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Oskarshamn site investigation

RAMAC and BIPS logging in boreholes KAV04A, KAV04B, HLX13 and HLX15

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June 2004

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Keywords: BIPS, RAMAC, Radar, TV.

Reading instruction

The directional radar antenna did not function in borehole KAV04B.

For revision no 1 of this report a recalculation of the directional radar data has been done. The strike angle between the line of the plane's cross-section with the surface and the Magnetic North direction was earlier counted counter-clockwise but it is now recalculated as such it counts clockwise, see Figure 5-2. New values for strike and dip are therefore updated in Table 5-5.

Abstract

This report includes the data gained in geophysical logging operations performed within the site investigation at Oskarshamn. The logging operations presented here includes borehole radar (RAMAC) in the core-drilled boreholes KAV04A, KAV04B and percussion drilled boreholes HLX13 and HLX15. All measurements were conducted by Malå Geoscience AB/RAYCON during May 2004.

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 borehole radar data quality from KAV04A, KAV04B, HLX13 and HLX15 was relatively satisfying, but in some parts of lower quality due to more conductive conditions. This conductive environment of course 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 KAV04A 138 radar reflectors were identified and half of them were also orientated (strike/dip). In KAV04B 25 radar reflectors were identified and the corresponding numbers for HLX13 and HLX15 are 22 and 32.

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Oskarshamn. Mätningarna som presenteras här omfattar borrhålsradarmätningar (RAMAC) i borrhålen KAV04A, KAV04B, HLX13 och HLX15. Alla mätningar är utförda av Malå Geoscience AB/RAYCON under maj 2004.

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

Borrhålsradardata från KAV04A, KAV04B, HLX13 och HLX15 var relativt tillfredställande, 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 drygt 138 radarreflektorer identifierats i KAV04A, varav cirka hälften har kunnat orienteras (strykning/stupning). Motsvarande antal för KAV04B, HLX13 och HLX15 är 25, 22 och 32.

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 Oskarshamn. The logging operations presented here includes borehole radar (RAMAC) and TV-logging (BIPS) in the core-drilled boreholes KAV04A and KAV04B and in the percussion-drilled boreholes HLX13 and HLX15. The work was carried out in accordance with activity plan AP PS 400-04-046. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

This report includes measurements from 0 to 1000 m in KAV04A and measurements from 0 to approximately 100 m in borehole KAV04B. The loggings were performed to approximately 200 m depth in borehole HLX13 and to 150 m in HLX15. The boreholes HLX13 and HLX15 are drilled with a diameter of approximately 140 and 137 mm respectively and KAV04A and KAV04B with a diameter of 76 mm.

All measurements were conducted by Malå Geoscience AB/RAYCON during May 2004. The location of the boreholes is shown in Figure 1-1.

The used investigation techniques comprised:

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

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

Activity plan	**Number**	**Version**
Borrhålsradar och BIPS i KAV04A, KAV04B, HLX13 och HLX15	AP PS 400-04-046	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för TV- loggning med BIPS	SKB MD 222.006	1.0
Metodbeskrivning för borrhålsradar	SKB MD 252.020	1.0

Figure 1-1. *General overview over the Simpevarp and Laxemar subareas in Oskarshamn with the location of the boreholes KAV04A, KAV04B, HLX13 and HLX15.*

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.

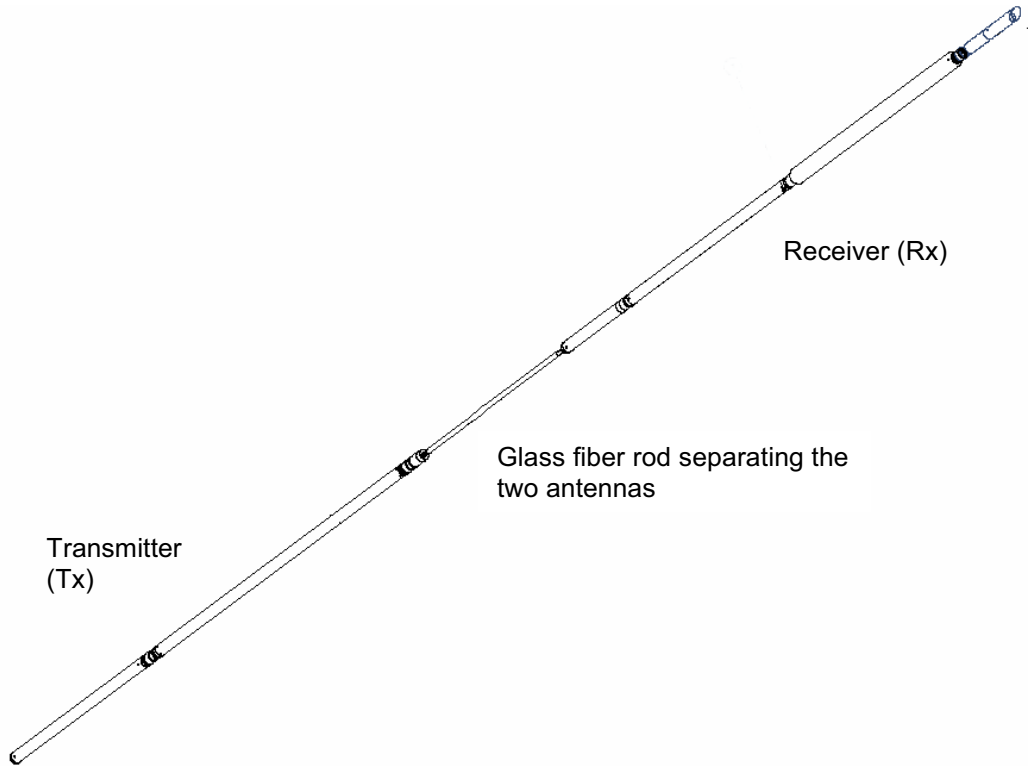


Figure 3-1. *Example of a borehole radar antenna.*

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 360 pixels/circle.

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

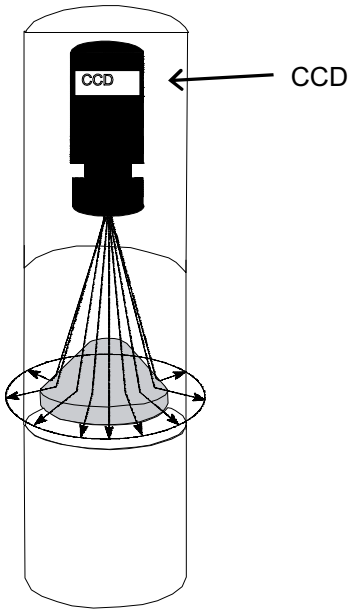


Figure 3-2. *The BIP-system. Illustration of the conical mirror scanning.*

4 Execution

4.1 General

4.1.1 RAMAC Radar

The measurements in KAV04A, KAV04B, HLX13 and HLX15, were carried out with dipole radar antennas, with frequencies of 250, 100 and 20 MHz. In KAV04A and KAV04B measurements were also made using the directional antenna, with a central frequency of 60 MHz. However, the measurements with the directional antenna in KAV04B failed due to too much rotation of the antenna, so they are no further commented in this report.

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 Table 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). All cleaning of the antennas and cable was performed according to the internal document SKB MD 600.004 before the logging operation.

The functionality of the directional antenna was tested before measurements in KAV04A and KAV04B. This is done 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 measured by compass and the result achieved from the directional antenna was about 10 degrees. This can be considered as satisfying due to the disturbed environment, with metallic objects etc at the test site.

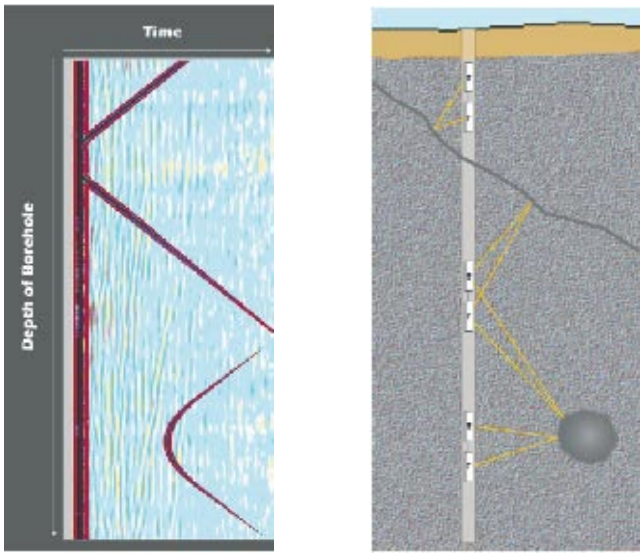


Figure 4-1. *The principle of radar borehole reflection survey and an example of result.*

For more information on system settings used in the investigation of KAV04A, KAV04B, HLX13 and HLX15, see Table 4-1 to 4-4 below.

Table 4-1. Radar logging information from KAV04A.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KAV04A**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional / Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Logging date:	04-05-26	04-05-25	04-05-25	04-05-25
	Reference:	T.O.C.	T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):	665	2588	951	247
	Number of samples:	512	619	518	518
	Number of stacks:	32	Auto	Auto	Auto
	Signal position:	365.7	–0.32	–032	1.35
	Logging from (m):	103.4	101.5	102.6	106.25
	Logging to (m):	993.4	996.9	997.6	991.3
	Trace interval (m):	0.5	0.25	0.2	0.1
	Antenna separation (m):	5.73	2.4	3.9	10.05

Table 4-2. Radar logging information from KAV04B.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KAV04B**	**Equipment:**	**SKB RAMAC**		
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
			250 MHz	**100 MHz**	**20 MHz**
	Logging date:		04-05-25	04-05-25	04-05-25
	Reference:		T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):		2588	951	257
	Number of samples:		619	518	518
	Number of stacks:		Auto	Auto	Auto
	Signal position:		–0.32	–0.32	–1.35
	Logging from (m):		1.5	2.6	6.25
	Logging to (m):		99.0	98.1	93.3
	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 HLX13.

Site:	Oskarshamn	Logging company:	RAYCON		
BH:	HLX13	Equipment:	SKB RAMAC		
Type:	Dipole	Manufacturer:	MALÅ GeoScience		
Operator:	CG	Antenna			
			250 MHz	100 MHz	20 MHz
	Logging date:		04-05-28	04-05-28	04-05-28
	Reference:		T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):		2588	951	257
	Number of samples:		619	518	518
	Number of stacks:		Auto	Auto	Auto
	Signal position:		–0.32	–0.32	–1.43
	Logging from (m):		1.5	2.6	6.25
	Logging to (m):		198.3	197.3	192.1
	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 HLX15.

Site:	Oskarshamn	Logging company:	RAYCON		
BH:	HLX15	Equipment:	SKB RAMAC		
Type:	Dipole	Manufacturer:	MALÅ GeoScience		
Operator:	CG	Antenna			
			250 MHz	100 MHz	20 MHz
	Logging date:		04-05-27	04-05-27	04-05-27
	Reference:		T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):		2588	951	257
	Number of samples:		619	518	518
	Number of stacks:		Auto	Auto	Auto
	Signal position:		–0.32	–0.43	–1.43
	Logging from (m):		1.5	2.6	6.25
	Logging to (m):		150.2	149.3	145.9
	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 KAV04A, HLX13 and HLX15. In KAV04B the compass was used to measure the orientation.

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 the last one. 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.

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 experience we have from earlier measurements in the core-drilled boreholes in Forsmark and Oskarshamn is that the depth divergence is less than 50 cm in the deepest parts of the boreholes.

For the measurements with the directional antenna in KAV04A the depth divergence was at most 1.5 m. This divergence is taken into account in the results below, Table 5-5.

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 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 120 m/micro seconds. The velocity measurement was performed in borehole KSH01B with the 100 MHz antennas /1/.

The visualization of data in Appendix 1 to 4 is made with ReflexWin, a Windows based processing software for filtering and analysis of borehole radar data. The processing steps are shown in Tables 4-5 to 4-8.

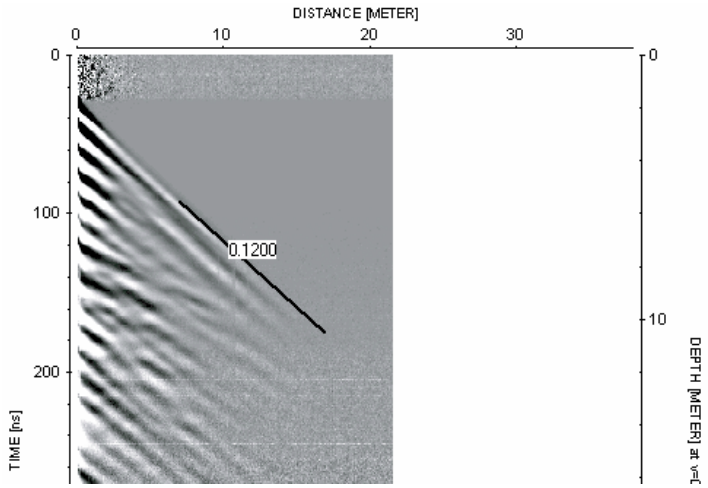


Figure 4-3. *Results from velocity measurements in KSH01B with 100 MHz dipole antennas /1/.*

Table 4-5. Processing steps for borehole radar data from KAV04A.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KAV04A**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JA**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Processing:	DC removal	DC removal	DC removal	DC removal
		Time gain	Move start time	Move start time	Move start time
		FIR	Gain	Gain	Gain

Table 4-6. Processing steps for borehole radar data from KAV04B.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KAV04B**	**Equipment:**	**SKB RAMAC**		
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JA**	**Antenna**			
			250 MHz	**100 MHz**	**20 MHz**
	Processing:		DC removal	DC removal	DC removal
			Move start time	Move start time	Move start time
			Gain	Gain	Gain

Table 4-7. Processing steps for borehole radar data from HLX13.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**HLX13**	**Equipment:**	**SKB RAMAC**		
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JA**	**Antenna**			
			250 MHz	**100 MHz**	**20 MHz**
	Processing:		DC removal	DC removal	DC removal
			Move start time	Move start time	Move start time
			Gain	Gain	Gain

Table 4-8. Processing steps for borehole radar data from HLX15.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**HLX15**	**Equipment:**	**SKB RAMAC**		
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JA**	**Antenna**			
			250 MHz	**100 MHz**	**20 MHz**
	Processing:		DC removal	DC removal	DC removal
			Move start time	Move start time	Move start time
			Gain	Gain	Gain

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 5-1 to 5-8 and are also visible on the radargrams in Appendix 1 to 4.

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 visible in the BIPS image. For printing of the BIPS images the printing software PDPP from RaaX was used.

4.3 Nonconformities

The directional radar antenna did not function in borehole KAV04B.

For revision no 1 of this report a recalculation of the directional radar data has been done. The strike angle between the line of the plane's cross-section with the surface and the Magnetic North direction was earlier counted counter-clockwise but it is now recalculated as such it counts clockwise, see Figure 5-2. New values for strike and dip are therefore updated in Table 5-5.

5 Results

The results from the radar and BIPS measurements were delivered as raw data (*.bip-files) on CD-ROMs to SKB 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-ROMs stored by SKB.

The RAMAC radar data was delivered as raw data (fileformat *.rd3 or *.rd5) for KAV04A, KAV04B, HLX13 and HLX15 with corresponding information files (file format *.rad) whereas the data processing steps and results are presented in this report. Relevant information, including the interpretation presented in this report, was inserted into the SKB database SICADA.

The delivered raw and processed data have been inserted in the database of SKB (SICADA). The SICADA reference to the present activity is Field note 367.

5.1 RAMAC logging

The results of the interpretation of the radar measurements are presented in Tables 5-1 to 5-8. Radardata is also visualized in Appendix 1 to 4. It should be remembered that the images in Appendix 1 to 4 is only a composite picture of all events 360 degrees around the borehole, and do not reflect the orientation of the structures.

Only the larger clearly visible structures are interpreted in RadinterSKB. A number of minor structures also exist, indicated in Appendix 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.

The data quality from KAV04A, KAV04B, HLX13 and HLX15, (as seen in Appendix 1 to 4) is relatively satisfying, but in some parts of lower quality due to more conductive conditions. A conductive environment makes the radar wave to attenuate, which decreases the penetration. This is for instance seen very clearly in the data from HLX13 from a depth of 74 m, in HLX15 from a depth of 100 m and in KAV04A from a depth of 500 m. 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 deteriorated quality due to increased electrical conductivity in the bedrock or in the borehole fluid is especially seen for the 20 MHz data below 570 m (KAV04A), which therefore is not displayed in Appendix 1. This effect is also seen in the directional antenna (see Figure 5-1), which makes it more difficult to interpret the direction to the identified structures.

As also seen in Appendix 1 to 4 the resolution and penetration of radar waves depend on the antenna frequency used. Low antenna frequency gives less resolution but higher penetration rate compared to a higher frequency.

In Tables 5-1 to 5-4 below the distribution of identified structures along the borehole are listed for KAV04A, KAV04B, HLX13 and HLX15.

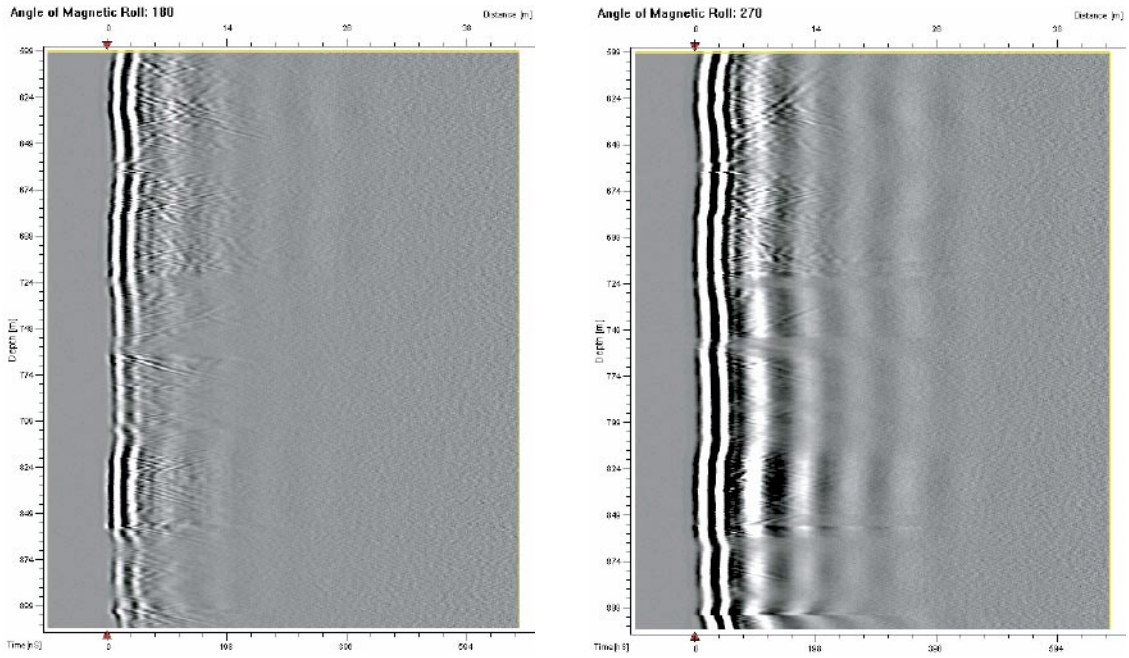


Figure 5-1. *Example of data quality from the directional antenna in KAV04A, depending on direction. To the left 180 degrees and to the right 270 degrees.*

Table 5-1. Identified structures as a function of depth in KAV04A.

Depth (m)	No of structures
–150	8
150–200	6
200–250	13
250–300	14
300–350	9
350–400	8
400–450	14
450–500	9
500–550	9
550–600	5
600–650	8
650–700	6
700–750	4
750–800	5
800–850	5
850–900	3
900–950	4
950–	8

Table 5-2. Identified structures as a function of depth in KAV04B.

Depth (m)	No of structures
0–10	1
10–20	2
20–30	2
30–40	2
40–50	1
50–60	4
60–70	1
70–80	3
80–90	5
90–100	2
100–	1

Table 5-3. Identified structures as a function of depth in HLX13.

Depth (m)	No of structures
–50	3
50–100	5
100–120	2
120–140	2
140–160	3
160–180	5
180–200	–
200–	2

Table 5-4. Identified structures as a function of depth in HLX15.

Depth (m)	No of structures
–10	1
10–20	1
20–30	2
30–40	2
40–50	2
50–60	2
60–70	1
70–80	2
80–90	4
90–100	2
100–120	3
120–140	4
140–	6

Tables 5-5 to 5-8 summarises the interpretation of radar data from KAV04A, KAV04B, HLX13 and HLX15. As seen some radar reflectors are marked with ±, which indicates an uncertainty in the interpretation of the direction to the reflector. The direction can in these cases be ±180 degrees. The direction to the reflector (the plane) is defined in Figure 5-2. As the borehole is near vertical (>85 degrees) the direction to object is calculated using magnetic roll. This direction and the intersection angle are also recalculated to strike and dip, also given in Table 5-5. The plane strike is the angle between line of the plane's cross-section with the surface and the Magnetic North direction. It counts clockwise and can be between 0 and 359 degrees. A strike of 0 degrees implies a dip to the east while a strike of 180 degrees implies a dip to the west. The plane dip is the angle between the plane and the surface. It can vary between 0 and 90 degrees.

Table 5-5. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz and the directional antenna in borehole KAV04A.

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

Site: Oskarshamn
Borehole name: KAV04A
Nominal velocity (m/µs): 120.0

Name	Intersection depth	Intersection angle	Direction to object (magnetic roll)	Dip 1	Strike 1	Dip 2	Strike 2
103	85.00	4					
A	114.90	40	180	50	270		
Cx	115.30	47					
B	117.10	42					
C	119.00	67	321±	19	51	19	231
Ex	139.40	59	336±	30	66	30	246
D	149.10	12	315	77	45		
E	149.40	56	24±	35	114	35	294
F	153.40	63					
G	158.50	47	42±	41	132	41	312
I	159.60	31	213±	60	303	60	123
H	167.00	42					
J	174.20	64					
K	186.90	66	108±	20	198	20	18
N	200.70	65					
M	203.90	57					
L	204.20	38	174	51	264		
O	210.10	54					
P	211.70	49	288±	40	18	40	198
Q	217.80	47					
R	220.00	49	90±	40	180	40	0
S	222.90	53	153±	34	243	34	63
T	225.10	59					
U	233.50	40	120	51	210		
Ux	235.60	82	348±	8	78	8	258
V	239.80	51	177±	34	267	34	87
W	242.90	63					
X	250.30	66					

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

Site: Oskarshamn
Borehole name: KAV04A
Nominal velocity (m/µs): 120.0

Name	Intersection depth	Intersection angle	Direction to object (magnetic roll)	Dip 1	Strike 1	Dip 2	Strike 2
2x	255.30	8	18	82	108		
Y	256.70	74	120±	16	210	16	30
Z	268.20	64					
1	269.30	63					
2	272.70	24					
3	260.60	22	129	68	219		
4	281.50	41	36	47	126		
5	289.70	58					
6	291.70	55					
7	294.40	53					
104	296.20	17					
8	296.90	64					
9	297.90	50					
11	310.30	73					
10	311.60	48					
12	317.40	43	237±	46	327	46	147
13	323.50	49	339±	39	69	39	249
14	327.40	54					
15	333.90	50	159±	35	249	35	69
16	337.30	52	48±	38	138	38	318
105	340.90	69					
17	345.10	45	183	44	273		
18	355.70	64	330	26	60		
19	357.00	40					
20	365.50	48	359±	39	89	39	261
21	367.60	49	18±	36	108	36	288
22	382.00	52	177	38	267		
24	388.40	83					
23	390.50	34					
26	399.35	23					
28	410.10	45	237	46	327		
30	412.20	55					
25	412.30	38	39	52	129		
29	414.40	31	57	57	147		
29x	414.60	78	24	13	114		
27	415.90	51	213±	38	303	38	123
31	421.80	61					
32	429.80	61	0±	33	90	33	270
33	432.10	62	3±	29	93	29	273
34	435.90	56					
35	442.60	67					
36	445.80	53					

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

Site: Oskarshamn
Borehole name: KAV04A
Nominal velocity (m/µs): 120.0

Name	Intersection depth	Intersection angle	Direction to object (magnetic roll)	Dip 1	Strike 1	Dip 2	Strike 2
37	448.70	53					
38	464.50	61					
39	466.30	47					
40	467.90	45	39	41	129		
41	474.40	59					
42	484.90	54					
43	484.40	82					
44	489.60	45	333	42	63		
45	494.40	70	153±	26	243	26	63
46	497.60	77					
47	503.80	62	3±	27	93	27	273
48	506.20	69					
102	507.40	58					
49	509.20	69	12±	24	102	24	282
50	513.20	66	345	26	75		
51	526.70	56	153±	26	243	26	63
52	531.00	65	102±	20	192	20	12
53	541.40	62					
54	546.10	52	114	38	204		
55	549.60	56					
56	556.30	58	222±	29	312	29	132
57	566.10	36	234±	55	324	55	144
58	568.90	35	255	54	345		
59	577.50	44	237±	45	327	45	147
58x	595.90	54	42	36	132		
61	604.40	90					
60	605.50	90	240±	0	330	0	150
62	607.40	90					
65	612.80	29					
63	624.30	68					
64	624.70	36	36	53	126		
66	628.50	48					
67	643.70	59	210±	34	300	34	120
68	662.20	87					
69	662.60	17	252	74	342		
72	681.20	60	219±	32	309	32	129
70	684.40	59					
71	691.60	53	237	34	327		
73	695.70	69					
74	706.70	71	129±	15	219	15	39
75	715.40	65	141	29	231		
76	723.80	72					

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

Site: **Oskarshamn**
Borehole name: **KAV04A**
Nominal velocity (m/µs): **120.0**

Name	Intersection depth	Intersection angle	Direction to object (magnetic roll)	Dip 1	Strike 1	Dip 2	Strike 2
77	747.90	72					
78	756.90	76					
78x	758.80	63	156±	51	246	51	66
79	760.80	45					
80	775.70	63	261±	32	351	32	171
81	798.98	77					
82	812.80	88					
83	815.60	84	150±	5	240	5	60
84	825.50	67	63±	27	153	27	333
85	831.30	90					
86	831.60	41	141±	45	231	45	51
87	852.00	65	90±	25	180	25	0
88	859.30	67					
89	873.50	55	90±	30	180	30	0
90	905.50	90					
91	939.90	90	114±	0	204	0	24
93	941.60	80					
94	947.70	90					
92	955.50	57					
95	973.10	90					
96	980.50	56					
97	983.20	57					
98	985.20	57					
99	992.50	45					
100	994.00	66					
101	996.40	89					

Table 5-6. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz and the directional antenna in borehole KAV04B.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas and Directional antenna)			
Site:	**Oskarshamn**		
Borehole name:	**KAV04B**		
Nominal velocity (m/µs):	**120.0**		
Object type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	W	–123.10	26
PLANE	A	3.60	33
PLANE	B	13.20	56
PLANE	C	18.70	84
PLANE	D	24.90	49
PLANE	E	28.10	48
PLANE	F	36.20	40
PLANE	G	38.70	39
PLANE	H	48.80	65
PLANE	I	51.90	58
PLANE	K	55.20	33
PLANE	J	56.00	50
PLANE	L	59.10	43
PLANE	M	67.20	38
PLANE	N	72.40	24
PLANE	Nx	74.50	35
PLANE	Qx	79.80	51
PLANE	0	80.30	14
PLANE	P	81.70	11
PLANE	Q	82.10	47
PLANE	R	84.00	56
PLANE	S	86.90	55
PLANE	T	92.20	46
PLANE	U	93.70	41
PLANE	V	122.10	11

Table 5-7. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HLX13.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:	**Oskarshamn**		
Borehole name:	**HLX13**		
Nominal velocity (m/µs):	**120.0**		
Object type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	A	28.00	50
PLANE	B	29.30	48
PLANE	C	40.00	46
PLANE	E	73.70	27
PLANE	G	76.90	54
PLANE	D	77.40	14
PLANE	F	82.80	35
PLANE	I	84.90	8
PLANE	H	114.40	57
PLANE	R	117.40	39
PLANE	Q	126.70	59
PLANE	J	132.60	54
PLANE	M	140.00	82
PLANE	Dx	149.90	4
PLANE	P	157.70	36
PLANE	K	160.70	66
PLANE	L	168.90	50
PLANE	1	169.70	7
PLANE	N	175.90	56
PLANE	O	178.00	31
PLANE	3	244.40	33
PLANE	2	318.90	10

Table 5-8. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HLX15.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:	**Oskarshamn**		
Borehole name:	**HLX13**		
Nominal velocity (m/µs):	**120.0**		
Object type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	F	–34.90	6
PLANE	A	18.60	51
PLANE	B	25.30	59
PLANE	C	27.40	65
PLANE	D	30.80	47
PLANE	E	38.20	26
PLANE	G	43.30	35
PLANE	H	44.90	48
PLANE	K	53.70	42
PLANE	I	54.70	34
PLANE	L	69.50	44
PLANE	M	72.80	33
PLANE	N	78.30	60
PLANE	O	82.60	59
PLANE	P	84.70	37
PLANE	Q	86.40	72
PLANE	6	87.60	23
PLANE	R	93.40	35
PLANE	S	99.50	49
PLANE	T	104.20	47
PLANE	V	110.20	69
PLANE	J	111.20	13
PLANE	U	120.20	63
PLANE	W	130.90	31
PLANE	X	138.30	45
PLANE	Y	139.40	31
PLANE	Z	141.00	42
PLANE	1	152.70	48
PLANE	3	157.20	55
PLANE	2	166.80	25
PLANE	4	192.80	39
PLANE	5	461.30	8

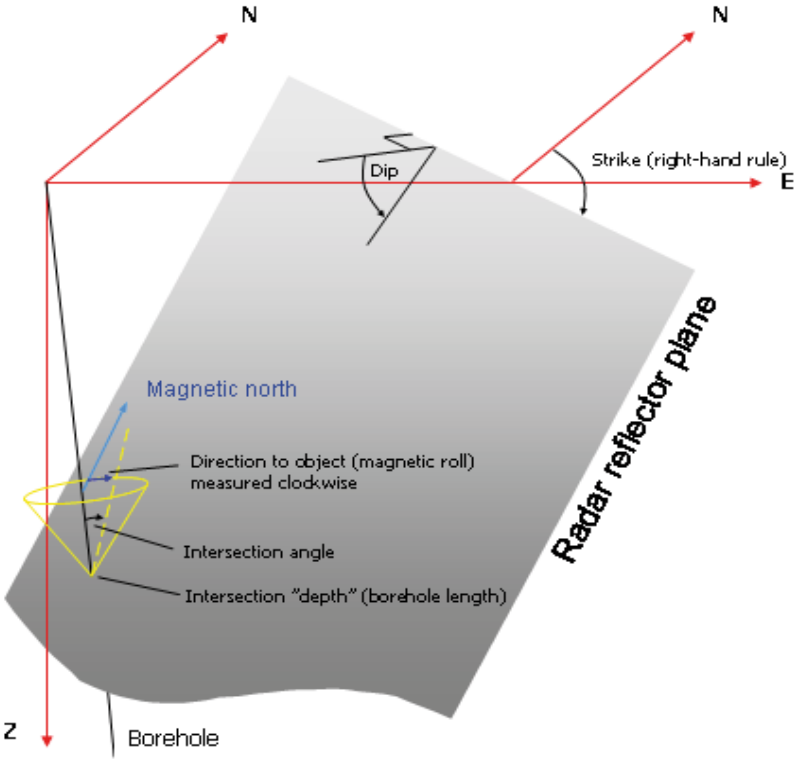


Figure 5-2. *Definition of intersection angle, direction to object using magnetic roll, dip and strike using the right hand rule as presented in Table 5-5.*

In Appendix 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 volume of rock surrounding the borehole. A decrease in this amplitude may indicate fracture zones, clay or rock volumes with increases in water content, i.e. increases in electric conductivity. The decrease in amplitude is shown in Tables 5-9 to 5-12.

Table 5-9. Decrease in amplitude for the 250 MHz antenna for borehole KAV04A.

Depth (m)
115–130
150–155
155–165
165
220
225
235
240–250
255
265–270
345–350
355–360
365
380–390
405
430
445–450
465
485
490–520
525–535
540–555
565
580–615
625
640–670
685
695
715
725–730
730–765
775
790–800
800–815
850–855
860
865–905
915–925
945–965
965–970
975
980
995–1000

Table 5-10. Decrease in amplitude for the 250 MHz antenna for borehole KAV04B.

Depth (m)
50
55–60
65–70
70–75
90–95

Table 5-11. Decrease in amplitude for the 250 MHz antenna for borehole HLX13.

Depth (m)
30
55
75–110
135
140
155–160
180

Table 5-12. Decrease in amplitude for the 250 MHz antenna for borehole HLX15.

Depth (m)
0–55
100–150

5.2 BIPS logging

The BIPS pictures are presented in Appendix 5 to 8.

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 are visible on the BIPS screen. The recorded length is adjusted to these visible marks. In percussion drilled boreholes we use these marks on the cable as reference for the depth adjustment. The experience from one year of logging is that the marks on the logging cable is very good and differs very little compared with the results from core-drilled boreholes. At present we have marks at 110, 150 and 200 meter 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. The resulting images displayed no difference regarding the colours and focus of the images. Results of the test loggings were included in the delivery of the raw data.

The logging of KAV04A was impaired by some drilling induced discolouring of parts of the borehole wall, see Appendix 5. In the lowermost part of the borehole wall there is some mud. However there is no serious problem to detect and orient single fractures and make observations of colour changes depending on changing of rock types and alteration.

The logging of KAV04B was performed during the same logging campaign and has images of good quality without any discolouring induced by the drilling. Observe the indication of water inflow running downwards along the borehole shown up as white colouring at about 49 and 50 metres in Appendix 6.

For the logging in HLX13 the water quality and the visibility of the borehole wall were of good quality along the borehole until a depth of 75 metres, see Appendix 7. From this level mud is covering the most part of the borehole wall and reduces the visibility of the borehole wall. Below 108 metres the visibility of he borehole wall increases and is covered by mud to 50% in the bottom part of the borehole.

In borehole HLX15 the visibility of the borehole wall was of good quality, see Appendix 8. Some amount of debris cover the upper side of the lowermost part of the borehole wall.

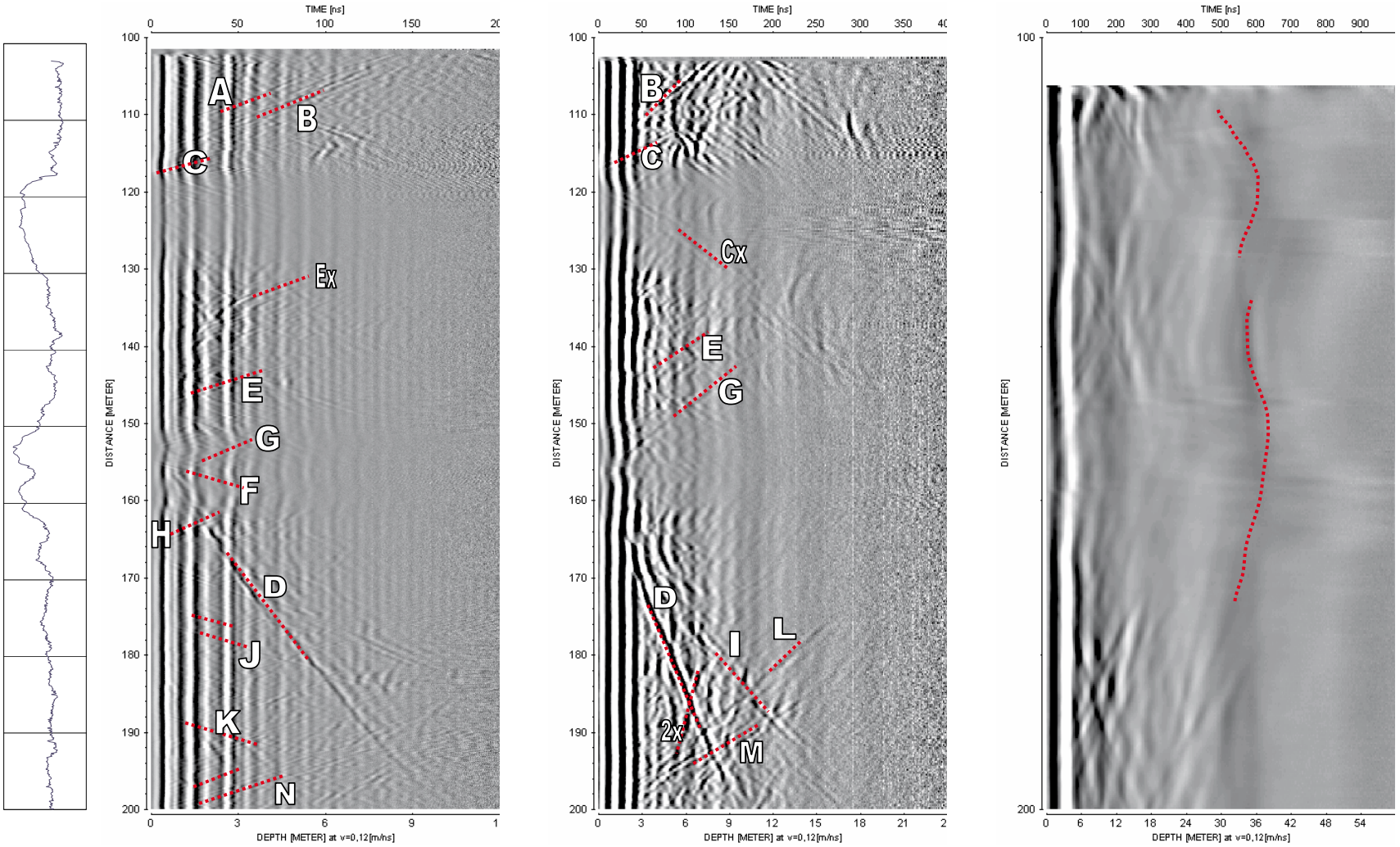
References

/1/ **Aaltonen J, Gustafsson C, Nilsson P, 2003.** Oskarshamn site investigation. RAMAC and BIPS logging and deviation measurements in boreholes KSH01A, KSH01B and the upper part of KSH02. SKB P-03-73.

Appendix 1

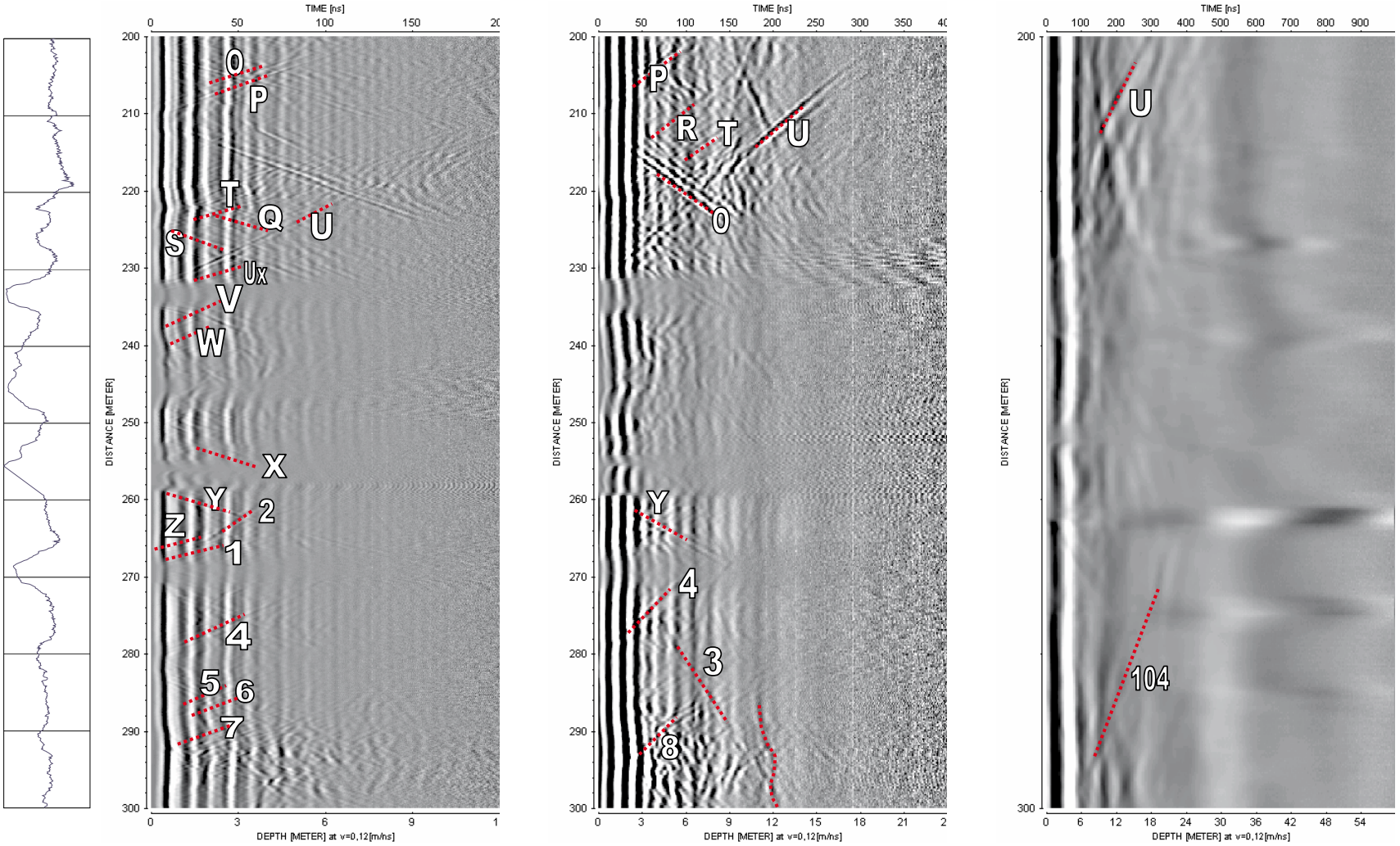
Radar logging in KAV04A, 100 to 1000 m, directional and dipole antennas 250, 100 and 20 MHz

Simpevarp KAV04A



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

Simpevarp KAV04A

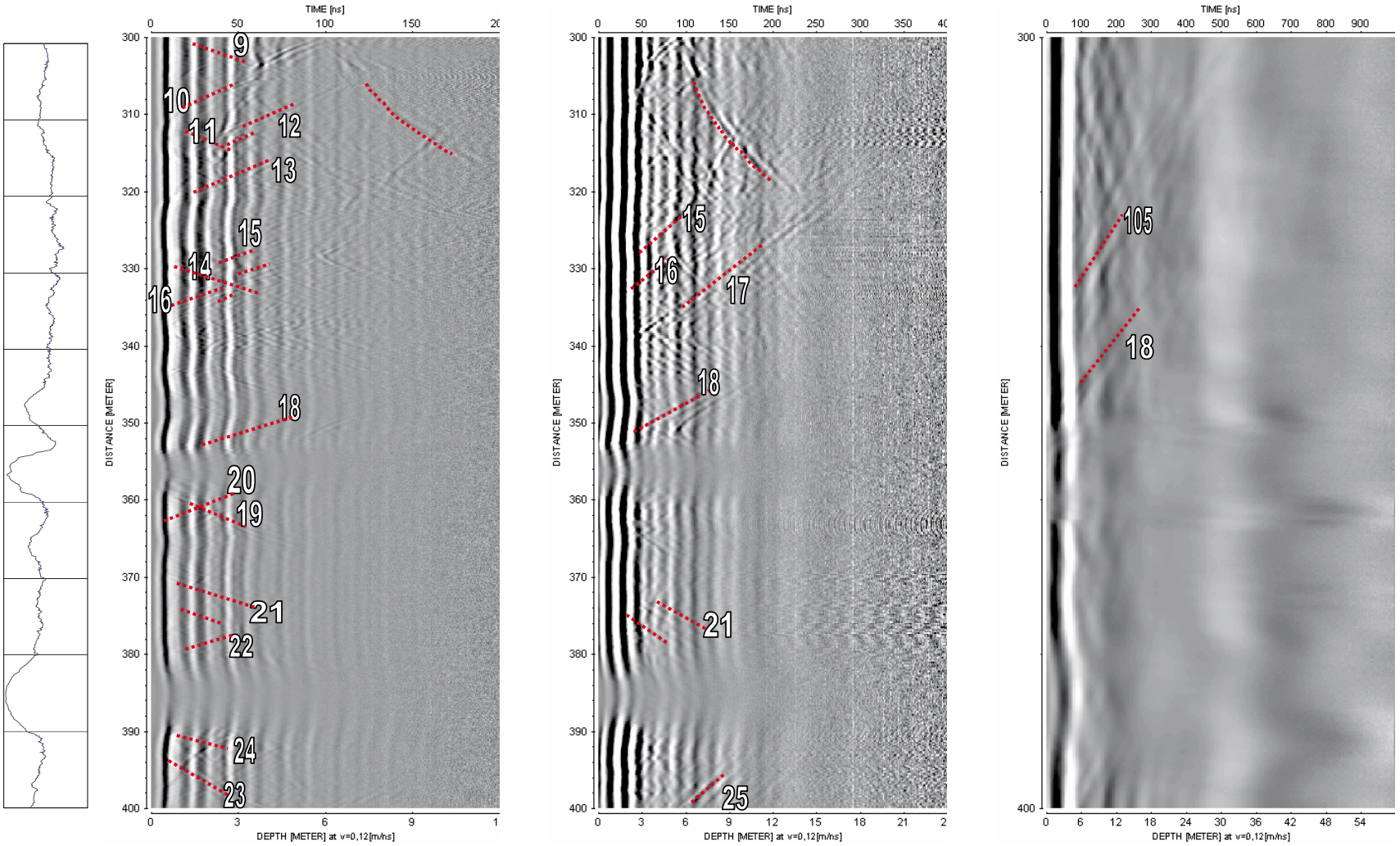


250 MHz

100 MHz

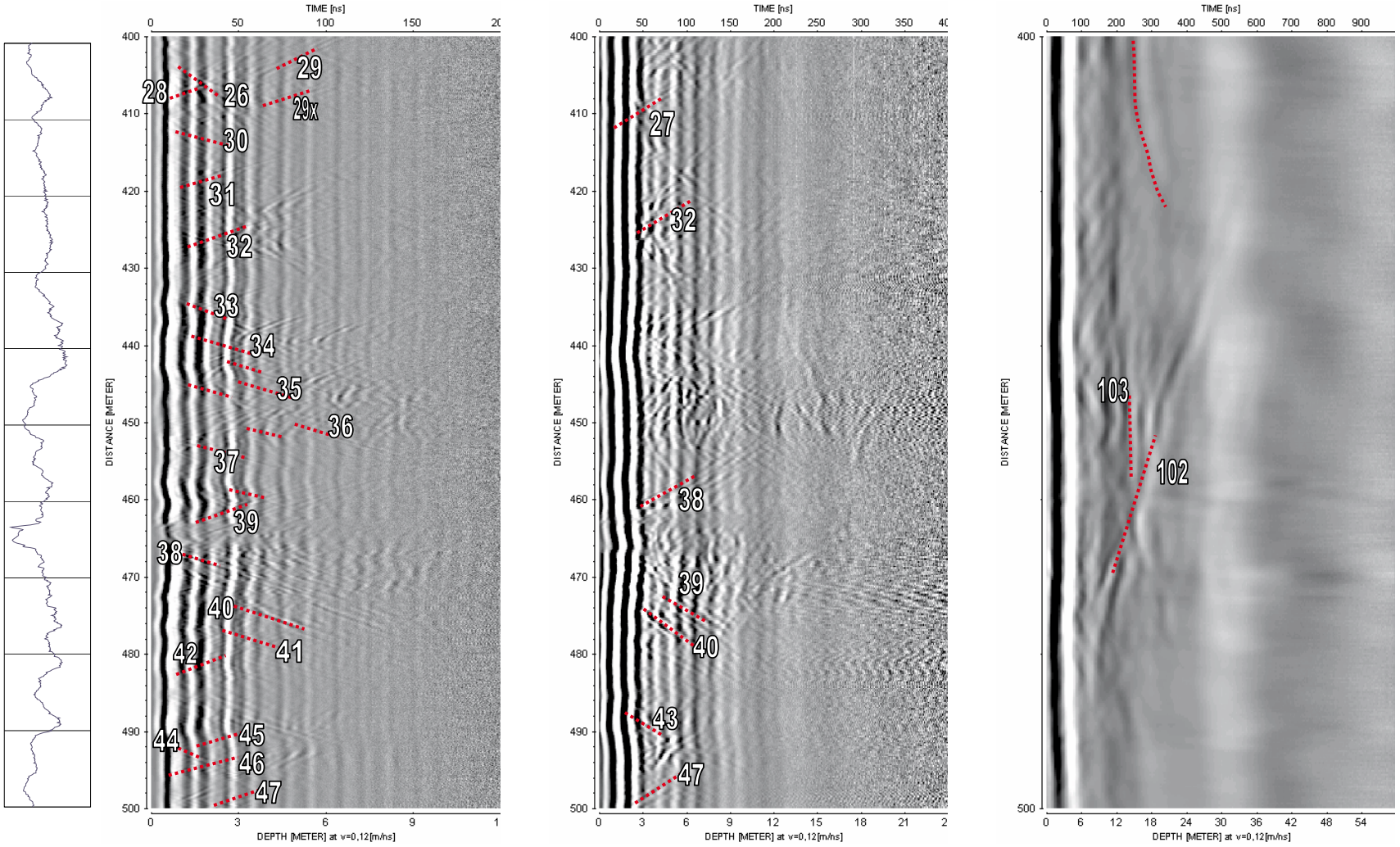
20 MHz

Simpevarp KAV04A



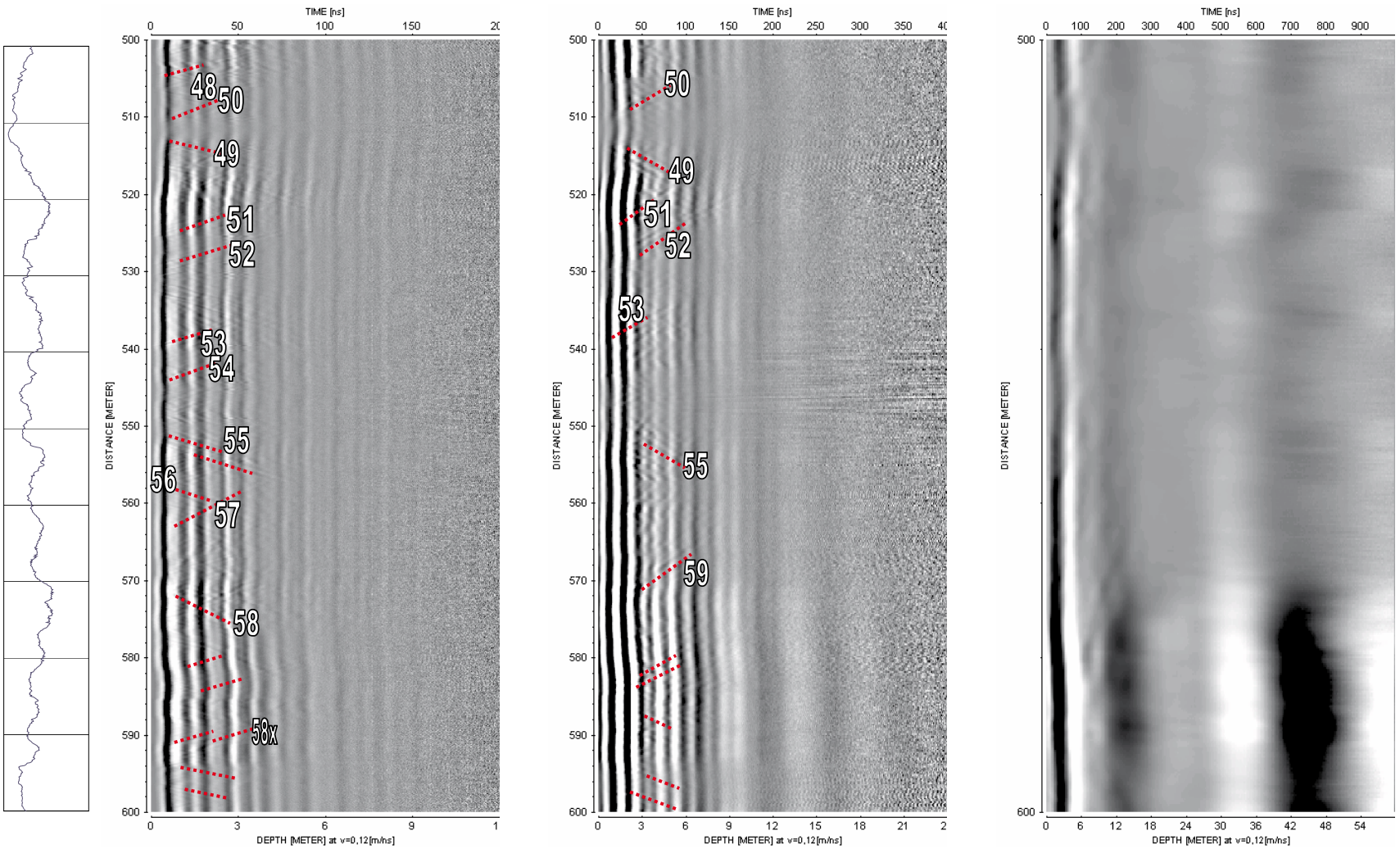
250 MHz | **100 MHz** | **20 MHz**

Simpevarp KAV04A

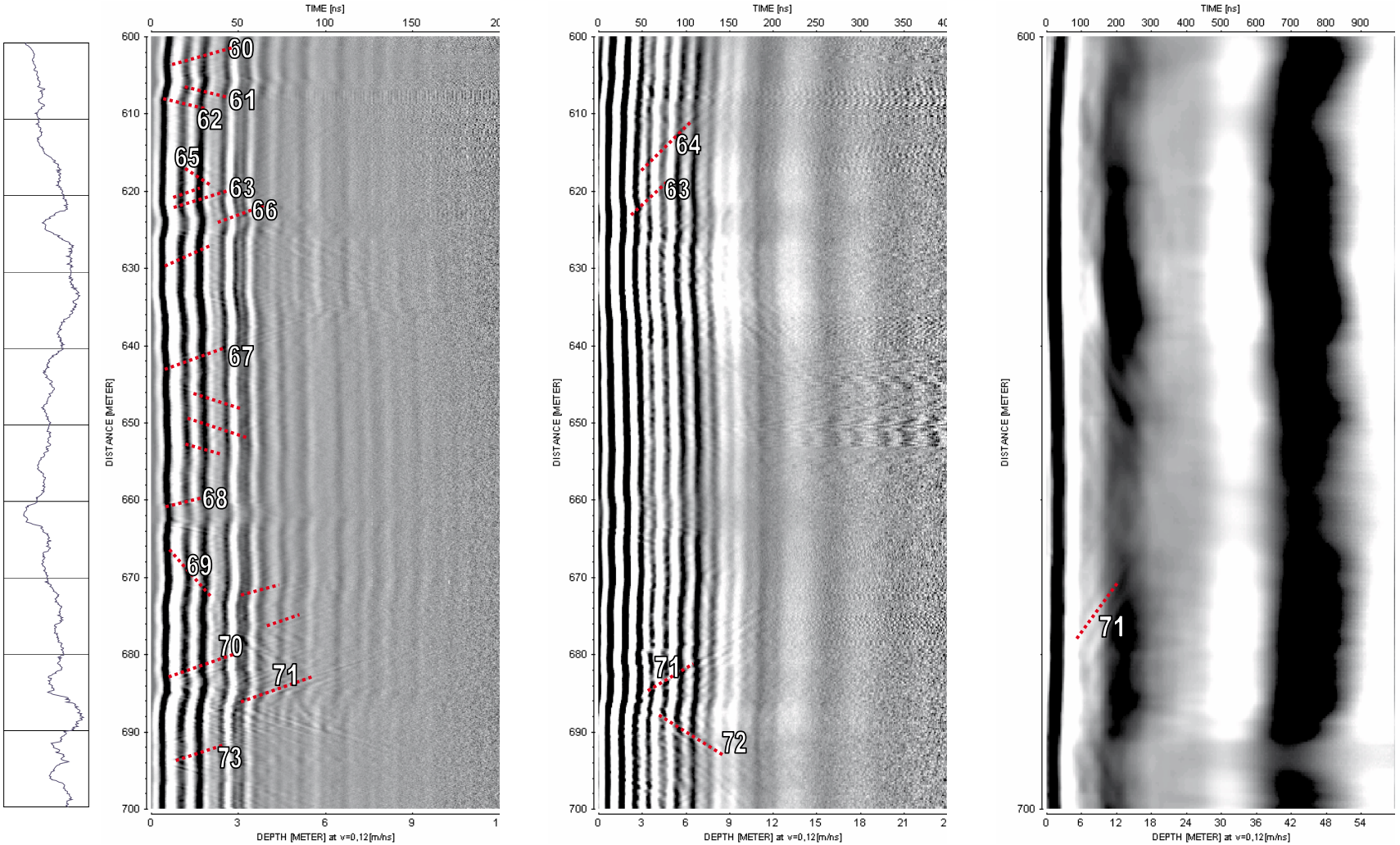


250 MHz **100 MHz** **20 MHz**

Simpevarp KAV04A

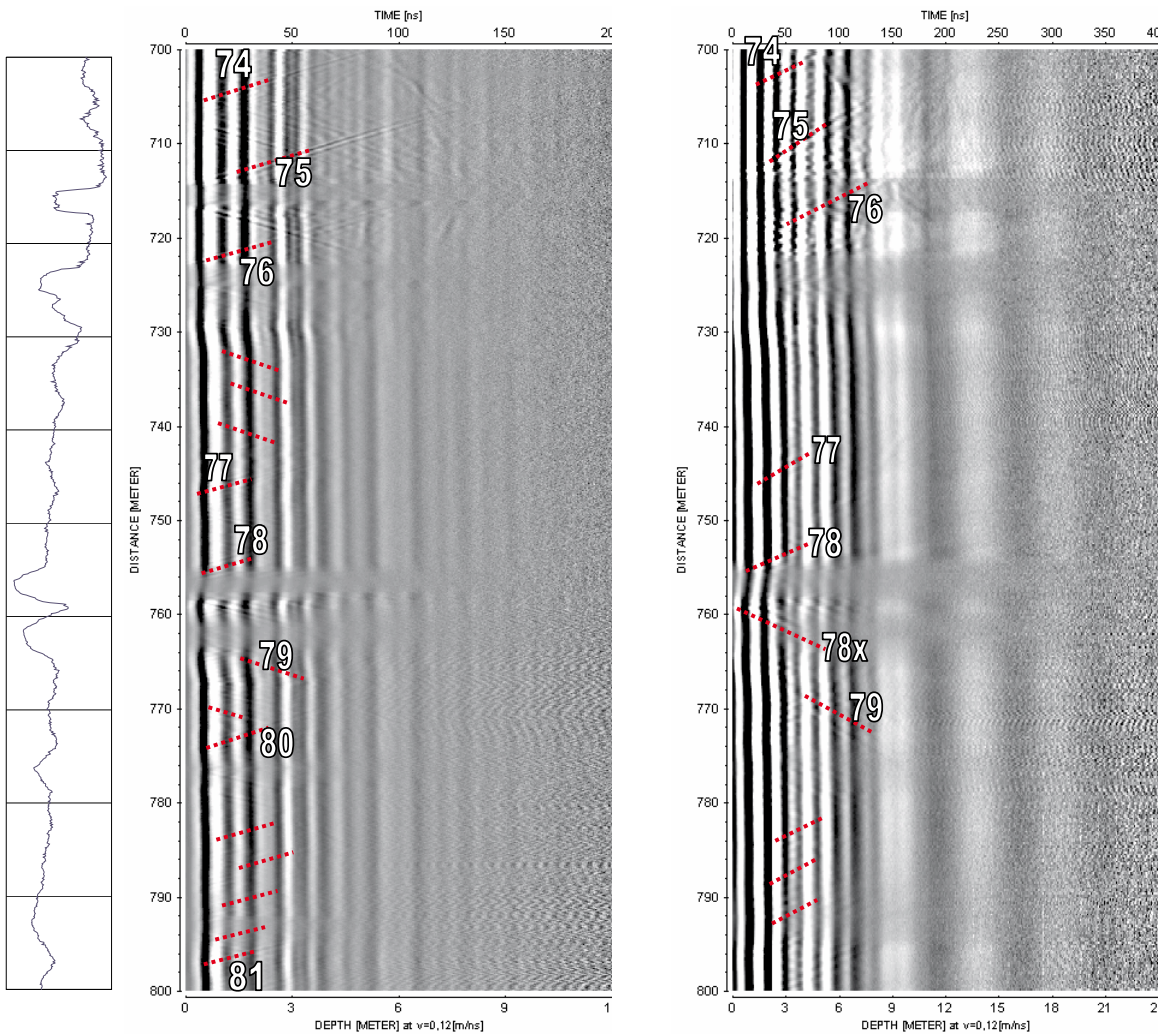


Simpevarp KAV04A



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

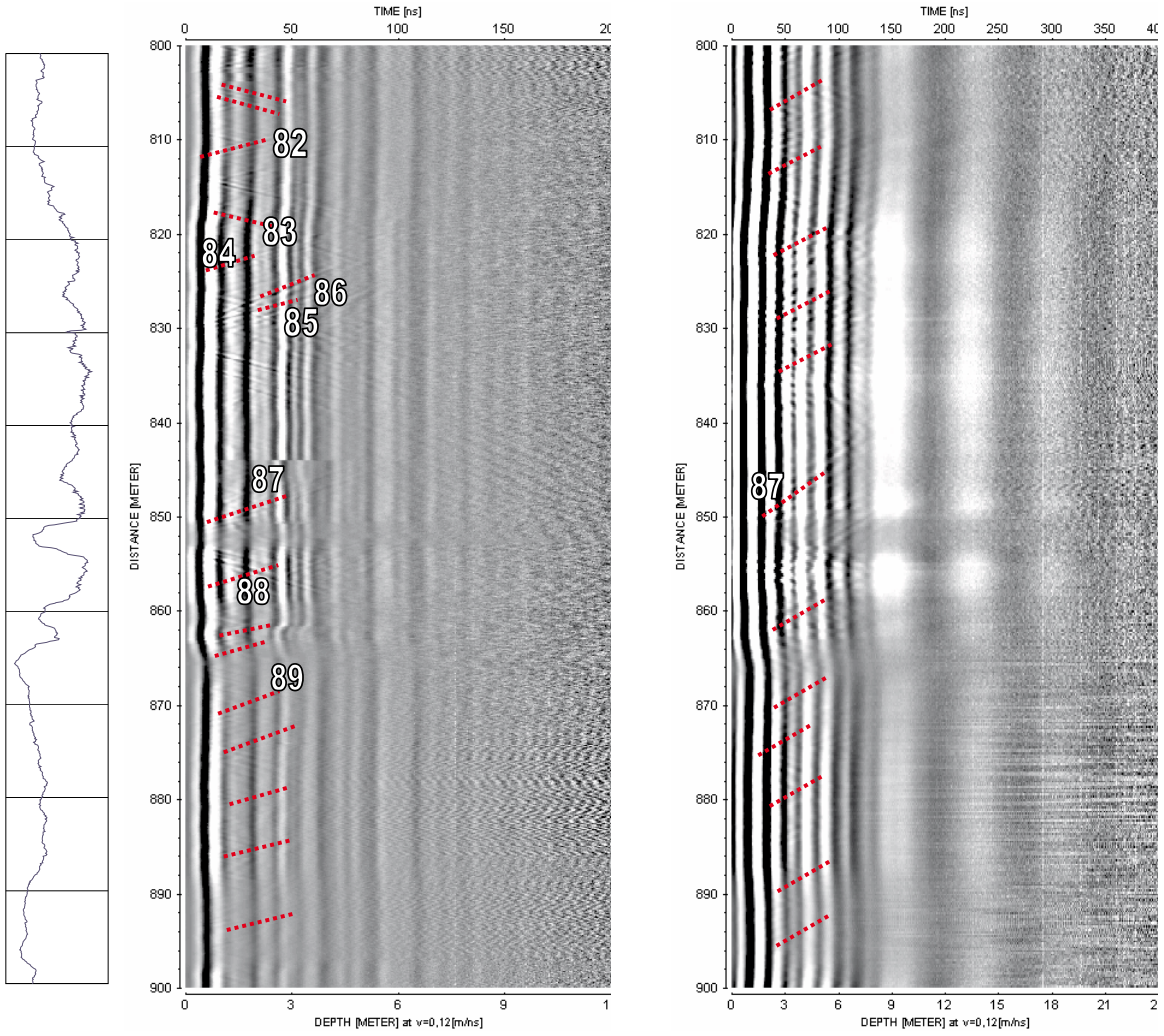
Simpevarp KAV04A



250 MHz

100 MHz

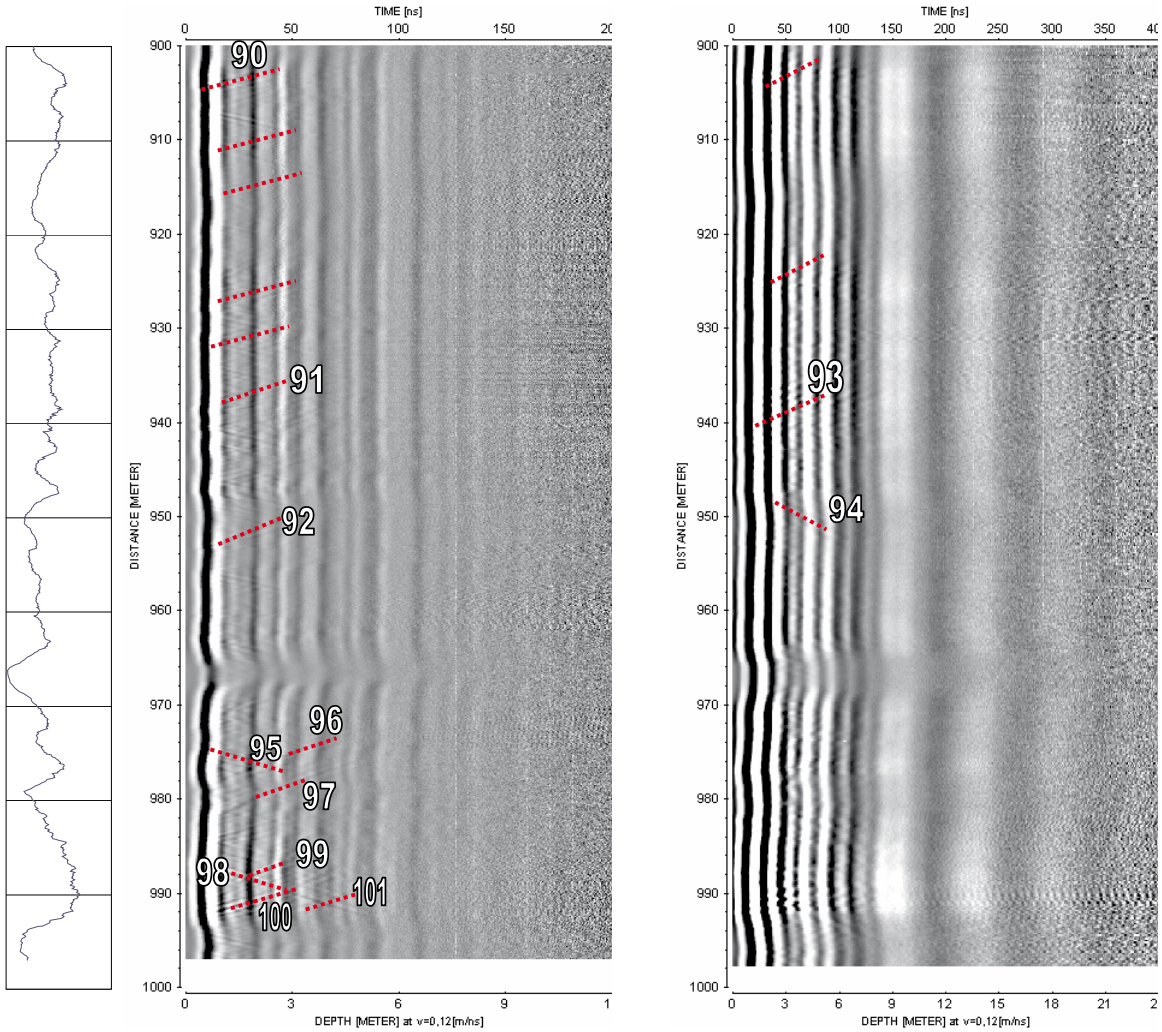
Simpevarp KAV04A



250 MHz

100 MHz

Simepvarp KAV04A



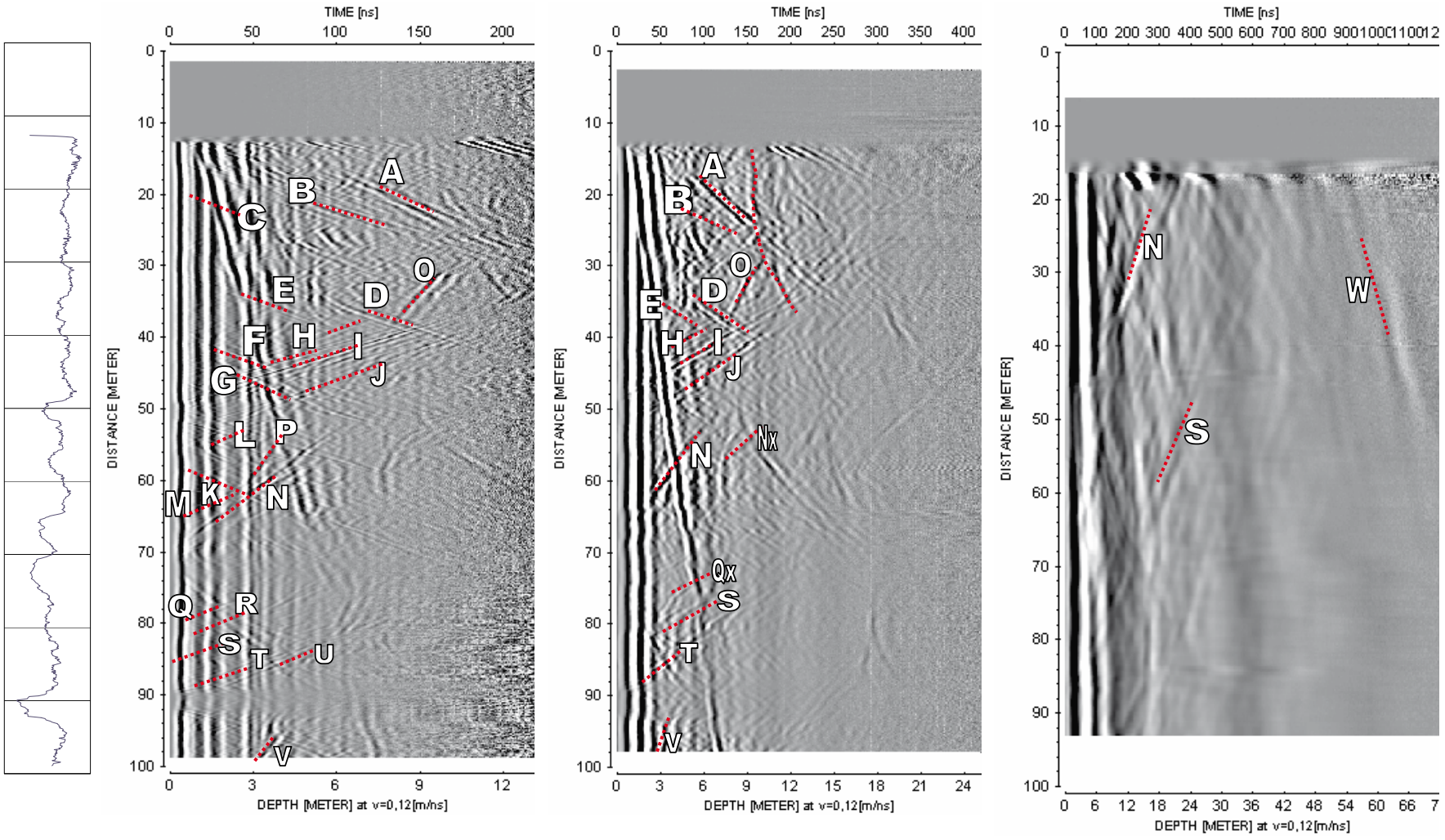
250 MHz

100 MHz

Appendix 2

Radar logging in KAV04B, 0 to 100 m, dipole antennas 250, 100 and 20 MHz

Simpevarp KAV04B

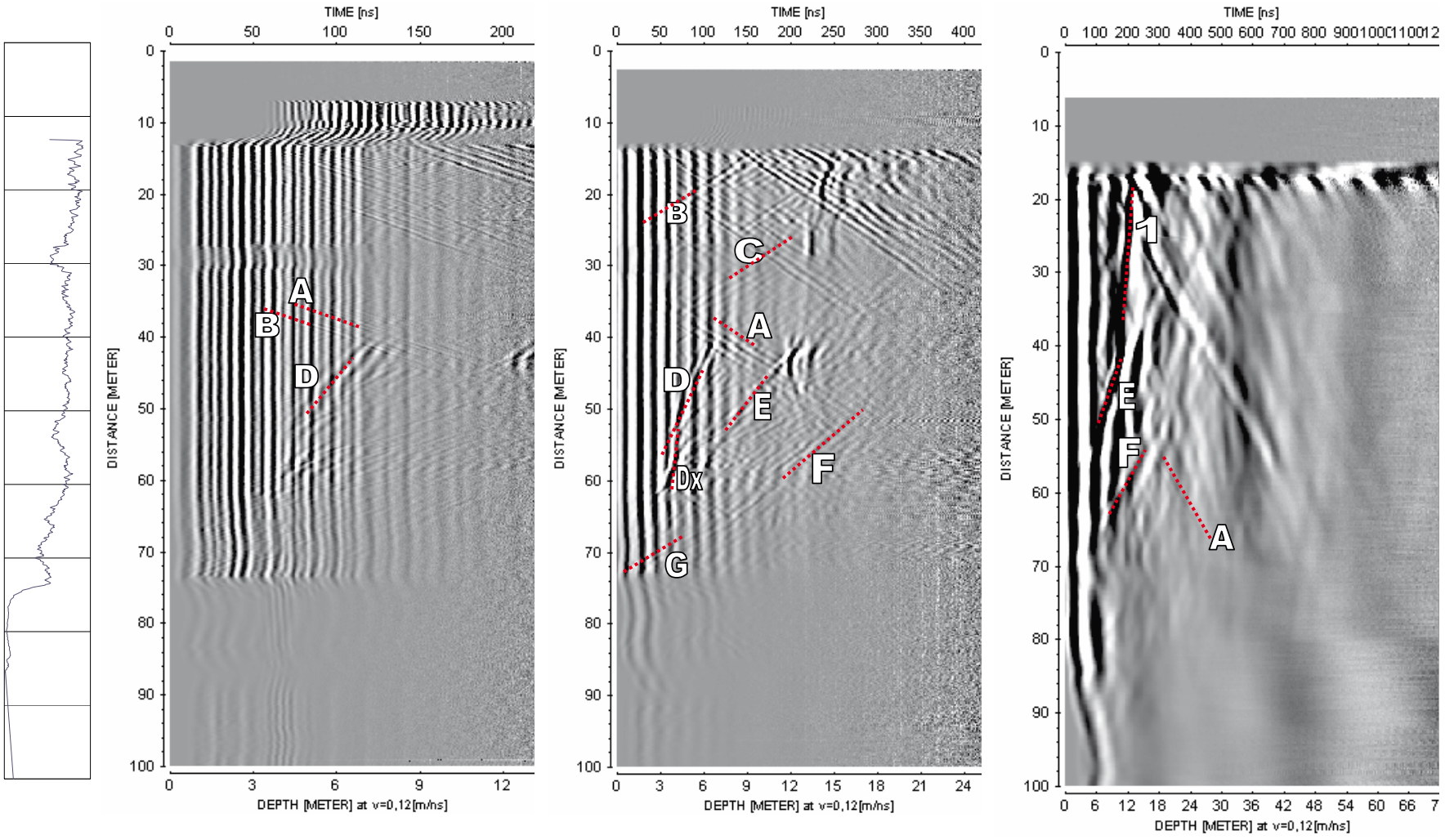


250 MHz | **100 MHz** | **20 MHz**

Appendix 3

Radar logging in HLX13, 0 to 200 m, dipole antennas 250, 100 and 20 MHz

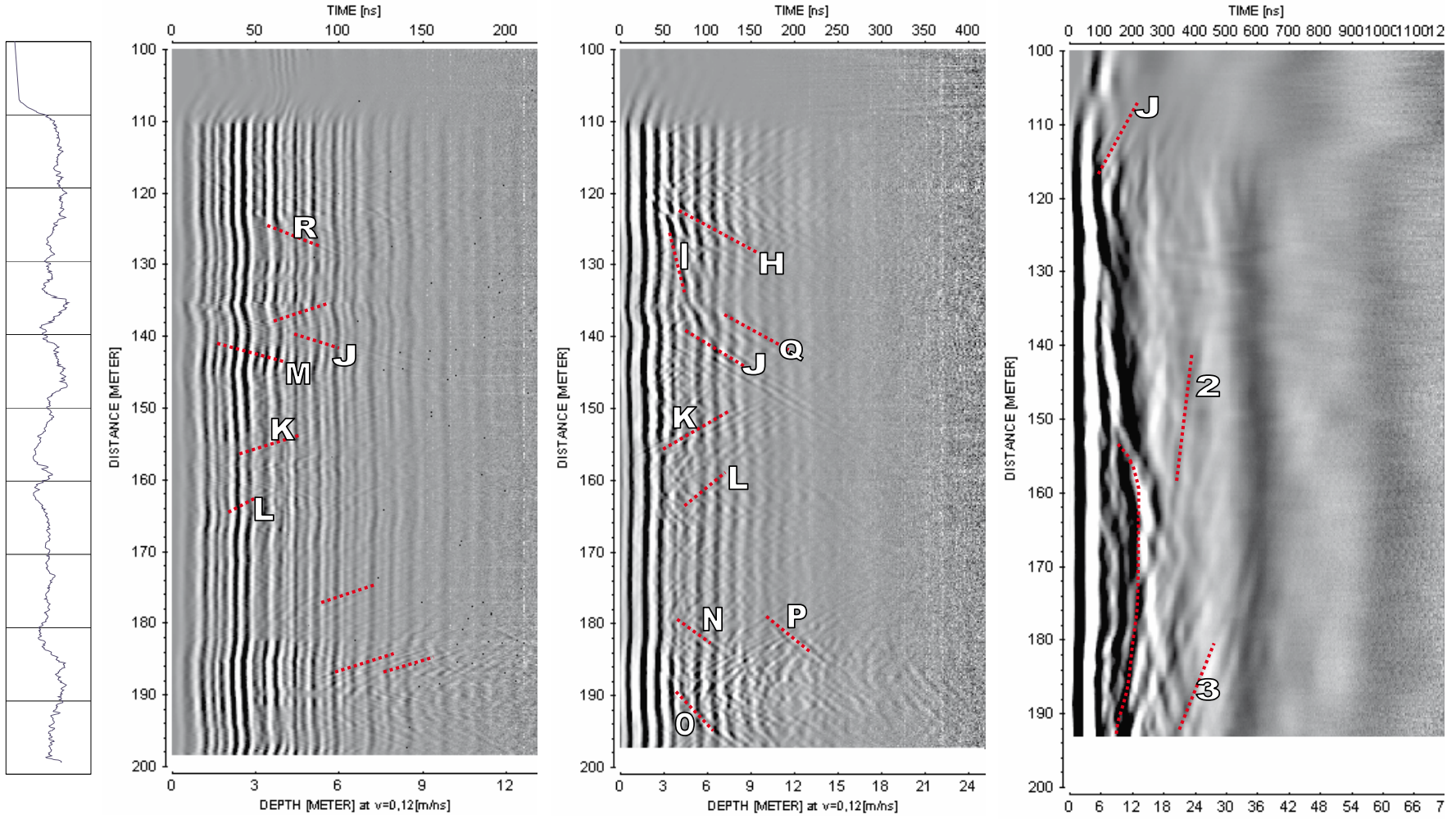
Laxemar HLX13



100 MHz

20 MHz

Laxemar HLX13

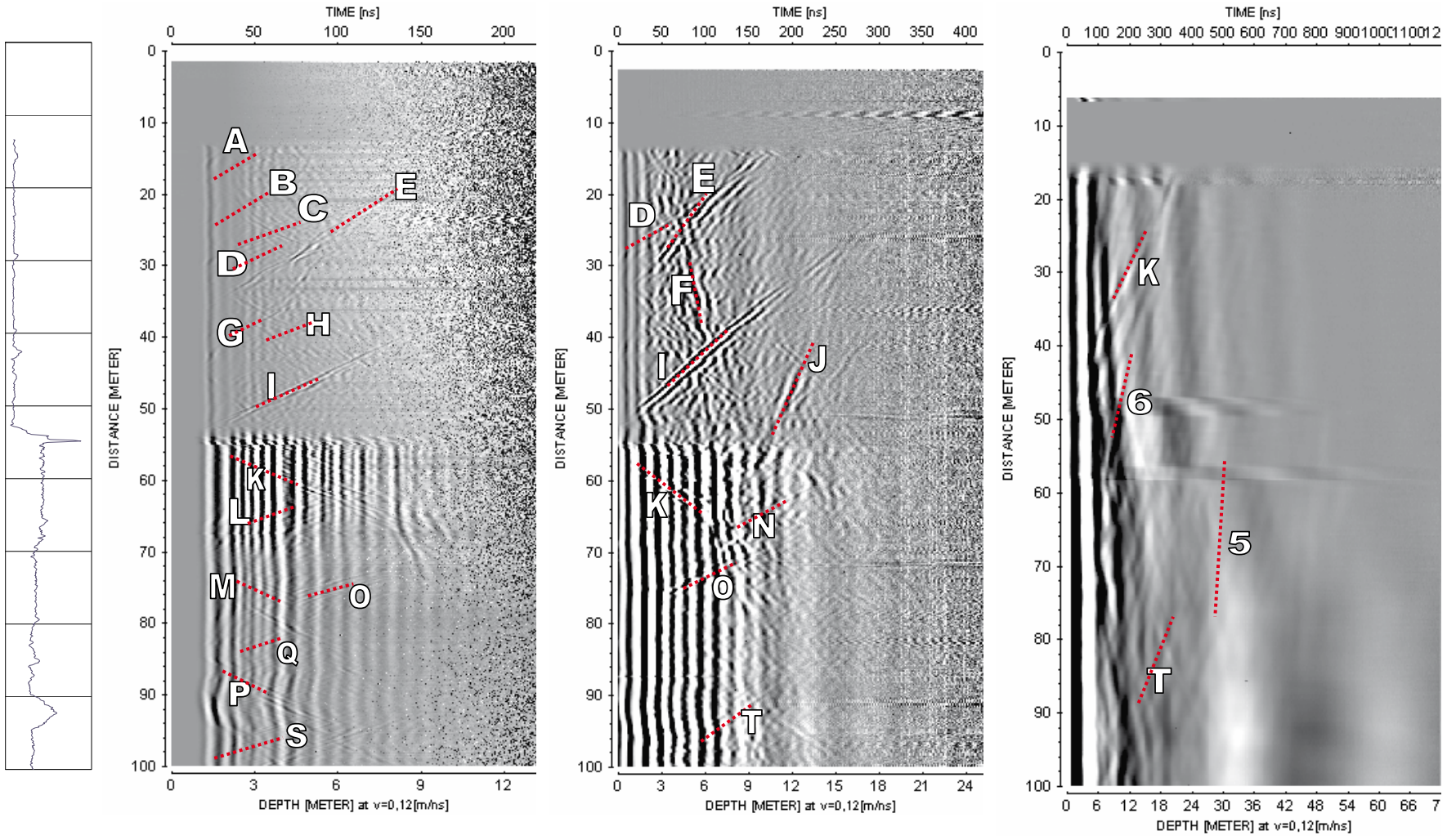


250 MHz **100 MHz** **20 MHz**

Appendix 4

Radar logging in HLX15, 0 to 150 m, dipole antennas 250, 100 and 20 MHz

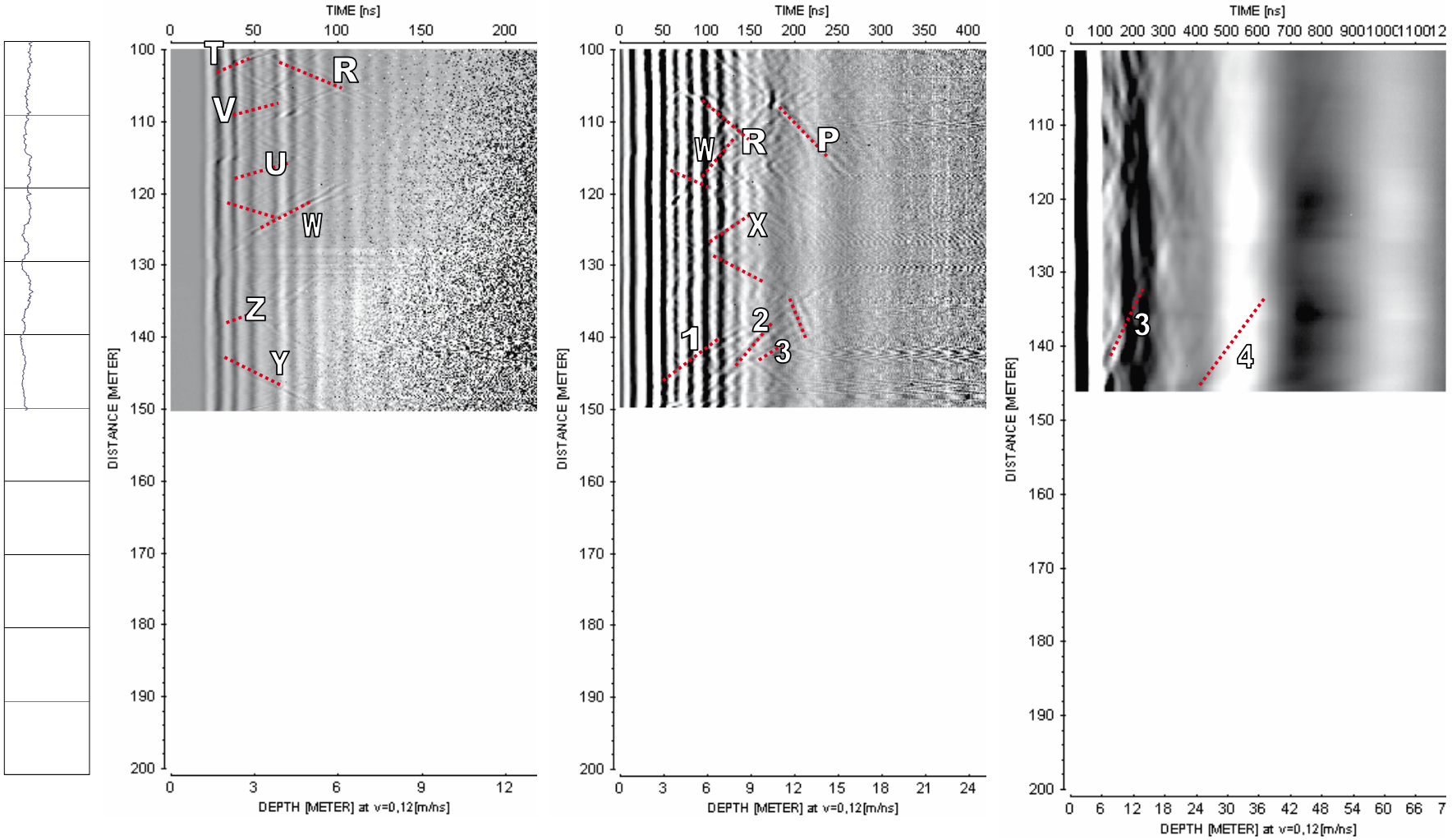
Laxemar HLX15



100 MHz

20 MHz

Laxemar HLX15



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

Appendix 5

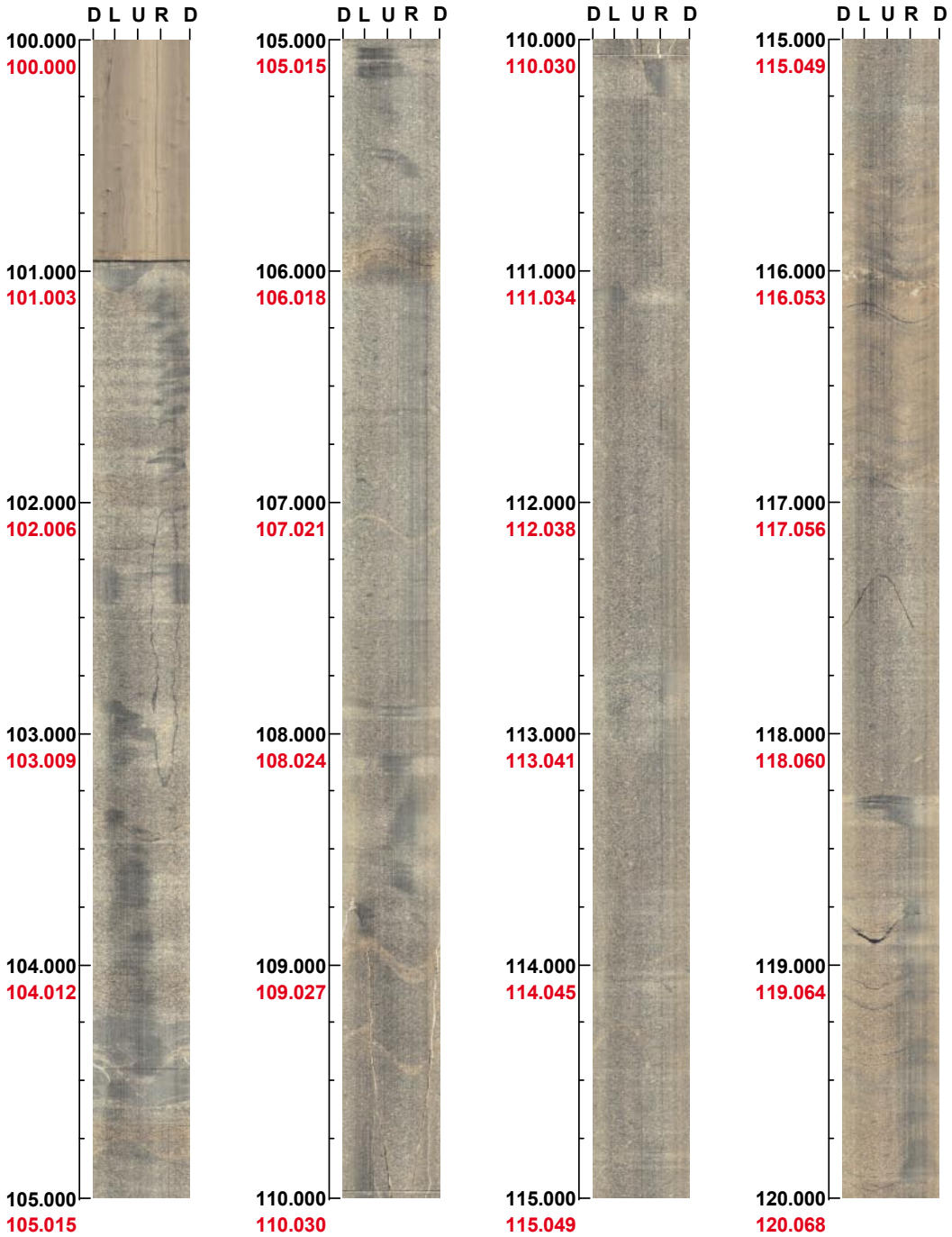
BIPS logging in KAV04A, 100 to 998 m

Project name: Simpevarp

Image file	**: c:\work\r5291s~1\kav04a\bips\kav04a1.bip**
BDT file	**: c:\work\r5291s~1\kav04a\bips\kav04a1.bdt**
Locality	**: SIMPAN**
Bore hole number	**: KAV04A**
Date	**: 04/05/24**
Time	**: 13:48:00**
Depth range	**: 100.000 - 998.637 m**
Azimuth	**: 77**
Inclination	**: -85**
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	**: 26**
Color	**: +0 +0 +0**

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

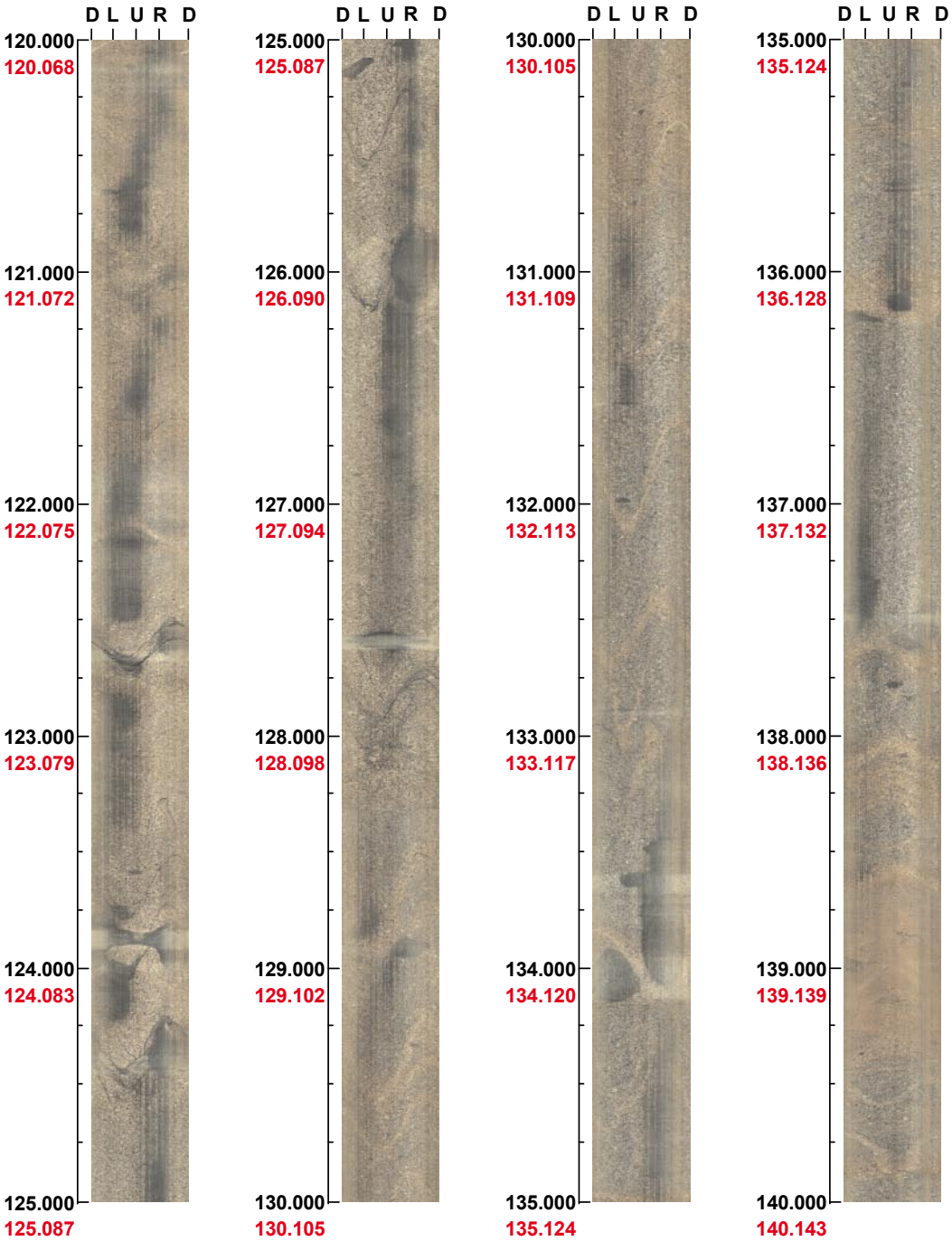
Depth range: 100.000 - 120.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

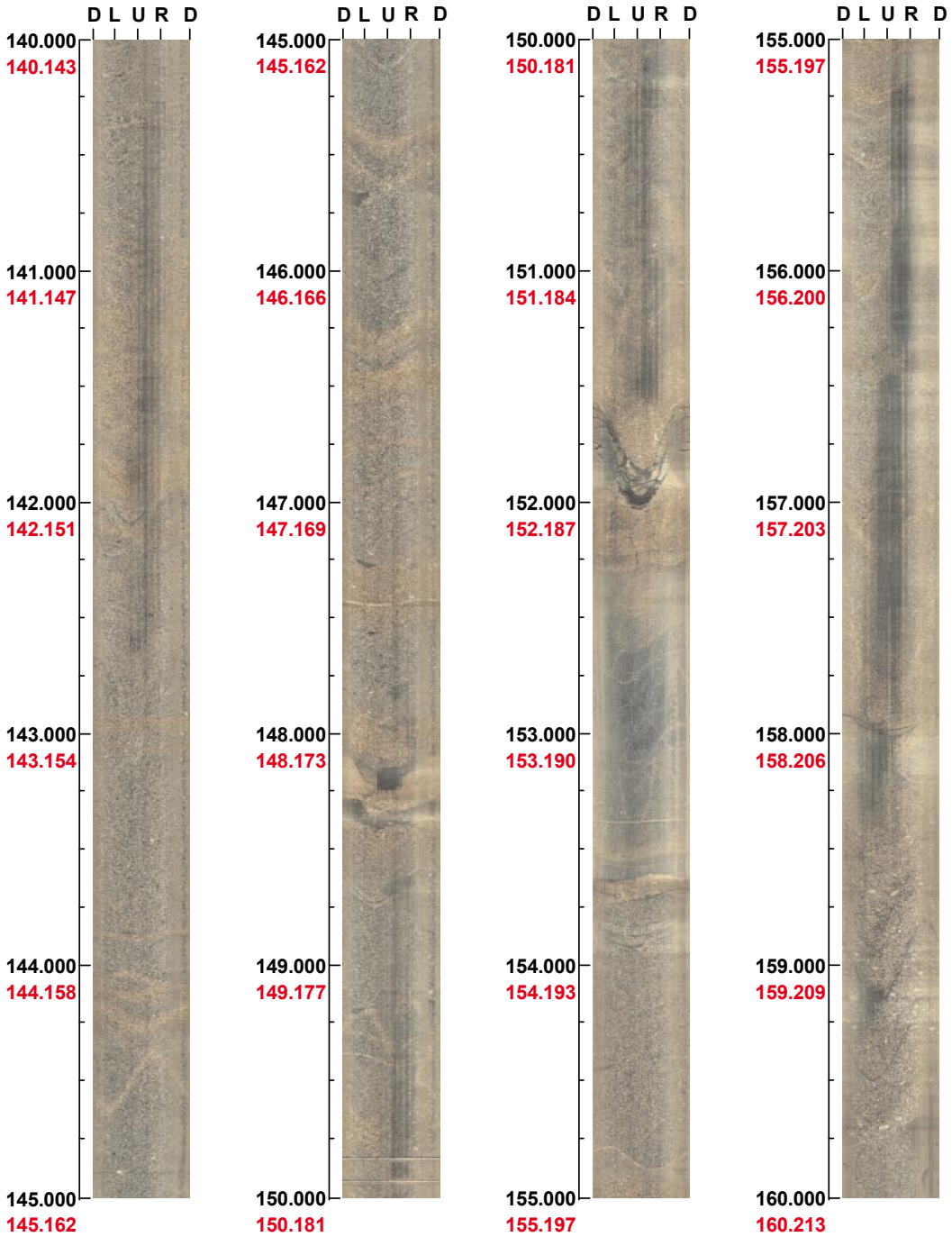
Depth range: 120.000 - 140.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

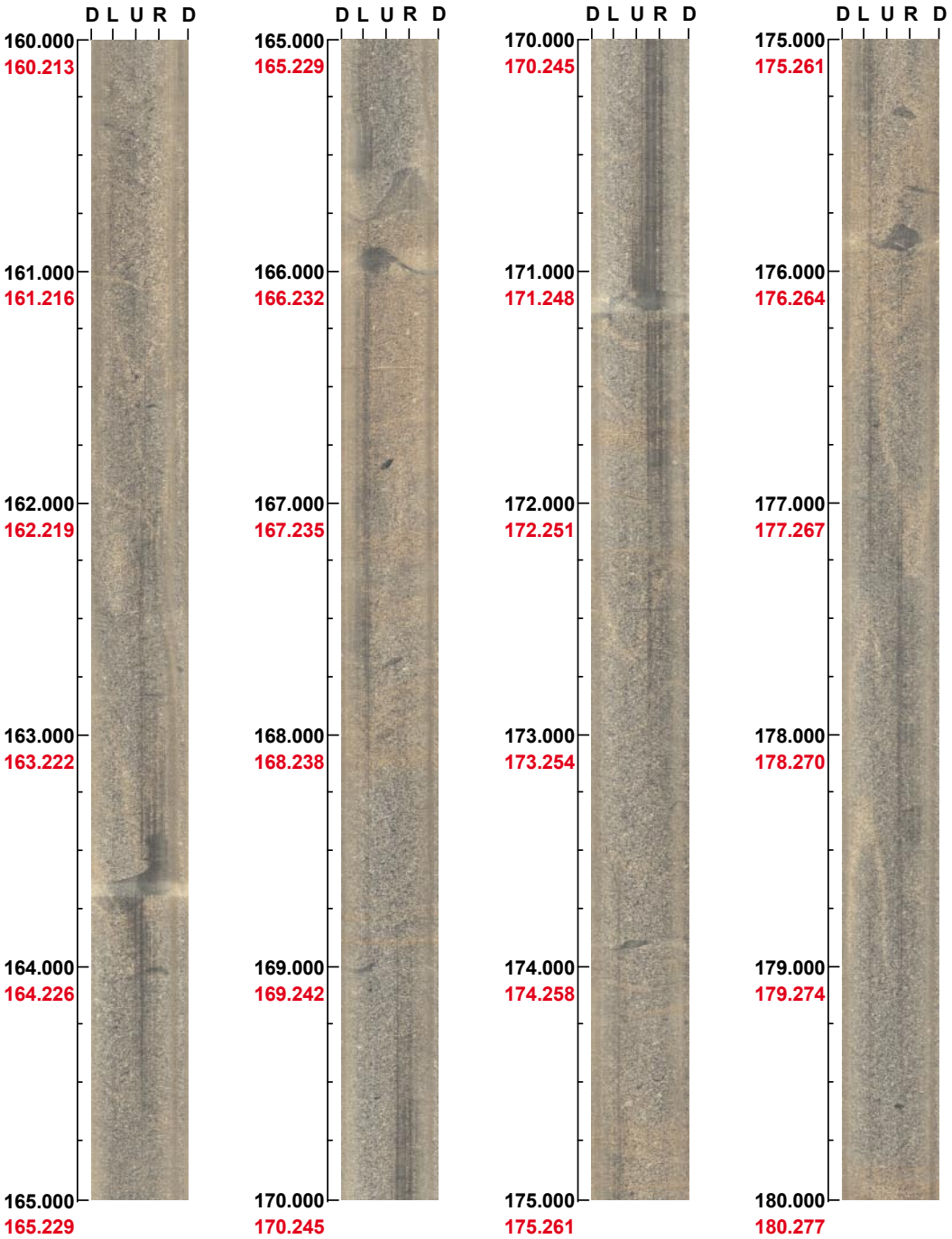
Depth range: 140.000 - 160.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

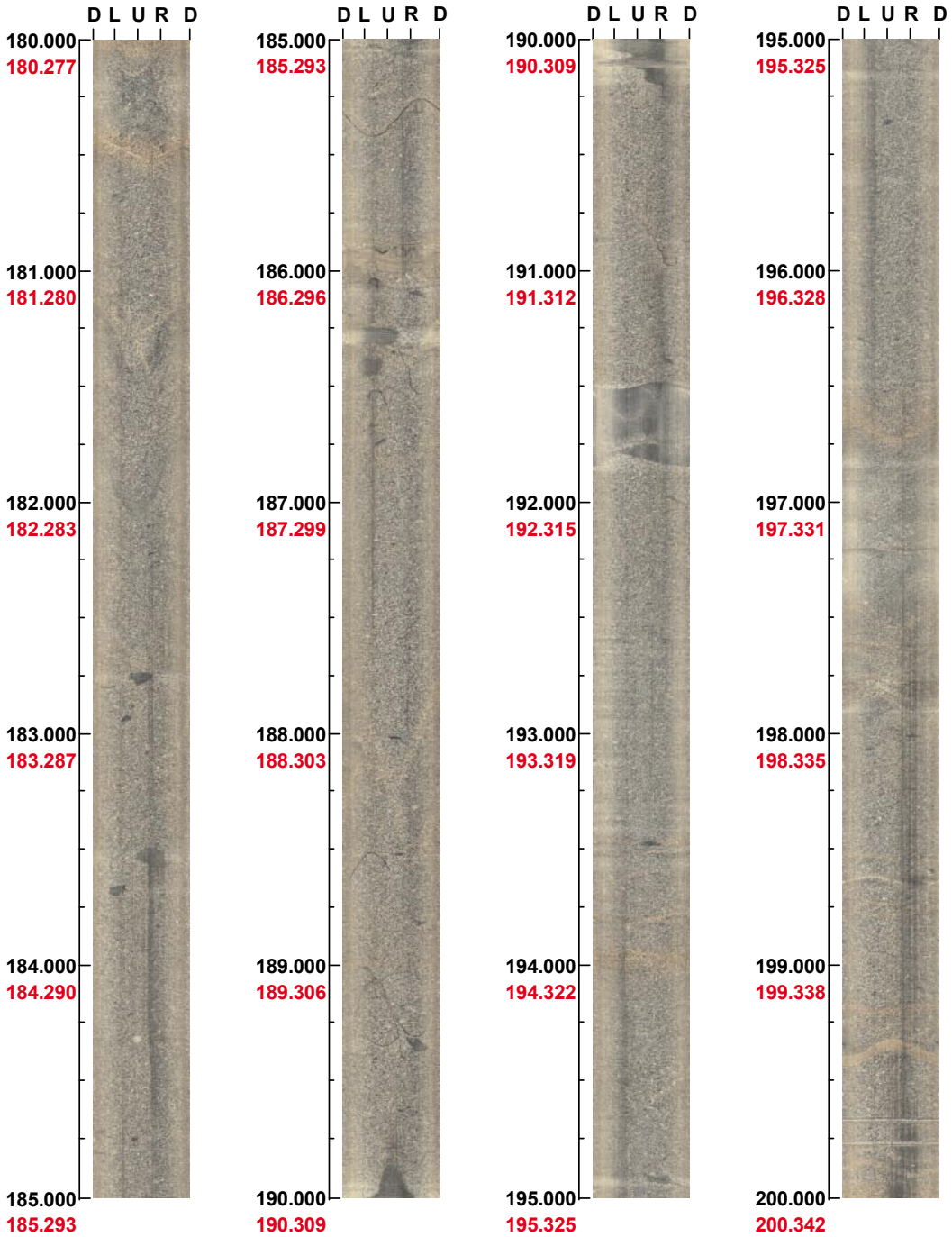
Depth range: 160.000 - 180.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

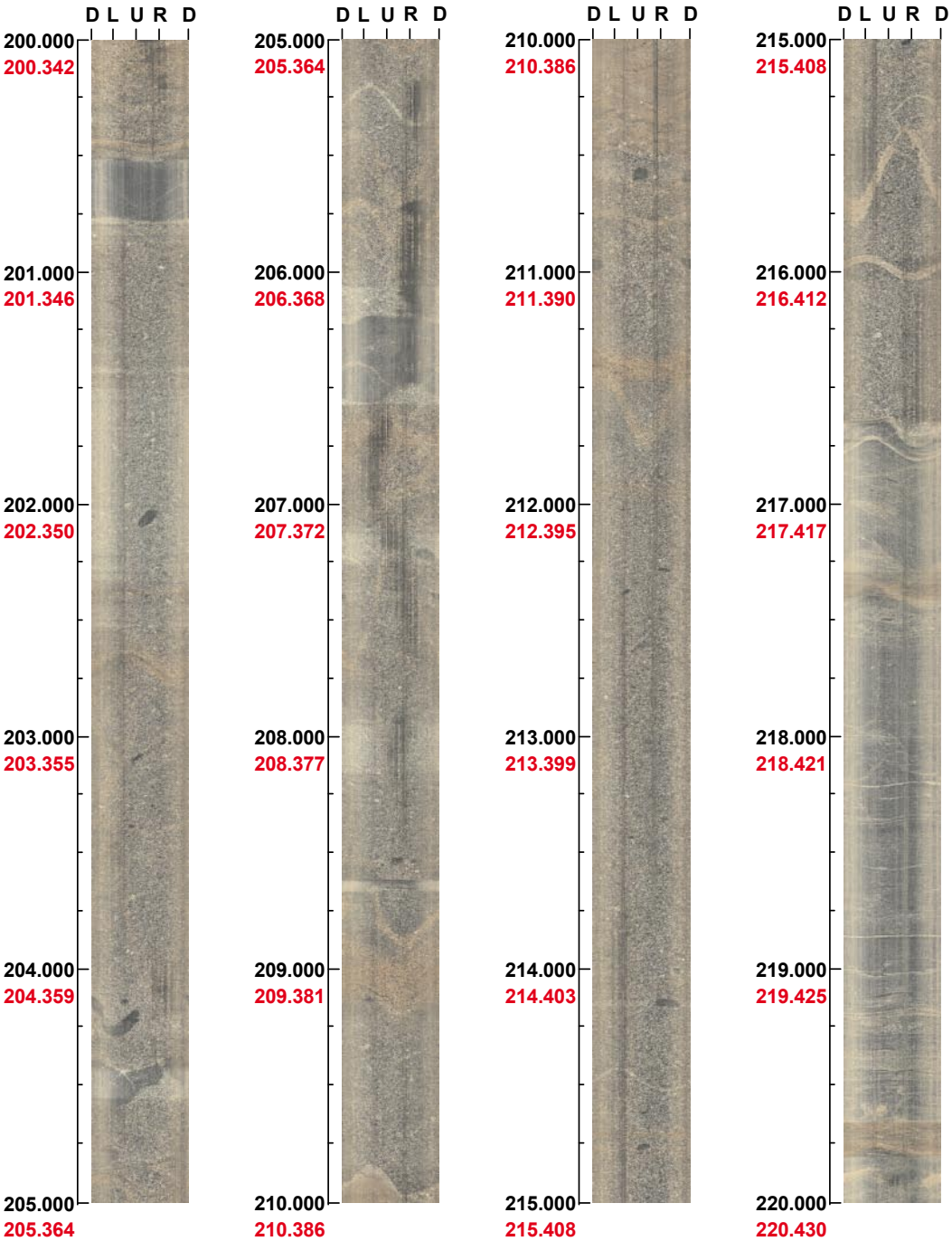
Depth range: 180.000 - 200.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

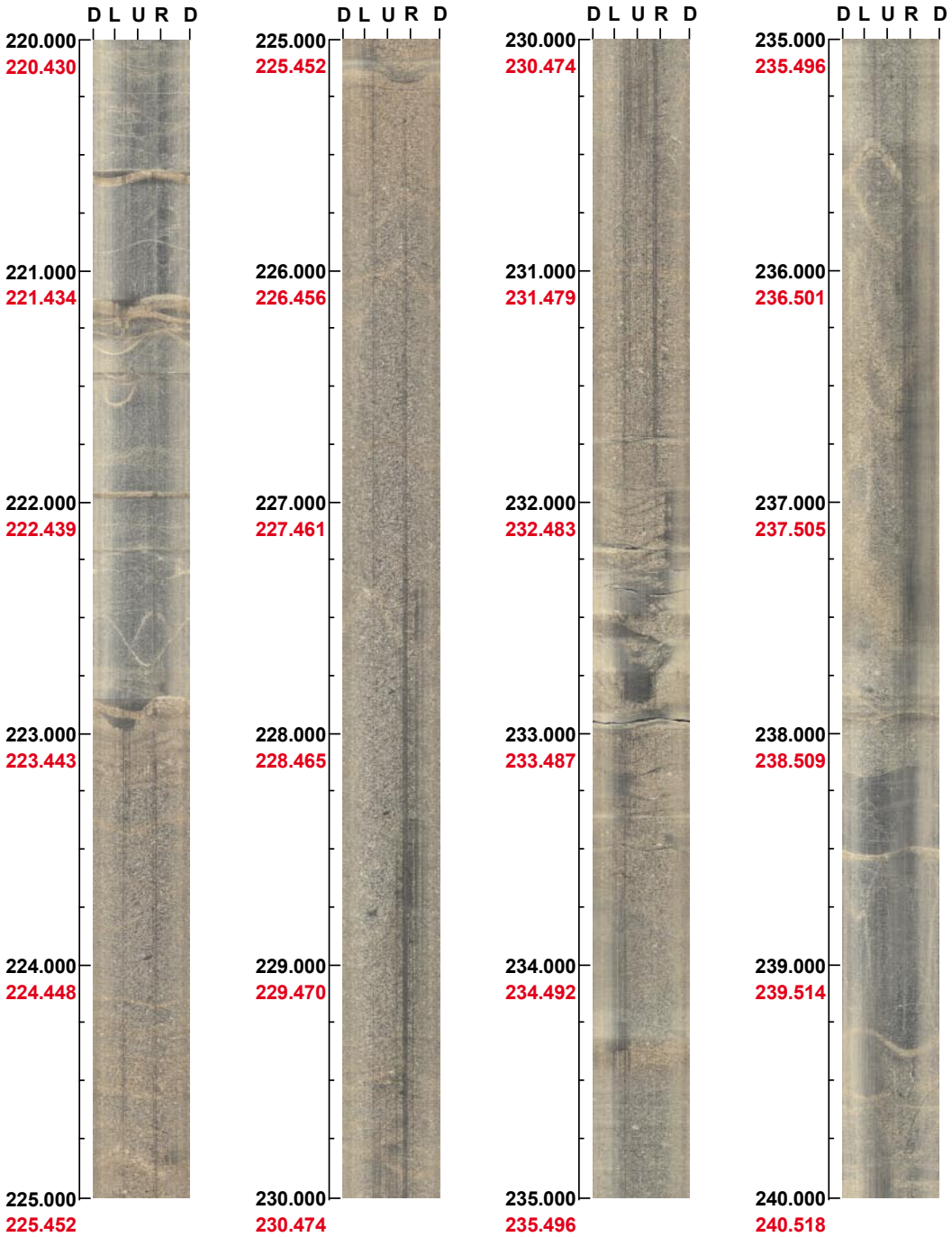
Depth range: 200.000 - 220.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

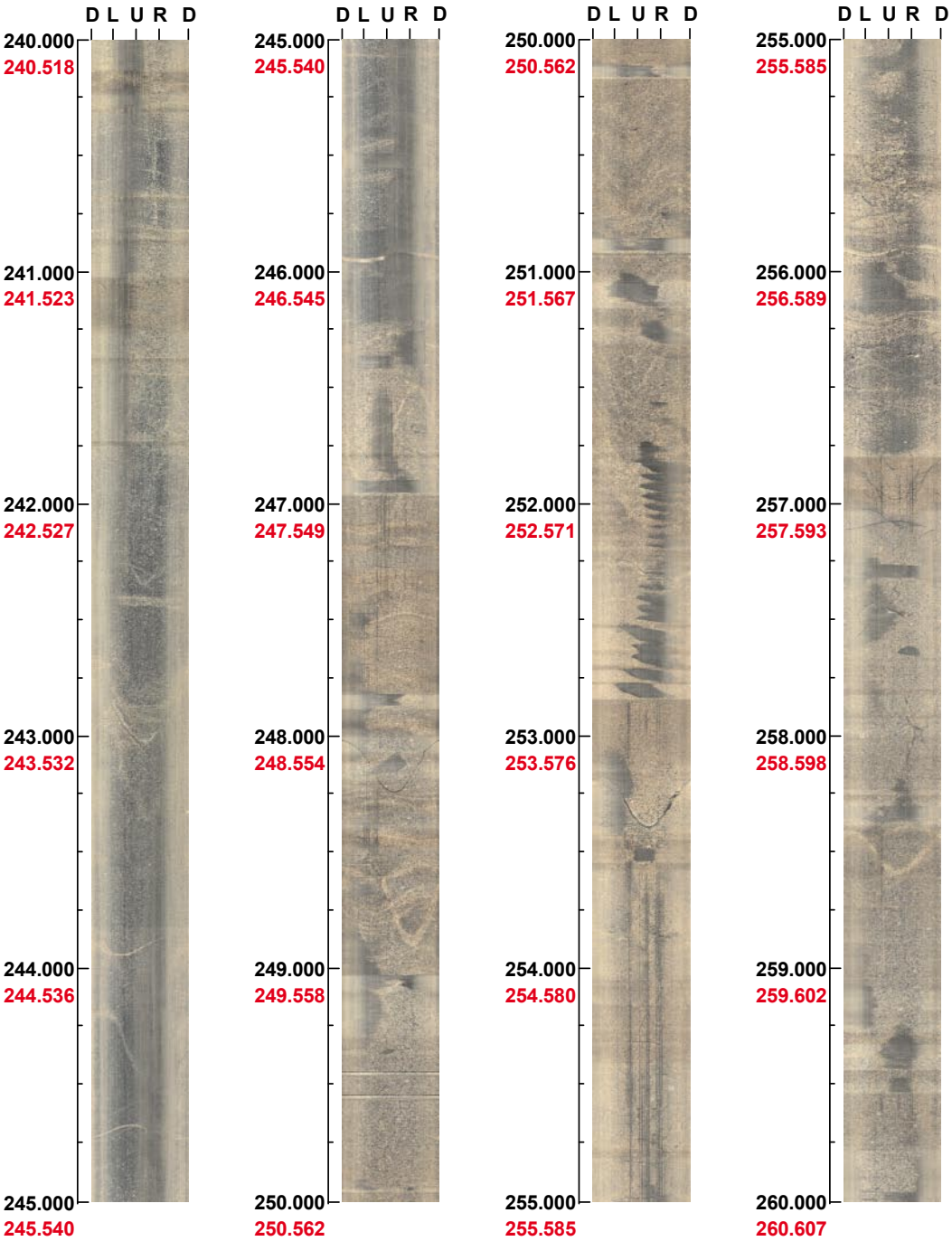
Depth range: 220.000 - 240.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

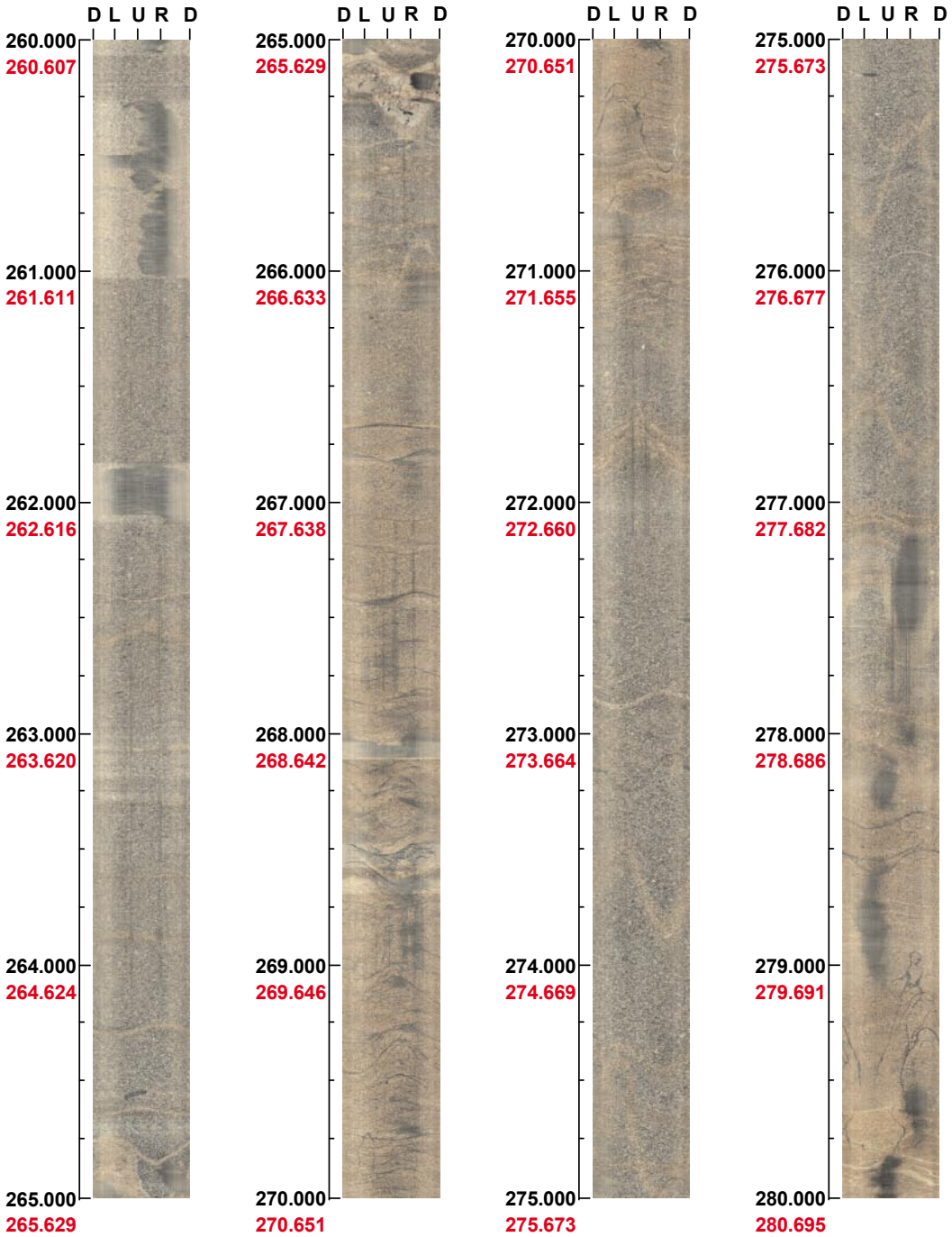
Depth range: 240.000 - 260.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

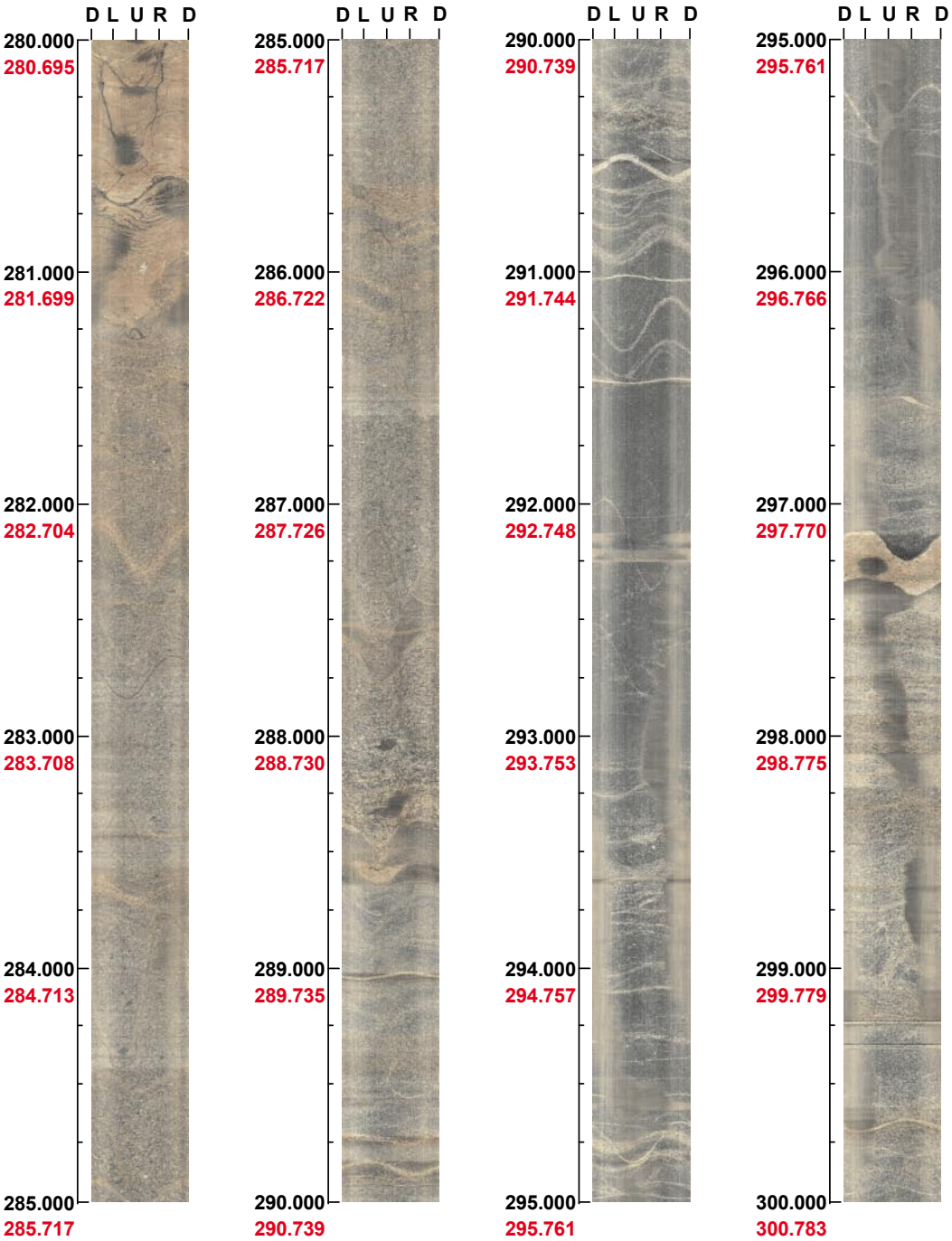
Depth range: 260.000 - 280.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

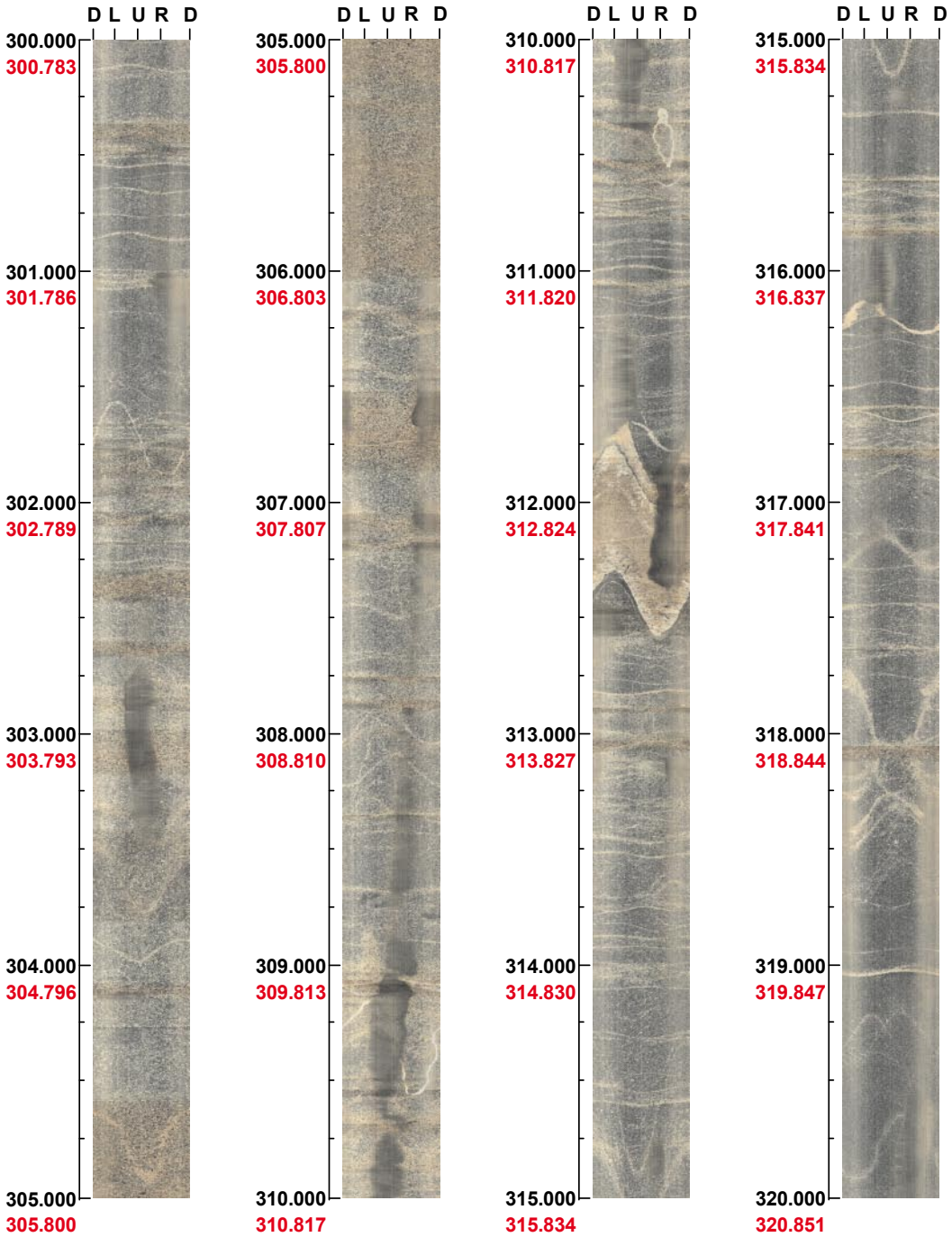
Depth range: 280.000 - 300.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

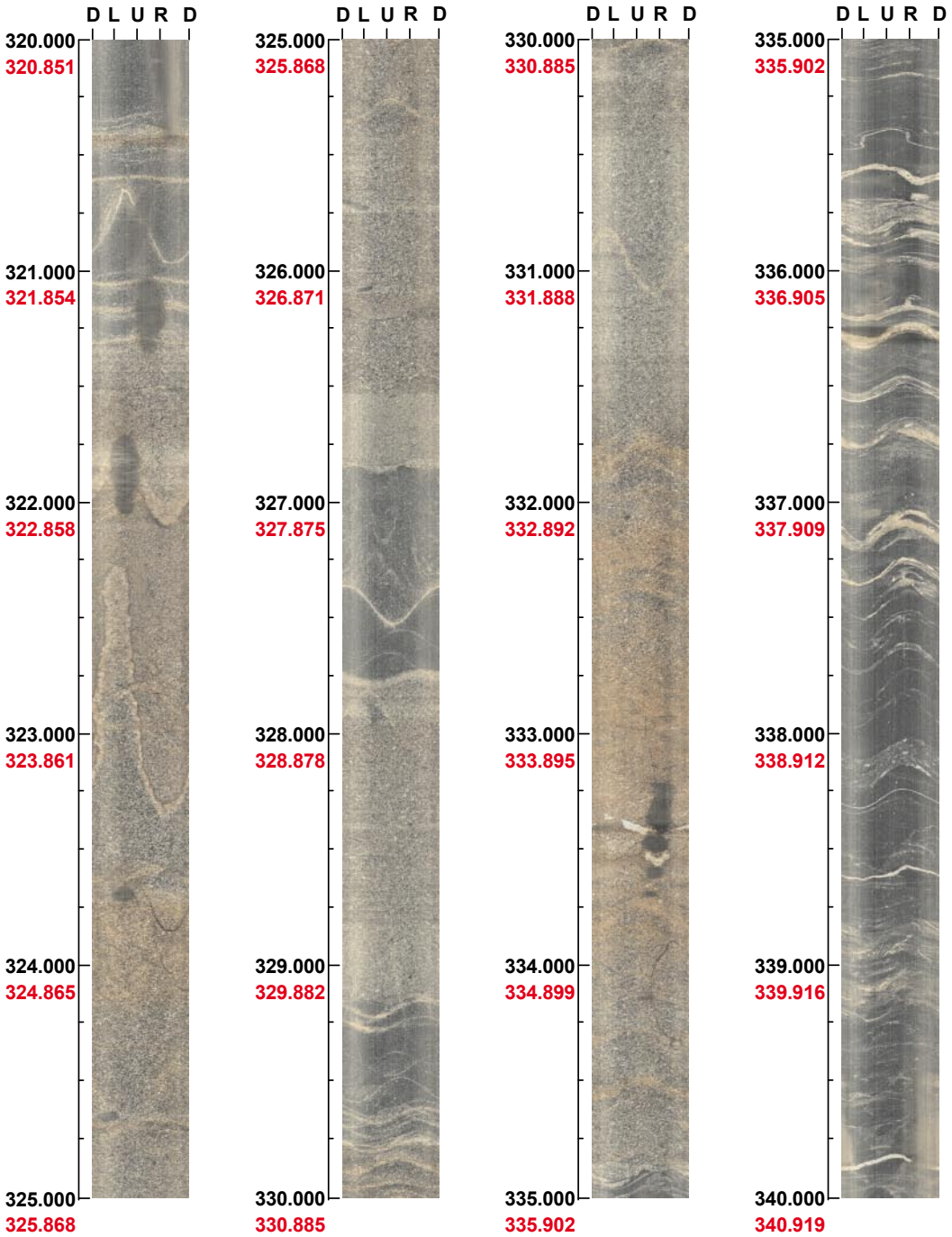
Depth range: 300.000 - 320.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

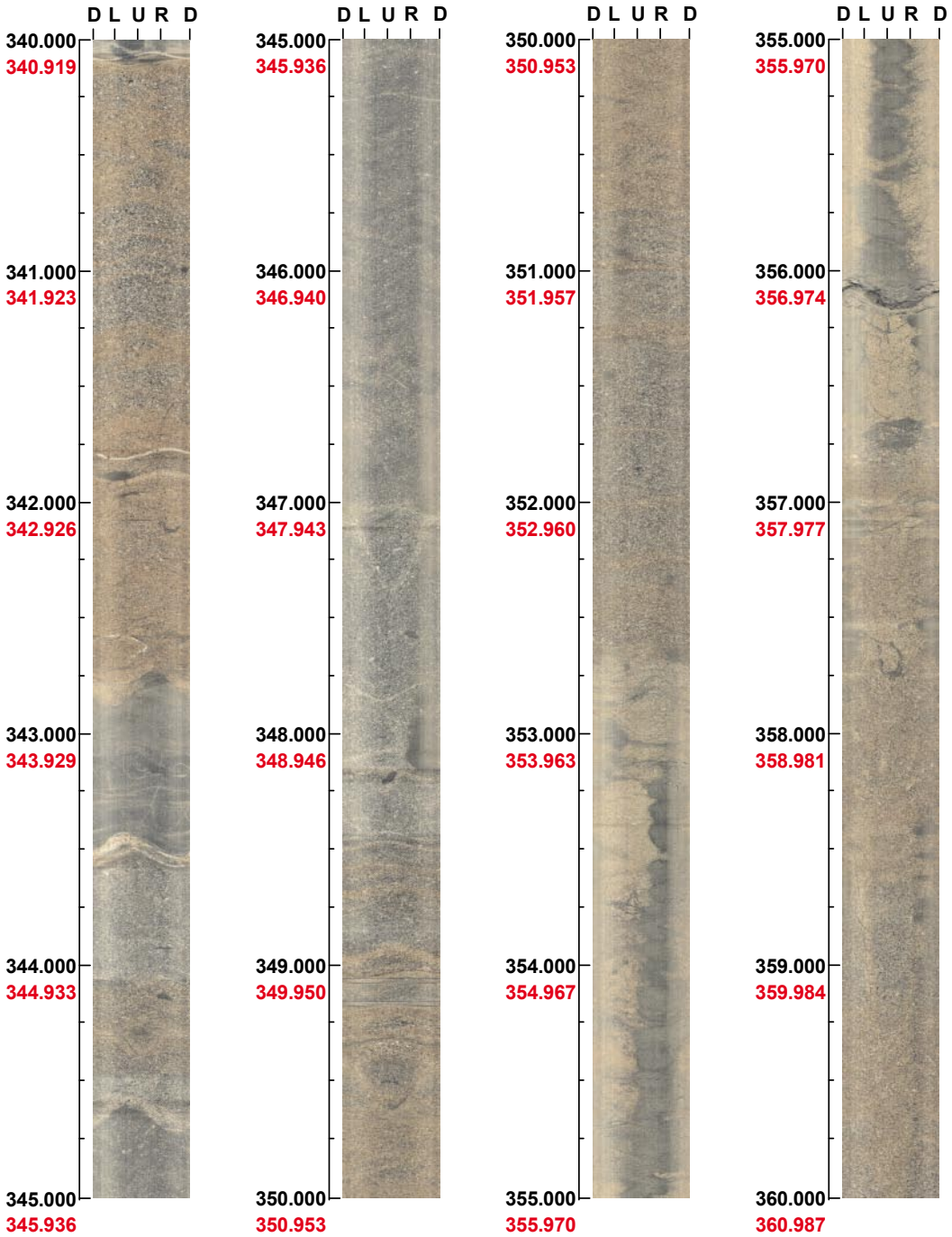
Depth range: 320.000 - 340.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

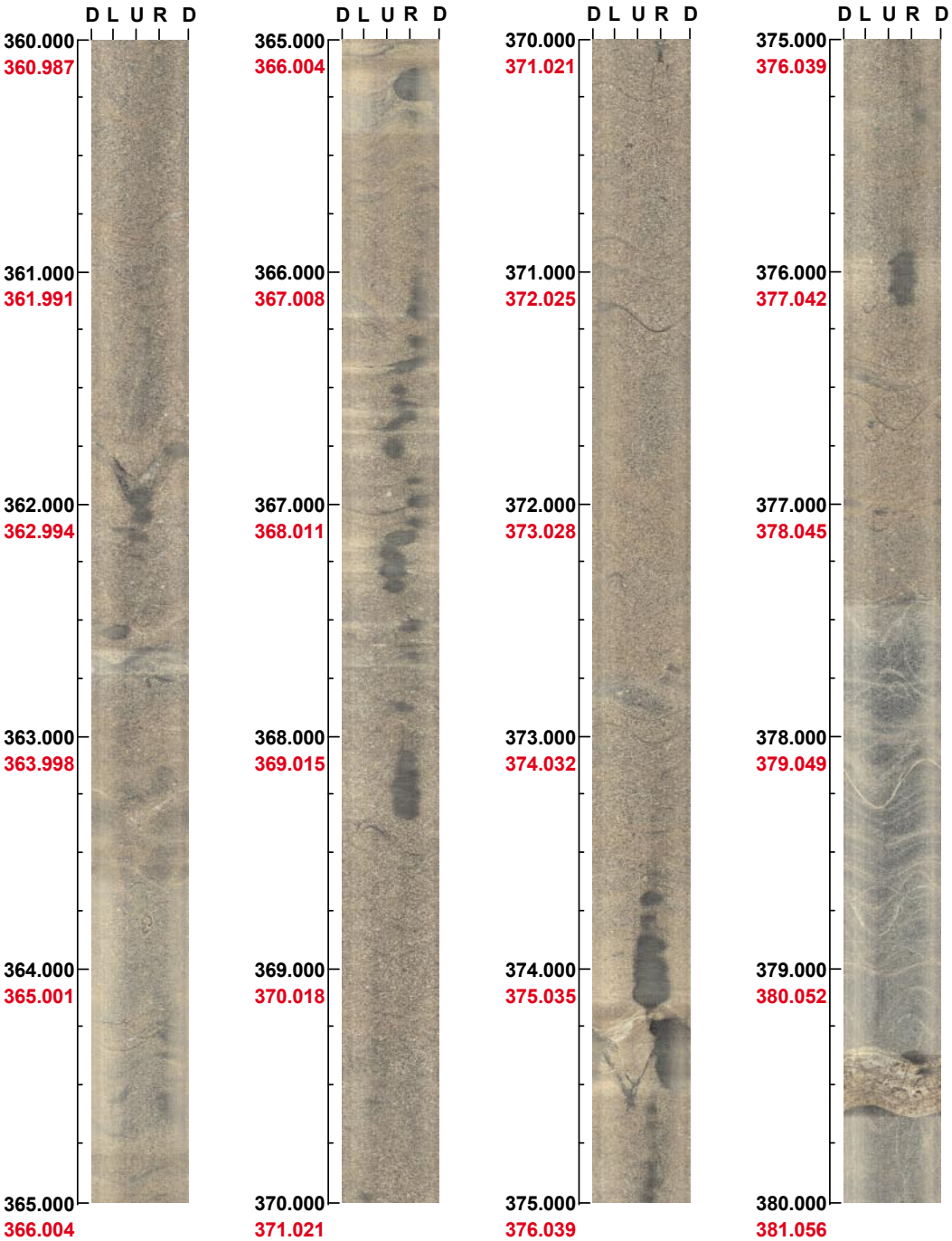
Depth range: 340.000 - 360.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

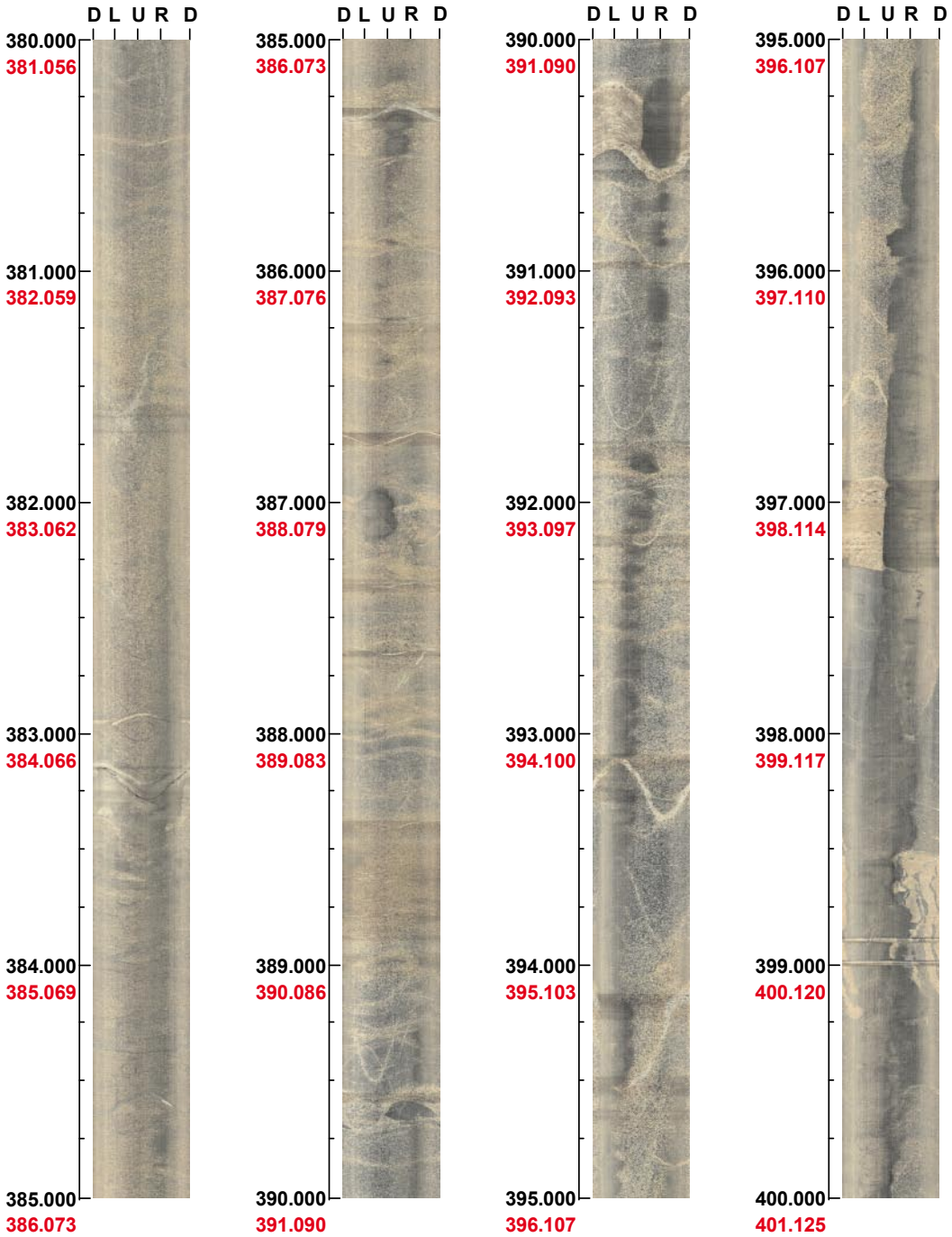
Depth range: 360.000 - 380.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

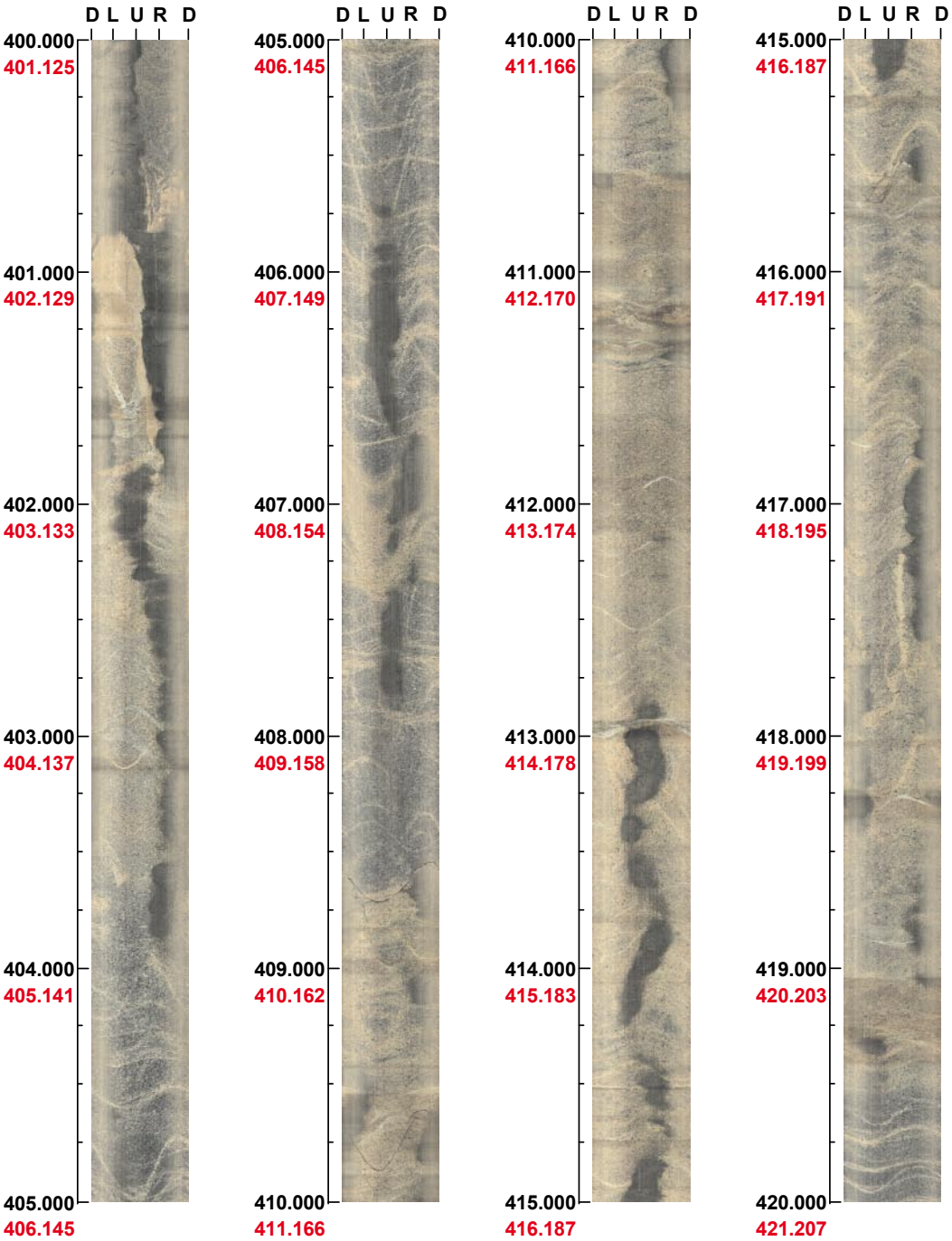
Depth range: 380.000 - 400.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

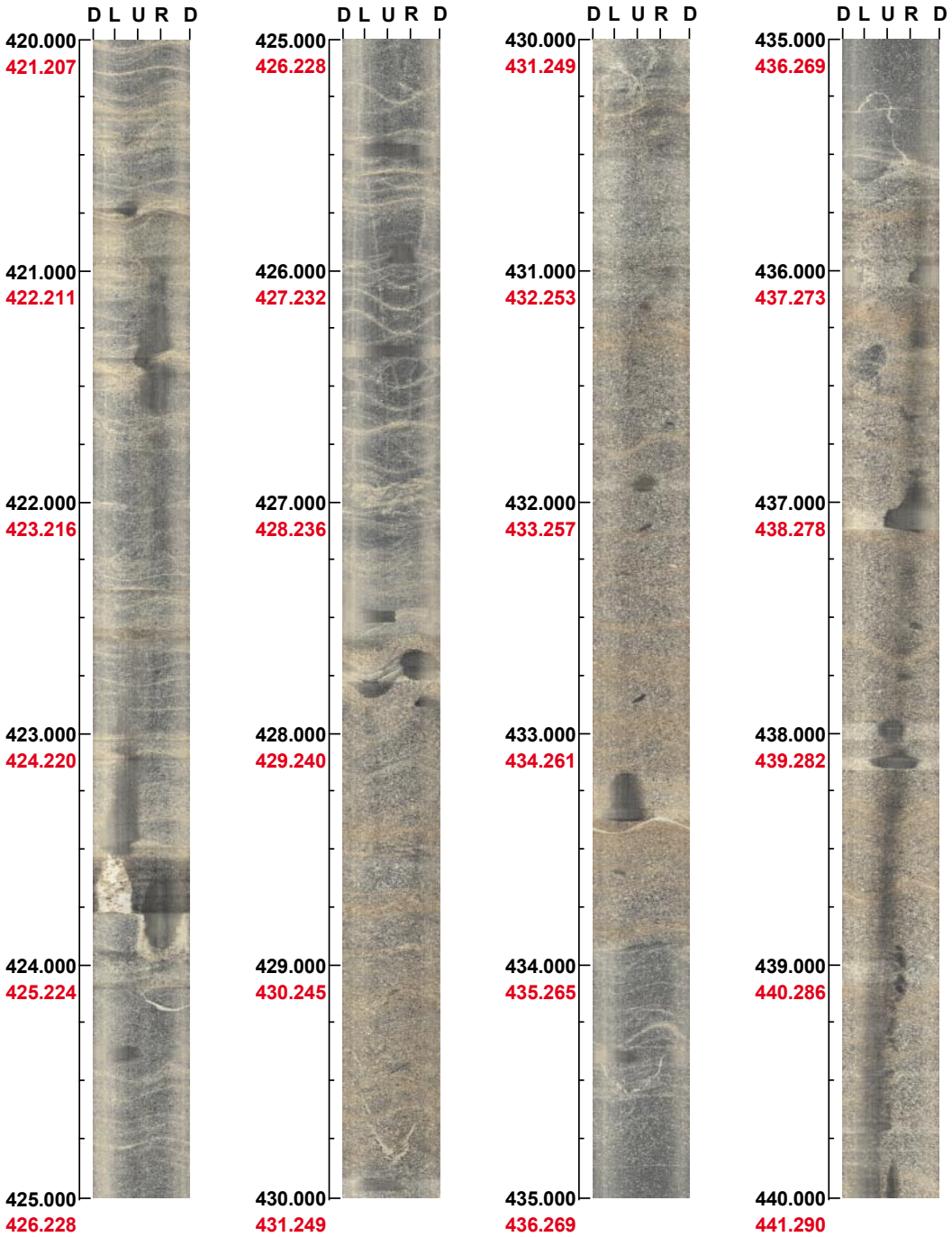
Depth range: 400.000 - 420.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

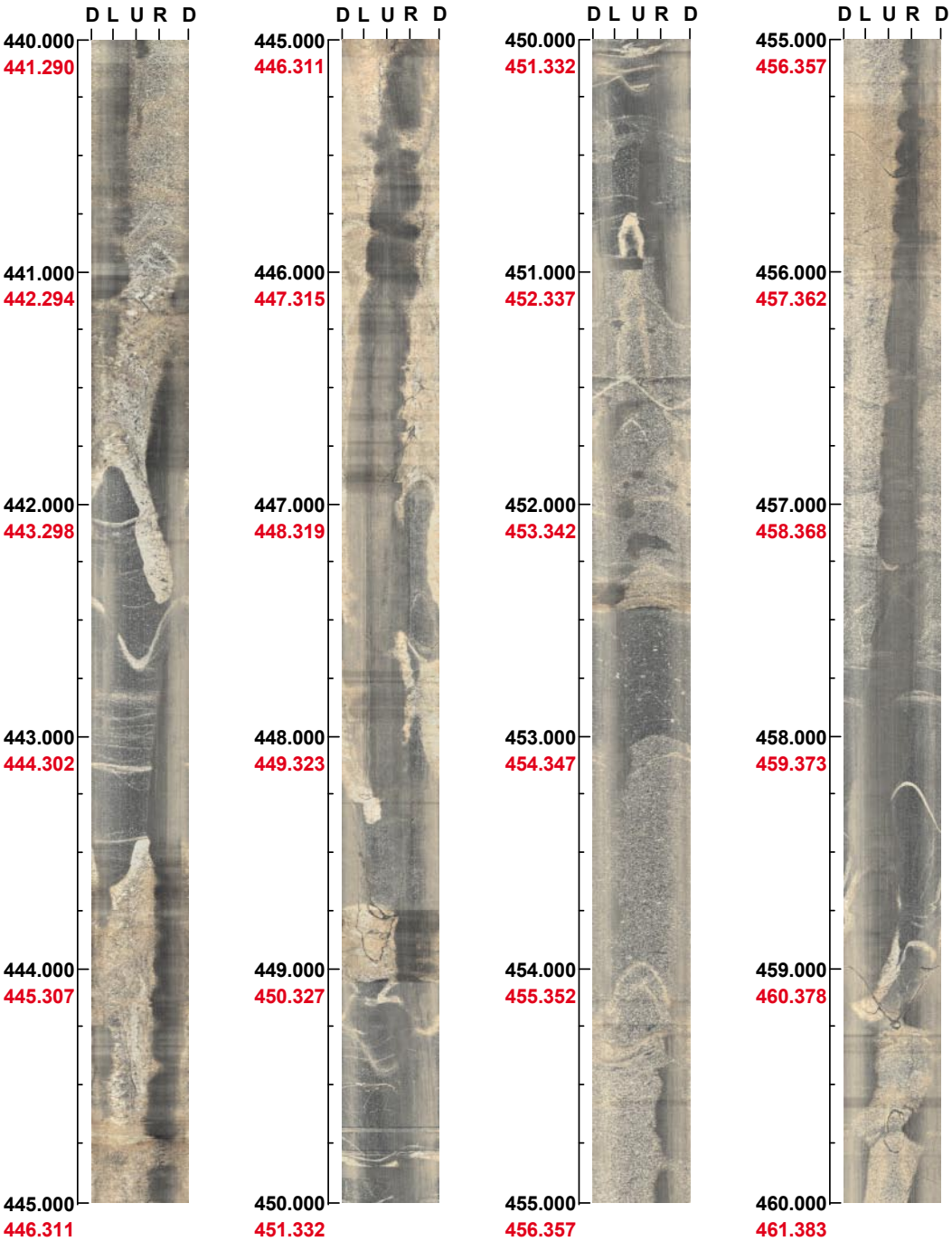
Depth range: 420.000 - 440.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

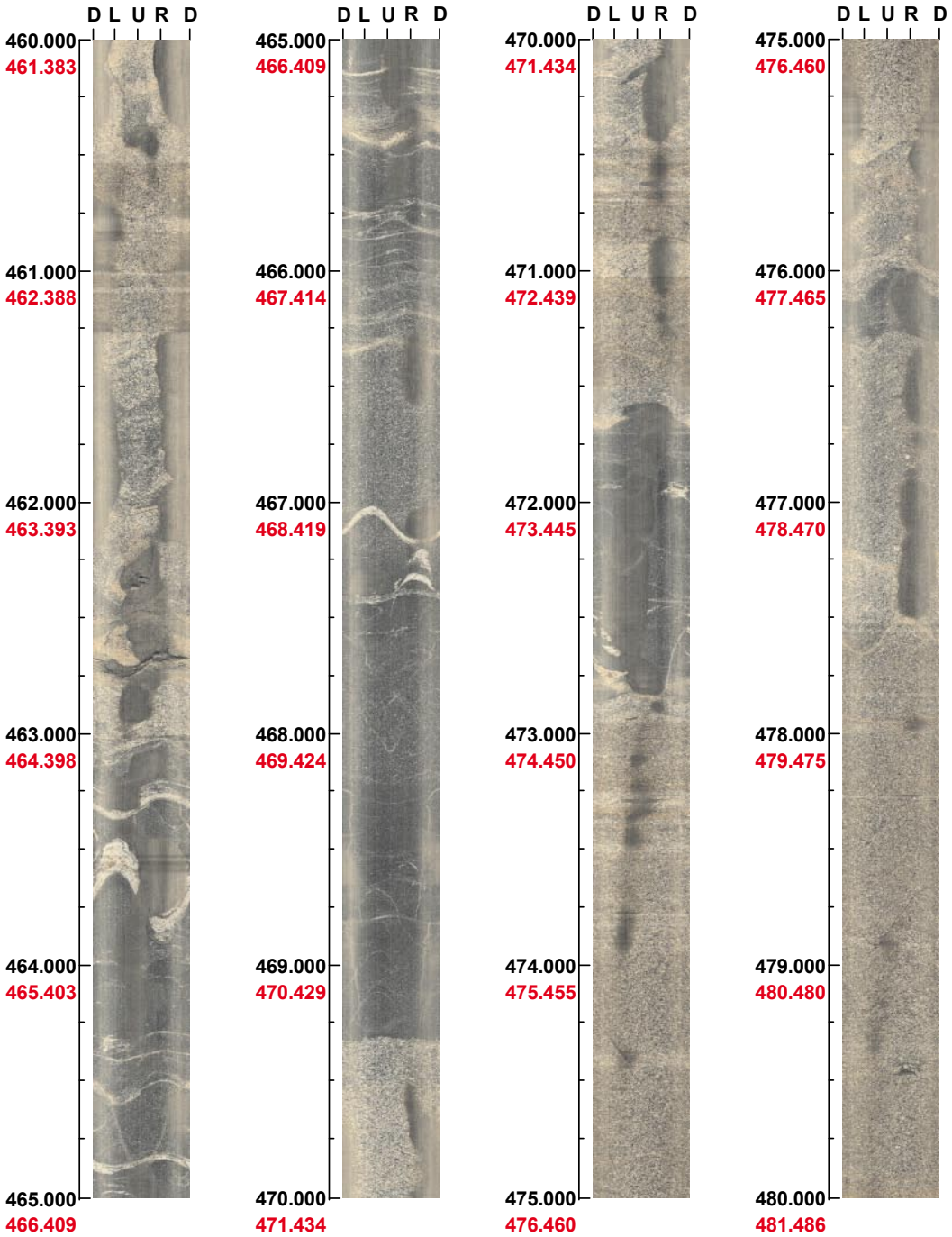
Depth range: 440.000 - 460.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

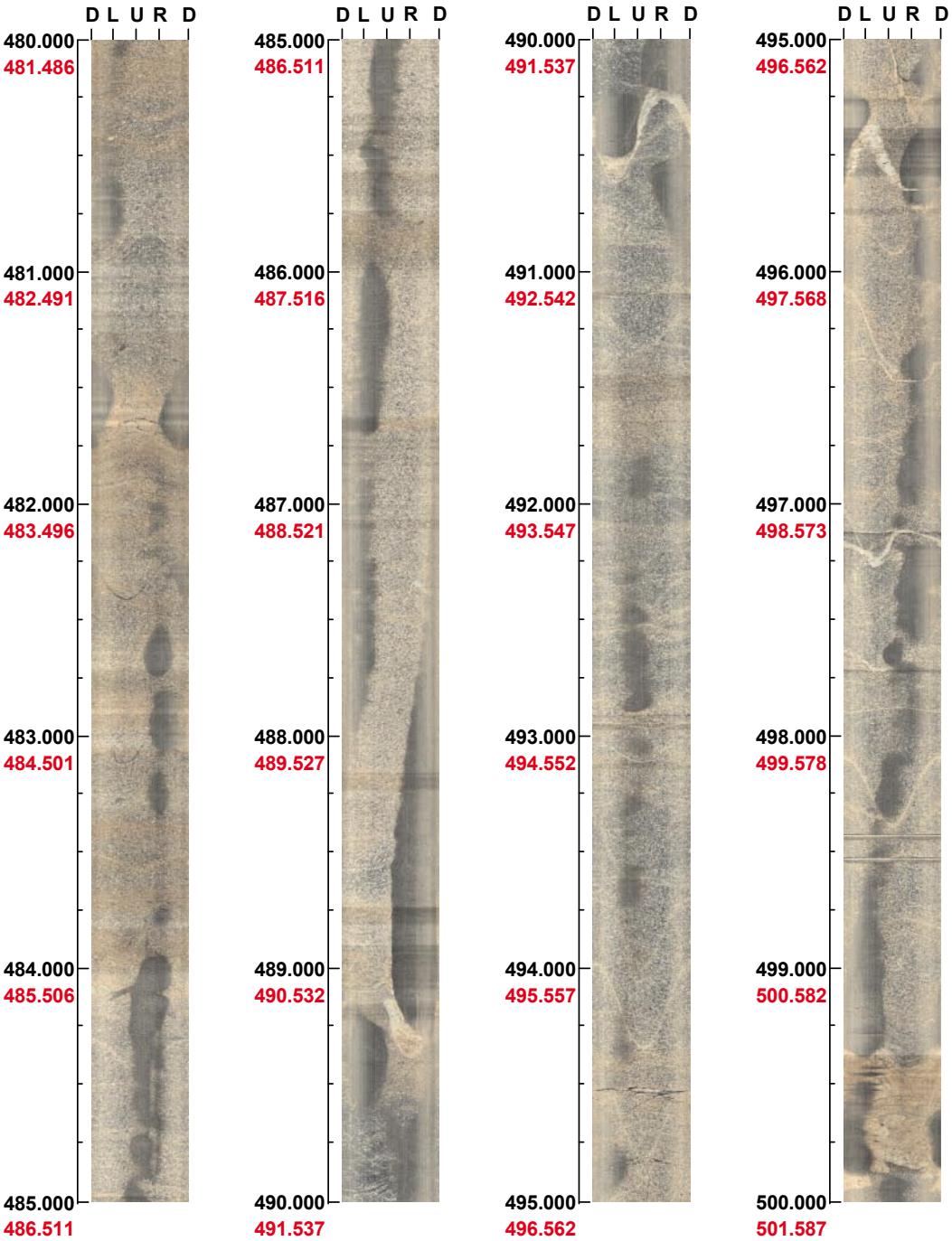
Depth range: 460.000 - 480.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

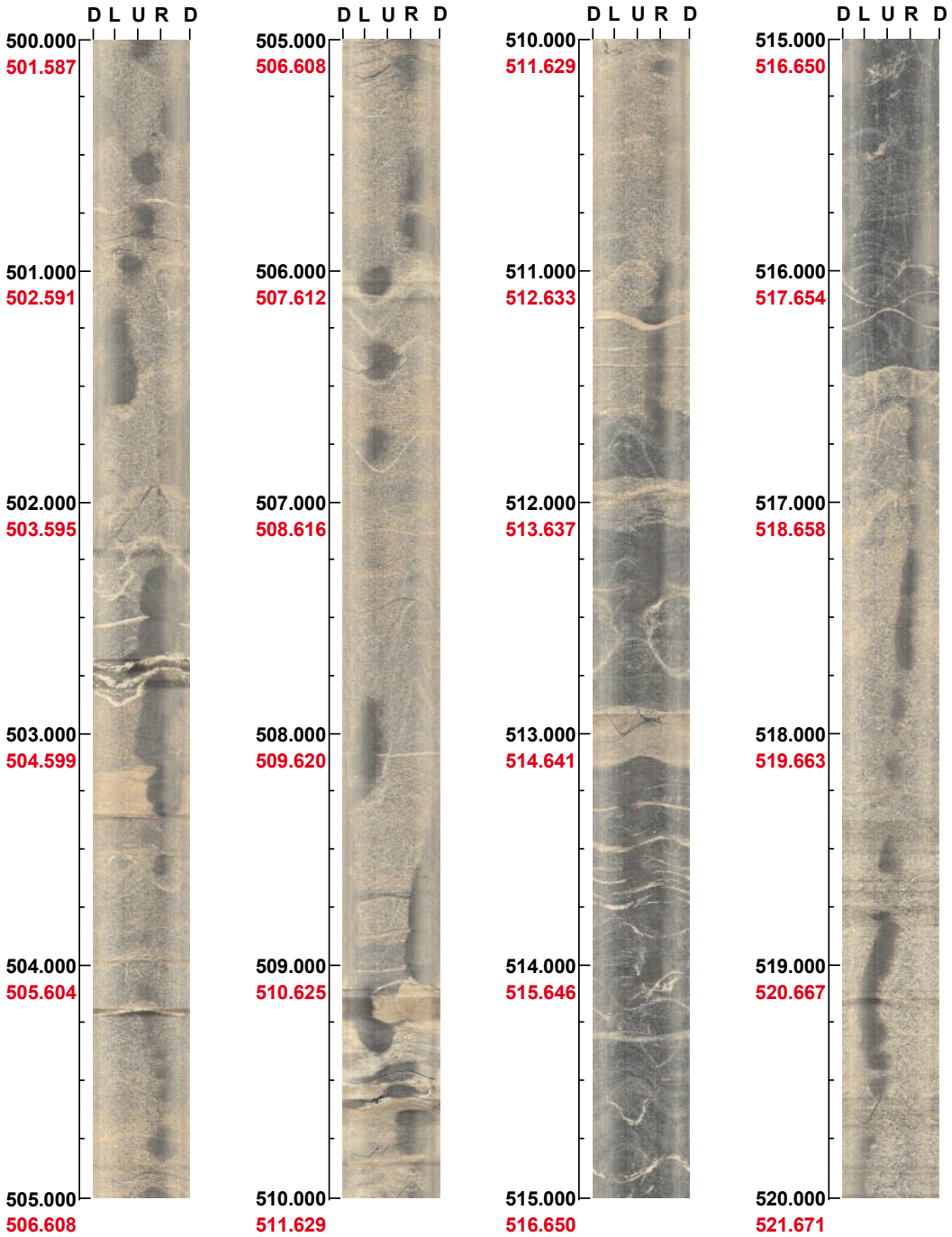
Depth range: 480.000 - 500.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

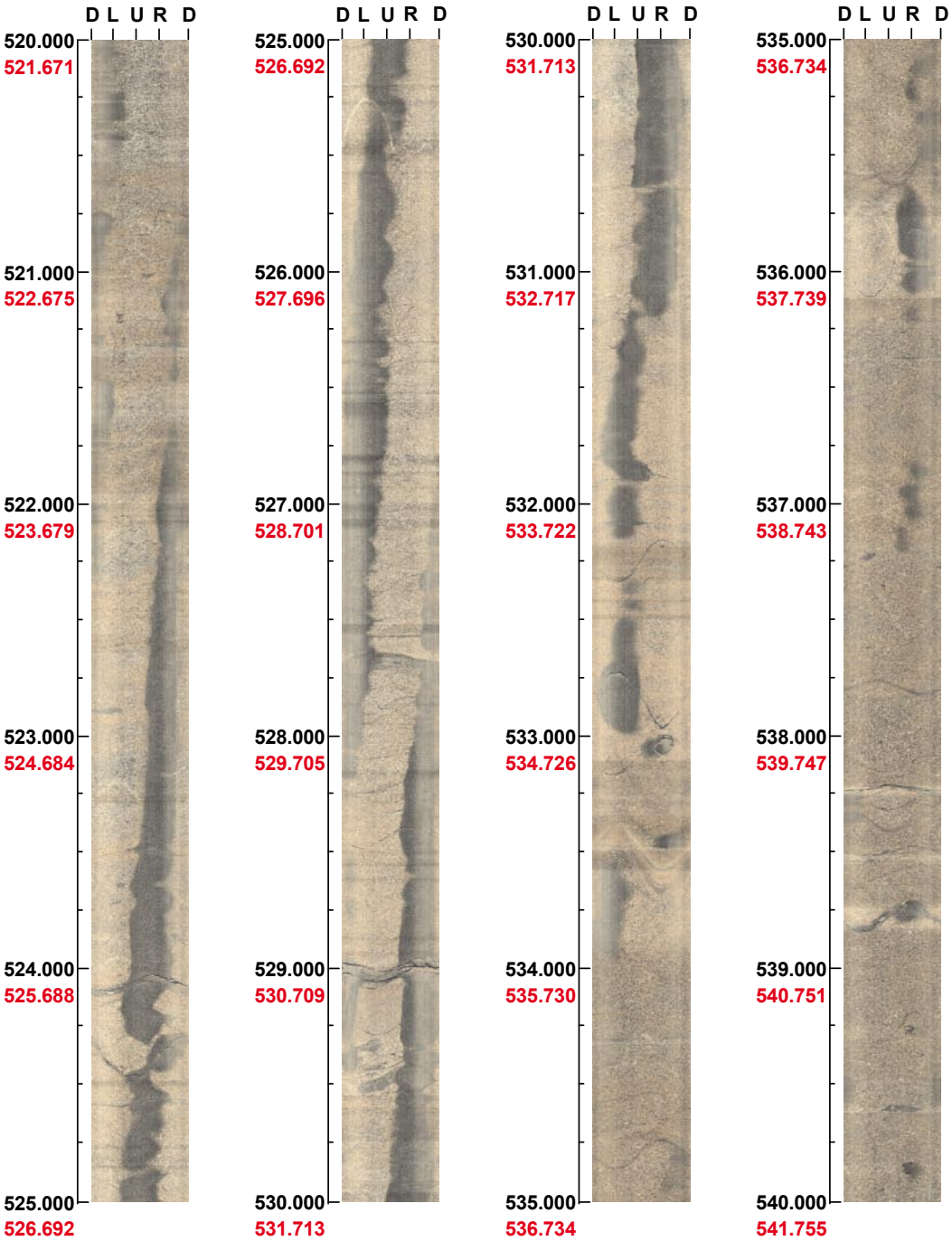
Depth range: 500.000 - 520.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

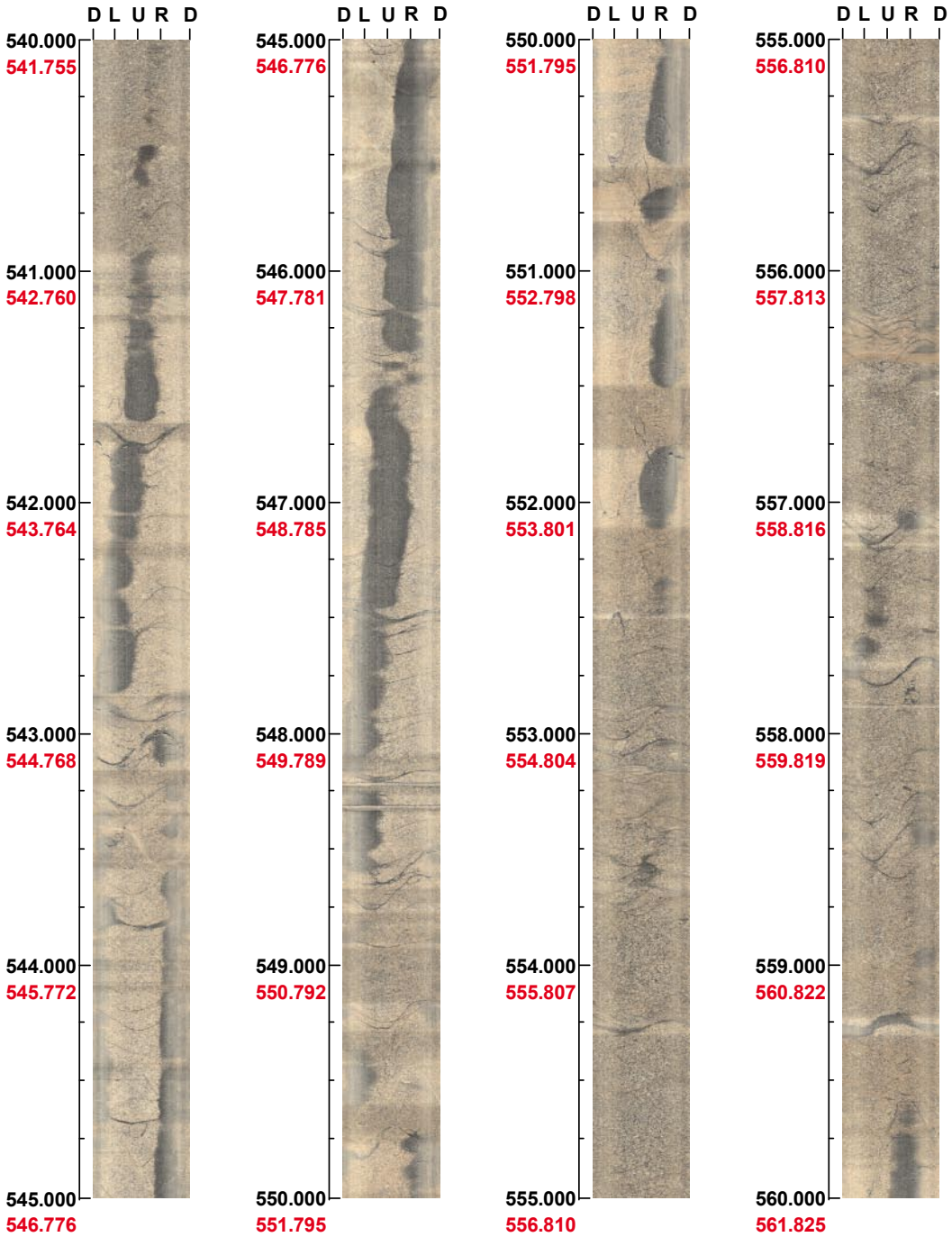
Depth range: 520.000 - 540.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

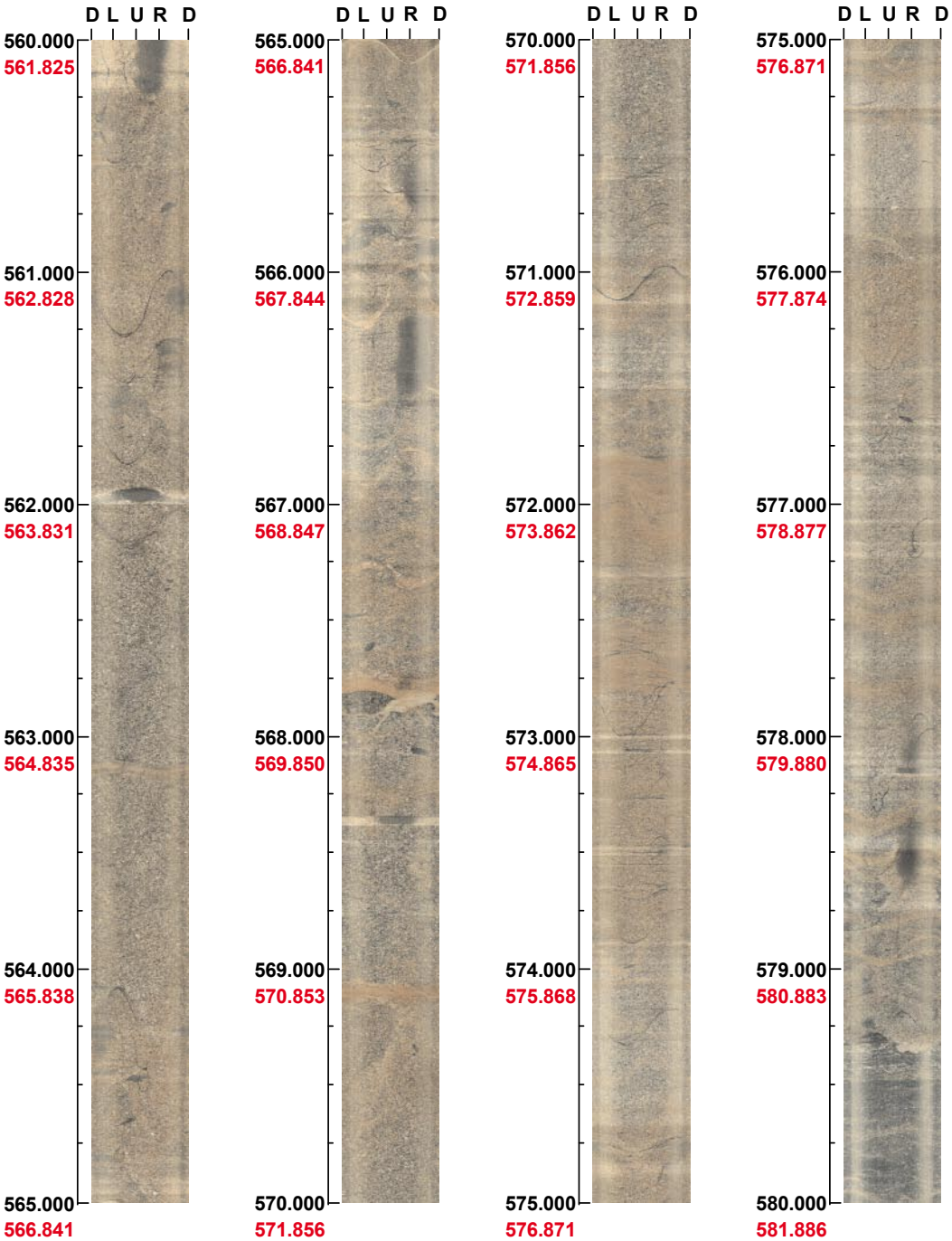
Depth range: 540.000 - 560.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

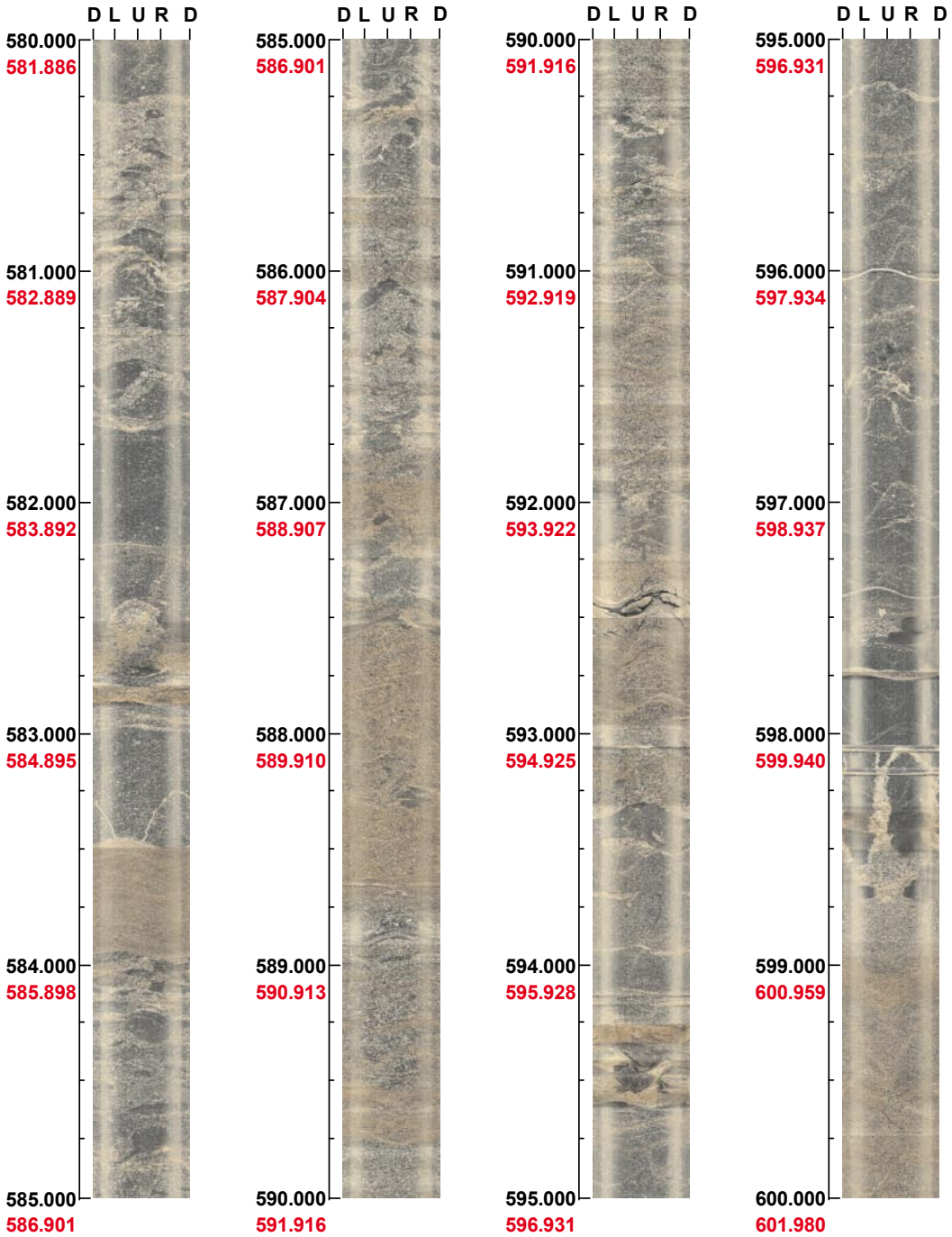
Depth range: 560.000 - 580.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

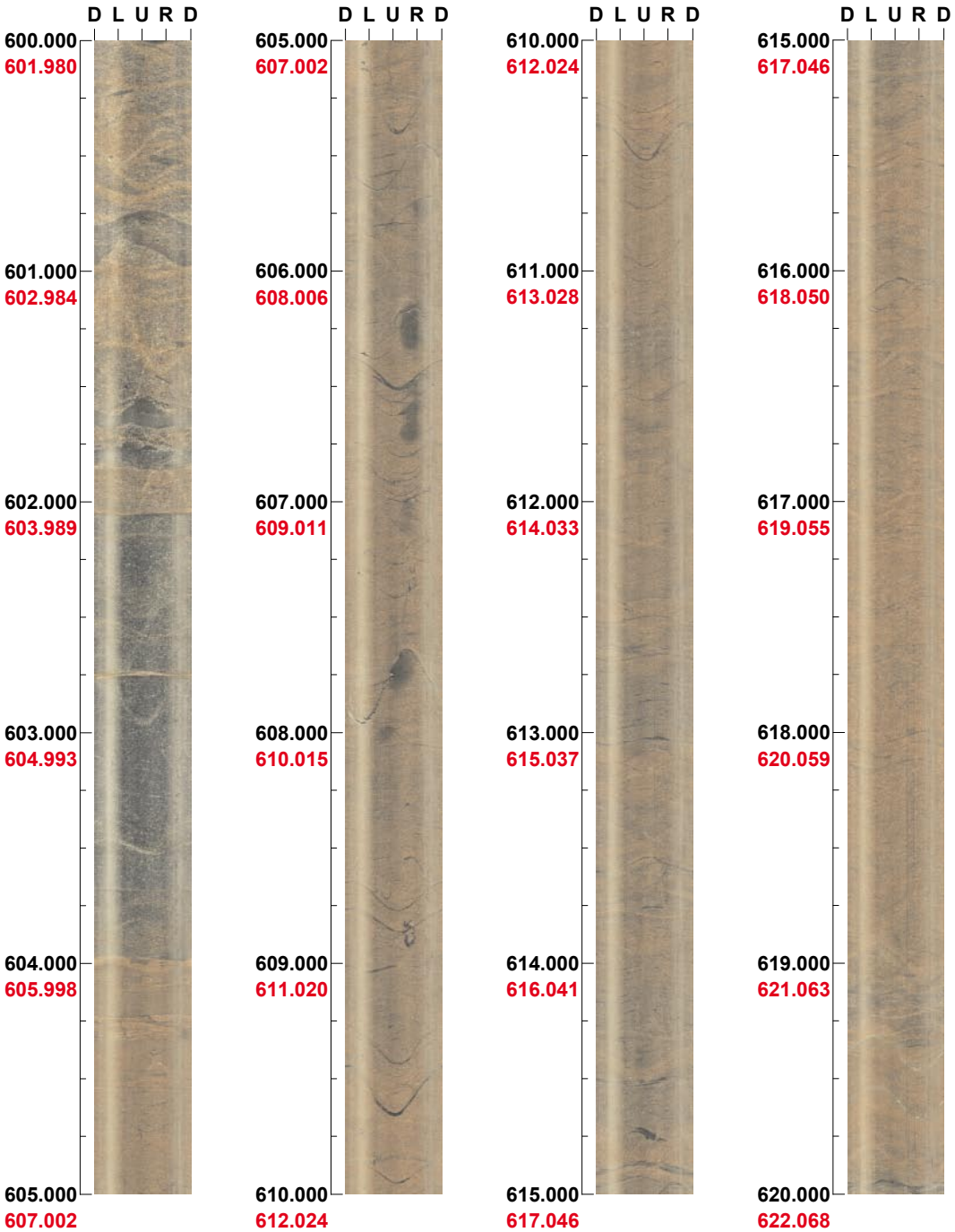
Depth range: 580.000 - 600.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

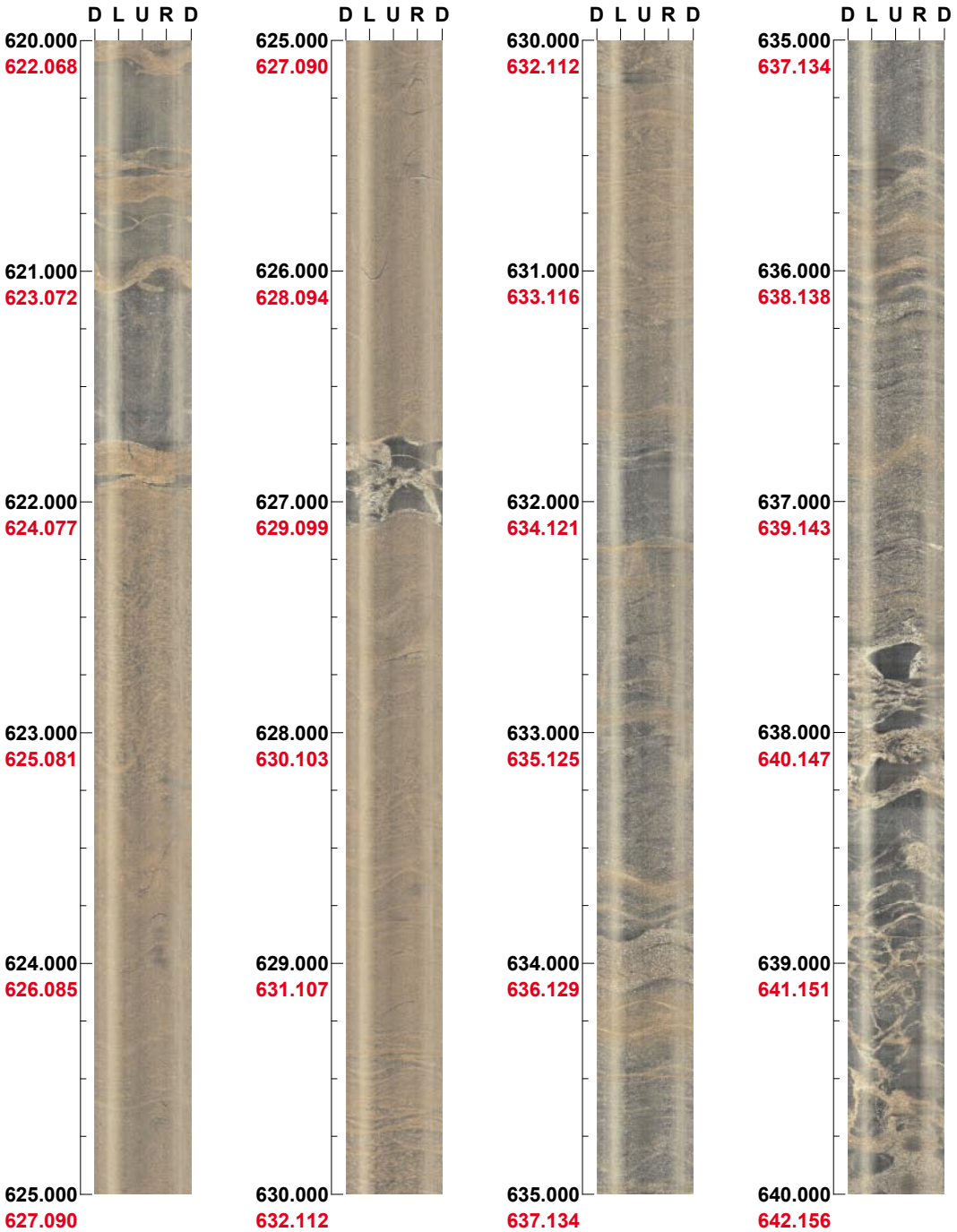
Depth range: 600.000 - 620.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

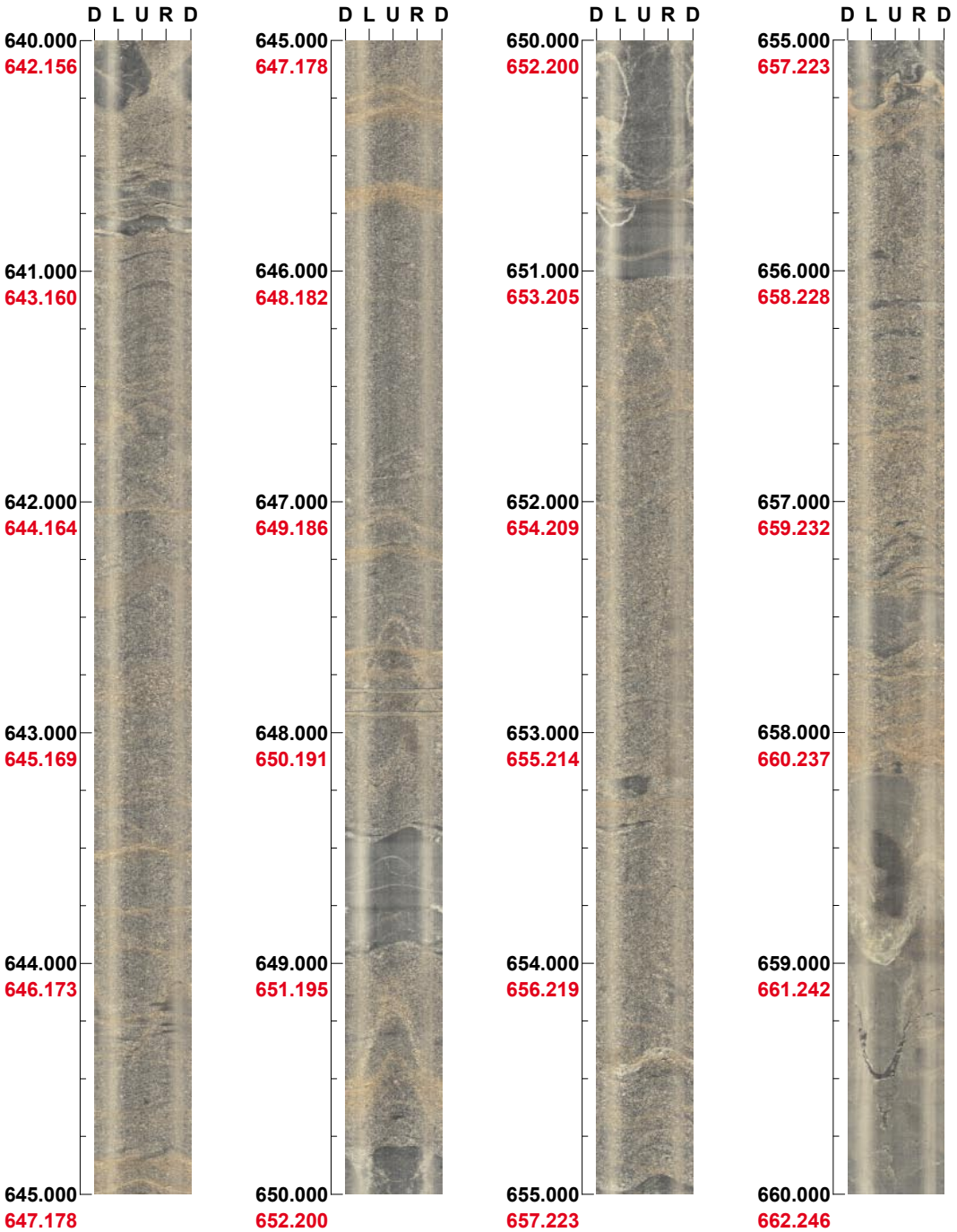
Depth range: 620.000 - 640.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

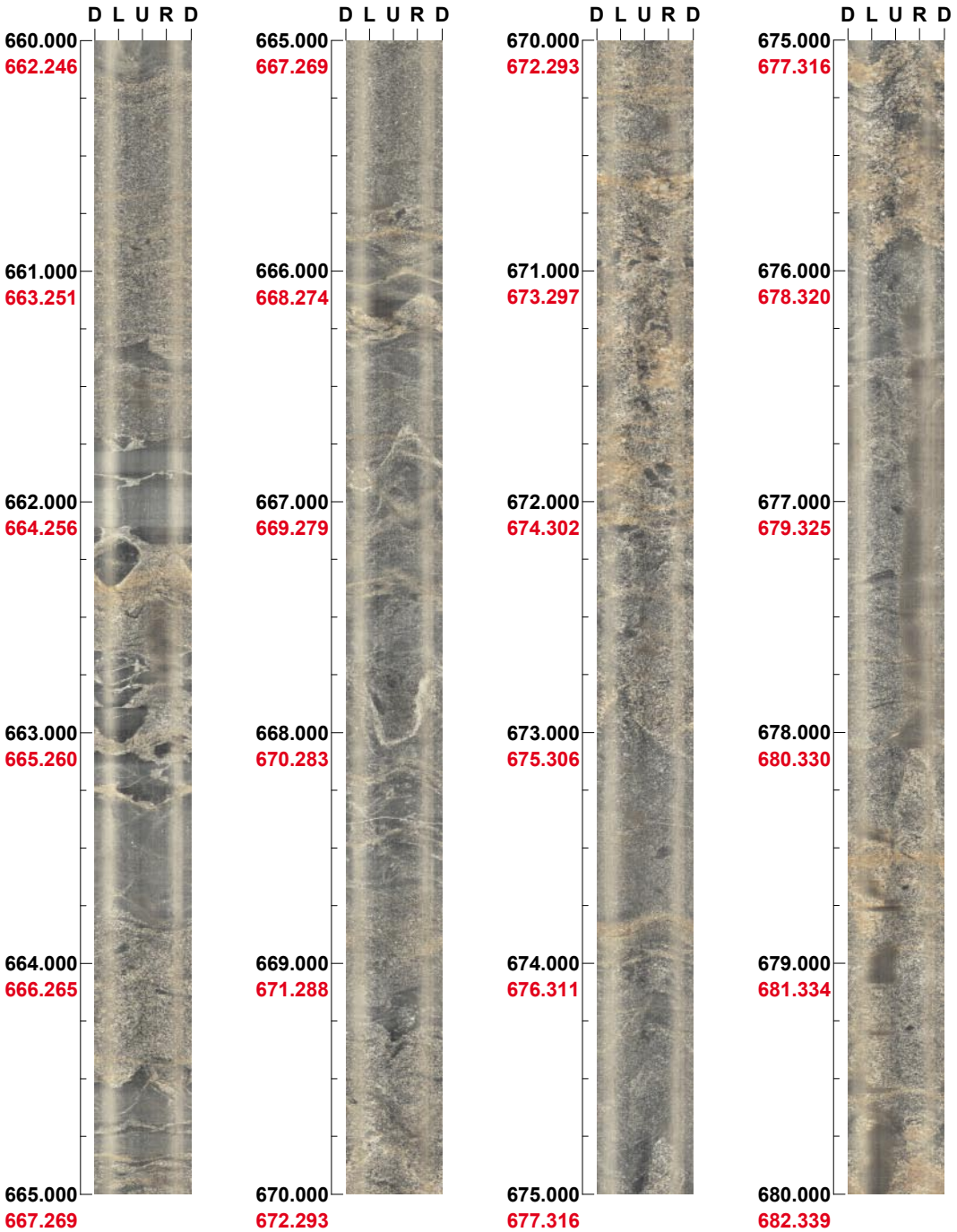
Depth range: 640.000 - 660.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

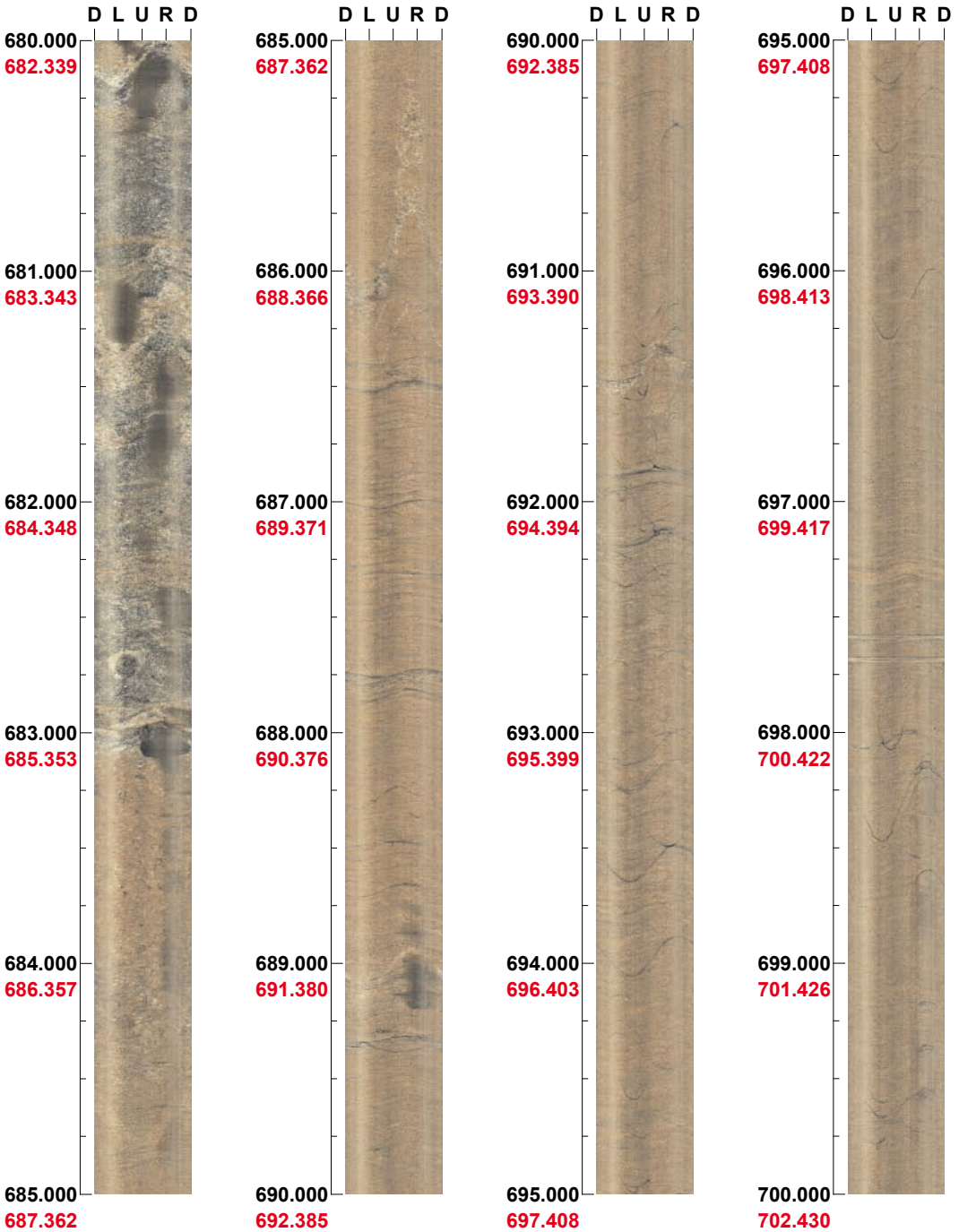
Depth range: 660.000 - 680.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

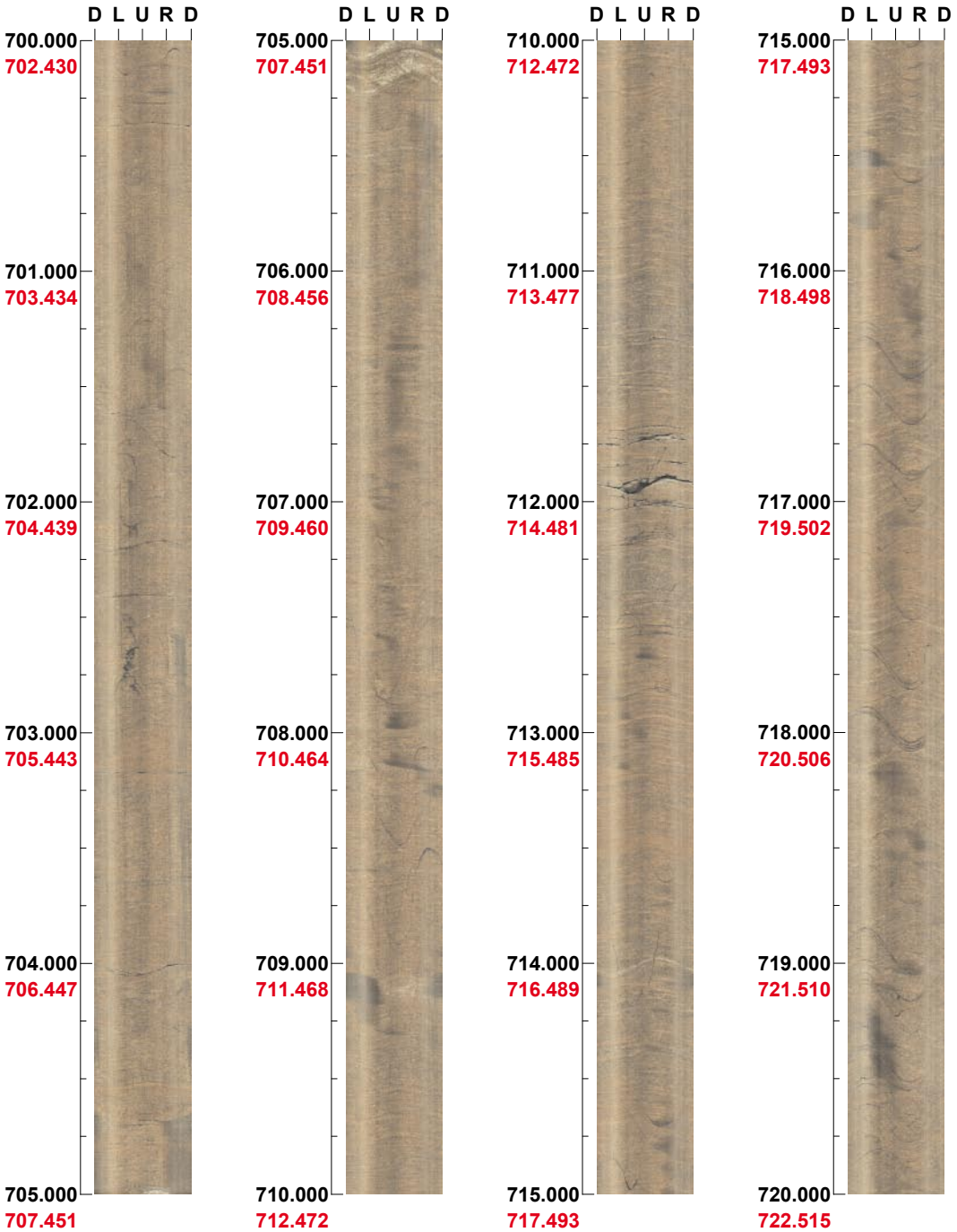
Depth range: 680.000 - 700.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

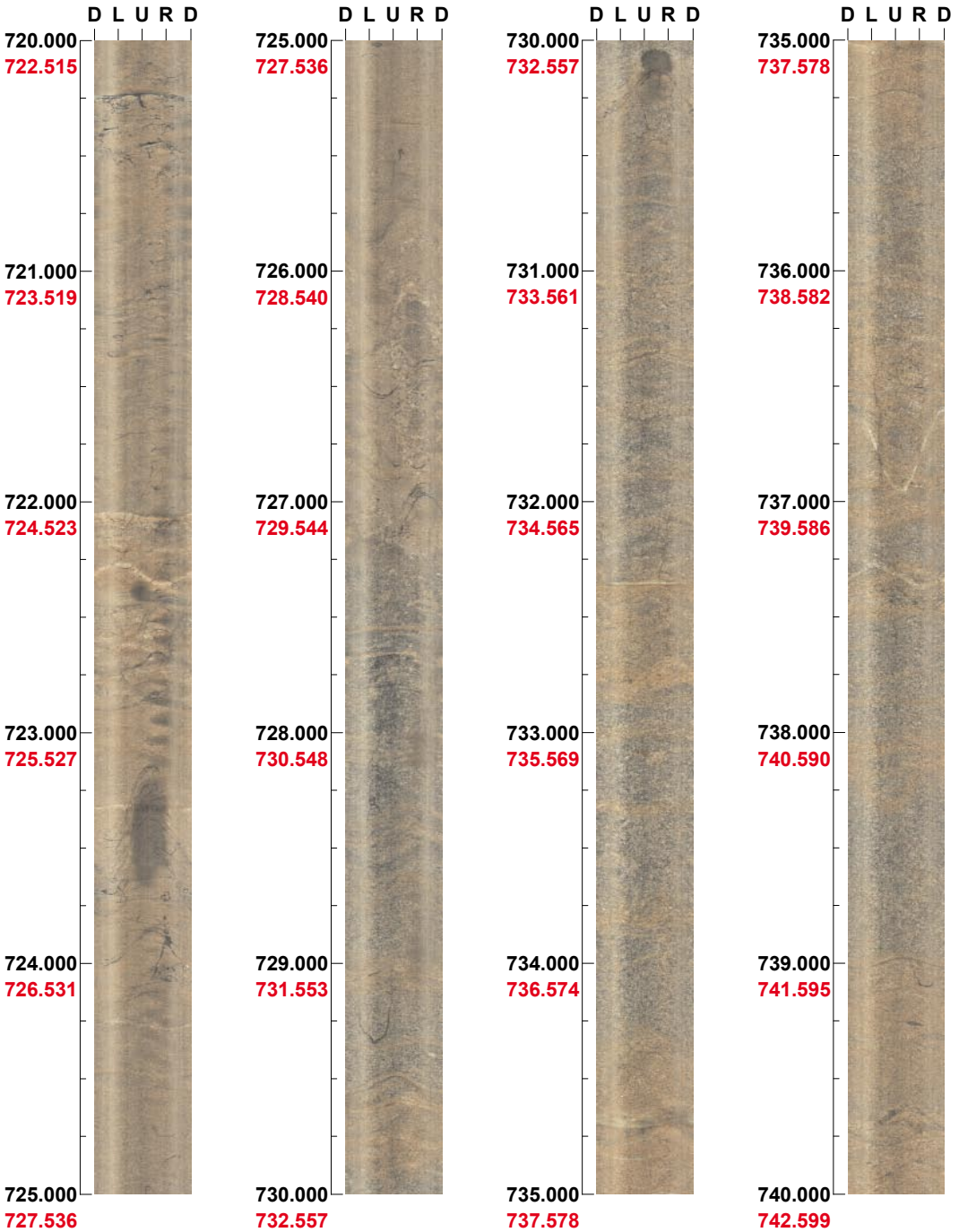
Depth range: 700.000 - 720.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

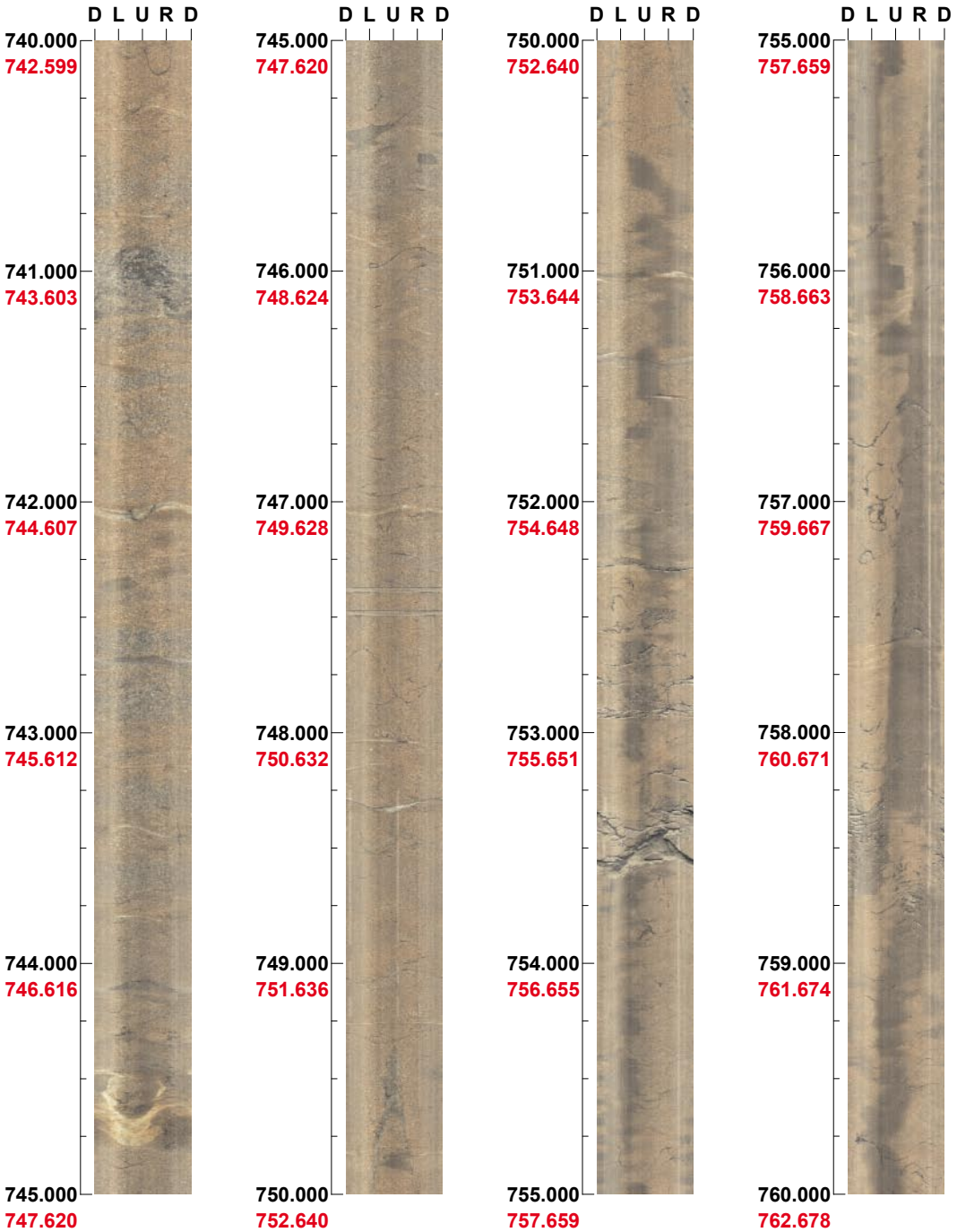
Depth range: 720.000 - 740.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

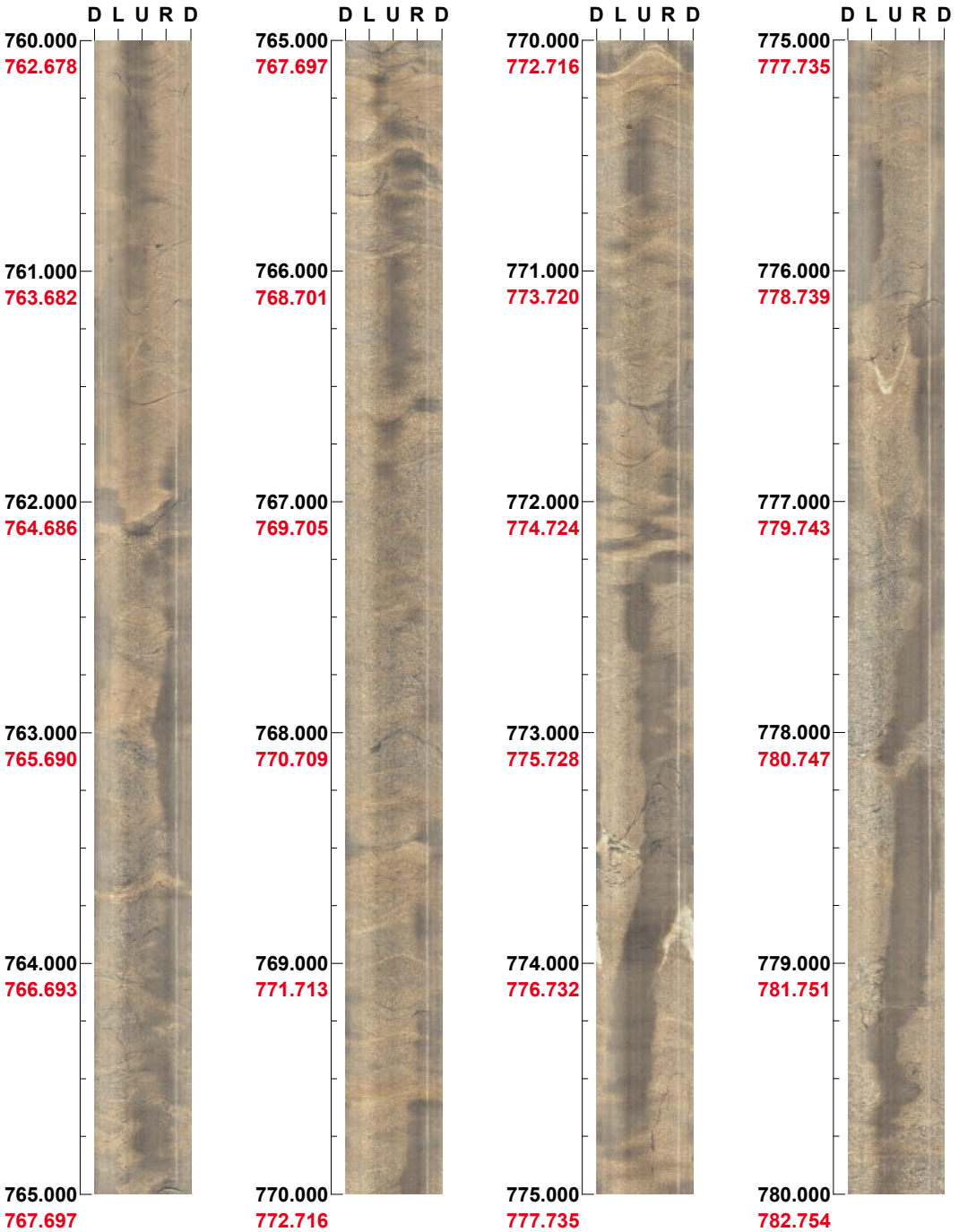
Depth range: 740.000 - 760.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

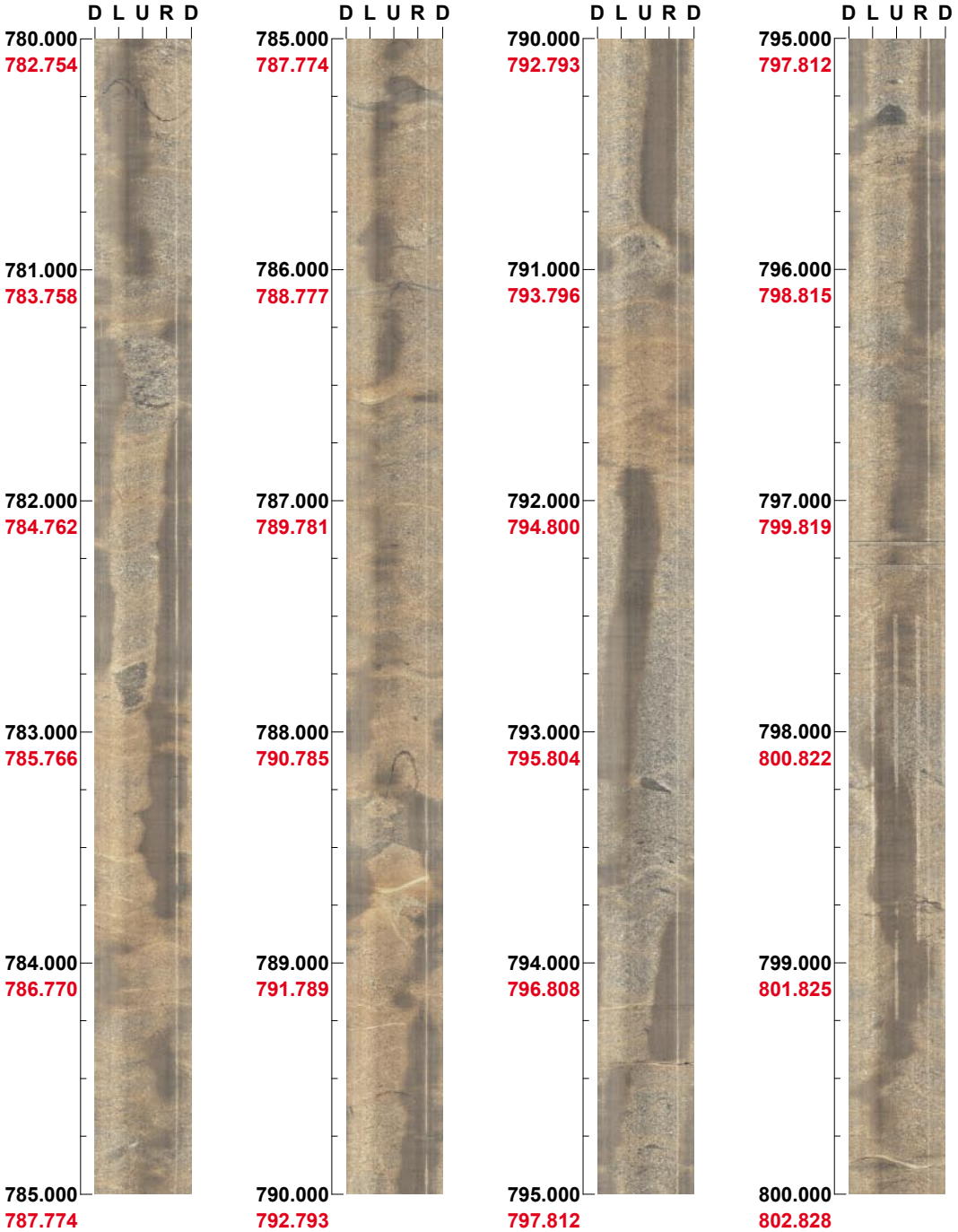
Depth range: 760.000 - 780.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

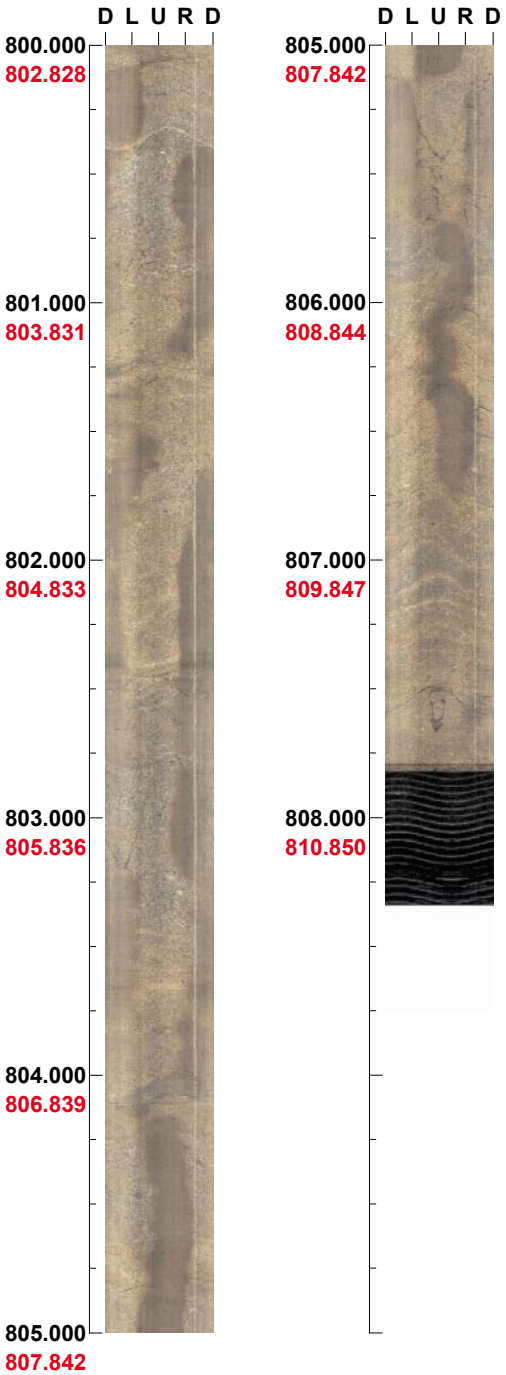
Depth range: 780.000 - 800.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

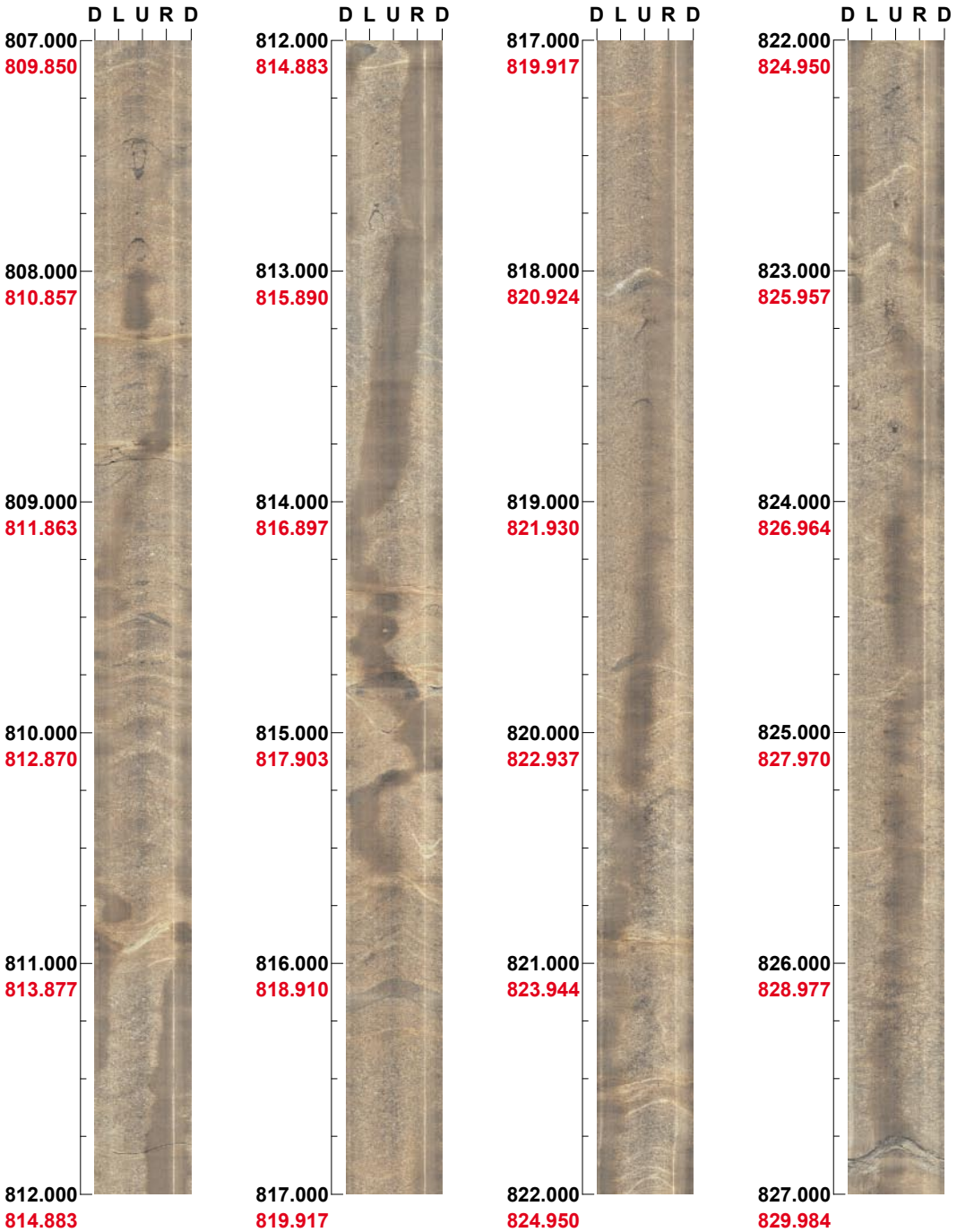
Depth range: 800.000 - 808.339 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

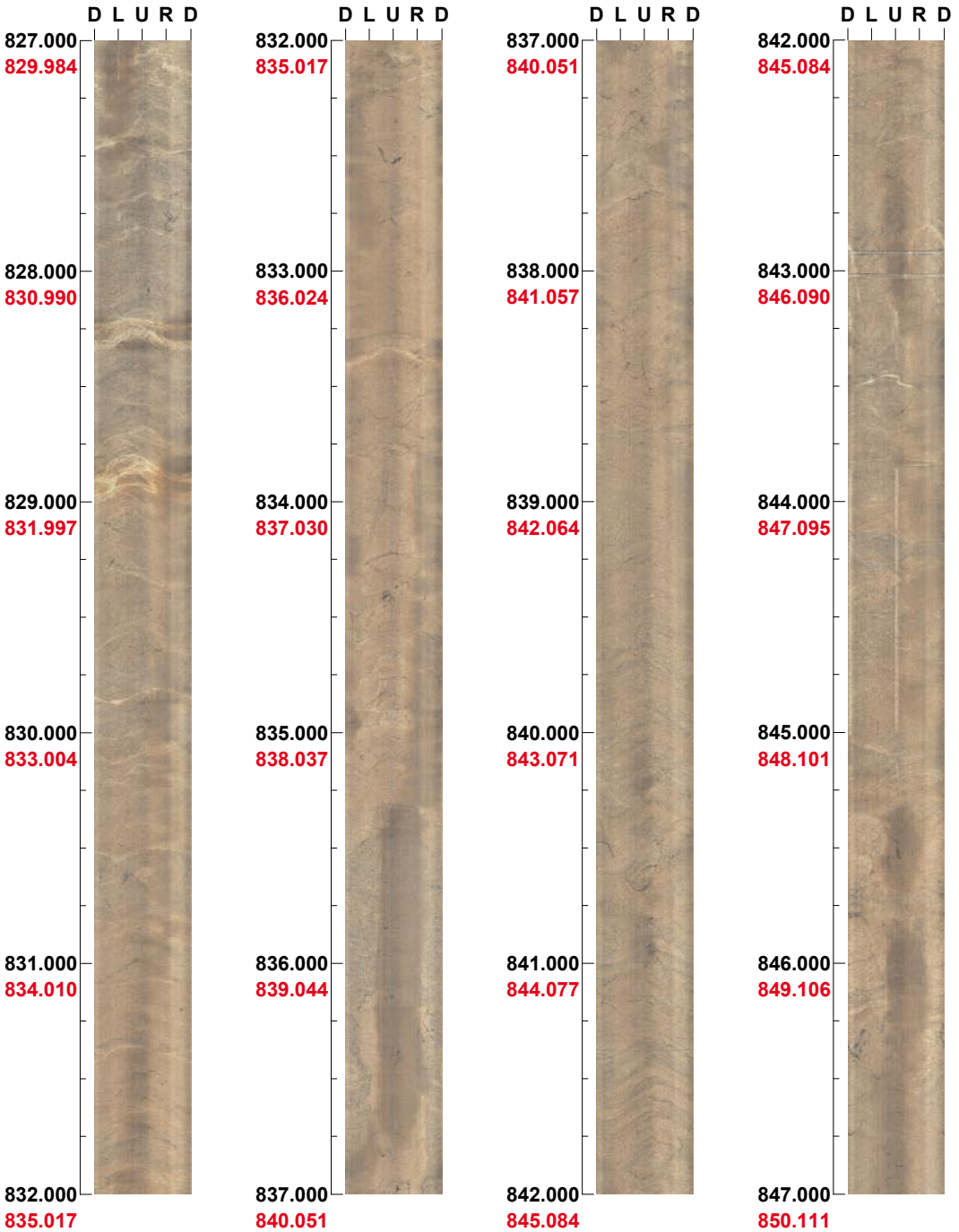
Depth range: 807.000 - 827.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

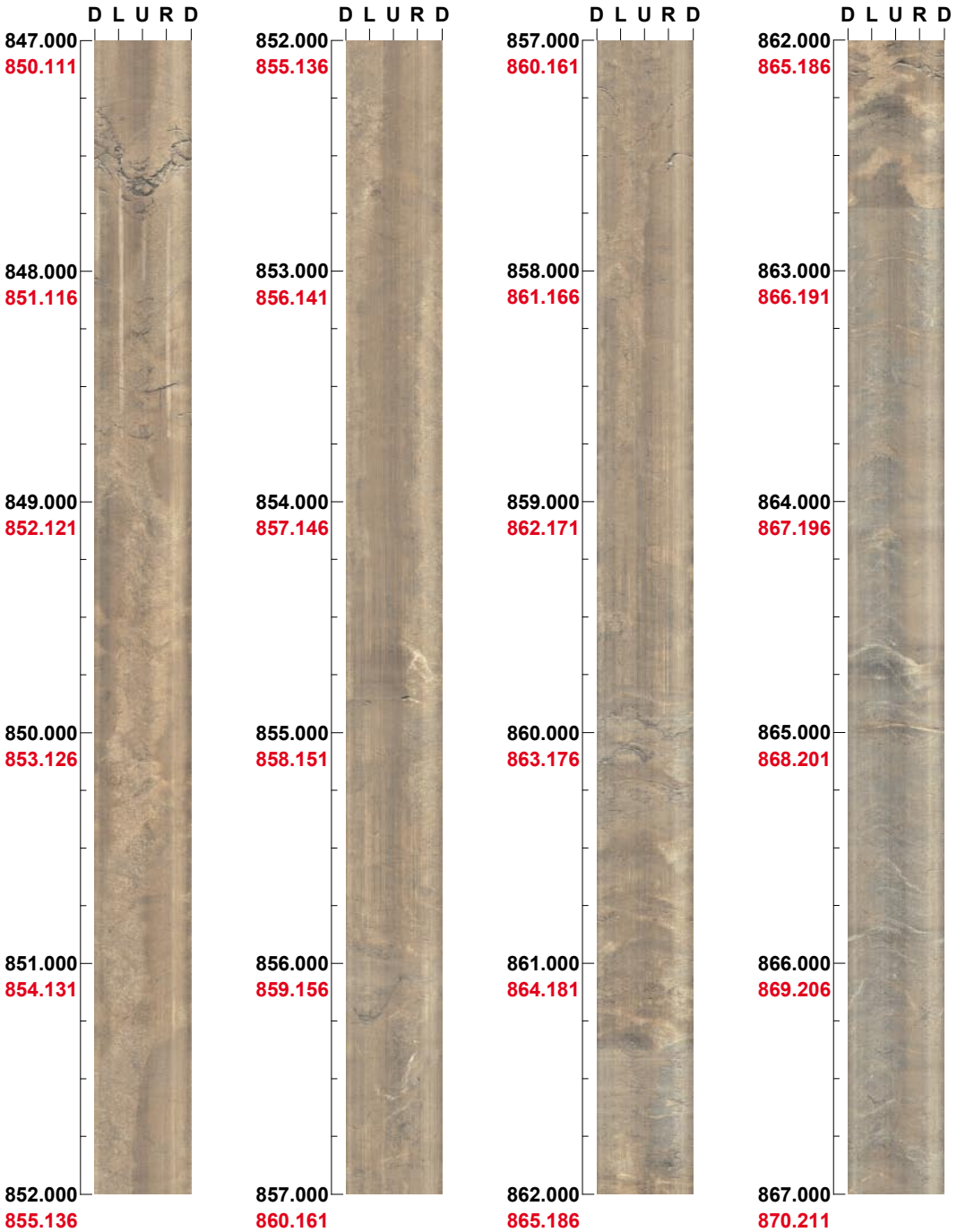
Depth range: 827.000 - 847.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

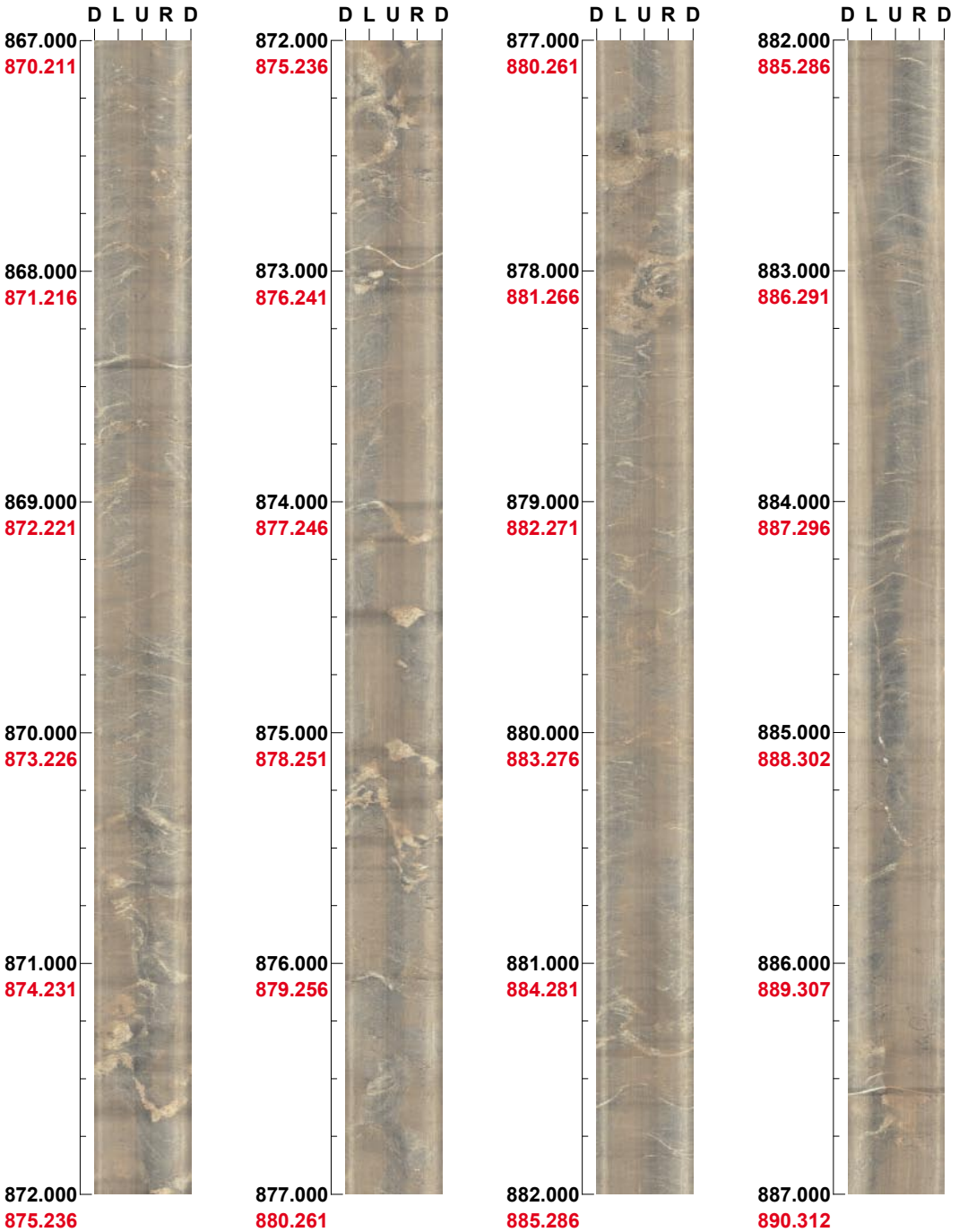
Depth range: 847.000 - 867.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

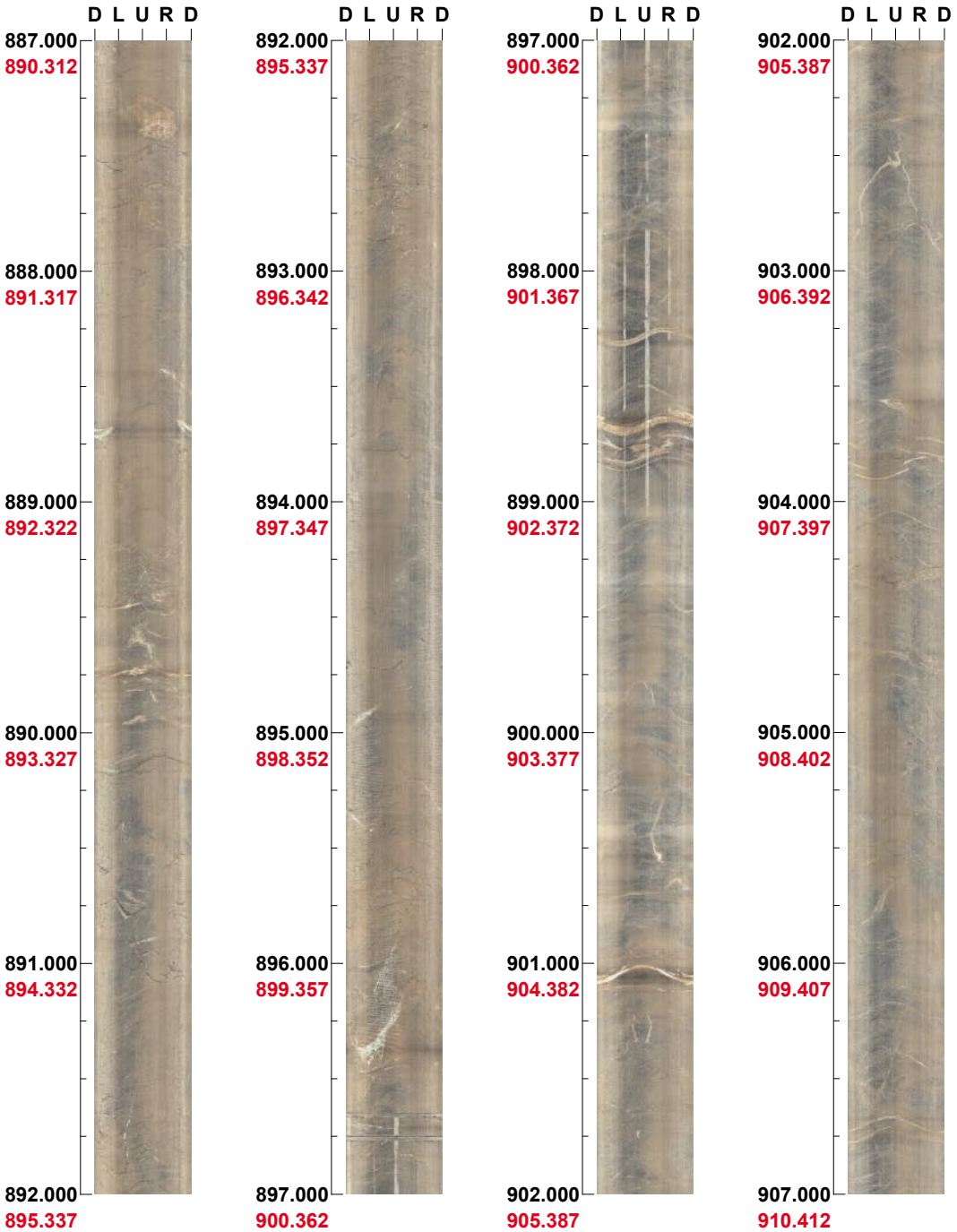
Depth range: 867.000 - 887.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

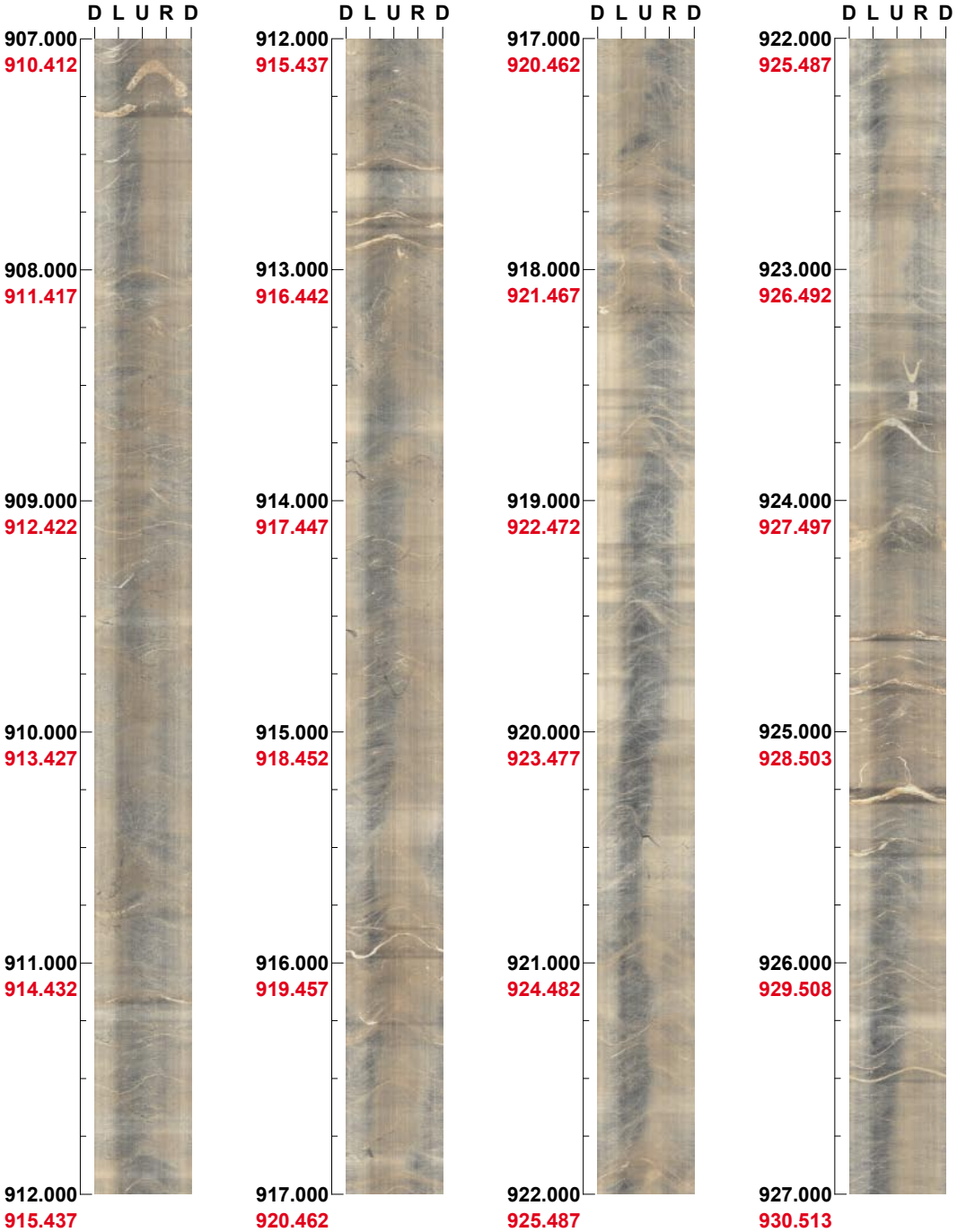
Depth range: 887.000 - 907.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

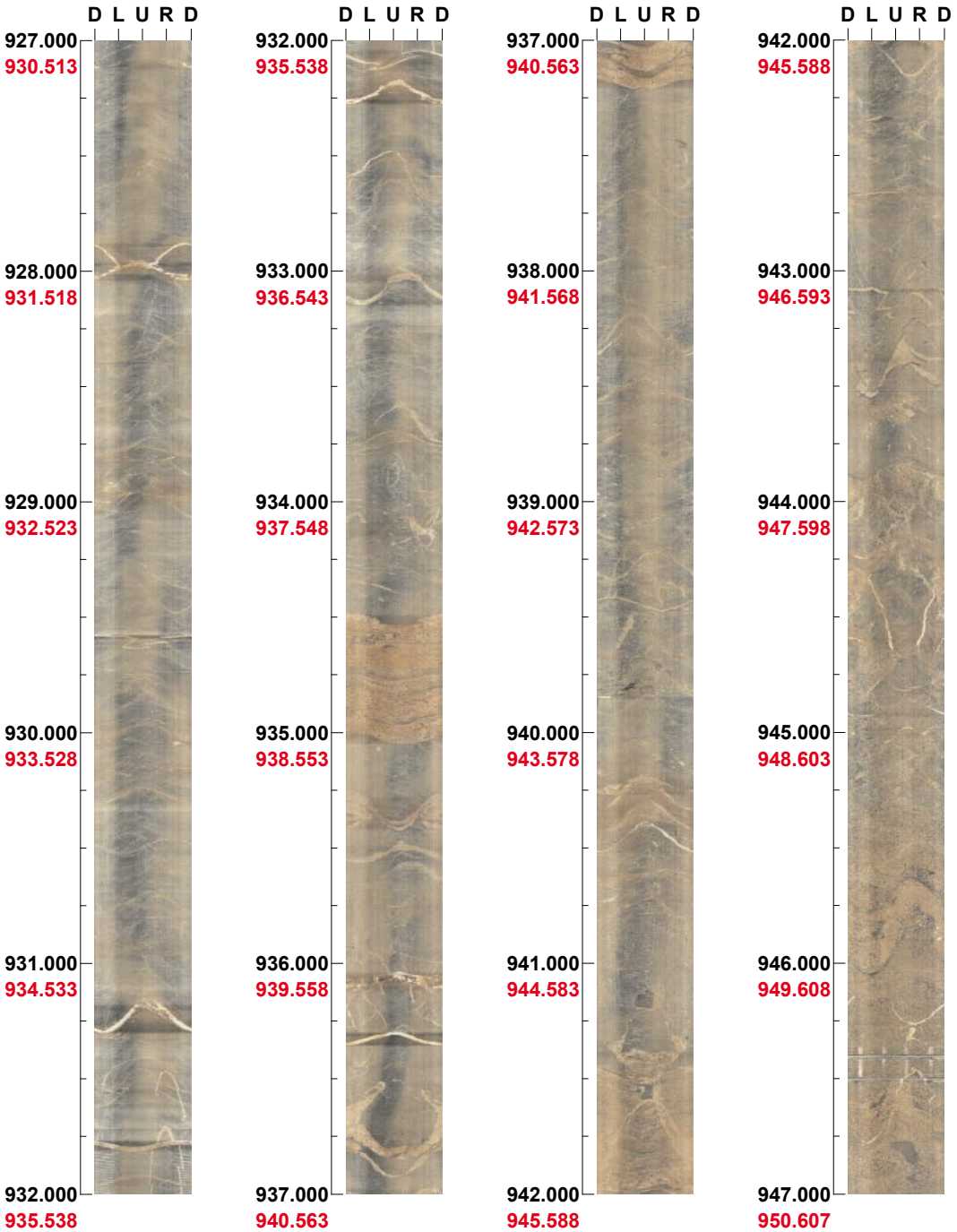
Depth range: 907.000 - 927.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

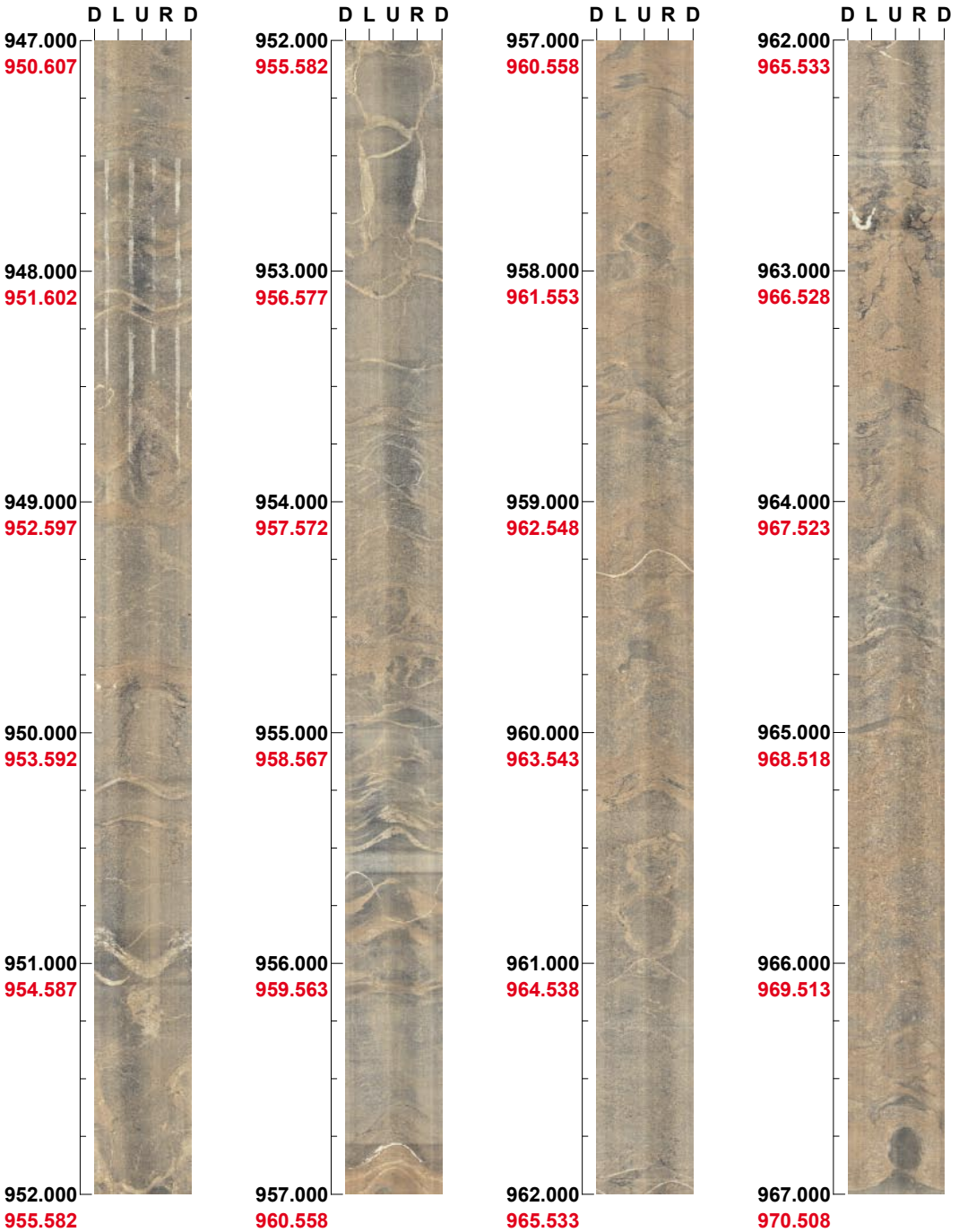
Depth range: 927.000 - 947.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

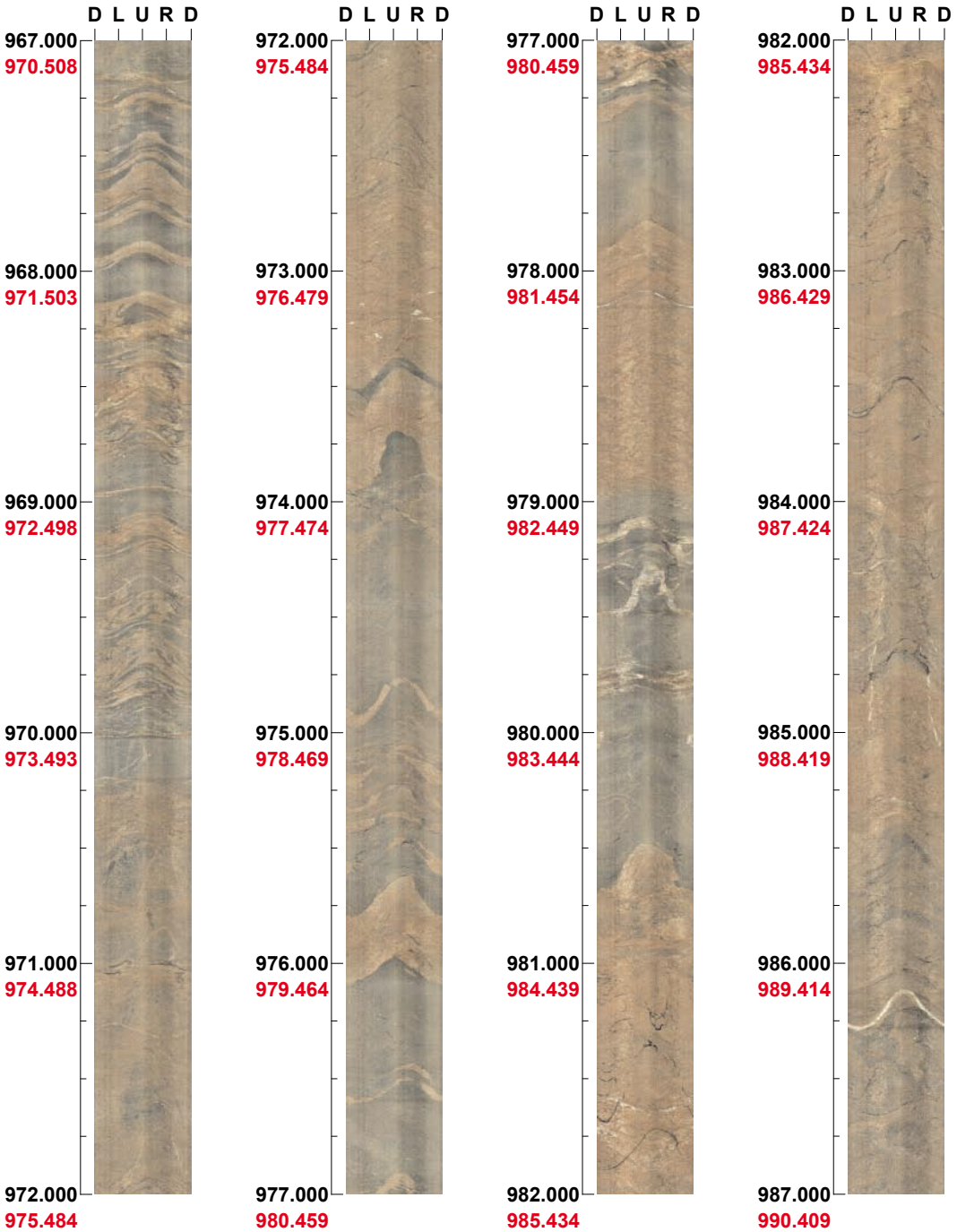
Depth range: 947.000 - 967.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

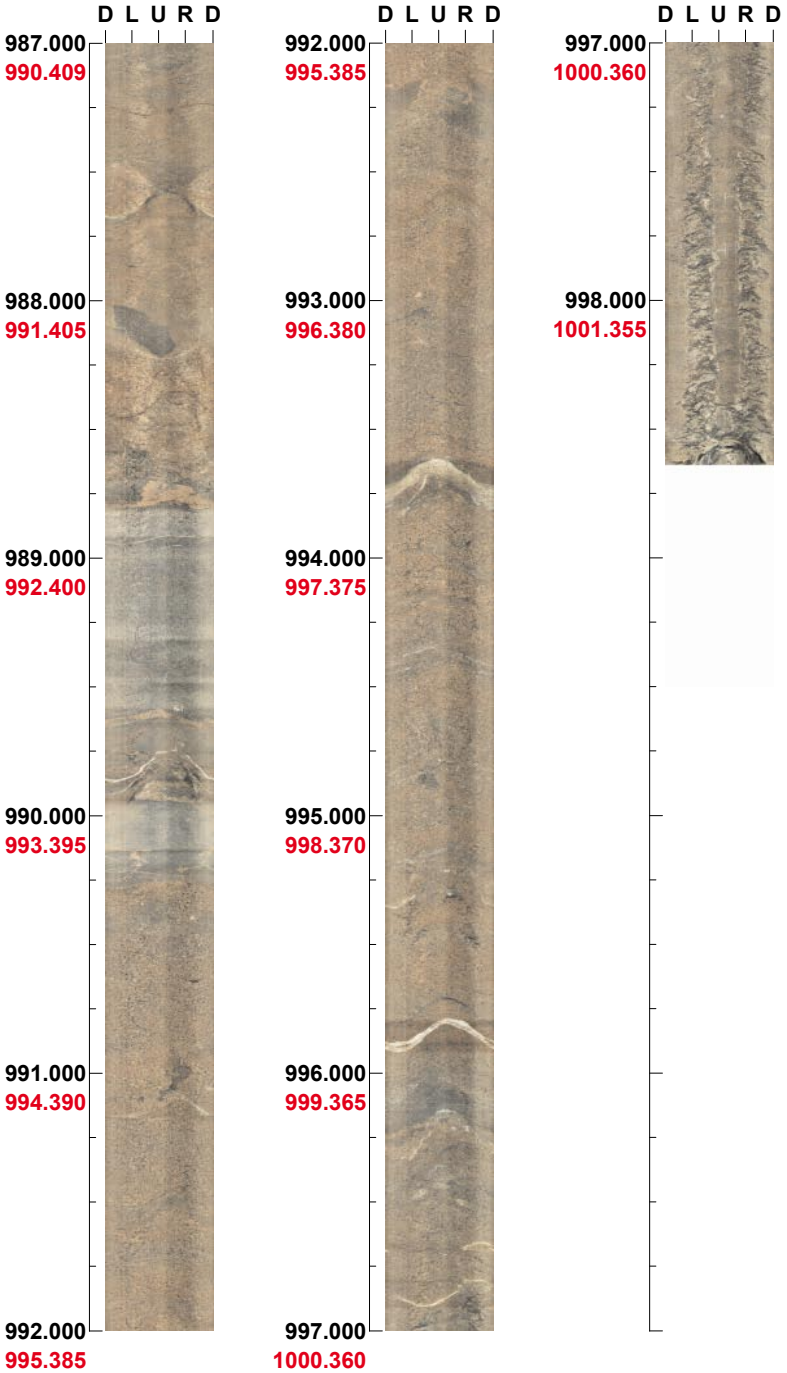
Depth range: 967.000 - 987.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04A **Azimuth: 77** **Inclination: -85**

Depth range: 987.000 - 998.638 m



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

Appendix 6

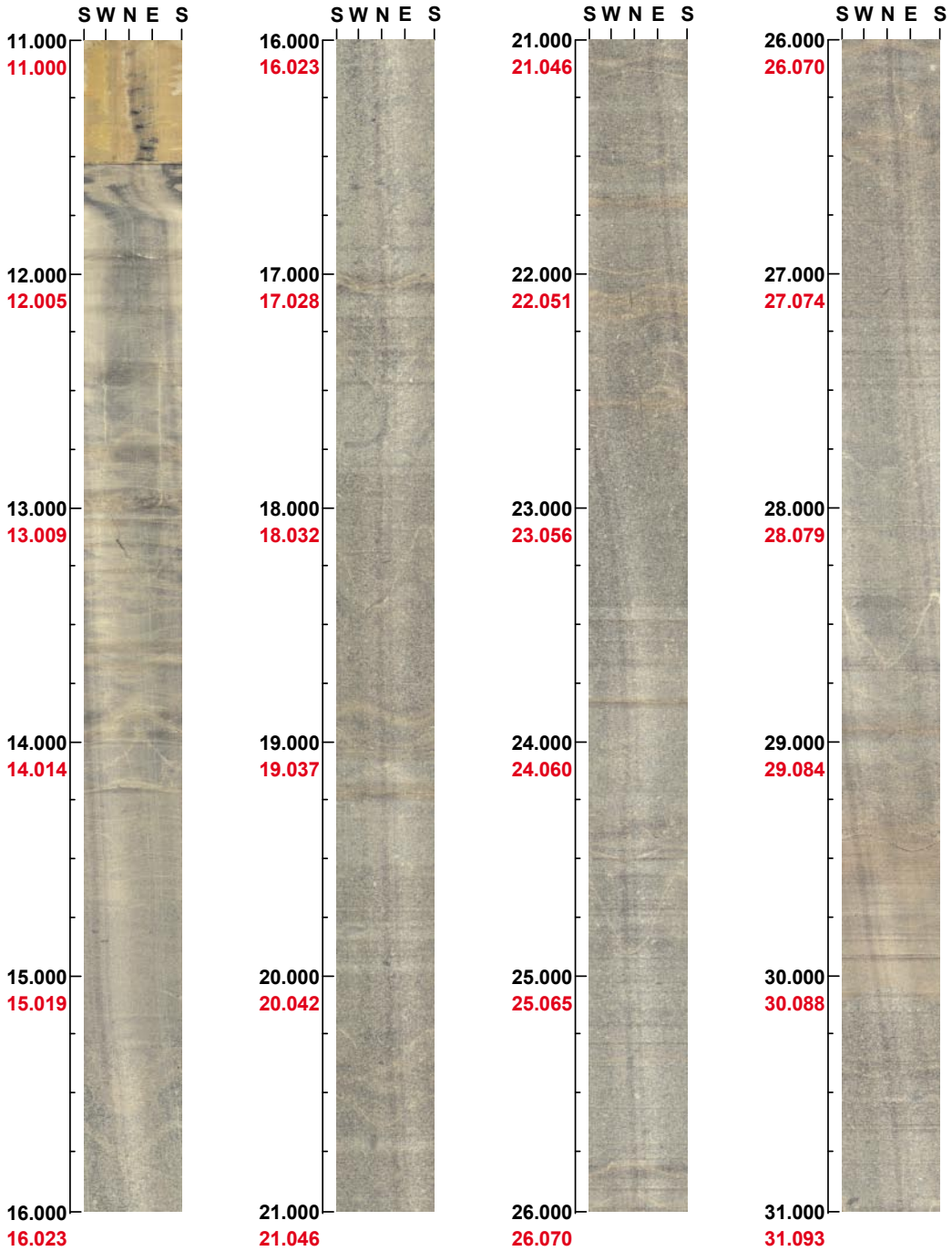
BIPS logging in KAV04B, 11 to 99 m

Project name: Simpevarp

Image file	**: c:\work\r5291s~1\kav04b\bips\kav04b.bip**
BDT file	**: c:\work\r5291s~1\kav04b\bips\kav04b.bdt**
Locality	**: SIMPAN**
Bore hole number	**: KAV04B**
Date	**: 04/05/24**
Time	**: 20:59:00**
Depth range	**: 11.000 - 99.363 m**
Azimuth	**: 0**
Inclination	**: -90**
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	**: 5**
Color	**: +0 +0 +0**

Project name: Simpevarp
Bore hole No.: KAV04B **Azimuth: 0** **Inclination: -90**

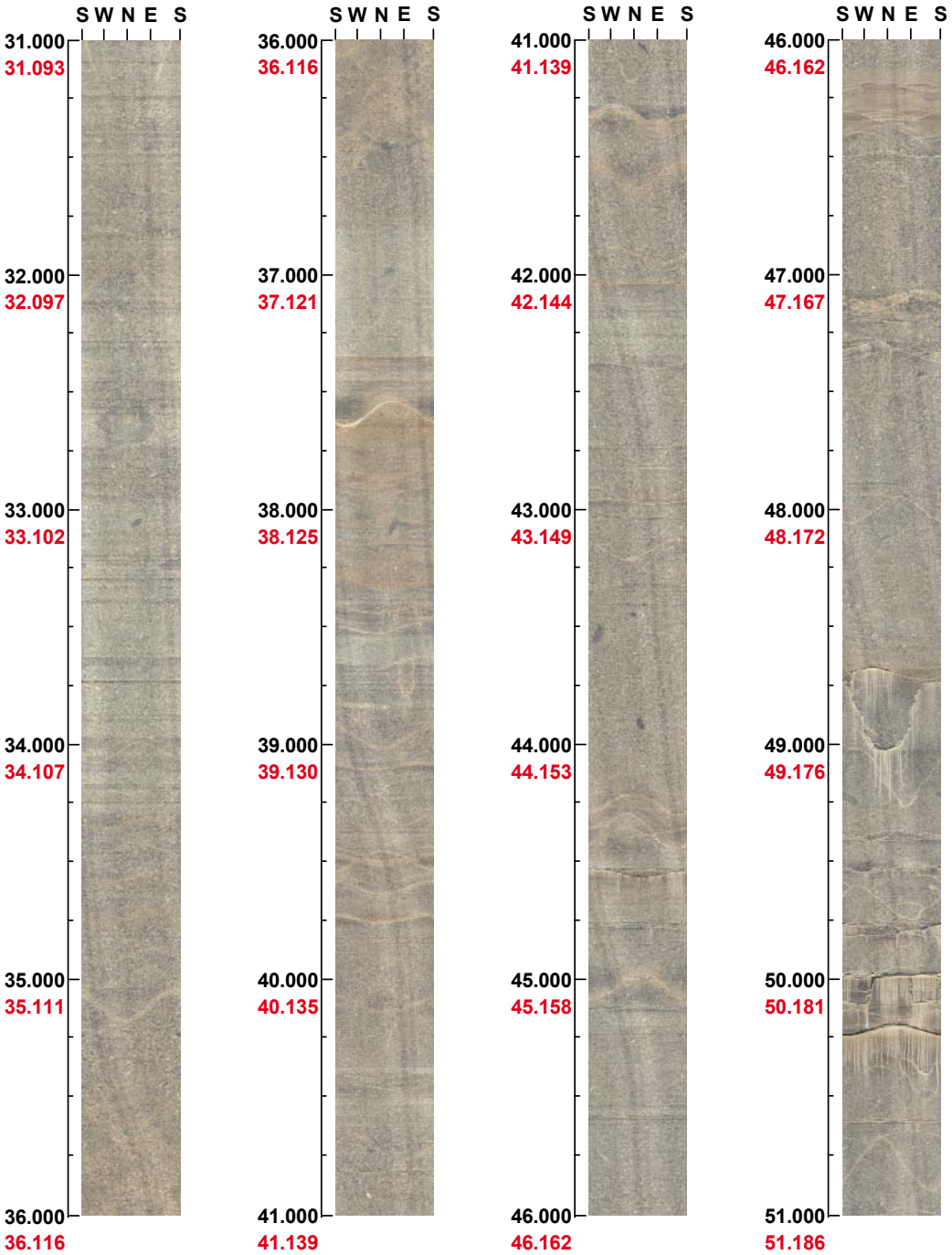
Depth range: 11.000 - 31.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04B **Azimuth: 0** **Inclination: -90**

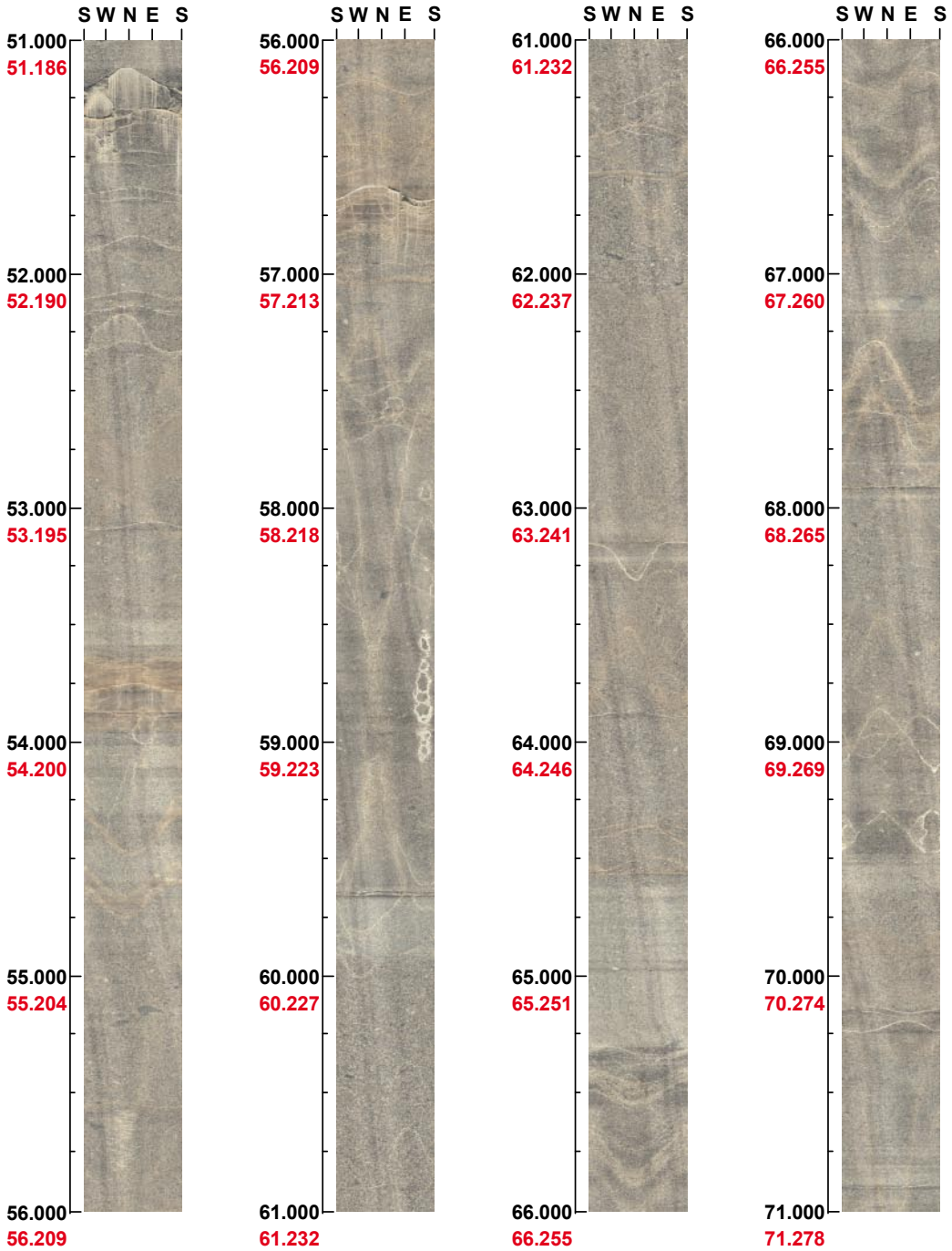
Depth range: 31.000 - 51.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04B **Azimuth: 0** **Inclination: -90**

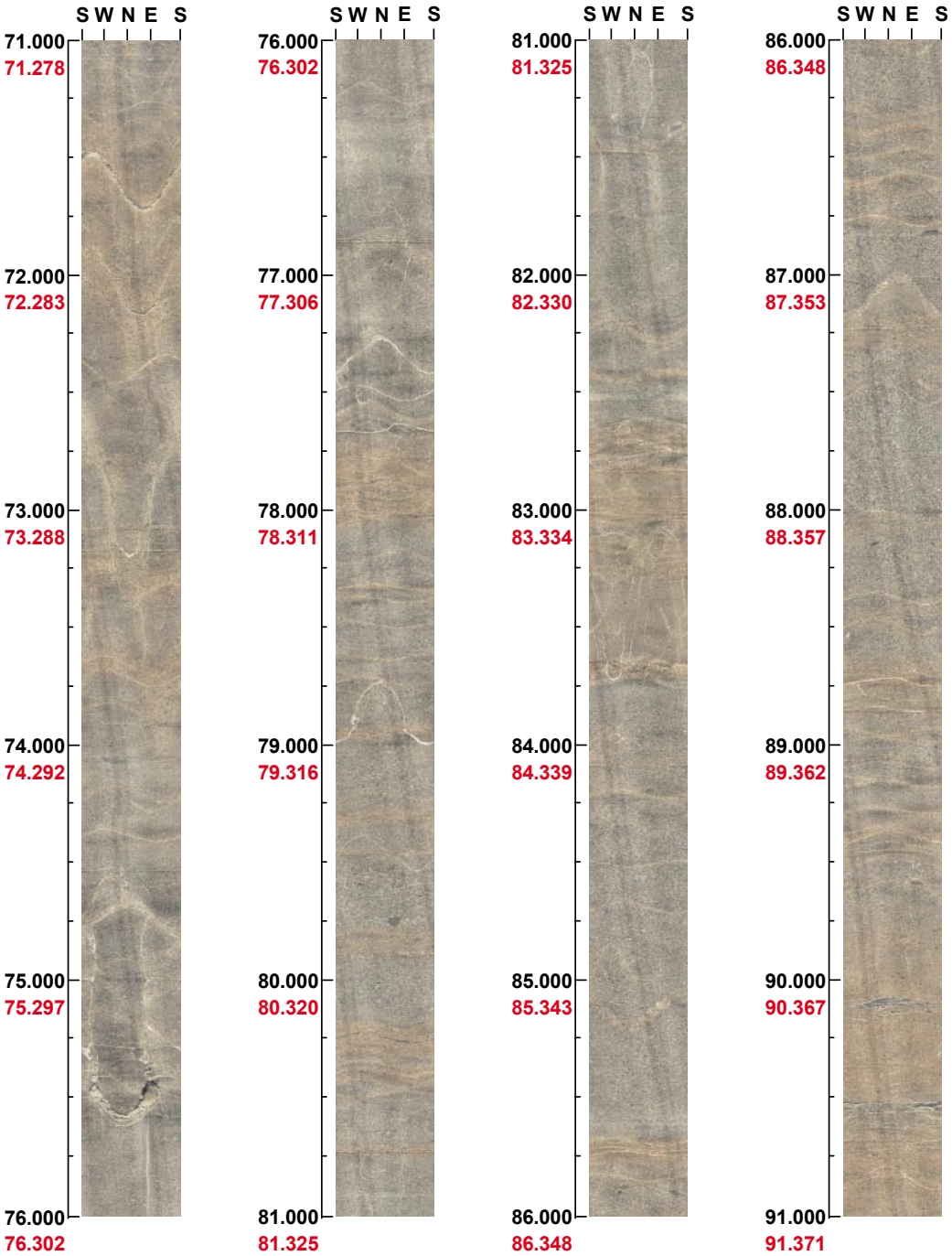
Depth range: 51.000 - 71.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04B **Azimuth: 0** **Inclination: -90**

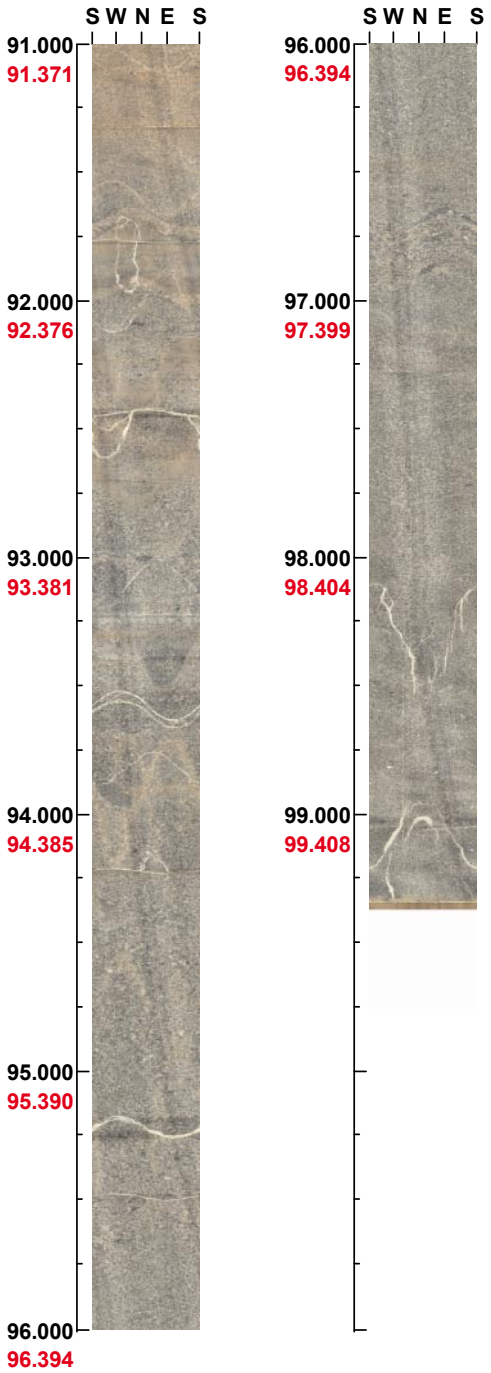
Depth range: 71.000 - 91.000 m



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

Project name: Simpevarp
Bore hole No.: KAV04B **Azimuth: 0** **Inclination: -90**

Depth range: 91.000 - 99.363 m



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

Appendix 7

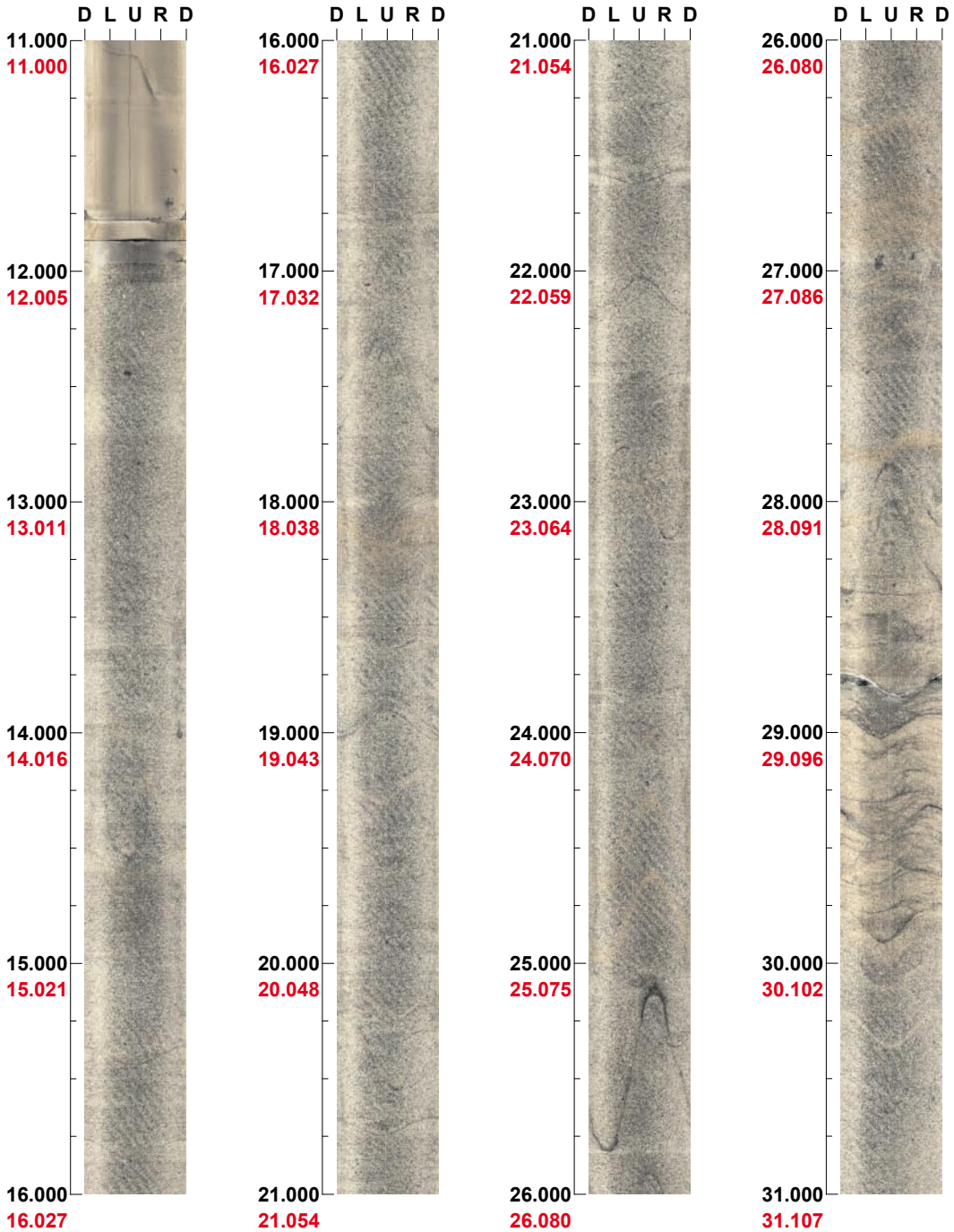
BIPS logging in HLX13, 11 to 199 m

Project name: Simpevarp

Image file	**: c:\work\r5291s~1\hlx13\bips\hlx13a.bip**
BDT file	**: c:\work\r5291s~1\hlx13\bips\hlx13a.bdt**
Locality	**: LAXEMAR**
Bore hole number	**: HLX13**
Date	**: 04/05/28**
Time	**: 07:06:00**
Depth range	**: 11.000 - 198.91 m**
Azimuth	**: 185**
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	**: 4**
Color	**: +0 +0 +0**

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

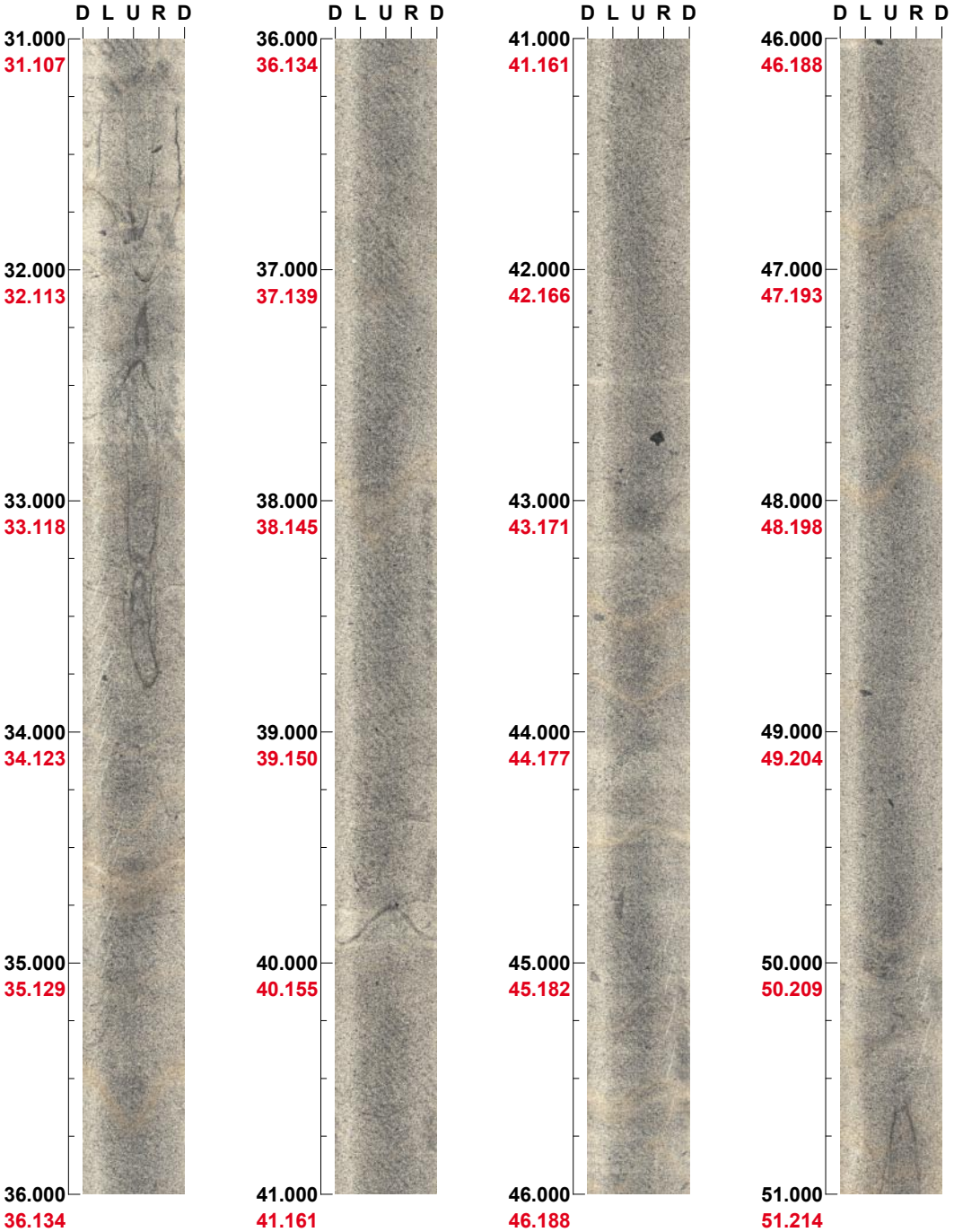
Depth range: 11.000 - 31.000 m



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

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

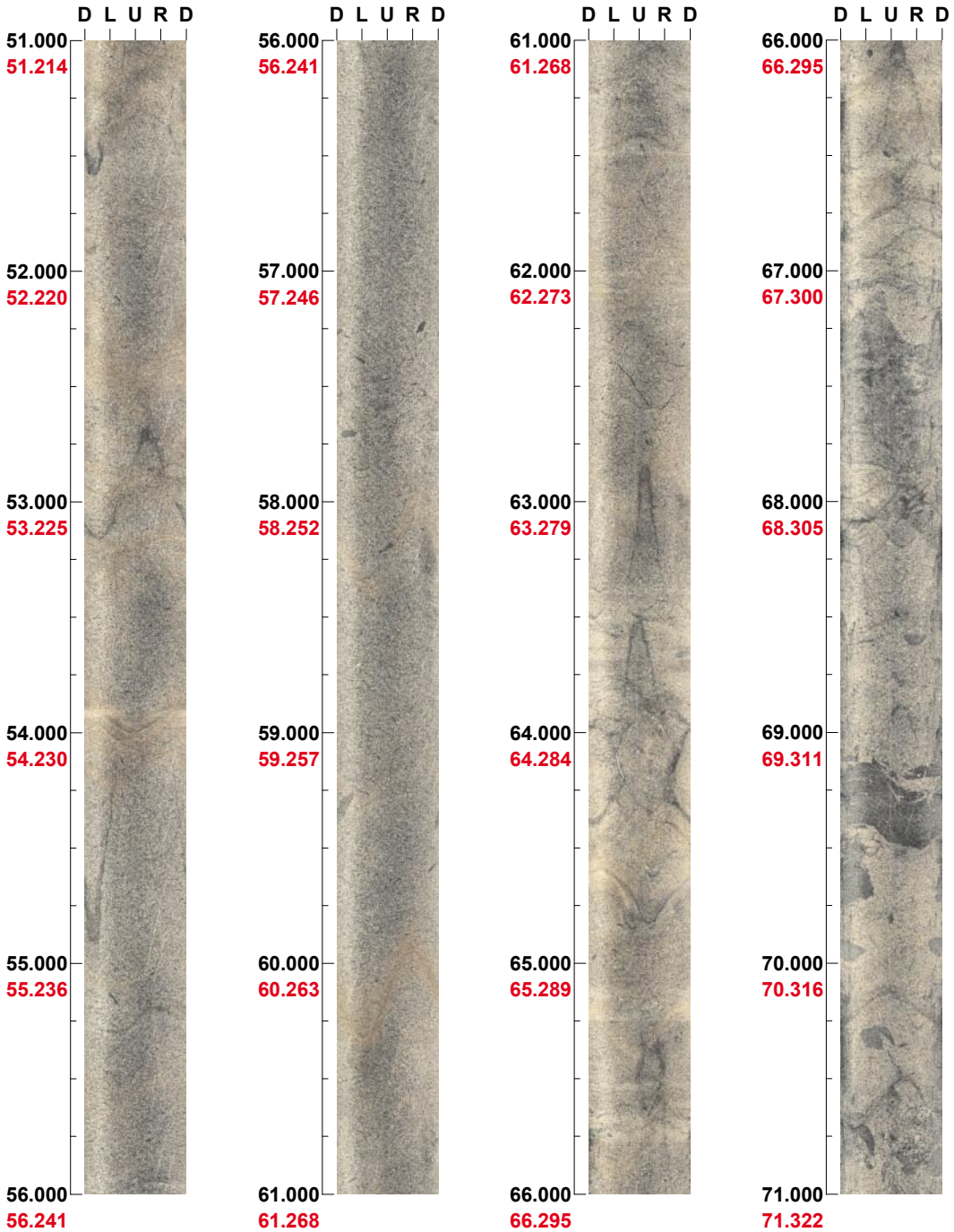
Depth range: 31.000 - 51.000 m



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

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

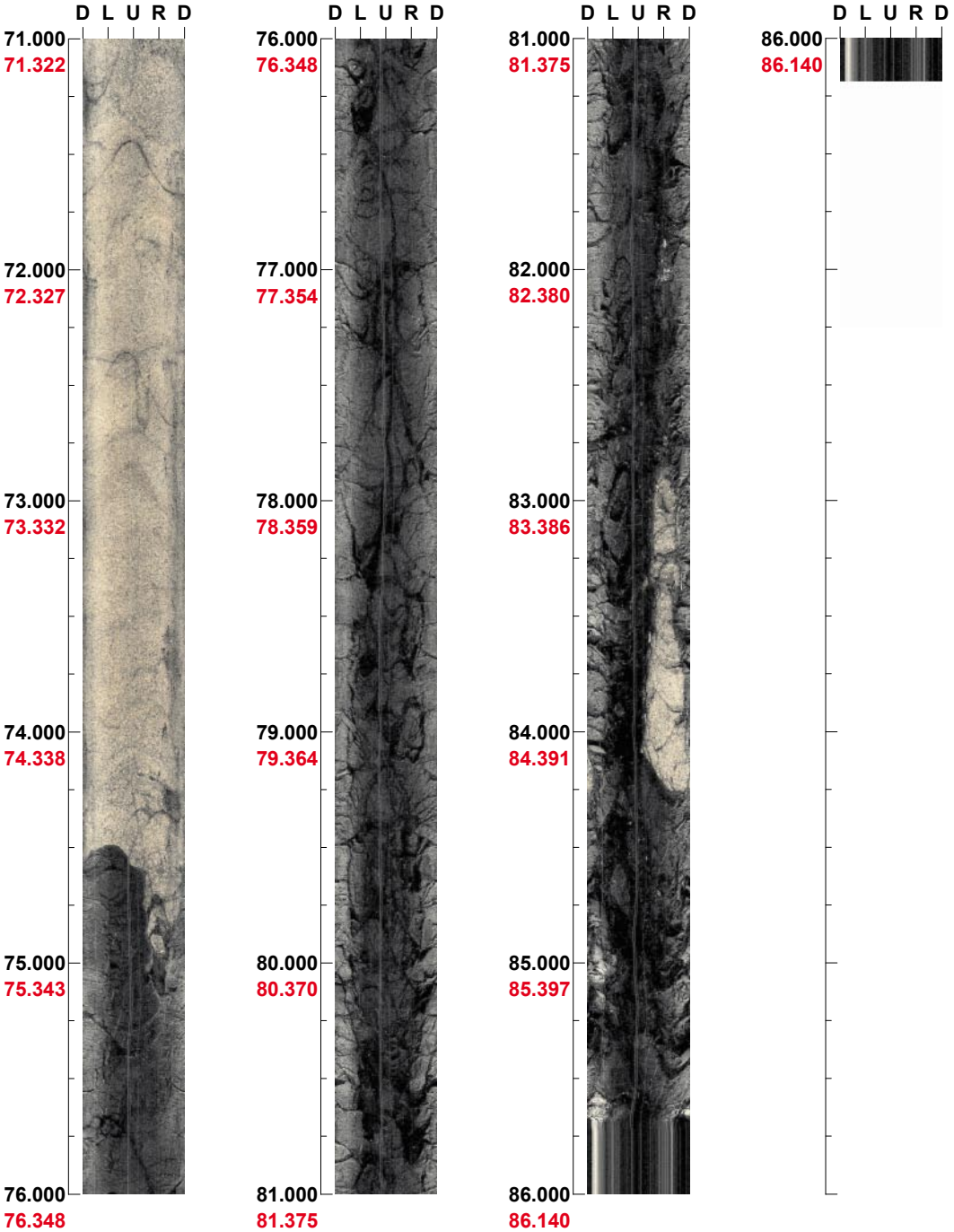
Depth range: 51.000 - 71.000 m



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

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

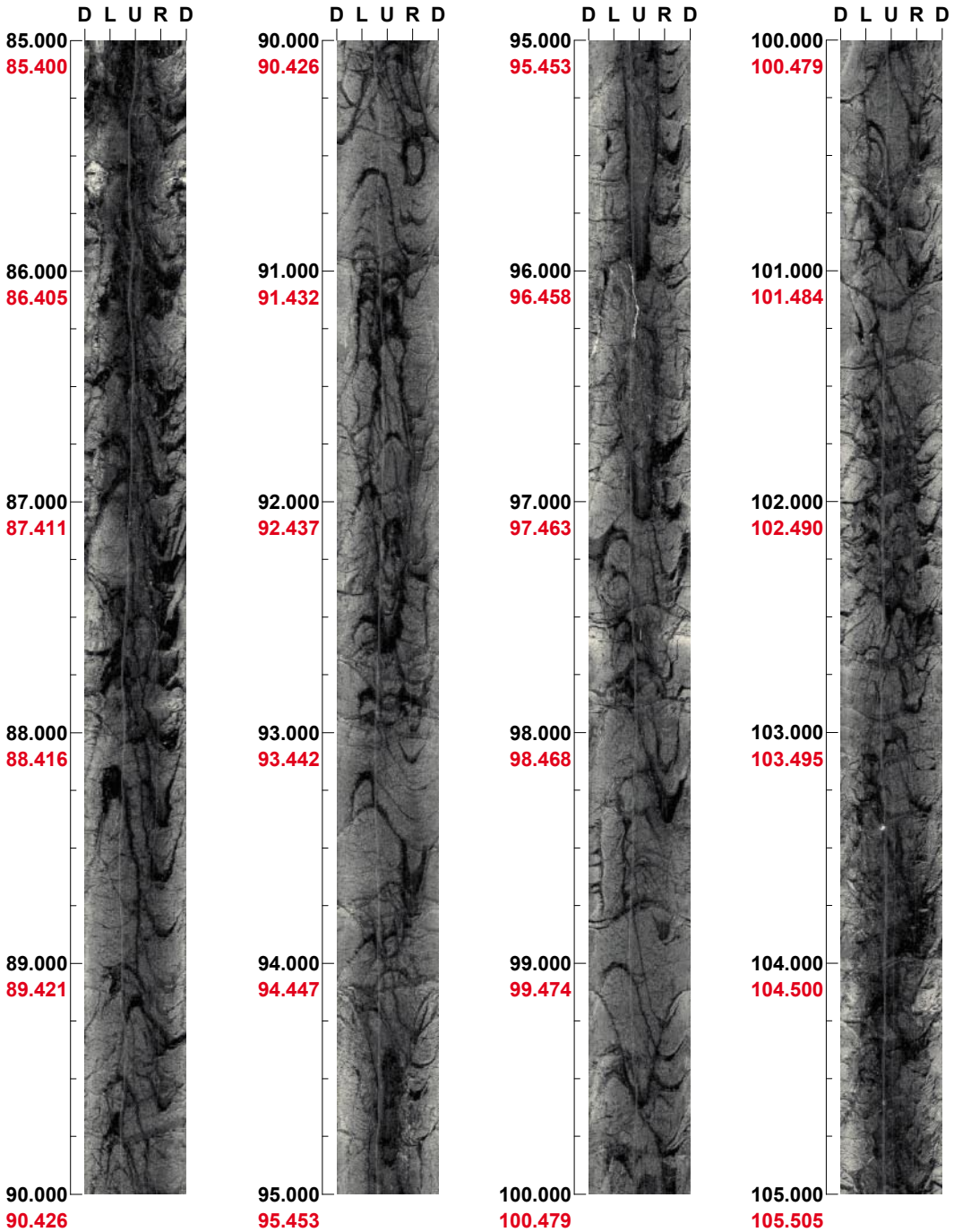
Depth range: 71.000 - 86.188 m



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

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

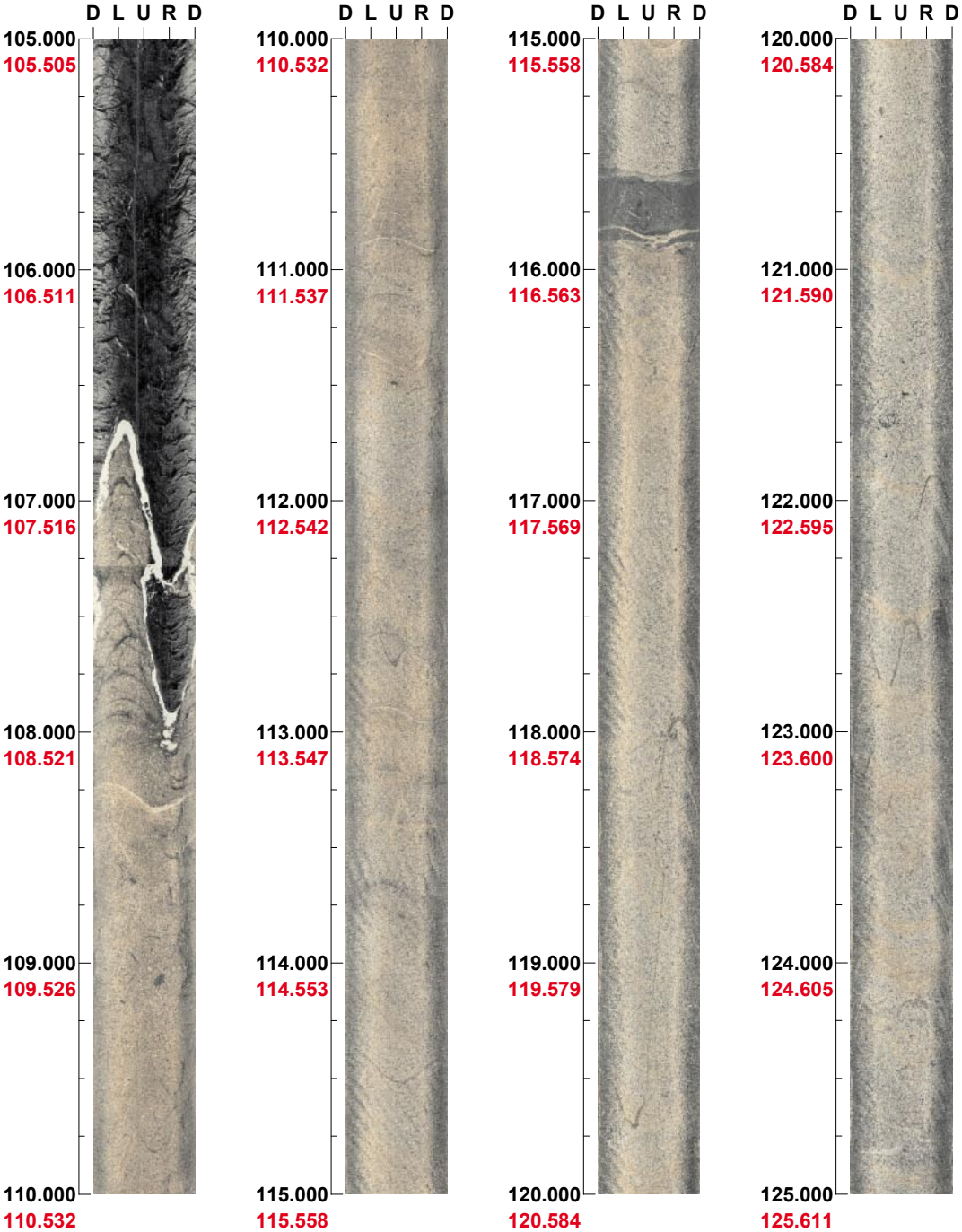
Depth range: 85.000 - 105.000 m



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

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

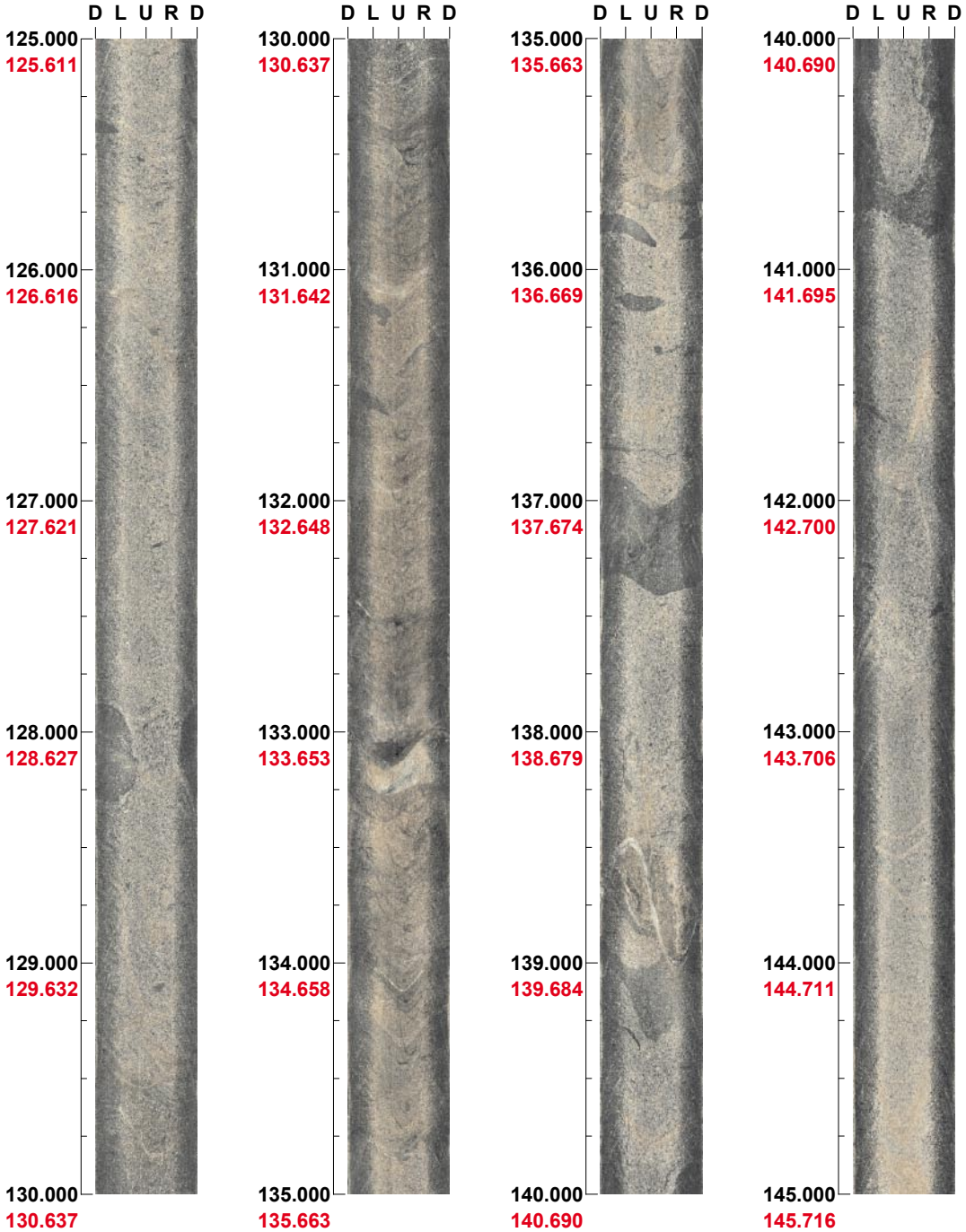
Depth range: 105.000 - 125.000 m



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

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

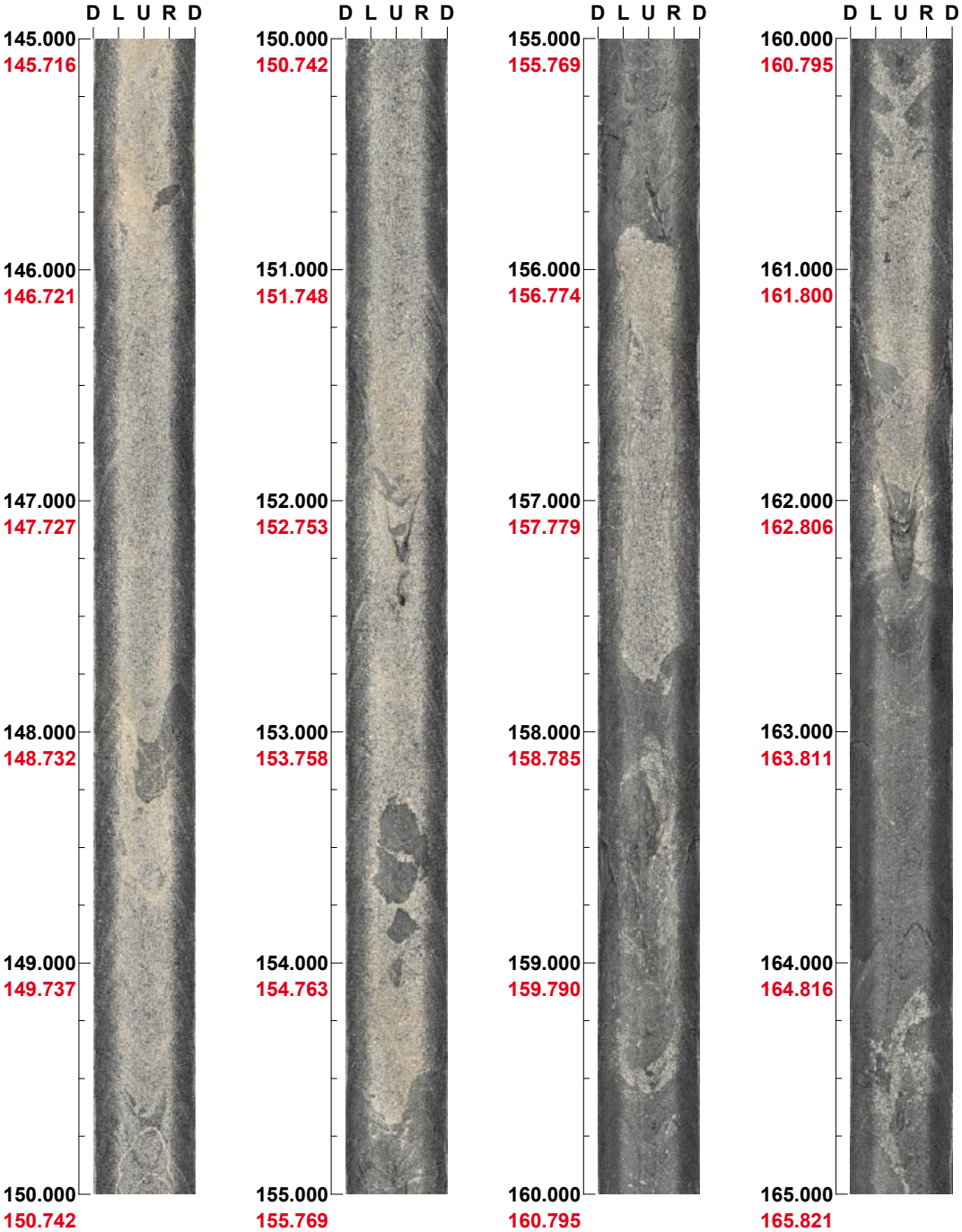
Depth range: 125.000 - 145.000 m



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

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

Depth range: 145.000 - 165.000 m



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

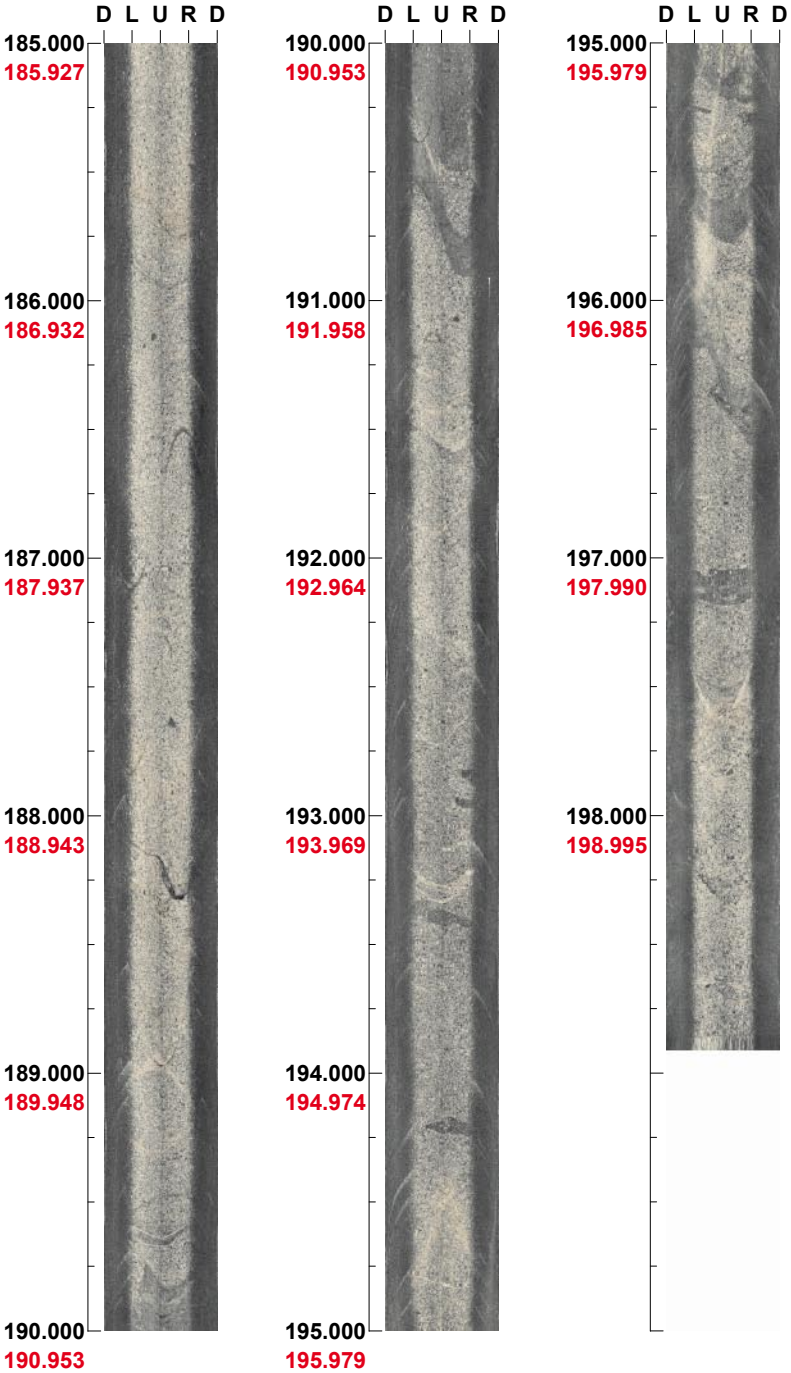
Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

Depth range: 165.000 - 185.000 m

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

Project name: Simpevarp
Bore hole No.: HLX13 **Azimuth: 185** **Inclination: -58**

Depth range: 185.000 - 198.910 m



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

Appendix 8

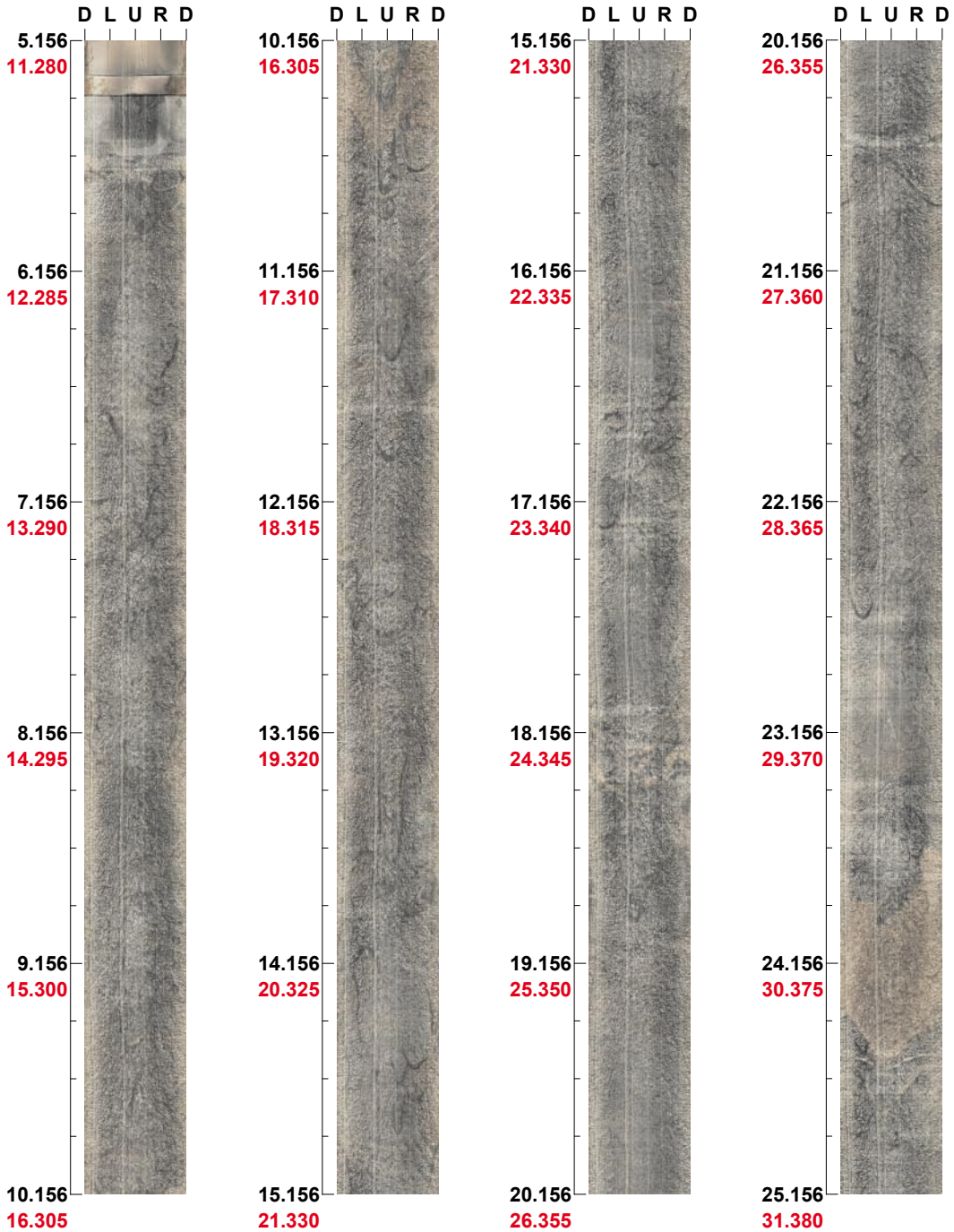
BIPS logging in HLX15, 11 to 151 m

Project name: Laxemar

Image file	**: c:\work\r5291s~1\hlx15\bips\hlx15.bip**
BDT file	**: c:\work\r5291s~1\hlx15\bips\hlx15.bdt**
Locality	**: LAXEMAR**
Bore hole number	**: HLX15**
Date	**: 04/05/27**
Time	**: 17:26:00**
Depth range	**: 5.156 - 144.738 m**
Azimuth	**: 185**
Inclination	**: -58**
Diameter	**: 137.0 mm**
Magnetic declination	**: 0.0**
Span	**: 4**
Scan interval	**: 0.25**
Scan direction	**: To bottom**
Scale	**: 1/25**
Aspect ratio	**: 100 %**
Pages	**: 7**
Color	**: +0 +0 +0**

Project name: Laxemar
Bore hole No.: HLX15 **Azimuth: 185** **Inclination: -58**

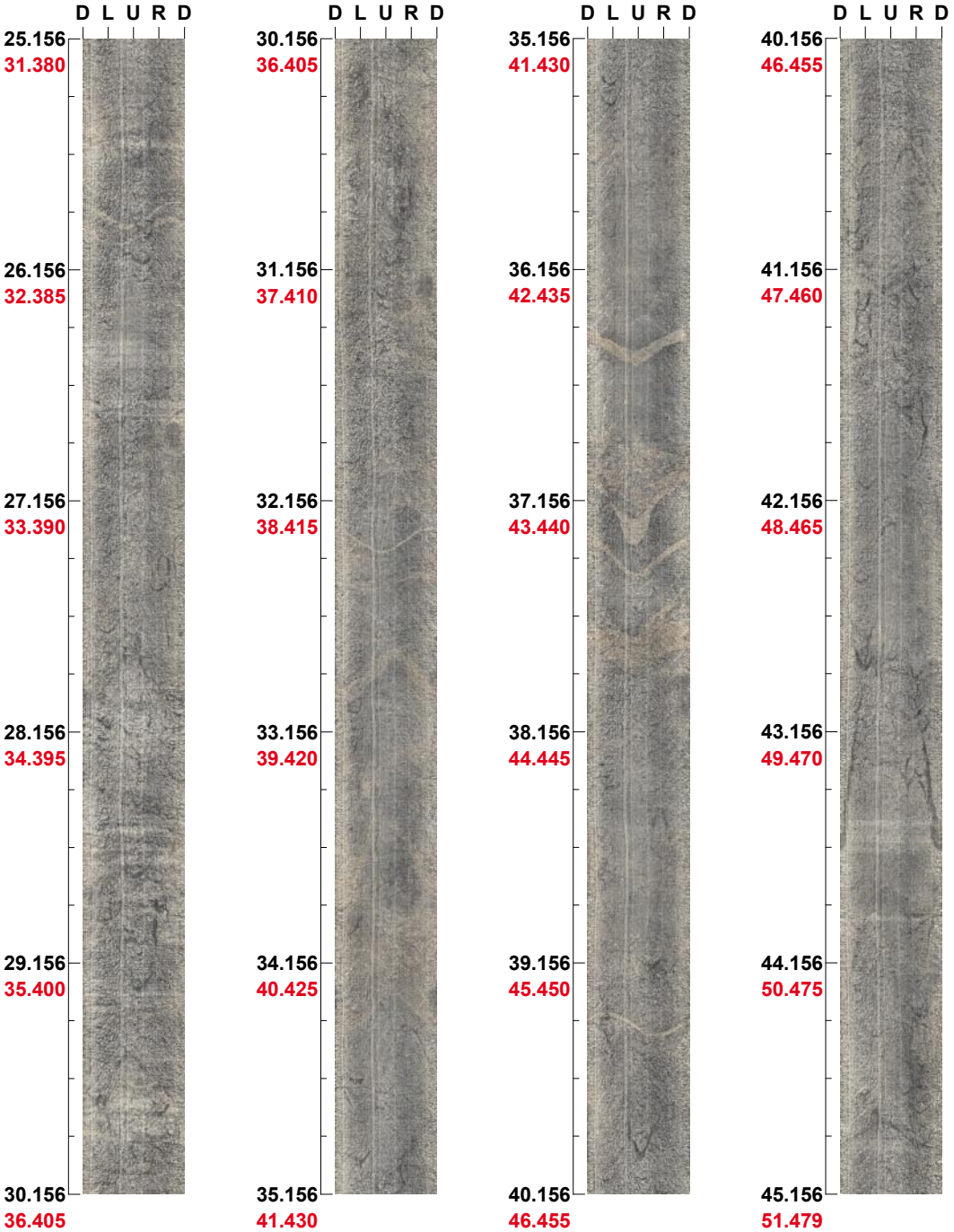
Depth range: 5.156 - 25.156 m



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

Project name: Laxemar
Bore hole No.: HLX15 **Azimuth: 185** **Inclination: -58**

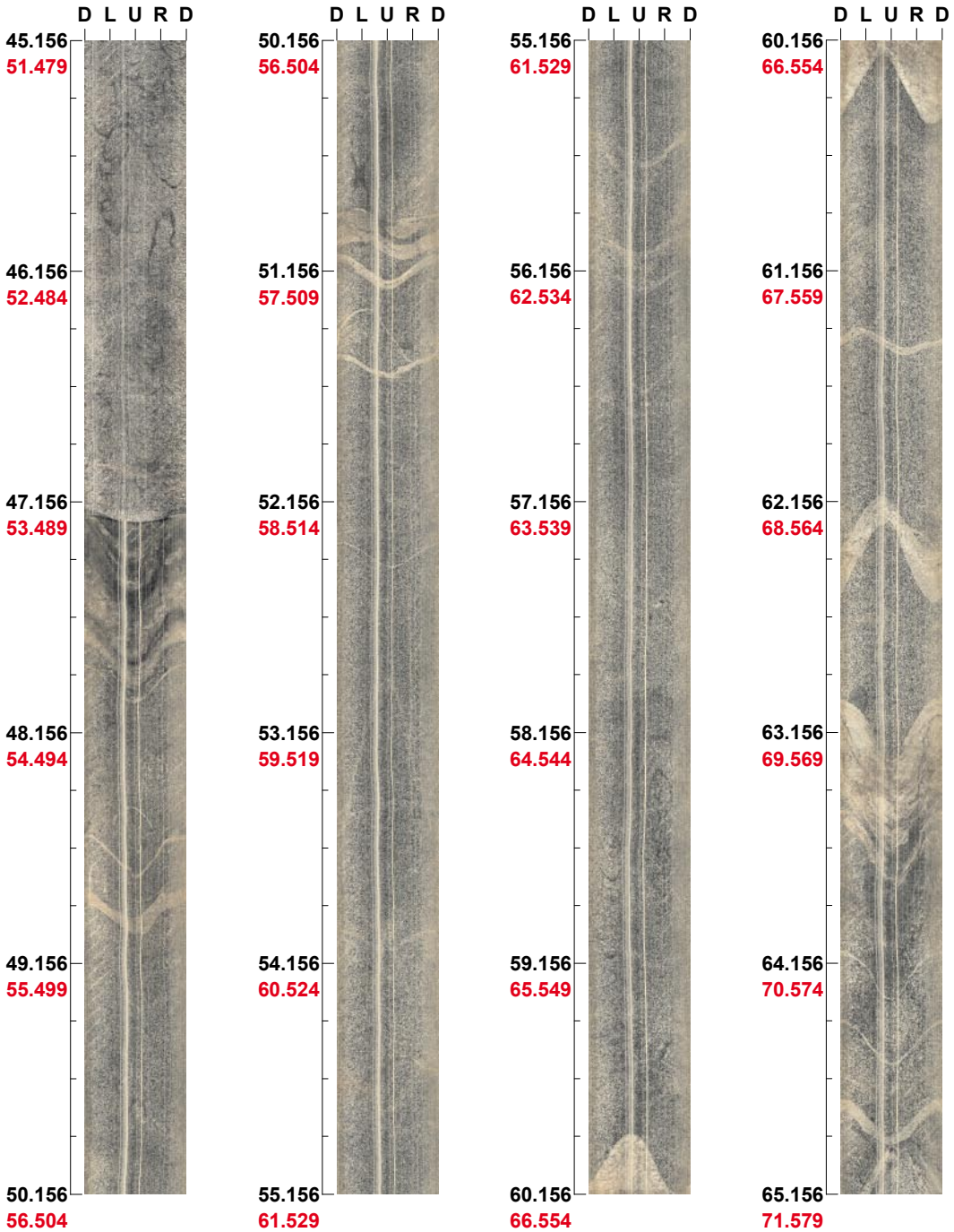
Depth range: 25.156 - 45.156 m



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

Project name: Laxemar
Bore hole No.: HLX15 **Azimuth: 185** **Inclination: -58**

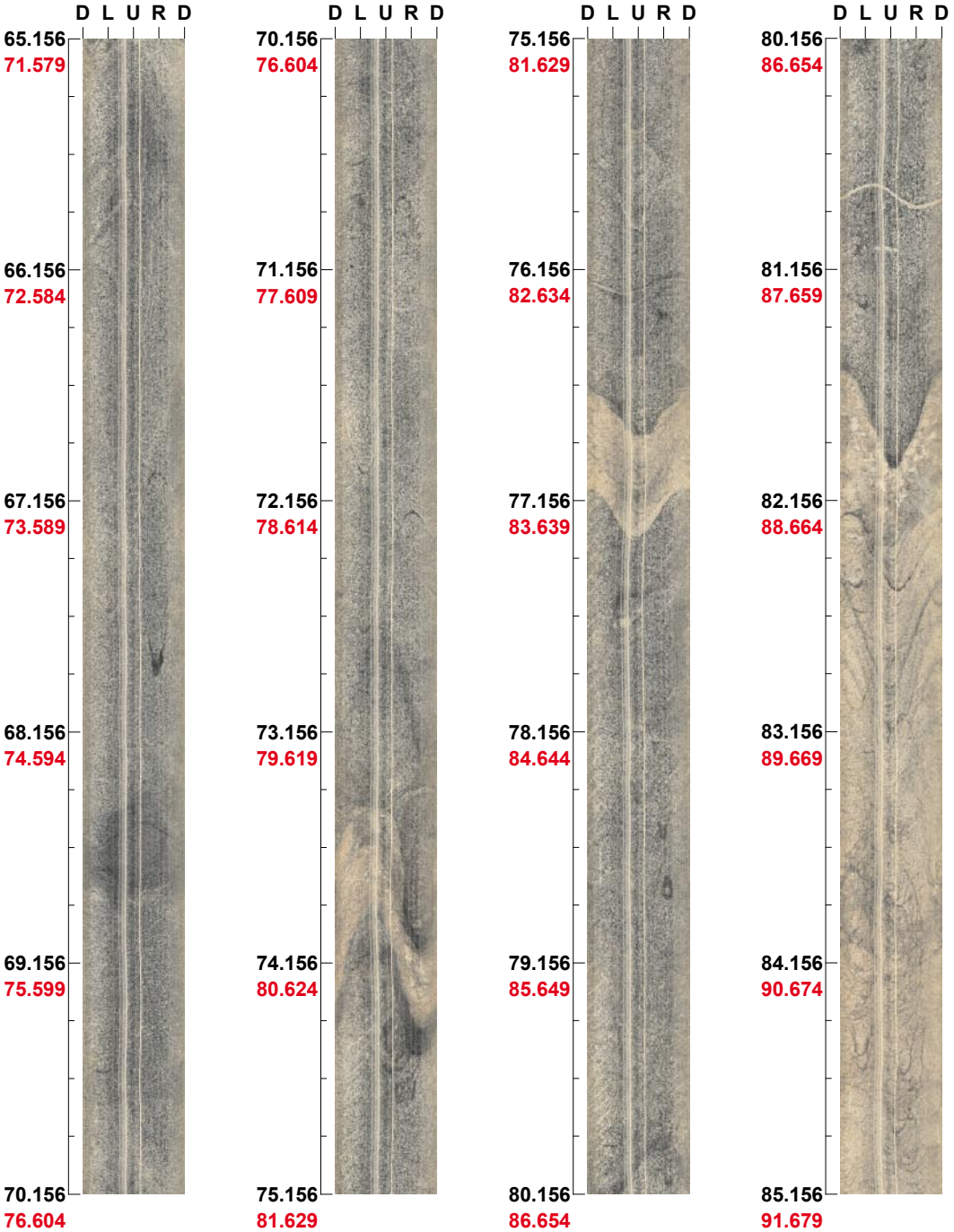
Depth range: 45.156 - 65.156 m



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

Project name: Laxemar
Bore hole No.: HLX15 **Azimuth: 185** **Inclination: -58**

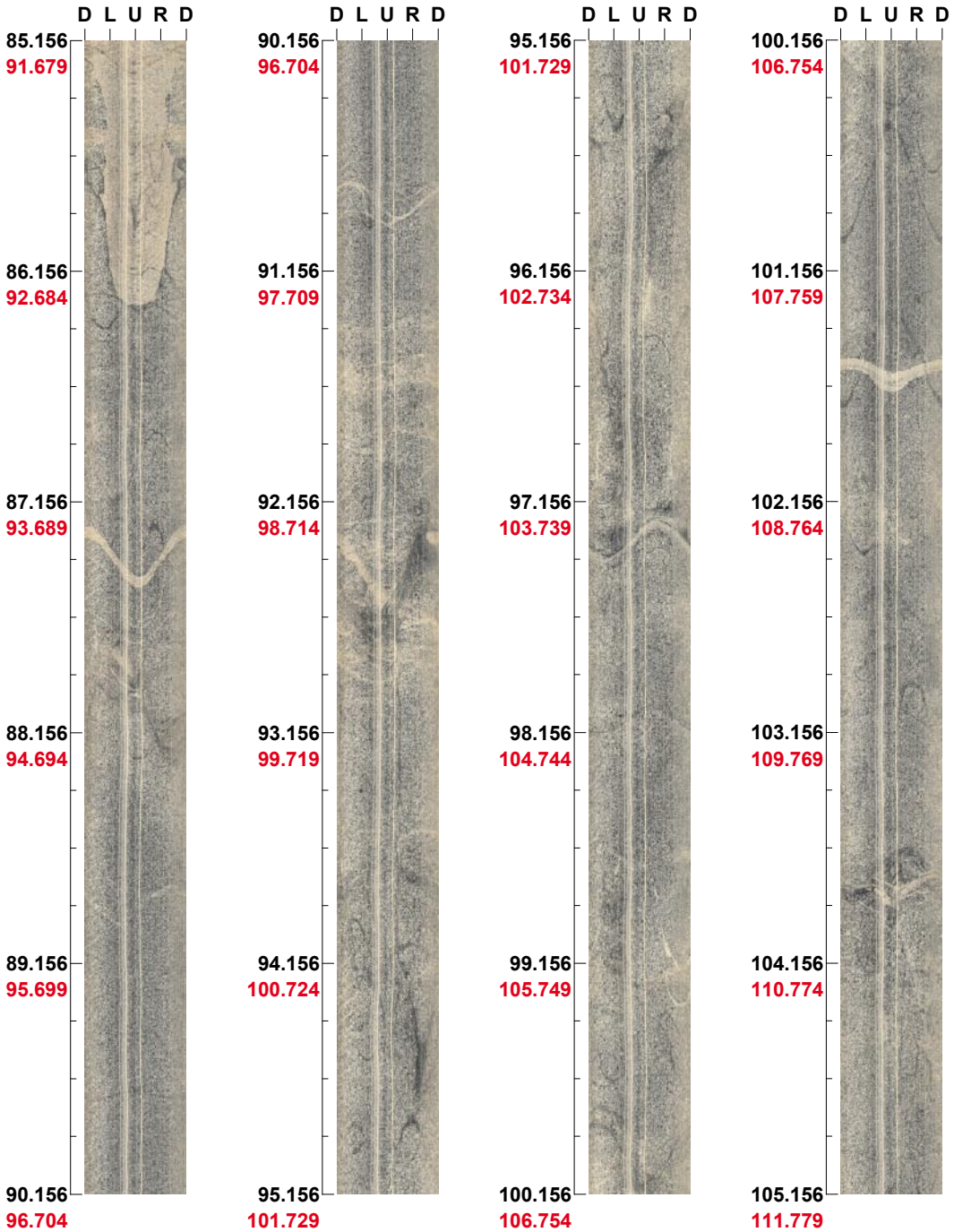
Depth range: 65.156 - 85.156 m



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

Project name: Laxemar
Bore hole No.: HLX15 **Azimuth: 185** **Inclination: -58**

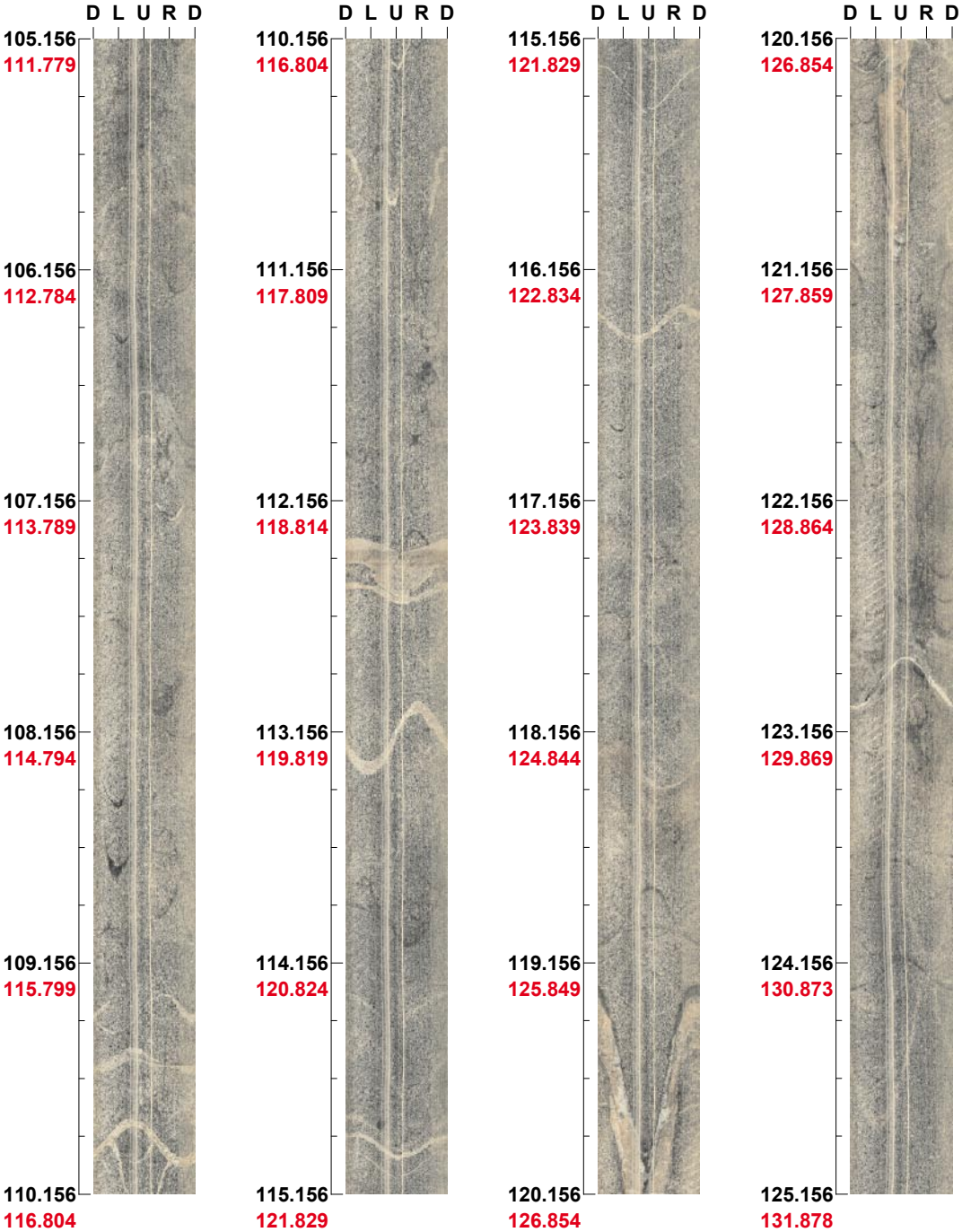
Depth range: 85.156 - 105.156 m



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

Project name: Laxemar
Bore hole No.: HLX15 **Azimuth: 185** **Inclination: -58**

Depth range: 105.156 - 125.156 m



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