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Forsmark site investigation

RAMAC and BIPS logging in boreholes KFM08C, HFM30, HFM31, HFM33 and HFM34

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September 2006

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Keywords: BIPS, RAMAC, Radar, TV, Forsmark, AP PF 400-06-046.

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.

A pdf version of this document can be downloaded from www.skb.se

Abstract

This report includes the data gained in geophysical logging operations performed within the site investigation at Forsmark. The logging operations presented here includes BIPS and borehole radar (RAMAC) logging in the core-drilled borehole KFM08C and in the percussion drilled boreholes HFM30, HFM31, HFM33 and HFM34. All measurements were conducted by Malå Geoscience AB during June 2006.

The objective of the radar surveys is to achieve information on the rock mass around the borehole. Borehole radar is used to investigate the nature and the structure of the rock mass enclosing the boreholes.

The objective of the BIPS logging is to achieve information of the borehole including occurrence of rock types as well as determination of fracture distribution and orientation.

This report describes the equipment used as well as the measurement procedures and data gained. For the BIPS surveys, the results are presented as images. Radar data is presented in radargrams and the identified reflectors are listed.

The borehole radar data quality from all holes varied from rather bad in the percussion-drilled borehole to quite good in the core-drilled boreholes, but also here some parts have lower quality due to more conductive conditions. This conductive environment reduces the possibility to distinguish and interpret possible structures in the rock mass which otherwise could give a reflection. However, the borehole radar measurements resulted in a number of identified radar reflectors: 250 reflectors were identified in KFM08C of which 43 were orientated (dip/strike). 29 reflectors were identified in HFM30, 52 in HFM31, 41 in HFM33, and 53 reflectors in HFM34.

Two different runs with the BIPS have been performed in KFM08C. The first run resulted in very bad image quality in the deeper parts of the borehole due to dirty water and mud covering the lower most part of the borehole walls. The second run, after cleaning by nitrogen blowing, resulted in a much better image quality, except for the discoloring effects induced by the drilling. The images in HFM30, HFM31 and HFM33 were relatively good due to clean water and no mud coverage on the walls. In HFM34 the quality was not good, dirty water reduces the visibility from 96 m down to the bottom.

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Forsmark. Mätningarna som presenteras här omfattar BIPS-loggning och borrhålsradarmätningar (RAMAC) i kärnborrhålet KFM08C och i hammarborrhålen HFM30, HFM31, HFM33 och HFM34. Alla mätningar är utförda av Malå Geoscience AB under juni 2006.

Syftet med radarmätningarna är att samla information om bergmassan runt borrhålet. Borrhålsradar används till att karakterisera bergets egenskaper och strukturer i bergmassan närmast borrhålet.

Syftet med BIPS loggningen är att skaffa information om borrhålet inkluderande förekommande bergarter och bestämning av sprickors fördelning och deras orientering.

Rapporten beskriver utrustningen som använts liksom mätprocedurer och en beskrivning och tolkning av data som erhållits. För BIPS loggningarna presenteras data i form av plottar längs med borrhålet. Radardata presenteras i radargram, och en lista över tolkade radarreflektorer ges.

Kvalitén på borrhålsradardata från hålen varierade från relativt dålig i hammarborrhålen till bra i kärnborrhålet, men även där tidvis av sämre kvalité, troligen till stor del beroende på en konduktiv miljö. En konduktiv miljö minskar möjligheterna att identifiera strukturer från borrhålsradardata. Dock har 250 radarreflektorer identifierats i KFM08C, varav 43 är orienterade (strykning och stupning). I HFM30 identifierades 29 strukturer, i HFM31 52, i HFM33 41 och i HFM34 53 strukturer.

Två loggningar har utförts i KFM08C. Den första loggningen resulterade i dåliga bilder men efter ytterligare kvävgasblåsningar och rengöring blev bilderna betydligt bättre vid den andra loggningen. Även bildkvalitén för HFM30, HFM31 och HFM33 är godtagbara. Däremot är det betydligt sämre vattenkvalitet i HFM34 från 96 m ner till botten.

Contents

1 Introduction

This document reports the data gained in geophysical logging operations, which is one of the activities performed within the site investigation at Forsmark. The logging operations presented here includes TV-logging (BIPS) and borehole radar (RAMAC) in the core-drilled borehole KFM08C and in the percussion drilled boreholes HFM30, HFM31, HFM33 and HFM34. The work was carried out in accordance with activity plans AP PF 400-06-046. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

This report includes measurements from 0 to approximately 947 m in borehole KFM08C. This core-drilled borehole has a diameter of approximately 76 mm. In HFM30 the measurements includes 0 to 197 m, in HFM31 0 to 197 m, in HFM33 0 to 137 m and in HFM34 0 to 195 m. These percussion-drilled boreholes have a diameter of approximately 139 mm.

Malå Geoscience AB conducted all measurements during June 2006. Figure 1-1 shows the borehole locations.

The used investigation techniques comprised:

- Borehole radar measurements (Malå Geoscience AB:s RAMAC system) with dipole and directional antennas.
- Borehole TV logging with the Borehole Image Processing System (BIPS) which is a high resolution, side viewing, colour borehole TV system.

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

Activity plan	Number	Version
BIPS- och RADARloggning i KFM08C och KFM10A samt HFM30, HFM31 och HFM33 med tillägg avseende HFM34, HFM35 och HFM38.	AP PF 400-06-046	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för TV- loggning med BIPS	SKB MD 222.006	1.0
Metodbeskrivning för borrhålsradar	SKB MD 252.020	2.0

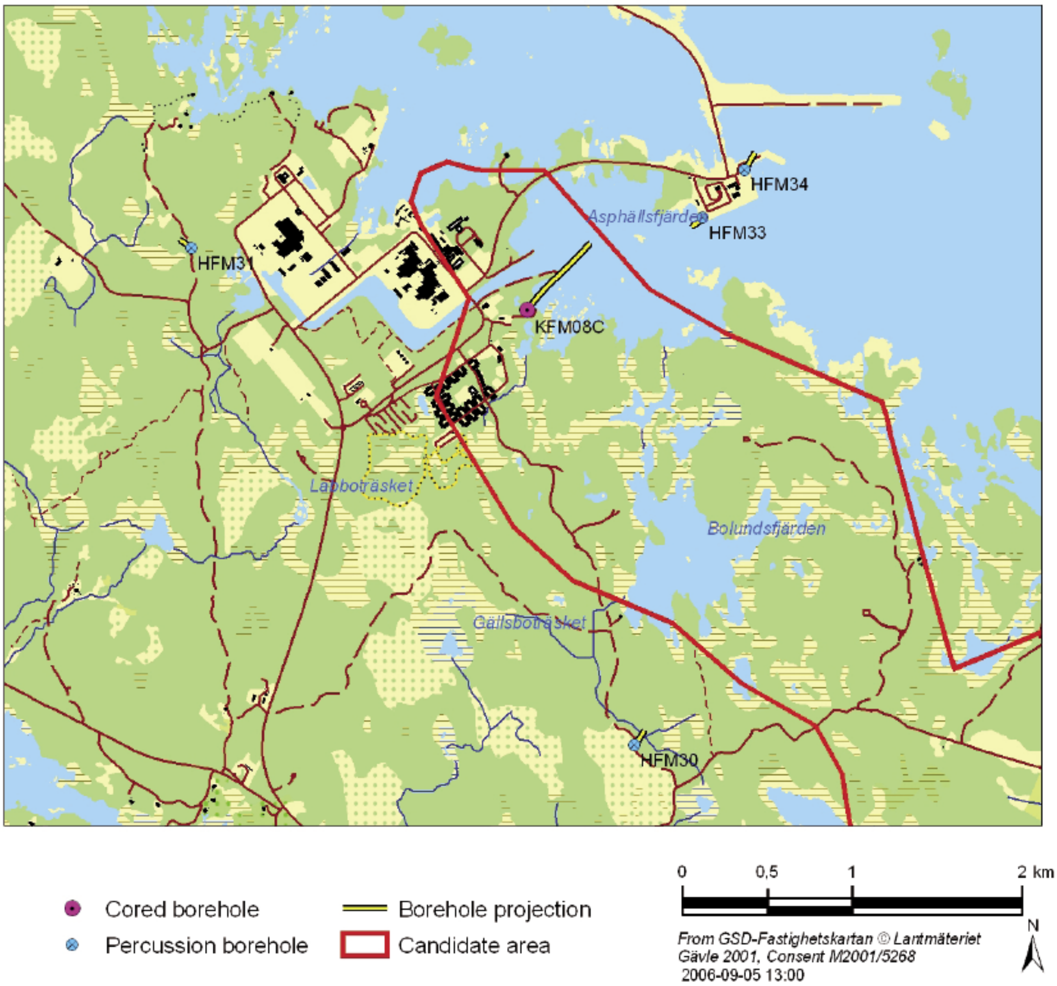


Figure 1-1. *Overview over the Forsmark investigation area, showing the location of the boreholes KFM08C, HFM30, HFM31, HFM33 and HFM34, surveyed and presented in this report.*

2 Objective and scope

The objective of the radar and BIPS surveys is to achieve information on the borehole conditions (borehole wall) as well as on the rock mass around the borehole. Borehole radar is 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. For the BIPS surveys, the results are presented as images. Radar data are presented in radargrams and the identified reflectors are listed.

3 Equipment

3.1 Radar measurements RAMAC

The RAMAC GPR system owned by SKB is a fully digital GPR system where emphasis has been laid on fast survey speed and easy field operation. The system operates dipole and directional antennas (see Figure 3-1). A system description is given in the SKB internal controlling document MD 252.021.

The borehole radar system consists of a transmitter and a receiver antenna. During operation an electromagnetic pulse, within the frequency range of 20 MHz up to 250 MHz, is emitted into the bedrock. Once a feature, e.g. a water-filled fracture, with sufficiently different electrical properties is encountered, the pulse is reflected back to the receiver and recorded.

3.2 TV-Camera, BIPS

The BIPS 1500 system used is owned by SKB and described in SKB internal controlling document MD 222.005. 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 one pixel per degree.

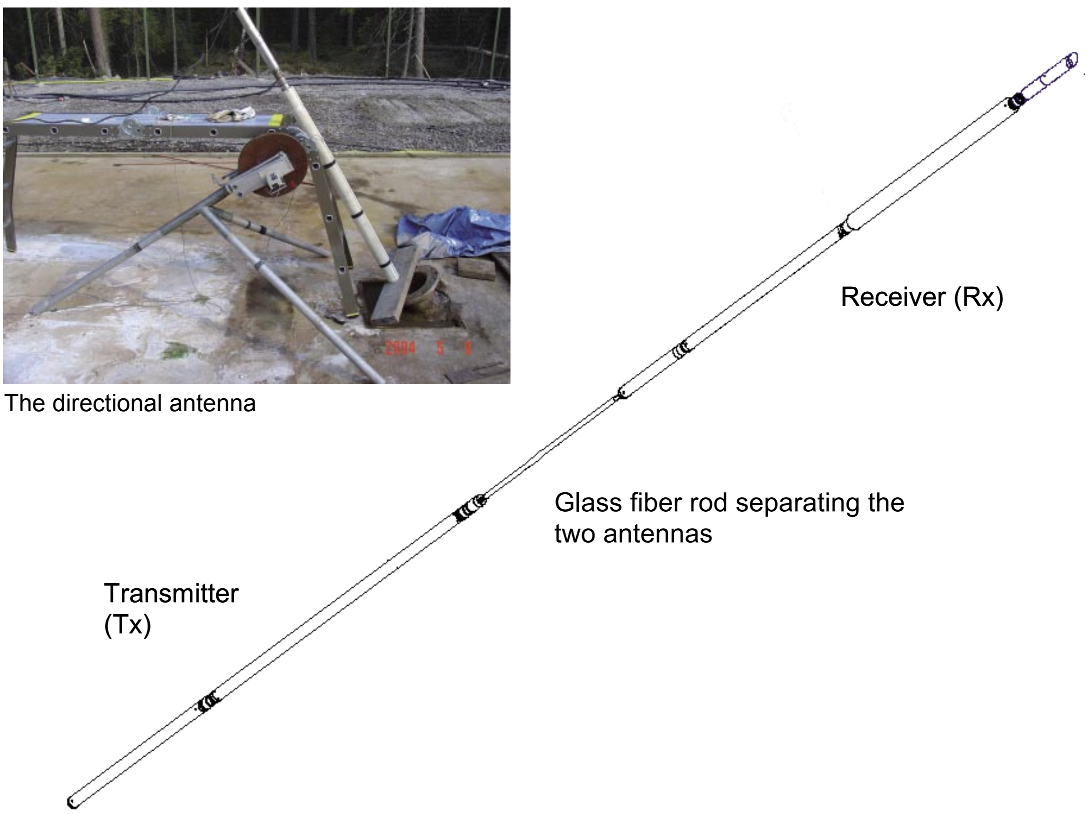


Figure 3-1. *Example of a borehole radar antenna.*

The system orientates the BIPS images according to two alternative methods, either using a compass (vertical boreholes) or with a gravity sensor (inclined boreholes).

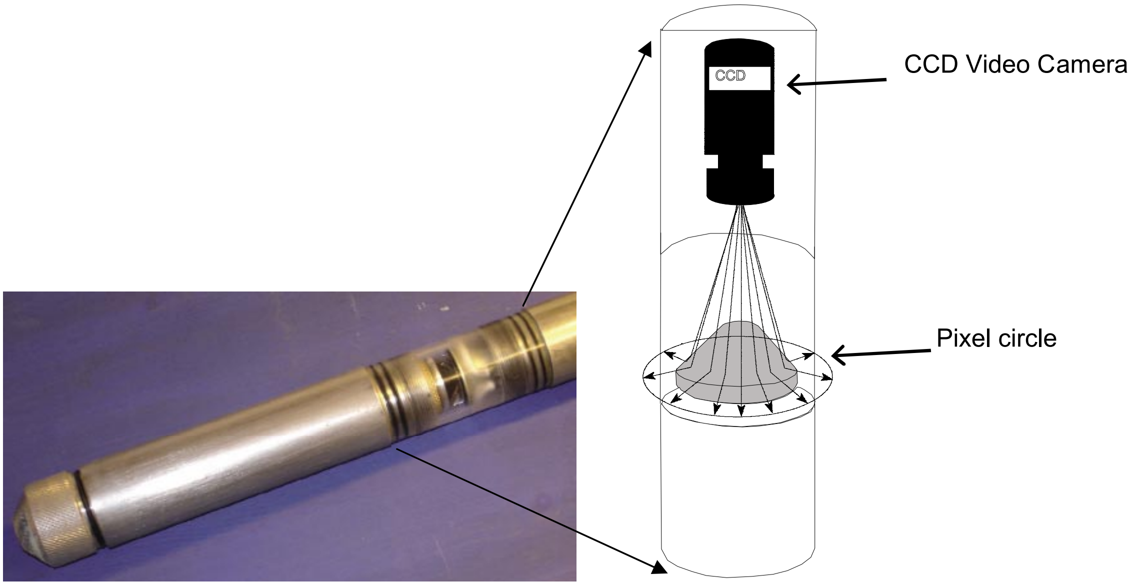


Figure 3-2. *The BIP-system. To the right a sketch showing the principles of the conical mirror.*

4 Execution

4.1 General

4.1.1 RAMAC Radar

The measurements in all boreholes were carried out with dipole radar antennas with frequencies of 250, 100 and 20 MHz. In KFM08C the measurements were also carried out using the directional antenna with a central frequency of 60 MHz.

During logging the dipole antennas (transmitter and receiver) were lowered continuously into the borehole, and data were recorded on a field PC along the measured interval. The measurement with the directional antenna is made step wise, with a short pause for each measurement occasion. The antennas (transmitter and receiver, both for dipole and directional) are kept at a fixed separation by glass fiber rods according to Tables 4-1 to 4-5. See also Figure 3-1 and 4-1.

All measurements were performed in accordance with the instructions and guidelines from SKB (internal document MD 252.020). Before the logging operation, the antennas and cable were cleaned according to the internal document SKB MD 600.004.

The functionality of the directional antenna was tested before measurements in KFM08C. This was performed by measurements in the air, where the receiver antenna and the transmitter antenna are placed apart. While transmitting and measuring the receiver antenna is turned around and by that giving the direction from the receiver antenna to the transmitter antenna. The difference in direction is measured by compass and the result difference achieved from the directional antenna was about 10 degrees. This can be considered to be satisfying, considering the disturbed environment with metallic objects etc at the test site.

For more information on system settings used in the investigation of KFM08C, HFM30, HFM31, HFM33 and HFM34, see Tables 4-1 to 4-5 below.

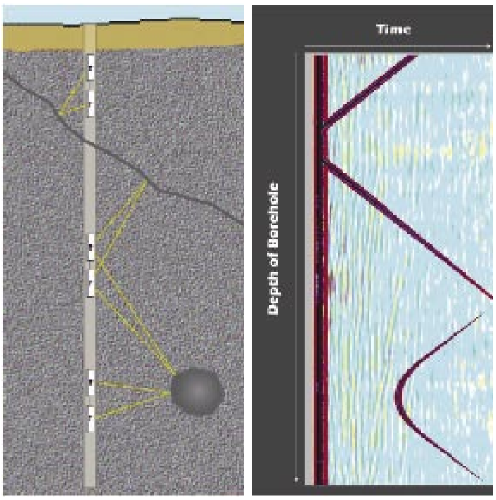


Figure 4-1. *The principle of radar borehole reflection survey (left) and an example of result (right).*

Table 4-1. Radar logging information from KFM08C.

Site:	**Forsmark**	**Logging company:**	**Malå Geoscience**		
BH:	**KFM08C**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional / Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
Logging date:		2006-06-20 and 2006-06-28	2006-06-28	2006-06-28–29	2006-06-29
Reference:		T.O.C.	T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):		615	2,424	891	239
Number of samples:		512	619	518	518
Number of stacks:		32	Auto	Auto	Auto
Signal position:		410.5	–0.39	–0.36	–1.42
Logging from (m):		103.4	1.5	2.6	6.25
Logging to (m):		938.4	947.6	947.1	941.2
Trace interval (m):		0.5	0.1	0.2	0.25
Antenna separation (m):		5.73	2.4	3.9	10.05

Table 4-2. Radar logging information from HFM30.

Site:	**Forsmark**	**Logging company:**	**Malå Geoscience**
BH:	**HFM30**	**Equipment:**	**SKB RAMAC**
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**
Operator:	**CG**	**Antenna**	
		100 MHz	**20 MHz**
Logging date:		2006-06-19	2006-06-19
Reference:		T.O.C.	T.O.C.
Sampling frequency (MHz):		891	239
Number of samples:		518	518
Number of stacks:		Auto	Auto
Signal position:		–0.36	–1.42
Logging from (m):		2.6	6.25
Logging to (m):		197.1	193.65
Trace interval (m):		0.2	0.25
Antenna separation (m):		3.9	10.05

Table 4-3. Radar logging information from HFM31.

Site: Forsmark **BH:** HFM31 **Type:** Dipole **Operator:** CG	**Logging company:** **Equipment:** **Manufacturer:** **Antenna** **250 MHz**	**Malå Geoscience** **SKB RAMAC** **MALÅ GeoScience** **100 MHz**	 **20 MHz**
Logging date:	06-06-01	06-06-01	06-06-01
Reference:	T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):	2,424	891	239
Number of samples:	619	518	518
Number of stacks:	Auto	Auto	Auto
Signal position:	–0.35	–0.35	–1.42
Logging from (m):	1.5	2.6	6.25
Logging to (m):	197	197.8	193.15
Trace interval (m):	0.1	0.2	0.25
Antenna separation (m):	2.4	3.9	10.05

Table 4-4. Radar logging information from HFM33.

Site: Forsmark **BH:** HFM33 **Type:** Dipole **Operator:** CG	**Logging company:** **Equipment:** **Manufacturer:** **Antenna** **250 MHz**	**Malå Geoscience** **SKB RAMAC** **MALÅ GeoScience** **100 MHz**	 **20 MHz**
Logging date:	06-06-01	06-06-01	06-06-01
Reference:	T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):	2,424	891	239
Number of samples:	619	518	518
Number of stacks:	Auto	Auto	Auto
Signal position:	–0.35	–0.36	–1.42
Logging from (m):	1.5	2.6	6.25
Logging to (m):	137.3	136.9	132.95
Trace interval (m):	0.1	0.2	0.25
Antenna separation (m):	2.4	3.9	10.05

Table 4-5. Radar logging information from HFM34.

Site:	**Forsmark**	**Logging company:**	**Malå Geoscience AB**	
BH:	**HFM34**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Logging date:		2006-06-12	2006-06-12	2006-06-12
Reference:		T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):		2,424	891	239
Number of samples:		619	518	518
Number of stacks:		Auto	Auto	Auto
Signal position:		–0.35	–0.36	–1.42
Logging from (m):		1.5	2.6	6.25
Logging to (m):		195.6	194.4	190.15
Trace interval (m):		0.1	0.2	0.25
Antenna separation (m):		2.4	3.9	10.05

4.1.2 BIPS

All measurements were performed in accordance with the instructions and guidelines from SKB (internal document MD 222.006). All cleaning of the probe and cable was performed according to the internal document SKB MD 600.004 before the logging operation.

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

A gravity sensor was used to measure the orientation of the images in all the measured boreholes.

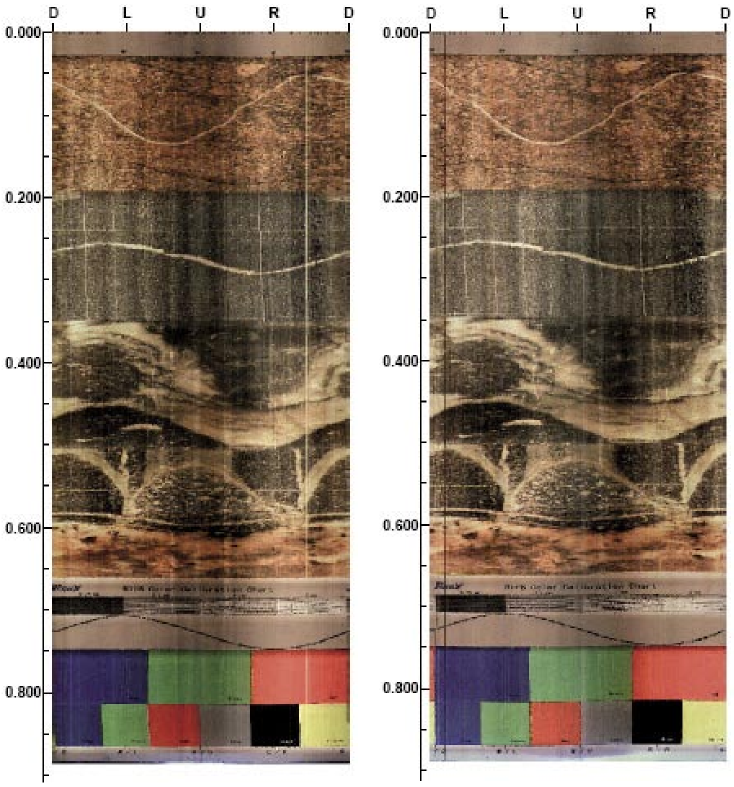
In order to control the quality of the system, calibration measurements were performed in a test pipe before logging and after logging. Figure 4-2 and 4-3 corresponds to the test logging performed before and after the logging campaigns in June. The results showed no difference regarding the colours and focus of the images. Results of the test loggings were included in the delivery of the raw data.

The BIPS logging information is found in the header for every single borehole presented in Appendices 6 to 10 in this report.

4.1.3 Length measurements

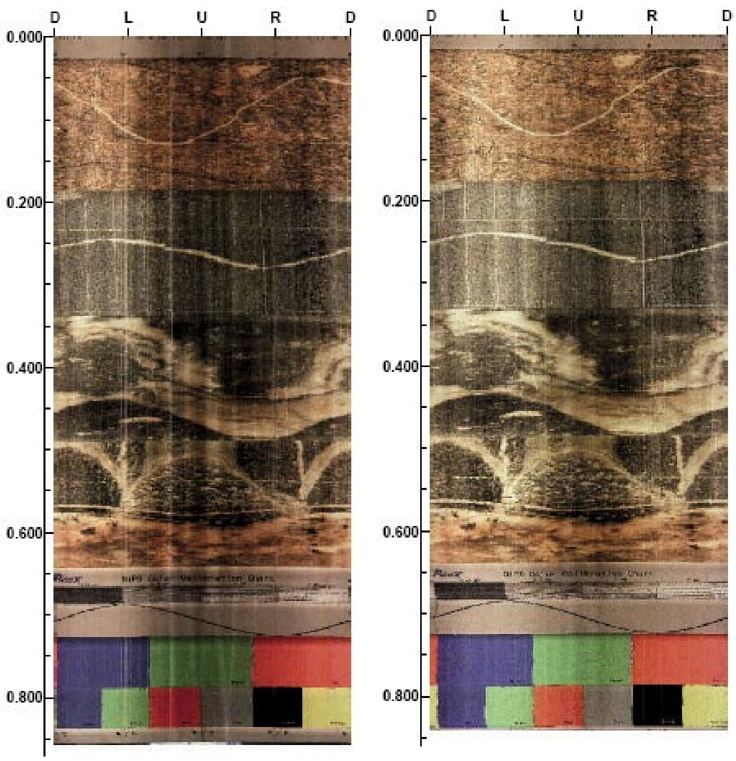
During logging the length recording for the RAMAC systems is taken care of by a measuring wheel mounted on the cable winch. The logging is measured from TOC (Top of Casing). The length is adjusted to the bottom of casing when visible in the BIPS image.

During the BIPS logging in core drilled boreholes, where the reference marks in the borehole wall is visible on the image, the position where the length mark is visible is marked with scotch tape on the logging cable. During BIPS logging the measured length was adjusted to true length according to length mark visible in the BIPS image. The adjusted true length is marked with red in the image plot together with the non-adjusted measured length in black, see Appendices 6 to 10. The tape marks on the logging cable are then used for length adjustment of the RAMAC measurements.



Before logging in HFM31 **After logging in HFM33**

Figure 4-2. *Results from logging in the test pipe before and after the logging campaign 2006-06-01. The length scales are not essential in the test measurements*



Before logging in HFM34 **After logging in KFM08C**

Figure 4-3. *Results from logging in the test pipe before and after the logging campaign 2006-06-12 to 2006-06-29. The length scales are not essential in the test measurements.*

The experience we have from earlier measurements with dipole antennas in the core drilled boreholes in Forsmark and Oskarshamn for the radar logging is that the length divergence is less than 100 cm in the deepest parts of a 1,000 m deep borehole. The resulting tables in Chapter 5 are corrected for the length divergence.

4.2 Analyses and Interpretation

4.2.1 Radar

The result from radar measurements is most often presented in the form of a radargram where the position of the probes is shown along one axis and the propagation is shown along the other axis. The amplitude of the received signal is shown in the radargram with a gray scale where black color corresponds to the large positive signals and white color to large negative signals. Grey color corresponds to no reflected signals.

The presented data in this report is adjusted for the measurement point of the antennas. The measurement point is defined to be the central point between the transmitter and the receiver antenna.

The two basic patterns to interpret in borehole measurements are point and plane reflectors. In the reflection mode, borehole radar essentially gives a high-resolution image of the rock mass, showing the geometry of plane structures which may or may not, intersect the borehole (contact between layers, thin marker beds, fractures) or showing the presence of local features around the borehole (cavities, lenses etc.).

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 the same everywhere.

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 the borehole while moving the receiver downwards in the borehole. The result is plotted in Figure 4-4 and the calculation shows a velocity of 128 m/µs (metres per microsecond) /1/. The velocity measurement was performed with the 100 MHz antenna.

The visualization of data in Appendices 1 to 5 is made with ReflexWin, a Windows based processing software for filtering and analysis of borehole radar data. The processing steps for the data presented in Appendices 1 to 5 are given in Tables 4-6 to 4-10. The filters applied affect the whole borehole length and are not always suitable in all parts, depending on the geological conditions and conductivity of the borehole fluid. During interpretation further processing can be done, most often in form of bandpass filtering. This filtering can be applied just in parts of the borehole, where needed.

For the interpretation of the intersection angle between the borehole axis and the planes visible on the radargrams the RadinterSKB software has been used. The interpreted intersection points and intersection angles of the detected structures are presented in the Tables 5-6 to 5-10 and are also visible on the radargrams in Appendices 1 to 5.

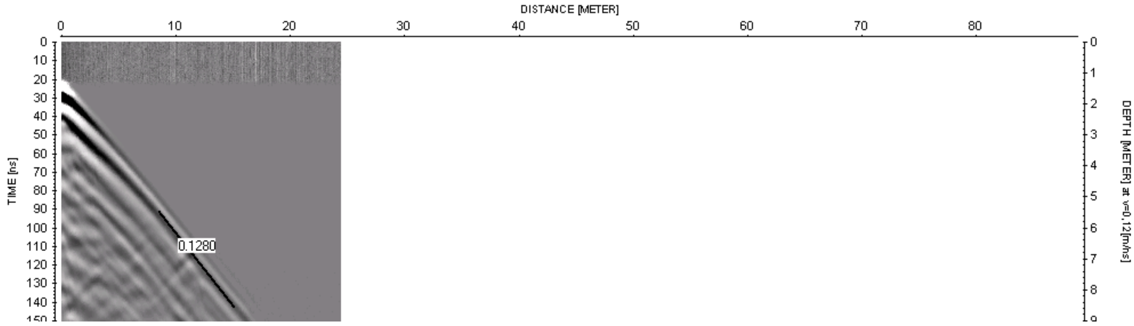


Figure 4-4. Results from velocity measurements in HFM03 /1/.

Table 4-6. Processing steps for borehole radar data from KFM08C.

Site:	**Forsmark**	**Logging company:**	**Malå GeoScience AB**		
BH:	**KFM08C**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
Processing:		Move start time (–32 samples)	Move start time (–28)	Move start time (–28.9)	Move start time (–83.5)
		DC shift (350–511)	DC shift (190–240)	DC shift (460–520)	DC shift (1,800–2,100)
		Time gain (start 71 lin 100 exp 1)	Gain (start 27 lin 1.7 exp 1.2)	Gain (start 55 lin 1.7 exp 0.8)	Gain (start 129 lin 2.8 exp 0.17)
		(FIR)			

Table 4-7. Processing steps for borehole radar data from HFM30.

Site:	**Forsmark**	**Logging company:**	**MALÅ GeoScience AB**
BH:	**HFM30**	**Equipment:**	**SKB RAMAC**
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**
Interpret:	**JG**	**Antenna**	
		100 MHz	**20 MHz**
Processing:		Move start time (–21.9)	Move start time (–94)
		DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 38 lin 4.3 exp 0.5)	Gain (start 100 lin 1.4 exp 0)
			Bandpass 7/120

Table 4-8. Processing steps for borehole radar data from HFM31.

Site:	**Forsmark**	**Logging company:**	**MALÅ GeoScience AB**	
BH:	**HFM31**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Processing:		Move start time (–19.8)	Move start time (–28.1)	Move start time (–121)
		DC shift (190–240)	DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 16 lin 1.4 exp 1)	Gain (start 35 lin 2.4 exp 0.5)	Gain (start 121 lin 3 exp 0)

Table 4-9. Processing steps for borehole radar data from HFM33.

Site:	**Forsmark**	**Logging company:**	**MALÅ GeoScience AB**	
BH:	**HFM33**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Processing:		Move start time (–18.8)	Move start time (–42.5)	Move start time (–80.3)
		DC shift (190–240)	DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 18 lin 4.3 exp 1)	Gain (start 11 lin 4 exp 0.6)	Gain (start 120 lin 3.6 exp 0.3)
				Bandpass 6/100

Table 4-10. Processing steps for borehole radar data from HFM34.

Site:	**Forsmark**	**Logging company:**	**MALÅ GeoScience AB**	
BH:	**HFM34**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Processing:		Move start time (–25.2)	Move start time (–34)	Move start time (–84.7)
		DC shift (190–240)	DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 16 lin 3.6 exp 0.6)	Gain (start 38 lin 4.3 exp 0.6)	Gain (start 90 lin 4 exp 0)
				Bandpass 7/120

4.2.2 BIPS

The visualization of data is made with BDPP, a Windows based processing software for filtering, presentation and analysis of BIPS data. As no fracture mapping of the BIPS image is performed, the raw data was delivered on a CD-ROM together with printable pictures in *.pdf format before the field crew left the investigation site.

The printed results were delivered with measured length, together with adjusted length according to the length marks made on the cable when logging core-drilled boreholes (where the length marks are visible in the BIPS image). For printing of the BIPS images the printing software PDPP from RaaX was used.

4.3 Nonconformities

Due to problems with the transmitter in the 250 MHz dipole antenna when logging HFM30, no loggings were carried out in this hole with this frequency.

5 Results

The results from the BIPS measurements in KFM08C, HFM30, HFM31, HFM33 and HFM34 were delivered as raw data (*.bip-files) together with printable BIPS pictures in *.pdf format before the field crew left the investigation site. The information of the measurements was registered in SICADA, and the CD-ROM:s stored by SKB.

The RAMAC radar data for the holes were delivered as raw data (file format *.rd3 or *.rd5) with corresponding information files (file format *.rad) on CD-ROM:s to SKB before the field crew left the investigation site, whereas the data processing steps and results are presented in this report. Relevant information, including the interpretation presented in this report, was inserted into the SKB database SICADA.

5.1 RAMAC logging

The results of the interpretation of the radar measurements are presented in Tables 5-1 to 5-16. Radar data are also visualized in Appendices 1 to 5. It should be remembered that the images in Appendices 1 to 5 is only a composite picture of all events 360 degrees around the borehole, and do not reflect the orientation of the structures.

Only the larger clearly visible structures are interpreted in RadinterSKB. Overviews of the five boreholes are given in Figure 5-1 next page.

A number of minor structures also exist, indicated in Appendices 1 to 5. Often a number of structures can be noticed, but most probably lying so close to each other that it is impossible to distinguish one from the other. Larger structures parallel to the borehole, if present, are also indicated in Appendices 1 to 5. It should also be pointed out that interpreted reflectors always have an intersection point with the borehole, although this can be located out of the physical borehole length.

The data quality from KFM08C, HFM30, HFM31, HFM33 and HFM34 (as seen in Figure 5-1 and Appendices 1 to 5) varies from rather bad in some of the percussion-drilled holes to good especially in the core-drilled hole. In all holes parts are found with a lower quality due to more conductive conditions. A conductive environment causes an attenuation of the radar wave, which in turn decreases the penetration. This conductive environment of course also reduces the possibility to distinguish and interpret possible structures in the rock which otherwise could give a reflection.

This effect is also seen in the directional antenna for KFM08C, which makes it more difficult to interpret the direction to the identified structures.

In parts with an increased conductivity and thereby a decreased depth penetration most often only the edges of structures can be distinguished, giving an intersection angle of 90 degrees.

As also seen in Appendices 1 to 5 the resolution and penetration of radar waves depend on the antenna frequency used. Low antenna frequency gives less resolution but better penetration compared to a higher frequency. If structures can be identified with all three antenna frequencies, it can probably be concluded that the structure is quite significant.

In Tables 5-1 to 5-5 below the distribution of identified structures along the boreholes are listed for KFM08C, HFM30, HFM31, HFM33 and HFM34.

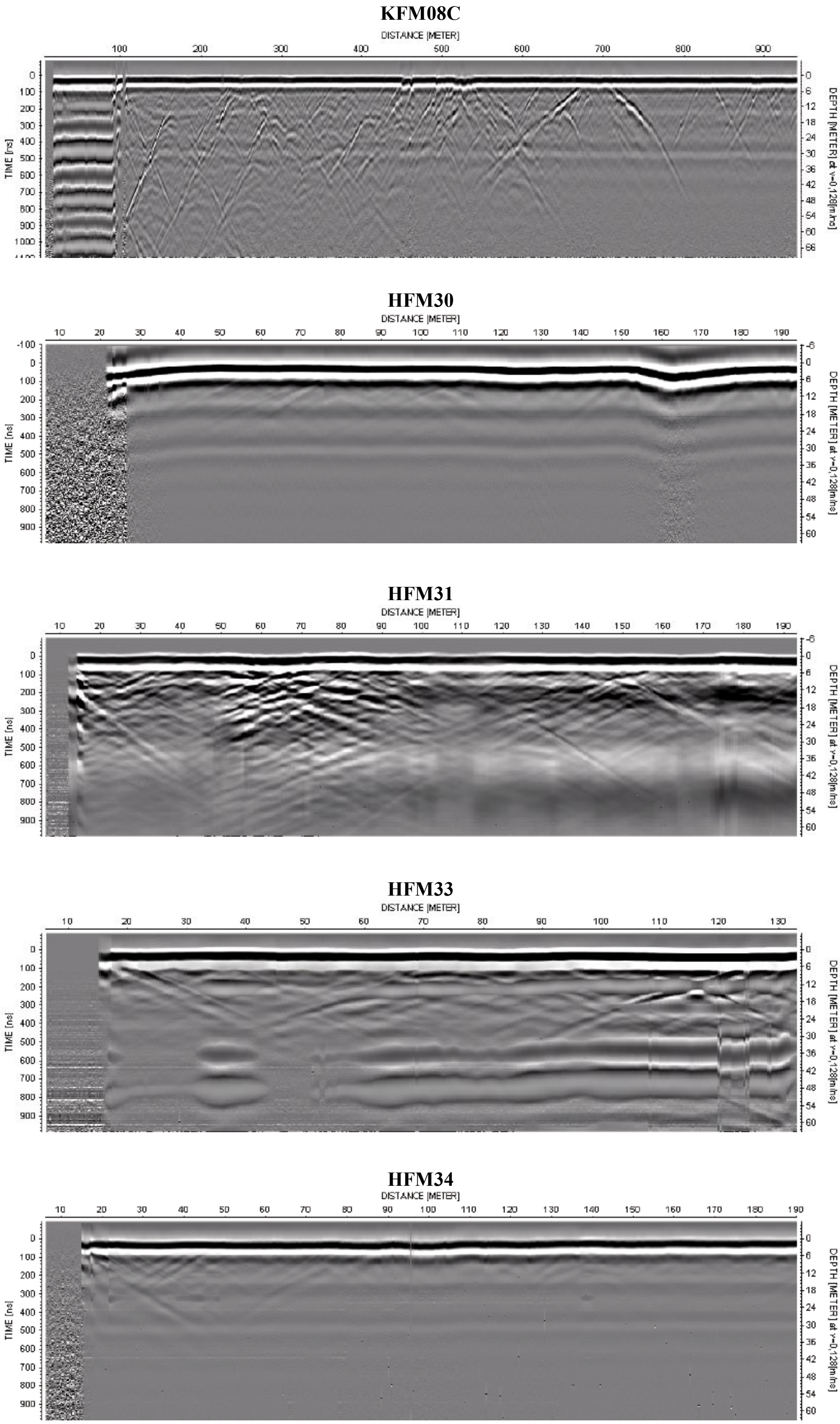


Figure 5-1. *An overview (20 MHz data) of the radar data for the five boreholes KFM08C, HFM30, HFM31, HFM33 and HFM34. Observe that the borehole length (x-scale) and depth (y-scale) differs between the different boreholes.*

Table 5-1. Identified structures as a function of borehole intersection length in KFM08C.

Length (m)	No. of structures
0–50	16
50–100	24
100–150	7
150–200	14
200–250	12
250–300	13
300–350	13
350–400	13
400–450	17
450–500	12
500–550	11
550–600	10
600–650	9
650–700	14
700–750	17
750–800	10
800–850	12
850–900	10
900–	15

Table 5-2. Identified structures as a function of borehole intersection in HFM30.

Length (m)	No. of structures
–0	–
0–20	–
20–40	2
40–60	2
60–80	5
80–100	6
100–120	2
120–140	4
140–160	3
160–180	2
180–	3

Table 5-3. Identified structures as a function of borehole intersection in HFM31.

Length (m)	No. of structures
–0	–
0–20	3
20–40	8
40–60	7
60–80	5
80–100	5
100–120	5
120–140	3
140–160	4
160–180	8
180–	4

Table 5-4. Identified structures as a function of borehole intersection in HFM33.

Length (m)	No. of structures
–0	–
0–20	3
20–40	7
40–60	5
60–80	6
80–100	5
100–120	8
120–140	6
140–	1

Table 5-5. Identified structures as a function of borehole intersection in HFM34.

Length (m)	No. of structures
–0	–
0–20	7
20–40	8
40–60	6
60–80	4
80–100	4
100–120	3
120–140	5
140–160	7
160–180	4
180–	5

Tables 5-6 to 5-10 summarises the interpretation of radar data from KFM08C, HFM30, HFM31, HFM33 and HFM34. In the tables the borehole length and intersection angle to the identified structures are listed.

For KFM08C the direction to the objects identified is also given. As seen, some radar reflectors in Table 5-6 is marked with ±, which indicates an uncertainty in the interpretation of direction. The direction can in these cases be ±180 degrees. The direction to the object (the plane) is defined in Figure 5-2. This direction and the intersection angle are recalculated to strike and dip, also given in the tables below. The plane strike is the angle between the line of the plane's intersection with the surface and the Magnetic North direction. A strike of 0 degrees implies a dip to the east while a strike of 180 degrees implies a dip to the west (right-hand rule). The strike is measured clockwise and can vary from 0 to 359 degrees. The dip of the plane is the angle between the ground surface and the plane, and can vary from 0 to 90 degrees.

Observe that the interpretation of an undulating structure can result in several different angles and different intersection lengths. An example of this phenomenon is seen in Table 5-6 and Appendix 1: the reflectors named 33, 33x, 33xx and 33xxx most likely originates from the same geological structure.

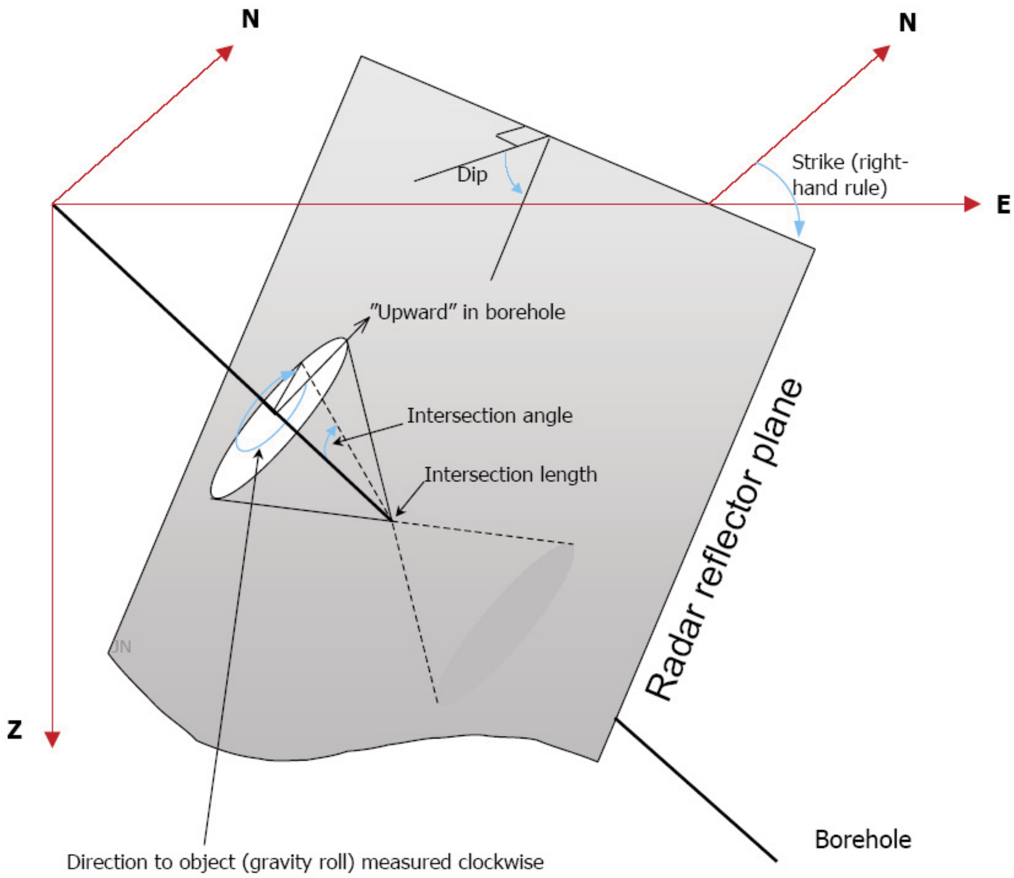


***Figure 5-2.** Definition of direction to reflector (gravity roll) as presented in Table 5-6.*

Table 5-6. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz in borehole KFM08C.

RADINTER MODEL INFORMATION (Directional and dipole antennas)							
Site:		**Forsmark**					
Borehole name:		**KFM08C**					
Nominal velocity (m/μs):		**128.0**					
Name	**Intersection length**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
36	4.9	9					
2	6.1	74					
3	7.6	60					
8xx	11.7	8					
1	14.4	37					
226	20.7	44					
200	23.4	25					
8	26.5	12					
5	28.5	77					
8x	29.2	16					
4	30.1	71					
6	33.0	67					
7	33.9	61					
201	41.1	87					
9	44.8	72					
10	49.1	67					
11	51.3	75					
12	54.1	68					
29	55.3	14	288 ±	88	59	69	226
202	57.5	87					
14	64.4	63					
13	65.1	65					
26	66.9	62					
228	69.6	31					
227	69.9	60					
15	72.0	65					
17	73.2	57					
16	73.4	67					
218	80.4	34					
18	80.5	43					
203	81.0	64					
19	85.0	62					
20	87.0	64					
204	90.2	70					
21	91.8	69					
22	93.4	65					
24	95.5	66					
23	95.6	75					
28	96.0	61					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site:	**Forsmark**
Borehole name:	**KFM08C**
Nominal velocity (m/μs):	**128.0**

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
25	99.1	68					
27	102.8	70					
30	114.6	52					
31	116.5	62	87 ±	44	175	42	77
32	119.8	53					
35	137.5	57	159	12	226		
34	138.2	46					
37	147.9	50	93 ±	48	188	51	70
205	156.6	61					
236	162.9	61					
33x	167.1	10					
33xx	168.3	15					
219	173.2	65					
38	173.9	50	174	8	279		
237	174.3	23	57	86	178		
39	174.3	45					
40	177.2	57					
41	178.3	57					
33	178.4	9	252	73	27		
206	186.0	56					
33xxx	188.9	10					
42	189.5	57					
43	206.7	53					
207	208.9	49					
221	209.4	43					
44	211.3	60					
45	218.8	64					
46	225.4	58					
47	226.9	61					
208	231.4	58					
48	235.9	48	24	74	145		
234	244.7	50	225	27	38		
55	245.6	43	195	20	343		
209	249.1	47					
52	255.6	51					
50	256.4	56					
229	256.6	41					
53	258.6	52	3	70	130		
49	260.8	47					
51	261.1	37					
222	271.0	43	69	64	178		
210	271.4	39					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM08C
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
54	279.8	42					
57	280.9	38	66	70	178		
56	283.6	59					
58	289.2	41					
59	293.1	46					
62	302.8	76					
64	309.2	48					
67x	310.2	42					
60	312.5	41					
65	315.6	42					
238	317.9	34	240	46	36		
67	319.1	40	39	77	160		
66	320.8	51					
69	323.7	49					
63	329.5	53					
73	341.9	57					
70	345.4	35					
72	346.9	45					
74	354.6	48					
71	355.1	38	114	47	216		
77	359.0	48					
81	363.0	13					
76	372.1	44					
78	372.7	61					
75	377.9	31	105	56	214		
220	378.1	6					
79	381.5	54					
239	384.8	36	246 ±	48	45	72	182
80	387.1	34					
235	387.5	48					
82	394.1	26					
83	401.3	35					
211	403.4	35					
84	407.0	26					
85	410.5	35					
88	416.8	62					
86	418.7	28					
87	420.7	29					
92	426.4	29					
94	428.4	31					
90	429.1	38					
89	429.4	27					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM08C
Nominal velocity (m/µs): 128.0

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
91	434.1	32					
95	438.5	41					
93	439.9	31	105 ±	55	212	71	72
98	444.6	36					
233	444.9	30					
99	447.0	41					
96	451.9	36					
97	456.6	36	285	69	74		
100	457.6	50	141 ±	22	211	66	107
101	468.1	33	300	77	84		
102	471.4	51					
103	473.3	50					
104	476.2	48					
105	481.7	46					
114	485.3	33					
106	487.9	32					
108	497.9	61					
107	499.2	41					
110	503.2	54					
109	509.0	37	240	44	42		
111	511.7	49					
113	515.8	45					
112	520.4	44					
223	520.5	42	114	45	213		
231	520.9	30					
115	528.2	32					
116	530.5	30					
117	535.2	36					
118	547.6	27					
121	550.4	21					
119	550.5	31					
212	559.4	45					
124	565.5	64					
120	567.3	41					
126	567.7	36					
122	570.6	43					
123	579.9	42					
125	583.8	37					
232	596.2	33					
127	611.4	25	264	66	52		
129	616.8	45					
132	621.8	45					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: **Forsmark**
Borehole name: **KFM08C**
Nominal velocity (m/μs): **128.0**

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
128	625.8	37	57	78	175		
130	628.8	34					
213	629.2	35					
131	633.6	41	39	79	160		
134	634.4	35					
136	649.3	69					
133x	650.0	11					
137	652.0	68					
135	660.0	37	39 ±	84	162	34	20
133	662.5	29					
142	675.8	67					
214	681.8	28					
138	683.2	30	81	71	196		
139	683.7	44					
140	686.5	51					
141	687.6	22					
143x	692.6	20					
144	696.5	40					
224	697.4	40					
143	698.0	16	9	71	320		
145	701.5	36	222 ±	34	25	82	164
146	702.8	41					
147	707.0	44					
148	708.3	42					
149	710.5	45					
150	716.9	65					
154	719.2	64					
143xx	724.3	39					
156	727.1	62	285 ±	50	95	38	171
151	727.6	55					
152	730.6	60					
153	733.7	46					
155	734.8	49					
157	736.2	79					
159	738.7	54					
158	741.6	81					
160	748.9	54					
161	754.6	46	240	37	59		
162	757.5	58					
163	762.8	47					
164	766.3	53					
165	768.2	52					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: **Forsmark**
Borehole name: **KFM08C**
Nominal velocity (m/μs): **128.0**

Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
166	789.5	38	243	46	44		
167	791.3	37					
168	793.6	37					
169	795.6	39					
170	799.0	37					
171	800.5	29					
172	803.5	37					
173	807.2	29					
174	809.1	43	258 ±	51	61	64	183
175	819.9	41	255	51	57		
215	820.2	43					
176	821.6	41					
177	829.7	46	78	61	179		
177x	830.0	41					
178	844.0	34					
179	846.8	43					
180	849.1	44	177	10	295		
181	854.2	65					
184	874.0	42	129	35	212		
216	878.7	52					
183	884.5	38					
182	889.9	51					
186	891.4	51					
225	893.2	50					
185	893.9	41					
230	894.5	36					
217	898.2	59					
187	903.3	49	252	43	66		
187x	904.5	47					
189	911.8	53					
188	913.1	49	99 ±	48	187	57	79
187xx	917.7	31					
190	917.7	55					
191	921.6	59	75	56	170		
192	921.7	48	252 ±	45	63	63	174
193	933.8	41					
194	934.9	49					
198	946.9	28					
197	949.0	29					
196	952.3	43					
195	952.7	56					
199	959.4	58					

Table 5-7. Interpretation of radar reflectors from dipole antennas 20 and 100 MHz borehole HFM30.

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

Site:	**Forsmark**
Borehole name:	**HFM30**
Nominal velocity (m/μs):	**128.00**

Object type	Name	Intersection depth	Intersection angle
PLANE	2	36.4	53
PLANE	1	39.1	59
PLANE	3	44.0	59
PLANE	4	55.4	59
PLANE	6	61.6	58
PLANE	5	65.2	53
PLANE	7	70.5	59
PLANE	8	71.8	84
PLANE	9	79.7	55
PLANE	10	80.5	43
PLANE	26	81.2	53
PLANE	27	88.4	58
PLANE	11	89.2	40
PLANE	11x	89.5	47
PLANE	12	90.9	49
PLANE	13	110.2	57
PLANE	13	114.5	32
PLANE	14	120.2	79
PLANE	15	128.4	31
PLANE	16	133.2	89
PLANE	17	137.7	80
PLANE	18	141.2	90
PLANE	19	153.6	90
PLANE	20	159.2	77
PLANE	21	171.3	90
PLANE	22	178.5	90
PLANE	25	183.0	69
PLANE	23	196.0	56
PLANE	24	201.6	79

Table 5-8. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz borehole HFM31.

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

Site:	**Forsmark**
Borehole name:	**HFM31**
Nominal velocity (m/μs):	**128.00**

Object type	Name	Intersection depth	Intersection angle
PLANE	49	5.6	47
PLANE	1	17.5	48
PLANE	2	19.6	46
PLANE	3	20.8	56
PLANE	4	23.2	72
PLANE	5	26.9	44
PLANE	45	27.2	31
PLANE	6	28.5	48
PLANE	7	31.1	46
PLANE	9	31.1	59
PLANE	8	35.3	45
PLANE	10	42.3	42
PLANE	11	42.9	90
PLANE	18	44.6	76
PLANE	12	46.2	90
PLANE	13	50.2	62
PLANE	15	53.3	90
PLANE	16	58.6	55
PLANE	17	62.1	57
PLANE	14	68.4	41
PLANE	19	76.2	73
PLANE	43	78.9	55
PLANE	20	79.9	68
PLANE	21	84.8	65
PLANE	22	86.3	64
PLANE	23	90.7	44
PLANE	44	93.6	64
PLANE	24	99.0	74
PLANE	25	101.2	72
PLANE	27	108.9	43
PLANE	26	114.9	25
PLANE	28	116.8	48
PLANE	29	119.1	54
PLANE	30	127.8	68
PLANE	31	130.5	73
PLANE	32	137.1	59
PLANE	33	141.5	53
PLANE	34	146.7	67
PLANE	46x	150.0	36
PLANE	35	154.7	63

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

Site: **Forsmark**
Borehole name: **HFM31**
Nominal velocity (m/μs): **128.00**

Object type	Name	Intersection depth	Intersection angle
PLANE	36	160.9	63
PLANE	37	163.6	70
PLANE	47	166.1	47
PLANE	38x	173.1	33
PLANE	46	173.7	27
PLANE	38	177.9	25
PLANE	48	177.9	53
PLANE	39	179.6	40
PLANE	39x	180.7	36
PLANE	40	189.3	44
PLANE	41	195.1	41
PLANE	42	204.6	51

Table 5-9. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz borehole HFM33.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:		**Forsmark**	
Borehole name:		**HFM33**	
Nominal velocity (m/μs):		**128.00**	
Object type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	1x	7.6	59
PLANE	1	9.2	70
PLANE	2	15.4	84
PLANE	39	20.4	63
PLANE	3	20.6	60
PLANE	4	22.6	59
PLANE	5	24.7	55
PLANE	6	27.7	60
PLANE	7	30.0	64
PLANE	8	31.9	64
PLANE	9	40.7	47
PLANE	10	42.6	52
PLANE	11	49.7	60
PLANE	12	49.9	50
PLANE	13	52.0	54
PLANE	15	60.4	65
PLANE	38	60.8	73
PLANE	14	63.4	64
PLANE	35	67.1	56
PLANE	16	76.0	68
PLANE	17	77.7	73
PLANE	18	81.1	71
PLANE	19	86.8	79
PLANE	21	95.1	75
PLANE	20	96.1	59
PLANE	22	98.5	71
PLANE	34	103.7	78
PLANE	23	105.5	64
PLANE	24	107.0	73
PLANE	25	109.4	79
PLANE	32	110.1	64
PLANE	37	115.3	68
PLANE	36	117.4	43
PLANE	26	118.5	67
PLANE	27	120.8	72
PLANE	33	126.9	89
PLANE	28	129.7	65
PLANE	29	136.1	53
PLANE	30	139.9	77
PLANE	31	139.8	60
PLANE	40	163.4	76

Table 5-10. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz borehole HFM34.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:		Forsmark	
Borehole name:		HFM34	
Nominal velocity (m/μs):		128.00	
Object type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	51	4.2	62
PLANE	3	8.8	62
PLANE	3x	9.5	90
PLANE	47	11.7	52
PLANE	2x	13.9	59
PLANE	1	15.6	64
PLANE	2	16.6	64
PLANE	4	24.2	72
PLANE	7	25.3	57
PLANE	8	28.9	65
PLANE	5	29.5	55
PLANE	9	30.0	62
PLANE	5x	32.0	31
PLANE	6	33.9	51
PLANE	12	39.4	53
PLANE	10	41.7	47
PLANE	11	43.1	48
PLANE	13	49.3	44
PLANE	14	52.9	50
PLANE	52	55.0	70
PLANE	48	55.3	53
PLANE	17	62.8	57
PLANE	15	66.0	57
PLANE	16	68.3	71
PLANE	18	74.7	60
PLANE	19	81.5	57
PLANE	20	84.1	60
PLANE	21	86.1	73
PLANE	22	96.8	90
PLANE	23	103.1	83
PLANE	24	105.3	85
PLANE	25	109.8	87
PLANE	26	120.1	89
PLANE	27	121.6	34
PLANE	28	130.4	68
PLANE	29	132.8	49
PLANE	30	132.7	66
PLANE	31	143.3	61
PLANE	32	145.7	30

PLANE	33	150.2	71
PLANE	34	152.3	67
PLANE	35	156.8	43
PLANE	38	157.2	79
PLANE	39	158.9	45
PLANE	40	160.3	73
PLANE	41	171.7	70
PLANE	49	172.3	41
PLANE	42	176.1	42
PLANE	43	181.5	53
PLANE	44	190.2	57
PLANE	46	196.3	53
PLANE	45	197.7	81
PLANE	50	207.0	20

In Appendices 1 to 5, the amplitude of the first arrival is plotted against the borehole length, for the 250 MHz dipole antennas (in HFM30 for the 100 MHz antenna). The amplitude variation along the borehole indicates changes of the electrical conductivity of the rock volume surrounding the borehole. A decrease in this amplitude may indicate fracture zones, clay or rock volumes with increased water content. i.e. increased electric conductivity. The borehole length intervals showing decreased amplitude are listed in Tables 5-11 to 5-15.

Table 5-11. Borehole length intervals in KFM08C with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
35	495–500
115	520–535
170	580
180	685
185–190	695
245–250	830
255	890–895
260	905
310	935
455–465	

Table 5-12. Borehole length intervals in HFM30 with decreased amplitude for the 100 MHz antenna.

Length (m)	Length (m)
20–40	115–145
55	145–185
80–90	195

Table 5-13. Borehole length intervals in HFM31 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
15	125
40–50	130
55–75	145
85	150–170
90–95	175
100–110	180–200
120	

Table 5-14. Borehole length intervals in HFM33 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
20	80
25–30	85–90
40–55	95
60	135–140
70	

Table 5-15. Borehole length intervals in HFM34 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
5	120–125
30–35	130–135
50–70	145–160
80–85	170
95–105	180–185
110	

Finally, the structures considered as the most important (clear in the radargram, identified with several antenna frequencies, stretching out far from the borehole wall etc.) are listed in Table 5-16 below.

Table 5-16. Some important structures in KFM08, HFM30, HFM31, HFM33 and HFM34.

Borehole	KFM08C	HFM30	HFM31	HFM33	HFM34
Structures	1, 2, 8, 8x, 13, 17, 22, 24, 27, 29, 33, 33x, 33xx, 33xxx, 36, 41, 48, 67, 67x, 75, 93, 97, 107, 108, 109, 115, 119, 143, 143x, 174, 177, 177x, 187, 187x, 187xx, 218, 226, 229, 231, 233 and 238	10, 11, 11x, 12, 15, 19 and 20	8, 10, 26, 32, 38, 44, 46 and 46x	1, 1x, 20, 29 and 39	2, 2x, 3, 3x, 13, 14, 21 and 51

Observe that it is can be very difficult to classify different structures in an objective manner, along a borehole. This is due to the fact that the water quality (the conductivity) amongst other parameters varies along the borehole length and by that reason affects the results of the radar logging, by for instance attenuating the radar waves differently. Also the intersection angle of the identified structures affects the amplitude on the resulting radargram. A small angle will most often cause larger amplitude than a large angle, and by that a more clear structure.

5.2 BIPS logging

The BIPS pictures are presented in Appendices 6 to 10.

To get the best possible length accuracy, the BIPS images are adjusted to the reference marks on the logging cable. Additionally the marks on the borehole wall created by the drill rig in core-drilled boreholes are visible on the BIPS screen. The recorded length is adjusted to these visible marks.

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 last borehole in the campaign. The resulting images displayed no difference regarding the colours and focus of the images. The results of the test logging were included in the delivery of the field data and are also presented in Figure 4-2 and 4-3 in this report.

The values for inclination and azimuth of the boreholes, presented in the heading in Appendices 6 to 10, are based on preliminary specifications.

Two different runs with the BIPS have been performed in KFM08C. The first run resulted in very bad image quality in the deeper parts of the borehole due to dirty water and mud covering the lower most part of the borehole walls. After the first logging the borehole were cleaned by nitrogen blowing, The second run, after the cleaning resulted in a much better image quality except for the induced discoloring effects from the drilling. Figure 5-3 shows the improvements of the image quality after the cleaning. In this report only the result from the second logging is presented.

The images in HFM30, HFM31 and HFM33 were relatively good due to clean water and no mud coverage on the walls. For HFM34 the quality was not good, dirty water reduces the visibility from 96 m down to the bottom. The dirty water are probably coming from the big fracture zone at 96.5 m.

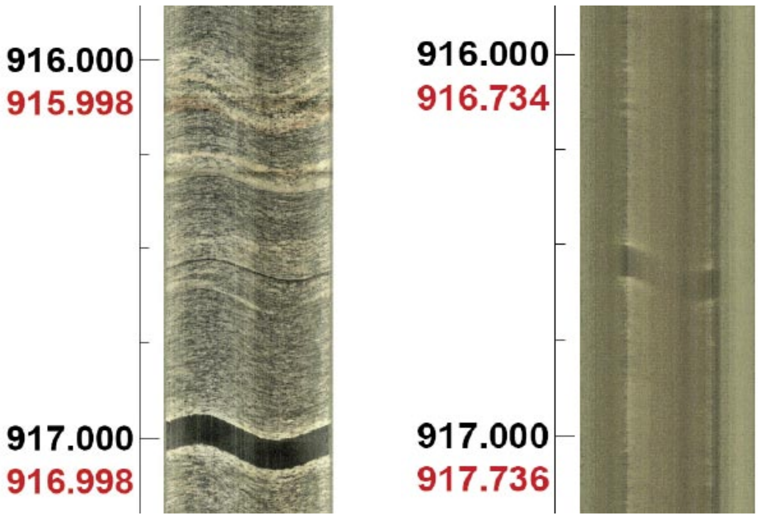


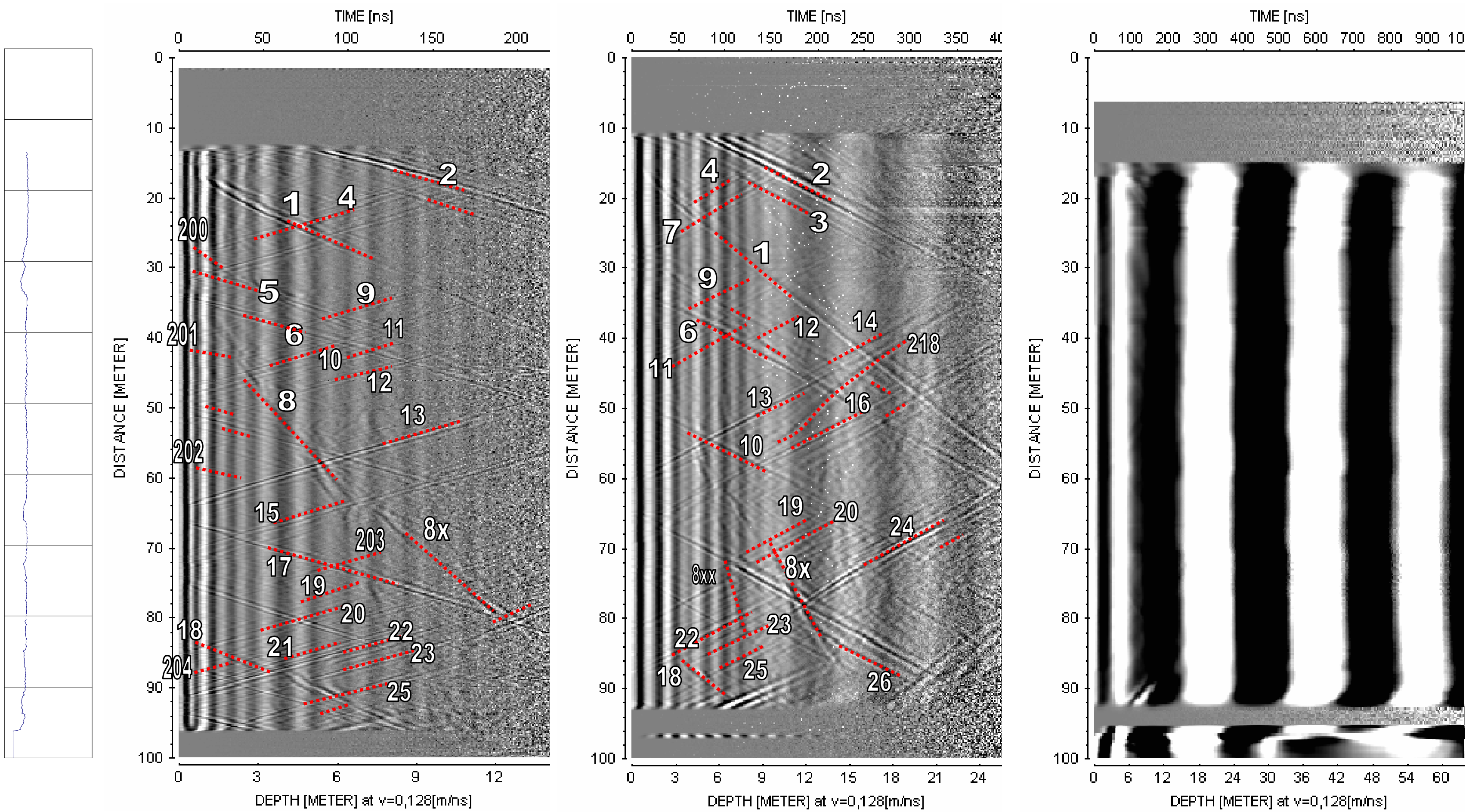
***Figure 5-3.** Improvements of the image quality in KFM08C, the second logging to the left.*

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.

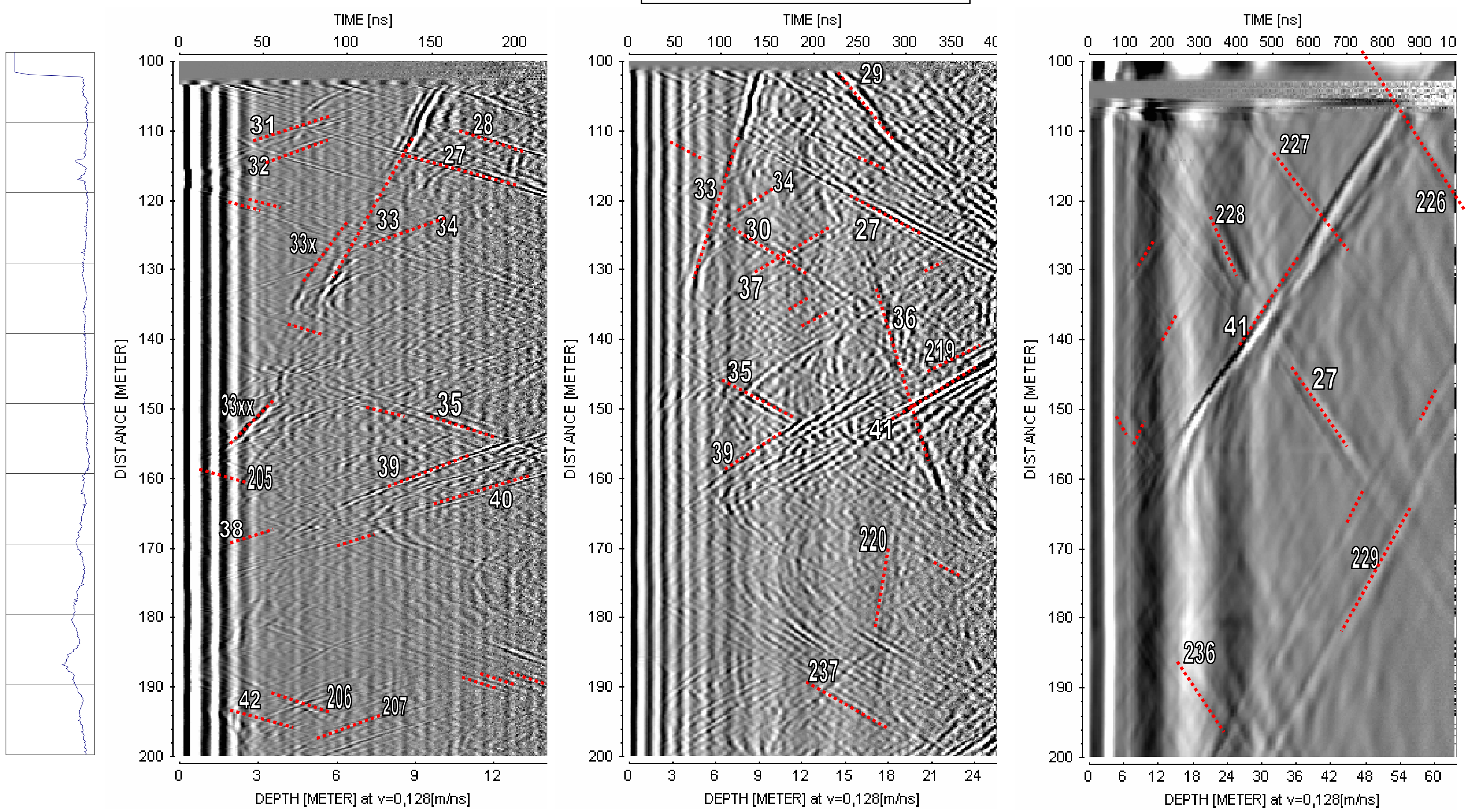
Radar logging in KFM08C. 0 to 947 m, dipole antennas 250. 100 and 20 MHz

Forsmark KFM08C

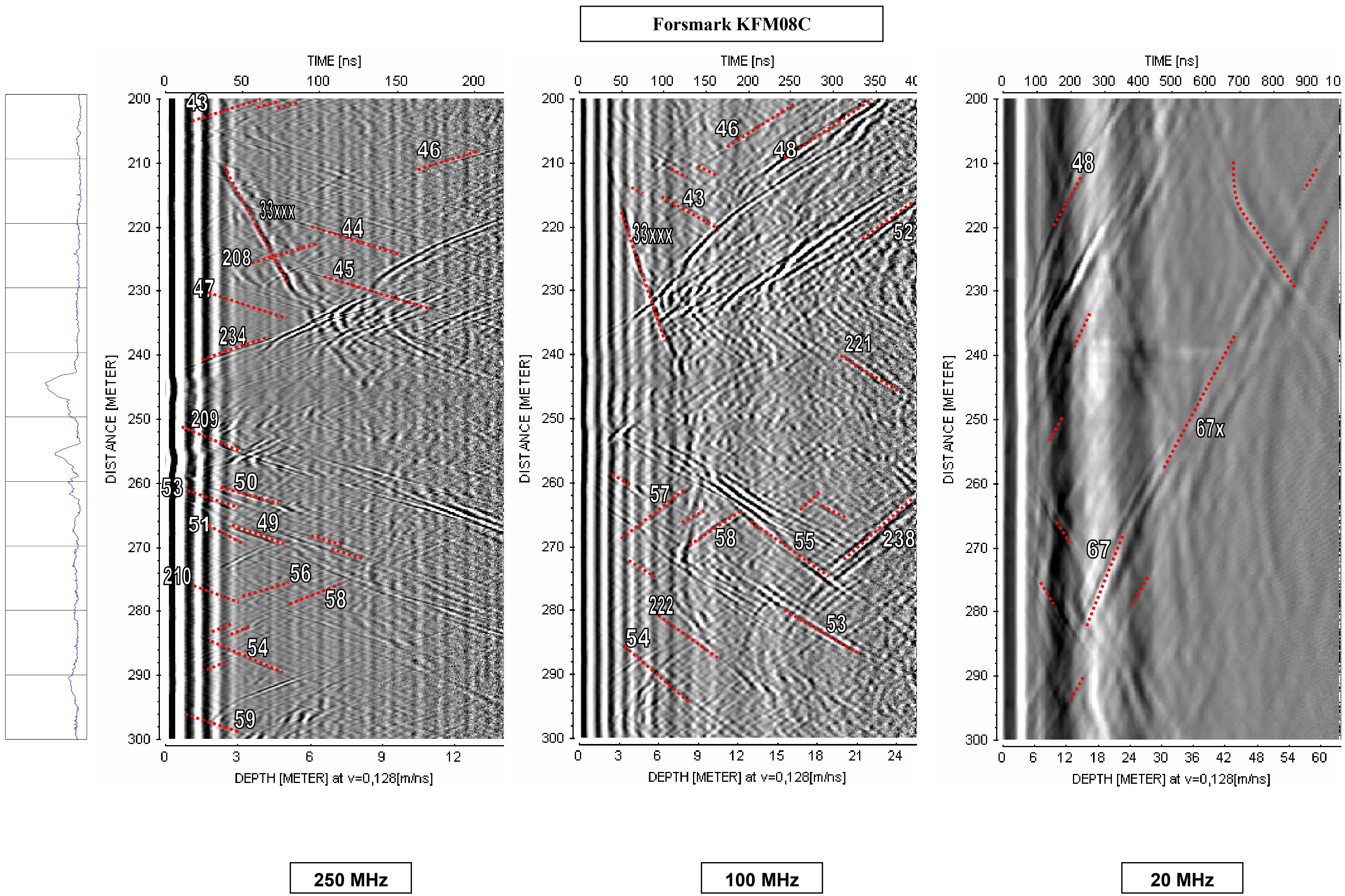


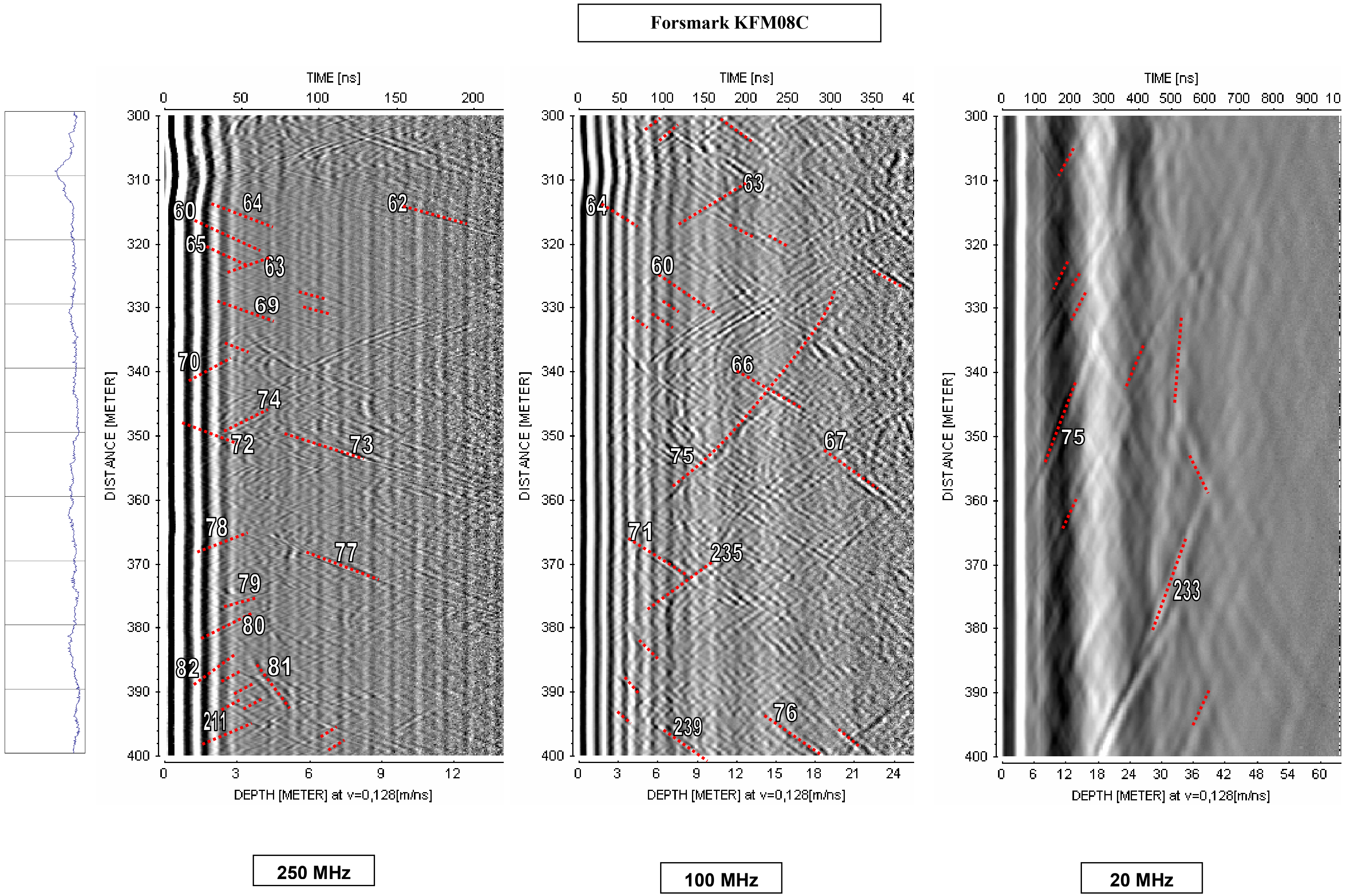
250 MHz   100 MHz   20 MHz

Forsmark KFM08C

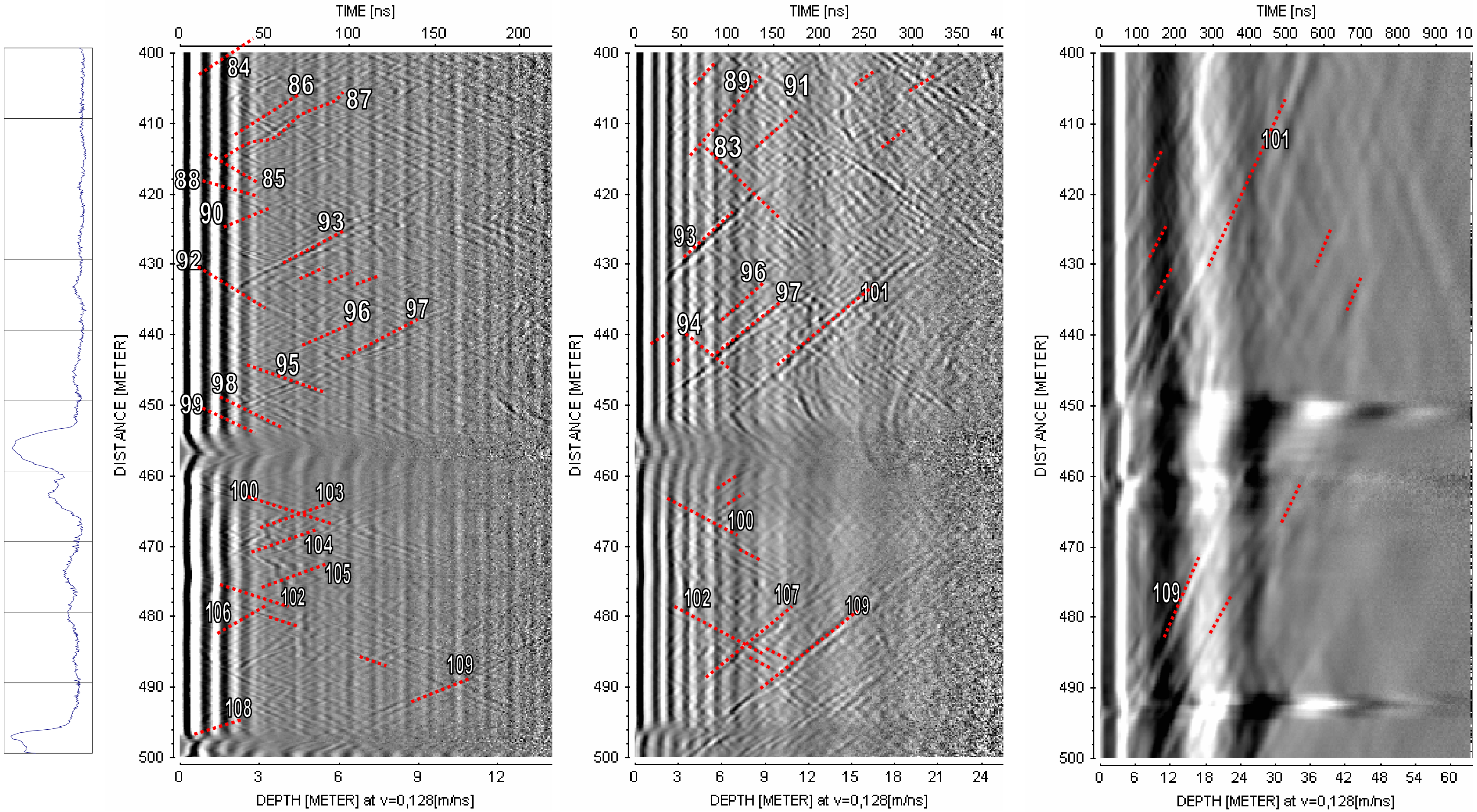


250 MHz **100 MHz** **20 MHz**

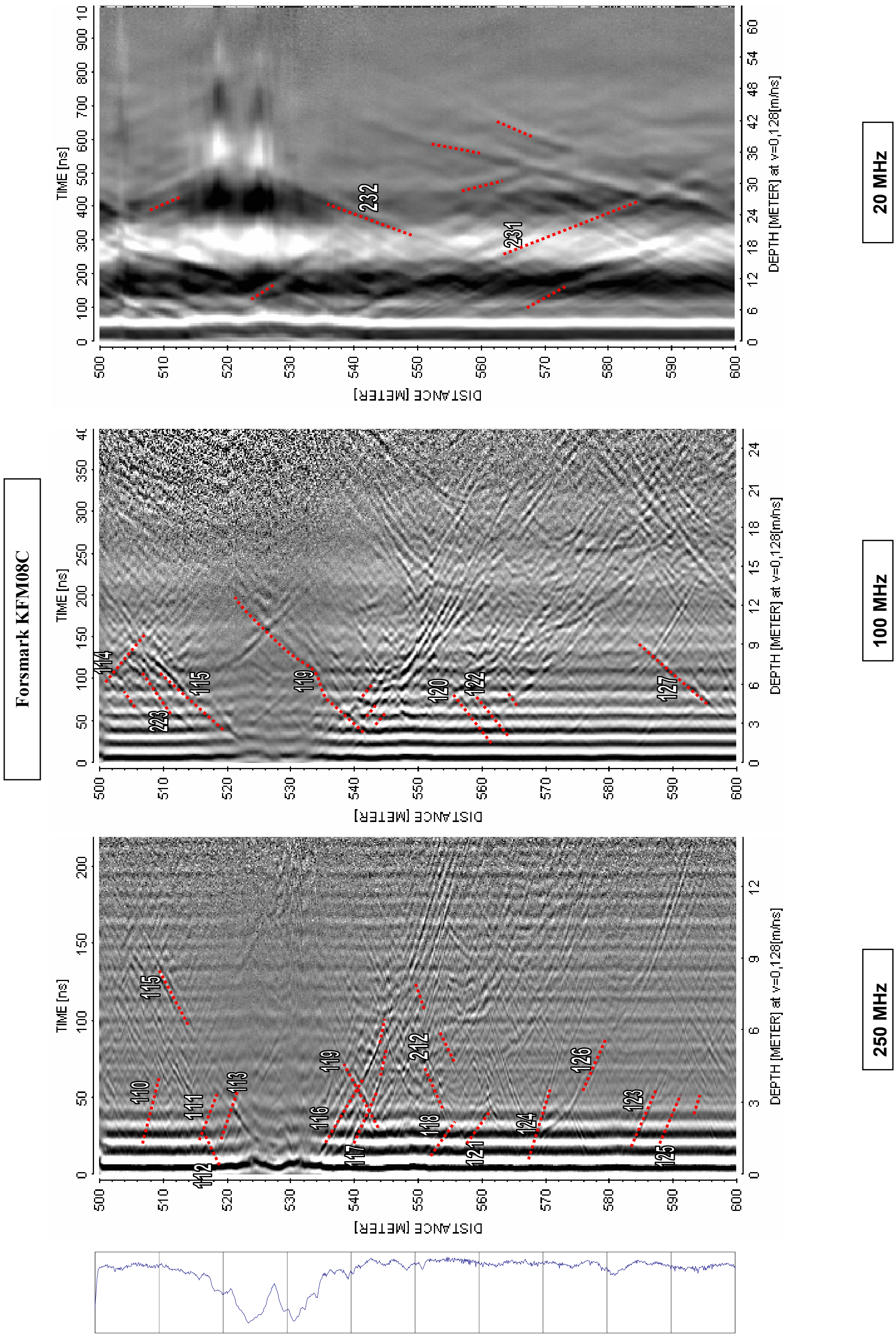

Forsmark KFM08C
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
43
46
33xxx
44
208
45
47
234
209
53
50
51
49
210
56
58
54
59
48
52
221
57
55
238
222
54
67x
67
250 MHz
100 MHz
20 MHz


Forsmark KFM08C
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
60
64
65
63
69
70
74
72
73
62
78
77
79
80
82
81
211
60
66
75
67
71
235
239
76
233
250 MHz
100 MHz
20 MHz

Forsmark KFM08C

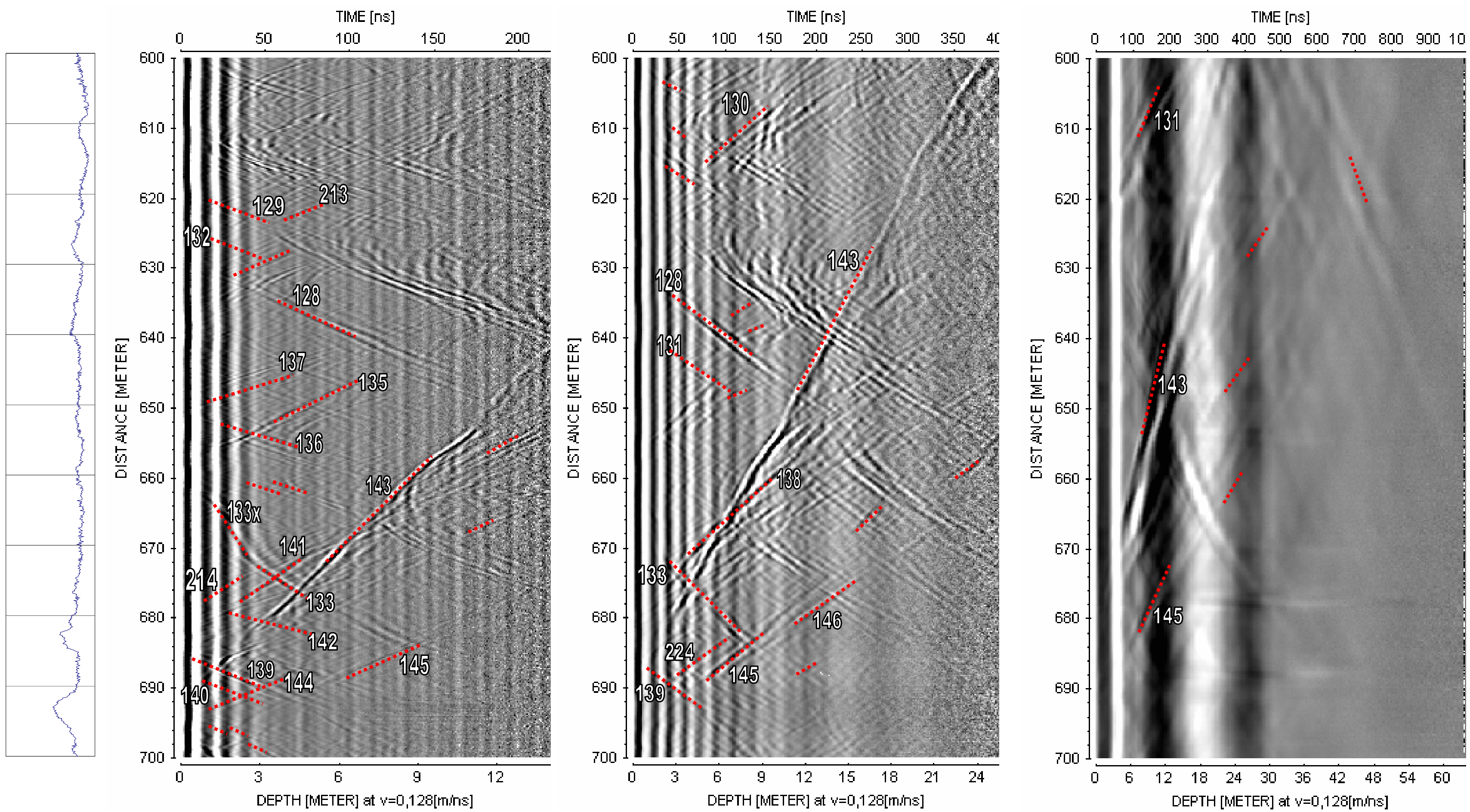


250 MHz **100 MHz** **20 MHz**



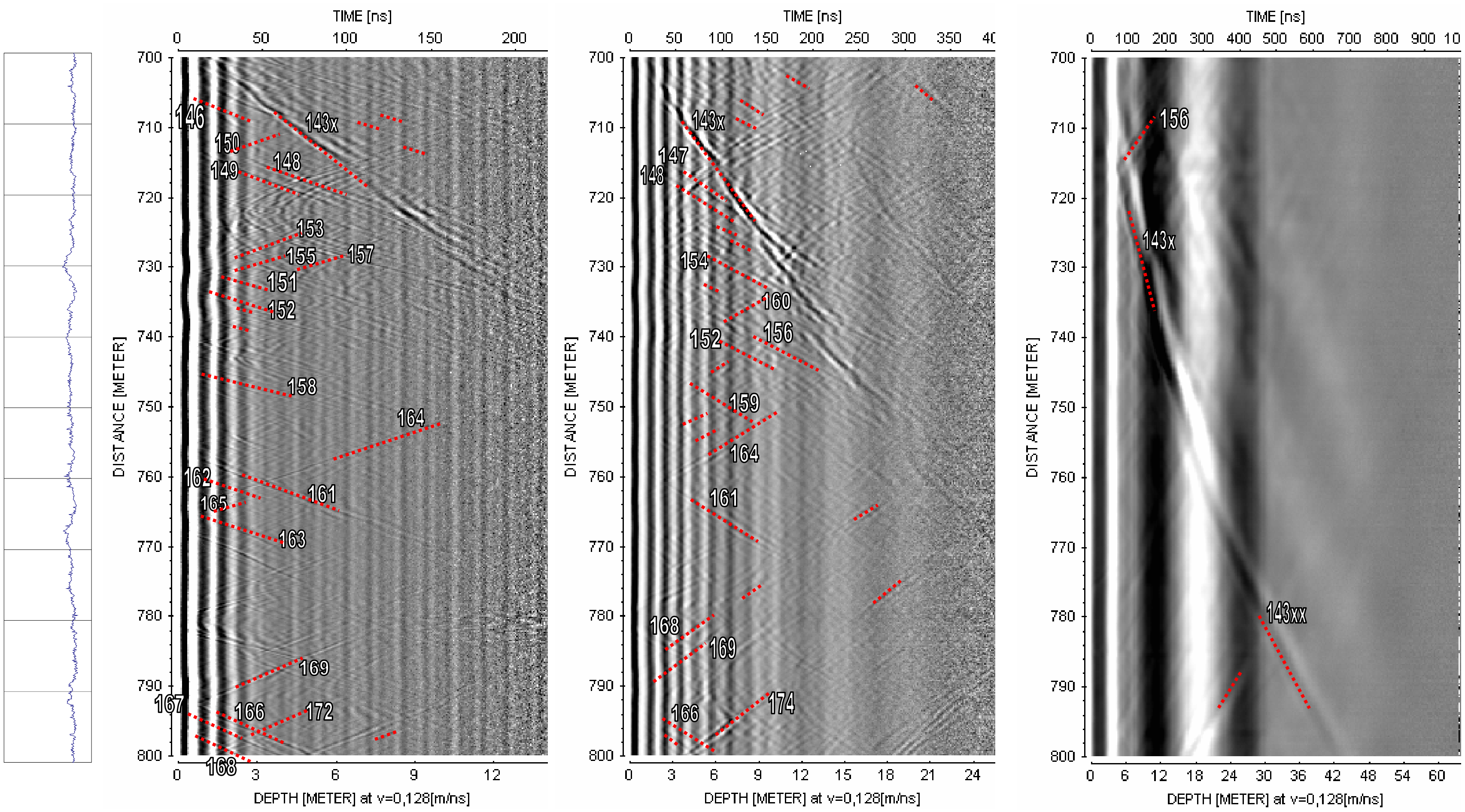
Forsmark KFM08C
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]

Forsmark KFM08C



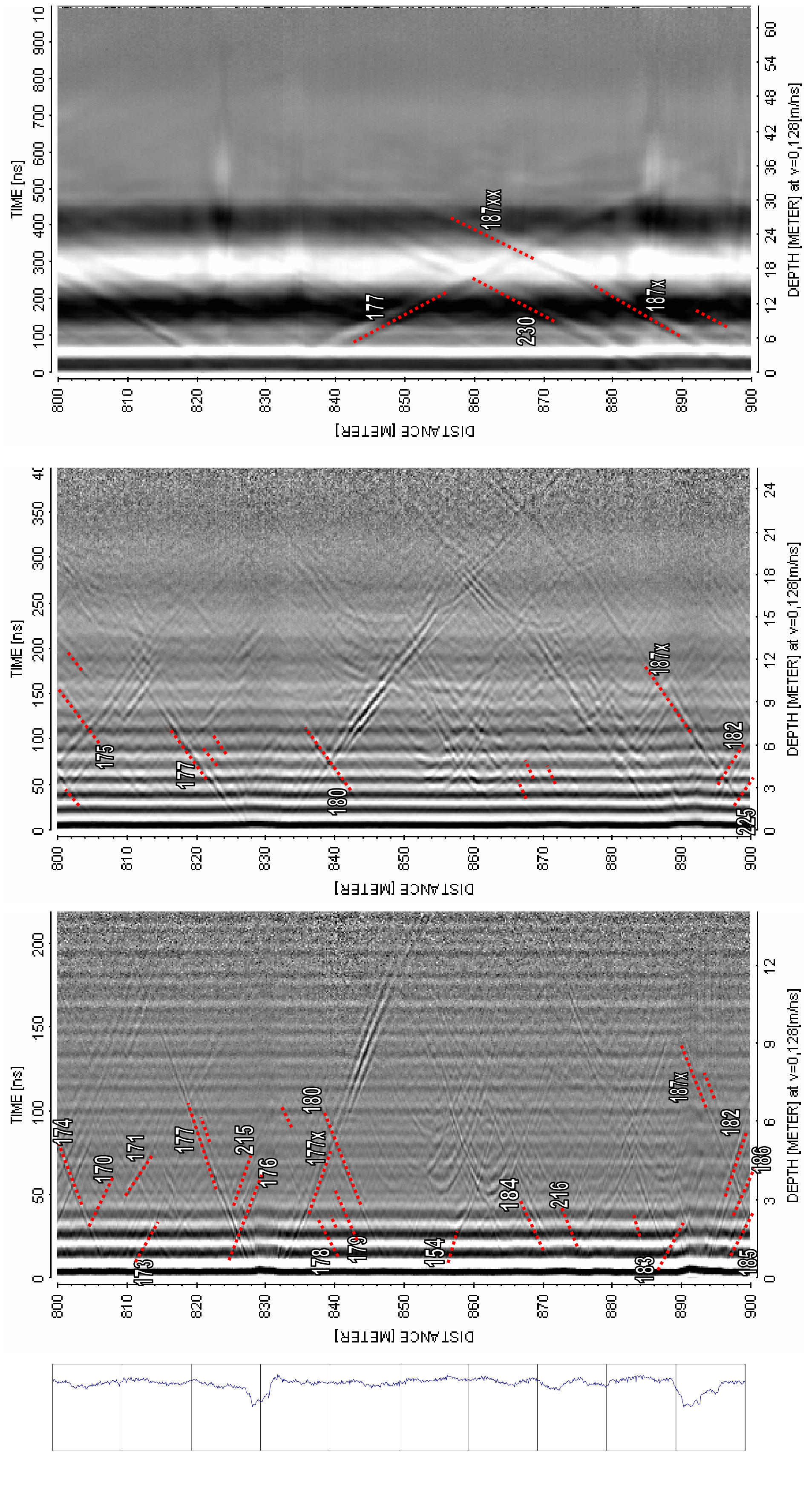
250 MHz **100 MHz** **20 MHz**

Forsmark KFM08C



250 MHz **100 MHz** **20 MHz**

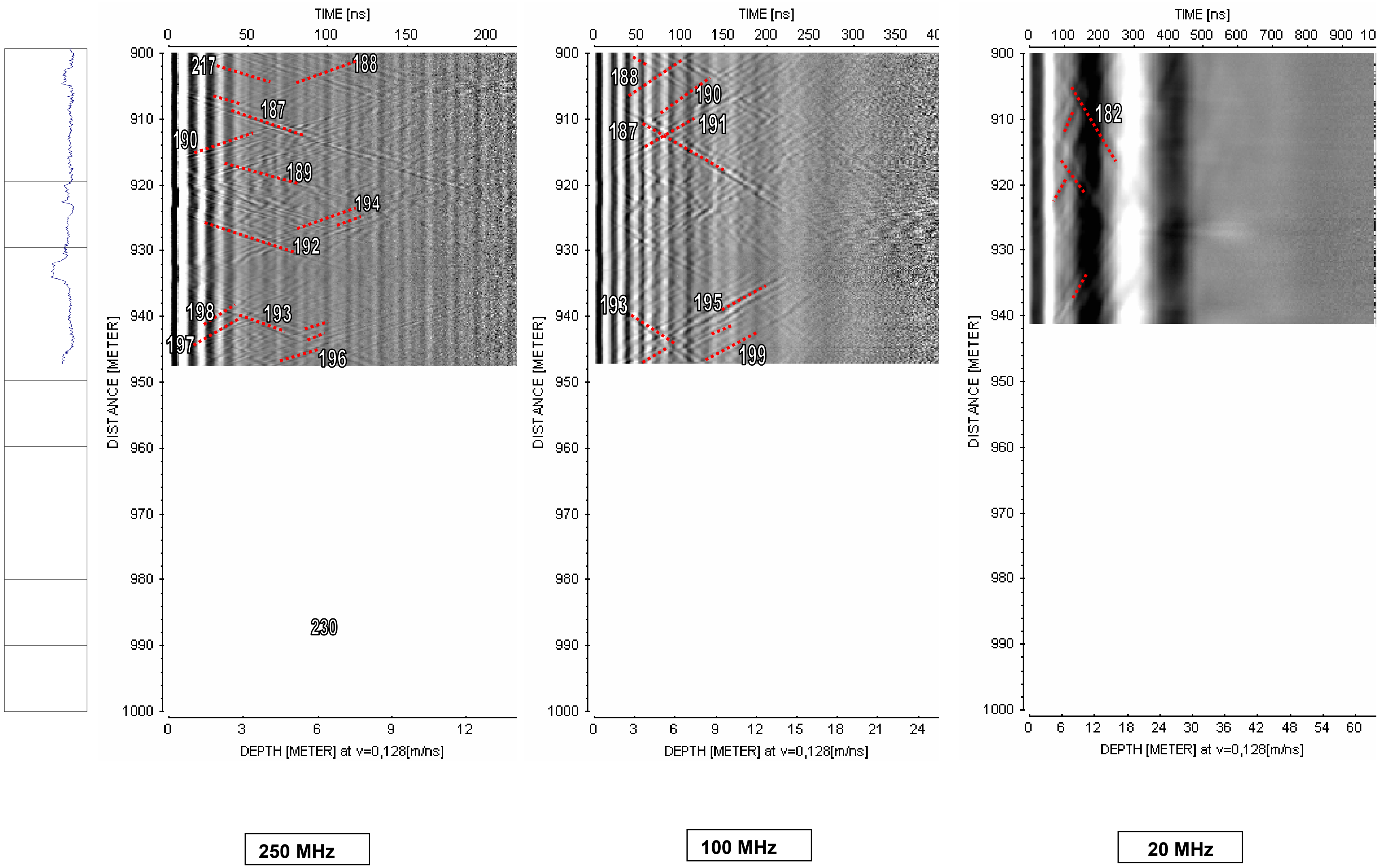
Forsmark KFM08C



250 MHz

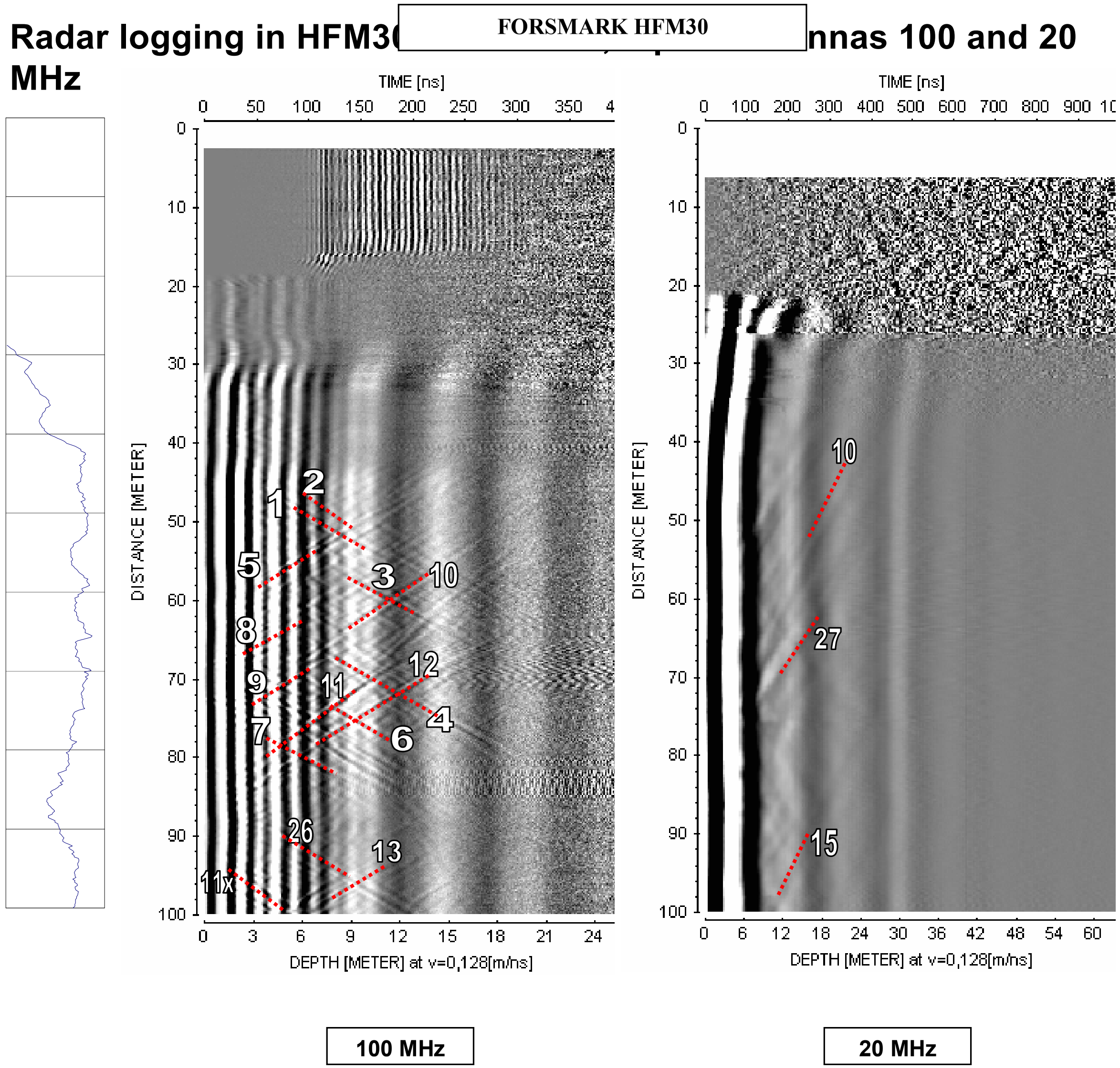
100 MHz

Forsmark KFM08C

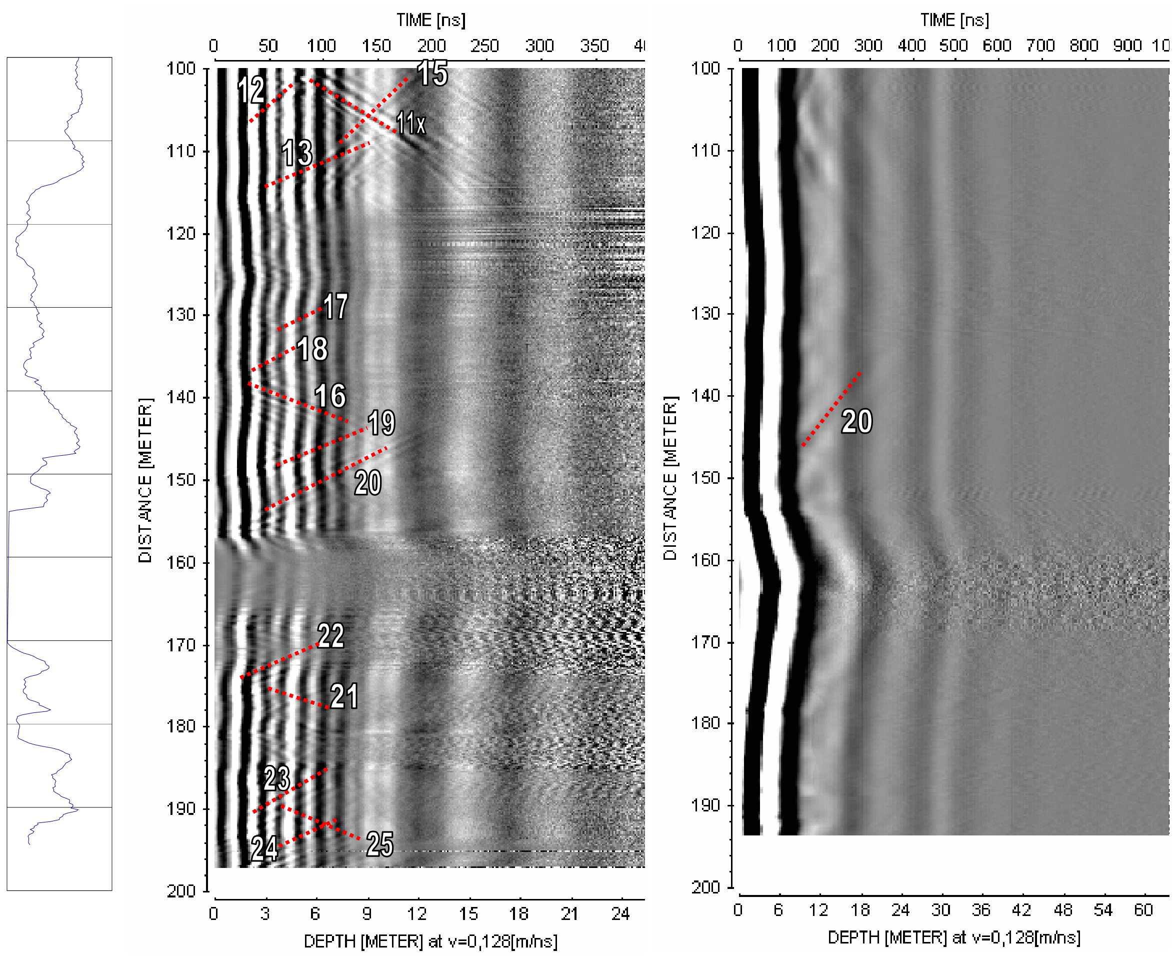


Appendix 2

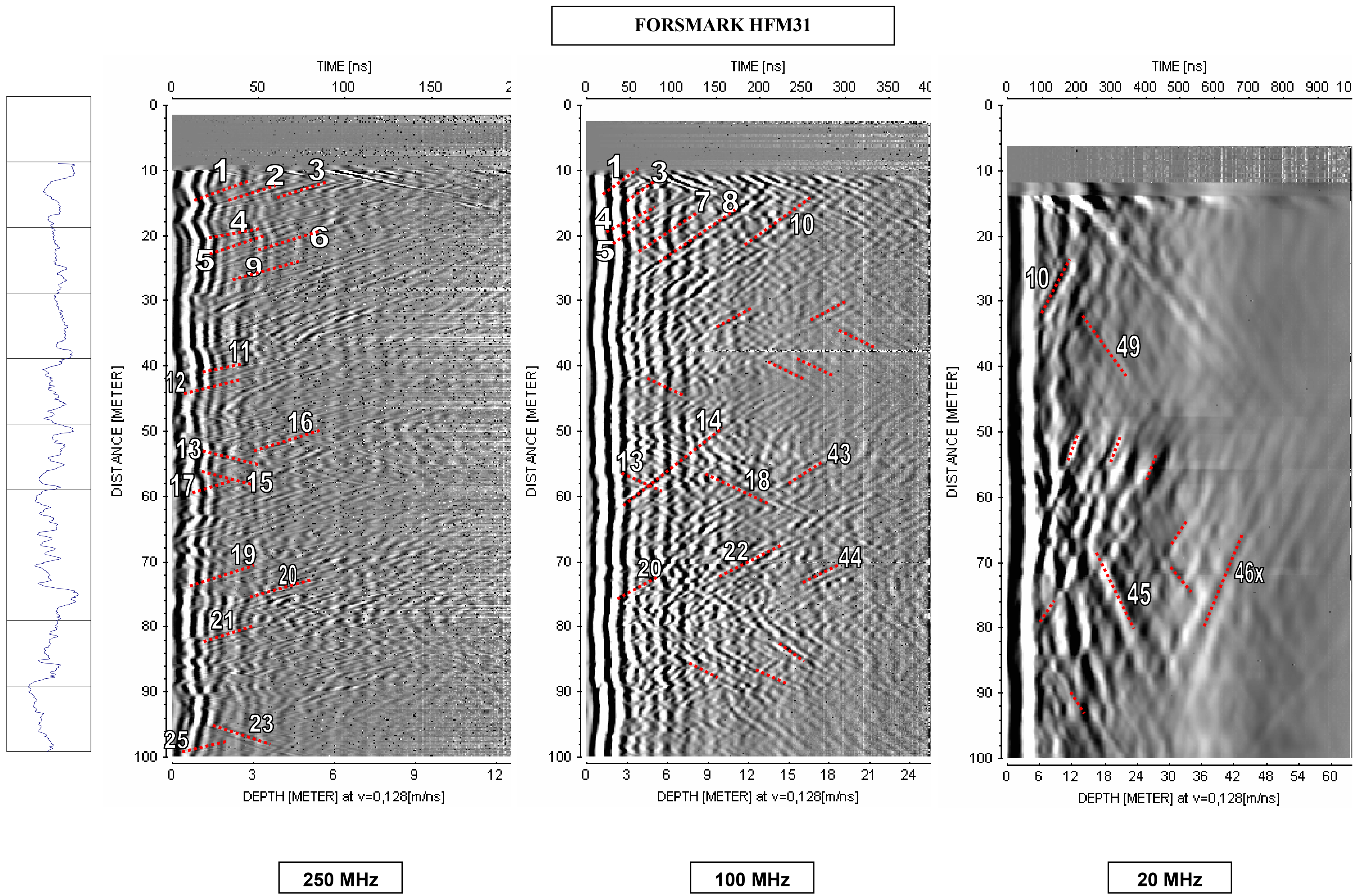
Radar logging in HFM30 ... nnas 100 and 20 MHz



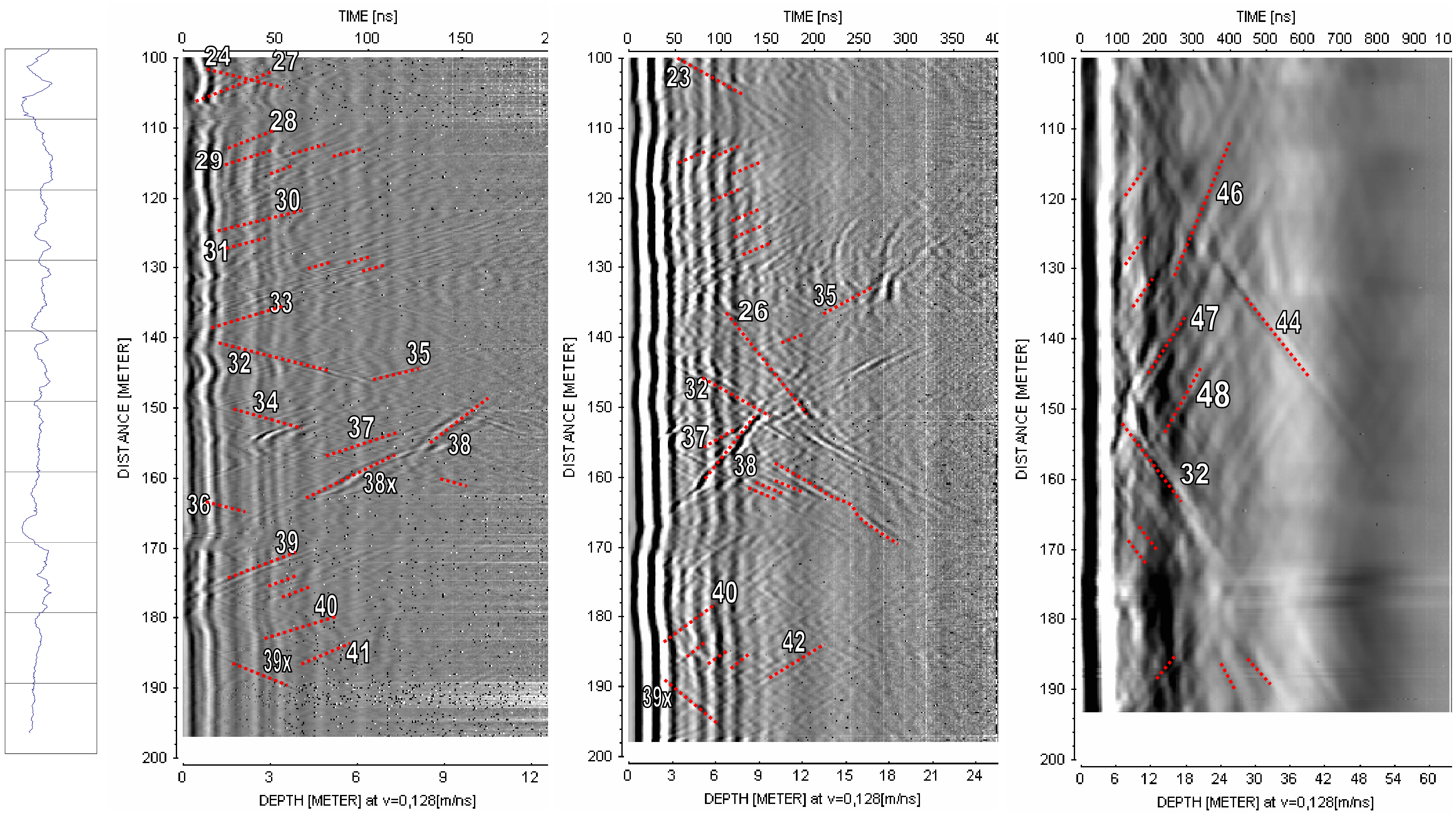
FORSMARK HFM30



Radar logging in HFM31. 0 to 195 m, dipole antennas 250. 100 and 20 MHz

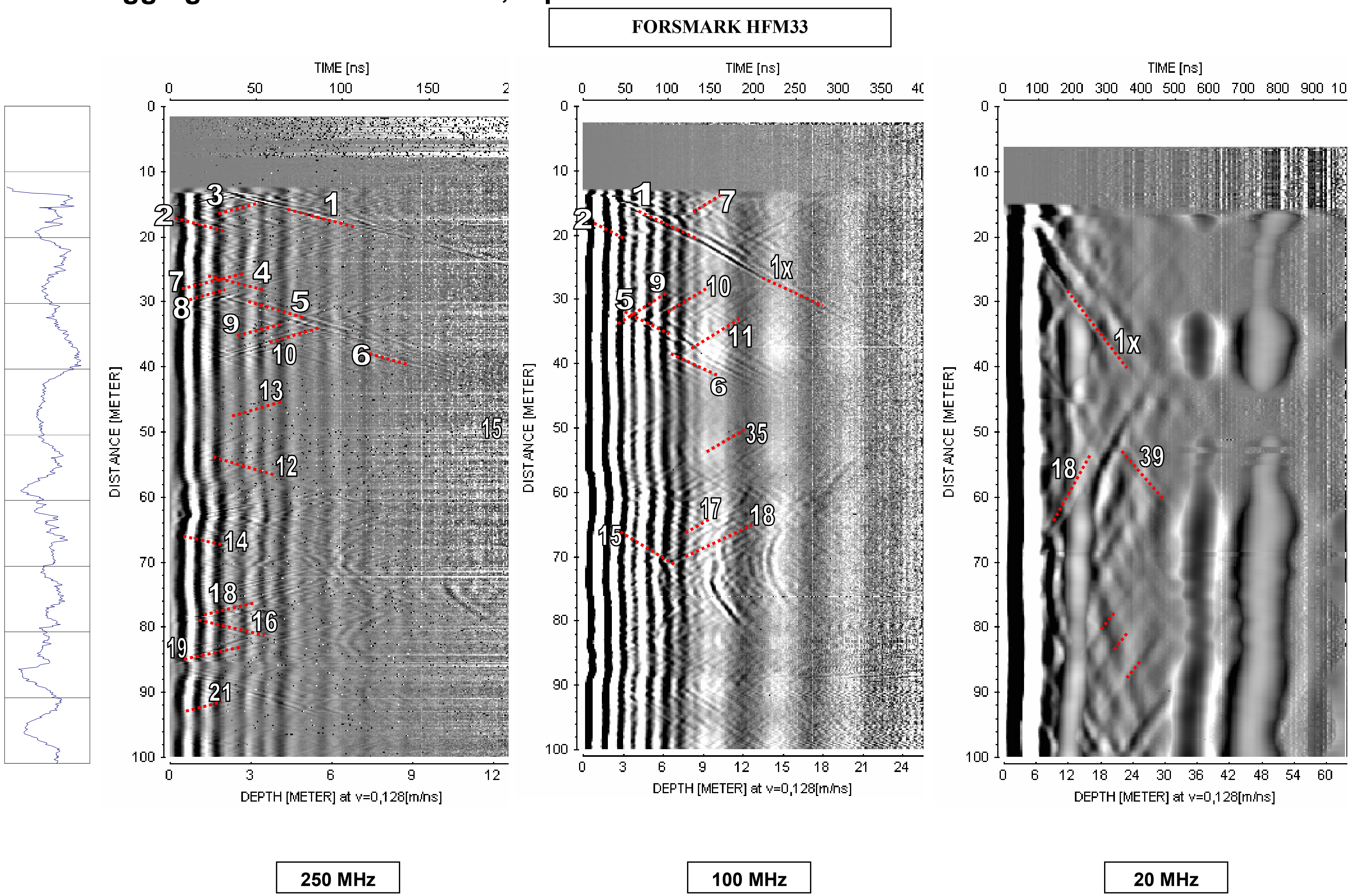


FORSMARK HFM31

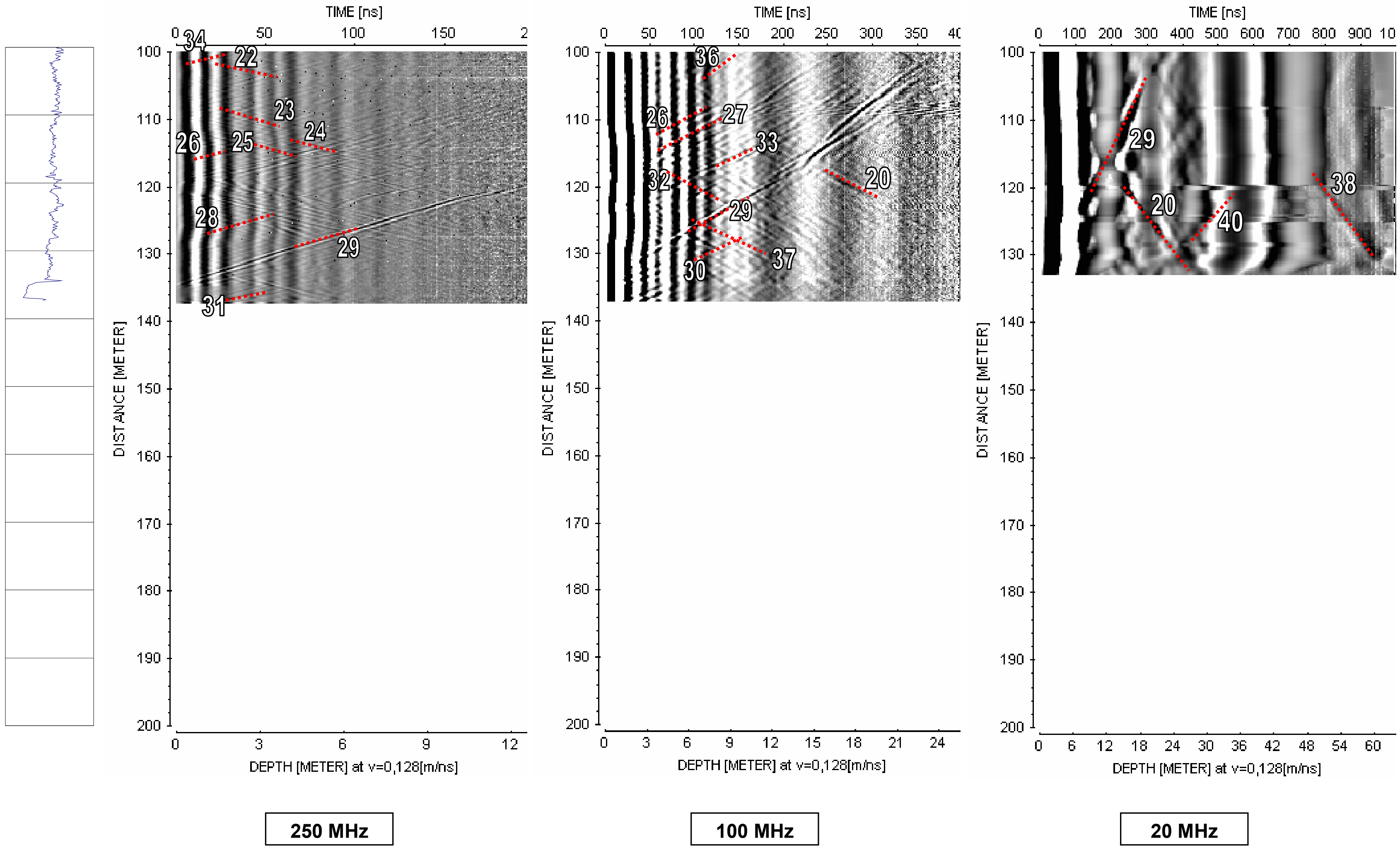


250 MHz **100 MHz** **20 MHz**

Radar logging in HFM33. 0 to 135 m, dipole antennas 250. 100 and 20 MHz



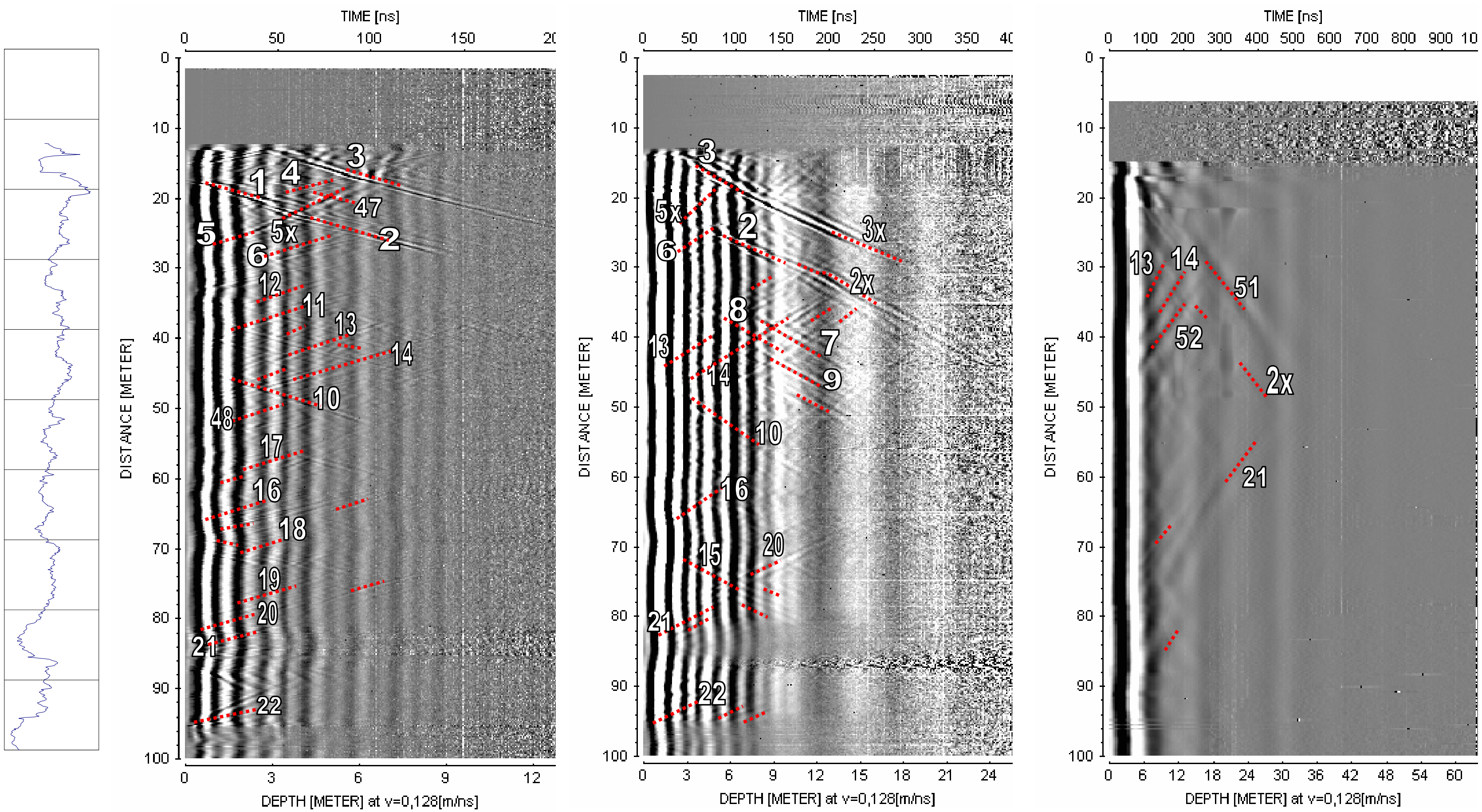
FORSMARK HFM33



Appendix 5

Radar logging in HFM34. 0 to 194 m, dipole antennas 250. 100 and 20 MHz

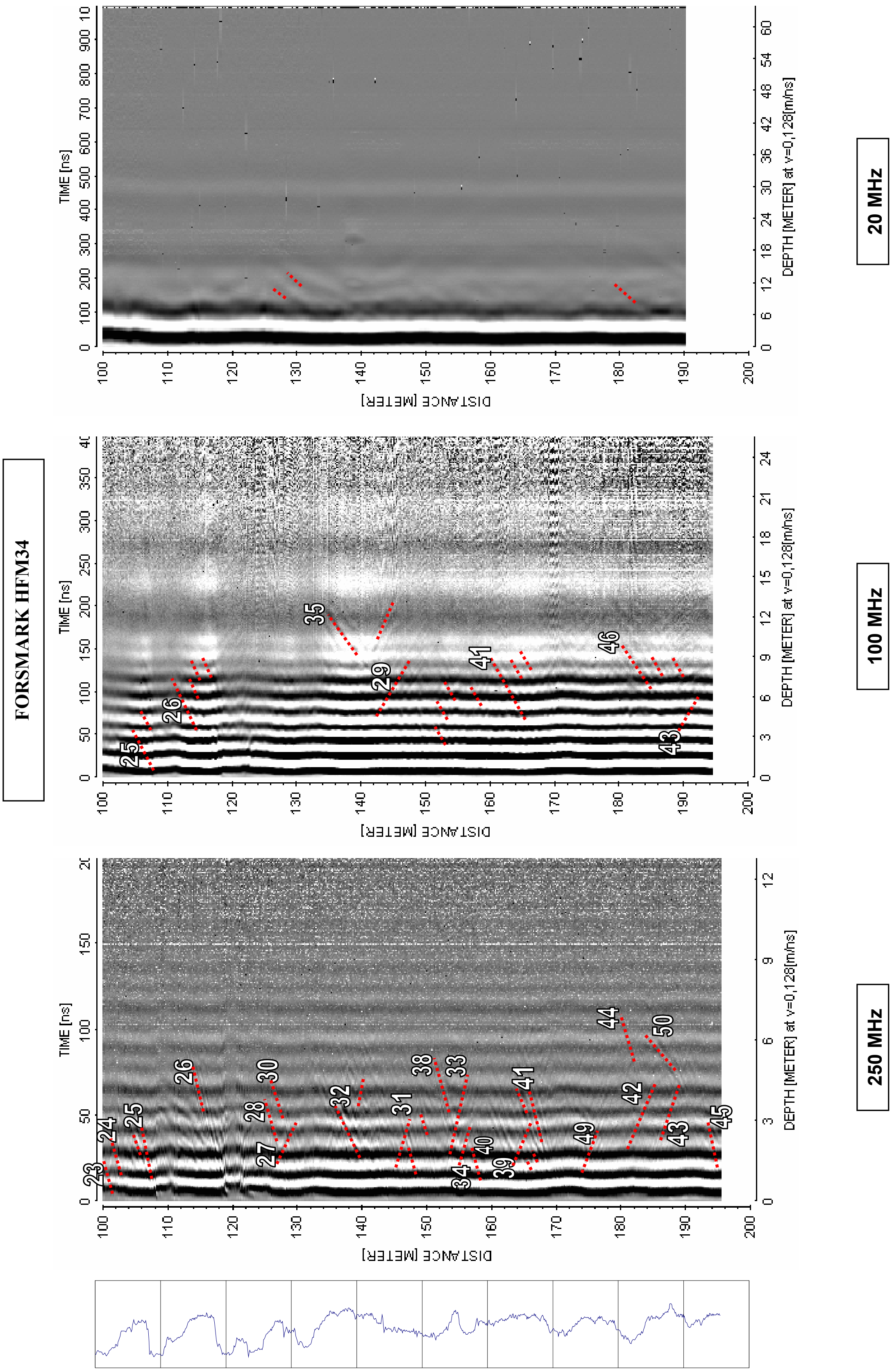
FORSMARK HFM34



250 MHz

100 MHz

20 MHz


FORSMARK HFM34
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]

Appendix 6

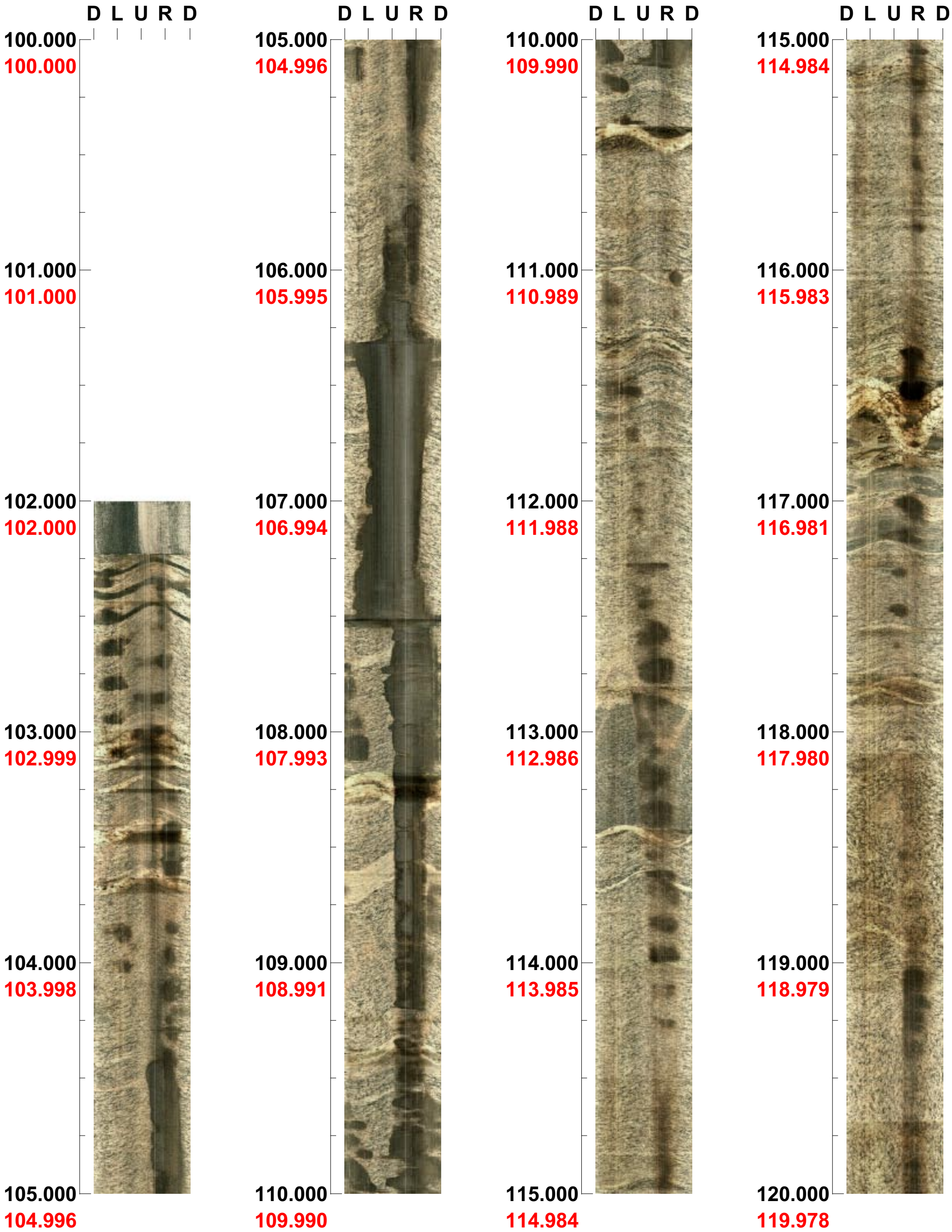
BIPS logging in KFM08C. 102 to 951 m

Project name: Forsmark

Image file	: c:\work\r5537f~1\bips\kfm08c\060620\kfm08c_1.bip
BDT file	: c:\work\r5537f~1\bips\kfm08c\060620\kfm08c_1.bdt
Locality	: FORSMARK
Bore hole number	: KFM08C
Date	: 06/06/19
Time	: 17:14:00
Depth range	: 102.000 - 951.217 m
Azimuth	: 36
Inclination	: -60
Diameter	: 76.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 175 %
Pages	: 28
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: KFM08C Azimuth: 36 Inclination: -60

Depth range: 100.000 - 120.000 m



(1 / 28) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08C   Azimuth: 36   Inclination: -60

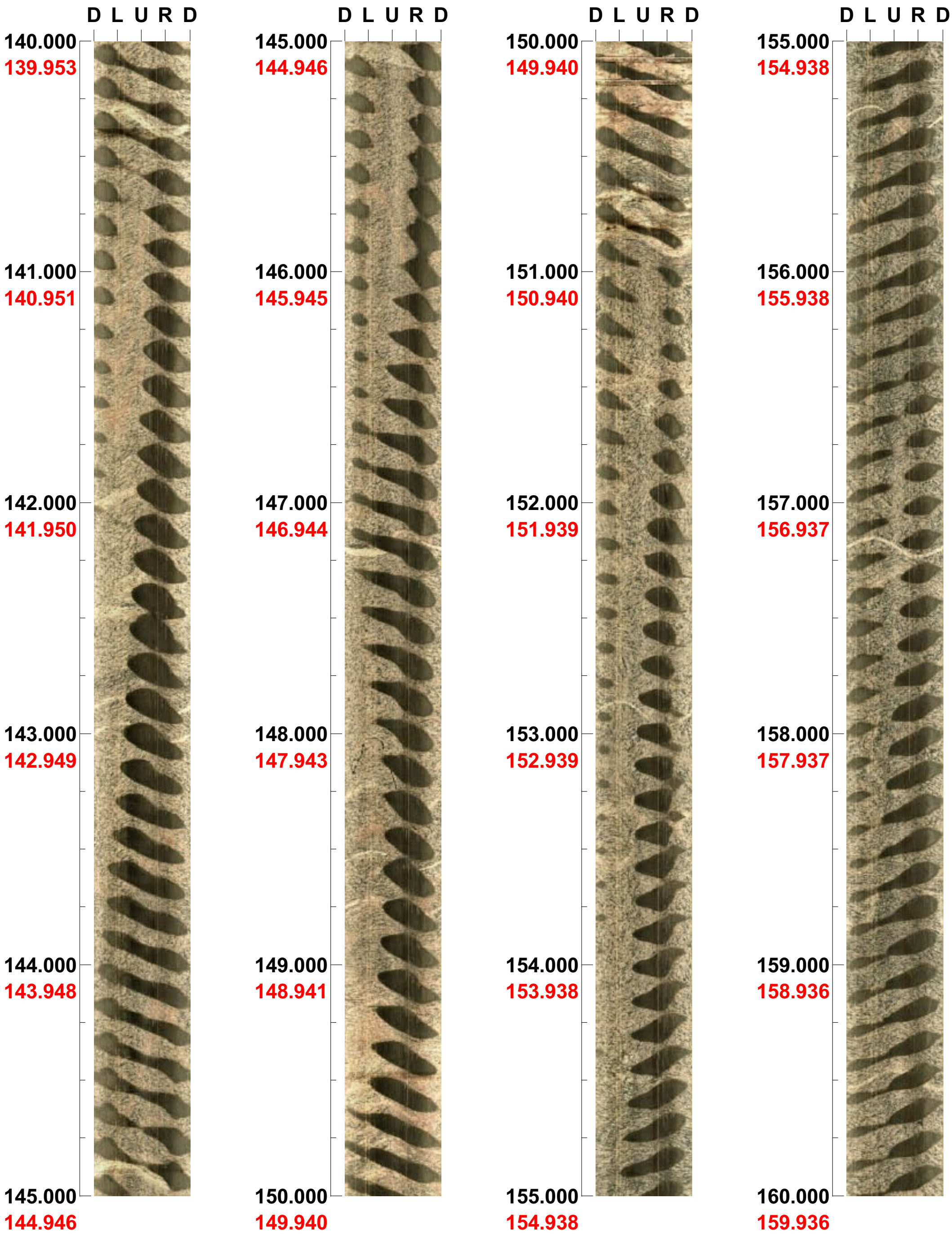
Depth range: 120.000 - 140.000 m

(2 / 28)   Scale: 1/25   Aspect ratio: 175 %

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 140.000 - 160.000 m



(3 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 160.000 - 180.000 m

(4 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 180.000 - 200.000 m

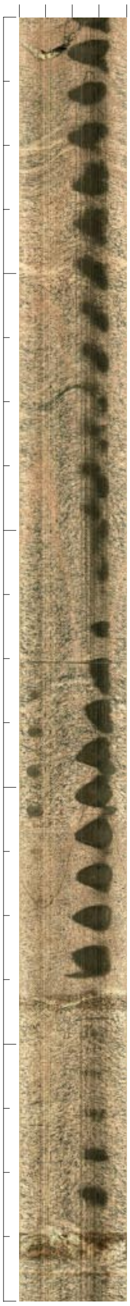
D L U R D

180.000 / 179.928
181.000 / 180.928
182.000 / 181.927
183.000 / 182.927
184.000 / 183.926
185.000 / 184.926

D L U R D

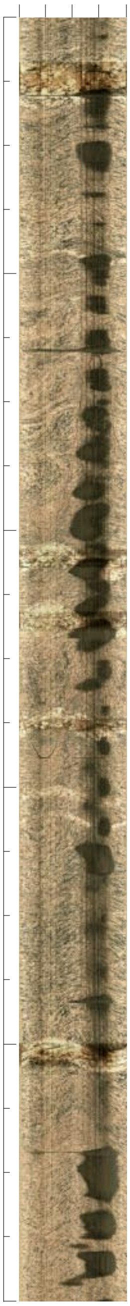
185.000 / 184.926
186.000 / 185.926
187.000 / 186.925
188.000 / 187.925
189.000 / 188.924
190.000 / 189.924

D L U R D



190.000 / 189.924
191.000 / 190.924
192.000 / 191.923
193.000 / 192.923
194.000 / 193.922
195.000 / 194.922

D L U R D



195.000 / 194.922
196.000 / 195.922
197.000 / 196.921
198.000 / 197.921
199.000 / 198.920
200.000 / 199.920

(5 / 28) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark

Bore hole No.: KFM08C Azimuth: 36 Inclination: -60

Depth range: 200.000 - 220.000 m

(6 / 28) Scale: 1/25 Aspect ratio: 175 %

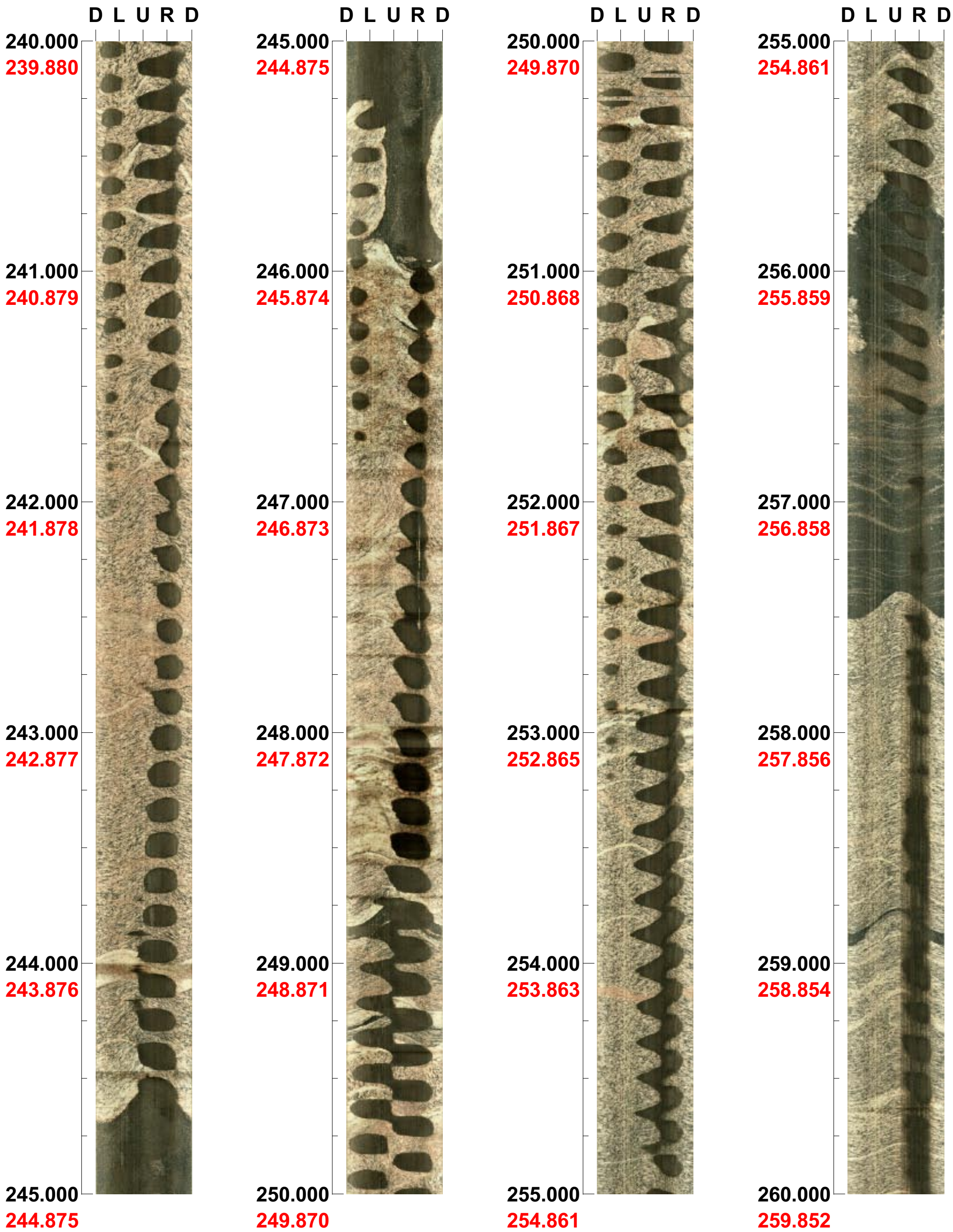
Project name: Forsmark
Bore hole No.: KFM08C Azimuth: 36 Inclination: -60

Depth range: 220.000 - 240.000 m

(7 / 28) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 240.000 - 260.000 m



(8 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

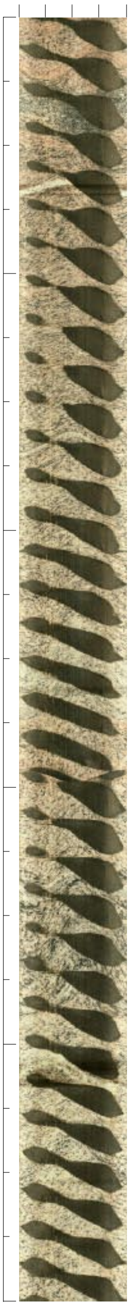
Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

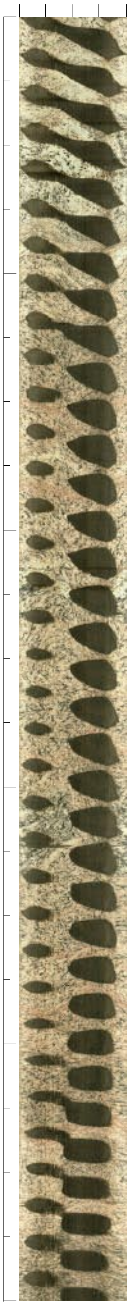
Depth range: 260.000 - 280.000 m

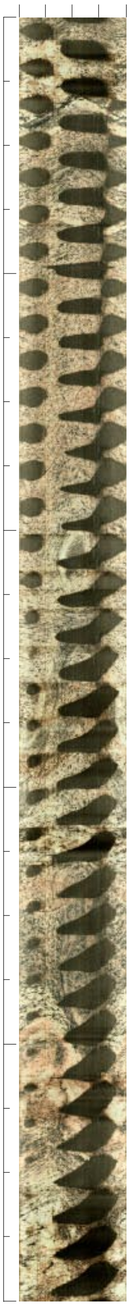
(9 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 280.000 - 300.000 m





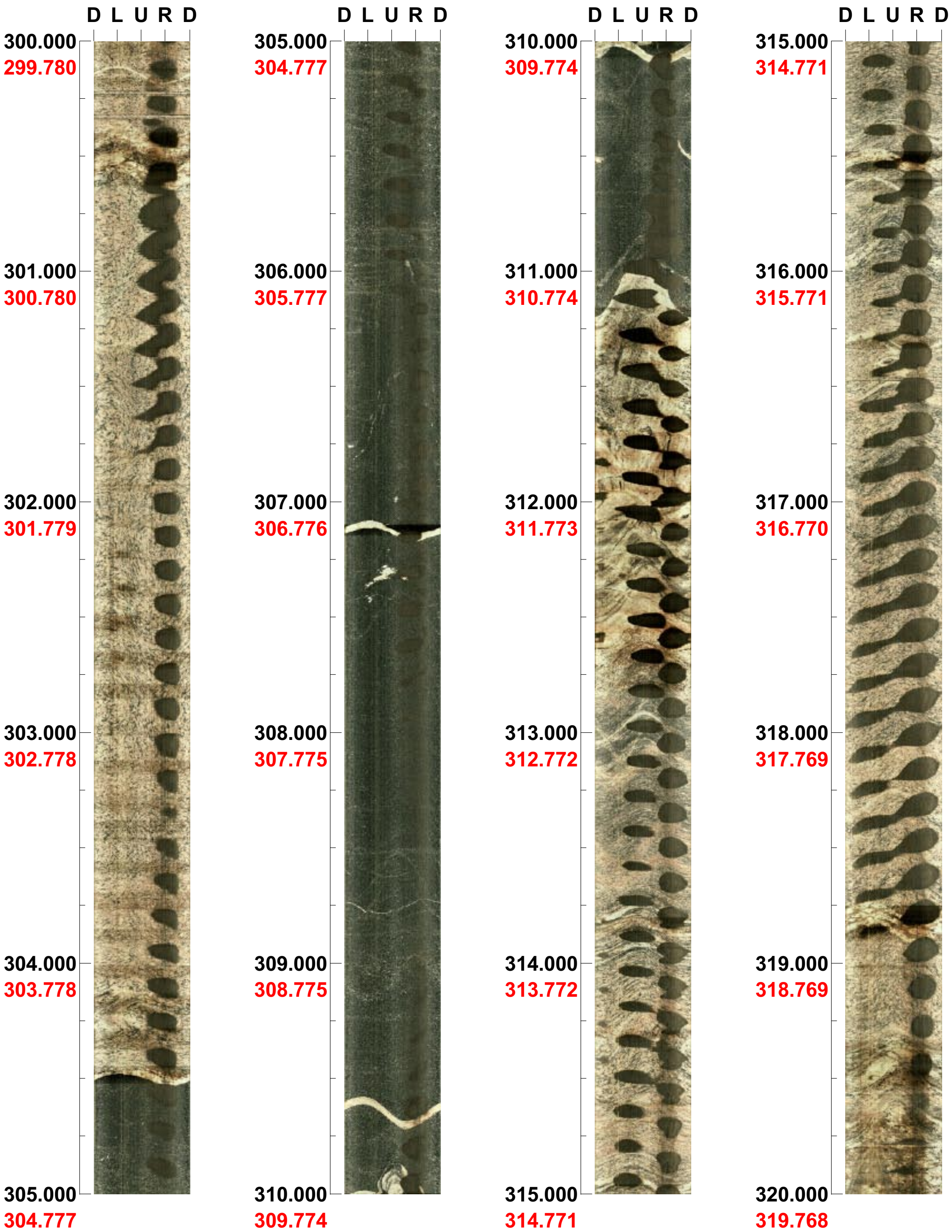


(10 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 300.000 - 320.000 m



(11 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

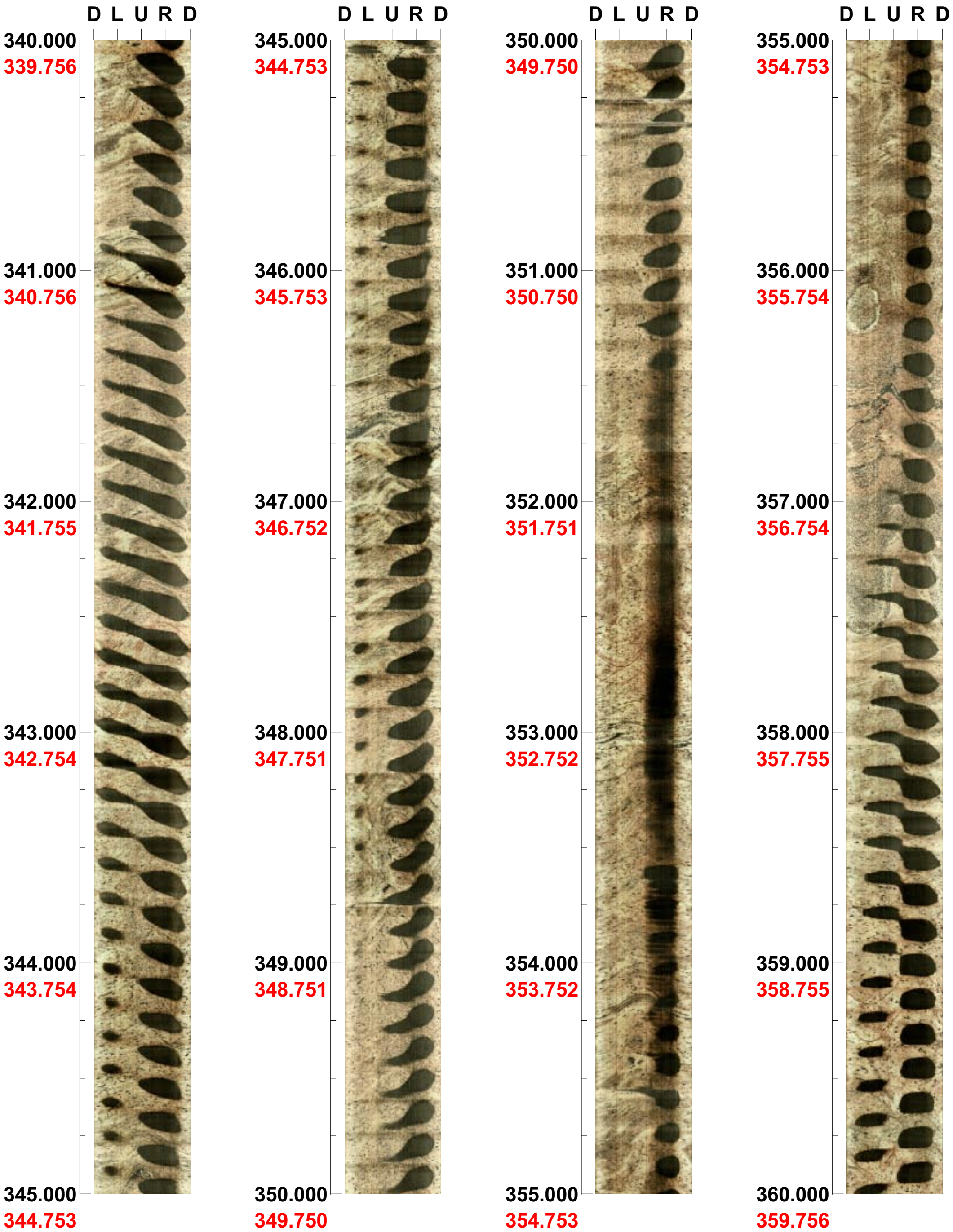
Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 320.000 - 340.000 m

(12 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 340.000 - 360.000 m



(13 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

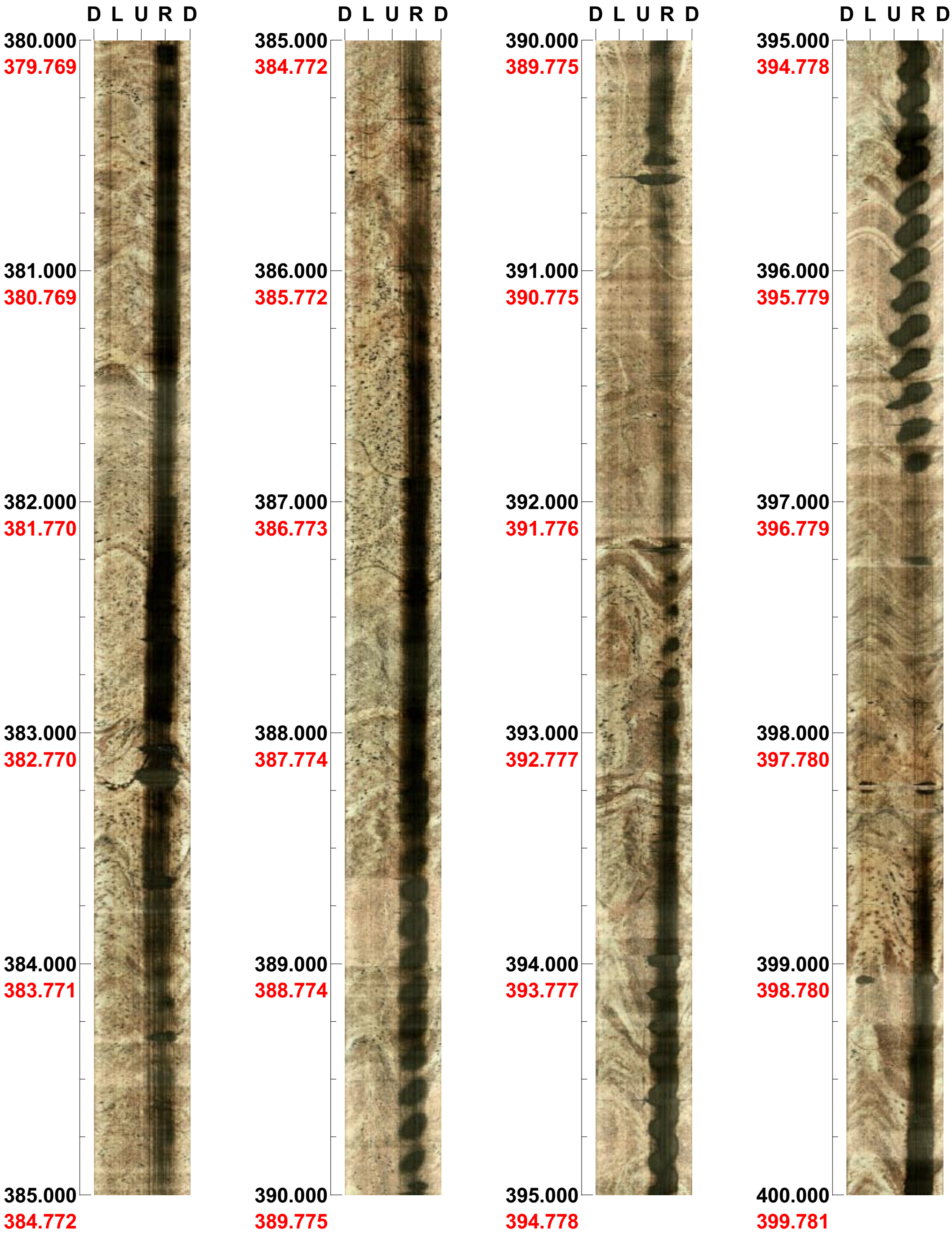
Project name: Forsmark
Bore hole No.: KFM08C Azimuth: 36 Inclination: -60

Depth range: 360.000 - 380.000 m

(14 / 28) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 380.000 - 400.000 m



(15 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C

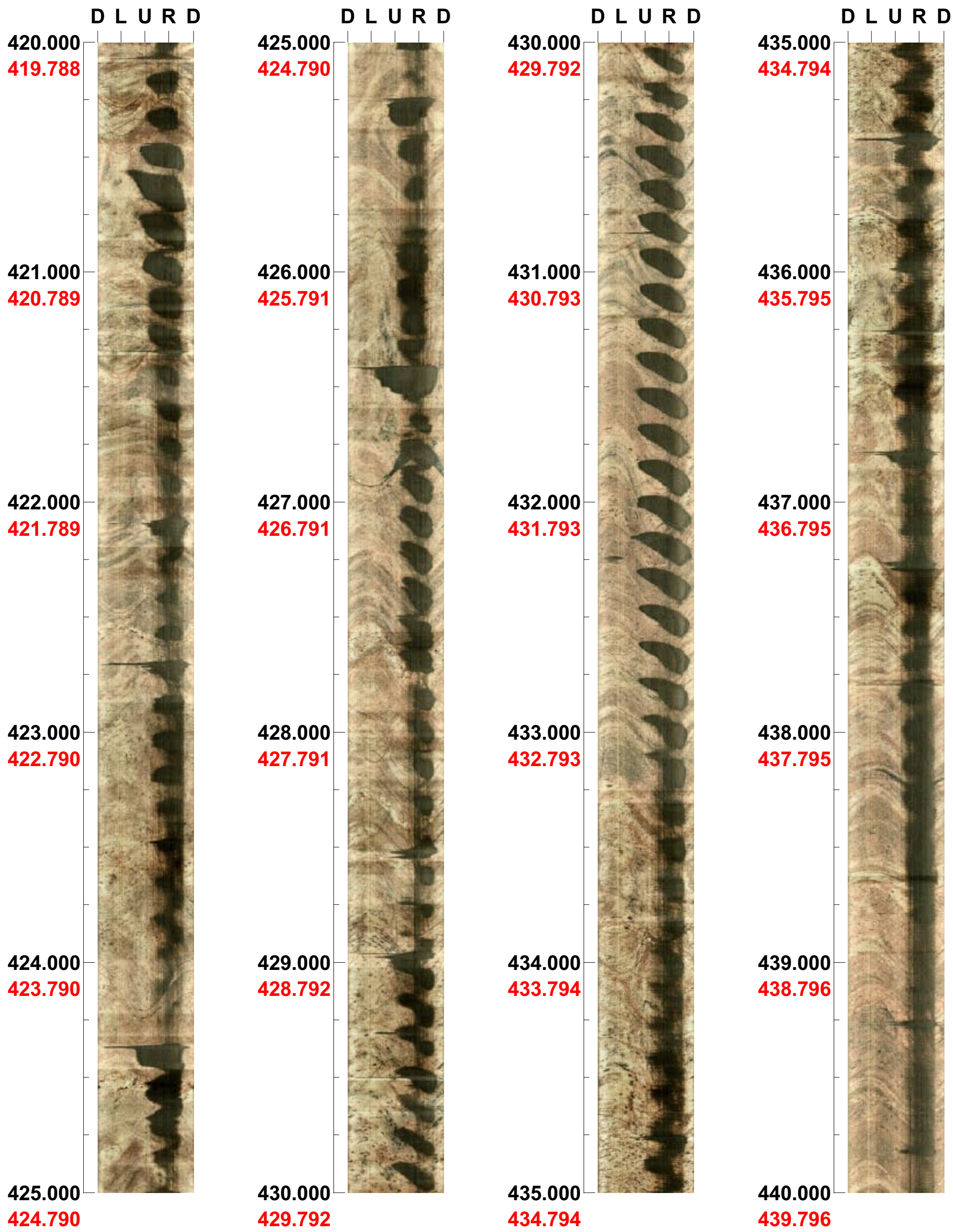
Azimuth: 36 Inclination: -60

Depth range: 400.000 - 420.000 m

(16 / 28) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 420.000 - 440.000 m



(17 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 440.000 - 460.000 m

(18 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

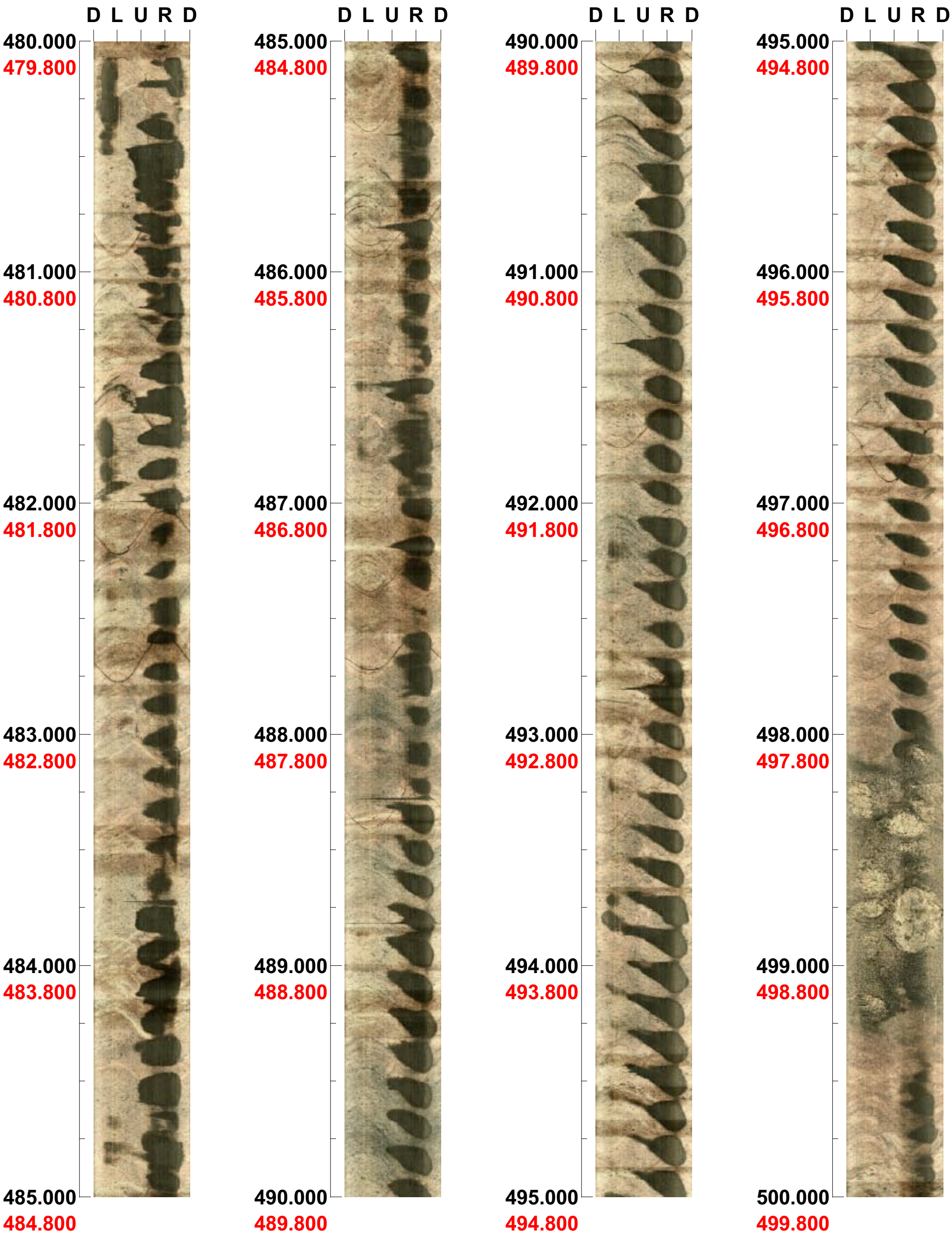
Depth range: 460.000 - 480.000 m

(19 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

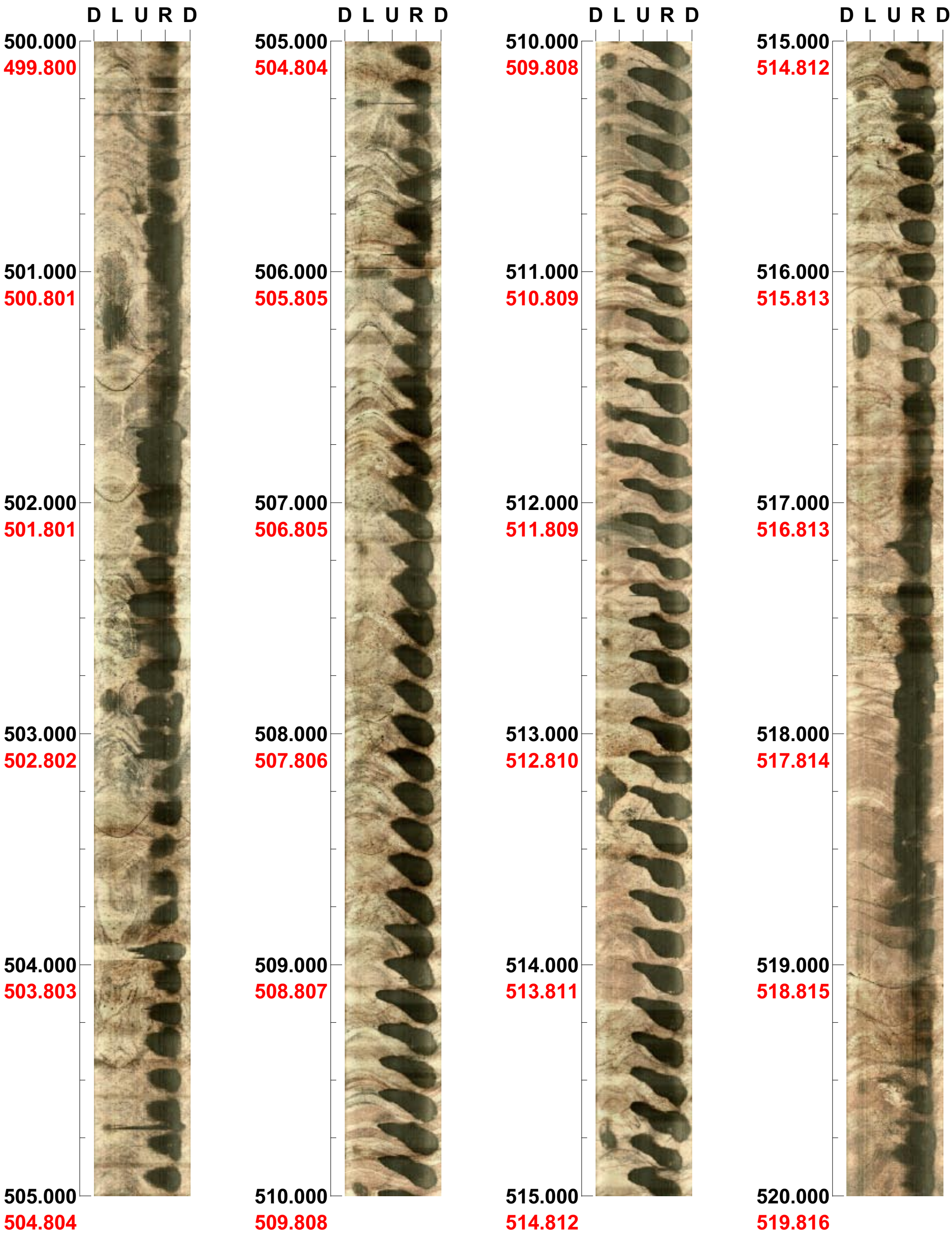
Depth range: 480.000 - 500.000 m



(20 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 500.000 - 520.000 m

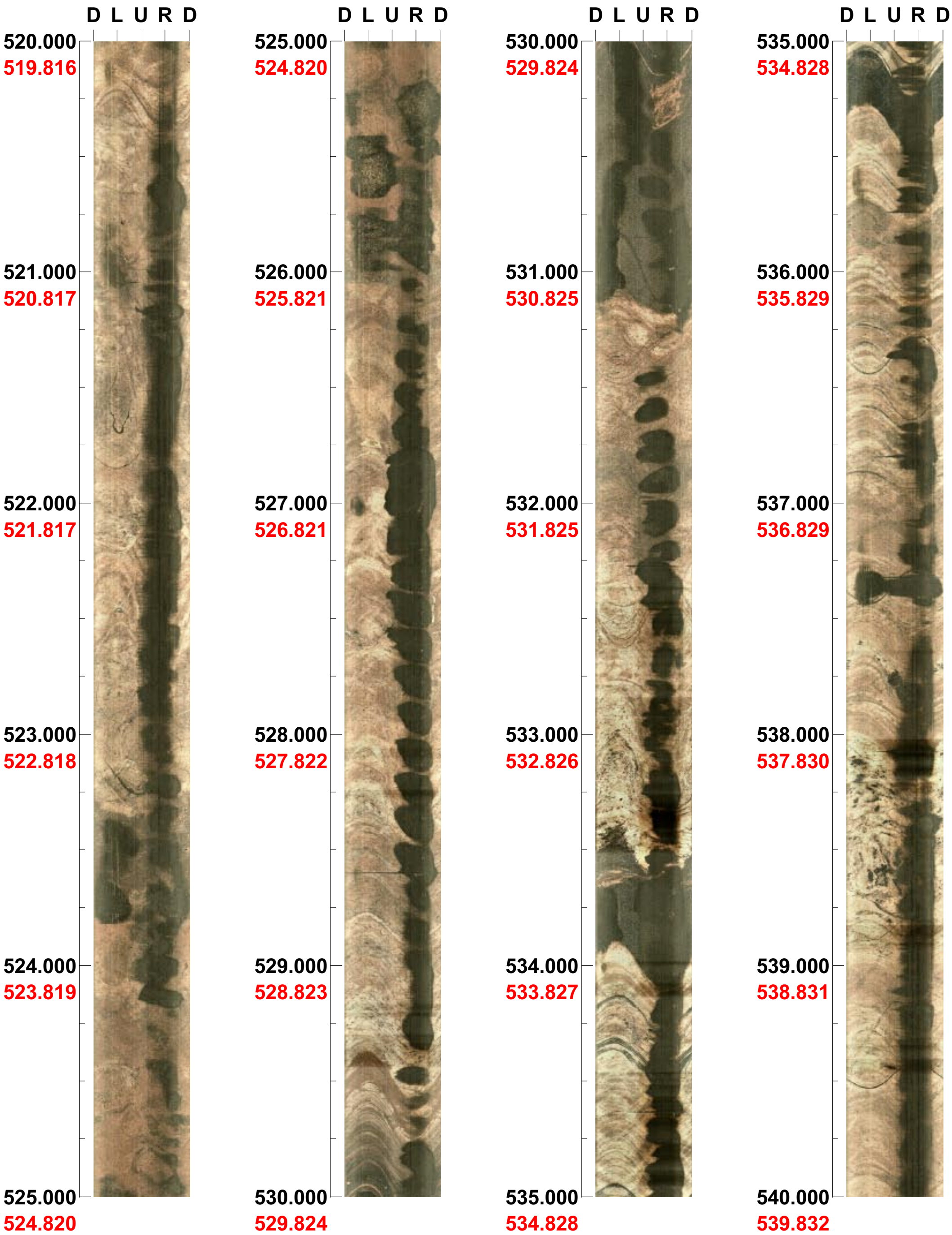


(21 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

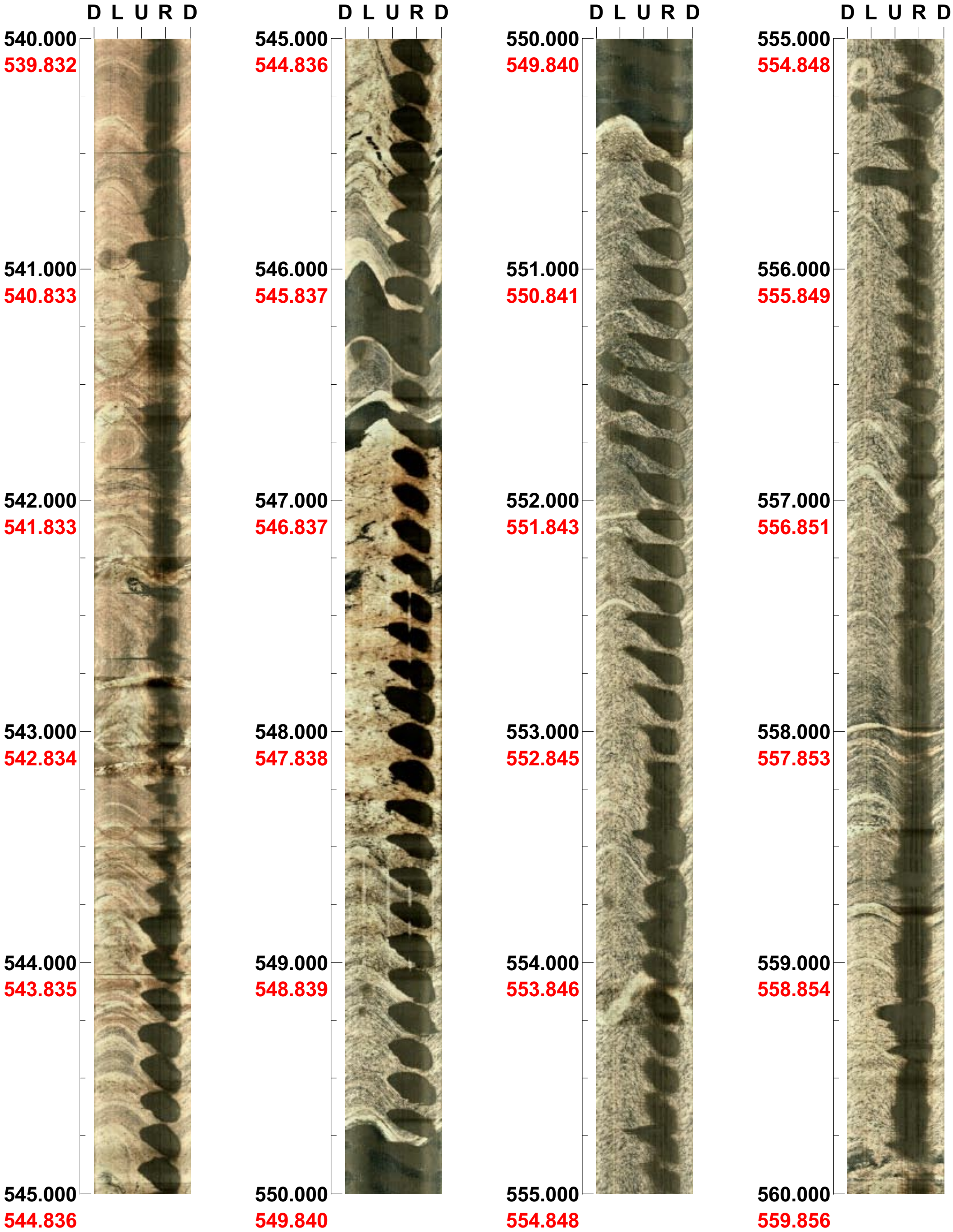
Depth range: 520.000 - 540.000 m



(22 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C Azimuth: 36 Inclination: -60

Depth range: 540.000 - 560.000 m



(23 / 28) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 560.000 - 580.000 m

(24 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

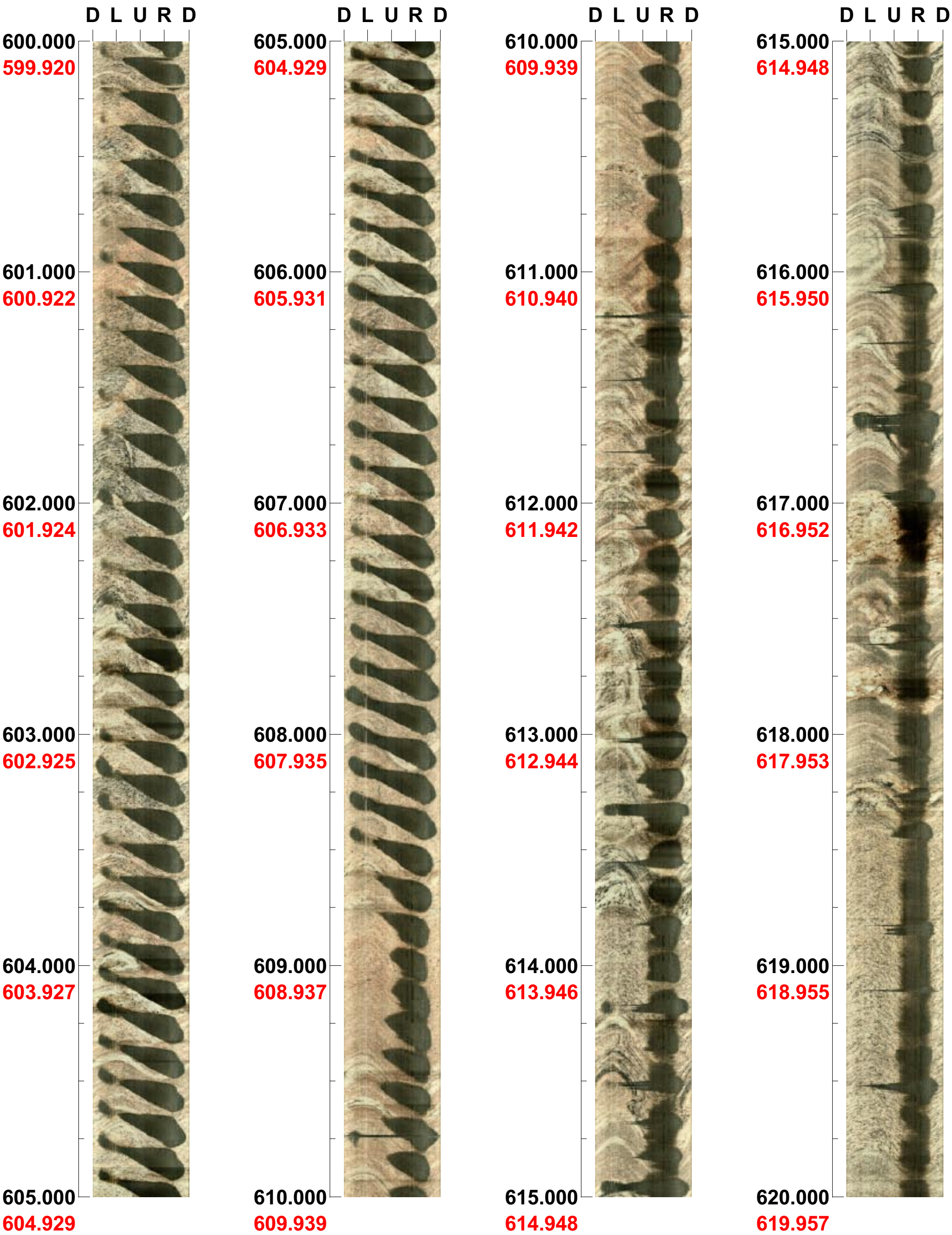
Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 580.000 - 600.000 m

(25 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C Azimuth: 36 Inclination: -60

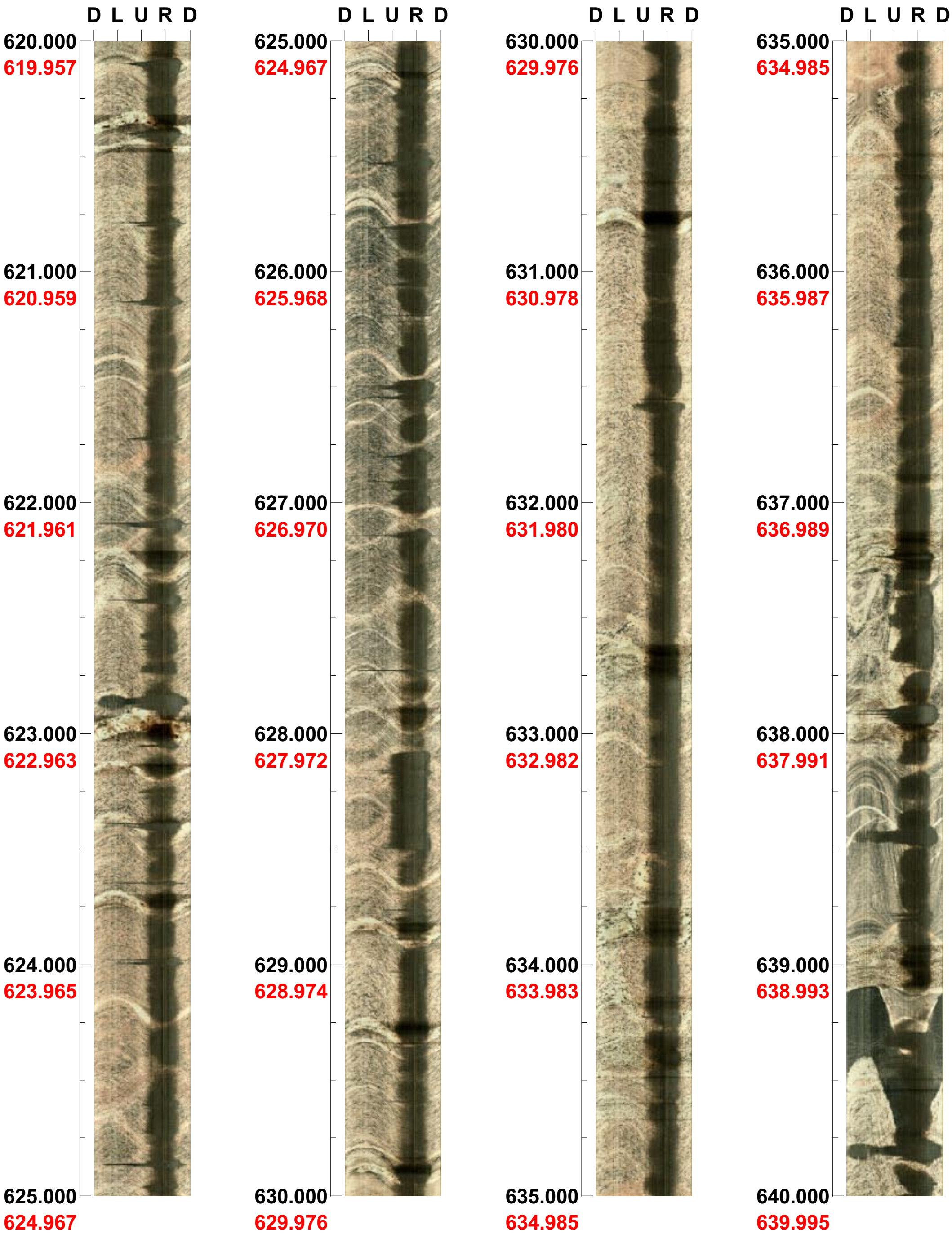
Depth range: 600.000 - 620.000 m



(26 / 28) Scale: 1/25 Aspect ratio: 175 %

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 620.000 - 640.000 m



(27 / 28) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 640.000 - 660.000 m

(1 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 660.000 - 680.000 m

(2 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 680.000 - 700.000 m

(3 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

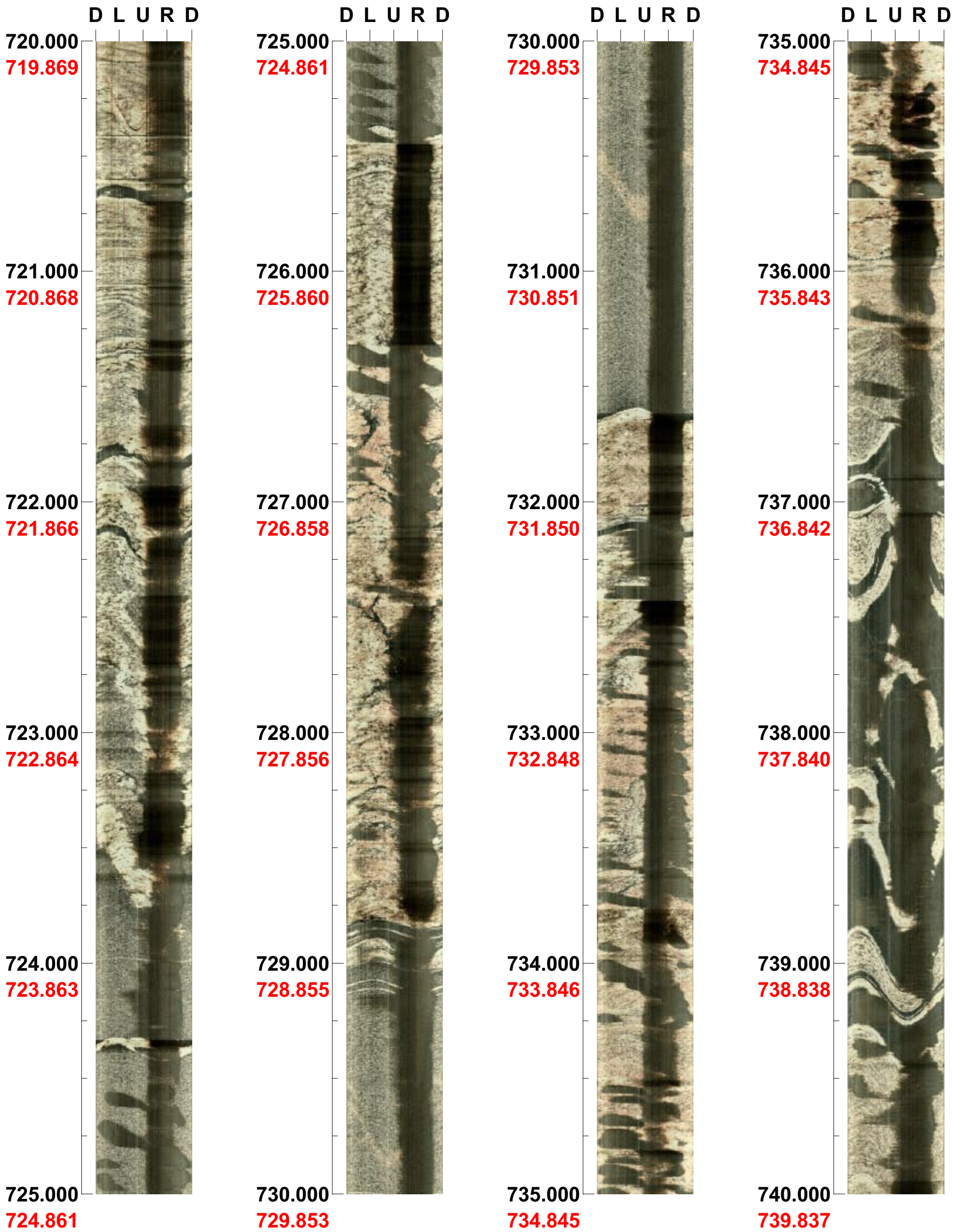
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 700.000 - 720.000 m

(4 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

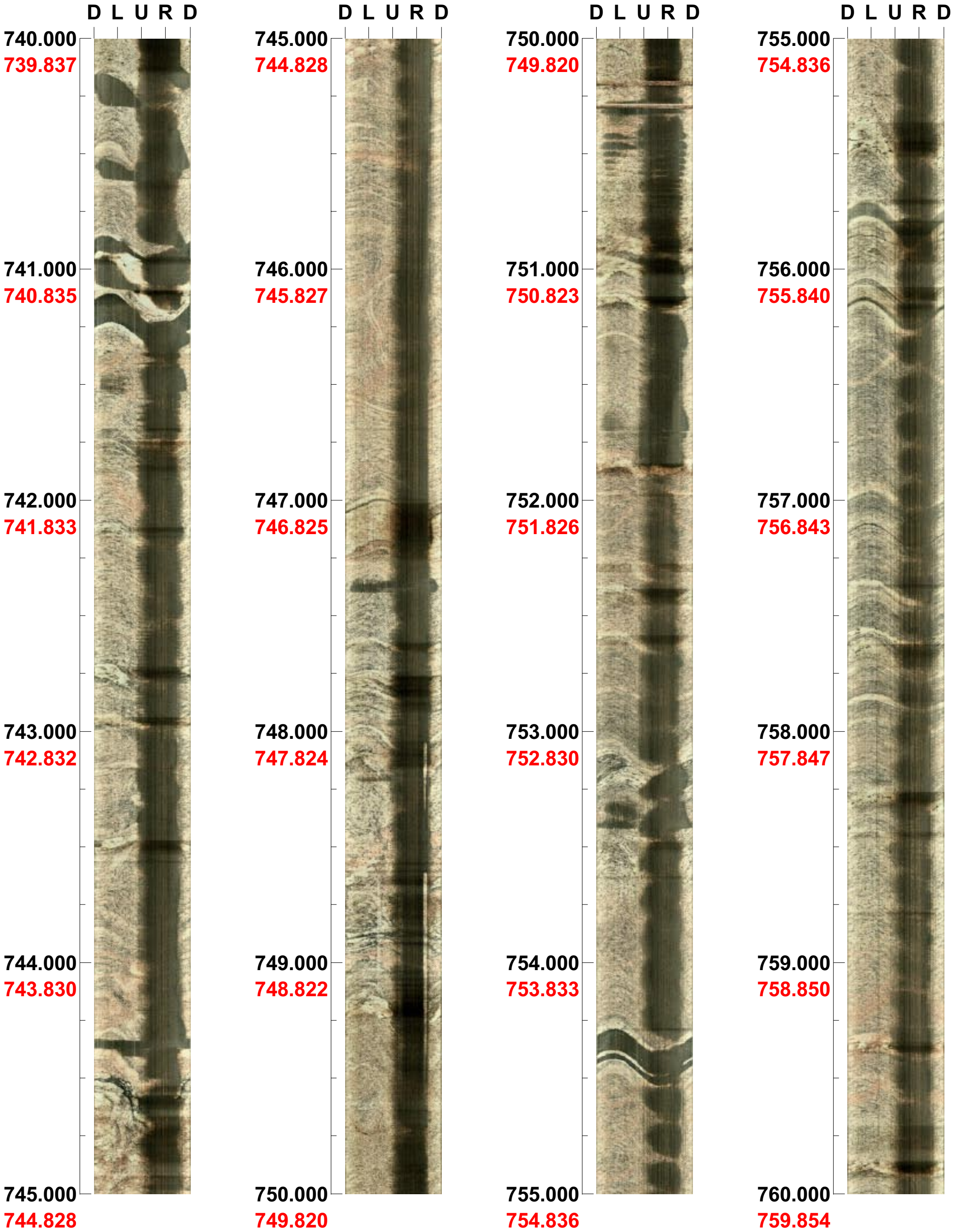
Depth range: 720.000 - 740.000 m



(5 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 740.000 - 760.000 m



(6 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 760.000 - 780.000 m

(7 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 780.000 - 800.000 m

(8 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 800.000 - 820.000 m

(9 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 820.000 - 840.000 m

(10 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 840.000 - 860.000 m

(11 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

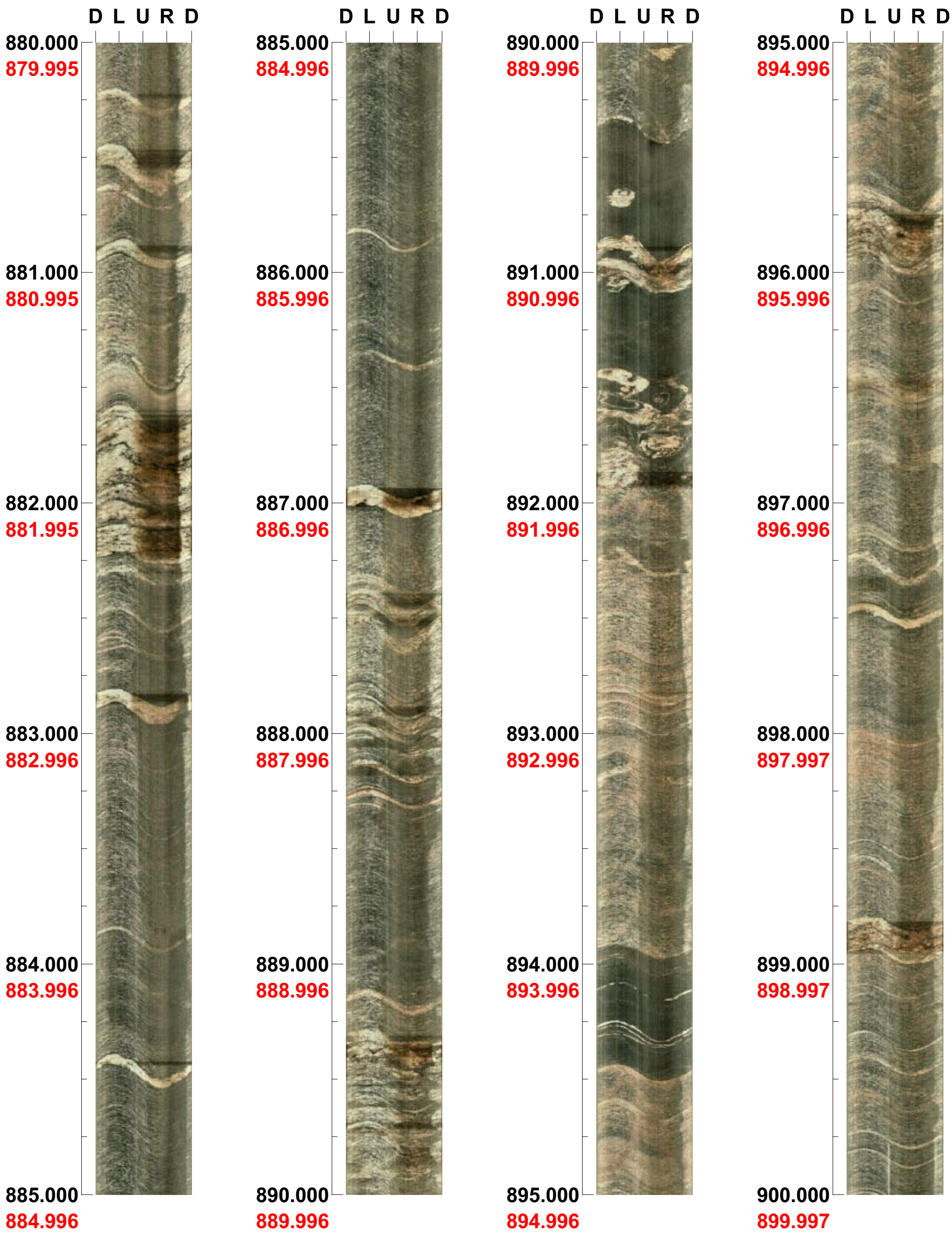
Depth range: 860.000 - 880.000 m

(12 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

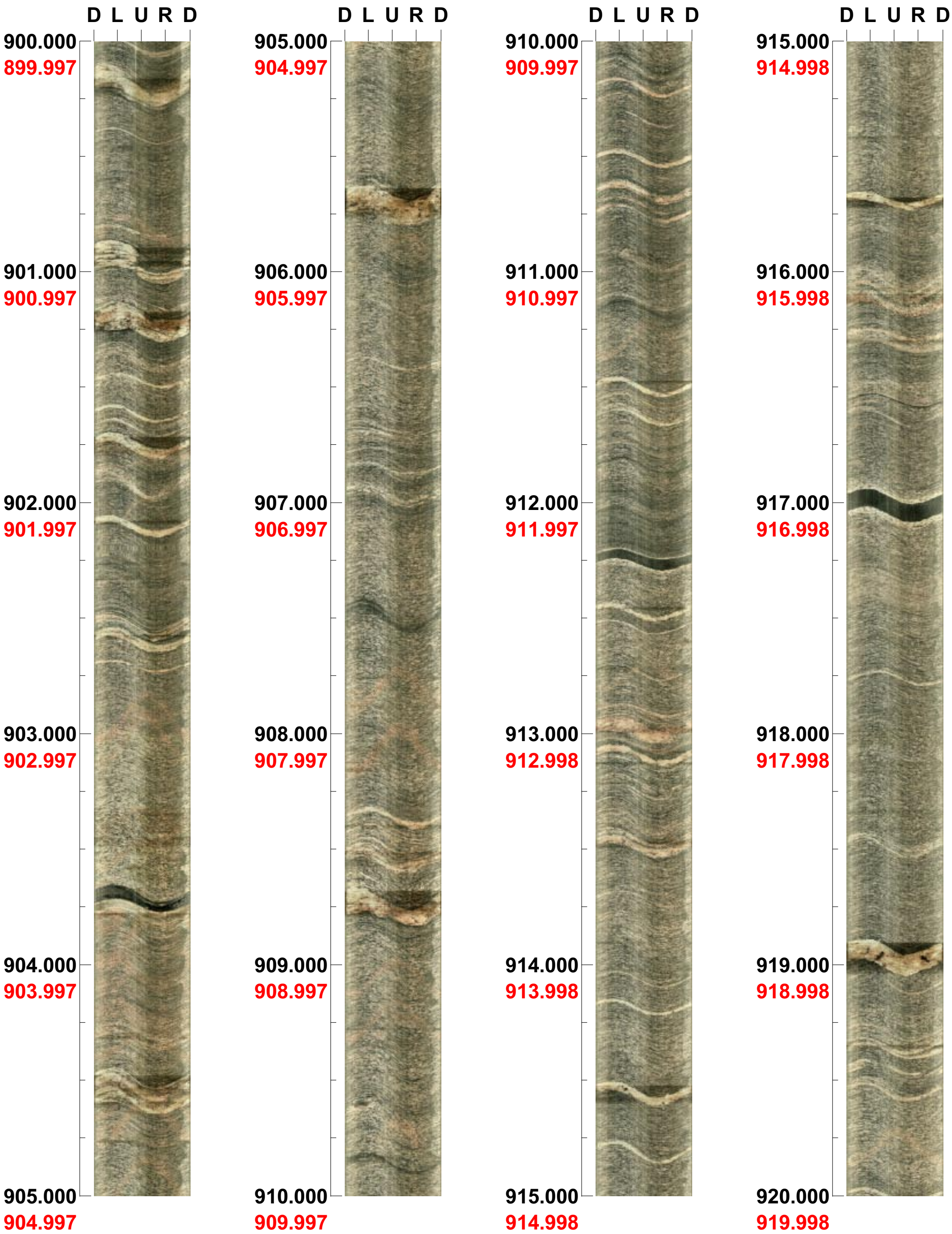
Depth range: 880.000 - 900.000 m



(13 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 900.000 - 920.000 m

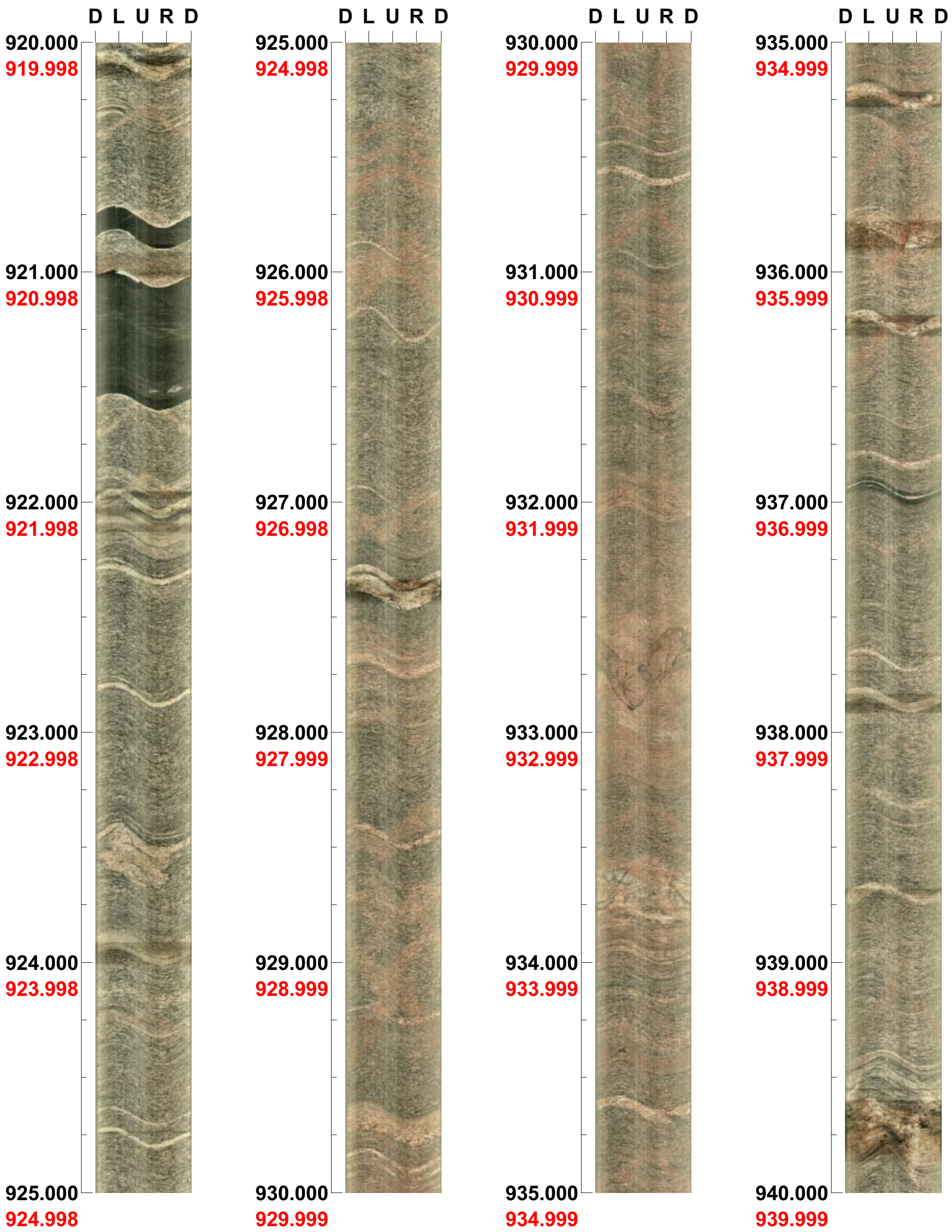


(14 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

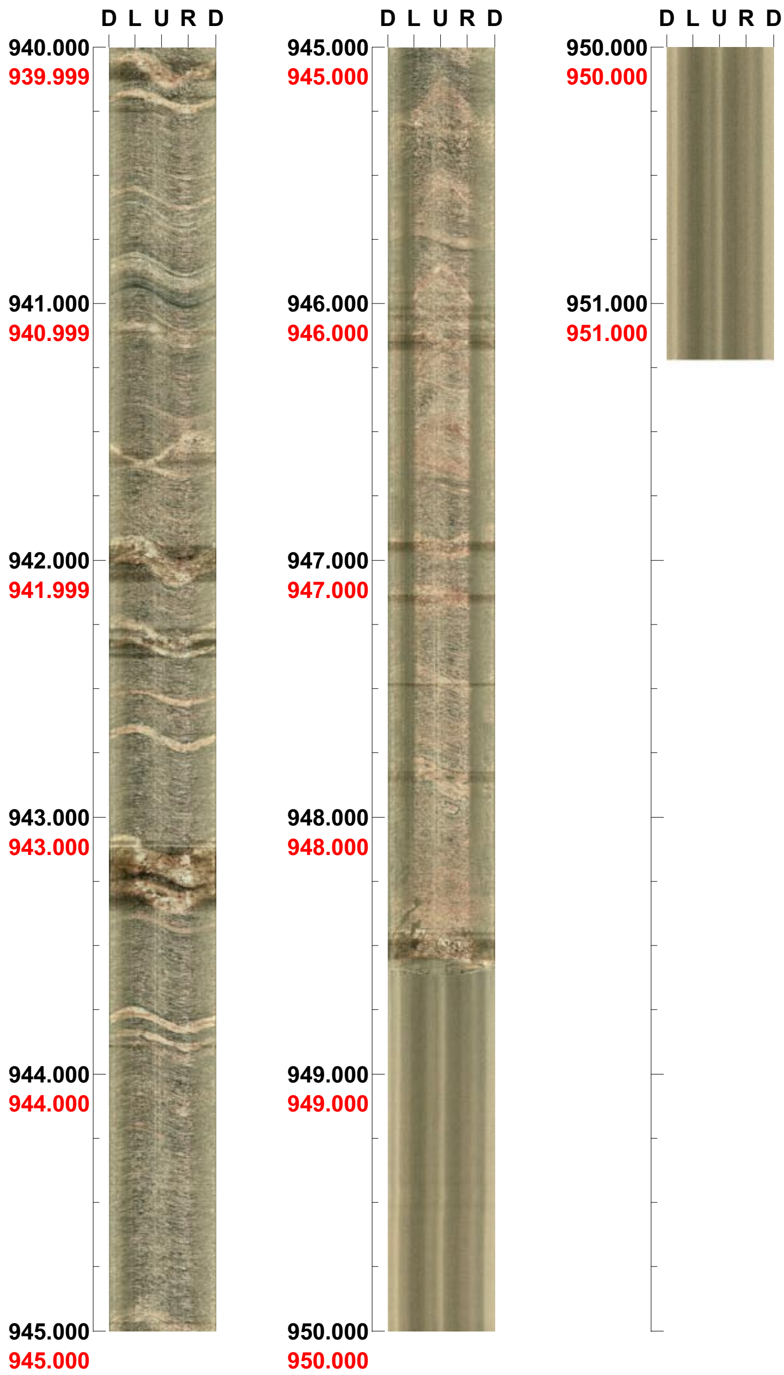
Depth range: 920.000 - 940.000 m



(15 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark
Bore hole No.: KFM08C **Azimuth: 36** **Inclination: -60**

Depth range: 940.000 - 951.217 m



(16 / 16) **Scale: 1/25** **Aspect ratio: 175 %**

Appendix 7

BIPS logging in HFM30. 17 to 200 m

Project name: Forsmark

Image file	: c:\work\r5537f~1\bips\hfm30\hfm30.bip
BDT file	: c:\work\r5537f~1\bips\hfm30\hfm30.bdt
Locality	: FORSMARK
Bore hole number	: HFM30
Date	: 06/06/19
Time	: 11:05:00
Depth range	: 17.000 - 200.270 m
Azimuth	: 29
Inclination	: -55
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	: 11
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

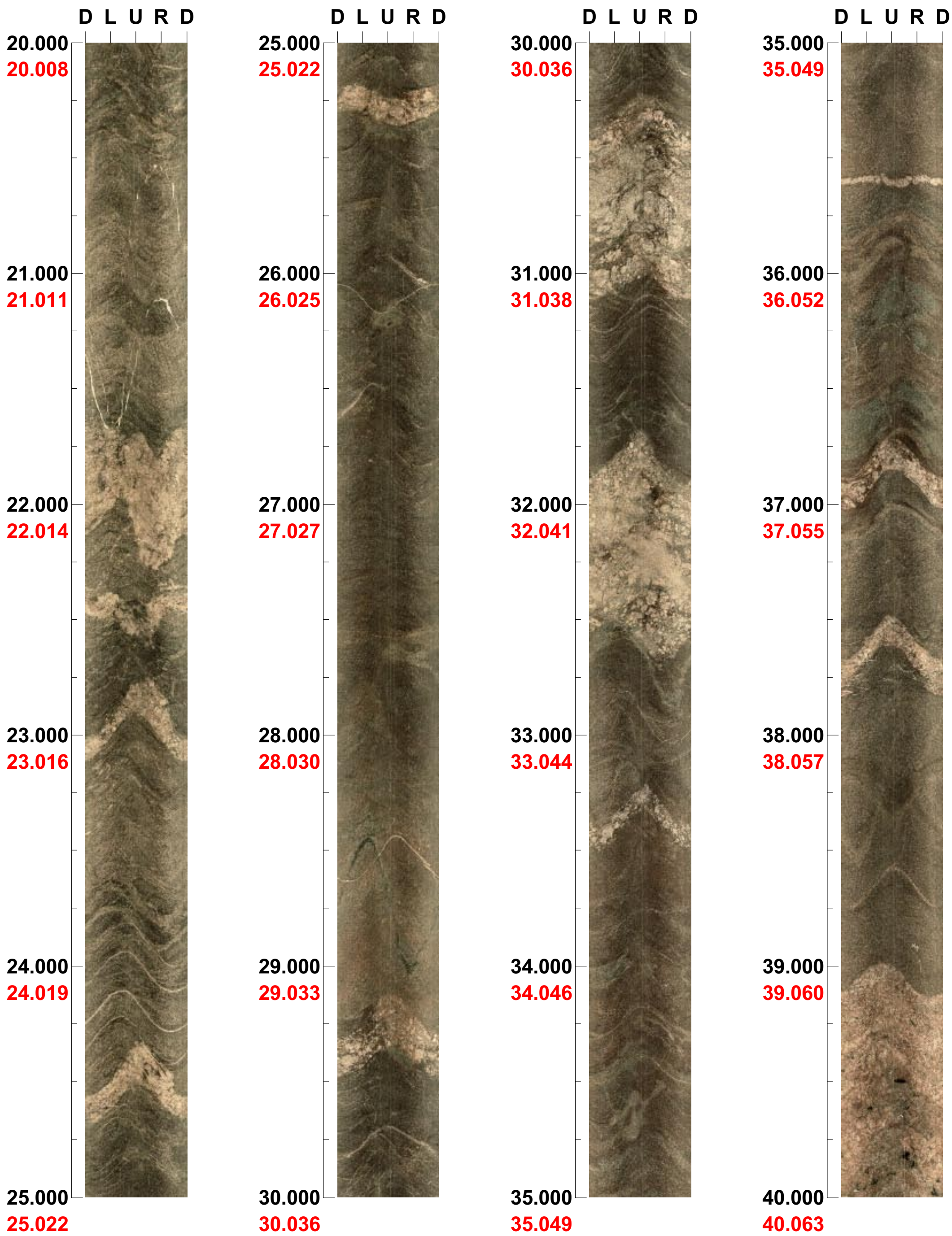
Depth range: 0.000 - 20.000 m

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

Project name: Forsmark

Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

Depth range: 20.000 - 40.000 m

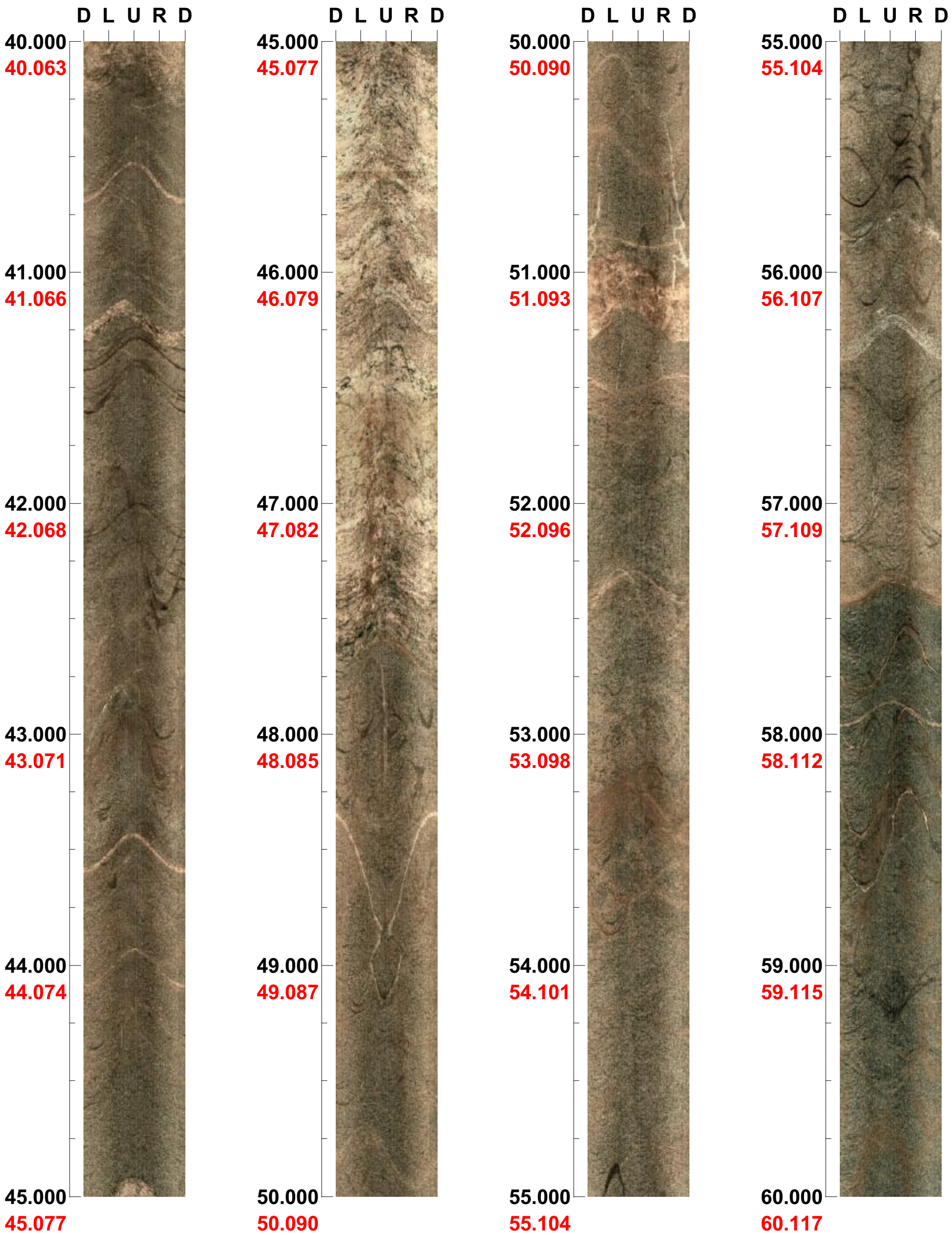


(2 / 11) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

Depth range: 40.000 - 60.000 m

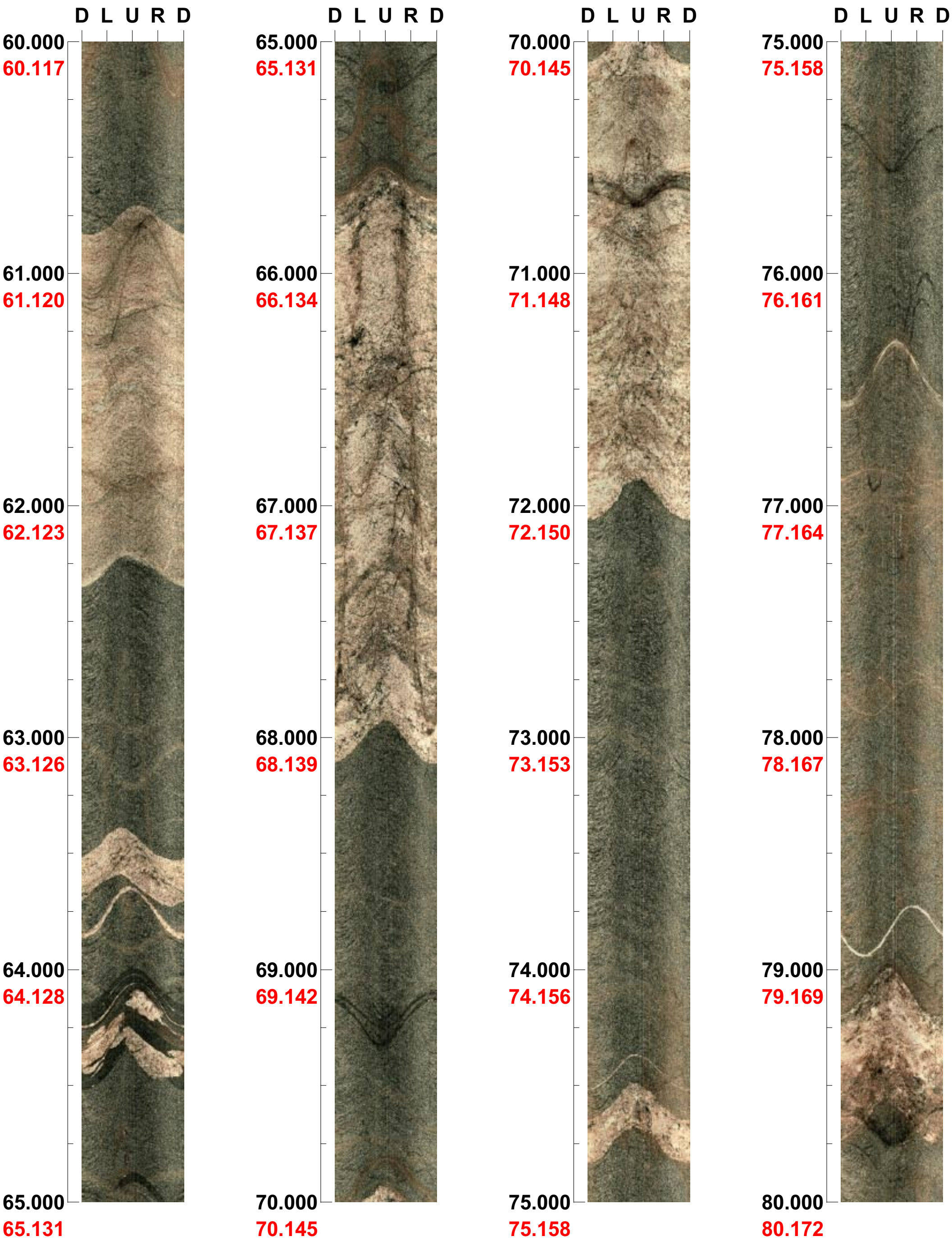


(3 / 11) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

Depth range: 60.000 - 80.000 m



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

Project name: Forsmark

Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

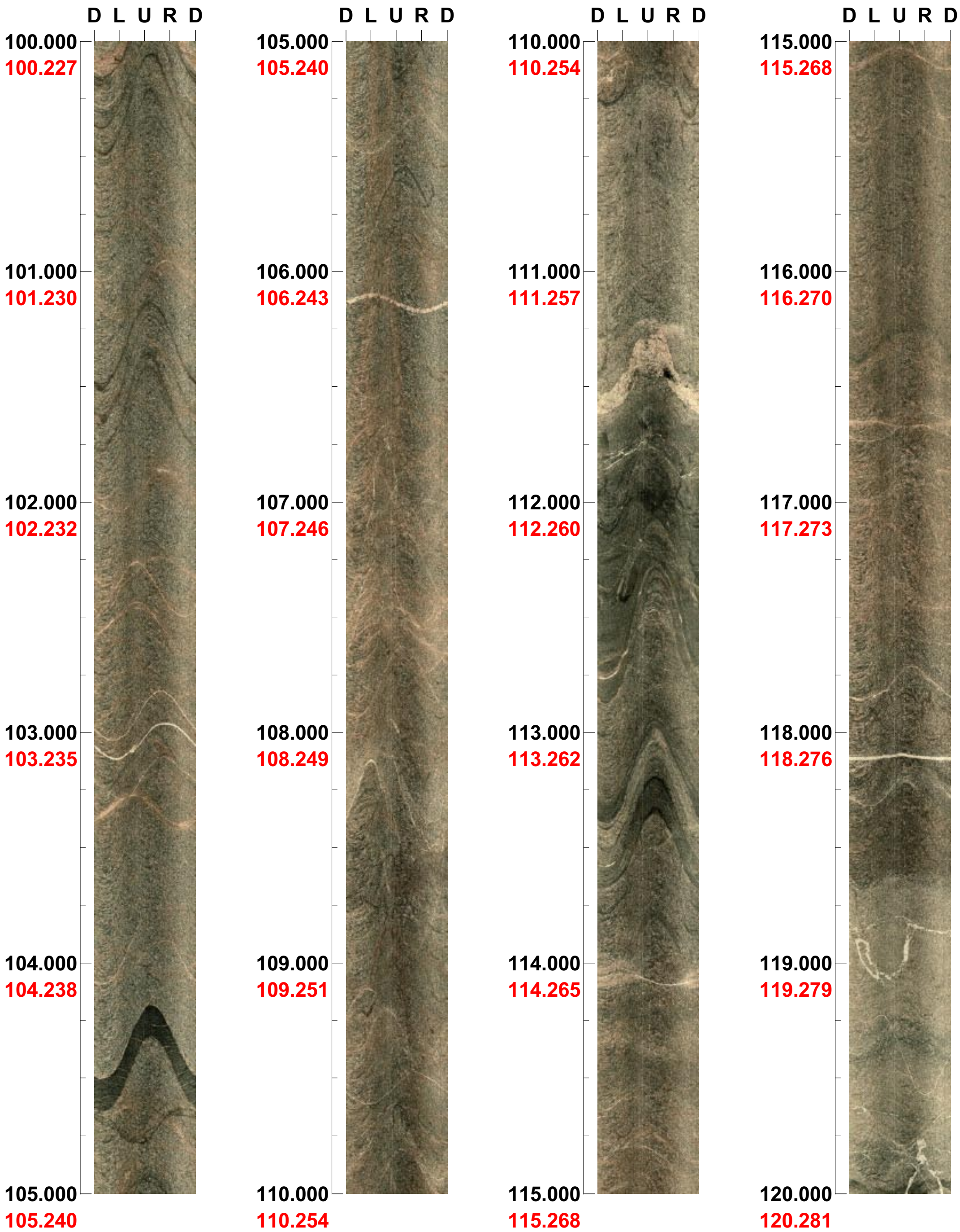
Depth range: 80.000 - 100.000 m

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

Project name: Forsmark

Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

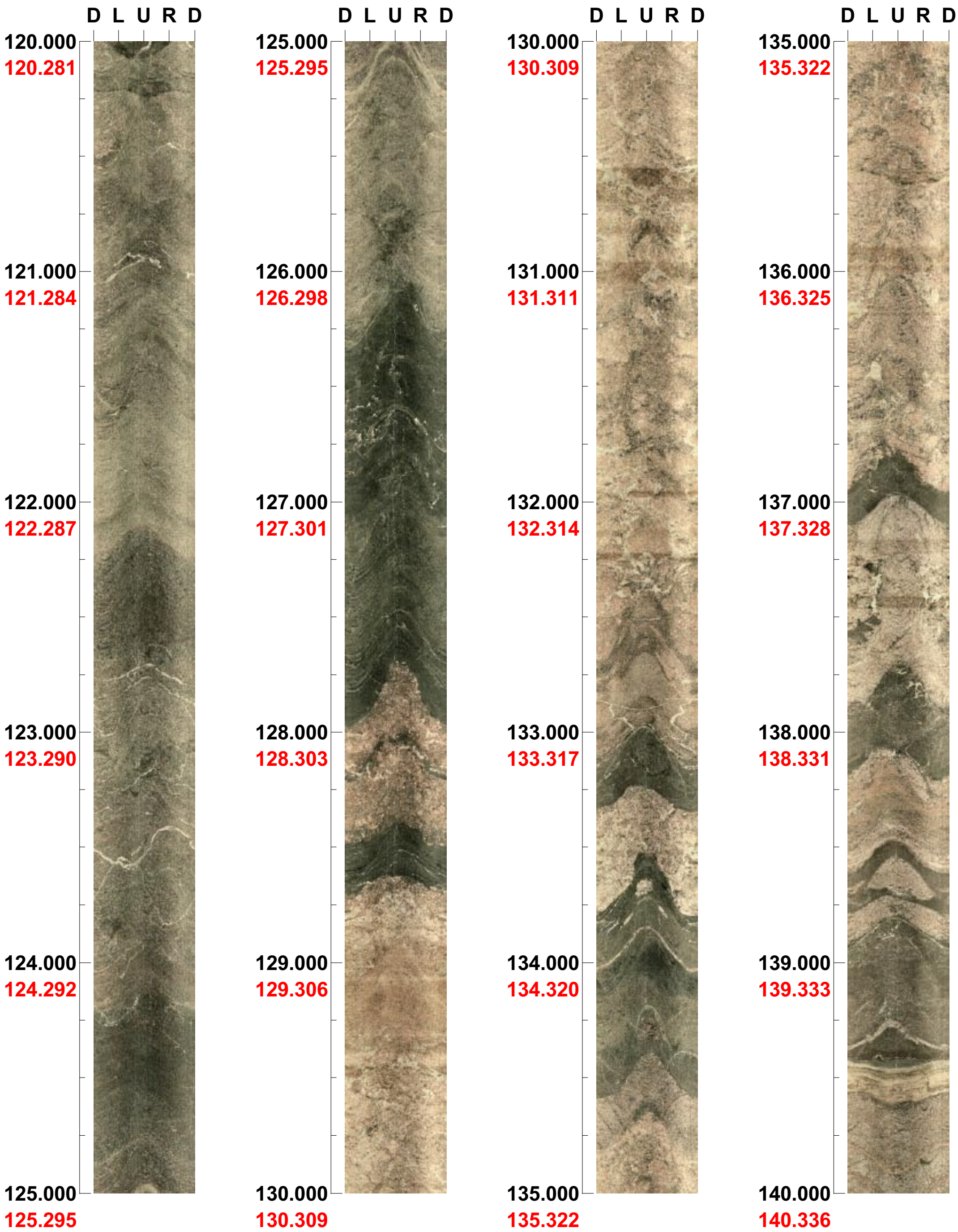
Depth range: 100.000 - 120.000 m



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

Project name: Forsmark
Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

Depth range: 120.000 - 140.000 m

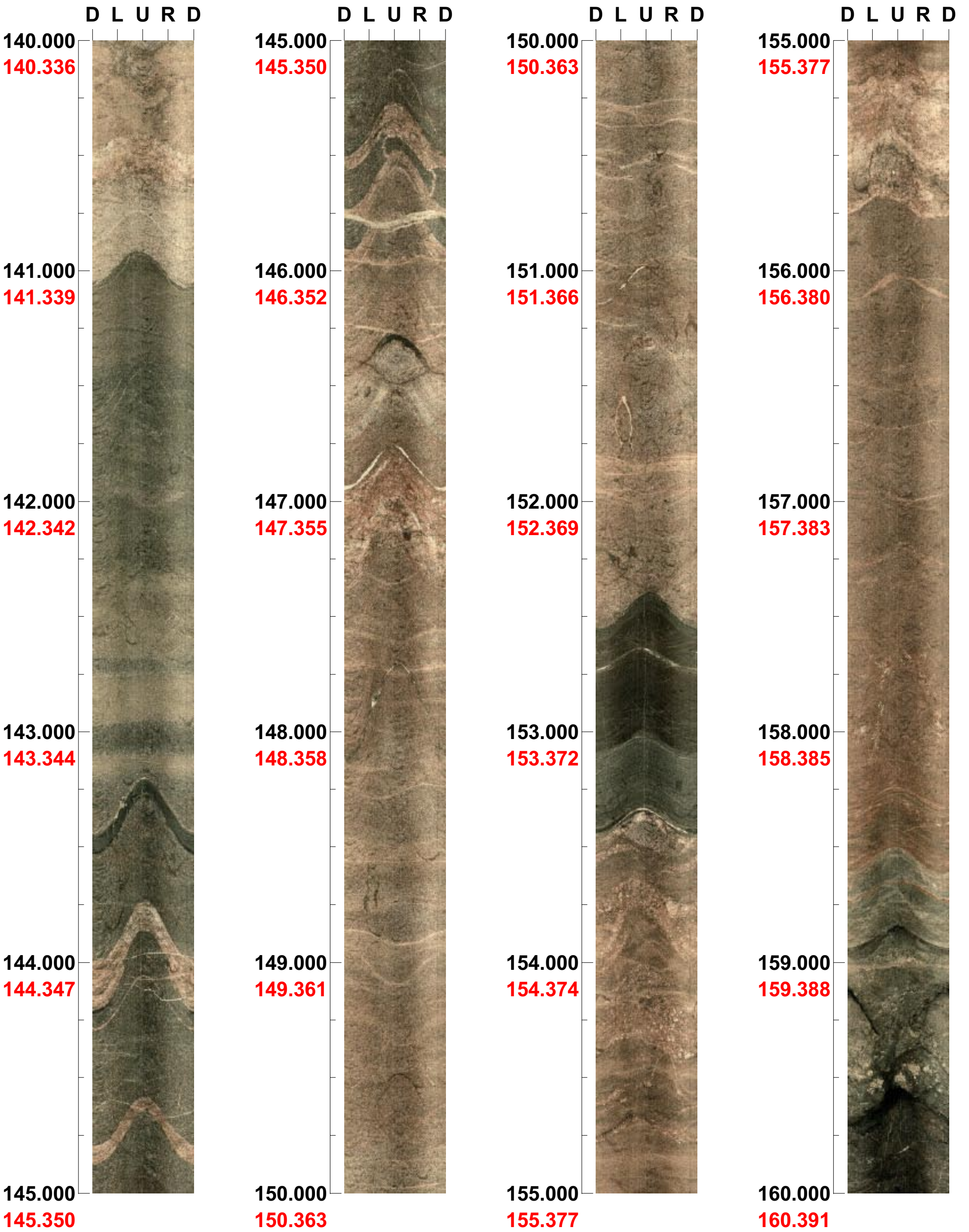


(7 / 11) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

Depth range: 140.000 - 160.000 m



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

Project name: Forsmark

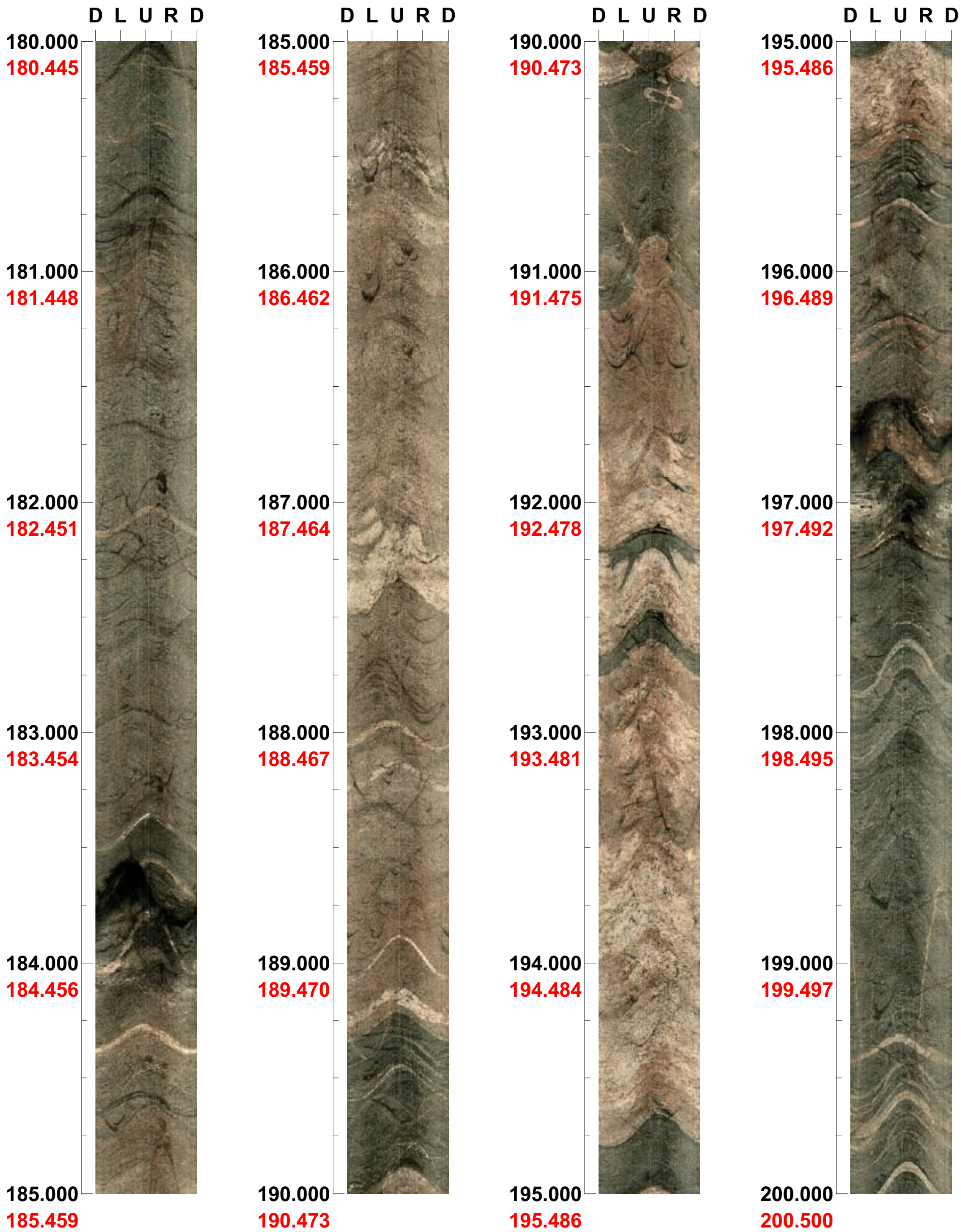
Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

Depth range: 160.000 - 180.000 m

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

Project name: Forsmark
Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

Depth range: 180.000 - 200.000 m



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

Project name: Forsmark

Bore hole No.: HFM30 **Azimuth: 29** **Inclination: -55**

Depth range: 200.000 - 200.270 m

D L U R D

200.000

200.500

(11 / 11) Scale: 1/25 Aspect ratio: 100 %

Appendix 8

BIPS logging in HFM31. 8 to 199 m

Appendix 8

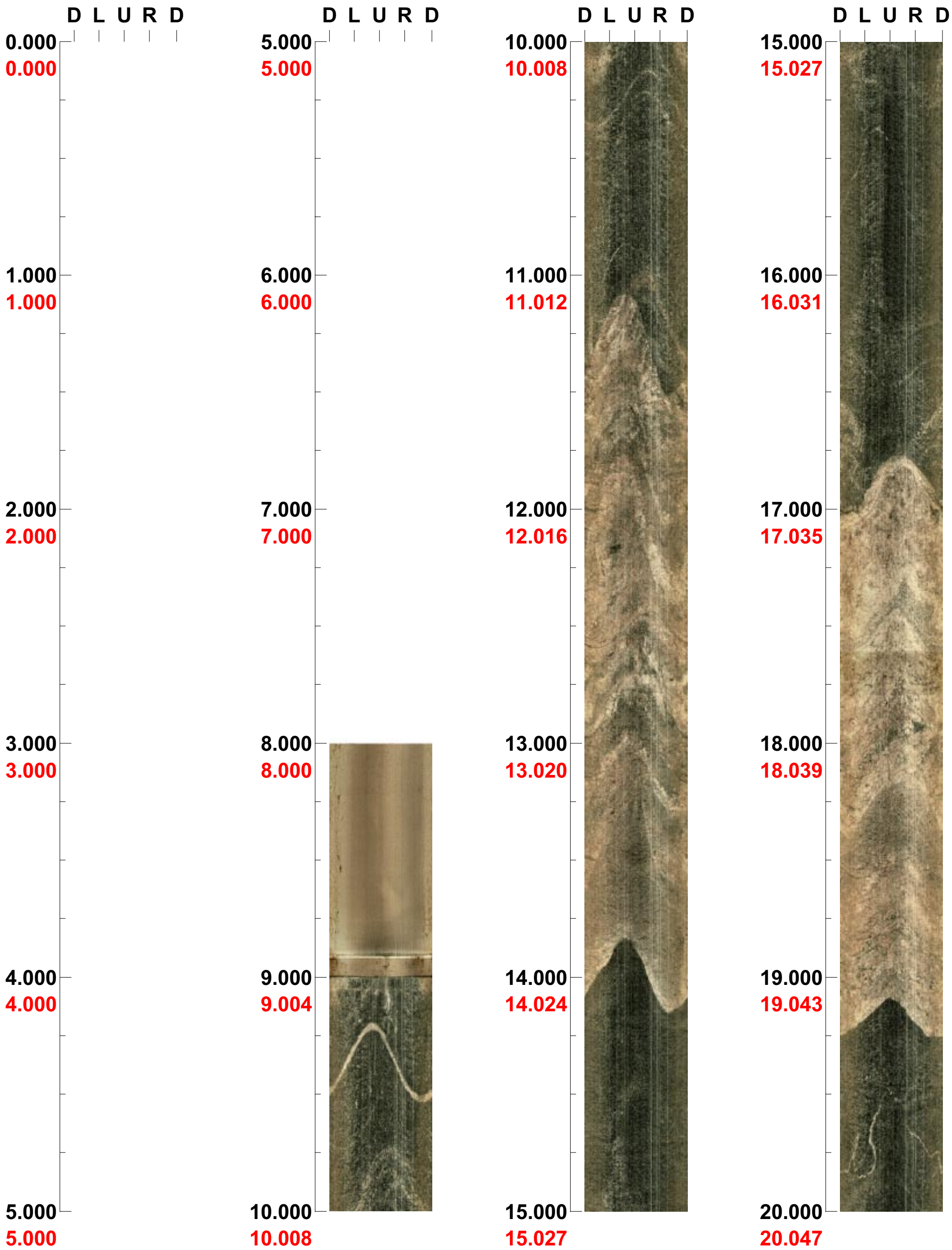
Project name: Forsmark

Image file	: c:\work\r5537f~1\bips\1juni~1\hfm31.bip
BDT file	: c:\work\r5537f~1\bips\1juni~1\hfm31.bdt
Locality	: FORSMARK
Bore hole number	: HFM31
Date	: 06/06/01
Time	: 08:39:00
Depth range	: 8.000 - 199.876 m
Azimuth	: 312
Inclination	: -69
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.: HFM31 **Azimuth: 312** **Inclination: -69**

Depth range: 0.000 - 20.000 m

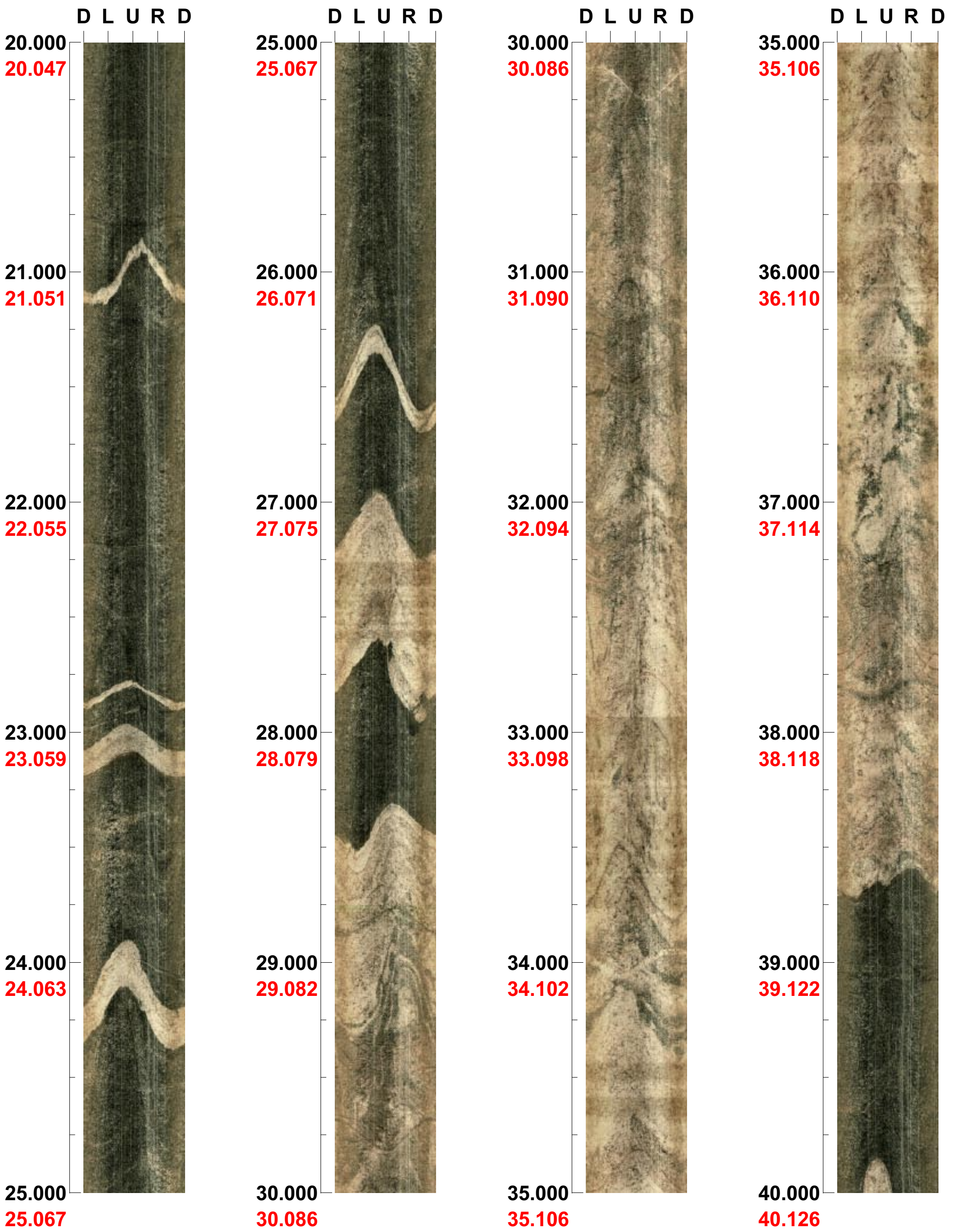


(1 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM31 **Azimuth: 312** **Inclination: -69**

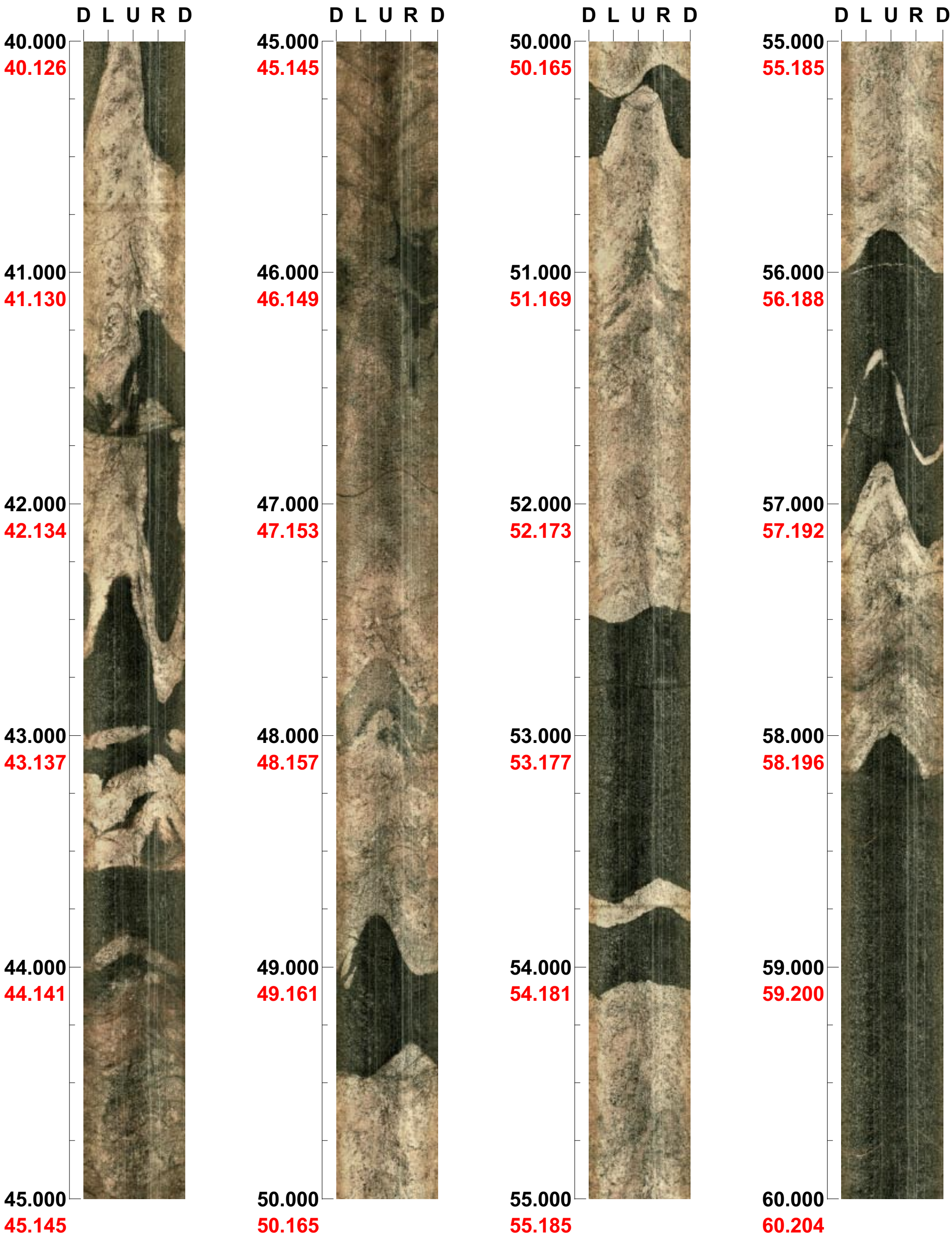
Depth range: 20.000 - 40.000 m



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

Project name: Forsmark
Bore hole No.: HFM31 Azimuth: 312 Inclination: -69

Depth range: 40.000 - 60.000 m

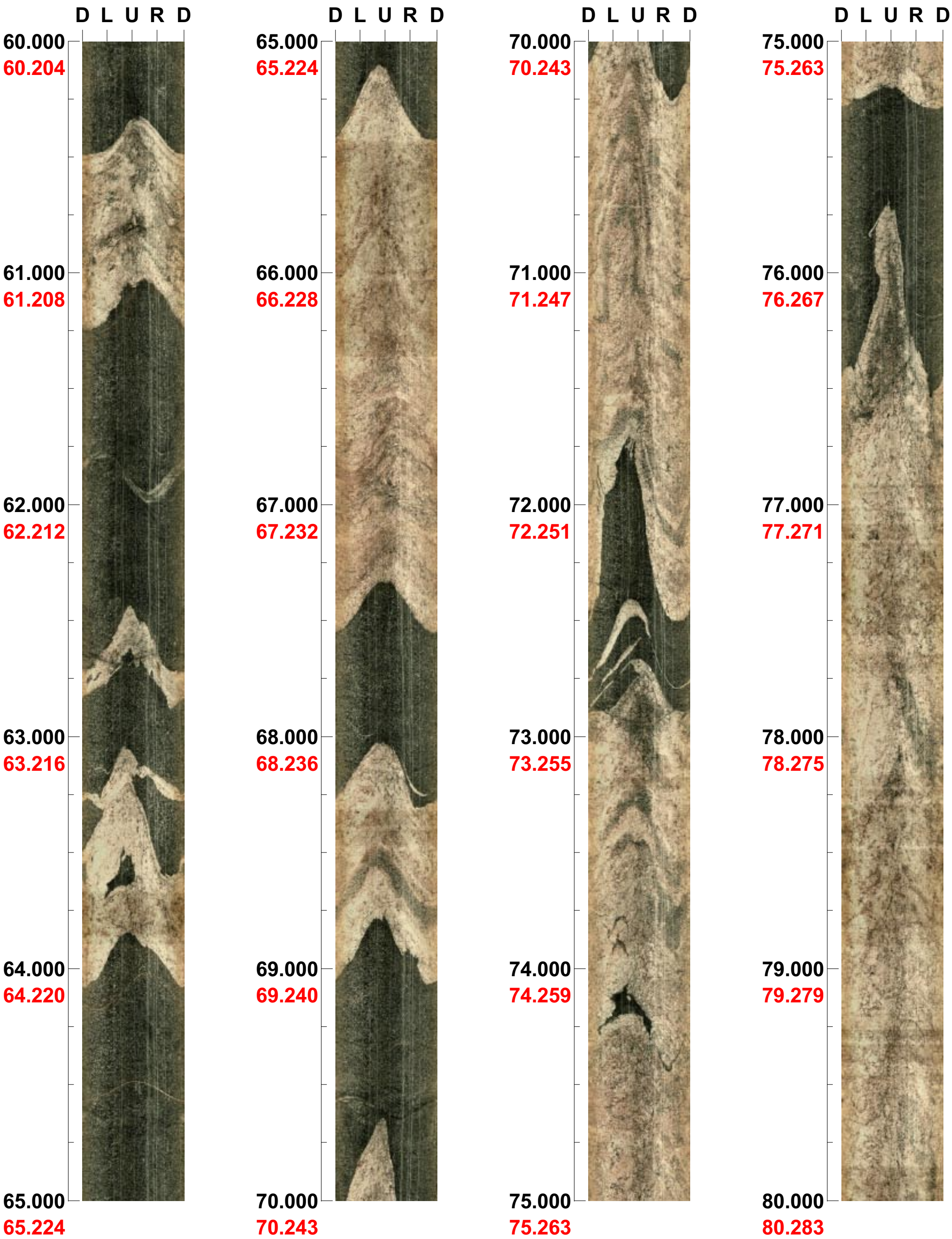


(3 / 10) Scale: 1/25 Aspect ratio: 100 %

Project name: Forsmark

Bore hole No.: HFM31 Azimuth: 312 Inclination: -69

Depth range: 60.000 - 80.000 m



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

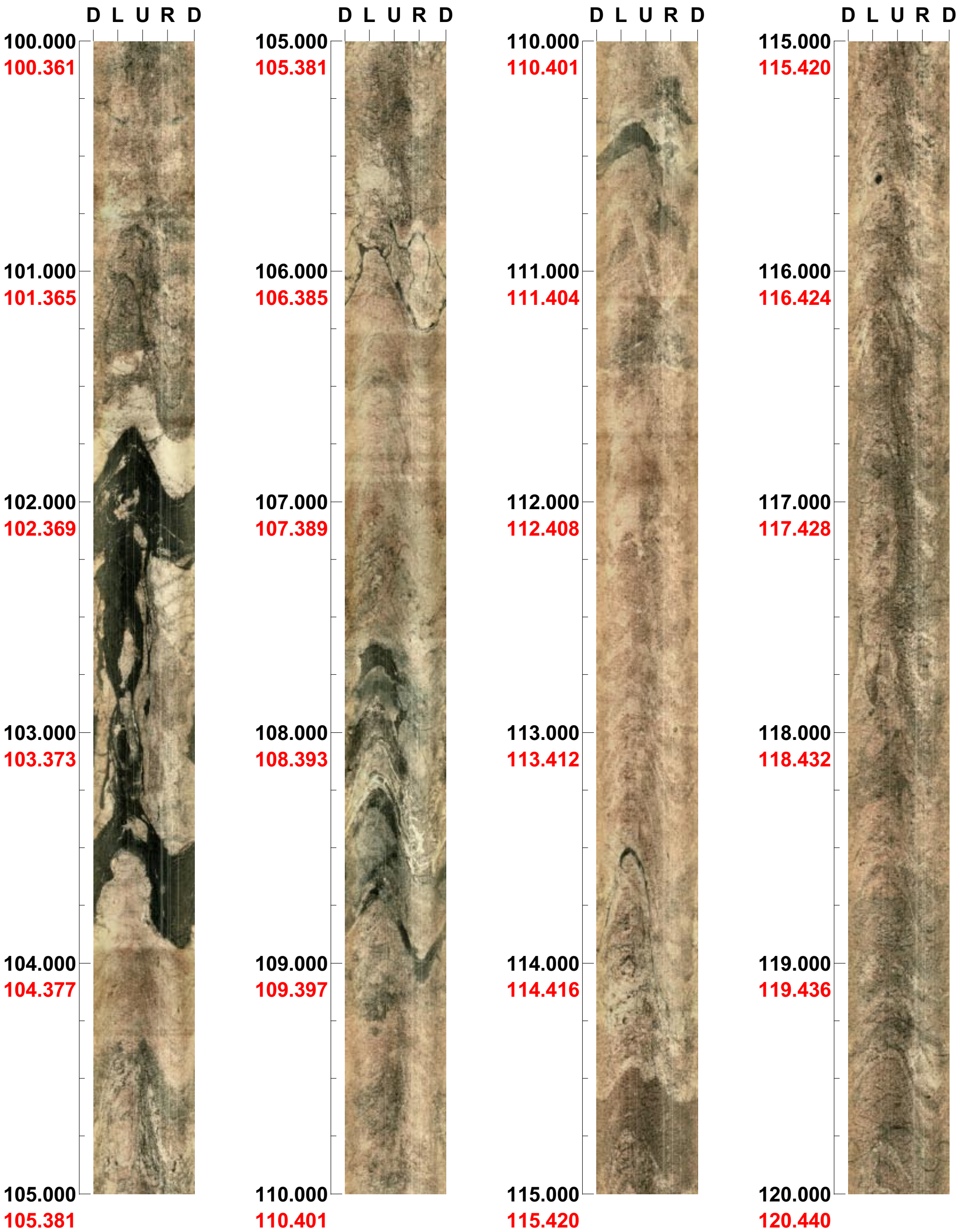
Project name: Forsmark
Bore hole No.: HFM31 **Azimuth: 312** **Inclination: -69**

Depth range: 80.000 - 100.000 m

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

Project name: Forsmark
Bore hole No.: HFM31 **Azimuth: 312** **Inclination: -69**

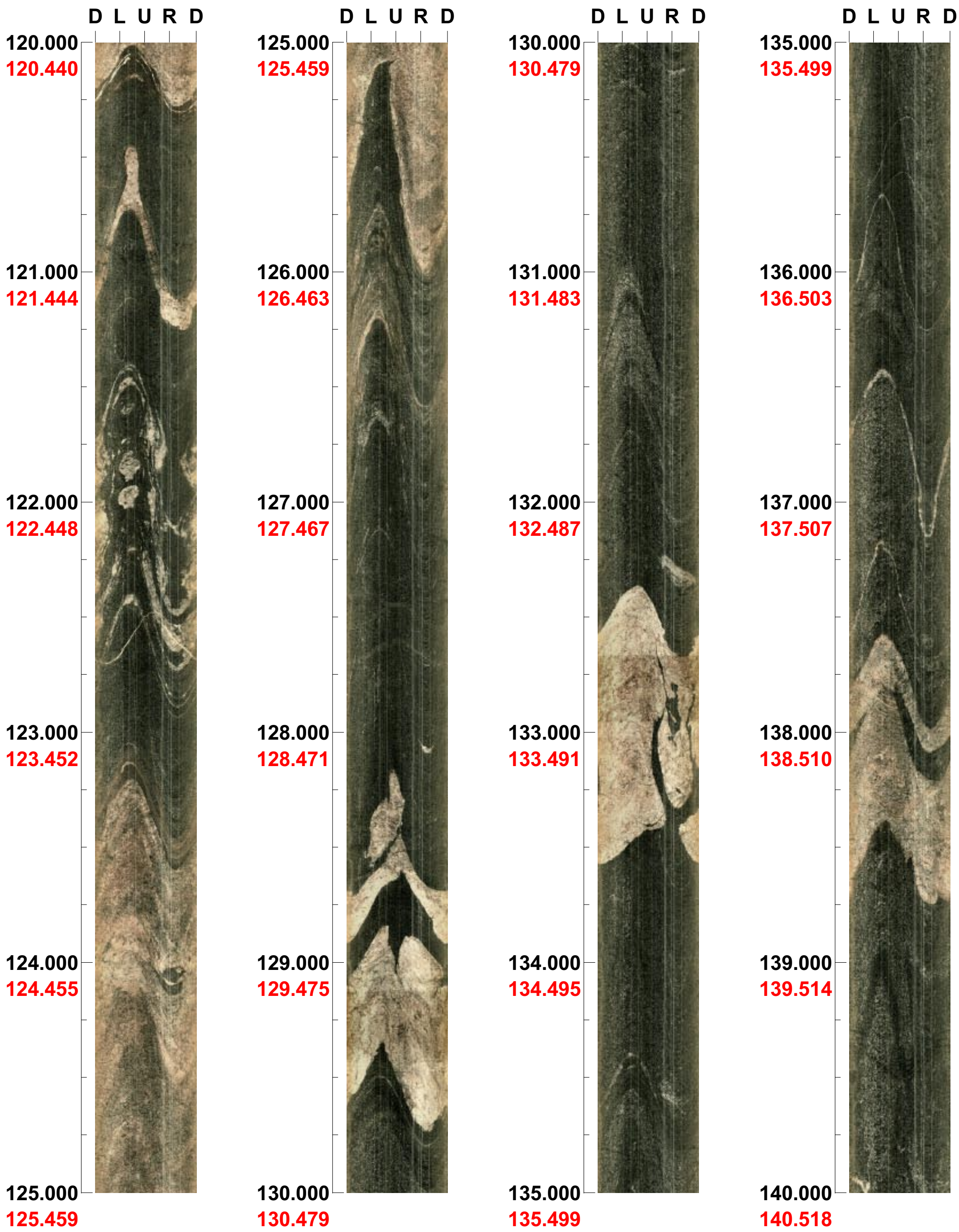
Depth range: 100.000 - 120.000 m



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

Project name: Forsmark
Bore hole No.: HFM31 **Azimuth: 312** **Inclination: -69**

Depth range: 120.000 - 140.000 m

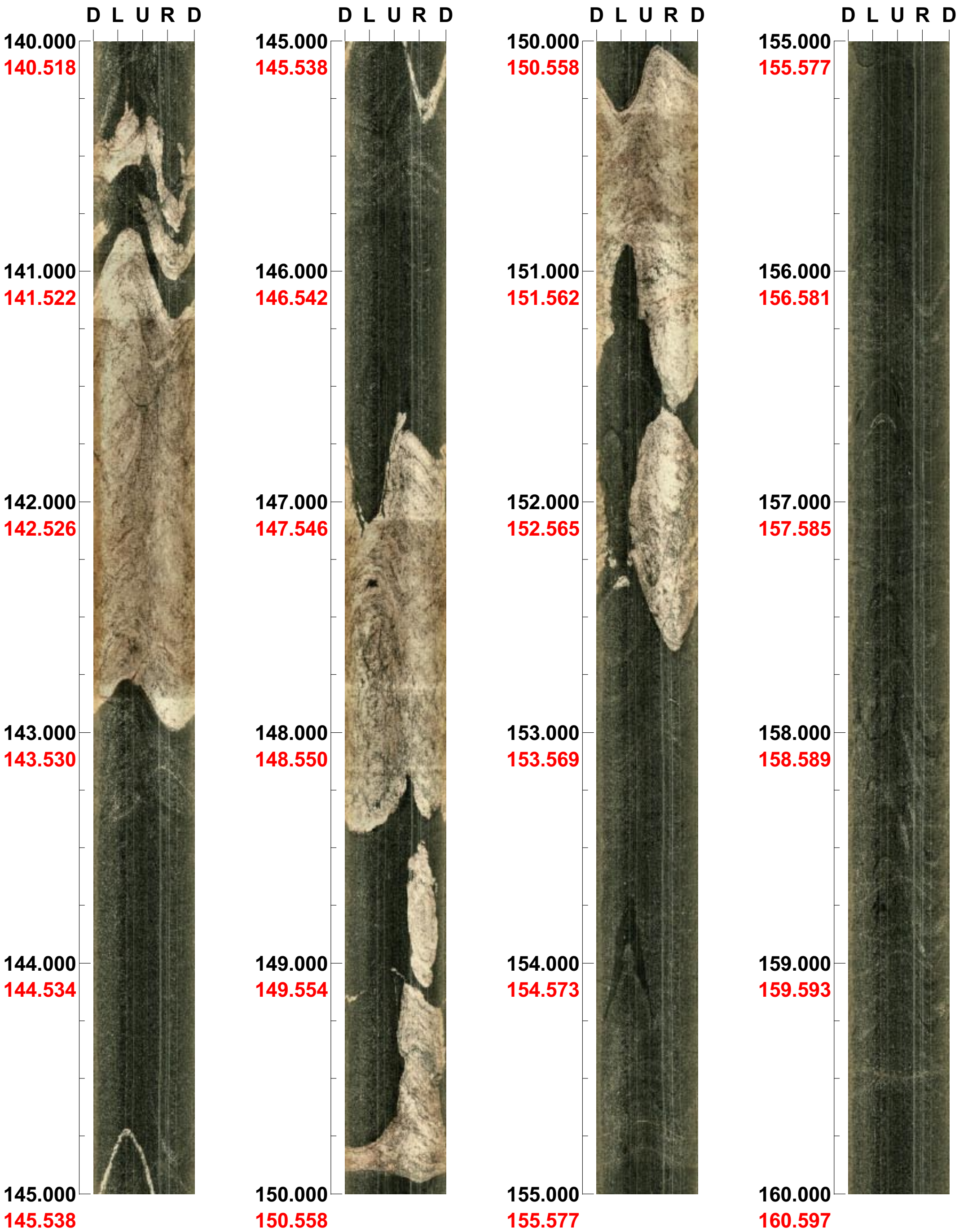


(7 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM31 **Azimuth: 312** **Inclination: -69**

Depth range: 140.000 - 160.000 m

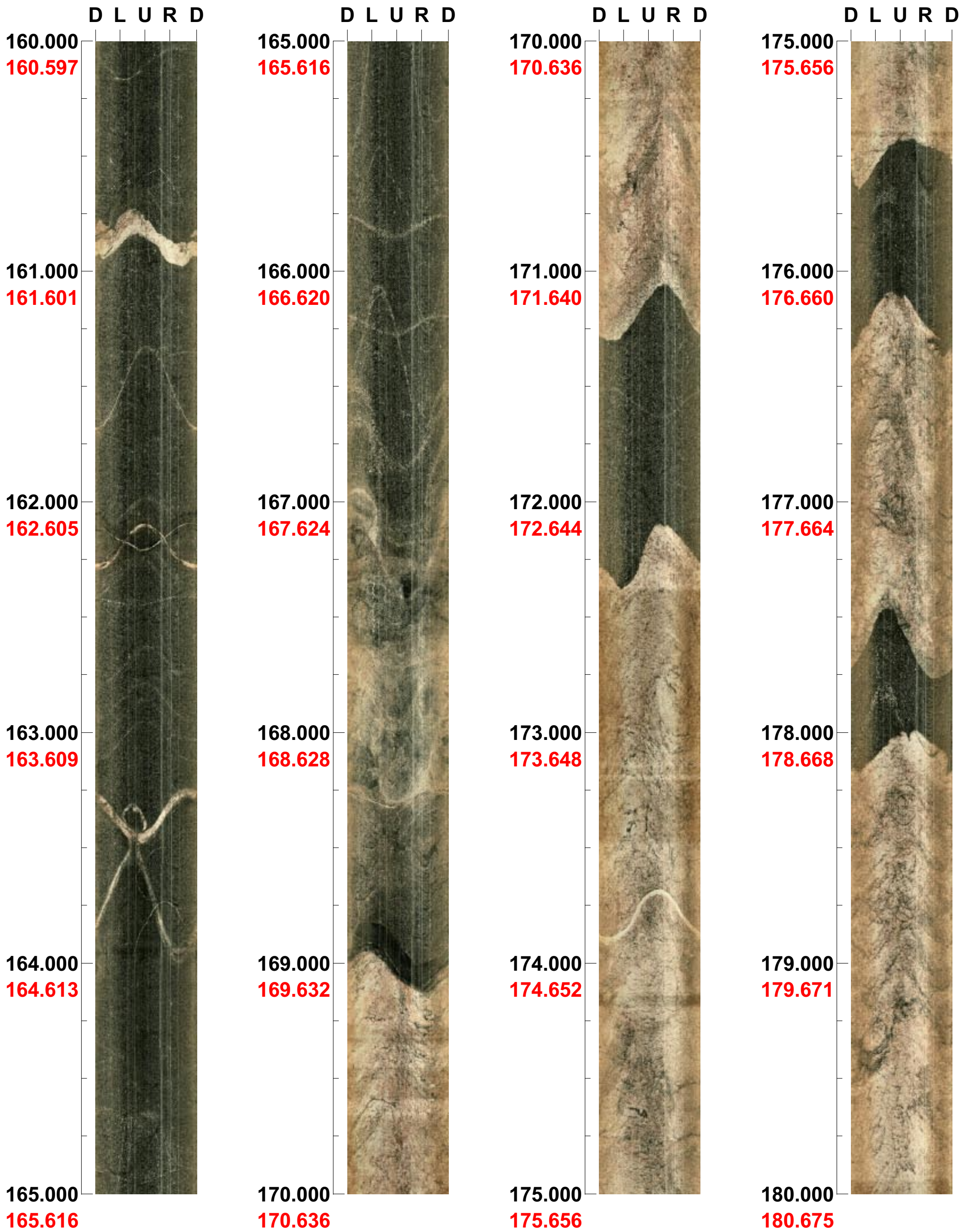


(8 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM31 **Azimuth: 312** **Inclination: -69**

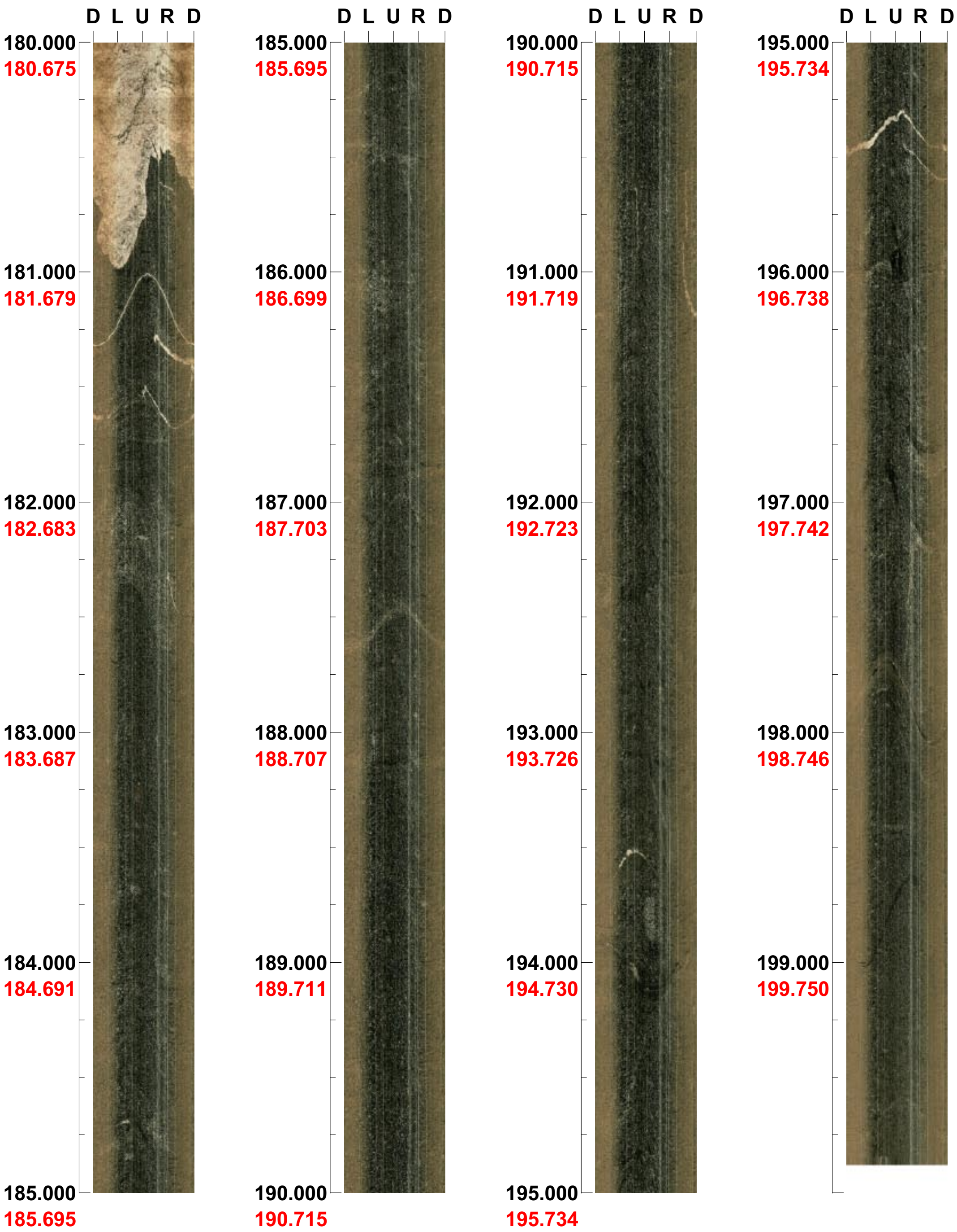
Depth range: 160.000 - 180.000 m



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

Project name: Forsmark
Bore hole No.: HFM31 **Azimuth: 312** **Inclination: -69**

Depth range: 180.000 - 199.876 m



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

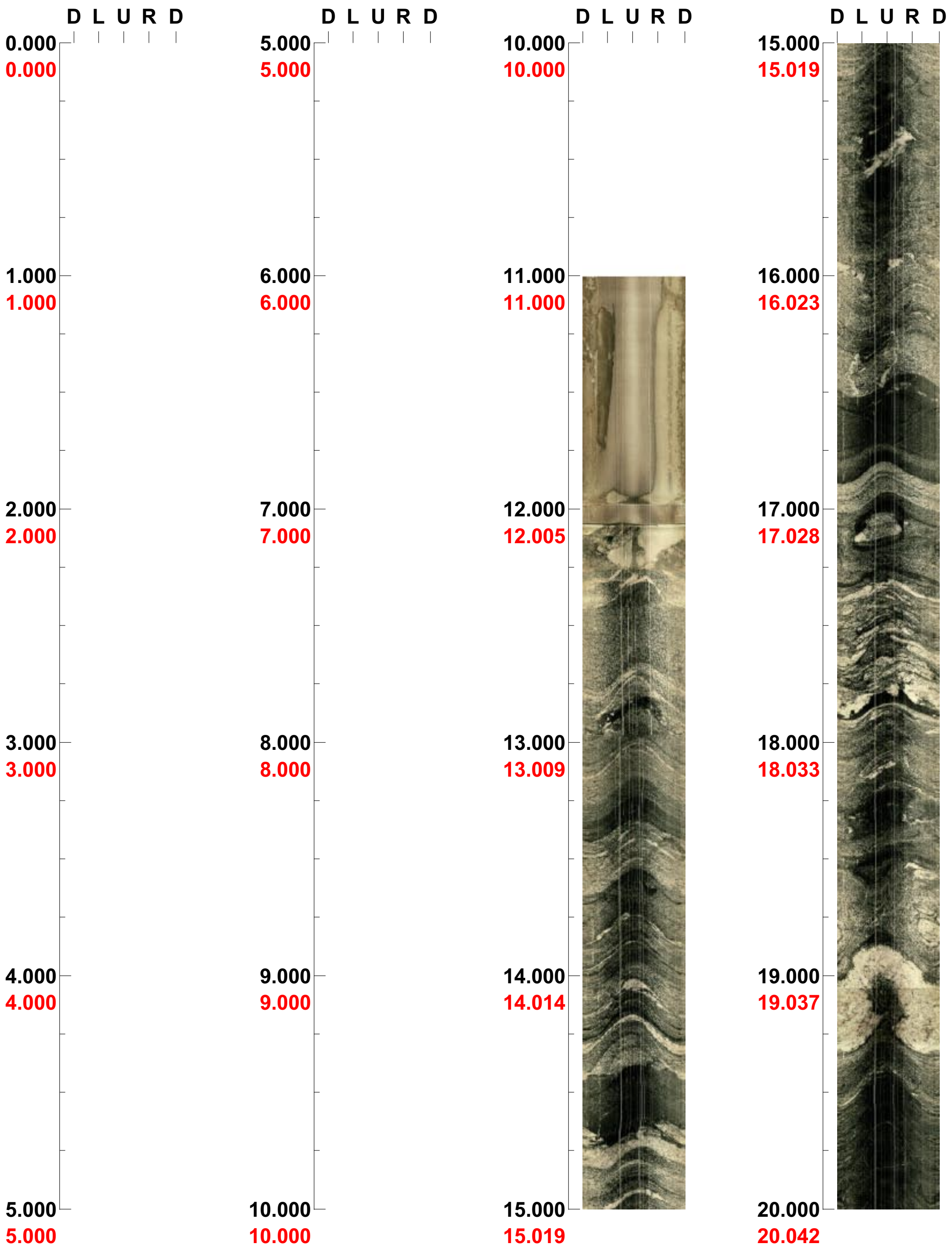
BIPS logging in HFM33. 11 to 135 m

Project name: Forsmark

Image file	: c:\work\r5537f~1\bips\1juni~1\hfm33.bip
BDT file	: c:\work\r5537f~1\bips\1juni~1\hfm33.bdt
Locality	: FORSMARK
Bore hole number	: HFM33
Date	: 06/06/01
Time	: 15:54:00
Depth range	: 11.000 - 139.790 m
Azimuth	: 272
Inclination	: -59
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	: 7
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: HFM33 **Azimuth: 272** **Inclination: -59**

Depth range: 0.000 - 20.000 m

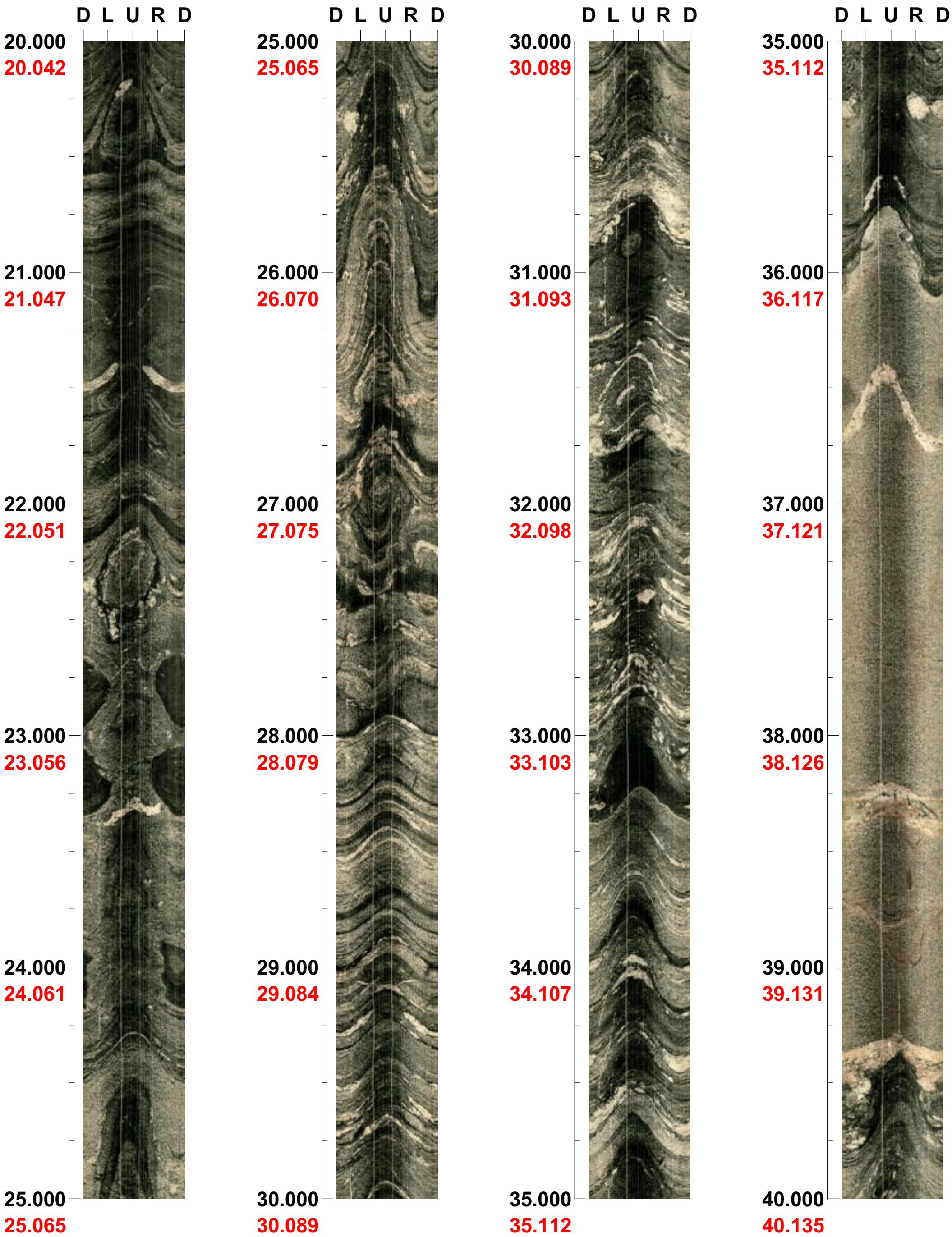


(1 / 7) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM33 **Azimuth: 272** **Inclination: -59**

Depth range: 20.000 - 40.000 m

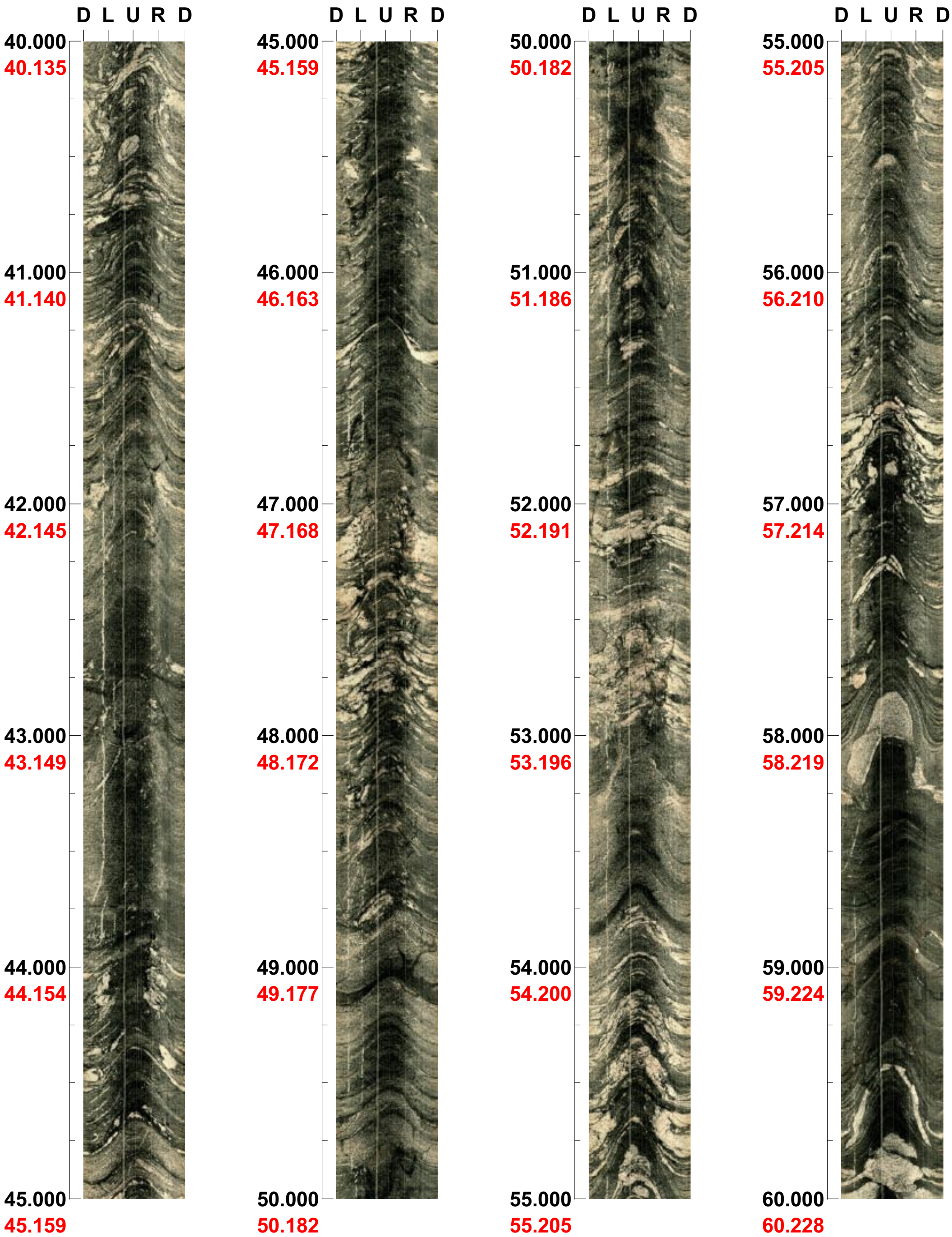


(2 / 7) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM33 **Azimuth: 272** **Inclination: -59**

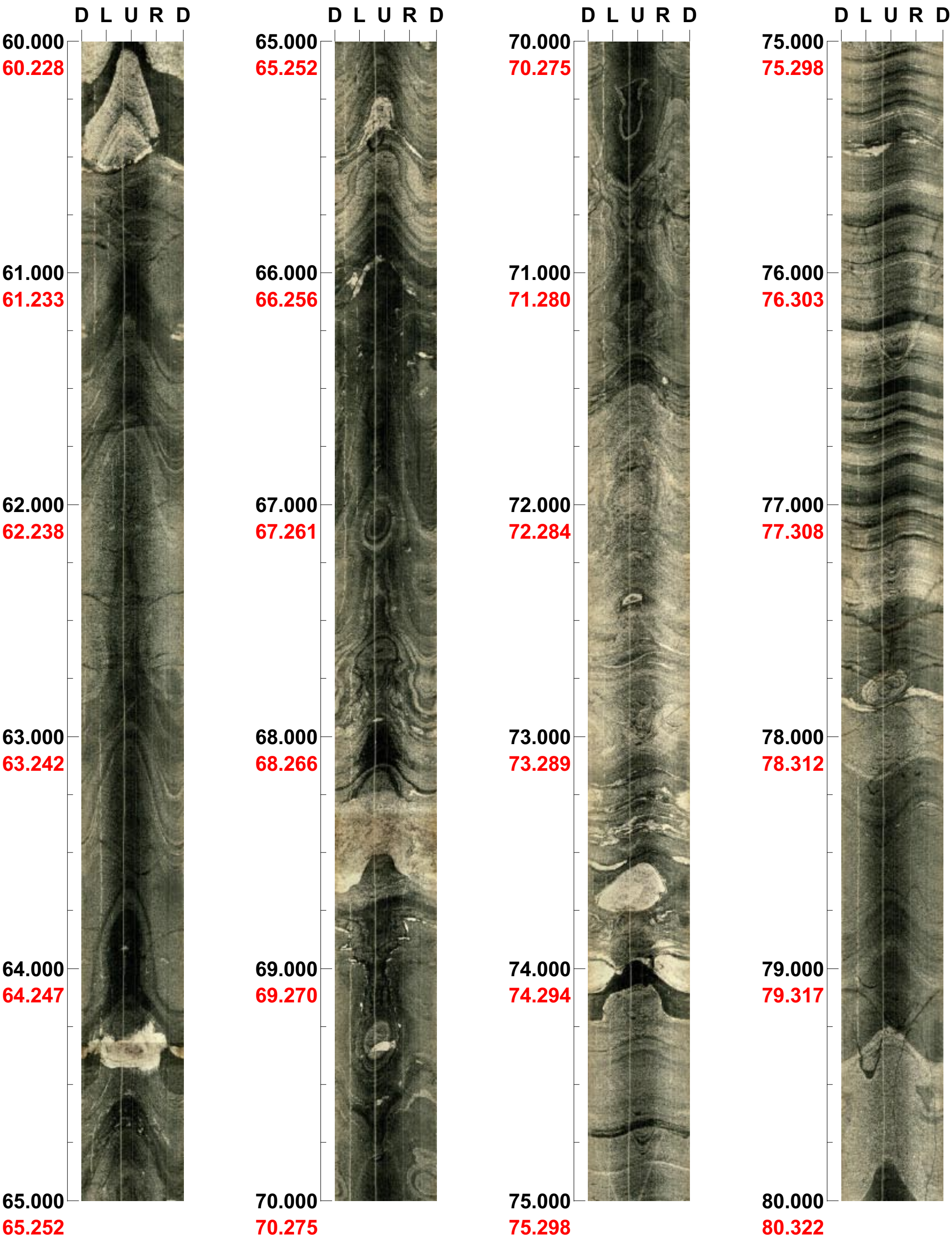
Depth range: 40.000 - 60.000 m



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

Project name: Forsmark
Bore hole No.: HFM33 **Azimuth: 272** **Inclination: -59**

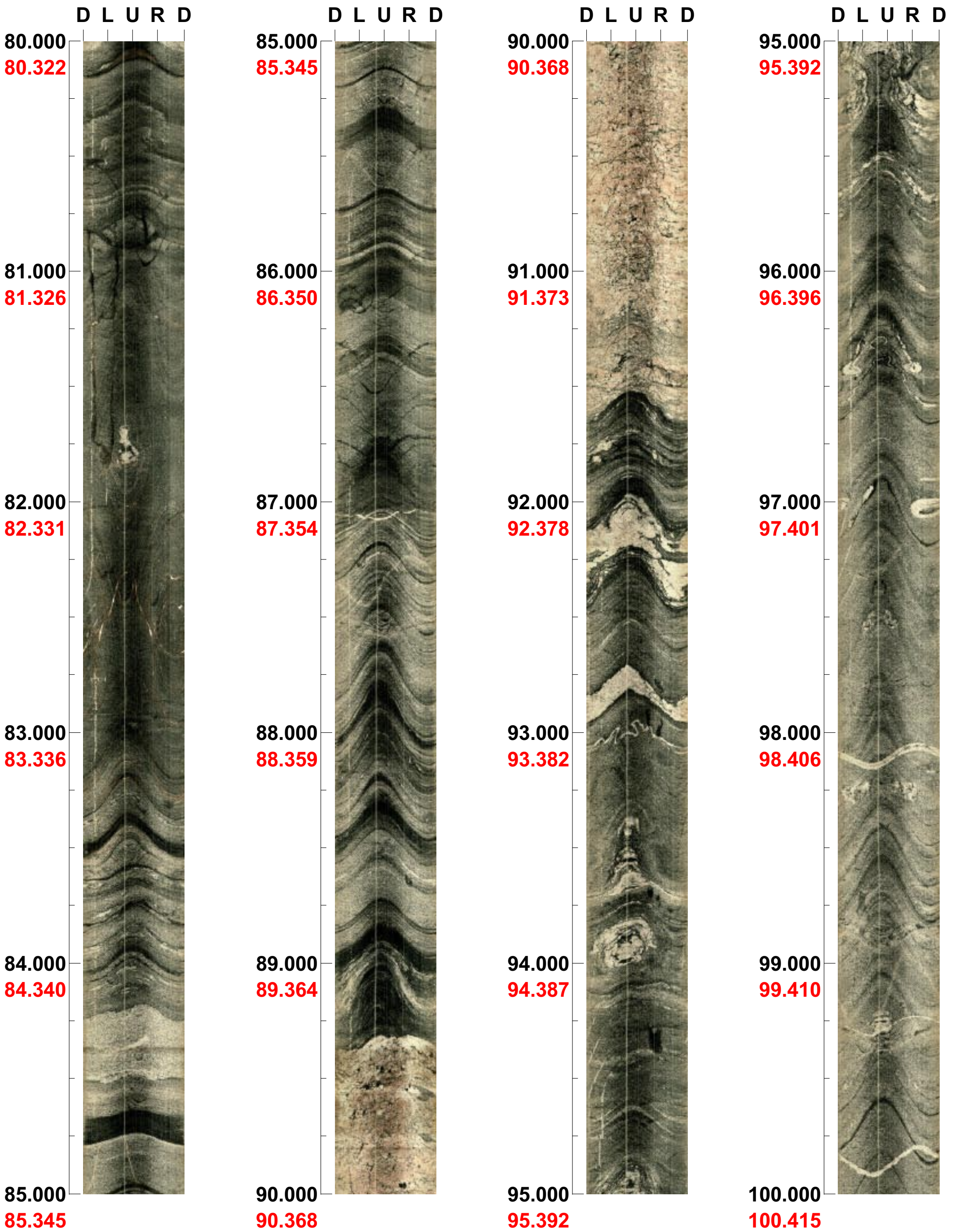
Depth range: 60.000 - 80.000 m



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

Project name: Forsmark
Bore hole No.: HFM33 **Azimuth: 272** **Inclination: -59**

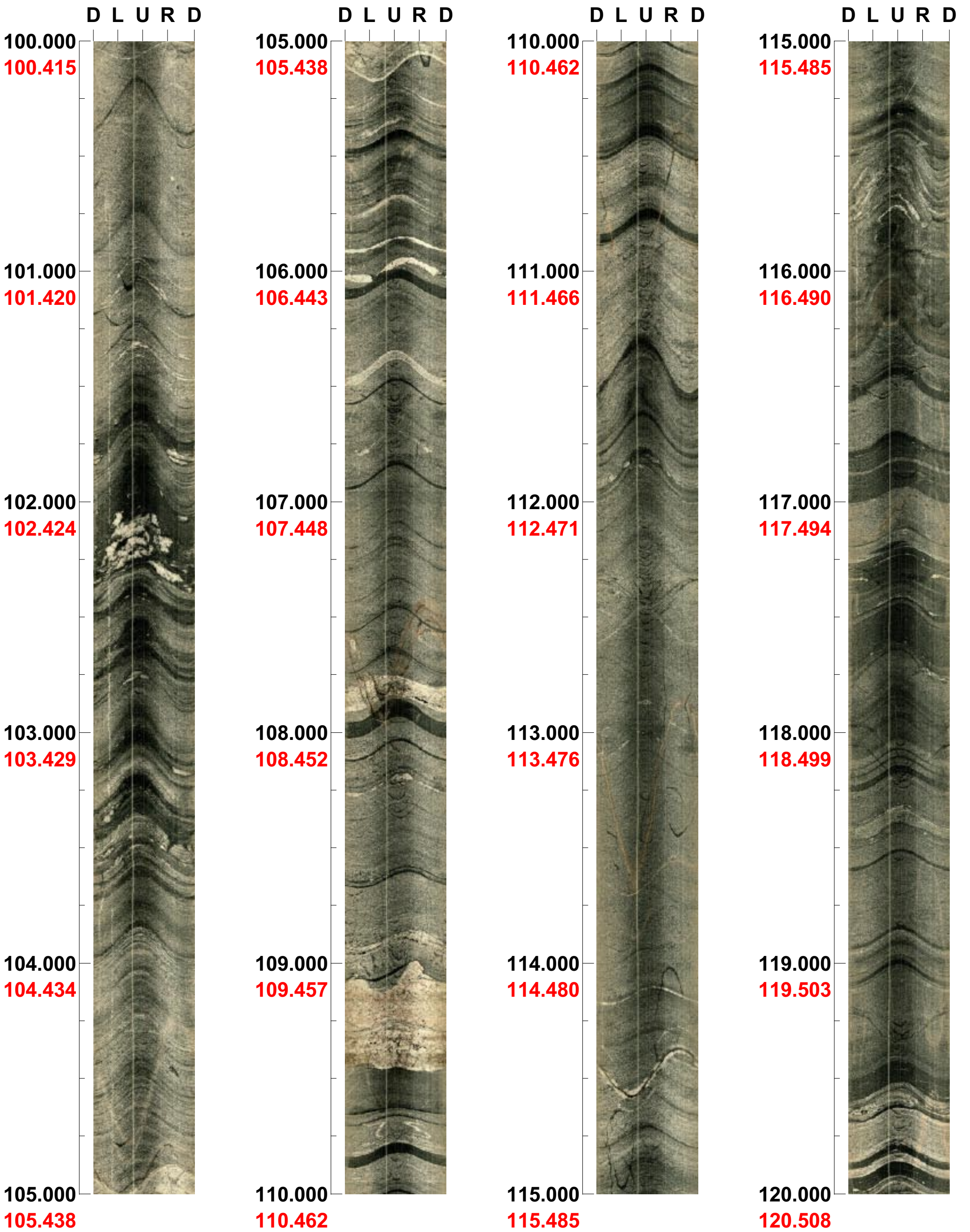
Depth range: 80.000 - 100.000 m



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

Project name: Forsmark
Bore hole No.: HFM33 **Azimuth: 272** **Inclination: -59**

Depth range: 100.000 - 120.000 m

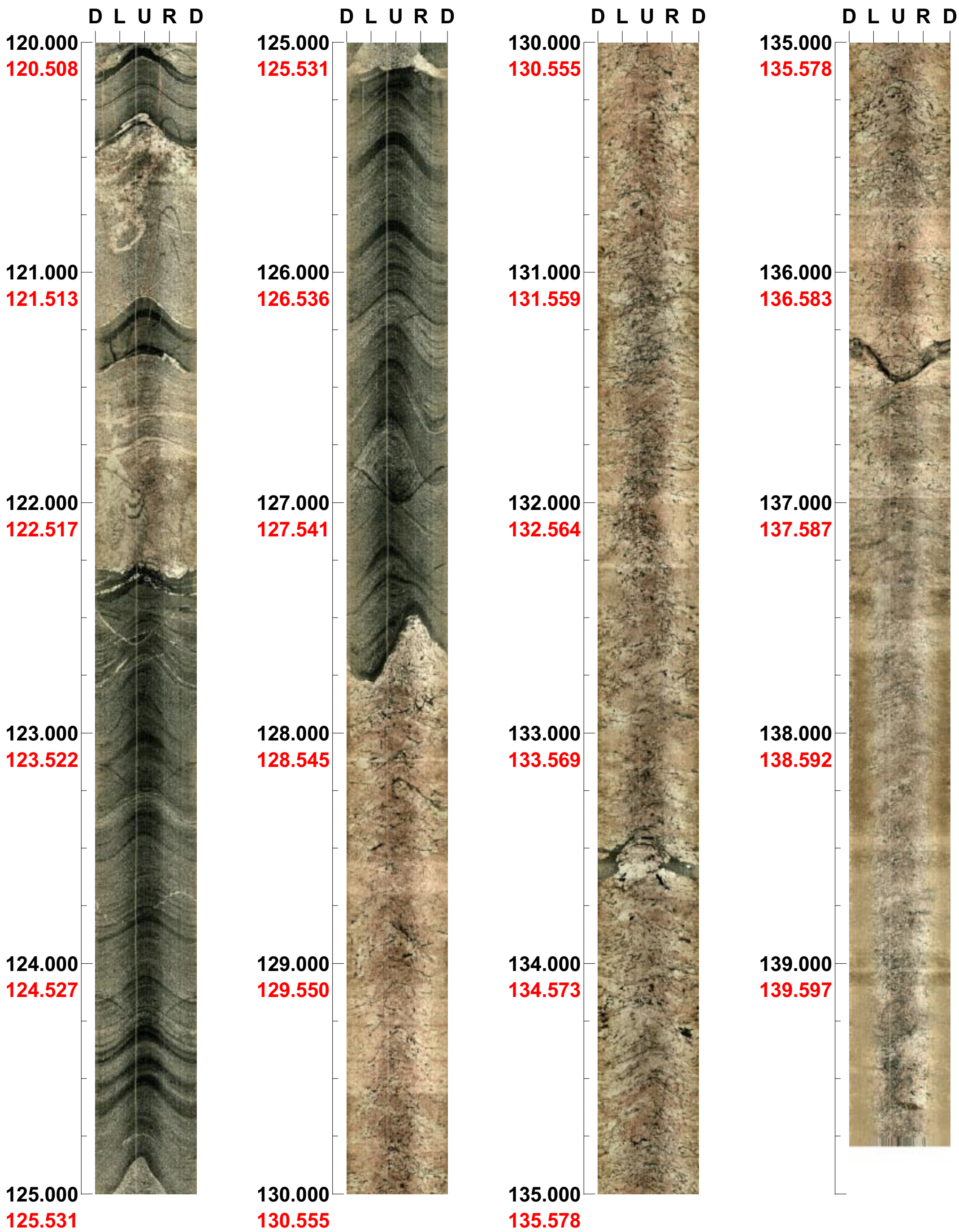


(6 / 7) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM33 **Azimuth: 272** **Inclination: -59**

Depth range: 120.000 - 139.790 m



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

Appendix 10

BIPS logging in HFM34. 11 to 195 m

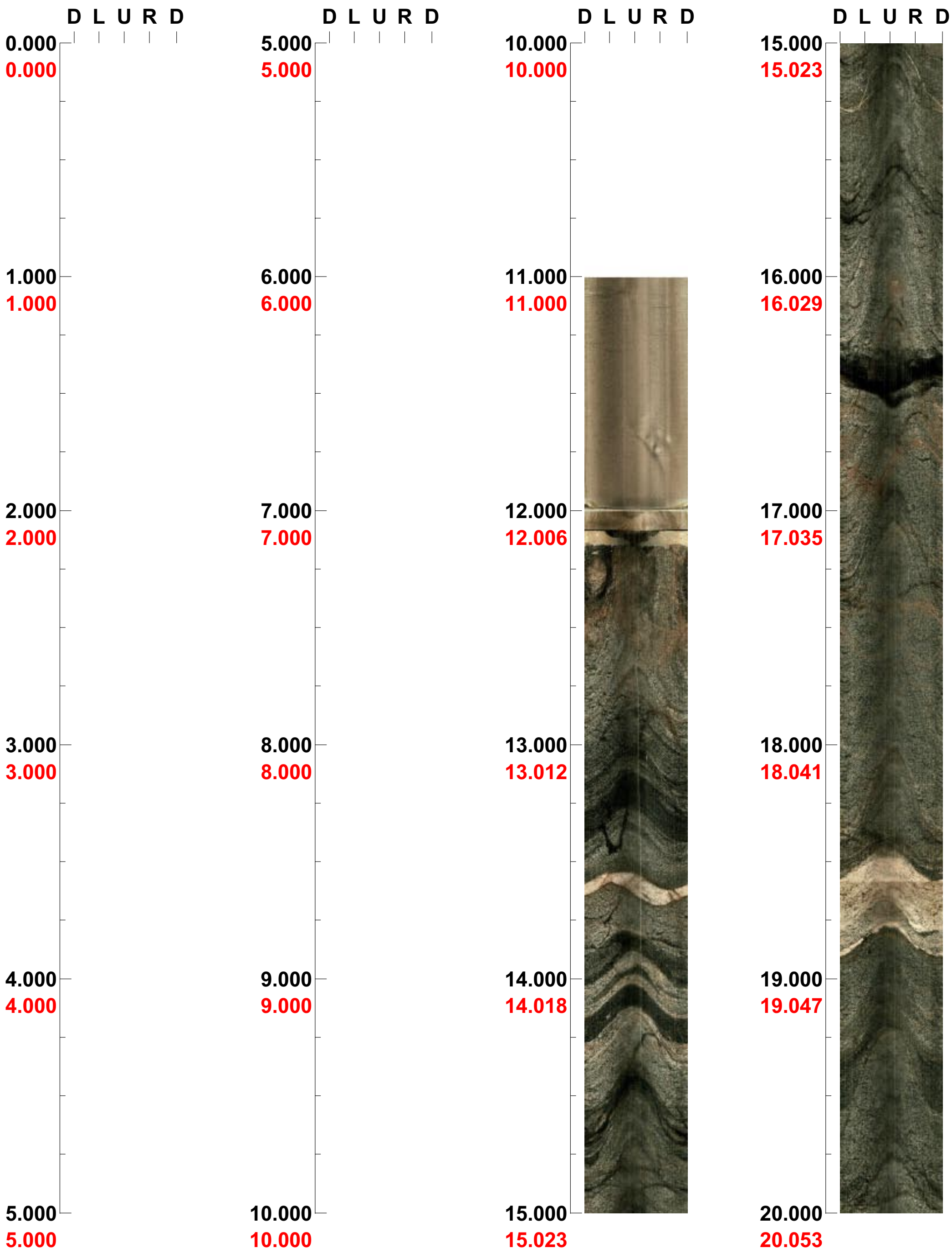
Project name: Forsmark

Image file	: c:\work\r5537f~1\bips\hfm34\hfm34_1.bip
BDT file	: c:\work\r5537f~1\bips\hfm34\hfm34_1.bdt
Locality	: FORSMARK
Bore hole number	: HFM34
Date	: 06/06/12
Time	: 10:37:00
Depth range	: 11.000 - 194.988 m
Azimuth	: 39
Inclination	: -59
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	: 11
Color	: +0 +0 +0

Project name: Forsmark

Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

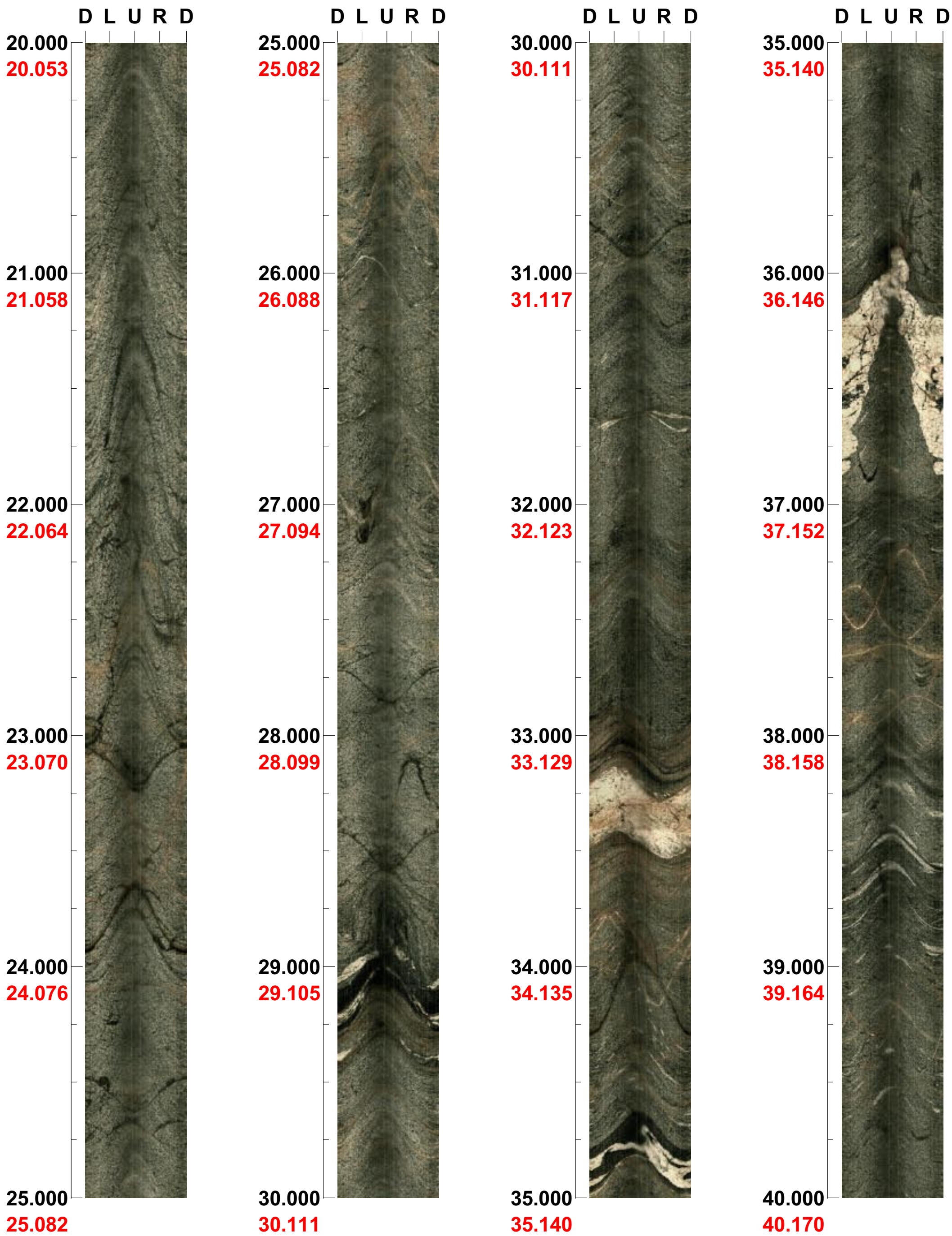
Depth range: 0.000 - 20.000 m



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

Project name: Forsmark
Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

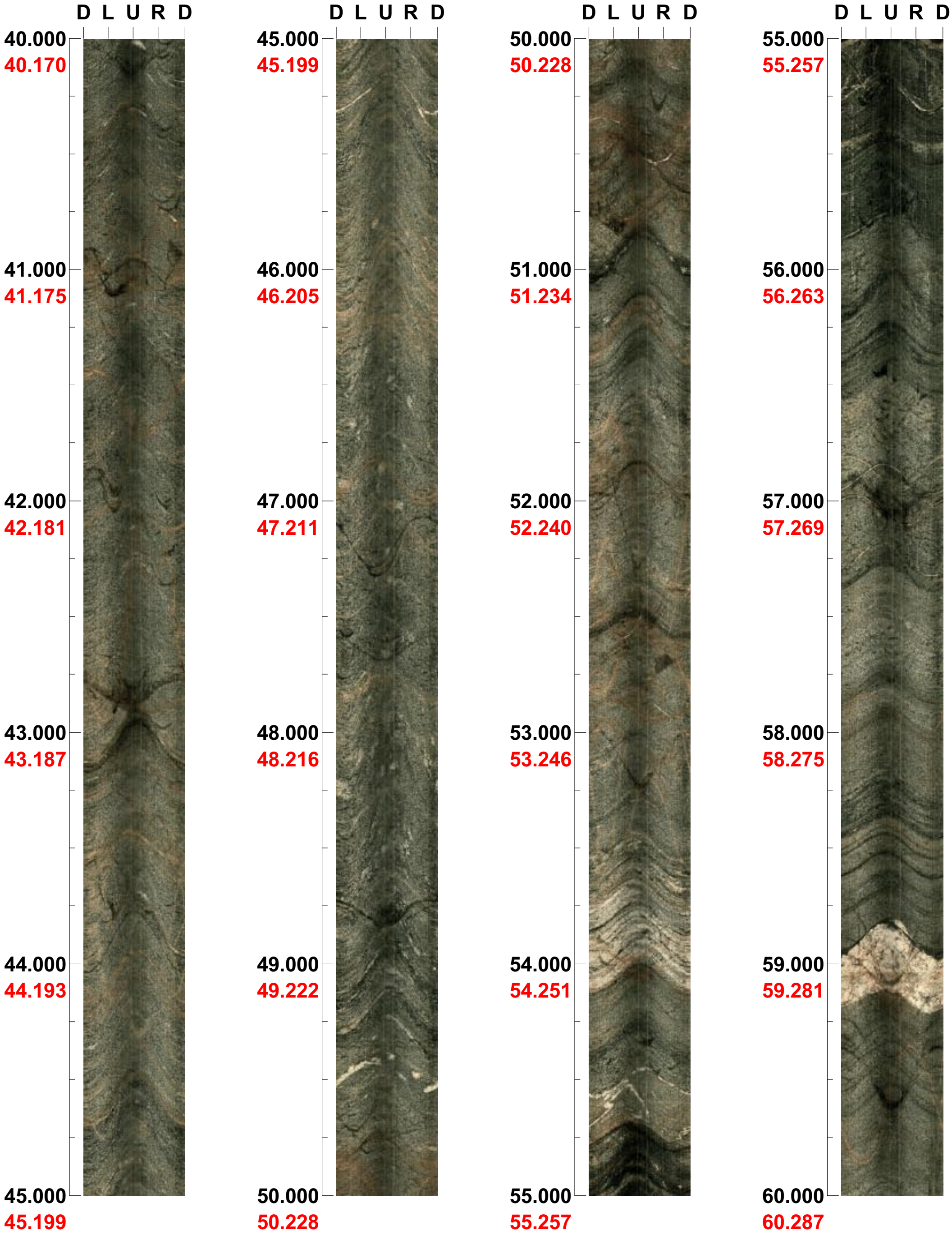
Depth range: 20.000 - 40.000 m



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

Project name: Forsmark
Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

Depth range: 40.000 - 60.000 m

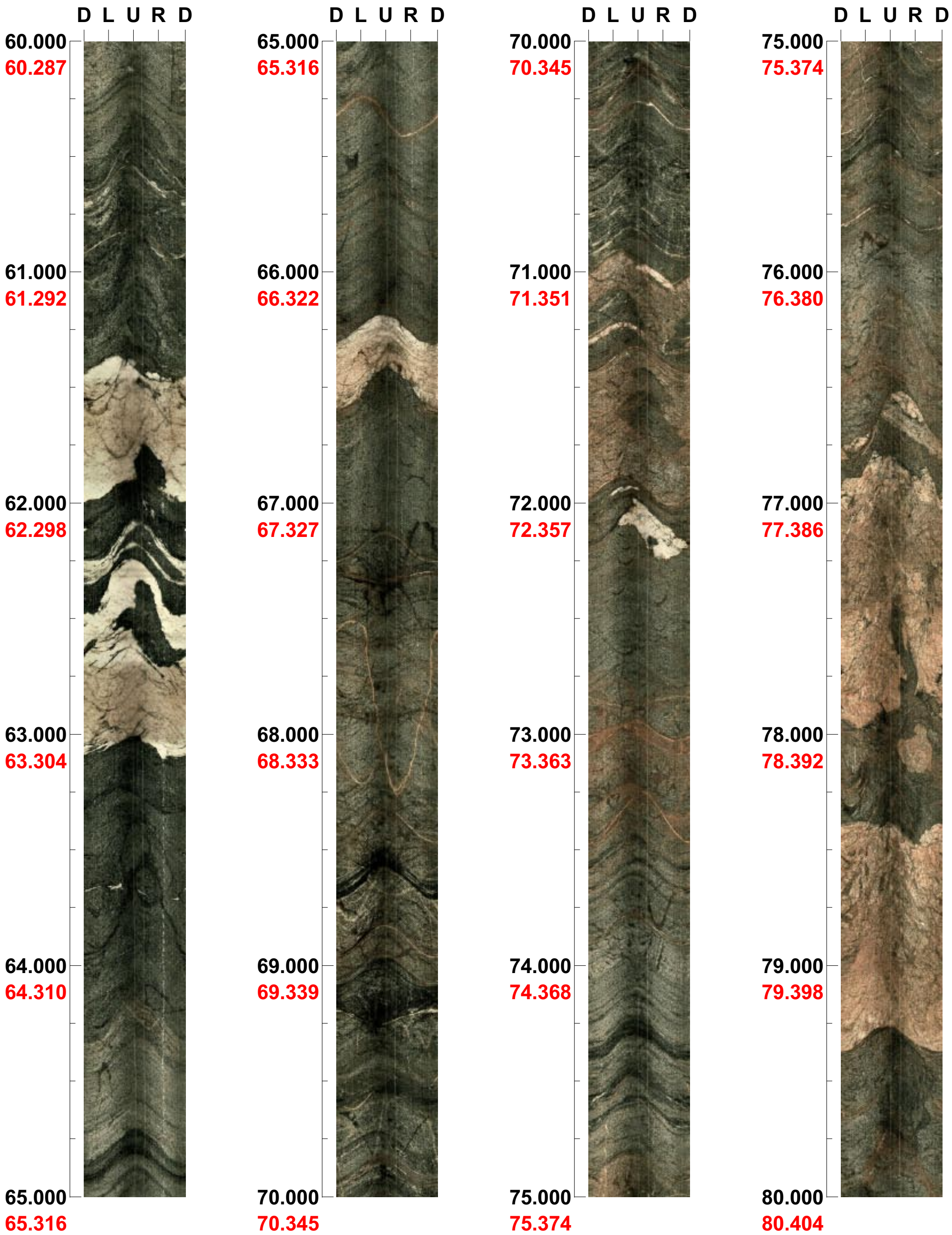


(3 / 5) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

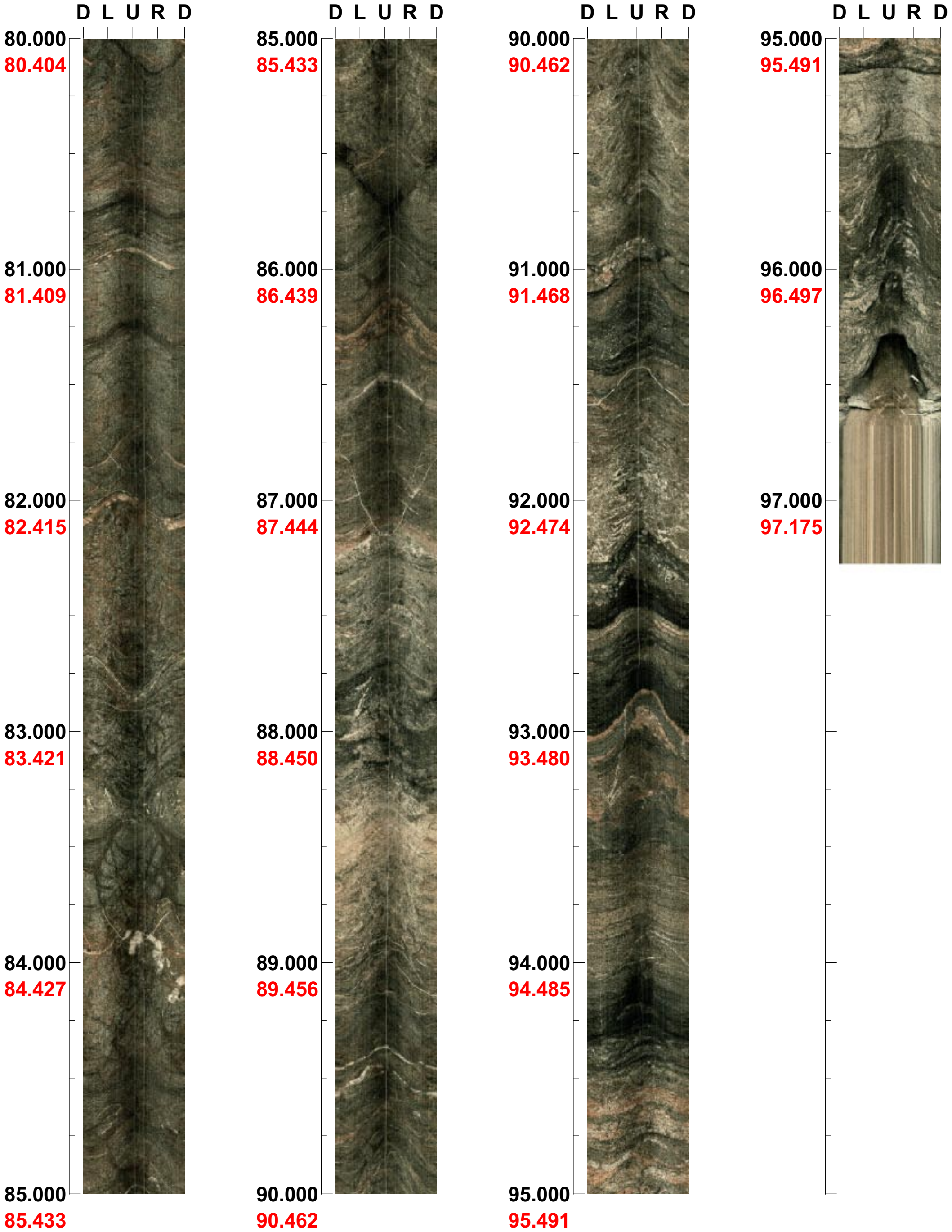
Depth range: 60.000 - 80.000 m



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

Project name: Forsmark
Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

Depth range: 80.000 - 97.270 m

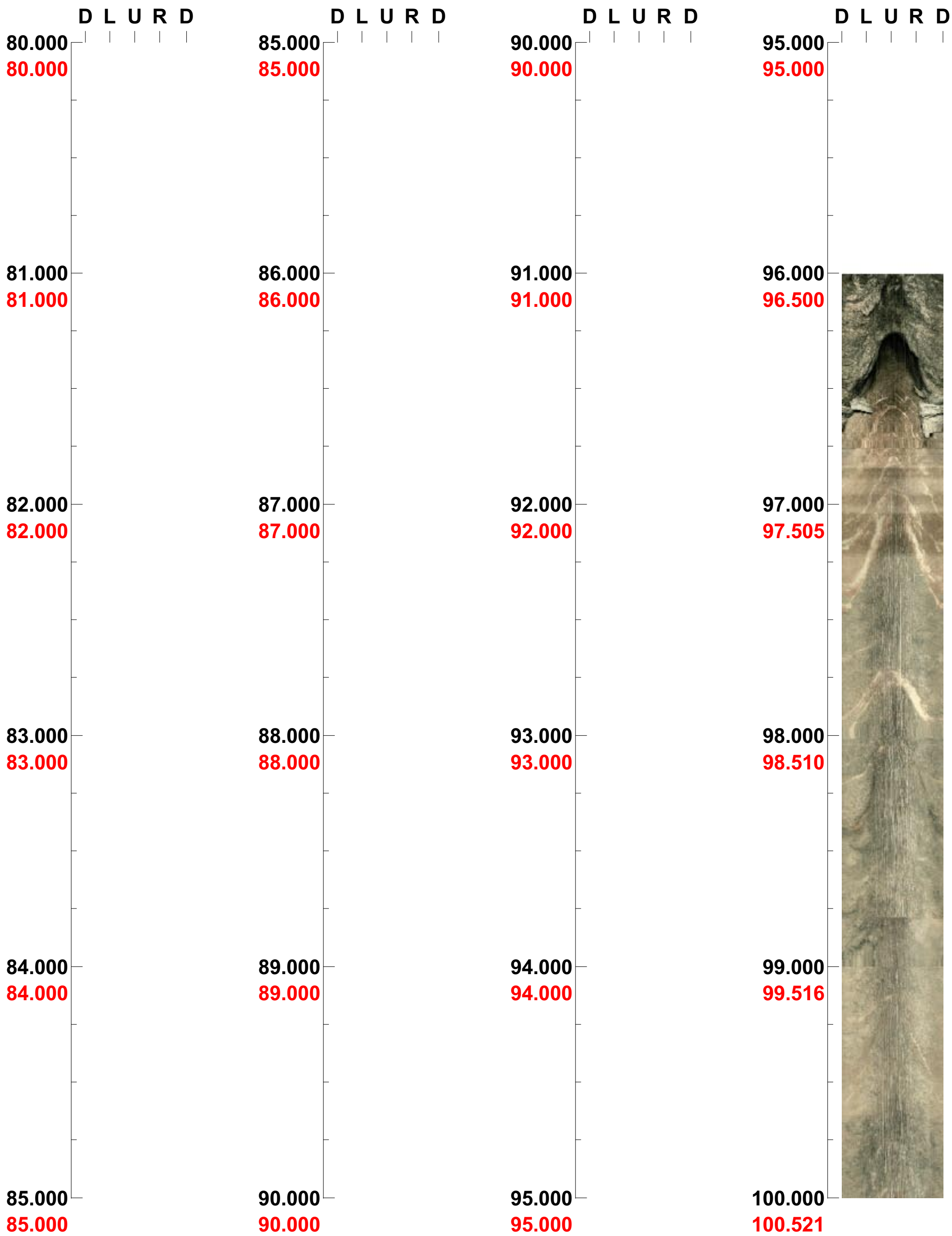


(5 / 5) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

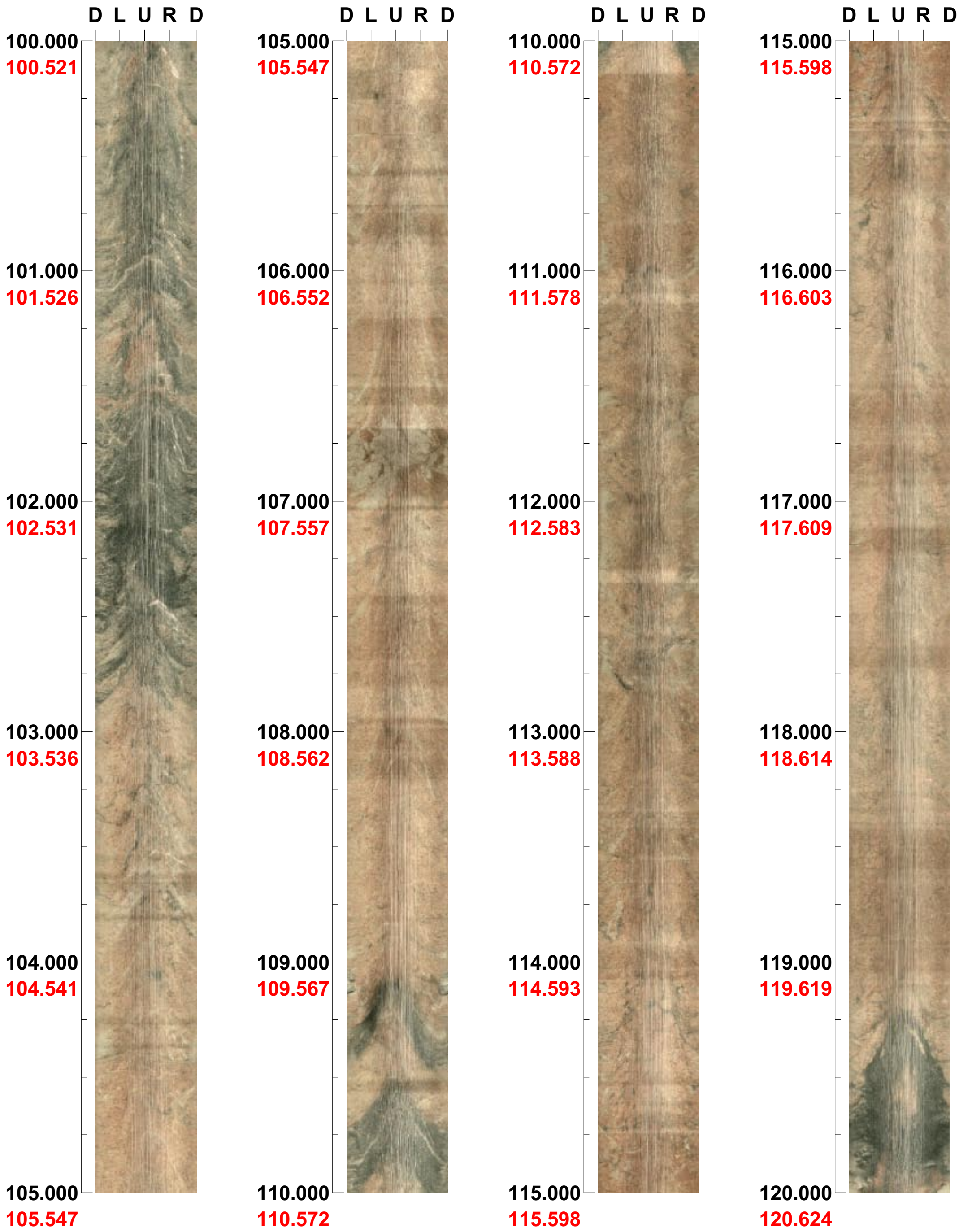
Depth range: 80.000 - 100.000 m



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

Project name: Forsmark
Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

Depth range: 100.000 - 120.000 m

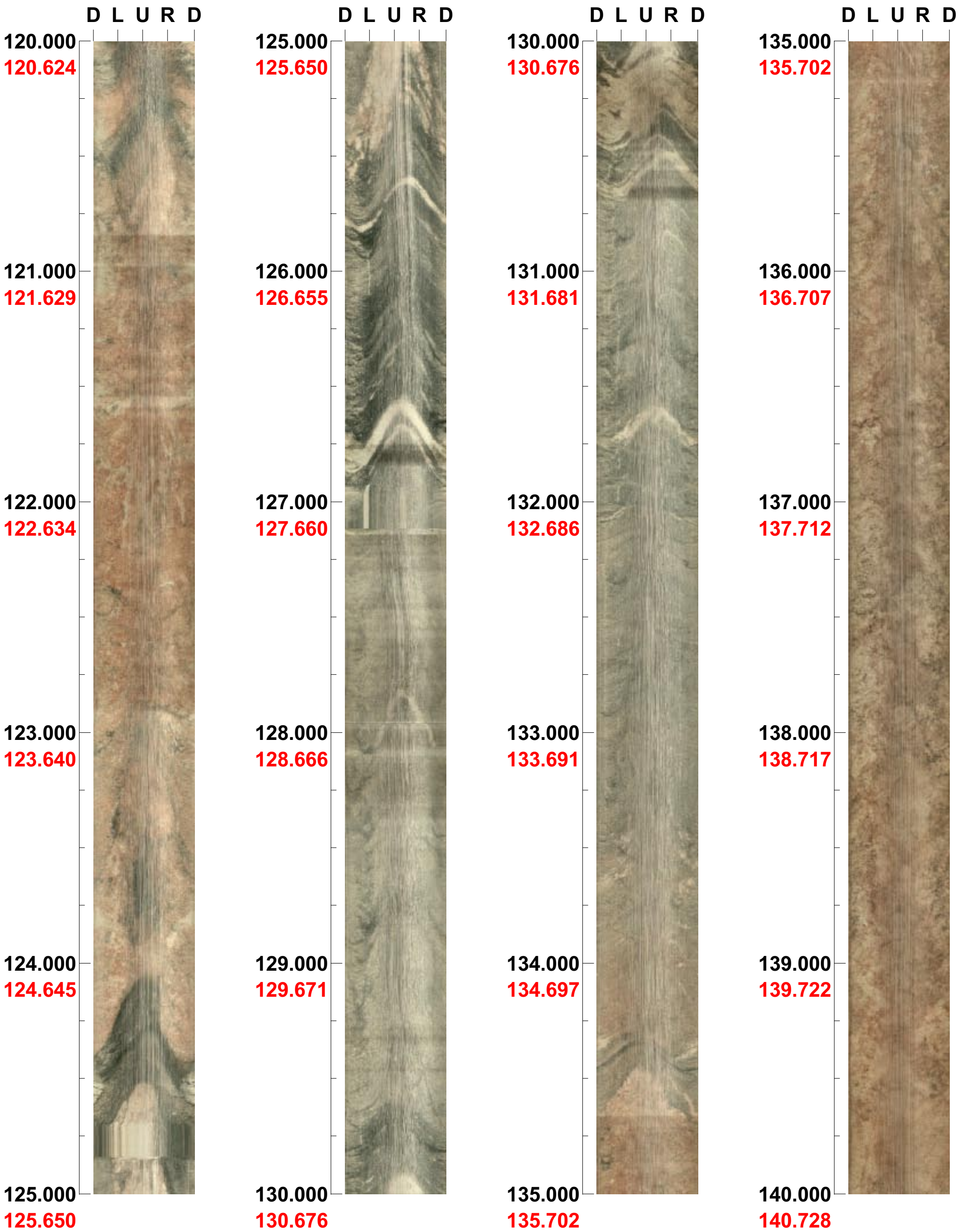


(2 / 6) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

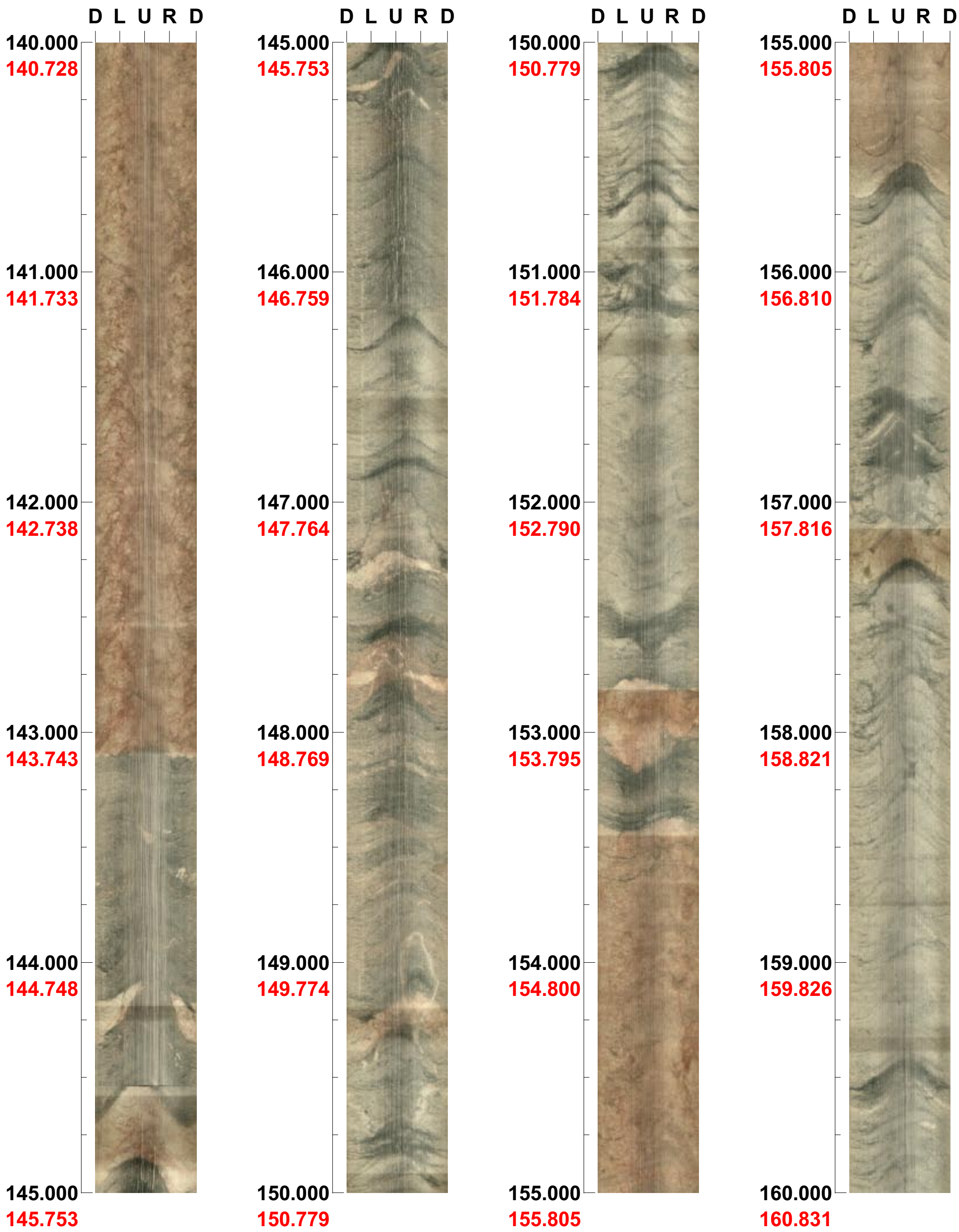
Depth range: 120.000 - 140.000 m



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

Project name: Forsmark
Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

Depth range: 140.000 - 160.000 m

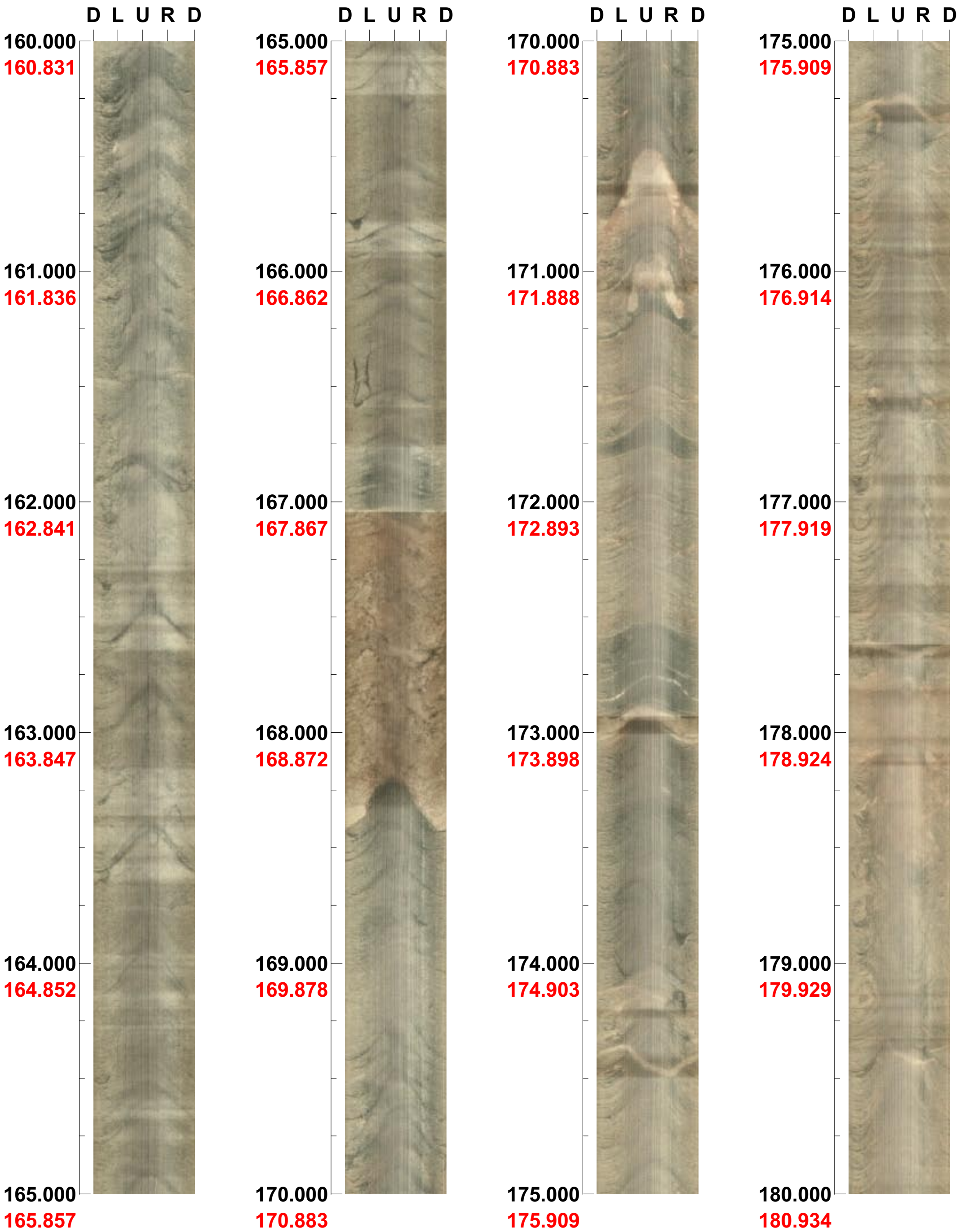


(4 / 6) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

Depth range: 160.000 - 180.000 m

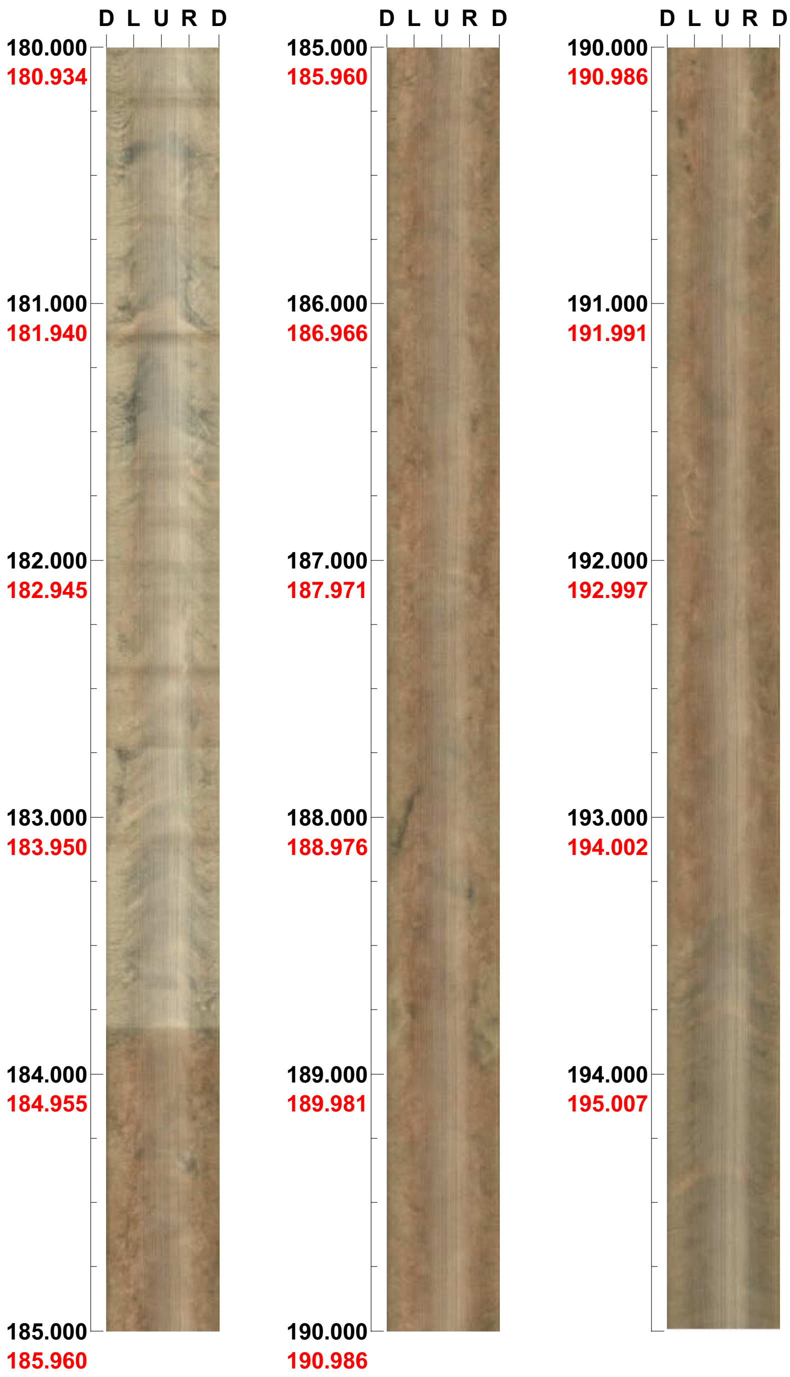


(5 / 6) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM34 **Azimuth: 39** **Inclination: -59**

Depth range: 180.000 - 194.988 m



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