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## Oskarshamn site investigation

# RAMAC and BIPS logging in boreholes KLX10B, KLX10C and KLX12A

Jaana Gustafsson, Christer Gustafsson, Johan Friborg
Malå Geoscience AB/RAYCON

September 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 KLX10B, KLX10C and KLX12A. All measurements were conducted by Malå Geoscience AB/RAYCON during March 2006.

The objective of the radar surveys is to achieve information on the rock mass around the borehole. Borehole radar is used to investigate the nature and the structure of the rock mass enclosing the boreholes.

The objective of the BIPS logging is to achieve information of the borehole including occurrence of rock types as well as determination of fracture distribution and orientation.

This report describes the equipment used as well as the measurement procedures and data gained. For the BIPS survey, the result is presented as images. Radar data is presented in radargrams and the identified reflectors are listed.

The borehole radar data quality from KLX10B, KLX10C and KLX12A was relatively satisfying, but in some parts of lower quality due to more conductive conditions. This conductive environment of course reduces the possibility to distinguish and interpret possible structures in the rock mass which otherwise could give a reflection. However, in KLX10B the borehole radar measurements resulted in 18 identified radar reflectors, and of these 3 were oriented (strike/dip). In KLX10C 23 radar reflectors were identified, and of these 6 were oriented. In KLX12A 137 reflectors were identified and of these 15 were orientated.

The BIPS images from KLX10B, KLX10C and KLX12A are relatively good and makes the geological core logging easy to perform.

# Sammanfattning


Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Oskarshamn. Mätningarna som presenteras här omfattar borrhålsradarmätningar (RAMAC), och BIPS-loggningar i kärnborrhålen KLX10B, KLX10C och KLX12A. Alla mätningar är utförda av Malå Geoscience AB/RAYCON under mars 2006.

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

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

Rapporten beskriver utrustningen som använts liksom mätprocedurer och en beskrivning och tolkning av data som erhållits. För BIPS-loggningen presenteras data som plottar längs med borrhålet. Radardata presenteras i radargram och en lista över tolkade radarreflektorer ges.

Borrhålsradardata från KLX10B, KLX10C och KLX12A var relativt tillfredställande, men bitvis med sämre djuppenetration troligen till stor del beroende på en konduktiv miljö. En konduktiv miljö minskar möjligheterna att identifiera strukturer från borrhålsradardata. Dock har 18 radarreflektorer identifierats i KLX10B och av dessa har 3 orienterats (med strykning/stupning). I KLX10C har 23 radarreflektorer identifierats, varav 6 har orienterats. I KLX12A har 137 radarreflektorer identifierats och av dessa har 15 orienterats.

BIPS bilderna från KLX10B, KLX10C och KLX12A är av tillräcklig kvalitet för den geologiska borrkärnekarteringen.

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# 1 Introduction

This report presents the data collected 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 in the core drilled boreholes KLX10B, KLX10C and KLX12A.

The work was carried out in accordance with activity plan AP PS 400-06-033. In Table 1-1 controlling documents for performing this activity are listed. Both activity plans and method descriptions are SKB's internal controlling documents.

This report includes measurements from 0 to 50 m in KLX10B, from 0 to 143 in KLX10C and from 0 to 600 in KLX12A.

All measurements were conducted by Malå Geoscience AB/RAYCON during March 2006. 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.

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 KLX12A | AP PS 400-06-033 | 1.0 |
| Tillägg till AP PS 400-06-033 ”BIPS och RADAR i KLX12A ” med BIPS och radar i KLX10B och KLX10C | AP PS 400-06-033 | 1.0 |
| **Method descriptions** | **Number** | **Version** |
| Metodbeskrivning för TV- loggning med BIPS | SKB MD 222.006 | 1.0 |
| Metodbeskrivning för borrhålsradar | SKB MD 252.020 | 2.0 |


***Figure 1-1.*** *Map of the location of the boreholes KLX10B, KLX10C (close to KLX10) and KLX12A, 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.

This report describes the equipment used for the radar and BIPS 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.

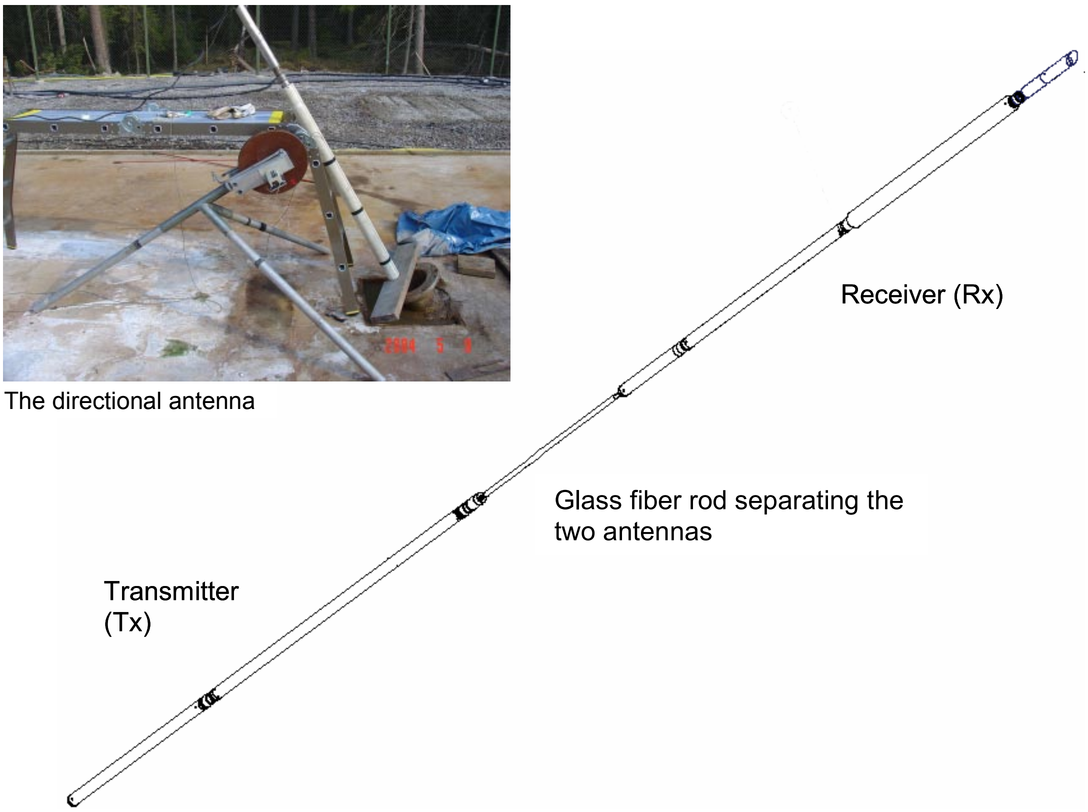



***Figure 3-1.*** *Example of a borehole radar antenna.*

## 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).

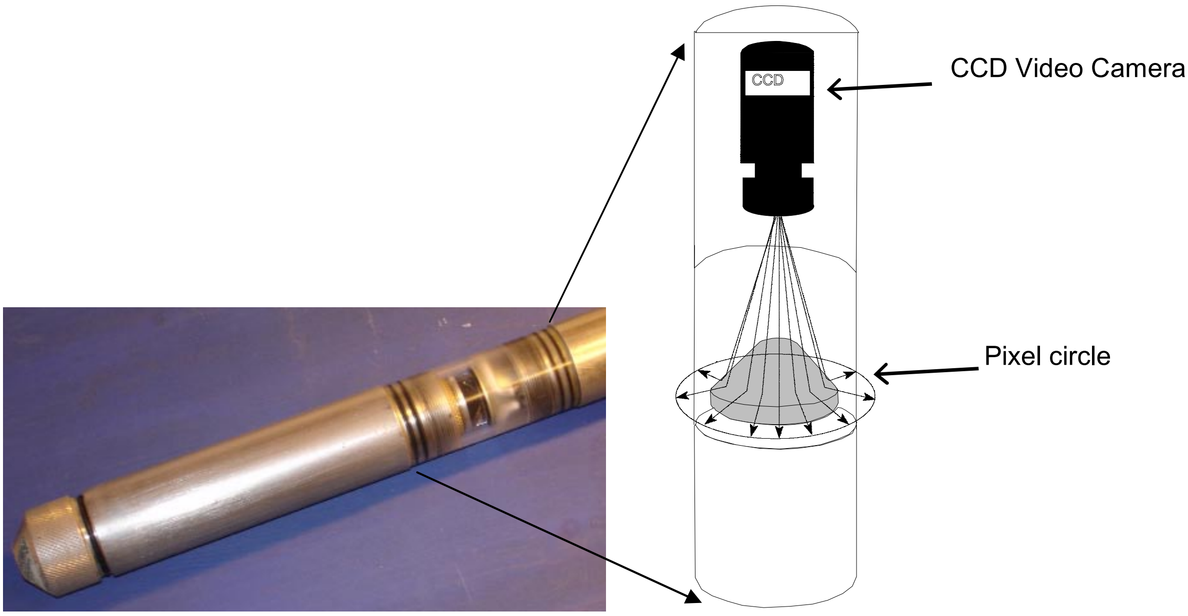



*Figure 3-2. The BIP-system. Illustration of the conical mirror scanning.*

# 4 Execution

## 4.1 General

### 4.1.1 RAMAC Radar

The measurements in KLX10B, KLX10C, and KLX12A were carried out with dipole radar antennas, with frequencies of 250, 100 and 20 MHz. as well as with the directional antenna, with a central frequency of 60 MHz.

During logging the dipole antennas (transmitter and receiver) were lowered continuously into the borehole and data were recorded on a field PC along the measured interval. The measurement with the directional antenna is made step wise, with a short pause for each measurement occasion. The antennas (transmitter and receiver, both for dipole and directional) are kept at a fixed separation by glass fiber rods according to Tables 4-1 to 4-3. See also Figures 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 KLX10B and KLX10C, as well as before measurements in KLX12A. 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 as measured by compass and the direction obtained directional antenna was about 8 degrees in both tests, respectively. These can be considered good results and indicates that there were no problems with the directional antenna. This can be considered to be 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 KLX10B, KLX10C and KLX12A, see Tables 4-1 through 4-3 below.

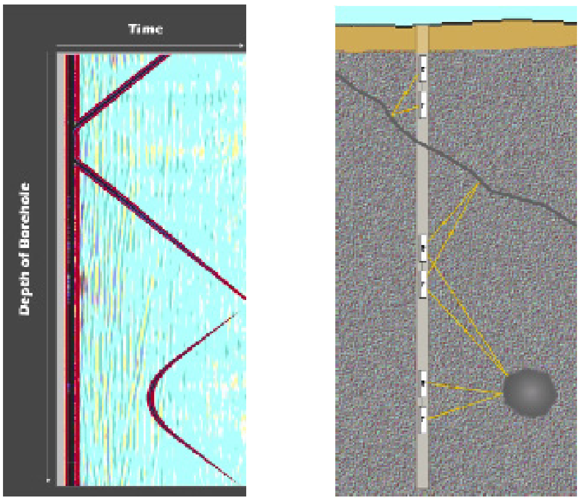



***Figure 4-1.*** *The principle of radar borehole reflection survey and an example of result.*

**Table 4-1. Radar logging information from KLX10B.**

| Site: | Oskarshamn | Logging company: | RAYCON | |
|---|---|---|---|---|
| BH: | KLX10B | Equipment: | SKB RAMAC | |
| Type: | Directional/Dipole | Manufacturer: | MALÅ GeoScience | |
| Operator: | CG | Antenna | | |
| | Directional | 250 MHz | 100 MHz | 20 MHz |
| Logging date: | 06-03-23 | 06-03-23 | 06-03-23 | 06-03-23 |
| 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 | –0.35 | –0.35 | –1.42 |
| Logging from (m): | 12.4 | 1.5 | 2.6 | 6.25 |
| Logging to (m): | 44.4 | 48.1 | 47.2 | 43.55 |
| 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 KLX10C.**

| Site: | Oskarshamn | Logging company: | RAYCON | |
|---|---|---|---|---|
| BH: | KLX10C | Equipment: | SKB RAMAC | |
| Type: | Directional/Dipole | Manufacturer: | MALÅ GeoScience | |
| Operator: | CG | Antenna | | |
| | Directional | 250 MHz | 100 MHz | 20 MHz |
| Logging date: | 06-03-23 | 06-03-23 | 06-03-23 | 06-03-23 |
| 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): | 12.4 | 1.5 | 2.6 | 6.25 |
| Logging to (m): | 141.9 | 144.4 | 144.0 | 139.0 |
| Trace interval (m): | 0.5 | 0.1 | 0.2 | 0.25 |
| Antenna separation (m): | 5.73 | 2.4 | 3.9 | 10.05 |

**Table 4-3. Radar logging information from KLX12A.**

| Site: | Oskarshamn | Logging company: | RAYCON | |
|---|---|---|---|---|
| BH: | KLX12A | Equipment: | SKB RAMAC | |
| Type: | Directional/Dipole | Manufacturer: | MALÅ GeoScience | |
| Operator: | CG | Antenna | | |
| | Directional | 250 MHz | 100 MHz | 20 MHz |
| Logging date: | 06-03-27 | 06-03-27 | 06-03-27 | 06-03-27 |
| 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 | –0.35 | –0.35 | –1.42 |
| Logging from (m): | 105.4 | 1.5 | 2.6 | 6.25 |
| Logging to (m): | 593.4 | 596.5 | 596.6 | 598.4 |
| Trace interval (m): | 0.5 | 0.1 | 0.2 | 0.25 |
| 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 boreholes KLX10B, KLX10C and KLX12A.

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 shows the results of the test logging performed before and after the logging of KLX10B and KLX12A, respectively. 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.

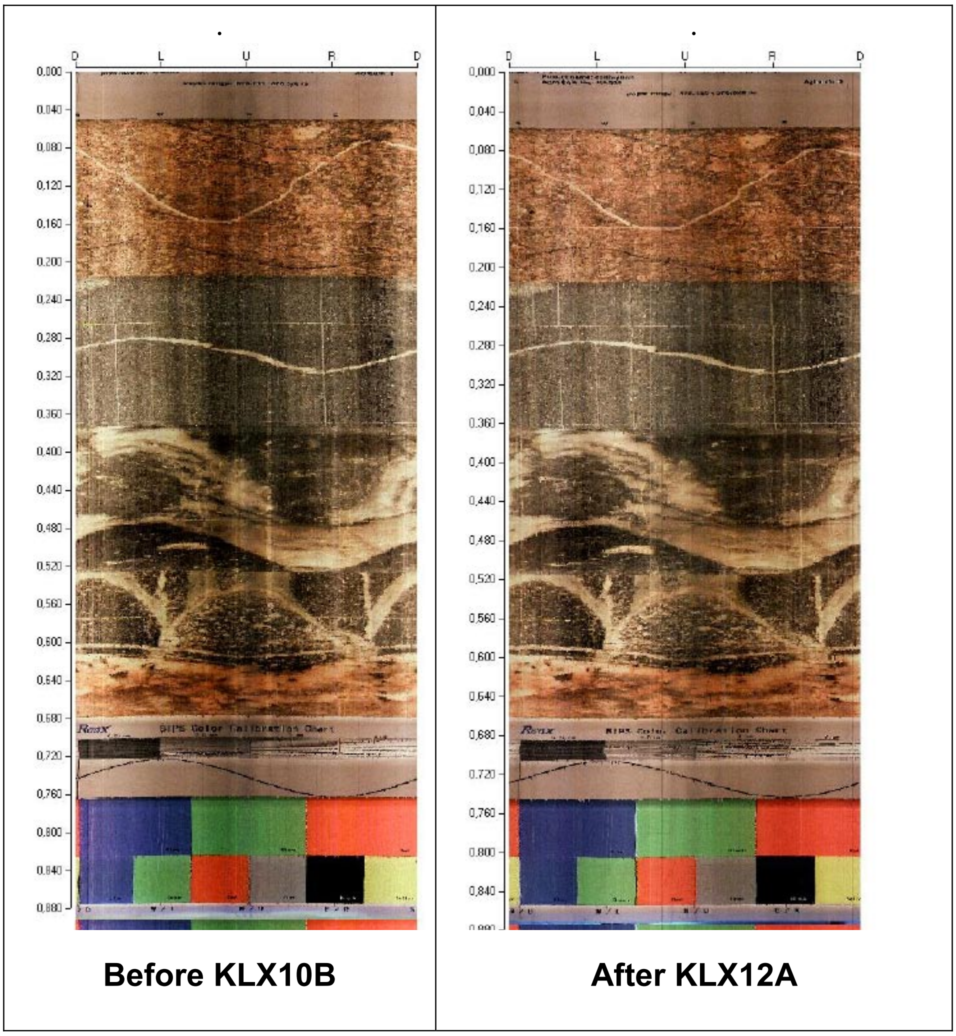



***Figure 4-2.** Results from logging in the test pipe before and after the logging campaign in March 22th to 27th, 2006.*

### 4.1.3 Length measurements

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

During the BIPS logging in core drilled boreholes, where the reference marks in the 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 metre deep borehole.

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

## 4.2 Analyses and interpretatoin

### 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 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. For this logging campaign the velocity determination earlier performed between KLX07A and KLX07B was used. The transmitter was kept fixed in one borehole while the receiver was moved 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.

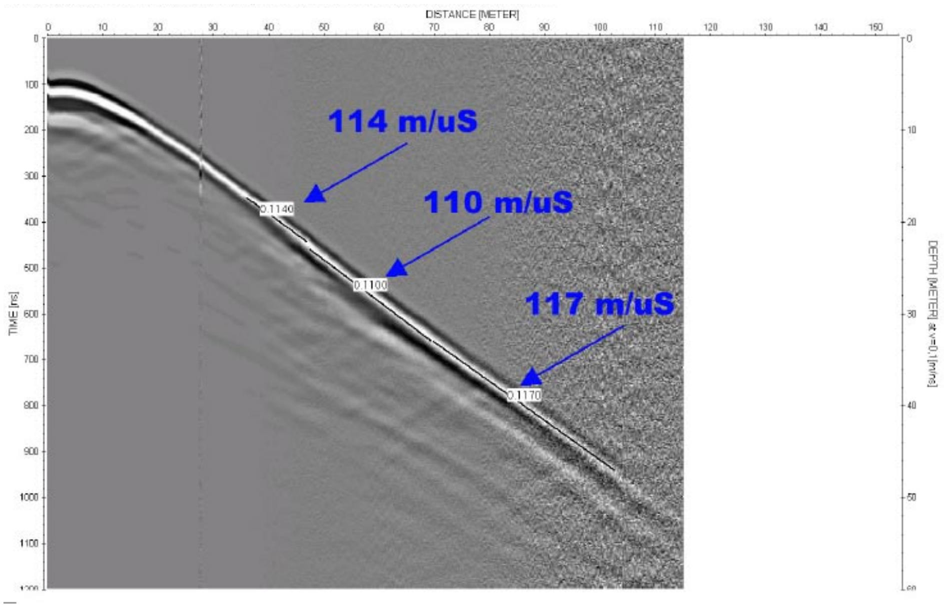



*Figure 4-3.* *Results from velocity measurements /1/.*

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 these tables refer to Appendices 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 through 5-6 and the structures are also indicated on the radargrams in Appendices 1 to 3.

**Table 4-4. Processing steps for borehole radar data from KLX10B.**

| | | | | |
|---|---|---|---|---|
| **Site:** | **Oskarshamn** | **Logging company:** | **RAYCON** | |
| **BH:** | **KLX10B** | **Equipment:** | **SKB RAMAC** | |
| **Type:** | **Directional/Dipole** | **Manufacturer:** | **MALÅ GeoScience** | |
| **Interpret:** | **JFr** | **Antenna** | | |
| | **Directional** | **250 MHz** | **100 MHz** | **20 MHz** |
| Processing: | Move start time (–56 samples) | Move start time (–14.0) | Move start time (–21.0) | Move start time (–87.0) |
| | DC shift (400–510) | DC shift (190–230) | DC shift (470–530) | DC shift (1,800–2,000) |
| | Time gain (start 99 lin 150 exp 1) | Gain (start 10 lin 4 exp 0.6) | Gain (start 20 lin 5.0 exp 0.3) | Gain (start 100.0 lin 8.0 exp 0.156) |
| | (FIR) | Median (trace 3, samples 5) | | |

**Table 4-5. Processing steps for borehole radar data from KLX10C.**

| | | | | |
|---|---|---|---|---|
| **Site:** | **Oskarshamn** | **Logging company:** | **RAYCON** | |
| **BH:** | **KLX10C** | **Equipment:** | **SKB RAMAC** | |
| **Type:** | **Directional/Dipole** | **Manufacturer:** | **MALÅ GeoScience** | |
| **Interpret:** | **JFr** | **Antenna** | | |
| | **Directional** | **250 MHz** | **100 MHz** | **20 MHz** |
| Processing: | Move start time (–56 samples) | Move start time (–6.5) | Move start time (–40.0) | Move start time (–80.0) |
| | DC shift (400–510) | DC shift (190–230) | DC shift (470–530) | DC shift (1,800–2,000) |
| | Time gain (start 99 lin 150 exp 1) | Gain (start 15 lin 8.0 exp 0.4) | Gain (start 25 lin 8.0 exp 0.3) | Gain (start 110.0 lin 16.0 exp 0.1) |
| | (FIR) | Median (trace 3, samples 5) | | Bandpass frequency (4, 9.6, 28.8, 38.4) |

**Table 4-6. Processing steps for borehole radar data from KLX12A.**

| | | | | |
|---|---|---|---|---|
| **Site:** | **Oskarshamn** | **Logging company:** | **RAYCON** | |
| **BH:** | **KLX12A** | **Equipment:** | **SKB RAMAC** | |
| **Type:** | **Directional/Dipole** | **Manufacturer:** | **MALÅ GeoScience** | |
| **Interpret:** | **JG** | **Antenna** | | |
| | **Directional** | **250 MHz** | **100 MHz** | **20 MHz** |
| Processing: | Move start time (–30 samples) | Move start time (–15) | Move start time (–37) | Move start time (–79) |
| | DC shift (400–510) | DC shift (190–240) | DC shift (460–520) | DC shift (1,800–2,100) |
| | Time gain (start 73 lin 100 exp 2) | Gain (start 13 lin 1.4 exp 1.2) | Gain (start 36 lin 2.9 exp 0.5) | Gain (start 121 lin 3 exp 0.3) |
| | (FIR) | | | |

### 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.

## 4.3 Nonconformities

No nonconformities occurred during the logging campaign in March 2006.

# 5 Results

The results from the BIPS measurements for KLX10B, KLX10C and KLX12A 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 KLX10B, KLX10C and KLX12A 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) and data are traceable by the activity plan number.

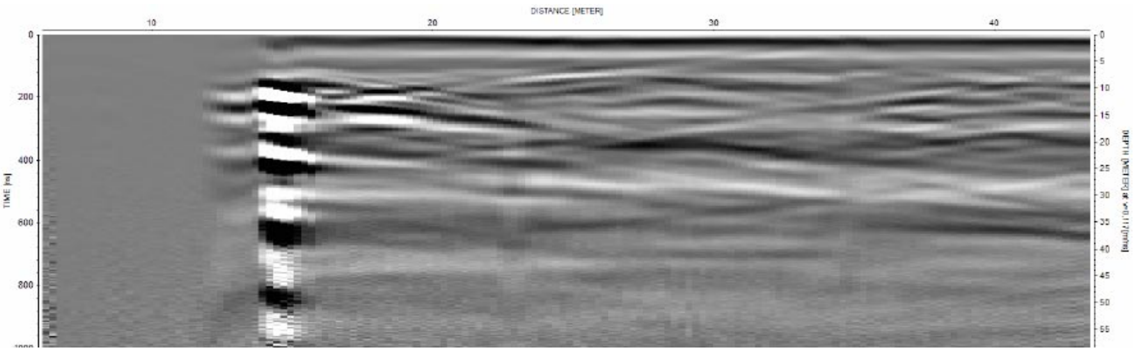
## 5.1 RAMAC logging

The results of the interpretation of the radar measurements are presented in Tables 5-1 through 5-6. Radar data is also visualized in Appendices 1, 2 and 3. It should be remembered that the images in these appendices are only a composite picture of all events 360 degrees around the borehole, and do not reflect the orientation of the structures.

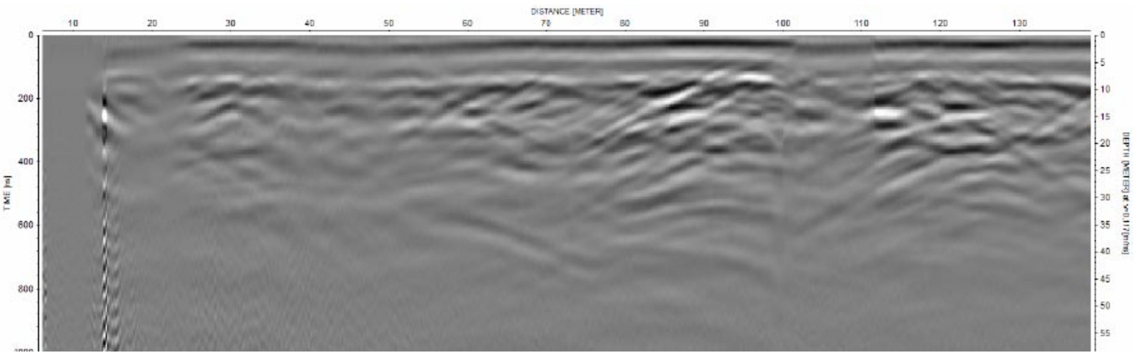
Only the larger visible structures are interpreted in RadinterSKB. Overviews of the three boreholes are given in Figure 5-1 below. A number of minor structures also exist but is not interpreted as indicated in Appendices 1 through 3. Often a number of structures can be noticed, but most probably lying so close to each other that it is impossible to distinguish one from the other (See Figure 5-2). Larger structures parallel to the borehole, if present, are also indicated in the Appendices. 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 KLX10B, KLX10C (as seen in Appendices 1, 2 and 3) is satisfying. Only minor parts have lower quality due to more electrical conductive conditions. The data quality from KLX12A is not as good. Between 250 and 400 metres the conditions appear to be electrical conductive although this is not clearly seen in the 250 MHz first arrival amplitude data. An electrical conductive environment attenuates the radar wave, 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.

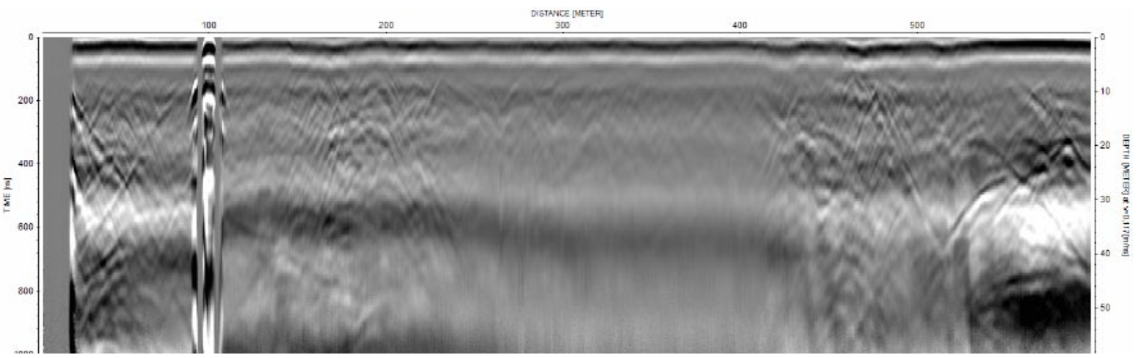
The strong feature at about 100 metres in KLX12A is caused by a piece of metal casing in the borehole, as shown by the BIPS image.




**KLX10B**




**KLX10C**




**KLX12A**

***Figure 5-1.*** *An overview (20 MHz data) of the radar data for the three boreholes; KLX10B, KLX10C and KLX12A. Observe that the length (x-scale)and depth (y-scale) differs between the different boreholes.*

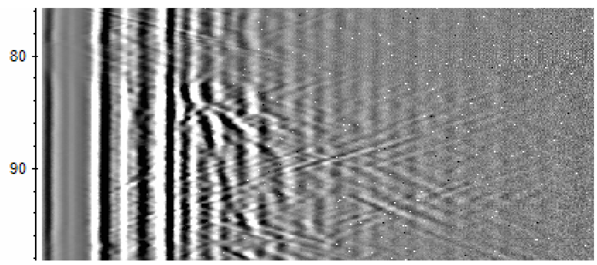



***Figure 5-2.*** *Example of data from KLX10C (250 MHz data) where a number of structures are visible but lying so close to each other, that they are not easily distinguished from each other.*

In parts with an increased electrical conductivity and thereby a decreased depth penetration most often only the edges of structures can be distinguished, giving an intersection angle of 90 degrees. Such structures are not included in the interpretation.

As also seen in Appendices 1 through 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.

Tables 5-1, 5-2 and 5-3 list the distribution of identified structures along the boreholes for KLX10B, KLX10C and KLX12A, respectively.

**Table 5-1. Identified structures as a function of length in KLX10B.**

| Length (m) | No. of structures |
|---|---|
| – 20 | 7 |
| 20 – 40 | 7 |
| 40 – 60 | 3 |
| 60 – 80 | 1 |
| 80 – | 1 |

**Table 5-2. Identified structures as a function of length in KLX10C.**

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

**Table 5-3. Identified structures as a function of length in KLX12A.**

| Length (m) | No. of structures |
|---|---|
| – 100 | 15 |
| 100 – 150 | 10 |
| 150 – 200 | 16 |
| 200 – 250 | 12 |
| 250 – 300 | 9 |
| 300 – 350 | 13 |
| 350 – 400 | 10 |
| 400 – 450 | 12 |
| 450 – 500 | 12 |
| 500 – 550 | 15 |
| 550 – 600 | 9 |
| 600 – | 3 |

Tables 5-4, 5-5 and 5-6 summarise the interpretation of radar data from KLX10B, KLX10C and KLX12A. As seen some radar reflectors in these tables 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 (object) is defined in Figure 5-3. As the borehole inclination 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 5-4, 5-5 and 5-6. 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 structures 72 and 108 in KLX12A. 72x and 108x are probable extensions of these structures.

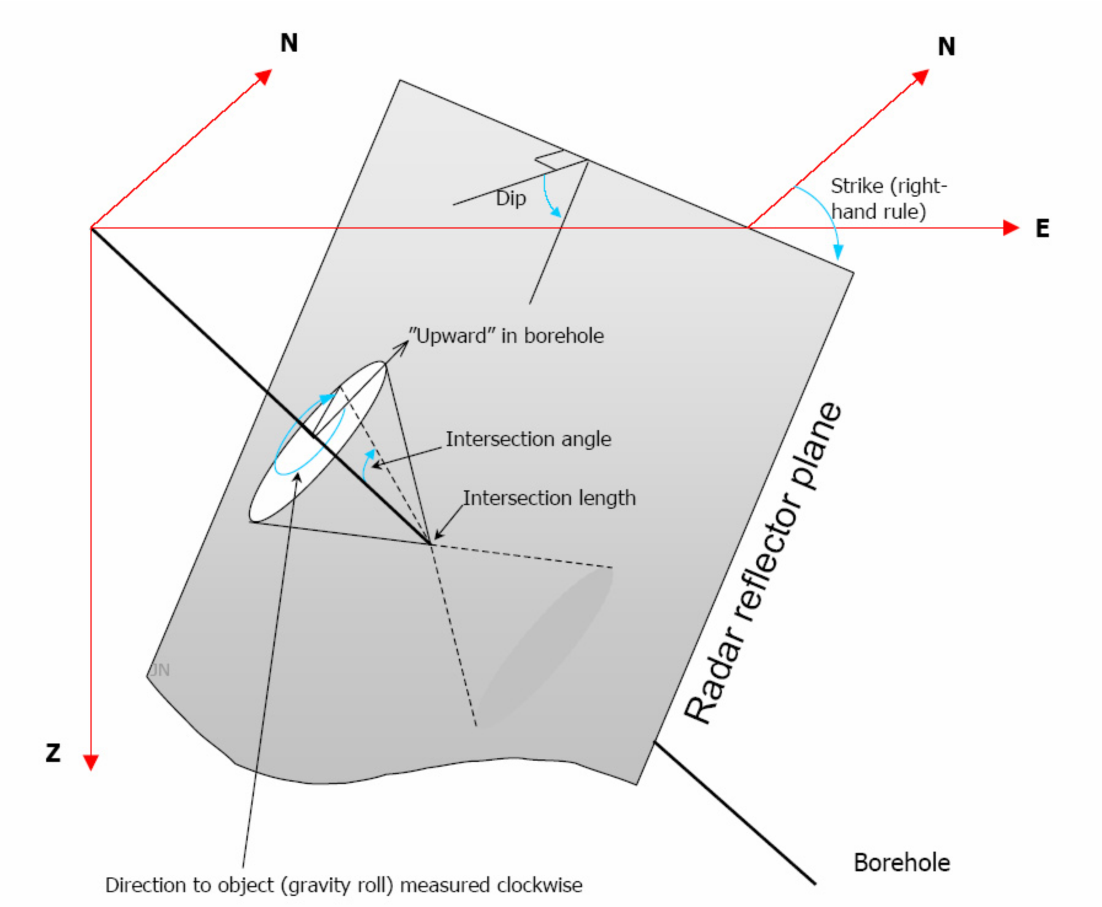



***Figure 5-3.*** *Definition of intersection angle, direction to object using gravity roll, dip and strike using the right hand rule as presented in Tables 5-4 through 5-6.*

**Table 5-4. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, and the directional antenna 60 MHz in borehole KLX10B.**

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

**Site:** Oskarshamn
**Borehole name:** KLX10B
**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 |
|---|---|---|---|---|---|---|---|
| 1 | 0.2 | 50 | | | | | |
| 17 | 1.5 | 70 | | | | | |
| 8 | 5.0 | 55 | | | | | |
| 2 | 6.0 | 49 | | | | | |
| 9 | 13.6 | 58 | | | | | |
| 12 | 16.4 | 47 | | | | | |
| 3 | 20.5 | 30 | | | | | |
| 13 | 27.3 | 62 | | | | | |
| 10 | 27.6 | 52 | | | | | |
| 7 | 31.3 | 61 | | | | | |
| 14 | 32.5 | 56 | | | | | |
| 11 | 37.4 | 29 | | | | | |
| 5 | 39.9 | 51 | | | | | |
| 4 | 41.0 | 47 | 15± | 72 | 274 | 15 | 125 |
| 15 | 43.6 | 37 | 207 | 30 | 131 | | |
| 6 | 55.2 | 62 | 180 | 2 | 263 | | |
| 16 | 65.1 | 38 | | | | | |
| 18 | 85.8 | 45 | | | | | |

**Table 5-5. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, and the directional antenna 60 MHz in borehole KLX10C.**

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

**Site:** Oskarshamn
**Borehole name:** KLX10C
**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 |
|---|---|---|---|---|---|---|---|
| 18 | –10.9 | 32 | | | | | |
| 1 | 16.7 | 58 | | | | | |
| 2 | 19.4 | 55 | 6± | 65 | 90 | 5 | 313 |
| 5 | 41.2 | 8 | | | | | |
| 6 | 44.3 | 6 | | | | | |
| 3 | 71.2 | 37 | | | | | |
| 9 | 73.9 | 73 | | | | | |
| 4 | 75.8 | 35 | | | | | |
| 11 | 78.3 | 33 | 357 | 88 | 84 | | |
| 24 | 80.3 | 69 | 354± | 51 | 84 | 10 | 98 |
| 10 | 86.4 | 28 | | | | | |
| 7 | 98.8 | 47 | | | | | |
| 20 | 103.9 | 78 | | | | | |
| 8 | 104.7 | 49 | 144± | 25 | 193 | 71 | 60 |
| 19 | 105.6 | 52 | | | | | |
| 12 | 110.6 | 50 | | | | | |
| 17 | 110.6 | 59 | | | | | |
| 13 | 123.4 | 29 | | | | | |
| 16 | 125.0 | 46 | 135 | 32 | 187 | | |
| 14 | 125.6 | 52 | | | | | |
| 23 | 134.5 | 76 | 270± | 33 | 60 | 34 | 114 |
| 15 | 141.0 | 59 | | | | | |
| 22 | 152.95 | 81 | | | | | |

**Table 5-6. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, and the directional antenna 60 MHz in borehole KLX12A.**

**RADINTER MODEL INFORMATION**
**(Directional antenna)**

**Site:** Oskarshamn
**Borehole name:** KLX12A
**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 |
|---|---|---|---|---|---|---|---|
| 129 | –110.6 | 10 | | | | | |
| 127 | –5.6 | 34 | | | | | |
| 4 | 21.0 | 61 | | | | | |
| 3 | 24.8 | 58 | | | | | |
| 5 | 36.4 | 80 | | | | | |
| 1 | 39.2 | 74 | | | | | |
| 2 | 40.0 | 76 | | | | | |
| 6 | 46.5 | 61 | | | | | |
| 7 | 50.9 | 85 | | | | | |
| 8 | 53.2 | 62 | | | | | |
| 9 | 64.1 | 85 | | | | | |
| 10 | 65.6 | 74 | | | | | |
| 11 | 69.2 | 62 | | | | | |
| 13 | 75.1 | 69 | | | | | |
| 12 | 87.0 | 39 | | | | | |
| 126 | 104.1 | 37 | | | | | |
| 14 | 113.2 | 33 | | | | | |
| 16 | 112.5 | 55 | | | | | |
| 15 | 118.0 | 66 | | | | | |
| 17 | 119.8 | 37 | | | | | |
| 19 | 134.5 | 67 | | | | | |
| 18 | 134.7 | 17 | | | | | |
| 20 | 136.1 | 72 | | | | | |
| 21 | 144.0 | 55 | | | | | |
| 24 | 145.6 | 18 | | | | | |
| 22 | 150.5 | 72 | | | | | |
| 23 | 153.0 | 46 | | | | | |
| 26 | 155.6 | 51 | | | | | |
| 27 | 156.0 | 56 | | | | | |
| 25 | 158.3 | 54 | | | | | |
| 128 | 169.8 | 21 | | | | | |
| 29 | 176.6 | 73 | | | | | |
| 28 | 178.6 | 78 | | | | | |
| 30 | 182.4 | 71 | | | | | |
| 43 | 183.9 | 21 | 354 | 87 | 29 | 53 | 208 |
| 31 | 184.8 | 59 | | | | | |
| 32 | 185.9 | 79 | | | | | |
| 33 | 191.9 | 57 | | | | | |
| 34 | 194.8 | 54 | | | | | |
| 35 | 195.8 | 60 | | | | | |
| 36 | 198.4 | 78 | | | | | |
| 37 | 208.2 | 80 | | | | | |
| 38 | 210.1 | 61 | | | | | |
| 39 | 218.1 | 55 | | | | | |

**RADINTER MODEL INFORMATION**
**(Directional antenna)**

**Site:** Oskarshamn
**Borehole name:** KLX12A
**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 |
|---|---|---|---|---|---|---|---|
| 40 | 220.2 | 50 | | | | | |
| 42 | 222.3 | 46 | | | | | |
| 41 | 224.2 | 29 | | | | | |
| 44 | 225.1 | 56 | | | | | |
| 47 | 226.7 | 67 | | | | | |
| 45 | 228.8 | 58 | | | | | |
| 46 | 230.7 | 71 | 204 | 13 | 270 | 42 | 51 |
| 48 | 239.6 | 64 | | | | | |
| 49 | 241.4 | 56 | 213 | 22 | 271 | 49 | 59 |
| 50 | 270.9 | 78 | 279 | 24 | 351 | 20 | 85 |
| 52 | 277.1 | 80 | | | | | |
| 51 | 279.5 | 20 | | | | | |
| 56 | 281.4 | 71 | | | | | |
| 53 | 285.2 | 61 | | | | | |
| 54 | 286.1 | 76 | | | | | |
| 55 | 286.5 | 44 | | | | | |
| 57 | 296.9 | 66 | | | | | |
| 58 | 299.9 | 73 | 342 | 86 | 23 | 8 | 160 |
| 59 | 305.0 | 18 | 165 | 57 | 197 | 86 | 20 |
| 61 | 311.7 | 24 | | | | | |
| 60 | 314.8 | 17 | | | | | |
| 62 | 316.8 | 50 | | | | | |
| 64 | 321.9 | 57 | | | | | |
| 63 | 322.8 | 42 | 117 | 43 | 137 | 56 | 341 |
| 69 | 330.1 | 15 | | | | | |
| 65 | 333.4 | 61 | 117 | 26 | 123 | 39 | 349 |
| 66 | 334.1 | 73 | | | | | |
| 68 | 339.8 | 63 | | | | | |
| 67 | 342.9 | 81 | | | | | |
| 70 | 345.3 | 53 | | | | | |
| 71 | 347.9 | 70 | | | | | |
| 73 | 358.4 | 67 | | | | | |
| 74 | 364.2 | 74 | | | | | |
| 76 | 366.3 | 75 | | | | | |
| 75 | 368.5 | 72 | | | | | |
| 77 | 373.7 | 54 | | | | | |
| 78 | 378.4 | 63 | | | | | |
| 79 | 379.8 | 42 | | | | | |
| 80 | 382.3 | 47 | | | | | |
| 81 | 383.8 | 64 | | | | | |
| 84 | 397.8 | 77 | | | | | |
| 72 | 400.0 | 7 | 189 | 67 | 225 | | |
| 83 | 406.4 | 43 | | | | | |
| 85 | 409.9 | 23 | | | | | |
| 82 | 411.1 | 43 | | | | | |
| 86 | 420.0 | 72 | | | | | |
| 87 | 430.4 | 54 | | | | | |

**RADINTER MODEL INFORMATION**
**(Directional antenna)**

**Site:** Oskarshamn
**Borehole name:** KLX12A
**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 |
|---|---|---|---|---|---|---|---|
| 88 | 432.4 | 59 | | | | | |
| 91 | 439.3 | 54 | | | | | |
| 72x | 443.0 | 5 | 195 | 70 | 230 | | |
| 89 | 443.5 | 64 | | | | | |
| 90 | 447.8 | 53 | | | | | |
| 130 | 449.6 | 51 | | | | | |
| 92 | 451.2 | 57 | | | | | |
| 94 | 452.7 | 68 | | | | | |
| 131 | 452.8 | 45 | | | | | |
| 93 | 455.6 | 54 | | | | | |
| 95 | 456.6 | 18 | | | | | |
| 96 | 468.2 | 34 | | | | | |
| 132 | 481.6 | 24 | | | | | |
| 97 | 481.8 | 43 | | | | | |
| 98 | 485.9 | 57 | | | | | |
| 100 | 493.7 | 29 | 105 | 57 | 131 | 65 | 326 |
| 101 | 495.8 | 63 | | | | | |
| 99 | 499.6 | 73 | | | | | |
| 102 | 505.6 | 56 | | | | | |
| 103 | 512.6 | 45 | | | | | |
| 107 | 514.3 | 54 | | | | | |
| 104 | 518.0 | 59 | | | | | |
| 106 | 520.9 | 10 | | | | | |
| 108 | 522.0 | 20 | 312 | 80 | 349 | | |
| 111 | 527.8 | 67 | | | | | |
| 105 | 529.4 | 75 | | | | | |
| 108x | 530.2 | 26 | 309 | 75 | 347 | | |
| 121 | 534.7 | 9 | | | | | |
| 109 | 535.7 | 53 | | | | | |
| 110 | 538.6 | 49 | | | | | |
| 112 | 542.6 | 57 | | | | | |
| 113 | 543.7 | 56 | | | | | |
| 114 | 549.3 | 75 | | | | | |
| 115 | 552.0 | 69 | | | | | |
| 116 | 553.3 | 54 | | | | | |
| 117 | 556.1 | 52 | 210 | 27 | 257 | | |
| 118 | 562.7 | 46 | | | | | |
| 119 | 564.0 | 67 | | | | | |
| 120 | 574.2 | 66 | | | | | |
| 124 | 575.6 | 63 | | | | | |
| 125 | 593.6 | 27 | | | | | |
| 123 | 598.0 | 66 | | | | | |
| 122 | 678.3 | 15 | | | | | |
| 134 | 840.0 | 6 | | | | | |
| 133 | 1,536.0 | 3 | | | | | |
| 135 | 432.9 | 10 | 9 | 86 | 223 | | |

In Appendices 1 to 3 the amplitude of the first arrival is plotted against the length 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. Tables 5-7 through 5-9 lists areas with decreased amplitude in the three boreholes.

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 KLX10B with decreased amplitude for the 250 MHz antenna.**

| Length (m) |
|---|
| 20 – 31 |

**Table 5-8. Borehole length intervals in KLX10C with decreased amplitude for the 250 MHz antenna.**

| Length (m) |
|---|
| 15 – 21 |
| 35 – 40 |
| 42 – 56 |
| 72 – 76 |
| 78 – 82 |
| 105 – 108 |

**Table 5-9. Borehole length intervals in KLX12A with decreased amplitude for the 250 MHz antenna.**

| Length (m) | Length (m) |
|---|---|
| 0 – 100 | 405 – 435 |
| 105 – 130 | 440 – 450 |
| 140 – 195 | 456 – 472 |
| 270 – 272 | 485 – 490 |
| 278 – 282 | 510 – 515 |
| 300 – 310 | 522 – 525 |
| 392 – 400 | |

**Table 5-10. Some important structures in KLX10B, KLX10C and KLX12A.**

| Borehole | KLX10B | KLX10C | KLX12A |
|---|---|---|---|
| Structures | 4, 6, 15 | 2, 7, 8, 11 | 8, 10, 27, 31, 43, 48, 49, 72, 72x, 95, 100, 108, 108x, 126, 127, 128, 129, 132 and 133 |

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 electrical 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 an increased amplitude than a larger angle and by that a more clear structure.

## 5.2 BIPS logging

The BIPS pictures from KLX10B, KLX10C and KLX12A 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 previous reference marks on the cable for the logging in KLX10B and KLX10C. It is only in KLX12A the reference marks are created and therefore used for length adjustment.

The error in the length recording depends mainly on the tension of the cable and error of the depth readings from the measuring wheel. The adjusted length is showed in red colour and the recorded length have black colour in the printouts.

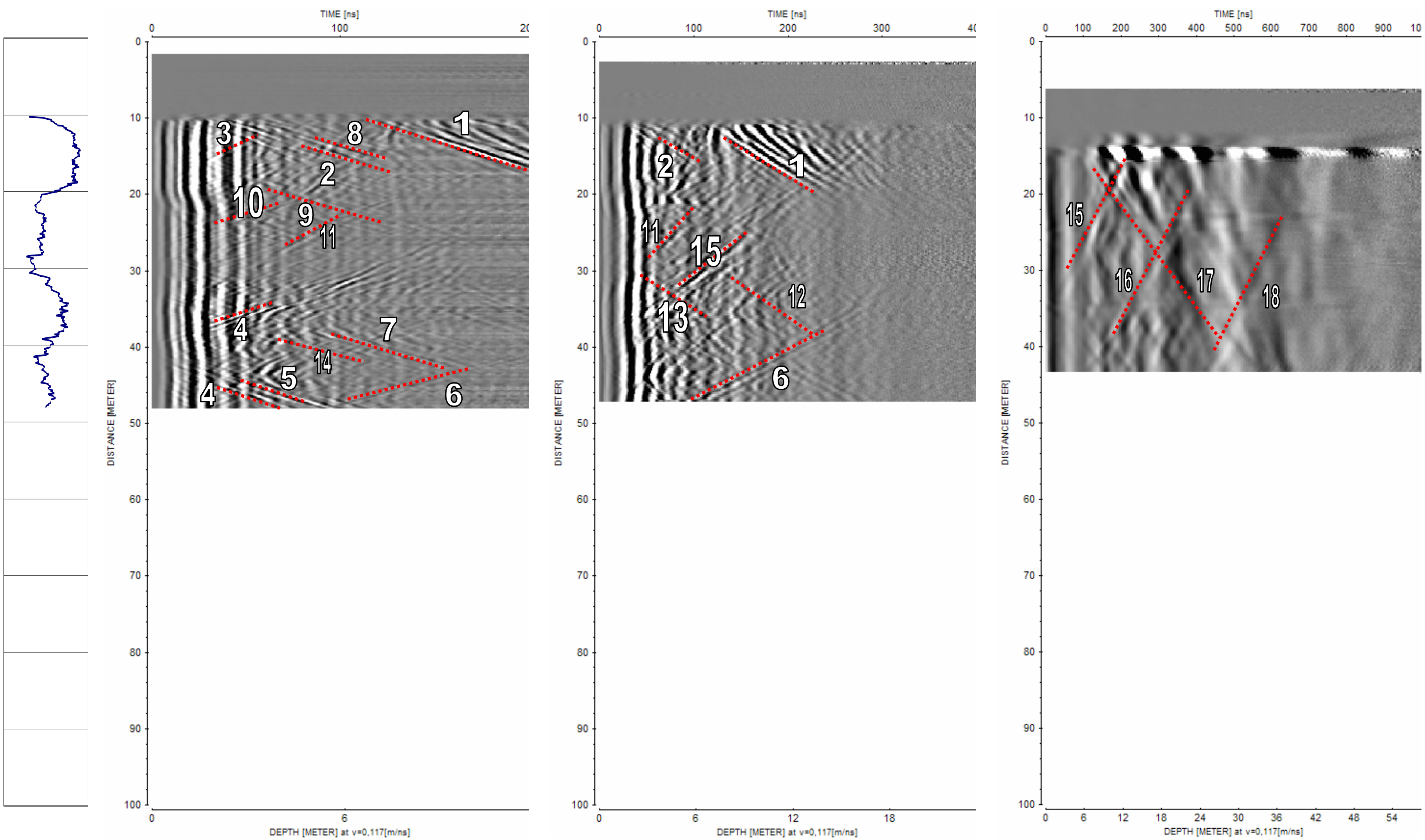
The images are satisfying due to the good water quality in the three boreholes. The quality problem is mud covering the lowermost part of the borehole wall. In the 197 mm part of KLX12A the water quality in combination of relatively dark colour of the borehole wall reduces the visibility and results in very dark images.

# 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.

# Radar logging in KLX10B, 0 to 48 m, dipole antennas 250, 100 and 20 MHz

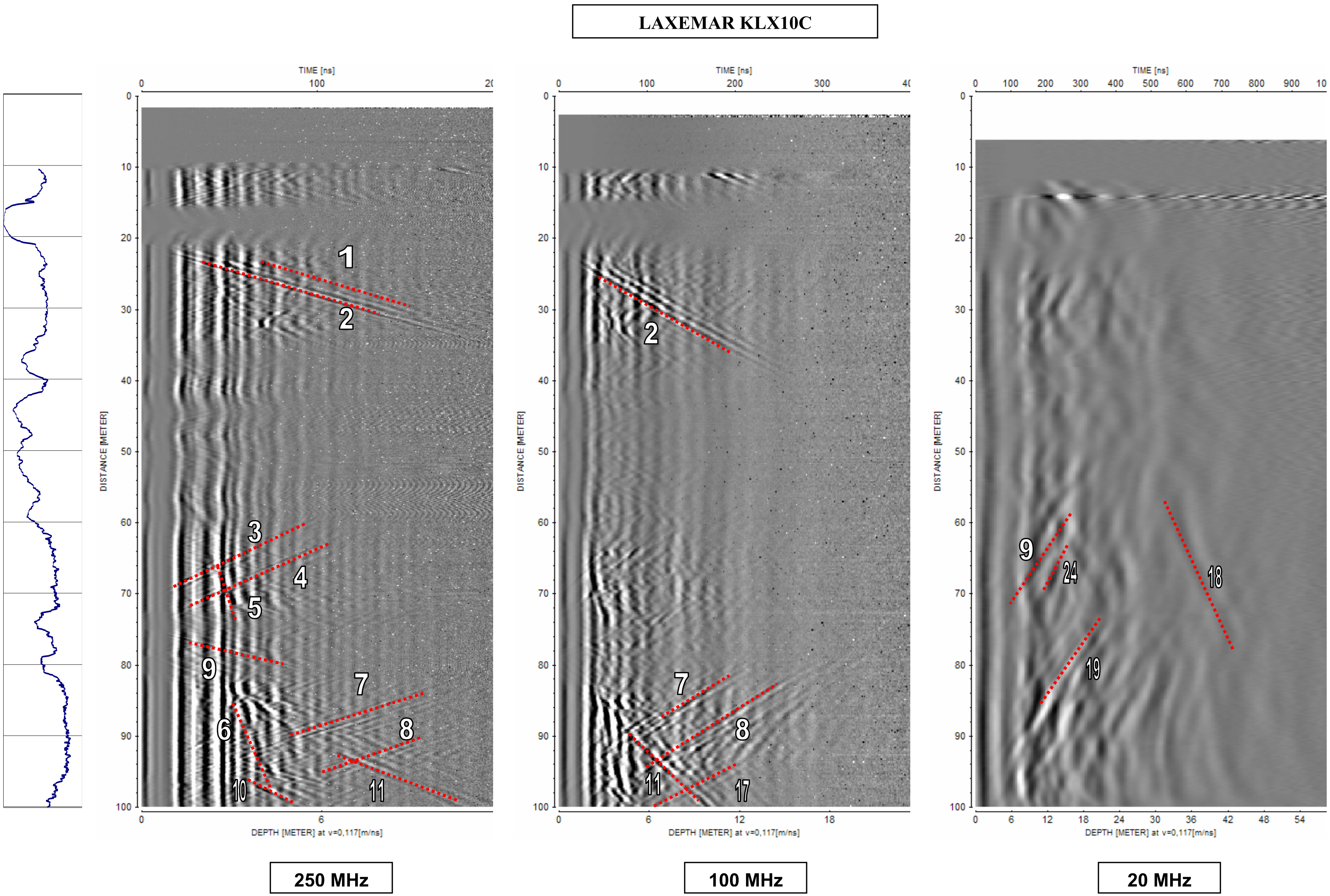
**LAXEMAR KLX10B**



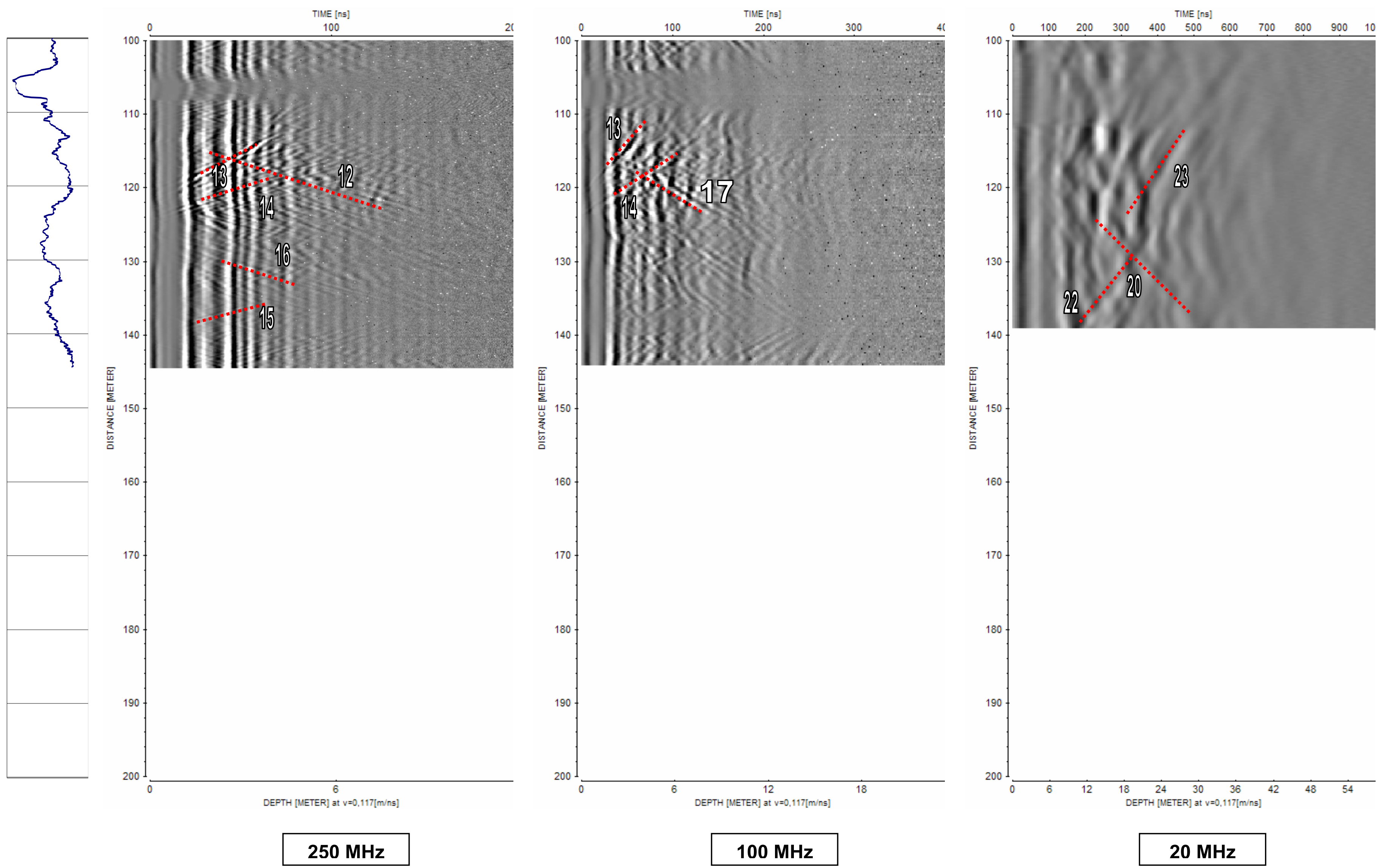

**250 MHz** **100 MHz** **20 MHz**

## Appendix 2

# Radar logging in KLX10C, 0 to 144 m, dipole antennas 250, 100 and 20 MHz

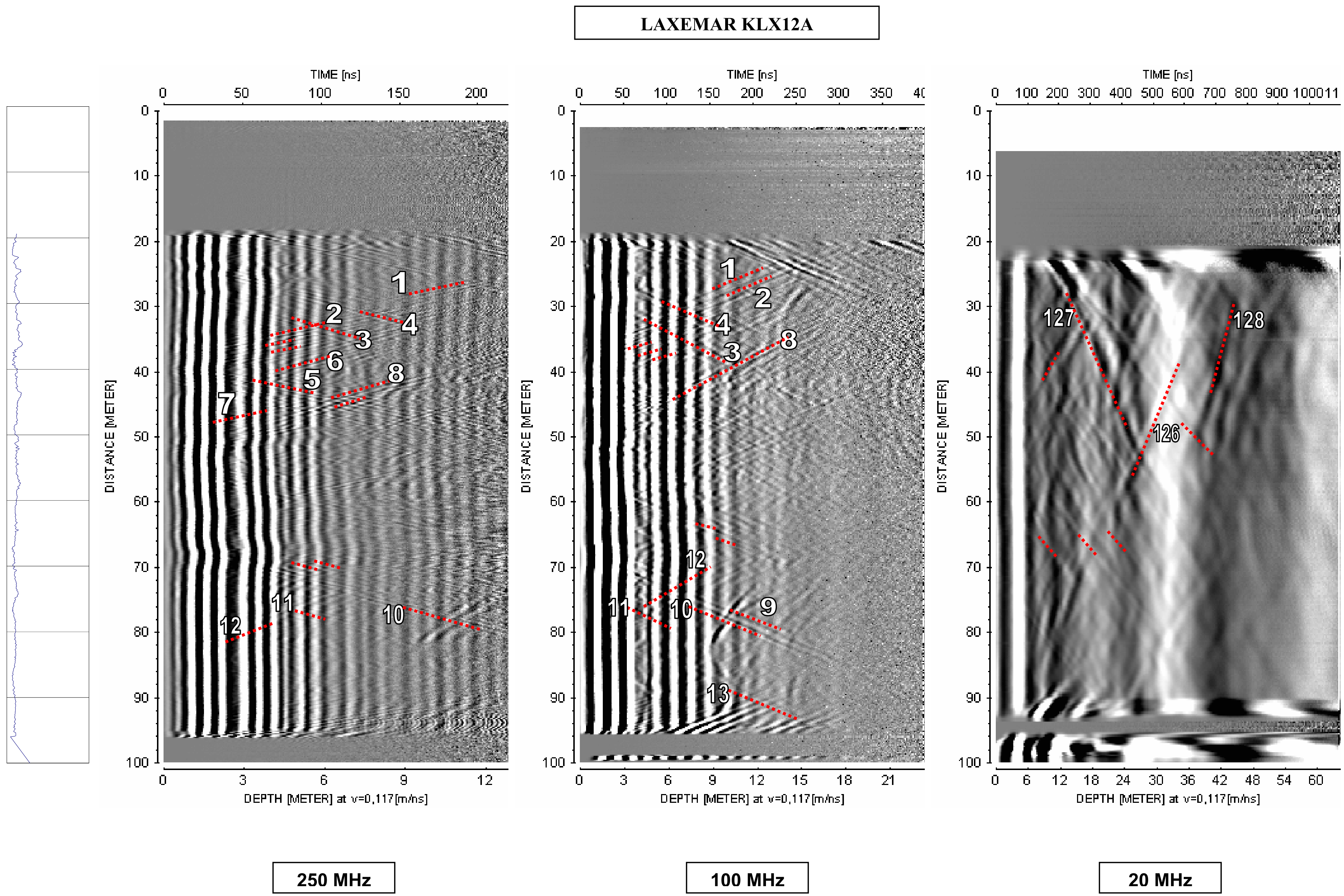


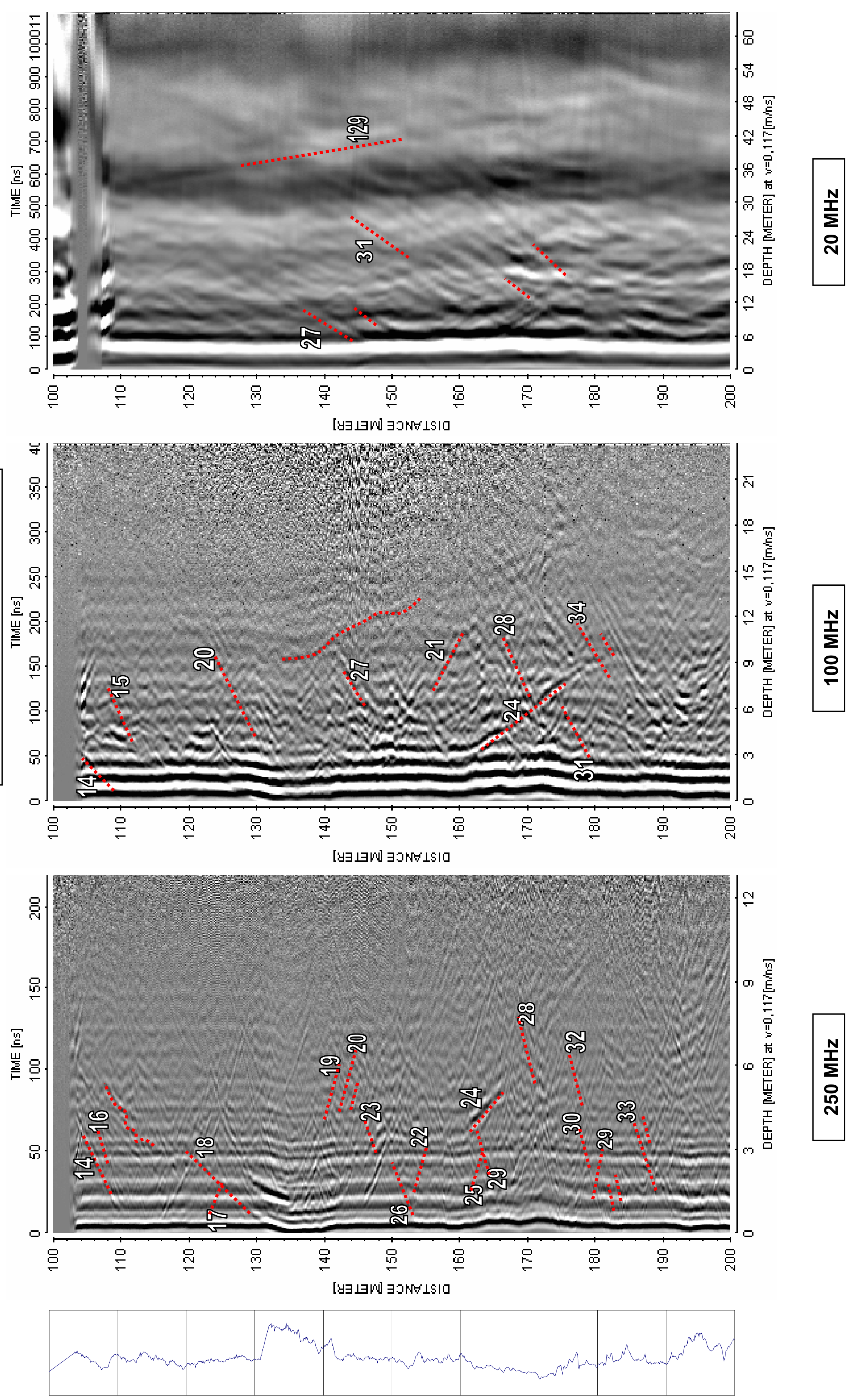
**LAXEMAR KLX10C**



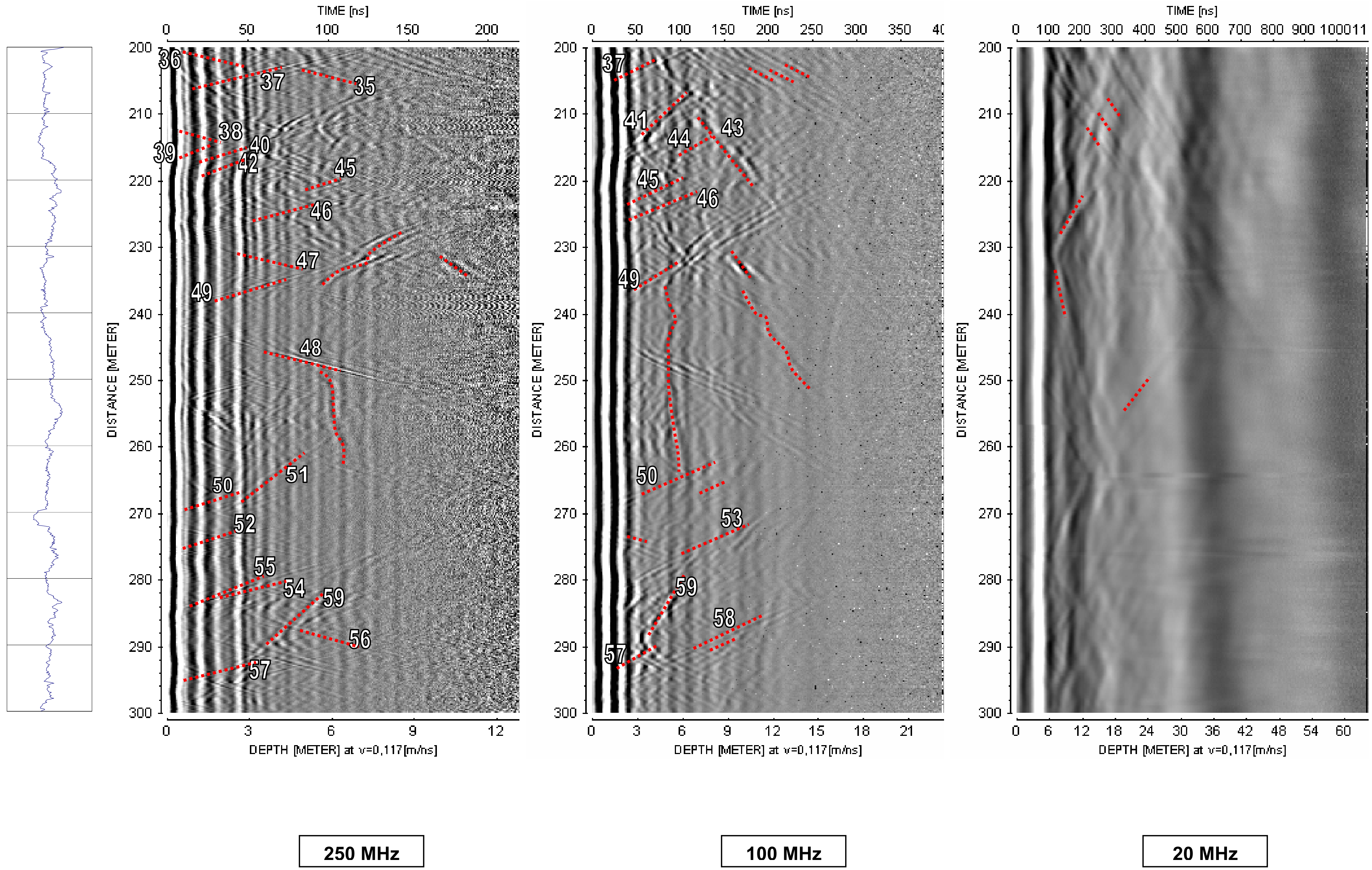
# Appendix 3

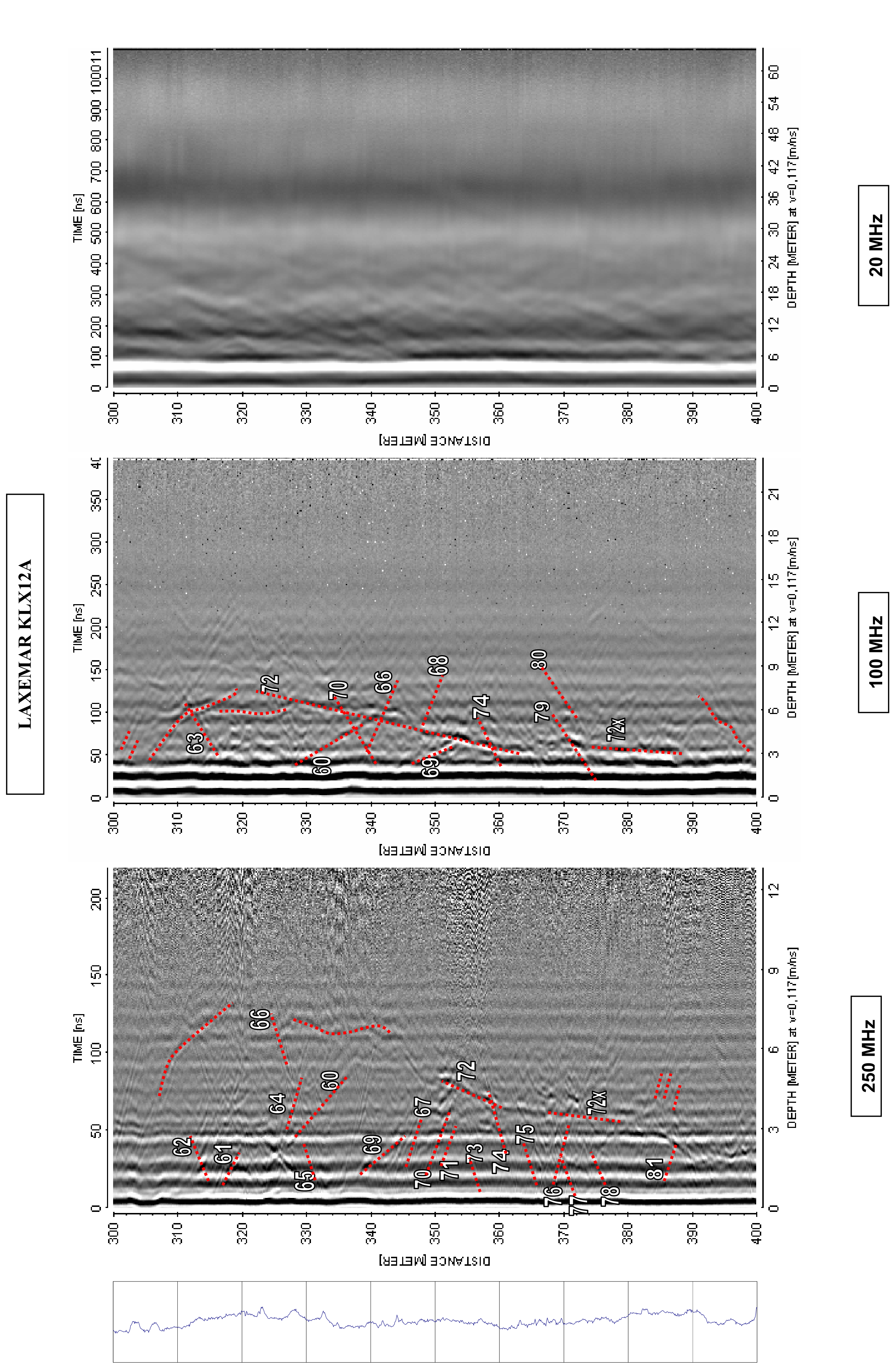
## Radar logging in KLX12A, 0 to 595 m, dipole antennas 250, 100 and 20 MHz



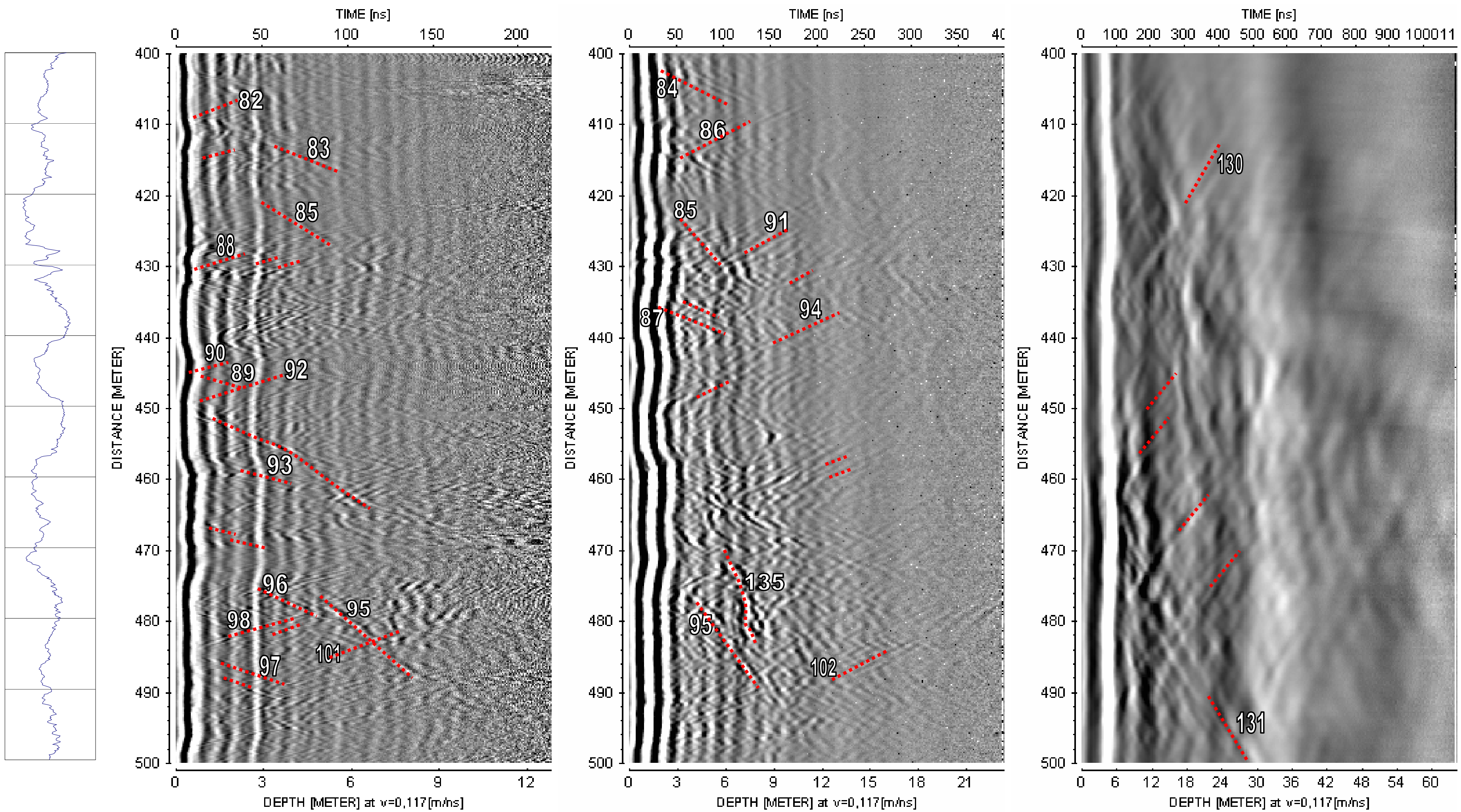

LAXEMAR KLX12A
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,117 [m/ns]

**LAXEMAR KLX12A**




LAXEMAR KLX12A
250 MHz
100 MHz
20 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,117[m/ns]

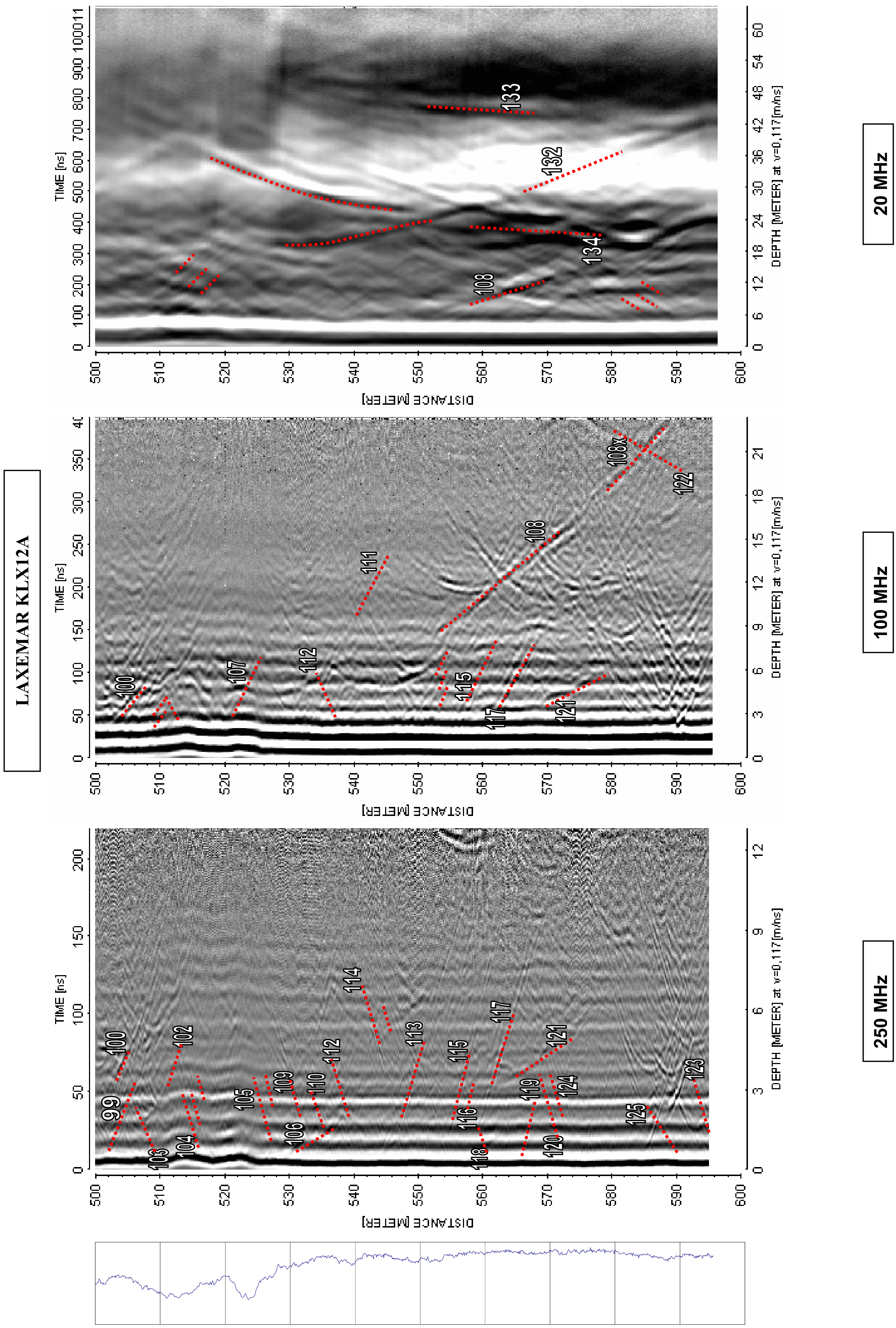
**LAXEMAR KLX12A**




**250 MHz**

**100 MHz**

**20 MHz**


LAXEMAR KLX12A
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,117[m/ns]
20 MHz
100 MHz
250 MHz

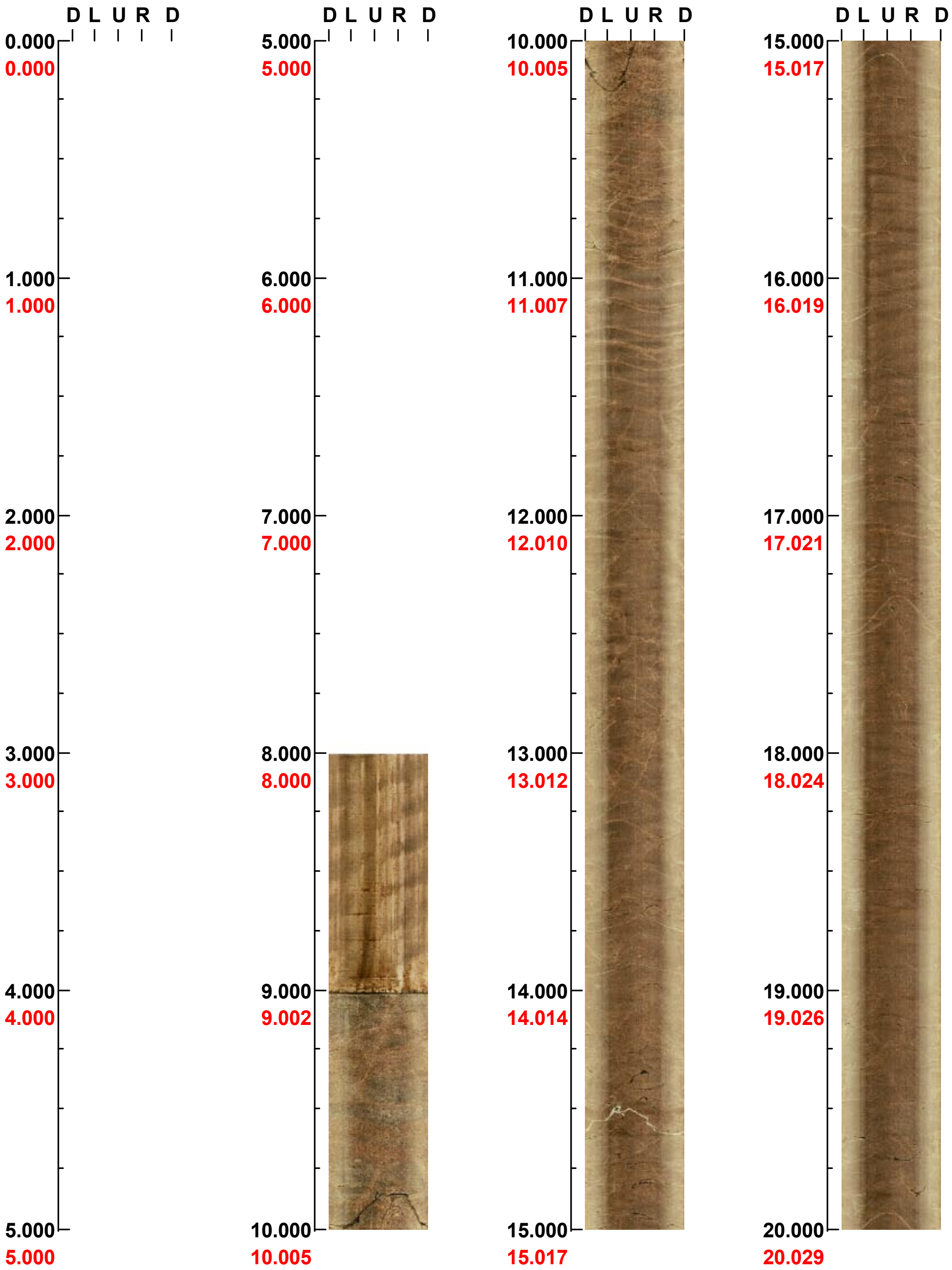
## BIPS logging in KLX10B, 8 to 50 m

**Project name: Laxemar**

| | |
|---|---|
| Image file | : d:\work\simpev~1\r5515a~1\klx10b\bips\klx10b. |
| BDT file | : d:\work\simpev~1\r5515a~1\klx10b\bips\klx10b. |
| Locality | : LAXEMAR |
| Bore hole number | : KLX10B |
| Date | : 06/03/22 |
| Time | : 12:28:00 |
| Depth range | : 8.000 - 49.990 m |
| Azimuth | : 160 |
| Inclination | : -60 |
| Diameter | : 76.0 mm |
| Magnetic declination | : 0.0 |
| Span | : 4 |
| Scan interval | : 0.25 |
| Scan direction | : To bottom |
| Scale | : 1/25 |
| Aspect ratio | : 175 % |
| Pages | : 3 |
| Color | : +0 +0 +0 |

**Project name: Laxemar**
**Bore hole No.: KLX10B** **Azimuth: 160** **Inclination: -60**

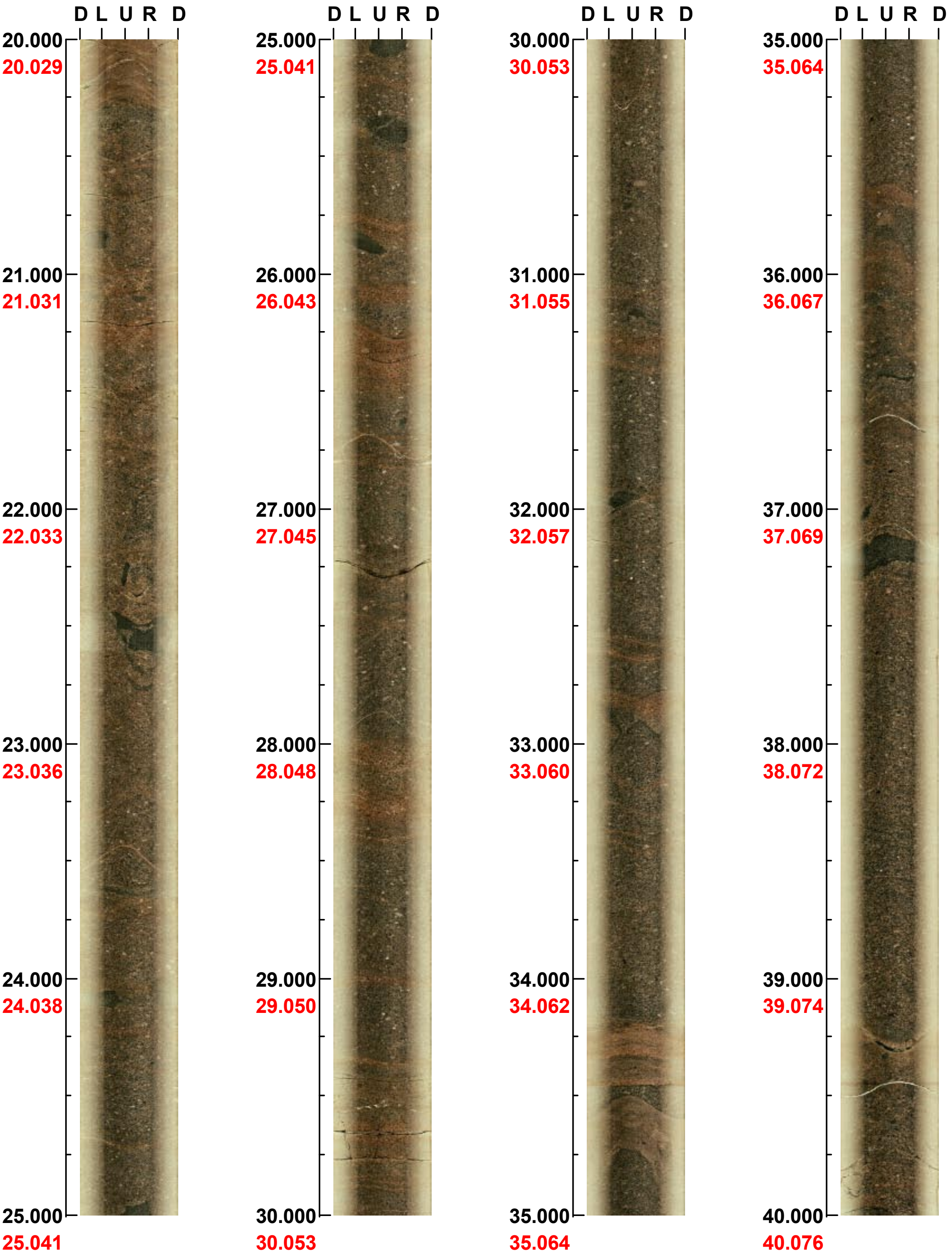
**Depth range: 0.000 - 20.000 m**




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

**Project name: Laxemar**
**Bore hole No.: KLX10B** **Azimuth: 160** **Inclination: -60**

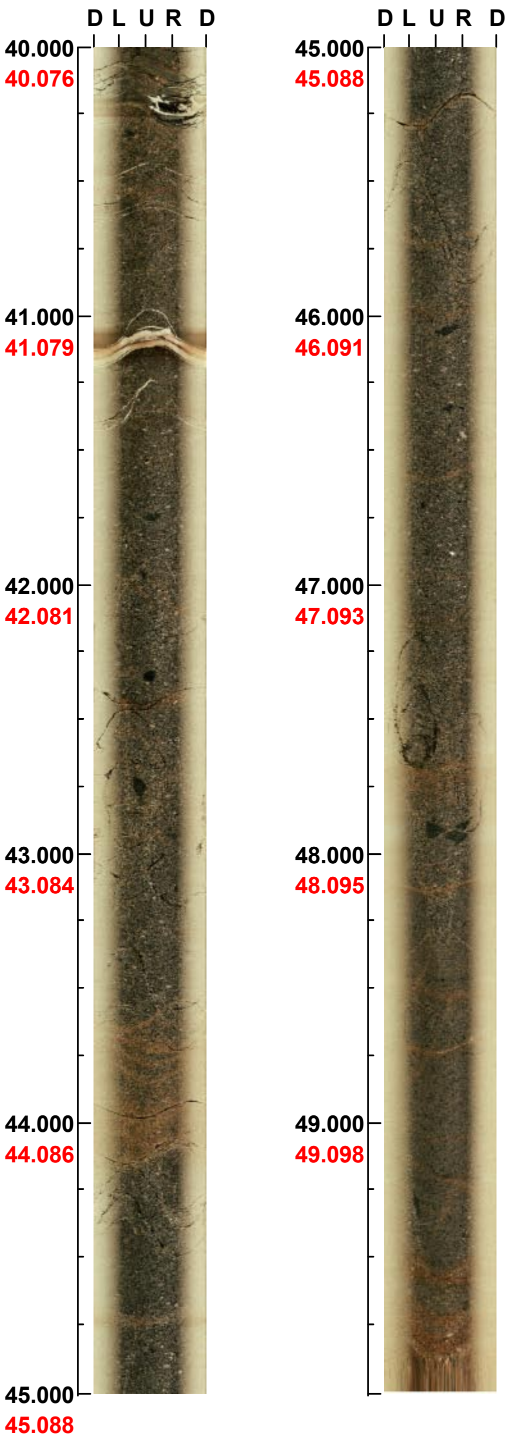
**Depth range: 20.000 - 40.000 m**




**( 2 / 3 )** **Scale: 1/25** **Aspect ratio: 175 %**

**Project name: Laxemar**
**Bore hole No.: KLX10B** **Azimuth: 160** **Inclination: -60**

**Depth range: 40.000 - 49.990 m**




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

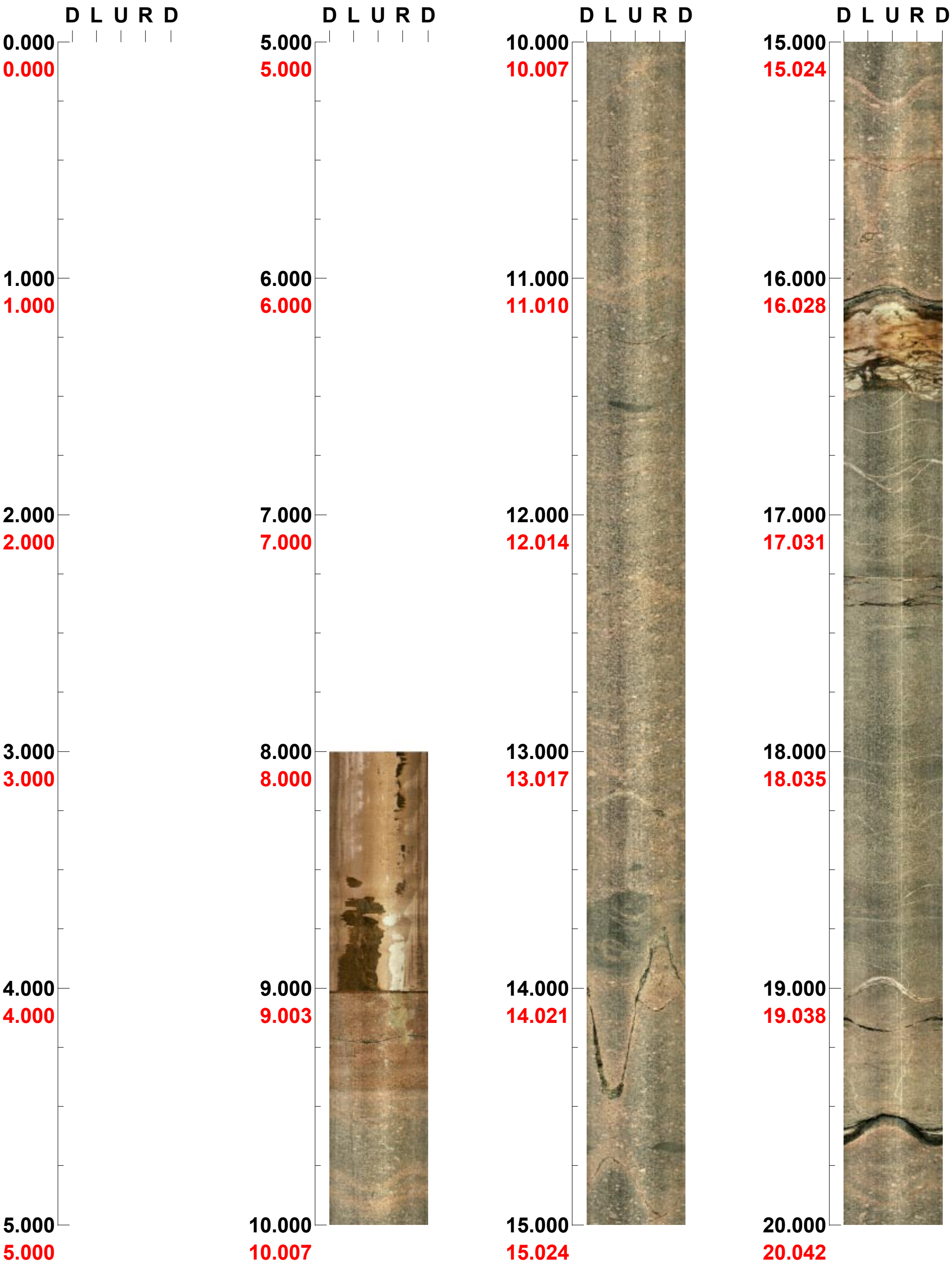
## BIPS logging in KLX10C, 8 to 145 m

**Project name: Laxemar**

| | |
|---|---|
| Image file | : c:\work\r5515k~1\klx10c\bips\klx10c.bip |
| BDT file | : c:\work\r5515k~1\klx10c\bips\klx10c.bdt |
| Locality | : LAXEMAR |
| Bore hole number | : KLX10C |
| Date | : 06/03/23 |
| Time | : 15:01:00 |
| Depth range | : 8.000 - 145.425 m |
| Azimuth | : 350 |
| Inclination | : -60 |
| Diameter | : 76.0 mm |
| Magnetic declination | : 0.0 |
| Span | : 4 |
| Scan interval | : 0.25 |
| Scan direction | : To bottom |
| Scale | : 1/25 |
| Aspect ratio | : 175 % |
| Pages | : 8 |
| Color | : +0 +0 +0 |

Project name: Laxemar
Bore hole No.: KLX10C Azimuth: 350 Inclination: -60

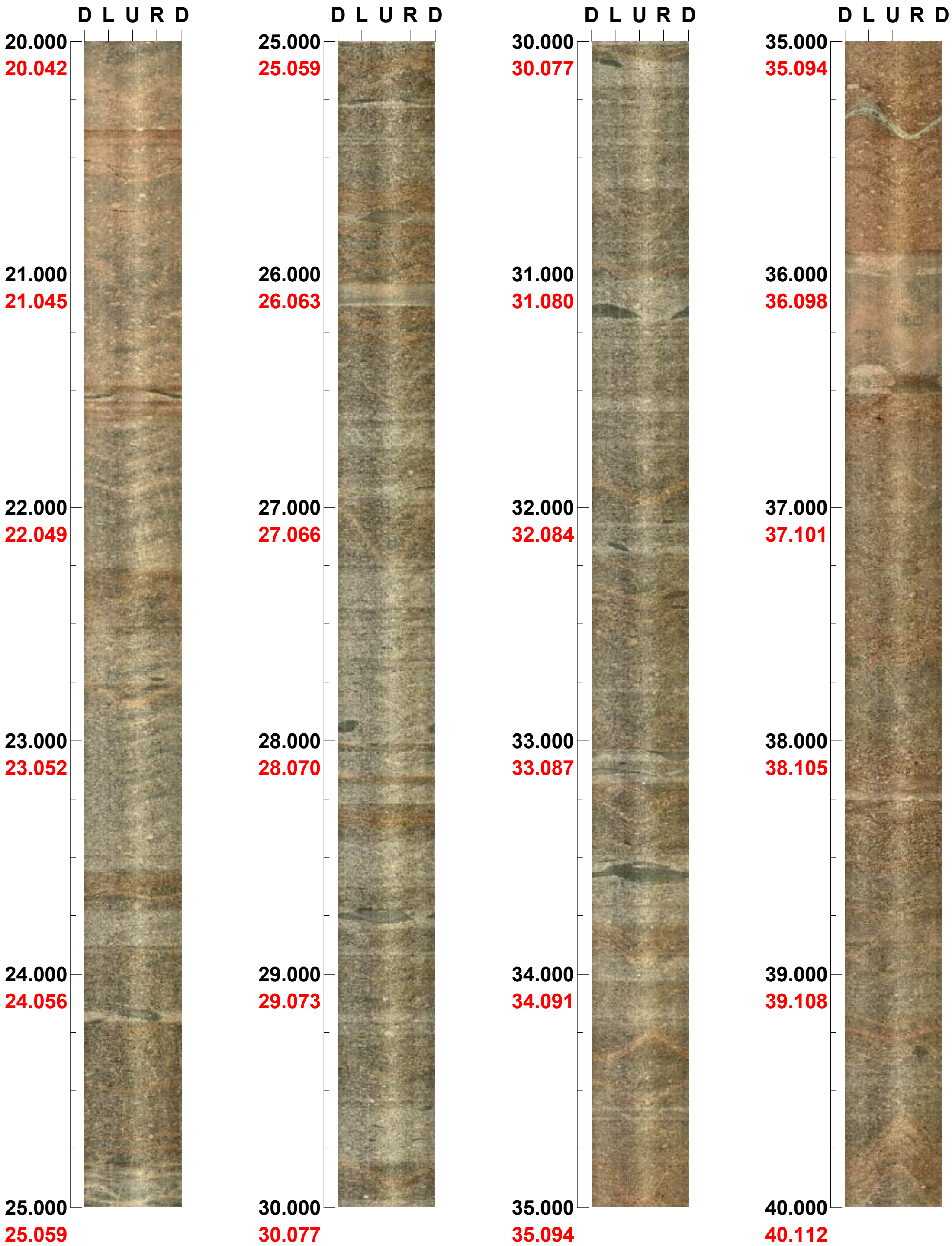
Depth range: 0.000 - 20.000 m




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

**Project name: Laxemar**
**Bore hole No.: KLX10C** **Azimuth: 350** **Inclination: -60**

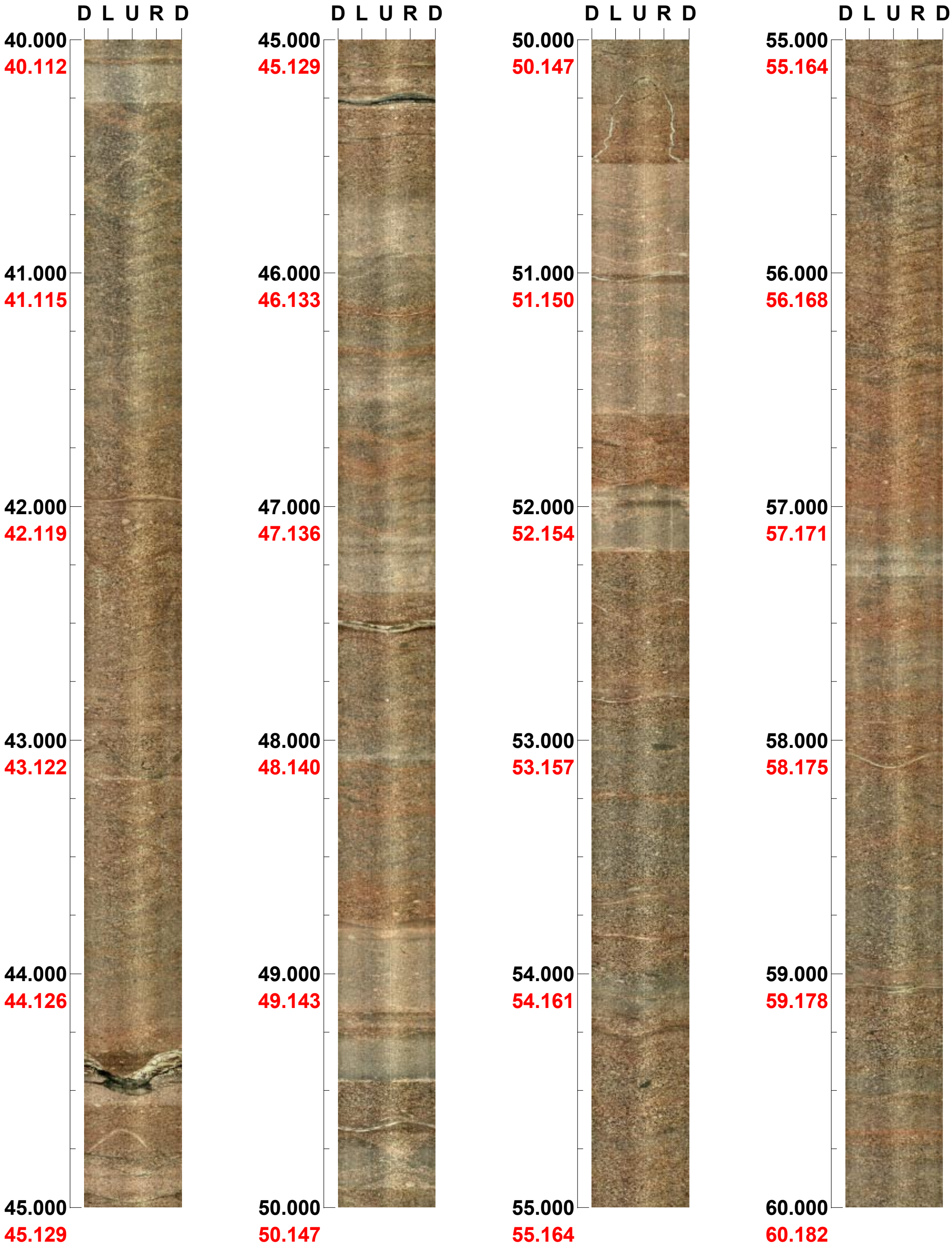
**Depth range: 20.000 - 40.000 m**




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

Project name: Laxemar
Bore hole No.: KLX10C Azimuth: 350 Inclination: -60

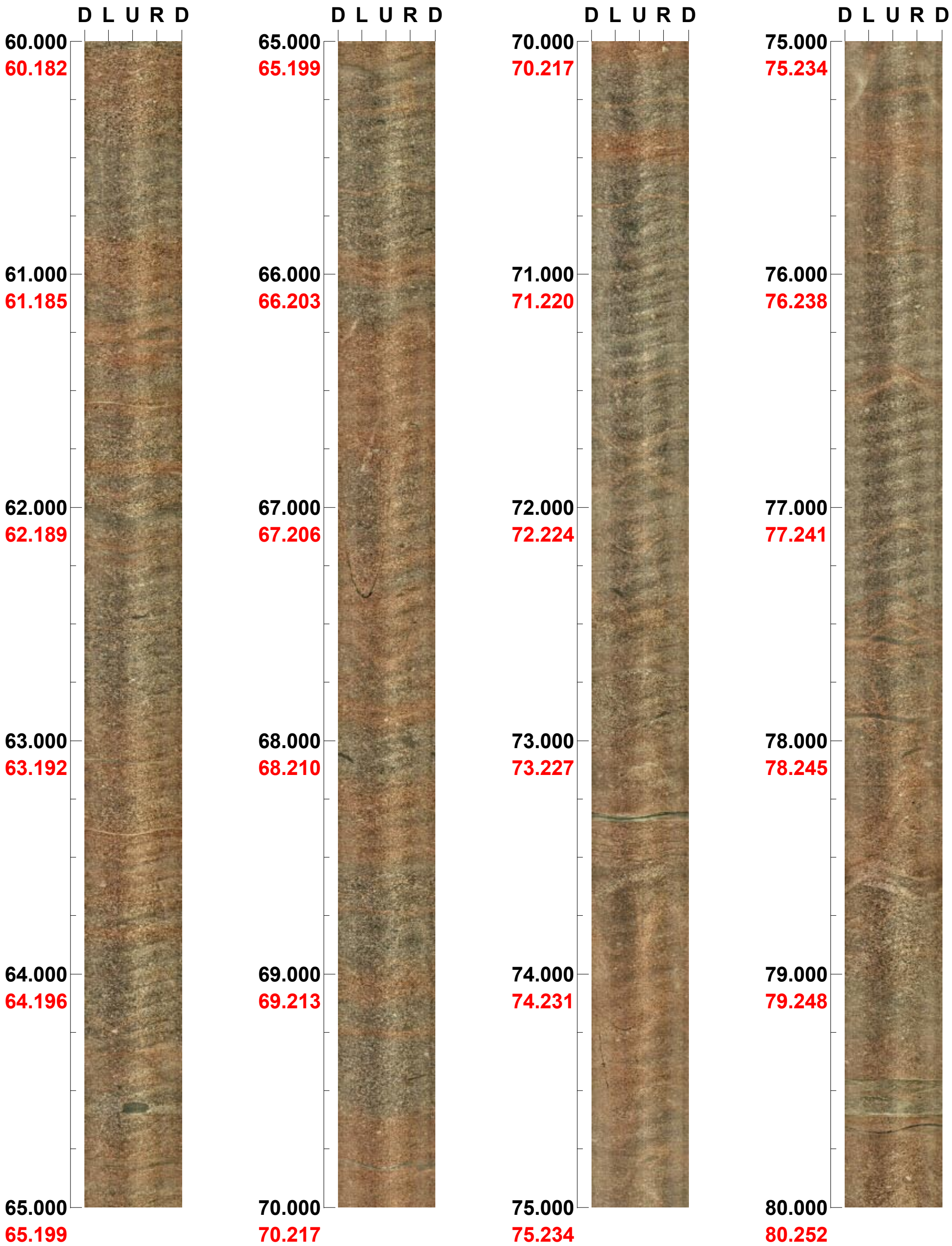
Depth range: 40.000 - 60.000 m




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

**Project name: Laxemar**
**Bore hole No.: KLX10C** **Azimuth: 350** **Inclination: -60**

**Depth range: 60.000 - 80.000 m**




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

**Project name: Laxemar**

**Bore hole No.: KLX10C** **Azimuth: 350** **Inclination: -60**

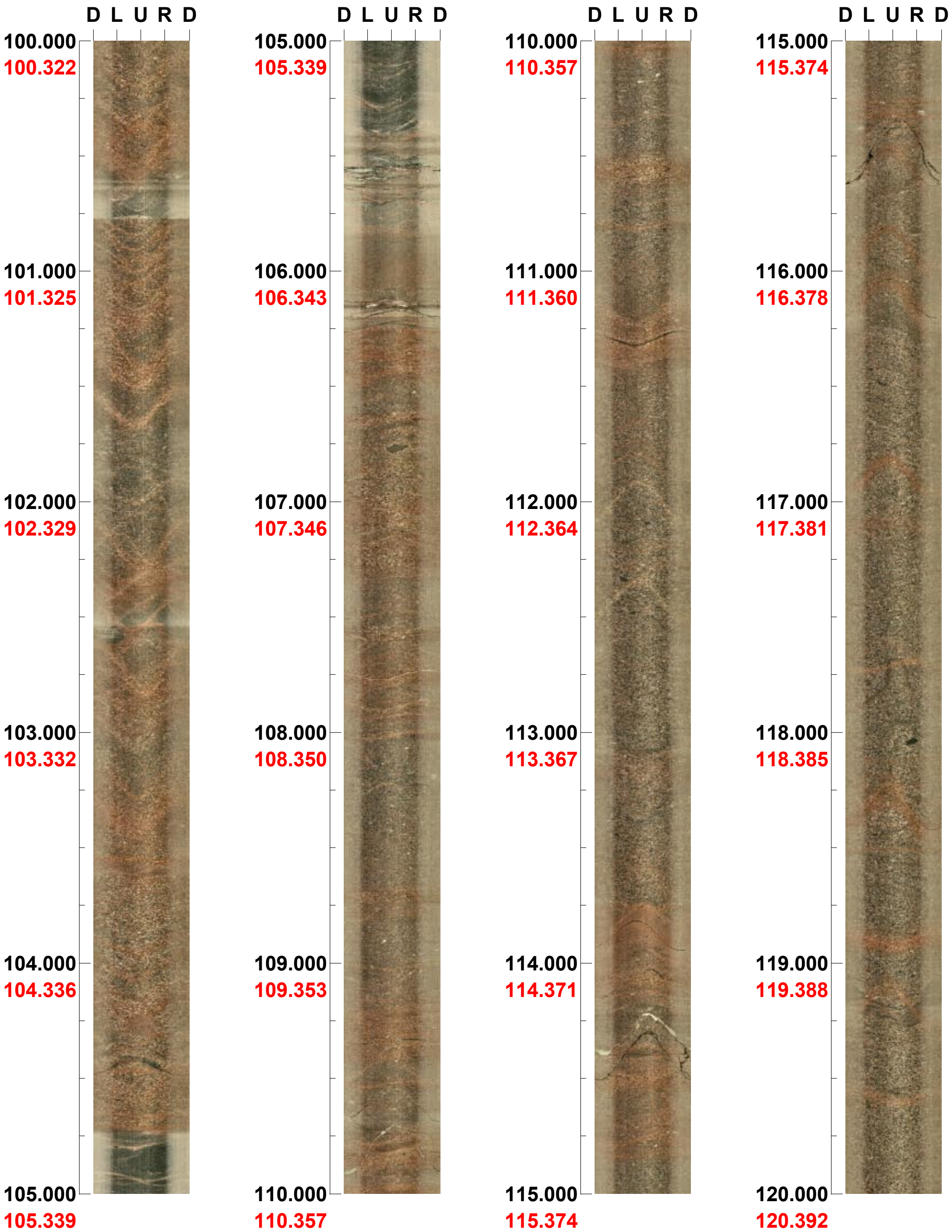
**Depth range: 80.000 - 100.000 m**


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

Project name: Laxemar
Bore hole No.: KLX10C

Azimuth: 350 Inclination: -60

Depth range: 100.000 - 120.000 m




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

**Project name: Laxemar**
**Bore hole No.: KLX10C** **Azimuth: 350** **Inclination: -60**

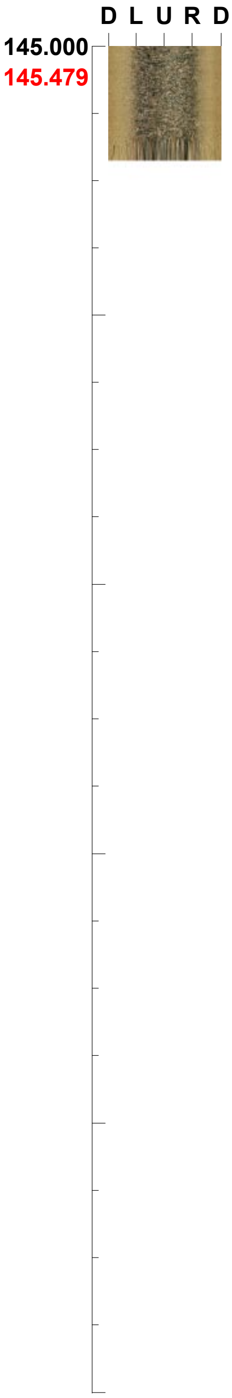
**Depth range: 120.000 - 140.000 m**


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

Project name: Laxemar
Bore hole No.: KLX10C

Azimuth: 350 Inclination: -60

Depth range: 140.000 - 145.425 m


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

## Appendix 6

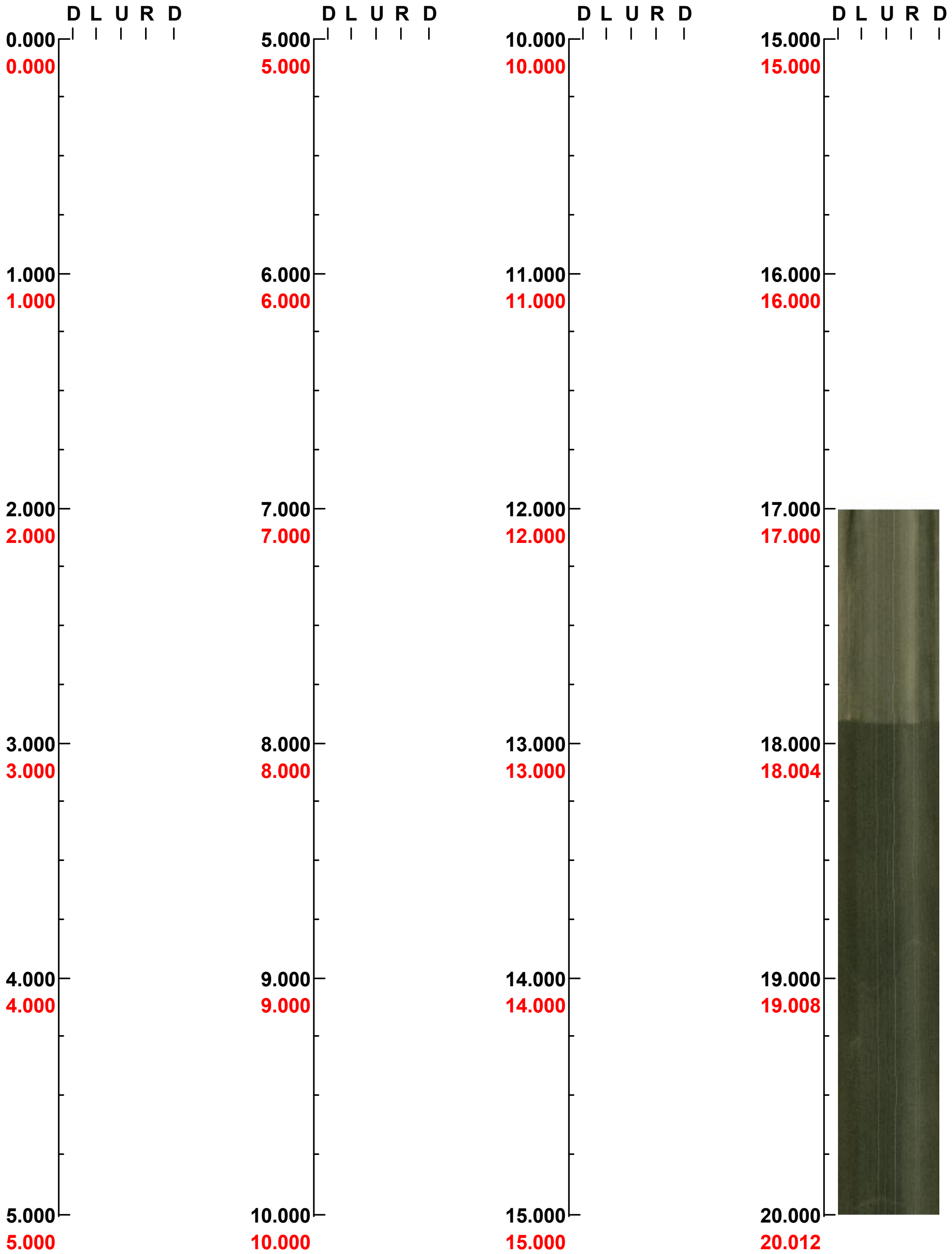
## BIPS logging in KLX12A, 17 to 599 m

**Project name: Laxemar**

| | |
|---|---|
| Image file | : d:\work\simpev~1\r5515a~1\klx12a\bips\klx12a_ |
| BDT file | : d:\work\simpev~1\r5515a~1\klx12a\bips\klx12a_ |
| Locality | : LAXEMAR |
| Bore hole number | : KLX12A |
| Date | : 06/03/24 |
| Time | : 12:36:00 |
| Depth range | : 17.000 - 97.498 m |
| Azimuth | : 316 |
| Inclination | : -75 |
| 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.: KLX12A** **Azimuth: 316** **Inclination: -75**

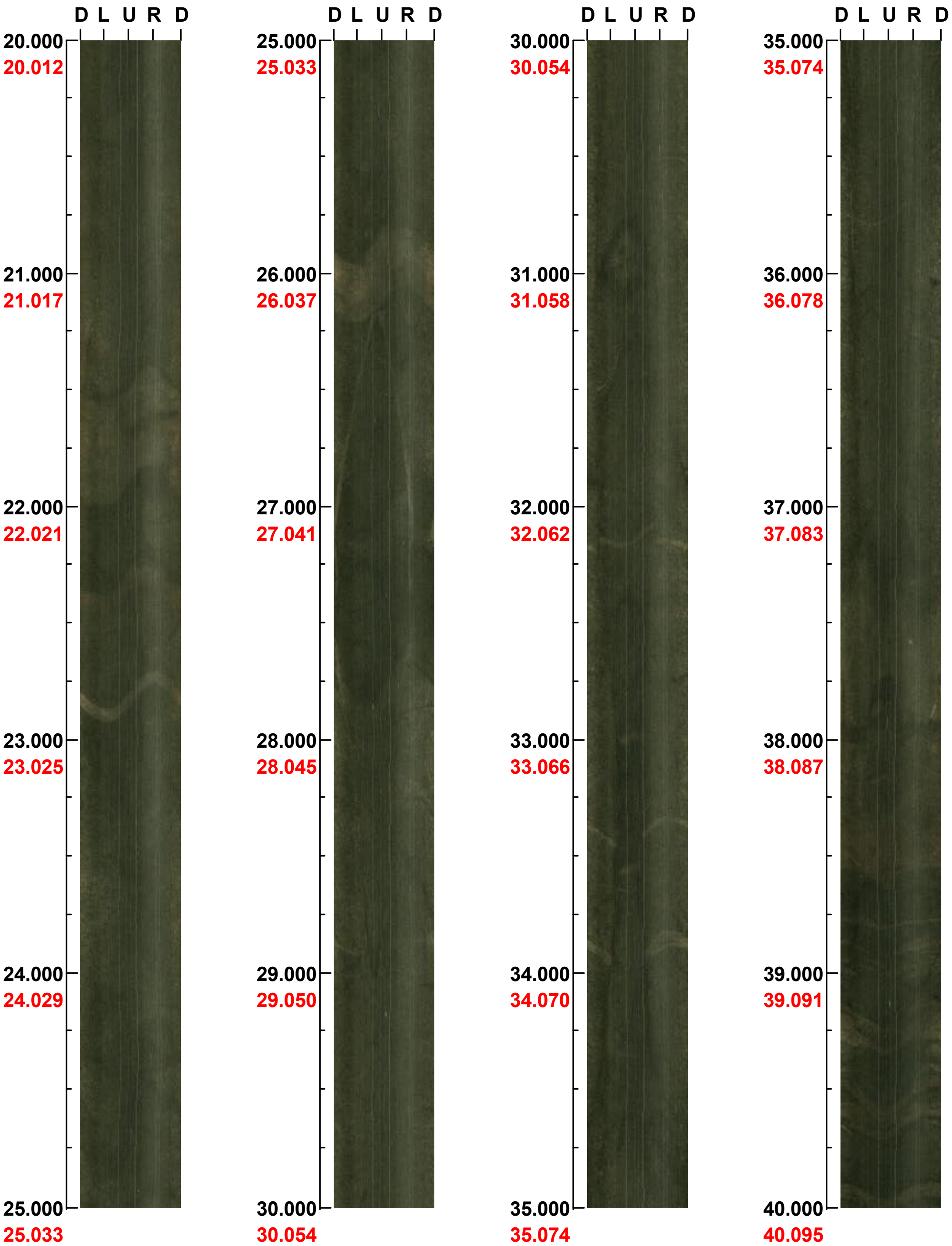
**Depth range: 0.000 - 20.000 m**




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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 20.000 - 40.000 m**




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

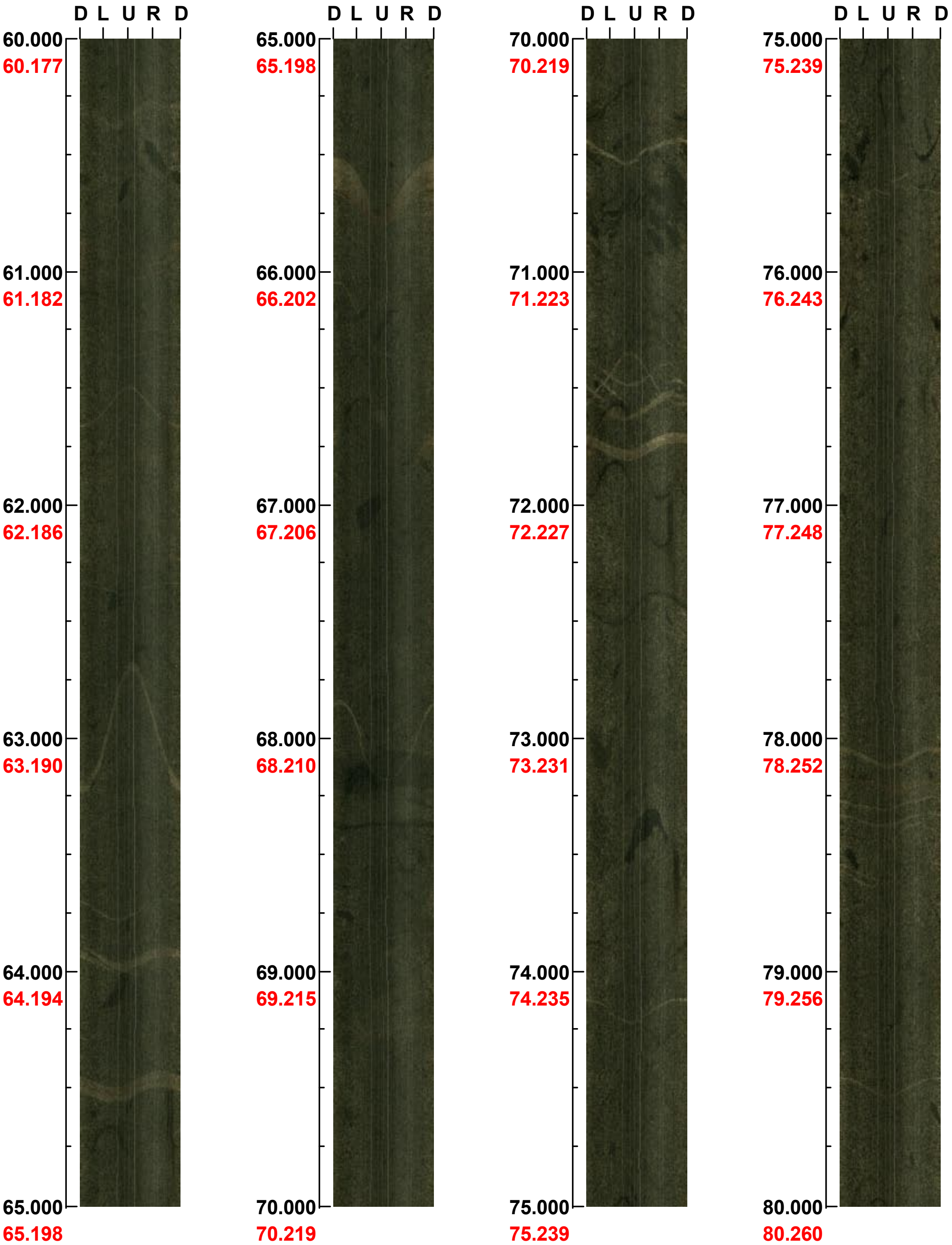
**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 40.000 - 60.000 m**


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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 60.000 - 80.000 m**




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

Project name: Laxemar
Bore hole No.: KLX12A Azimuth: 316 Inclination: -75

Depth range: 80.000 - 97.498 m


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

**Project name: Laxemar**

| | |
|---|---|
| **Image file** | **: c:\work\r5515k~1\klx12a\bips\klx12a_2.bip** |
| **BDT file** | **: c:\work\r5515k~1\klx12a\bips\klx12a_2.bdt** |
| **Locality** | **: LAXEMAR** |
| **Bore hole number** | **: KLX12A** |
| **Date** | **: 06/03/24** |
| **Time** | **: 09:26:00** |
| **Depth range** | **: 101.000 - 599.171 m** |
| **Azimuth** | **: 316** |
| **Inclination** | **: -75** |
| **Diameter** | **: 76.0 mm** |
| **Magnetic declination** | **: 0.0** |
| **Span** | **: 4** |
| **Scan interval** | **: 0.25** |
| **Scan direction** | **: To bottom** |
| **Scale** | **: 1/25** |
| **Aspect ratio** | **: 175 %** |
| **Pages** | **: 12** |
| **Color** | **: +0 +0 +0** |

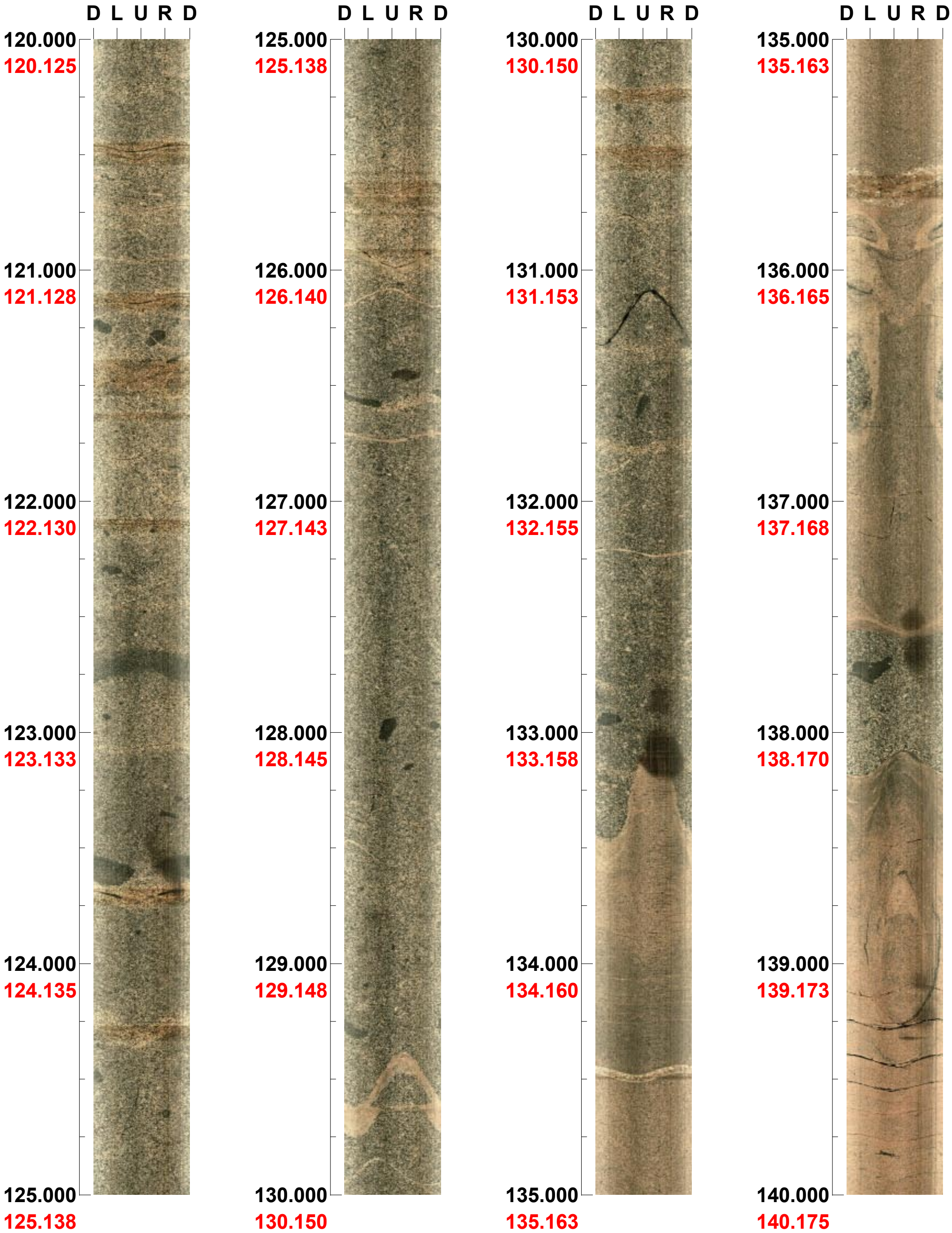
**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 100.000 - 120.000 m**


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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 120.000 - 140.000 m**

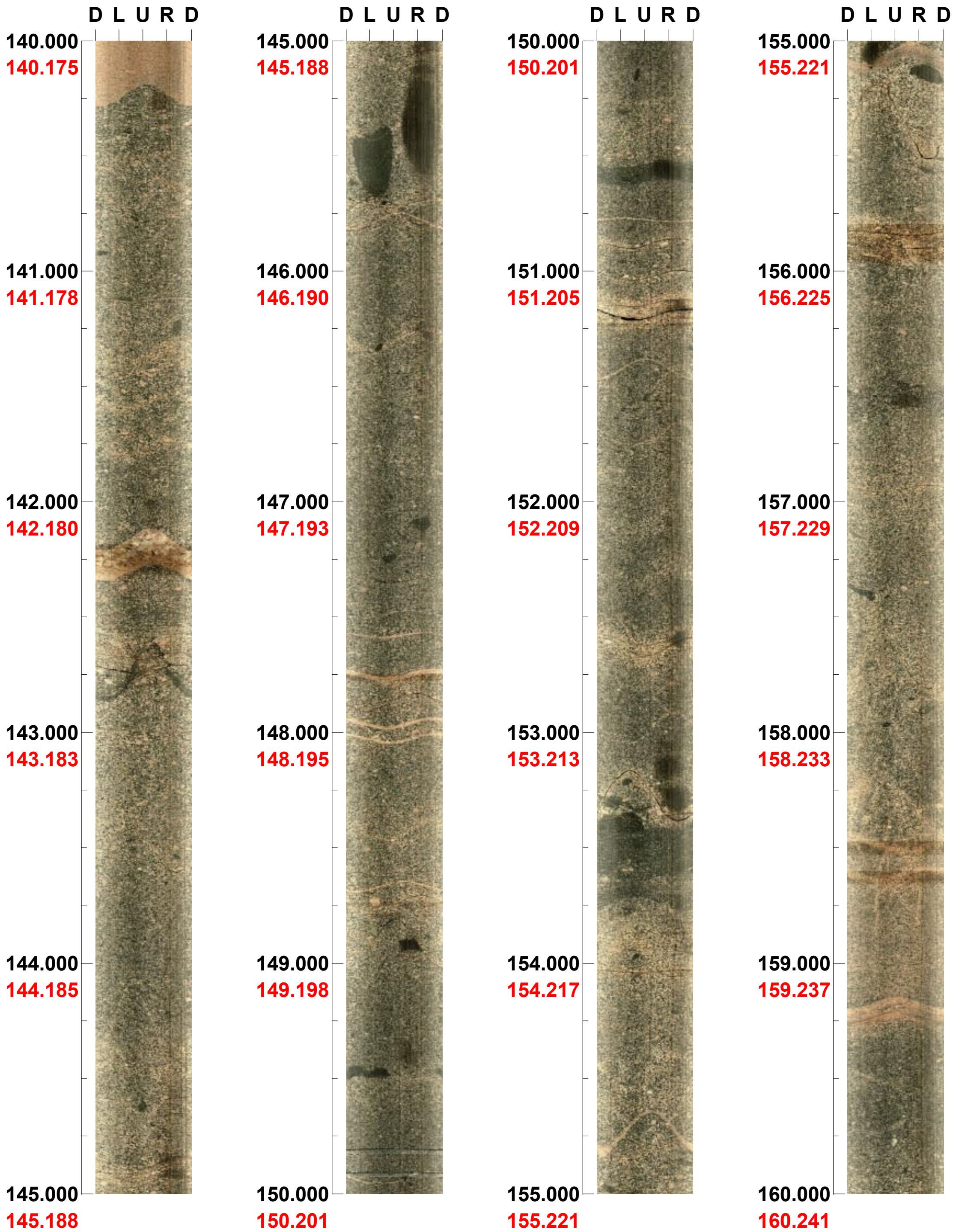



**( 2 / 12 )** **Scale: 1/25** **Aspect ratio: 175 %**

**Project name: Laxemar**

**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

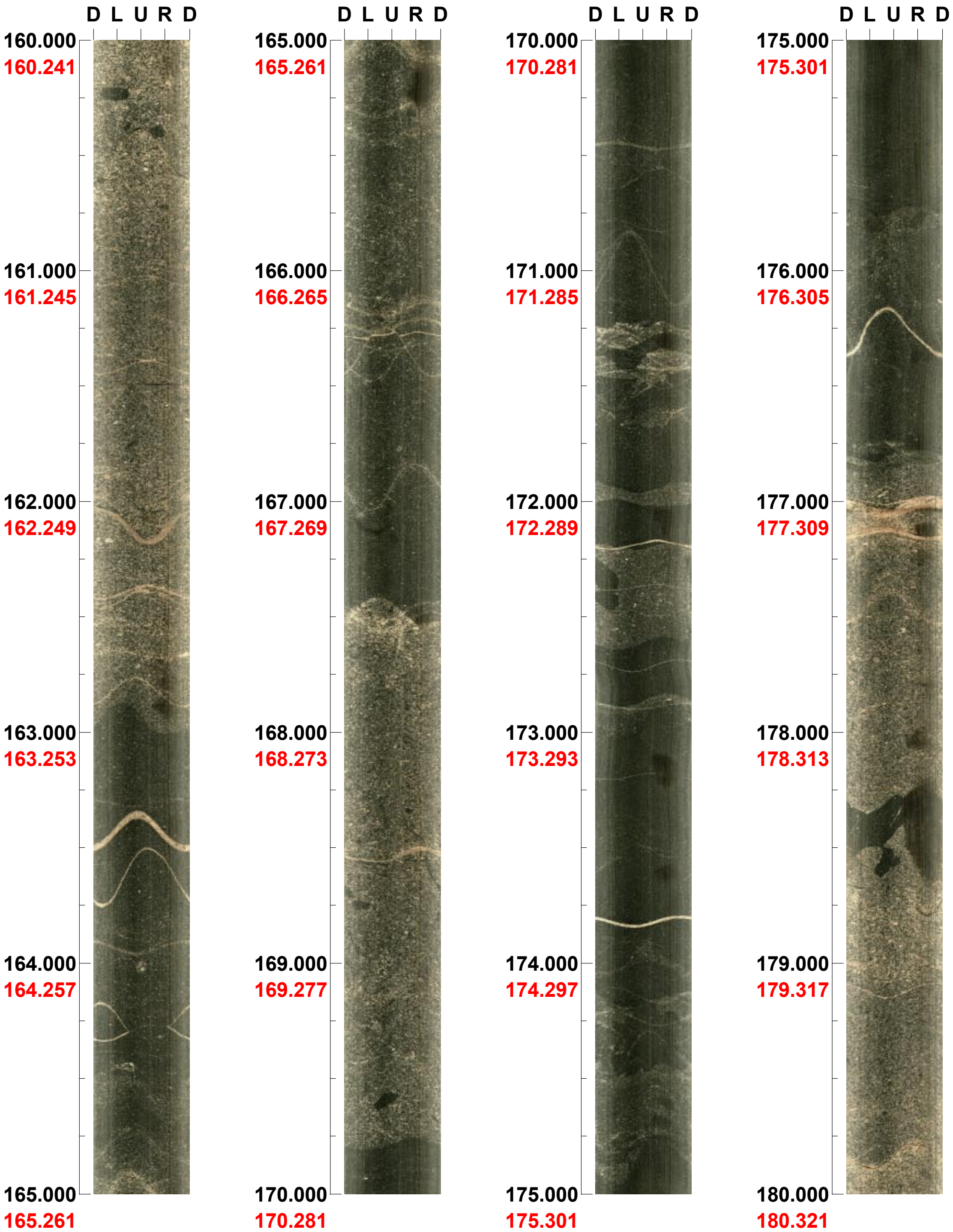
**Depth range: 140.000 - 160.000 m**




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

Project name: Laxemar
Bore hole No.: KLX12A　　　　Azimuth: 316　　Inclination: -75

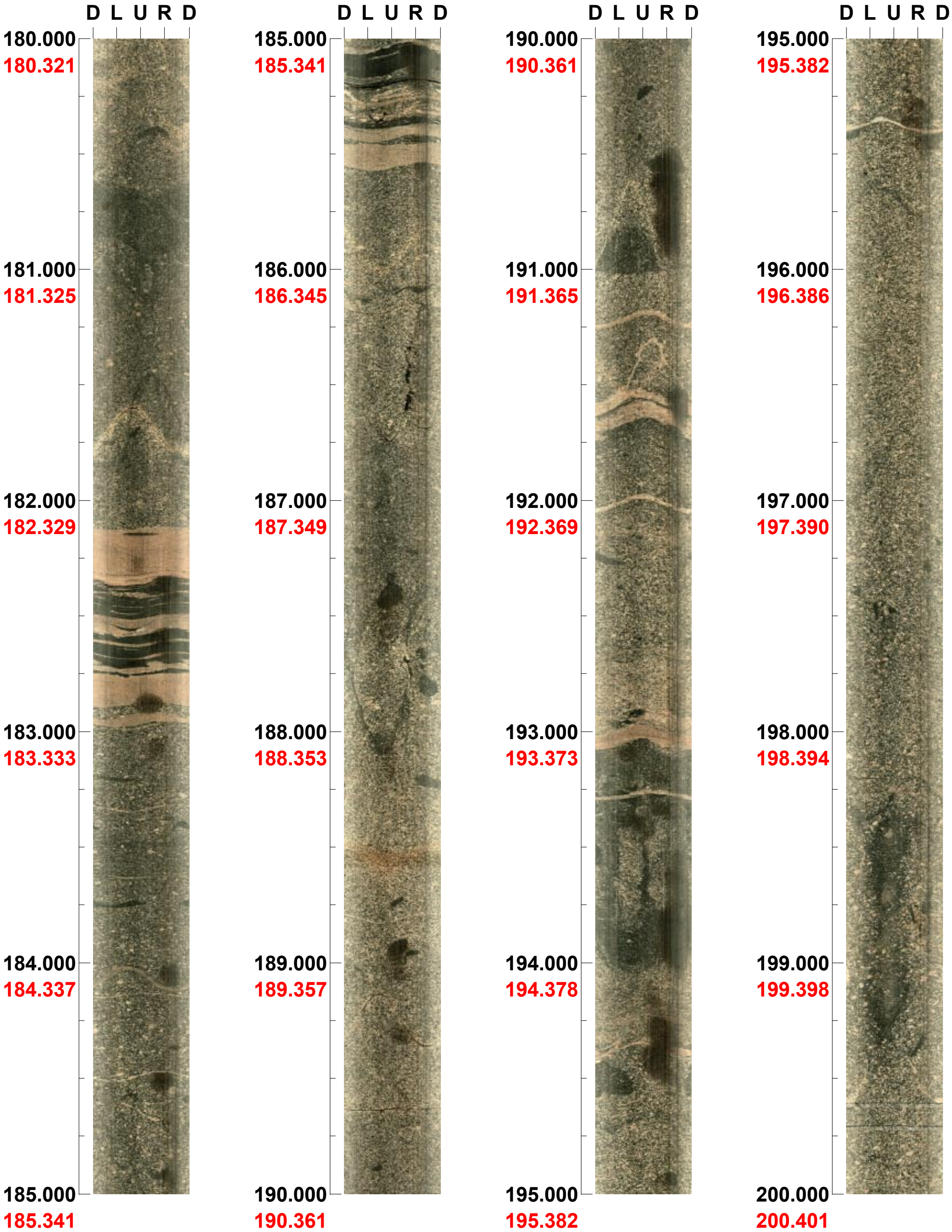
Depth range: 160.000 - 180.000 m




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

**Project name: Laxemar**
**Bore hole No.: KLX12A** Azimuth: 316 Inclination: -75

**Depth range: 180.000 - 200.000 m**




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

Project name: Laxemar
Bore hole No.: KLX12A

Azimuth: 316 Inclination: -75

Depth range: 200.000 - 220.000 m


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

Project name: Laxemar
Bore hole No.: KLX12A Azimuth: 316 Inclination: -75

Depth range: 220.000 - 240.000 m


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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 240.000 - 260.000 m**


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

**Project name: Laxemar**

**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

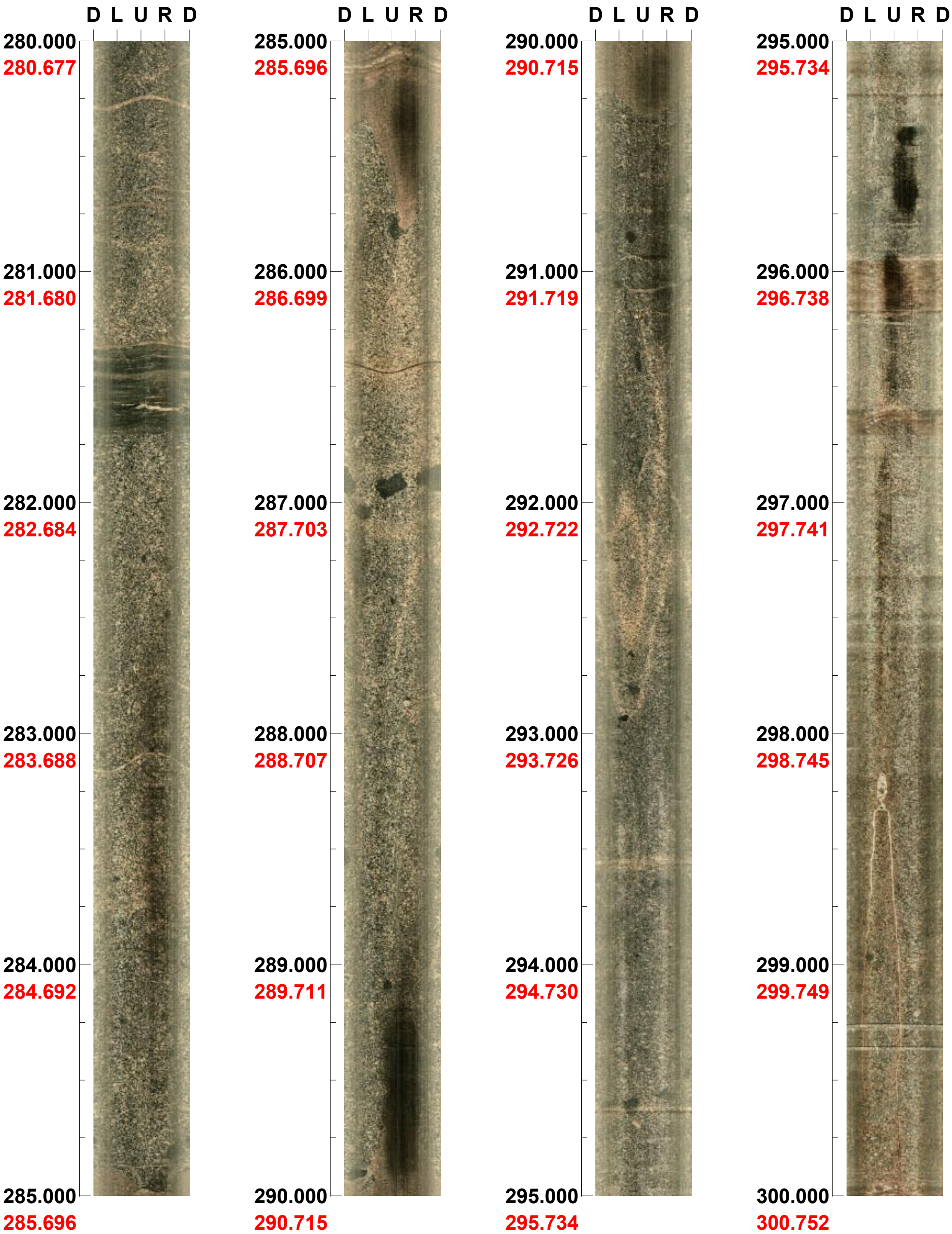
**Depth range: 260.000 - 280.000 m**


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

**Project name: Laxemar**

**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

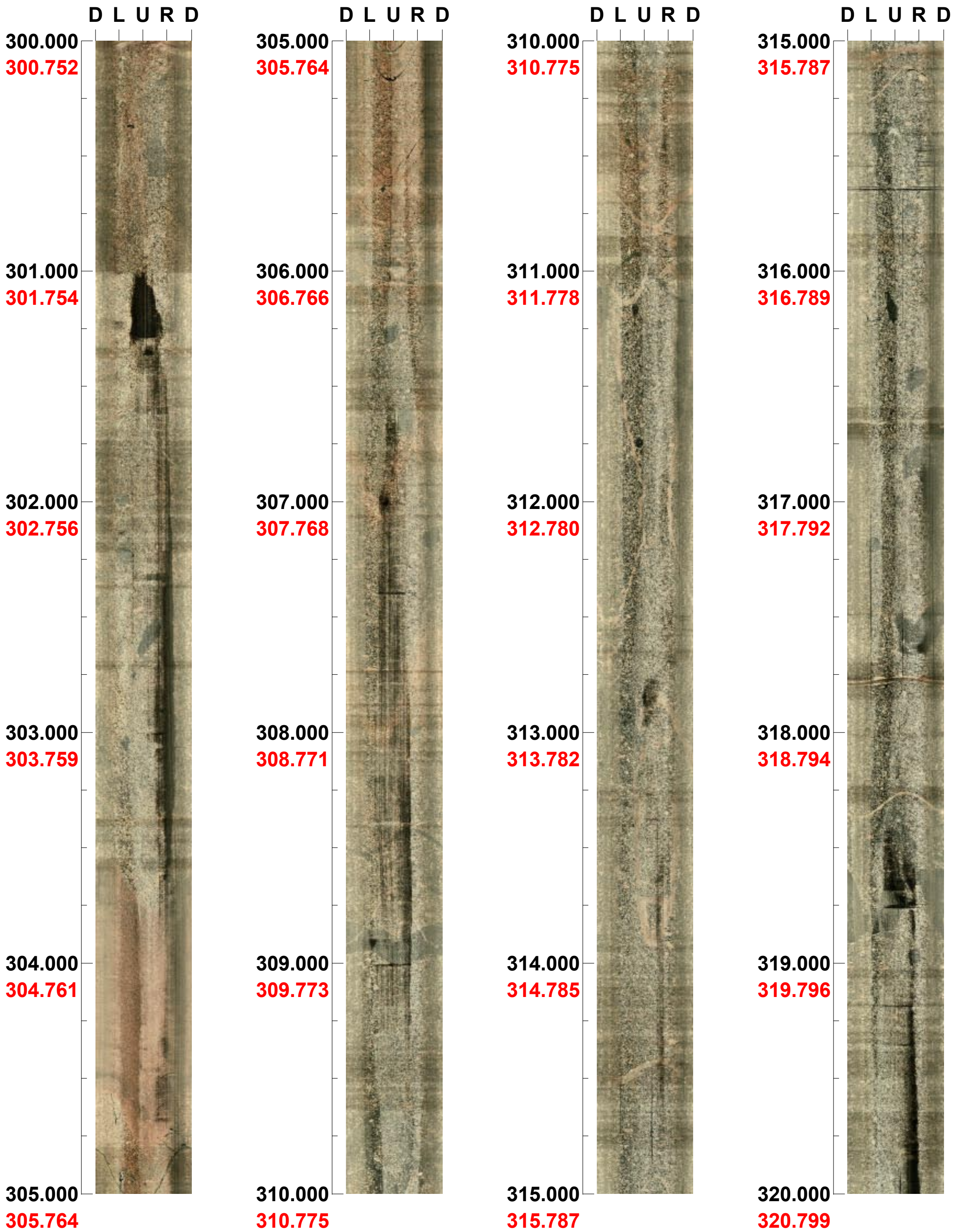
**Depth range: 280.000 - 300.000 m**




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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 300.000 - 320.000 m**

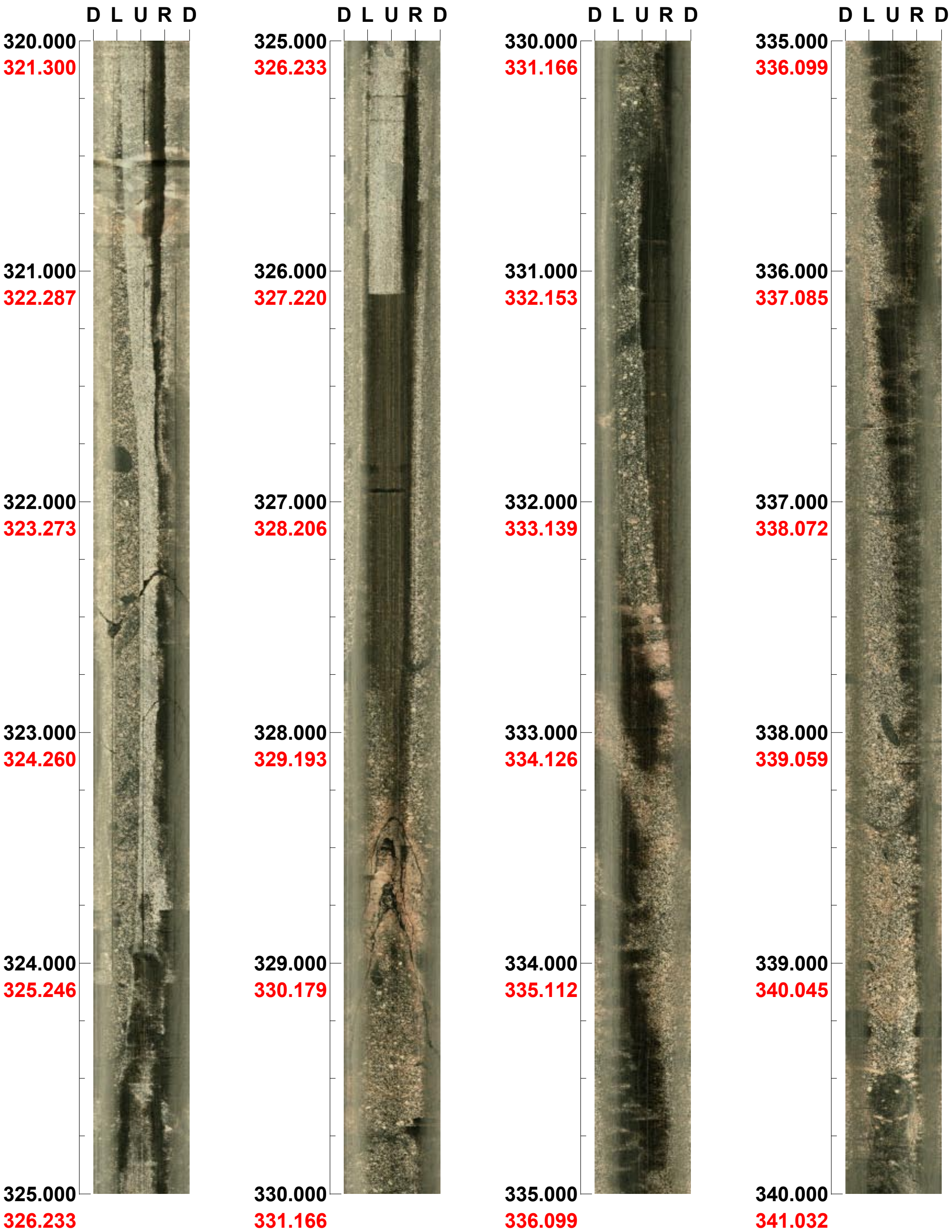



**( 11 / 12 )** **Scale: 1/25** **Aspect ratio: 175 %**

Project name: Laxemar
Bore hole No.: KLX12A

Azimuth: 316 Inclination: -75

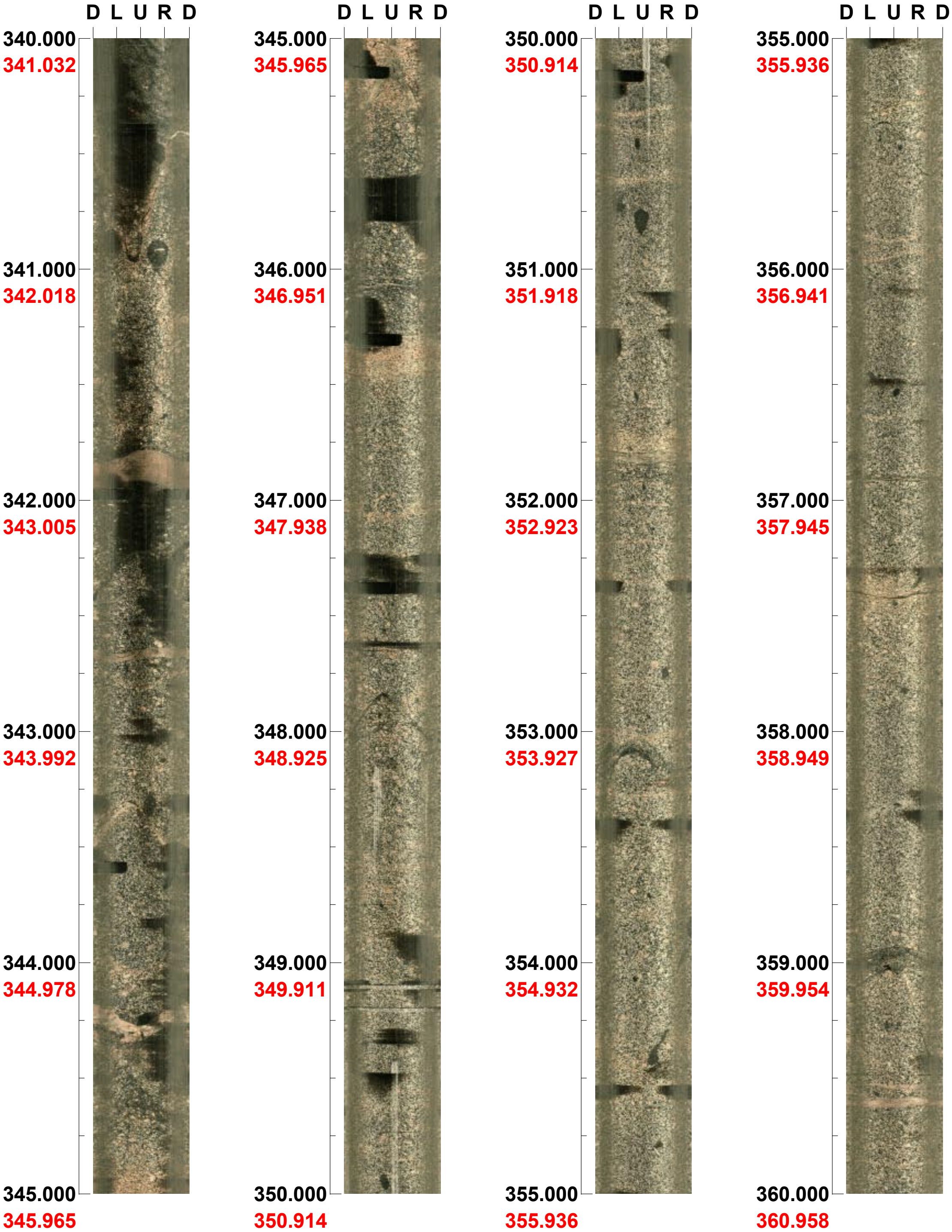
Depth range: 320.000 - 340.000 m




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

Project name: Laxemar
Bore hole No.: KLX12A
Azimuth: 316 Inclination: -75

Depth range: 340.000 - 360.000 m

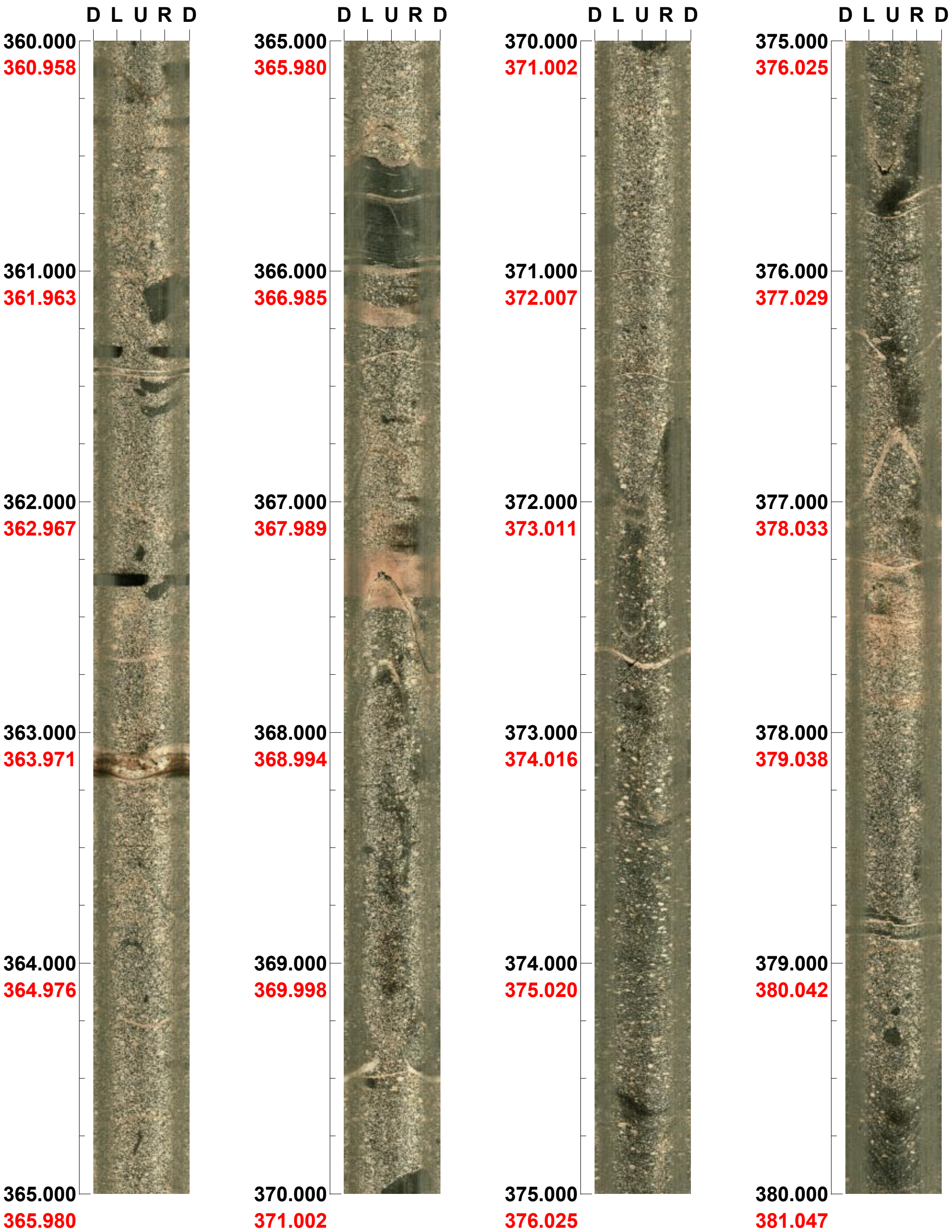



( 2 / 6 ) Scale: 1/25 Aspect ratio: 175 %

**Project name: Laxemar**

**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 360.000 - 380.000 m**




( 3 / 6 ) Scale: 1/25 Aspect ratio: 175 %

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 380.000 - 400.000 m**


( 4 / 6 ) Scale: 1/25 Aspect ratio: 175 %

**Project name: Laxemar**

**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 400.000 - 420.000 m**


**( 5 / 6 )** **Scale: 1/25** **Aspect ratio: 175 %**

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 420.000 - 440.000 m**


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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 440.000 - 460.000 m**


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

**Project name: Laxemar**

**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 460.000 - 480.000 m**


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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 480.000 - 500.000 m**


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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 500.000 - 520.000 m**


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

**Project name: Laxemar**

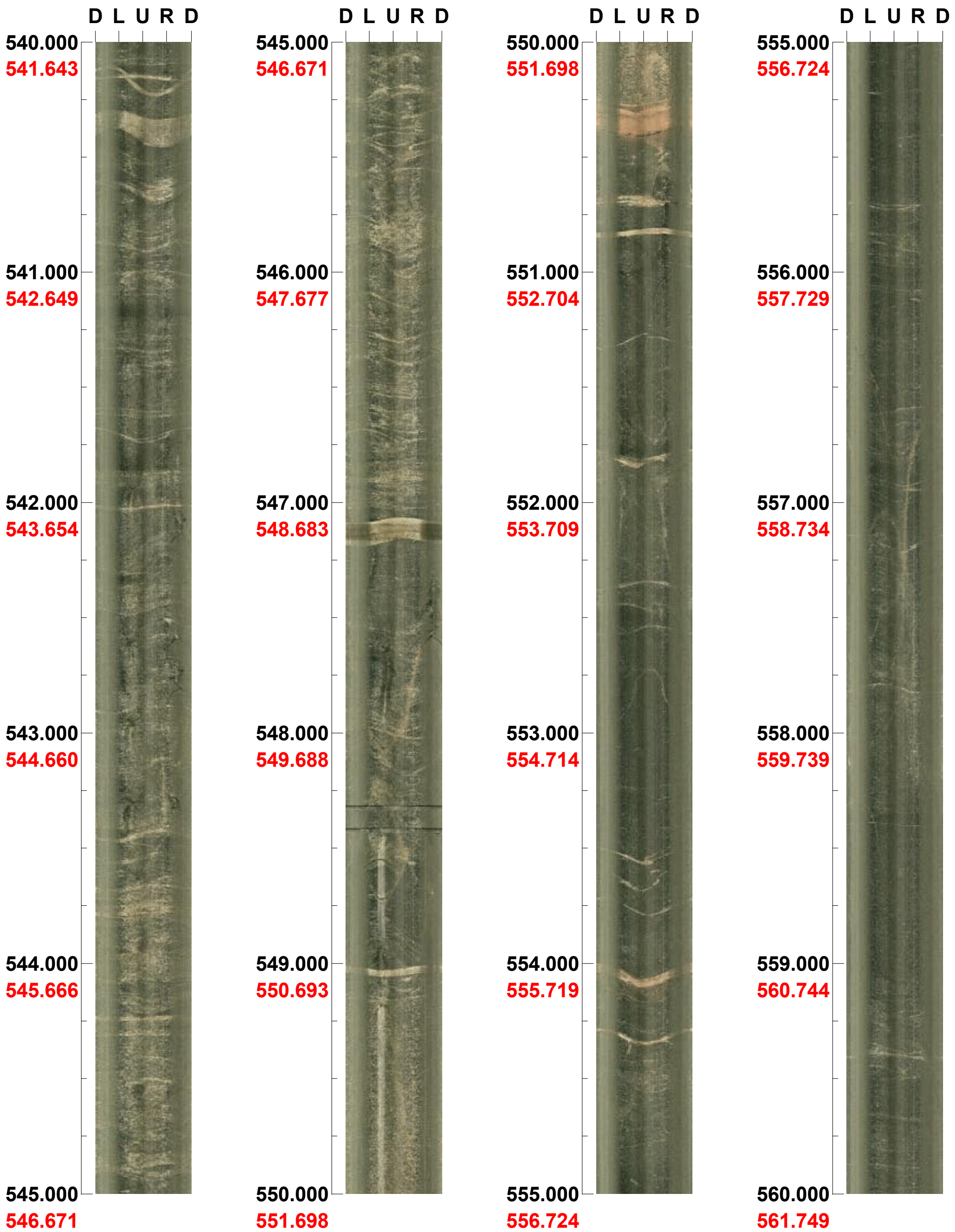
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 520.000 - 540.000 m**


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

**Project name: Laxemar**
**Bore hole No.: KLX12A** **Azimuth: 316** **Inclination: -75**

**Depth range: 540.000 - 560.000 m**




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

Project name: Laxemar
Bore hole No.: KLX12A  Azimuth: 316  Inclination: -75

Depth range: 560.000 - 580.000 m


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

Project name: Laxemar
Bore hole No.: KLX12A                Azimuth: 316        Inclination: -75

Depth range:  580.000 - 599.171 m


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