P-06-120

# Forsmark site investigation

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Jaana Gustafsson, Christer Gustafsson, Johan Friborg
Malå Geoscience AB

December 2006

**Svensk Kärnbränslehantering AB**
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

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*Keywords:* BIPS, RAMAC, Radar, TV, Forsmark, AP PF 400-06-082,
AP PF 400-05-112.

# Abstract


This report includes the data gained in geophysical logging operations performed within the site investigation at Forsmark. The logging operations presented here includes BIPS and borehole radar (RAMAC) logging in the core-drilled borehole KFM07C and in the percussion-drilled boreholes HFM36, HFM37 and a re-measurement with the BIPS in HFM26. The logging was conducted by Malå Geoscience AB during September 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 KFM07C was relatively satisfying, but in some parts of lower quality due to more conductive conditions. The data quality from HFM36 and HFM37 was less satisfying; high conductivities caused low penetration and short-time reverberation. This conductive environment reduces the possibility to distinguish and interpret possible structures in the rock mass which otherwise could give a reflection. However, the borehole radar measurements resulted in a number of identified radar reflectors: in KFM07C 115 reflectors were identified of which 20 were orientated (dip/strike). 10 reflectors were identified in HFM36 and 18 reflectors in HFM37.

The BIPS images from KFM07C is of high quality except for the last 100 meter were mud covering the lower most part of the borehole wall limits the visibility. In HFM36 and HFM37 the image quality was very good. Several BIPS-loggings has been performed in HFM 26 before, all with bad image quality. Therefore the borehole was cleaned by nitrogen blowing, and the present logging resulted in an improved image quality.

# Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Forsmark. Mätningarna som presenteras här omfattar BIPS-loggning och borrhålsradarmätningar (RAMAC) i KFM07C, HFM36 och HFM37 samt omloggning med BIPS i HFM26. Alla mätningar är utförda av Malå Geoscience AB under september 2006.

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

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

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

Borrhålsradardata från KFM07C var relativt tillfredställande, men tidvis av sämre kvalité troligen till stor del beroende på en konduktiv miljö. Borrhålsradardata från HFM36 och HFM37 var mindre tillfredsställande. Höga konduktiviteter orsakade låg penetration och ringning. En konduktiv miljö minskar möjligheterna att identifiera strukturer från borrhålsradardata. Dock har 115 radarreflektorer identifierats i KFM07C, varav 20 orienterade. I HFM36 identifierades 10 strukturer och i HFM37 18 strukturer.

BIPS-bilderna från KFM07C av bra kvalité förutom de sista hundra metrarna där suspendat från borrningen delvis täcker borrhålsväggen. Bildkvalitén var i HFM36 och HFM37 var mycket bra. Omloggningen i HFM26, genomförd efter kvävgasblåsning, resulterade i en betydande kvalitetsförbättring av bilderna.

# Contents

# 1 Introduction

This document reports the data gained in geophysical logging operations, which is one of the activities performed within the site investigation at Forsmark. The logging operations presented here includes TV-logging (BIPS) and borehole radar (RAMAC) in the core-drilled borehole KFM07C and in the percussion-drilled boreholes HFM36, HFM37 and a BIPS re-logging in HFM26. The work was carried out in accordance with activity plan AP PF 400-06-120 except for the BIPS survey in HFM26 which was included in AP PF 400-05-112. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

This report includes measurements from 100 to approximately 500 m in borehole KFM07C. In HFM36 the loggings were performed to approximately 150 m borehole length, and in HFM37 to approximately 190 m borehole length. The percussion-drilled boreholes have a diameter of approximately 135 to 140 mm and the core-drilled holes a diameter of 76–77 mm.

All measurements were conducted by Malå Geoscience AB during September 2006. Figure 1-1 shows the borehole locations.

The used investigation techniques comprised:

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

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

| **Activity plan** | **Number** | **Version** |
|---|---|---|
| BIPS- och RADAR-loggning i KFM07C samt HFM36 och HFM37 | AP PF 400-06-120 | 1.0 |
| BIPS- och RADAR–loggning i KFM01C (0-450 m) och KFM09B (0-615 m) samt i HFM24, HFM26, HFM27 och HFM29 | AP PF 400-05-112 | 1.0 |
| **Method descriptions** | **Number** | **Version** |
| Metodbeskrivning för TV-loggning med BIPS | SKB MD 222.006 | 1.0 |
| Metodbeskrivning för borrhålsradar | SKB MD 252.020 | 2.0 |

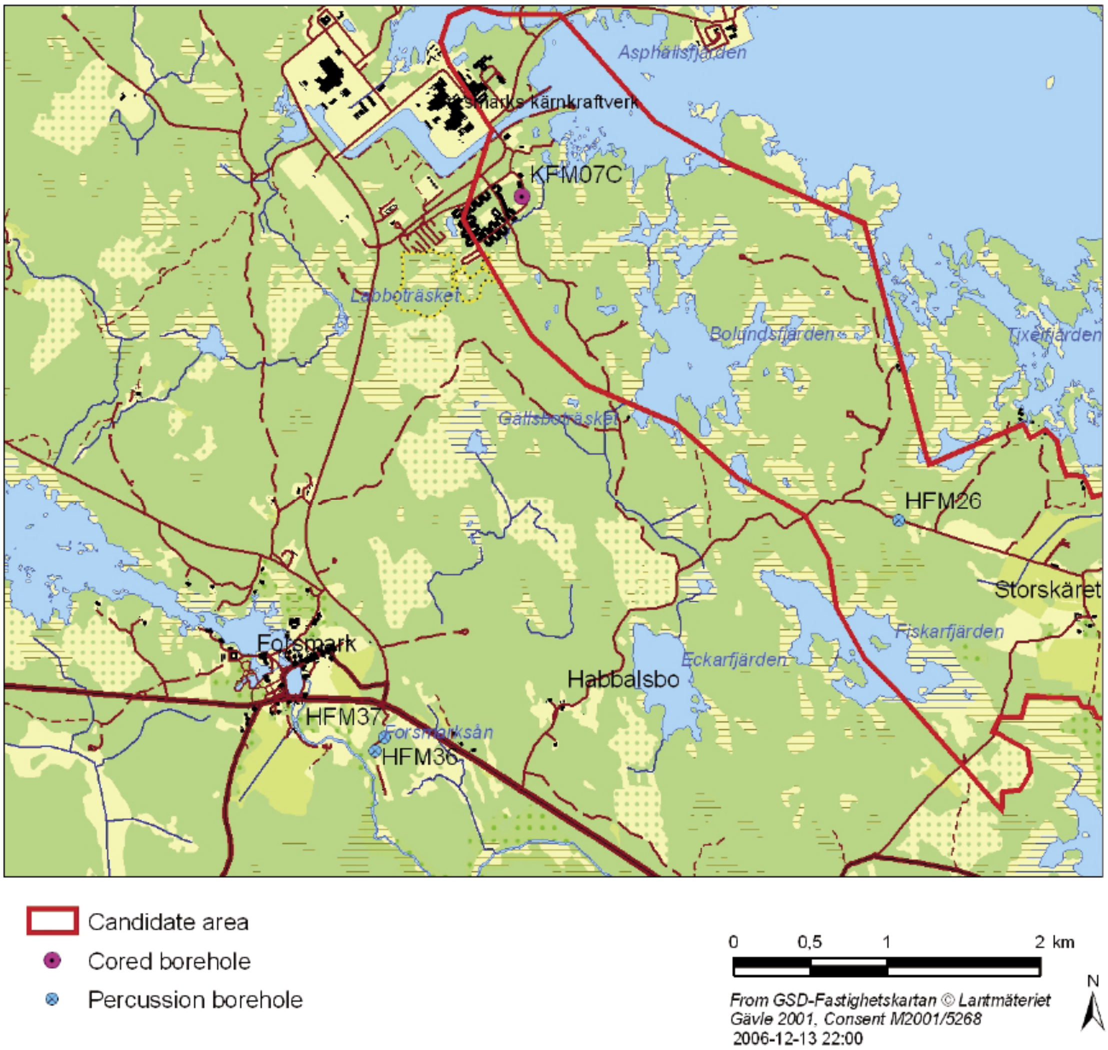



***Figure 1-1.*** *General overview over the Forsmark area showing the location of the boreholes surveyed and presented in this report.*

# 2 Objective and scope

The objective of the radar and BIPS surveys is to achieve information on the borehole conditions (borehole wall) as well as on the rock mass around the borehole. Borehole radar is engaged to investigate the nature and the structure of the rock mass enclosing the boreholes, and borehole TV for geological surveying of the borehole including determination of fracture distribution and orientation.

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

# 3 Equipment

## 3.1 Radar measurements RAMAC

The RAMAC GPR system owned by SKB is a fully digital GPR system where emphasis has been laid on fast survey speed and easy field operation. The system operates dipole and directional antennas (see Figure 3-1). A system description is given in the SKB internal controlling document MD 252.021.

The borehole radar system consists of a transmitter and a receiver antenna. During operation an electromagnetic pulse, within the frequency range of 20 MHz up to 250 MHz, is emitted into the bedrock. Once a feature, e.g. a water-filled fracture, with sufficiently different electrical properties is encountered, the pulse is reflected back to the receiver and recorded.

## 3.2 TV-Camera, BIPS

The BIPS 1500 system used is owned by SKB and described in SKB internal controlling document MD 222.005. The BIPS method for borehole logging produces a digital scan of the borehole wall. In principle, a standard CCD video camera is installed in the probe in front of a conical mirror (see Figure 3-2). An acrylic window covers the mirror part and the borehole image is reflected through the window and displayed on the cone, from where it is recorded. During the measuring operation, pixel circles are grabbed with a resolution of one pixel per degree.

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

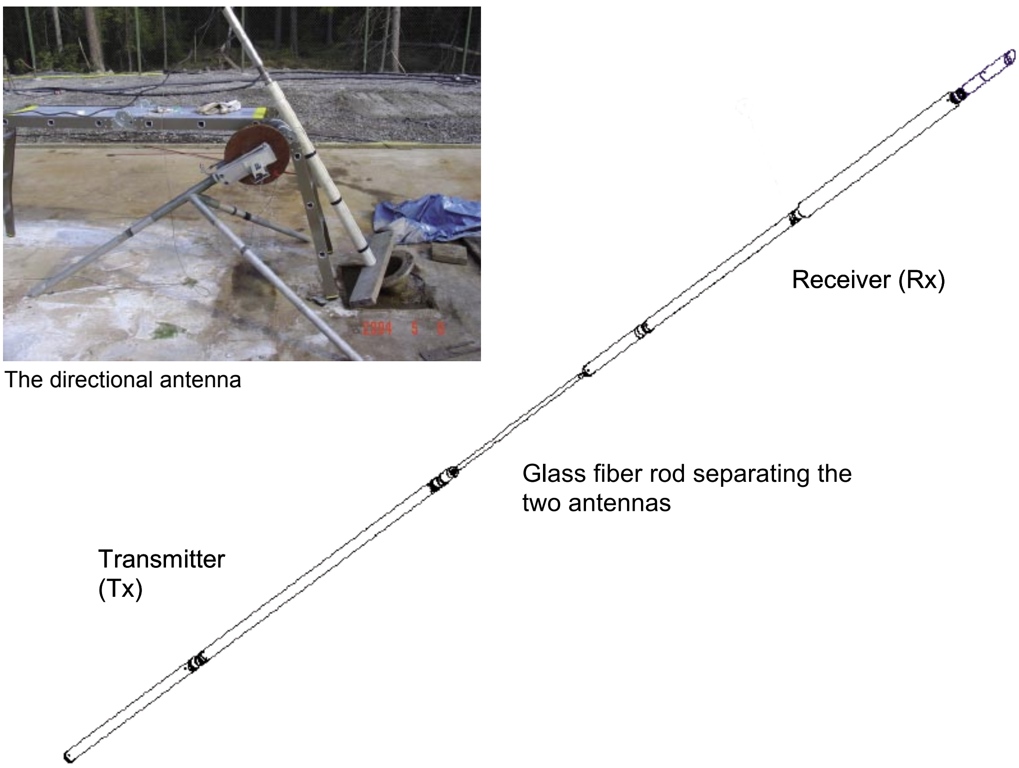



***Figure 3-1.*** *Example of a borehole radar antenna.*

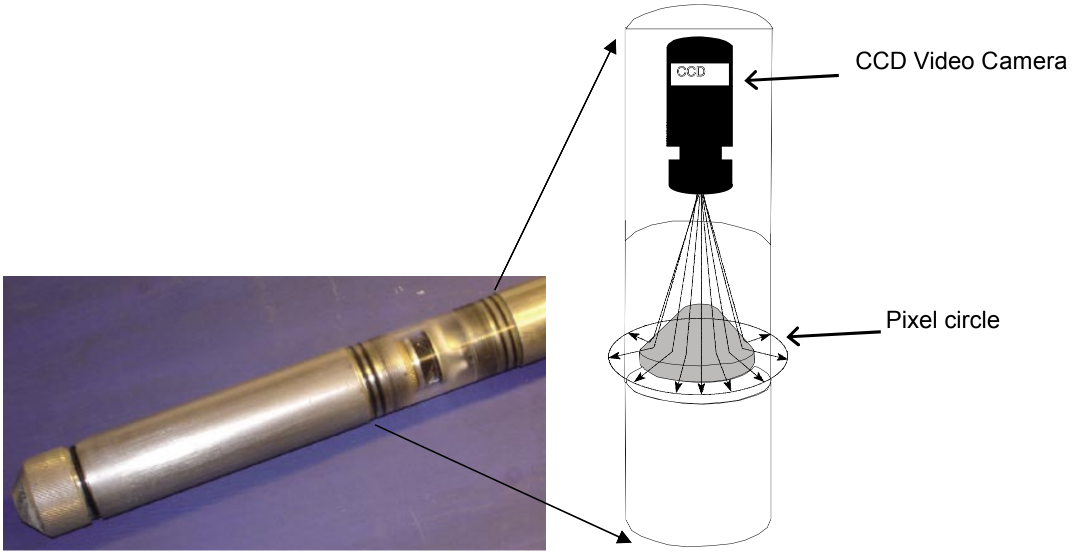



***Figure 3-2.*** *The BIP-system. To the right a sketch showing the principles of the conical mirror.*

# 4 Execution

## 4.1 General

### 4.1.1 RAMAC Radar

The measurements in KFM07C, HFM36 and HFM37 were carried out with dipole radar antennas, with frequencies of 250, 100 and 20 MHz. In KFM07C measurements were also carried out using the directional antenna, with a central frequency of 60 MHz.

During logging the dipole antennas (transmitter and receiver) were lowered continuously into the borehole and data were recorded on a field PC along the measured interval. The measurement with the directional antenna is made step wise, with a short pause for each measurement occasion. The antennas (transmitter and receiver, both for dipole and directional) are kept at a fixed separation by glass fiber rods according to Tables 4-1 to 4-3. 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). Before the logging operation, the antennas and cable were cleaned according to the internal document SKB MD 600.004.

The functionality of the directional antenna was tested before measurements in KFM07C. 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 5 degrees. This can be considered to be good, considering the disturbed environment with metallic objects etc at the test site.

For more information on system settings used in the investigation of KFM07C, HFM36 and HFM37, see Tables 4-1 to 4-3 below.

**Table 4-1. Radar logging information from KFM07C.**

| | | | | | |
|---|---|---|---|---|---|
| **Site:** | **Forsmark** | **Logging company:** | **RAYCON** | | |
| **BH:** | **KFM07C** | **Equipment:** | **SKB RAMAC** | | |
| **Type:** | **Directional/dipole** | **Manufacturer:** | **MALÅ GeoScience** | | |
| **Operator:** | **CG** | **Antenna** | | | |
| | | **Directional** | **250 MHz** | **100 MHz** | **20 MHz** |
| Logging date: | | 06-09-21–06-09-22 | 06-09-21 | 06-09-21 | 06-09-21 |
| 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 | -0.36 | -0.36 | –1.42 |
| Logging from (m): | | 103.4 | 101.5 | 102.6 | 106.25 |
| Logging to (m): | | 493.4 | 498.5 | 497.0 | 493.05 |
| 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 HFM36.**

| | | | | |
|---|---|---|---|---|
| **Site:** | **Forsmark** | **Logging company:** | **RAYCON** | |
| **BH:** | **HFM36** | **Equipment:** | **SKB RAMAC** | |
| **Type:** | **Dipole** | **Manufacturer:** | **MALÅ GeoScience** | |
| **Operator:** | **CG** | **Antenna** | | |
| | | **250 MHz** | **100 MHz** | **20 MHz** |
| Logging date: | | 06-09-21 | 06-09-21 | 06-09-21 |
| 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: | | –0.36 | –0.36 | –1.42 |
| Logging from (m): | | 1.5 | 2.6 | 6.25 |
| Logging to (m): | | 149.4 | 149.2 | 145.2 |
| 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 HFM37.**

| | | | | |
|---|---|---|---|---|
| **Site:** | **Forsmark** | **Logging company:** | **RAYCON** | |
| **BH:** | **HFM37** | **Equipment:** | **SKB RAMAC** | |
| **Type:** | **Dipole** | **Manufacturer:** | **MALÅ GeoScience** | |
| **Operator:** | **CG** | **Antenna** | | |
| | | **250 MHz** | **100 MHz** | **20 MHz** |
| Logging date: | | 06-09-20 | 06-09-20 | 06-09-20 |
| 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: | | –0.36 | –0.36 | –1.42 |
| Logging from (m): | | 1.5 | 2.6 | 6.25 |
| Logging to (m): | | 188.3 | 185.6 | 184.05 |
| Trace interval (m): | | 0.1 | 0.2 | 0.25 |
| Antenna separation (m): | | 2.4 | 3.9 | 10.05 |

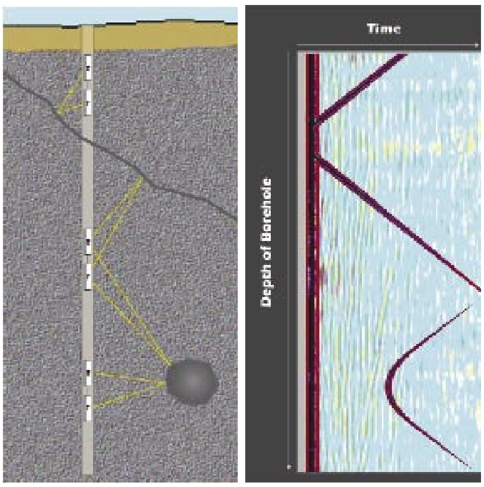



***Figure 4-1.*** *The principle of radar borehole reflection survey (left) and an example of result (right).*

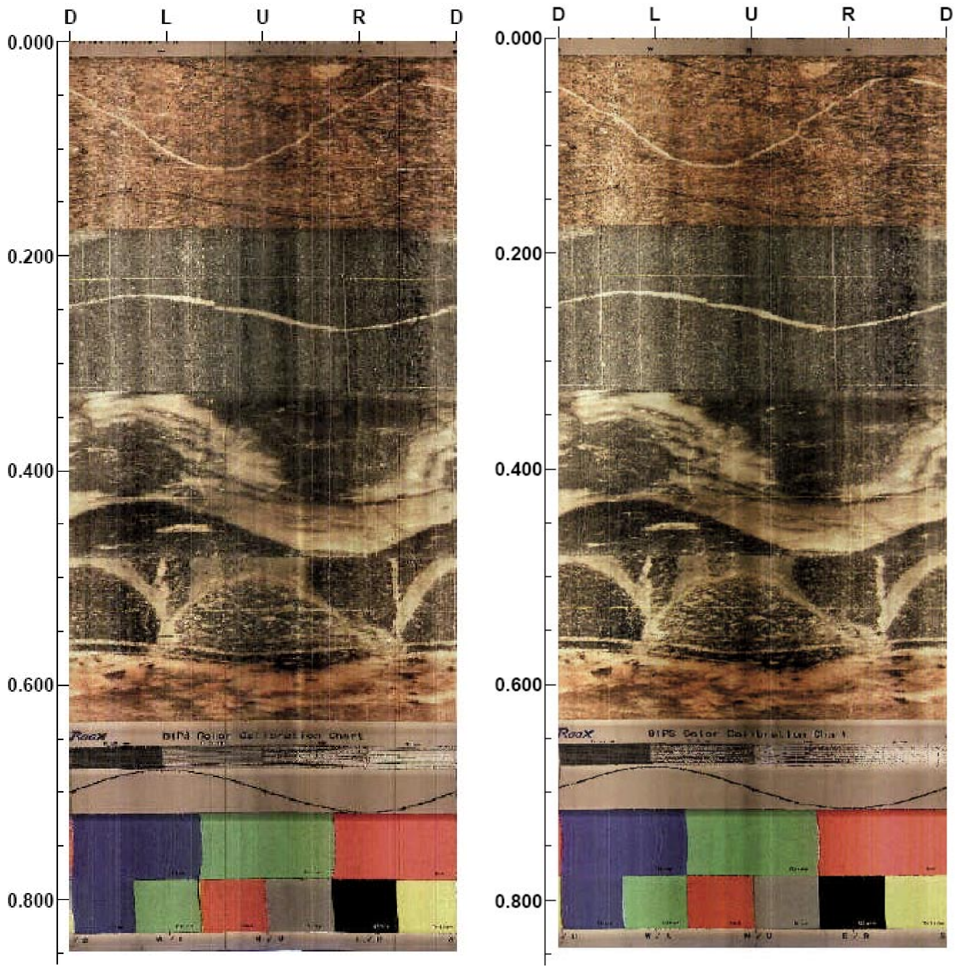
All measurements were performed in accordance with the instructions and guidelines from SKB (internal document MD 222.006). All cleaning of the probe and cable was performed according to the internal document SKB MD 600.004 before the logging operation.

During the measurement, a pixel circle with a resolution of 360 pixels/circle was used and the digital circles were stored at every 1 mm on a MO-disc in the surface unit. The maximum speed during data collection was 1.5 m/minute.

A gravity sensor was used to measure the orientation of the images in the borehole KFM07C, HFM36, HFM37 and HFM26.

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 corresponds to the test logging performed before and after the logging campaign in September. 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 7 in this report.




**Before logging in HFM37** **After logging in HFM26**

**2006-09-20** **2006-09-22**

***Figure 4-2.*** *Results from logging in the test pipe before and after the logging campaign in September 2006. The length scales are not essential in the test measurements.*

### 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 7. 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 length divergence is less than 100 cm in the deepest parts of a 1,000 metre long borehole.

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

## 4.2 Analyses and Interpretation

### 4.2.1 Radar

The result from radar measurements is most often presented in the form of a radargram where the position of the probes is shown along one axis and the propagation is shown along the other axis. The amplitude of the received signal is shown in the radargram with a grey scale where black color corresponds to the large positive signals and white color to large negative signals. Grey color corresponds to no reflected signals.

The presented data in this report is adjusted for the measurement point of the antennas. The measurement point is defined to be the central point between the transmitter and the receiver antenna.

The two basic patterns to interpret in borehole measurements are point and plane reflectors. In the reflection mode, borehole radar essentially gives a high-resolution image of the rock mass, showing the geometry of plane structures which may or may not, intersect the borehole (contact between layers, thin marker beds, fractures) or showing the presence of local features around the borehole (cavities, lenses etc.).

The distance to a reflecting object or plane is determined by measuring the difference in arrival time between the direct and the reflected pulse. The basic assumption is that the speed of propagation is the same everywhere.

There are several ways to determine the radar wave propagation velocity. Each of them has its advantages and its disadvantages. In this project the velocity determination was performed by keeping the transmitter fixed in the borehole while moving the receiver downwards in the borehole. The result is plotted in Figure 4-3 and the calculation shows a velocity of 128 m/µs (metres per microsecond) /1/. The velocity measurement was performed with the 100 MHz antenna.

The visualization of data in Appendices 1 to 3 is made with ReflexWin, a Windows based processing software for filtering and analysis of borehole radar data. The processing steps for the data presented in Appendices 1 to 3 are given in Tables 4-4 to 4-6. 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.

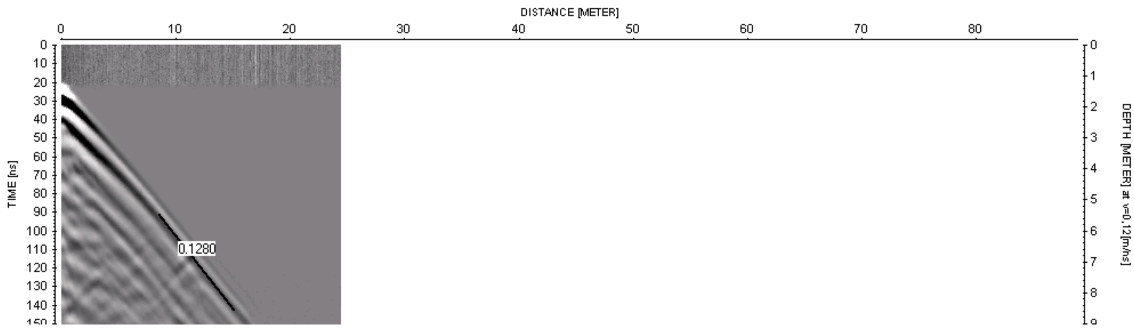



***Figure 4-3.*** *Results from velocity measurements in HFM03, described in /1/.*

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 KFM07C.**

| | | | | | |
|---|---|---|---|---|---|
| **Site:** | **Forsmark** | **Logging company:** | **Malå Geoscience AB** | | |
| **BH:** | **KFM07C** | **Equipment:** | **SKB RAMAC** | | |
| **Type:** | **Directional/dipole** | **Manufacturer:** | **MALÅ GeoScience** | | |
| **Interpret:** | **JG** | **Antenna** | | | |
| | | **Directional** | **250 MHz** | **100 MHz** | **20 MHz** |
| Processing: | | Move start time (46 samples) | Move start time (–33.1) | Move start time (–33.8) | Move start time (–87.4) |
| | | DC shift (390–510) | DC shift (190–230) | DC shift (470–530) | DC shift (1,800–2,000) |
| | | Time gain (start 91 lin 100 exp 1) | Gain (Start 31 lin 1.6 exp 0.8) | Gain (Start 50 lin 1.7 exp 0.5) | Gain (Start 120 lin 6 exp 0.1) |
| | | (FIR) | | | |

**Table 4-5. Processing steps for borehole radar data from HFM36.**

| | | | | |
|---|---|---|---|---|
| **Site:** | **Forsmark** | **Logging company:** | **Malå Geoscience AB** | |
| **BH:** | **HFM36** | **Equipment:** | **SKB RAMAC** | |
| **Type:** | **Dipole** | **Manufacturer:** | **MALÅ GeoScience** | |
| **Interpret:** | **JF** | **Antenna** | | |
| | | **250 MHz** | **100 MHz** | **20 MHz** |
| Processing: | | Move start time (–12.7) | Move start time (–21) | Move start time (–63.5) |
| | | DC shift (190–230) | DC shift (470–530) | DC shift (1,800–2,000) |
| | | Gain (start 12 lin 3.0 exp 1.2) | Gain (start 35 lin 5 exp 0.6) | Bandpassfrequency (4, 8, 30, 38) |
| | | | | Gain (start 27.5 lin 28.5 exp 0.07) |
| | | | | Bandpassfrequency (6, 10, 30, 35) |

**Table 4-6. Processing steps for borehole radar data from HFM37.**

| | | | | |
|---|---|---|---|---|
| **Site:** | **Forsmark** | **Logging company:** | **Malå Geoscience AB** | |
| **BH:** | **HFM37** | **Equipment:** | **SKB RAMAC** | |
| **Type:** | **Dipole** | **Manufacturer:** | **MALÅ GeoScience** | |
| **Interpret:** | **JF** | **Antenna** | | |
| | | **250 MHz** | **100 MHz** | **20 MHz** |
| Processing: | | Move start time (–9.0) | Move start time (–13.8) | Move start time (–85.0) |
| | | DC shift (190–230) | DC shift (470–530) | DC shift (1,800–2,000) |
| | | Gain (start 15.0 lin 0.4 exp 1.5) | Gain (start 35.0 lin 2.0 exp 0.8) | Gain (start 29.9 lin 7.5 exp 0.12) |
| | | | | Bandpassfrequency (4, 8, 30, 38) |

### 4.2.2 BIPS

The visualization of data is made with BDPP, a Windows based processing software for filtering, presentation and analysis of BIPS data. As no fracture mapping of the BIPS image is performed, the raw data was delivered on a CD-ROM together with printable pictures in *.pdf format before the field crew left the investigation site.

The printed results were delivered with measured length, together with adjusted length according to the length marks made on the cable when logging core-drilled boreholes (where the length marks are visible in the BIPS image). For printing of the BIPS images the printing software PDPP from RaaX was used.

## 4.3 Nonconformities

No non-conformities occurred during the logging of KFM07C, HFM36, HFM37 and HFM26.

# 5 Results

The results from the BIPS measurements in KFM07C, HFM36, HFM37 and HFM26 were delivered as raw data (*.bip-files) together with printable BIPS pictures in *.pdf format before the field crew left the investigation site. The information of the measurements was registered in SICADA, and the CD-ROM:s stored by SKB.

The RAMAC radar data for KFM07C, HFM36 and HFM37 was delivered as raw data (file format *.rd3 or *.rd5) with corresponding information files (file format *.rad) on CD-ROM:s to SKB before the field crew left the investigation site, whereas the data processing steps and results are presented in this report. Relevant information, including the interpretation presented in this report, was inserted into the SKB database SICADA.

## 5.1 RAMAC logging

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

Only the larger clearly visible structures are interpreted in RadinterSKB. Overviews of the three 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 KFM07C is satisfying. HFM36 is of lower quality due to a more conductive environment. HFM37 is mostly satisfying, although there are lower-quality sections affected by high conductivity (70–100 m and 135–145 m). A conductive environment causes an attenuation of the radar wave, which in turn decreases the penetration. This conductive environment of course also reduces the possibility to distinguish and interpret possibly structures in the rock which otherwise could give a reflection.

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 better penetration compared to a higher frequency. If structures can be identified with all three antenna frequencies, it can probably be concluded that the structure is quite significant.

In Tables 5-1 to 5-3 below the distribution of identified structures along the boreholes are listed for KFM07C, HFM36 and HFM37.

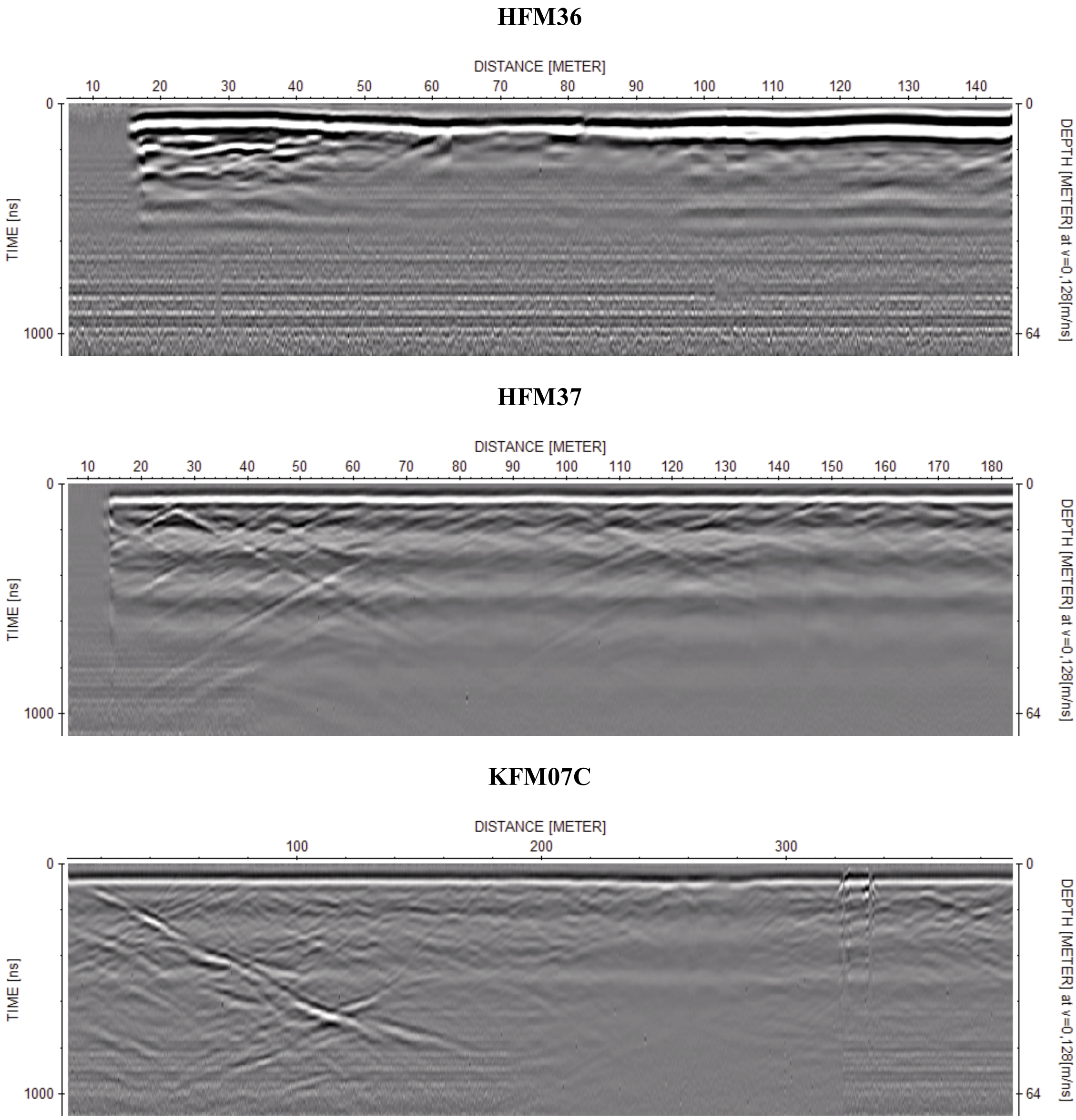



***Figure 5-1.*** *An overview (20 MHz data) of the radar data for the different boreholes; HFM36, HF-M37and KFM07C. Observe that the length (x-scale) and depth (y-scale) differs between the different boreholes. Sections influenced by high conductivity (decreased penetration) include: most of HFM36, HFM37 (70–100 m and 135–145 m) and KFM07C (220–300 m).*

**Table 5-1. Identified structures as a function of borehole intersection length in KFM07C.**

| Length (m) | No. of structures |
|---|---|
| –100 | 9 |
| 100–150 | 11 |
| 150–200 | 17 |
| 200–250 | 9 |
| 250–300 | 14 |
| 300–350 | 10 |
| 350–400 | 17 |
| 400–450 | 14 |
| 450–500 | 13 |
| 500–550 | 1 |

**Table 5-2. Identified structures as a function of borehole intersection length in HFM36.**

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

**Table 5-3. Identified structures as a function of borehole intersection length in HFM37.**

| Length (m) | No. of structures |
|---|---|
| –0 | – |
| 0–20 | 2 |
| 20–40 | 2 |
| 40–60 | 1 |
| 60–80 | 2 |
| 80–100 | 1 |
| 100–120 | 2 |
| 120–140 | 2 |
| 140–160 | 6 |

Tables 5-4 to 5-6 summarises the interpretation of radar data from KFM07C, HFM36 and HFM37. In the tables the borehole length and intersection angle to the identified structures are listed.

The strong anomaly between 428–430 m (see Appendix 1) is caused by a perforated steel plate used for stabilizing the borehole.

For KFM07C the direction to the object 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 object (the plane) is defined in Figure 5-2. This direction and the intersection angle are recalculated to strike and dip, also given in the tables below. The plane strike is the angle between the line of the plane's intersection with the surface and the Magnetic North direction. A strike of 0 degrees implies a dip to the east while a strike of 180 degrees implies a dip to the west (right-hand rule). The strike is measured clockwise and can vary from 0 to 359 deg. The dip of the plane is the angle between the ground surface and the plane, and can vary from 0 to 90 degrees.

Observe that the interpretation of an undulating structure can result in several different angles and different intersection depths. An example of this phenomenon is seen in Table 5-4 and Appendix 1: the reflectors named 19, 19x and 19xx most likely originates from the same geological structure.

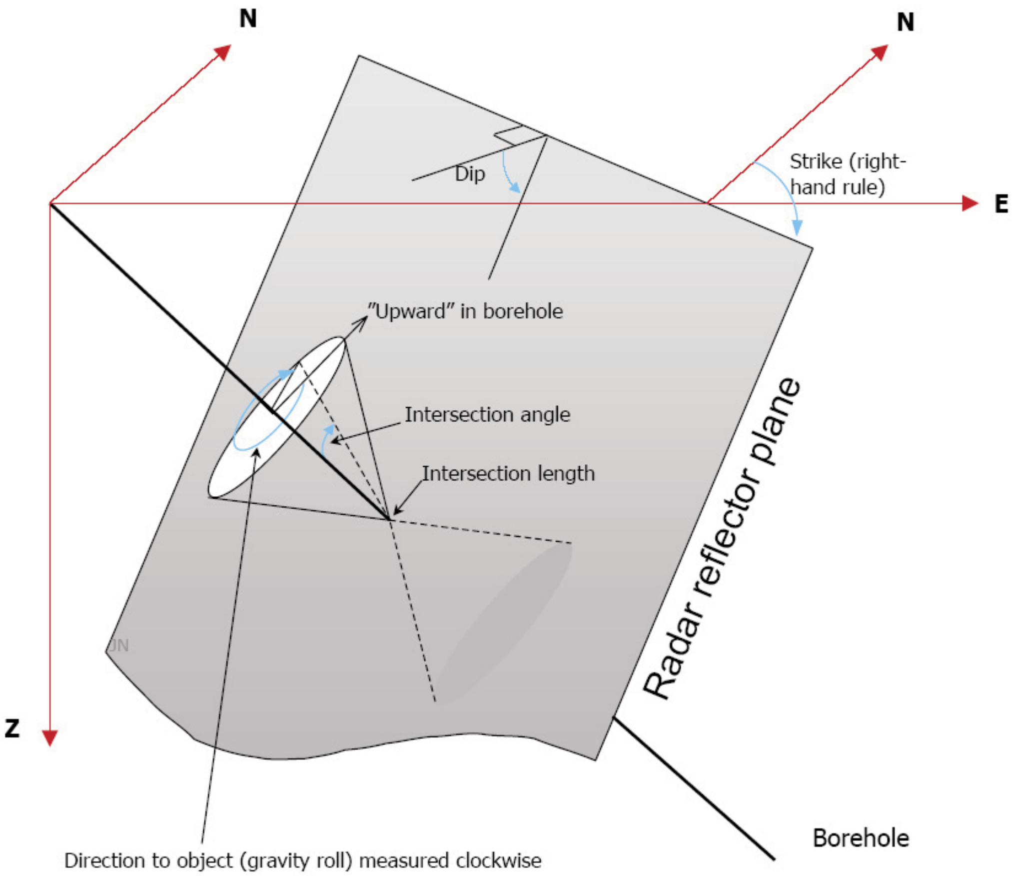



*Figure 5-2.* *Definition of direction to reflector as presented in Table 5-4.*

**Table 5-4. Interpretation of radar reflectors from the dipole antennas 250, 100 and 20 MHz, and the directional antenna 60 MHz in borehole KFM07C.**

**RADINTER MODEL INFORMATION**
**(Directional and dipole antennas)**

**Site:** Forsmark
**Borehole name:** KFM07C
**Nominal velocity (m/μs):** 128.0

| Name | Intersection depth | Intersection angle | RadInter direction to object (gravity roll) | Dip 1 | Strike 1 | Dip 2 | Strike 2 |
|---|---|---|---|---|---|---|---|
| 99 | –13.6 | 11 | 117 ± | 76 | 351 | 82 | 173 |
| 96 | 31.0 | 14 | 24 | 81 | 262 | | |
| 102 | 50.8 | 13 | 15 | 83 | 253 | | |
| 2 | 76.5 | 12 | | | | | |
| 6 | 91.9 | 75 | | | | | |
| 2x | 94.0 | 22 | 279 | 68 | 160 | | |
| 3 | 96.4 | 81 | | | | | |
| 1 | 97.7 | 22 | | | | | |
| 10 | 98.0 | 38 | 267 ± | 49 | 151 | 50 | 320 |
| 4 | 102.6 | 22 | 270 | 68 | 151 | | |
| 97 | 103.1 | 79 | | | | | |
| 4x | 107.5 | 28 | | | | | |
| 7 | 109.2 | 58 | | | | | |

**RADINTER MODEL INFORMATION**
**(Directional and dipole antennas)**

| | |
|---|---|
| **Site:** | **Forsmark** |
| **Borehole name:** | **KFM07C** |
| **Nominal velocity (m/μs):** | **128.0** |

| Name | Intersection depth | Intersection angle | RadInter direction to object (gravity roll) | Dip 1 | Strike 1 | Dip 2 | Strike 2 |
|---|---|---|---|---|---|---|---|
| 5 | 115.3 | 38 | | | | | |
| 19xxx | 123.0 | 9 | 300 | 84 | 179 | | |
| 8 | 123.5 | 81 | | | | | |
| 13 | 134.7 | 15 | | | | | |
| 9 | 134.8 | 74 | | | | | |
| 11 | 139.8 | 47 | | | | | |
| 12 | 144.5 | 80 | | | | | |
| 19xx | 150.2 | 13 | | | | | |
| 14 | 156.7 | 85 | 339 ± | 14 | 226 | 3 | 354 |
| 16x | 156.9 | 42 | | | | | |
| 17 | 160.4 | 41 | | | | | |
| 15 | 164.2 | 86 | | | | | |
| 18 | 164.6 | 55 | | | | | |
| 19x | 165.6 | 21 | 297 | 73 | 177 | | |
| 16 | 166.6 | 27 | 252 | 62 | 133 | | |
| 19 | 170.3 | 31 | | | | | |
| 25 | 181.3 | 21 | | | | | |
| 23 | 184.4 | 57 | | | | | |
| 20 | 185.4 | 20 | | | | | |
| 24 | 188.7 | 61 | | | | | |
| 27 | 189.1 | 11 | 315 ± | 84 | 193 | 75 | 11 |
| 21 | 194.3 | 19 | 279 ± | 72 | 159 | 69 | 335 |
| 28 | 197.9 | 11 | | | | | |
| 27x | 198.0 | 15 | | | | | |
| 22 | 200.9 | 20 | | | | | |
| 26 | 203.7 | 18 | | | | | |
| 93 | 211.4 | 8 | | | | | |
| 41 | 213.3 | 19 | | | | | |
| 29 | 223.5 | 28 | 105 ± | 61 | 339 | 64 | 165 |
| 30 | 226.7 | 77 | | | | | |
| 31 | 230.8 | 63 | | | | | |
| 32 | 232.9 | 61 | | | | | |
| 33 | 248.4 | 39 | | | | | |
| 34 | 257.2 | 45 | | | | | |
| 42 | 259.6 | 43 | | | | | |
| 43 | 266.5 | 48 | 339 ± | 50 | 216 | 38 | 31 |
| 38 | 269.5 | 62 | | | | | |
| 39 | 272.0 | 70 | | | | | |
| 40 | 276.4 | 60 | | | | | |
| 78 | 277.1 | 5 | | | | | |
| 94 | 279.4 | 57 | | | | | |
| 47 | 284.2 | 52 | | | | | |

**RADINTER MODEL INFORMATION**
**(Directional and dipole antennas)**

**Site:** **Forsmark**
**Borehole name:** **KFM07C**
**Nominal velocity (m/μs):** **128.0**

| Name | Intersection depth | Intersection angle | RadInter direction to object (gravity roll) | Dip 1 | Strike 1 | Dip 2 | Strike 2 |
|---|---|---|---|---|---|---|---|
| 35 | 286.3 | 13 | 264 ± | 76 | 140 | 78 | 318 |
| 101x | 288.8 | 45 | | | | | |
| 36 | 289.2 | 15 | 288 | 77 | 166 | | |
| 44 | 295.6 | 20 | | | | | |
| 37 | 297.2 | 14 | | | | | |
| 46 | 321.0 | 50 | | | | | |
| 45 | 323.8 | 21 | | | | | |
| 89 | 327.9 | 10 | | | | | |
| 50 | 330.5 | 31 | | | | | |
| 103 | 331.4 | 57 | | | | | |
| 48 | 332.4 | 21 | 30 ± | 73 | 264 | 62 | 86 |
| 52 | 335.1 | 45 | | | | | |
| 51 | 339.5 | 65 | | | | | |
| 61 | 340.6 | 13 | 252 | 76 | 130 | | |
| 53 | 349.0 | 34 | | | | | |
| 55 | 357.2 | 42 | | | | | |
| 77 | 364.0 | 15 | | | | | |
| 54 | 364.3 | 19 | | | | | |
| 49 | 366.3 | 8 | | | | | |
| 64x | 366.8 | 12 | | | | | |
| 58 | 366.7 | 54 | | | | | |
| 56 | 370.4 | 59 | | | | | |
| 59 | 376.2 | 46 | | | | | |
| 54x | 377.9 | 12 | | | | | |
| 57 | 378.5 | 52 | | | | | |
| 98 | 381.3 | 13 | | | | | |
| 65 | 382.9 | 46 | | | | | |
| 64 | 384.8 | 24 | | | | | |
| 60 | 386.7 | 47 | | | | | |
| 66 | 388.5 | 27 | 42 ± | 70 | 276 | 58 | 102 |
| 78x | 389.1 | 15 | | | | | |
| 62 | 392.1 | 46 | | | | | |
| 69 | 404.2 | 46 | | | | | |
| 67 | 408.0 | 45 | | | | | |
| 68 | 410.4 | 37 | | | | | |
| 100 | 416.2 | 15 | | | | | |
| 71 | 416.4 | 73 | | | | | |
| 101 | 417.3 | 12 | 84 | 78 | 318 | | |
| 70 | 420.3 | 79 | | | | | |
| 63 | 430.1 | 10 | | | | | |
| 75 | 435.9 | 59 | | | | | |
| 76 | 440.8 | 56 | | | | | |

| RADINTER MODEL INFORMATION (Directional and dipole antennas) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Site: | | Forsmark | | | | | |
| Borehole name: | | KFM07C | | | | | |
| Nominal velocity (m/μs): | | 128.0 | | | | | |
| **Name** | **Intersection depth** | **Intersection angle** | **RadInter direction to object (gravity roll)** | **Dip 1** | **Strike 1** | **Dip 2** | **Strike 2** |
| 73 | 443.1 | 29 | | | | | |
| 72 | 443.3 | 45 | | | | | |
| 83 | 445.1 | 40 | | | | | |
| 79 | 449.7 | 48 | | | | | |
| 74x | 450.2 | 39 | | | | | |
| 74 | 452.5 | 31 | | | | | |
| 92 | 457.2 | 55 | | | | | |
| 82 | 463.4 | 68 | | | | | |
| 84 | 465.7 | 57 | | | | | |
| 85 | 466.2 | 41 | | | | | |
| 86 | 474.7 | 61 | | | | | |
| 91 | 477.2 | 51 | | | | | |
| 90 | 487.5 | 57 | | | | | |
| 80 | 490.1 | 12 | | | | | |
| 87 | 492.0 | 50 | | | | | |
| 81 | 495.2 | 12 | | | | | |
| 88 | 497.1 | 54 | | | | | |
| 81x | 507.8 | 9 | | | | | |

**Table 5-5. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz borehole HFM36.**

| RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas) | | | |
|---|---|---|---|
| Site: | | Forsmark | |
| Borehole name: | | HFM36 | |
| Nominal velocity (m/μs): | | 128.00 | |
| **Object type** | **Name** | **Intersection depth** | **Intersection angle** |
| PLANE | 9 | 2.7 | 52 |
| PLANE | 1 | 16.7 | 56 |
| PLANE | 2 | 27.3 | 63 |
| PLANE | 3 | 31.7 | 65 |
| PLANE | 4 | 41.9 | 68 |
| PLANE | 6 | 49.3 | 66 |
| PLANE | 5 | 70.6 | 50 |
| PLANE | 7 | 72.0 | 73 |
| PLANE | 10 | 130.9 | 57 |
| PLANE | 8 | 163.6 | 49 |

**Table 5-6. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HFM37.**

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

| | |
|---|---|
| **Site:** | **Forsmark** |
| **Borehole name:** | **HFM37** |
| **Nominal velocity (m/µs):** | **128.00** |

| Object type | Name | Intersection depth | Intersection angle |
|---|---|---|---|
| PLANE | 15 | 2.9 | 64 |
| PLANE | 2 | 15.6 | 56 |
| PLANE | 16 | 24.5 | 60 |
| PLANE | 1 | 38.5 | 58 |
| PLANE | 3 | 56.5 | 59 |
| PLANE | 4 | 68.4 | 62 |
| PLANE | 5 | 76.3 | 67 |
| PLANE | 6 | 88.6 | 58 |
| PLANE | 7 | 104.9 | 54 |
| PLANE | 17 | 105.2 | 27 |
| PLANE | 11 | 122.5 | 36 |
| PLANE | 13 | 139.1 | 81 |
| PLANE | 9 | 141.4 | 77 |
| PLANE | 8 | 143.7 | 39 |
| PLANE | 10 | 147.6 | 74 |
| PLANE | 12 | 149.5 | 30 |
| PLANE | 14 | 157.2 | 33 |
| PLANE | 18 | 160.0 | 33 |

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 rock volume surrounding the borehole. A decrease in this amplitude may indicate fracture zones, clay or rock volumes with increased water content, i.e. increased electric conductivity. The borehole length intervals showing decreased amplitude are given in Tables 5-7 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 KFM07C with decreased amplitude for the 250 MHz antenna.**

| Length (m) |
|---|
| 320–390 |
| 426–434 |

**Table 5-8. Borehole length intervals in HFM36 with decreased amplitude for the 250 MHz antenna.**

| Length (m) | Length (m) |
|---|---|
| 13–18 | 34 |
| 26–30 | 42–150 |

**Table 5-9. Borehole length intervals in HFM37 with decreased amplitude for the 250 MHz antenna.**

| Length (m) | Length (m) |
|---|---|
| 15–18 | 84–92 |
| 52–55 | 100–104 |
| 67–70 | |

**Table 5-10. Some important structures in KFM07C, HFM36 and HFM37.**

| Borehole | KFM07C | HFM36 | HFM37 |
|---|---|---|---|
| Structures | 1, 2, 2x, 4, 16, 16x, 21, 22, 19, 19x, 19xx, 19xxx, 27, 27x, 29, 35, 36, 54, 54x, 61, 64, 64x, 78, 78x, 81, 81x, 99, 101, 101x and 102 | 1 and 9 | 1, 2, 3, 4, 5, 6, 7, 8, 9, 12 and 14 |

Observe that it is can be very difficult to classify different structures in an objective manner, along a borehole. This is due to the fact that the water quality (the conductivity) amongst other parameters varies along the borehole length and 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 cause a larger amplitude than a larger angle, and by that a more clear structure.

## 5.2 BIPS logging

The BIPS pictures are presented in Appendices 4 to 7.

To get the best possible depth accuracy, the BIPS images are adjusted to the reference marks on the logging cable. Additionally the marks on the borehole wall created by the drill rig in core-drilled boreholes are visible on the BIPS screen. The recorded length is adjusted to these visible marks. In percussion drilled boreholes we use marks on the logging cable as references for the depth adjustment. These marks on the cable are calibrated against the visible marks in core-drilled boreholes. At present we have marks at 110, 150 and 200 meter on the logging cable that are used for depth adjustments of the BIPS results in percussion drilled boreholes.

In order to control the quality of the system, calibration measurements were performed in a test pipe before logging the first borehole and after logging of the last borehole in the campaign. The resulting images displayed no difference regarding the colours and focus of the images. The results of the test logging were included in the delivery of the field data and are also presented in Figure 4-2 in this report.

Values for the inclination and azimuth of the boreholes, presented in this report, are only preliminary.

The BIPS images from KFM07C are of high quality with limited presence of the othervise frequently occuring discolouring effects caused by drilling. Some problems occur below 100 meter, where mud covering the lower-most part of the borehole wall limits the visibility. The perforated steel plate mentioned in section 5.1 is clearly seen in the BIPS-images between 428-430 m borehole length. In HFM36 the image quality is very good down to 110 meter where mud limits the visibility to some extent in the rest of the borehole. The image quality in HFM37 is excellent.

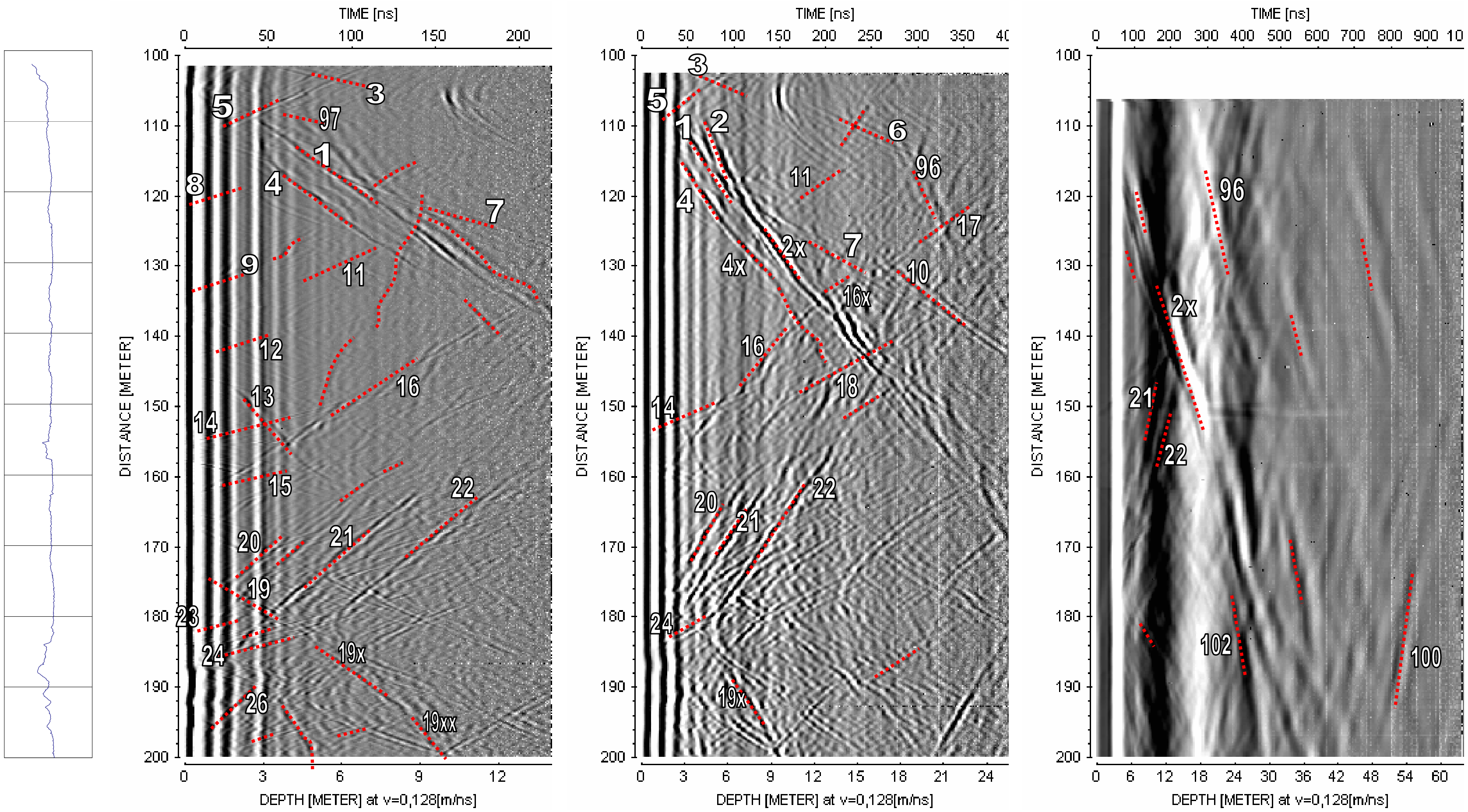
Several earlier attempts of BIPS-logging HFM26 resulted in very bad image quality. Therefore a cleaning procedure has been undertaken in the borehole before the survey presented in this report. The result is not good but much improved compared to previous attempts. Still the result has to be considered to be problematic for the geological mapping.

# References

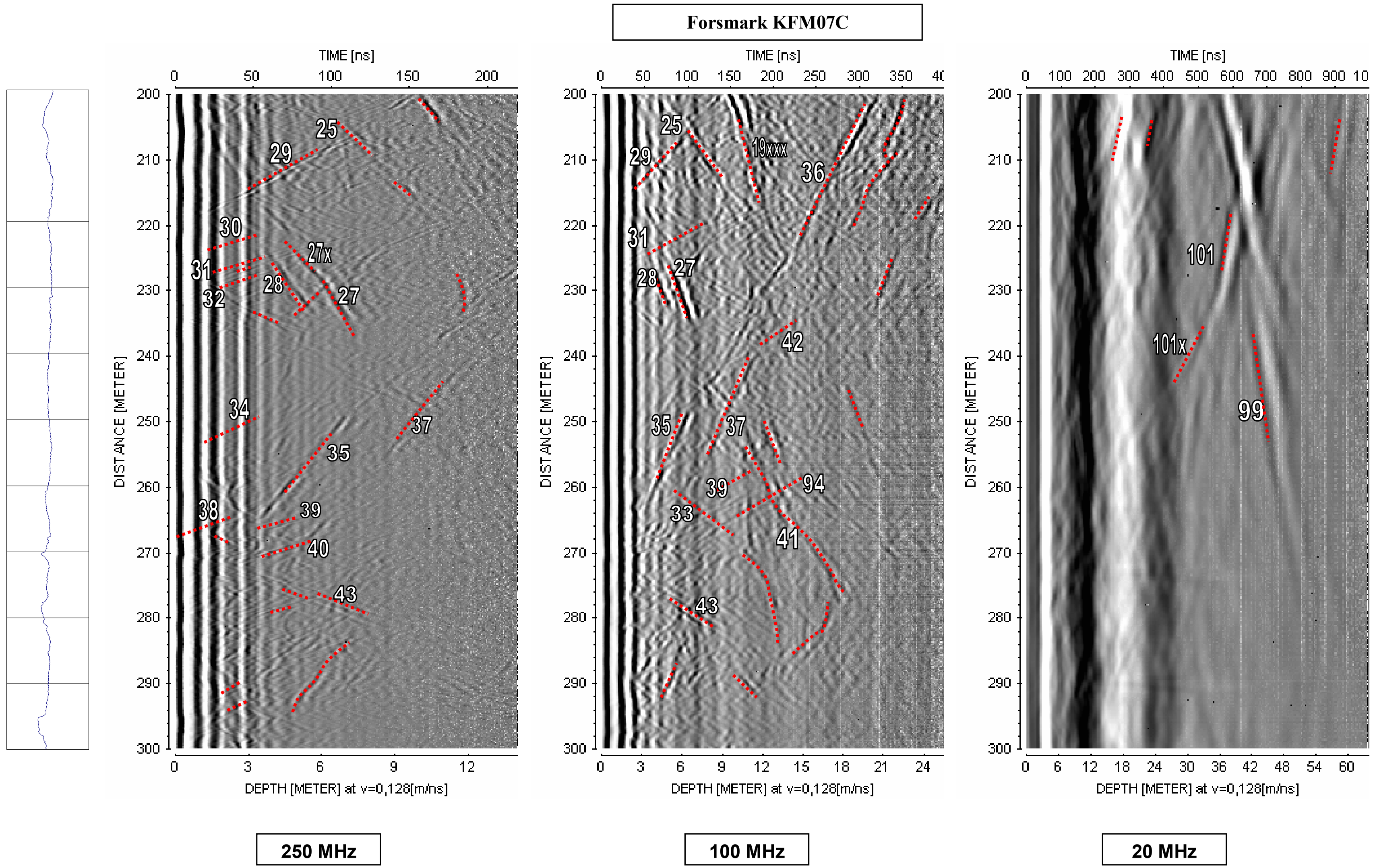
/1/ **Gustafsson C, Nilsson P, 2003.** Geophysical Radar and BIPS logging in borehole HFM01, HFM02, HFM03 and the percussion drilled part of KFM01A.
SKB P-03-39. Svensk Kärnbränslehantering AB.

## Radar logging in KFM07C, 100 to 497 m, dipole antennas 250, 100 and 20 MHz

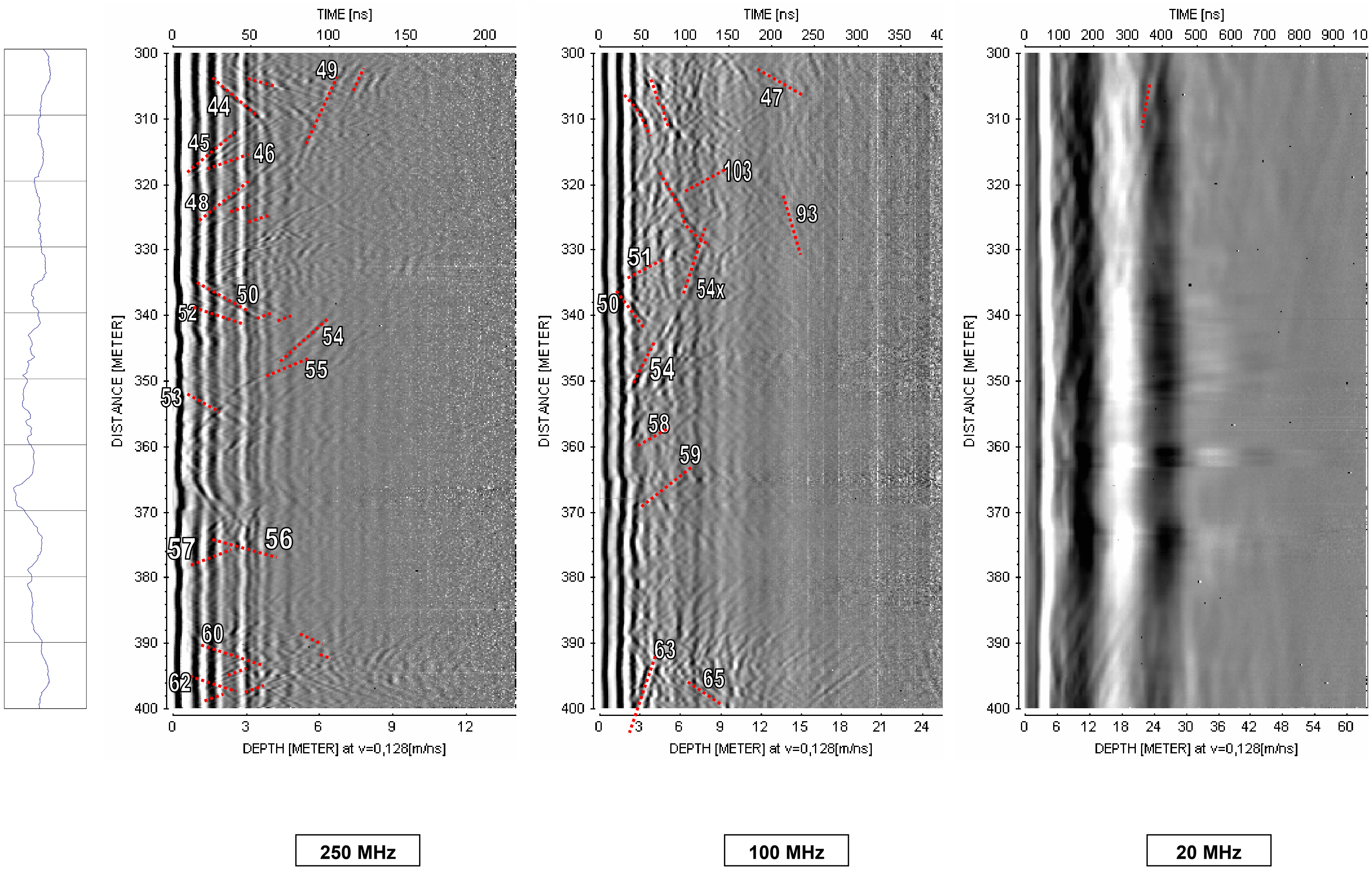
**Forsmark KFM07C**

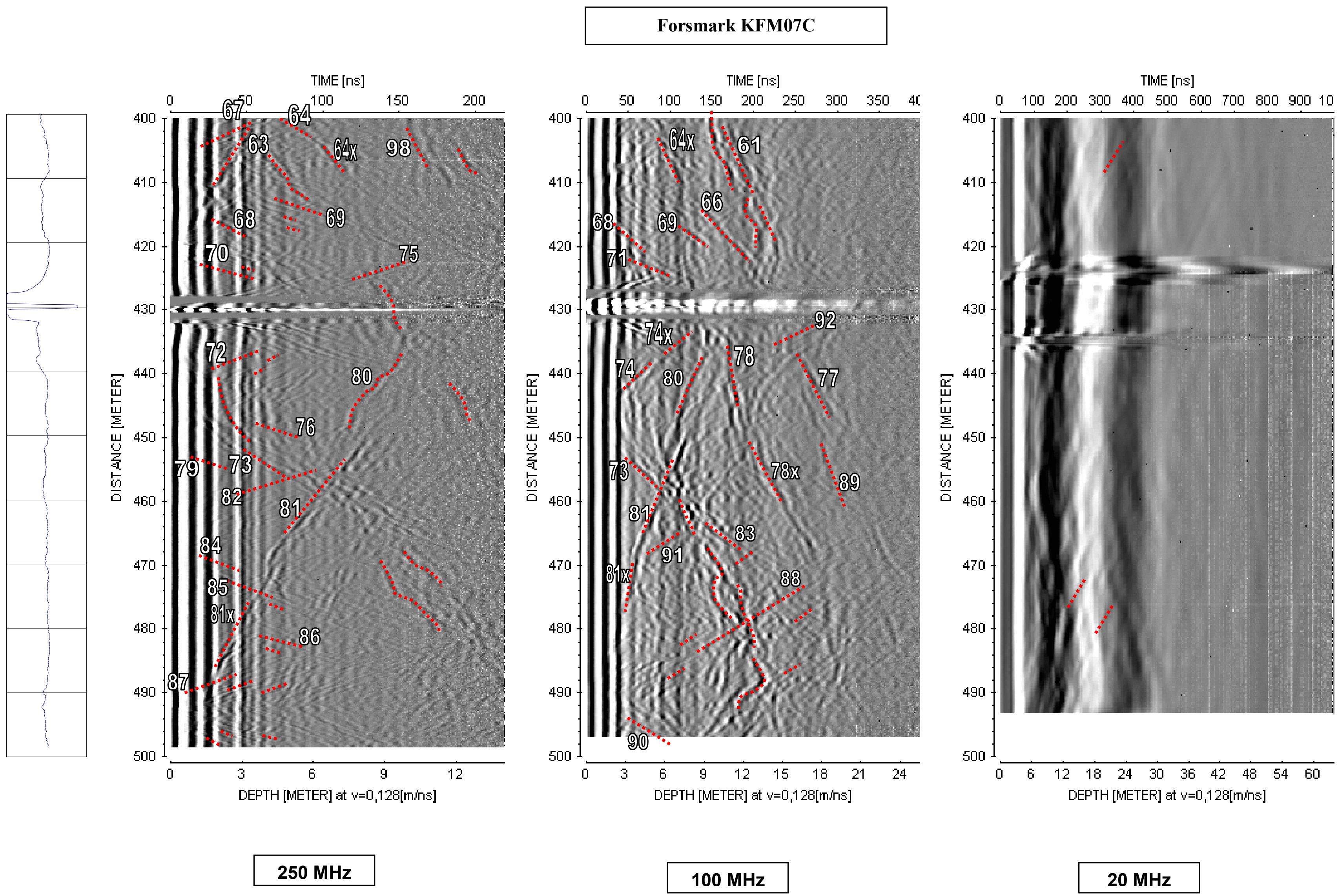



**250 MHz** **100 MHz** **20 MHz**


Forsmark KFM07C
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
25
29
30
31
32
27x
28
27
34
35
37
38
39
40
43
19xxx
36
42
33
94
41
101
101x
99
250 MHz
100 MHz
20 MHz

**Forsmark KFM07C**

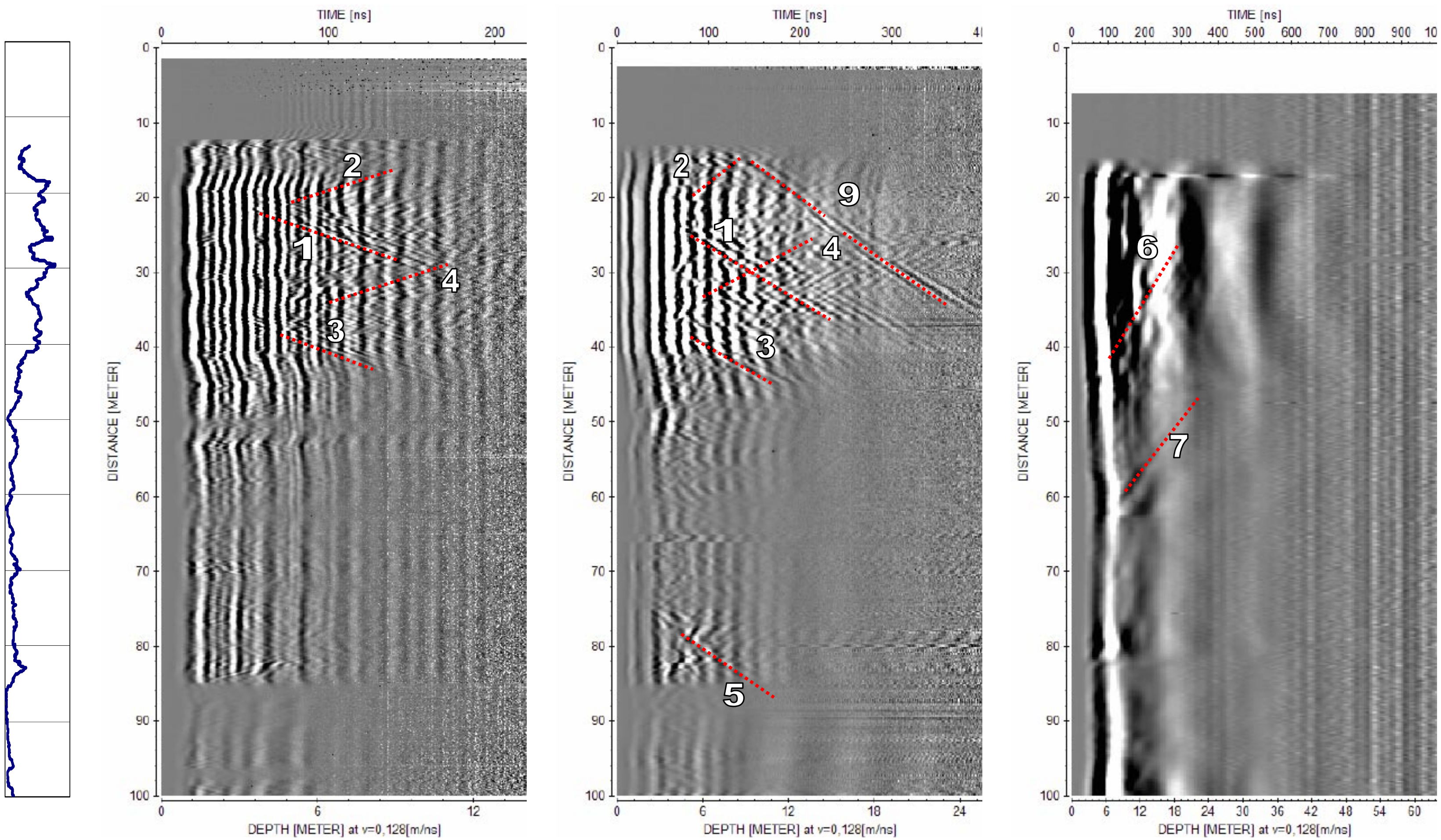




Forsmark KFM07C
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]
250 MHz
100 MHz
20 MHz

## Radar logging in HFM36, 0 to 150 m, dipole antennas 250, 100 and 20 MHz

Forsmark HFM36

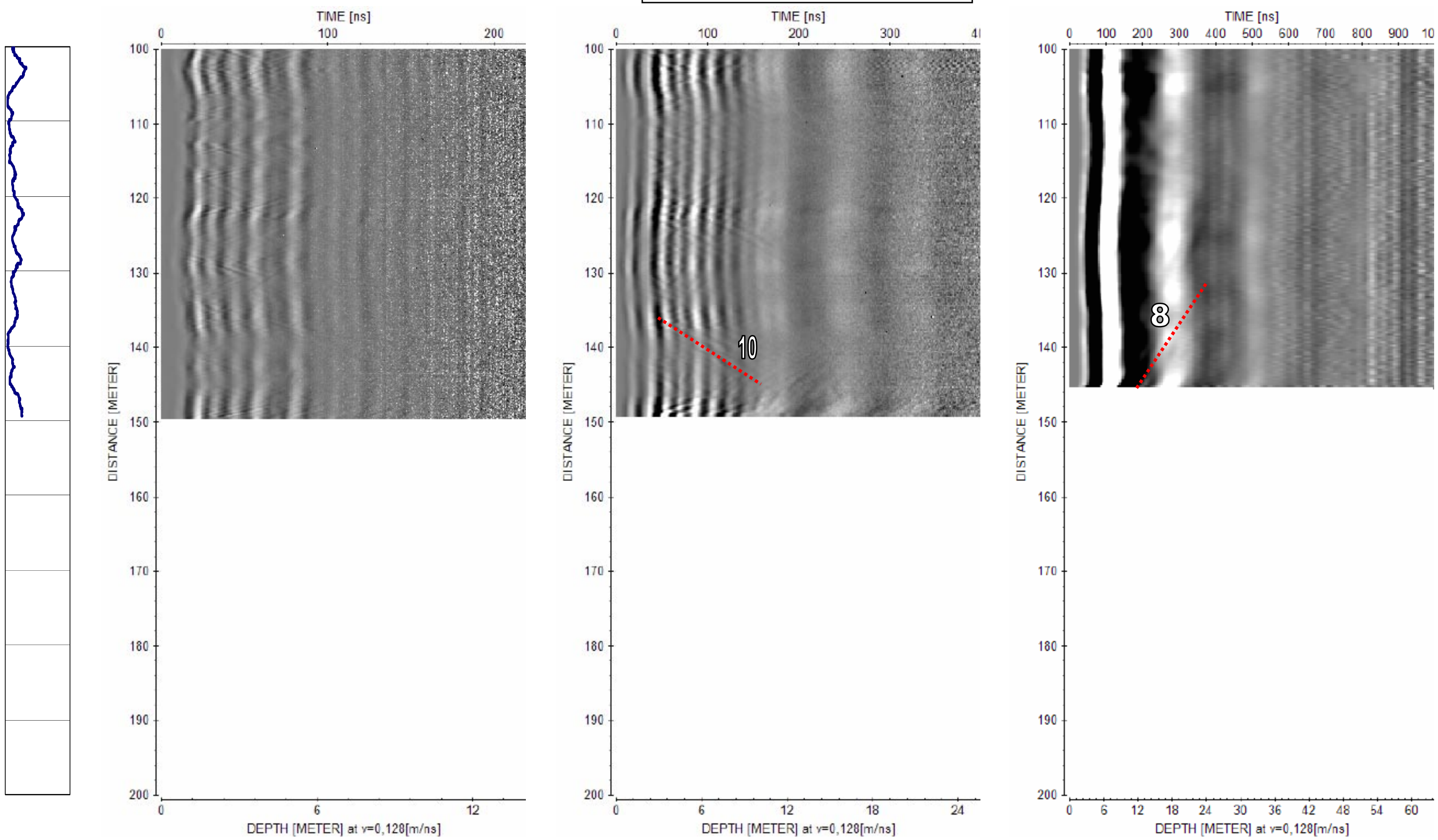



250 MHz

100 MHz

20 MHz

**Forsmark HFM36**

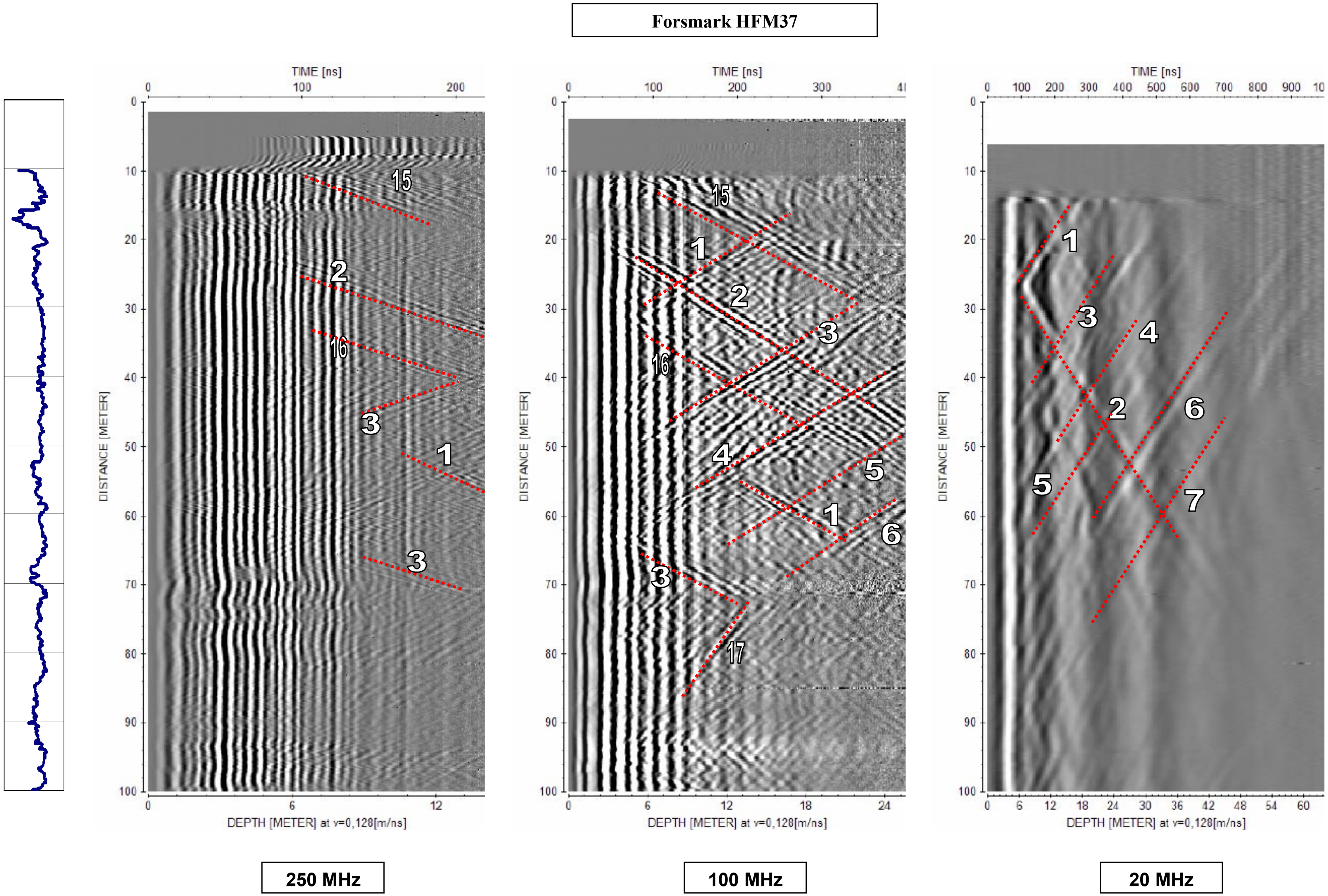


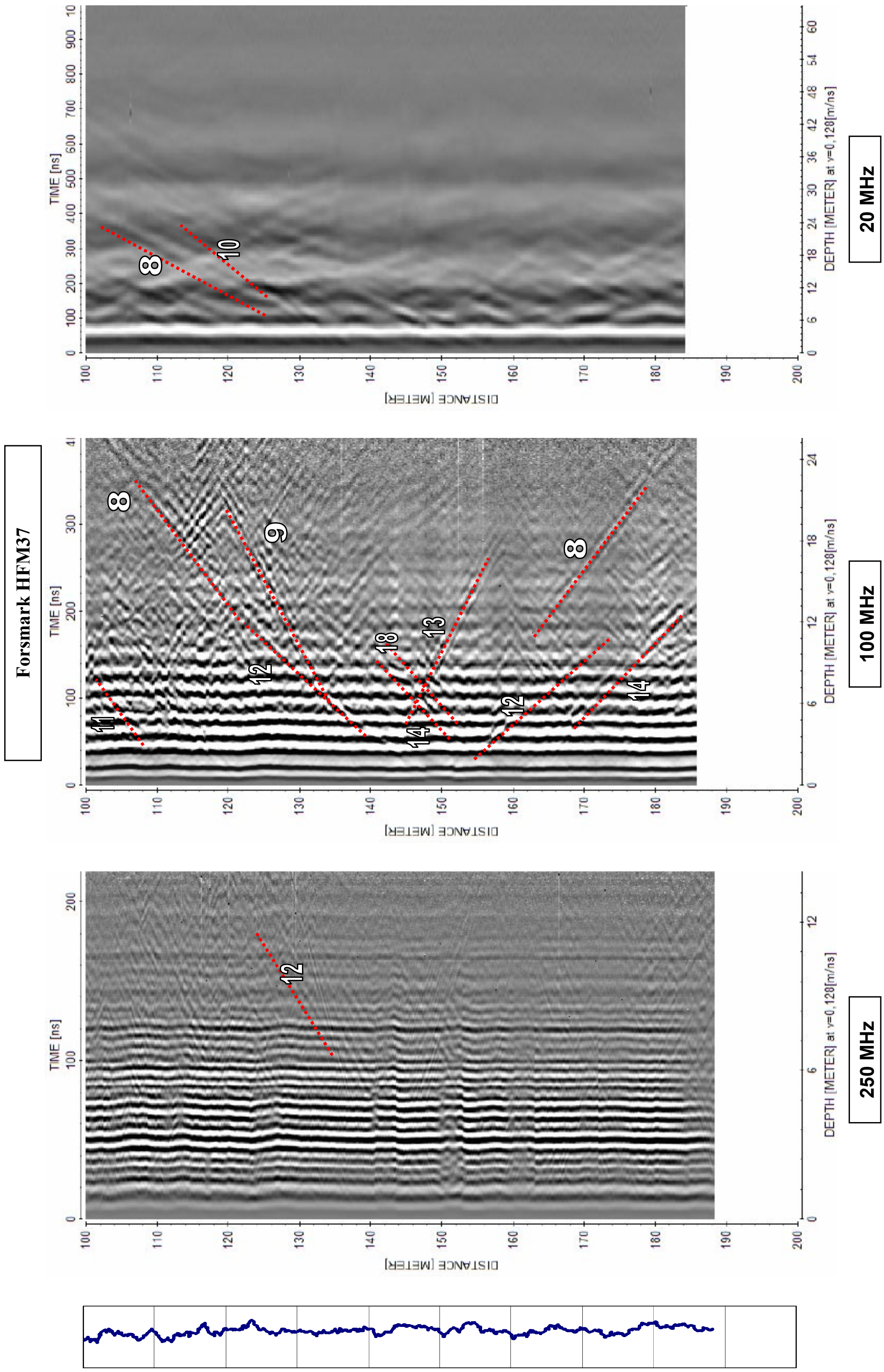

250 MHz

100 MHz

20 MHz

## Radar logging in HFM37, 0 to 188 m, dipole antennas 250, 100 and 20 MHz





Forsmark HFM37
20 MHz
100 MHz
250 MHz
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,128[m/ns]

**Appendix 4**

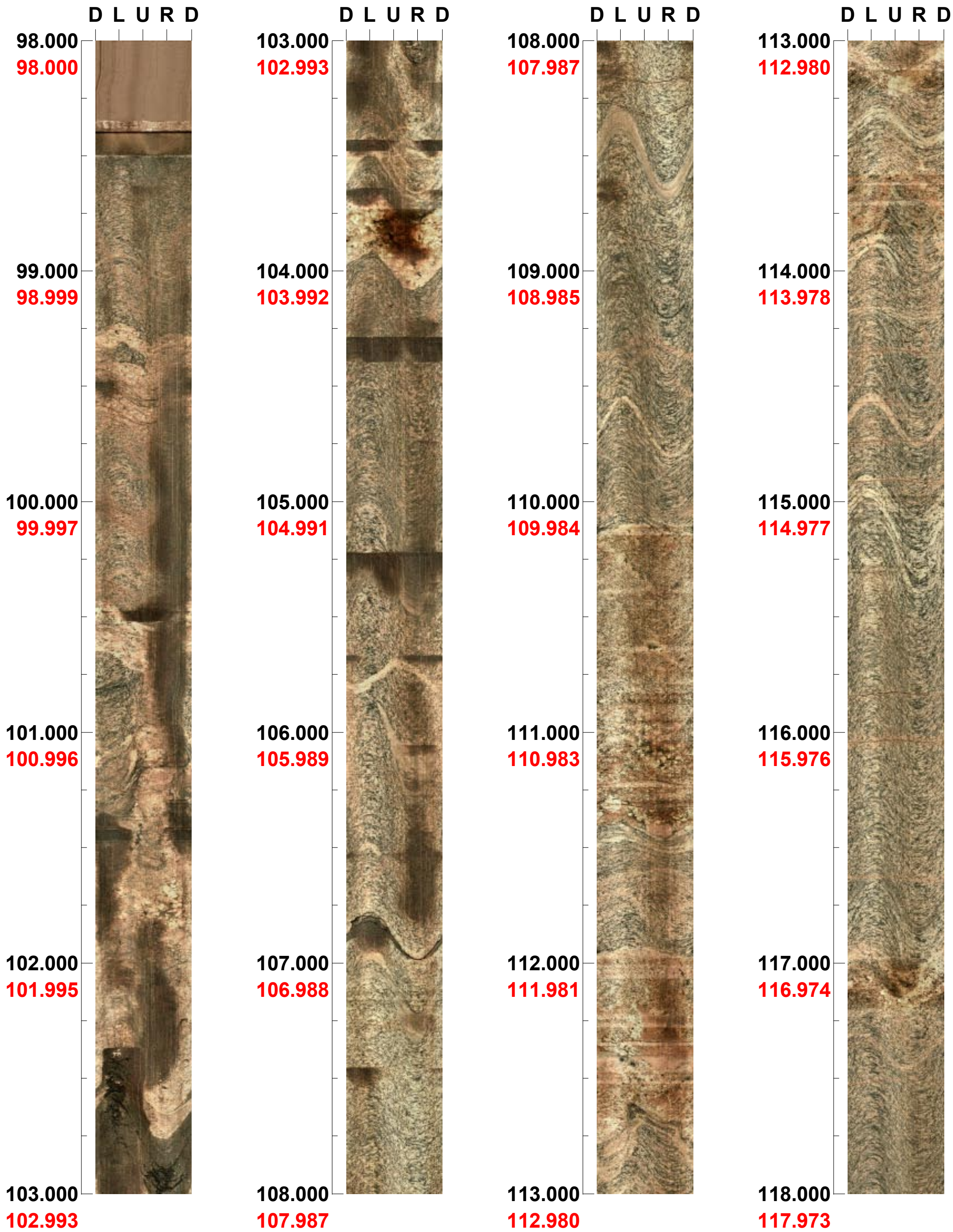
## BIPS logging in KFM07C, 98 to 498 m

**Project name: Forsmark**

| | |
|---|---|
| Image file | : c:\work\r55__k~2\bips\kfm07c.bip |
| BDT file | : c:\work\r55__k~2\bips\kfm07c.bdt |
| Locality | : FORSMARK |
| Bore hole number | : KFM07C |
| Date | : 06/09/21 |
| Time | : 13:37:00 |
| Depth range | : 98.000 - 498.255 m |
| Azimuth | : 143 |
| 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 | : 21 |
| Color | : +0 +0 +0 |

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

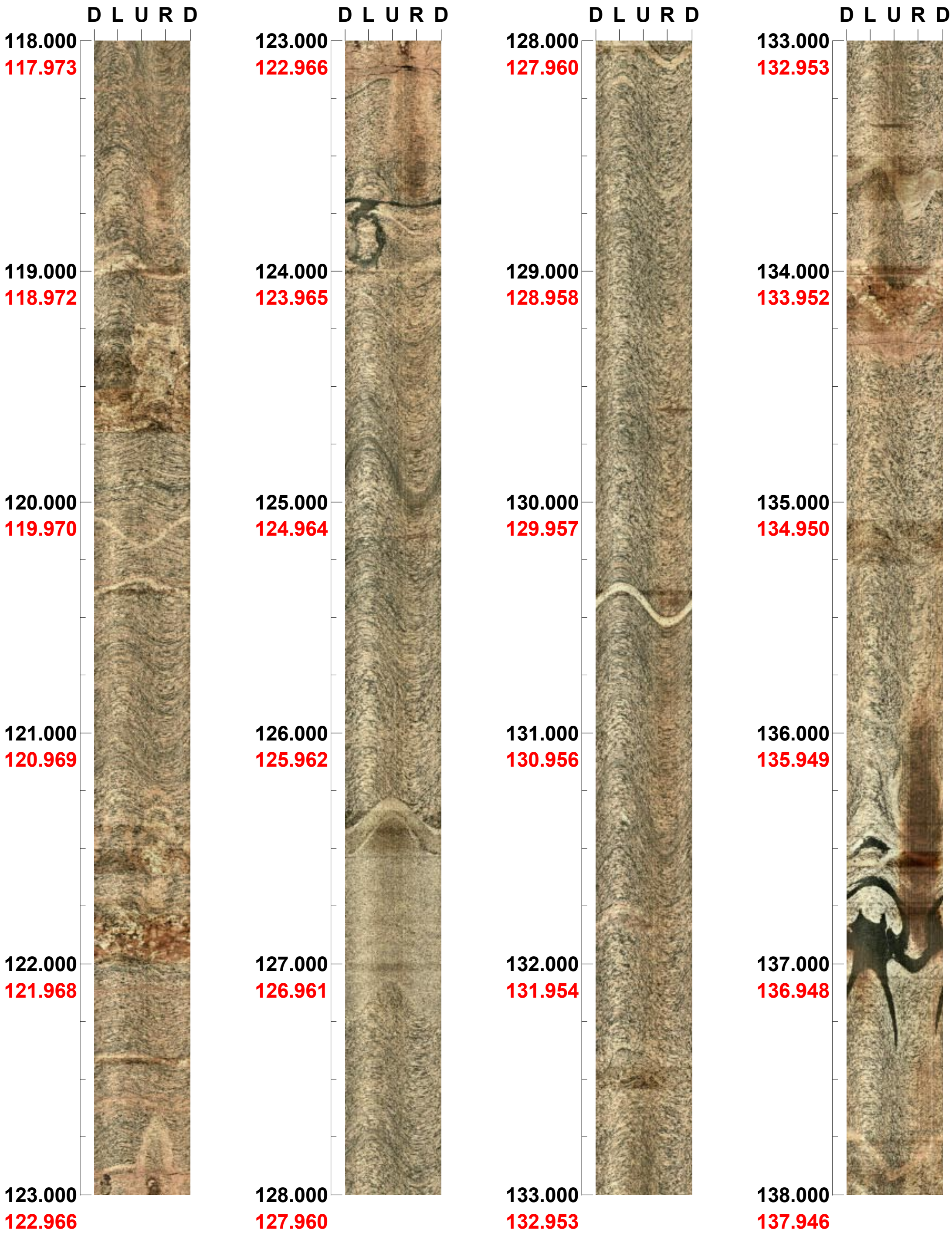
**Depth range: 98.000 - 118.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

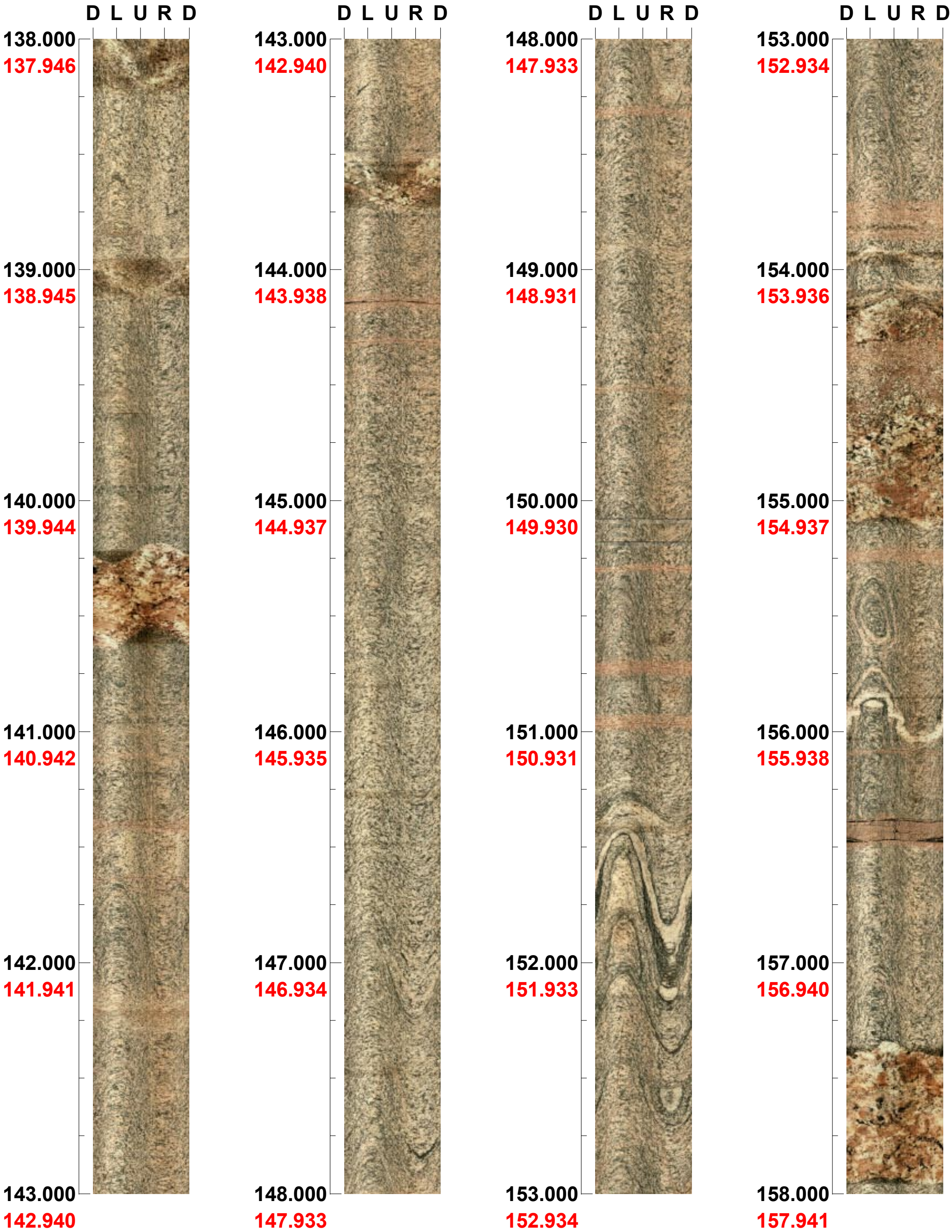
**Depth range: 118.000 - 138.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

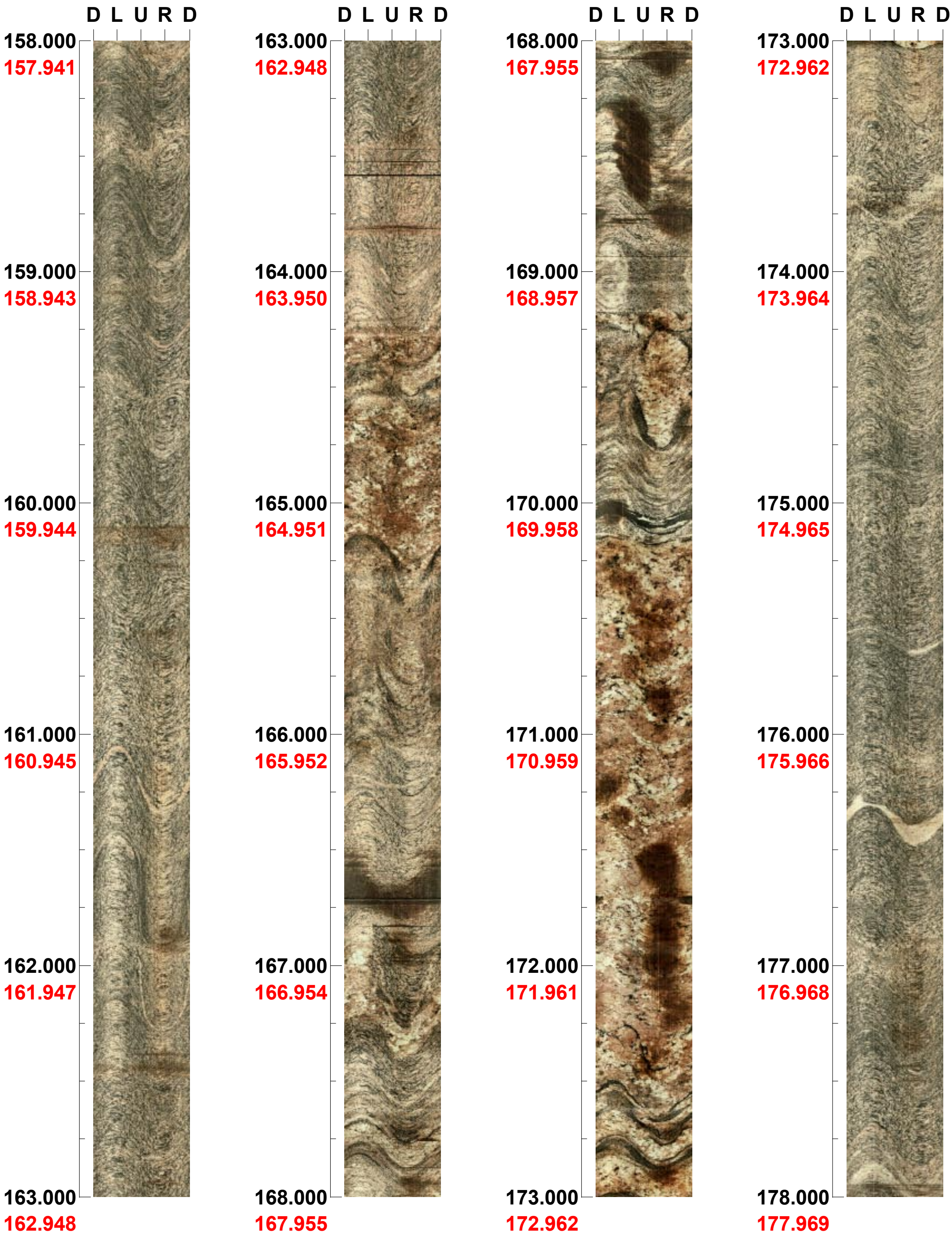
**Depth range: 138.000 - 158.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

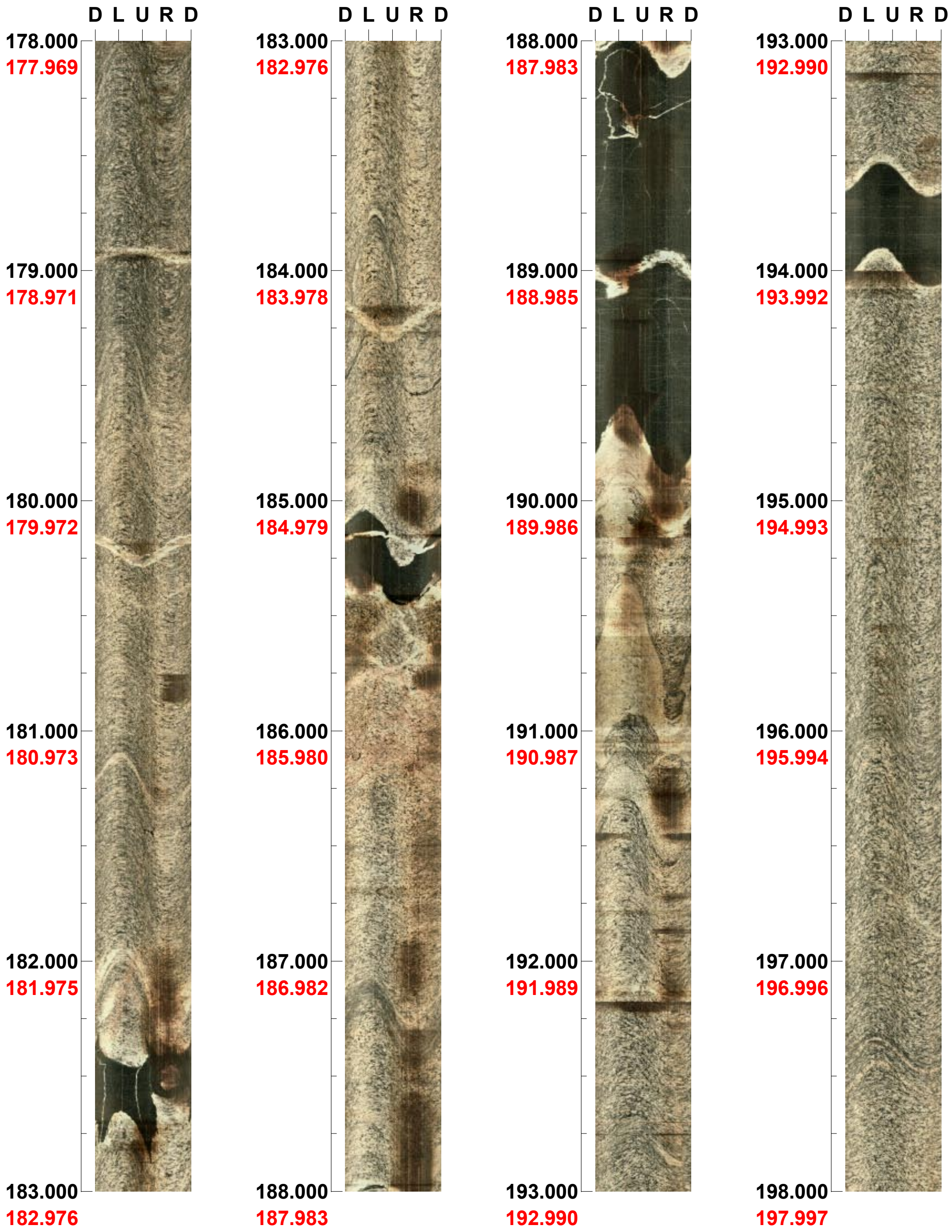
**Depth range: 158.000 - 178.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 178.000 - 198.000 m**




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

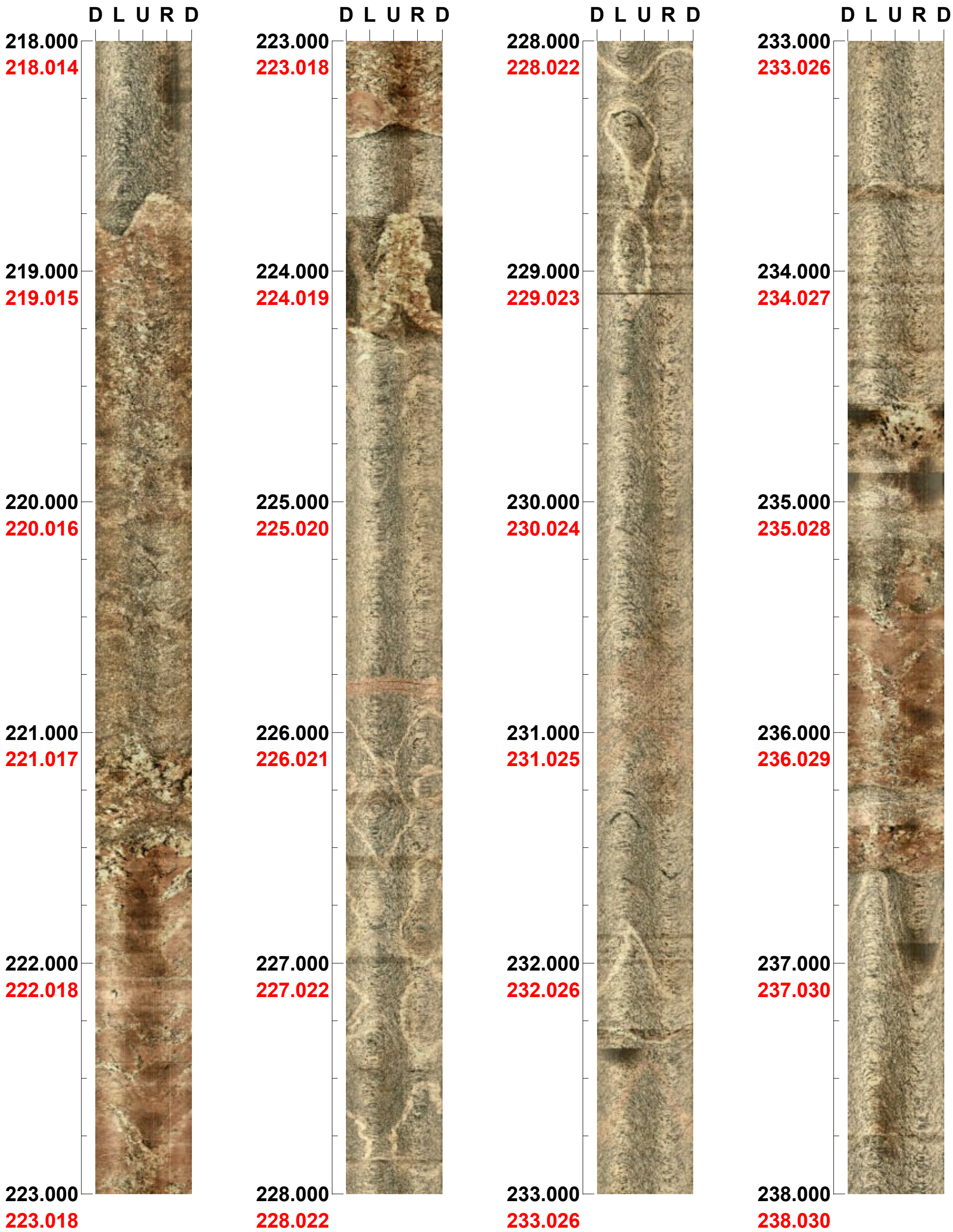
**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 198.000 - 218.000 m**


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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

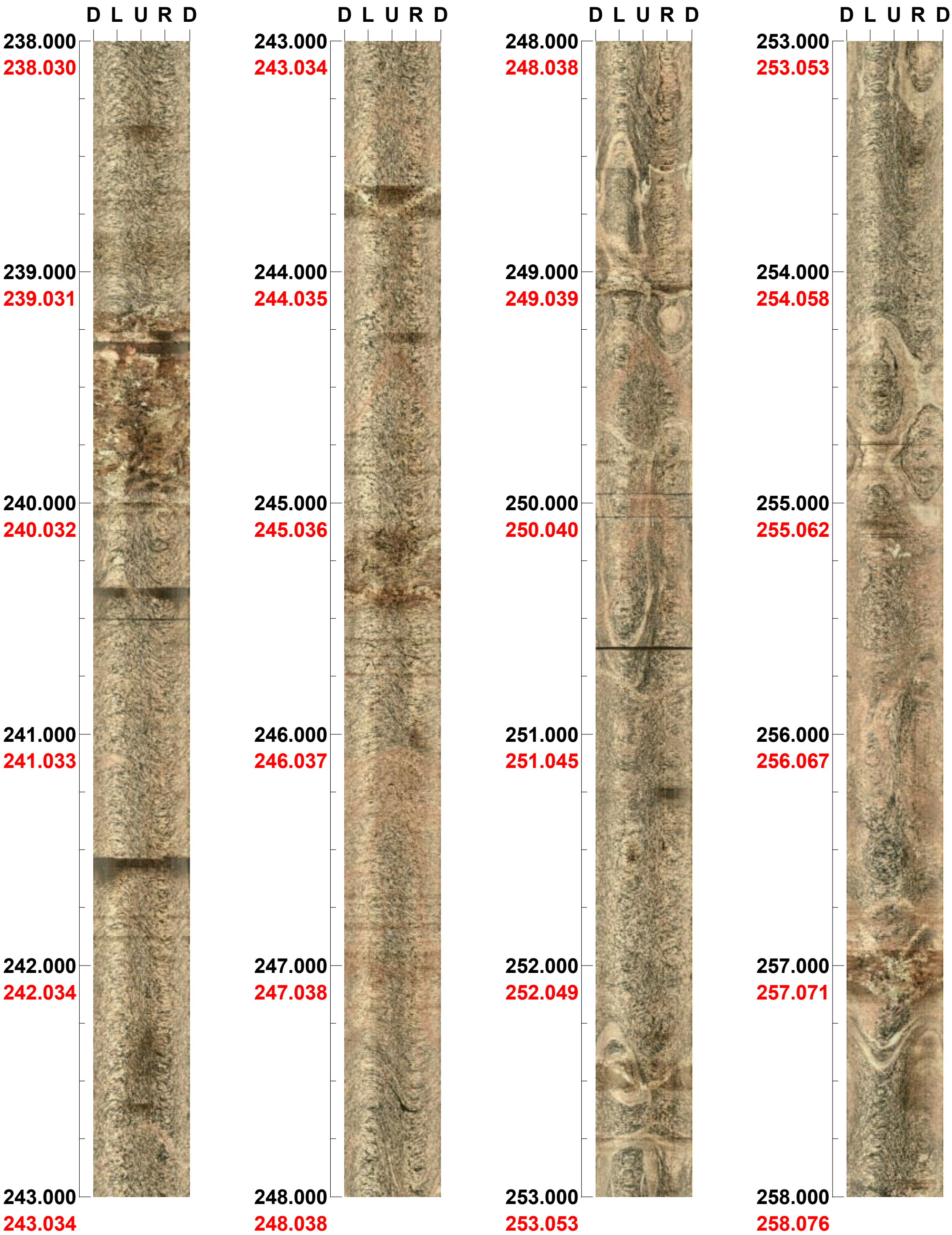
**Depth range: 218.000 - 238.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 238.000 - 258.000 m**




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

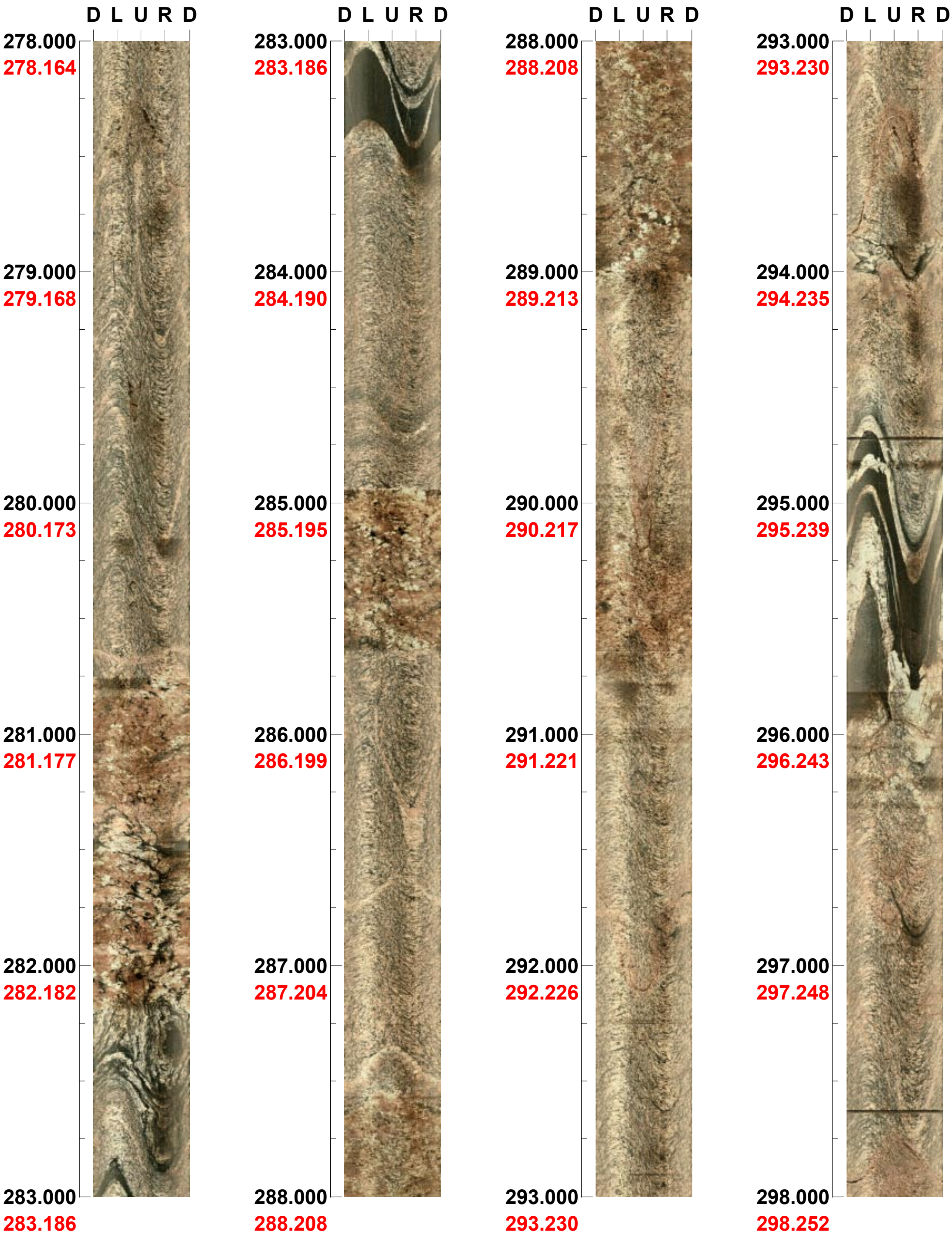
**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 258.000 - 278.000 m**


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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

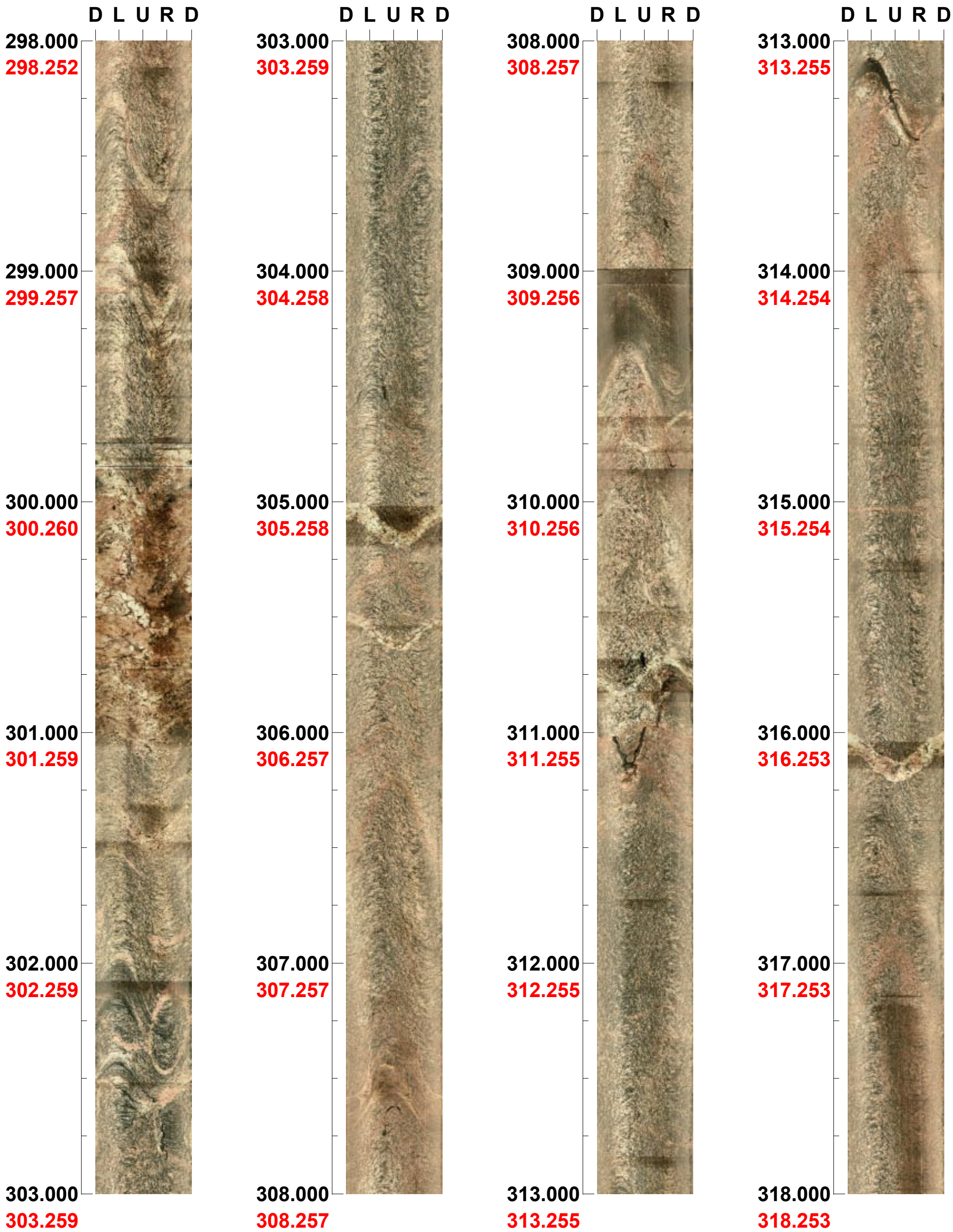
**Depth range: 278.000 - 298.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

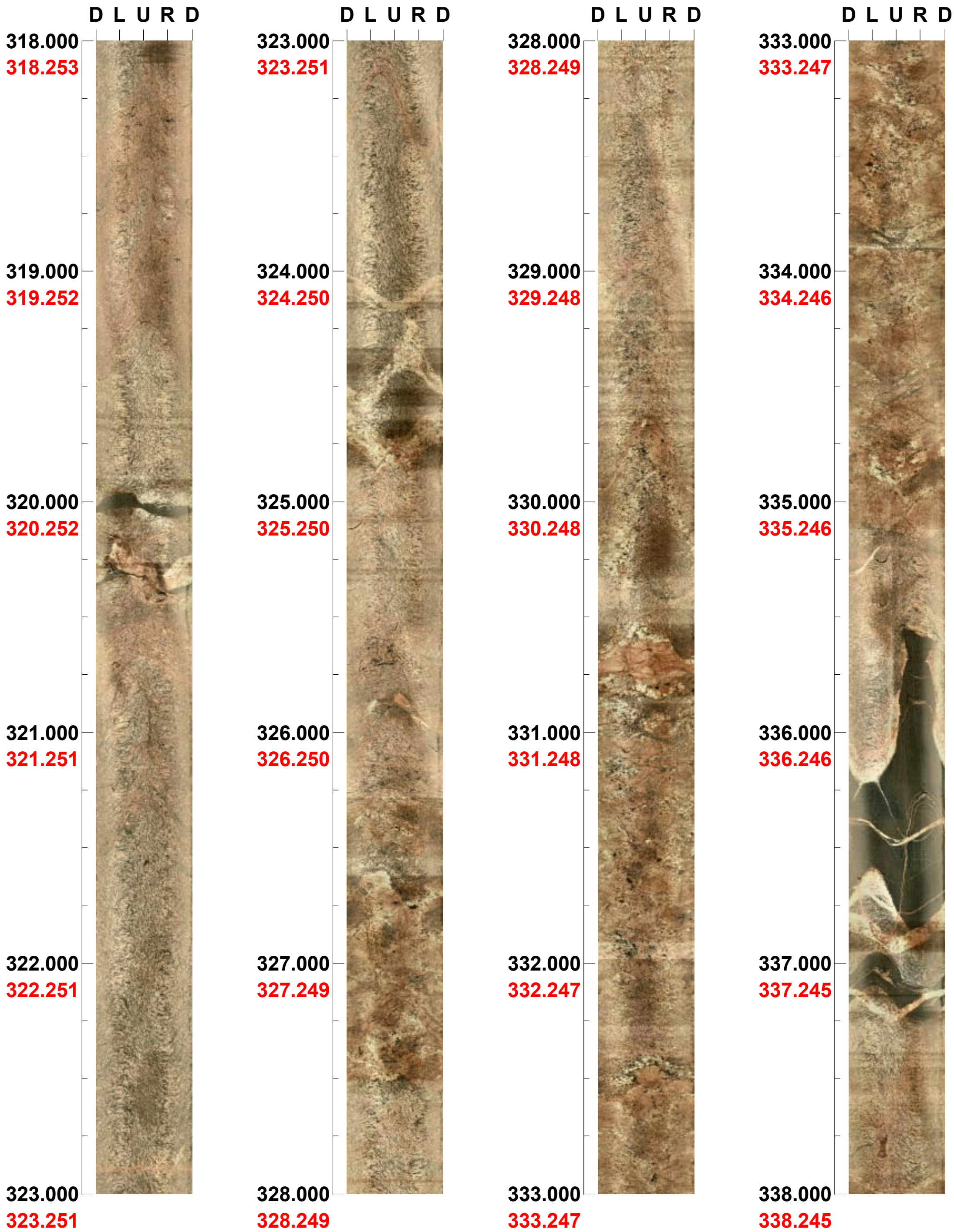
**Depth range: 298.000 - 318.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** Azimuth: 143 Inclination: -85

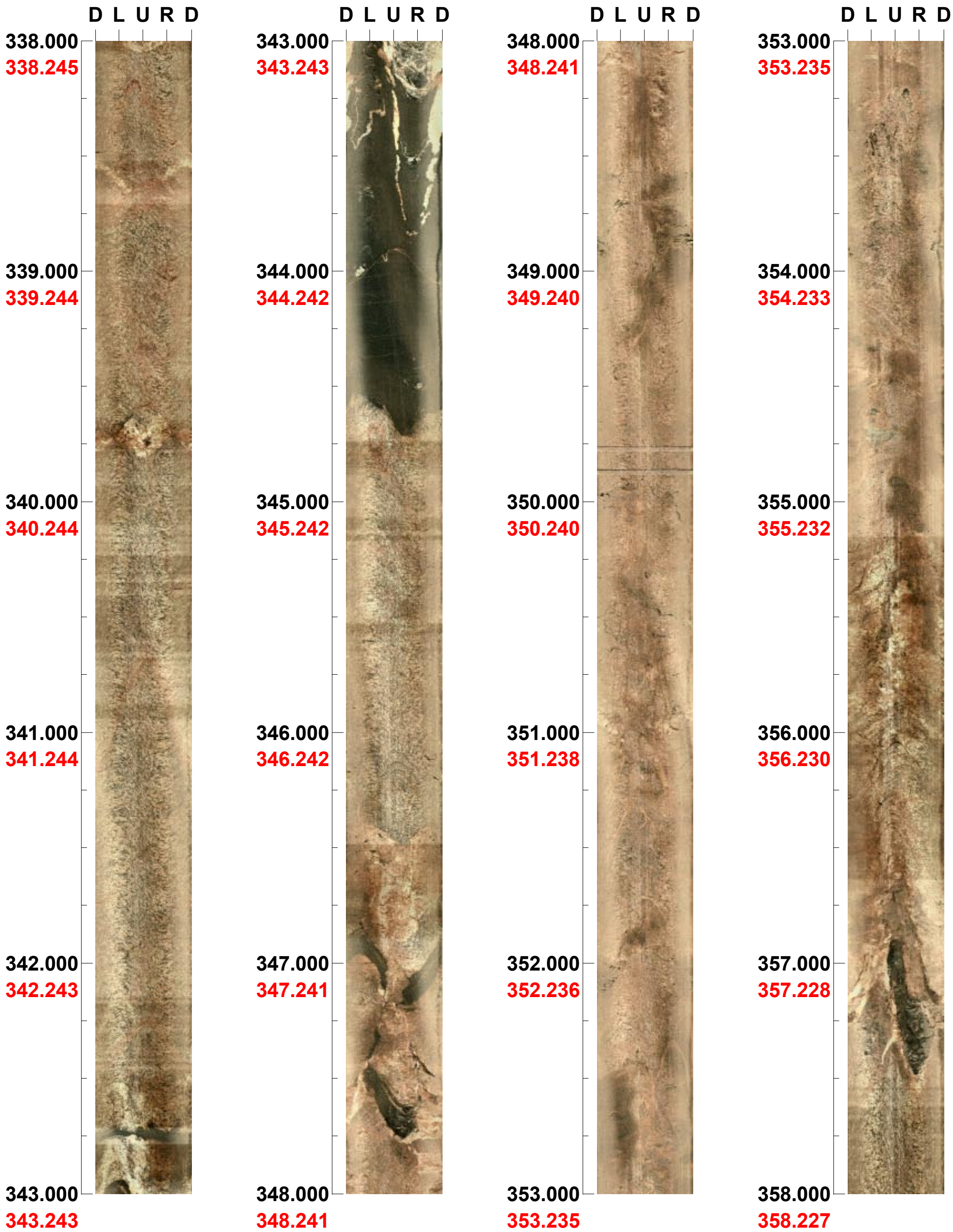
**Depth range: 318.000 - 338.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 338.000 - 358.000 m**




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

**Project name: Forsmark**

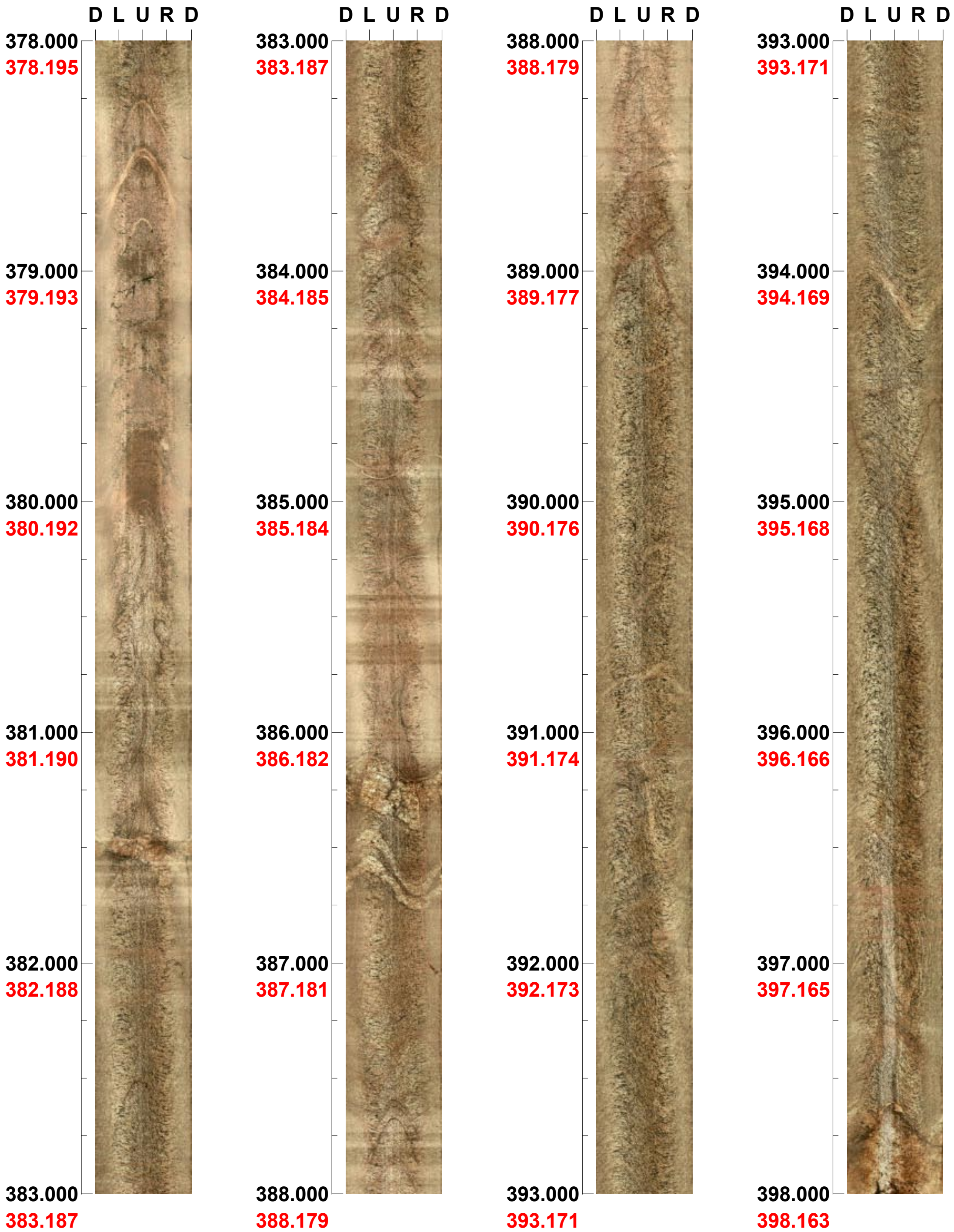
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 358.000 - 378.000 m**


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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

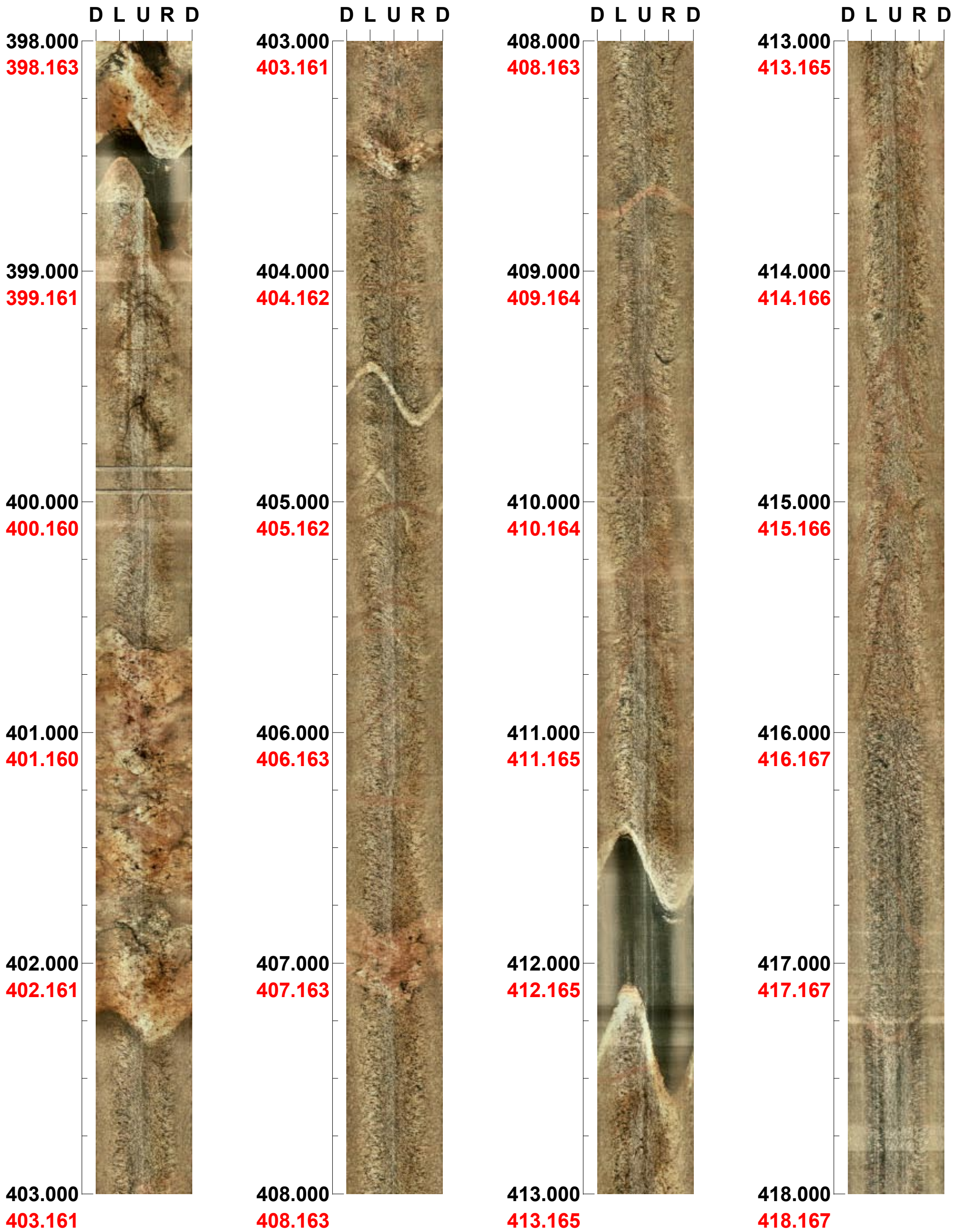
**Depth range: 378.000 - 398.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 398.000 - 418.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** Azimuth: 143 Inclination: -85

**Depth range: 418.000 - 438.000 m**


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

**Project name: Forsmark**

**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 438.000 - 458.000 m**


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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

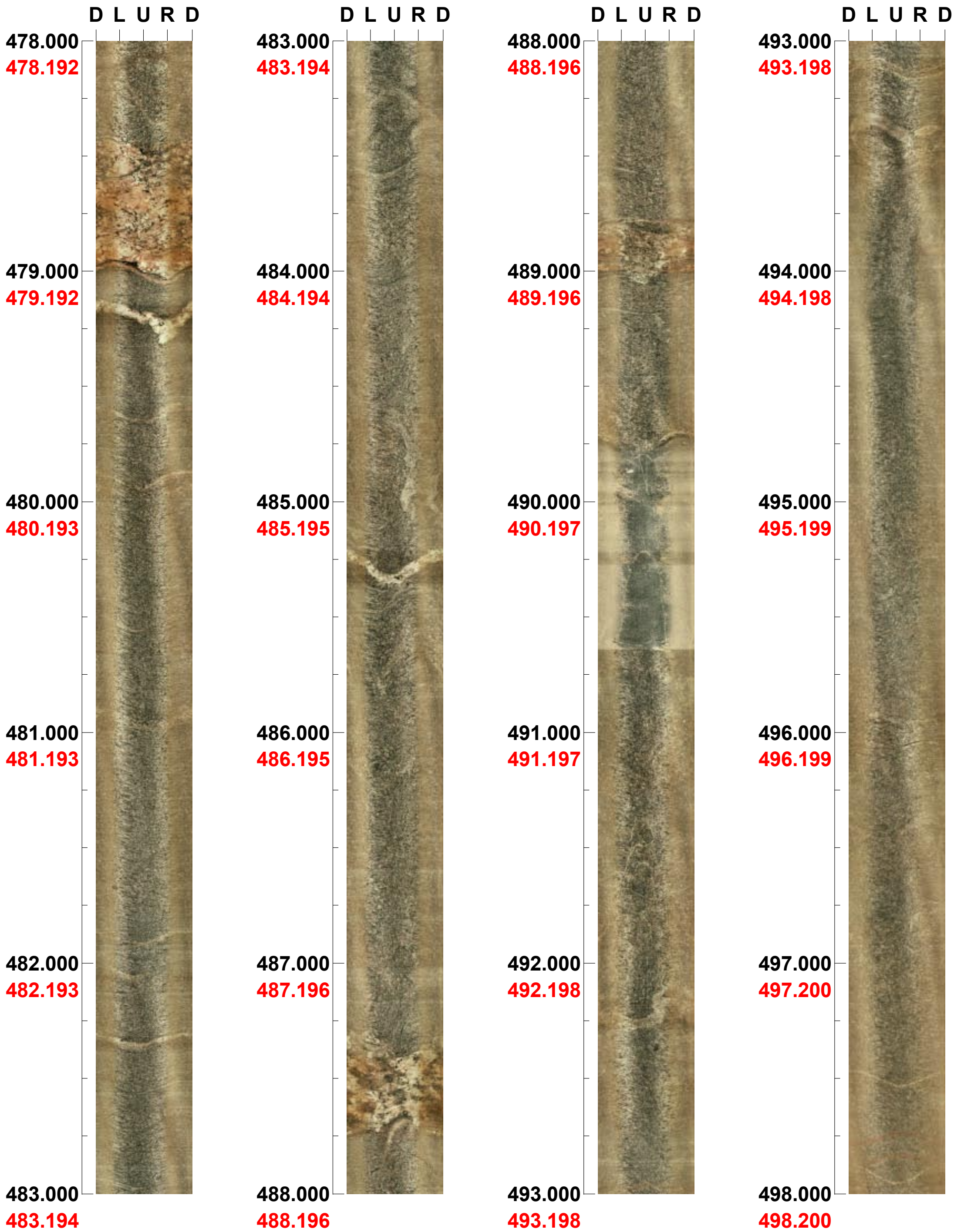
**Depth range: 458.000 - 478.000 m**


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

**Project name: Forsmark**

**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

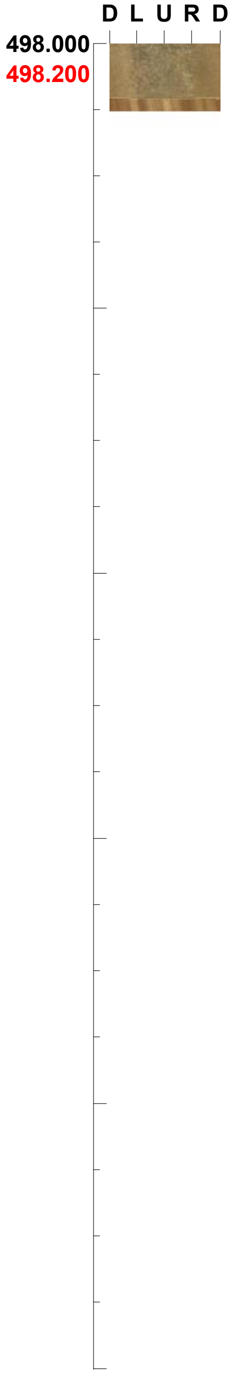
**Depth range: 478.000 - 498.000 m**




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

**Project name: Forsmark**
**Bore hole No.: KFM07C** **Azimuth: 143** **Inclination: -85**

**Depth range: 498.000 - 498.255 m**




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

## Appendix 5

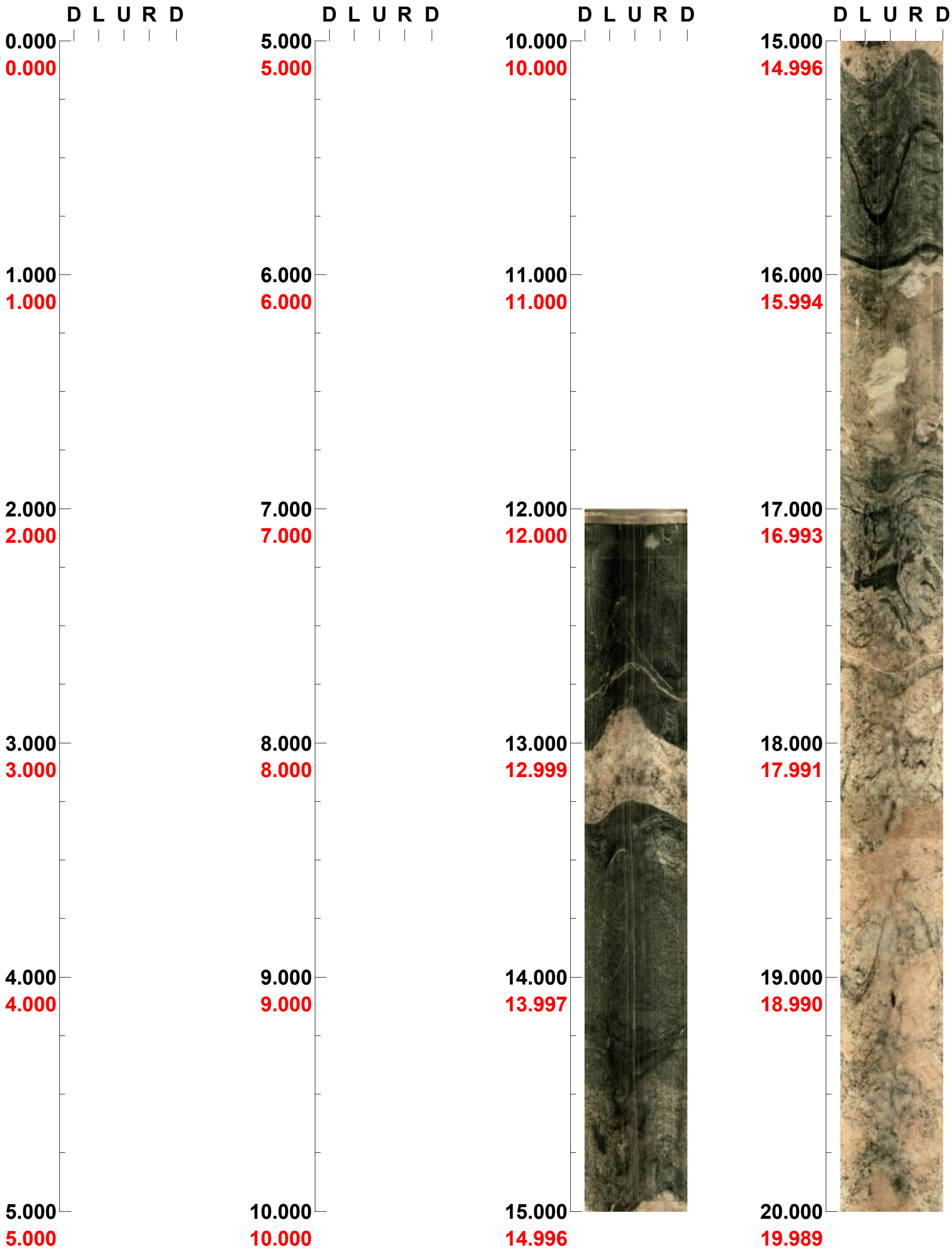
### BIPS logging in HFM36, 12 to 152 m

**Project name: Forsmark**

| | |
|---|---|
| Image file | : c:\work\r55__k~2\bips\hfm36.bip |
| BDT file | : c:\work\r55__k~2\bips\hfm36.bdt |
| Locality | : FORSMARK |
| Bore hole number | : HFM36 |
| Date | : 06/09/21 |
| Time | : 07:46:00 |
| Depth range | : 12.000 - 151.701 m |
| Azimuth | : 257 |
| 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 | : 8 |
| Color | : +0 +0 +0 |

**Project name: Forsmark**
**Bore hole No.: HFM36** **Azimuth: 257** **Inclination: -59**

**Depth range: 0.000 - 20.000 m**

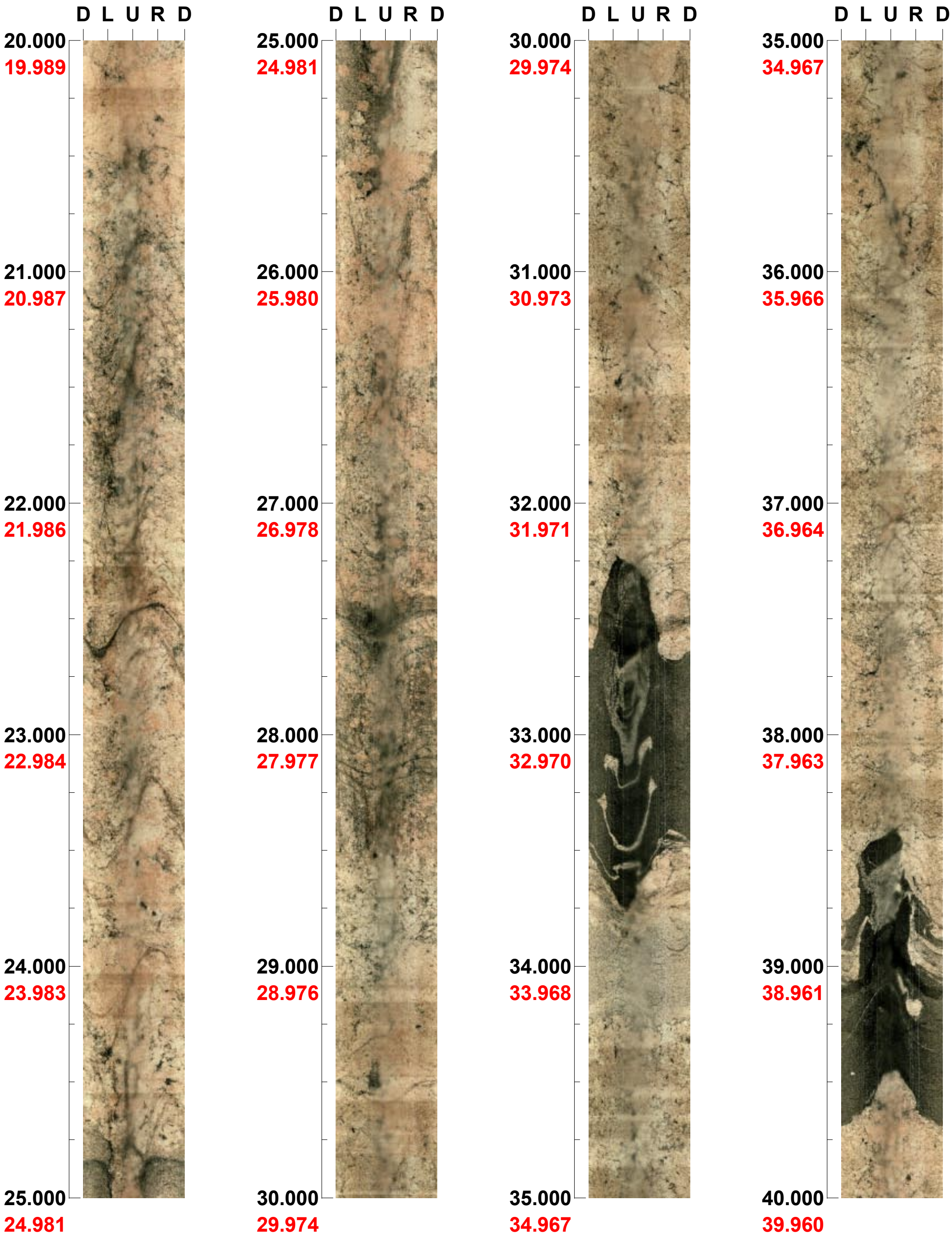



**( 1 / 8 )** **Scale: 1/25** **Aspect ratio: 100 %**

**Project name: Forsmark**

**Bore hole No.: HFM36** **Azimuth: 257** **Inclination: -59**

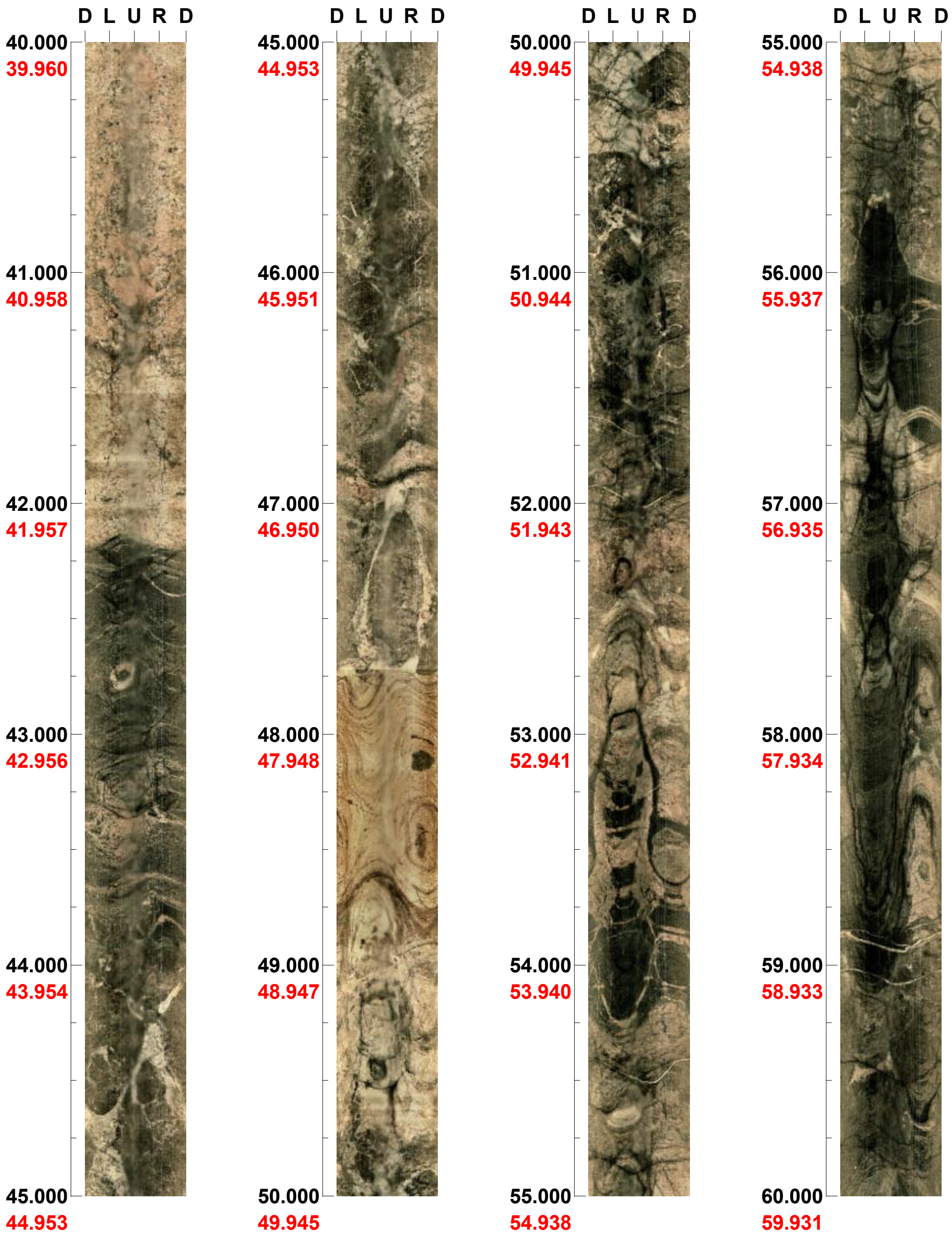
**Depth range: 20.000 - 40.000 m**




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

**Project name: Forsmark**
**Bore hole No.: HFM36** **Azimuth: 257** **Inclination: -59**

**Depth range: 40.000 - 60.000 m**

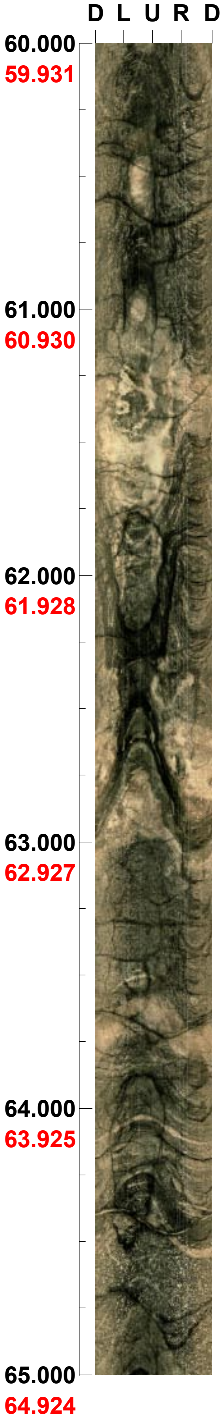


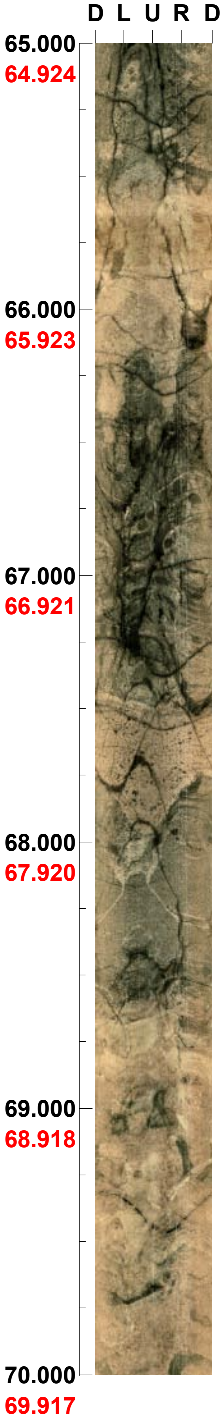

**( 3 / 8 )** **Scale: 1/25** **Aspect ratio: 100 %**

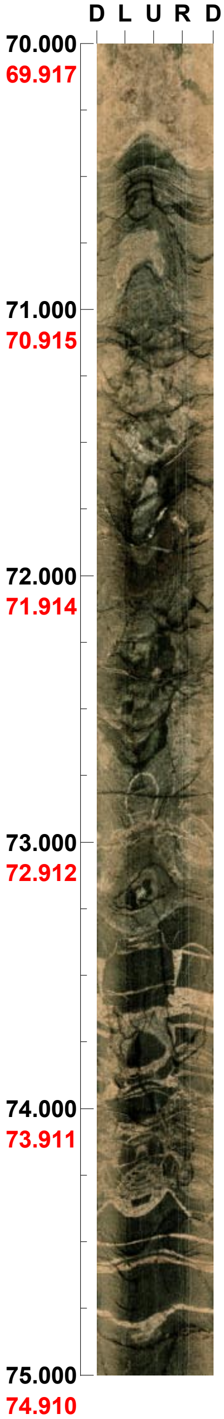
**Project name: Forsmark**

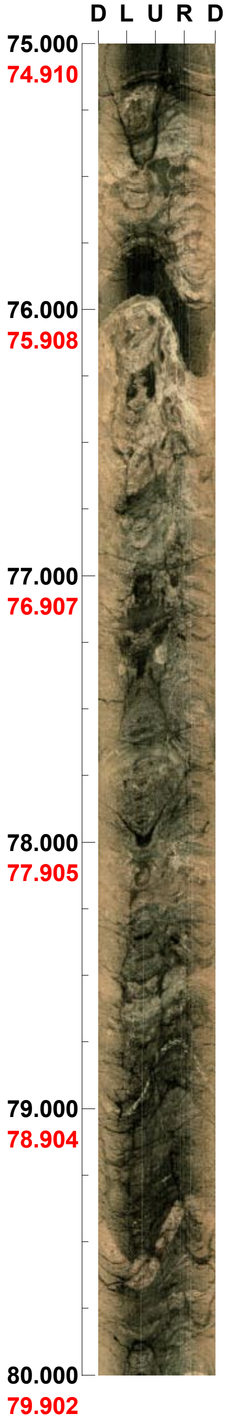
**Bore hole No.: HFM36** **Azimuth: 257** **Inclination: -59**

**Depth range: 60.000 - 80.000 m**



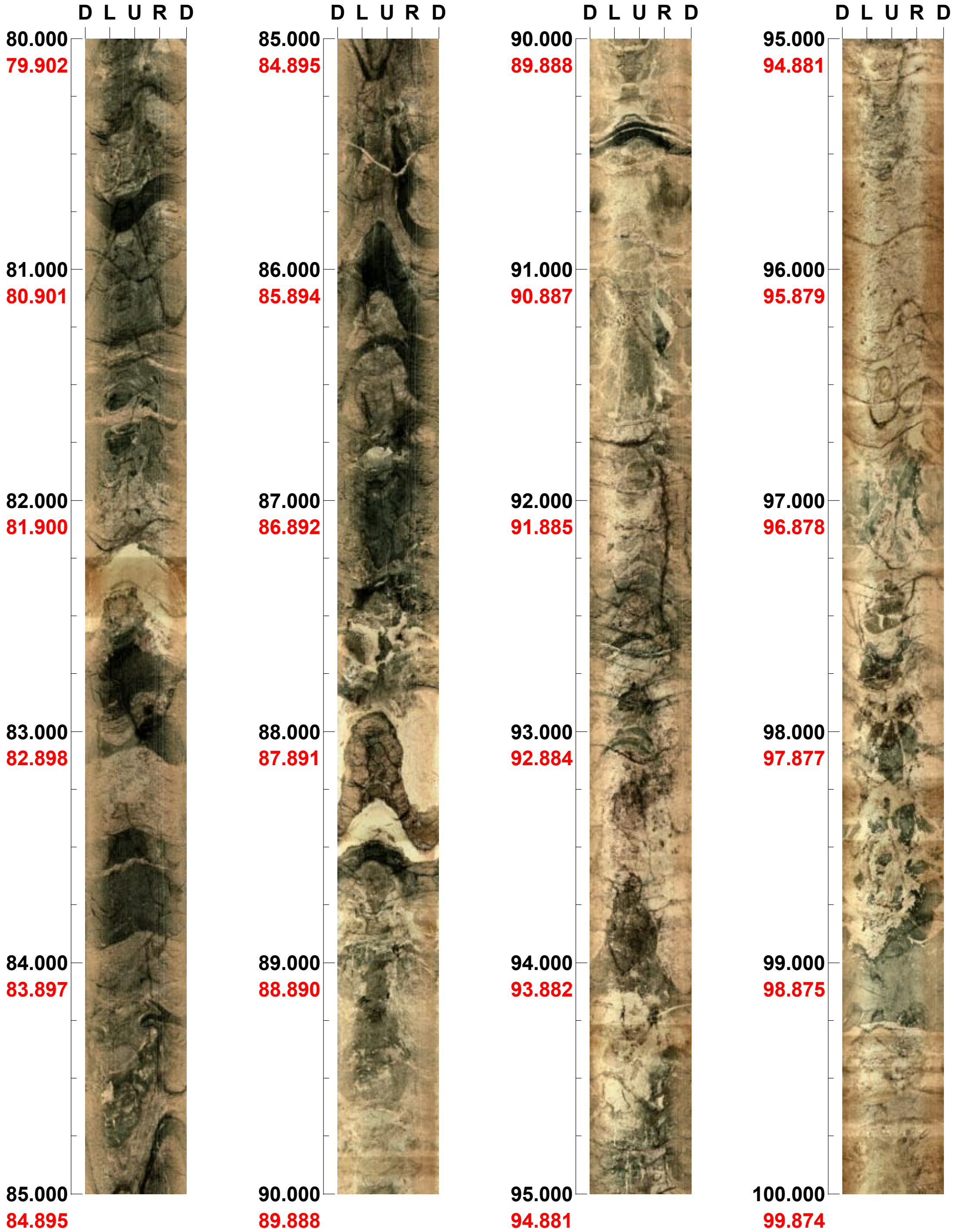




**( 4 / 8 )** **Scale: 1/25** **Aspect ratio: 100 %**

**Project name: Forsmark**

**Bore hole No.: HFM36** **Azimuth: 257** **Inclination: -59**

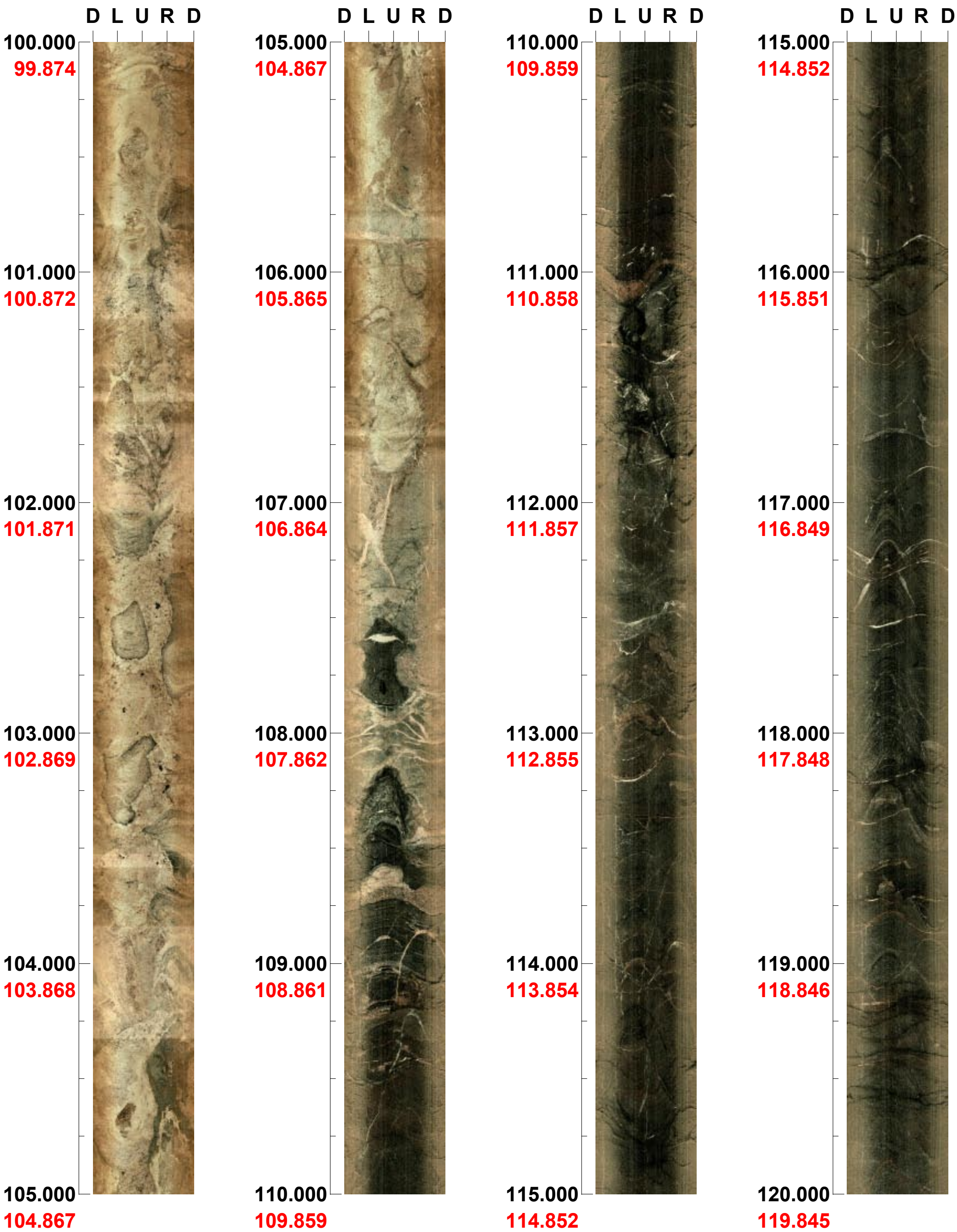
**Depth range: 80.000 - 100.000 m**




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

Project name: Forsmark
Bore hole No.: HFM36 Azimuth: 257 Inclination: -59

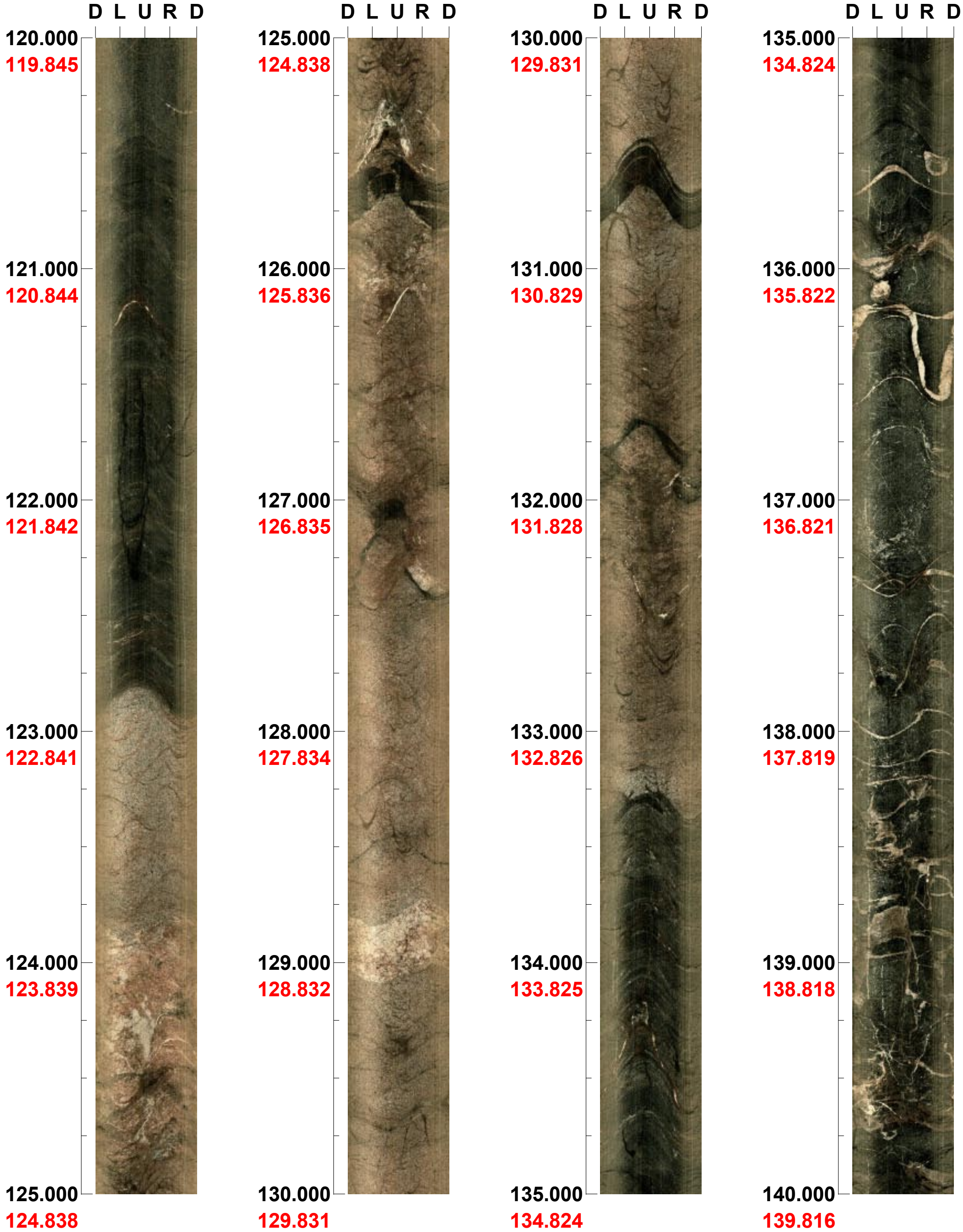
Depth range: 100.000 - 120.000 m




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

**Project name: Forsmark**
**Bore hole No.: HFM36** **Azimuth: 257** **Inclination: -59**

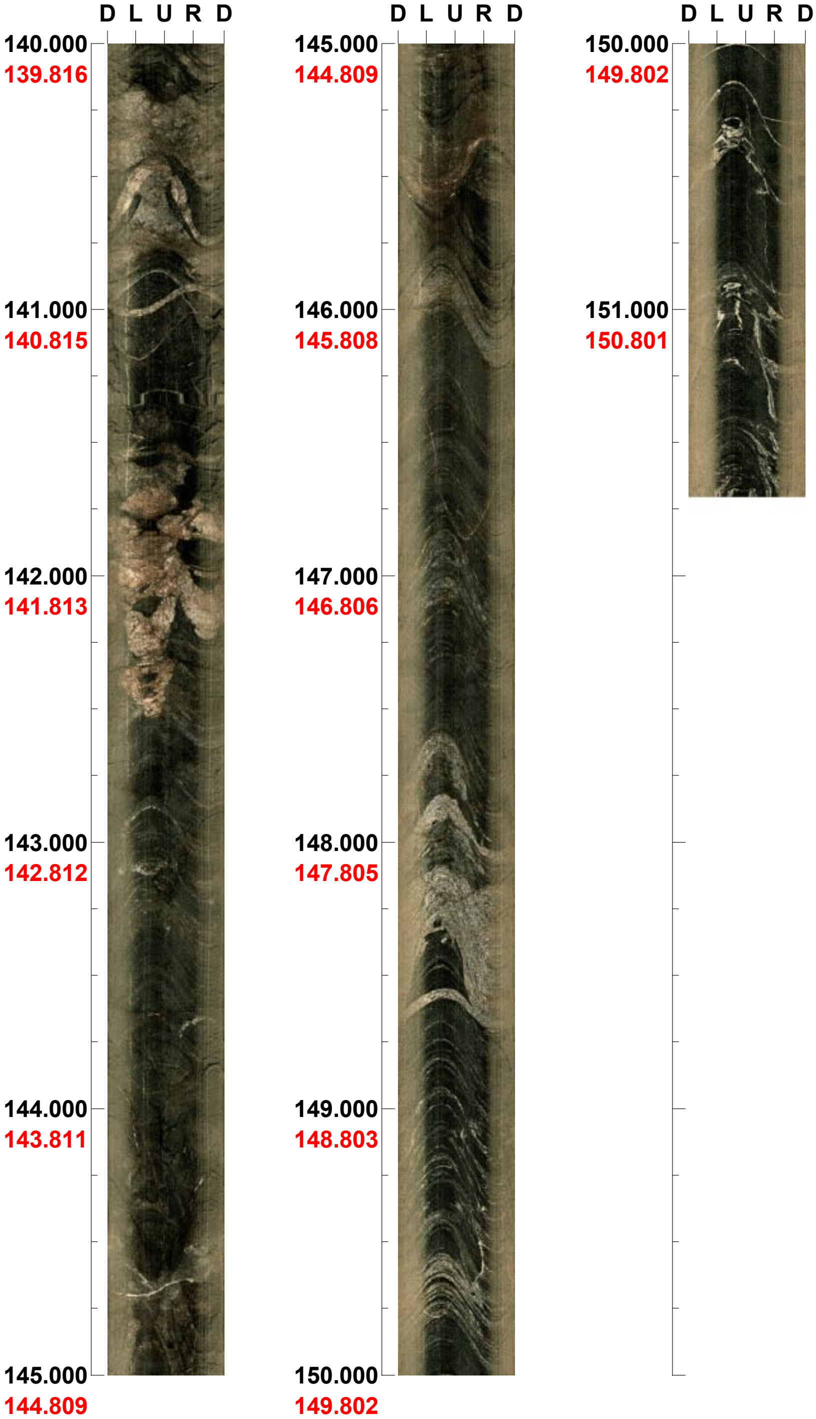
**Depth range: 120.000 - 140.000 m**




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

**Project name: Forsmark**
**Bore hole No.: HFM36** **Azimuth: 257** **Inclination: -59**

**Depth range: 140.000 - 151.701 m**




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

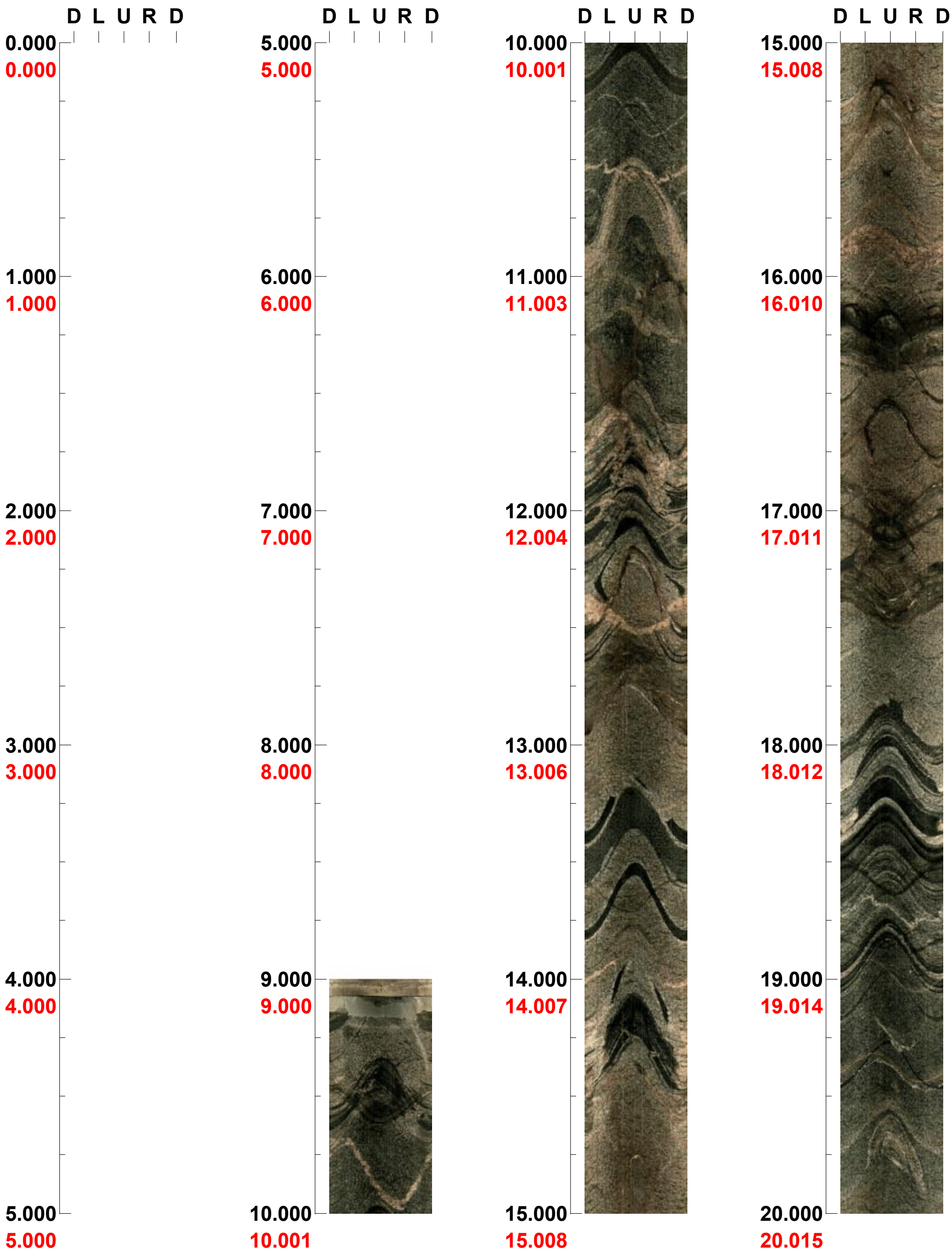
## BIPS logging in HFM37, 9 to 191 m

**Project name: Forsmark**

| | |
|---|---|
| Image file | : c:\work\r55__k~2\bips\hfm37.bip |
| BDT file | : c:\work\r55__k~2\bips\hfm37.bdt |
| Locality | : FORSMARK |
| Bore hole number | : HFM37 |
| Date | : 06/09/20 |
| Time | : 14:15:00 |
| Depth range | : 9.000 - 190.923 m |
| Azimuth | : 41 |
| 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: Forsmark**
**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

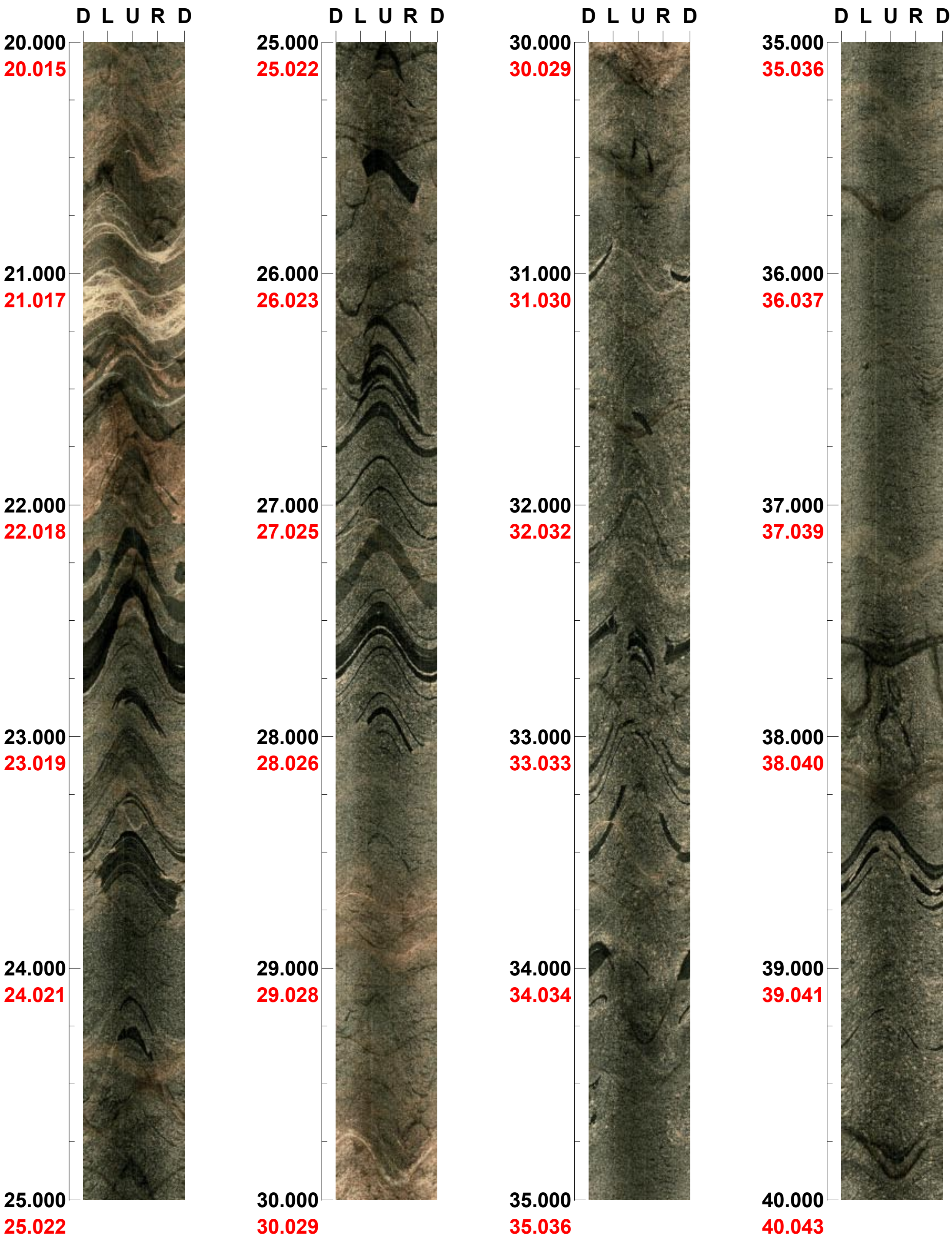
**Depth range: 0.000 - 20.000 m**




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

**Project name: Forsmark**
**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

**Depth range: 20.000 - 40.000 m**

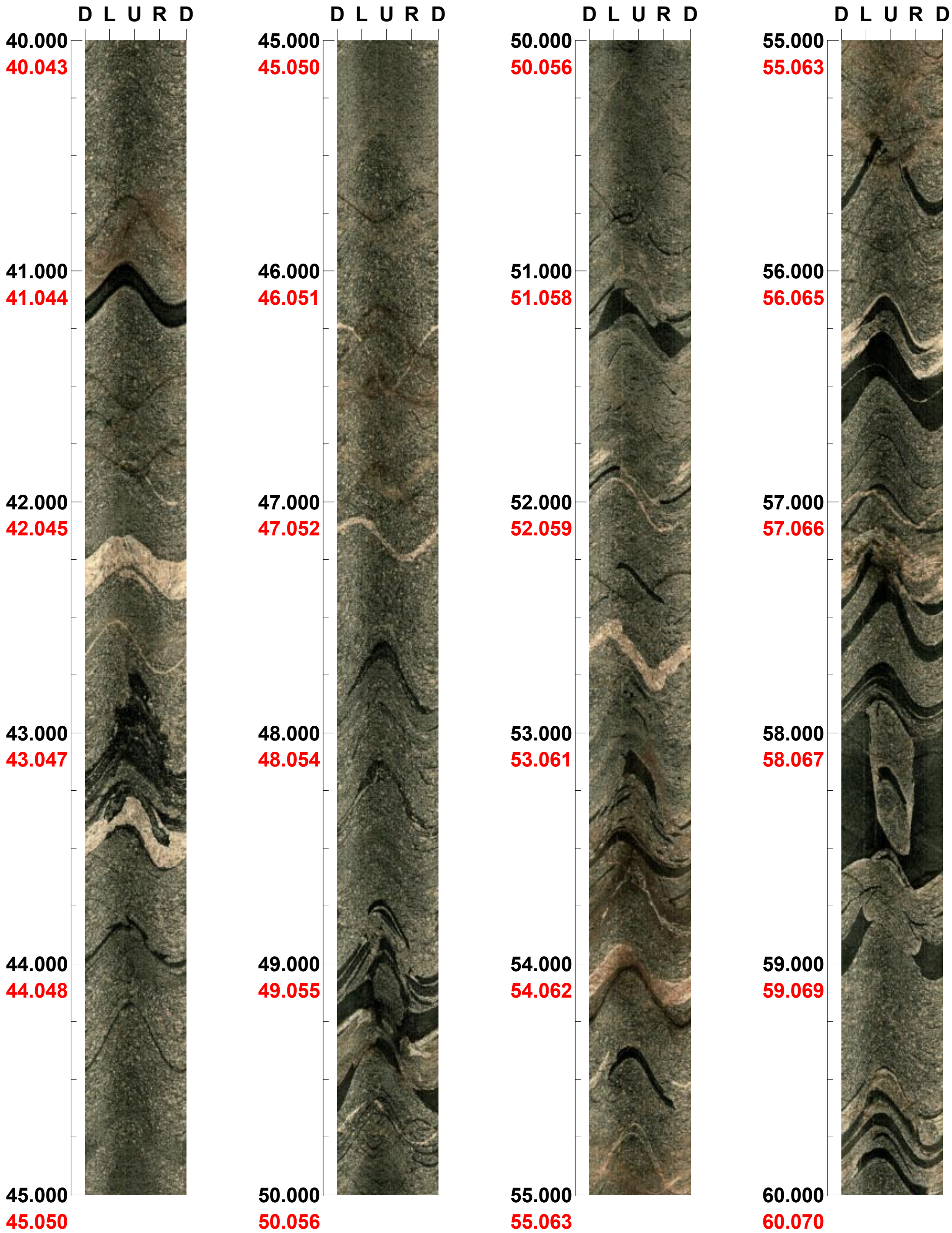



**( 2 / 10 )** **Scale: 1/25** **Aspect ratio: 100 %**

**Project name: Forsmark**

**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

**Depth range: 40.000 - 60.000 m**

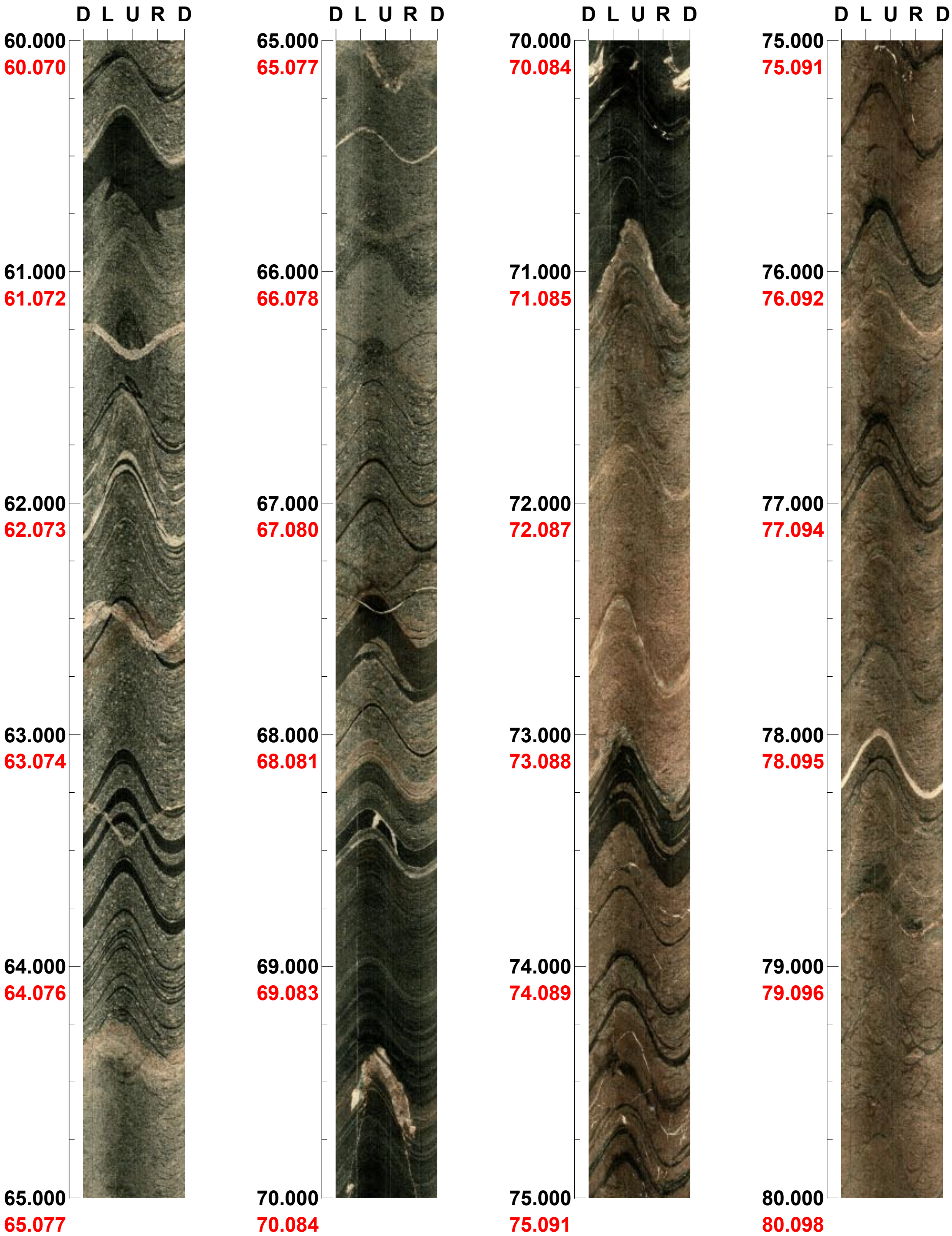



**( 3 / 10 )** **Scale: 1/25** **Aspect ratio: 100 %**

**Project name: Forsmark**

**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

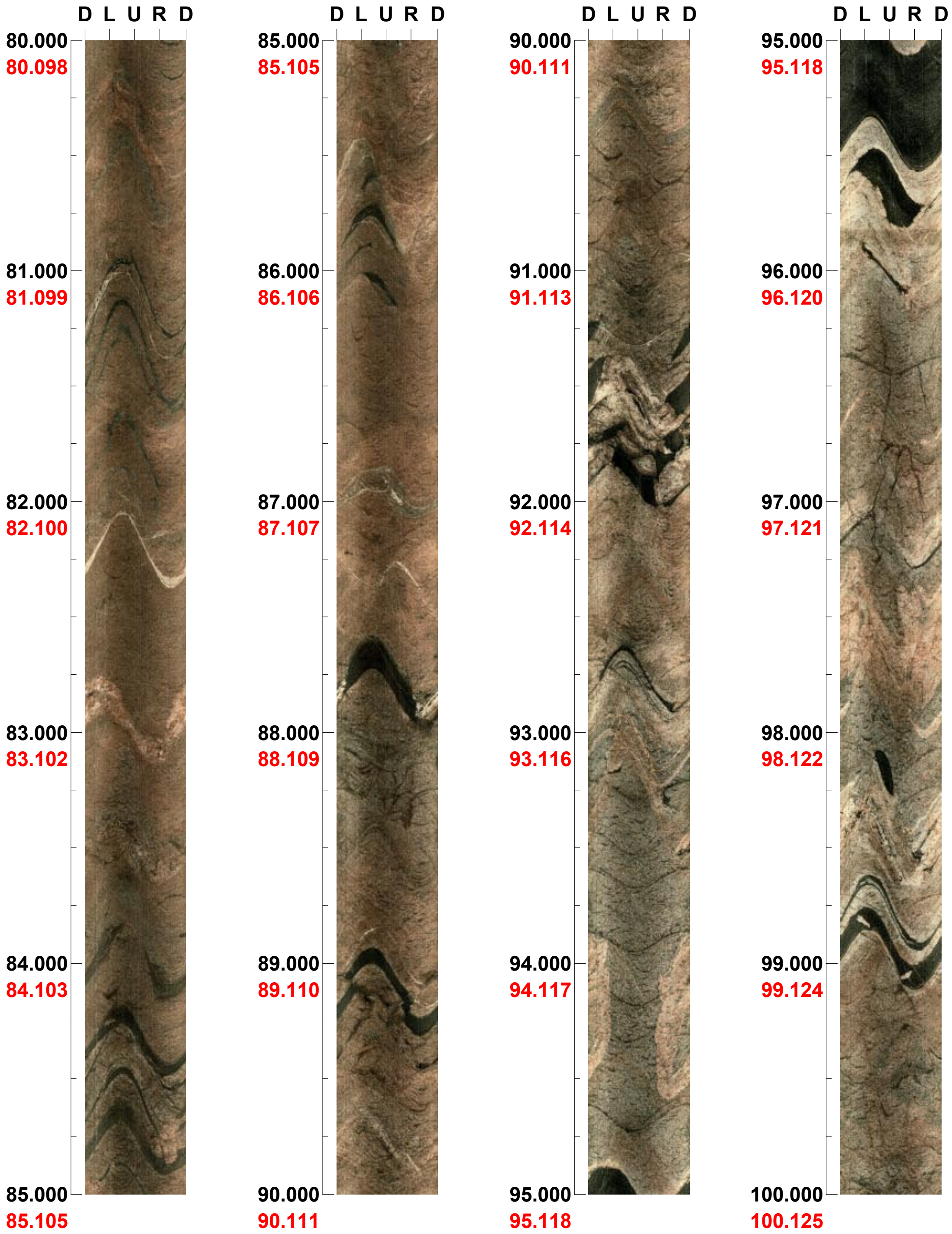
**Depth range: 60.000 - 80.000 m**




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

**Project name: Forsmark**
**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

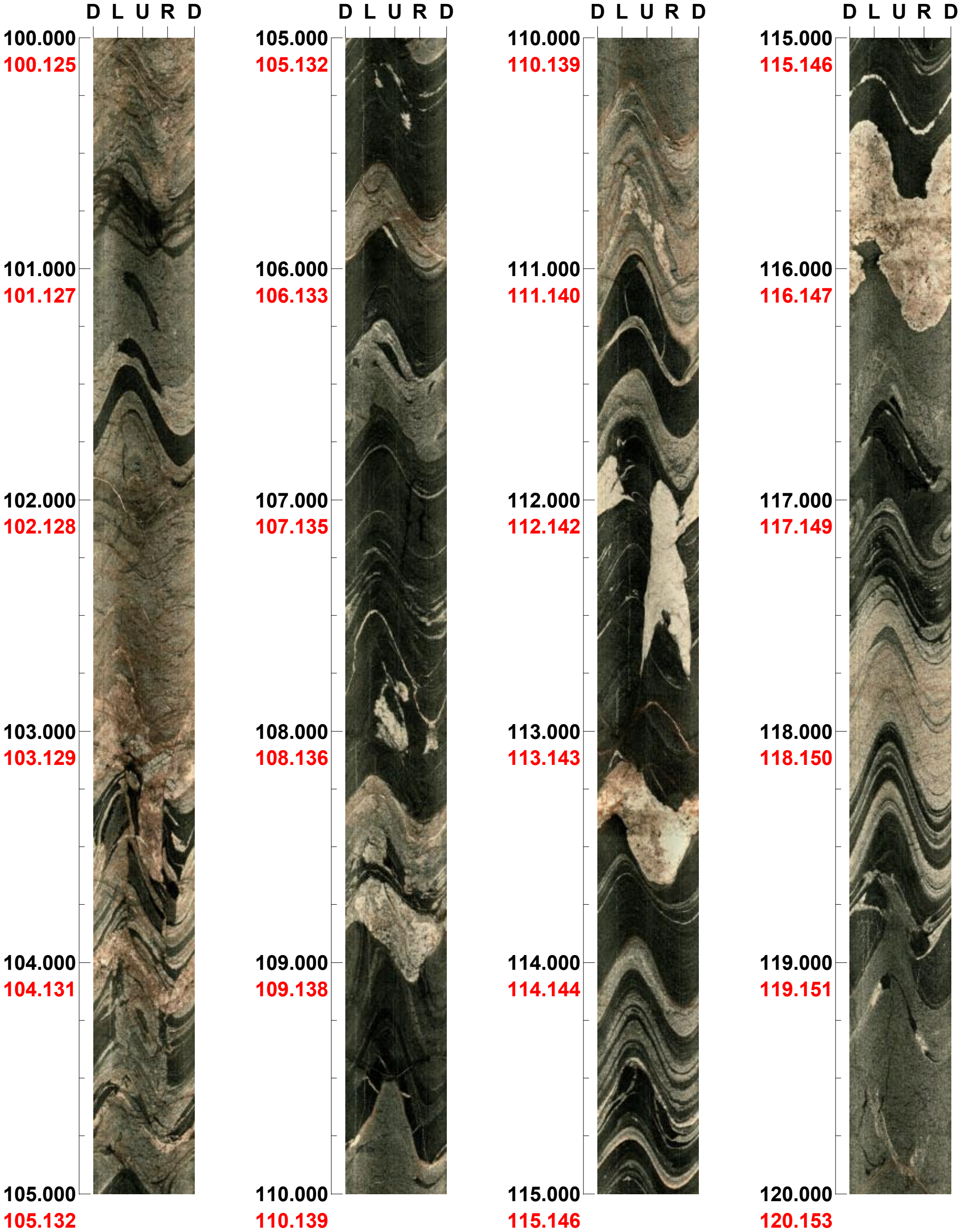
**Depth range: 80.000 - 100.000 m**




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

Project name: Forsmark
Bore hole No.: HFM37 Azimuth: 41 Inclination: -59

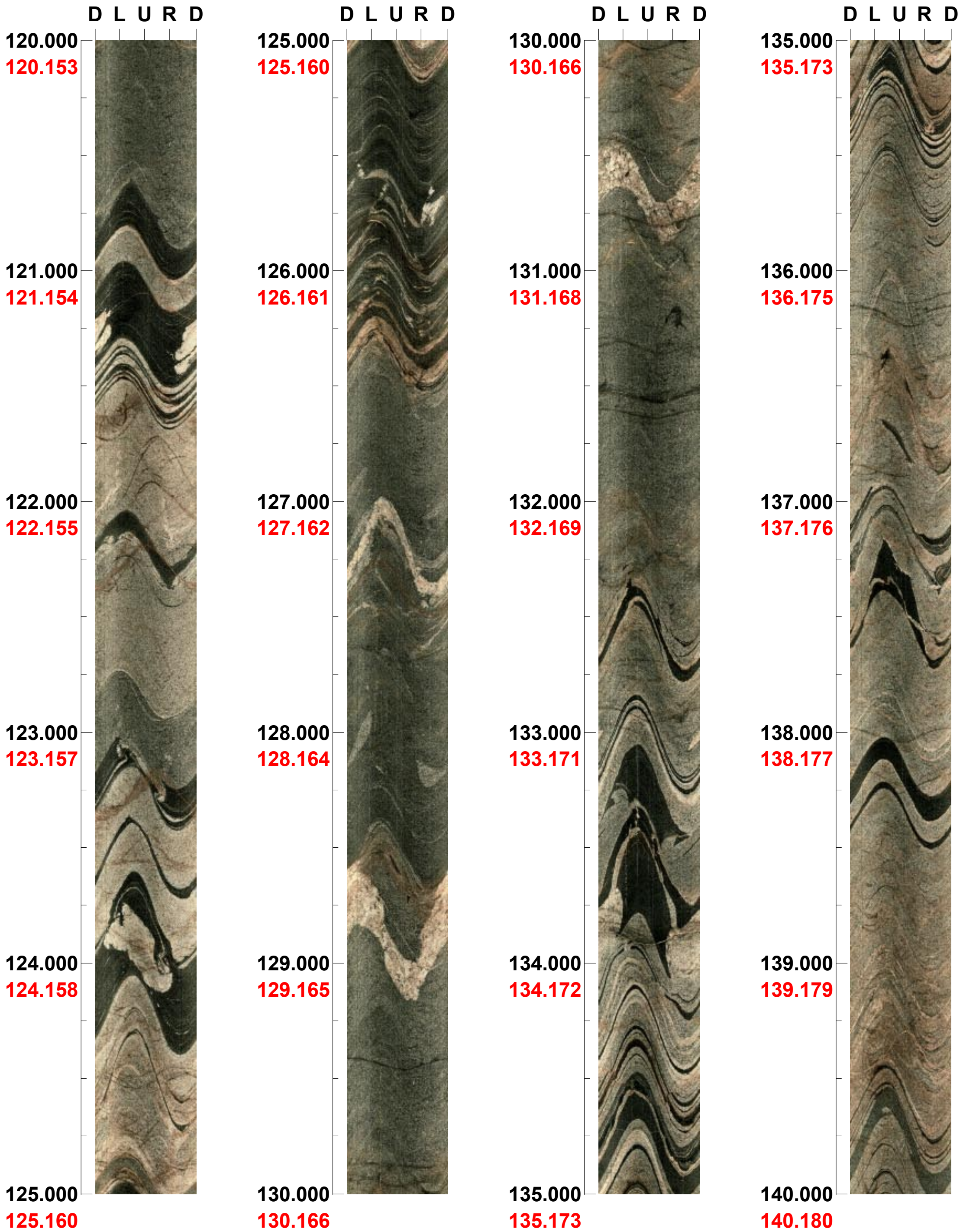
Depth range: 100.000 - 120.000 m




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

**Project name: Forsmark**
**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

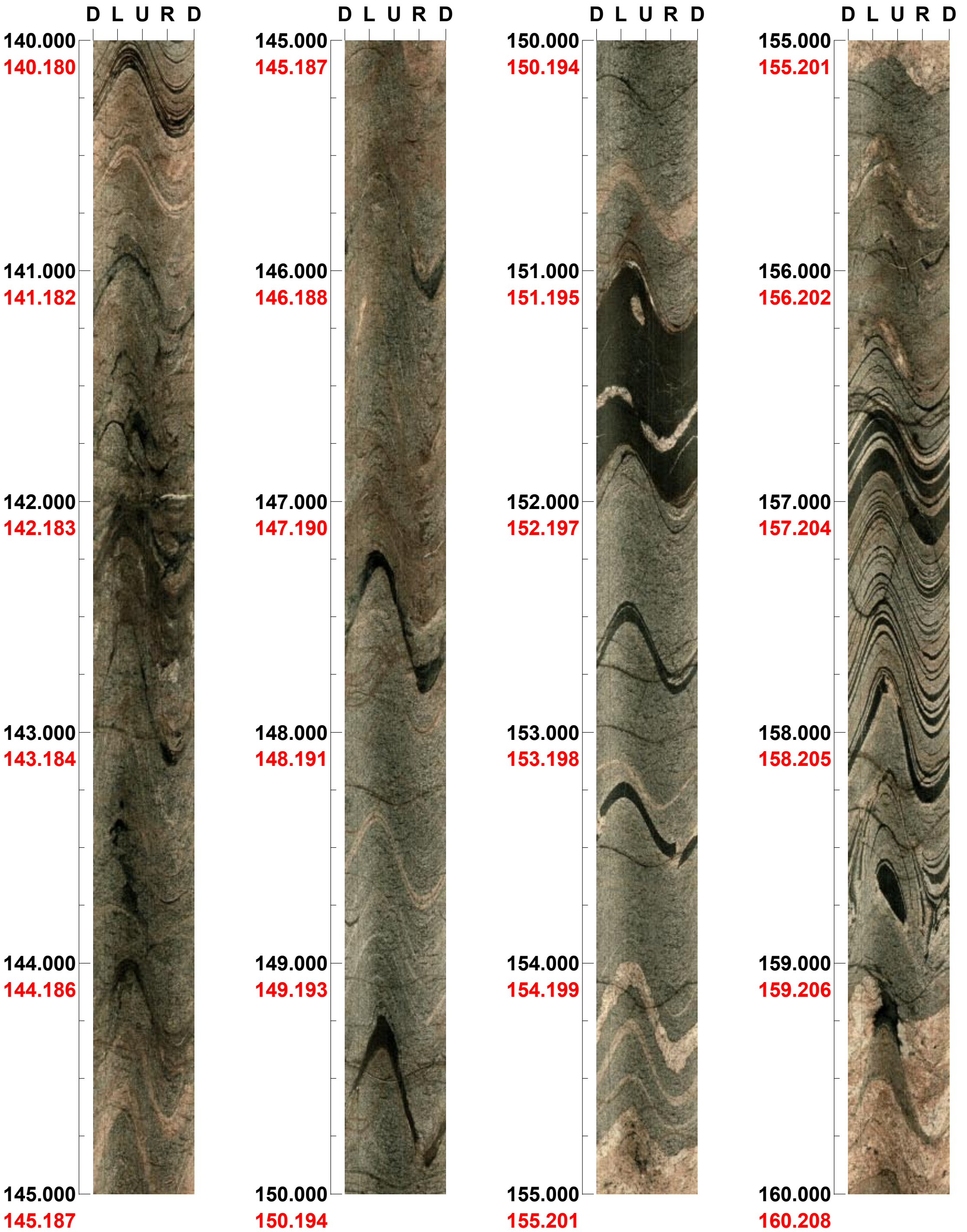
**Depth range: 120.000 - 140.000 m**




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

**Project name: Forsmark**
**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

**Depth range: 140.000 - 160.000 m**




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

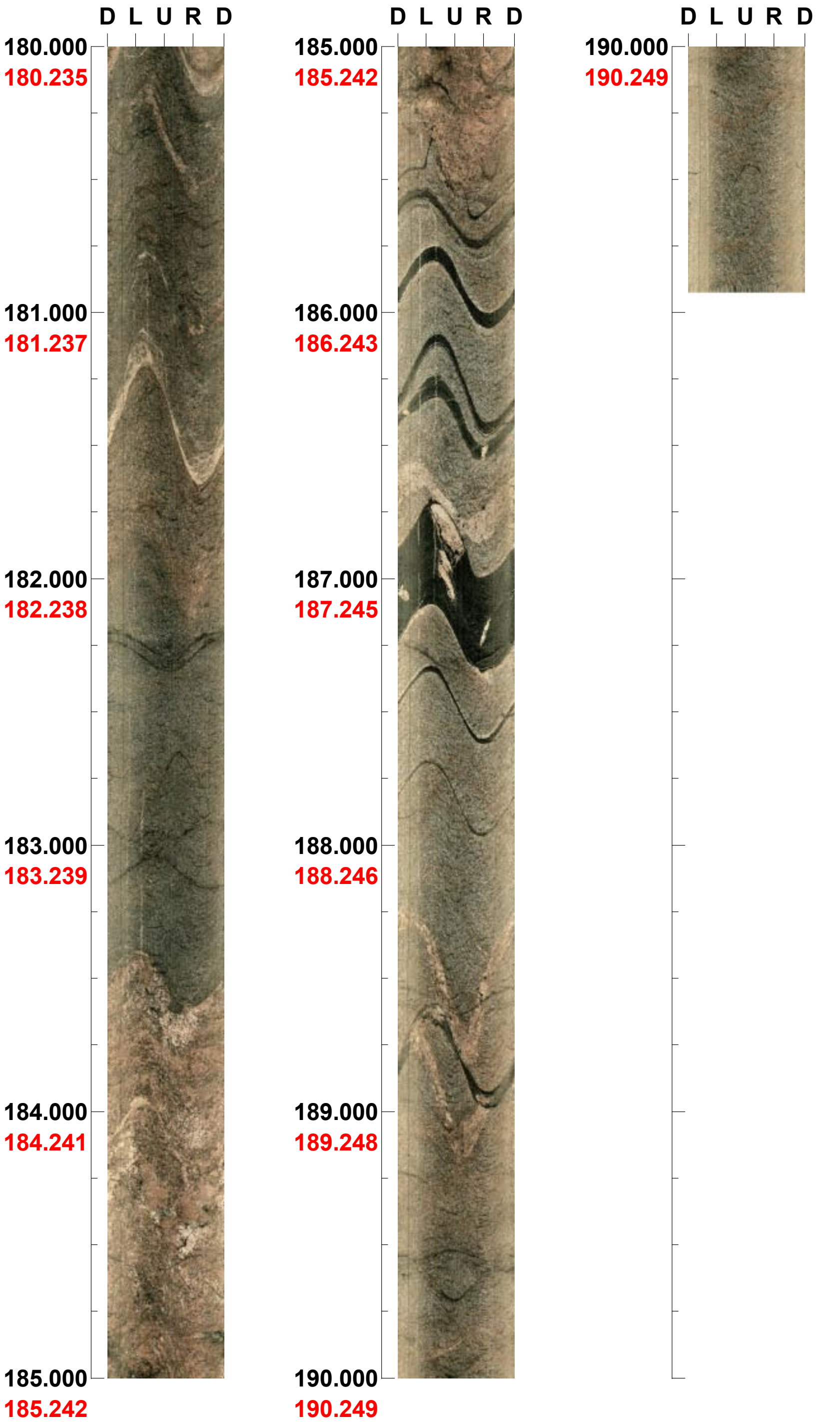
**Project name: Forsmark**
**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

**Depth range: 160.000 - 180.000 m**


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

**Project name: Forsmark**
**Bore hole No.: HFM37** **Azimuth: 41** **Inclination: -59**

**Depth range: 180.000 - 190.923 m**




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

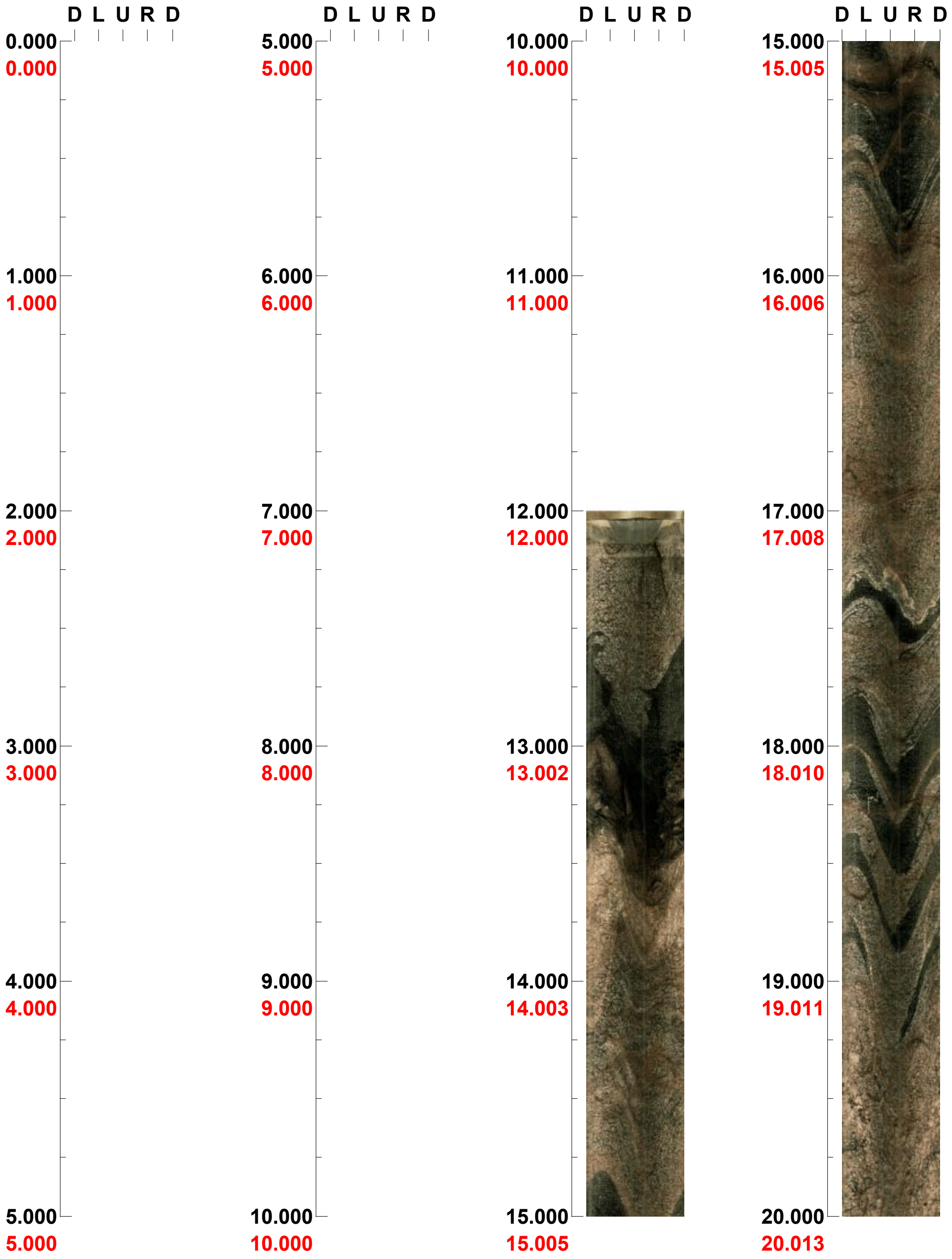
## BIPS logging in HFM26, 12 to 202 m

**Project name: Forsmark**

| | |
|---|---|
| Image file | : c:\work\r55__k~2\bips\hfm26.bip |
| BDT file | : c:\work\r55__k~2\bips\hfm26.bdt |
| Locality | : FORSMARK |
| Bore hole number | : HFM26 |
| Date | : 06/09/22 |
| Time | : 08:49:00 |
| Depth range | : 12.000 - 201.995 m |
| Azimuth | : 112 |
| Inclination | : -54 |
| 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 | : 11 |
| Color | : +0 +0 +0 |

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

**Depth range: 0.000 - 20.000 m**




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

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

**Depth range: 20.000 - 40.000 m**


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

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

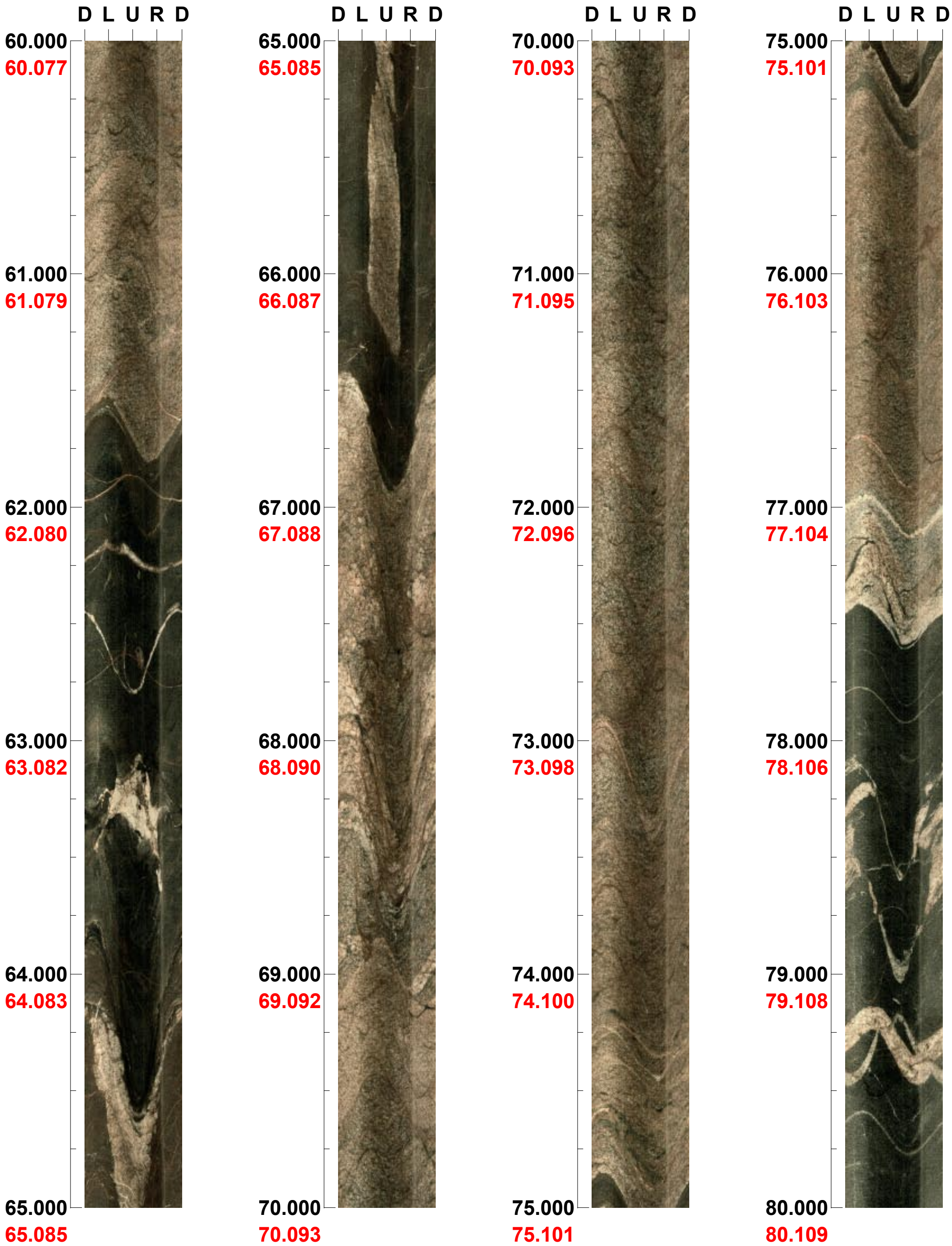
**Depth range: 40.000 - 60.000 m**


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

**Project name: Forsmark**

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

**Depth range: 60.000 - 80.000 m**




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

**Project name: Forsmark**

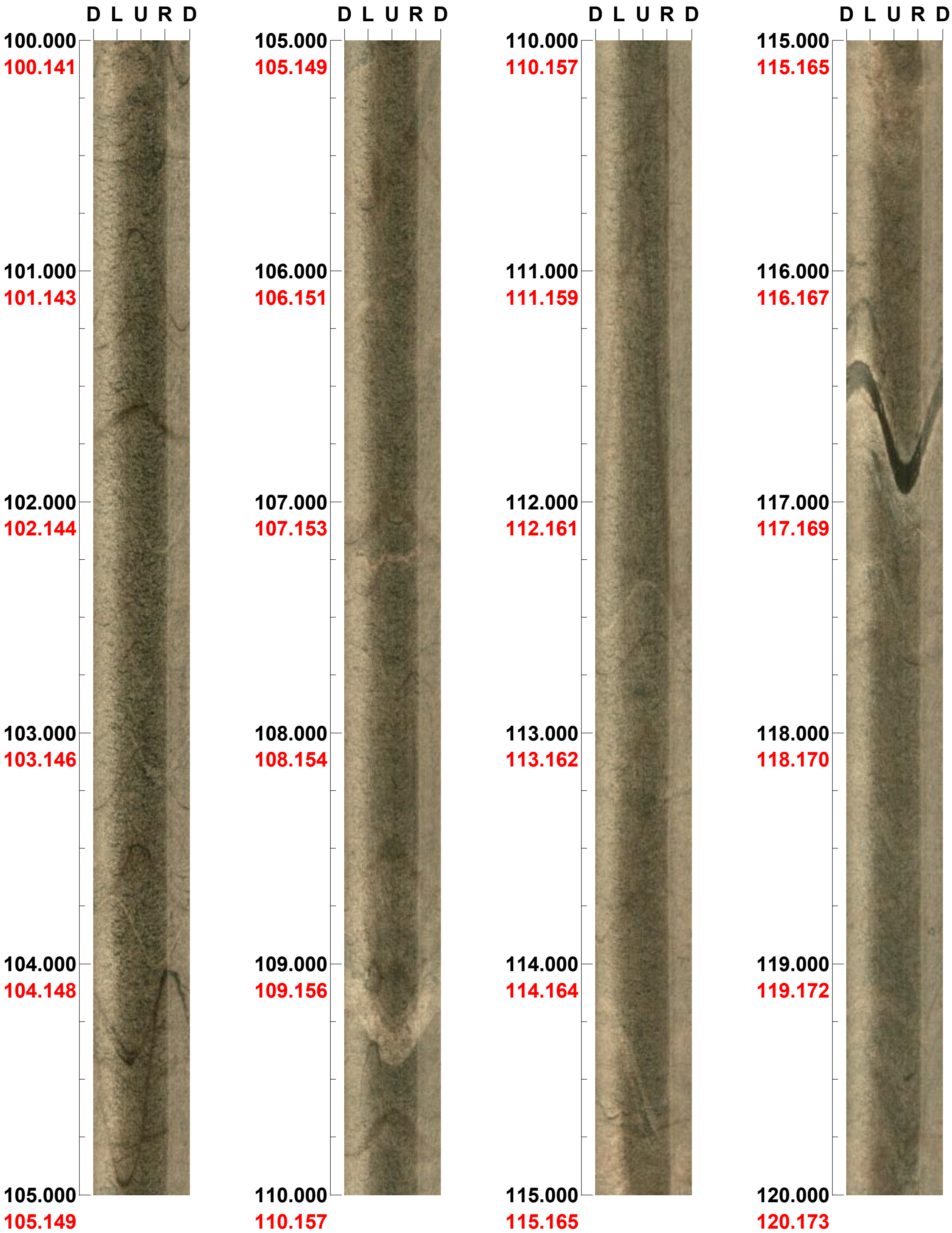
**Bore hole No.: HFM26** **Azimuth: 112** **Inclination: -54**

**Depth range: 80.000 - 100.000 m**


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

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

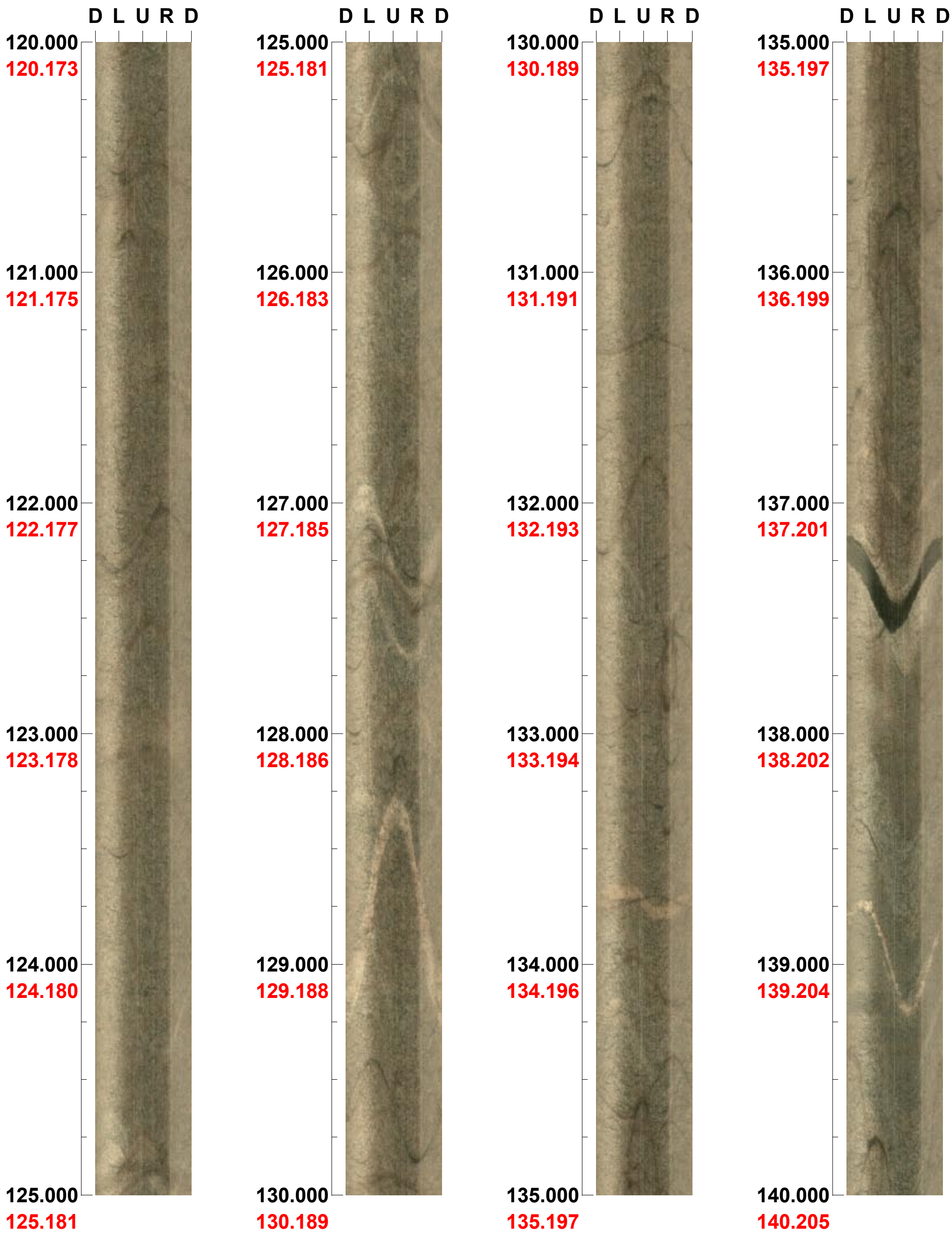
**Depth range: 100.000 - 120.000 m**




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

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

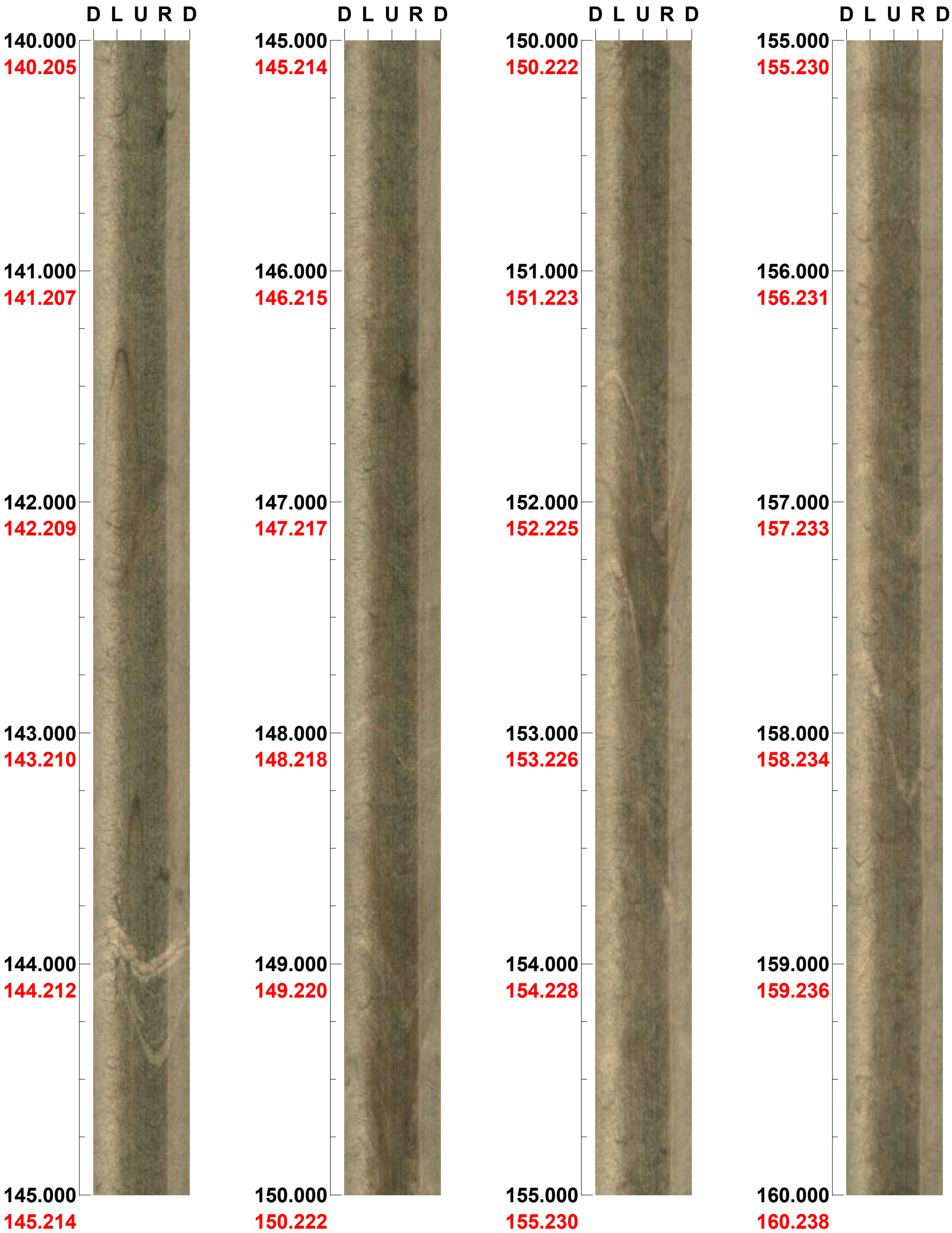
**Depth range: 120.000 - 140.000 m**




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

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

**Depth range: 140.000 - 160.000 m**




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

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

**Depth range: 160.000 - 180.000 m**

D L U R D

160.000
160.238
161.000
161.239
162.000
162.241
163.000
163.242
164.000
164.244
165.000
165.246

D L U R D

165.000
165.246
166.000
166.247
167.000
167.249
168.000
168.250
169.000
169.252
170.000
170.254

D L U R D

170.000
170.254
171.000
171.255
172.000
172.257
173.000
173.258
174.000
174.260
175.000
175.262

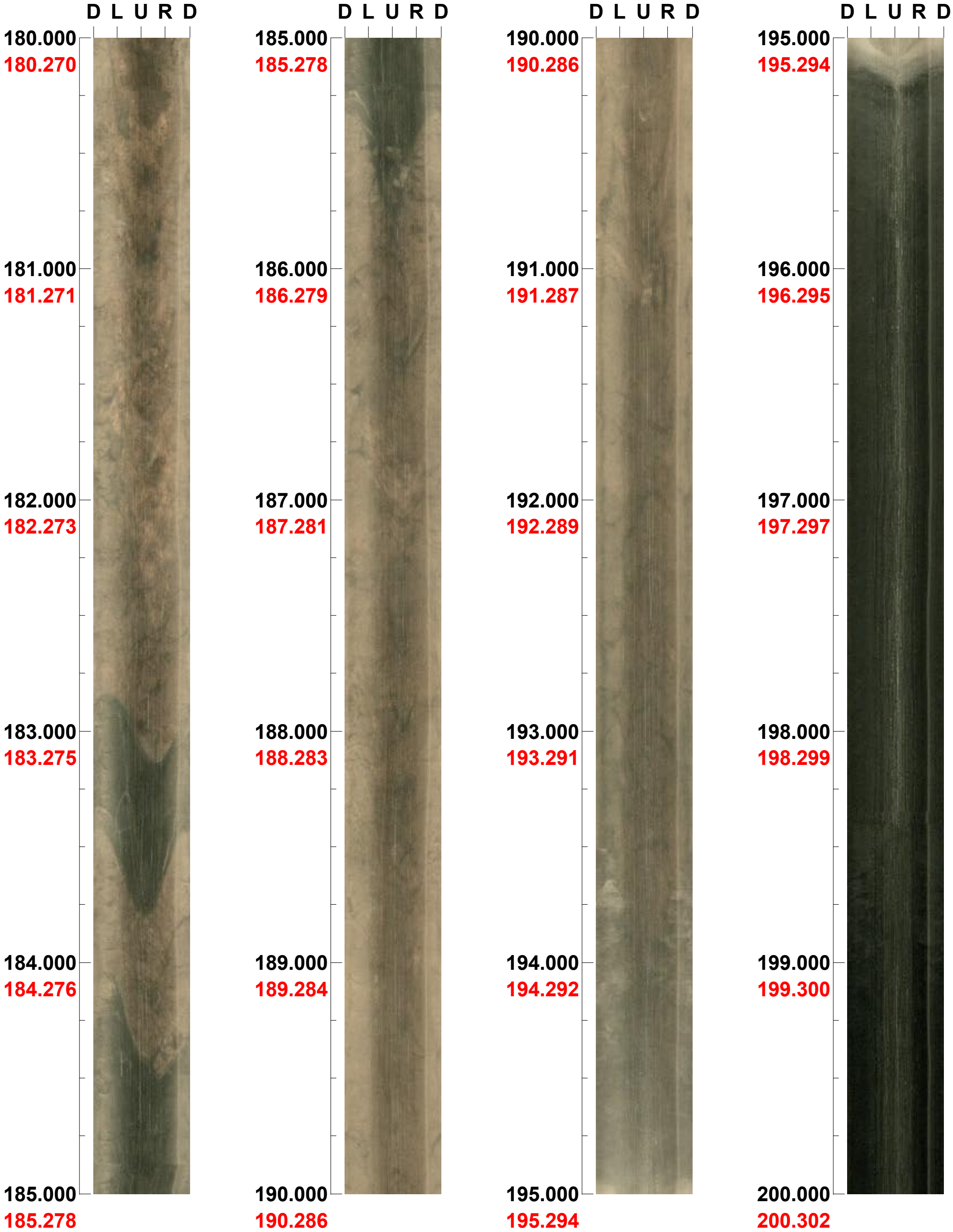
D L U R D

175.000
175.262
176.000
176.263
177.000
177.265
178.000
178.266
179.000
179.268
180.000
180.270

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

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

**Depth range: 180.000 - 200.000 m**

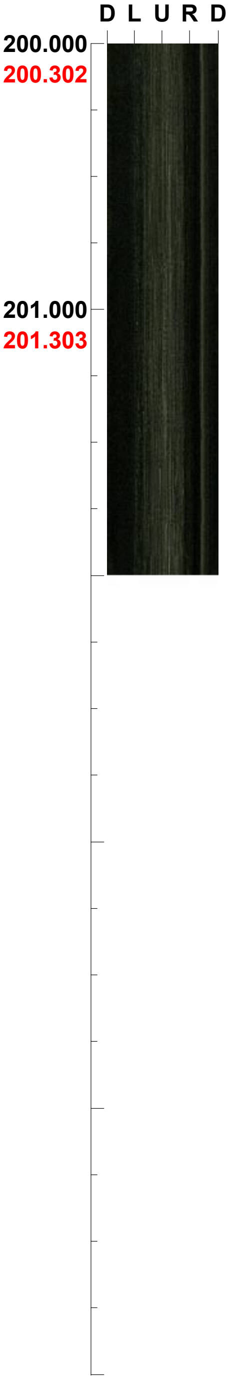



**( 10 / 11 )** **Scale: 1/25** **Aspect ratio: 175 %**

**Project name: Forsmark**

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

**Depth range: 200.000 - 201.995 m**




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