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Revised April 2006

Oskarshamn site investigation

RAMAC and BIPS logging in borehole KLX04

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Malå Geoscience AB/RAYCON

October 2004

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Keywords: BIPS, RAMAC, Radar, TV.

Reading instruction

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 5-1. New values for strike and dip are therefore updated in Table 5-2.

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) and BIPS logging in the core-drilled borehole KLX04. All measurements were conducted by Malå Geoscience AB/RAYCON during July 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 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 KLX04 was relatively satisfying, but in large 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 and over 160 radar reflectors were identified and a part of them were also orientated (strike/dip).

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Oskarshamn. Mätningarna som presenteras här omfattar borrhålsradarmätningar (RAMAC) och BIPS-loggningar i borrhål KLX04. Alla mätningar är utförda av Malå Geoscience AB/ RAYCON under juli 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.

Syftet med BIPS loggingen 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 som plottar längs med borrhålet. Radardata presenteras i radardiagram och en lista över tolkade radarreflektorer ges.

Borrhålsradardata från KLX04 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 160 radarreflektorer identifierats i KLX04, varav en del har kunnat orienteras (med strykning/stupning).

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 borehole KLX04. The work was carried out in accordance with activity plan AP PS 400-04-060. 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 12 to 990 m in KLX04. The borehole KLX04 is drilled with a diameter of 76 mm.

All measurements were conducted by Malå Geoscience AB/RAYCON during July 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.

The delivered raw and processed data have been inserted in the database of SKB (SICADA). The SICADA field note reference to the present activity is presented in Table 1-2.

Table 1-1. Controlling documents for the performance of the activity (SKB internal controlling documents).

Activity plan	Number	Version
Borrhålsradar och BIPS i KLX04	AP PS 400-04-060	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 borehole KLX04 in Laxemar.*

Table1-2. Data references.

Subactivity	Database	Identity number
Loggning BIPS och radar KLX04	SICADA	Field note 422

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 rock types as well as 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.

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.

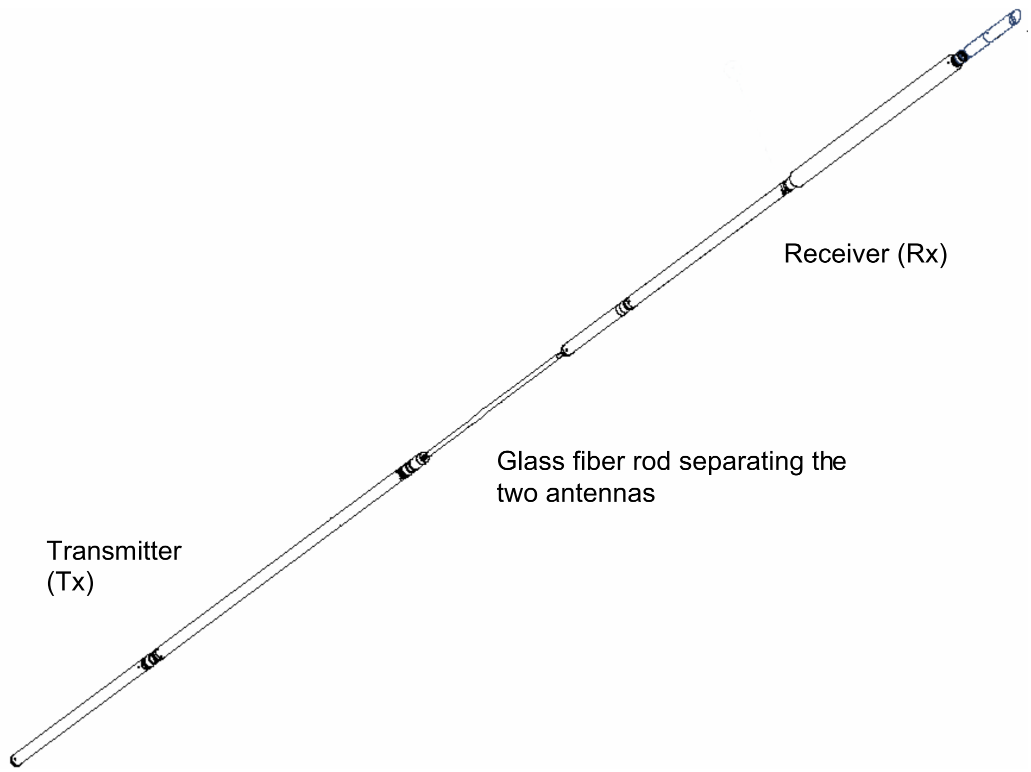


Figure 3-1. *Example of a borehole radar antenna.*

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).

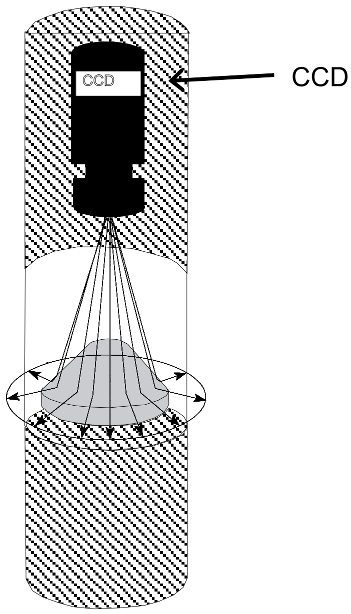


Figure 3-2. The BIP-system. Illustration of the conical mirror scanning.

4 Execution

4.1 General

4.1.1 RAMAC Radar

The measurements in KLX04, were carried out with dipole radar antennas, with frequencies of 250, 100 and 20 MHz, and also 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 Table 4-1. 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 KLX04. 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 5 degrees. This can be considered as good due to the disturbed environment, with metallic objects etc at the test site.

For more information on system settings used in the investigation of KLX04, see Table 4-1 below.

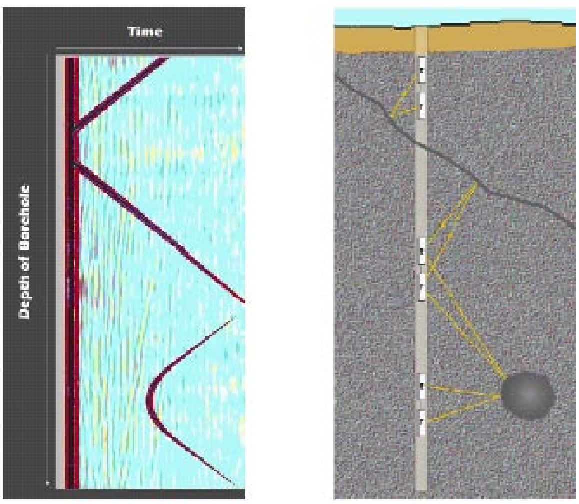


Figure 4-1. *The principle of radar borehole reflection survey and an example of result.*

Table 4-1. Radar logging information from KLX04.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KLX04**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Logging date:	04-07-13	04-07-14	04-07-14	04-07-20
	Reference:	T.O.C.	T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):	615	2,424	891	238
	Number of samples:	512	619	518	518
	Number of stacks:	32	Auto	Auto	Auto
	Signal position:	390.48	–0.34	–0.34	1.54
	Logging from (m):	103.4	1.5	2.6	6.25
	Logging to (m):	987.4	990.5	989.6	986.25
	Trace interval (m):	0.5	0.25	0.2	0.1
	Antenna separation (m):	5.73	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 borehole KLX04.

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.

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 4-2 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 is made with ReflexWin, a Windows based processing software for filtering and analysis of borehole radar data. The processing steps are shown in Table 4-2.

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 5-2 and are also visible on the radargrams in Appendix 1.

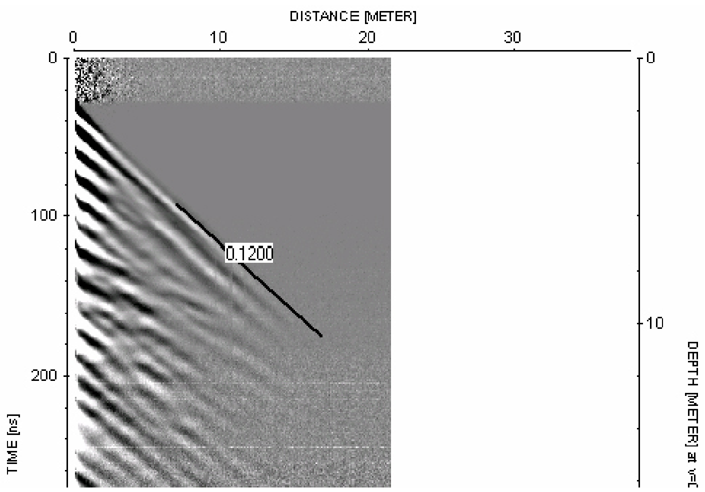


Figure 4-2. *Results from velocity measurements in KSH01B with 100 MHz dipole antennas /1/.*

Table 4-2. Processing steps for borehole radar data from KLX04.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KLX04**	**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

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

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 5-1. New values for strike and dip are therefore updated in Table 5-2.

5 Results

The results from the 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 KLX04 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 422.

5.1 RAMAC logging

The results of the interpretation of the radar measurements are presented in Table 5-1 and 5-2. Radardata is also visualized in Appendix 1. It should be remembered that the images in Appendix 1 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. 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 KLX04, (as seen in Appendix 1) is relatively satisfying, but in 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 250 MHz data almost along the whole borehole. This conductive environment of course also reduces the possibility to distinguish and interpret possibly structures in the rock which otherwise could give a reflection.

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

As also seen in Appendix 1 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 below the distribution of identified structures along the borehole are listed for KLX04.

Table 5-2 summarises the interpretation of radar data from KLX04. As seen some radar reflectors are marked with ±, which indicates an uncertainty in the interpretation of direction of to the reflector. The direction can in these cases be ±180 degrees. The direction to the reflector (the plane) is defined in Figure 5-1. As the borehole inclination for KLX04 is less than 85° the direction to object is calculated using gravity roll. The direction to object and the intersection angle are recalculated to strike and dip, also given in Table 5-2. 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 5-1. Identified structures as a function of depth in KLX04.

Depth (m)	No. of structures
–100	14
100–150	10
150–200	13
200–250	9
250–300	12
300–350	6
350–400	13
400–450	12
450–500	8
500–550	10
550–600	8
600–650	5
650–700	8
700–750	7
750–800	8
800–850	10
850–900	9
900–950	8
950–	5

Table 5-2. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz and the directional antenna in borehole KLX04.

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

Site:	**Oskarshamn**
Borehole name:	**KLX04**
Nominal velocity (m/μs):	**120.0**

Name	Intersection depth	Intersection angle	Direction to object (gravity roll)	Interpreted Dip 1	Interpreted Strike 1	Interpreted Dip 2	Interpreted Strike 2
68	–378.40	1					
B	43.90	75					
A	44.10	69					
C	47.00	69					
D	47.80	83					
E	58.10	79					
F	60.00	75					

Name	Intersection depth	Intersection angle	Direction to object (gravity roll)	Interpreted Dip 1	Interpreted Strike 1	Interpreted Dip 2	Interpreted Strike 2
G	62.50	75					
Gx	63.70	67					
H	73.90	60					
5x	74.50	6	270	84	8		
I	76.20	79					
J	81.00	64					
K	88.60	78					
L	103.50	48					
M	115.50	39					
Mx	115.60	15	231	71	329		
N	122.90	69	177±	16	274	28	96
O	127.10	58					
Q	128.60	20					
P	135.30	52					
R	139.40	47					
Rx	139.60	34					
S	142.10	70					
T	152.40	58					
V	162.10	61	162	26	259		
5	165.90	12					
Ux	168.10	48	219	36	326		
U	168.20	60					
W	174.80	66					
136	175.40	21					
X	176.80	66					
Xx	177.60	36					
Y	178.80	68	129±	20	219	27	61
Yx	179.90	46					
1	190.80	52					
Z	195.60	54	204	30	312		
71	200.10	2					
1x	206.30	64	354	32	99		
2	212.80	60	78±	34	173		
4	217.50	72					
3x	219.20	57	27±	37	128	27	317
6	229.10	71	33±	15	333		
7	237.60	72	264±	20	27	21	176
8	240.80	41					
3	245.70	50					
9	255.20	59					
10	258.40	61	342±	38	94	26	268
11	261.40	62					
13	264.70	76	261±	15	35	17	173
12	264.80	61					
14	275.30	63	81±	26	172	24	19
15	277.90	69					
16	283.20	62					
17	286.70	55					
135	289.70	69					

Name	Intersection depth	Intersection angle	Direction to object (gravity roll)	Interpreted Dip 1	Interpreted Strike 1	Interpreted Dip 2	Interpreted Strike 2
18	296.90	70					
19	298.80	70					
20	301.90	87					
21	317.40	66	249±	23	20	27	175
22	325.40	89					
23	327.00	82	135	12	234		
25	339.40	89					
26	342.30	78					
27	350.70	70					
24	352.10	20					
28	357.80	67					
29	363.10	63					
30	364.60	63	210±	24	336	34	146
31	365.90	19					
32	366.50	60					
35	376.70	55					
33	381.30	54					
34	383.90	56	147	31	296		
36	384.50	39					
39	395.50	80	147	6	291		
38	397.30	78	144	14	252		
41	404.10	55					
52	405.50	14					
44	410.10	52					
40	413.00	70	12±	25	132	13	320
43	419.20	72					
42	421.00	76					
45	422.20	67	129	11	229		
53	423.30	12					
48	433.20	32					
47x	435.00	69	90±	21	201	21	53
47	437.10	79	15	16	135		
46	442.90	90					
49	455.90	55	321±	43	93	34	263
51	460.20	59					
58	466.80	10					
134	467.30	34					
54	474.10	72					
55	478.20	61					
56	472.90	69					
57	480.60	25					
59	502.50	66					
60	513.80	75					
61	514.70	29					
62	516.10	68					
63	518.60	28					
66	521.30	36					
64	524.00	27					
65x	541.30	51					

Name	Intersection depth	Intersection angle	Direction to object (gravity roll)	Interpreted Dip 1	Interpreted Strike 1	Interpreted Dip 2	Interpreted Strike 2
65	543.40	22					
64x	545.40	21	141	64	273		
69	552.50	35					
70	553.90	48					
75	567.30	11	114	76	246		
133	577.50	48					
132	584.60	18					
72	587.60	58					
73	590.00	43					
72x	598.50	60	27±	35	163	25	353
74	607.70	45					
76	615.40	53					
77	627.40	54					
78	629.40	42					
79	647.90	58					
80	651.20	29					
81	651.60	55					
82	664.10	51					
67	664.80	3					
83	675.30	66					
84	684.20	42					
85	695.60	61					
131	696.40	13					
86	707.50	60	252±	29	42	33	199
88	716.40	54					
87	718.70	50	252	41	38		
87x	726.60	25					
89	728.80	63					
90	731.90	60					
91	737.20	55					
93	760.50	65					
92	762.80	65					
94	764.30	70					
95	770.80	50					
96	778.10	62					
97	784.30	90					
98	787.80	90					
100	790.40	72					
106	802.60	28					
99	806.30	50					
101	809.50	78					
102	812.00	90					
103	815.60	65					
130	825.90	8					
104	831.50	61	240	23	45		
105	832.50	70					
107	843.80	74	351	22	145		
108	848.40	64					
109	854.00	65					

Name	Intersection depth	Intersection angle	Direction to object (gravity roll)	Interpreted Dip 1	Interpreted Strike 1	Interpreted Dip 2	Interpreted Strike 2
128	859.60	53					
128x	868.20	68	216	16	24		
129	870.60	48					
110	877.50	73	303±	25	106	6	311
111	876.30	52					
112	888.50	21					
113	893.80	70					
114	897.80	88					
121	905.50	69					
115	908.10	58					
123	915.70	31					
127	918.50	68					
122	921.40	85					
116	932.60	55					
126	938.70	55					
120	941.50	57					
124	966.40	78					
117	970.70	79	330±	20	134	7	270
125	988.00	32					
118	991.50	50					
119	1,017.20	28					

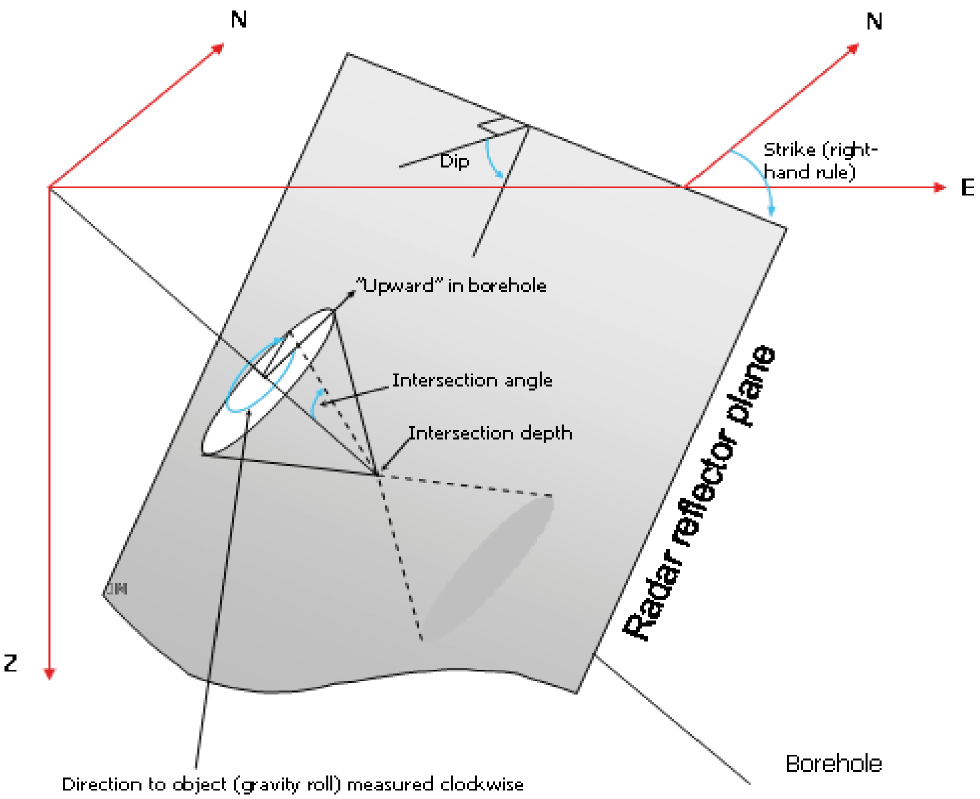


Figure 5-1. *Definition of intersection angle, direction to object using gravity roll, dip and strike using the right hand rule as presented in Table 5-2.*

In Appendix 1, 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 Table 5-3.

Table 5-3. Decrease in amplitude for the 250 MHz antenna for borehole KLX04.

Depth (m)
55–60
95–105
115
170
175
215–220
230
235
255
265
270–280
295–300
320–330
345–355
380–385
415
420
435
445
460
550
585
595
625–635
660–670
675–680
685
700–705
725–730
765
845–850
875–880
885–895
940–975

5.2 BIPS logging

The BIPS pictures are presented in Appendix 2.

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

The logging in KLX04 was performed during two runs, the first run was performed 04-07-12 between 12 meter down to 573 meter when the batteries in the probe was flatten out. The second run 04-07-12 started at 573 meter and ended at 986 meter when the probe entered into the bottom mud. The BIPS Images in the appendix is adjusted for the tension of the cable and recording of the depth readings from the measuring wheel. The adjusted depth is showed in red colour and the recording depth have black colour in the printouts.

The quality of the images in the borehole is one of the best ever performed in core drilled boreholes since the start of the PLU programme at the Forsmark and Oskarshamn sites. The water is of superb quality and there are limited discolouring effects from the drilling phase along the borehole. The poorest quality is in-between 500 and 600 meter. This part of the borehole have a higher content of mud covering the lowermost part of the borehole wall but still there is no problem for the geological characterisation and mapping.

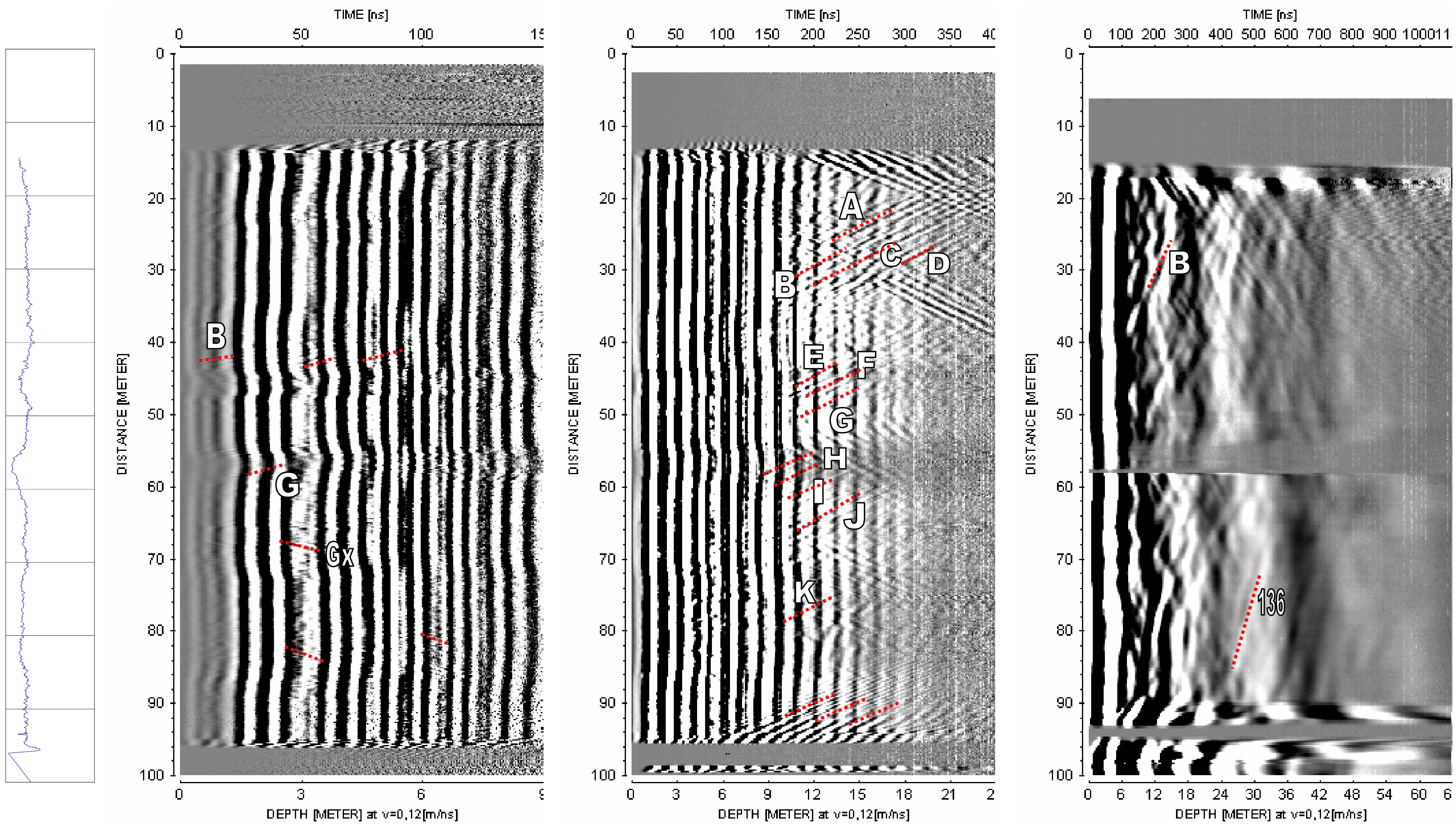
References

/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 KLX04, 12 to 990 m, dipole antennas 250, 100 and 20 MHz

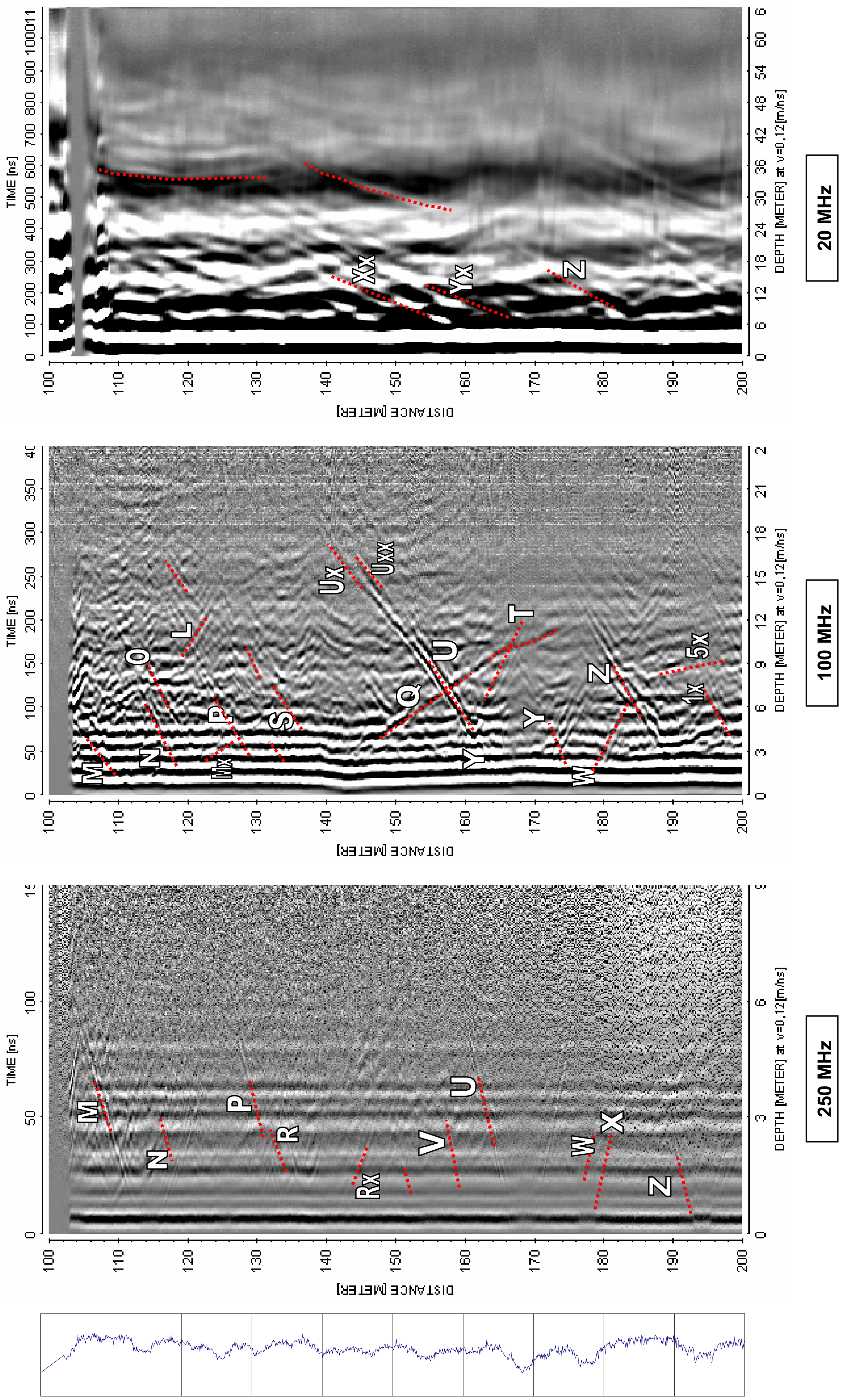
LAXEMAR KLX04

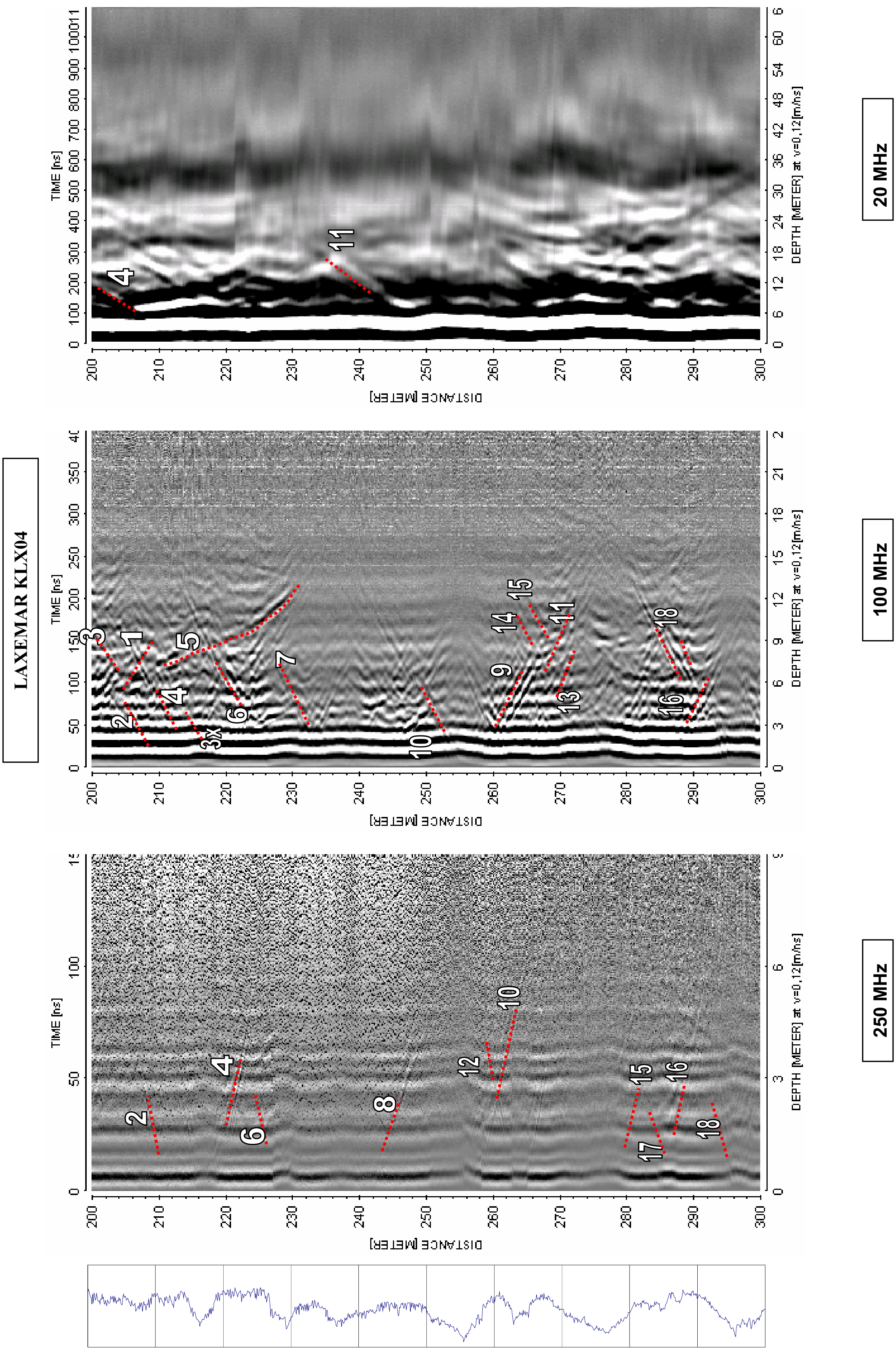


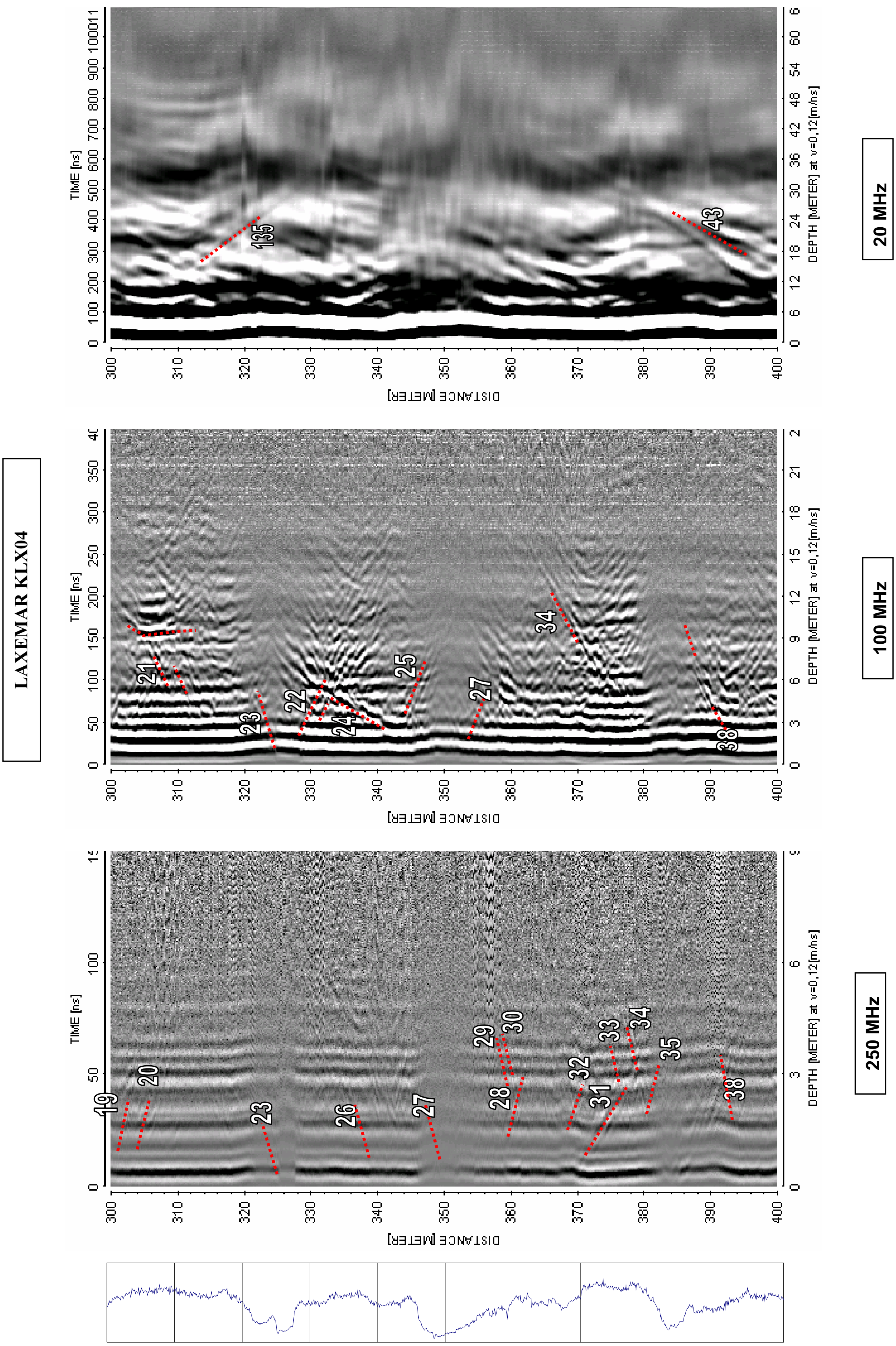
250 MHz

100 MHz

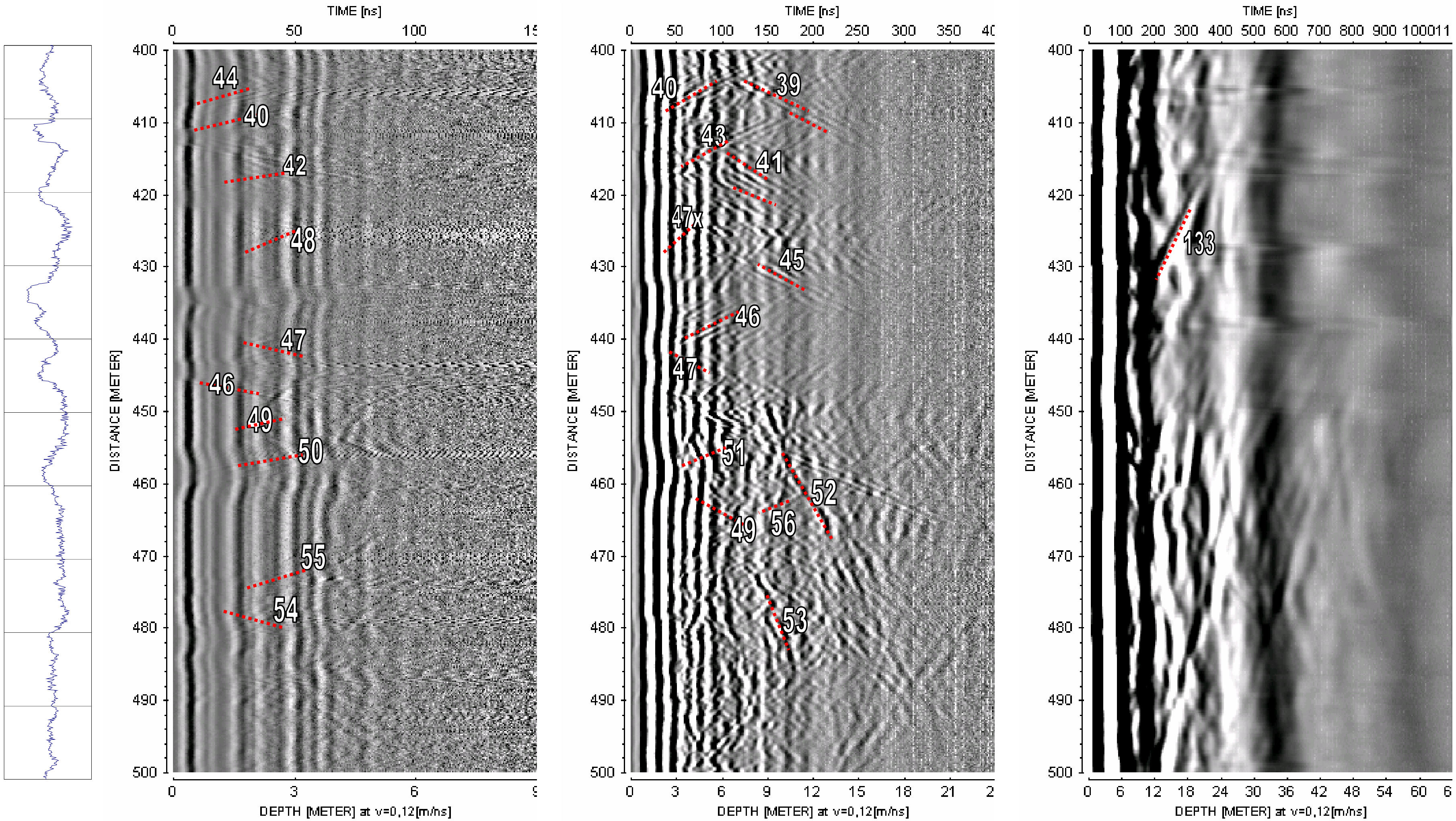
20 MHz


LAXEMAR KLX04
20 MHz
100 MHz
250 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,12[m/ns]


LAXEMAR KLX04
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,12[m/ns]


LAXEMAR KLX04
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,12[m/ns]

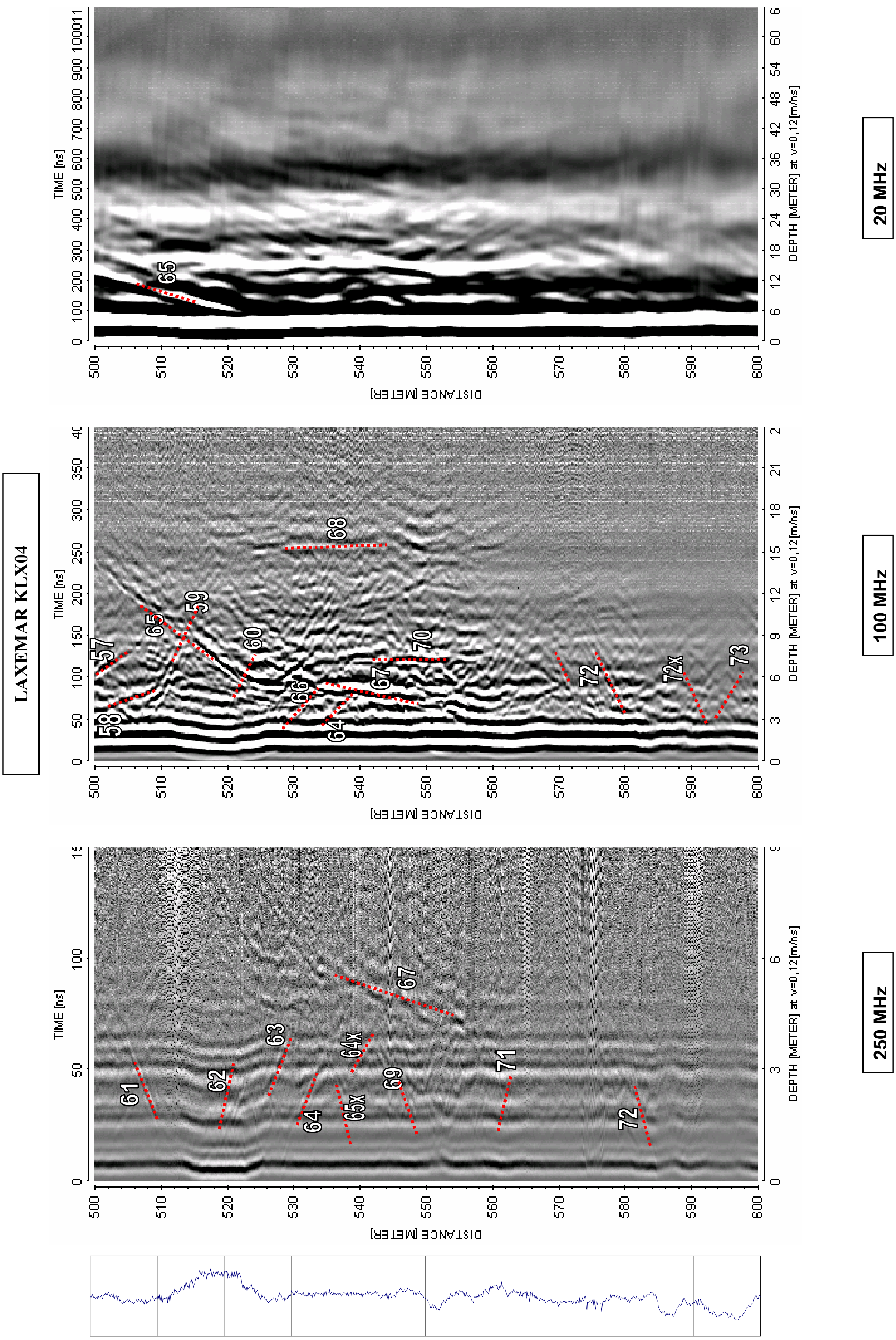
LAXEMAR KLX04



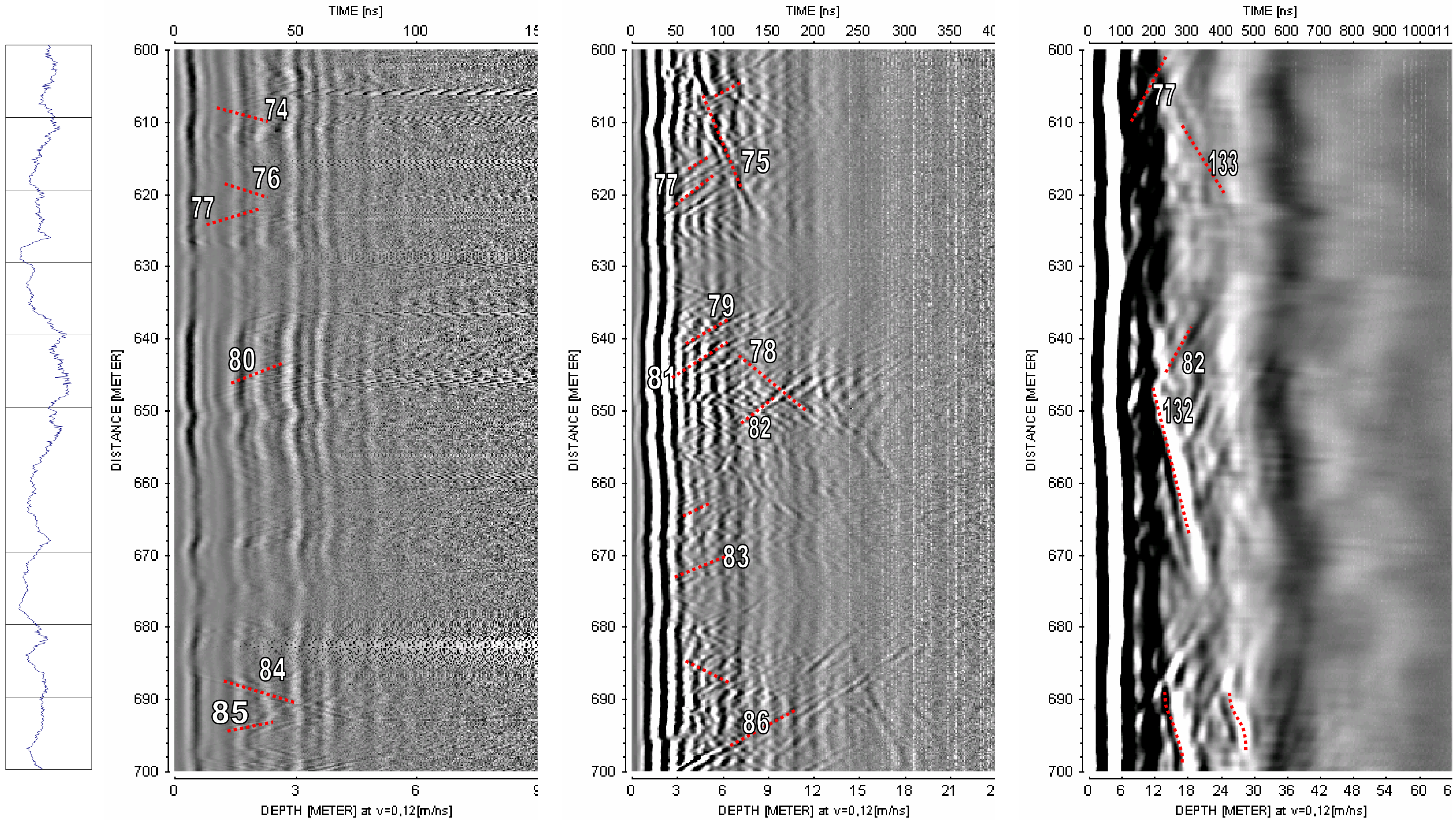
250 MHz

100 MHz

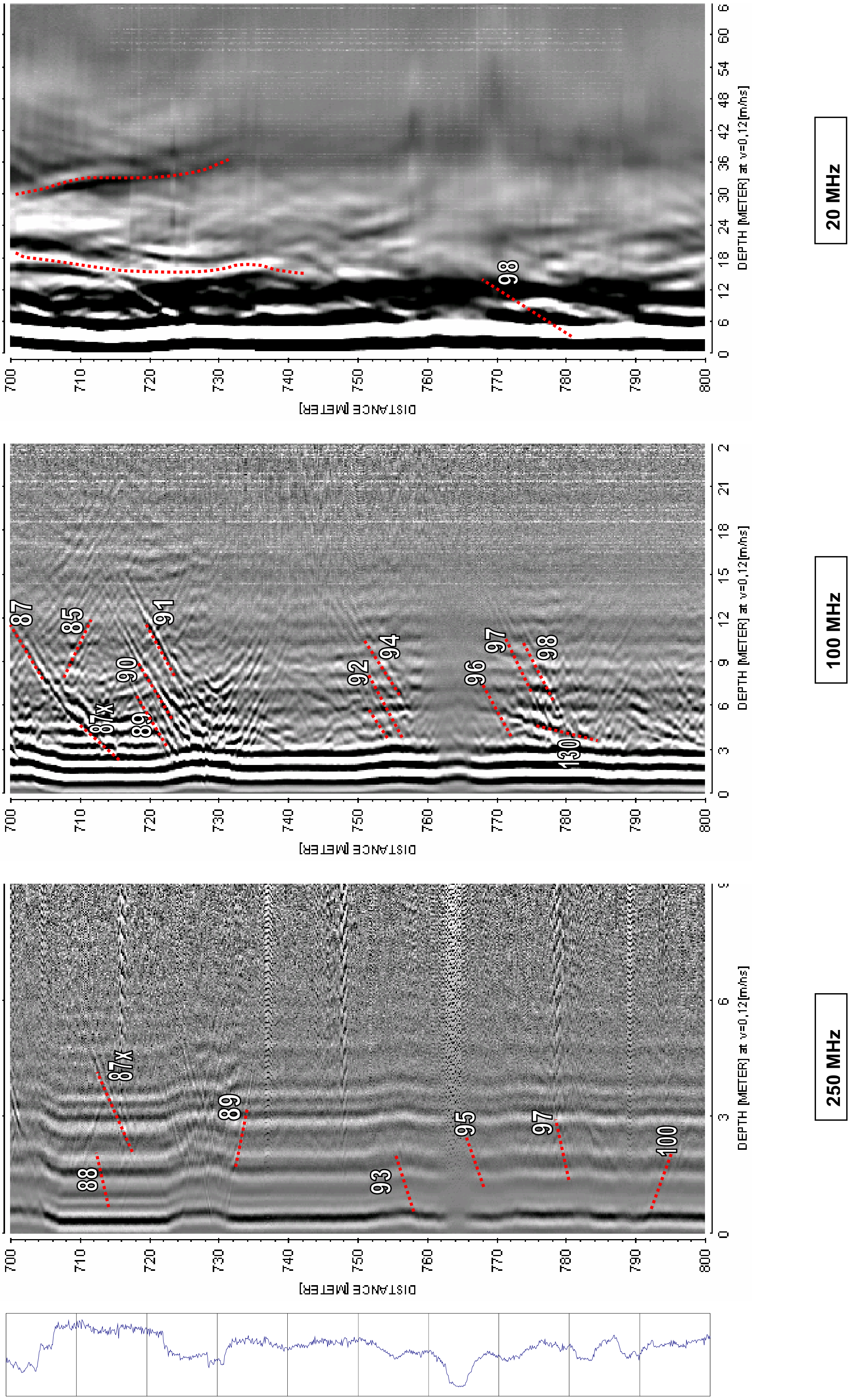
20 MHz


LAXEMAR KLX04
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,12[m/ns]
20 MHz
100 MHz
250 MHz

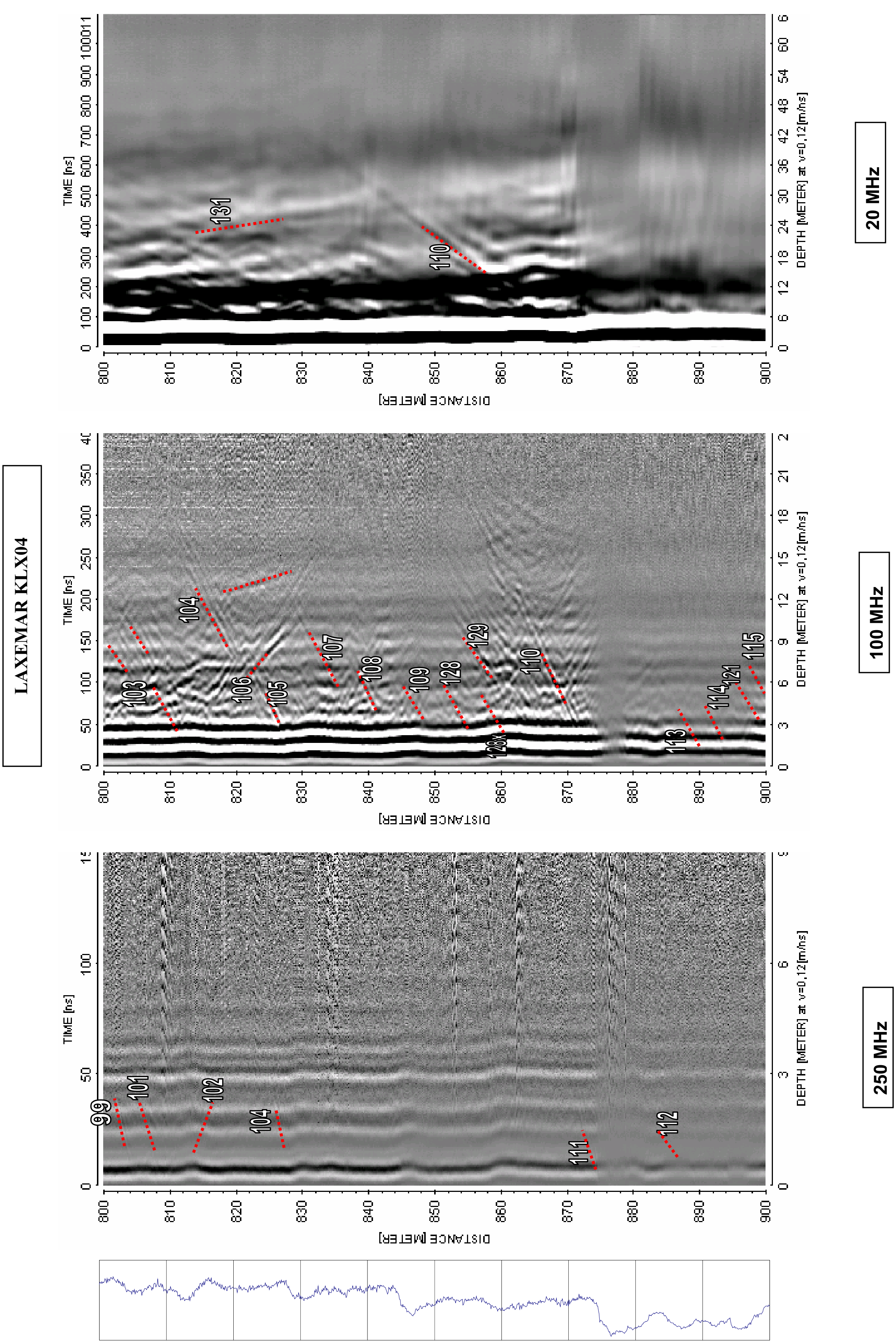
LAXEMAR KLX04

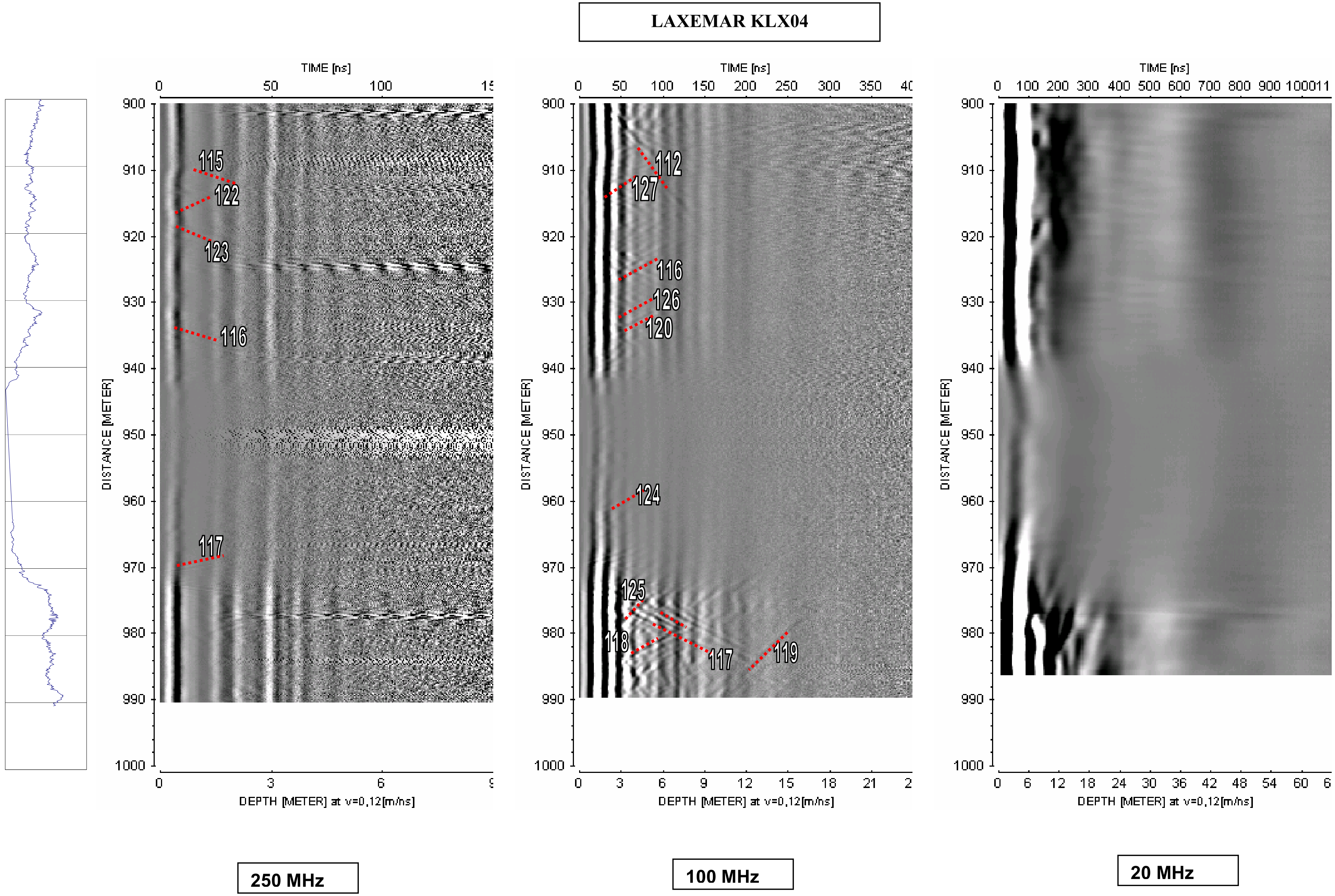


250 MHz **100 MHz** **20 MHz**



LAXEMAR KLX04
250 MHz
100 MHz
20 MHz
DISTANCE [METER]
TIME [ns]
DEPTH [METER] at v=0,12[m/ns]


LAXEMAR KLX04
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,12[m/ns]


LAXEMAR KLX04
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,12[m/ns]
115
122
123
116
117
112
127
116
126
120
124
125
118
117
119
250 MHz
100 MHz
20 MHz

Appendix 2

BIPS logging in KLX04, 12 to 986 m

Project name: Laxemar

Image file	: c:\work\r53__l~1\klx04\bips\12_97.bip
BDT file	: c:\work\r53__l~1\klx04\bips\12_97.bdt
Locality	: LAXEMAR
Bore hole number	: KLX04
Date	: 04/07/12
Time	: 15:18:00
Depth range	: 12.000 - 96.808 m
Azimuth	: 0
Inclination	: -85
Diameter	: 196.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 70 %
Pages	: 5
Color	: +0 +0 +0

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 12.000 - 32.000 m

(1 / 5) **Scale: 1/25** **Aspect ratio: 70 %**

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 32.000 - 52.000 m

(2 / 5) **Scale: 1/25** **Aspect ratio: 70 %**

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 52.000 - 72.000 m

(3 / 5) **Scale: 1/25** **Aspect ratio: 70 %**

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 72.000 - 92.000 m

(4 / 5) **Scale: 1/25** **Aspect ratio: 70 %**

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 92.000 - 96.808 m

(5 / 5) **Scale: 1/25** **Aspect ratio: 70 %**

Project name: Laxemar

Image file	: c:\work\r53__l~1\klx04\bips\100_573.bip
BDT file	: c:\work\r53__l~1\klx04\bips\100_573.bdt
Locality	: LAXEMAR
Bore hole number	: KLX04
Date	: 04/07/12
Time	: 16:53:00
Depth range	: 100.000 - 986.007 m
Azimuth	: 0
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	: 24
Color	: +0 +0 +0

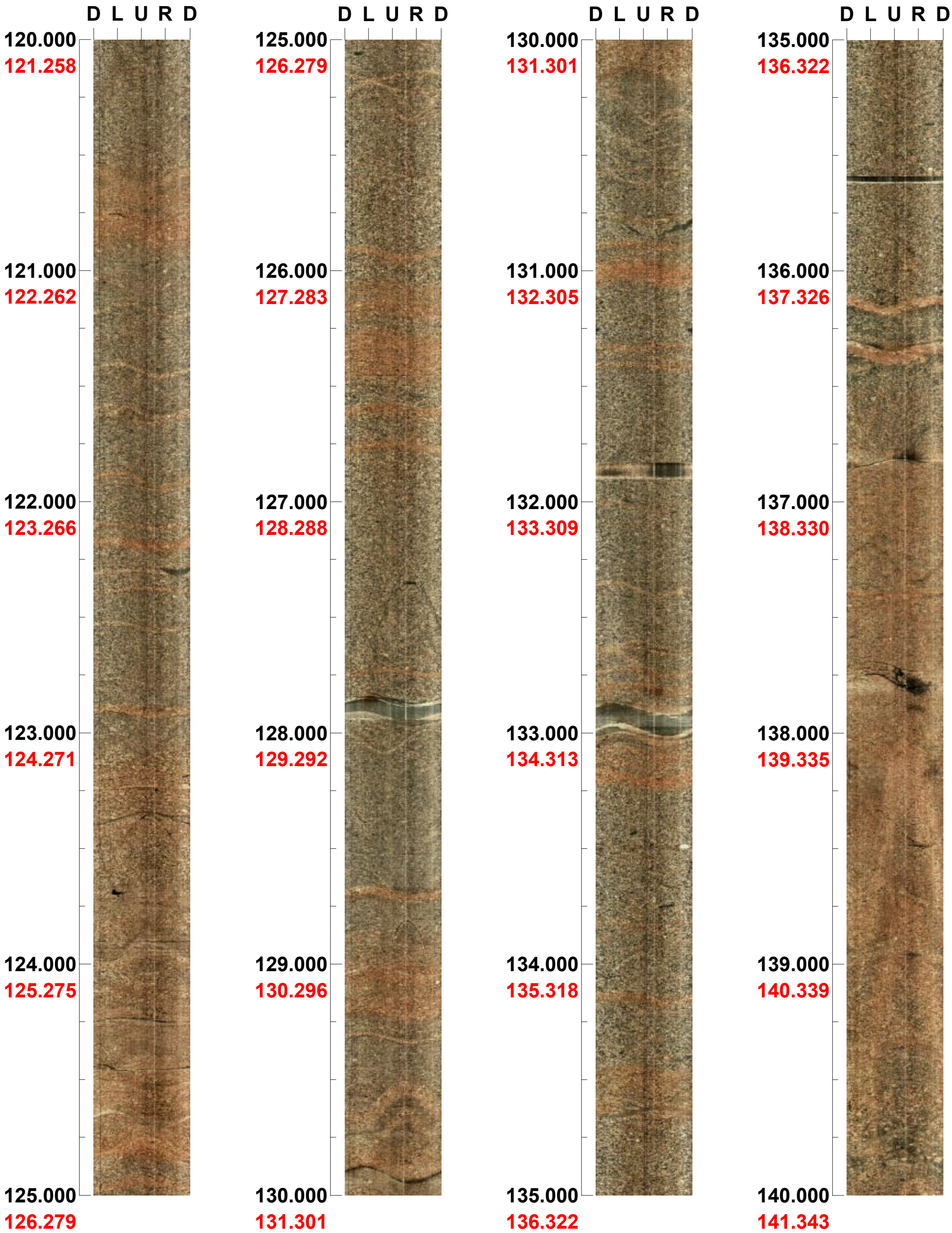
Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 100.000 - 120.000 m

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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

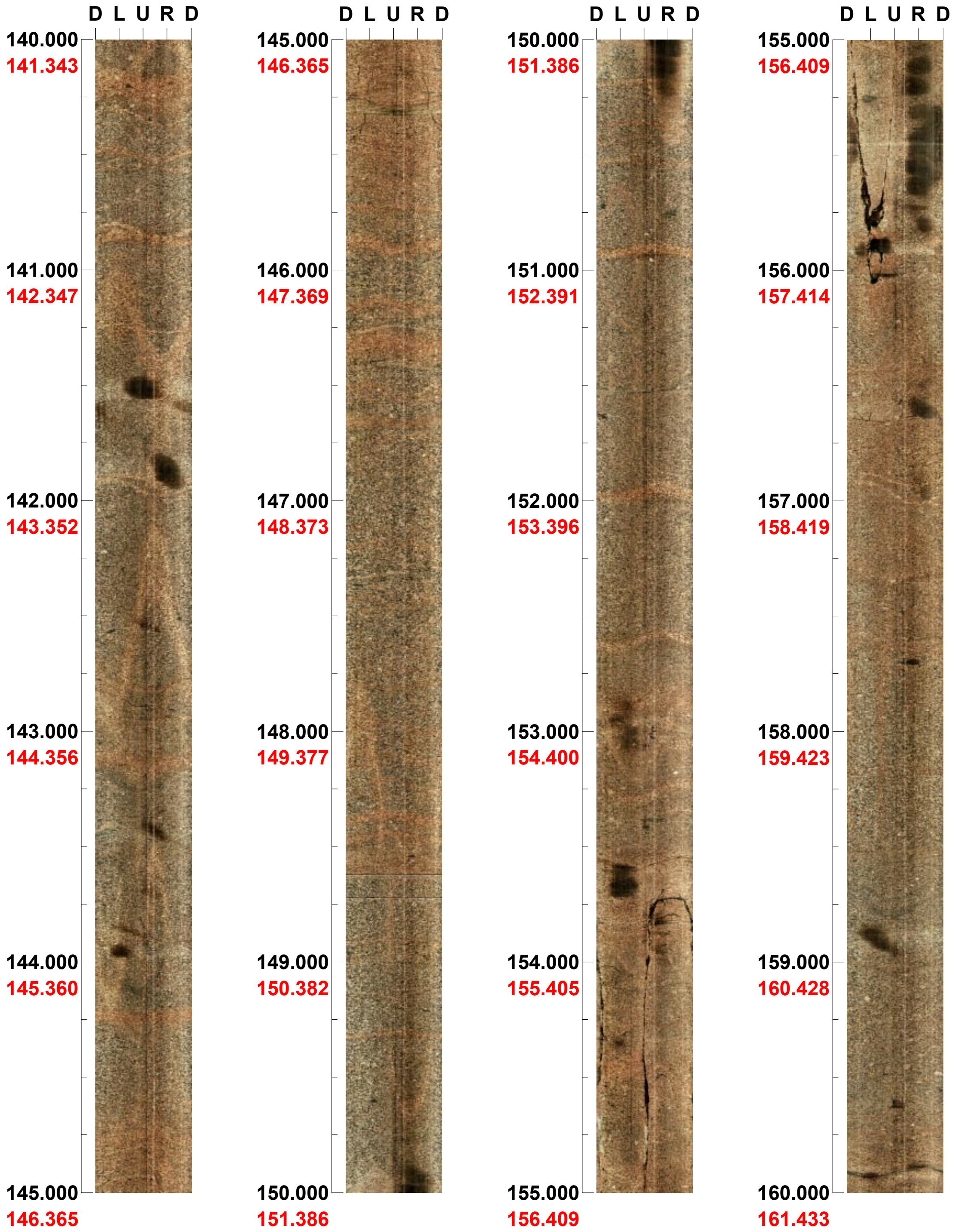
Depth range: 120.000 - 140.000 m



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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 140.000 - 160.000 m

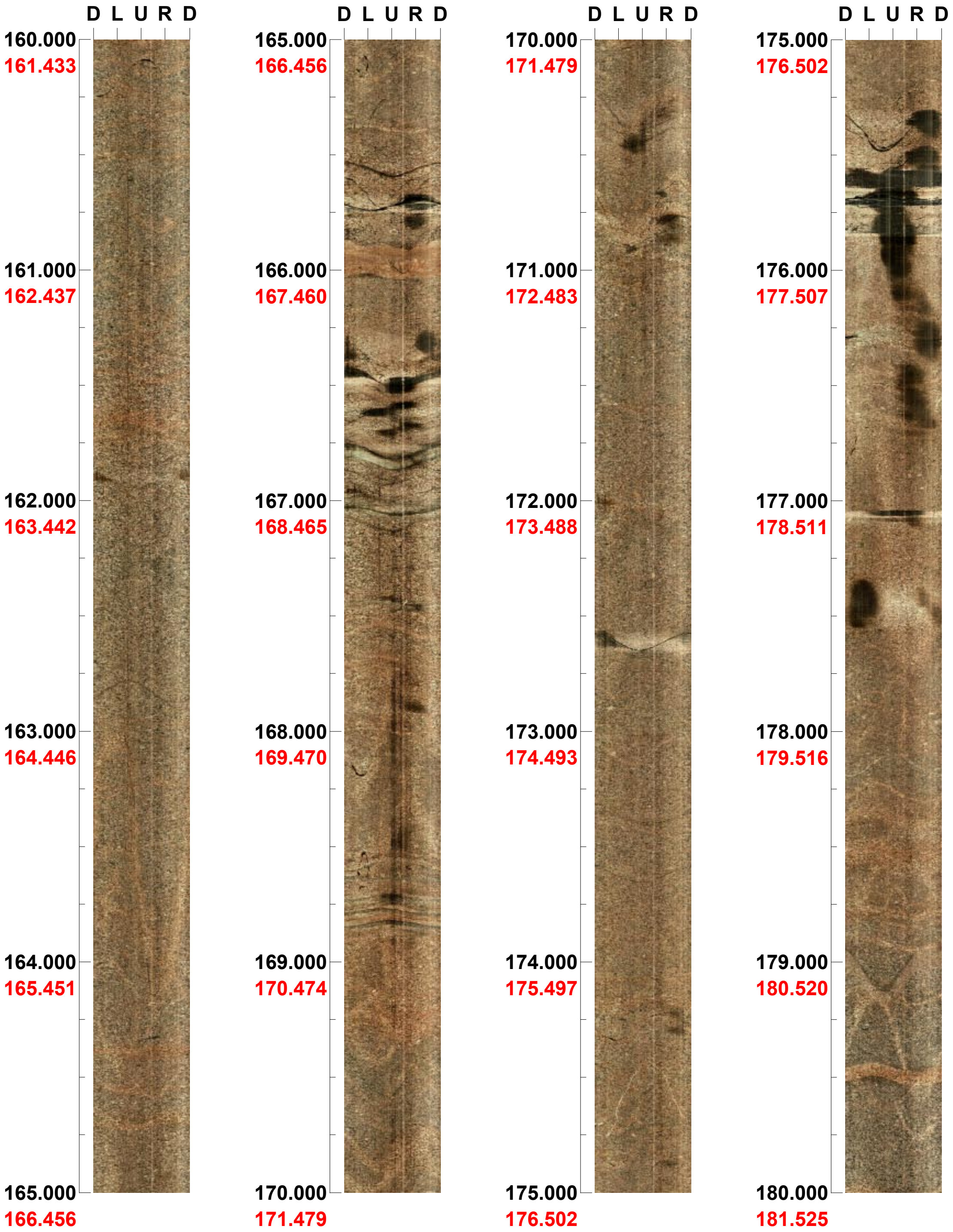


(3 / 24) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 160.000 - 180.000 m

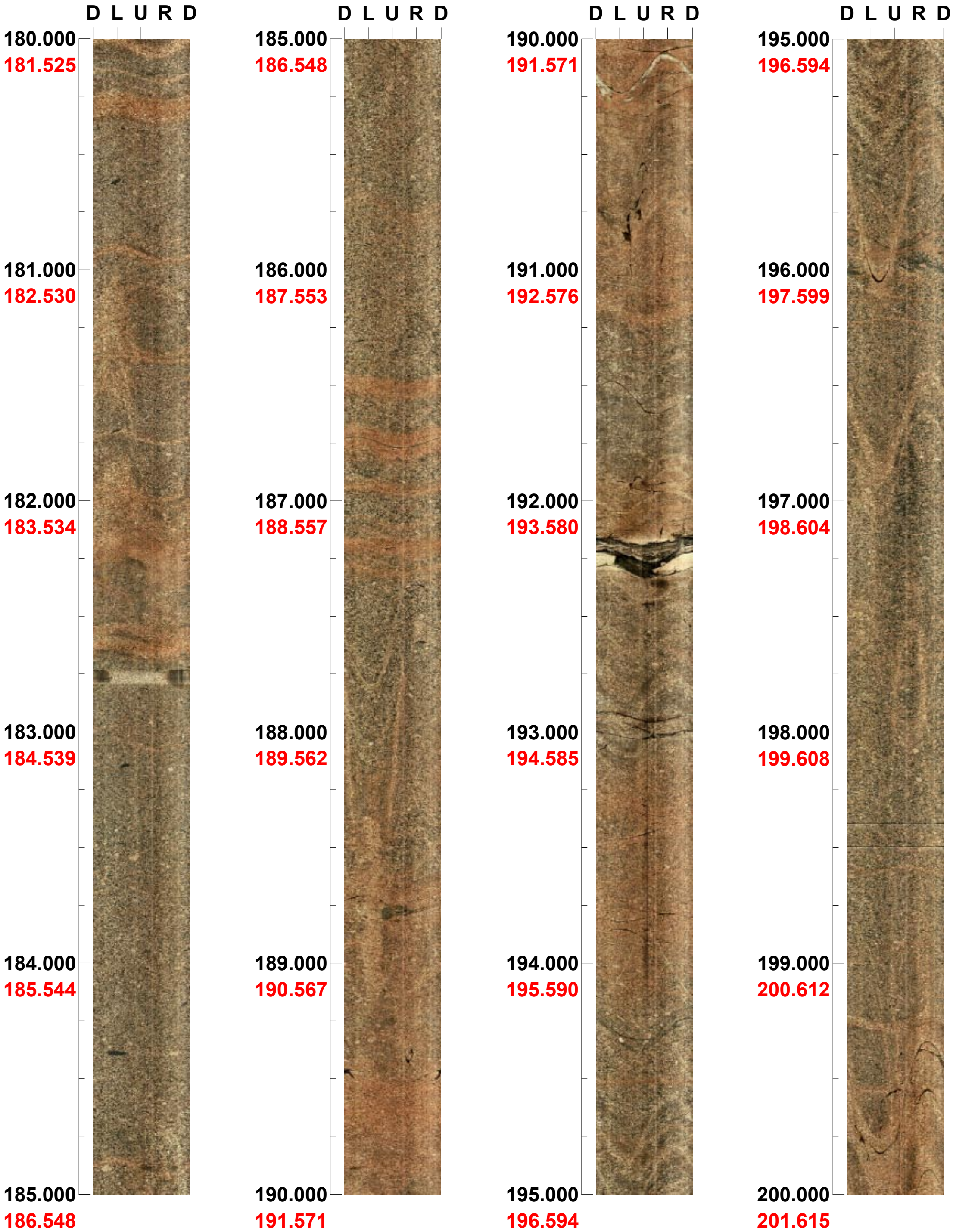


(4 / 24) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

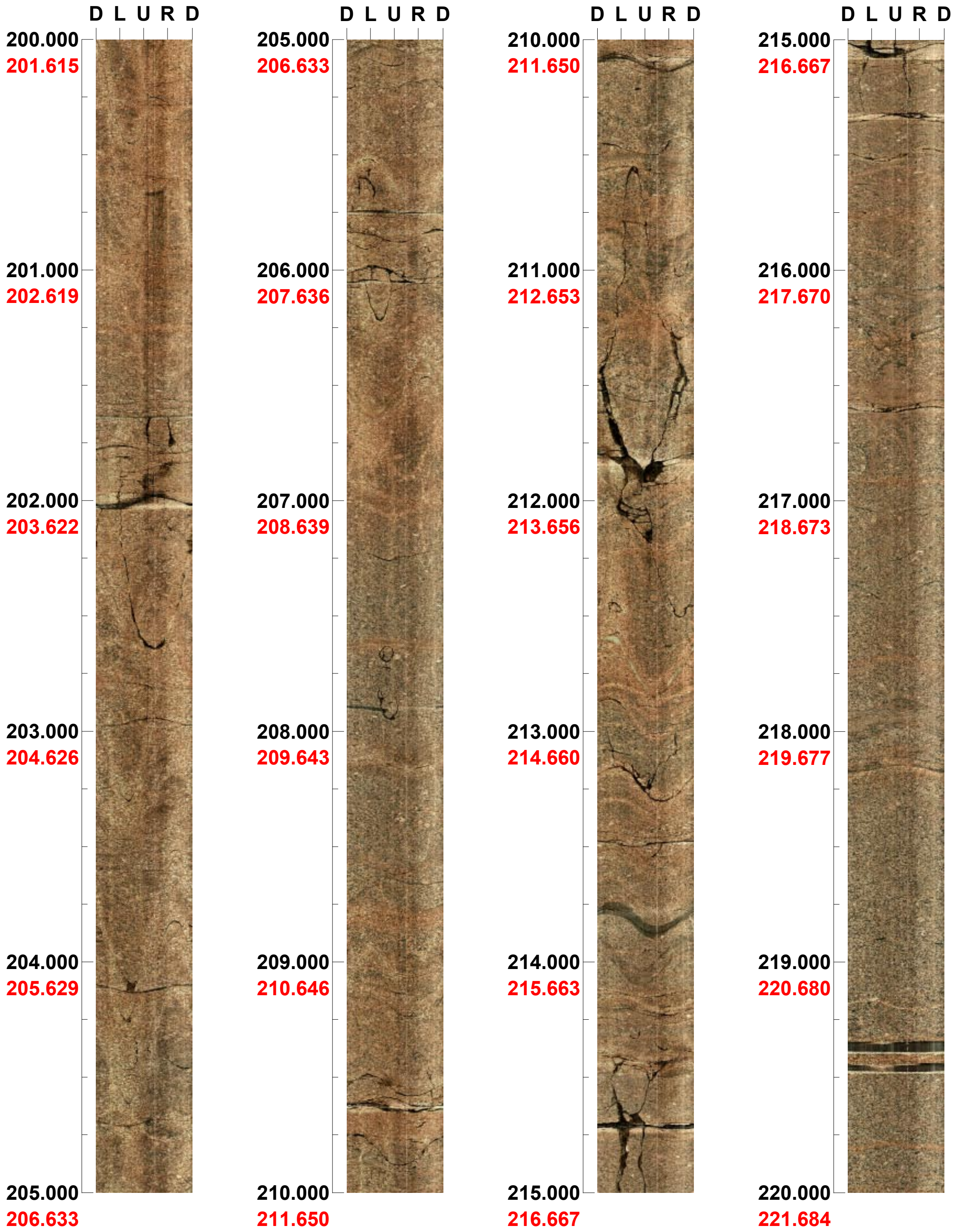
Depth range: 180.000 - 200.000 m



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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 200.000 - 220.000 m

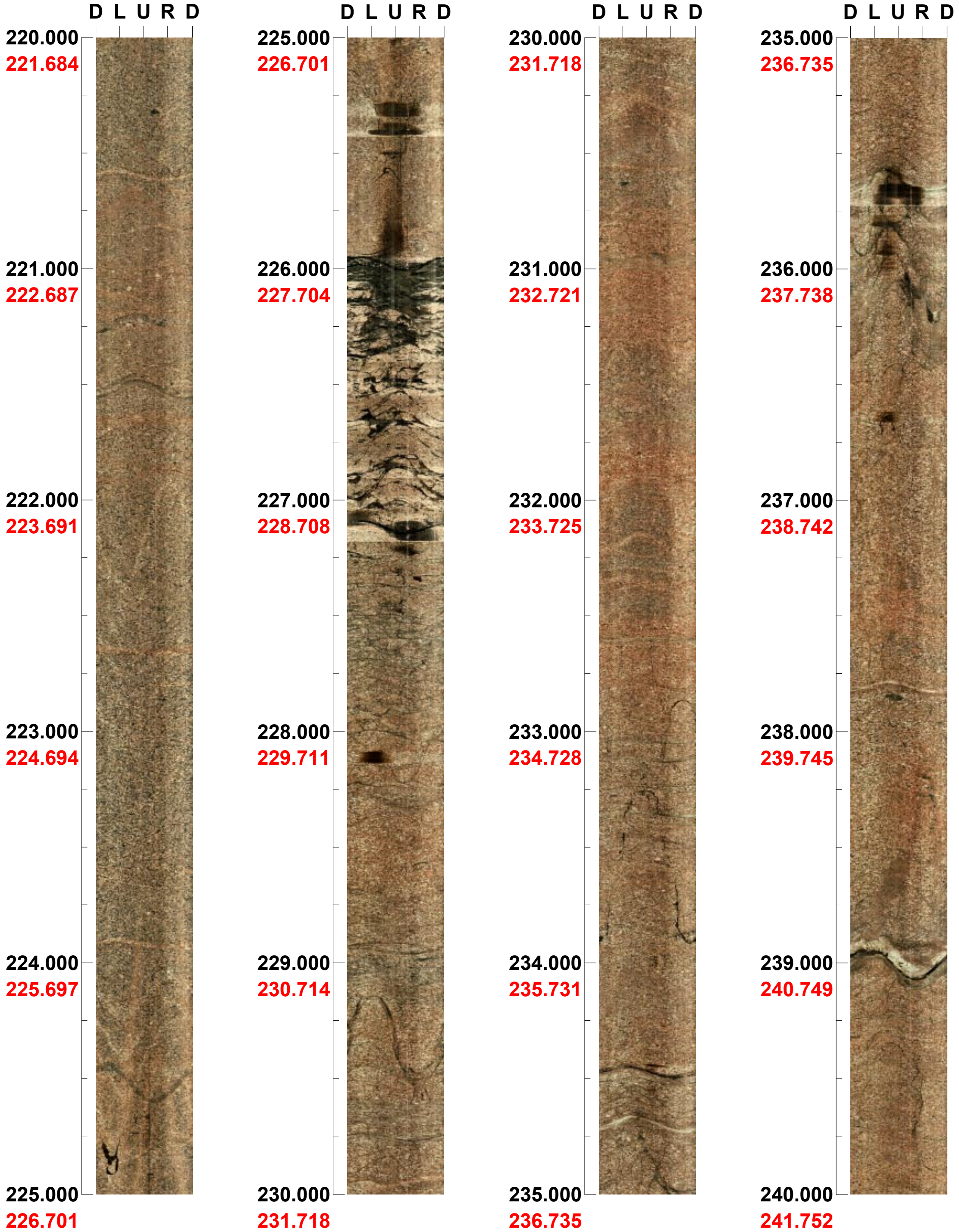


(6 / 24) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

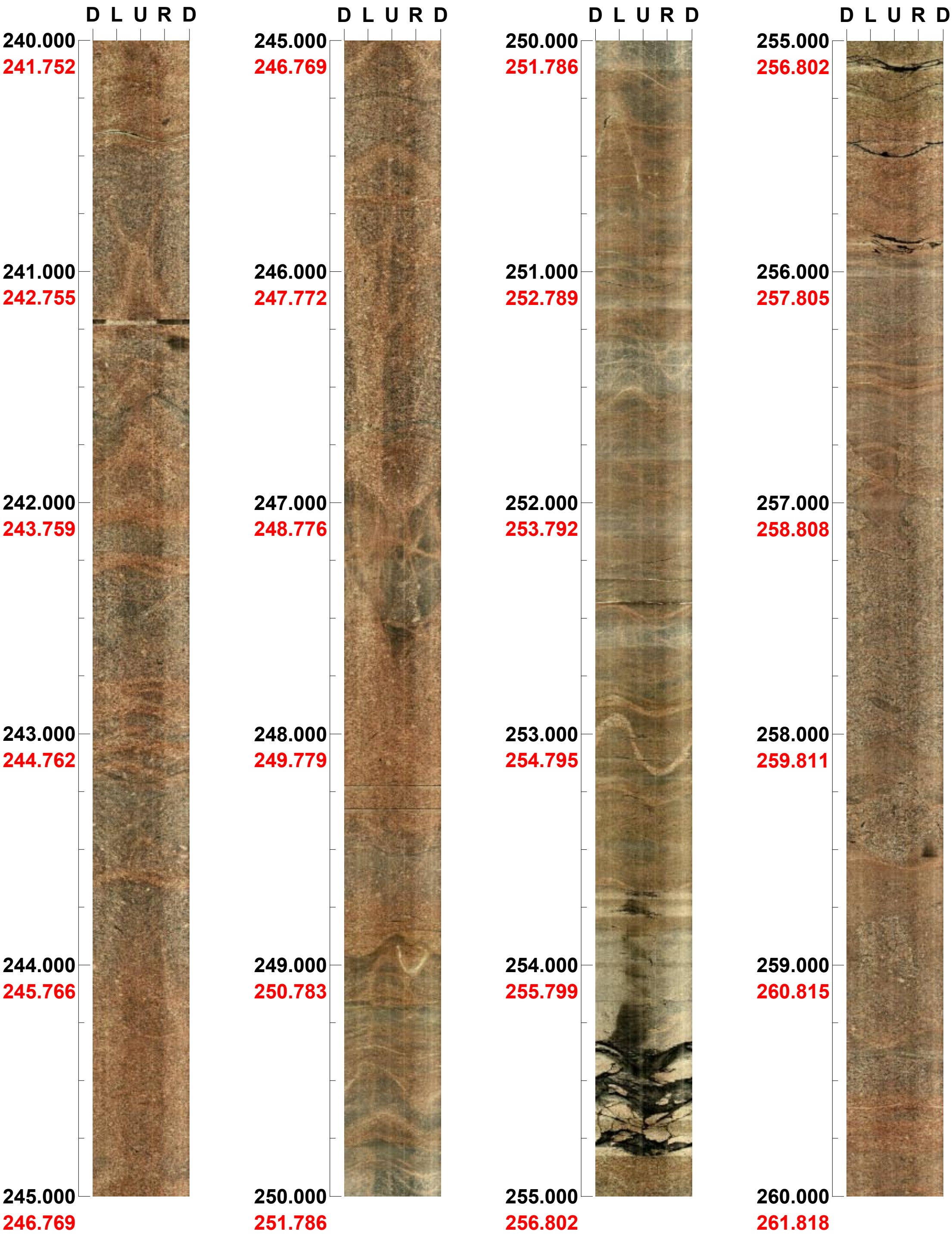
Depth range: 220.000 - 240.000 m



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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 240.000 - 260.000 m



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

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

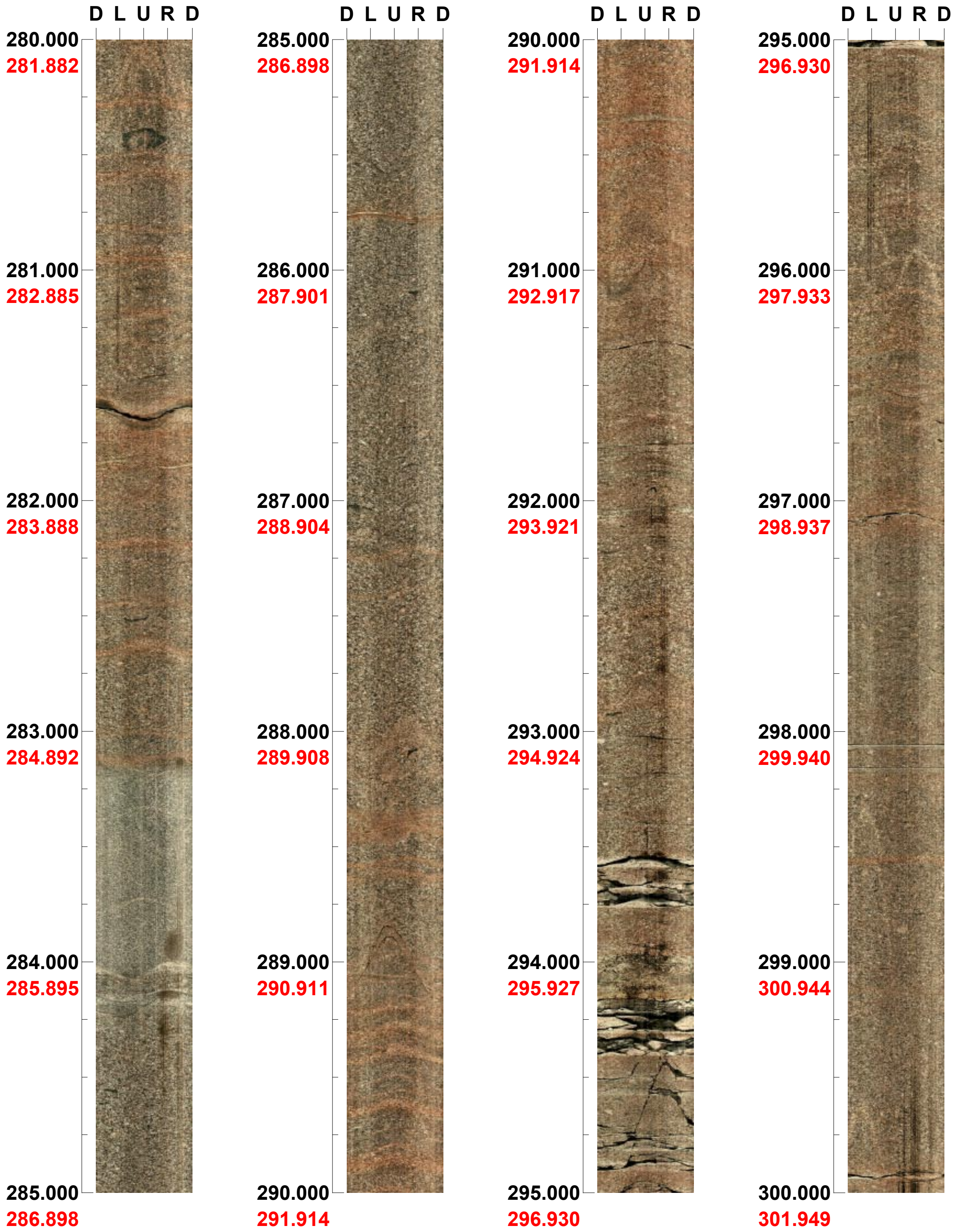
Depth range: 260.000 - 280.000 m

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

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

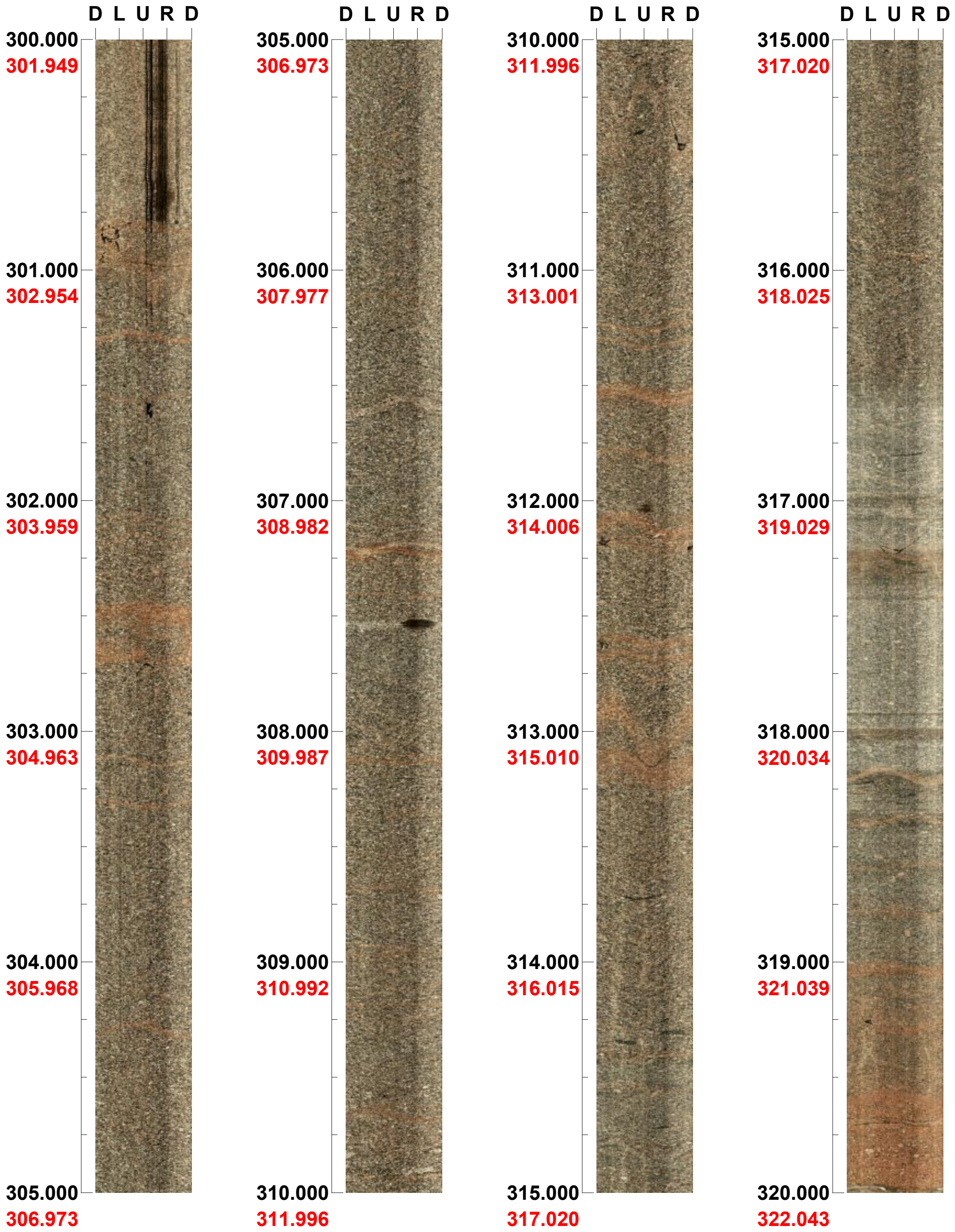
Depth range: 280.000 - 300.000 m



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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 300.000 - 320.000 m



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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 320.000 - 340.000 m

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

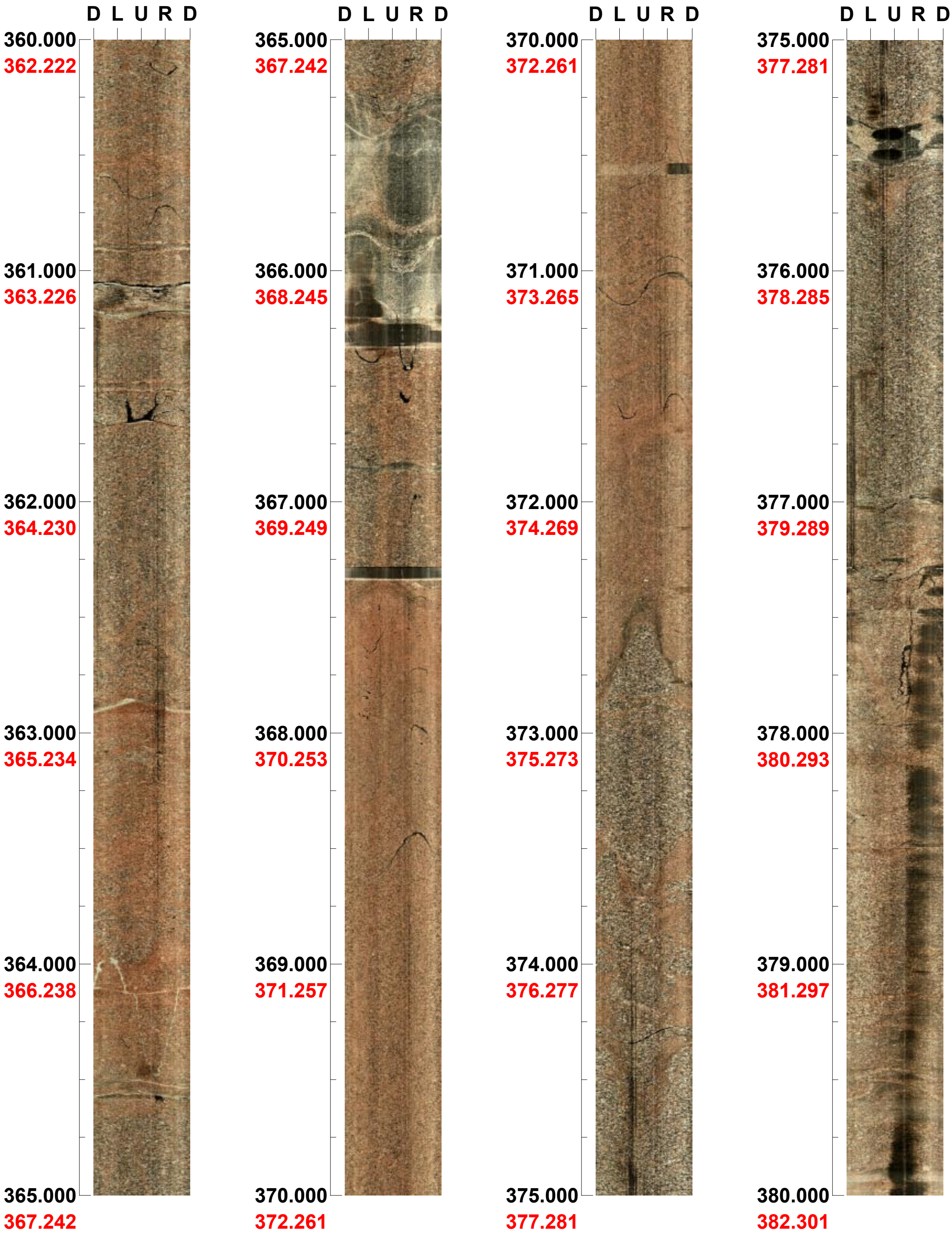
Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 340.000 - 360.000 m

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

Project name: Laxemar
Bore hole No.: KLX04A Azimuth: 0 Inclination: -85

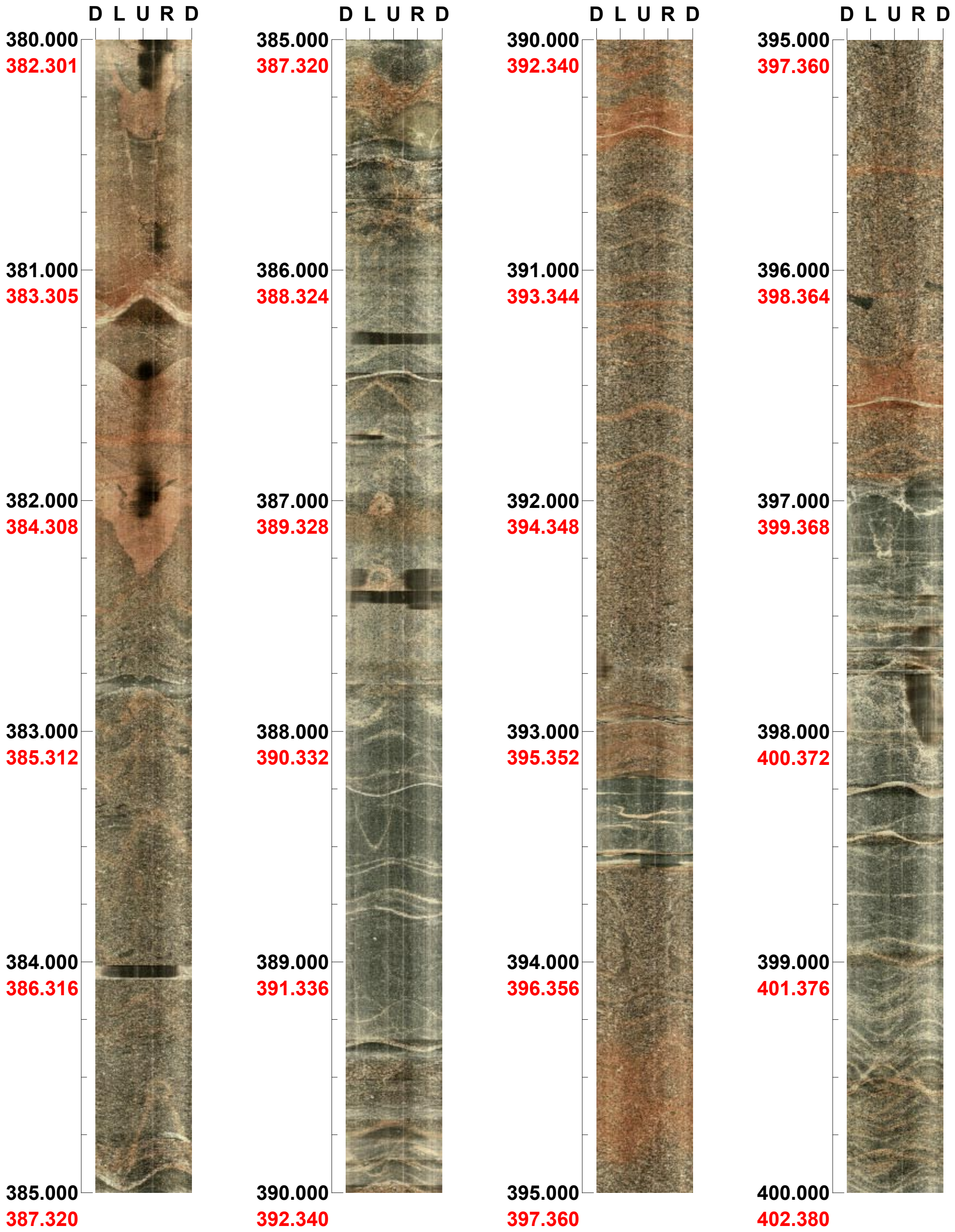
Depth range: 360.000 - 380.000 m



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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 380.000 - 400.000 m



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

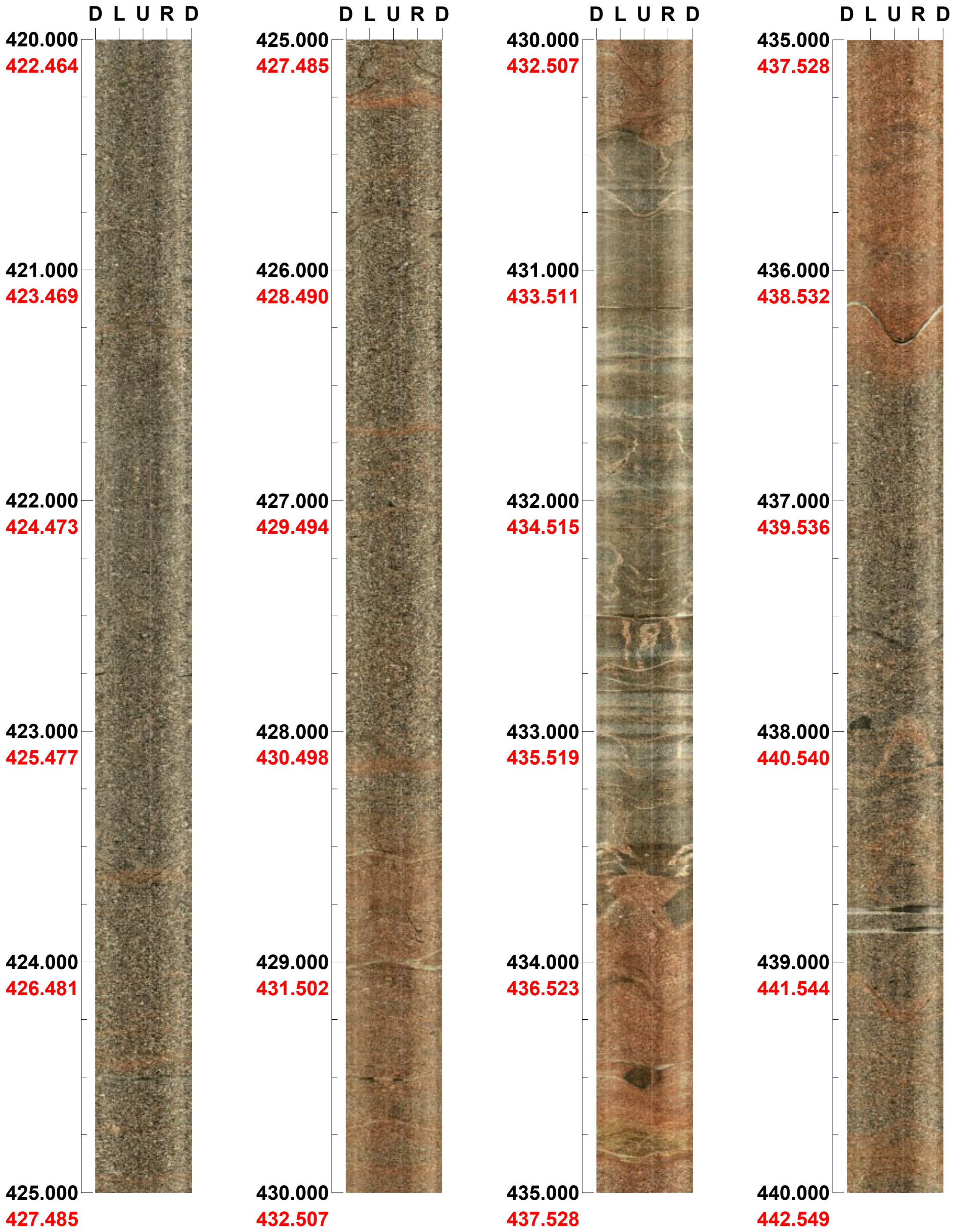
Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 400.000 - 420.000 m

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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 420.000 - 440.000 m



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

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 440.000 - 460.000 m

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

Project name: Laxemar

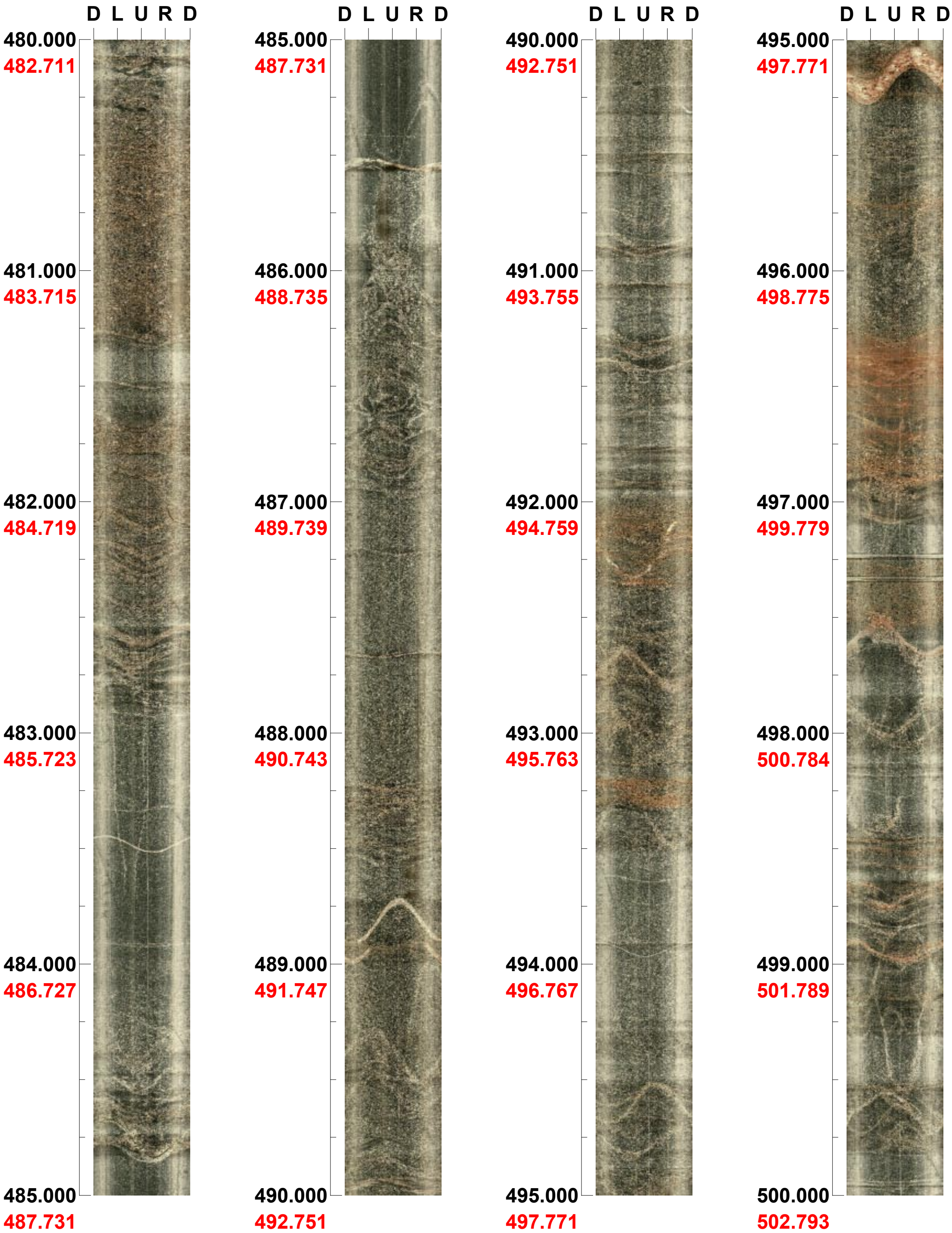
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 460.000 - 480.000 m

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

Project name: Laxemar
Bore hole No.: KLX04A Azimuth: 0 Inclination: -85

Depth range: 480.000 - 500.000 m

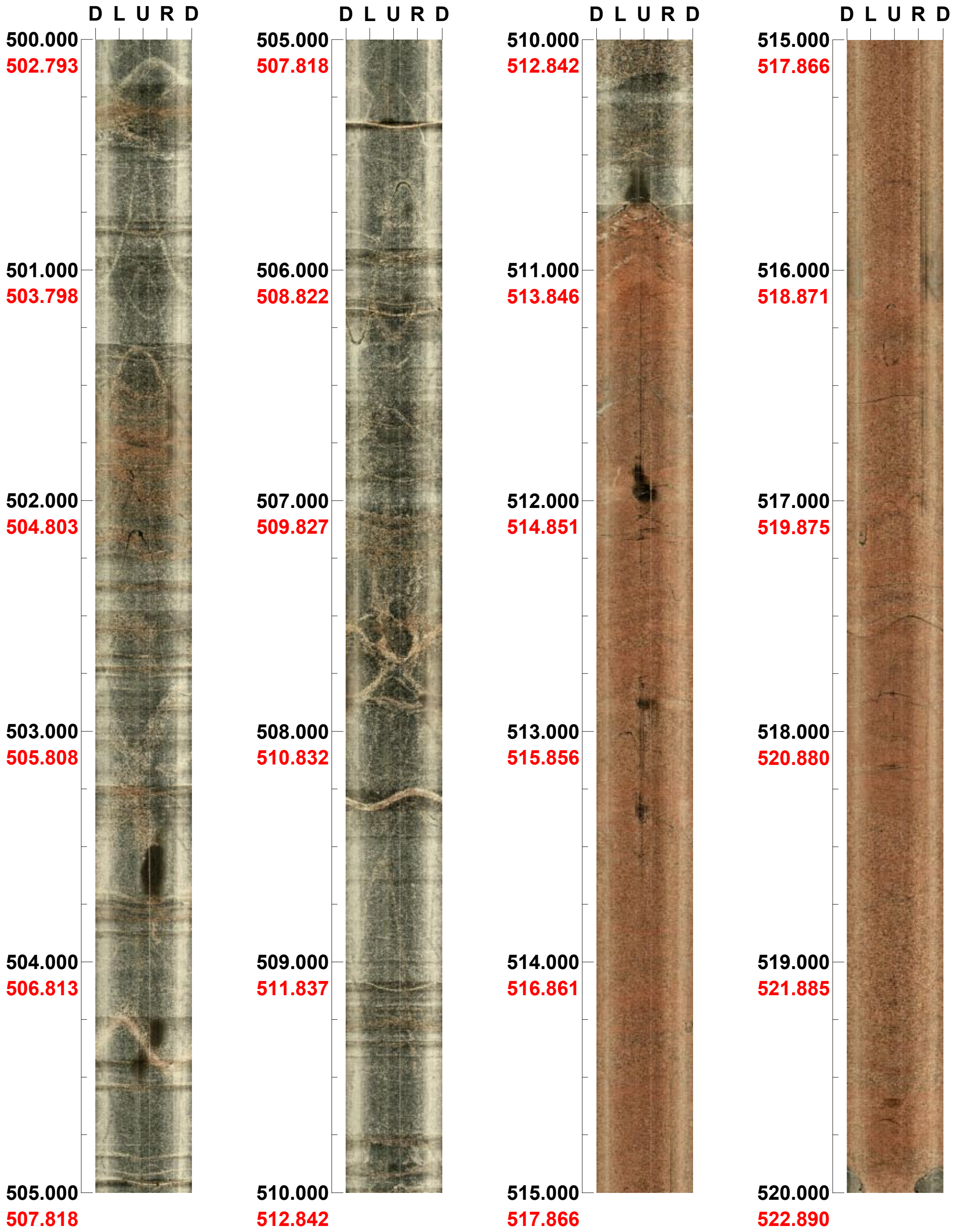


(20 / 24) Scale: 1/25 Aspect ratio: 175 %

Project name: Laxemar

Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 500.000 - 520.000 m



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

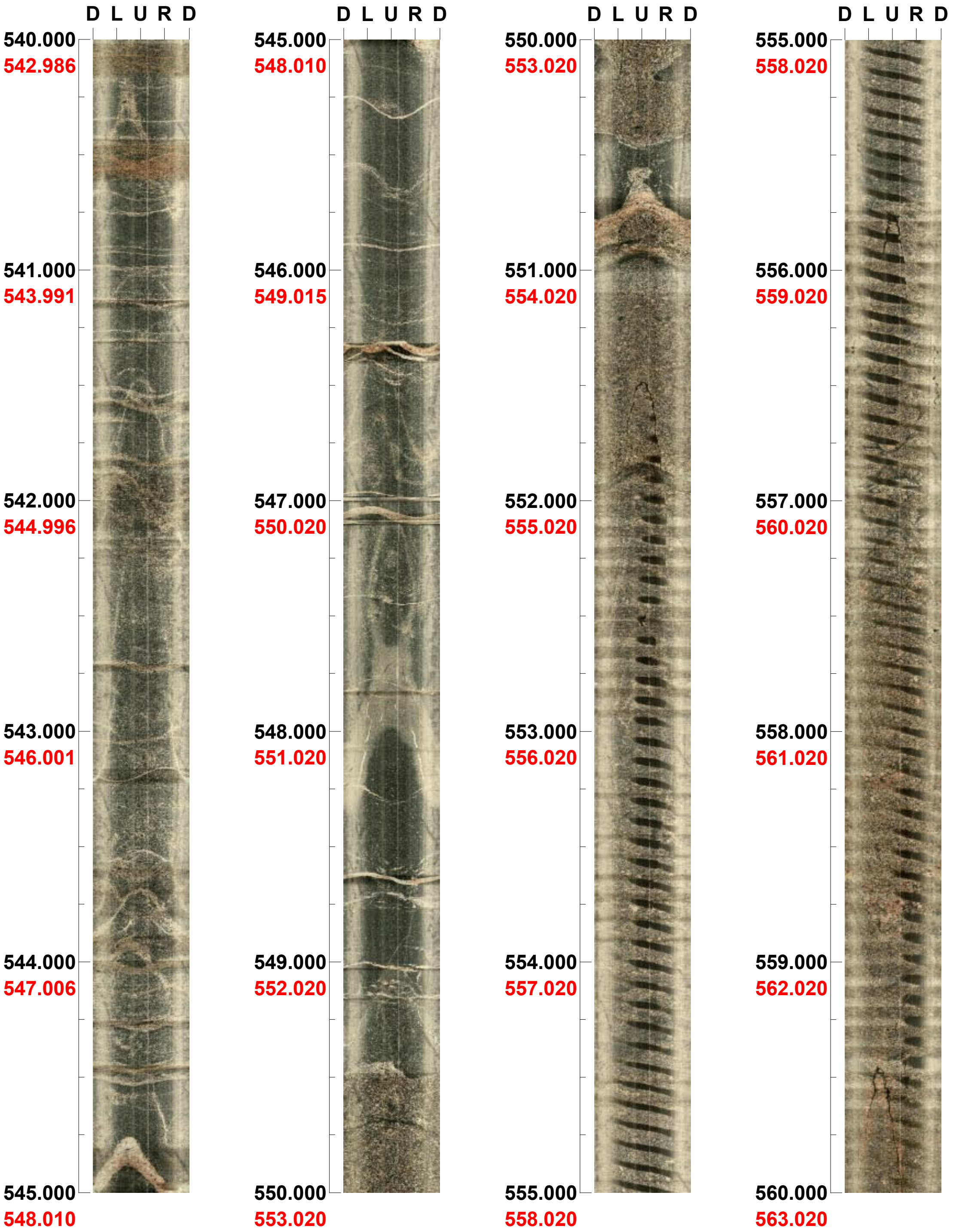
Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

Depth range: 520.000 - 540.000 m

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

Project name: Laxemar
Bore hole No.: KLX04A   Azimuth: 0   Inclination: -85

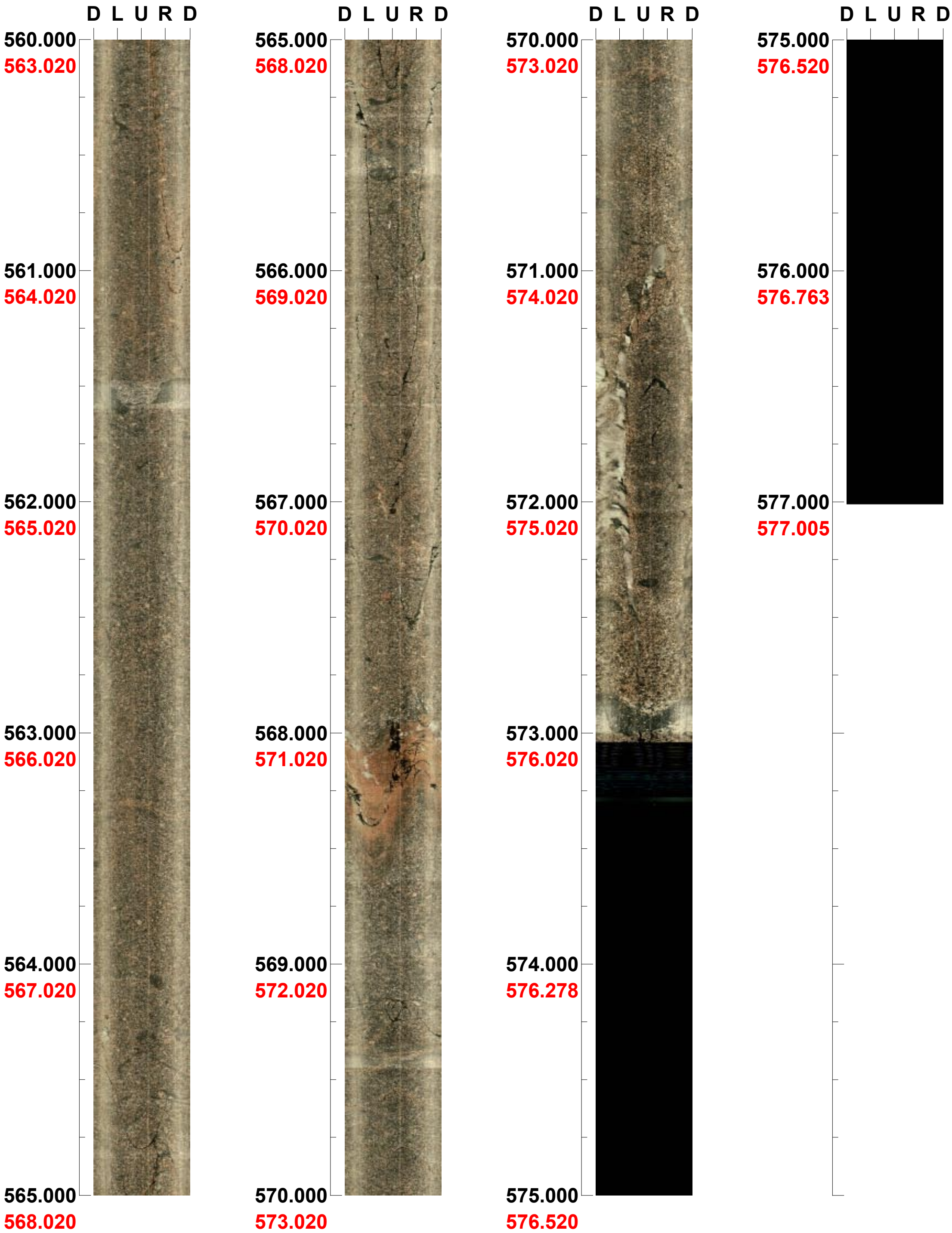
Depth range: 540.000 - 560.000 m



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

Project name: Laxemar
Bore hole No.: KLX04A **Azimuth: 0** **Inclination: -85**

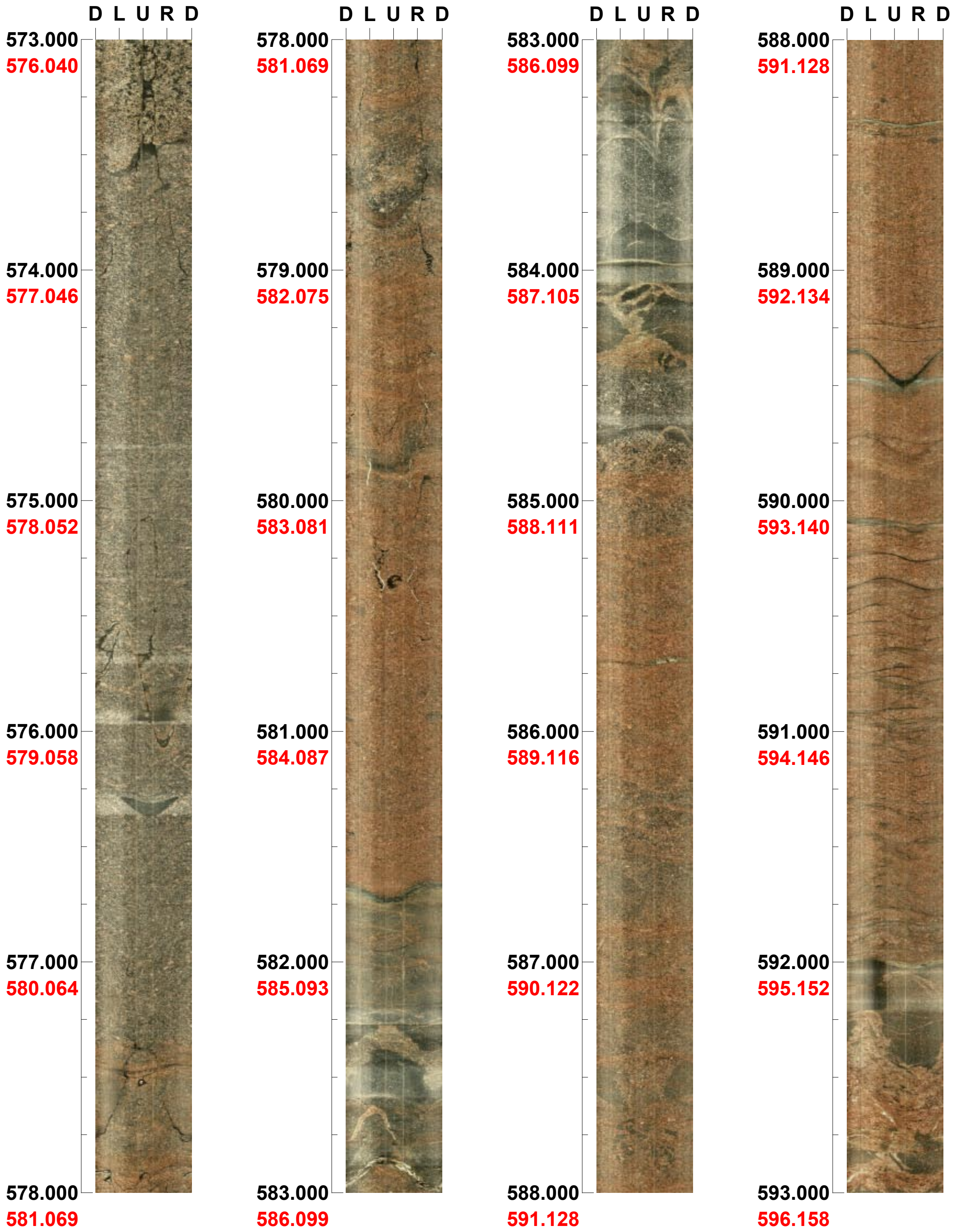
Depth range: 560.000 - 577.007 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 573.000 - 593.000 m

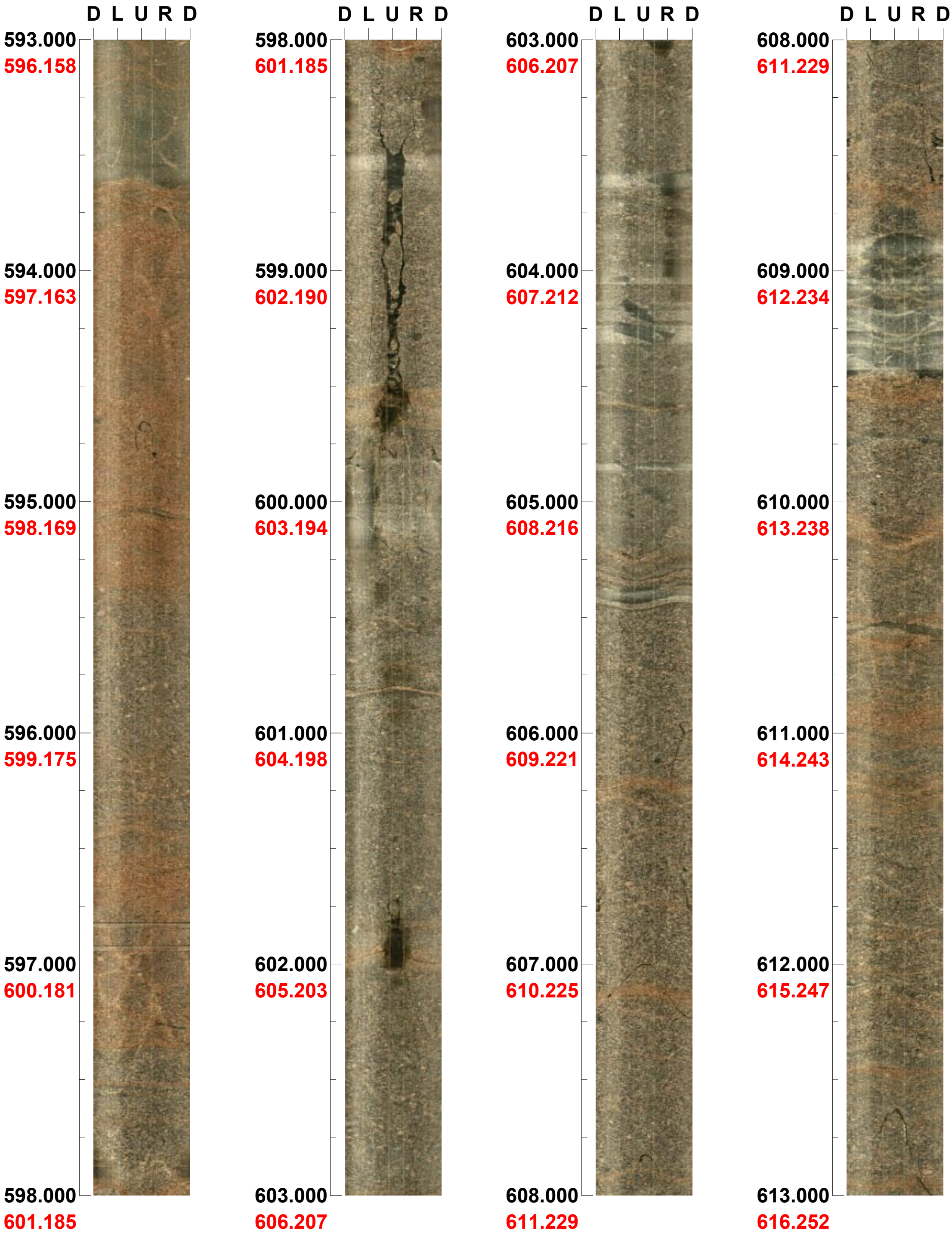


(1 / 21) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

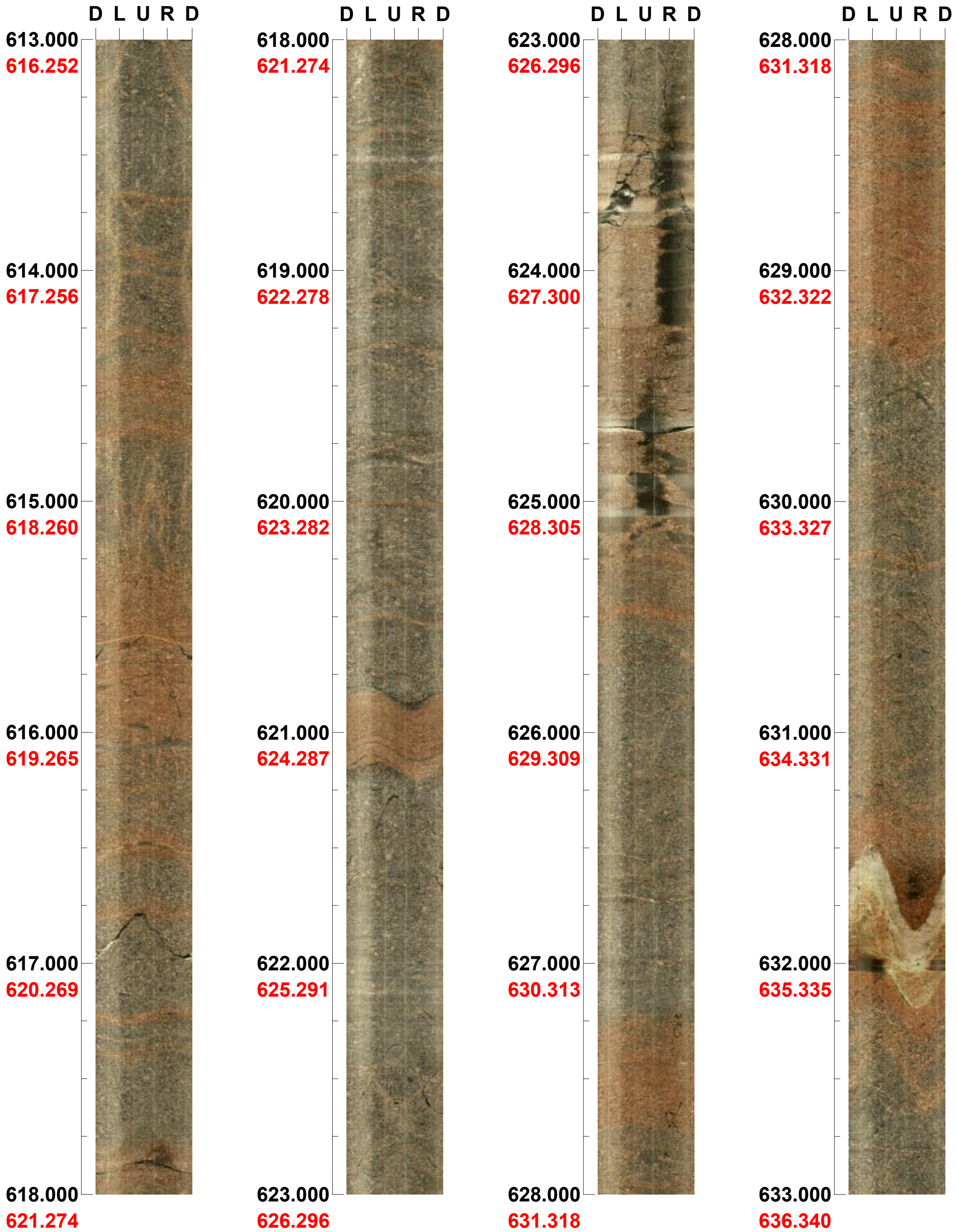
Depth range: 593.000 - 613.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 613.000 - 633.000 m



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

Project name: Laxemar

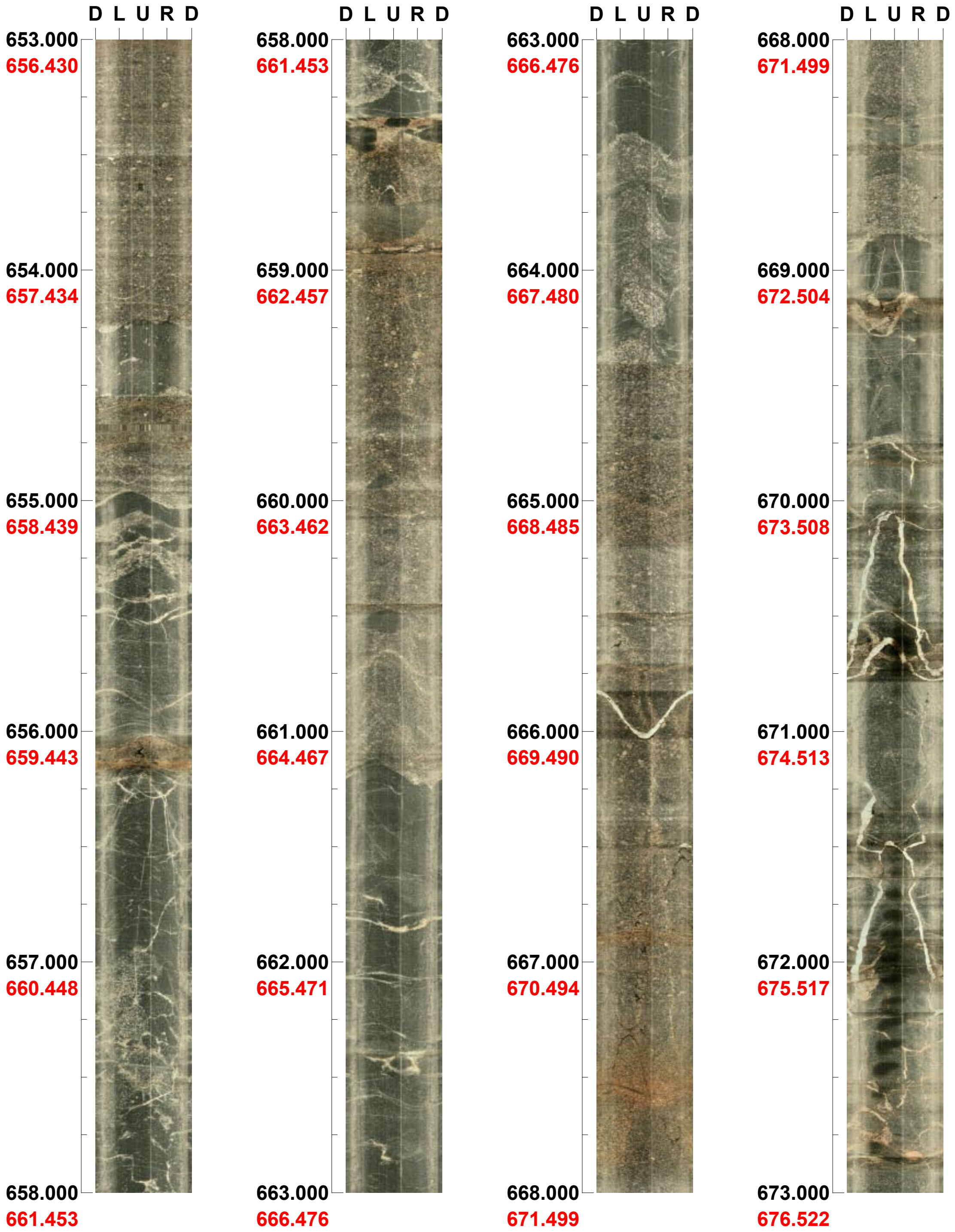
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 633.000 - 653.000 m

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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

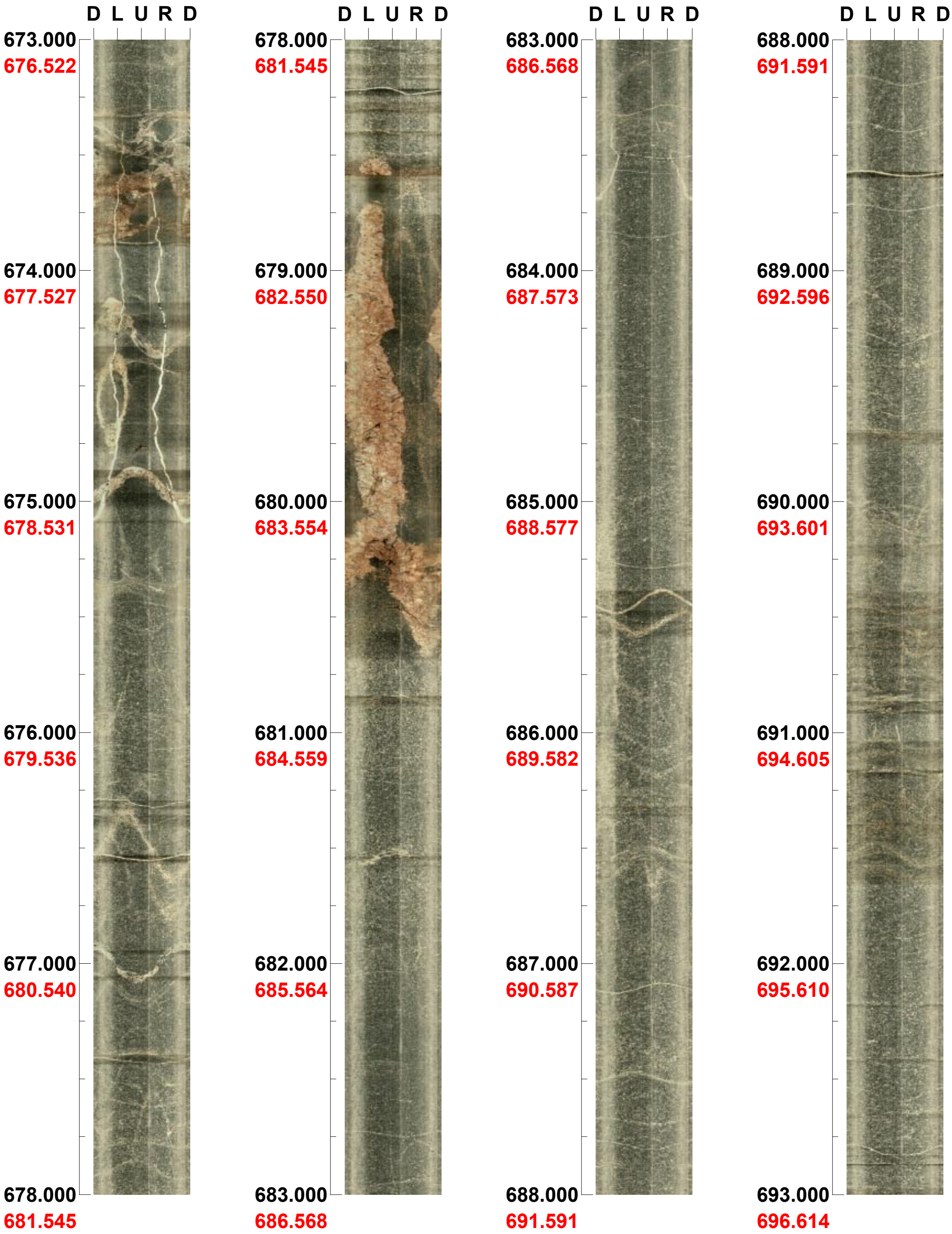
Depth range: 653.000 - 673.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

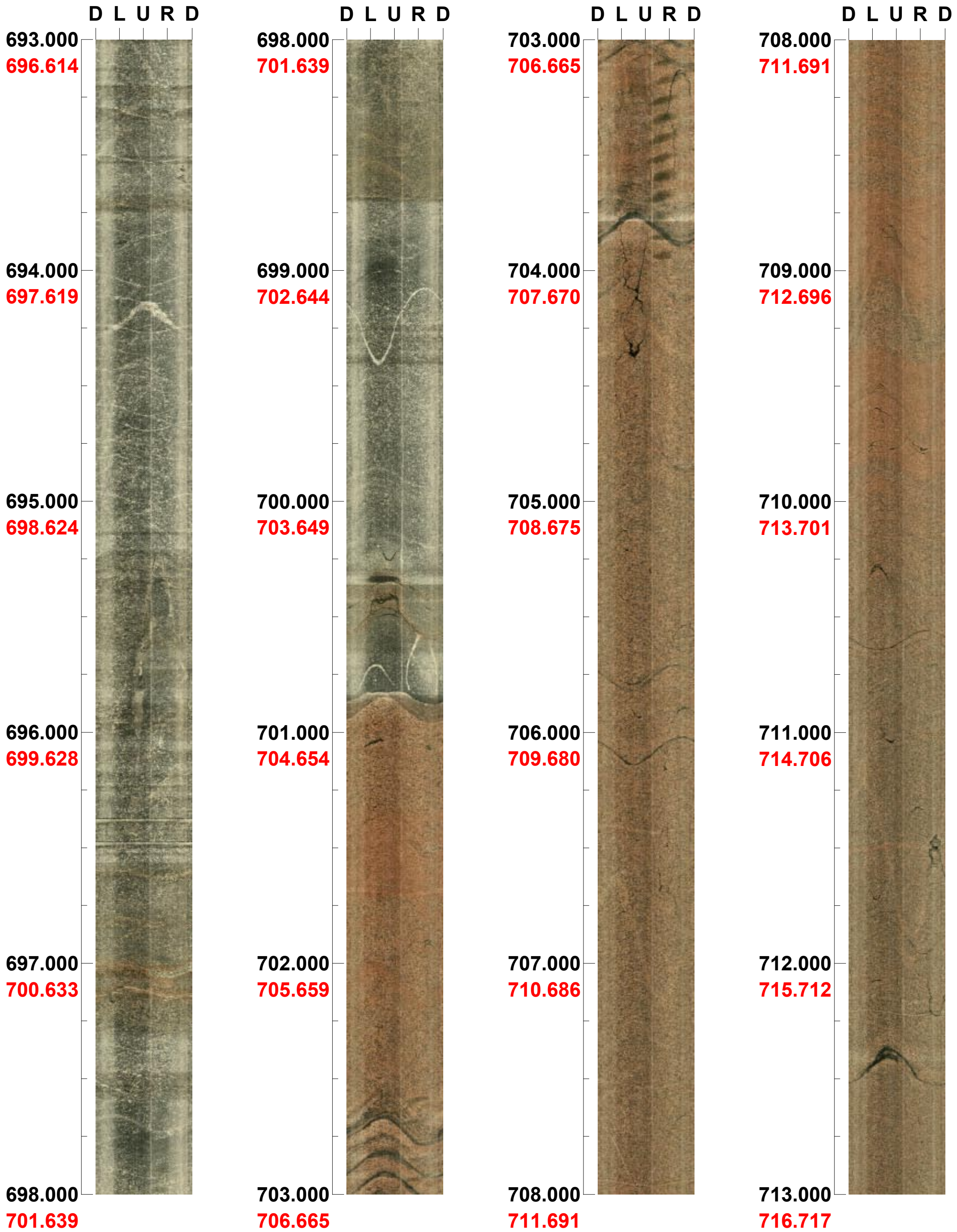
Depth range: 673.000 - 693.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

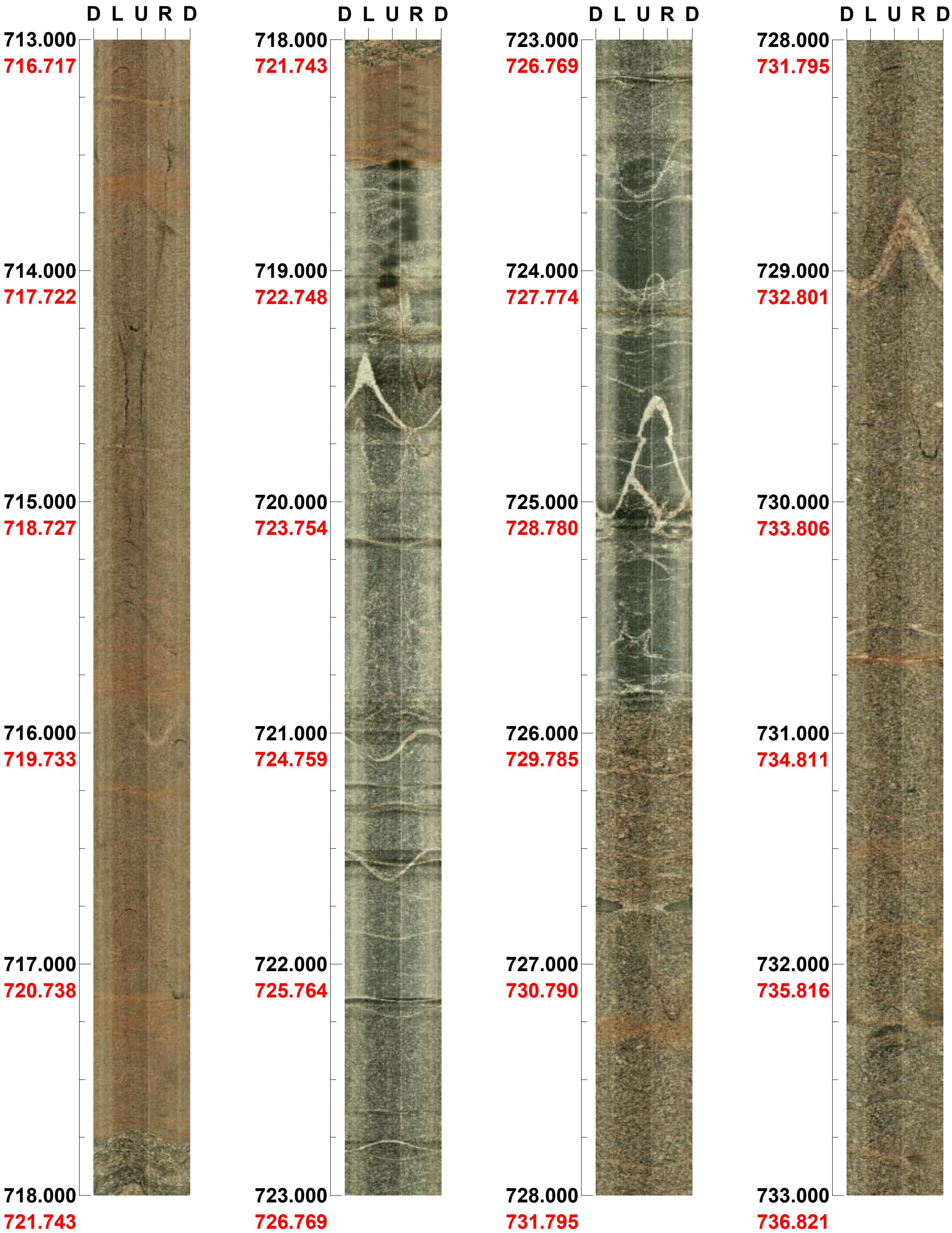
Depth range: 693.000 - 713.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

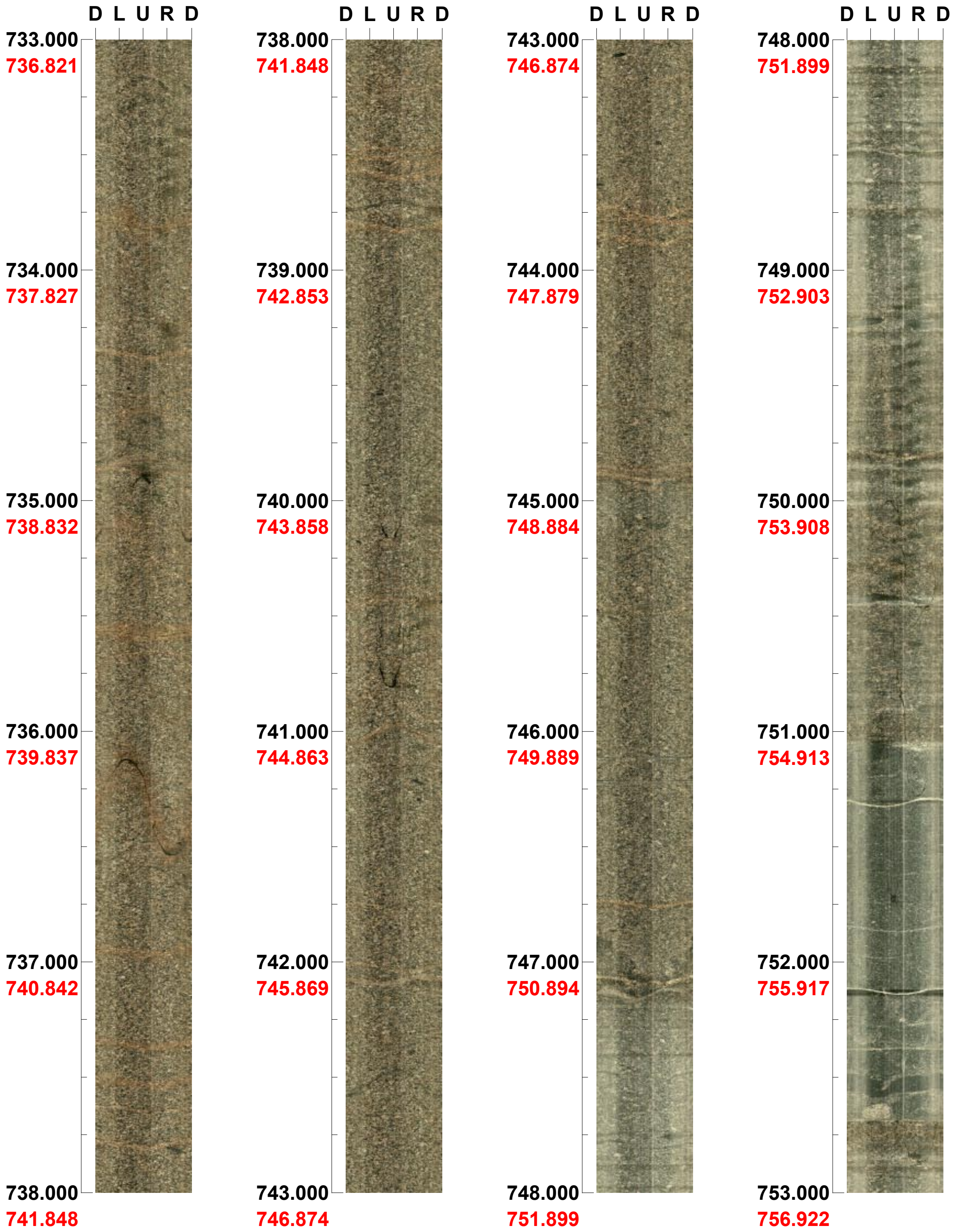
Depth range: 713.000 - 733.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

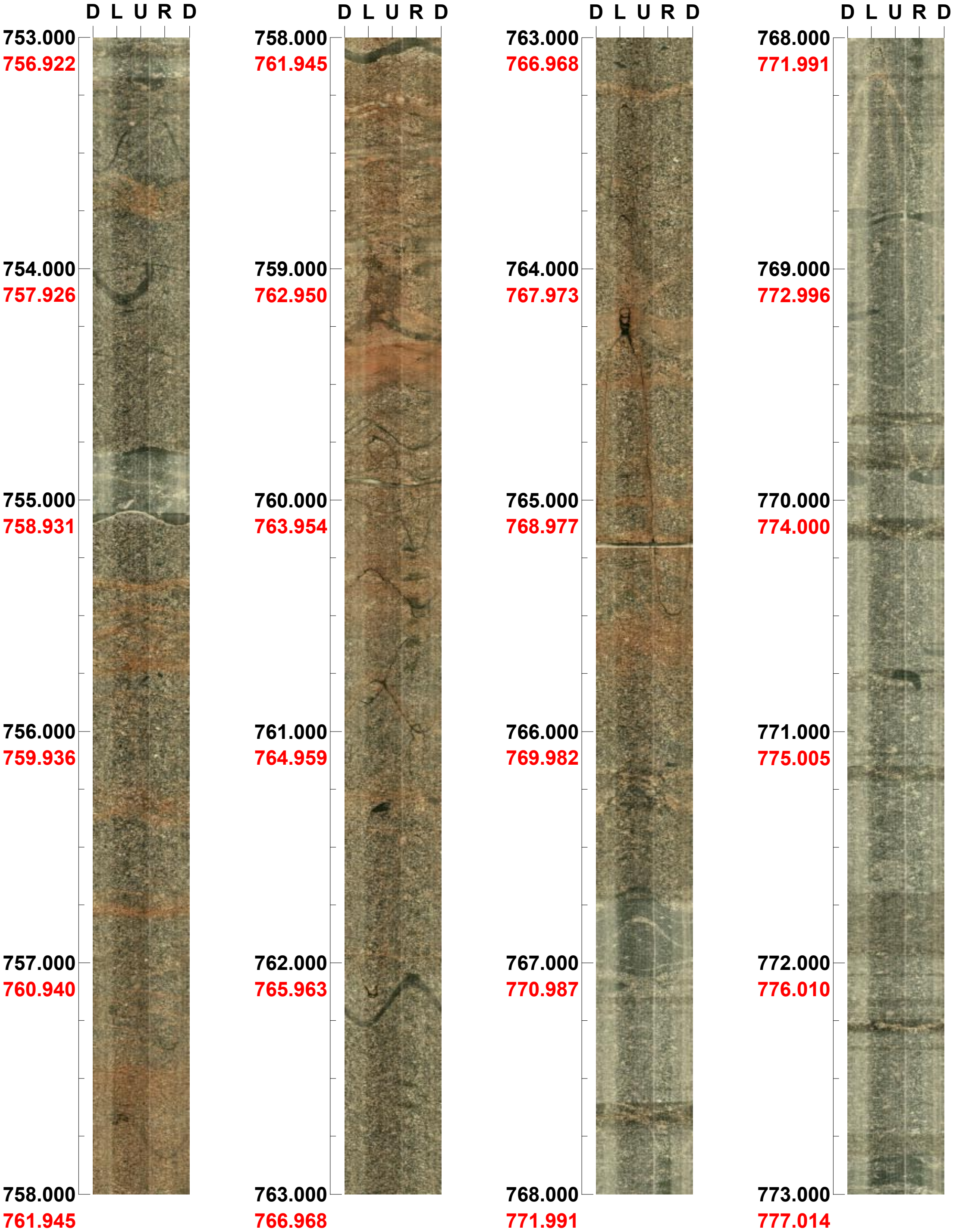
Depth range: 733.000 - 753.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

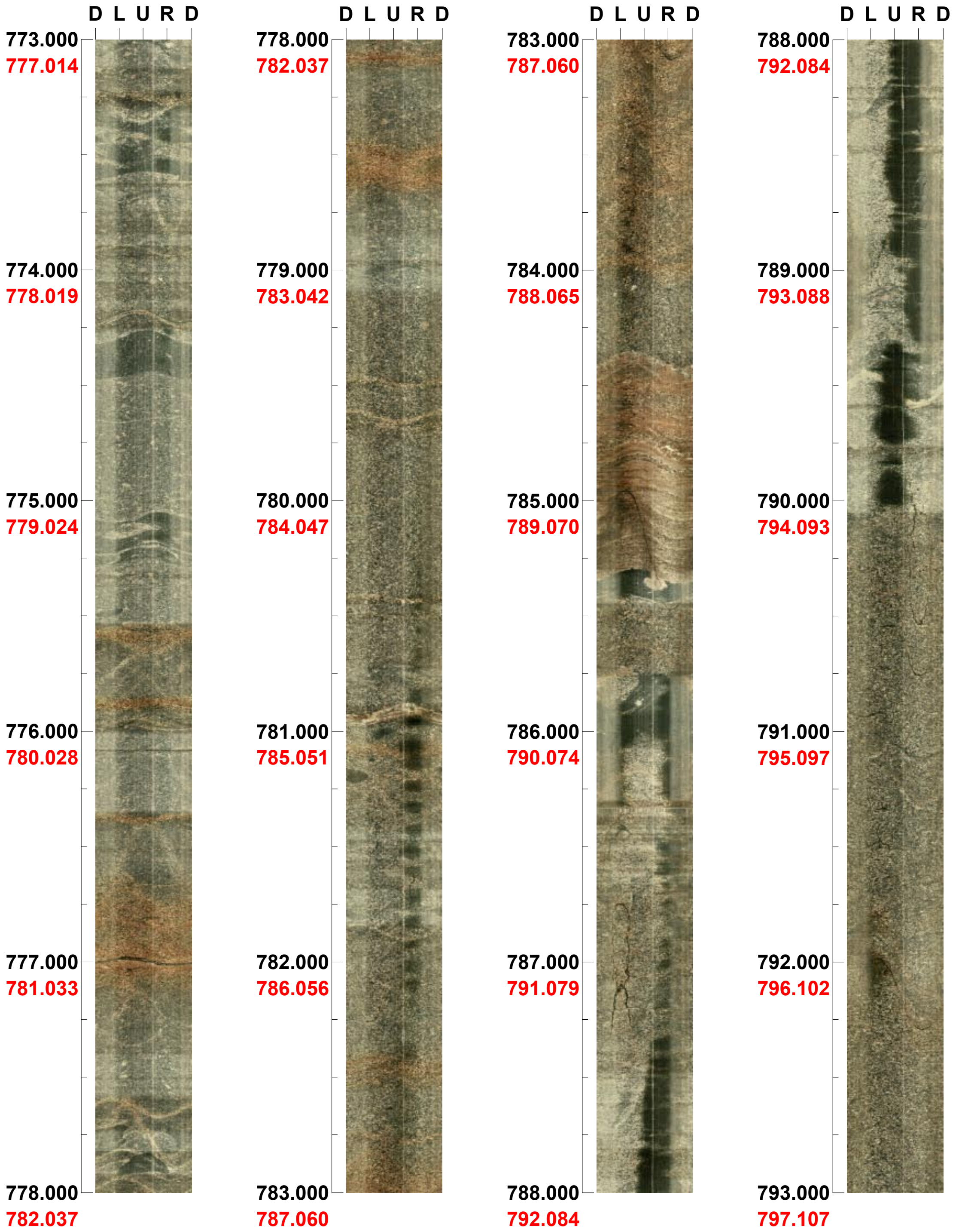
Depth range: 753.000 - 773.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

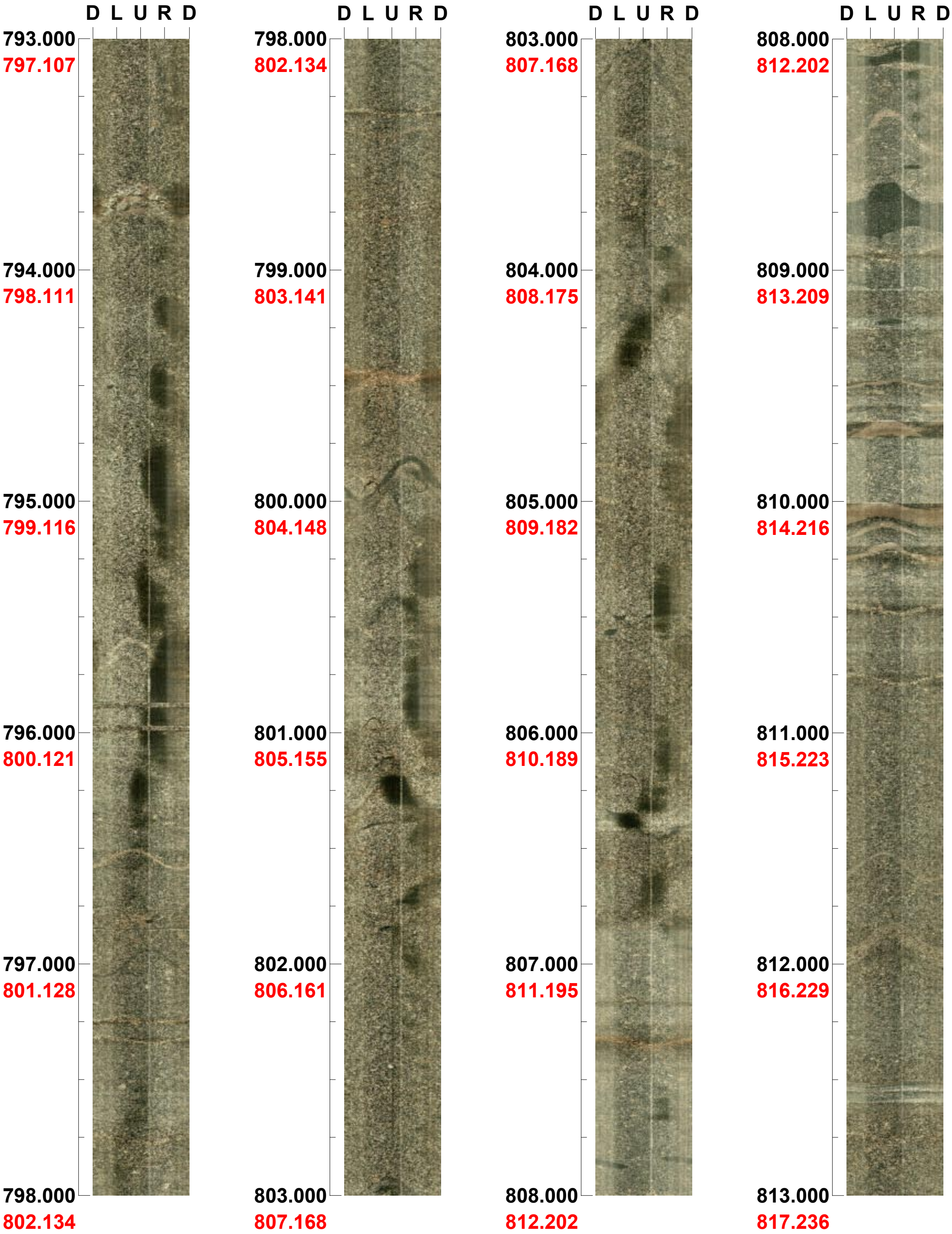
Depth range: 773.000 - 793.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

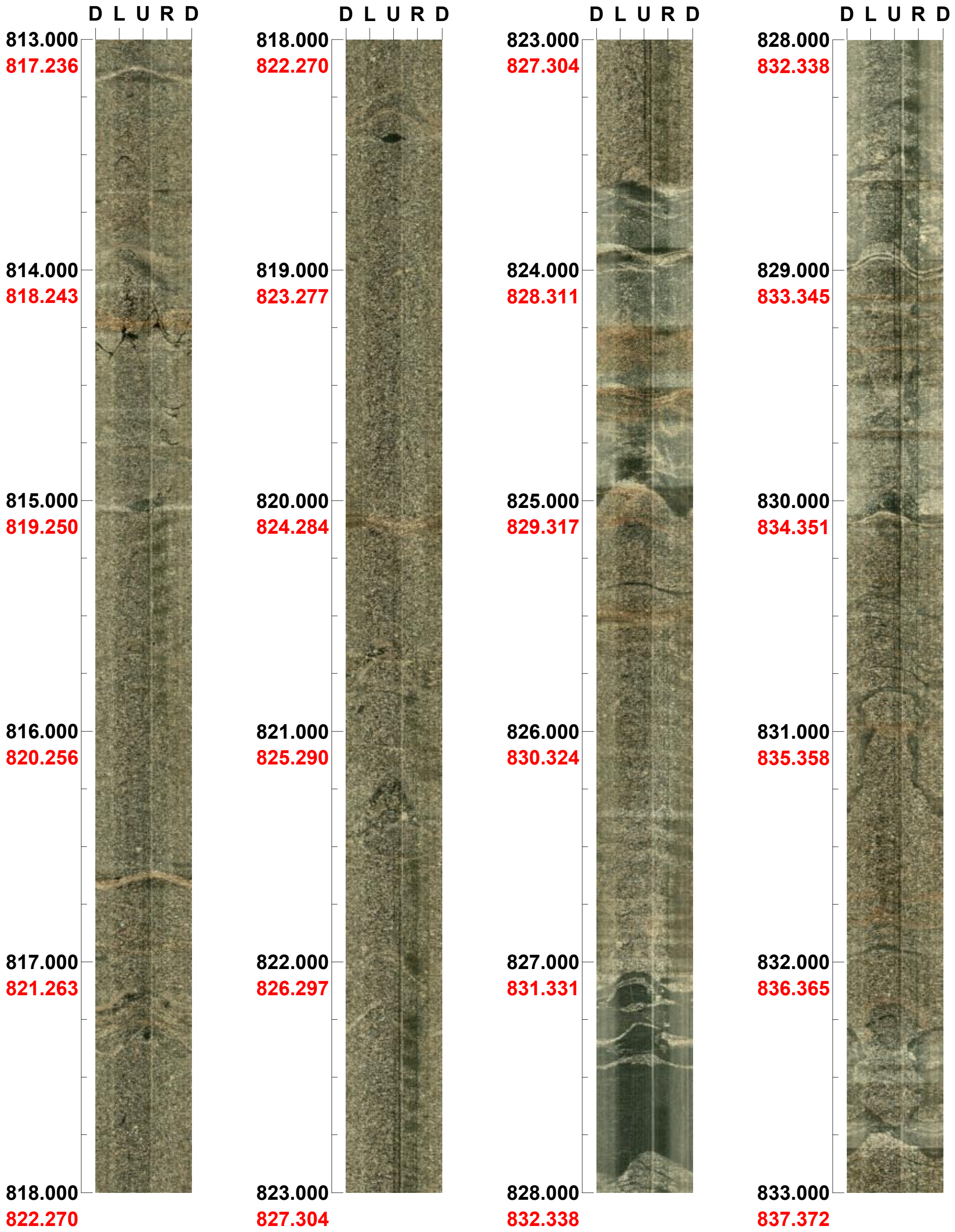
Depth range: 793.000 - 813.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 813.000 - 833.000 m

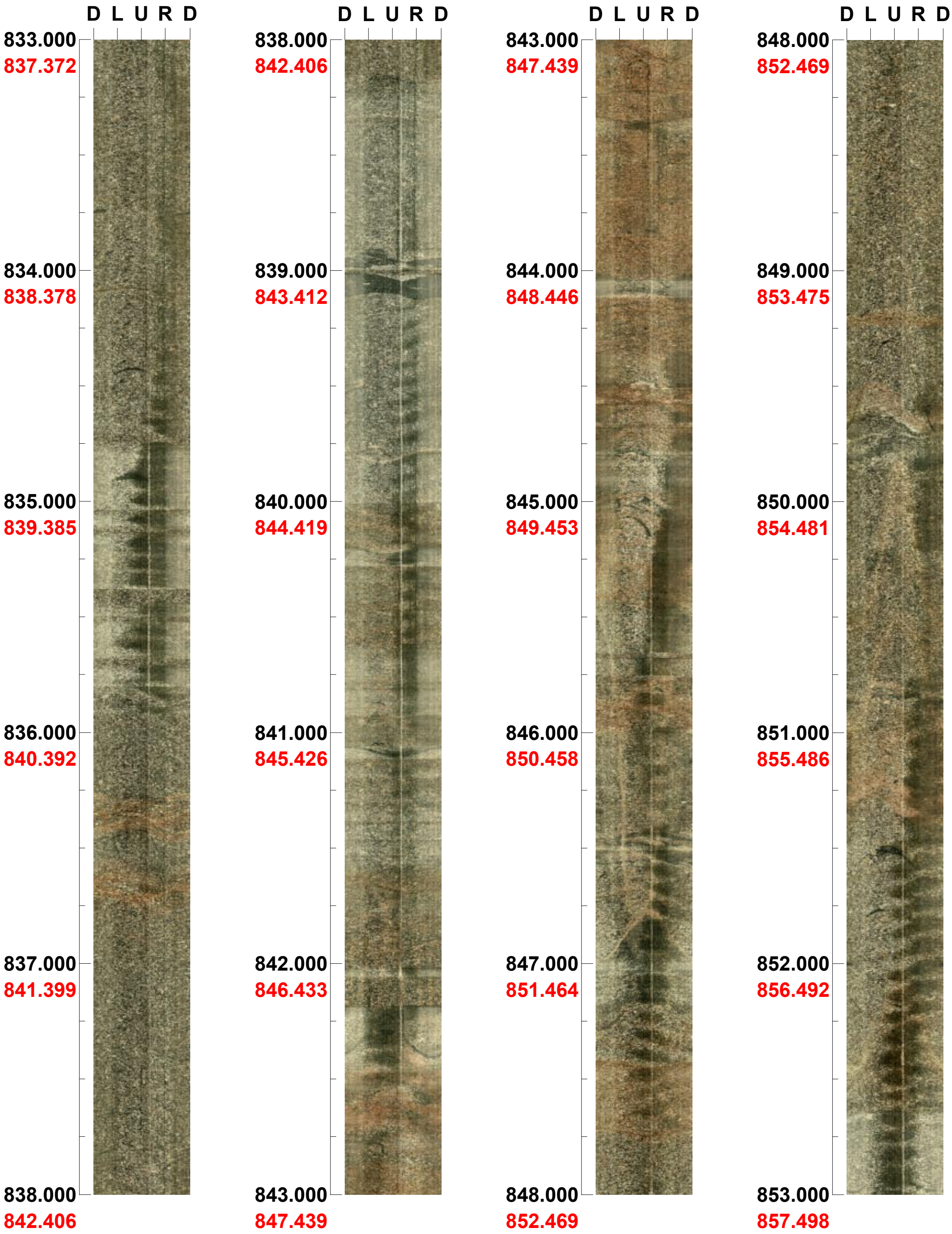


(13 / 21) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 833.000 - 853.000 m

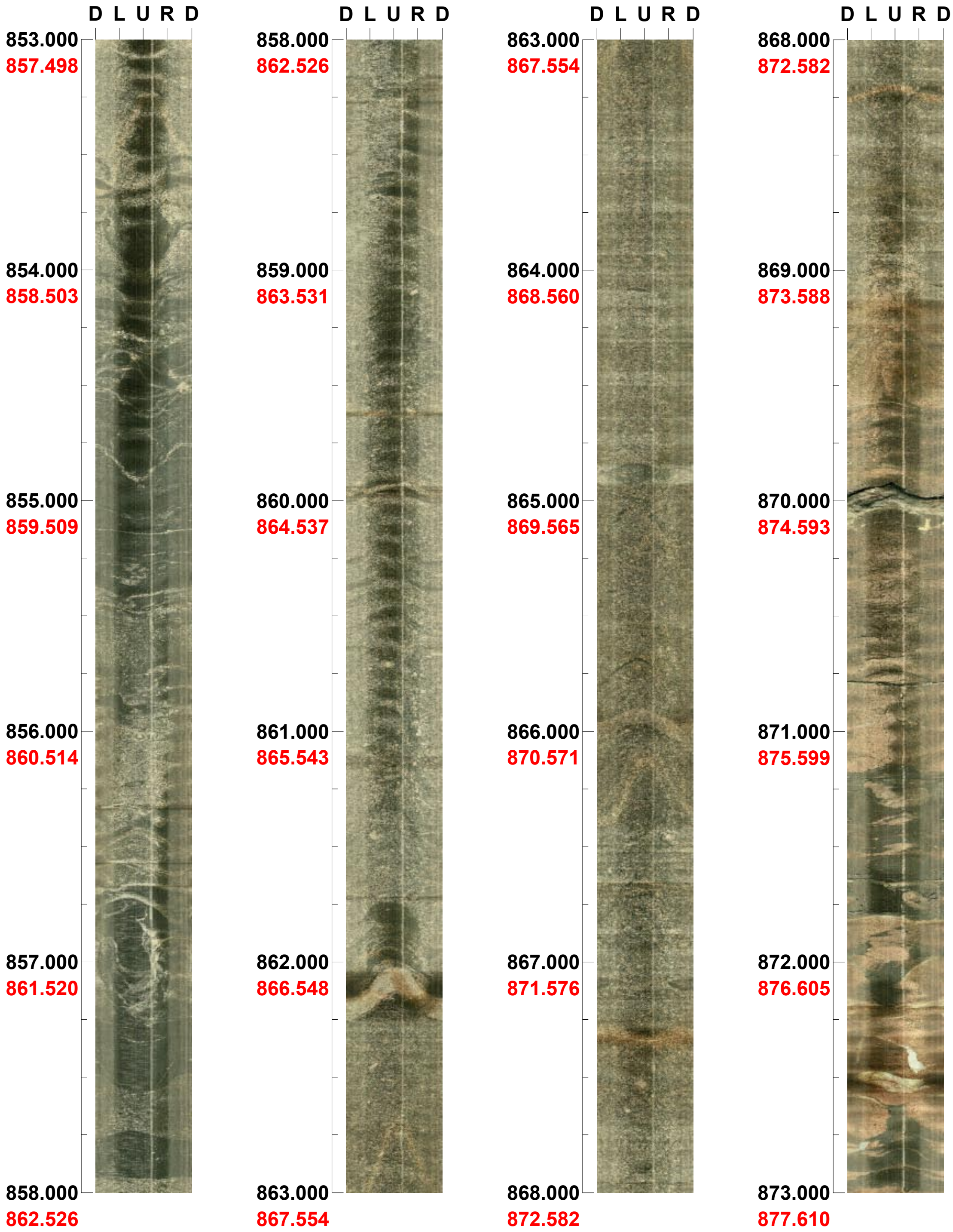


(14 / 21) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 853.000 - 873.000 m

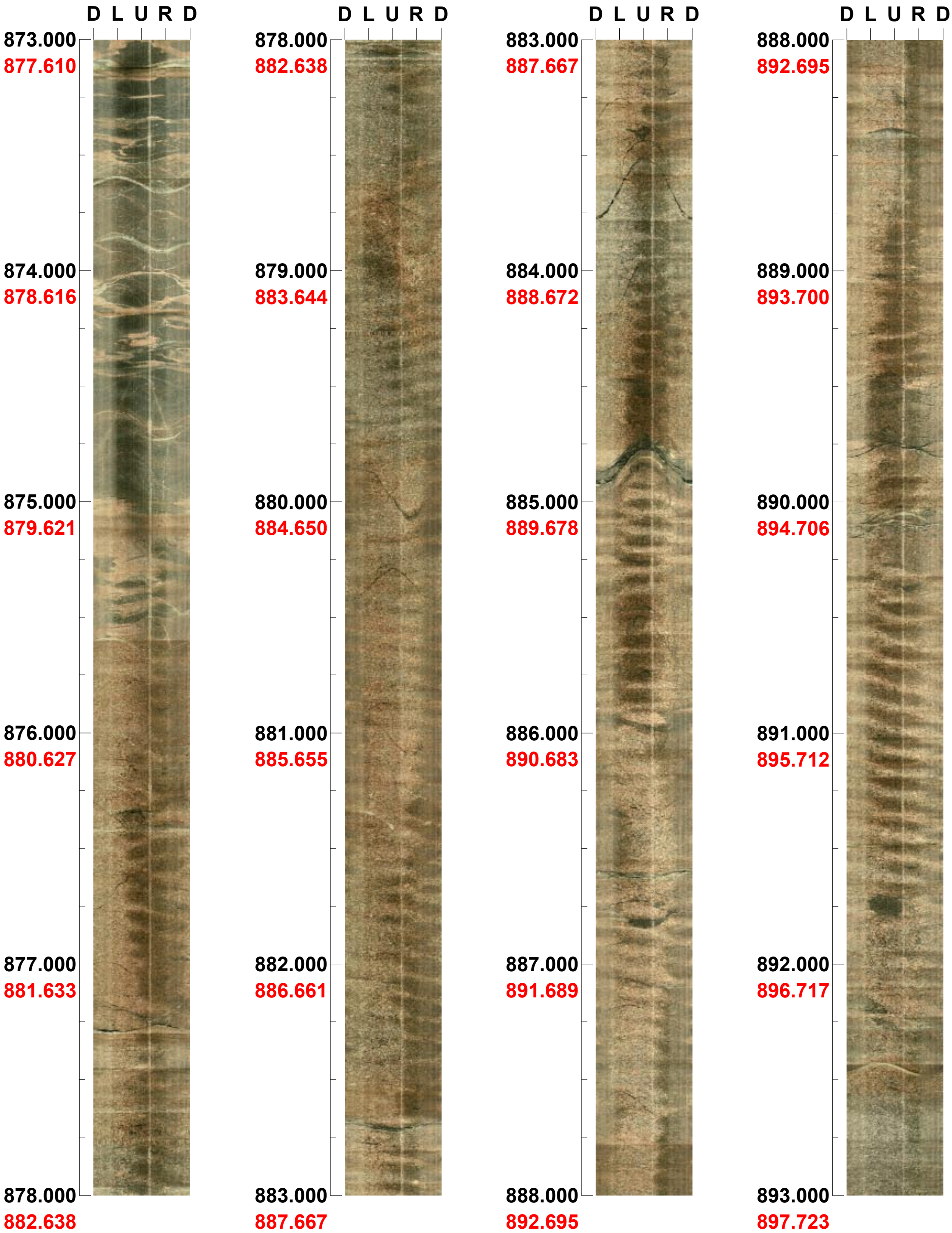


(15 / 21) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 873.000 - 893.000 m

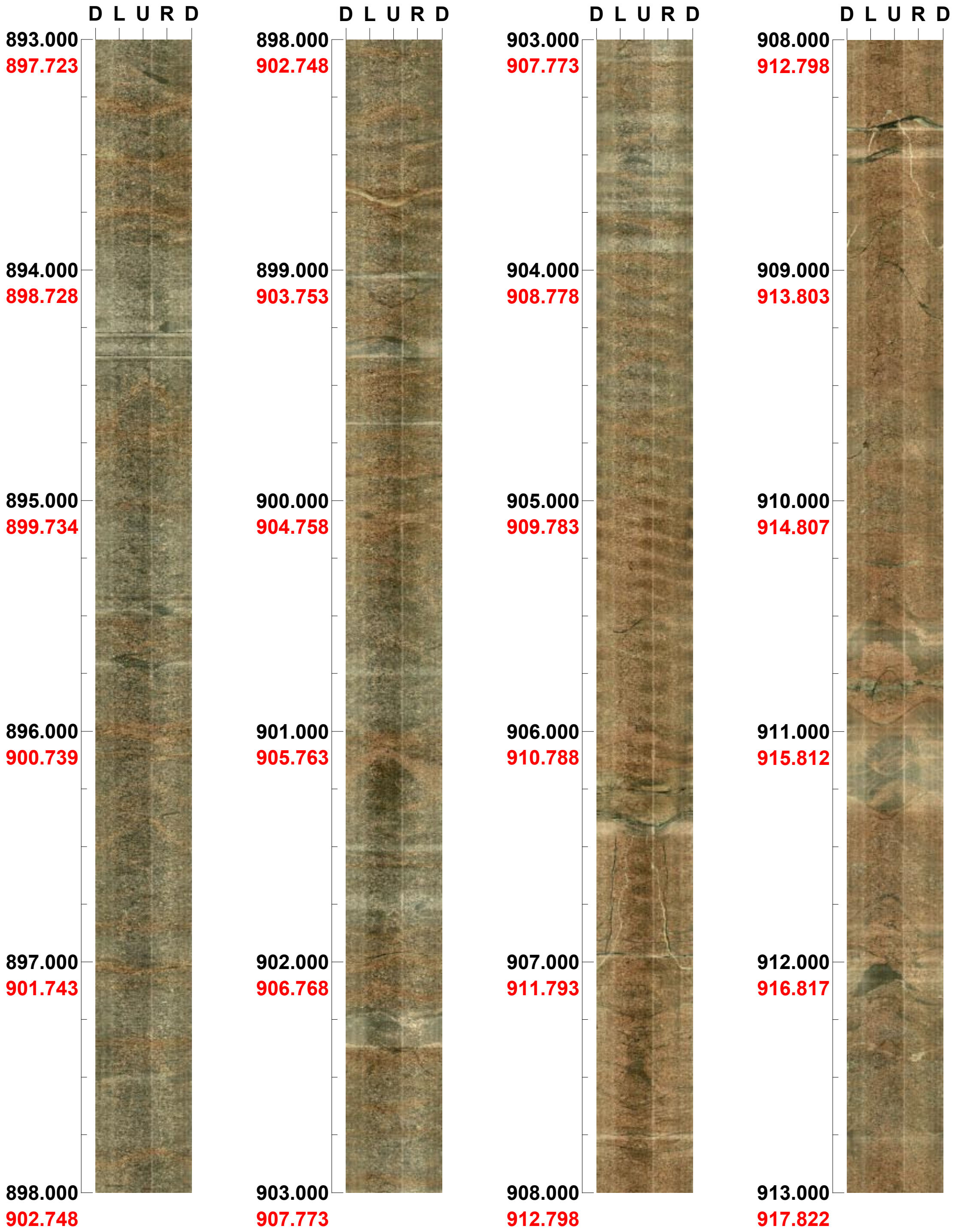


(16 / 21) Scale: 1/25 Aspect ratio: 175 %

Project name: Laxemar

Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

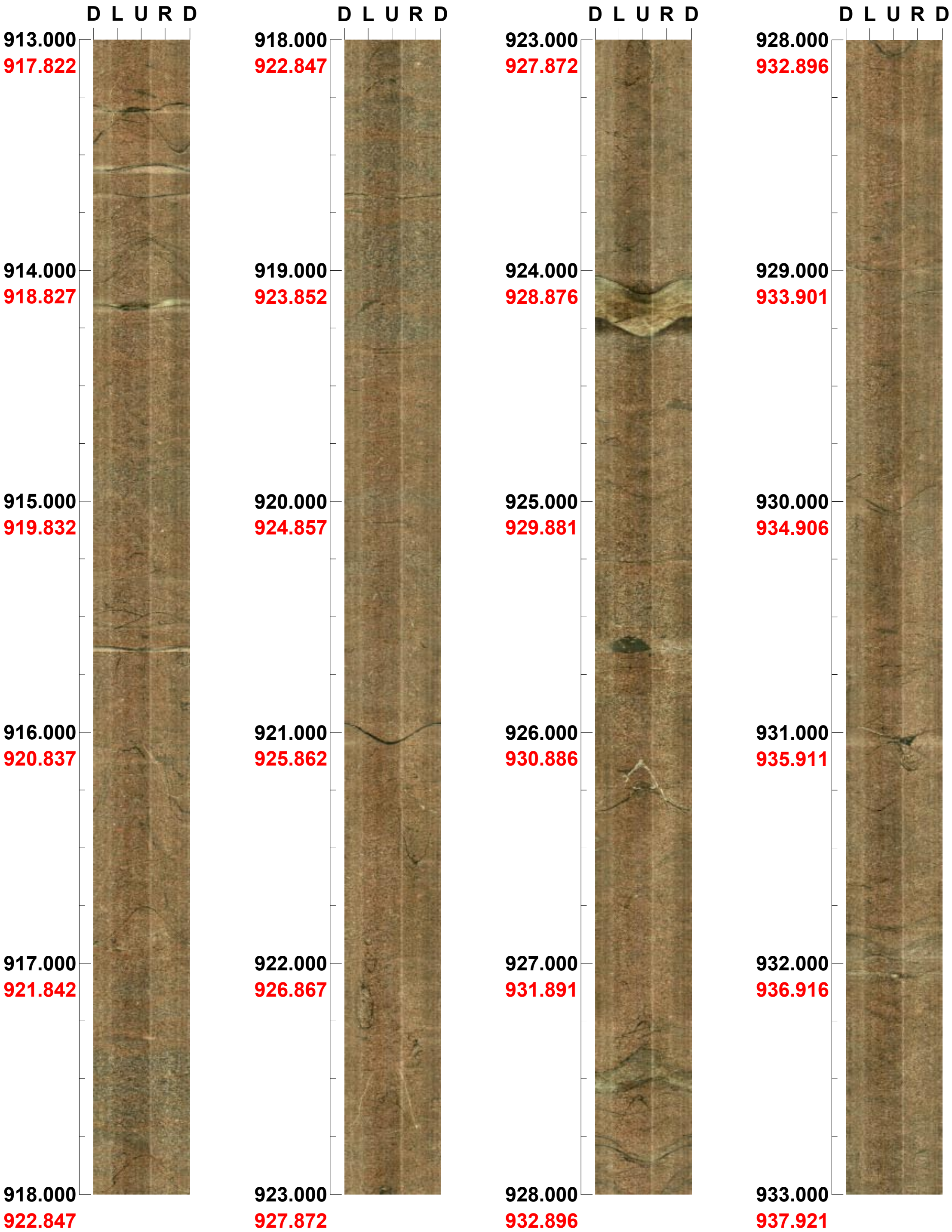
Depth range: 893.000 - 913.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

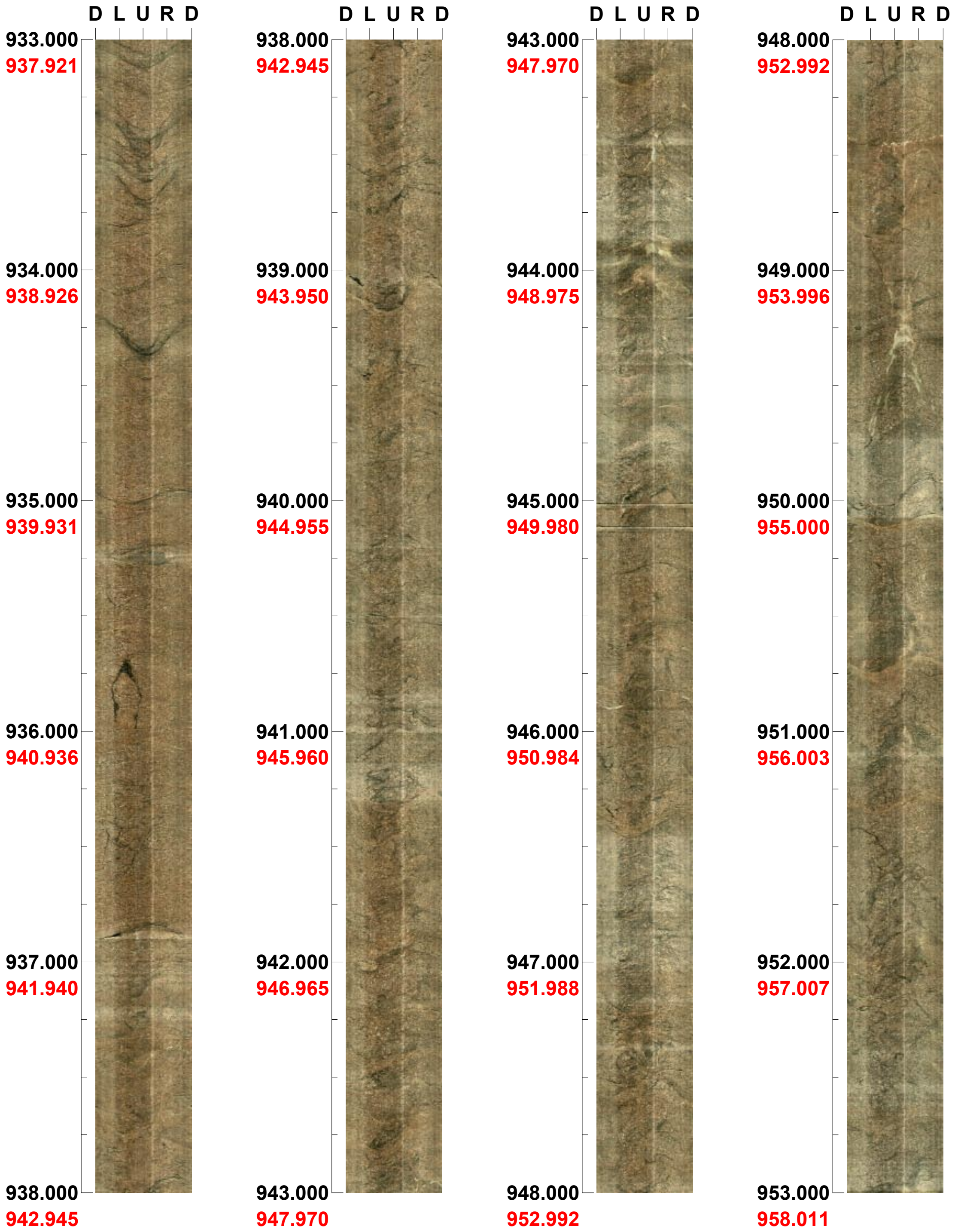
Depth range: 913.000 - 933.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

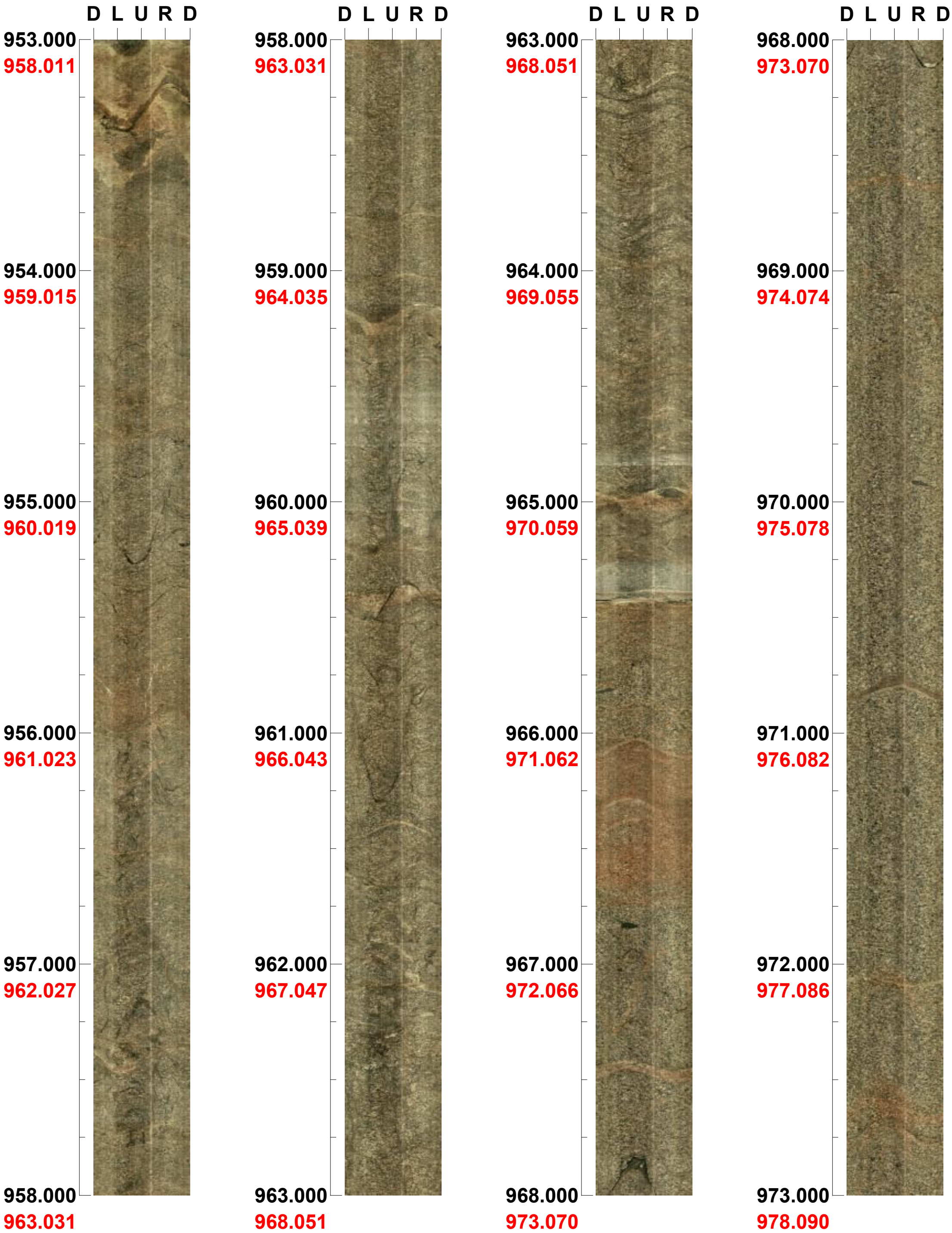
Depth range: 933.000 - 953.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 953.000 - 973.000 m



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

Project name: Laxemar
Bore hole No.: KLX04 **Azimuth: 0** **Inclination: -85**

Depth range: 973.000 - 985.961 m

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