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Oskarshamn site investigation

RAMAC and BIPS logging in boreholes KLX09, HLX36 and HLX37 and deviation logging in HLX36 and HLX37

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February 2006

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Keywords: BIPS, RAMAC, Radar, TV.

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 KLX09 and in the percussion drilled boreholes HLX36 and HLX37. In HLX36 and HLX37 deviation loggings were also carried out. All measurements were conducted by Malå Geoscience AB/RAYCON during December 2005.

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.

The objective of the deviation measurement is to achieve information on borehole coordinates as well as dip and azimuth along the borehole length.

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 deviation measurement is presented as a list of data.

The borehole radar data quality from KLX09, HLX36 and HLX37 was relatively satisfying, but in 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 210 identified radar reflectors in KLX09 and of these 24 were orientated (strike/dip). In HLX36 32 radar reflectors were identified and in HLX37 37 reflectors were identified.

The BIPS images from the boreholes are of very good quality and makes the geological core logging very easy to perform.

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Oskarshamn. Mätningarna som presenteras här omfattar borrhålsradarmätningar (RAMAC), och BIPS-loggningar i kärnborrhålet KLX09, samt i hammarborrhålen HLX36 och HLX37. I borrhålen HLX36 och HLX37 genomfördes även avvikelsemätningar, s k krökningsmätningar. Alla mätningar är utförda av Malå Geoscience AB/RAYCON under december 2005.

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

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

Syftet med krökningsmätningarna är att få fram koordinater samt lutning och riktning för punkter längs med borrhålet.

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 radargram och en lista över tolkade radarreflektorer ges. Krökningsmätningen presenteras som en lista med lägesdata.

Borrhålsradardata från KLX09, HLX36 och HLX37 var relativt tillfredställande, men i delar var djuppenetrationen sämre troligen till stor del beroende på en konduktiv miljö. En konduktiv miljö minskar möjligheterna att identifiera strukturer från borrhålsradardata. Dock har 210 radarreflektorer identifierats i KLX09 och av dessa har 24 orienterats (med strykning/stupning). I HLX36 har 32 radarreflektorer identifierats och 37 reflektorer identifierades i HLX37.

BIPS bilderna från samtliga borrhål är av utmärkt kvalitet vilket gör den geologiska borrkärnekarteringen enkel.

Contents

1 Introduction

This report presents 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 BIPS measurements in the core drilled borehole KLX09 and in the percussion drilled boreholes HLX36 and HLX37. In boreholes HLX36 and HLX37 deviation measurements were also carried out.

The work was carried out in accordance with activity plan AP PS 400-05-093. 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 870 m in KLX09, from 0 to 195 in HLX36 and from 0 to 195 m in HLX37.

The borehole KLX09 are percussion drilled with a diameter of 197 mm down to 100.5 m, from there the borehole is core drilled with a diameter of 76 mm. The percussion drilled boreholes HLX36 and HLX37 are drilled with diameter of 140 mm.

All measurements were conducted by Malå Geoscience AB/RAYCON during December 2005. The investigation site and 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.
- Borehole deviation equipment (Flexit SmartTool from Flexit AB), measuring azimuth, inclination (dip), tool face (gravity and magnetic) and magnetic dip.

The delivered raw and processed data have been inserted in the database of SKB (SICADA) and data are traceable by the activity plan number.

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

Activity plan	**Number**	**Version**
Borrhålsradar och BIPS i KLX09, HLX36 och HLX37 samt krökningsmätning i HLX36 och HLX37	AP PS 400-05-093	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för TV-loggning med BIPS	SKB MD 222.006	1.0
Metodbeskrivning för borrhålsradar	SKB MD 252.020	2.0
Metodbeskrivning för krökningsmätning av hammar- och kärnborrhål	SKB MD 224.001	1.0

Figure 1-1. *Map of the location of the boreholes KLX09, HLX36 and HLX37, in the Laxemar subarea, Oskarshamn.*

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.

The objective of deviation logging is to achieve information of the borehole coordinates as well as dip and azimuth along the entire borehole length.

This report describes the equipment used for the radar, BIPS and deviation surveys 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 deviation measurements are presented as lists of data (coordinates etc).

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.

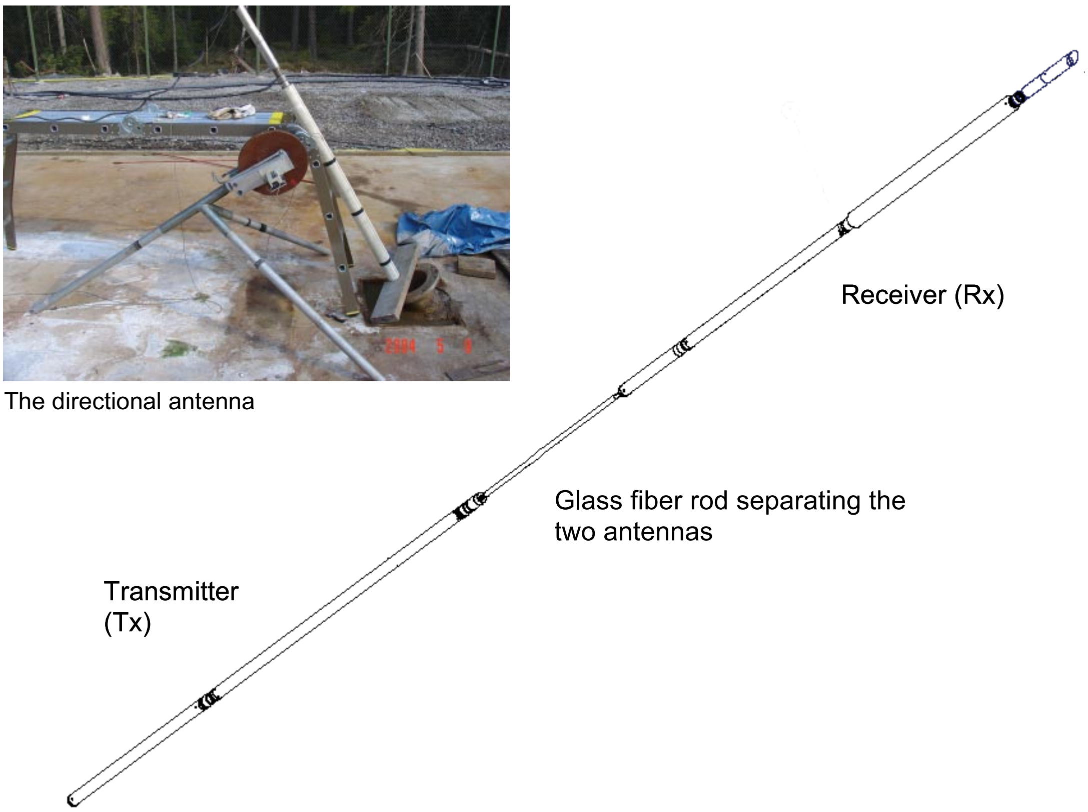


Figure 3-1. *Example of a borehole radar antenna.*

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).

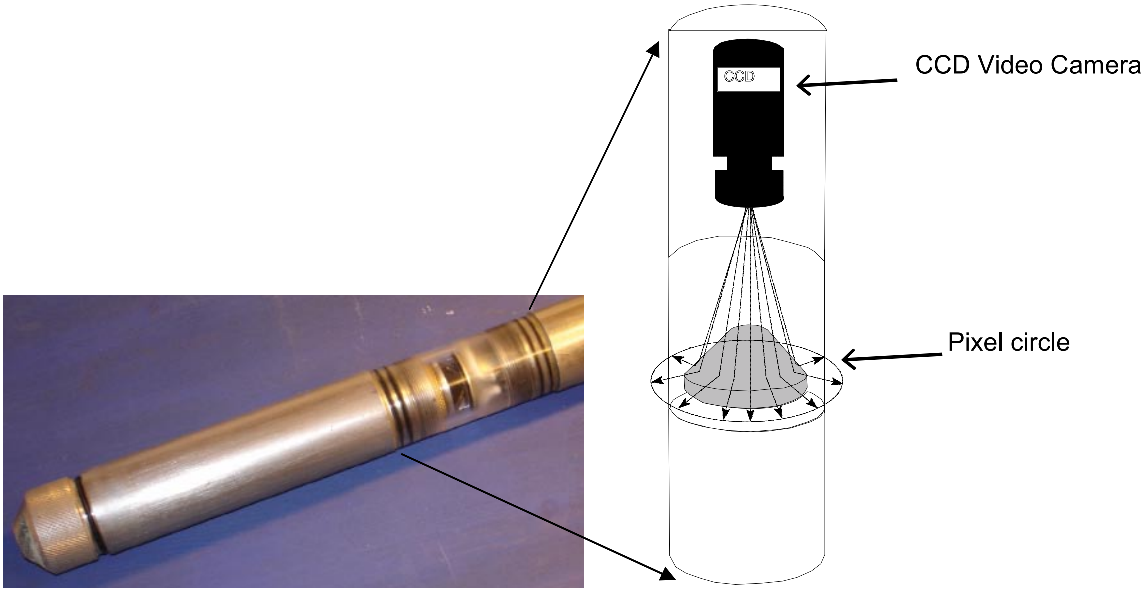


Figure 3-2. *The BIP-system. Illustration of the conical mirror scanning.*

3.3 Deviation measurements, Flexit SmartTool

The deviation measurements were carried out with the Flexit SmartTool Deviation equipment, Figure 3-3. The system is based on station readings.

The system consist of a borehole probe (SensIT) including 3-component magnetometers and accelerometers, measuring a number of different parameters. Table 3-1 describe the delivered parameters. Inside the probe the radio link is also built in were all data is downloaded after the end of the survey. The probe are controlled during the measurement either by an external PC and the software package called MeasureIT or a data pad StoreIT. For processing and reporting data the PC software MeasureIT and DisplayIt are used.

In the Flexit SmartTool system there is a magnetic integrity check to detect magnetic disturbance in the survey measurements. Magnetic disturbance results in incorrect/inaccurate azimuth values. The operator can select the average values for this parameters in the MeasureIT software and run a magnetic integrity check and if necessary change or delete azimuth values. If the azimuth value is changed the new added value by the operator is interpolated from the nearby station readings.

For more information and technical specification visit www.flexit.se.

Table 3-1. Flexit SmartTool result tables.

Dip:	Inclination of the borehole at the position for reading
Azimuth:	Direction of the borehole at the position for reading
Easting Northing and Elevation:	Co-ordinate of the borehole at the position for reading
Mag. Field:	Strength of earth’s magnetic field
Mag. Dip:	Inclination of earth’s magnetic field
Grav. Field:	Indicates if the probe was moved during recording at that station
Status:	Indicates if the azimuth value at the reading station was disturbed or changed by the operator. If the azimuth value has been edited or the magnetic integrity check have indicated a magnetic disturbance at the reading station a symbol with more than two “hands” is visible in the status field. 
Updown:	Shows the distance the actual reading station is above or below the planned straight line for the borehole given the starting direction.
Left/Right:	Shows the distance the actual reading station is left or right the planned straight line for the borehole given the starting direction.
Short Fall:	Shows the amount the actual point falls short of the planned survey point

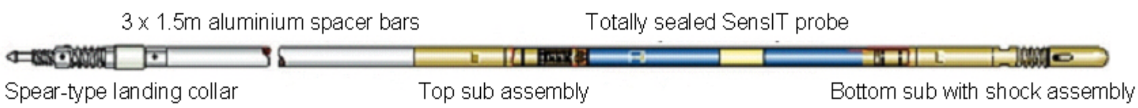


Figure 3-3. *The FlexIT SmartTool-system. Illustration of the set-up in the borehole.*

4 Execution

4.1 General

4.1.1 RAMAC Radar

The measurements in KLX09, HLX36 and HLX37 were carried out with dipole radar antennas, with frequencies of 250, 100 and 20 MHz. In KLX09 measurements were also carried out using the directional antenna, with a central frequency of 60 MHz.

During logging the dipole antennas (transmitter and receiver) were lowered continuously into the borehole and data were recorded on a field PC along the measured interval. The measurement with the directional antenna is made step wise, with a short pause for each measurement occasion. The antennas (transmitter and receiver, both for dipole and directional) are kept at a fixed separation by glass fibre rods according to Tables 4-1 to 4-3. 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 KLX09. This was performed by measurements in the air, where the receiver antenna and the transmitter antenna are placed apart. While transmitting and measuring the receiver antenna is turned around and by that giving the direction from the receiver antenna to the transmitter antenna. The difference in direction is measured by compass and the result difference achieved from the directional antenna was about 9 degrees. This can be considered to be good due to the disturbed environment, with metallic objects etc at the test site.

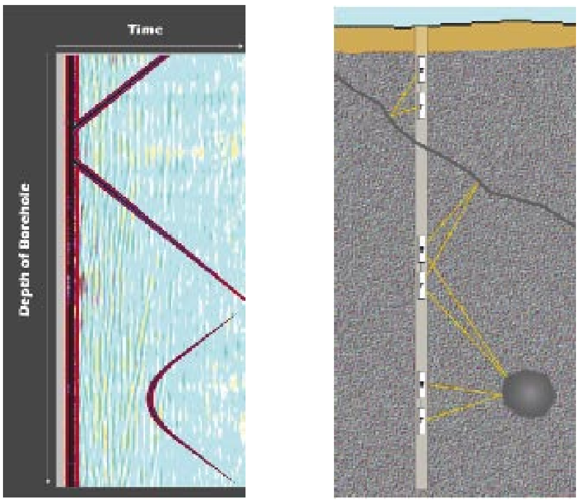


Figure 4-1. *The principle of radar borehole reflection survey and an example of result.*

For more information on system settings used in the investigation of KLX09, HLX36 and HLX37, see Tables 4-1 to 4-3 below.

Table 4-1. Radar logging information from KLX09.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KLX09**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
Logging date:		05-12-10	05-12-06	05-12-06	05-12-06
Reference:		T.O.C.	T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):		615	2,424	891	239
Number of samples:		512	619	518	518
Number of stacks:		32	Auto	Auto	Auto
Signal position:		410.5	–0.34	–0.35	1.42
Logging from (m):		103.4	1.5	2.6	6.25
Logging to (m):		868.4	872.3	872	867.4
Trace interval (m):		0.5	0.1	0.2	0.25
Antenna separation (m):		5.73	2.4	3.9	10.05

Table 4-2. Radar logging information from HLX36.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**	
BH:	**HLX36**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Logging date:		05-12-07	05-12-07	05-12-07
Reference:		T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):		2,424	891	239
Number of samples:		619	518	518
Number of stacks:		Auto	Auto	Auto
Signal position:		–0.34	–0.35	–1.42
Logging from (m):		1.5	2.6	6.25
Logging to (m):		197.8	196.7	192.6
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 HLX37.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**	
BH:	**HLX37**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Logging date:		05-12-07	05-12-07	05-12-07
Reference:		T.O.C.	T.O.C.	T.O.C.
Sampling frequency (MHz):		2,424	891	239
Number of samples:		619	518	518
Number of stacks:		Auto	Auto	Auto
Signal position:		–0.34	–0.35	–1.42
Logging from (m):		1.5	2.6	6.25
Logging to (m):		197.9	196.9	192.6
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 KLX09, HLX36 and HLX37.

In order to control the quality of the system, calibration measurements were performed in a test pipe before logging and after logging. Figure 4-2 show the results of the test logging performed before and after the logging of KLX09, HLX36 and HLX37. The results showed no difference regarding the colours and focus of the images. Results of the test loggings were included in the delivery of the raw data.

The BIPS logging information is found in the header for every single borehole presented in Appendices 4 to 6 in this report.

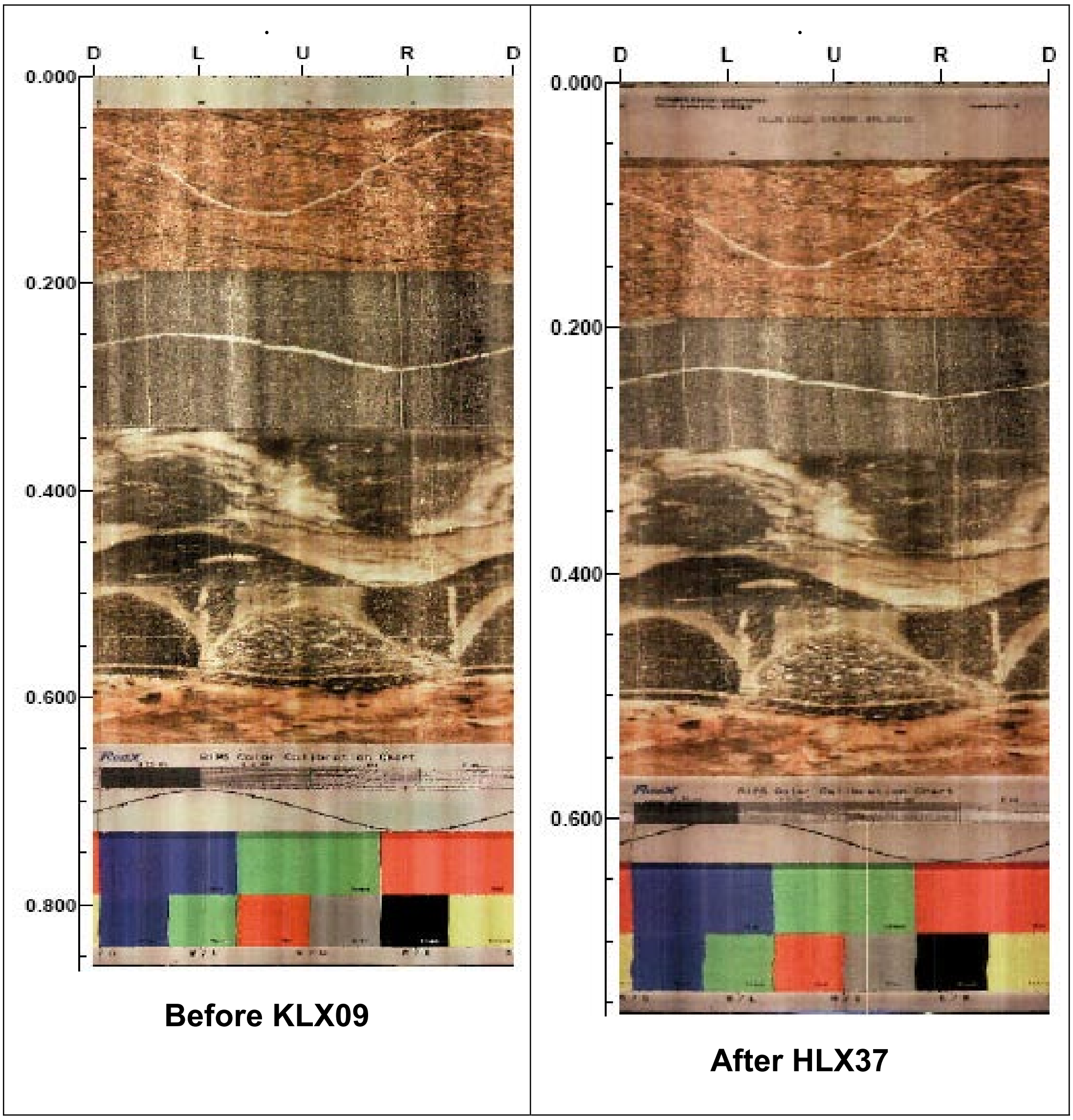


Figure 4-2. Results from logging in the test pipe before and after the logging campaign in December 1st to 7th , 2005.

4.1.3 Deviation measuremnts

The deviation measurements were carried out according to the instructions and guidelines from SKB (internal document MD 224.001). All cleaning of the probe and cable was performed according to the internal document SKB MD 600.004 before the logging operation.

During the logging a measurement were performed for each 3 m. The logging was carried out in two directions, both from the surface measuring to the bottom of the borehole and a second run measuring from the bottom of the borehole up to the surface. For the operation in the borehole the RAMAC/BIPS winch installed in the container was used together with the standard length measuring devices. For an accurate depth control the length recording was adjusted regularly for every 50 m by the actual marks on the logging cable.

4.1.4 Length measurements

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

During the BIPS logging in core drilled boreholes, where the reference marks in the borehole wall is visible on the image, the position where the depth mark is visible is marked with scotch tape on the logging cable. During BIPS logging the measured length was adjusted to true length according to depth mark visible in the BIPS image. The adjusted true length is marked with red in the image plot together with the non-adjusted measured length. The non-adjusted length is marked with black as seen in Appendices 4 to 6. The tape marks on the logging cable are then used for controlling the RAMAC measurement.

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

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

4.2 Analyses and interpretation

4.2.1 Radar

The result from radar measurements is most often presented in the form of a radargram where the position of the probes is shown along one axis and the radar wave propagation and reflection 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 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. For this logging campaign the velocity determination was performed between KLX07A and KLX07B by keeping the transmitter fixed in one borehole while moving the receiver downwards in a nearby borehole. The velocity measurement was performed with the 20 MHz antennas in boreholes KLX07A and KLX07B /1/.

The result is plotted in Figure 4-3 and the calculation shows a velocity varying between 110 and 117 m/micro seconds. The lower velocities most probably represent a fracture zone in the depth interval 40 to 60 m.

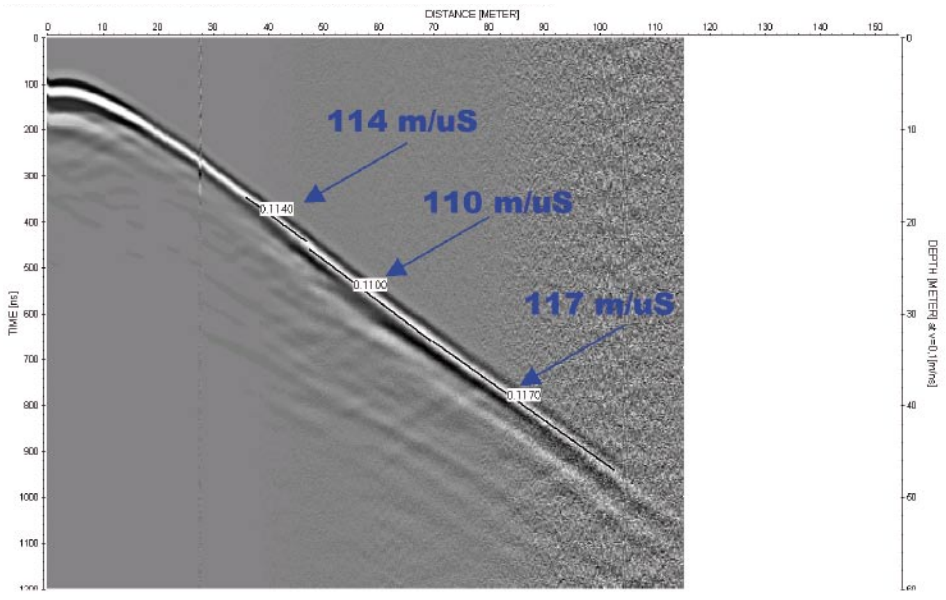


Figure 4-3. *Results from velocity measurements /1/.*

The visualization of data is made with ReflexWin, a Windows based processing software for filtering and analysis of borehole radar data. The processing steps are shown in Tables 4-4 to 4-6. It should be observed that the processing steps in Tables 4-4 to 4-6 below refer to Appendix 1 to 3 in this report. The filters applied affect the whole borehole length and are not always suitable in all parts, depending on the geological conditions and conductivity of the borehole fluid. During interpretation further processing can be done, most often in form of bandpass filtering. This filtering can be applied just in parts of the borehole, where needed.

For the interpretation of the intersection angle between the borehole axis and the planes visible on the radargrams the RadinterSKB software has been used. The interpreted intersection points and intersection angles of the detected structures are presented in the Tables 5-4 to 5-6 and are also visible on the radargrams in Appendices 1 to 3.

Table 4-4. Processing steps for borehole radar data from KLX09.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KLX09**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
Processing:		Move start time (–56 samples)	Move start time (–35)	Move start time (–53.7)	Move start time (–107.7)
		DC shift (400–510)	DC shift (190–230)	DC shift (470–530)	DC shift (1,800–2,000)
		Time gain (start 98 lin 100 exp 2)	Gain (start 9 lin 1 exp 1)	Gain (start 47 lin 1.2 exp 0.64)	Gain (start 155 lin 1.44 exp 0.25)
		(FIR)			

Table 4-5. Processing steps for borehole radar data from HLX36.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**	
BH:	**HLX36**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Processing:		Move start time (–36.4)	Move start time (–53.8)	Move start time (–112.4)
		DC removal (190–230)	DC removal (470–530)	DC removal (1,800–2,000)
		Gain (start 25 linear 0 exp. 1.4)	Gain (start 64 linear 0.8 exp 0.8)	Gain (start 90 linear 1, exp 0.2)

Table 4-6. Processing steps for borehole radar data from HLX37.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**	
BH:	**HLX37**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Processing:		Move start time (–37.6)	Move start time (–55.3)	Move start time (–112.4)
		DC removal (190–230)	DC removal (470–530)	DC removal (1,800–2,000)
		Gain (start 31 linear 0 exp. 2.5)	Gain (start 62 linear 1 exp 0.64)	Gain (start 125 linear 1, exp 0.26)

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 BIPP from RaaX was used.

4.2.3 Deviation meausrements

The resulting data from the deviation measurements were corrected relatively to the magnetic North, 2.33 degrees east of RT90 North for the presentation in Appendices 7 and 8. For delivery to SICADA the azimuth was delivered relatively to magnetic North.

4.3 Nonconformities

No nonconformities occurred during this logging campaign.

5 Results

The results from the BIPS measurements for KLX09, HLX36 and HLX37 were delivered as raw data (*.bip-files) on CD-ROM disks and MO-disks 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 digital data and VHS tapes stored by SKB.

The RAMAC radar data was delivered as raw data (file format *.rd3 or *.rd5) for KLX09, HLX36 and HLX37 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 results from the deviation measurement were delivered to SKB in form of raw Flexit files and Excel-files, and also presented in Appendices 7 and 8 in this report. Each reading station depth are referred from TOC in the appendices.

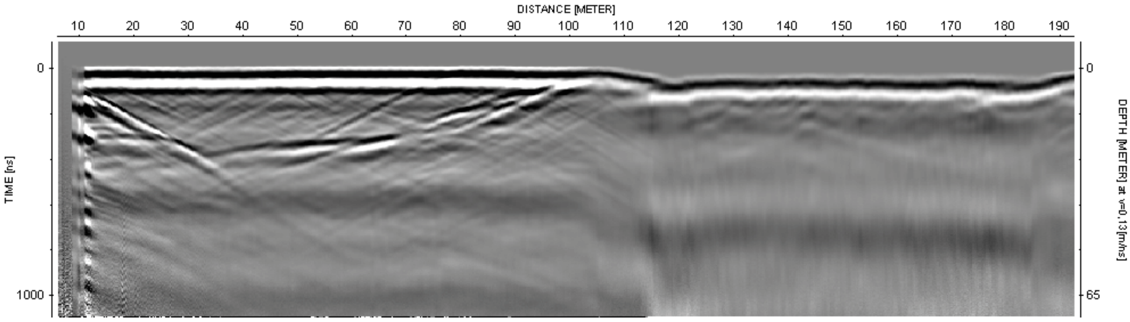
The delivered raw and processed data have been inserted in the database of SKB (SICADA) and data are traceable by the activity plan number.

5.1 RAMAC logging

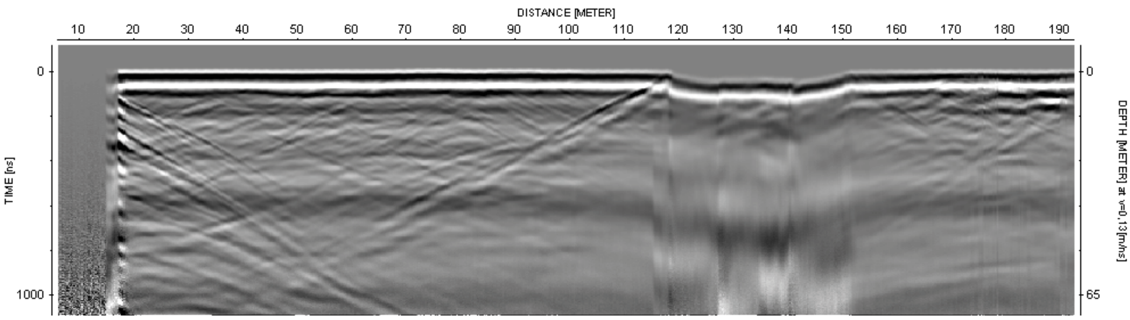
The results of the interpretation of the radar measurements are presented in Tables 5-1 to 5-6 and in Table 5-10. Radardata is also visualized in Appendices 1 to 3. It should be remembered that the images in Appendices 1 to 3 are only a composite picture of all events 360 degrees around the borehole, and do not reflect the orientation of the structures.

Only the larger clearly visible structures are interpreted in RadinterSKB. Overviews of the four different boreholes are given in Figure 5-1 below. A number of minor structures also exist, indicated in Appendices 1 to 3. Often a number of structures can be noticed, but most probably lying so close to each other that it is impossible to distinguish one from the other. Larger structures parallel to the borehole, if present, are also indicated in Appendices 1 to 3. 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.

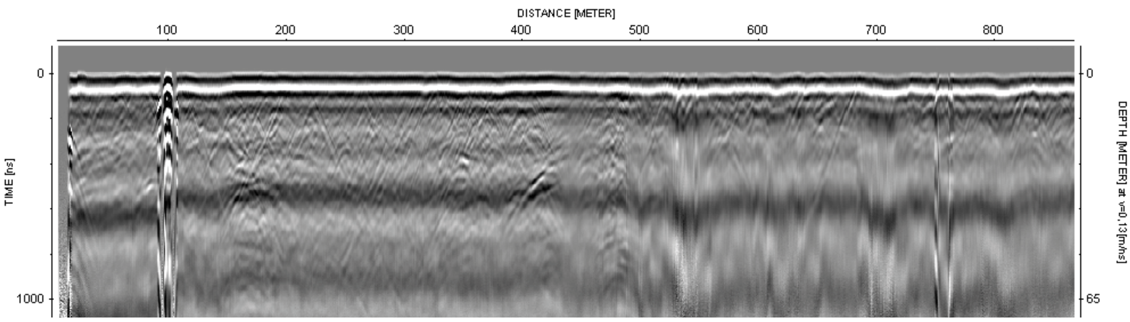
The data quality from KLX09, HLX36 and HLX37, (as seen in Appendices 1 to 3) is satisfying, but in relatively large parts of lower quality due to more conductive conditions. This is seen for all the three boreholes. In the two percussion drilled boreholes the lower penetration are received is due to a mafic dike intersecting the boreholes. The mafic dike intersect in HLX 36 in-between 112 m and 191 m and in HLX37 in-between 122 m and 146 m. In the upper part of the boreholes the boundary between the granite and the mafic dike is clearly indicated on the radargrams. A conductive environment makes the radar wave to attenuate, which decreases the penetration. This conductive environment of course also reduces the possibility to distinguish and interpret possibly structures in the rock which otherwise could give a reflection. For KLX09 the conductive condition that limits the penetration is caused buy a higher salinity of the borehole water.



HLX36



HLX37



KLX09

Figure 5-1. *An overview (20 MHz data) of the radar data for the three different boreholes; HLX36, HLX37 and KLX09. Observe that the length (x-scale) differs between the different boreholes.*

This effect is also seen in the directional antenna for KLX09, which makes it more difficult to interpret the direction to the identified structures.

Further on, depending on the size of the borehole, the conductivity and the antenna frequency, so called ringing can be achieved, which again makes the interpretation of single structures quite complicated. This is seen for instance in the data from KLX09, (250 and 100 MHz data) for the first 100 m, where the borehole diameter is larger. See also Figure 5-2.

In parts with an increased conductivity and thereby a decreased depth penetration most often only the edges of structures can be distinguished, giving an intersection angle of 90 degrees. This is especially seen in the 250 MHz data for HLX36 and HLX37 in Appendices 2 and 3.

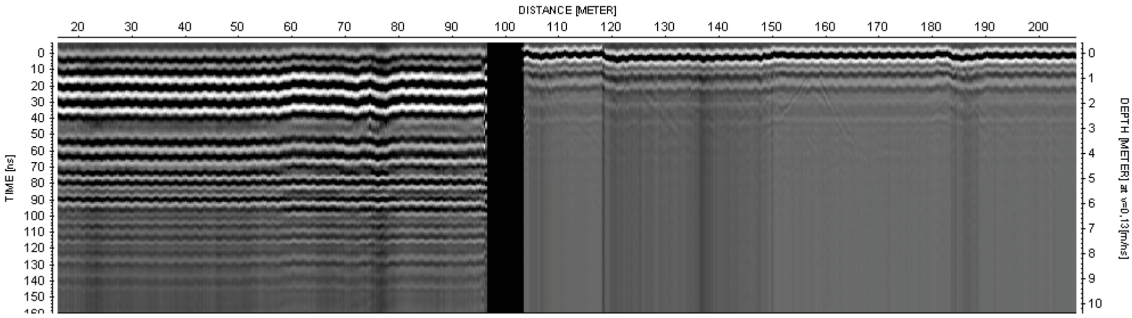


Figure 5-2. *Example of raw data from KLX09 (250 MHz data). The effect of the two different borehole diameters are clearly seen, in the amount of so called ringing, in the upper part compared to the lower part of the picture.*

As also seen in Appendices 1 to 3 the resolution and penetration of radar waves depend on the antenna frequency used. Low antenna frequency gives less resolution but higher penetration depth compared to a higher frequency. If structures can be identified with all three antenna frequencies, it can probably be explained by that the structure is quite significant.

In Table 5-1 to 5-3 below the distribution of identified structures along the borehole are listed for KLX09, HLX36 and HLX37.

Table 5-1. Identified structures as a function of depth in KLX09.

Depth (m)	No. of structures
–100	3
100–150	18
150–200	18
200–250	15
250–300	15
300–350	16
350–400	18
400–450	12
450–500	12
500–550	10
550–600	14
600–650	12
650–700	12
700–750	13
750–800	10
800–850	8
850–	4

Table 5-2. Identified structures as a function of depth in HLX36.

Depth (m)	No. of structures
–20	3
20–40	4
40–60	6
60–80	5
80–100	3
100–120	4
120–140	4
140–160	1
160–180	1
180–	1

Table 5-3. Identified structures as a function of depth in HLX37.

Depth (m)	No. of structures
–20	3
20–40	4
40–60	4
60–80	5
80–100	4
100–120	2
120–140	2
140–160	7
160–180	1
180–	5

Tables 5-4 to 5-6 summarises the interpretation of radar data from KLX09, HLX36 and HLX37. For KLX09 the direction to the reflector is also given. As seen some radar reflectors in Table 5-4 are marked with ±, which indicates an uncertainty in the interpretation of direction. The direction can in these cases be ± 180 degrees. The direction to the reflector (the plane) is defined in Figure 5-3. As the borehole inclination is less than 85 degrees 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 5-4. 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.

Observe that a structure can have several different angles, if the structure is undulating, and thereby also different intersection depths is given. This is seen for structure 173 in Table 5-4 and Appendix 1. To this structure, most likely, also structure 173x belongs.

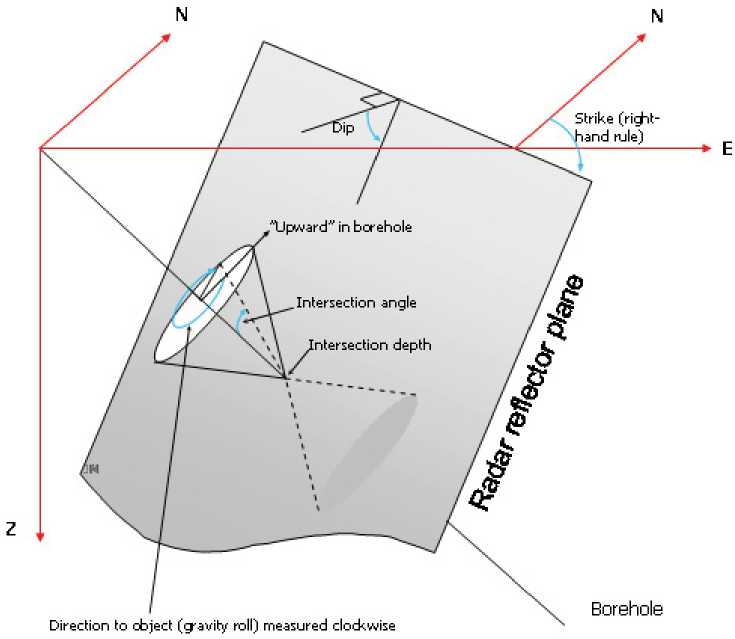


Figure 5-3. *Definition of intersection angle, direction to object using gravity roll, dip and strike using the right hand rule as presented in Table 5-4.*

Table 5-4. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, and the directional antenna 60 MHz in borehole KLX09.

RADINTER MODEL INFORMATION
(Directional antenna)

Site:	**Oskarshamn**
Borehole name:	**KLX09**
Nominal velocity (m/µs):	**117.0**

Name	Intersection depth	Intersection angle	Radinter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
9	37.0	11					
1	48.4	61					
2	74.1	73					
4	103.6	58					
3	105.7	61	351	39	353		
5	108.9	57					
6	110.9	64					
8	117.1	15					
7	118.8	43					
12	122.8	46					
10	124.0	60					
13	125.3	66					
14	126.6	53					
21	130.2	37					
11	131.7	58					
15	135.8	68					
16	138.2	53					
17	140.7	47					
20	144.1	45					
18	146.6	61					
19	149.4	67					

RADINTER MODEL INFORMATION (Directional antenna)							
Site:		**Oskarshamn**					
Borehole name:		**KLX09**					
Nominal velocity (m/μs):		**117.0**					
Name	**Intersection depth**	**Intersection angle**	**Radinter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
25	150.4	62					
22	151.6	61					
27	152.9	44					
23	153.3	23					
26	154.9	73					
24	159.9	61					
28	171.8	46					
36	172.9	56					
198	177.1	43					
30	181.9	48					
29	182.7	53					
31	185.5	49					
35	187.7	23					
32	190.0	55					
34	193.6	48					
33	194.6	15					
37	195.6	41					
41	198.0	52					
43	202.7	15	63	78	62		
206	203.4	10	108	77	108		
38	207.2	55					
40	208.3	49	72 ±	46	66	42	261
42	208.9	65					
44	211.7	56					
39	212.8	35					
45	215.1	47					
46	219.9	50					
51	231.1	37					
50	232.4	70					
199	233.0	48					
47	236.7	62					
48	238.3	72					
49	240.4	67					
53	252.8	57					
52	257.9	50					
54	261.8	67					
55	262.8	70	105 ±	22	88	26	301
56	264.3	60					
57	272.2	62					
58	279.8	73					
59	281.4	79					
61	281.8	55					
60	282.6	75					
62	287.5	63					
64	289.0	74					
65	292.9	56					
63	293.3	55	147 ±	29	141	41	333
66	294.8	59					

RADINTER MODEL INFORMATION
(Directional antenna)

Site:	**Oskarshamn**
Borehole name:	**KLX09**
Nominal velocity (m/μs):	**117.0**

Name	Intersection depth	Intersection angle	Radinter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
68	300.9	54					
67	302.9	67					
69	304.5	67					
70	305.4	62	270 ±	28	285	28	77
71	315.4	45					
72	319.8	49					
73	323.2	54					
200	330.6	41					
76	331.2	25					
74	333.6	51	141 ±	33	135	44	327
75	334.0	69					
81	341.1	53					
77	343.6	59	303 ±	34	313	26	112
79	344.8	35					
78	345.3	57					
79x	347.2	57					
82	353.8	46					
83	354.1	54					
84	355.3	54					
80	361.0	50	177 ±	31	177	46	358
85	363.6	71					
201	365.5	43					
86	365.6	60					
87	368.3	43					
202	373.9	70					
88	375.6	59					
91	380.6	55					
89	384.1	49					
90	385.1	68					
92	387.8	67					
96	390.6	45					
93	392.2	65					
94	394.2	59					
98	398.3	60					
97	400.7	63					
95	407.1	65					
102	411.9	55	189 ±	30	191	43	8
100	417.7	65					
99	418.9	63					
104	421.9	50					
101	425.5	49					
203	430.3	49					
103	431.2	46					
106	441.9	47					
105	442.7	68					
107	442.7	53					
109	459.1	51					
111	463.0	17					

RADINTER MODEL INFORMATION
(Directional antenna)

Site:	**Oskarshamn**
Borehole name:	**KLX09**
Nominal velocity (m/μs):	**117.0**

Name	**Intersection depth**	**Intersection angle**	**Radinter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
108	464.5	45					
110	466.8	40					
112	471.3	42					
113	473.3	69					
117	481.0	62					
204	482.4	44					
114	484.3	52					
115	490.1	62					
116	493.6	61					
118	495.9	71					
120	500.6	25					
119	525.4	57					
121	528.4	69					
123	530.3	61	291 ±	30	302	25	96
122	531.3	65					
125	537.2	63					
124	541.6	51	75 ±	42	66	37	263
126	541.9	36					
128	548.8	69					
127	548.9	60					
129	552.6	50					
131	555.4	58					
130	555.8	47	273 ±	44	279	43	84
132	559.2	43					
133	569.2	38					
134	571.5	60					
135	579.0	66					
139	583.4	64					
140	588.2	64					
136	591.2	66					
137	593.6	67	285 ±	24	299	21	86
144	595.7	72					
138	595.7	74					
142	597.5	56					
143	603.5	66					
141	603.7	74					
145	613.4	83					
146	616.5	77					
147	614.3	38					
148	620.4	78					
150	627.6	39					
151	632.3	59					
149	633.9	60	315 ±	33	320	24	121
153	641.6	45					
152	644.1	68					
154	649.7	47					
155	652.8	66					

RADINTER MODEL INFORMATION (Directional antenna)							
Site:		**Oskarshamn**					
Borehole name:		**KLX09**					
Nominal velocity (m/μs):		**117.0**					
Name	**Intersection depth**	**Intersection angle**	**Radinter direction to object (gravity roll)**	**Dip 1**	**Strike 1**	**Dip 2**	**Strike 2**
156	658.7	48					
158	660.4	64					
157	666.9	47					
159	662.1	64					
160	664.1	62					
161	667.5	29					
164	676.3	53					
205	688.6	60					
165	689.8	56					
162	690.7	50	318	44	319		
167	693.4	31					
166	700.7	55					
163	703.5	12	195	70	192		
168	707.1	63					
169	711.6	60					
170	713.8	62	168 ±	21	160	34	345
172	719.7	78					
171	723.0	86					
173	724.2	31					
173x	726.9	54					
174	734.6	63	75 ±	30	58	27	263
178	739.8	63					
175	743.8	65					
176	746.2	69					
177x	752.7	41					
177	754.6	32					
179	758.5	24					
180	775.7	44					
182	779.1	61					
181	780.9	67					
183	788.0	79					
184	792.2	57					
186	790.8	71					
185	797.4	64					
187	807.4	58					
191	809.6	10	12	87	7		
188	815.0	55					
189	818.6	57					
190	828.0	59					
207	837.3	18	228	68	225		
192	841.8	45	297 ±	45	298	39	104
194	845.3	55					
193	852.1	46					
195	859.6	64					
196	862.4	60	99 ±	32	83	34	284
197	864.5	51					

Table 5-5. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, in borehole HLX36.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:		**Oskarshamn**	
Borehole name:		**HLX36**	
Nominal velocity (m/µs):		**117.0**	
Reflector type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	4	3.8	54
PLANE	1	5.6	52
PLANE	5	17.3	47
PLANE	3	20.2	14
PLANE	2	25.8	53
PLANE	6	32.4	53
PLANE	15	39.2	49
PLANE	7	41.0	42
PLANE	13	42.8	40
PLANE	11	43.9	54
PLANE	8	47.6	48
PLANE	27	56.0	44
PLANE	9	59.6	53
PLANE	10	62.9	54
PLANE	28	65.5	39
PLANE	12	72.5	55
PLANE	16	74.7	53
PLANE	20	76.7	43
PLANE	17	84.6	45
PLANE	14	84.8	36
PLANE	18	99.5	46
PLANE	19	109.3	42
PLANE	29	110.8	44
PLANE	29x	112.7	31
PLANE	21	114.1	50
PLANE	22	123.2	57
PLANE	30	125.8	49
PLANE	23	135.1	44
PLANE	24	139.9	53
PLANE	25	145.6	68
PLANE	26	161.5	68
PLANE	29xx	222.5	9

Table 5-6. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, in borehole HLX37.

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

Site:	**Oskarshamn**
Borehole name:	**HLX37**
Nominal velocity (m/μs):	**117.0**

Reflector type	Name	Intersection depth	Intersection angle
PLANE	1	5.3	57
PLANE	35	12.5	39
PLANE	4	16.0	66
PLANE	5	26.1	65
PLANE	2	33.9	57
PLANE	13	36.1	38
PLANE	3	36.4	53
PLANE	6	41.1	58
PLANE	7	47.4	51
PLANE	8	52.4	56
PLANE	33	56.2	32
PLANE	9	60.4	54
PLANE	34	63.2	62
PLANE	10	66.7	67
PLANE	11	74.3	44
PLANE	12	75.6	53
PLANE	14	84.9	44
PLANE	15	93.3	55
PLANE	19	95.6	48
PLANE	16	95.9	28
PLANE	18	106.8	59
PLANE	17	108.7	44
PLANE	20	125.1	47
PLANE	21	126.8	50
PLANE	22	140.9	52
PLANE	23	144.0	66
PLANE	32	146.4	46
PLANE	36	147.1	25
PLANE	31	151.0	43
PLANE	24	152.7	39
PLANE	37	157.1	38
PLANE	25	160.3	39
PLANE	26	192.0	41
PLANE	27	196.8	48
PLANE	28	200.0	44
PLANE	30	200.3	53
PLANE	29	205.5	64

In Appendices 1 to 3, 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 5-7 to 5-9.

Finally, the structures considered as the most important (clear in the radargram, identified with several antenna frequencies, stretching out far from the borehole wall etc.) are listed in Table 5-10 below.

Table 5-7. Borehole length intervals in KLX09 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
120–150	625
185	640–645
320	675
445	690
475	700–720
495	740–745
505–515	755–760
530–555	770
570	800–820
610–620	

Table 5-8. Borehole length intervals in HLX36 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
110–190	

Table 5-9. Borehole length intervals in HLX37 with decreased amplitude for the 250 MHz antenna.

Length (m)	Length (m)
120–150	

Table 5-10. Some important structures in KLX09, HLX36 and HLX37.

Borehole	KLX09	HLX36	HLX37
Structures	3, 4, 9, 27, 37, 40, 63, 71, 74, 77, 123, 154, 162, 200 and 201	1, 10, 17, 29, 29x and 29xx	1, 12, 15, 20, 23, 29 and 36

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

5.2 BIPS logging

The BIPS pictures from KLX09, HLX36and HLX37 are presented in Appendices 4 to 6.

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.

To get the best possible depth accuracy, the BIPS images are adjusted to the reference mark on the cable for the logging in KLX09. For the other boreholes the marks on the logging cable at 110 m and 150 m were used for adjustment of the depth.

The error in the depth recording depends mainly on the tension of the cable and error 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 BIPS images from the boreholes are of very good quality. No discolouring on the borehole wall in combination with very good water quality results in very good images and makes the geological core logging very easy to perform.

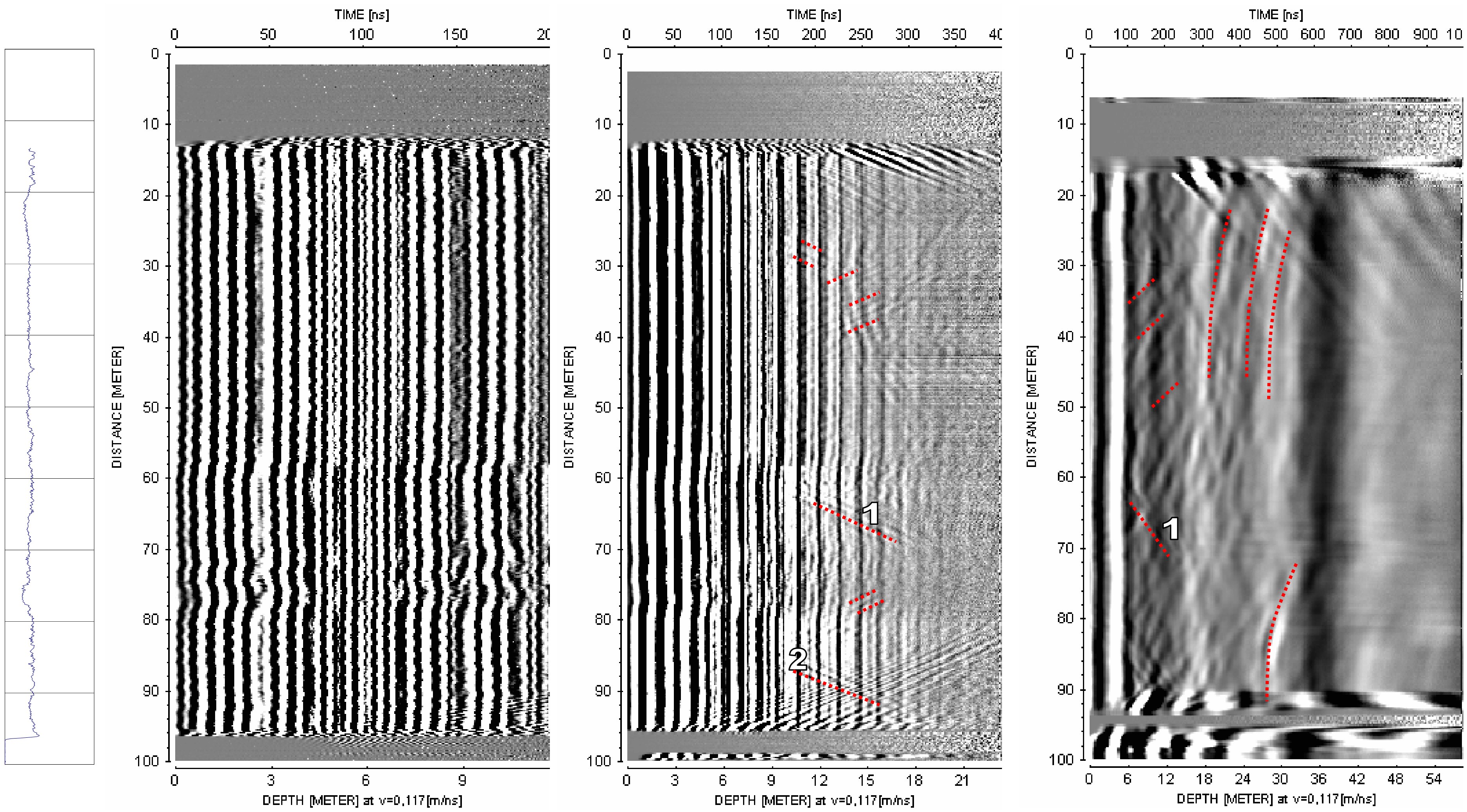
References

/1/ **Gustafsson J, Gustafsson C, 2005.** Oskarshamn site investigation. RAMAC and BIPS logging in boreholes KLX07A, KLX07B, HLX34 and HLX35 and deviation logging in boreholes KLX07B, HLX34 and HLX35. SKB P-05-231, Svensk Kärnbränslehantering AB.

Appendix 1

Radar logging in KLX09, 0 to 872 m, dipole antennas 250, 100 and 20 MHz

LAXEMAR KLX09

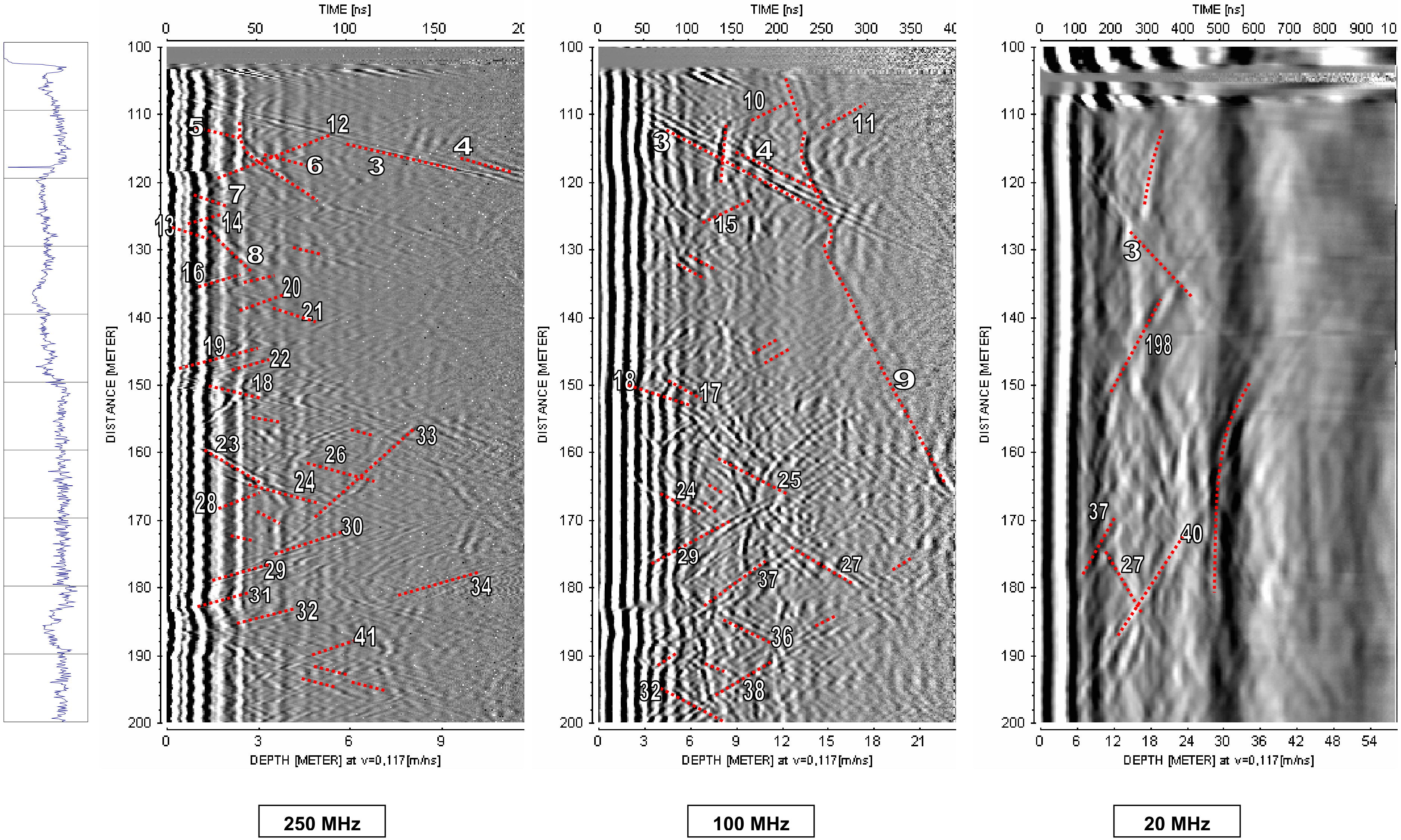


250 MHz

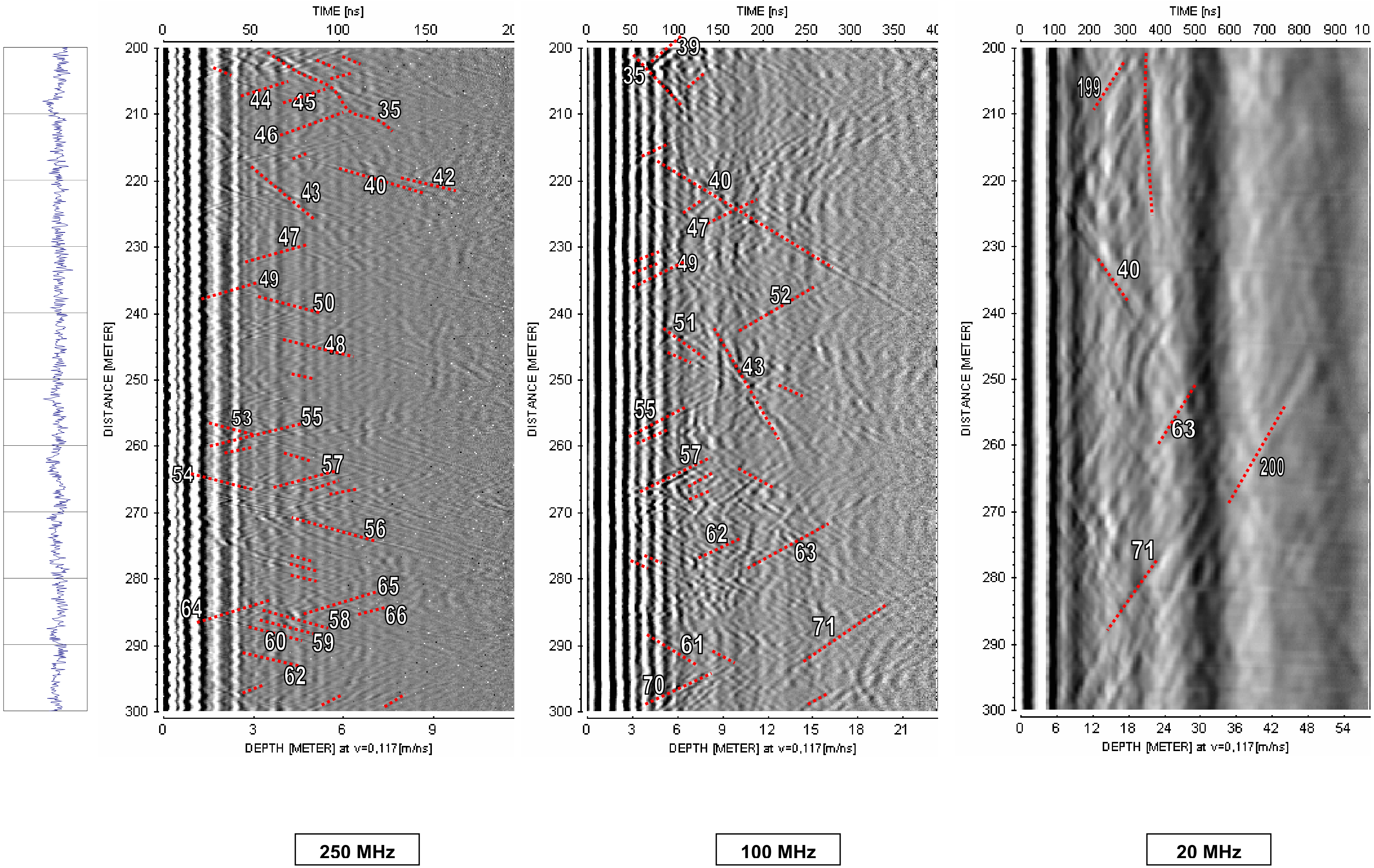
100 MHz

20 MHz

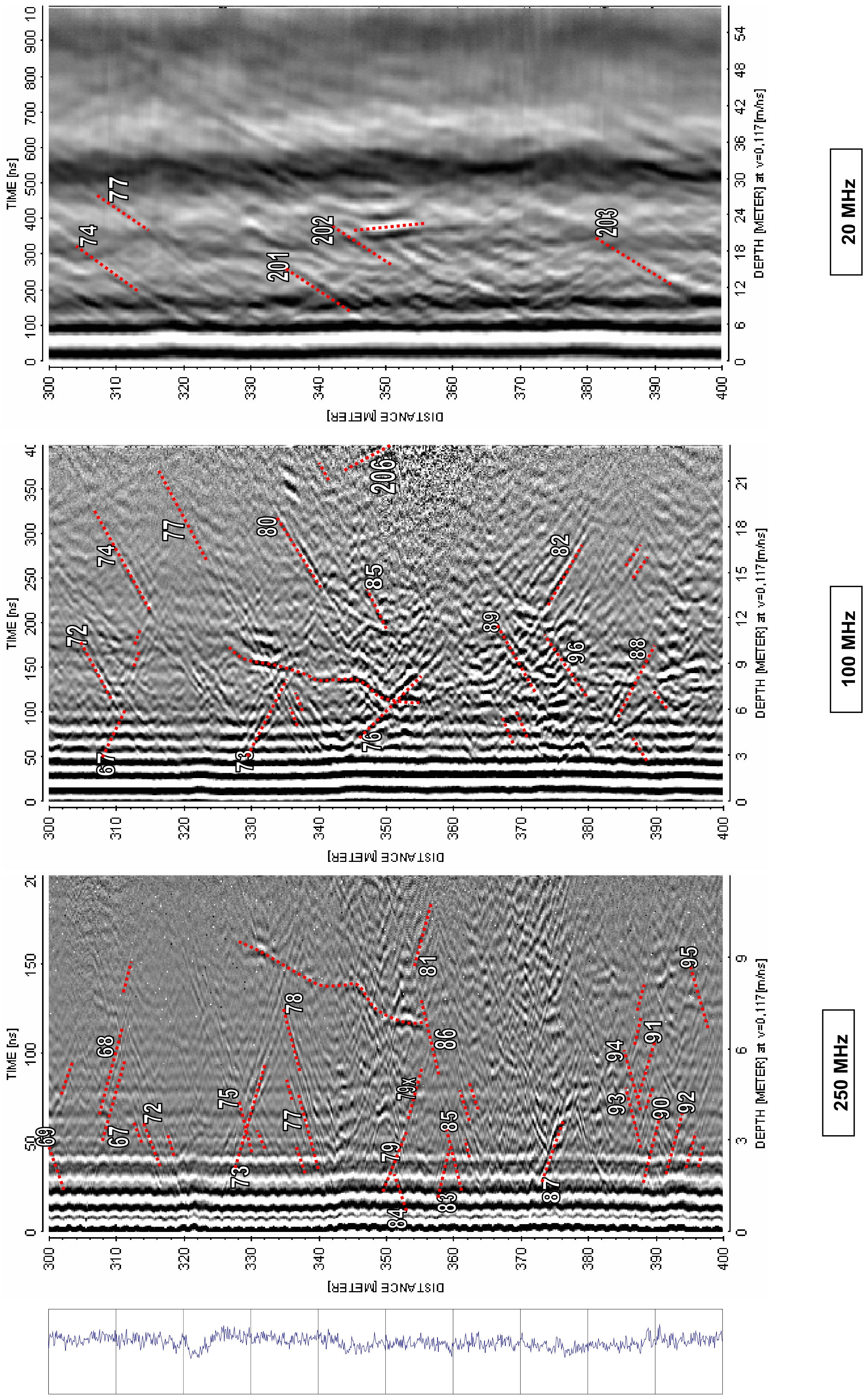
LAXEMAR KLX09

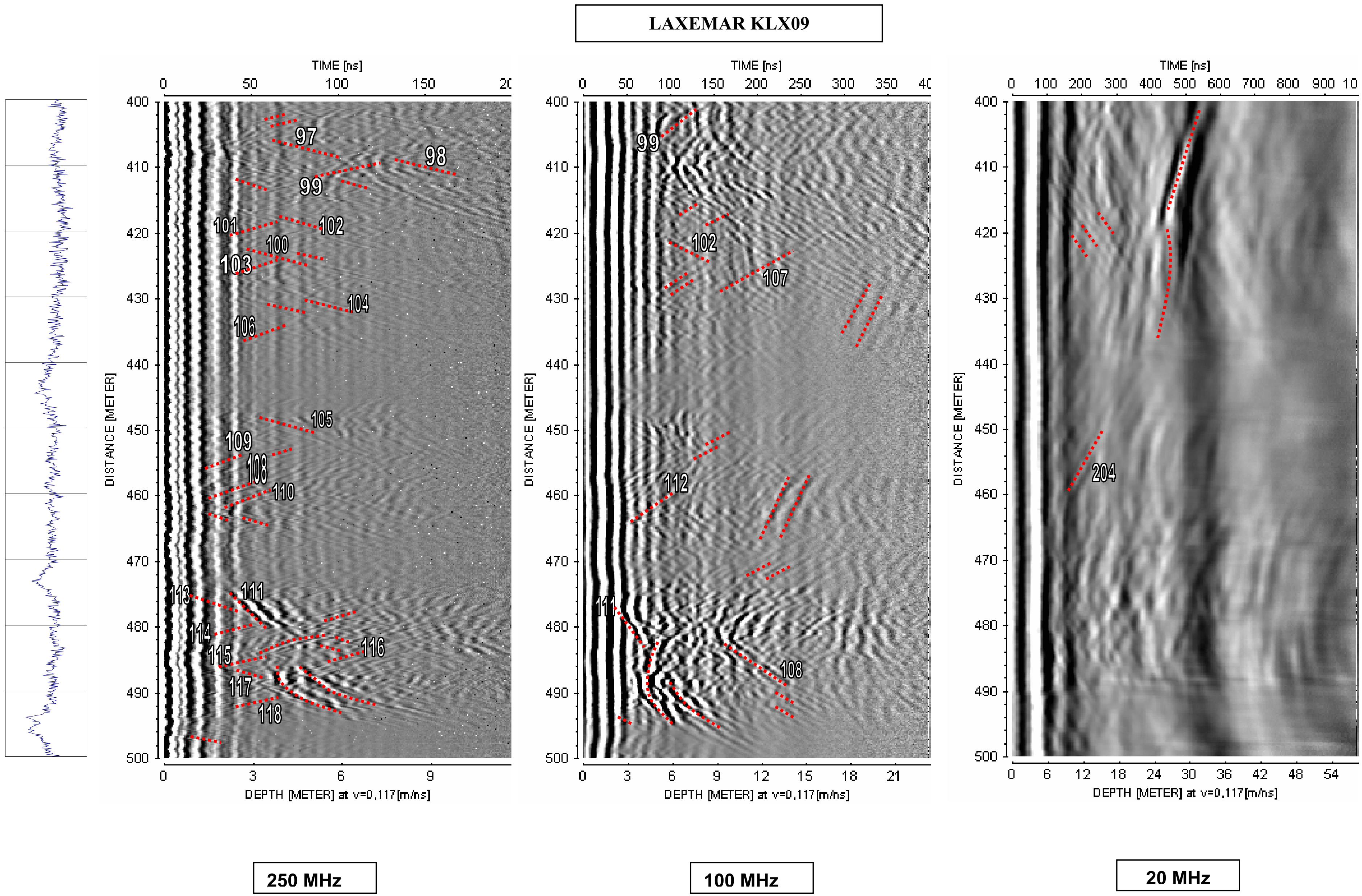


LAXEMAR KLX09

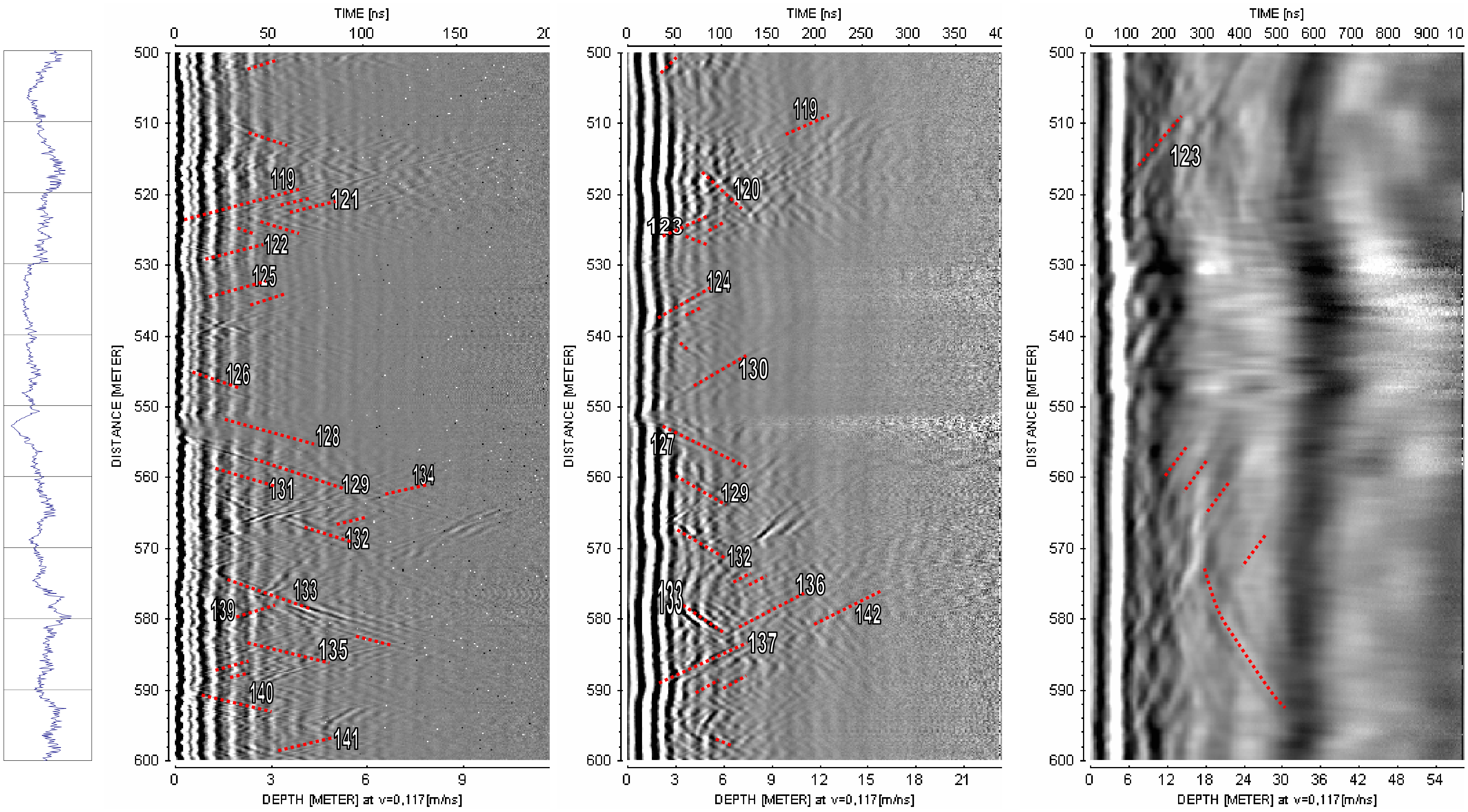


LAXEMAR KLX09




LAXEMAR KLX09
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,117[m/ns]
250 MHz
100 MHz
20 MHz
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
204

LAXEMAR KLX09

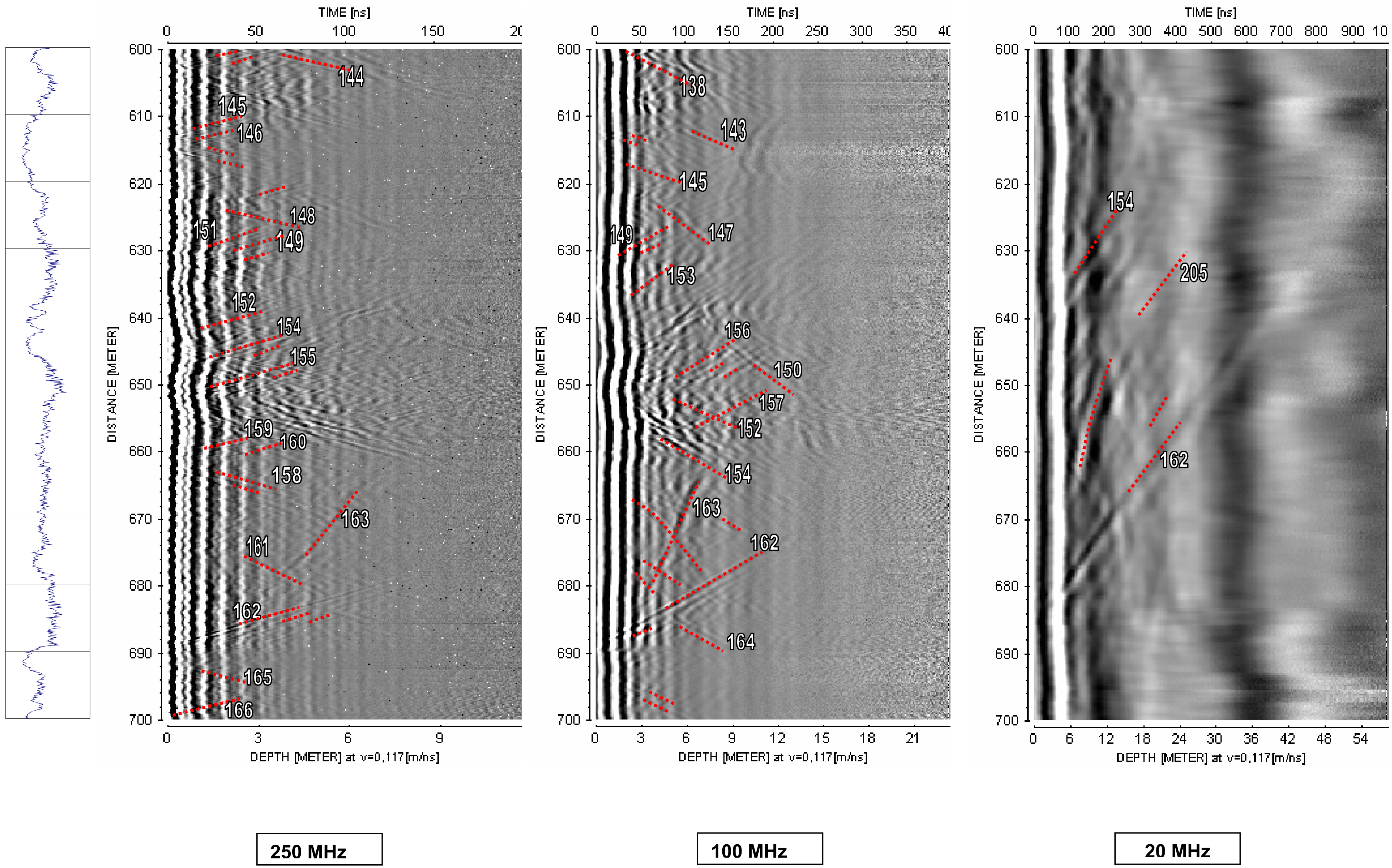


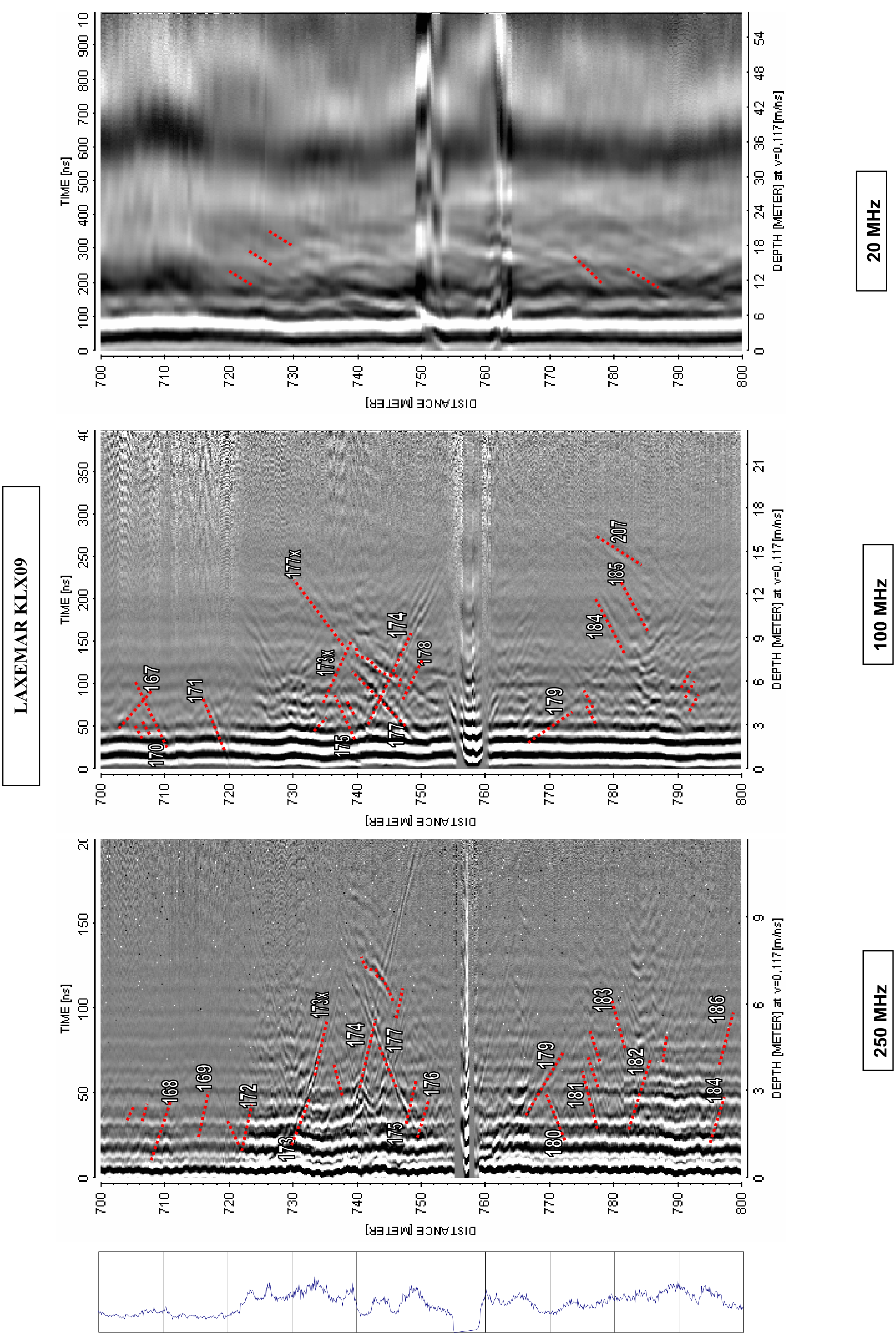
250 MHz

100 MHz

20 MHz

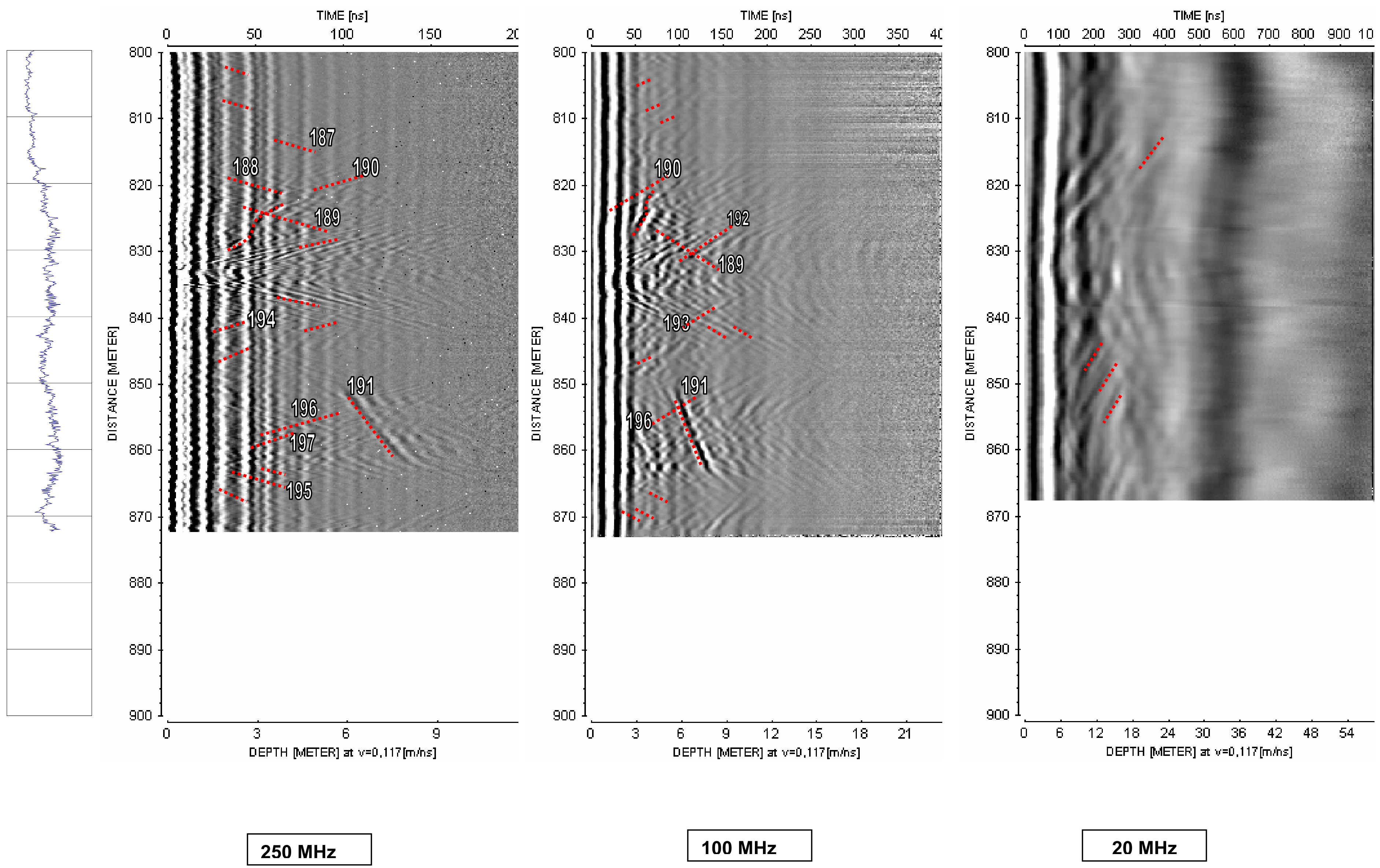
LAXEMAR KLX09





LAXEMAR KLX09
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,117[m/ns]
250 MHz
100 MHz
20 MHz

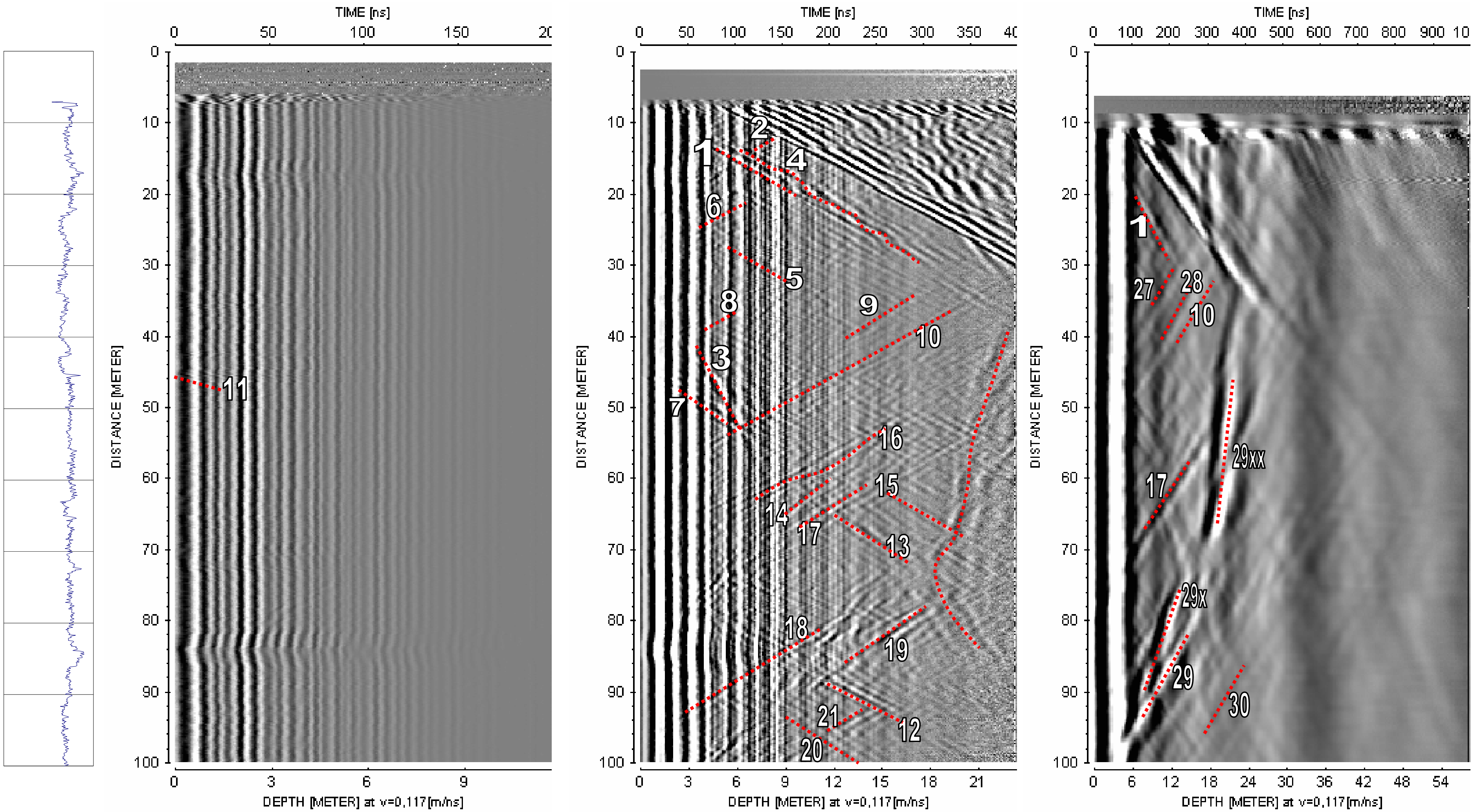
LAXEMAR KLX09



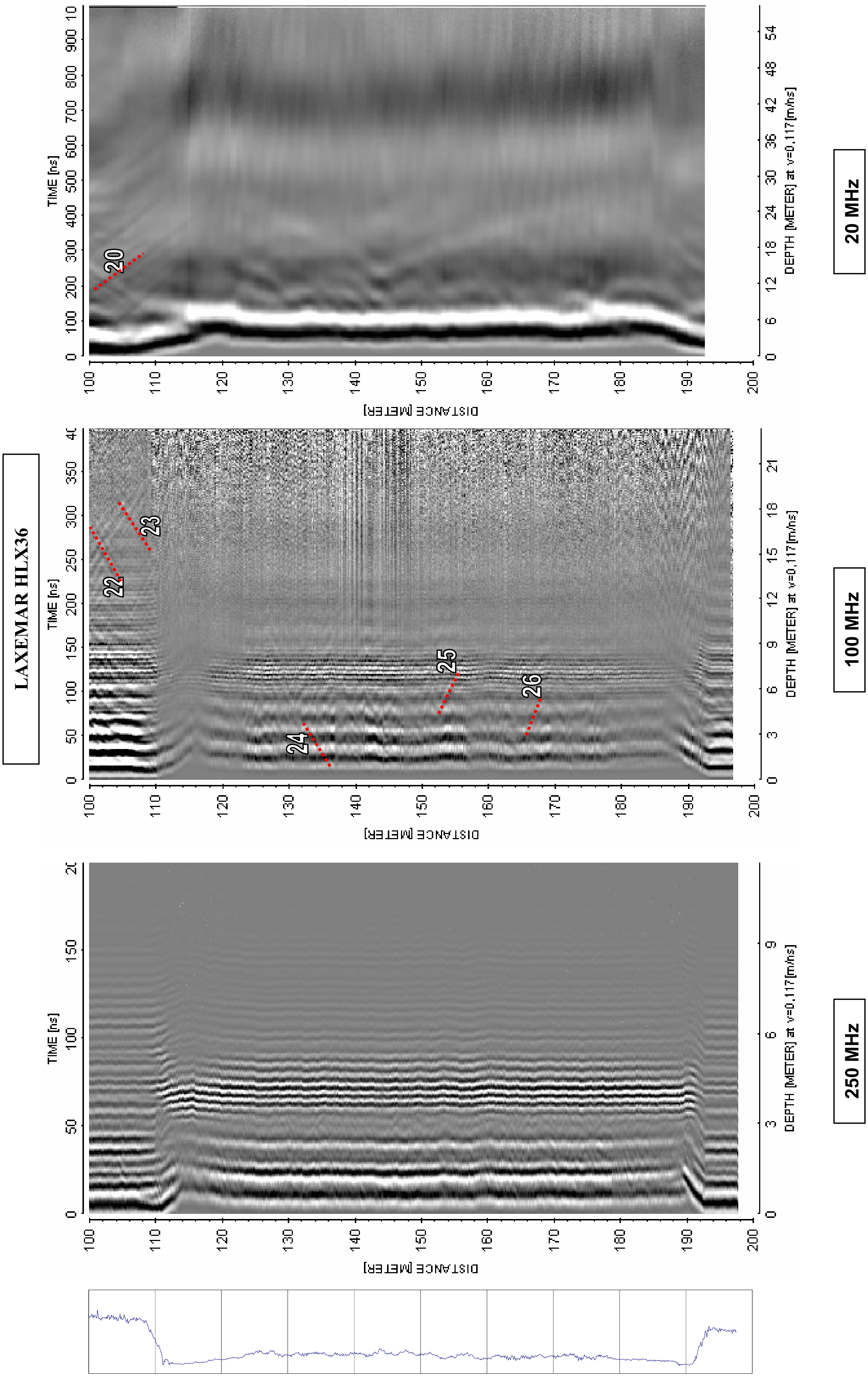
Appendix 2

Radar logging in HLX36, 0 to 198 m, dipole antennas 250, 100 and 20 MHz

LAXEMAR HLX36



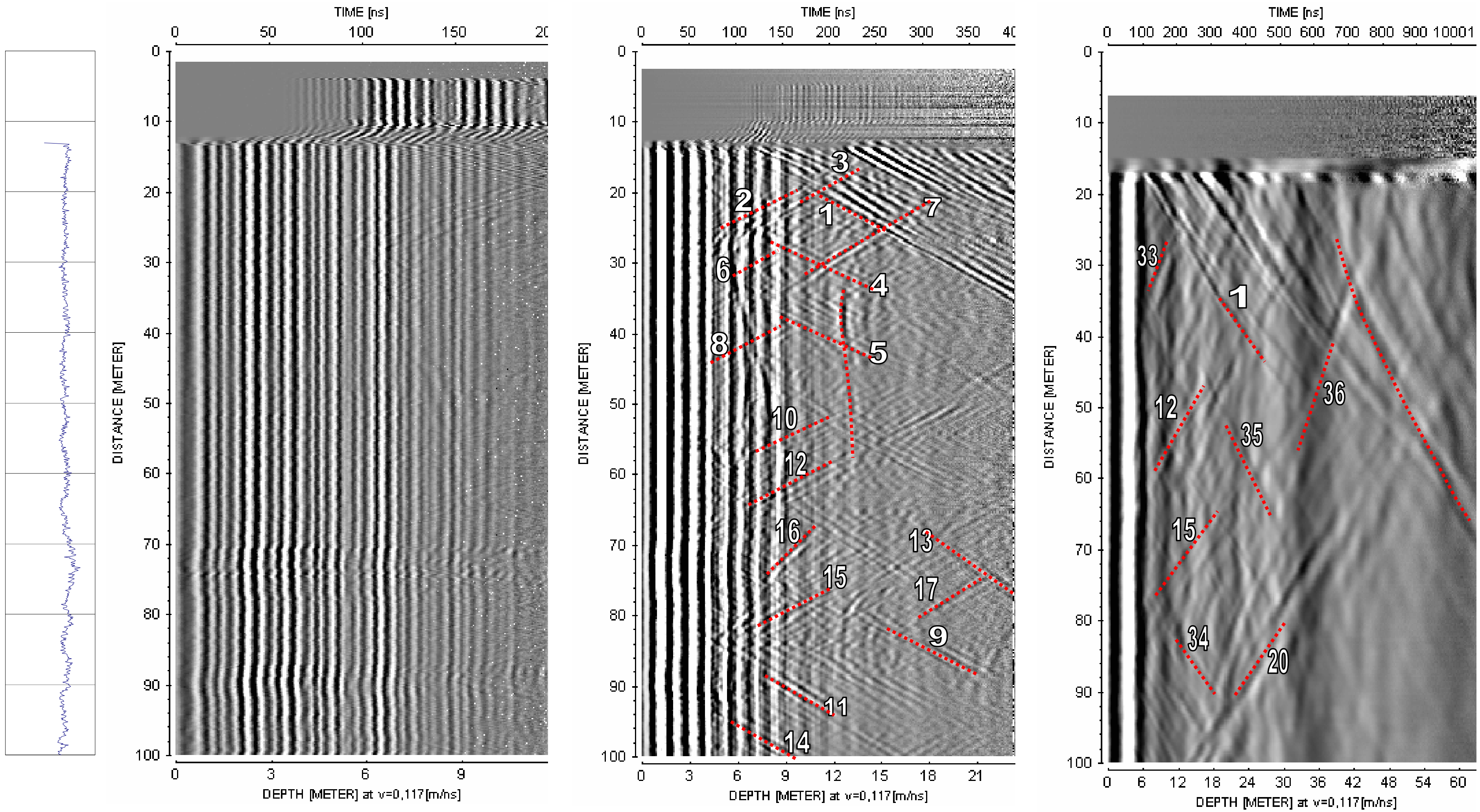
250 MHz **100 MHz** **20 MHz**


LAXEMAR HLX36
20 MHz
100 MHz
250 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,117[m/ns]
20
22
23
24
25
26

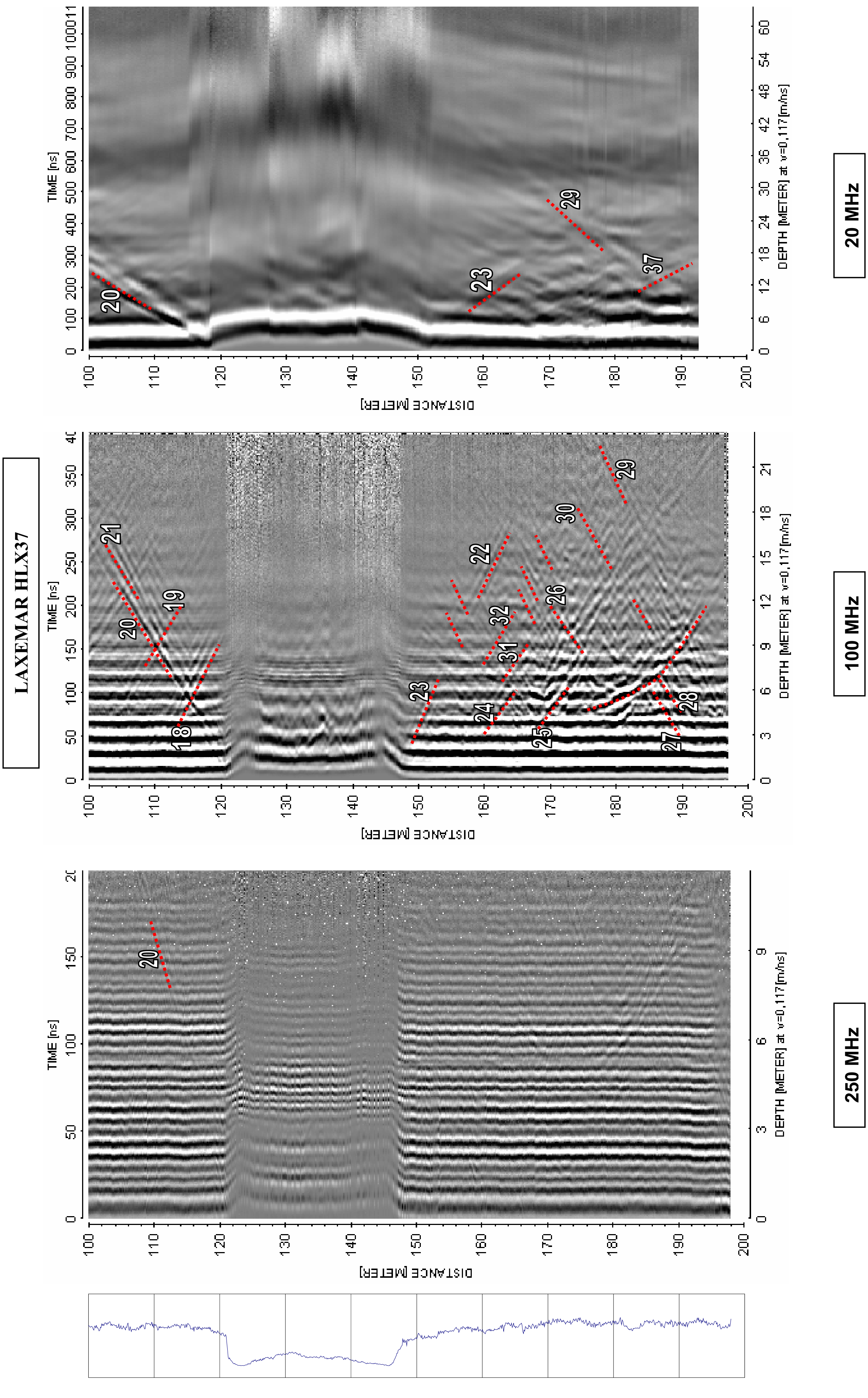
Appendix 3

Radar logging in HLX37, 0 to 196 m, dipole antennas 250, 100 and 20 MHz

LAXEMAR HLX37



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



LAXEMAR HLX37
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,117 [m/ns]

Appendix 4

BIPS logging in KLX09, 11 to 870 m

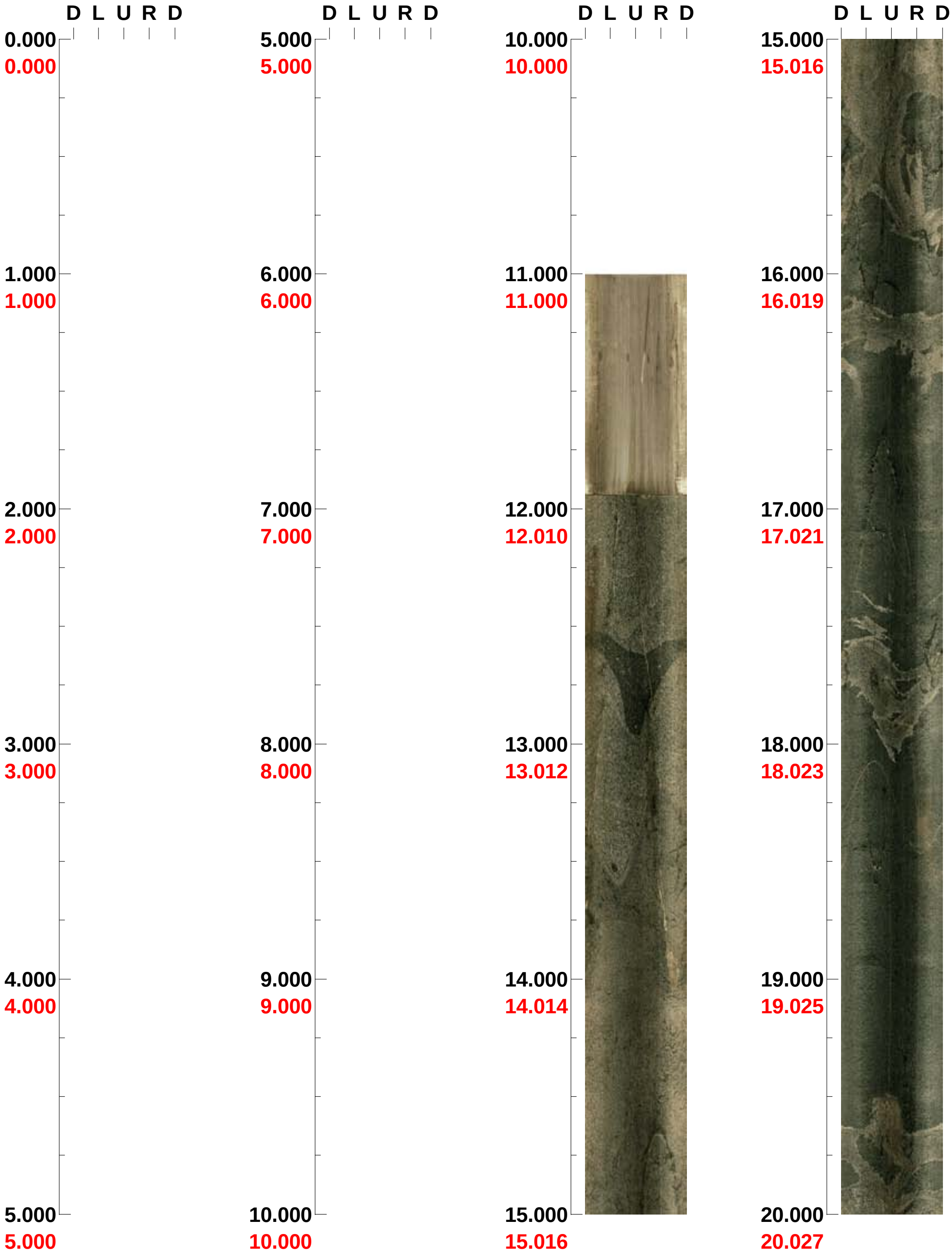
Project name: laxemar

Image file	: c:\work\r5485s~1\klx09\bips\klx09_a.bip
BDT file	: c:\work\r5485s~1\klx09\bips\klx09_a.bdt
Locality	: LAXEMAR
Bore hole number	: KLX09
Date	: 05/12/01
Time	: 17:03:00
Depth range	: 11.000 - 97.334 m
Azimuth	: 267
Inclination	: -85
Diameter	: 197.0 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.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 0.000 - 20.000 m



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

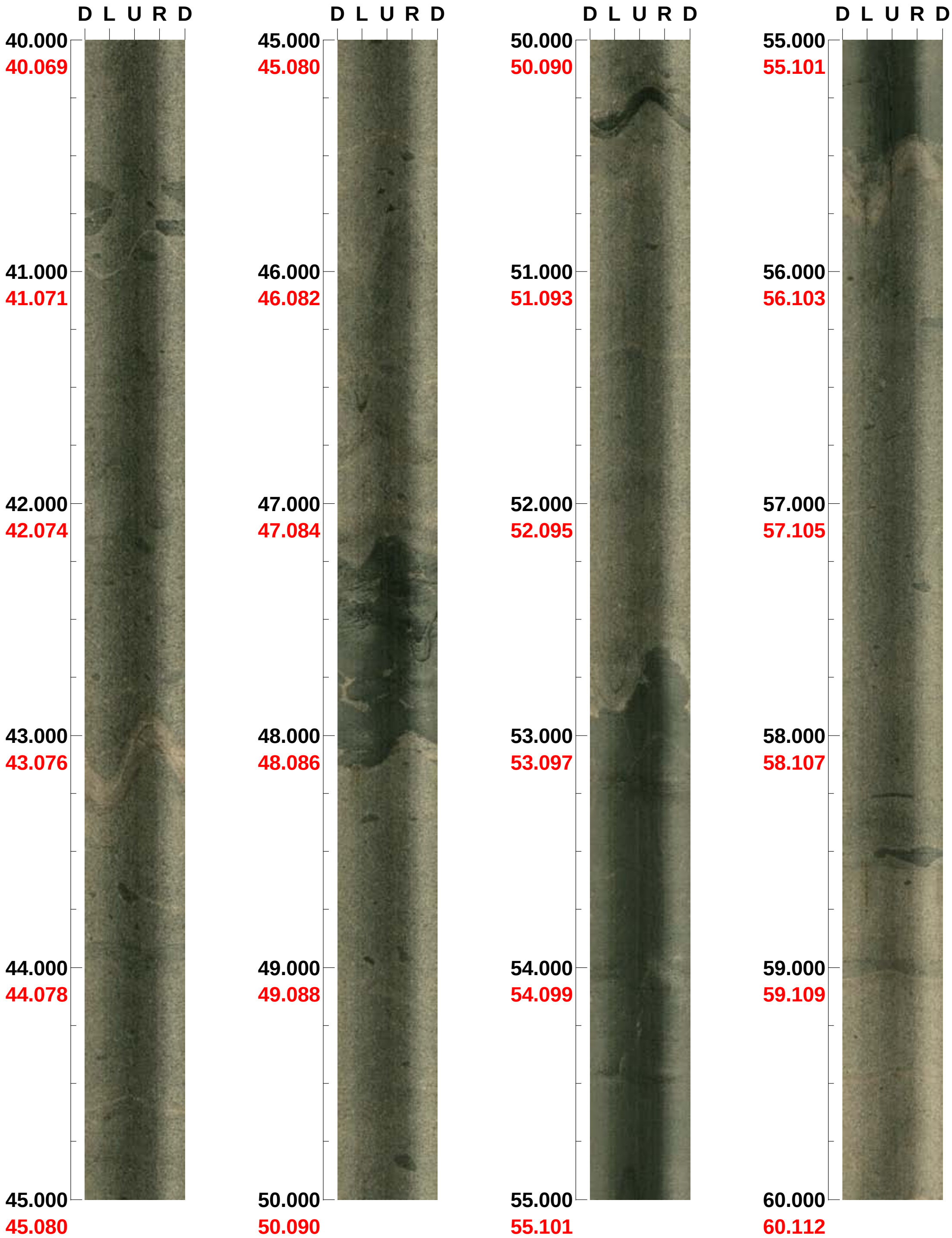
Project name: laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 20.000 - 40.000 m

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

Project name: laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

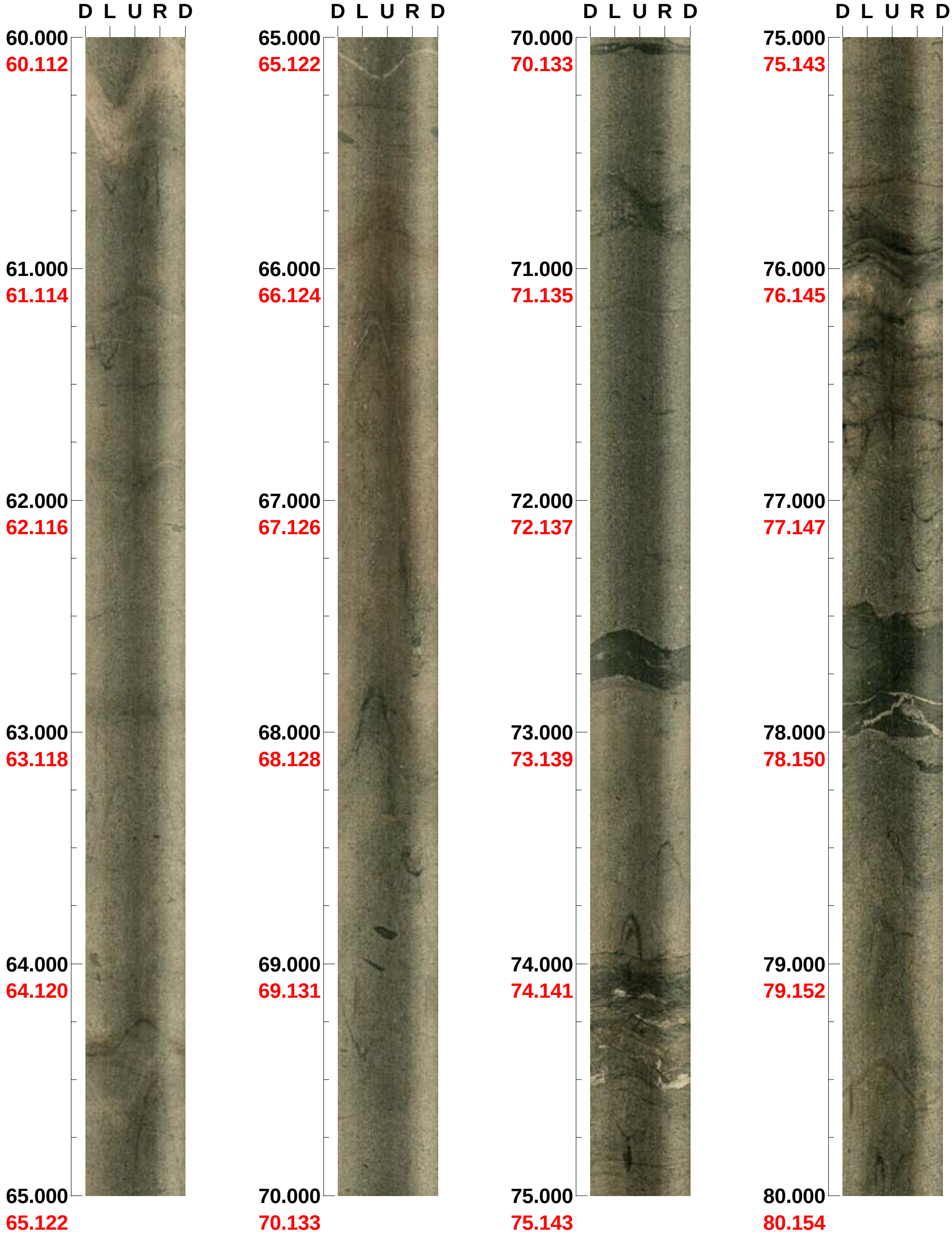
Depth range: 40.000 - 60.000 m



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

Project name: laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 60.000 - 80.000 m



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

Project name: laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 80.000 - 97.334 m

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

Project name: Laxemar

Image file	: c:\work\r5485s~1\klx09\bips\klx09_b.bip
BDT file	: c:\work\r5485s~1\klx09\bips\klx09_b.bdt
Locality	: LAXEMAR
Bore hole number	: KLX09
Date	: 05/12/01
Time	: 18:32:00
Depth range	: 101.000 - 481.939 m
Azimuth	: 267
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	: 20
Color	: +0 +0 +0

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 100.000 - 120.000 m

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

Project name: Laxemar

Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 120.000 - 140.000 m

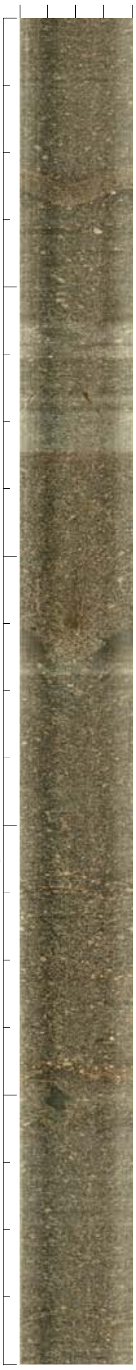
D L U R D

120.000
120.184

121.000
121.190
122.000
122.196
123.000
123.203
124.000
124.209
125.000
125.215

D L U R D

125.000
125.215



126.000
126.221
127.000
127.228
128.000
128.234
129.000
129.240
130.000
130.247

D L U R D

130.000
130.247

131.000
131.253
132.000
132.259
133.000
133.265
134.000
134.272
135.000
135.278

D L U R D

135.000
135.278

136.000
136.284
137.000
137.291
138.000
138.297
139.000
139.303
140.000
140.309

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 140.000 - 160.000 m

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

Project name: Laxemar

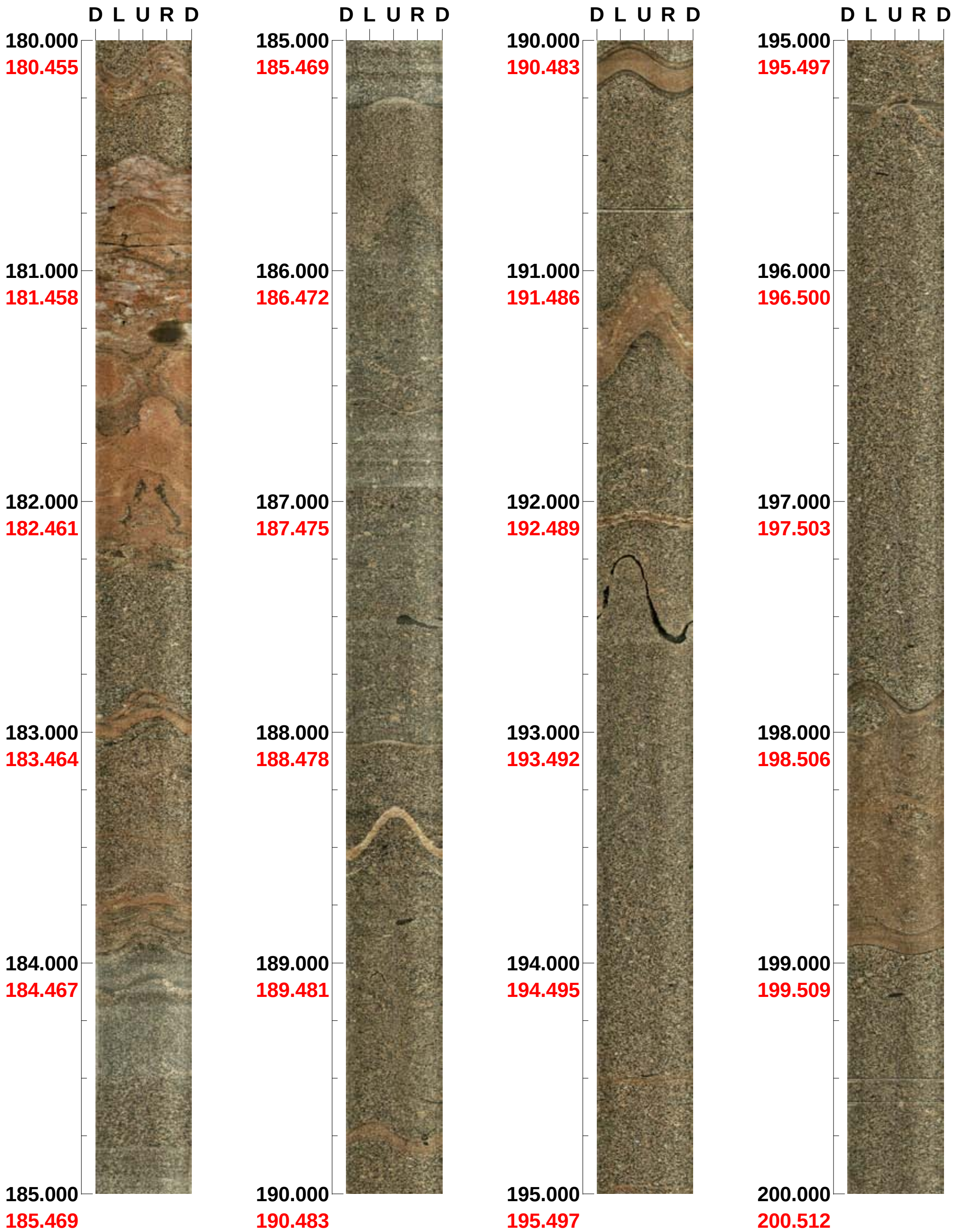
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 160.000 - 180.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 180.000 - 200.000 m



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

Project name: Laxemar

Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 200.000 - 220.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 Azimuth: 267 Inclination: -85

Depth range: 220.000 - 240.000 m

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

Project name: Laxemar

Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 240.000 - 260.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 260.000 - 280.000 m

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

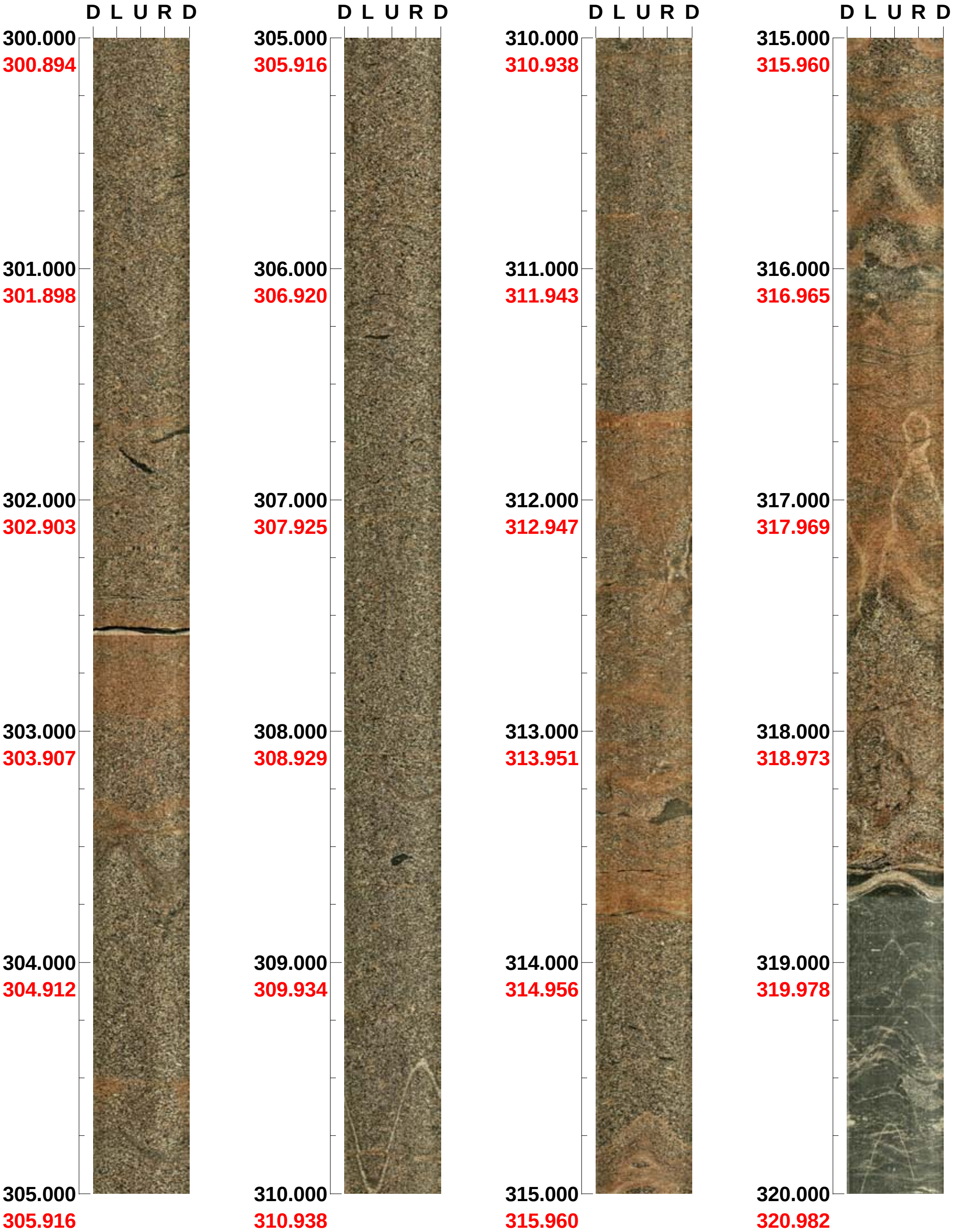
Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 280.000 - 300.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

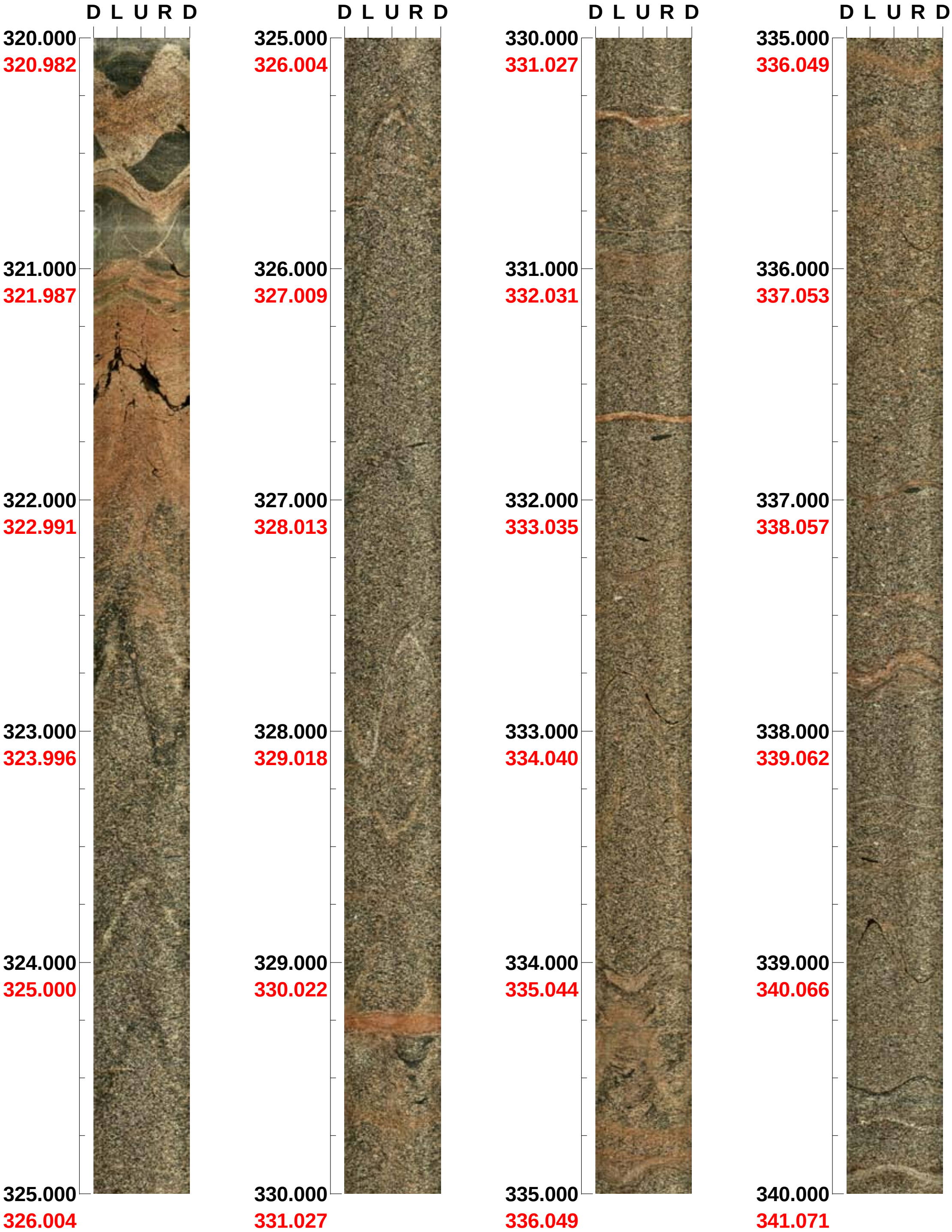
Depth range: 300.000 - 320.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

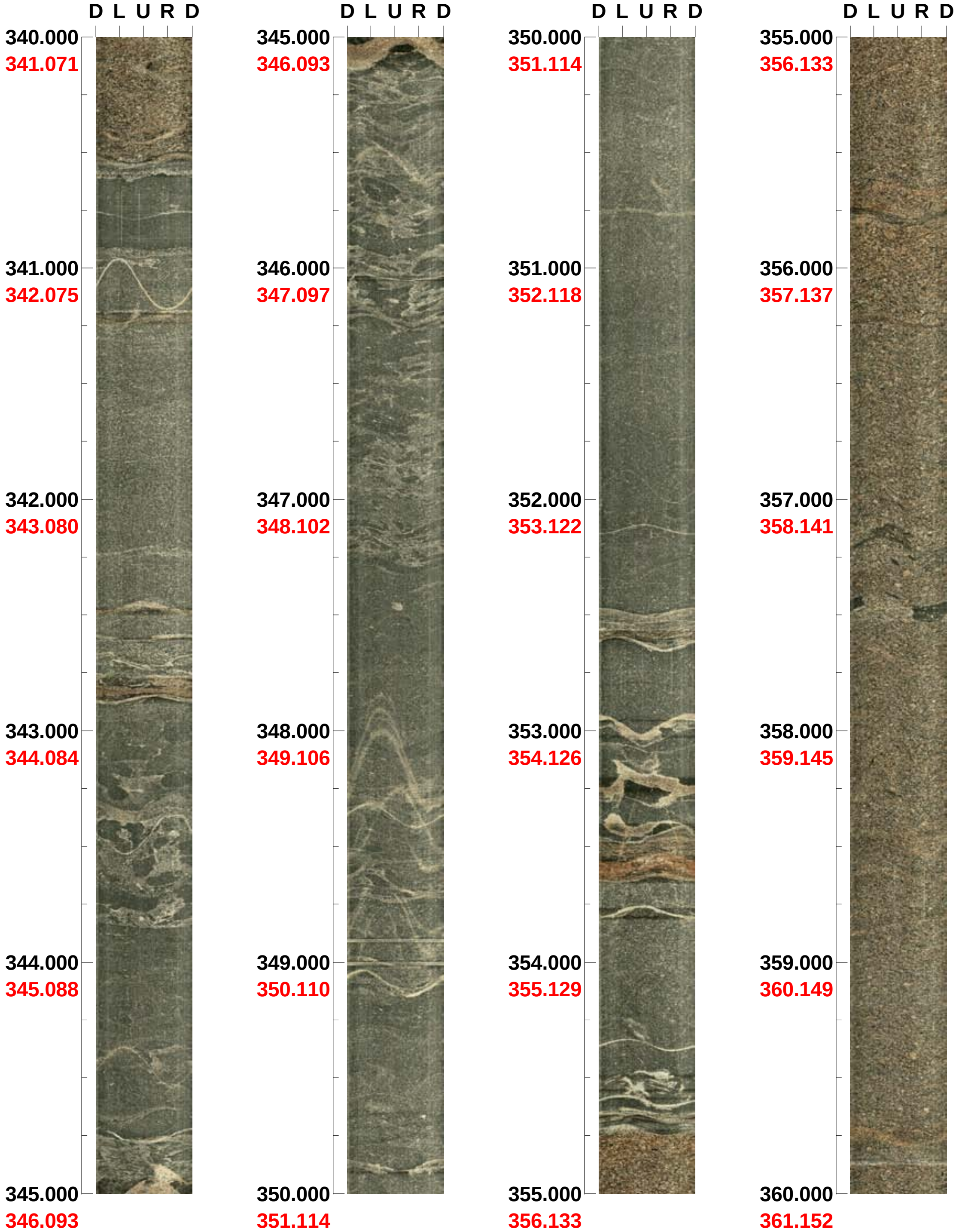
Depth range: 320.000 - 340.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 Azimuth: 267 Inclination: -85

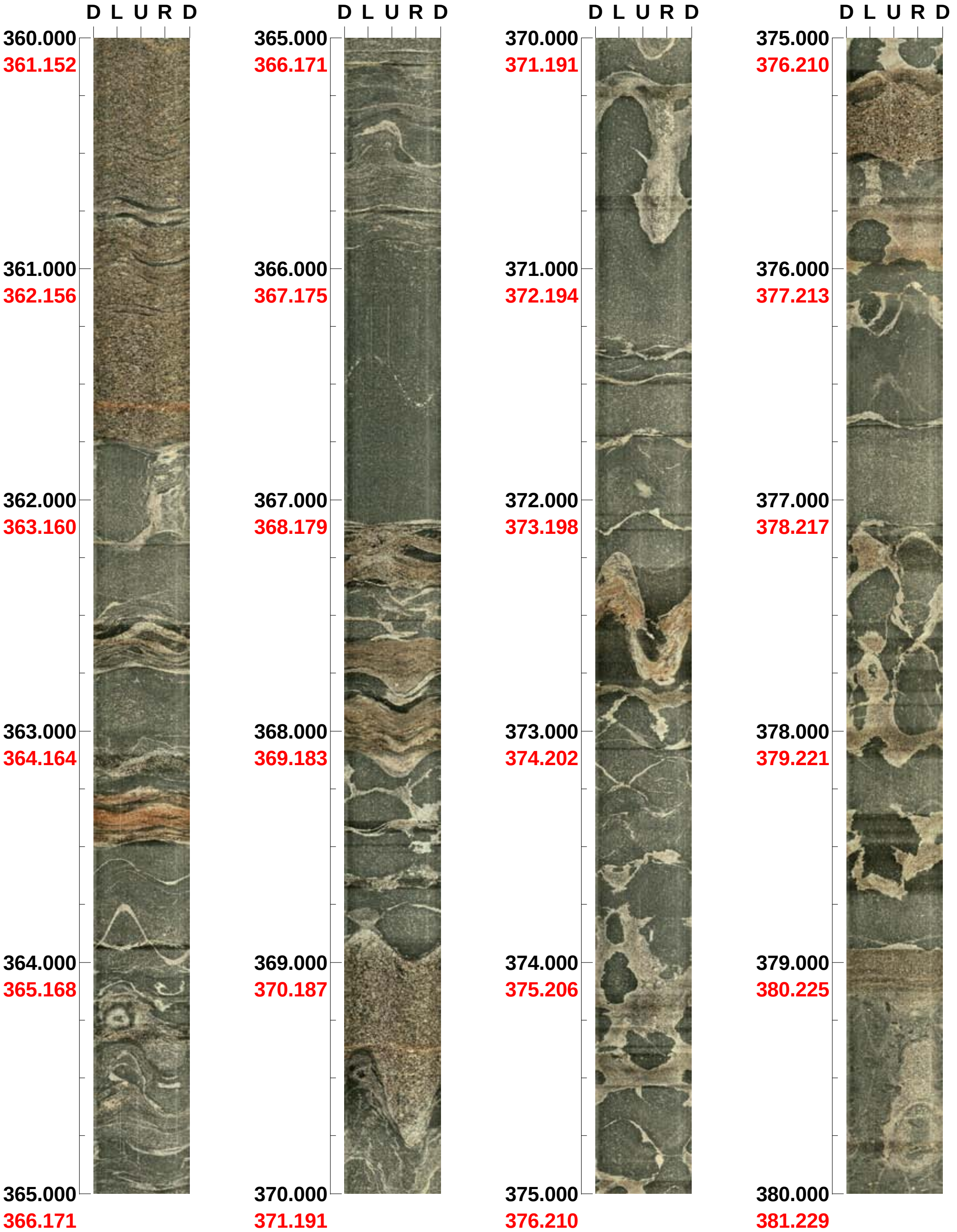
Depth range: 340.000 - 360.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 360.000 - 380.000 m



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

Project name: Laxemar

Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 380.000 - 400.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 400.000 - 420.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 420.000 - 440.000 m

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

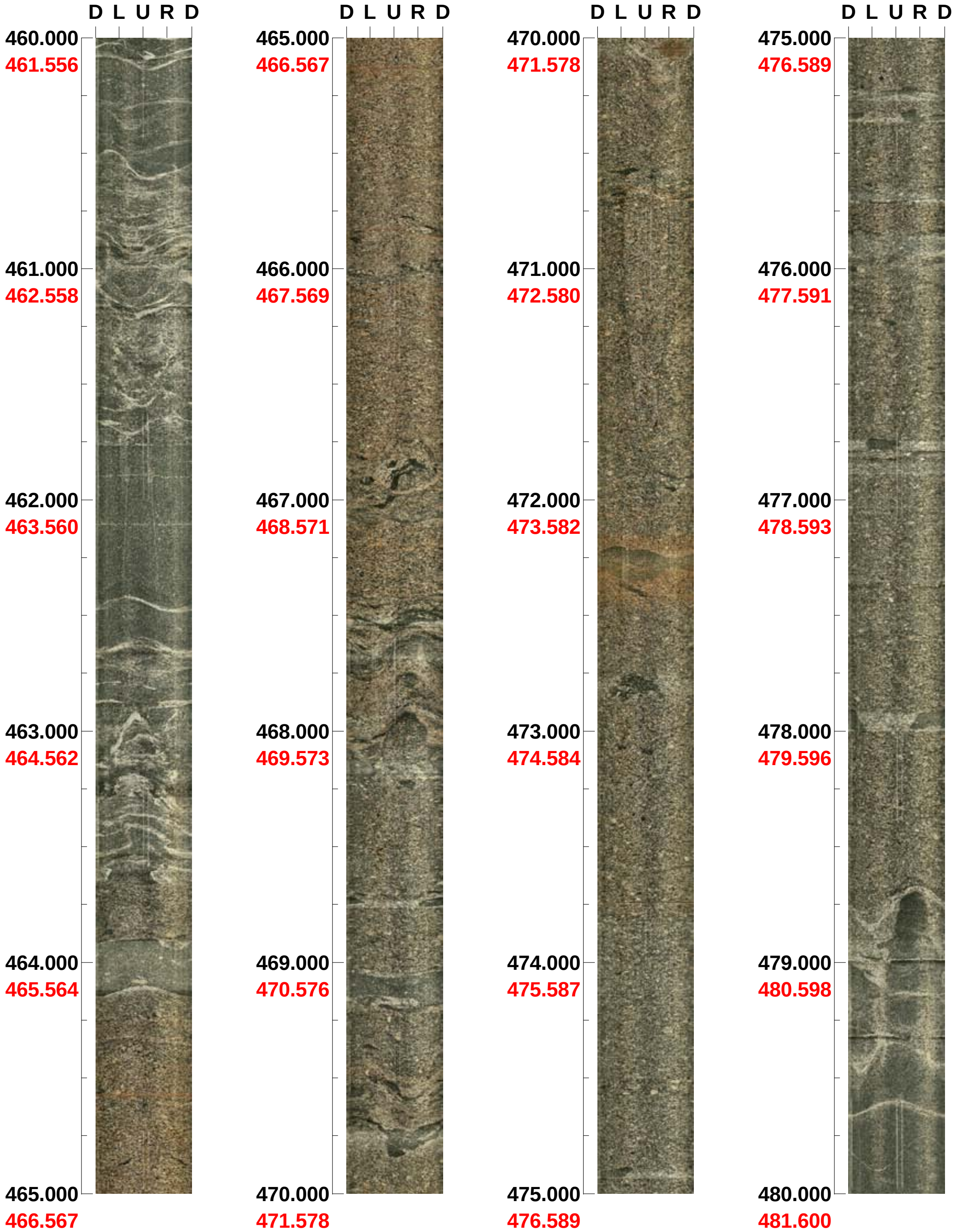
Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 440.000 - 460.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

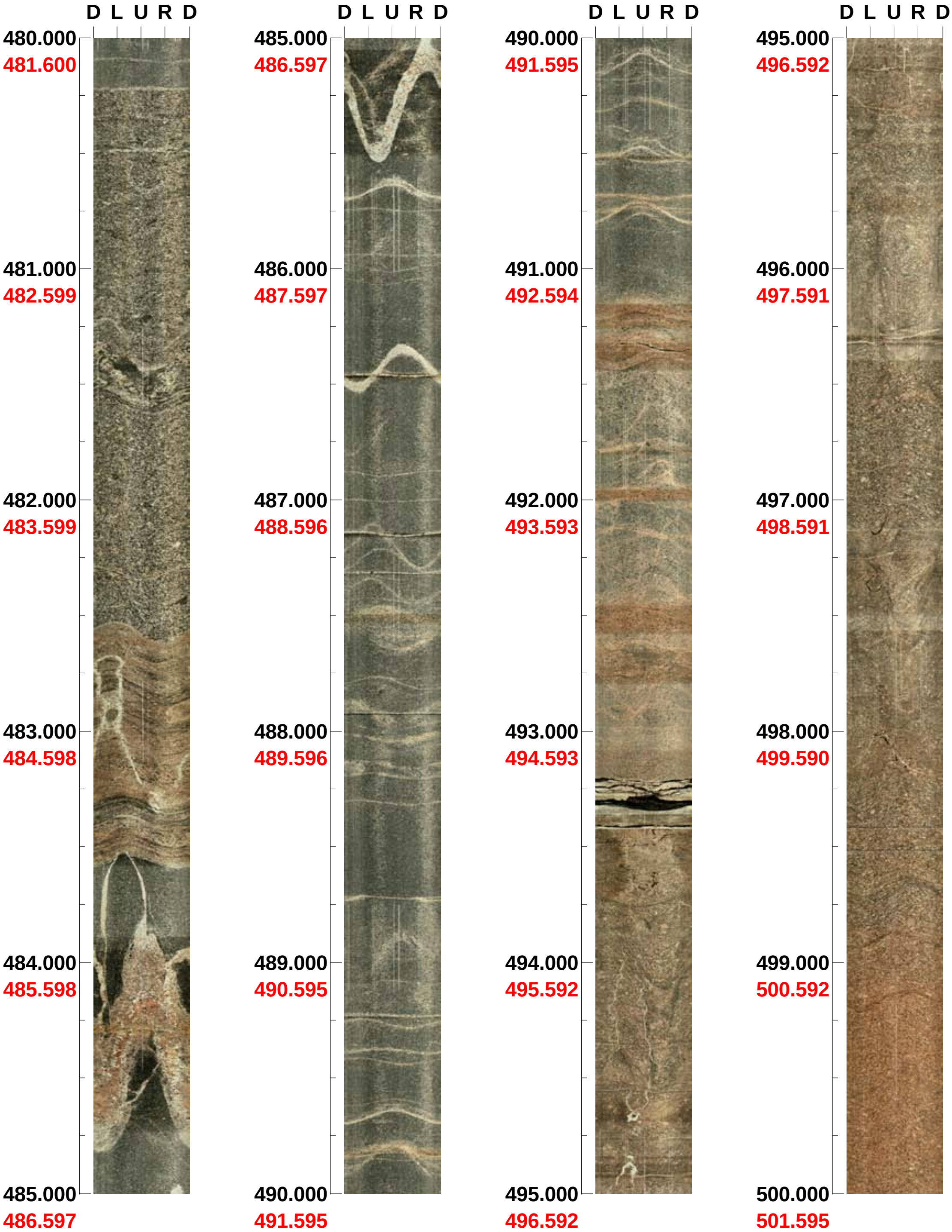
Depth range: 460.000 - 480.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

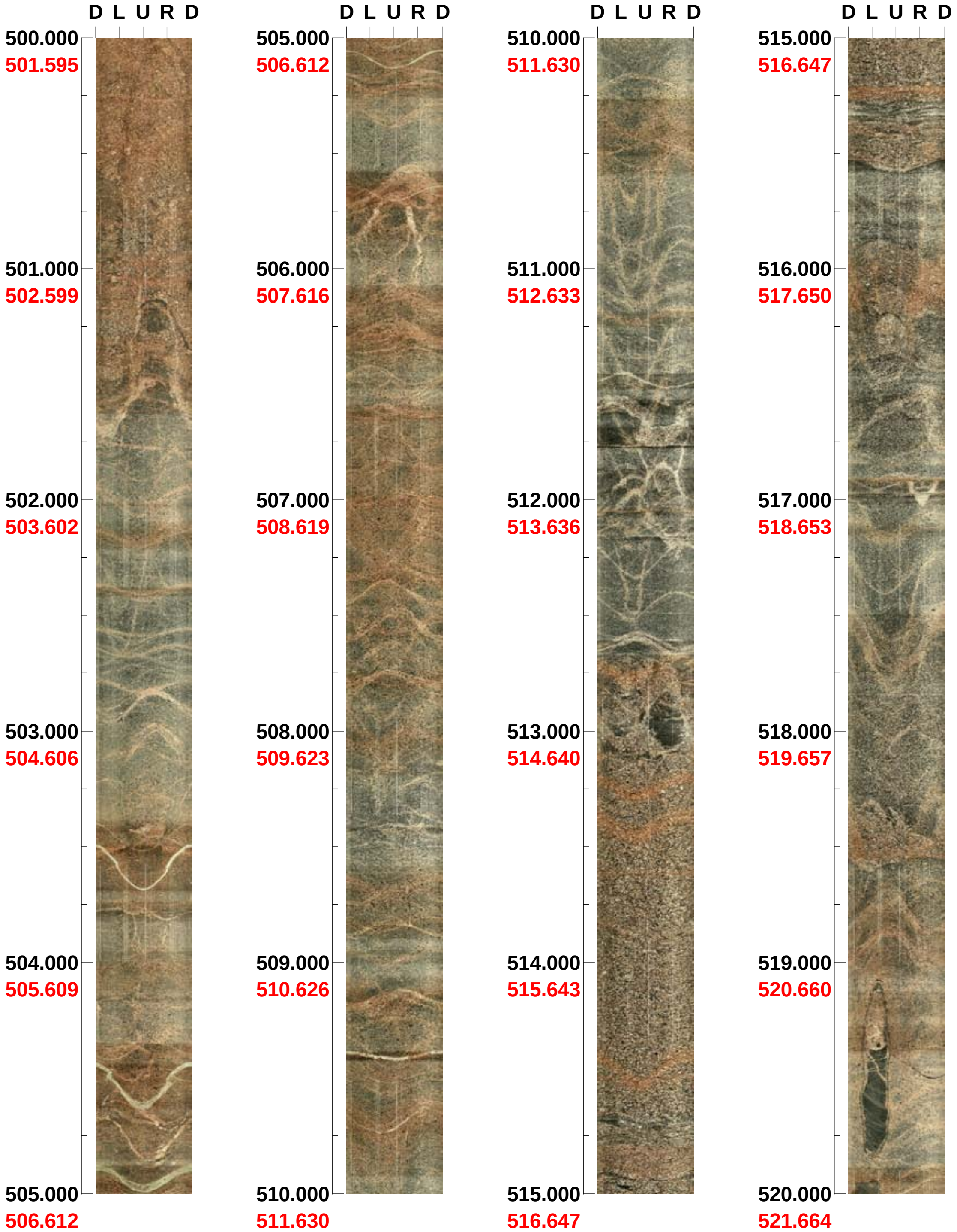
Depth range: 480.000 - 500.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 500.000 - 520.000 m

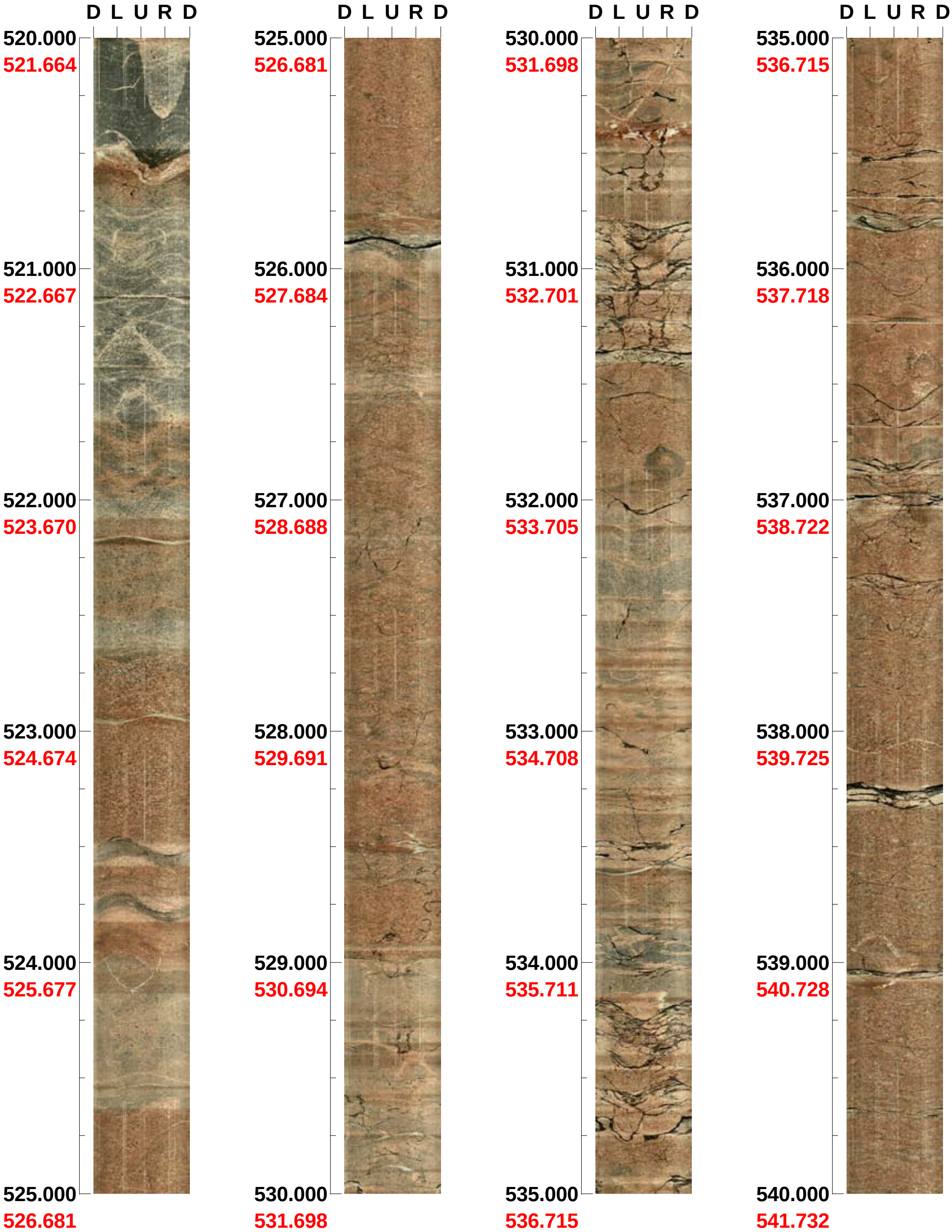


(2 / 20) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 520.000 - 540.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 540.000 - 560.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 560.000 - 580.000 m

D L U R D

560.000
561.788

561.000
562.791

562.000
563.793

563.000
564.796

564.000
565.798

565.000
566.800

D L U R D

565.000
566.800

566.000
567.803

567.000
568.805

568.000
569.808

569.000
570.810

570.000
571.812

D L U R D

570.000
571.812

571.000
572.815

572.000
573.817

573.000
574.820

574.000
575.822

575.000
576.824

D L U R D

575.000
576.824

576.000
577.827

577.000
578.829

578.000
579.832

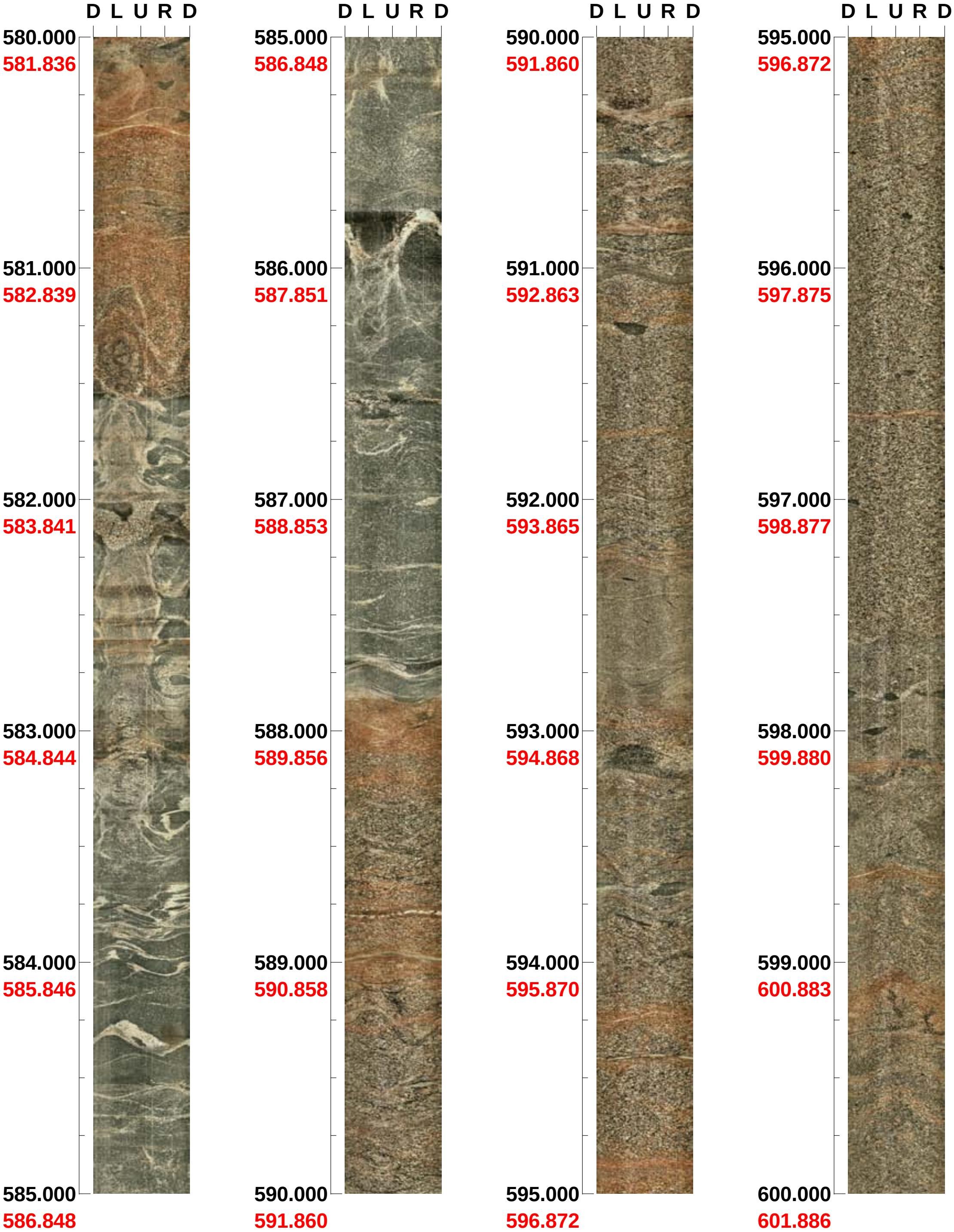
579.000
580.834

580.000
581.836

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

Project name: Laxemar
Bore hole No.: KLX09 Azimuth: 267 Inclination: -85

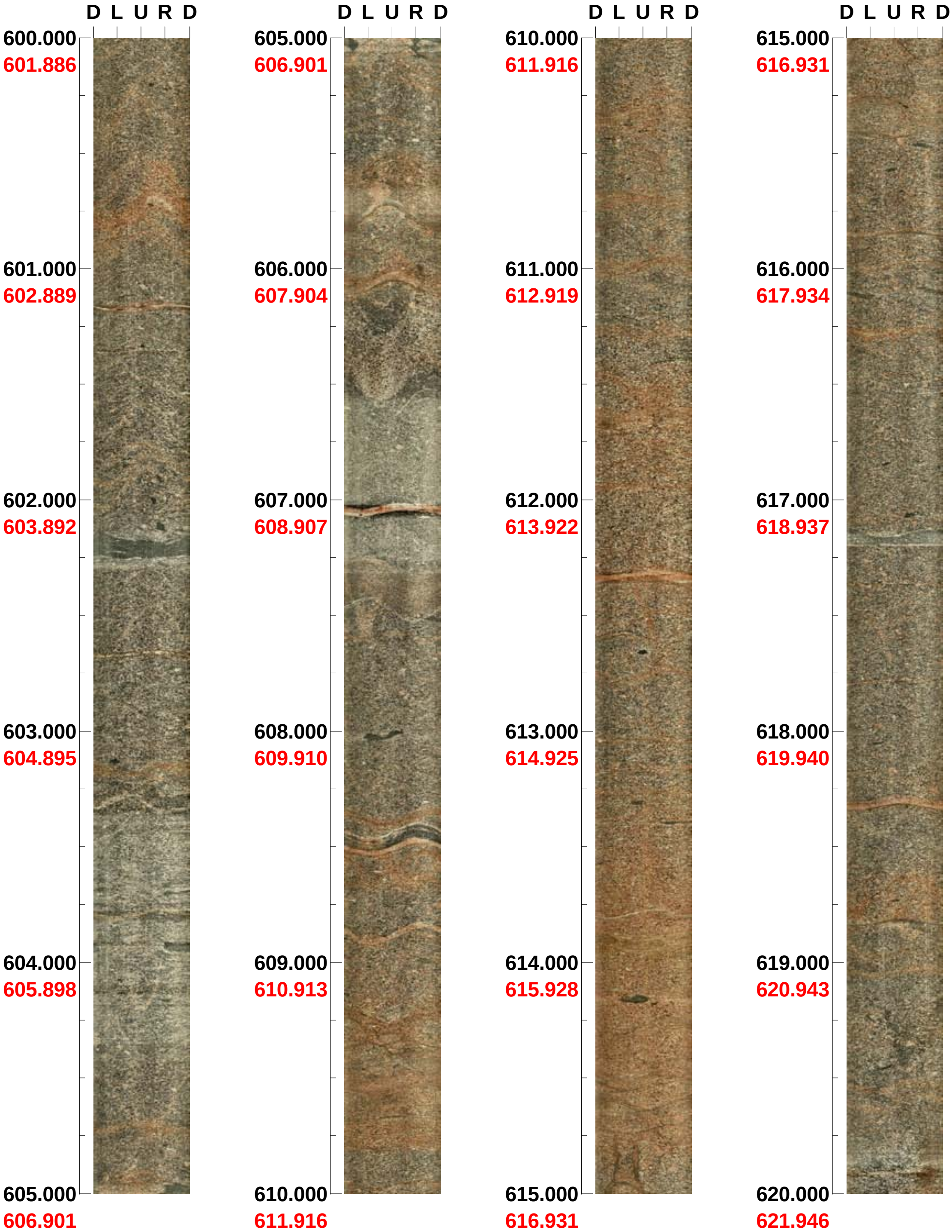
Depth range: 580.000 - 600.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

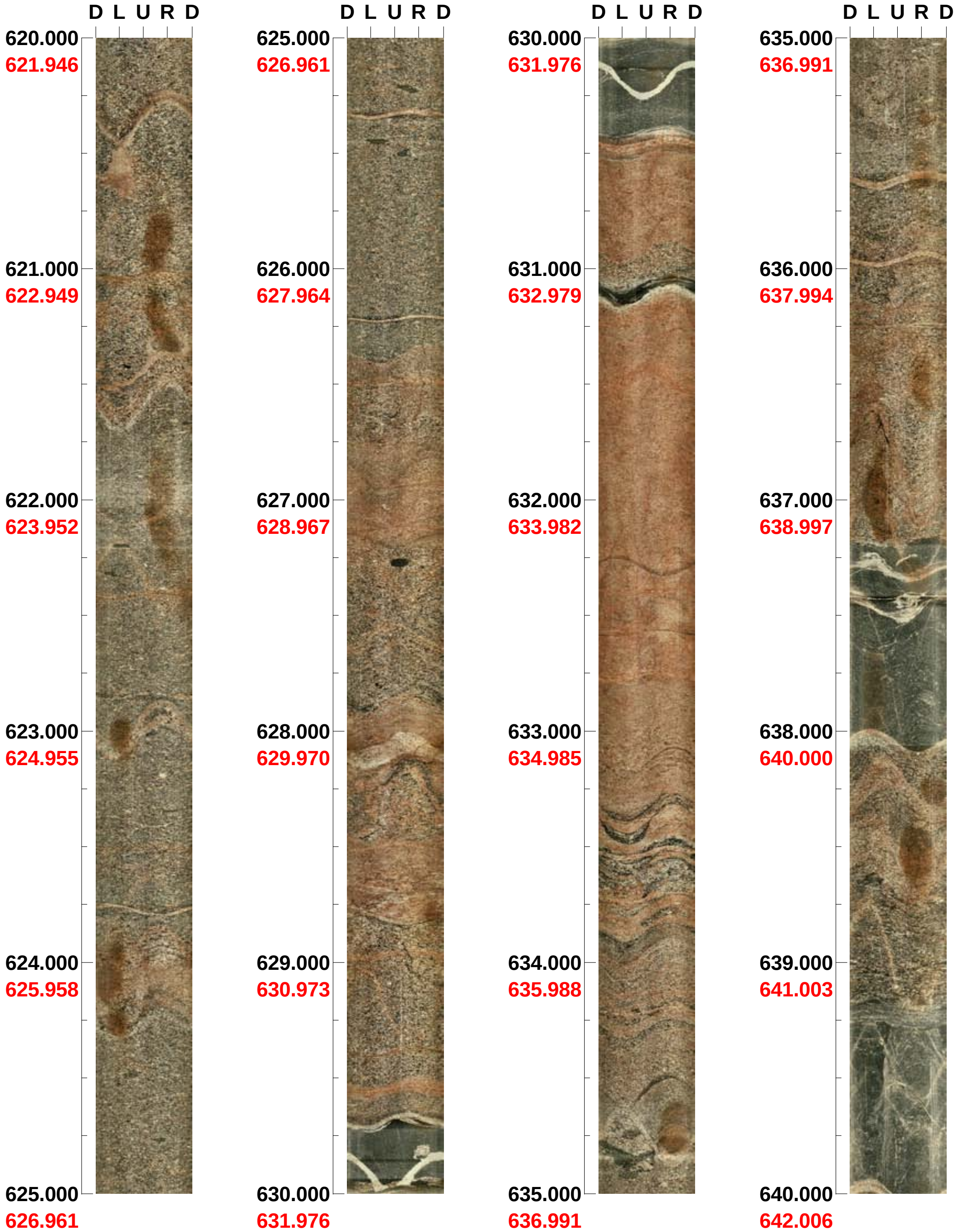
Depth range: 600.000 - 620.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

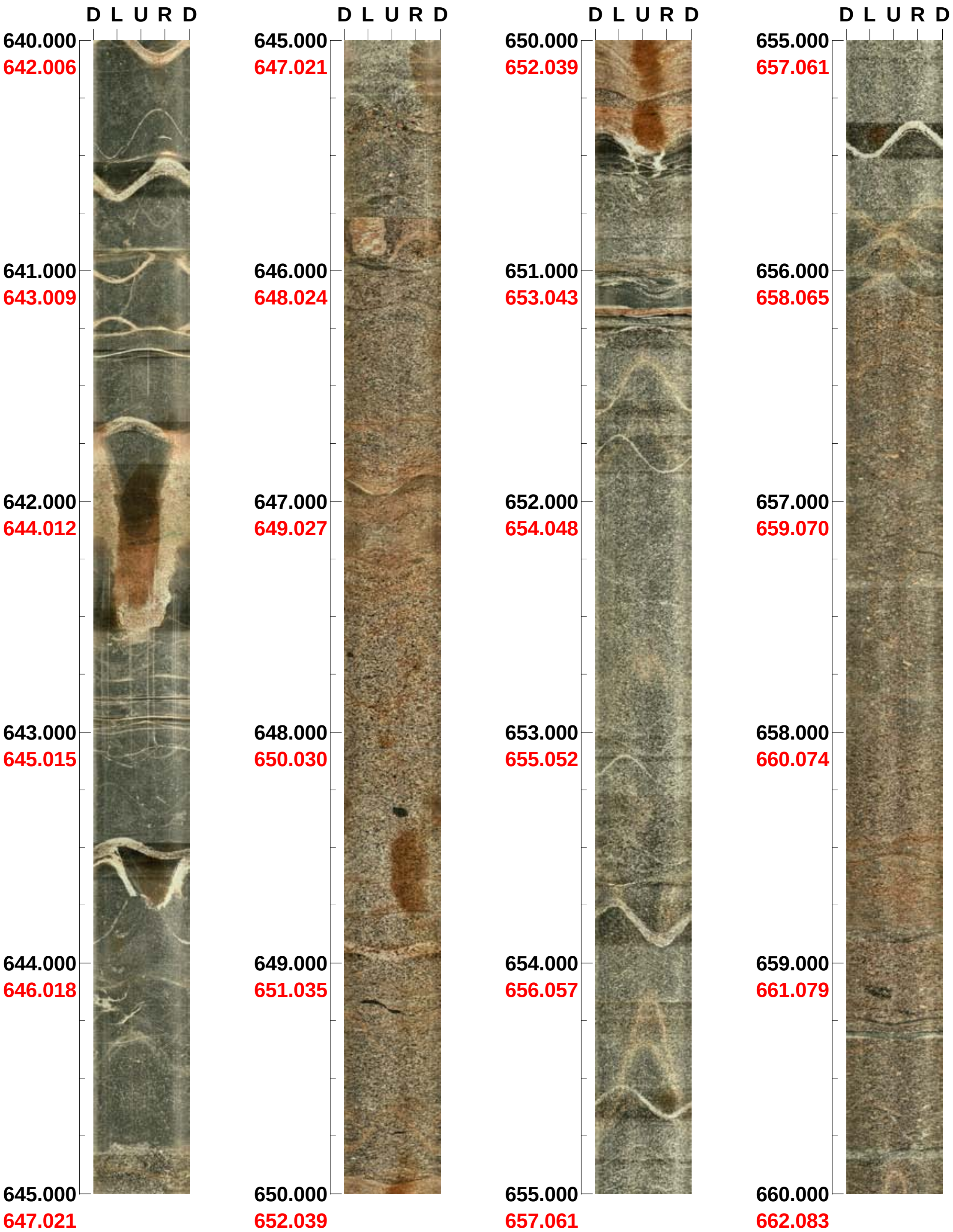
Depth range: 620.000 - 640.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 640.000 - 660.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 Azimuth: 267 Inclination: -85

Depth range: 660.000 - 680.000 m

D L U R D

660.000
662.083
661.000
663.088
662.000
664.092
663.000
665.096
664.000
666.101
665.000
667.105

D L U R D

665.000
667.105
666.000
668.110
667.000
669.114
668.000
670.119
669.000
671.123
670.000
672.127

D L U R D

670.000
672.127
671.000
673.132
672.000
674.136
673.000
675.141
674.000
676.145
675.000
677.149

D L U R D

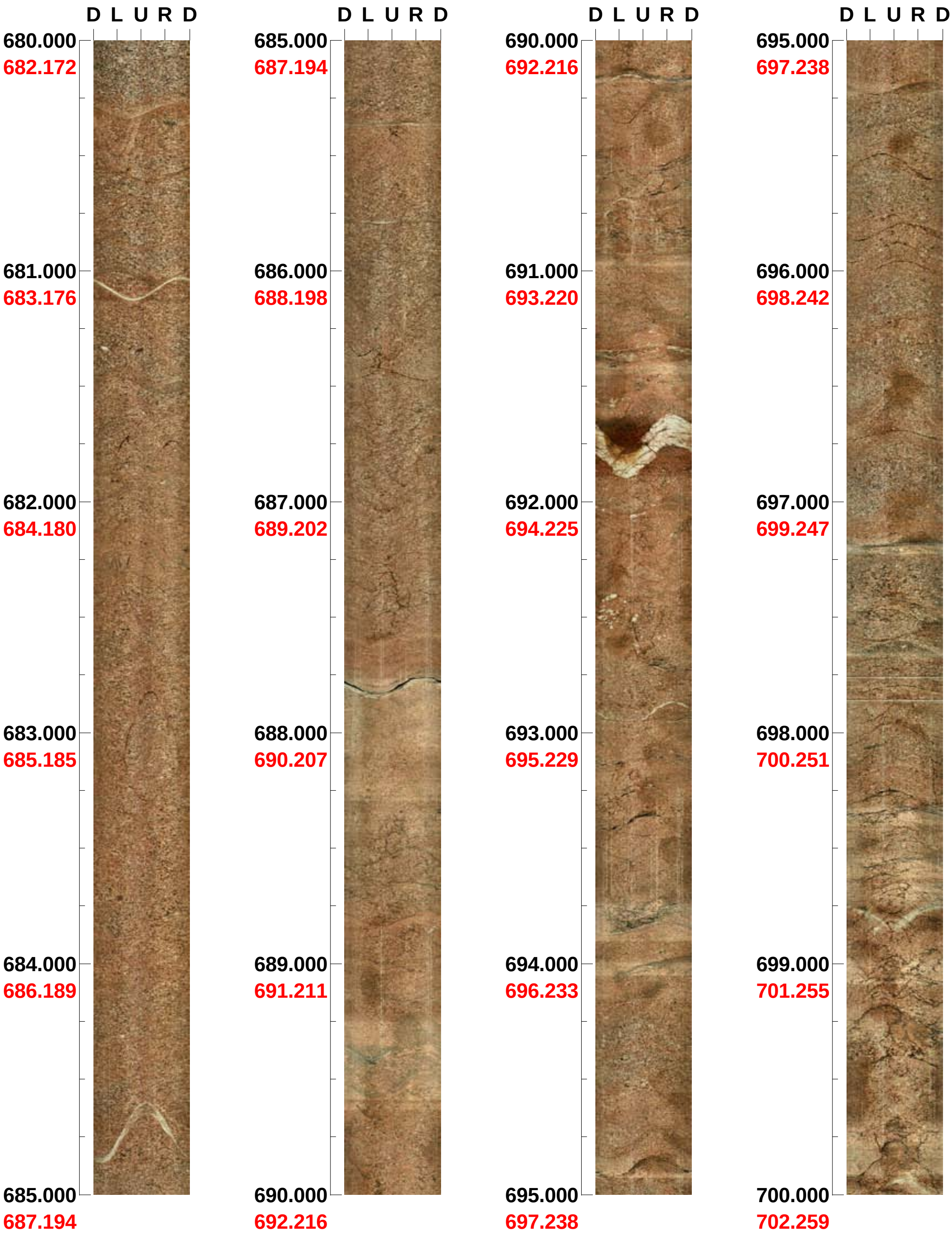
675.000
677.149
676.000
678.154
677.000
679.158
678.000
680.163
679.000
681.167
680.000
682.172

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

Project name: Laxemar

Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

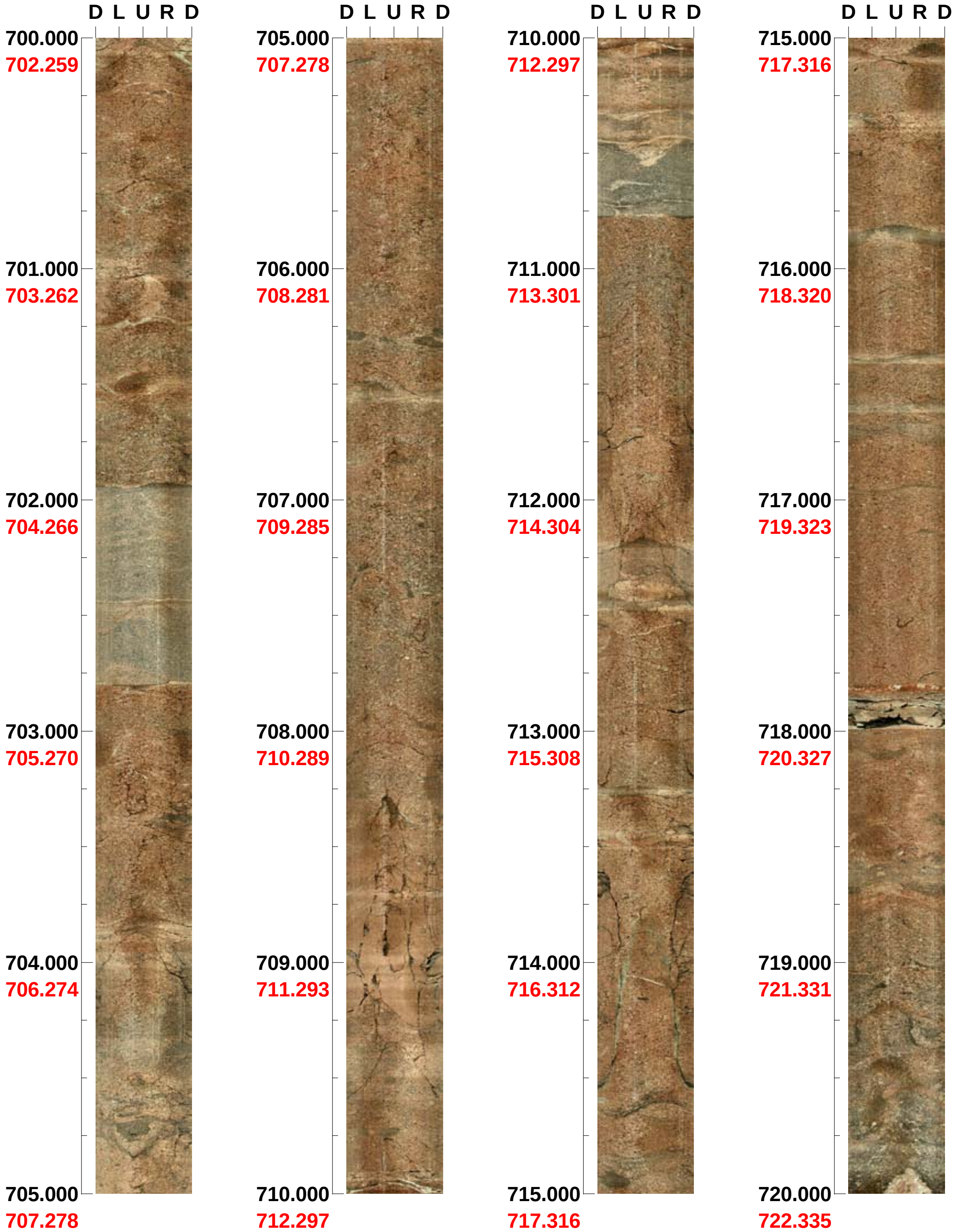
Depth range: 680.000 - 700.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

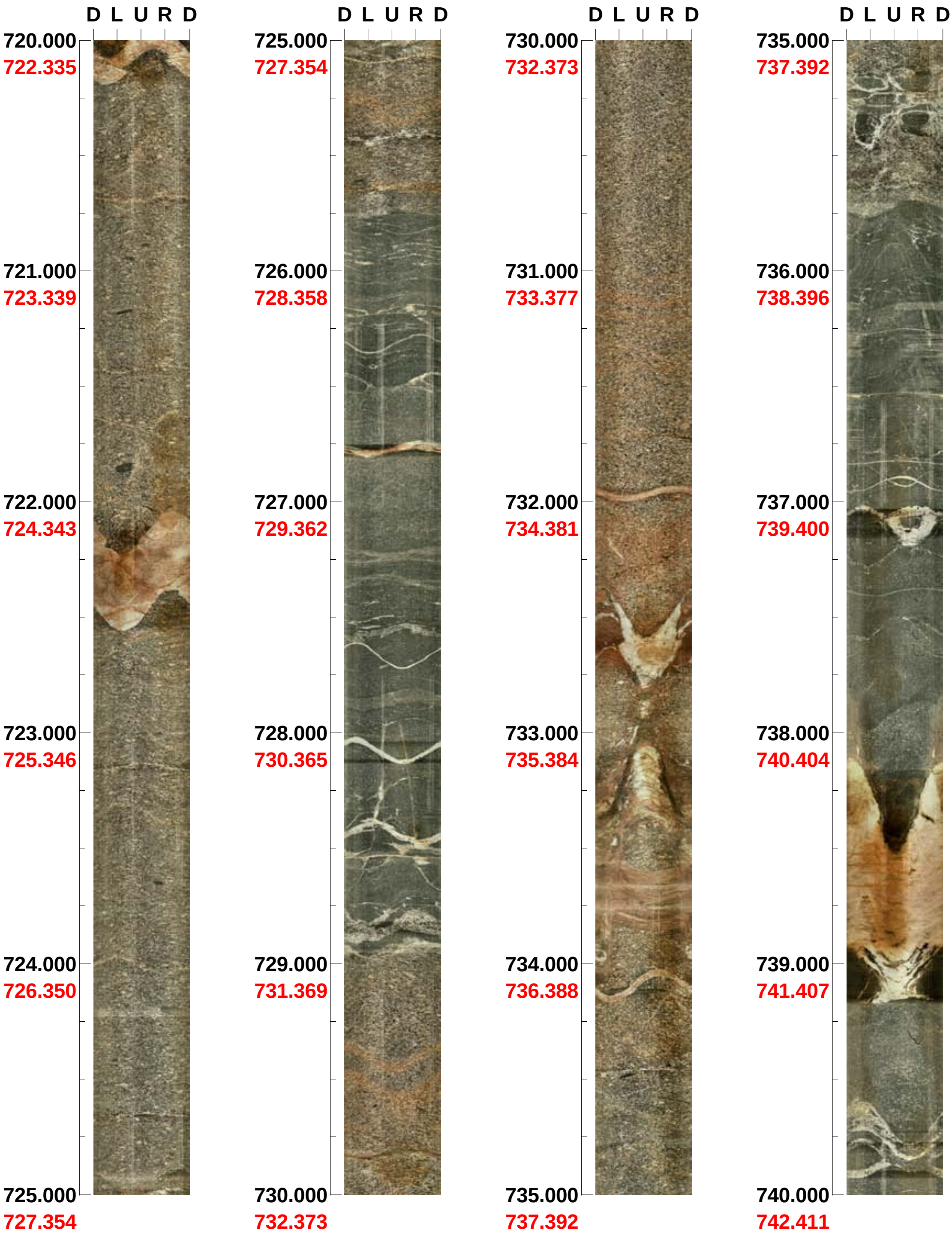
Depth range: 700.000 - 720.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 720.000 - 740.000 m

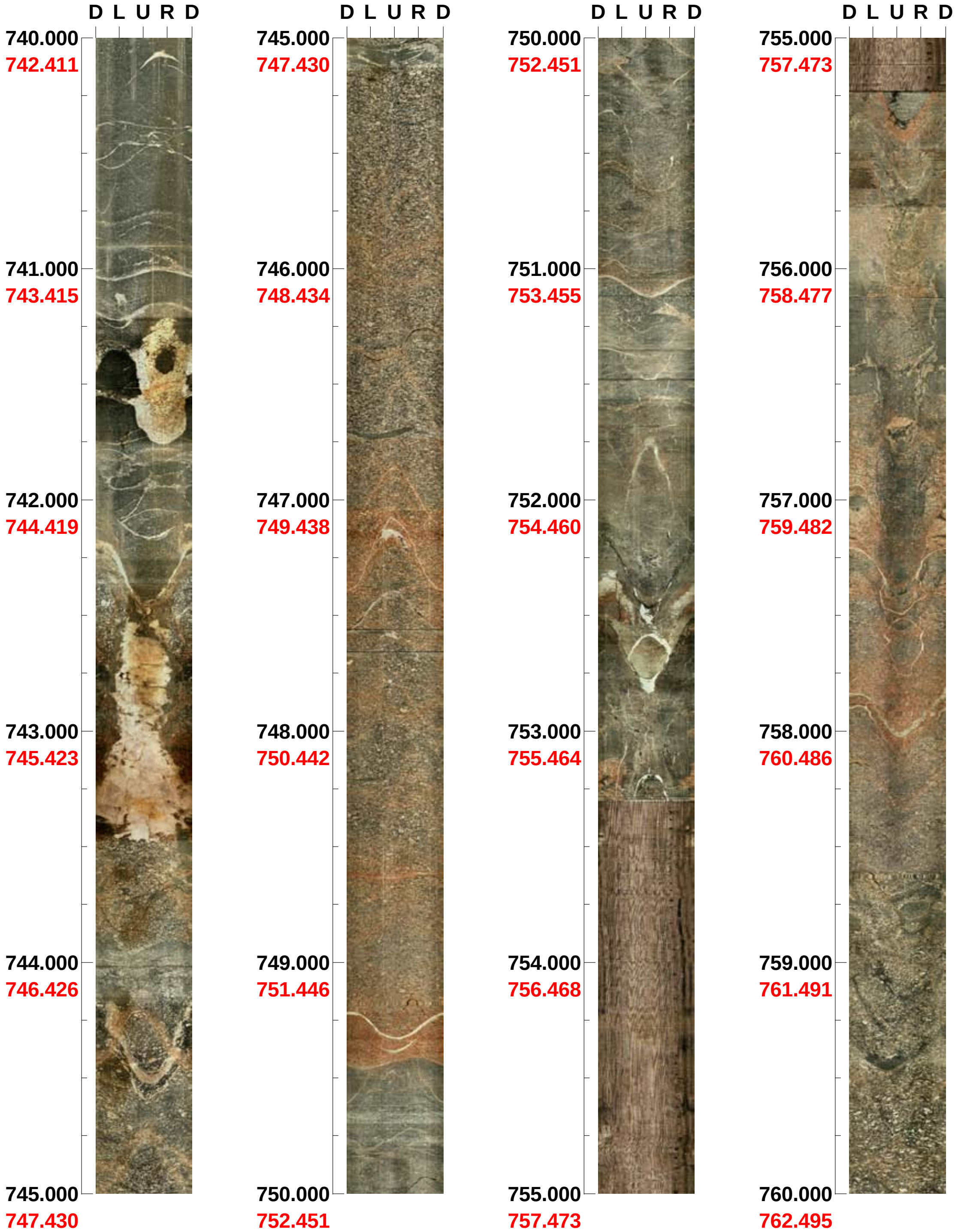


(13 / 20) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX09 Azimuth: 267 Inclination: -85

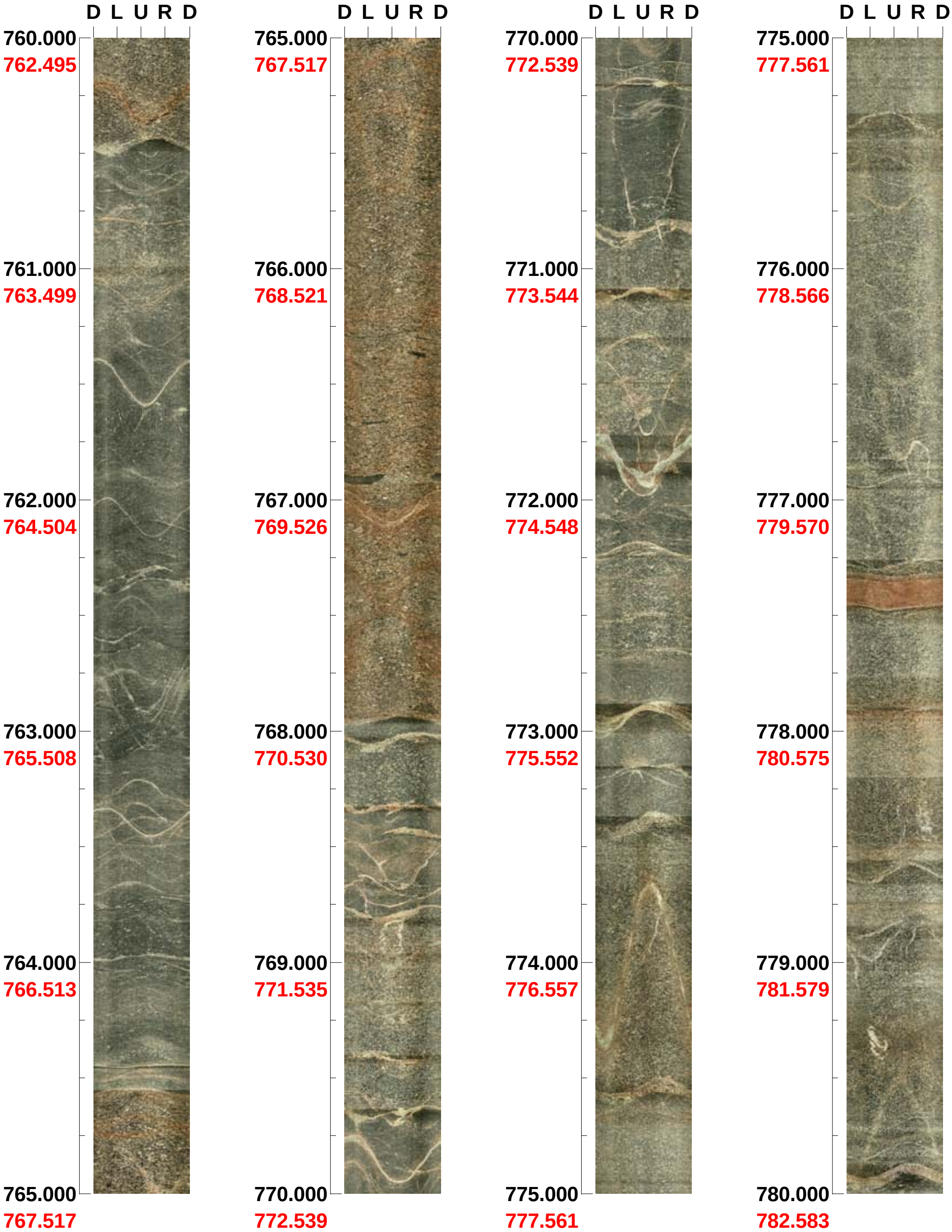
Depth range: 740.000 - 760.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 760.000 - 780.000 m

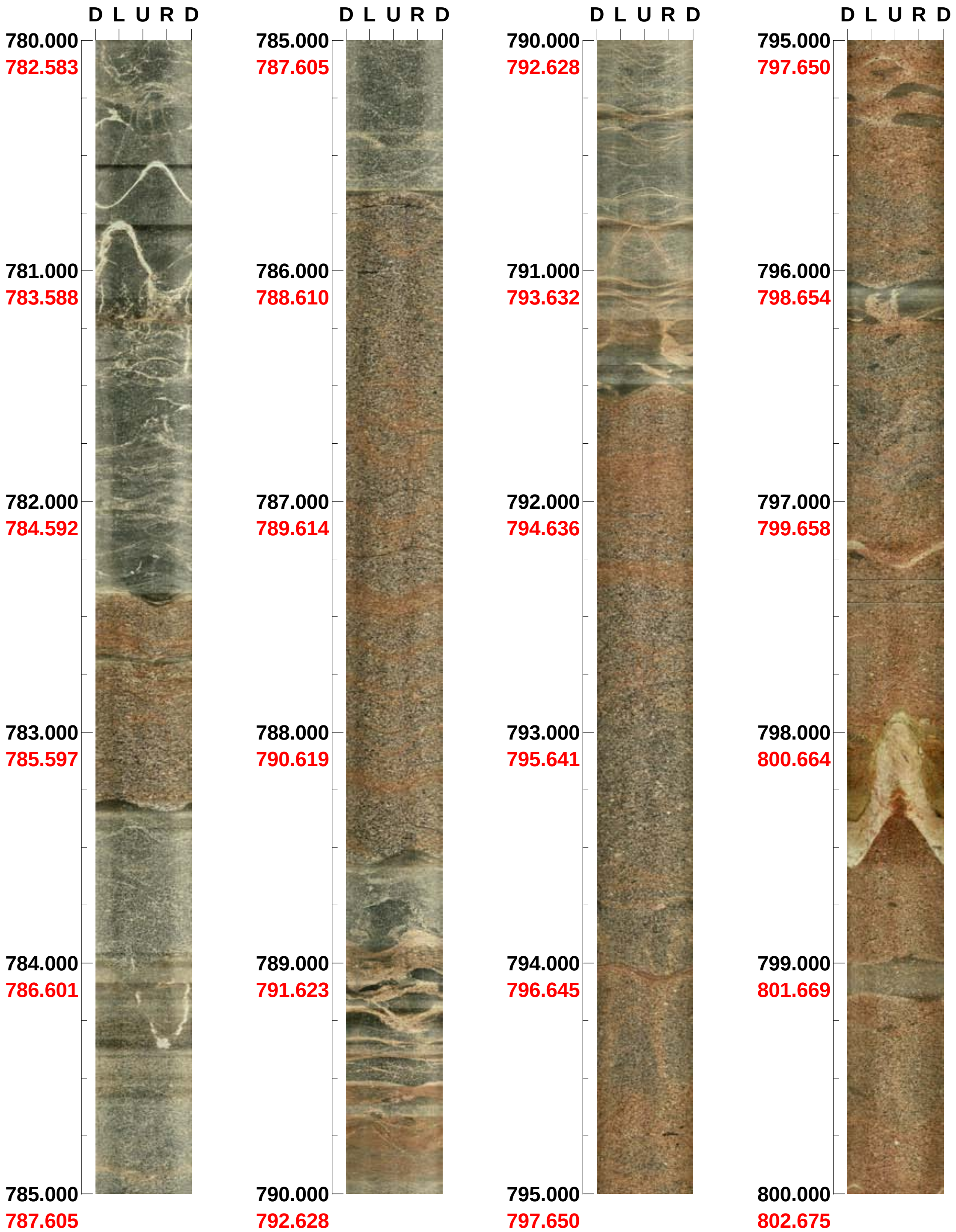


(15 / 20) **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar

Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 780.000 - 800.000 m



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

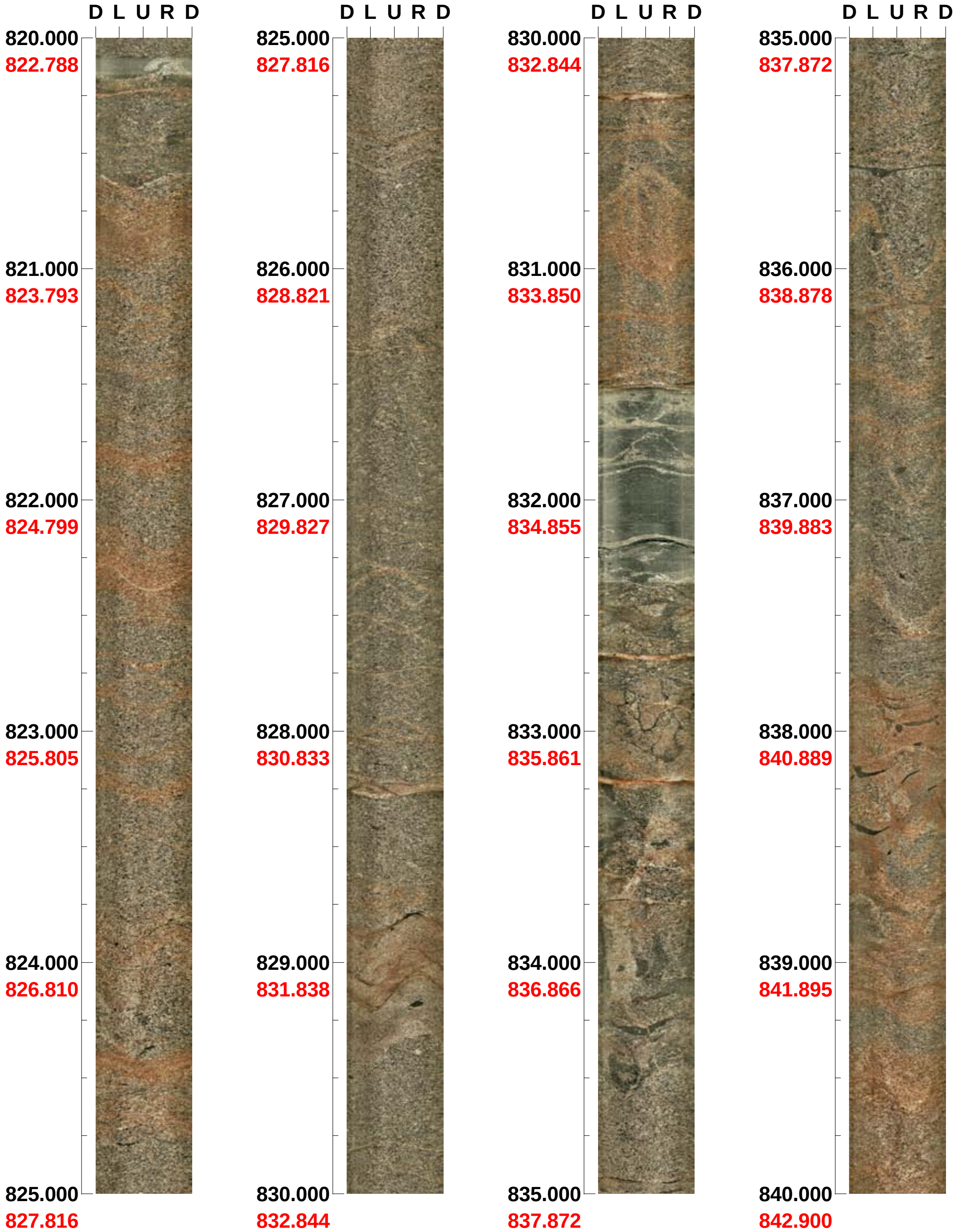
Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 800.000 - 820.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 820.000 - 840.000 m



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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 840.000 - 860.000 m

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

Project name: Laxemar
Bore hole No.: KLX09 **Azimuth: 267** **Inclination: -85**

Depth range: 860.000 - 870.609 m

D L U R D

860.000
862.974
861.000
863.976
862.000
864.979
863.000
865.982
864.000
866.984
865.000
867.987

D L U R D

865.000
867.987
866.000
868.990
867.000
869.992
868.000
870.995
869.000
871.997
870.000
873.000

D L U R D

870.000
873.000

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

Appendix 5

BIPS logging in HLX36, 5 to 193 m

Project name: Laxemar

Image file	: c:\work\r5485s~1\hlx36\bips\hlx36.bip
BDT file	: c:\work\r5485s~1\hlx36\bips\hlx36.bdt
Locality	: LAXEMAR
Bore hole number	: HLX36
Date	: 05/12/06
Time	: 15:57:00
Depth range	: 5.000 - 192.853 m
Azimuth	: 271
Inclination	: -59
Diameter	: 140.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 100 %
Pages	: 10
Color	: +0 +0 +0

Project name: Laxemar
Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

Depth range: 0.000 - 20.000 m

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

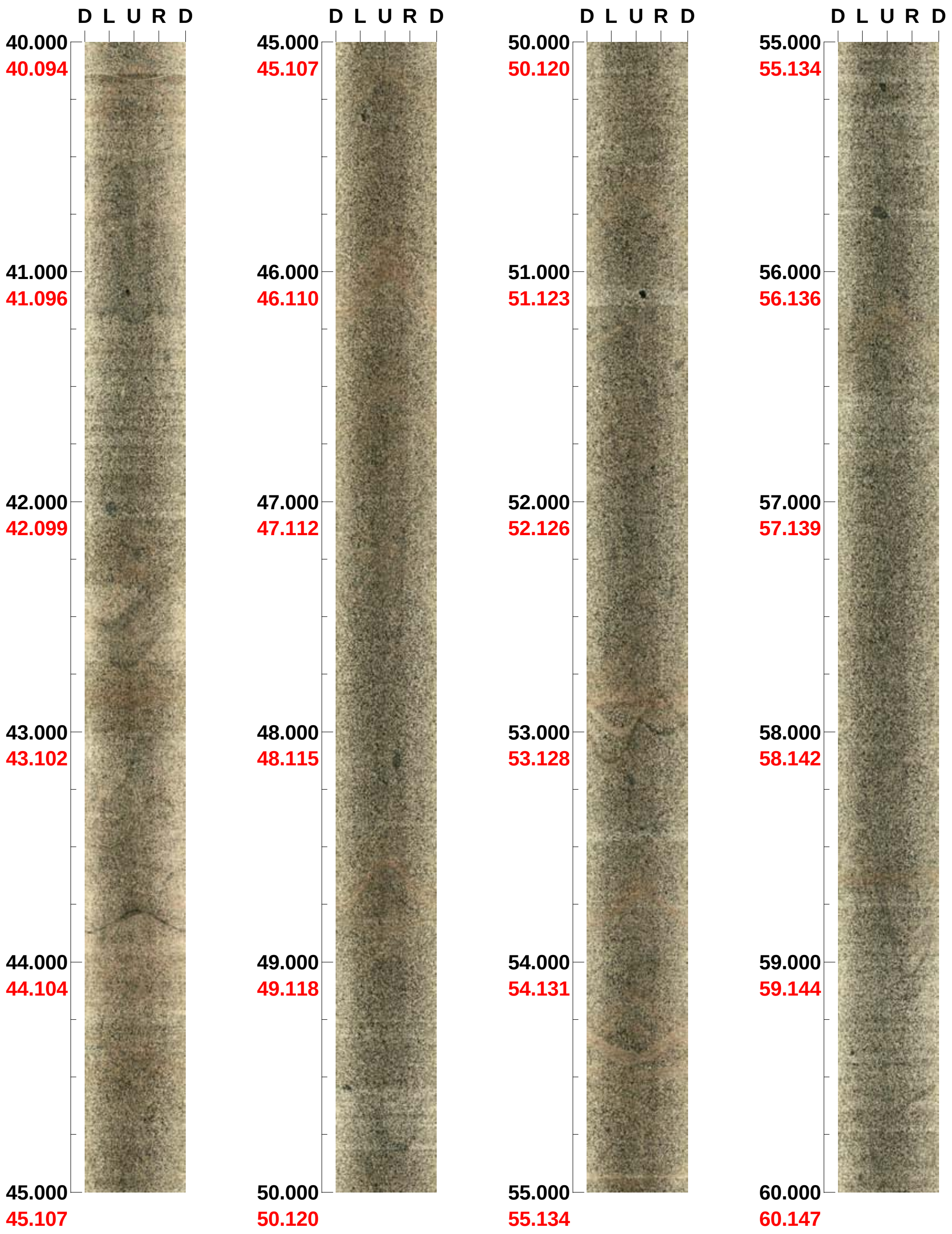
Project name: Laxemar
Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

Depth range: 20.000 - 40.000 m

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

Project name: Laxemar
Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

Depth range: 40.000 - 60.000 m



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

Project name: Laxemar

Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

Depth range: 60.000 - 80.000 m

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

Project name: Laxemar
Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

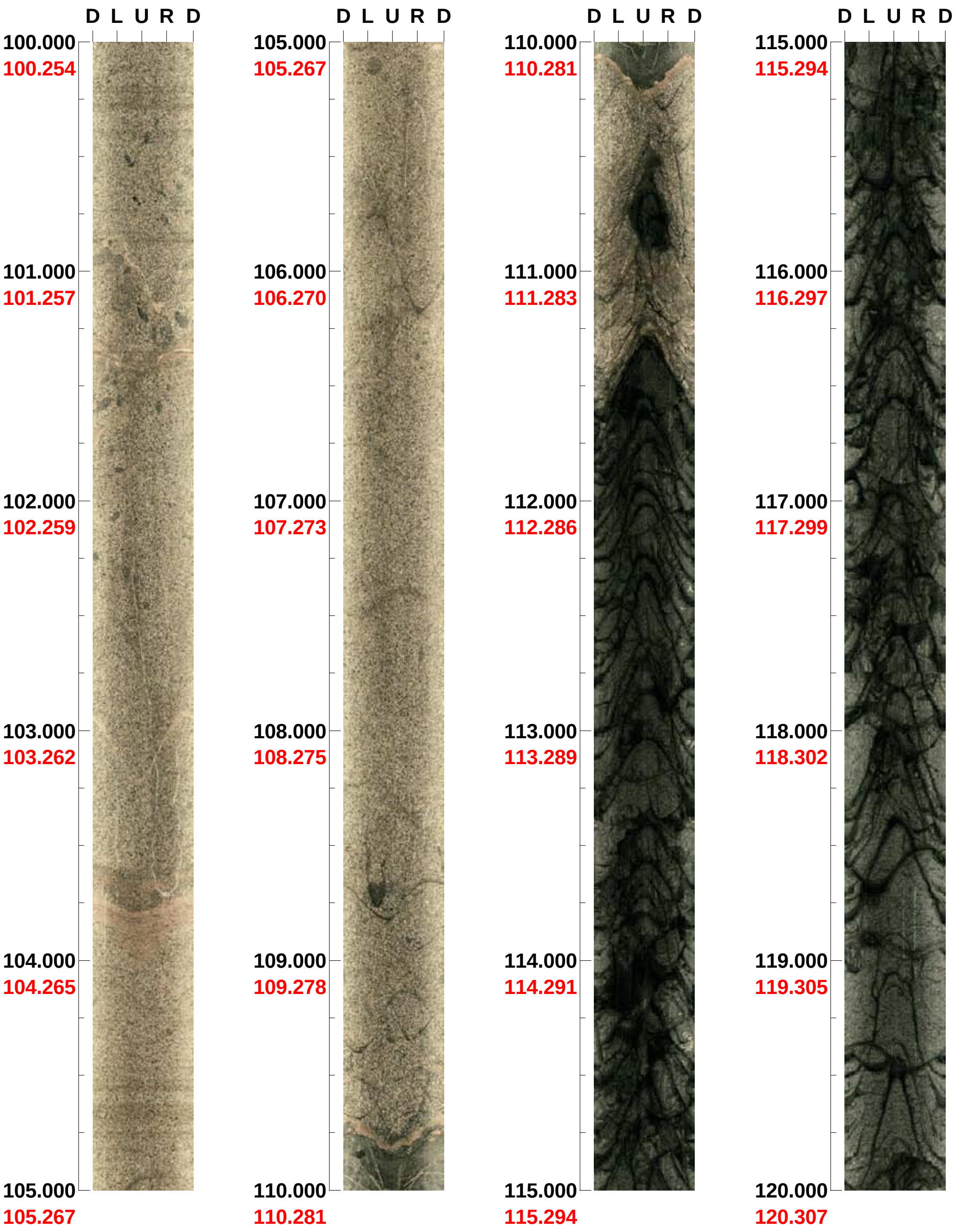
Depth range: 80.000 - 100.000 m

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

Project name: Laxemar

Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

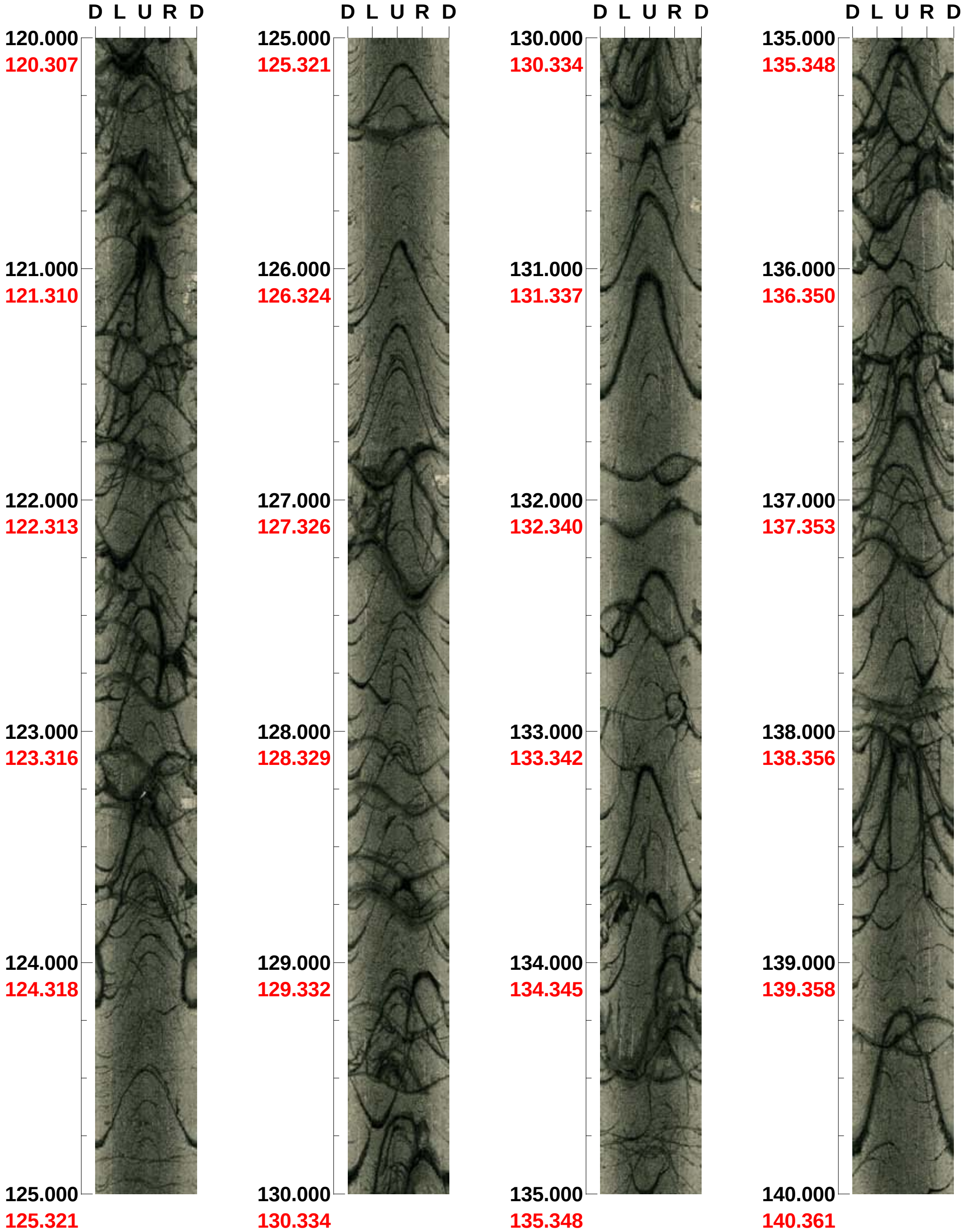
Depth range: 100.000 - 120.000 m



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

Project name: Laxemar
Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

Depth range: 120.000 - 140.000 m

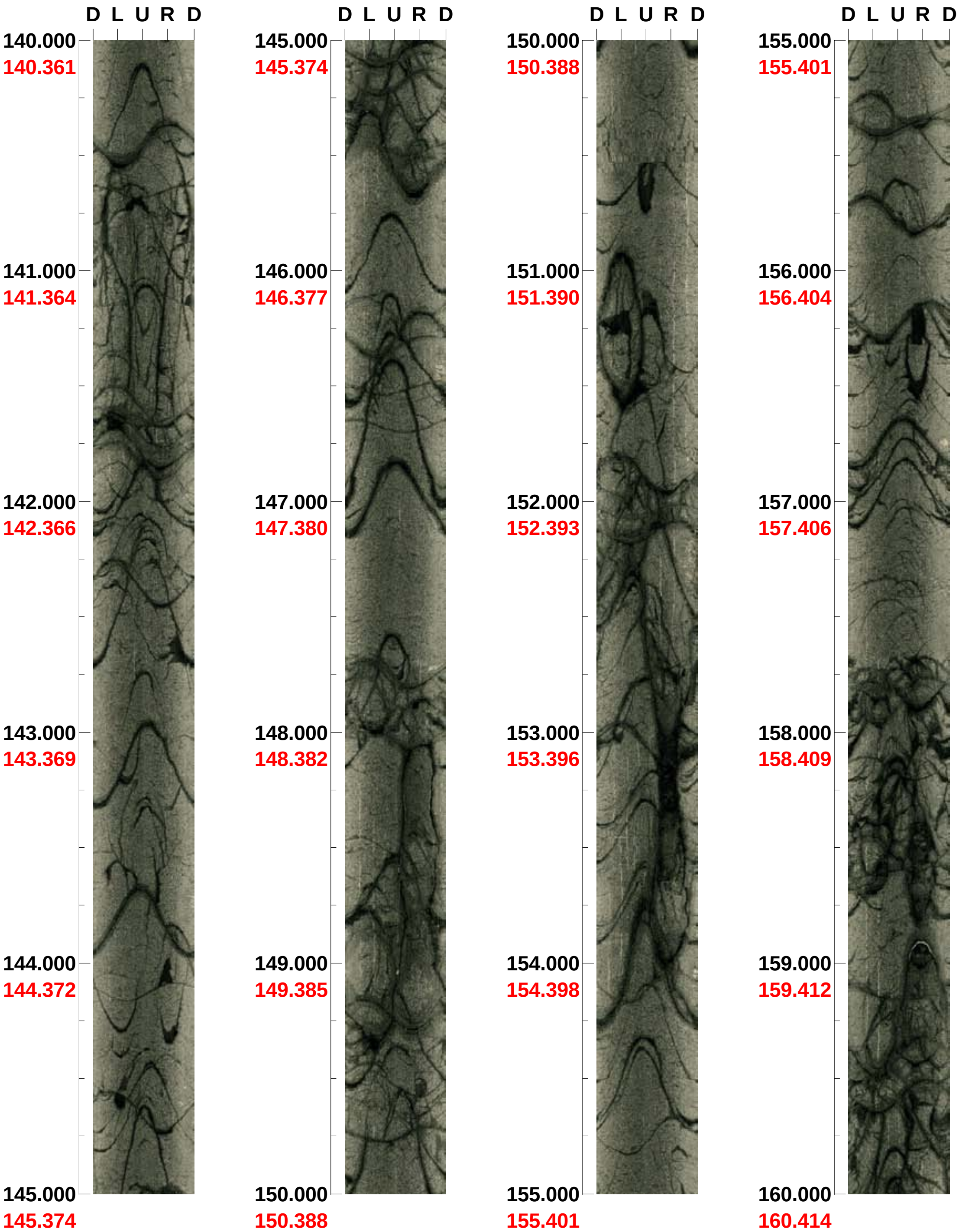


(7 / 10) **Scale: 1/25** **Aspect ratio: 100 %**

Project name: Laxemar

Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

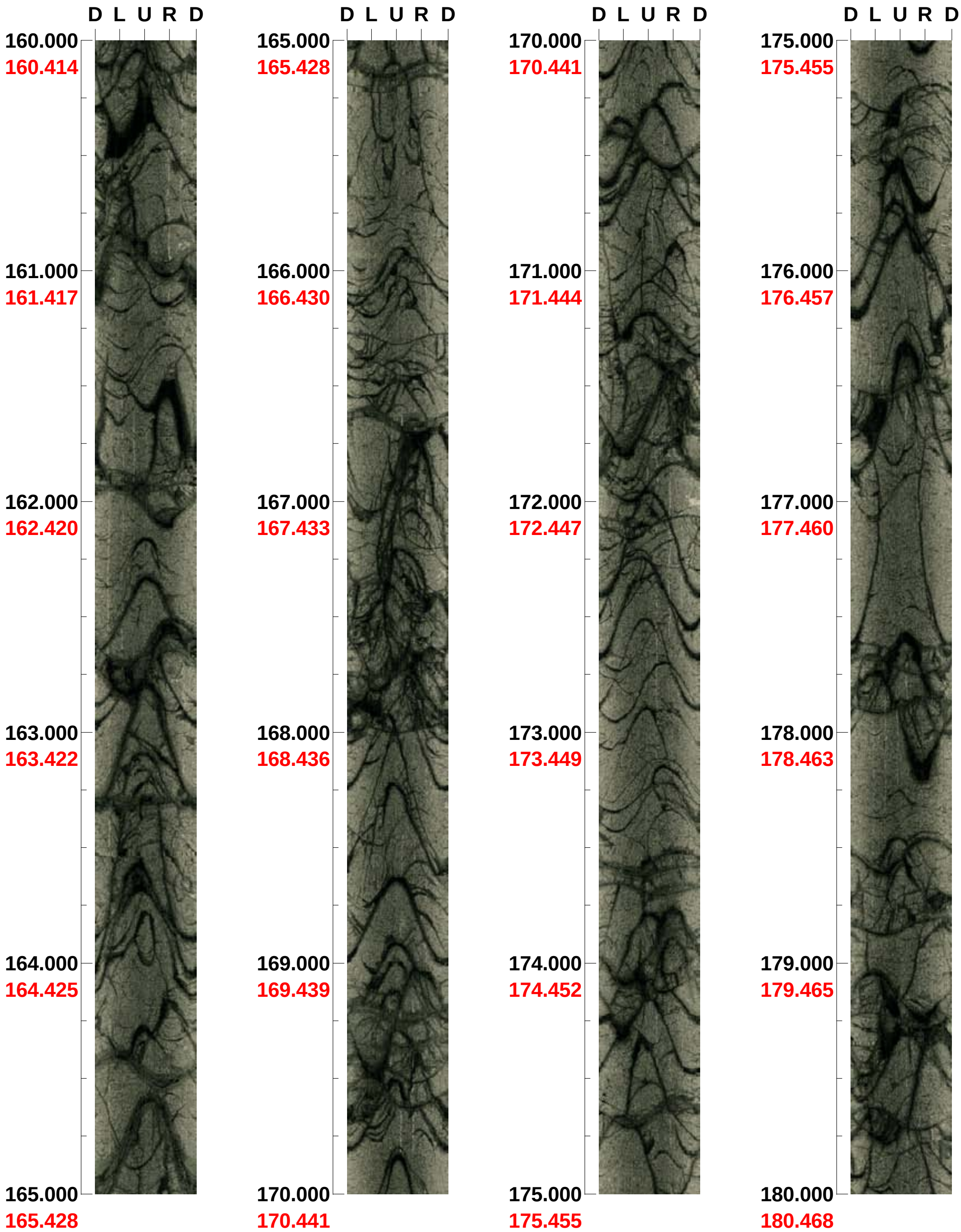
Depth range: 140.000 - 160.000 m



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

Project name: Laxemar
Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

Depth range: 160.000 - 180.000 m



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

Project name: Laxemar
Bore hole No.: HLX36 **Azimuth: 271** **Inclination: -59**

Depth range: 180.000 - 192.853 m

D L U R D

180.000
180.468

181.000
181.471

182.000
182.473

183.000
183.476

184.000
184.479

185.000
185.481

D L U R D

185.000
185.481

186.000
186.484

187.000
187.487

188.000
188.489

189.000
189.492

190.000
190.495

D L U R D

190.000
190.495

191.000
191.497

192.000
192.500

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

BIPS logging in HLX37, 11 to 199 m

Project name: Laxemar

Image file	: c:\work\r5485s~1\hlx37\bips\hlx37.bip
BDT file	: c:\work\r5485s~1\hlx37\bips\hlx37.bdt
Locality	: LAXEMAR
Bore hole number	: HLX37
Date	: 05/12/07
Time	: 11:35:00
Depth range	: 11.000 - 198.637 m
Azimuth	: 86
Inclination	: -59
Diameter	: 140.0 mm
Magnetic declination	: 0.0
Span	: 4
Scan interval	: 0.25
Scan direction	: To bottom
Scale	: 1/25
Aspect ratio	: 100 %
Pages	: 10
Color	: +0 +0 +0

Project name: Laxemar
Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 0.000 - 20.000 m

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

Project name: Laxemar
Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 20.000 - 40.000 m

D L U R D

20.000 / 20.024

21.000 / 21.027 — 22.000 / 22.029 — 23.000 / 23.032 — 24.000 / 24.035 — 25.000 / 25.037

D L U R D

25.000 / 25.037

26.000 / 26.040 — 27.000 / 27.043 — 28.000 / 28.045 — 29.000 / 29.048 — 30.000 / 30.051

D L U R D

30.000 / 30.051

31.000 / 31.053 — 32.000 / 32.056 — 33.000 / 33.059 — 34.000 / 34.061 — 35.000 / 35.064

D L U R D

35.000 / 35.064

36.000 / 36.067 — 37.000 / 37.070 — 38.000 / 38.072 — 39.000 / 39.075 — 40.000 / 40.078

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

Project name: Laxemar

Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 40.000 - 60.000 m

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

Project name: Laxemar

Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

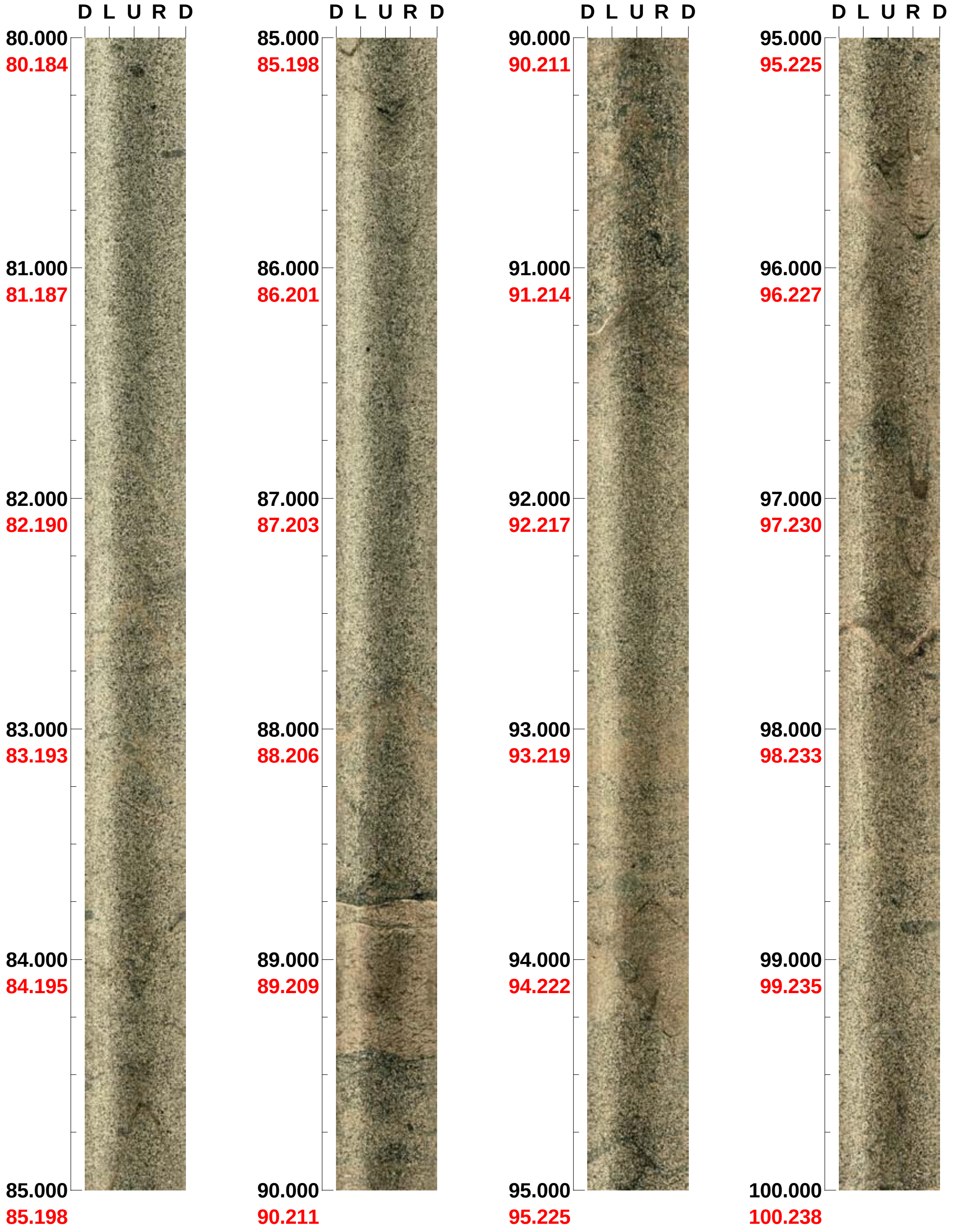
Depth range: 60.000 - 80.000 m

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

Project name: Laxemar

Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 80.000 - 100.000 m



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

Project name: Laxemar
Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 100.000 - 120.000 m

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

Project name: Laxemar
Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 120.000 - 140.000 m

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

Project name: Laxemar
Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 140.000 - 160.000 m

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

Project name: Laxemar

Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 160.000 - 180.000 m

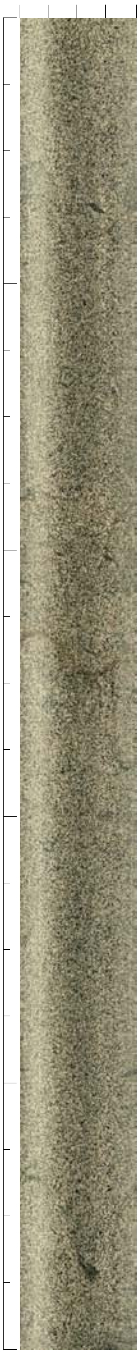
D L U R D

160.000 / 160.398
161.000 / 161.401
162.000 / 162.404
163.000 / 163.406
164.000 / 164.409
165.000 / 165.412

D L U R D

165.000 / 165.412
166.000 / 166.414
167.000 / 167.417
168.000 / 168.420
169.000 / 169.422
170.000 / 170.425

D L U R D



170.000 / 170.425
171.000 / 171.428
172.000 / 172.430
173.000 / 173.433
174.000 / 174.436
175.000 / 175.439

D L U R D

175.000 / 175.439
176.000 / 176.441
177.000 / 177.444
178.000 / 178.447
179.000 / 179.449
180.000 / 180.452

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

Project name: Laxemar

Bore hole No.: HLX37 **Azimuth: 86** **Inclination: -59**

Depth range: 180.000 - 198.637 m

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

Deviation logging in HLX36, 0 to 198 m

New MeasureIT files

Survey name:	**HLX36 IN**
Survey date:	06/12/2006 18:36:25
Project:	PLU
Location:	Laxemar

Country:	Sweden		
Survey company:	RAYCON		
Surveyed by:	Christer Gustafsson		
Survey type:	STANDARD		
Operating conditions:			
General comments:			
Client name:	SKB		
Client ID number:	AP PS 400-05-93		
Client reference:	Leif Stenberg		
Drill company:			
Drill rig:			
Drill diameter:	140	Survey run on:	Wireline
Survey direction:	INTO hole	Magnetic Var.:	2,33 degrees East of North

Conventions

Linear units:	Metres
Angular units:	Degrees
Temperature units:	Centigrade
Co-ordinate system:	0 North
Elevation positive	Up
Dip origin:	0 Horizontal
Dip positive:	Up

Magnetic Integrity Check (MagIC)

	Mid value	± limit	
Field strength:	49600	1000	nano Tesla
Magnetic dip:	71.4	1.5	Degrees

SURVEY	Actual start	End of survey	Difference
Station:	0,0	198,0	198,0
East:	1546558,45	1546441,14	-117,31
North:	6366172,94	6366178,81	5,87
Elevation:	15,56	-143,52	-159,08
Dip:	-59,36	-49,46	9,90
Azimuth:	271,33	274,01	2,68

OFFSETS at end

Offsets relative to:
ACTUAL START

19,95 metres upwards
3,15 metres right
1,29 metres shortfall

Printed on: 2006-03-06 11:32:29

Page 1 of 4

FLEXIT: SmartTool drillhole survey result table.

Survey name : HLX36 IN
Survey date : 06/12/2006 18:36:25
Printed on 2006-03-06 11:33:06

Station	Dip	Azimuth	Easting	Northing	Elevation	Mag.Field	Mag.Dip	Grav.Field	Status	UpDown	LeftRight	Shortfall
Metres	Degrees	Degrees	Metres	Metres	Metres	nT	Degrees	G	*	Metres	Metres	Metres
0,0	-59,36	271,33	1546558,45	6366172,94	15,56	47754	67,76	0,999603	✍✍✍	0,00	0,00	0,00
3,0	-59,02	271,33	1546556,92	6366172,97	12,98	48628	70,71	0,999417	✍	0,01	0,00	0,00
6,0	-58,94	270,77	1546555,37	6366173,00	10,41	49734	70,82	0,999243	✍	0,03	-0,01	0,00
9,0	-58,85	270,12	1546553,82	6366173,01	7,84	49688	70,95	0,998106	✍	0,05	-0,03	0,00
12,0	-58,73	270,38	1546552,27	6366173,02	5,28	49748	71,20	0,997602	✍	0,08	-0,06	0,00
15,0	-58,45	270,12	1546550,70	6366173,02	2,72	49787	71,03	0,997608	✍	0,12	-0,09	0,00
18,0	-58,31	270,39	1546549,13	6366173,03	0,16	49883	71,03	0,997294	✍	0,17	-0,12	0,00
21,0	-58,03	270,36	1546547,55	6366173,04	-2,39	49758	71,10	0,997093	✍	0,24	-0,15	0,00
24,0	-57,77	269,82	1546545,95	6366173,04	-4,93	49802	71,22	0,997784	✍	0,31	-0,18	0,00
27,0	-57,57	270,84	1546544,35	6366173,05	-7,46	49873	71,01	0,997385	✍	0,40	-0,21	0,00
30,0	-57,32	271,53	1546542,73	6366173,09	-9,99	49869	70,91	0,997249	✍	0,50	-0,21	-0,01
33,0	-56,51	271,00	1546541,10	6366173,12	-12,51	49740	71,05	0,997403	✍	0,63	-0,21	-0,01
36,0	-56,50	271,28	1546539,44	6366173,16	-15,01	49656	71,09	0,997834	✍	0,78	-0,22	-0,01
39,0	-56,27	271,47	1546537,78	6366173,20	-17,51	49648	71,21	0,998020	✍	0,93	-0,22	-0,02
42,0	-56,09	271,87	1546536,11	6366173,24	-20,00	49734	71,11	0,996987	✍	1,10	-0,21	-0,02
45,0	-55,92	271,60	1546534,44	6366173,30	-22,49	49782	70,94	0,996995	✍	1,28	-0,20	-0,03
48,0	-55,67	271,40	1546532,75	6366173,34	-24,97	49870	70,96	0,997230	✍	1,46	-0,19	-0,03
51,0	-55,45	271,62	1546531,05	6366173,38	-27,44	49873	71,01	0,997413	✍	1,66	-0,19	-0,04
54,0	-55,25	271,07	1546529,35	6366173,42	-29,91	49905	70,99	0,997275	✍	1,87	-0,19	-0,05
57,0	-55,06	271,40	1546527,64	6366173,46	-32,37	49867	70,91	0,997481	✍	2,09	-0,19	-0,05
60,0	-54,90	271,02	1546525,91	6366173,50	-34,83	49753	71,09	0,997117	✍	2,32	-0,19	-0,06
63,0	-54,58	271,27	1546524,18	6366173,53	-37,28	50095	71,43	0,996983	✍	2,56	-0,20	-0,07
66,0	-54,59	271,04	1546522,44	6366173,57	-39,72	49661	70,84	0,997179	✍	2,81	-0,20	-0,08
69,0	-54,52	273,42	1546520,71	6366173,64	-42,17	49903	70,77	0,996595	✍	3,06	-0,18	-0,09
72,0	-54,26	271,60	1546518,96	6366173,71	-44,61	49927	70,90	0,996822	✍	3,32	-0,14	-0,11
75,0	-54,22	271,50	1546517,21	6366173,76	-47,04	49836	70,95	0,997244	✍	3,59	-0,13	-0,12
78,0	-54,04	271,68	1546515,45	6366173,81	-49,47	49738	70,81	0,996721	✍	3,86	-0,13	-0,13
81,0	-53,92	272,08	1546513,69	6366173,87	-51,90	49753	70,87	0,996991	✍	4,14	-0,11	-0,14
84,0	-53,49	272,27	1546511,91	6366173,93	-54,32	49908	70,95	0,997701	✍	4,44	-0,08	-0,16
87,0	-53,24	272,43	1546510,12	6366174,01	-56,72	49780	70,96	0,998321	✍	4,75	-0,05	-0,17
90,0	-53,07	272,50	1546508,33	6366174,08	-59,12	49765	70,95	0,997659	✍	5,08	-0,02	-0,19
93,0	-52,91	273,66	1546506,52	6366174,18	-61,52	50439	71,17	0,998830	✍	5,41	0,04	-0,21
96,0	-52,81	272,98	1546504,72	6366174,29	-63,91	49859	71,13	0,998856	✍	5,75	0,10	-0,23

Survey name : HLX36 IN

Survey date : 06/12/2006 18:36:25

Printed on 2006-03-06 11:33:06

Station Metres	Dip Degrees	Azimuth Degrees	Easting Metres	Northing Metres	Elevation Metres	Mag.Field nT	Mag.Dip Degrees	Grav.Field G	Status *	UpDown Metres	LeftRight Metres	Shortfall Metres
99,0	-52,74	273,27	1546502,90	6366174,38	-66,30	49700	71,03	0,999338	✍	6,09	0,16	-0,25
102,0	-52,67	273,28	1546501,09	6366174,49	-68,69	49722	71,10	0,999348	✍	6,44	0,22	-0,27
105,0	-52,52	273,95	1546499,27	6366174,60	-71,07	49493	70,95	0,999370	✍	6,79	0,29	-0,29
108,0	-52,42	275,69	1546497,45	6366174,76	-73,45	49985	70,92	0,999572	✍	7,14	0,41	-0,32
111,0	-52,39	273,79	1546495,63	6366174,91	-75,83	49619	71,22	0,999275	✍	7,50	0,51	-0,34
114,0	-52,52	274,75	1546493,80	6366175,04	-78,20	49310	70,88	0,999736	✍	7,86	0,61	-0,36
117,0	-52,38	272,24	1546491,98	6366175,16	-80,58	49529	71,20	0,999823	✍	8,22	0,68	-0,39
120,0	-52,19	273,04	1546490,15	6366175,24	-82,96	49484	71,57	0,999971	✍	8,59	0,72	-0,41
123,0	-52,19	274,45	1546488,31	6366175,36	-85,33	49972	71,01	0,999795	✍	8,96	0,80	-0,43
126,0	-52,11	276,08	1546486,48	6366175,53	-87,70	49404	70,52	0,999850	✍	9,34	0,92	-0,46
129,0	-51,97	275,25	1546484,64	6366175,71	-90,06	49328	70,65	0,999869	✍	9,71	1,06	-0,49
132,0	-51,90	274,05	1546482,80	6366175,86	-92,42	49681	71,12	0,999944	✍	10,10	1,17	-0,51
135,0	-51,77	272,85	1546480,95	6366175,97	-94,78	49446	71,13	1,000097	✍	10,49	1,24	-0,54
138,0	-51,69	273,59	1546479,09	6366176,08	-97,14	49344	71,04	0,999914	✍	10,89	1,30	-0,57
141,0	-51,57	273,92	1546477,23	6366176,20	-99,49	49489	71,00	1,000032	✍	11,29	1,38	-0,60
144,0	-51,56	273,51	1546475,37	6366176,32	-101,84	50218	70,80	1,000021	✍	11,70	1,46	-0,62
147,0	-51,40	273,33	1546473,51	6366176,43	-104,19	49652	71,63	0,999980	✍	12,11	1,52	-0,65
150,0	-51,20	274,01	1546471,64	6366176,55	-106,53	49836	70,32	1,000032	✍	12,53	1,60	-0,68
153,0	-51,09	275,27	1546469,76	6366176,70	-108,86	50026	70,64	1,000207	✍	12,95	1,71	-0,72
156,0	-50,98	273,70	1546467,88	6366176,85	-111,20	49757	71,05	1,000092	✍	13,38	1,81	-0,75
159,0	-50,97	273,80	1546465,99	6366176,97	-113,53	49550	70,38	0,999814	✍	13,82	1,89	-0,78
162,0	-50,72	274,23	1546464,10	6366177,11	-115,85	50066	70,94	1,000221	✍	14,26	1,98	-0,82
165,0	-50,68	273,26	1546462,21	6366177,23	-118,17	49585	71,02	1,000716	✍	14,71	2,06	-0,85
168,0	-50,60	275,59	1546460,31	6366177,38	-120,49	49553	71,21	0,999675	✍	15,16	2,16	-0,89
171,0	-50,54	272,87	1546458,41	6366177,52	-122,81	49656	71,22	1,000295	✍	15,62	2,26	-0,92
174,0	-50,46	273,57	1546456,51	6366177,63	-125,13	49408	71,03	1,000527	✍	16,08	2,32	-0,96
177,0	-50,43	273,94	1546454,60	6366177,75	-127,44	49633	70,95	0,999888	✍	16,54	2,40	-1,00
180,0	-50,30	274,33	1546452,69	6366177,89	-129,75	49859	70,98	1,000046	✍	17,01	2,50	-1,04
183,0	-50,14	274,89	1546450,78	6366178,04	-132,05	49631	71,45	1,001208	✍	17,49	2,61	-1,08
186,0	-49,90	272,93	1546448,85	6366178,17	-134,35	49763	71,15	1,000388	✍	17,97	2,69	-1,12
189,0	-49,92	275,74	1546446,93	6366178,32	-136,65	49589	70,89	1,000102	✍	18,46	2,80	-1,16
192,0	-49,89	274,44	1546445,00	6366178,49	-138,94	49598	70,96	1,000914	✍	18,95	2,92	-1,20
195,0	-49,72	275,14	1546443,07	6366178,65	-141,23	49533	70,70	1,002298	✍	19,44	3,04	-1,24

FLEXIT: SmartTool drillhole survey result table.

Survey name : HLX36 IN
Survey date : 06/12/2006 18:36:25

Printed on 2006-03-06 11:33:06

Station	Dip	Azimuth	Easting	Northing	Elevation	Mag.Field	Mag.Dip	Grav.Field	Status	UpDown	LeftRight	Shortfall
Metres	Degrees	Degrees	Metres	Metres	Metres	nT	Degrees	G	*	Metres	Metres	Metres
198,0	-49,46	274,01	1546441,14	6366178,81	-143,52	49547	70,60	0,997450	✍	19,95	3,15	-1,29

Deviation logging in HLX37, 0 to 198 m

New MeasureIT files

Survey name:	HLX37 IN
Survey date:	07/12/2006 14:15:32
Project:	PLU
Location:	Laxemar
Country:	Sweden
Survey company:	RAYCON
Surveyed by:	Christer Gustafsson
Survey type:	STANDARD
Operating conditions:	
General comments:	
Client name:	SKB
Client ID number:	AP PS 400-05-93
Client reference:	Leif Stenberg
Drill company:	
Drill rig:	
Drill diameter:	140
Survey direction:	INTO hole
Survey run on:	Wireline
Magnetic Var.:	2,33 degrees East of North

FLEXIT

Conventions	
Linear units:	Metres
Angular units:	Degrees
Temperature units:	Centigrade
Co-ordinate system:	0 North
Elevation positive	Up
Dip origin:	0 Horizontal
Dip positive:	Up

Magnetic Integrity Check (MagIC)

	Mid value	± limit	
Field strength:	49600	1000	nano Tesla
Magnetic dip:	71.4	1.5	Degrees

SURVEY	Actual start	End of survey	Difference
Station:	0,0	198,0	198,0
East:	1546406,21	1546515,60	109,39
North:	6366183,66	6366183,34	-0,32
Elevation:	15,19	-149,60	-164,79
Dip:	-59,48	-52,85	6,63
Azimuth:	88,33	92,80	4,47

OFFSETS at end

Offsets relative to:
ACTUAL START

10,48 metres upwards
3,51 metres right
0,52 metres shortfall

Printed on: 2006-03-06 13:28:33

Page 1 of 4

FLEXIT: SmartTool drillhole survey result table.

Survey name : HLX37 IN

Survey date : 07/12/2006 14:15:32

Printed on 2006-03-06 13:29:30

Station Metres	Dip Degrees	Azimuth Degrees	Easting Metres	Northing Metres	Elevation Metres	Mag.Field nT	Mag.Dip Degrees	Grav.Field G	Status *	UpDown Metres	LeftRight Metres	Shortfall Metres
0,0	-59,48	88,33	1546406,21	6366183,66	15,19	49280	70,90	1,002724	✍	0,00	0,00	0,00
3,0	-59,34	88,33	1546407,74	6366183,70	12,61	50066	71,73	1,002582	✍	0,00	0,00	0,00
6,0	-59,23	88,33	1546409,27	6366183,75	10,03	48847	68,52	0,999299	✍✍	0,01	0,00	0,00
9,0	-59,46	88,33	1546410,80	6366183,79	7,45	48798	70,69	0,999815	✍	0,02	0,00	0,00
12,0	-59,37	87,14	1546412,33	6366183,85	4,86	49765	70,75	1,000821	✍	0,02	-0,02	0,00
15,0	-59,29	86,80	1546413,85	6366183,93	2,28	49732	70,80	1,000967	✍	0,03	-0,05	0,00
18,0	-59,30	86,87	1546415,38	6366184,02	-0,30	49699	70,74	1,000780	✍	0,04	-0,09	0,00
21,0	-59,34	86,55	1546416,91	6366184,11	-2,88	49792	70,81	1,000826	✍	0,05	-0,14	0,00
24,0	-59,33	86,94	1546418,44	6366184,19	-5,46	49859	70,84	1,001191	✍	0,05	-0,18	0,00
27,0	-59,37	86,96	1546419,97	6366184,28	-8,04	49712	70,97	1,000880	✍	0,06	-0,21	0,00
30,0	-59,36	86,82	1546421,49	6366184,36	-10,62	49770	70,87	1,001123	✍	0,07	-0,25	0,00
33,0	-59,31	87,24	1546423,02	6366184,44	-13,20	49740	70,92	0,999805	✍	0,07	-0,29	0,00
36,0	-59,24	87,53	1546424,55	6366184,51	-15,78	49718	70,84	0,999762	✍	0,08	-0,31	0,00
39,0	-58,98	87,33	1546426,09	6366184,58	-18,35	49853	70,96	0,998639	✍	0,10	-0,34	0,00
42,0	-58,95	87,66	1546427,64	6366184,64	-20,92	49742	70,93	0,998694	✍	0,13	-0,36	0,00
45,0	-58,80	87,63	1546429,19	6366184,71	-23,49	49890	70,87	0,999030	✍	0,16	-0,38	0,00
48,0	-58,75	88,73	1546430,74	6366184,76	-26,06	49827	70,72	0,998745	✍	0,20	-0,38	0,00
51,0	-58,73	87,60	1546432,30	6366184,81	-28,62	49707	70,74	0,999121	✍	0,24	-0,39	0,00
54,0	-58,70	87,65	1546433,85	6366184,87	-31,19	49716	70,95	0,998795	✍	0,27	-0,41	0,00
57,0	-58,63	88,80	1546435,41	6366184,92	-33,75	49810	70,72	0,998822	✍	0,32	-0,41	0,00
60,0	-58,57	88,84	1546436,97	6366184,95	-36,31	49750	70,75	0,998712	✍	0,36	-0,40	0,00
63,0	-58,48	87,44	1546438,54	6366185,00	-38,87	49689	71,14	0,999042	✍	0,41	-0,40	0,00
66,0	-58,46	88,55	1546440,11	6366185,06	-41,42	49799	70,80	0,999127	✍	0,47	-0,41	-0,01
69,0	-58,39	88,67	1546441,68	6366185,10	-43,98	49779	70,92	0,999426	✍	0,52	-0,40	-0,01
72,0	-58,08	87,75	1546443,26	6366185,15	-46,53	50117	70,84	0,999199	✍	0,59	-0,41	-0,01
75,0	-57,97	87,98	1546444,84	6366185,20	-49,08	50539	70,50	0,999523	✍	0,66	-0,42	-0,01
78,0	-57,83	89,85	1546446,44	6366185,23	-51,62	49751	70,81	0,999329	✍	0,74	-0,40	-0,01
81,0	-57,50	89,75	1546448,04	6366185,24	-54,15	49684	70,87	0,999599	✍	0,84	-0,36	-0,01
84,0	-57,17	89,58	1546449,66	6366185,25	-56,68	49603	70,60	0,999305	✍	0,95	-0,32	-0,01
87,0	-56,98	89,23	1546451,29	6366185,27	-59,20	49631	70,82	0,999783	✍	1,08	-0,29	-0,02
90,0	-56,91	88,71	1546452,93	6366185,30	-61,71	49718	70,86	1,000235	✍	1,21	-0,27	-0,02
93,0	-56,67	89,79	1546454,57	6366185,32	-64,22	49579	70,82	1,000251	✍	1,35	-0,25	-0,02
96,0	-56,60	90,08	1546456,22	6366185,32	-66,73	49823	70,72	0,999940	✍	1,50	-0,20	-0,03

Survey name : HLX37 IN
Survey date : 07/12/2006 14:15:32
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Station	Dip	Azimuth	Easting	Northing	Elevation	Mag.Field	Mag.Dip	Grav.Field	Status	UpDown	LeftRight	Shortfall
Metres	Degrees	Degrees	Metres	Metres	Metres	nT	Degrees	G	*	Metres	Metres	Metres
99,0	-56,36	90,86	1546457,88	6366185,31	-69,23	49794	71,22	0,999954	✓	1,65	-0,14	-0,03
102,0	-56,25	89,91	1546459,54	6366185,29	-71,72	49810	70,98	1,000447	✓	1,82	-0,08	-0,04
105,0	-56,11	91,52	1546461,21	6366185,27	-74,22	49702	70,91	1,000436	✓	1,99	-0,01	-0,04
108,0	-56,00	92,56	1546462,89	6366185,21	-76,70	49578	70,78	1,000476	✓	2,16	0,10	-0,05
111,0	-55,79	91,96	1546464,57	6366185,15	-79,19	49798	71,09	1,000762	✓	2,35	0,21	-0,06
114,0	-55,52	91,52	1546466,26	6366185,10	-81,66	49874	70,82	1,001059	✓	2,55	0,31	-0,06
117,0	-55,39	92,13	1546467,96	6366185,04	-84,14	49699	70,86	1,000631	✓	2,75	0,42	-0,07
120,0	-55,32	93,53	1546469,66	6366184,96	-86,60	49732	70,82	1,000225	✓	2,96	0,55	-0,08
123,0	-55,23	92,03	1546471,37	6366184,88	-89,07	49671	71,05	1,000439	✓	3,18	0,68	-0,09
126,0	-55,02	91,36	1546473,08	6366184,82	-91,53	49886	70,65	1,000444	✓	3,41	0,78	-0,10
129,0	-54,94	90,79	1546474,80	6366184,79	-93,99	49956	71,12	1,001057	✓	3,64	0,87	-0,12
132,0	-54,85	89,05	1546476,53	6366184,79	-96,44	49798	70,83	1,001559	✓	3,88	0,91	-0,13
135,0	-54,73	89,84	1546478,26	6366184,81	-98,89	49477	71,31	1,001799	✓	4,12	0,95	-0,14
138,0	-54,58	91,24	1546480,00	6366184,80	-101,34	49726	70,97	1,001675	✓	4,37	1,02	-0,15
141,0	-54,34	90,59	1546481,74	6366184,77	-103,78	49937	70,05	1,001745	✓	4,63	1,09	-0,16
144,0	-53,96	90,24	1546483,50	6366184,75	-106,21	49997	71,17	1,002335	✓	4,91	1,16	-0,17
147,0	-53,93	90,57	1546485,26	6366184,74	-108,64	49803	71,08	1,001169	✓	5,20	1,22	-0,19
150,0	-53,86	90,98	1546487,03	6366184,72	-111,06	50373	71,23	1,001307	✓	5,49	1,30	-0,20
153,0	-53,94	91,39	1546488,80	6366184,68	-113,49	49601	71,05	1,002061	✓	5,78	1,39	-0,22
156,0	-53,75	91,90	1546490,57	6366184,63	-115,91	49609	70,92	1,001955	✓	6,07	1,49	-0,23
159,0	-53,68	92,37	1546492,34	6366184,56	-118,33	49484	71,05	1,000972	✓	6,37	1,61	-0,25
162,0	-53,68	91,62	1546494,12	6366184,50	-120,74	49819	71,01	1,001757	✓	6,67	1,72	-0,27
165,0	-53,54	92,52	1546495,89	6366184,44	-123,16	49923	70,91	1,000987	✓	6,97	1,84	-0,29
168,0	-53,53	91,88	1546497,68	6366184,37	-125,57	50028	70,99	1,001680	✓	7,28	1,96	-0,30
171,0	-53,48	93,39	1546499,46	6366184,29	-127,98	49810	71,00	1,000843	✓	7,59	2,09	-0,32
174,0	-53,40	93,49	1546501,24	6366184,18	-130,39	49886	70,98	1,001168	✓	7,90	2,25	-0,34
177,0	-53,41	92,71	1546503,03	6366184,08	-132,80	49759	70,80	1,001754	✓	8,21	2,40	-0,36
180,0	-53,28	93,17	1546504,82	6366183,99	-135,21	49718	70,90	1,001130	✓	8,52	2,54	-0,38
183,0	-53,28	93,72	1546506,61	6366183,88	-137,61	49665	70,82	1,001225	✓	8,84	2,70	-0,40
186,0	-53,27	93,93	1546508,40	6366183,76	-140,02	49859	70,76	1,001251	✓	9,16	2,87	-0,43
189,0	-53,16	94,39	1546510,19	6366183,63	-142,42	49366	71,00	1,001380	✓	9,48	3,06	-0,45
192,0	-52,92	93,53	1546511,99	6366183,51	-144,82	49914	70,98	1,000681	✓	9,81	3,23	-0,47
195,0	-52,92	92,33	1546513,79	6366183,42	-147,21	49324	71,24	1,000423	✓	10,14	3,38	-0,49

FLEXIT: SmartTool drillhole survey result table.

Survey name : HLX37 IN
Survey date : 07/12/2006 14:15:32

Printed on 2006-03-06 13:29:30

Station	Dip	Azimuth	Easting	Northing	Elevation	Mag.Field	Mag.Dip	Grav.Field	Status	UpDown	LeftRight	Shortfall
Metres	Degrees	Degrees	Metres	Metres	Metres	nT	Degrees	G	*	Metres	Metres	Metres
198,0	-52,85	92,80	1546515,60	6366183,34	-149,60	49755	71,06	0,999722	✍	10,48	3,51	-0,52