P-04-39

Forsmark site investigation

RAMAC and BIPS logging in borehole HFM11 and HFM12

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March 2004

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Keywords: BIPS, RAMAC, Radar, TV, Geophysical logging.

Contents

1 Introduction

This document reports data gained during geophysical logging, which is one of the activities performed within the site investigation at Forsmark. The logging operations presented here include borehole radar (RAMAC) and TV-logging (BIPS) and were carried out in the percussion drilled boreholes HFM11 and HFM12. The two boreholes are inclined (50 degrees from horizontal) and have a length of 182 and 210 metres respectively. The purpose of the boreholes was to investigate the Eckarfjärden fracture zone (see Figure 1-1 and 1-2). The radar and BIPS measurements in HFM11 were made from 10 m to a depth of approximately 180 m and in HFM12 from 10 to approximately 205 m.

The borehole radar measurements and BIPS measurements were conducted by Malå Geoscience AB / RAYCON during October 2003 according to activity plan AP PF 400-03-87 (SKB internal controlling document).

The applied investigation techniques comprised:

- Borehole radar with dipole radar antennas.
- Borehole TV logging with the so-called BIP-system (Borehole Image Processing System), which is a high resolution, side viewing, colour borehole TV system.

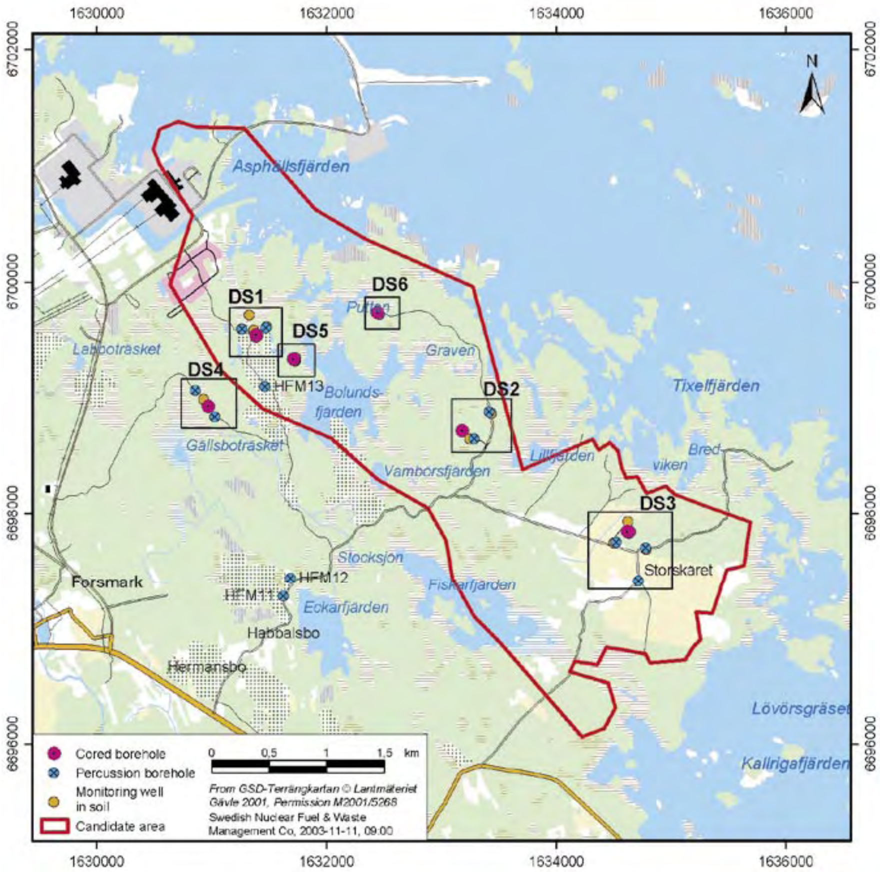


Figure 1-1. Drill sites in the Forsmark site investigation area.

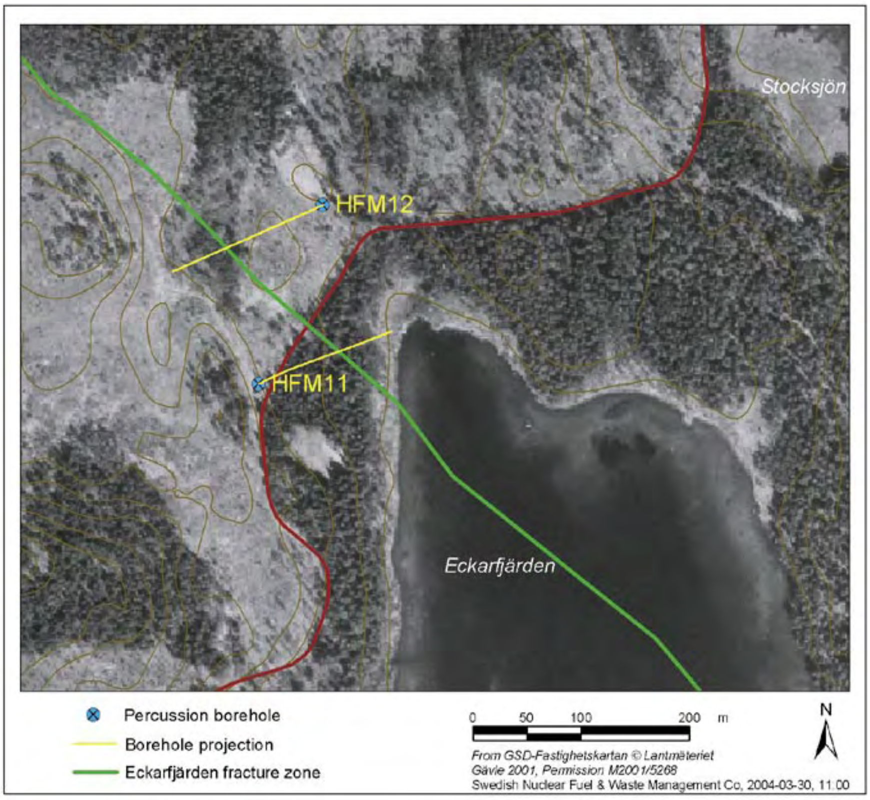


Figure 1-2. *Percussion borehole HFM11 and HFM12.*

2 Objective and scope

The objective of the radar- and BIPS-surveys was to achieve information on the borehole conditions (borehole wall) as well as on the rock mass around the borehole. Borehole radar was engaged to investigate the nature and the structure of the rock mass enclosing the boreholes, and borehole TV for geological surveying of the borehole including determination of fracture distribution and orientation.

This report describes the equipment used as well the measurement procedures and data gained.

3 Equipment

3.1 Borehole radar – RAMAC

The RAMAC GPR system owned by SKB is fully digital, and emphasis has been laid on high survey speed and smooth field operation. The system operates dipole and directional antennas (see Figure 3-1). A system description is given in the method description "Metodbeskrivning för borrhålsradar" (SKB MD 252.020, Version 1.0).

The borehole radar system consists of a transmitter and a receiver. During operation, an electromagnetic pulse, within the frequency range 20 to 250 MHz is emitted and penetrates the bedrock. The resolution and penetration of the radar waves depend on the antenna frequency used. A low antenna frequency results in lower resolution but higher penetration rate compared to a higher frequency. If a feature, e.g. a water-filled fracture, with anomalous electrical properties compared to the surrounding is encountered, the pulse is reflected back to the receiver and recorded.

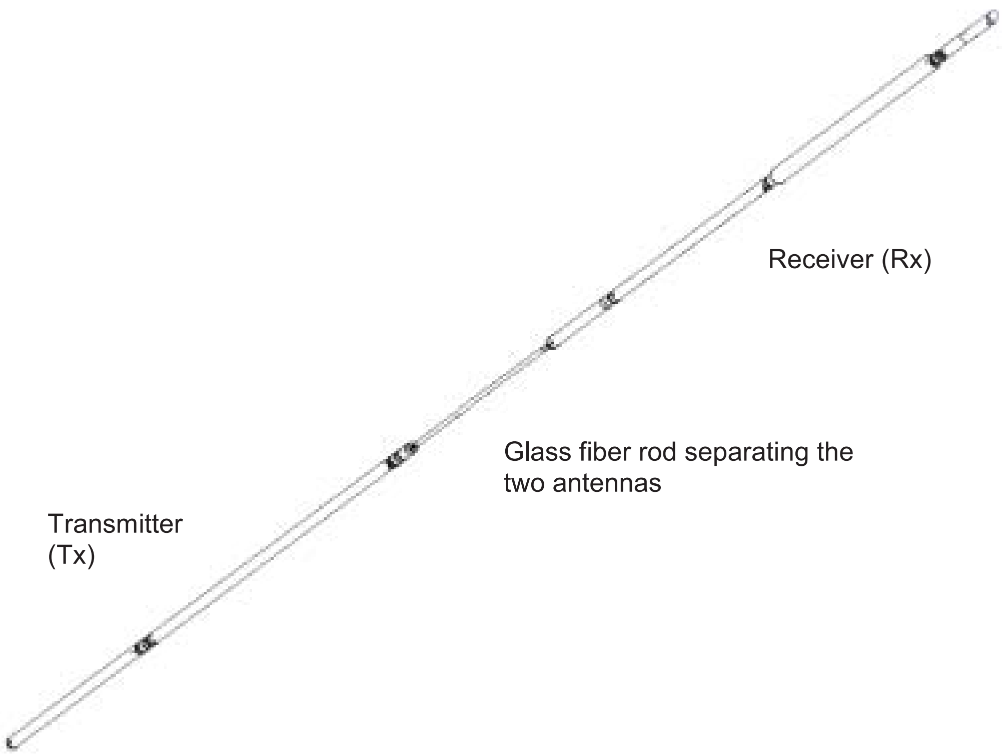


Figure 3-1. *Example of a borehole antenna.*

3.2 TV-Camera – BIPS

The BIPS 1500 system used is owned by SKB and described in the method description "Metodbeskrivning för TV-loggning med BIPS" (SKB MD 222.006, Version 1.0). The BIPS method for borehole logging produces a digital scan of the borehole wall. In principle, a standard CCD video camera is installed in the probe in front of a conical mirror (see Figure 3-2). An acrylic window covers the mirror part and the borehole image is reflected through the window and displayed on the cone, from where it is recorded. During the measuring operation, pixel circles are grabbed with a resolution of 360 pixels/circle.

The BIPS images can be orientated by means of to two alternative methods, either with a compass (vertical and sub-vertical boreholes) or with a gravity sensor (inclined boreholes).

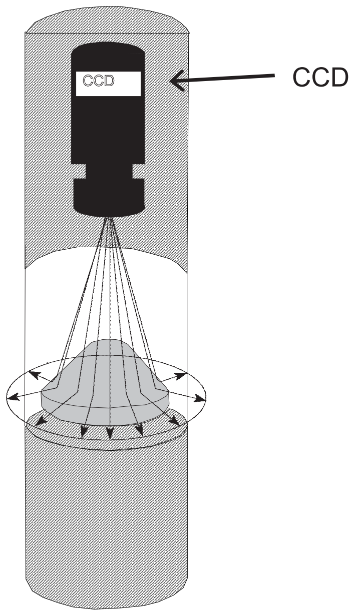


Figure 3-2. *The BIP-system. Illustration of the conical mirror scanning.*

4 Execution

4.1 Data aquisition

RAMAC

For the borehole radar measurements, dipole antennas were engaged. The dipole antennas used have central frequencies of 20 MHz, 100 MHz and 250 MHz, respectively.

During logging, the dipole antennas (transmitter and receiver) were lowered continuously into the borehole and the data recorded on a field PC. The antennas are kept at a fixed separation by glass fibre rods according to Table 4-1 to 4-2. See also Figure 3-1 and 4-1.

For detailed information see the SKB MD 252.020 for method description and MD 600.004 for cleaning of equipment.

Information on the system settings for the different antennas used in the investigation of HFM11 and HFM12 is presented in Table 4-1 to 4-3 below.

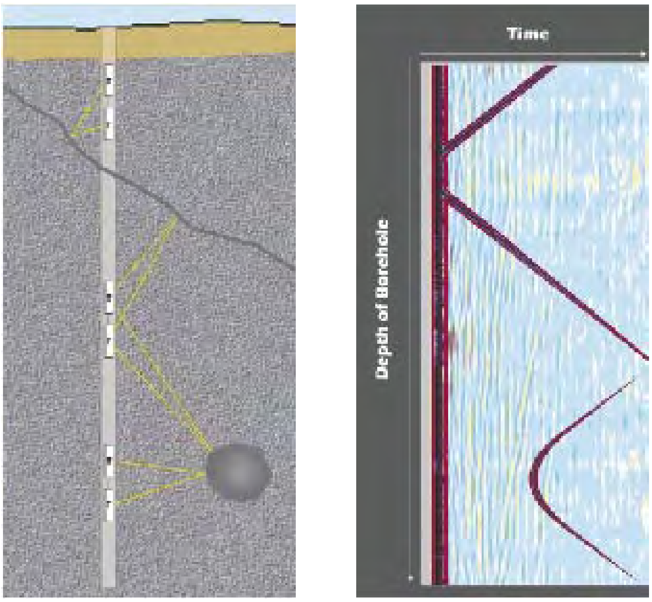


Figure 4-1. *The principle of radar borehole reflection survey (left) and a resulting radargram (right).*

Table 4-1. Radar logging information from HFM11.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM11**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operators:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Logging date:	03-10-23	03-10-23	03-10-23
	Reference:	T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):	2588	951	257
	Number of samples:	619	518	518
	Number of stacks:	Auto	Auto	Auto
	Signal position:	–0.317	–0.32	–1.43
	Logging from (m):	11.5	12.6	16.25
	Logging to (m):	178.5	175.4	174.6
	Trace interval (m):	0.1	0.2	0.25
	Antenna separation (m):	2.4	3.9	10.05

Table 4-2. Radar logging information from HFM12.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM12**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operators:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Logging date:	03-10-22	03-10-22	03-10-22
	Reference:	T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):	2588	951	257
	Number of samples:	Auto	Auto	Auto
	Number of stacks:	619	518	518
	Signal position:	–0.317	–0.32	–1.43
	Logging from (m):	11.5	12.6	16.25
	Logging to (m):	206.5	205.4	201.4
	Trace interval (m):	0.1	0.2	0.25
	Antenna separation (m):	2.4	3.9	10.05

BIPS

For detailed information on BIPS measurements see the SKB MD 222.006 for a method description and MD 600.004 for cleaning of equipment.

During the measurement, pixel circles with a resolution of 360 pixels/circle were recorded and the digital circles were stored at every 1 millimetre on a MO-disc in the surface unit. The maximum speed during data collection was 1.5 metre/minute.

As HFM11 and HFM12 have an inclination of 50 degrees, the gravity sensor was used for the orientation of the BIPS images.

Depth measurements

The depth recording for the RAMAC and BIPS systems is taken care of by a measuring wheel mounted on the cable winch. During logging in core drilled boreholes, reference marks in the boreholes are visible on the BIPS image. To control the depth recording during the RAMAC logging, the logging cable is marked with a piece of scotch tape for every single depth mark. These marks are then used for depth controlling of the BIPS and RAMAC loggings in percussion drilled boreholes, where there are no reference marks.

As both the measured boreholes are less than 210 m deep, the divergences in depth measurements are assumed to be very small.

4.2 Analyses and Interpretation

Radar

The results from radar measurements are commonly presented in the form of a radargram, where the position of the probes is displayed along one axis and the propagation along the other. The amplitude of the received signal is shown with a grey scale where black colour corresponds to the large positive signals and white colour to large negative signals. Grey colour corresponds to no reflected signal.

The data presented in this report is related to the "measurement point", which is defined to be the central point between the transmitter and the receiver antenna.

In the reflection mode, borehole radar primarily offer a high-resolution image of the rock mass, visualizing the geometry of plane structures (contacts between rock units of different lithology, thin marker beds, fractures, fracture zones etc), which may or may not intersect the borehole, or showing the presence of local features (cavities, lenses etc) around the borehole.

The distance to a reflecting object or plane is determined by measuring the difference in arrival time between the direct and the reflected pulse. The basic assumption is that the speed of propagation is consistent in the rock volume investigated.

There are several ways to determine the radar wave propagation velocity. Each of them has its advantages and its disadvantages. In this project, the velocity determination was performed by keeping the transmitter fixed in a borehole at drill site No. 1 (the percussion drilled borehole HFM03) while moving the receiver downwards in the borehole. The result is plotted in Figure 4-2. The calculation shows a velocity of 128 m/micro seconds. The velocity measurement was performed with the 100 MHz antenna /1/.

The visualization of data in Appendix 1 to 2 is made with REFLEX, a Windows based processing software for filtering and analysis of radar data. The processing steps are shown in Table 4-3 to 4-4.

For the interpretation of the intersection angle between the borehole axis and the planes visible on the radargrams the RadinterSKB software has been applied. The interpreted intersection points and intersection angles of the detected structures are presented in Tables 5-3 and 5-4 and also visible on the radargrams in Appendix 1 and 2.

Figure 4-2. *Results from velocity measurements in HFM03 /1/.*

Table 4-3. Processing steps for borehole radar data from HFM11.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM11**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JA**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Processing:	DC removal	DC removal	DC removal
		Move start time	Move start time	Move start time
		Gain	Gain	Gain
		Mean filter		

Table 4-4. Processing steps for borehole radar data from HFM12.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM12**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JA**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Processing:	DC removal	DC removal	DC removal
		Move start time	Move start time	Move start time
		Gain	Gain	Gain

BIPS

The visualization of data is made with BDPP (see Appendix 3 and 4), a Windows based processing software for filtering, presentation and analyzing of BIPS data. No fracture mapping based on the BIPS images was performed.

5 Results and data delivery

The results from the radar and BIPS measurements were delivered to SKB as raw data (*.bip-files) on CD-ROMs together with printable BIPS pictures in *.pdf format before the field crew left the investigation site. The information of the measurements is registered in SICADA, and the field data, VHS-tapes, MO-disks and CD-ROMs is stored by SKB.

RAMAC radar data have been delivered as raw data (fileformat *.rd3 or *.rd5) with corresponding information files (file format *.rad), whereas the data processing steps and results are presented in this report. Relevant information, including the interpretation presented in this report, has been inserted into the SKB database SICADA.

The SICADA reference to the BIPS and RAMAC logging activities in HFM11 and HFM12 is Field note Forsmark No. 193.

5.1 RAMAC logging

The results of the interpretation of the radar measurements are presented in Table 5-1 to 5-4. Radar data is also visualized in Appendix 1 to 2. It should be remembered that the images in Appendix 1 to 2 are only composite pictures of all events, 360 degrees around the borehole, and do not reflect the true orientation of the structures.

Only the major, clearly visible structures are interpreted in RadinterSKB. A number of minor structures were also encountered as indicated in Appendix 1 to 2.

The data quality, as seen in Appendix 1 to 2, is relatively satisfying, except for HFM12 where the lack of depth penetration is very clear. The measurements suffer from deteriorated quality mostly due to increased electrical conductivity in the rock or borehole fluid but also because of the large borehole diameter. A conductive environment entails attenuation of the radar waves, resulting in decreased penetration. See for example Appendix 1 and 2, especially data obtained with the 250 MHz antenna. This conductive environment of course also affects the possibility to map the different structures in the borehole.

As also seen in Appendix 1 to 2, the resolution and penetration of the radar waves depend of the antenna frequency. A high frequency will result in a high resolution but a lower penetration rate compared to a lower frequency.

Table 5-3 to 5-4 summarises the interpretation of radar data from HFM11 and HFM12. Many structures can be identified in the data from more than one antenna frequency.

Table 5-1. Identified structures as a function of depth in HFM11.

Depth (m)	No. of structures
10–30	3
30–40	5
40–50	1
50–60	3
60–70	2
70–80	2
80–90	1
90–100	2
100–110	1
110–120	-
120–130	2
130–140	3
140–150	1
150–160	2
160–170	2
170–180	2
180–190	2
190–200	1
200–	2

Table 5-2. Identified structures as a function of depth in HFM12.

Depth (m)	No. of structures
0–30	2
30–40	4
40–50	1
50–60	2
60–70	2
70–80	-
80–90	4
90–100	1
100–110	2
110–120	2
120–130	1
130–140	3
140–150	1
150–160	4
160–170	-
170–180	3
180–190	1

Table 5-3. Model information from dipole antennas 20, 100 and 250 MHz, HFM11.

RADINTER MODEL INFORMATION
(20, 100 and 250 MHz Dipole Antennas)

Site:	Forsmark
Borehole name:	HFM11
Nominal velocity (m/μs):	128.00

Object type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	D	9.2	34
PLANE	A	29.3	36
PLANE	AA	31.7	28
PLANE	B	32.6	42
PLANE	C	37.6	48
PLANE	J	38.9	34
PLANE	K	46.2	32
PLANE	E	54.5	30
PLANE	O	56	26
PLANE	G	65.9	50
PLANE	F	66.4	26
PLANE	H	80.9	25
PLANE	L	83.7	43
PLANE	M	88	40
PLANE	I	88.1	22
PLANE	N	97.5	35
PLANE	NN	100.5	56
PLANE	P	106.2	47
PLANE	Q	110.5	62
PLANE	R	118.9	72
PLANE	S	125.7	61
PLANE	T	130.8	61
PLANE	U	135.6	56
PLANE	V	139.9	56
PLANE	X	143.8	67
PLANE	Z	151.3	59
PLANE	4	152.9	52.3
PLANE	W	153.4	41
PLANE	Y	157.2	73.5
PLANE	1	172.5	52
PLANE	2	173.7	53
PLANE	3	176.9	74
PLANE	5	186.1	51

Names in table according to Appendix 1.

Table 5-4. Model information from dipole antennas 20, 100 and 250 MHz, HFM12.

RADINTER MODEL INFORMATION
(20, 100 and 250 MHz Dipole Antennas)

Site:	Forsmark
Borehole name:	HFM12
Nominal velocity (m/μs):	128.00

Object type	Name	Intersection depth	Intersection angle
PLANE	S	11.7	17
PLANE	A	18.7	52
PLANE	B	23	48
PLANE	C	30.5	65
PLANE	D	35.3	28
PLANE	E	36	62.8
PLANE	G	39.4	26
PLANE	F	39.7	58
PLANE	H	45.7	57
PLANE	I	50.9	61
PLANE	J	55.5	55
PLANE	K	59.7	54
PLANE	L	63.8	70
PLANE	M	67	48
PLANE	O	72	50
PLANE	P	79	33
PLANE	N	84.8	16
PLANE	Q	90.7	47
PLANE	R	94.5	47
PLANE	T	113.3	46
PLANE	9	121.7	41
PLANE	U	123.6	57
PLANE	V	133.4	65
PLANE	W	136.2	68
PLANE	X	139.9	75
PLANE	10	142.5	38
PLANE	Y	150.7	50
PLANE	Z	151.5	63
PLANE	11	166.5	57
PLANE	1	169.2	35
PLANE	2	172.3	43
PLANE	3	179.1	63
PLANE	4	182.1	62
PLANE	5	189.1	63
PLANE	6	194.3	70
PLANE	7	204.6	52.7
PLANE	8	206.4	53

Names in table according to Appendix 2.

In Appendix 1 and 2, the amplitude of the first arrival is plotted against the depth, for the 250 MHz dipole antennas. The amplitude variation along the borehole indicates changes of the electrical conductivity of the material. A decrease in this amplitude may indicate fracture zones, clay or rock volumes with increased water content. The decrease in amplitude is seen for the following sections in HFM11:

Depth (m)
25
30–35
80–90
95–100
105–110
110–115
125
130
135
145–150
155
165
170–

And for HFM12:

Depth (m)
20
30–35
40
45
50
55
65
90–95
105
120–125
135–140
150–160
165–170
175–180
185
190

5.2 BIPS logging

To get the best possible depth accuracy, the BIPS images are adjusted to the reference labels on the logging cable. During previously performed logging in core-drilled boreholes, reference labels are attached to the logging cable according to the reference marks on the borehole wall. In percussion drilled boreholes these labels are used as a reference for the depth adjustment. The experience during the IPLU work is that these labels differ very little compared to the results from operations in core drilled boreholes. At present, the cable is labelled at 110, 150 and 200 meter.

In order to control the quality of the system, calibration measurements were performed in a test pipe before logging the first borehole and after logging of the borehole. The resulting images displayed no difference regarding the colours and focus of the images. Results of the test loggings were included in the delivery of the raw data.

The logging in HFM11 was performed 03-10-23. The water conditions was good along the borehole. The only quality problem is mud that covers the lowermost part (10 last meters) of the borehole wall. See Figure 5-1 below.

The logging in HFM12 was performed 03-10-22. The water quality and the visibility of the borehole wall is good along the borehole down to 140 meter. From that point, mud that covers the borehole wall increases down to the bottom of the borehole. Still there is no problem to interpret the structures intersecting the borehole, see Figure 5-2 below.

There is some distortion of the images due to unsynchronised movement of the cable measuring device at surface and the borehole probe. This phenomena is related to the increased friction of the probe/cable and the borehole wall in inclined boreholes, as compared to vertical or sub-vertical holes.

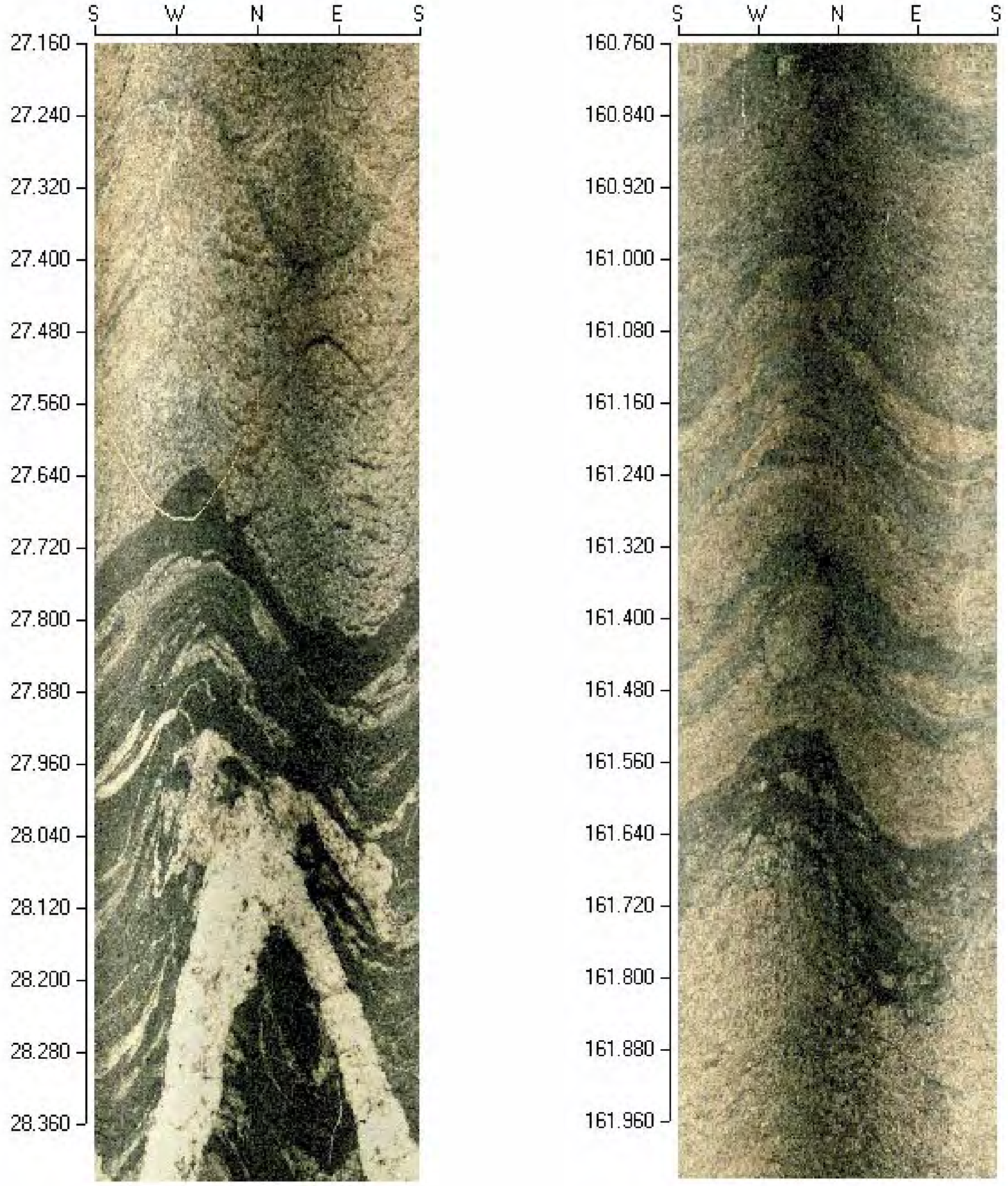


Figure 5-1. *Differences in the image quality between the top and bottom part of borehole HFM11.*

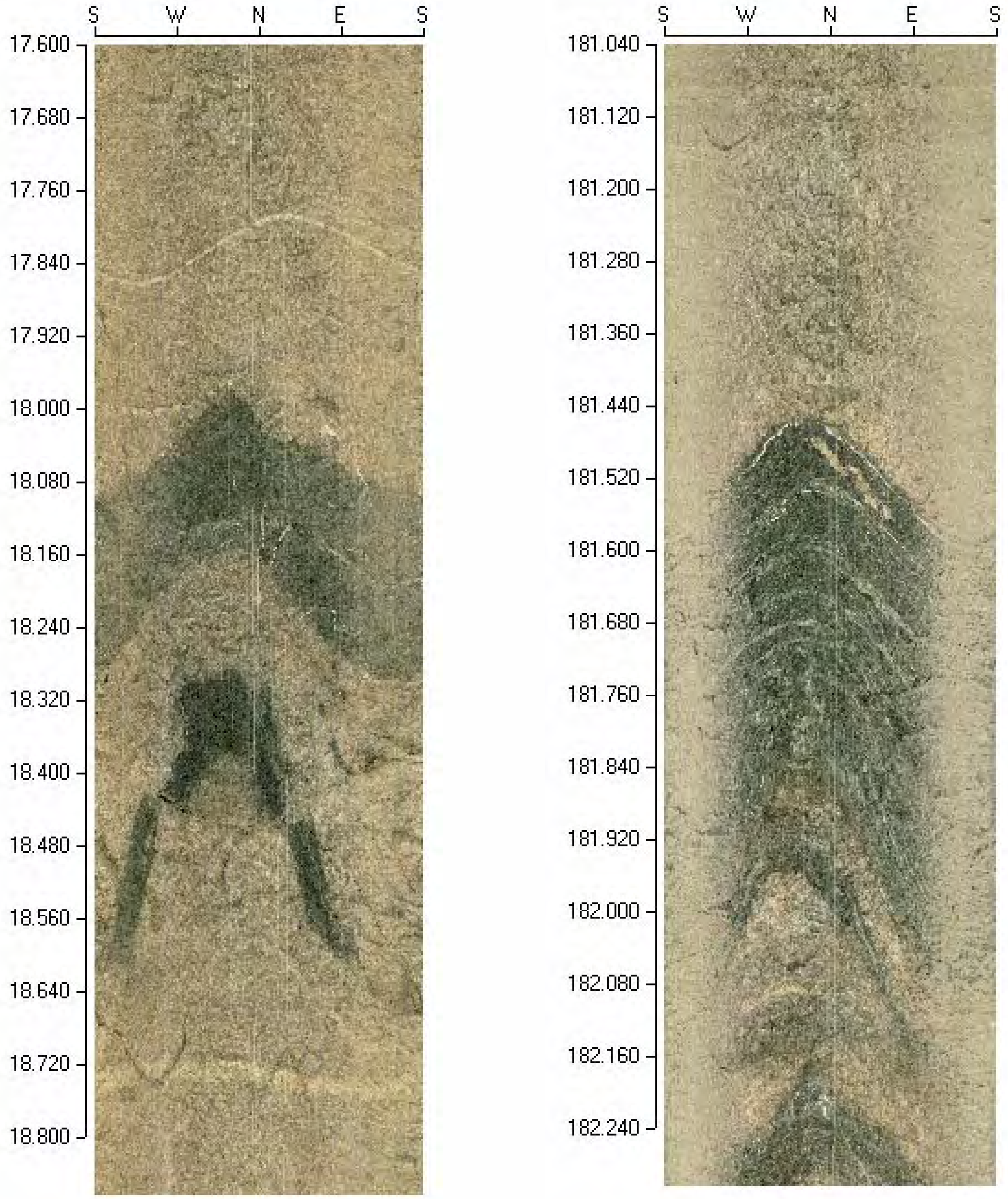


Figure 5-2. *Differences in the image quality between the top and bottom part of borehole HFM12.*

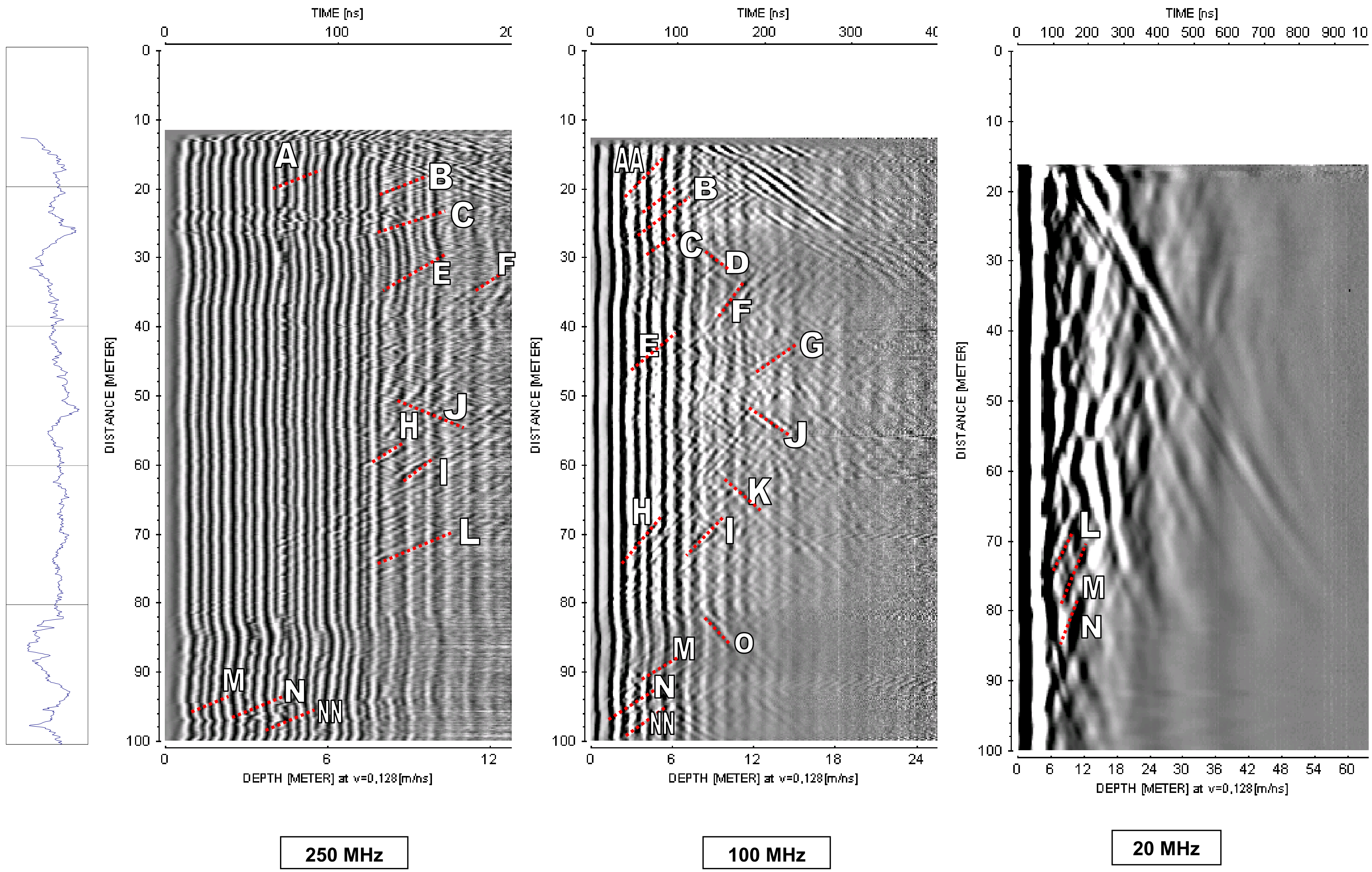
6 References

/1/ **Gustafsson C, Nilsson P, 2003.** Geophysical Radar and BIPS logging in borehole HFM01, HFM02, HFM03 and the percussion drilled part of KFM01A. SKB P-03-39. Svensk Kärnbränslehantering AB.

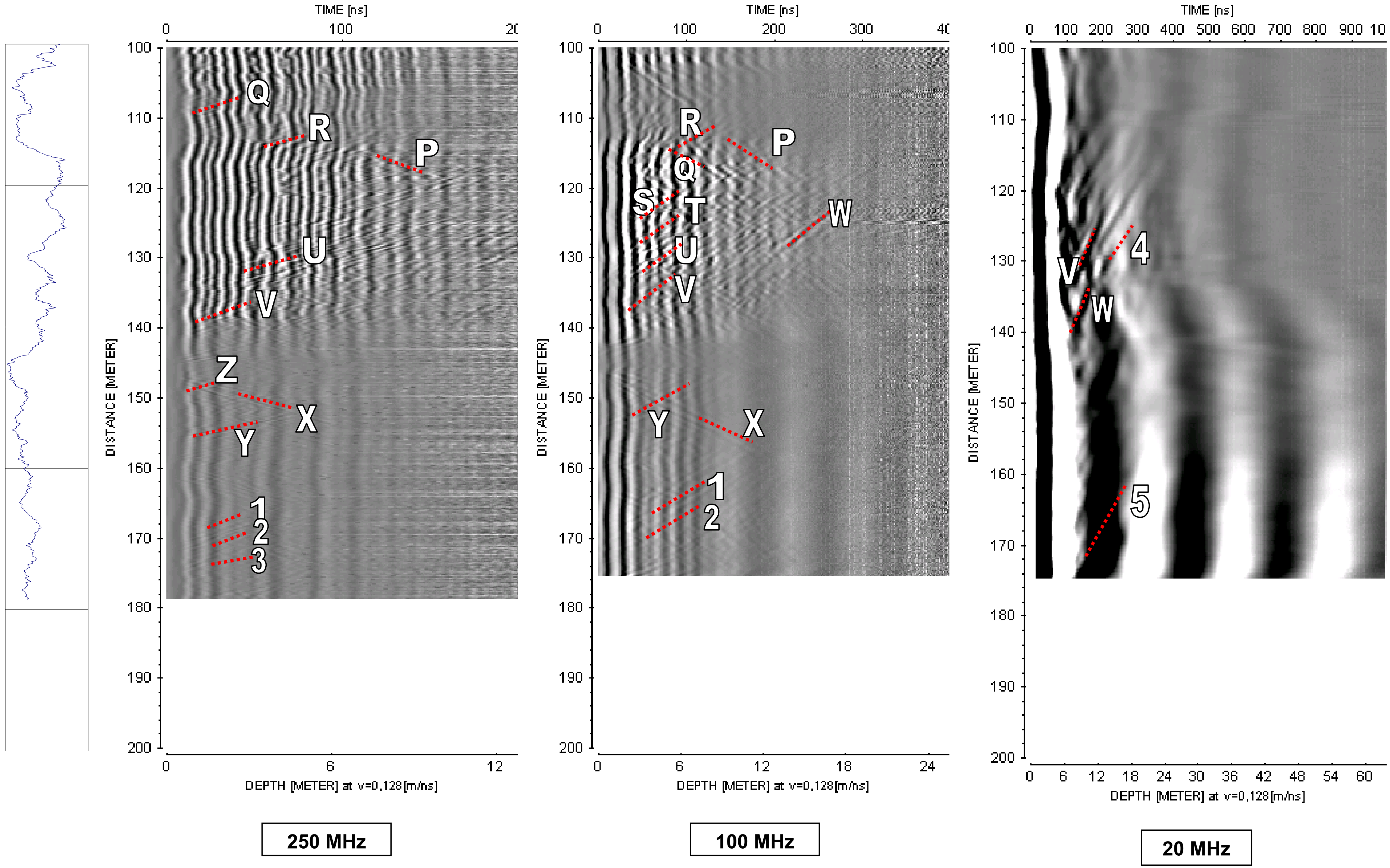
Appendix 1

Radar logging of HFM11. Dipole antennas 250, 100 and 20 MHz

FORSMARK HFM11 with interpretation



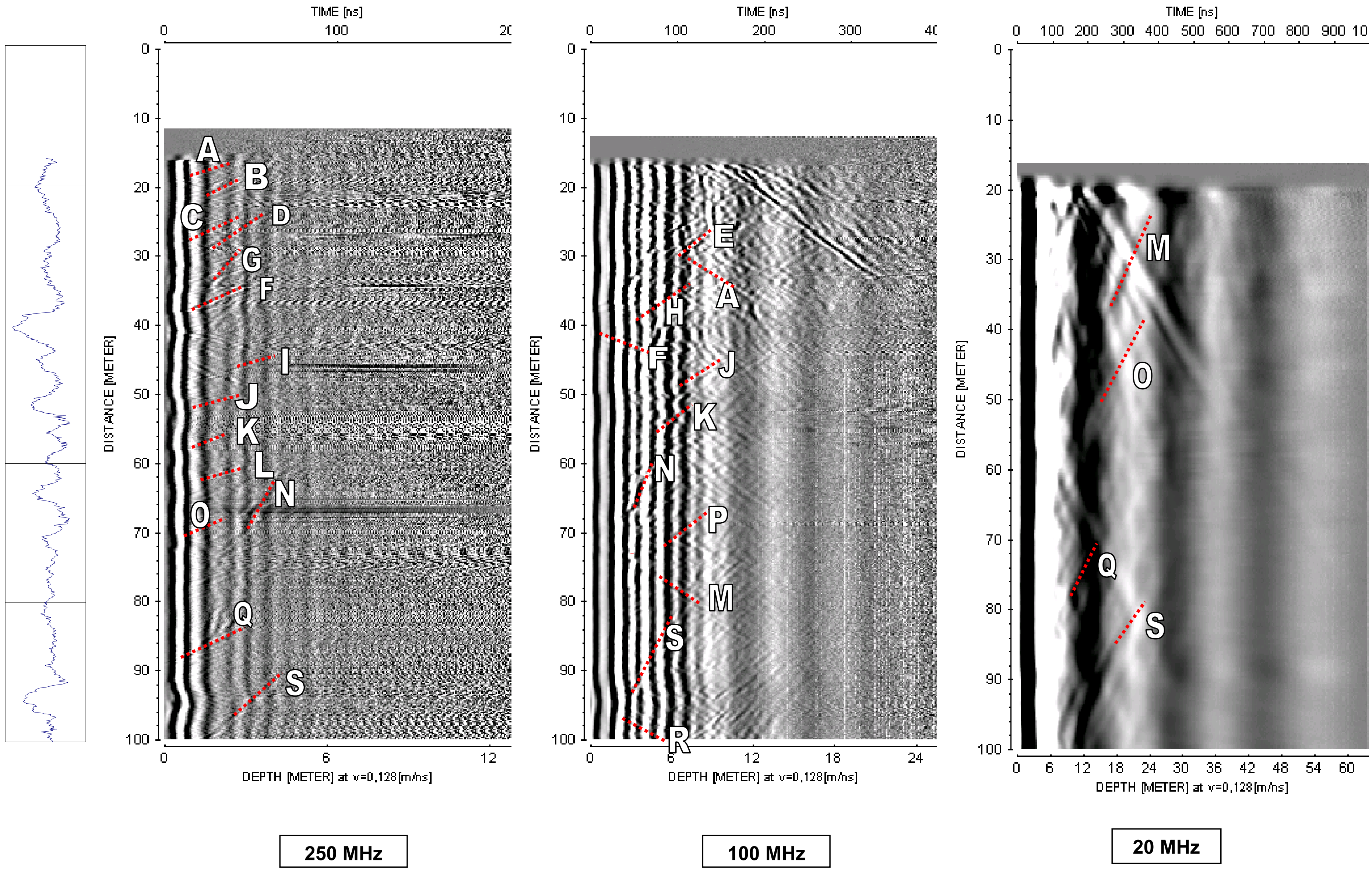
FORSMARK HFM11 with interpretation



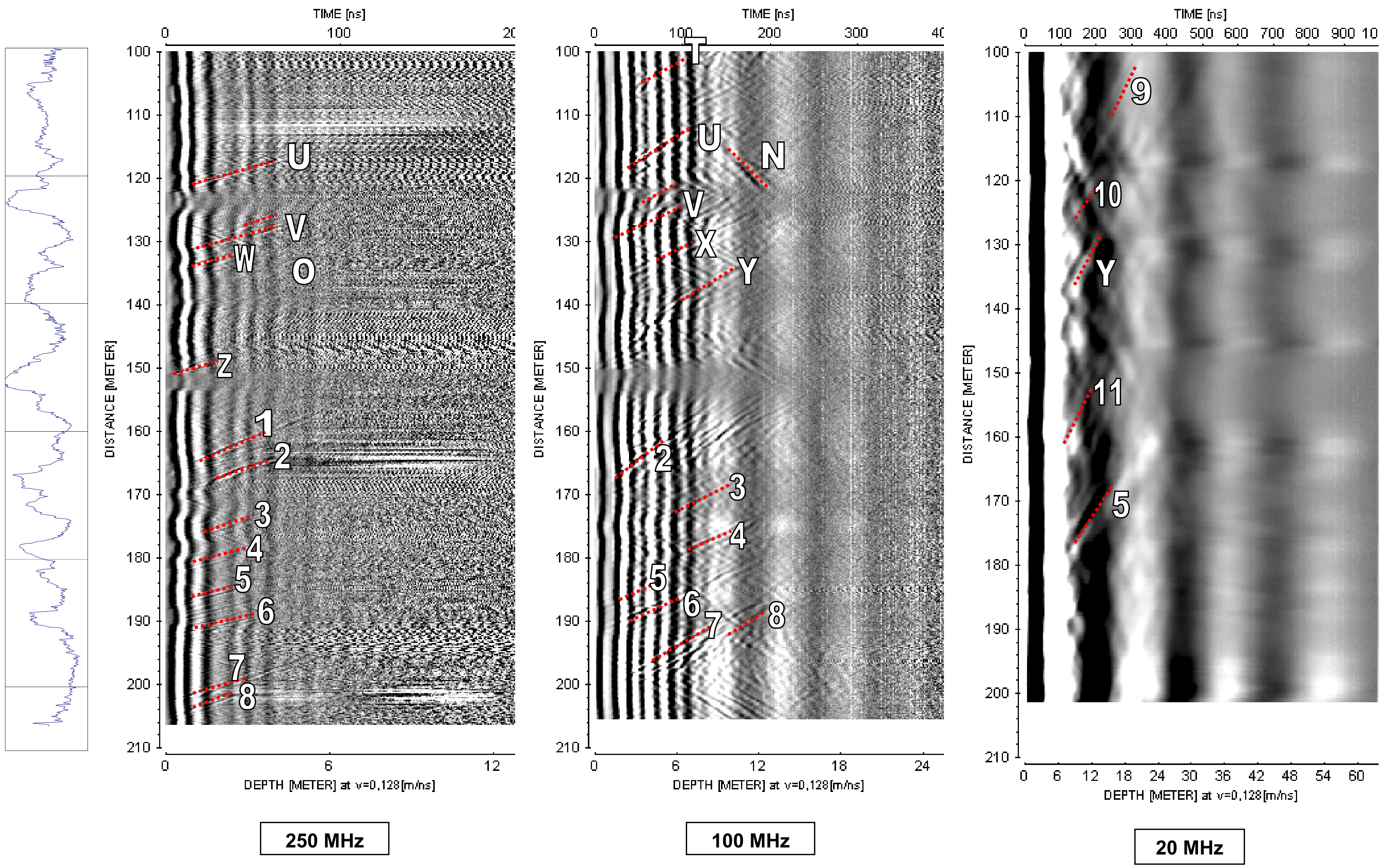
Appendix 2

Radar logging of HFM12. Dipole antennas 250, 100 and 20 MHz

FORSMARK HFM12 with interpretation



FORSMARK HFM12 with interpretation



BIPS logging in HFM11

Project name: Forsmark

Image file	: h:\work\hfm11\hfm11.bip
BDT file	: h:\work\hfm11\hfm11.bdt
Locality	: FORSMARK
Bore hole number	: HFM11
Date	: 03/10/23
Time	: 15:10:00
Depth range	: 11.000 - 181.323 m (red figures = corrected values)
Azimuth	: 60
Inclination	: -50
Diameter	: 140.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 100 %
Pages	: 9
Color	: +0 +0 +0

Project name: Forsmark

Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

Depth range: 11.000 - 31.000 m

D L U R D

11.000 / 11.000
12.000 / 12.005
13.000 / 13.009
14.000 / 14.014
15.000 / 15.019
16.000 / 16.023

D L U R D

16.000 / 16.023
17.000 / 17.028
18.000 / 18.033
19.000 / 19.038
20.000 / 20.042
21.000 / 21.047

D L U R D

21.000 / 21.047
22.000 / 22.052
23.000 / 23.056
24.000 / 24.061
25.000 / 25.066
26.000 / 26.070

D L U R D

26.000 / 26.070
27.000 / 27.075
28.000 / 28.080
29.000 / 29.085
30.000 / 30.089
31.000 / 31.094

(1 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

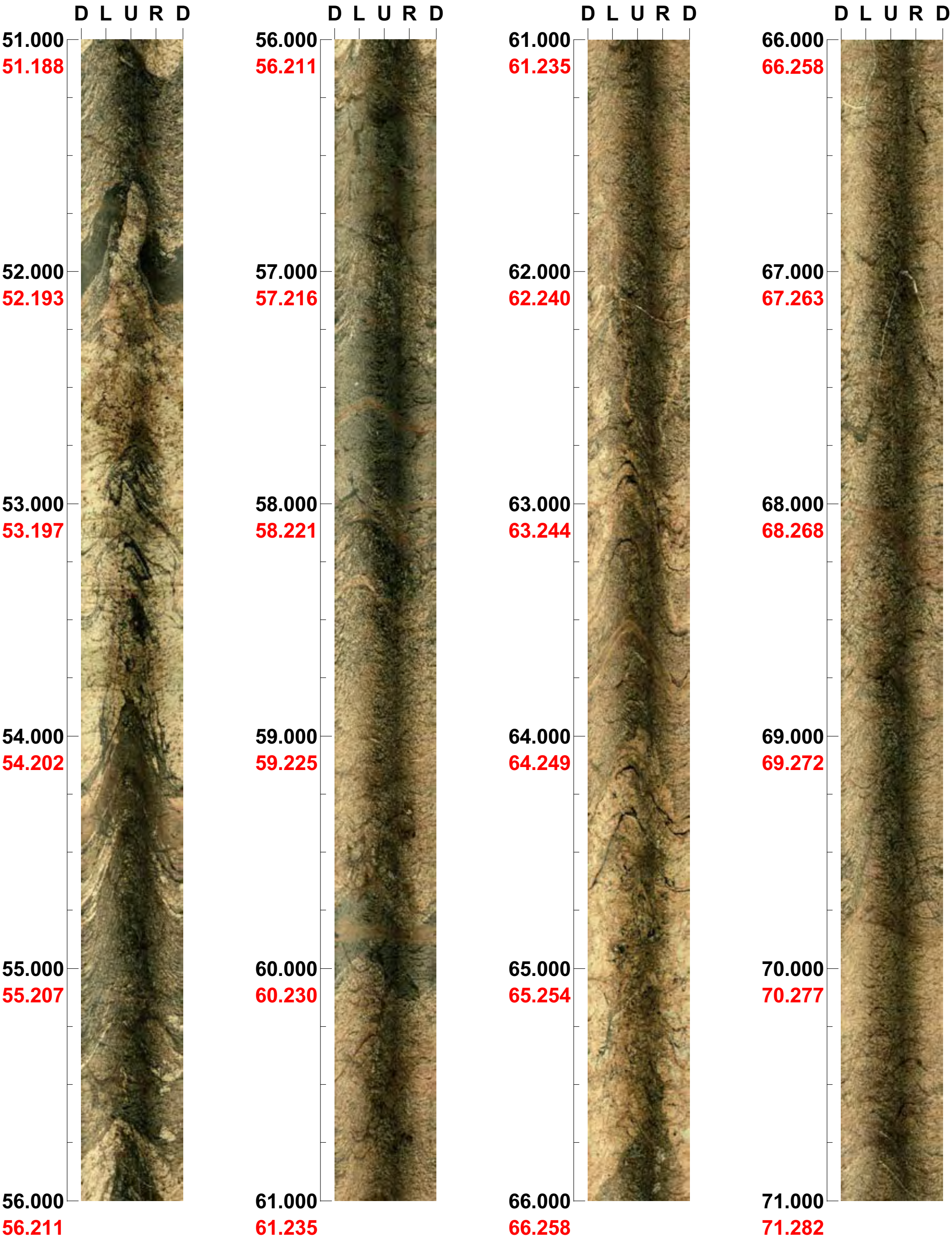
Depth range: 31.000 - 51.000 m

(2 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

Depth range: 51.000 - 71.000 m



(3 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

Depth range: 71.000 - 91.000 m

(4 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

Depth range: 91.000 - 111.000 m

(5 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

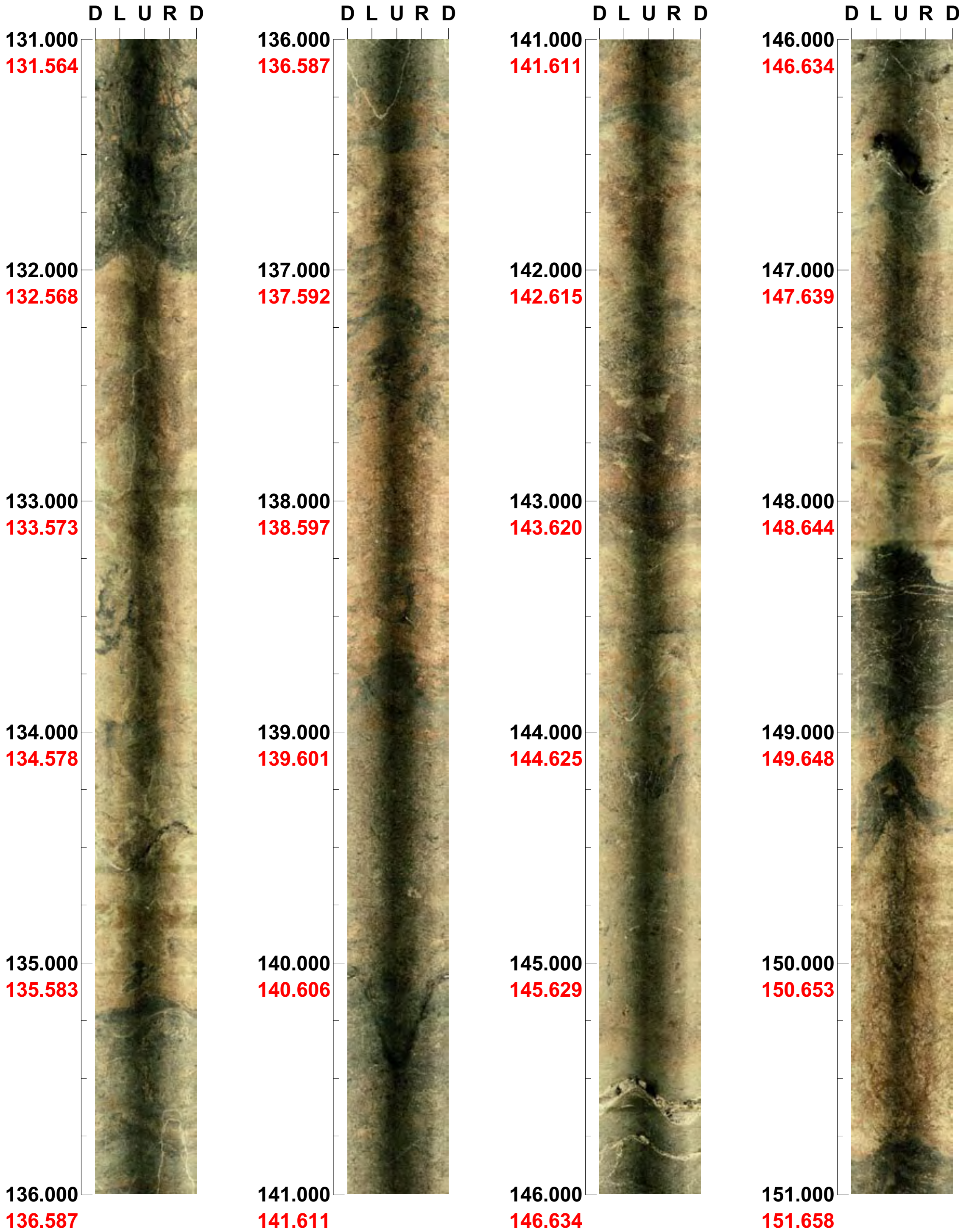
Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

Depth range: 111.000 - 131.000 m

(6 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

Depth range: 131.000 - 151.000 m



(7 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

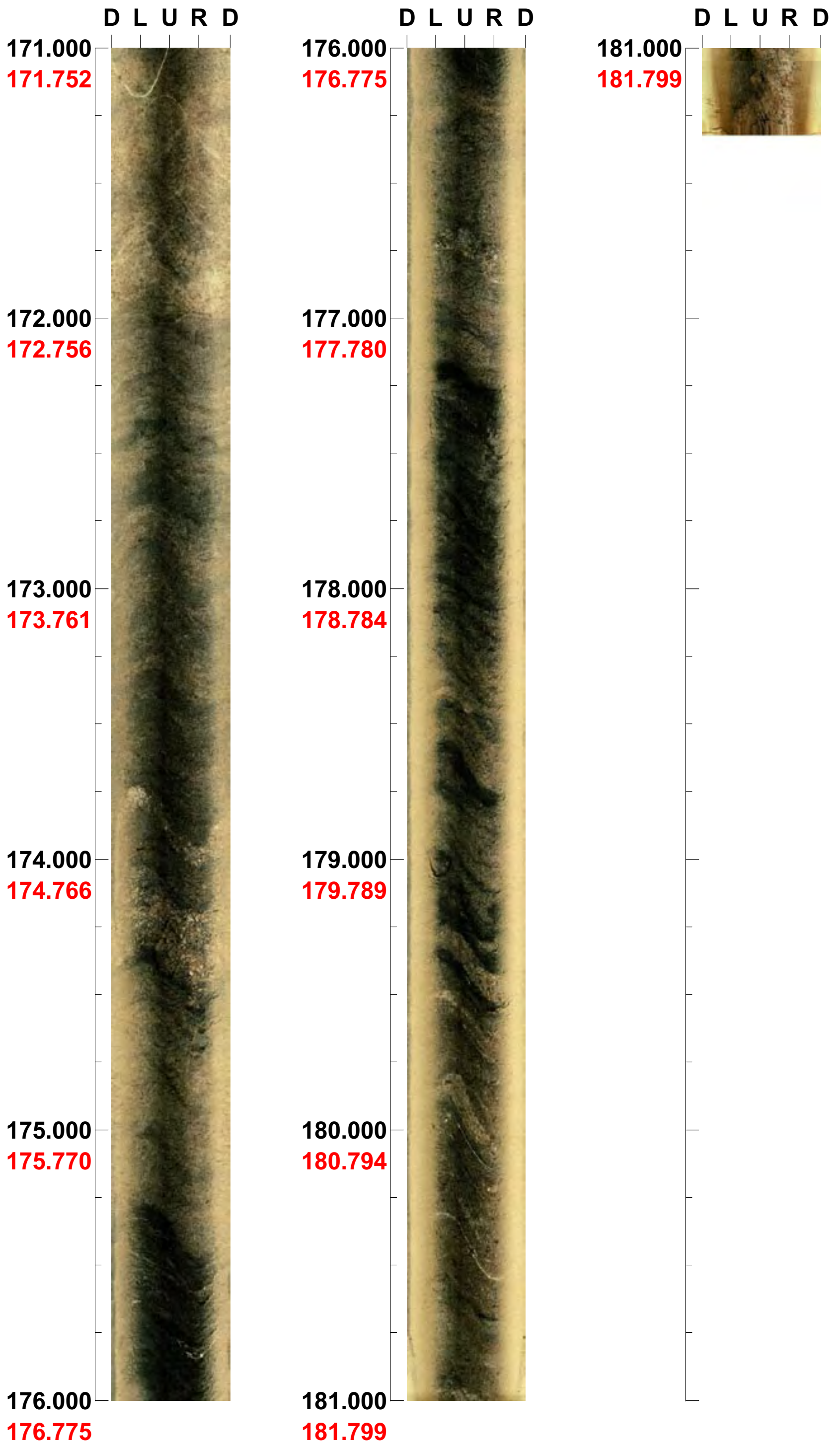
Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

Depth range: 151.000 - 171.000 m

(8 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM11 **Azimuth: 60** **Inclination: -50**

Depth range: 171.000 - 181.323 m



(9 / 9) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 4

BIPS logging in HFM12

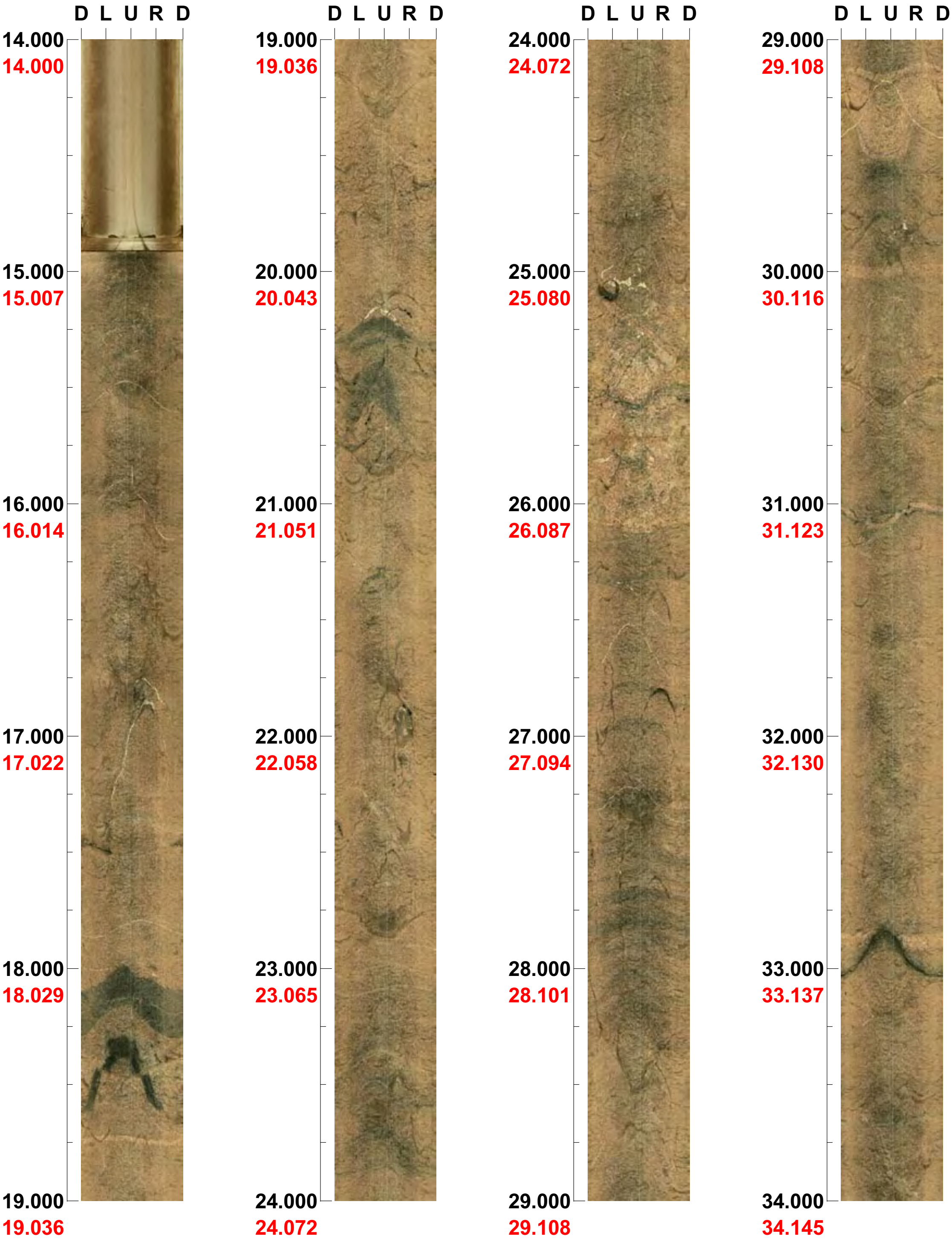
Project name: Forsmark

Image file	: h:\work\hfm12\hfm12.bip
BDT file	: h:\work\hfm12\hfm12.bdt
Locality	: FORSMARK
Bore hole number	: HFM12
Date	: 03/10/22
Time	: 15:02:00
Depth range	: 14.000 - 207.604 m (red figures = corrected values)
Azimuth	: 240
Inclination	: -50
Diameter	: 140.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 100 %
Pages	: 10
Color	: +0 +0 +0

Project name: Forsmark

Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

Depth range: 14.000 - 34.000 m

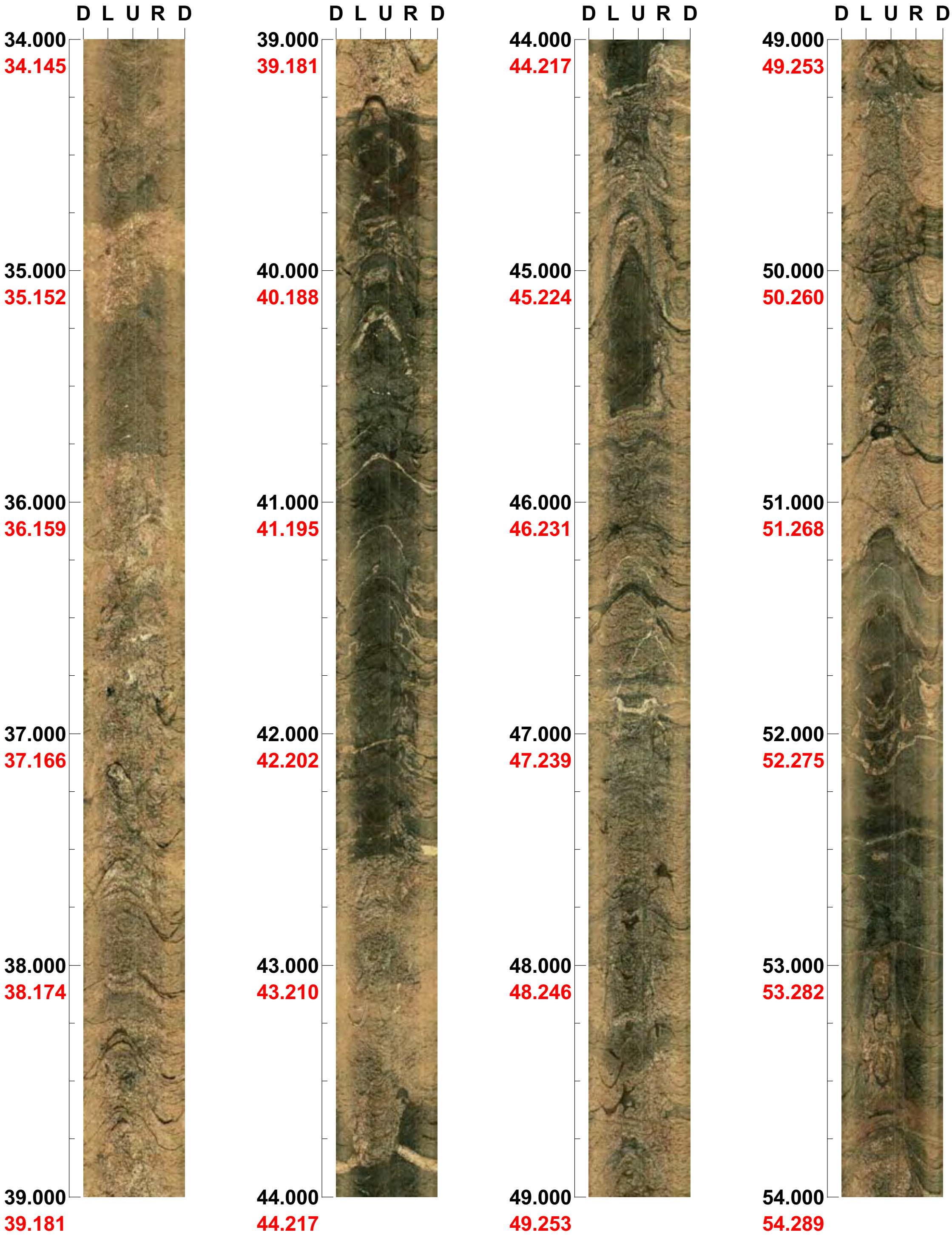


(1 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

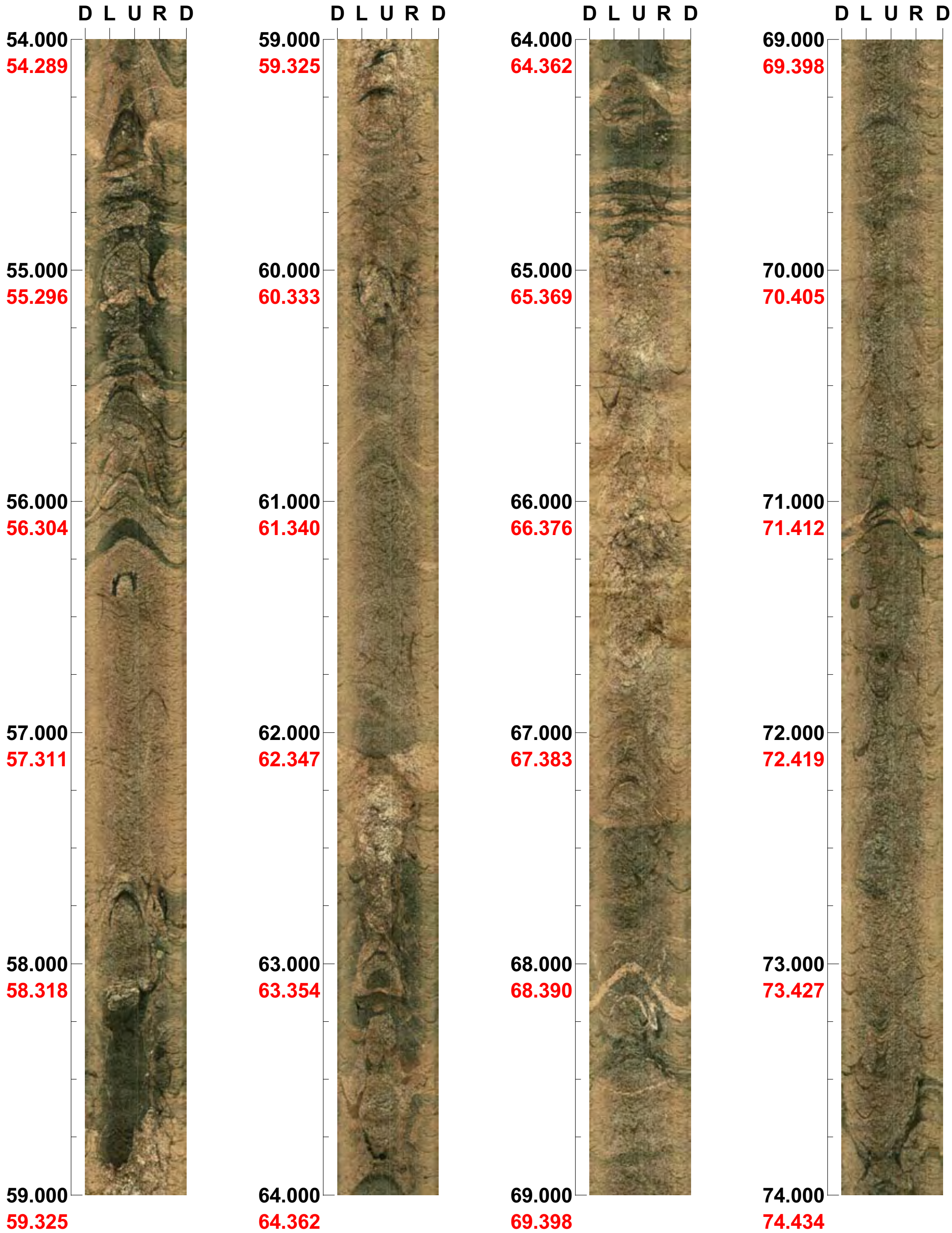
Depth range: 34.000 - 54.000 m



(2 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

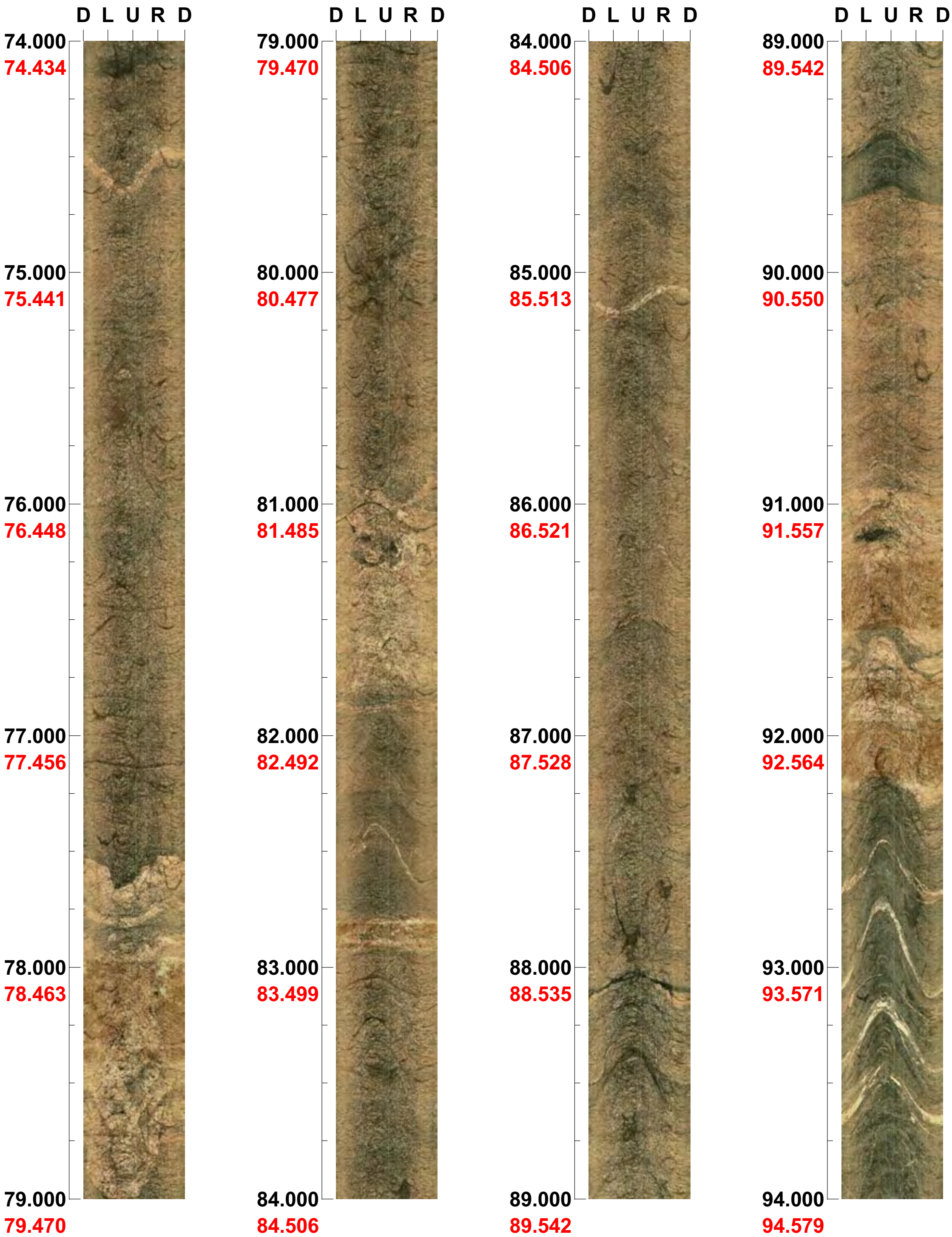
Depth range: 54.000 - 74.000 m



(3 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM12 Azimuth: 240 Inclination: -50

Depth range: 74.000 - 94.000 m

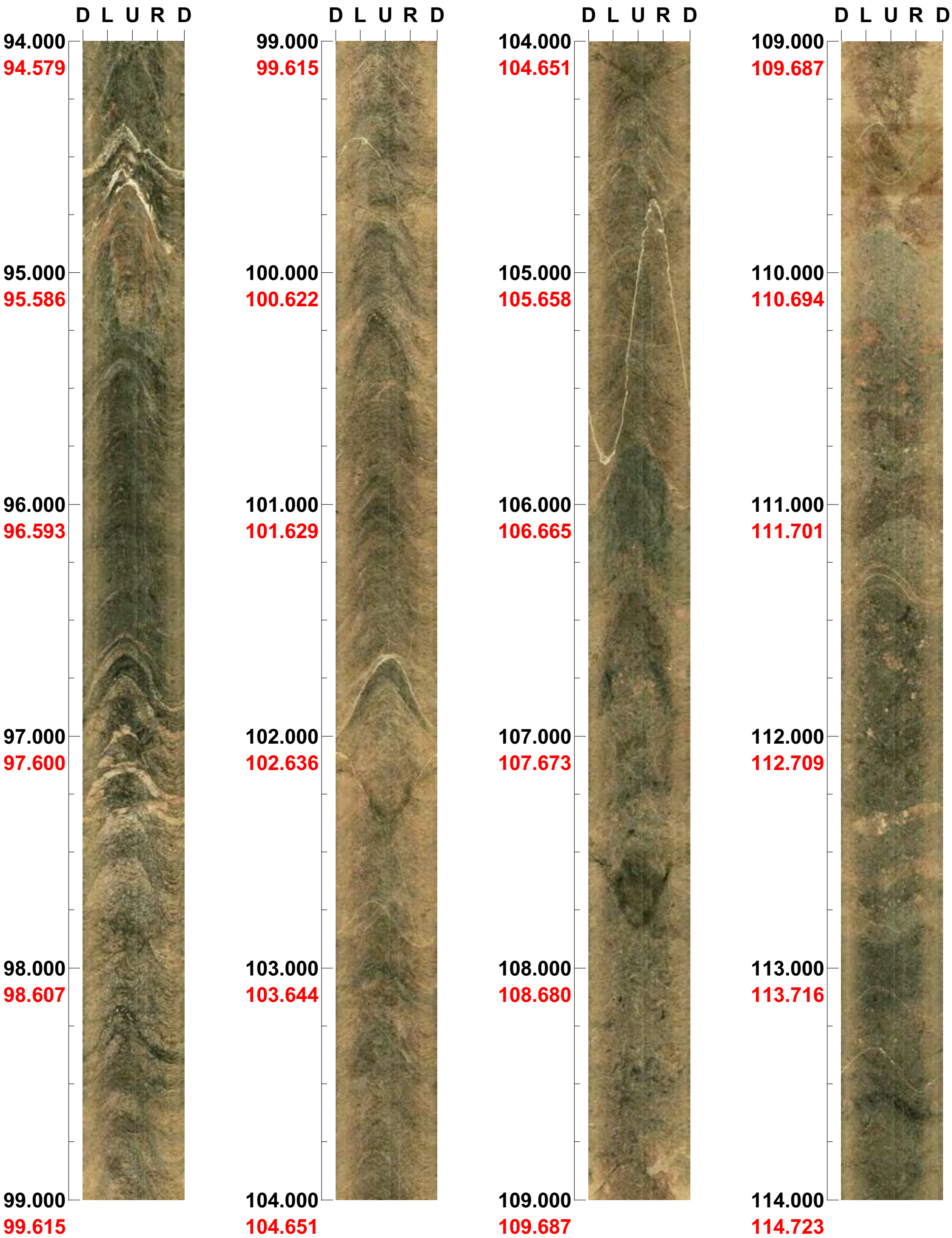


(4 / 10) Scale: 1/25 Aspect ratio: 100 %

Project name: Forsmark

Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

Depth range: 94.000 - 114.000 m

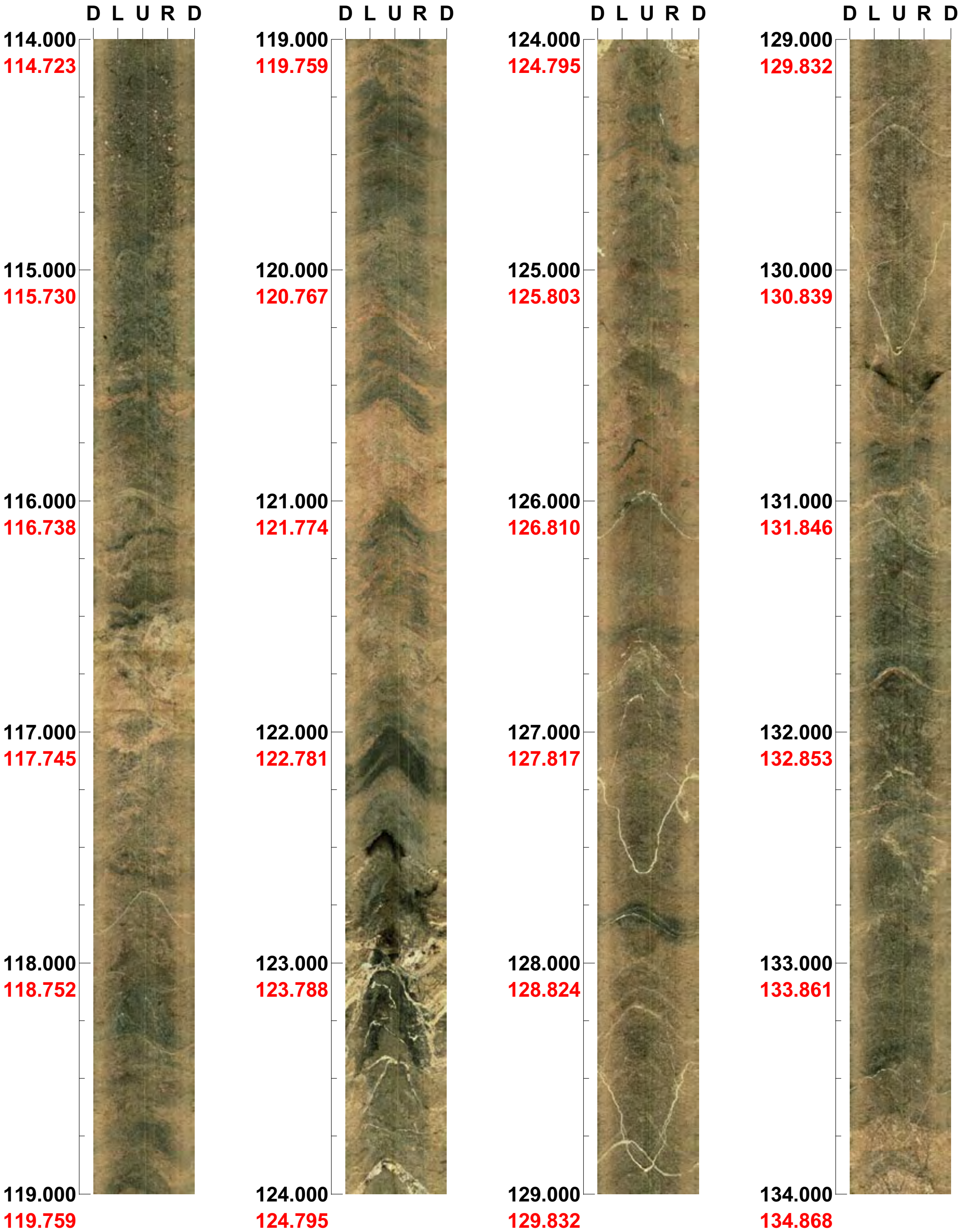


(5 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

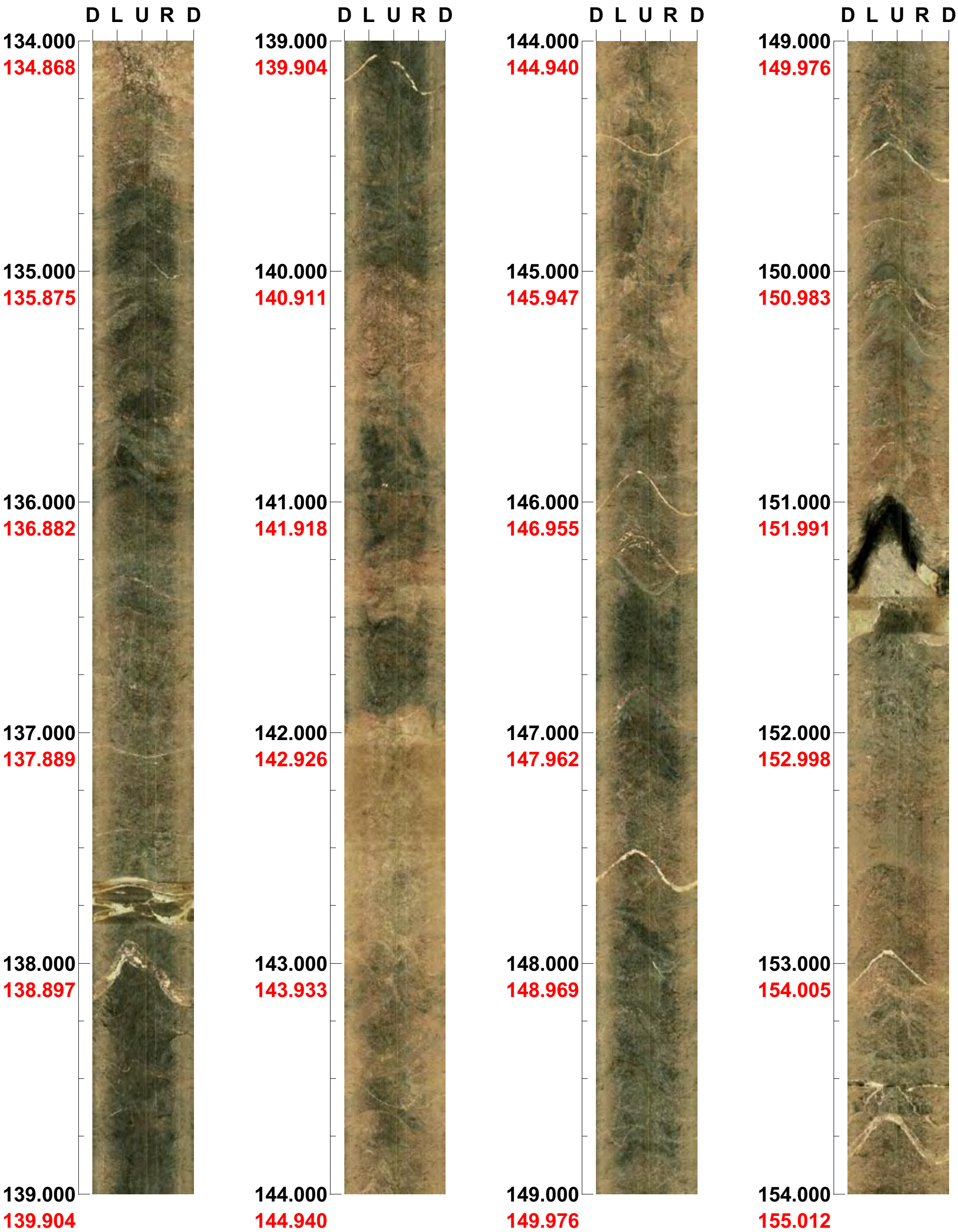
Depth range: 114.000 - 134.000 m



(6 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

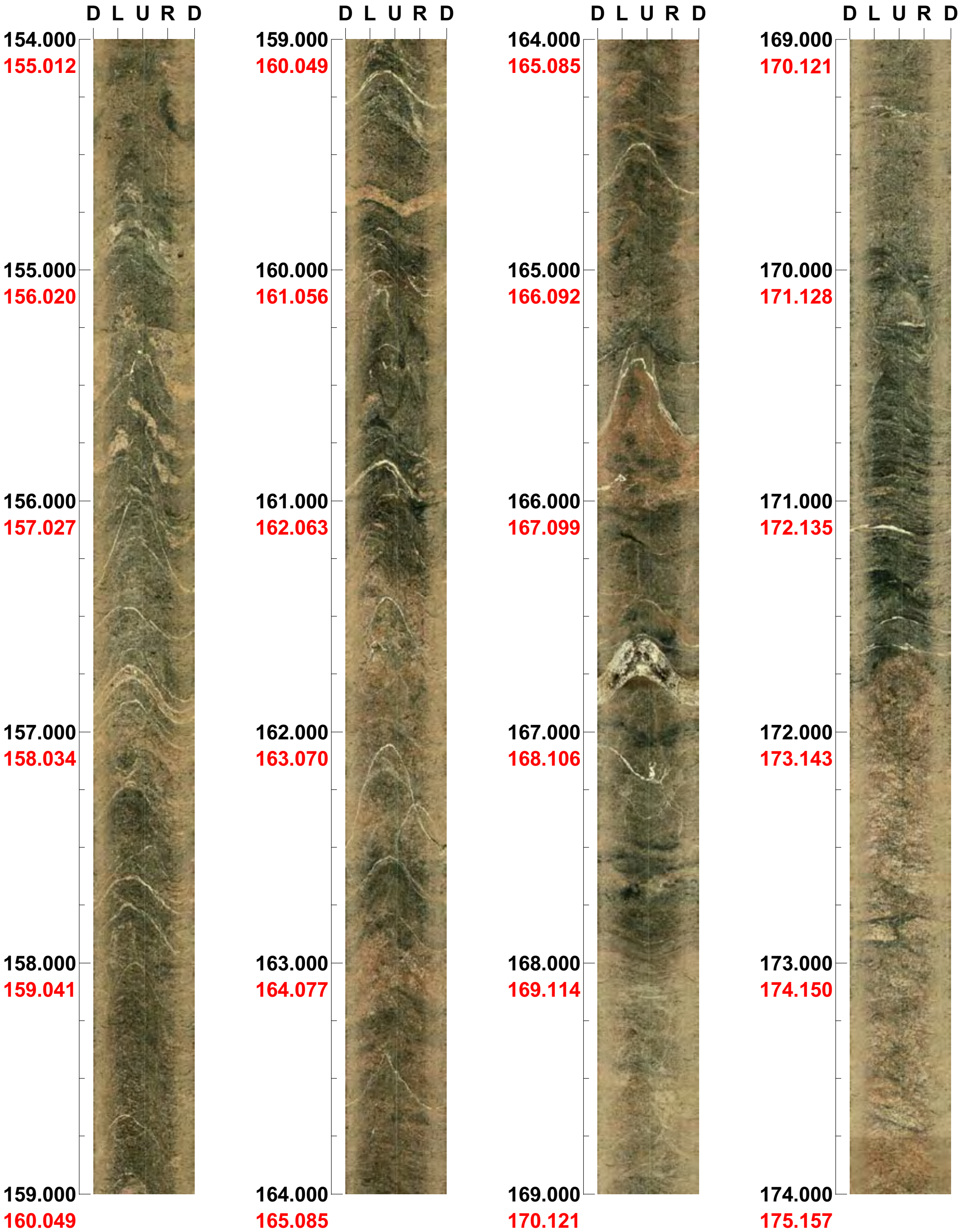
Depth range: 134.000 - 154.000 m



(7 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

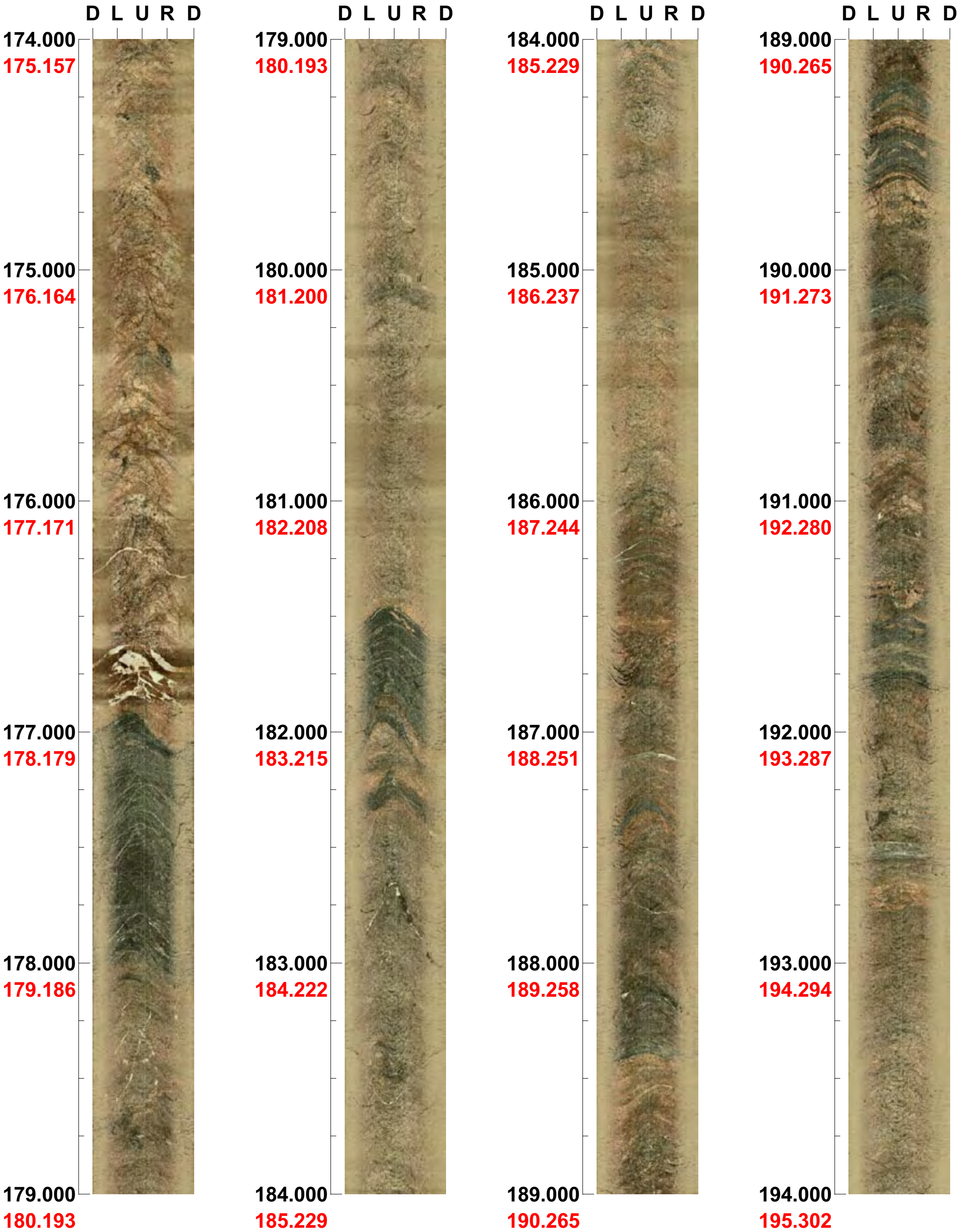
Depth range: 154.000 - 174.000 m



(8 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

Depth range: 174.000 - 194.000 m

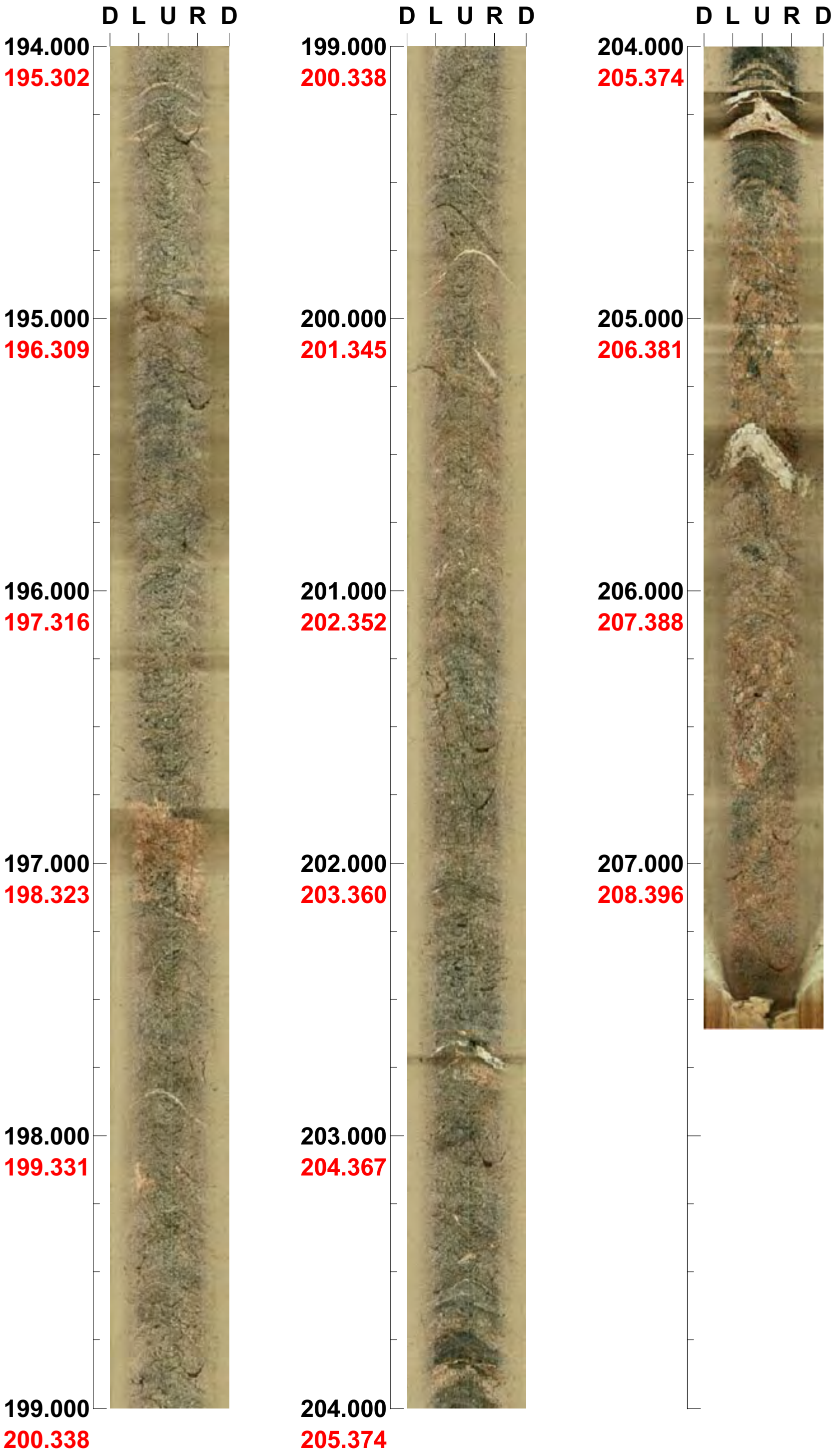


(9 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM12 **Azimuth: 240** **Inclination: -50**

Depth range: 194.000 - 207.604 m



(10 / 10) **Scale: 1/25** **Aspect ratio: 100 %**