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Forsmark site investigation

RAMAC and BIPS logging in boreholes KFM07B, KFM09A, HFM25 and HFM28

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February 2006

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Keywords: BIPS, RAMAC, Radar, TV, Forsmark, AP PF 400-05-067.

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 boreholes KFM07B and KFM09A and in the percussion-drilled boreholes HFM25 and HFM28. All measurements were conducted by Malå Geoscience AB/RAYCON during November 2005, except the BIPS logging in HFM28 which were performed in January 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 survey, the result is presented as images. Radar data is presented in radargrams and the identified reflectors are listed.

The borehole radar data quality from KFM07B, KFM09A, HFM25 and HFM28 was relatively satisfying, but in some parts of 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: in KFM07B 87 reflectors were identified of which 13 were orientated (dip/strike) and in KFM09A 304 reflectors were identified of which 39 were orientated. 51 reflectors were identified in HFM25 and 39 reflectors in HFM28.

The BIPS images from KFM07B and KFM09A show medium quality. It is the typical discolouring effects induced from the drilling in the core-drilled boreholes that causes the main quality problems but also mud covering the lower most parts of the borehole wall make the geological mapping more difficult. In HFM25 the water quality was very good but in HFM28 we needed to perform a new measurement in January to get acceptable images.

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Forsmark. Mätningarna som presenteras här omfattar BIPS-loggning och borrhålsradarmätningar (RAMAC) i KFM07B, KFM09A, HFM25 och HFM28. Alla mätningar är utförda av Malå Geoscience AB/RAYCON under november 2005 förutom omloggningen av BIPS i HFM28 som utfördes januari 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 loggningen presenteras data i form av plottar längs med borrhålet. Radardata presenteras i radargram och en lista över tolkade radarreflektorer ges.

Borrhålsradardata från KFM07B, KFM09A, HFM25och HFM28 var relativt tillfredsställande, men 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 87 radarreflektorer identifierats i KFM07B, varav 13 orienterade. Motsvarande siffror för KFM09A är 304 och 39. I HFM25 identifierades 51 strukturer och i HFM28 39 strukturer.

BIPS-bilderna från KFM07B och KFM09A är av medelkvalité. Det är främst svärtningarna som reducerar möjligheterna för karteringen men, också det faktum att finkornigt material som täcker borrhålens ligg-sida drar ner kvalitetsbetyget. Hammarborrhålen däremot uppvisar stora kvalitetsskillnader vid loggningen november 2005. Det var optimal bildkvalitet i HFM25 men i HFM28 var vattenkvaliteten mycket dålig. En ny loggning genomfördes i januari 2006 efter kvävgasblåsning, och där vi också fick en betydande kvalitetsförbättring av bilderna.

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 boreholes KFM07B and KFM09A and in the percussion-drilled boreholes HFM25 and HFM28. The work was carried out in accordance with activity plan AP PF 400-04-067. 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 300 m in borehole KFM07B and from 0 to approximately 800 m in KFM09A. In KFM07B borehole radar logging was performed only from approximately 60 m borehole length. In HFM25 the loggings were performed to approximately 180 m depth and in HFM28 to approximately 145 m depth. The percussion-drilled boreholes have a diameter of approximately 135 to 140 mm and the core-drilled holes a diameter of 76–77 mm.

All measurements were conducted by Malå Geoscience AB/RAYCON during November 2005 except for the BIPS-logging of KFM07B from 0 to 65 m performed in June 2005 and the re-measurement with the BIPS in HFM28 performed in January 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 RADAR loggning i kärnborrhålen KFM09B (0–800 m) och KFM07B (0–300 m) samt hammarborrhålen HFM25 och HFM28	AP PF 400-05-067	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

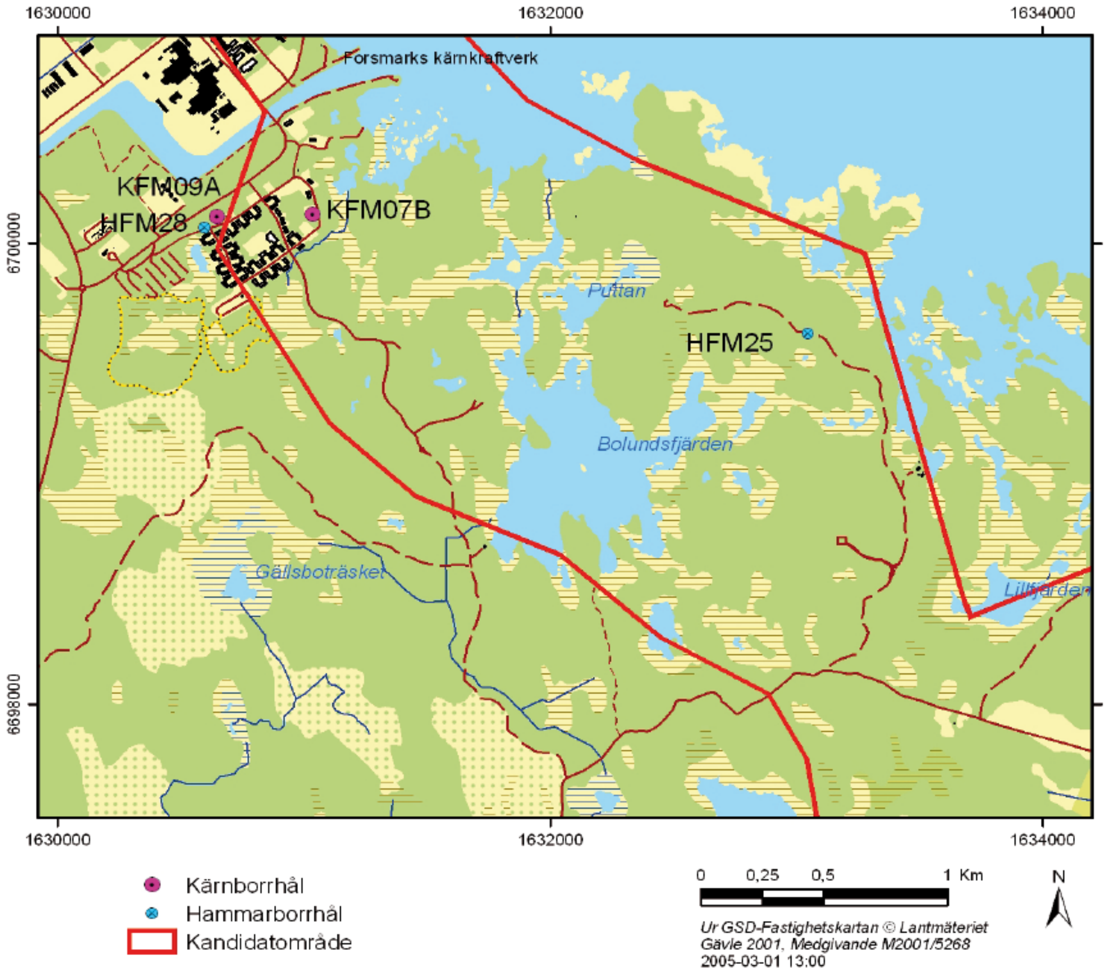


Figure 1-1. *General overview over the Forsmark area showing the location of the boreholes surveyed and presented in this report.*

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 survey, the result is presented as images. Radar data is 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.

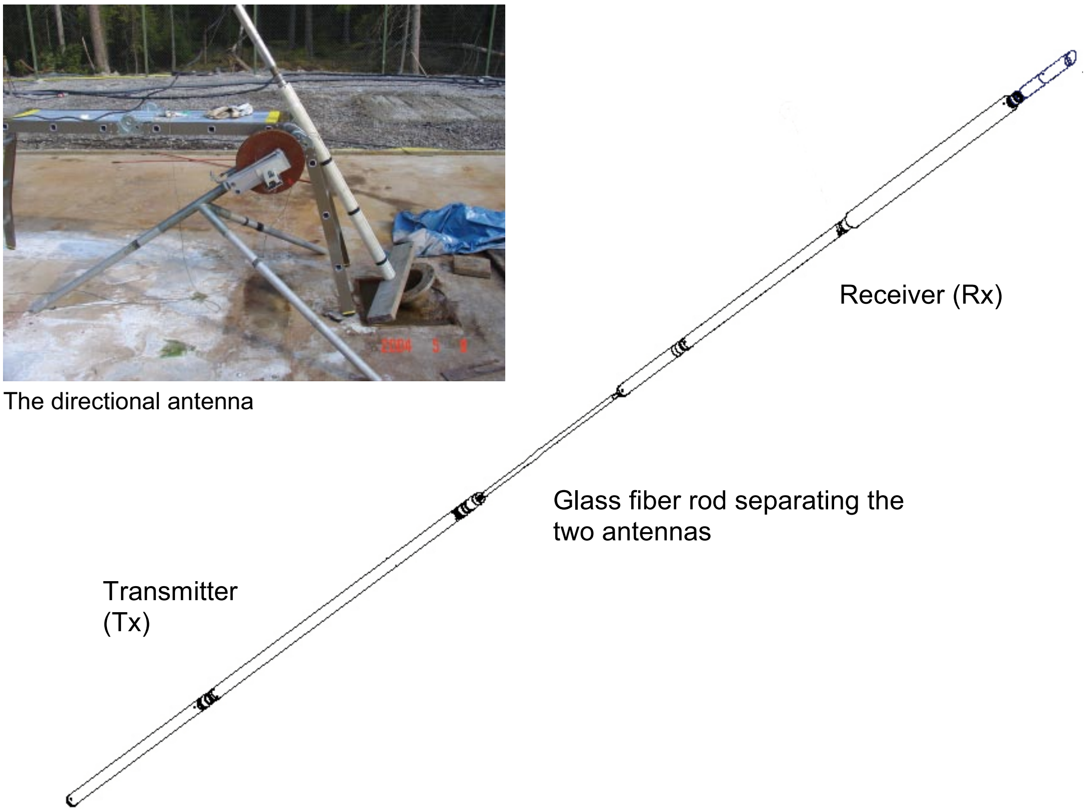


Figure 3-1. *Example of a borehole radar antenna.*

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.

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

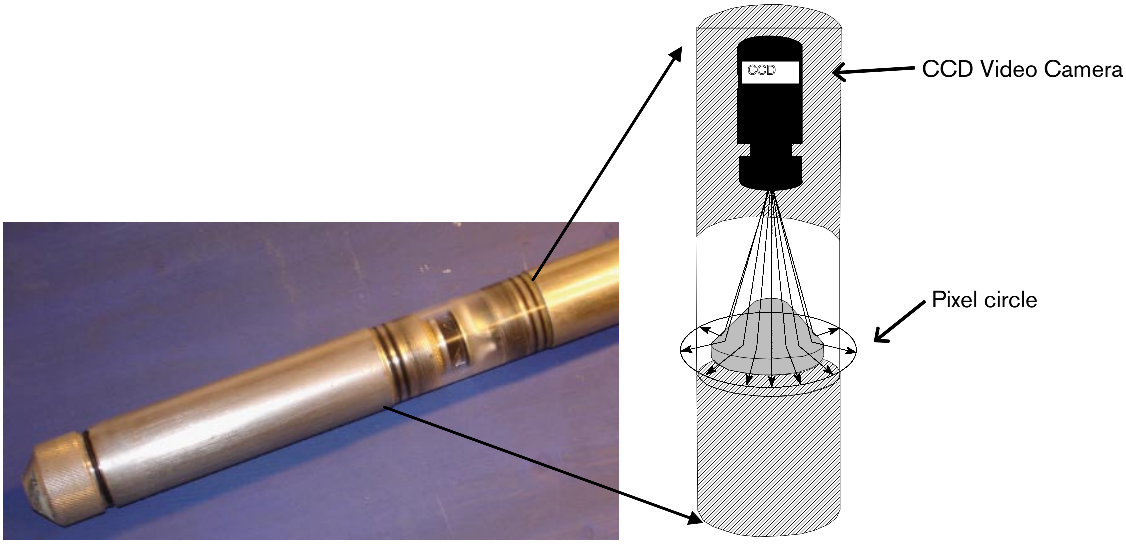


Figure 3-2. *The BIP-system. To the right a sketch showing the principles of the conical mirror.*

4 Execution

4.1 General

4.1.1 RAMAC Radar

The measurements in KFM07B, KFM09A, HFM25 and HFM28 were carried out with dipole radar antennas, with frequencies of 250, 100 and 20 MHz. In KFM07B and KFM09A 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 4-4. 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 KFM09A. 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 3°. This can be considered to be very good, considering the disturbed environment with metallic objects etc at the test site.

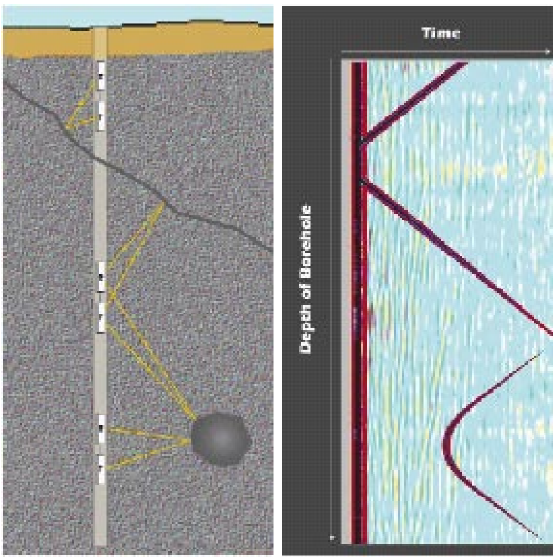


Figure 4-1. *The principle of radar borehole reflection survey (left) and an example of result (right).*

For more information on system settings used in the investigation of KFM07B, KFM09A, HFM25 and HFM28, see Tables 4-1 to 4-4 below.

Table 4-1. Radar logging information from KFM07B.

Site:	**Forsmark**	**Logging company:**	**RAYCON**		
BH:	**KFM07B**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Logging date:	05-11-07	05-11-07	05-11-07	05-11-07
	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	–0.34	–0.35	–1.42
	Logging from (m):	68.4	61.5	62.6	66.25
	Logging to (m):	291.4	297.2	296.7	288.1
	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 KFM09A.

Site:	**Forsmark**	**Logging company:**	**RAYCON**		
BH:	**KFM09A**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Logging date:	05-11-04	05-11-05	05-11-05	05-11-05
	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	–0.34	–0.35	–1.42
	Logging from (m):	11.4	1.5	2.6	6.25
	Logging to (m):	793.4	795.5	795.6	790.5
	Trace interval (m):	0.5	0.1	0.2	0.25
	Antenna separation (m):	5.73	2.4	3.9	10.05

Table 4-3. Radar logging information from HFM25.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM25**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Logging date:	05-11-04	05-11-04	05-11-04
	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:	–0.34	–0.35	–1.42
	Logging from (m):	1.5	2.6	6.25
	Logging to (m):	185.9	184.7	180.65
	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 HFM28.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM28**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Logging date:	05-11-08	05-11-08	05-11-08
	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:	–0.34	–0.35	–1.42
	Logging from (m):	1.5	2.6	6.25
	Logging to (m):	146.7	146.9	141.65
	Trace interval (m):	0.1	0.2	0.25
	Antenna separation (m):	2.4	3.9	10.05

4.1.2 BIPS

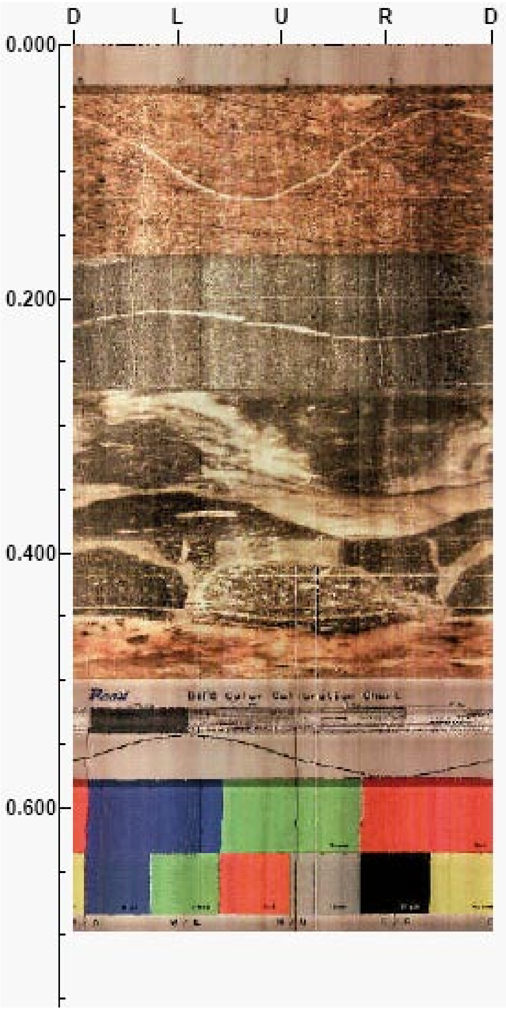
All measurements were performed in accordance with the instructions and guidelines from SKB (internal document MD 222.006). All cleaning of the probe and cable was performed according to the internal document SKB MD 600.004 before the logging operation.

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.

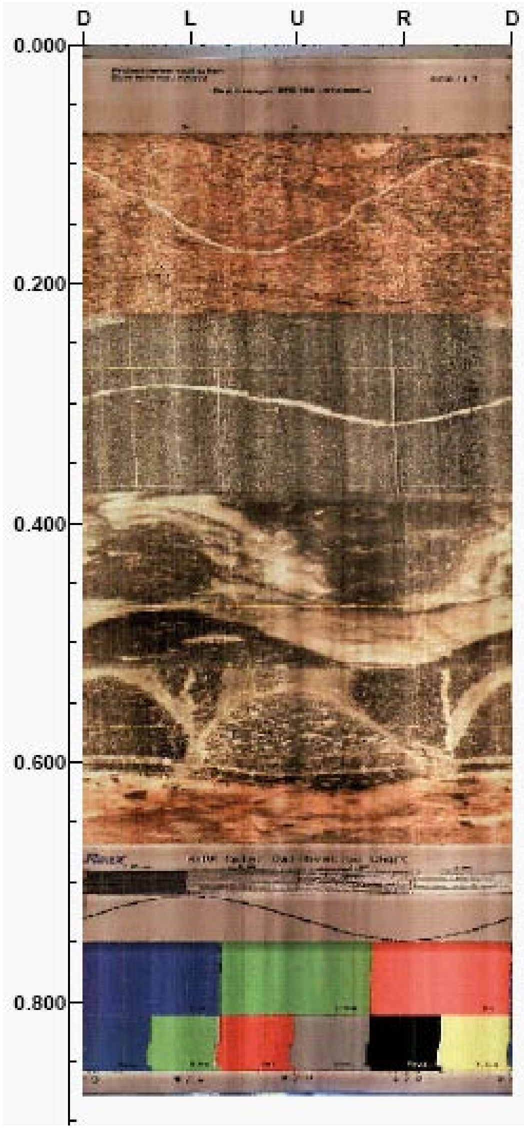
A gravity sensor was used to measure the orientation of the images in the boreholes KFM07B, KFM09A, HFM25 and HFM28.

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 corresponds to the test logging performed before and after the logging campaign in November. 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 5 to 9 in this report.



Before logging in HFM25



After logging in HFM28

Figure 4-2. *Results from logging in the test pipe before and after the logging campaign in November 2005. The length scales are not essential in the test measurements.*

4.1.3 Length measurements

During logging the depth 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 bore-hole wall is visible on the image, the position where the depth 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 depth 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. The non-adjusted length is marked with black as seen in Appendices 5 to 9. The tape marks on the logging cable are then used for controlling the RAMAC measurement.

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 depth divergence is less than 100 cm in the deepest parts of a 1,000 m deep borehole.

The depth divergence is taken into account in the resulting tables in Chapter 5.

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 grey 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 4-3 and the calculation shows a velocity of 128 m/μs (metres per microsecond) /1/. The velocity measurement was performed with the 100 MHz antenna.

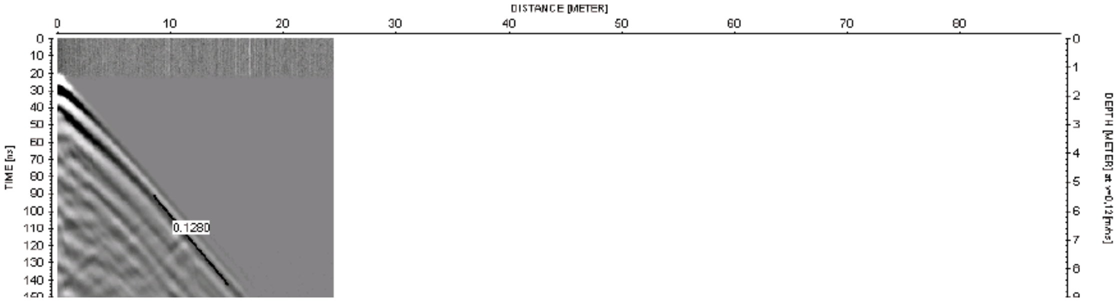


Figure 4-3. *Results from velocity measurements in HFM03.*

The visualization of data in Appendices 1 to 4 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 4 are given in Tables 4-5 to 4-8. 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 5-5 to 5-8 and are also visible on the radargrams in Appendices 1 to 4.

Table 4-5. Processing steps for borehole radar data from KFM07B.

Site:	**Forsmark**	**Logging company:**	**RAYCON**		
BH:	**KFM07B**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
Processing:		Move start time (–59 samples)	Move start time (–23.2)	Move start time (–42.4)	Move start time (–94)
		DC shift (440–510)	DC shift (190–230)	DC shift (470–530)	DC shift (1,800–2,000)
		Time gain (start 96 lin 100 exp 5)	Gain (Start 18 lin 1.2 exp 1.2)	Gain (Start 58 lin 1.7 exp 0.8)	Gain (Start 94 lin 1.4 exp 0.3)
		(FIR)			

Table 4-6. Processing steps for borehole radar data from KFM09A.

Site:	**Forsmark**	**Logging company:**	**RAYCON**		
BH:	**KFM09A**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
Processing:		Move start time (–53 samples)	Move start time (–21.4)	Move start time (–41.9)	Move start time (–90.6)
		DC shift (440–510)	DC shift (190–230)	DC shift (470–530)	DC shift (1,800–2,000)
		Time gain (start 95 lin 150 exp 5)	Gain (Start 29 lin 1.7 exp 0.5)	Gain (Start 63 lin 1.4 exp 0.6)	Gain (Start 120 lin 2.1 exp 0.2)
		(FIR)			

Table 4-7. Processing steps for borehole radar data from HFM25.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM25**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Processing:		Move start time (–21.2)	Move start time (–47)	Move start time (–95)
		DC shift (190–230)	DC shift (470–530)	DC shift (1,800–2,000)
		Gain (Start 18 lin 2.1 exp 0.8)	Gain (Start 44 lin 1.7 exp 0.6)	Contrast

Table 4-8. Processing steps for borehole radar data from HFM28.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM28**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Processing:		Move start time (–23.4)	Move start time (–46)	Move start time (–95)
		DC shift (190–230)	DC shift (470–530)	DC shift (1,800–2,000)
		Gain (Start 32 lin 0.6 exp 1.4)	Gain (Start 68 lin 1 exp 0.8)	Gain (Start 120 lin 1 exp 0.3)

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

No non-conformities occurred during the logging campaign of KFM07B, KFM09A, HFM25 and HFM28.

5 Results

The results from the BIPS measurements in KFM07B, KFM09A, HFM25 and HFM28 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 KFM07B, KFM09A, HFM25 and HFM28 was 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 5-13. Radar data are also visualized in Appendices 1 to 4. It should be remembered that the images in Appendices 1 to 4 is only a composite picture of all events 360° 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 four different boreholes are given in Figure 5-1 below. A number of minor structures also exist, indicated in Appendices 1 to 4. 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 (see Figure 5-2). Larger structures parallel to the borehole, if present, are also indicated in Appendices 1 to 4. It should also be pointed out that reflections interpreted will always get an intersection point with the borehole, but being located further away. They may in some cases not reach the borehole.

Although the boreholes KFM09A and HFM28 are located close to each other, they cannot be identified as radar reflectors. Another nearby borehole (KFM09B) was drilled after the radar logging of KFM09A and HFM28.

The data quality from KFM07B, KFM09A, HFM25 and HFM28, (as seen in Appendices 1 to 4) is satisfying to very good (especially in the core-drilled boreholes), but in parts of lower quality due to more conductive conditions. This is seen in all boreholes. 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 possibly structures in the rock which otherwise could give a reflection.

This effect is also seen in the directional antenna for KFM07B and KFM09A, which makes it more difficult to interpret the direction to the identified structures.

As also seen in Appendices 1 to 4 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 5-4 below the distribution of identified structures along the boreholes are listed for KFM07B, KFM09A, HFM25 and HFM28.

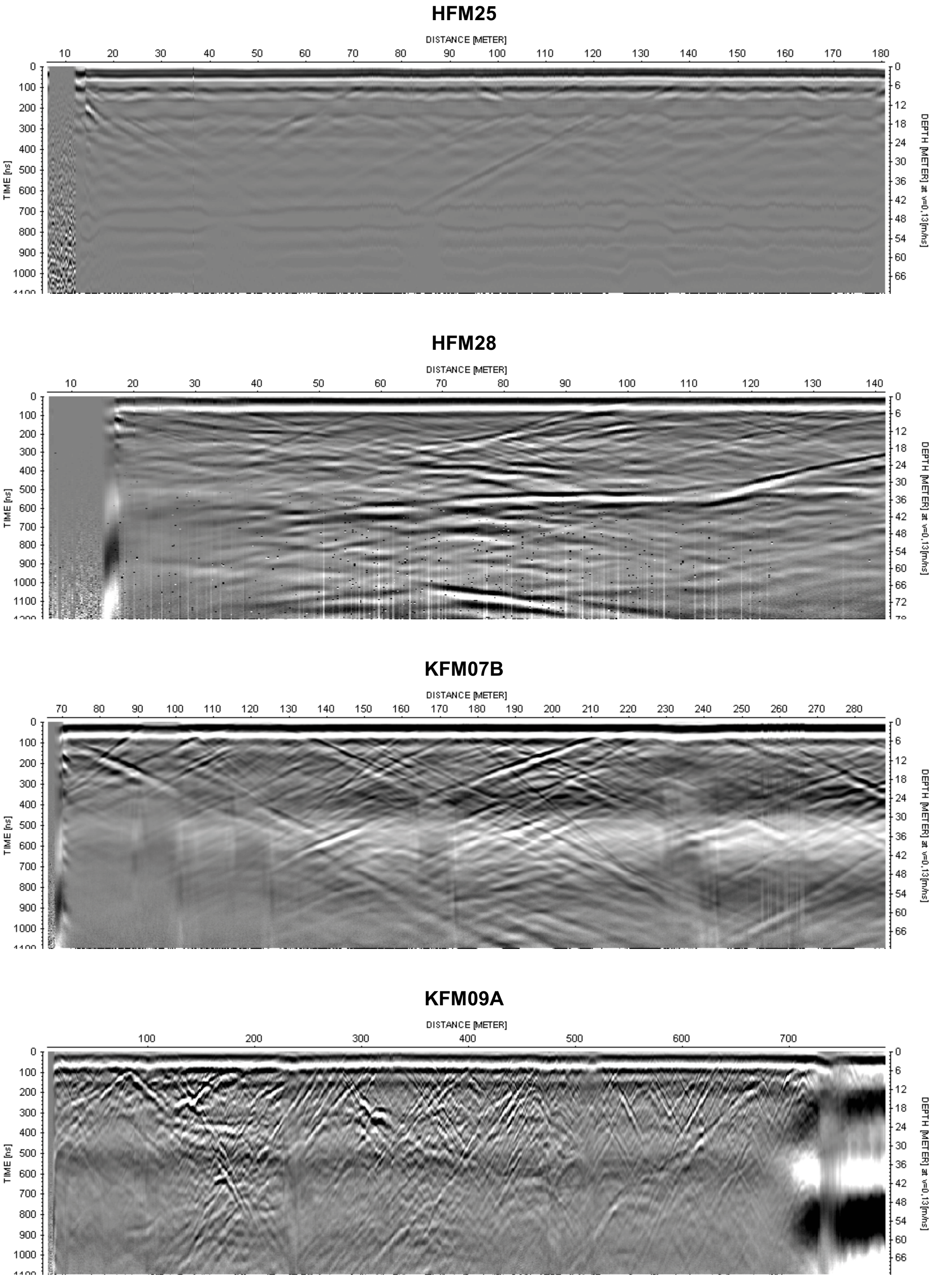


Figure 5-1. *An overview (20 MHz data) of the radar data for the different boreholes; HFM25, HFM28, KFM07B and KFM09A. Observe that the length (x-scale) and depth (y-scale) differs between the different boreholes. In the data from KFM09A the effect of a low conductivity (most probably in the water) is clearly seen at 720 m, as a decreased depth penetration and increased ringing.*

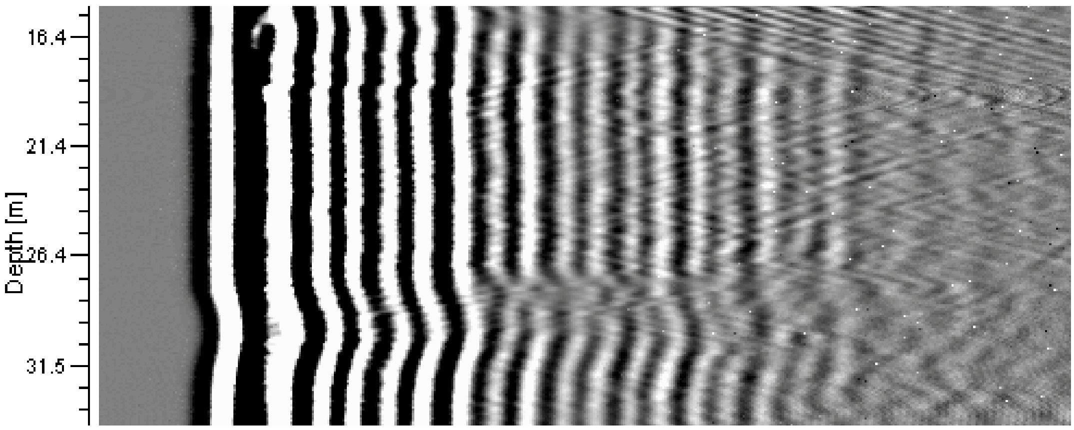


Figure 5-2. Example of data from HFM28 (250 MHz) where a number of structures are seen but lying so close to each other, that one can not be distinguished from the other. The effect of ringing is also seen, due to a large borehole diameter.

Table 5-1. Identified structures as a function of borehole intersection length in KFM07B.

Length (m)	No of structures
–100	18
100–150	16
150–200	19
200–250	13
250–300	13
300–350	6
350–400	2

Table 5-2. Identified structures as a function of borehole intersection length in KFM09A.

Length (m)	No of structures
–100	32
100–150	24
150–200	20
200–250	15
250–300	25
300–350	28
350–400	20
400–450	30
450–500	27
500–550	14
550–600	17
600–650	21
650–700	14
700–750	9
750–800	8

Table 5-3. Identified structures as a function of borehole intersection length in HFM25.

Length (m)	No of structures
–0	–
0–20	4
20–40	1
40–60	9
60–80	5
80–100	5
100–120	8
120–140	6
140–160	6
160–180	4
180–200	1
200–220	2

Table 5-4. Identified structures as a function of borehole intersection length in HFM28.

Length (m)	No of structures
–0	3
0–20	1
20–40	3
40–60	5
60–80	6
80–100	6
100–120	4
120–140	5
140–160	–
160–180	2
180–200	1
200–	3

Tables 5-5 to 5-8 summarises the interpretation of radar data from KFM07B, KFM09A, HFM25 and HFM28. In the tables the borehole length and intersection angle to the identified structures are listed.

For KFM07B and KFM09A the direction to the object is also given. As seen some radar reflectors in Tables 5-5 and 5-6 are marked with ±, which indicates an uncertainty in the interpretation of direction. The direction can in these cases be ± 180°. The direction to the object (the plane) is defined in Figure 5-3. 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° implies a dip to the east while a strike of 180° implies a dip to the west (right-hand rule). The strike is measured clockwise and can vary from 0 to 359°. The dip of the plane is the angle between the ground surface and the plane, and can vary from 0 to 90°.

Observe that the interpretation of an undulating structure can result in several different angles and different intersection depths. An example of this phenomenon is seen in Table 5-5 and Appendix 1: the reflectors named 36, 36x and 36xx most likely originates from the same geological structure.

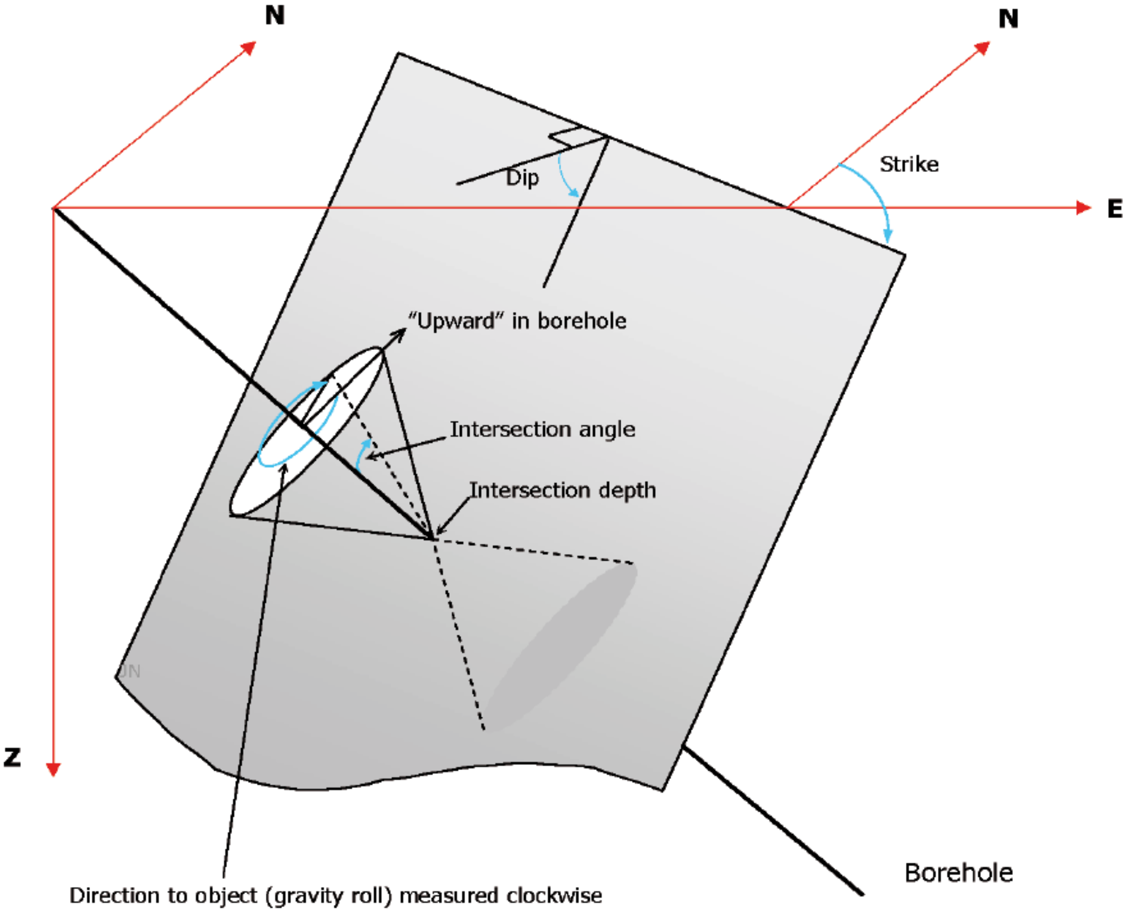


Figure 5-3. *Definition of direction to reflector as presented in Tables 5-5 and 5-6.*

Table 5-5. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, and the directional antenna 60 MHz in borehole KFM07B.

RADINTER MODEL INFORMATION
(Directional and Dipole antennas)

Site: Forsmark
Borehole name: KFM07B
Nominal velocity (m/µs): 128.0

Name	Intersection depth	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
2	51.8	39					
1	52.9	31	99 ±	61	295	71	153
3	54.7	75					
8x	55.8	18					
1x	58.9	36					
5	65.6	55					

RADINTER MODEL INFORMATION

(Directional and Dipole antennas)

Site:	**Forsmark**
Borehole name:	**KFM07B**
Nominal velocity (m/µs):	**128.0**

Name	**Intersection depth**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
4	66.8	69					
70	67.6	34					
8	70.9	36					
13	76.3	68					
12	77.7	68					
6	80.4	70					
7	90.5	55					
9	92.8	71					
10	96.1	74	9 ±	54	221	19	209
11x	97.5	25					
15	99.1	58					
16	99.6	50					
11	102.4	19					
18	106.0	73					
19	110.5	56					
20	110.7	28					
17	118.1	26					
14	120.1	33	333	90	195		
22	127.1	30	267	64	145		
21	127.2	72					
23	128.7	38					
24	133.3	32					
25	136.2	38	120 ±	44	305		
39	138.7	22					
38	144.8	21					
26	146.1	72	0 ±	54	217	19	217
28	148.2	44					
28x	149.5	43					
27	150.4	52					
68x	152.6	52					
35	155.1	65					
68	162.3	33					
31x	162.6	27					
30	163.3	26					
71	165.2	35					
29	169.0	74	0 ±	52	217	19	217
69	171.7	39	354 ±	87	212	16	20
31	175.4	51					
32	178.4	66					
72	178.5	33					
34	185.8	41					

RADINTER MODEL INFORMATION							
(Directional and Dipole antennas)							
Site:	**Forsmark**						
Borehole name:	**KFM07B**						
Nominal velocity (m/μs):	**128.0**						

Name	Intersection depth	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
33	188.9	31	165	25	5		
36xx	197.1	35					
37	197.4	61					
36	198.2	30					
44	198.3	42					
43	199.3	16					
67	200.4	43					
36x	204.5	24					
41	206.4	34					
40	208.5	31	105 ±	58	300	75	157
42	231.7	24	285	79	153		
45	233.7	48					
42x	234.9	20					
60	234.7	29					
49	236.7	32					
46	238.4	35					
48	245.5	13					
53	247.0	47					
73	248.3	29					
54	250.9	10					
57	251.5	23					
58	253.5	24					
50	257.6	46					
56	258.0	24					
47	260.0	19					
52	261.4	41					
56x	264.0	30					
75	264.9	37					
74	275.7	26					
55	282.0	26	267 ±	68	141	71	289
59	286.9	44					
55x	287.1	22					
64	309.9	36					
62	313.2	19					
63	318.4	20					
65	326.7	23					
77	330.7	39					
76	349.8	45					
61	357.5	19	258 ±	68	129	82	287
66	367.6	14					

Table 5-6. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, and the directional antenna 60 MHz in borehole KFM09A.

RADINTER MODEL INFORMATION							
(Directional and dipole antennas)							
Site:	Forsmark						
Borehole name:	KFM09A						
Nominal velocity (m/μs):	128.0						
Name	**Intersection depth**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
270	–447.4	3					
284	–278.2	3	285	85	44		
46	–183.4	4					
268	–0.5	19					
1	9.4	55					
44	13.6	6					
4	17.8	62					
2	18.8	55	198	11	192		
3	20.0	57					
5	21.7	64					
9	25.7	57					
6	30.8	56					
7	38.0	54					
8	41.5	52					
10	49.1	73					
17	54.1	17					
11	54.3	66					
12	56.5	69					
13	60.8	54					
17x	61.5	21	63	85	356		
49	62.2	3	0	61	120		
14	62.7	46					
15	65.5	49	333 ±	67	283	17	43
18	75.4	59					
19	77.6	67					
20	79.7	22					
39	83.0	26	222 ±	44	180	89	336
26	93.0	49					
27	94.8	55					
21	97.1	12					
50	97.4	6					
22	97.5	48	27	70	318		
25	103.1	50					
23	106.5	50					
271	109.0	41					
28	109.2	58					
24	110.7	17	255	67	206		
29	110.9	54					
30	115.0	68					

RADINTER MODEL INFORMATION

(Directional and dipole antennas)

Site:	**Forsmark**
Borehole name:	**KFM09A**
Nominal velocity (m/μs):	**128.0**

Name	Intersection depth	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
43	117.5	39					
31	120.6	29					
34	121.2	54					
32	124.1	31					
33	125.3	58					
269	125.7	50					
45	127.5	52					
40	128.4	54					
37	132.7	47					
38	135.4	53					
36	136.7	51					
41	139.8	54					
47	141.8	50					
48	143.1	51					
50x	144.2	12					
42	144.8	46					
51	149.7	51					
61	150.7	42					
52	151.0	53					
272	155.9	51					
53	157.3	54					
56	163.3	55					
54	164.4	46					
55	166.7	50					
16	168.7	8	69	86	187		
57	170.9	52					
59	179.3	50					
60	186.0	50					
74	191.6	51					
73	191.6	57					
62	191.8	44					
58x	194.3	21					
63	195.3	32					
67	195.4	44					
64	196.1	47					
65	197.4	48					
66	199.3	45					
35	201.3	8	75	89	192		
68	202.3	44					
72	205.0	57					
69	207.6	51	306 ±	64	264	31	19

RADINTER MODEL INFORMATION

(Directional and dipole antennas)

Site:	**Forsmark**
Borehole name:	**KFM09A**
Nominal velocity (m/µs):	**128.0**

Name	Intersection depth	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
75	210.2	50					
79	215.6	24					
58	219.7	12					
78	227.9	37					
279	230.0	49					
71	234.7	40					
76	235.8	53					
83	244.0	50					
70	246.8	8	s33	71	154		
77	246.9	22					
121	248.4	25					
86	252.7	28					
85	255.7	40					
87	257.6	52					
81	261.2	16					
90	265.8	40	186	16	139		
98	268.0	34					
88	268.7	28					
85x	269.4	22					
89	269.9	34					
91	273.9	30	255	57	219		
92	274.0	33					
94	277.5	35					
84	277.8	32	231	44	195		
99	278.1	62					
93	279.4	33					
95	284.0	44					
96	288.0	38					
114	289.9	24					
97	291.8	35					
80	293.2	7					
110	294.8	54					
265	295.6	40					
102	296.8	39					
101	298.3	37					
112	298.5	25					
100	301.7	27	246 ±	53	211	78	357
82	303.5	11	81	86	17		
104	303.7	39					
105	307.9	33					
103	311.2	28					

RADINTER MODEL INFORMATION							
(Directional and dipole antennas)							
Site:	Forsmark						
Borehole name:	KFM09A						
Nominal velocity (m/μs):	128.0						
Name	**Intersection depth**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
106	313.3	28					
111	314.1	45					
105x	314.4	21					
108	315.3	30	243	52	208		
107	316.6	29					
109	319.8	29	66	78	357		
113	321.2	27					
115	321.7	37					
118	322.2	68					
115x	323.8	28					
108x	324.7	23					
123	325.9	33					
108xx	328.4	18					
125	329.1	59					
116	329.8	35	72	70	358		
117	331.4	31					
129	334.9	31					
103x	337.9	16					
119x	338.5	36					
127	339.1	73					
120	342.2	42					
119	343.4	28					
128	347.9	51					
130	353.0	61					
131	354.0	52					
122	354.1	49					
147	362.4	39					
141	364.0	58					
124	367.3	39					
133	370.9	63					
132	376.3	67					
280	378.8	27					
134	380.9	28					
138	382.6	60					
281	385.4	31					
169	386.3	44					
136	387.3	33					
145	387.4	47					
135	388.5	24					
137	390.7	28	249 ±	55	215	77	1
137x	391.4	29					

RADINTER MODEL INFORMATION							
(Directional and dipole antennas)							
Site:	**Forsmark**						
Borehole name:	**KFM09A**						
Nominal velocity (m/μs):	**128.0**						
Name	**Intersection depth**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
139	394.9	48					
144	397.7	64					
153	403.7	60					
148	404.0	34					
149	406.3	34					
143	407.8	28					
142	408.1	26					
140	408.3	23					
150	410.4	31					
146x	410.9	26	255	61	218		
151	414.3	32					
154	416.0	72					
152	417.0	35					
140x	423.9	12					
155	420.5	37					
156	422.8	35					
146	425.6	20	219 ±	44	193	80	172
158	427.3	32					
160	428.0	34	204	26	186		
164	429.3	51					
163	430.1	62					
157	432.2	28					
159	432.3	33					
162	433.1	77					
161x	434.4	35					
167	434.9	61					
165	435.9	52					
161	440.1	29					
171	444.2	40					
168	446.3	35					
179	447.0	45					
170	448.4	33					
166	453.0	38	207	24	198		
173	455.7	34					
256	455.8	48					
273	455.9	24					
172	458.3	37					
173x	462.3	44					
176	464.7	54					
181	464.9	39					
174	466.1	31					

RADINTER MODEL INFORMATION							
(Directional and dipole antennas)							
Site:	**Forsmark**						
Borehole name:	**KFM09A**						
Nominal velocity (m/μs):	**128.0**						
Name	**Intersection depth**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
177	469.0	33					
257	471.5	50					
174	474.9	32					
182	477.3	61					
180	477.4	46					
178	477.7	33					
183	480.5	36					
275	480.2	29					
282	481.0	35					
184	485.1	43					
175	486.4	36					
185	490.2	38					
285	491.6	42	207	21	207		
186	492.6	50					
276	496.7	37					
258	497.6	57					
187	498.2	45					
189	499.9	44					
188	501.5	42	174 ±	11	111	86	310
190	501.8	33					
274	505.9	21					
193	506.7	45					
191	510.0	45					
259	511.0	36					
192	517.0	38					
195	518.3	47					
194	518.8	40					
263	526.5	55					
266	534.8	37					
260	539.7	48					
196	545.1	42	15	86	331		
197	549.6	42					
198	552.9	40	18 ±	88	333	16	199
261	555.5	44					
199	555.6	35	18	86	154		
262	557.1	46					
199x	558.0	40					
201	566.2	52					
216	566.7	50					
200	568.6	48					
202	571.3	71					

RADINTER MODEL INFORMATION							
(Directional and dipole antennas)							
Site:	**Forsmark**						
Borehole name:	**KFM09A**						
Nominal velocity (m/μs):	**128.0**						
Name	**Intersection depth**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
264	573.0	52					
203x	577.0	43					
203	578.2	40	204	19	209		
204	581.0	36					
205	582.7	35					
206	592.9	45					
211	595.2	37					
207	596.1	34					
208	602.6	41	183 ±	10	156	87	145
267	605.6	52					
210	607.9	48					
209	609.6	40	195 ±	14	199	90	154
218	609.9	45					
209x	610.5	36					
212	619.5	37					
213	619.6	53					
214	621.1	53					
215	623.9	37					
217	628.7	58	246 ±	39	271	61	357
219	631.3	58					
220	633.1	62					
228	635.7	51					
283	636.2	35					
221	639.1	35					
222	642.9	35					
223	644.5	40					
224	645.5	42					
225	645.6	54					
226	649.9	42					
227	655.0	42					
229	658.7	43					
231	660.7	47					
230	661.7	48					
232	662.1	51					
233	665.9	44	3	89	325		
234	670.2	44					
235	673.4	37					
237	677.5	42					
238x	679.3	48					
238	679.9	43	177 ±	3	107	90	325
239	690.3	49					

RADINTER MODEL INFORMATION							
(Directional and dipole antennas)							
Site:	Forsmark						
Borehole name:	KFM09A						
Nominal velocity (m/μs):	128.0						
Name	**Intersection depth**	**Intersection angle**	**RadInter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
240	696.9	47					
236	699.6	49					
241	700.0	46	177	2	62		
278	711.9	21					
242	711.9	57					
243	713.9	81					
244	722.2	47					
245	729.7	44					
246x	730.0	51	174	7	360		
246	731.6	45					
247	734.2	57					
248	752.0	61					
249	761.9	66					
250	768.9	47					
251	771.2	69					
252	774.0	49					
253	783.9	48	339 ±	84	313	14	44
255	790.9	49					
254	796.0	52					

Table 5-7. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz borehole HFM25.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:	Forsmark		
Borehole name:	HFM25		
Nominal velocity (m/μs):	128.00		
Object type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	1	2.8	73
PLANE	2	11.1	66
PLANE	4	15.4	40
PLANE	3	19.5	67
PLANE	5	27.7	42
PLANE	45	40.4	20
PLANE	6	43.2	42
PLANE	7	45.3	47
PLANE	6xx	49.3	25
PLANE	6x	49.8	29
PLANE	11	50.1	29
PLANE	10	50.7	85
PLANE	9	52.6	83

PLANE	8	54.2	45
PLANE	12	62.0	58
PLANE	14	64.7	48
PLANE	15	69.4	47
PLANE	13	74.9	48
PLANE	16	77.5	46
PLANE	17	83.7	53
PLANE	19	83.9	59
PLANE	18	85.0	51
PLANE	22	93.5	45
PLANE	20	96.1	45
PLANE	21	100.5	48
PLANE	23	102.1	55
PLANE	24	103.5	57
PLANE	26	105.7	52
PLANE	25	107.9	35
PLANE	28	111.1	69
PLANE	27	113.2	39
PLANE	29	119.6	38
PLANE	30	120.4	41
PLANE	31xx	128.2	31
PLANE	31x	130.0	33
PLANE	31	131.8	37
PLANE	32	134.1	63
PLANE	33	135.9	38
PLANE	34	144.1	66
PLANE	35	145.3	57
PLANE	36	148.4	47
PLANE	36x	149.7	53
PLANE	37	152.0	56
PLANE	38	153.2	58
PLANE	39	169.2	45
PLANE	40	170.8	64
PLANE	42	175.2	54
PLANE	41	175.4	72
PLANE	43	182.1	48
PLANE	44	201.9	32
PLANE	46	202.1	27

Table 5-8. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HFM28.

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

Site: Forsmark

Borehole name: HFM28

Nominal velocity (m/μs): 128.00

Object type	Name	Intersection depth	Intersection angle
PLANE	37	–183.9	7
PLANE	39	–157.8	19
PLANE	33	–36.6	12
PLANE	2	6.5	20
PLANE	1	23.8	78
PLANE	18	27.9	17
PLANE	3	30.4	72
PLANE	5	44.5	73
PLANE	6	47.5	45
PLANE	8	48.0	42
PLANE	35	48.8	63
PLANE	4	53.4	82
PLANE	14	61.1	63
PLANE	10	63.1	44
PLANE	7	64.1	84
PLANE	11	67.4	55
PLANE	9	69.0	63
PLANE	34	73.5	44
PLANE	12	81.4	53
PLANE	13	82.6	54
PLANE	19	90.3	56
PLANE	20x	97.9	41
PLANE	15	99.1	64
PLANE	20	99.6	53
PLANE	28	110.8	72
PLANE	27	111.1	62
PLANE	29	112.9	78
PLANE	26	116.2	48
PLANE	36	129.2	20
PLANE	23	132.0	49
PLANE	30	134.7	65
PLANE	31	136.8	56
PLANE	32	138.8	74
PLANE	21	160.7	27
PLANE	16	174.8	6
PLANE	24	199.0	25
PLANE	17	208.9	8
PLANE	22	281.4	6
PLANE	38	576.7	5

In Appendices 1 to 4, 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 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 given in Tables 5-9 to 5-12.

Table 5-9. Borehole length intervals in KFM07B with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
95–100	170
120	235–240
135	

Table 5-10. Borehole length intervals in KFM09A with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
15–20	305
30	320–330
55	420–425
90–100	470–485
100–105	490–495
125	500
215	510–520
225–235	630–635
240–250	730–755
275	760
290	785

Table 5-11. Borehole length intervals in HFM25 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
25–30	105
40–45	130–135
50–55	145
85	150–155

Table 5-12. Borehole length intervals in HFM28 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
15	105
30	120–125
35–40	135–140
55–65	

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 5-13 below.

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 a larger amplitude than a larger angle, and by that a more clear structure.

Table 5-13. Some important structures in KFM07B, KFM09A, HFM25 and HFM28.

Borehole	KFM07B	KFM09A	HFM25	HFM28
Structures	1, 1x, 10, 14, 25, 29, 30, 30x, 40, 42, 55, 55x, 56, 61, 65, 66, 67, 71 and 76	2, 16, 17x, 24, 35, 49, 70, 82, 91, 98, 103, 103x, 108, 108x, 117, 137, 137x, 146, 146x, 147, 152, 169, 192, 196, 197, 198, 199, 200, 203, 203x, 204, 207, 217, 223, 225, 229, 236, 238, 241, 242, 245, 270, 271, 273, 274, 275 and 278	6, 6x, 6xx, 18, 19, 31, 31x, 31xx, 36, 36x and 44	16, 17, 20, 21, 22, 24, 33, 37, 38 and 39

5.2 BIPS logging

The BIPS pictures are presented in Appendices 5 to 9.

To get the best possible depth 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 percussion drilled boreholes we use marks on the logging cable as references for the depth adjustment. These marks on the cable are calibrated against the visible marks in core-drilled boreholes. At present we have marks at 110, 150 and 200 m on the logging cable that are used for depth adjustments of the BIPS results in percussion drilled boreholes.

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 in this report.

Values for the inclination and azimuth of the boreholes, presented in this report, are only preliminary.

The BIPS logging in the core drilled boreholes resulted in the typical discolouring effects (caused by the drilling) on the borehole wall. This is seen especially in the bottom part of the boreholes where mud covers the lowermost part of the borehole wall. The images are of low quality and the geological mapping is problematic.

For the percussion drilled borehole the images from HFM25 was of perfect quality. In HFM28 the logging performed in November 2005 showed images of very bad quality. To improve the conditions in the borehole a nitrogen blowing were performed in December. That blowing, in combination with no activities in the borehole during several weeks, resulted in a second trial with the BIPS giving much better images. Figure 5-4 illustrates the improvement of the image quality in the borehole.

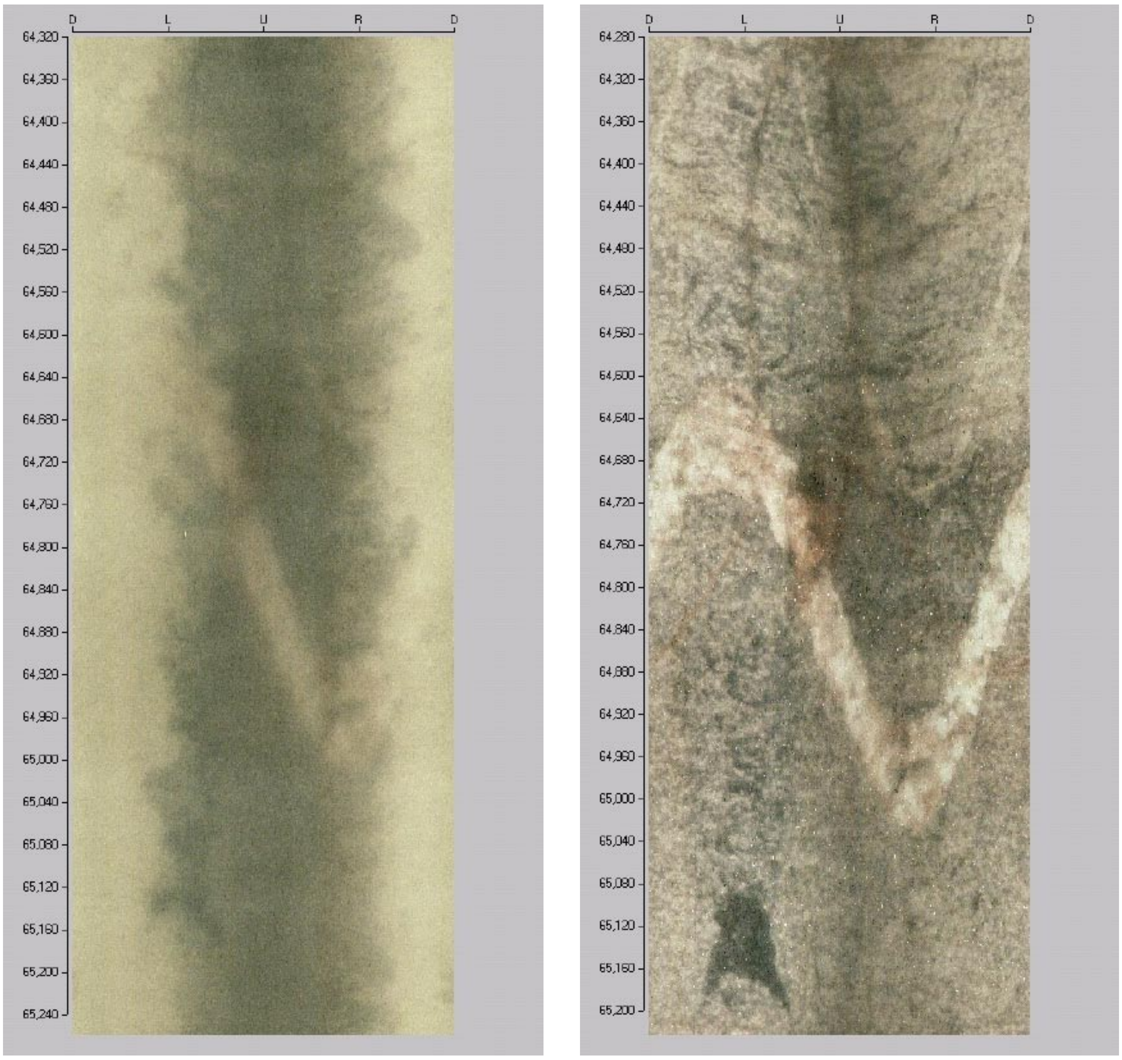


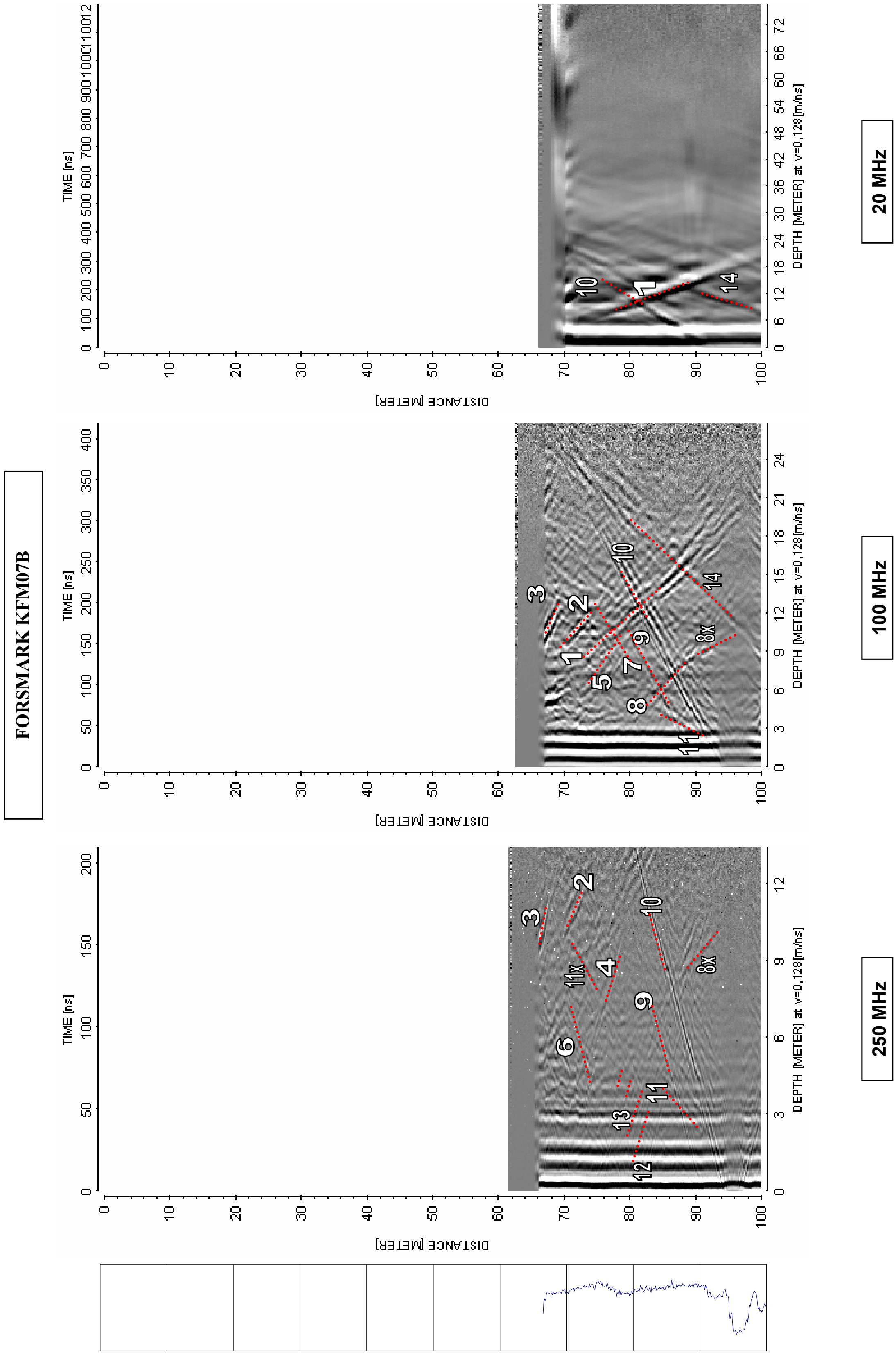
Figure 5-4. *Improvements of the image quality in HFM28 from logging in November 2005 (left) compared with the logging in January 2006 (right).*

References

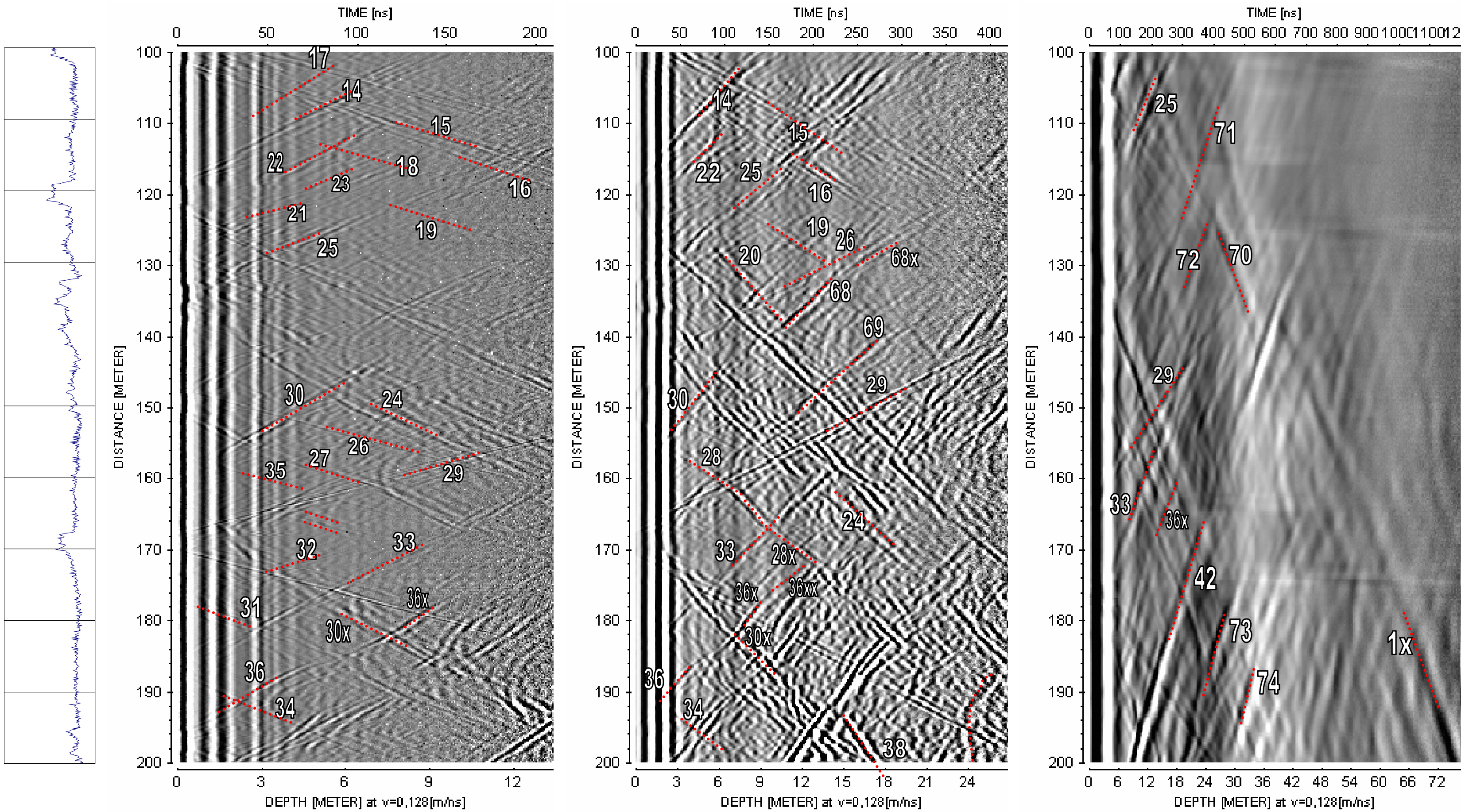
/1/ **Gustafsson C, Nilsson P, 2003.** Geophysical Radar and BIPS logging in borehole HFM01, HFM02, HFM03 and the percussion drilled part of KFM01A. SKB P-03-39. Svensk Kärnbränslehantering AB.

Appendix 1

Radar logging in KFM07B, 60 to 295 m, dipole antennas 250, 100 and 20 MHz

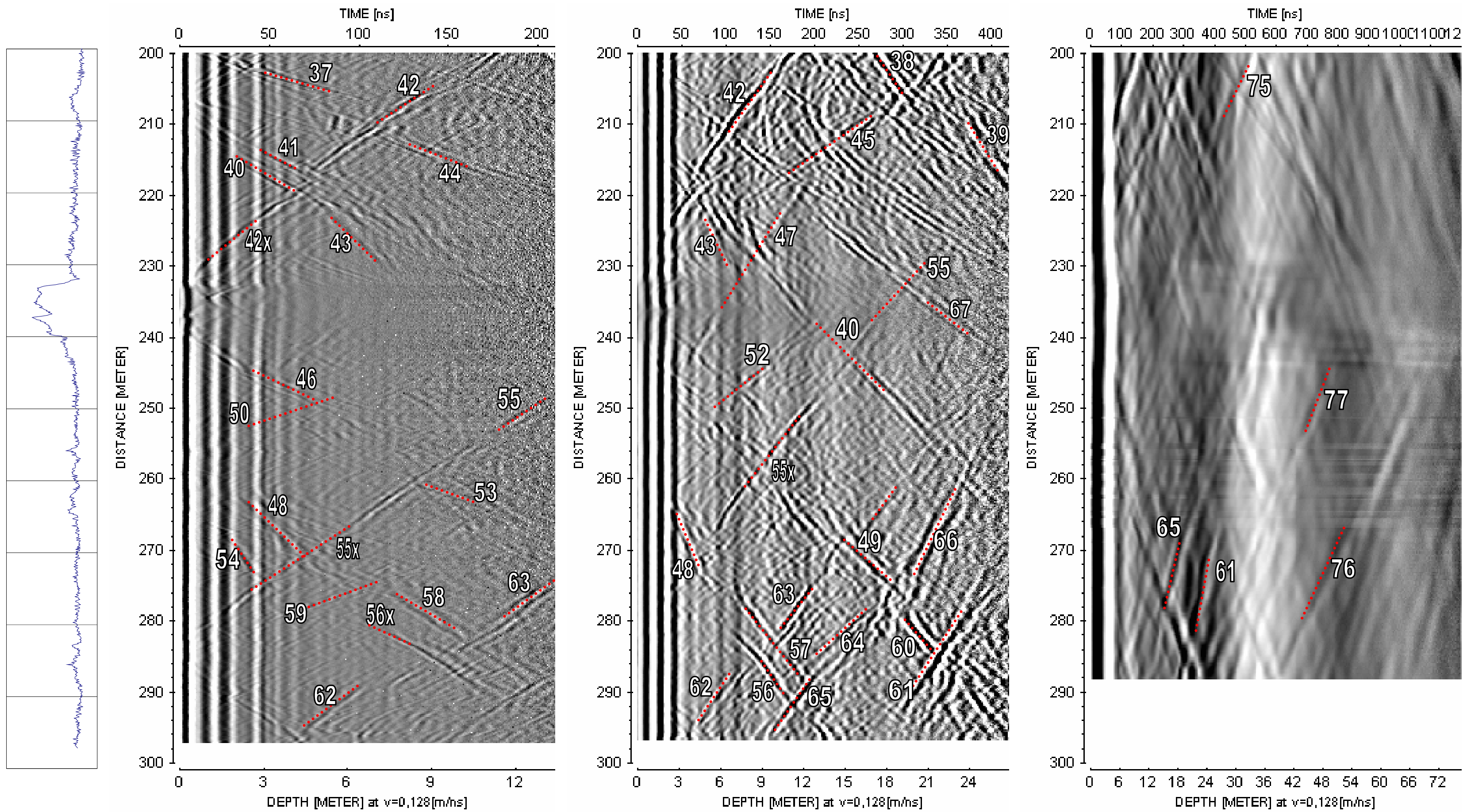


FORSMARK KFM07B



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

FORSMARK KFM07B

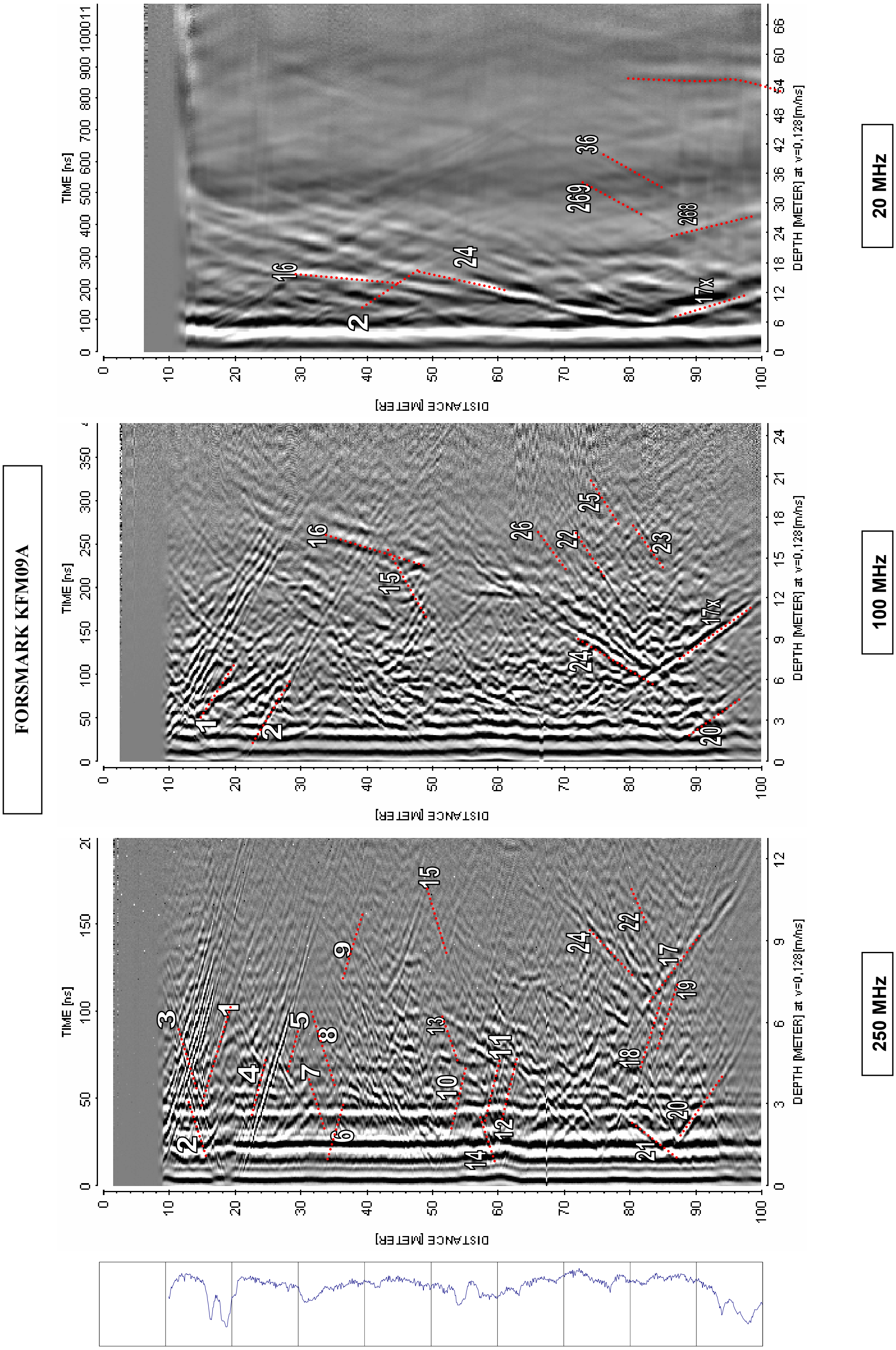


250 MHz

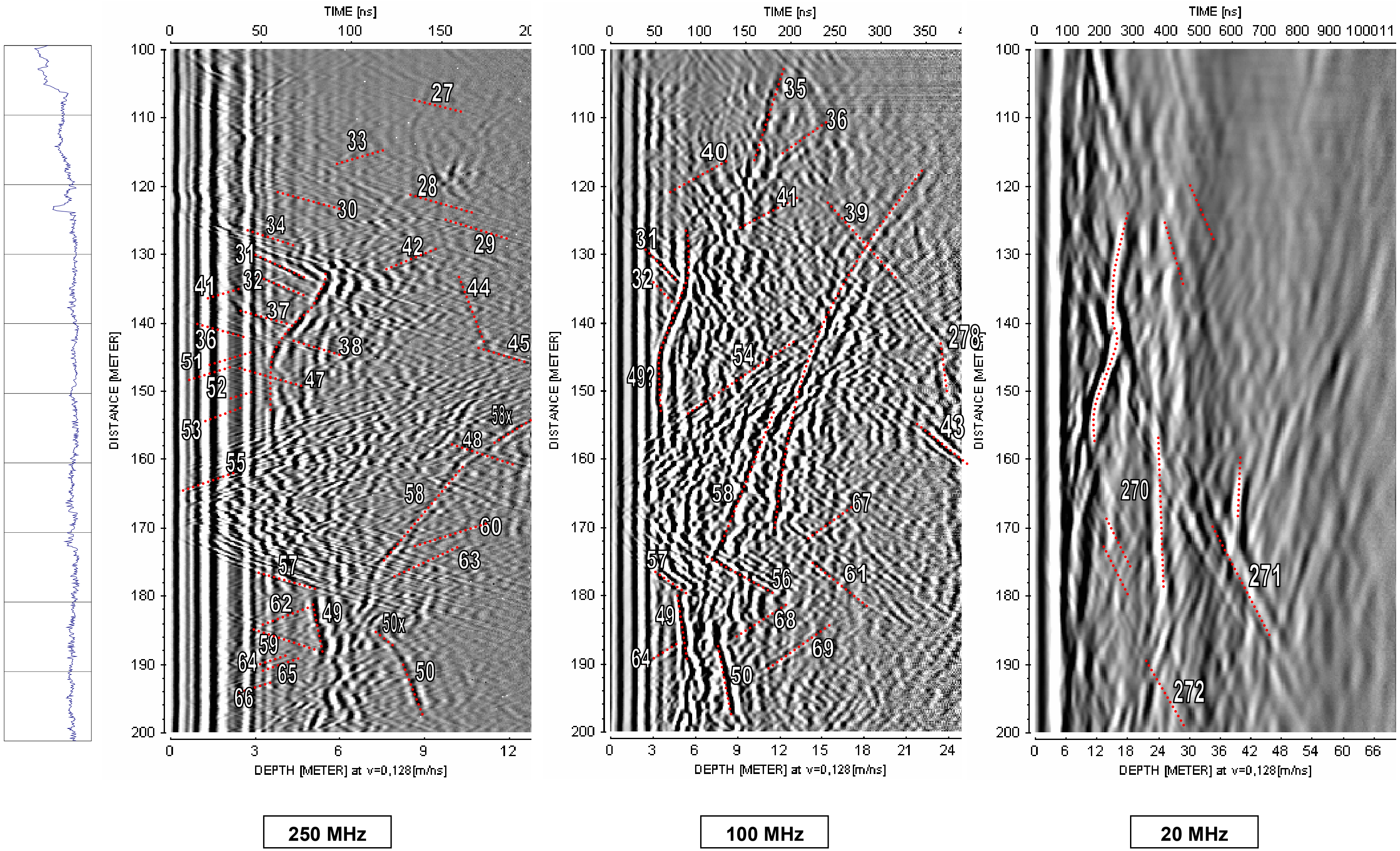
100 MHz

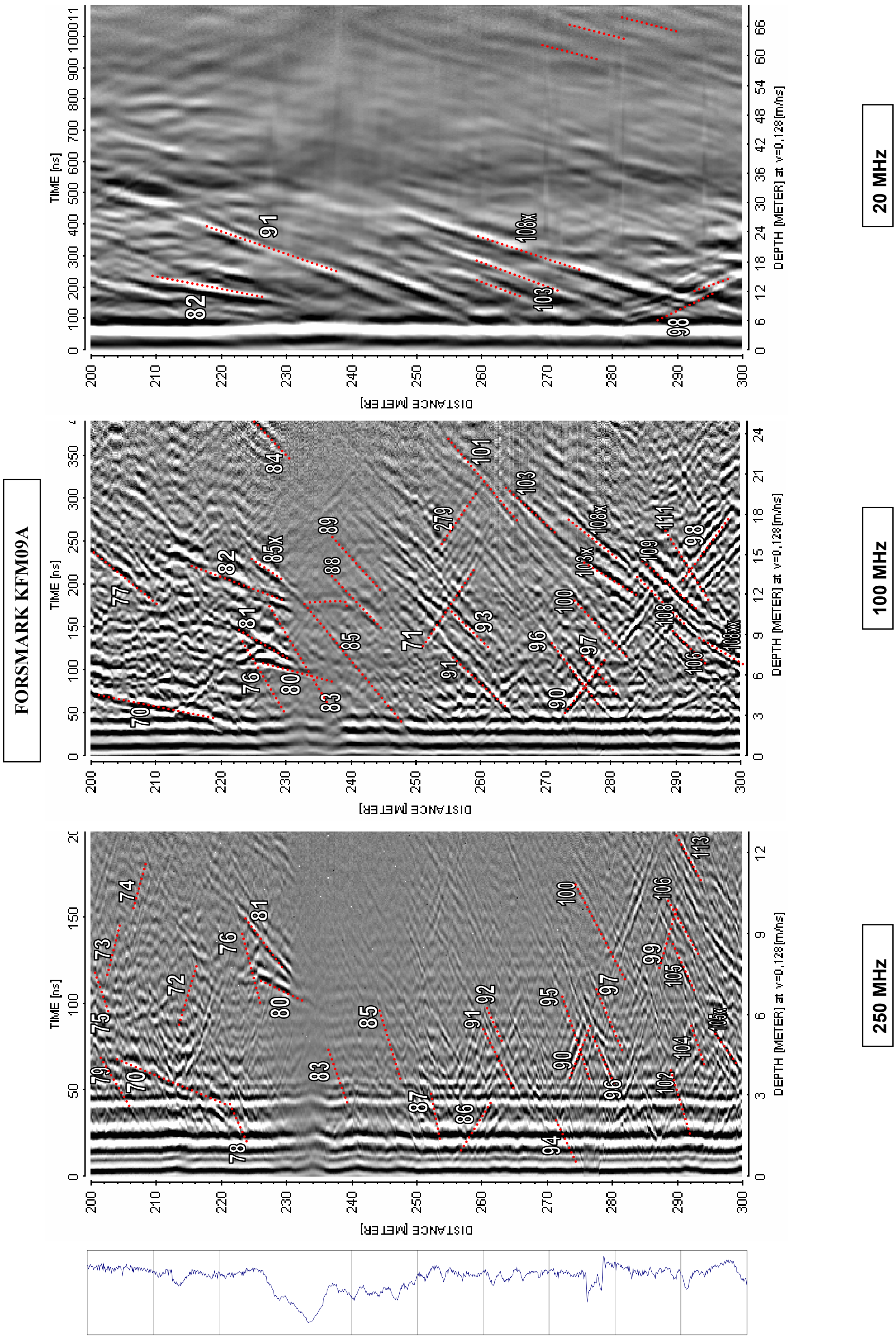
20 MHz

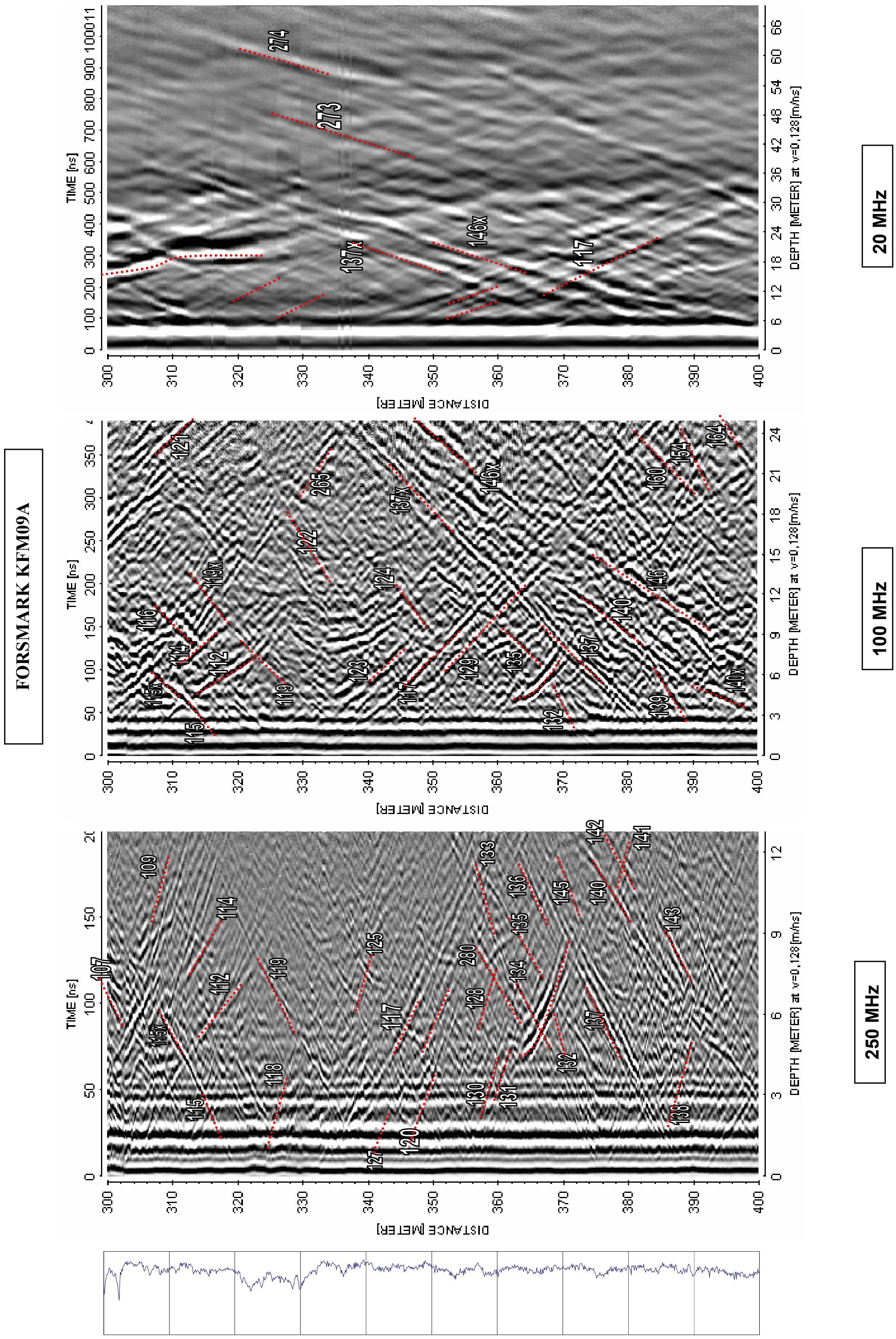
Radar logging in KFM09A, 0 to 795 m, dipole antennas 250, 100 and 20 MHz



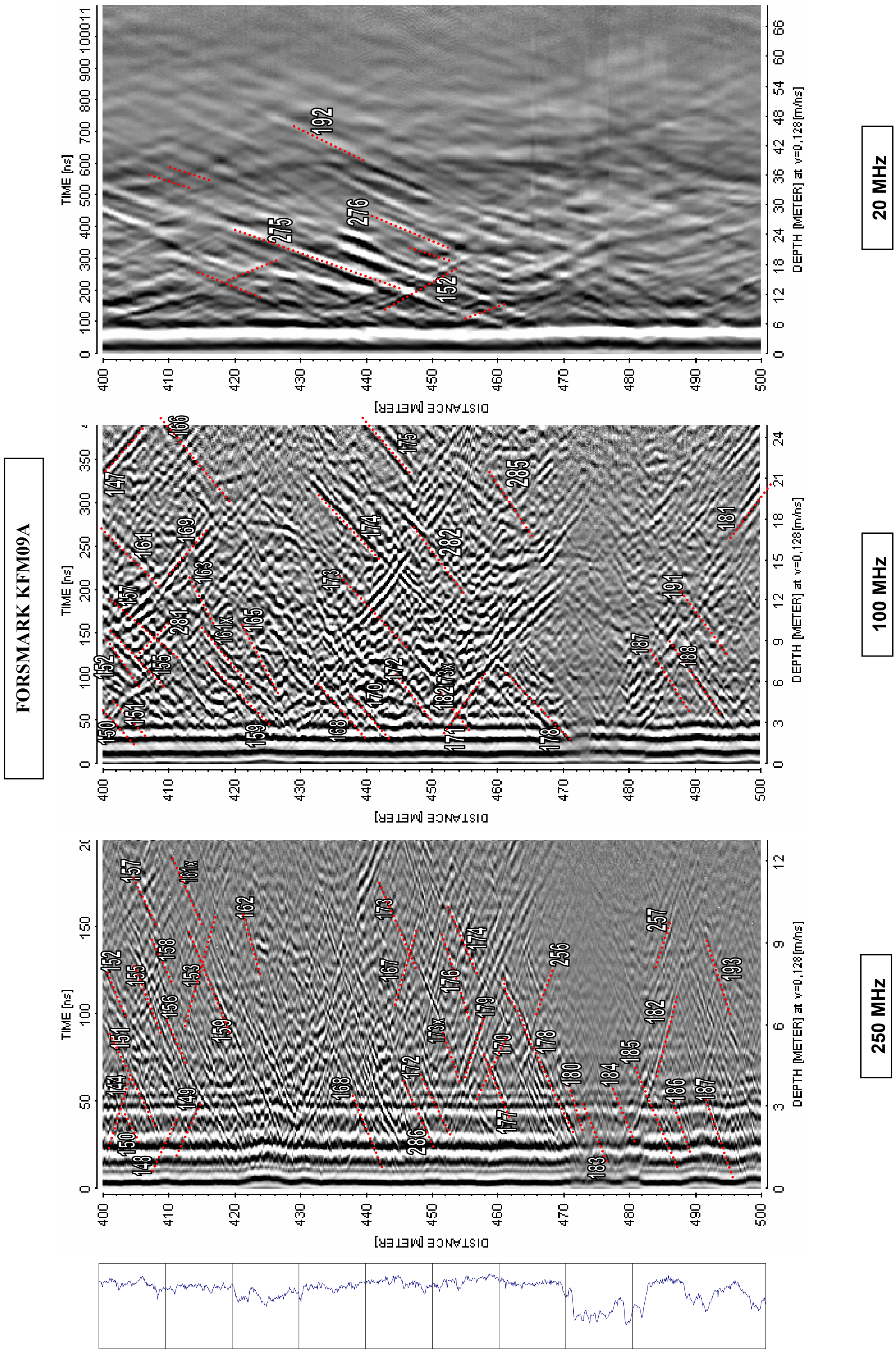
FORSMARK KFM09A



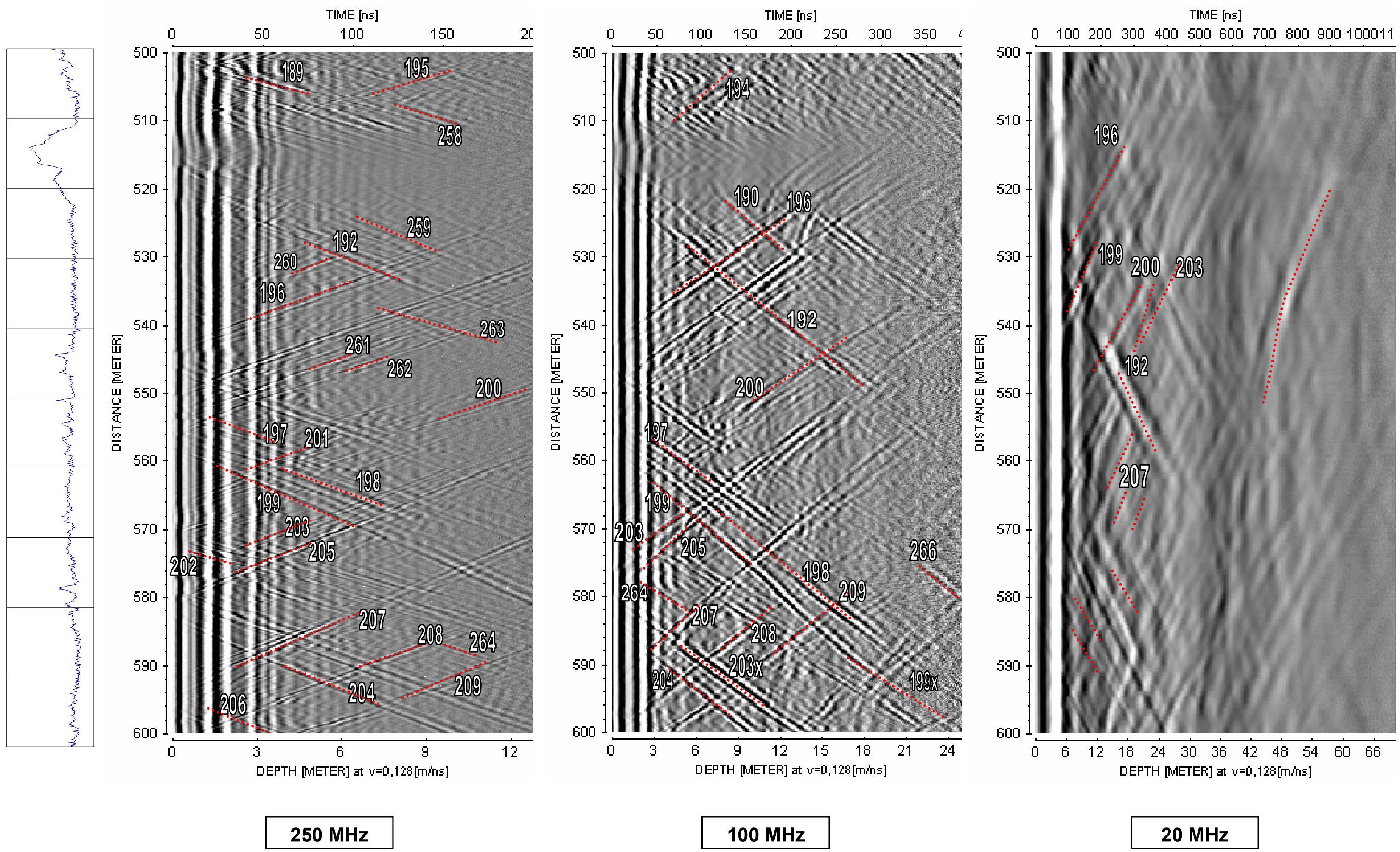

FORSMARK KFM09A
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]

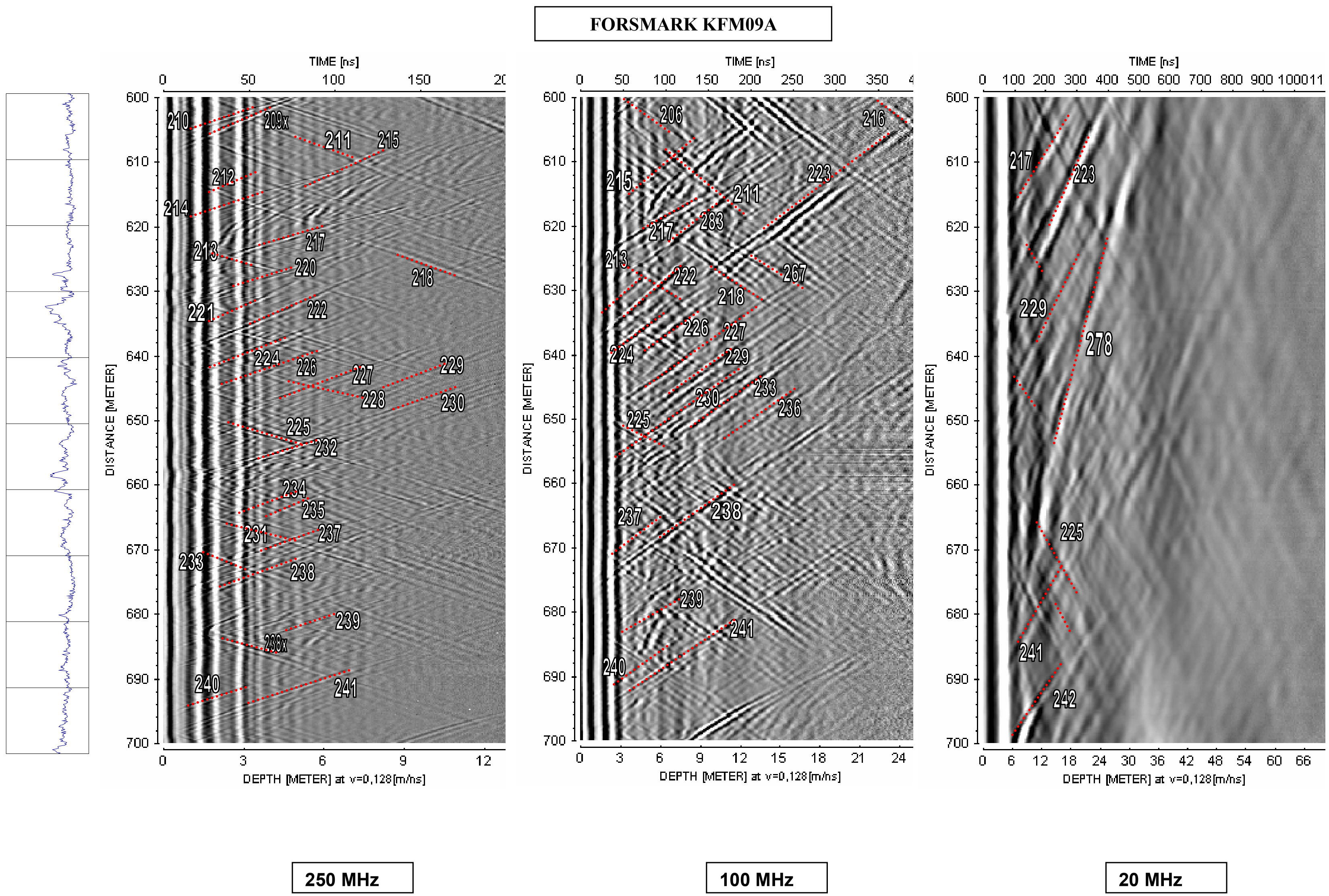


FORSMARK KFM09A
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128 [m/ns]

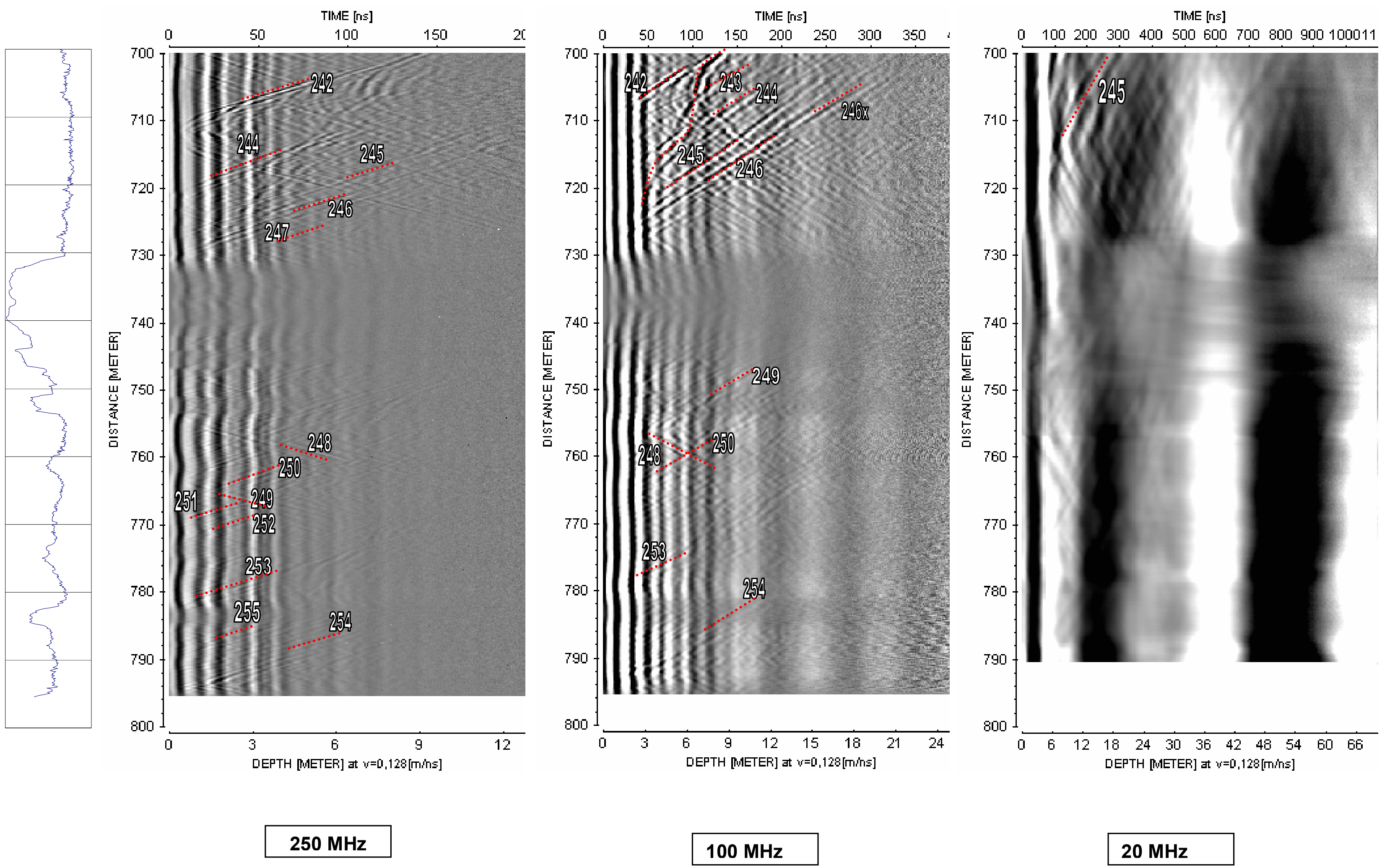

FORSMARK KFM09A
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]

FORSMARK KFM09A

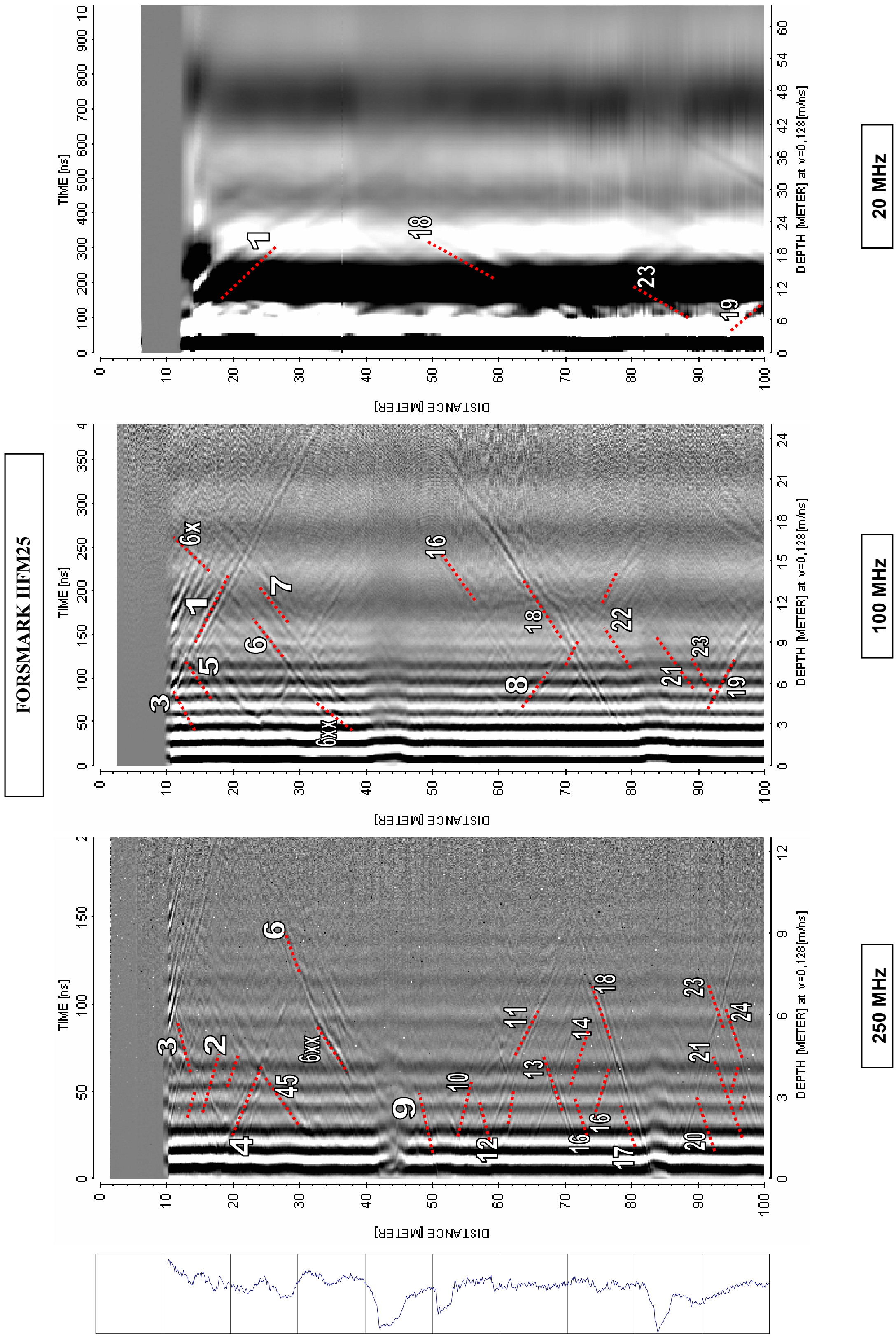


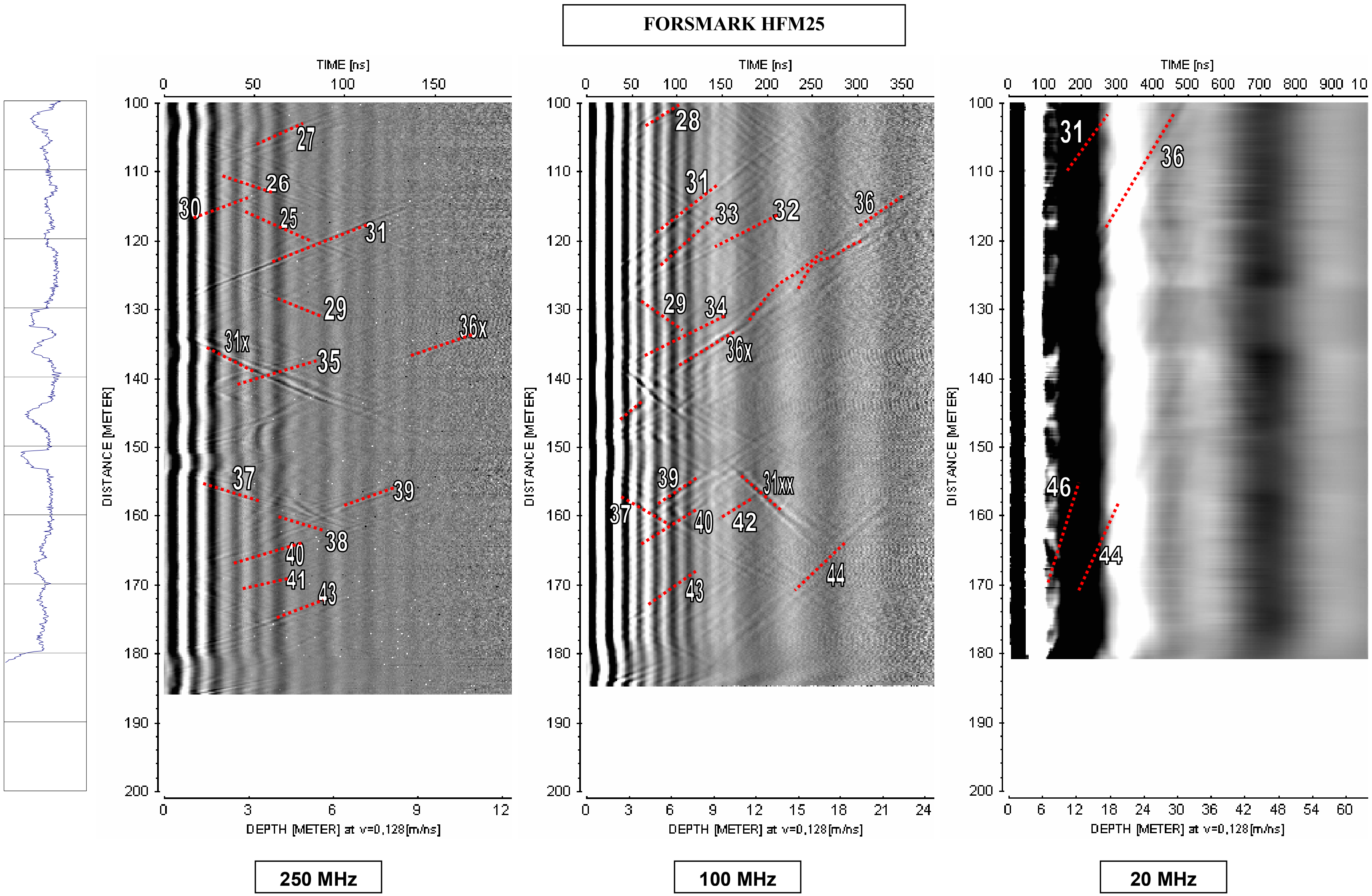

FORSMARK KFM09A
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
210
209x
211
215
212
214
213
217
220
218
221
222
224
226
227
229
228
230
225
232
234
235
231
237
233
238
239
236x
240
241
206
216
223
283
267
233
236
237
242
278
250 MHz
100 MHz
20 MHz

FORSMARK KFM09A

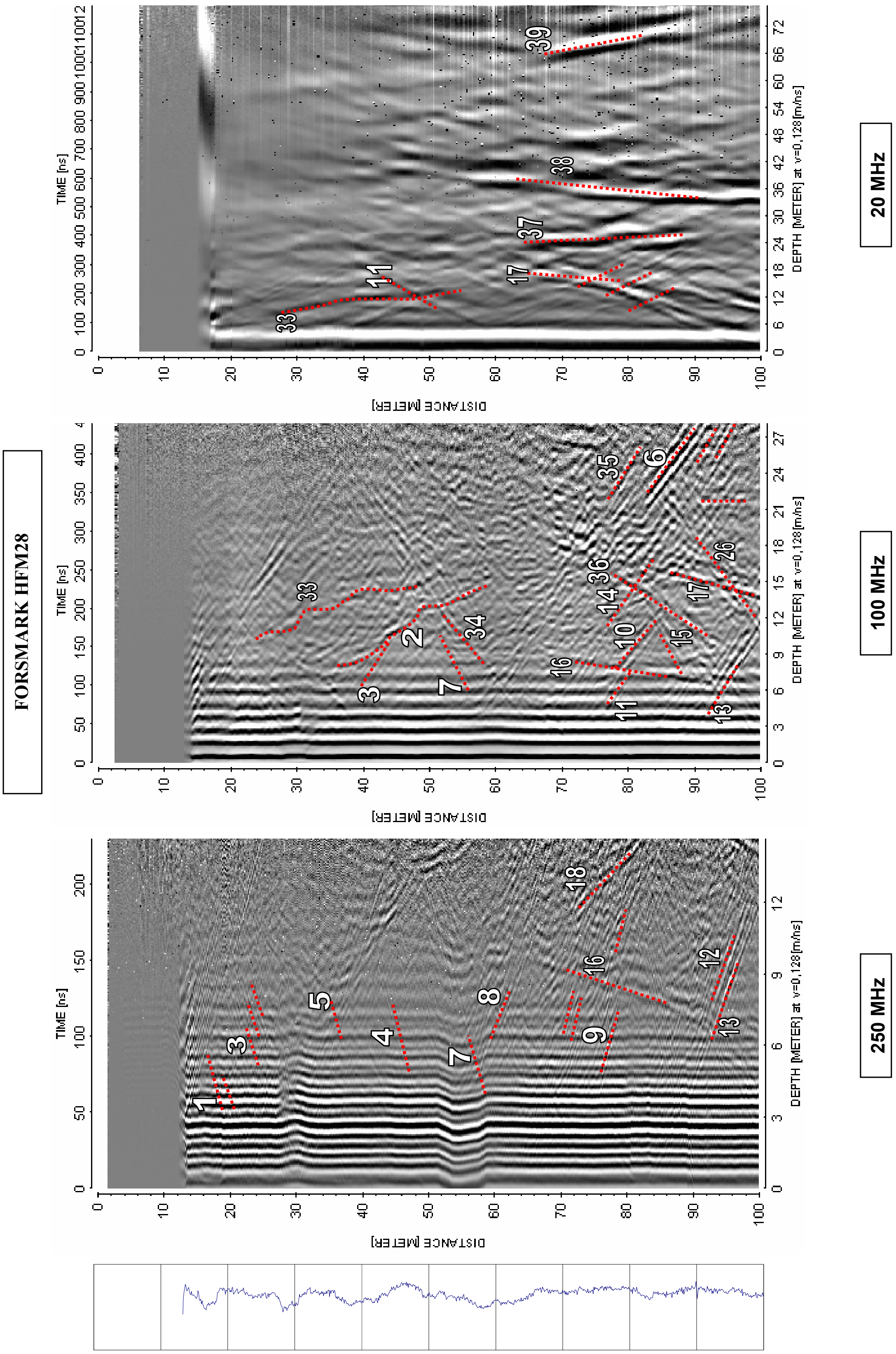


Radar logging in HFM25, 0 to 185 m, dipole antennas 250, 100 and 20 MHz

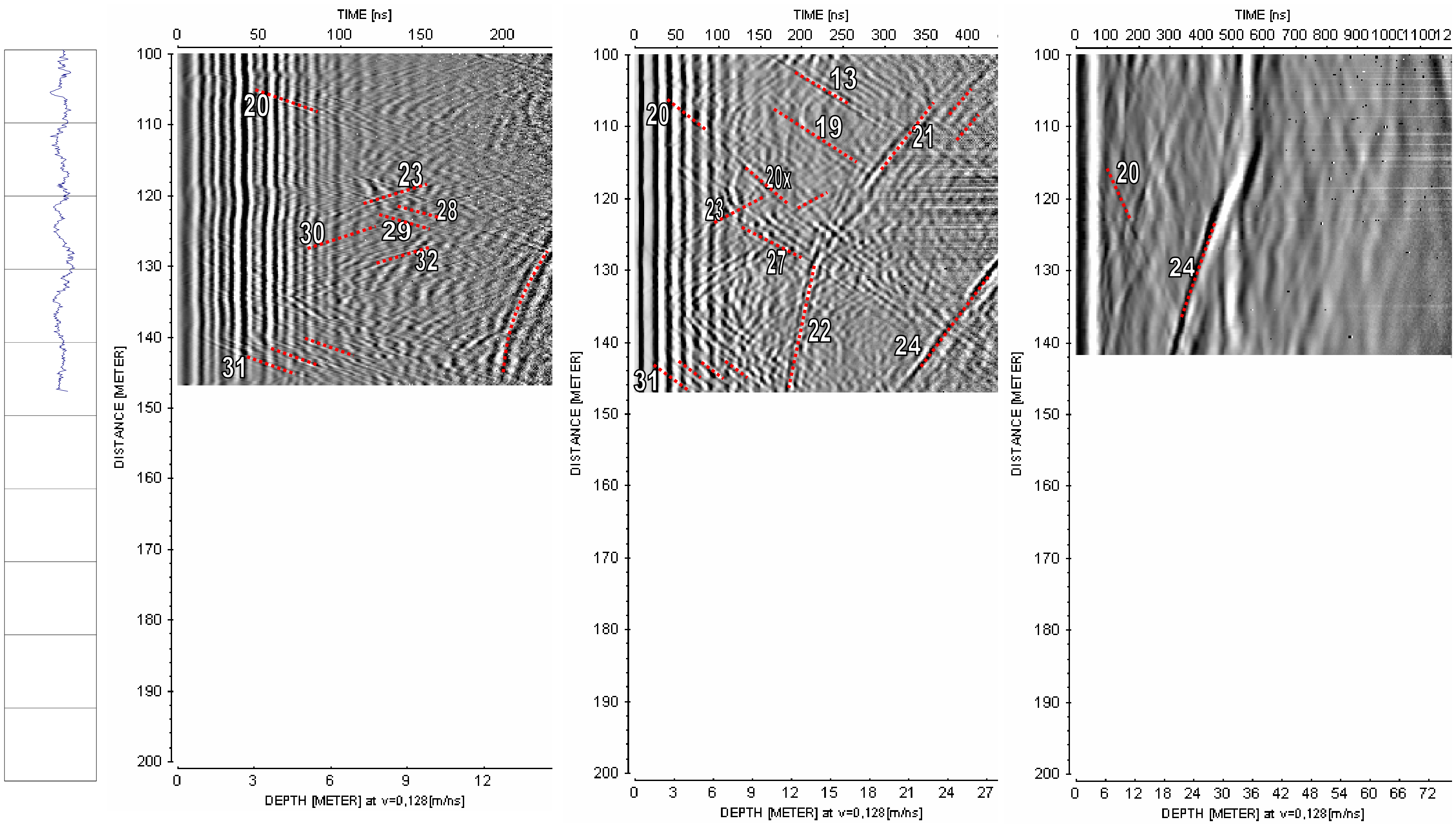



FORSMARK HFM25
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
250 MHz
100 MHz
20 MHz
27
26
30
25
31
29
36x
31x
35
37
39
38
40
41
43
28
33
32
36
34
42
31xx
44
46

Radar logging in HFM28, 0 to 145 m, dipole antennas 250, 100 and 20 MHz



FORSMARK HFM28



250 MHz

100 MHz

20 MHz

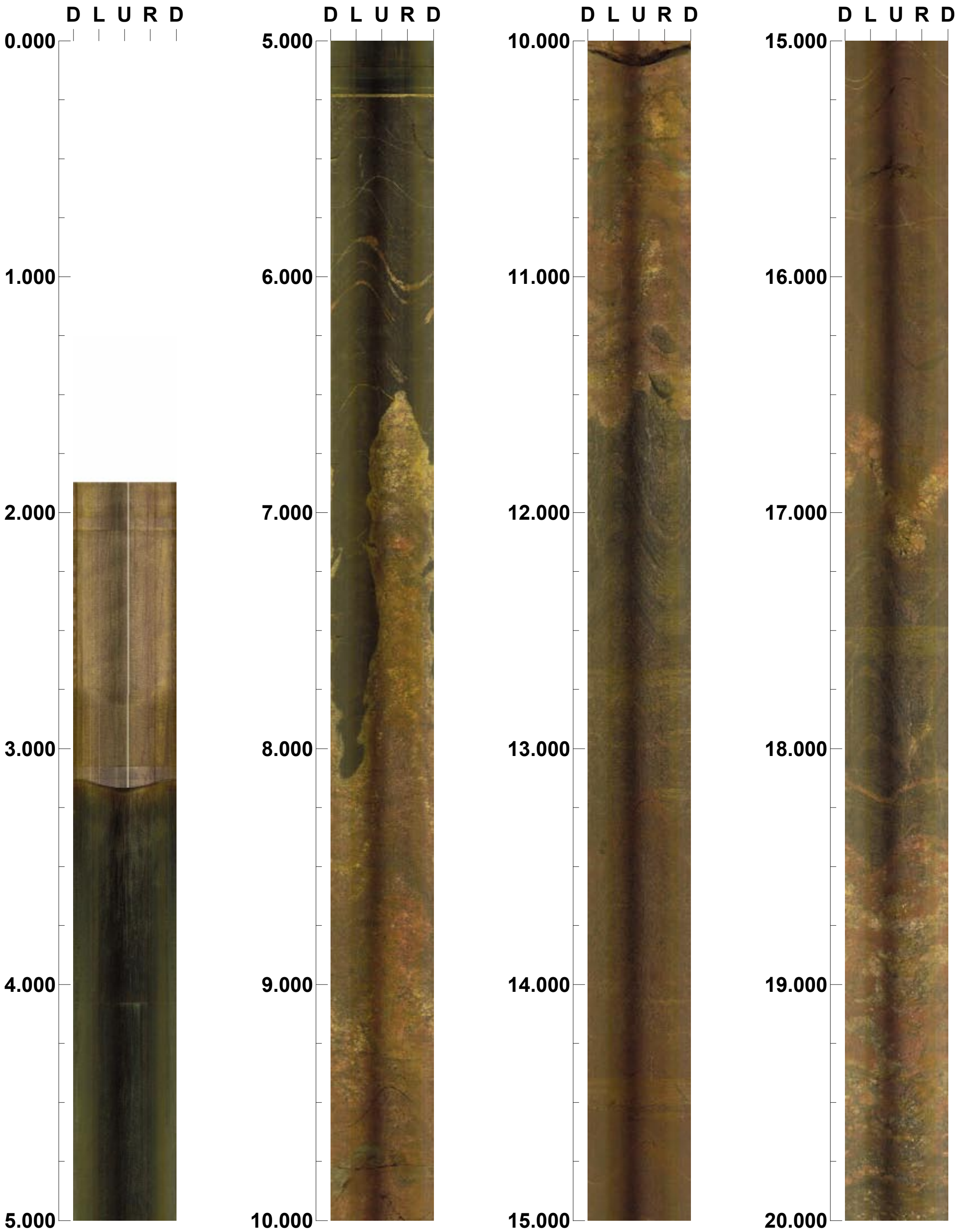
BIPS logging in KFM07B, 0 to 65 m

Project name: Forsmark

Image file	**: c:\~1\kfm07b~1.bip**
BDT file	**: c:\~1\kfm07b~1.bdt**
Locality	**: FORSMARK**
Bore hole number	**: KFM07B**
Date	**: 05/06/21**
Time	**: 09:44:00**
Depth range	**: 1.870 - 65.064 m**
Azimuth	**: 131**
Inclination	**: -55**
Diameter	**: 96.0 mm**
Magnetic declination	**: 0.0**
Span	**: 4**
Scan interval	**: 0.25**
Scan direction	**: To bottom**
Scale	**: 1/25**
Aspect ratio	**: 145 %**
Pages	**: 4**
Color	**: +0 +0 +0**

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 131** **Inclination: -55**

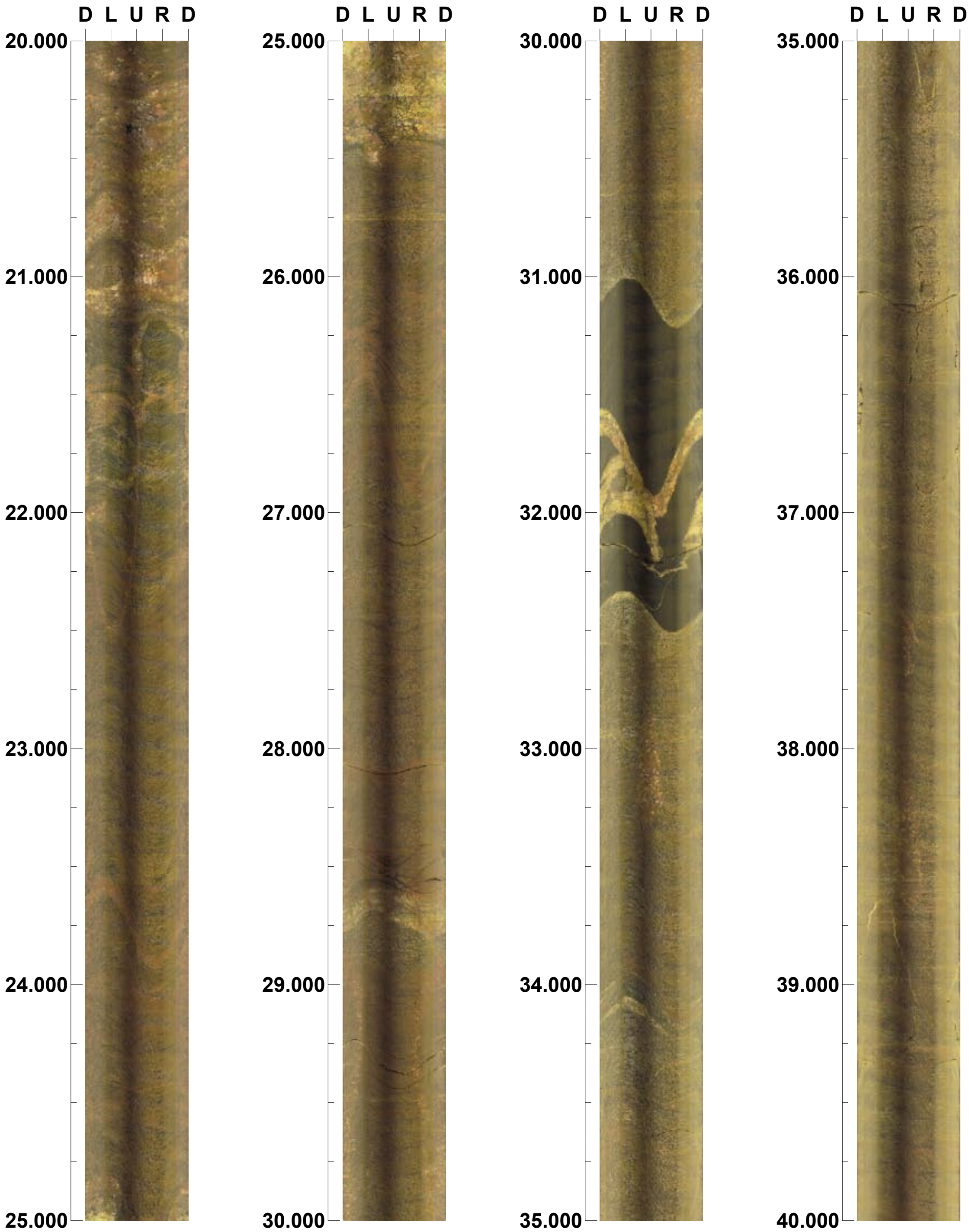
Depth range: 0.000 - 20.000 m



(1 / 4) **Scale: 1/25** **Aspect ratio: 145 %**

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 131** **Inclination: -55**

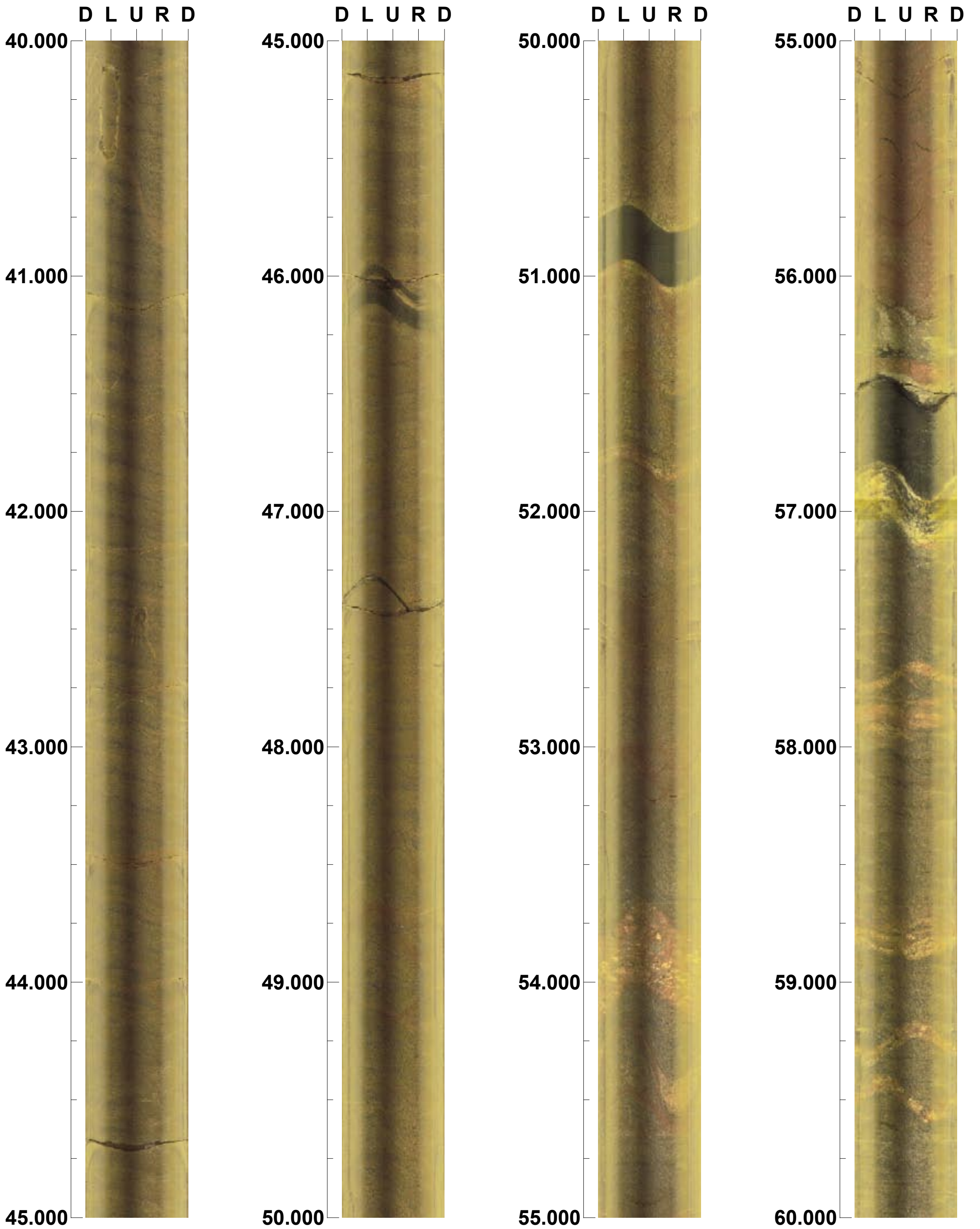
Depth range: 20.000 - 40.000 m



(2 / 4) **Scale: 1/25** **Aspect ratio: 145 %**

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 131** **Inclination: -55**

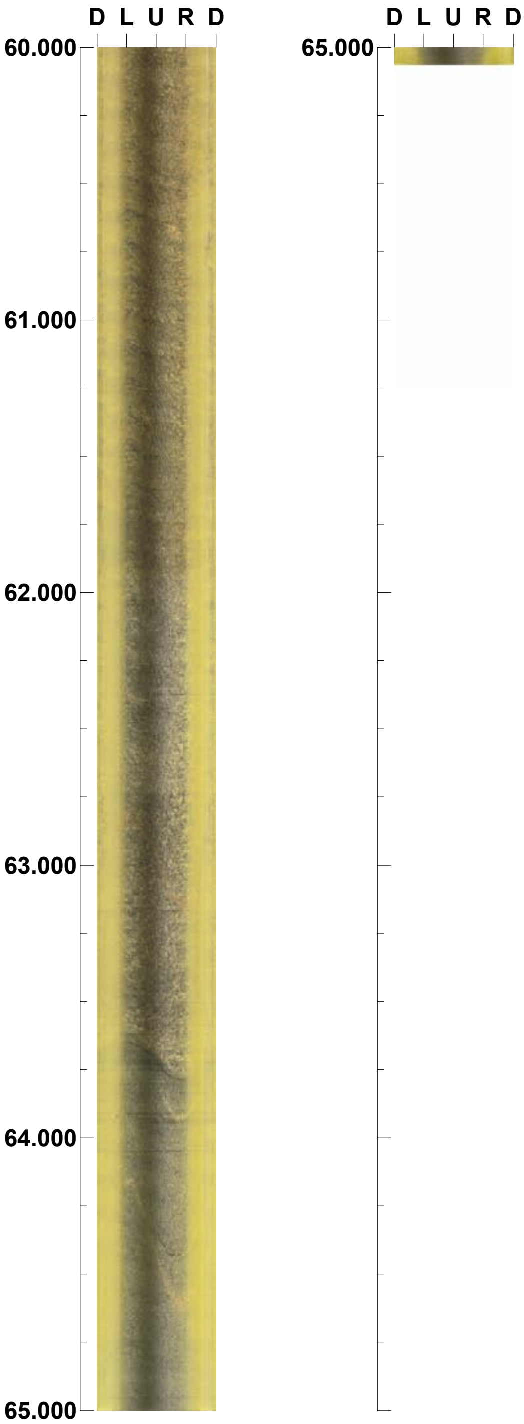
Depth range: 40.000 - 60.000 m



(3 / 4) **Scale: 1/25** **Aspect ratio: 145 %**

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 131** **Inclination: -55**

Depth range: 60.000 - 65.064 m



(4 / 4) **Scale: 1/25** **Aspect ratio: 145 %**

Appendix 6

BIPS logging in KFM07B, 65 to 297 m

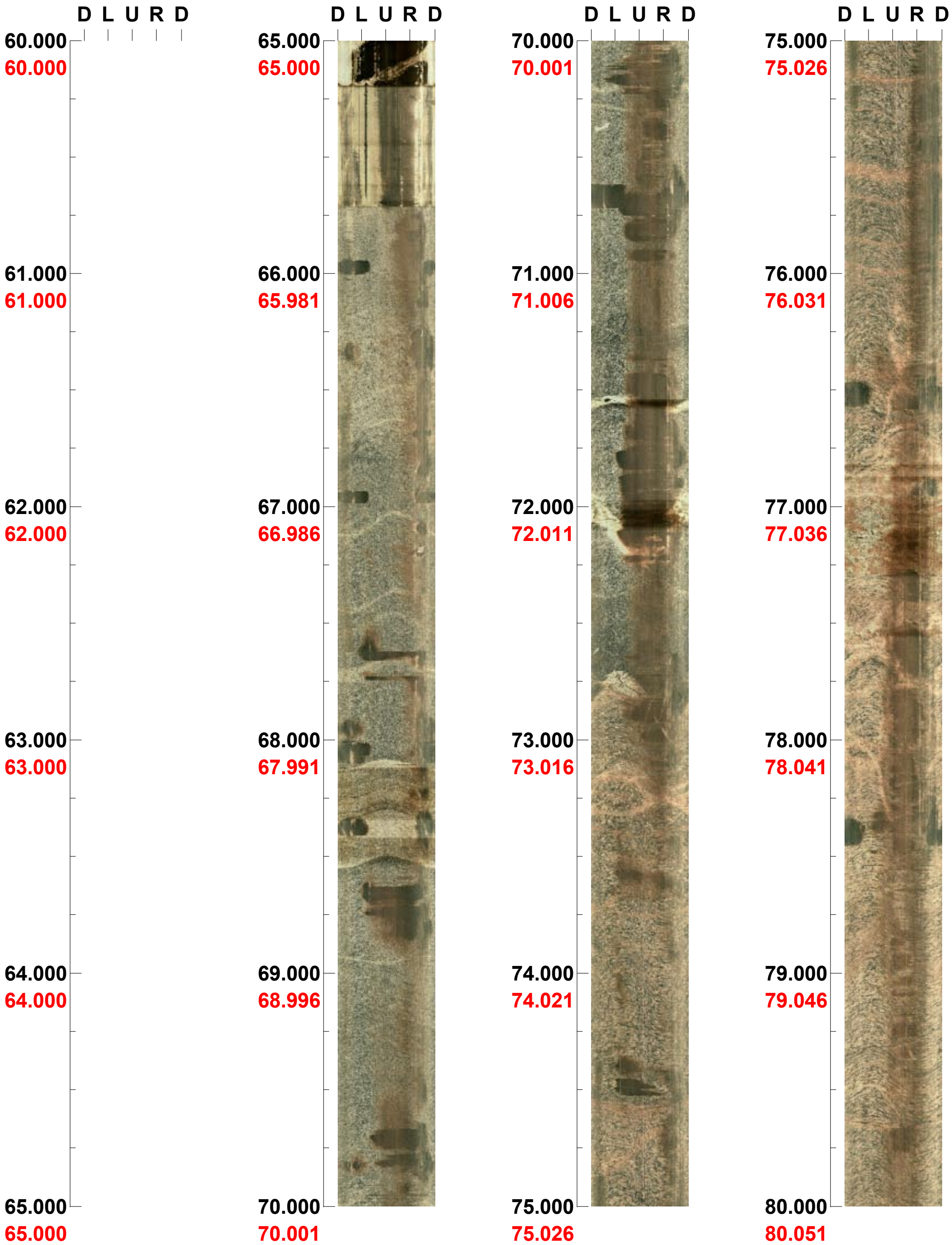
Project name: Forsmark

Image file	: c:\work\r5478s~1\kfm07b\bips\kfm07b.bip
BDT file	: c:\work\r5478s~1\kfm07b\bips\kfm07b.bdt
Locality	: FORSMARK
Bore hole number	: KFM07B
Date	: 05/11/07
Time	: 10:16:00
Depth range	: 65.000 - 297.876 m
Azimuth	: 134
Inclination	: -54
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	: 12
Color	: +0 +0 +0

Project name: Forsmark

Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

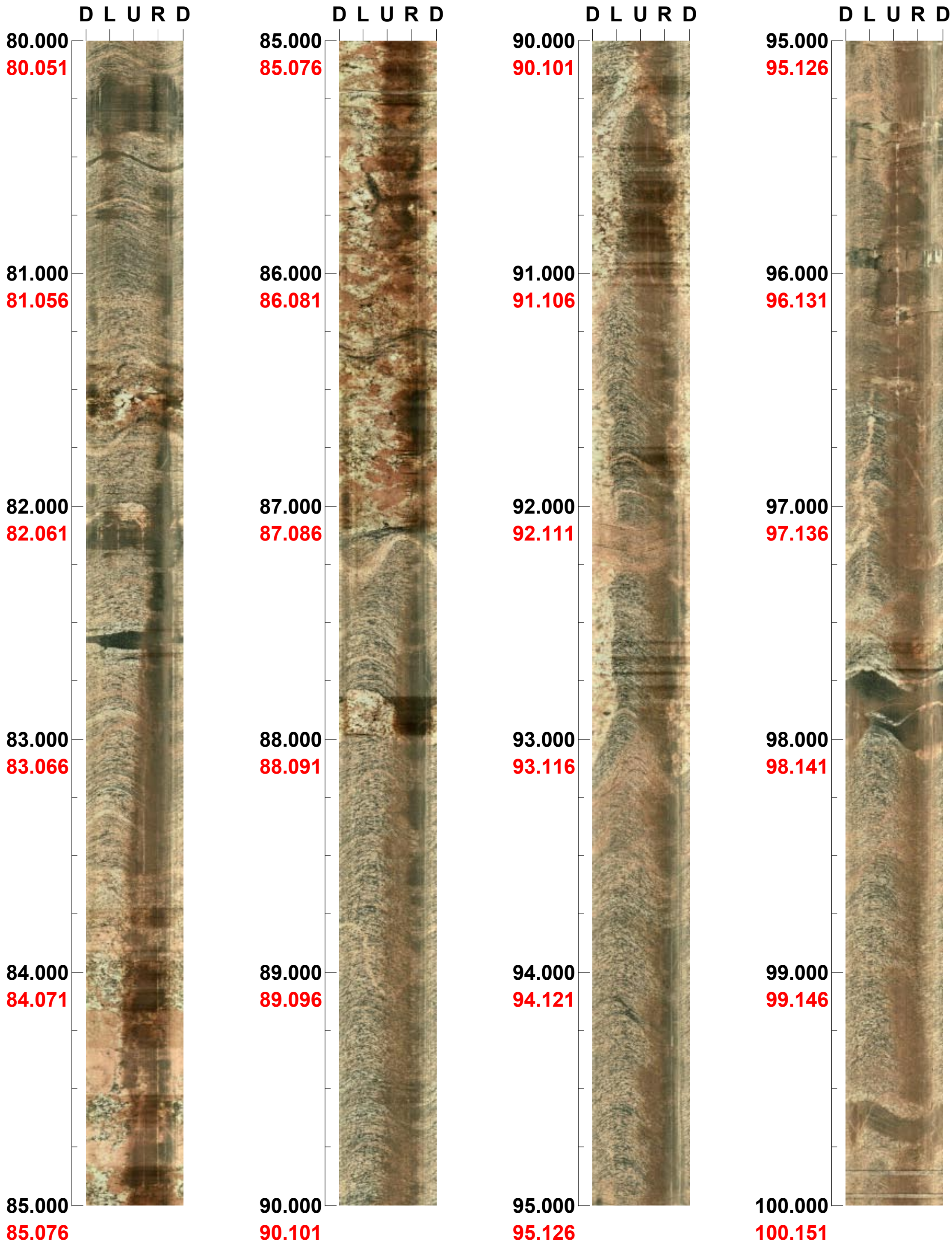
Depth range: 60.000 - 80.000 m



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

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

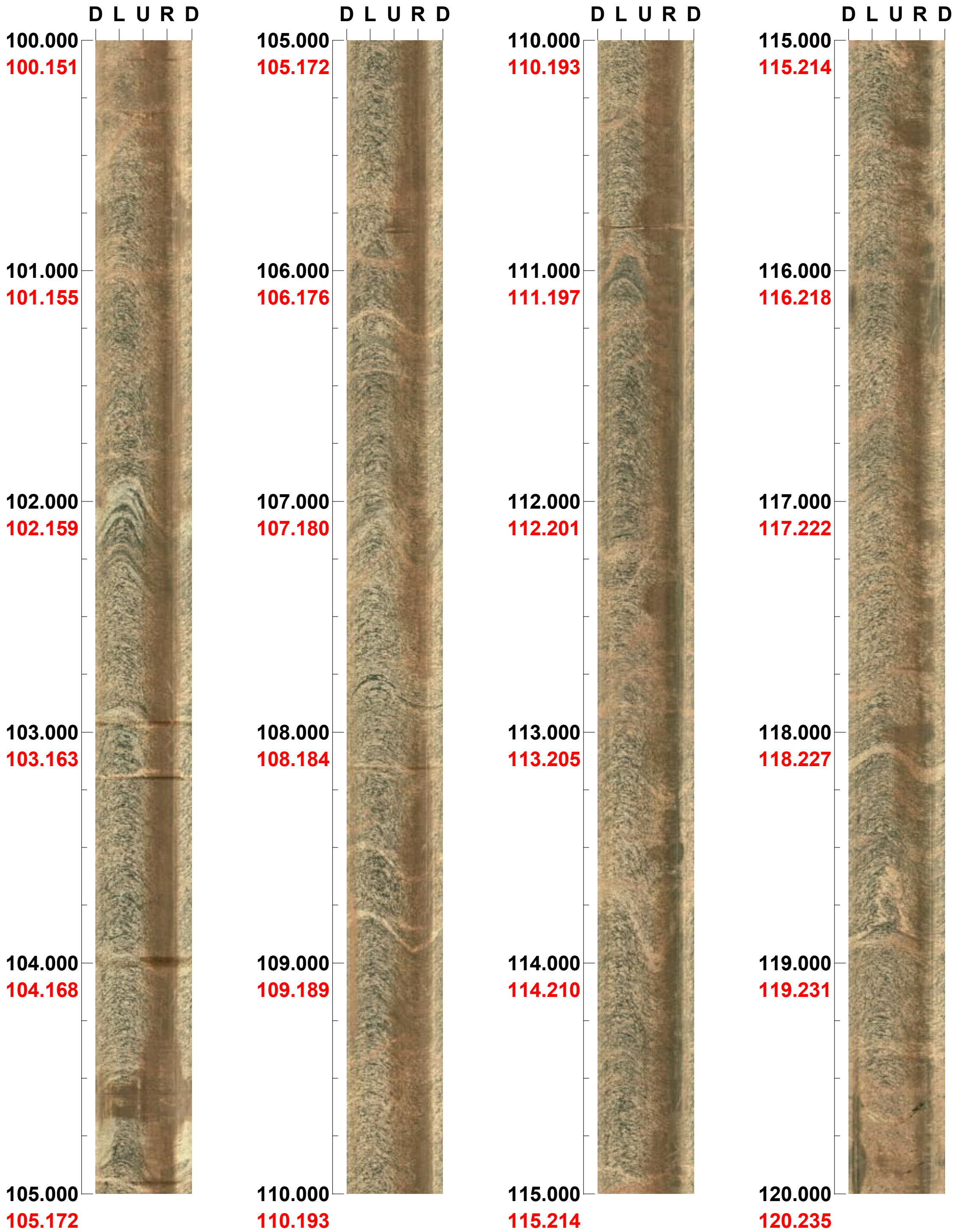
Depth range: 80.000 - 100.000 m



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

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

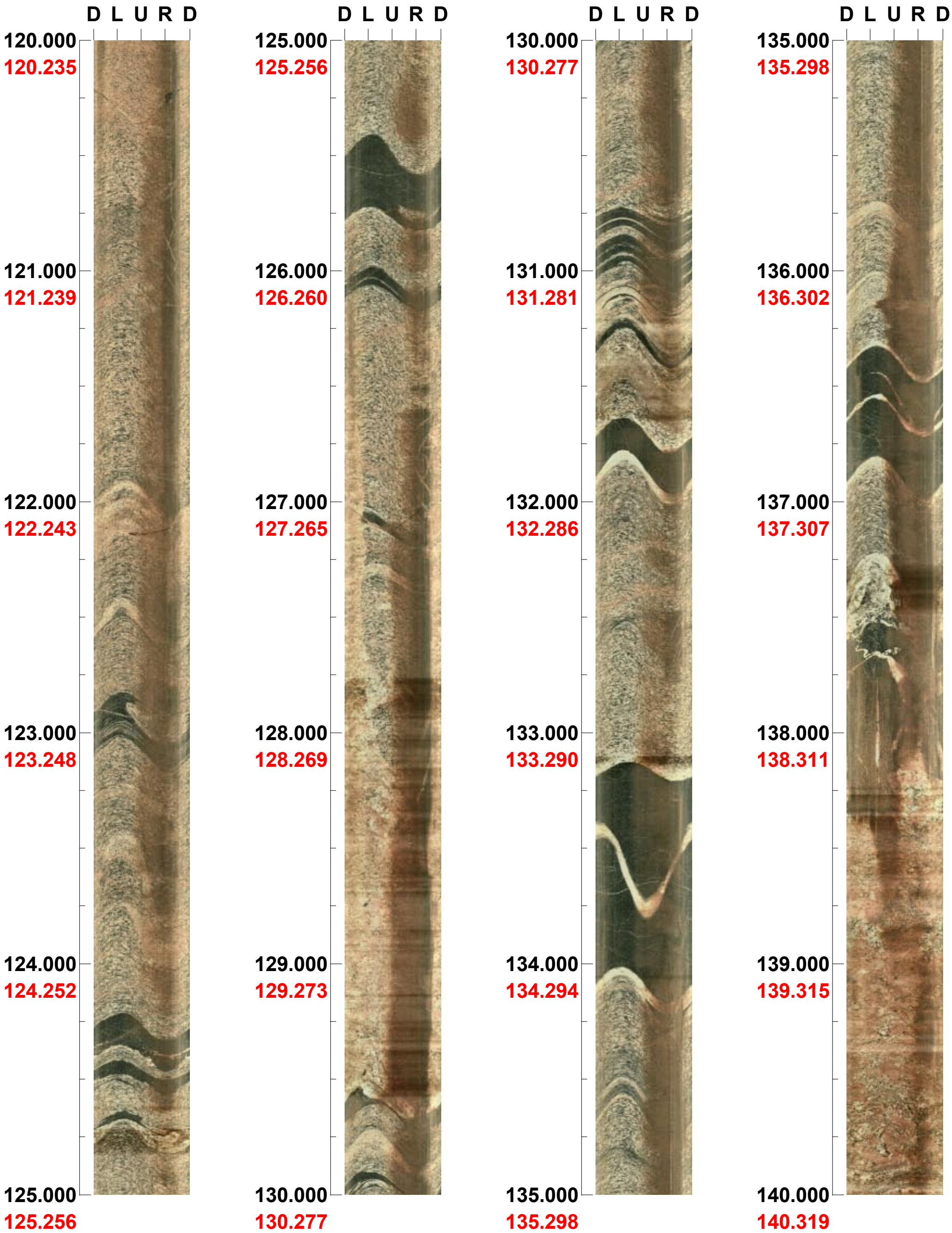
Depth range: 100.000 - 120.000 m



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

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

Depth range: 120.000 - 140.000 m



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

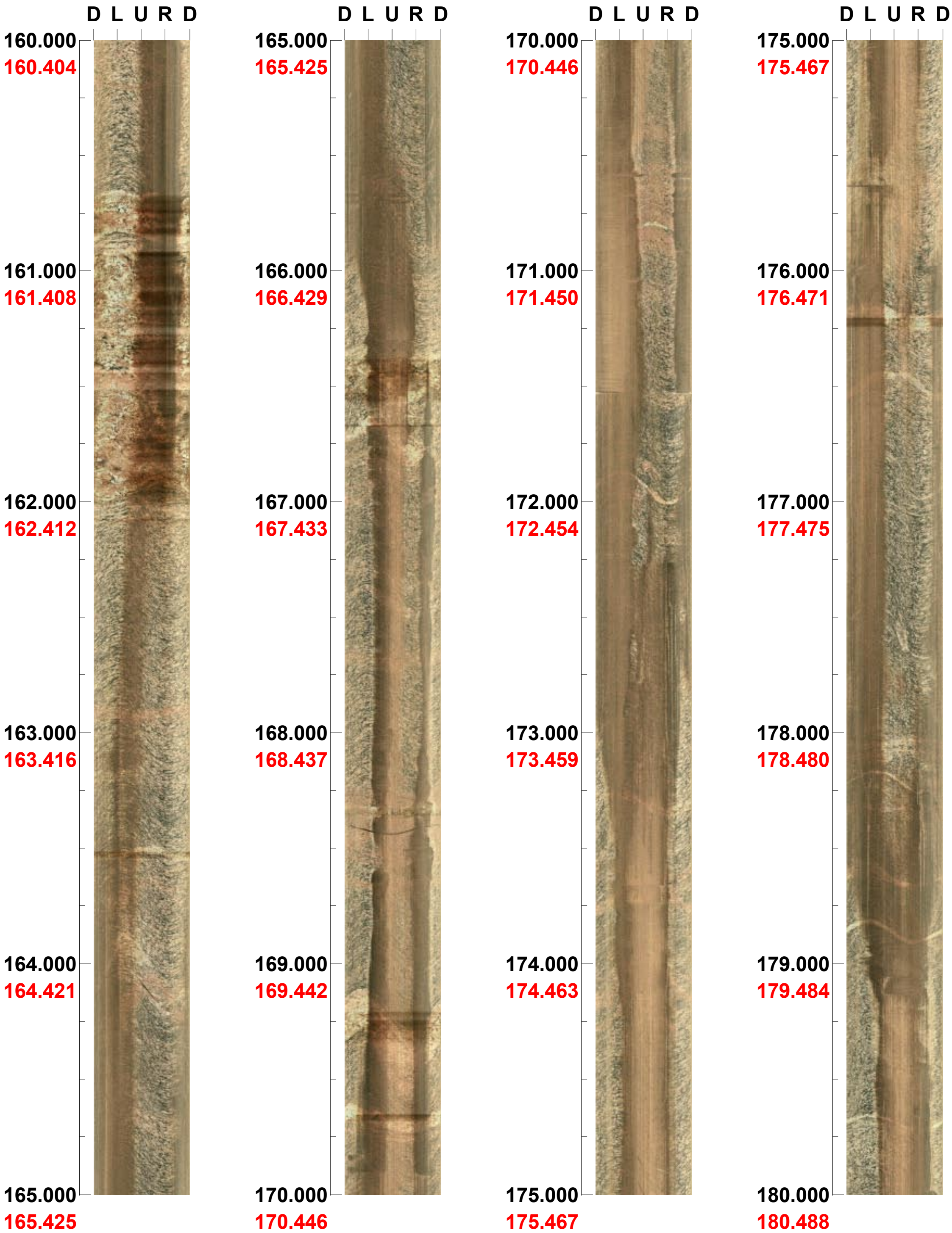
Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

Depth range: 140.000 - 160.000 m

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

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

Depth range: 160.000 - 180.000 m

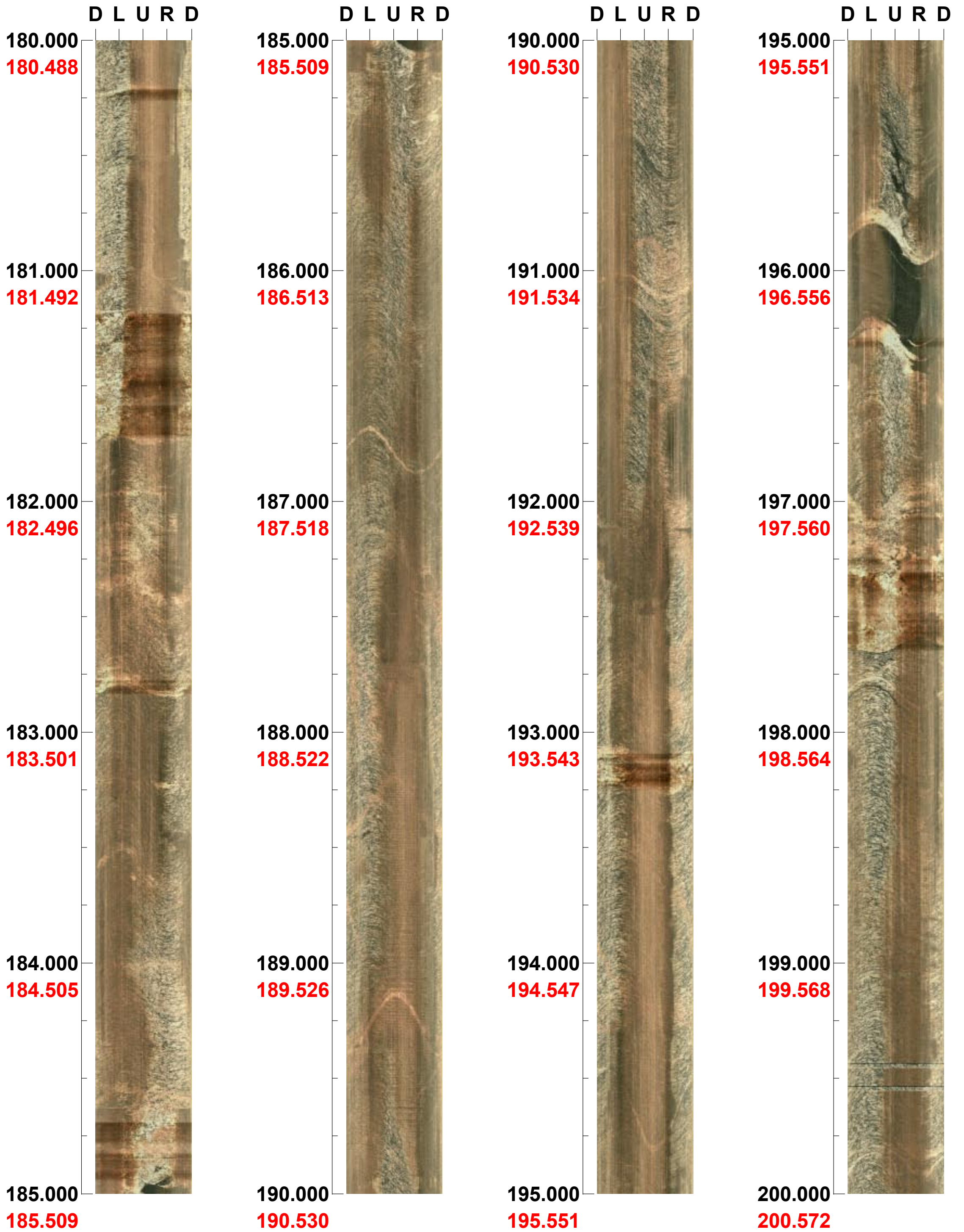


(6 / 12) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

Depth range: 180.000 - 200.000 m



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

Project name: Forsmark

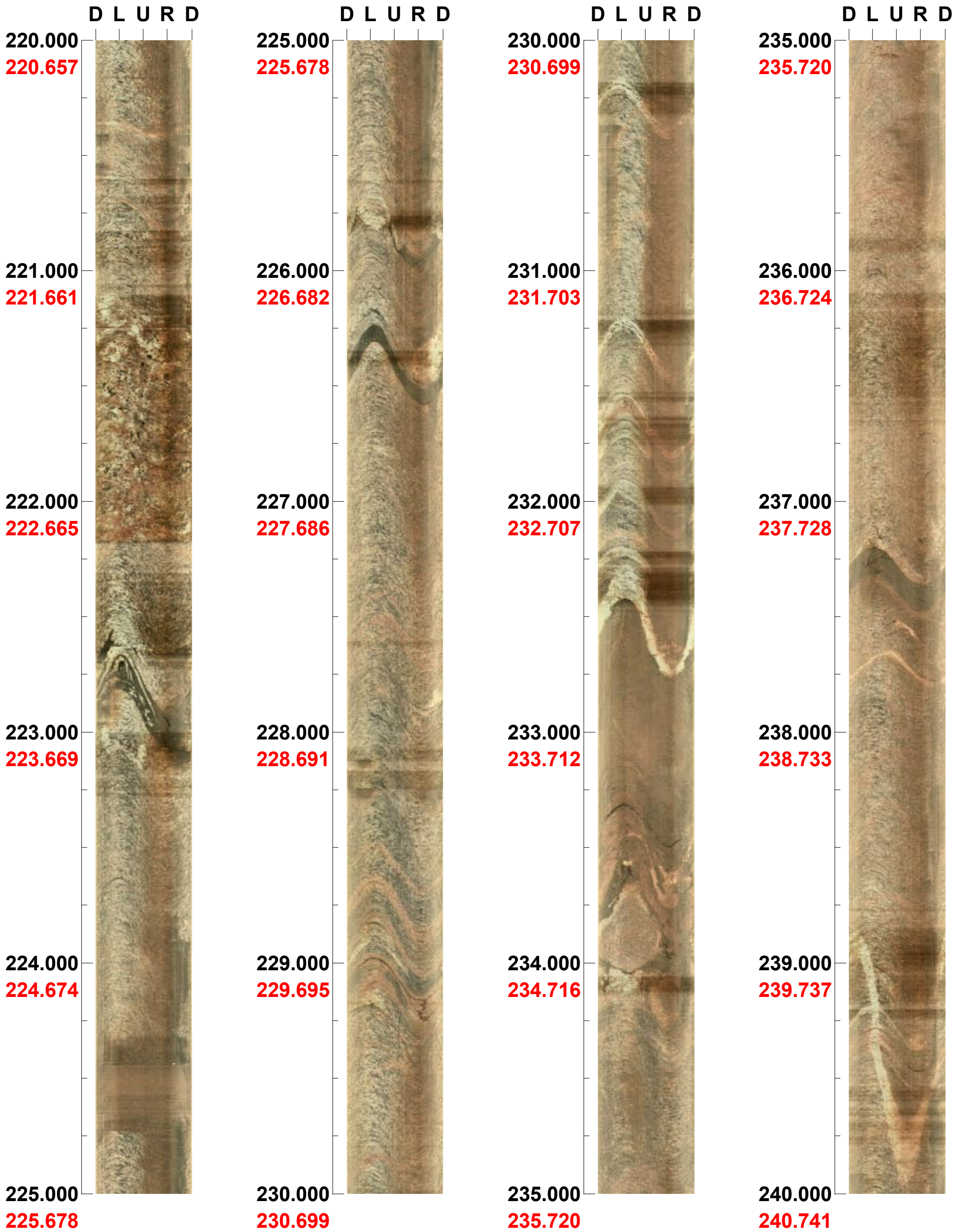
Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

Depth range: 200.000 - 220.000 m

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

Project name: Forsmark
Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

Depth range: 220.000 - 240.000 m

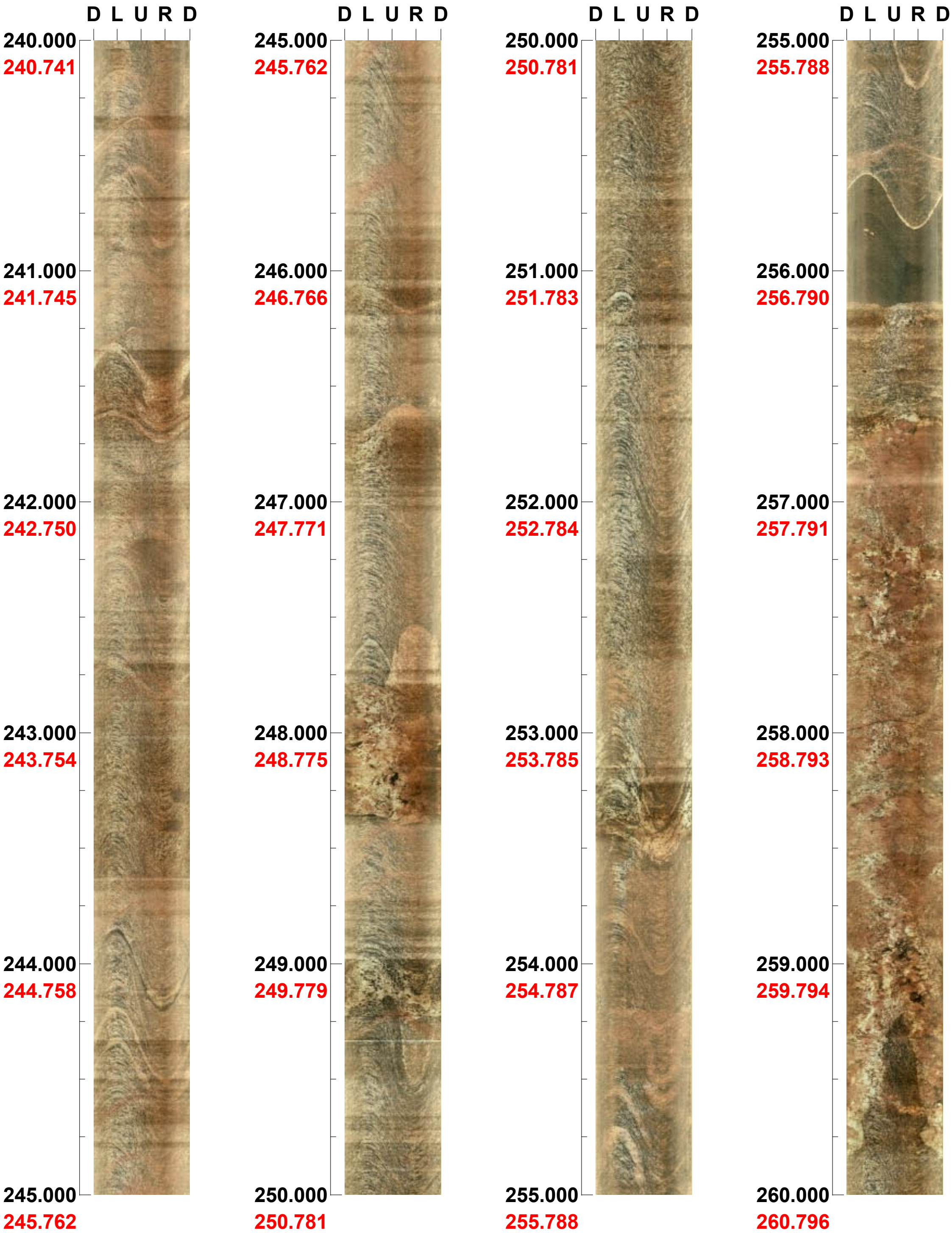


(9 / 12) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM07B **Azimuth: 134** **Inclination: -54**

Depth range: 240.000 - 260.000 m



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

Project name: Forsmark
Bore hole No.: KFM07B Azimuth: 134 Inclination: -54

Depth range: 260.000 - 280.000 m

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

Project name: Forsmark

Bore hole No.: KFM07B

Azimuth: 134 Inclination: -54

Depth range: 280.000 - 297.876 m

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

Appendix 7

BIPS logging in KFM09A, 7 to 792 m

Project name: Forsmark

Image file	: c:\work\r5478s~1\kfm09a\bips\kfm09a_1.bip
BDT file	: c:\work\r5478s~1\kfm09a\bips\kfm09a_1.bdt
Locality	: FORSMARK
Bore hole number	: KFM09A
Date	: 05/11/06
Time	: 06:51:00
Depth range	: 7.000 - 792.022 m
Azimuth	: 200
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	: 29
Color	: +0 +0 +0

Project name: Forsmark

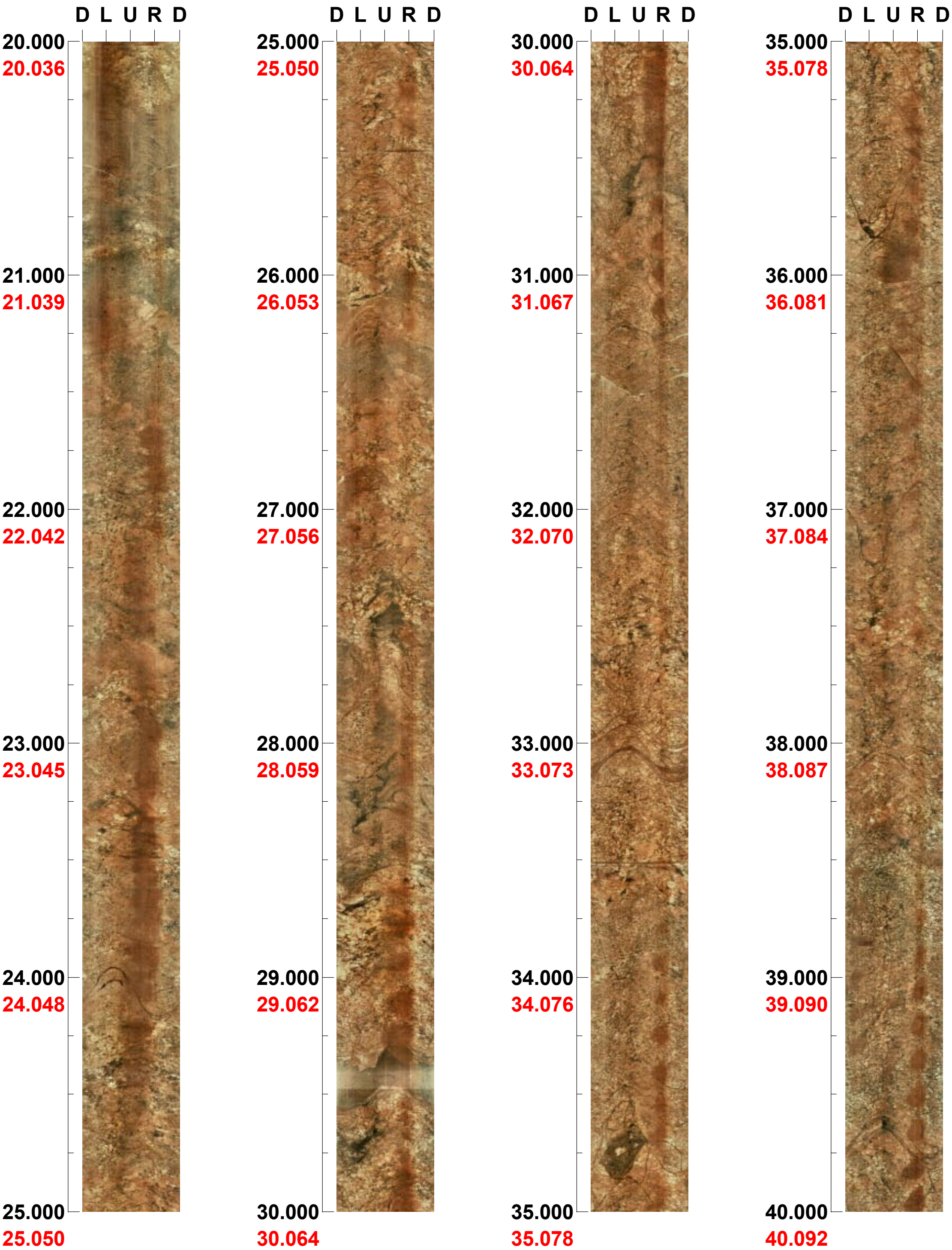
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 0.000 - 20.000 m

Project name: Forsmark

Bore hole No.: KFM09A   Azimuth: 200   Inclination: -60

Depth range: 20.000 - 40.000 m



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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 40.000 - 60.000 m

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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 60.000 - 80.000 m

D L U R D

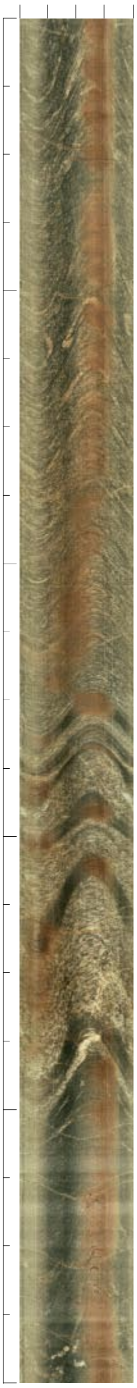
60.000 / 60.166
61.000 / 61.170
62.000 / 62.175
63.000 / 63.179
64.000 / 64.184
65.000 / 65.188

D L U R D

65.000 / 65.188
66.000 / 66.193
67.000 / 67.197
68.000 / 68.202
69.000 / 69.206
70.000 / 70.211

D L U R D

70.000 / 70.211
71.000 / 71.215
72.000 / 72.220
73.000 / 73.224
74.000 / 74.229
75.000 / 75.233



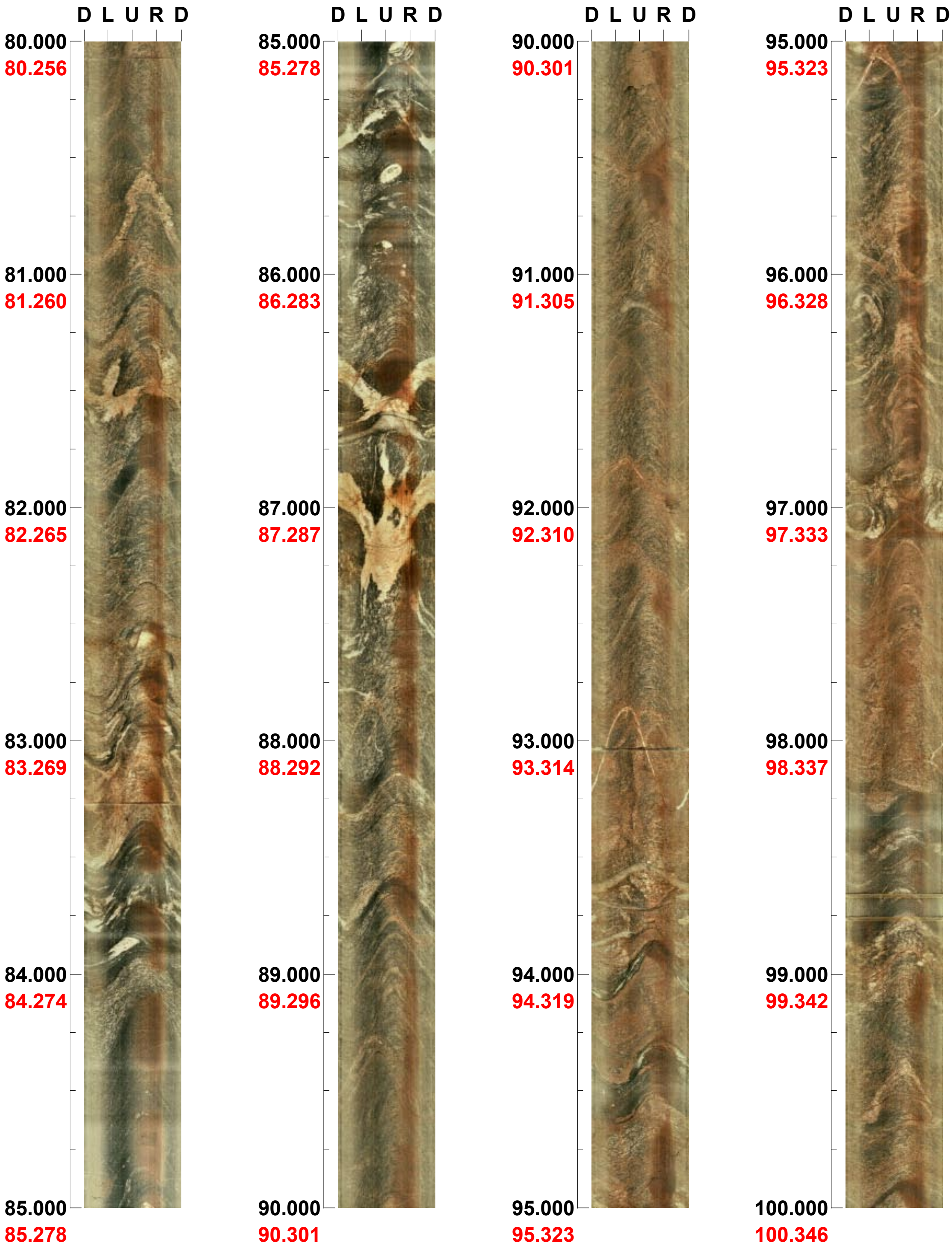
D L U R D

75.000 / 75.233
76.000 / 76.238
77.000 / 77.242
78.000 / 78.247
79.000 / 79.251
80.000 / 80.256

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 80.000 - 100.000 m



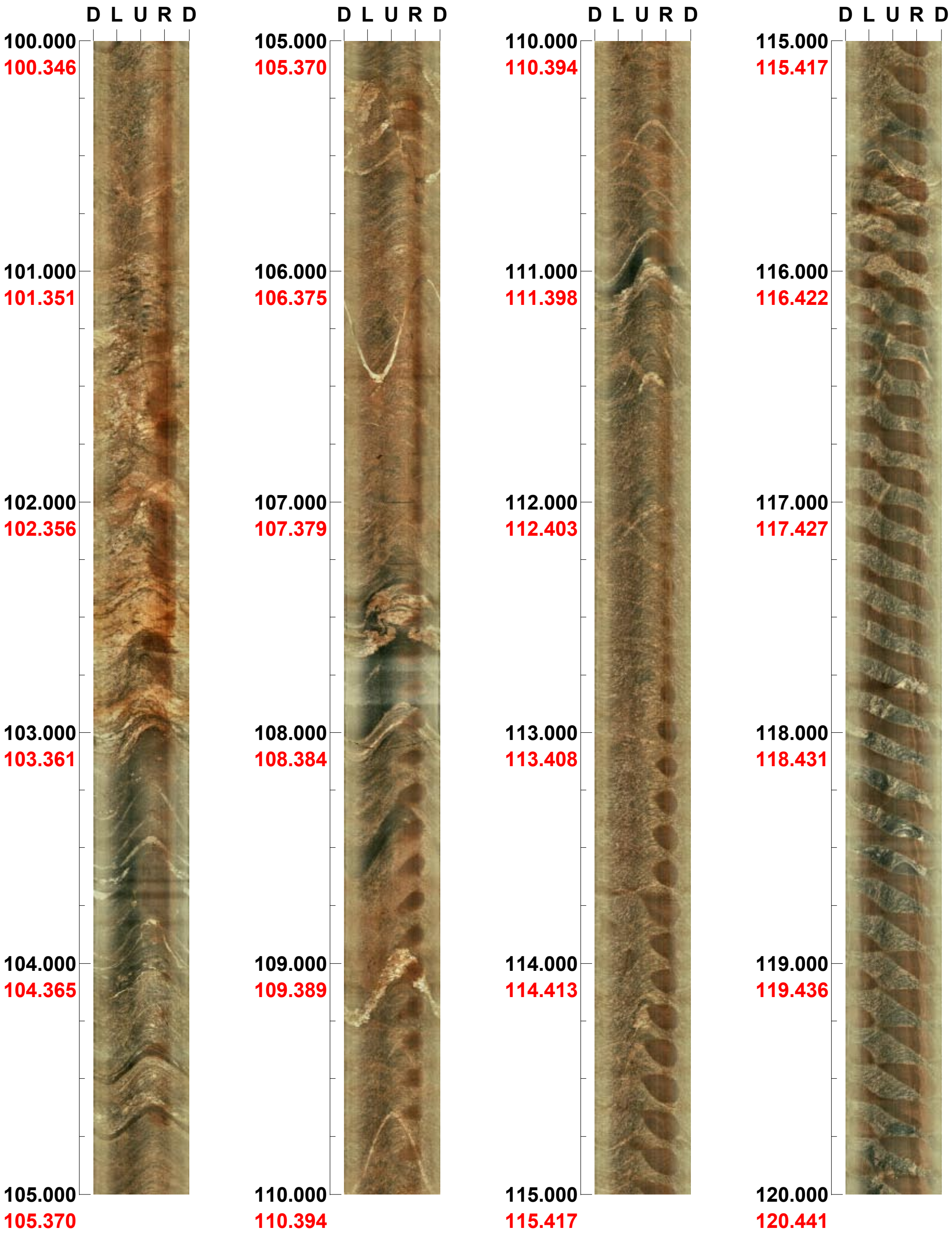
(5 / 29) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Forsmark

Bore hole No.: KFM09A

Azimuth: 200 Inclination: -60

Depth range: 100.000 - 120.000 m



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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 120.000 - 140.000 m

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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 140.000 - 160.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A Azimuth: 200 Inclination: -60

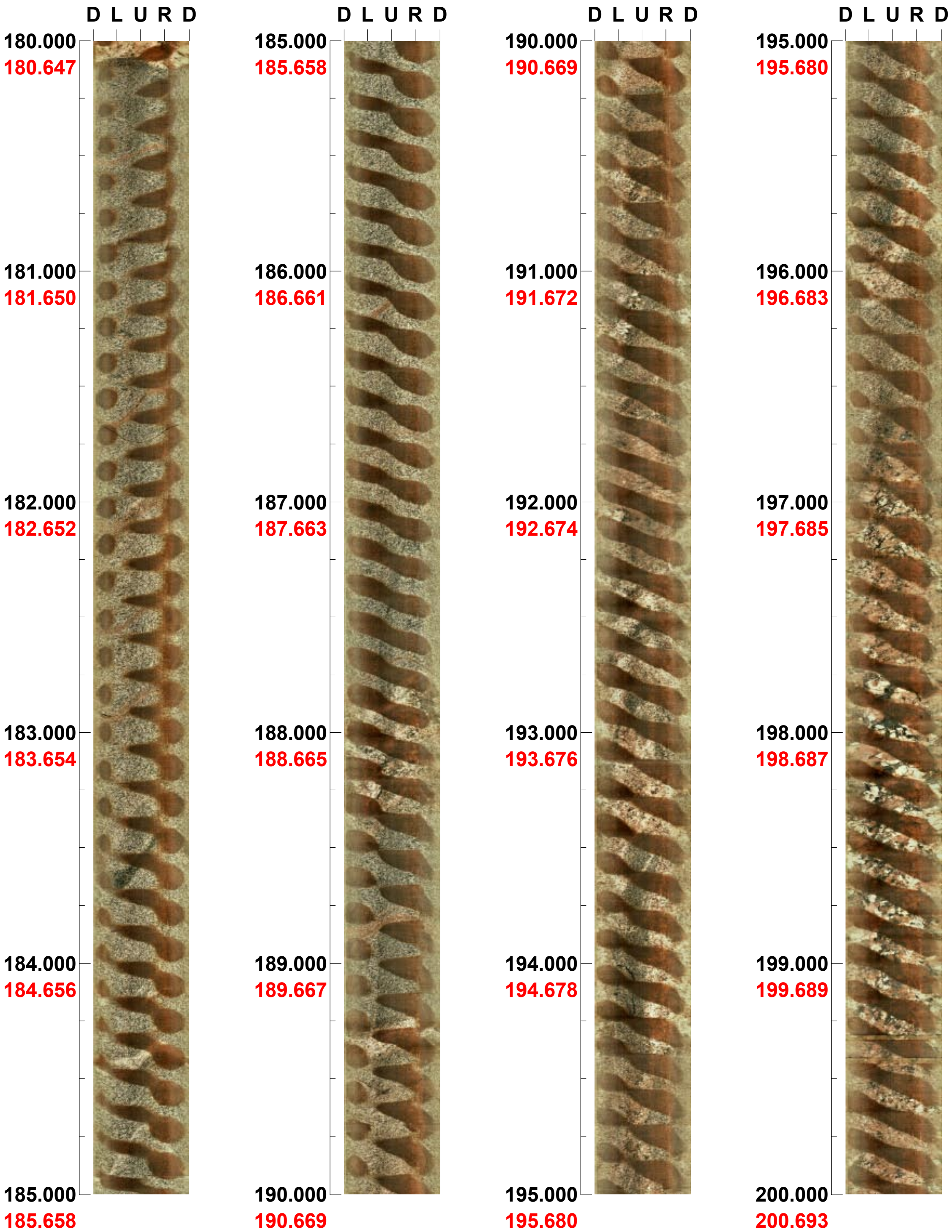
Depth range: 160.000 - 180.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A

Azimuth: 200 Inclination: -60

Depth range: 180.000 - 200.000 m



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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 200.000 - 220.000 m

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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 220.000 - 240.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A Azimuth: 200 Inclination: -60

Depth range: 240.000 - 260.000 m

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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 260.000 - 280.000 m

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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 300.000 - 320.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 300.000 - 320.000 m

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

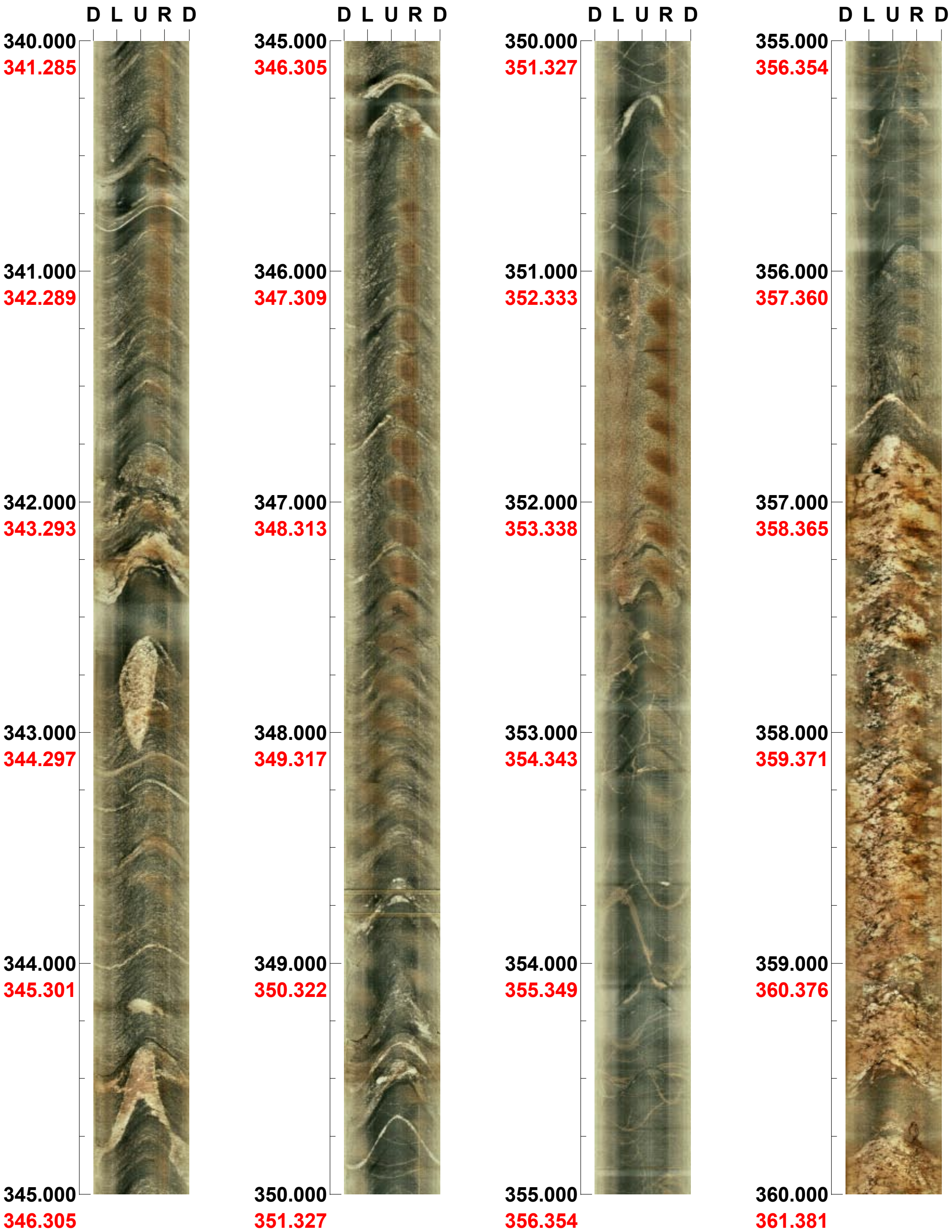
Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 320.000 - 340.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A Azimuth: 200 Inclination: -60

Depth range: 340.000 - 360.000 m



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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 360.000 - 380.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 380.000 - 400.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A   Azimuth: 200   Inclination: -60

Depth range: 400.000 - 420.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 420.000 - 440.000 m

D L U R D

420.000 421.690
421.000 422.694
422.000 423.699
423.000 424.704
424.000 425.708
425.000 426.713

D L U R D

425.000 426.713
426.000 427.718
427.000 428.722
428.000 429.727
429.000 430.731
430.000 431.736

D L U R D

430.000 431.736
431.000 432.741
432.000 433.745
433.000 434.750
434.000 435.754
435.000 436.759

D L U R D

435.000 436.759
436.000 437.764
437.000 438.768
438.000 439.773
439.000 440.778
440.000 441.782

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 440.000 - 460.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 460.000 - 480.000 m

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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 480.000 - 500.000 m

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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 500.000 - 520.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A   Azimuth: 200   Inclination: -60

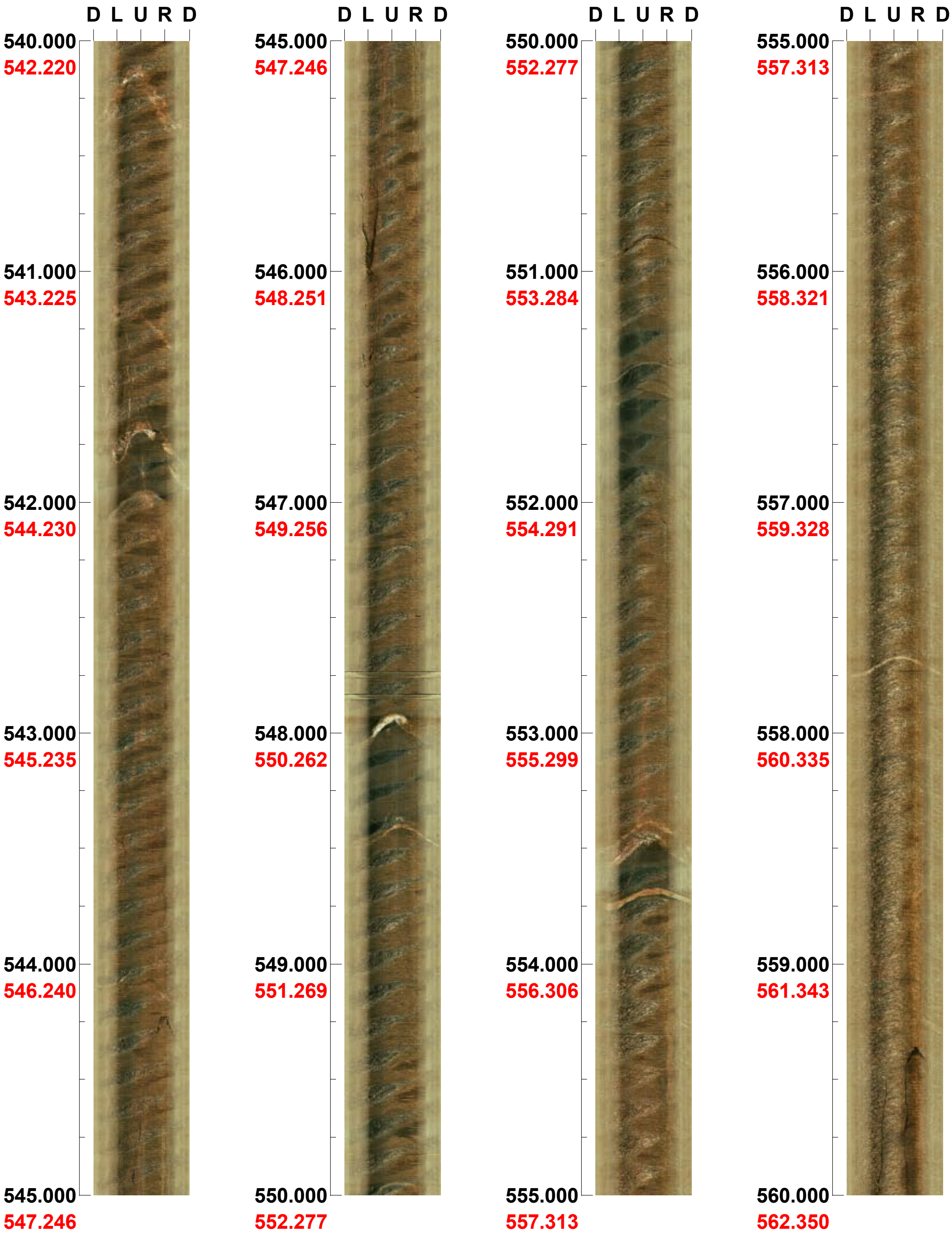
Depth range: 520.000 - 540.000 m

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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 540.000 - 560.000 m



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

Project name: Forsmark

Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 560.000 - 580.000 m

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

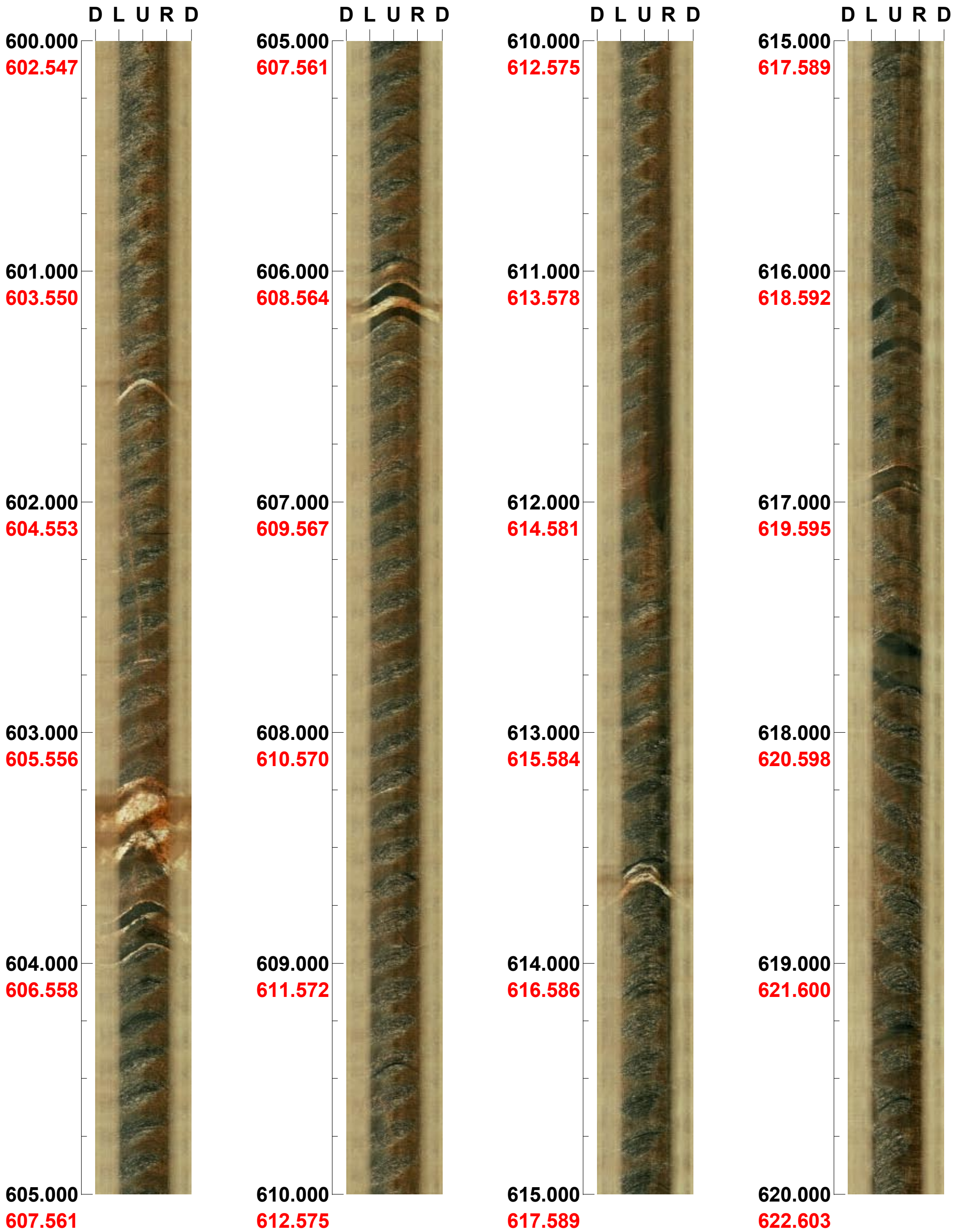
Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 580.000 - 600.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A Azimuth: 200 Inclination: -60

Depth range: 600.000 - 620.000 m



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

Project name: Forsmark

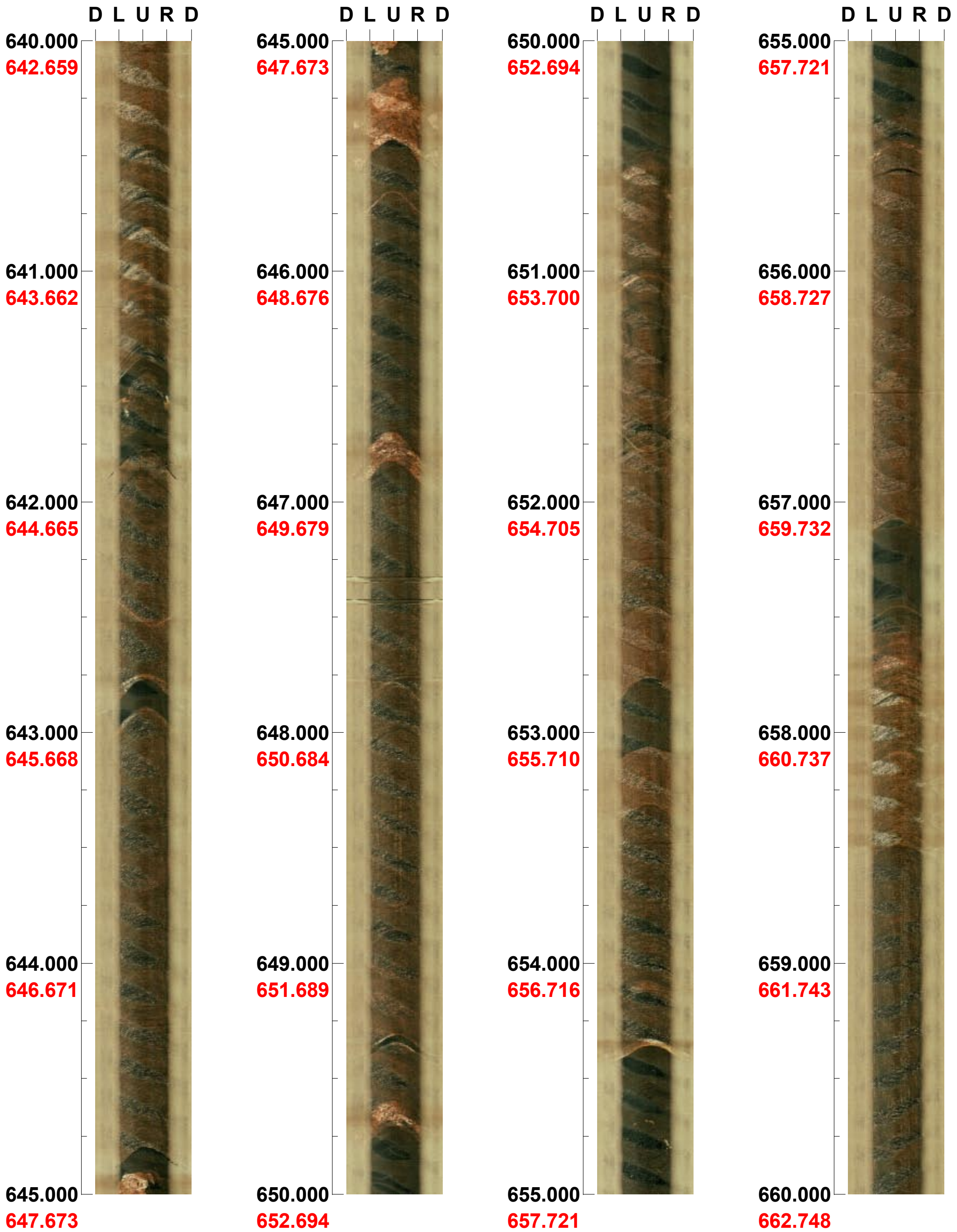
Bore hole No.: KFM09A   Azimuth: 200   Inclination: -60

Depth range: 620.000 - 640.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A Azimuth: 200 Inclination: -60

Depth range: 640.000 - 660.000 m



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

Project name: Forsmark
Bore hole No.: KFM09A Azimuth: 200 Inclination: -60

Depth range: 660.000 - 680.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A Azimuth: 200 Inclination: -60

Depth range: 680.000 - 700.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 700.000 - 720.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 720.000 - 740.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A Azimuth: 200 Inclination: -60

Depth range: 740.000 - 760.000 m

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

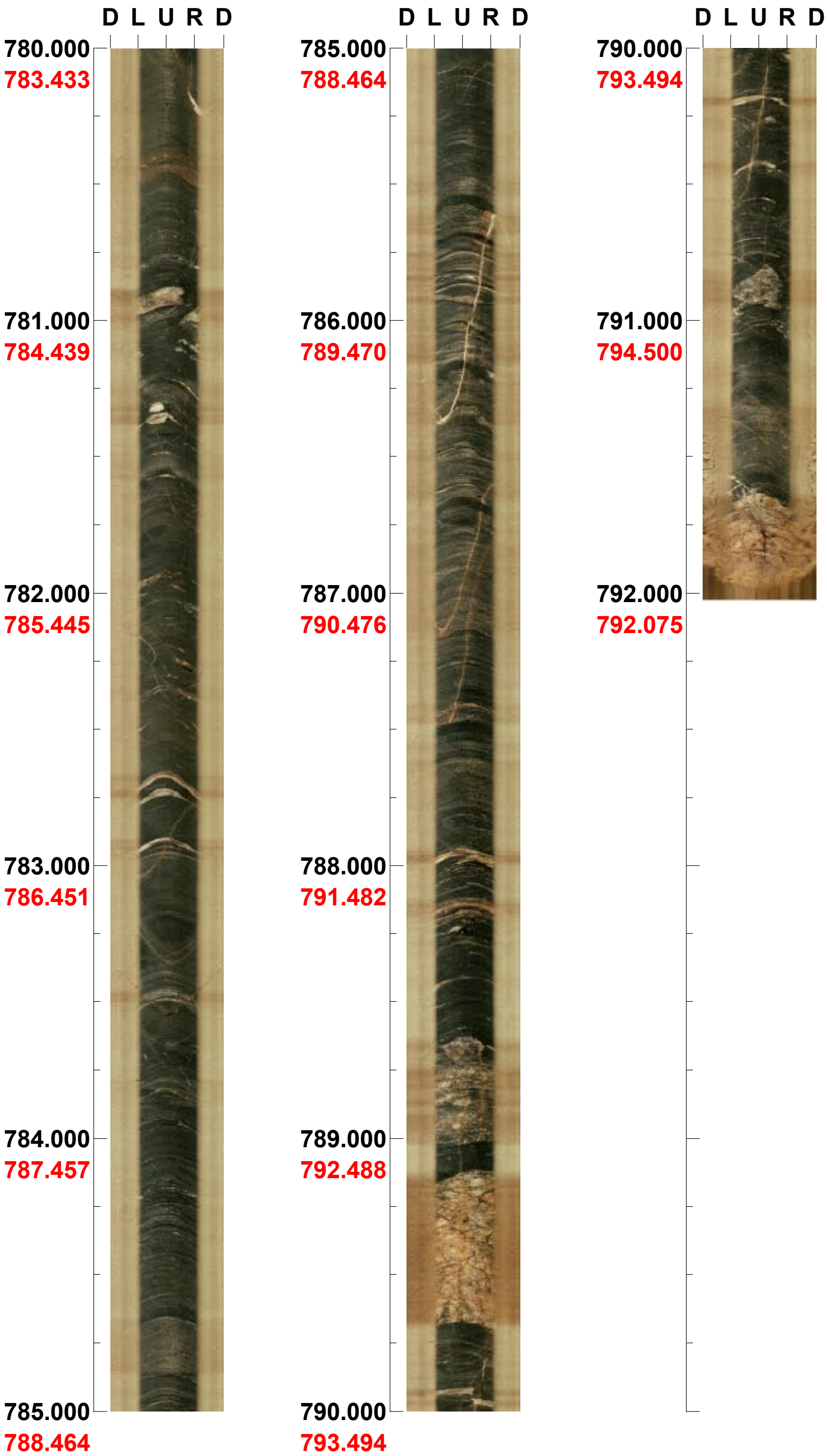
Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 760.000 - 780.000 m

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

Project name: Forsmark
Bore hole No.: KFM09A **Azimuth: 200** **Inclination: -60**

Depth range: 780.000 - 792.022 m



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

Appendix 8

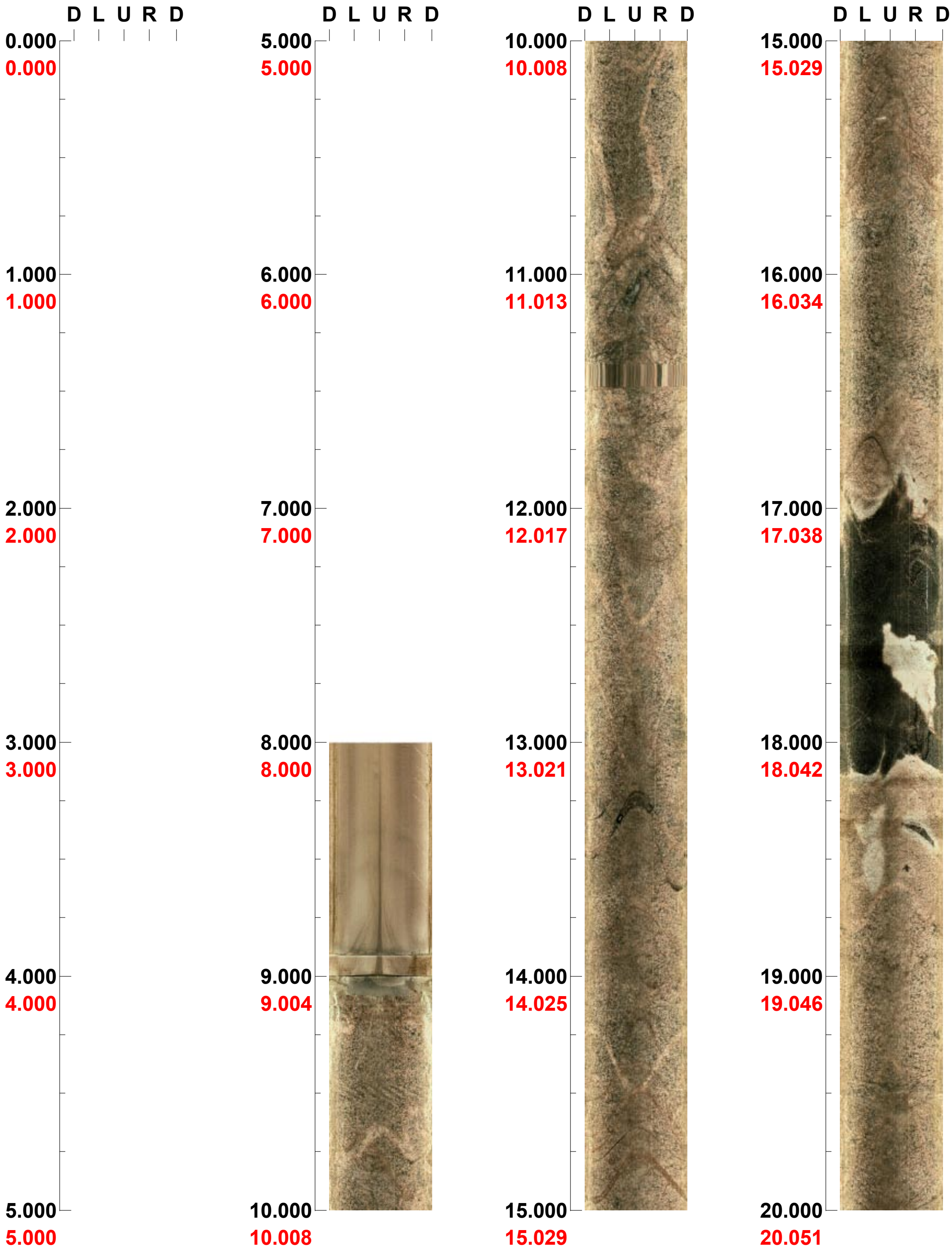
BIPS logging in HFM25, 8 to 186 m

Project name: Forsmark

Image file	: c:\work\r5478s~1\hfm25\bips\hfm25.bip
BDT file	: c:\work\r5478s~1\hfm25\bips\hfm25.bdt
Locality	: FORSMARK
Bore hole number	: HFM25
Date	: 05/11/04
Time	: 11:10:00
Depth range	: 8.000 - 186.375 m
Azimuth	: 141
Inclination	: -58
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.: HFM25 **Azimuth: 141** **Inclination: -58**

Depth range: 0.000 - 20.000 m



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

Project name: Forsmark
Bore hole No.: HFM25 **Azimuth: 141** **Inclination: -58**

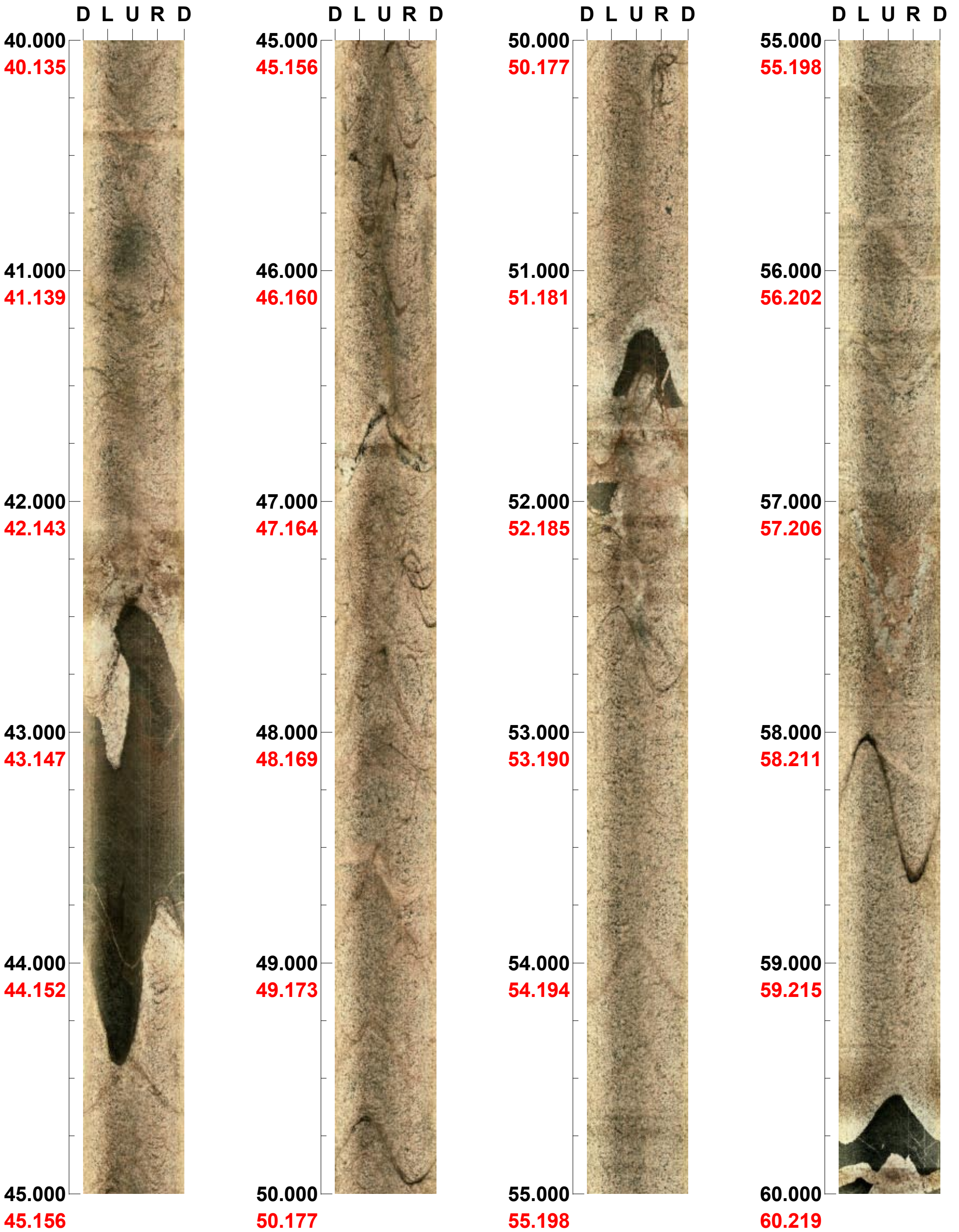
Depth range: 20.000 - 40.000 m

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

Project name: Forsmark

Bore hole No.: HFM25 **Azimuth: 141** **Inclination: -58**

Depth range: 40.000 - 60.000 m

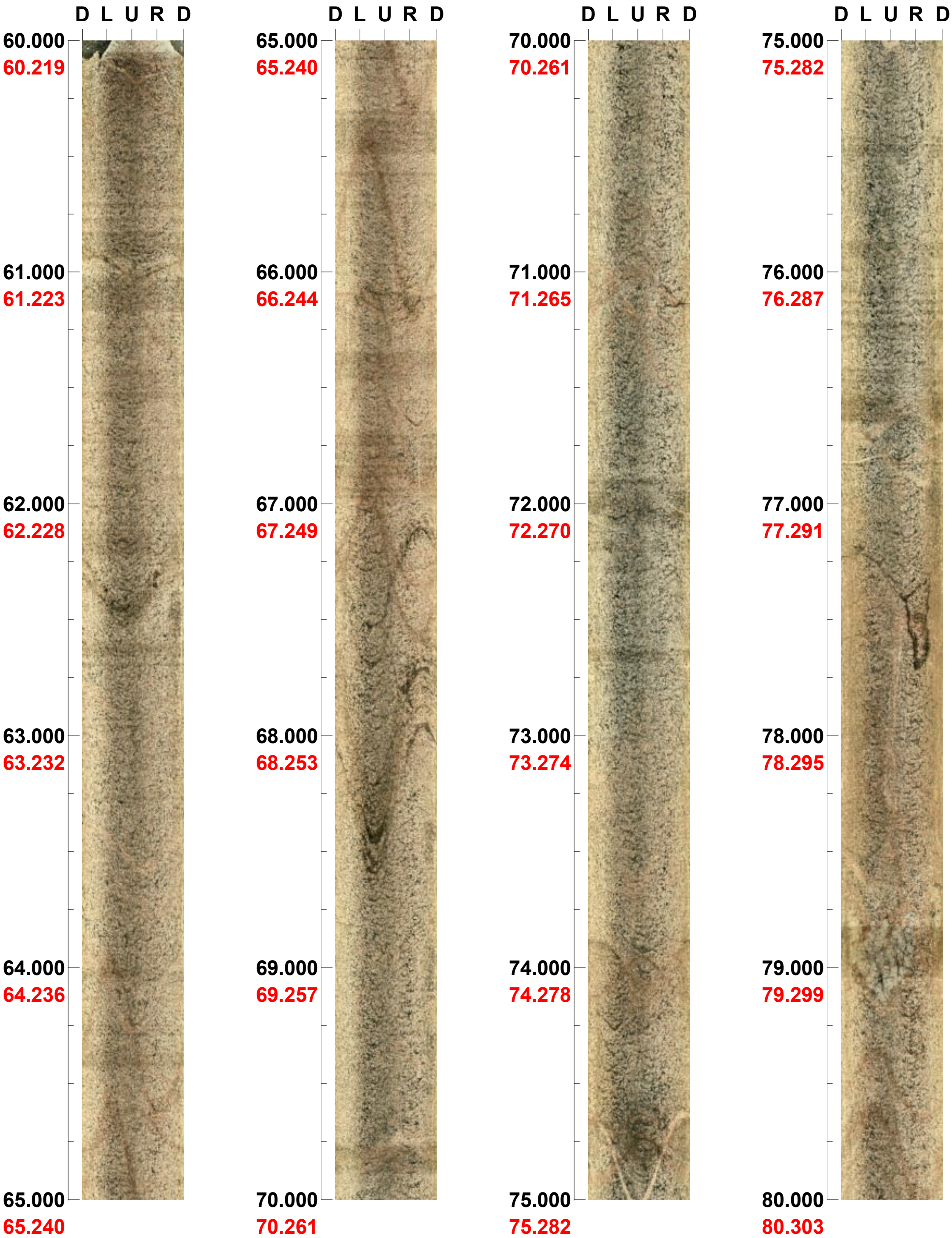


(3 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark

Bore hole No.: HFM25 **Azimuth: 141** **Inclination: -58**

Depth range: 60.000 - 80.000 m



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

Project name: Forsmark

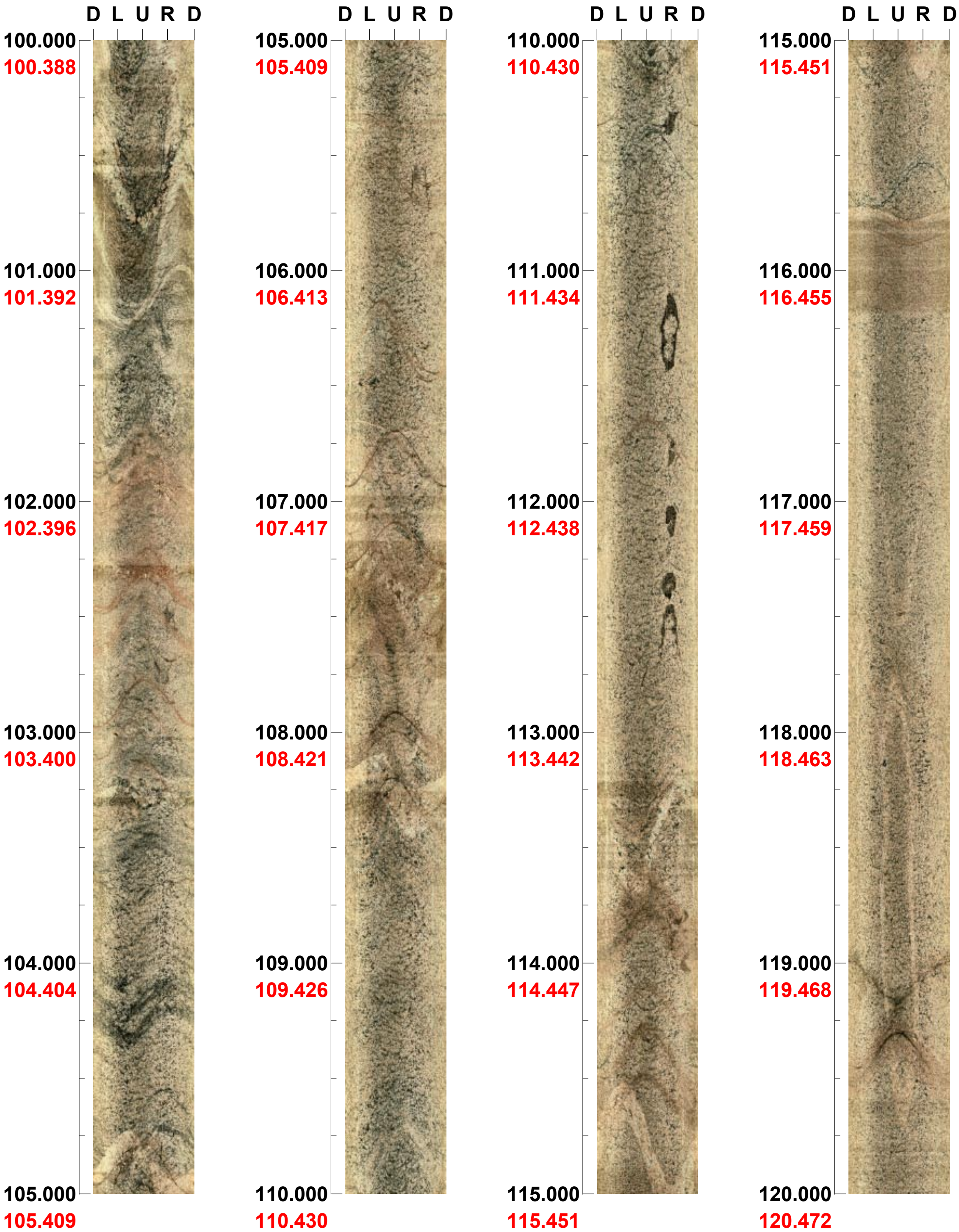
Bore hole No.: HFM25 **Azimuth: 141** **Inclination: -58**

Depth range: 80.000 - 100.000 m

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

Project name: Forsmark
Bore hole No.: HFM25 **Azimuth: 141** **Inclination: -58**

Depth range: 100.000 - 120.000 m



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

Project name: Forsmark
Bore hole No.: HFM25 **Azimuth: 141** **Inclination: -58**

Depth range: 120.000 - 140.000 m

D L U R D

120.000
120.472

121.000
121.476
122.000
122.480
123.000
123.485
124.000
124.489
125.000
125.493

D L U R D

125.000
125.493

126.000
126.497
127.000
127.501
128.000
128.506
129.000
129.510
130.000
130.514

D L U R D

130.000
130.514

131.000
131.518
132.000
132.522
133.000
133.527
134.000
134.531
135.000
135.535

D L U R D

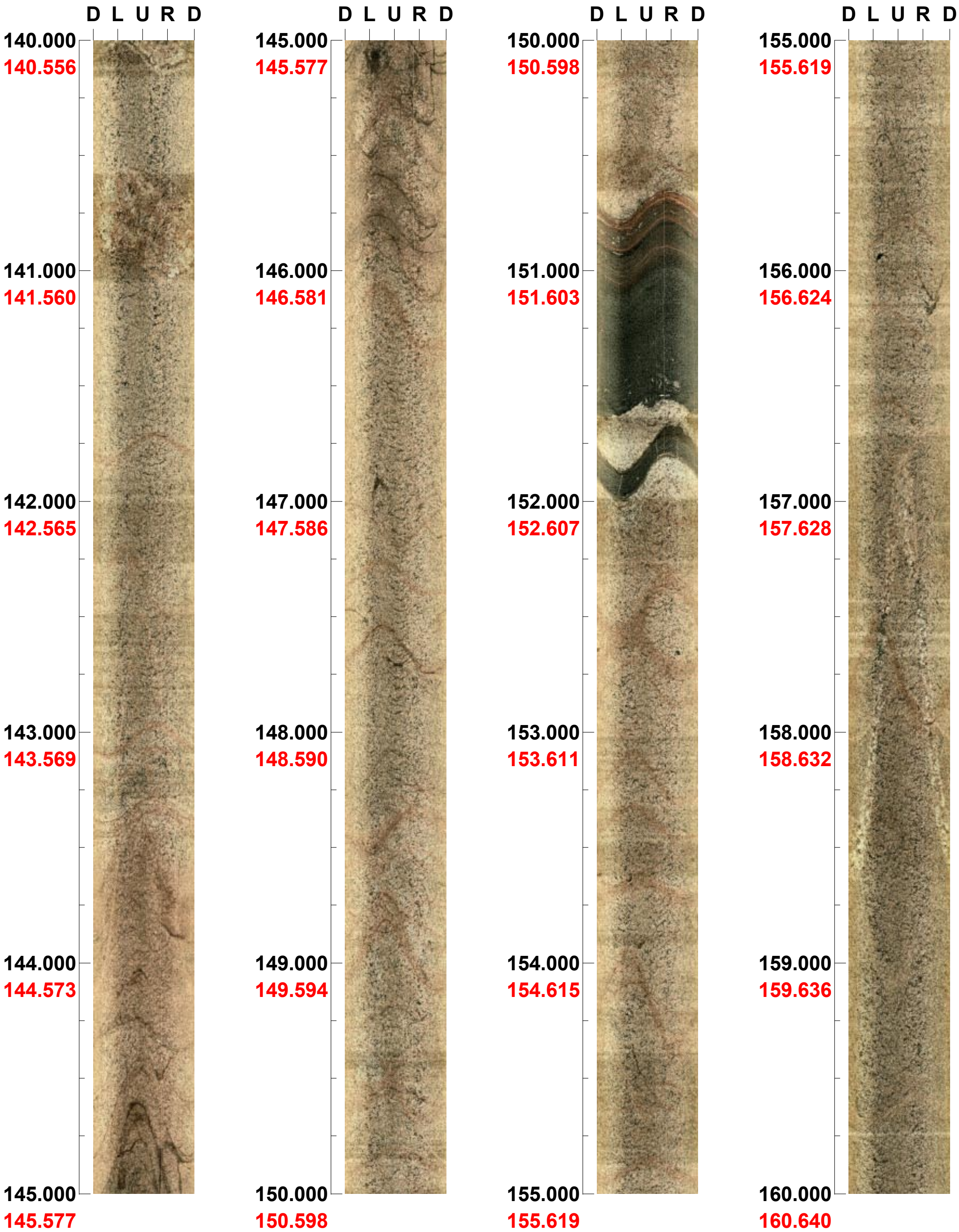
135.000
135.535

136.000
136.539
137.000
137.544
138.000
138.548
139.000
139.552
140.000
140.556

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

Project name: Forsmark
Bore hole No.: HFM25 Azimuth: 141 Inclination: -58

Depth range: 140.000 - 160.000 m

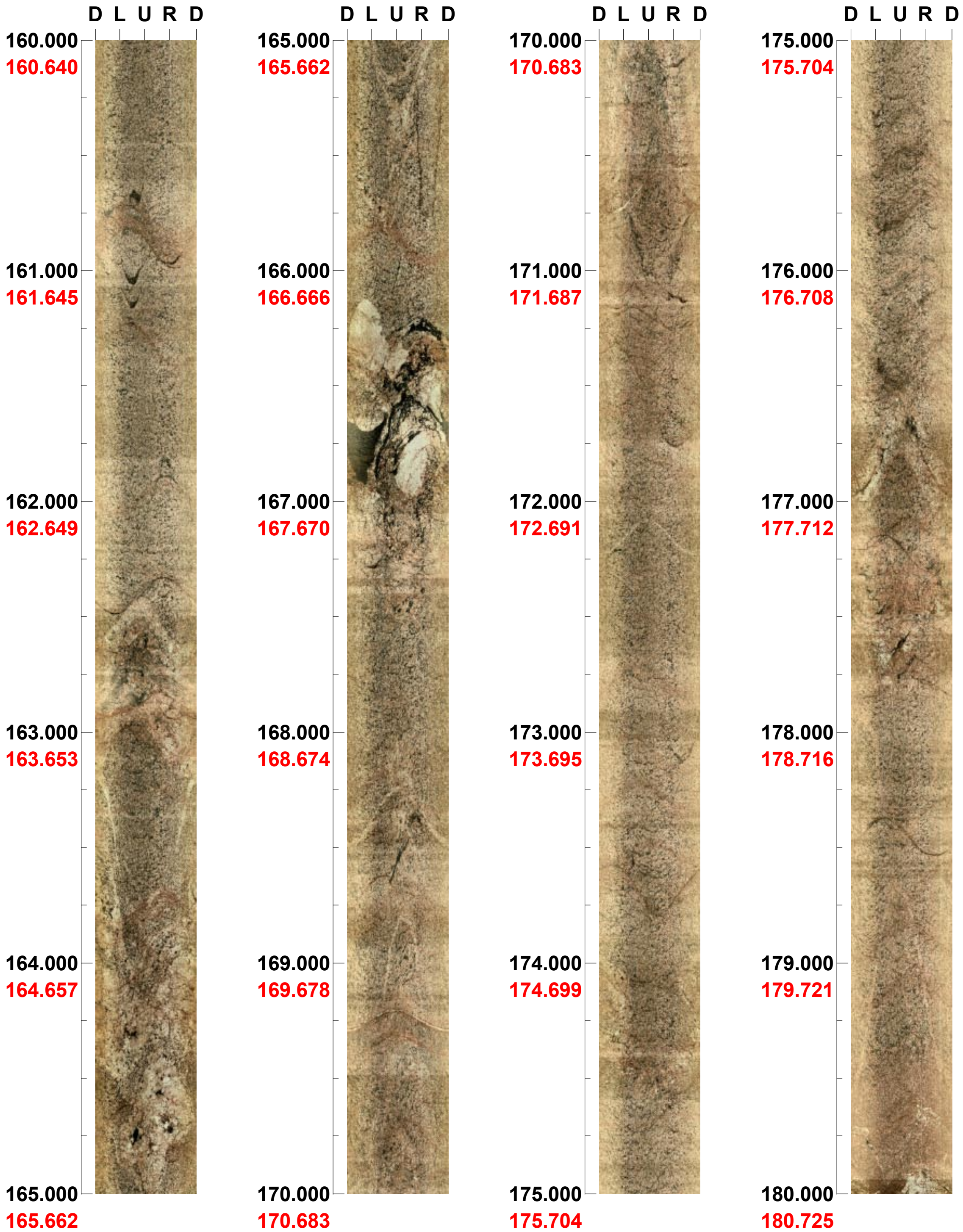


(8 / 10) Scale: 1/25 Aspect ratio: 100 %

Project name: Forsmark

Bore hole No.: HFM25 **Azimuth: 141** **Inclination: -58**

Depth range: 160.000 - 180.000 m

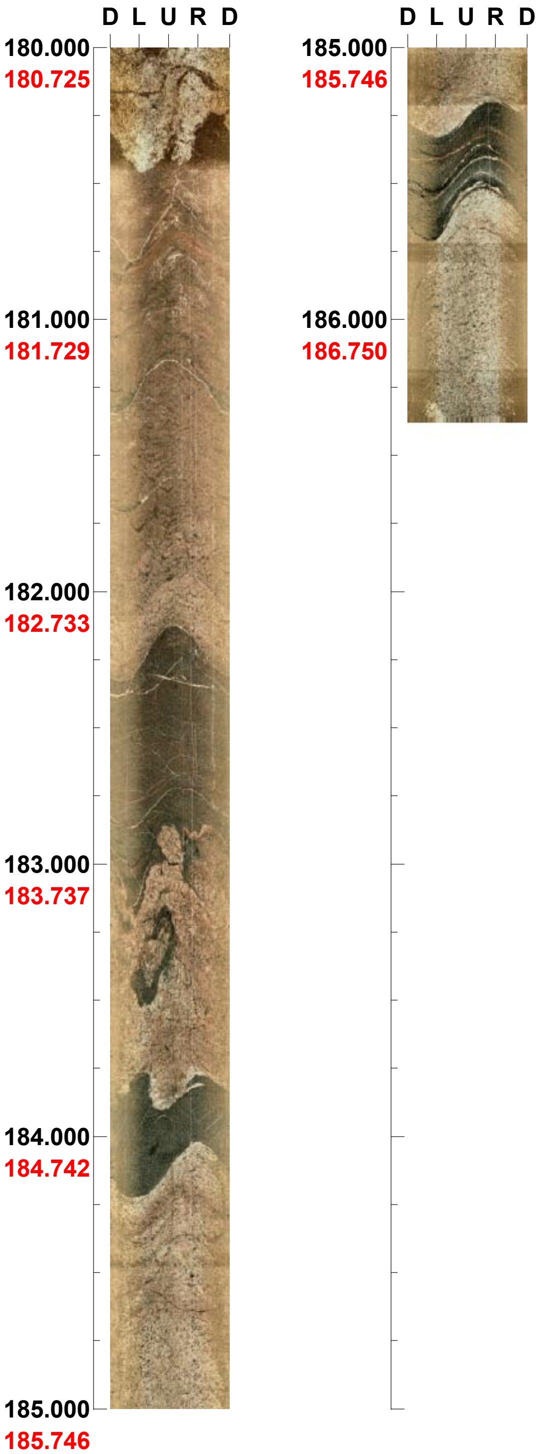


(9 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Forsmark
Bore hole No.: HFM25

Azimuth: 141 Inclination: -58

Depth range: 180.000 - 186.375 m



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

Appendix 9

BIPS logging in HFM28, 11 to 145 m

Project name: Forsmark

Image file	: c:\work\r5484f~1\hfm28\bips\hfm28.bip
BDT file	: c:\work\r5484f~1\hfm28\bips\hfm28.bdt
Locality	: FORSMARK
Bore hole number	: HFM28
Date	: 06/01/17
Time	: 20:04:00
Depth range	: 11.000 - 148.653 m
Azimuth	: 145
Inclination	: -85
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	: 8
Color	: +0 +0 +0

Project name: Forsmark
Bore hole No.: HFM28 **Azimuth: 145** **Inclination: -85**

Depth range: 0.000 - 20.000 m

D L U R D

0.000
0.000
1.000
1.000
2.000
2.000
3.000
3.000
4.000
4.000
5.000
5.000

D L U R D

5.000
5.000
6.000
6.000
7.000
7.000
8.000
8.000
9.000
9.000
10.000
10.000

D L U R D

10.000
10.000
11.000
11.000
12.000
12.004
13.000
13.009
14.000
14.013
15.000
15.018

D L U R D

15.000
15.018
16.000
16.022
17.000
17.026
18.000
18.031
19.000
19.035
20.000
20.039

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

Project name: Forsmark

Bore hole No.: HFM28 **Azimuth: 145** **Inclination: -85**

Depth range: 20.000 - 40.000 m

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

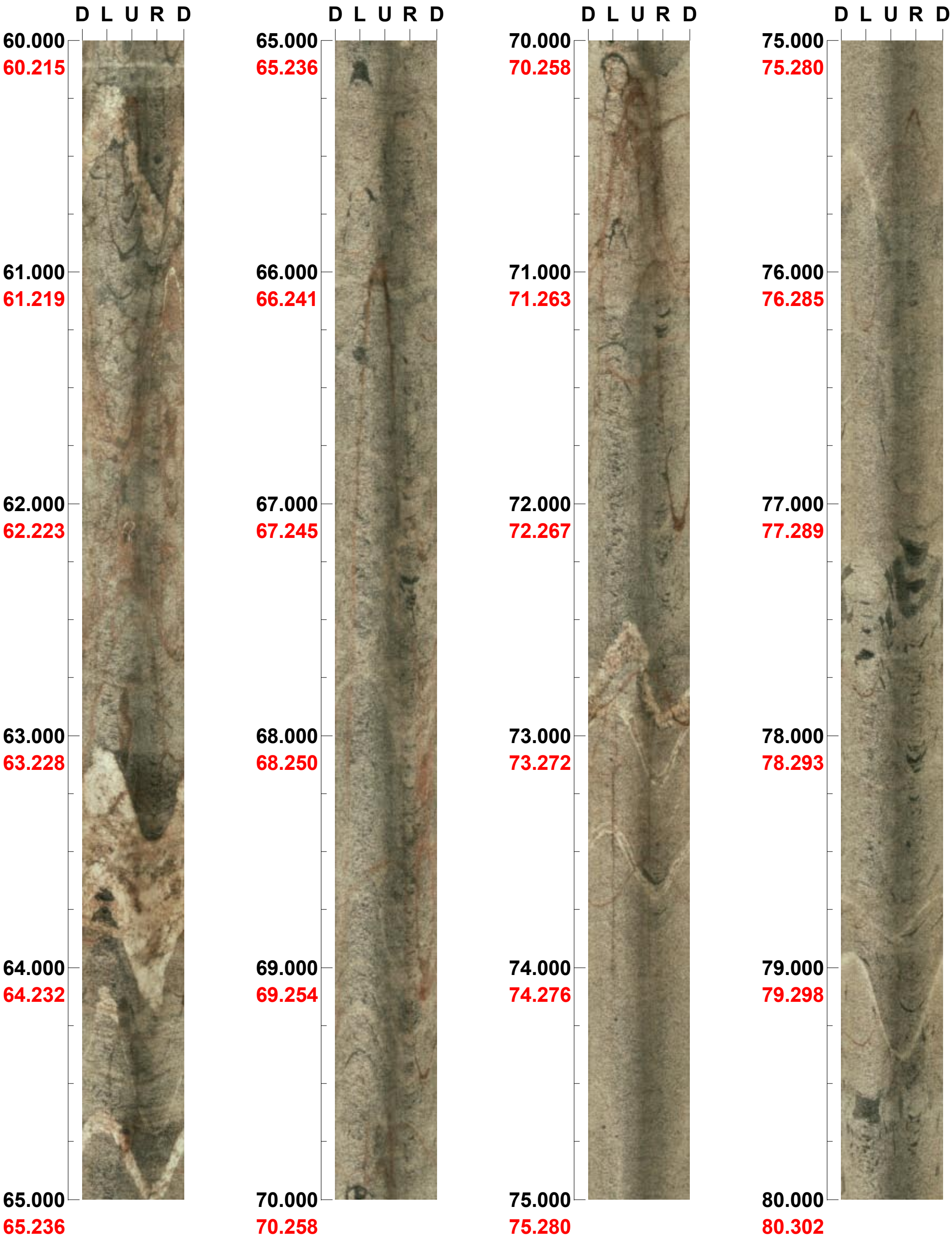
Project name: Forsmark
Bore hole No.: HFM28 **Azimuth: 145** **Inclination: -85**

Depth range: 40.000 - 60.000 m

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

Project name: Forsmark
Bore hole No.: HFM28 **Azimuth: 145** **Inclination: -85**

Depth range: 60.000 - 80.000 m



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

Project name: Forsmark
Bore hole No.: HFM28 **Azimuth: 145** **Inclination: -85**

Depth range: 80.000 - 100.000 m

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

Project name: Forsmark
Bore hole No.: HFM28 **Azimuth: 145** **Inclination: -85**

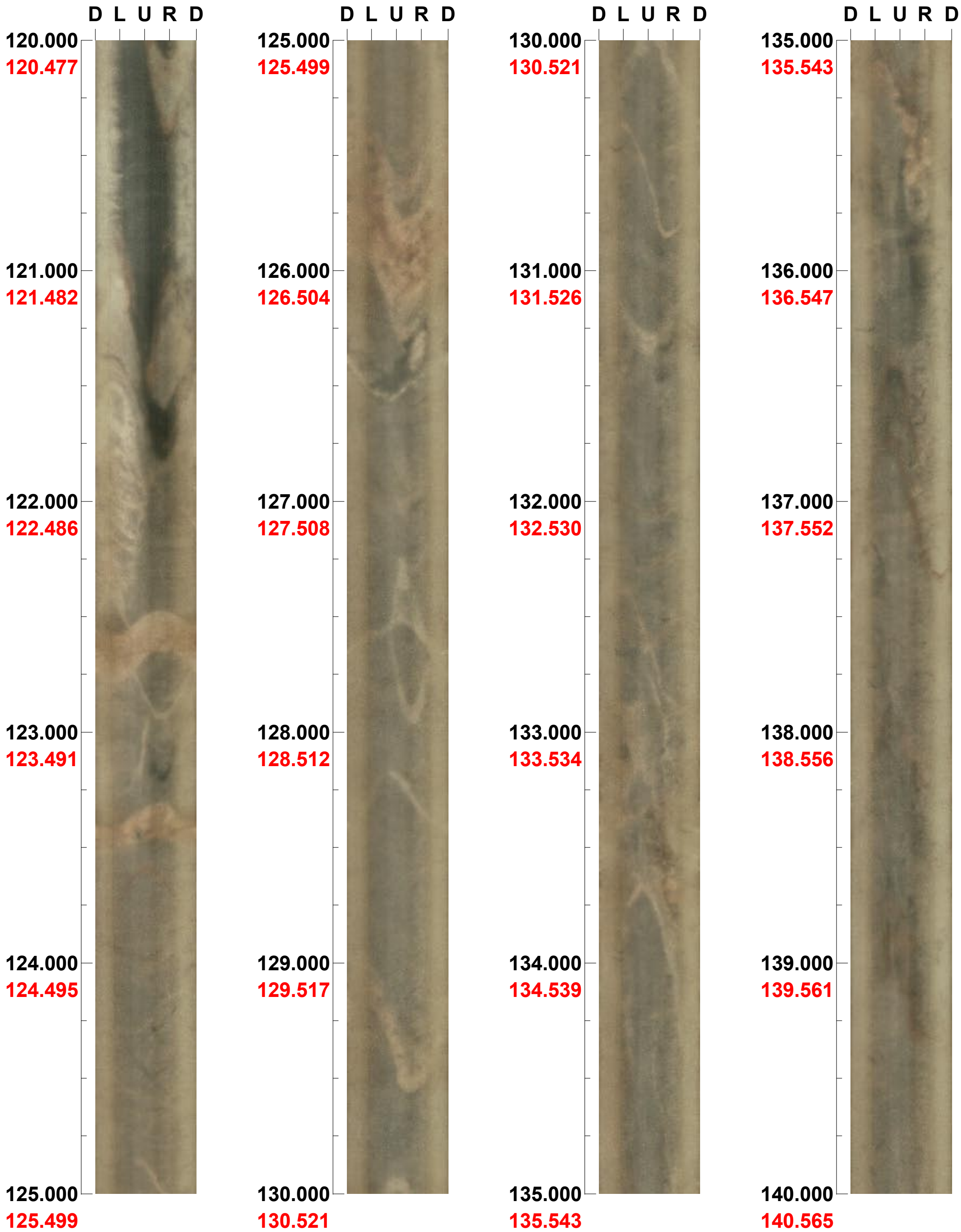
Depth range: 100.000 - 120.000 m

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

Project name: Forsmark

Bore hole No.: HFM28 **Azimuth: 145** **Inclination: -85**

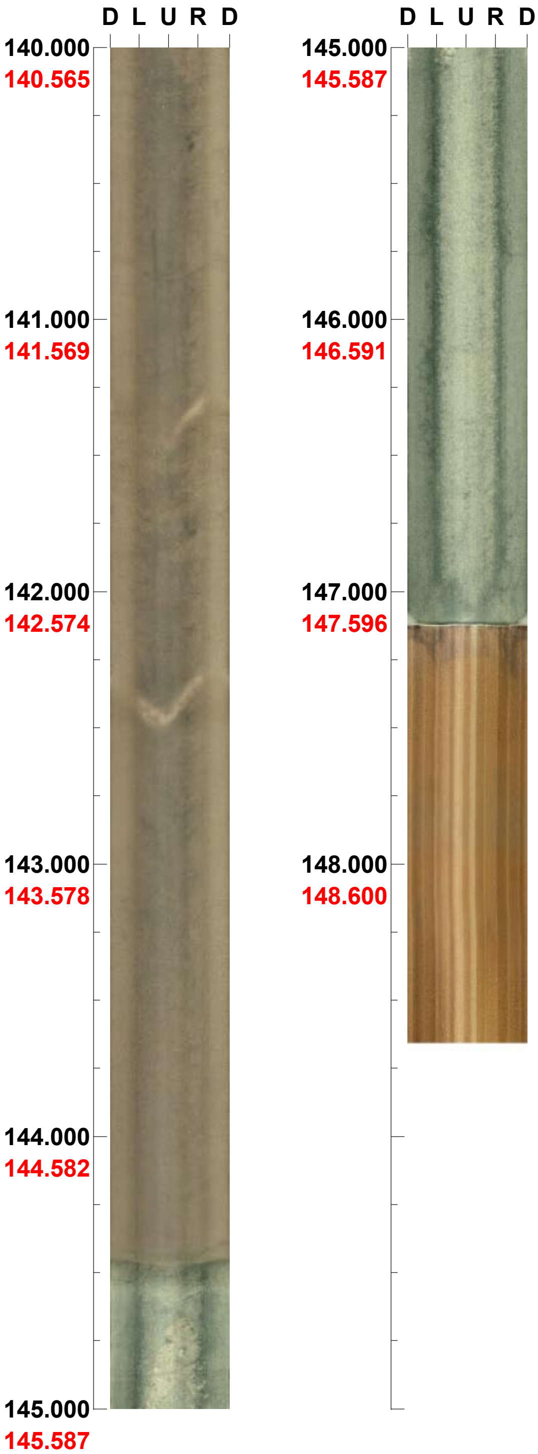
Depth range: 120.000 - 140.000 m



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

Project name: Forsmark
Bore hole No.: HFM28 **Azimuth: 145** **Inclination: -85**

Depth range: 140.000 - 148.653 m



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