P-08-21

Oskarshamn site investigation

Core drilling of short borehole KLX14A

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March 2008

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ISSN 1651-4416
SKB P-08-21

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Keywords: Core drilling, Investigation of deformation zones, Hydraulic injection tests.

Abstract

Drilling of the short cored borehole KLX14A was made to gain further knowledge of the southern part of deformation zone NS059.

The borehole was drilled in August and September, 2006 to planned length.

The drill core is dominated by Quartz monzodiorite with intercalations of fine-grained granite. Thin veins of dolerite were encountered in an interval coinciding with elevated amount of rock oxidization and fracture frequency between ca 68 and 115 m. This interval corresponds well with the anticipated position of deformation zone NS059.

Sammanfattning

Det korta kärnborrhålet KLX14A borrades för att ge ökad kunskap om den södra delen av deformationszon NS059.

Kärnborrhålet borrades i augusti och september 2006 till planerad längd.

Borrkärnan domineras av kvartsmonzodiorit med inslag av finkornig granit. Tunna diabasgångar påträffades i ett intervall som sammanfaller med ökad mängd oxidation i berget och förhöjd sprickfrekvens mellan ca 68 och 115 m. Detta intervall sammanfaller väl med det förväntade läget på deformationszon NS059.

Contents

1 Introduction

SKB performs site investigations in order to evaluate the feasibility of locating a deep repository for spent nuclear fuel in Oskarshamn municipality, Sweden /1/.

Drilling of the short cored borehole KLX14A was made to gain further knowledge of the southern part of deformation zone NS059 /2/.

The location of borehole KLX14A is shown in Figure 1-1.

The drilling and all related on-site operations were performed according to specific activity plans, see Table 1-1. Reference is given in the activity plans to procedures in the SKB Method Description for Core Drilling (SKB MD 620.003, Version 2.0) and relevant method instructions for handling of chemicals, surveying and evaluation of cuttings. Method descriptions and activity plans are SKB internal documents.

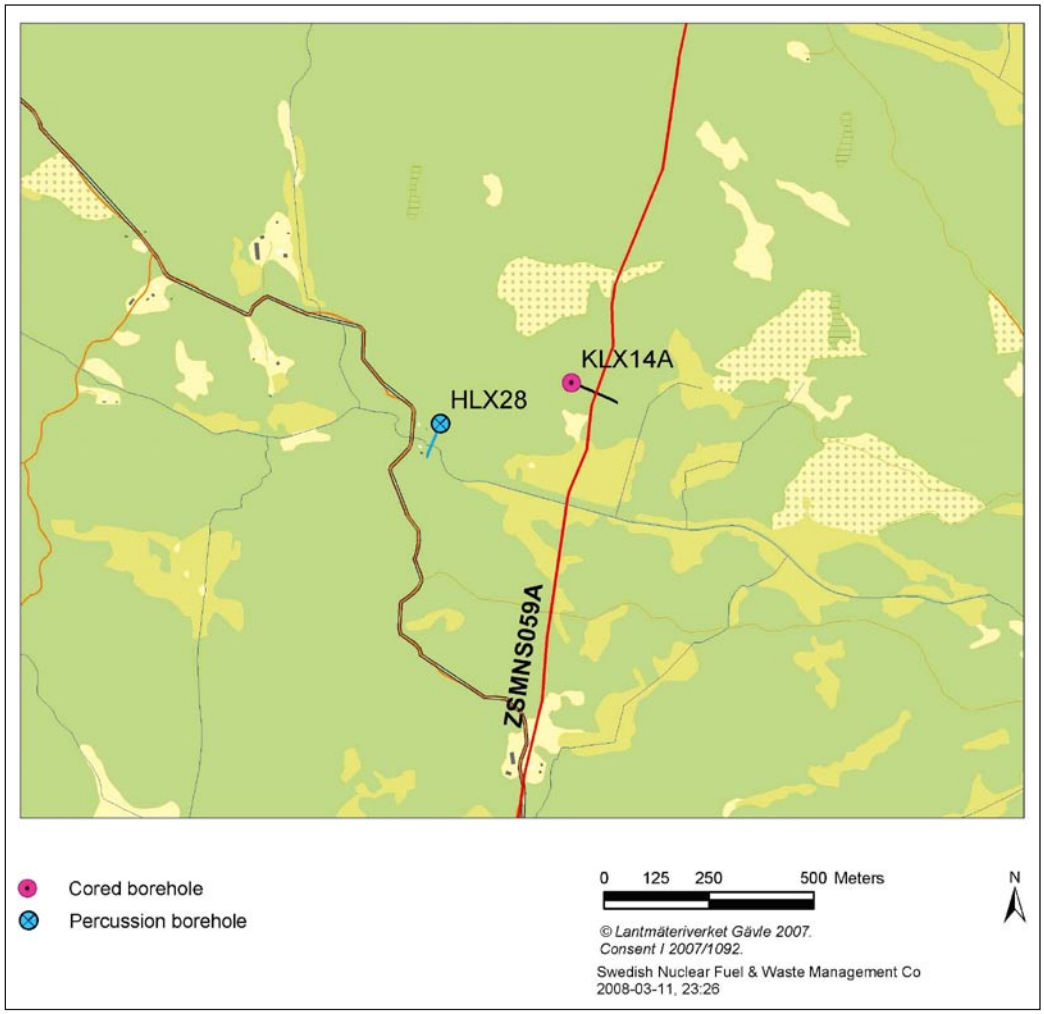


Figure 1-1. *Location of the short cored borehole KLX14A together with the flushing water source HLX28 and deformation zone NS059.*

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

Activity plan	ID Number	Version
Kärnborrning KLX14A	AP PS 400-06-091	1.0
Method descriptions	**ID Number**	**Version**
Metodbeskrivning för kärnborrning	SKB MD 620.003	2.0
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 längdmarkering i kärnborrhål	SKB MD 620.009	2.0
Instruktion för hantering och provtagning av borrkärna	SKB MD 143.007	1.0
Instruktion för miljökontroll av ytnära grundvatten och mark vid borrning och pumpning i berg	SKB MD 300.003	2.0

All drilling data was stored in the SICADA database for Oskarshamn.

The decision to drill KLX14A was taken on 2006-06-27, SKB id 1056704, internal document.

A letter of information to the Regional Authority, Länstyrelsen Kalmar län, was sent on 2006-06-30, SKB id 1056970, internal document.

2 Objective and scope

This report will describe the drilling of the short cored boreholes KLX14A and the measurements of hydraulic responses performed as part of the drilling activity.

The main objective for the borehole prior to drilling was to improve the understanding of modelled deformation zone NS059. The borehole was expected to drill through the deformation zone at 70 to 150 m drilled length.

3 Equipment

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

3.1 Drilling equipment

Drilling of borehole KLX14A was made with a trackmounted, self-propelled Geomachines GM200 drilling machine supplied with accessories.

The main core drilling was done with N-size, ie giving a borehole of 76 mm diameter. The core barrel was of the type AC Corac N3/50, a triple-tube wireline equipment which gives a core diameter of 50.2 mm. The rods were of type NT.

Reaming of the borehole wall in order to place a casing was made with HQ equipment. The HQ bit gives a borehole diameter of 96 mm.

Drilling through overburden was made by casing drilling with dimension HV, giving a hole of 116 mm diameter.

Figure 3-1. *The Geomachines GM200 drill rig.*

3.2 Equipment for measurements and sampling

In accordance with the activity plans, measurements of drill penetration rate, flushing and return water flow and flushing water pressure were not done during the drilling activity.

Hydraulic injection tests, performed with the drill rig at the drill site, were made in three different intervals as part of the drilling activity

4 Execution

Drilling and borehole completion were made by contractor Drillcon AB.

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,
- core drilling in hard rock and casing grouting,
- observations, measurements and flushing water handling,
- borehole completion,
- hydraulic responses,
- data handling,
- environmental control.

An overview of the time schedule for core drilling of borehole KLX14A is given in Figure 4-1.

4.1 Preparations

The preparation stage included the Contractor's functional control of equipment. The machinery and chemicals 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

Drilling through unconsolidated overburden was done from the surface to 3.20 m metres below reference level (TOC) by casing drilling with HV equipment which gives a 116 mm diameter hole.

4.3 Core drilling in hard rock and casing grouting

Core drilling was started with N-size drilling (76 mm diameter) at the bedrock surface, i.e. 3.20 metres below reference level. The borehole was then reamed between 3.20 and 6.45 m to a diameter of 96 mm and a casing with 90/77 mm diameter was emplaced.

In order to prevent surface water and shallow groundwater to infiltrate into deeper parts of the borehole, the annular space between the borehole wall and the casing was grouted with cement, see Figure 4-2.

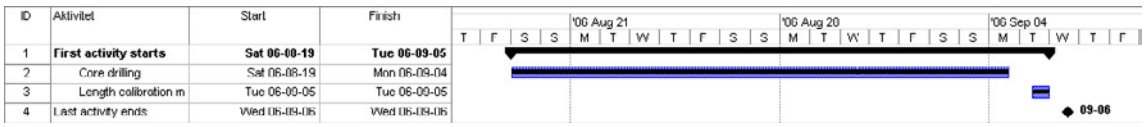


Figure 4-1. *Overview of the time schedule for core drilling of borehole KLX14A.*

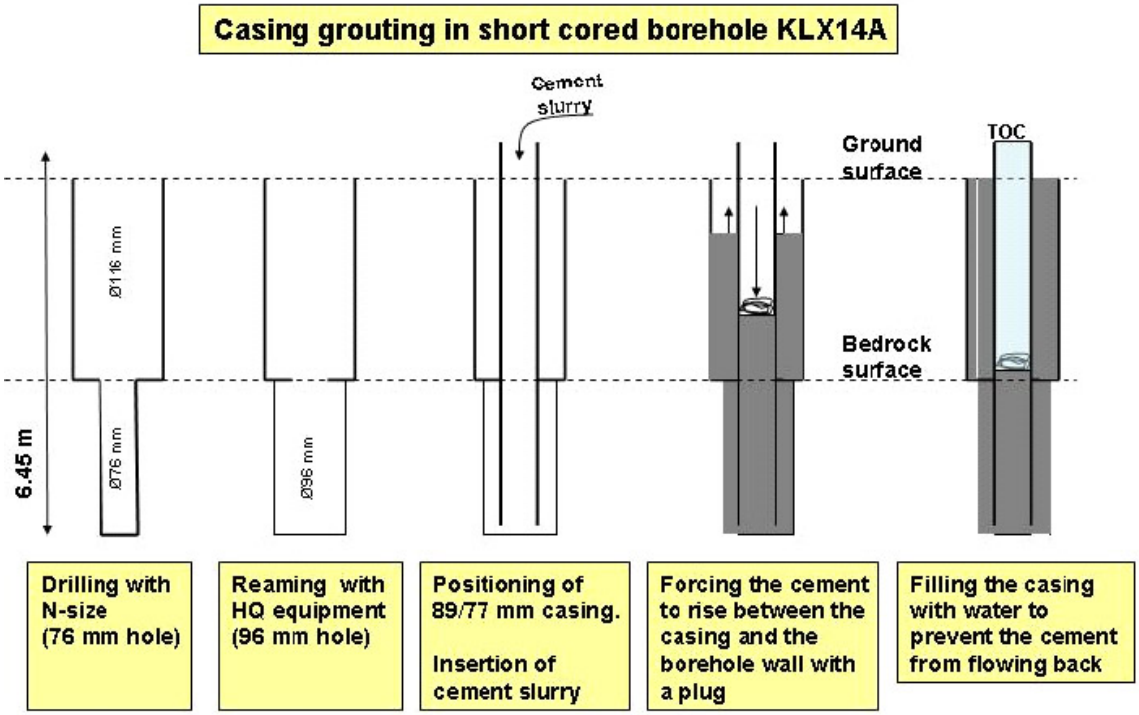


Figure 4-2. *Casing installation and grouting in borehole KLX14A.*

The stainless steel casing was emplaced and cement slurry for casing grouting was entered into the casing. A plug of paper was placed on top of the slurry. The plug, and hence the cement slurry, is forced down the borehole making the slurry rise on the outside of the casing thus filling the annular space between casing and borehole wall. The casing was then filled with water to provide buoyancy and prevent the cement from flowing back. The casing grouting was done on August 20, 2006.

The concrete was allowed to harden. No data is available on possible reductions in the water level in the casing during the time of concrete hardening, see also section 5.6 “Nonconformities”.

Drilling with N-size was then made to remove the concrete inside the casing. Core drilling in rock could then be resumed to planned length.

4.4 Observations, measurements and flushing water handling

No water losses or reductions in flushing water pressure during drilling were noted by the drill crew.

Manual measurements of ground water levels were taken in KLX14A at the start of the shift before the drilling started up for the day, see Table 4-1.

The water was transported to the drill site in water tanks. A uranine tracer was added by the SKB drill coordinators. No measurements of the return water volumes were made.

Deviation measurements were not made as part of the drilling activities.

Table 4-1. Manual measurements of ground water levels.

Borehole	Section length in borehole from (m)	to (m)	Date and time*	Measured depth (metres along borehole)
KLX14A	6.45	47.18	2006-08-24 06:00:00	12.00
KLX14A	6.45	74.18	2006-08-25 06:00:00	12.10
KLX14A	6.45	87.76	2006-08-26 06:00:00	14.40
KLX14A	6.45	90.91	2006-08-27 06:00:00	13.90
KLX14A	6.45	108.55	2006-08-28 06:00:00	14.05
KLX14A	6.45	117.47	2006-08-29 06:00:00	14.15
KLX14A	6.45	129.73	2006-08-30 06:00:00	14.15
KLX14A	6.45	137.27	2006-09-01 06:00:00	14.33
KLX14A	6.45	146.27	2006-09-02 06:00:00	14.12
KLX14A	6.45	158.27	2006-09-03 06:00:00	14.00
KLX14A	6.45	167.27	2006-09-04 06:00:00	13.84
KLX14A	6.45	176.27	2006-09-06 06:00:00	14.60
KLX14A	6.45	176.27	2006-09-06 08:00:00	14.17

* local time ie including daylight saving time (GMT+2)

4.5 Borehole completion

Reaming of depth reference slots was made in boreholes according to Table 4-2 where the positions of the reamed slots and the dates for reaming are given.

When the drilling was completed the holes was rinsed from drill cuttings and water by flushing with high pressure nitrogen gas. The times and dates for flushing of the boreholes with nitrogen gas for rinsing of water and cuttings are given in Table 4-3.

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

Table 4-2. Position and reaming dates of depth reference slots in borehole KLX14A.

Borehole	Start date	Reference slot position (m)	Slot traceable
KLX14A	2006-09-05	50.00	Yes
KLX14A	2006-09-05	100.00	Yes
KLX14A	2006-09-05	150.00	No

Table 4-3. Dates and times* for nitrogen gas flushings in KLX14A.

Borehole	Date	Time*	From (m)	To (m)
KLX14A	2006-09-09	7.00–12.00**	6.45	176.27
KLX14A	2006-09-22	16.00–16.30	6.45	176.27
KLX14A	2006-09-23	10.10–11.00	6.45	176.27

* the times are given in local time ie with daylight saving time

** the time interval is given in the activity logs and Sicada database. It is nevertheless likely that nitrogen gas lifting was performed also during the afternoon of September 9 judging from hydraulic responses, see section 5.2.

The drilling 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.

Deviation measurements were not made in conjunction with drilling of KLX14A but were performed as part of separate geophysical logging activity, AP PS-400-06-083, SKB internal document. The final deviation file (code EG154 in the Sicada database) is based on deviation measurements together with the surveyed bearing and inclination of the casing. The calculations are made according to routines specified in the Sicada database and general expert judgement. Further comment on the method for calculation of the final borehole deviation is given in /3/.

4.6 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.

4.7 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 in the immediate vicinity of the drilling area.

The nominal amount of drill cuttings liberated from drilling with N-size (76 mm diameter) is 700 kg per 100 m of drilling which would give 1,230 kg from 176 metres of drilling.

5 Results

The short cored borehole KLX14A was drilled to planned length in order to gain further knowledge of the deformation zone NS059.

5.1 Borehole technical summary

Geometric and technical data from the borehole are presented in Table 5-1.

A technical drawing of the borehole is given in Appendix 1. Core losses were noted during the geological mapping. The intervals are given in Table 5-2.

5.2 Hydrogeological results

No record of the amount of flushing water consumed during drilling of the borehole was kept.

Table 5-1. Geometric and technical data for borehole KLX14A.

Parameter	KLX14A	
Drilling period	From 2006-08-19 to 2006-09-04	
Borehole inclination (starting point) (0 to –90)	–49.96°	
Borehole azimuth (0–360)	111.95°	
Borehole length	176.27 m	
Soil depth	3.20 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6365959.69 m Easting: 547146.87 m Elevation: 16.35 m.a.s.l.	
Borehole diameter	0.3–3.20 m	116 mm
(interval) (diameter mm)	3.20–6.45 m	96 mm
	6.45–176.27	76 mm
Casing diameter	0–6.45 m	$Ø_o$ = 90
(interval) (diameter mm)		$Ø_i$ = 77

Table 5-2. Core losses in KLX14A.

From (m)	To (m)	Core loss (m)
4.19	4.54	0.35
81.68	81.73	0.05
87.66	87.89	0.22
90.73	90.91	0.18
92.35	92.63	0.28
132.93	132.96	0.03

Injection tests

Hydraulic injection tests were made in KLX14A in conjunction with drilling as shown in Table 5-3.

Hydraulic responses

Monitoring of hydraulic responses was done during the drilling activities in KLX14A in a number of near-by percussion and core drilled observation boreholes, see Figure 5-1.

Table 5-3. Hydraulic injection tests in KLX14A.

Borehole ID	Date	From BH length (m)	To BH length (m)	Section length (m)	Test no	Injection pressure (kPa)	Injected volume (L)	Injection time (seconds)
KLX14A	20060823	7.4	47.18	39.78	1	200	84	600
KLX14A	20060823	7.4	47.18	39.78	2	500	174	600
KLX14A	20060826	72	89.18	17.18	1	200	75	600
KLX14A	20060826	72	89.18	17.18	2	500	118	600
KLX14A	20060906	7.27	176.27	169	1	200	514	600

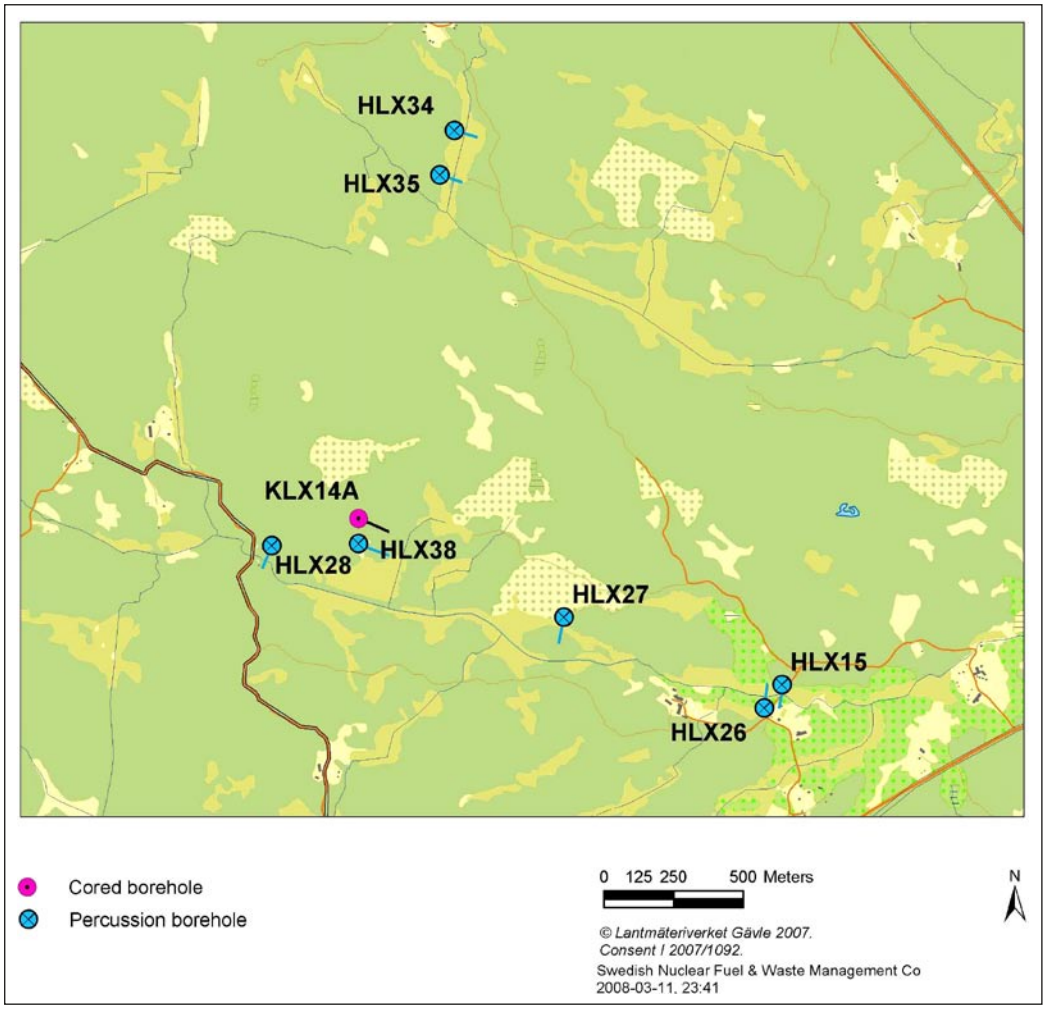


Figure 5-1. *Location of KLX14A and the observation boreholes for study of hydraulic responses.*

No hydraulic response could be seen in observation boreholes HLX28, HLX32, HLX34, HLX35, KLX03 or KLX11A. No water level data was available from KLX20A during the nitrogen lifting in KLX14A.

A distinct response from nitrogen lifting and probably also from reaming of reference slots in KLX14A could be seen in HLX38, see Figure 5-2. The groundwater level in borehole HLX38 is affected by nitrogen gas lifting in borehole KLX14A. Clear hydraulic responses from the nitrogen gas lifting in KLX14A can be seen as drawdowns in HLX38 on September 9, 22 and 23. It should be noted that there is also a hydraulic response in HLX38 on the afternoon of September 9, 2006. There is no note of nitrogen lifting or any other activity in KLX14A at this time that would give a drawdown in HLX38. It is nevertheless likely that the drawdown on the afternoon of September 9 is caused by nitrogen lifting in KLX14A.

The temporary increase in water level on September 6 and 7 coincide in time with reaming of reference slots in KLX14A and are therefore here interpreted as a hydraulic injection response.

5.3 Geological results

A preliminary geological mapping of the cores was done as part of the drilling activity. The geological results, given as major lithological units and observations on rock alteration, are given in Appendix 2 together with the fracture frequency expressed as open fractures except those included in crushed zones.

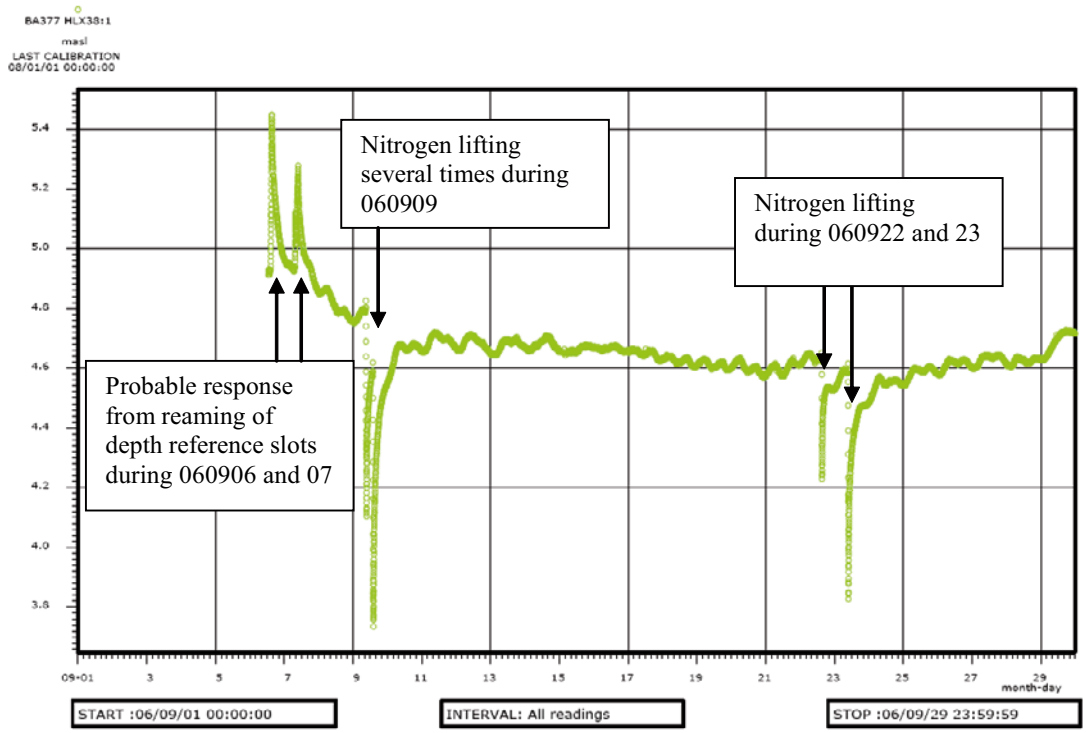


Figure 5-2. *Groundwater level in borehole HLX38 during nitrogen gas lifting in borehole KLX14A, 2006-09-01 to 2006-09-29. Clear hydraulic responses from nitrogen gas lifting in KLX14A can be seen as drawdowns in HLX38 on September 9, 22 and 23. The temporary increase in water level on September 6 and 7 are here interpreted as hydraulic responses from reaming of reference slots in KLX14A. The times are given in Swedish Normal Time GMT+1.*

The drill core is dominated by Quartz monzodiorite with intercalations of fine-grained granite. Thin veins of dolerite were encountered in an interval coinciding with elevated amount of rock oxidization and fracture frequency between ca 68 and 115 m. This interval corresponds well with the anticipated position of deformation zone NS059.

5.4 Hydrogeochemistry

No water samples were taken during the drilling activity.

5.5 Consumption of oil and chemicals

A total of 20 litres of concrete slurry was used for casing grouting in KLX14A.

No other amounts of consumption of other chemical compounds have been noted.

5.6 Nonconformities

No record of the amount of flushing water consumed during drilling of KLX14A was kept.

Testing the water tightness of the casing grouting was not done according to the method instruction.

6 References

/1/ **SKB, 2001.** Geovetenskapligt program för platsundersökning vid Simpevarp. SKB R-01-44, Svensk Kärnbränslehantering AB.

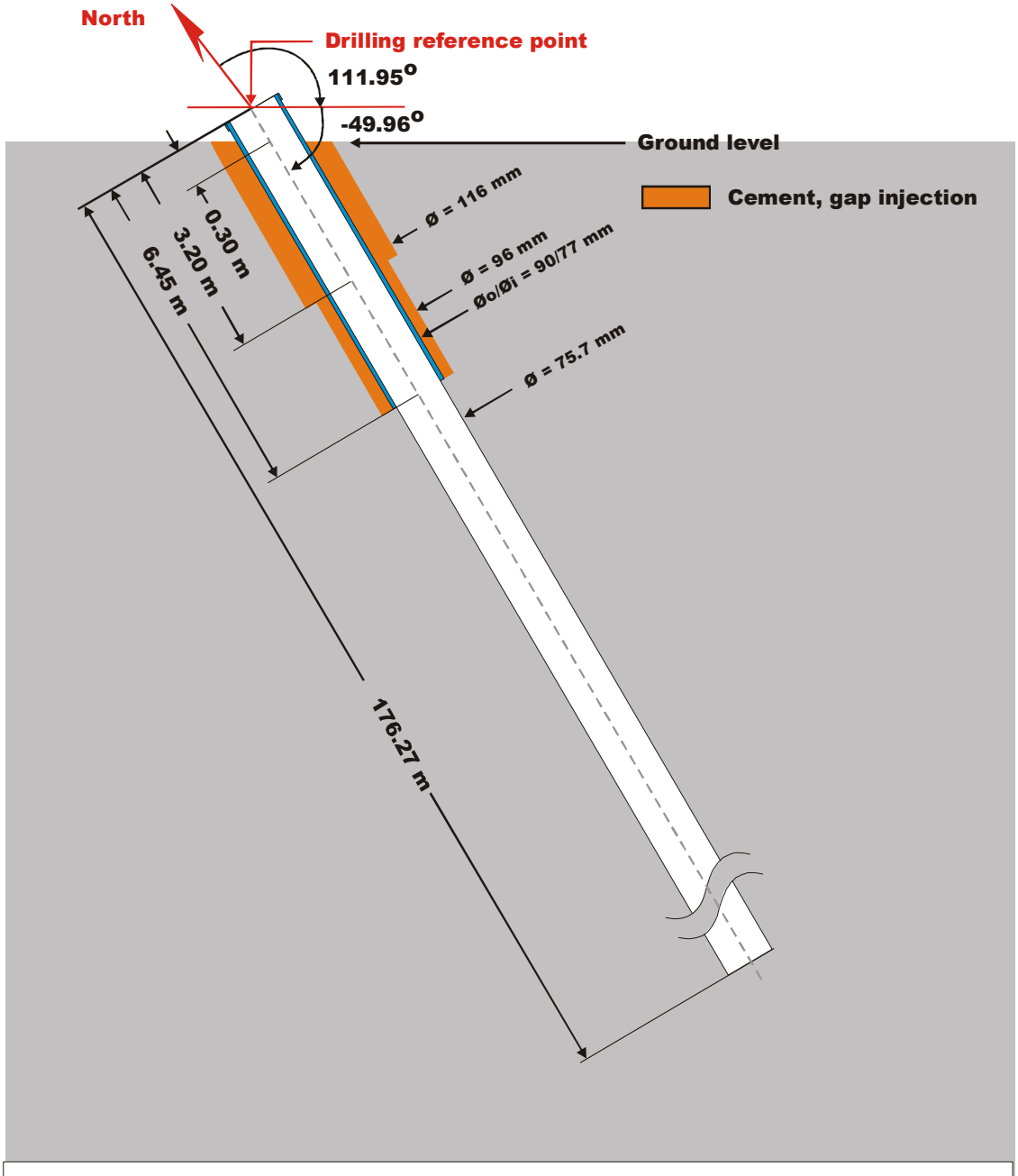
/2/ **SKB, 2005.** Program för fortsatta undersökningar av berggrund, mark, vatten och miljö inom delområde Laxemar. SKB R-05-37, Svensk Kärnbränslehantering AB.

/3/ **Stenberg L, Håkanson N, 2007.** Revision of borehole deviation measurements in Oskarshamn. SKB P-07-55, Svensk Kärnbränslehantering AB.

Technical data of cored borehole KLX14A

Technical data

Borehole KLX14A



Drilling reference point

Northing: 6365959.69 (m), RT90 2,5 gon V 0:-15
Easting: 1547146.87 (m), RT90 2,5 gon V 0:-15
Elevation: 16.35 (m), RHB 70

Drilling period

Drilling start date: 2006-08-19
Drilling stop date: 2006-09-04

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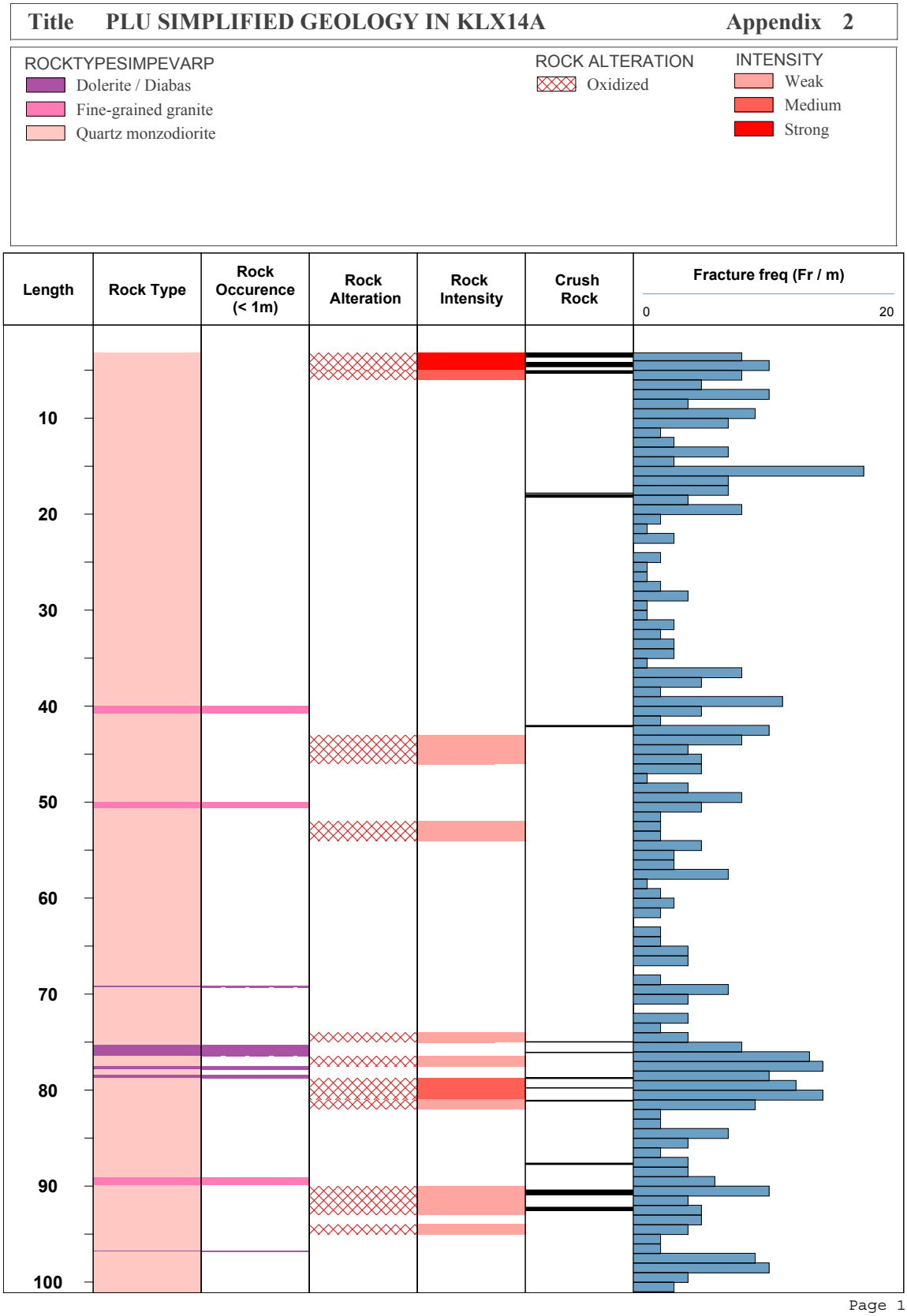
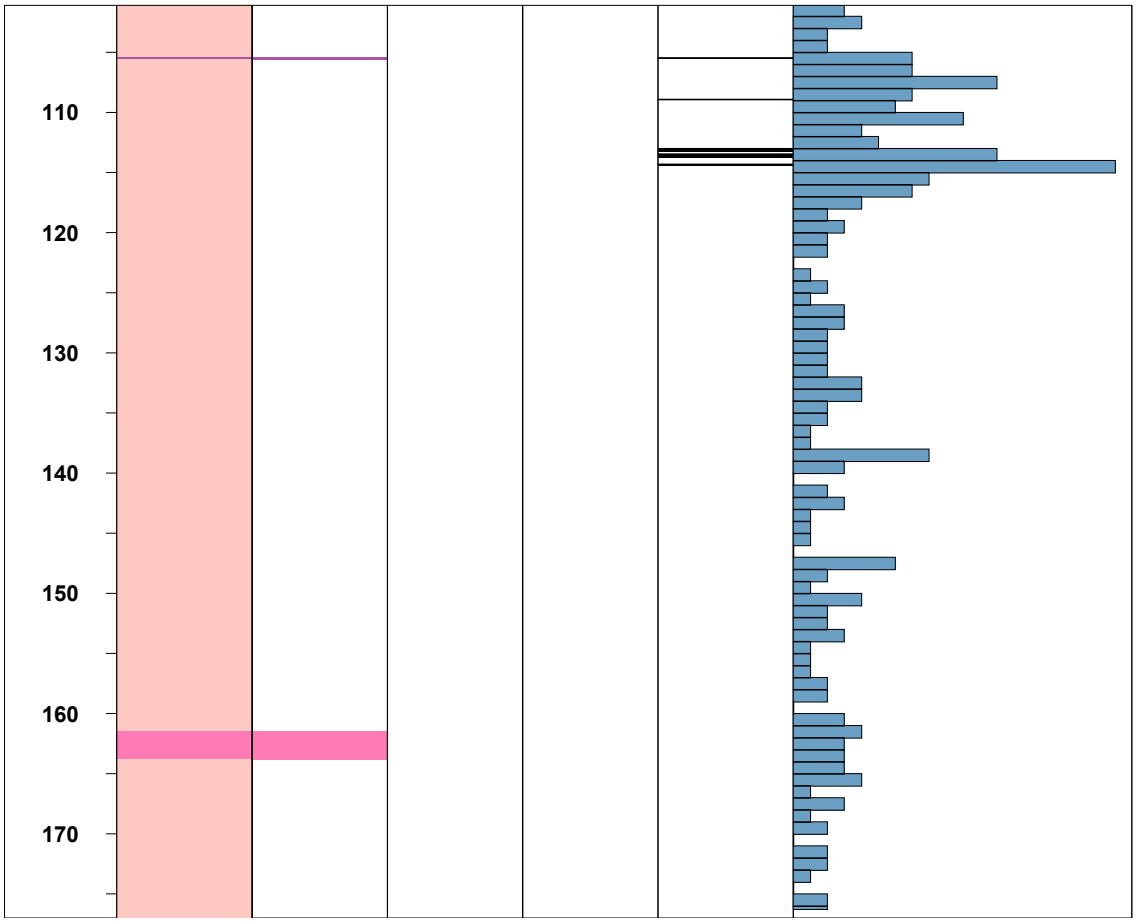
Results from the preliminary geological logging in borehole KLX14A

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