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Forsmark site investigation

RAMAC and BIPS logging in boreholes KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32

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April 2006

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

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Abstract

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) in the core-drilled borehole KFM09B and in the percussion-drilled boreholes HFM24, HFM26, HFM27, HFM29 and HFM32. All measurements were conducted by Malå Geoscience AB/RAYCON during two campaigns in January 2006 except for the re-measurements in March of the BIPS in KFM09B from 440 m down to the bottom of the borehole.

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 KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32 was relatively satisfying, but in some parts of low 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 KFM09B 149 reflectors were identified, of which 39 were orientated (dip/strike). 36 reflectors were identified in HFM24, 36 reflectors in HFM26, 25 reflectors in HFM27, 55 reflectors in HFM29 and 14 reflectors in HFM32.

The BIPS images are of various quality. Bad water quality in the bottom part of KFM09B resulted in re-measurement of that part. The second run resulted in improved images. For the percussion-drilled boreholes the quality are acceptable for the images except for HFM26 were the borehole walls are covered with dark material probably induced from the drilling.

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Forsmark. Mätningarna som presenteras här omfattar BIPS-loggning och borrhålsradarmätningar (RAMAC) i KFM09B, HFM24, HFM26, HFM27, HFM29 och HFM32. Alla mätningar är utförda av Malå Geoscience AB/RAYCON under två mätkampanjer i januari 2006, utom omloggning av BIPS i nedre delen av KFM09B som genomfördes under mars 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 KFM01C, KFM09B, HFM24, HFM26, HFM27och HFM29 var relativt tillfredställande, men tidvis av dålig kvalité troligen till stor del beroende på en konduktiv miljö. En konduktiv miljö minskar möjligheterna att identifiera strukturer från borrhålsradardata. Dock har 149 radarreflektorer identifierats i KFM09B, varav 39 orienterade med strykning och stupning. I HFM24 identifierades 36 strukturer, i HFM26 36 strukturer, i HFM27 25 strukturer, i HFM29 55 strukturer och i HFM32 14 strukturer.

BIPS data är av varierande kvalitet för de rubricerade borrhålen. Sämst kvalitet var det i den nedre delen av KFM09B där det också har genomförts en omloggning som resulterade i ett bättre resultat. Av hammarborrhålen uppvisar samtliga borrhål en bra kvalitet förutom i HFM26 där bilderna blev mycket mörka, troligen beroende på material som satt sig på borrhålsväggen under borrning.

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 coredrilled borehole KFM09B and in the percussion-drilled boreholes HFM24, HFM26, HFM27, HFM29 and HFM32. The work was carried out in accordance with activity plan AP PF 400-05-112. 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 615 m in KFM09B. In HFM24 the loggings were performed to approximately 150 m borehole length, in HFM26 to 200 m, in HFM27 to 125 m, in HFM29 and HFM32 to approximately 200 m. The percussion-drilled boreholes have a diameter of approximately 140 mm and the core-drilled borehole a diameter of 76 mm.

All measurements were conducted by Malå Geoscience AB/RAYCON during January and March 2006. Figure 1-1 shows the location of the boreholes surveyed.

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 KFM01C (0–450 m) och KFM09B (0–615 m) samt HFM24, HFM26, HFM27 och HFM29 samt tillägg avseende HFM23 och HFM32.	AP PF 400-05-112	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

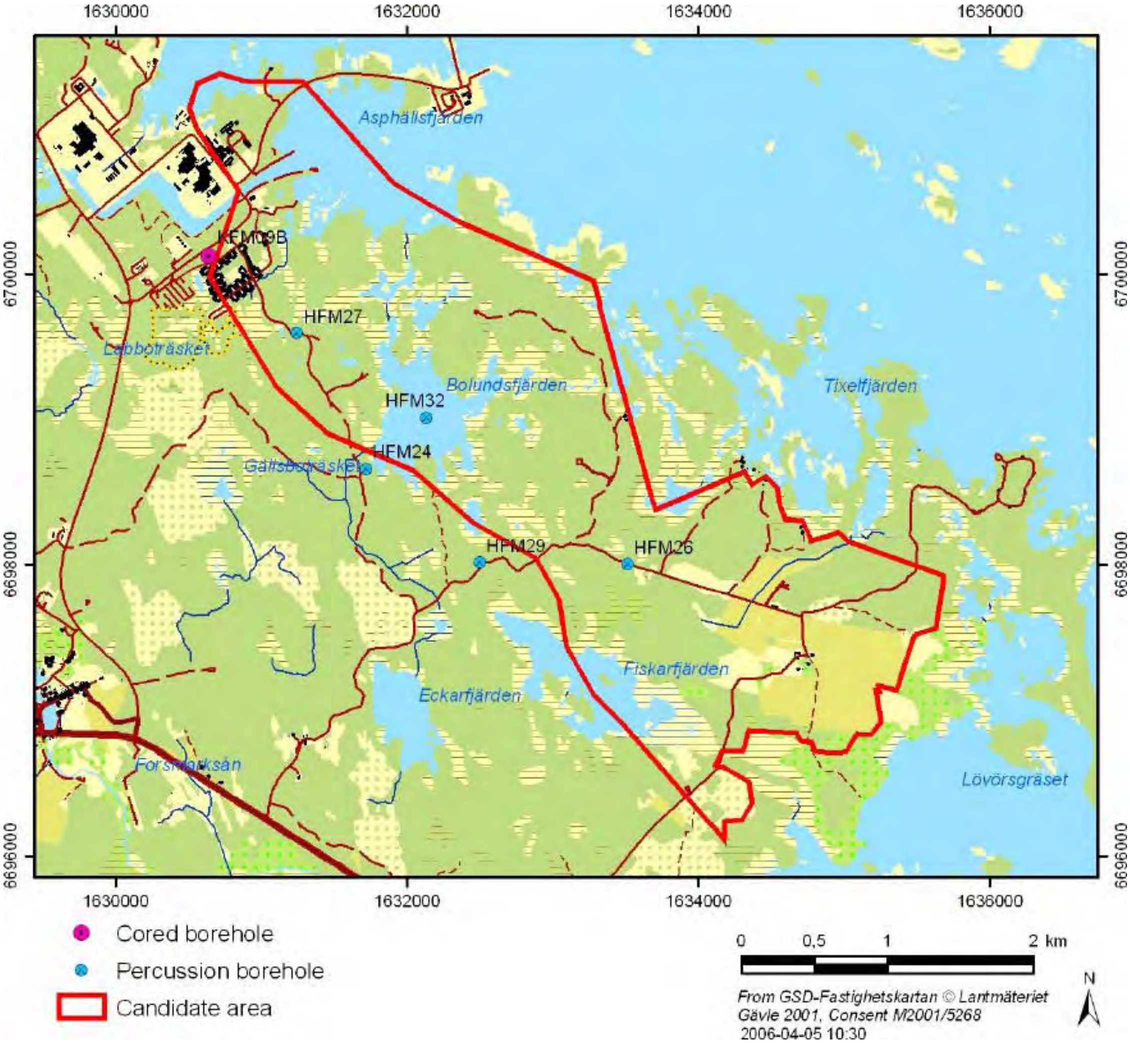


Figure 1-1. *General overview over the Forsmark area showing the location of the boreholes surveyed and presented in this report.*

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.

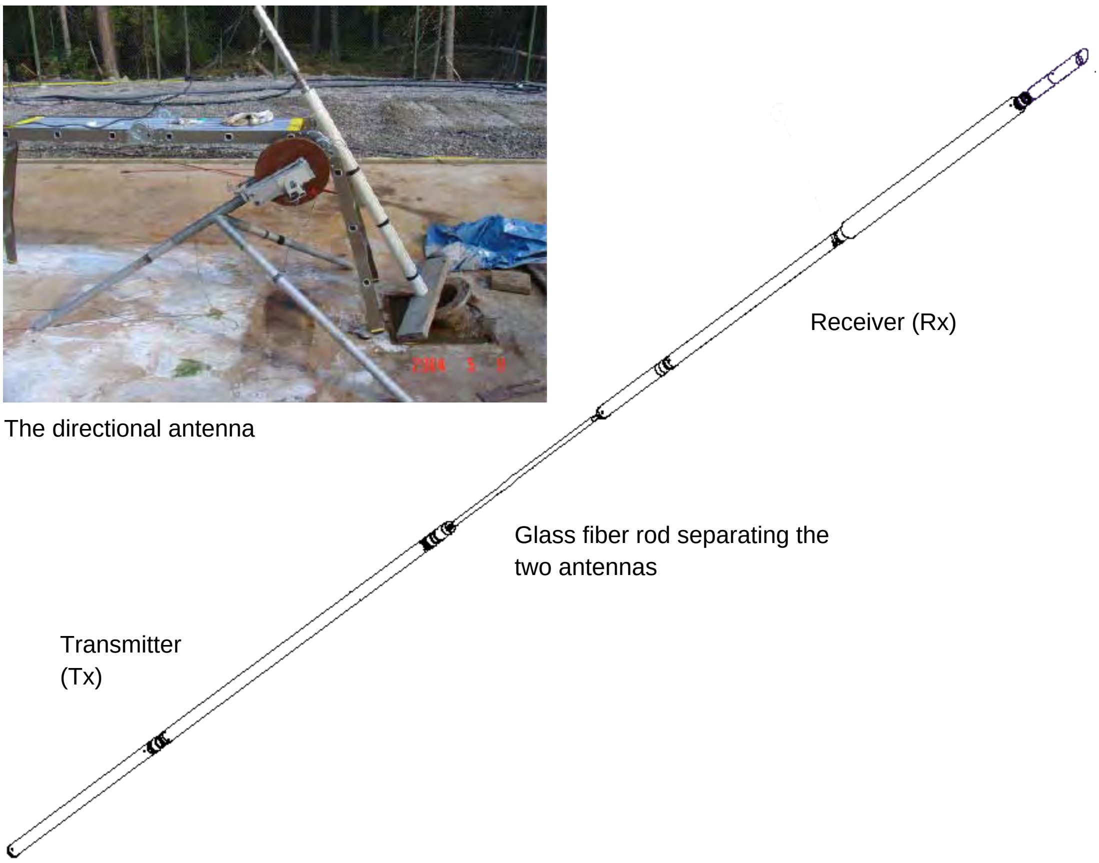


Figure 3-1. *Example of a borehole radar antenna.*

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 (in near-vertical boreholes) or with a gravity sensor (in inclined boreholes).

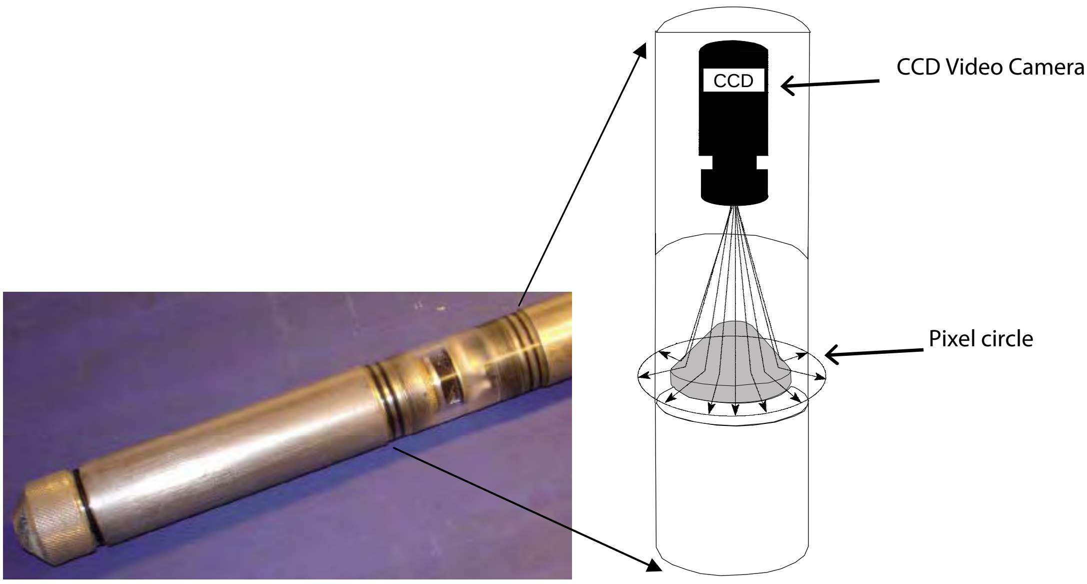


Figure 3-2. The BIP-system. To the right a sketch showing the principles of the conical mirror.

4 Execution

4.1 General

4.1.1 RAMAC Radar

The radar measurements in KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32 were carried out with dipole radar antennas, with frequencies of 250, 100 and 20 MHz. In KFM09B 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 4-6. 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 KFM09B. The test was performed by taking measurements in the air, where the receiver antenna and the transmitter antenna are placed several metres apart. While transmitting and measuring, the receiver antenna is rotated about its axis. The difference in direction achieved from the directional antenna and from a compass was about 13 degrees. This can be considered to be acceptable, considering the disturbed environment with metallic objects etc at the test site.

For more information on system settings used in the investigation of KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32 see Tables 4-1 to 4-6 below.

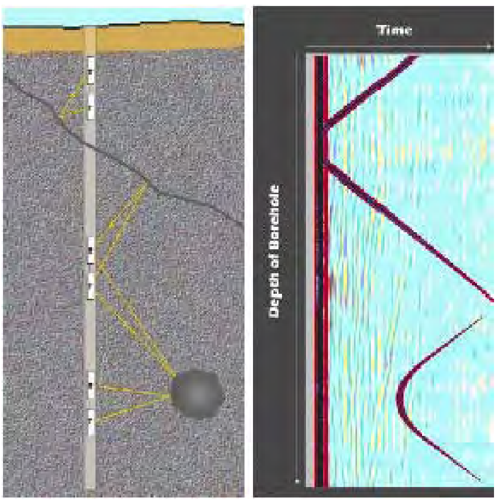


Figure 4-1. *The principle of radar borehole reflection survey (left) and an example of result (right).*

Table 4-1. Radar logging information from KFM09B.

Site:	**Forsmark**	**Logging company:**	**RAYCON**		
BH:	**KFM09B**	**Equipment:**	**SKB RAMAC**		
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
		Directional	**250MHz**	**100MHz**	**20MHz**
	Logging date:	06-01-26	06-01-25	06-01-25	06-01-25
	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	603
	Number of stacks:	32	Auto	Auto	Auto
	Signal position:	410.5	–0.34	–0.35	–1.42
	Logging from (m):	12.4	1.5	2.6	6.25
	Logging to (m):	607.4	607.4	608.6	607.7
	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 HFM24.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM24**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG/JG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Logging date:	06-01-03	06-01-03	06-01-03
	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):	149.9	149.1	144.95
	Trace interval (m):	0.1	0.2	0.25
	Antenna separation (m):	2.4	3.9	10.05

Table 4-3. Radar logging information from HFM26.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM26**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Logging date:	06-01-17	06-01-17	06-01-17
	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):	201.5	200.9	197.85
	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 HFM27.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM27**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG/JG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Logging date:	06-01-03	06-01-03	06-01-03
	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):	125.8	124.7	120.75
	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 HFM29.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM29**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG/JG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Logging date:	06-01-04	06-01-04	06-01-04
	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):	199.6	197.9	193.2
	Trace interval (m):	0.1	0.2	0.25
	Antenna separation (m):	2.4	3.9	10.05

Table 4-6. Radar logging information from HFM32.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM32**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Logging date:	06-01-19	06-01-19	06-01-19
	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):	200.4	200.5	197.4
	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 KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32.

In order to control the quality of the system, calibration measurements were performed in a test pipe before logging and after logging. Figures 4-2 and 4-3 corresponds to the test loggings performed before and after the two logging campaigns in January. 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 7 to 12 in this report.

4.1.3 Length measurements

During logging the borehole length recording for the RAMAC systems is taken care of by a measuring wheel mounted on the cable winch. The length is measured from TOC (Top of Casing), and the length is adjusted to the bottom of casing according to 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 on the logging cable where the length mark is observed is marked with scotch tape. During BIPS logging the measured length was adjusted to true length according to length marks visible in the BIPS image. The adjusted true length is marked with red numbers in the BIPS image plot, together with the non-adjusted length (black numbers), see Appendices 7 to 12. The tape marks on the logging cable are then used for controlling the RAMAC measurement.

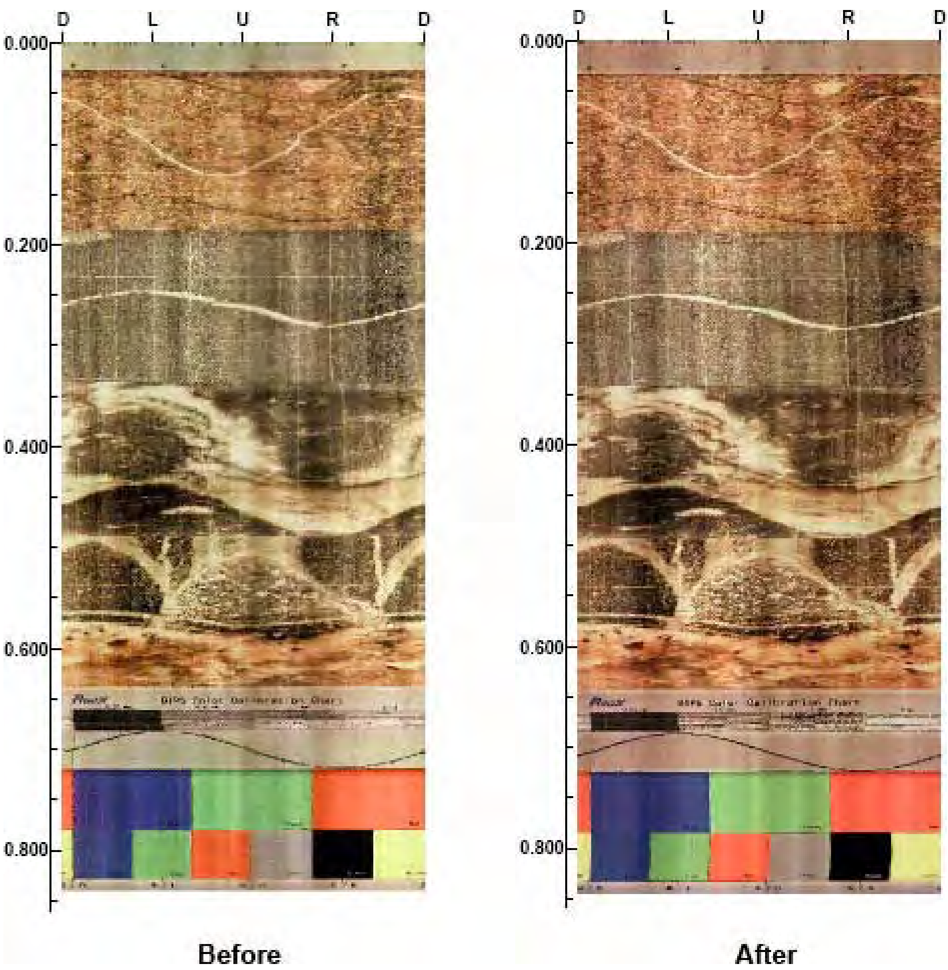


Figure 4-2. *Results from BIPS logging in the test pipe before and after the logging campaign January 2nd to 4th, 2006.*

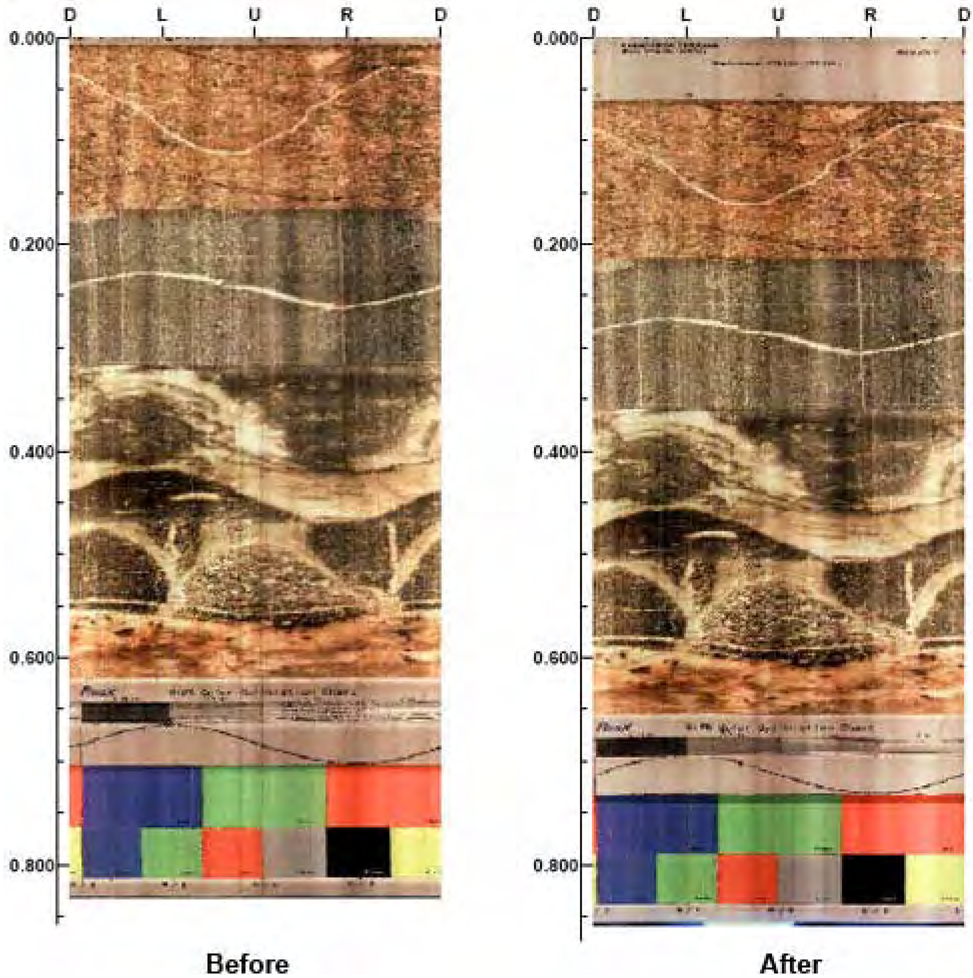


Figure 4-3. Results from BIPS logging in the test pipe before and after the logging campaign in January 16th to 31st, 2006.

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 length 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 colour corresponds to the large positive signals and white colour to large negative signals. Grey colour corresponds to no reflected signals.

The presented data in this report is adjusted for the separation of the antennas, and 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 bore-hole (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 constant at the site of investigation.

The visualization of data in Appendices 1 to 6 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 6 are listed in Tables 4-7 to 4-12. 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.

There exists several methods to determine the radar wave propagation velocity. Each of them has its advantages and 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.

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 5-7 to 5-12 and are also visible on the radargrams in Appendices 1 to 6.

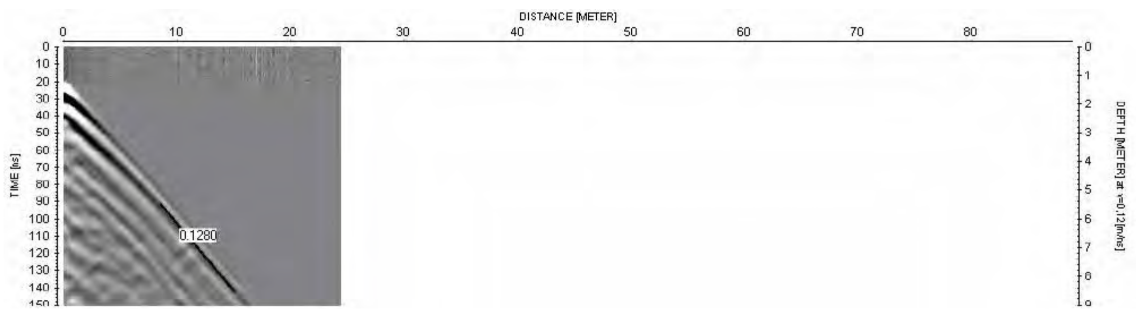


Fig 4-4. *Results from velocity measurements in HFM03.*

Table 4-7. Processing steps for borehole radar data from KFM09B.

Site:	**Forsmark**	**Logging company:**	**RAYCON**		
BH:	**KFM09B**	**Equipment:**	**SKB RAMAC**		
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**JG**	**Antenna**			
		Directional	**250MHz**	**100MHz**	**20MHz**
	Processing:	Move start time (–47 samples)	Move start time (–19.3)	Move start time (–39.1)	Move start time (–82.5)
		DC shift (400–510)	DC shift (190–230)	DC shift (460–520)	DC shift (1,800–2,100)
		Time gain (start 79 lin 150 exp 2)	Gain (start 16 lin 1.4 exp 4)	Gain (start 54 lin 2.5 exp 0.5)	Gain (start 105 lin 3.6 exp 0.9)
		(FIR)			

Table 4-8. Processing steps for borehole radar data from HFM24.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM24**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**JG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Processing:	Move start time (–34)	Move start time (–62.3)	Move start time (–112)
		DC shift (190–230)	DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 19 lin 1 exp 1.4)	Gain (start 35 lin 1.4 exp 0.6)	Gain (start 120 lin 2.5 exp 0.09)
				Bandpass 10/40

Table 4-9. Processing steps for borehole radar data from HFM26.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM26**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**JG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Processing:	Move start time (–34.3)	Move start time (–52.8)	Move start time (–110)
		DC shift (190–230)	DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 21 lin 0.15 exp 2)	Gain (start 50 lin 2.5 exp 0.2)	Gain (start 115 lin 2.4 exp 0.2)

Table 4-10. Processing steps for borehole radar data from HFM27.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM27**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**JG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Processing:	Move start time (–34.8)	Move start time (–54.7)	Move start time (–117)
		DC shift (190–230)	DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 21 lin 0.8 exp 1)	Gain (start 60 lin 0.6 exp 0.8)	Gain (start 121 lin 1 exp 0.2)
				Bandpass 10/40

Table 4-11. Processing steps for borehole radar data from HFM29.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM29**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**JG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Processing:	Move start time (–32.2)	Move start time (–56.2)	Move start time (–100.8)
		DC shift (190–230)	DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 17 lin 1.7 exp 0.8)	Gain (start 37 lin 0.6 exp 0.7)	Gain (start 124 lin 1 exp 0.1)

Table 4-12. Processing steps for borehole radar data from HFM32.

Site:	**Forsmark**	**Logging company:**	**RAYCON**	
BH:	**HFM32**	**Equipment:**	**SKB RAMAC**	
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**JG**	**Antenna**		
		250MHz	**100MHz**	**20MHz**
	Processing:	Move start time (–33.3)	Move start time (–51.3)	Move start time (–107)
		DC shift (190–230)	DC shift (460–520)	DC shift (1,800–2,100)
		Gain (start 25 lin 0.2 exp 0)	Gain (start 55 lin 1.7 exp 0.2)	Gain (start 170 lin 1.1 exp 0.1)

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

Two boreholes (KFM01C and HFM23) are included in the present activity plan (AP PF 400-05-112), but not reported in this report for the following reasons.

During the first logging campaign, 2nd to 4th January, the BIPS logging in KFM01C was interrupted at approximately 200 m due to problems in the borehole. This logging was completed during the second logging campaign, together with measurements with the RAMAC dipole antennas. However, during this second logging campaign the RAMAC directional antenna was stuck at 85 m, due to stabilization plates in the borehole. Therefore this borehole will be reported at a later stage.

The logging of HFM23 could not be carried out due to the extreme dip in the lower parts of the borehole (from –54 degrees in the beginning to –4 degrees at the end). At 105 m the dip is –21 degrees and the BIPS probe got stuck even though push rods were used. To perform the logging to the end of the borehole a drill rig is most probably needed in order to push the BIPS probes.

5 Results

The results from the BIPS measurements in KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32 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 KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32 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.

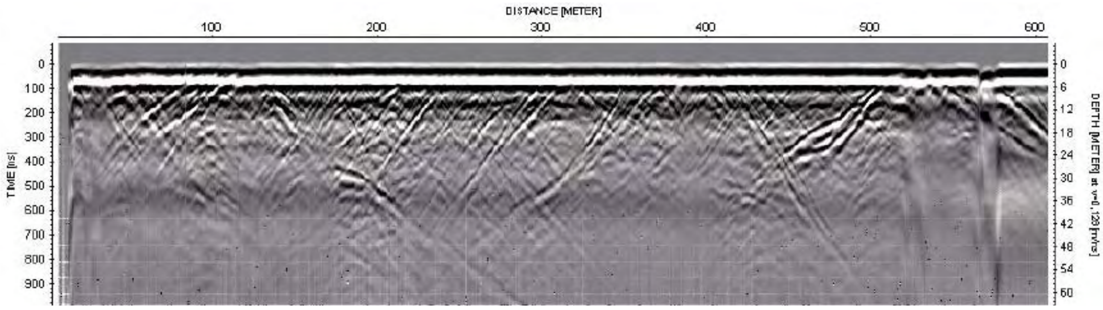
5.1 RAMAC logging

The results of the interpretation of the radar measurements are presented in Tables 5-1 to 5-19. Radar data are also visualized in Appendices 1 to 6. It should be remembered that the images in Appendices 1 to 6 are 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 four different boreholes are given in Figure 5-1 below. A number of minor structures also exist, as indicated in Appendices 1 to 6. Often a number of structures can be noticed, but most probably lying so close to each other that it is difficult 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 6. It should also be pointed out that reflections interpreted will always result in an intersection point with the borehole, but this intersection point can be located further away, in some cases outside the borehole.

The data quality from KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32, (as seen in Appendices 1 to 6) is satisfying to good (especially in the core-drilled borehole KFM09B), but in parts of lower quality due to more conductive conditions. See for instance HFM32 with bad data quality along the whole borehole. 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.

KFM09B



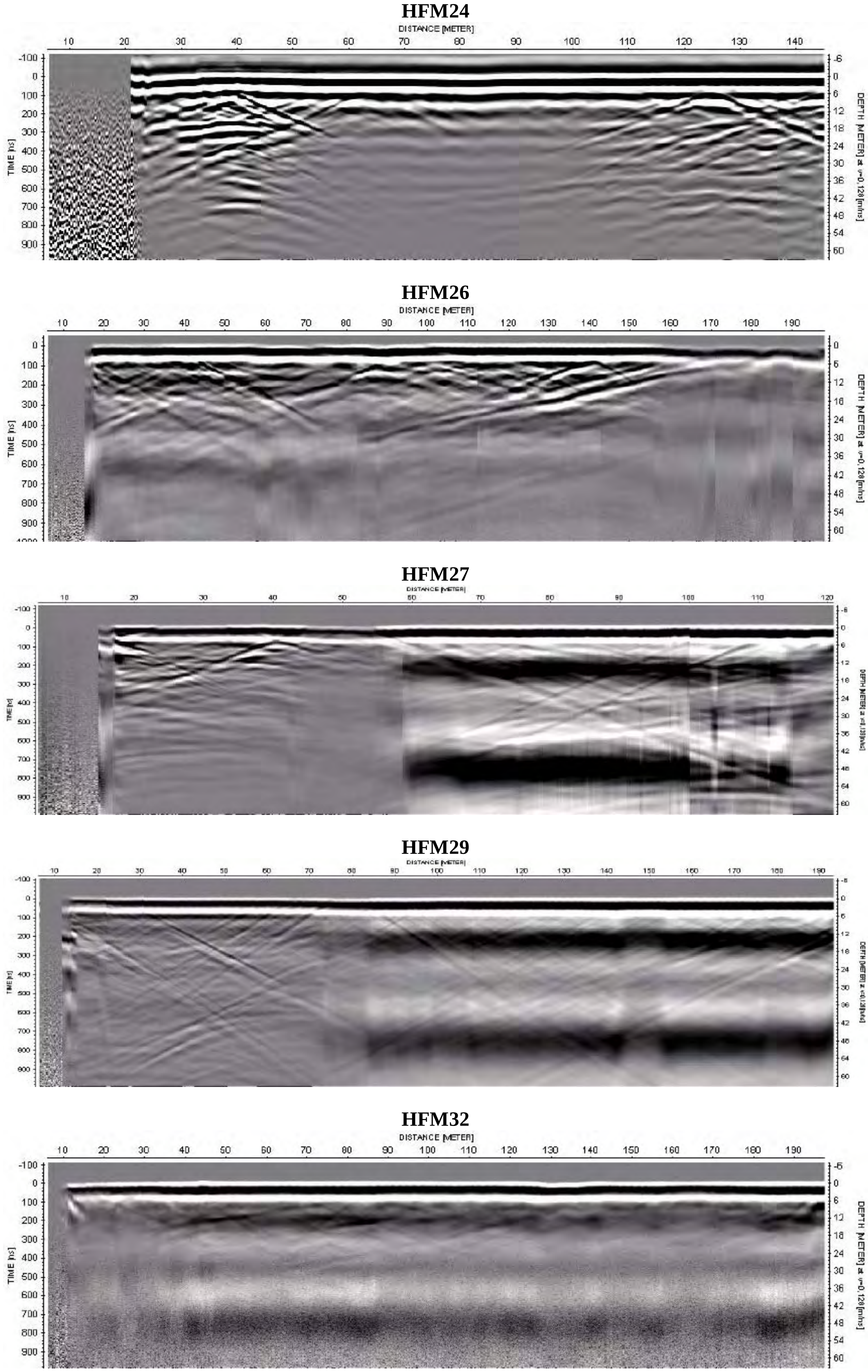


__Figure 5-1.__ An overview (based upon 20 MHz data) of the radar data for the boreholes KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32. Observe that the borehole length (x-scale) and distance (y-scale) differs between the different boreholes. In the data from HFM27 and HFM29 the effect of low conductivity (most probably in the water) is clearly seen from 60 respectively 85 m borehole length as decreased penetration and increased ringing.

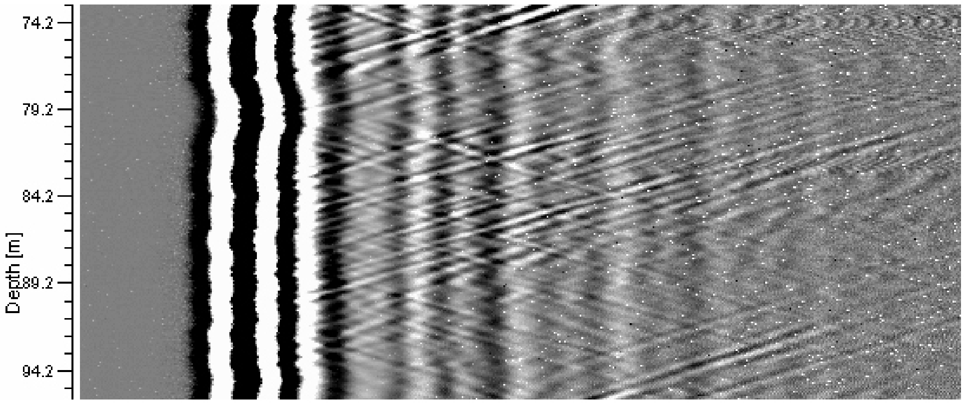


Figure 5-2. Example of data from HFM29 (250 MHz) where a number of structures are seen but lying so close to each other, that it is hard to distinguished one from the other.

Further on, depending on the diameter of the borehole, the conductivity and the antenna frequency, so called ringing can be achieved, which again makes the interpretation of single structures quite complicated.

These effects are also seen in the directional antenna for KFM09B, which makes it more difficult to interpret the direction to the identified structures.

As also seen in Appendices 1 to 6 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 5-6 below the distribution of identified structures along the boreholes are listed for KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32. Observe, that the borehole intersection length can be outside the borehole.

Table 5-1. Identified structures as a function of borehole intersection length in KFM09B.

Length (m)	No. of structures
–100	22
100–150	17
150–200	15
200–250	13
250–300	11
300–350	14
350–400	13
400–450	16
450–500	10
500–550	10
550–	8

Table 5-2. Identified structures as a function of borehole intersection length in HFM24.

Length (m)	No. of structures
0–20	1
20–40	3
40–60	8
60–80	7
80–100	3
100–120	5
120–140	2
140–160	5
160–	2

Table 5-3. Identified structures as a function of borehole intersection length in HFM26.

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

Table 5-4. Identified structures as a function of borehole intersection length in HFM27.

Length (m)	No. of structures
–0	–
0–20	–
20–40	1
40–60	6
60–80	6
80–100	1
100–120	7
120–140	2
140–	2

Table 5-5. Identified structures as a function of borehole intersection length in HFM29.

Length (m)	No. of structures
–0	0
0–20	1
20–40	6
40–60	4
60–80	7
80–100	5
100–120	10
120–140	5
140–160	6
160–180	5
180–200	3
200–	4

Table 5-6. Identified structures as a function of borehole intersection length in HFM32.

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

Tables 5-7 to 5-12 summarises the interpretation of radar data from KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32. In the tables the borehole length and intersection angle to the identified structures are listed.

For KFM09B the direction to the object is also given. As seen some radar reflectors in Table 5-7 are 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 5-3. 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 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 values for the angle and the intersection length. An example of this phenomenon is seen in Table 5-7 and Appendix 1; the reflectors named 102, 102x, 102xx and 102xxx most likely originates from the same geological structure.

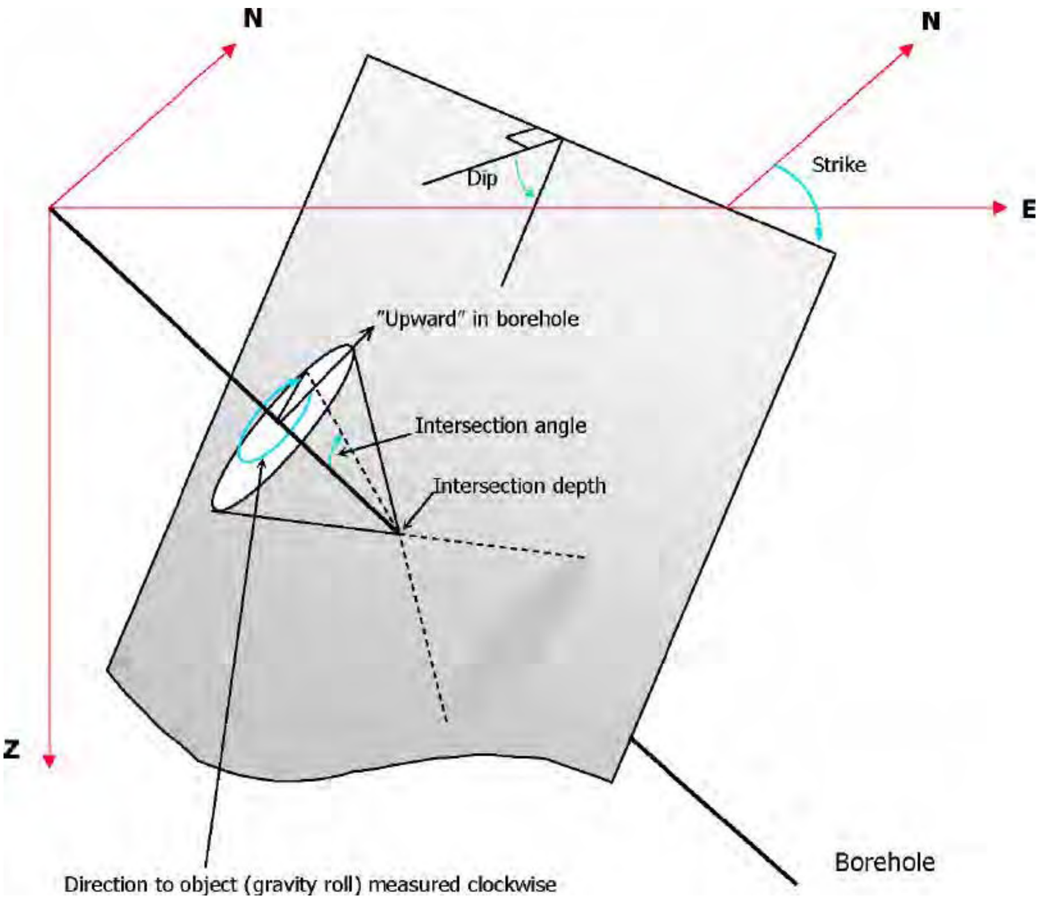


Figure 5-3. *Definition of direction to object as presented in Table 5-7.*

Table 5-7. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, and the directional antenna 60 MHz in borehole KFM09B.

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM09B
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter object direction (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
131	–1.5	20					
128	13.5	42					
1	18.4	48					
2	20.5	54					
3	28.2	56	15	70	235		
8	30.6	22					
7	31.8	29					
6	33.2	46					
4	39.0	48					
5	40.4	40	6	86	230		
10	49.2	49					
9	49.6	46	192 ±	11	95	79	234
12	57.0	50					
124	60.1	49					
13	67.0	47					
14	71.8	53					
11	76.5	17	261 ±	71	139	82	299
15	77.1	50					
20	81.6	25	318	88	9		
16x	86.4	38					
20x	91.0	38					
137	92.9	21					
17	101.7	52	192 ±	8	124	74	233
16	105.5	20	249	62	131		
26	110.9	40					
129	112.1	45					
21	115.2	52					
22	116.3	47					
115	119.0	15					
23	120.9	45					
19	122.9	23					
18	123.7	24	267	69	148		
125	125.8	49					
24	128.7	45					
34	128.9	45					
25	131.4	51					
130	137.9	18					
27	137.9	45					
28	145.1	43	201 ±	17	106	81	241

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM09B
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter object direction (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
29	150.6	43	3	83	228		
116	156.5	47					
31	157.3	25					
30	157.7	43					
132	160.7	54					
32	160.9	42					
33	171.2	20					
35	175.5	40	315	78	192		
36	176.7	52					
40	180.1	53					
49	183.9	48					
42	185.9	44					
39	195.9	32	267	62	154		
37	197.6	37					
38	199.6	44					
41	204.5	35	21 ±	89	240	23	92
43	206.3	37					
48	208.1	28					
44	213.5	54					
117	220.9	47					
45	225.5	40					
46	228.3	40	177	10	30		
56	230.0	10	318	71	358		
47	233.6	42					
118	236.1	26					
50	239.1	49					
138	244.6	22					
52	249.5	64					
140	250.6	32	27 ±	87	65	28	97
136	251.8	39					
51	253.3	46	192 ±	10	101	81	230
55	258.7	16					
54	265.6	43					
60	269.1	10	321 ±	69	6	52	356
53	276.8	18					
59	278.5	52					
62	283.3	16	315	78	4		
58	287.8	44	9 ±	83	228	9	89
119	298.4	37	303 ±	80	178	43	311
57	302.1	21					
123	303.3	17					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: Forsmark
Borehole name: KFM09B
Nominal velocity (m/μs): 128.0

Name	Intersection length	Intersection angle	RadInter object direction (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
120	309.5	44					
61	311.7	38	192	16	94		
119x	316.1	22					
63	322.0	40					
65	327.2	31					
63x	327.9	29	168 ±	23	29	81	46
64	335.0	30	30	85	74		
67	335.4	33					
57x	336.4	9	261 ±	77	130	89	299
66	340.3	40					
69	345.8	45					
68	349.0	45					
72	357.5	44	356	85	226		
70	359.7	46					
73	362.2	43	24	83	245		
121	363.5	49					
126	364.0	43					
71	364.9	38					
79	377.1	40					
74	378.8	39					
75	378.9	39					
77	383.8	38					
78	387.9	41					
76	390.1	28					
80	395.4	41					
89	400.1	41					
84	405.0	38					
81	406.0	52					
127	406.4	18					
83	407.4	45					
82	407.8	27	264	65	154		
85	407.9	49					
86	409.2	35					
122	411.8	41	66 ±	73	276	46	155
87	413.9	28					
135	414.1	55					
97	421.6	35					
88	430.0	42					
121x	430.5	16					
90	438.1	41					
134	442.3	37					

RADINTER MODEL INFORMATION
(Directional and dipole antennas)

Site: **Forsmark**
Borehole name: **KFM09B**
Nominal velocity (m/μs): **128.0**

Name	Intersection length	Intersection angle	RadInter object direction (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
92	454.2	29	315	85	7		
93	457.2	45					
91	457.4	19	243	58	132		
96	457.7	34					
94	459.5	29					
95	472.7	31	261 ±	61	161	71	294
102x	490.3	42	270	61	168		
98	492.5	53					
99	498.9	41					
101	499.5	21					
100	504.8	60					
102xx	511.9	24	271	74	155		
102xxxx	515.9	19					
102	522.7	26	255	61	145		
105	527.7	38					
103	536.0	47					
139	538.3	11	234	58	122		
106	543.5	50					
107	547.1	50					
104	548.5	20					
113	550.9	15					
114	551.0	23	282	82	156		
133	551.7	23					
108	557.0	46					
109	569.2	63	300 ±	60	196	37	262
110	572.1	72					
111	581.3	44	162	13	316		
112	585.8	30					

Table 5-8. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz borehole HFM24.

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

Site:	**Forsmark**
Borehole name:	**HFM24**
Nominal velocity (m/μs):	**128.00**

Object type	Name	Intersection length	Intersection angle
PLANE	1	19.6	40
PLANE	1x	22.2	47
PLANE	2	29.1	61
PLANE	3	34.7	59
PLANE	7	41.0	66
PLANE	6	43.4	51
PLANE	4	44.1	49
PLANE	5	48.5	43
PLANE	10	48.5	57
PLANE	8	50.0	51
PLANE	9	52.3	61
PLANE	11	55.7	53
PLANE	12	62.6	47
PLANE	32	62.6	55
PLANE	13	67.1	54
PLANE	14	69.5	54
PLANE	16	73.4	61
PLANE	15	75.1	56
PLANE	15x	76.5	46
PLANE	17	87.0	56
PLANE	20	95.0	27
PLANE	18	97.8	54
PLANE	19	100.7	63
PLANE	22	109.9	48
PLANE	23	112.0	46
PLANE	21	114.2	44
PLANE	33	115.1	61
PLANE	24	136.0	42
PLANE	27	139.1	41
PLANE	25	140.7	39
PLANE	26	141.5	42
PLANE	29	152.6	48
PLANE	28	152.9	38
PLANE	30	155.6	47
PLANE	31	169.0	48
PLANE	34	186.0	22

Table 5-9. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HFM26.

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

Site:	**Forsmark**
Borehole name:	**HFM26**
Nominal velocity (m/μs):	**128.00**

Object type	Name	Intersection length	Intersection angle
PLANE	2	13.6	65
PLANE	3	17.9	39
PLANE	29	20.8	49
PLANE	1	29.1	47
PLANE	4	29.5	56
PLANE	1x	31.0	46
PLANE	5	43.5	38
PLANE	8	53.0	47
PLANE	7	56.5	53
PLANE	9	62.5	46
PLANE	11	69.5	20
PLANE	28	70.6	35
PLANE	13	75.1	57
PLANE	12	76.9	36
PLANE	15	83.2	11
PLANE	26	85.5	81
PLANE	15x	92.6	16
PLANE	10	99.2	61
PLANE	6x	99.9	45
PLANE	6	103.9	37
PLANE	14	116.0	49
PLANE	30	120.4	29
PLANE	16	128.1	58
PLANE	17	131.0	67
PLANE	27	132.9	56
PLANE	21	136.1	22
PLANE	18	140.0	66
PLANE	19x	154.8	33
PLANE	20	156.3	59
PLANE	19	160.5	25
PLANE	22	171.9	31
PLANE	23	183.7	20
PLANE	25	189.6	52
PLANE	24	201.1	17
PLANE	24x	217.5	14
PLANE	31	255.2	23

Table 5-10. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HFM27.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:	**Forsmark**		
Borehole name:	**HFM27**		
Nominal velocity (m/μs):	**128.00**		
Object type	**Name**	**Intersection length**	**Intersection angle**
PLANE	1	27.7	43
PLANE	2	48.2	64
PLANE	3	49.1	63
PLANE	4	51.0	62
PLANE	5	53.1	62
PLANE	6	55.2	54
PLANE	7	57.8	70
PLANE	10	60.5	50
PLANE	8	61.2	53
PLANE	9	67.3	60
PLANE	12	70.3	60
PLANE	11	76.2	64
PLANE	14	79.7	69
PLANE	13	81.1	67
PLANE	16	106.5	64
PLANE	17	107.2	83
PLANE	15	110.6	72
PLANE	23	114.0	64
PLANE	19	115.2	80
PLANE	18	116.9	84
PLANE	21	119.2	88
PLANE	20	120.7	86
PLANE	22	128.5	75
PLANE	24	236.3	16
PLANE	25	903.8	4

Table 5-11. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HFM29.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:	**Forsmark**		
Borehole name:	**HFM29**		
Nominal velocity (m/μs):	**128.00**		
Object type	**Name**	**Intersection length**	**Intersection angle**
PLANE	5	17.6	50
PLANE	1	21.4	44
PLANE	2	22.1	47
PLANE	6	23.7	61
PLANE	3	27.3	50
PLANE	4	29.9	72
PLANE	7	35.7	49

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

Site:	**Forsmark**
Borehole name:	**HFM29**
Nominal velocity (m/µs):	**128.00**

Object type	Name	Intersection length	Intersection angle
PLANE	8	41.4	60
PLANE	9	43.5	55
PLANE	10	48.2	56
PLANE	11	52.5	61
PLANE	13	61.6	65
PLANE	12	62.7	64
PLANE	14	69.9	66
PLANE	15	71.0	65
PLANE	16	73.8	62
PLANE	17	76.5	79
PLANE	18	79.2	75
PLANE	19	86.7	59
PLANE	20	88.0	71
PLANE	21	92.0	67
PLANE	22	93.3	62
PLANE	23	95.1	58
PLANE	24	102.1	60
PLANE	56	102.7	74
PLANE	25	104.5	57
PLANE	26	105.4	64
PLANE	53	107.8	45
PLANE	27	108.3	69
PLANE	28	112.2	50
PLANE	29	114.0	47
PLANE	31	117.2	48
PLANE	30	119.0	49
PLANE	32	123.0	50
PLANE	33	128.4	46
PLANE	35	135.8	48
PLANE	34	139.3	49
PLANE	36	139.3	46
PLANE	37	141.7	41
PLANE	38	144.8	40
PLANE	40	147.1	71
PLANE	54	148.6	61
PLANE	41	149.5	43
PLANE	39	153.9	42
PLANE	42	164.3	38
PLANE	44	165.3	59
PLANE	43	166.5	45
PLANE	45	170.5	46
PLANE	47	178.9	42
PLANE	49	184.0	36
PLANE	46	187.3	37
PLANE	48	191.9	38
PLANE	50	200.7	83
PLANE	51	214.8	42
PLANE	52	220.4	40
PLANE	55	221.9	23

Table 5-12. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HFM32.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:	Forsmark		
Borehole name:	HFM32		
Nominal velocity (m/μs):	128.00		
Object type	**Name**	**Intersection length**	**Intersection angle**
PLANE	1	16.5	90
PLANE	2	26.8	90
PLANE	3	35.8	68
PLANE	4	53.3	39
PLANE	5	78.1	73
PLANE	6	92.4	71
PLANE	7	112.9	15
PLANE	8	146.8	75
PLANE	10	160.8	75
PLANE	9	164.8	72
PLANE	11	177.4	79
PLANE	14	187.2	10
PLANE	15	190.7	16
PLANE	13	204.7	88

In Appendices 1 to 6, the amplitude of the first arrival is plotted against the borehole length (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 5-13 to 5-18.

Table 5-13. Borehole length intervals in KFM09B with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
5–25	520–530
30–35	567–575
120	
325	

Table 5-14. Borehole length intervals in HFM24 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
25–30	110
50–90	135–150

Table 5-15. Borehole length intervals in HFM26 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
60–70	90–95
80	160–200

Table 5-16. Borehole length intervals in HFM27 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
25–30	115–125
45–50	

Table 5-17. Borehole length intervals in HFM29 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
40	140–150
70–85	

Table 5-18. Borehole length intervals in HFM32 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
25–30	130–140

Finally, the structures considered as the most important (clearly seen in the radargrams, identified with several antenna frequencies, stretching out far from the borehole wall etc.) are listed in Table 5-19 below.

Table 5-19. Some important structures in KFM09B, HFM24, HFM26, HFM27, HFM29 and HFM32.

Borehole	KFM09B	HFM24	HFM26	HFM27	HFM29	HFM32
Structures	9, 16, 16x, 18, 35, 57, 57x, 58, 60, 61, 62, 63, 63x, 66, 89, 102, 102x, 102xx, 102xxx, 103, 104, 121, 121x and 133	1, 1x, 13, 15, 15x, 26 and 29	1, 1x, 6, 6x, 11, 19, 19x, 23, 24, 24x, 28 and 31	1, 2, 15, 18, 20, 24 and 25	5, 7, 8, 9, 15, 18, 51, 53, 54 and 55	6, 7, 14 and 15

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 thereby affects the results of the radar logging, for instance by 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.

5.2 BIPS logging

The BIPS pictures are presented in Appendices 7 to 12.

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 percussion drilled boreholes we use marks on the logging cable as references for the length 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 length 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 loggings were included in the delivery of the field data and are also presented in Figures 4-2 and 4-3 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 borehole KFM09B resulted in the typical discolouring effect (caused by the drilling) on the borehole wall. This is seen along the whole borehole. The water quality was not acceptable during the first run in the lower part of the borehole. During a second run the section from 440 m to 610 m was remeasured and showed improved images.

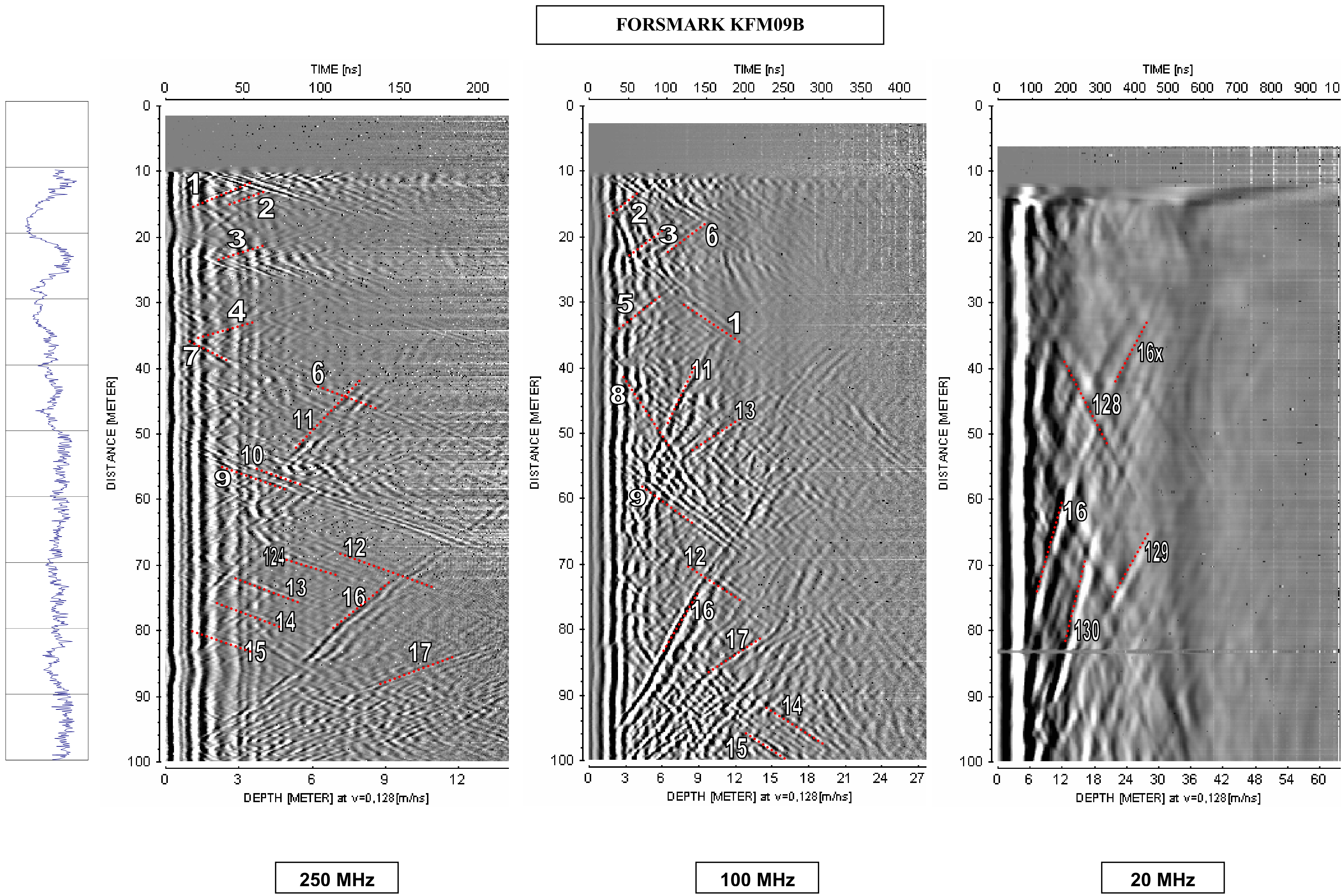
The percussion-drilled boreholes has a good quality except for HFM26 where the borehole walls are covered with dark material, probably induced by the drilling. This dark material on the walls causes very bad results. To achieve acceptable images the borehole need to be cleaned.

References

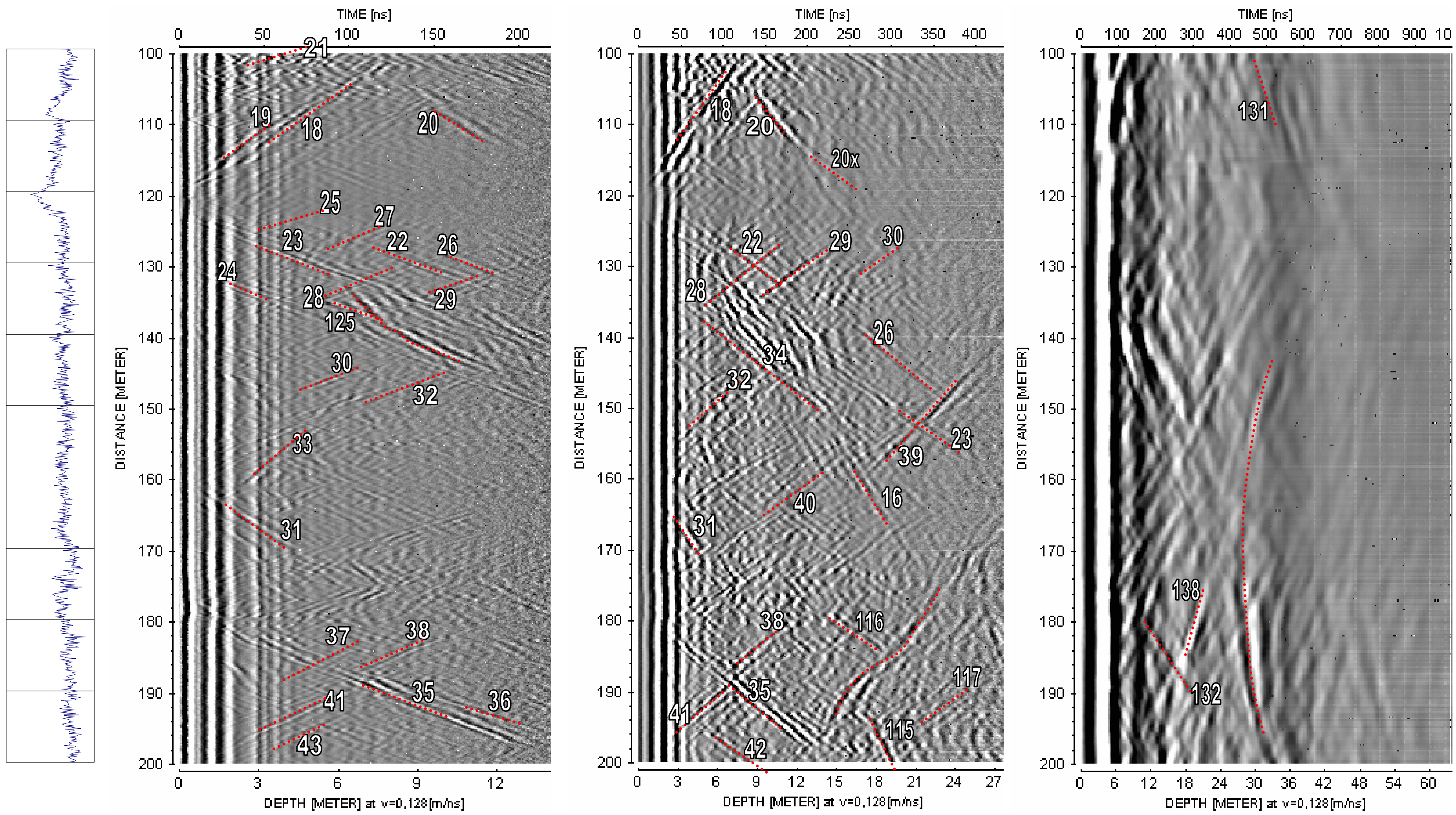
/1/ **Gustafsson C, Nilsson P, 2003.** Geophysical Radar and BIPS logging in borehole HFM01, HFM02, HFM03 and the percussion drilled part of KFM01A. SKB P-03-39. Svensk Kärnbränslehantering AB.

Appendix 1

Radar logging in KFM09B, 0 to 610 m, dipole antennas 250, 100 and 20 MHz

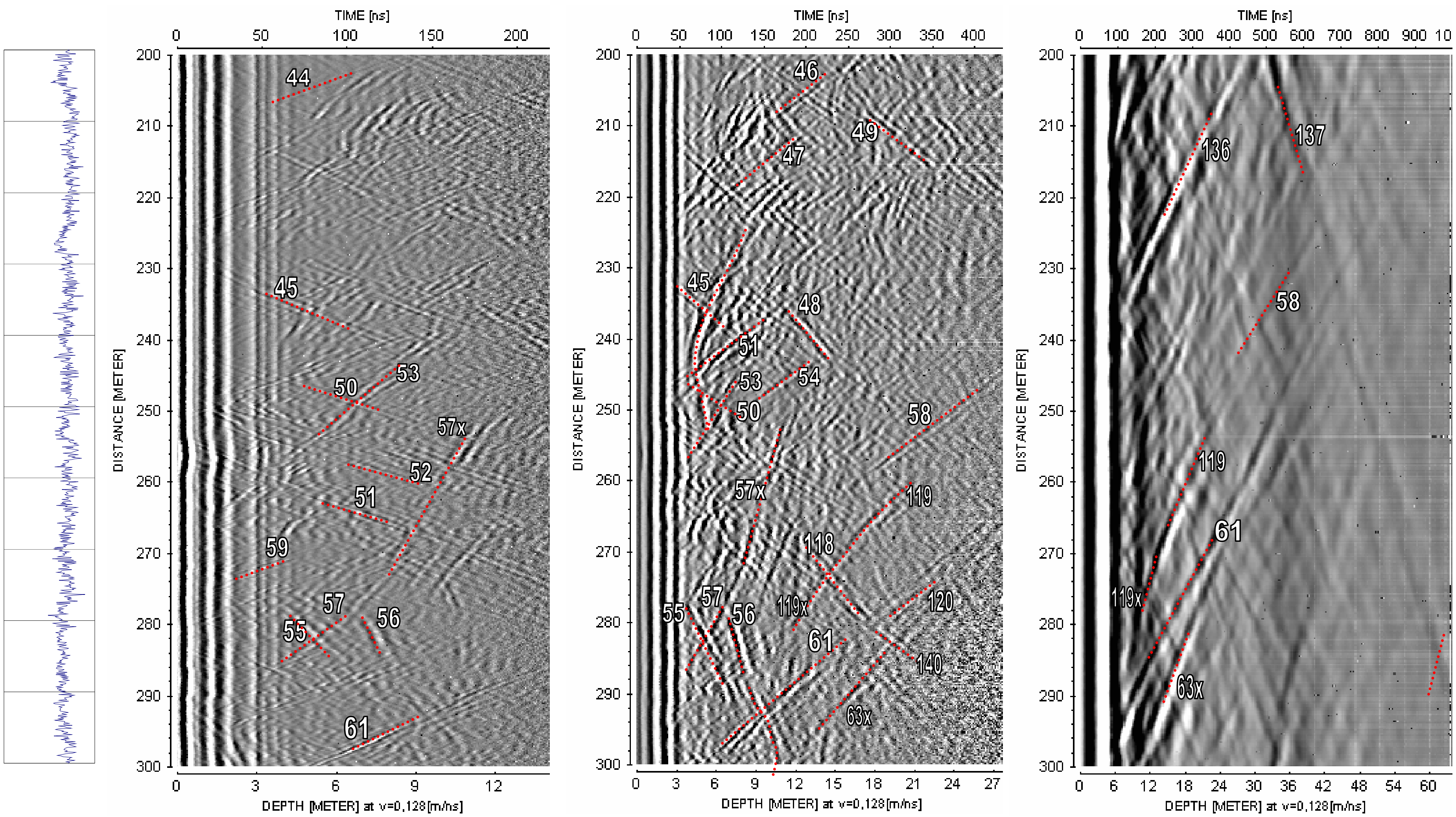


FORSMARK KFM09B

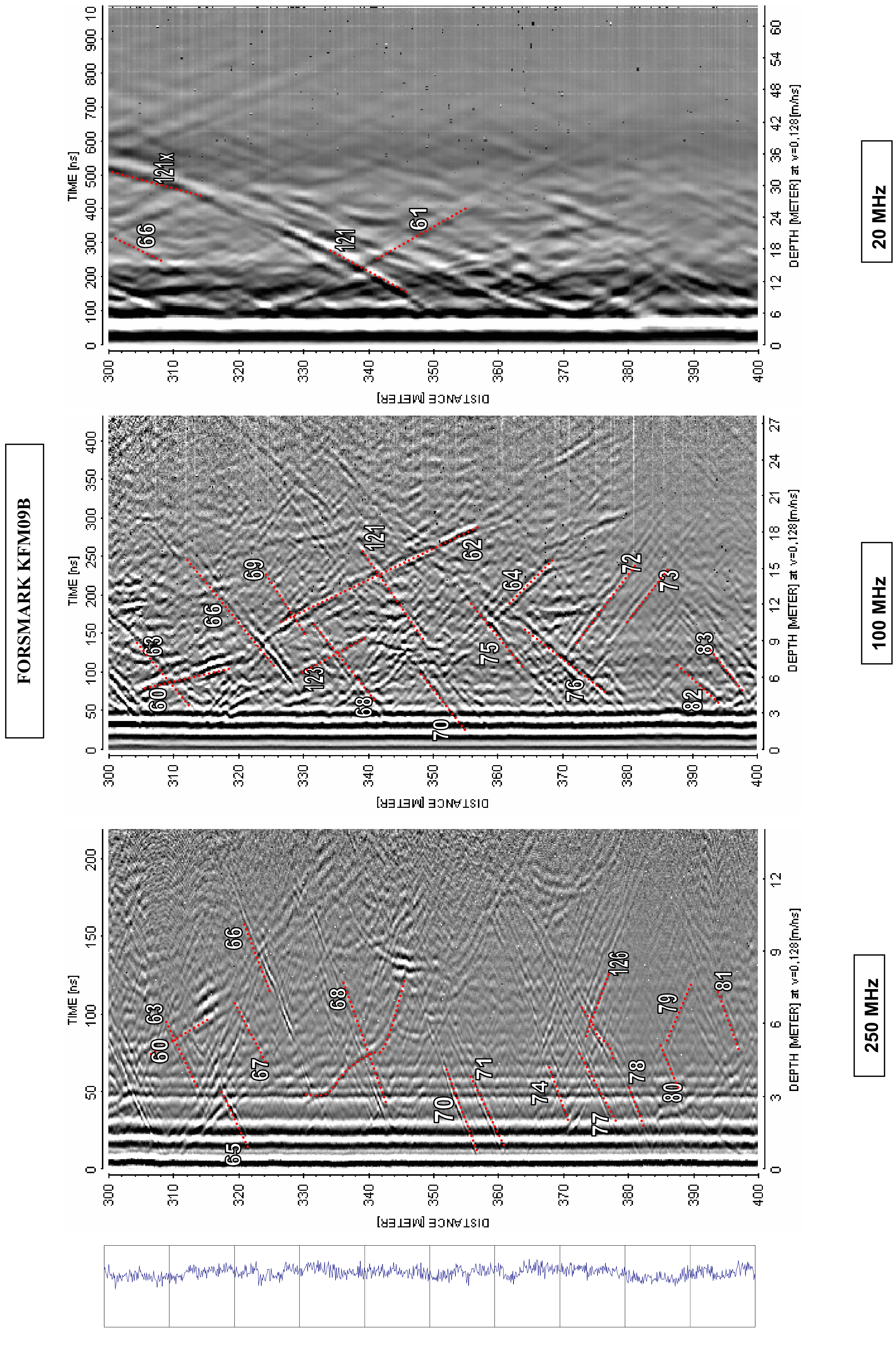


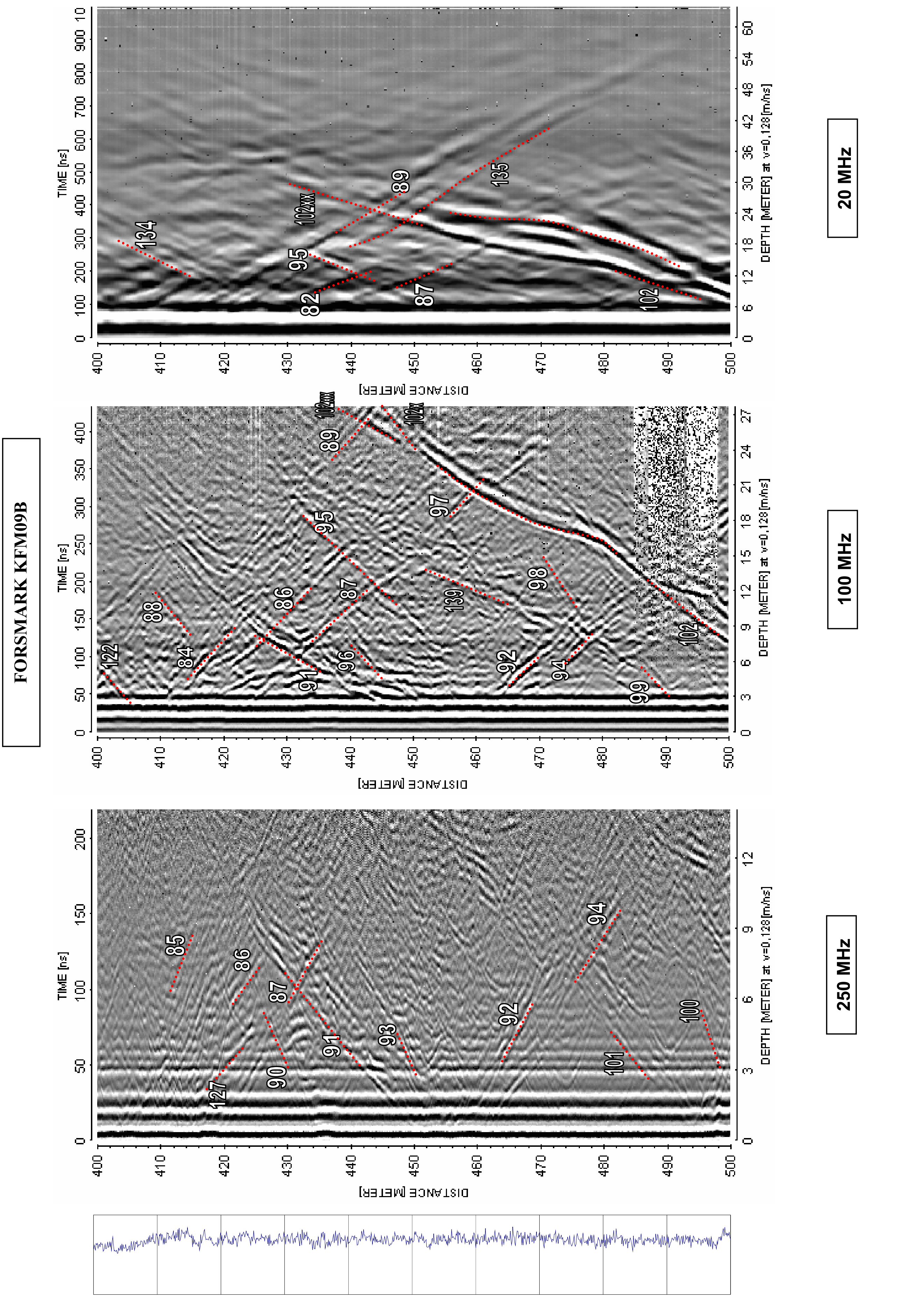
250 MHz **100 MHz** **20 MHz**

FORSMARK KFM09B

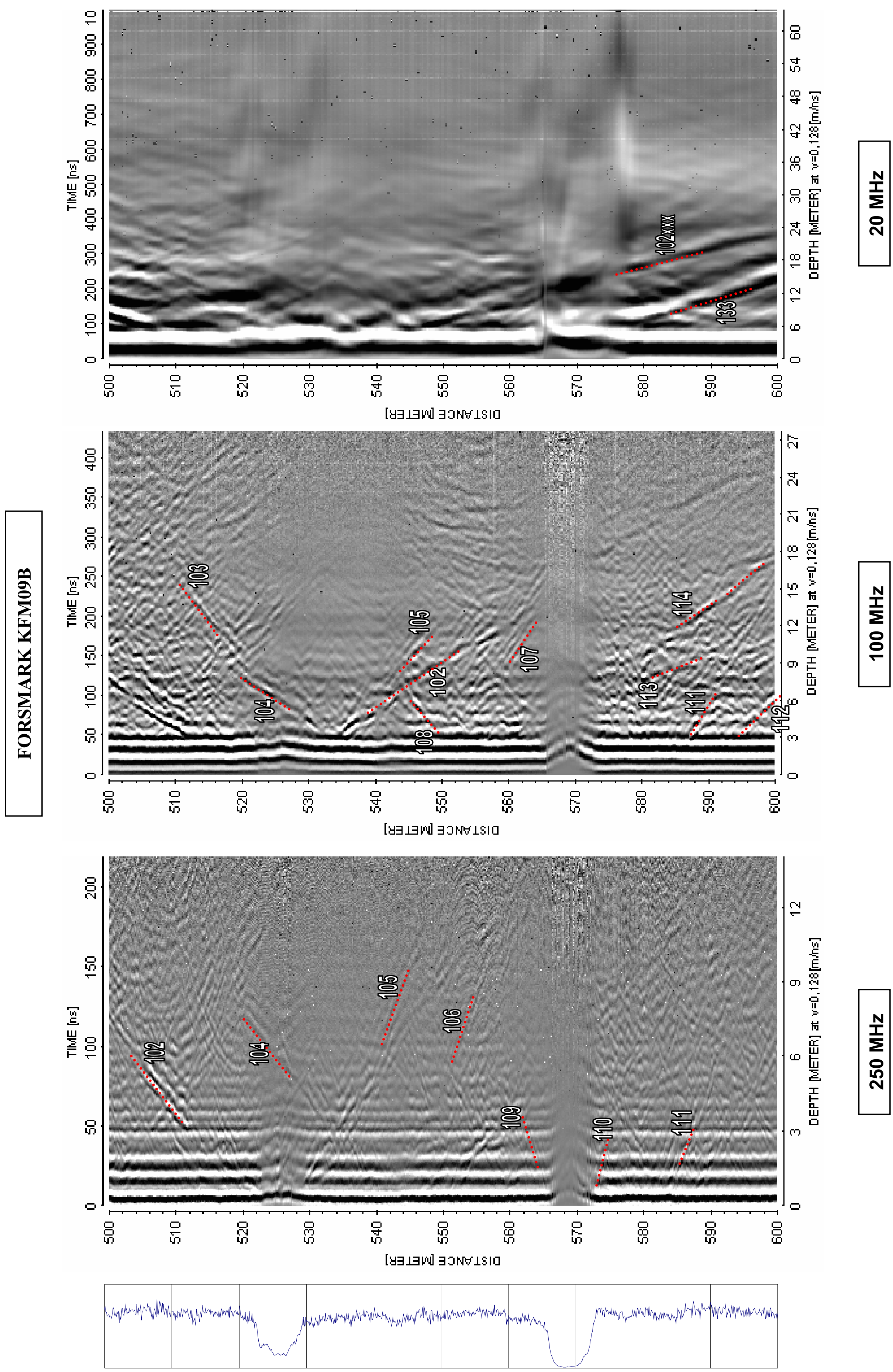


250 MHz **100 MHz** **20 MHz**

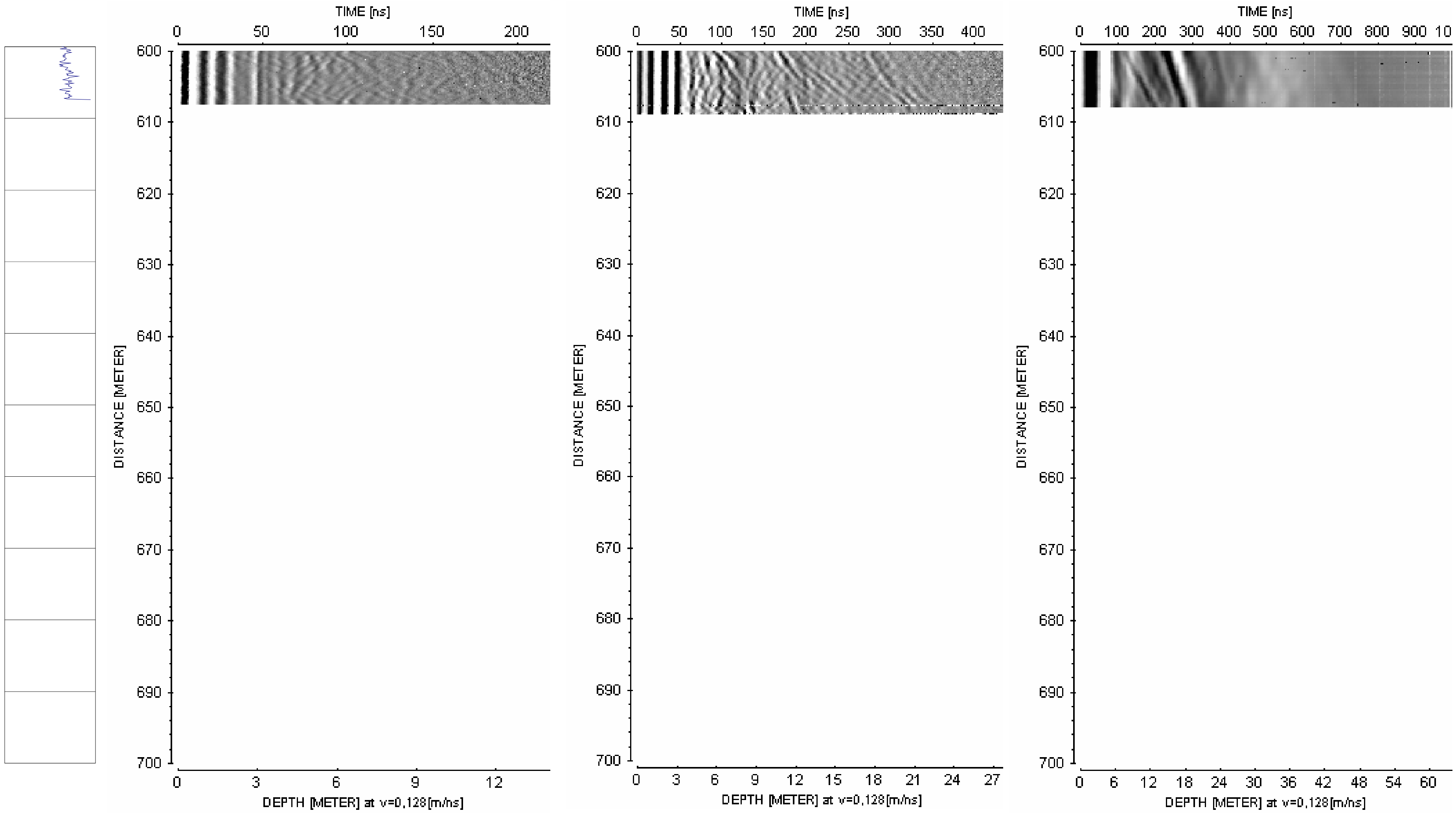

FORSMARK KFM09B
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128 [m/ns]



FORSMARK KFM09B
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]


FORSMARK KFM09B
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
102
104
105
106
109
110
111
103
107
108
113
114
112
102xxx
133

FORSMARK KFM09B

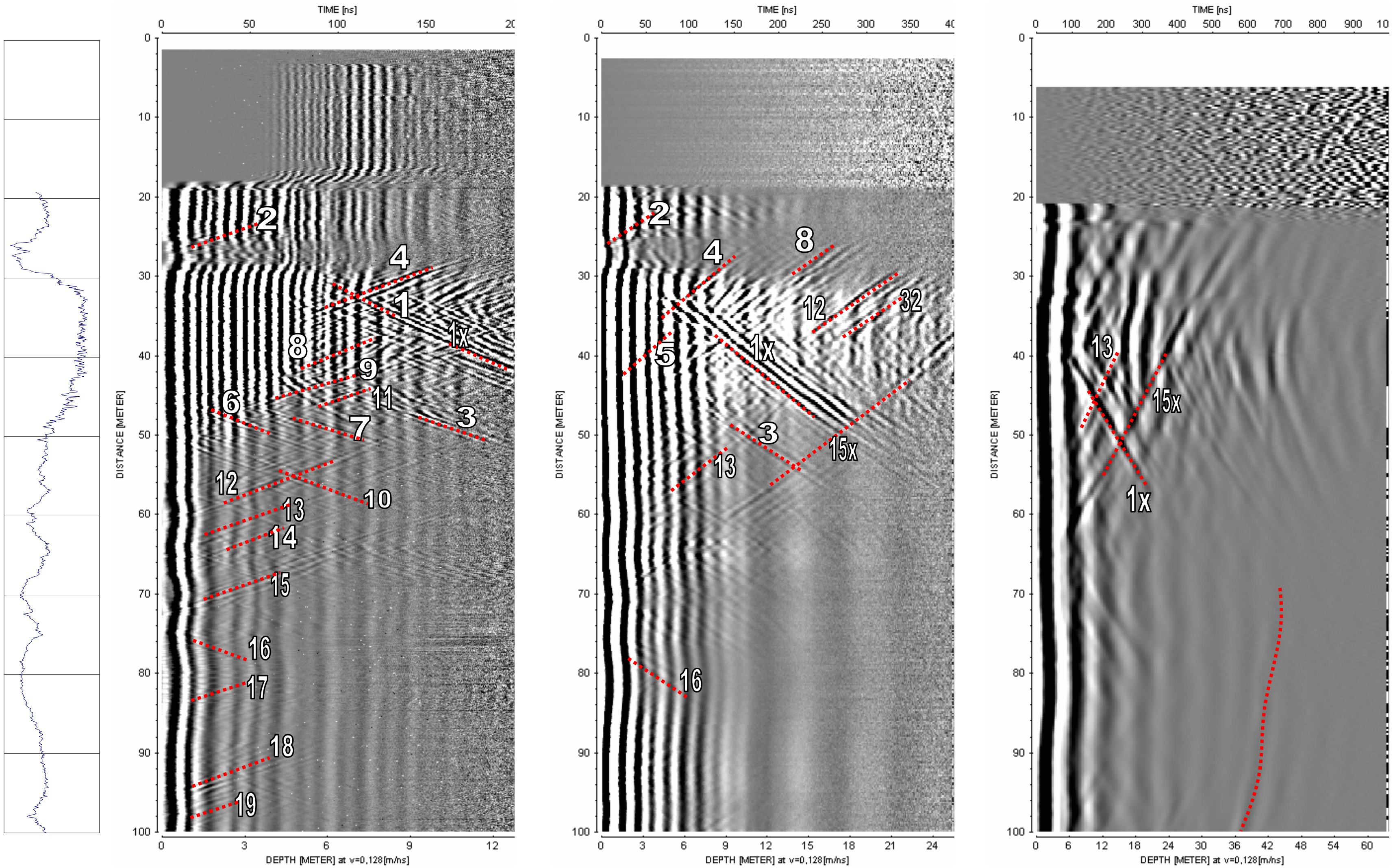


250 MHz **100 MHz** **20 MHz**

Appendix 2

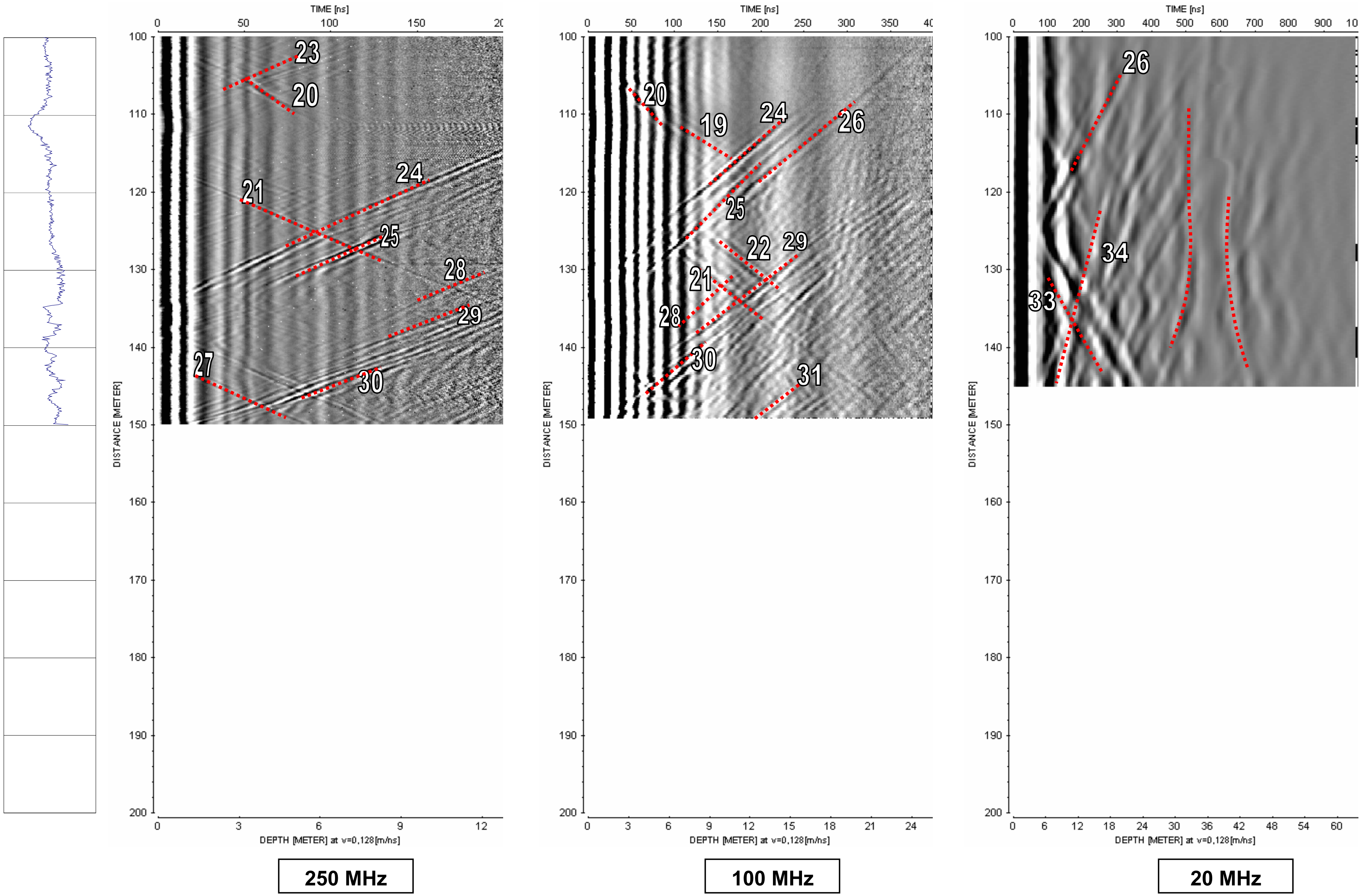
Radar logging in HFM24, 0 to 148 m, dipole antennas 250, 100 and 20 MHz

FORSMARK HFM24

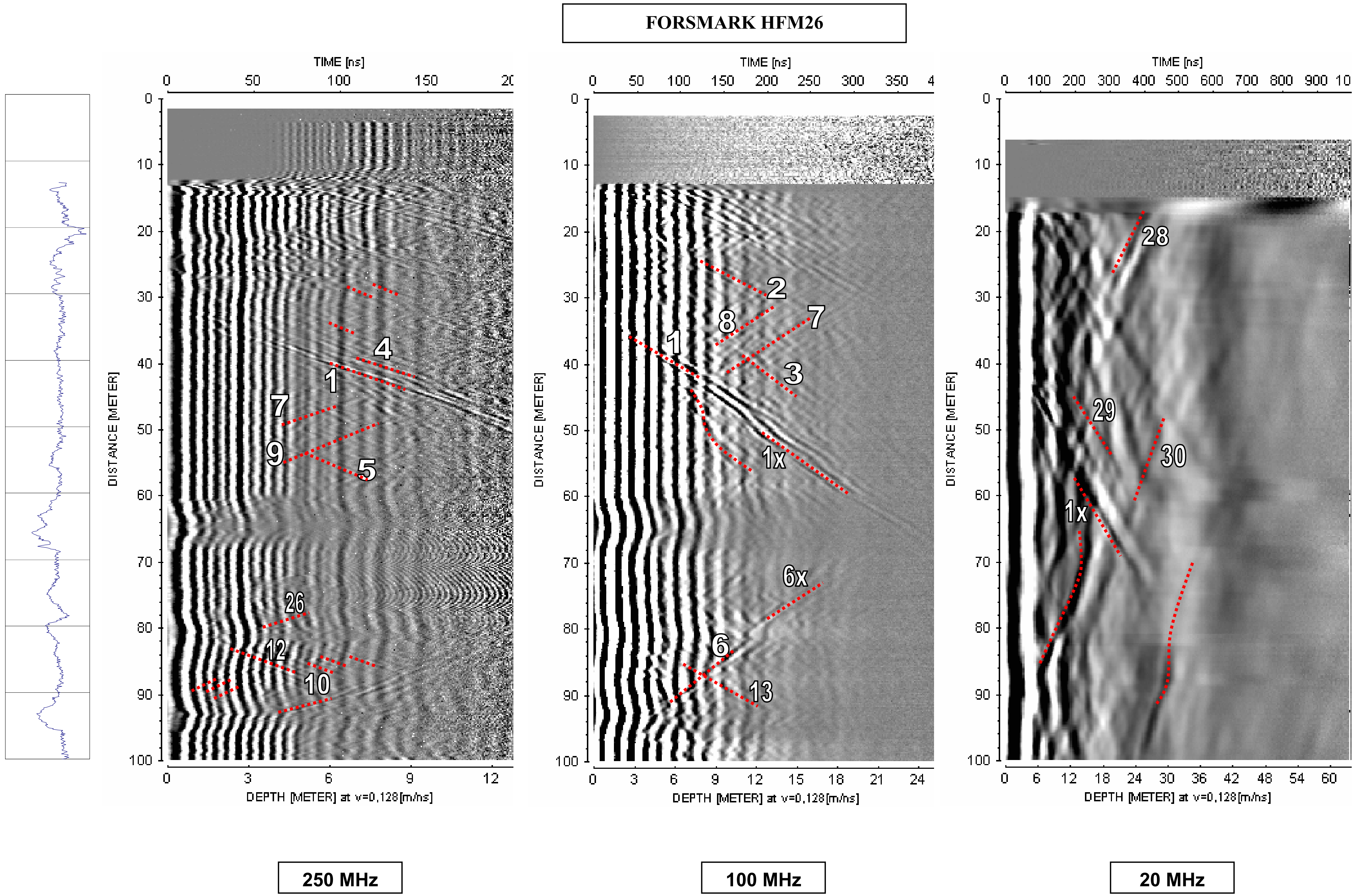


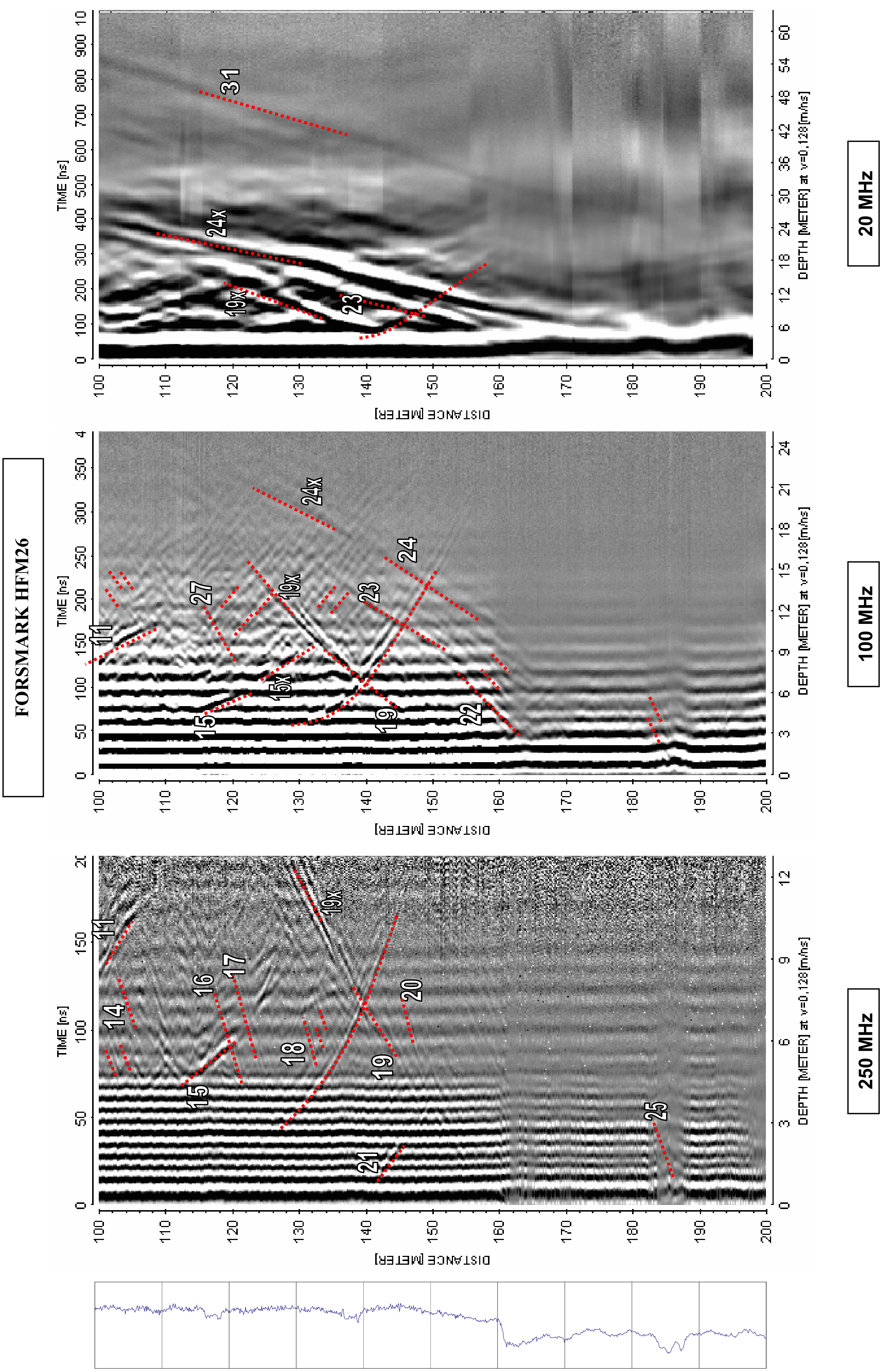
250 MHz **100 MHz** **20 MHz**

FORSMARK HFM24



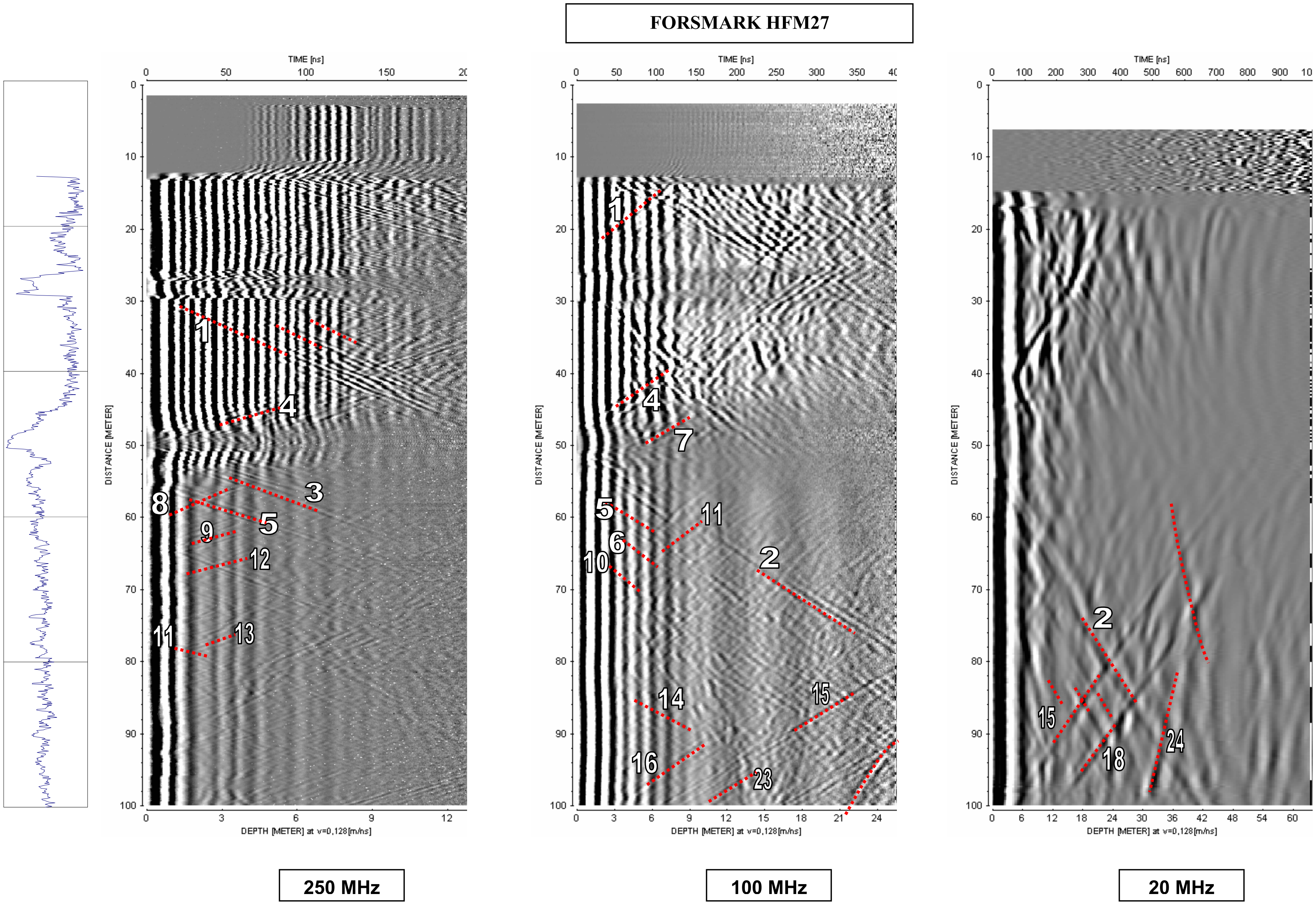
Radar logging in HFM26, 0 to 200 m, dipole antennas 250, 100 and 20 MHz



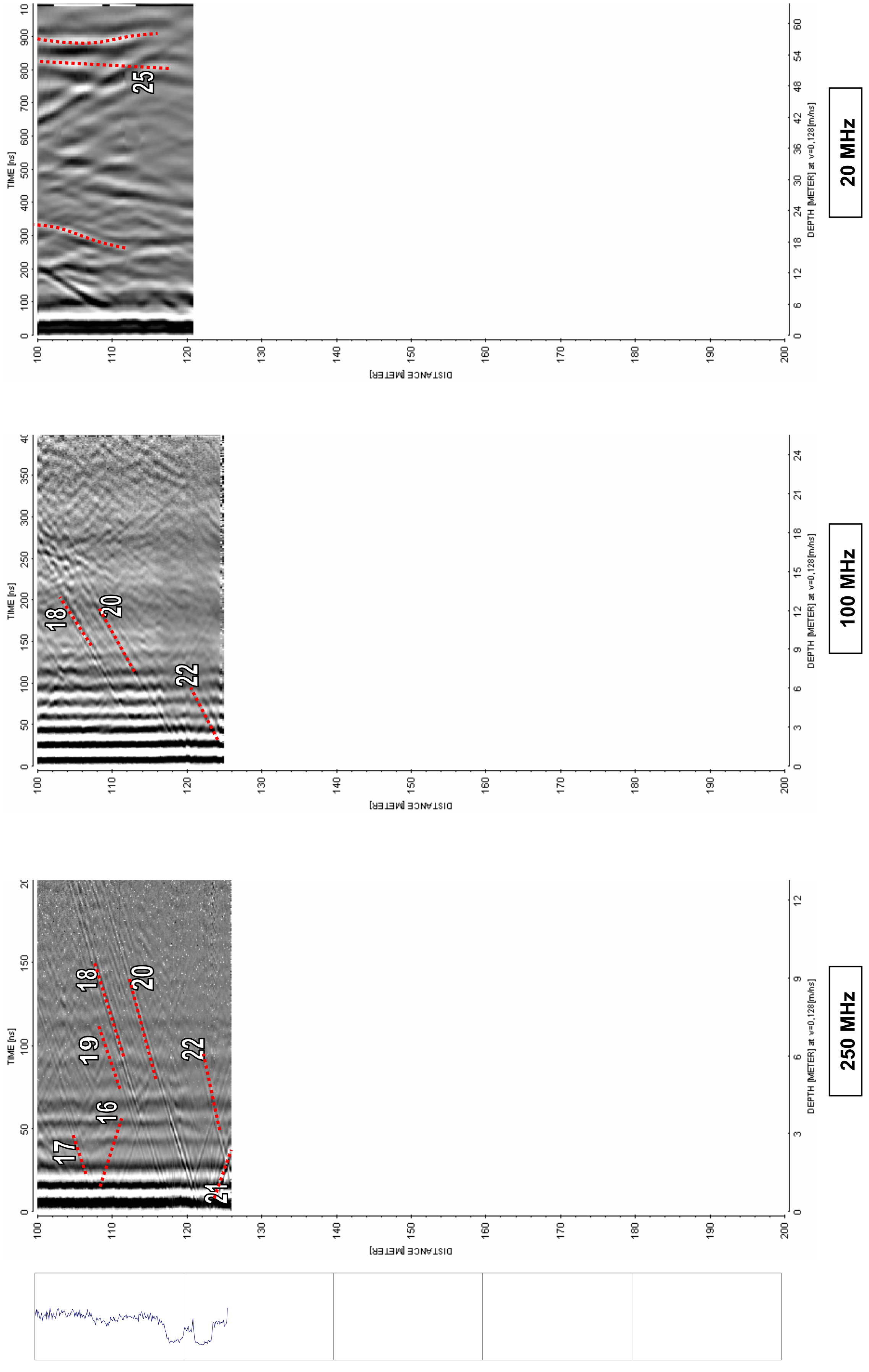

FORSMARK HFM26
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128 [m/ns]
11
14
15
16
17
18
19
19x
20
21
25
15x
22
23
24
24x
27
31

Appendix 4

Radar logging in HFM27, 0 to 121 m, dipole antennas 250, 100 and 20 MHz



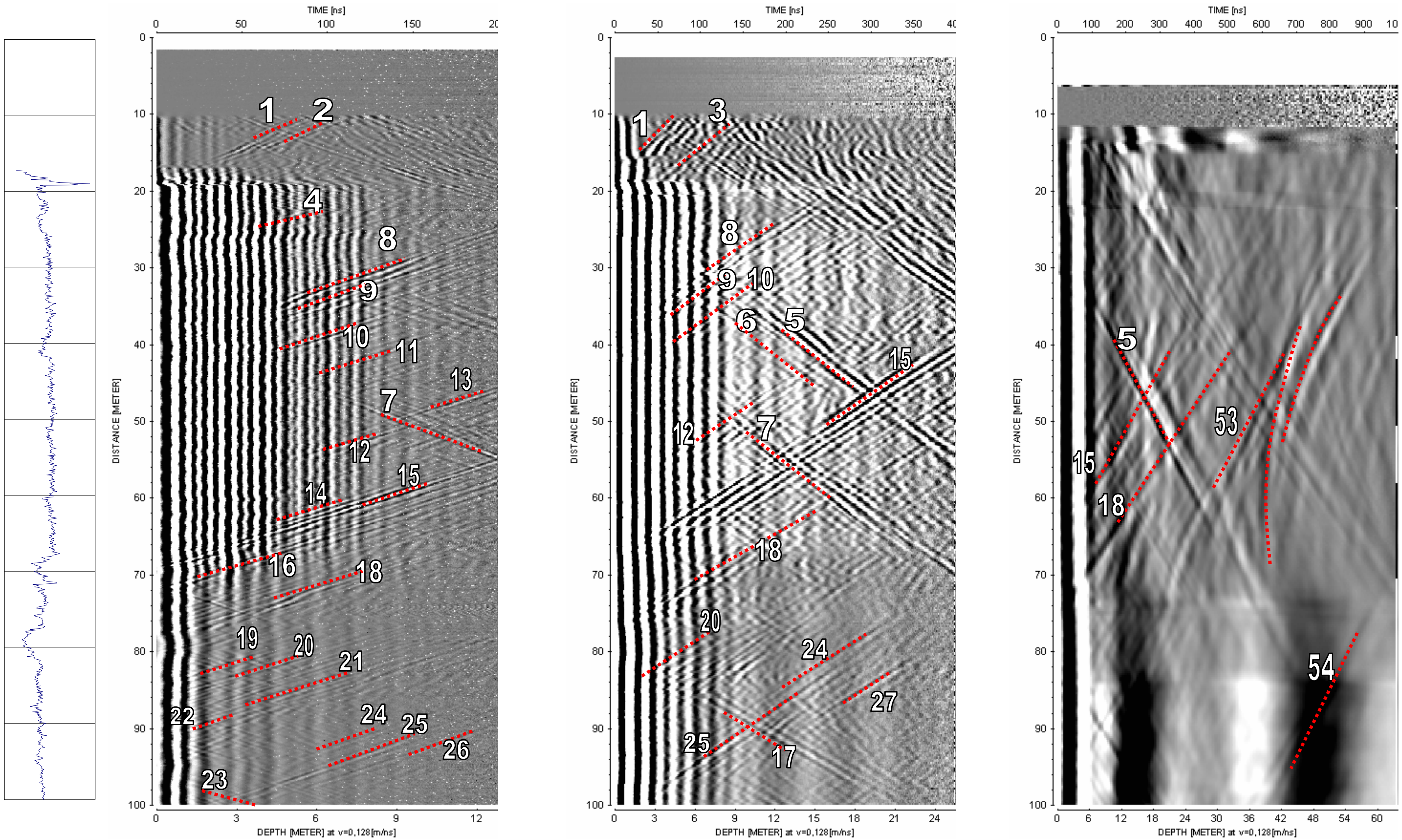
FORSMARK HFM27



Appendix 5

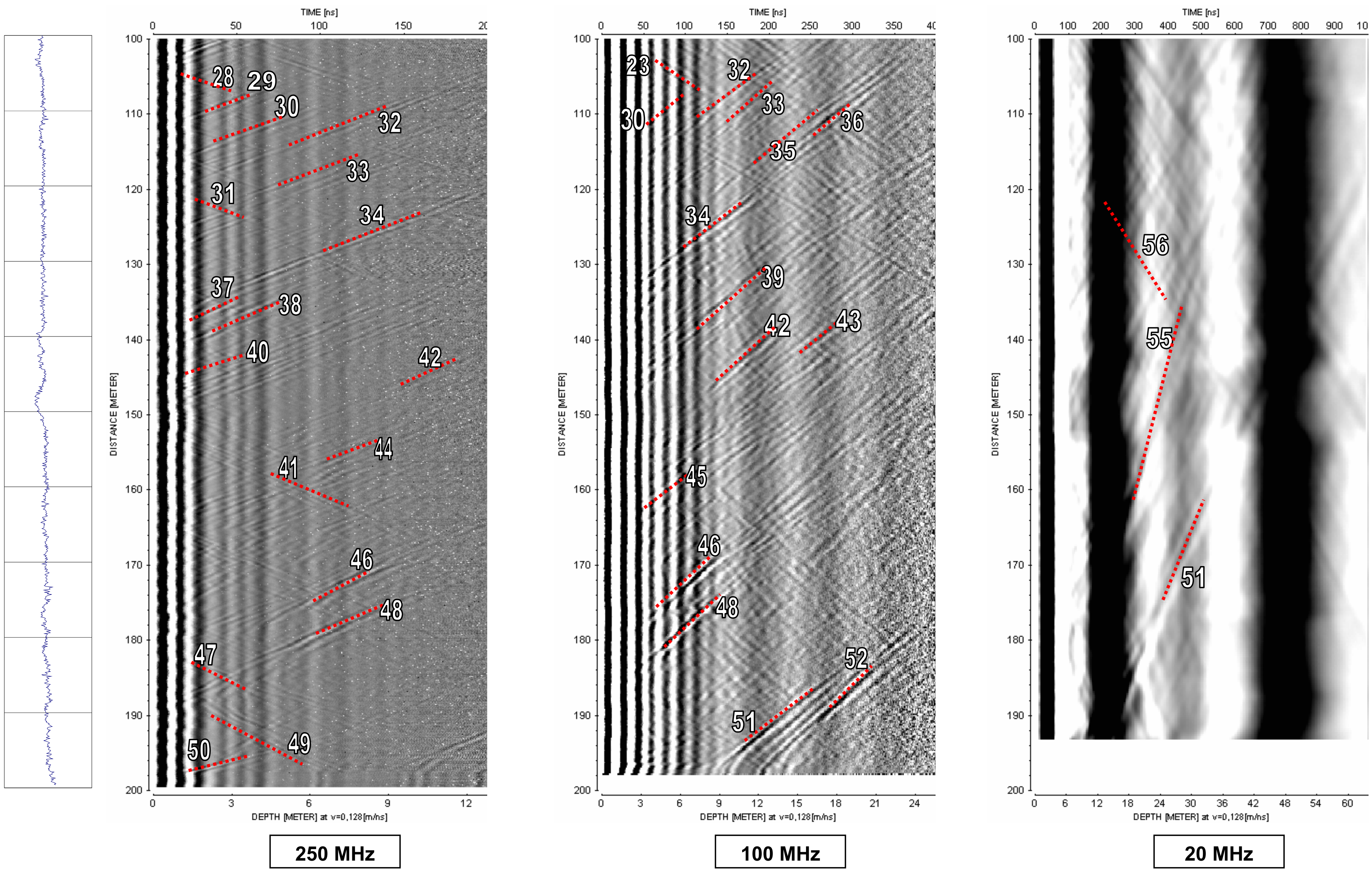
Radar logging in HFM29, 0 to 197 m, dipole antennas 250, 100 and 20 MHz

FORSMARK HFM29



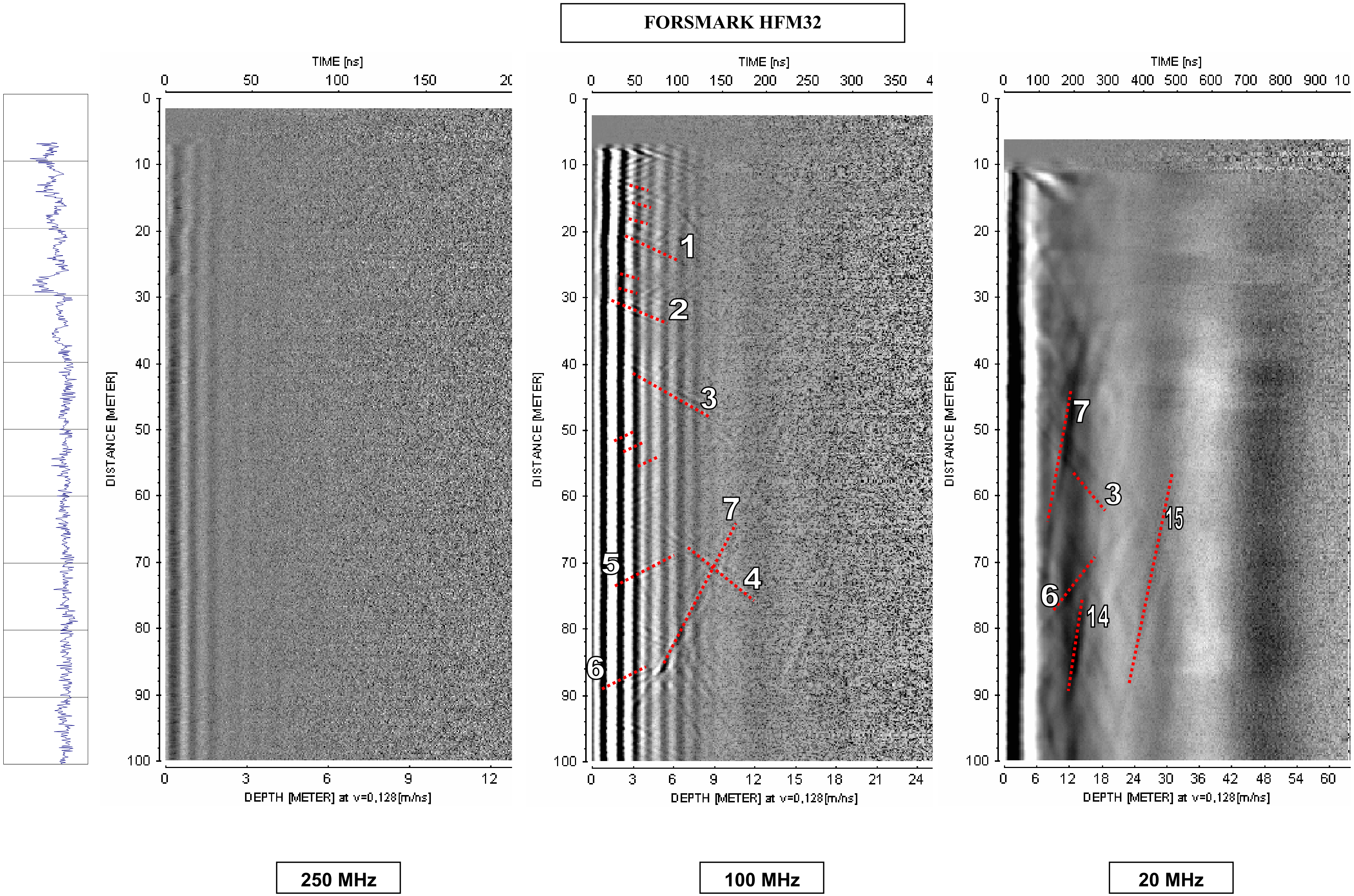
250 MHz | **100 MHz** | **20 MHz**

FORSMARK HFM29

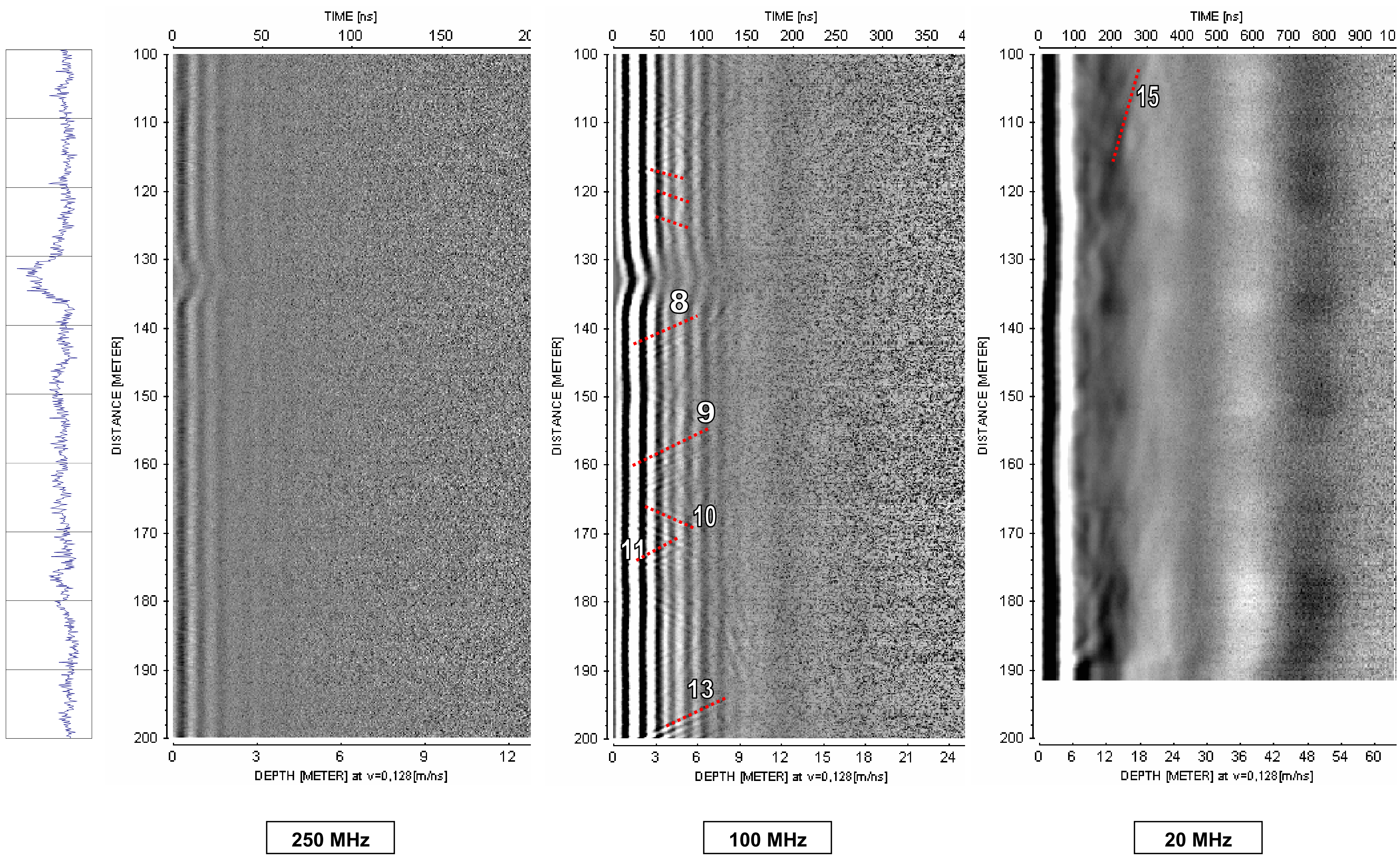


Appendix 6

Radar logging in HFM32, 0 to 199 m, dipole antennas 250, 100 and 20 MHz



FORSMARK HFM32



Appendix 7A

BIPS logging in KFM09B, 8 to 440 m

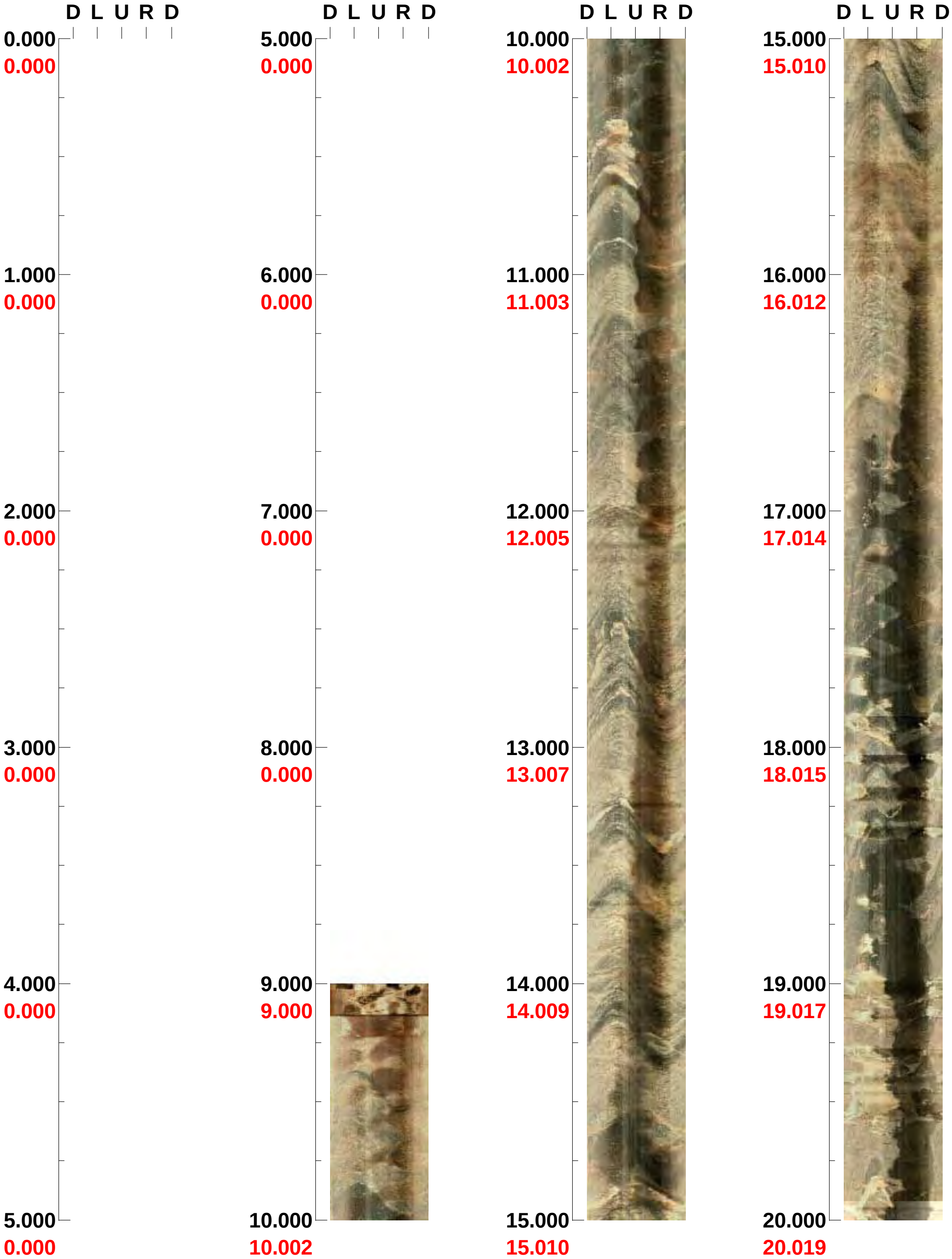
Project name: Forsmark

Image file	: c:\work\r5484f~1\kfm09b\bips\kfm09b_1.bip
BDT file	: c:\work\r5484f~1\kfm09b\bips\kfm09b_1.bdt
Locality	: FORSMARK
Bore hole number	: KFM09B
Date	: 06/01/25
Time	: 07:35:00
Depth range	: 9.000 - 610.072 m
Azimuth	: 141
Inclination	: -55
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	: 16
Color	: +0 +0 +0

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 0.000 - 20.000 m



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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 20.000 - 40.000 m

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

Appendix 7A

Project name: Forsmark

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 40.000 - 60.000 m

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

Appendix 7A **Project name: Forsmark**
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 60.000 - 80.000 m

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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 80.000 - 100.000 m

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

Appendix 7A **Project name: Forsmark**

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 100.000 - 120.000 m

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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B   **Azimuth: 141**   **Inclination: -55**

Depth range: 120.000 - 140.000 m

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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 140.000 - 160.000 m

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

Appendix 7A **Project name: Forsmark**

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 160.000 - 180.000 m

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

Appendix 7A **Project name: Forsmark**
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 180.000 - 200.000 m

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

Appendix 7A

Project name: Forsmark

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 200.000 - 220.000 m

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

Appendix 7A **Project name: Forsmark**
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 220.000 - 240.000 m

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

Appendix 7A

Project name: Forsmark

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 240.000 - 260.000 m

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

Appendix 7A **Project name: Forsmark**
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 260.000 - 280.000 m

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

Appendix 7A **Project name: Forsmark**
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 280.000 - 300.000 m

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

Appendix 7A

Project name: Forsmark

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 300.000 - 320.000 m

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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 320.000 - 340.000 m

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

Appendix 7A

Project name: Forsmark

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 340.000 - 360.000 m

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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 360.000 - 380.000 m

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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 380.000 - 400.000 m

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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 400.000 - 420.000 m

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

Appendix 7A

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 420.000 - 440.000 m

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

Appendix 7B

BIPS logging in KFM09B, 440 to 610 m

Project name: Forsmark

Image file	: c:\work\r5484f~1\bips\kfm09b.bip
BDT file	: c:\work\r5484f~1\bips\kfm09b.bdt
Locality	: FORSMARK
Bore hole number	: KFM09B
Date	: 06/03/16
Time	: 14:21:00
Depth range	: 440.000 - 610.179 m
Azimuth	: 141
Inclination	: -55
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	: 9
Color	: +0 +0 +0

Appendix 7B

Project name: Forsmark

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 440.000 - 460.000 m

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

Appendix 7B

Project name: Forsmark

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 460.000 - 480.000 m

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

Appendix 7B

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 480.000 - 500.000 m

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

Appendix 7B **Project name: Forsmark**

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 500.000 - 520.000 m

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

Appendix 7B

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 520.000 - 540.000 m

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

Appendix 7B

Project name: Forsmark
Bore hole No.: KFM09B Azimuth: 141 Inclination: -55

Depth range: 540.000 - 560.000 m

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

Appendix 7B

Project name: Forsmark

Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 560.000 - 580.000 m

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

Appendix 7B

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 580.000 - 600.000 m

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

Appendix 7B

Project name: Forsmark
Bore hole No.: KFM09B **Azimuth: 141** **Inclination: -55**

Depth range: 600.000 - 610.179 m

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

BIPS logging in HFM24, 17 to 151 m

Project name: Forsmark

Image file	: c:\work\r5484f~1\hfm24\bips\hfm24.bip
BDT file	: c:\work\r5484f~1\hfm24\bips\hfm24.bdt
Locality	: FORSMARK
Bore hole number	: HFM24
Date	: 06/01/03
Time	: 14:25:00
Depth range	: 17.000 - 151.261 m
Azimuth	: 47
Inclination	: -60
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

Appendix 8

Project name: Forsmark
Bore hole No.: HFM24 **Azimuth: 47** **Inclination: -60**

Depth range: 0.000 - 20.000 m

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

Appendix 8

Project name: Forsmark

Bore hole No.: HFM24 **Azimuth: 47** **Inclination: -60**

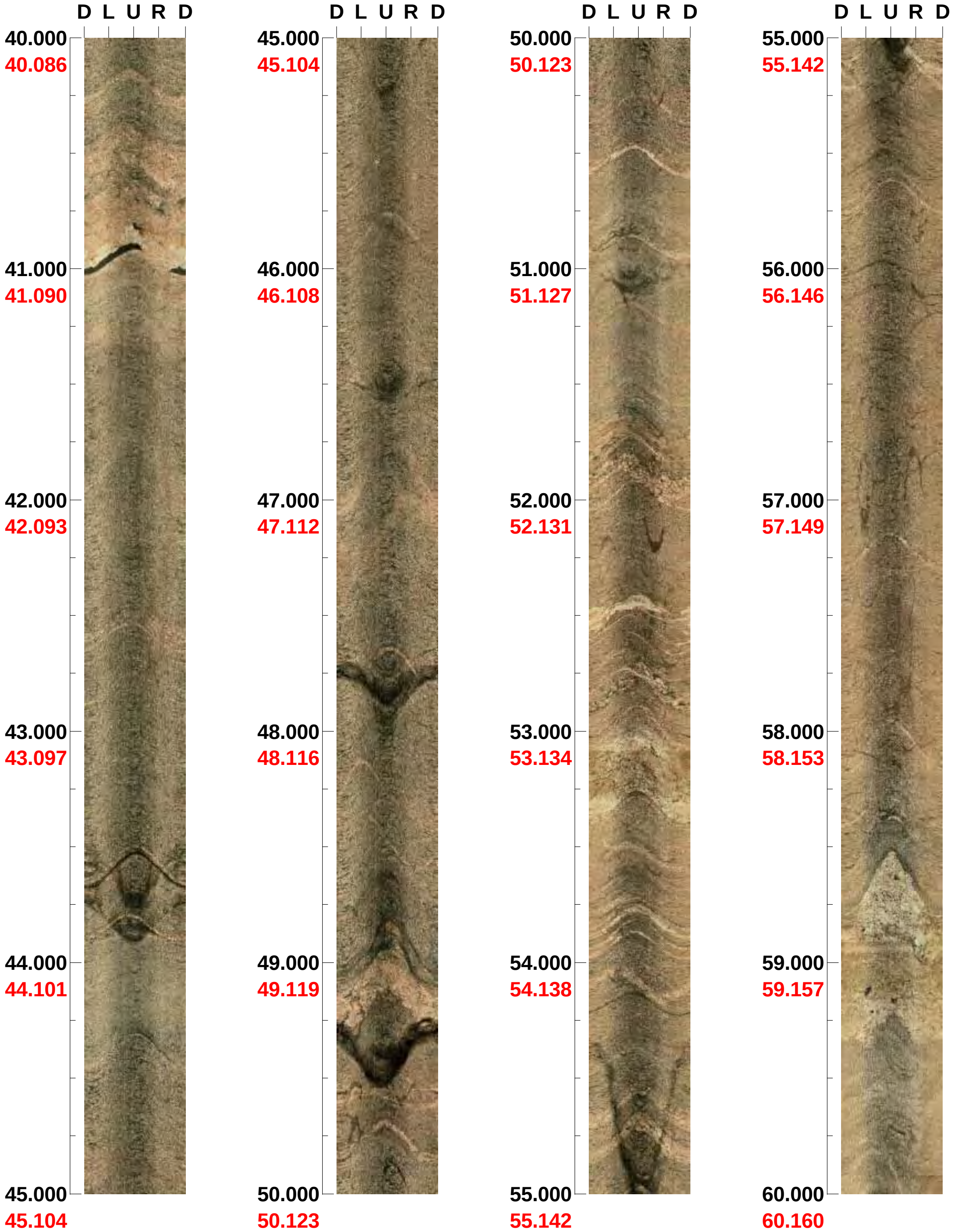
Depth range: 20.000 - 40.000 m

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

Appendix 8

Project name: Forsmark
Bore hole No.: HFM24 **Azimuth: 47** **Inclination: -60**

Depth range: 40.000 - 60.000 m

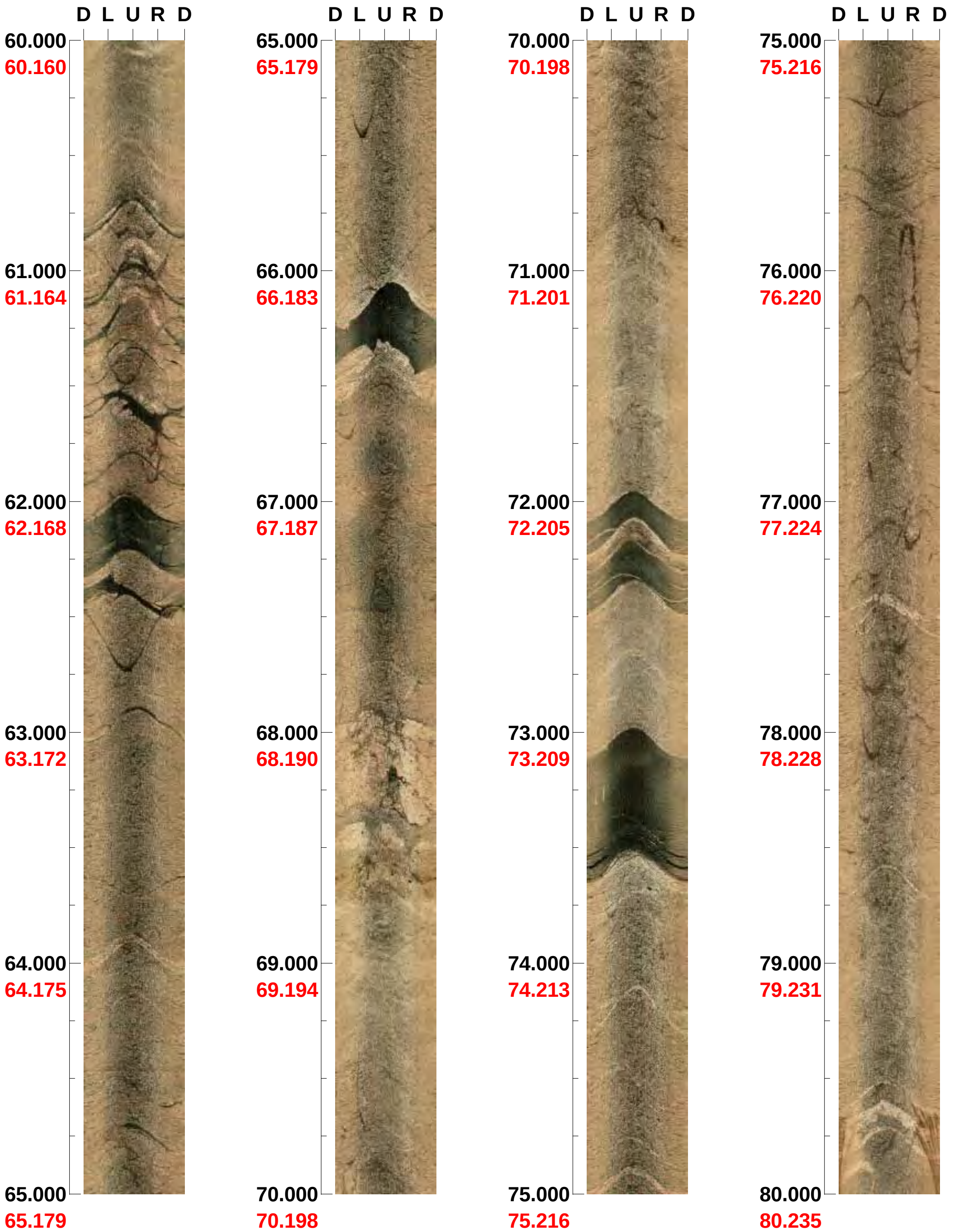


(3 / 8) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 8

Project name: Forsmark
Bore hole No.: HFM24 **Azimuth: 47** **Inclination: -60**

Depth range: 60.000 - 80.000 m



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

Appendix 8

Project name: Forsmark
Bore hole No.: HFM24 **Azimuth: 47** **Inclination: -60**

Depth range: 80.000 - 100.000 m

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

Appendix 8

Project name: Forsmark
Bore hole No.: HFM24 **Azimuth: 47** **Inclination: -60**

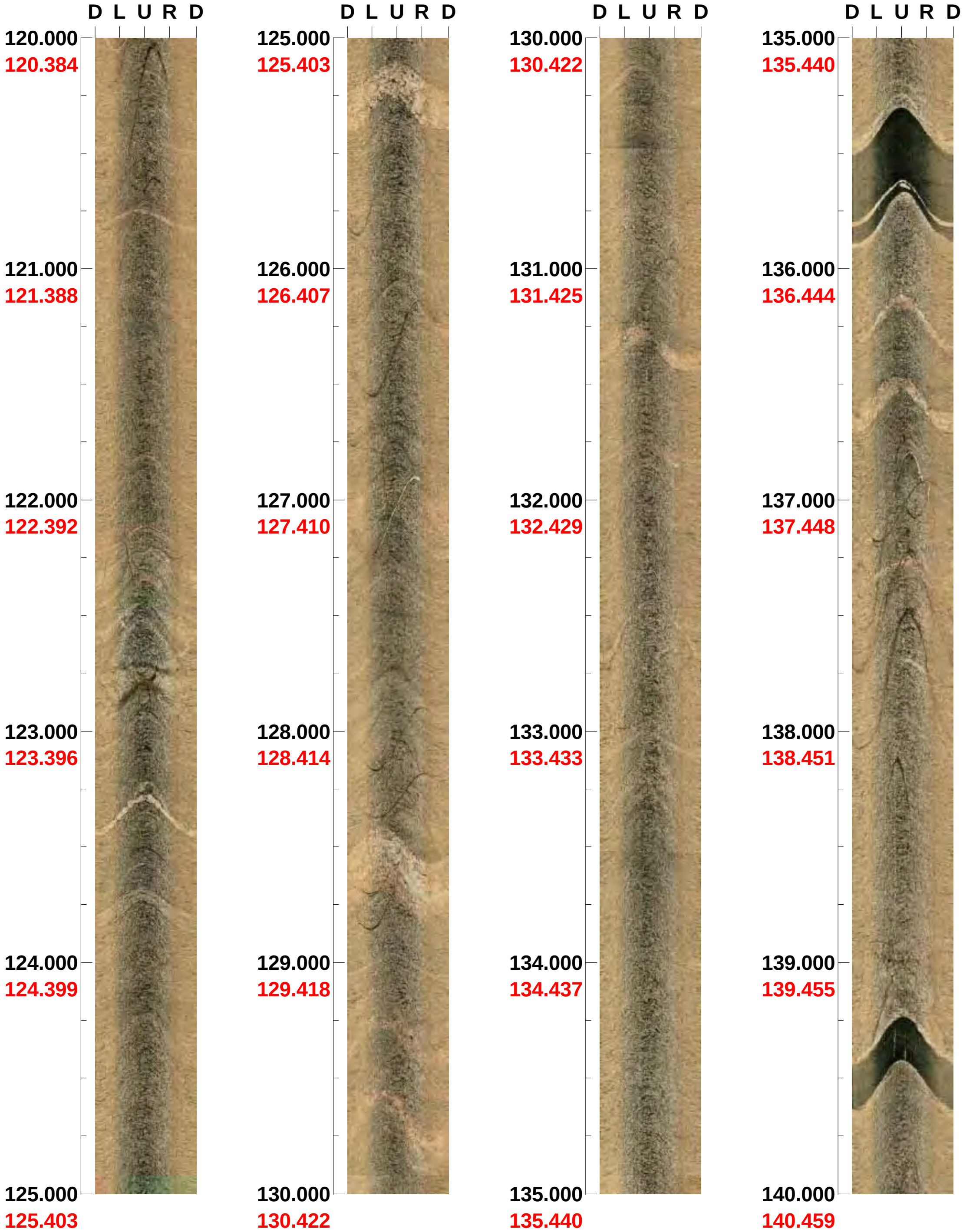
Depth range: 100.000 - 120.000 m

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

Appendix 8

Project name: Forsmark
Bore hole No.: HFM24 **Azimuth: 47** **Inclination: -60**

Depth range: 120.000 - 140.000 m



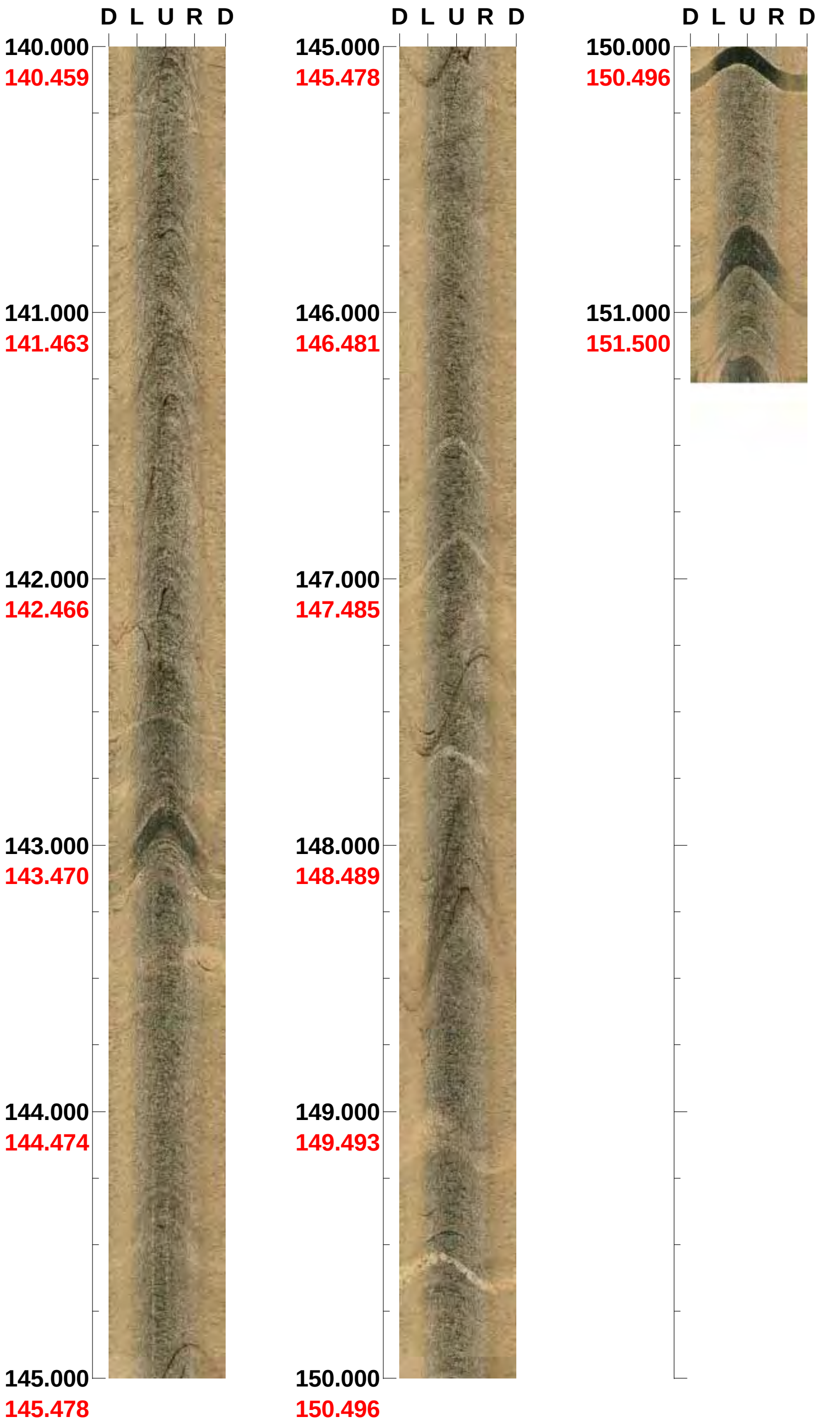
(7 / 8) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 8

Project name: Forsmark

Bore hole No.: HFM24 **Azimuth: 47** **Inclination: -60**

Depth range: 140.000 - 151.261 m



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

BIPS logging in HFM26, 8 to 199 m

Project name: Forsmark

Image file	: c:\work\r5484f~1\bips\hfm26.bip
BDT file	: c:\work\r5484f~1\bips\hfm26.bdt
Locality	: FORSMARK
Bore hole number	: HFM26
Date	: 06/01/16
Time	: 18:08:00
Depth range	: 8.000 - 199.265 m
Azimuth	: 112
Inclination	: -54
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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

Depth range: 0.000 - 20.000 m

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

Appendix 9

Project name: Forsmark

Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

Depth range: 20.000 - 40.000 m

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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

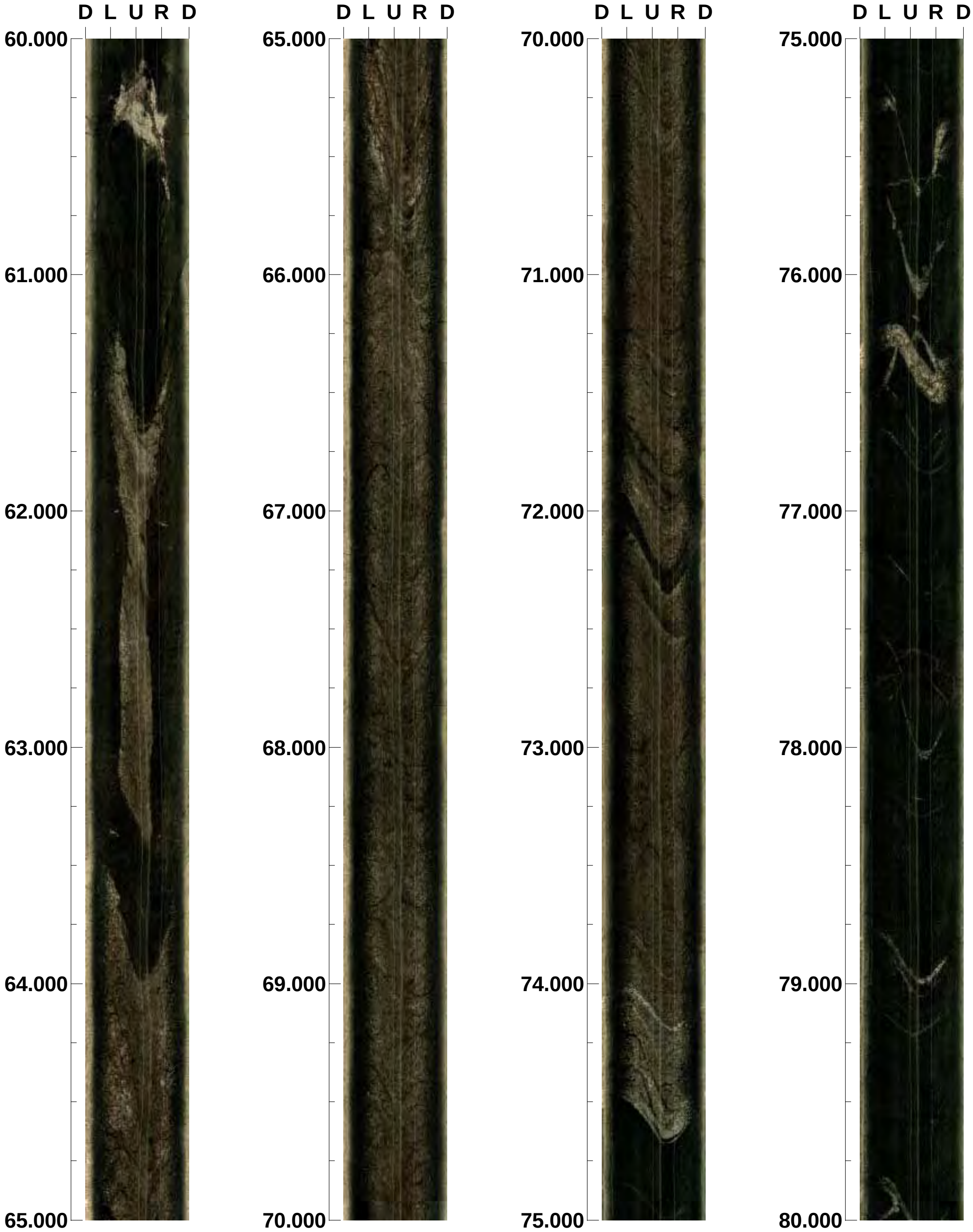
Depth range: 40.000 - 60.000 m

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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

Depth range: 60.000 - 80.000 m



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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

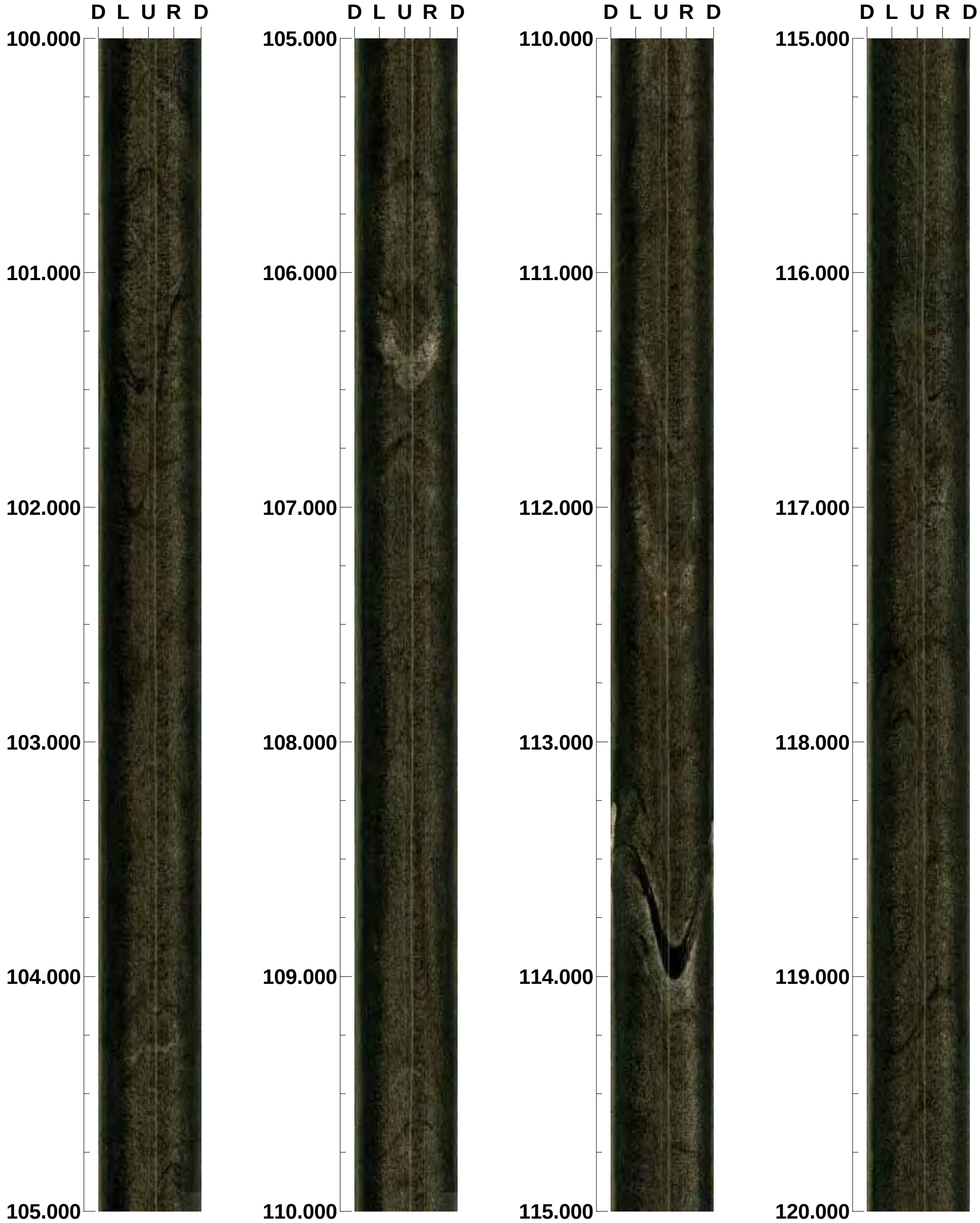
Depth range: 80.000 - 100.000 m

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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

Depth range: 100.000 - 120.000 m



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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

Depth range: 120.000 - 140.000 m

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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

Depth range: 140.000 - 160.000 m

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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

Depth range: 160.000 - 180.000 m

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

Appendix 9

Project name: Forsmark
Bore hole No.: HFM26 **Azimuth: 112** **Inclination: -54**

Depth range: 180.000 - 199.265 m

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

BIPS logging in HFM27, 11 to 127 m

Project name: Forsmark

Image file	: c:\work\r5484f~1\hfm27\bips\hfm27.bip
BDT file	: c:\work\r5484f~1\hfm27\bips\hfm27.bdt
Locality	: FORSMARK
Bore hole number	: HFM27
Date	: 06/01/03
Time	: 08:46:00
Depth range	: 11.000 - 127.517 m
Azimuth	: 337
Inclination	: -68
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

Appendix 10

Project name: Forsmark
Bore hole No.: HFM27 **Azimuth: 337** **Inclination: -68**

Depth range: 0.000 - 20.000 m

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

Appendix 10 **Project name: Forsmark**
Bore hole No.: HFM27 **Azimuth: 337** **Inclination: -68**

Depth range: 20.000 - 40.000 m

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

Appendix 10

Project name: Forsmark
Bore hole No.: HFM27 **Azimuth: 337** **Inclination: -68**

Depth range: 40.000 - 60.000 m

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

Appendix 10 **Project name: Forsmark**
Bore hole No.: HFM27 **Azimuth: 337** **Inclination: -68**

Depth range: 60.000 - 80.000 m

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

Appendix 10

Project name: Forsmark

Bore hole No.: HFM27 **Azimuth: 337** **Inclination: -68**

Depth range: 80.000 - 100.000 m

D L U R D

80.000
80.208

81.000 / 81.211
82.000 / 82.214
83.000 / 83.217
84.000 / 84.220
85.000 / 85.223

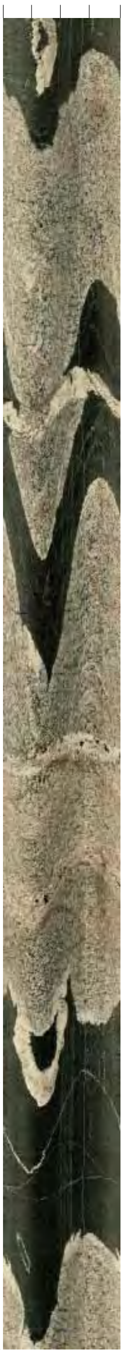
D L U R D

85.000
85.223

86.000 / 86.226
87.000 / 87.229
88.000 / 88.232
89.000 / 89.235
90.000 / 90.238

D L U R D

90.000
90.238



91.000 / 91.241
92.000 / 92.244
93.000 / 93.247
94.000 / 94.250
95.000 / 95.253

D L U R D

95.000
95.253

96.000 / 96.256
97.000 / 97.259
98.000 / 98.263
99.000 / 99.266
100.000 / 100.269

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

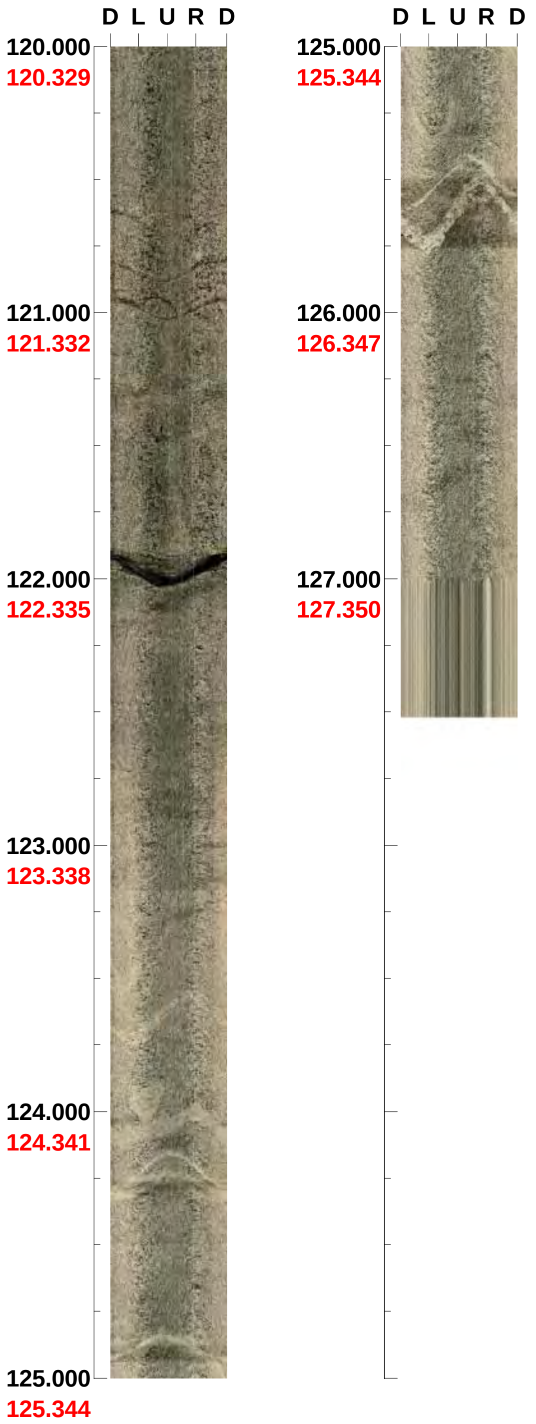
Appendix 10 **Project name: Forsmark**
Bore hole No.: HFM27 **Azimuth: 337** **Inclination: -68**

Depth range: 100.000 - 120.000 m

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

Project name: Forsmark
Bore hole No.: HFM27 **Azimuth: 337** **Inclination: -68**

Depth range: 120.000 - 127.517 m



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

BIPS logging in HFM29, 8 to 199 m

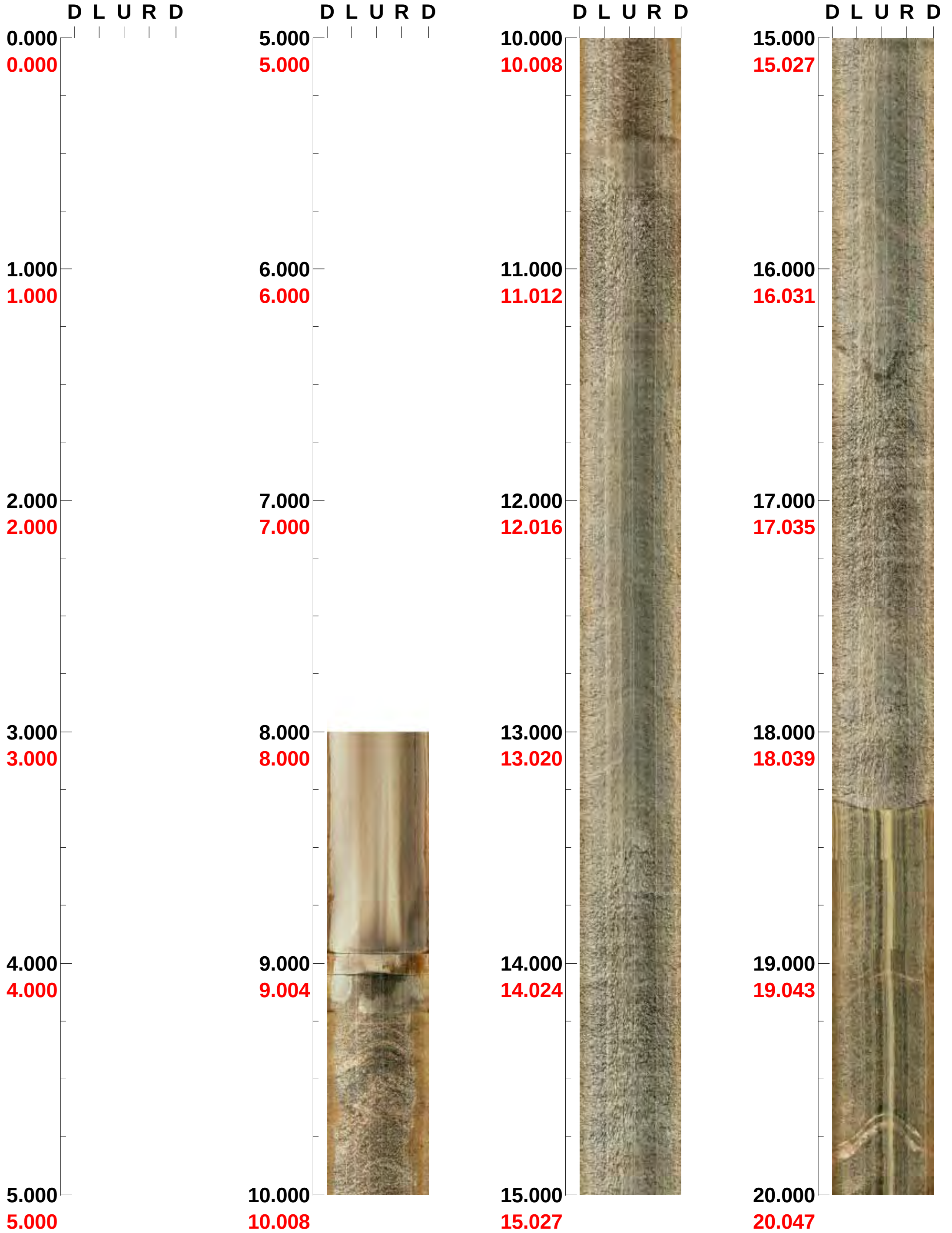
Project name: Forsmark

Image file	: c:\work\r5484f~1\hfm29\bips\hfm29.bip
BDT file	: c:\work\r5484f~1\hfm29\bips\hfm29.bdt
Locality	: FORSMARK
Bore hole number	: HFM29
Date	: 06/01/04
Time	: 09:14:00
Depth range	: 8.000 - 199.178 m
Azimuth	: 30
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	: 10
Color	: +0 +0 +0

Appendix 11

Project name: Forsmark
Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 0.000 - 20.000 m



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

Appendix 11

Project name: Forsmark

Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 20.000 - 40.000 m

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

Appendix 11

Project name: Forsmark
Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 40.000 - 60.000 m

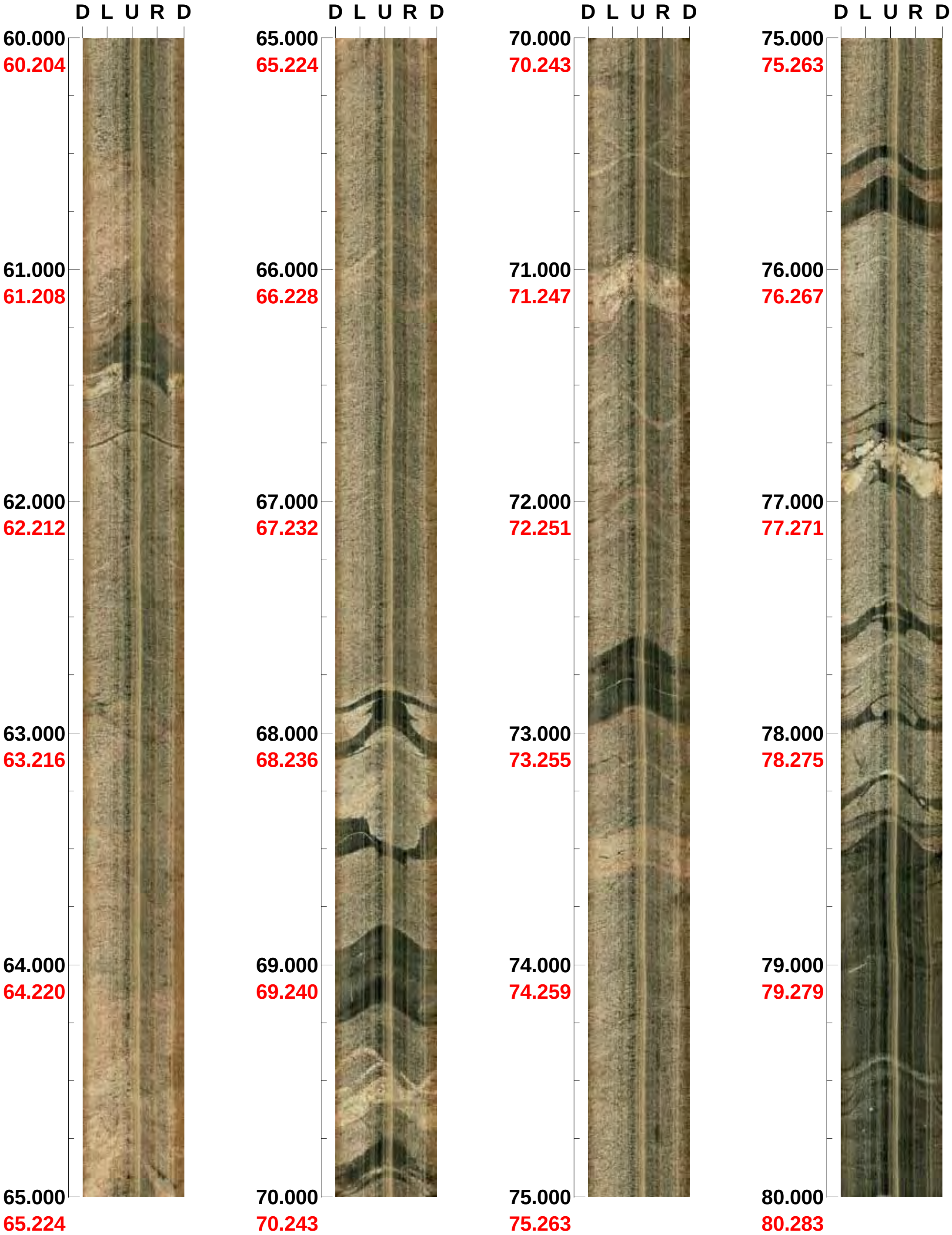
(3 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 11

Project name: Forsmark

Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 60.000 - 80.000 m

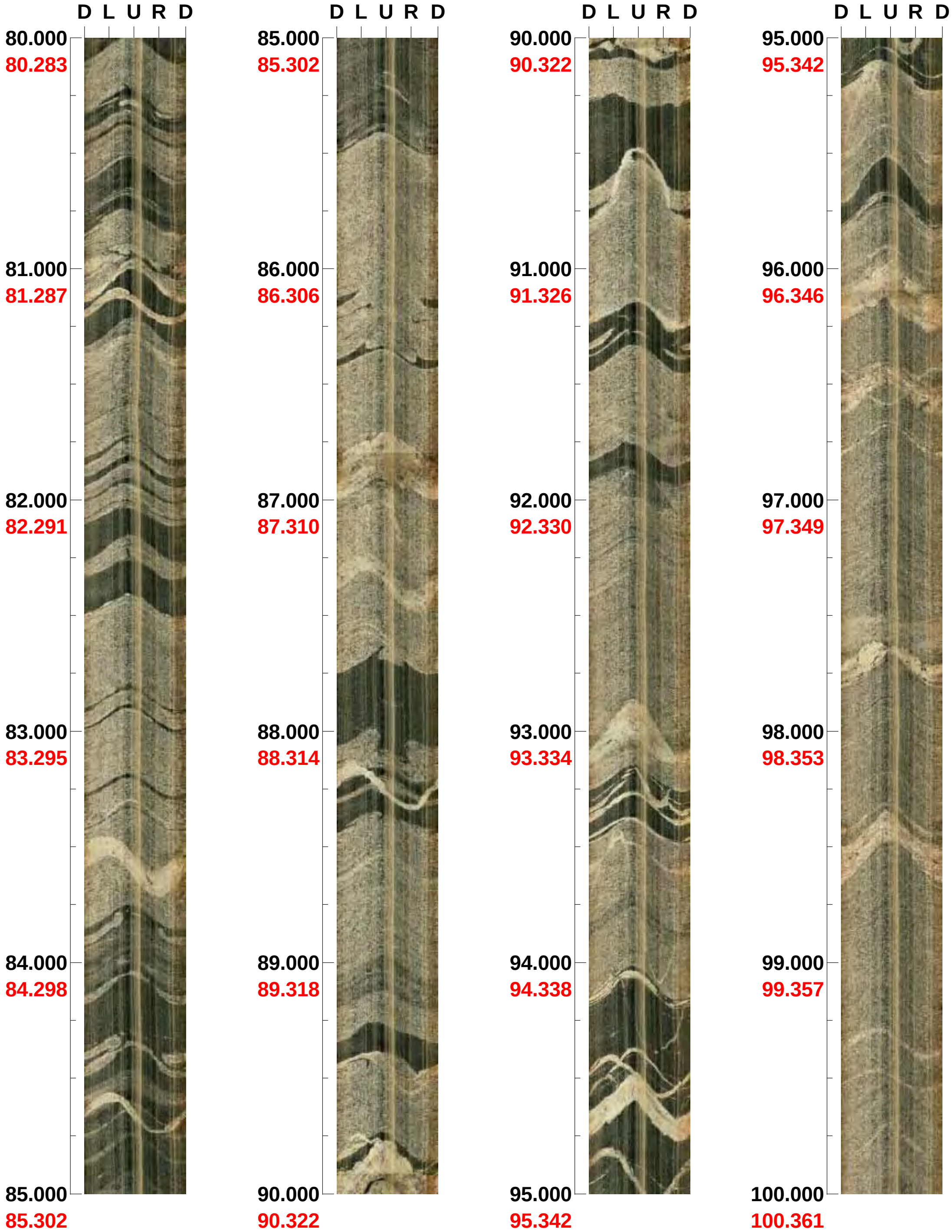


(4 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 11

Project name: Forsmark
Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 80.000 - 100.000 m

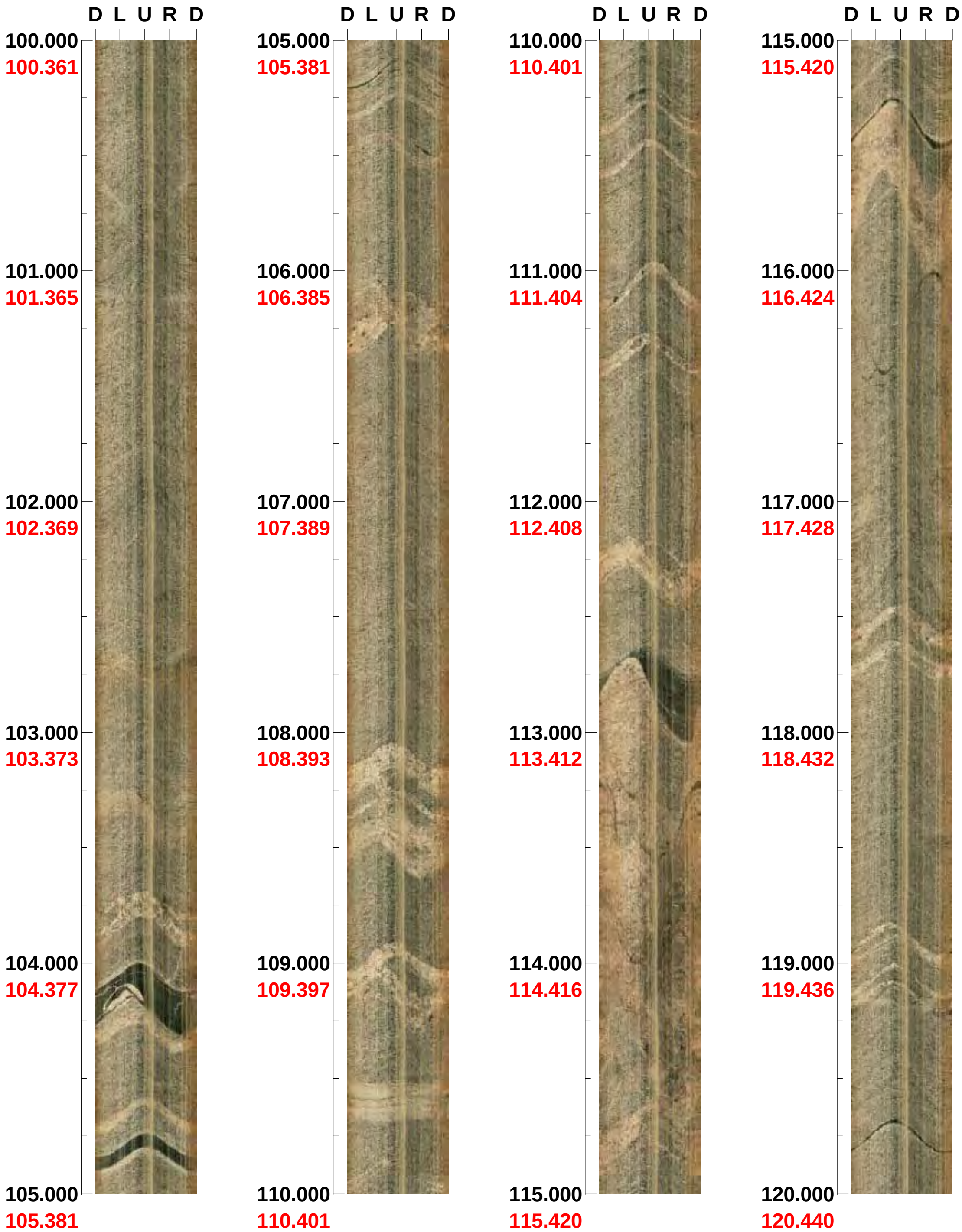


(5 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 11

Project name: Forsmark
Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 100.000 - 120.000 m



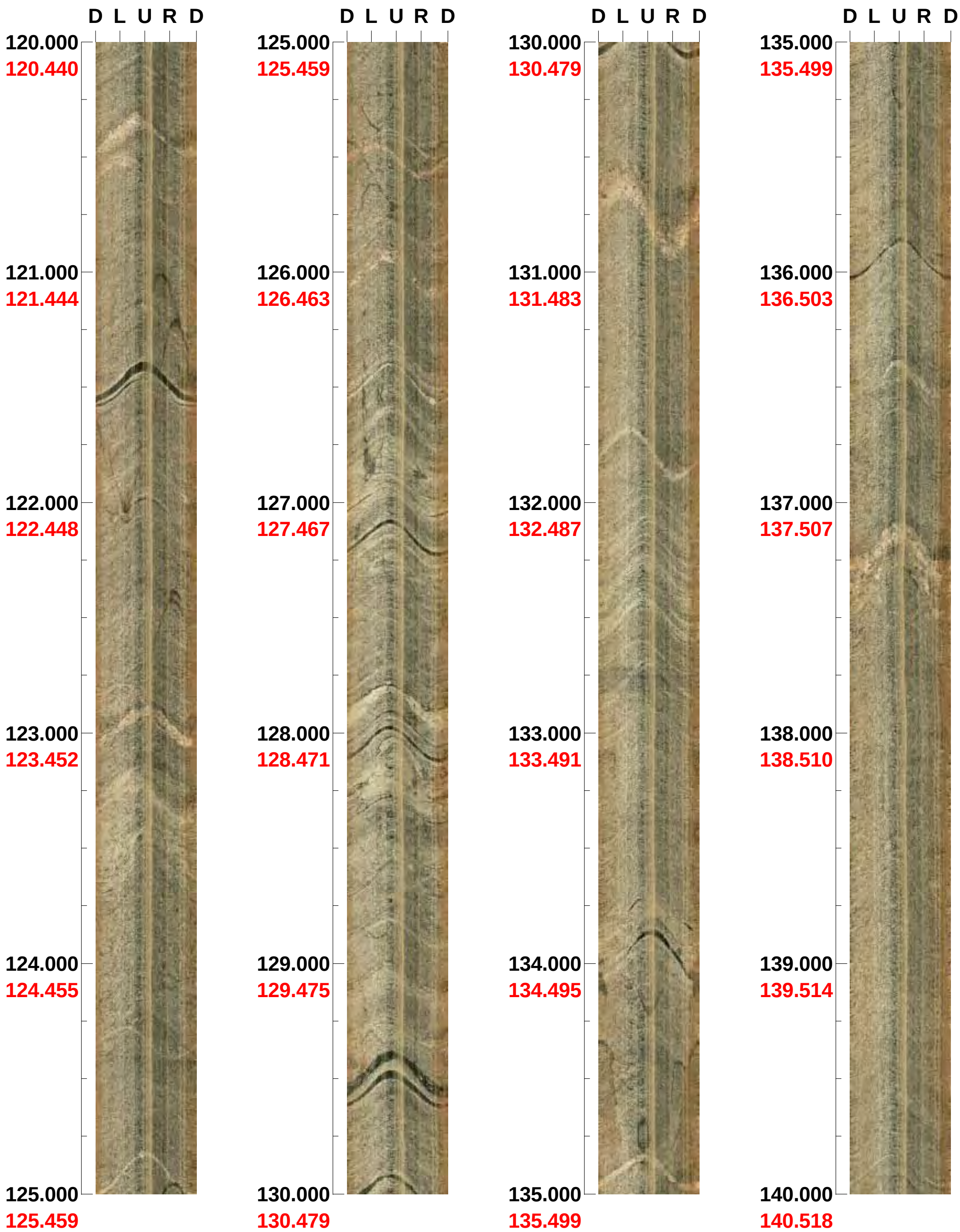
(6 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 11

Project name: Forsmark

Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 120.000 - 140.000 m



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

Appendix 11 **Project name: Forsmark**

Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 140.000 - 160.000 m

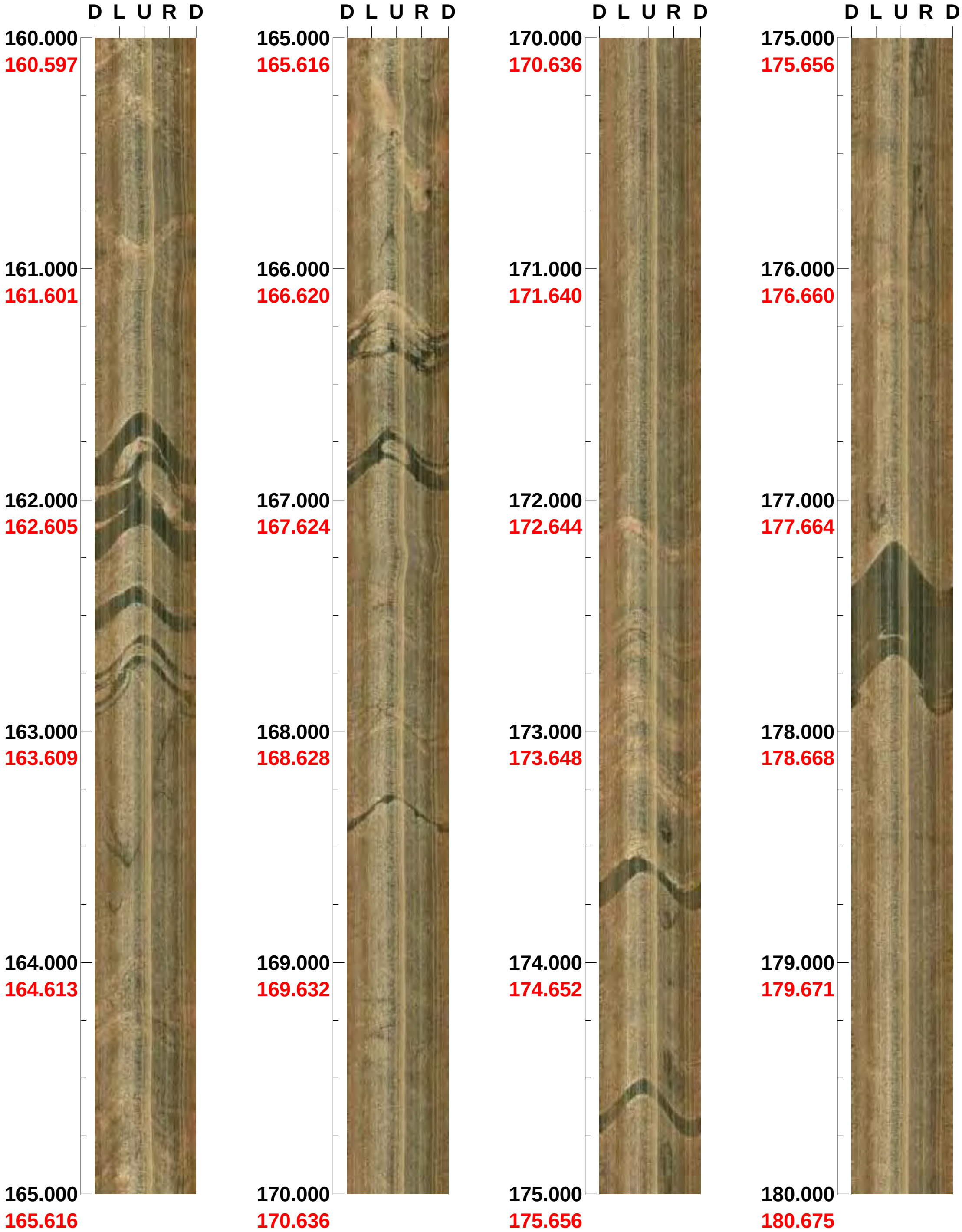
(8 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 11

Project name: Forsmark

Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

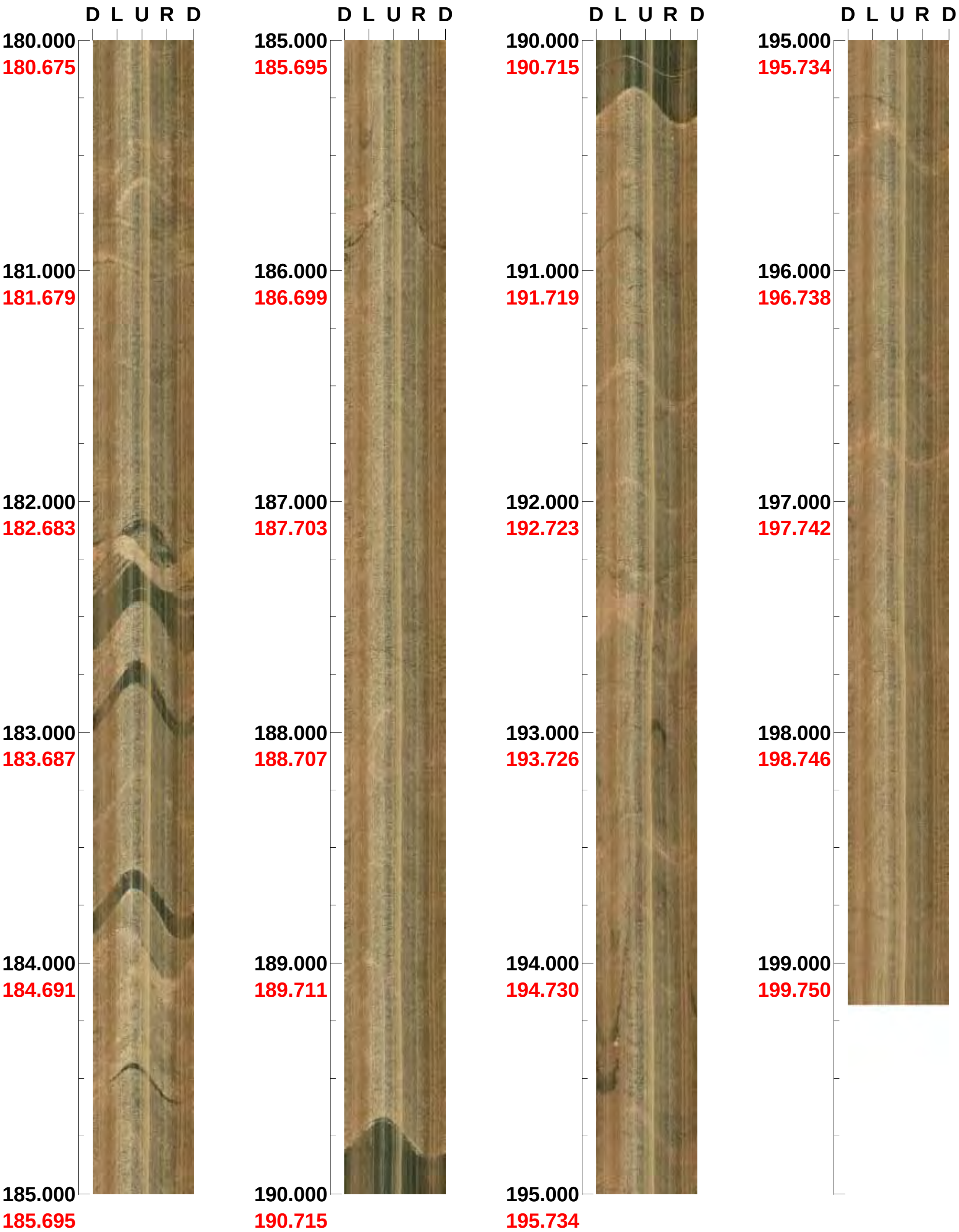
Depth range: 160.000 - 180.000 m



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

Appendix 11 **Project name: Forsmark**
Bore hole No.: HFM29 **Azimuth: 30** **Inclination: -59**

Depth range: 180.000 - 199.178 m



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

BIPS logging in HFM32, 5 to 201 m

Project name: Forsmark

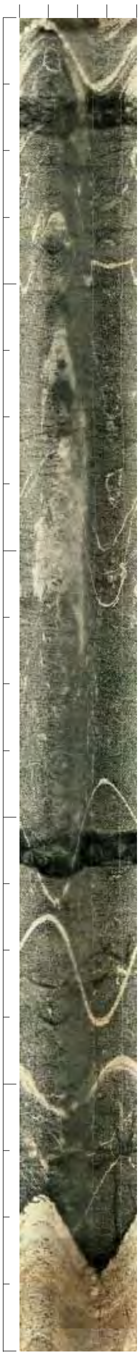
Image file	: c:\work\r5484f~1\hfm32\bips\hfm32.bip
BDT file	: c:\work\r5484f~1\hfm32\bips\hfm32.bdt
Locality	: FORSMARK
Bore hole number	: HFM32
Date	: 06/01/19
Time	: 08:32:00
Depth range	: 5.000 - 201.736 m
Azimuth	: 116
Inclination	: -86
Diameter	: 140.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 100 %
Pages	: 11
Color	: +0 +0 +0

Appendix 12

Project name: Forsmark
Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 0.000 - 20.000 m

0.000 – 5.000	5.000 – 10.000	10.000 – 15.000	15.000 – 20.000
D L U R D	D L U R D	D L U R D	D L U R D
0.000 / 0.000	5.000 / 5.000	10.000 / 10.019	15.000 / 15.038
1.000 / 1.000	6.000 / 6.004	11.000 / 11.023	16.000 / 16.042
2.000 / 2.000	7.000 / 7.008	12.000 / 12.027	17.000 / 17.046
3.000 / 3.000	8.000 / 8.011	13.000 / 13.031	18.000 / 18.050
4.000 / 4.000	9.000 / 9.015	14.000 / 14.034	19.000 / 19.054
5.000 / 5.000	10.000 / 10.019	15.000 / 15.038	20.000 / 20.057



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

Appendix 12 **Project name: Forsmark**
Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 20.000 - 40.000 m

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

Appendix 12

Project name: Forsmark

Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 40.000 - 60.000 m

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

Appendix 12

Project name: Forsmark
Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 60.000 - 80.000 m

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

Appendix 12

Project name: Forsmark
Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 80.000 - 100.000 m

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

Appendix 12

Project name: Forsmark
Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 100.000 - 120.000 m

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

Appendix 12

Project name: Forsmark

Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

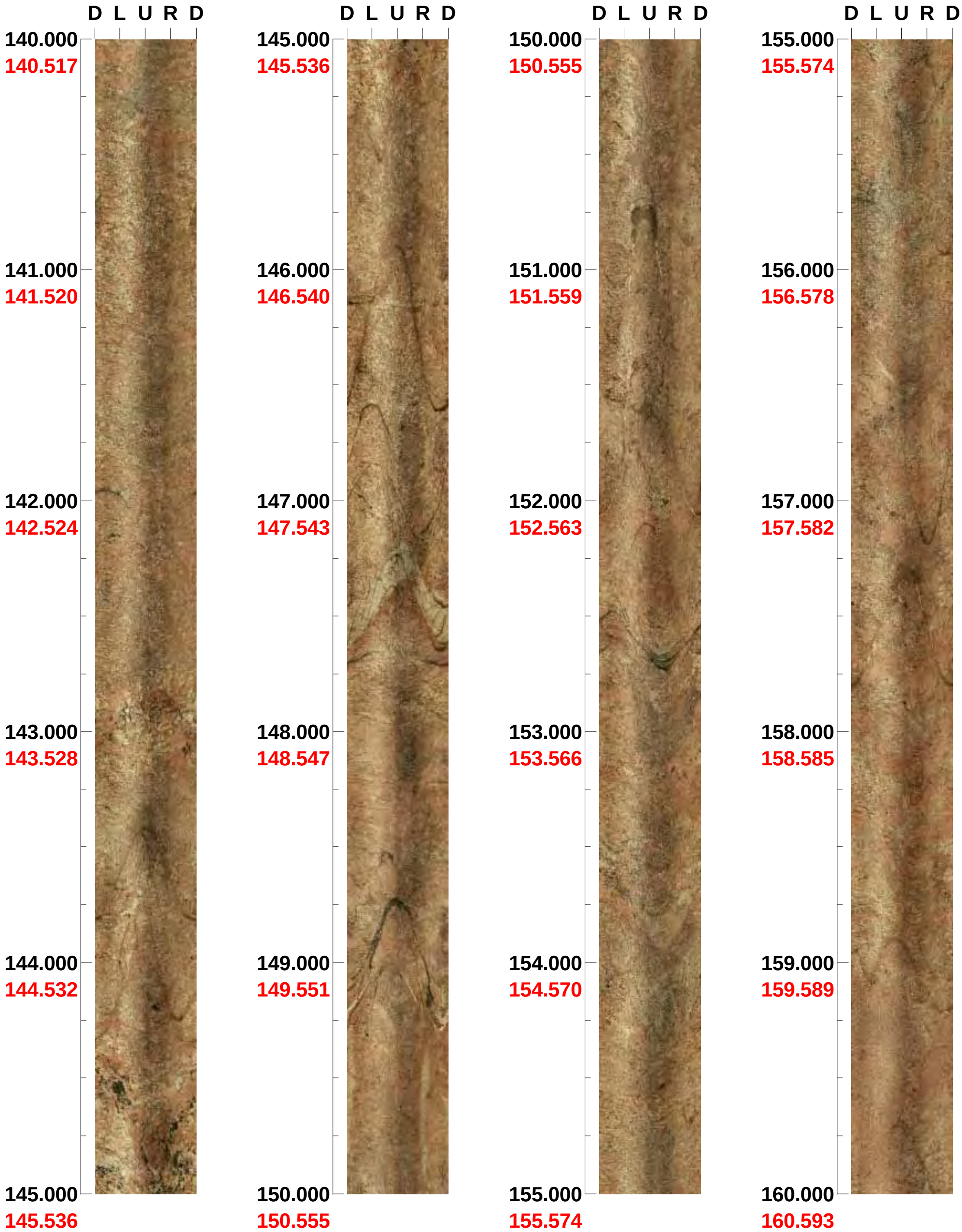
Depth range: 120.000 - 140.000 m

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

Appendix 12

Project name: Forsmark
Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 140.000 - 160.000 m



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

Appendix 12

Project name: Forsmark

Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 160.000 - 180.000 m

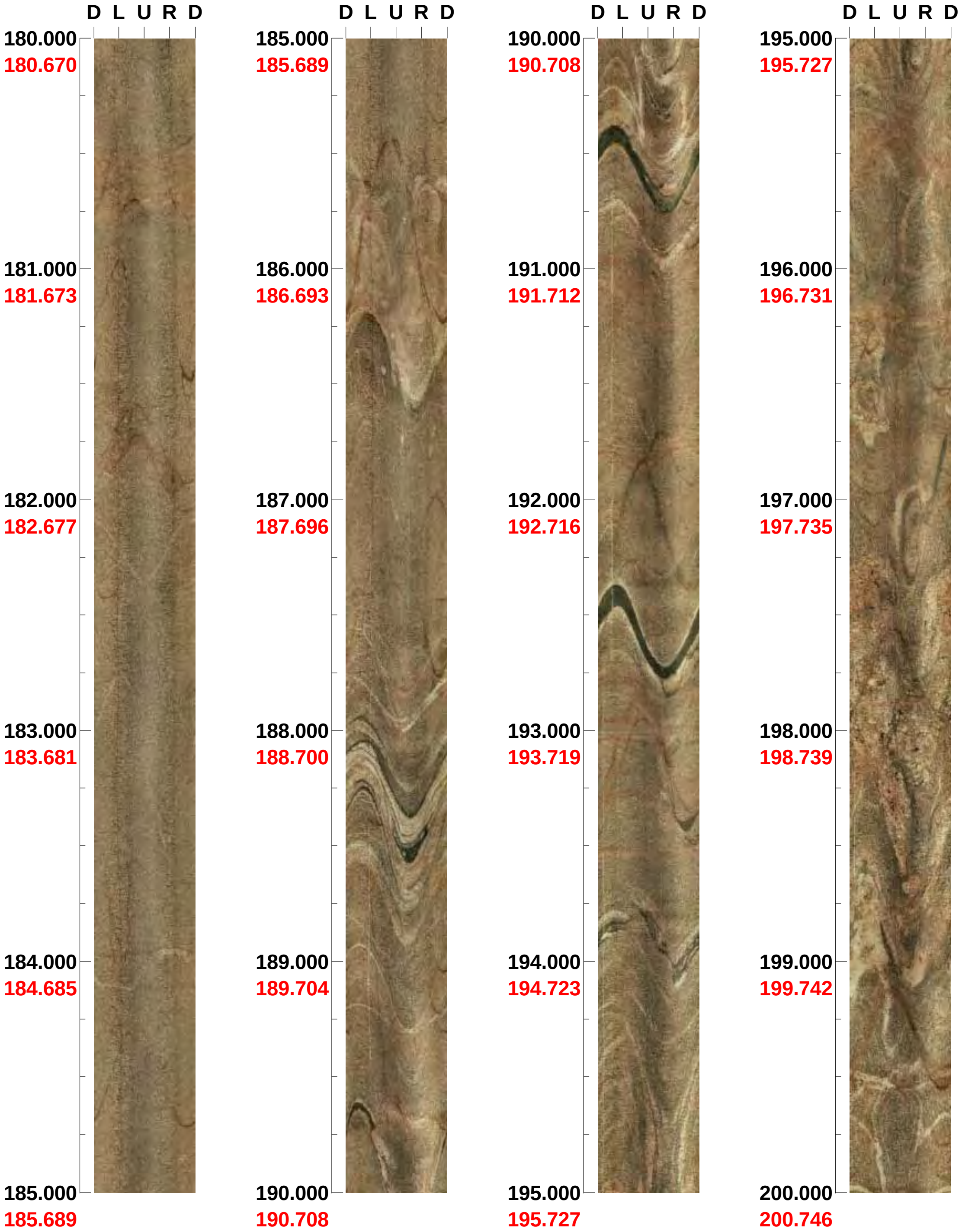
(9 / 11) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 12

Project name: Forsmark

Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 180.000 - 200.000 m

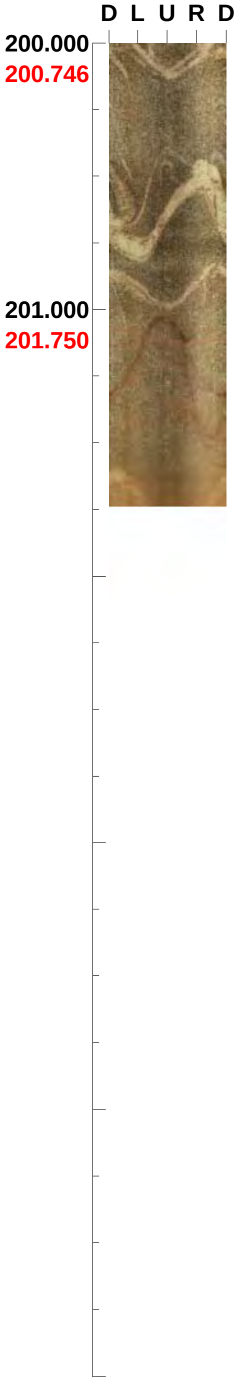


(10 / 11) **Scale: 1/25** **Aspect ratio: 100 %**

Appendix 12

Project name: Forsmark
Bore hole No.: HFM32 **Azimuth: 116** **Inclination: -86**

Depth range: 200.000 - 201.736 m



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