P-03-114

Oskarshamn site investigation

Drilling of three flushing water wells, HSH01, HSH02 and HSH03

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March 2004

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ISSN 1651-4416
SKB P-03-114

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Keywords: Percussion drilling, Flushing water well, Soil, Bedrock.

Summary

Drilling of percussion holes is required as a supplement to the drilling of deep cored holes. In general, the percussion holes serve two principal purposes: water supply for core drilling and as investigation boreholes to shallow depth.

Boreholes HSH01 and HSH02 were drilled for supply of flushing water to the deep cored boreholes KSH01 and KSH02 respectively.

Drillhole HSH01 did not yield enough water, however, and a second percussion hole was drilled close by but in a different direction. The new hole was called HSH03.

The hydraulic properties of HSH02 and HSH03 were improved by hydraulic fracturing. The operation was successful in HSH03 and this hole was utilized as a water supply for KSH01. As the yield at HSH02 was not sufficient, the water supply for KSH02 was solved by transportation from another location.

The drilling was performed by contractor Sven Andersson in Uppsala AB under June and July, 2002. The dates for drilling are given in Table 2.1.

Supportive means to the drilling operations were given from SKB personnel regarding planning, coordination, infrastructure, sampling and on-site measurements.

A summary of data from drillholes HSH01–03 is given in Table 0-1.

Lengths in the drillholes are given as metres below “top of casing”.

Table 0-1. Technical summary.

	HSH 01	HSH 02	HSH 03
Easting RT90	1552546	1551368	1552545
Northing RT90	6366218	6365683	6366214
Elevation (m a s l) RH70	2,864	6,649	2,523
Azimuth (0–360)	5	186	219
Dip (0–90)	–70	–80	–80
Drilling dates	020624–020702	020627–020708	020702–020709
Casing depth	12 m	12 m	12 m
Casing inner diameter(mm)	160	160	160
Hole diameter (mm)	140	140	140
Length (m)	200	200	201
Hydraulic fracturing	No	Yes	Yes
Water yield	1 l/min	8 l/min	35 l/min

Contents

1 Introduction

SKB performs site investigations in order to evaluate the feasibility of locating a deep repository for high level radioactive waste /1/ in two Swedish municipalities: Östhammar and Oskarshamn. The investigation area in Oskarshamn is situated close to the nuclear power plant at Simpevarp /2/, see Figure 1-1.

Drilling is an important activity performed within the frame of the site investigations. Three main types of boreholes are produced: core drilled or percussion drilled boreholes in hard rock and boreholes drilled through unconsolidated soil.

This report will describe the drilling of the three percussion holes, HSH01, HSH02 and HSH03, and the measurements performed during the drilling phase. Measurements performed in the holes after the drilling was completed will be presented in other reports.

The drilling and all related on-site operations were performed according to a specific Activity Plan (AP PS-02-003). Reference is given in the activity plan to procedures in the SKB Method Description for Percussion Drilling (SKB MD 610.003, Version 1.0) and relevant method instructions for handling of chemicals, surveying and evaluation of cuttings. Method descriptions and activity plans are SKB internal documents.

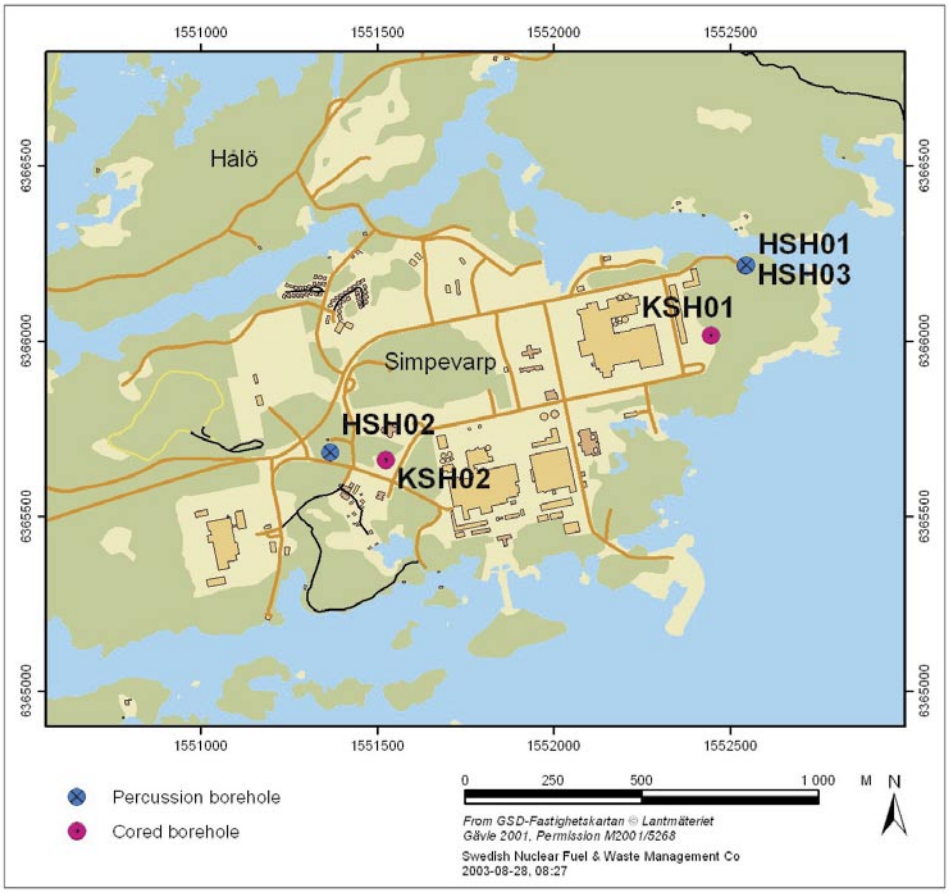


Figure 1-1. *Location of drillings in the Simpevarp subarea. Holes marked HSH are percussion drillholes and holes marked KSH are cored drillholes.*

2 Equipment and methods

In this chapter descriptions are given of the drilling equipment, the technique and equipment for gap injection of the borehole casings and of the instrumentation used for deviation measurements performed after completion of drilling. Also the equipment used for measurements and sampling during drilling is briefly described.

Drilling, completion and deviation measurements were made by contractor Sven Andersson, Uppsala AB.

2.1 Drilling equipment

Drilling of the three percussion boreholes was made with a Nemek 407 RTS percussion drilling machine supplied with accessories.

The drilling machine was equipped with separate engines for transportation and power supplies. For the raising of water and drill cuttings from the borehole, a 27 bar diesel air-compressor, type Atlas-Copco XRVS 455 Md was used. The DTH drillhammer was of type Secoroc 5", lowered into the borehole by a Driconeq 76 mm pipe string.

Figure 2-1. *The percussion drill rig.*

2.2 Equipment for down-the-hole measurements

Deviation measurements were performed in all three boreholes using a Reflex MAXIBOR™ (non magnetic) equipment. Azimuth and dip was measured every third metre. The coordinates for the starting point and the measured values were used for calculating the coordinates for every measured point.

2.3 Equipment for measurements and sampling during drilling

Flow measurements during drilling were performed using measuring vessels of different sizes and a stop watch. Measurements of drilling penetration rate were accomplished with a carpenter's rule and a stop watch.

Samples of soil and drill cuttings were collected in sampling pots and groundwater in bottles.

3 Execution

The work was performed in accordance with SKB MD 610.003, Version 1.0 (Method Description for Percussion Drilling, SKB internal document) and consisted of:

- preparations,
- drilling through overburden,
- gap injection techniques and equipment,
- percussion drilling in hard rock,
- sampling and measurements,
- borehole completion,
- data handling,
- environmental control.

3.1 Preparations

The preparation stage included the Contractor's functional control of his equipment. The machinery and chemicals used have to comply with SKB MD 600.006, Version 1.0 (Method Instruction for Chemical Products and Materials, SKB internal document).

The equipment was cleaned to level 2 in accordance with SKB MD 600.004, Version 1.0 (Method Instruction for Cleaning Borehole Equipment and certain Ground-based Equipment, SKB internal document).

3.2 Drilling through overburden

The terrain encountered in the Simpevarp area of investigation consists of gently undulating bedrock surface with low to moderate relief. The crystalline rock basement frequently outcrops or subcrops in the higher terrain and is covered with unconsolidated soil in the more shallow parts.

Excentric percussion drilling with 260 mm diameter ("ODEX 215") was made through the unconsolidated soil and fractured near-surface bedrock.

In HSH01 ODEX drilling was made to a depth of 1.5 m whereas in HSH02 and HSH03 the ODEX drilling was made to 3.4 m.

This method leaves a casing of 254 mm (outer diameter). A smaller diameter casing was installed and aligned to provide guidance of further drilling. A pilot hole of diameter 107 mm was drilled to fresh rock at about 12 m depth with a 4" DTH-hammer. The guiding, smaller diameter, casing was removed.

The pilot hole was then reamed to 215 mm diameter with the NO-X method. The NO-X drilling leaves a 168 mm outer diameter casing and a casing bit of diameter 148 mm at the bottom of the casing.

The outer casing (254 mm) in HSH01 was removed after drilling. The outer casings were left in the ground in holes HSH02 and HSH03 to a depth of 3.4 m.

3.3 Gap injection techniques and equipment

In order to prevent surface water and shallow groundwater to infiltrate into deeper parts of the borehole, the gap between the borehole wall and the casing pipe with cement was grouted.

A cement plug was installed at the bottom of the cased section and the cement paste introduced between the casing and bedrock wall.

Standard cement without additives was used and mixed to a 0.5 water-to-cement ratio. A reference sample of the cement paste was kept cool and dark on the surface to ensure that drilling was not resumed until the mixture had hardened.

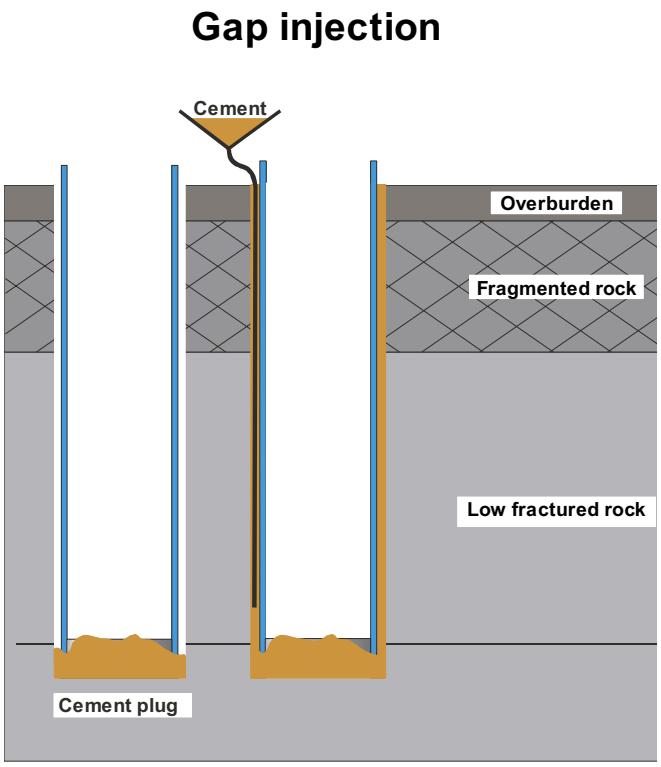


Figure 3-1. *Gap injection technique.*

3.4 Percussion drilling in hard rock

After allowing the cement to harden, drilling could continue and was performed to the full borehole length with conventional percussion drilling with diameter 140 mm. At the beginning and end of drilling the diameter of the drill bit was measured. The decrease in diameter on the drill bits and drilled lengths are given in Table 4-1.

3.5 Sampling and measurements

Sampling and measurements done by the drill coordinators during drilling included:

- Soil samples were taken while drilling through the overburden as follows:

Borehole	Interval
HSH01	0.3–0.8 m
HSH02	0.2–1.3 m
HSH03	Not taken

  The samples were stored for later logging.

- Samples of rock chip drill cuttings were taken along the entire length of the holes. Three grab samples were taken over a length of three metres and collected to one sample. The samples were stored for later logging and analysis.
- Penetration rate (expressed as seconds per 20 cm) was manually recorded.
- Noticeable changes in water flow and colour of return water were recorded manually.

The water yield from the hole was estimated after drilling was done to full length. The method employed was to blow compressed air through the drillstem and to measure the amount of return water during steady state conditions.

When the drilling was completed the hole was rinsed from drill cuttings by blowing air with the compressor at maximum capacity for 30 minutes.

3.6 Borehole completion

The borehole was secured by mounting a lockable steel cap on the casing.

All equipment was removed, the site cleaned and a joint inspection was made by representatives from SKB and the Contractor to ensure that the site had been restored to a satisfactory level.

3.7 Data handling

Data collected by the drill coordinators were reported in daily logs and other protocols and delivered to the Activity Leader. The information was entered to SICADA (SKB database) by database operators.

3.8 Environmental control

The SKB routine for environmental control (SDP-301, SKB internal document) was followed throughout the activity. A checklist was filled in and signed by the Activity Leader and filed in the SKB archive.

All waste generated during the establishment, drilling and completion phases have been removed and disposed of properly. Water effluent from drilling was led to the Baltic Sea (HSH01 and HSH03) or allowed to infiltrate to the ground (HSH02) in accordance with an agreement with the environmental authorities. The water amounted to very small quantities.

Recovered drill cuttings were collected in a steel container. After completion of drilling, the container was removed from the site and emptied at an approved site.

4 Results

The main purpose for the drillholes was to provide a water supply for the subsequent core drilling.

Boreholes HSH01 and HSH02 were constructed for supply of flushing water to the deep cored boreholes KSH01 and KSH02 respectively.

Drillhole HSH01 did not yield water, however, and a second percussion hole was drilled close by but in a different direction. The new hole was called HSH03.

The hydraulic properties of HSH02 and HSH03 were improved by hydraulic fracturing. The operation was successful in HSH03 and this hole was utilized as a water supply for KSH01. As the yield at HSH02 was not sufficient, the water supply for KSH02 was solved by transportation from another location.

All data were stored in the SICADA database for Oskarshamn. The field note numbers for entry into SICADA are:

Simpevarp 5	HSH01
Simpevarp 7	HSH02
Simpevarp 8	HSH03

4.1 Borehole design

A summary of data from holes HSH01–03 is presented in the Table 4-1.

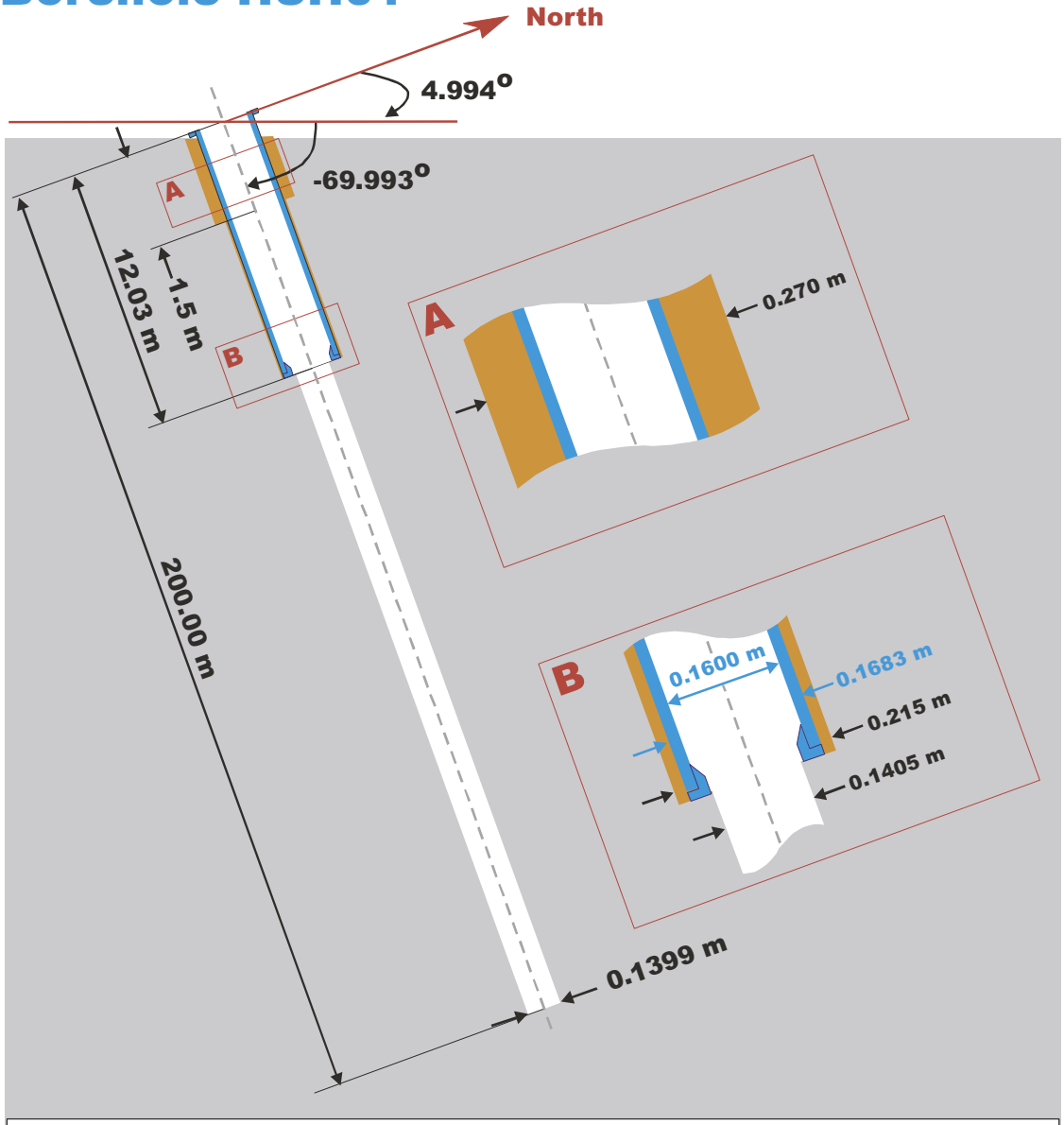
Table 4-1. Geometric and technical data for boreholes HSH01–03.

Parameter	HSH01		HSH02		HSH03	
Drilling period	From 2002-06-24 to 2002-07-02		From 2002-06-27 to 2002-07-08		From 2002-07-02 to 2002-07-09	
Borehole inclination (starting point) (0 to –90)	–69.993°		–80.088°		–79.493°	
Borehole azimuth (0–360)	4.994°		186.103°		218.942°	
Borehole length	200.00 m		200.00 m		201.00 m	
Soil depth	0.9 m		1.3 m		1.2 m	
Drill bit diameter	Start of drilling: 0.1405 m End of drilling: 0.1399 m		Start of drilling: 0.1405 m End of drilling: 0.1396 m		Start of drilling: 0.1396 m End of drilling: 0.1390 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6366217.770 m Easting: 1552545.717 m Elevation: 2.864 m a s l		Northing: 6365682.896 m Easting: 1551368.337 m Elevation: 6.649 m a s l		Northing: 6366213.946 m Easting: 552544.526 m Elevation: 2.523 m a s l	
Water yield before hydraulic fracturing	1 l/min		5 l/min		25 l/min	
Water yield after hydraulic fracturing	N/A		8 l/min		35 l/min	
Borehole diameter	0–1.5 m	270	0–3.4 m	270	0–3.4 m	270
(interval) (diameter mm)	1.5–12.03 m	215	3.4–12.03 m	215	3.4–12.03 m	215
	12.03–200 m	139.9	12.03–200.0 m	139.6	12.03–201.0 m	139.0
Casing diameter			0–3.4 m	$Ø_o$ = 254	0–3.4 m	$Ø_o$ = 254
(interval) (diameter mm)	0–12.0 m	$Ø_o$ = 168,3 $Ø_i$ = 160	3.4–12.0 m	$Ø_o$ = 168.3 $Ø_i$ = 160	3.4–12.0 m	$Ø_o$ = 168.3 $Ø_i$ = 160.0
	12.0–12.03 m	$Ø_o$ = 168.3 $Ø_i$ = 148.0	12.0–12.03 m	$Ø_o$ = 168.3 $Ø_i$ = 148.0	12.0–12.03 m	$Ø_o$ = 168.3 $Ø_i$ = 148.0

The design of each borehole is illustrated in drawings in Figures 4-1, 4-2, and 4-3.

Technical data

Borehole HSH01



Drilling reference point

Northing:	**6366217.770 (m), RT90 2,5 gon V 0:-15**
Easting:	**1552545.717 (m), RT90 2,5 gon V 0:-15**
Elevation:	**2.864 (m), RHB 70**

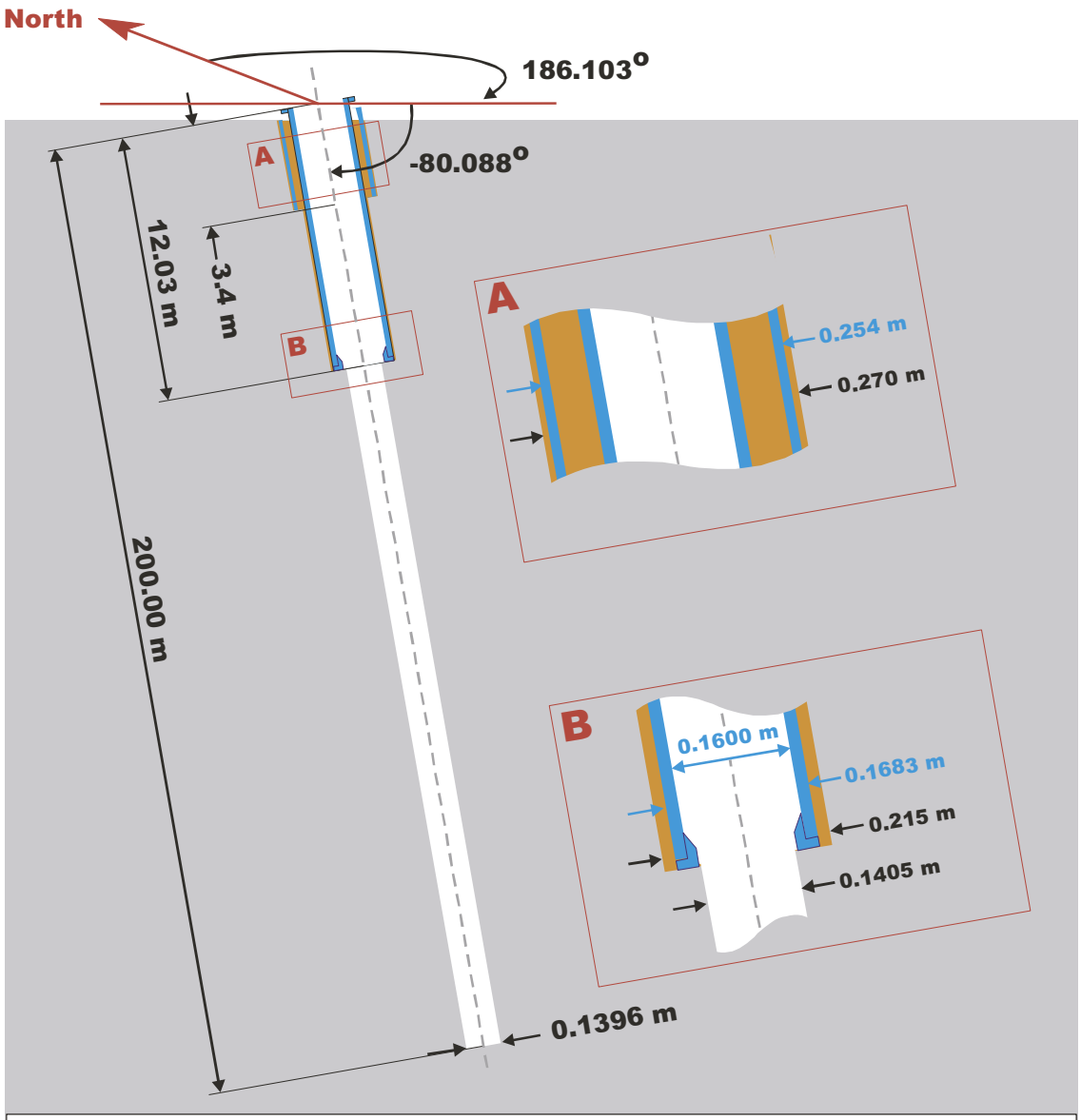
Drilling period

Drilling start date:	**2002-06-24**
Drilling stop date:	**2002-07-02**

Figure 4-1. *Technical data for borehole HSH01.*

Technical data

Borehole HSH02



Drilling reference point

Northing: 6365682.896 (m), RT90 2,5 gon V 0:-15
Easting: 1551368.337 (m), RT90 2,5 gon V 0:-15
Elevation: 6.649 (m), RHB 70

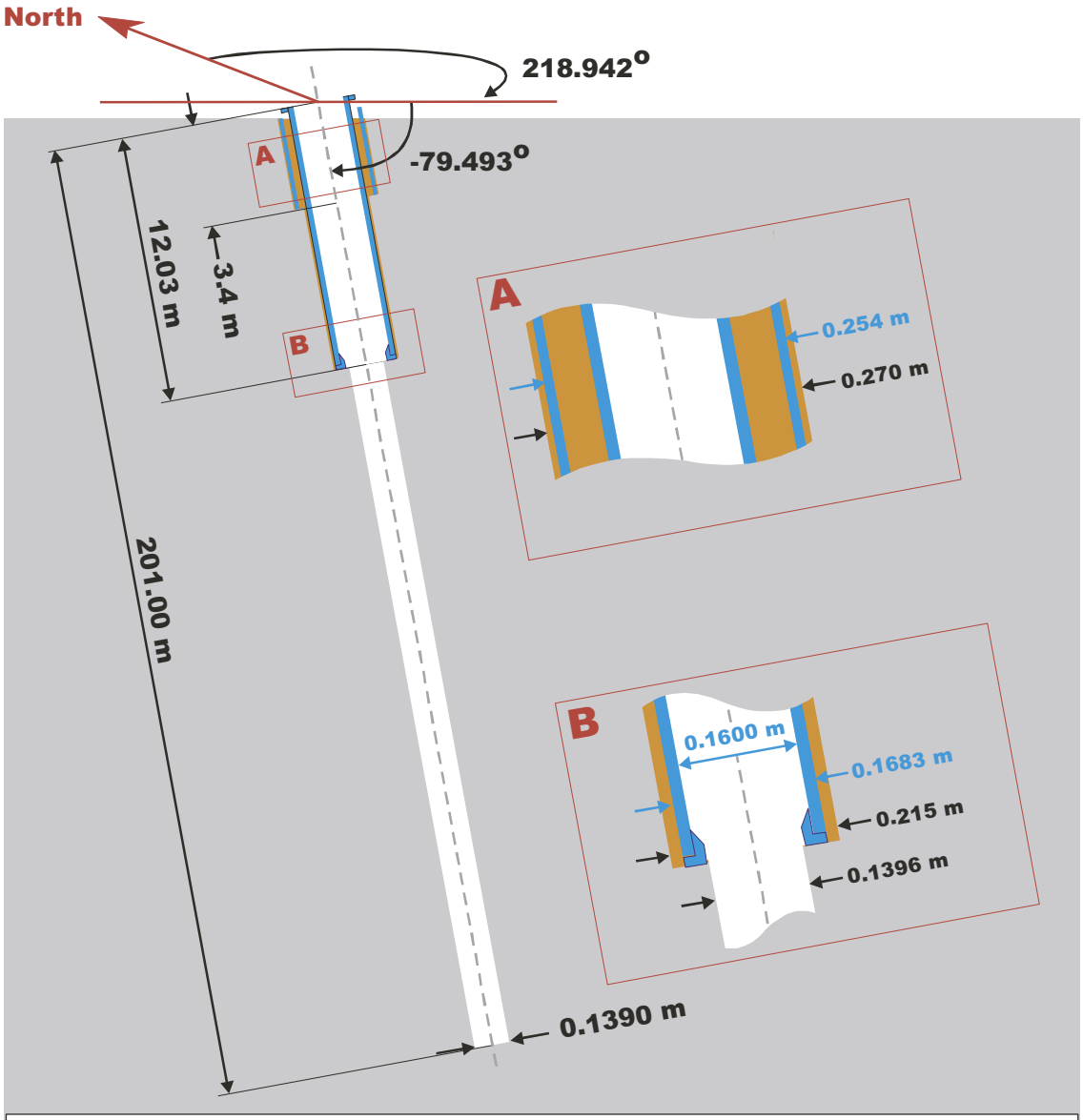
Drilling period

Drilling start date: 2002-06-27
Drilling stop date: 2002-07-08

Figure 4-2. *Technical data for borehole HSH02.*

Technical data

Borehole HSH03



Drilling reference point

Northing:	**6366213.946 (m), RT90 2,5 gon V 0:-15**
Easting:	**1552544.526 (m), RT90 2,5 gon V 0:-15**
Elevation:	**2.523 (m), RHB 70**

Drilling period

Drilling start date:	**2002-07-02**
Drilling stop date:	**2002-07-09**

Figure 4-3. *Technical data for borehole HSH03.*

4.2 Consumption of oil and chemicals

The amount of oil products consumed in each borehole during drilling is reported in Table 4-2. Regarding hammer oil and compressor oil, these products are indeed entering the borehole but are, on the other hand, continuously retrieved from the borehole due to the permanent air flushing during drilling. After completion of drilling, only minor remainders of the products are left in the borehole.

Table 4-2. Oil consumption.

Borehole	Hammer air oil Preem Hydra 46
HSH01	10 L
HSH02	10 L
HSH03	10 L

No consumption of compressor oil (Schuman 46) was noted

Consumption of cement paste was estimated to 200 litres for HSH01 and 180 litres each for HSH02 and HSH03.

4.3 Geological summary

HSH01 is dominated by quartz monzodiorite with intercalations of dioritoid and granite. HSH02 consists of dioritoid with minor portions of fine-grained granite.

The uppermost 60 m of HSH03 is granite and below this the rock is dominated by quartz monzodiorite with minor intercalations of granite and Ävrö granite.

An increase in fracture frequency was noted in HSH01 between 40 m and 50 m.

The fractures frequency increases at 20 m, 90 m, 110 m and 130 m in HSH02. Below 150 m no fractures could be noted.

A very modest increase in fracture frequency was noted in HSH03 between 60 and 80 m.

Technical and geological results achieved in conjunction with drilling are presented in Appendices 1, 2 and 3. Rock types and fracture data are taken from the Boremap logging /3/.

5 References

/1/ **SKB, 2001.** Platsundersökningar. Undersökningsmetoder och generellt genomförandeprogram. SKB R-01-10, Svensk Kärnbränslehantering AB.

/2/ **SKB, 2001.** Geovetenskapligt program för platsundersökning vid Simpevarp. SKB R-01-44, Svensk Kärnbränslehantering AB.

/3/ **SKB, 2004.** Oskarshamn site investigation. Boremap mapping of percussion holes HSH01–03. SKB P-04-02 (in prep), Svensk Kärnbränslehantering AB.

Title	PERCUSSION BOREHOLE HSH01		APPENDIX:1

Site	SIMPEVARP	**Coordinate System**	RT90-RHB70
Borehole	HSH01	**Northing [m]**	6366216.95
Diameter [m]	139	**Easting [m]**	1552545.76
Length [m]	200.000	**Elevation [m.a.s.l.]**	2.79
Bearing [°]	4.99	**Drilling Start Date**	2002-06-24 16:00:00
Inclination [°]	-69.99	**Drilling Stop Date**	2002-07-02 17:30:00
Remark		**Plot Date**	2004-03-07 21:03:24

ROCKTYPE SIMPEVARP

- **Fine-grained granite**
- **Granite**
- **Quartz monzodiorite**
- **Fine-grained dioritoid**

SOIL

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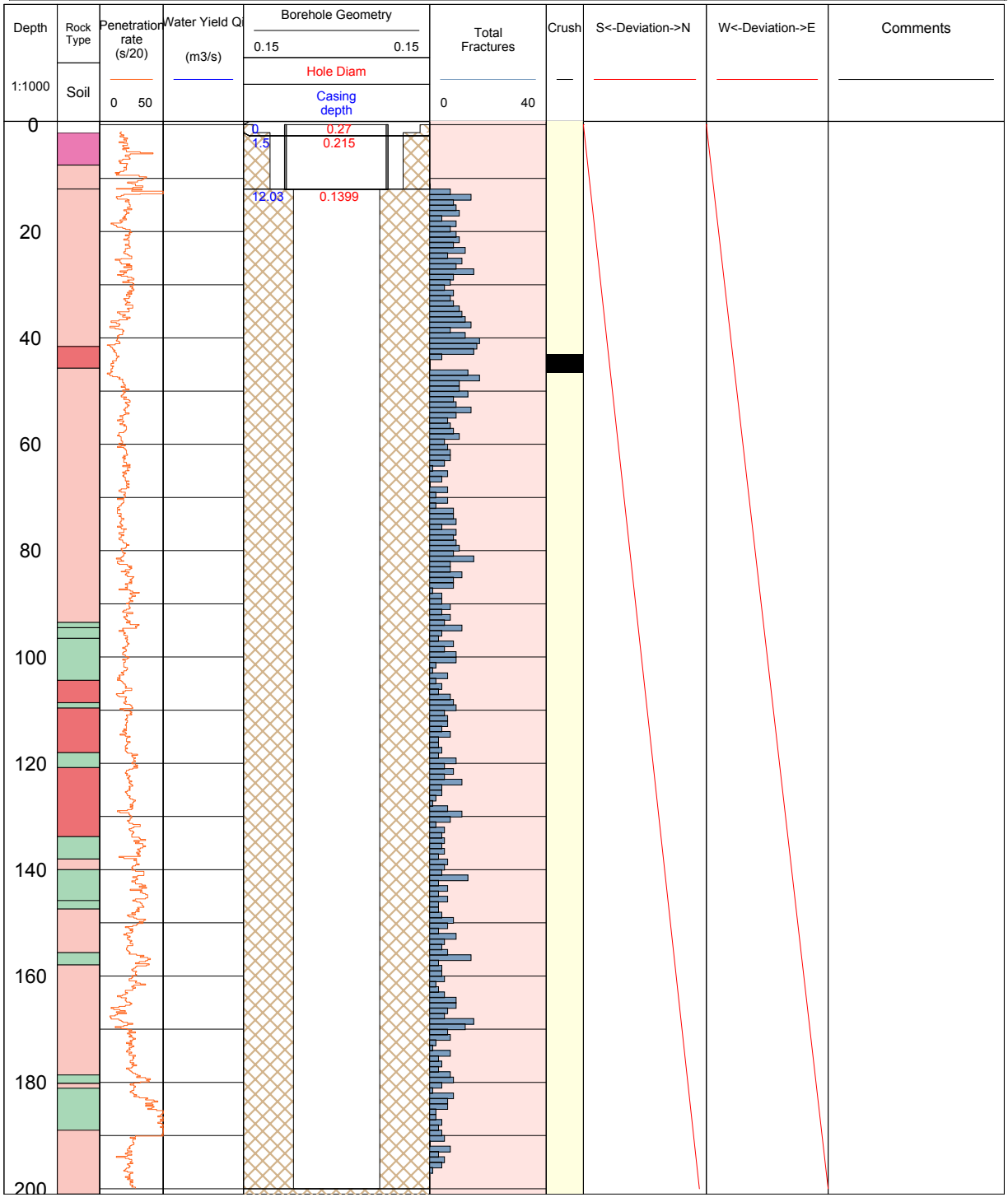


Title	PERCUSSION BOREHOLE HSH02		APPENDIX:2

Site	SIMPEVARP	**Coordinate System**	RT90-RHB70
Borehole	HSH02	**Northing [m]**	6365682.07
Diameter [m]	139	**Easting [m]**	1551368.38
Length [m]	200.000	**Elevation [m.a.s.l.]**	6.57
Bearing [°]	186.10	**Drilling Start Date**	2002-06-27 07:00:00
Inclination [°]	-80.08	**Drilling Stop Date**	2002-07-08 19:00:00
Remark		**Plot Date**	2004-03-07 21:03:24

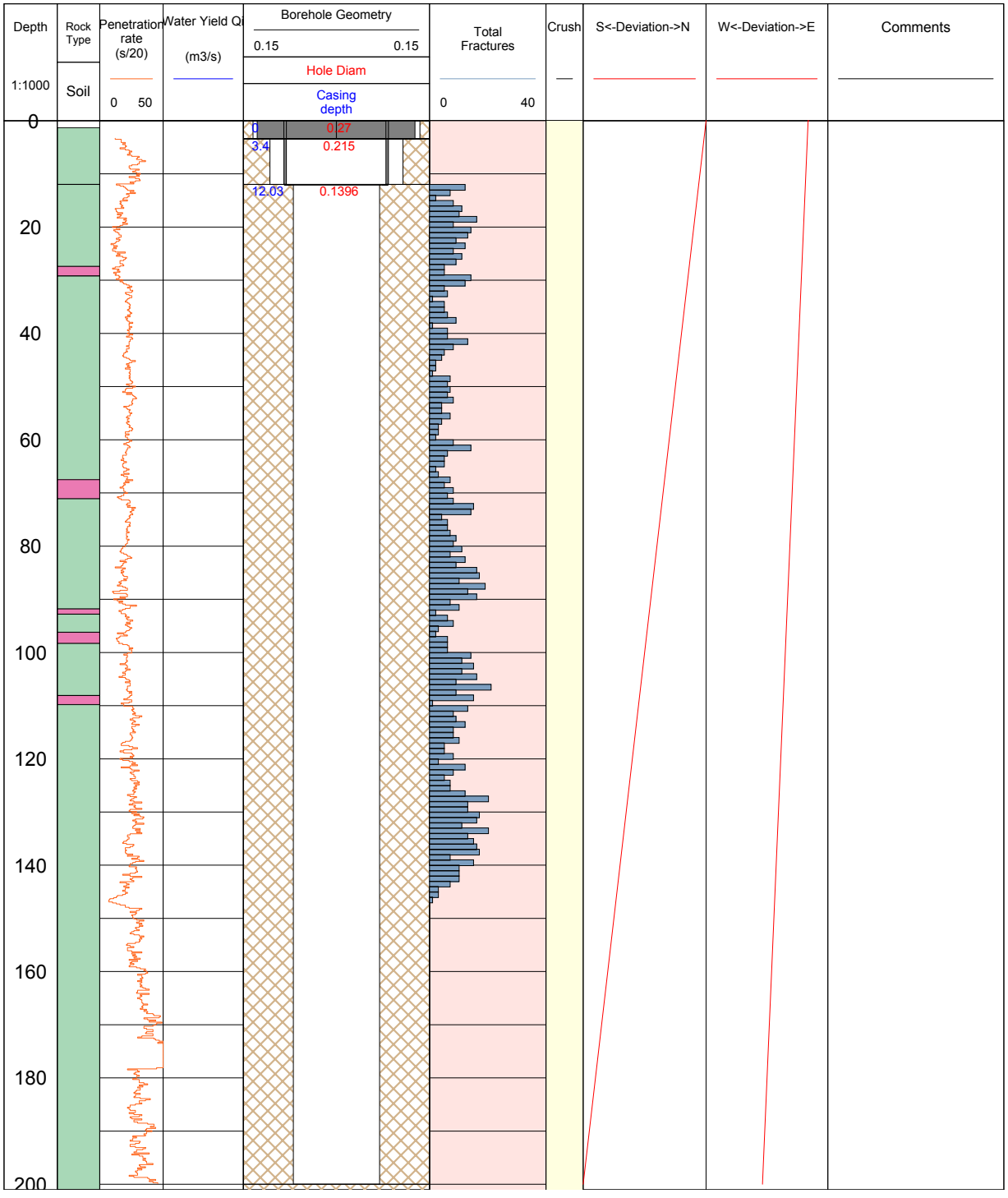
ROCKTYPE SIMPEVARP

Fine-grained granite

Fine-grained dioritoid

SOIL

SCRIPT NAME A4_HammarBorrHål_SIMPEVARP_Eng_Log_2003-03-28_[SICADA].sql



Title	PERCUSSION BOREHOLE HSH03		APPENDIX:3

Site	SIMPEVARP	**Coordinate System**	RT90-RHB70
Borehole	HSH03	**Northing [m]**	6366213.12
Diameter [m]	139	**Easting [m]**	1552544.57
Length [m]	201.000	**Elevation [m.a.s.l.]**	2.45
Bearing [°]	218.94	**Drilling Start Date**	2002-07-02 17:30:00
Inclination [°]	-79.49	**Drilling Stop Date**	2002-07-09 19:00:00
Remark		**Plot Date**	2004-03-07 21:03:24

ROCKTYPE SIMPEVARP

- **Granite**
- **Ävrö granite**
- **Quartz monzodiorite**

SOIL

SCRIPT NAME A4_HammarBorrHål_SIMPEVARP_Eng_Log_2003-03-28_[SICADA].sql