P-07-04

Forsmark site investigation

Geophysical borehole logging in boreholes KFM07C, HFM36 and HFM37

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January 2007

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Geophysical borehole logging in boreholes KFM07C, HFM36 and HFM37

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Abstract

Geophysical borehole logging has been performed in boreholes KFM07C, HFM36 and HFM37 all situated in Forsmark, Sweden.

The objective of the survey is to determine the physical properties of the rock mass around the borehole, e.g. to determine rock types and quantify the fracture frequency and localise deformation zones in the rock. Geophysical borehole logging was used to measure changes in physical properties in the borehole fluid and the bedrock surrounding the boreholes.

All boreholes were recorded from Top Of Casing (TOC). The logging in KFM07C was recorded to app. 500 m, HFM36 was recorded to app. 150 m and HFM37 was recorded to app. 190 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 1–3.

Sammanfattning

Geofysisk borrhålsloggning har genomförts i borrhålen KFM07C, HFM36 och HFM37 i Forsmark.

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 KFM07C från TOC (Top Of Casing, överkanten på det borrör som sticker upp över markytan) till ca 500 m, i HFM36 från TOC till ca 150 m och i HFM37 från TOC till ca 190 m.

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

Processerade loggar presenteras i Appendix 1–3.

Contents

1 Introduction

This document reports the results gained by the geophysical borehole logging in boreholes KFM07C, HFM36 and HFM37, which is one of the activities performed within the site investigation at Forsmark. The work was carried out in accordance with activity plan AP PF 400-06-081 (SKB internal controlling document). In Table 1-1 controlling documents for performing this activity are listed.

All measurements were conducted by RAMBØLL during the period September 18 to 20, 2006. The borehole was recorded from Top Of Casing (TOC) to the bottom of the borehole. The technical data from the boreholes is shown in Table 1-2. The location of the boreholes is shown in Figure 1-1.

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

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

Activity plan	**Number**	**Version**
Geofysisk borrhålsloggning i KFM07C HFM36 HFM37 ver 1.0.doc	AP PF 400-06-081	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för geofysisk borrhålsloggning	SKB MD 221.002	2.0
Metodbeskrivning för krökningsmätning av hammar- och kärnborrhål	SKB MD 224.001	1.0

Table 1-2. Technical data for the boreholes.

Borehole parameter	**KFM07C**	**HFM36**	**HFM37**
Co-ordinates (RT90)	6700125.613 1631034.452	6696504.026 1630081.681	6696592.431 1630137.368
Elevation (RHB70)	3.351	8.415	11.391
Azimuth	142.71°	256.61°	41.35°
Inclination (from horizontal)	–85.40°	–58.91°	–59.15°
Length [m]	500.34	152.55	191.75
Casing [m]	98.39	12.06	9.07
Borehole diameter [mm]	75.8	136.8	138.5
Cleaning level	Level 1	Level 2	Level 2

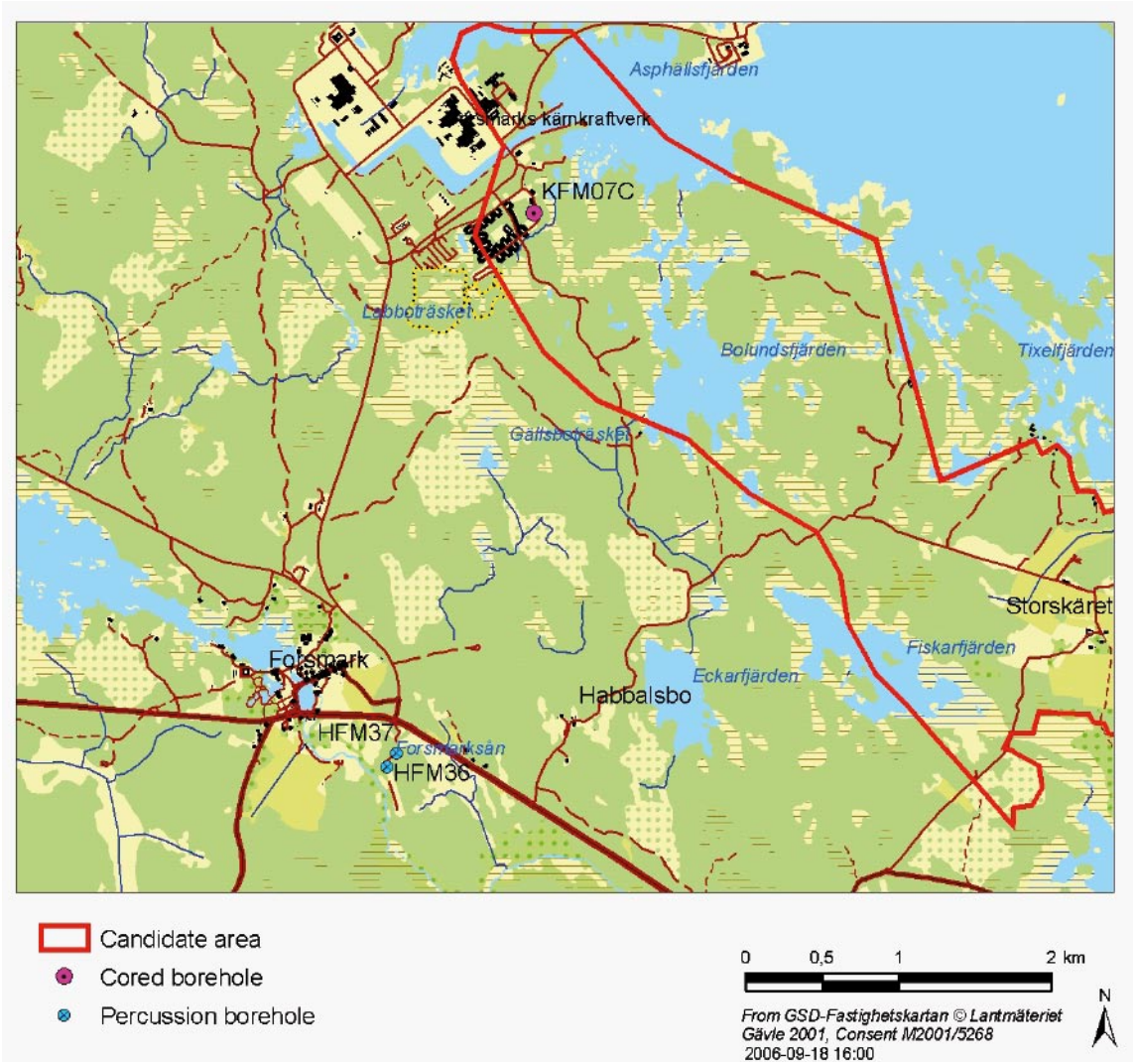
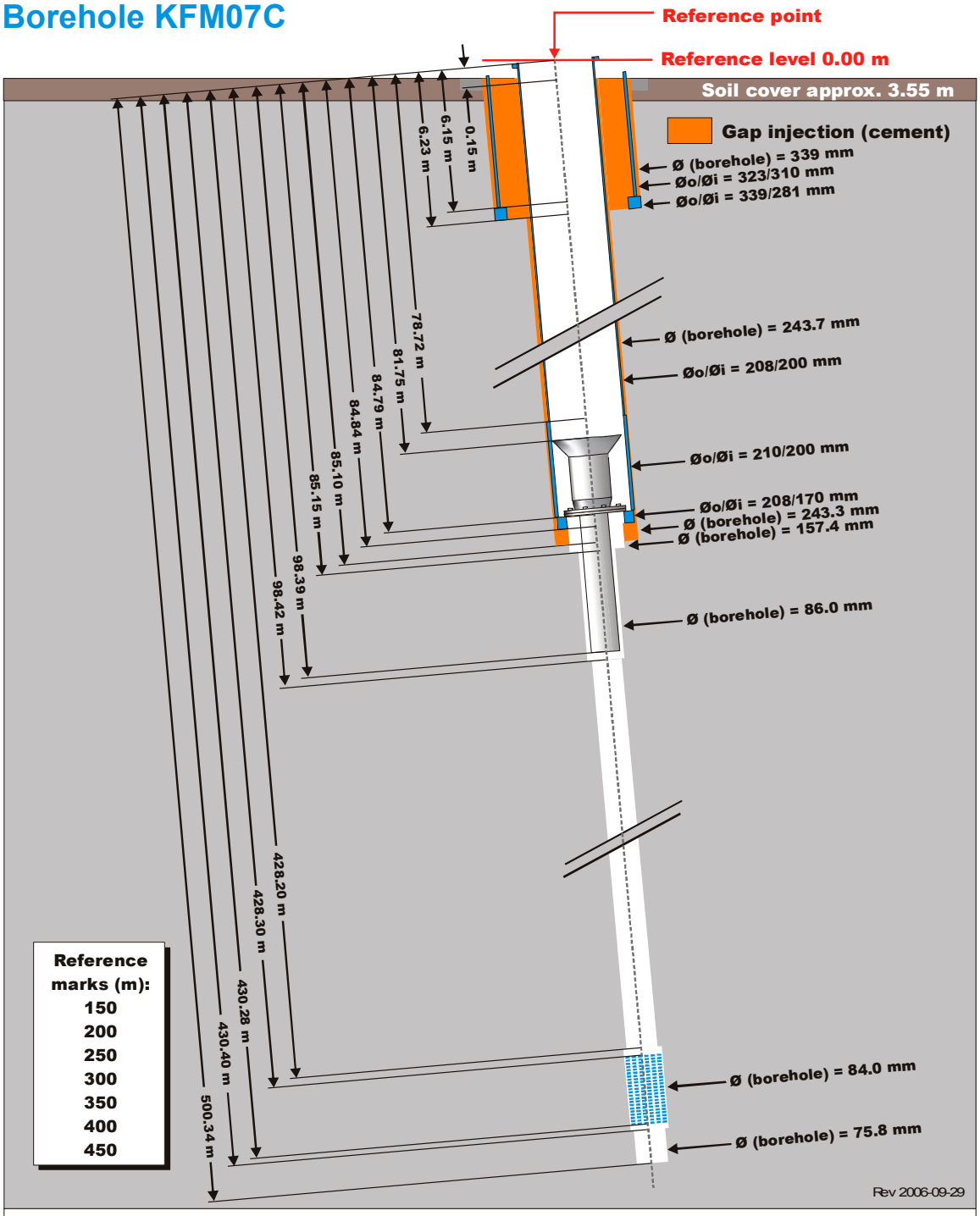


Figure 1-1. *General overview over the Forsmark area showing the location of the boreholes KFM07C, HFM36 and HFM37.*

Technical data
Borehole KFM07C



Drilling reference point

Northing:	**6700125.61 (m), RT90 2,5 gon V 0:-15**
Easting:	**1631034.45 (m), RT90 2,5 gon V 0:-15**
Elevation:	**3.35 (m), RHB 70**

Orientation

Bearing (degrees):	**142.71°**
Inclination (degrees):	**-85.40°**

Borehole

Length:	**500.34 m**

Percussion drilling period

Drilling start date: 2005-12-20
Drilling stop date: 2006-01-17

Core drilling period

Drilling start date: 2006-03-30
Drilling stop date: 2006-08-08

Figure 1-2. Technical description of borehole KFM07C.

Technical data

Borehole HFM36

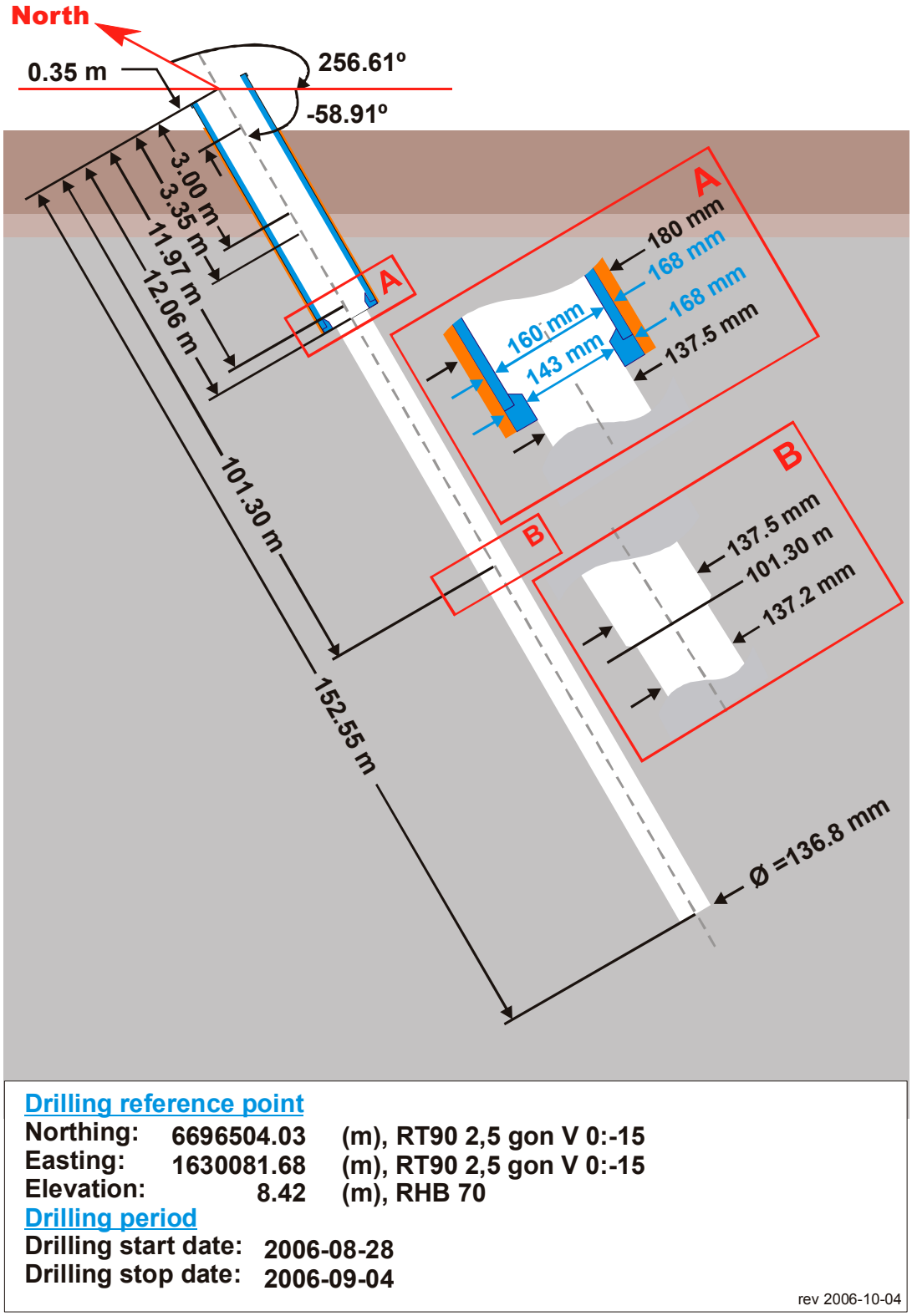
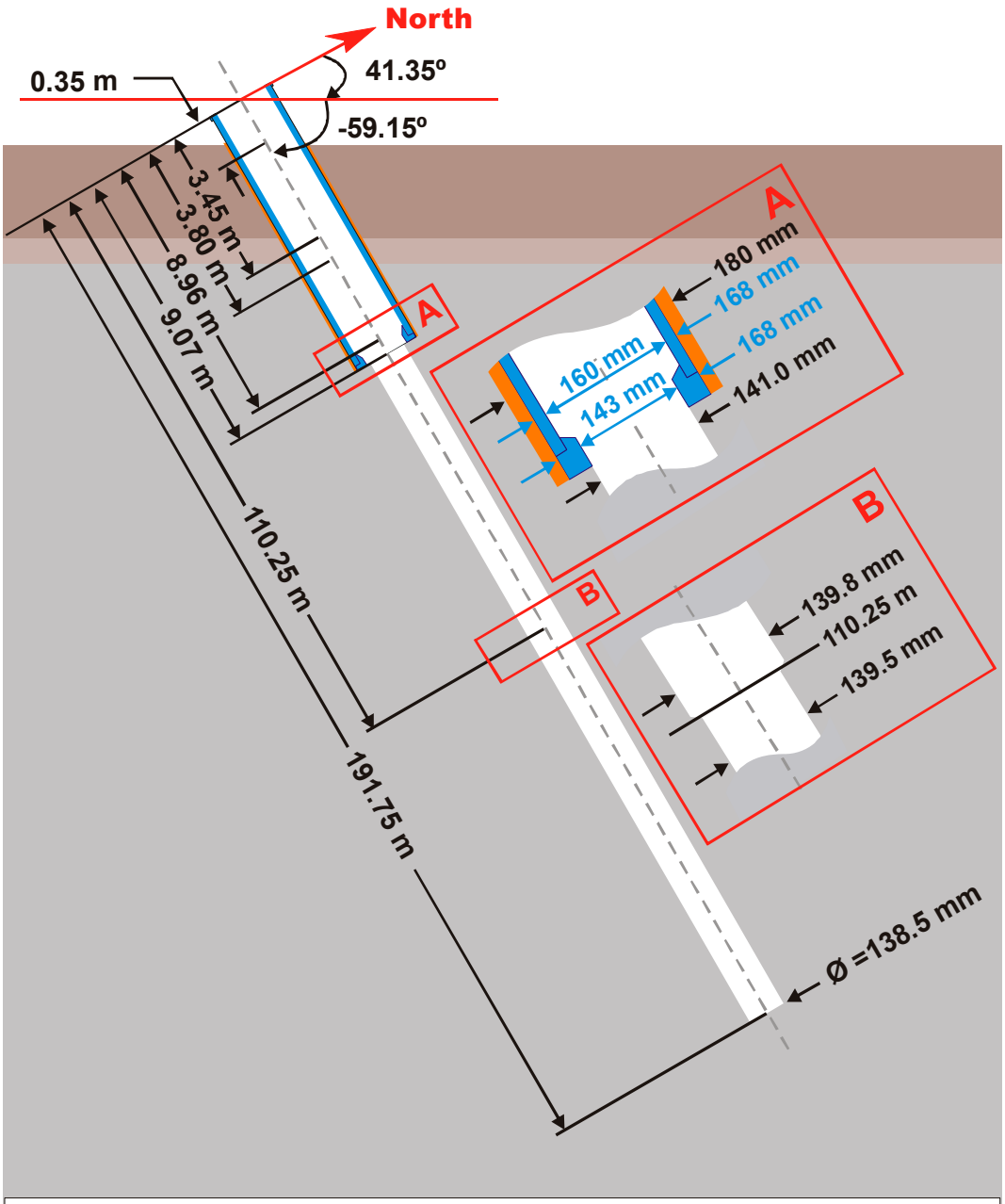


Figure 1-3. *Technical description of borehole HFM36.*

Technical data

Borehole HFM37



Drilling reference point

Northing:	6696592.43	(m), RT90 2,5 gon V 0:-15
Easting:	1630137.37	(m), RT90 2,5 gon V 0:-15
Elevation:	11.39	(m), RHB 70

Drilling period

Drilling start date:	2006-08-07
Drilling stop date:	2006-08-16

rev 2006-09-08

Figure 1-4. *Technical description of borehole HFM37.*

2 Objective and scope

The objective of the survey is to both receive information of the borehole itself, and from the rock mass around the borehole. Geophysical borehole logging was used to measure changes in physical properties in the borehole fluid and the bedrock surrounding the boreholes. Acoustic televiewer was used for determination of the deviation of the borehole (azimuth and inclination) as well as to determine the length marks in the core-drilled borehole KFM07C.

This field report describes the equipment used as well as the measurement procedures. Geophysical borehole logging data is presented in graphs as a function of borehole length on drawings listed in Table 2-1.

Table 2-1. Appendix and drawing no.

Borehole	Drawing no.	Appendix
KFM07C	1.1	1
KFM36	2.1	2
KFM37	3.1	3

3 Equipment

The geophysical borehole logging program were performed with 7 multi tool probes and resulted in a suite of 16 log types, listed in Table 5-1. The tools and recorded logs are listed in Table 3-1.

Table 3-1. Logging tools and logs recorded.

Tool	Recorded logs	Dimensions	Source detector spacing and type	Tool position in borehole	Tool used in borehole
Century 8144. Normal resistivity.	Normal resistivity (16 and 64 inch), single point resistance and natural gamma.	237×5.3 cm			All boreholes
Century 8622. Magnetic susceptibility.	Magnetic susceptibility, natural gamma.	203×4.1 cm			All boreholes
Century 9042. Fluid temperature and fluid resistivity.	Fluid temperatur, fluid resistivity and natural gamma.	137×4.1 cm			All boreholes
Century 9072. 3 m focused guard.	3 m focused guard log resistivity and natural gamma.	310×6.4 cm			All boreholes
Century 9139. Compensated gamma density.	Compensated Gamma density, natural gamma, 140 cm focused guard log resistivity, 1-arm caliper.	380.3×5.6 cm	20.3 cm 125 m 200 mCi Cs137	Sidewall. Gamma source focused.	All boreholes
Century 9310. Sonic.	Full wave form travel-time providing P and S-wave velocity picking, compensated P-wave travel-time and natural gamma.	300×6.0 cm	Near 91.4 cm Far 121.9 cm	Centralized.	All boreholes
RG 25 112 000. HiRAT Acoustic televiewer.	Full waveform acoustic amplitude and travel-time, 360° orientated acoustic image, 360° very high resolution caliper, borehole azimuth and dip and natural gamma.	246×4 cm		Centralized.	All boreholes

4 Execution

4.1 General

In general the measurement procedures follow the SKB method description (MD 221.002, SKB internal controlling document). The logging program was executed in the period September 18 to 20, 2006. All relevant logging events are described in the daily report sheets elivered to SICADA, and are traceable by the activity plan number.

The fluid resistivity and temperature logs are recorded in downward direction, as the first log run. All other log types are recorded running the tool in upward direction in the borehole.

The applied logging equipment was calibrated and cleaned before arriving at the site according to SKB cleaning level 2 (SKB internal controlling document SKB MD 600.004). Furthermore, all equipment was wiped with alcohol before it was lowered into the borehole.

For control, each log run is normally recorded both in down and in upward direction using the down run as a repeat section. For logging tool 9139 recording a repeat section in upward direction controls the data. The depth of the probe in the borehole is shown on both the recording computer and the winch. On the winch the tension of the cable is also shown. The winch will automatically stop, if the tension changes rapidly. The tension was recorded on all log runs using Century equipment, except tool 9310.

All data was recorded with max.10 cm sample interval. The speed of the logging for the 9139 tool was 5 m/min, for the 8622 tool 20 m/min and for all other tools 10 m/min, except for the HiRAT Acoustic tool in borehole KFM07C where the speed was 2 m/min.

4.2 Nonconformities

For borehole HFM36, are the resistivity logs, RES(16N), RES (64N), SPR and Lateral, are not reported due to unreliable results. These loggings will be completed in February, 2007.

The other logging has been performed in accordance with the activity plan AP PF 400-06-081.

5 Results

5.1 Presentation

All relevant logging events were described in the daily report sheets, which were delivered separately.

Logs presented in drawings no. 1.1–3.1 are presented in Table 5-1.

Table 5-1. Logs presented in drawings no. 1.1 through 3.1 in Appendices 1 to 3.

Log	Log name short	Unit	Tool	Recorded/calculated in borehole
Fluid temperature	TEMP(FL)	Deg C	9042	All
Fluid resistivity	RES(FL)	Ohm-m	9042	All
Normal resistivity 16 inch	RES(16N)	Ohm-m	8144	Not reported in HFM36
Normal resistivity 64 inch	RES(64N)	Ohm-m	8144	Not reported in HFM36
Lateral resistivity	LATERAL	Ohm-m	8144	Not reported in HFM36
Single point resistance	SPR	Ohm	8144	Not reported in HFM36
Self potential	SP	mV	8144	All
Magnetic susceptibility	MAGSUSCEP	$SI \cdot 10^{-5}$	8622	All
Caliper, 1-arm	CALIPER1	mm	9139	All
Gamma-gamma density	DENSITY	kg/m^3	9139	All
Focused guard log resistivity, 127 cm	RES(SG)	Ohm-m	9139	All
Natural gamma.	GAM(NAT)	μR/h	9072	All
Focused guard log resistivity, 300 cm	RES(DG)	Ohm-m	9072	All
P-wave velocity.	P-VEL	m/s	9310	All
Full wave form, near receiver	AMP(N)	μs	9310	All
Full wave form, far receiver.	AMP(F)	μs	9310	All
Caliper, high resolution. 360°	CALIPER 3D	mm	HiRAT	All
High resolution 1D Caliper	CALIPER MEAN	mm	HiRAT	All
Borehole azimuth magnetic north	AZIMUTH MN	Deg	HIRAT	All
Borehole inclination from horizontal	DIP	Deg	HIRAT	All
360° orientated acoustic travel time	TRAVEL TIME	100 ns	HiRAT	All
360° orientated acoustic travel time	AMPLITUDE	–	HiRAT	All

5.2 Orientation, alignment and stretch of logs

5.2.1 Orientation of images

The orientation of the results from the HiRAT Acoustic tool, are processed in the tool while recording, using the magnetometers and accelerometers in the tool.

5.2.2 Overlapping data

If the log data from one probe have been recorded in more than one file, the files are merged using events in both files. Overlapping in data is always used from the topmost-recorded file (overlapping data are never the mean value from two log runs).

5.2.3 Alignment of data

In order to obtain an exact length 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 lengths from the track marks and from the HiRAT tool are used to make a new length scale in WellCAD. All log files are shifted using the new length scale.

5.2.4 Stretch of logs

There is a minor difference in the length registration between up- and down runs for the used winch. The size of the defect is about 1.5 m/km. To compensate for this the logs are stretched using another new length scale for each tool. The length 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 length scale is made and added to the log. The bottom of the borehole is considered in stretching the logs in case that no data will occur below the bottom of the borehole.

5.2.5 Removing of data

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

5.2.6 Repicking of sonic log

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

5.3 Calculated log curves

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

Table 5-2. Calculated log curves.

Log	Description of log calculation
Caliper, 1-arm	The Caliper was converted from [cm] to [mm] units by multiplying [cm] with 10.
Gamma-gamma density	The Gamma-gamma was converted from [g/cm^3] to [kg/m^3] units by multiplying with 1,000.
Focused guard log resistivity, 140 cm	–
Natural gamma	The natural gamma log was converted from CPS to μR/h by multiplying the constant 0.077. This constant was computed from the logs previously performed in borehole KLX02 located in Oskarshamn.
Fluid temperature	–
Fluid resistivity	–
Normal resistivity 16 inch	–
Normal resistivity 64 inch	–
Lateral resistivity	–
Single point resistance	–
Self-potential	The SP value was converted from [mV] to [V] by dividing with 1,000.
Focused guard log resistivity, 300 cm	–
P-wave velocity	The P-VEL velocity is calculated using the difference in distance between the far and near receiver divided by time difference between the first arrival from the far and near signal. (121.9 cm–91.4 cm)/(Time(far)–Time(near)).
Full wave form, near receiver	–
Full wave form, far receiver	–
Magnetic susceptibility	The magnetic susceptibility was converted for CGS units to SI units by multiplying the CGS value by 4π.
Caliper, high resolution. 360° CALIPER 3D	The Caliper 3D is calculated using the acoustic travel time and the velocity in the borehole fluid. The velocity in the fluid is calculated using the fluid temperature and fluid conductivity.
High resolution 1D Caliper CALIPER MEAN	The Caliper mean is calculated using the mean travel time from the acoustic televiewer, the fluid temperature, fluid velocity and the internal travel time in the acoustic televiewer.
Borehole azimuth magnetic north	See 5.3.1.
Borehole Inclination from lateral	See 5.3.1.
360° orientated acoustic travel time	–
360° orientated acoustic amplitude	–

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. The coordinates were calculated from 5 m below the casing bottom.

5.4 Borehole KFM07C

In order to obtain an exact length calibration in borehole KFM07C, the reference track marks made while drilling are used. The correlation between the track marks and the logs is obtained from the HiRAT Acoustic tool.

The reference track marks in the borehole and the recorded track marks from the HiRAT are observed at the positions listed in Table 5-3.

To compensate for the difference between the reference track marks and the recorded track marks the logs are stretched. The result from the stretching is a new length scale. The new length scale is applied to the HiRAT file. In this way a perfect match between given lengths of the reference marks and the recorded data is obtained. By means of alignment of the observed gamma events in KFM07C, between all log runs, the obtained reference mark correlation is transferred to the other logs.

The complete log suite for borehole KFM07C is presented as composite log sheets in drawing 1.1 in Appendix 1. The logs presented in drawing no. 1.1 are listed in Table 5-1.

5.5 Borehole HFM36

Using the natural gamma from the Hirat as reference, the natural gamma logs from the other probes are aligned to the same length. A new length scale is added to each log and afterwards the logs are stretched using different gamma events.

The complete log suite for borehole HFM36 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 HFM37

Using the natural gamma from the Hirat as reference, the natural gamma logs from the other probes are aligned to the same length. A new length scale is added to each log and afterwards the logs are stretched using different gamma events.

The complete log suite for borehole HFM37 is presented as composite log sheet in drawing no. 3.1 in Appendix 3. The logs presented in drawing no. 3.1 are listed in Table 5-1.

Table 5-3. The reference track marks in the borehole and the recorded track marks form the HiRAT in borehole KFM07C.

Reference mark	HIRAT recorded
98.39	98.39
150.00	150.245
200.00	200.392
250.00	250.559
300.00	300.718
350.00	350.873
400.00	401.024
450.00	451.189

6 Data delivery

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

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

The processed files shown on the drawings have been delivered in WellCAD, Table 6-2, and as excel files (one for each borehole) in SICADA format, Table 6-3.

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

Borehole	Probe	Log direction	WellCAD File	Description
KFM07C	8144	Up	KFM07C_09-20-06_14-09_8144C_.10_ –0.70_500.30_ORIG.log	Start Length: 500.3 m. End Length: –0.7 m.
KFM07C	8622	Up	KFM07C_09-20-06_07-57_8622C_.10_ –0.70_500.50_ORIG.log	Start Length: 500.5 m. End Length: –0.7 m.
KFM07C	9042	Down	KFM07C_09-19-06_13-25_9042C_. 10_0.20_501.80_ORIG.log	Start Length: 0.2 m. End Length: 501.8 m.
KFM07C	9072	Up	KFM07C_09-20-06_15-22_9072C_.10_ –0.20_500.30_ORIG.log	Start Length: 500.3 m. End Length: –0.2 m.
KFM07C	9139	Up	KFM07C_09-20-06_10-50_9139A_.10_ –0.40_500.80_ORIG.log	Start Length: 500.8 m. End Length: –0.4 m.
KFM07C	9310	Up	KFM07C_09-20-06_12-59_9310C2_.10_ –0.30_499.90_ORIG.log	Start Length: 499.9 m. End Length: –0.3 m.
KFM07C	HiRAT	Up	KFM07C_HIRAT_180pixels_up_run1.HED	Start Length: 499 m. End Length: 0 m.
HFM37	8144	Up	HFM37_09-18-06_16-48_8144C_.10_ –0.30_191.70_ORIG.log	Start Length: 191.7 m. End Length: –0.3 m.
HFM37	8622	Up	HFM37_09-18-06_17-24_8622C_.10_ –0.40_191.10_ORIG.log	Start Length: 191.1 m. End Length: –0.4 m.
HFM37	9042	Down	HFM37_09-18-06_13-58_9042C_.10_ 0.20_193.80_ORIG.log	Start Length: 0.2 m. End Length: 193.8 m.
HFM37	9072	Up	HFM37_09-18-06_14-57_9072C_.10_ –0.20_191.50_ORIG.log	Start Length: 191.5 m. End Length: –0.2 m.
HFM37	9139	Up	HFM37_09-18-06_15-31_9139A_.10_ –0.30_191.30_ORIG.log	Start Length: 191.3 m. End Length: –0.3 m
HFM37	9310	Up	HFM37_09-18-06_18-08_9310C2_.10_ –0.50_190.20_ORIG.log	Start Length: 190.2 m. End Length: –0.5 m.
HFM37	HiRAT	Up	HFM37_HIRAT_180pixels_up_run2.HED	Start Length: 189 m. End Length 0 m.
HFM36	8144	Up	HFM36_09-19-06_09-22_8144C_.10_ –0.30_152.10_ORIG.log	Start Length: 152.1 m. End Length: –0.3 m.
HFM36	8622	Up	HFM36_09-19-06_11-24_8622C_.10_ –0.40_151.90_ORIG.log	Start Length: 151.9 m. End Length: –0.4 m.
HFM36	9042	Down	HFM36_09-19-06_08-05_9042C_.10_ 0.20_18.70_ORIG.log	Start Length: 0.2 m. End Length: 18.7 m.
HFM36	9042	Down	HFM36_09-19-06_08-18_9042C_.10_ 17.50_153.10_ORIG.log	Start Length: 17.5 m. End Length: 153.1 m.
HFM36	9072	Up	HFM36_09-19-06_08-53_9072C_.10_ –0.30_152.10_ORIG.log	Start Length: 152.1 m. End Length: –0.3 m.
HFM36	9139	Up	HFM36_09-19-06_10-35_9139A_.10_ –0.50_151.80_ORIG.log	Start Length: 151.8 m. End Length: –0.5 m.
HFM36	9310	Up	HFM36_09-19-06_11-53_9310C2_.10_ –0.50_150.80_ORIG.log	Start Length: 150.8 m. End Length: –0.5 m.
HFM36	HiRAT	Up	HFM36_HIRAT_180pixels_up_run1.HED	Start Length: 150 m. End Length: 134 m.

Table 6-2. Drawing files in WellCad format.

Borehole	Drawing	WellCad file
KFM07C	1.1	KFM07C_Presentation.WCL
HFM36	2.1	HFM36_Presentation.WCL
HFM37	3.1	HFM37_Presentation.WCL

Table 6-3. Data files in SICADA format.

Sheet	Comment
“Borehole”_CALIPER1_GP040 – Caliper logging.xls	
“Borehole”_CALIPER MEAN_GP041 – 3-D caliper.xls	
“Borehole”_TEMP(FL)_RES(FL)_GP060 – Fluid temperature and resistivity logging.xls	
“Borehole”_DENSITY_GP090 – Density logging.xls	
“Borehole”_MAGSUSCEP_GP110 – Magnetic susceptibility logging.xls	
“Borehole”_GAM(NAT)_GP120 – Natural gamma logging.xls	
“Borehole”_SPR_GP150 – Single point resistance logging.xls	Not reported for borehole HFM36
“Borehole”_RES(64N)_GP160 – Resistivity, normal 1.6 m (64 in).xls	Not reported for borehole HFM36
“Borehole”_RES(MG)_GP161 – Resistivity, focused 140 cm.xls	
“Borehole”_RES(DG)_GP162 – Resistivity, focused 300 cm.xls	
“Borehole”_LATERAL_GP163 – Resistivity, lateral 1.6–0.1 m.xls	Not reported for borehole HFM36
“Borehole”_RES(16N)_GP164 – Resistivity, normal 0.4 m (16 in).xls	Not reported for borehole HFM36
“Borehole”_P-VEL_GP175 – Fullwave sonic.xls	
“Borehole”_GP830 – Acoustic televiewer.xls	
“Borehole”_SP_GP180 – Self potential logging.xls	

Borehole KFM07C. Drawing no. 1.1. Borehole logs

Borehole No. KFM07C

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

Northing: 6700125.61m Easting: 1631034.45m Elevation: 3.35m, RHB70

Diameter:	75.8mm
Reaming Diameter:	243.7mm
Outer Casing:	208mm
Inner Casing:	200mm
Casing Length:	98.39m
Borehole Length:	500.34m
Cone:	
Inclination at ground surface:	-85.40°
Azimuth:	142.71°
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9139	mm
DENSITY	Gamma-gamma density	9139	kg/m³
RES(SG)	Focused guard log resistivity, 128 cm	9139	ohm-m
GAM(NAT)	Natural gamma	9072	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	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
RADIUS	360 degrees orientated acoustic radius	HiRAT	mm
AMPLITUDE	360 degrees orientated acoustic amplitude	HiRAT	-
THORIUM	Spectral gamma, Thorium component	9080	PPM
URANIUM	Spectral gamma, Uranium component	9080	PPM
POTASSIUM	Spectral gamma, Potassium component	9080	percent
RES(16N)	Normal resistivity 16 inch	8144	ohm-m
RES(64N)	Normal resistivity 64 inch	8144	ohm-m
LATERAL	Lateral resistivity	8144	ohm-m
SPR	Single point resistivity	8144	ohm
SP	Self Potential	8144	V

Rev.	Date	Drawn by	Control	Approved
0	2006-10-20	JRI	UTN	UTN

Job 547310A

Scale 1:500

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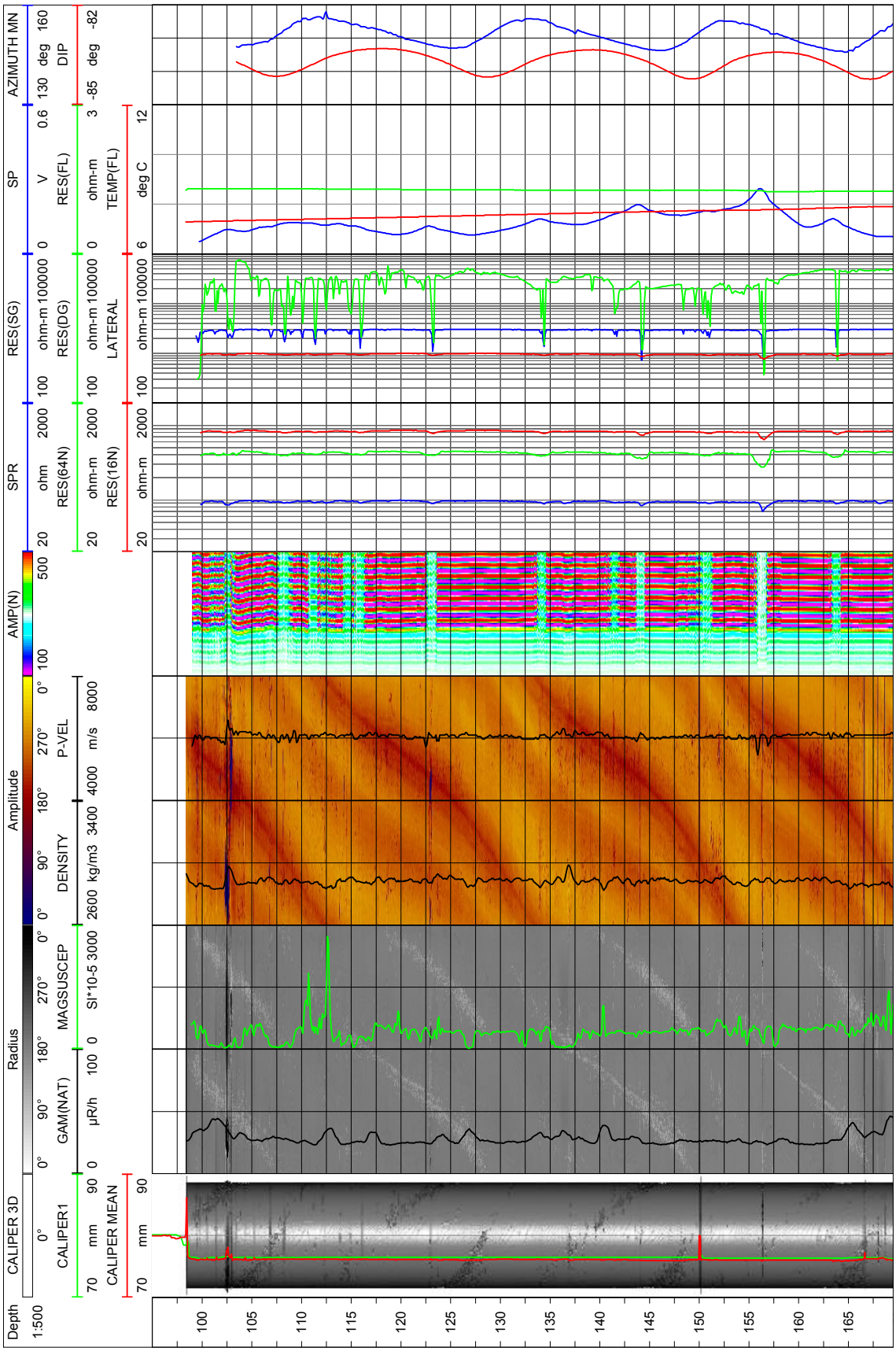
SKB geophysical borehole logging
Borehole KFM07C

Presentation

Filename: KFM07C_Presentation.wcl

Drawing no.: **1.1**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CALIPER1
70 mm 90
CALIPER MEAN
70 mm 90
Radius
0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 100
MAGSUSCEP
0 SI*10-5 3000
Amplitude
0° 90° 180° 270° 0°
DENSITY
2600 kg/m3 3400
P-VEL
4000 m/s 8000
AMP(N)
0° 100 500
SPR
20 ohm 2000
RES(64N)
20 ohm-m 2000
RES(16N)
20 ohm-m 2000
RES(SG)
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
LATERAL
100 ohm-m 100000
SP
0 V 0.6
RES(FL)
0 ohm-m 3
TEMP(FL)
6 deg C 12
AZIMUTH MN
130 deg 160
DIP
-85 deg -82
100
105
110
115
120
125
130
135
140
145
150
155
160
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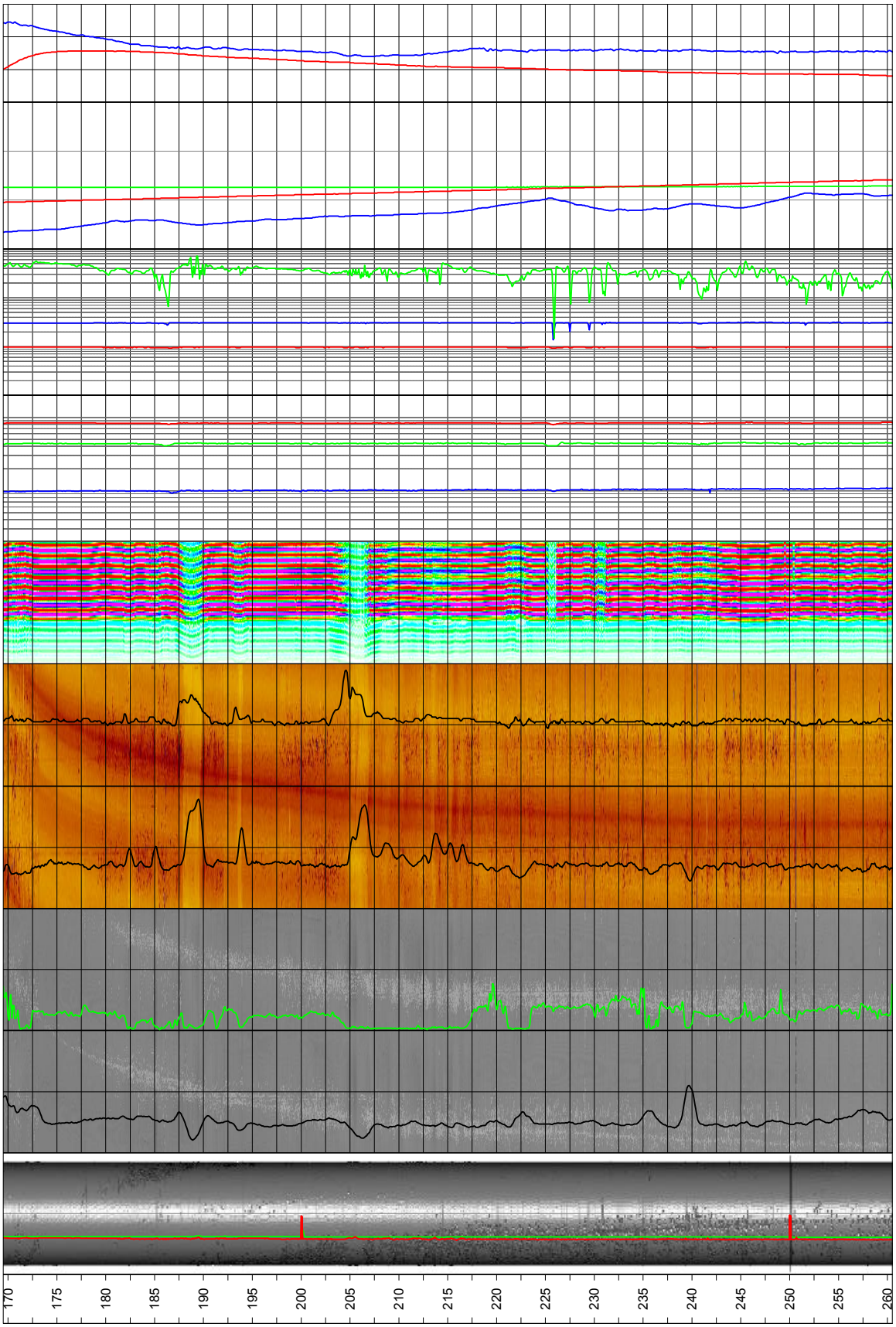
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250
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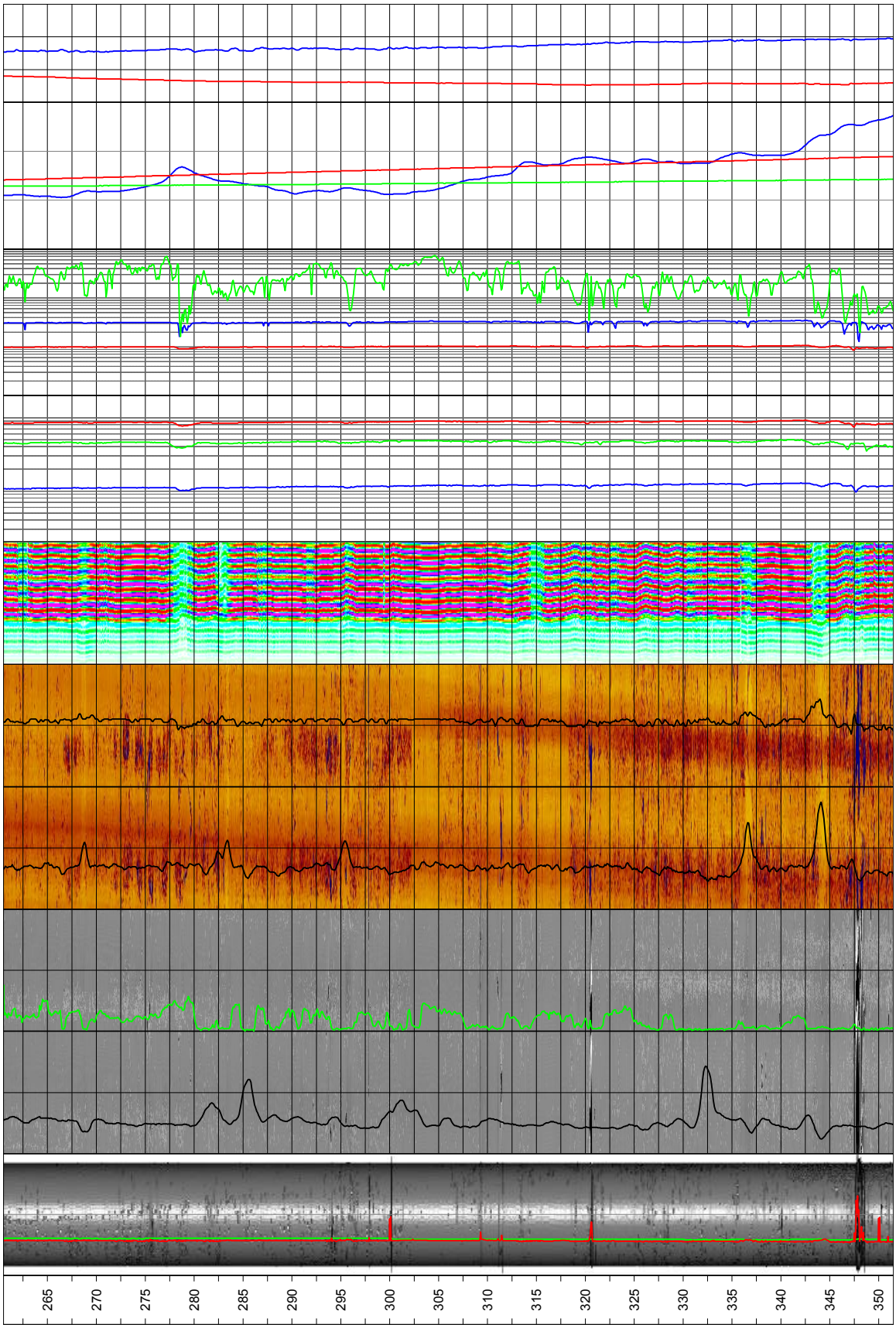
260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340
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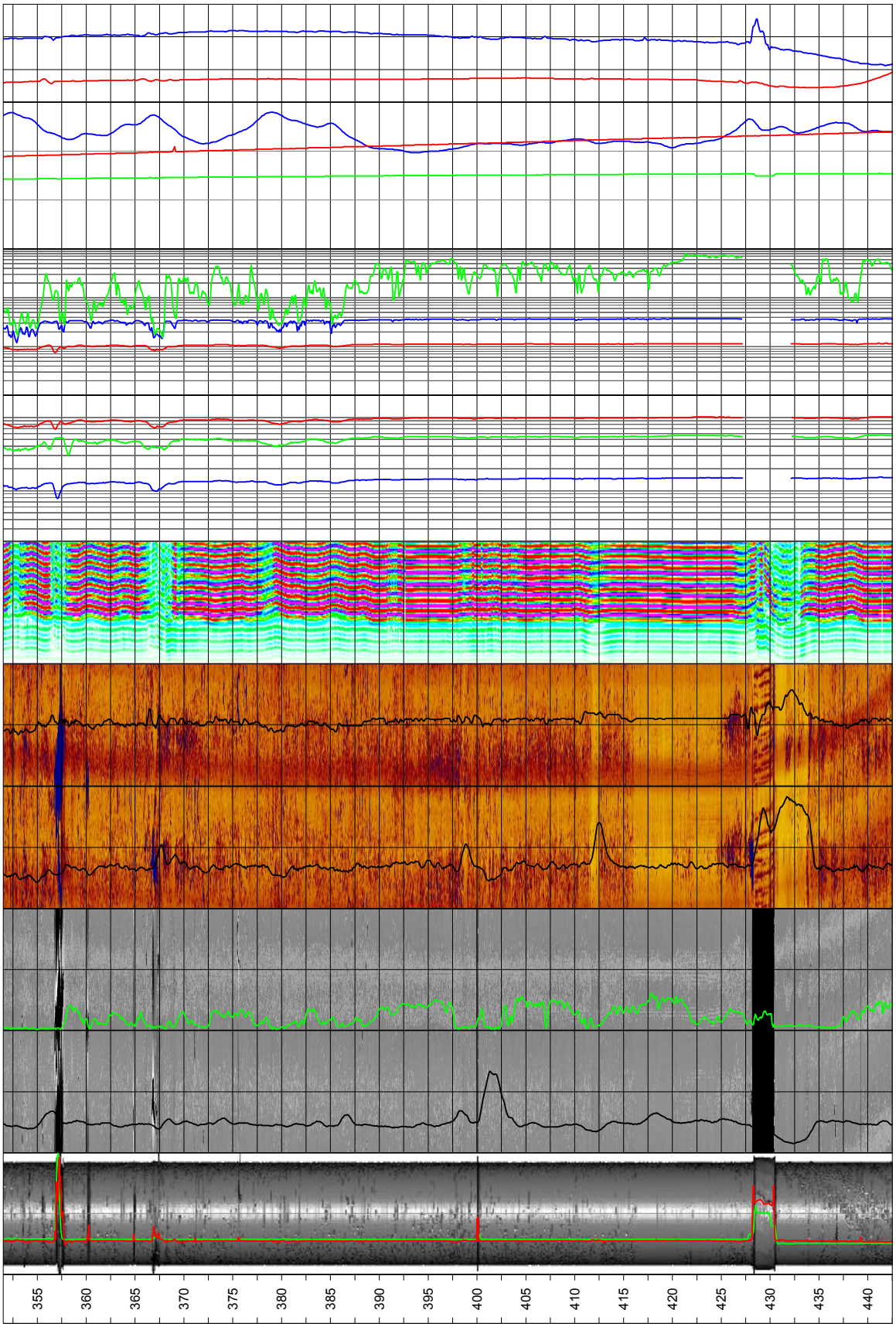
350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405
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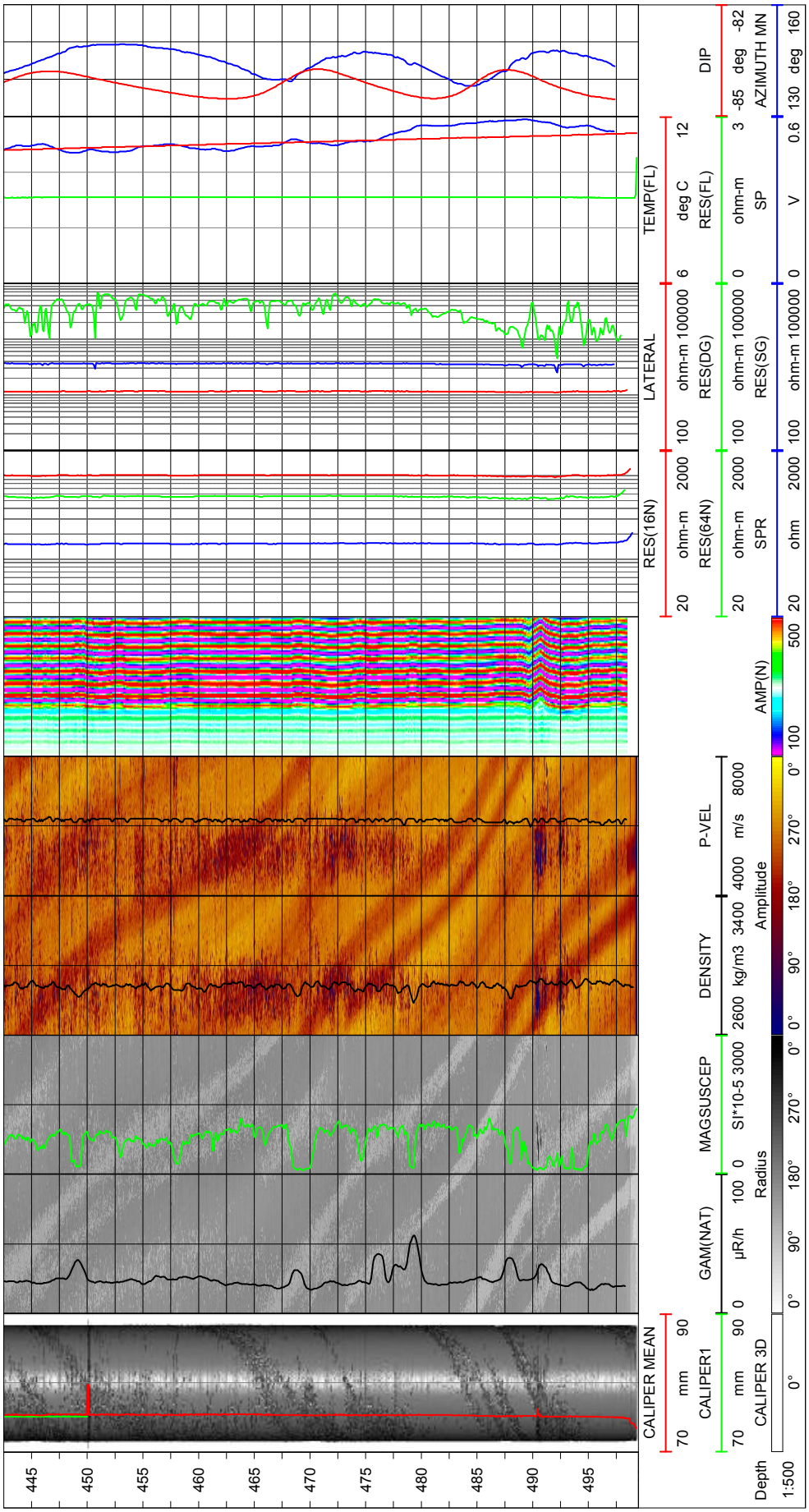
415
420
425
430
435
440


CALIPER MEAN
70 mm 90
CALIPER1
70 mm 90
CALIPER 3D
0° 0° 90° 180° 270° 0°
GAM(NAT)
0 µR/h 100
Radius
MAGSUSCEP
0 SI*10-5 3000
DENSITY
2600 kg/m3 3400
Amplitude
P-VEL
4000 m/s 8000
AMP(N)
100 500
RES(16N)
20 ohm-m 2000
RES(64N)
20 ohm-m 2000
SPR
20 ohm 2000
LATERAL
100 ohm-m 100000
RES(DG)
100 ohm-m 100000
RES(SG)
100 ohm-m 100000
TEMP(FL)
6 deg C 12
RES(FL)
0 ohm-m 3
SP
0 V 0.6
DIP
-85 deg -82
AZIMUTH MN
0° 90° 180° 270° 0° 130 deg 160
Depth
1:500
445
450
455
460
465
470
475
480
485
490
495

Appendix 2

Borehole HFM36. Drawing no. 2.1. Borehole logs

Borehole No. HFM36

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

Northing: 6696504.03m Easting: 1630081.68m Elevation: 8.42m, RHB70

Diameter:	137mm
Reaming Diameter:	180mm
Outer Casing:	168mm
Inner Casing:	160mm
Casing Length:	12.06m
Borehole Length:	152.55m
Cone:	
Inclination at ground surface:	-58.91°
Azimuth:	256.61°m GN
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9139	mm
DENSITY	Gamma-gamma density	9139	kg/m³
RES(SG)	Focused guard log resistivity, 128 cm	9139	ohm-m
GAM(NAT)	Natural gamma	9072	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	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
RADIUS	360 degrees orientated acoustic radius	HiRAT	mm
AMPLITUDE	360 degrees orientated acoustic amplitude	HiRAT	-
THORIUM	Spectral gamma, Thorium component	9080	PPM
URANIUM	Spectral gamma, Uranium component	9080	PPM
POTASSIUM	Spectral gamma, Potassium component	9080	percent
RES(16N)	Normal resistivity 16 inch	8144	ohm-m
RES(64N)	Normal resistivity 64 inch	8144	ohm-m
LATERAL	Lateral resistivity	8144	ohm-m
SPR	Single point resistivity	8144	ohm
SP	Self Potential	8144	V

Rev.	Date	Drawn by	Control	Approved
0	2006-12-14	JRI	UTN	UTN

Job 547310A

Scale 1:500

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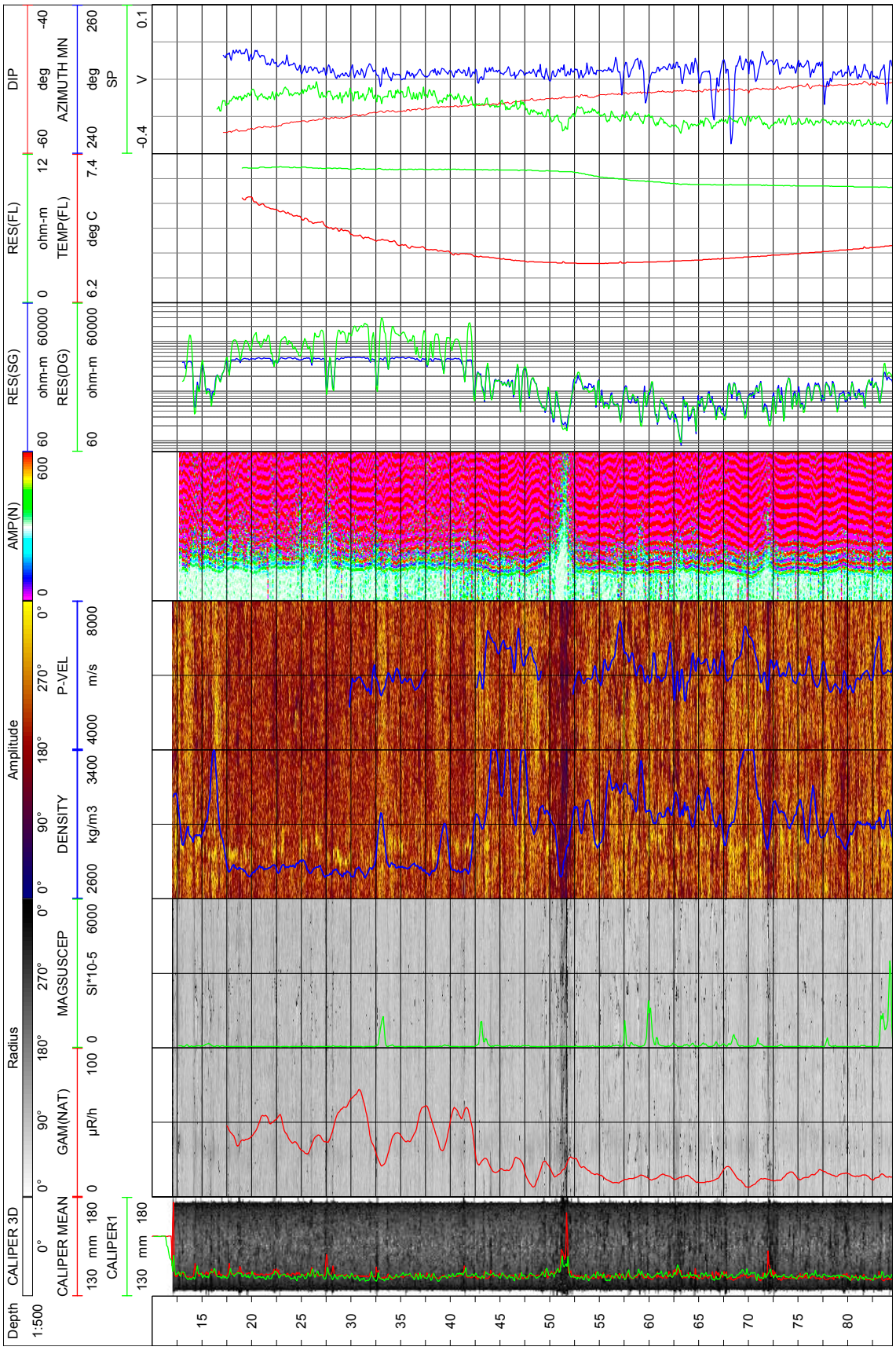
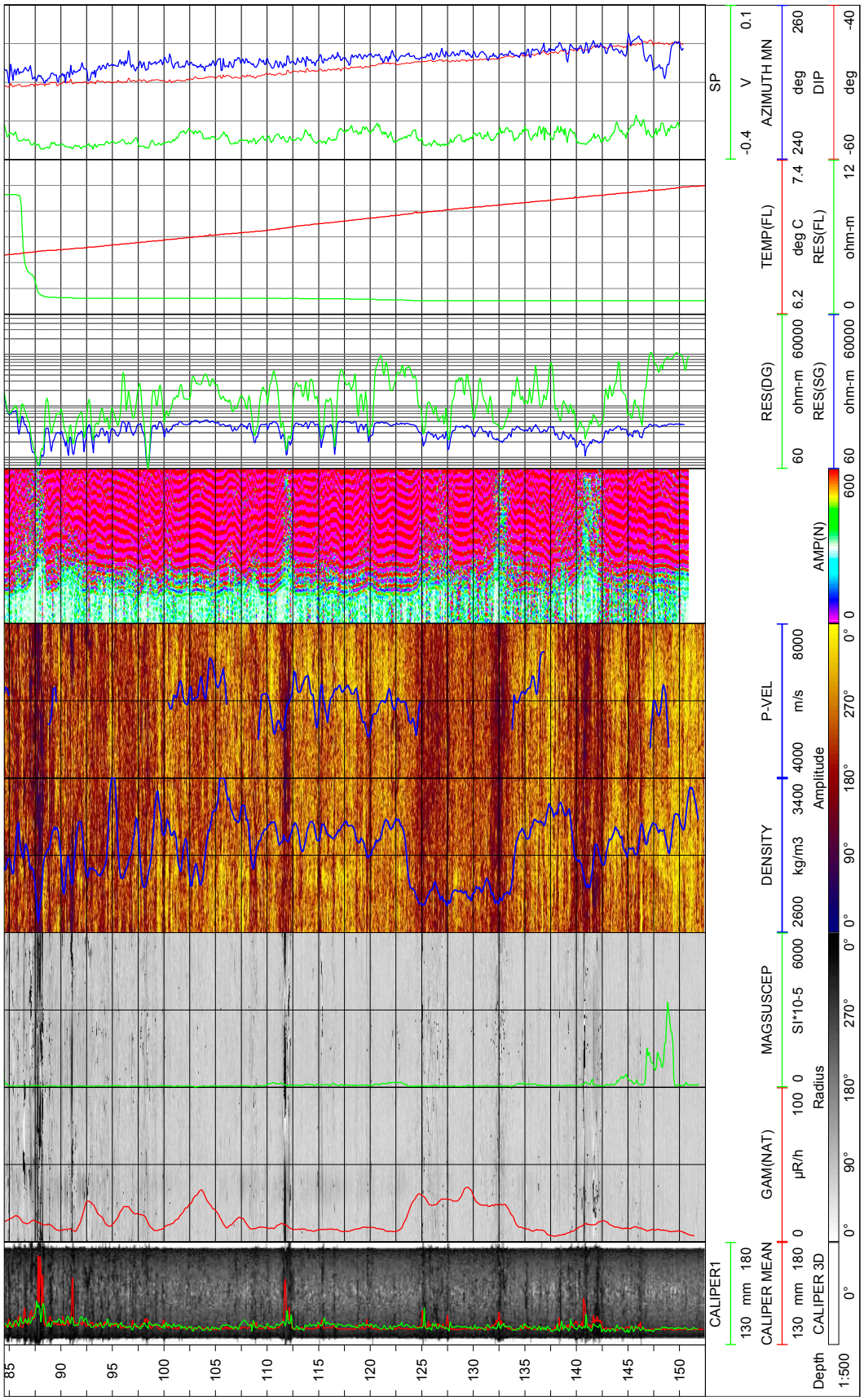
SKB geophysical borehole logging
Borehole HFM36

Presentation

Filename: HFM36_Presentation.wcl

Drawing no.: **2.1**


Depth
1:500
CALIPER 3D
0° 0° 90°
CALIPER MEAN
130 mm 180
CALIPER1
130 mm 180
Radius
180° 270° 0°
GAM(NAT)
0 µR/h 100
MAGSUSCEP
0 SI*10-5 6000
Amplitude
0° 0° 90°
DENSITY
2600 kg/m3 3400
180° 270° 0°
P-VEL
4000 m/s 8000
AMP(N)
0 600
RES(SG)
60 ohm-m 60000
RES(DG)
60 ohm-m 60000
RES(FL)
0 ohm-m 60000
TEMP(FL)
6.2 deg C 7.4
DIP
12 -60 240 deg
AZIMUTH MN
-40 deg 260
SP
-0.4 V 0.1
15
20
25
30
35
40
45
50
55
60
65
70
75
80


Depth
1:500
CALIPER 3D
0° 0° 90° 180° 270° 0°
CALIPER MEAN
130 mm 180
CALIPER1
130 mm 180
GAM(NAT)
0 µR/h 100
Radius
MAGSUSCEP
0 SI*10-5 6000
DENSITY
2600 kg/m3 3400
Amplitude
P-VEL
4000 m/s 8000
AMP(N)
0° 0° 90° 180° 270° 0°
RES(DG)
60 ohm-m 60000
RES(SG)
60 ohm-m 60000
TEMP(FL)
6.2 deg C 7.4
RES(FL)
0 ohm-m 12
AZIMUTH MN
240 deg 260
DIP
-60 deg -40
SP
-0.4 V 0.1
85
90
95
100
105
110
115
120
125
130
135
140
145
150

Appendix 3

Borehole HFM37. Drawing no. 3.1. Borehole logs

Borehole No. HFM37

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

Northing: 6696592.43m Easting: 1630137.37m Elevation: 11.39m, RHB70

Diameter:	138.5-141mm
Reaming Diameter:	180mm
Outer Casing:	168mm
Inner Casing:	160mm
Casing Length:	9.07m
Borehole Length:	191.75m
Cone:	
Inclination at ground surface:	-59.15°
Azimuth:	41.35°
Comments:	

Borehole logging programme

Name	Description	Tool	Unit
CALIPER1	Caliper, 1-arm	9139	mm
DENSITY	Gamma-gamma density	9139	kg/m³
RES(SG)	Focused guard log resistivity, 128 cm	9139	ohm-m
GAM(NAT)	Natural gamma	9072	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	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
RADIUS	360 degrees orientated acoustic radius	HiRAT	mm
AMPLITUDE	360 degrees orientated acoustic amplitude	HiRAT	-
THORIUM	Spectral gamma, Thorium component	9080	PPM
URANIUM	Spectral gamma, Uranium component	9080	PPM
POTASSIUM	Spectral gamma, Potassium component	9080	percent
RES(16N)	Normal resistivity 16 inch	8144	ohm-m
RES(64N)	Normal resistivity 64 inch	8144	ohm-m
LATERAL	Lateral resistivity	8144	ohm-m
SPR	Single point resistivity	8144	ohm
SP	Self Potential	8144	V

Rev.	Date	Drawn by	Control	Approved
0	2007-01-11	JRI	UTN	UTN

Job 547310A

Scale 1:500

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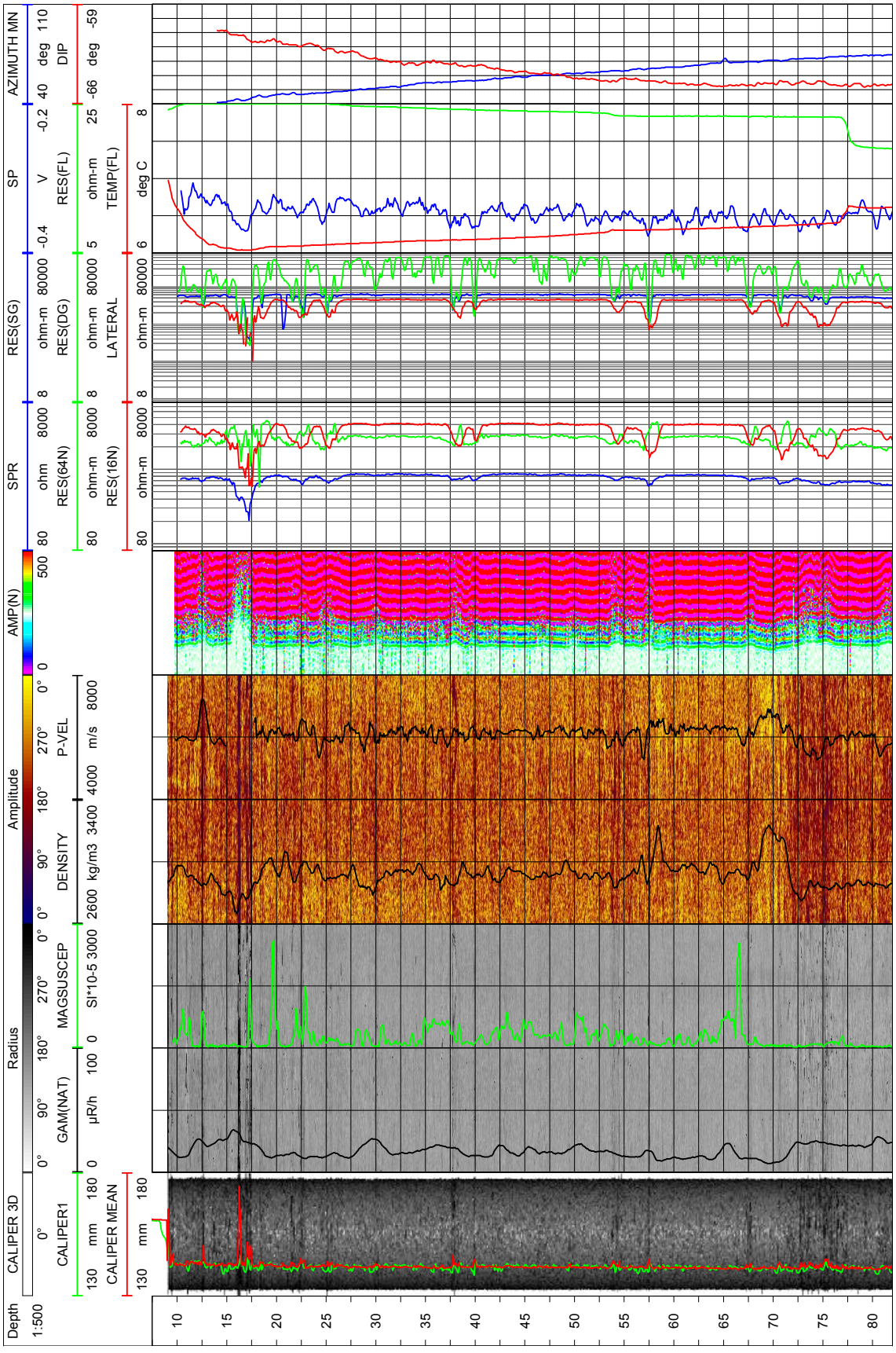
SKB geophysical borehole logging
Borehole HFM37

Presentation

Filename: HFM37_Presentation.wcl

Drawing no.: **3.1**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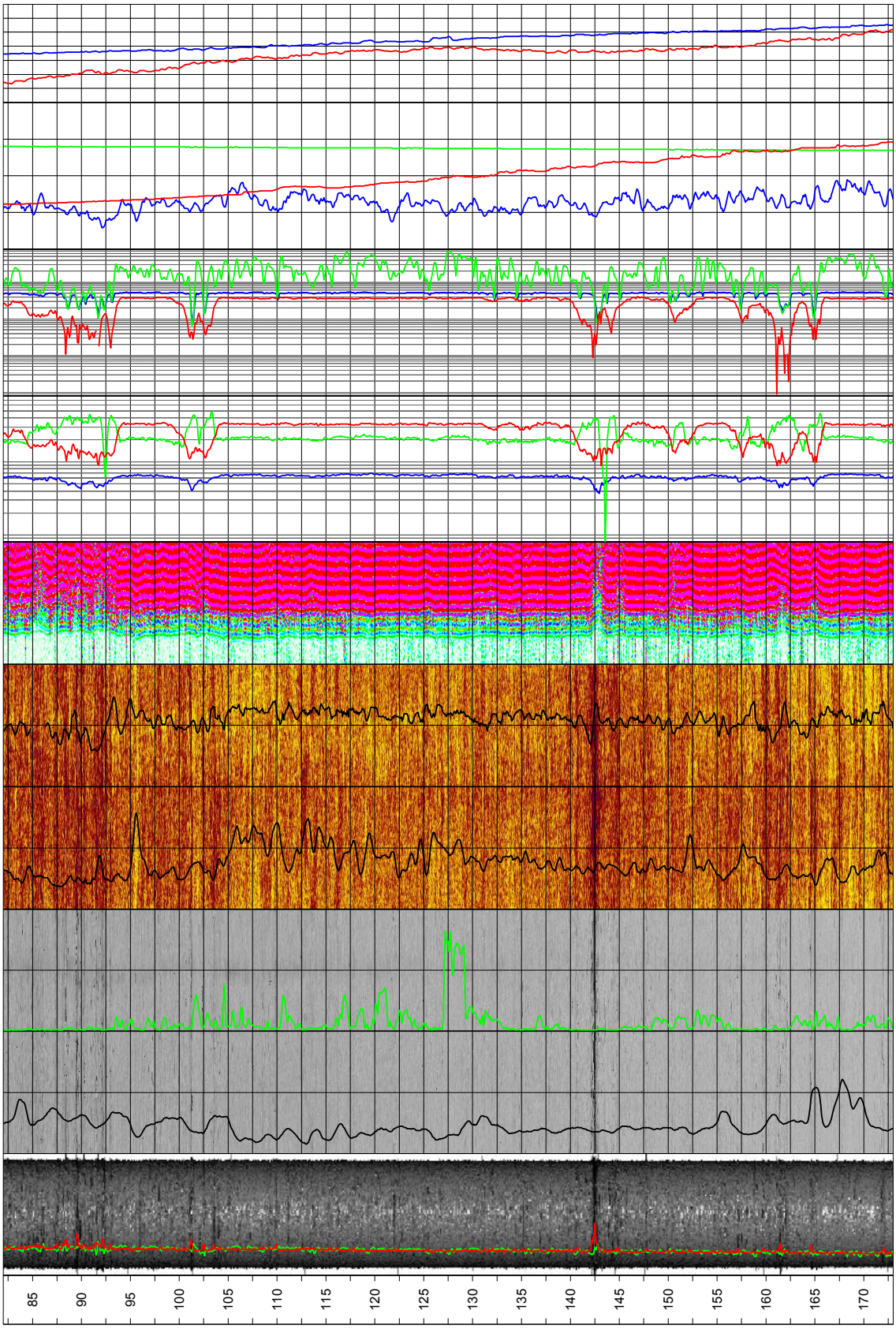
1:500
CALIPER 3D
0° 90° 180° 270° 0°
130 mm 180
CALIPER1
130 mm 180
CALIPER MEAN
Radius
0° 90° 180° 270° 0°
0 µR/h 100
GAM(NAT)
Amplitude
0° 90° 180° 270° 0°
0 SI*10-5 3000
MAGSUSCEP
2600 kg/m3 3400
DENSITY
4000 m/s 8000
P-VEL
AMP(N)
0° 500
SPR
80 ohm 8000
RES(64N)
80 ohm-m 8000
RES(16N)
80 ohm-m 8000
RES(SG)
8 ohm-m 80000
RES(DG)
8 ohm-m 80000
LATERAL
8 ohm-m 80000
SP
-0.4 V -0.2
RES(FL)
6 deg C 8
TEMP(FL)
AZIMUTH MN
40 deg 110
DIP
25 -66 deg -59
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80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90
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100
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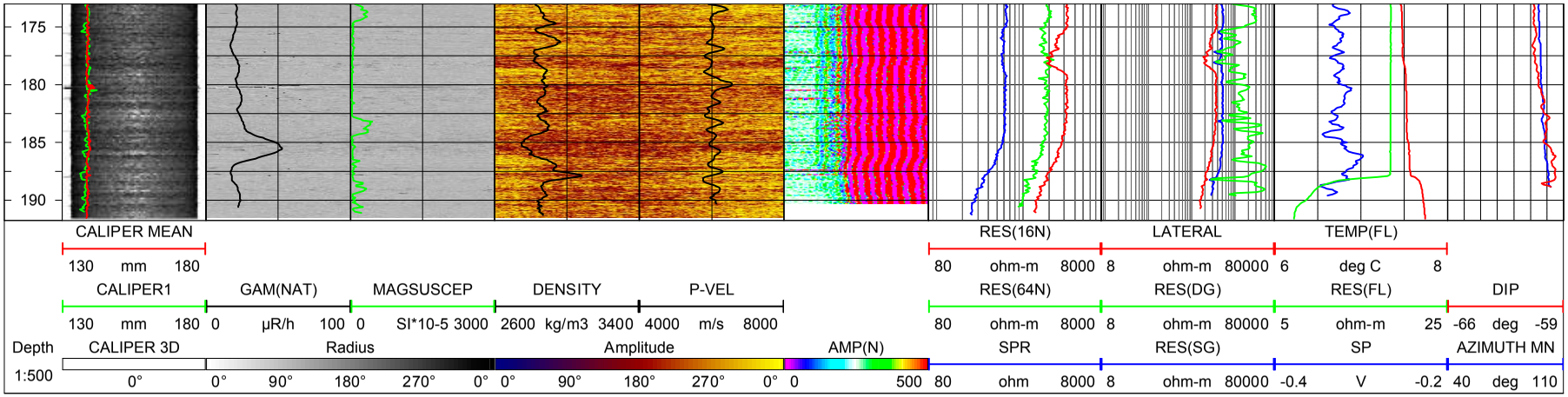
110
115
120
125
130
135
140
145
150
155
160
165
170


175
180
185
190
CALIPER MEAN
130 mm 180
CALIPER1
130 mm 180
GAM(NAT)
0 µR/h 100
MAGSUSCEP
0 SI*10-5 3000
DENSITY
2600 kg/m3 3400
P-VEL
4000 m/s 8000
Depth
1:500
CALIPER 3D
0°
Radius
0° 90° 180° 270° 0°
Amplitude
0° 90° 180° 270° 0°
AMP(N)
0 500
RES(16N)
80 ohm-m 8000
LATERAL
8 ohm-m 80000
TEMP(FL)
6 deg C 8
RES(64N)
80 ohm-m 8000
RES(DG)
8 ohm-m 80000
RES(FL)
5 ohm-m 25
DIP
-66 deg -59
SPR
80 ohm 8000
RES(SG)
8 ohm-m 80000
SP
-0.4 V -0.2
AZIMUTH MN
40 deg 110