P-05-271

Oskarshamn site investigation

Water sampling in KLX04 and KLX06

Summary of analyses from water sampling during pumping with The Pipe String System

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June 2006

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Keywords: Groundwater, Borehole, Chemical analyses, Isotope determinations, AP PS 400-04-075, AP PS 400-04-118.

Abstract

Water sampling in the core-drilled boreholes KLX04 and KLX06 within the site investigation programme at Oskarshamn was performed during pumping with the Pipe String System (PSS).

The results from this activity include groundwater chemistry data in accordance with SKB class 5 chemistry from two sections in KLX04 (510.6–515.6 m and 971.2–976.2 m), class 4 from one section in KLX04 (104.0–109.0 m) and one section in KLX06 (260.0–265.0 m) and class 3 samples from the remaining two sections in KLX06 (558.2–563.2 m and 776.2–781.2 m). The data were obtained during August 2004–April 2005.

All analytical data from the activity are stored in the SICADA database.

Sammanfattning

Vattenprovtagning i kärnborrhålen KLX04 och KLX06 inom platsundersökningen i Oskarshamn, har utförts vid pumpning med Pipe String System (PSS).

Resultaten från denna aktivitet inkluderar vattenkemidata enligt SKB kemiklass 5 från två sektioner i KLX04 (510,6–515,6 m och 971,2–976,2 m), kemiklass 4 från en sektion i KLX04 (104,0–109,0 m) och en sektion i KLX06 (260,0–265,0 m) samt kemiklass 3 i resterande två sektioner i KLX06 (558,2–563,2 m and 776,2–781,2 m). Proverna är tagna under perioden augusti 2004 till april 2005.

Alla resultat från vattenanalyserna finns i databasen SICADA.

Contents

1 Introduction

This document summarises the results obtained from water sampling during pumping with the Pipe String System (PSS) in boreholes KLX04 and KLX06 within the site investigation programme at Oskarshamn. The work was conducted in accordance with activity plans SKB AP PS 400-04-075 (KLX04) and SKB AP PS 400-04-118 (KLX06). Controlling documents for performance of the water sampling activities are listed in Table 1-1. Both activity plans and method description are SKB's internal controlling documents. The data were obtained during August 2004–April 2005 and are reported in the SICADA database. Maps showing the location of the boreholes KLX04 and KLX06 are presented in Figure 1-1.

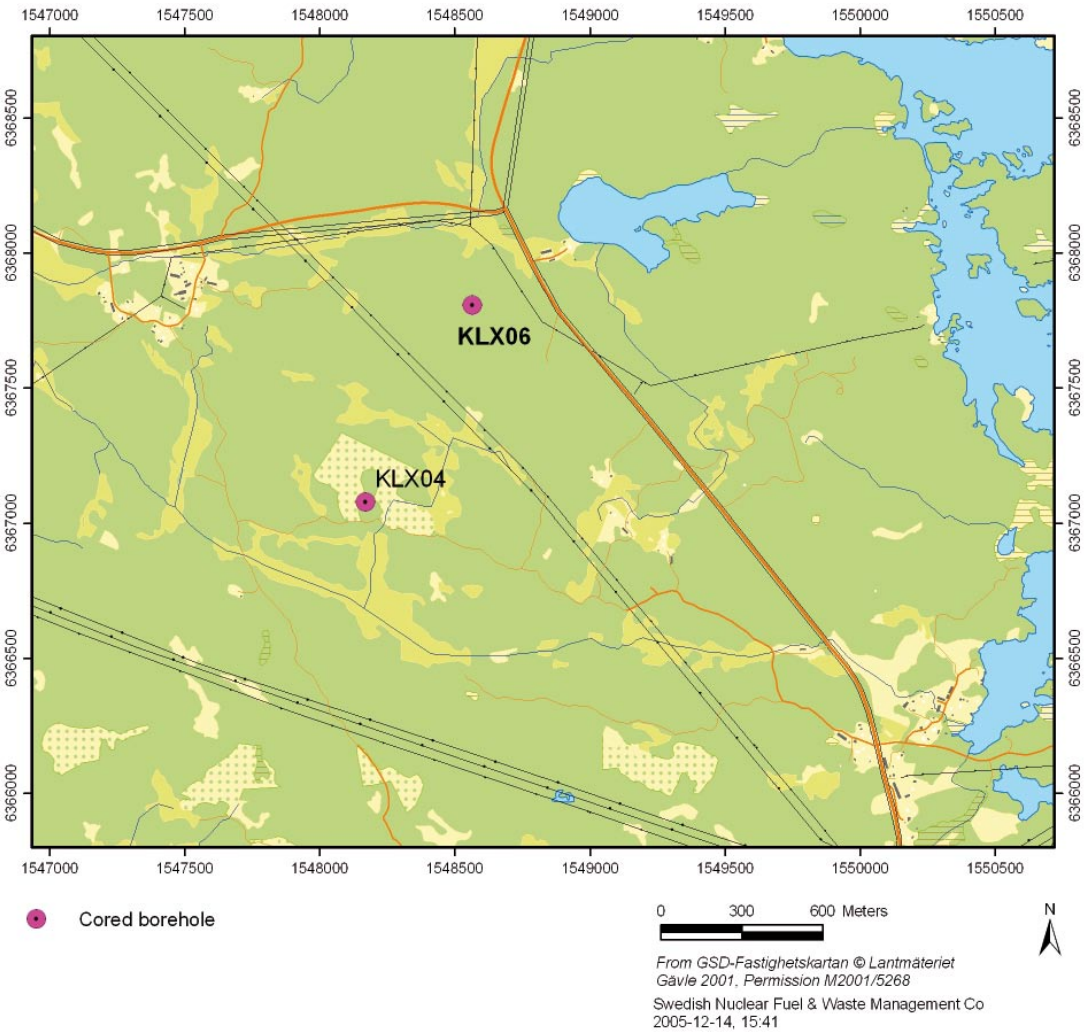

Figure 1-1. *Location of the boreholes KLX04 and KLX06 within the Oskarshamn investigation area.*

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

Activity plan	Number	Version
Test pumping and hydraulic injection tests in borehole KLX04.	AP PS 400-04-075	1.0
Test pumping and hydraulic injection tests in borehole KLX06.	AP PS 400-04-118	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för provtagning under pumptester i kärnborrhål.	SKB MD 430.018	1.0

The report presents groundwater chemistry data from the following six borehole sections:

KLX04

- 104.0–109.0 m
- 510.6–515.6 m
- 971.2–976.2 m

KLX06

- 260.0–265.0 m
- 558.2–563.2 m
- 776.2–781.2 m

2 Objective and scope

This report summarises the analytical results from the water chemistry samples collected during pumping with PSS in three sections in borehole KLX04 and three sections in borehole KLX06. Selection of section lengths is based on results from differential flow logging /1, 2/. The water sampling is performed in order to increase the quantity of chemical data from the borehole, and carried out according to SKB class 4 and 5 (with the options presented in Appendix 1). The sampling in the uppermost sections are carried out according to SKB class 4 and the other two deeper sections, in each borehole, are carried out according to class 5.

When the drill water content is 5% or lower, a final SKB sample is normally collected. However, since the maximum pumping time for each section is 7 days, this drill water content criterion may not be achieved. Then, the water sample may be analysed according to a lower class.

3 Equipment

3.1 Pipe String system (PSS)

The SKB downhole pipe string system (PSS) is normally used for hydraulic injection and pumping tests but in this case it was used for pumping and chemical sampling. For pumping it is designed for flow rates between 5 to 40 L/min. The equipment is described in SKB MD 345.100–124 (Pipe String System, SKB internal controlling document).

3.1.1 PSS equipment facility container

The PSS is primarily designed for pumping and injection tests in packed-off borehole sections. All of the equipment needed to perform the tests is located in a self-contained steel container, which is placed on pallets in order to ensure a suitable working level in relation to the borehole casing. The container is divided into a computer-room and a workshop compartment, see Figure 3-1.

The hoisting rig is of a hydraulic chain-feed type. The jaws, holding the pipe string, are opened hydraulically and closed mechanically using springs. The rig is equipped with a load transmitter, maximum 22 kN, and a limiting value for the load may be adjusted.

Water filled pressure vessels operate the packers and the test valve. Expansion and release of packers as well as opening and closing of the test valve is done by magnetic valves controlled by the software in the data acquisition system.

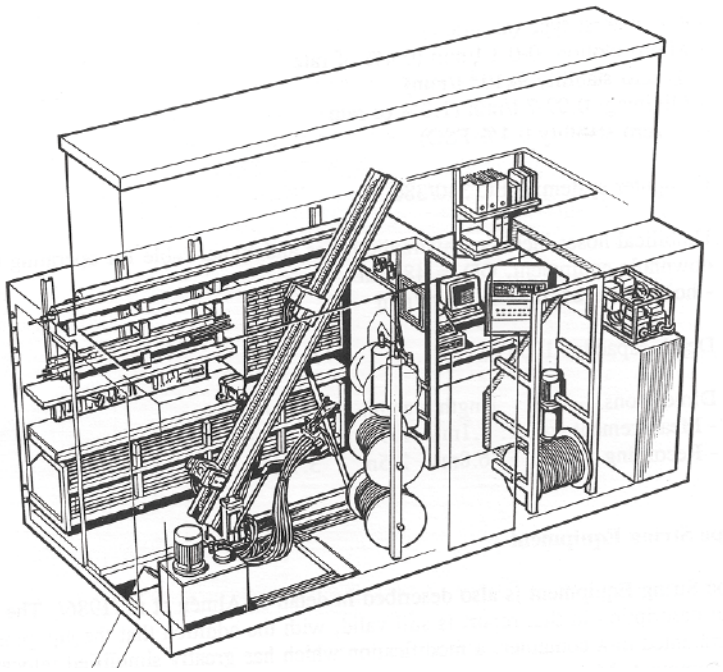

Figure 3-1. *Outline of the PSS equipment facility container.*

3.1.2 Downhole equipment

A schematic drawing of the downhole equipment container is shown in Figure 3-2. The pipe string consists of aluminium pipes of 3 m lengths and with an inner diameter of 21 mm, connected by stainless steel taps sealed with double o-rings. The test section is constructed using 5 m pipe lengths which can be adjusted to investigate 5, 20 or 100 m borehole sections, corresponding to available lengths of electric cable. Pressure is measured above (P_a), within (P) and below (P_b) the test section which is isolated by two packers. The groundwater temperature in the test section is also measured. The hydraulic connection between the pipe string and the test section can be closed or opened by a test valve operated from the equipment facility container. At the lower end of the borehole equipment, a level indicator (caliper type) gives a signal when the reference length marks along the borehole are passed.

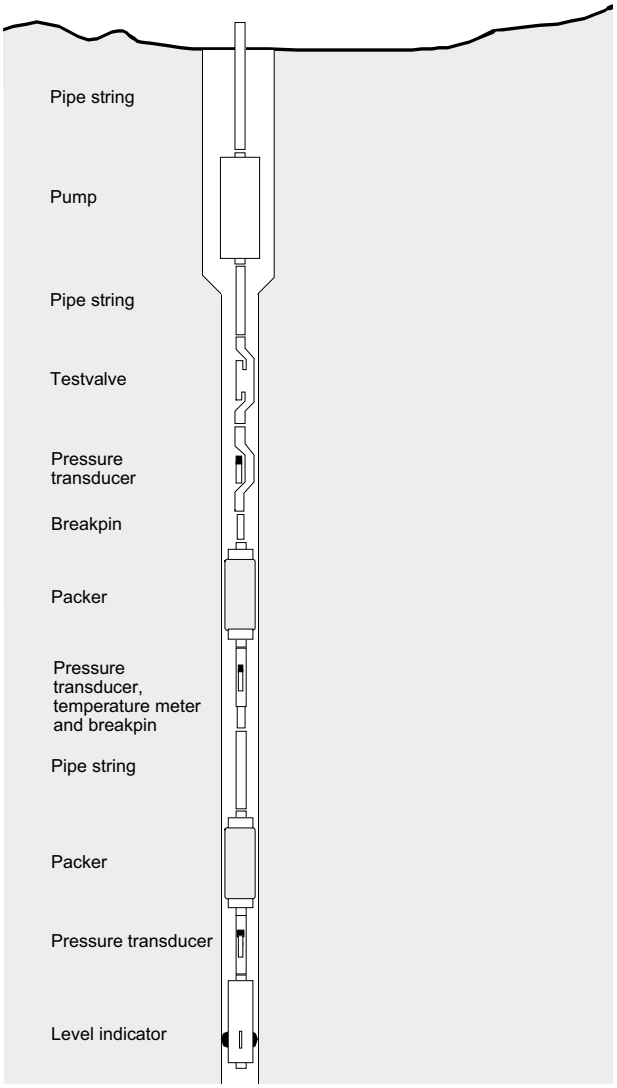

Figure 3-2. *Schematic drawing of the downhole equipment in the PSS system.*

4 Performance

4.1 General

Using the PSS system /3, 4/, pumping and water sampling in KLX04 was performed following the injection tests in the borehole. In KLX06 the pumping and water sampling was performed prior to the injection tests /5/. These activities were performed in accordance with the activity plans listed in Table 1-1 and following the method description SKB MD 430.018 (Metodbeskrivning för provtagning under pumptester i kärnborrhål, SKB internal controlling document).

The main objective of the pumping was to sample water from three sections in each borehole. A final SKB sample, class 4 or 5 (with the options presented in Appendix 1) see Appendix 1, is normally collected when the drill water content is 5% or lower. However, since the maximum pumping time for each section is 7 days, this may not be achieved. Filtering of the samples was not performed in the field. The collected samples were immediately brought to the Äspö laboratory for further preparation and conservation.

4.2 Reference sampling

In KLX04, besides the three packed-off borehole sections, water samples were collected also from the injection tanks prior to the water sampling campaign, Table 4-1. These tanks contain water pumped from KLX04 already traced with Uranine from drilling; further Uranine was added in the tanks before the injection tests.

Table 4-1. Sampling from injection tank.

Date and time	Sampling activity	SKB no
2004-08-26 11:47	Water sampling (in 3 m^3 tank): Uranine	7739
2004-08-26 11:49	Water sampling (in 1.8 m^3 tank): Uranine	7738

4.3 Performance in KLX04

Samples for Uranine analyses were collected once daily until the drill water content was 10% or lower. Following that, samples for Uranine was collected twice each day, once in the morning and once in the afternoon. The final water sample, a SKB chemistry sample, was collected when the drill water content was 5% or lower. The decision when to collect the final water sample in each section was made by the SKB Activity Leader for hydrogeochemistry at Oskarshamn. Besides the final water sample, a control sample was taken from each of the sections in KLX04.

Class 4 analysis was carried out on the sample from the uppermost section (104.0–109.0 m); class 5 analysis was carried out on samples from the other two sections (510.7–515.7 m and 971.2–976.2 m).

4.3.1 Section 104.0–109.0 m

Besides sampling for Uranine, two class 4 samples were collected from this section. The first sample was analysed for class 4 parameters with all options and density. Archive samples were stored in a freezer. The second sample was collected as a control sample and was analysed for HCO_3^-, SO_4^{2-}, Cl^-, Br^-, F^-, HS^-, Fe-tot, Fe^{2+}, NH_4^+, pH, electrical conductivity, Uranine and density. The rest of the control sample, and the archive samples, were stored in a freezer (tritium in a refrigerator). A split from one of the archive samples (from the control sample 7857) was sent to Analytica, almost a year after the sampling occasion, for control analyses of Br^-. The result is not presented in this report.

Water samples collected during the pumping period are listed in Table 4-2.

4.3.2 Section 510.6–515.6 m

Besides sampling for Uranine, two class 5 samples were collected from this section and analysed for all parameters. The density of the sample was also determined. Archive samples were stored in a freezer. The second sample was collected as a control sample and was analysed for HCO_3^-, SO_4^{2-}, Cl^-, Br^-, F^-, HS^-, Fe-tot, Fe^{2+}, NH_4^+, pH, electrical conductivity, Uranine, density and the isotopes Ra^{226} and Rn^{222}. The rest of the control sample, together with archive samples, were stored in a freezer (tritium in a refrigerator). Splits from the archive samples (from the samples 7776 and 7777) were sent to Analytica, almost a year after the sampling occasion, for control analyses of Br^-.

Water samples collected during the pumping period are listed in Table 4-3.

4.3.3 Section 971.2–976.2 m

Besides sampling for Uranine, two class 5 samples were collected from this section and was analysed for all parameters. The density of the sample was also determined. Archive samples were stored in a freezer. The second sample was collected as a control sample and analysed for HCO_3^-, SO_4^{2-}, Cl^-, Br^-, F^-, HS^-, Fe-tot, Fe^{2+}, NH_4^+, pH, electrical conductivity, Uranine, density and the isotopes Ra^{226} and Rn^{222}. The rest of the control sample, and archive samples, were stored in a freezer (tritium in a refrigerator). Splits from the archive samples (from the samples 7752 and 7753) were sent to Analytica, almost a year after the sampling occasion, for control analyses of Br^-.

Water samples collected during the pumping period are listed in Table 4-4.

Table 4-2. Sampling performed in section 104.00–109.00 in KLX04.

Date and time	Sampling activity	SKB no
2004-09-30 08:00	Water sampling: Uranine	7806
2004-09-30 10:10	Water sampling: Class 4	7856
2004-09-30 10:12	Water sampling: Class 4 (Control sample)	7857

Table 4-3. Sampling performed in section 510.56–515.56 in KLX04.

Date and time	Sampling activity	SKB no
2004-09-17 19:25	Water sampling: Uranine	7734
2004-09-18 07:55	Water sampling: Uranine	7729
2004-09-18 17:40	Water sampling: Uranine	7730
2004-09-19 07:50	Water sampling: Uranine	7731
2004-09-19 18:20	Water sampling: Uranine	7732
2004-09-20 07:55	Water sampling: Uranine	7733
2004-09-20 19:00	Water sampling: Uranine	7765
2004-09-21 08:10	Water sampling: Uranine	7766
2004-09-21 17:45	Water sampling: Uranine	7767
2004-09-22 08:00	Water sampling: Uranine	7768
2004-09-22 17:35	Water sampling: Uranine	7769
2004-09-23 08:00	Water sampling: Uranine	7770
2004-09-23 17:30	Water sampling: Uranine	7771
2004-09-24 08:10	Water sampling: Uranine	7772
2004-09-24 18:20	Water sampling: Uranine	7773
2004-09-25 08:20	Water sampling: Uranine	7774
2004-09-25 17:20	Water sampling: Uranine	7801
2004-09-26 08:10	Water sampling: Uranine	7800
2004-09-26 17:30	Water sampling: Uranine	7801
2004-09-27 08:15	Water sampling: Uranine	7802
2004-09-27 18:00	Water sampling: Uranine	7803
2004-09-28 08:05	Water sampling: Uranine	7804
2004-09-28 17:55	Water sampling: Uranine	7805
2004-09-29 08:30	Water sampling: Class 5	7776
2004-09-29 09:00	Water sampling: Class 5 (Control sample)	7777

Table 4-4. Sampling performed in section 971.21–976.21 in KLX04.

Date and time	Sampling activity	SKB no
2004-09-09 21:30	Water sampling: Uranine	7748
2004-09-10 09:00	Water sampling: Uranine	7747
2004-09-11 06:10	Water sampling: Uranine	7745
2004-09-12 18:00	Water sampling: Uranine	7744
2004-09-13 14:00	Water sampling: Uranine	7743
2004-09-14 08:45	Water sampling: Uranine	7742
2004-09-14 16:00	Water sampling: Uranine	7741
2004-09-15 09:45	Water sampling: Uranine	7740
2004-09-15 16:00	Water sampling: Uranine	7737
2004-09-16 07:50	Water sampling: Uranine	7736
2004-09-16 12:30	Water sampling: Uranine	7735
2004-09-16 11:00	Water sampling: Class 5	7752
2004-09-16 12:30	Water sampling: Class 5 (Control sample)	7753

4.4 Performance in KLX06

Samples for Uranine analyses were collected each day after pumping commenced. The aim of achieving 5% drill water content was not reached in any of the three sections and the decision to stop pumping and collect the final water sample was taken by the SKB Activity Leader. Hence, no sampling/analysis according to class 5 was performed.

A class 4 water sample was analysed from the uppermost section (260.0–265.0 m) and also class 3 samples from the other two sections (558.2–563.2 m and 776.2–781.2 m). No control samples were collected from any of the three sections investigated in borehole KLX06.

4.4.1 Section 260.0–265.0 m

Besides sampling for Uranine, one SKB 4 sample, including all options, was collected from this section; the density of the sample was also determined. Archive samples were stored in a freezer.

Water samples collected during the pumping period in section 260.0–265.0 m are listed in Table 4-5.

4.4.2 Section 558.2–563.2 m

Besides of sampling of Uranine, one class 3 sample with options for deuterium (δ^2H) oxygen-18 ($\delta^{18}O$) and tritium (^3H) was collected from this section; the density of the sample was also determined. Archive samples were stored in a freezer.

Water samples collected during the pumping period in section 558.2–563.2 m are listed in Table 4-6.

4.4.3 Section 776.2–781.2 m

Besides water sampling for Uranine, one class 3 sample with options for deuterium (δ^2H) oxygen-18 ($\delta^{18}O$) and tritium (^3H) was collected from this section; the density of the sample was also determined. Archive samples were stored in a freezer.

Water samples collected during the pumping period in section 776.2–781.2 m are listed in Table 4-7.

Table 4-5. Sampling performed in section 260.00–265.00 in KLX06.

Date and time	Sampling activity	SKB no
2005-03-07 10:20	Water sampling: Uranine	10117
2005-03-07 19:30	Water sampling: Uranine	10118
2005-03-08 14:00	Water sampling: Uranine	10119
2005-03-09 08:45	Water sampling: Uranine	10120
2005-03-09 09:45	Water sampling: Uranine	10121
2005-03-09 11:00	Water sampling: Class 4	10122

Table 4-6. Sampling performed in section 558.20–563.20 in KLX06.

Date and time	Sampling activity	SKB no
2005-03-10 19:32	Water sampling: Uranine	10123
2005-03-11 17:00	Water sampling: Uranine	10124
2005-03-12 18:30	Water sampling: Uranine	10125
2005-03-13 17:00	Water sampling: Uranine	10126
2005-03-14 17:00	Water sampling: Uranine	10128
2005-03-15 17:00	Water sampling: Uranine	10129
2005-03-16 08:30	Water sampling: Class 3	10130
2005-03-16 08:40	Water sampling: Uranine	10131

Table 4-7. Sampling performed in section 776.20–781.20 in KLX06.

Date and time	Sampling activity	SKB no
2005-03-17 16:41	Water sampling: Uranine	10132
2005-03-18 18:00	Water sampling: Uranine	10133
2005-03-19 18:00	Water sampling: Uranine	10134
2005-03-20 18:00	Water sampling: Uranine	10135
2005-03-21 18:00	Water sampling: Uranine	10144
2005-03-22 18:00	Water sampling: Uranine	10145
2005-03-23 09:05	Water sampling: Uranine	10146
2005-03-23 09:10	Water sampling: Class 3	10147

4.5 Water sample treatment and analyses

An overview of sample treatment and analytical routines for major constituents, minor anions, trace metals and isotopes is given in Appendix 1.

4.6 Handling of water analytical data

The following routines for quality control and data management are generally applied for hydrogeochemical analytical data, independently of sampling method or sampling object.

Some of the constituents are determined by more than one method and/or laboratory. All analytical results are stored in the SICADA database. The applied hierarchy path "Hydrochemistry/Hydrochemical investigation/Analyses/Water in the database" contains two types of tables, raw data tables and primary data tables (final data tables).

Data on **basic water analyses** are inserted into the raw data tables for further evaluation. The evaluation results in a final reduced data set for each sample. These data sets are compiled in a primary data table named "water composition". The evaluation is based on:

- Comparison of the results from different laboratories and/or methods.
- Calculation of charge balance errors, equation (1). Relative errors within ± 5% are considered acceptable.

$$\text{Relative error } (\%) = 100 \times \frac{\sum \text{cations}(\text{equivalents}) - \sum \text{anions}(\text{equivalents})}{\sum \text{cations}(\text{equivalents}) + \sum \text{anions}(\text{equivalents})} \quad (1)$$

- General judgement of plausibility based on earlier results and experience.

All results from **special analyses of trace metals and isotopes** are inserted directly into primary data tables. In cases where the analyses are repeated or performed by more than one laboratory, a "best choice" notation will indicate those results which are considered most reliable.

An overview of the data management is given in Figure 4-1.

4.7 Nonconformities

The sampling of water was conducted according to activity plan AP PS 400-04-073 (KLX04) and AP PS 400-04-118 (KLX06) during the pumping tests with PSS.

Sample no. 10122 from section 260.0–265.0 in KLX06 was erroneously analysed for TOC at the consulted laboratory (the analysis ordered was DOC).

No deviation reports were written regarding the handling of chemical water sampling in any of the two boreholes. A deviation report was established regarding discharge of borehole water to the environment during water sampling in KLX06.

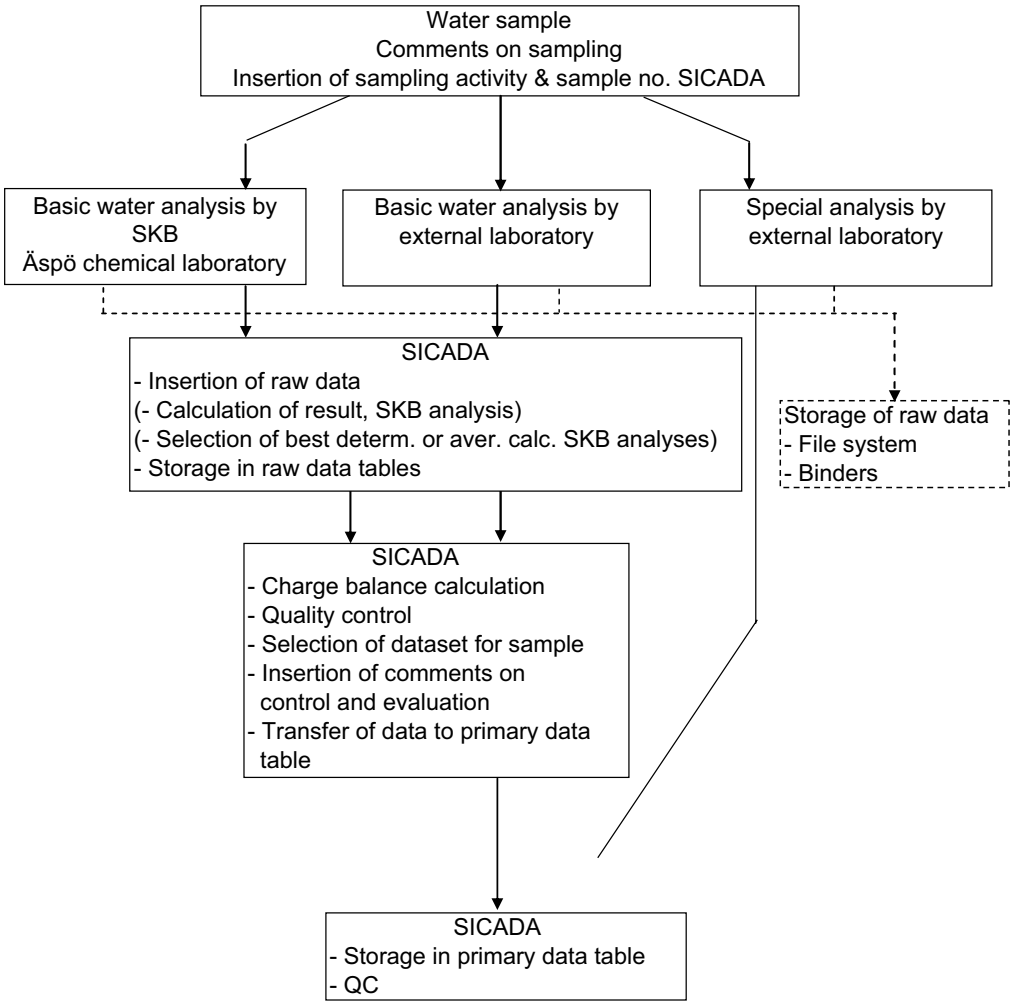

Figure 4-1. *Overview of data management for hydrogeochemical data.*

5 Results of water analysis

The results from the chemical analysis are presented below. The results are stored in the SICADA data base and are traceable by the activity plan number and sample number.

Water sampling in KLX04 and KLX06 was performed according to Table 5-1. In KLX06 sections 558.2–563.2 and 776.2–781.2 m, class 3 sampling was performed due to drill water content being above 5%.

Table 5-1. Water sampling in KLX04 and KLX06 was performed according to SKB class 3, 4 and 5.

KLX04 section (m)	Water sample SKB class	KLX06 section (m)	Water sample SKB class
104.0–109.0	4	260.0–265.0	4
510.6–515.6	5	558.2–563.2	3
971.2–976.2	5	776.2–781.2	3

5.1 Basic water analyses

The basic water analyses include Na, K, Ca, Mg, Fe, Li, Mn, S, Sr, P, SO_4^{2-}, Cl^-, Si, HCO_3^-, Br^-, F^-, I^-, HS^-, NH_4^+, NO_2^-, NO_3^-, TOC and DOC. Furthermore, measurements are made of pH, electrical conductivity, flushing water content and density in each class sample. The basic water analysis data and relative charge balance errors are compiled in Appendix 2, Table A2-1, and Appendix 3, Table A3-1, for KLX04 and KLX06, respectively.

The charge balance error gives an indication of the quality and uncertainty of the analyses of major constituents. The charge balance error does not exceed the acceptable level of ± 5% in any case.

The flushing water content in the samples collected during the pumping/measurement periods in the borehole sections are presented in Figure 5-1 for KLX04 and Figure 5-2 for KLX06.

The results from the Br analysis performed at the Äspö laboratory (except for samples 7856, 7857, 10122, 10130) are only stored in the SICADA raw data tables due to analytical problems. Instead, the Br results from the control samples sent to Analytica are stored in the primary tables in SICADA, i.e. in this report, the Br results from KLX04 are analysed at Analytica (except for samples 7856 and 7857).

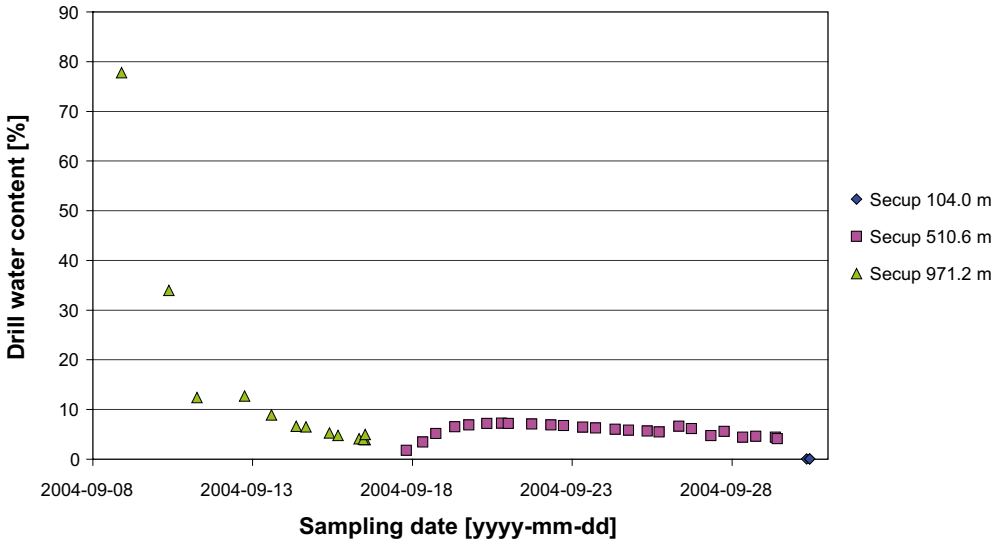

Figure 5-1. *Drill water content in samples collected in the three sections sampled using the PSS equipment in KLX04.*

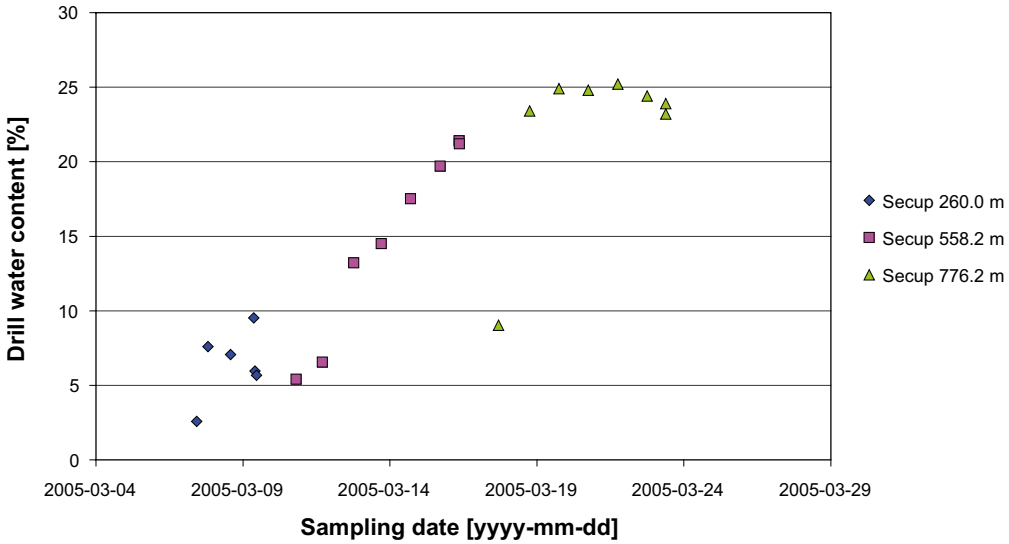

Figure 5-2. *Drill water content in samples collected in the three sections sampled using the PSS equipment in KLX06.*

The iron concentrations determined by ICP-AES (total Fe) and by spectrophotometry (Fe^{2+} and Fe-tot) in the three sections in KLX04 are compared in Figure 5-3. Since only one class 4 sample was collected in KLX06, values for Fe-tot and Fe^{2+} determined by spectrophotometry are not available for comparison in the borehole sections.

Sulphate (SO_4^{2-}) analysed by using ion chromatography (IC) is compared with sulphate determined as total sulphur using inductively coupled plasma atomic emission spectrometry (ICP-AES) in Figure 5-4 (KLX04) and Figure 5-5 (KLX06). As shown, there is a satisfactory agreement in the shallow sections while in the deeper section the ICP-AES values are somewhat higher than the IC values.

The chloride concentrations are plotted versus the corresponding electric conductivity values in Figure 5-6. The plot gives an approximate indication that the values are reasonable. The data from the borehole sections agree well with earlier data from the Äspö Hard Rock Laboratory.

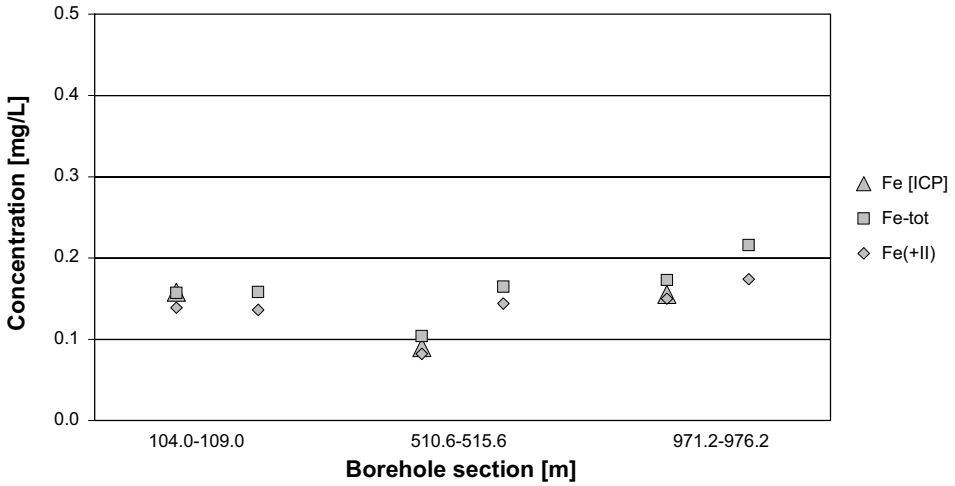

Figure 5-3. *Comparison of iron concentrations in the three borehole sections obtained by ICP-AES and spectrophotometry, respectively, in KLX04. The control sample from eaech section is presented to the right.*

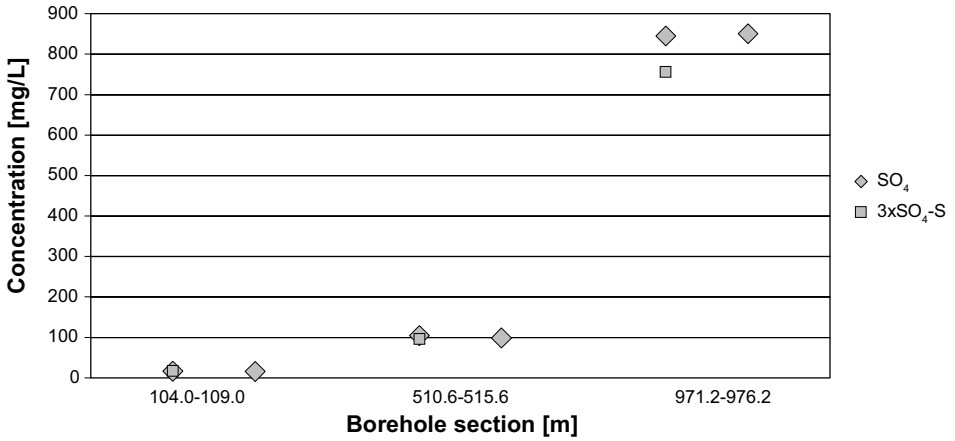

Figure 5-4. *Sulphate (SO_4 by IC) compared to sulphate calculated from total sulphur ($3\times SO_4$-S by ICP) for three sections investigated in KLX04. The control sample from each section is presented to the right.*

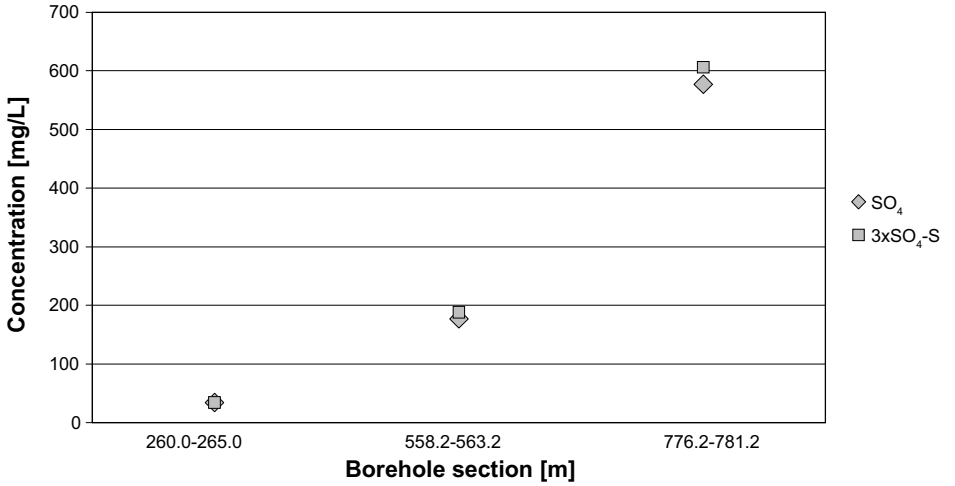

Figure 5-5. *Sulphate (SO_4 by IC) compared to sulphate calculated from total sulphur ($3\times SO_4$-S by ICP) for three sections investigated in KLX06.*

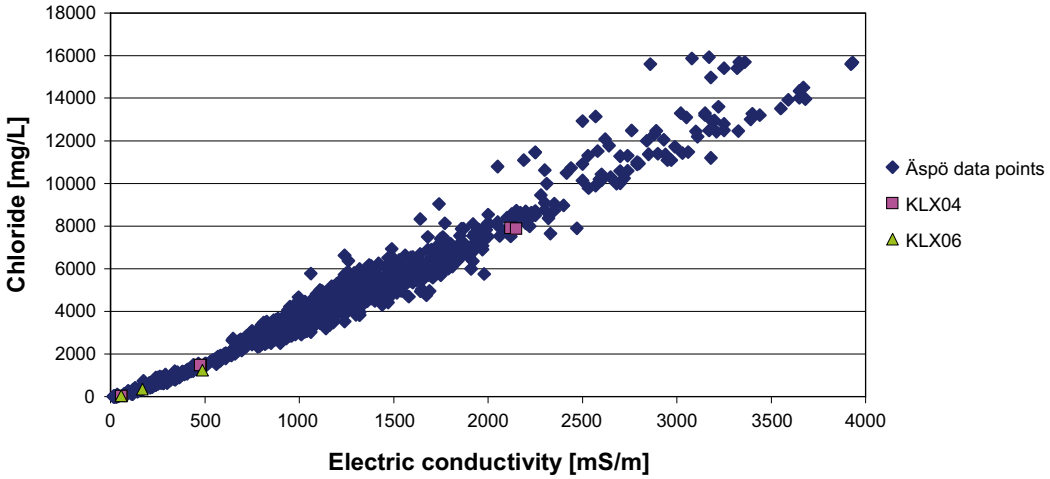

Figure 5-6. *Chloride concentration versus electrical conductivity. Data from earlier investigations at the Äspö Hard Rock Laboratory are used to show the overall trend.*

5.2 Trace elements (rare earth metals and others)

The analyses of trace and rare earth metals include U, Th, As, Sc, Cd, Hg, V, Rb, Y, Zr, In, Cs, Ba, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu. Commonly occurring metals, such as Cu, Zn, Pb, Sb and Mo are not included in the analytical programme due to contamination considerations. The trace element data are compiled in Appendix 2, Table A2-3. No trace elements are available from borehole KLX06 since no class 5 samples were analysed in the three investigated sections.

5.3 Stable and radioactive isotopes

The isotope determinations include the stable isotopes δ^2H, $\delta^{18}O$, $^{10}B/^{11}B$, $\delta^{34}S$, $\delta^{13}C$, $\delta^{37}Cl$ and $^{87}Sr/^{86}Sr$ as well as the radioactive isotopes ^3H (TU), ^{14}C (pmC), ^{238}U, ^{235}U, ^{234}U, ^{232}Th, ^{230}Th, ^{226}Ra and ^{222}Rn. The isotope data are compiled in Appendix 2, Table A2-2 and Table A2-4 for KLX04 and in Appendix 3, Table A3-2 for KLX06. Since no class 5 samples were collected in KLX06, only the stable isotopes δ^2H and $\delta^{18}O$ and the radioactive isotope tritium was determined in samples from KLX06.

The ^3H and $\delta^{18}O$ results from sections 104.0–109.0 m, 510.6–515.6 m and 971.2–976.2 m in KLX04 are presented in Figure 5-7. The results from the same isotopes from sections 260.0–265.0 m, 558.2–563.2 m and 776.2–781.2 m in KLX06 are presented in Figure 5-8. The ^3H content was below the detection (BD) limit (0.8 Tritium Units (TU)) in the deepest sampled section in KLX04 i.e. section 971.2–976.2 m, and in the most shallow section in KLX06 i.e. section 260.0–265.0 m.

A comparison between re-calculated uranium and thorium isotope determinations and ICP-analyses of the elements for the two class 5 samples collected in KLX04 (sections 510.6–515.6 m and 971.2–976.2 m) is given in Table 5-2. The isotopes ^{238}U and ^{232}Th are converted to element concentrations. Generally, values of the same order of magnitude from the different methods indicate a satisfactory agreement.

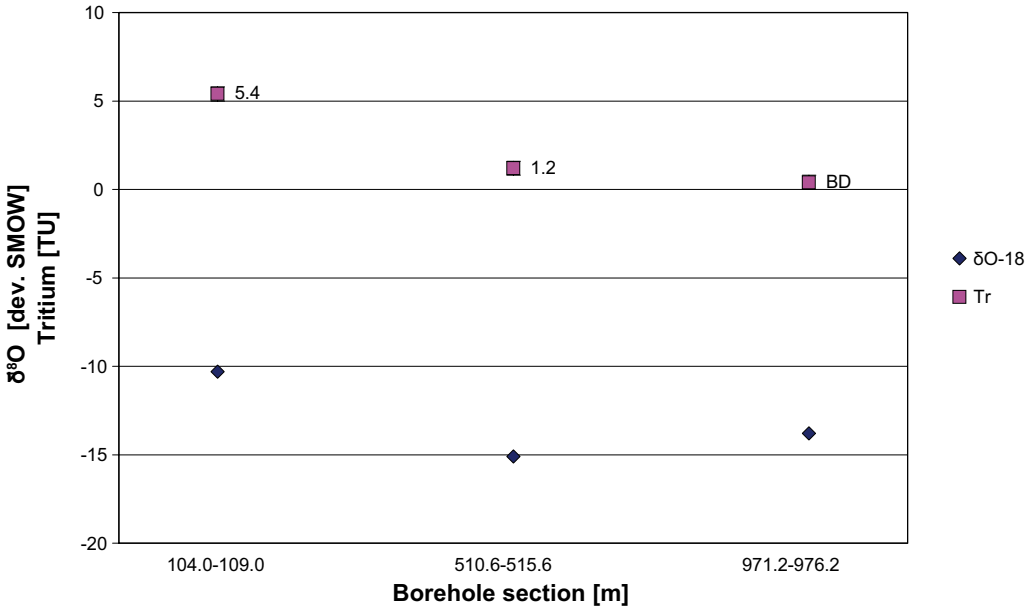

Figure 5-7. *^{3}H and $\delta^{18}O$ data from samples collected in three sections in the core drilled borehole KLX04.*

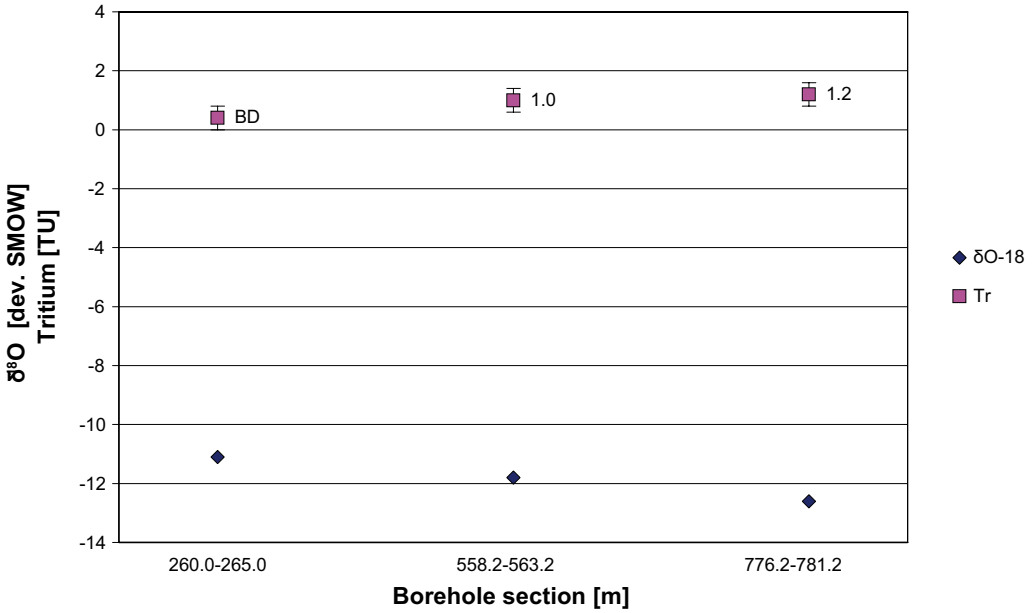

Figure 5-8. *^{3}H and $\delta^{18}O$ data from samples collected in three sections in the core drilled borehole KLX06.*

Table 5-2. Comparison of isotope determinations (^{238}U and ^{232}Th) and ICP-analyses of the elements uranium and thorium[1].

Borehole section [m]	Sample no.	Date	U [µg/L]	U [µg/L][2]	Th [µg/L]	Th [µg/L][3]
510.6–515.6	7776	2004-09-21	0.253	< 4	0.356	< 12.7
971.2–976.2	7752	2004-09-29	0.288	< 4	0.235	< 12.7

[1] The following expressions are applicable to convert activity to concentration, for ^{238}U and ^{232}Th: 1 ppm U = 12.4 Bq/kg^{238}U and 1 ppm Th = 3.93 Bq/kg^{232}Th.

[2] Recalculated from ^{238}U (mBq/L).

[3] Recalculated from ^{232}Th (mBq/L).

6 Summary

This report summarises the results obtained from the chemical sampling in three sections in KLX04 and three sections in KLX06 during August 2004–April 2005.

The final sample in each of the three sections KLX04 was below 5% drill water content. The three sections in KLX06 had a drill water content above 5%; section 260.0–265.0 m, 558.2–563.2 m and 776.2–781.2 m showed drill water contents of 6%, 21% and 23%, respectively.

The results from this activity include groundwater chemistry data in accordance with SKB class 5 chemistry from two sections in KLX04 (510.6–515.6 m and 971.2–976.2 m), class 4 from one section in KLX04 (104.0–109.0 m) and one section in KLX06 (260.0–265.0 m) and class 3 samples from the remaining two sections in KLX06 (558.2–563.2 m and 776.2–781.2 m).

The data set is complete, i.e all of the results from the chemical analyses are reported in the SICADA database.

Sample comments:

- Comparison of the results from different laboratories and/or methods showed agreement.
- The charge balance error did not exceed the limit, ± 5%, in any case.
- General judgement of plausibility based on earlier results and experience showed reasonable values.

7 References

/1/ **Rouhianien P, Sokolnicki M, 2005.** Oskarshamn site investigation. Difference flow logging of borehole KLX04. Subarea Laxemar. SKB P-05-68. Svensk Kärnbränslehantering AB.

/2/ **Sokolnicki M, Rouhianien P, 2005.** Oskarshamn site investigation. Difference flow logging in borehole KLX06. Subarea Laxemar. SKB P-05-74. Svensk Kärnbränslehantering AB.

/3/ **Rahm N, Enachescu C, 2004.** Oskarshamn site investigation. Hydraulic injection tests in borehole KLX04, 2004. Sub-area Laxemar. SKB P-04-292. Svensk Kärnbränslehantering AB.

/4/ **Rahm N, Enachescu C, 2005.** Oskarshamn site investigation. Pumping tests and water sampling in borehole KLX04, 2004. Sub-area Laxemar. SKB P-05-16. Svensk Kärnbränslehantering AB.

/5/ **Rahm N, Enachescu C, 2005.** Oskarshamn site investigation. Pumping tests and hydraulic injection tests in borehole KLX06, 2005. Subarea Laxemar. SKB P-05-184. Svensk Kärnbränslehantering AB.

Appendix 1

Sampling and analytical methods

Table A1-1. Sample handling routines and analytical methods.

SKB class 3 chemistry

Analysis	Sample container (material)	Preparation	SKB label	Laboratory	Analysis method	Comment
pH, conductivity, alkalinity	250 ml plastic	–	green	Äspö chemistry lab.	Titration Pot. meas, Cond. meas	Analysed within 24 hours
Anions (F^-, Br^-, Cl^-, SO_4^{2-})	250 ml plastic	–	green	Äspö chemistry lab. Analytica AB (control of Br^-)	Titration (Cl^-) IC (Cl^-, SO_4^{2-}, Br^-, F^-) ISE (F^-)	
Uranine	100 ml brown glass	–	green	Äspö chemistry lab.		
Density	250 ml	–	green	Äspö chemistry lab.	Pycnometer	
Cations, Si and S	Analytica's 100 ml acid washed	1 ml HNO_3 suprapur, filtering membrane filter	red	Analytica AB	ICP-AES ICP-MS	
Archive samples	2×250 ml plastic	Filtering Pallfilter	green			Stored in a freezer
Options						
Deuterium, O-18	100 ml square plastic	–	green	IFE	MS	
Tritium	500 ml dried plastic	–	green	University of Waterloo	LSC	Flooded at least once
Sr-87	100 ml square plastic	–	green	IFE	TIMS	
Cl-37	500 ml plastic	–	green	University of Waterloo	ICP-MS	
B-10	Same as for cations	Same as for cations	red	Analytica AB	ICP-MS	
C-13, PMC	2×100 ml brown glass	–	green	University of Waterloo	(A)MS	
S-34	1,000 ml plastic	–	green	IFE	Combustion, ICP-MS	

SKB class 4 chemistry

Analysis	Sample container (material)	Preparation	SKB label	Laboratory	Analysis method	Comment
pH, conductivity, alkalinity	250 ml plastic	–	green	Äspö chemistry lab.	Titration Pot. meas, Cond. meas	Analysed within 24 hours
Anions (F^-, Br^-, Cl^-, SO_4^{2-})	250 ml plastic	–	green	Äspö chemistry lab. Analytica AB (control of Br^-)	Titration (Cl^-) IC (Cl^-, SO_4^{2-}, Br^-, F^-) ISE (F^-)	
Uranine	100 ml brown glass	–	green	Äspö chemistry lab.		
Density	250 ml	–	green	Äspö chemistry lab.	Pycnometer	
Cations, Si and S	Analytica's 100 ml acid washed plastic	1 ml HNO_3 suprapur, filtering membrane filter	red	Analytica AB	ICP-AES ICP-MS	
Fe II + Fe tot	500 ml acid washed PEH	5 ml HCl suprapur, filtering membrane filter	red	Äspö chemistry lab.	Spectrophotometry Ferrozine method	Analysed as soon as possible the same day as the sampling occasion
NH_4	25 ml in 2 ea reagents dished 50 ml measurements vessels	–	–	Äspö chemistry lab.	Spectrophotometry	Analysed within 24 hours
HS^-	2 Winkler (glass)	Filtering Pallfilter Conserved with 0.5 ml 1M ZnAc and 1M NaOH	–	Äspö chemistry lab.	Spectrophotometry	Analysed immediately or if conserved, within a few days
DOC	250 ml plastic	Filtering Pallfilter	green	Paavo Ristola OY	UV oxidation, IR Carbon analysator Shimadzu TOC5000	
Deuterium, O-18	100 ml square plastic	–	green	IFE	MS	
Tritium	500 ml dried plastic	–	green	University of Waterloo	LSC	Flooded at least once
Archive samples	2×250 ml plastic	Filtering Pallfilter	green			Stored in a freezer
Archive samples	2×100 ml acid washed plastic	1 ml HNO_3 suprapur, filtering membrane filter	red			Stored in a freezer
Options						
I^-	Analytica's 100 ml plastic	Filtering membrane filter	green	Analytica AB	ICP-MS	
Nutrient salts (NO_2, NO_3, NO_2+NO_3 and PO_4)	250 ml plastic	Filtering Pallfilter	green	Dept. of Systemecology	Spectrophotometry	

SKB class 5 chemistry

Analysis	Sample container (material)	Preparation	SKB label	Laboratory	Analysis method	Comment
pH, conductivity, alkalinity	250 ml plastic	–	green	Äspö chemistry lab.	Titration Pot. meas, Cond. meas	Analysed within 24 hours
Anions (F^-, Br^-, Cl^-, SO_4^{2-})	250 ml plastic	–	green	Äspö chemistry lab. Analytica AB (control of Br^-)	Titration (Cl^-) IC (Cl^-, SO_4^{2-}, Br^-, F^-) ISE (F^-)	
Uranine	100 ml brown glass	–	green	Äspö chemistry lab.		
Density	250 ml	–	green	Äspö chemistry lab.	Pycnometer	
Cations, Si and S	Analytica's 100 ml acid washed plastic	1 ml HNO_3 suprapur, filtering membrane filter	red	Analytica AB	ICP-AES ICP-MS	
Fe II + Fe tot	500 ml acid washed PEH	5 ml HCl suprapur, filtering membrane filter	red	Äspö chemistry lab.	Spectrophotometry Ferrozine method	Analysed as soon as possible the same day as the sampling occasion
NH_4	25 ml in 2 ea reagents dished 50 ml measurements vessels	–	–	Äspö chemistry lab.	Spectrophotometry	Analysed within 24 hours
HS^-	2×Winkler (glass)	Filtering Pallfilter Conserved with 0.5 ml 1M ZnAc and 1M NaOH	–	Äspö chemistry lab.	Spectrophotometry	Analysed immediately or if conserved, within a few days
B-10 As, In Environmental metals Lanthanides Trace elements	Analytica's 100 ml acid washed plastic	1 ml HNO_3 suprapur, filtering membrane filter	red	Analytica AB	ICP-AES ICP-MS	
I^-	Analytica's 100 ml plastic	Filtering membrane filter	green	Analytica AB	ICP-MS	
Nutrient salts (NO_2, NO_3, NO_2+NO_3 and PO_4)	250 ml plastic	Filtering Pallfilter	green	Dept. of Systemecology	Spectrophotometry	
DOC	250 ml plastic	Filtering Pallfilter	green	Paavo Ristola OY	UV oxidation, IR Carbon analysator Shimadzu TOC5000	

Analysis	Sample container (material)	Preparation	SKB label	Laboratory	Analysis method	Comment
TOC	250 ml plastic	–	green	Paavo Ristola OY	UV oxidation, IR Carbon analysator Shimadzu TOC5000	
Deuterium, O-18	100 ml square plastic	–	green	IFE	MS	
Sr-87	100 ml square plastic	–	green	IFE	TIMS	
Tritium	500 ml dried plastic	–	green	University of Waterloo	LSC	Flooded at least once
Cl-37	500 ml plastic	–	green	University of Waterloo	ICP-MS	
C-13, PMC	2×100 ml brown glass	–	green	University of Waterloo	(A)MS	
S-34	1,000 ml plastic	–	green	IFE	Combustion, ICP-MS	
U-, Th-isotopes	50 ml plastic	–	green	IFE	Chemical separat. Alfa/gamma spectrometry	
Ra-, Rn-isotopes	500 ml plastic	–	green	IFE	EDE, RD-200	Immediate transport to laboratory
Archive samples	2×250 ml plastic	Filtering Pallfilter	green			Stored in a freezer
Archive samples	2×100 ml acid washed plastic	1 ml HNO_3 suprapur, filtering membrane filter	red			Stored in a freezer
TOC, C-13, PMC, S-34, Cl-37, Sr-87, B-10, As, In, environmental metals, lanthanides, trace elements, U-, Th-, Ra-, and Rn-isotopes are options						

Table A1-2. Reporting limits and measurement uncertainties.

Component	Method	Detection limit	Reporting limit or range	Unit	Measurement uncertainty[2]	"Total" uncertainty[3]
HCO_3	Alkalinity titration	0.2	1	mg/L	4%	<10%
Cl^-	Mohr titration	5	70	mg/L	5%	<10%
Cl^-	IC	0.2	0.5		6%	10%
SO_4	IC	0.2	0.5	mg/L	6%	15%
Br^-	IC	0.2	0.7	mg/L	9%	20%
Br^-	ICP	–	0.001–0.010[1]		15%	
F^-	IC	0.2	0.6	mg/L	10%	20%
F^-	Potentiometry	–	–		–	–
I^-	ICP	–	0.001–0.010[1]	mg/L	15%	20%
Na	ICP	–	0.1	mg/L	4%	10%
K	ICP	–	0.4	mg/L	6%	15%
Ca	ICP	–	0.1	mg/L	4%	10%
Mg	ICP	–	0.09	mg/L	4%	10%
S(tot)	ICP	–	0.160	mg/L	10%	15%
Si(tot)	ICP	–	0.03	mg/L	4%	15%
Sr	ICP	–	0.002	mg/L	4%	15%
Li	ICP	–	0.2–2[1]	µg/L	10%	20%
DOC	See Table 1	–	0.5	mg/L	8%	30%
TOC	See Table 1	–	0.5	mg/L	10%	30%
δ^2H	MS	–	2	‰ SMOW[4]	1.0‰	–
$\delta^{18}O$	MS	–	0.1	‰ SMOW[4]	0.2‰	–
^3H	LSC	–	0.8 or 0.1	TU[5]	0.8 or 0.1 TU	–
$\delta^{37}Cl$	ICP MS	–	0.2‰ (20 mg/L)	‰ SMOC[6]	–	–
$\delta^{13}C$	A (MS)	–	>20 mg Carbon	‰ PDB[7]	–	–
pmC (^{14}C)	A (MS)	–	>20 mg kol	PmC[8]	–	–
δ^{34} S	ICP MS	–	0.2‰	‰ CDT[9]	0.2‰	–
$^{87}Sr/^{86}Sr$	MS	–	–	No unit (ratio)[10]	0.000020	–
$^{10}B/^{11}B$	ICP MS	–	–	No unit (ratio)[10]	0.0020	–
^{234}U, ^{235}U, ^{238}U, ^{232}Th, ^{230}Th	Alfa spectr.	–	0.05	Bq/L[11]	0.05 Bq/L	Right order of magnitude
^{222}Rn, ^{226}Rn	LSC	–	0.1	Bq/L	0.05 Bq/L	
Density	Pycnometer	–	–	g/mL	0.15%	–

1. Reporting limits at salinity ≤ 0.4% (520 mS/m) and ≤ 3.5% (3,810 mS/m) respectively.
2. Measurement uncertainty reported by consulted laboratory, generally 95% confidence interval.
3. Estimated total uncertainty by experience (includes effects of sampling and sample handling).
4. Per mill deviation[12] from SMOW (Standard Mean Oceanic Water).
5. TU=Tritium Units, where one TU corresponds to a Tritium/hydrogen ratio of 10^{-18} (1 Bq/L Tritium = 8.45 TU).
6. Per mill deviation[12] from SMOC (Standard Mean Oceanic Chloride).
7. Per mill deviation[12] from PDB (the standard PeeDee Belemnite).
8. The following relation is valid between pmC (percent modern carbon) and Carbon-14 age:
   $pmC = 100 \times e^{((1,950-y-1.03t)/8,274)}$
   where y = the year of the C-14 measurement and t = C-14 age.
9. Per mill deviation[12] from CDT (the standard Canyon Diablo Troilite).
10. Isotope ratio without unit.
11. The following expressions are applicable to convert activity to concentration, for uranium-238 and thorium-232:
    1 ppm U = 12.4 Bq/kg ^{238}U
    1 ppm Th = 3.93 Bq/kg ^{232}Th
12. Isotopes are often reported as per mill deviation from a standard. The deviation is calculated as:
    $\delta^yI = 1{,}000 \times (K_{sample} - K_{standard})/K_{standard}$, where K= the isotope ratio and $^yI = ^2H$, ^{18}O, ^{37}Cl, ^{13}C or ^{34}S etc.

Table A1-3. Participant laboratories.

Äspö water chemical laboratory (SKB)
Inainööritoimisto Paavo Ristola Oy Teollisuus-ja Voimalaitoskemia Rajantorpantie 8, C-talo 01600 Vantaa FINLAND
Dept. of System Ecology Stockholm University 10691 Stockholm
Analytica AB Aurorum 10 977 75 Luleå (Nytorpsvägen 16 Box 511 183 25 Täby)
Environmental Isotope Laboratory Dep. of Earth Sciences University of Waterloo Waterloo, Ontario N2L 3G1 CANADA
Institutt for energiteknik (IFE) Insituttveien 18 P.O Box 40 2027 Kjeller NORGE

Appendix 2

Groundwater chemistry data KLX04

Table A2-1. Water composition. Compilation October 2005.

Idcode	Secup	Seclow	Sample	Sampling	Charge	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	FeII	Mn	Li
	m	m	no.	date and time	Bal %	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
			7739	2004-08-26 11:47:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			7738	2004-08-26 11:49:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	104.00	109.00	7806	2004-09-30 08:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	104.00	109.00	7856	2004-09-30 10:10:00	–3.24	95.1	2.73	26.5	5.9	324.00	23.5	15.90	5.66	<0.2#	2.17	8.04	0.158	0.157	0.139	0.16200	0.016
KLX04	104.00	109.00	7857	2004-09-30 10:12:00		xxx	xxx	xxx	xxx	321.00	23.4	15.70	xxx	<0.2#	2.19	xxx	xxx	0.158	0.136	xxx	xxx
KLX04	510.56	515.56	7734	2004-09-17 19:25:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7729	2004-09-18 07:55:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7730	2004-09-18 17:40:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7731	2004-09-19 07:50:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7732	2004-09-19 18:20:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7733	2004-09-20 07:55:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7765	2004-09-20 19:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7766	2004-09-21 08:10:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7767	2004-09-21 17:45:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7768	2004-09-22 08:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7769	2004-09-22 17:35:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7770	2004-09-23 08:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7771	2004-09-23 17:30:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7772	2004-09-24 08:10:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7773	2004-09-24 18:20:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7774	2004-09-25 08:20:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Idcode	Secup	Seclow	Sample	Sampling	Charge	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	FeII	Mn	Li
	m	m	no.	date and time	Bal %	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KLX04	510.56	515.56	7799	2004-09-25 17:20:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7800	2004-09-26 08:10:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7801	2004-09-26 17:30:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7802	2004-09-27 08:15:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7803	2004-09-27 18:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7804	2004-09-28 08:05:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7805	2004-09-28 17:55:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	510.56	515.56	7776	2004-09-29 08:30:00	–2.65	691	3.19	234	6.9	51.4	1,480	104	32.0	8.4	2.70	6.63	0.090	0.104	0.082	0.109	0.152
KLX04	510.56	515.56	7777	2004-09-29 10:00:00		xxx	xxx	xxx	xxx	51.5	1,480	98.8	xxx	7.2	2.05	xxx	xxx	0.165	0.144	xxx	xxx
KLX04	971.21	976.21	7748	2004-09-08 21:30:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7747	2004-09-10 09:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7745	2004-09-11 06:10:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7744	2004-09-12 18:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7743	2004-09-13 14:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7742	2004-09-14 08:45:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7741	2004-09-14 16:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7740	2004-09-15 09:45:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7737	2004-09-15 16:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7736	2004-09-16 07:50:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7735	2004-09-16 12:30:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX04	971.21	976.21	7752	2004-09-16 11:00:00	–3.32	2,010	7.71	2,710	5.0	8.48	7,910	845	252	62.3	1.7	4.58	0.155	0.173	0.150	0.0743	0.665
KLX04	971.21	976.21	7753	2004-09-16 12:30:00		xxx	xxx	xxx	xxx	8.51	7,880	851	xxx	56.0	1.6	xxx	xxx	0.216	0.174	xxx	xxx

cont.

Idcode	Secup m	Seclow m	Sample no.	Sampling date and time	Sr mg/L	I^- mg/L	pH	DOC mg/L	TOC mg/L	HS^- mg/L	Drill_water %	ElCond mS/m	NO_2N mg/L	NO_3N mg/L	NO_2NO_3N mg/L	NH_4N mg/L	PO_4P mg/L	Density g/mL
			7739	2004-08-26 11:47:00	–	–	–	–	–	–	72.7	–	–	–	–	–	–	–
			7738	2004-08-26 11:49:00	–	–	–	–	–	–	79.4	–	–	–	–	–	–	–
KLX04	104.00	109.00	7806	2004-09-30 08:00:00	–	–	–	–	–	–	0.09	–	–	–	–	–	–	–
KLX04	104.00	109.00	7856	2004-09-30 10:10:00	0.375	0.006	7.73	9.9	–	0.010	0.09	59.6	0.0007	<0.0002	0.0005	0.1200	0.0045	0.9966
KLX04	104.00	109.00	7857	2004-09-30 10:12:00	xxx	xxx	7.76	xxx	xxx	0.015	0.09	57.9	xxx	xxx	xxx	0.1190	xxx	0.9965
KLX04	510.56	515.56	7734	2004-09-17 19:25:00	–	–	–	–	–	–	1.79	–	–	–	–	–	–	–
KLX04	510.56	515.56	7729	2004-09-18 07:55:00	–	–	–	–	–	–	3.45	–	–	–	–	–	–	–
KLX04	510.56	515.56	7730	2004-09-18 17:40:00	–	–	–	–	–	–	5.19	–	–	–	–	–	–	–
KLX04	510.56	515.56	7731	2004-09-19 07:50:00	–	–	–	–	–	–	6.49	–	–	–	–	–	–	–
KLX04	510.56	515.56	7732	2004-09-19 18:20:00	–	–	–	–	–	–	6.90	–	–	–	–	–	–	–
KLX04	510.56	515.56	7733	2004-09-20 07:55:00	–	–	–	–	–	–	7.20	–	–	–	–	–	–	–
KLX04	510.56	515.56	7765	2004-09-20 19:00:00	–	–	–	–	–	–	7.25	–	–	–	–	–	–	–
KLX04	510.56	515.56	7766	2004-09-21 08:10:00	–	–	–	–	–	–	7.18	–	–	–	–	–	–	–
KLX04	510.56	515.56	7767	2004-09-21 17:45:00	–	–	–	–	–	–	7.07	–	–	–	–	–	–	–
KLX04	510.56	515.56	7768	2004-09-22 08:00:00	–	–	–	–	–	–	6.89	–	–	–	–	–	–	–
KLX04	510.56	515.56	7769	2004-09-22 17:35:00	–	–	–	–	–	–	6.76	–	–	–	–	–	–	–
KLX04	510.56	515.56	7770	2004-09-23 08:00:00	–	–	–	–	–	–	6.47	–	–	–	–	–	–	–
KLX04	510.56	515.56	7771	2004-09-23 17:30:00	–	–	–	–	–	–	6.26	–	–	–	–	–	–	–
KLX04	510.56	515.56	7772	2004-09-24 08:10:00	–	–	–	–	–	–	6.01	–	–	–	–	–	–	–
KLX04	510.56	515.56	7773	2004-09-24 18:20:00	–	–	–	–	–	–	5.83	–	–	–	–	–	–	–
KLX04	510.56	515.56	7774	2004-09-25 08:20:00	–	–	–	–	–	–	5.65	–	–	–	–	–	–	–
KLX04	510.56	515.56	7799	2004-09-25 17:20:00	–	–	–	–	–	–	5.46	–	–	–	–	–	–	–
KLX04	510.56	515.56	7800	2004-09-26 08:10:00	–	–	–	–	–	–	6.61	–	–	–	–	–	–	–
KLX04	510.56	515.56	7801	2004-09-26 17:30:00	–	–	–	–	–	–	6.12	–	–	–	–	–	–	–
KLX04	510.56	515.56	7802	2004-09-27 08:15:00	–	–	–	–	–	–	4.70	–	–	–	–	–	–	–
KLX04	510.56	515.56	7803	2004-09-27 18:00:00	–	–	–	–	–	–	5.60	–	–	–	–	–	–	–

Idcode	Secup	Seclow	Sample	Sampling	Sr	I^-	pH	DOC	TOC	HS^-	Drill_water	ElCond	NO_2N	NO_3N	NO_2NO_3N	NH_4N	PO_4P	Density
	m	m	no.	date and time	mg/L	mg/L		mg/L	mg/L	mg/L	%	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	g/mL
KLX04	510.56	515.56	7804	2004-09-28 08:05:00	–	–	–	–	–	–	4.43	–	–	–	–	–	–	–
KLX04	510.56	515.56	7805	2004-09-28 17:55:00	–	–	–	–	–	–	4.62	–	–	–	–	–	–	–
KLX04	510.56	515.56	7776	2004-09-29 08:30:00	4.67	0.071	7.83	2.2	2.4	0.006	4.41	478	0.0002	0.0003	0.0005	0.0319	0.0009	0.9982
KLX04	510.56	515.56	7777	2004-09-29 10:00:00	xxx	xxx	7.79	xxx	xxx	0.005	4.11	475	xxx	xxx	xxx	0.0300	xxx	0.9982
KLX04	971.21	976.21	7748	2004-09-08 21:30:00	–	–	–	–	–	–	77.80	–	–	–	–	–	–	–
KLX04	971.21	976.21	7747	2004-09-10 09:00:00	–	–	–	–	–	–	34.00	–	–	–	–	–	–	–
KLX04	971.21	976.21	7745	2004-09-11 06:10:00	–	–	–	–	–	–	12.40	–	–	–	–	–	–	–
KLX04	971.21	976.21	7744	2004-09-12 18:00:00	–	–	–	–	–	–	12.70	–	–	–	–	–	–	–
KLX04	971.21	976.21	7743	2004-09-13 14:00:00	–	–	–	–	–	–	8.89	–	–	–	–	–	–	–
KLX04	971.21	976.21	7742	2004-09-14 08:45:00	–	–	–	–	–	–	6.62	–	–	–	–	–	–	–
KLX04	971.21	976.21	7741	2004-09-14 16:00:00	–	–	–	–	–	–	6.52	–	–	–	–	–	–	–
KLX04	971.21	976.21	7740	2004-09-15 09:45:00	–	–	–	–	–	–	5.27	–	–	–	–	–	–	–
KLX04	971.21	976.21	7737	2004-09-15 16:00:00	–	–	–	–	–	–	4.78	–	–	–	–	–	–	–
KLX04	971.21	976.21	7736	2004-09-16 07:50:00	–	–	–	–	–	–	4.11	–	–	–	–	–	–	–
KLX04	971.21	976.21	7735	2004-09-16 12:30:00	–	–	–	–	–	–	3.94	–	–	–	–	–	–	–
KLX04	971.21	976.21	7752	2004-09-16 11:00:00	47.7	0.244	7.61	<1	<1	0.022	3.98	2,120	0.0001	0.0002	0.0003	0.0057	0.0005	1.0069
KLX04	971.21	976.21	7753	2004-09-16 12:30:00	xxx	xxx	7.71	xxx	xxx	0.041	4.96	2,150	xxx	xxx	xxx	0.0071	xxx	1.0068

– = Not analysed

x = No result due to sampling problems

xx = No result due to analysis problems

xxx = Sample stored in freezer

< “value” = result less than detection limit

ChargeBal % = Rel. charge balance error %

= Äspö water chemical laboratory

Table A2-2. Isotopes I (H-, O-, B-, S-, Cl- and C-isotopes). Compilation October 2005.

Idcode	Secup	Seclow	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$^{10}B/^{11}B$	$\delta^{34}S$	$\delta^{13}C$	$^{87}Sr/^{86}Sr$	$\delta^{37}Cl$	^{14}C	AGE_BP	AGE_BP_corr
	m	m	no	date	dev SMOW	TU	dev SMOW	no unit	dev CDT	dev PDB	no unit	dev SMOC	pmC	years	years
KLX04	104.00	109.00	7856	2004-09-30 10:10:00	–75.3	5.4	–10.3	–	–	–	–	–	–	–	–
KLX04	104.00	109.00	7857	2004-09-30 10:12:00	xxx	xxx	xxx	–	–	–	–	–	–	–	–
KLX04	510.00	515.00	7776	2004-09-29 08:30:00	–112.9	1.2	–15.1	0.2313	12.7	xx	0.715849	–0.12	43.29	6,670	35
KLX04	510.00	515.00	7777	2004-09-29 10:00:00	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
KLX04	971.21	976.21	7752	2004-09-16 11:00:00	–101.4	<0.8	–13.8	0.2398	9.1	xx	0.716186	0.37	xx	xx	xx
KLX04	971.21	976.21	7753	2004-09-16 12:30:00	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

– = Not analysed
A = results will be reported later
x = No result due to sampling problems
xx = No result due to analytical problems
xxx = Sample stored in freezer
< “value” = result less than detection limit

Table A2-3. Trace elements. Compilation October 2005.

Idcode	Secup	Seclow	Sample	Sampling	U	Th	As	Sc	Cd	Hg	V	Rb	Y	Zr	In	Cs	Ba	La	Hf
	m	m	no.	date	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
KLX04	510.00	515.00	7776	2004-09-29 08:30:00	0.253	0.356	<1	<0.5	0.0478	0.0026	0.177	10.2	0.0877	<0.3	<0.5	0.621	142	0.139	<0.05
KLX04	510.00	515.00	7777	2004-09-29 10:00:00	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
KLX04	971.21	976.21	7752	2004-09-16 11:00:00	0.288	0.235	<1	<0.5	<0.05	0.0054	<0.05	39.8	0.226	<0.3	<0.5	4.47	79.1	0.0898	<0.05
KLX04	971.21	976.21	7753	2004-09-16 12:30:00	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

Cont.

Idcode	Secup	Seclow	Sample	Sampling	Tl	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
	m	m	no.	date	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
KLX04	510.00	515.00	7776	2004-09-29 08:30:00	<0.3	0.175	<0.05	0.0544	<0.05	<0.05	<0.05	<0.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
KLX04	510.00	515.00	7777	2004-09-29 10:00:00	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
KLX04	971.21	976.21	7752	2004-09-16 11:00:00	<0.3	0.0802	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
KLX04	971.21	976.21	7753	2004-09-16 12:30:00	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

– = Not analysed
A = Results will be reported later
x = No result due to sampling problems
xx = No result due to analysis problems
xxx = Sample stored in freezer
< “value” = result less than detection limit

Table A2-4. Isotopes II (U-, Th, Ra- and Rn-isotopes). Compilation October 2005.

Idcode	Secup	Seclow	Sample	Sampling	^{238}U	^{235}U	^{234}U	^{232}Th	^{230}Th	^{226}Ra	^{222}Rn
	m	m	no.	date	mBq/L	mBq/L	mBq/L	mBq/L	mBq/L	Bq/L	Bq/L
KLX04	510.00	515.00	7776	2004-09-29 08:30:00	<50	<50	<50	<50	<50	0.900	275
KLX04	510.00	515.00	7777	2004-09-29 10:00:00	xxx	xxx	xxx	xxx	xxx	0.800	256
KLX04	971.21	976.21	7752	2004-09-16 11:00:00	<50	<50	<50	<50	<50	1.50	25.1
KLX04	971.21	976.21	7753	2004-09-16 12:30:00	xxx	xxx	xxx	xxx	xxx	1.50	22.5

– = Not analysed
A = Results will be reported later
x = No result due to sampling problems
xx = No result due to analysis problems
xxx = Sample stored in freezer
< “value” = result less than detection limit

Appendix 3

Groundwater chemistry data KLX06

Table A3-1. Water Composition. Compilation October 2005.

Idcode	Secup	Seclow	Sample	Sampling	Charge	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	FeII	Mn	Li
	m	m	no.	date and time	Bal %	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KLX06	260.00	265.00	10117	2005-03-07 10:20:00		-	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	260.00	265.00	10118	2005-03-07 19:30:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	260.00	265.00	10119	2005-03-08 14:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	260.00	265.00	10120	2005-03-09 08:45:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	260.00	265.00	10121	2005-03-09 09:45:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	260.00	265.00	10122	2005-03-09 11:00:00	–2.99	114	1.50	7.3	1.2	226	36.8	34.3	11.3	<0.2#	6.79	6.93	0.0592	0.055	0.031	0.0116	0.018
KLX06	558.20	563.20	10123	2005-03-10 19:32:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	558.20	563.20	10124	2005-03-11 17:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	558.20	563.20	10125	2005-03-12 18:30:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	558.20	563.20	10126	2005-03-13 17:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	558.20	563.20	10128	2005-03-14 17:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	558.20	563.20	10129	2005-03-15 17:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	558.20	563.20	10130	2005-03-16 08:30:00	–1.45	288	4.34	62.3	3.9	155	348	177	62.7	<0.2#	5.75	7.52	0.250	–	–	0.0765	0.047
KLX06	558.20	583.20	10131	2005-03-16 08:40:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10132	2005-03-17 16:41:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10133	2005-03-18 18:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10134	2005-03-19 18:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10135	2005-03-20 18:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10144	2005-03-21 18:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10145	2005-03-22 18:00:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10146	2005-03-23 09:05:00		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10147	2005-03-23 09:10:00	0.50	738	7.56	318	20.6	107	1240	577	202	xx	3.30	9.03	0.640	–	–	0.202	0.112

cont.

Idcode	Secup m	Seclow m	Sample no.	Sampling date and time	Sr mg/L	I^- mg/L	pH	DOC mg/L	TOC mg/L	HS^- mg/L	Drill_water %	ElCond mS/m	NO_2N mg/L	NO_3N mg/L	NO_2NO_3N mg/L	NH_4N mg/L	PO_4P mg/L	Density g/mL
KLX06	260.00	265.00	10117	2005-03-07 10:20:00	–	–	–	–	–	–	2.59	–	–	–	–	–	–	–
KLX06	260.00	265.00	10118	2005-03-07 19:30:00	–	–	–	–	–	–	7.60	–	–	–	–	–	–	–
KLX06	260.00	265.00	10119	2005-03-08 14:00:00	–	–	–	–	–	–	7.07	–	–	–	–	–	–	–
KLX06	260.00	265.00	10120	2005-03-09 08:45:00	–	–	–	–	–	–	9.53	–	–	–	–	–	–	–
KLX06	260.00	265.00	10121	2005-03-09 09:45:00	–	–	–	–	–	–	5.95	–	–	–	–	–	–	–
KLX06	260.00	265.00	10122	2005-03-09 11:00:00	0.211	0.006	8.72	xx	3.0	0.022	5.68	56.7	0.0030	0.0020	0.0050	0.0292	0.0090	0.9964
KLX06	558.20	563.20	10123	2005-03-10 19:32:00	–	–	–	–	–	–	5.41	–	–	–	–	–	–	–
KLX06	558.20	563.20	10124	2005-03-11 17:00:00	–	–	–	–	–	–	6.56	–	–	–	–	–	–	–
KLX06	558.20	563.20	10125	2005-03-12 18:30:00	–	–	–	–	–	–	13.20	–	–	–	–	–	–	–
KLX06	558.20	563.20	10126	2005-03-13 17:00:00	–	–	–	–	–	–	14.50	–	–	–	–	–	–	–
KLX06	558.20	563.20	10128	2005-03-14 17:00:00	–	–	–	–	–	–	17.50	–	–	–	–	–	–	–
KLX06	558.20	563.20	10129	2005-03-15 17:00:00	–	–	–	–	–	–	19.70	–	–	–	–	–	–	–
KLX06	558.20	563.20	10130	2005-03-16 08:30:00	1.24	–	8.39	–	–	–	21.40	169	–	–	–	–	–	0.9971
KLX06	558.20	583.20	10131	2005-03-16 08:40:00	–	–	–	–	–	–	21.20	–	–	–	–	–	–	–
KLX06	776.20	781.20	10132	2005-03-17 16:41:00	–	–	–	–	–	–	9.04	–	–	–	–	–	–	–
KLX06	776.20	781.20	10133	2005-03-18 18:00:00	–	–	–	–	–	–	23.40	–	–	–	–	–	–	–
KLX06	776.20	781.20	10134	2005-03-19 18:00:00	–	–	–	–	–	–	24.90	–	–	–	–	–	–	–
KLX06	776.20	781.20	10135	2005-03-20 18:00:00	–	–	–	–	–	–	24.80	–	–	–	–	–	–	–
KLX06	776.20	781.20	10144	2005-03-21 18:00:00	–	–	–	–	–	–	25.20	–	–	–	–	–	–	–
KLX06	776.20	781.20	10145	2005-03-22 18:00:00	–	–	–	–	–	–	24.40	–	–	–	–	–	–	–
KLX06	776.20	781.20	10146	2005-03-23 09:05:00	–	–	–	–	–	–	23.90	–	–	–	–	–	–	–
KLX06	776.20	781.20	10147	2005-03-23 09:10:00	5.96	–	7.94	–	–	–	23.20	487	–	–	–	–	–	0.9987

– = Not analysed
x = No result due to sampling problems
xx = No result due to analysis problems
xxx = Sample stored in freezer
< “value” = result less than detection limit
ChargeBal % = Rel. charge balance error %
= Äspö water chemical laboratory

Table A3-2. Isotopes I (H-, O-, B-, S-, Cl- and C-isotopes). Compilation October 2005.

Idcode	Secup	Seclow	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$^{10}B/^{11}B$	$\delta^{34}S$	$\delta^{13}C$	$^{87}Sr/^{86}Sr$	$\delta^{37}Cl$	^{14}C	AGE_BP	AGE_BP_corr
	m	m	no	date	dev SMOW	TU	dev SMOW	no unit	dev CDT	dev PDB	no unit	dev SMOC	pmC	years	years
KLX06	260.00	265.00	10122	2005/03/09 11:00:00	–80.4	<0.8	–11.1	–	–	–	–	–	–	–	–
KLX06	558.20	563.20	10130	2005/03/16 08:30:00	–84.8	1.0	–11.8	–	–	–	–	–	–	–	–
KLX06	776.20	781.20	10147	2005/03/23 09:10:00	–91.4	1.2	–12.6	–	–	–	–	–	–	–	–

– = Not analysed

A = results will be reported later

x = No result due to sampling problems

xx = No result due to analytical problems

xxx = Sample stored in freezer

< “value” = result less than detection limit