

**P-07-126**

## **Oskarshamn site investigation**

### **Hydrochemical logging in KLX16A**

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November 2007

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*Keywords:* Hydrochemical logging, Core drilled borehole, Groundwater, Water sampling, Chemical analyses, AP PS 400-07-013, KLX16A.

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## Abstract

Hydrochemical logging, also called tube sampling, has been performed in the core drilled borehole KLX16A. 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. 430 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 ( $^3\text{H}$ ) in a refrigerator); oxygen-18 ( $\delta^{18}\text{O}$ ), deuterium ( $\delta^2\text{H}$ ), tritium ( $^3\text{H}$ ), 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 ( $^{14}\text{C}$ ) from even-numbered tube units. If these samples are analysed later, the results will be reported in a separate report.

The drill water content remaining in the borehole after drilling was 3% in the upper part of the borehole (60–110 m and 160–210 m), while in the deepest part of the borehole (260–310 and 360–410 m) it was 37% and 43% respectively. The relative charge balance error exceeded the acceptable limit of  $\pm 5\%$ , for two of the four samples analysed, the same two samples for which the drill water content was high (260–310 and 360–410 m).

\* 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 KLX16A. 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 430 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 isotop-tillvalen togs ut vid provtagningstillfället och sparades i frys (tritium ( $^3\text{H}$ ) i kylskåp); syre-18 ( $\delta^{18}\text{O}$ ), deuterium ( $\delta^2\text{H}$ ), tritium ( $^3\text{H}$ ), 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 ( $^{14}\text{C}$ ) 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 kring 3 % i den övre delen av borrhålet (60–110 m samt 160–210 m) medan den var 37 % respektive 43 % i den djupaste delen av borrhålet, 260–310 m, och 360–410 m. Det relativa felet i jonbalansen översteg den acceptabla nivån av  $\pm 5\%$  i två av de fyra analyserade proverna, samma två prover i vilka spolvattenhalten var hög (260–310 m och 360–410 m).

\* 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  $^{11}\text{B}/^{10}\text{B}$ , dvs  $1/(^{10}\text{B}/^{11}\text{B})$ .

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# 1 Introduction

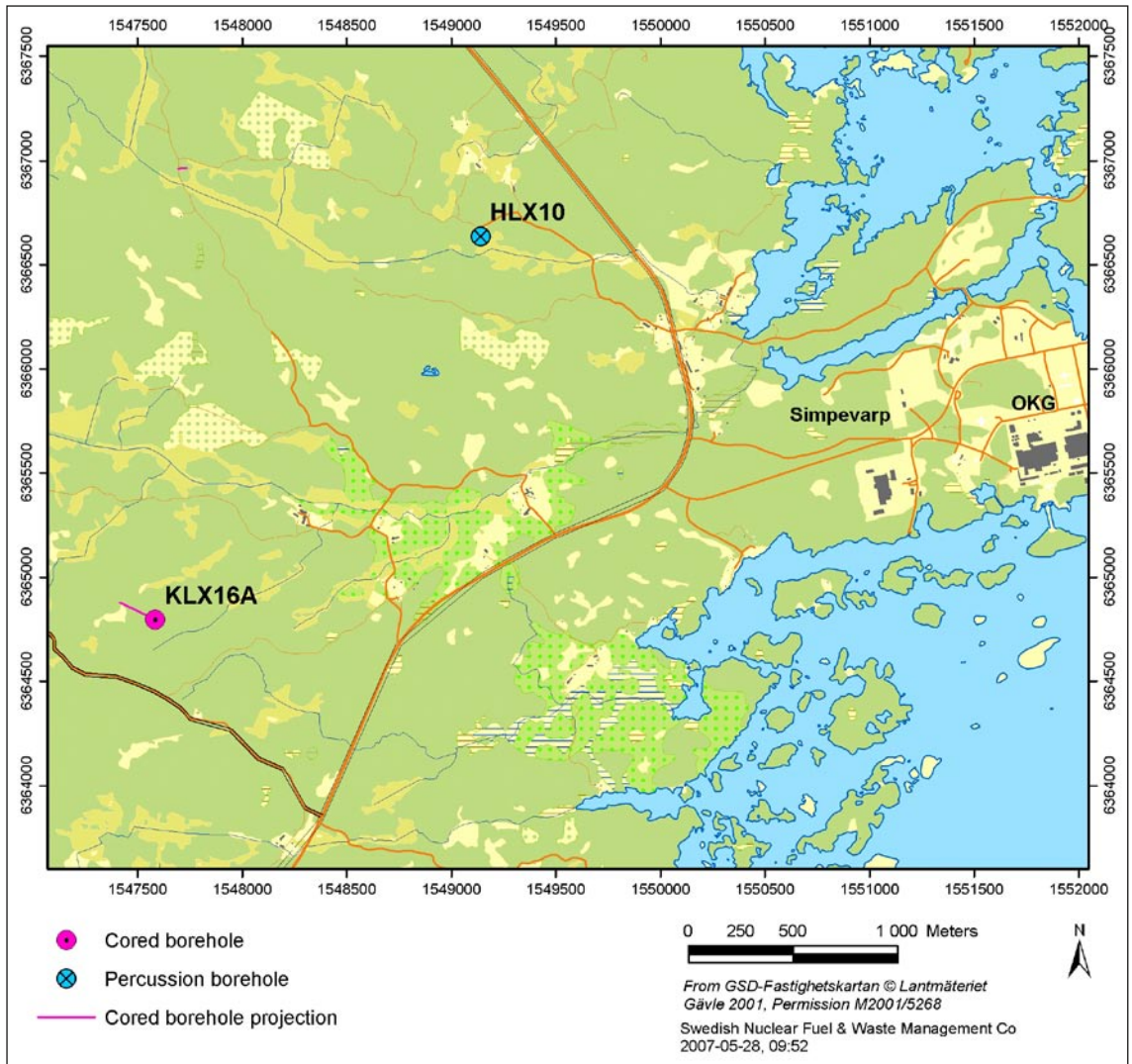
This document reports the performance and results from the Hydrochemical logging in borehole KLX16A. Hydrochemical logging is one of the activities performed within the site investigation at Oskarshamn /1, 2/. The work was carried out in accordance with activity plan AP PS 400-07-013. In Table 1-1 controlling 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 KLX16A is a 433.55 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 KLX16A. The locations of KLX16A and HLX10 are shown in Figure 1-1.

The borehole KLX16A 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.**

<b>Activity Plan</b>	<b>Number</b>	<b>Version</b>
Hydrokemisk loggning i KLX16A	AP PS 400-07-013	1.0
<b>Method Descriptions</b>	<b>Number</b>	<b>Version</b>
Metodbeskrivning för hydrokemisk loggning	SKB MD 422.001	2.0
Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning	SKB MD 600.004	1.0



**Figure 1-1.** Location of the core drilled borehole KLX16A 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 KLX16A. 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.

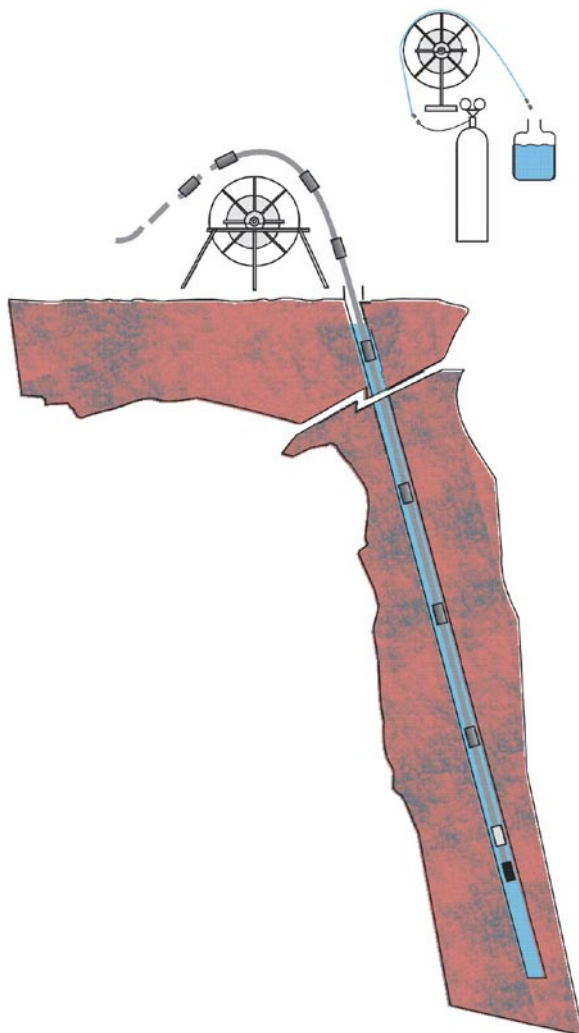


### 3 Sampling equipment

For the Hydrochemical logging an approximately 450 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 KLX16A was performed on February 6, 2007 according to the Activity Plan AP PS 400-07-013 and in compliance with the Method Description SKB MD 422.001 (cf. Table 1-1).

The equipment was lowered to 410 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 08:43 and the lifting of the tubes started at 10:29. The last tube unit was retrieved at 11:11. 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 11.16 and 11.20 m, respectively, below top of casing. As the tube unit at the top of the tube array only was lowered to 10 metres of its length, this tube unit was not filled with any 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

**Table 4-1. Overview of samples collected at the Hydrochemical logging in KLX16A. Filled cells represent collected samples. Striped (blue) fillings represent samples sent for analyses, light (yellow) fillings represent samples collected and stored in a freezer (<sup>3</sup>H 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	<sup>3</sup> H	$\delta^2\text{H}$ $\delta^{18}\text{O}$	$\delta^{37}\text{Cl}$	<sup>10</sup> B/ <sup>11</sup> B*	<sup>87</sup> Sr/ <sup>86</sup> Sr	$\delta^{34}\text{S}$	$\delta^{13}\text{C}$ and $^{14}\text{C}$	Filtered 2 x 250 mL
20	0	-	-	-	-	-	-	-	-	-	-	-	-	
	10													
8	60	11696												
7	110	11697												
6	160	11698												
5	210	11699												
4	260	11700												
3	310	11701												
2	360	11702												
1	410	11703												

- No sample due to missing water in the tube unit.

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

but not sent for analysis. These samples are stored in a freezer at SKB (except for the samples collected for  $^3\text{H}$  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 11696–11703.

The uppermost tube unit was not filled with any 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 (0–10 m), no samples at all were obtained from this part of the borehole.

### 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).

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.

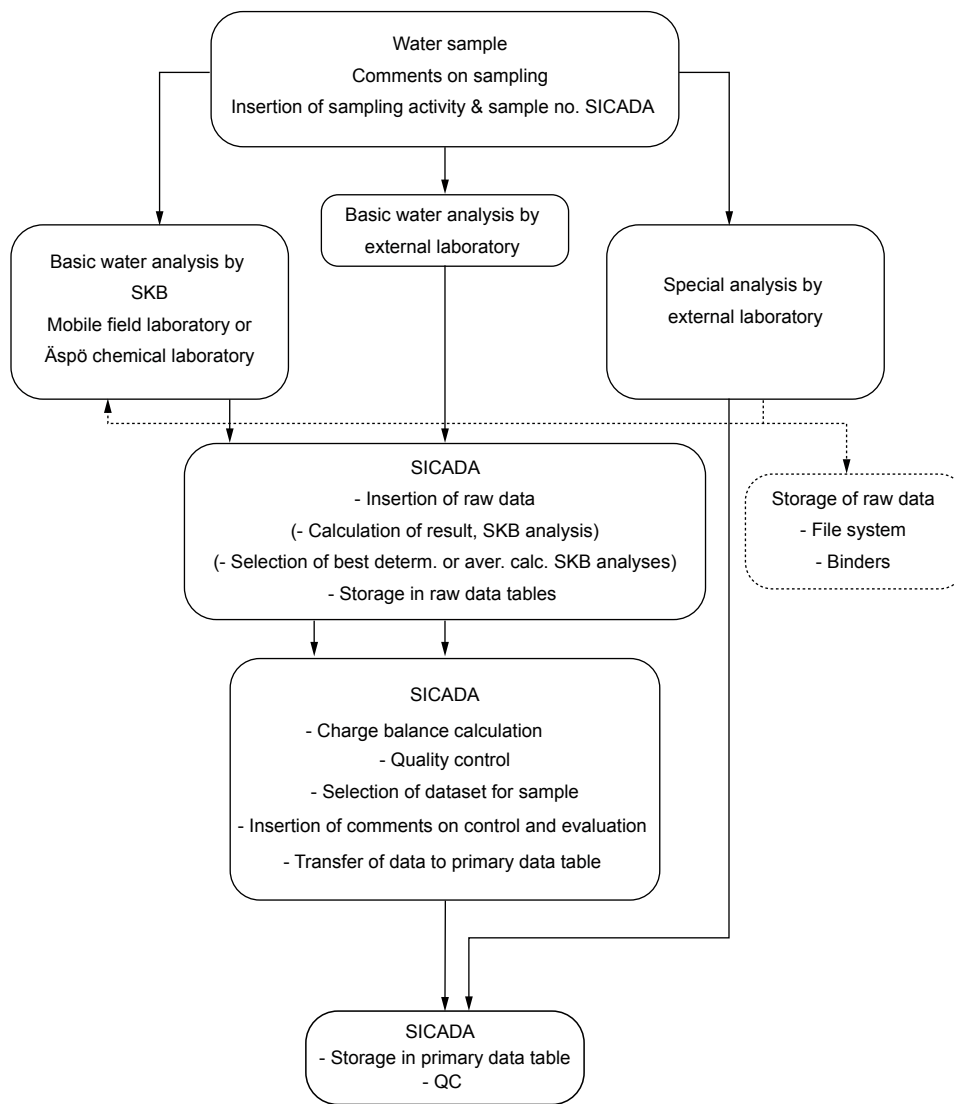
### 4.4 Nonconformities

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.

No water at all was collected in the upper tube unit (sampling tube number 20 (0–10 m), due to the large distance to the ground water (11.2 m), hence the sampling from this borehole interval was omitted.

At the first control of the ion charge balance, the error exceeded 5% for the sample representing borehole interval 260–310 m. Accordingly, the consulted laboratories were asked to perform a second analysis of the remaining sample portion. The results from the first analysis were confirmed. Hence, the results from borehole length 260–310 m (sample number 11701) are not regarded as reliable. Also in sample number 11703 (representing borehole length 360–410 m) the error slightly exceeded 5%, but the sample was not re-analysed.

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.



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

## 5 Results

### 5.1 Analytical results

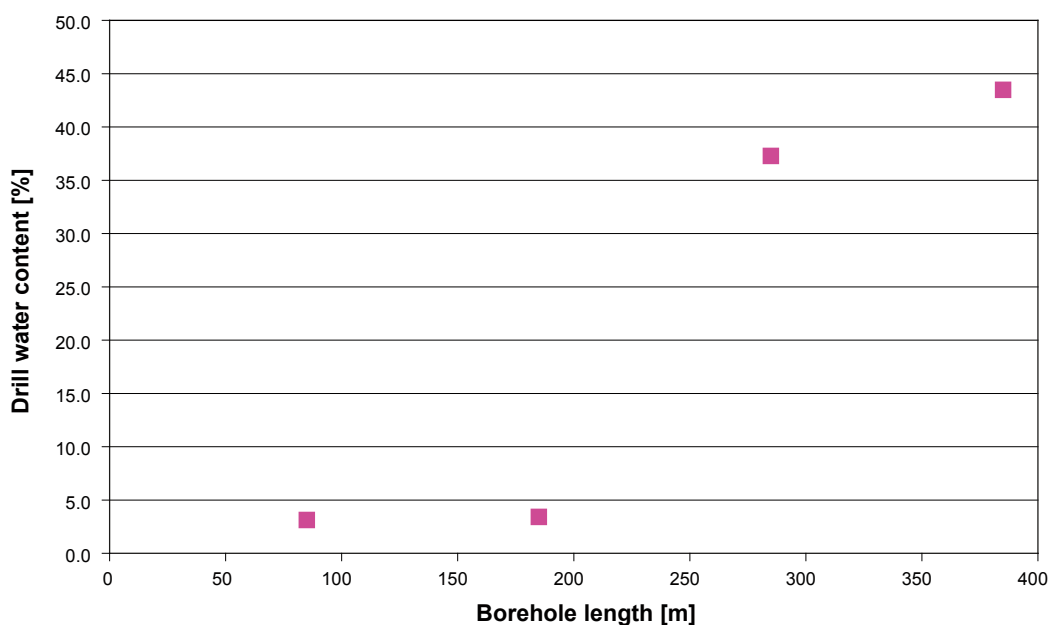
The results from the chemical analyses are presented in Appendix 2. The original results are stored in the primary data base (SICADA), and the data in this data base will be used for further interpretation (modelling).

The two samples from borehole lengths 310–360 m and 410–460 m are presented in the figures below (Figures 5-1 to 5-6) although the results from these two samples are not considered as reliable (see Section 5.2).

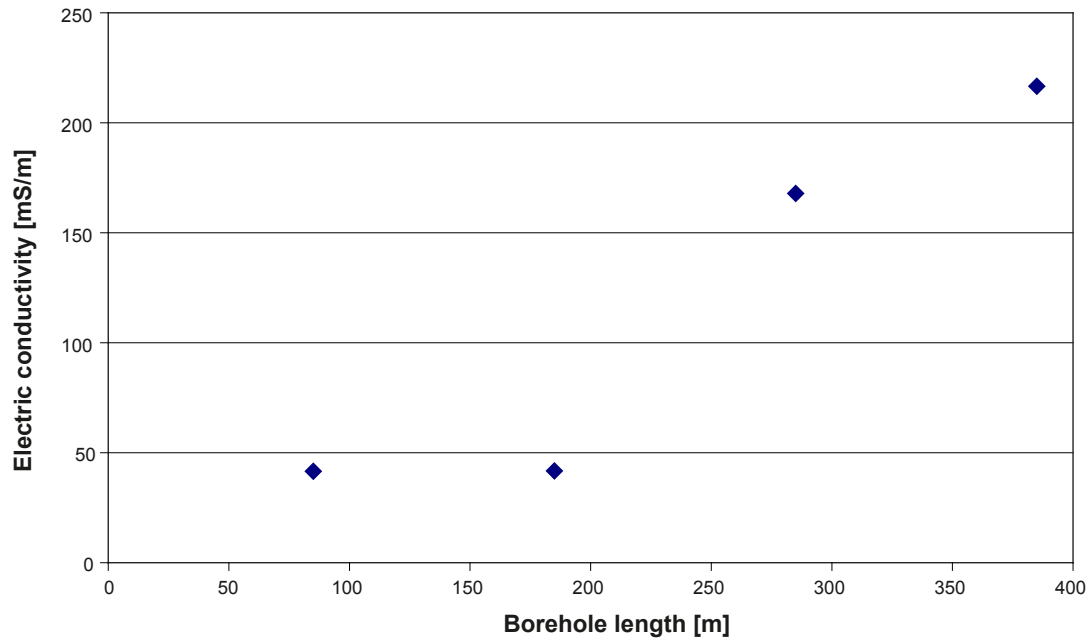
Diagrams showing the drill water content and the electric conductivity along the borehole, at the time of the Hydrochemical logging, are presented in Figures 5-1 and 5-2. Results from analyses of pH,  $\text{HCO}_3^-$  and some of the major constituents ( $\text{Na}^+$ ,  $\text{Ca}^+$  and  $\text{Cl}^-$ ) are shown in Figures 5-3 to 5-5, respectively. Sulphate ( $\text{SO}_4^{2-}$ ) 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. The results are plotted for the mid-length of each tube unit.

### 5.2 Quality of the analyses

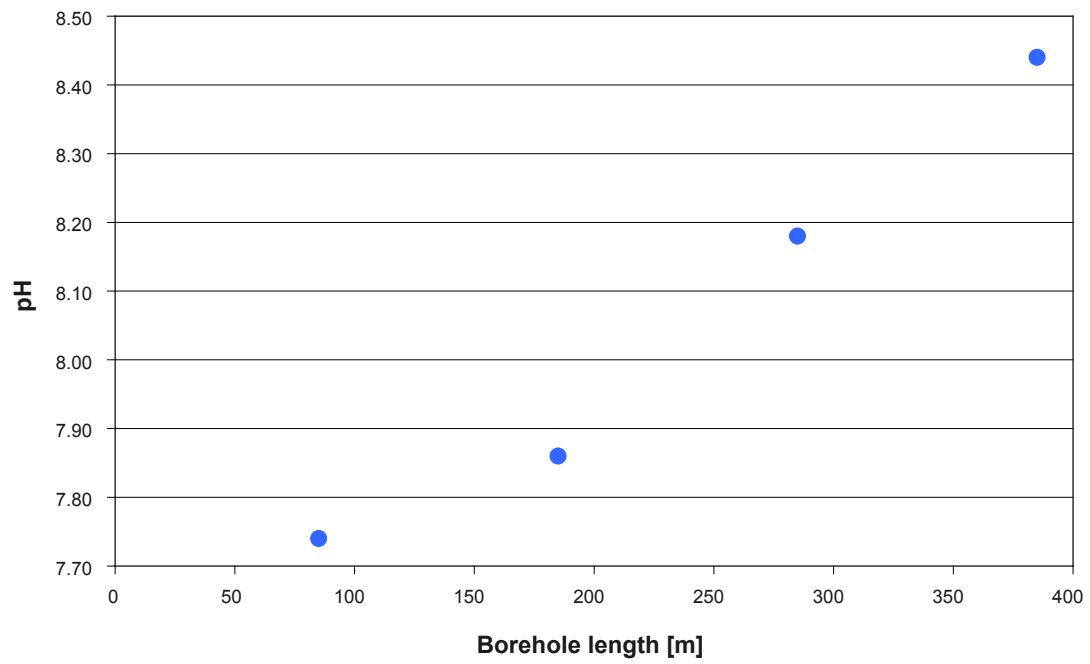
The charge balance errors give an indication of the quality and uncertainty of the analyses of major constituents. The relative charge balance errors were calculated for the selected sets of data, see Appendix 2. If the relative errors are within  $\pm 5\%$  they are considered acceptable. For two of the samples the relative errors did not exceed 5%. This indicates that the analyses of the major components are consistent for these samples. However, the errors exceeded 5% for the other two of the four analysed samples. The samples from borehole lengths 260–310 m and 360–410 m showed a relative charge balance error of  $\pm 9\%$  and  $\pm 5.5\%$  respectively. 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.



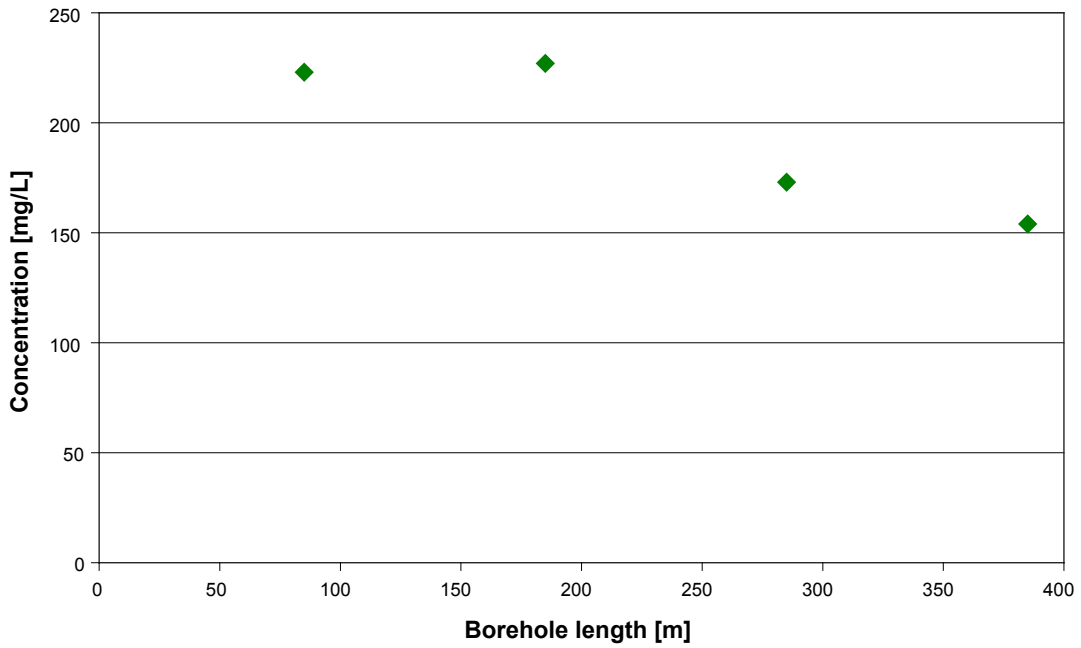
*Figure 5-1. Drill water content remaining at different borehole lengths at the time of the Hydrochemical logging in KLX16A.*



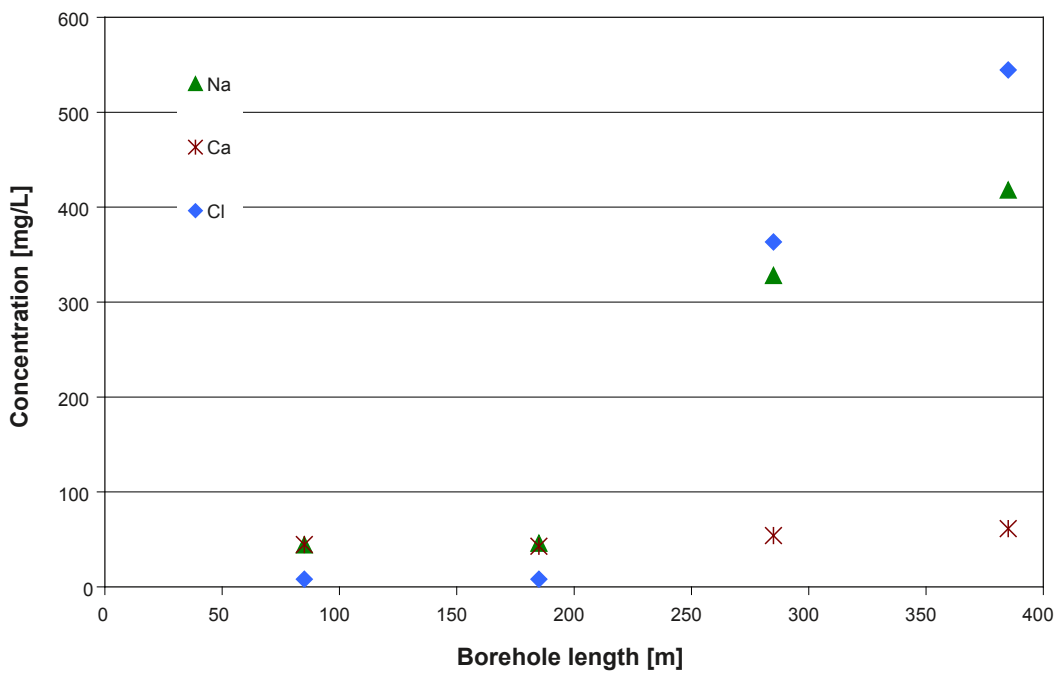
*Figure 5-2. Electric conductivity values obtained from the Hydrochemical logging in KLX16A.*



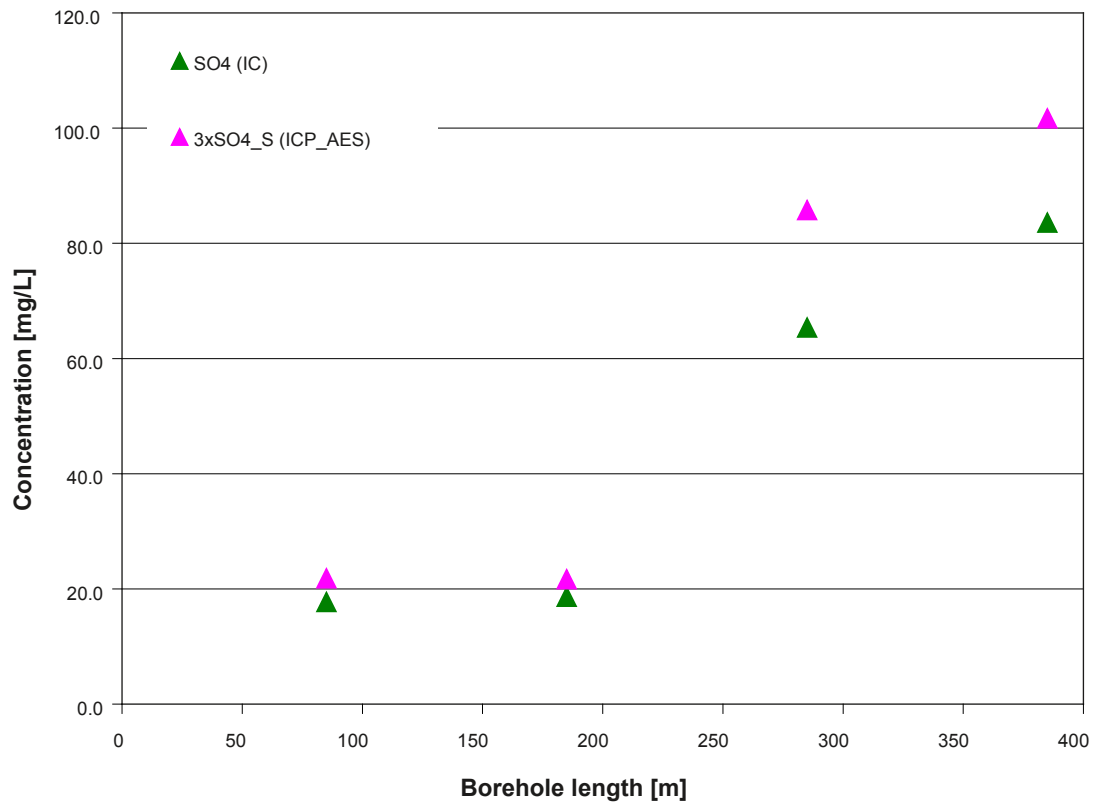
*Figure 5-3. Results from pH measurements obtained from the Hydrochemical logging in KLX16A.*



**Figure 5-4.** Results from analysis of hydrogen carbonate ( $HCO_3^-$ ) in water samples obtained from the Hydrochemical logging in KLX16A.



**Figure 5-5.** Results from analysis of the constituents  $Na^+$ ,  $Ca^{2+}$  and  $Cl^-$  in water samples obtained from the Hydrochemical logging in KLX16A.



*Figure 5-6. Sulphate (IC) compared to total sulphur (ICP-AES), results from the Hydrochemical logging in KLX16A.*



## 6 Summary and discussions

The Hydrochemical logging of KLX16A 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 about 3% in the two upper tube units analysed and in the two lower tube units it was 37% and 43%.
- The charge balance error, giving an indication of the quality and uncertainty of the analyses, exceeded the acceptable level ( $\pm 5\%$ ) in two of the samples. This indicates that the analyses of the major components are not consistent for these samples. However, these samples were the same ones that showed a high content of remaining drill water.
- The samples from the two tube units with drill water content of 3% and an acceptable charge balance error (representing 60–110 m and 160–210 m) can be considered as representative for the water chemistry in the water-bearing fractures of the borehole. The analytical results for these two tube units are very similar.
- In the two tube units that can be considered as representative of the water chemistry in the borehole (60–110 m and 160–210 m), the electric conductivity was 41.6 and 41.7 mS/m respectively and the chloride concentrations 8.1 mg/L and 8.0 mg/L. In the lowermost tube unit the corresponding values are 217 mS/m and 545 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 <sub>3</sub> <sup>-</sup> pH (lab) cond (lab)	Plastic	250	No	No	Titration Pot. meas, Cond. meas	The same day – maximum 24 hours
Anions 2	Cl <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , Br <sup>-</sup> , F <sup>-</sup>	Plastic	250	Yes (in connection with analysis)	No	Titration (Cl <sup>-</sup> ) IC (Cl <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , Br <sup>-</sup> , F <sup>-</sup> ) ISE (F <sup>-</sup> )	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 <sub>3</sub> )	ICP-AES ICP-MS	Not critical (month)
Environmental isotopes	δ <sup>2</sup> H, δ <sup>18</sup> O	Plastic	100	No	–	MS	Not critical (month)
Tritium	<sup>3</sup> H (enhanced.)	Plastic (dry bottle)	500	No	–	LSC	
Chlorine-37	δ <sup>37</sup> Cl	Plastic	500	No	–	ICP MS	Not critical (month)
Carbon isotopes	δ <sup>13</sup> C, pmC ( <sup>14</sup> C)	Plastic (fluorated)	100 × 2	No	–	(A)MS	A few days
Sulphur isotopes	δ <sup>34</sup> S	Plastic	500–1,000	No	–	Combustion, ICP MS	No limit
Strontium-isotopes	<sup>87</sup> Sr/ <sup>86</sup> Sr	Plastic	100	No	–	TIMS	Days or Week
Boron isotopes	<sup>10</sup> B/ <sup>11</sup> B **	Plastic	100	Yes	Yes (1 mL HNO <sub>3</sub> )	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 <sup>10</sup>B/<sup>11</sup>B (the result reported from the consulting laboratory). The notation according to international standard for environmental isotopes is <sup>11</sup>B/<sup>10</sup>B, i.e. 1/(<sup>10</sup>B/<sup>11</sup>B).

### 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 Spectrometry

**Table A1-2. Reporting limits and measurement uncertainties.**

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

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

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 deviation<sup>13</sup> from SMOW (Standard Mean Oceanic Water).
5. TU=Tritium Units, where one TU corresponds to a Tritium/hydrogen ratio of 10<sup>-18</sup> (1 Bq/L Tritium = 8.45 TU).
6. Per mille deviation<sup>13</sup> from SMOC (Standard Mean Oceanic Chloride).
7. Per mille deviation<sup>13</sup> from PDB (the standard PeeDee Belemnite).
8. The following relation is valid between pmC (percent modern carbon) and Carbon-14 age:  
pmC = 100 × e<sup>((1950–y–1.03t)/8274)</sup> where y = the year of the C-14 measurement and t = C-14 age.
9. Per mille deviation<sup>13</sup> 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:  
δyI = 1,000×(K<sub>sample</sub>–K<sub>standard</sub>)/K<sub>standard</sub>, where K = the isotope ratio and yI = <sup>2</sup>H, <sup>18</sup>O, <sup>37</sup>Cl, <sup>13</sup>C or <sup>34</sup>S etc.

## Appendix 2

### Water composition

Compilation April 2007

Idcode	Secup m	Seclow m	Sample no.	Charge Bal %	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	HCO <sub>3</sub> <sup>-</sup> mg/L	Cl <sup>-</sup> mg/L	SO <sub>4</sub> <sup>2-</sup> mg/L	SO <sub>4</sub> -S mg/L	Br <sup>-</sup> mg/L	F <sup>-</sup> mg/L	Si mg/L	Fe mg/L	Mn mg/L	Li mg/L	Sr mg/L	pH	Drill_ water %
KLX16A	10.00	60.00	11696	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX16A	60.00	110.00	11697	4.29	44.3	4.43	44.7	6.2	223	8.1	17.8	7.29	< 0.2	1.17	6.68	0.126	0.278	0.012	0.216	7.74	3.11
KLX16A	110.00	160.00	11698	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX16A	160.00	210.00	11699	3.32	46.0	4.43	42.8	6.2	227	8.1	18.6	7.23	< 0.2	1.24	6.64	0.546	0.270	0.012	0.216	7.86	3.41
KLX16A	210.00	260.00	11700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX16A	260.00	310.00	11701	9.45	328	7.85	54.0	11.4	173	363	65.4	28.6	1.35	2.18	5.42	0.0848	0.147	0.034	0.631	8.18	37.3
KLX16A	310.00	360.00	11702	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX16A	360.00	410.00	11703	5.47	418	8.72	61.4	12.4	154	545	83.6	33.9	2.28	2.63	5.53	0.268	0.107	0.043	0.853	8.44	43.5

Idcode	Secup m	Seclow m	Sample no.	EICond mS/m	δ <sup>2</sup> H dev SMOW	δ <sup>18</sup> O dev SMOW	<sup>3</sup> H TU	δ <sup>37</sup> Cl dev SMOC	<sup>10</sup> B/ <sup>11</sup> B no unit	<sup>87</sup> Sr/ <sup>86</sup> Sr no unit	δ <sup>34</sup> S dev CDT	δ <sup>13</sup> C dev PDB	<sup>14</sup> C pmC
KLX16A	10.00	60.00	11696	-	-	-	-	-	-	-	xxx	xxx	xxx
KLX16A	60.00	110.00	11697	41.6	xxx	xxx	xxx	xxx	xxx	xxx *	-	-	-
KLX16A	110.00	160.00	11698	-	-	-	-	-	-	-	xxx	xxx	xxx
KLX16A	160.00	210.00	11699	41.7	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX16A	210.00	260.00	11700	-	-	-	-	-	-	-	xxx	xxx	xxx
KLX16A	260.00	310.00	11701	168	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX16A	310.00	360.00	11702	-	-	-	-	-	-	-	xxx	xxx	xxx
KLX16A	360.00	410.00	11703	217	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-

- = Not analysed

x = No sample due to sampling problems

xxx = Stored in freezer/refrigerator

< = below detection limit

ChargeBal % = Relative charge balance error %