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RAMAC and BIPS logging in boreholes KSH03A, KSH03B, HAV09, HAV10 and BIPS in KAV01

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March 2004

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Keywords: BIPS, RAMAC, Radar, TV.

Reading instruction

For revision no. 1 of this report a recalculation of the directional radar data has been done. The strike angle between the line of the plane's cross-section with the surface and the Magnetic North direction was earlier counted counter-clockwise but it is now recalculated as such it counts clockwise, see Figure 5-2. New values for strike and dip are therefore updated in Tables 5-5 to 5-6.

Abstract

This report includes the data gained in geophysical logging operations performed within the site investigation at Oskarshamn. The logging operations presented here includes borehole radar (RAMAC) and TV-logging (BIPS) in the core-drilled boreholes KSH03A and KSH03B and in the percussion-drilled boreholes HAV09 and HAV10. BIPS was also performed in the core-drilled borehole KAV01. All measurements were conducted by Malå Geoscience AB / RAYCON during December 2003.

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 used 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.

The borehole radar data quality from KSH03A, KSH03B, HAV09 and HAV10 was relatively satisfying, but in some parts of lower quality due to more conductive conditions. This conductive environment of course reduces the possibility to distinguish and interpret possible structures in the rock mass which otherwise could give a reflection. However, the borehole radar measurements resulted in a number of identified radar reflectors. In KSH03A over 100 radar reflectors were identified and most of them also orientated (strike/dip). About 20 radar reflectors were identified in KSH03B and the corresponding numbers for HAV09 and HAV10 is 30 respectively 15. In HAV09 and HAV10 no radar reflectors were oriented due to that no directional antenna is measured in percussion drilled boreholes.

The BIPS measurement resulted in images of the borehole wall, no further fracture mapping was done in this report. The quality of the images varies in-between the boreholes. In KSH03A for instance, the result was impaired by some system independent quality problems. These problems are related to a drilling induced discolouring of parts of the borehole wall. In the parts that are heavily defected there will most probably be problems to map thin structures and single fractures. Further on mud cover or dirty water in the lowermost parts of KSH03A, KSH03B, HAV09 and HAV10 reduces the possibility to clearly map thin structure planes. In KAV01 there is a spiral form all the way along the borehole. Drilling operations probably causes this spiral form. The borehole is an old borehole drilled in 1977, 1986 and later on in 1997.

Sammanfattning

Denna rapport omfattar geofysiska loggningar inom platsundersökningsprogrammet för Oskarshamn. Mätningarna som presenteras här omfattar borrhålsradarmätningar (RAMAC) och TV-loggning (BIPS) i kärnborrhålen KSH03A och KSH03B, och i hammarborrhålen HAV09 och HAV10. BIPS-mätningar i kärnborrhål KAV01 redovisas också. Alla mätningar är utförda av Malå Geoscience AB /RAYCON under december 2003.

Syftet med radar- och BIPS-mätningarna är att samla information om borrhålet (borrhålsväggen) men även om bergmassan runt borrhålet. Borrhålsradar används till att karakterisera bergets egenskaper och strukturer i bergmassan närmast borrhålet, medan BIPS-mätningar görs för att karakterisera borrhålsväggen geologiskt, samt identifiera och orientera möjliga strukturer.

Borrhålsradardata från KSH03A, KSH03B, HAV09 och HAV10 var relativt tillfredställande, men tidvis av sämre kvalité troligen till stor del beroende på en konduktiv miljö. En konduktiv miljö minskar möjligheterna att identifiera strukturer ur borrhålsradardata. Dock har drygt 100 radarreflektorer identifierats i KSH03A, varav de flesta har kunnat orienteras (strykning/stupning). Motsvarande antal för KSH03B, HAV09 och HAV10 är cirka 20, 30 och 15. I HAV09 och HAV10 har ingen orientering av reflektorer utförts pg a att mätning med radar riktantenn ej genomförs i hammarborrhål.

BIPS-mätningarna resulterade i bilder av borrhålsväggen, någon vidare sprickkartläggning har ej utförts inom denna rapport. Bildkvalitén varierar mellan borrhålen. T ex är bilderna från KSH03A delvis påverkade av en missfärgning som beror på borrtekniken. I de flesta fall är även de djupaste delarna av borrhålsväggarna i KSH03A, KSH03B, HAV09 och HAV10 delvis täckta av lera eller med smutsigt vatten så även här påverkas bildkvalitén, vilket gör att det kan vara svårt att kartlägga de finaste strukturerna. I KAV01 syns ett spiralformat mönster längs med hela borrhålsväggen, troligen pg a av borrningen som är gjord i flera omgångar.

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1 Introduction

This document reports the data gained in geophysical logging operations, which is one of the activities performed within the site investigation at Oskarshamn. The logging operations presented here includes borehole radar (RAMAC) and TV-logging (BIPS) in in the core-drilled boreholes KSH03A and KSH03B and in the percussion-drilled boreholes HAV09 and HAV10. BIPS was also performed in the core-drilled borehole KAV01. This report includes measurements from 0 to 1000 m in KSH03A and measurements from 0 to approximately 100 m in borehole KSH03B. The loggings were performed to approximately 200 m depth in borehole HAV09 and to 100 m in HAV10. The borehole KAV01 was logged with BIPS from 69 to 741 m. The boreholes HAV09 and HAV10 are drilled with a diameter of approximately 136 and 140 mm respectively and KSH03A and KHSH03B with a diameter of 76 mm. KAV01 was drilled with a diameter of 56 mm. This borehole was drilled 1977 to 502 m depth, later drilled further to a depth of 744 in 1986 and a drilling test was performed in 1997 to a depth of 757 m.

All measurements were conducted by Malå Geoscience AB / RAYCON during December 2004 in accordance with the instructions and guidelines from SKB (Activity plan AP PS 400-03-081 and method description SKB MD 252.020 and SKB MD 222.006, SKB internal controlling documents) and under supervision of Leif Stenberg, SKB. The location of the boreholes is shown in Figure 1-1.

The used investigation techniques comprised:

- Borehole radar measurements (Malå Geoscinece 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.

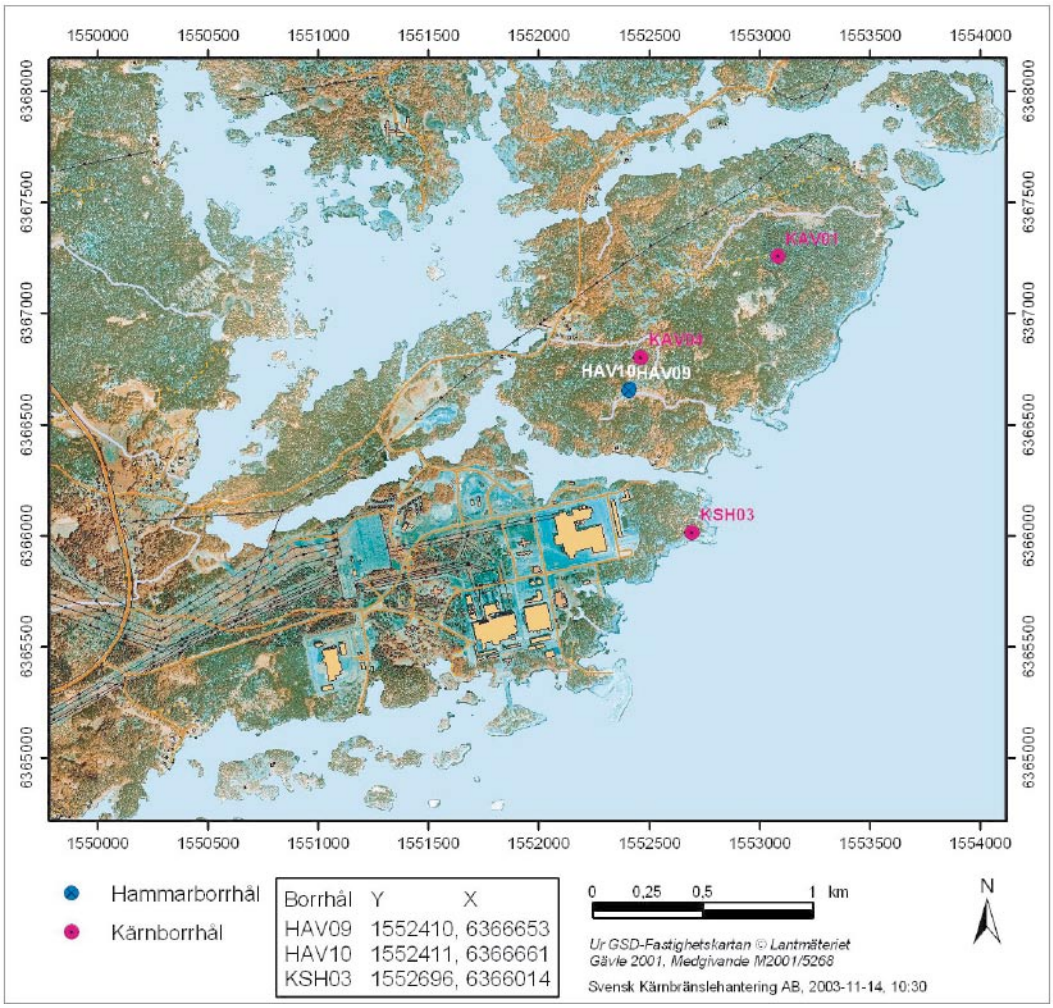


Figure 1-1. *General overview over the Simpevarp subarea in Oskarshamn with the location of the boreholes KSH03A and KSH03B (drilled close to each other at the location KSH03). The percussion- drilled boreholes HAV09 and HAV10 and the core-drilled borehole KAV01 are located on the Ävrö island.*

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.

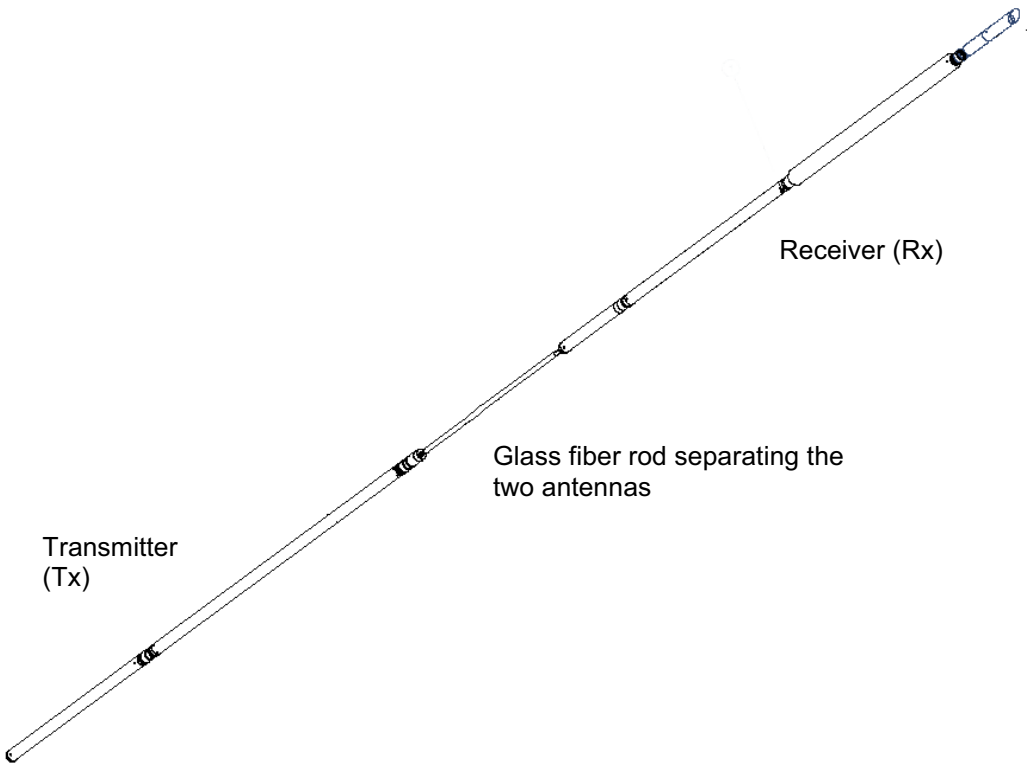


Figure 3-1. *Example of a borehole radar antenna.*

3.2 TV-Camera, BIPS

The BIPS 1500 system used is owned by SKB and described in SKB internal controlling document MD 222.005. The BIPS method for borehole logging produces a digital scan of the borehole wall. In principle, a standard CCD video camera is installed in the probe in front of a conical mirror (see Figure 3-2). An acrylic window covers the mirror part and the borehole image is reflected through the window and displayed on the cone, from where it is recorded. During the measuring operation, pixel circles are grabbed with a resolution of 360 pixels/circle.

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

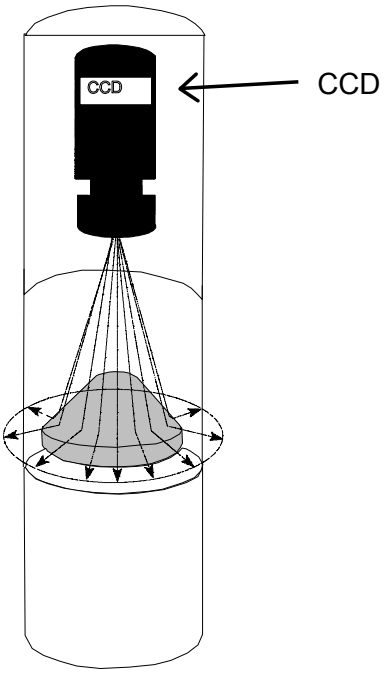


Figure 3-2. *The BIP-system. Illustration of the conical mirror scanning.*

4 Execution

4.1 Execution of measurements

4.1.1 RAMAC radar

The measurements in KSH03A, KSH03B, HAV09 and HAV10, were carried out with dipole radar antennas, with frequencies of 250, 100 and 20 MHz. In KSH03A and KSH03B measurements were also made using the directional antenna, with a central frequency of 60 MHz.

During logging the dipole antennas (transmitter and receiver) were lowered continuously into the borehole and data were recorded on a field PC along the measured interval. The measurement with the directional antenna is made step wise, with a short pause for each measurement occasion. The antennas (transmitter and receiver, both for dipole and directional) are kept at a fixed separation by glass fiber rods according to Table 4-1 to 4-4. See also Figure 4-1.

All measurements were performed in accordance with the instructions and guidelines from SKB (internal document MD 252.020). All cleaning of the antennas and cable was performed according to the internal document SKB MD 600.004 before the logging operation.

The functionality of the directional antenna was tested before measurements in KSH03A and KSH03B. This is done by measurements in the air, where the receiver antenna and the transmitter antenna are placed apart. While transmitting and measuring the receiver antenna is turned around and by that giving the direction from the receiver antenna to the transmitter antenna. The difference in direction measured by compass and the result achieved from the directional antenna was about 10 degrees. This can be considered as satisfying due to the disturbed environment, with metallic objects etc at the test site.

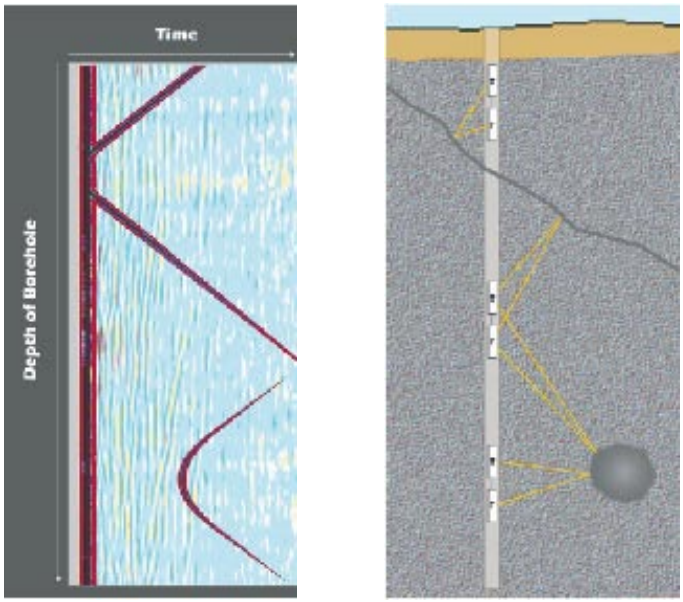


Figure 4-1. *The principle of radar borehole reflection survey and an example of result.*

For more information on system settings used in the investigation of KSH03A, KSH03B, HAV09 and HAV10, see Table 4-1 to 4-4 below.

Table 4-1. Radar logging information from KSH03A.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KSH03A**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional / Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operator:	**CG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Logging date:	03-12-12	03-12-11	03-12-13	03-12-13
	Reference:	T.O.C.	T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):	665	2588	951	247
	Number of samples:	512	575	518	512
	Number of stacks:	64	32	32	32
	Signal position:	373.987	–0.319	–0.358	–1.361
	Logging from (m):	103.4	101.5	102.6	106.25
	Logging to (m):	990.4	996.5	997.6	993.6
	Trace interval (m):	0.5	0.25	0.2	0.1
	Antenna separation (m):	5.73	1.9	2.9	10.05

Table 4-2. Radar logging information from KSH03B.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KSH03B**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional / Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Operators:	**CG**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Logging date:	03-12-11	03-12-12	03-12-13	03-12-13
	Reference:	T.O.C.	T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):	665	2588	951	247
	Number of samples:	512	575	518	512
	Number of stacks:	64	32	32	32
	Signal position:	373.987	–0.319	–0.358	–1.361
	Logging from (m):	8.4	1.5	2.6	6.25
	Logging to (m):	93.4	98.8	97.6	93.8
	Trace interval (m):	0.5	0.25	0.2	0.1
	Antenna separation (m):	5.73	1.9	2.9	10.05

Table 4-3. Radar logging information from HAV09.

Site:	**Oskarshman**	**Logging company:**	**RAYCON**	
BH:	**HAV09**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Logging date:	03-12-14	03-12-14	03-12-14
	Reference:	T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):	2588	951	257
	Number of samples:	619	518	518
	Number of stacks:	Auto	Auto	Auto
	Signal position:	–0.32	–0.32	–1.43
	Logging from (m):	1.5	2.6	6.25
	Logging to (m):	198.2	197.3	193.0
	Trace interval (m):	0.1	0.2	0.25
	Antenna separation (m):	2.4	3.9	10.05

Table 4-4. Radar logging information from HAV10.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**	
BH:	**HAV10**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Operator:	**CG**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Logging date:	03-12-14	03-12-14	03-12-14
	Reference:	T.O.C.	T.O.C.	T.O.C.
	Sampling frequency (MHz):	2588	951	257
	Number of samples:	619	518	518
	Number of stacks:	Auto	Auto	Auto
	Signal position:	–0.32	–0.32	–1.43
	Logging from (m):	1.5	2.6	6.25
	Logging to (m):	96.2	97.0	92.9
	Trace interval (m):	0.1	0.2	0.25
	Antenna separation (m):	2.4	3.9	10.05

4.1.2 BIPS

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

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

A gravity sensor was used to measure the orientation of the images in all the boreholes KSH01A, KSH01B, HAV09 and HAV10. In KAV01 the compass was used to measure the orientation.

In order to control the quality of the system, calibration measurements were performed in a test pipe before logging the first borehole and after logging the last one for the two field mobilizations. The results showed no difference regarding the colours and focus of the images. Results of the test loggings were included in the delivery of the raw data.

4.1.3 Length measurements

During logging the depth recording for the RAMAC systems is taken care of by a measuring wheel mounted on the cable winch. The experience we have from earlier measurements in the core-drilled boreholes in Forsmark and Oskarshamn is that the depth divergence is less than 50 cm in the deepest parts of the boreholes.

For the measurements with the directional antenna in KSH03A the depth divergence was at most 10 cm.

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 4-2 and the calculation shows a velocity of 122 m/micro seconds. The velocity measurement was performed in borehole HAV10 with the 100 MHz dipole antennas.

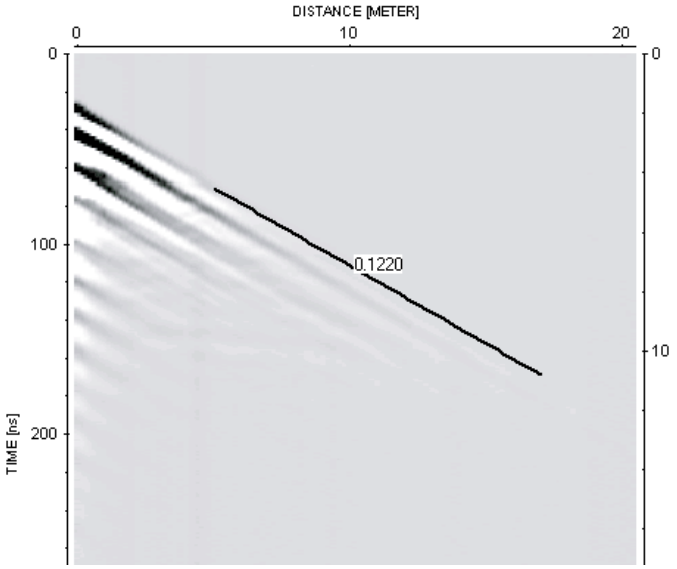


Figure 4-2. *Results from velocity measurements in HAV10 with the 100 MHz dipole antennas.*

The visualization of data in Appendix 1 to 5 is made with ReflexWin, a Windows based processing software for filtering and analysis of borehole radar data. The processing steps are shown in Tables 4-5 to 4-8.

For the interpretation of the intersection angle between the borehole axis and the planes visible on the radargrams the RadinterSKB software has been used. The interpreted intersection points and intersection angles of the detected structures are presented in the Tables 5-1 to 5-8 and are also visible on the radargrams in Appendix 1 to 5.

Table 4-5. Processing steps for borehole radar data from KSH03A.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KSH03A**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JA**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Processing:	DC removal	DC removal	DC removal	DC removal
		Time gain	Move start time	Move start time	Move start time
		FIR	Gain	Gain	Gain

Table 4-6. Processing steps for borehole radar data from KSH03B.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**		
BH:	**KSH03B**	**Equipment:**	**SKB RAMAC**		
Type:	**Directional/Dipole**	**Manufacturer:**	**MALÅ GeoScience**		
Interpret:	**JA**	**Antenna**			
		Directional	**250 MHz**	**100 MHz**	**20 MHz**
	Processing:	DC removal	DC removal	DC removal	DC removal
		Time gain	Move start time	Move start time	Move start time
		FIR	Gain	Gain	Gain

Table 4-7. Processing steps for borehole radar data from HAV09.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**	
BH:	**HAV09**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JA**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
Processing:		DC removal	DC removal	DC removal
		Move start time	Move start time	Move start time
		Gain	Gain	Gain

Table 4-8. Processing steps for borehole radar data from HAV10.

Site:	**Oskarshamn**	**Logging company:**	**RAYCON**	
BH:	**HAV10**	**Equipment:**	**SKB RAMAC**	
Type:	**Dipole**	**Manufacturer:**	**MALÅ GeoScience**	
Interpret:	**JA**	**Antenna**		
		250 MHz	**100 MHz**	**20 MHz**
	Processing:	DC removal	DC removal	DC removal
		Move start time	Move start time	Move start time
		Gain	Gain	Gain

4.2.2 BIPS

The visualization of data is made with BDPP, a Windows based processing software for filtering, presentation and analysis of BIPS data. As no fracture mapping of the BIPS image is performed, the raw data was delivered on a CD-ROM together with printable pictures in *.pdf format before the field crew left the investigation site. The used scale is 25 m of BIPS images/A4 for KSH03A, KSH03B and KAV01, and 20 m/A4 for HAV09 and HAV10. The printed results were delivered with measured length, together with adjusted length according to the length marks visible in the BIPS image. For printing of the BIPS images the printing software PDPP from RaaX was used.

4.3 Nonconformities

For revision no. 1 of this report a recalculation of the directional radar data has been done. The strike angle between the line of the plane's cross-section with the surface and the Magnetic North direction was earlier counted counter-clockwise but it is now recalculated as such it counts clockwise, see Figure 5-2. New values for strike and dip are therefore updated in Tables 5-5 to 5-6.

5 Results and data delivery

The results from the radar and BIPS measurements were delivered as raw data (*.bip-files) on CD-ROMs to SKB together with printable BIPS pictures in *.pdf format before the field crew left the investigation site. The information of the measurements is registered in SICADA, and the CD-ROMs stored by SKB.

The RAMAC radar data was delivered as raw data (fileformat *.rd3 or *.rd5) for HAV09, HAV10, KSH03A and KSH03B with corresponding information files (file format *.rad) whereas the data processing steps and results are presented in this report. Relevant information, including the interpretation presented in this report, was inserted into the SKB database SICADA.

The delivered raw and processed data have been inserted in the database of SKB (SICADA). The SICADA reference to the present activity is Field Note 196.

5.1 RAMAC logging

The results of the interpretation of the radar measurements are presented in Tables 5-1 to 5-8. Radardata is also visualized in Appendix 1 to 5. It should be remembered that the images in Appendix 1 to 5 is only a composite picture of all events 360 degrees around the borehole, and do not reflect the orientation of the structures.

Only the larger clearly visible structures are interpreted in RadinterSKB. A number of minor structures also exist, indicated in Appendix 1 to 5. 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 KSH03A, KSH03B, HAV09 and HAV10, (as seen in Appendix 1 to 5) is relatively satisfying, but in some parts of lower quality due to more conductive conditions. A conductive environment makes the radar wave to attenuate, which decreases the penetration (See Figure 5-1). This is for instance seen very clearly in the data from HAV09 from a depth of 80 to 100 m, and in KSH03A down to a depth of 280 m. 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 Appendix 1 to 5 the resolution and penetration of radar waves depend on the antenna frequency used. Low antenna frequency gives less resolution but higher penetration rate compared to a higher frequency. An example is given below in Figure 5-1, where radar reflectors are clearly identified with the 60 MHz directional antenna, but when looking at the dipole data these reflectors are not as clear.

In Tables 5-1 to 5-4 below the distribution of identified structures along the borehole are listed for KSH03A, KSH03B, HAV09 and HAV10.

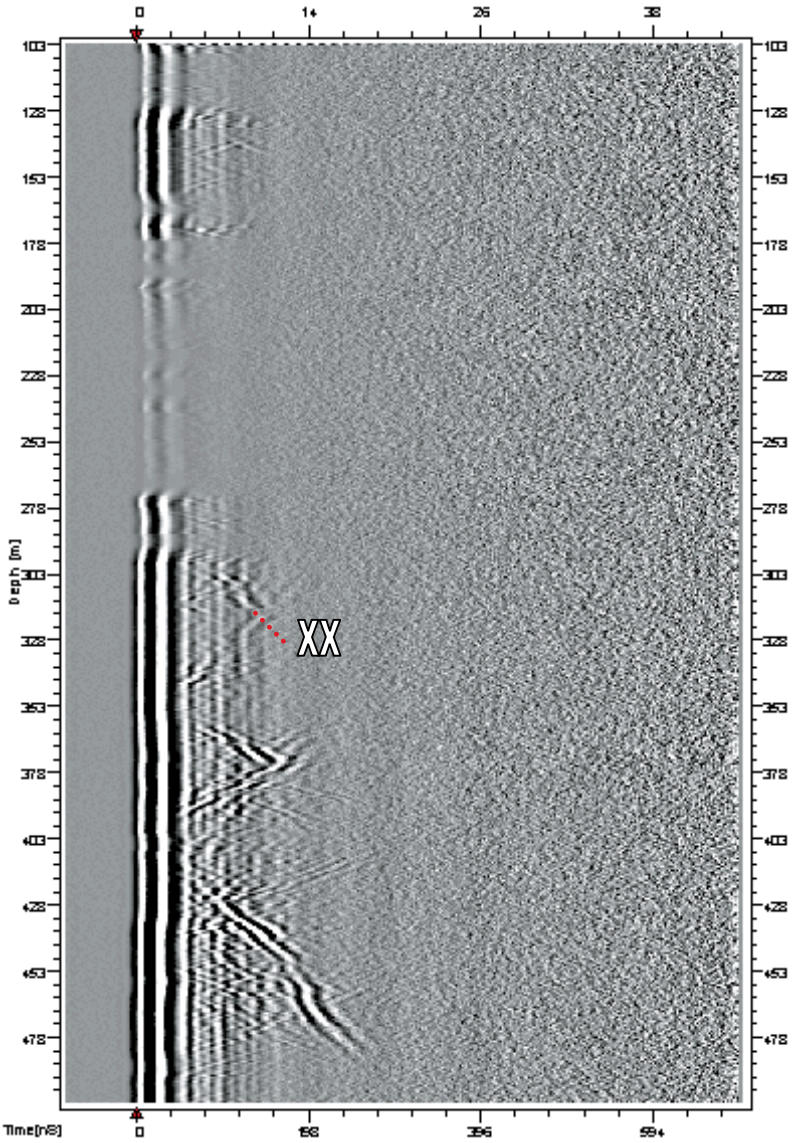


Figure 5-1. *Picture of a part from the dipole component of the directional antenna, showing radar reflectors at a depth of 300 to 480 m in more detail. These reflectors are hard to define in the dipole measurements (250, 100 and 20 MHz frequencies). The radar reflector at a depth of 300 m is hardly seen at all. The data also shows a part (180 m to 270 m) where the radar signal is very weak, giving little information of possibly structures in this area.*

Table 5-1. Identified structures as a function of depth in KSH03A.

Depth (m)	No of structures
100 – 150	10
150 – 200	6
200 – 250	4
250 – 300	5
300 – 350	9
350 – 400	6
400 – 450	7
450 – 500	6
500 – 550	7
550 – 600	5
600 – 650	5
650 – 700	5
700 – 750	3
750 – 800	2
800 – 850	4
850 – 900	5
900 – 950	5
950 – 1000	5
1000 –	4

Table 5-2. Identified structures as a function of depth in KSH03B.

Depth (m)	No of structures
0 – 10	2
10 – 20	2
20 – 30	1
30 – 40	2
40 – 50	3
50 – 60	1
60 – 70	3
70 – 80	3
80 – 90	1
90 – 100	2
100 –	1

Table 5-3. Identified structures as a function of depth in HAV09.

Depth (m)	No of structures
0 – 20	2
20 – 40	2
40 – 60	2
60 – 80	2
80 – 100	3
100 – 120	5
120 – 140	4
140 – 160	5
160 – 180	2
180 – 200	2

Table 5-4. Identified structures as a function of depth in HAV10.

Depth (m)	No of structures
0 – 10	–
10 – 20	1
20 – 30	2
30 – 40	1
40 – 50	2
50 – 60	2
60 – 70	1
70 – 80	2
80 – 90	–
90 – 100	1
100 –	3

Tables 5-5 to 5-8 summarises the interpretation of radar data from KSH03A, KSH03B HAV09 and HAV10. As seen some radar reflectors are marked with ±, which indicates an uncertainty in the interpretation of the direction to the reflector. The direction can in these cases be ±180 degrees. The direction to the reflector (the plane) is defined in Figure 5-2. As the borehole inclination for KSH03A and KSH03B is less than 85° the direction to object is calculated using gravity roll. This direction and the intersection angle are also recalculated to strike and dip, also given in Tables 5-5 to 5-6. The plane strike is the angle between line of the plane's cross-section with the surface and the Magnetic North direction. It counts clockwise and can be between 0 and 359 degrees. A strike of 0 degrees implies a dip to the east while a strike of 180 degrees implies a dip to the west. The plane dip is the angle between the plane and the surface. It can vary between 0 and 90 degrees.

Table 5-5. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz and the directional antenna in borehole KSH03A.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas and Directional antenna)			
Site:	**Oskarshamn**		
Borehole name:	**KSH03A**		
Nominal velocity (m/µs):	**120.0**		
Name	**Intersection depth**	**Intersection angle**	**Direction to object (gravity roll)**
A	111.7	27	
B	112.2	89	
C	117.8	77	
D	125.1	86	30
E	127.8	69	357
Ex	136.0	46	60
F	139.9	31	
G	139.6	75	63
H	142.5	73	
I	145.4	71	
J	156.5	51	237
K	166.3	35	165 ±
L	169.4	52	
M	181.3	68	108
N	190.3	65	
O	198.9	74	
P	209.0	90	
Q	234.8	90	
R	236.4	73	
XX in Fig 5-1	244.6	9	102
S	245.6	90	
T	250.6	90	
U	254.8	60	90 ±
V	268.6	82	
W	272.5	72	
X	292.5	71	129
Y	303.5	46	348 ±
Yx	306.3	53	174
Z	319.9	46	93
1	321.2	58	282
2	327.2	60	
3	332.8	49	
4	340.7	60	
5	351.8	47	
6	361.6	64	12 ±
7	346.9	21	270
8	376.4	50	15 ±
9	397.4	46	
10	406.9	21	108
10a	403.8	15	

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

Site:	**Oskarshamn**
Borehole name:	**KSH03A**
Nominal velocity (m/µs):	**120.0**

Name	Intersection depth	Intersection angle	Direction to object (gravity roll)
10b	333.8	6	
11	415.9	40	
12	419.9	34	
13	432.1	56	
14	447.3	29	
14x	448.6	46	234
15	460.2	39	
15x	462.1	53	90
16	471.8	41	117 ±
17	486.6	37	
18	492.2	44	
18x	497.1	30	57
19	500.6	40	54
20	503.3	60	66
21	508.7	49	159 ±
22	518.6	43	
23	525.5	44	228
23x	533.7	51	48 ±
24	542.6	40	54 ±
25	558.9	23	
26	586.9	39	228 ±
27	591.1	33	
28	594.6	43	90 ±
29	622.5	58	51
30	635.3	50	234 ±
31	643.9	47	
32	649.7	47	51 ±
33	657.5	43	
34	667.1	52	
35	677.3	54	54 ±
36	685.9	51	69
37	689.9	47	
38	700.6	62	
39	717.0	51	219
40	724.7	51	
41	751.6	37	
42	1217.3	2	105
42a	841.8	11	90
42b	1188.9	2	78
43	790.2	37	
44	804.2	41	
45	813.3	49	36

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas and Directional antenna)			
Site:	**Oskarshamn**		
Borehole name:	**KSH03A**		
Nominal velocity (m/µs):	**120.0**		
Name	**Intersection depth**	**Intersection angle**	**Direction to object (gravity roll)**
46	849.7	38	57
47	860.8	40	84
48	865.9	43	93
48x	870.2	44	168
49	881.2	47	
50	896.2	46	
51	907.8	38	27
52	927.4	25	51 ±
53	927.8	63	
54	1044.0	8	123
55	937.5	18	291 ±
56	957.8	40	
57	970.6	62	171
58	986.8	18	120
59	948.6	17	
60	988.5	77	
61	994.2	54	
62	368.4	53	
63	616.6	24	
64	586.8	66	
65	1012.9	49	30

Table 5-6. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz and the directional antenna in borehole KSH03B.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas and Directional antenna)				
Site:	**Oskarshamn**			
Borehole name:	**KSH03B**			
Nominal velocity (m/µs):	**120.0**			
Name	**Intersection depth**	**Intersection angle**	**Direction to object (gravity roll)**	**Interpreted**
A	70.6	10	24	78 / 59
B	16.8	29		
C	16.5	39		
D	27.0	33		
E	30.2	44		
F	35.5	38	69 ±	61 / 268
G	41.5	23		
H	42.4	41	63 ±	61 / 264
I	46.8	22		
Ix	54.8	49	204	20 / 85

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

Site:	**Oskarshamn**
Borehole name:	**KSH03B**
Nominal velocity (m/µs):	**120.0**

Name	Intersection depth	Intersection angle	Direction to object (gravity roll)	Interpreted
J	60.5	51		
Jx	63.2	46	81	53 / 276
K	69.4	47		
Kx	73.7	61	213	15 / 128
L	75.4	49	210	22 / 97
M	84.2	55	135	24 / 309
N	90.5	51	294	51 / 171
O	95.6	62		
P	–75.6	23		
Q	–32.0	9		
R	133.8	19		

Table 5-7. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HAV09.

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

Site:	**Oskarshamn**
Borehole name:	**HAV09**
Nominal velocity (m/µs):	**122.00**

Object type	Name	Intersection depth	Intersection angle
PLANE	A	19.38	31
PLANE	B	21.8	50
PLANE	C	39.3	24
PLANE	D	41.8	62
PLANE	E	50.3	55
PLANE	F	64.2	53
PLANE	G	71.9	57
PLANE	H	80.7	51
PLANE	I	103.4	80
PLANE	J	104.7	46
PLANE	K	109.5	45
PLANE	L	117.6	29
PLANE	M	120.6	55
PLANE	N	126.6	27
PLANE	O	131.0	67
PLANE	P	139.5	62
PLANE	Q	141.8	98
PLANE	R	146.4	15
PLANE	S	152.6	28
PLANE	T	155.5	73

PLANE	U	155.2	25
PLANE	V	177.0	39
PLANE	W	177.5	55
PLANE	X	190.7	86
PLANE	Y	197.2	71
PLANE	1	89.9	29
PLANE	2	100.5	44
PLANE	3	–51	21
PLANE	4	87.5	21

Table 5-8. Interpretation of radar reflectors from dipole antennas 20, 100 and 250 MHz in borehole HAV10.

RADINTER MODEL INFORMATION (20, 100 and 250 MHz Dipole Antennas)			
Site:		**Oskarshamn**	
Borehole name:		**HAV10**	
Nominal velocity (m/µs):		**122.00**	
Object type	**Name**	**Intersection depth**	**Intersection angle**
PLANE	A	16.9	67
PLANE	B	22.2	73
PLANE	C	26.4	77.8
PLANE	D	36.1	58
PLANE	E	44.3	46
PLANE	F	48.8	42
PLANE	G	53.2	46
PLANE	H	60.0	48
PLANE	I	66.3	53
PLANE	J	73.0	47
PLANE	K	78.8	49
PLANE	L	95.2	45
PLANE	M	167.6	26
PLANE	N	376.8	4
PLANE	O	178.5	31

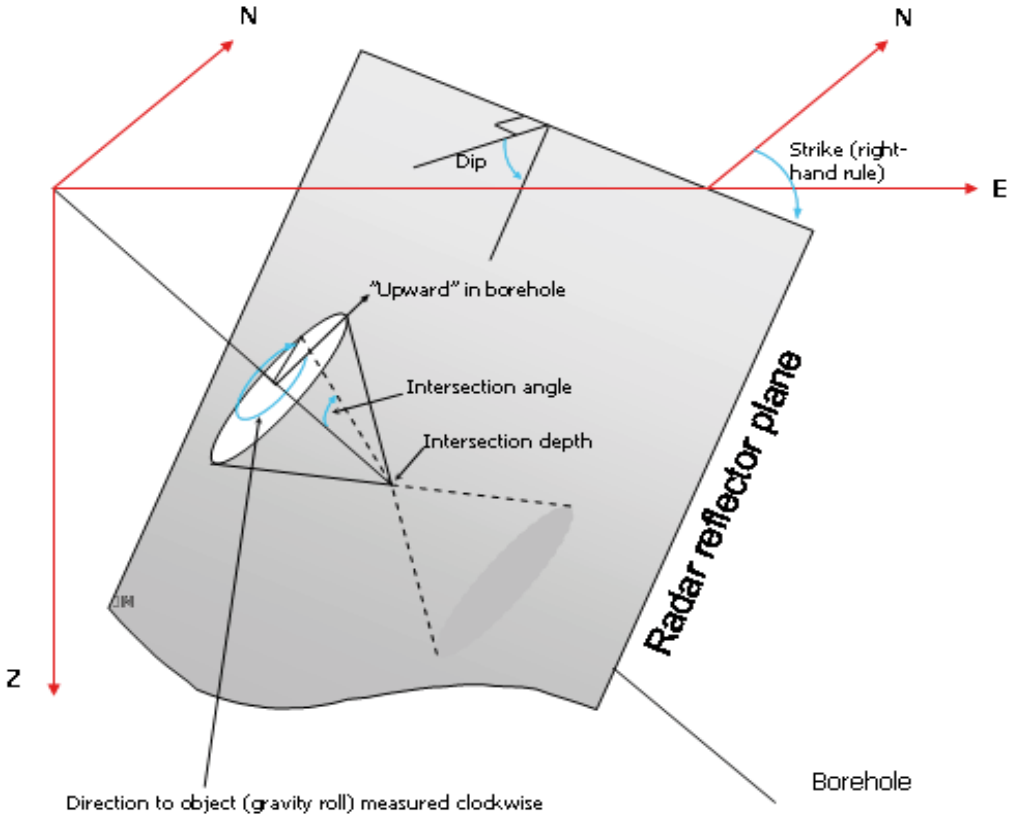


Figure 5-2. *Definition of intersection angle, direction to object using gravity roll, dip and strike using the right hand rule as presented in Tables 5-4 and 5-5.*

In Appendix 1 to 5, the amplitude of the first arrival is plotted against the depth, for the 250 MHz dipole antennas. The amplitude variation along the borehole indicates changes of the electrical conductivity of the volume of rock surrounding the borehole. A decrease in this amplitude may indicate fracture zones, clay or rock volumes with increases in water content, i.e. increases in electric conductivity. The decrease in amplitude is shown in Tables 5-9 to 5-12. HAV09.

Table 5-9. Decrease in amplitude for the 250 MHz antenna for borehole KSH03A.

Depth (m)
105 – 125
160 – 170
180 – 280
290
360
410
590
515 – 525
540
565
590
605 – 615
645 – 670

675
685
715 – 750
805
850
865
900 – 910
970

Table 5-10. Decrease in amplitude for the 250 MHz antenna for borehole KSH03B.

Depth (m)
15
20
30
35 – 40
45 – 55
95 – 70
85 – 95

Table 5-11. Decrease in amplitude for the 250 MHz antenna for borehole HAV09.

Depth (m)
20
30 – 40
45 – 50
50 – 55
70 – 100
100 – 105
110 – 120
120 – 130
150 – 160
175 – 180
195

Table 5-12. Decrease in amplitude for the 250 MHz antenna for borehole HAV10.

Depth (m)
15
20 – 25
30 – 40
45
55
65 – 75

5.2 BIPS logging

The BIPS pictures are presented in Appendix 6 to 10.

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 is visible on the BIPS screen. The recorded length is adjusted to these visible marks. In percussion drilled boreholes we use these marks on the cable as reference for the depth adjustment. The experience from one year of logging is that the marks on the logging cable is very good and differs very little compared with the results from core-drilled boreholes. At present we have marks at 110, 150 and 200 m 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. The resulting images displayed no difference regarding the colours and focus of the images. Results of the test loggings were included in the delivery of the raw data.

The logging of KSH03A was impaired by some quality problems, which, however, are system independent. Instead, the problems are related to a drilling induced discolouring of parts of the borehole wall. In the parts that are heavily defected there will most probably be problems to map thin structures and single fractures. Except for the discolouring problem the visibility of the borehole wall is not perfect. Both mud covering the lowermost part of the borehole wall and dirty water reduces the possibilities to get images of good quality.

The logging of KSH03B was performed during the same logging campaign and has images with the same quality as for KSH03A except that the induced discolouring from the drilling is not present.

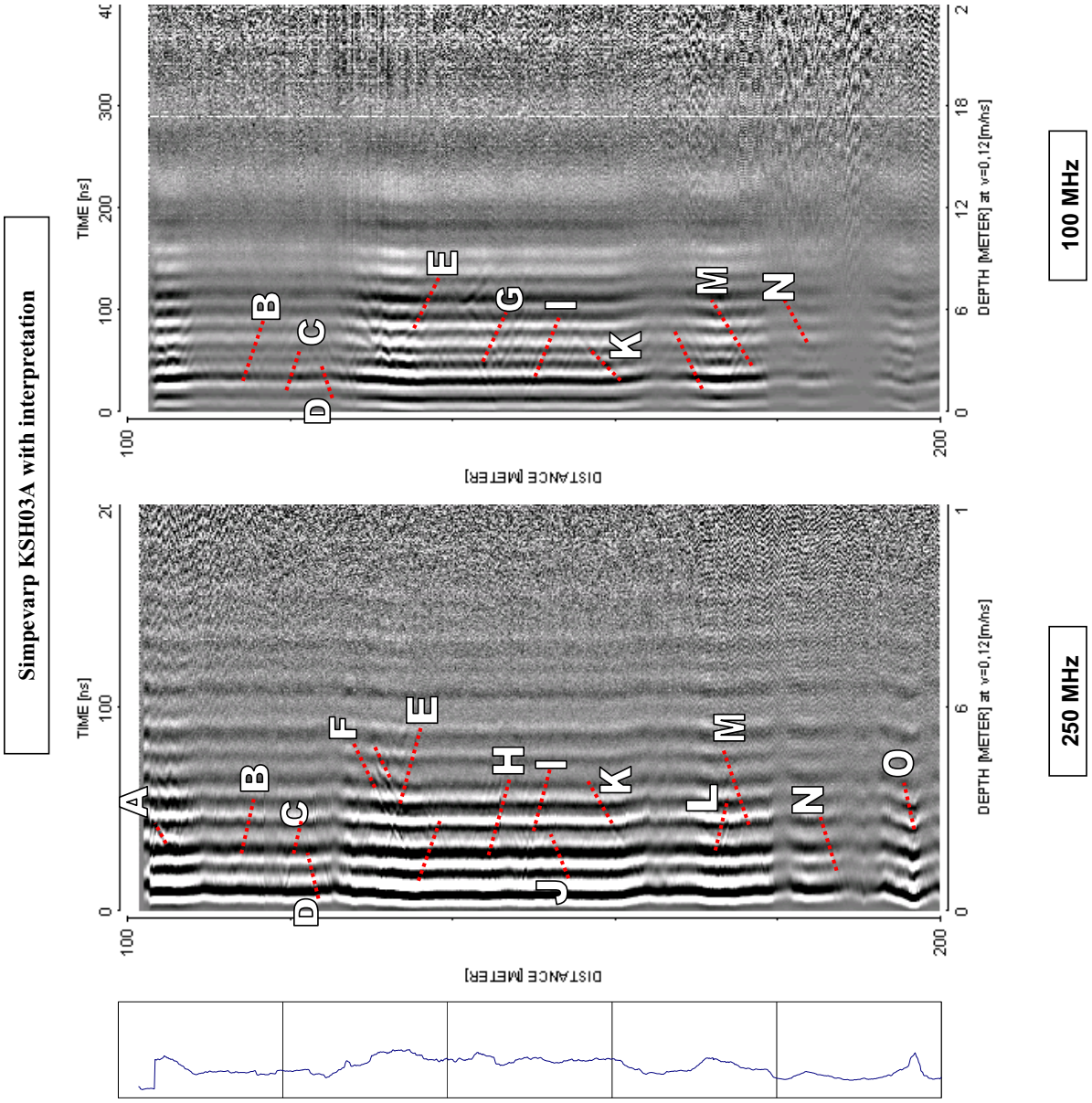
For the logging in HAV09 the water quality and the visibility of the borehole wall were of very good quality along the borehole until a depth of 140 meter. From this level and all the way to the bottom, mud is covering the lower most part of the borehole wall and reduces the visibility of the borehole wall. Still there is no problem to map thin fracture planes. It has to be stated that even if the borehole wall is covered with mud to 50% and completely hide the wall, mapping with good resolution is possible if the water quality is good. It is enough for the interpretation software to calculate the dip and strike angles even if 50% of the borehole is not visible.

In borehole HAV10 the visibility of the upper part of the wall was of good quality. Some amount of mud covering the lowermost part of the borehole wall decreased the visibility. This effect gets stronger deeper in the borehole and in the bottom it is impossible to indicate and map thin fractures. There is no problem to conduct the geological mapping except for the last 15 meters.

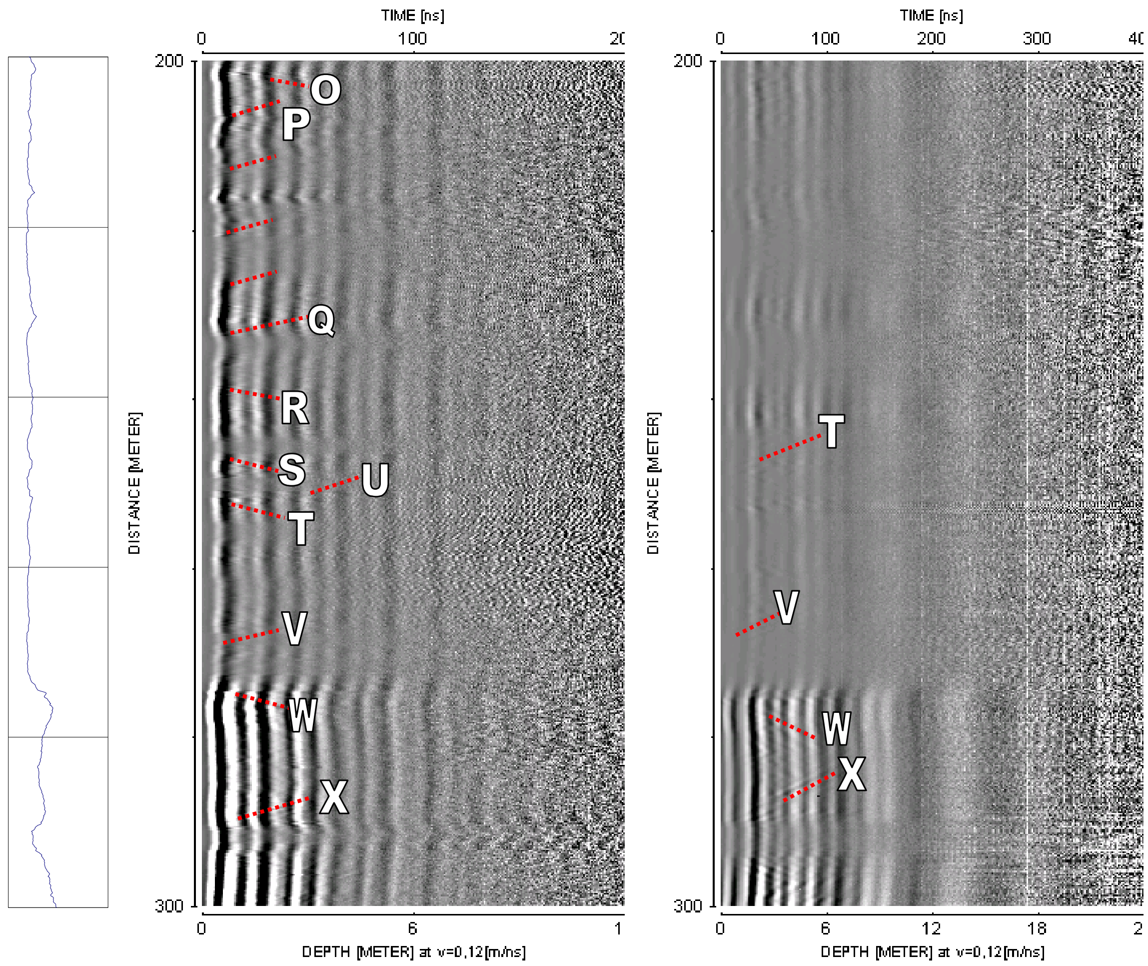
In KAV01 there is a spiral form all the way along the borehole. This spiral form is probably caused by drilling operations. The borehole is an old borehole drilled in 1977, 1986 and later on in 1997.

Appendix 1

Radar logging in KSH03A, 100 to 1000 m, dipole antennas 250 and 100 MHz.



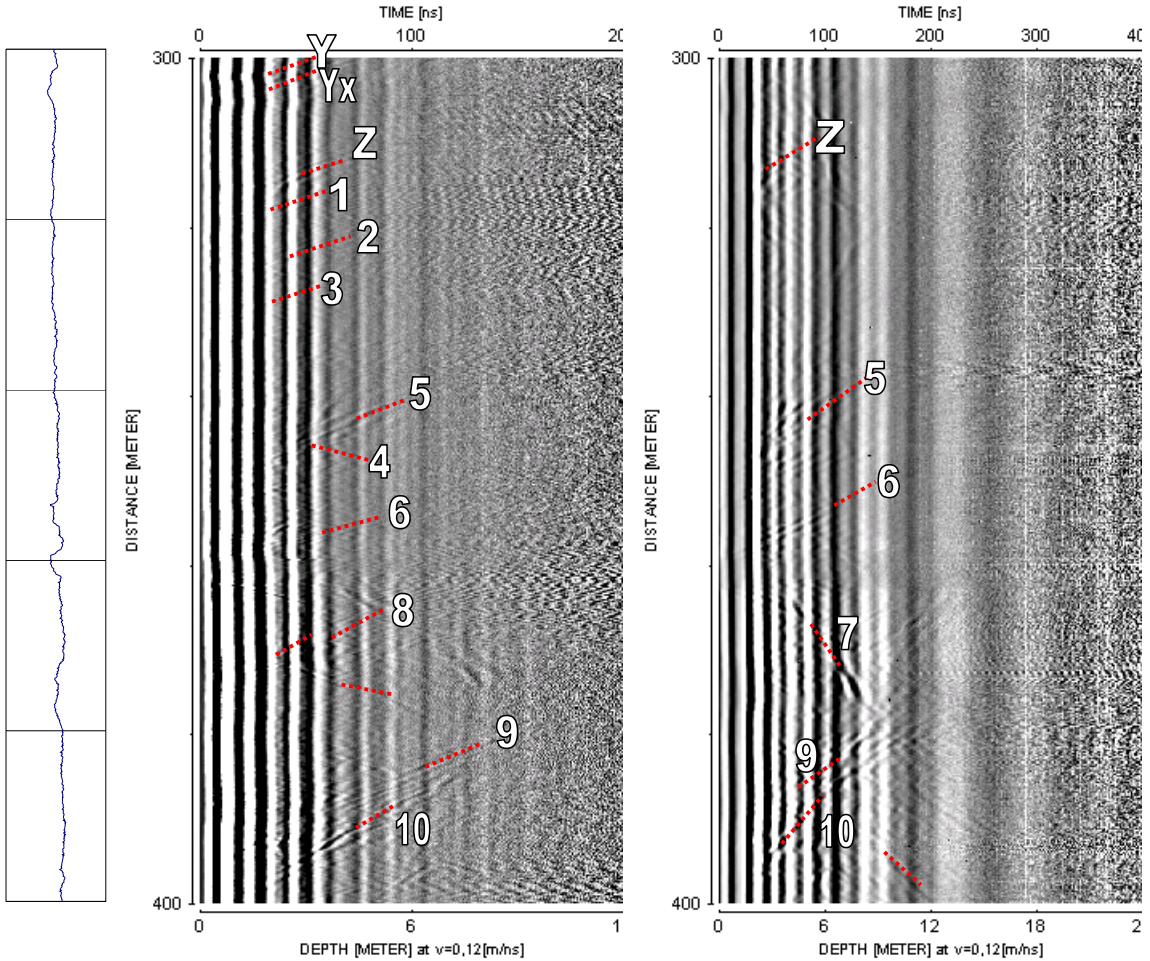
Simpevarp KSH03A with interpretation



250 MHz

100 MHz

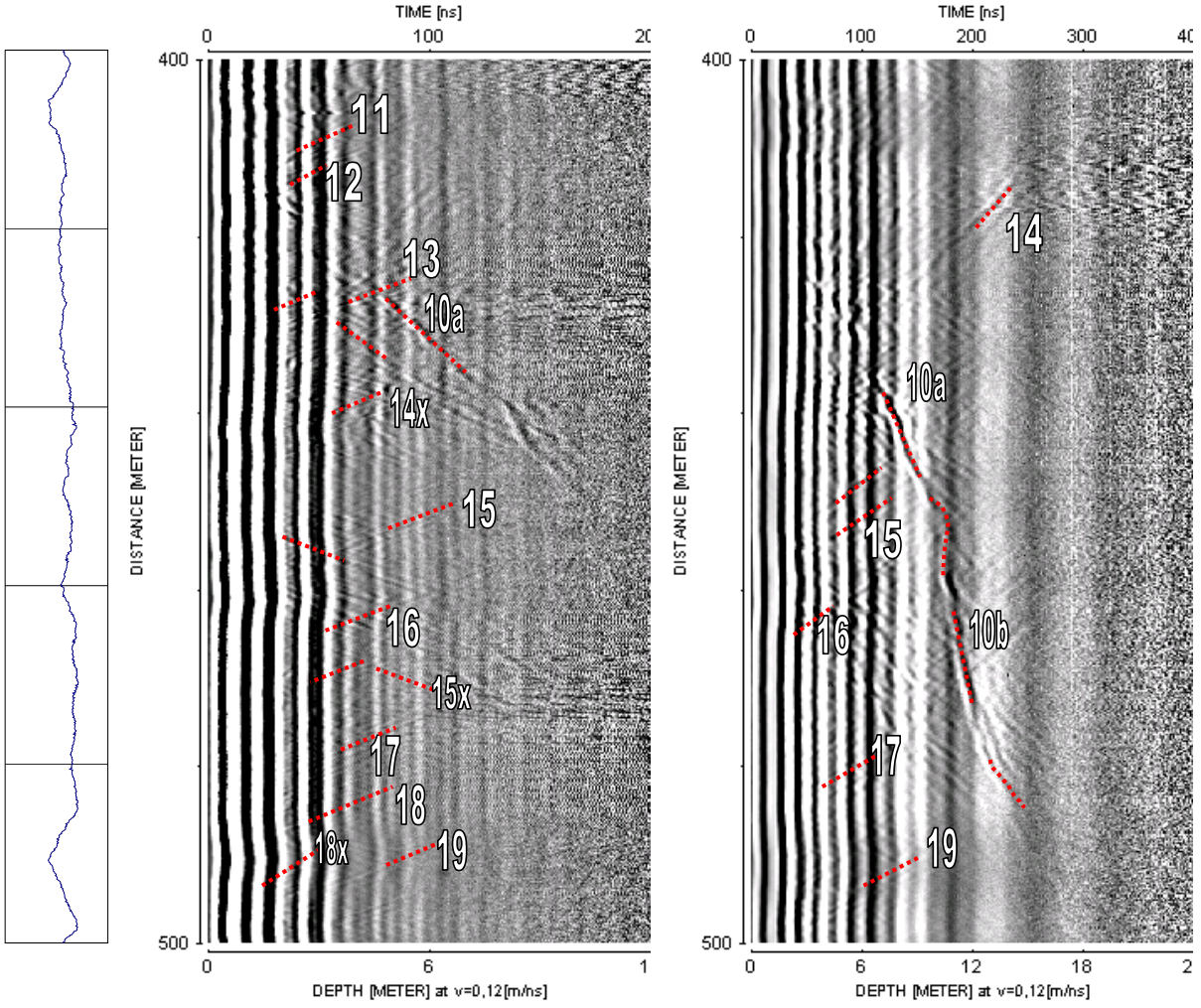
Simpevarp KSH03A with interpretation



250 MHz

100 MHz

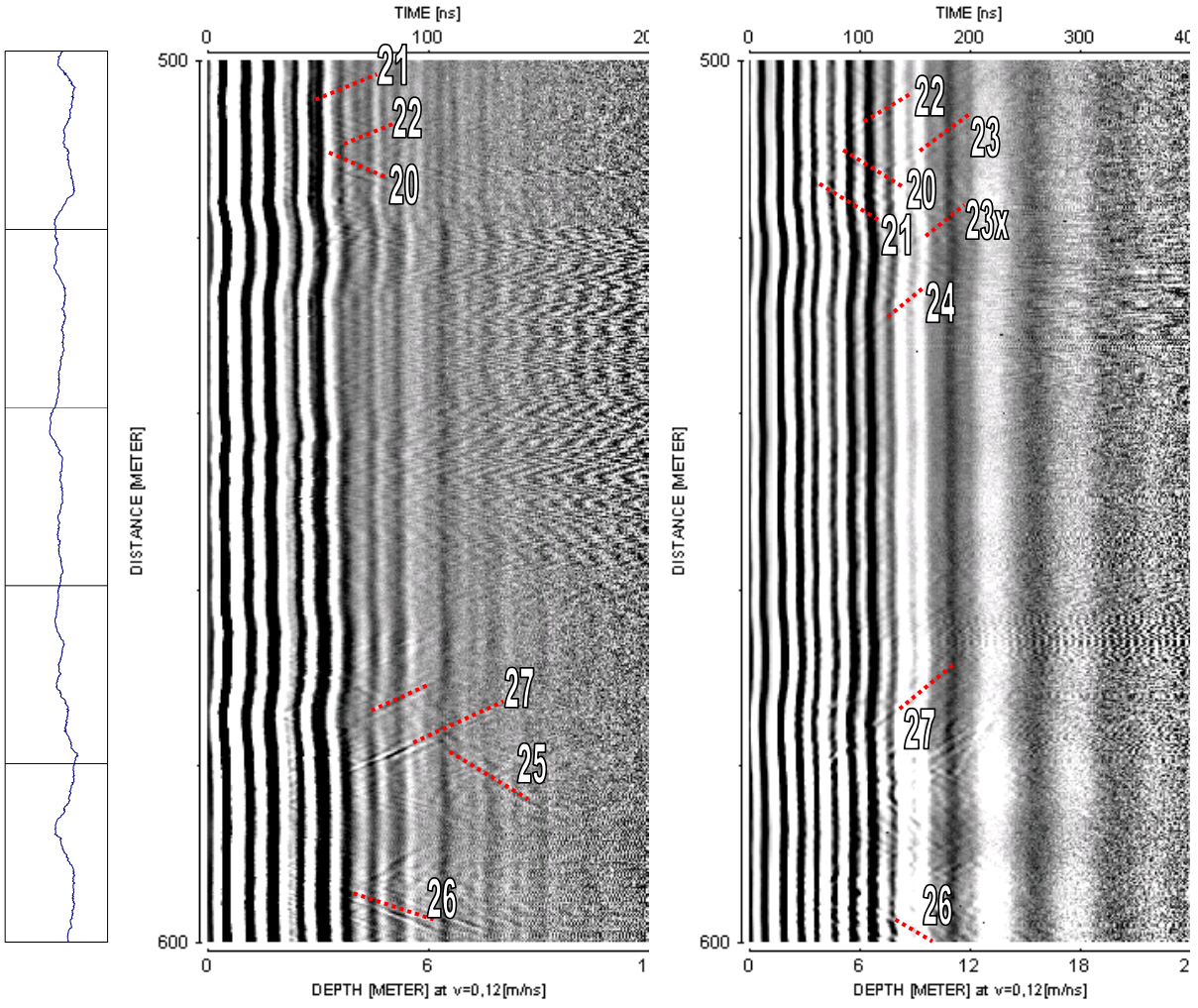
Simpevarp KSH03A with interpretation



250 MHz

100 MHz

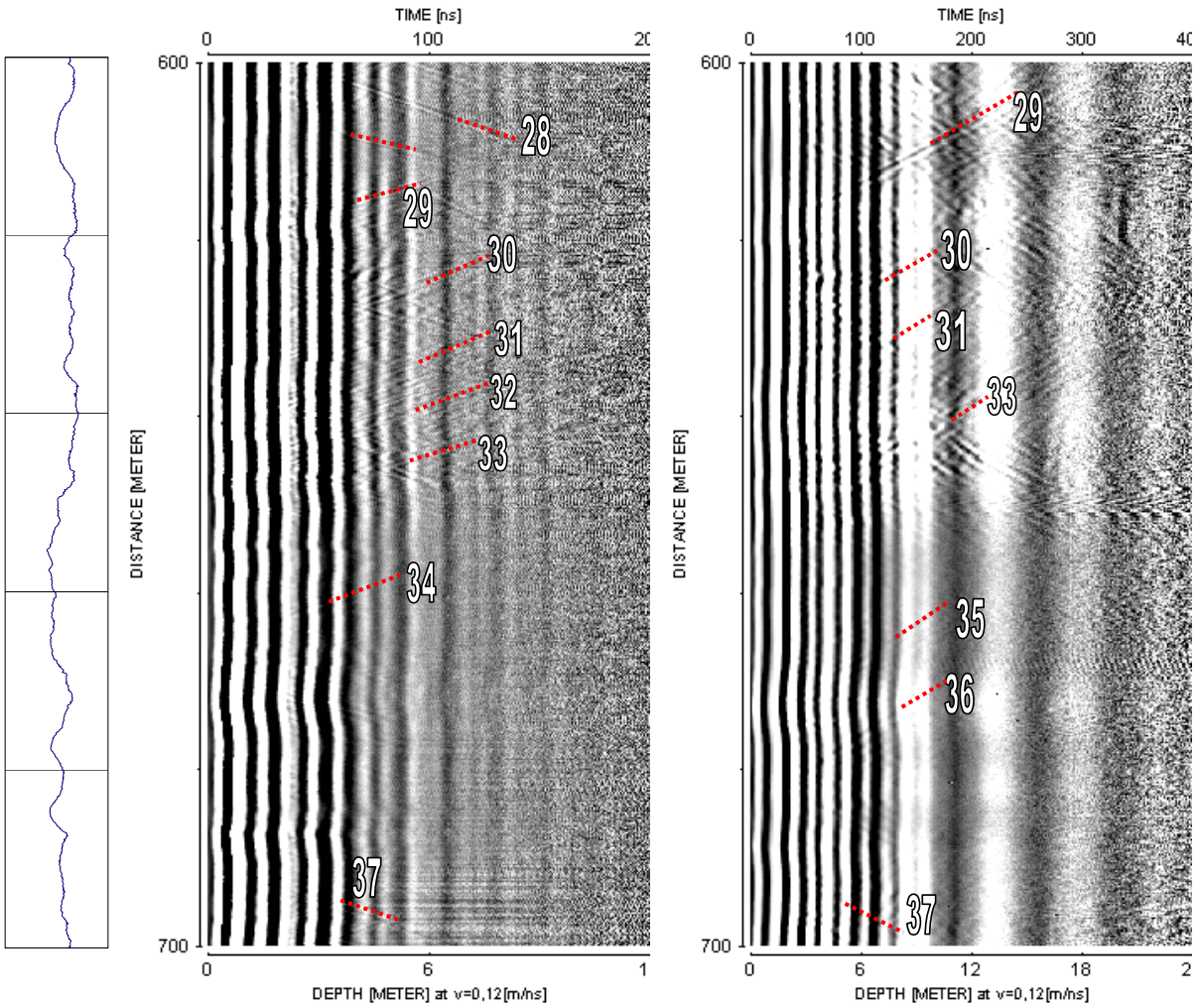
Simpevarp KSH03A with interpretation



250 MHz

100 MHz

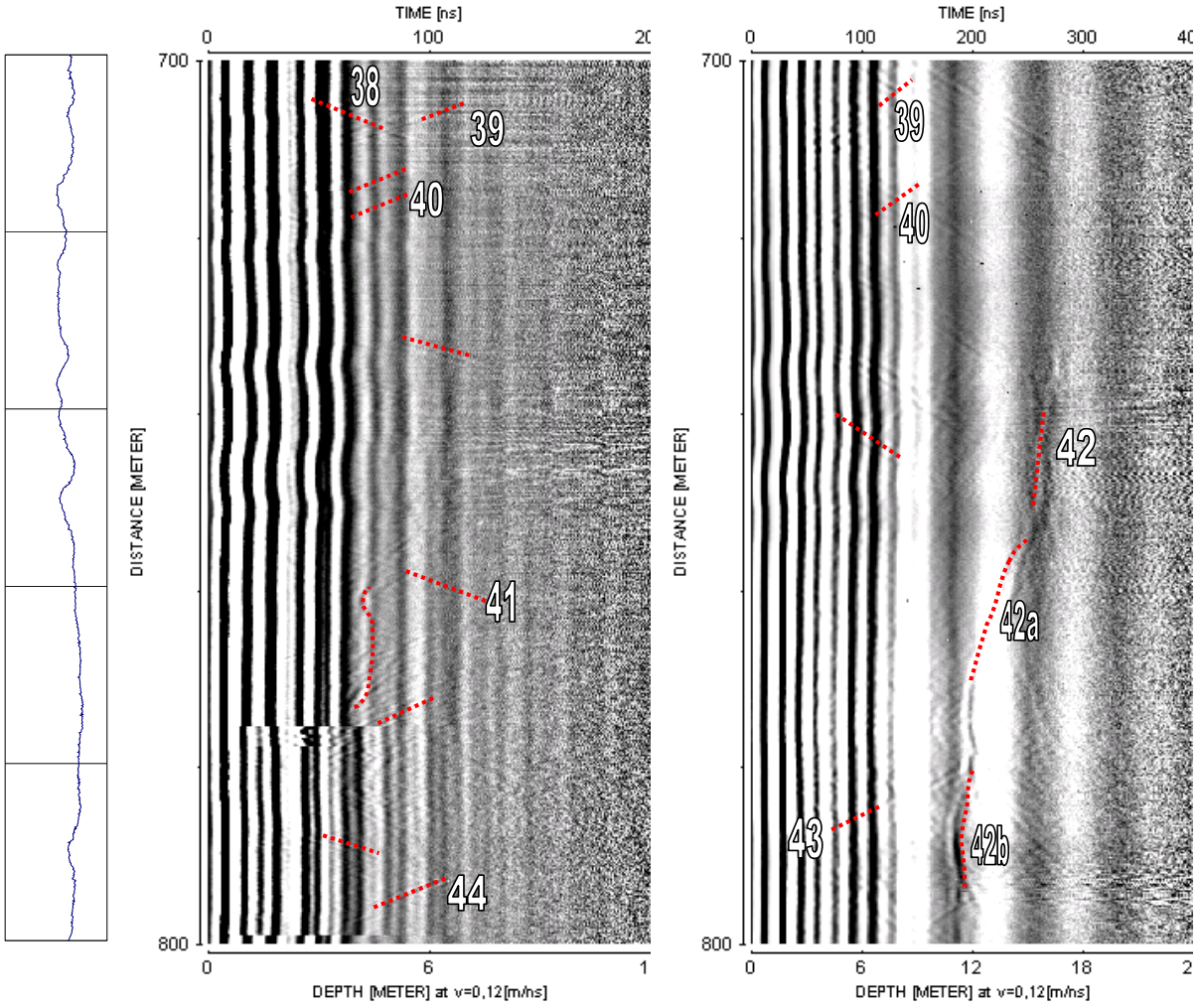
Simpevarp KSH03A with interpretation



250 MHz

100 MHz

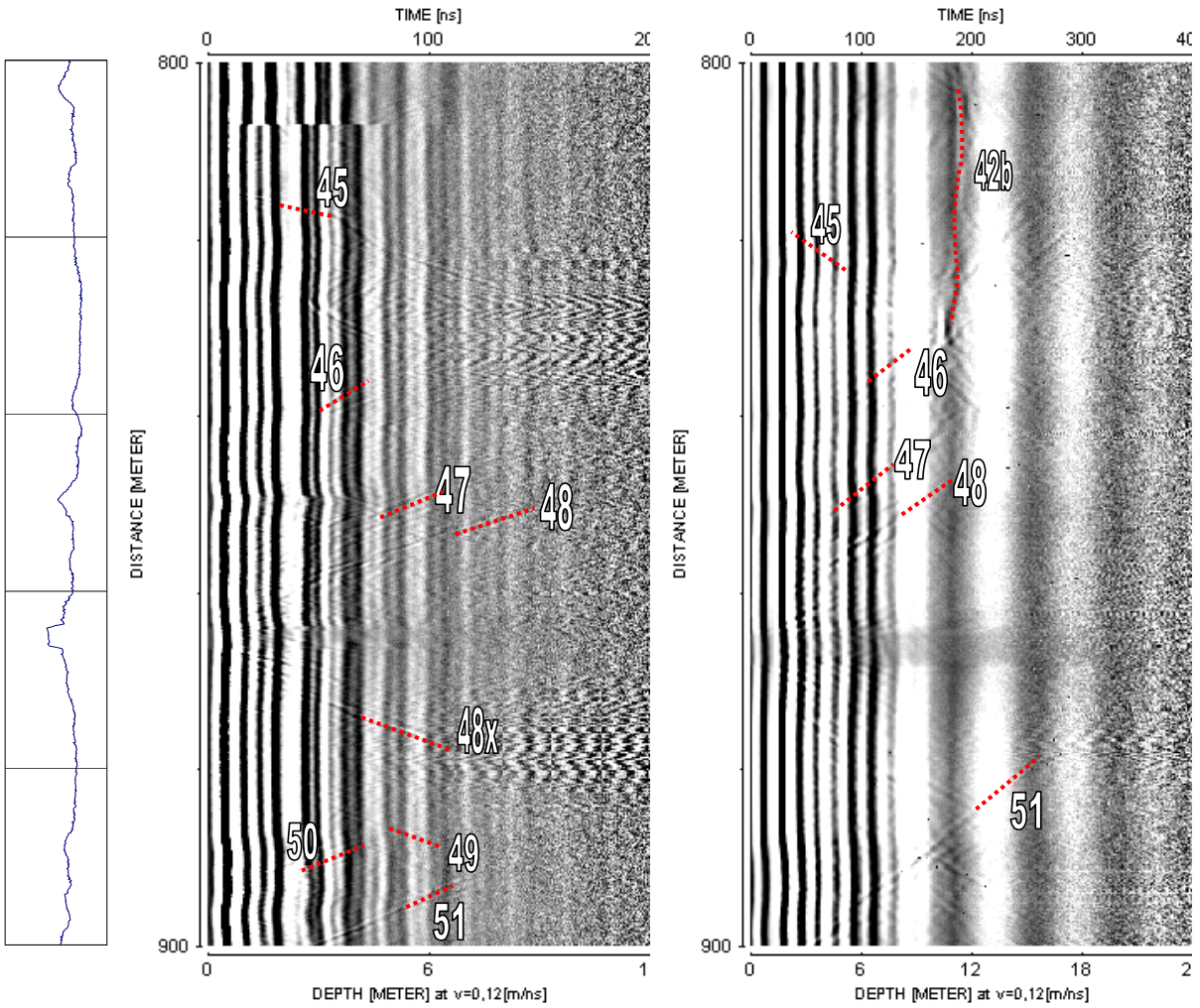
Simpevarp KSH03A with interpretation



250 MHz

100 MHz

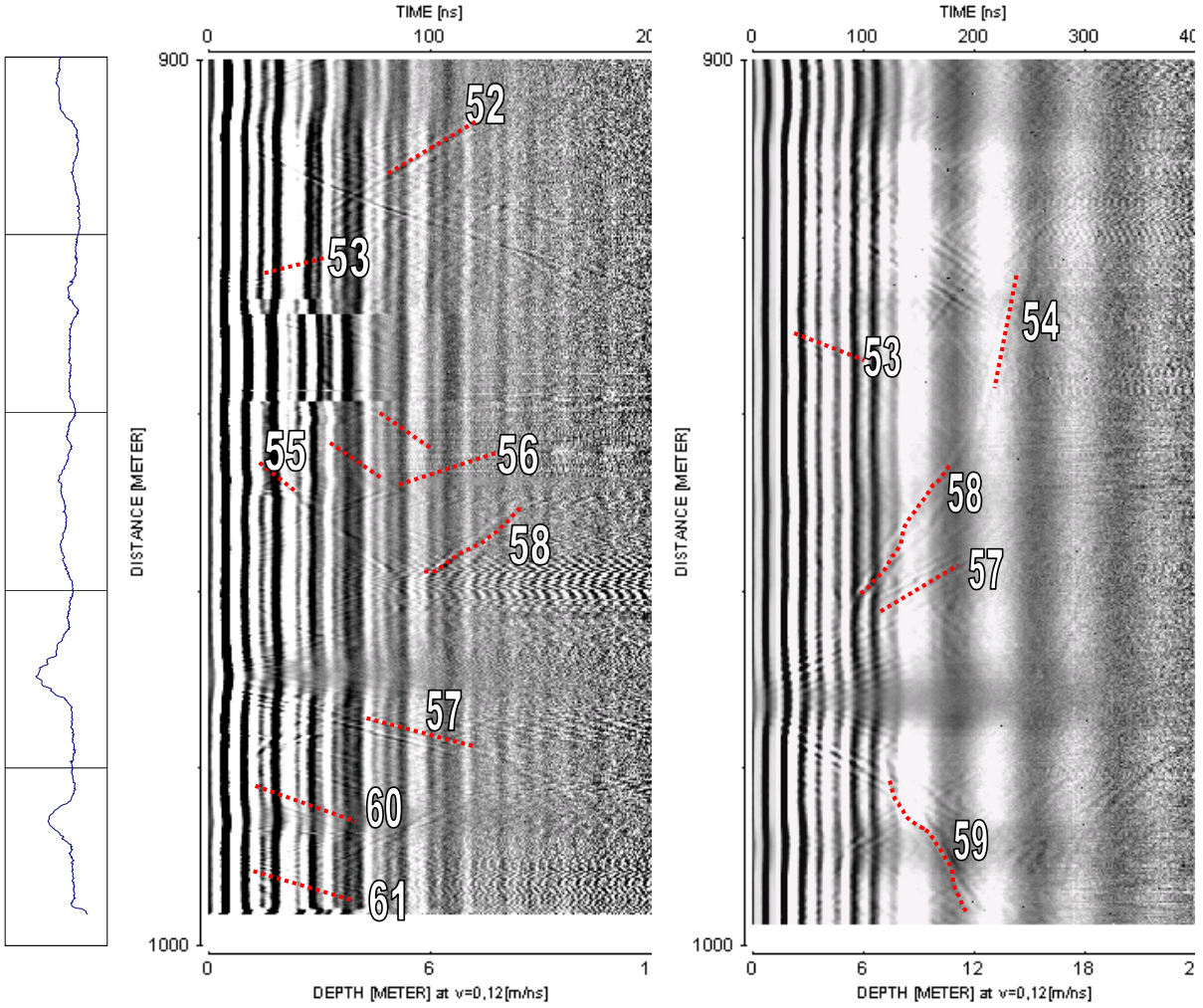
Simpevarp KSH03A with interpretation



250 MHz

100 MHz

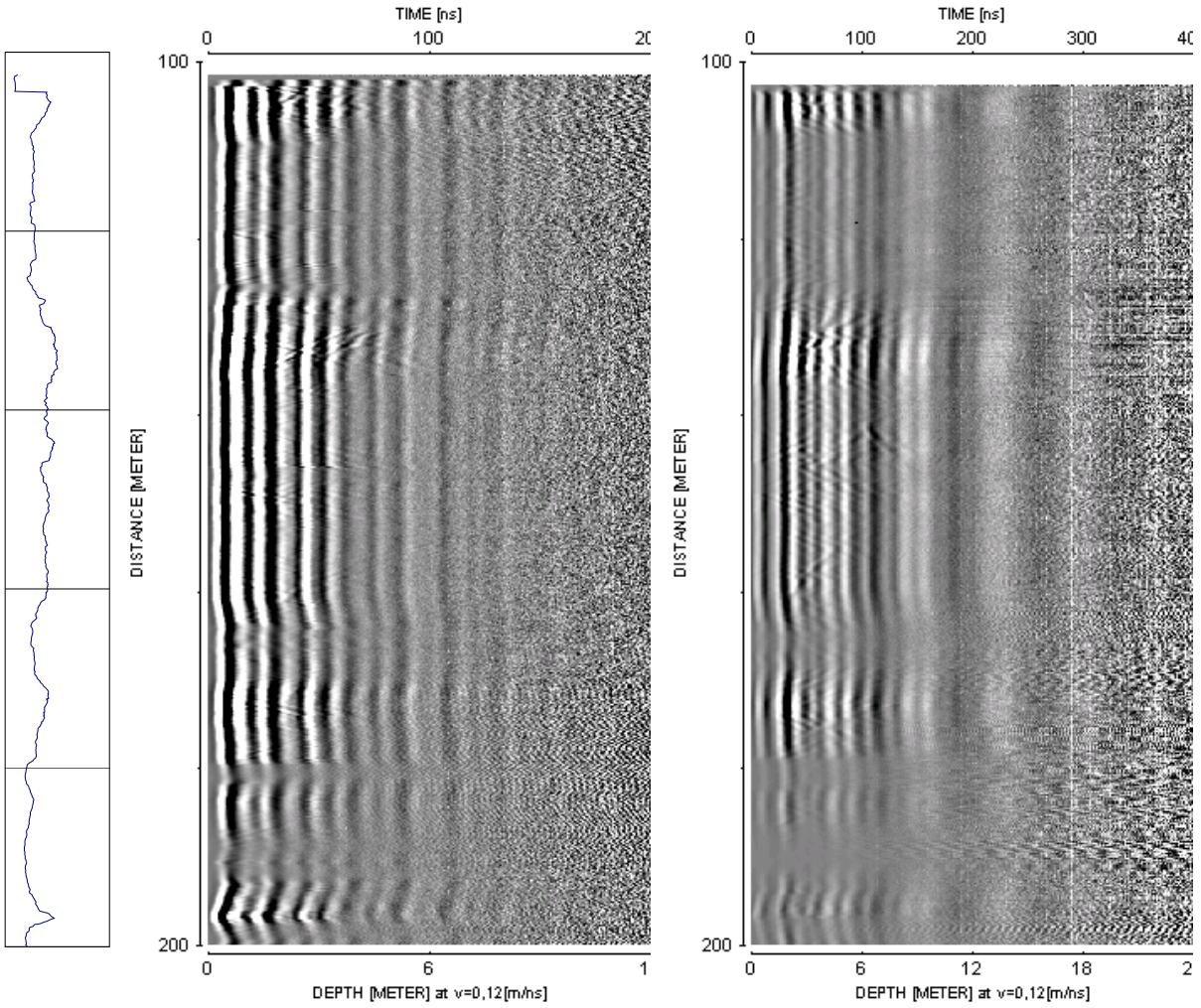
Simpevarp KSH03A with interpretation



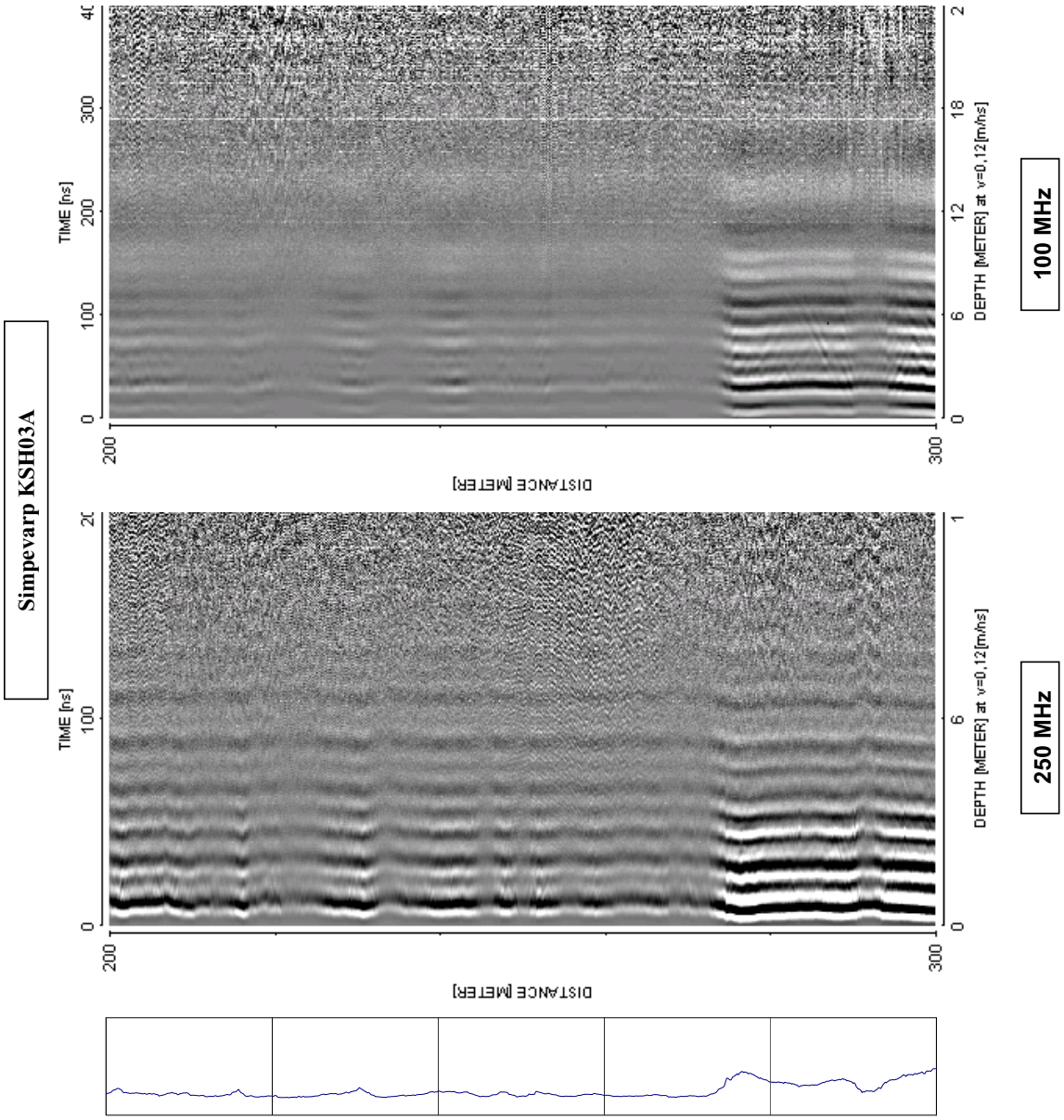
250 MHz

100 MHz

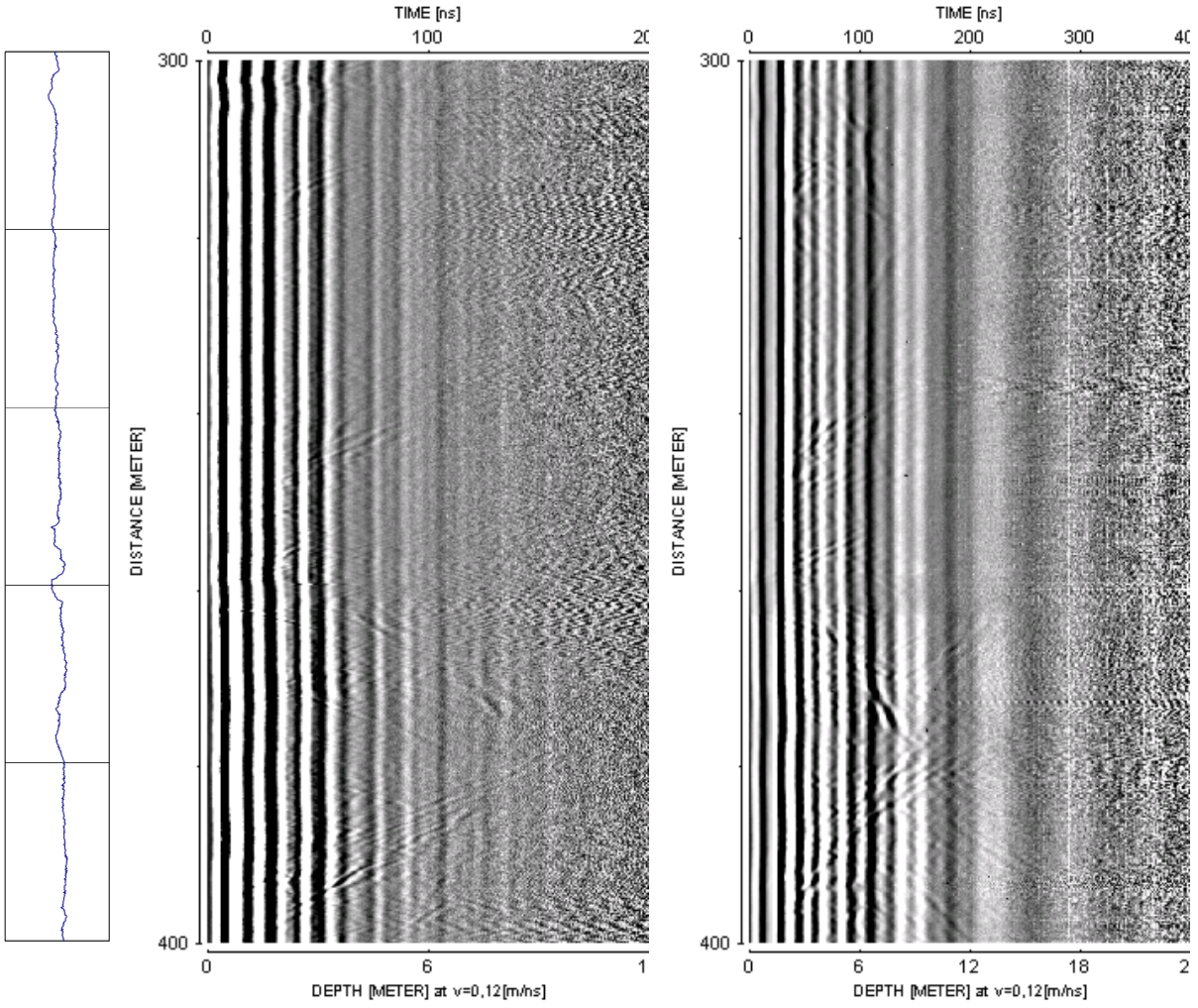
Simpevarp KSH03A



250 MHz **100 MHz**


Simpevarp KSH03A
TIME [ns]
DISTANCE [METER]
DEPTH [METER] at v=0,12[m/ns]
250 MHz
100 MHz

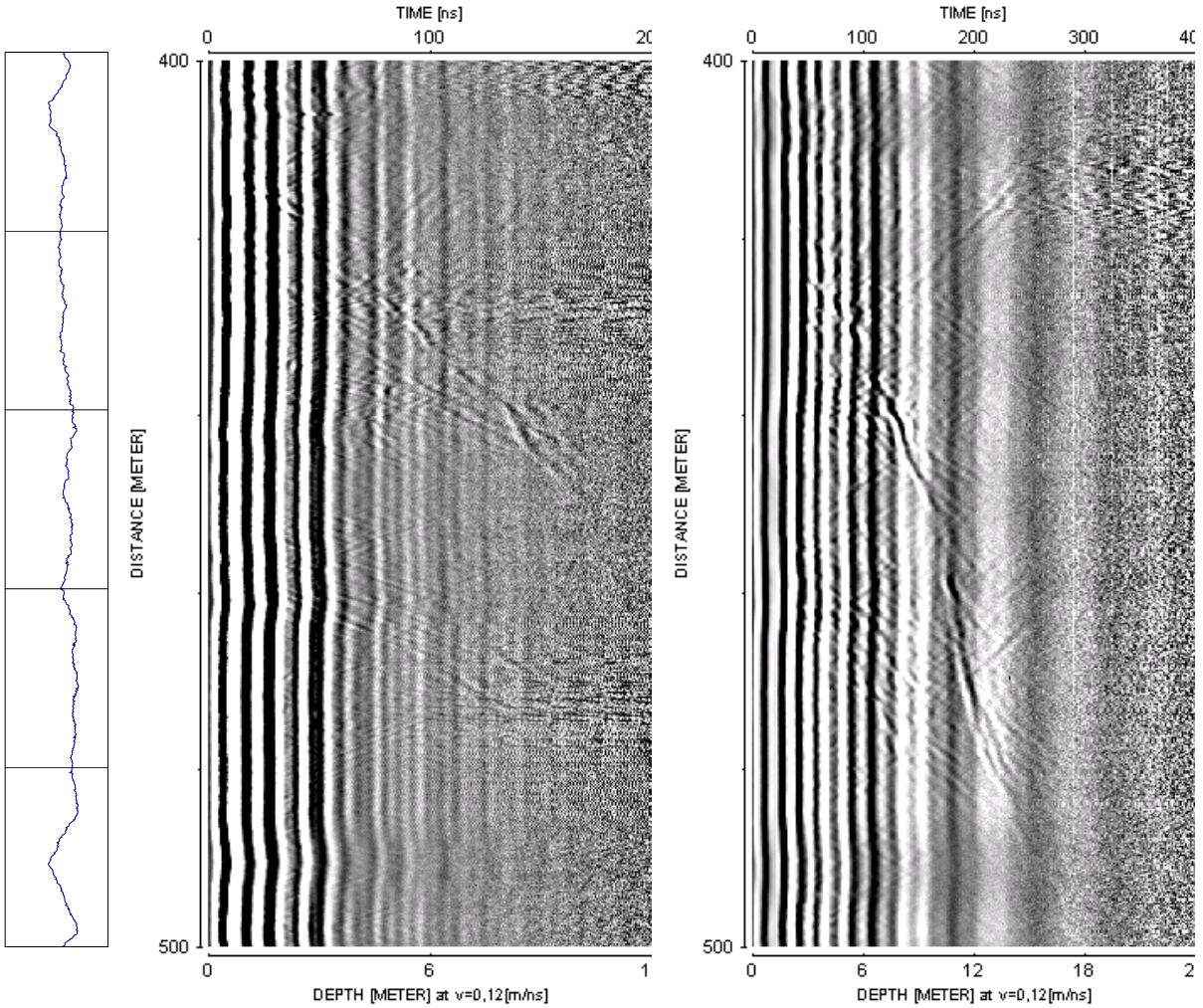
Simpevarp KSH03A



250 MHz

100 MHz

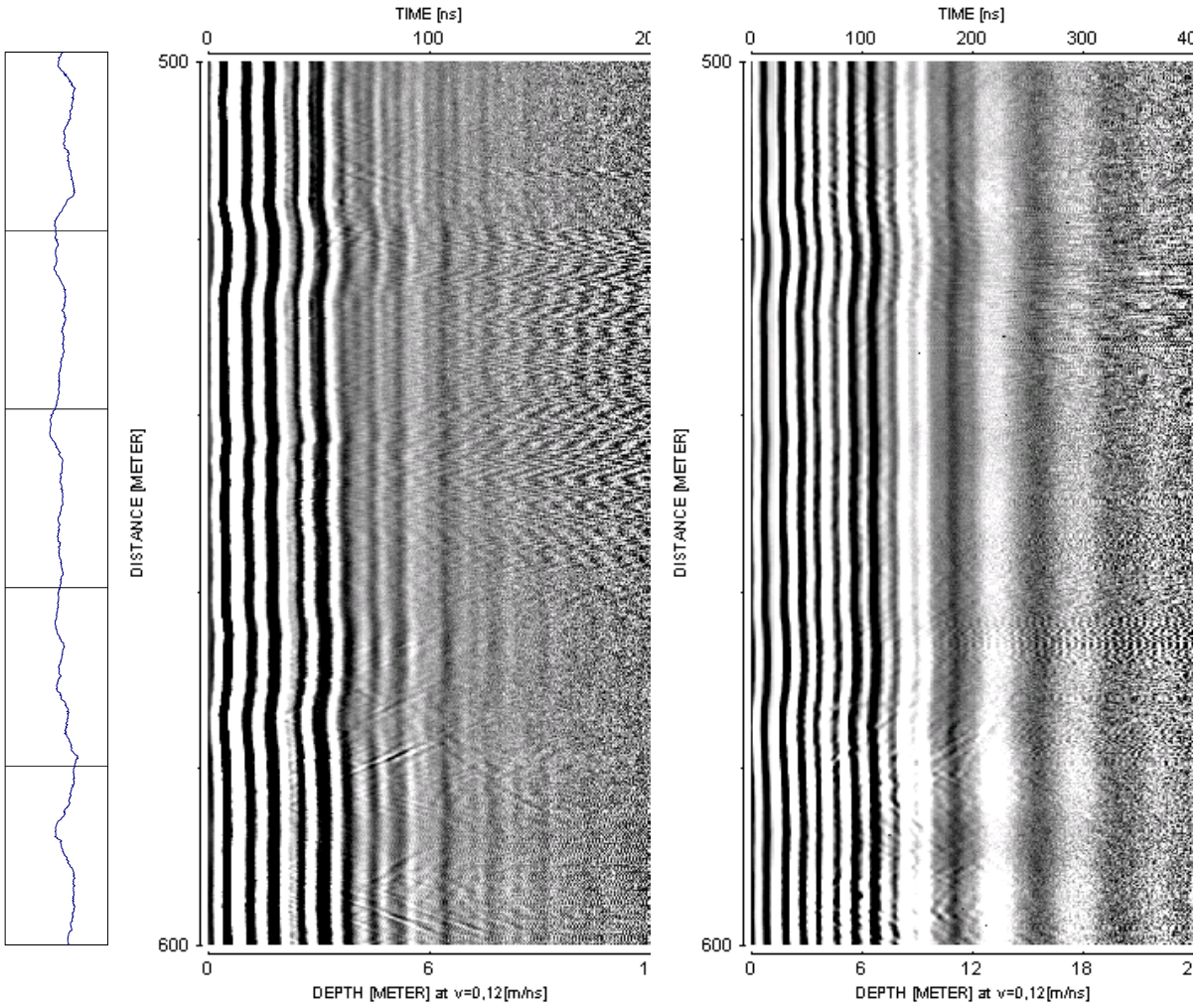
Simpevarp KSH03A



250 MHz

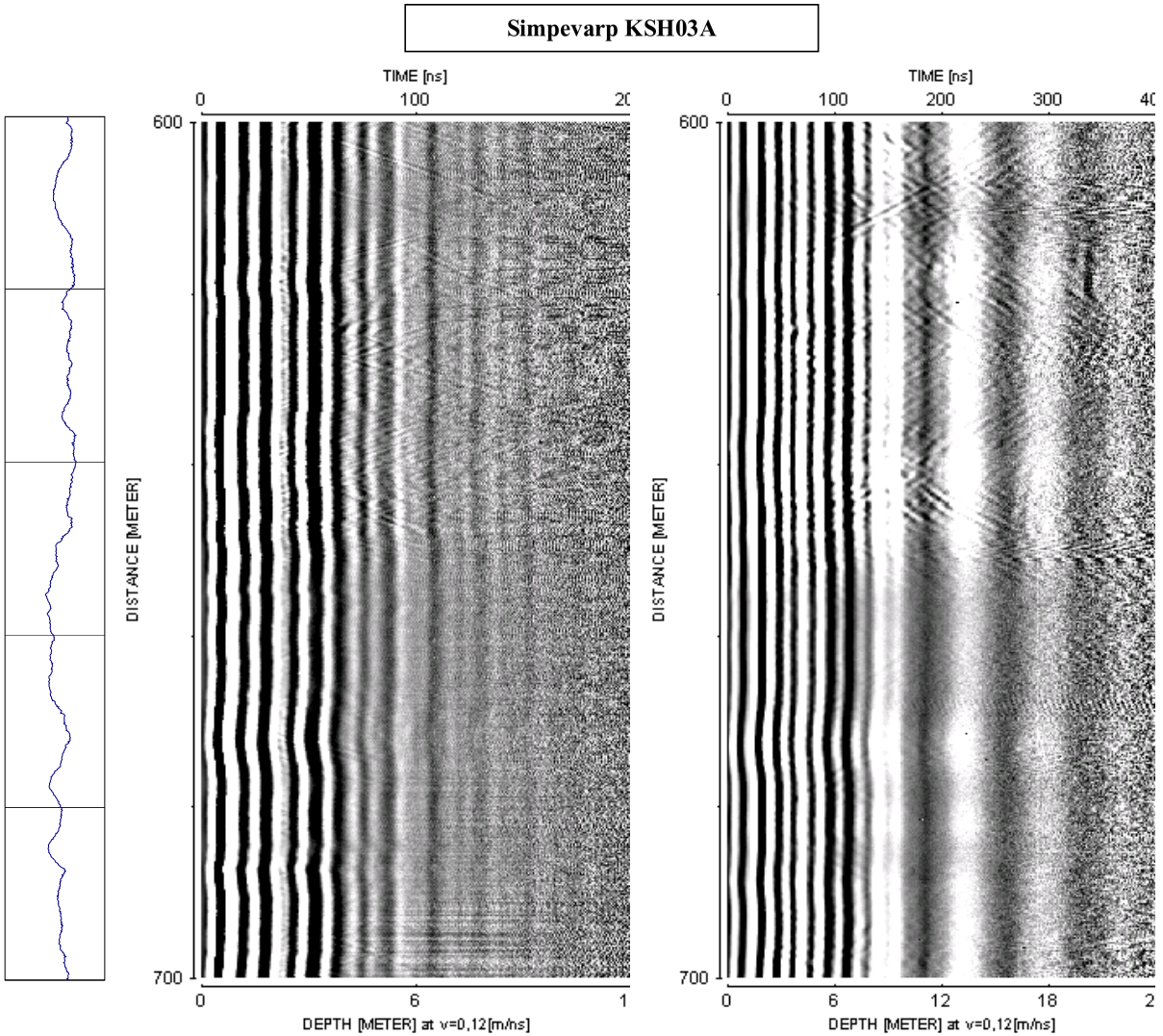
100 MHz

Simpevarp KSH03A

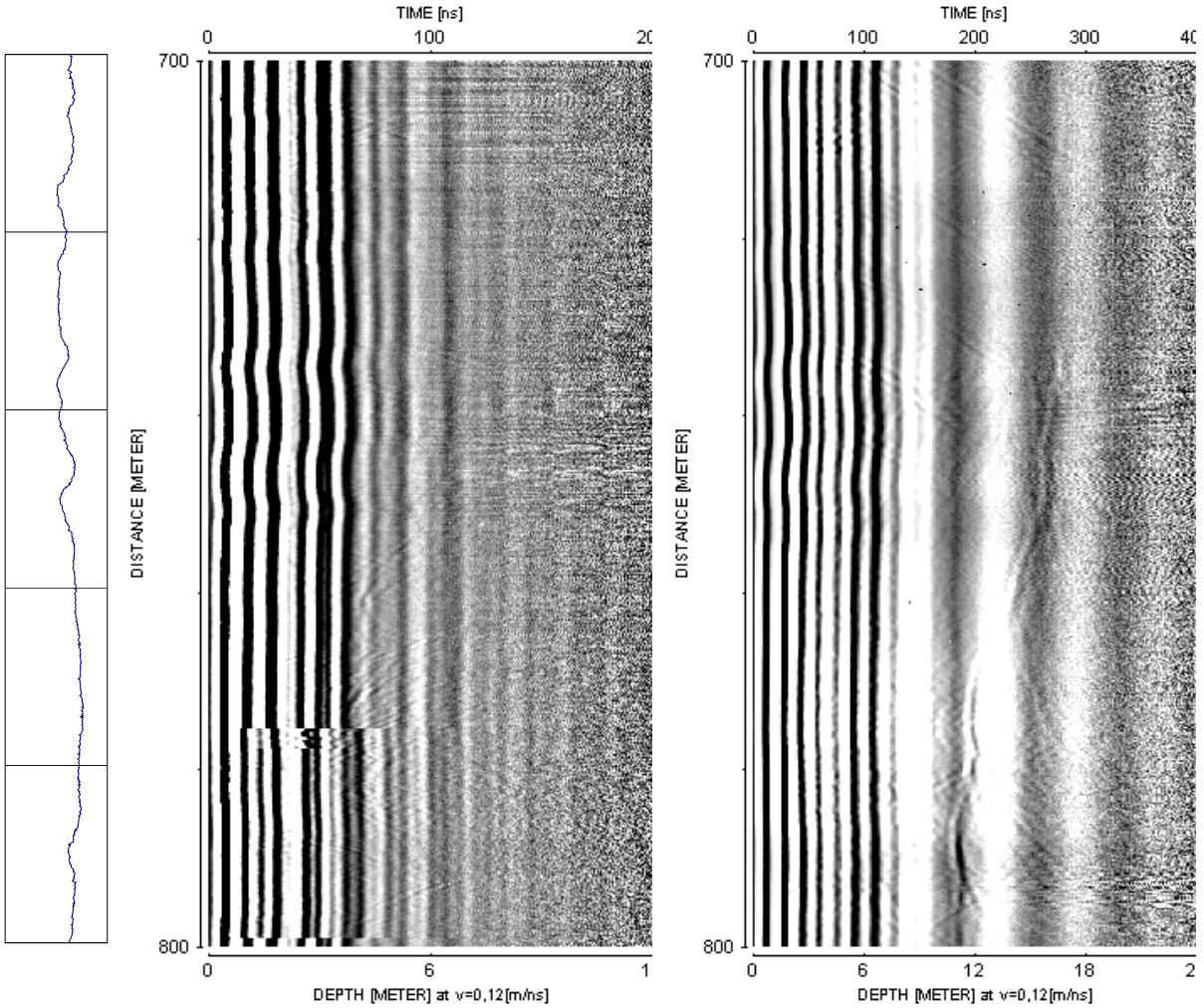


250 MHz

100 MHz


Simpevarp KSH03A
TIME [ns]
0
100
600
700
DISTANCE [METER]
0
6
DEPTH [METER] at v=0,12[m/ns]
TIME [ns]
0
100
200
300
600
700
DISTANCE [METER]
0
6
12
18
DEPTH [METER] at v=0,12[m/ns]
250 MHz
100 MHz

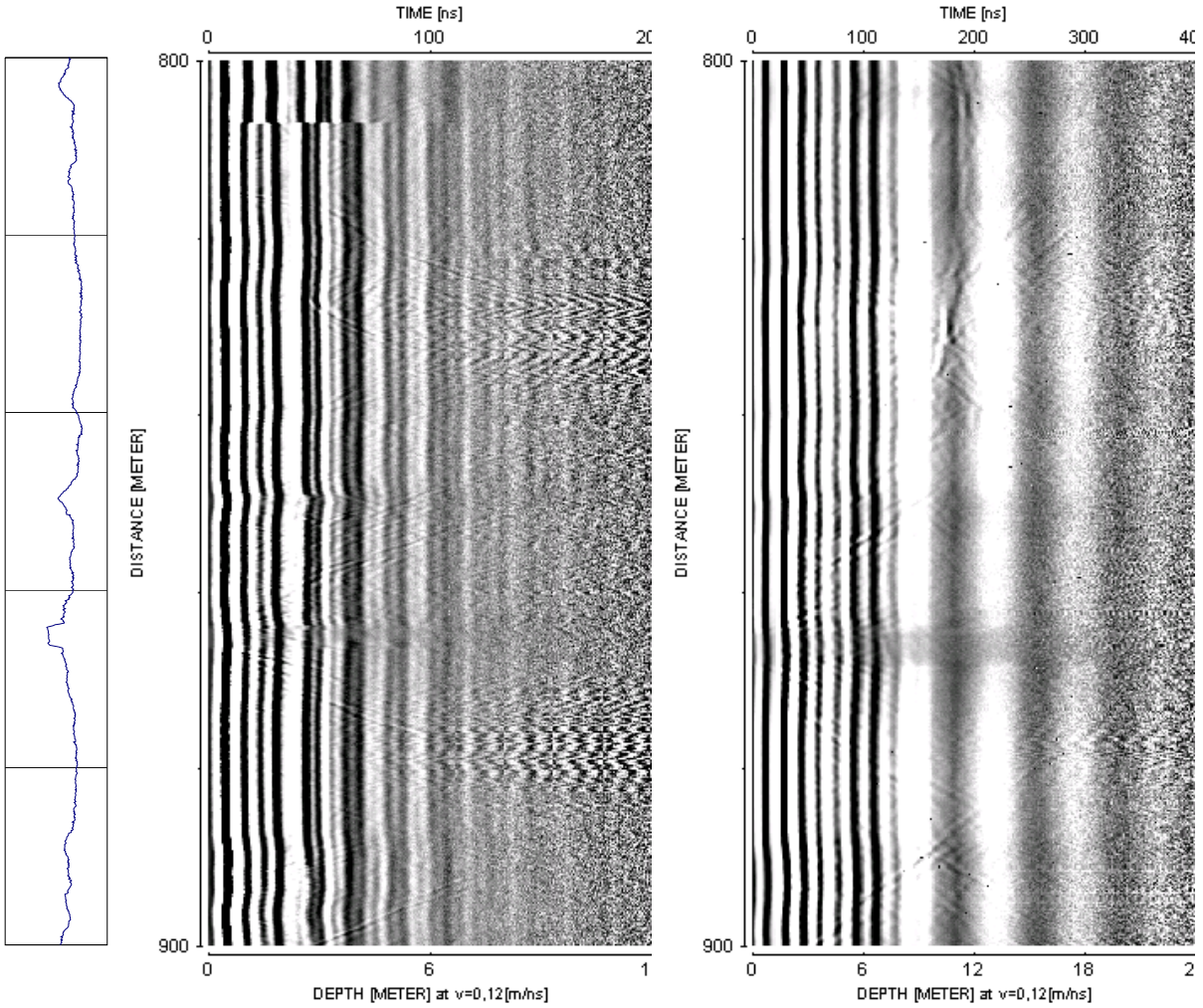
Simpevarp KSH03A



250 MHz

100 MHz

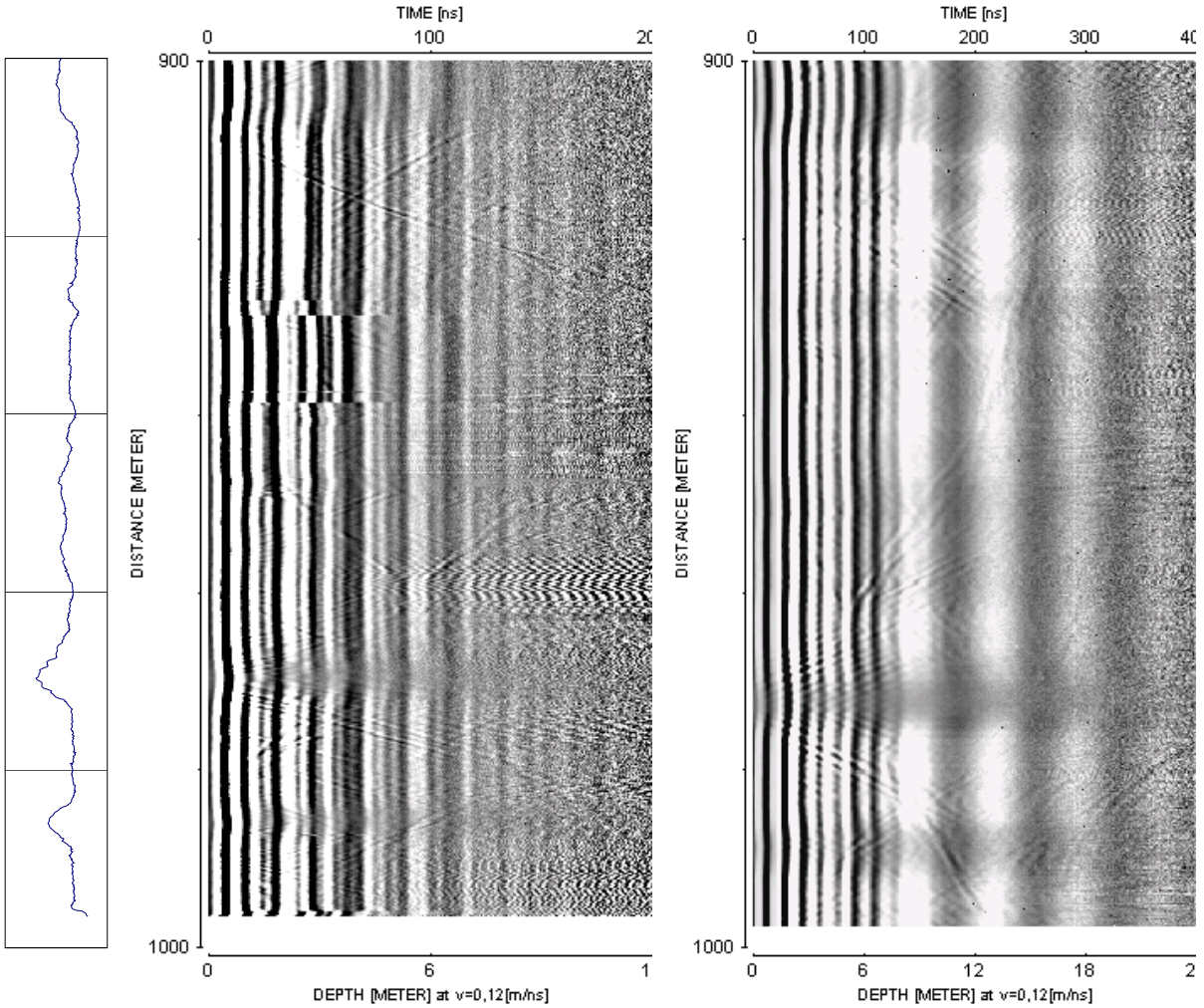
Simpevarp KSH03A



250 MHz

100 MHz

Simpevarp KSH03A



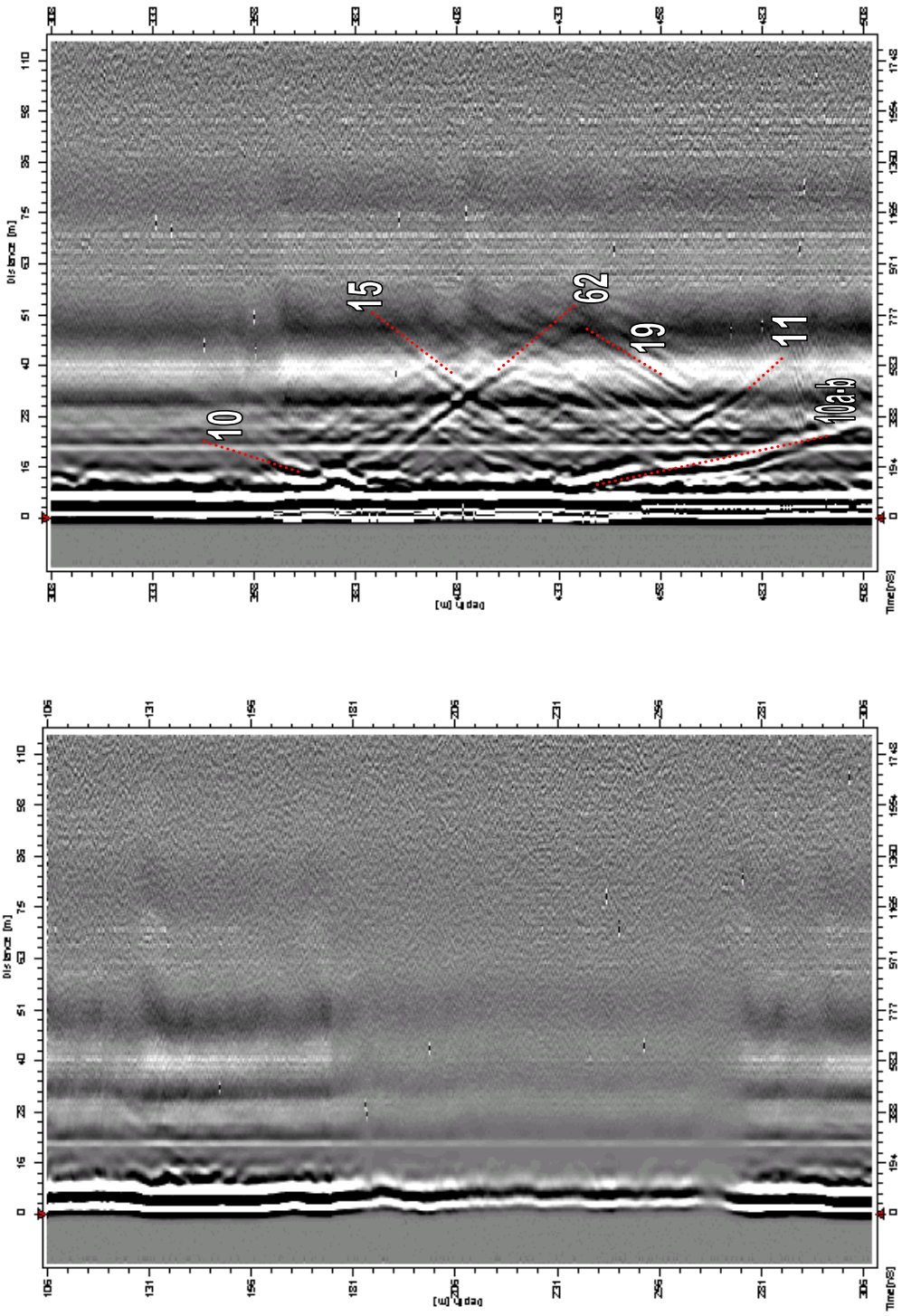
250 MHz

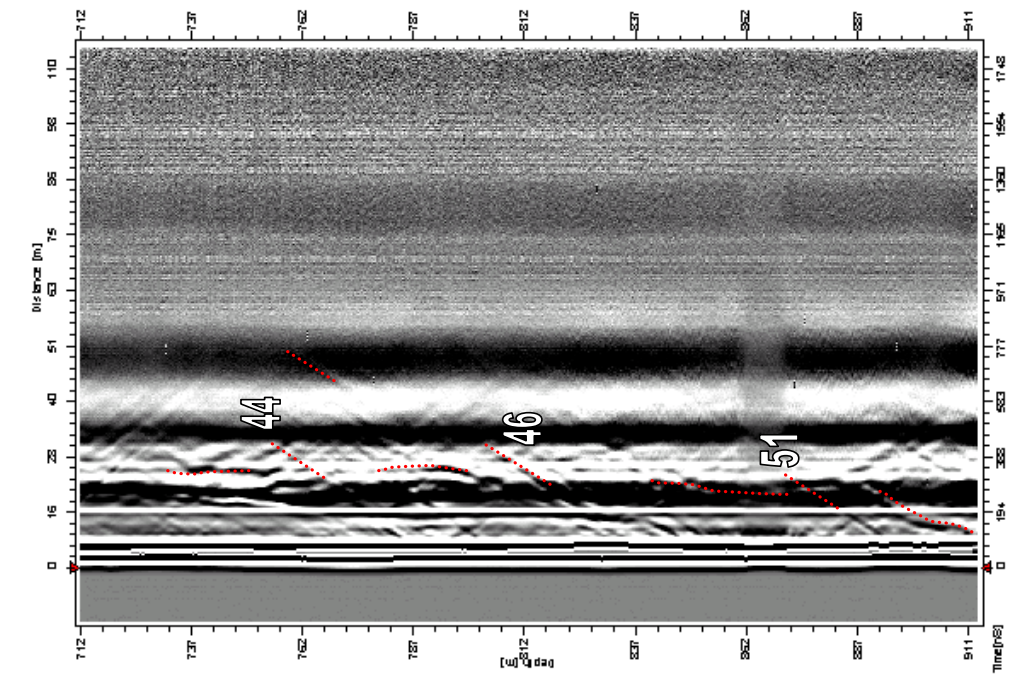
100 MHz

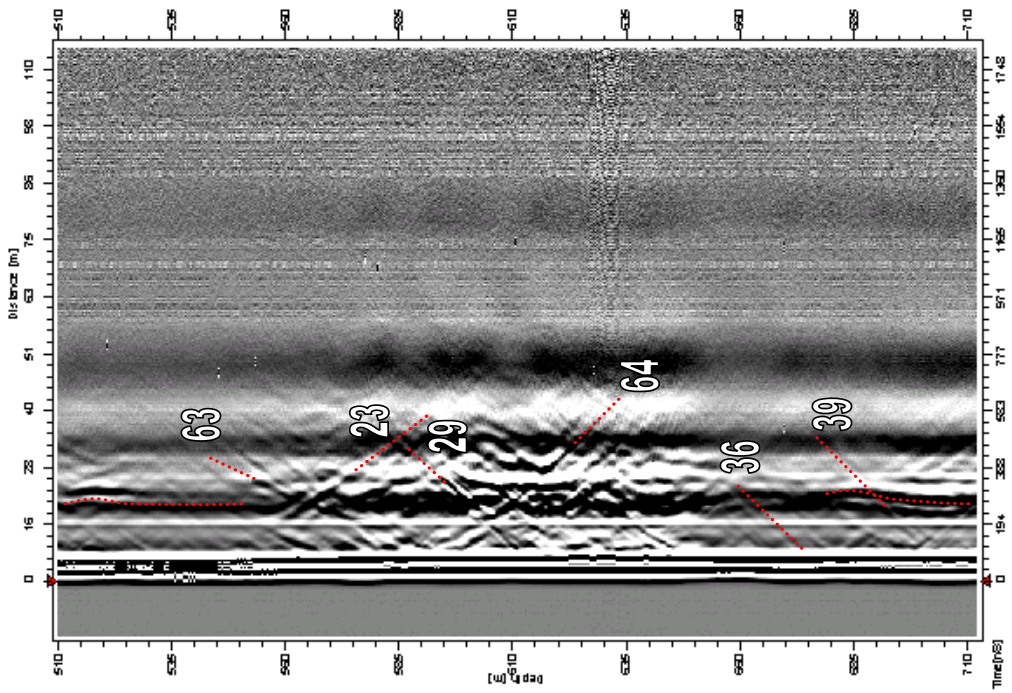
Appendix 2

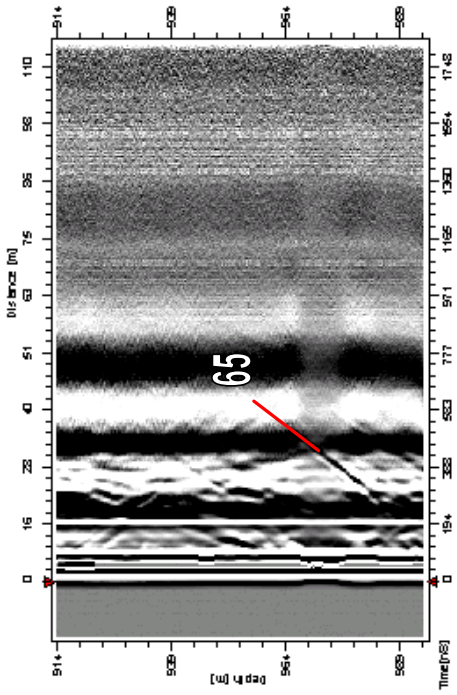
Radar logging in KSH03A, 100 to 1000 m, dipole antenna 20 MHz.

Simpevarp KSH03A 20 MHz with interpretation

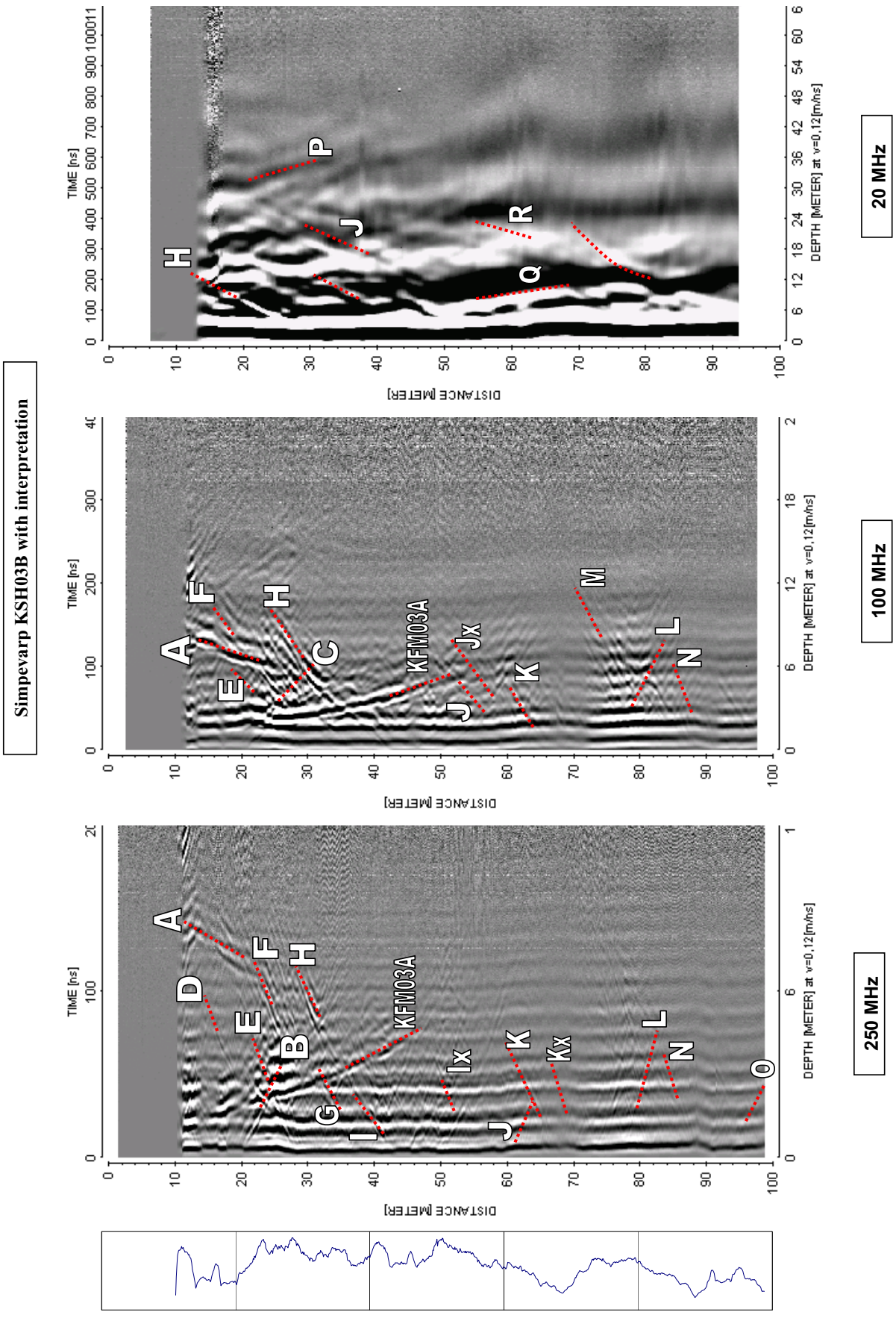



44
46
51

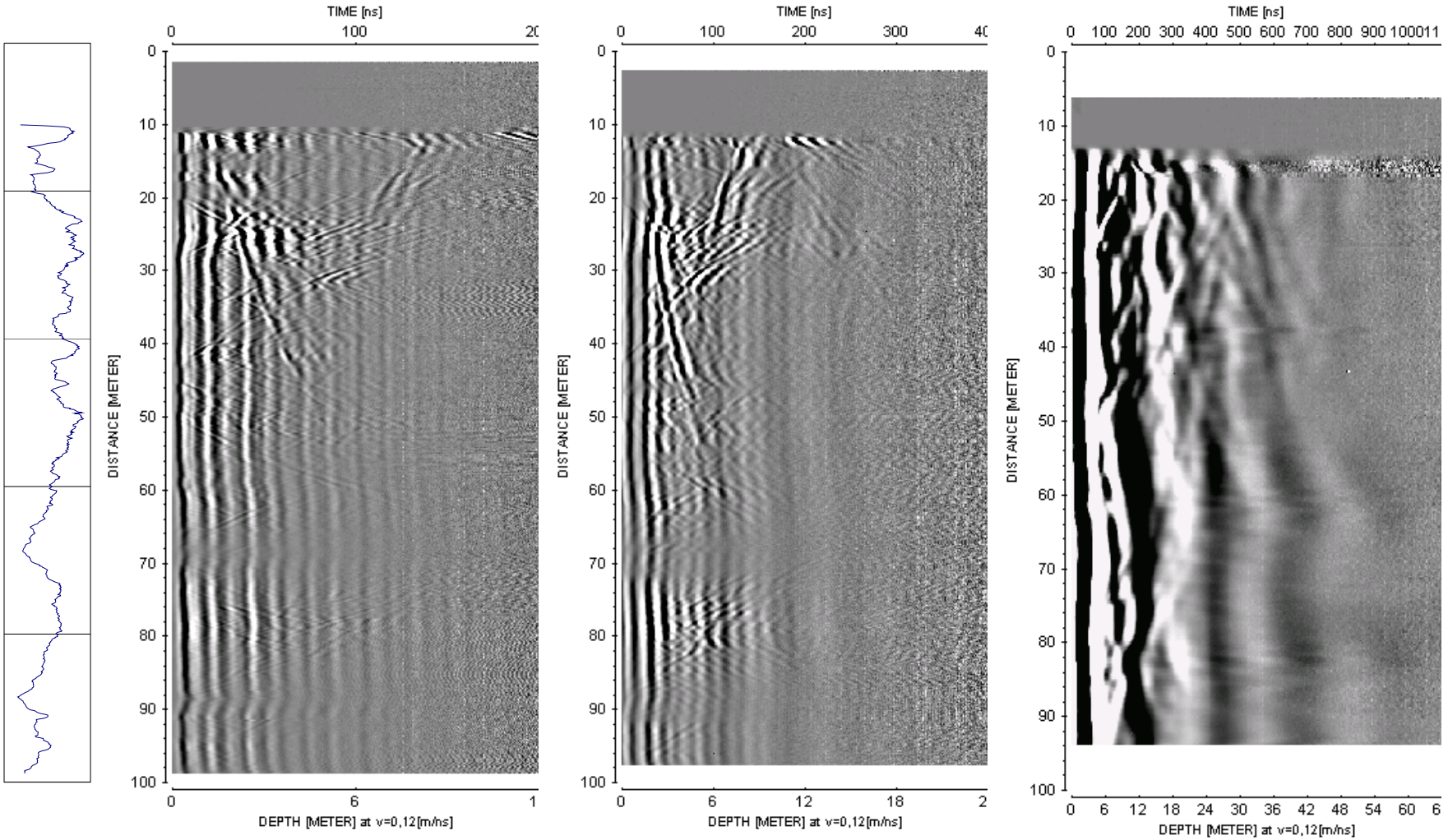

63
23
29
64
36
39


65
Distance [m]
Depth [m]
Time [ns]

Radar logging in KSH03B, 0 to 100 m, dipole antennas 250, 100 and 20 MHz.

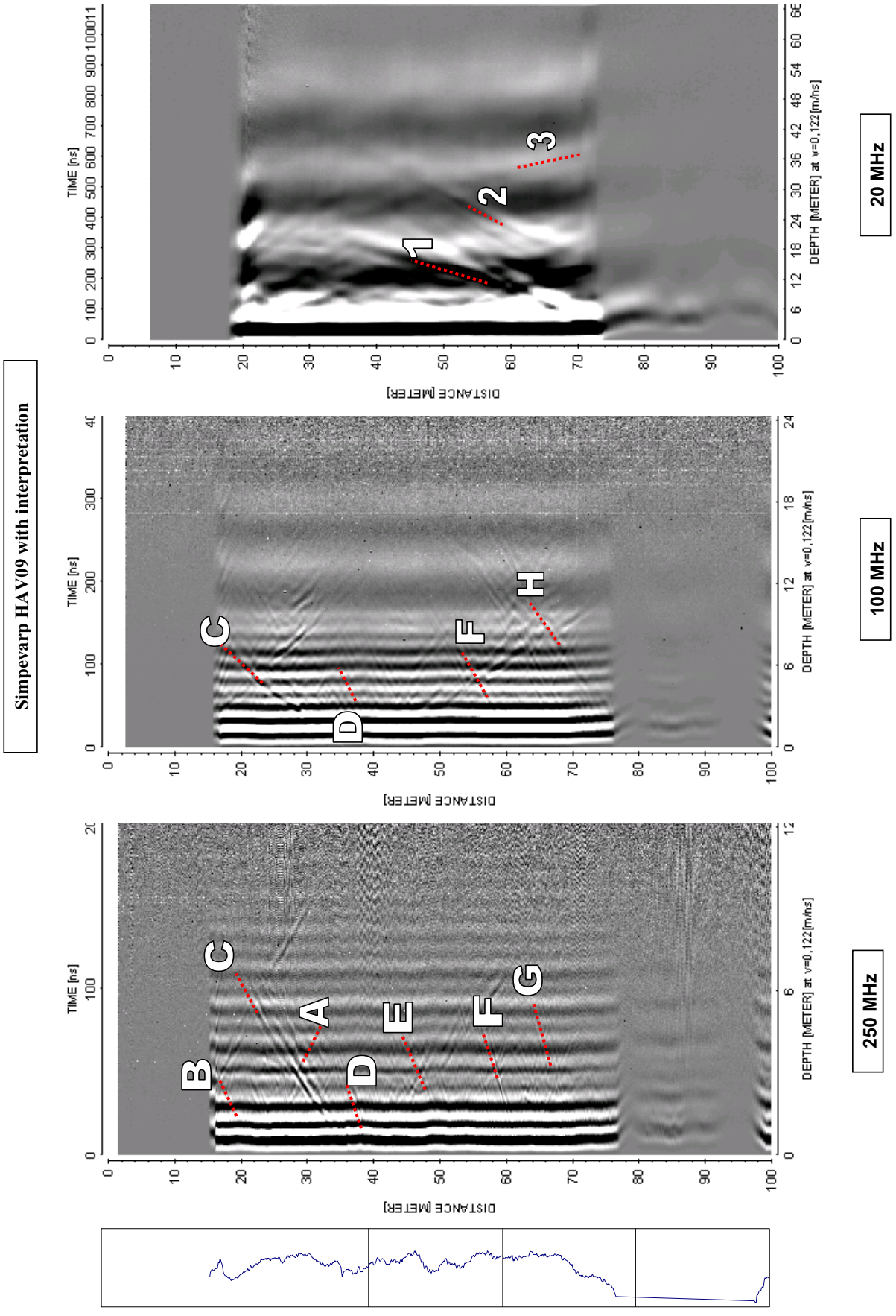


Simpevarp KSH03B

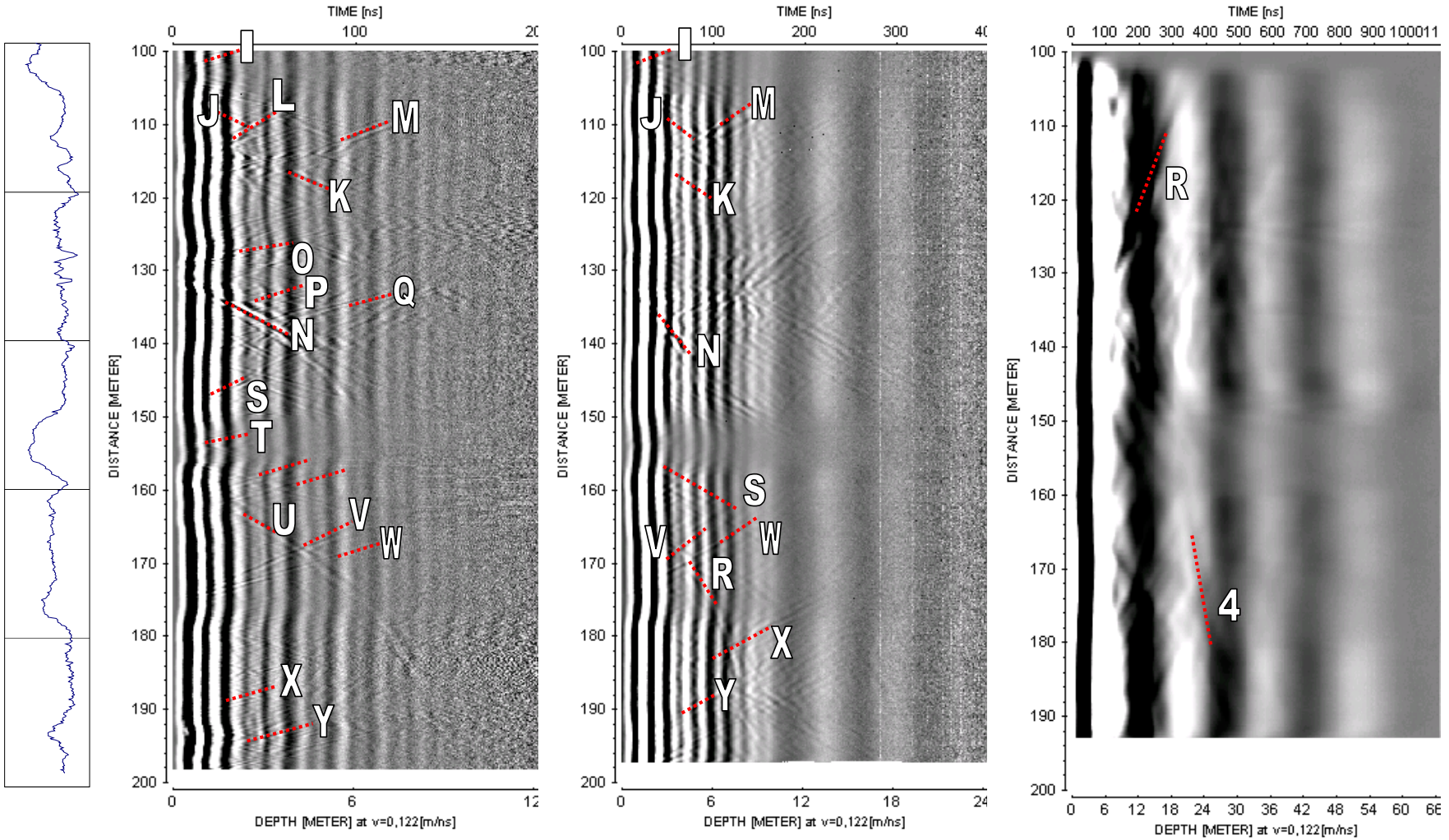


Appendix 4

Radar logging in HAV09, 0 to 200 m, dipole antennas 250, 100 and 20 MHz.

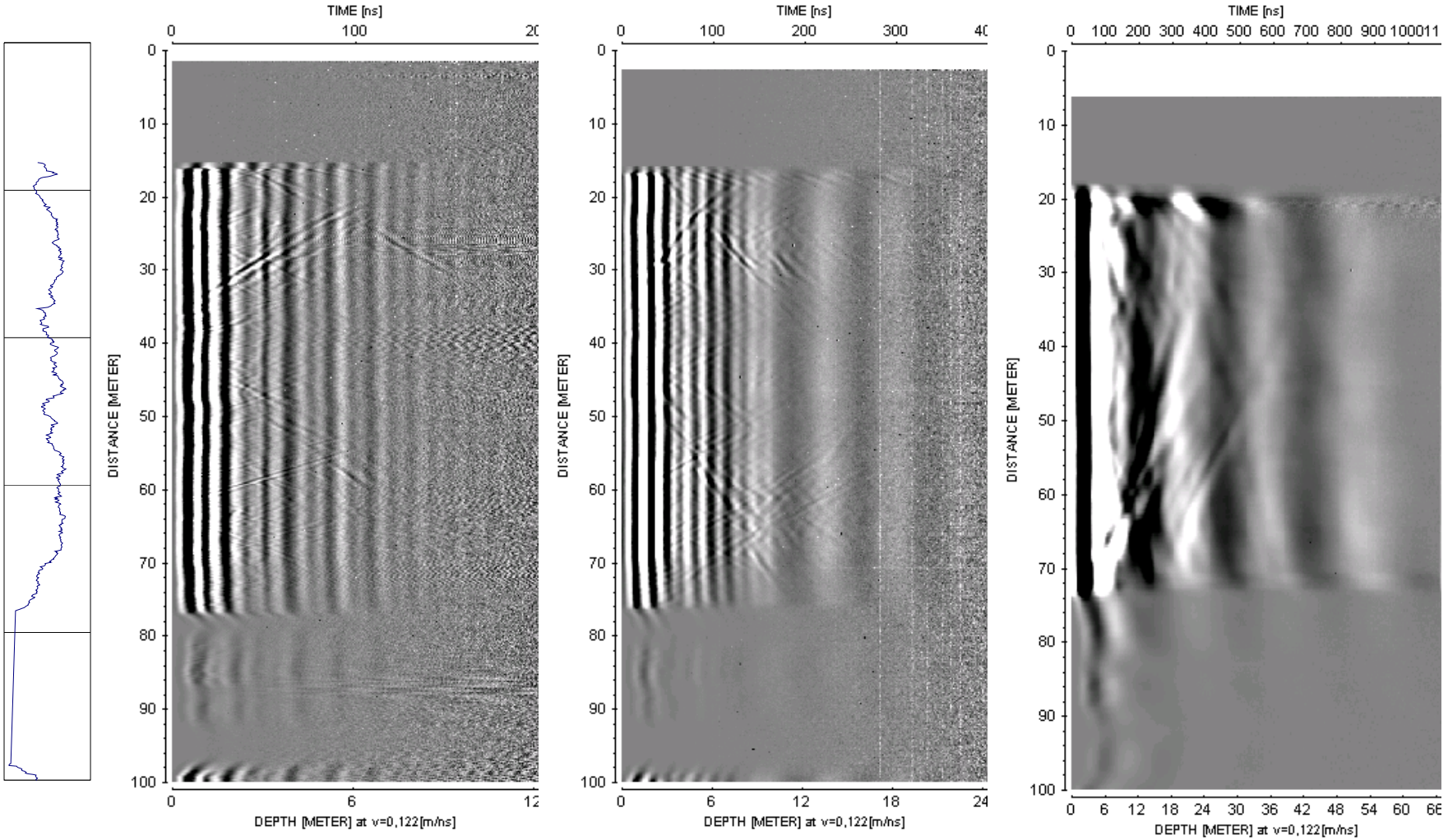


Simpevarp HAV09 with interpretation



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

Simpevarp HAV09

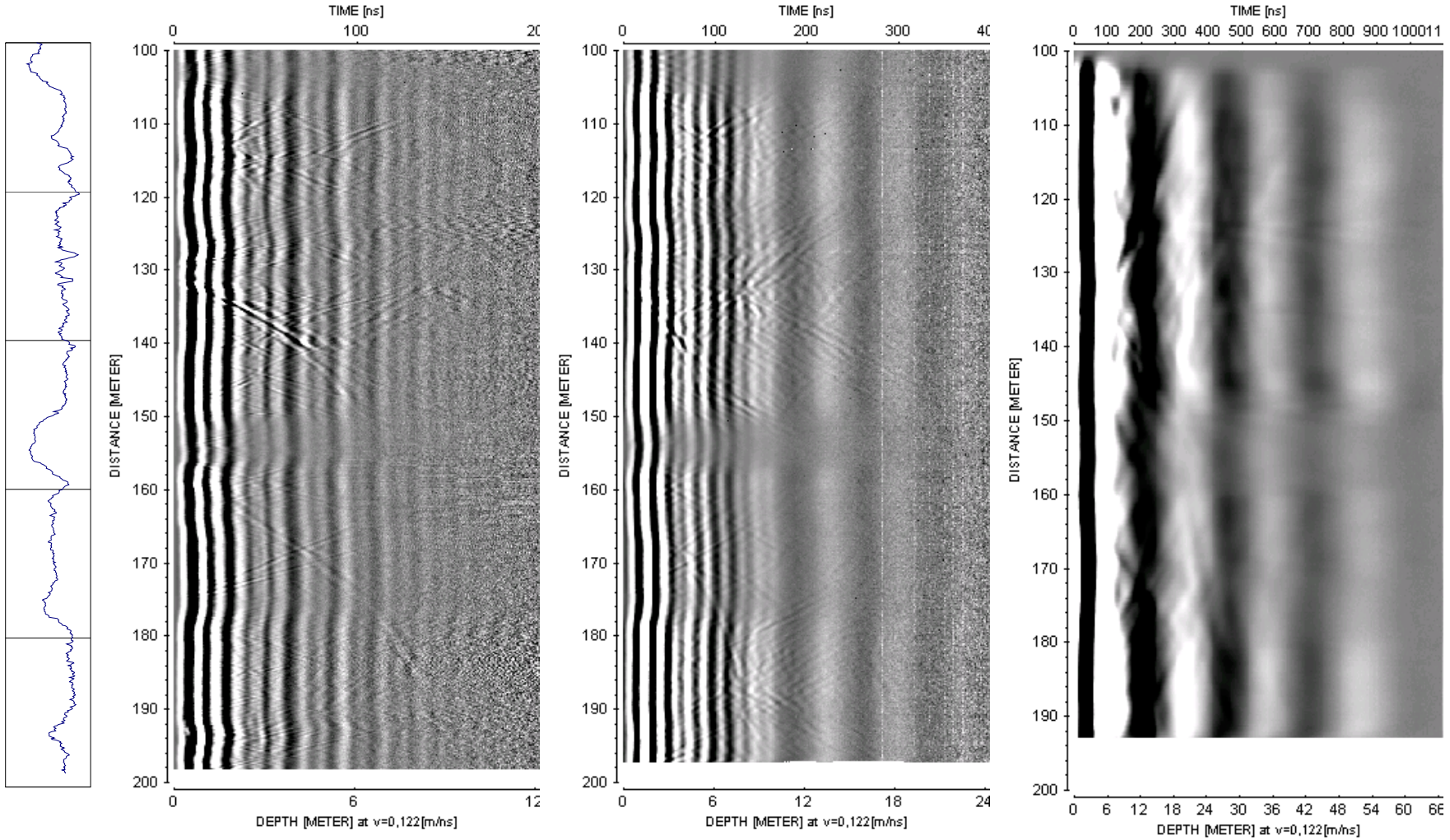


250 MHz

100 MHz

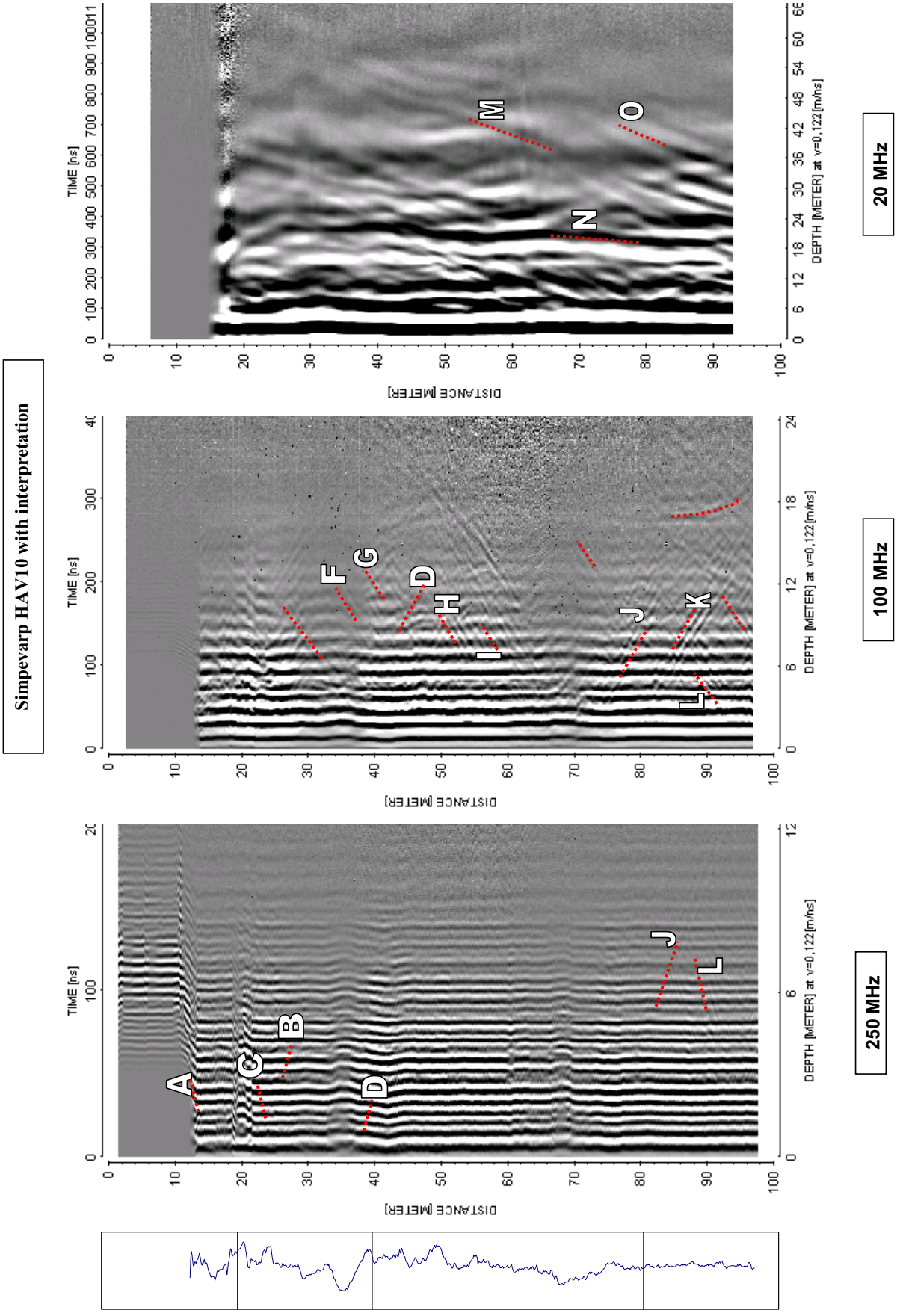
20 MHz

Simpevarp HAV09

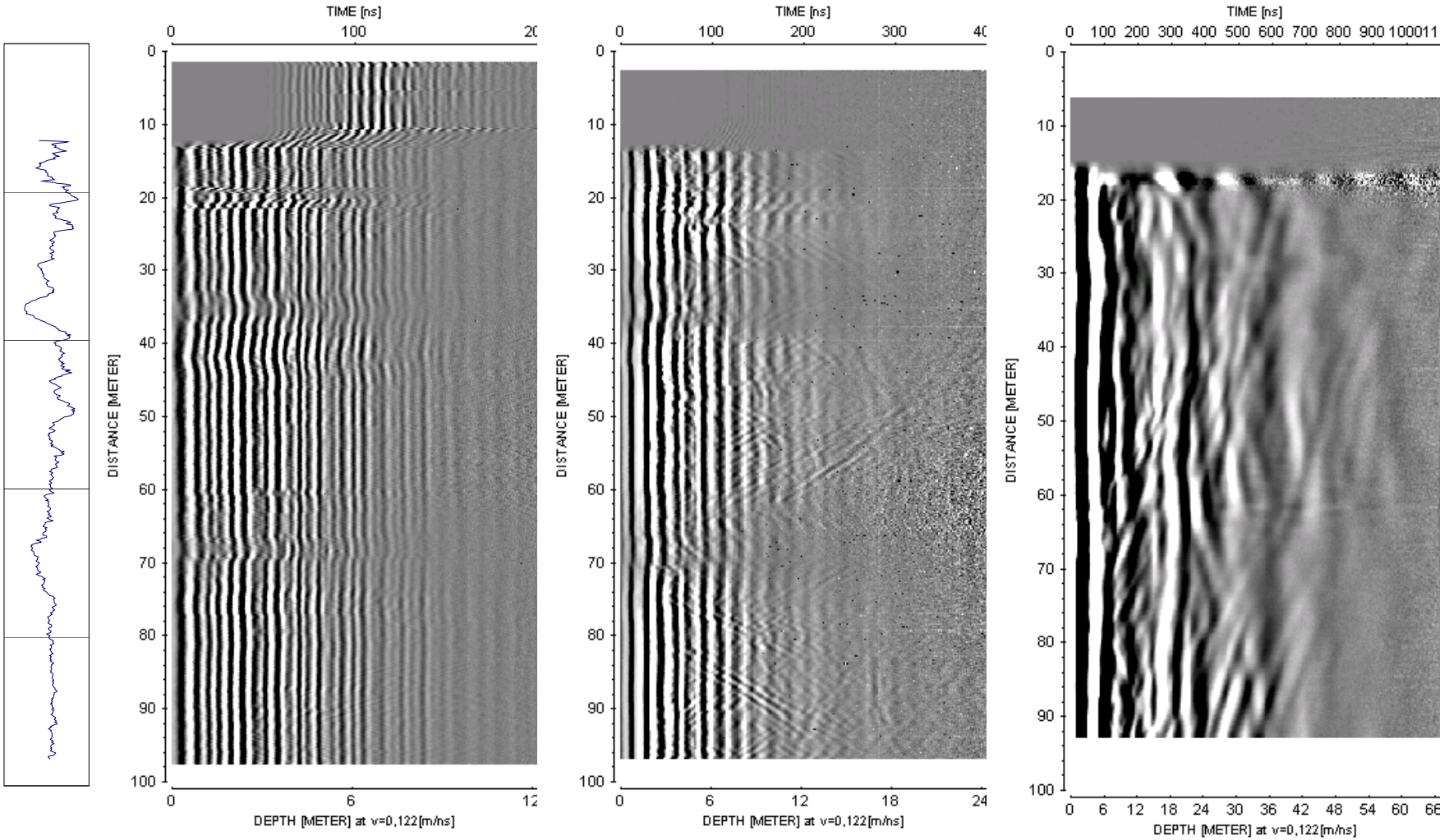


Appendix 5

Radar logging in HAV10, 0 to 100 m, dipole antennas 250, 100 and 20 MHz.



Simpevarp HAV10



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

Appendix 6

BIPS logging in KSH03A, 101 to 997.3 m.

Project name: Simpevarp

Image file	**: c:\work\r5228s~1\ksh03a\bips\ksh03a_1.bip**
BDT file	**: c:\work\r5228s~1\ksh03a\bips\ksh03a_1.bdt**
Locality	**: SIMPEVARP**
Bore hole number	**: KSH03A**
Date	**: 03/12/10**
Time	**: 13:34:00**
Depth range	**: 101.000 - 599.010 m**
Azimuth	**: 123**
Inclination	**: -57**
Diameter	**: 76.0 mm**
Magnetic declination	**: 0.0**
Span	**: 4**
Scan interval	**: 0.25**
Scan direction	**: To bottom**
Scale	**: 1/25**
Aspect ratio	**: 100 %**
Pages	**: 20**
Color	**:**  **+0 +0 +0**

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 101.000 - 126.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 126.000 - 151.000 m

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

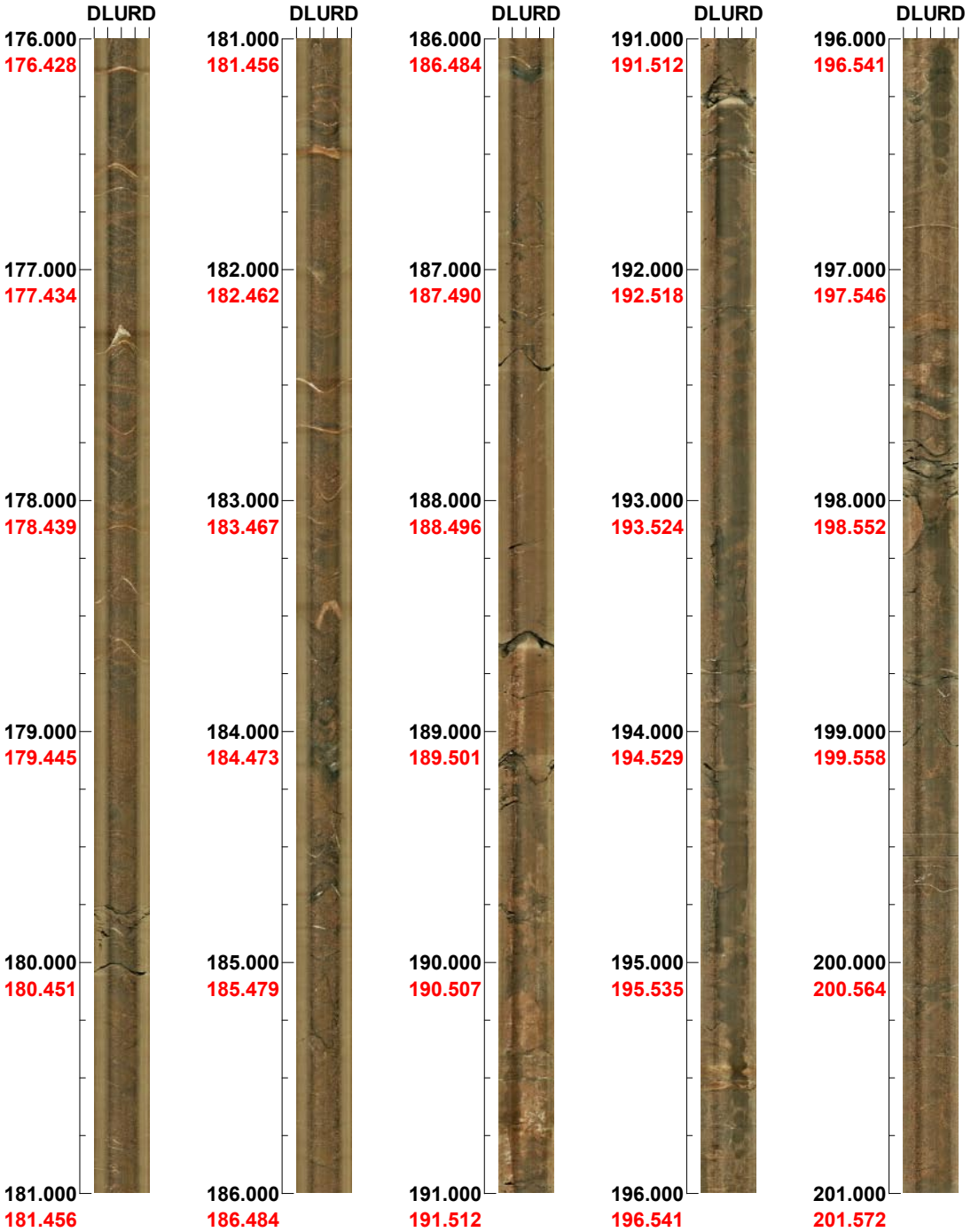
Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 151.000 - 176.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 176.000 - 201.000 m



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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 201.000 - 226.000 m

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

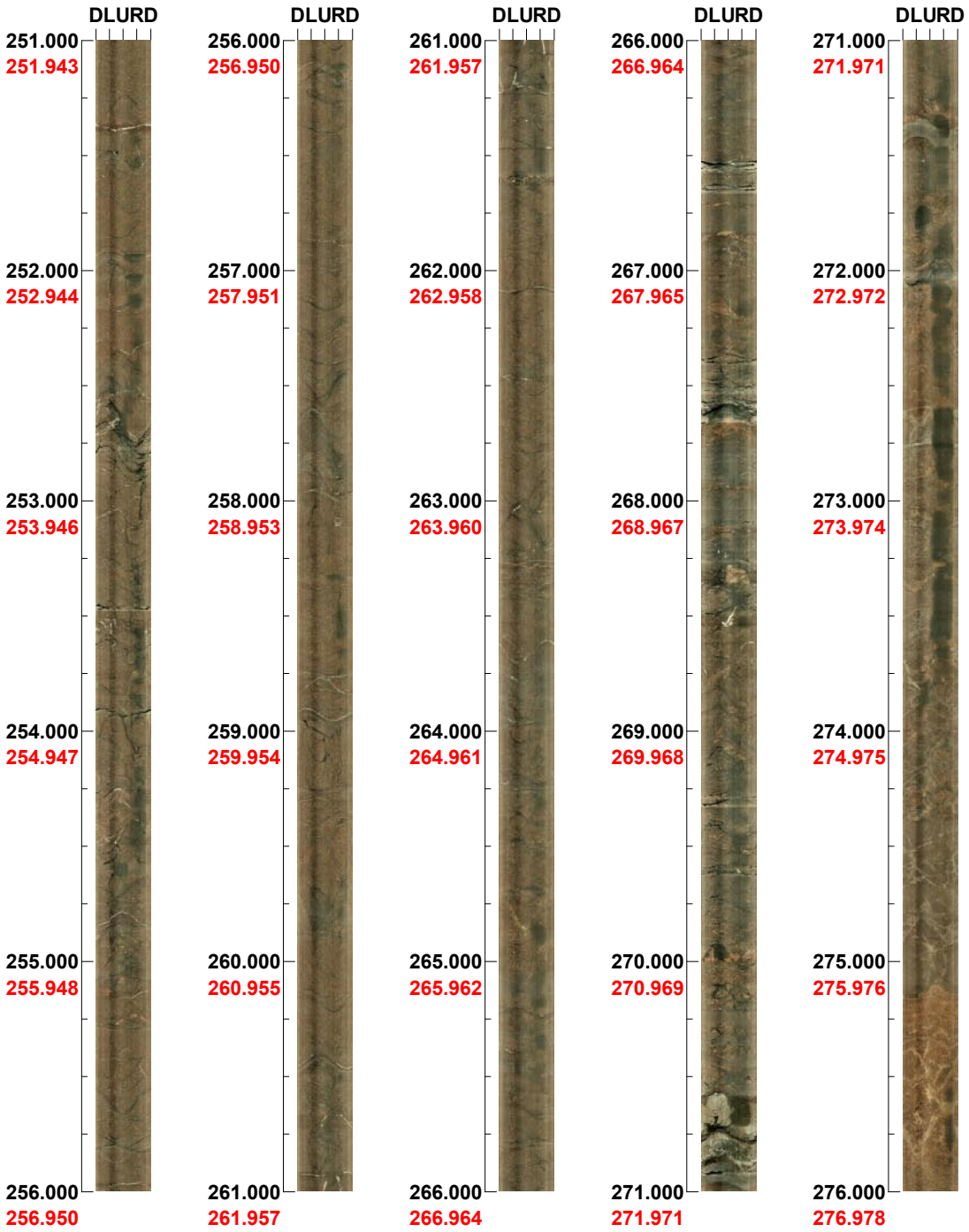
Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 226.000 - 251.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 251.000 - 276.000 m



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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 276.000 - 301.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 301.000 - 326.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 326.000 - 351.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 351.000 - 376.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 376.000 - 401.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 401.000 - 426.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 426.000 - 451.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 451.000 - 476.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 476.000 - 501.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 501.000 - 526.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 526.000 - 551.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 551.000 - 576.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 551.000 - 576.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 123** **Inclination: -57**

Depth range: 576.000 - 599.010 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 600.000 - 625.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 625.000 - 650.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 650.000 - 675.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 675.000 - 700.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 700.000 - 725.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 725.000 - 750.000 m

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

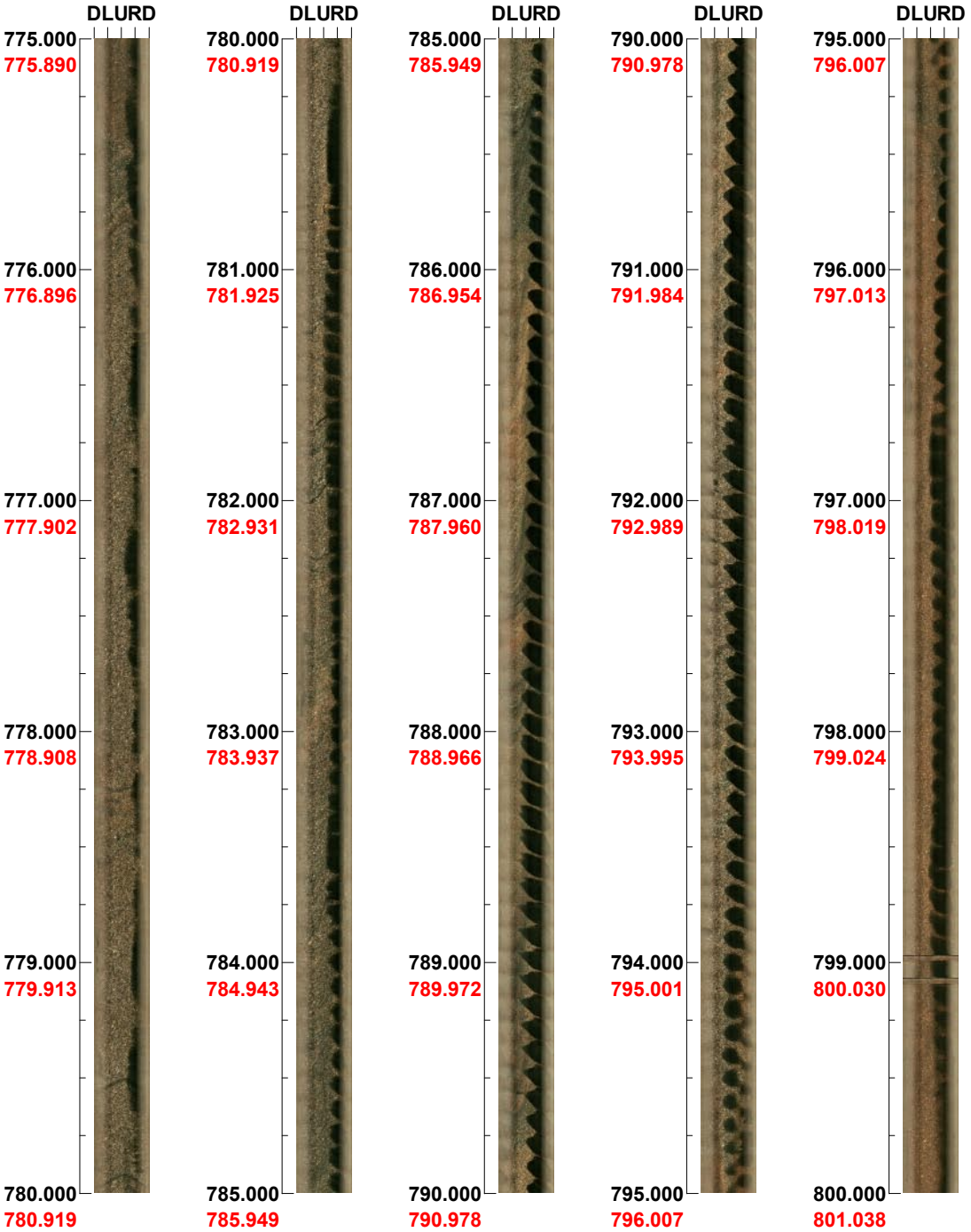
Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 750.000 - 775.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 775.000 - 800.000 m



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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 800.000 - 825.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 825.000 - 850.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 850.000 - 875.000 m

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

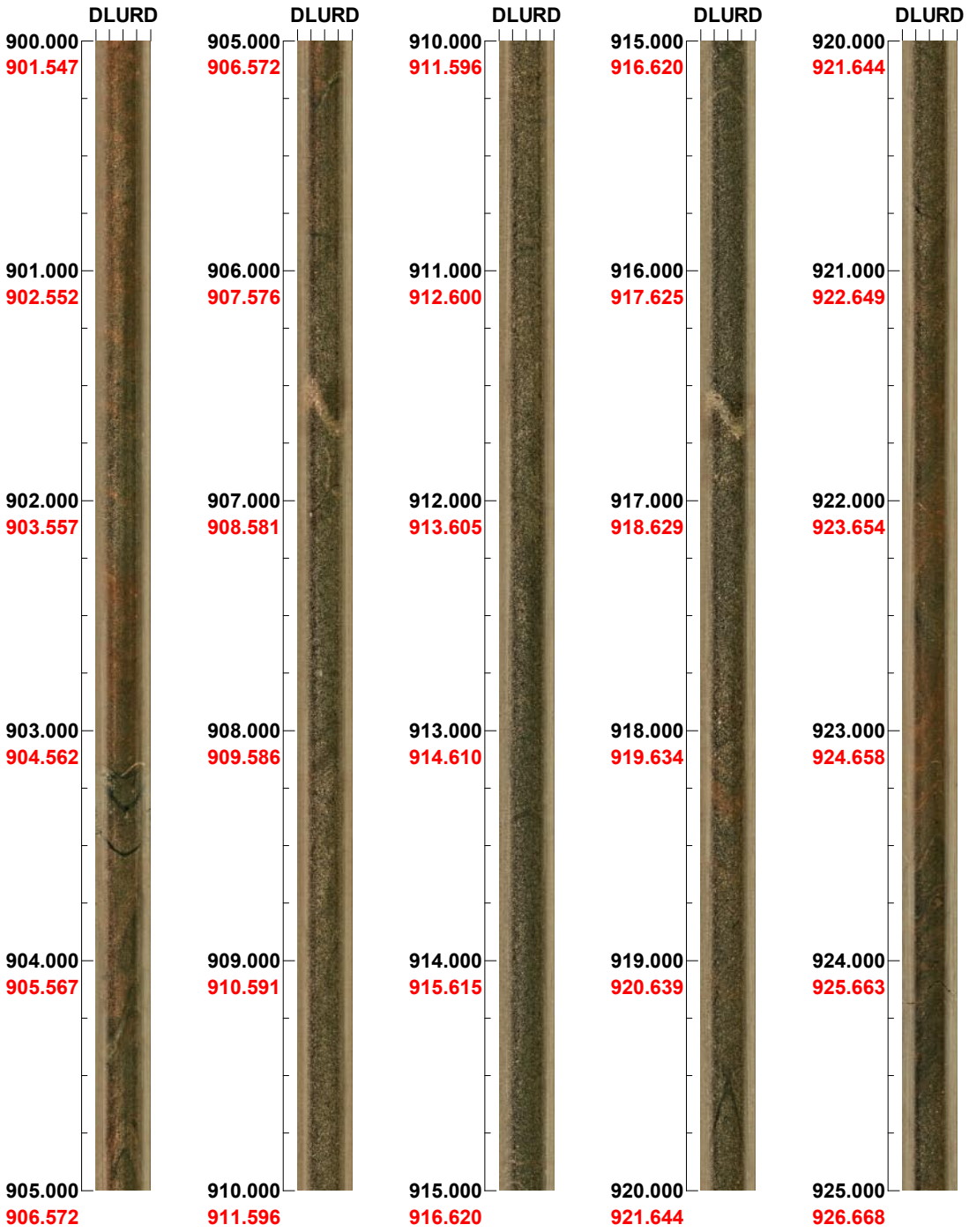
Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 875.000 - 900.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 900.000 - 925.000 m



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

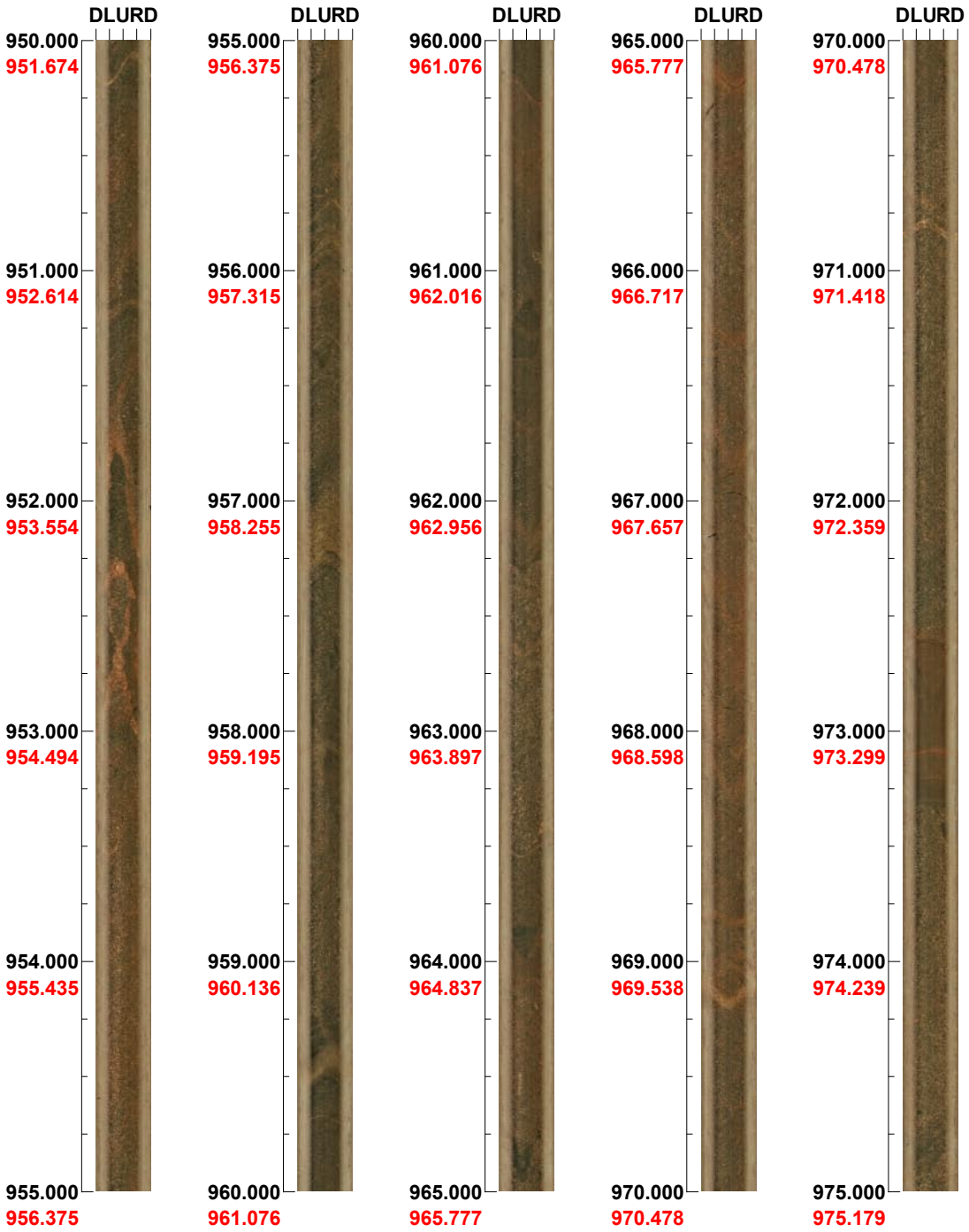
Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 925.000 - 950.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

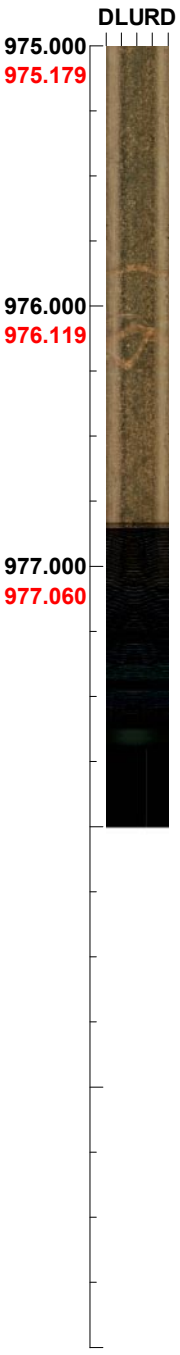
Depth range: 950.000 - 975.000 m



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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 153** **Inclination: -58**

Depth range: 975.000 - 977.999 m



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

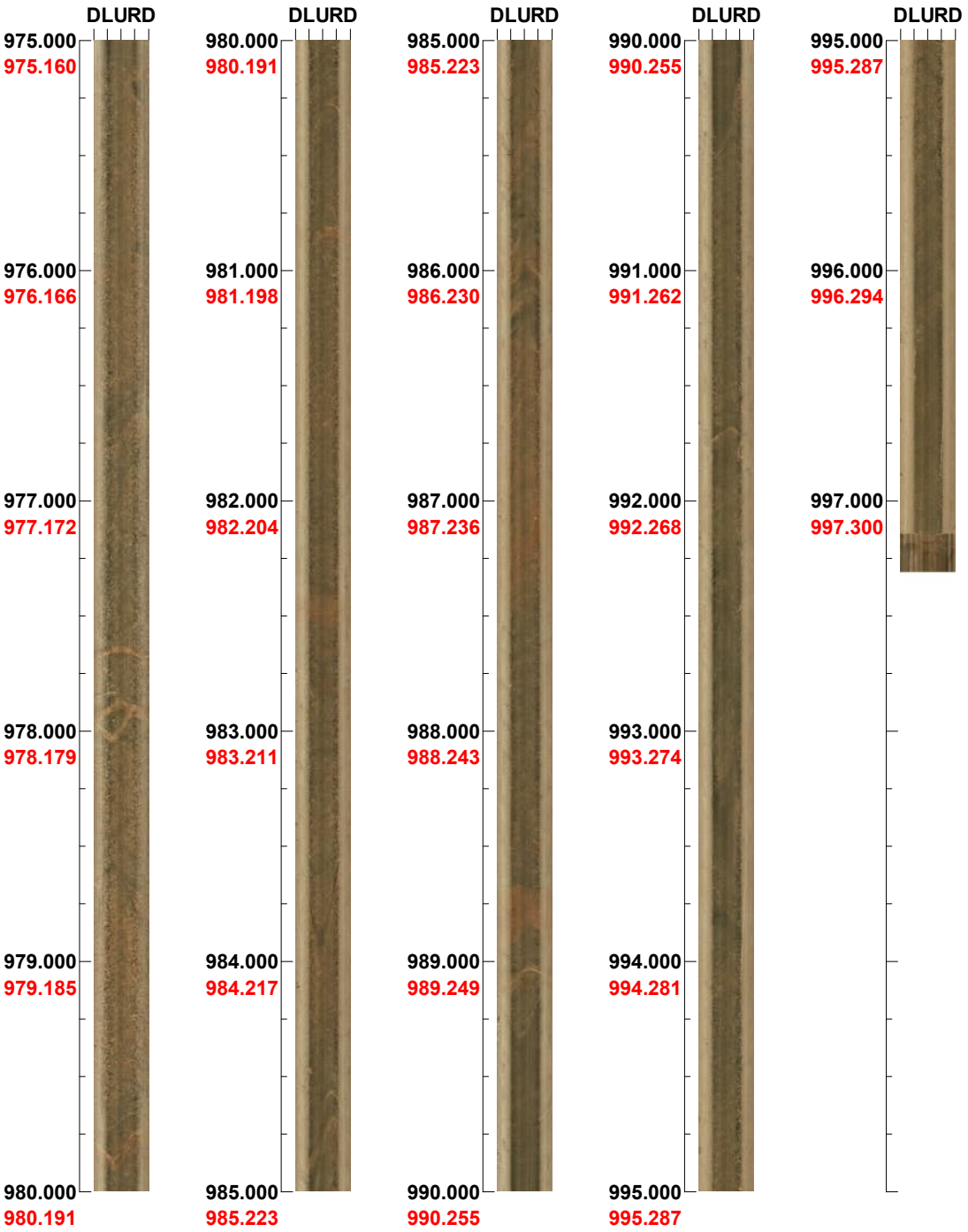
Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 178** **Inclination: -48**

Depth range: 950.000 - 975.000 m

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

Project name: Simpevarp
Bore hole No.: KSH03A **Azimuth: 178** **Inclination: -48**

Depth range: 975.000 - 997.306 m



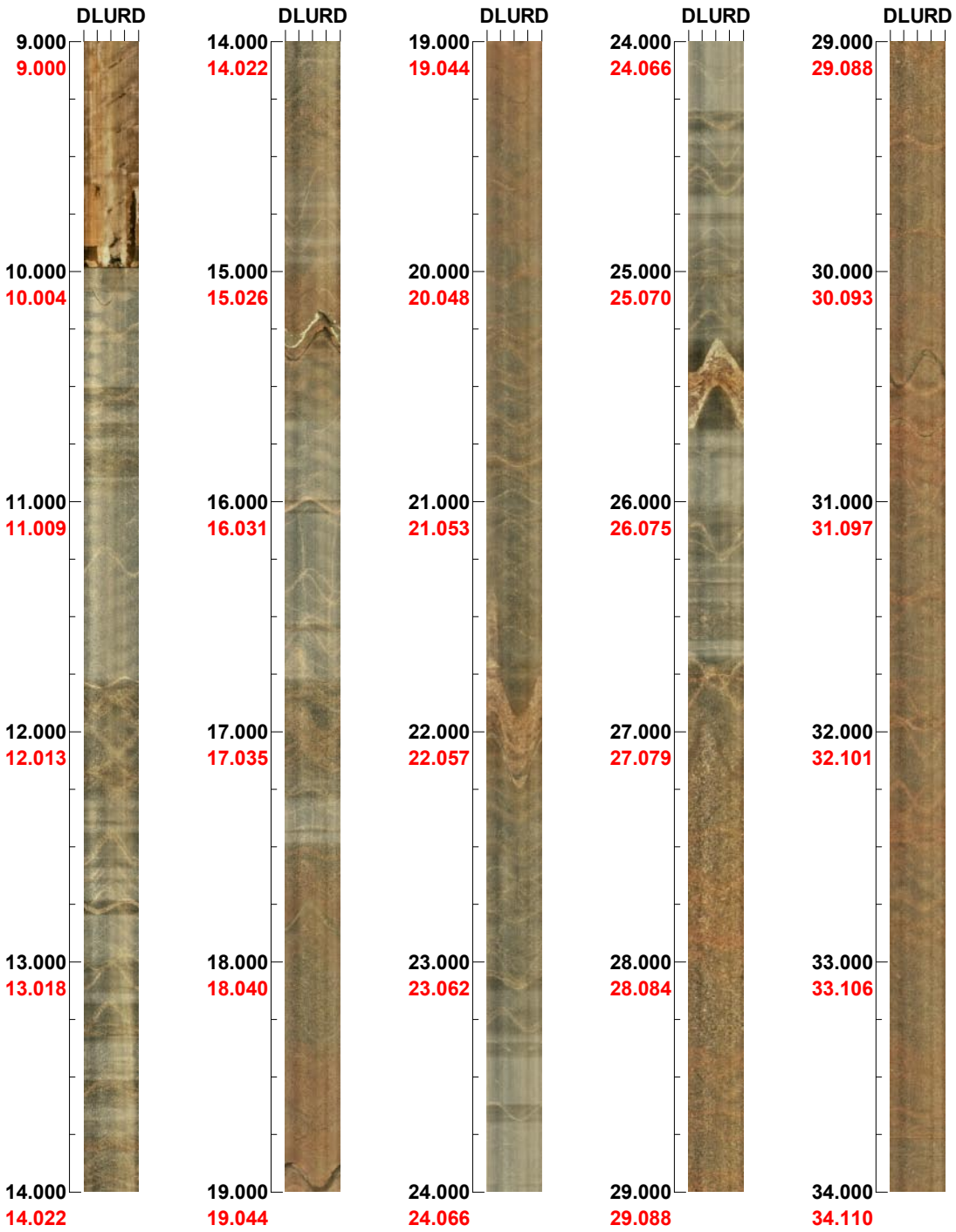
(2 / 2) **Scale: 1/25** **Aspect ratio: 100 %**

BIPS logging in KSH03B, 9 to 99.3 m.

Image file	**: c:\work\r5228s~1\ksh03b\bips\ksh03b.bip**
BDT file	**: c:\work\r5228s~1\ksh03b\bips\ksh03b.bdt**
Locality	**: SIMPEVARP**
Bore hole number	**: KSH03B**
Date	**: 03/12/11**
Time	**: 20:07:00**
Depth range	**: 9.000 - 99.865 m**
Azimuth	**: 128**
Inclination	**: -65**
Diameter	**: 76.0 mm**
Magnetic declination	**: 0.0**
Span	**: 4**
Scan interval	**: 0.25**
Scan direction	**: To bottom**
Scale	**: 1/25**
Aspect ratio	**: 100 %**
Pages	**: 4**
Color	**: +0 +0 +0**

Project name: SIMPEVARP
Bore hole No.: KSH03B **Azimuth: 128** **Inclination: -65**

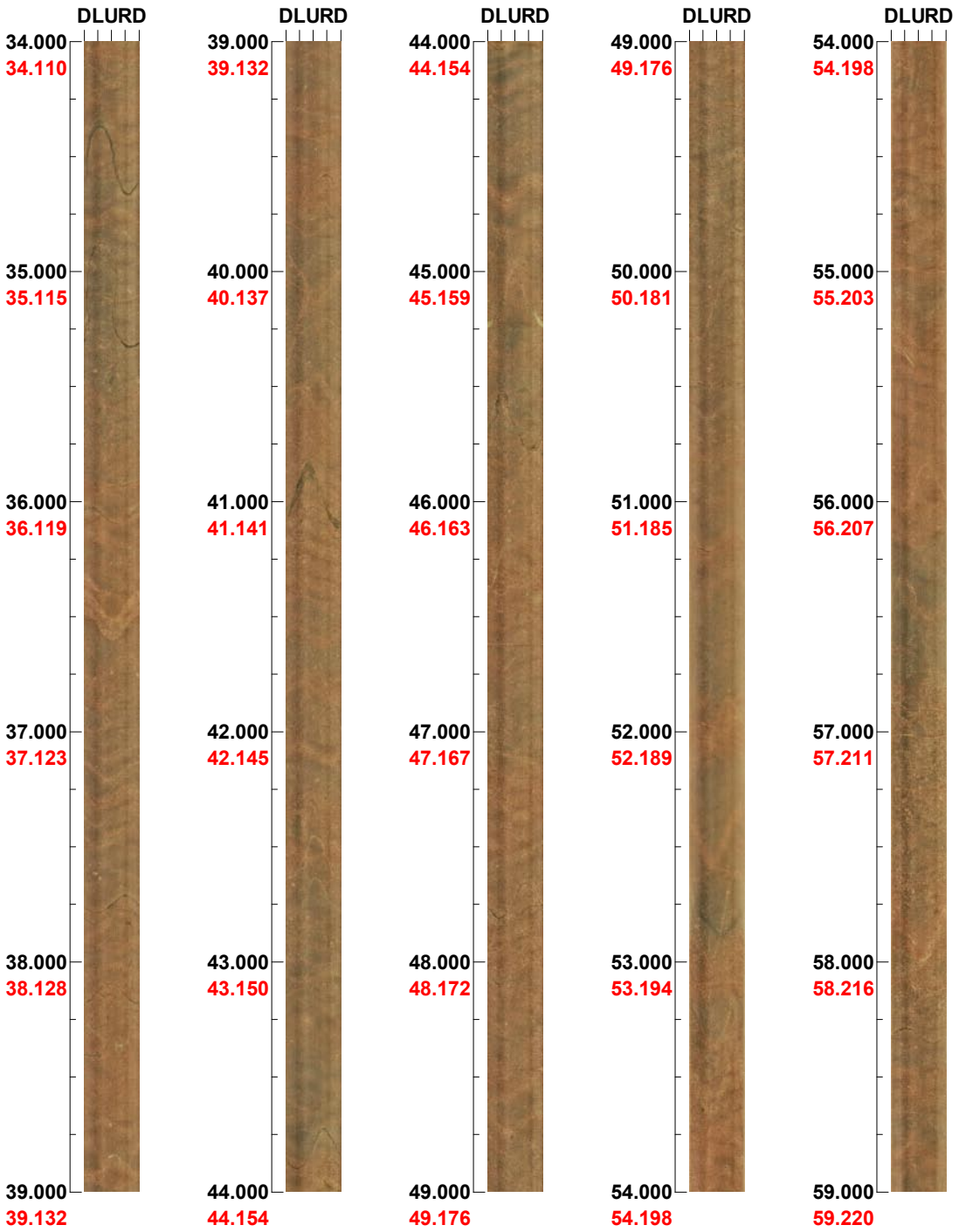
Depth range: 9.000 - 34.000 m



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

Project name: SIMPEVARP
Bore hole No.: KSH03B **Azimuth: 128** **Inclination: -65**

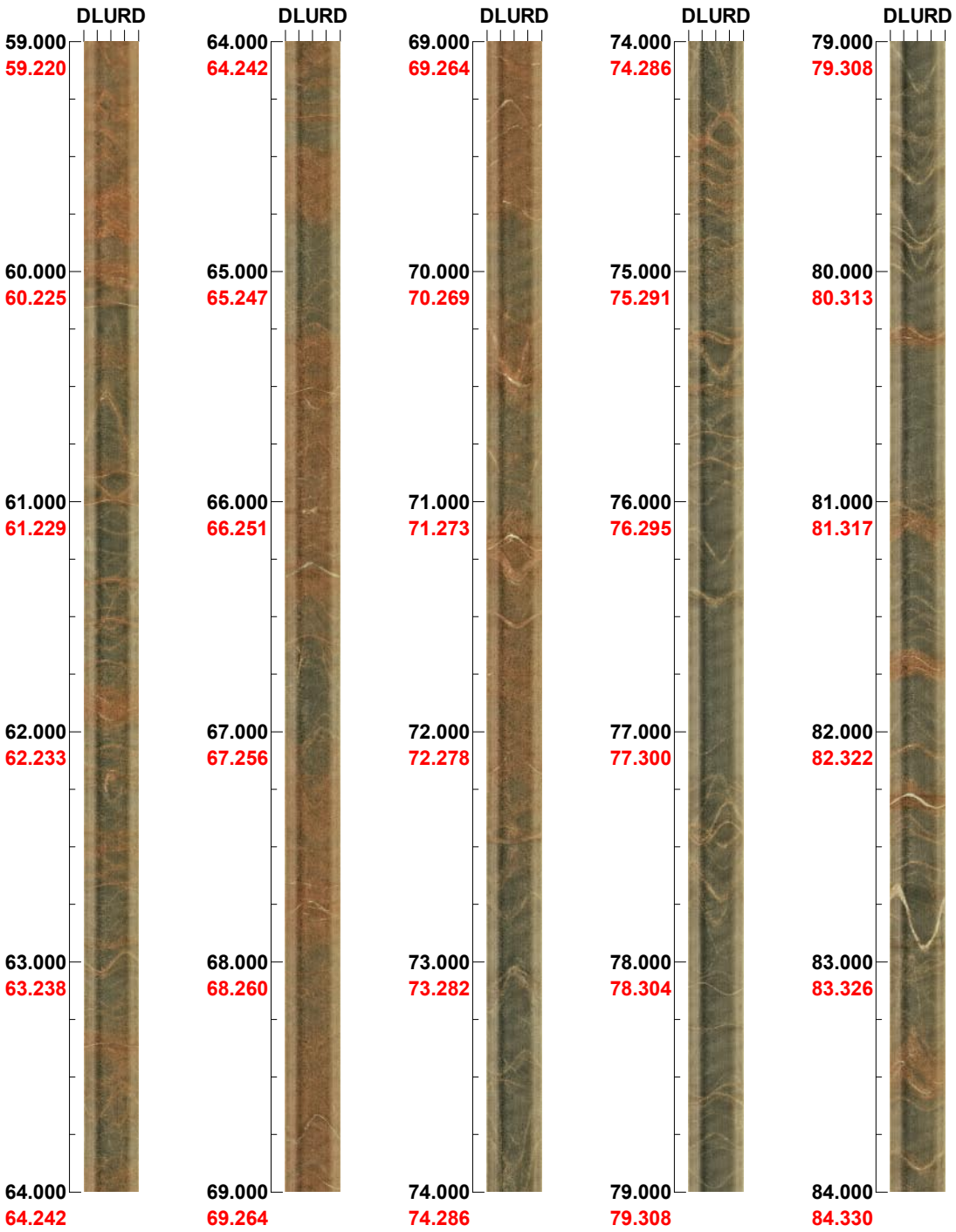
Depth range: 34.000 - 59.000 m



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

Project name: SIMPEVARP
Bore hole No.: KSH03B **Azimuth: 128** **Inclination: -65**

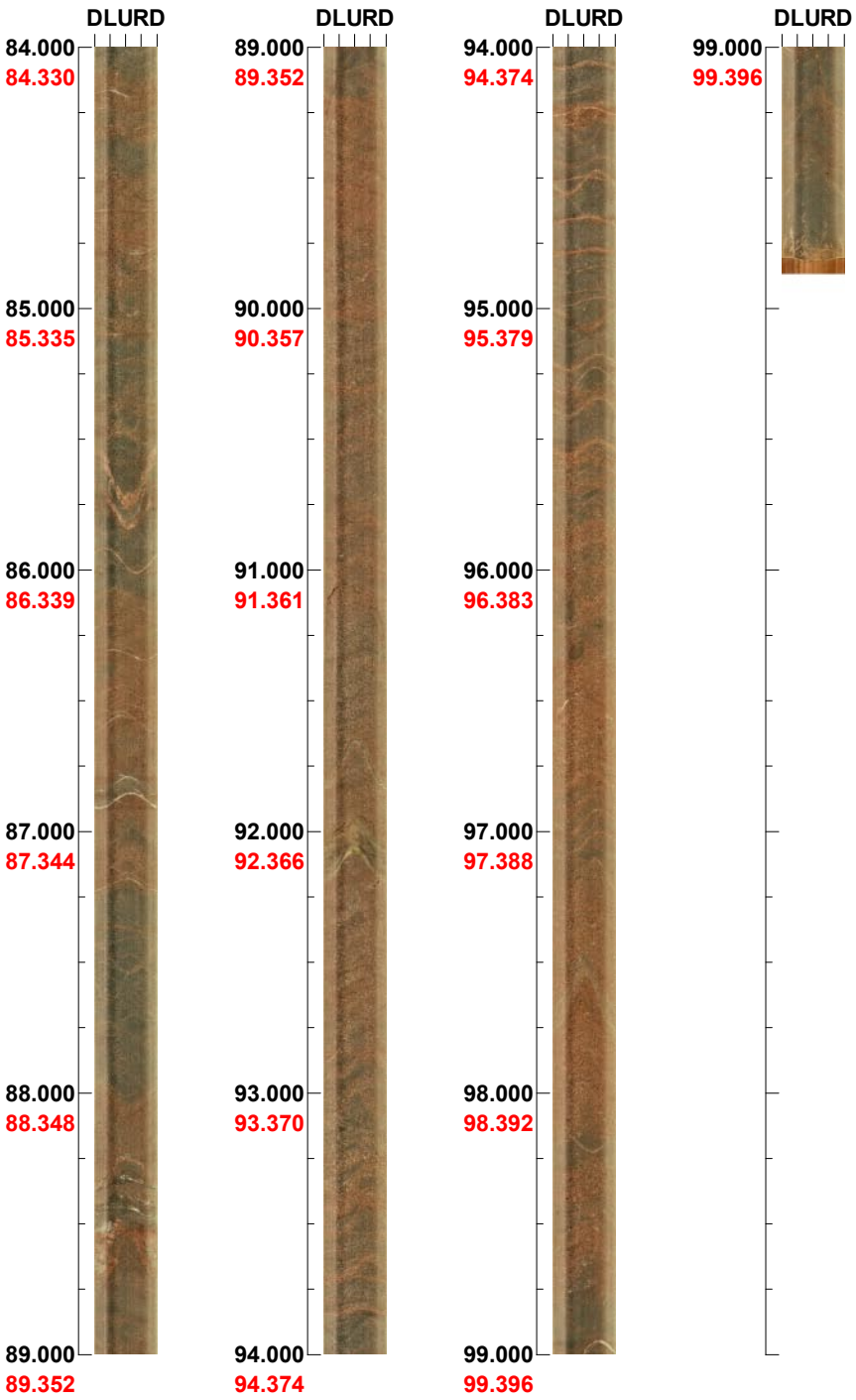
Depth range: 59.000 - 84.000 m



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

Project name: SIMPEVARP
Bore hole No.: KSH03B **Azimuth: 128** **Inclination: -65**

Depth range: 84.000 - 99.865 m



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

Appendix 8

BIPS logging in HAV09, 14 to 199.3 m.

Image file	**: c:\work\r5228s~1\hav09\bips\hav09.bip**
BDT file	**: c:\work\r5228s~1\hav09\bips\hav09.bdt**
Locality	**: SIMPEVARP**
Bore hole number	**: HAV09**
Date	**: 03/12/13**
Time	**: 15:17:00**
Depth range	**: 14.000 - 199.259 m**
Azimuth	**: 178**
Inclination	**: -68**
Diameter	**: 136.0 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**

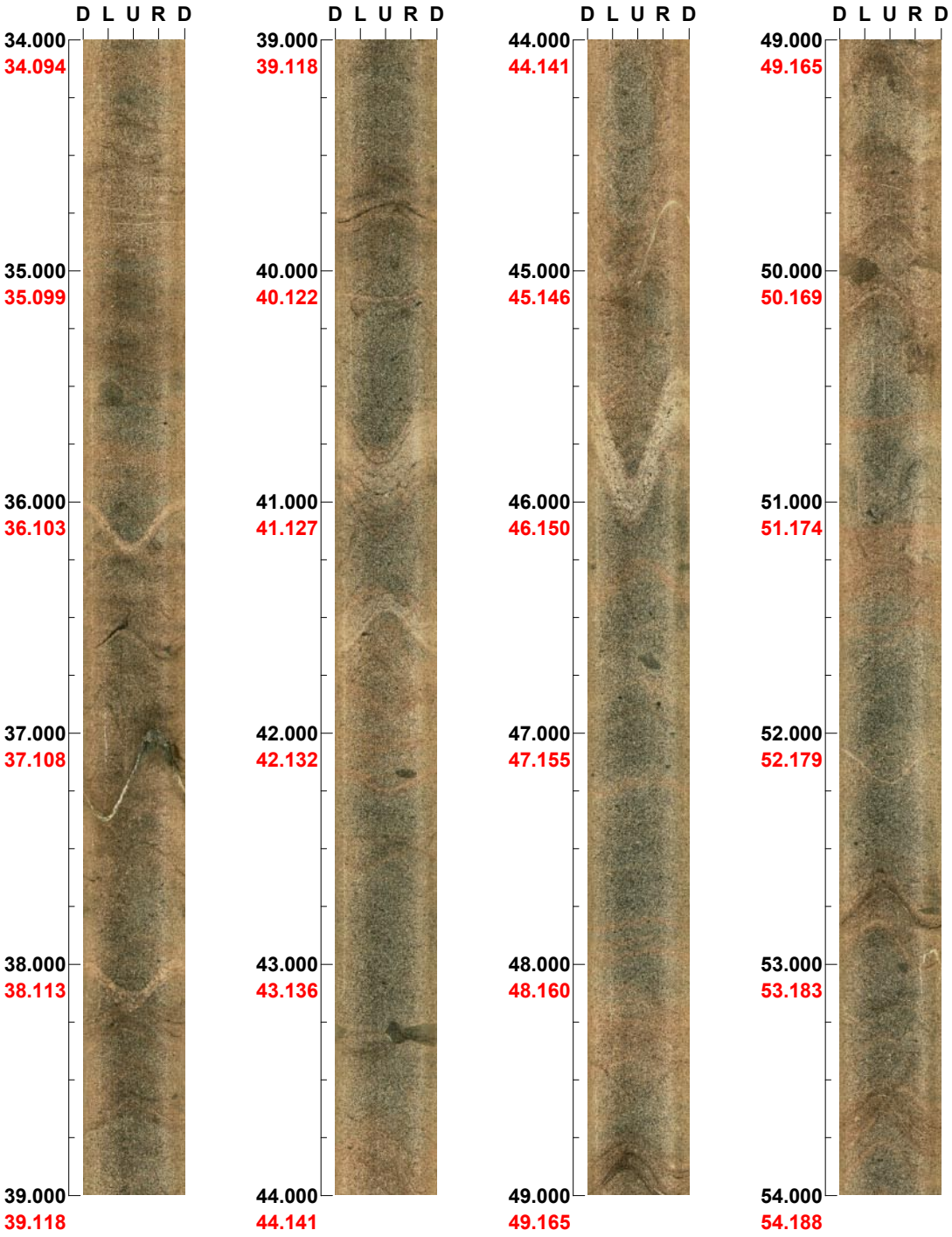
Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

Depth range: 14.000 - 34.000 m

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

Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

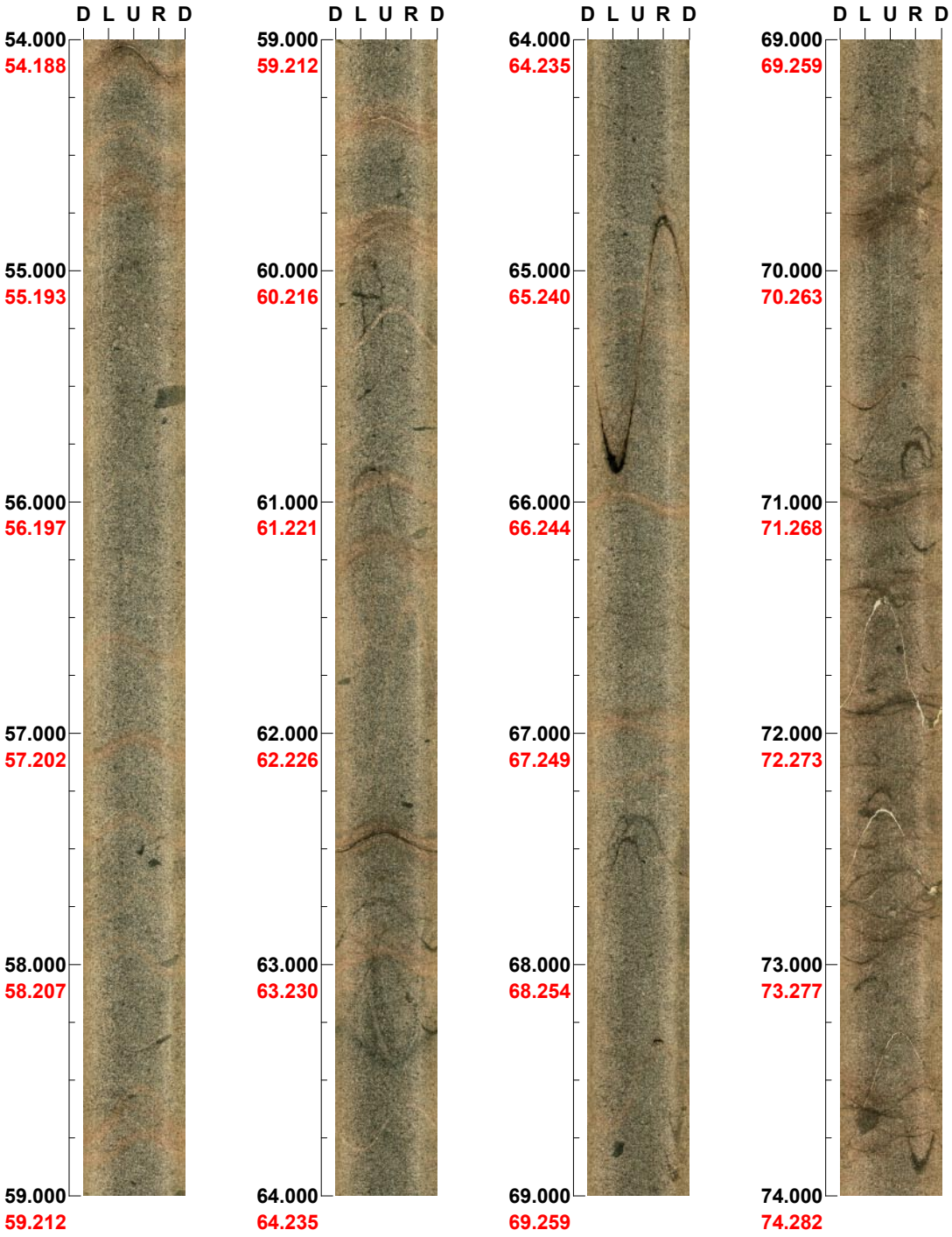
Depth range: 34.000 - 54.000 m



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

Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

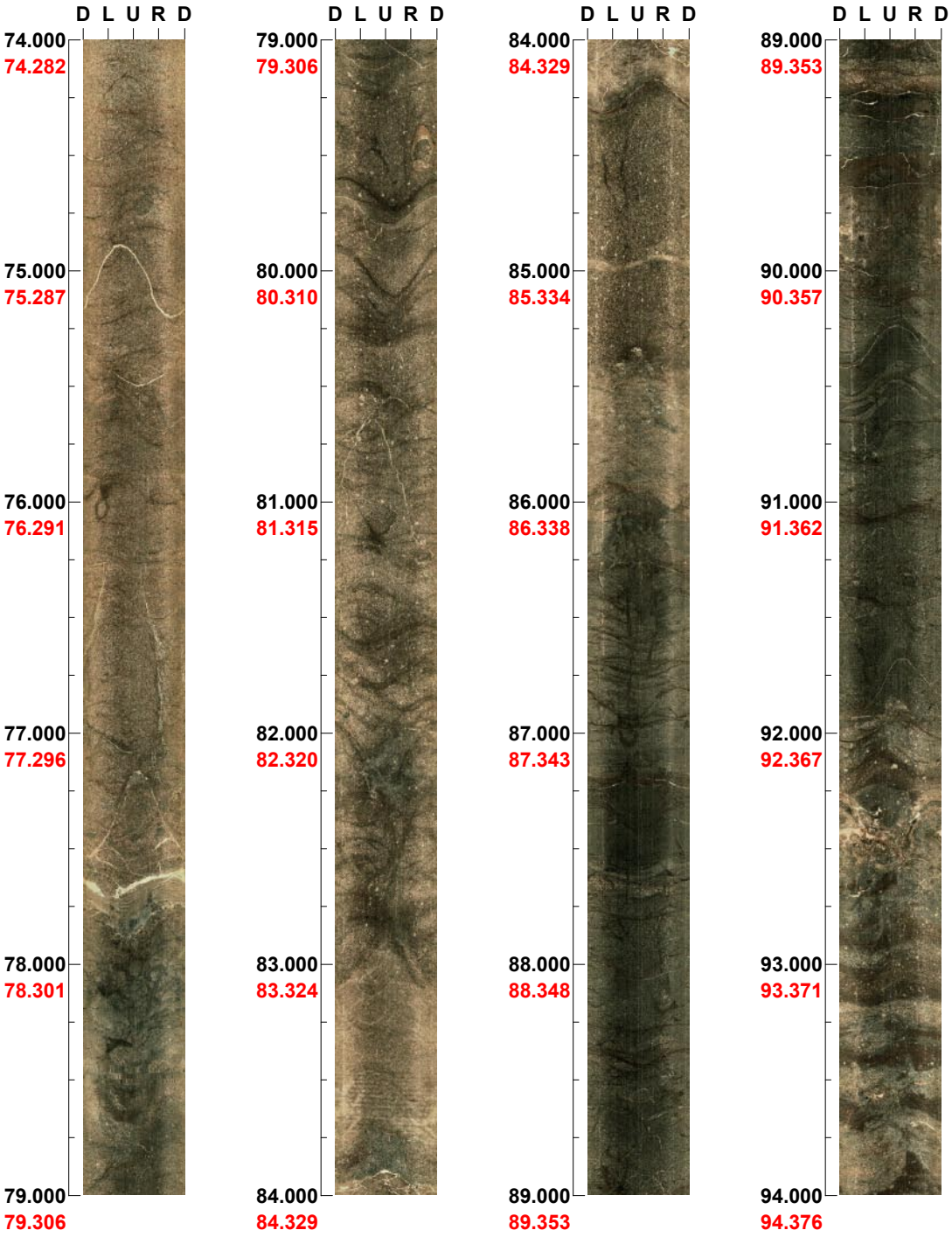
Depth range: 54.000 - 74.000 m



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

Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

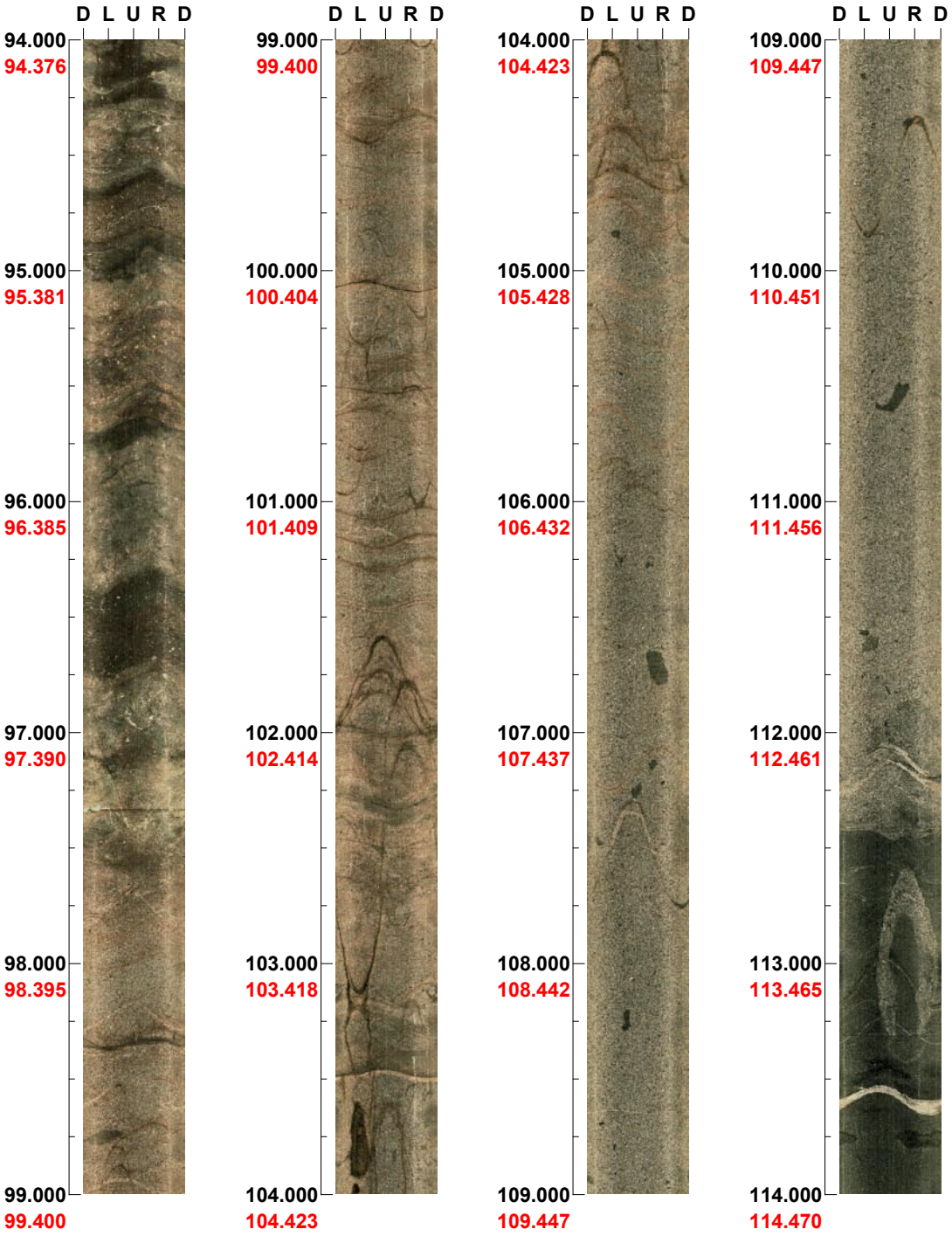
Depth range: 74.000 - 94.000 m



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

Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

Depth range: 94.000 - 114.000 m



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

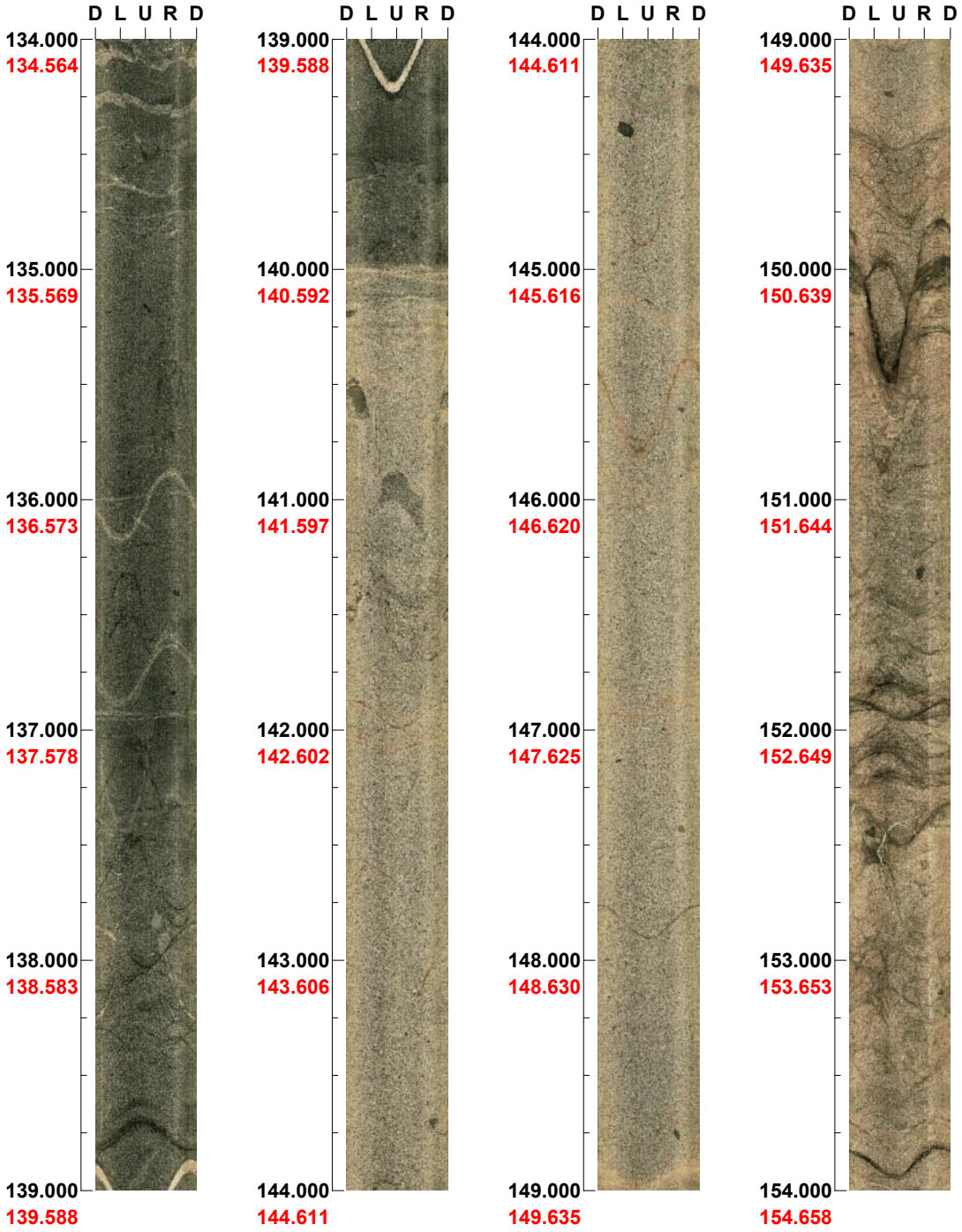
Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

Depth range: 114.000 - 134.000 m

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

Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

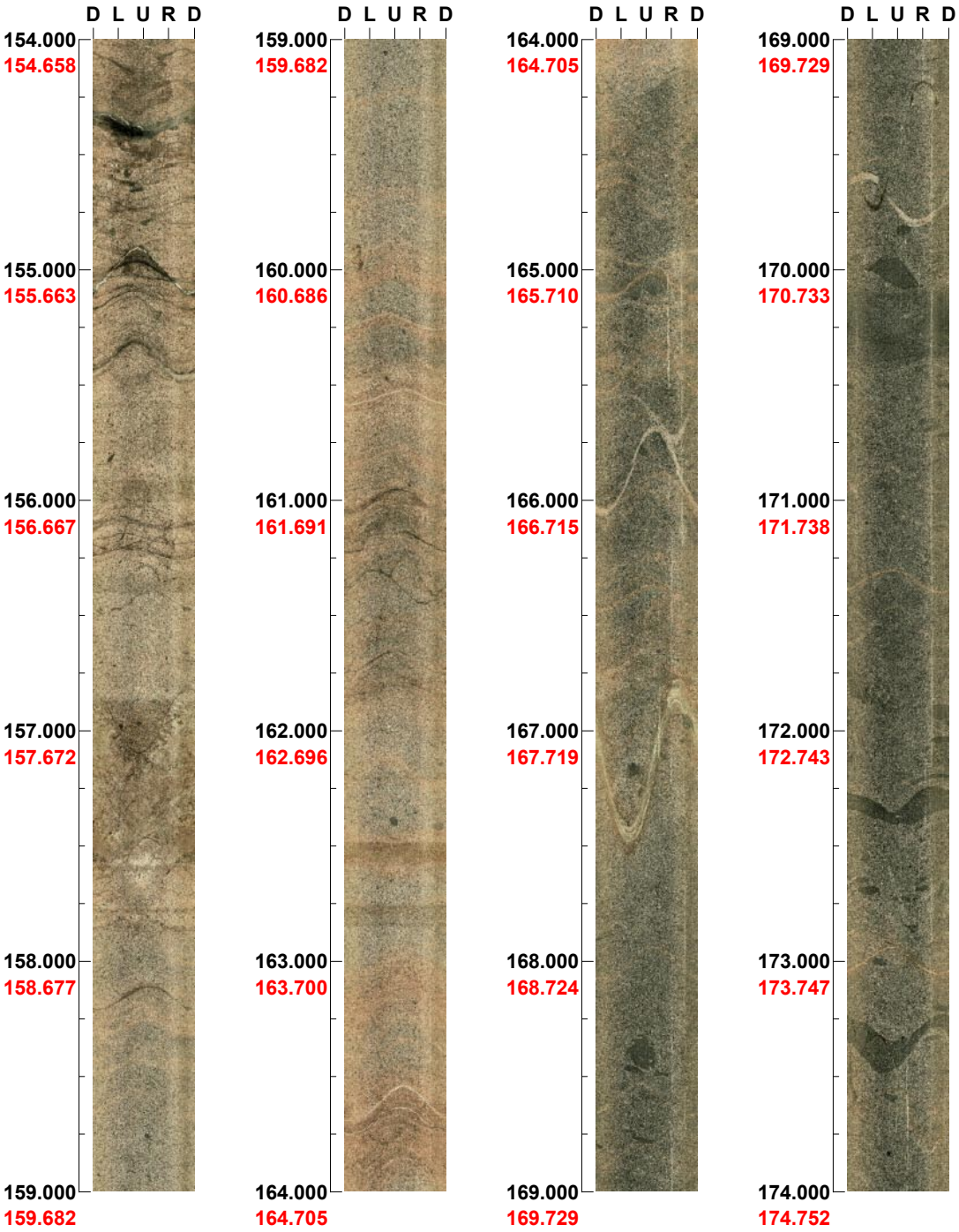
Depth range: 134.000 - 154.000 m



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

Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

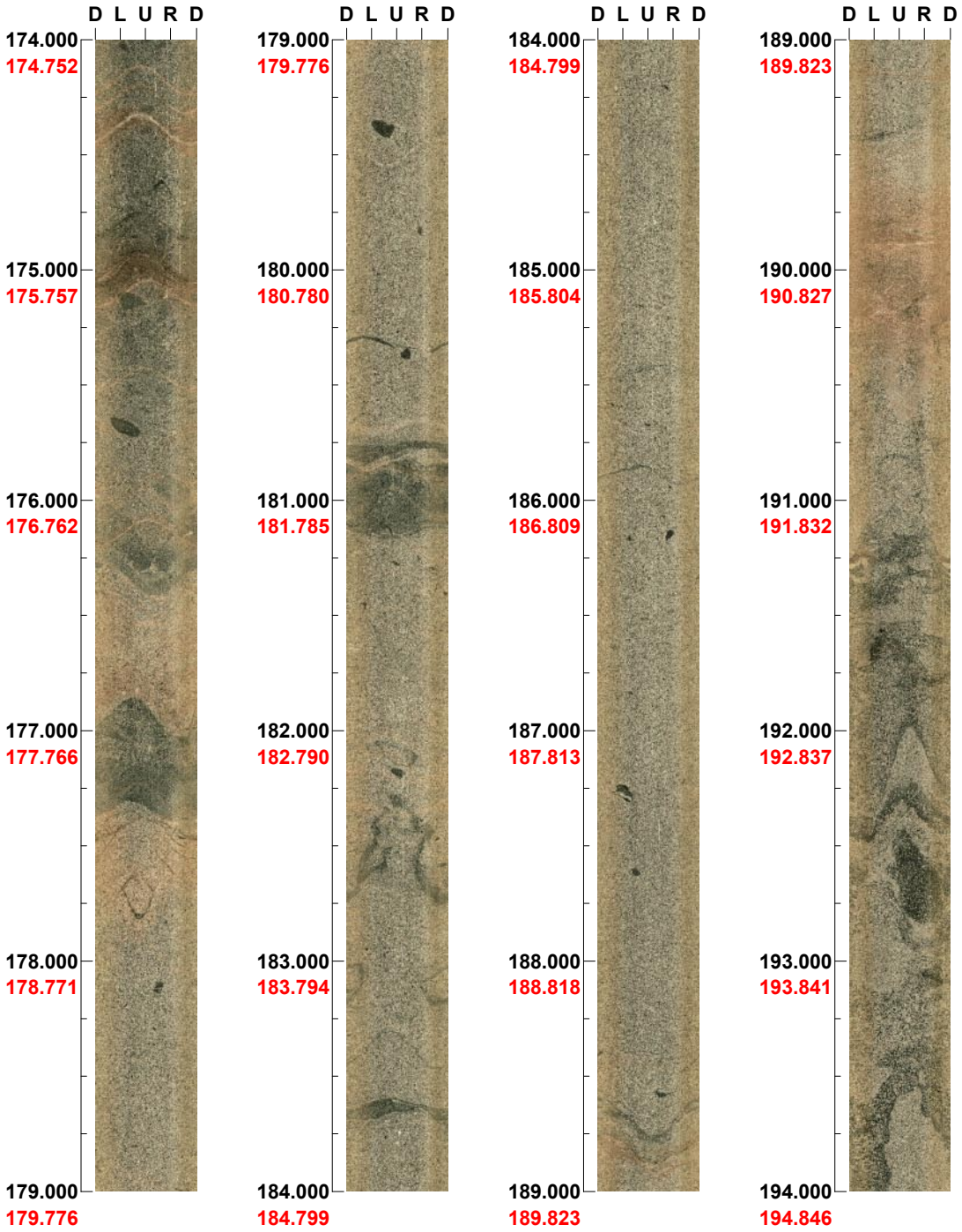
Depth range: 154.000 - 174.000 m



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

Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

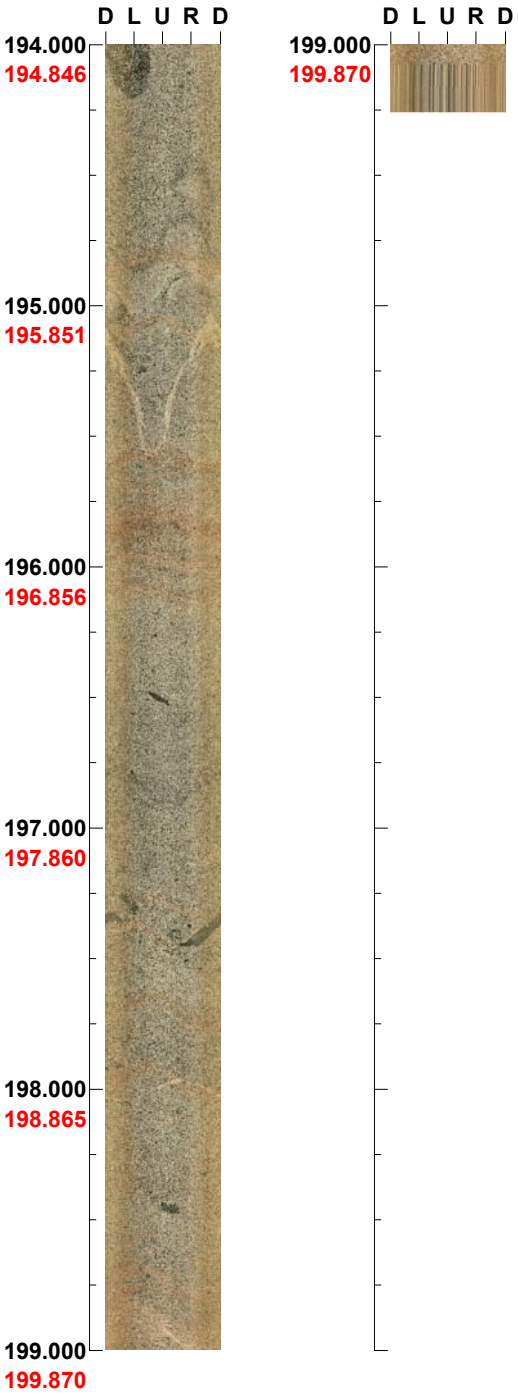
Depth range: 174.000 - 194.000 m



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

Project name: SIMPEVARP
Bore hole No.: HAV09 **Azimuth: 178** **Inclination: -68**

Depth range: 194.000 - 199.259 m



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

Appendix 9

BIPS logging in HAV10, 11 to 99.4 m.

Image file	**: c:\work\r5228s~1\hav10\bips\hav10.bip**
BDT file	**: c:\work\r5228s~1\hav10\bips\hav10.bdt**
Locality	**: SIMPEVARP**
Bore hole number	**: HAV10**
Date	**: 03/12/13**
Time	**: 17:48:00**
Depth range	**: 11.000 - 99.350 m**
Azimuth	**: 35**
Inclination	**: -68**
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	**: 5**
Color	**: +0 +0 +0**

Project name: SIMPEVARP
Bore hole No.: HAV10 **Azimuth: 35** **Inclination: -68**

Depth range: 11.000 - 31.000 m

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

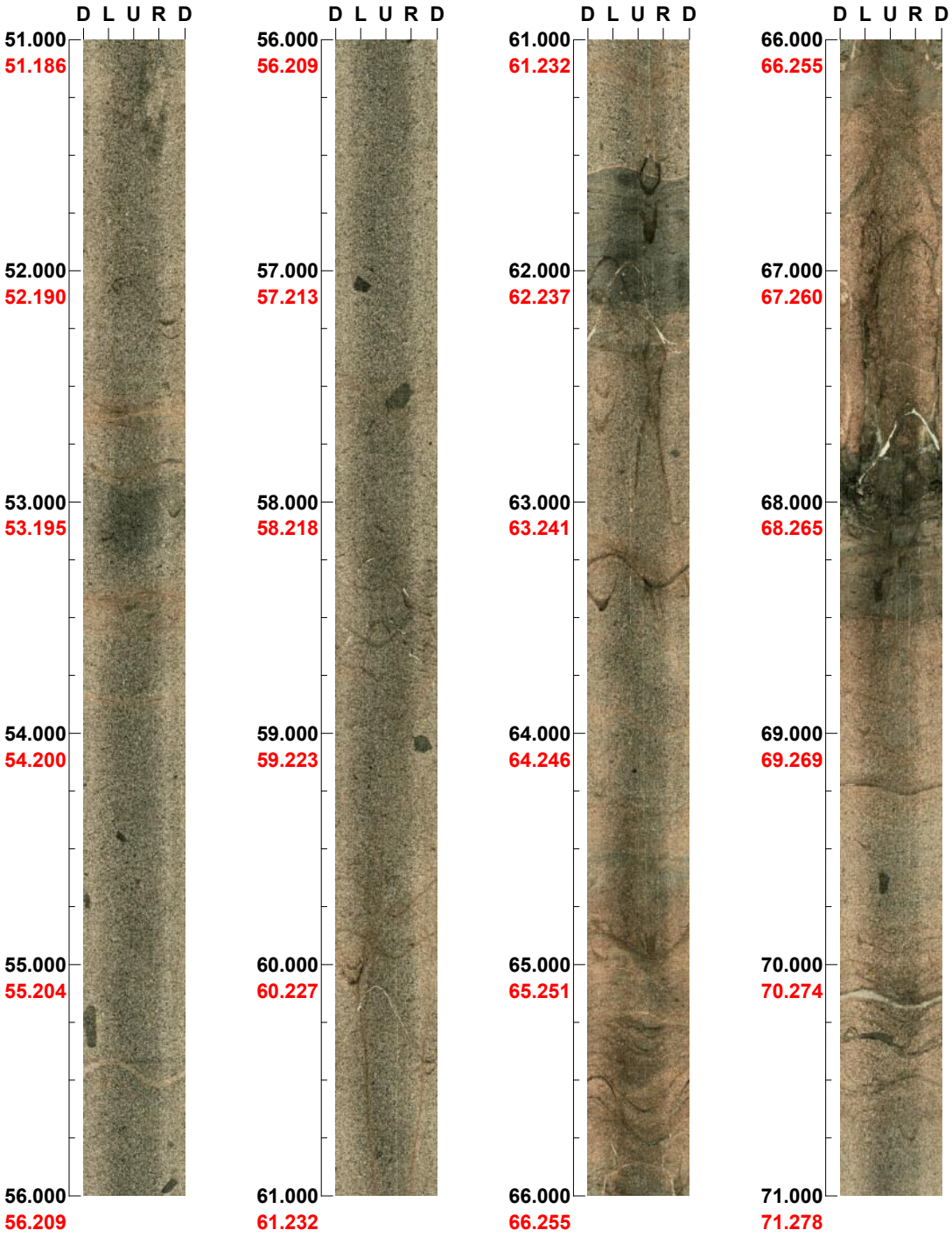
Project name:SIMPEVARP
Bore hole No.: HAV10 **Azimuth: 35** **Inclination: -68**

Depth range: 31.000 - 51.000 m

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

Project name: SIMPEVARP
Bore hole No.: HAV10 **Azimuth: 35** **Inclination: -68**

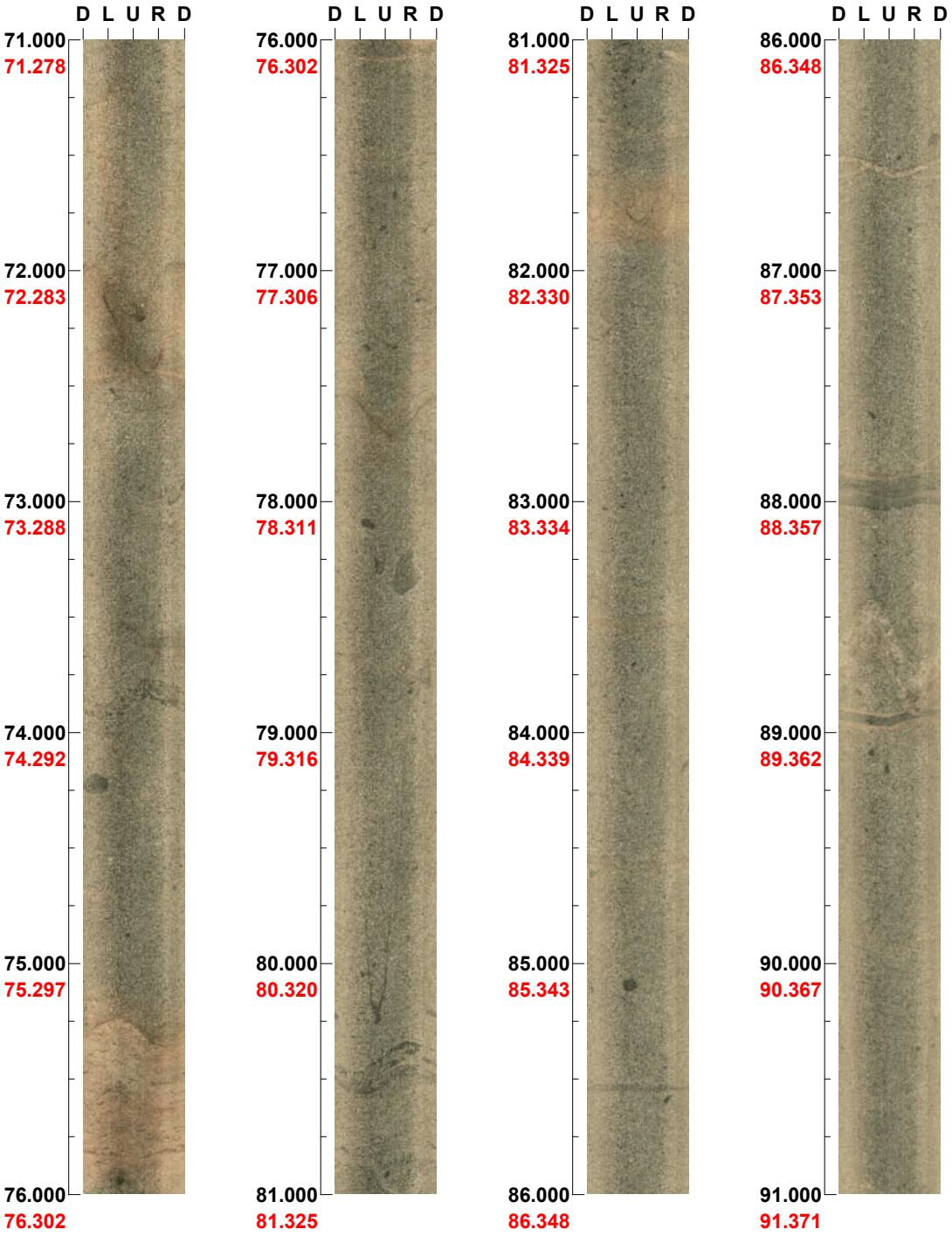
Depth range: 51.000 - 71.000 m



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

Project name: SIMPEVARP
Bore hole No.: HAV10 **Azimuth: 35** **Inclination: -68**

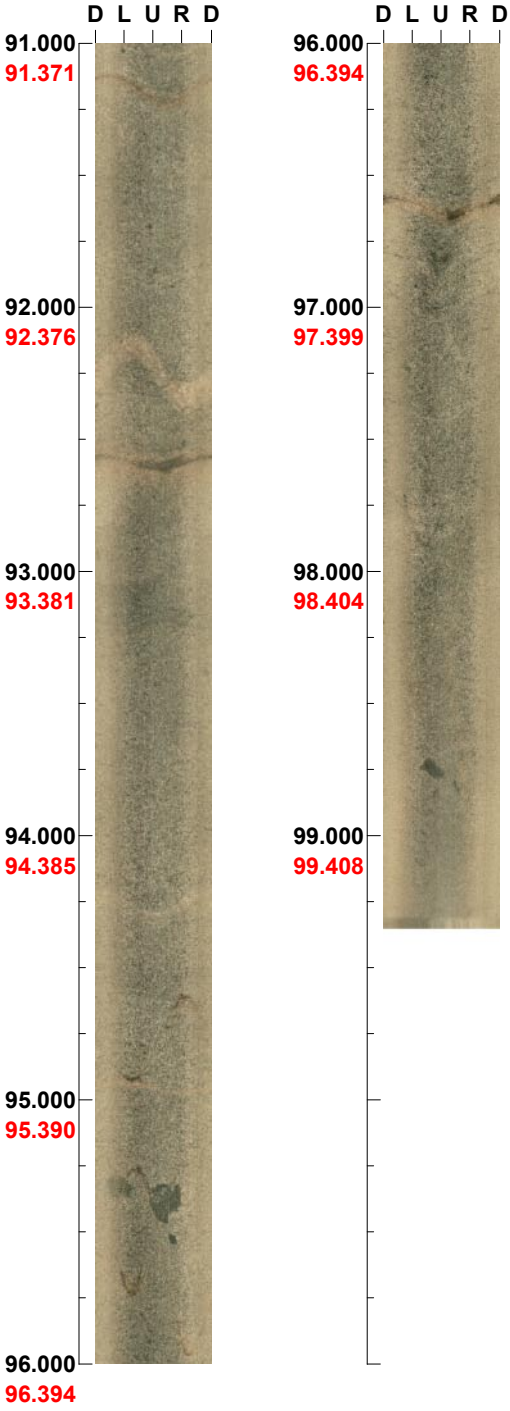
Depth range: 71.000 - 91.000 m



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

Project name: SIMPEVARP
Bore hole No.: HAV10 **Azimuth: 35** **Inclination: -68**

Depth range: 91.000 - 99.350 m



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

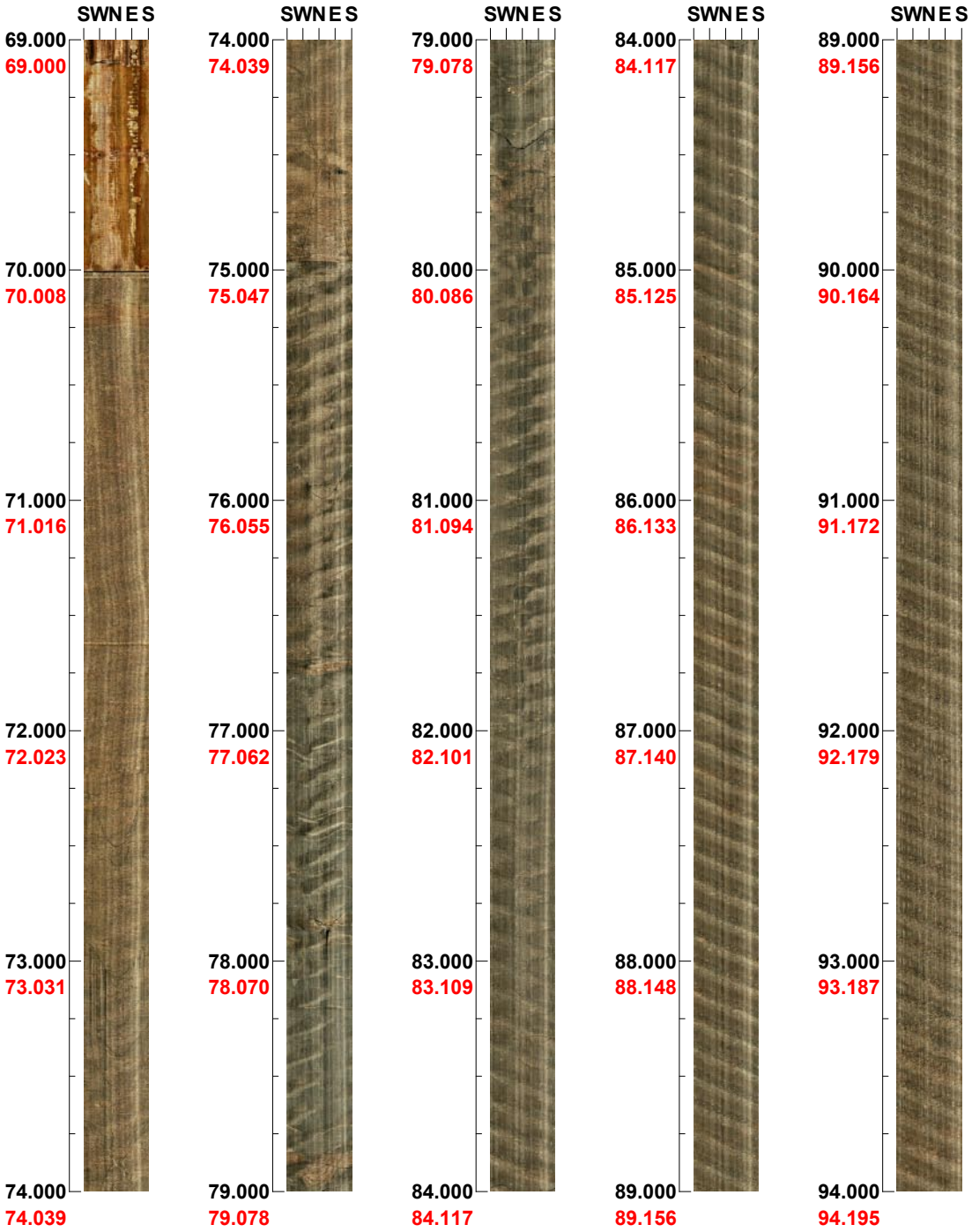
Appendix 10

BIPS logging in KAV01, 69 to 741.6 m.

Image file	**: c:\work\r5228s~1\kav01\kav01_a.bip**
BDT file	**: c:\work\r5228s~1\kav01\kav01_a.bdt**
Locality	**: SIMPEVARP**
Bore hole number	**: KAV01**
Date	**: 03/12/14**
Time	**: 17:54:00**
Depth range	**: 69.000 - 547.734 m**
Azimuth	**: 0**
Inclination	**: -90**
Diameter	**: 56.0 mm**
Magnetic declination	**: 0.0**
Span	**: 4**
Scan interval	**: 0.25**
Scan direction	**: To bottom**
Scale	**: 1/25**
Aspect ratio	**: 160 %**
Pages	**: 20**
Color	**:**  **+0 +0 +0**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

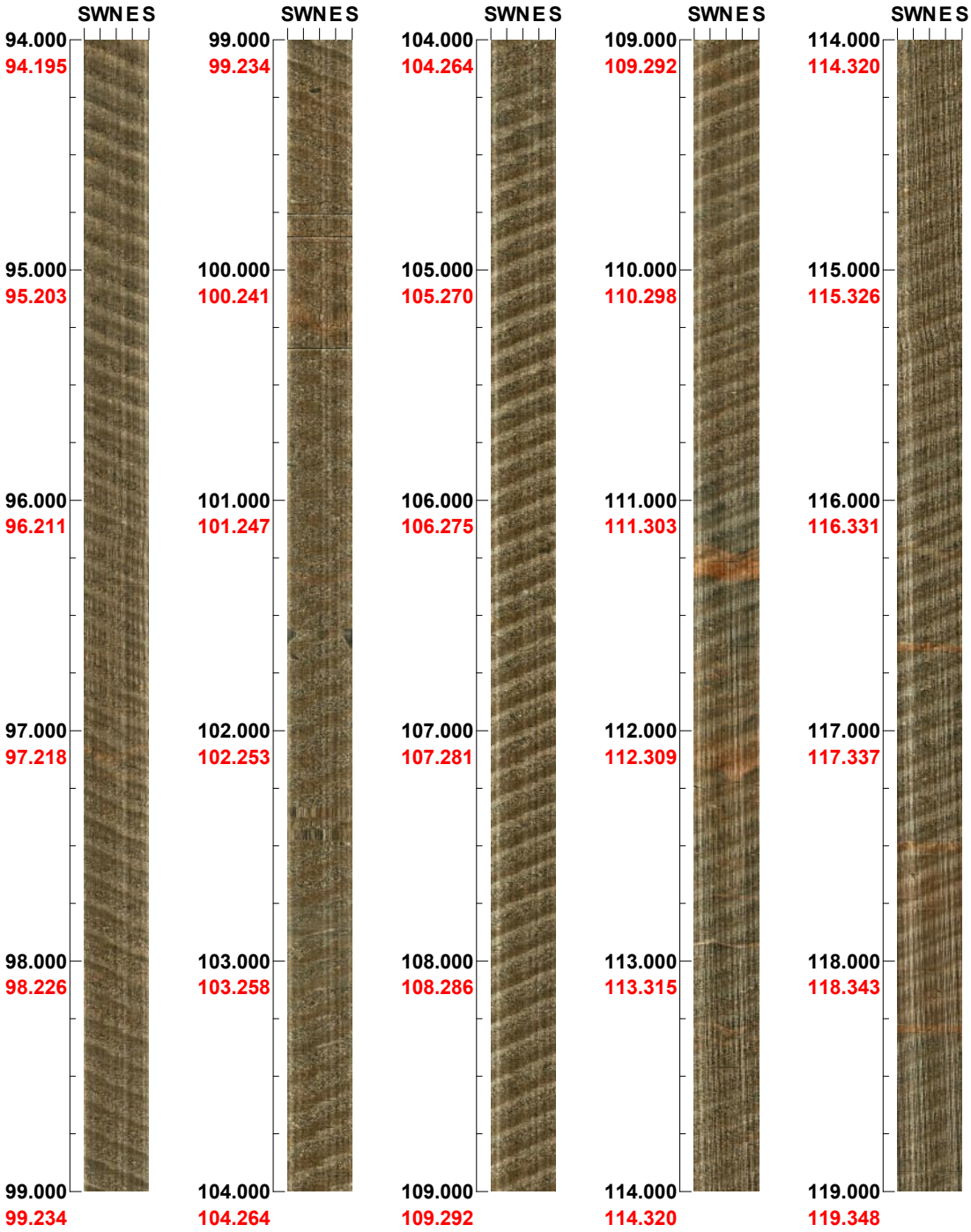
Depth range: 69.000 - 94.000 m



(1 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

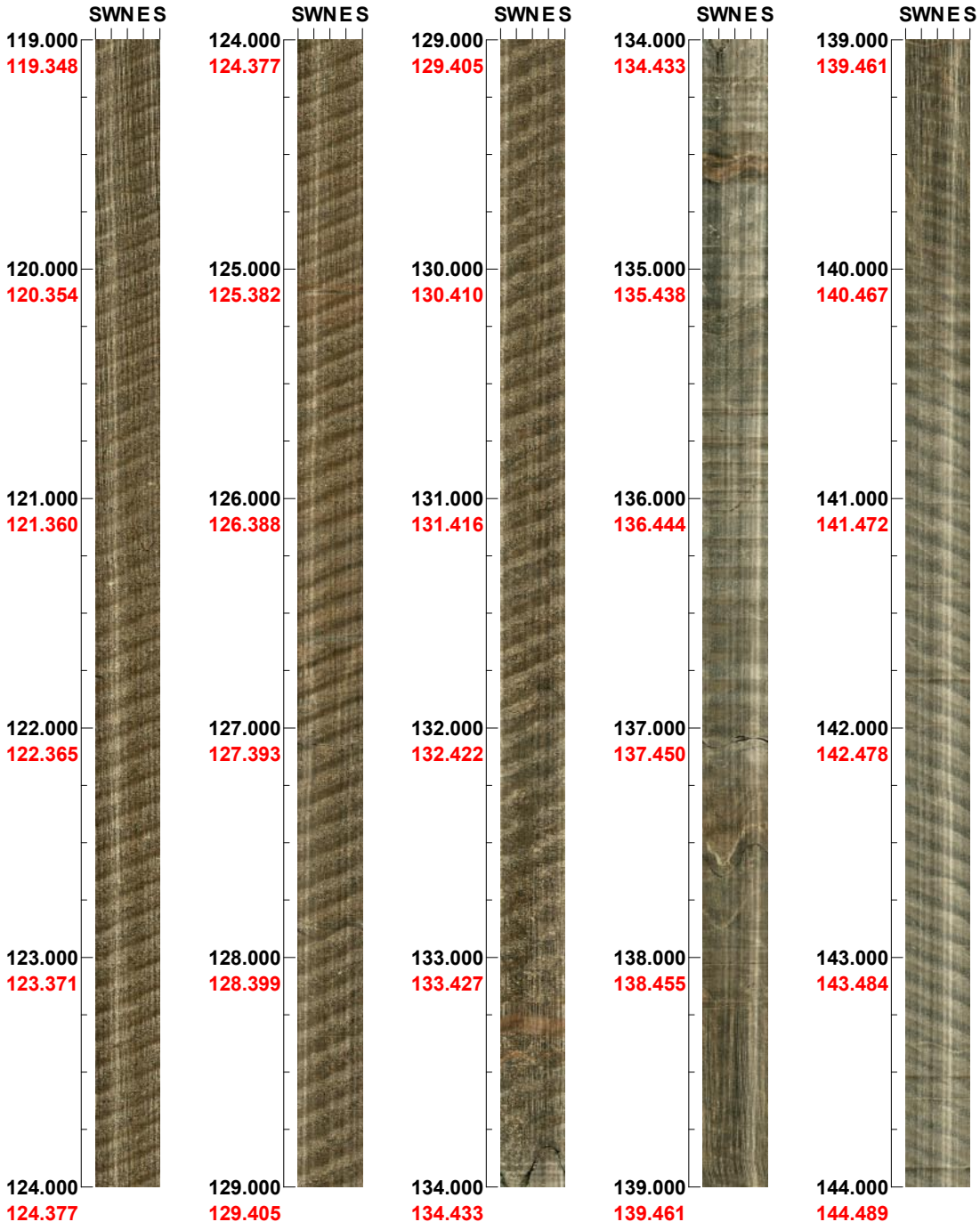
Depth range: 94.000 - 119.000 m



(2 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

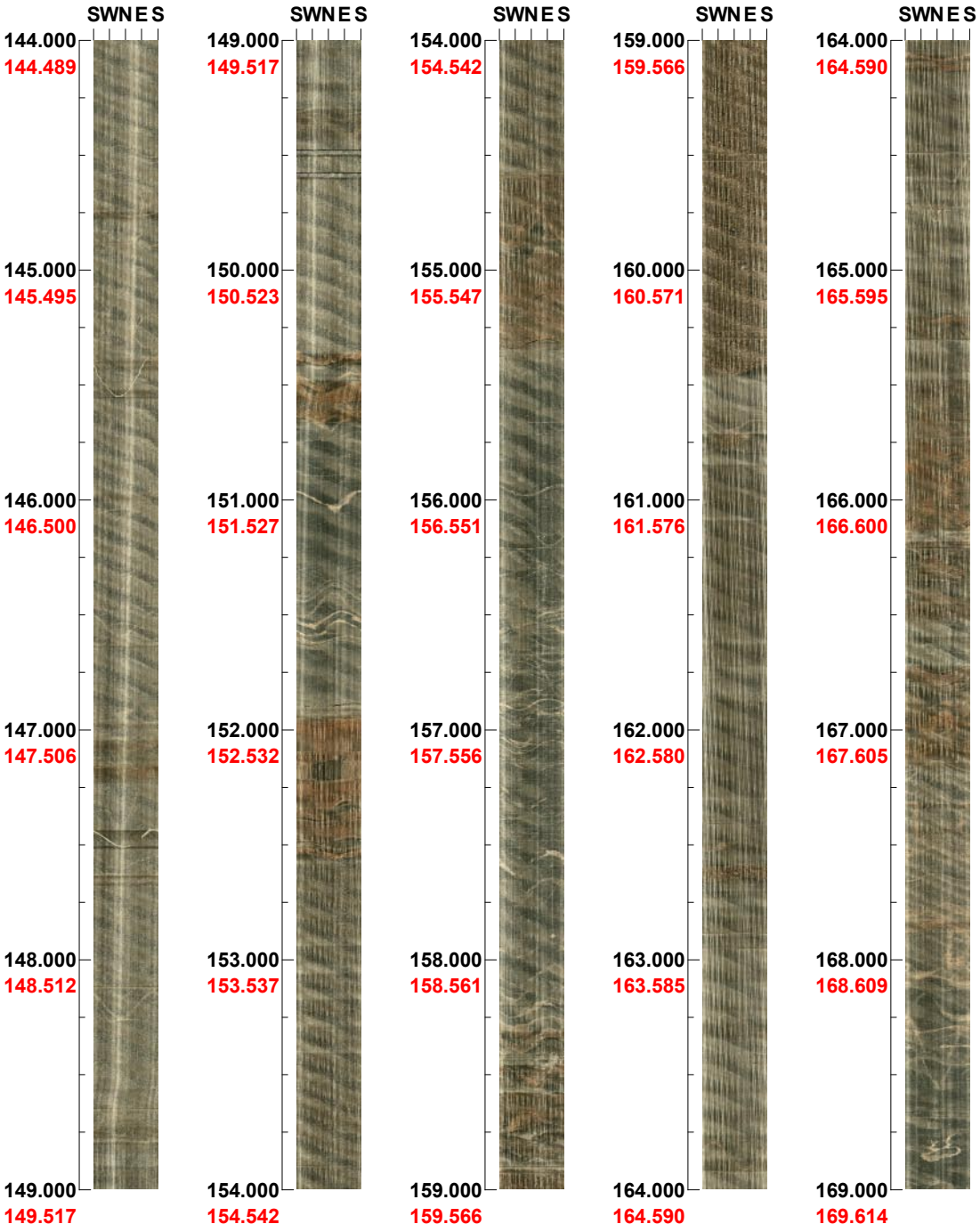
Depth range: 119.000 - 144.000 m



(3 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

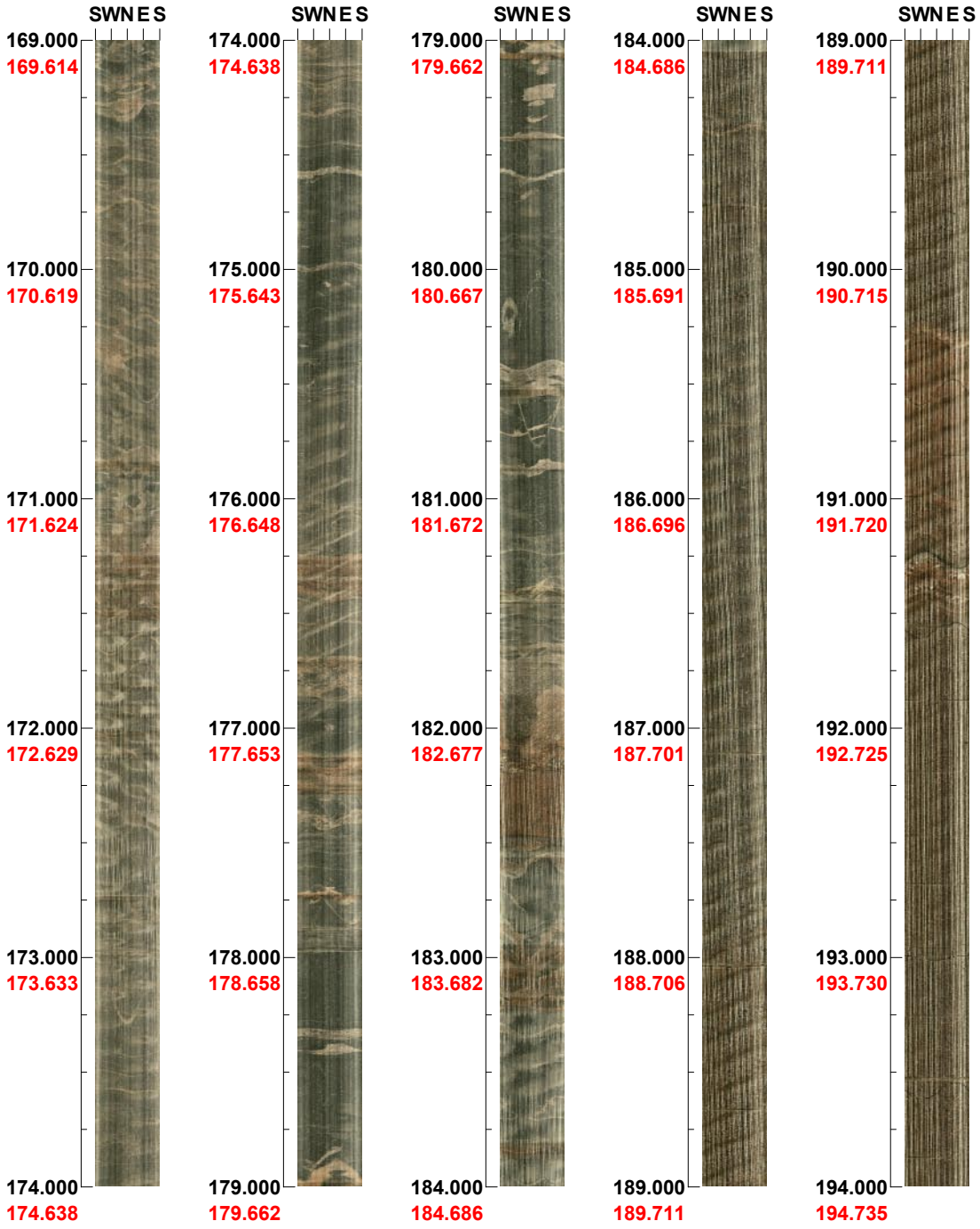
Depth range: 144.000 - 169.000 m



(4 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

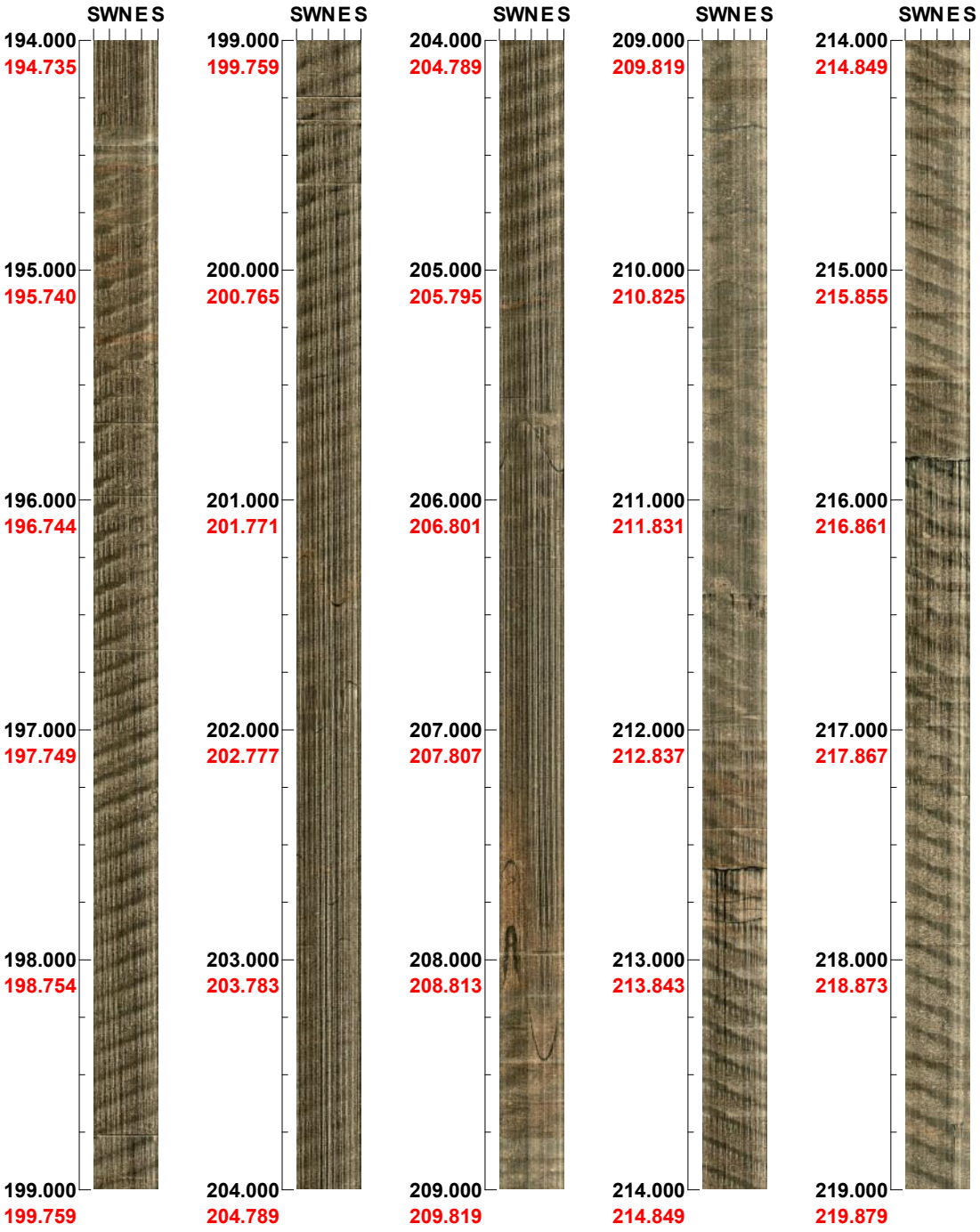
Depth range: 169.000 - 194.000 m



(5 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

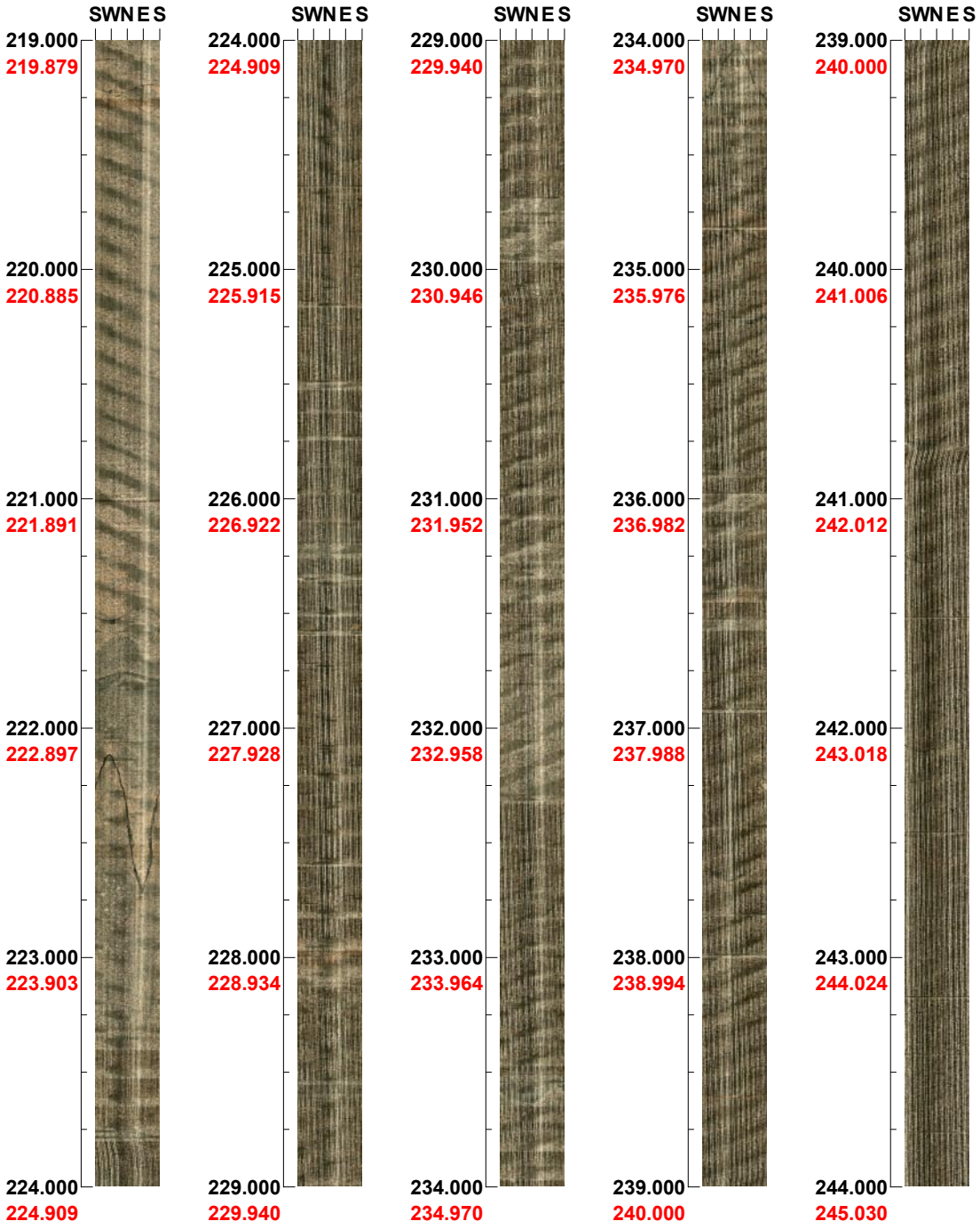
Depth range: 194.000 - 219.000 m



(6 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

Depth range: 219.000 - 244.000 m



(7 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

Depth range: 244.000 - 269.000 m

(8 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

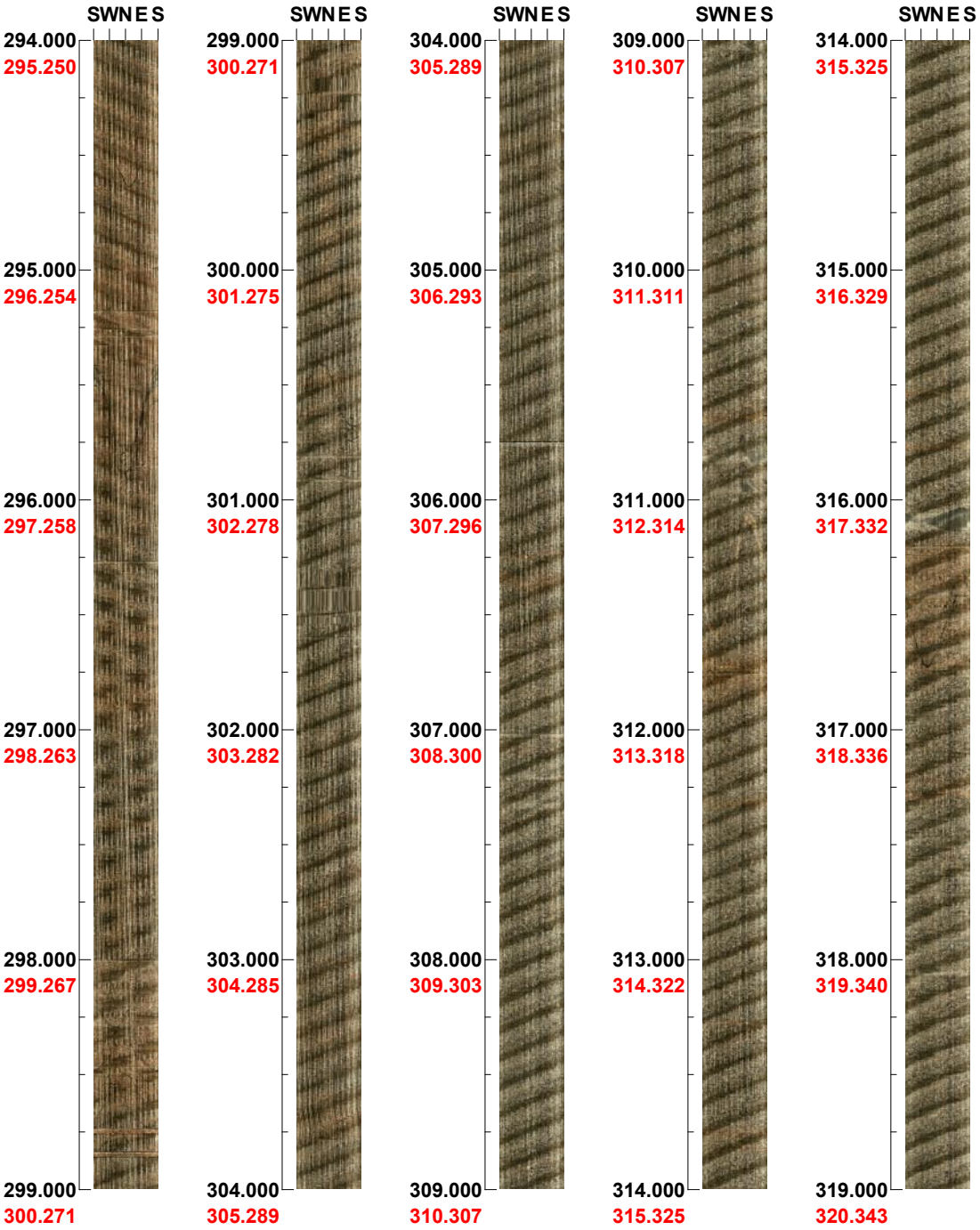
Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

Depth range: 269.000 - 294.000 m

(9 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

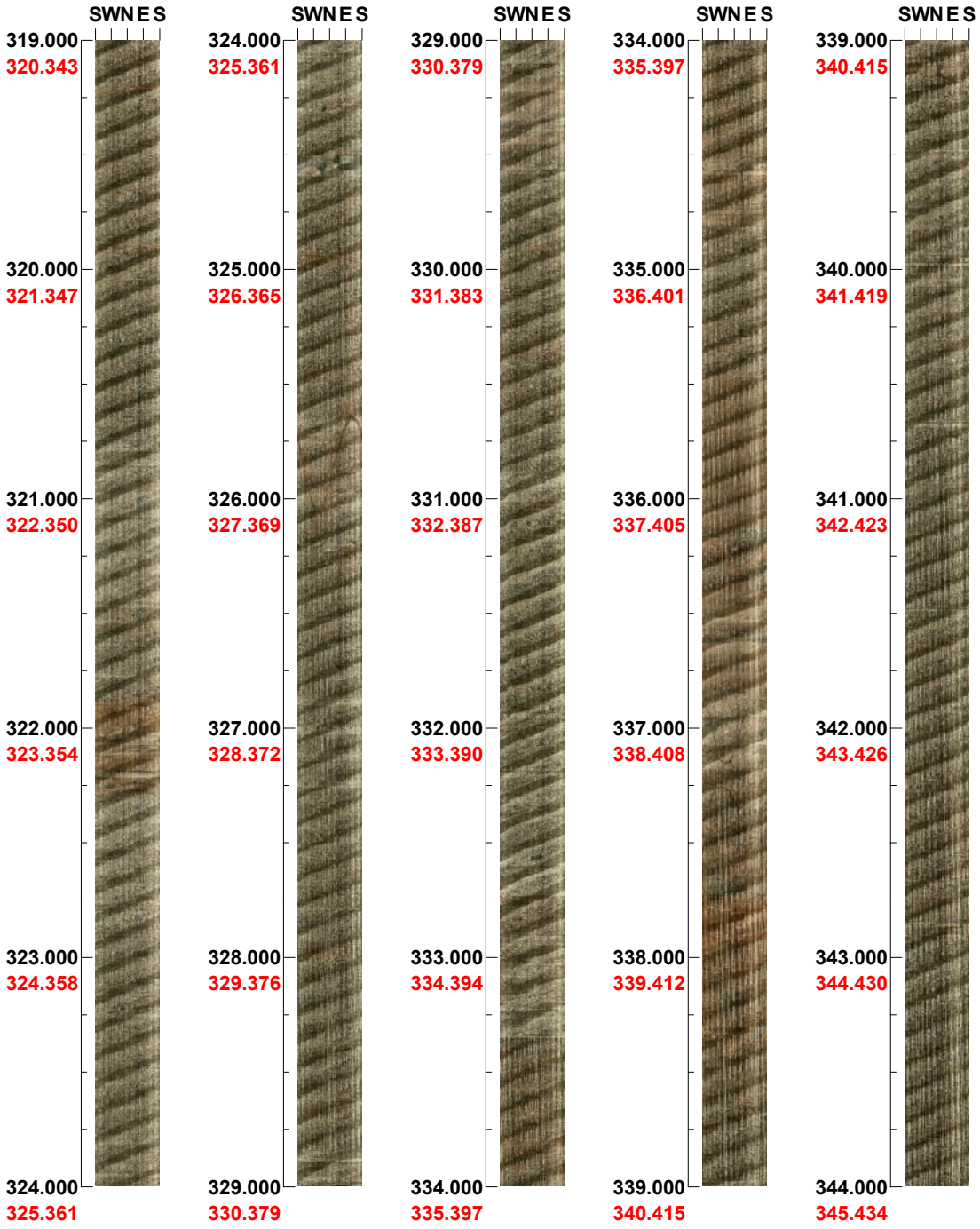
Depth range: 294.000 - 319.000 m



(10 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

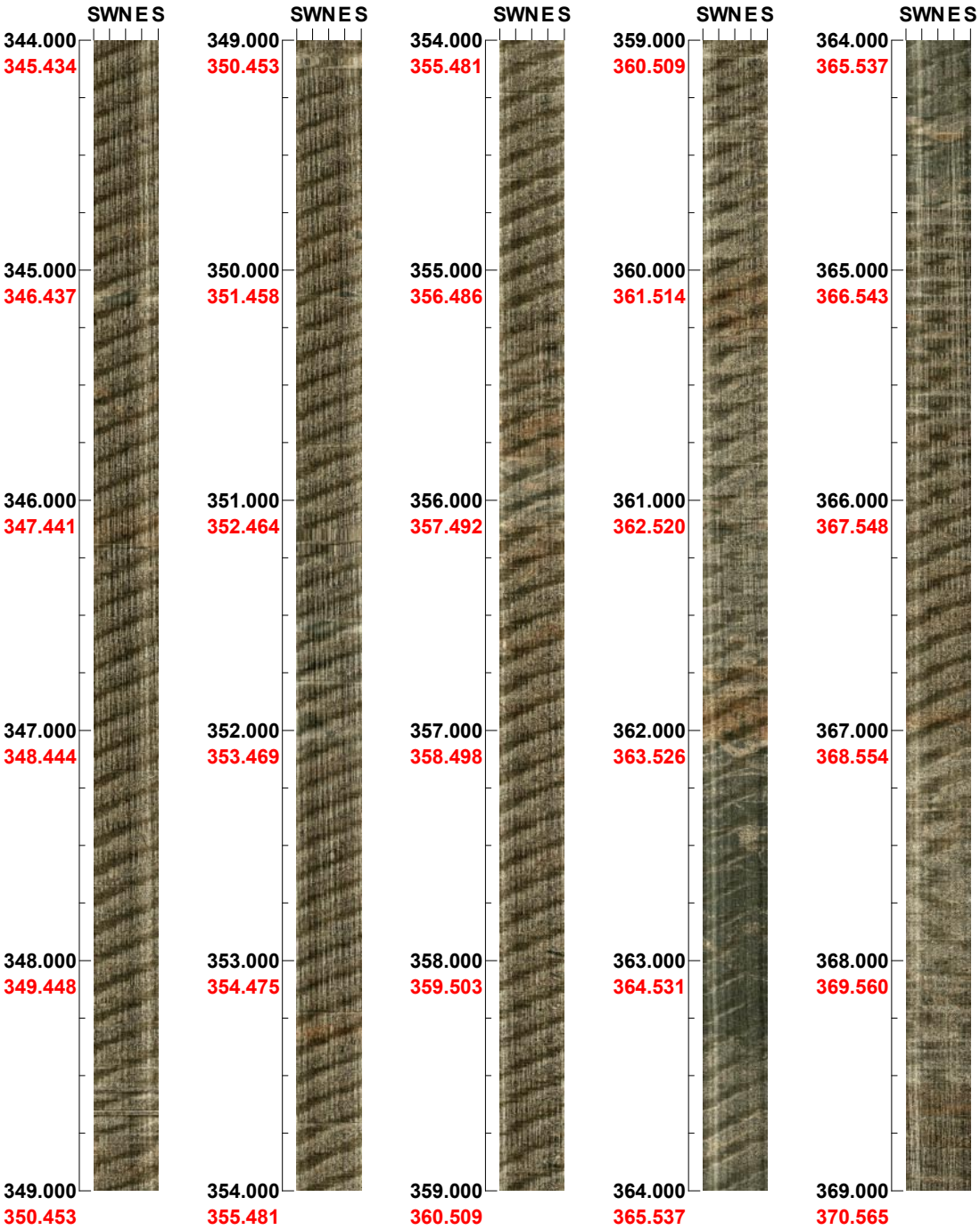
Depth range: 319.000 - 344.000 m



(11 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

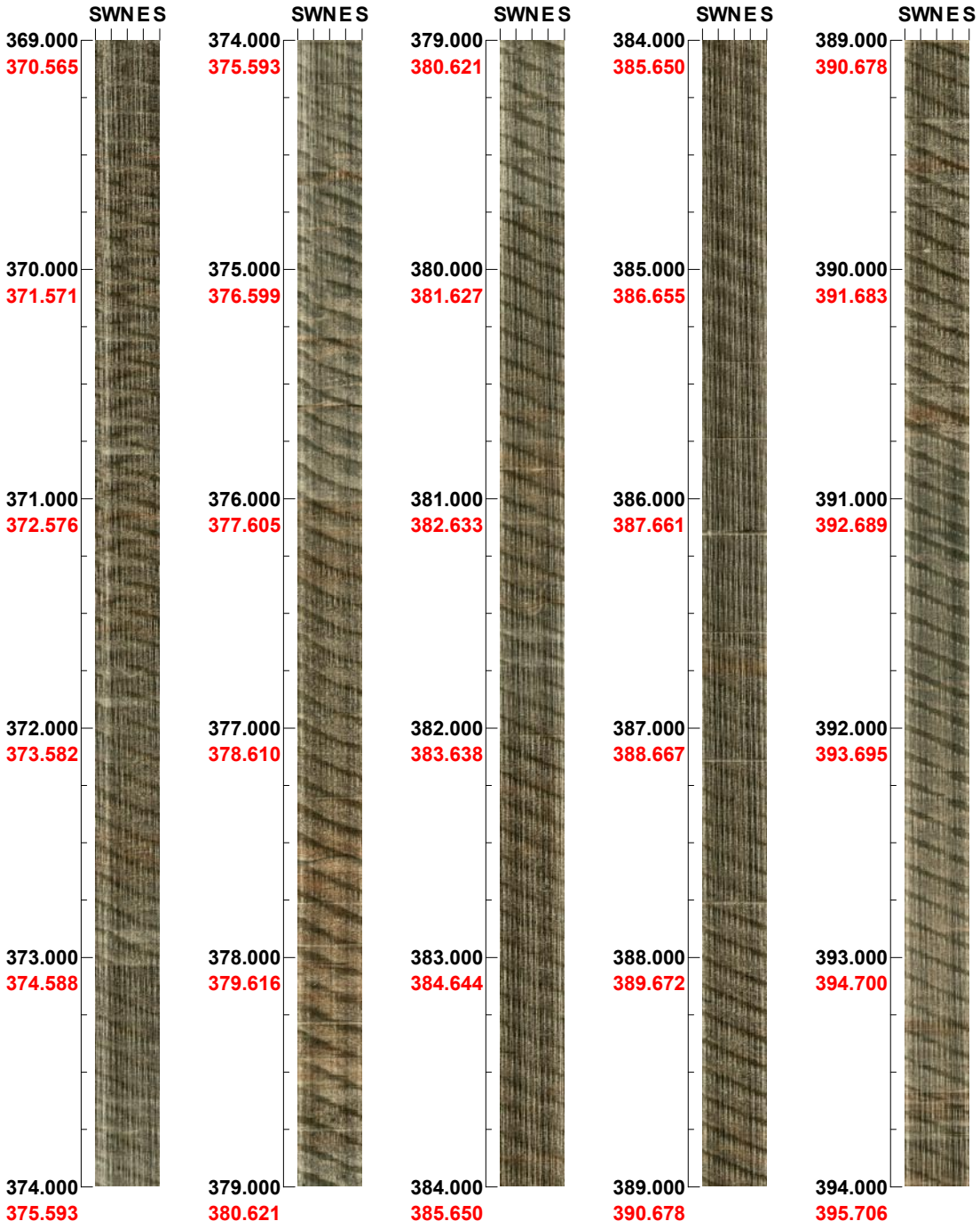
Depth range: 344.000 - 369.000 m



(12 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

Depth range: 369.000 - 394.000 m



(13 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

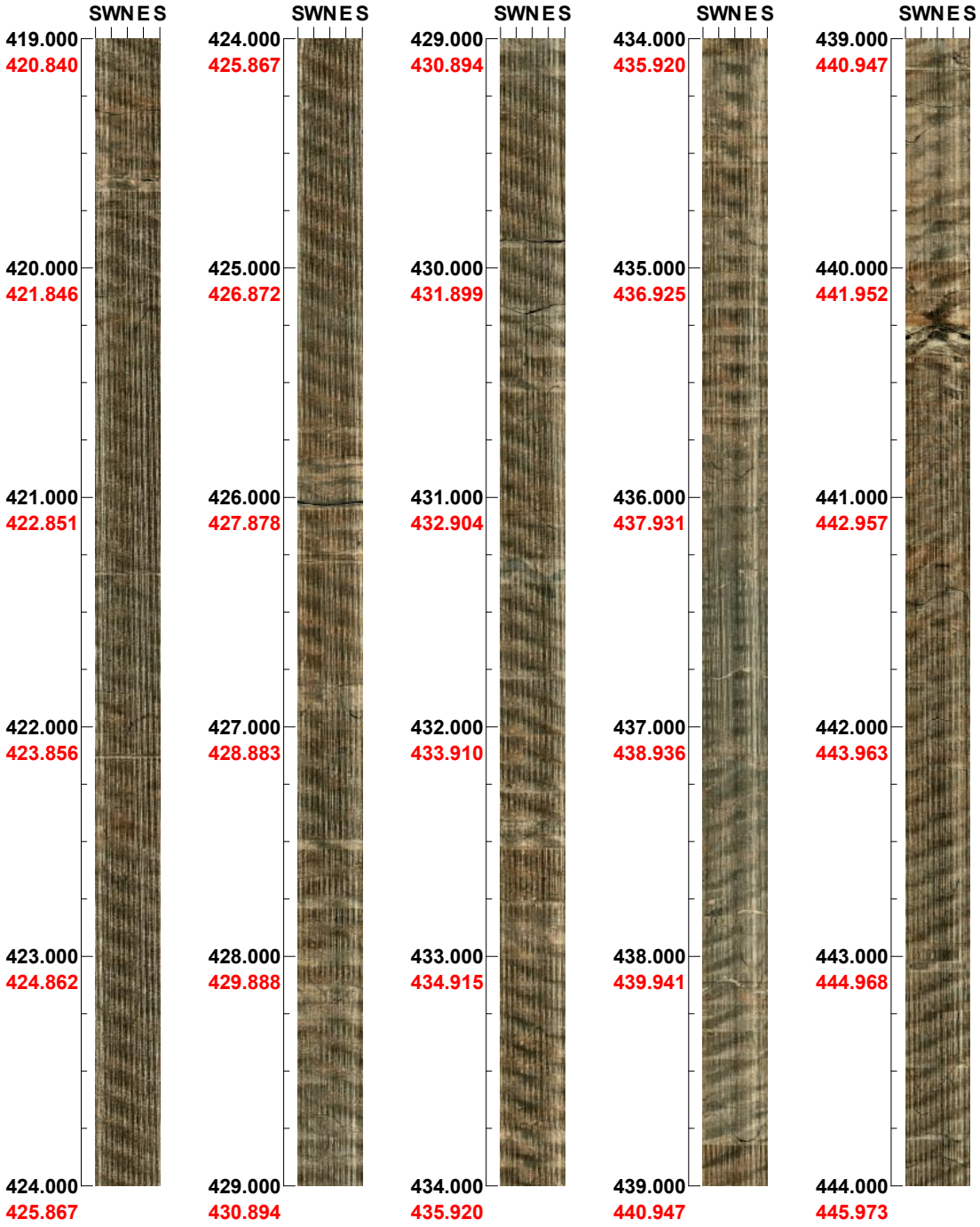
Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

Depth range: 394.000 - 419.000 m

(14 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

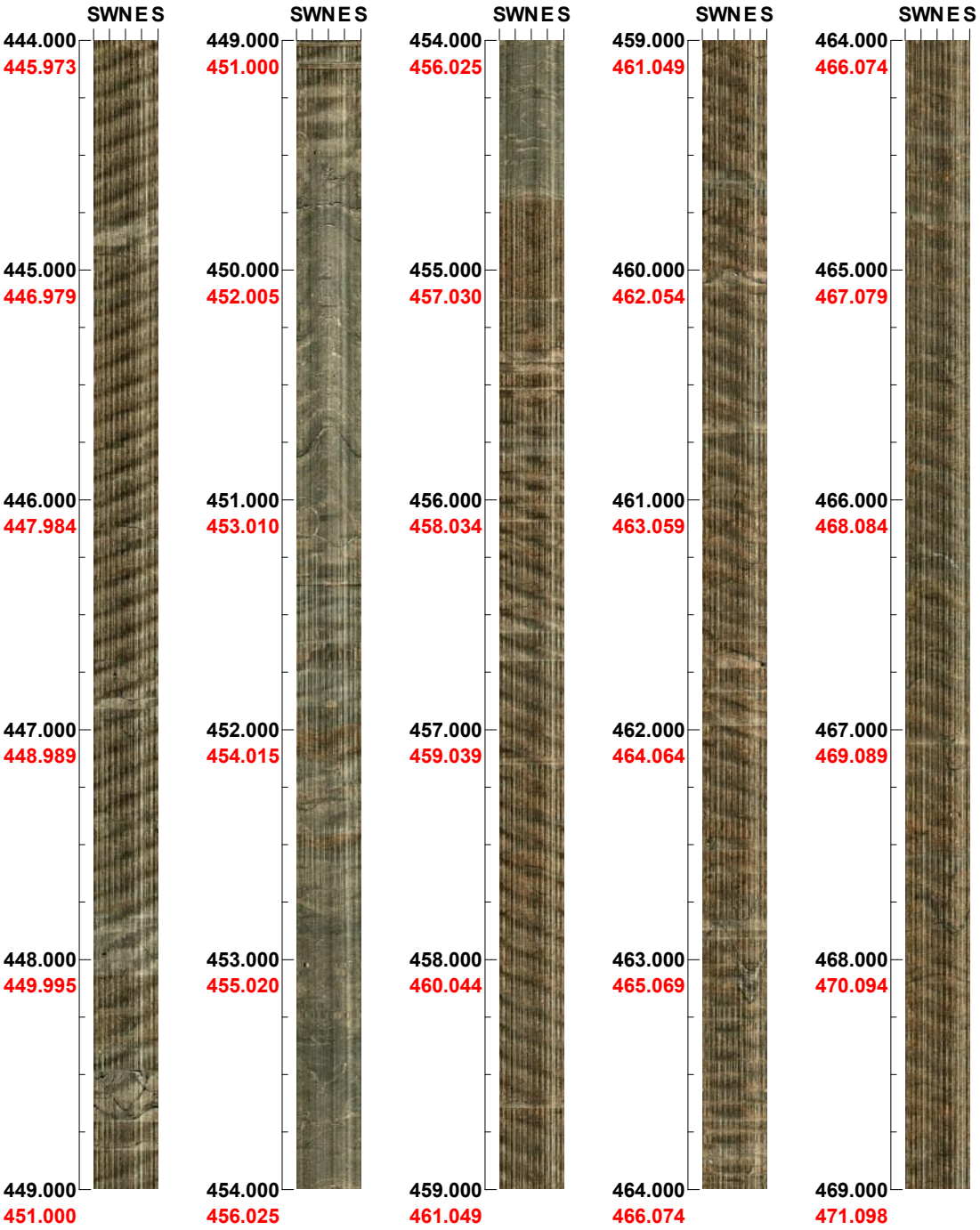
Depth range: 419.000 - 444.000 m



(15 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

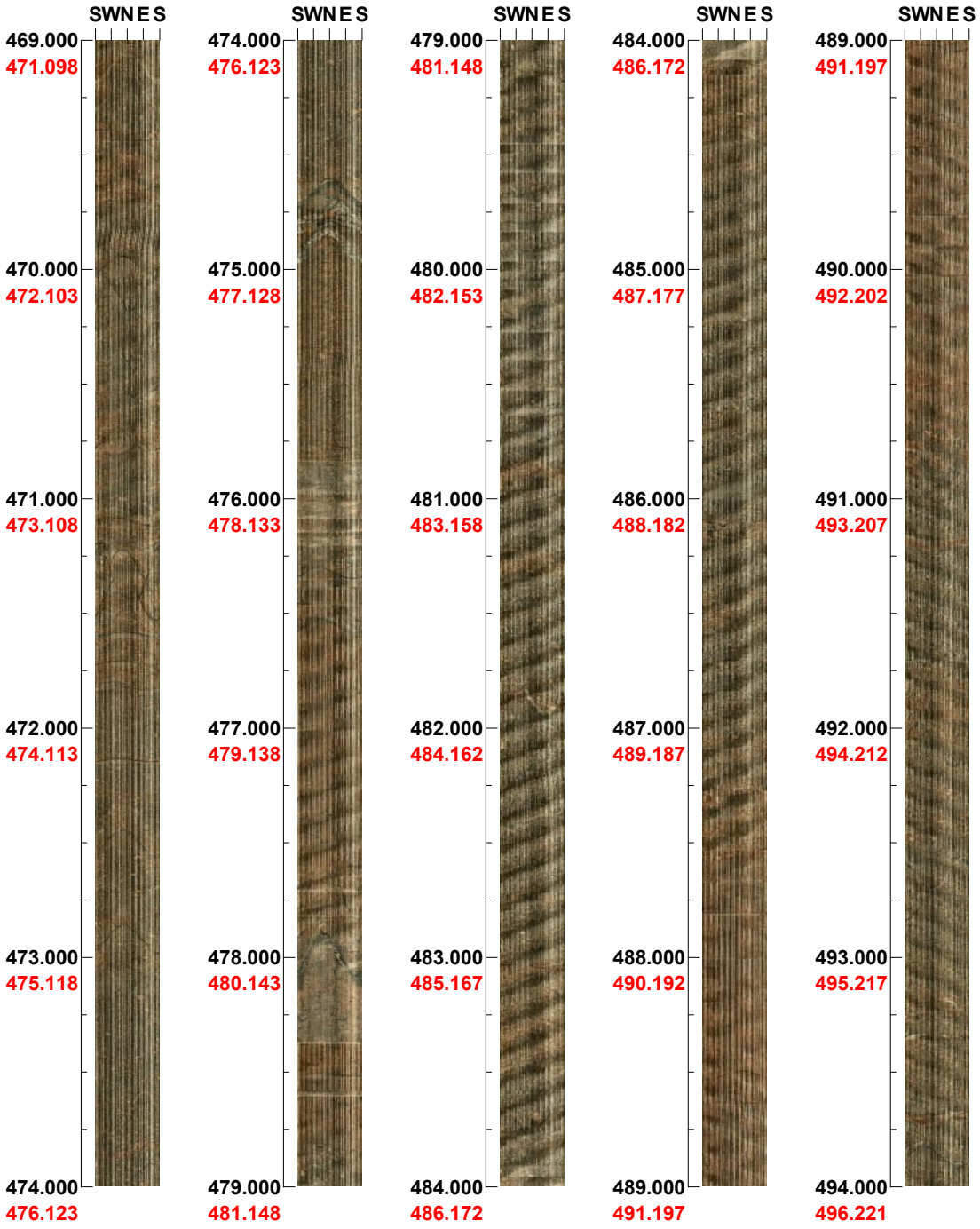
Depth range: 444.000 - 469.000 m



(16 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

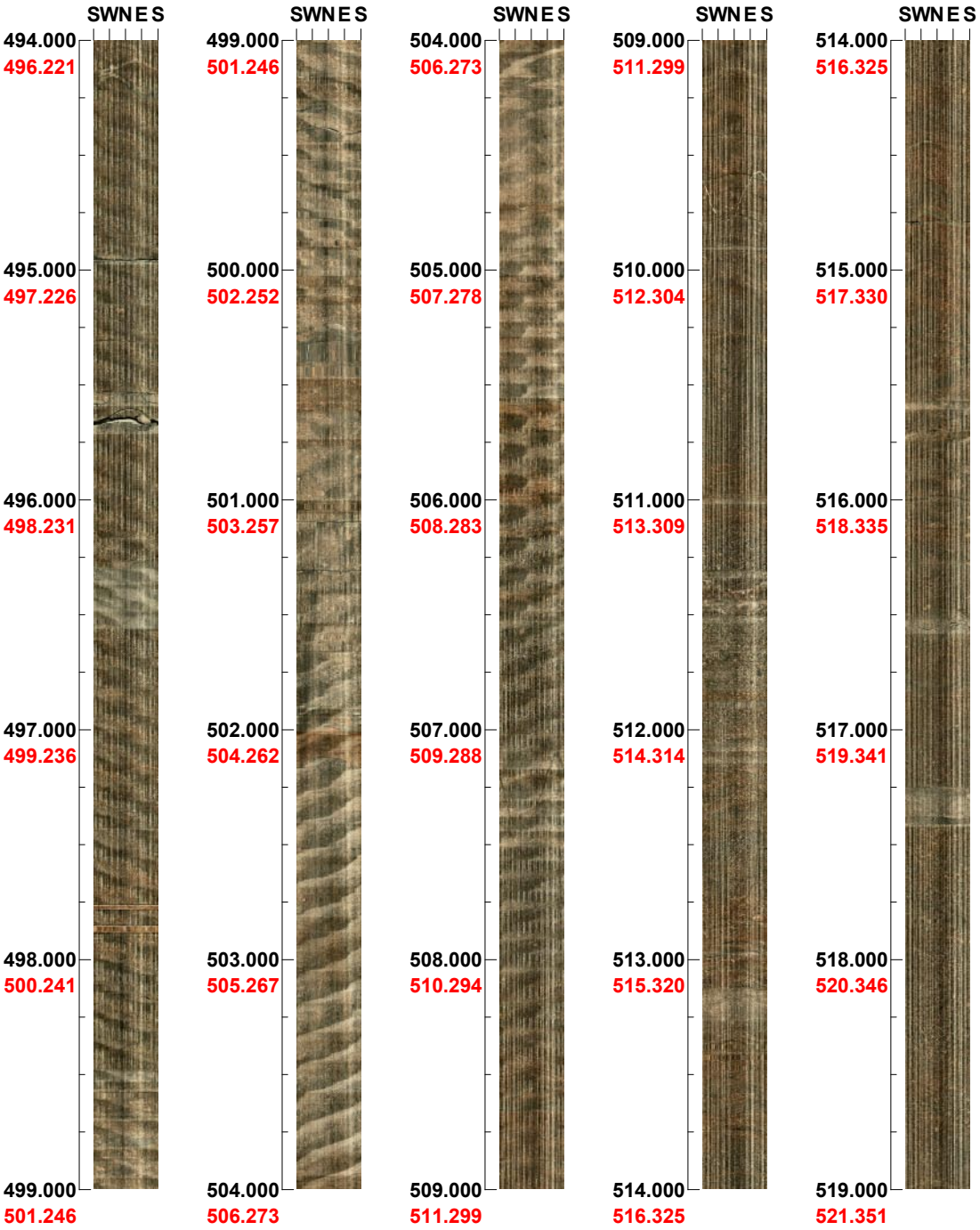
Depth range: 469.000 - 494.000 m



(17 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

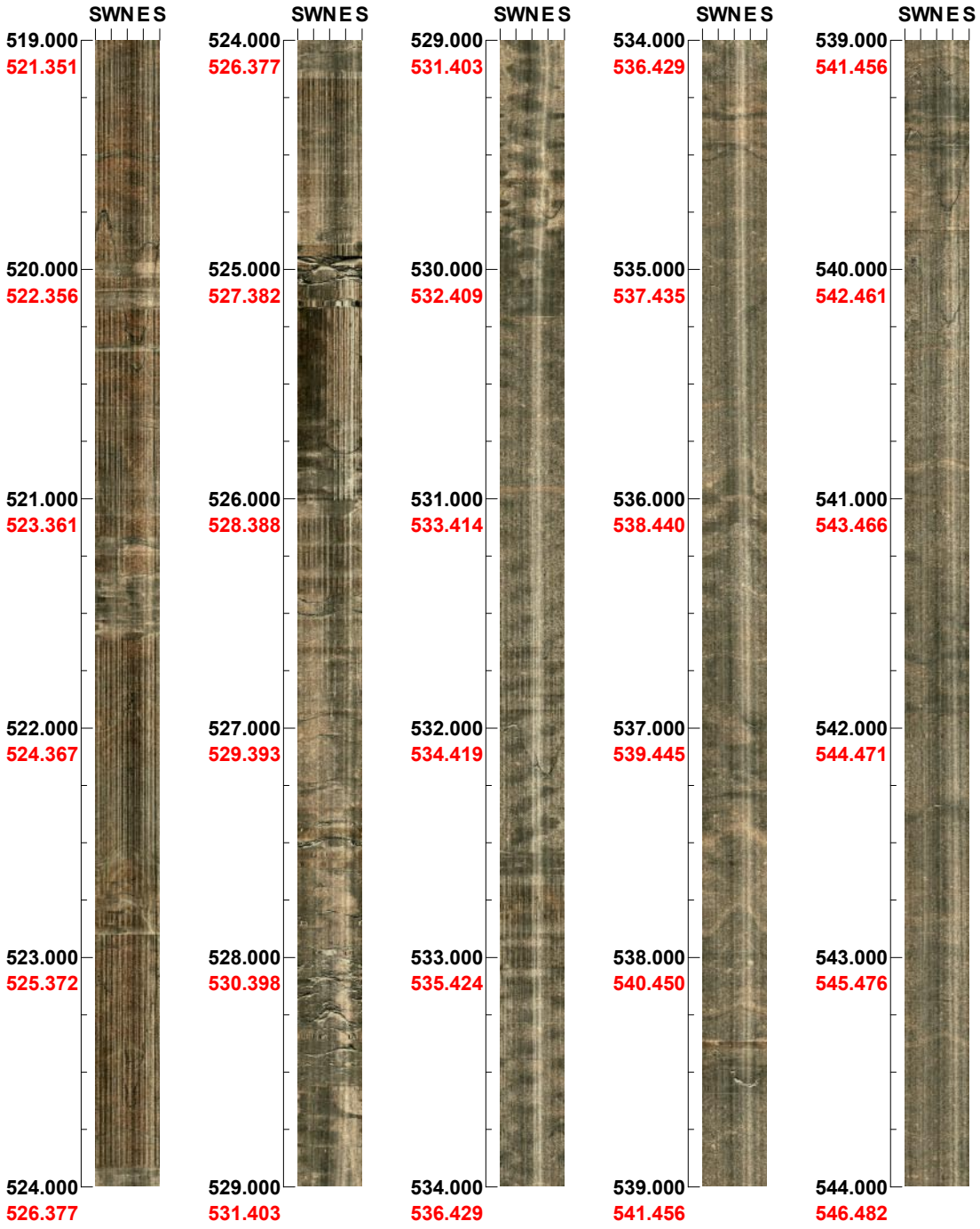
Depth range: 494.000 - 519.000 m



(18 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPAN
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

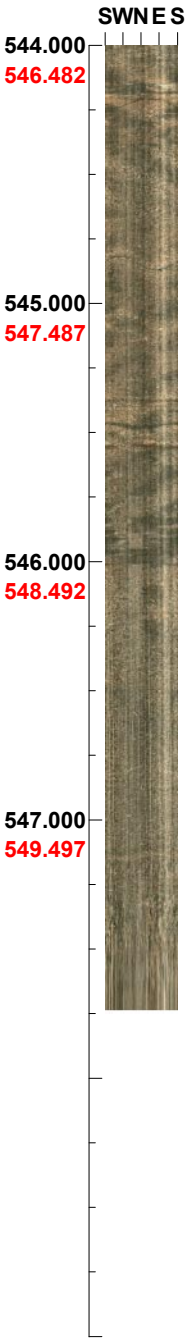
Depth range: 519.000 - 544.000 m



(19 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

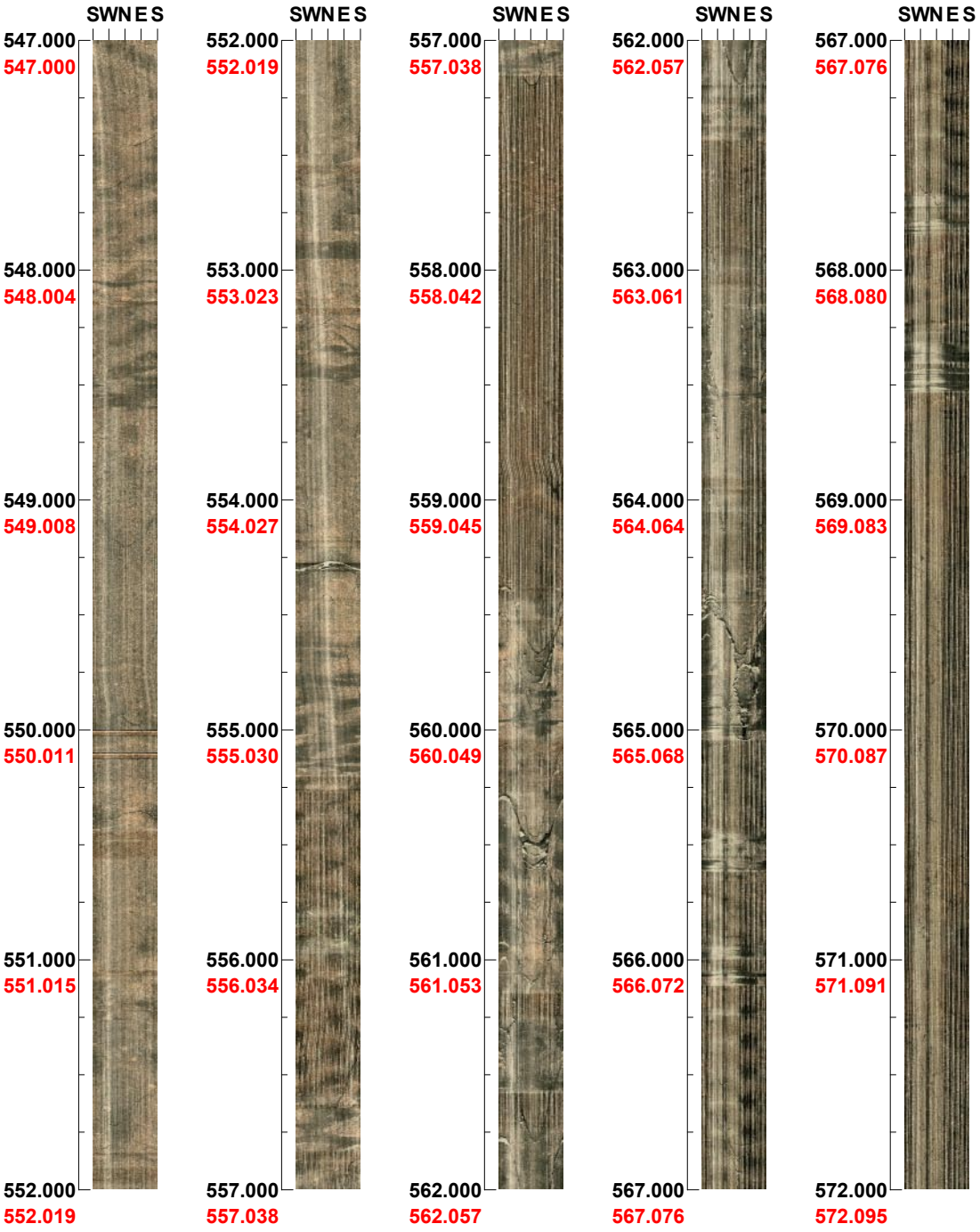
Depth range: 544.000 - 547.734 m



(20 / 20) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

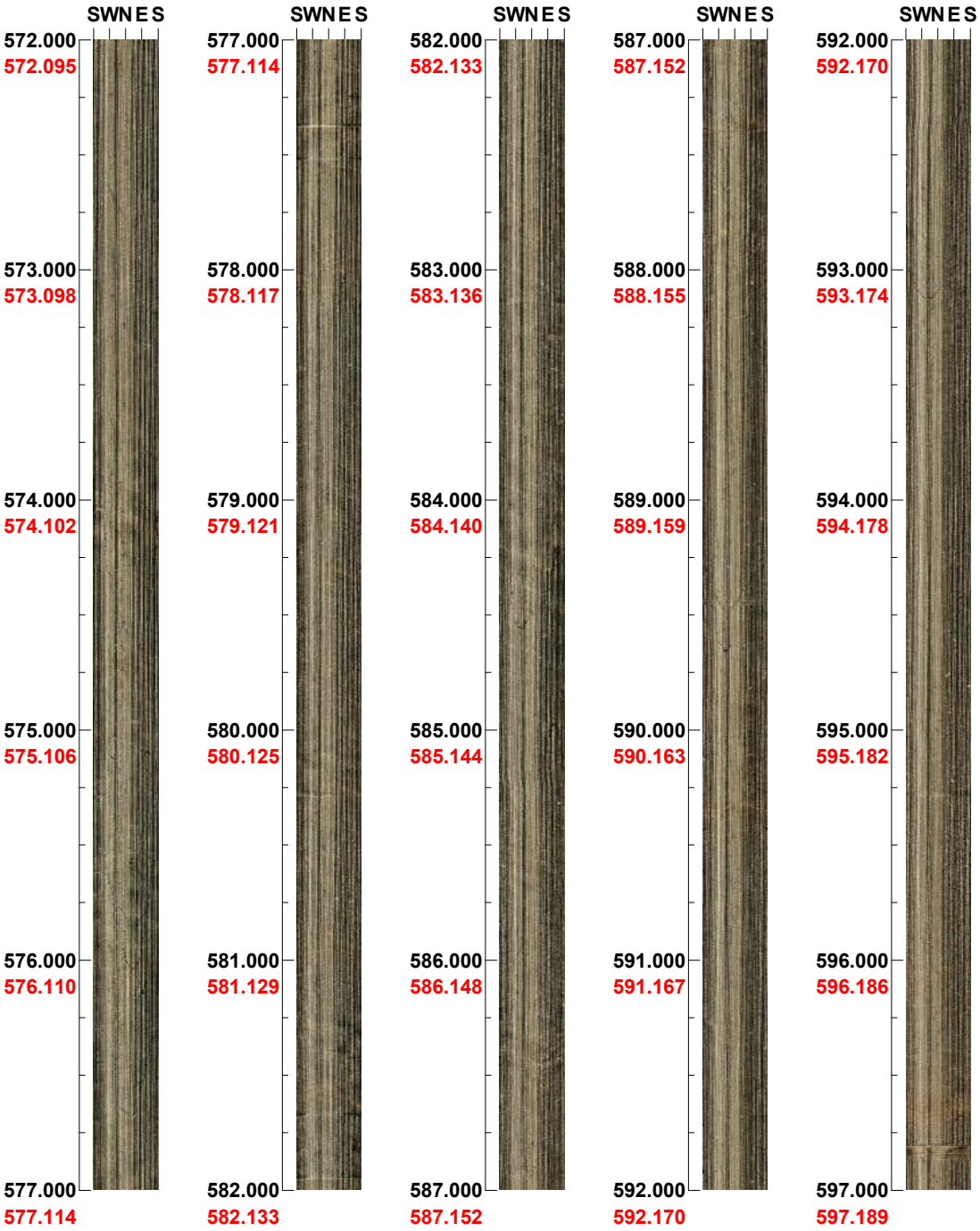
Depth range: 547.000 - 572.000 m



(1 / 8) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

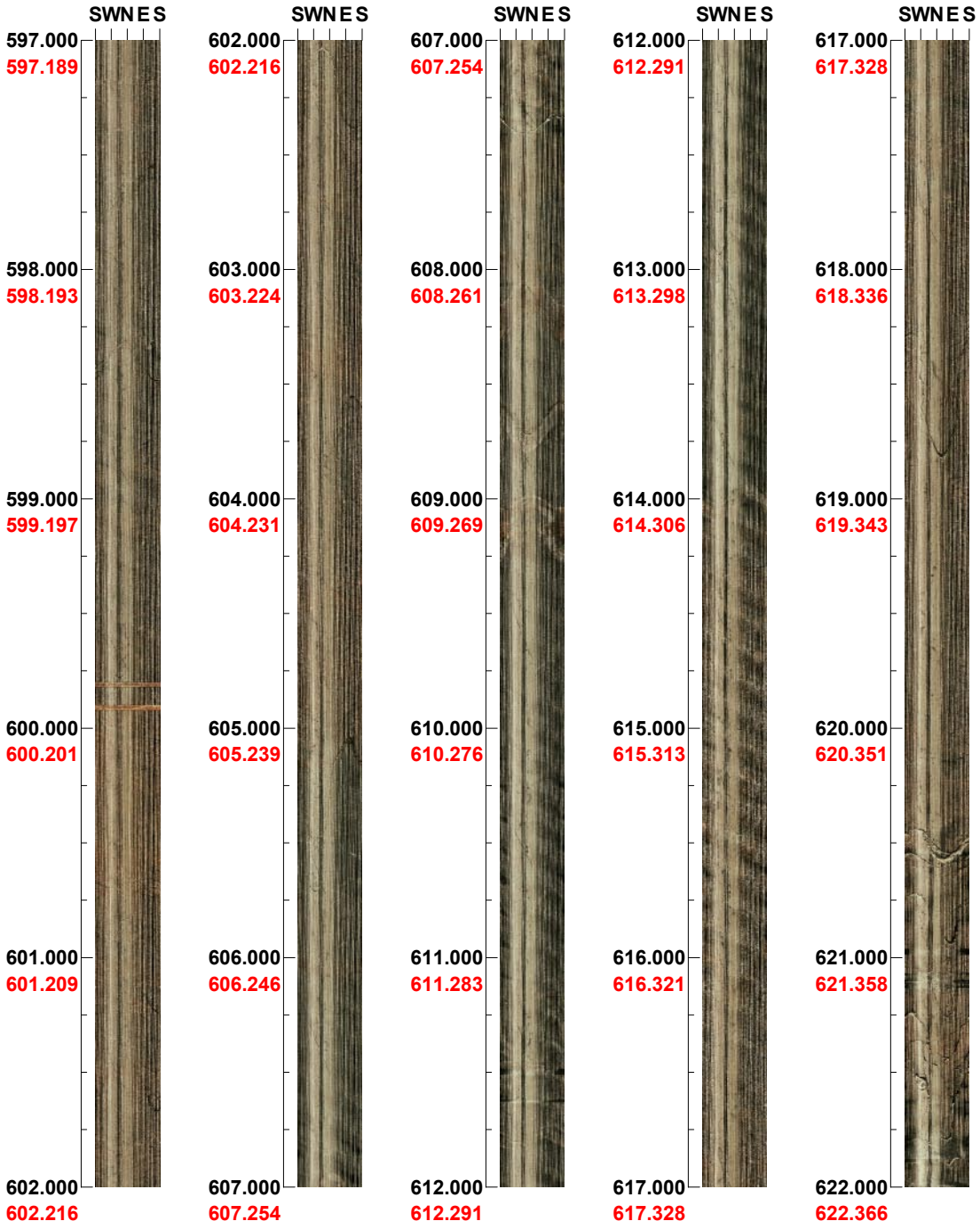
Depth range: 572.000 - 597.000 m



(2 / 8) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

Depth range: 597.000 - 622.000 m



(3 / 8) **Scale: 1/25** **Aspect ratio: 160 %**

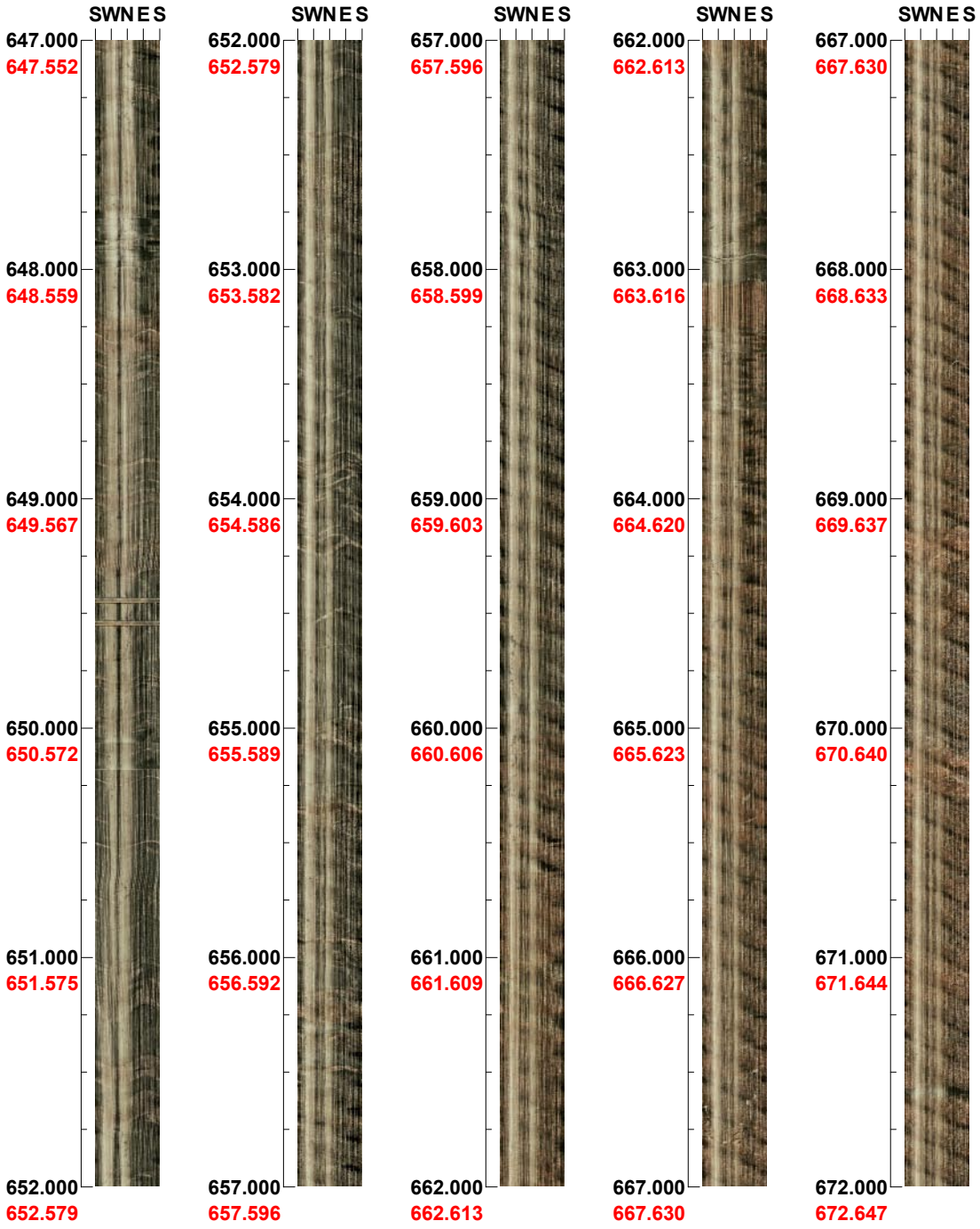
Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

Depth range: 622.000 - 647.000 m

(4 / 8) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

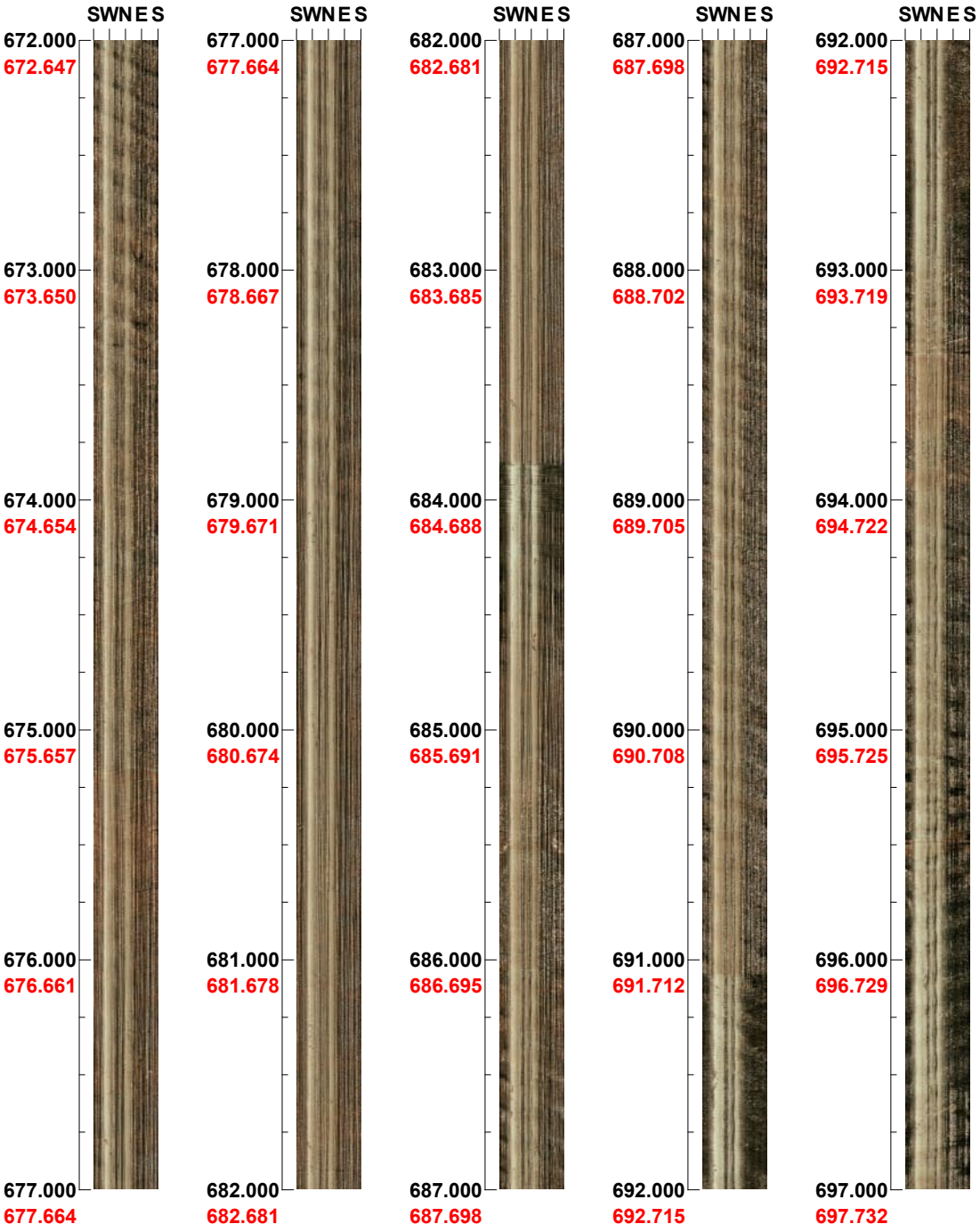
Depth range: 647.000 - 672.000 m



(5 / 8) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

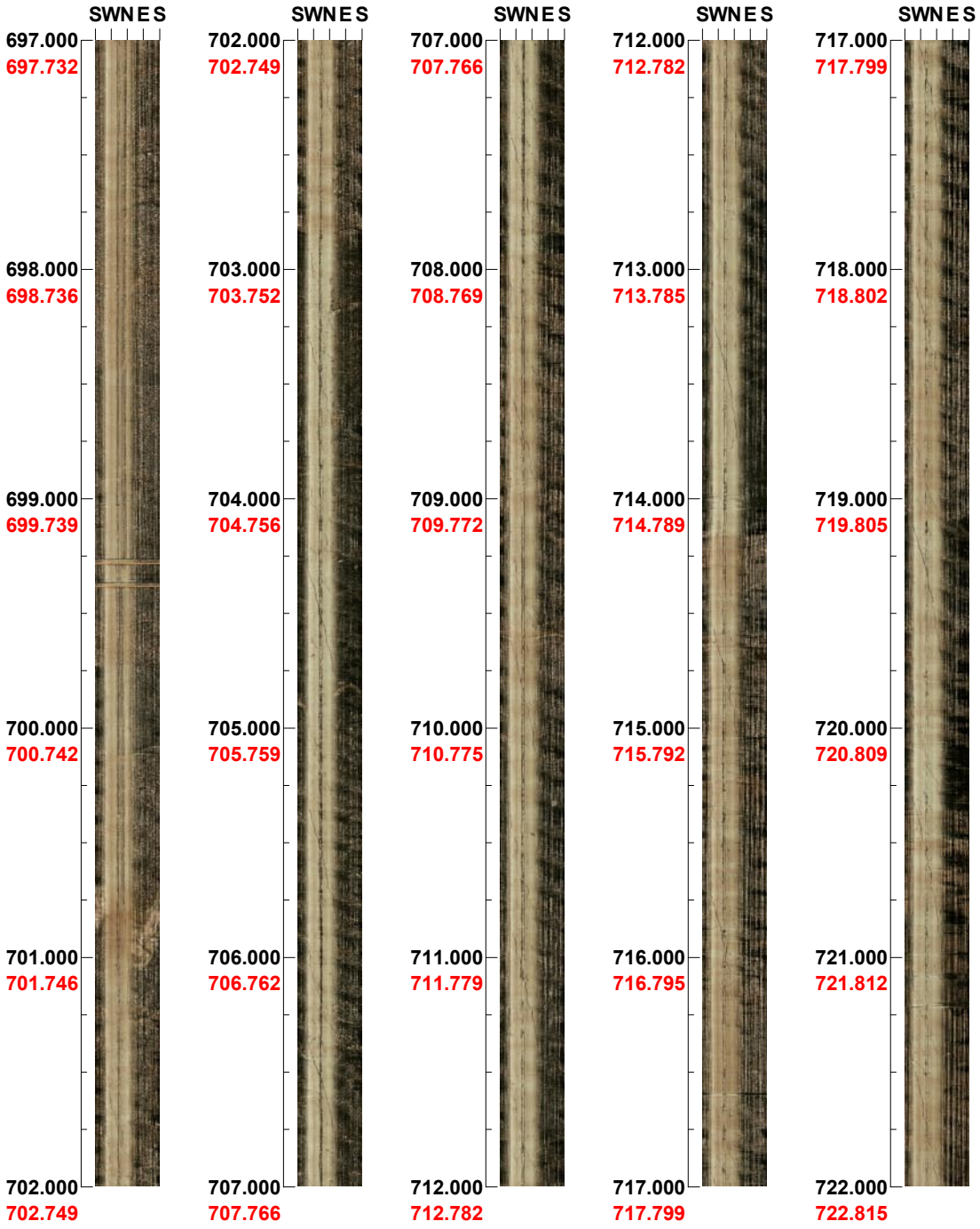
Depth range: 672.000 - 697.000 m



(6 / 8) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

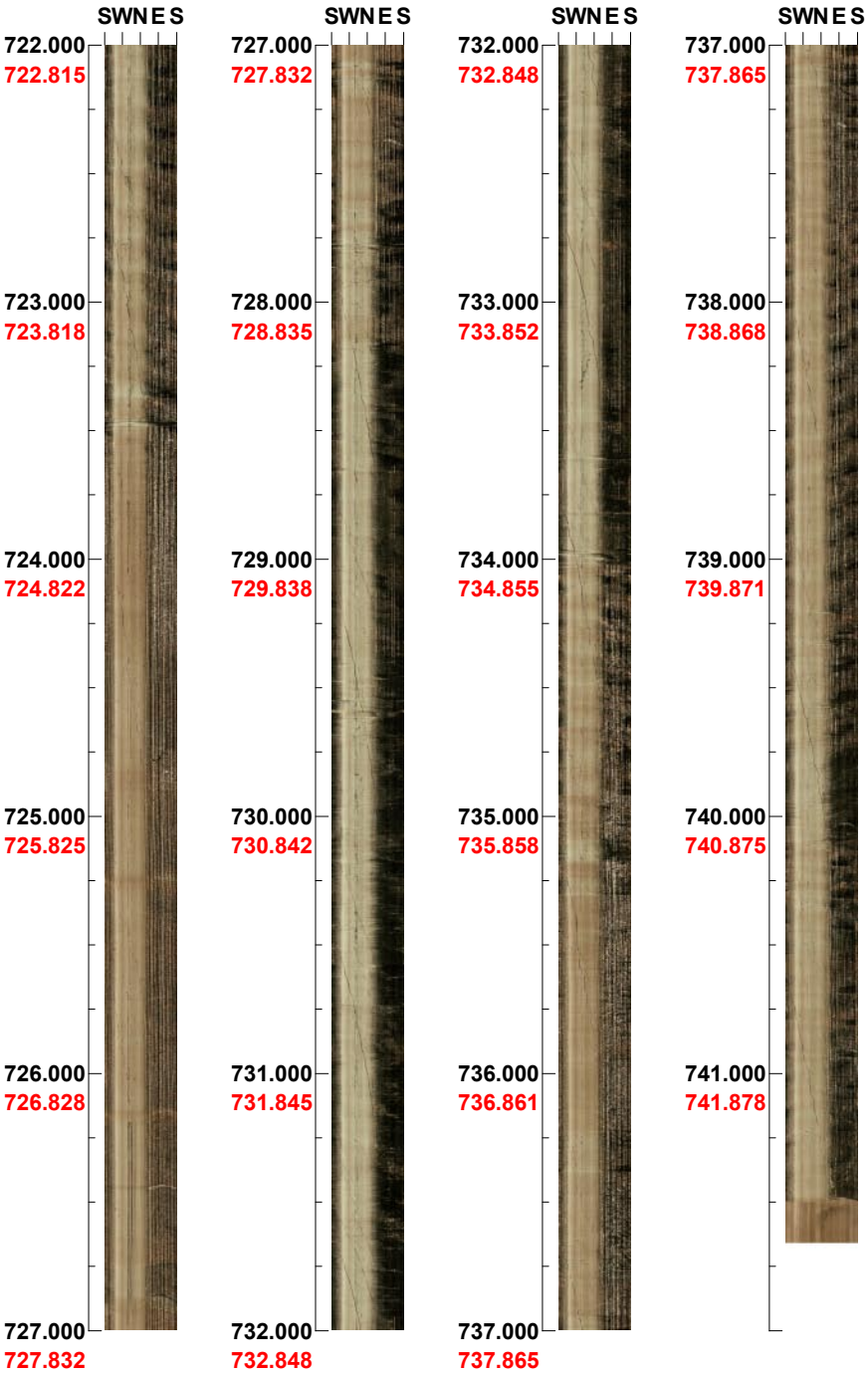
Depth range: 697.000 - 722.000 m



(7 / 8) **Scale: 1/25** **Aspect ratio: 160 %**

Project name: SIMPEVARP
Bore hole No.: KAV01 **Azimuth: 0** **Inclination: -90**

Depth range: 722.000 - 741.656 m



(8 / 8) **Scale: 1/25** **Aspect ratio: 160 %**