

P-07-73

Oskarshamn site investigation

Hydrochemical logging in KLX21B

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August 2007

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Keywords: Hydrochemical logging, Core drilled borehole, Groundwater, Water sampling, Chemical analyses, AP PS 400-06-155.

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

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Abstract

Hydrochemical logging, also called tube sampling, has been performed in the core drilled borehole KLX21B. The method is a fast and simple sampling technique for obtaining information about the chemical composition of the water along an open borehole. The equipment consists of an approximately 1,000 m long polyamide tube divided into units of 50 m. An appropriate number of tube units can be used to suit the actual borehole length, in this case c. 850 m.

The water content in each tube unit constituted one sample. Every second sample, starting with the lowermost tube unit, was analysed according to SKB chemistry class 3 (isotope options excluded). Samples for isotope determination were collected at the time of sampling and stored in a freezer (tritium; ^3H ; in a refrigerator); oxygen-18 ($\delta^{18}\text{O}$), deuterium ($\delta^2\text{H}$), ^3H , boron-10/boron-11 ratio ($^{10}\text{B}/^{11}\text{B}$)*, chlorine-37 ($\delta^{37}\text{Cl}$) and strontium-87/strontium-86 ratio ($^{87}\text{Sr}/^{86}\text{Sr}$) from odd-numbered tube units and sulphur-34 ($\delta^{34}\text{S}$), carbon-13 ($\delta^{13}\text{C}$) and carbon-14 (^{14}C) from even-numbered tube units. If these samples are analysed later, the results from the analyses will be presented in a separate report.

The drill water content remaining in the borehole after drilling was low (between 0.3 and 1.6%) for all tube units except the two ones representing the deepest part of the borehole, 690–740 m and 790–840 m, where the drill water content was 23.7% and 50% respectively. The relative charge balance error exceeded the acceptable limit of $\pm 5\%$, for two of the nine analysed samples, the same two samples where the drill water content was high (690–740 m and 790–840 m). The results from all samples except these two are therefore considered as representative for the water bearing fractures of the borehole.

* The B-isotope ratio is given as $^{10}\text{B}/^{11}\text{B}$ (the result reported from the consulting laboratory). The notation according to international standard for environmental isotopes is $^{11}\text{B}/^{10}\text{B}$, i.e. $1/(^{10}\text{B}/^{11}\text{B})$.

Sammanfattning

Hydrokemisk loggning, även kallad slangprovtagning, har utförts i det kärnborrade borrhålet KLX21B. Metoden är snabb och enkel att använda för att erhålla information om den kemiska sammansättningen hos grundvattnet längs ett öppet borrhål. Utrustningen består av en cirka 1 000 m lång polyamidslang uppdelad i enheter om vardera 50 m. Lämpligt antal slangenheter kan användas för att anpassa längden till det aktuella borrhålets längd, i detta fall ca 850 m.

Innehållet i en slangenhet utgör ett prov. Varannan slangenhet, med start från den nedersta, analyserades enligt SKB kemiklass 3 (exklusive alla tillval). Prover för bestämning av isotoptillvalen togs ut vid provtagningstillfället och sparades i frys (tritium; ^3H ; i kylskåp); syre-18 ($\delta^{18}\text{O}$), deuterium ($\delta^2\text{H}$), ^3H , kvoten bor-10/bor-11 ($^{10}\text{B}/^{11}\text{B}$)*, klor-37 ($\delta^{37}\text{Cl}$) och kvoten strontium-87/strontium-86 ($^{87}\text{Sr}/^{86}\text{Sr}$) ur udda enheter, svavel-34 ($\delta^{34}\text{S}$), kol-13 ($\delta^{13}\text{C}$) och kol-14 (^{14}C) ur jämna enheter. Om dessa prover analyseras senare kommer resultaten av dessa analyser att sammanfattas i en separat rapport.

Halten kvarvarande spolvatten i borrhålet efter avslutad borrning var låg (mellan 0,3 och 1,6 %) för alla slangenheter utom de två som representerar den djupaste delen av borrhålet, 690–740 m och 790–840 m, där spolvattenhalten var 23,7 % respektive 50 %. Det relativa felet i jonbalansen översteg den acceptabla nivån av ± 5 % i två av de nio analyserade proverna, i samma två prover där spolvattenhalten var hög (690–740 m, och 790–840 m). Resultaten från alla prover utom dessa två kan därför anses vara representativa för de vattenförande sprickorna i borrhålet.

* B-isotop kvoten ges som $^{10}\text{B}/^{11}\text{B}$ (resultatet som rapporteras av det konsulterande laboratoriet). Beteckningen enligt den internationella standarden för miljöisotoper är $^{11}\text{B}/^{10}\text{B}$, d.v.s. $1/(^{10}\text{B}/^{11}\text{B})$.

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1 Introduction

This document reports the performance and results from the Hydrochemical logging in borehole KLX21B. The Hydrochemical logging is one of the activities performed within the site investigation at Oskarshamn /1, 2/. The work was carried out in accordance with activity plan AP PS 400-06-155. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents. The obtained data from the activity are reported to the database SICADA, where they are traceable by the activity plan number.

Borehole KLX21B is an 858.78 m long telescopic borehole, drilled within the site investigation in the Oskarshamn area. The percussion drilled borehole HLX10 served as the source of flushing water for the drilling of KLX21B. The locations of KLX21B and HLX10 are shown in Figure 1-1.

The borehole KLX21B is not one of the so called SKB chemical type; see method descriptions MD 620.003 (Method description for drilling cored boreholes) and 610.003 (Method description for percussion drilling). The cleaning procedures of all equipment used in the borehole, during and after drilling, were performed according to level 1 in the cleaning instructions in MD 600.004 (Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning).

Table 1-1. SKB internal controlling documents for the performance of the activity.

Activity plan	Number	Version
Hydrokemisk loggning i KLX21B	AP PS 400-06-155	1.0
Method descriptions	Number	Version
Metodbeskrivning för hydrokemisk loggning	SKB MD 422.001	2.0
Instruktion för rengöring av borrhåls- utrustning och viss markbaserad utrustning	SKB MD 600.004	1.0

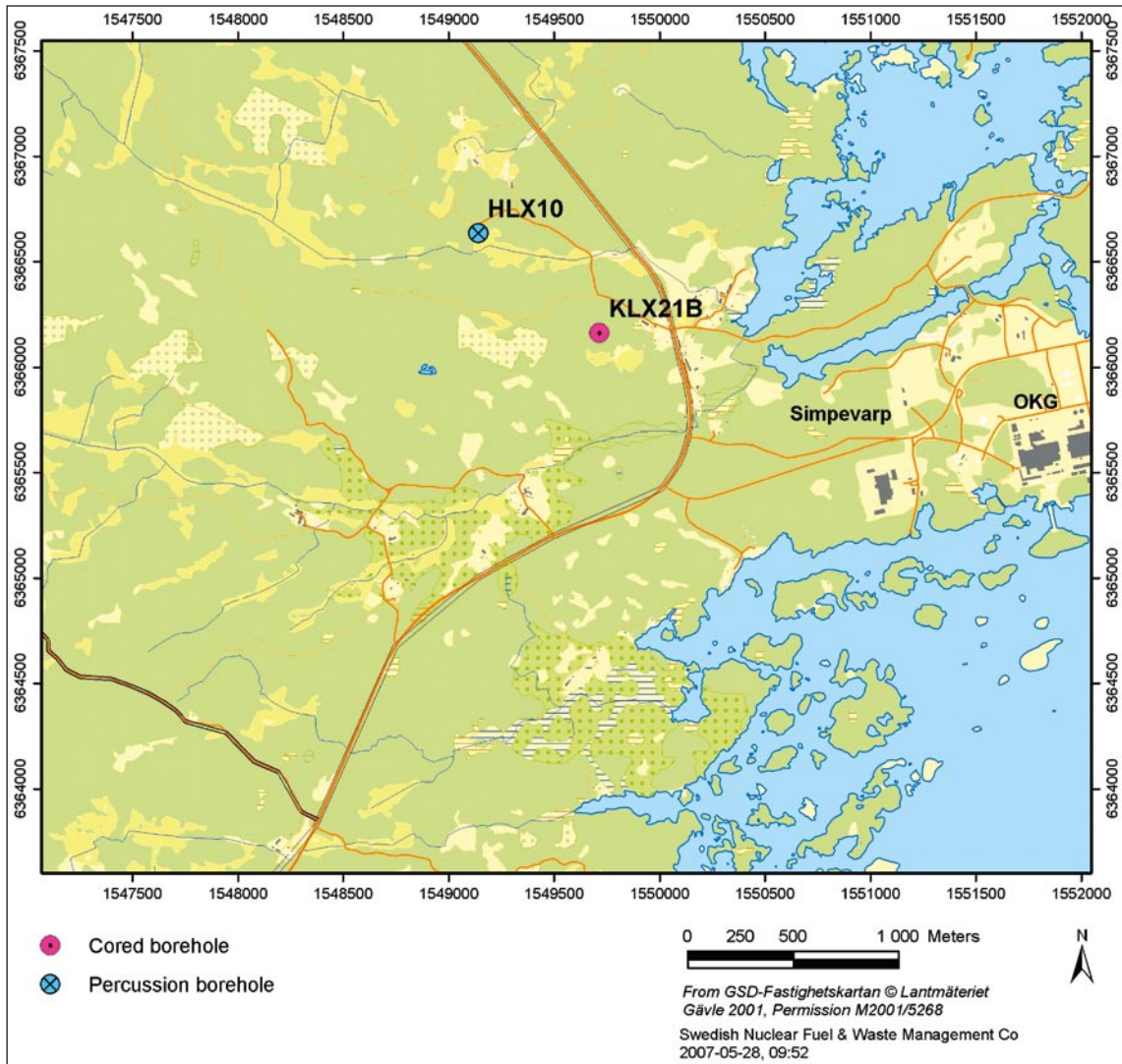


Figure 1-1. Location of the core drilled borehole KLX21B and the percussion drilled borehole HLX10 within the site investigation in the Oskarshamn area.

2 Objective and scope

Hydrochemical logging was performed in order to obtain an overview of the chemical composition of the water along the open borehole KLX21B. The technique used for sampling is fast and simple, also for boreholes of considerable lengths.

The analysis program was carried out according to SKB chemistry class 3 except for optional isotopes. Sample portions intended for isotope analyses were collected at the time of sampling. If these samples will be analysed, the results will be presented in a separate report.

3 Sampling equipment

For the Hydrochemical logging an approximately 850 m long polyamide tube, divided into units of 50 m, was used. The equipment is described in the method description, see Table 1-1.

A schematic picture of the equipment used for the Hydrochemical logging is shown in Figure 3-1. The tube units are connected using metal couplings and manual shut off valves. The external and internal diameters of the tube units are 10 and 8 mm, respectively. The first tube lowered down the borehole has a non-return valve at the bottom to prevent water outflow while lifting the tube units. At the lower end of the tube array, a weight is added in order to stretch the array and thereby prevent fastening.

The water content in each tube unit constitutes one sample, and the volume of each sample is approximately two and a half litres.



Figure 3-1. Equipment for Hydrochemical logging in boreholes. At the lower end of the tube array there is a non-return valve and a weight connected. Each tube unit is 50 m long.

4 Execution

4.1 Hydrochemical logging

The Hydrochemical logging in KLX21B was performed on January 9, 2007 according to the activity plan AP PS 400-06-155 and in compliance with the method description SKB MD 422.001 (cf. Table 1-1).

The equipment was lowered to a length of 840 m of borehole length, in order to avoid potential settled drilling debris at the bottom of the borehole, and thereby decrease the risk of fastening. The tubes were lowered down the borehole at a rate of about five m/minute. The lowering of the tube units started at 08:23 and the lifting of the tubes started at 11:51. The last tube unit was retrieved at 12:58. Pressurized nitrogen gas was used to empty the tube units and the water samples were portioned into sample bottles. Each tube unit represented one sample.

The ground water level measured before and after the Hydrochemical logging was 3.92 and 3.95 m, respectively, below top of casing. As the tube unit at the top of the tube array only was lowered to 40 m of its length, this tube unit was not completely filled with sample water.

4.2 Sample treatment and chemical analysis

An overview of sample treatment and analysis routines of the activity is given in Appendix 1.

An overview showing the samples obtained at the logging occasion is given in Table 4-1. The analysis program was carried out according to SKB chemistry class 3 except for optional isotopes. Sample portions intended for isotope analyses were collected at the sampling occasion but not sent for analysis. These samples are stored in a freezer at SKB (except for the samples collected for ^3H determinations which are stored in a refrigerator). If these samples will be sent for analysis the results will be presented in a separate report. The data from the Hydrochemical logging are stored in the database SICADA. The SKB sample numbers are 11613–11629.

The uppermost tube unit was not completely filled with sample water, see section 4.1. All other tube units seemed, by visual inspection, to be fully filled with sample water; only small bubbles of gas was observed during lifting. Due to the lack of water in tube unit number twenty (0–40 m), see above, archive samples from tube unit number sixteen were not obtained. Water intended for archive samples from tube unit number sixteen was used to fill sample bottles for analyses of ^3H , $\delta^2\text{H}$, $\delta^{18}\text{O}$ and ^{37}Cl from tube unit number twenty (0–40 m), and sampling of $^{10}\text{B}/^{11}\text{B}$ and $^{87}\text{Sr}/^{86}\text{Sr}$ was omitted. Also, the water volume in tube unit 15 was not sufficient for all samples. Hence, water from tube unit 14 was used to fill the sample bottle intended for analysis of $^{87}\text{Sr}/^{86}\text{Sr}$.

4.3 Data handling

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

All analytical results were 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).

Table 4-1. Overview of samples collected at the Hydrochemical logging in KLX21B. Filled cells represent collected samples. Striped (blue) filling represent samples sent for analyses, light (yellow) filling represent samples collected and stored in a freezer (³H in a refrigerator) and dashed (purple) cells represent archive samples.

Sample information			Collected sample portions											Archive
Tube unit	Length [m]	SKB no.	Cond., pH, alk.	Major Comp.	Ura-nine	An-ions	³ H	δ ² H δ ¹⁸ O	δ ³⁷ Cl	¹⁰ B/ ¹¹ B*	⁸⁷ Sr/ ⁸⁶ Sr	δ ³⁴ S	δ ¹³ C and ¹⁴ C	Filtered 2x250 mL
20	0-40	11613					α	α	α	—	—			
16	90	11614												—
15	140	11615									ω			
14	190	11616												
13	240	11617												
12	290	11618												
11	340	11619												
10	390	11620												
9	440	11621												
8	490	11622												
7	540	11623												
6	590	11624												
5	640	11625												
4	690	11626												
3	740	11627												
2	790	11628												
1	840	11629												

– No sample due to lack of water in tube unit.

α Filled with sample water from tube unit number 16.

ω Filled with sample water from tube unit number 14.

* The B-isotope ratio is given as ¹⁰B/¹¹B (the result reported from the consulting laboratory). The notation according to international standard for environmental isotopes is ¹¹B/¹⁰B, i.e. 1/(¹⁰B/¹¹B).

Data from *basic water analyses* are inserted into raw data tables for further evaluation. The evaluation results in a final 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. The analyses are repeated if a large disparity is noted (generally more than 10%).

Calculation of charge balance errors. Relative errors within $\pm 5\%$ are considered acceptable (in surface waters $\pm 10\%$).

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

General judgement of plausibility based on earlier results and experiences.

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 the results considered most reliable.

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

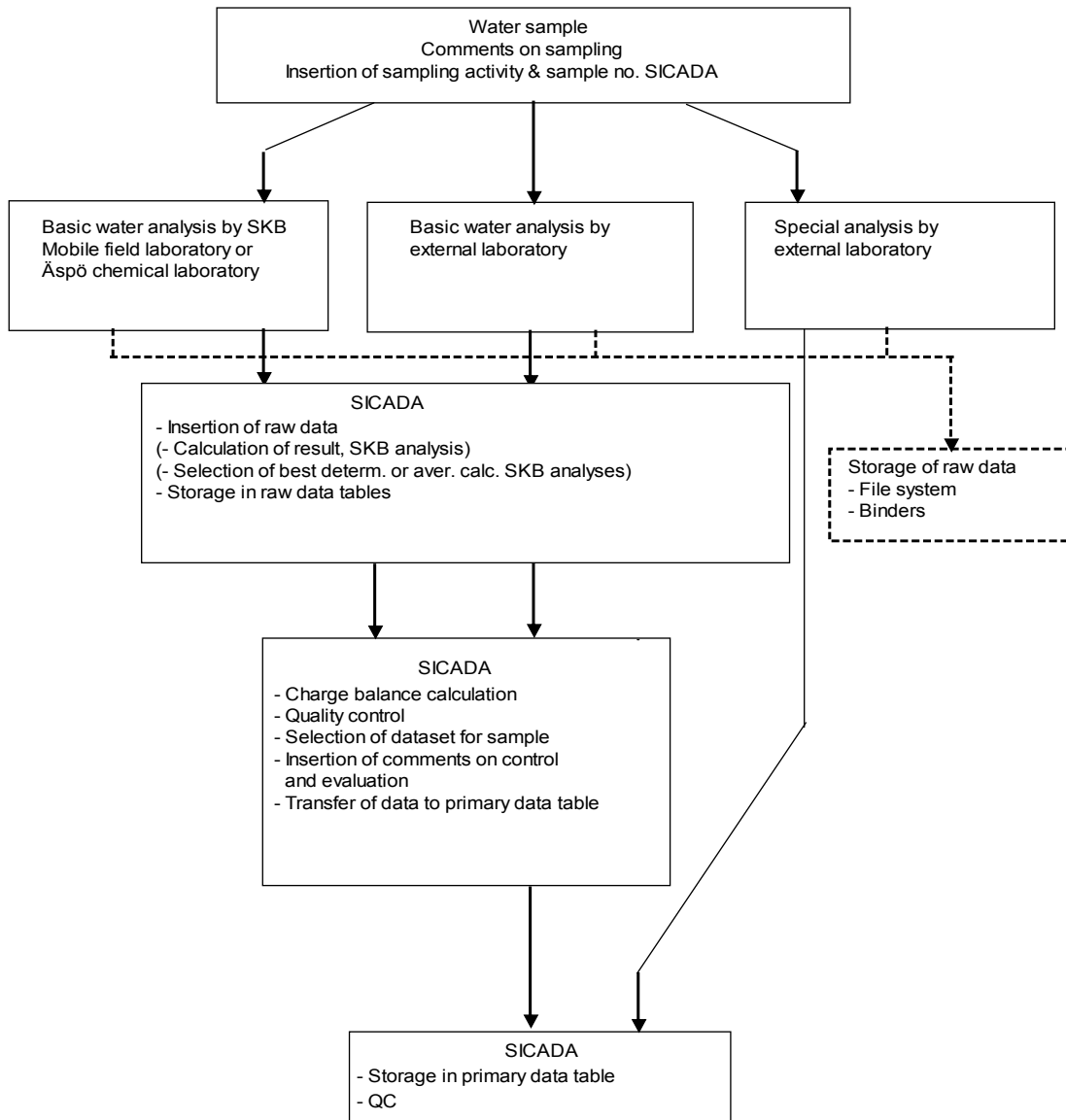


Figure 4-1. Overview of data management for hydrogeochemical data.

4.4 Nonconformities

The activity was performed without any deviations from the controlling documents for the activity that can affect the quality of data. However, the following is worth pointing out.

Due to problems with lack of water in sampling tube number 20 (0–40 m), the archive samples from the following tube unit (number 16) was omitted in favour of samples intended for analysis of ^3H , $\delta^2\text{H}$, $\delta^{18}\text{O}$ and ^{37}Cl . Despite this, the amount of water was not enough to fill the bottles for analysis of $^{10}\text{B}/^{11}\text{B}$ and $^{87}\text{Sr}/^{86}\text{Sr}$. Also in tube unit number 15 the amount of water was not enough to fill all the bottles. Hence water from tube unit number 14 was used for the samples intended for $^{87}\text{Sr}/^{86}\text{Sr}$ analysis.

At the first control of the ion charge balance, the error exceeded 5% for the two samples representing the deepest part of the borehole. Hence, the consulted laboratories were asked to do a second analysis of the remaining sample portions. The results from the first analysis were confirmed. Hence, the results from borehole length 690–740 m and 790–840 m (sample numbers 11627 and 11629) are not regarded as reliable.

As the drill water content was high in both of the erroneous samples, the water is not regarded as representative for the water-bearing fractures in the borehole. It was decided that no further investigations should be made.

5 Results

Original data from the reported activity are stored in the primary database Sicada. Data are traceable in Sicada by the Activity Plan number (AP PS 400-06-155). Only data in databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. However, such revision of the database will not necessarily result in a revision of this report, although the normal procedure is that major data revisions entail a revision of P-reports. Minor data revisions are normally presented as supplements, available at www.skb.se.

5.1 Analytical results

The results from the chemical analyses are presented in Appendix 2. The two samples from borehole lengths 690–740 m and 790–840 m are presented in the figures below (Figure 5-1 to 5-6) although the results from these two samples are not considered as reliable (see Section 5.2).

Diagrams showing the drill water content and the electric conductivity along the borehole, at the time of the Hydrochemical logging, are presented in Figures 5-1 and 5-2. Results from analyses of pH, HCO_3^- and some of the major constituents (Na^+ , Ca^+ and Cl^-) are shown in Figures 5-3 to 5-5, respectively. Sulphate (SO_4^{2-}) analysed by ion chromatography (IC) is compared with sulphate determined as total sulphur using inductively coupled plasma atomic emission spectrometry (ICP-AES) in Figure 5-6. Results are plotted for the mid-length of each tube unit.

5.2 Quality of the analyses

The charge balance errors give an indication of the quality and uncertainty of the analyses of major constituents. The relative charge balance errors were calculated for the selected sets of data, see Appendix 2. If the relative errors are within $\pm 5\%$ they are considered acceptable.

For seven of the nine samples analysed the errors did not exceed 5%. This indicates that the analyses of the major components are consistent for these seven samples. However, the errors exceeded 5% for two of the nine analysed samples. The samples from borehole lengths 690–740 m and 790–840 m showed a relative charge balance error of nearly $\pm 20\%$. Hence, the analytical results from these samples are not considered as reliable. This fact was commented when the analytical results were stored in the SICADA database.

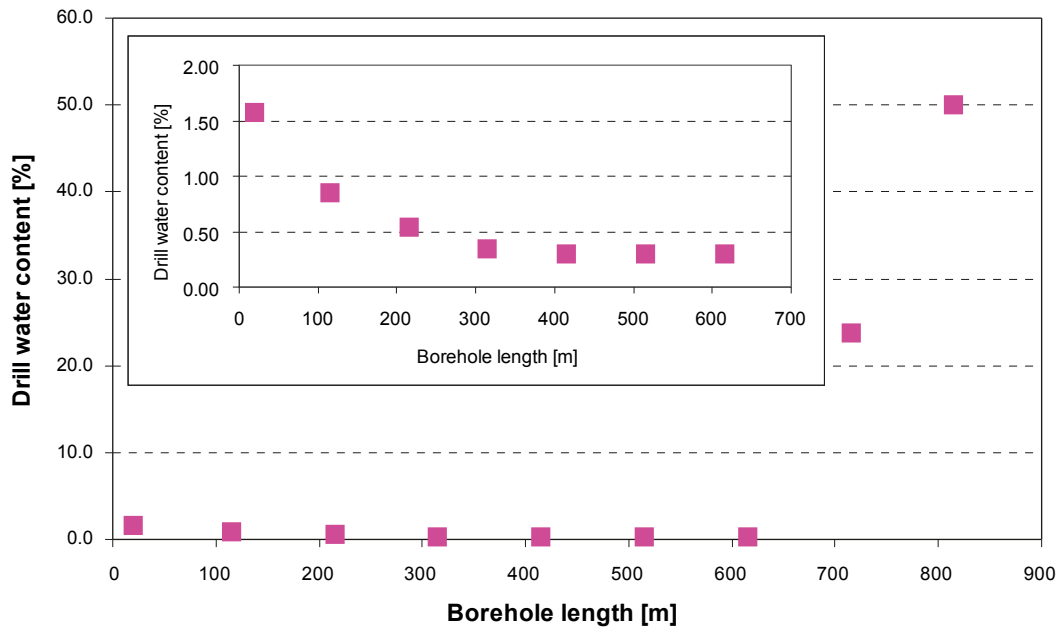


Figure 5-1. Drill water content remaining at different borehole lengths at the time of the Hydrochemical logging in KLX21B. The small figure shows a more detailed resolution of the low drill water content.

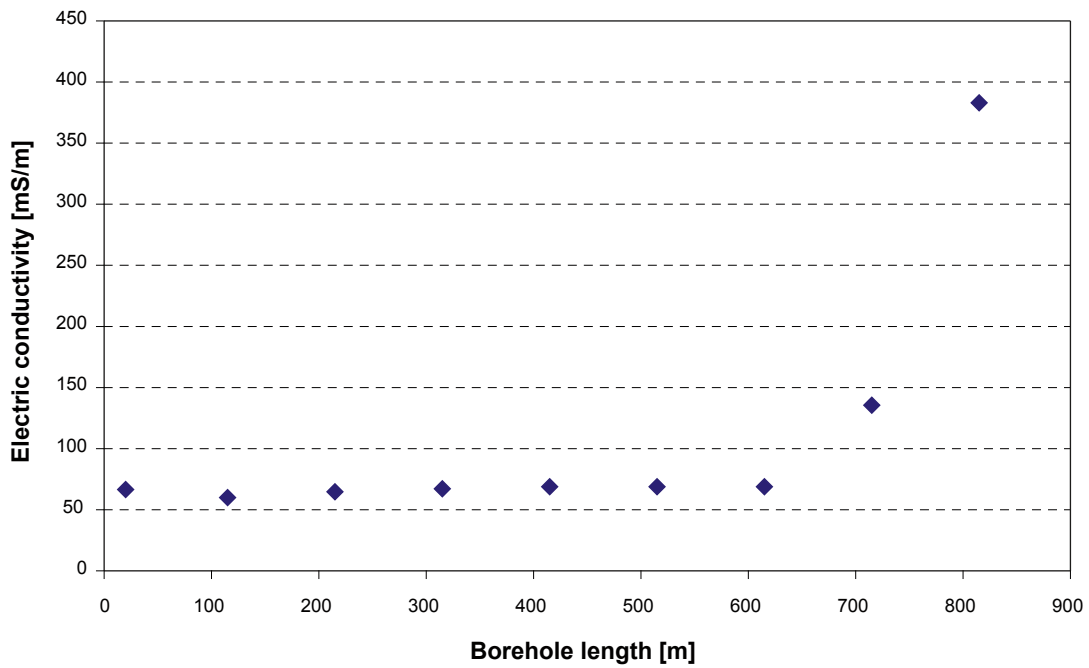


Figure 5-2. Electric conductivity values obtained from the Hydrochemical logging in KLX21B.

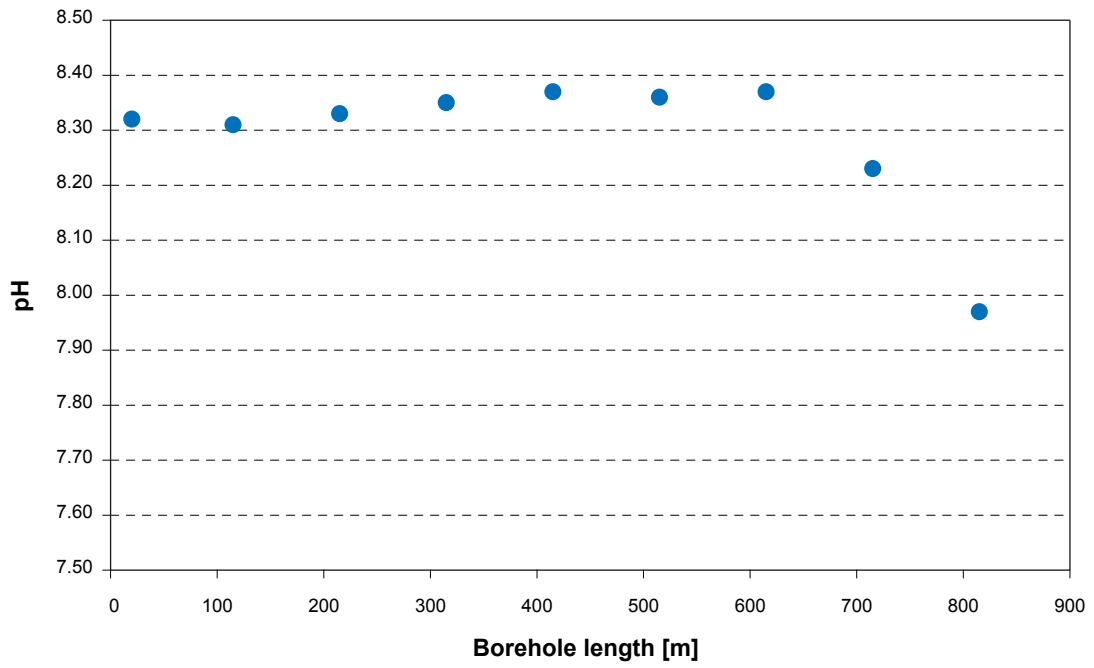


Figure 5-3. Results from pH measurements obtained from the Hydrochemical logging in KLX21B.

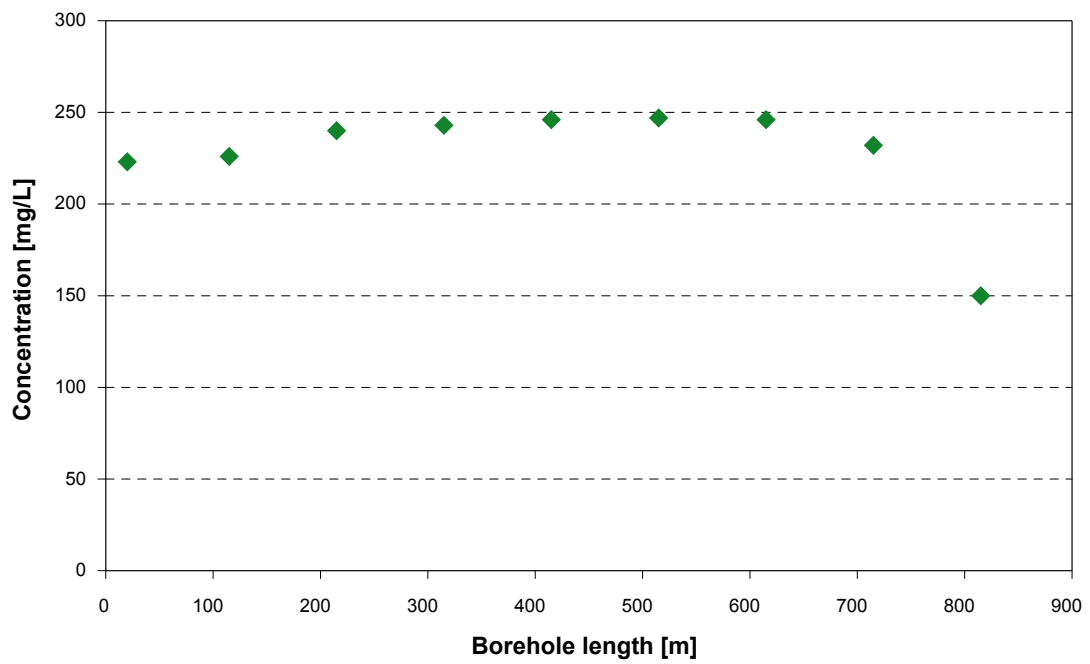


Figure 5-4. Results from analysis of hydrogen carbonate (HCO_3^-) in water samples obtained from the Hydrochemical logging in KLX21B.

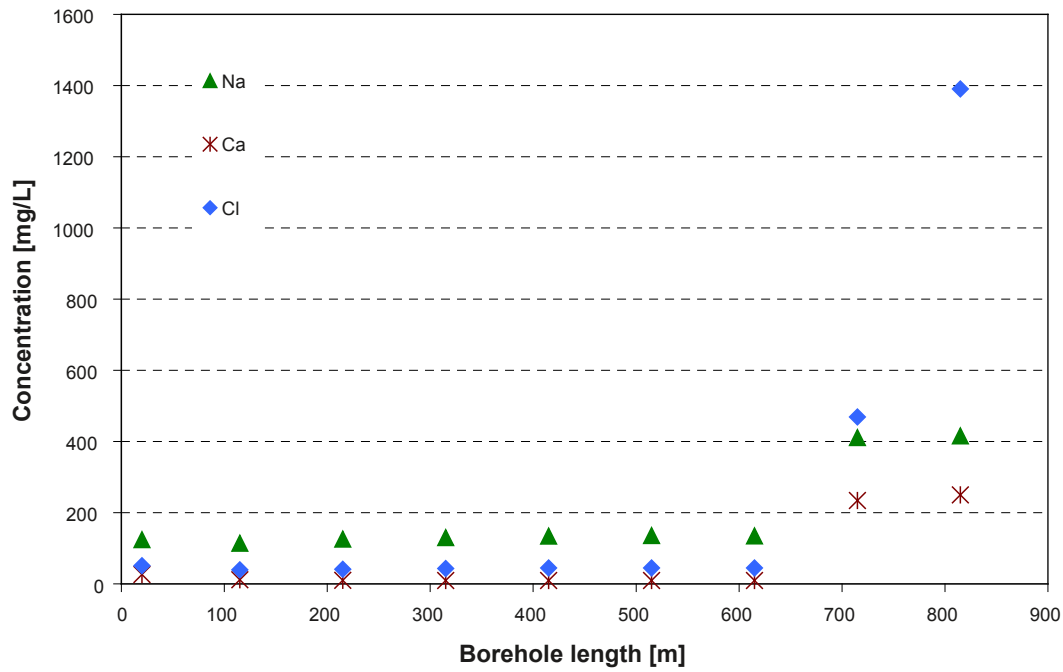


Figure 5-5. Results from analysis of the constituents Na⁺, Ca²⁺ and Cl⁻ in water samples obtained from the Hydrochemical logging in KLX21B.

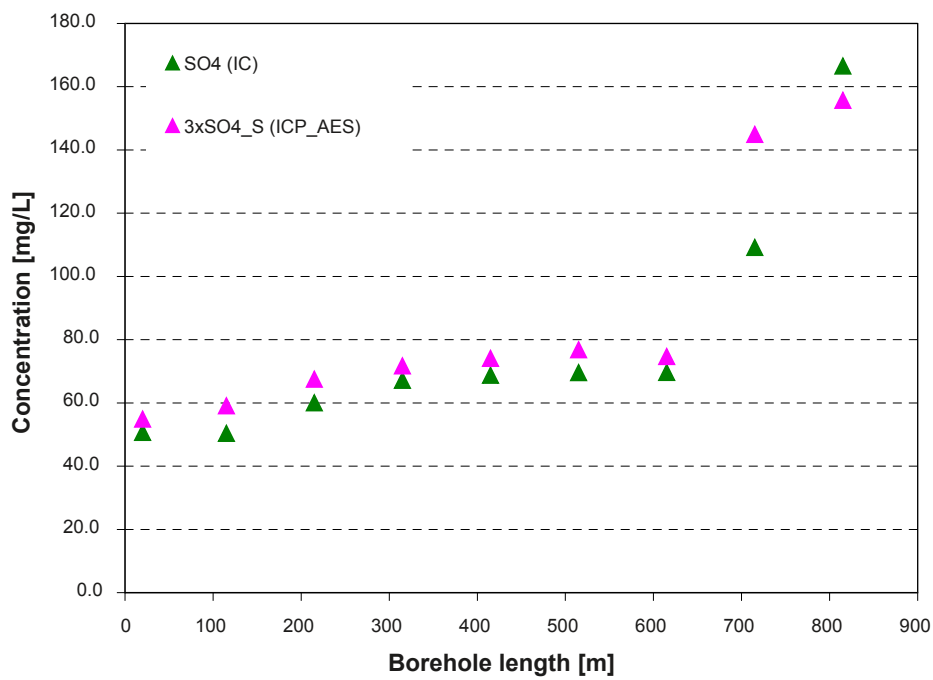


Figure 5-6. Sulphate (IC) compared to total sulphur (ICP-AES), results from the Hydrochemical logging in KLX21B.

6 Summary and discussions

The Hydrochemical logging of KLX21B was conducted successfully. The main results are summarized and discussed below.

- The amount of remaining drill water at the time of the Hydrochemical logging was generally low, a maximum of 1.6% in all tube units except the two ones representing the deepest part of the borehole (690–740 m and 790–840 m) where the drill water content was c. 25% and 50% respectively.
- The charge balance error, giving an indication of the quality and uncertainty of the analyses, did not exceed the acceptable level ($\pm 5\%$) in the samples from the analysed upper seven tube units (representing 0–640 m borehole length). This indicates that the analyses of the major components in these samples are consistent.
- The results from two tube units (690–740 m and 790–840 m) are not considered reliable since the charge balance error exceeded the acceptable level ($\pm 5\%$). Also, the drill water content in these two samples are above 20% and is therefore not be considered as representative for the water chemistry in the water-bearing fractures of the borehole.
- Owing to the low drill water content in the samples the results from the upper seven tube units can be considered as representative for the water chemistry in the water-bearing fractures of the borehole at 0–640 m.
- For the seven tube units with drill water content below 2% and an acceptable charge balance error, the water chemistry results are in general similar or somewhat increasing with increasing borehole length.
- In the tube units that can be considered as representative of the water chemistry in the borehole (0–640 m), the electric conductivity ranges from 60.0 to 68.8 mS/m and the chloride concentrations from 39.5 mg/L to 51.3 mg/L. In the lowermost tube unit the corresponding values are 383 mS/m and 1,390 mg/L respectively.

7 References

- /1/ **SKB, 2001.** Generellt genomförande program för platsundersökningar. SKB R-01-10, Svensk Kärnbränslehantering AB.
- /2/ **SKB, 2005.** Platsundersökning Oskarshamn. Program för fortsatta undersökningar av berggrund, mark, vatten och miljö inom delområde Laxemar. SKB R-05-37, Svensk Kärnbränslehantering AB.

Sampling and analytical methods

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

Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Analysis within – or delivery time to lab.
Anions 1	HCO ₃ ⁻ pH (lab) cond (lab)	Plastic	250	No	No	Titration Pot. meas, Cond. meas	The same day – maximum 24 hours
Anions 2	Cl ⁻ , SO ₄ ²⁻ , Br ⁻ , F ⁻	Plastic	250	Yes (in connection with analysis)	No	Titration (Cl ⁻) IC (Cl ⁻ , SO ₄ ²⁻ , Br ⁻ , F ⁻) ISE (F ⁻)	Not critical (month)
Cations, Si and S according to SKB class 3	Na, K, Ca, Mg, S(tot), Si(tot), Li, Sr	Plastic (at low conc. acid washed bottles)	100	Yes (not in the field)	Yes (not in the field, 1 mL HNO ₃)	ICP-AES ICP-MS	Not critical (month)
Environmental isotopes	δ ² H, δ ¹⁸ O	Plastic	100	No	– –	MS	Not critical (month)
Tritium	³ H (enhanced.)	Plastic (dry bottle)	500	No	–	LSC	
Chlorine-37	δ ³⁷ C1	Plastic	500	No	–	ICP MS	Not critical (month)
Carbon isotopes	δ ¹³ C, pmC (¹⁴ C)	Plastic (fluorated)	100×2	No	–	(A)MS	A few days
Sulphur isotopes	δ ³⁴ S	Plastic	500–1,000	No	–	Combustion, ICP MS	No limit
Strontium-isotopes	⁸⁷ Sr/ ⁸⁶ Sr	Plastic	100	No	–	TIMS	Days or Week
Boron isotopes	¹⁰ B/ ¹¹ B **	Plastic	100	Yes	Yes (1 mL HNO ₃)	ICP – MS	No limit
Archive samples without acid	–	Plastic	250×2	Yes	No	–	Storage in freeze container

* Suprapur acid is used for conservation of samples.

** The B-isotope ratio is given as ¹⁰B/¹¹B (the result reported from the consulting laboratory). The notation according to international standard for environmental isotopes is ¹¹B/¹⁰B, i.e. 1/(¹⁰B/¹¹B).

Abbreviations and definitions:

IC	Ion Chromatograph
ISE	Ion Selective Electrode
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectrometry
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
MS	Mass Spectrometry
LSC	Liquid Scintillation Counting
(A)MS	(Accelerator) Mass Spectrometry
TIMS	Thermal Ionization Mass Spectrometer

Table A1-2. Reporting limits and measurement uncertainties.

Component	Method	Reporting limits or range	Unit	Measurement uncertainty ²	“Total” uncertainty ³
HCO ₃ ⁻	Alkalinity titration	1	mg/L	4%	< 10%
pH	Pot. meas.	–	–	5%	–
Cond.	Cond. meas.	0.02	mS/m	4%	–
Cl ⁻	Mohr– titration	> 70	mg/L	5%	< 10%
Cl ⁻	IC	1–100		6%	10%
SO ₄ ²⁻	IC	1	mg/L	10%	15%
Br ⁻	IC	0.2	mg/L	9%	20%
F ⁻	IC	0.1	mg/L	10%	20%
F ⁻	ISE	–		–	
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	21%	15%
Si(tot)	ICP	0.03	mg/L	4%	15%
Sr	ICP	0.002	mg/L	4%	15%
Li	ICP	0.2 ¹	2 mg/L	10%	20%
δ ² H	MS	2	‰ SMOW ⁴	1‰	–
δ ¹⁸ O	MS	0.1	‰ SMOW ⁴	0.2‰	–
³ H	LSC	0.8 or 0.1	TU ⁵	0.8 or 0.1	Correct order of size
δ ³⁷ Cl	ICP MS	0.2‰ (20 mg/L)	‰ SMOC ⁶	–	–
δ ¹³ C	A (MS)	–	‰ PDB ⁷	–	–
pmC (¹⁴ C)	A (MS)	–	pmC ⁸	–	–
δ ³⁴ S	ICP MS	0.2‰	‰ CDT ⁹	0.3‰	–
⁸⁷ Sr/ ⁸⁶ Sr	TIMS	–	No unit (ratio) ¹⁰	–	–
¹⁰ B/ ¹¹ B **	ICP MS	–	No unit (ratio) ¹⁰	–	–

** The B-isotope ratio is given as ¹⁰B/¹¹B (the result reported from the consulting laboratory). The notation according to international standard for environmental isotopes is ¹¹B/¹⁰B, i.e. 1/(¹⁰B/¹¹B).

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 mille deviation¹³ 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 mille deviation¹³ from SMOC (Standard Mean Oceanic Chloride).
7. Per mille deviation¹³ from PDB (the standard PeeDee Belemnite).
8. The following relation is valid between pmC (percent modern carbon) and Carbon-14 age:

$$\text{pmC} = 100 \times e^{((1.950 - y - 1.03t)/8.274)}$$
 where y = the year of the C-14 measurement and t = C-14 age.
9. Per mille deviation¹³ from CDT (the standard Canyon Diablo Troilite).
10. Isotope ratio without unit.

Isotopes are often reported as per mill deviation from a standard. The deviation is calculated as:

$$\delta y \text{‰} = 1,000 \times (K_{\text{sample}} - K_{\text{standard}}) / K_{\text{standard}}$$
 where K = the isotope ratio and y = ²H, ¹⁸O, ³⁷Cl, ¹³C or ³⁴S etc.

Water composition

Compilation March 2007.

Idcode	Secup m	Seclow m	Sample no	Charge Bal %	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	HCO ₃ ⁻ mg/L	Cl ⁻ mg/L	SO ₄ ²⁻ mg/L	SO ₄ -S mg/L	Br ⁻ mg/L	F ⁻ mg/L	Si mg/L	Fe mg/L	Mn mg/L	Li mg/L	Sr mg/L	pH	Drill_water %	ElCond mS/m
KLX21B	0.00	40.00	11613	4.32	124	3.75	26.3	2.6	223	51.3	50.7	18.3	0.26	3.77	6.90	0.453	0.069	0.014	0.418	8.32	1.57	66.5
KLX21B	40.00	90.00	11614	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX21B	90.00	140.00	11615	-3.52	114	3.42	11.4	2.4	226	39.5	50.4	19.7	< 0.2	3.69	6.52	0.165	0.034	0.013	0.226	8.31	0.85	60.0
KLX21B	140.00	190.00	11616	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX21B	190.00	240.00	11617	-3.06	126	3.61	10.1	2.6	240	40.8	60.0	22.5	< 0.2	3.91	6.71	0.256	0.031	0.015	0.226	8.33	0.54	64.7
KLX21B	240.00	290.00	11618	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX21B	290.00	340.00	11619	-3.45	130	3.65	9.4	2.6	243	43.2	67.2	23.9	< 0.2	4.00	6.29	0.055	0.027	0.015	0.225	8.35	0.34	67.2
KLX21B	340.00	390.00	11620	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX21B	390.00	440.00	11621	-3.32	134	3.79	9.5	2.7	246	44.5	68.8	24.7	< 0.2	4.86	6.32	0.076	0.027	0.014	0.231	8.37	0.30	68.8
KLX21B	440.00	490.00	11622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX21B	490.00	540.00	11623	-3.12	136	3.83	9.6	2.8	247	44.7	69.6	25.6	< 0.2	4.86	6.52	0.103	0.027	0.015	0.236	8.36	0.30	68.8
KLX21B	540.00	590.00	11624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX21B	590.00	640.00	11625	-3.17	135	3.81	9.4	2.7	246	44.8	69.6	24.9	< 0.2	4.88	6.34	0.072	0.026	0.014	0.232	8.37	0.30	68.8
KLX21B	640.00	690.00	11626	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX21B	690.00	740.00	11627	19.99	411	6.85	234	7.8	232	469	109	48.3	3.09	4.51	6.08	0.285	0.160	0.071	4.150	8.23	23.7	136
KLX21B	740.00	790.00	11628	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX21B	790.00	840.00	11629	-17.80	416	6.43	250	8.2	150	1,390	167	51.9	9.71	2.78	5.98	0.522	0.157	0.075	4.360	7.97	51.1	383

- = Not analysed

x = No sample due to sampling problems

xxx = Stored in freezer/refrigerator

* = Sample collected from tube unit below

< = below detection limit

ChargeBal % Relative charge balance error %

Compilation March 2007.

Idcode	Secup m	Seclow m	Sample no.	$\delta^2\text{H}$ dev SMOW	$\delta^{18}\text{O}$ dev SMOW	^3H TU	$\delta^{37}\text{Cl}$ dev SMOC	$^{11}\text{B}/^{10}\text{B}$ no unit	$^{87}\text{Sr}/^{86}\text{Sr}$ no unit	$\delta^{34}\text{S}$ dev CDT	$\delta^{13}\text{C}$ dev PDB	^{14}C pmC
KLX21B	0.00	40.00	11613	xxx *	xxx *	xxx *	xxx *	x	x	—	—	—
KLX21B	40.00	90.00	11614	—	—	—	—	—	—	xxx	xxx	xxx
KLX21B	90.00	140.00	11615	xxx	xxx	xxx	xxx	xxx	xxx *	—	—	—
KLX21B	140.00	190.00	11616	—	—	—	—	—	—	xxx	xxx	xxx
KLX21B	190.00	240.00	11617	xxx	xxx	xxx	xxx	xxx	xxx	—	—	—
KLX21B	240.00	290.00	11618	—	—	—	—	—	—	xxx	xxx	xxx
KLX21B	290.00	340.00	11619	xxx	xxx	xxx	xxx	xxx	xxx	—	—	—
KLX21B	340.00	390.00	11620	—	—	—	—	—	—	xxx	xxx	xxx
KLX21B	390.00	440.00	11621	xxx	xxx	xxx	xxx	xxx	xxx	—	—	—
KLX21B	440.00	490.00	11622	—	—	—	—	—	—	xxx	xxx	xxx
KLX21B	490.00	540.00	11623	xxx	xxx	xxx	xxx	xxx	xxx	—	—	—
KLX21B	540.00	590.00	11624	—	—	—	—	—	—	xxx	xxx	xxx
KLX21B	590.00	640.00	11625	xxx	xxx	xxx	xxx	xxx	xxx	—	—	—
KLX21B	640.00	690.00	11626	—	—	—	—	—	—	xxx	xxx	xxx
KLX21B	690.00	740.00	11627	xxx	xxx	xxx	xxx	xxx	xxx	—	—	—
KLX21B	740.00	790.00	11628	—	—	—	—	—	—	xxx	xxx	xxx
KLX21B	790.00	840.00	11629	xxx	xxx	xxx	xxx	xxx	xxx	—	—	—

— = Not analysed

x = No sample due to sampling problems

xxx = Stored in freezer/refrigerator

* = Sample collected from tube unit below

< = below detection limit

ChargeBal % Relative charge balance error %