P-04-97

Forsmark site investigation

Geophysical borehole logging in borehole KFM02A, KFM03A and KFM03B

Uffe Torben Nielsen, Jørgen Ringgaard
RAMBØLL

June 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-04-97

Forsmark site investigation

Geophysical borehole logging in borehole KFM02A, KFM03A and KFM03B

Uffe Torben Nielsen, Jørgen Ringgaard
RAMBØLL

June 2004

Keywords: Geophysical logging, AP PF 400-03-46, Field note Forsmark 154.

Summary

According to a request from Svensk Kärnbränslehantering AB, geophysical borehole logging has been performed in the boreholes KFM02A, KFM03A and KFM03B, all situated in Forsmark, Sweden. The logging in KFM02A was performed from 0 m to 1000 m, in KFM03A from 0 to 1000 m and KFM03B from 0 to 100 m.

The present report comprises a description of the applied equipment and the performed logging program, the fieldwork and a presentation and discussion of the results.

The logging data were delivered to SKB on CDs, the raw data in Century and Robertson format and the processed data in WellCad and Excel format.

Contents

1 Introduction

This document reports geophysical logging operations in the boreholes KFM02A, KFM03A and KFM03B in the Forsmark area, see Figures 1-1 to 1-3.

The boreholes KFM02A and KFM03A are telescope boreholes, implying that the upper part, 0–100 m, is percussion drilled with a large diameter (254 mm in KFM02A and 200 mm in KFM03A). The cored drilled part of the boreholes, 100–1000 m, have a diameter of c 76 mm. Geophysical logging in the percussion part of KFM02A was conducted by Malå Geoscience /1/. In the percussion part of KFM03A, no geophysical logging was carried out since a second cored borehole, KFM03B, was drilled only a few metres away. The diameter of KFM03B is c 76 mm.

In borehole KFM02A, logging data was recorded from 100 m to 1000 m, 5 months after completion of drilling. In borehole KFM03A, logging data was recorded from 100 m to 1000 m, 7 weeks after drilling, and in borehole KFM03B from 0 to 100 m, 4 weeks after drilling.

All measurements were conducted by RAMBØLL during the period August 4 to August 12, 2003 in accordance with the instructions and guidelines from SKB (activity plan AP PF 400-03-46 and method description MD 221.002 version, 1.0, SKB internal controlling documents). RAMBØLL is acting as a subcontractor to DGE and ÅF-IPK.

Although the operations were carried out in August 2003, the sonic data from KFM02A was later, in June 2004, reprocessed (hand-picking of first arrivals).

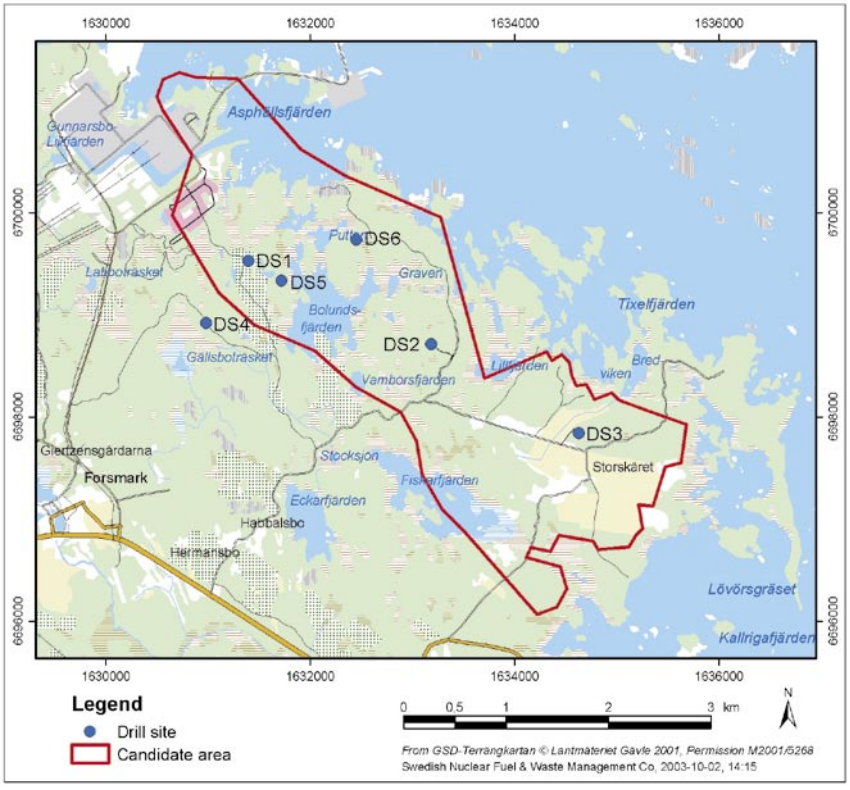


Figure 1-1. *Forsmark, drill site 1-6. BoreholeKFM02A is located at drill site 2 (see Figure 1-2) and boreholes KFM03A and KFM03B at drill site 3 (see Figure 1-3).*

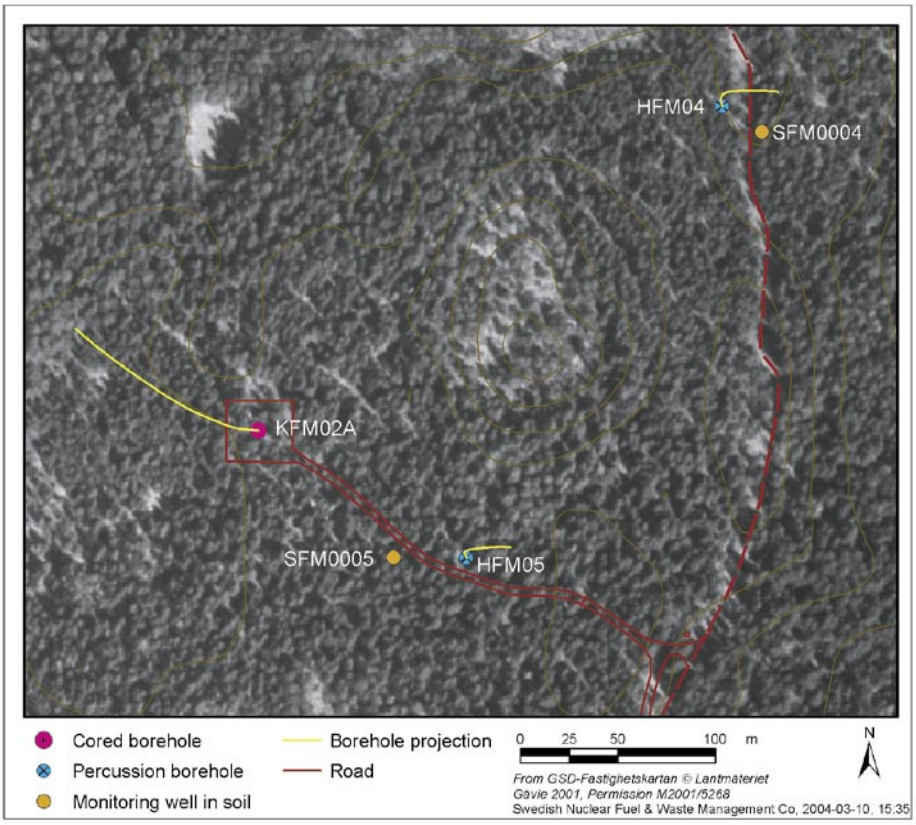


Figure 1-2. *Forsmark, drill site 2.*

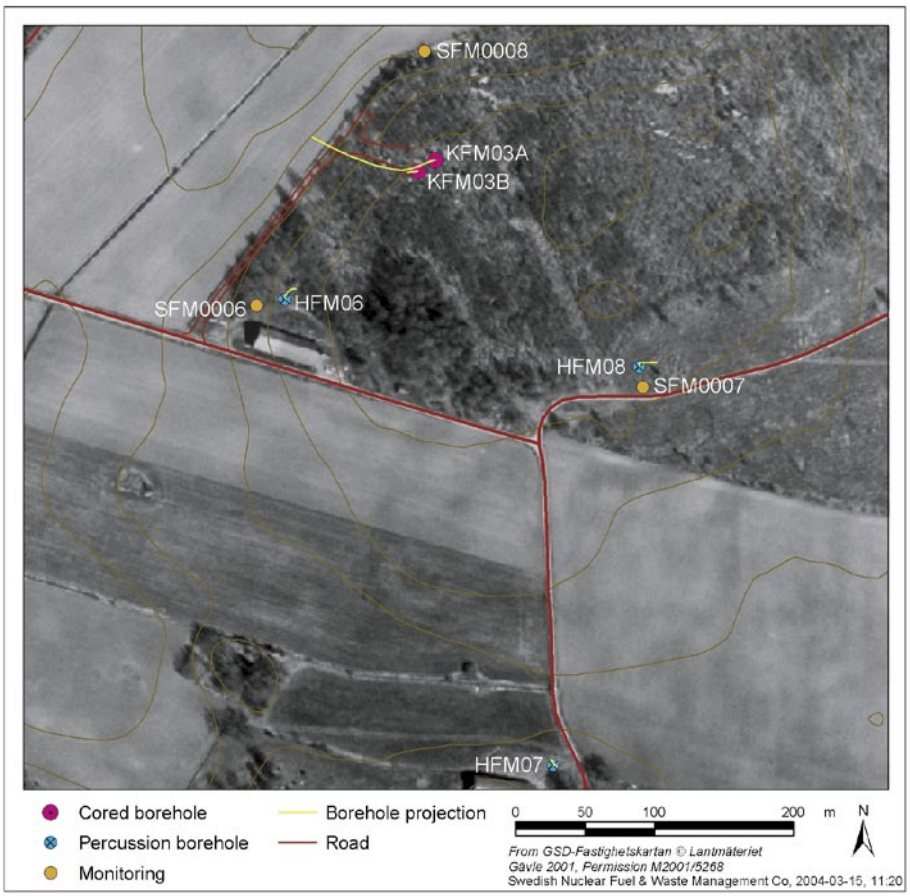


Figure 1-3. *Forsmark, drill site 3.*

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. Also the deviation of the borehole is determined.

This field report describes the equipment used as well the measurement procedures. Geophysical borehole logging data are presented in Appendix 1 and 2.

3 Equipment

The geophysical borehole logging program in KFM02A and KFM03A was performed with 7 multi tool probes and resulted in a suite of 20 log types. The geophysical borehole logging program in KFM03B was performed with 6 multi tool probes and resulted in a suite of 17 log types. All log types are 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	Source type	Comment
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	
Century 9042 Fluid resistivity and temperature	Fluid resistivity, fluid temperature, fluid delta temperature, natural gamma	137·4.1 cm			
Century 9072 3 m focused guard	3 m focused guard log resistivity and natural gamma	310·6.4 cm			
Century 9080 Spectral gamma	Potassium (K) Percent 40, Uranium (U), Thorium (T)	204.5·7.1 cm			Not recorded in KFM03B
Century 9320 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	
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			

4 Execution

In general the measurement procedures followed the SKB method description (MD 221.002, version 1.0 (“Metodbeskrivning för geofysisk borrhålsloggning”). The logging program in borehole KFM02A was executed during the period August 4 to 8, in KFM03A from August 8 to 11 and in KFM03B from August 4 to 5, 2003. All relevant logging events were described in the daily report sheets.

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 the SKB method description MD 600.004, version 1.0 (“Instruktion för rengöring av borrhålsutrustning och viss mark-baserad utrustning”), cleaning level 2 before arriving at the site. Furthermore, all equipment was wiped with alcohol before it was lowered to the boreholes. The applied logging equipment was calibrated before arriving at the site.

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 verifies the repeatability of 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 9320.

All data were recorded with maximum 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, for which the speed was 2.3 m/min.

The spectral gamma tool was rented for the job. The tool was calibrated by the owner. As the logging results gave negative values, it was evident, that the tool was not calibrated properly. A new secondary calibration was later done by RAMBØLL, and the actual value at the time of acquisition was found by interpolation between the two calibration times. Century Geophysical then recalibrated the recorded files. However, the Uranium values still tend to be a bit low, and the absolute accuracy of the values will be lower than what should be obtainable with a proper fresh calibration file.

5 Results

5.1 Presentation

Table 5-1 lists the logs presented in Appendix 1-3. The logs have not been filtered during logging or presentation.

Table 5-1. Logs presented in Appendix 1 and 2.

Log	Log name short	Unit	Tool
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
Fluid temperature	TEMP (FL)	deg C	9042
Fluid resistivity	RES (FL)	ohm-m	9042
Focused guard log resistivity, 300 cm	RES (DG)	ohm-m	9072
P-wave velocity	P-VEL	m/s	9320
Full wave form, near receiver	AMP (N)	µs	9320
Full wave form, far receiver	AMP (F)	µs	9320
Magnetic susceptibility	MAGSUSCEP	SI*10-5	8622
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 lateral	DIP	deg	HiRAT
360° orientated acoustic travel time	TRAVEL TIME	100 ns	HiRAT
360° orientated acoustic travel time	AMPLITUDE	–	HiRAT
Thorium	THORIUM	PPM	9080 (not in KFM03B)
Uranium	URANIUM	PPM	9080 (not in KFM03B)
Potassium	POTASSIUM	Percent	9080 (not in KFM03B)

5.2 Calculated curves

5.2.1 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 acquired by means of the current International Geomagnetic Reference Field (IGRF), see Table 5-2. The actual values are presented 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 (top of casing, TOC). In the same calculation, the magnetic declination was added. Finally, the relative coordinates were added to the given TOC-coordinates (XYZ) in RT90 2.5 gon W and RH70B.

5.2.2 Conversion of the magnetic susceptibility

The magnetic susceptibility was converted for CGS units to SI units by multiplying the CGS value by 4π.

5.2.3 Conversion of natural gamma log

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.

Table 5-2. International Geomagnetic Reference Field (IGRF2000) components.

Location	
Latitude (North)	60 deg 22 min 34 sec
Longitude (East)	18 deg 14 min 45 sec
Elevation	0.02 km
Date of interest	2003-04-08
Magnetic field components	
Total magnetic field	51113 nT
Declination (east)	4 deg 1 min
Inclination (down)	73 deg 8 min
Horizontal field	14832 nT
Horizontal field (north)	14832 nT
Horizontal field (east)	1041 nT
Vertical field	48914 nT

5.3 Borehole KFM02A

In order to obtain an exact depth calibration in borehole KFM02A, the track marks made while drilling were used. The connection between the track marks and the logs was obtained from the HiRAT acoustic tool.

To obtain a common depth reference point, the track mark at 109.212 m in the HiRAT file is used as the marker at depth 110 m. The HiRAT tool was therefore shifted 0.788 m down. The same correction value was used for the entire borehole.

The reference marks in the borehole, the recorded track marks from the HiRAT and the corrected depths are presented in Table 5-3.

Using the natural gamma from the HiRAT as reference, the natural gamma logs from the other probes are aligned to the same depth, and the shift correction value for the other tools was thus identified. These values are shown in Table 5-4.

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

Reference mark	HIRAT recorded	HIRAT after shift
110	109.212	110.000
150	149.167	149.955
200	199.21	199.998
250	249.186	249.974
304.5	303.713	304.501
350	349.189	349.977
400	399.204	399.992
450	449.188	449.976
506	505.192	505.980
550	549.166	549.954
600	599.168	599.956
650	649.185	649.973
700	699.175	699.963
750	749.167	749.955
800	799.189	799.977
850	849.186	849.974
900	899.171	899.959
950	949.188	949.976

Table 5-4. Shift correction values in borehole KFM02A.

Tool	Shift correction value
8622	0.340 m down
9030	1.195 m down
9030. Medium guard	1.395 m down
9042	0.325 m down
9072	1.355 m down
9080	0.980 m down
9320	0.685 m down
HiRAT	0.788 m down

There is a minor difference, about 1.5 m/km, in the depth registration between up- and down runs. To compensate for this, the logs recorded downward are stretched. The stretch value is found by means of comparison of the gamma logs. In this borehole, only the logs from the 9042 have been stretched.

The complete log suite for borehole KFM02A is presented as composite log sheets in Appendix 1 (Drawing no 1.1). The logs presented are listed in Table 5-1.

5.4 Borehole KFM03A

In the same way as for borehole KFM02A, the track marks made while drilling were used in order to obtain the depth calibration in borehole KFM03A.

The track mark at 108.868 m in the HiRAT file was used as the marker at the depth of 110 m. The HiRAT tool was therefore shifted 1.132 m down and this correction value was used for the entire borehole.

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 5-5.

Using the natural gamma from the HiRAT as reference, the natural gamma logs from the other probes were aligned to the same depths, whereby the shift correction value for the other tools was determined. These values are shown in Table 5-6.

There is a minor difference, about 1.5 m/km, in the depth registration between up- and down runs. To compensate for this, the logs recorded downward is stretched. The stretch value is found by means of comparison of the gamma logs. In this borehole, only the logs from the 9042 have been stretched.

The complete log suite for borehole KFM03A is presented as composite log sheets in Appendix 2 (Drawing no 2.1). The logs presented are listed in Table 5-1.

Table 5-5. The reference marks in the borehole, the recorded track marks form the HiRAT and the corrected depths.

Reference mark	HIRAT recorded	HIRAT after shift
110.00	108.868	110.000
150.00	148.966	150.098
200.00	198.929	200.061
250.00	248.904	250.036
300.00	298.894	300.026
350.00	348.926	350.058
403.00	401.75	402.882
453.00	451.763	452.895
500.00	498.792	499.924
550.00	548.657	549.789
600.00	598.67	599.802
650.00	648.683	649.815
700.00	698.627	699.759
750.00	748.579	749.711
800.00	798.571	799.703
850.00	848.52	849.652
900.00	898.499	899.631

Table 5-6. Shift correction values in borehole KFM03A.

Tool	Shift correction value
8622	1.25 m down
9030	1.43 m down
9030. Medium guard	1.63 m down
9042	0.41m down
9072	1.00 m down
9080	0.93 m down
9320	1.37 m down
HiRAT	1.132 m down

5.5 Borehole KFM03B

Using the natural gamma log from the 9042 as reference, the natural gamma logs from the other probes were aligned to the same depth, and the shift correction values for the other were fund. These values are shown in Table 5-7.

The complete log suite for borehole KFM03B is presented as composite log sheet in Appendix 3 (Drawing no 3.1). The logs presented are listed in Table 5-1.

Table 5-7. Shift correction values in borehole KFM03B for the other tools using natural gamma logs from the other probes.

Tool	Shift correction value
8622	0.06 m down
9030	0.06 m down
9030. Medium guard	0.26 m down
9042	0 m down
9072	0.11 m down
9320	0.11 m down
HiRAT	0.22 m down

6 Data delivery

Apart from the present report, a comprehensive field report was delivered to SKB /2/. The field report comprises logging reports, processing logs, logging reference point descriptions and cleaning and probe sensor descriptions. The calibration values from the probes 8622, 9030, 9072 and 9080 are also included (probe 9320 and HiRAT shall not be calibrated).

Raw-data from the measurements, recorded in Century and Robertson format, see Table 6-1, were delivered directly after the termination of the field activities. The recorded raw-data files used in the processing have also been delivered in WellCAD format.

The processed files were 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.

The data delivered in the "magn_inclination" column, in the "Acoustic televiewer" sheet, were 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.

The SICADA reference to the data from the logging operations are field note Forsmark 154.

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

Borehole	Probe	Log direction	WellCAD File
KFM02A	8622	Up	F:\KFM02A\KFM02A_08-04-03_18-30_8622C_.04_829.64_1001.13_ORIG.log
KFM02A	8622	Up	F:\KFM02A\KFM02A_08-04-03_19-45_8622C_.04_0.76_822.14_ORIG.log
KFM02A	9030	Up	F:\KFM02A\ KFM02A_08-11-03_09-05_9030CA_.04_21.17_1001.13_PROC.log
KFM02A	9042	Down	F:\KFM02A\KFM02A_08-05-03_07-42_9042C_.04_0.24_1000.45_ORIG.log
KFM02A	9042	Down	F:\KFM02A\KFM02A_08-05-03_10-54_9042C_.04_925.20_1001.13_ORIG.log
KFM02A	9072	Up	F:\KFM02A\KFM02A_08-08-03_10-31_9072C_.04_1.48_1000.81_ORIG.log
KFM02A	9080	Up	F:\KFM02A\KFM02A_08-07-03_10-26_9080A_.04_3.31_1000.77_ORIG.log
KFM02A	9320	Up	F:\KFM02A\KFM02A_08-08-03_12-40_9320C2_.10_-0.50_382.50_ORIG.log
KFM02A	9320	Up	F:\KFM02A\KFM02A_08-05-03_18-16_9320C2_.10_326.70_1000.80_ORIG.log
KFM02A	HiRAT	Up	F:\KFM02A\KFM02A_HiRAT_up_120_run2.LGX
KFM02A	HiRAT	Up	F:\KFM02A\KFM02A_HiRAT_up_120_run3.LGX
KFM03A	8622	Up	F:\Kfm03a\KFM03A_08-11-03_12-02_8622C_.04_1.48_999.73_ORIG.log
KFM03A	9030	Up	F:\Kfm03a\KFM03A_08-09-03_17-06_9030CA_.04_1.60_999.10_ORIG.log
KFM03A	9042	Down	F:\Kfm03a\KFM03A_08-08-03_14-22_9042C_.10_0.20_1001.50_ORIG.log
KFM03A	9072	Up	F:\Kfm03a\KFM03A_08-11-03_13-43_9072C_.04_2.00_999.81_ORIG.log
KFM03A	9080	Up	F:\Kfm03a\KFM03A_08-10-03_10-38_9080A_.04_3.43_999.10_ORIG.log
KFM03A	9320	Up	F:\Kfm03a\KFM03A_08-11-03_18-36_9320C2_.10_-1.00_998.90_ORIG.log
KFM03A	HiRAT	Up	F:\Kfm03a\KFM03A_HiRAT_up_120_run1.LGX
KFM03B	8622	Up	F:\KFM03B\KFM03B_08-04-03_13-07_8622C_.04_3.07_100.43_ORIG.log
KFM03B	9030	Up	F:\KFM03B\KFM03B_08-04-03_11-04_9030CA_.04_0.60_99.79_ORIG.log
KFM03B	9042	Down	F:\KFM03B\KFM03B_08-04-03_09-57_9042C_.04_0.24_100.31_ORIG.log
KFM03B	9072	Up	F:\KFM03B\KFM03B_08-04-03_12-34_9072C_.04_0.48_100.19_ORIG.log
KFM03B	9320	Up	F:\KFM03B\KFM03B_08-04-03_13-39_9320C2_.10_0.20_99.80_ORIG.log
KFM03B	HiRAT	Up	F:\KFM03B\KFM03B_HiRAT_up_120_run2.LGX
KFM03B	HiRAT	Up	F:\KFM03B\KFM03B_HiRAT_up_120_run1.LGX

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KFM02A	1.1	KFM02A_Presentation.WCL
KFM02A	1.2	KFM02A_Deviation.WCL
KFM02A	1.3	KFM02A_Deviation.WCL
KFM03A	2.1	KFM03A_Presentation.WCL
KFM03A	2.2	KFM03A_Deviation.WCL
KFM03A	2.3	KFM03A_Deviation.WCL
KFM03B	3.1	KFM03B_Presentation.WCL
KFM03B	3.2	KFM03B_Deviation.WCL
KFM03B	3.3	KFM03B_Deviation.WCL

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

Borehole	Excel file
KFM02A	KFM02A_data.xls
KFM03A	KFM03A_data.xls
KFM03B	KFM03B_data.xls

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

Sheet	Borehole	Other
Acoustic televiewer	KFM02A, KFM03A, KFM03B	See description of “total magnetic field” and “magnetic inclination” below
Focused resistivity 140 cm	KFM02A, KFM03A, KFM03B	
Focused resistivity 300 cm	KFM02A, KFM03A, KFM03B	
Fullwave sonic	KFM02A, KFM03A, KFM03B	column: v_velocity (shear wave), not interpreted from the recorded data
Caliper1	KFM02A, KFM03A, KFM03B	
Caliper Mean	KFM02A, KFM03A, KFM03B	Calculated using Fluid resistivity and Acoustic televiewer
Fluid resistivity	KFM02A, KFM03A, KFM03B	
Fluid Temperature	KFM02A, KFM03A, KFM03B	
Density	KFM02A, KFM03A, KFM03B	
Resistivity	KFM02A, KFM03A, KFM03B	
Natural gamma	KFM02A, KFM03A, KFM03B	
Self potential	KFM02A, KFM03A, KFM03B	
Single point resistivity	KFM02A, KFM03A, KFM03B	
Magnetic susceptibility	KFM02A, KFM03A, KFM03B	
Potassium	KFM02A, KFM03A	Sheet Spectral gamma
Uranium	KFM02A, KFM03A	Sheet Spectral gamma
Thorium	KFM02A, KFM03A	Sheet Spectral gamma

References

/1/ **Gustafsson C, Nilsson P, 2003.** Geophysical, radar and BIPS logging in boreholes HFM04, HFM05, and the percussion drilled part of KFM02A. SKB P-03-53. Svensk Kärnbränslehantering AB.

/2/ **Nielsen U T, Ringgaard J, 2003.** Geophysical borehole logging in borehole KFM02A, KFM03A and KFM03B. Rambøll Report S-0204213/5.

Appendix 1

Geophysical borehole logging, borehole KFM02A

Borehole No. KFM02A

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

X: 6698712.501 m Y: 1633182.863 m Z: 7.353 m, RHB 70

Diameter:	76 mm
Reaming Diameter:	-
Outer Casing:	-
Inner Casing:	-
Borehole Length:	1002.44 m
Cone:	-
Inclination at ground surface:	-84.734°
Azimuth:	318.352°
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	deg C
RES(FL)	Fluid resistivity	9042	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

Rev.	Date	Drawn by	Control	Approved
0	2003-09-18	JRI	UTN	UTN

Job: 360210A

Scale: 1:500

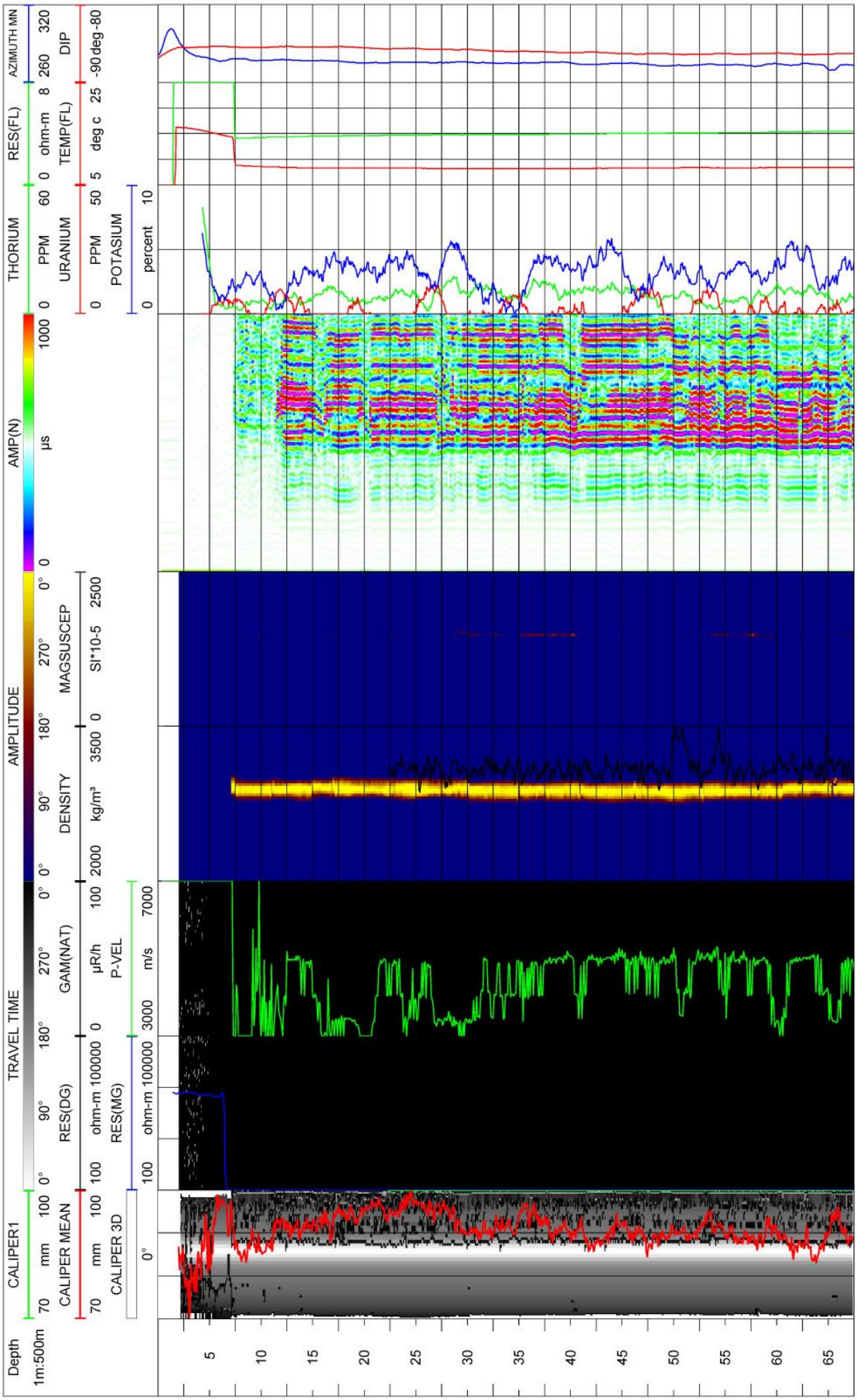
DGE Dansk Geo-servEx a/s
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

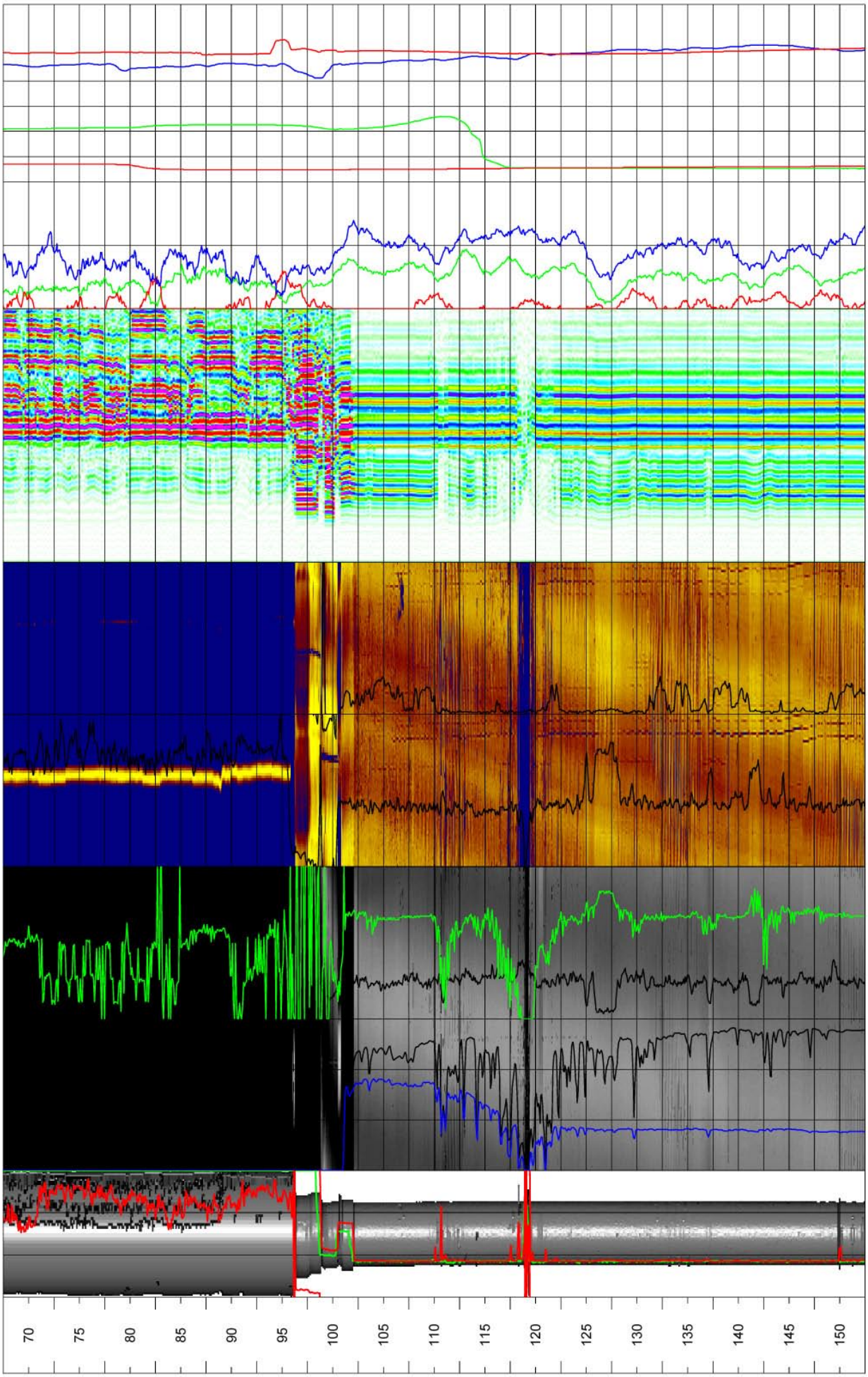
SKB geophysical borehole logging
Borehole KFM02A Forsmark

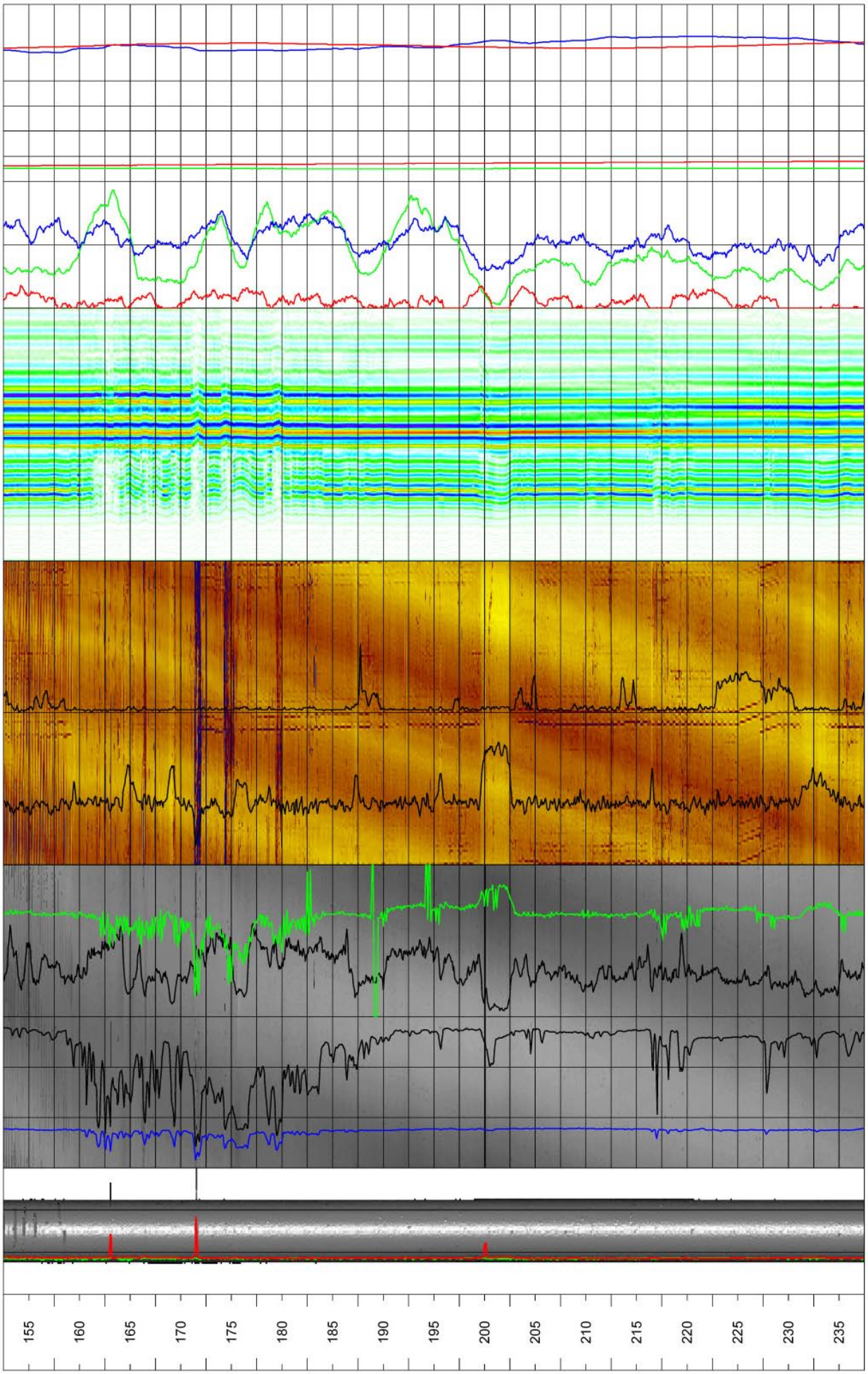
Presentation

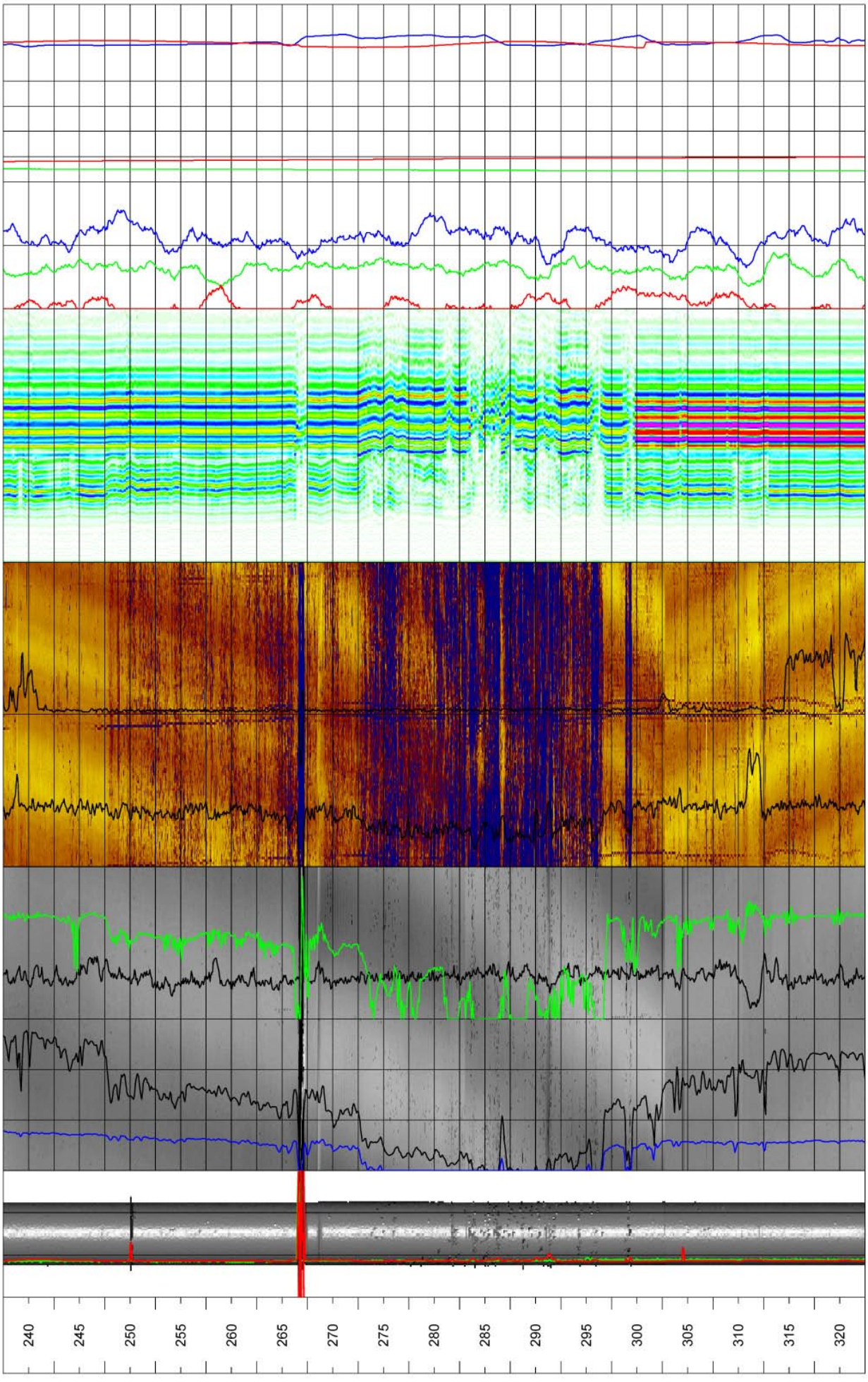
Filename: KFM02A_Presentation.wcl

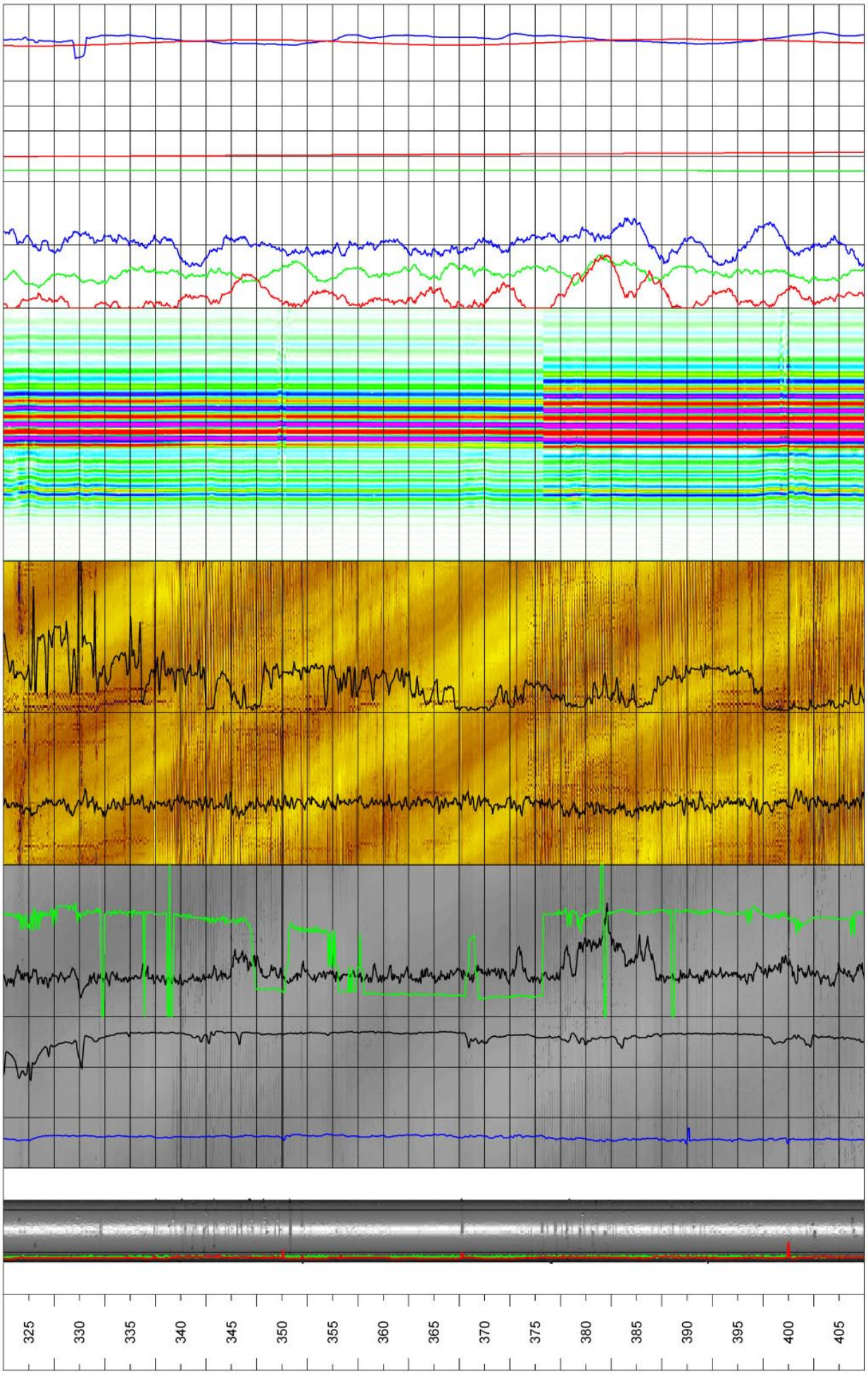
Drawing no.: **1.1**

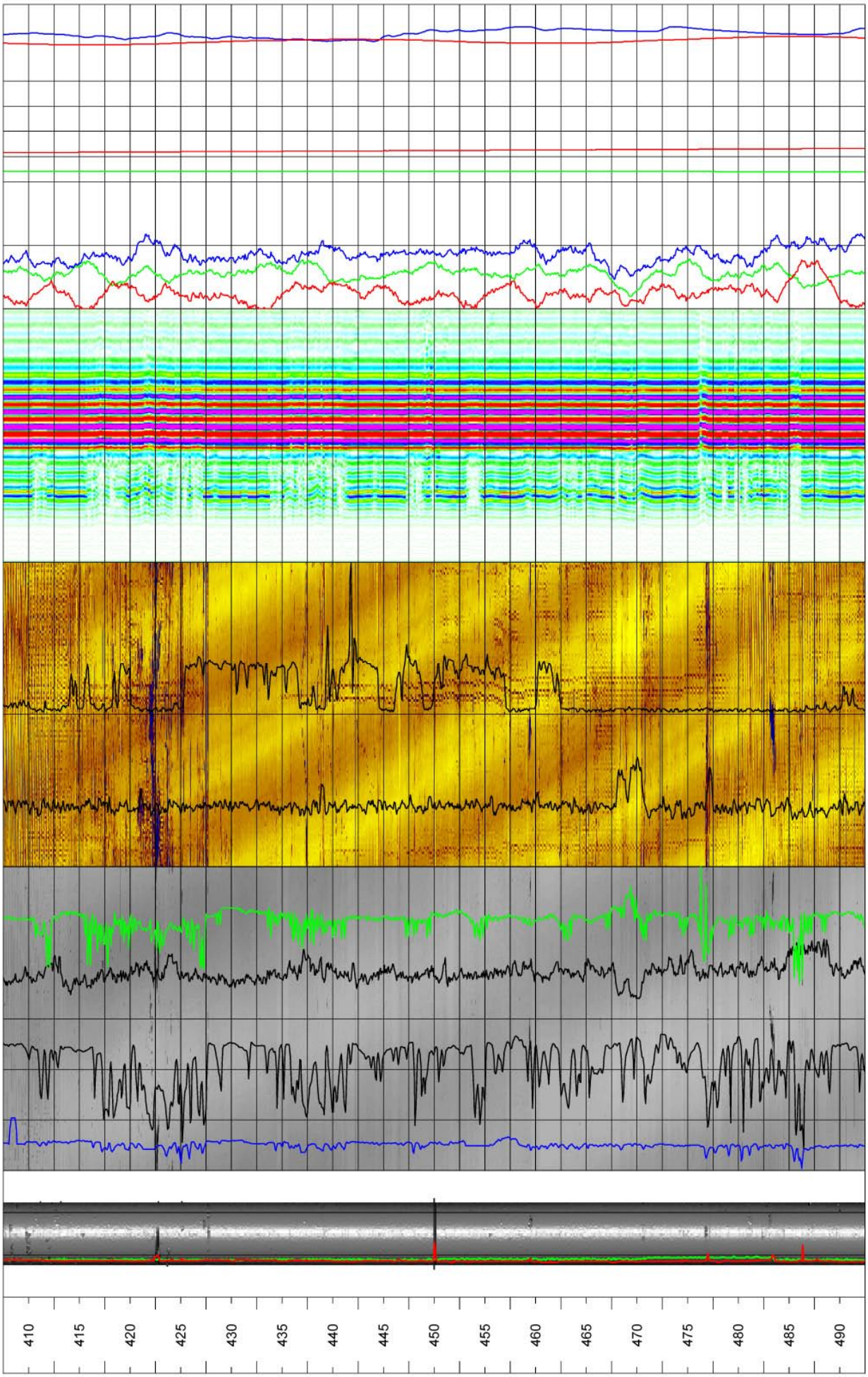

Depth
1m:500m
CALIPER1
70 mm 100
CALIPER MEAN
70 mm 100
CALIPER 3D
0° 100
TRAVEL TIME
0° 90° 180° 270° 0°
RES(DG)
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
AMPLITUDE
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 100
P-VEL
3000 m/s 7000
DENSITY
2000 kg/m³ 3500
MAGSUSCEP
0 SI*10-5 2500
AMP(N)
0 µs 1000
THORIUM
0 PPM 60
URANIUM
0 PPM 50
POTASIUM
0 percent 10
RES(FL)
0 ohm-m 8
TEMP(FL)
5 deg c 25
AZIMUTH MN
260 320
DIP
-90 deg -80
5
10
15
20
25
30
35
40
45
50
55
60
65

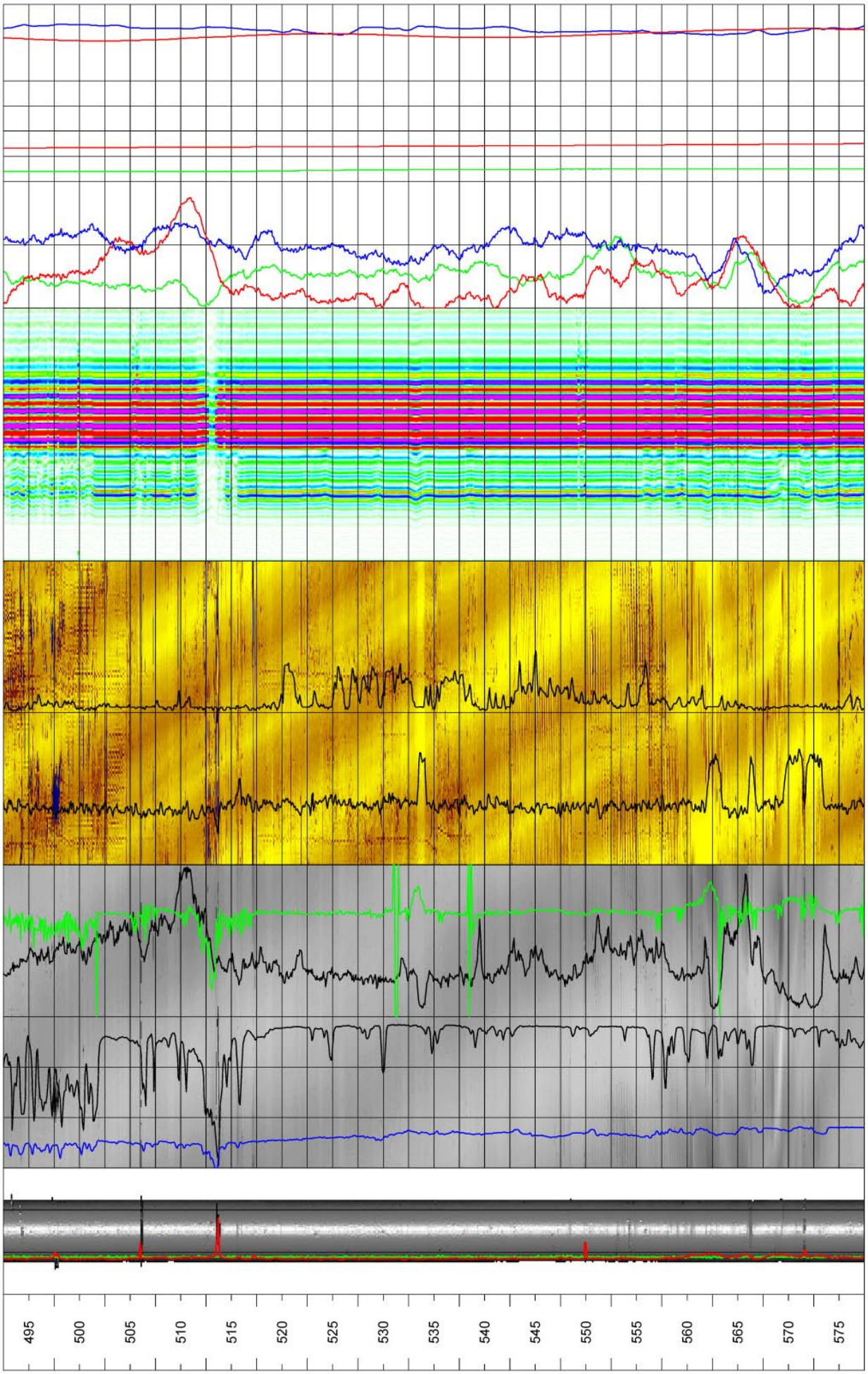

70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150

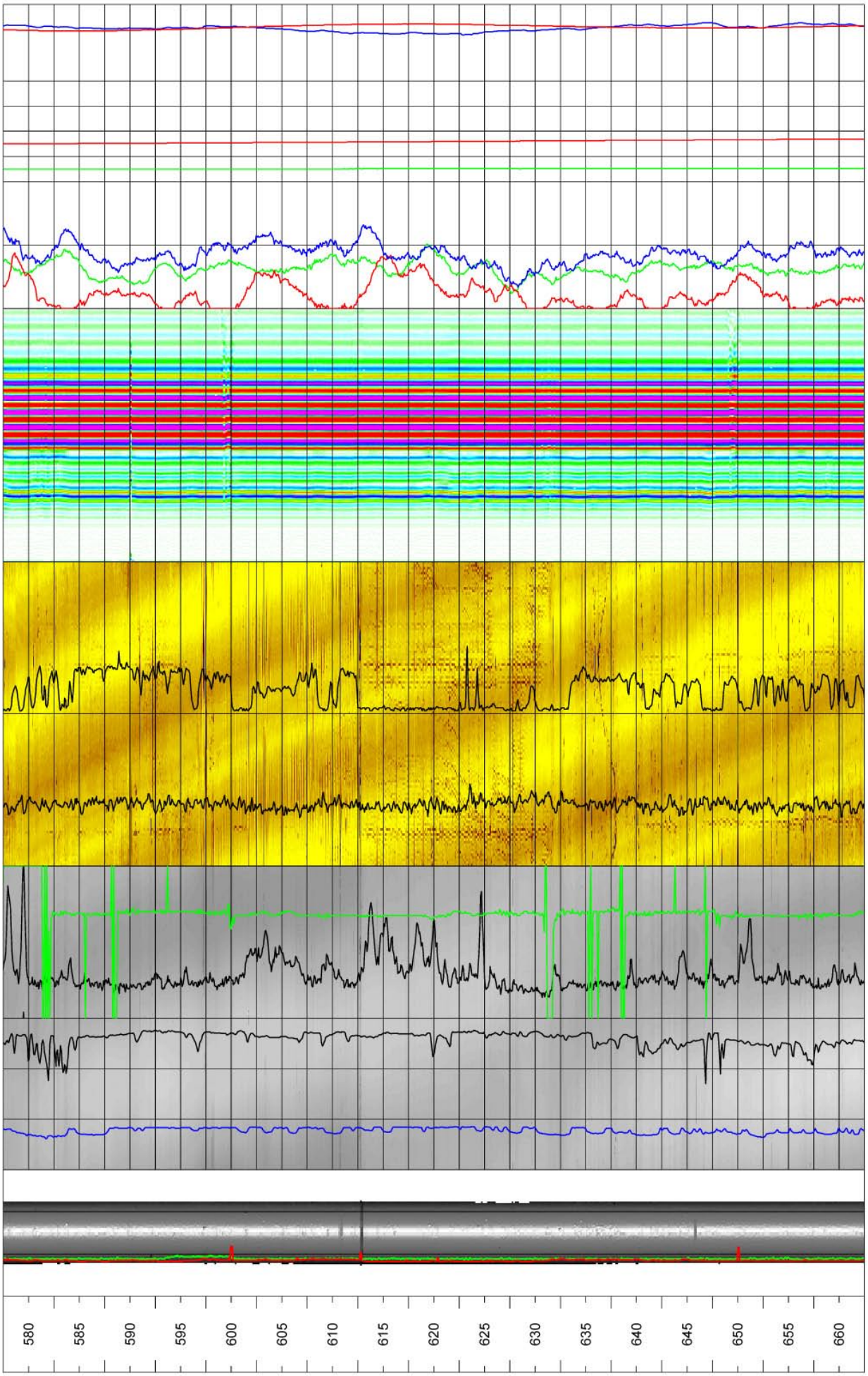

155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235


240
245
250
255
260
265
270
275
280
285
290
295
300
305
310
315
320

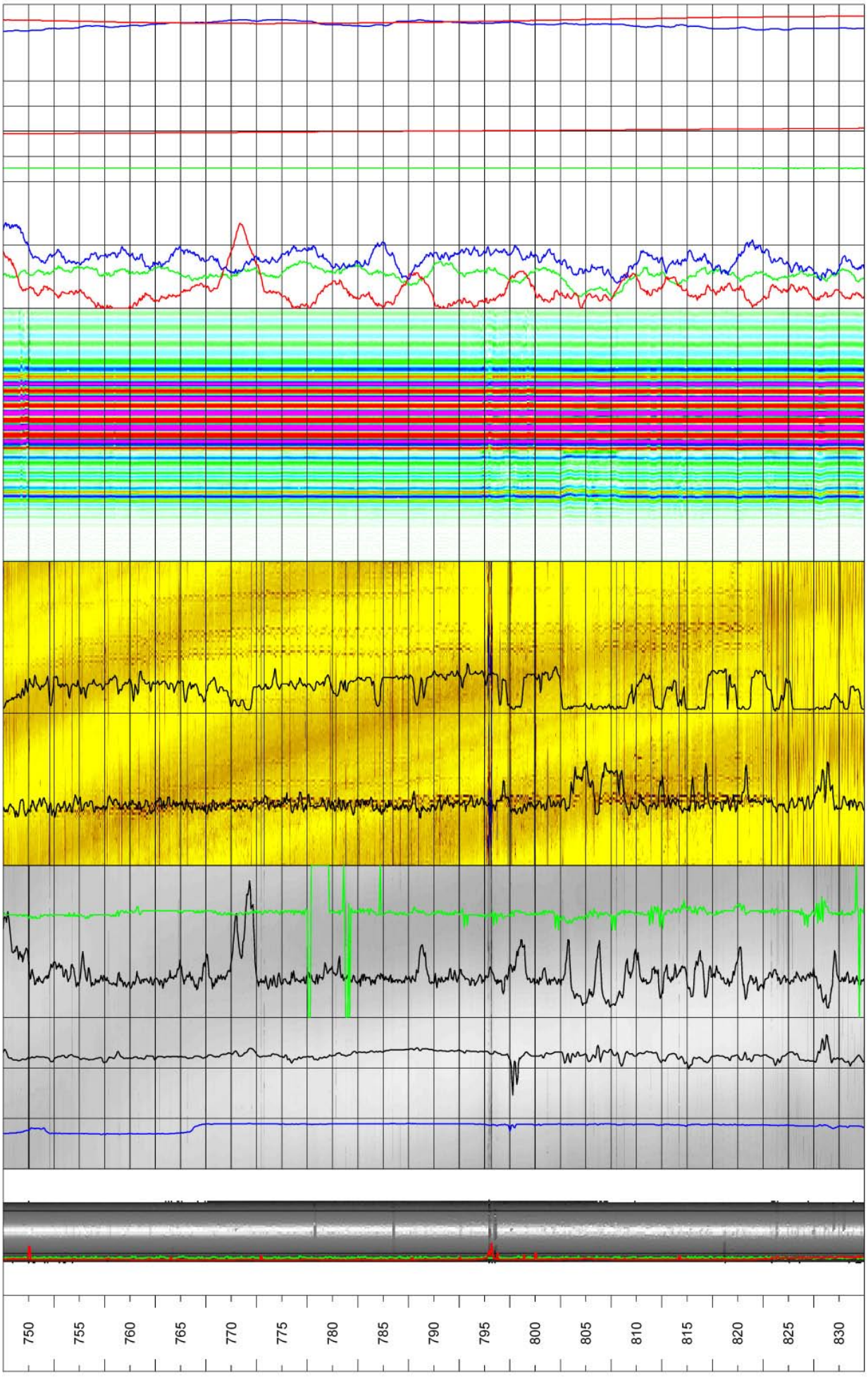

325
330
335
340
345
350
355
360
365
370
375
380
385
390
395
400
405

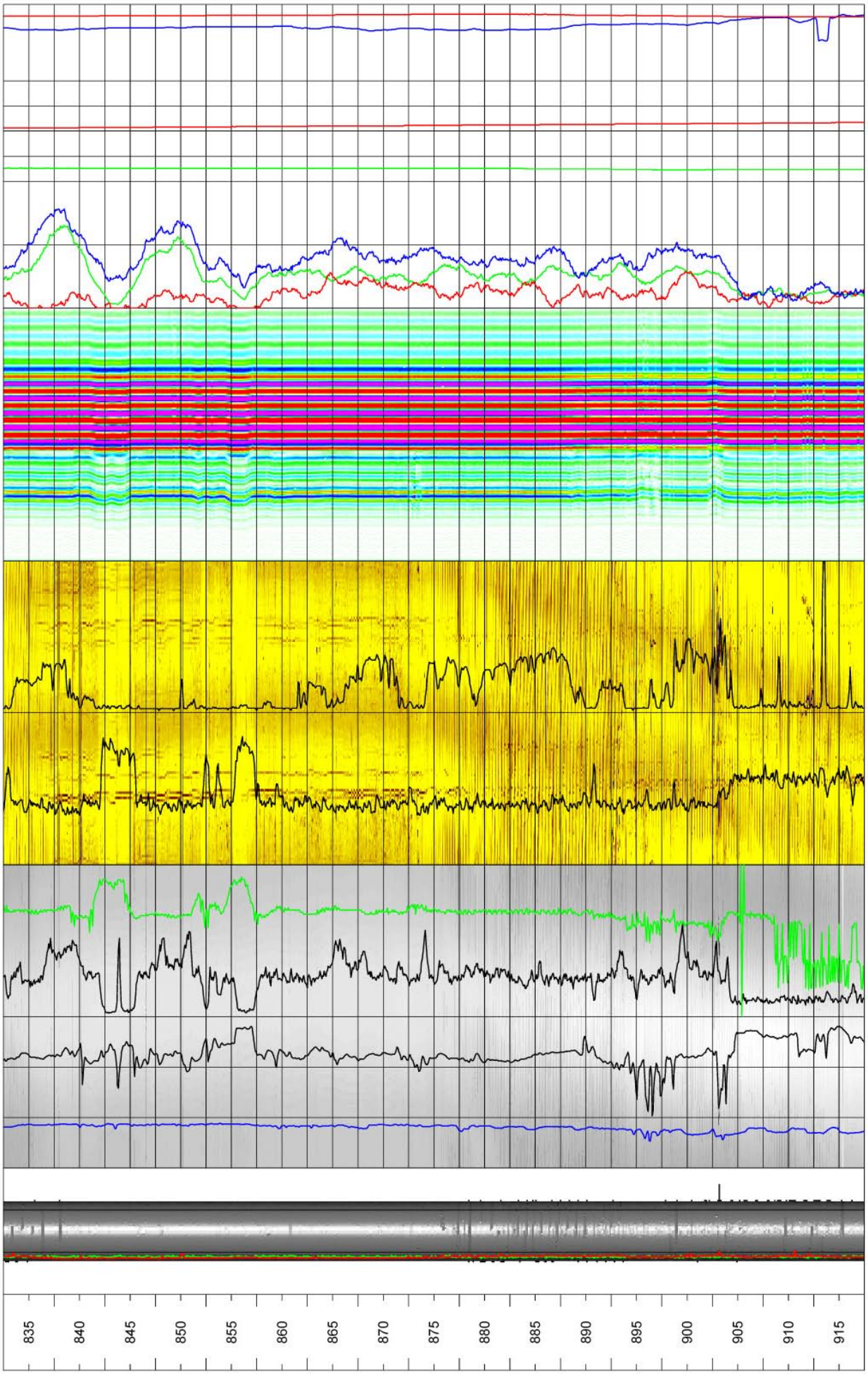

410
415
420
425
430
435
440
445
450
455
460
465
470
475
480
485
490

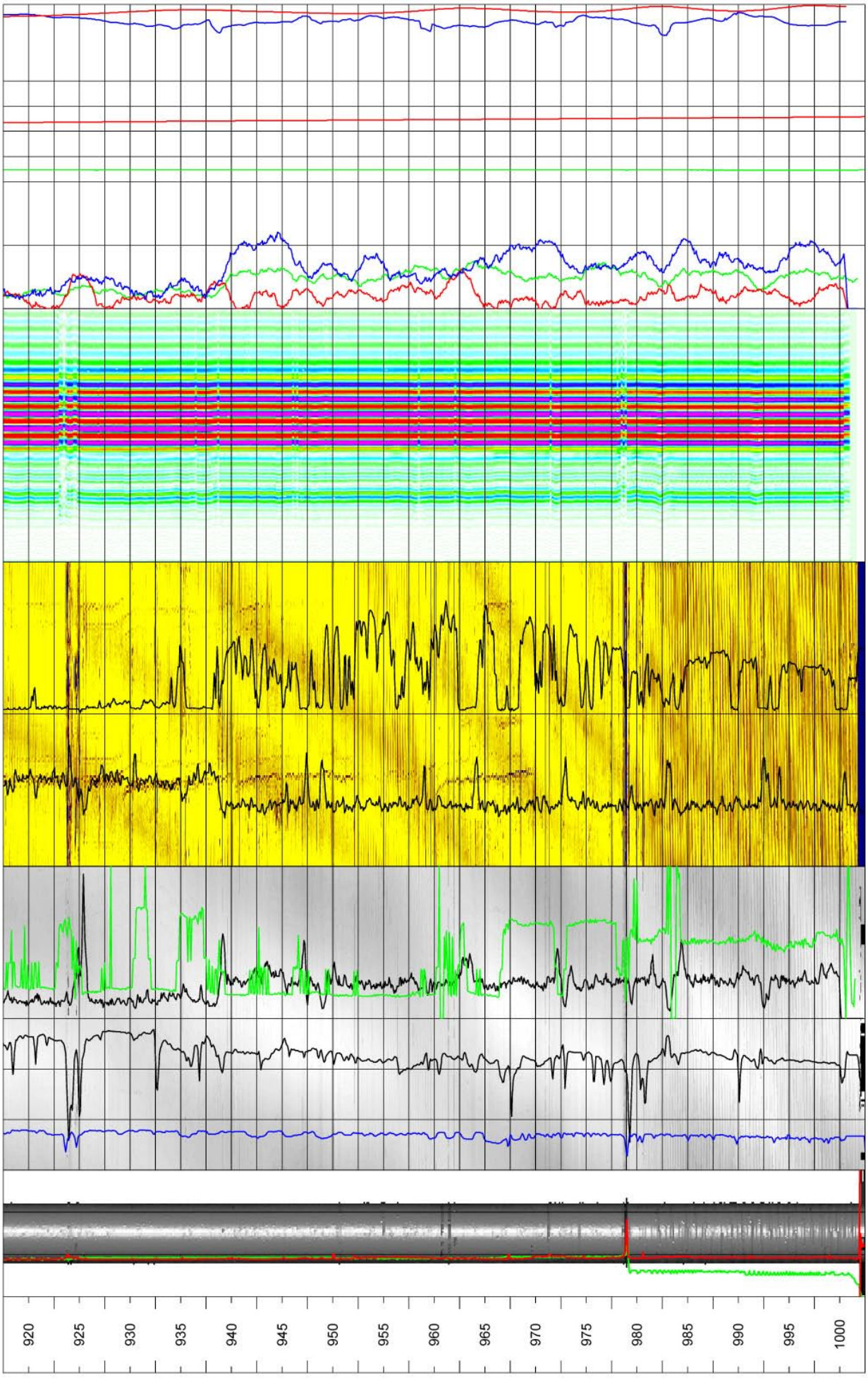

495
500
505
510
515
520
525
530
535
540
545
550
555
560
565
570
575


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
935
940
945
950
955
960
965
970
975
980
985
990
995
1000

Appendix 2

Geophysical borehole logging, borehole KFM03A

Borehole No. KFM03A

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

X: 6697852.096 m Y: 1634630.733 m Z: 8.285 m, RHB70

Diameter:	76 mm
Reaming Diameter:	196 mm
Outer Casing:	-
Inner Casing:	-
Borehole Length:	1001.19 m
Cone:	97.2 - 101.85 m
Inclination at ground surface:	-85.75°
Azimuth:	271.52°
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	deg C
RES(FL)	Fluid resistivity	9042	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

Rev.	Date	Drawn by	Control	Approved
0	2003-09-19	JRI	JRI	UTN

Job: 360210A

Scale: 1:500

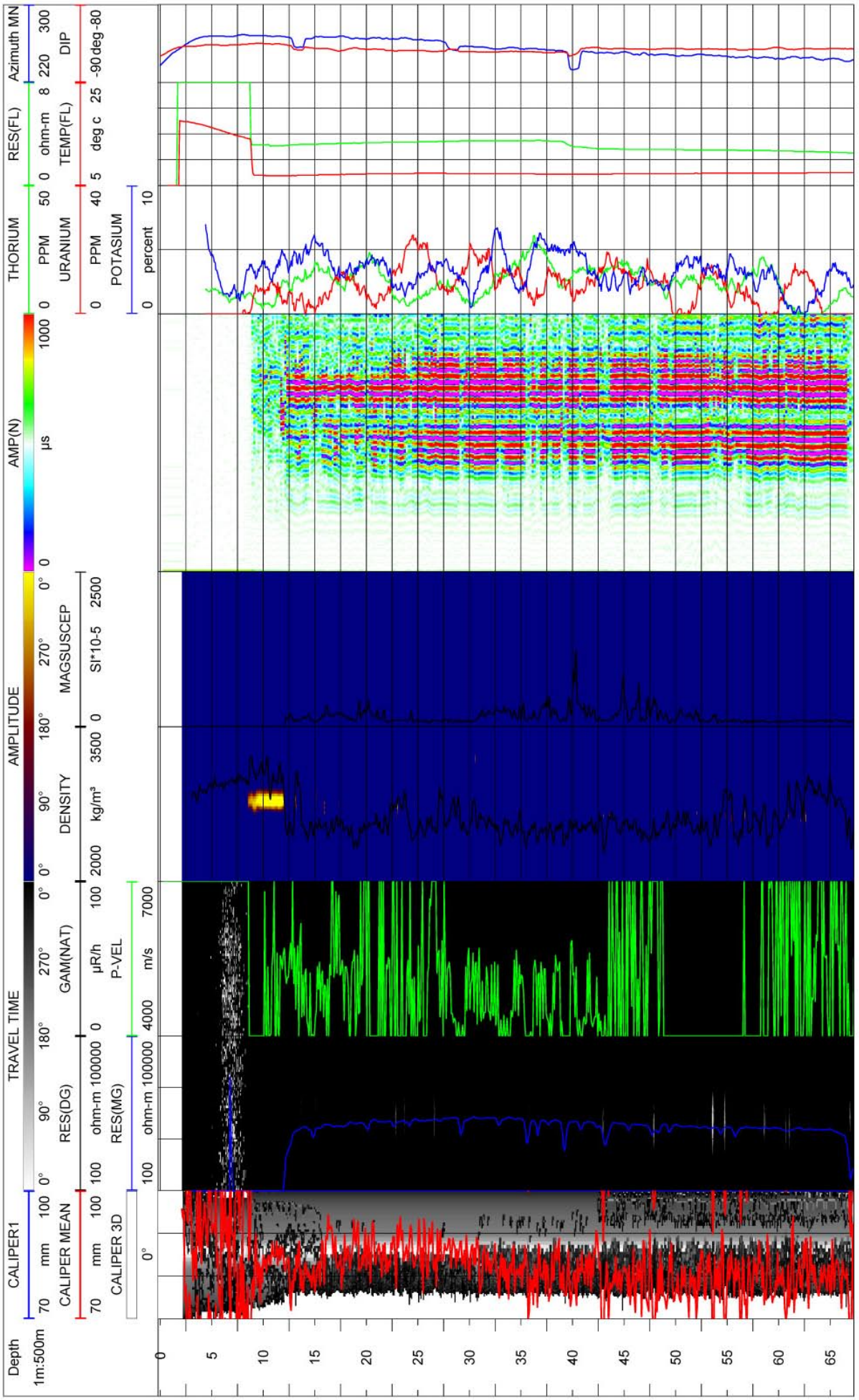
DGE Dansk Geo-servEx a/s
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

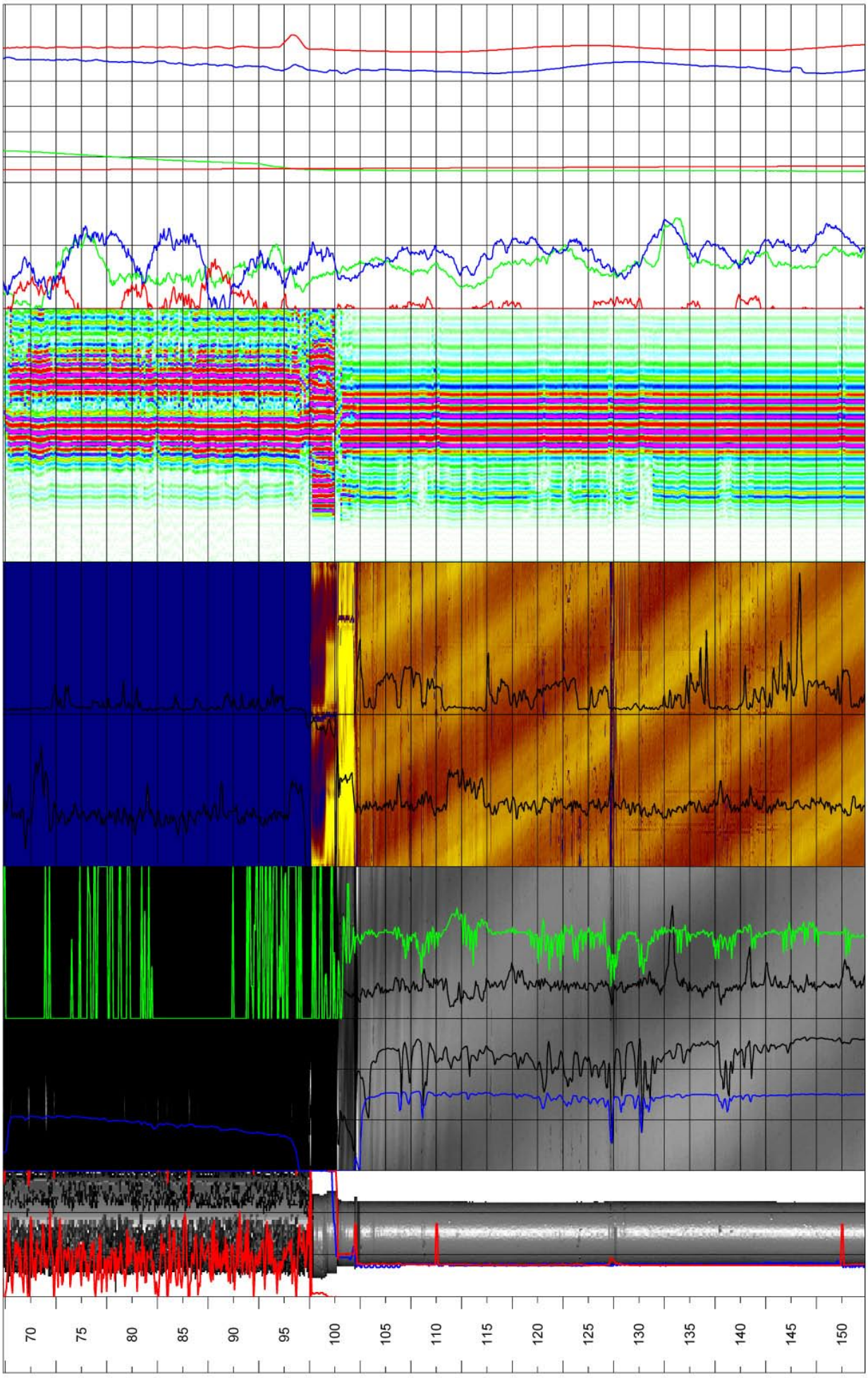
SKB geophysical borehole logging
Borehole KFM03A Forsmark

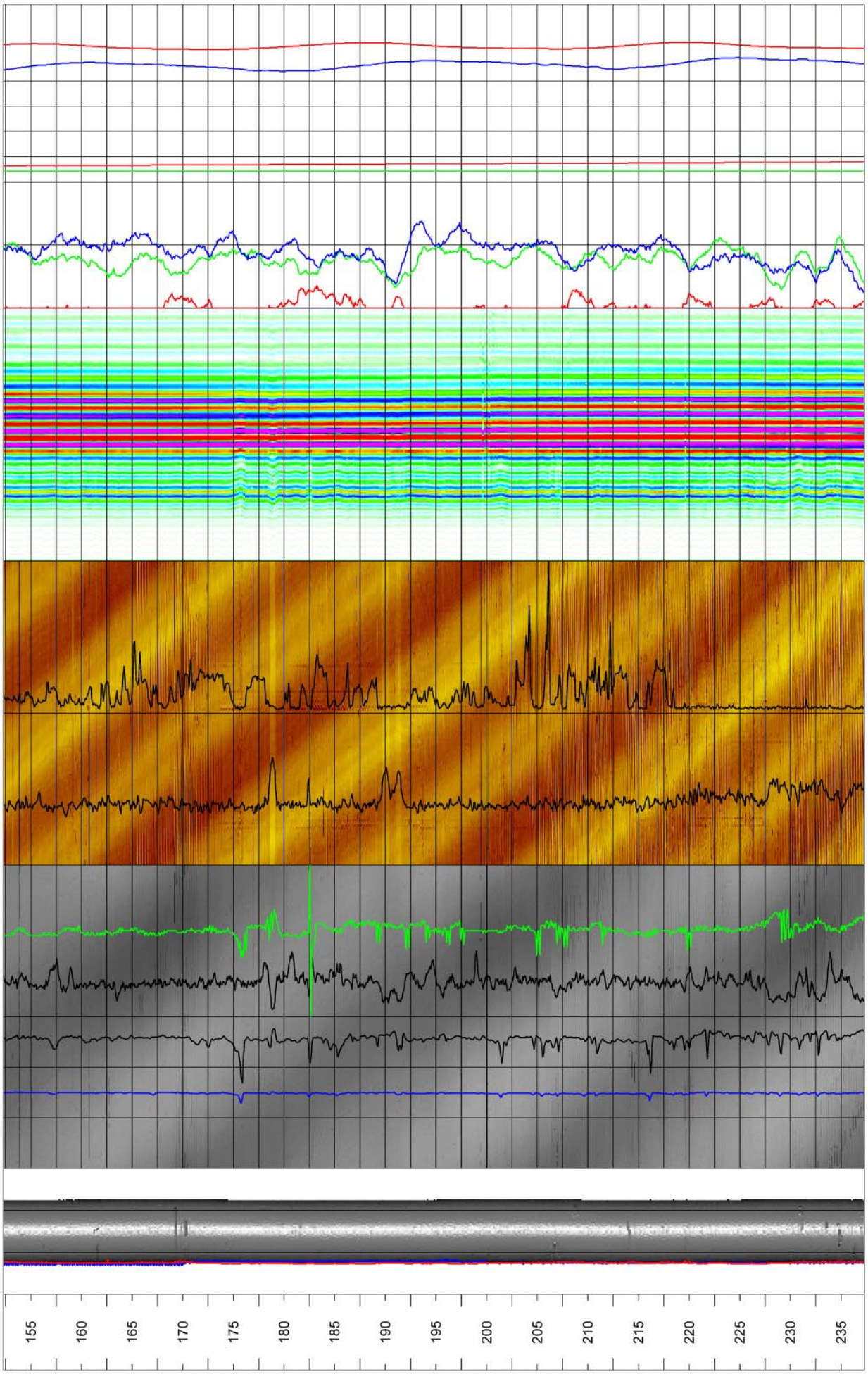
Presentation

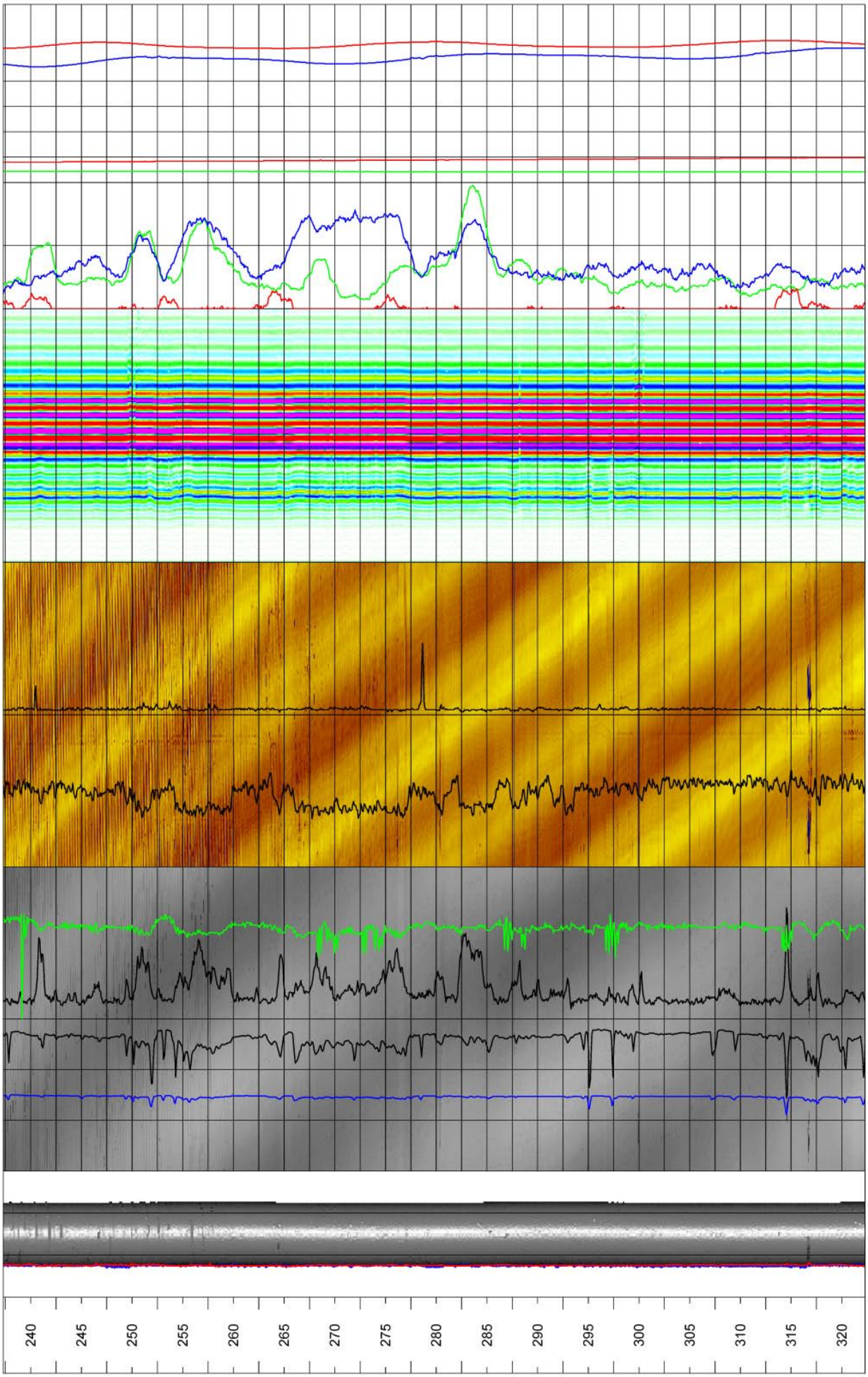
Filename: KFM03A_Presentation.wcl

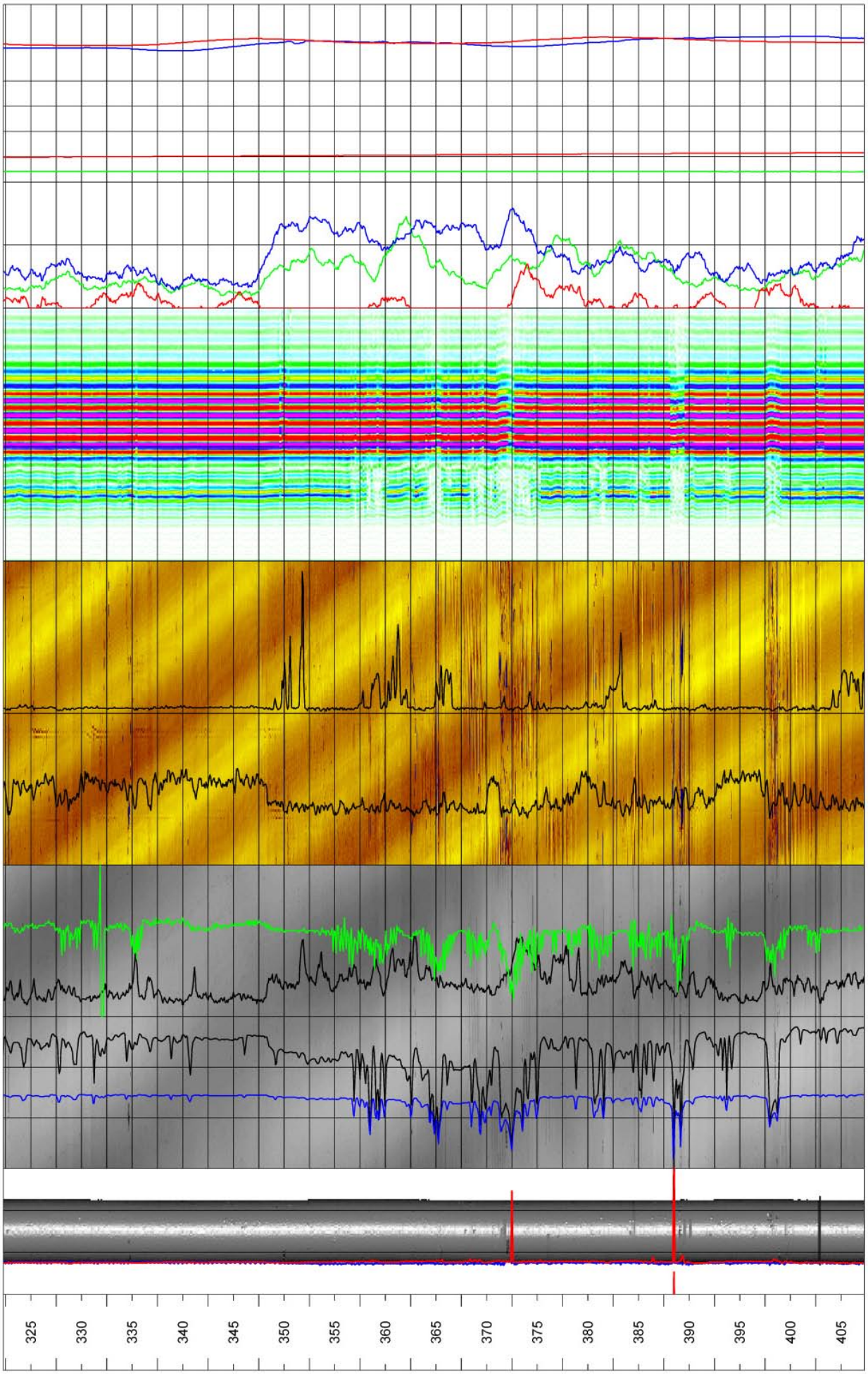
Drawing no.: **2.1**

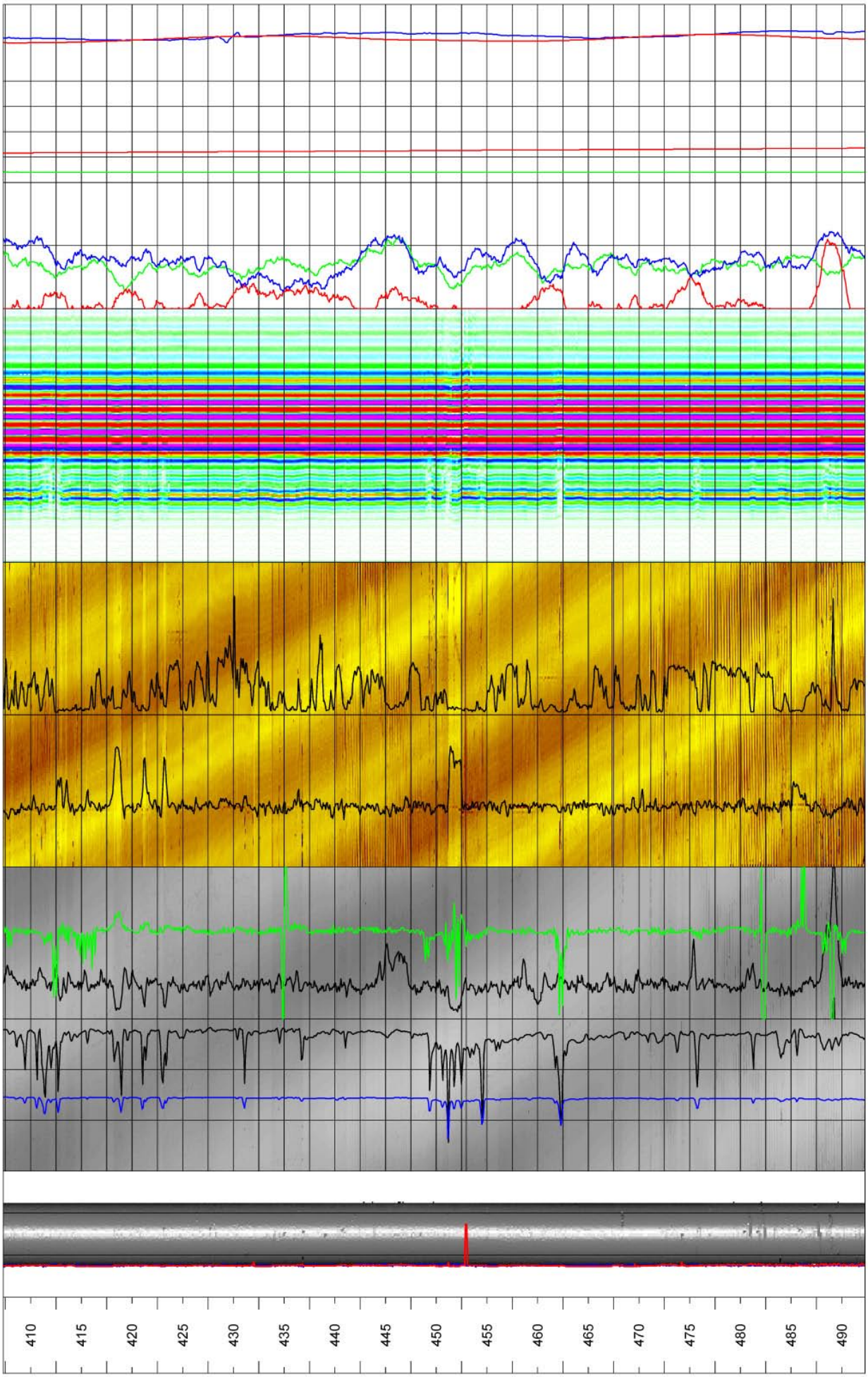

Depth
1m:500m
CALIPER1
70 mm 100
CALIPER MEAN
70 mm 100
CALIPER 3D
0°
TRAVEL TIME
0° 90° 180° 270° 0°
RES(DG)
100 ohm-m 100000
RES(MG)
100 ohm-m 100000
AMPLITUDE
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 100
P-VEL
4000 m/s 7000
DENSITY
2000 kg/m³ 3500
MAGSUSCEP
0 SI*10-5 2500
AMP(N)
1000 0 µs
THORIUM
0 PPM 50
URANIUM
0 PPM 40
POTASIUM
0 percent 10
RES(FL)
0 ohm-m 8
TEMP(FL)
5 deg c 25
Azimuth MN
220 300
DIP
-90 deg -80
0
5
10
15
20
25
30
35
40
45
50
55
60
65

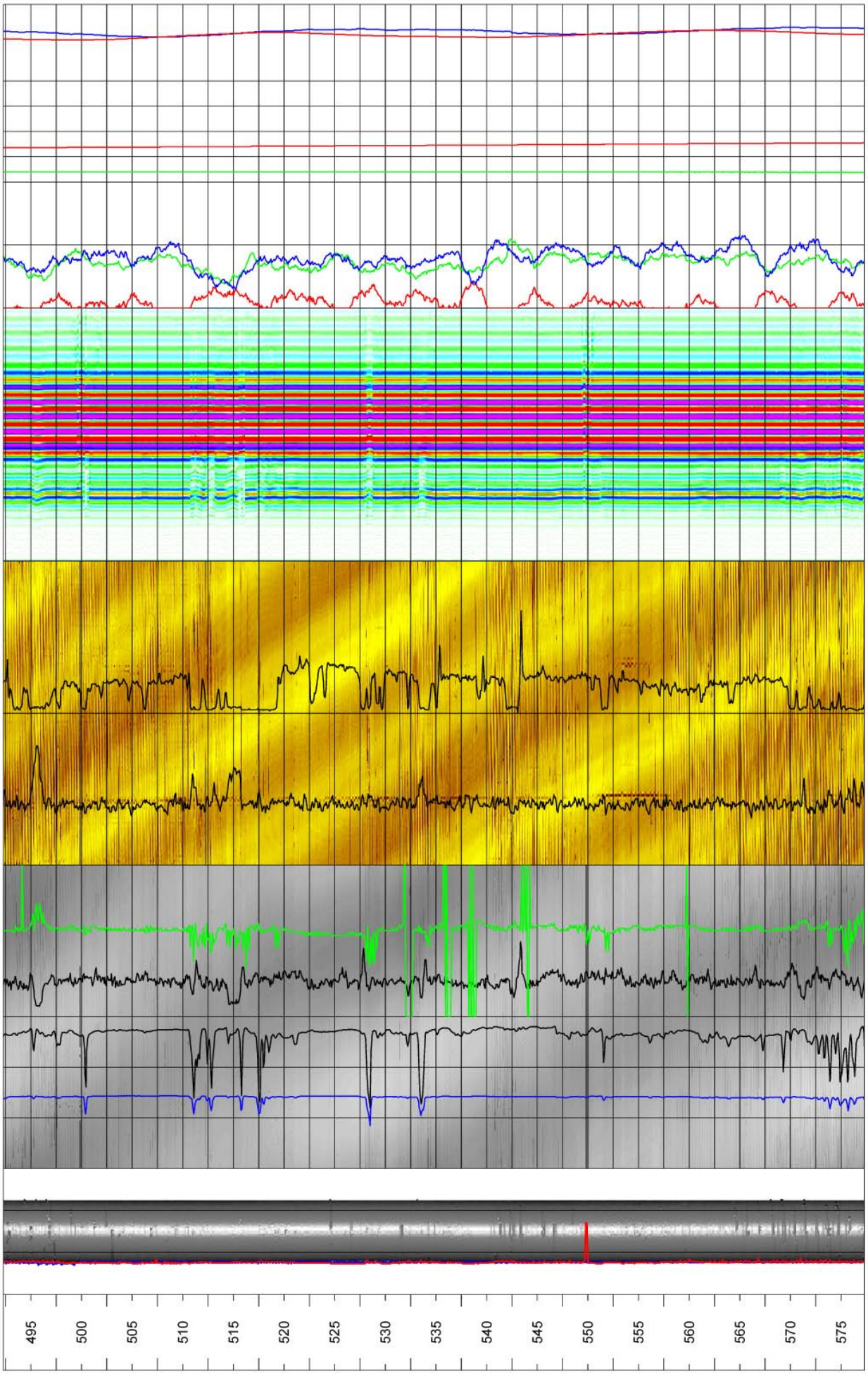

70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150

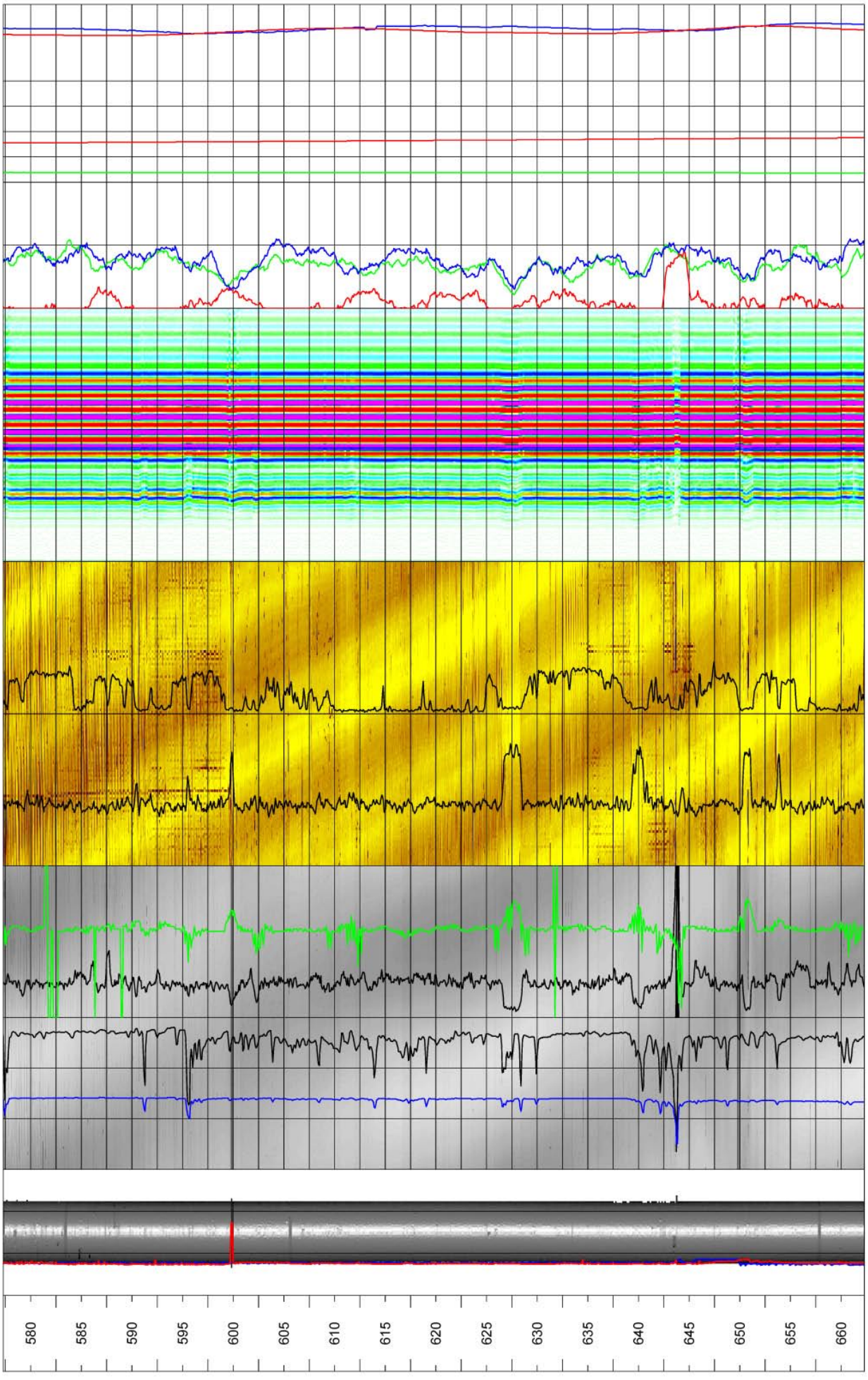

155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235

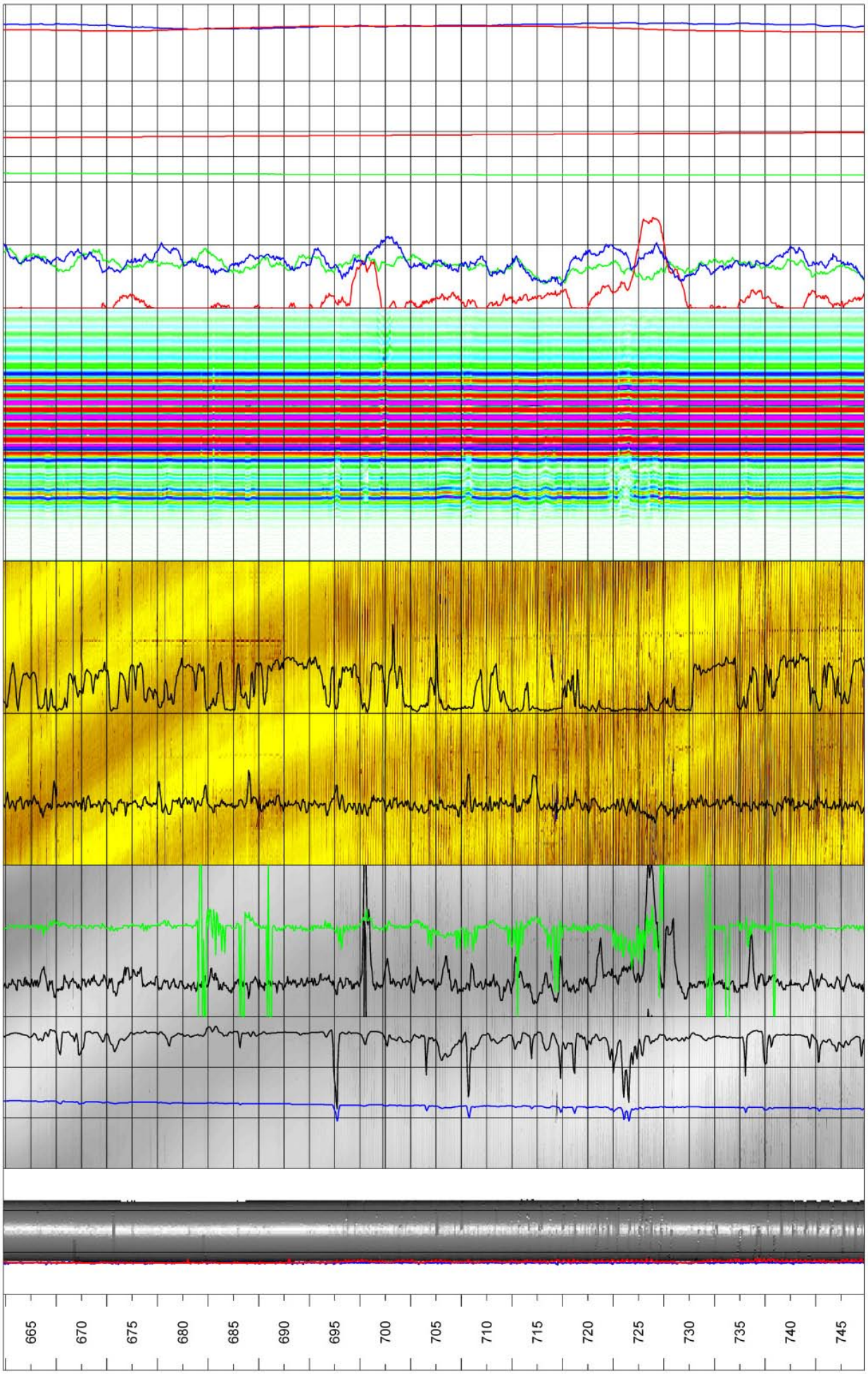

240
245
250
255
260
265
270
275
280
285
290
295
300
305
310
315
320

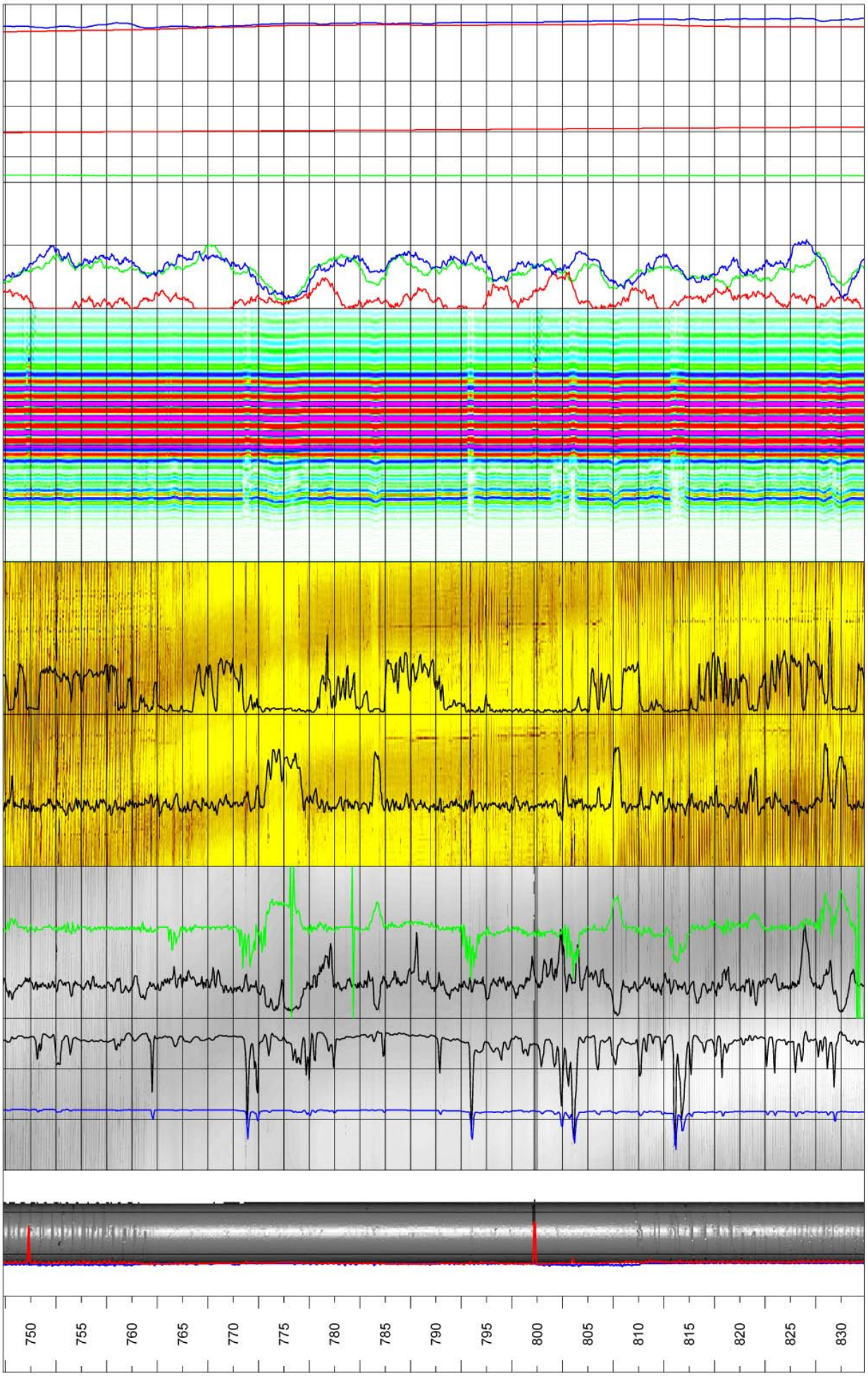

325
330
335
340
345
350
355
360
365
370
375
380
385
390
395
400
405

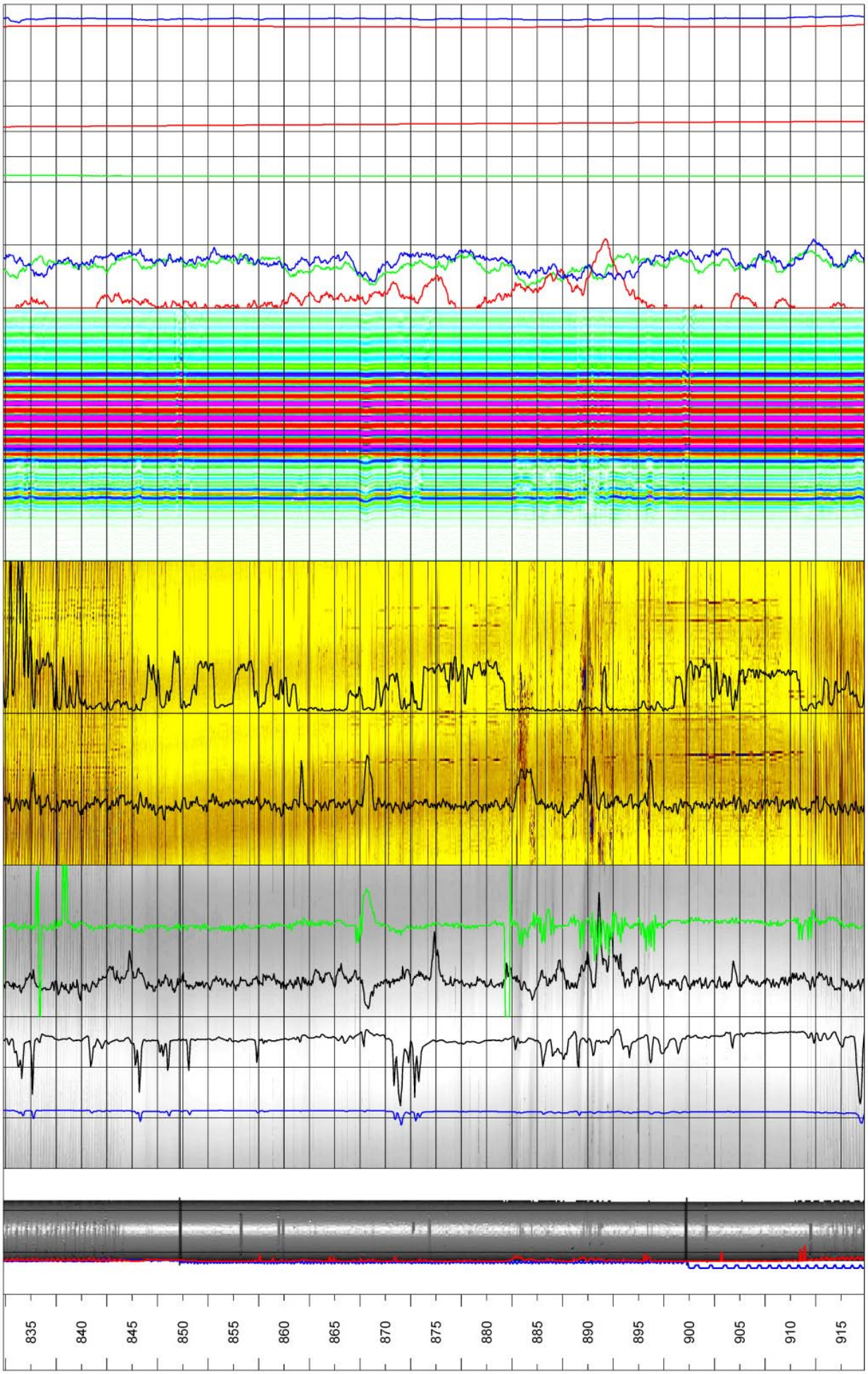

410
415
420
425
430
435
440
445
450
455
460
465
470
475
480
485
490

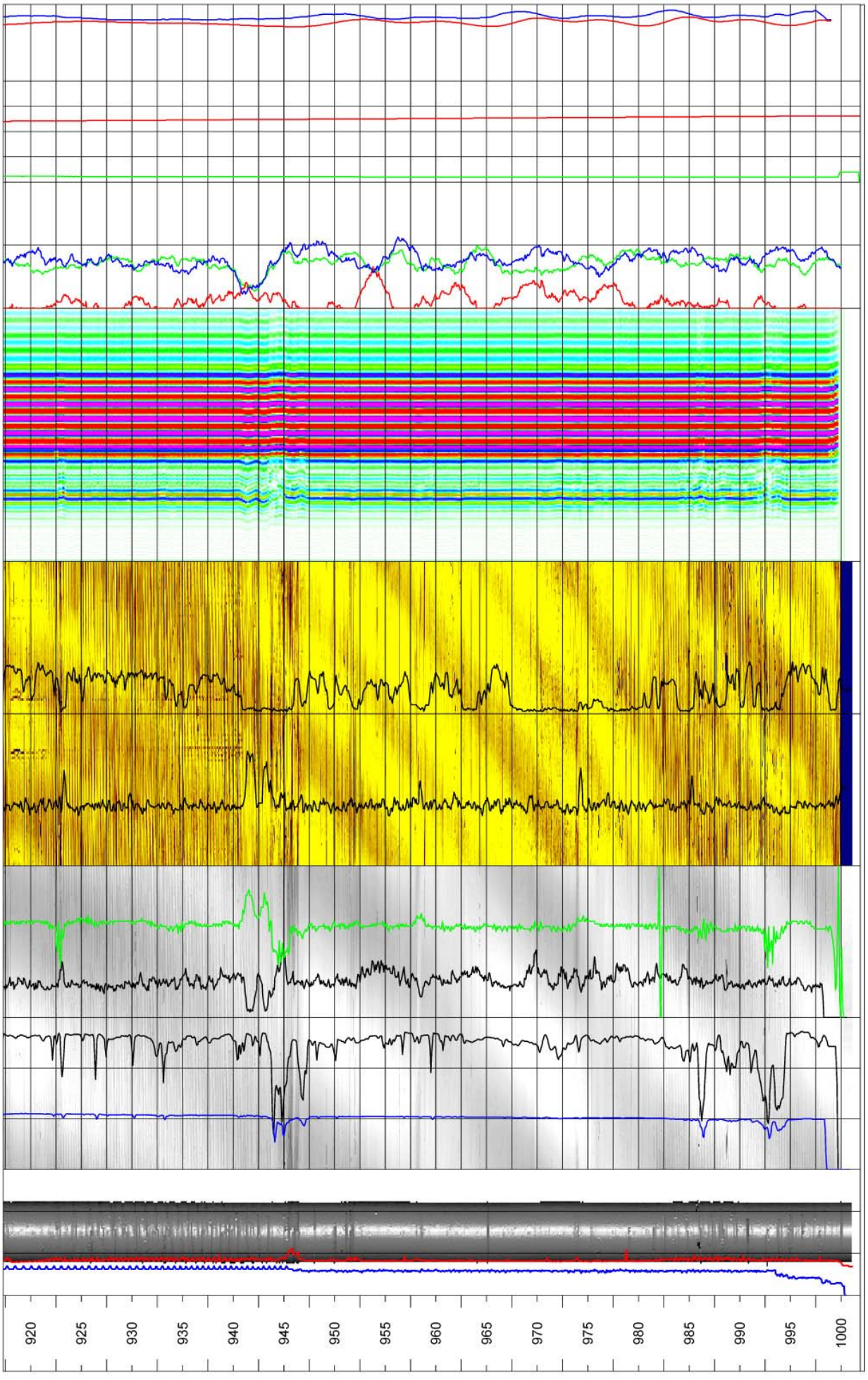

495
500
505
510
515
520
525
530
535
540
545
550
555
560
565
570
575


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
935
940
945
950
955
960
965
970
975
980
985
990
995
1000

Appendix 3

Geophysical borehole logging, borehole KFM03B

Borehole No. KFM03B

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

X: 6697844.200 m Y: 1634618.681 m Z: 8.468 m, RHB70

Diameter:	76 mm
Reaming Diameter:	-
Outer Casing:	-
Inner Casing:	-
Borehole Length:	100 m
Cone:	-
Inclination at ground surface:	-85.30°
Azimuth:	264.48°
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	deg C
RES(FL)	Fluid resistivity	9042	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

Rev.	Date	Drawn by	Control	Approved
0	2003-09-24	JRI	UTN	UTN

Job: 360210A

Scale: 1:200

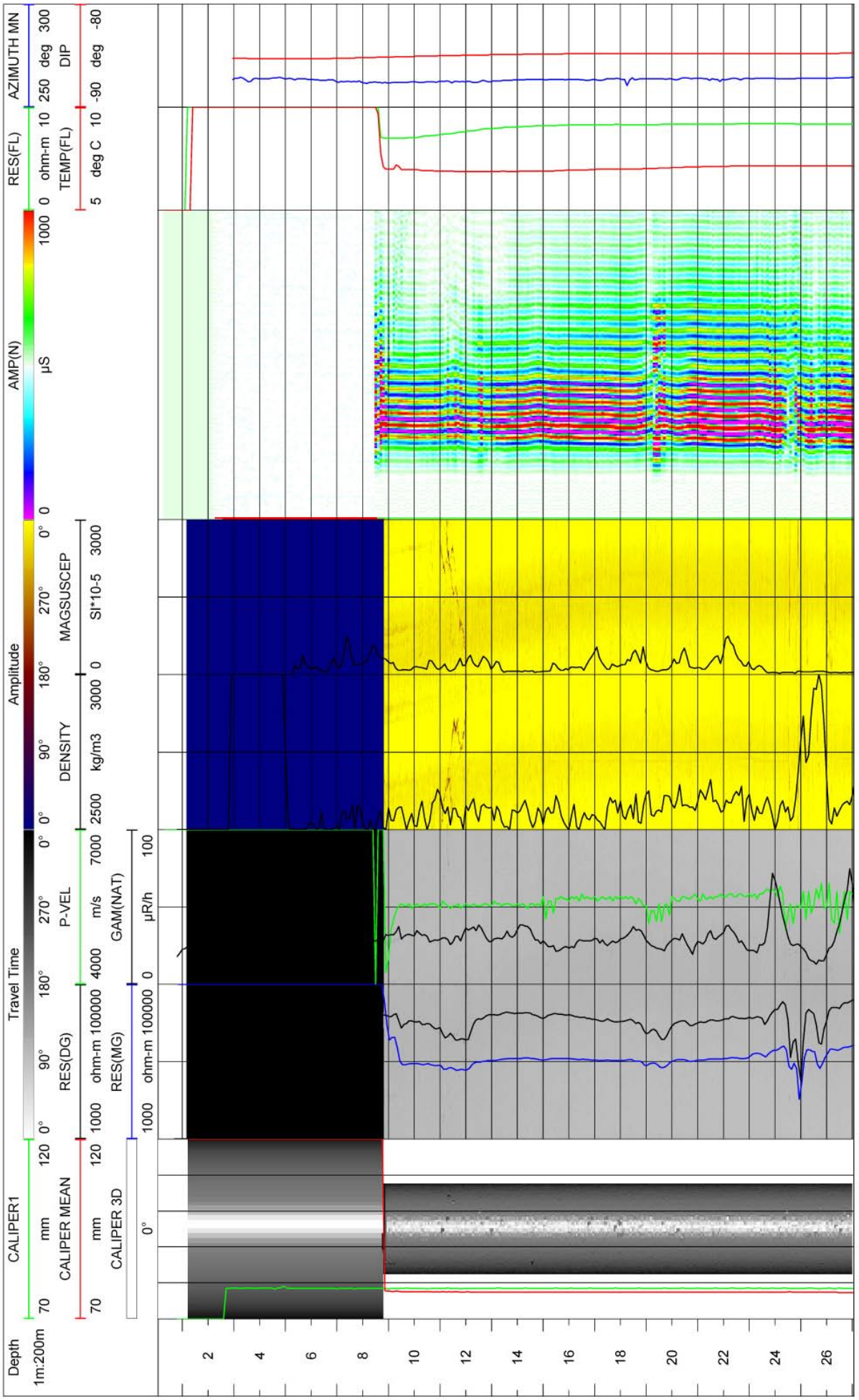
DGE Dansk Geo-servEx a/s
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

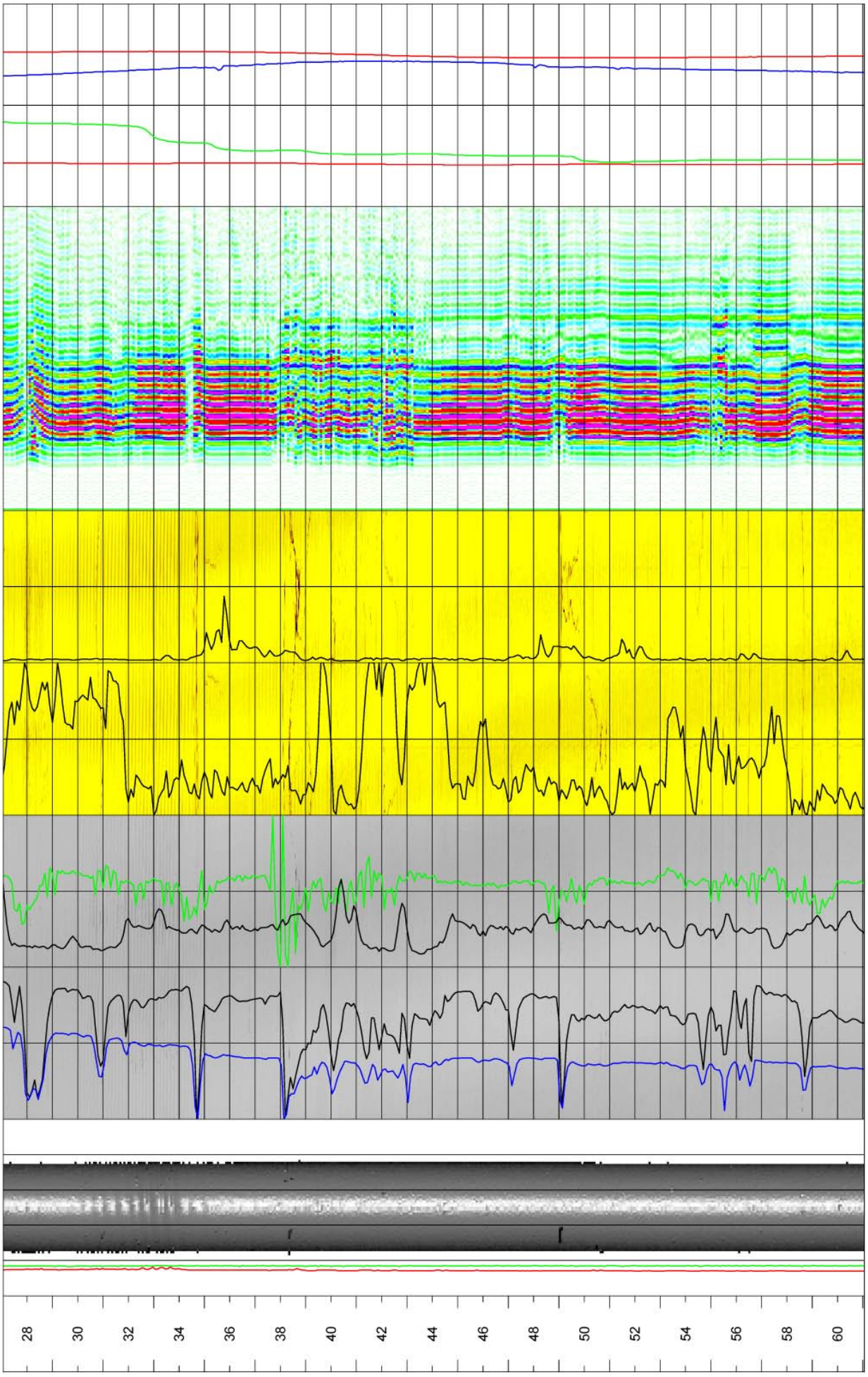
SKB geophysical borehole logging
Borehole KFM03B Forsmark

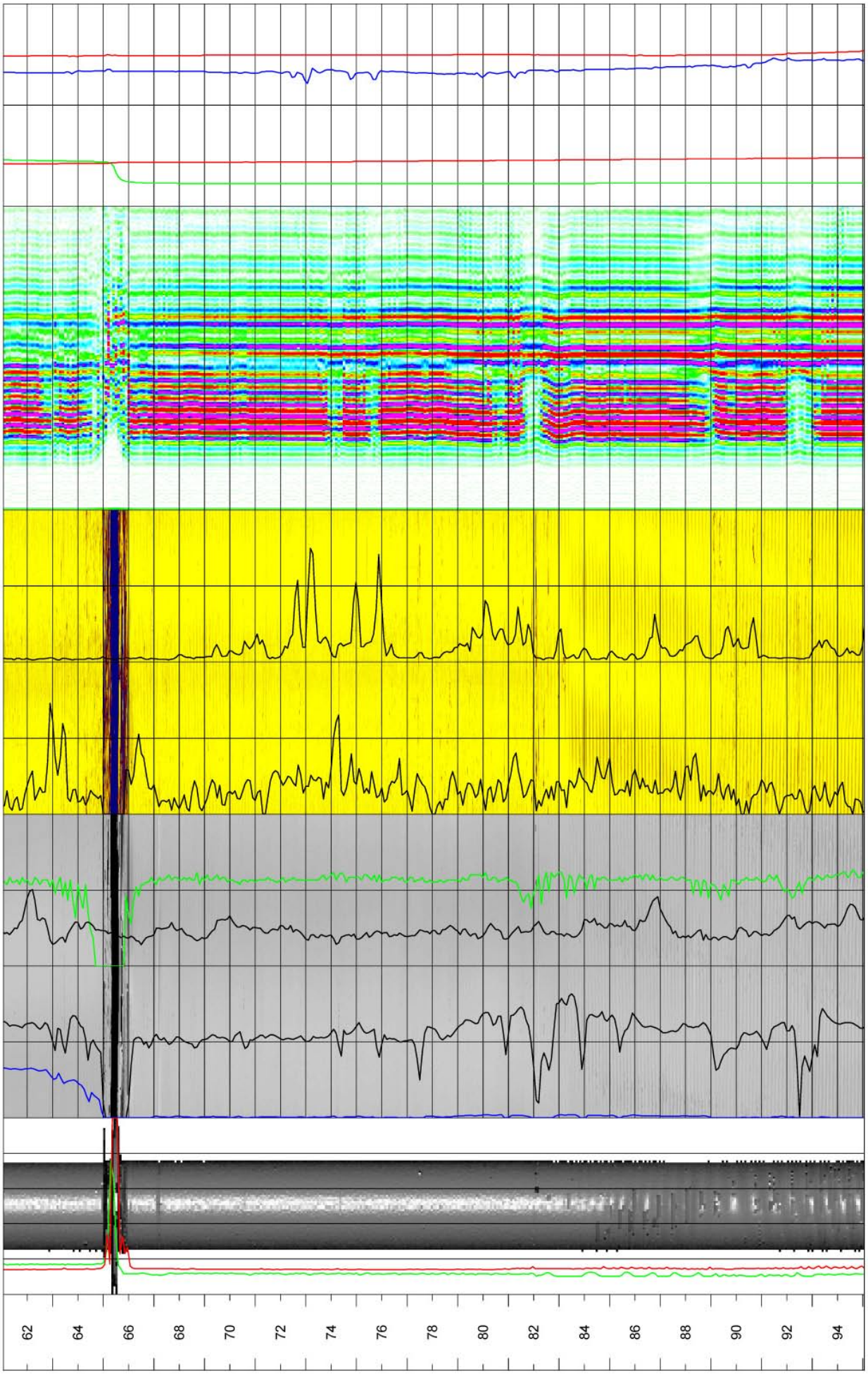
Presentation

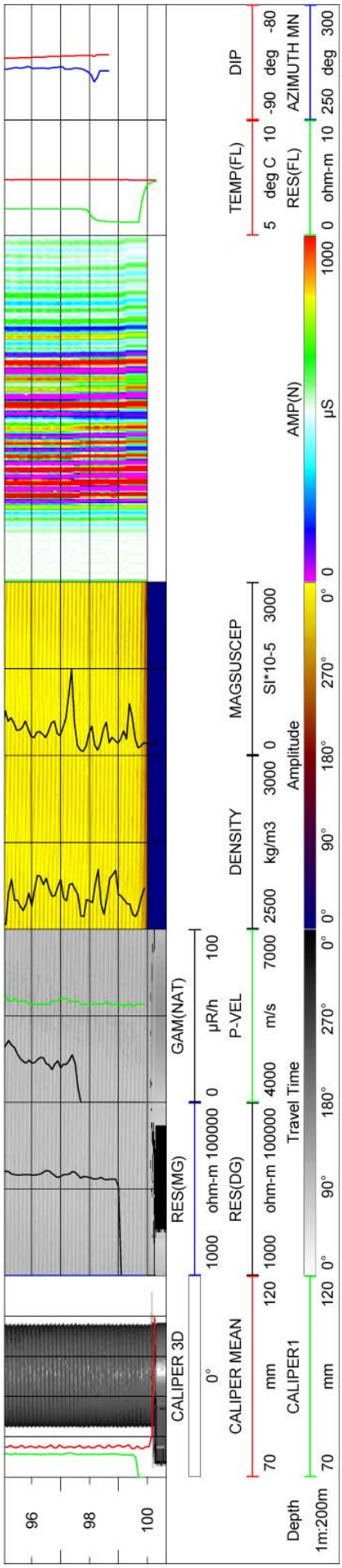
Filename: KFM03B_Presentation.wcl

Drawing no.: **3.1**


Depth
1m:200m
CALIPER1
70
mm
120
CALIPER MEAN
70
mm
120
CALIPER 3D
0°
Travel Time
0°
90°
180°
270°
0°
RES(DG)
1000
ohm-m
100000
RES(MG)
1000
ohm-m
100000
P-VEL
4000
m/s
7000
GAM(NAT)
0
µR/h
100
Amplitude
0°
90°
180°
270°
0°
DENSITY
2500
kg/m3
3000
MAGSUSCEP
0
SI*10-5
3000
AMP(N)
0
µS
1000
RES(FL)
0
ohm-m
10
TEMP(FL)
5
deg C
10
AZIMUTH MN
250
deg
300
DIP
-90
deg
-80
2
4
6
8
10
12
14
16
18
20
22
24
26


28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60


62
64
66
68
70
72
74
76
78
80
82
84
86
88
90
92
94


Depth
1m:200m
CALIPER1
CALIPER MEAN
CALIPER 3D
RES(MG)
RES(DG)
GAM(NAT)
Travel Time
P-VEL
DENSITY
MAGSUSCEP
Amplitude
AMP(N)
TEMP(FL)
RES(FL)
DIP
AZIMUTH MN
mm
ohm-m
µR/h
m/s
kg/m3
SI*10-5
µS
deg C
deg