P-04-235

Oskarshamn site investigation

Percussion drilling of boreholes HLX15, HLX26, HLX27, HLX28, HLX29 and HLX32 for investigation of lineament NW042

Henrik Ask, H Ask Geokonsult AB

Lars-Erik Samuelsson, Svensk Kärnbränslehantering AB

Miriam Zetterlund, Sweco

March 2005

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

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Keywords: Percussion drilling, Lineament investigation, Hydraulic responses.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

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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.

Boreholes HLX15, HLX26, HLX27, HLX28, HLX29 and HLX32 were drilled for investigation of lineament NW042 in the southern part of the Laxemar subarea.

The encountered geology in the boreholes corresponds well with expectations based on surface geological mapping.

The water yields varied from nil to over 185 litres per minute which indicates highly variable water-bearing properties along strike of the lineament.

No definite indication of a deformation zone could be established from the drilling results in boreholes HLX15 and 26.

A moderate water bearing structure was found in HLX32.

Significant water bearing structures, interpreted here with a steep northern dip in order to connect to the surface lineament, were encountered in HLX27 and HLX28 ie in the western end of the investigated area.

No clear hydraulic responses in surrounding holes (HLX15, 26, 27 or 28) could be seen during drilling or pumping in HLX32.

Sammanfattning

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

Borrhålen HLX15, HLX26, HLX27, HLX28, HLX29, utfördes för undersökning av lineament NW042 i den södra delen av Laxemarsområdet.

Den geologi som påträffades i borrhålen överrensstämmer väl med det som kunde förväntas från den geologiska karteringen på ytan.

Vatteninflödet i borrhålen varierade mellan ingenting och 185 minutliter vilket tyder på mycket varierande vattenförande egenskaper i lineamentets strykningsriktning.

Ingen tydlig indikation på någon deformationszon kunde erhållas från borrningsresultaten i hålen HLX15 och HLX26.

En måttligt vattenförande struktur påträffades i HLX32.

Ordentligt vattenförande strukturer, som här tolkas med en brant nordlig stupning för att kunna knytas fast med lineamentet på markytan, påträffades i HLX27 och HLX28, det vill säga i den västra kanten av det undersökta området.

Inga tydliga responser kunde ses i omgivande borrhål (HLX15, 26, 27 eller 28) vid borrning eller pumpning i HLX32.

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/.

A number of linear features, lineaments, covering the site investigation area were identified by airborne geophysical methods or by remote sensing, primarily topography /3/.

Follow-up ground geophysics, as outlined in Figure 1-1, was done over selected lineaments /4/.

The percussion drilling to depths of 150–200 metres was done to investigate the interpreted lineament and related geophysical anomalies.

This report will describe the drilling of the six percussion holes, HLX15, 26, 27, 28, 29 and HLX32, and the measurements performed during the drilling phase.

The holes were drilled on the lineament NW042 in the Laxemar subarea of the Oskarshamn site investigation, see Figure 1-1.

The decisions to perform the drillings are given in SKB id 1023837 (HLX15) and SKB id 1027822 (the remaining boreholes), internal documents.

The regional authorities were informed by letters on 2004-04-26, SKB id 1024003 and 2004-09-10, SKB id 1028807, internal documents.

The drilling and all related on-site operations were performed according to a specific Activity Plan (AP PS-04-039). 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 HLX15 för lineamentsundersökning	AP PS 400-04-039	1.0
Hammarborrning av HLX21–HLX29	AP PS 400-04-072	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

*An amendment including the drilling of HLX32 is included in AP PS 400-04-072.

The activity plans and method descriptions are SKB internal documents.

All data were stored in the SICADA database for Oskarshamn.

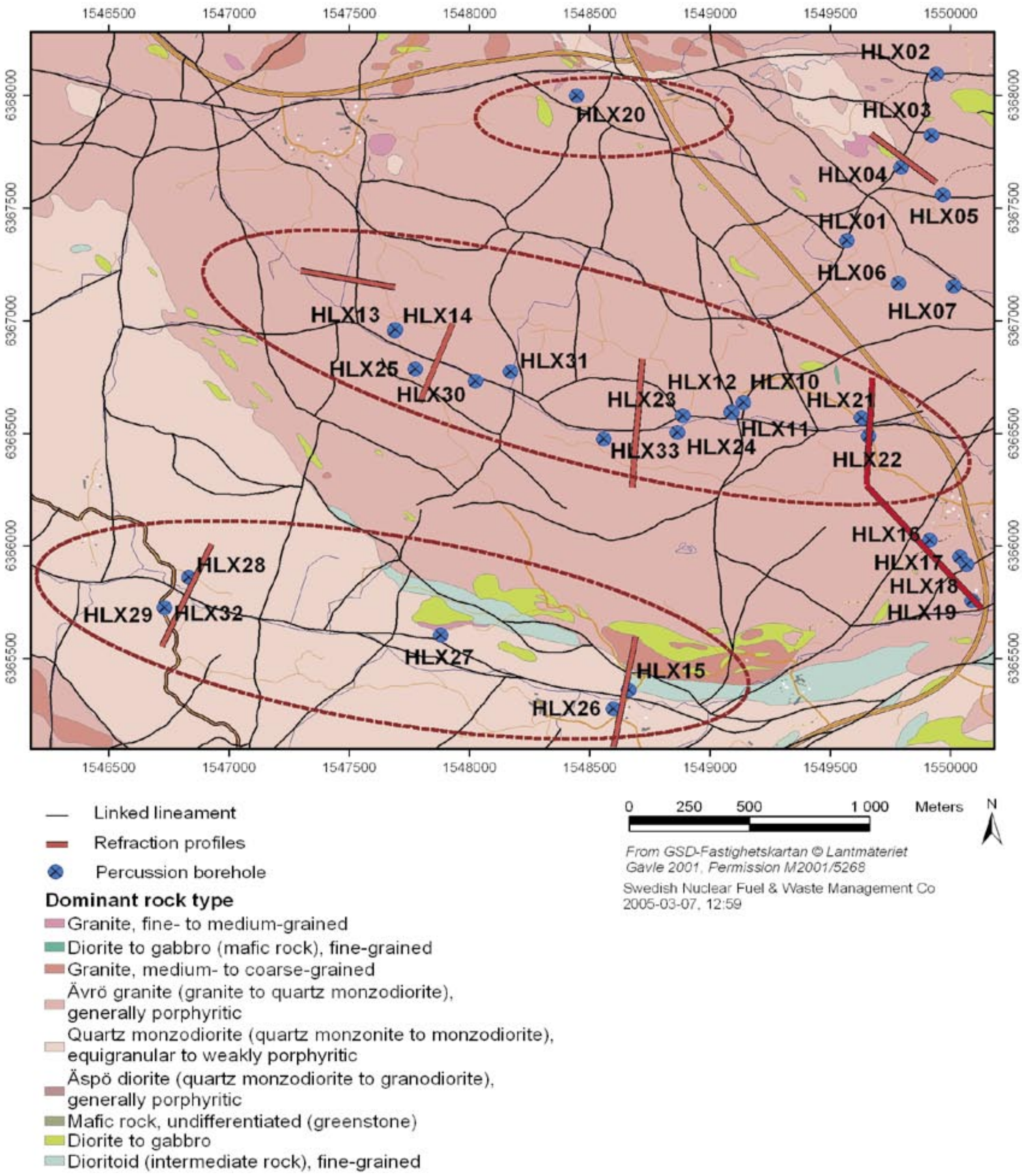


Figure 1-1. *Location of boreholes HLX15, HLX26, HLX2, HLX28, HLX29 and HLX32 in the Laxemar subarea.. The map shows the bedrock geology, lineaments and surface geophysical profiles. The boreholes are located within the southernmost ellipse which circumscribes the east-west trending lineament NW042.*

2 Objective and scope

This report will describe the drilling of the six percussion holes, HLX15, HLX26, HLX27, HLX28, HLX29 and HLX32 and the measurements performed during the drilling ie logging of preliminary geology, pump test and measurements of hydraulic responses.

The objectives for the boreholes, prior to drilling, are summarised in Table 2-1.

Table 2-1. Borehole objectives before drilling.

Borehole	Drilling objective
HLX15	The borehole would intercept a possible subvertical deformation zone at 50–100 metres drilled length. The hole was drilled before the ground geophysics were made.
HLX26	The borehole would intercept a possible subvertical deformation zone at 80–120 metres drilled length. Drilled along a ground geophysical profile.
HLX27	The borehole would intercept a possible subvertical deformation zone that could be connected to a topographic lineament at 100 metres drilled length.
HLX28	The borehole would intercept a possible subvertical deformation zone at 150–170 metres drilled length that could correlate to a low velocity zone along a ground geophysical profile.
HLX29/32	The borehole was drilled along a ground geophysical profile.

3 Equipment

In this chapter the drilling equipment and the equipment used for measurements and sampling is briefly described.

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

3.1 Drilling equipment

Drilling of the boreholes HLX15, 26, 27, 28 and 29 was made with a Puntel percussion drilling machine supplied with accessories. Borehole HLX32 was drilled with a Comacchio MMC 1500 rig.

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.

3.2 Equipment for measurements and sampling

Flow measurements during drilling were performed using measuring a graded vessel and a stop watch. Measurement of the drilling penetration time was done manually with readings for every 20 centimetres or automatically.

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

The pumping test was done with a submersible pump, Grundfoss MS 402 SP2A-23.

4 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,
- pumping tests and hydraulic responses,
- data handling,
- environmental control.

4.1 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).

4.2 Drilling through overburden

Excentric percussion drilling with 200 mm diameter ("ODEX 160") was made through the unconsolidated soil and fractured near-surface bedrock to a depth of between 6 and 12 metres.

4.3 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 4-1.

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.

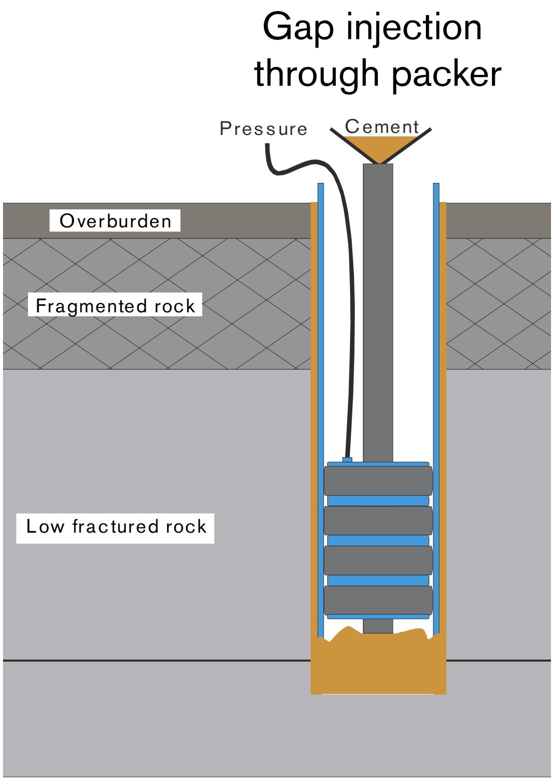


Figure 4-1. *Gap injection technique.*

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

4.4 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.

4.5 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 hole. One sample was taken per metre drilled. The samples were stored for subsequent logging of preliminary geology (lithology, dominant mineralogy, grain-size, roundness and, if possible, structural or textural information) and measurement of magnetic susceptibility with hand held equipment. Small cups of return water were collected during drilling, one for every metre, for estimation of water colour and intensity which in turn gives an indication of clay content and level of oxidation.

Figure 4-2. *Drilling equipment at the site for HLX27.*

- Penetration time (expressed as seconds per 20 cm) was manually recorded in HLX15. In the remaining holes the penetration rate was logged automatically.
- The water yield from the hole was estimated when noticeable changes in water flow occurred and after the drilling phase was completed. 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.

Deviation measurements were not made in conjunction with drilling of the holes.

4.6 Borehole completion

The boreholes were secured by mounting of lockable steel caps on the casing.

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

4.7 Pumping test and hydraulic responses

Pumping test

Pumping tests as specified in the activity plan was only made in HLX32.

The lack of water in HLX15 and 26 prevented the testing of these holes. Borehole HLX27 was subjected to a separate pumping test within another activity, AP PS 400-04-105 (SKB internal document) and will therefore not be reported here.

HLX28 is located in the same profile as HLX32 and was therefore not tested by pumping.

The water level and pumped flow was measured manually. Initially the flow was measured frequently, when stable flow conditions were achieved, the measurements were conducted with longer intervals.

Hydraulic responses

Measurements of hydraulic responses during drilling and pumping tests were conducted by emplacing pressure loggers in nearby holes. The logger installations were:

Scan time: 1 s

Log time: 10 s

Event: 0.1 kPa

The scan time is the interval for the pressure readings. With an event function of 0.1 kPa, the logger saves any data that has changed more than 0.1 kPa since the previous scanning. The log time is the interval between data savings regardless of pressure changes. Manual measurements of the groundwater level were conducted to check the logger data.

4.8 Data handling

Data collected by the drillers and drill site personnel 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.

4.9 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 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.

5 Results

The main purpose for the boreholes was to identify and localize possible deformation zones. The boreholes were drilled as planned except for HLX29 which had to be discontinued after drilling only to 12.9 metres and replaced by a new hole, HLX32.

Boreholes HLX27 and HLX28 were drilled to slightly less than planned length due to high inflow of water which created a practical lower depth for drilling

The water yields varied from nil to over 185 litres per minute which indicates highly variable water-bearing properties along strike of the lineament.

The encountered geology in the boreholes corresponds well with expectations based on surface mapping.

5.1 Borehole design

A summary of data from the borehole are presented in Tables 5-1 and 5-2.

Technical drawings of the boreholes are given in Appendix 1.

Table 5-1. Geometric and technical data for borehole HLX15, HLX26 and HLX27.

Parameter	HLX15		HLX26		HLX27	
Drilling period	From 2004-04-27 to 2004-04-29		From 2004-09-23 to 2004-09-28		From 2004-09-20 to 2004-09-22	
Borehole inclination (starting point) (0 to –90)	–58.37°		–60.42°		–59.41°	
Borehole azimuth (0–360)	184.6°		12.4°		191.0°	
Borehole length	151.90 m		151.20 m		164.70 m	
Soil depth	2.8 m		5.0 m		3.1 m	
Drill bit diameter	0.137 m		0.137 m		0.137 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6365361.97 m Easting: 1548664.02 m Elevation: 4.807 m.a.s.l.		Northing: 6365278.71 m Easting: 1548600.52 m Elevation: 6.487 m.a.s.l.		Northing: 6365605.07 m Easting: 1547882.68 m Elevation: 4.248 m.a.s.l.	
Water yield (interval)	0 l/min		0 l/min		115 l/min (0–164.7 m)	
Borehole diameter	0–12.24 m	190 mm	0–9.10 m	190 mm	0–6.10 m	190 mm
(interval) (diameter mm)	12.24–151.9 m	137 mm	9.10–151.2 m	137 mm	6.10–164.7 m	137 mm
Casing diameter	0–11.95 m	$Ø_o = 168$	0–8.94 m	$Ø_o = 168$	0–5.94 m	$Ø_o = 168$
(interval) (diameter mm)	11.95–12.04 m	$Ø_i = 160$ $Ø_o = 168$ $Ø_i = 147$	8.94–9.03 m	$Ø_i = 160$ $Ø_o = 168$ $Ø_i = 147$	5.94–6.03 m	$Ø_i = 160$ $Ø_o = 168$ $Ø_i = 147$

Table 5-2. Geometric and technical data for borehole HLX28, HLX29 and HLX32.

Parameter	HLX28		HLX29		HLX32	
Drilling period	From 2004-09-29 to 2004-10-02		From 2004-10-02 to 2004-10-03		From 2005-01-04 to 2005-01-11	
Borehole inclination (starting point) (0 to –90)	–59.48°		–56.95°		–58.67°	
Borehole azimuth (0–360)	201.4°		22.3°		28.6°	
Borehole length	154.20 m		12.90 m		162.60 m	
Soil depth	2.2 m		3.0 m		4.0 m	
Drill bit diameter	0.136 m		0.137 m		0.140 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6365861.70 m Easting: 1546834.47 m Elevation: 13.424 m.a.s.l.		Northing: 6365726.24 m Easting: 1546733.15 m Elevation: 10.701 m.a.s.l.		Northing: 6365725.79 m Easting: 1546734.36 m Elevation: 10.844 m.a.s.l.	
Water yield (interval)	185 l/min (0–154.2 m)		0 l/min		8 l/min (0–162.6 m)	
Borehole diameter	0–6.10 m	190 mm	0–6.10 m	190 mm	0–12.30 m	191 mm
(interval) (diameter mm)	6.10–154.2 m	136 mm	6.10–12.90 m	137 mm	12.30–162.60 m	140 mm
Casing diameter	0–5.94 m	$\text{Ø}_o = 168$	0–5.94 m	$\text{Ø}_o = 168$	0–12.21 m	$\text{Ø}_o = 168$
(interval) (diameter mm)	5.94–6.03 m	$\text{Ø}_i = 160$ $\text{Ø}_o = 168$ $\text{Ø}_i = 147$	5.94–6.03 m	$\text{Ø}_i = 160$ $\text{Ø}_o = 168$ $\text{Ø}_i = 147$	12.21–12.30 m	$\text{Ø}_i = 160$ $\text{Ø}_o = 168$ $\text{Ø}_i = 147$

5.2 Hydrogeological results

Results from drilling

The water yields obtained from blowing of compressed air during drilling are given in Table 5-3 and are also shown in Appendix 2.

The level at which the water yield was measured does not always correspond to the observed levels of water inflow. In Table 5-4 the observed level of inflow is given. These levels are also shown in Figure 6-1.

The amount of effluent water that was released to the ground from the drilling activities is estimated in Table 5-5.

The release of water was made within 30 metres from the collar location.

A pumping test was done in HLX32 in February 2005, the results are given in Figure 5-1. The specific capacity, Q/s was calculated to 1.4×10^{-5} m^2/s and the transmissivity, according to /5/, was calculated to 1.9×10^{-5} m^2/s. The pumped flow averaged 14 litres per minute.

The results from monitoring hydraulic responses in surrounding boreholes during drilling of HLX32 is presented in Figure 5-2. The water level in HLX28 does drop one or two centimetres more than the other boreholes that are located further away. However there is no clear indication of recovery in HLX28 after drilling in HLX32 was stopped. The actual reduction in water level in HLX28 is very low and should probably be attributed to other reasons.

Measurements of hydraulic responses in the surrounding boreholes during a pumping test in HLX32 is shown in Figures 5-3 and 5-4. No response ie reduction in the water table that can be related to the pumping in HLX32 can be seen.

Table 5-3. Observed water yields from drilling.

Borehole	From (m)	To (m)	Measured water yield (L/min)	Date	Time for final rinsing by air blow (local time)
HLX15	12.04	151.9	0	040429	18:45
HLX26	9.03	151.2	0	040928	16:00
HLX27	6.03	108.9	16	040921	
HLX27	6.03	120.9	18	040921	
HLX27	6.03	120.9	47	040922	
HLX27	6.03	160.2	78	040922	
HLX27	6.03	164.7	> 115	040922	18:30
HLX28	6.03	78.9	60	041001	
HLX28	6.03	82.2	170	041001	
HLX28	6.03	121.2	188	041001	
HLX28	6.03	121.1	218	041001	
HLX28	6.03	154.2	> 185	041001	17:30
HLX29	6.03	12.9*	0*	041003	*
HLX32	12.21	24.6	16	050110	
HLX32	12.21	99.6	9.2	050110	
HLX32	12.21	99.6	22	050111	
HLX32	12.21	162.6	8	050111	13:30

* The hole was discontinued and replaced by the drilling of HLX32.

Table 5-4. Observed levels of water inflow during drilling.

Borehole	Observed levels of water inflow during drilling (metres drilled length)
HLX15	N/A
HLX26	N/A
HLX27	107, 158, 164 m
HLX28	80 m
HLX29	N/A
HLX32	23 m

Table 5-5. Amount of released water from drilling.

Borehole (interval m)	Estimated amount of water released (m^3)
HLX15	0
HLX26	0
HLX27	52
HLX28	135
HLX29	0
HLX32	5

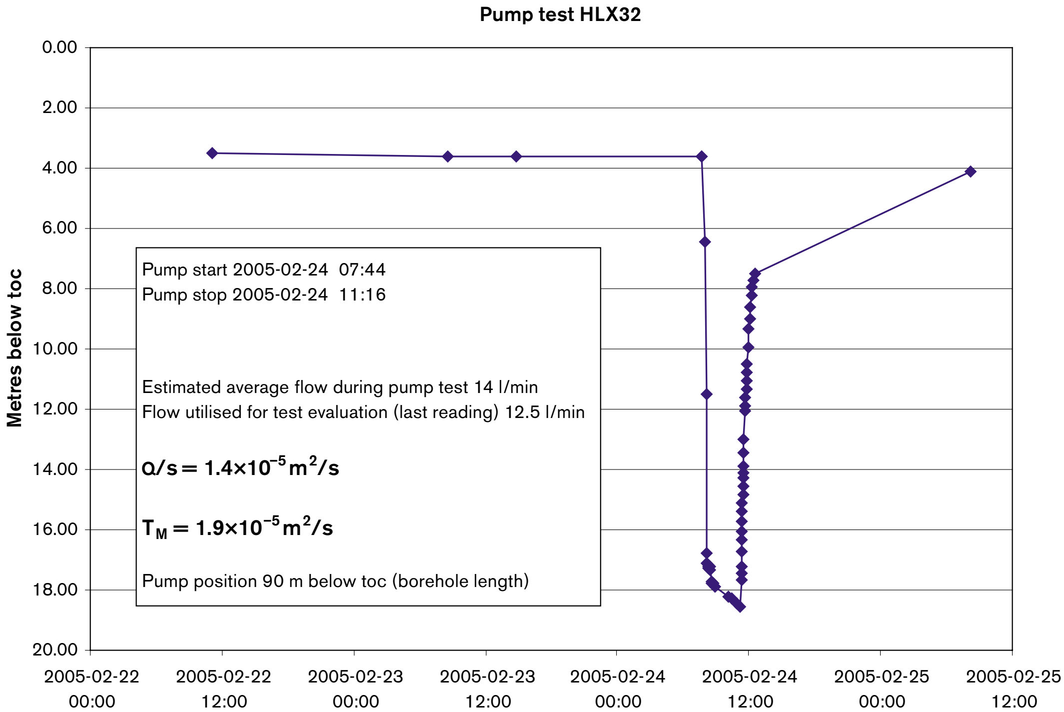


Figure 5-1. *Pumping test in HLX32.*

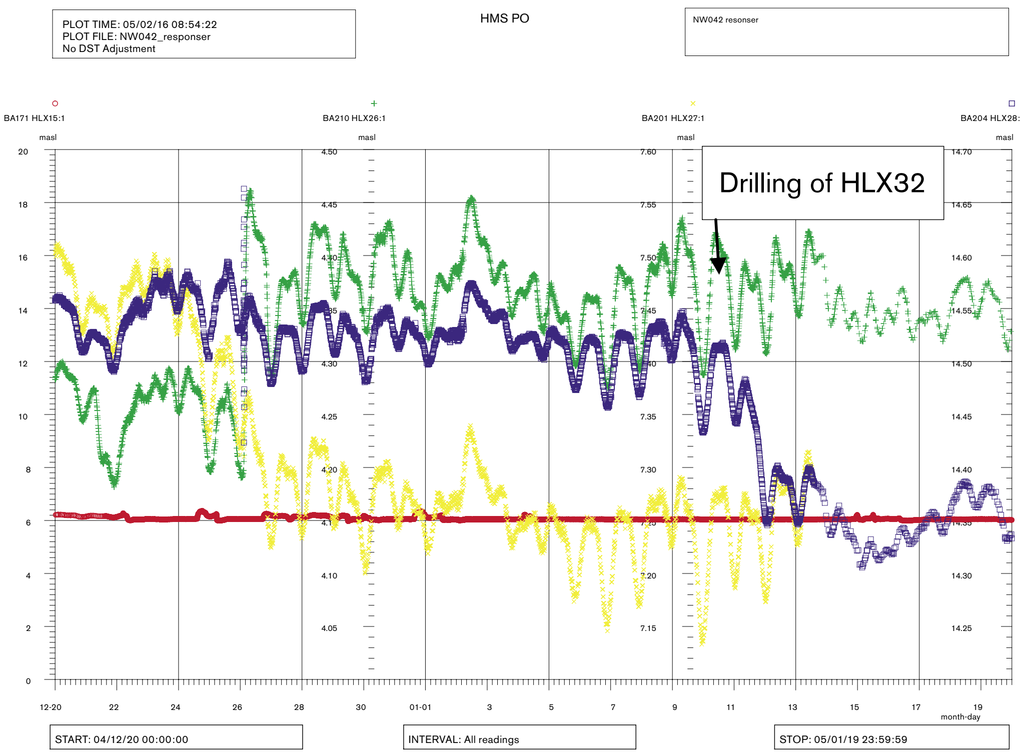


Figure 5-2. *Responses in boreholes HLX15, 26, 27 and 28 during drilling of HLX32. No clear response in HLX28 (blue) can be seen during the period 050110–050111 when HLX32 was drilled. The drop in curve for HLX28 after December 11 corresponds to 0.15 kPa or 1.5 cm which is interpreted here as a non-significant change, see also Figure 5-3. The undulations in the curves can be ascribed to tidal effects. HLX15 (red line) is artesian and does not show any variations in the water table.*

Responses were measured in HLX27 during pumping in HLX32. No influence from the pumping can be seen in HLX27, see Figure 5-4.

Boreholes HLX15 and HLX28 were artesian.

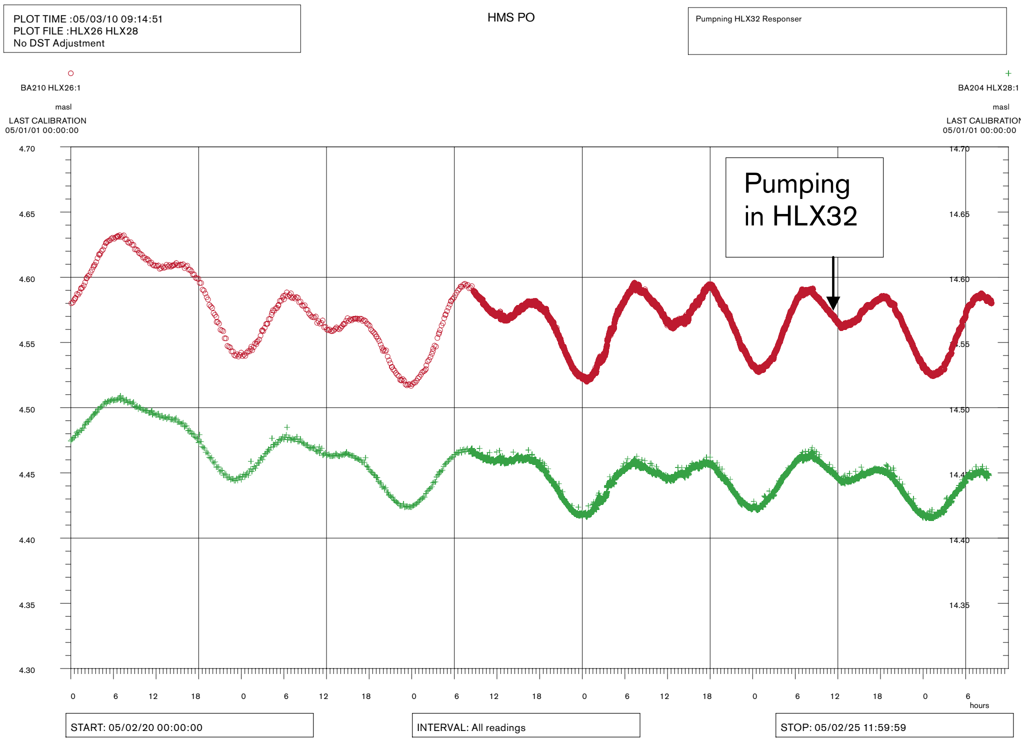


Figure 5-3. *No hydraulic responses in boreholes HLX26 (red) and HLX28 (green) could be seen during pumping in HLX32. The undulations in the curves can be ascribed to tidal effects.*

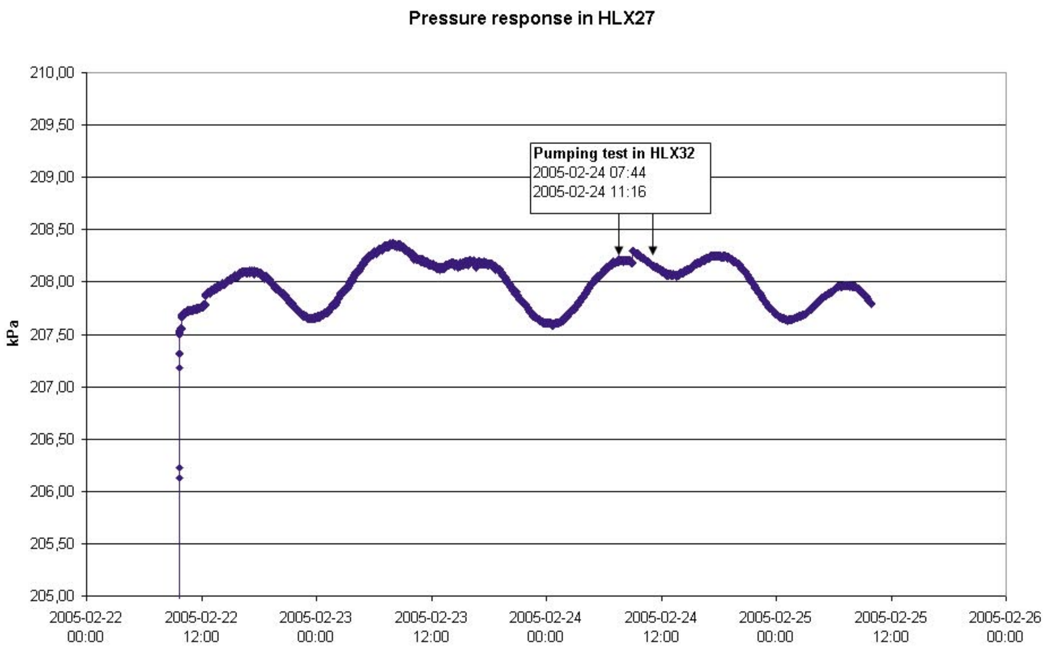


Figure 5-4. *No hydraulic response in HLX27 could be seen while pumping in HLX32. The undulations in the curve can be ascribed to tidal effects.*

5.3 Geological results

Lithologically the holes were dominated by quartz monzodiorite with minor intercalations of subordinate rock types. This corresponds well to the surface geological mapping in the area.

Discriminating between oxidised varieties and quartz monzodiorite was sometimes difficult in the cuttings. The preliminary logging, ie without the support of the borehole images, BIPS, especially in HLX15 is uncertain and it is quite likely that the sections here logged as granite could in fact be oxidized quartz monzodiorite.

Logging results of preliminary geology together with magnetic susceptibility, penetration time and measured water flow are presented in Figure 6-1 and Appendix 2.

5.4 Hydrogeochemical results

No water samples were taken during the activity.

5.5 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.

The consumption of cement paste (low alkali cement) and oils is given in Table 5-6.

Table 5-6. Consumption of cement paste and oils.

Borehole	Cement paste used (litres/kg)	Hammer oil (Preem Hydra 46)	Compressor oil (Schuman 46)
HLX15	80/71	10	None noted
HLX26	60/35.5	10	None noted
HLX27	40/35.5	10	None noted
HLX28	40/35.5	10	None noted
HLX29	40/35.5	10	None noted
HLX32	80/72	10	None noted

5.6 Nonconformities

Borehole HLX29 was drilled to only 12.9 metres instead of the planned length of 150 metres. During drilling a zone of very weak, sandy material was encountered between 7.1 and 8 metres. As the casing was installed to a length of 6.03 metres the decision was taken to discontinue the borehole. Subsequently an amendment to the activity plan was made where it is stated that borehole HLX32 was to be drilled as a replacement for HLX29.

Short time pumping tests were planned to be made for each hole according to the activity plan (AP PS 400-04-072). Pumping could not be made in the holes were no water was encountered (HLX15 and 26). Nor could pumping be done in HLX29 as the hole was not completed for technical reasons.

HLX27 was tested hydraulically as part of another specific activity plan, AP PS 400-04-105, SKB internal document, and will therefore not be reported here.

No pumping test was made in HLX28 because is located in the same profile as HLX32, which was tested.

Unsuccessful attempts to measure the hydraulic recovery in each borehole were made in accordance with the activity plan. It was found that the method described in the activity plan was not feasible in the boreholes as either the recovery of the water table was too fast (HLX27, 28 and 32) or too slow (HLX15 and 26).

6 Interpretation

A continuous behaviour of a deformation zone corresponding to the interpreted surface lineament NW042 could not be established by drilling of the boreholes in this report.

No definite indication of any deformation zone could be established from the drilling results in boreholes HLX15 and 26.

Significant water bearing structures, interpreted here with a steep northern dip, were encountered in HLX27 and HLX28.

A moderate water bearing structure, interpreted here with a gentle dip to the south, was found in HLX32.

No clear hydraulic response could be seen in HLX28 while drilling in HLX32, see Figure 5-2.

No hydraulic response could be seen in HLX26 or HLX28 while pumping in HLX32, see Figure 5-3.

No hydraulic response could be seen in HLX27 while pumping in HLX32, see Figure 5-4.

The hydraulic connectivity between HLX27 and HLX28 has not been tested in this activity since a separate pumping test (AP PS 400-04-105) was performed in HLX27.

The drilling results are summarised in vertical profiles in Figure 6-1.

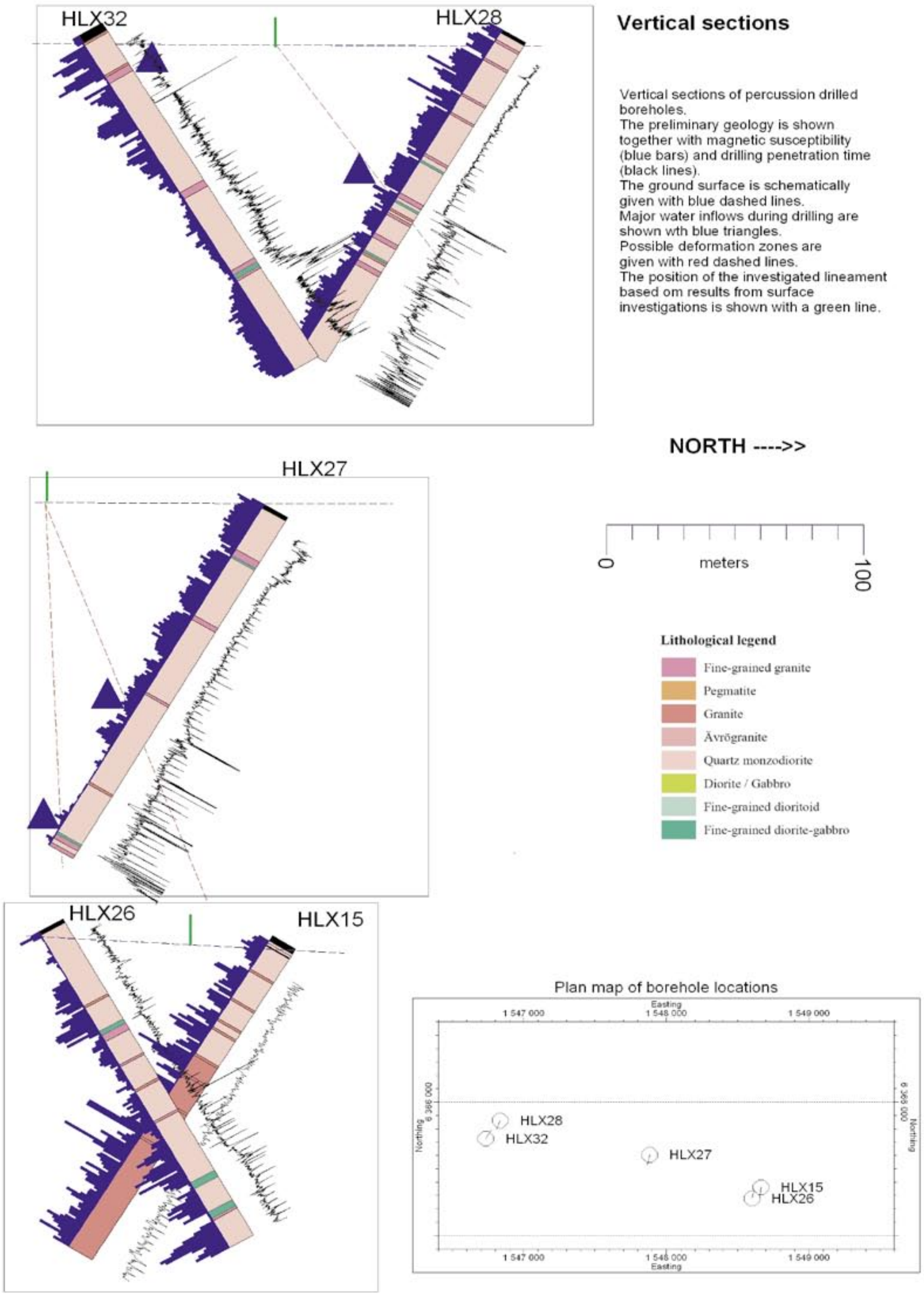


Figure 6-1. *Boreholes HLX15, 26, 27, 28 and 32 are shown with preliminary geological results, magnetic susceptibility (blue bars) and drilling penetration time (black line). Positions for water inflow are indicated by blue triangles. Borehole HLX29 has been omitted in this figure since it coincides with HLX32.*

7 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. Joint interpretation of lineaments . SKB P-04-49, Svensk Kärnbränslehantering AB.

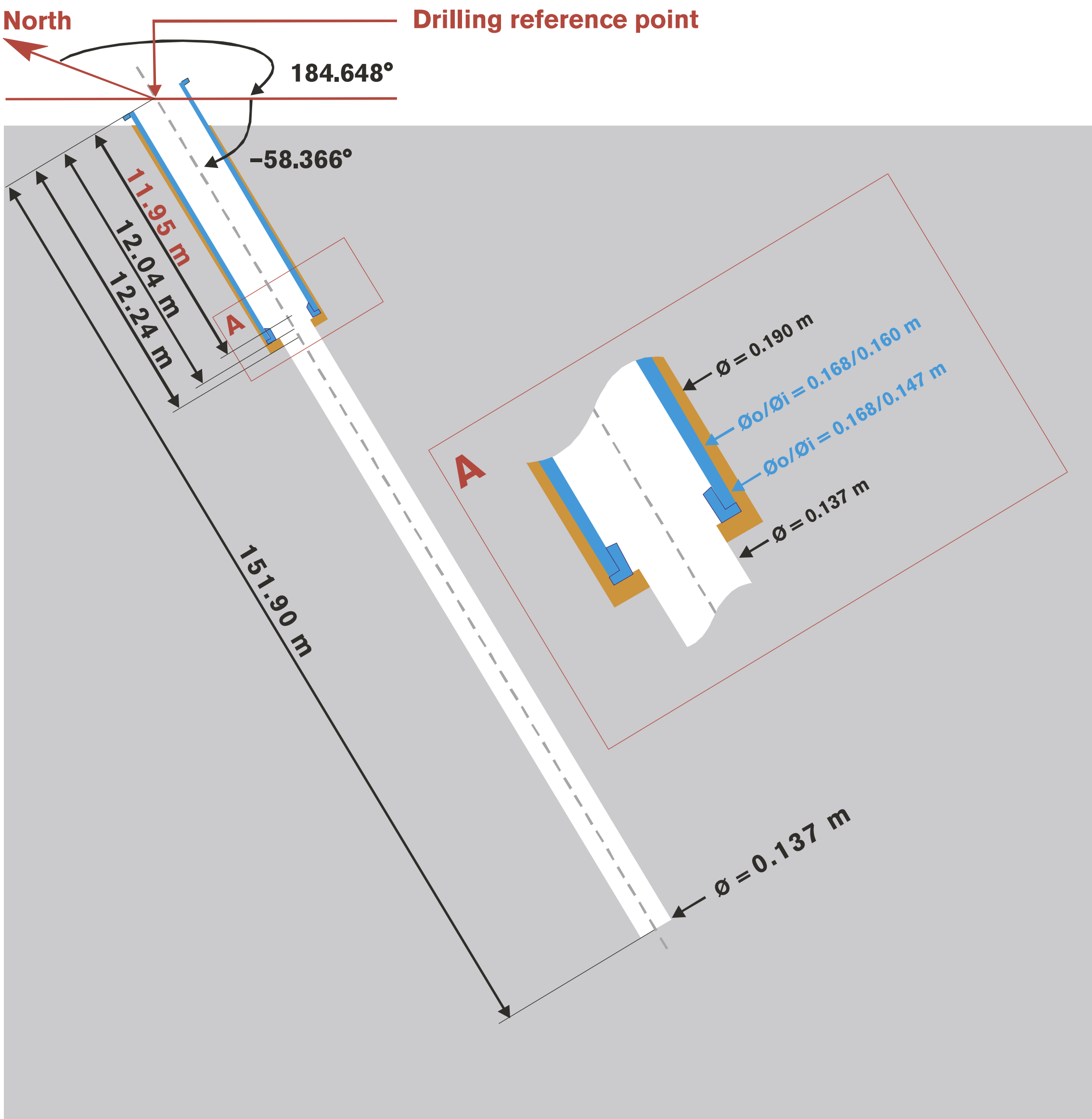
/4/ **SKB, 2004.** Oskarshamn site investigation. Refraction seismic measurements in Laxemar. SKB P-04-134, Svensk Kärnbränslehantering AB.

/5/ **Moye D G, 1967.** Diamond drilling for foundation exploration. Civil Eng. Trans., Inst. Eng, Australia.

Technical data boreholes HLX15, 26, 27, 28, 29 and 32

Technical data

Borehole HLX15



Drilling reference point

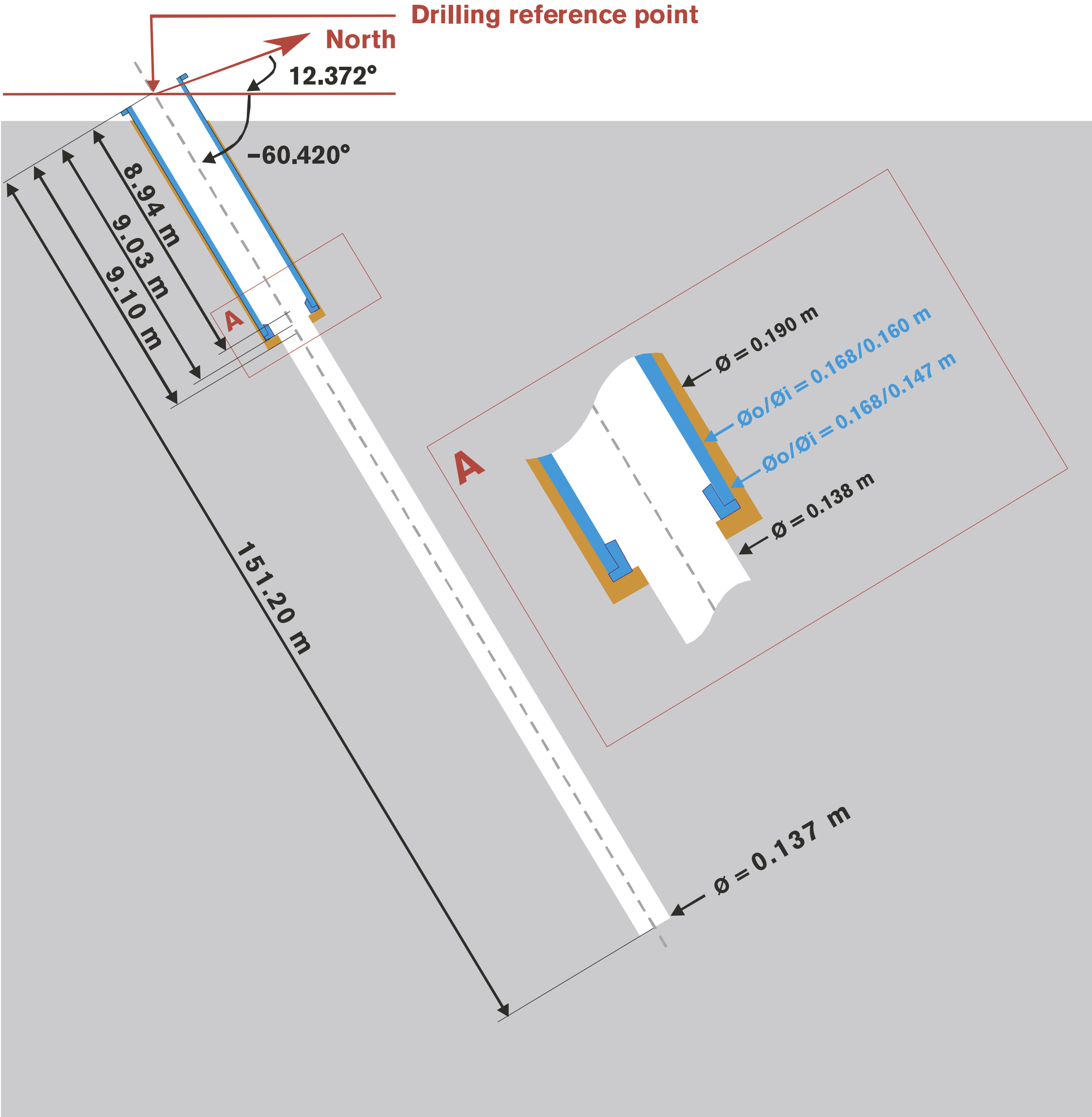
Northing:	6365361.975 (m), RT90 2,5 gon V 0:-15
Easting:	1548664.018 (m), RT90 2,5 gon V 0:-15
Elevation:	4.807 (m), RHB 70

Drilling period

Drilling start date:	2004-04-27
Drilling stop date:	2004-04-29

Technical data

Borehole HLX26



Drilling reference point

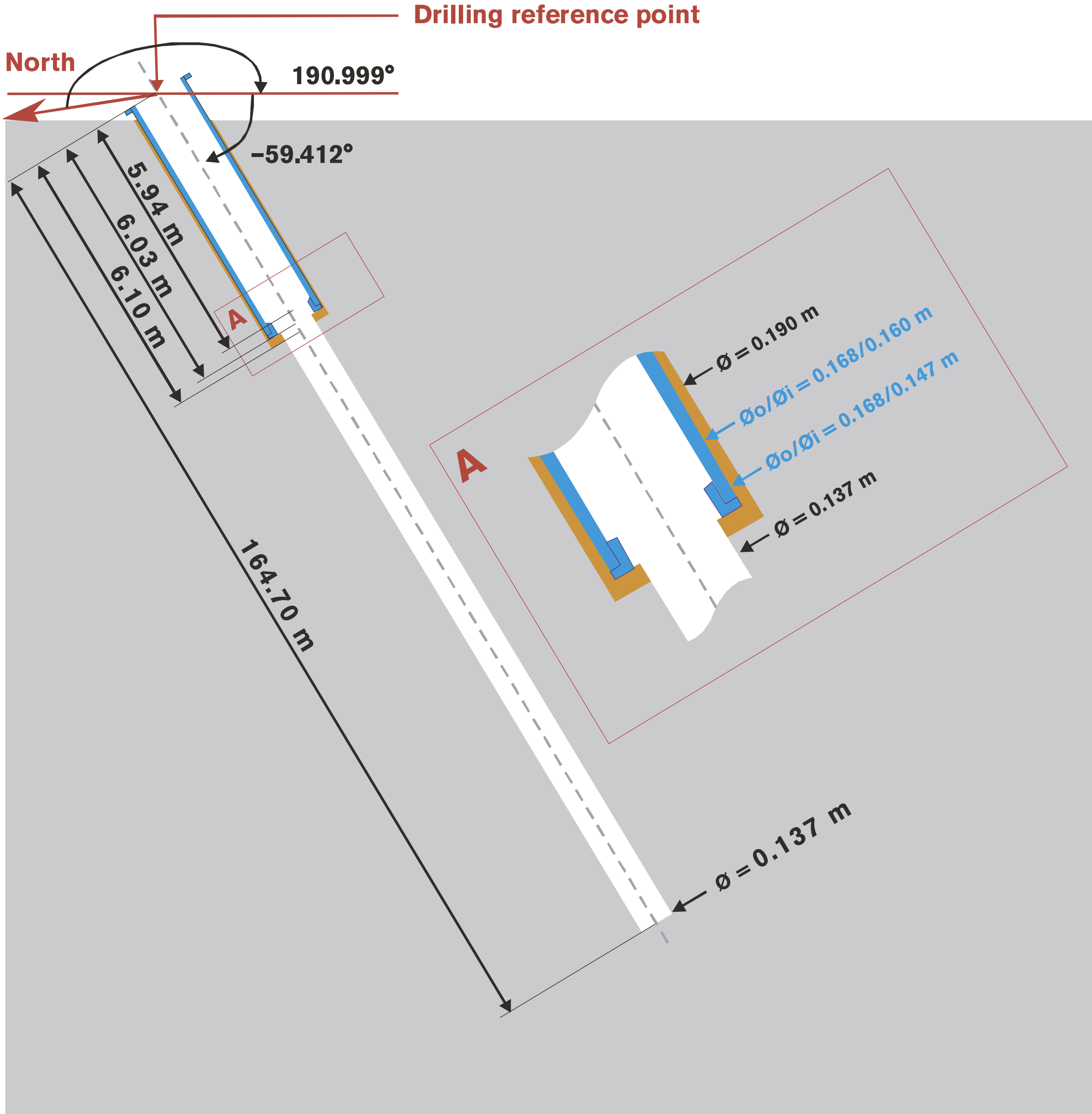
Northing:	**6365278.707 (m), RT90 2,5 gon V 0:-15**
Easting:	**1548600.525 (m), RT90 2,5 gon V 0:-15**
Elevation:	**6.478 (m), RHB 70**

Drilling period

Drilling start date:	**2004-09-23**
Drilling stop date:	**2004-09-28**

Technical data

Borehole HLX27



Drilling reference point

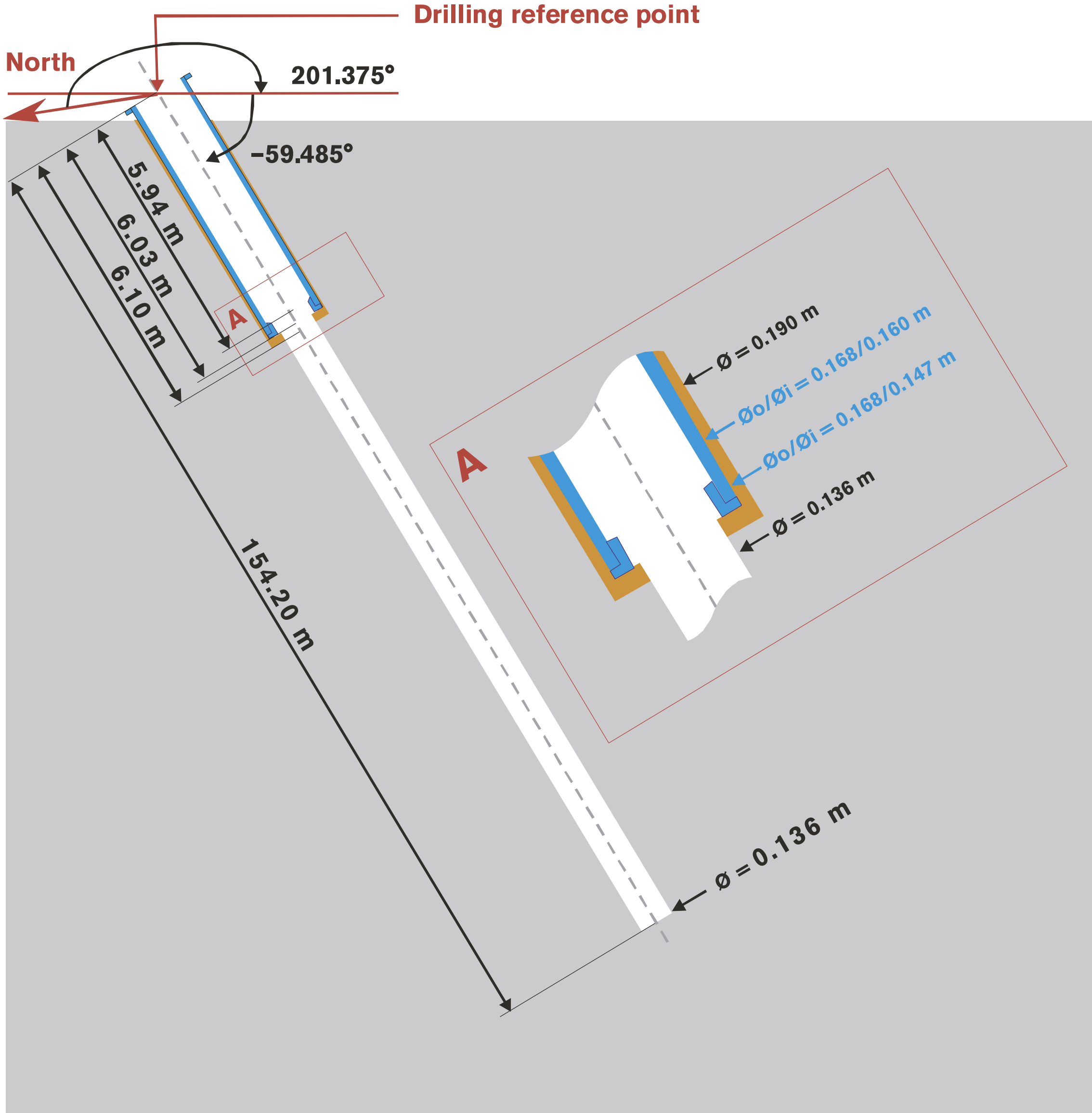
Northing:	6365605.073 (m), RT90 2,5 gon V 0:-15
Easting:	1547882.686 (m), RT90 2,5 gon V 0:-15
Elevation:	8.248 (m), RHB 70

Drilling period

Drilling start date:	2004-09-20
Drilling stop date:	2004-09-22

Technical data

Borehole HLX28



Drilling reference point

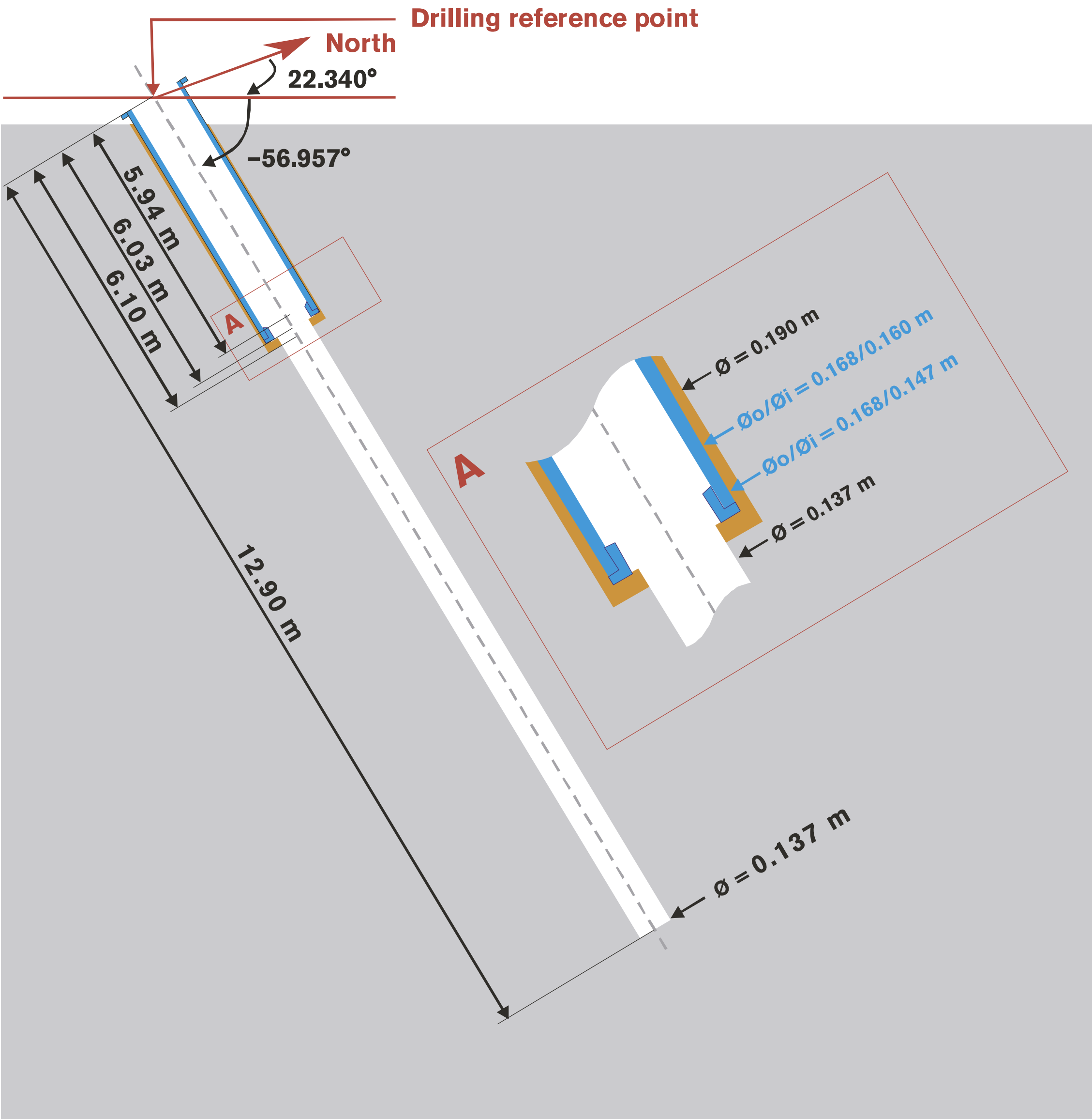
Northing:	6365861.704 (m), RT90 2,5 gon V 0:-15
Easting:	1546834.473 (m), RT90 2,5 gon V 0:-15
Elevation:	13.424 (m), RHB 70

Drilling period

Drilling start date:	2004-09-29
Drilling stop date:	2004-10-02

Technical data

Borehole HLX29



Drilling reference point

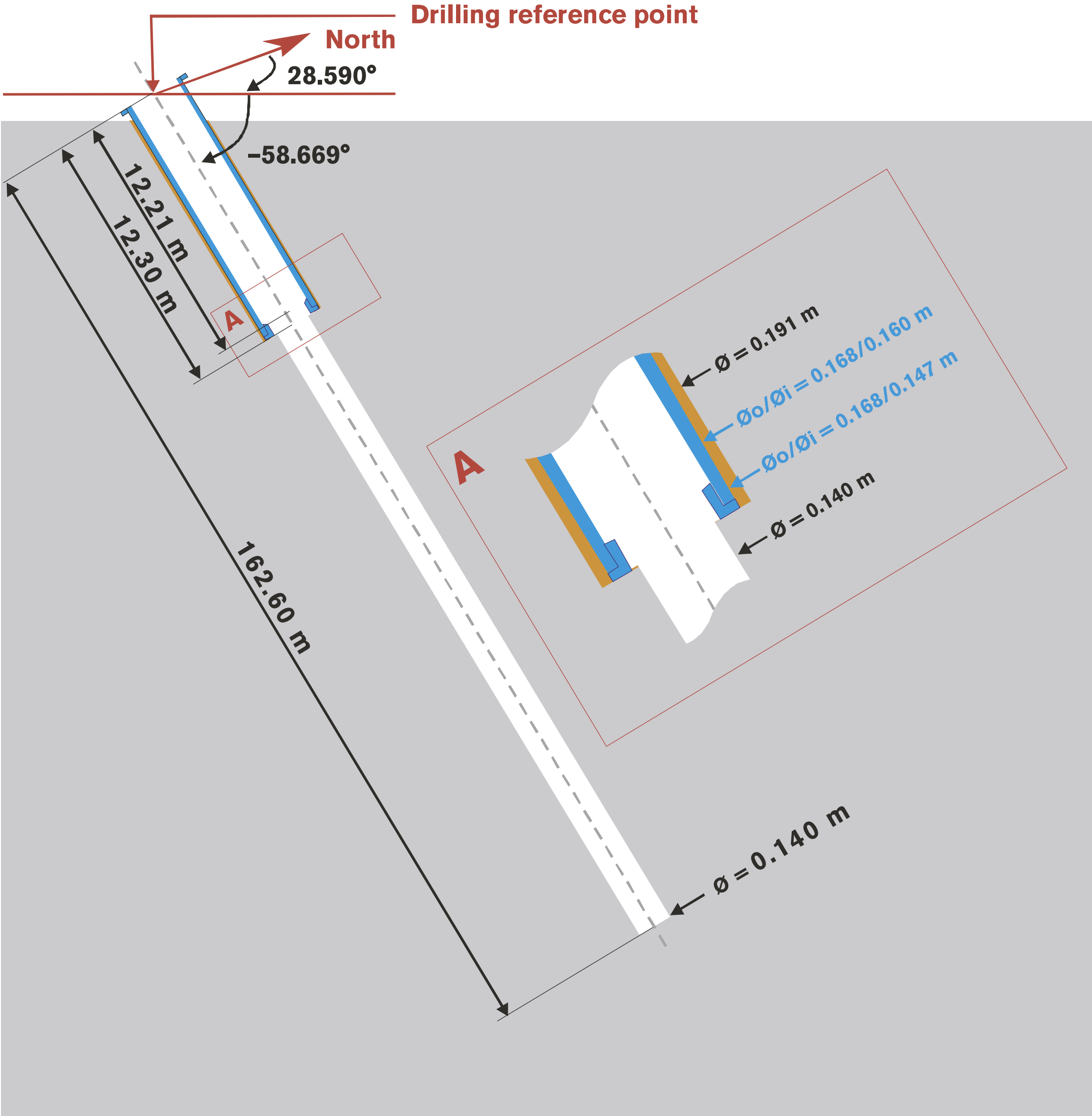
Northing:	**6365726.243 (m), RT90 2,5 gon V 0:-15**
Easting:	**1546733.146 (m), RT90 2,5 gon V 0:-15**
Elevation:	**10.701 (m), RHB 70**

Drilling period

Drilling start date:	**2004-10-02**
Drilling stop date:	**2004-10-03**

Technical data

Borehole HLX32



Drilling reference point

Northing:	6365725.793 (m), RT90 2,5 gon V 0:-15
Easting:	1546734.363 (m), RT90 2,5 gon V 0:-15
Elevation:	10.844 (m), RHB 70

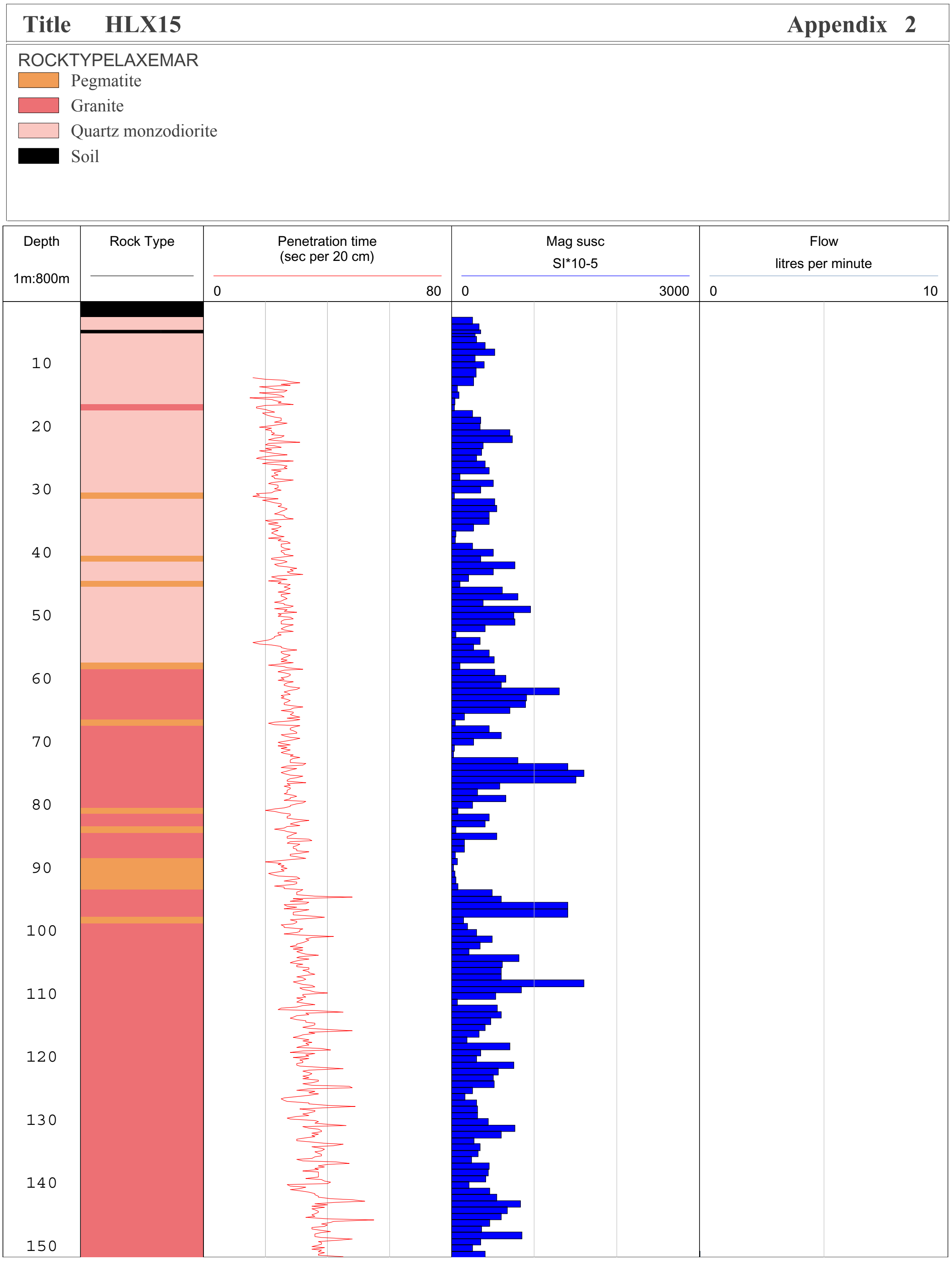
Drilling period

Drilling start date:	2005-01-04
Drilling stop date:	2005-01-11

Appendix 2

WellCad plots for boreholes HLX15, 26, 27, 28, 29 and 32

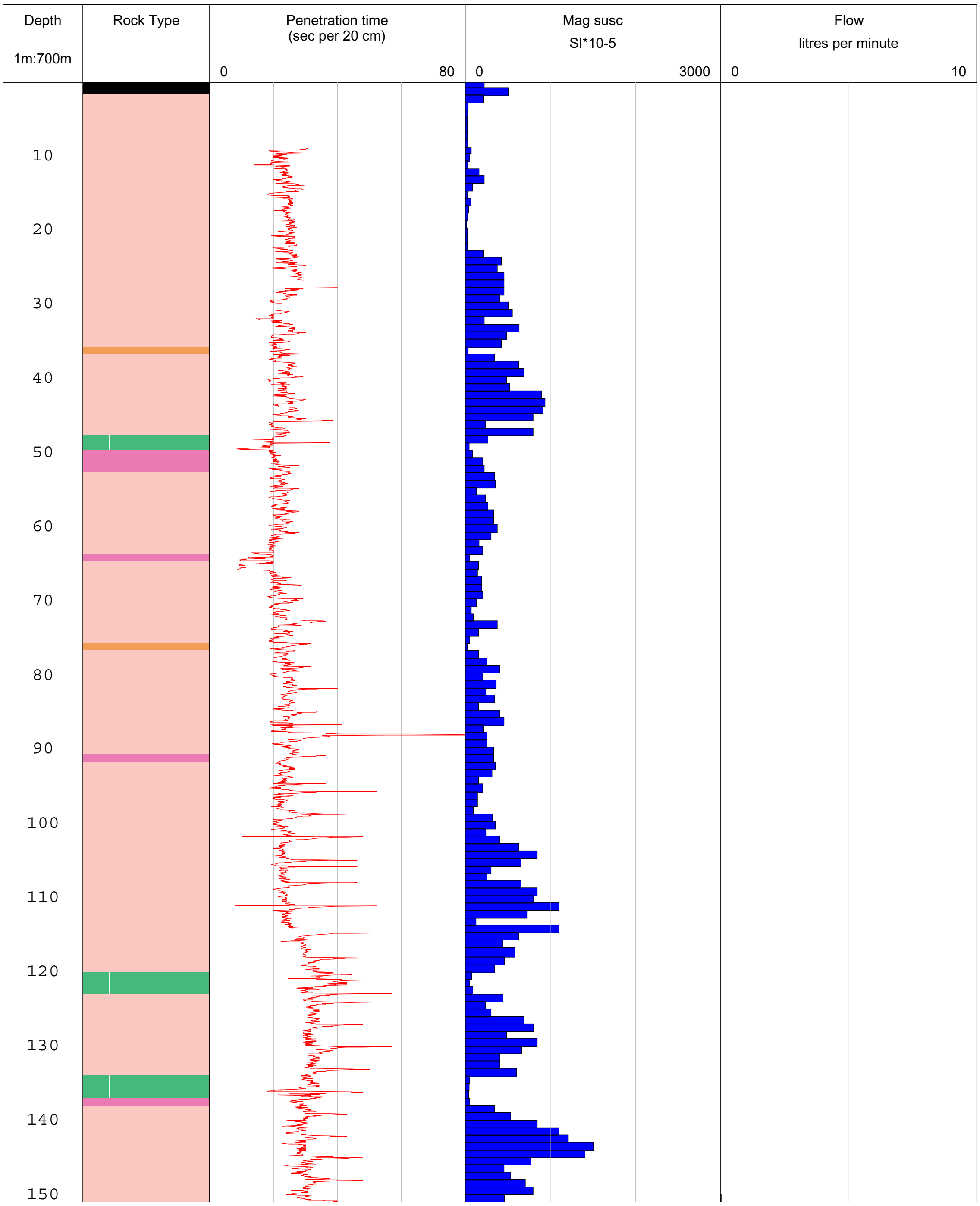
Geology, drill penetration and magnetic susceptibility



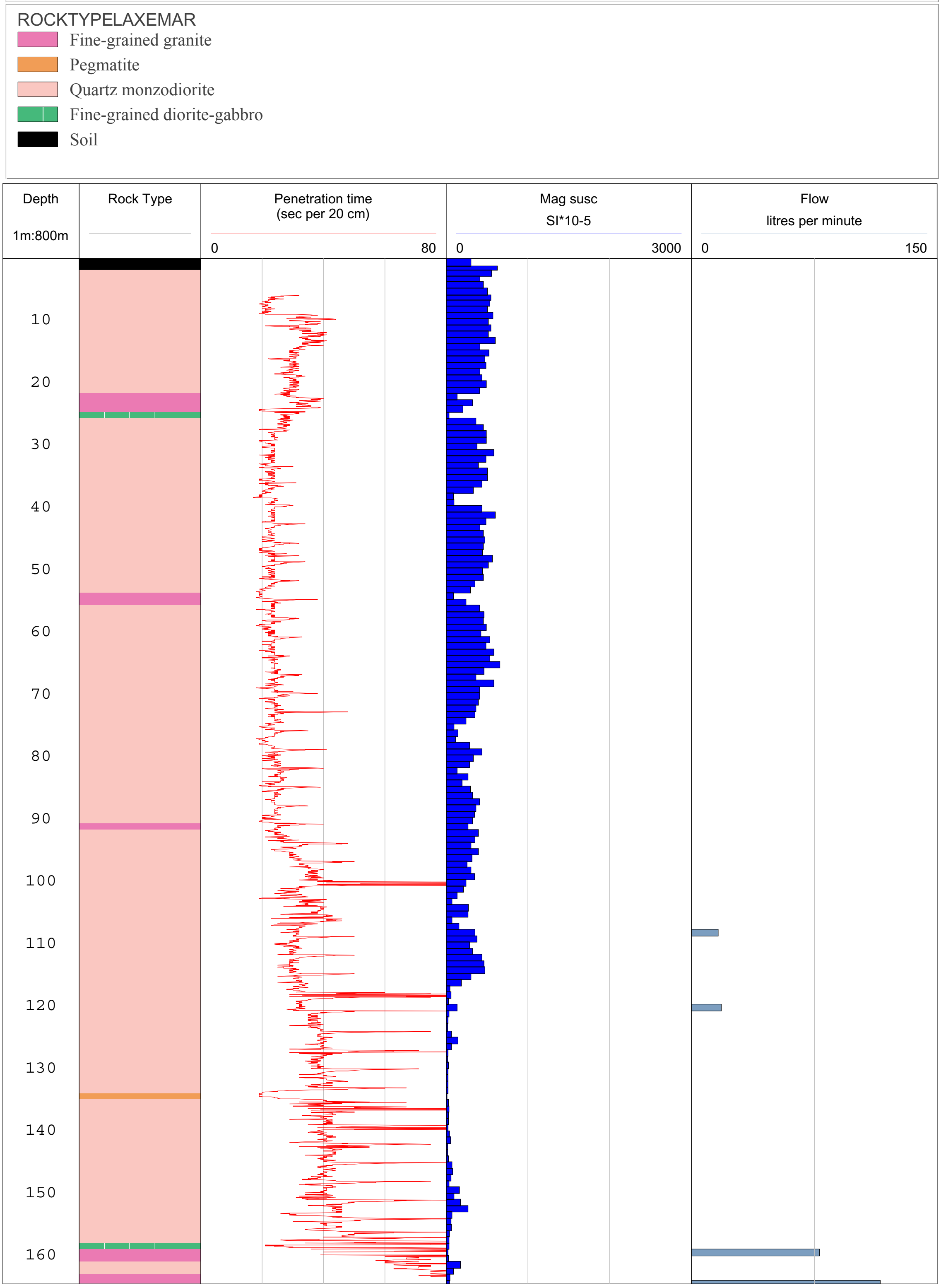
Title HLX26 **Appendix 2**

ROCKTYPELAXEMAR

- Fine-grained granite
- Pegmatite
- Quartz monzodiorite
- Fine-grained diorite-gabbro
- Soil



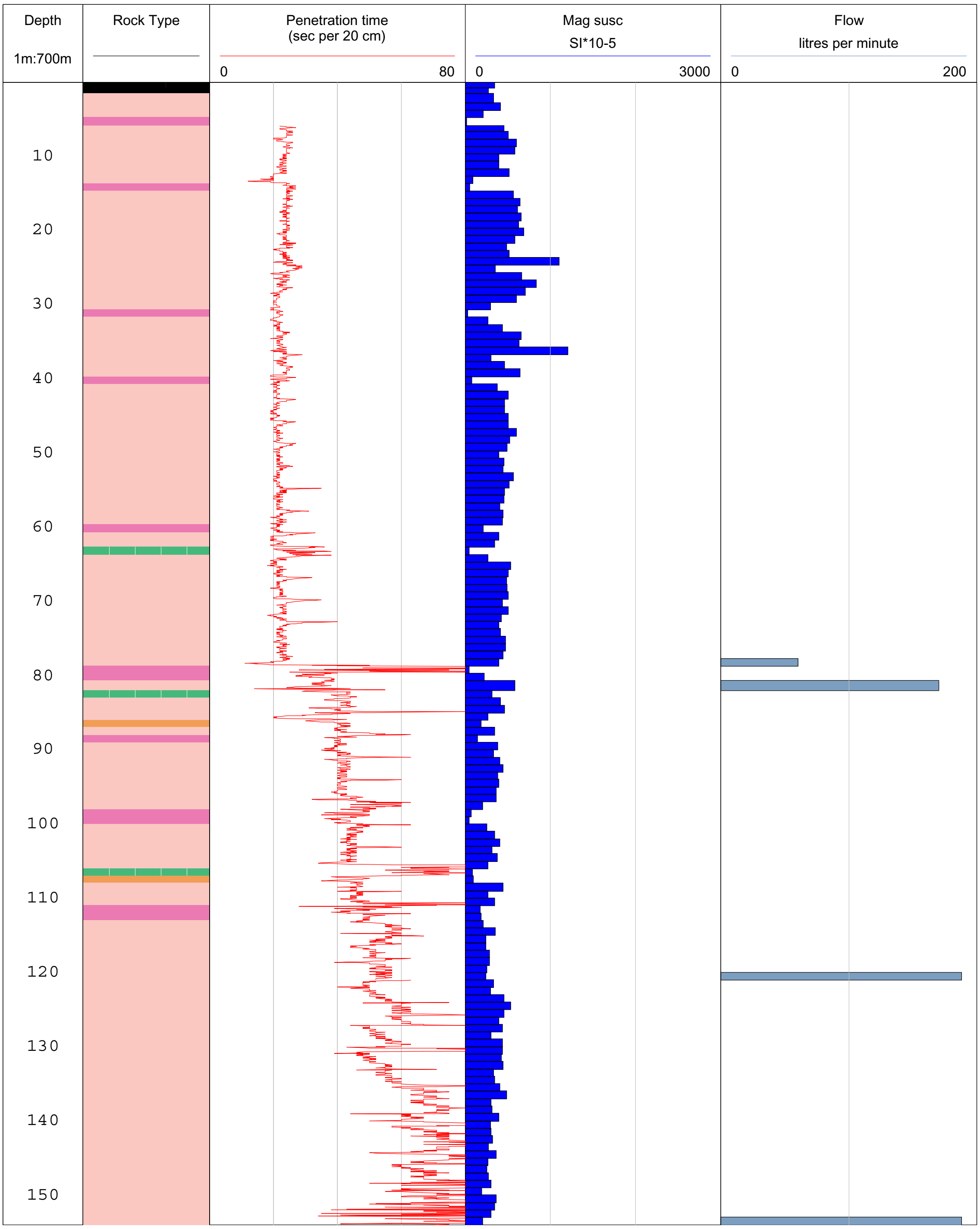
Title HLX27 Appendix 2



Title HLX28 **Appendix 2**

ROCKTYPELAXEMAR

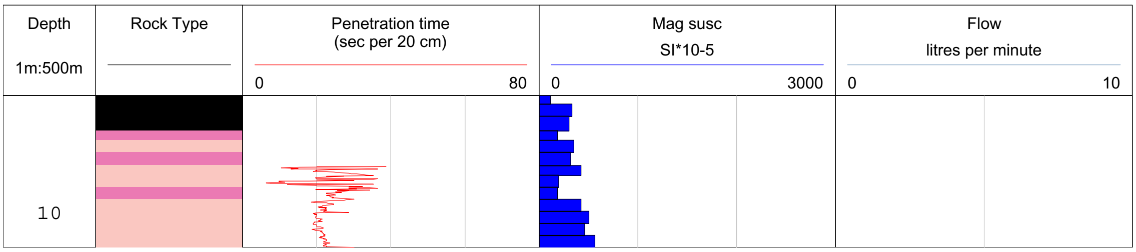
- Fine-grained granite
- Pegmatite
- Quartz monzodiorite
- Fine-grained diorite-gabbro
- Soil



Title **HLX29** **Appendix 2**

ROCKTYPELAXEMAR

- Fine-grained granite
- Quartz monzodiorite
- Soil



Title HLX32 **Appendix 2**

ROCKTYPELAXEMAR

- Fine-grained granite
- Pegmatite
- Granite
- Quartz monzodiorite
- Fine-grained diorite-gabbro
- Soil