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Forsmark site investigation

Geophysical borehole logging in borehole KFM05A and HFM19

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RAMBØLL

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Summary

According to a request from Svensk Kärnbränslehantering AB, geophysical borehole logging has been performed in the boreholes KFM05A and HFM19 in the Forsmark site investigation area. The loggings have been recorded from top of casing (TOC) to the bottom of the boreholes, c 1000 m and 185 m, respectively.

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

The processing of the data includes removing of spikes, negative data and data in the casing. All data are stretched. In HFM19, the data are stretched and shifted using one gamma event in the top of the borehole and one in the bottom. In KFM05A, which contains depth markers in the borehole wall, all data are stretched to every marker.

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

Contents

1 Introduction

This document reports logging operations in the boreholes KFM05A and HFM19 in the Forsmark area, see Figure 1-1.

KFM05A is a telescope borehole, implying that the upper part, 0–100 m, is percussion drilled with a larger diameter and the remaining, major part of the borehole is core drilled. The core drilled part of the borehole, 100-1000 m, has a diameter of c. 76 mm. HFM19 is percussion drilled with a diameter of c.137 mm. Both boreholes have been recorded from TOC (top of casing) to the bottom. The technical data from the boreholes are shown in Table 1-1.

The measurements in KFM05A were conducted by RAMBØLL in May 2004, in accordance with the instructions and guidelines from SKB (activity plan AP PF 400-04-48 and method description MD 221.002, SKB internal controlling documents).

The complete logging of HFM19 was intended to be carried out in January 2004. Indications of fall outs from the borehole wall, implying increased risk of getting stuck and eventually loosing a probe, led to the decision not to perform logging below the critical section. Later on, other logging operations in the borehole was conducted without problems and it was decided to complete also the geophysical logging. This was done during the same occasion as the logging of KFM05A and the complete logging of HFM19 is presented in this report.

Table 1-1. Technical data from the cored borehole KFM05A and the percussion borehole HFM19.

Borehole Parameter	KFM05A	HFM19
Co-ordinates (RT90, 2.5 gon W)	6699344.85 N 1631710.80 E	6699257.59 N 1631626.93 E
Elevation (RH70B)	5.53 m	3.66 m
Azimuth	80.90°	280.91°
Inclination at ground surface	–59.80°	–58.10°
Length	1002.71 m	185.20 m
Casing	110.10 m	12.04 m
Cleaning level	Level 2	Level 1
Borehole diameter	76 mm	137 mm

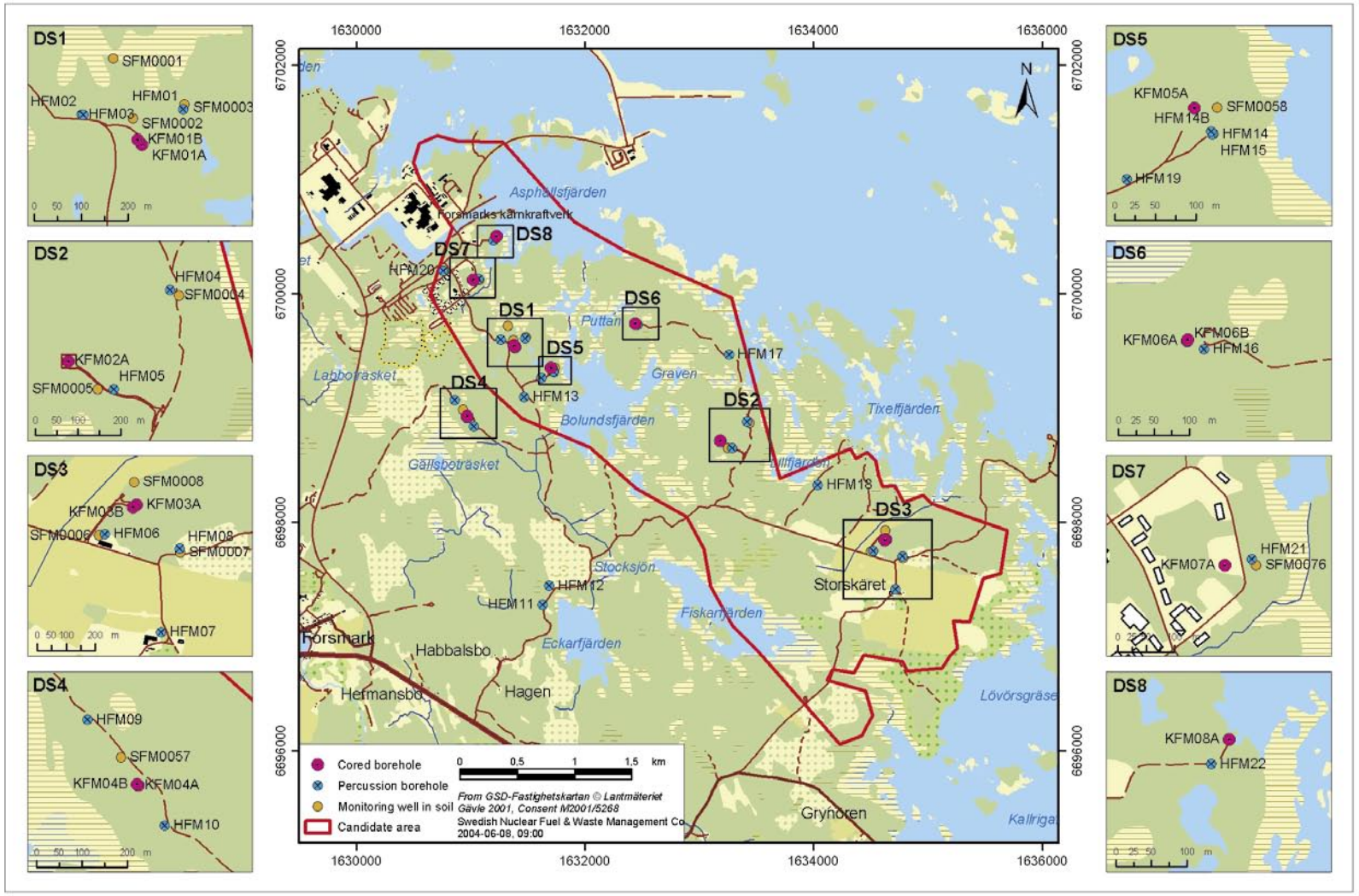


Figure 1-1. *Forsmark, drill site 1-6. Borehole KFM05A is located at drill site 5, and HFM19 close to the same drill site.*

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 report describes the equipment used as well the measurement procedures. Geophysical borehole logging data are presented in Appendix 1 (KFM05A) and Appendix 2 (HFM19).

3 Equipment

The geophysical borehole logging programme in KFM05A and HFM19 was performed with 6 multi tool probes and resulted in a suite of 22 log types, listed in Table 5-1 (see Section 5-1).

The tools and recorded logs are listed in Table 3-1.

Table 3-1. Logging tools and logs recorded.

Tool	Recorded logs	Dimension	Source detector spacing and type	Tool position in borehole
Century 8044 Normal resistivity, Single point resistance and Self-potential	Fluid Conductivity, Fluid Temperature, Normal resistivity (16 and 64 inch), single point resistance, SP 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 caliper.	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 & S-wave velocity picking, compensated P-wave travel-time and natural gamma.	300·6.1 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/dip and natural gamma.	246·4 cm		Centralized

4 Execution

In general the measurement procedures follow the SKB method description MD 221.002, version 1.0 (“Metodbeskrivning för geofysisk borrhålsloggning”). The logging programme was executed in the January 2004 (parts of HFM19) and May 2004 (KFM05A and completion of HFM19). 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 calibrated and cleaned according to the SKB method description MD 600.004, version 1.0 (“Metodbeskrivning för rengöring av borrhåls-utrustning och viss markbaserad utrustning”) before arriving at the site.

For control, each log run is normally recorded both in downward and in upward direction using the down run as a repeat section. For logging tools 9030 and 9310, a repeat section is made in upward direction. 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.

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.

5 Results

5.1 Presentation

Table 5-1 lists the logs presented in Appendix 1 and 2. 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
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
Self-potential	SP	mV	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. When applicable, overlapping data from the topmost-recorded file is always used (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 a new depth scale for each tool. The depth scale is established 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 added to the log.

5.5.5 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.

5.5.6 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 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	–
Self-potential	–
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)).
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 High resolution 1D Caliper	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.
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), see Table 5-3. 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 (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.

Table 5-3. International Geomagnetic Reference Field (IGRF2000) components.

Location	
Latitude (North)	60 deg 23 min 28 sec
Longitude (East)	18 deg 13 min 20 sec
Elevation	0.00 km
Date of interest	2004-01-15
Magnetic field components	
Declination (east)	4 deg 4 min
Inclination (down)	73 deg 9 min

5.4 Borehole KFM05A

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.

To obtain a common depth reference point, the track mark at 117.03 m in the HiRAT file is used as the marker at depth 120 m. The HiRAT tool is therefore shifted 2.97 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 5-4.

Table 5-4. The reference marks made in the borehole, the recorded track marks form the HiRAT and the corrected depths.

Reference mark	HiRAT recorded	HiRAT after shift
120.00	117.03	120.000
152.00	149.05	152.020
199.00	196.06	199.030
252.00	249.17	252.140
300.00	297.22	300.190
352.00	349.28	352.250
402.00	399.39	402.360
450.00	447.4	450.370
606.00	603.75	606.720
750.00	748.01	750.980
800.00	798	800.970
850.00	848.07	851.040
900.00	898.12	901.090

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

Table 5-5. Gamma events in borehole KFM05A.

Events	Depths (m)
Top event	127.26
Mid event	515.62
Bottom event	973.36

Due to a poor calibration of the fluid resistivity some values have been negative. The negative values have not been removed. Instead, 0.8 ohm-m has been added to the fluid resistivity curve, RES(FL), to compensate for the calibration error.

The complete log suite for borehole KFM05A is presented as composite log sheets in Appendix 1 (Drawing no 1.1.). The logs presented are listed in Table 5-1.

5.5 Borehole HFM19

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 5-6.

Table 5-6. Gamma events in borehole HFM19.

Events	Depths (m)
Top event	1.8
Bottom event	106

Due to a poor calibration of the fluid resistivity some values have been negative. The negative values have not been removed. Instead, 0.8 ohm-m has been added to the fluid resistivity curve, RES(FL), to compensate for the calibration error.

The complete log suite for borehole HFM19 is presented as composite log sheets in Appendix 2 (Drawing no 2.1.). The logs presented are listed in Table 5-1.

6 Data delivery

Apart from the present report, a comprehensive field report was delivered to SKB /1/. 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 and 9072 are also included (probe 9320 and HiRAT shall not be calibrated).

The raw-data from the measurements, recorded in Century or 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 (Table 6-1).

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 Sicada reference to the data from the logging operations is field note Forsmark 346.

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

Borehole	Probe	Log direction	WellCAD File	Description
KFM05A	8044	Down	KFM05A_05-18-04_10-40_8044C_.1_0.30_1005.10_ORIG.log	Start Depth: 0.3 m. End Depth: 1005.1 m.
KFM05A	8622	Up	KFM05A_05-19-04_10-09_8622C_.10_-2.70_1003.60_ORIG.log	Start Depth: 1003.6 m. End Depth: –2.7 m.
KFM05A	9030	Up	KFM05A_05-20-04_12-18_9030CA_.10_87.40_1002.40_ORIG.log	Start Depth: 1002.4 m. End Depth: 87.4 m.
KFM05A	9072	Up	KFM05A_05-20-04_09-53_9072C_.10_-1.80_1005.70_ORIG.log	Start Depth: 1005.7 m. End Depth: –1.8 m.
KFM05A	9310	Up	KFM05A_05-18-04_15-53_9310C2_.10__672.10_PROC.LOG	Start Depth: 672.1 m. End Depth: 0 m.
KFM05A	9310	Up	KFM05A_05-18-04_14-50_9310C2_.10__990.70_PROC.LOG	Start Depth: 997 m. End Depth: 658 m.
KFM05A	HiRAT	Up	KFM05A_HiRAT_120pixels_up_run2.HED	Start Depth: 999 m. End Depth: 512 m.
KFM05A	HiRAT	Up	KFM05A_HiRAT_120pixels_up_run3.HED	Start Depth: 522 m. End Depth: 94 m.
HFM19	8044	Up	HFM19_05-18-04_17-44_8044C_.10_0.30_184.80_ORIG.log	Start Depth: 0.3 m. End Depth: 184.8 m.
HFM19	8622	Down	HFM19_01-14-04_14-55_8622C_.02_0.44_184.73_ORIG.log	Start Depth: 0.44 m. End Depth: 184.73 m.
HFM19	9030	Up	HFM19_05-18-04_18-39_9030CA_.10_-0.80_183.80_ORIG.log	Start Depth: 183.8 m. End Depth: –0.8 m.
HFM19	9072	Up	HFM19_01-14-04_15-20_9072C_.02_0.76_184.81_ORIG.log	Start Depth: 181 m. End Depth: –0.38 m.
HFM19	9310	Up	HFM19_05-18-04_19-14_9310C2_.10_-0.40_184.20_ORIG.log	Start Depth: 184.2 m. End Depth: –0.4 m.
HFM19	HiRAT	Up	HFM19_HiRAT_180pixels_up_run2.HED	Start Depth: 127 m. End Depth: –0.4 m.
HFM19	HiRAT	Up	HFM19_HiRAT_180pixels_up_run8.HED	Start Depth: 185 m. End Depth: 120 m.

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KFM05A	1.1	KFM05A_Presentation.WCL
KFM05A	1.2	KFM05A_Deviation.WCL
KFM05A	1.3	KFM05A_Deviation.WCL
HFM19	2.1	HFM19_Presentation.WCL
HFM19	2.2	HFM19_Deviation.WCL
HFM19	2.3	HFM19_Deviation.WCL

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

Borehole	Excel file
KFM05A	KFM05A _data.xls
HFM19	HFM19_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	
Self potential	
Single point resistivity	
Magnetic susceptibility	

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.

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.

The calculation do not include the inclination of the borehole, all boreholes are in the calculation defined to be vertical.

7 References

/1/ **Nielsen, U T, Ringgaard J, 2004.** Geophysical borehole logging in borehole KFM05A and HFM19. Rambøll Report 20040607utnaa.

Appendix 1

Geophysical borehole logging, borehole KFM05A

Borehole No. KFM05A

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

Northing: 6699344.85 m Easting: 1631710.80 m Elevation: 5.53 m, RHB70

Diameter:	77.3 mm
Reaming Diameter:	-
Outer Casing:	-
Inner Casing:	-
Borehole Length:	1002.71 m
Cone:	-
Inclination at ground surface:	-59.80°
Azimuth:	80.90°
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9030	mm
DENSITY	Gamma-gamma density	9030	kg/m³
RES(MG)	Focused guard log resistivity, 140cm	9030	ohm-m
GAM(NAT)	Natural gamma	9030	µR/h
TEMP(FL)	Fluid temperature	8044	deg C
RES(FL)	Fluid resistivity	8044	ohm-m
RES(DG)	Focused guard log resistivity, 300cm	9072	ohm-m
P-VEL	P-wave velocity	9310	m/s
AMP(N)	Full wave form, near receiver	9310	µs
AMP(F)	Full wave form, far receiver	9310	µs
MAGSUSCEP	Magnetic susceptibility	8622	SI*10-5
CALIPER 3D	Caliper, high resolution 360 degrees	HiRAT	mm
CALIPER MEAN	High resolution 1D caliper	HiRAT	mm
AZIMUTH MN	Borehole azimuth magnetic north	HiRAT	deg
DIP	Borehole inclination from horizontal	HiRAT	deg
TRAVEL TIME	360 degrees orientated acoustic travel time	HiRAT	100 ns
AMPLITUDE	360 degrees orientated acoustic amplitude	HiRAT	-
THORIUM	Spectral gamma, Thorium component	9080	PPM
URANIUM	Spectral gamma, Uranium component	9080	PPM
POTASSIUM	Spectral gamma, Potassium component	9080	percent
RES(16N)	Normal resistivity 16 inch	8044	ohm-m
RES(64N)	Normal resistivity 64 inch	8044	ohm-m
LATERAL	Lateral resistivity	8044	ohm-m
SPR	Single point resistivity	8044	ohm
SP	Self-potential	8044	mV

Rev.	Date	Drawn by	Control	Approved
0	2004-06-01	JIJ	JRI	UTN

Job: 360210A

Scale: 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

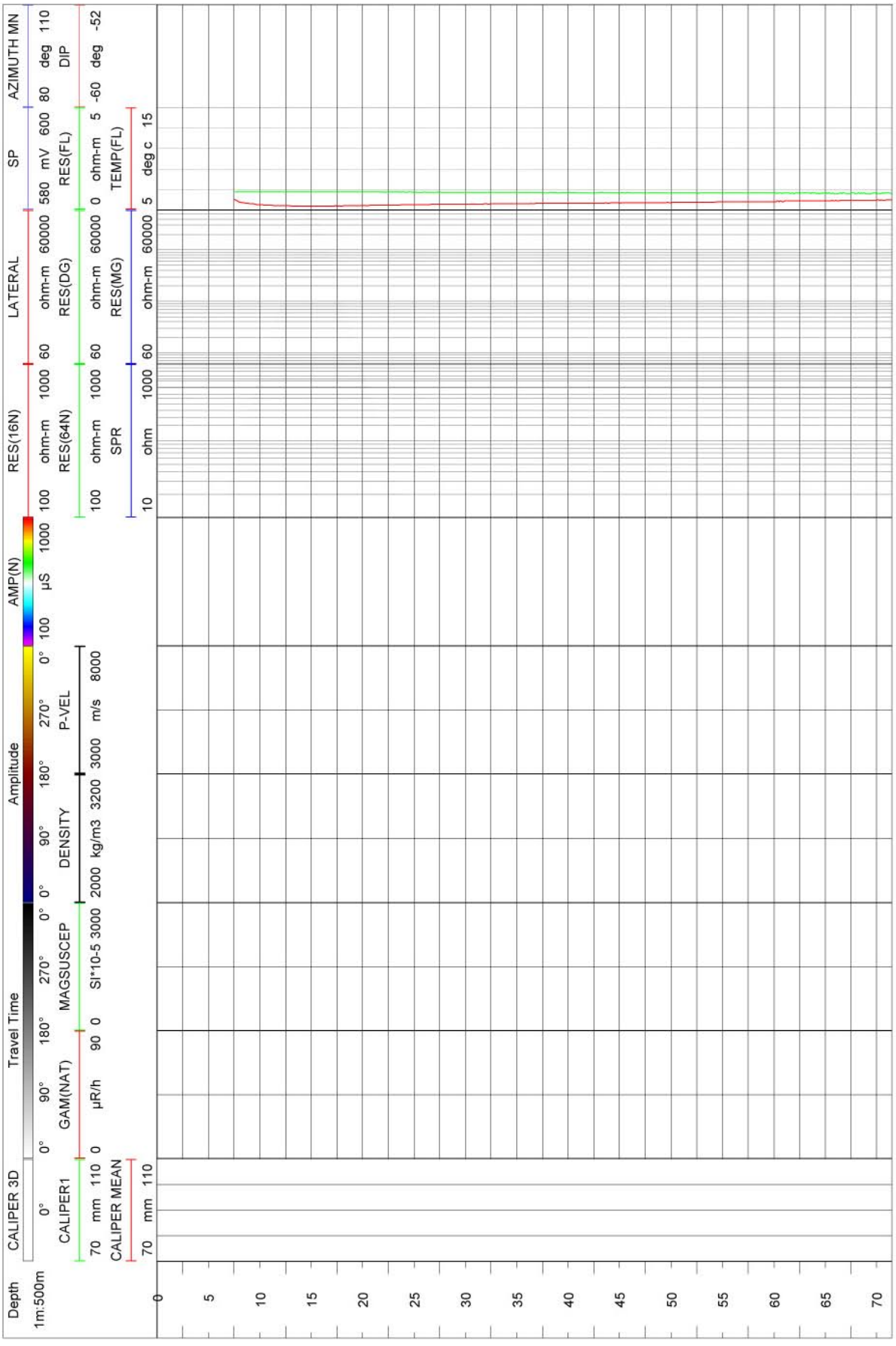
SKB geophysical borehole logging

Borehole KFM05A. Forsmark

Presentation

Filename: KFM05A_Presentation.wcl

Drawing no.: **1.1**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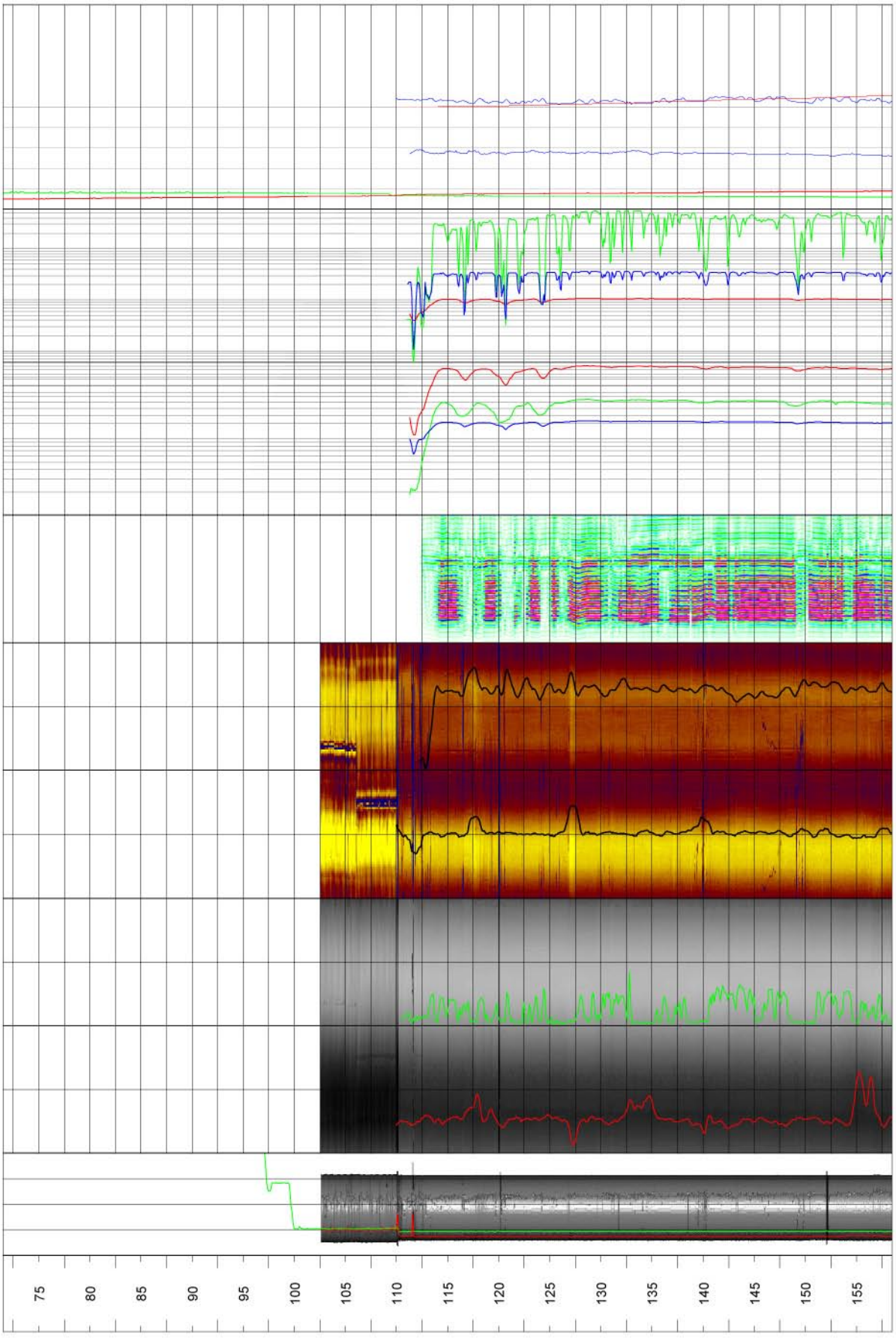
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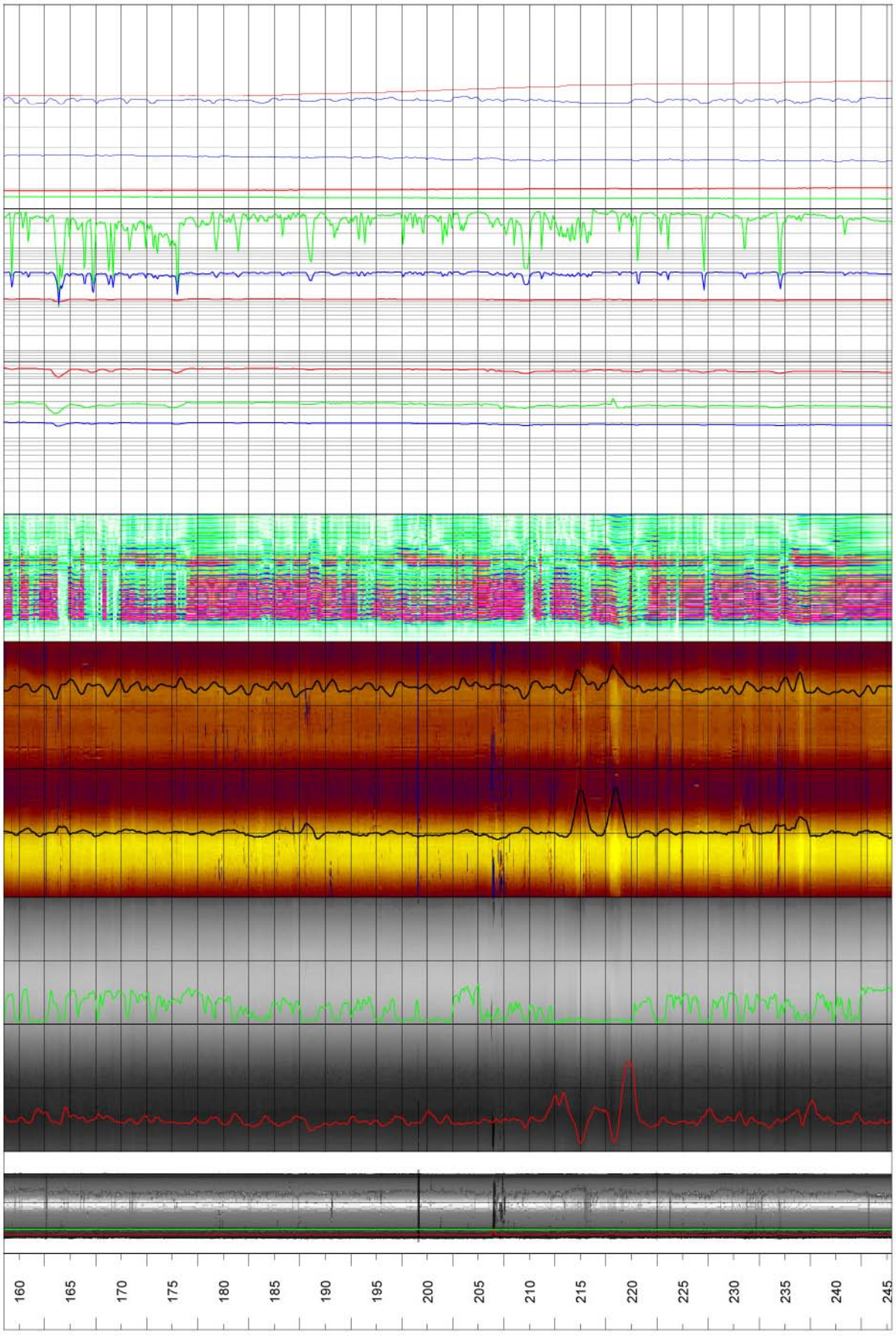
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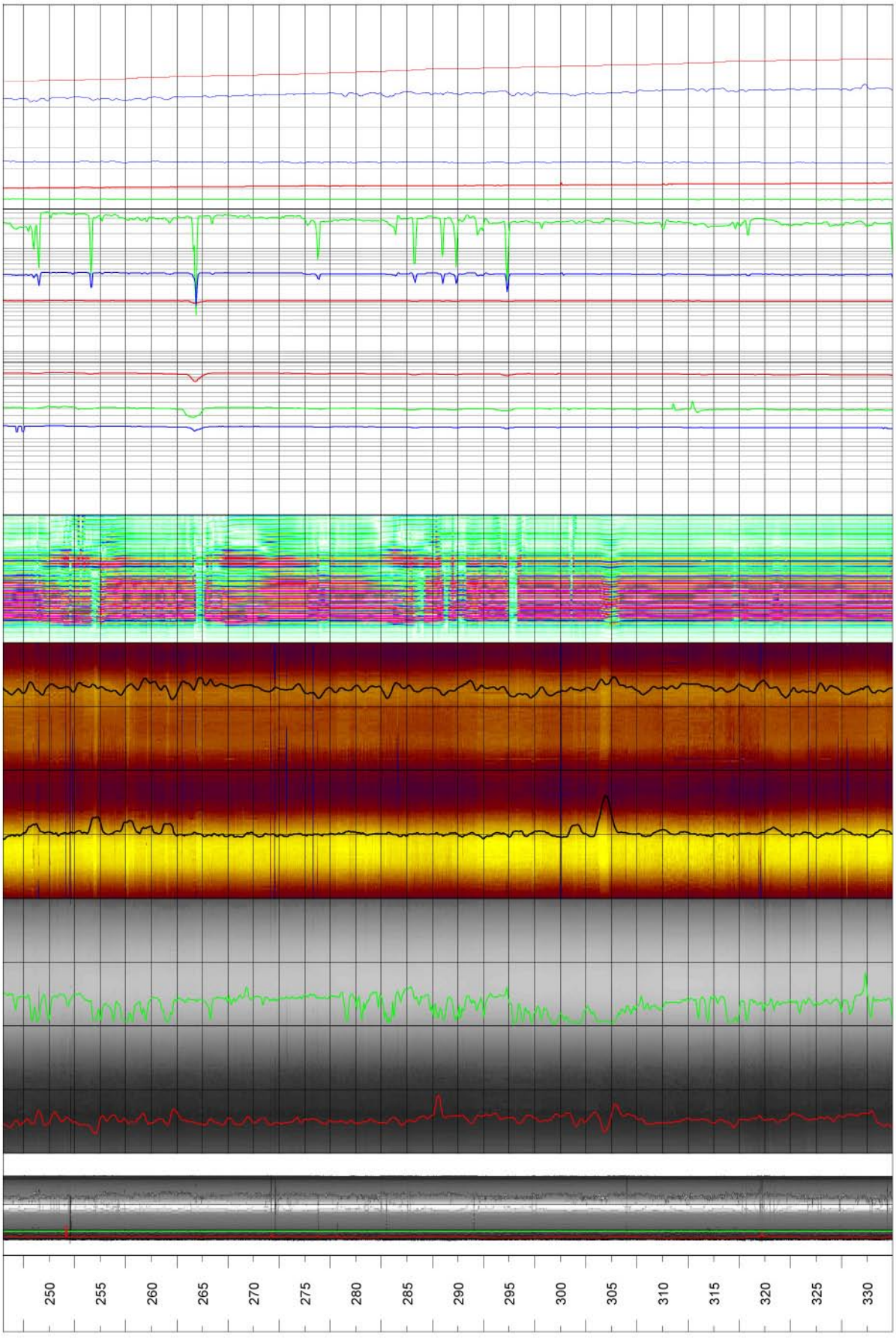
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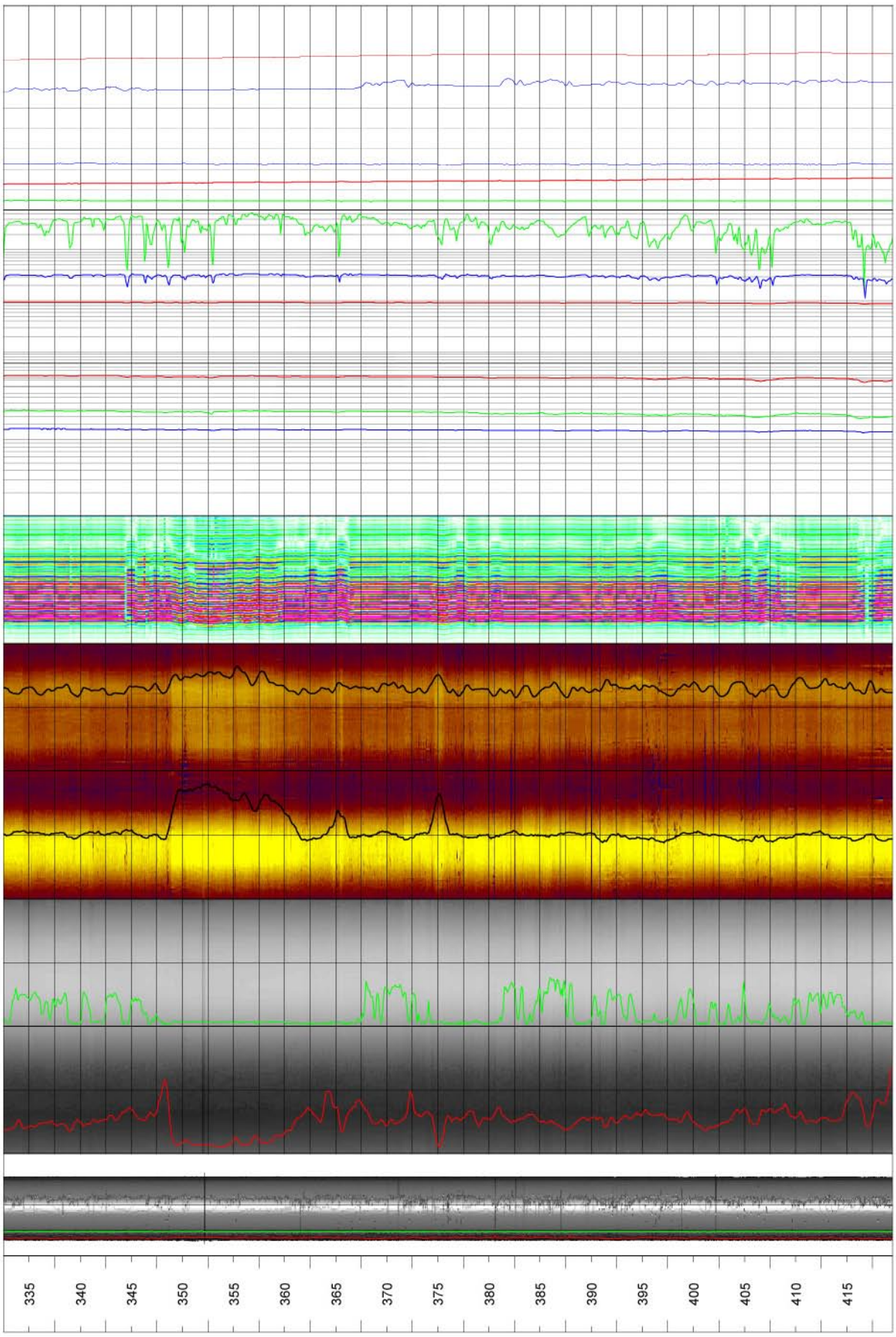
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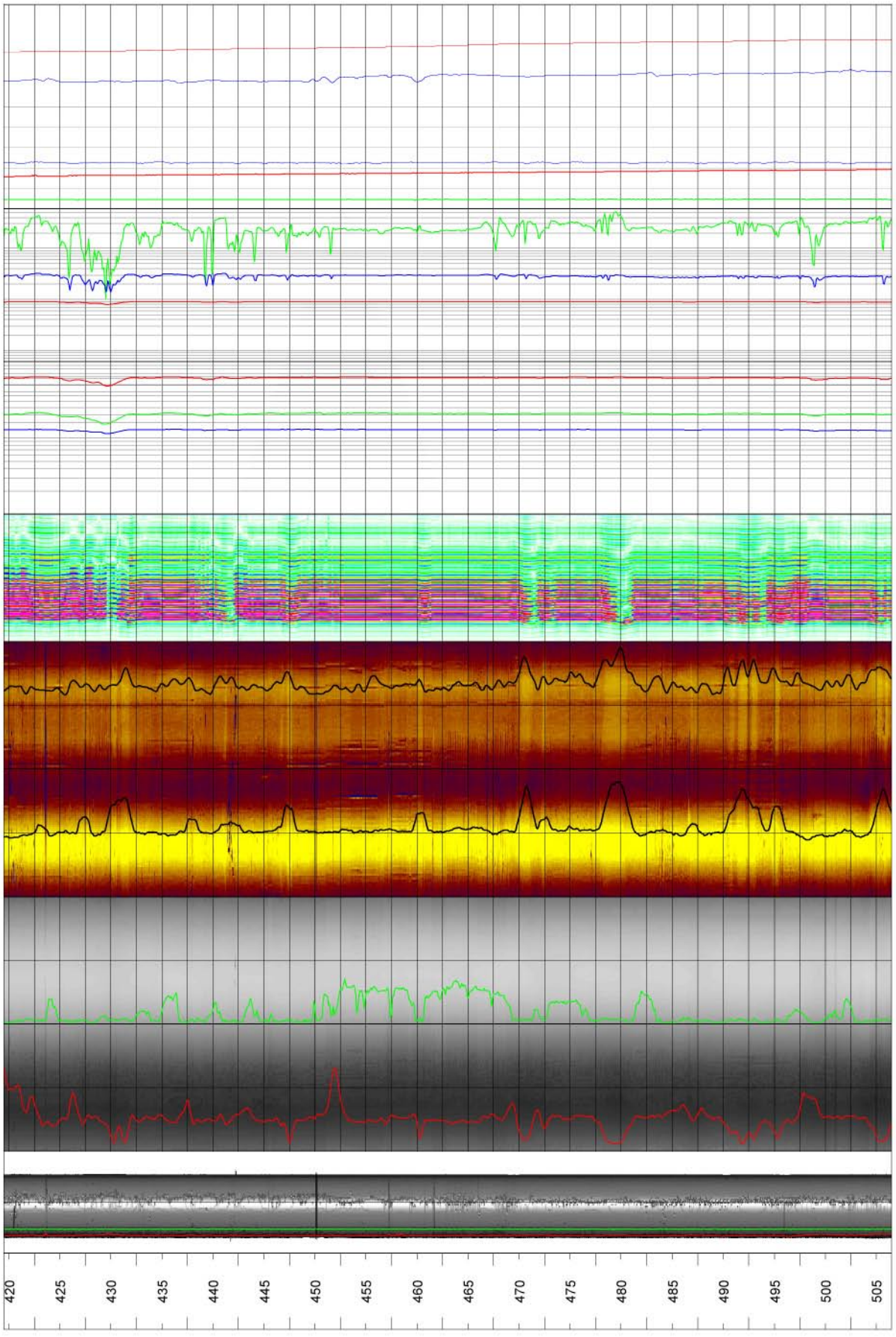
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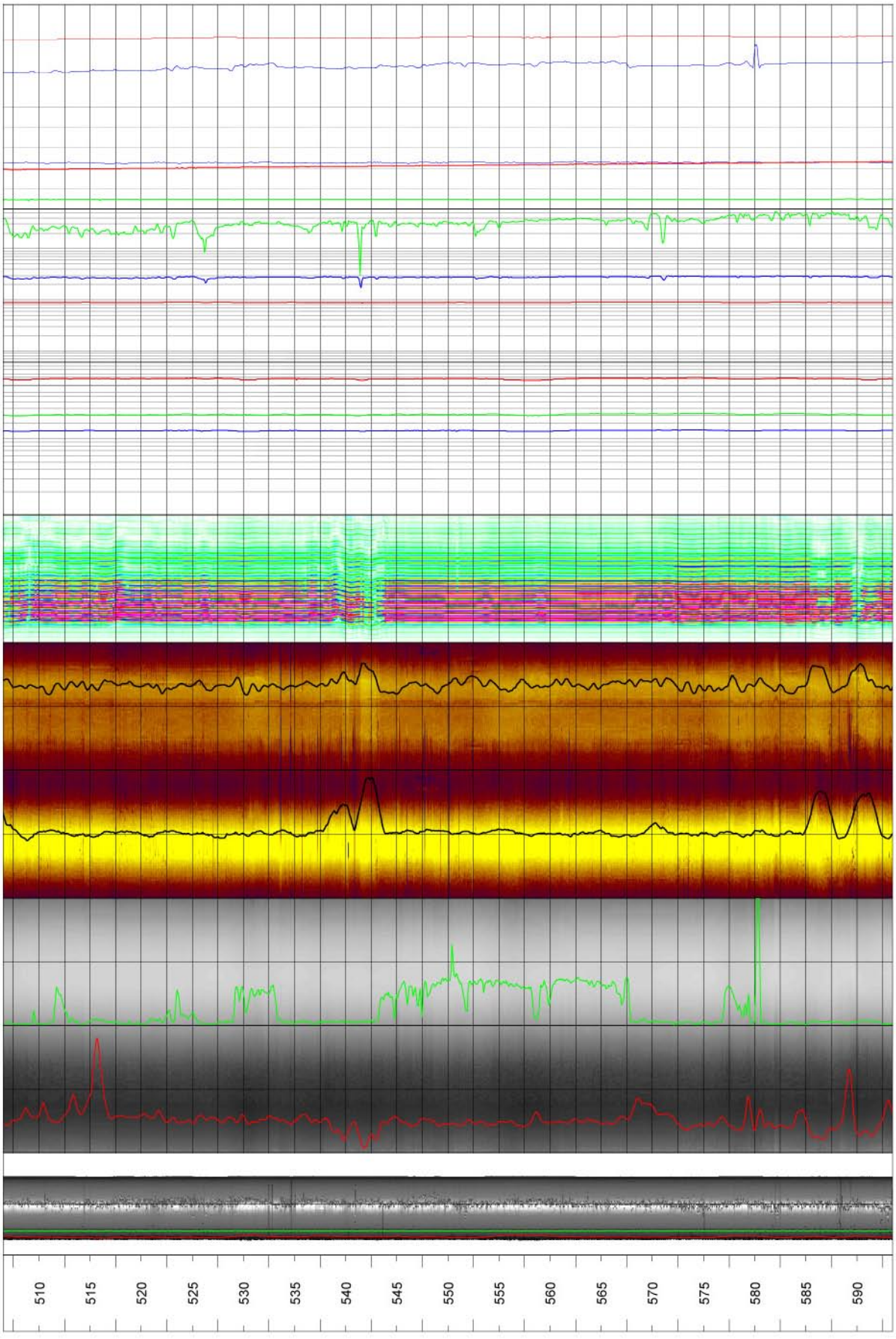
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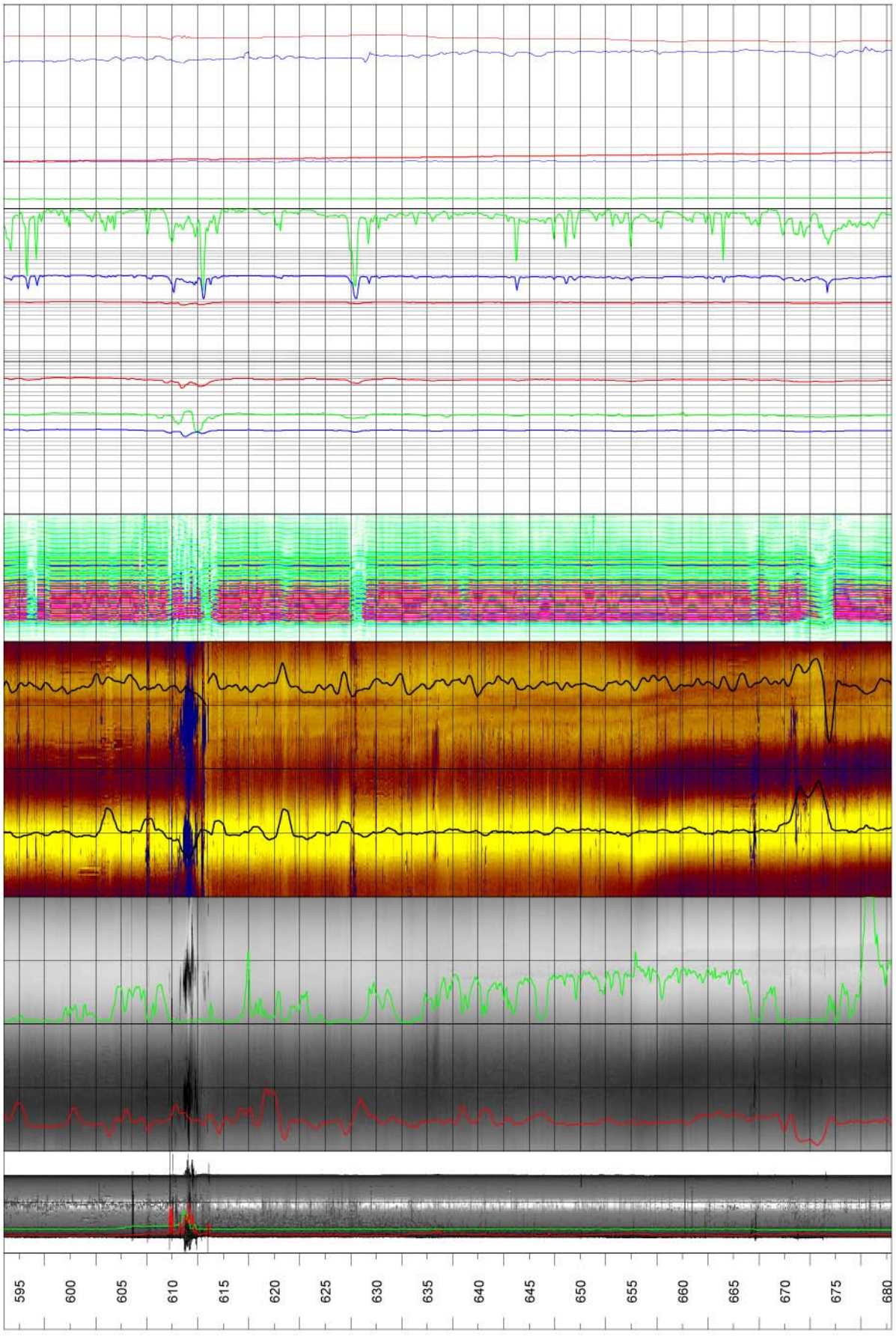
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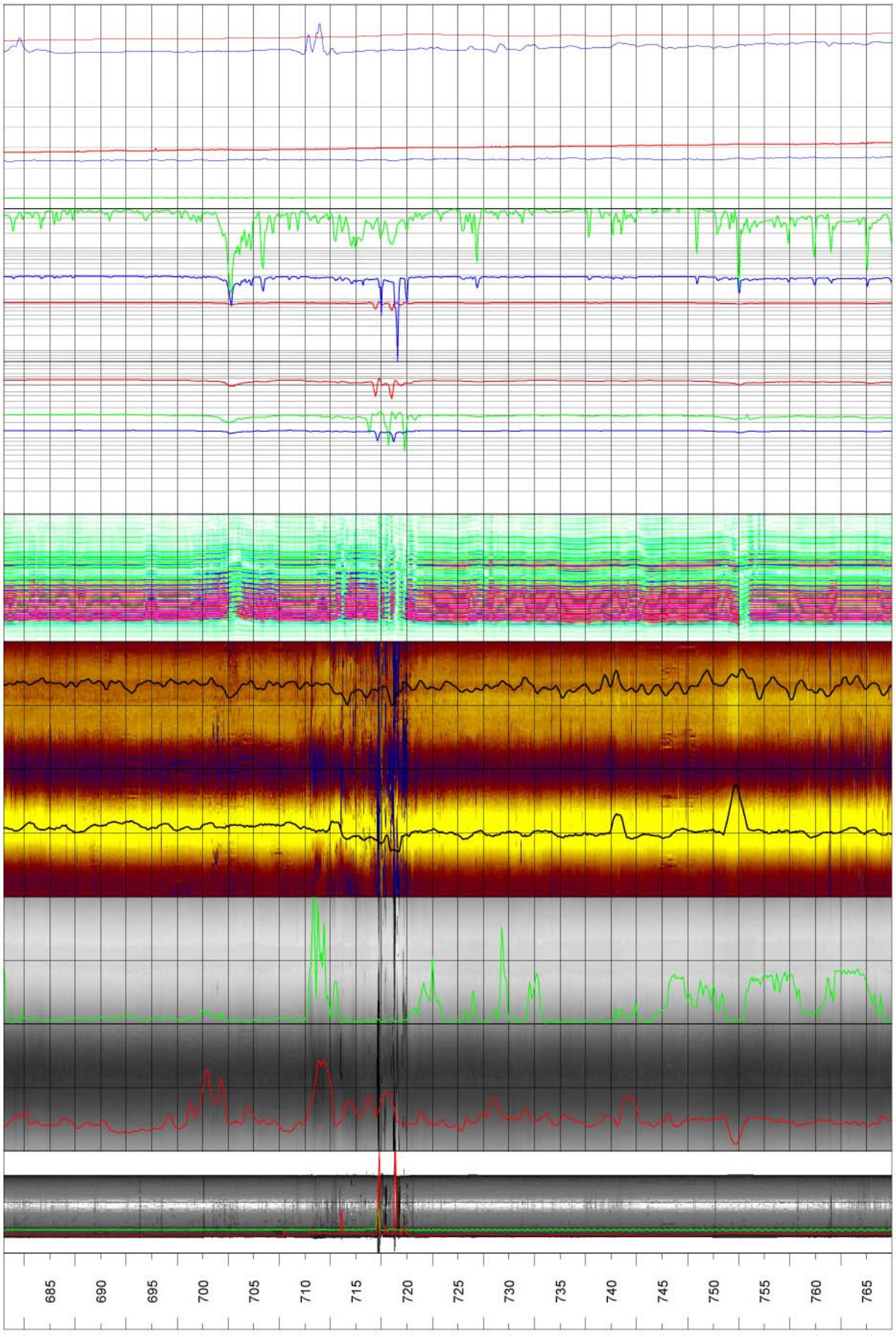
670
675
680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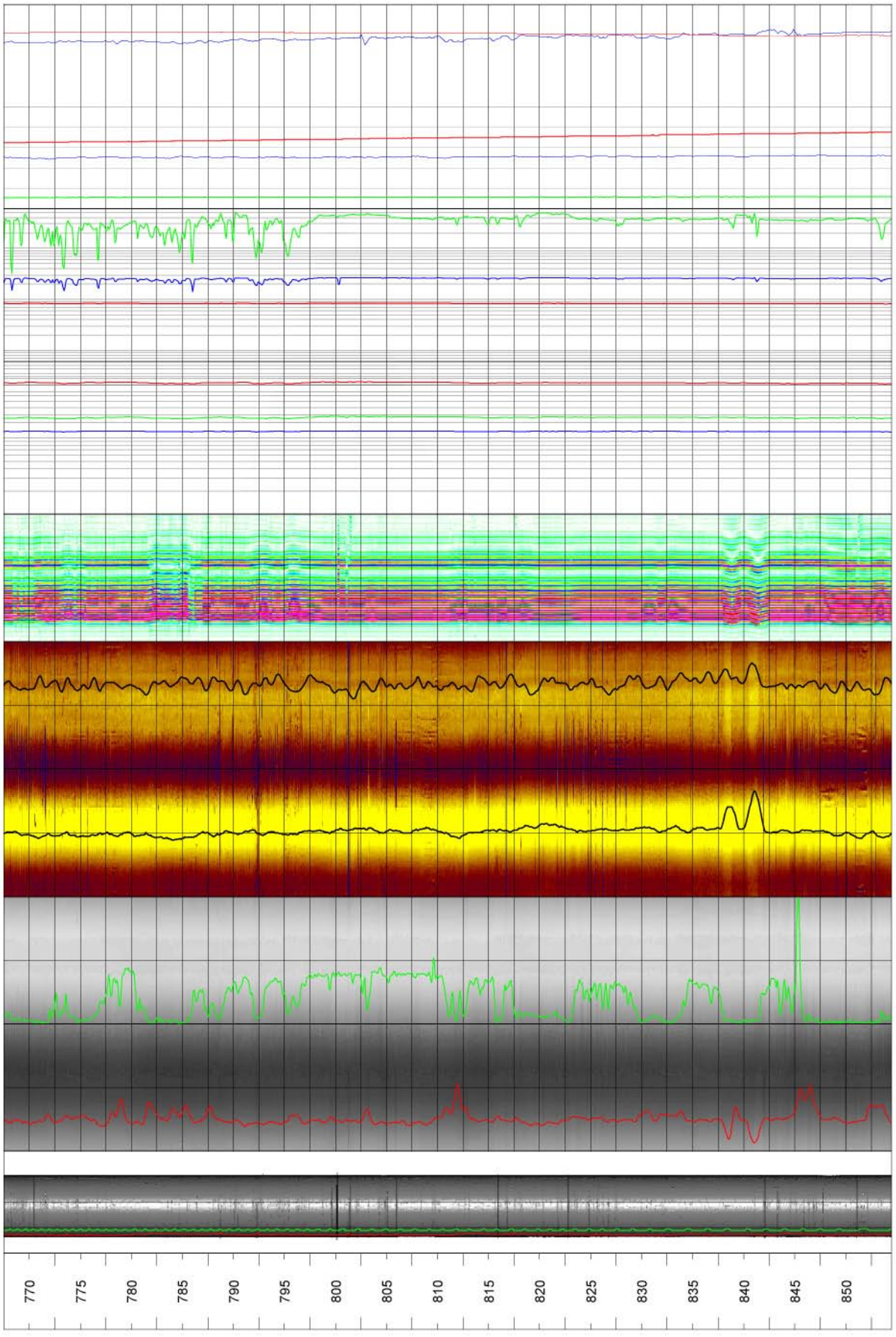
705
710
715
720
725
730
735
740
745
750
755
760
765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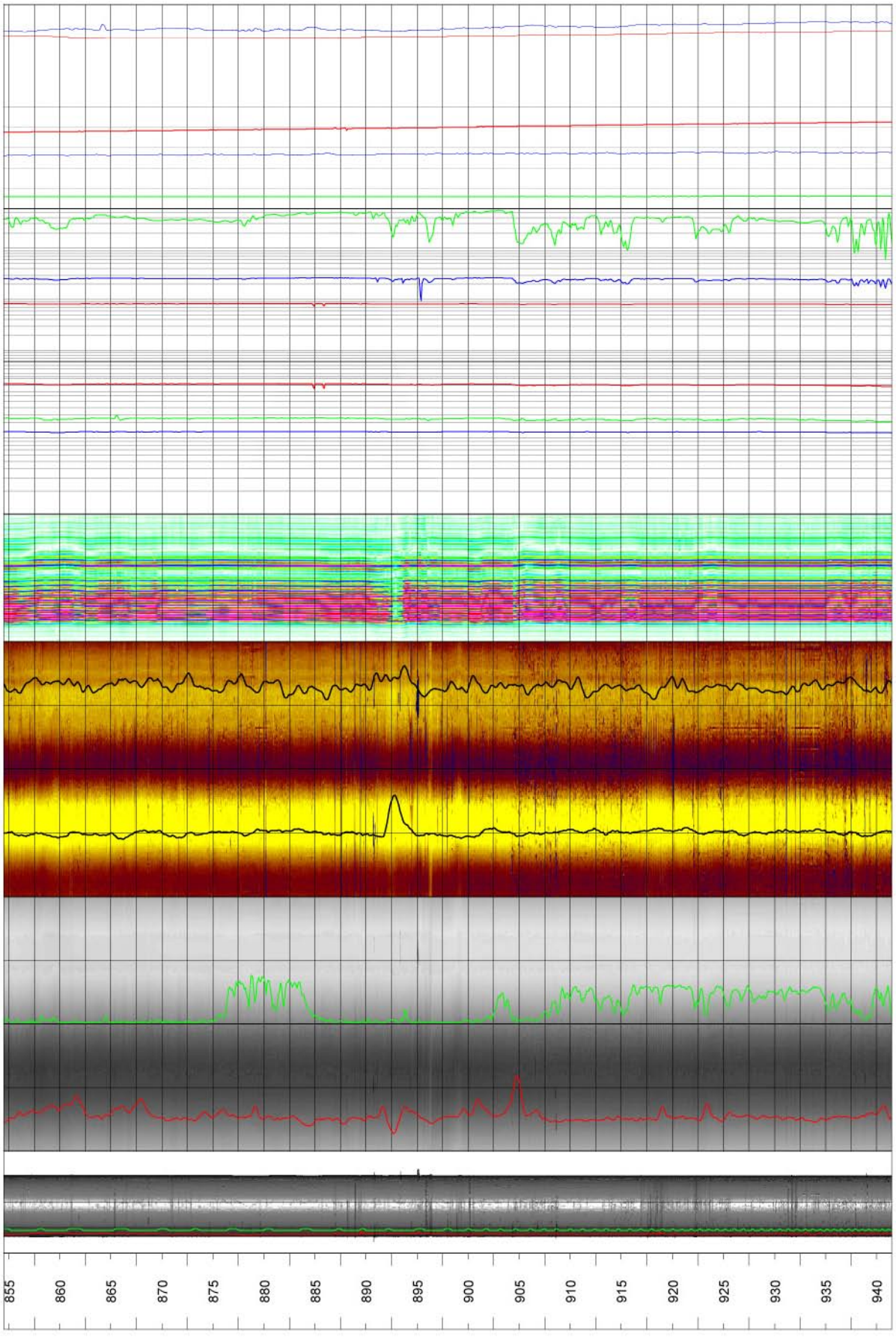
775
780
785
790
795
800
805
810
815
820
825
830
835
840
845
850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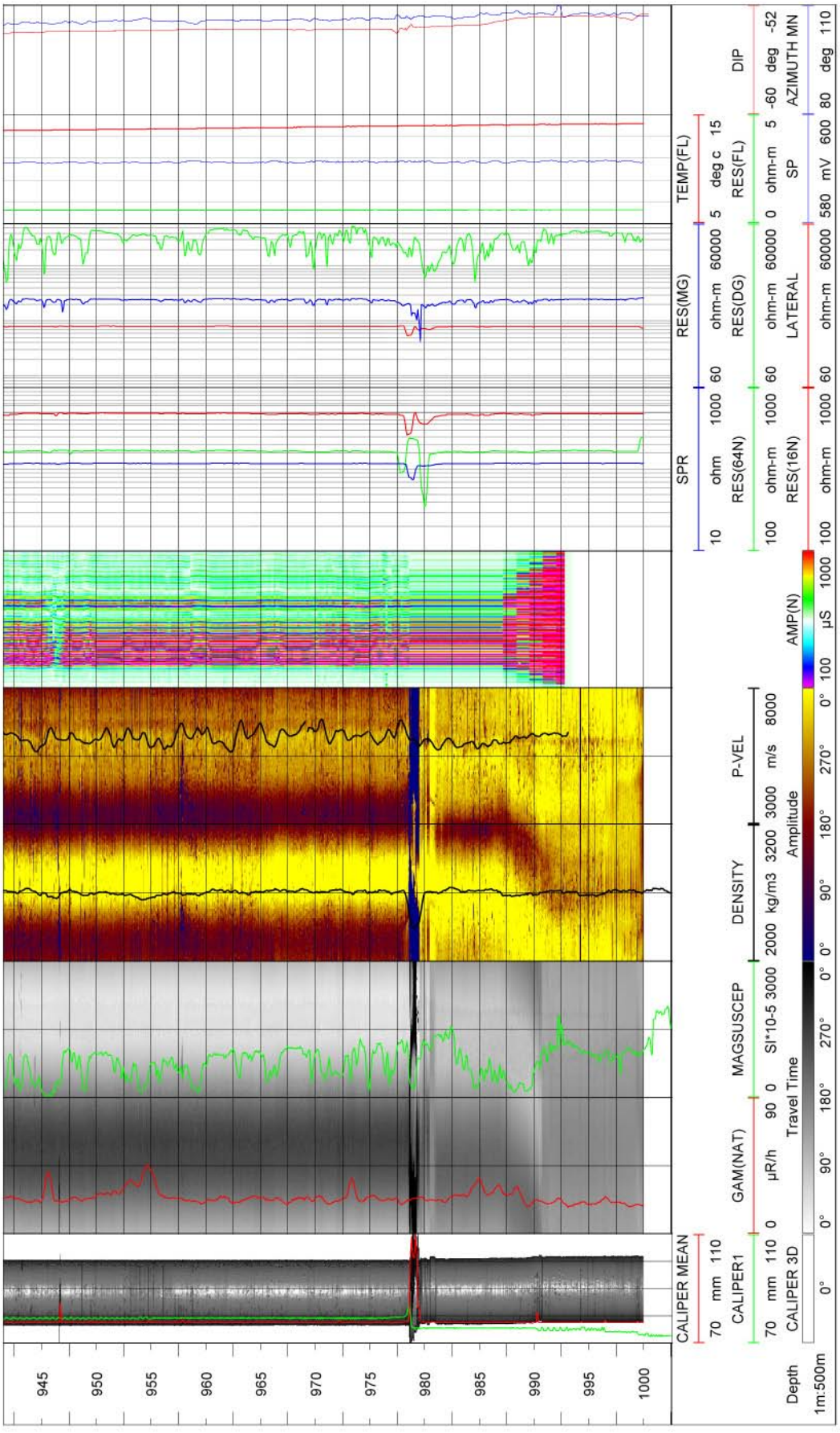
860
865
870
875
880
885
890
895
900
905
910
915
920
925
930
935
940


Depth
1m:500m
945
950
955
960
965
970
975
980
985
990
995
1000
CALIPER 3D
0° 0° 90° 180° 270° 0°
CALIPER1
70 mm 110
CALIPER MEAN
70 mm 110
GAM(NAT)
0 µR/h 90
Travel Time
MAGSUSCEP
0 SI*10-5 3000
DENSITY
2000 kg/m3 3200
Amplitude
P-VEL
3000 m/s 8000
AMP(N)
0° 100 µS 1000
SPR
10 ohm 1000
RES(64N)
100 ohm-m 1000
RES(MG)
60 ohm-m 60000
RES(DG)
60 ohm-m 60000
RES(16N)
60 ohm-m 60000
TEMP(FL)
5 deg c 15
RES(FL)
0 ohm-m 5
LATERAL
580 mV 600
DIP
-60 deg -52
SP
AZIMUTH MN
80 deg 110

Appendix 2

Geophysical borehole logging, borehole HFM19

Borehole No. HFM19

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

Northing: 6699257.585m Easting: 1631626.925m Elevation: 3.656m, RHB70.

Diameter:	137mm
Reaming Diameter:	
Outer Casing:	168mm
Inner Casing:	160mm
Borehole Length:	180.2m
Cone:	
Inclination at ground surface:	-58°
Azimuth:	280.9°
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	8044	ohm-m
RES(64N)	Normal resistivity 64 inch	8044	ohm-m
LATERAL	Lateral resistivity	8044	ohm-m
SPR	Single point resistivity	8044	ohm
SP	Self-potential	8044	mV

Rev.	Date	Drawn by	Control	Approved
0	2004-06-18	UTN	JRI	UTN

Job: 360210A

Scale: 1:500

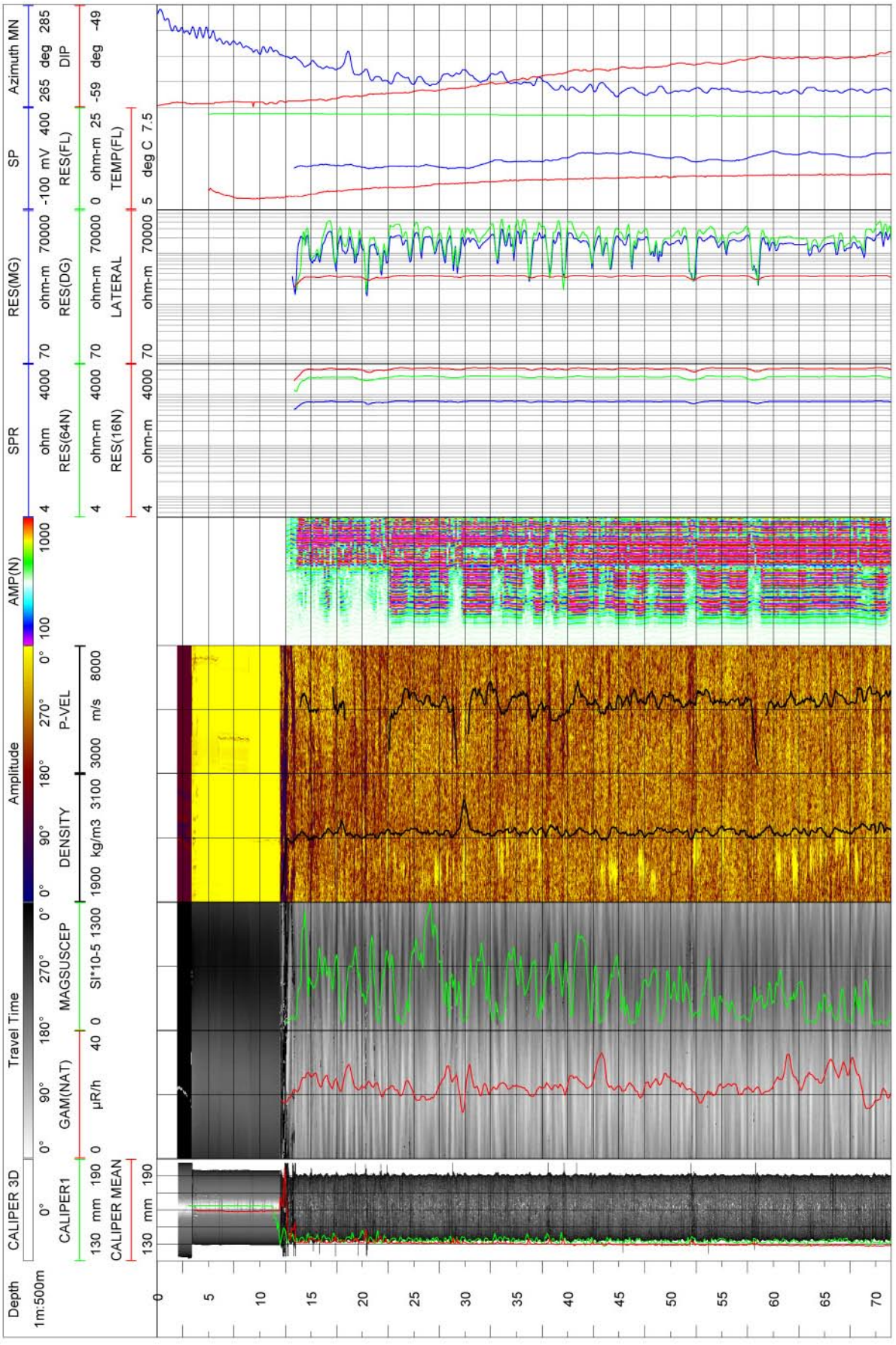
Dansk Geo-servEx a/s
DGE, Håndværkersvinget 11, 2970 Hørsholm, Phone +45 70 10 34 00, Fax + 45 39 16 39 90
RAMBØLL. Bredevej 2, DK-2830 Virum, Phone + 45 45 98 60 00, Fax + 45 45 98 67 00

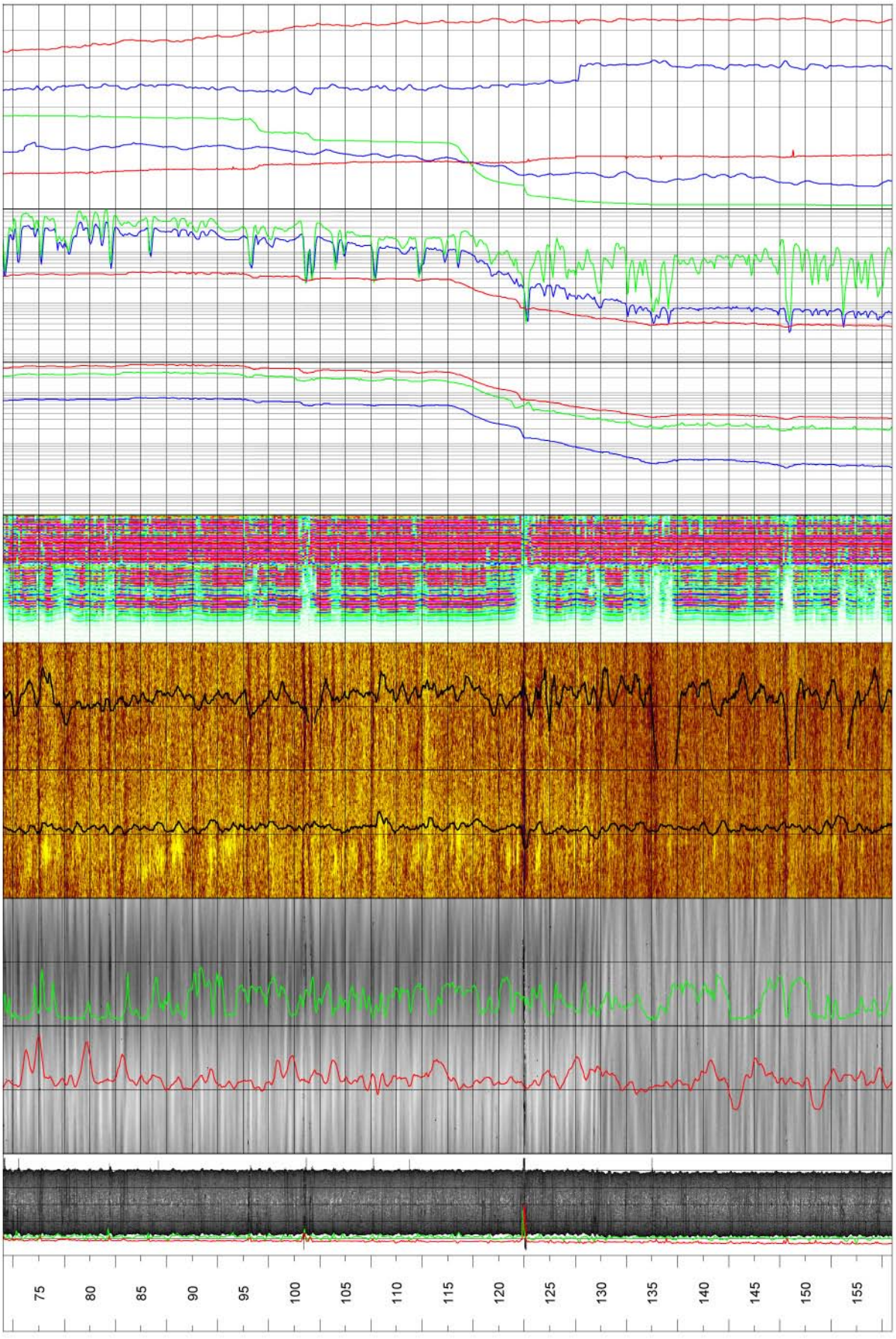
SKB geophysical borehole logging
Borehole HFM19. Forsmark

Presentation

Filename: HFM19_Presentation.wcl

Drawing no.: **2.1**


Depth
1m:500m
CALIPER 3D
Travel Time
Amplitude
AMP(N)
SPR
RES(MG)
SP
Azimuth MN
CALIPER1
GAM(NAT)
MAGSUSCEP
DENSITY
P-VEL
RES(64N)
RES(DG)
RES(FL)
DIP
RES(16N)
LATERAL
TEMP(FL)
CALIPER MEAN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80
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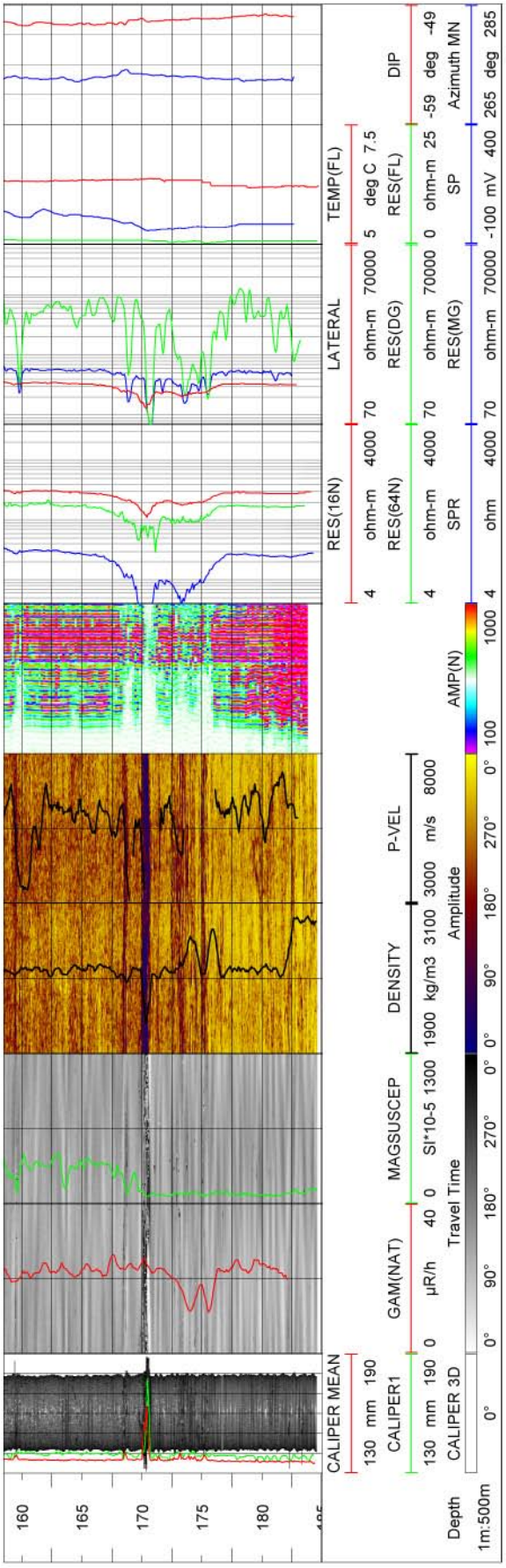
100
105
110
115
120
125
130
135
140
145
150
155


CALIPER MEAN
130 mm 190
CALIPER1
130 mm 190
CALIPER 3D
0° 0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 40
MAGSUSCEP
0 SI*10-5 1300
DENSITY
1900 kg/m3 3100
P-VEL
3000 m/s 8000
Travel Time
Amplitude
AMP(N)
0° 90° 180° 270° 0° 100 1000
RES(16N)
4 ohm-m 4000 70
RES(64N)
4 ohm-m 4000 70
SPR
4 ohm 4000 70
LATERAL
70000 5
RES(DG)
70000 0
RES(MG)
70000 -100 mV 400
TEMP(FL)
deg C 7.5
RES(FL)
ohm-m 25
SP
265
DIP
-59 deg -49
Azimuth MN
285
Depth
1m:500m
160
165
170
175
180