P-06-297

Oskarshamn site investigation

Core drilling of 13 short boreholes (KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A) for investigation of minor deformation zones (MDZ)

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January 2007

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

Abstract

Drilling of the 13 short cored boreholes KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A was made to gain further knowledge of the characteristics and spatial distribution of minor deformation zones.

The boreholes were drilled between January and September, 2006 to planned lengths between 50 and 150 m.

Sammanfattning

De 13 korta kärnborrhålen KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A och KLX29A borrades för att ge ökad kunskap om karaktären och den spatiala fördelningen av mindre deformationszoner, MDZ.

De korta kärnborrhålen borrades mellan januari och september 2006 till planerade längder mellan 50 och 150 meter.

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 boreholes KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A was made to gain further knowledge of the characteristics and spatial distribution of minor deformation zones, MDZ /2/.

The location of the boreholes, KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A, is shown in Figure 1-1.

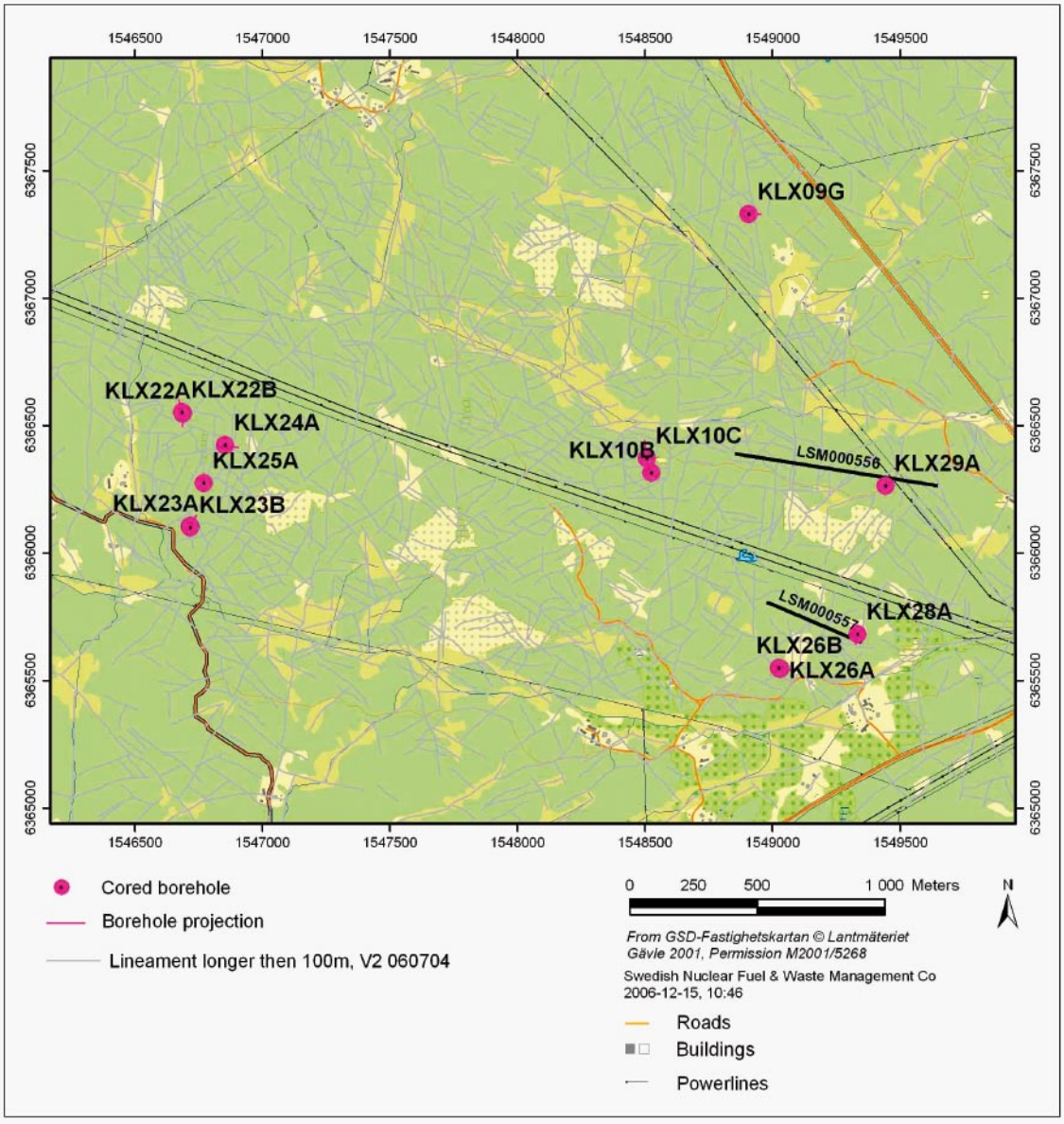


Figure 1-1. *Location of the short cored boreholes KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A in the Laxemar subarea. The location of the refraction seismic profiles LM000556 and LSM000557 are also shown.*

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 1.0) and relevant method instructions for handling of chemicals, surveying and evaluation of cuttings. Method descriptions and activity plans are SKB internal documents.

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

References to the drilling decisions for the boreholes and letters of information to the Regional Authority are given in Table 1-2. The decisions and letters are SKB internal documents.

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

Activity plan	ID Number	Version
Kärnborrning av KLX09G för undersöknng av mindre deformationszon	AP PS 400-05-100	1.0
Kärnborrning av KLX10B och KLX10C, undersökning av mindre deformationszoner	AP PS 400-05-102	1.0
Kärnborrning av ca 10 hål för undersökning av mindre deformationszoner	AP PS 400-06-055	1.0*
Method descriptions	**ID Number**	**Version**
Metodbeskrivning för kärnborrning	SKB MD 620.003	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 spolvattenhantering	SKB MD 620.007	1.0
Metodbeskrivning för krökningsmätning av hammar- och kärnborrhål	SKB MD 224.001	1.0
Instruktion för utsättning och ansättning av hammar- och kärnborrhål	SKB MD 600.002	1.0
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

* Three amendments to the activity plan exist.

Table 1-2. Drilling decision and information of Regional Authority reference table.

Borehole	Drilling decision (SKB document ID)	Letter of information to the Regional Authority (SKB document ID)
KLX09G	1049230	1047829
KLX10B and KLX10C	1049359	1047829
KLX22A, KLX22B, KLX23A and KLX23B	1054398	1052998 1053754
KLX24A and KLX25A	1055488	1052998 1053754
KLX26A and KLX26B	1057540	1056388
KLX28A and KLX29A	1059292	1058966

2 Objective and scope

This report will describe the drilling of the thirteen short cored boreholes; KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A and the measurements of hydraulic responses performed as part of the drilling activity.

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

Table 2-1. Borehole objectives prior to drilling.

Borehole	Drilling objective
KLX09G	The borehole would intercept a possible MDZ related to a magnetic surface lineament at 75 m drilled length if the zone is vertical. Trenching had been before drilling.
KLX10B	The borehole was drilled towards a lineament that was believed to be a dike of fine-grained granite.
KLX10C	The borehole was drilled towards three east-west trending magnetic anomalies.
KLX22A	The borehole was drilled towards a lineament identified by LIDAR (laser-scanning of topography) and detailed ground geophysical measurements. Check-up measurements with magnetometer and measurements of magnetic susceptibility on outcrops were also before drilling. Field work had identified the lineament as a ca 20 m wide depression with a steep rock exposure on the northern side. The borehole would reach a vertical MDZ related to the surface lineament at 30–90 m drilled length.
KLX22B	The borehole was drilled towards a lineament identified by LIDAR (laser-scanning of topography) and detailed ground geophysical measurements. Check-up measurements with magnetometer and measurements of magnetic susceptibility on outcrops were also before drilling. The borehole would reach a vertical MDZ related to the surface lineament at 50–60 m drilled length.
KLX23A	The borehole was drilled towards a lineament identified by LIDAR (laser-scanning of topography) and detailed ground geophysical measurements. Check-up measurements with magnetometer and measurements of magnetic susceptibility on outcrops were also before drilling. The borehole would reach a vertical MDZ related to the surface lineament at 50–60 m drilled length.
KLX23B	The borehole was drilled under an area that had been trenched. A low-magnetic signature was established in the trenched area. The borehole would reach a vertical MDZ related to the magnetic anomaly at 30–40 m drilled length.
KLX24A	The borehole was drilled towards two topographically and magnetically identified lineaments recognised by LIDAR (laser-scanning of topography) and detailed ground geophysical measurements. Geological field checks were made before drilling. Drilling would encounter any vertical structures related the surface lineaments at ca 40 and 90 metres drilled length respectively.
KLX25A	The borehole was drilled towards a topographically and magnetically identified lineament recognised by LIDAR (laser-scanning of topography) and detailed ground geophysical measurements. Geological field checks were made before drilling. Drilling would encounter a vertical structures related the surface lineament at 25–30 metres drilled length respectively.
KLX26A	The borehole was drilled towards: • one magnetically identified lineament and • one topographically and magnetically identified lineament. The lineaments are “coordinated” lineaments (recognised by LIDAR (laser-scanning of topography) and detailed ground geophysical measurements) according to preliminary model version L2.1, June 2006. Geological field checks were made before drilling. Drilling would encounter vertical structures related to the magnetic surface lineament at ca 30 metres and the topographically and magnetically lineament at ca 80 m drilled length.
KLX26B	The borehole was drilled towards a magnetically identified lineament from detailed ground geophysical measurements. The lineament is a “coordinated” lineament according to preliminary model version L2.1, June 2006 and probably consists of a fine-grained granite dike. Trenching was made 20 metres west of the borehole. Drilling would encounter a vertical structure related to the magnetic surface lineament at ca 30 metres drilled length and the topographically and magnetically lineament at ca 80 m drilled length.
KLX28A	The borehole was drilled towards an E-W trending lineament that coincides with a seismic low-velocity zone from profile LSM000557 /3/. The lineament is recognised by LIDAR (laser-scanning of topography) and detailed ground geophysical measurements.
KLX29A	The borehole was drilled towards a NE-SW trending lineament that coincides with a seismic low-velocity zone from profile LSM000556 /3/. The lineament is topographically visible in the field.

3 Equipment

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

3.1 Drilling equipment

Drilling of the 13 short cored boreholes was made with a trackmounted, self-propelled Geomachines GM200 drilling machine supplied with accessories.

The main core drilling was done with N-size, i.e. 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 only done in KLX28A. This was made by casing drilling with dimension HV, giving a hole of 116 mm diameter.

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 responses in observation boreholes were measured with Mini-Troll pressure loggers.

Hydraulic injection tests, performed with the drill rig at the drill site, were made over the entire length of the boreholes as part of the activity plan AP-PS 400-06-055 in KLX22A–KLX29A.

Figure 3-1. *The Geomachines GM200 drill rig at KLX10C.*

Figure 3-2. *The split-inner tube of the N3/50 core barrel with unbroken drill core.*

4 Execution

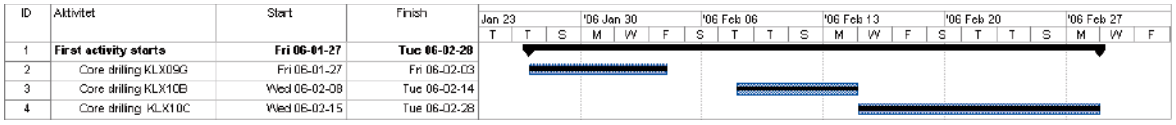
Drilling and borehole completion were made by contractor Drillcon AB.

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.

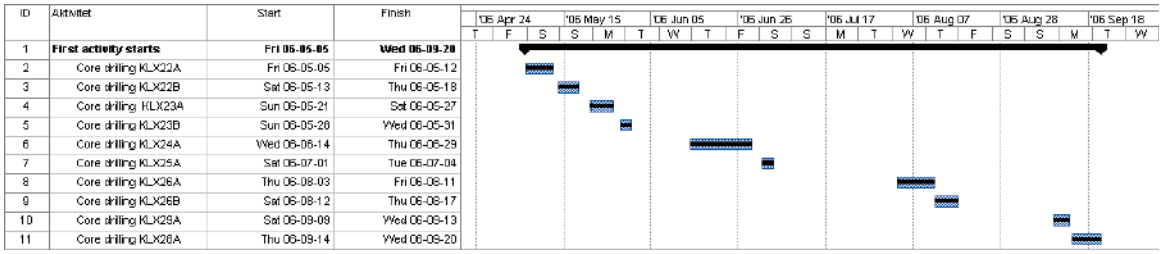
An overview of the time schedule for core drilling of boreholes KLX09G, KLX10B and KLX10C is given in Figures 4-1.

An overview of the time schedule for core drilling of boreholes KLX22A-KLX29A is given in Figure 4-2.



ID	Aktivitet	Start	Finish
1	**First activity starts**	**Fri 06-01-27**	**Tue 06-02-28**
2	Core drilling KLX09G	Fri 06-01-27	Fri 06-02-03
3	Core drilling KLX10B	Wed 06-02-08	Tue 06-02-14
4	Core drilling KLX10C	Wed 06-02-15	Tue 06-02-28

Figure 4-1. *Overview of the time schedule for core drilling of boreholes KLX09G, KLX10B and KLX10C.*



ID	Aktivitet	Start	Finish
1	**First activity starts**	**Fri 06-05-05**	**Wed 06-09-20**
2	Core drilling KLX22A	Fri 06-05-05	Fri 06-05-12
3	Core drilling KLX22B	Sat 06-05-13	Thu 06-05-18
4	Core drilling KLX23A	Sun 06-05-21	Sat 06-05-27
5	Core drilling KLX23B	Sun 06-05-28	Wed 06-05-31
6	Core drilling KLX24A	Wed 06-06-14	Thu 06-06-29
7	Core drilling KLX25A	Sat 06-07-01	Tue 06-07-04
8	Core drilling KLX26A	Thu 06-08-03	Fri 06-08-11
9	Core drilling KLX26B	Sat 06-08-12	Thu 06-08-17
10	Core drilling KLX28A	Sat 06-09-09	Wed 06-09-13
11	Core drilling KLX26A	Thu 06-09-14	Wed 06-09-20

Figure 4-2. *Overview of the time schedule for core drilling of boreholes KLX22A-KLX29A.*

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 only done in KLX28A. Drilling in this borehole was done from the surface to 2.85 m metres below reference level (TOC) by casing drilling with HV equipment which gives a 116 mm diameter hole. A temporary casing was left in the borehole in order to stabilise the overburden for core drilling in rock and emplacement of the 96 mm casing, see section 4.3.

4.3 Core drilling in hard rock and casing grouting

Core drilling in twelve boreholes; i.e. all boreholes except KLX28A, was started with N-size drilling (76 mm diameter) directly on the bedrock surface. Drilling with N-size was done to lengths as given in Table 4-1. Reaming was then done to a 96 mm diameter with HQ equipment.

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 casings was grouted with cement, see Figures 4-3 and 4-4.

Table 4-1. Drilled length with dimension N and HQ at the time for gap injection in the 13 MDZ boreholes.

Borehole	Diameter 76 mm Size N (length m)	Diameter 96 mm Size HQ (length m)	Comment
KLX09G	9.74	9.30	Drilling started in bedrock with N-size
KLX10B	9.35	9.00	Drilling started in bedrock with N-size
KLX10C	9.96	9.00	Drilling started in bedrock with N-size
KLX22A	2.05	2.00	Drilling started in bedrock with N-size
KLX22B	3.10	2.00	Drilling started in bedrock with N-size
KLX23A	2.89	2.35	Drilling started in bedrock with N-size
KLX23B	2.60	2.30	Drilling started in bedrock with N-size
KLX24A	2.98	2.41	Drilling started in bedrock with N-size
KLX25A	2.40	2.20	Drilling started in bedrock with N-size
KLX26A	2.64	2.64	Drilling started in bedrock with N-size
KLX26B	3.07	2.31	Drilling started in bedrock with N-size
KLX28A	5.30	5.10	Soil drilling with HV to 2.85 m
KLX29A	2.91	2.35	Drilling started in bedrock with N-size

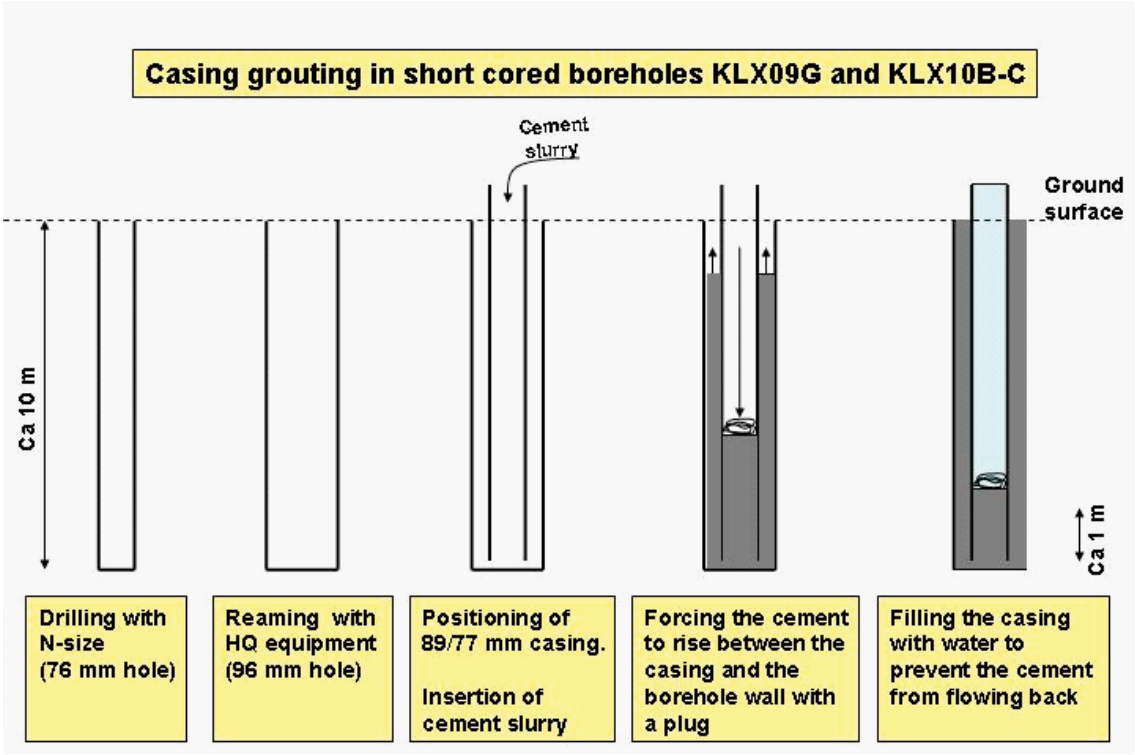


Figure 4-3. *Casing installation and grouting in boreholes KLX09G, KLX10B and KLX10C.*

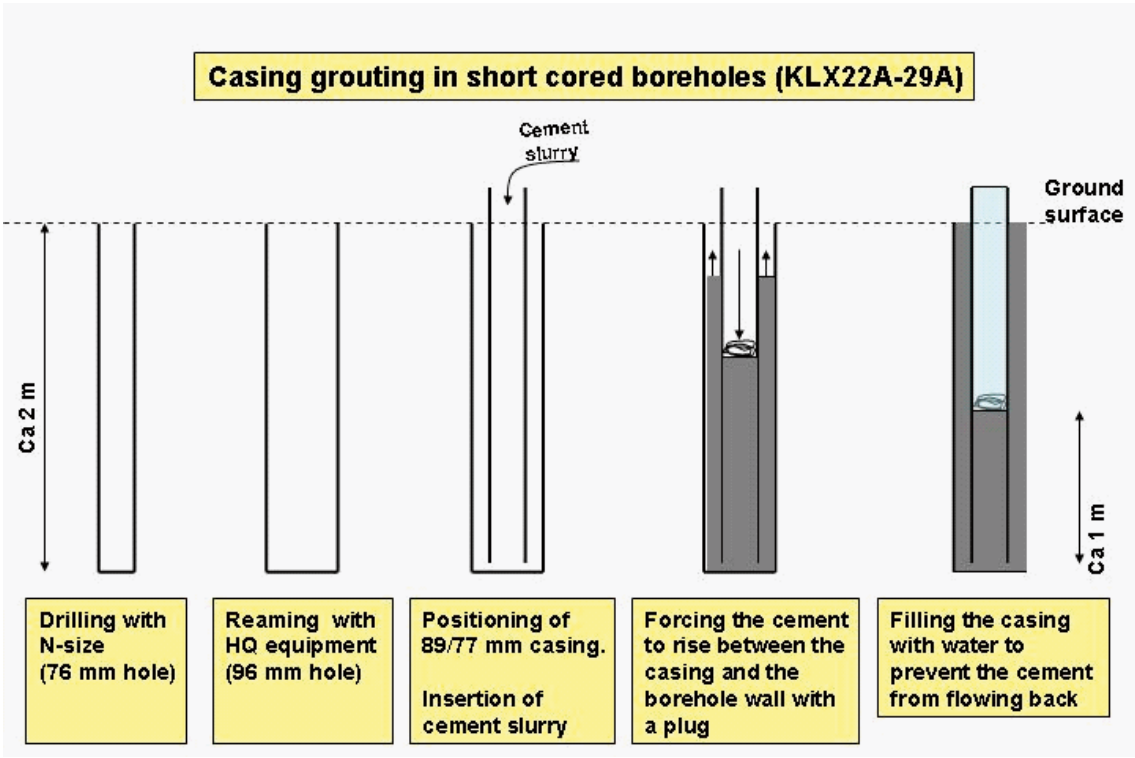


Figure 4-4. *Casing installation and grouting in boreholes KLX22A–KLX29A.*

In the typical case, drilling was commenced with N-size drilling to a depth of ca 2 metres. The borehole was then reamed to a diameter of 96 mm. 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 dates and times for the casing grouting are given in Table 4-2. The resulting grouting of the annular seal is shown in the technical drawings in Appendix 1.

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.

In the case of KLX28A the temporary casing from drilling through the overburden was removed after the emplacement of the 89/77 mm casing but before the gap injection.

4.4 Observations, measurements and flushing water handling

The observations from drilling are summarized in Table 4-3. No water losses or reductions in flushing water pressure during drilling were noted by the drill crew.

Manual measurements of ground water levels were typically taken in KLX22A–29A at the start of the shift before the drilling started up for the day, see Table 4-4.

Table 4-2. Dates and times for the casing grouting.

Borehole	Start Date	Stop Date
KLX09G	2006-01-28 16:00	2006-01-28 18:00
KLX10B	2006-02-09 16:00	2006-02-09 18:00
KLX10C	2006-02-15 15:00	2006-02-15 16:00
KLX22A	2006-05-05 14:00	2006-05-05 15:00
KLX22B	2006-05-13 11:30	2006-05-13 12:30
KLX23A	2006-05-21 12:00	2006-05-21 12:30
KLX23B	2006-05-28 16:00	2006-05-28 17:00
KLX24A	2006-06-14 14:00	2006-06-14 15:00
KLX25A	2006-07-01 16:00	2006-07-01 17:00
KLX26A	2006-08-08 15:00	2006-08-18 16:00
KLX26B	2006-08-12 12:00	2006-08-18 13:00
KLX29A	2006-09-09 15:00	2006-09-09 16:00
KLX28A	2006-09-14 15:00	2006-09-14 16:00

Table 4-3. Observations by the drill crew during drilling.

Borehole	Observation
KLX10C	Core loss 24.50–24.75
KLX22A	Fracture at 9.00 m

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

Borehole	Section length in borehole from (m)	to (m)	Date and Time*	measured depth (metres along borehole)
KLX22A	2.00	80.26	2006-05-12 06:30:00	6.88
KLX22A	2.00	100.45	2006-05-13 06:00:00	8.17
KLX22B	2.00	14.22	2006-05-15 06:30:00	4.5
KLX22B	2.00	32.22	2006-05-16 06:30:00	4.5
KLX22B	2.00	56.22	2006-05-17 06:30:00	4.5
KLX22B	2.00	83.22	2006-05-18 06:30:00	4.5
KLX22B	2.00	100.25	2006-05-19 06:30:00	4.59
KLX23A	2.30	11.27	2006-05-23 06:30:00	7.38
KLX23A	2.30	59.27	2006-05-25 06:25:00	8.31
KLX23A	2.30	83.27	2006-05-26 06:30:00	8.39
KLX23A	2.30	95.27	2006-05-27 06:30:00	9.09
KLX23A	2.30	100.15	2006-05-28 06:30:00	9.67
KLX23B	2.30	32.27	2006-05-31 06:05:00	8.4
KLX24A	2.41	22.25	2006-06-18 06:30:00	6.75
KLX24A	2.41	47.25	2006-06-19 06:30:00	9.45
KLX24A	2.41	65.21	2006-06-20 06:00:00	13.35
KLX24A	2.41	68.26	2006-06-28 06:05:00	11.1
KLX24A	2.41	91.72	2006-06-29 06:00:00	11.1
KLX25A	2.20	32.24	2006-07-04 06:00:00	8.3
KLX26A	2.64	28.64	2006-08-06 06:00:00	6.35
KLX26A	2.64	39.61	2006-08-07 06:00:00	7.02
KLX26A	2.64	46.57	2006-08-08 06:00:00	7.95
KLX26A	2.64	77.06	2006-08-10 06:00:00	7.63
KLX26B	2.31	11.35	2006-08-14 06:00:00	6.12
KLX26B	2.31	28.55	2006-08-15 06:00:00	5.05
KLX26B	2.31	40.84	2006-08-16 06:00:00	5.3
KLX26B	2.31	47.7	2006-08-17 06:00:00	5.9
KLX28A	5.10	32.46	2006-09-18 06:00:00	3.7
KLX28A	5.10	53.46	2006-09-19 06:10:00	3.65
KLX28A	5.10	71.46	2006-09-20 06:00:00	3.8
KLX29A	2.35	44.38	2006-09-13 06:00:00	2.05
KLX29A	2.35	60.25	2006-09-14 06:00:00	4.4
KLX29A	2.35	60.25	2006-09-14 08:00:00	3.9

* local time i.e. including daylight saving time.

Figure 4-5. *Drilling at KLX22A.*

The water was transported to the drill site in water tanks. A uranine tracer was added by the SKB drill coordinators who also kept track on the number of water tanks consumed i.e. the amount of water consumed during drilling. No measurements of the return water volumes were made.

Deviation measurements were not made as part of the drilling activities. According to the activity plans measurements with the Maxibor method should have been done in KLX09G, KLX10B and KLX10C. Deviation measurements in these boreholes were, however, performed as part of separate geophysical logging activities.

4.5 Borehole completion

Reaming of depth reference slots was made in boreholes according to Table 4-5 where the positions of the reamed slots and the dates for reaming are given.

Table 4-5. Position and reaming dates of depth reference slots in boreholes for MDZ investigation.

Borehole	Start Date	Stop Date	Reference slot position (m)	
KLX22B	2006-05-19 11:00	2006-05-19 13:00	50.00	80.00
KLX22A	2006-05-19 15:30	2006-05-19 17:30	50.00	80.00
KLX23A	2006-05-28 07:00	2006-05-28 10:30	50.00	80.00
KLX24A	2006-07-01 06:00	2006-07-01 08:00	50.00	80.00
KLX26A	2006-08-18 09:00	2006-08-18 12:20	50.00	80.00
KLX28A	2006-09-20 16:55	2006-09-20 18:10	50.00	N/A

When the drilling was completed the holes were 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 are given in Table 4-6.

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

The drilling 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.

4.6 Hydraulic responses

Monitoring of hydraulic responses was only done during nitrogen gas flushing in KLX22A, KLX22B, KLX23A and KLX23B. All logger installations referred to in this report were emplaced in open holesi.e. no packers were used.

The logger installations were:

Log time: 10 seconds

The log time is the interval between data savings regardless of pressure changes.

4.7 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. NB the data from logging of water levels in boreholes KLX22–KLX23 during nitrogen flushing are not stored in the Sicada database.

Table 4-6. Dates and times* for nitrogen gas flushings in the boreholes for investigation of minor deformation zones.

Borehole	Start Date*	Stop Date*	From (m)	To (m)
KLX09G	2006-02-08 13:00	2006-02-08 15:30	9.30	110.10
KLX10B	2006-03-01**	2006-03-01**	9.00	50.25
KLX10C	2006-03-01 08:30	2006-03-01 11:30	9.00	146.25
KLX23A	2006-07-01 10:00	2006-07-01 17:00	2.30	100.15
KLX23B	2006-07-01 10:00	2006-07-01 17:00	2.30	50.27
KLX24A	2006-07-01 10:00	2006-07-01 17:00	2.41	100.17
KLX22A	2006-07-02 08:50	2006-07-02 10:20	2.00	100.25
KLX22B	2006-07-02 08:50	2006-07-02 10:20	2.00	100.25
KLX25A	2006-07-06 14:23	2006-07-06 14:59	2.20	50.24
KLX26A	2006-08-20 11:11	2006-08-20 11:39	2.64	101.14
KLX26B	2006-08-20 11:59	2006-08-20 12:39	2.31	50.37
KLX29A	2006-09-20 12:30	2006-09-20 14:00	2.35	60.25
KLX29A	2006-09-20 18:30	2006-09-20 19:15	2.35	60.25
KLX28A	2006-09-21 10:30	2006-10-12 11:30	5.10	80.23

* the times are given in local time i.e. with daylight savings time

** no time has been recorded for the nitrogen flushing

4.8 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 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.

5 Results

The short cored boreholes KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A were drilled to planned lengths in order to gain further knowledge of the characteristics and spatial distribution of minor deformation zones, MDZ.

5.1 Borehole technical summary

Geometric and technical data from the boreholes are presented in Tables 5-1 to 5-5.

Technical drawings of the boreholes are given in Appendix 1.

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

Table 5-1. Geometric and technical data for borehole KLX09G, KLX10B and KLX10C.

Parameter	KLX09G		KLX10B		KLX10C	
Drilling period	From 2006-01-27 to 2006-02-03		From 2006-02-08 to 2006-02-14		From 2006-02-15 to 2006-02-28	
Borehole inclination (starting point) (0 to –90)	–60.96°		–59.65°		–60.15°	
Borehole azimuth (0–360)	85.41°		170.33°		352.43°	
Borehole length	100.10 m		50.25 m		146.25 m	
Soil depth	0 m		0 m		0 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6367330.09 m Easting: 1548905.77 m Elevation: 19.63 m.a.s.l.		Northing: 6366316.49 m Easting: 1548525.15 m Elevation: 18.15 m.a.s.l.		Northing: 6366372.07 m Easting: 1548506.94 m Elevation: 16.94 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–9.30 m 9.30–100.10 m	96 mm 75.7 mm	0.3–9.00 m 9.00–50.25 m	96 mm 75.7 mm	0.3–9.00 m 9.00–146.25 m	96 mm 75.7 mm
Casing diameter (interval) (diameter mm)	0–9.30 m	$Ø_o$ = 89 $Ø_i$ = 77	0–9.00 m	$Ø_o$ = 89 $Ø_i$ = 77	0–9.00 m	$Ø_o$ = 89 $Ø_i$ = 77

Table 5-2. Geometric and technical data for borehole KLX22A, KLX22B and KLX23A.

Parameter	KLX22A		KLX22B		KLX23A	
Drilling period	From 2006-05-05 to 2006-05-12		From 2006-05-13 to 2006-05-18		From 2006-05-21 to 2006-05-27	
Borehole inclination (starting point) (0 to –90)	–59.93°		–61.24°		–61.24°	
Borehole azimuth (0–360)	179.19°		343.96°		28.73°	
Borehole length	100.45 m		100.25 m		100.15 m	
Soil depth	0 m		0 m		0 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6366548.35 m Easting: 1546688.60 m Elevation: 21.98 m.a.s.l.		Northing: 6366553.13 m Easting: 1546685.40 m Elevation: 21.58 m.a.s.l.		Northing: 6366106.89 m Easting: 1546715.74 m Elevation: 22.26 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–2.00 m 2.00–100.45 m	96 mm 75.7 mm	0.3–2.00 m 2.00–100.25 m	96 mm 75.7 mm	0.3–2.35 m 2.35–100.15 m	96 mm 75.7 mm
Casing diameter (interval) (diameter mm)	0–2.00 m	$Ø_o$ = 89 $Ø_i$ = 77	0–2.00 m	$Ø_o$ = 89 $Ø_i$ = 77	0–2.30 m	$Ø_o$ = 89 $Ø_i$ = 77

Table 5-3. Geometric and technical data for borehole KLX23B, KLX24A and KLX25A.

Parameter	KLX23B		KLX24A		KLX25A	
Drilling period	From 2006-05-28 to 2006-05-31		From 2006-06-14 to 2006-06-29		From 2006-07-01 to 2006-07-04	
Borehole inclination (starting point) (0 to –90)	–60.54°		–59.15°		–59.46°	
Borehole azimuth (0–360)	121.36°		98.41°		145.73°	
Borehole length	50.27 m		100.17 m		50.24 m	
Soil depth	0 m		0 m		0 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6366101.90 m Easting: 1546717.33 m Elevation: 22.32 m.a.s.l.		Northing: 6366423.35 m Easting: 1546853.80 m Elevation: 21.29 m.a.s.l.		Northing: 6366274.74 m Easting: 1546769.66 m Elevation: 22.84 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–2.30 m 2.30–50.27 m	96 mm 75.7 mm	0.3–2.41 m 2.41–100.17 m	96 mm 75.7 mm	0.3–2.20 m 2.20–50.24 m	96 mm 75.7 mm
Casing diameter (interval) (diameter mm)	0–2.30 m	$Ø_o$ = 89 $Ø_i$ = 77	0–2.41 m	$Ø_o$ = 90 $Ø_i$ = 77	0–2.20 m	$Ø_o$ = 90 $Ø_i$ = 77

Table 5-4. Geometric and technical data for borehole KLX26A, KLX26BA and KLX28A.

Parameter	KLX26A		KLX26B		KLX28A	
Drilling period	From 2006-08-03 to 2006-08-11		From 2006-08-12 to 2006-08-17		From 2006-09-14 to 2006-09-20	
Borehole inclination (starting point) (0 to –90)	–60.45°		–60.01°		–59.23°	
Borehole azimuth (0–360)	93.47°		137.42°		189.70°	
Borehole length	101.14 m		50.37 m		80.23 m	
Soil depth	0 m		0 m		2.85 m (0.3–2.85 below TOC)	
Starting point coordinates (system RT90/RHB70)	Northing: 6365546.49 m Easting: 1549029.90 m Elevation: 15.63 m.a.s.l.		Northing: 6365550.66 m Easting: 1549025.61 m Elevation: 15.82 m.a.s.l.		Northing: 6365682.22 m Easting: 1549333.71 m Elevation: 15.82 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–2.64 m 2.64–101.14 m	96 mm 75.7 mm	0.3–2.31 m 2.31–50.37 m	96 mm 75.7 mm	0.3–2.85 m 2.85–5.10 m 5.10–80.23 m	116 mm 96 mm 75.7 mm
Casing diameter (interval) (diameter mm)	0–2.64 m	$Ø_o$ = 90 $Ø_i$ = 77	0–2.31 m	$Ø_o$ = 90 $Ø_i$ = 77	0–5.10 m	$Ø_o$ = 90 $Ø_i$ = 77

Table 5-5. Geometric and technical data for borehole KLX29A.

Parameter	KLX29A	
Drilling period	From 2006-09-09 to 2006-09-13	
Borehole inclination (starting point) (0 to –90)	–60.35°	
Borehole azimuth (0–360)	321.21°	
Borehole length	60.25 m	
Soil depth	0 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6366264.54 m Easting: 1549443.99 m Elevation: 13.63 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–2.35 m 2.35–60.25 m	96 mm 75.7 mm
Casing diameter (interval) (diameter mm)	0–2.35 m	$Ø_o$ = 90 $Ø_i$ = 77

5.2 Hydrogeological results

Injection tests

Hydraulic injection tests were made in KLX22A–KLX29A in conjunction with drilling as shown in Table 5-6.

Table 5-6. Hydraulic injection tests in KLX22A–KLX29A.

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)
KLX22A	20060607	63	100.45	37.45	1	200	48.2	180
KLX22A	20060607	63	100.45	37.45	2	500	69	180
KLX22A	20060607	63	100.45	37.45	3	200	39.4	180
KLX22B	20060607	16	100.25	84.25	1	200	29.2	180
KLX22B	20060607	16	100.25	84.25	2	500	83.3	180
KLX22B	20060607	16	100.25	84.25	3	200	36	180
KLX22B	20060607	20	100.25	80.25	1	200	7	180
KLX22B	20060607	20	100.25	80.25	2	500	18.2	180
KLX22B	20060607	20	100.25	80.25	3	200	3.3	180
KLX23A	20060605	50	100.15	50.15	1	200	7.9	180
KLX23A	20060606	50	100.15	50.15	2	500	5.2	180
KLX23A	20060607	50	100.15	50.15	3	200	4	180
KLX23B	20060604	2.5	50.27	47.79	1	200	7.4	180
KLX23B	20060604	2.5	50.27	47.79	2	500	17.6	180
KLX23B	20060604	2.5	50.27	47.79	3	200	5.3	180
KLX24A	20060629	2.7	100.17	97.47	1	200	65	180
KLX24A	20060629	2.7	100.17	97.47	2	500	94	180
KLX24A	20060629	2.7	100.17	97.47	3	200	46	180
KLX25A	20060705	3	50.24	47.24	1	200	26.7	180
KLX25A	20060705	3	50.24	47.24	2	500	35.7	180
KLX25A	20060705	3	50.24	47.24	3	200	21.4	180
KLX26A	20060817	2.8	101.14	98.34	1	200	45	180
KLX26A	20060817	2.8	101.14	98.34	2	500	93	180
KLX26A	20060817	2.8	101.14	98.34	3	200	50	180
KLX26A	20060807	29	44.16	15.16	1	200	115	600
KLX26A	20060807	29	44.16	15.16	2	500	208	600
KLX26B	20060817	2.6	50.37	47.77	1	200	68	180
KLX26B	20060817	2.6	50.37	47.77	2	500	111	180
KLX26B	20060817	2.6	50.37	47.77	3	200	67	180
KLX28A	20060920	5.8	80.23	74.43	1	200	31	600
KLX28A	20060920	5.8	80.23	74.43	2	500	48	600
KLX29A	20060911	11	60.25	49.25	1	200	347	600

Hydraulic responses

Flushing with nitrogen gas gives a strong drawdown of the water table in the borehole being flushed, which can give a hydraulic response in neighbouring boreholes. Boreholes KLX22A, KLX22B, KLX23A and KLX23B were monitored during flushing with nitrogen gas. The results are given in Figure 5-1. KLX23A and KLX23B were subjected to nitrogen flushing on July 1 and KLX22A and KLX22B were flushed on July 2. No hydraulic response can be seen in the KLX22 holes from flushing in the KLX23 boreholes and vice versa. NB the data from logging of water levels in boreholes KLX22-KLX23 during nitrogen flushing are not stored in the Sicada database.

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.

Vertical cross sections of the preliminary geology (major lithological units and open fractures) are given in Figures 5-2 and 5-3 for the thirteen boreholes.

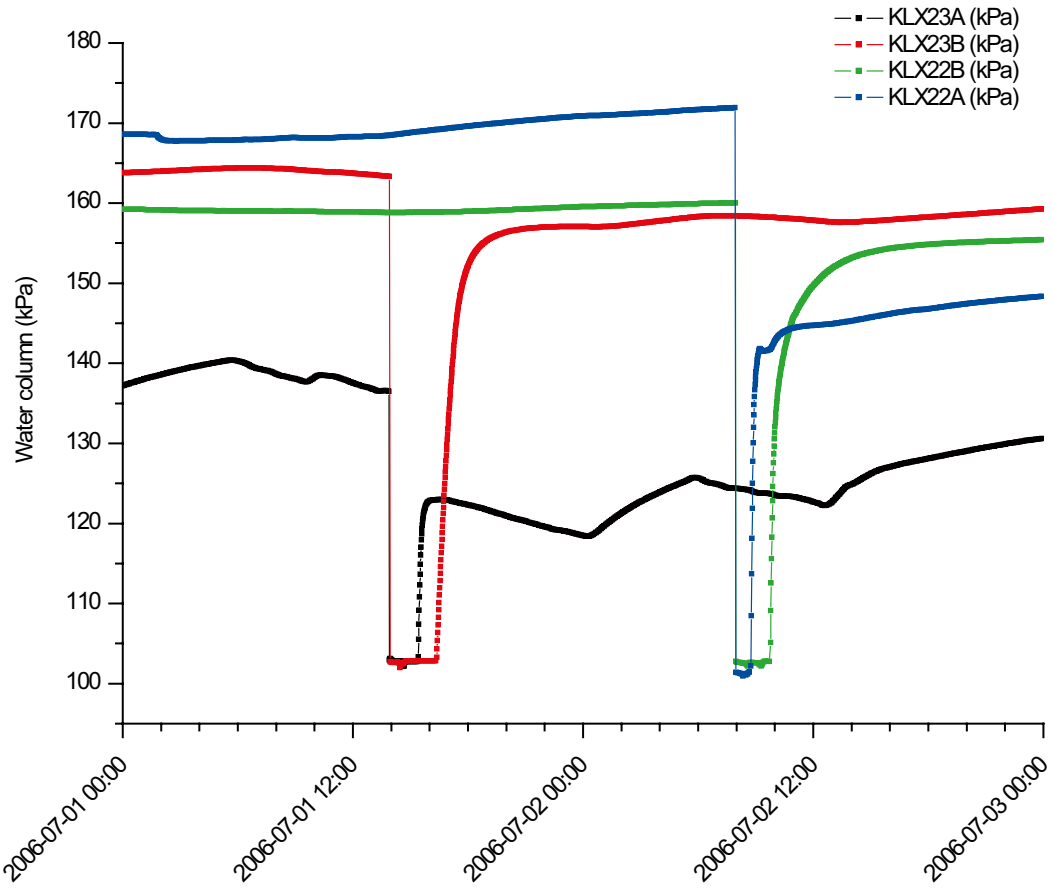


Figure 5-1. *Monitoring of water levels in KLX22A, KLX22B, KLX23A and KLX23B during nitrogen flushing in the boreholes. KLX23A and KLX23B were subjected to nitrogen flushing on July 1 and KLX22A and KLX22B were flushed on July 2. No hydraulic response can be seen in the KLX22 holes from flushing in the KLX23 boreholes and vice versa. NB the data from logging of water levels in boreholes KLX22-KLX23 during nitrogen flushing are not stored in the Sicada database.*

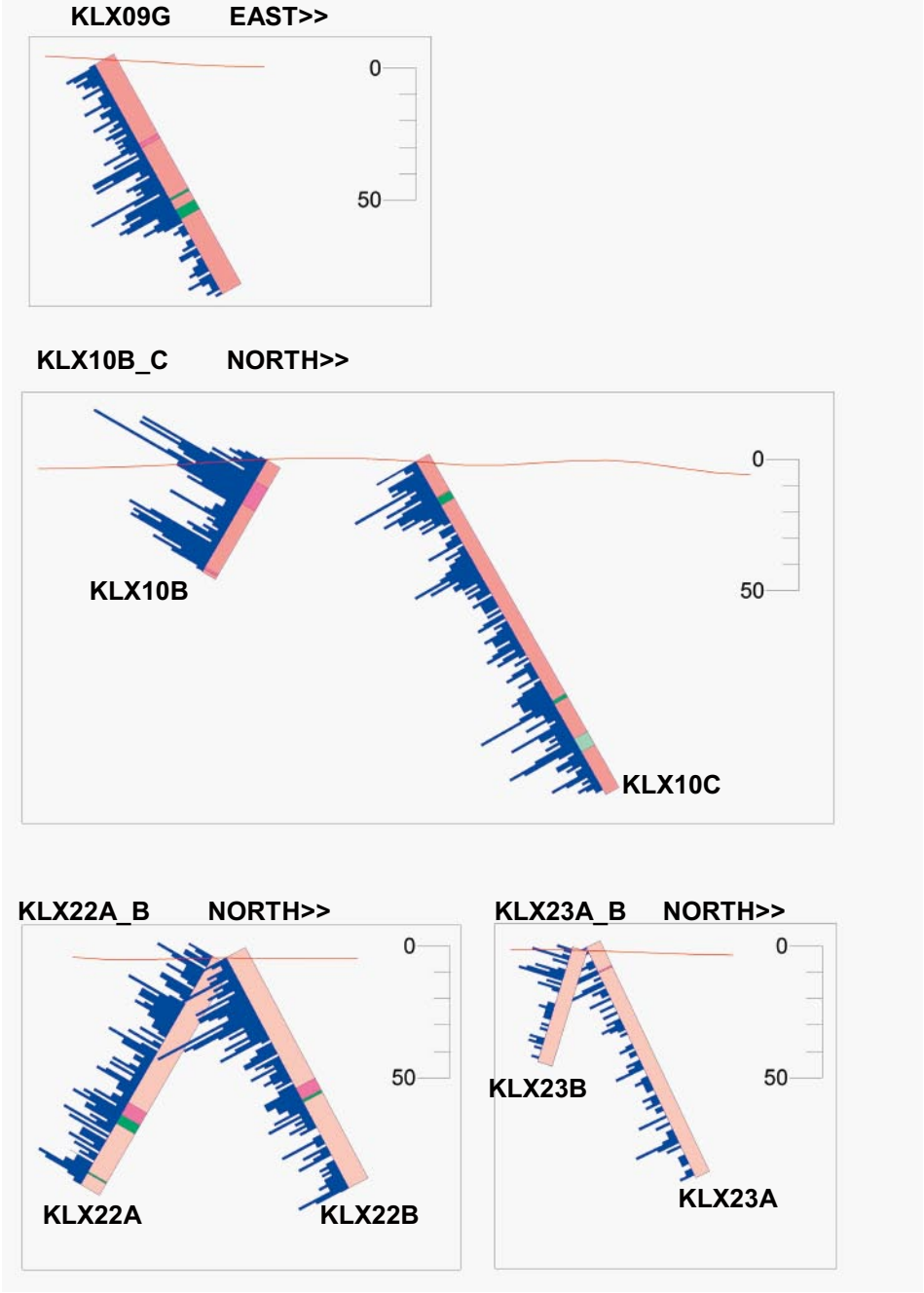


Figure 5-2. *Vertical cross sections of boreholes KLX09G; KLX10B and KLX10C; KLX22A and KLX22B; KLX23A and KLX23B. The ground surface is shown with a red line. Major lithological units (rock types) from the preliminary geological mapping are shown along the boreholes together with fracture frequency (blue bars). A legend to the various lithologies is given for each borehole in Appen-*

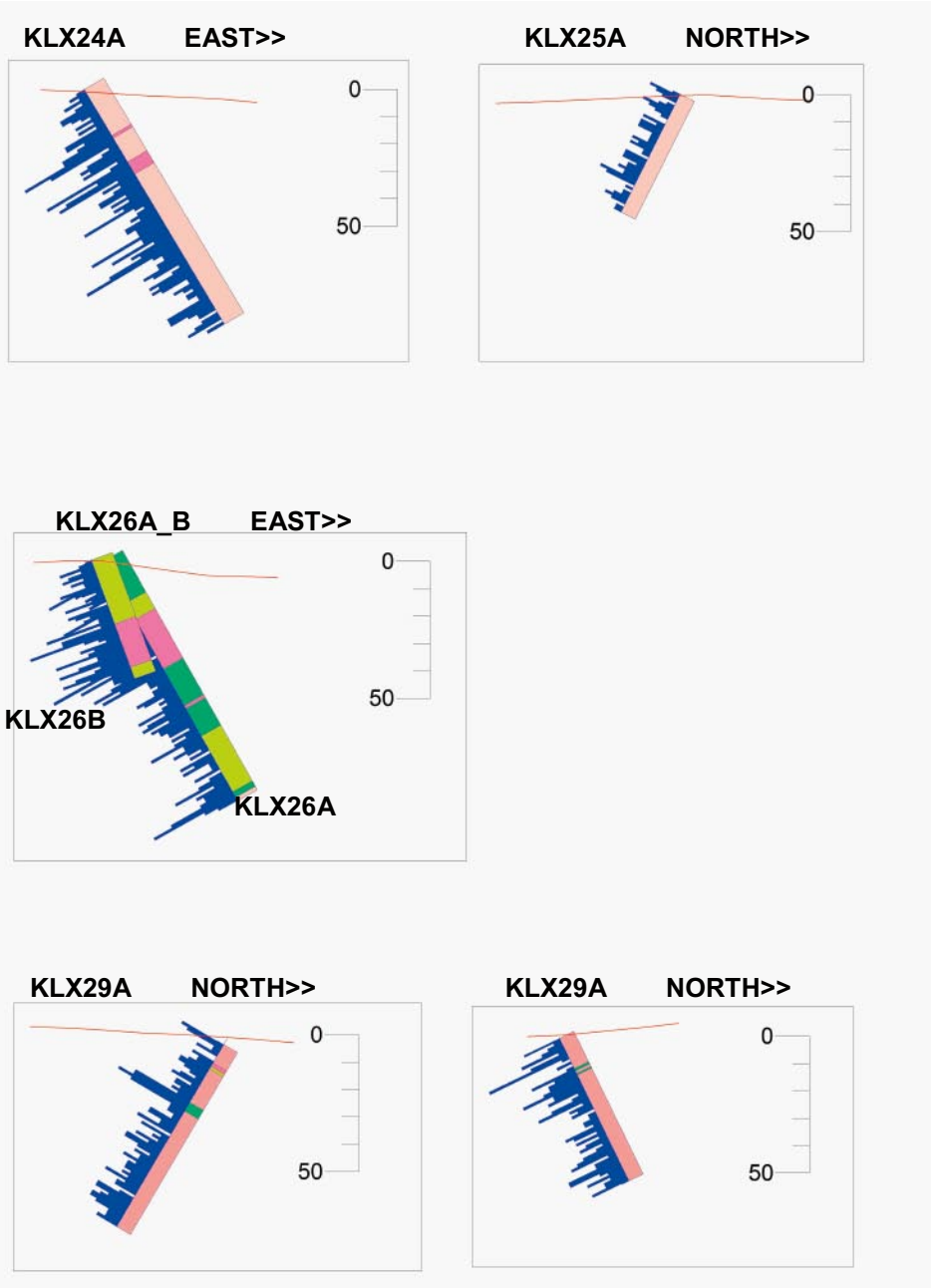


Figure 5-3. *Vertical cross sections of boreholes KLX24A; KLX25A; KLX26A and KLX26B; KLX28A and KLX29A. The ground surface is shown with a red curve. Major lithological units (rock types) from the preliminary geological mapping are shown along the boreholes together with fracture frequency (blue bars). A legend to the various lithologies is given for each borehole in Appendix 2.*

5.4 Hydrogeochemistry

No water samples were taken during the activity.

5.5 Consumption of oil and chemicals

The consumption and composition of concrete slurry for casing grouting is given in Table 5-7.

5.6 Nonconformities

Deviation measurements were not made in conjunction with drilling of KLX09G, KLX10B or KLX10C. According to the activity plans AP PS 400-05-100 and AP PS 400-05-102 measurements with the Maxibor method should have been done. Deviation measurements were performed with the Flexit method as part of separate geophysical logging activities.

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

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

The data from logging of water levels in boreholes KLX22A, B and KLX23A, B during nitrogen flushing are not stored in the Sicada database.

Table 5-7. Consumption and composition of concrete slurry for casing grouting.

		KLX09G, KLX10B, KLX10C	KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX29A	KLX28A
Consumption		40 litres	20 litres	51 litres
Composition	Low alkali cement	25 kg	12.5 kg	20 kg
	Silica	10.7 kg	5.7 kg	8.7 kg
	Water	28 litres	14 litres	22 litres
	Salt	1 kg	0.5 kg	0.8 kg

6 References

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

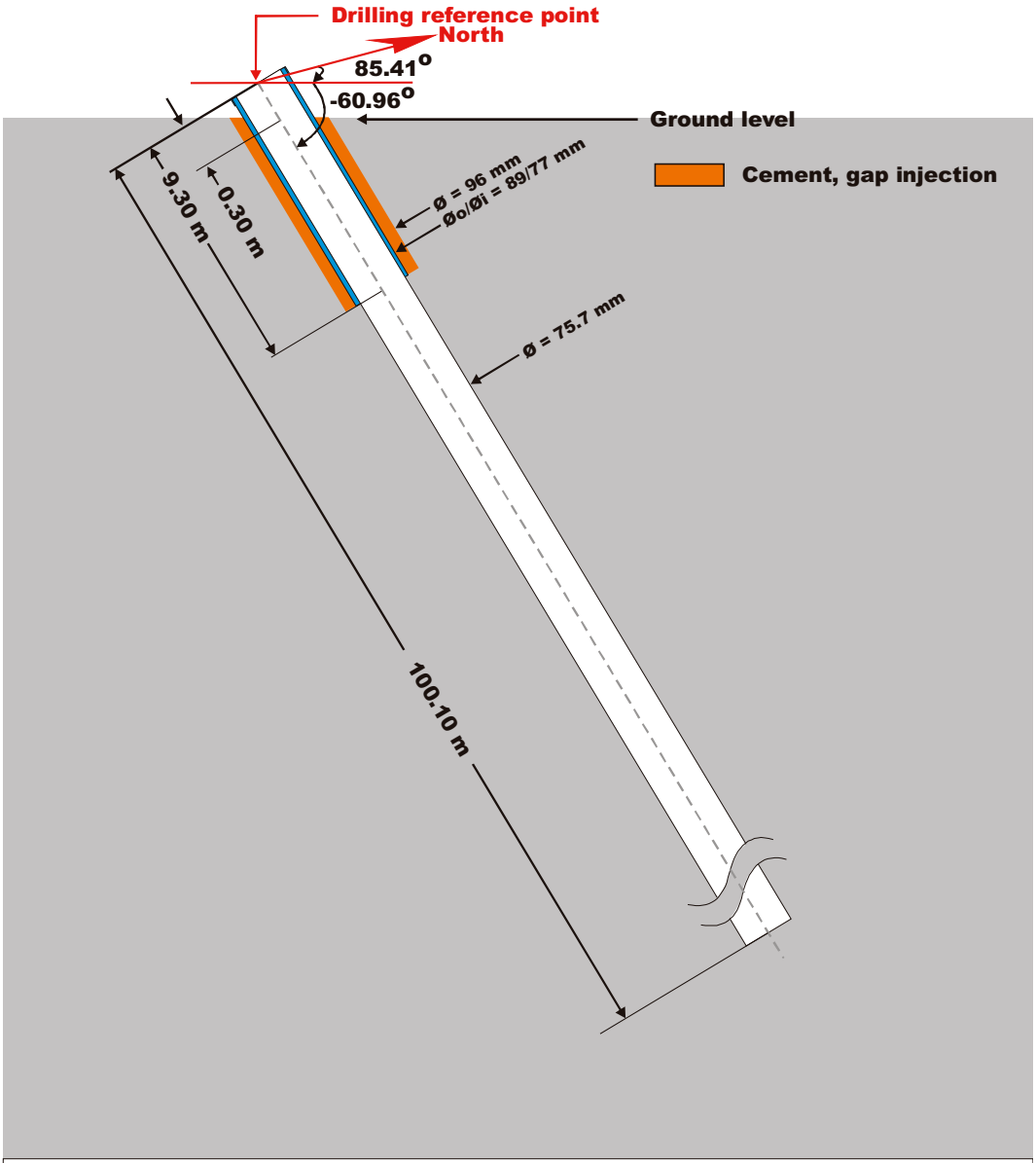
/2/ **SKB, 2005.** Program för fortsatta undersökningar av berggrund, mark, vatten och miljö inom delområde Laxemar. SKB R-05-37, Svensk Kärnbränslehantering AB.

/3/ **Lindqvist G, 2006.**Oskarshamn site investigation. Refraction seismics measurements in Laxemar, spring 2006. SKB P-06-49, Svensk Kärnbränslehantering AB.

Technical data of cored boreholes KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A

Technical data

Borehole KLX09G



Drilling reference point

Northing: 6367330.09 (m), RT90 2,5 gon V 0:-15
Easting: 1548905.77 (m), RT90 2,5 gon V0:-15
Elevation: 19.63 (m), RHB 70

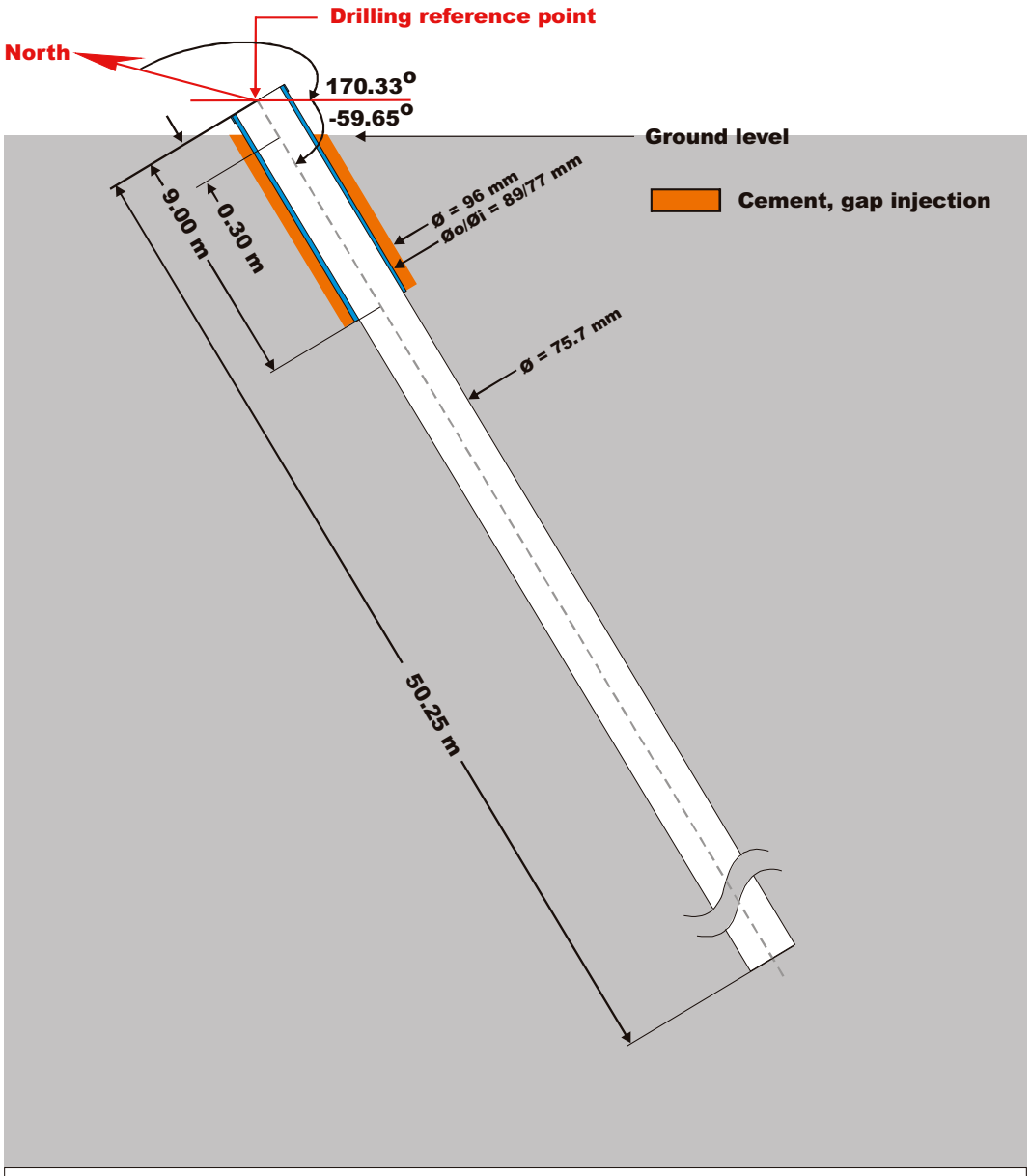
Drilling period

Drilling start date: 2006-01-27
Drilling stop date: 2006-02-03

Ver 2006-11-23

Technical data

Borehole KLX10B



Drilling reference point

Northing: 6366316.49 (m), RT90 2,5 gon V 0:-15
Easting: 1548525.15 (m), RT90 2,5 gon V0:-15
Elevation: 18.15 (m), RHB 70

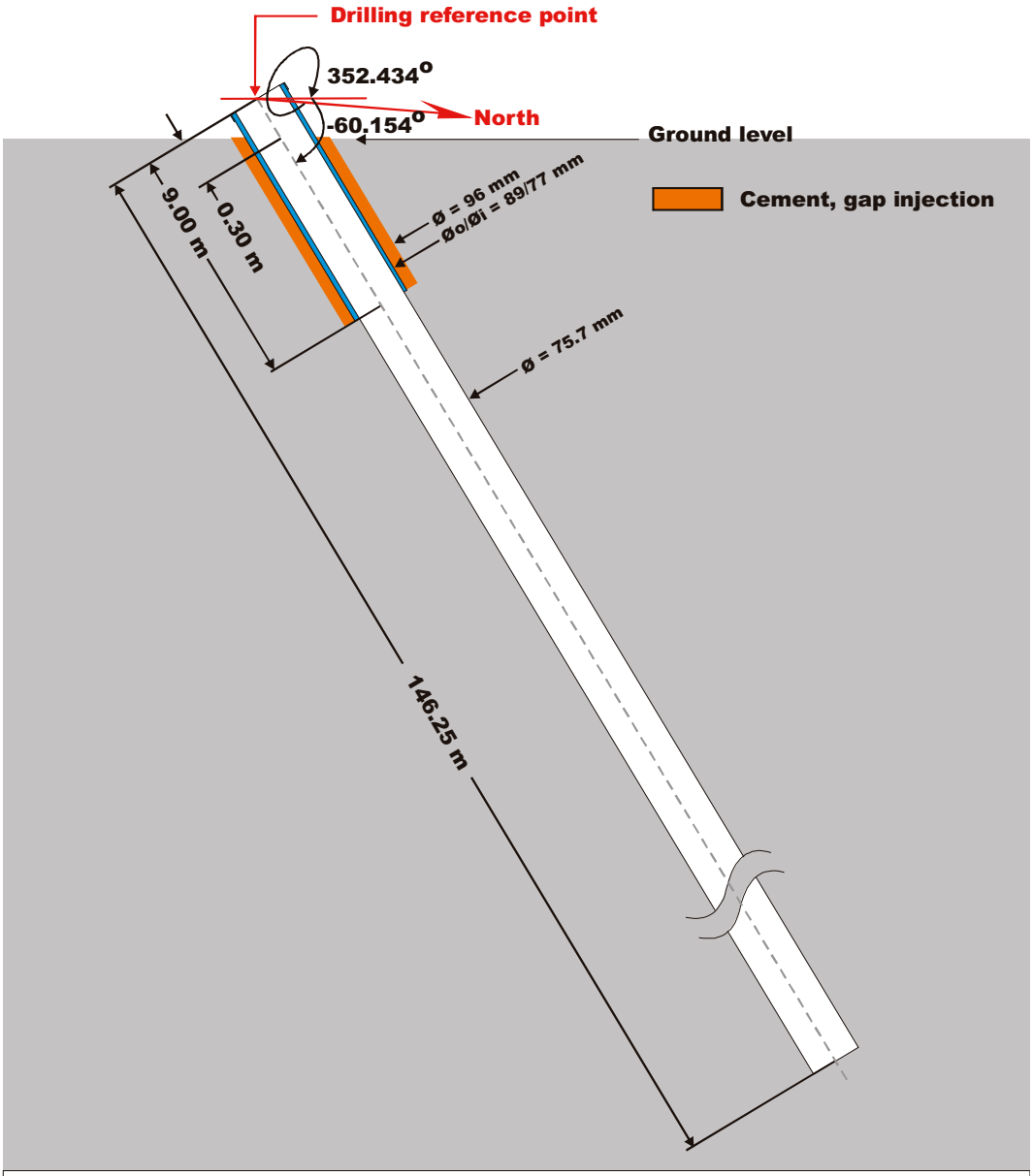
Drilling period

Drilling start date: 2006-02-08
Drilling stop date: 2006-02-14

Rev 2006-12-21

Technical data

Borehole KLX10C



Drilling reference point

Northing: 6366372.072 (m), RT90 2,5 gon V 0:-15
Easting: 1548506.941 (m), RT90 2,5 gon V0:-15
Elevation: 16.935 (m), RHB 70

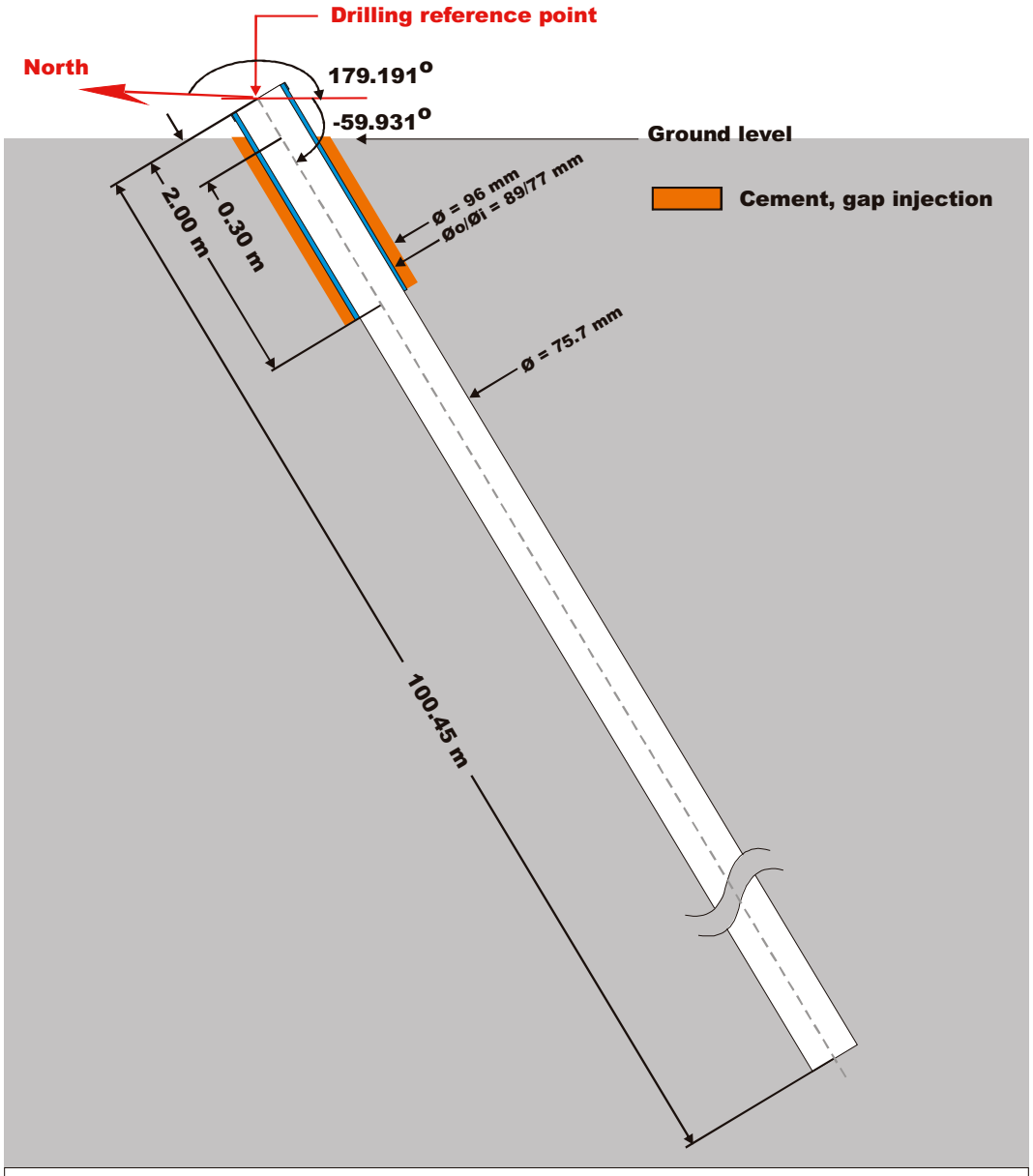
Drilling period

Drilling start date: 2006-02-15
Drilling stop date: 2006-02-28

Ver 2006-12-21

Technical data

Borehole KLX22A



Drilling reference point

Northing: 6366548.348 (m), RT90 2,5 gon V 0:-15
Easting: 1546688.595 (m), RT90 2,5 gon V 0:-15
Elevation: 21.976 (m), RHB 70

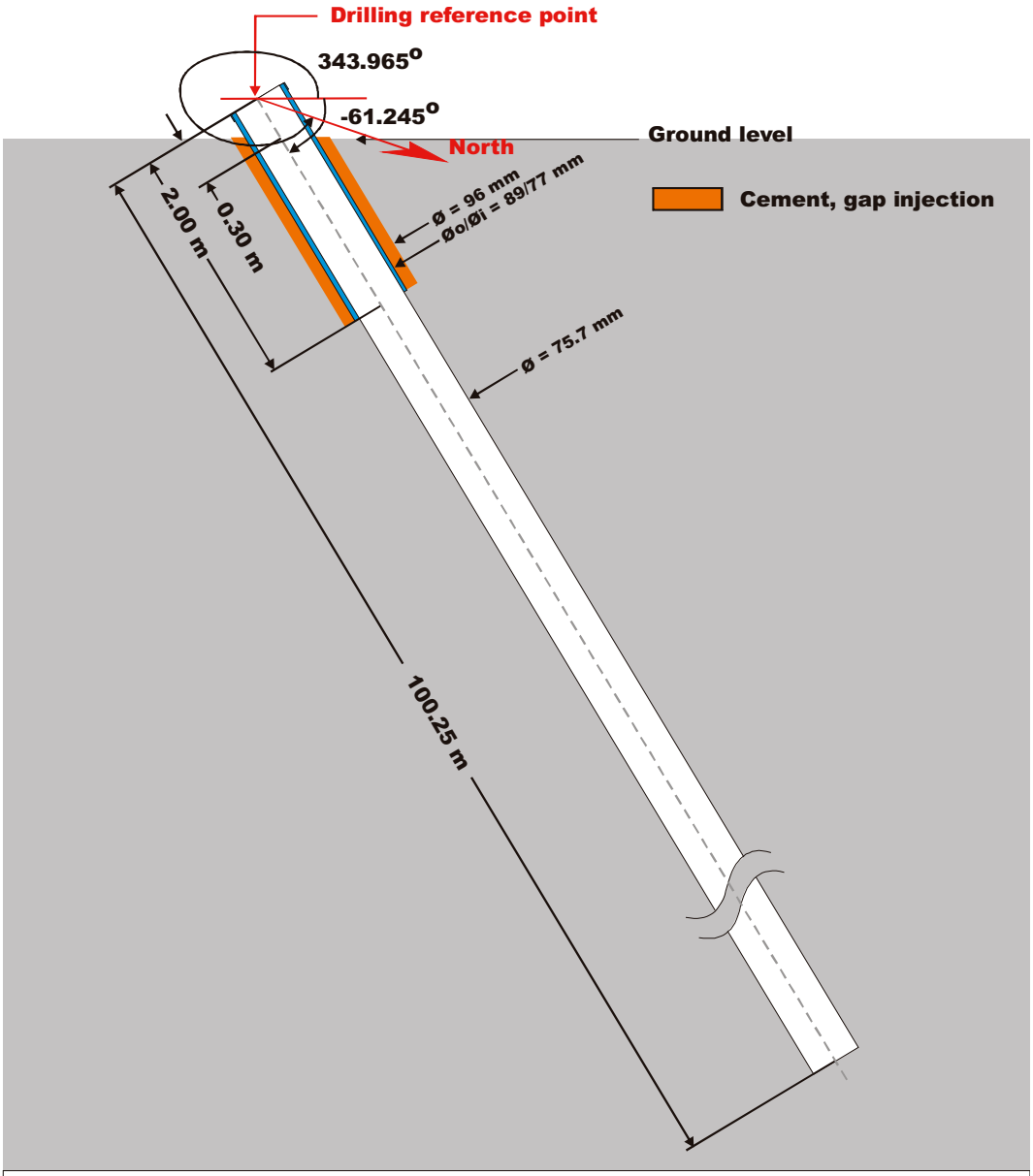
Drilling period

Drilling start date: 2006-05-05
Drilling stop date: 2006-05-12

Ver 2006-12-21

Technical data

Borehole KLX22B



Drilling reference point

Northing: 6366553.127 (m), RT90 2,5 gon V 0:-15
Easting: 1546685.405 (m), RT90 2,5 gon V 0:-15
Elevation: 21.575 (m), RHB 70

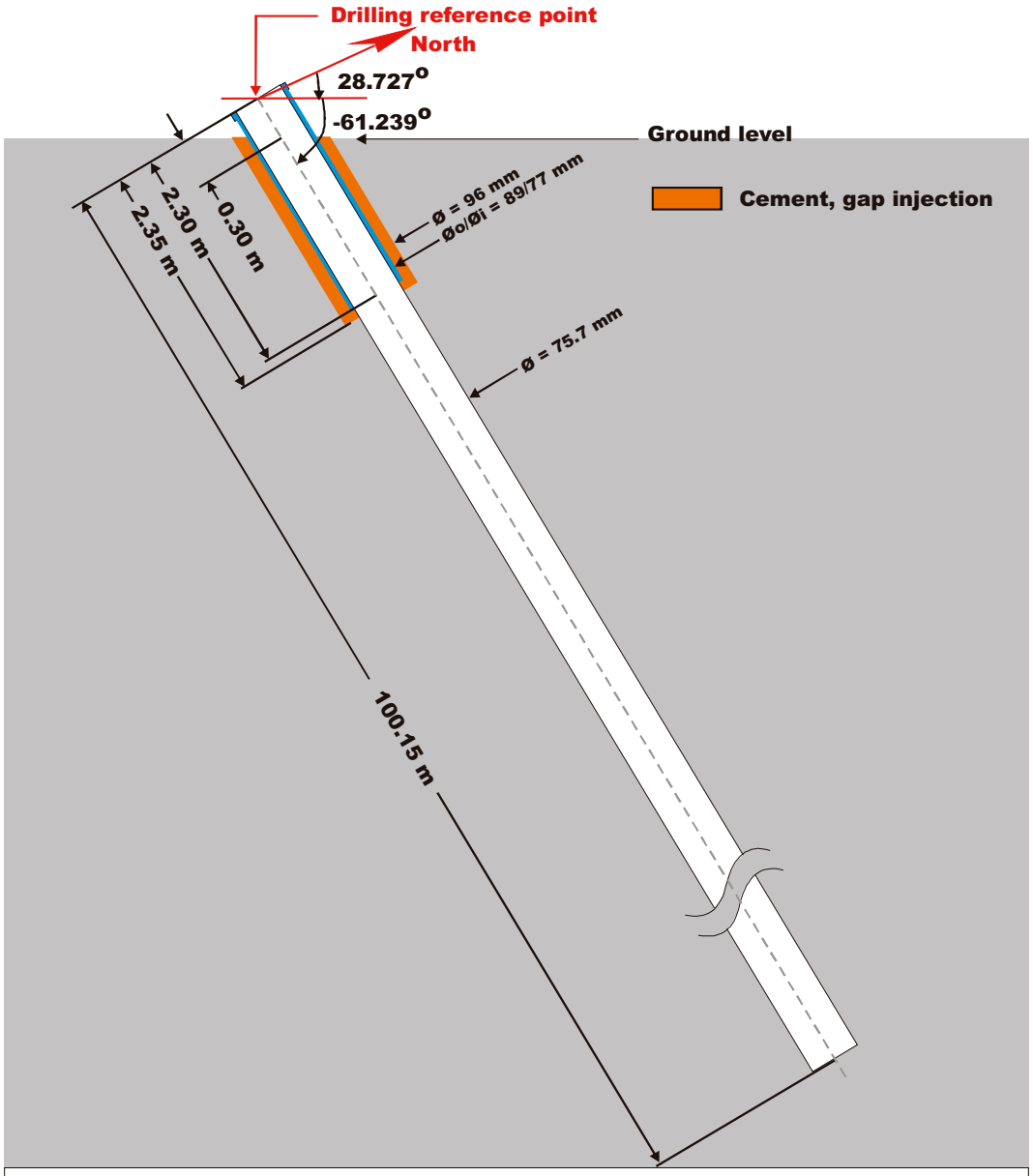
Drilling period

Drilling start date: 2006-05-13
Drilling stop date: 2006-05-18

Ver 2006-12-21

Technical data

Borehole KLX23A



Drilling reference point

Northing: 6366106.892 (m), RT90 2,5 gon V 0:-15
Easting: 1546715.743 (m), RT90 2,5 gon V 0:-15
Elevation: 22.263 (m), RHB 70

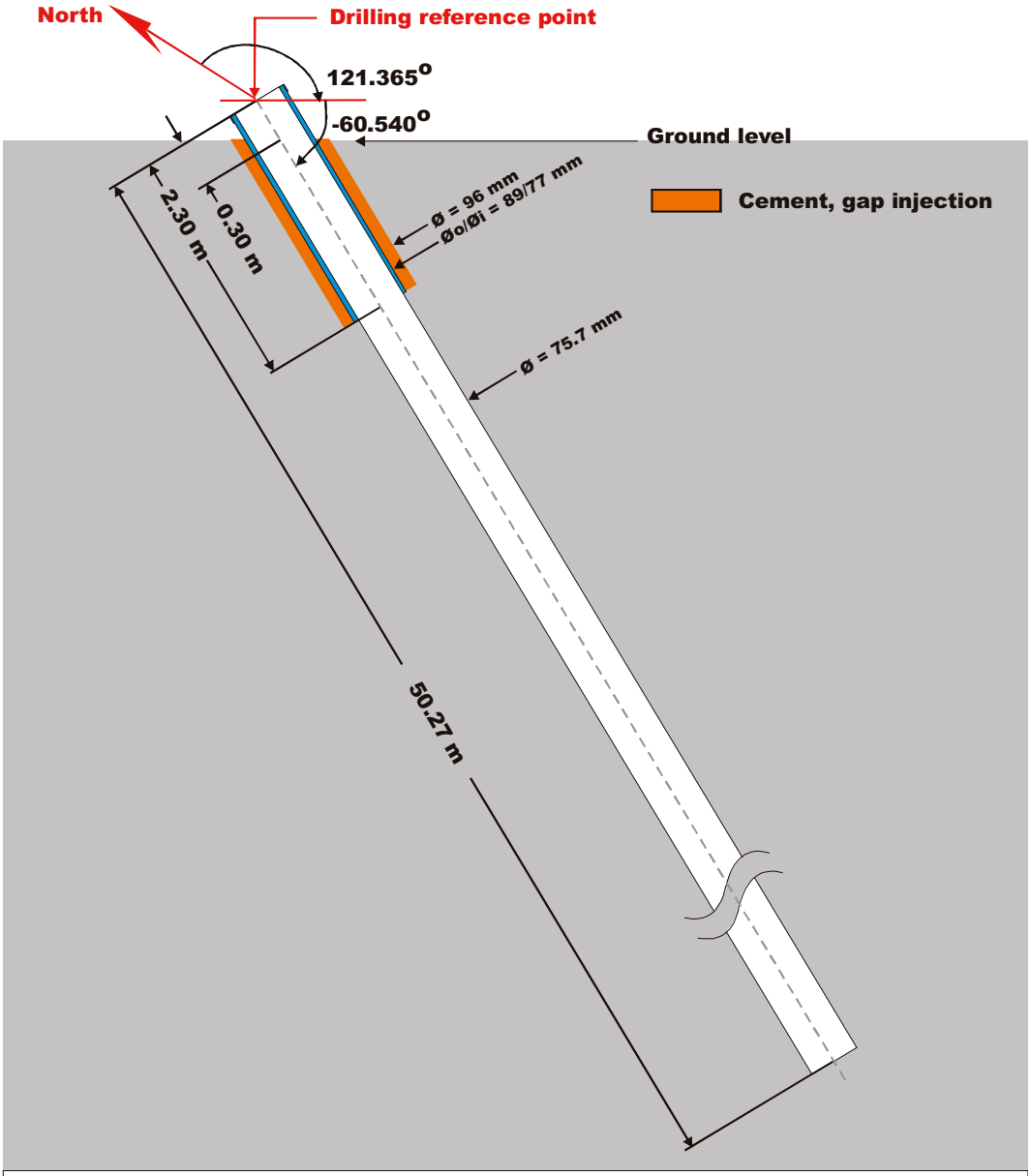
Drilling period

Drilling start date: 2006-05-21
Drilling stop date: 2006-05-27

Ver 2006-12-21

Technical data

Borehole KLX23B



Drilling reference point

Northing: 6366101.900 (m), RT90 2,5 gon V 0:-15
Easting: 1546717.332 (m), RT90 2,5 gon V 0:-15
Elevation: 22.317 (m), RHB 70

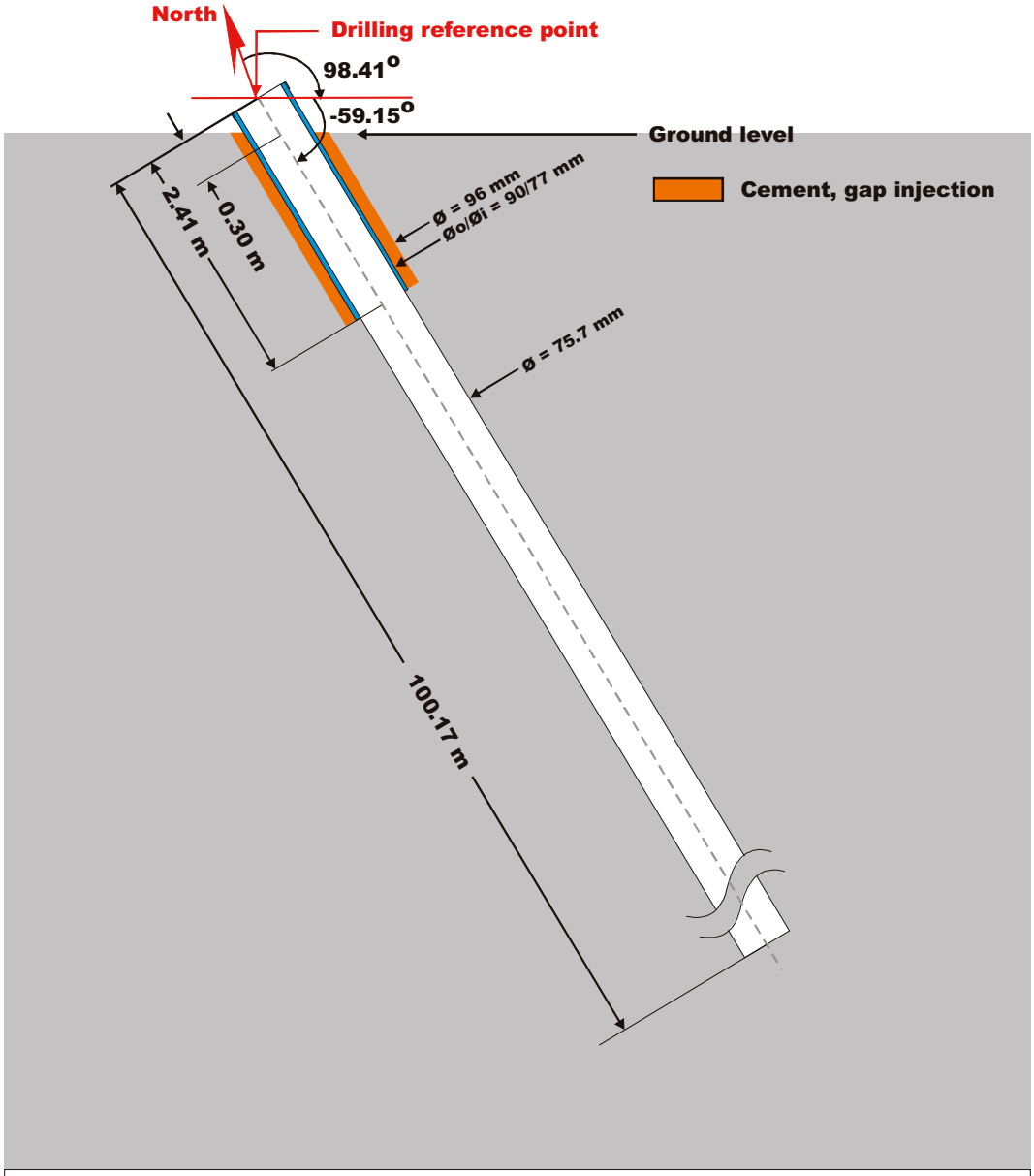
Drilling period

Drilling start date: 2006-05-28
Drilling stop date: 2006-05-31

Ver 2006-12-21

Technical data

Borehole KLX24A



Drilling reference point

Northing: 6366423.35 (m), RT90 2,5 gon V 0:-15

Easting: 1546853.80 (m), RT90 2,5 gon V 0:-15

Elevation: 21.29 (m), RHB 70

Drilling period

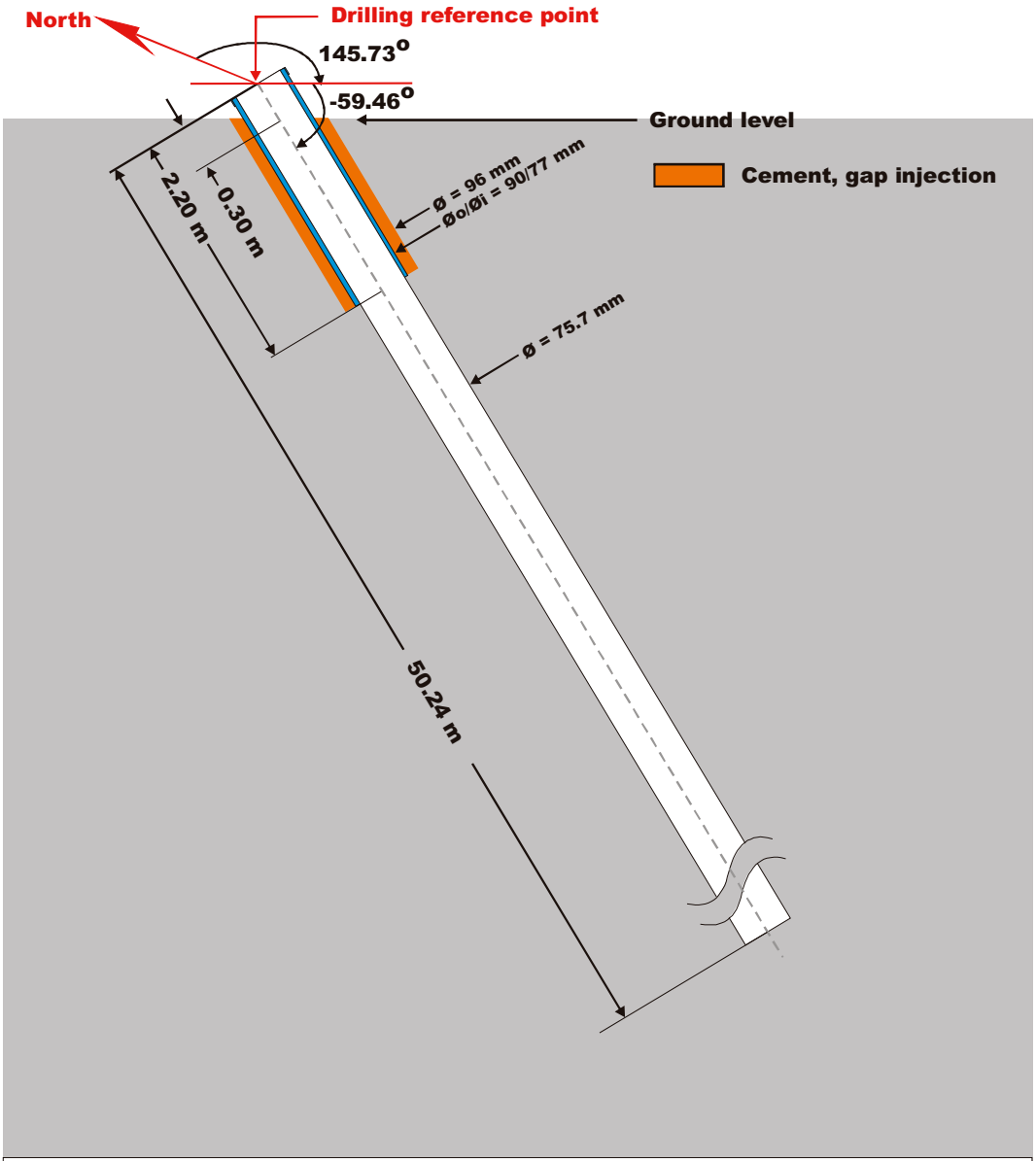
Drilling start date: 2006-06-14

Drilling stop date: 2006-06-29

Ver 2006-12-19

Technical data

Borehole KLX25A



Drilling reference point

Northing: 6366274.74 (m), RT90 2,5 gon V 0:-15
Easting: 1546769.66 (m), RT90 2,5 gon V 0:-15
Elevation: 22.84 (m), RHB 70

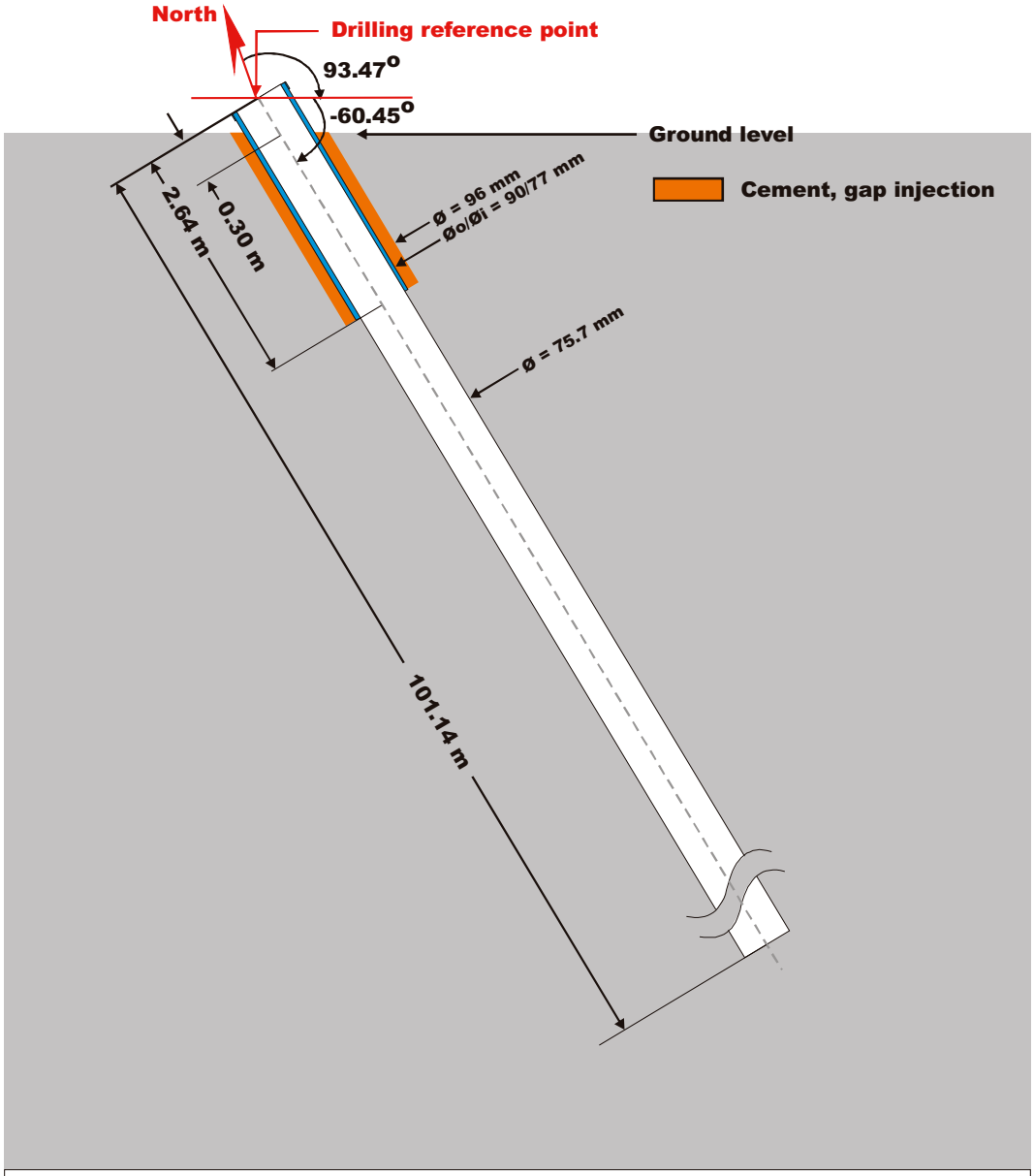
Drilling period

Drilling start date: 2006-07-01
Drilling stop date: 2006-07-04

Ver 2006-12-19

Technical data

Borehole KLX26A



Drilling reference point

Northing: 6365546.49 (m), RT90 2,5 gon V 0:-15
Easting: 1549029.90 (m), RT90 2,5 gon V 0:-15
Elevation: 15.63 (m), RHB 70

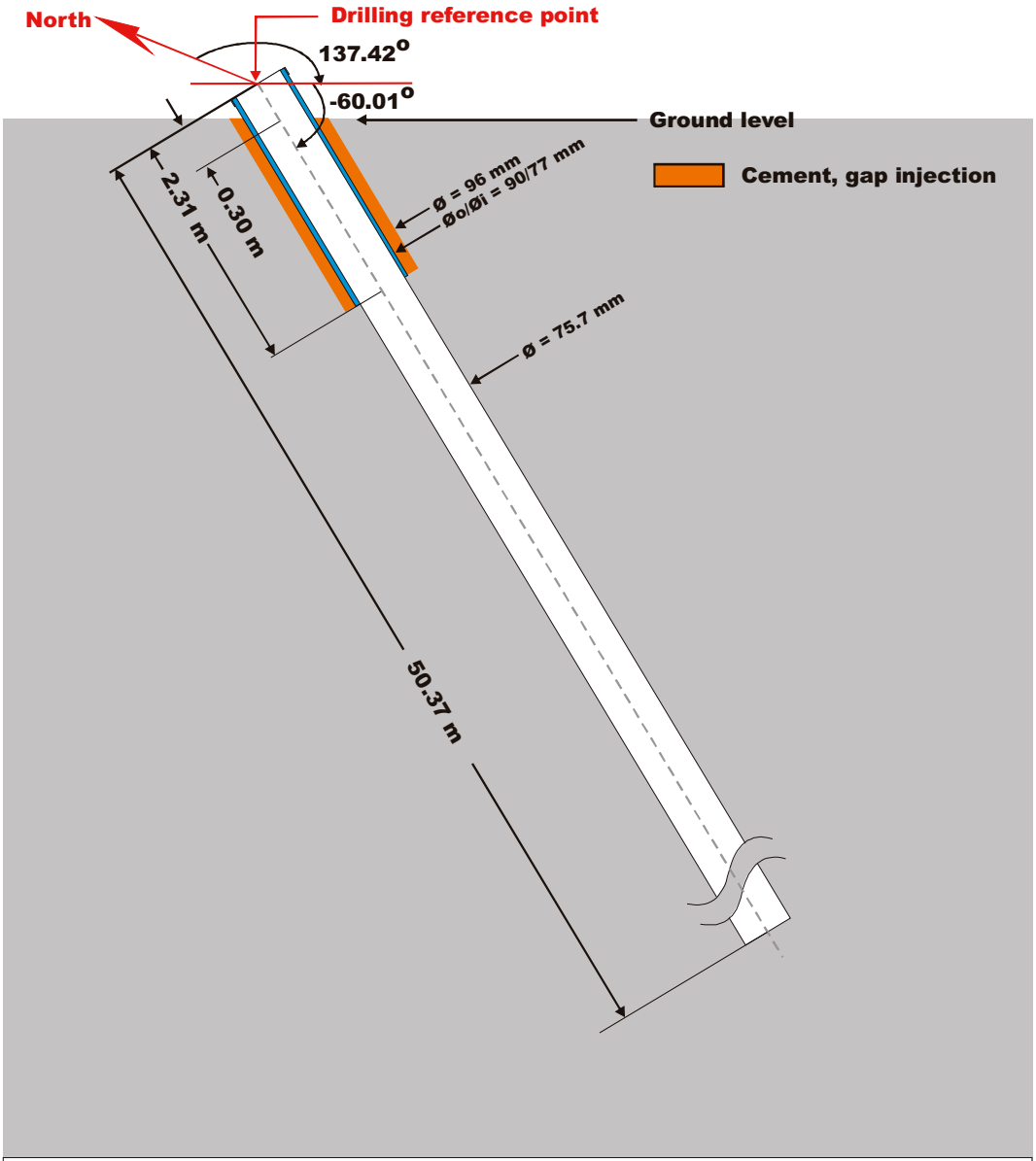
Drilling period

Drilling start date: 2006-08-03
Drilling stop date: 2006-08-11

Ver 2006-12-21

Technical data

Borehole KLX26B



Drilling reference point

Northing: 6365550.66 (m), RT90 2,5 gon V 0:-15

Easting: 1549025.61 (m), RT90 2,5 gon V 0:-15

Elevation: 15.82 (m), RHB 70

Drilling period

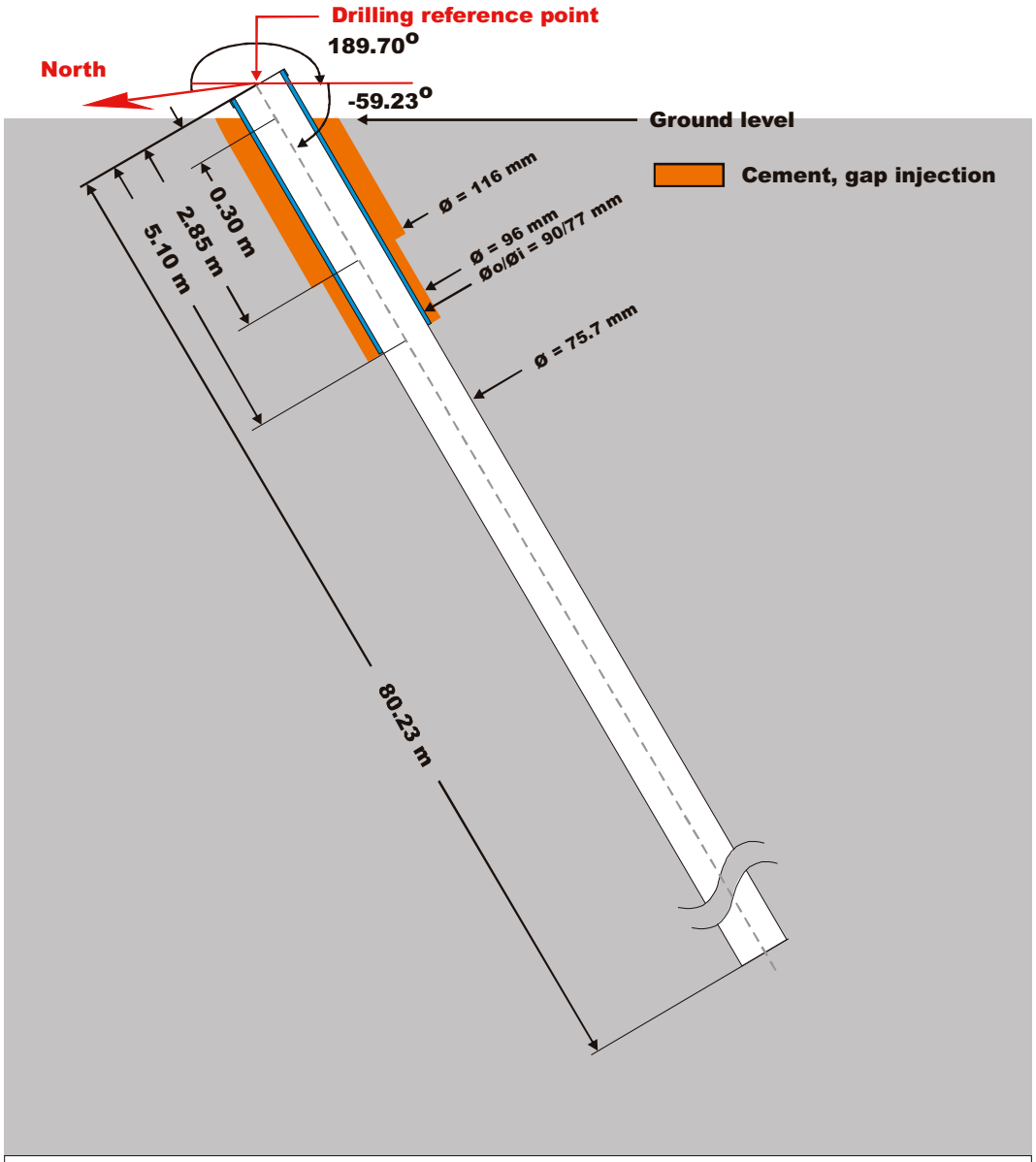
Drilling start date: 2006-08-12

Drilling stop date: 2006-08-17

Ver 2006-12-19

Technical data

Borehole KLX28A



Drilling reference point

Northing: 6365682.22 (m), RT90 2,5 gon V 0:-15
Easting: 1549333.71 (m), RT90 2,5 gon V 0:-15
Elevation: 15.82 (m), RHB 70

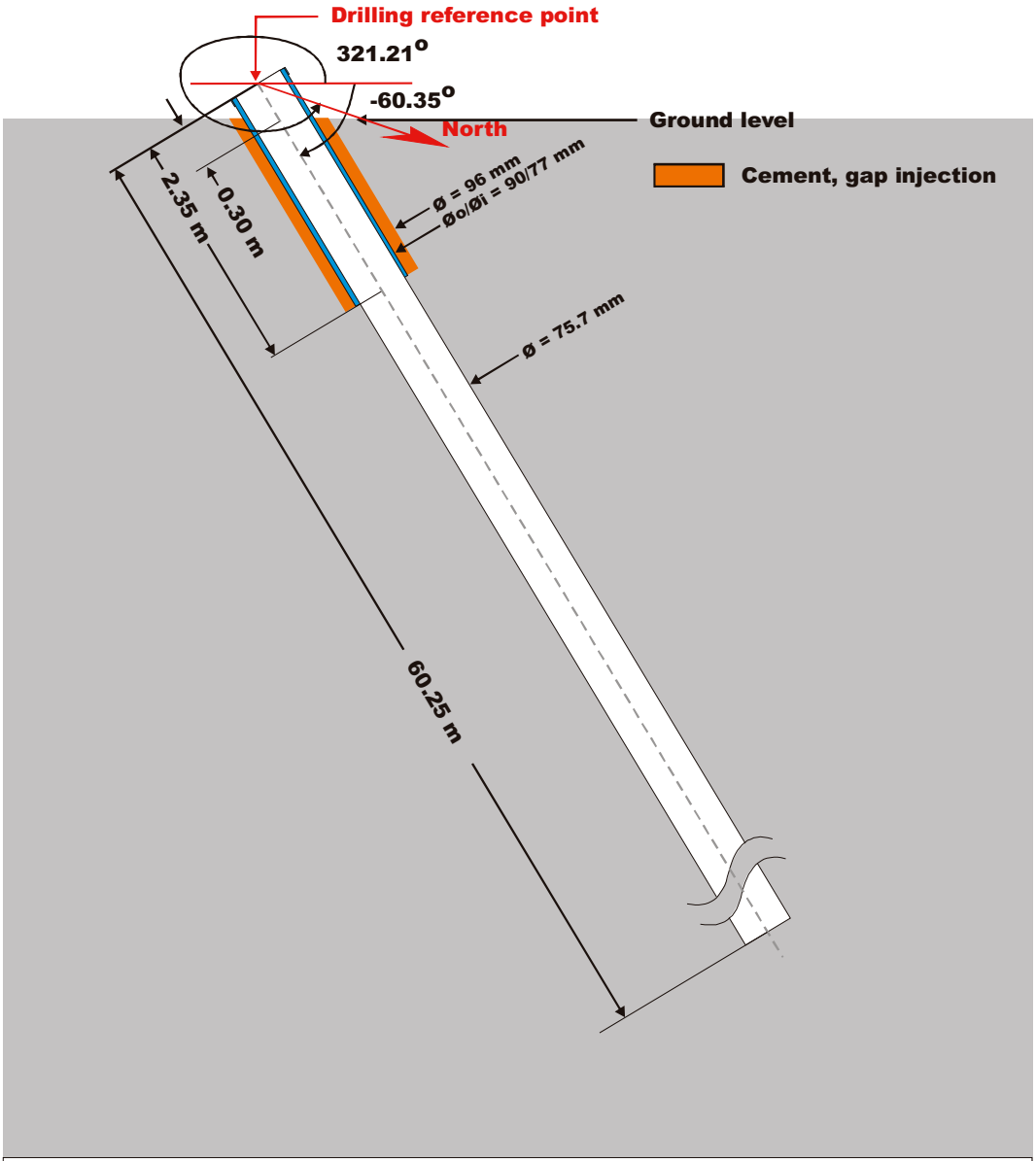
Drilling period

Drilling start date: 2006-09-14
Drilling stop date: 2006-09-20

Ver 2006-12-19

Technical data

Borehole KLX29A



Drilling reference point

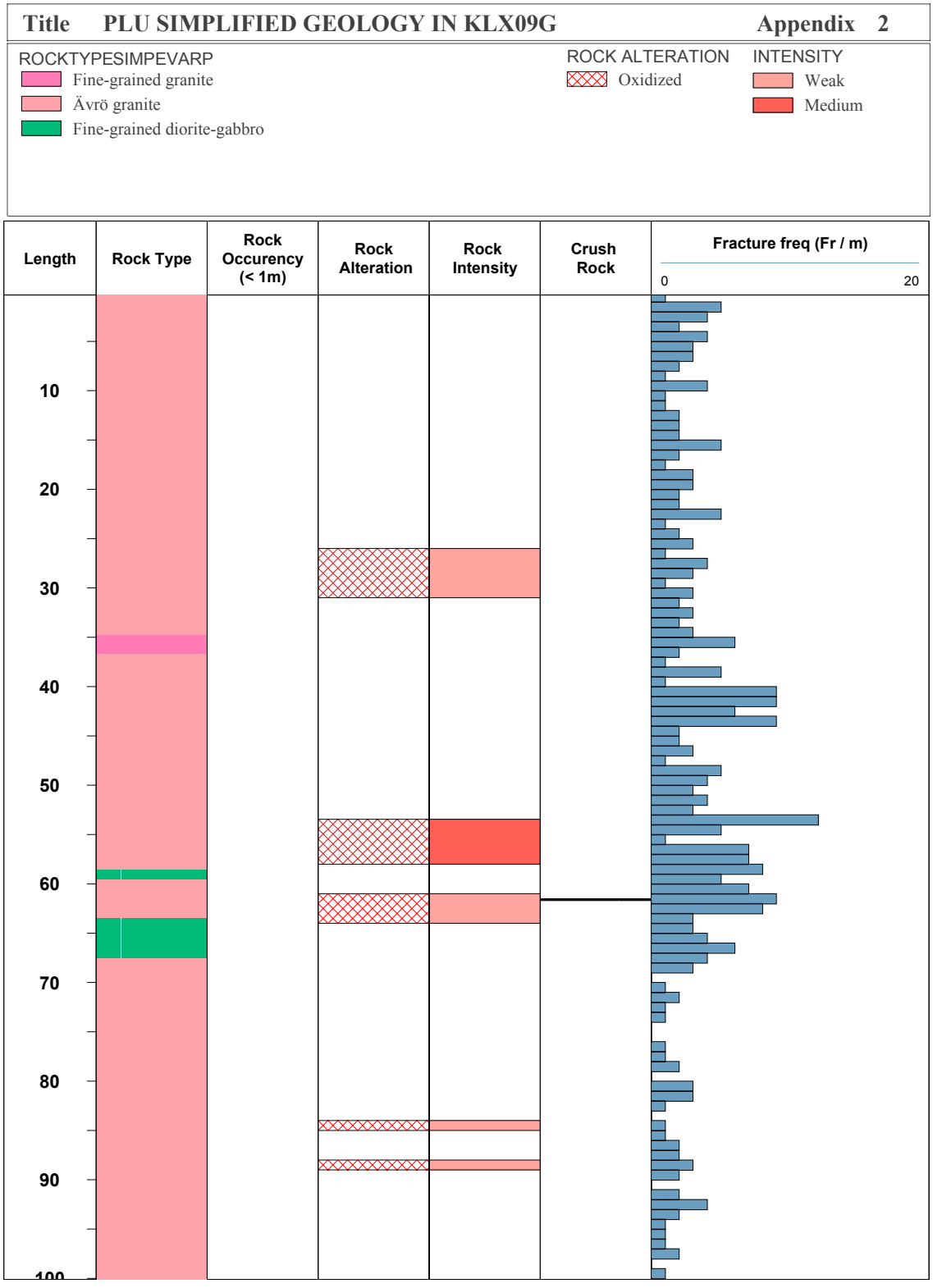
Northing: 6366264.54 (m), RT90 2,5 gon V 0:-15
Easting: 1549443.99 (m), RT90 2,5 gon V 0:-15
Elevation: 13.63 (m), RHB 70

Drilling period

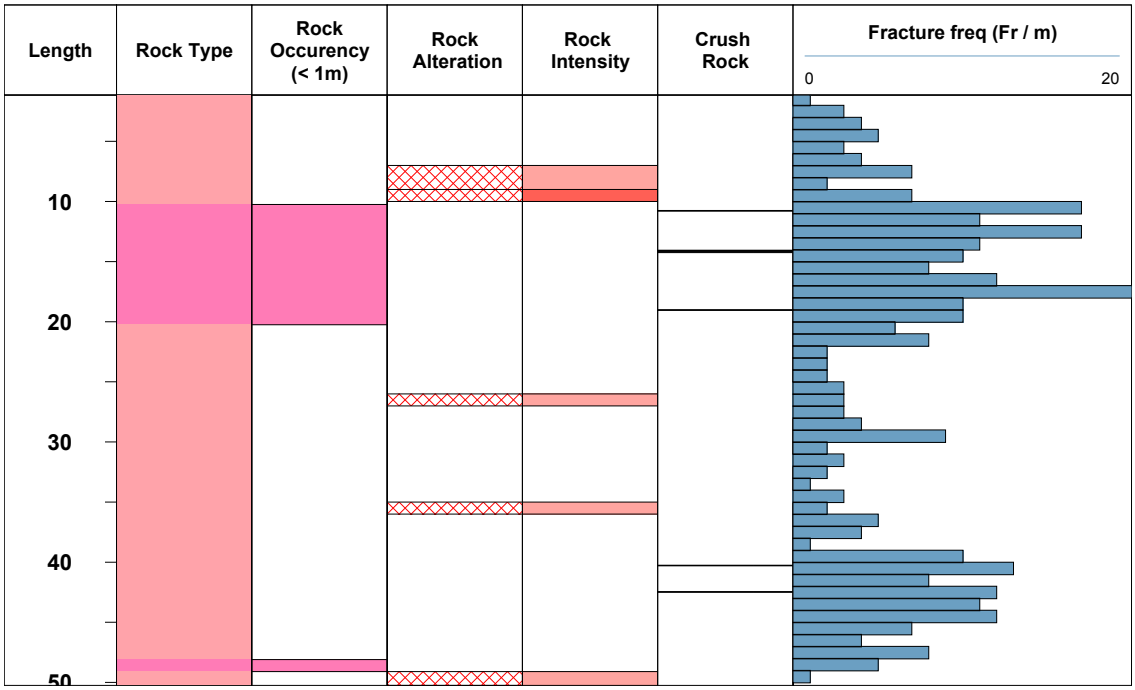
Drilling start date: 2006-09-09
Drilling stop date: 2006-09-13

Ver 2006-12-19

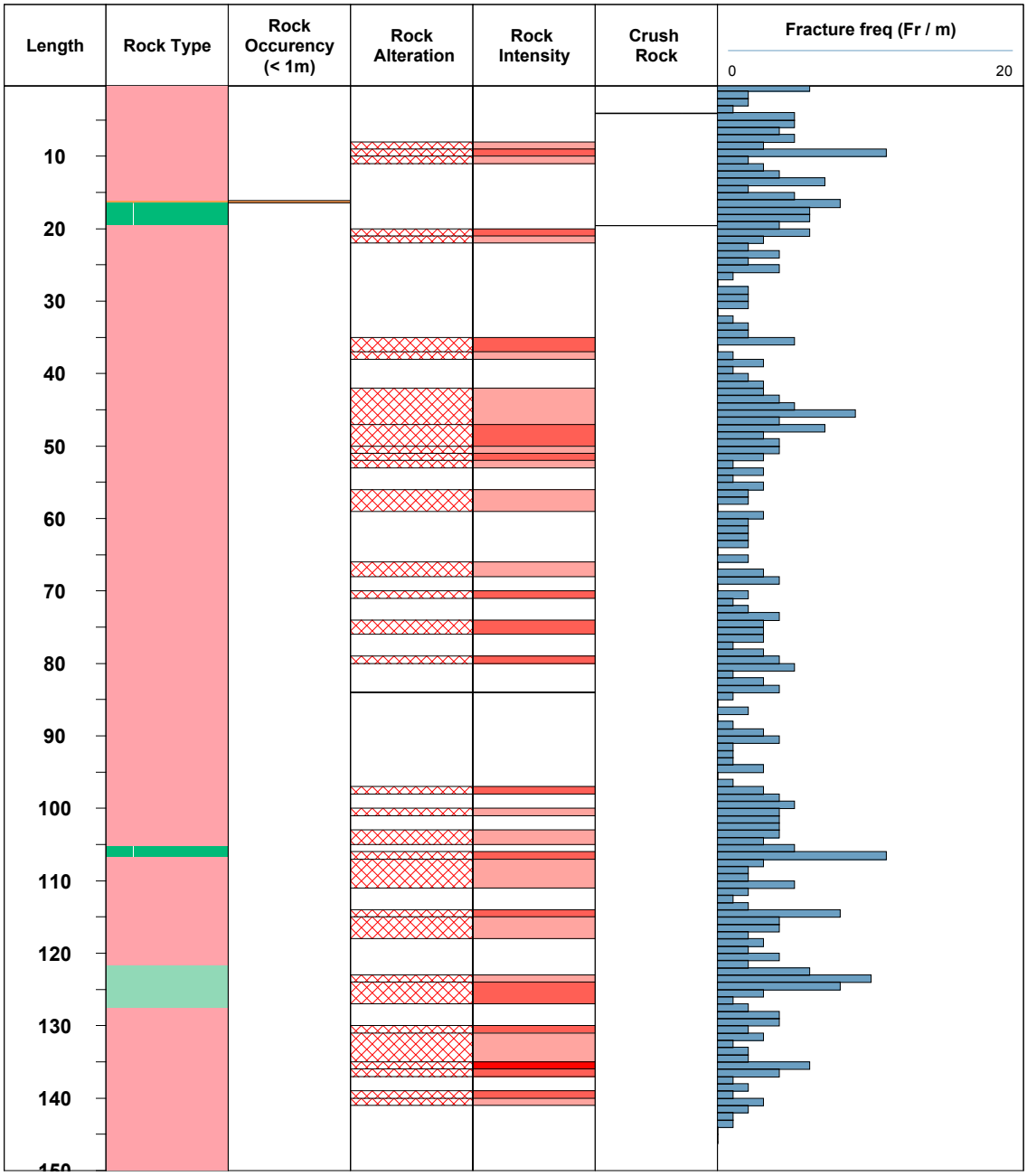
Wellcad plots – Results from the preliminary geological logging in boreholes KLX09G, KLX10B, KLX10C, KLX22A, KLX22B, KLX23A, KLX23B, KLX24A, KLX25A, KLX26A, KLX26B, KLX28A and KLX29A



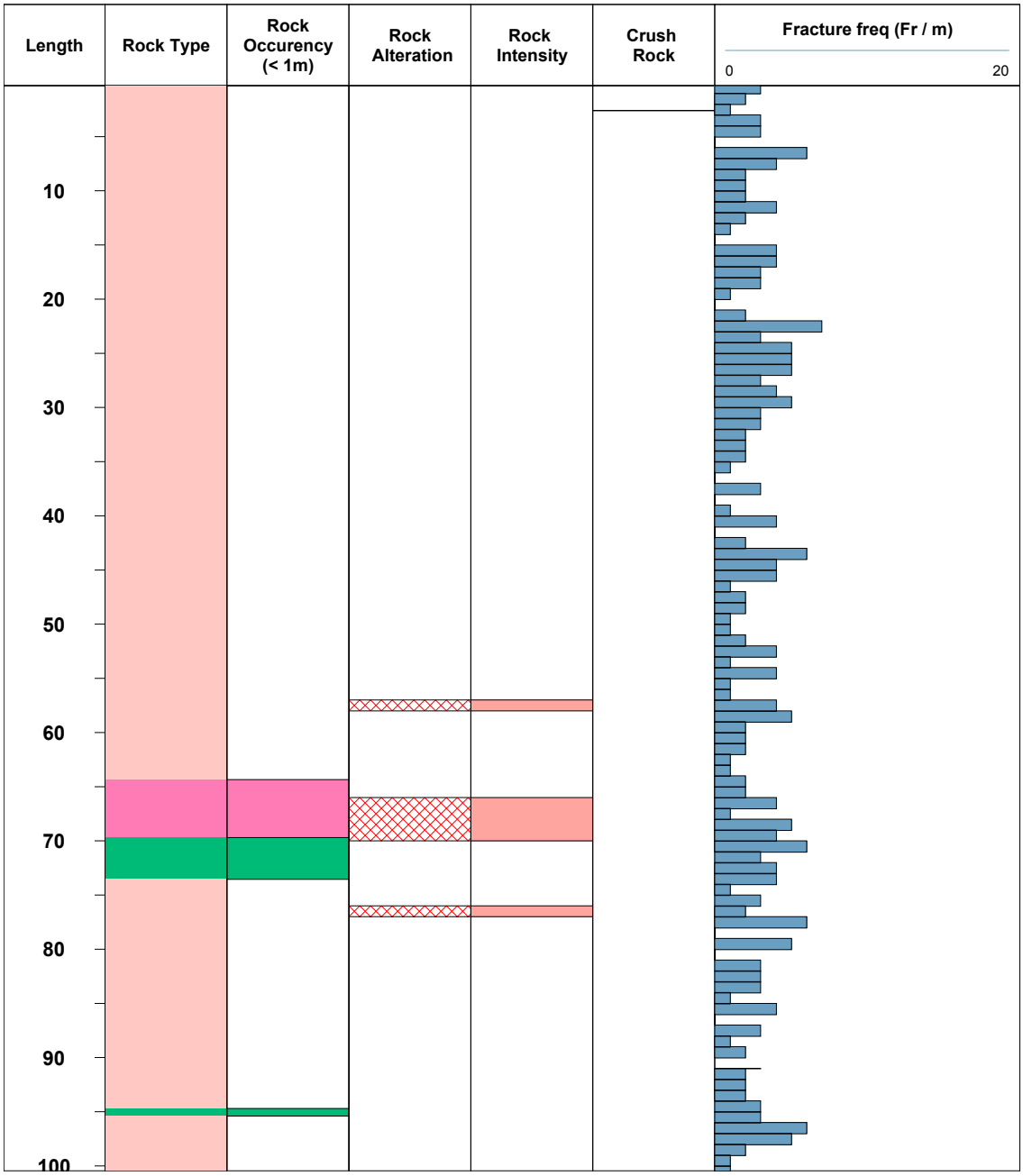
Title PLU SIMPLIFIED GEOLOGY IN KLX10B **Appendix 2**



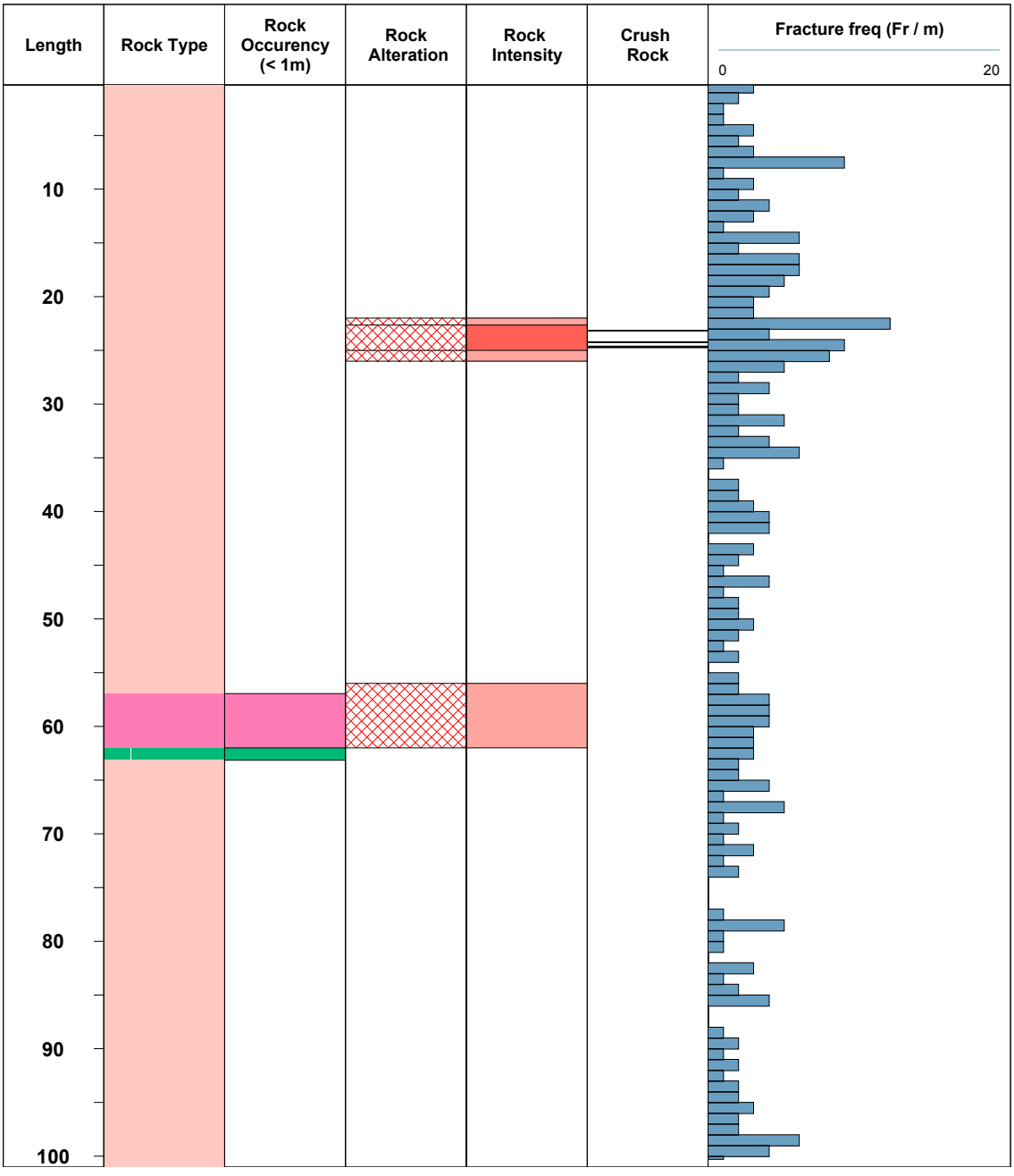
Title PLU SIMPLIFIED GEOLOGY IN KLX10C **Appendix 2**



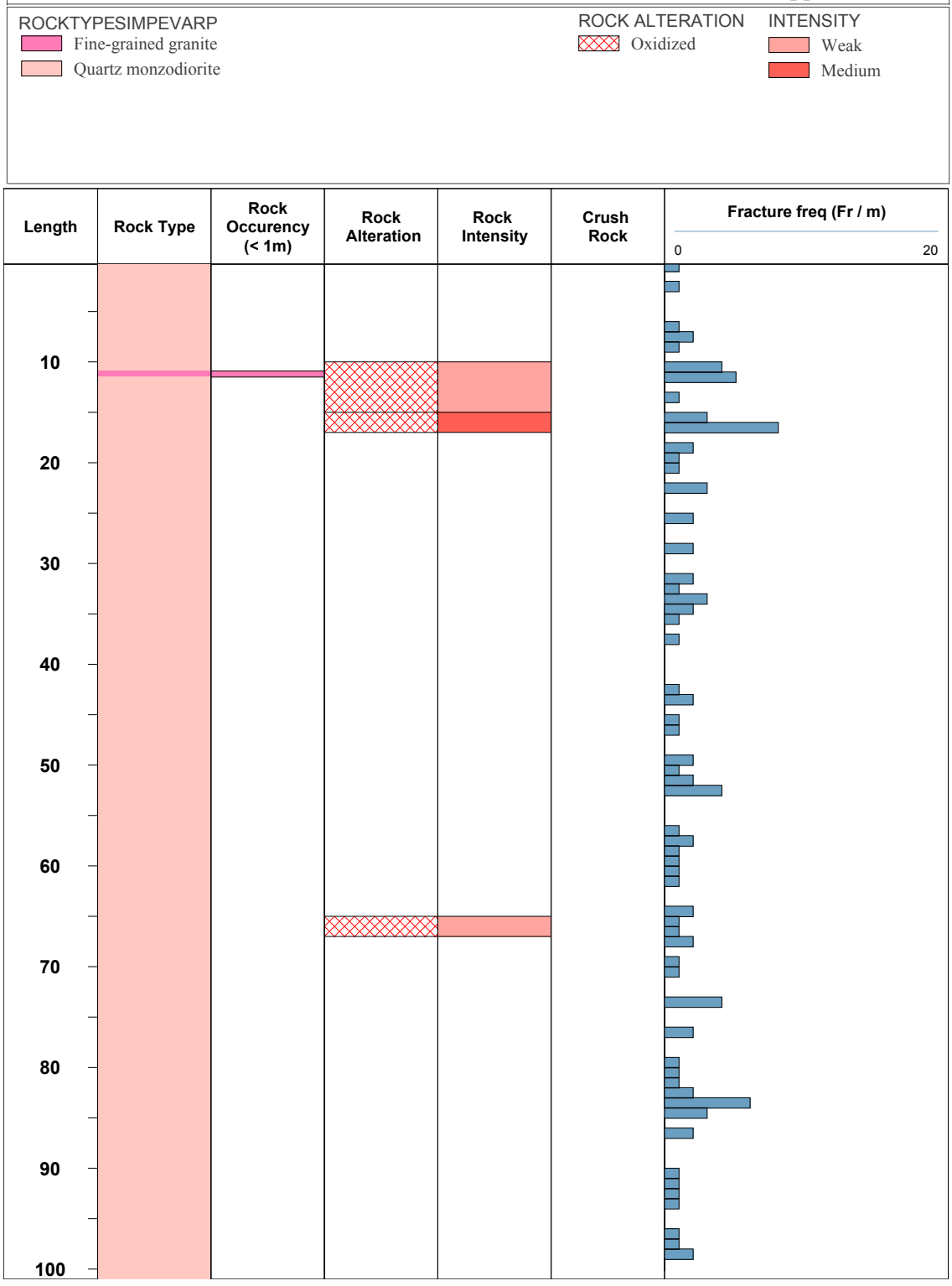
Title PLU SIMPLIFIED GEOLOGY IN KLX22A **Appendix** 2



Title PLU SIMPLIFIED GEOLOGY IN KLX22B **Appendix 2**



Title PLU SIMPLIFIED GEOLOGY IN KLX23A **Appendix 2**

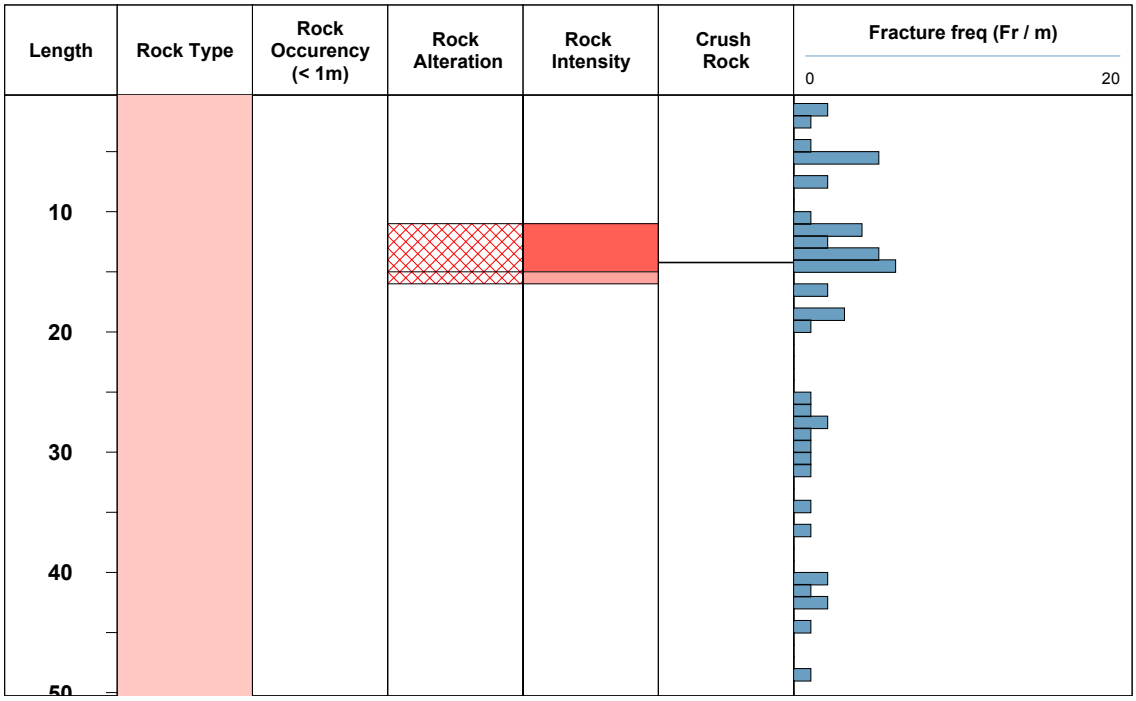


Title PLU SIMPLIFIED GEOLOGY IN KLX23B **Appendix** 2

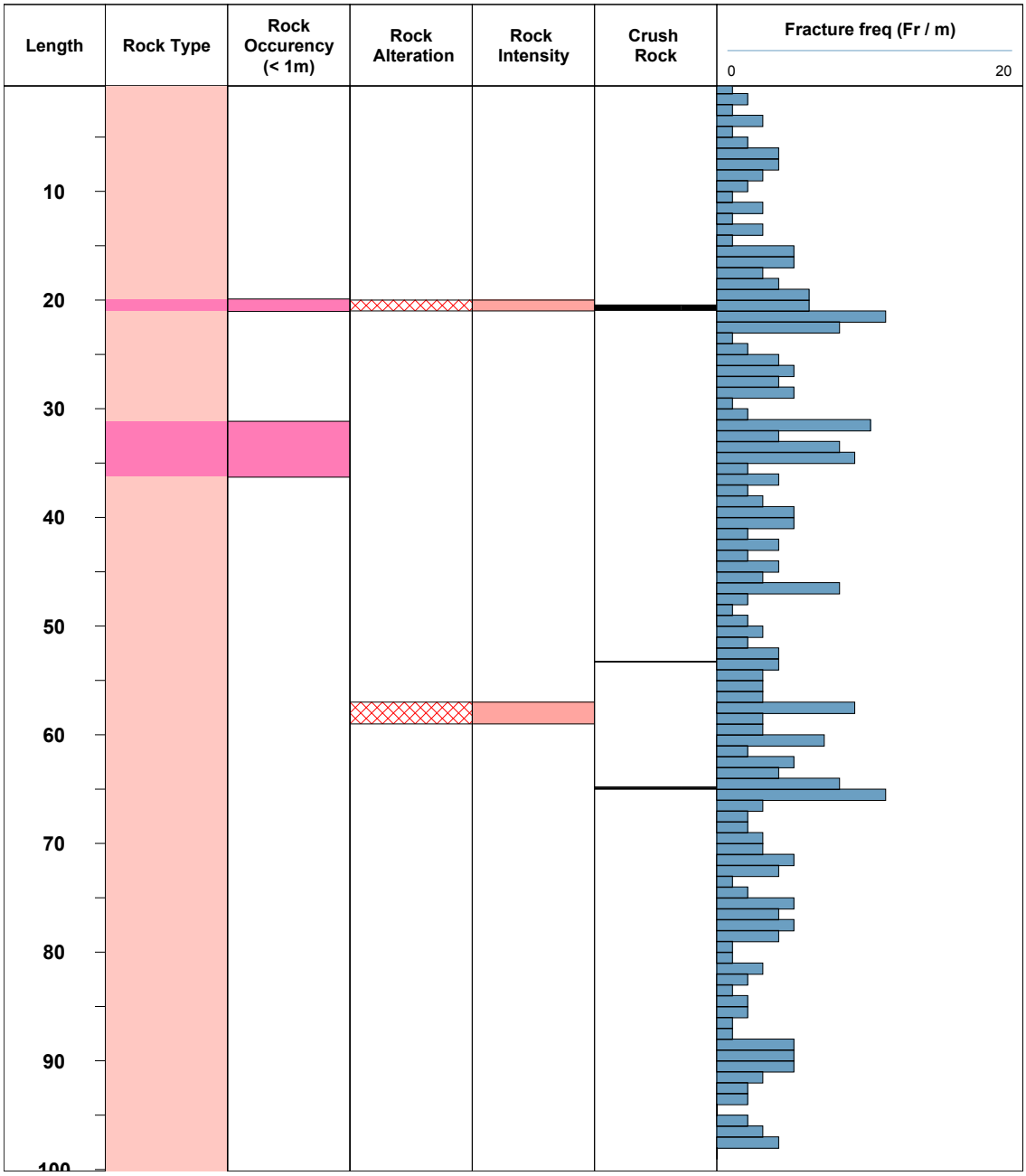
ROCKTYPESIMPEVARP
Quartz monzodiorite

ROCK ALTERATION
Oxidized

INTENSITY
Weak
Medium



Title PLU SIMPLIFIED GEOLOGY IN KLX24A **Appendix 2**

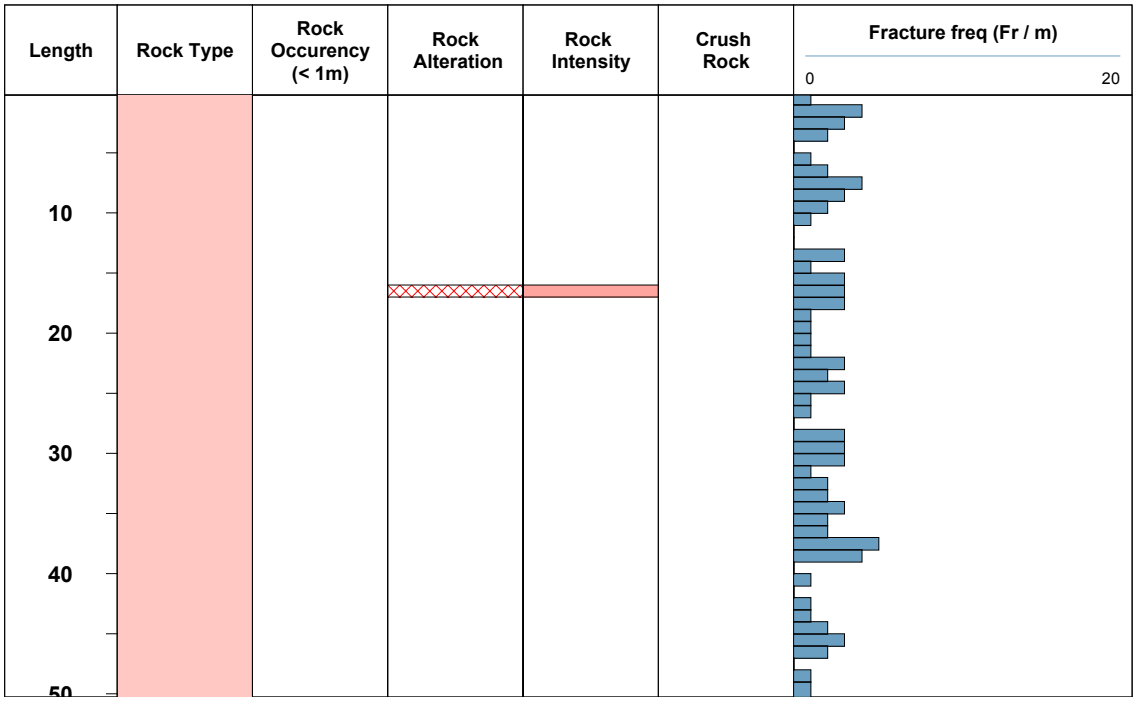


Title PLU SIMPLIFIED GEOLOGY IN KLX25A **Appendix** 2

ROCKTYPESIMPEVARP
Quartz monzodiorite

ROCK ALTERATION
Oxidized

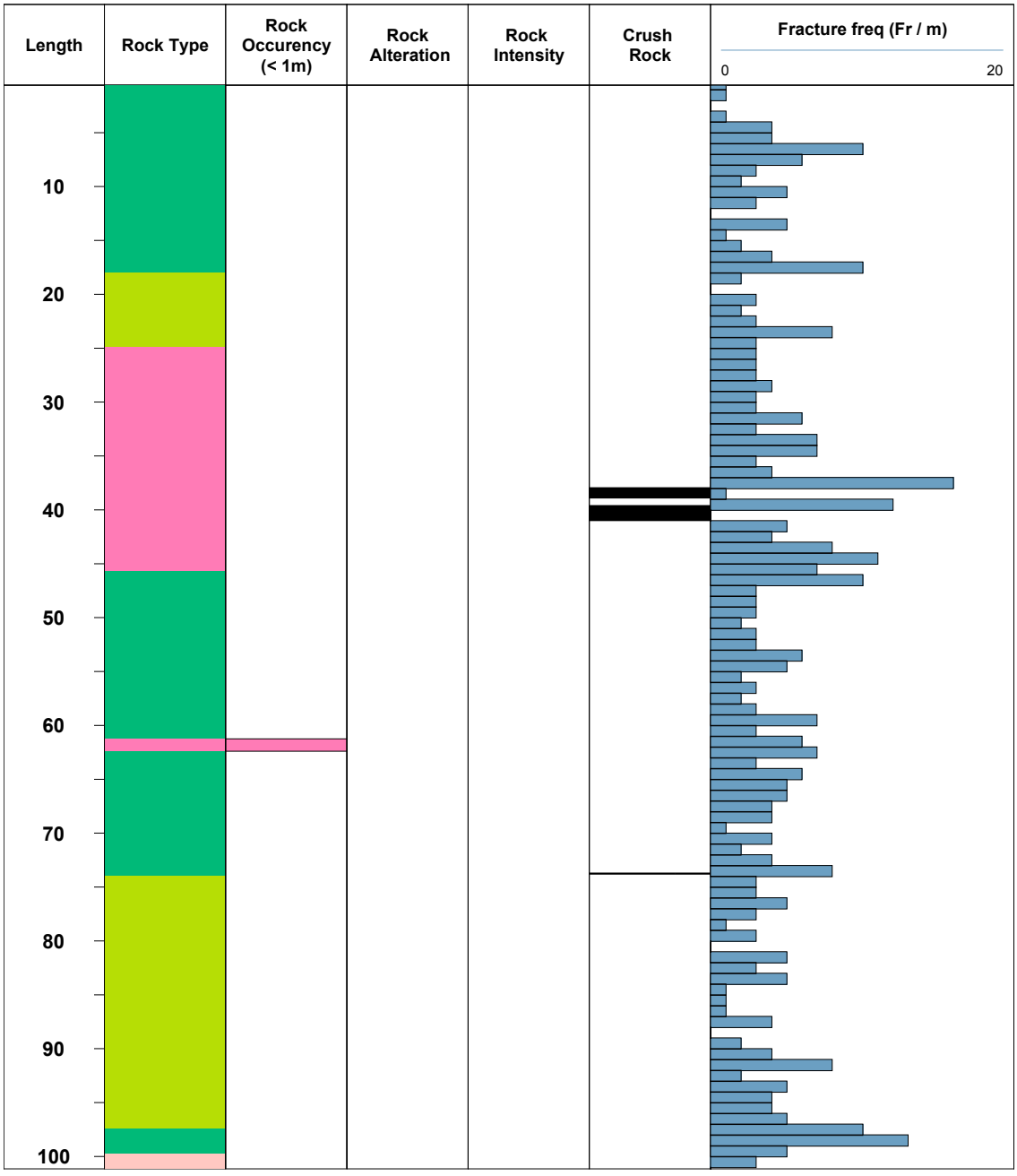
INTENSITY
Weak



Title PLU SIMPLIFIED GEOLOGY IN KLX26A **Appendix 2**

ROCKTYPESIMPEVARP
- Fine-grained granite
- Quartz monzodiorite
- Diorite / Gabbro
- Fine-grained diorite-gabbro

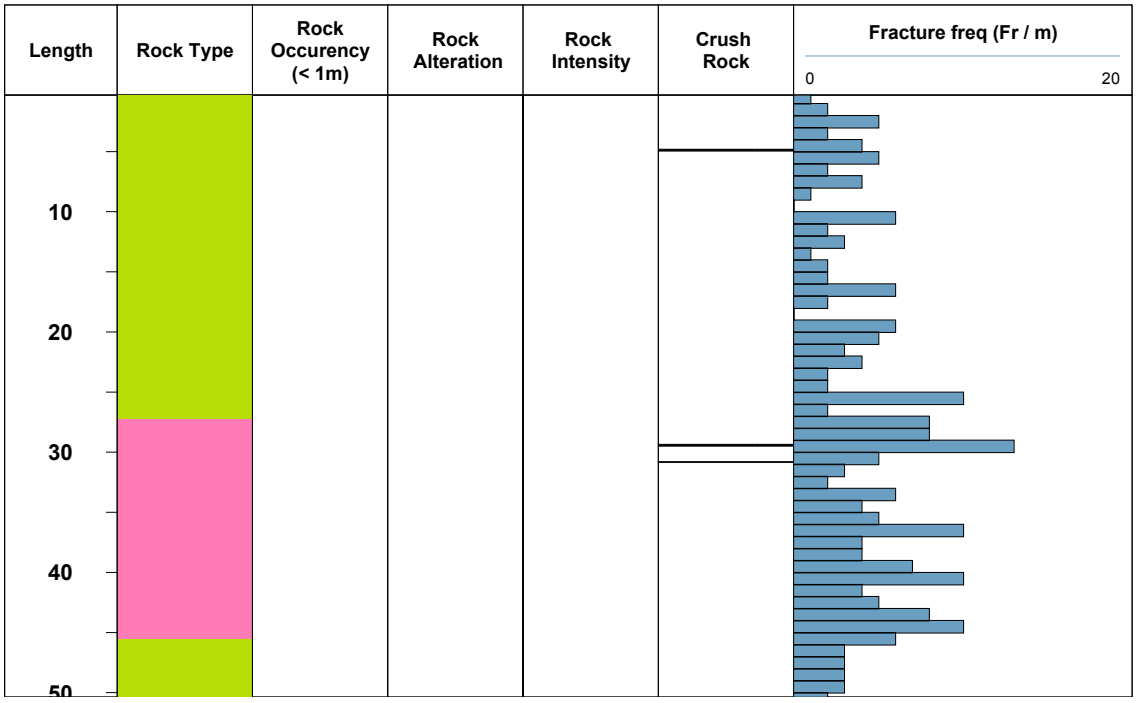
ROCK ALTERATION INTENSITY



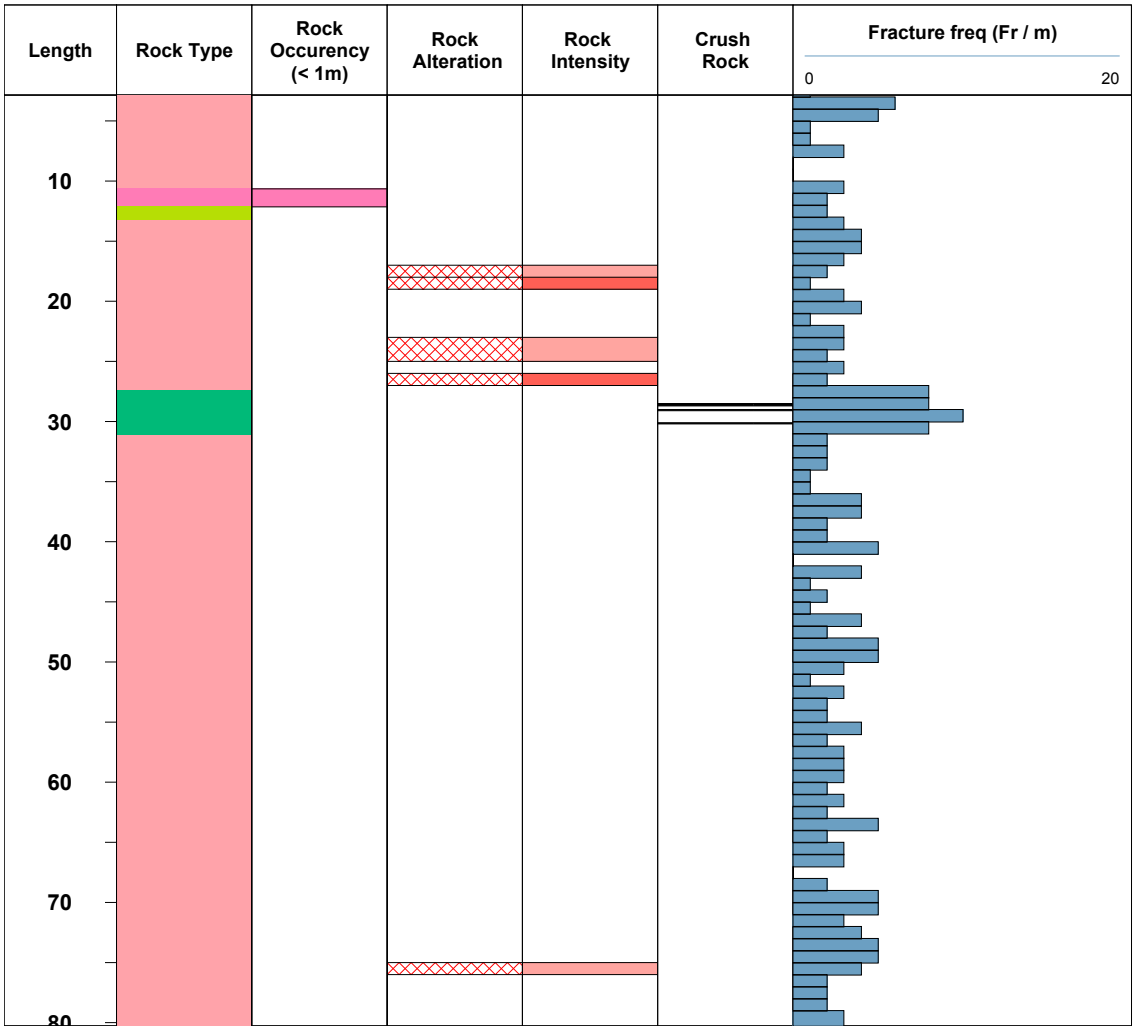
Title PLU SIMPLIFIED GEOLOGY IN KLX26B **Appendix** 2

ROCKTYPESIMPEVARP
Fine-grained granite
Diorite / Gabbro

ROCK ALTERATION INTENSITY



Title PLU SIMPLIFIED GEOLOGY IN KLX28A **Appendix 2**



Title PLU SIMPLIFIED GEOLOGY IN KLX29A **Appendix 2**