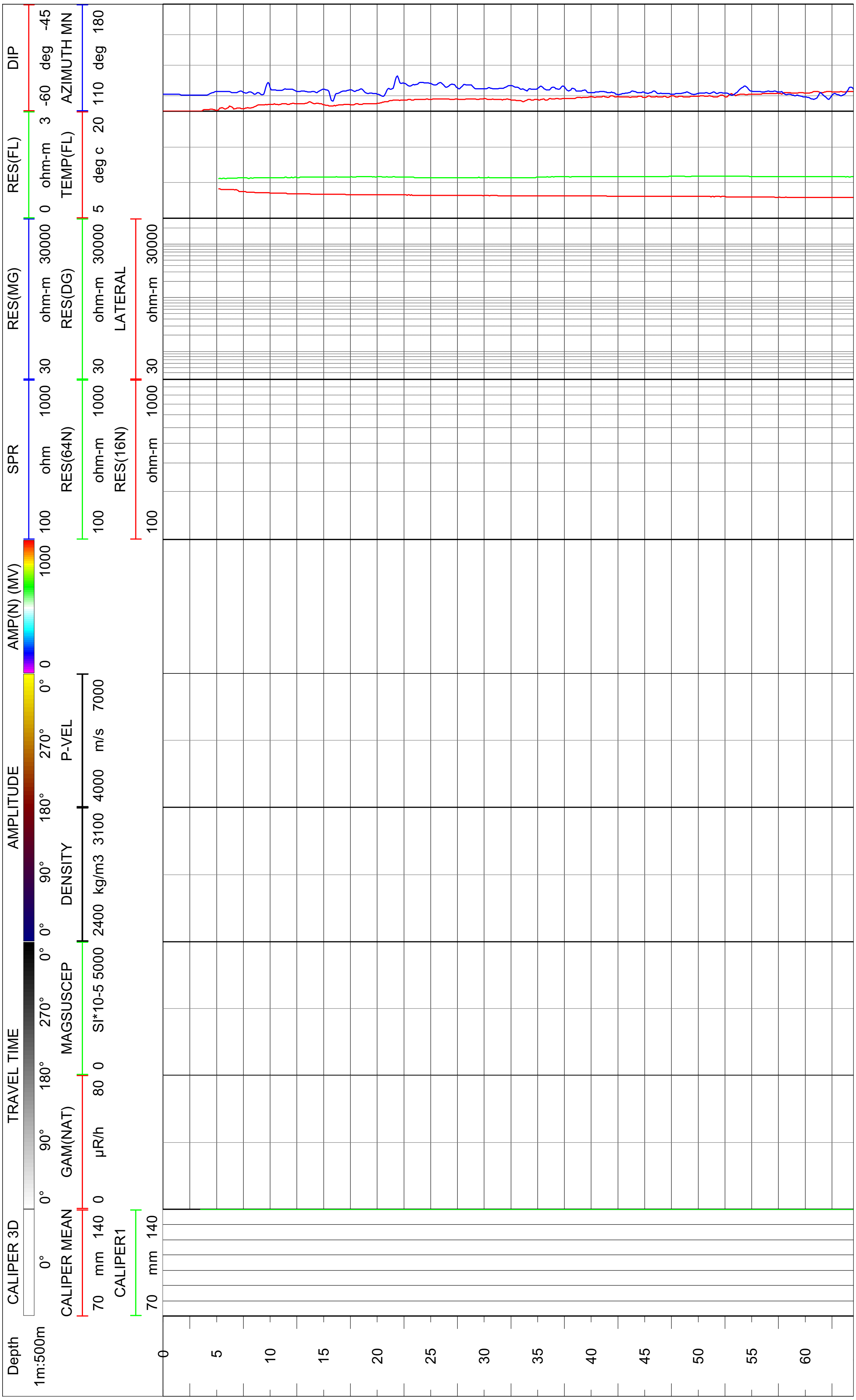
DGE Dansk Geo-servEx a/s RAMBØLL
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

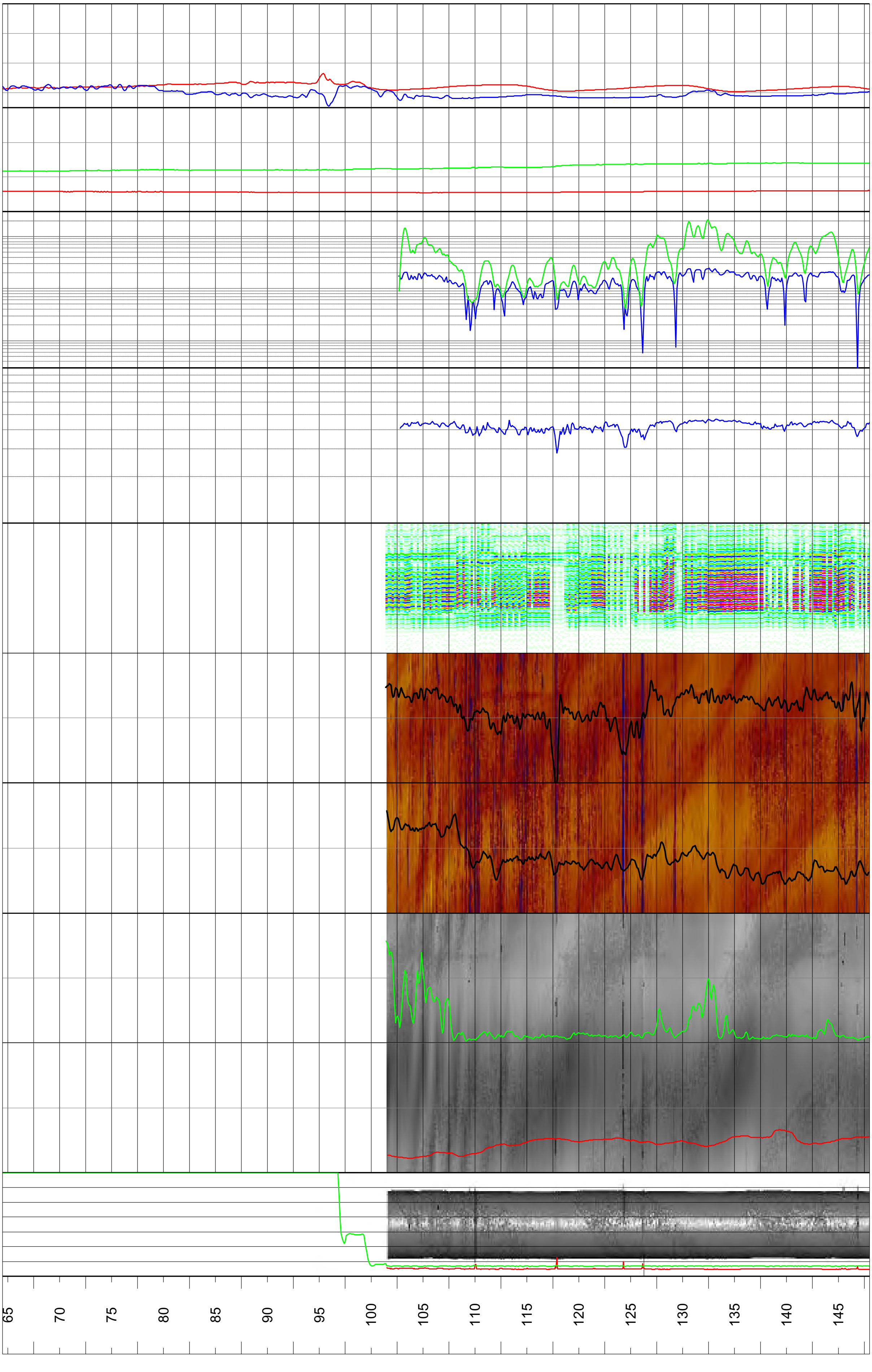
SKB geophysical borehole logging
Borehole KSH03A. Simpevarp

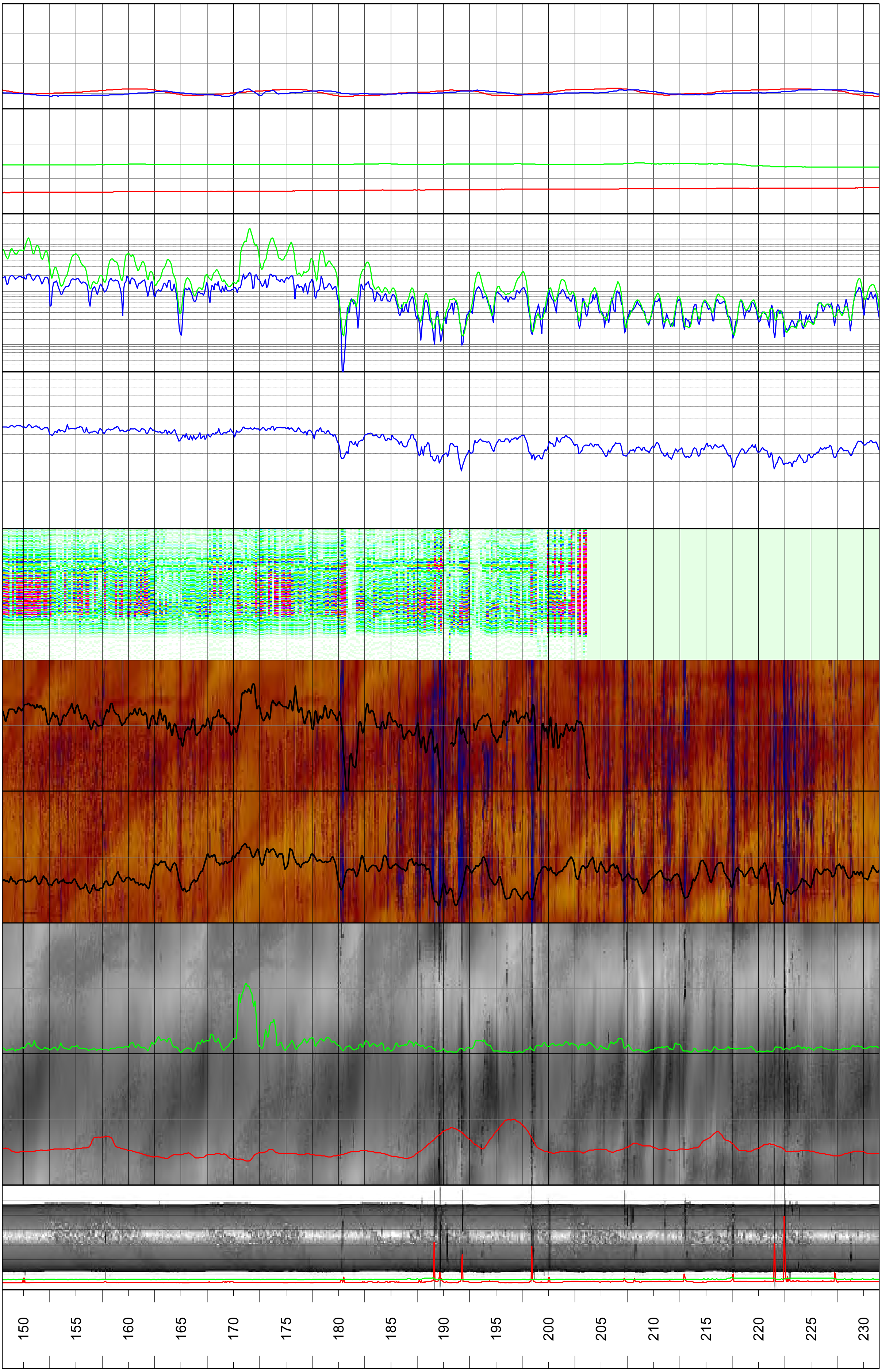
Presentation

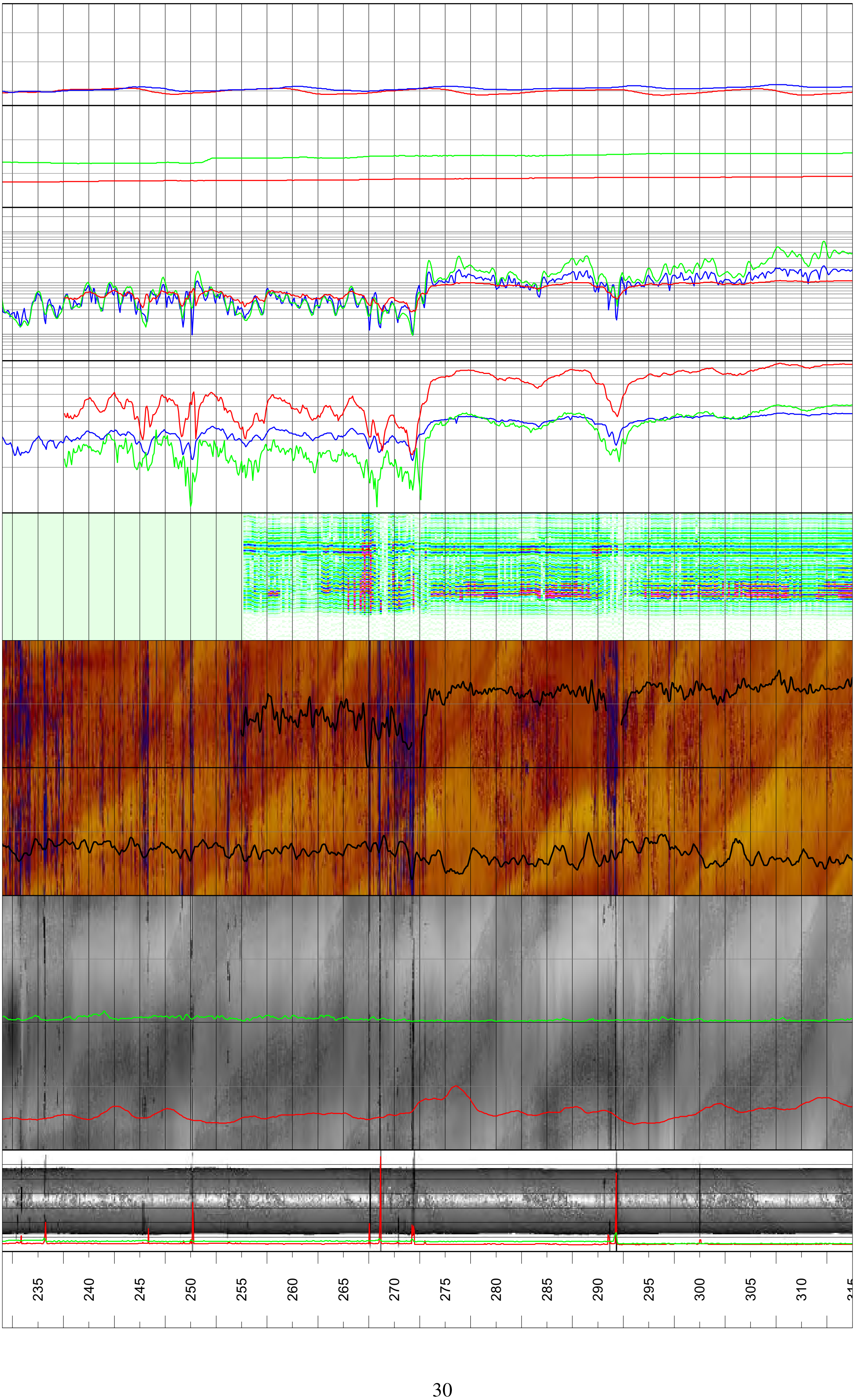
Filename:
KSH03A_Presentation.wcl

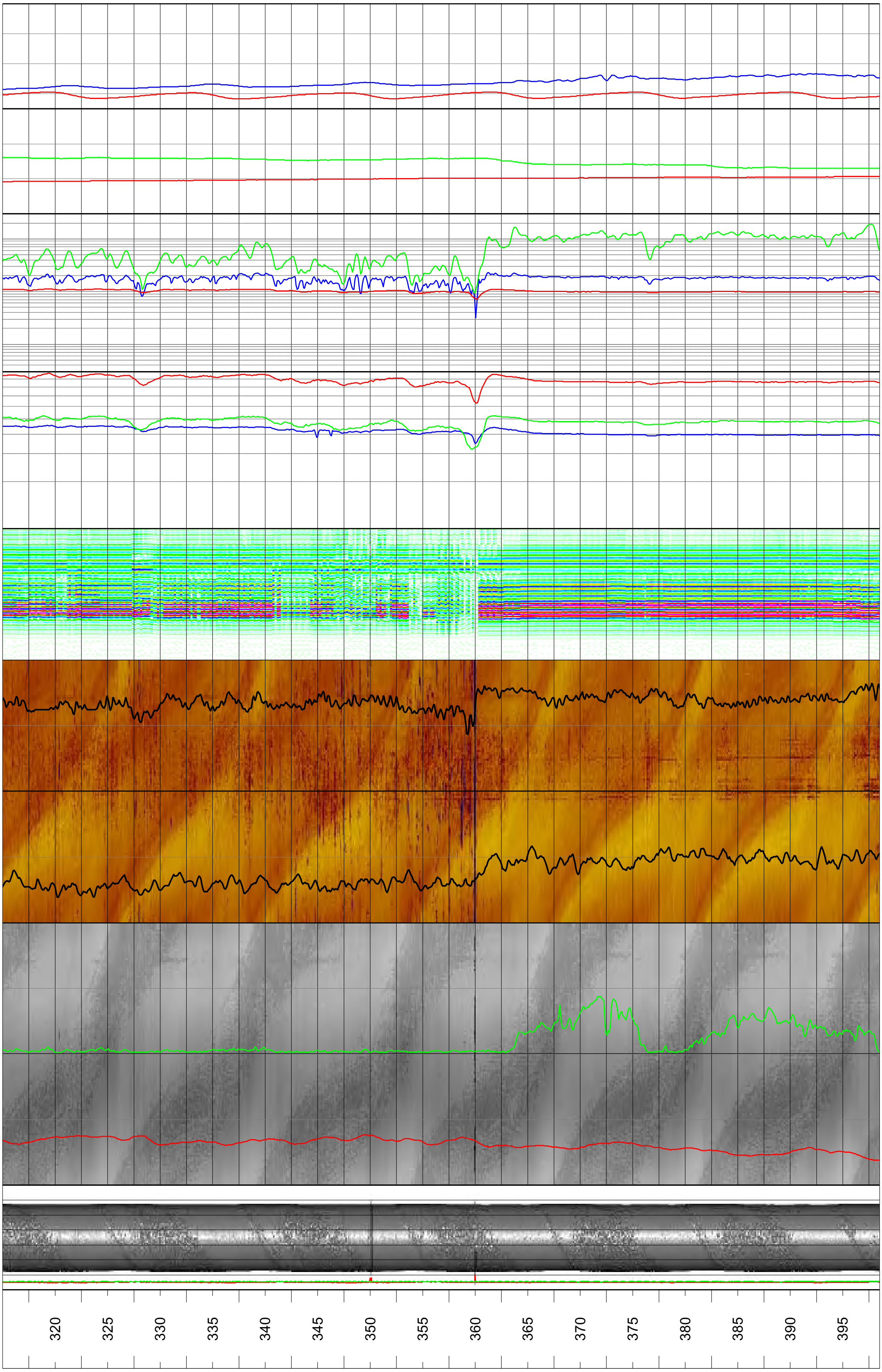
Drawing no.:
1.1


Depth
1m:500m
CALIPER 3D
0°
CALIPER MEAN
70 mm 140
CALIPER1
70 mm 140
TRAVEL TIME
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 80
MAGSUSCEP
0 SI*10-5 5000
AMPLITUDE
0° 90° 180° 270° 0°
DENSITY
2400 kg/m3 3100
P-VEL
4000 m/s 7000
AMP(N) (MV)
0 1000
SPR
100 ohm 1000
RES(64N)
100 ohm-m 1000
RES(16N)
100 ohm-m 1000
RES(MG)
30 ohm-m 30000
RES(DG)
30 ohm-m 30000
LATERAL
30 ohm-m 30000
RES(FL)
0 ohm-m 3
TEMP(FL)
5 deg c 20
DIP
-60 deg -45
AZIMUTH MN
110 deg 180
0 5 10 15 20 25 30 35 40 45 50 55 60

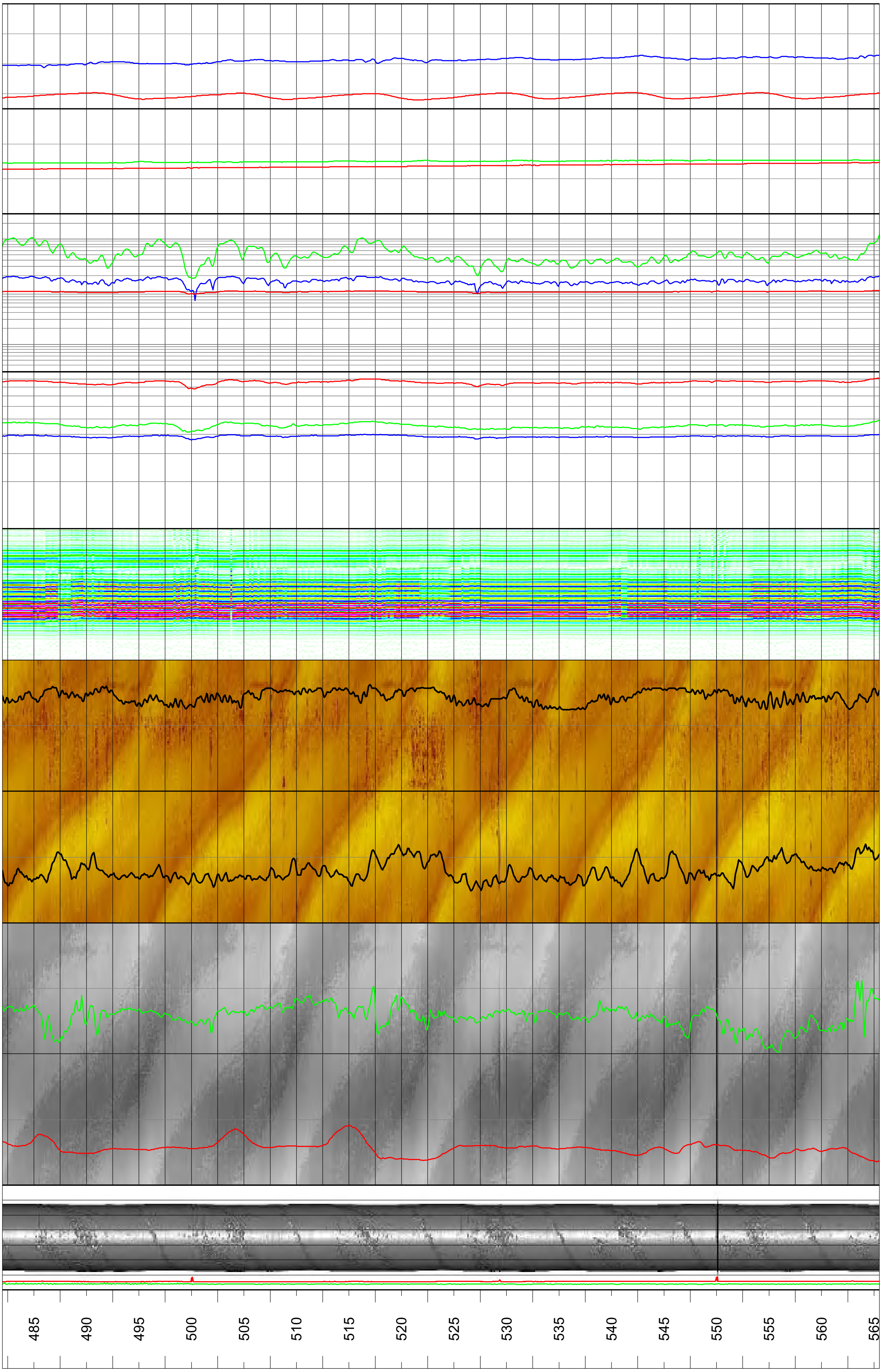

65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145

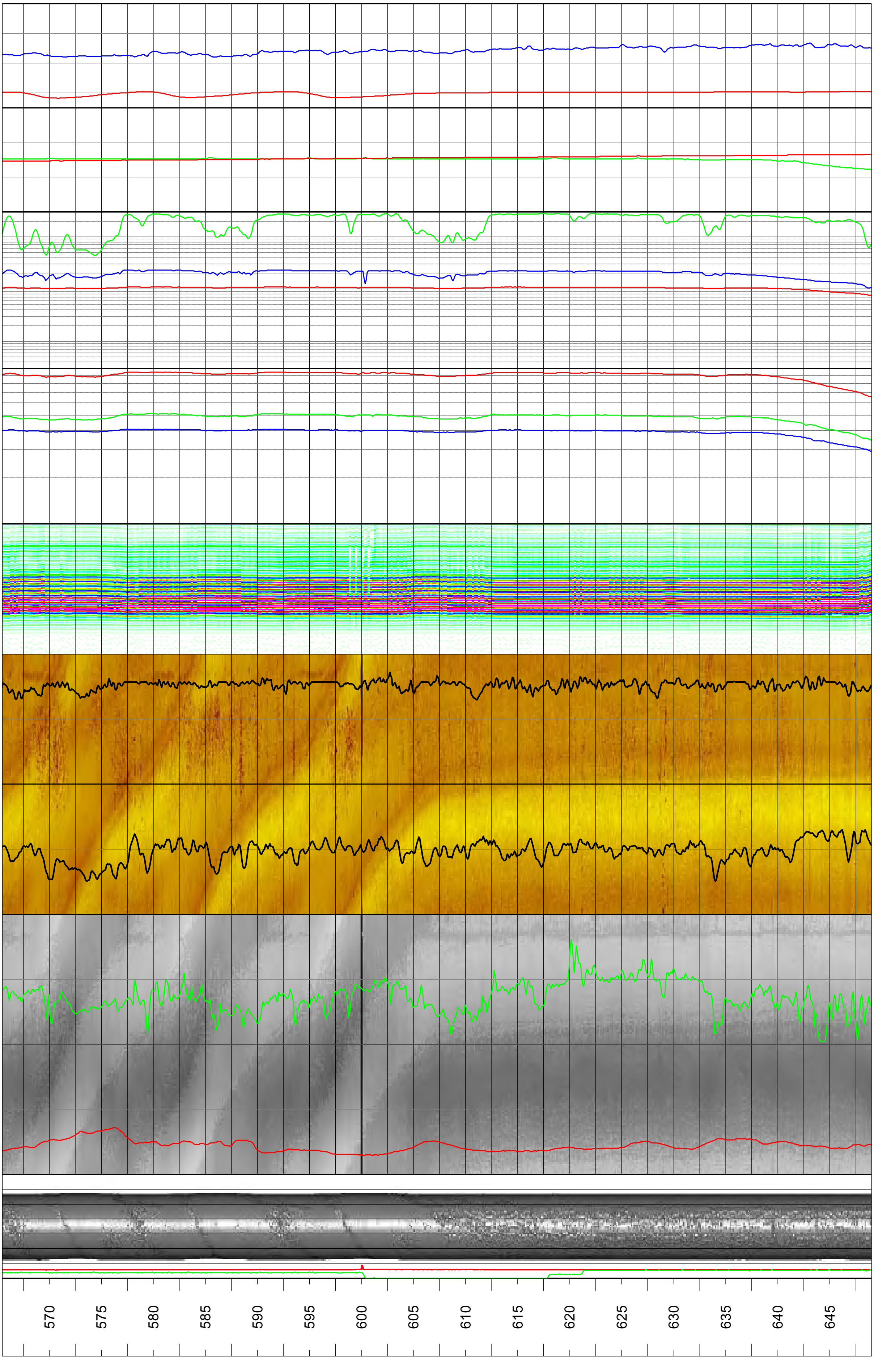

150
155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230

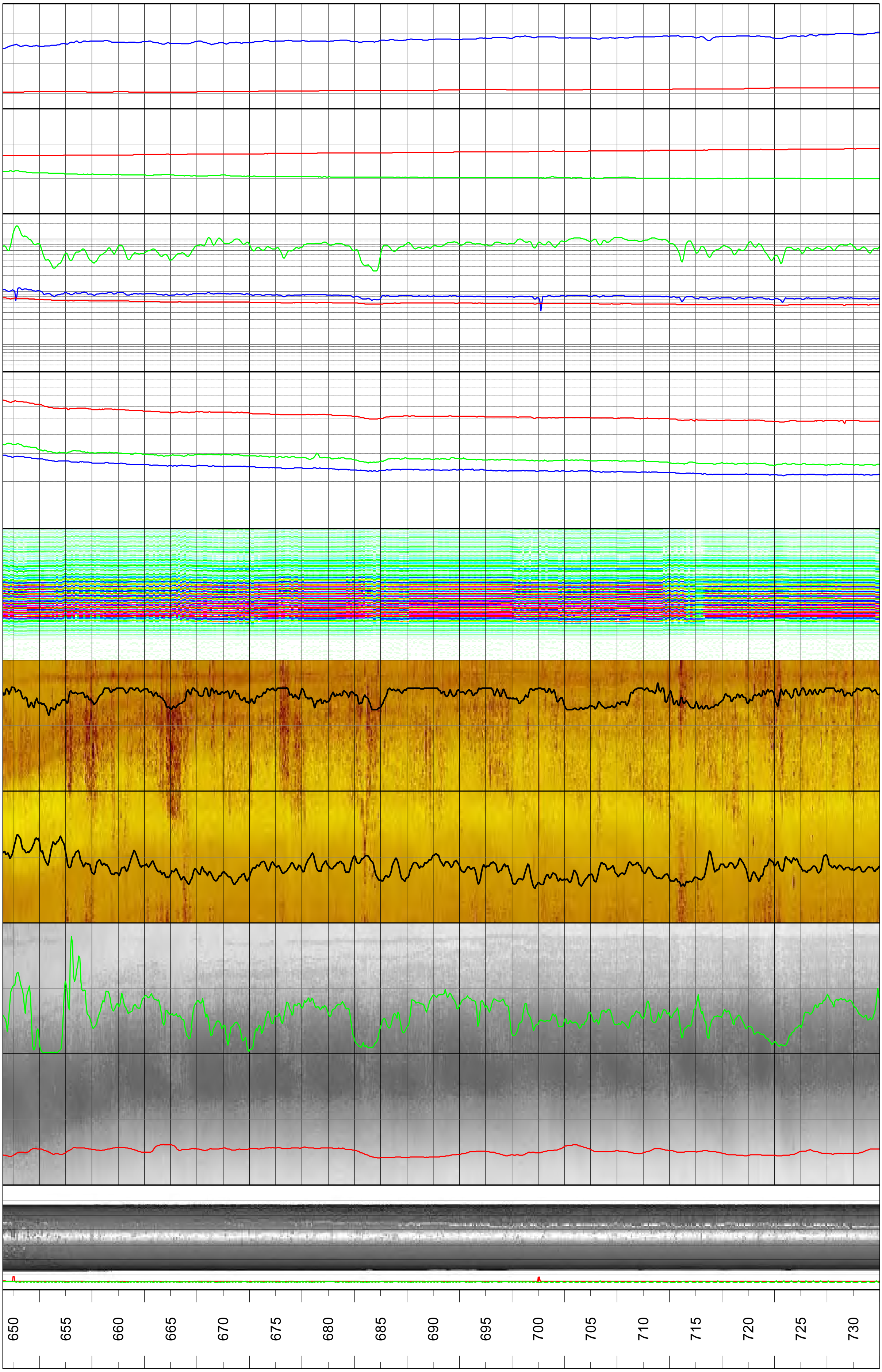

235
240
245
250
255
260
265
270
275
280
285
290
295
300
305
310

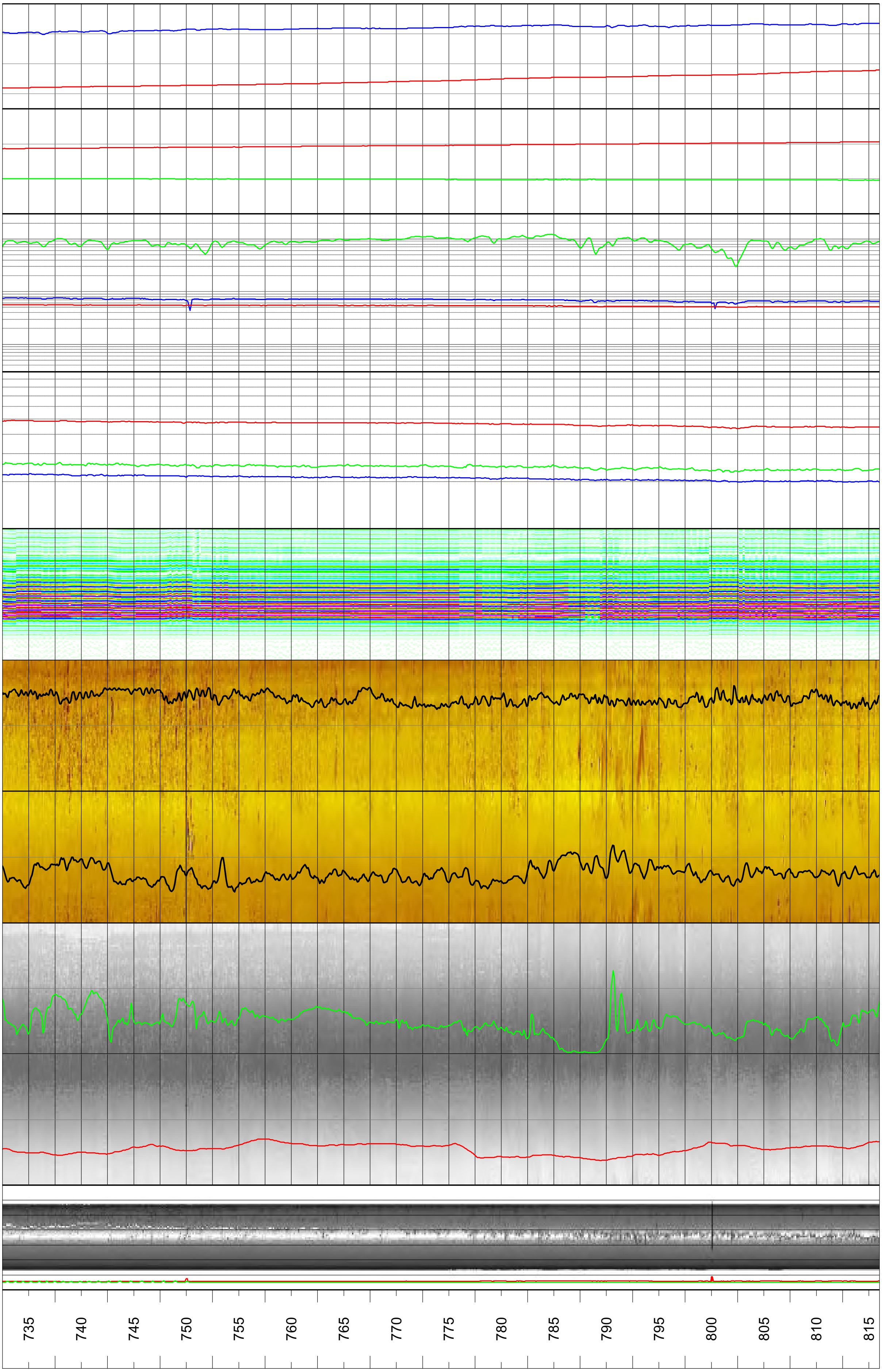

320
325
330
335
340
345
350
355
360
365
370
375
380
385
390
395

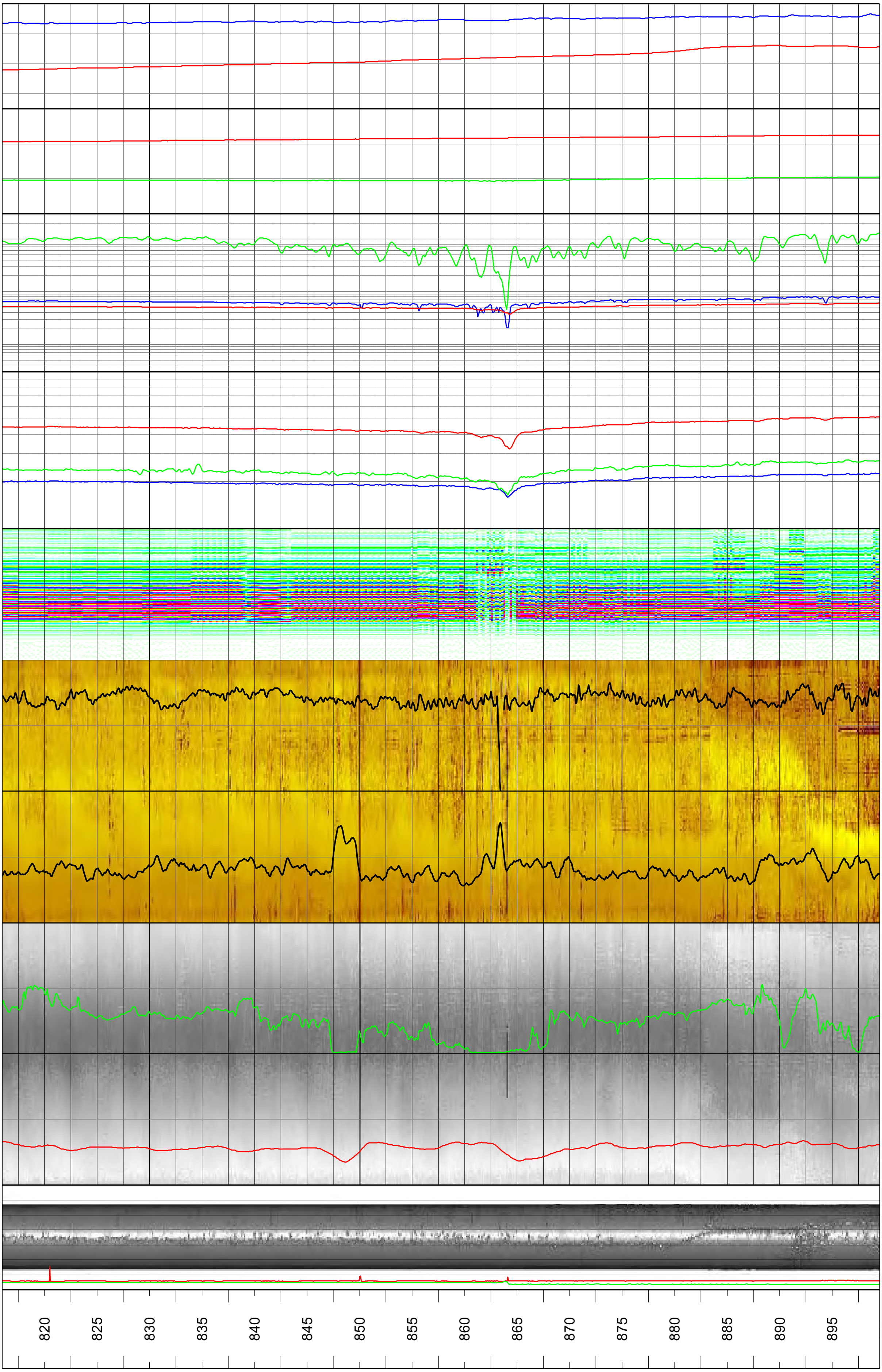

400
405
410
415
420
425
430
435
440
445
450
455
460
465
470
475
480

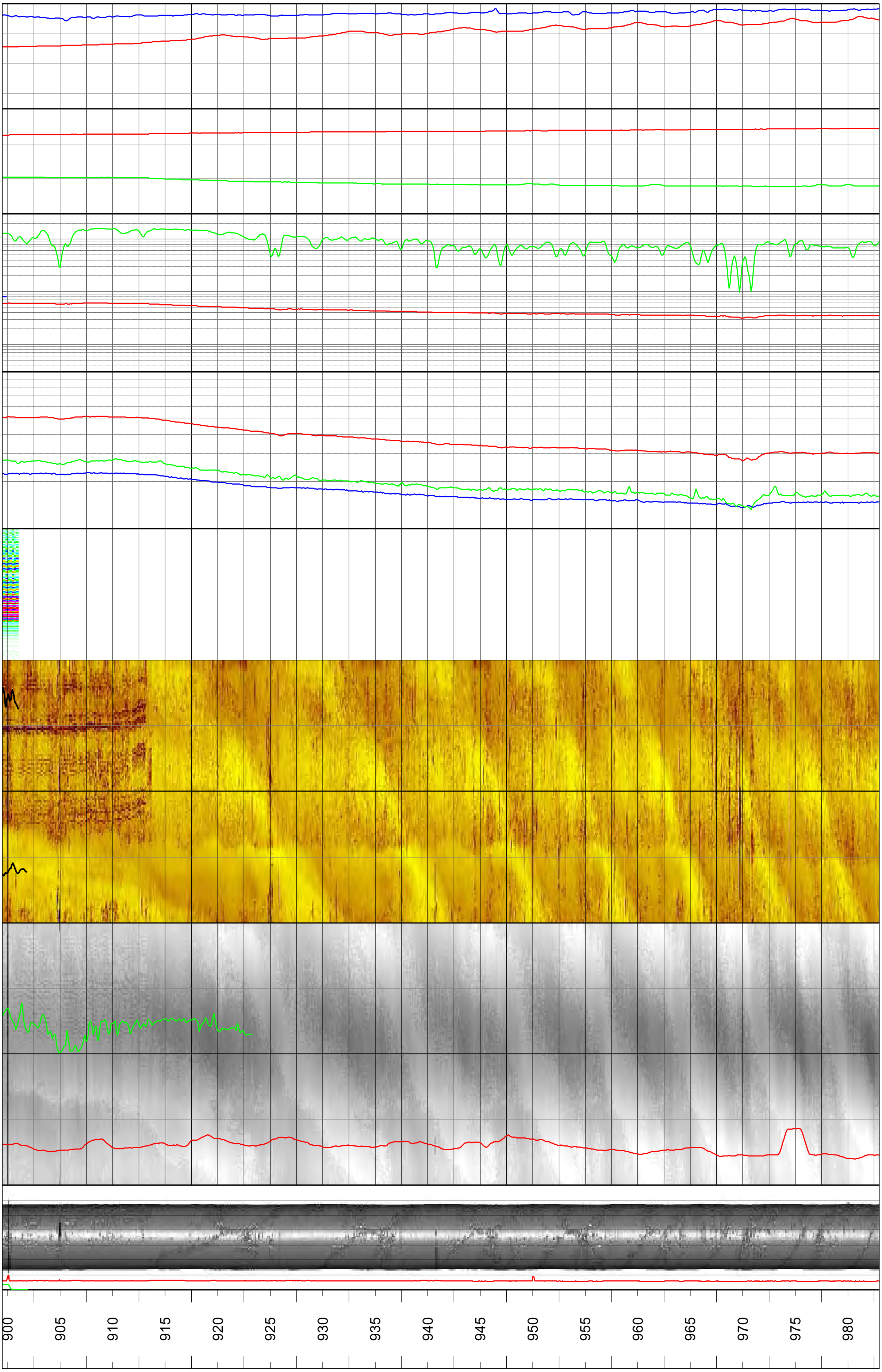

485
490
495
500
505
510
515
520
525
530
535
540
545
550
555
560
565

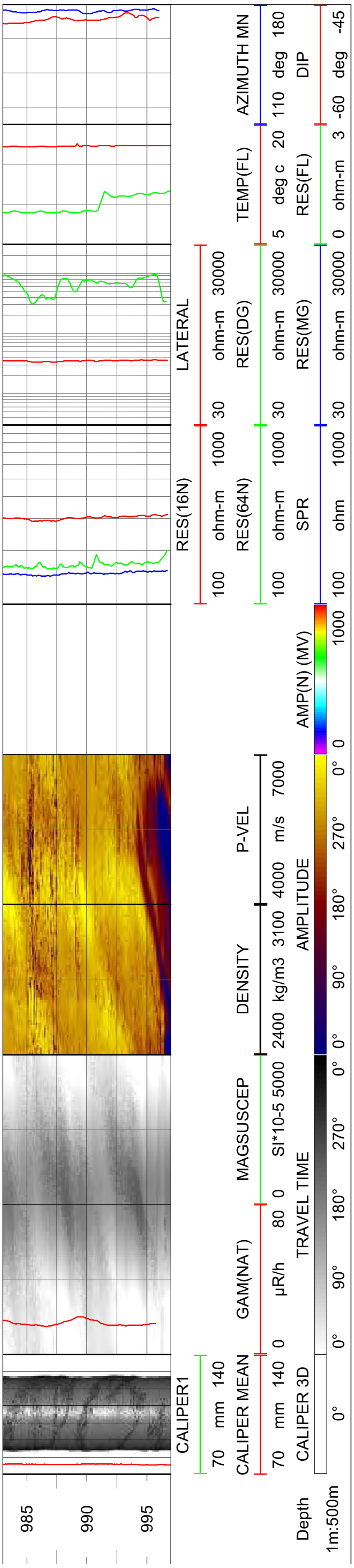

570
575
580
585
590
595
600
605
610
615
620
625
630
635
640
645


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
935
940
945
950
955
960
965
970
975
980


Depth
1m:500m
985
990
995
CALIPER1
70 mm 140
CALIPER MEAN
70 mm 140
CALIPER 3D
0°
GAM(NAT)
0 µR/h 80
MAGSUSCEP
0 SI*10-5 5000
TRAVEL TIME
0° 90° 180° 270° 0°
DENSITY
2400 kg/m3 3100
P-VEL
4000 m/s 7000
AMPLITUDE
0° 90° 180° 270° 0°
AMP(N) (MV)
0 1000
RES(16N)
100 ohm-m 1000
RES(64N)
100 ohm-m 1000
SPR
100 ohm 1000
LATERAL
30 ohm-m 30000
RES(DG)
30 ohm-m 30000
RES(MG)
30 ohm-m 30000
TEMP(FL)
5 deg c 20
RES(FL)
0 ohm-m 3
AZIMUTH MN
110 deg 180
DIP
-60 deg -45

Appendix 2

Borehole KSH03B. Drawing no. 2.1. Borehole logs

Borehole No. KSH03B

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

Northing: 6366019.054 m Easting: 1552710.613 m Elevation: 4.314 m, RHB70

Diameter:	76 mm
Reaming Diameter:	
Outer Casing:	
Inner Casing:	
Borehole Length:	
Cone:	
Inclination at ground surface:	-64.7°
Azimuth:	128.1°
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9030	mm
DENSITY	Gamma-gamma density	9030	kg/m³
RES(MG)	Focused guard log resistivity, 140cm	9030	ohm-m
GAM(NAT)	Natural gamma	9030	μR/h
TEMP(FL)	Fluid temperature	9042/9044	deg C
RES(FL)	Fluid resistivity	9042/9044	ohm-m
RES(DG)	Focused guard log resistivity, 300cm	9072	ohm-m
P-VEL	P-wave velocity	9320	m/s
AMP(N)	Full wave form, near receiver	9320	μs
AMP(F)	Full wave form, far receiver	9320	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	9044	ohm-m
RES(64N)	Normal resistivity 64 inch	9044	ohm-m
LATERAL	Lateral resistivity	9044	ohm-m
SPR	Single point resistivity	9044	ohm

Rev.	Date	Drawn by	Control	Approved
0	2003-12-18	FDH	UTN	UTN

Job	Scale
360210A	1:500

DGE Dansk Geo-servEx a/s RAMBØLL

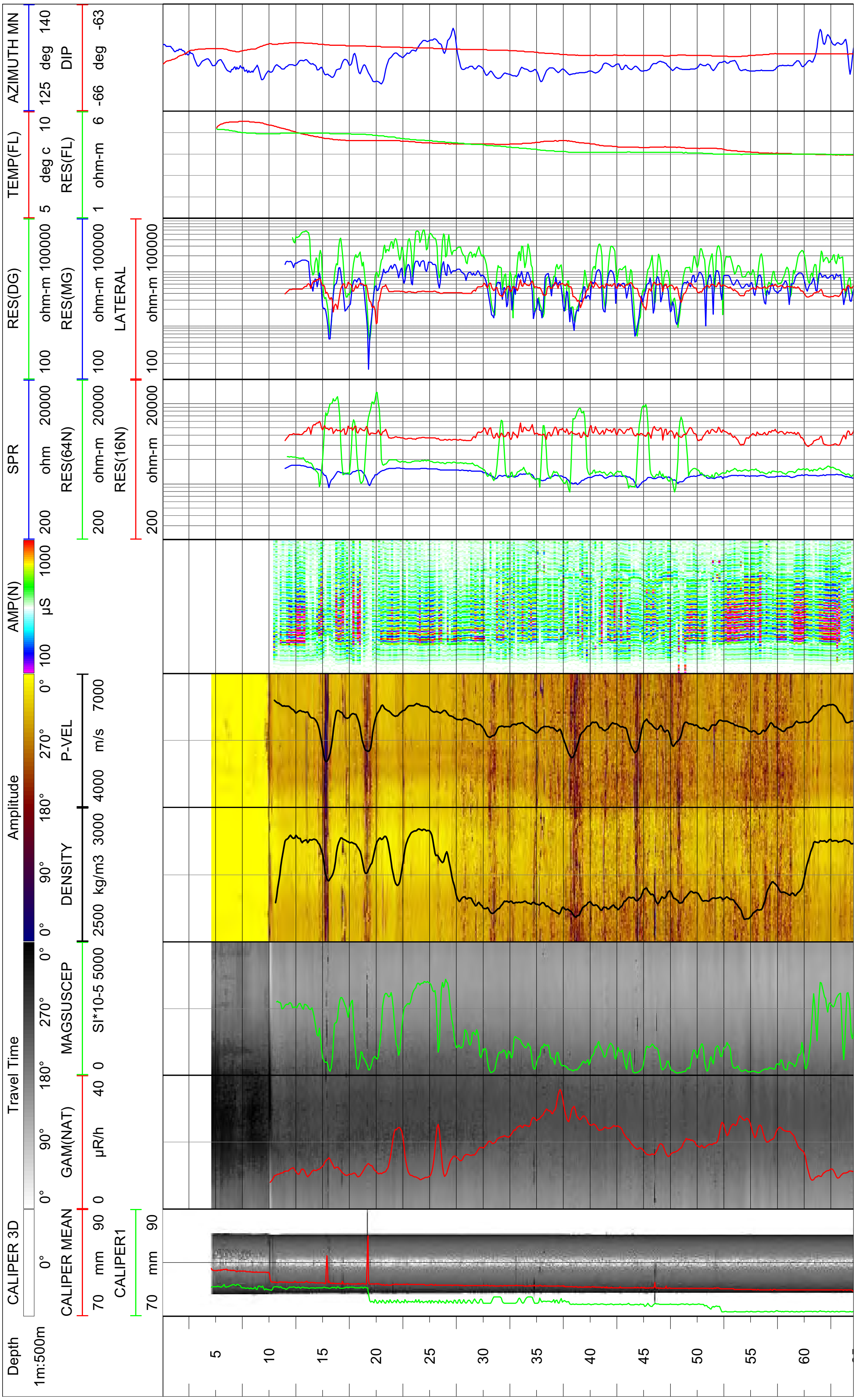
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

SKB geophysical borehole logging
Borehole KSH03B. Oskarshamn

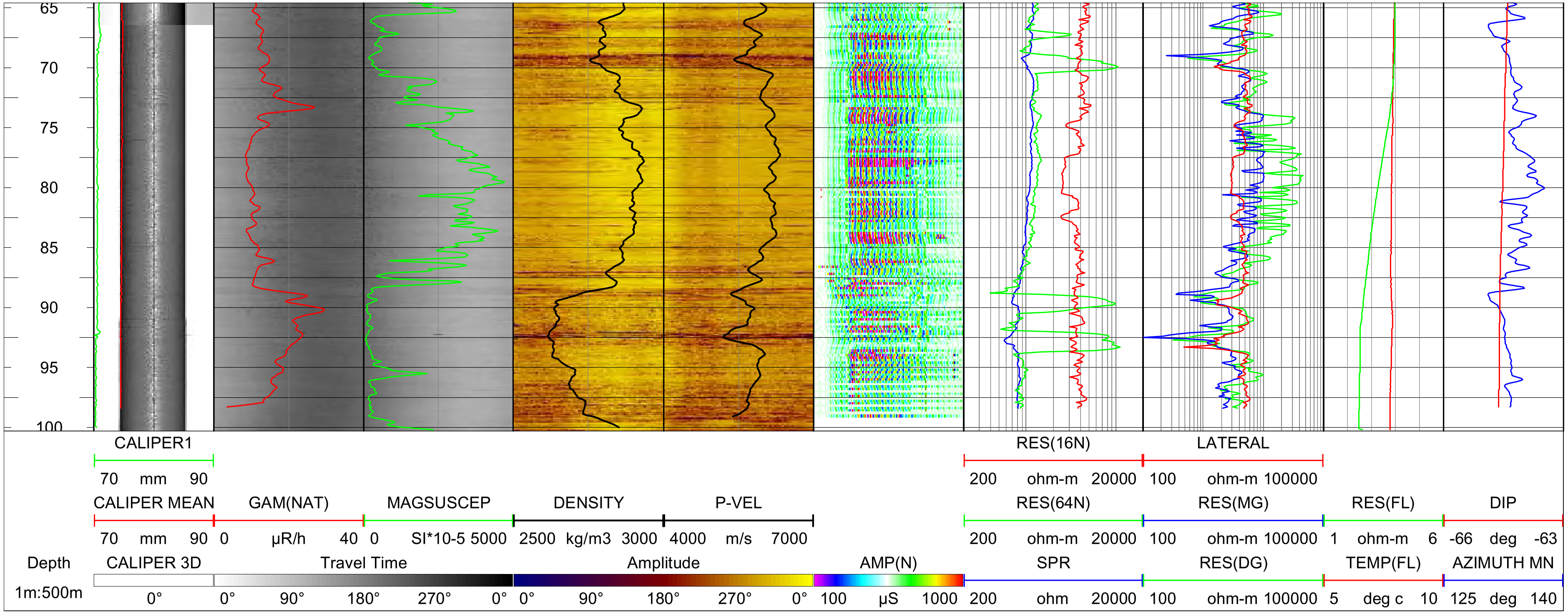
Presentation

Filename:
KSH03B_Presentation.wcl

Drawing no.:
2.1



Depth
1m:500m
CALIPER 3D
CALIPER MEAN
70 mm 90
CALIPER1
70 mm 90
Travel Time
GAM(NAT)
0 µR/h 40
MAGSUSCEP
0 SI*10-5 5000
Amplitude
DENSITY
2500 kg/m3 3000
P-VEL
4000 m/s 7000
AMP(N)
100 µS 1000
SPR
200 ohm 20000
RES(64N)
200 ohm-m 20000
RES(16N)
200 ohm-m 20000
RES(DG)
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
TEMP(FL)
5 deg c 10
RES(FL)
1 ohm-m 6
AZIMUTH MN
125 deg 140
DIP
-66 deg -63



65
70
75
80
85
90
95
100
CALIPER1
70 mm 90
CALIPER MEAN
70 mm 90
CALIPER 3D
0°
GAM(NAT)
0 µR/h 40
MAGSUSCEP
0 SI*10-5 5000
Travel Time
0° 90° 180° 270° 0°
DENSITY
2500 kg/m3 3000
P-VEL
4000 m/s 7000
Amplitude
0° 90° 180° 270° 0°
AMP(N)
100 µS 1000
RES(16N)
200 ohm-m 20000
RES(64N)
200 ohm-m 20000
SPR
200 ohm 20000
LATERAL
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(FL)
1 ohm-m 6
TEMP(FL)
5 deg c 10
DIP
-66 deg -63
AZIMUTH MN
125 deg 140
Depth
1m:500m

Appendix 3

Borehole HAV09. Drawing no. 3.1. Borehole logs

Borehole No. HAV09

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

Northing: 6366653.142m Easting: 1552411.359m Elevation: 2.172m, RHB70

Diameter:	136 mm
Reaming Diameter:	
Outer Casing:	168 mm
Inner Casing:	160 mm
Borehole Length:	100 m
Cone:	
Inclination at ground surface:	-68°
Azimuth:	178°
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	2004-02-12	JRI	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

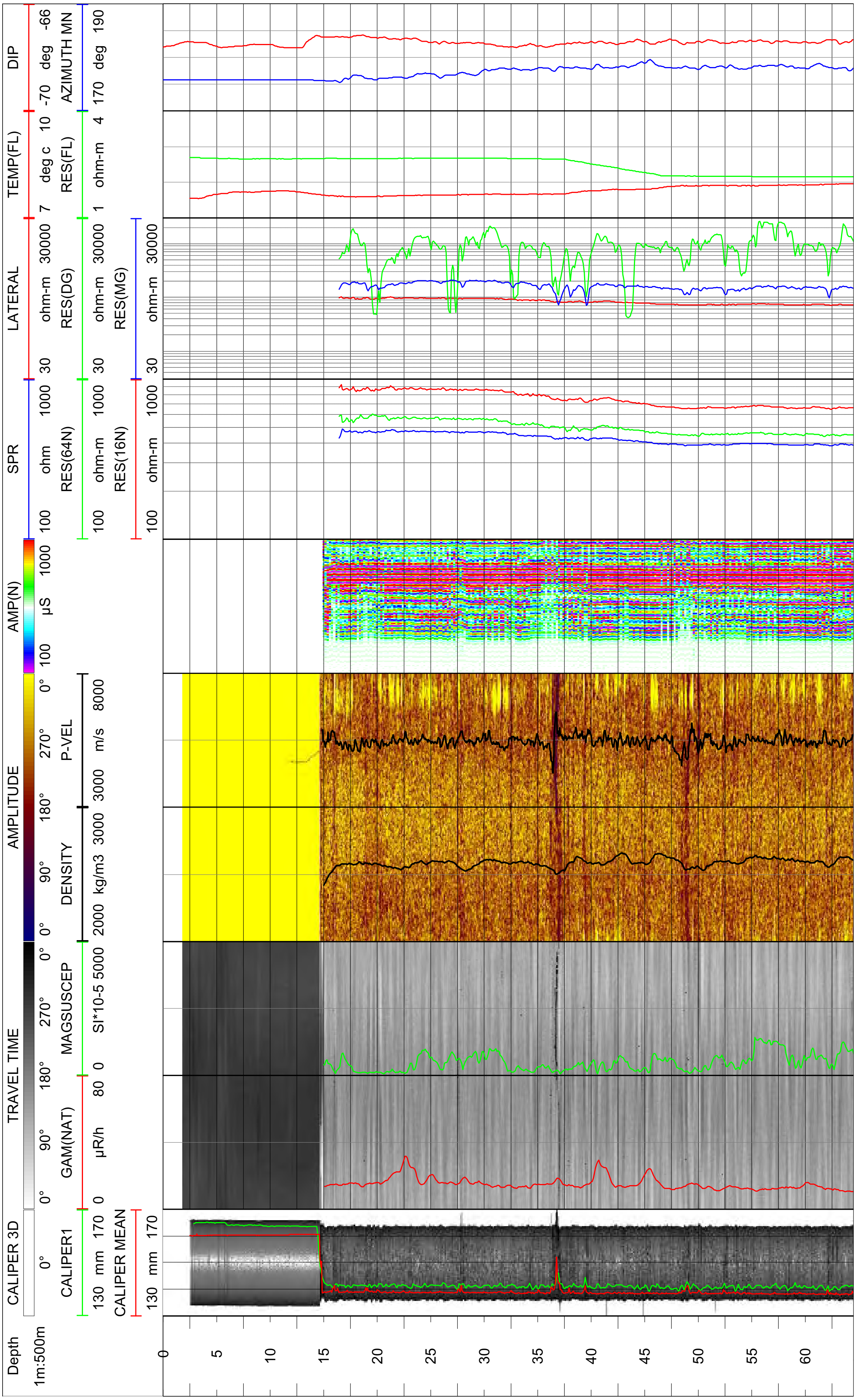
SKB geophysical borehole logging

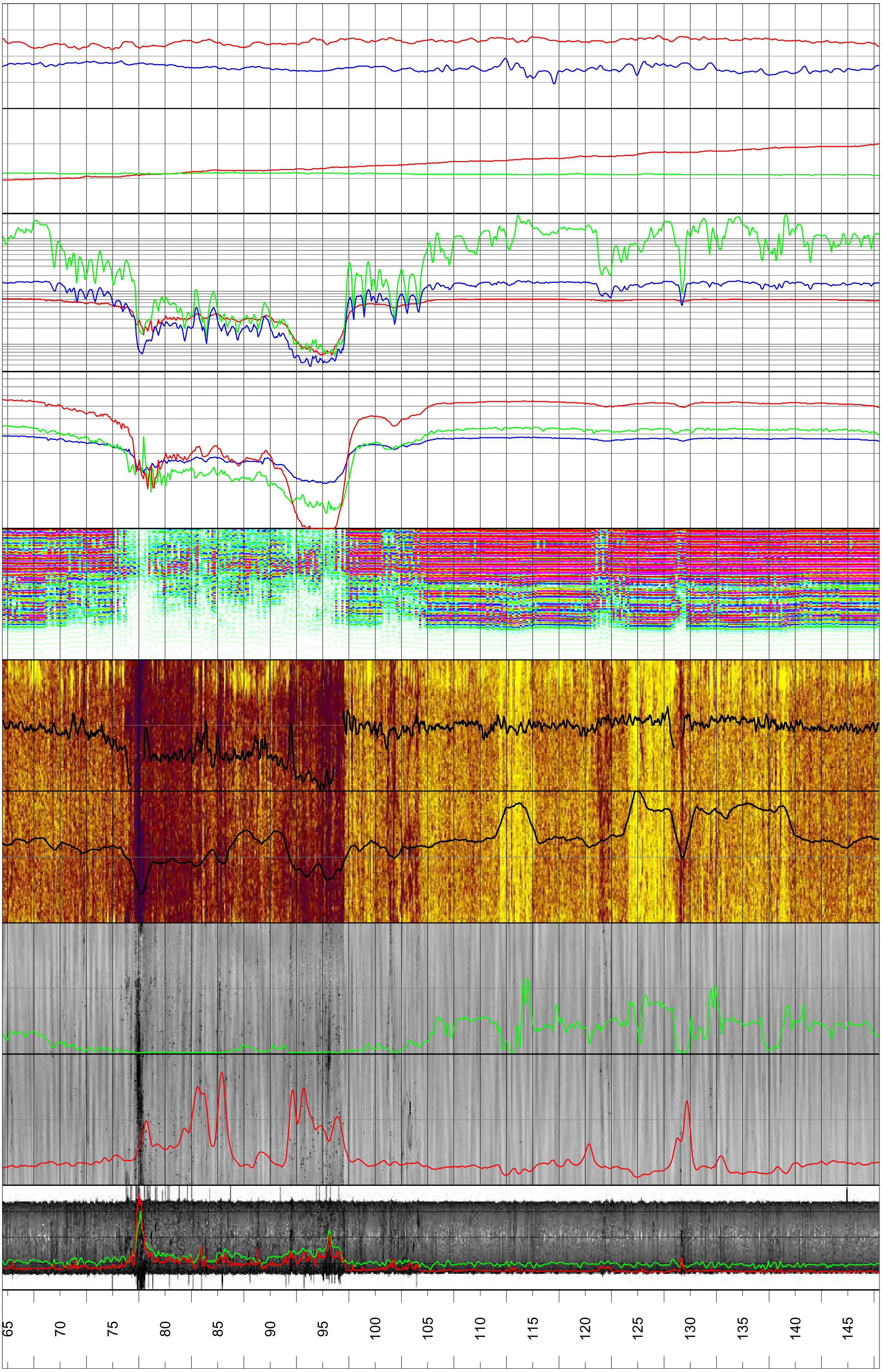
Borehole HAV09. Ävrö.

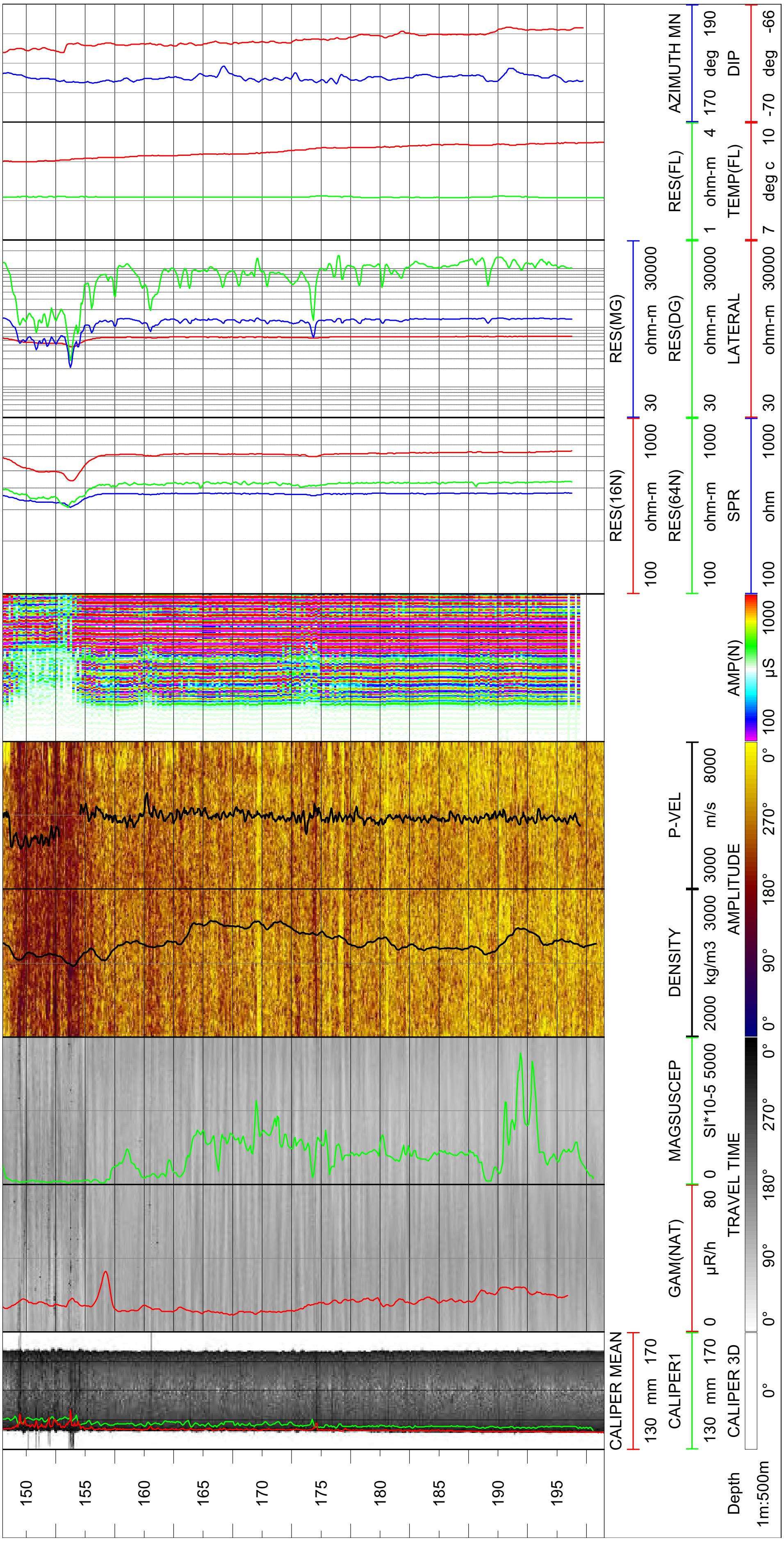
Presentation

Filename:
HAV09_Presentation.wcl

Drawing no.:
3.1


Depth
1m:500m
CALIPER 3D
CALIPER1
130 mm 170
CALIPER MEAN
130 mm 170
TRAVEL TIME
GAM(NAT)
0 µR/h 80
MAGSUSCEP
0 SI*10-5 5000
AMPLITUDE
DENSITY
2000 kg/m3 3000
P-VEL
3000 m/s 8000
AMP(N)
100 µS 1000
SPR
100 ohm 1000
RES(64N)
100 ohm-m 1000
RES(16N)
100 ohm-m 1000
LATERAL
30 ohm-m 30000
RES(DG)
30 ohm-m 30000
RES(MG)
30 ohm-m 30000
TEMP(FL)
7 deg c 10
RES(FL)
1 ohm-m 4
DIP
-70 deg -66
AZIMUTH MN
170 deg 190


65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145


Depth
1m:500m
150
155
160
165
170
175
180
185
190
195
CALIPER MEAN
130 mm 170
CALIPER1
130 mm 170
CALIPER 3D
0°
GAM(NAT)
0 µR/h 80
MAGSUSCEP
0 SI*10-5 5000
TRAVEL TIME
0° 90° 180° 270° 0°
DENSITY
2000 kg/m3 3000
P-VEL
3000 m/s 8000
AMPLITUDE
0° 90° 180° 270° 0°
AMP(N)
100 µS 1000
RES(16N)
100 ohm-m 1000
RES(64N)
100 ohm-m 1000
SPR
100 ohm 1000
RES(MG)
30 ohm-m 30000
RES(DG)
30 ohm-m 30000
LATERAL
30 ohm-m 30000
RES(FL)
1 ohm-m 4
TEMP(FL)
7 deg c 10
AZIMUTH MN
170 deg 190
DIP
-70 deg -66

Appendix 4

Borehole HAV10. Drawing no. 4.1. Borehole logs

Borehole No. HAV10

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

Northing: 6366660.566m Easting: 1552411.840m Elevation: 2.227m, RHB70

Diameter:	140 mm
Reaming Diameter:	
Outer Casing:	168 mm
Inner Casing:	160 mm
Borehole Length:	100 m
Cone:	
Inclination at ground surface:	-68°
Azimuth:	35°
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	2004-01-30	JRI	TVP	UTN

Job: 360210A
Scale: 1:500

DGE Dansk Geo-servEx a/s RAMBØLL

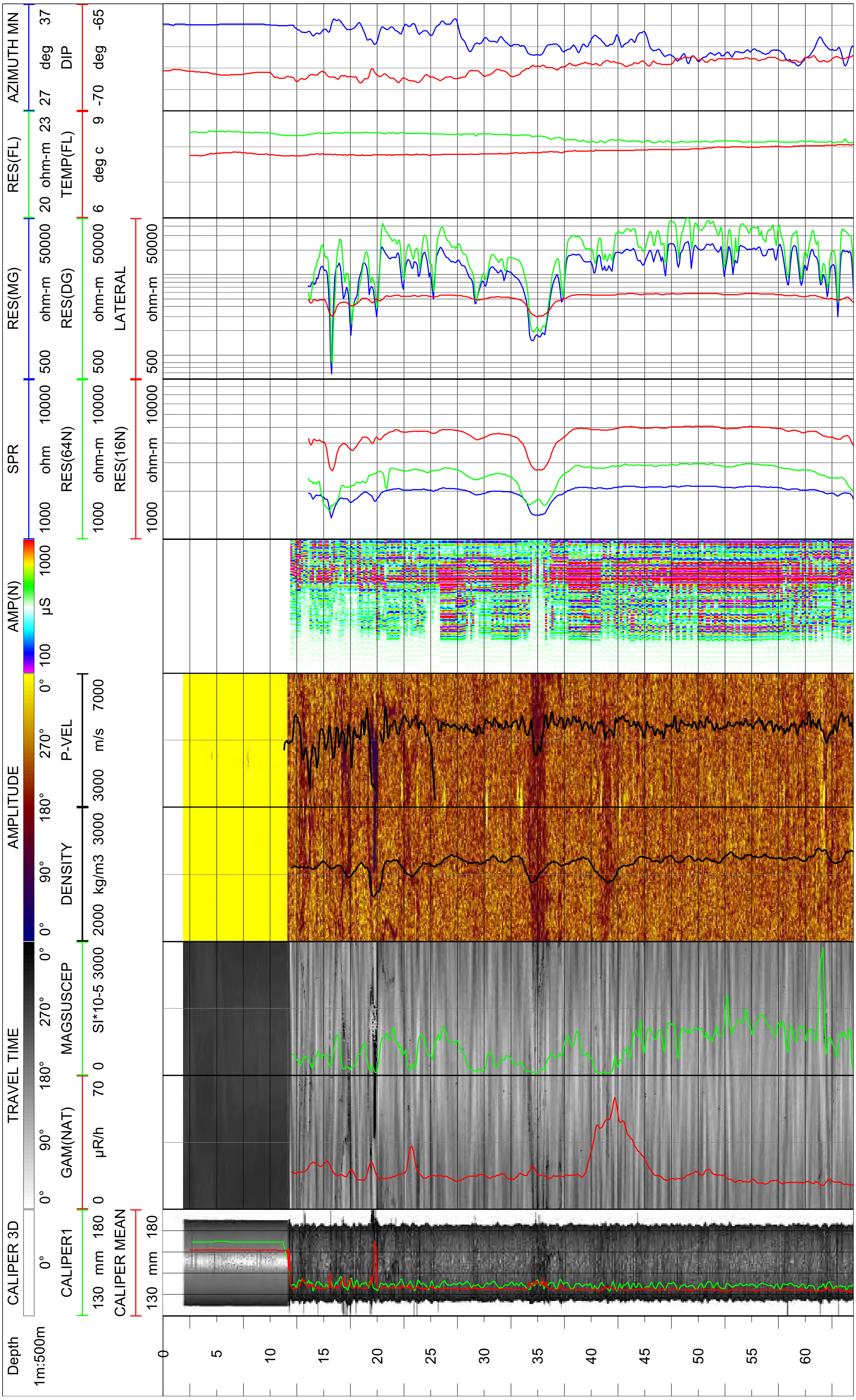
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

SKB geophysical borehole logging
Borehole HAV10. Ävrö.

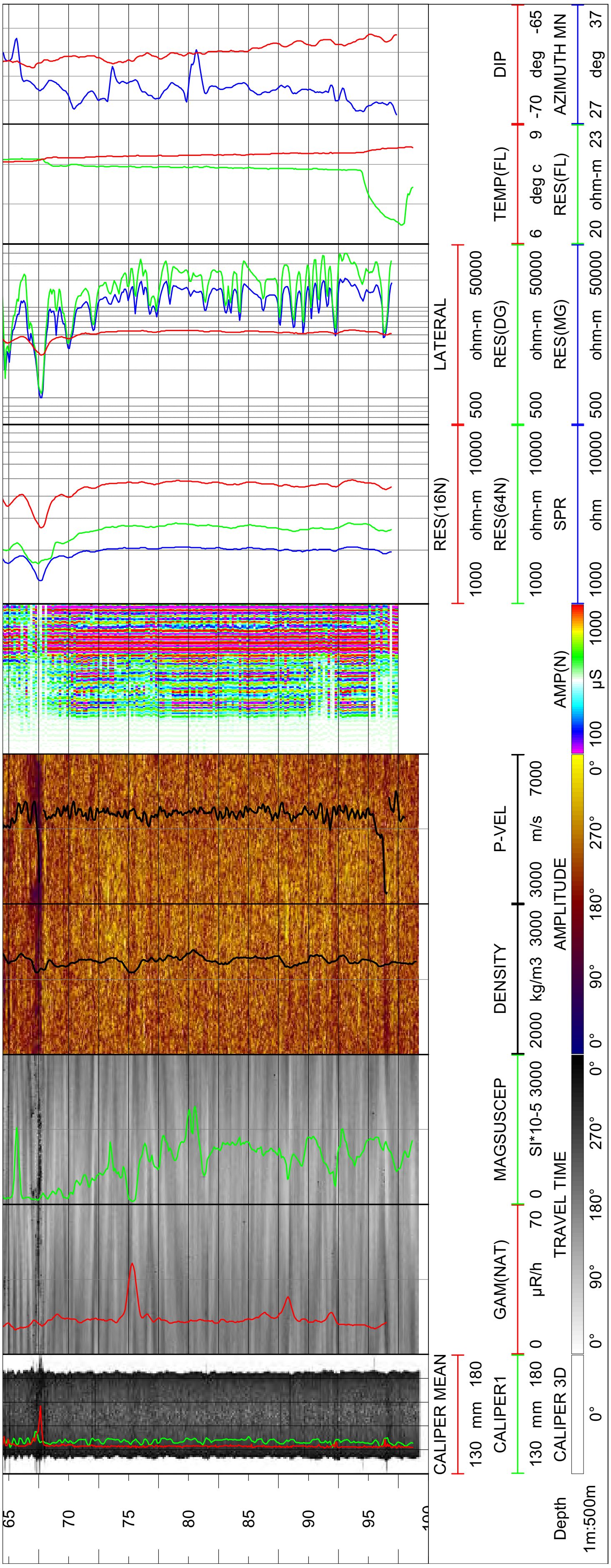
Presentation

Filename:
HAV10_Presentation.wcl

Drawing no.:
4.1



AZIMUTH MN
27 deg 37
DIP
-70 deg -65
RES(FL)
20 ohm-m 23
TEMP(FL)
6 deg c 9
RES(MG)
500 ohm-m 50000
RES(DG)
500 ohm-m 50000
LATERAL
500 ohm-m 50000
SPR
1000 ohm 10000
RES(64N)
1000 ohm-m 10000
RES(16N)
1000 ohm-m 10000
AMP(N)
100 µS 1000
AMPLITUDE
0° 90° 180° 270° 0°
P-VEL
3000 m/s 7000
DENSITY
2000 kg/m3 3000
TRAVEL TIME
0° 90° 180° 270° 0°
MAGSUSCEP
0 SI*10-5 3000
GAM(NAT)
0 µR/h 70
CALIPER 3D
0°
CALIPER1
130 mm 180
CALIPER MEAN
130 mm 180
Depth
1m:500m
0
5
10
15
20
25
30
35
40
45
50
55
60


65
70
75
80
85
90
95
100
Depth
1m:500m
CALIPER MEAN
130 mm 180
CALIPER1
130 mm 180
CALIPER 3D
0°
GAM(NAT)
0 µR/h 70
MAGSUSCEP
0 SI*10-5 3000
TRAVEL TIME
0° 90° 180° 270° 0°
DENSITY
2000 kg/m3 3000
P-VEL
3000 m/s 7000
AMPLITUDE
0° 90° 180° 270° 0°
AMP(N)
100 µS 1000
RES(16N)
1000 ohm-m 10000
RES(64N)
1000 ohm-m 10000
SPR
1000 ohm 10000
LATERAL
500 ohm-m 50000
RES(DG)
500 ohm-m 50000
RES(MG)
500 ohm-m 50000
TEMP(FL)
6 deg c 9
RES(FL)
20 ohm-m 23
DIP
-70 deg -65
AZIMUTH MN
27 deg 37