

## **Forsmark site investigation**

# **Geophysical borehole logging using the antares dual-laterolog in KFM01A and KFM02A**

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May 2005

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*Keywords:* AP PF 400-04-079, Geophysical logging, Resistivity, KFM01A, KFM02A.

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

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## **Abstract**

Focused resistivity logging has been performed in the depth interval between 100 and 1000 m in boreholes KFM01A and KFM02A at the Forsmark site. These geophysical measurements were executed with modified Dual Laterolog-Tools produced by ANTARES Datensysteme GmbH, Germany. The main objective was to increase the measurement range of the resistivity measurements beyond c 50,000  $\Omega\text{m}$  as produced by the Century 9072 tool used by Ramböll. The ANTARES tool was calibrated up to 400,000  $\Omega\text{m}$ . Before the focused resistivity logging was started, depth and resistivity calibrations were executed. The depth corrections were realised by comparing Natural Gamma measurements performed by Ramböll with measurements with the ANTARES tool.

# Sammanfattning

Fokuserad resistivitetsloggning har utförts i djupintervallet mellan 100 och 1000 m i borrhål KFM01A och KFM02A i Forsmarks undersökningsområde. De geofysiska mätningarna utfördes med en modifierad Dual-Laterolog-sond tillverkad av ANTARES Datensysteme GmbH, Tyskland. Huvudsyftet med loggningen var att öka mätområdet till över de ca 50 000  $\Omega\text{m}$  som Rambölls Century 9072-sond klarar. ANTARES-sonden kalibrerades upp till 400 000  $\Omega\text{m}$ . En djup- och resistivitetskalibrering utfördes innan loggningen startades. Djupkorrigering utfördes genom jämförelser mellan Rambölls tidigare Naturlig Gamma-mätning och ANTARES-sondens.

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# 1 Introduction

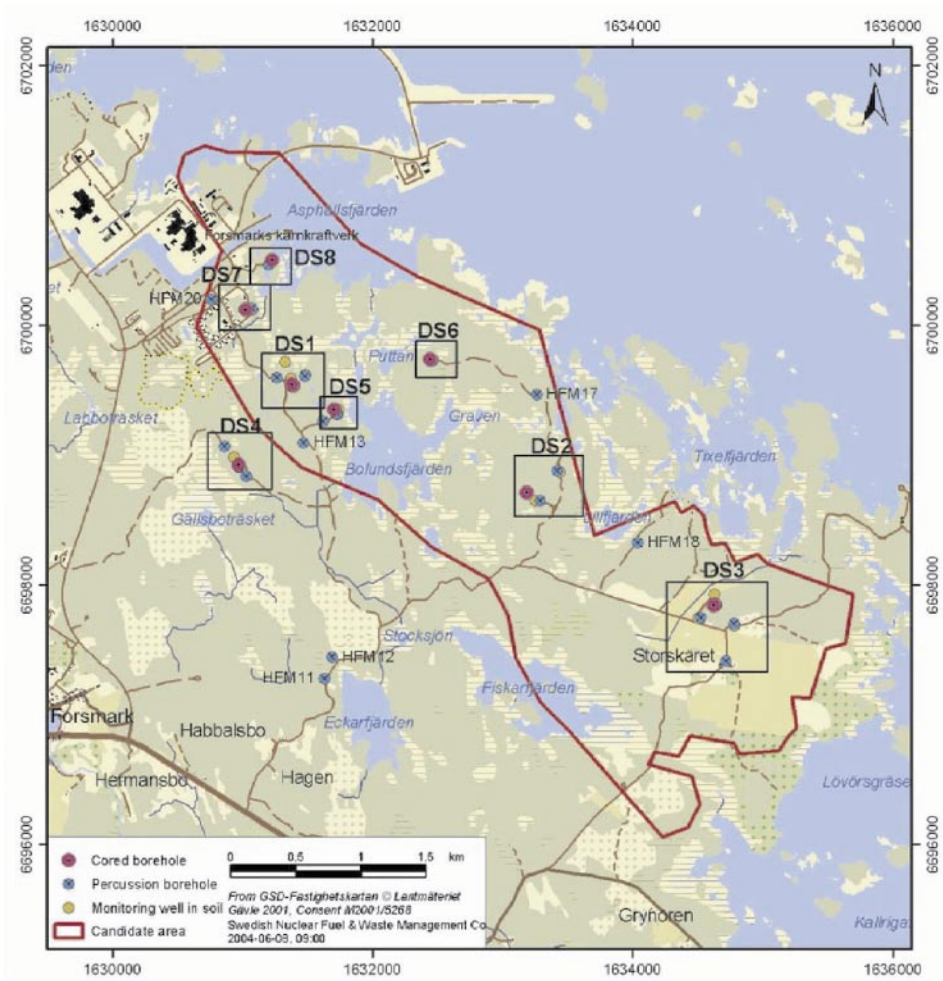
This document reports the data and results of focused resistivity logging, which is one of the activities performed within the site investigation at Forsmark. The work was carried out in accordance with SKB Activity Plan AP PF 400-04-079.

In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

The logging was performed on 2004-09-07 respectively 2004-09-08 in boreholes KFM01A and KFM02A at Forsmark, Sweden (see Figure 1-1). The data produced have been delivered to the SICADA database. They are traceable by the activity plan number AP PF 400-04-079.

**Table 1-1. Controlling documents for the performance of the activity.**

<b>Activity plan</b>	<b>Number</b>	<b>Version</b>
Determination of the Formation Factor using in-situ Resistivity data In KFM01A and KFM02A	AP PF 400-04-079	1.0
<b>Method descriptions</b>	<b>Number</b>	<b>Version</b>
Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning	SKB MD 600.004	1.0
Metodbeskrivning för geofysisk borrhålsloggning (in Swedish).	SKB MD 221.002	1.0



**Figure 1-1.** General overview of the Forsmark site investigation area with drill sites DS1–DS8. Borehole KFM01A is situated at DS1 and KFM02A at DS2.

## 2 Objective and scope

The main objective was to increase the measurement range of the resistivity measurements beyond c 50,000  $\Omega\text{m}$  as produced by the Century 9072 tool used by Ramböll /1/. The geophysical logging was realised to show high electrical formation-resistivities (max 400,000  $\Omega\text{m}$ ). In each borehole (boreholes KFM01A and KFM02A), one measurement was executed. The measured geophysical data are shown in Appendices 2 and 3.





## **4 Execution**

### **4.1 Preparations**

The used DLL-Tool was modified for these measurements at the Forsmark site by ANTARES Datensysteme GmbH Stuhr, Germany. The measuring range was increased from 40,000  $\Omega\text{m}$  to 400,000  $\Omega\text{m}$ . The geophysical measurements are based on a calibration for the interval between 1,000  $\Omega\text{m}$  and 20,000  $\Omega\text{m}$  with linear extrapolation to 400,000  $\Omega\text{m}$ .

### **4.2 Borehole logging**

In general the measurement procedures follow the SKB method description MD 221.002, version 1.0 (“Metodbeskrivning för geofysisk borrhålsloggning”). The logging programme in borehole KFM01A was executed 2004-09-07, and in borehole KFM02A 2004-09-08.

The DLL Tool measures focused rock resistivity with two electrode configurations, 19 cm and 91 cm (shallow and deep). In addition, temperature and natural gamma are measured. The logging equipment was cleaned according to SKB method description MD 600.004, version 1.0 (“Metodbeskrivning för rengöring av borrhålsutrustning och viss markbaserad utrustning”) before arriving at the site.

All data were recorded with 5 cm sample interval. The speed of the logging tool was in general 10 m/min.

### **4.3 Nonconformities**

None.

## 5 Results

This report includes the data and results of focused resistivity logging measured with Dual Laterolog in a depth interval between 100 and 1000 m in boreholes KFM01A and KFM02A at the Forsmark site. The results of the Dual Laterolog measurements are presented as plots and data files (see Appendices 2 and 3).

During the first DLL measurement in borehole KFM01A it was established that the Resistivity-Deep-Tool recorded irregular data. The Resistivity-Deep-Tool data only achieved 50% of the Resistivity-Shallow-Tool data. After the DLL-measurement, the raw data were sent to ANTARES Datensysteme GmbH Stuhr, Germany, the producer of used DLL-Tool, for examination. ANTARES verified that the Resistivity-Shallow-Tool worked correctly but needed to be recalibrated, and the R-Deep data were corrected afterwards in Germany.

## References

- /1/ **Nielsen U T, Ringgaard J, 2003.** Forsmark site investigation. Geophysical borehole logging in boreholes KFM01A, HFM01 and HFM02. SKB P-03-103. Svensk Kärnbränslehantering AB.

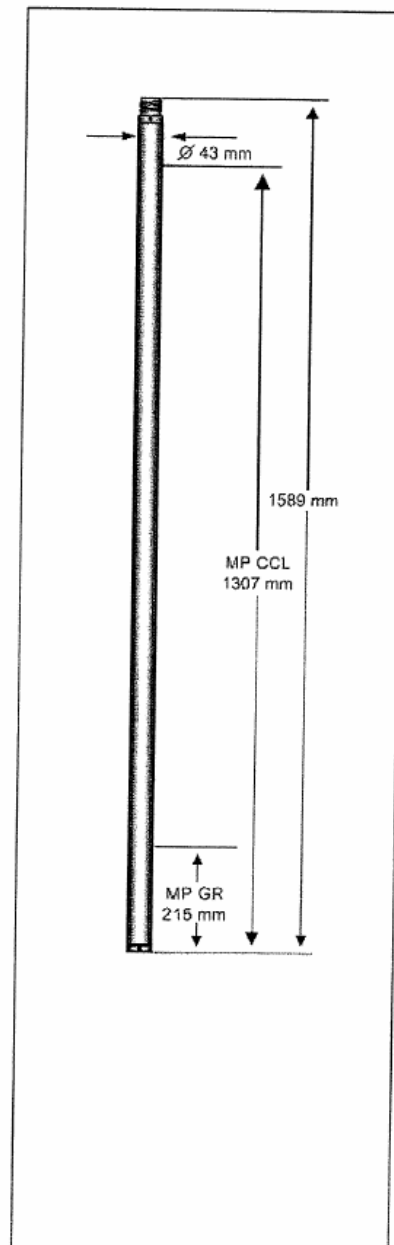
## Measurement equipment

Appendix 1



### ADTS/GR924 Digital Telemetry Sub/Gamma Ray/CCL/ACC

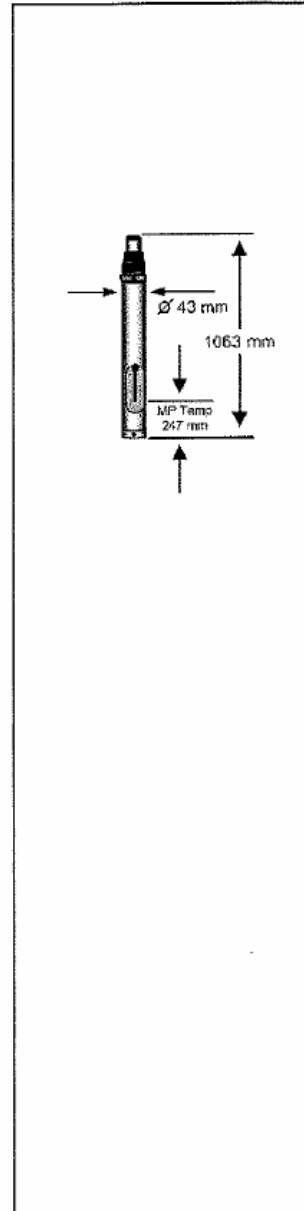
Diameter:	43 mm
Rec. Min. Hole Diameter:	78 mm
Rec. Max. Hole Diameter:	NA
Length:	appr. 1,589 m
Mass:	appr. 8 kg
Maximum Temperature:	125°C
Maximum Pressure:	80 MPa
Rec. Logging Speed:	NA
Data transmission:	digital
Cable requirements:	four conductor
Operating Voltage (at cablehead):	90 VDC
Top connector:	GO 4 conductor
Bottom connector:	ANTARES 14 pin
GR range:	0 to 3000 API
Accuracy:	3% of reading
GR	
Detector Type:	Nal
Measure Point:	
GR	215 mm
CCL	1307 mm
Recorded Curves:	Cablehead voltage Instrument temperature Gamma Ray CCL ACC min. ACC max. ACC avg.





## ATEMP1613 Temperature Instrument (in-line)

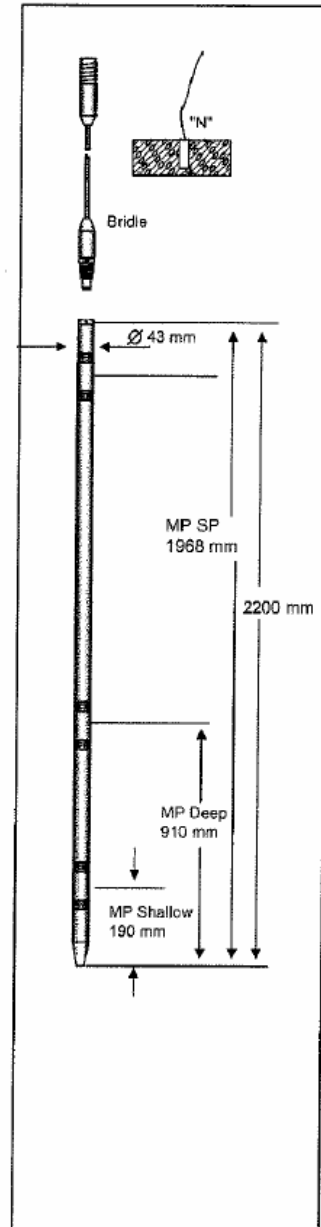
Diameter:	43 mm
Rec. Minimum Hole Diameter:	80 mm
Length:	1.063 m
Mass:	2.4 kg
Maximum Temperature:	130° C
Maximum Pressure:	80 MPa
Maximum Logging Speed:	6 m/min
Data transmission:	digital
Cable requirements:	ANTARES Toolbus Telemetry
Operating Voltage (at cablehead):	90 VDC
Top connector:	ANTARES 14pin
Bottom connector:	ANTARES 14pin
Temperature Measure Point:	247 mm
Sensor Type:	PT1000
Measuring range:	0 – 130°C
Accuracy:	1°C
Resolution:	0.05°C
Repeatability:	0.2°C
Recorded Curves:	Cablehead voltage Instrument temperature Borehole temperature in °C Differential temperature in °C





# ADLL1126 Slimhole Dual Laterolog3/SP

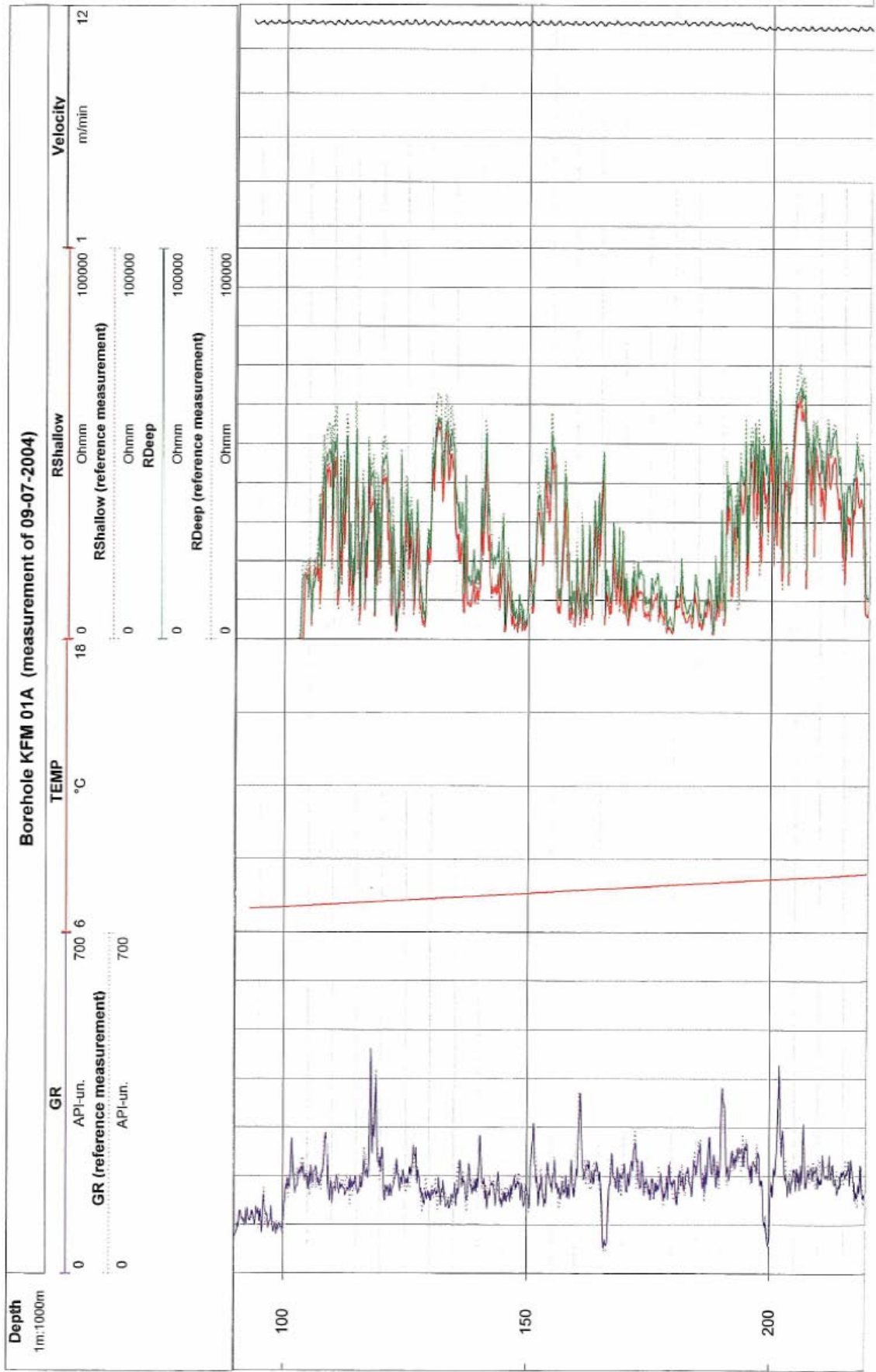
Diameter:	43 mm
Rec. Minimum Hole Diameter:	78 mm
Rec. Maximum Hole Diameter:	250 mm
Length (w/o bridle):	appr. 2.20 m
Mass:	appr. 16 kg
Maximum Temperature:	125°C
Maximum Pressure:	80 MPa
Rec. Logging Speed:	25 m/min
Cable requirements:	four conductor and bridle
Data Transmission:	digital
Operating Voltage (at cablehead):	90 VDC
Top connector:	ANTARES 14 pin
Bottom connector:	none
Measuring Range:	0.2 to 40,000 Ohmm
Accuracy:	0.2 – 10.000 2 % 1 – 40.000 10 %
Depth of Investigation:	depending on Resistivity
Vertical Resolution:	0.08 m
Measure Point:	910 mm deep 190 mm shallow 1968 mm SP
Recorded Curves:	Instrument Temp. Voltage deep Voltage shallow Current deep Current shallow RLD Resistivity Laterolog deep RLS Resistivity Laterolog shallow SP
Combinability:	with standard ANTARES digital instruments
Accessories:	Verification box with cabling Bridle Isolation sub (for combination logging required)
Bridle:	
Length:	6 m
Top connector:	GO 4conductor
Bottom connector:	GO 4conductor

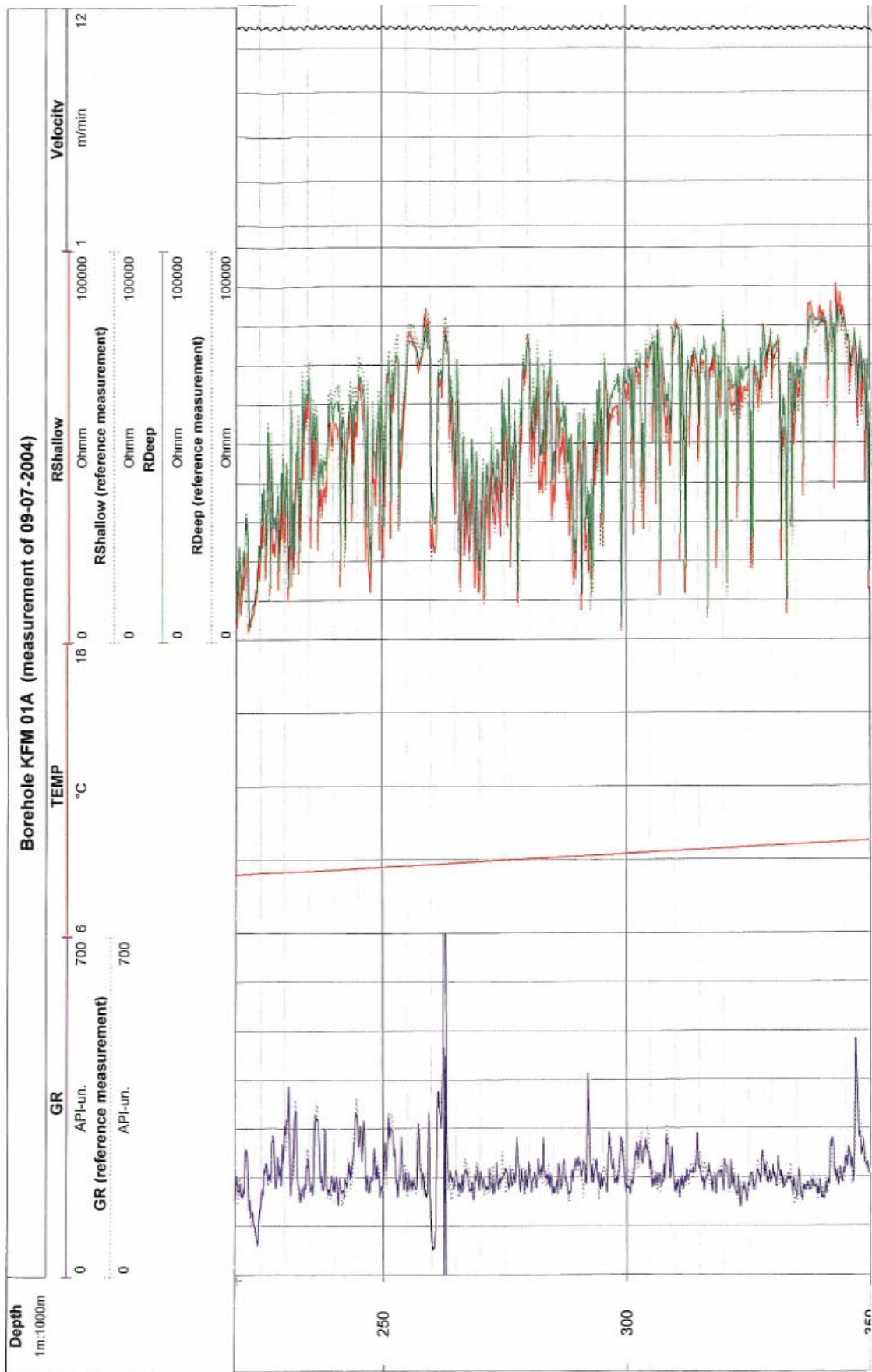


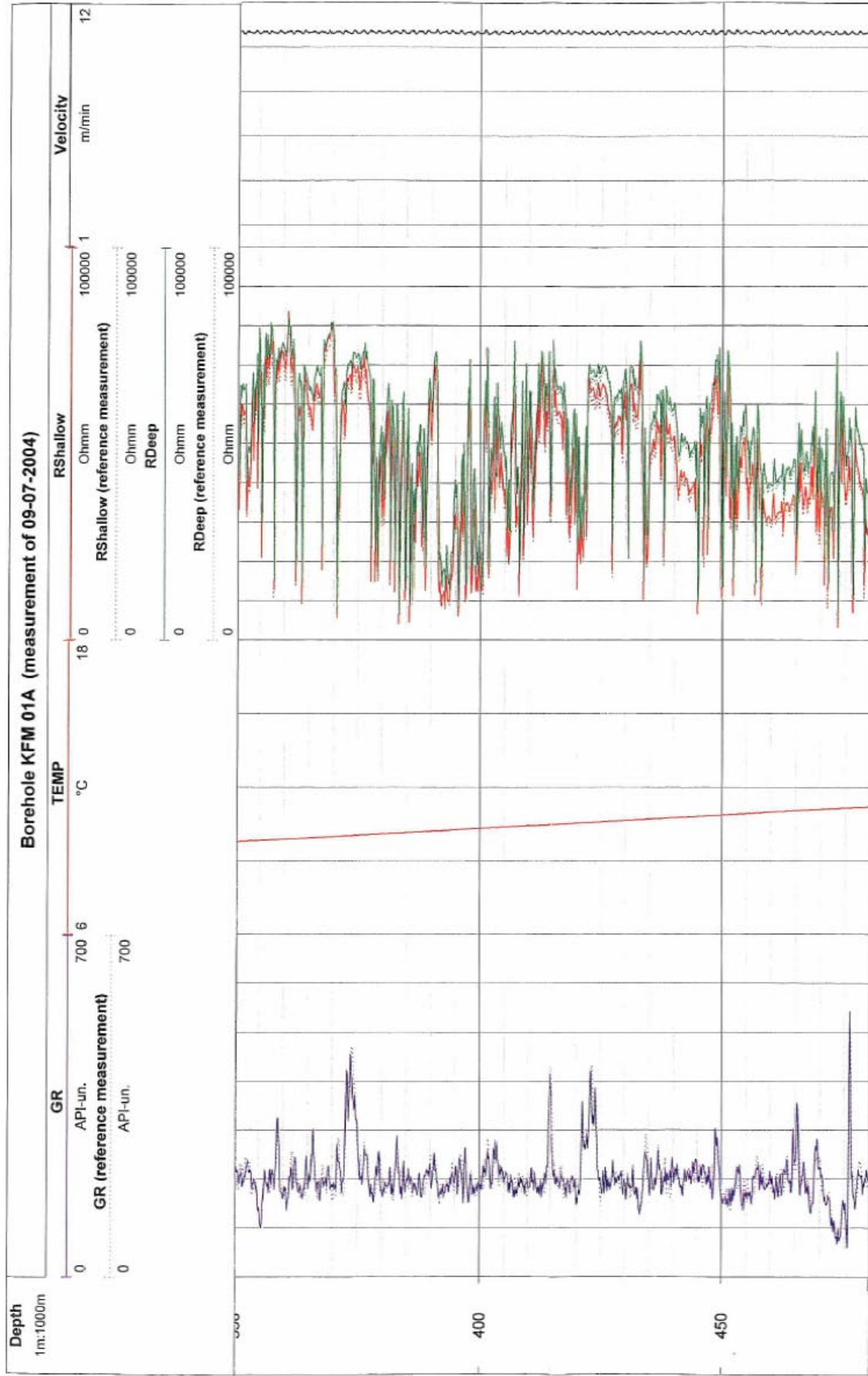
The specifications are subject to change without prior notice.

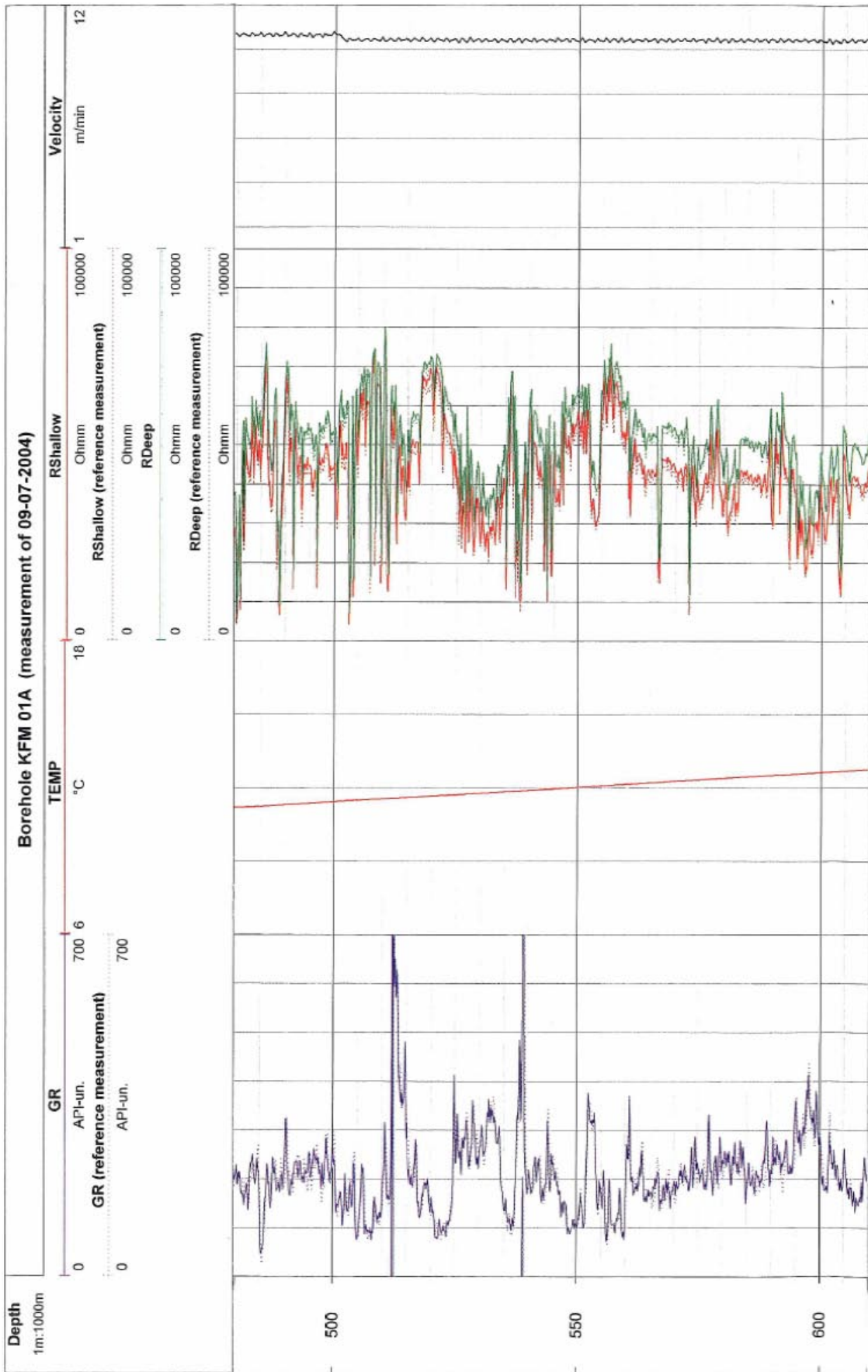




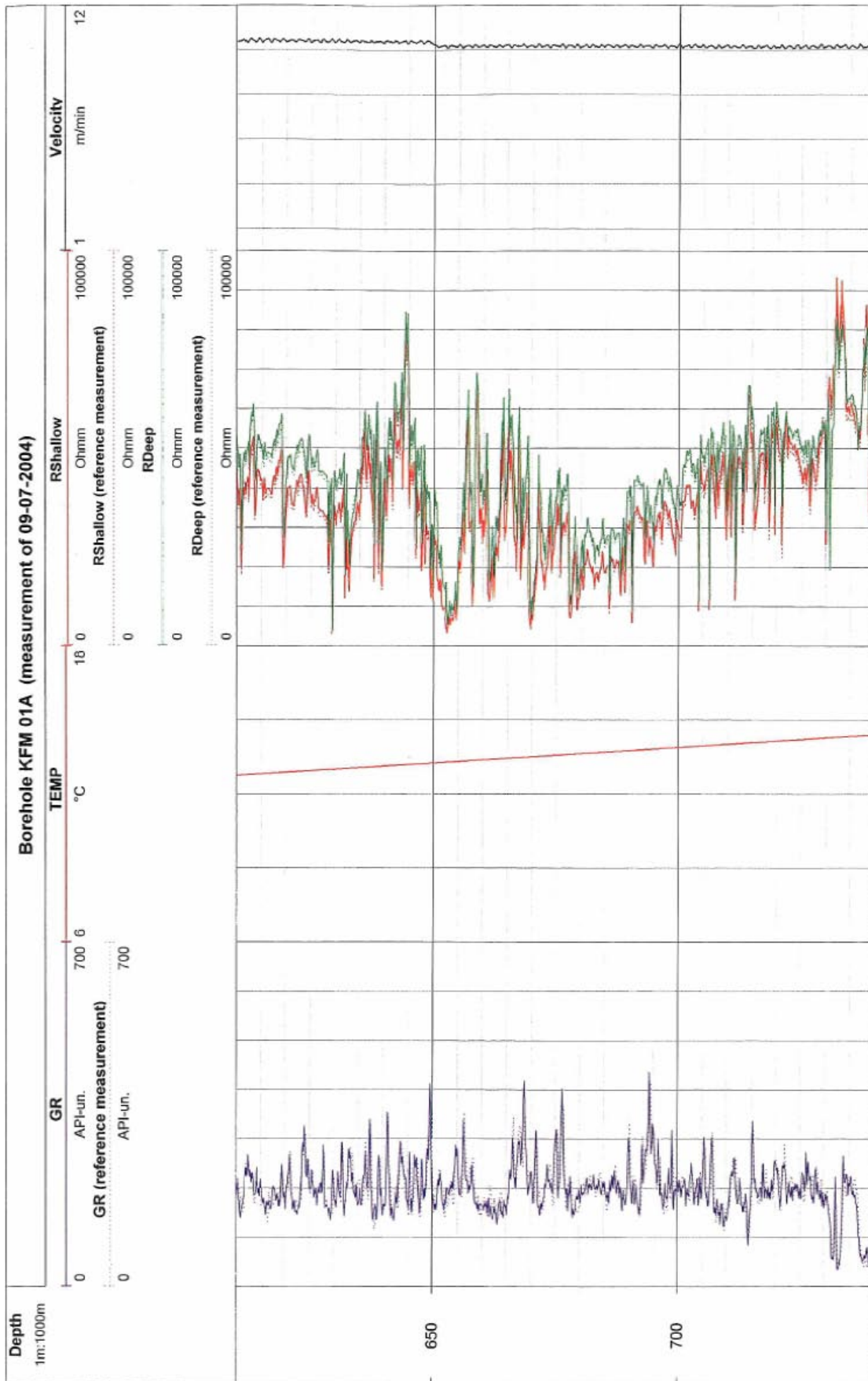


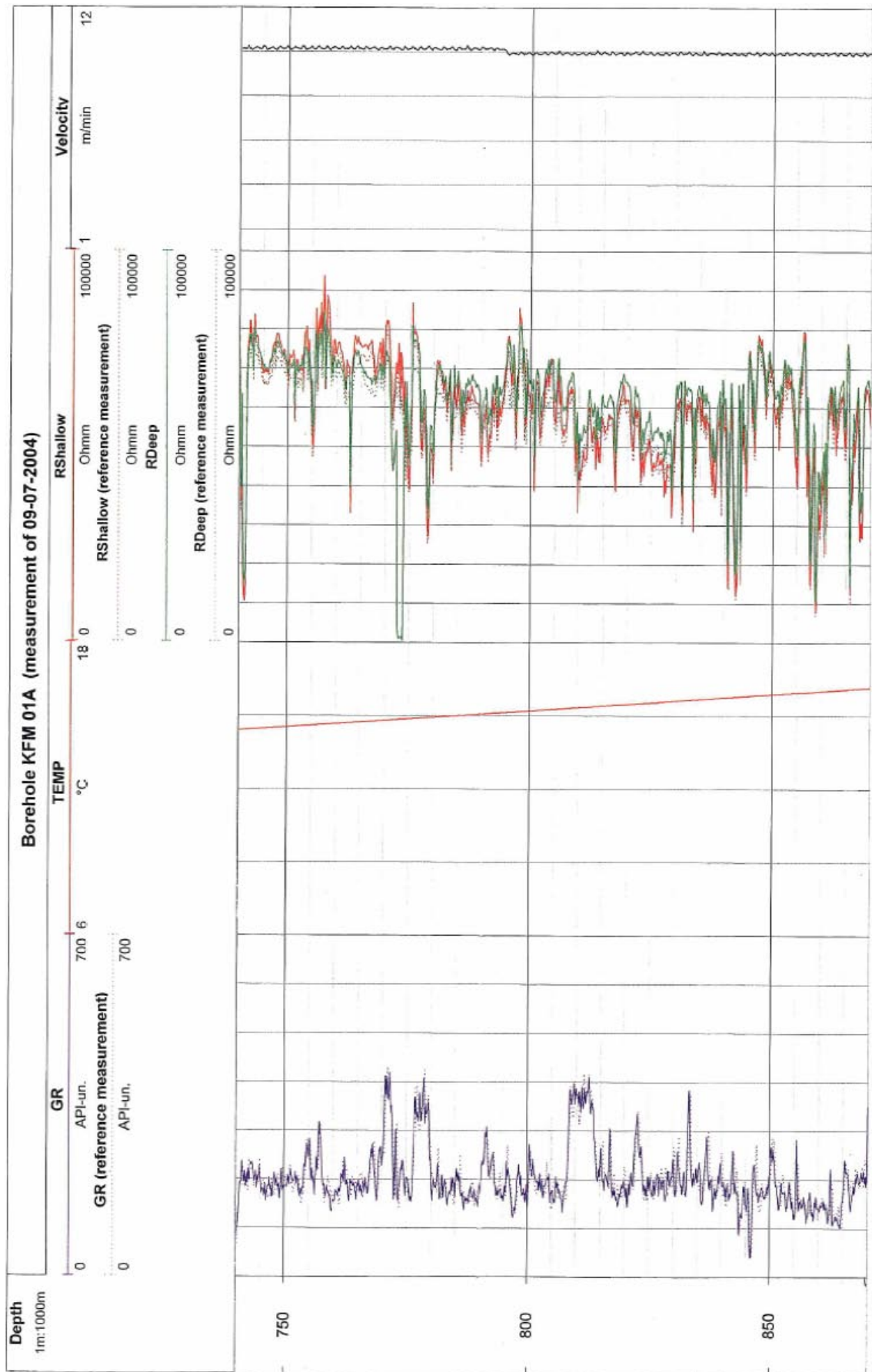


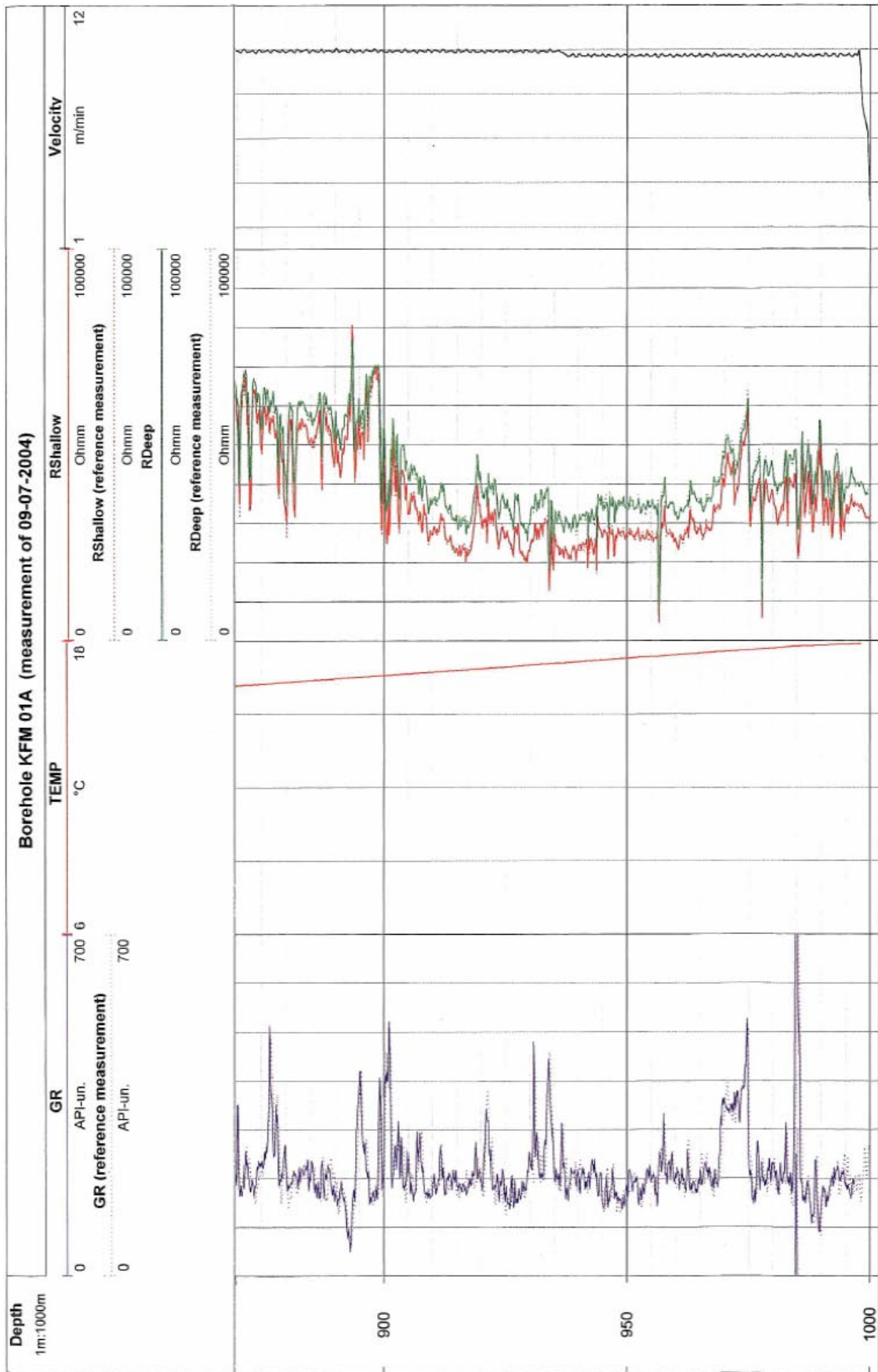











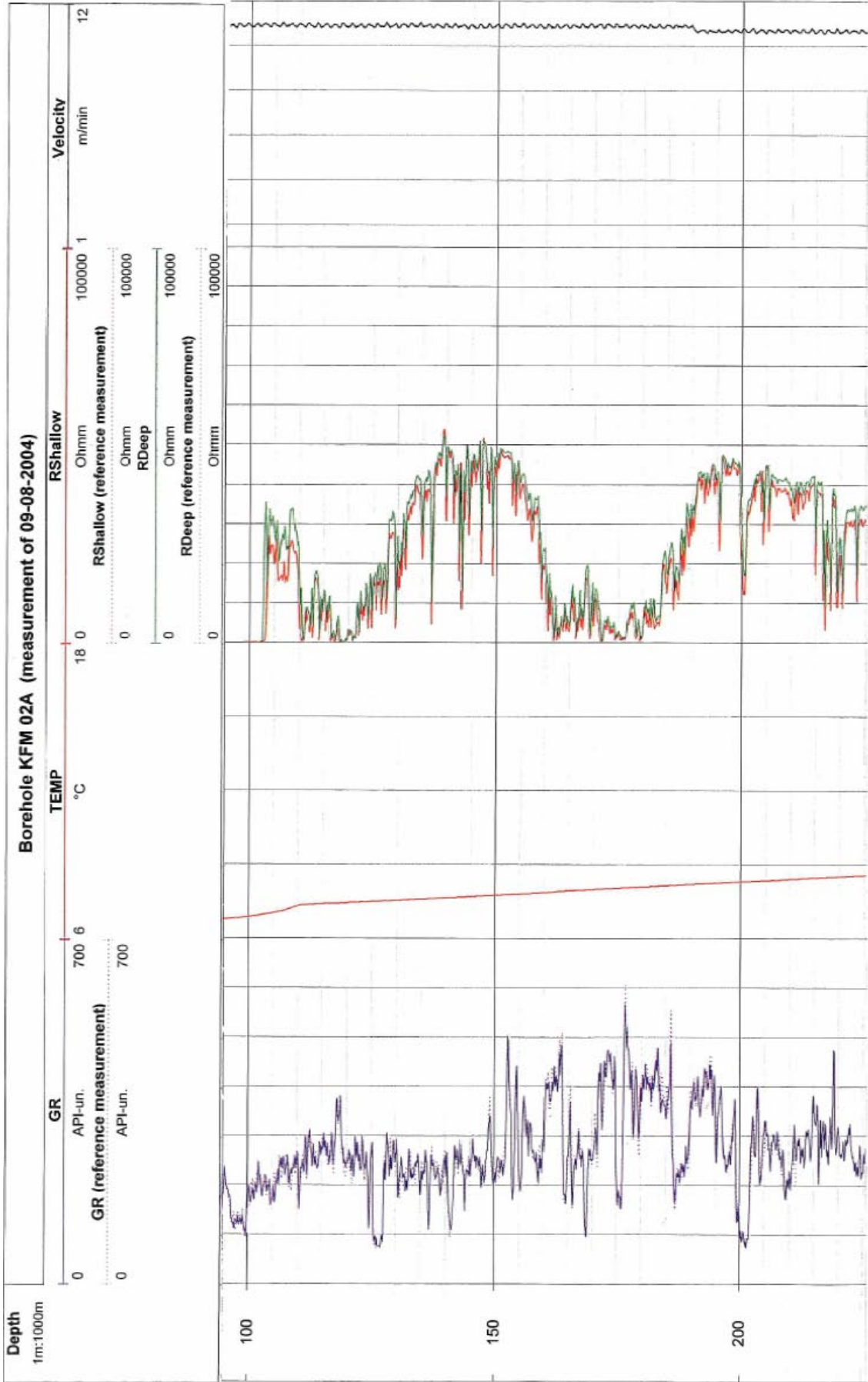


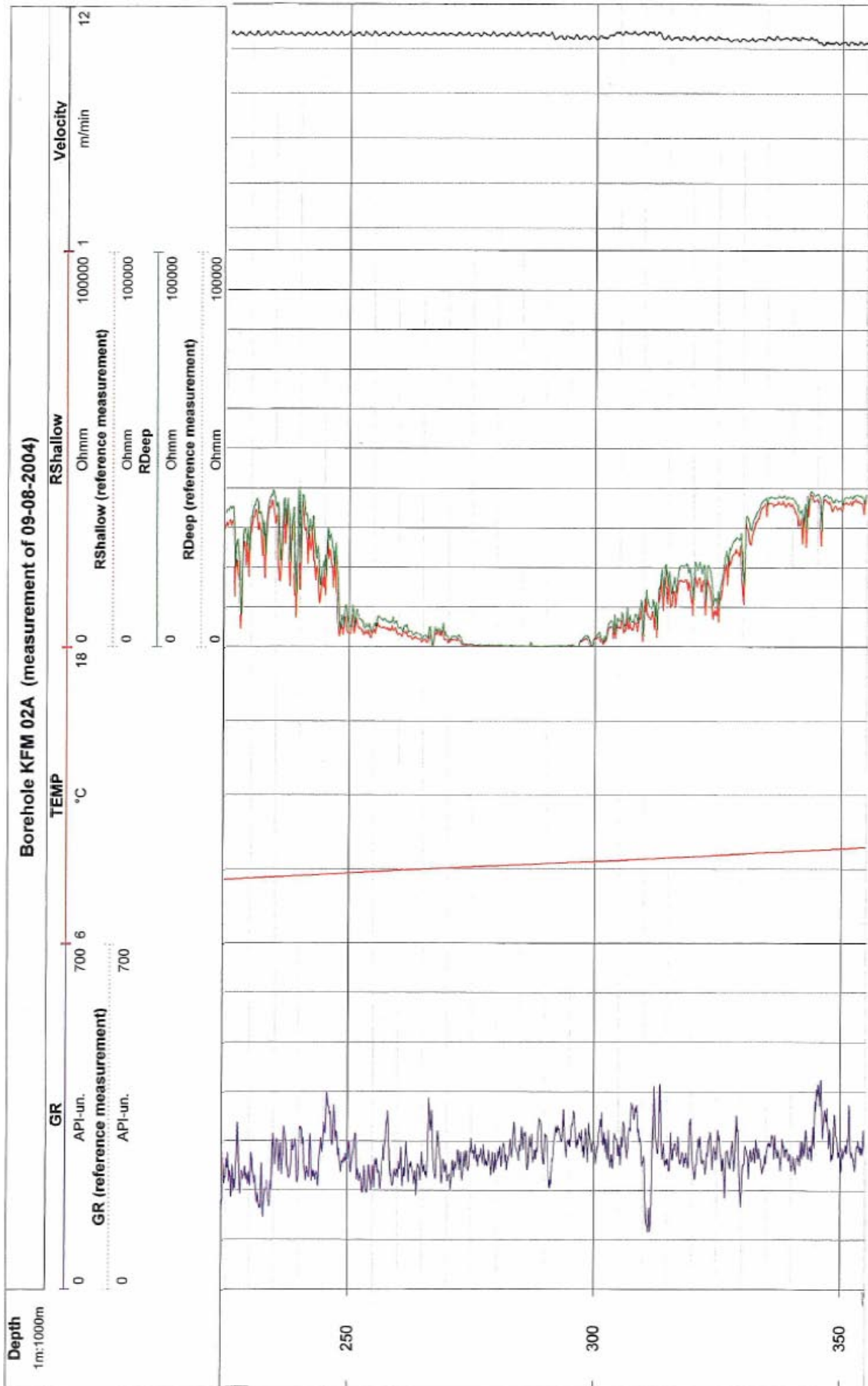
## Logging Report KFM02A

 <b>Gesellschaft für Bohrlochmessungen mbH</b> BLM Gesellschaft für Bohrlochmessungen mbH Industriepark Straße A Nr. 1 D-39245 Gommern		Internet: www.blm-online.de E-mail: blm.gom@t-online.de Tel./Fax: 039200-7400 / -74019	
<b>Appendix: 7</b>			
<b>Well</b> KFM 02A		<b>Location / Project</b> Forsmark	
<b>Scope:</b> Dual Laterolog			
<b>COMPANY:</b> SKB Plattsundersökning Forsmark ORDER NO: 1409404 STATE: COUNTRY: Sweden		<b>DEPTH SCALE:</b> 1 : 1000	<b>REFERENCE POINT:</b> ground level
Log date	09-08-2004		
Run			
Depth driller	1002.44 m		
Depth logger	1000.5 m		
Bottom logged interval	1000.5 m		
Top logged interval	95 m		
Casing shoe-driller	102 m		
Casing shoe-logger			
Casing diameter	80 mm		
Drilling diameter	73 mm		
Type fluid in hole	water		
Level			
Density			
Salinity			
Max. rec. temp.			
<b>Measurements</b>	<b>Dual Laterolog (DLL)</b>		
Measuring equipment	BRG-KK 77		
Recorded by	H. Schröter / H. Probst		
Observer	Hr. Andersson		
Processed by	E. Kraft		
Date	09-29-2004		
<b>Remarks:</b> SKB order no.: AP PF 400-04-79 date of order: 08-19-2004			

Die Interpretation von Messergebnissen - gleich, ob unmittelbar durch elektronische Datenverarbeitung oder auf anderem Wege - durch Organe der BLM oder deren Erklärungsgehilfen erfolgt nach bestem Wissen und Gewissen. Da in diese Interpretation empirische Fakten und Modellvorstellungen einfließen, sind die Interpretationsergebnisse und daraus abgeleitete Schlussfolgerungen nicht unfehlbar und können von den Ergebnissen der Auswertung durch den Auftraggeber oder Dritte abweichen. Keinesfalls sollen solche Interpretationen oder daraus abgeleitete Schlussfolgerungen als einzige Grundlage für Entscheidungen über Bohrungen, Komplettierungen oder ähnliche Maßnahmen dienen, die die Sicherheit des Bohrunternehmens, der Bohranlage, des Personals oder der Umwelt gefährden. (Auszug aus den AGB der BLM GmbH)







**Borehole KFM 02A (measurement of 09-08-2004)**

