

Äspö Hard Rock Laboratory

BIPS and radar in KA3011A01 and KA3065A01

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May 2013

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ISSN 1651-4416

SKB P-13-18

ID 1346445

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Keywords: BIPS, RAMAC, Radar, TV.

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Data in SKB's database can be changed for different reasons. Minor changes in SKB's database will not necessarily result in a revised report. Data revisions may also be presented as supplements, available at www.skb.se.

A pdf version of this document can be downloaded from www.skb.se.

Abstract

This report includes the data gained in geophysical logging operations performed within the extension of the Äspö HRL. The logging operations presented here includes BIPS and borehole radar in the core-drilled boreholes KA3011A01 and KA3065A01.

All measurements were conducted by Malå Geoscience AB in November and December 2011.

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 surveys, the results are presented as images. Radar data is presented in radargrams and the identified reflectors are listed.

The borehole radar data quality from KA3011A01 and KA3065A01 is relatively good. It is mainly the conductive formation water that makes the radar wave to attenuate, which decreases the penetration and reduces the ability for the radar to identify structures.

The borehole radar measurements resulted in KA3011A01 in 7 identified radar reflectors. Corresponding figures for KA3065A01 are 5.

The basic conditions of the BIPS logging for geological mapping and orientation of structures are very good for the boreholes in this project.

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom Äspö Utbyggnadsprojekt. Mätningarna som presenteras här omfattar borrhålsradarmätningar (RAMAC) och BIPS-loggningar. Alla mätningar är utförda av Malå Geoscience AB under november och december 2011.

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 KA3011A01 och KA3065A01 var relativt bra. Det är främst det konduktiva formationsvattnet som reducerar penetrationen och därmed minskar möjligheterna att identifiera strukturer. Totalt har 7 radarreflektorer identifierats i KA3011A01. Motsvarande siffror för KA3065A011 är 5.

BIPS-bilderna visar att förutsättningarna för geologisk kartering och sprickorientering är väldigt goda för de två borrhålen.

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1 Introduction

This report presents the data gained in geophysical logging operations, which is one of the activities performed within the extension of the Äspö HRL. The logging operations presented here includes borehole radar (RAMAC) and BIPS.

The work was carried out in accordance with activity plan AP TD TUDP002-11-082 for borehole KA3011A01 and activity plan AP TD TUDP002-11-094 for borehole KA3065A01. In Table 1-1 the controlling documents for performing this activity are listed. Both the activity plan and method descriptions are SKB's internal controlling documents.

This report includes measurements in the boreholes listed in Table 1-2.

All measurements were conducted by Malå Geoscience AB in-between November 22 and December 20 2011. The investigation site and location of the boreholes are 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's internal controlling documents).

Activity plan	Number	Version
Äspö utbyggnad, DP1-Karakterisering BIPS och radar i KA3011A01	AP TD TUDP002-11-082	1.0
Äspö utbyggnad, DP1-Karakterisering BIPS och radar i KA3065A01	AP TD TUDP002-11-094	1.0
Method descriptions	Number	Version
Metodbeskrivning för TV-loggning med BIPS	SKB MD 222.006	2.0
Metodbeskrivning för borrhålsradar	SKB MD 252.020	4.0
Metodinstruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning	SKB MD 600.004	1.0

Table 1-2. Technical data for the boreholes and performed surveys.

Performed surveys	KA3011A01	KA3065A01
BIPS	X	X
Radar 20MHz dipol	X	X
Radar directional	X	X
Borehole parameter		
Inclination at TOC	-1.18°	-0.56°
Bearing at TOC, RT90 2,5 gon V	43.0°	43.3°
Bearing at TOC, Äspö 96	54.97°	55.35°
Length (m)	100.15	125.25
Casing (m)	2.17	2.29
Borehole diameter (mm)	75.8	75.8

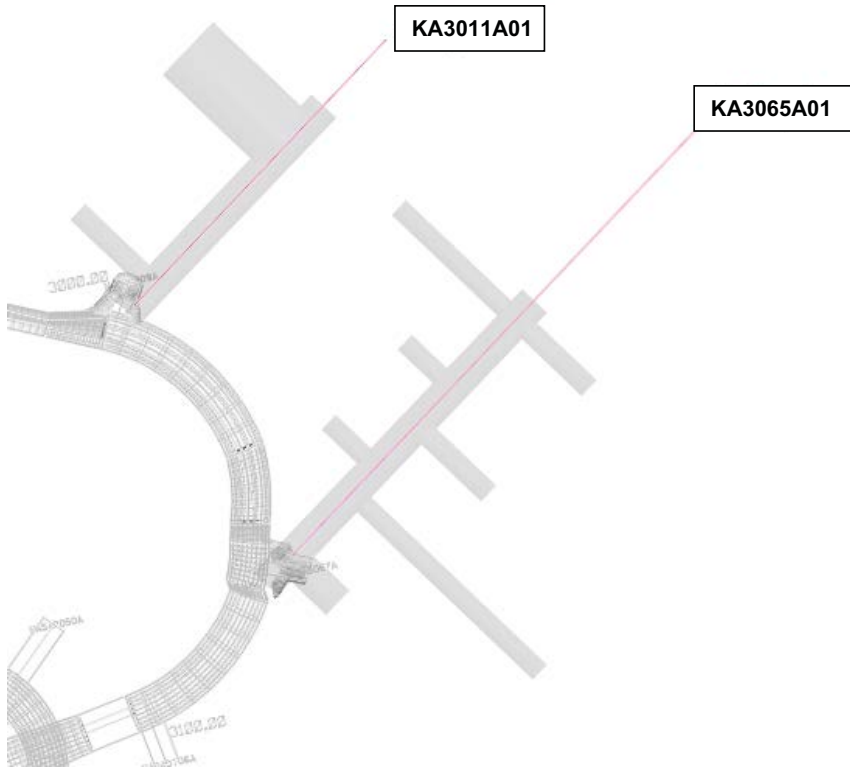


Figure 1-1. Map of the location of the boreholes at Äspö HRL.

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

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 SKB 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 60 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 SKB 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).

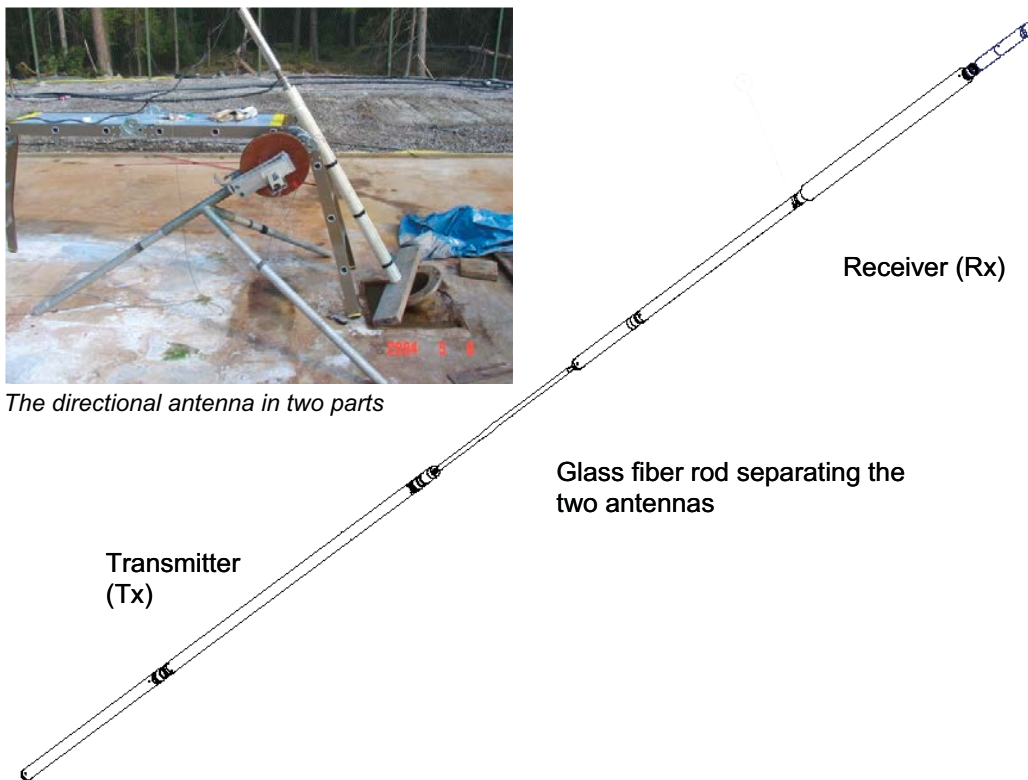


Figure 3-1. Example of a borehole radar antenna.

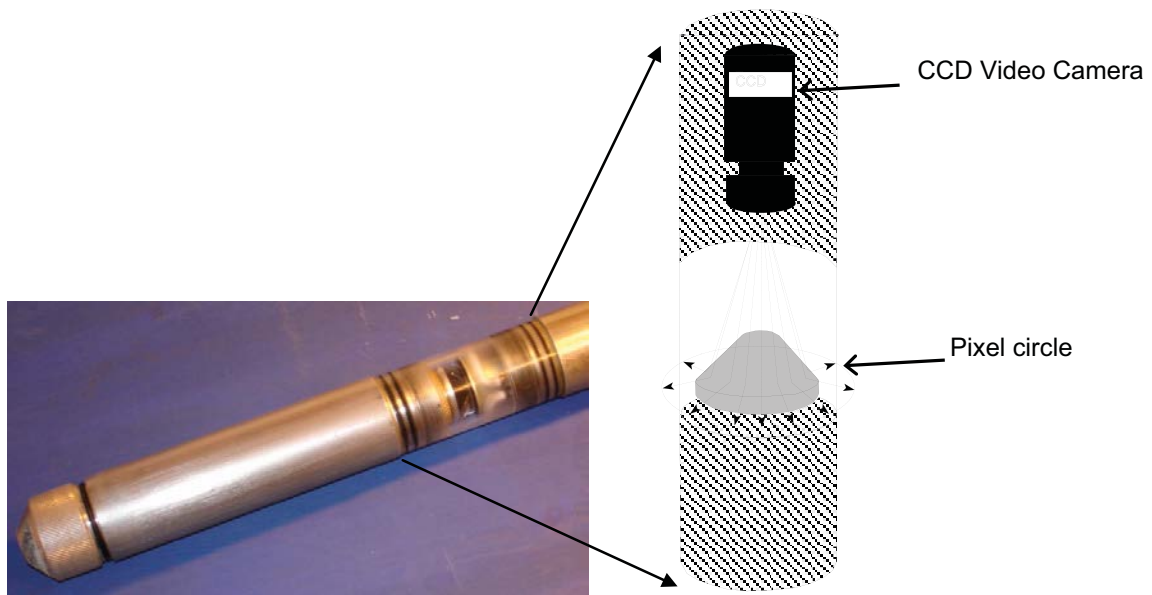


Figure 3-2. The BIP-system. Illustration of the conical mirror scanning.

4 Execution

4.1 General

4.1.1 RAMAC Radar

The measurements in KA3011A01 and KA3065A01 were carried out with dipole radar antennas, with a frequency of 20 MHz. Measurements were also carried out with a 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 was made step wise, with a short pause for each measurement occasion. The antennas (transmitter and receiver, both for dipole and directional) were kept at a fixed separation by glass fiber rods according to Table 4-1 and 4-2. See also Figures 3-1 and 4-1.

All measurements were performed in accordance with the instructions and guidelines from SKB (internal document SKB 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.

Table 4-1. Radar logging information from KA3011A01.

Site: Äspö HRL BH: KA3011A01 Type: Type: Directional/Dipole Operator: CG		Logging company: MALÅ GeoScience Equipment: SKB RAMAC Manufacturer: MALÅ GeoScience	
	Antenna	Directional	20 MHz
Logging date	2011-11-23	2011-11-23	2011-11-23
Reference	TOC	TOC	TOC
Sampling frequency (MHz)	615	239	239
Number of samples	512	518	518
Number of stacks	32	Auto	Auto
Signal position	411.3	-1.44	-1.44
Logging from (m)	3.40	6.25	6.25
Logging to (m)	95.4	92.7	92.7
Trace interval (m)	0.5	0.25	0.25
Antenna separation (m)	5.73	10.05	10.05

Table 4-2. Radar logging information from KA3065A01.

Site: Äspö HRL BH: KA3065A01 Type: Type: Directional/Dipole Operator: CG		Logging company: MALÅ GeoScience Equipment: SKB RAMAC Manufacturer: MALÅ GeoScience	
	Antenna	Directional	20 MHz
Logging date	2011-12-20	2011-12-19	2011-12-19
Reference	TOC	TOC	TOC
Sampling frequency (MHz)	615	239	239
Number of samples	512	518	518
Number of stacks	32	Auto	Auto
Signal position	410.5	-1.42	-1.42
Logging from (m)	3.40	6.25	6.25
Logging to (m)	120.4	117.50	117.50
Trace interval (m)	0.5	0.25	0.25
Antenna separation (m)	5.73	10.05	10.05

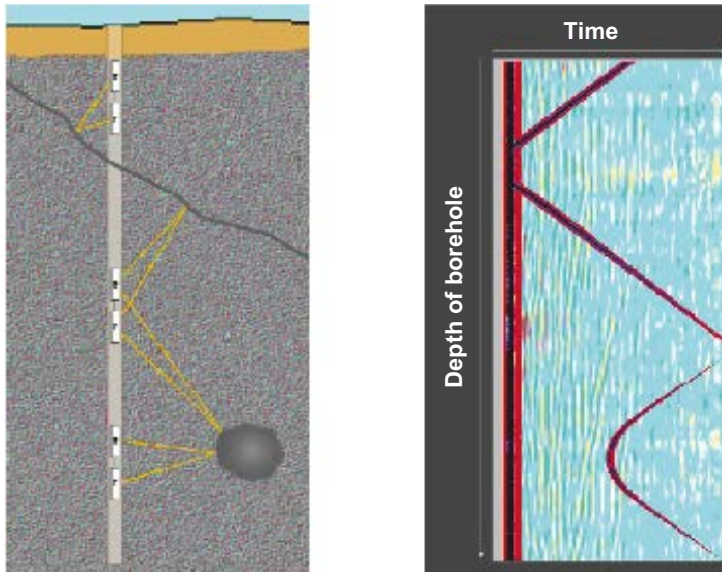


Figure 4-1. The principle of radar borehole reflection survey and an example of result.

The functionality of the directional antenna was tested before start of the survey in KA3011A01. 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 approximately 5 degrees. 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 for the surveyed boreholes see Table 4-1 to 4-3.

4.1.2 BIPS

All measurements were performed in accordance with the instructions and guidelines from SKB (internal document SKB 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 based on an air bulb in an alcohol liquid was used to measure the orientation of the images in the logged boreholes.

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 campaign. 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 presented in Appendices 3–4 in this report.

4.1.3 Length measurements

During logging of the RAMAC and BIPS systems the length measuring wheel on the push rig was used for length controlling of the survey. For an accurate depth control the length recording was adjusted regularly for every 50 metre by calculating the number of the 2 metre long aluminium rods.

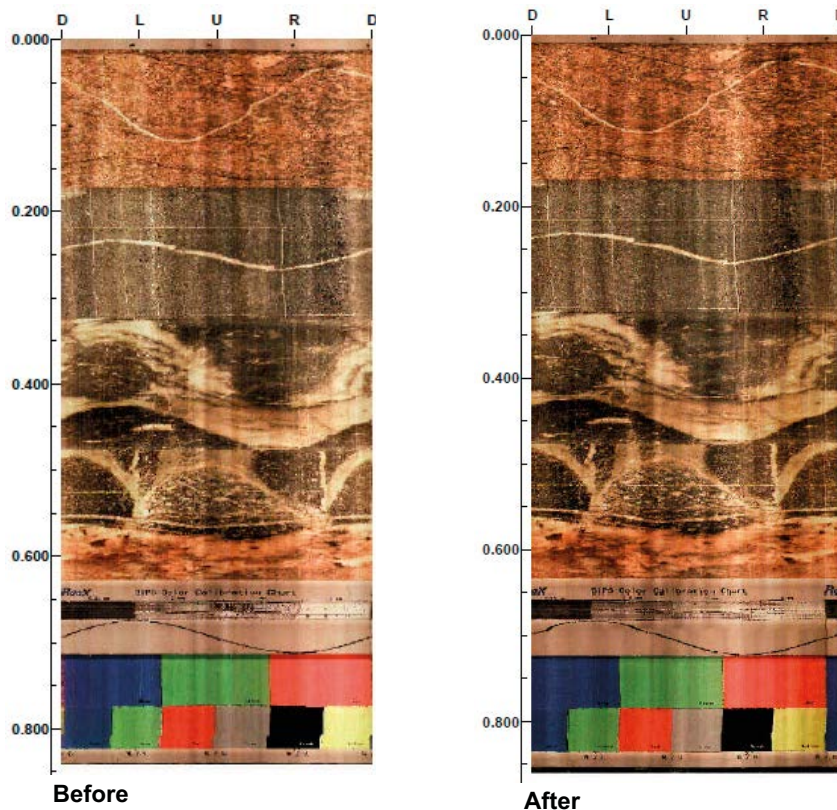


Figure 4-2. Results from logging in the test pipe before and after the logging campaign in November and December, 2011.

4.2 Analyses and Interpretation

4.2.1 Radar

The result from radar measurements is most often presented in the form of a radargram where the position of the probes is shown along one axis and the radar wave propagation and reflection is shown along the other axis. The amplitude of the received signal is shown in the radargram with a grey scale where black colour corresponds to 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 during the Oskarshamn site investigation is used between KLX07A and KLX07B. The velocity measurement was performed by keeping the transmitter fixed in one borehole while moving the receiver downwards in the second borehole. The velocity measurement was performed with the 20 MHz antennas in boreholes KLX07A and KLX07B (Gustafsson and Gustafsson 2005).

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.

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 Table 4-3. 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 Tables 5-1 to 5-2 and are also visible on the radargrams in Appendices 1-2.

Table 4-3. Processing steps for borehole radar data.

Site: Äspö HRL	Logging company: MALÅ GeoScience AB	
BH: KA3011A01, KA3065A01	Equipment: SKB RAMAC	
Type: Directional/Dipole	Manufacturer: MALÅ GeoScience	
Interpret: CG		
	Antenna	20 MHz
	Directional	
Processing	Move start time (-34 samples)	Move start time (-68)
	DC shift (300-511)	DC shift (300-500)
	Time gain (start 52 lin 222 exp 1)	Gain (start 77 lin 33 exp 0.1)
	(FIR)	

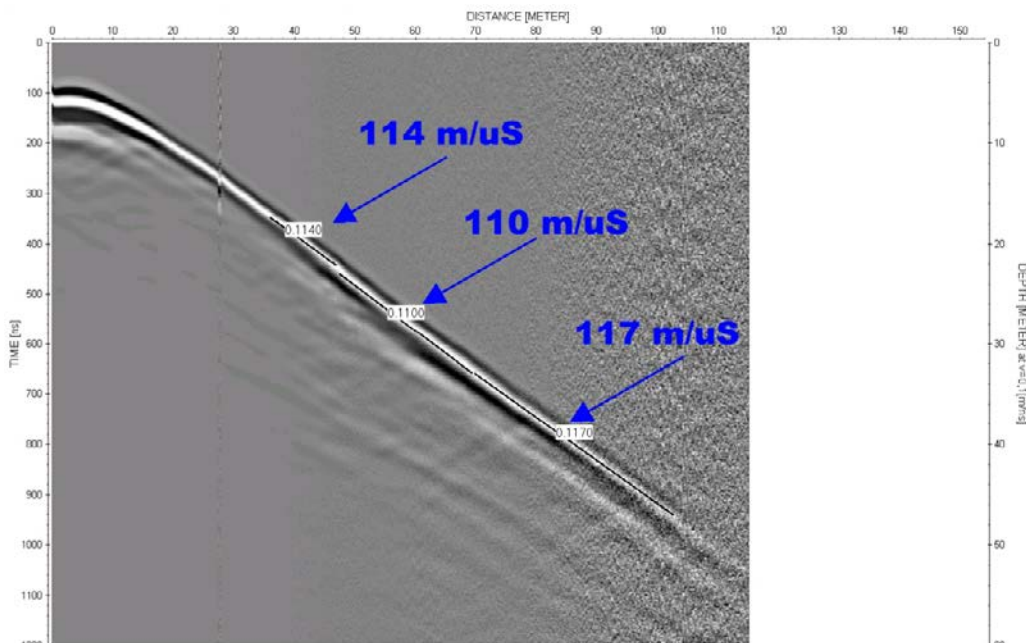


Figure 4-3. Results from velocity measurements (Gustafsson and Gustafsson 2005).

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 in November and December 2011.

5 Results

The results from the BIPS measurements 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 on CD and MO disks stored by SKB.

The RAMAC radar data was delivered as raw data file format *.rd3 (dipole antennas) or *.rd5 (directional antenna) for 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 to 5-5. Radar data is also visualized in Appendices 1–2. It should be remembered that the images in Appendices 1–2 are only a composite picture of all events 360 degrees around the borehole, and do not reflect the orientation of the structures.

Only the larger clearly visible structures are interpreted in RadinterSKB. An overview of the boreholes is given in Figures 5-1 to 5-2 below. A number of minor structures also exist but are not interpreted as indicated in Appendices 1–2. 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. It should also be pointed out that reflections interpreted will always get an intersection point with the borehole path, but being located further away. They may in some cases not reach the borehole.

The data quality from KA3011A01 and KA3065A01 (as seen in Appendix 1 and 2) is good. The borehole intersects with several structures but no big drop in the amplitude values for the first arrival occurs, which is an indication of a homogenous rock mass without zones carrying water. A conductive environment makes the radar wave to attenuate, which decreases the penetration. This conductive environment of course also reduces the possibility to distinguish and interpret possibly structures in the rock which otherwise could give a reflection.

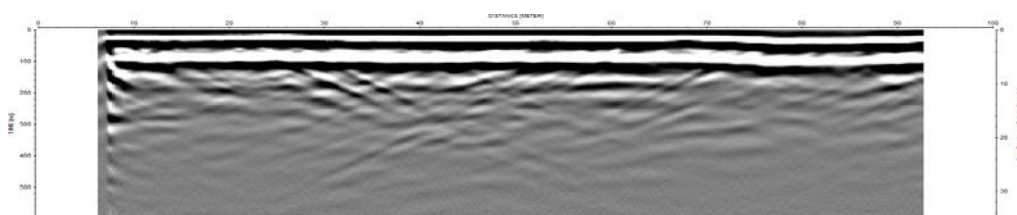


Figure 5-1. Overview (20 MHz data) of the radar data for the borehole KA3011A01.

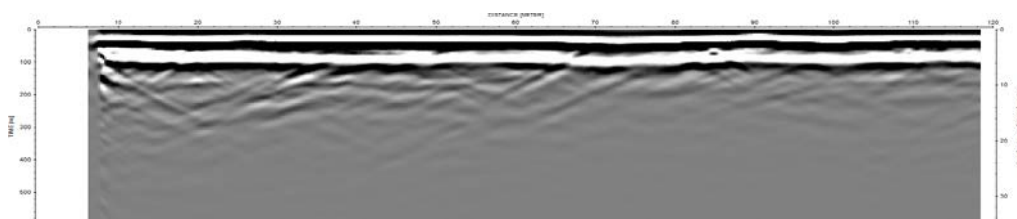


Figure 5-2. Overview (20 MHz data) of the radar data for the borehole KA3065A01.

The effect of a conductive environment is also seen in the directional antenna which makes it more difficult to interpret the direction to the identified structures.

Table 5-1 to Table 5-2 summarises the interpretation of radar data from KA3011A01 and KA3065A01. In the tables the intersection length and intersection angle to the identified structures are listed.

The direction to the reflector (object) is also given for structures that were possible to determine. As seen some radar reflectors in Tables 5-1 and 5-2 are marked with \pm , which indicates an uncertainty in the interpretation of direction. The direction can in these cases be ± 180 degrees. The definition for 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 the tables. The plane strike is the angle between line of the plane's cross-section with the surface and the Magnetic North direction. It counts clockwise and can be between 0 and 359 degrees. A strike of 0 degrees implies a dip to the east while a strike of 180 degrees implies a dip to the west. The plane dip is the angle between the plane and the surface. It can vary between 0 and 90 degrees.

Table 5-1. Interpretation of radar reflectors from the dipole antenna 20 MHz and the directional antenna 60 MHz in borehole KA3011A01.

Radinter model information (Directional and dipole antennas)							
Site: Äspö HRL Borehole name: KA3011A01 Nominal velocity (m/ μ s): 117.0							
Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
1	16.25	61	105	82	151		
2	20.44	56	273	89	273		
3	62.34	66	42 \pm	61	334	56	87
4	67.36	86	60 \pm	69	345	72	92
5	80.25	62	87 \pm	89	332	88	100
6	87.89	56	84 \pm	87	338	85	91
7	112.17	33	99 \pm	82	185	83	243

Table 5-2. Interpretation of radar reflectors from the dipole antenna 20 MHz and the directional antenna 60 MHz in borehole KA3065A01.

Radinter model information (Directional and dipole antennas)							
Site: Äspö HRL Borehole name: KA3065A01 Nominal velocity (m/ μ s): 117.0							
Name	Intersection length	Intersection angle	RadInter direction to object (gravity roll)	Dip 1	Strike 1	Dip 2	Strike 2
1	25.31	75	21	77	309		
2	45.40	43	147	50	157		
3	73.64	58	228	59	83		
4	87.54	40	231	69	96		
5	146.02	35					

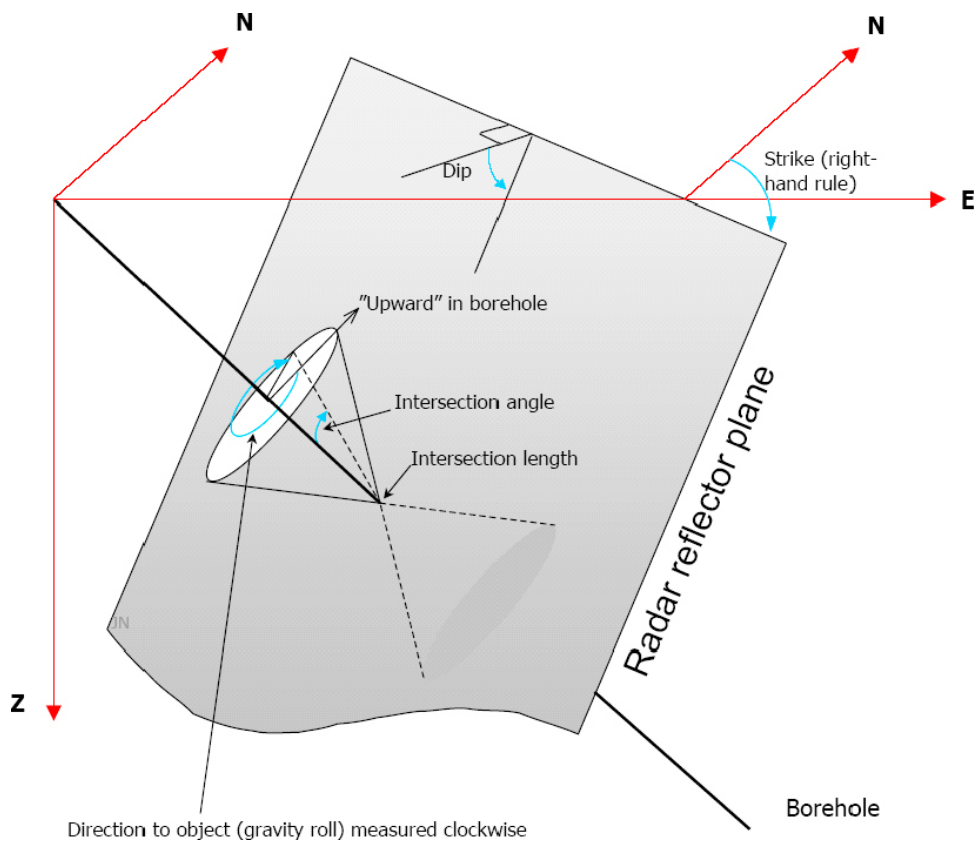


Figure 5-3. Definition of intersection angle, direction to object using gravity roll, dip and strike using the right hand rule as presented in Table 5-1 to 5-2.

In Appendices 1–2, the amplitude of the first arrival is plotted against the depth, for the 20 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 higher water content, i.e. increases in electric conductivity. Sections in the boreholes with a decrease in amplitude are shown in Table 5-3 to Table 5-4.

Table 5-3. Borehole length intervals in KA3011A01 with decreased amplitude for the 20 MHz antenna.

Length (m)
83–87

Table 5-4. Borehole length intervals in KA3065A01 with decreased amplitude for the 20 MHz antenna.

Length (m)
72–76

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 5-5 below.

Table 5-5. Some important structures in the boreholes.

Borehole	KA3011A01	KA3065A01
Structures	3 and 6	3

Observe that it can be very difficult to classify different structures in an objective manner, along a borehole. This is due to the fact that the water quality (the conductivity) amongst others varies along the borehole length and by that reason affects the results of the radar logging, by for instance attenuating the radar waves differently. Also the intersection angle of the identified structures affects the amplitude on the resulting radargram. Small intersection angles will most often give an increased amplitude compared to larger intersection angles, and by that a more clear structure. Another factor to consider is the long distance (10.05 m) in-between the 20 MHz transmitter (Tx) and receiver (Rx) antenna. Tiny structures intersecting the borehole with high attenuation result in a wide anomaly over a distance that is equal to the Tx and Rx distance.

5.2 BIPS logging

The BIPS images from KA3011A01 and KA3065A01 are presented in Appendices 3–4.

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 length accuracy, the BIPS images are adjusted by using the push rods as reference.

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

The BIPS images in the core drilled part of the borehole show very good quality along the borehole. Small amount of discolouring effect of the borehole walls make the geological mapping easy.

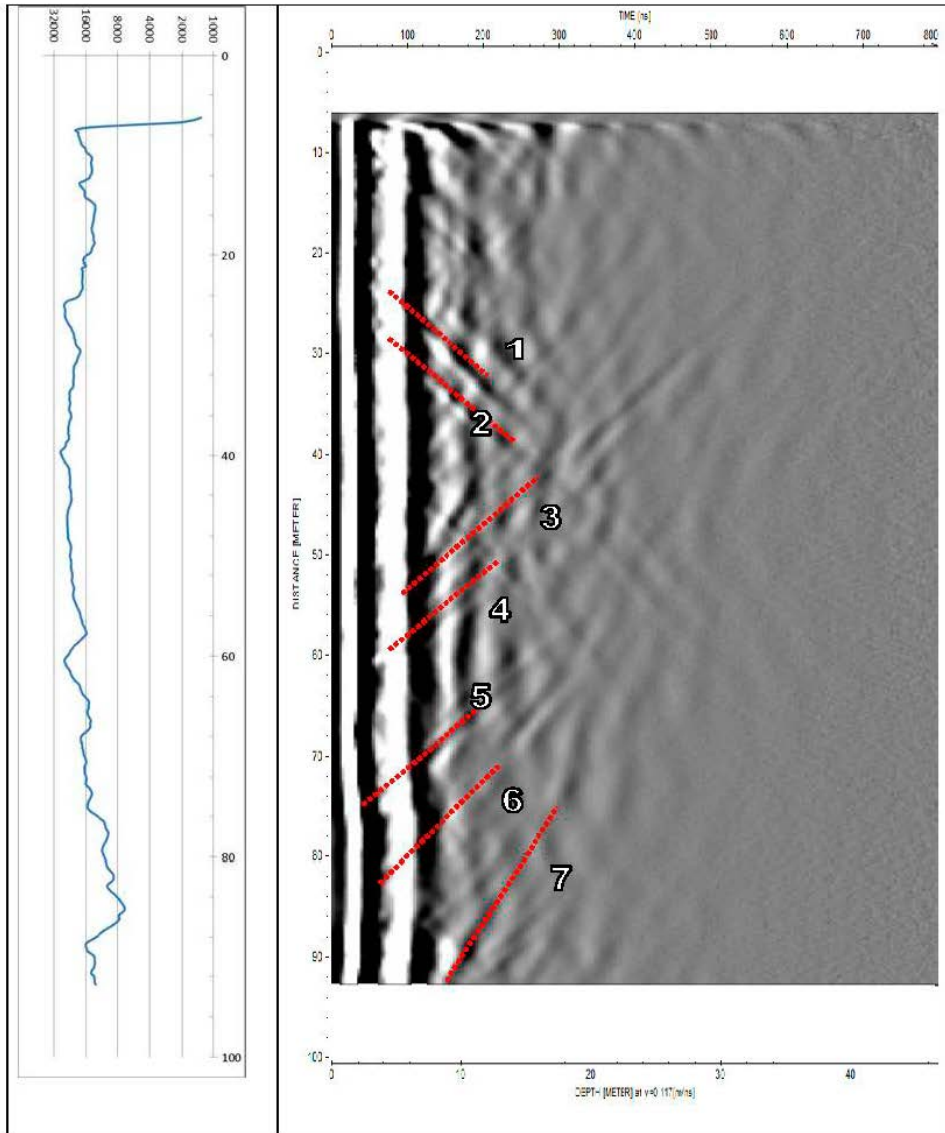
References

SKB's (Svensk Kärnbränslehantering AB) publications can be found at www.skb.se/publications.

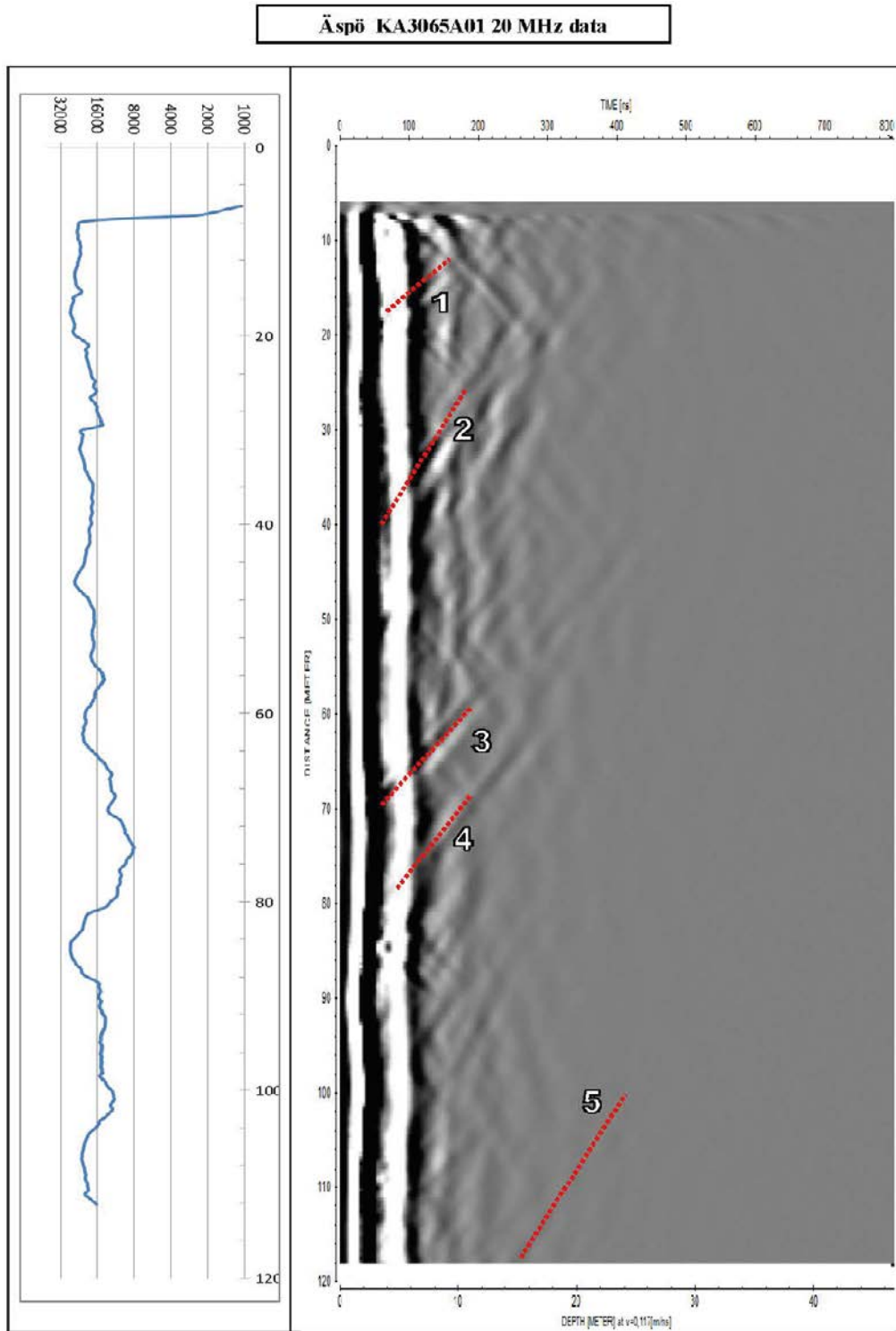
Gustafsson J, Gustafsson C, 2005. Oskarshamn site investigation. RAMAC and BIPS logging in boreholes KLX07A, KLX07B, HLX34 and HLX35 and deviation logging in boreholes KLX07B, HLX34 and HLX35. SKB P-05-231, Svensk Kärnbränslehantering AB.

Radar logging in KA3011A01, 6.25 to 92.7 m, dipole antenna 20 MHz

Äspö KA3011A01 20 MHz data




Radar logging in KA3065A01, 6.25 to 117.5 m, dipole antenna 20 MHz



BIPS logging in KA3011A01, 2.0 to 99.9 m

Project name: Äspö HRL

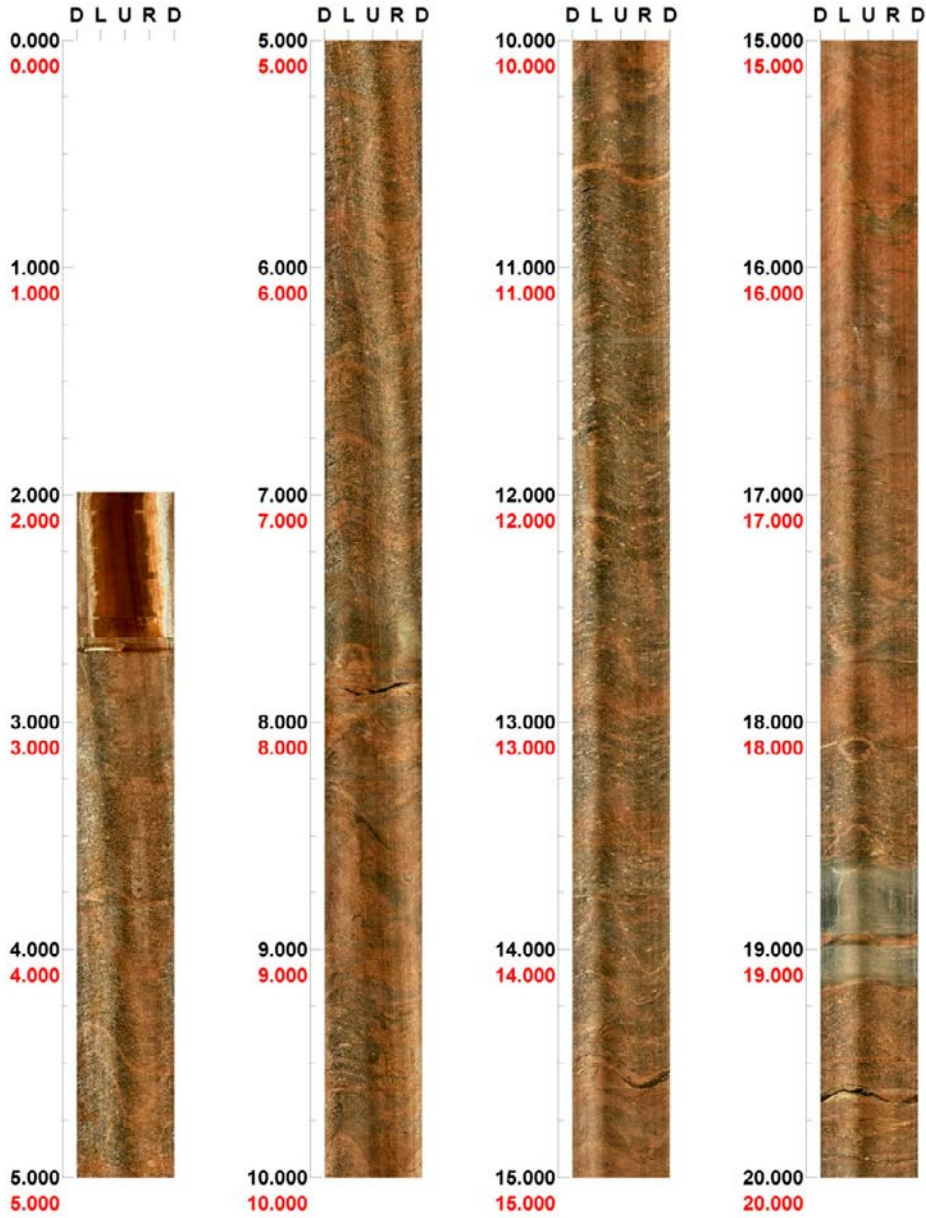
Image file : d:\work\sphrl~1\aptdtu~2\bips\ka3011~1.bip
BDT file : d:\work\sphrl~1\aptdtu~2\bips\ka3011~1.bdt
Locality : ASPO HRL
Bore hole number : KA3011A1
Date : 11/11/22
Time : 18:12:00
Depth range : 1.988 - 99.900 m
Azimuth : 43
Inclination : -1
Diameter : 76.0 mm
Magnetic declination : 0.0
Span : 4
Scan interval : 0.25
Scan direction : To entrance
Scale : 1/25
Aspect ratio : 180 %
Pages : 5
Color : 

Project name: Äspö HRL
Bore hole No.: KA3011A1

Azimuth: 43

Inclination: -1

Depth range: 0.000 - 20.000 m



Project name: Äspö HRL
Bore hole No.: KA3011A1

Azimuth: 43

Inclination: -1

Depth range: 20.000 - 40.000 m



Project name: Äspö HRL
Bore hole No.: KA3011A1

Azimuth: 43

Inclination: -1

Depth range: 40.000 - 60.000 m

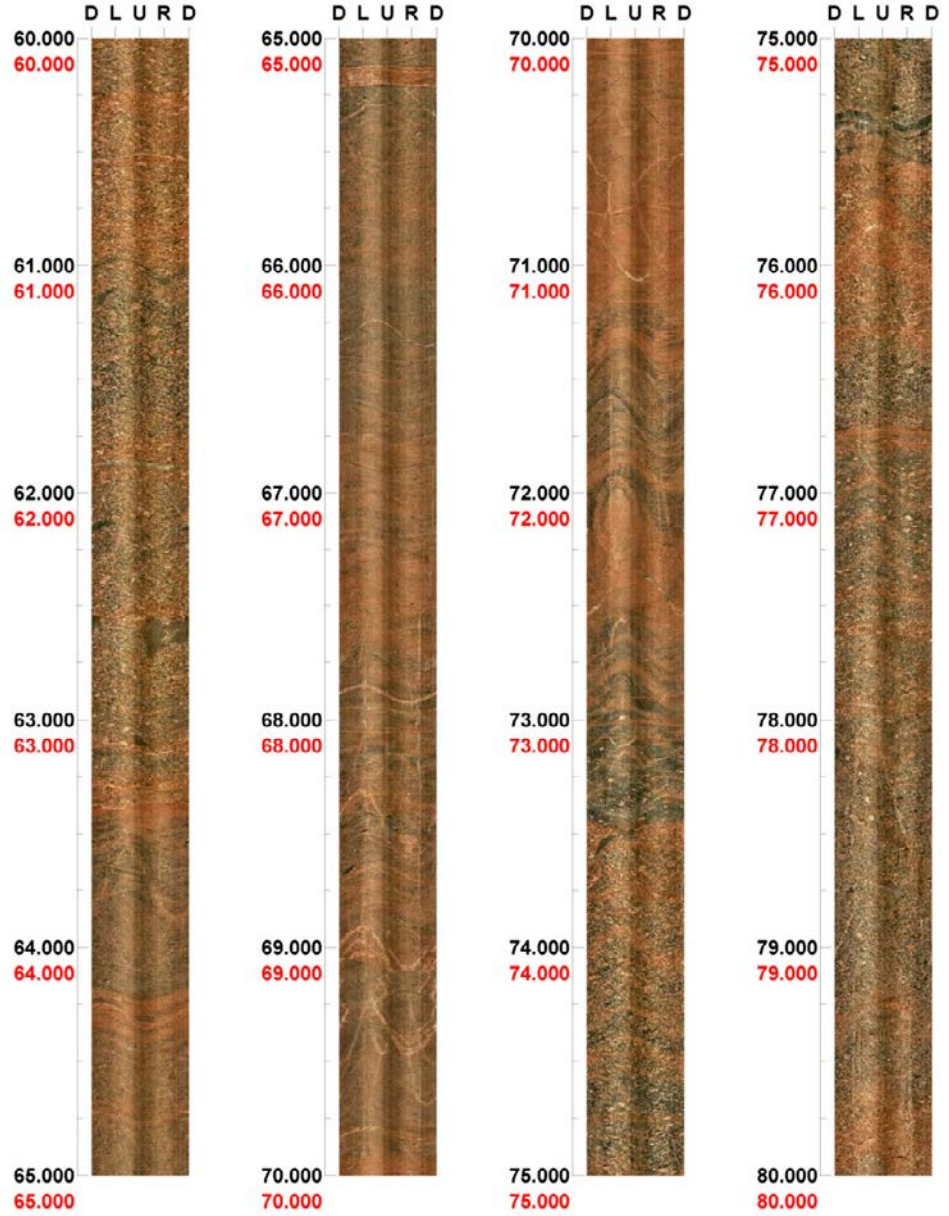


Project name: Äspö HRL
Bore hole No.: KA3011A1

Azimuth: 43

Inclination: -1

Depth range: 60.000 - 80.000 m



Project name: Äspö HRL
Bore hole No.: KA3011A1

Azimuth: 43


Inclination: -1

Depth range: 80.000 - 99.900 m



BIPS logging in KA3065A01, 2.15 to 125.0 m

Project name: Äspö HRL

Image file : d:\work\sphrl~1\aptdtu~3\ka3065~1\bips\ka3065~1.
BDT file : d:\work\sphrl~1\aptdtu~3\ka3065~1\bips\ka3065~1.
Locality : ASPO HRL
Bore hole number : KA3065A1
Date : 11/12/19
Time : 10:25:00
Depth range : 2.149 - 125.000 m
Azimuth : 55
Inclination : 0
Diameter : 76.0 mm
Magnetic declination : 0.0
Span : 4
Scan interval : 0.25
Scan direction : To entrance
Scale : 1/25
Aspect ratio : 180 %
Pages : 7
Color : 

Project name: Äspö HRL
Bore hole No.: KA3065A1

Azimuth: 55

Inclination: 0

Depth range: 0.000 - 20.000 m

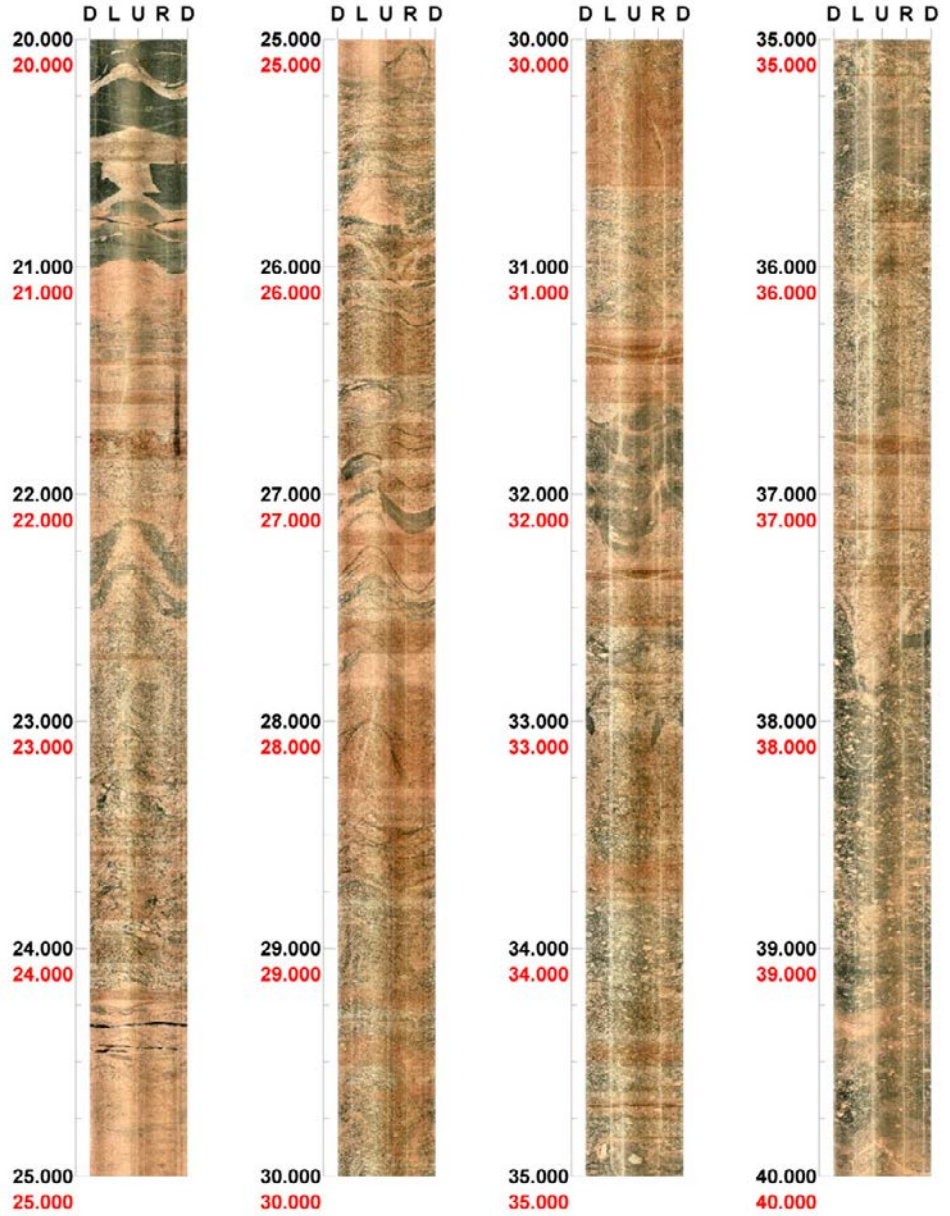


Project name: Äspö HRL
Bore hole No.: KA3065A1

Azimuth: 55

Inclination: 0

Depth range: 20.000 - 40.000 m

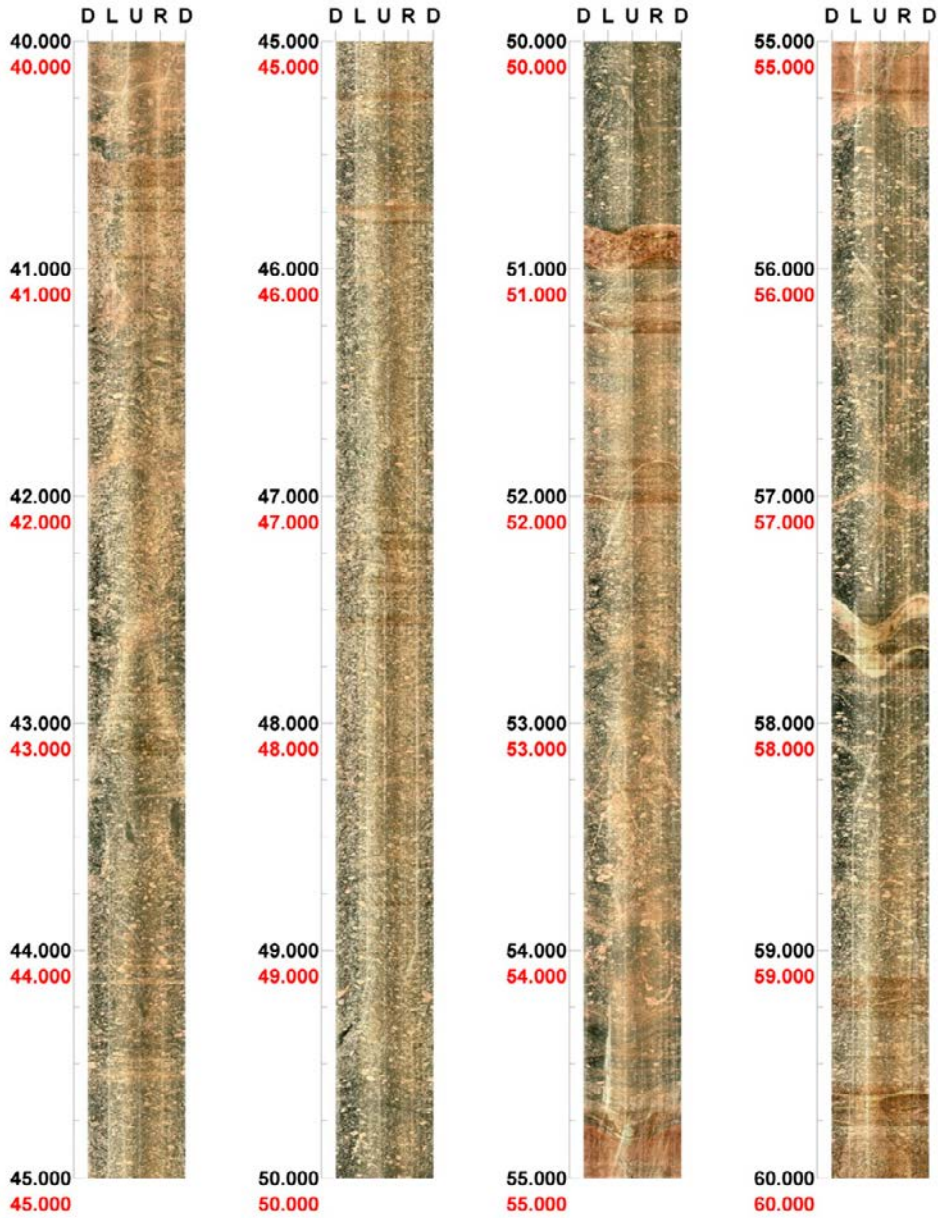


Project name: Äspö HRL
Bore hole No.: KA3065A1

Azimuth: 55

Inclination: 0

Depth range: 40.000 - 60.000 m

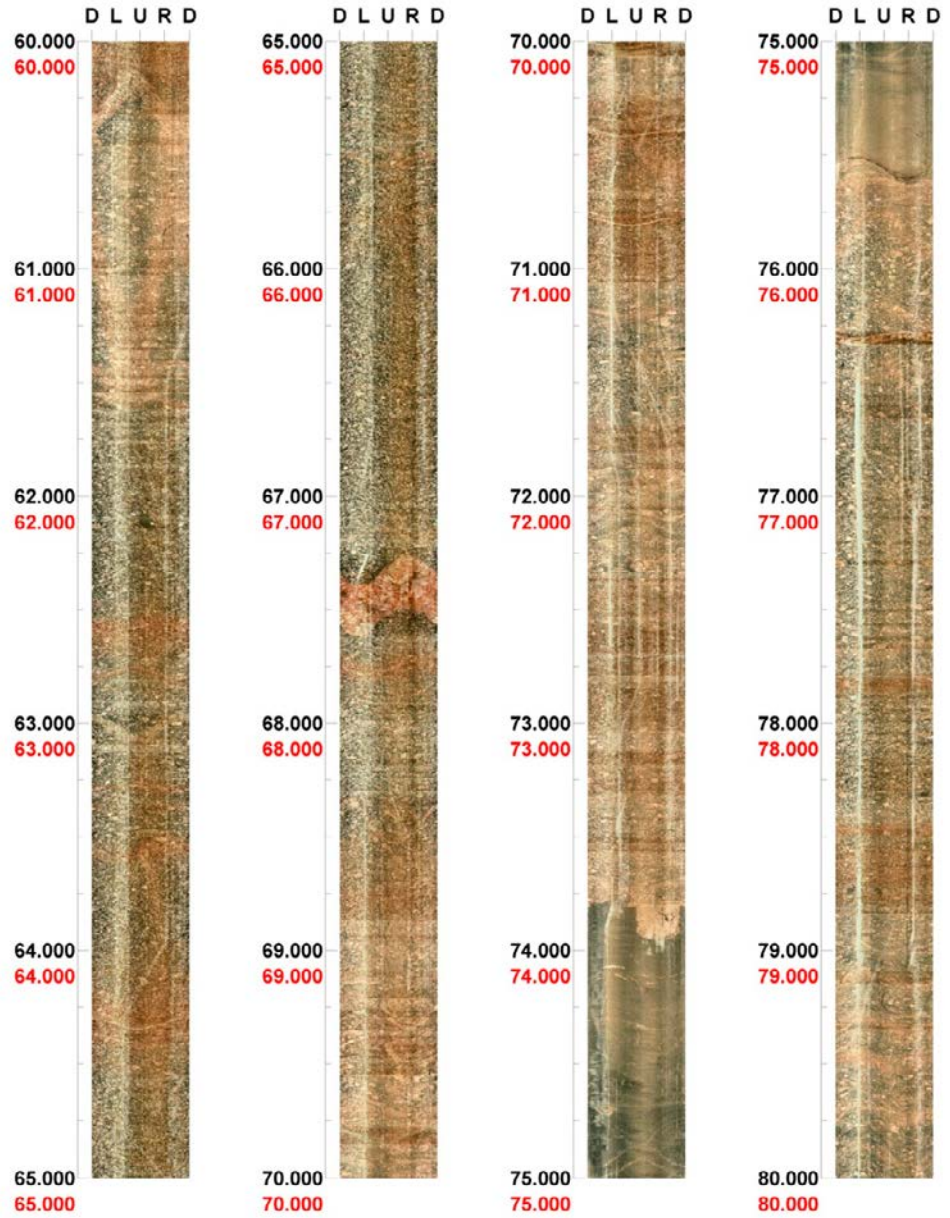


Project name: Äspö HRL
Bore hole No.: KA3065A1

Azimuth: 55

Inclination: 0

Depth range: 60.000 - 80.000 m

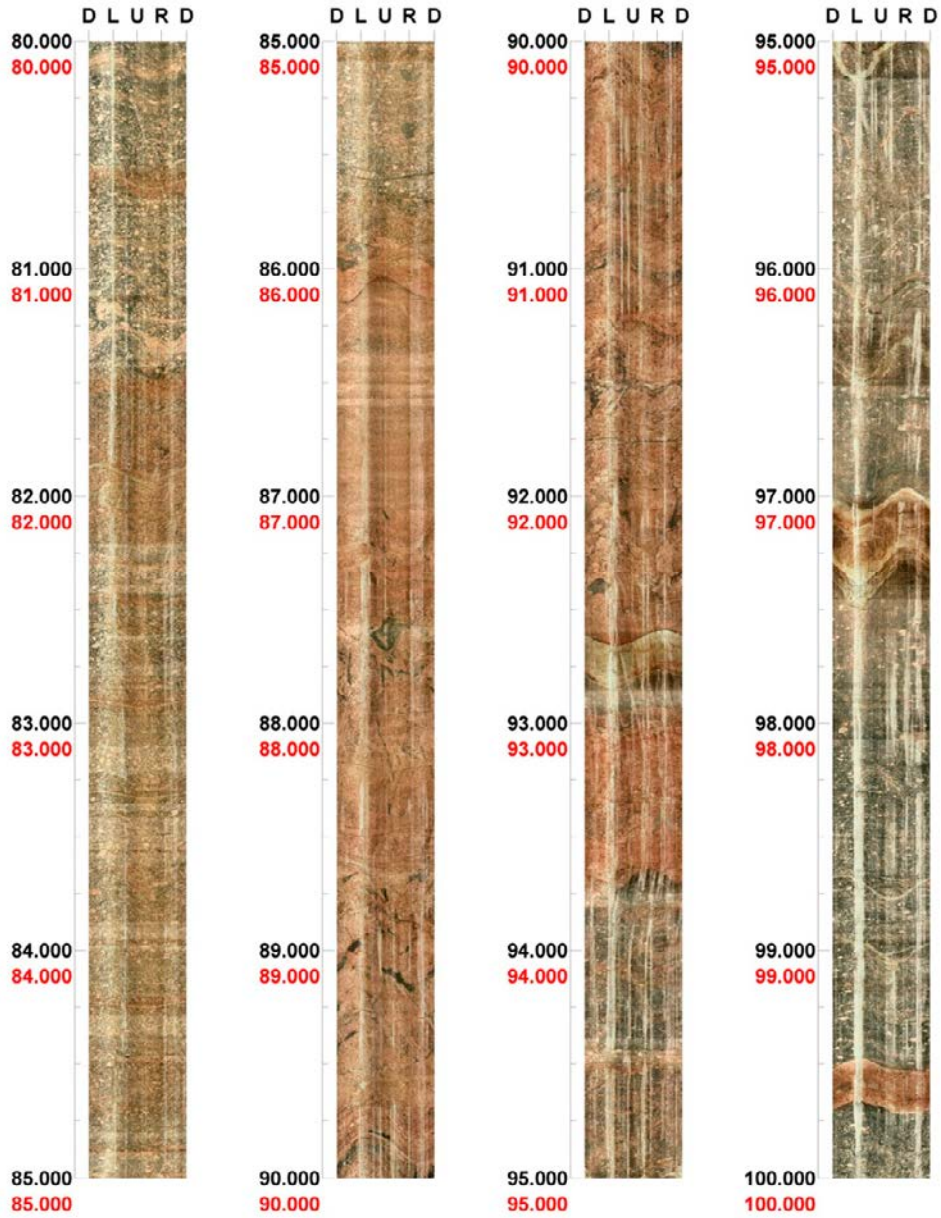


Project name: Äspö HRL
Bore hole No.: KA3065A1

Azimuth: 55

Inclination: 0

Depth range: 80.000 - 100.000 m

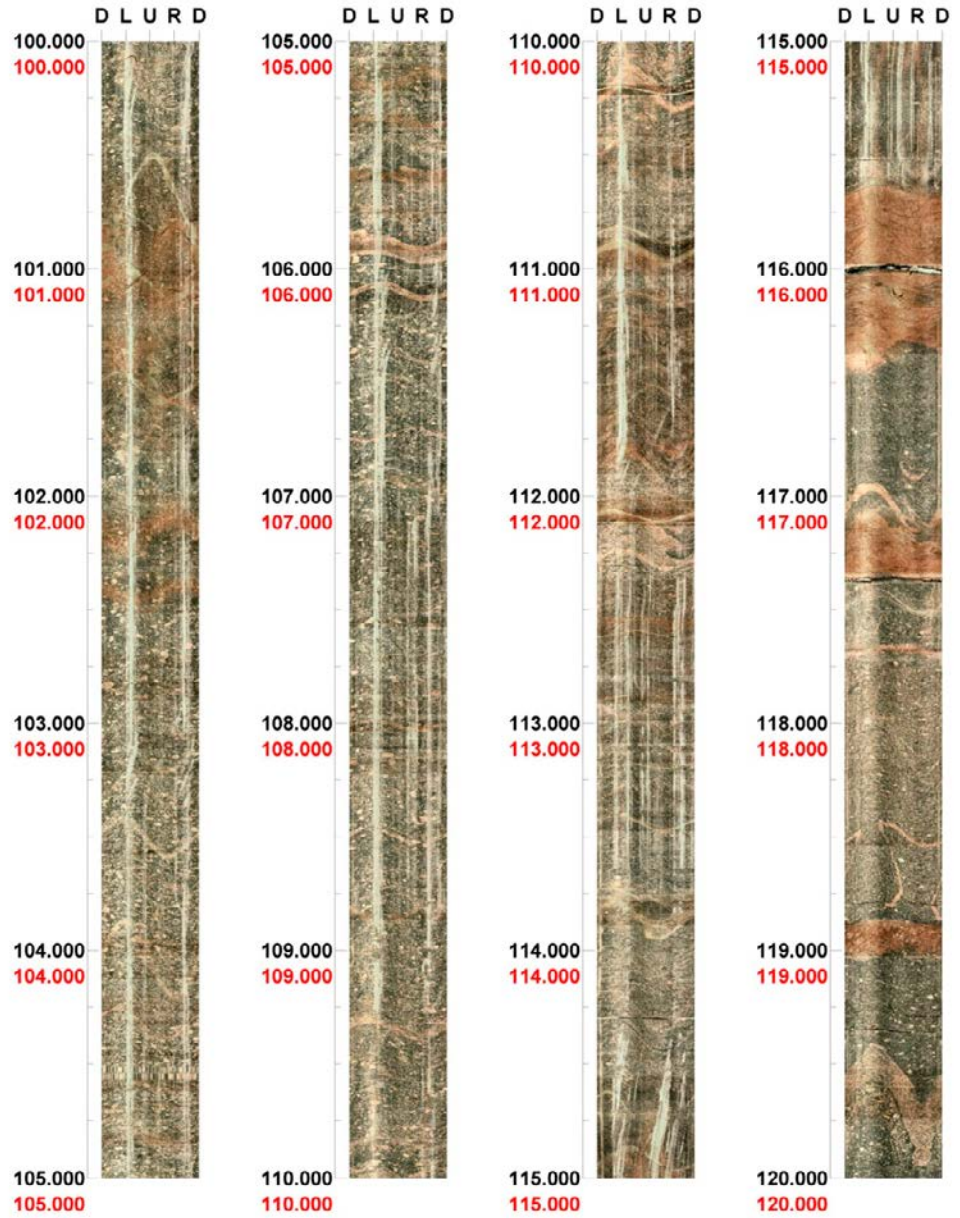


Project name: Äspö HRL
Bore hole No.: KA3065A1

Azimuth: 55

Inclination: 0

Depth range: 100.000 - 120.000 m



Project name: Äspö HRL
Bore hole No.: KA3065A1

Azimuth: 55

Inclination: 0

Depth range: 120.000 - 125.000 m

