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## **Oskarshamn site investigation**

### **Hydrochemical logging in KLX11A**

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Geosigma AB

December 2006

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*Keywords:* Hydrochemical logging, Core drilled borehole, Groundwater, Water sampling, Chemical analyses, AP PS 400-06-021.

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, or so called tube sampling, has been performed in the core drilled borehole KLX11A. 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.

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 ( $^3\text{H}$ ,  $\delta^{13}\text{C}$  and  $^{14}\text{C}$  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 from the analyses will be reported in a separate report.

The drill water content remaining in the borehole after drilling was below 20% for all tube units. The maximum drill water content was 15.5% in tube unit 935–985 m. The relative charge balance error did not exceed the acceptable limit of  $\pm 5\%$ , for any of the ten samples analysed.

## Sammanfattning

Hydrokemisk loggning, även kallad slangprovtagning, har utförts i det kärnborrade borrhålet KLX11A. 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.

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 ( $^3\text{H}$ ,  $\delta^{13}\text{C}$  and  $^{14}\text{C}$  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 under tjugo procent för alla slangenheter. Den högsta uppmätta halten var på 15,5 % i slangenhet 935–985 m. Det relativa felet i jonbalansen översteg inte den acceptabla nivån av  $\pm 5\%$  i något av de tio analyserade proverna.

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# 1 Introduction

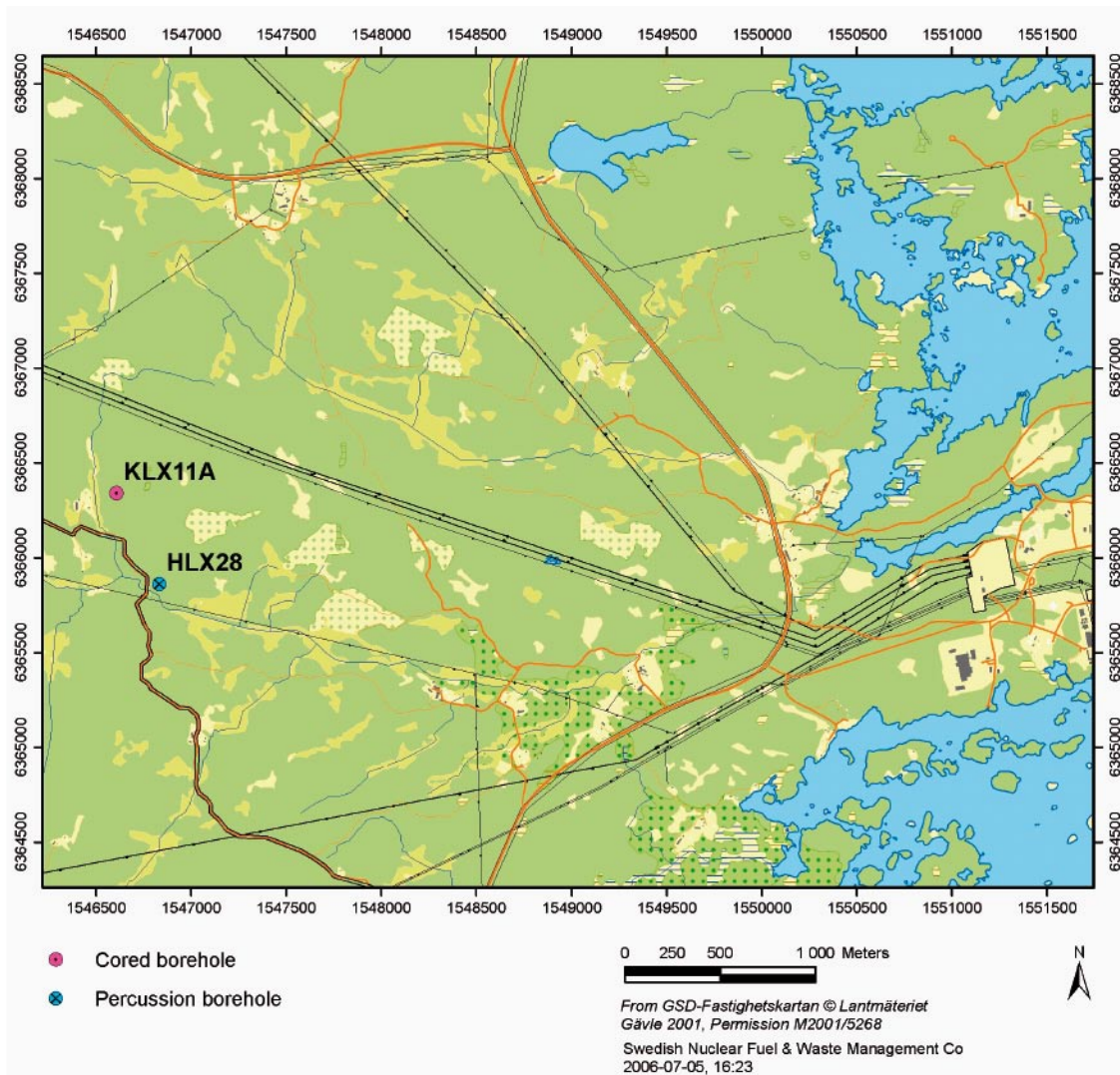
This document reports the performance and results from the Hydrochemical logging in borehole KLX11A. The Hydrochemical logging is one of the activities performed within the site investigation at Oskarshamn /1, 2/. The work was carried out in accordance with activity plan AP PS 400-06-021. In Table 1-1 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 KLX11A is a 992.29 m long telescopic borehole, drilled within the site investigation in the Oskarshamn area. The percussion borehole HLX28 served as the source of flushing water for the drilling of KLX11A. The locations of KLX11A and HLX28 are shown in Figure 1-1.

The borehole KLX11A 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 KLX11A	AP PS 400-06-021	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 KLX11A and the percussion borehole HLX28 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 KLX11A. 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.

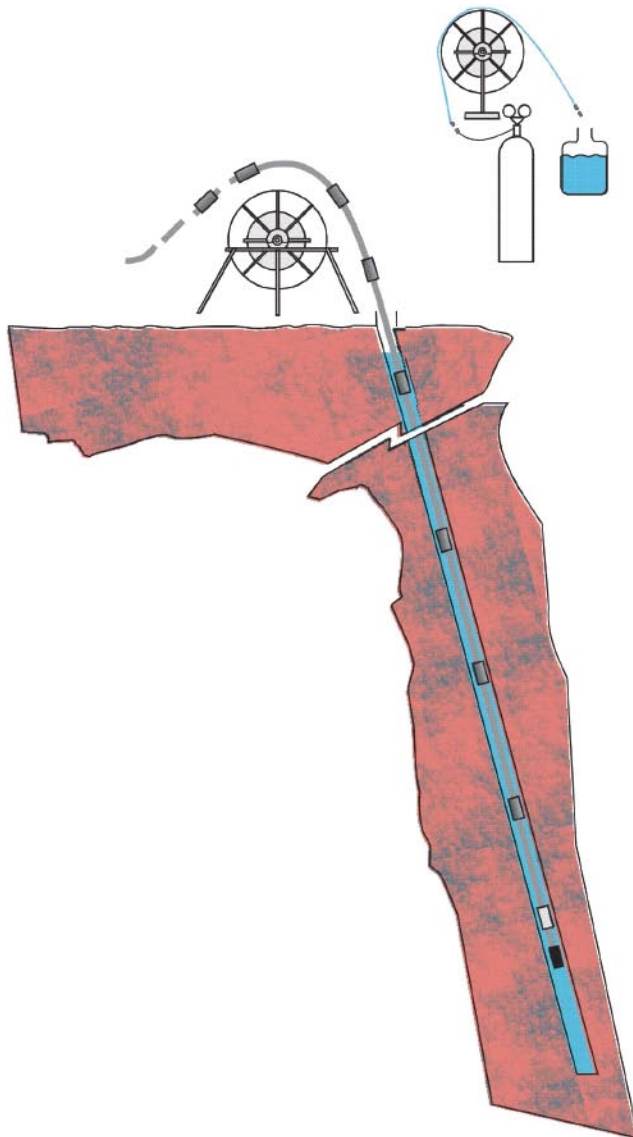


### 3 Sampling equipment

For the Hydrochemical logging an approximately 1,000 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 Performance

### 4.1 Hydrochemical logging

The Hydrochemical logging in KLX11A was performed on June 8, 2006 according to the activity plan AP PS 400-06-021 and in compliance with the method description SKB MD 422.001 (cf Table 1-1).

The equipment was lowered to a length of 985 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 07:44 and the lifting of the tubes started at 12:25. The last tube unit was retrieved at 14:36. 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 18.54 and 18.76 m, respectively, below top of casing. As the tube unit at the top of the tube array only was lowered to 35 metres 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  $^3\text{H}$ ,  $\delta^{13}\text{C}$  and  $^{14}\text{C}$  which are stored in a refrigerator). If these samples will be sent for analysis later, 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 11119–11138.

The uppermost tube unit was not completely filled, 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 the first tube unit, see above, no archive samples and no sample for  $\delta^{13}\text{C}$  and  $^{14}\text{C}$  were collected and the volume of sample for analysis of  $\delta^{34}\text{S}$  from the uppermost tube unit was reduced.

**Table 4-1. Overview of samples collected at the Hydrochemical logging in KLX11A. Filled cells represent collected samples. Blue filling represents samples sent for analyses, light yellow filling represents samples collected and stored in a freezer ( $^3\text{H}$ ,  $\delta^{13}\text{C}$  and  $^{14}\text{C}$  in a refrigerator) and 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	$^3\text{H}$	$\delta^2\text{H}$ $\delta^{18}\text{O}$	$\delta^{37}\text{Cl}$	$^{10}\text{B}/^{11}\text{B}$	$^{87}\text{Sr}/^{86}\text{Sr}$	$\delta^{34}\text{S}$	$\delta^{13}\text{C}$ and $^{14}\text{C}$	Filtered 2x250 mL
20	0 35	11119										ж	–	–
19	85	11120												
18	135	11121												
17	185	11122												
16	235	11123												
15	285	11124												
14	335	11125												
13	385	11126												
12	435	11127												
11	485	11128												
10	535	11129												
9	585	11130												
8	635	11131												
7	685	11132												
6	735	11133												
5	785	11134												
4	835	11135												
3	885	11136												
2	935	11137												
1	985	11138												

ж Only ca 400 ml.

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

### 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  $\pm 10\%$ ).

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

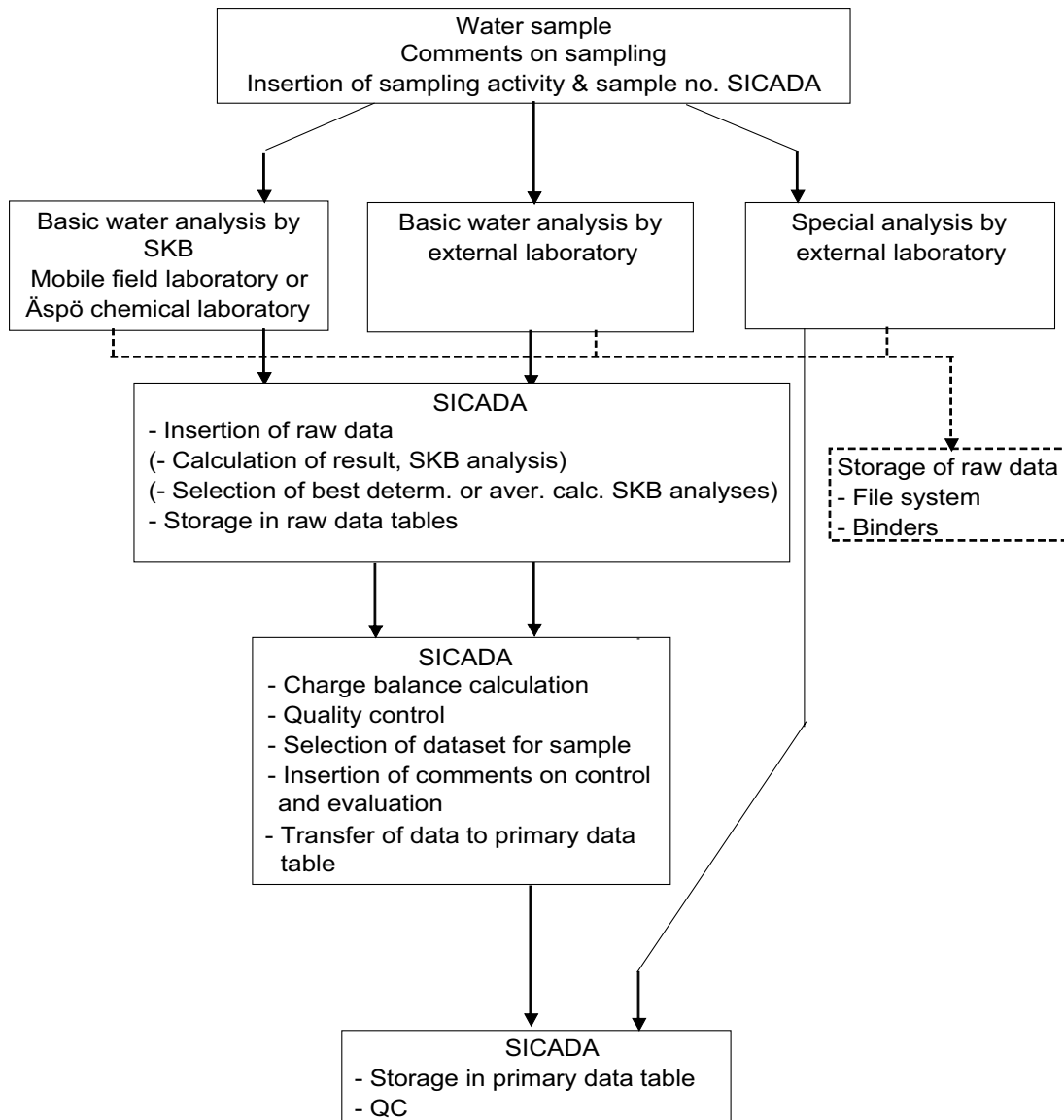
- General judgement of plausibility based on earlier results and experiences.

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. Due to problems with lack of water in sampling tube number 20 (0–35 m), the volume of the sample for analysis of  $\delta^{34}\text{S}$  was reduced and no archive sample or sample for  $\delta^{13}\text{C}$  and  $^{14}\text{C}$  determinations were collected in this section.



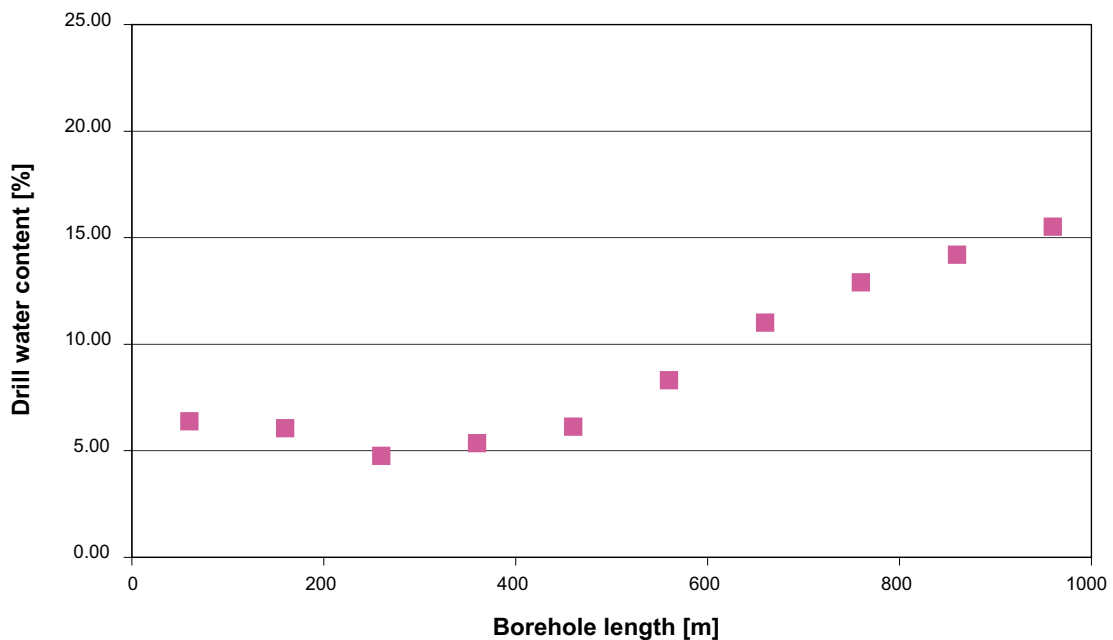
**Figure 4-1.** Overview of data management for hydrogeochemical data.

## 5 Results

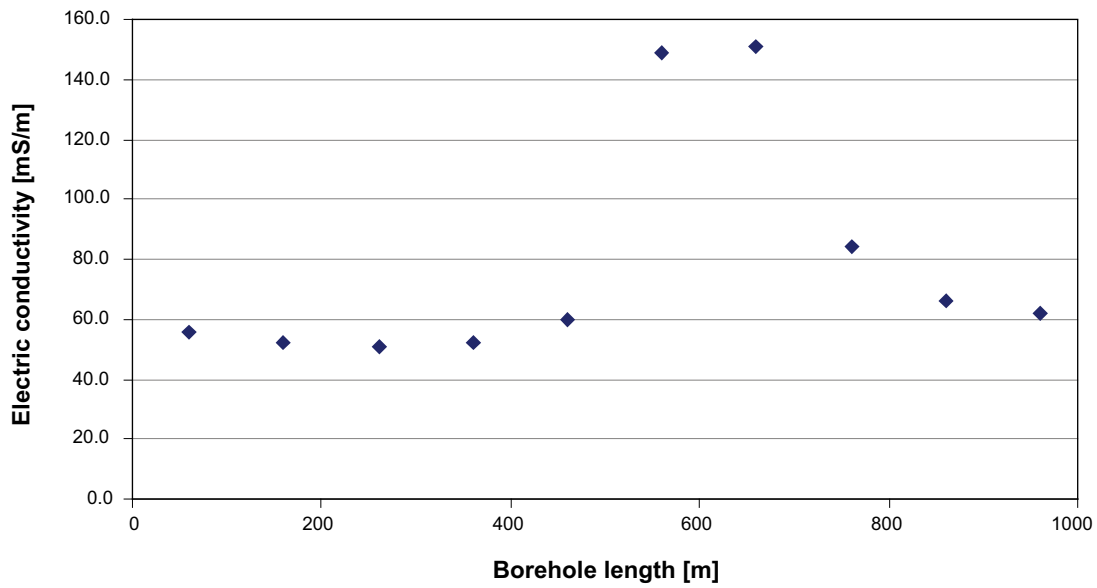
### 5.1 Analytical results

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).

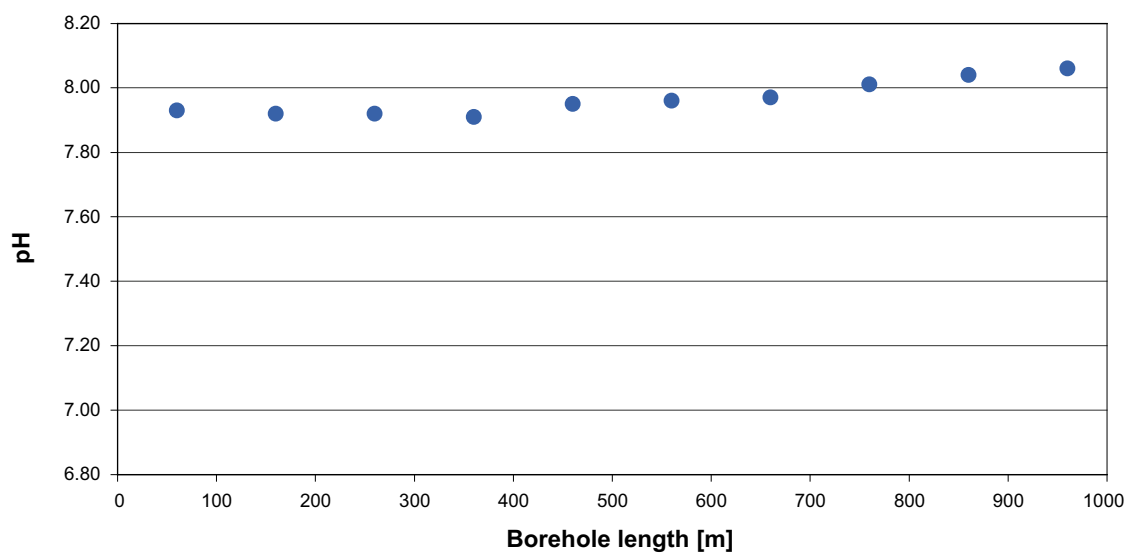
Diagrams showing the drill water content and the electric conductivity along the borehole, at the time of the Hydrochemical logging, are presented in Figures 5-1 and 5-2. Results from analyses of pH,  $\text{HCO}_3^-$  and some of the major constituents ( $\text{Na}^+$ ,  $\text{Ca}^+$  and  $\text{Cl}^-$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



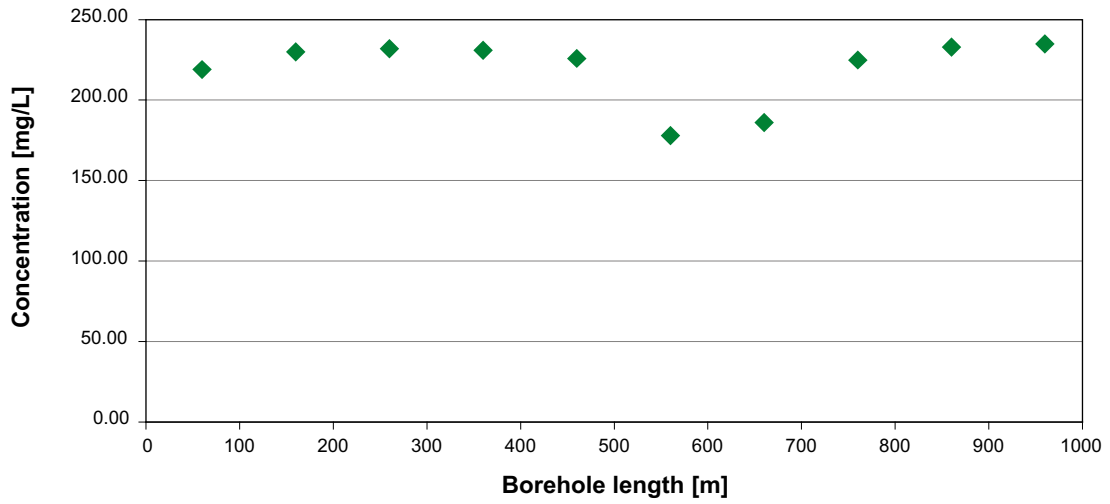
**Figure 5-1.** Drill water content remaining at different borehole lengths at the time of the Hydrochemical logging in KLX11A.



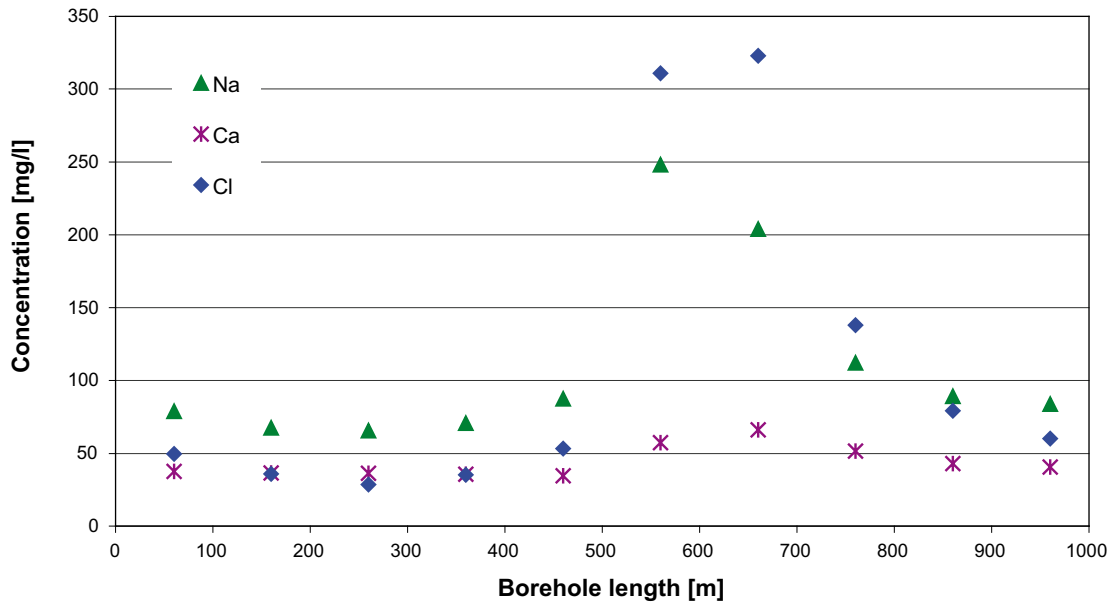
*Figure 5-2. Electric conductivity values along the borehole KLX11A obtained from the Hydrochemical logging in KLX11A.*



*Figure 5-3. Results from pH measurements obtained from the Hydrochemical logging in KLX11A.*

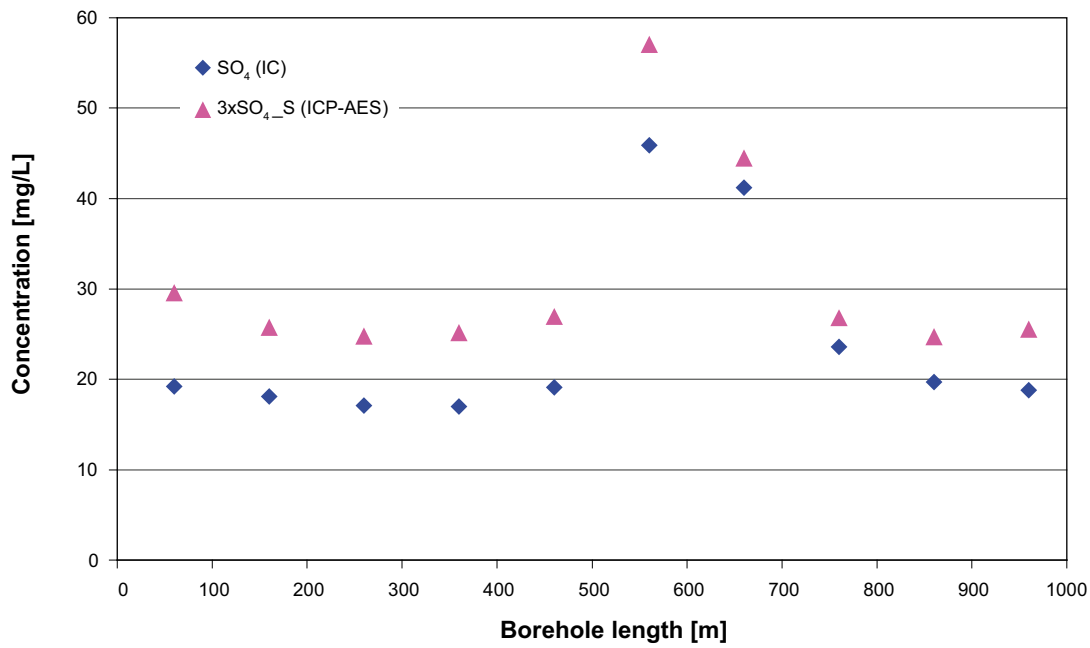


**Figure 5-4.** Results from analysis of hydrogen carbonate ( $HCO_3^-$ ) in water samples obtained from the Hydrochemical logging in KLX11A.



**Figure 5-5.** Results from analysis of the constituents  $Na^+$ ,  $Ca^{2+}$  and  $Cl^-$  in water samples obtained from the Hydrochemical logging in KLX11A.





**Figure 5-6.** Sulphate (IC) compared to total sulphur (ICP-AES), results from the Hydrochemical logging in KLX11A.

## 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. The errors did not exceed 5% for any of the ten analysed samples. This indicates that the analyses of the major components are consistent.

## 6 Conclusions

The Hydrochemical logging of KLX11A was conducted successfully. The main conclusions to be drawn from the Hydrochemical logging are:

- The amount of remaining drill water at the time of the Hydrochemical logging was below 20% for all tube units. Therefore the results can be considered as satisfactory representative for the water chemistry in the water-bearing fractures of the borehole. From 235 m and to the bottom the amount increased, reaching the highest content of 15.5% in the lowest section (935–985 m).
- The charge balance error, giving an indication of the quality and uncertainty of the analyses, was below the acceptable level ( $\pm 5\%$ ) for all samples. This indicates that the analyses of the major components are consistent. No results were considered unconfident, based on general trends.
- The conductivity and chloride concentration was much lower in KLX11A than in the adjacent borehole KLX20A. In KLX20A the highest values of conductivity and chloride concentration was recorded in tube unit 400–450 m borehole length (representing vertical depth c. 300–340 m) were 375 mS/m and 1,130 mg/L respectively. In KLX11A the conductivity in the water from tube unit 335–385 m representing almost the same vertical depth (c. 325–375 m) was c. 52.1 mS/m and the chloride concentration 35.4 mg/L. The drill water content in the two compared tube units were 5.35% in KLX11A and 4.3% in KLX20A. This indicates that the two boreholes intersect different water-bearing structures.
- The highest value of electric conductivity and chloride concentration in KLX11A was found in the tube unit from 635–685 m of borehole length. The values were 151 mS/m and 323 mg/L, respectively. Both values are lower than the highest corresponding values from KLX20A. The drill water content in the two compared tube units were 11.0% in KLX11A and 4.3% in KLX20A.

## 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	100	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 (14C)	Glass (dark)	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.

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 <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 eller 0.1	TU <sup>5</sup>	0.8 eller 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>	–	–

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>((1.950-y-1.031)/8.274)</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: δ<sup>y</sup>I = 1,000 × (K<sub>sample</sub> - K<sub>standard</sub>) / K<sub>standard</sub>, where K = the isotope ratio and <sup>y</sup>I = <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

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 %	EiCond mS/m	
KLX11A	0.00	35.00	11119	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	35.00	85.00	11120	1.06	78.9	4.14	37.7	5.3	219	496	19.2	9.84	0.23	2.65	7.29	0.087	0.162	0.012	0.219	7.93	6.37	55.8	
KLX11A	85.00	135.00	11121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	135.00	185.00	11122	-1.47	67.5	2.47	36.6	5.6	230	35.9	18.1	8.55	< 0.2	2.65	7.86	0.173	0.191	0.012	0.223	7.92	6.05	52.4	
KLX11A	185.00	235.00	11123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	235.00	285.00	11124	-0.38	65.6	2.69	36.5	5.7	232	28.7	17.1	8.23	< 0.2	2.64	8.16	0.224	0.209	0.012	0.234	7.92	4.76	50.5	
KLX11A	285.00	335.00	11125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	335.00	385.00	11126	-0.54	70.6	2.61	35.7	5.6	231	35.4	17.0	8.36	< 0.2	2.72	8.36	0.371	0.206	0.012	0.245	7.91	5.35	52.1	
KLX11A	385.00	435.00	11127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	435.00	485.00	11128	1.13	87.5	2.71	34.8	5.2	226	53.3	19.1	8.96	0.26	2.81	8.05	0.259	0.183	0.017	0.268	7.95	6.12	59.7	
KLX11A	485.00	535.00	11129	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	535.00	585.00	11130	3.92	248	2.87	57.5	4.8	178	311	45.9	19.0	1.70	3.40	7.42	0.218	0.174	0.027	0.662	7.96	8.30	149	
KLX11A	585.00	635.00	11131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	635.00	685.00	11132	-2.12	204	3.09	66.2	5.1	186	323	41.2	14.8	1.80	2.83	7.50	0.484	0.193	0.023	0.780	7.97	11.0	151	
KLX11A	685.00	735.00	11133	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	735.00	785.00	11134	-1.79	112	3.31	51.6	5.4	225	138	23.6	8.91	0.76	2.64	7.29	0.499	0.190	0.015	0.535	8.01	12.9	83.9	
KLX11A	785.00	835.00	11135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	835.00	885.00	11136	-1.05	89.1	3.57	43.1	5.3	233	79.2	19.7	8.21	0.47	2.64	7.02	0.648	0.187	0.013	0.380	8.04	14.2	66.4	
KLX11A	885.00	935.00	11137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLX11A	935.00	985.00	11138	0.07	83.7	3.69	40.7	5.5	235	60.2	18.8	8.49	0.31	2.62	7.70	1.250	0.194	0.014	0.339	8.06	15.5	61.6	

- = Not analysed.

x = No sample due to sampling problems.

xxx = Stored in freezer/refrigerator.

< = below detection limit.

ChargeBal % = Relative charge balance error %.

## Water composition

Idcode	Secup m	Seclow m	Sample no.	$\delta^2\text{H}$ dev SMOW	$\delta^{18}\text{O}$ dev SMOW	$^3\text{H}$ TU	$\delta^{37}\text{Cl}$ dev SMOC	$^{10}\text{B}/^{11}\text{B}$ no unit	$^{87}\text{Sr}/^{86}\text{Sr}$ no unit	$\delta^{34}\text{S}$ dev CDT	$\delta^{13}\text{C}$ dev PDB	$^{14}\text{C}$ pmC
KLX11A	0.00	35.00	11119	-	-	-	-	-	-	X	X	X
KLX11A	35.00	85.00	11120	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	85.00	135.00	11121	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	135.00	185.00	11122	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	185.00	235.00	11123	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	235.00	285.00	11124	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	285.00	335.00	11125	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	335.00	385.00	11126	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	385.00	435.00	11127	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	435.00	485.00	11128	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	485.00	535.00	11129	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	535.00	585.00	11130	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	585.00	635.00	11131	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	635.00	685.00	11132	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	685.00	735.00	11133	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	735.00	785.00	11134	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	785.00	835.00	11135	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	835.00	885.00	11136	xxx	xxx	xxx	xxx	xxx	xxx	-	-	-
KLX11A	885.00	935.00	11137	-	-	-	-	-	-	xxx	xxx	xxx
KLX11A	935.00	985.00	11138	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 %.