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Oskarshamn site investigation

Percussion drilling of borehole HLX20 for investigation of lineament EW002

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Keywords: Percussion drilling, flushing water well, soil, bedrock.

Abstract

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.

Borehole HLX20 was drilled for investigation of lineament EW002 in the northern part of the Laxemar subarea and also for a possible use as water supply for core drilling.

A possible deformation zone at between 110 and 180 m length in the borehole can be interpreted.

The water yield in the hole was measured at 45 l/min during drilling.

The drilling was performed by contractor Sven Andersson in Uppsala AB in June 2004.

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

Sammanfattning

Hammarborrhål borras i allmänhet två olika ändamål: dels vattenförsörjning för kärnborrrning dels för att möjliggöra undersökningar i ytligare berggrund.

Borrhål HLX20 utfördes för att ge information om lineament EW002 i norra delen av delområde Laxemar samt att om möjligt kunna vara en källa för spolvatten för kärnborrning.

En möjlig deformationszon mellan 110 och 180 m längd kan tolkas i borrhålet.

Den vattenmängd som uppmättes under borrning uppgick till 45 l/min.

Borrningen utfördes på entreprenad av Sven Andersson i Uppsala AB under juni 2004. SKB personal utförde planering och koordinering av aktiviteten samt vissa stödinsatser vid borrning tex borrplatsanläggning, provtagningar och mätningar.

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 /2/.

This report will describe the drilling of percussion hole HLX20 and the measurements performed during the drilling phase. The hole was drilled in the Laxemar subarea of the Oskarshamn site investigation, see Figure 1-1. Drilling of HLX20 was done towards the east-west trending lineament, EW002, situated immediately north of the borehole.

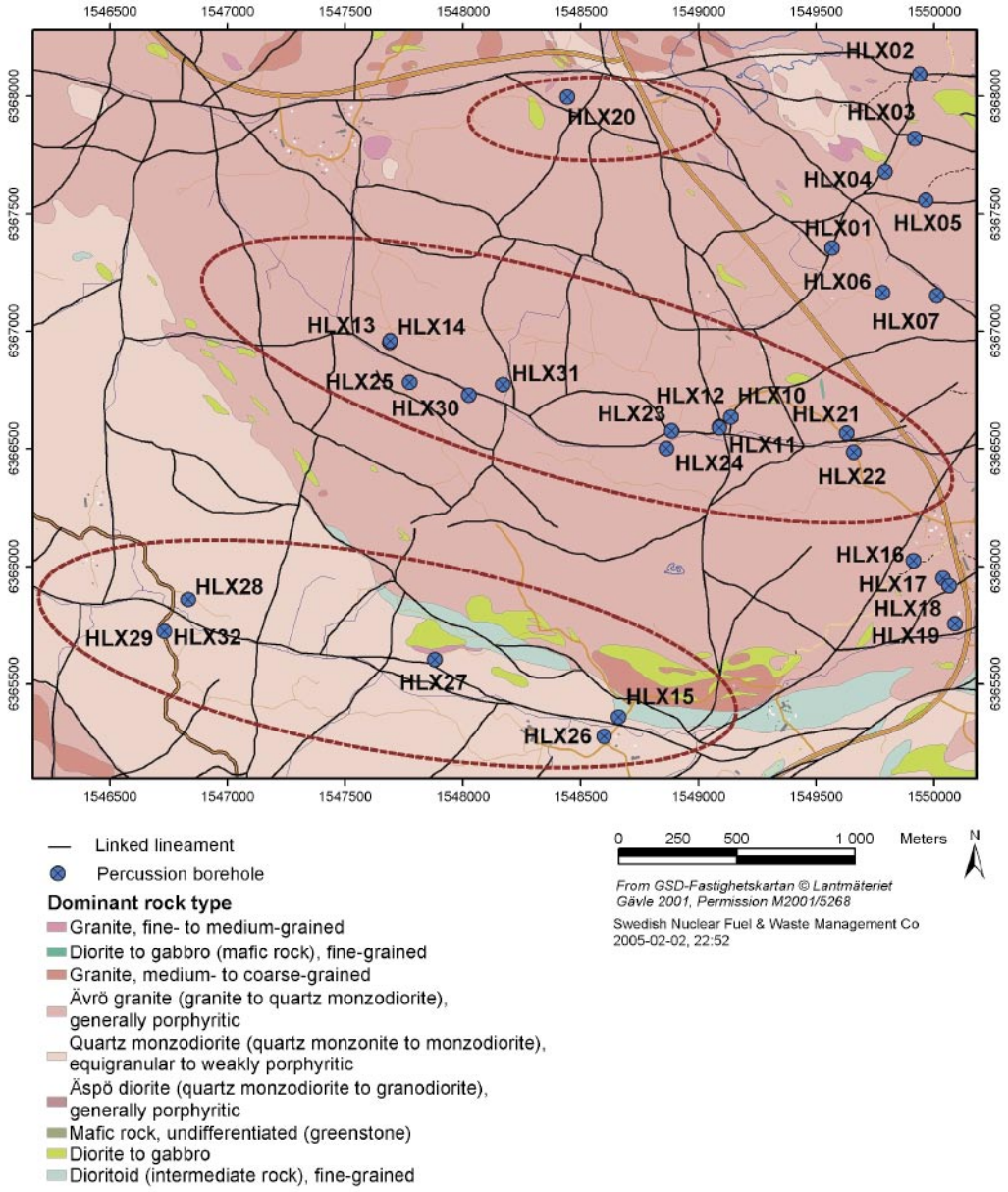


Figure 1-1. *The location of borehole HLX20 is inside the northernmost red ellipse. The map shows the bedrock geology, linked lineaments (black lines) and the locations of percussion drilled holes in the Laxemar subarea. Drilling of HLX20 was done towards the east-west trending lineament (EW002) situated immediately north of the borehole.*

The main purpose for the borehole was to identify and localize possible deformation zones that could be related to the surface lineament EW002. A second purpose for the hole was to supply water for the planned core drilling in KLX06.

The drilling and all related on-site operations were performed according to a specific Activity Plan (AP PS-04-057). 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.

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

Activity plan	**Number**	**Version**
Hammarborrning av HLX20	AP PS 400-04-057	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för hammarborrning	SKB MD 610.003	1.0
Metodbeskrivning för undersökning av borrkax	SKB MD 142.001	1.0
Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning	SKB MD 600.004	1.0
Instruktion för användning av kemiska produkter och material vid borrning och undersökningar	SKB MD 600.006	1.0
Instruktion för borrplatsanläggning	SKB MD 600.005	1.0
Instruktion för spolvattenhantering	SKB MD 620.007	1.0
Instruktion för utsättning och inmätning av borrhål	SKB MD 600.002	1.0

Information about the drilling was sent to the regional authorities on 2004-06-11, SKB id 1025990 (SKB internal document). The decision to drill HLX20 is given in SKB id 1026833 (SKB internal document).

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 and borehole completion were made by contractor Sven Andersson, Uppsala AB.

2.1 Drilling equipment

Drilling of the percussion borehole was made with a Puntel 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 114 mm pipe string.

2.2 Equipment for measurements and sampling during drilling

Flow measurements during drilling were performed using measuring a graded vessel and a stop watch. Measurement of the drilling penetration rate was done manually by the contractor.

Samples of soil and drill cuttings were collected in sampling pots. Water samples were collected in conjunction with flow measurements, typically at 100 m length and at full depth or where noticeable changes in water flow occurred. Sampling of cuttings and water flow were made by SKB personnel.

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 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 Laxemar subarea of investigation consists of gently undulating bedrock surface with low to moderate relief.

Excentric percussion drilling with 200 mm diameter ("ODEX 160") was made through the unconsolidated soil and fractured near-surface bedrock.

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 casings was grouted with cement, see Figure 3-1.

A packer was installed at the bottom of the cased section. The concrete was introduced through the packer and allowed to flow up between the casing and the bedrock wall. 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.

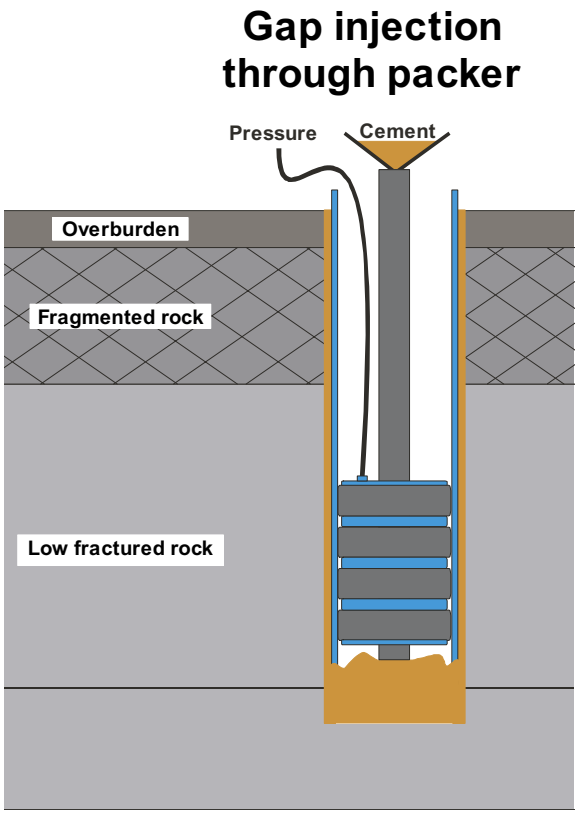


Figure 3-1. *Gap injection technique.*

The concrete seal was tested by blowing compressed air in the hole and measuring the amount of inflowing water. As no water could be measured in the hole, the tightness of the gap injection was considered to be sufficient.

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 a nominal diameter of 140 mm.

3.5 Sampling and measurements

Sampling and measurements done by the drillsite geologist and the drilling crew during drilling included:

- Samples of rock chip drill cuttings were taken along the holes. Three grab samples were taken over a length of three meter and collected to one sample. The samples were stored for subsequent logging of lithology and magnetic susceptibility.
- Penetration time (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 during drilling at levels where water inflow could be noted and after the drilling was done to full depth. The method employed was to blow compressed air through the drill stem 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.

Measurement of borehole deviation was not made in conjunction with drilling.

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 allowed to infiltrate to the ground 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 borehole was to identify and localize possible deformation zones that could be related to the surface lineament EW002. A second purpose for the hole was to supply water for the planned core drilling in KLX06.

Drilling was made between June 15 and 21.

A pumping test, including the taking of two water samples, was made during June 23 and 24.

4.1 Borehole design

A summary of technical and geometrical data from borehole HLX20 is presented in Table 4-1.

Table 4-1. Geometric and technical data for borehole HLX20.

Parameter	HLX20	
Drilling period	From 2004-06-15 to 2004-06-21	
Borehole inclination (starting point) (0 to–90)	–60.38°	
Borehole azimuth (0–360)	0.4°	
Borehole length	202.20 m	
Soil depth	2.3 m	
Drill bit diameter	0.138 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6367996.26 m Easting: 1548446.08 m Elevation: 11.179 m a s l	
Water yield (interval)	45 l/min (9–202.2 m)	
Borehole diameter (interval) (diameter mm)	0–9.12 m 9.12–202.2 m	190 mm 138 mm
Casing diameter (interval) (diameter mm)	0–8.94 8.94–9.03 m	$Ø_o$ = 168 $Ø_i$ = 160 $Ø_o$ = 168 $Ø_i$ = 147

The design of the borehole is illustrated in Appendix 1.

4.2 Hydrogeological results

The measured water yields during drilling are given in Table 4-2.

Table 4-2. Hydrogeological results from drilling.

Borehole	From (m)	To (m)	Water yield (L/min)	Comment
HLX20	9.03	80	5.5	Measured 040616
HLX20	9.03	151.2	11.5	Measured 040616
HLX20	9.03	151.2	20	Measured 040617
HLX20	9.03	178.2	28	Measured 040617
HLX20	9.03	202.2	28.5	Measured 040617
HLX20	9.03	202.2	45	Measured 040618

NB In the geoscientific summary given in Appendix 2 only the highest of two measurements from the same length in the borehole is presented.

The difference in water yield measured at the same length but at different times could be explained either by storage effects or by increasing inflow created by removal of clogging particles in the water bearing structures.

A pumping test was performed between June 23 and June 24. The flow was constant at 60 litres per minute during the test. The water level measurements were made by manual soundings. A drawdown and recovery curve is given in Figure 4-1.

The specific capacity, Q/s, and transmissivity, T_M, based on results from the pumping test are given in Table 4-3. The transmissivity was calculated according to /3/.

Measurements of electrical conductivity and water temprature were made in conjunction with the pumping test. The results are given in Figure 4-2. The measurements were made with field equipment ie hand held conductivity meter and thermometer.

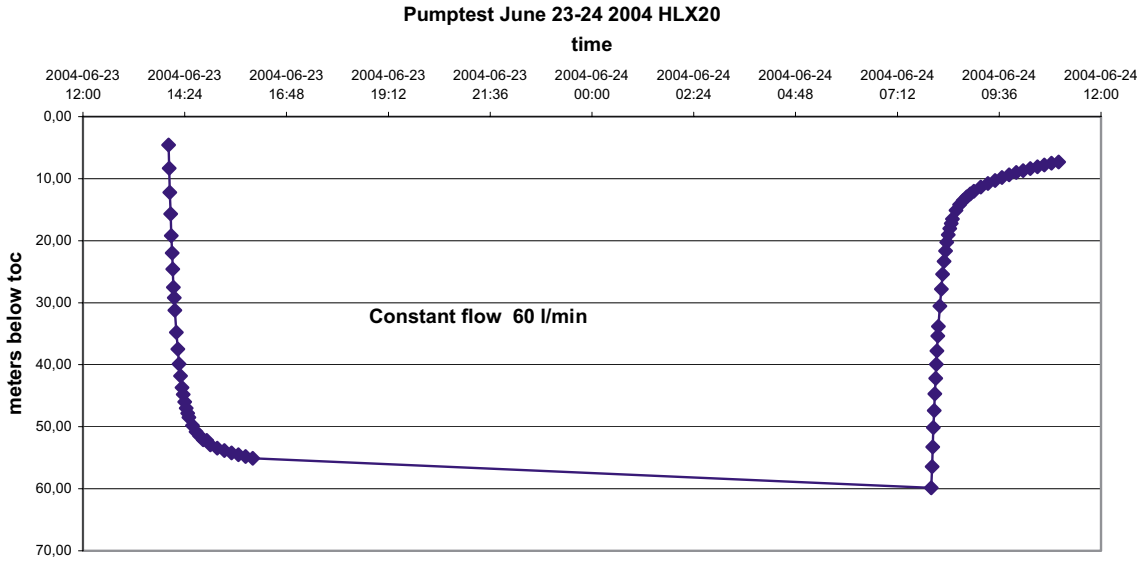


Figure 4-1. *Drawdown and recovery curve from pumping test in HLX20.*

Table 4-3. Specific capacity and transmissivity in HLX20.

Section (m)	Specific capacity, Q/s (m^2/s)	Transmissivity, T_M (m^2/s)
9.03–202.2	1.81×10^{-5}	2.55×10^{-5}

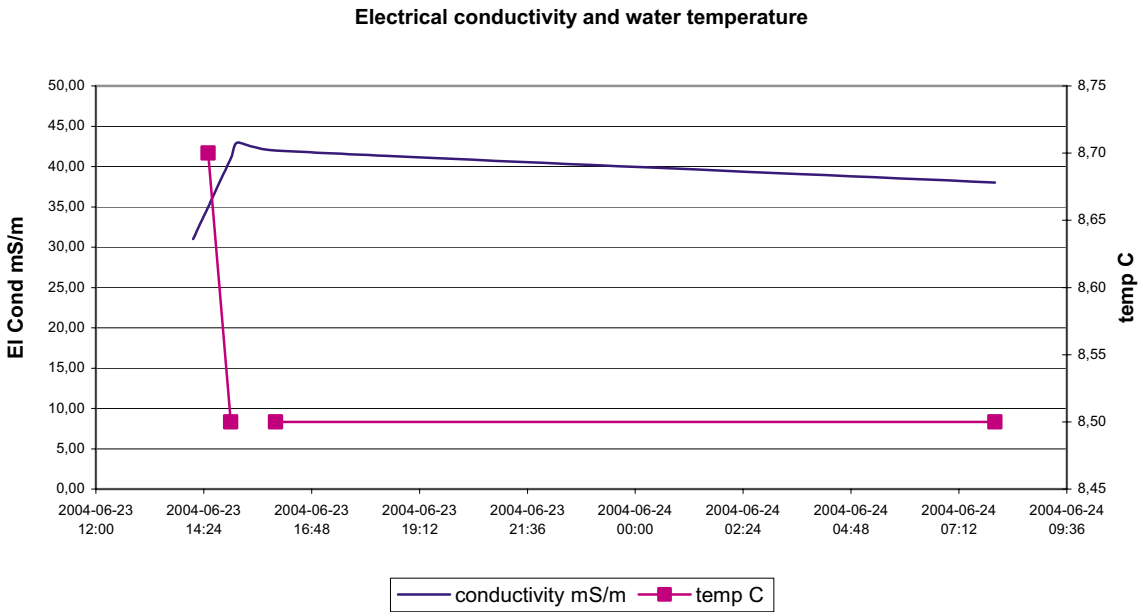


Figure 4-2. *Results from measurements of electrical conductivity and water temperature in conjunction with the pumping test in HLX20.*

4.3 Geological results

Borehole HLX20 is dominated by Ävrö granite with intercalations of pegmatite and fine-grained diorite-gabbro. A distinct reduction of magnetic susceptibility can be noted below 110 m length which could correspond to oxidisation of the rock.

The preliminary geological logging is presented in Appendix 2 together with measurements of magnetic susceptibility, drilling penetration time and measured water yield from drilling.

4.4 Hydrogeochemical results

Two water samples, 7560 and 7561, were taken during the pumping test. The primary reason for taking the samples was to provide chemical data for evaluation of the possible use of borehole HLX20 as a water supply for subsequent core drilling in KLX06. No water samples were taken during the drilling phase in HLX20.

Selected results from samples 7560 and 7561 are given in Table 4-4.

Table 4-4. Selected analytical results from water sampling of HLX20.

Date	2004-06-24	2004-06-24
Borehole	HLX20	HLX20
Sample No	7560	7561
HCO_3 (mg/l)	205.00	204.00
Cl (mg/l)	29.4	29.5
SO_4 (mg/l)	47.80	48.00
pH	8.42	8.43
El Cond (mS/m)	54.4	
TOC (mg/l)	2.4	

A complete account of the analytical results is presented in Appendix 3.

4.5 Consumption of oil and chemicals

Small amounts of hammer oil and compressor oil enter the holes during drilling but are continuously retrieved by air flushing during drilling. After the drilling is completed, only minor remainders of the products are left in the borehole.

No consumption of compressor oil (Schuman 46) was noted.

Consumption of hammer oil (Preem Hydra 46) was estimated at 10 litres.

Consumption of cement paste amounted to 60 litres (36 kg).

4.6 Nonconformities

No nonconformities are registered for the activity.

5 Summary and discussion

Borehole HLX20 was drilled for investigation of lineament EW002 in the northern part of the Laxemar subarea and also for a possible use as water supply for core drilling.

The water yield in the hole was measured at 45 l/min during drilling.

The drilling was performed by contractor Sven Andersson in Uppsala AB in June 2004.

Minor sections with reductions in penetration time that correlate well with reduced magnetic susceptibility can be noted at 10, 47–49 and 76 –78 m length. The latter section could also be correlated with the water inflow that was measured at 80 m length.

A possible deformation zone can be interpreted between 110 and 180 m length in the borehole based on the reduced magnetic susceptibility and measured inflow of water at 151 and 178 m. The correlation of the penetration time with water inflows below ca 130 m length is however not straightforward, see Appendix 2 and Figure 5-1.

Connecting the lineament EW002 at the surface with a deformation zone at 120 m length in the borehole would give an apparent dip of 65 degrees to the south, see Figure 5-1.

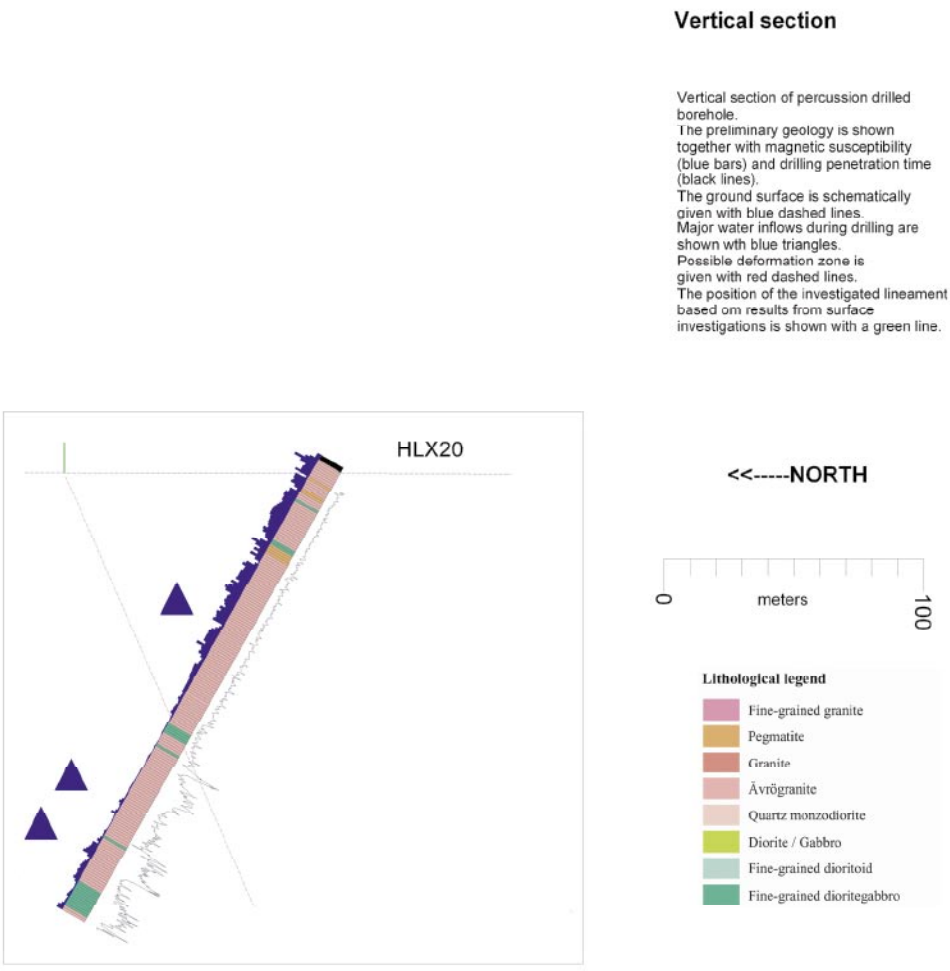


Figure 5-1. *Borehole HLX20 with preliminary geological results, magnetic susceptibility (blue bars) and drilling penetration time (black line). Positions for water inflow are indicated by blue triangles.*

6 References

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

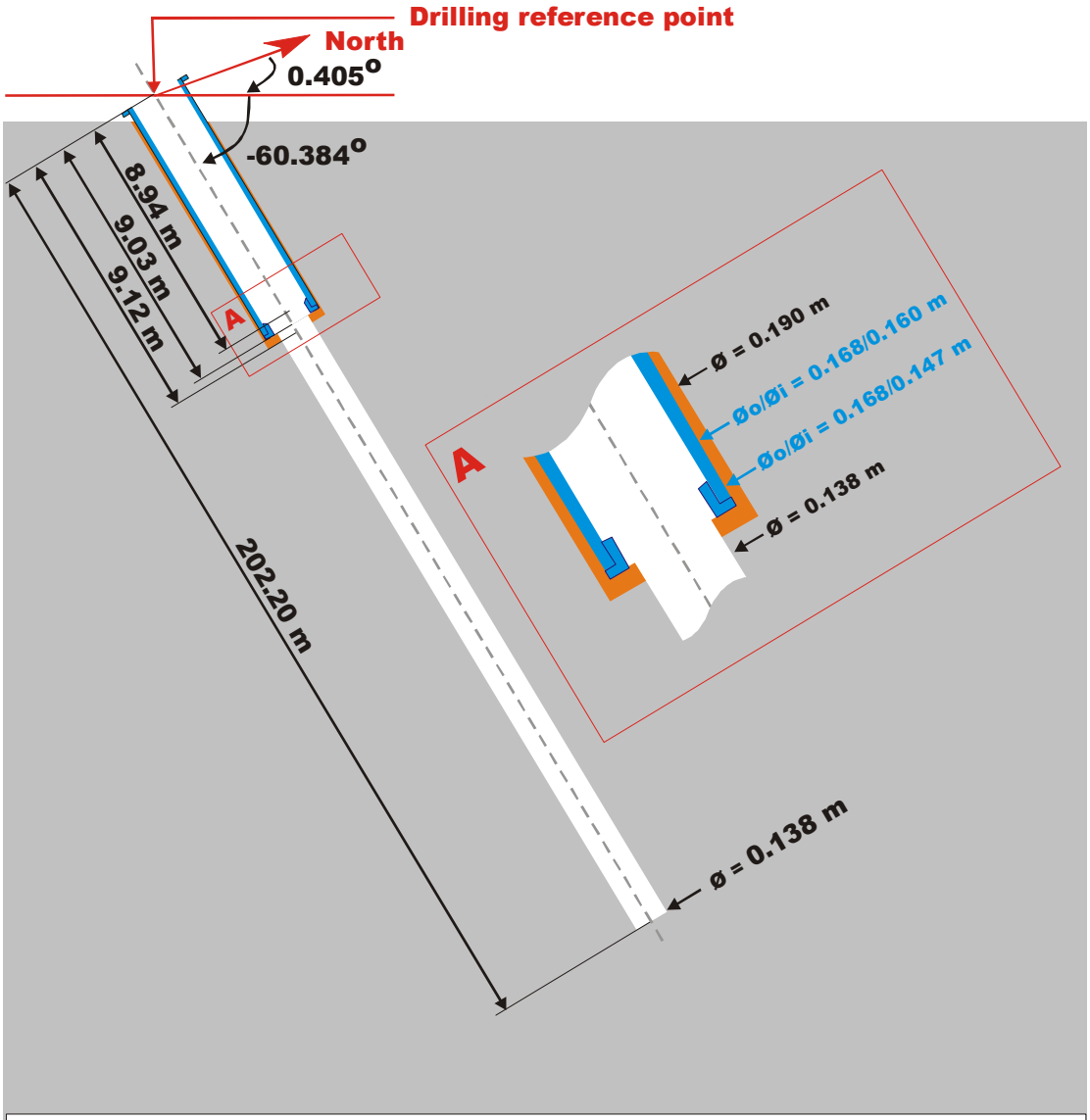
/2/ **SKB, 2001.** Geovetenskapligt program för platsundersökning vid Simpevarp. SKB R-01-44, Svensk Kärnbränslehantering AB.

/3/ **Moye D G, 1967.** Diamond drilling for foundation exploration. Civil Eng. Trans., Inst. Eng, Australia.

Technical data, borehole HLX20

Technical data

Borehole HLX20



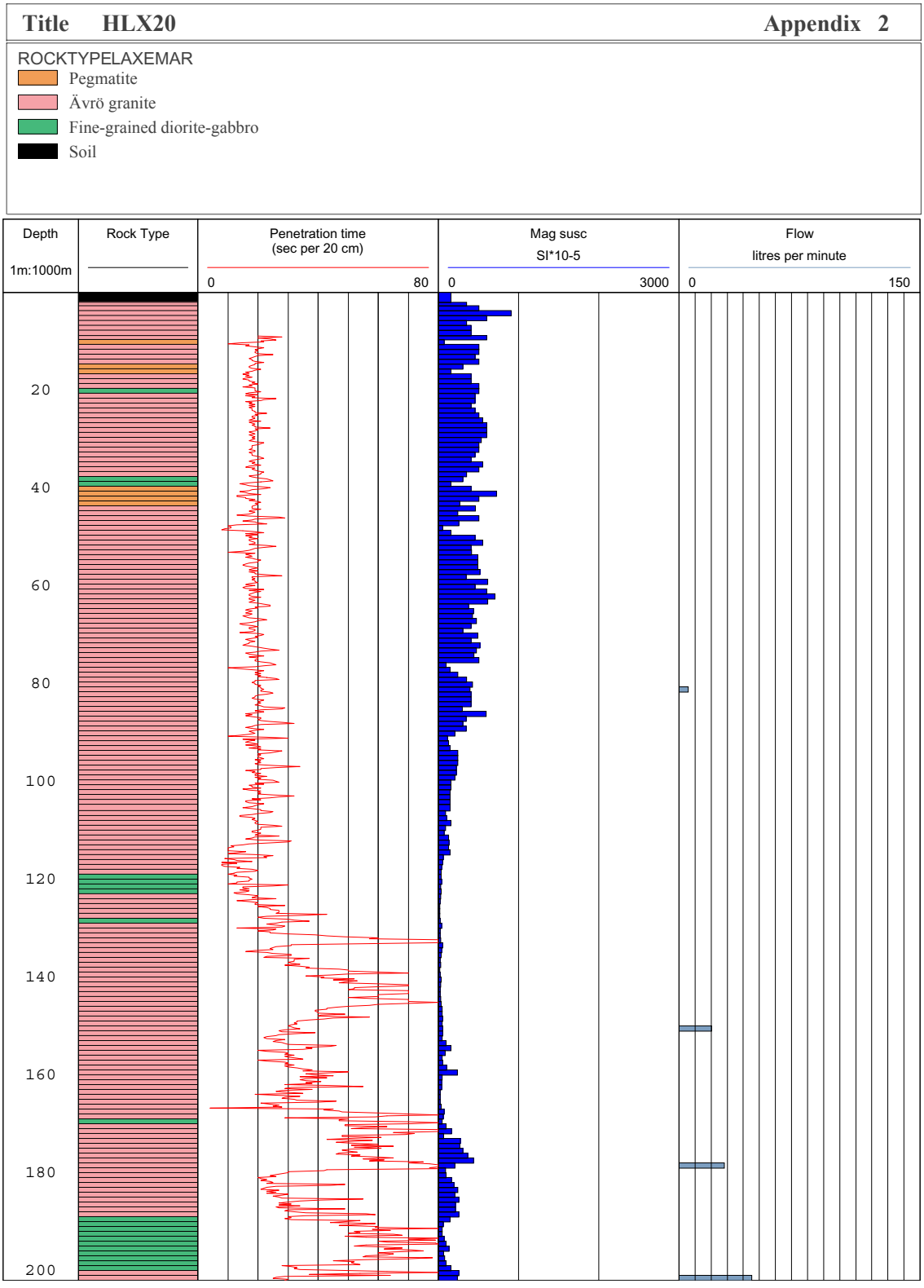
Drilling reference point

Northing:	**6367996.256 (m), RT90 2,5 gon V 0:-15**
Easting:	**1548446.085 (m), RT90 2,5 gon V 0:-15**
Elevation:	**11.179 (m), RHB 70**

Drilling period

Drilling start date:	**2004-06-15**
Drilling stop date:	**2004-06-21**

Geology, drill penetration rate, magnetic susceptibility and water flow



Appendix 3

Water chemistry, analytical results

Date	2004-06-24	2004-06-24
Borehole	HLX20	HLX20
Sample No	7560	7561
Na (mg/l)	107.0	
K (mg/l)	1.34	
Ca (mg/l)	7.5	
Mg (mg/l)	2.1	
HCO_3 (mg/l)	205.00	204.00
Cl (mg/l)	29.4	29.5
SO_4 (mg/l)	47.80	48.00
SO_4 S (mg/l)	16.00	
Br (mg/l)	0.200	
F (mg/l)	4.95	4.96
Si (mg/l)	6.39	
Fe (mg/l)	0.075	
Mn (mg/l)	0.02390	
Li (mg/l)	0.016	
Sr (mg/l)	0.137	
pH	8.42	8.43
El Cond (mS/m)	54.4	
TOC (mg/l)	2.4	
Charge Balance (%)	1.94	