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## **Oskarshamn site investigation**

### **Hydrochemical logging in KLX04**

#### **Results from isotope determinations (<sup>3</sup>H, δD and δ<sup>18</sup>O)**

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June 2005

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*Keywords:* Core drilled borehole, Groundwater, Water sampling, Chemical analyses.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author 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 coredrilled borehole KLX04. 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 metres long polyamide tube divided into units of 50 metres.

The water content in each tube unit constituted one sample. Every other sample, starting with the uppermost unit, was analysed according to SKB chemistry class 3 (excluding isotope options). The performance and results from this sampling has been reported in a previous report /1/. This gives the results from the performed isotope determinations of tritium ( $^3\text{H}$ ), deuterium ( $\delta\text{D}$ ) and  $\delta^{18}\text{O}$ . Samples for isotope determinations were collected at the sampling occasion and stored in a freezer (tritium in a refrigerator) for approximately three months before they were sent to the consulted laboratories for analyses.

## Sammanfattning

Hydrokemisk loggning, även kallad slangprovtagning, har utförts i kärnborrhålet KLX04. Hydrokemisk loggning är en snabb och enkel provtagningsteknik för att erhålla information om vattenpelarens kemiska sammansättning längs ett öppet borrhål. Utrustningen utgörs av en cirka 1 000 meter lång polyamid slang uppdelad i enheter om vardera 50 meter.

Innehållet i en slangenhet utgör ett prov. Varannan enhet, med start från den översta, analyserades i enlighet med SKB kemiklass 3 utan tillägg i direkt anslutning till provtagningstillfället. Utförande och resultat från denna provtagning har rapporterats i en tidigare primärdatarapport /1/. Denna rapport redovisar resultaten från utförda isotopanalyser av tritium ( $^3\text{H}$ ), deuterium ( $\delta\text{D}$ ) och  $\delta^{18}\text{O}$ . Isotopprover togs ut i samband med provtagningen och sparades i frys respektive kyl (tritium) i cirka tre månader innan de sändes iväg för analys till de konsulterade laboratorierna.

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# 1 Introduction

This document reports isotope results from the Hydrochemical logging in KLX04, which is one of the activities performed within the site investigation at Oskarshamn /2/. The work was carried out in accordance with activity plan SKB AP PS 400-04-058. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

This report is a complement to the previous report regarding the Hydrochemical logging in KLX04 /1/, which documented the performance and results from analyses of major constituents, anions, flushing water content, electric conductivity, pH and hydrogen carbonate. The data from the activity is reported to the database SICADA.

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

<b>Activity plan</b>	<b>Number</b>	<b>Version</b>
Hydrokemisk loggning i KLX04	AP PS 400-04-058	1.0
<b>Method descriptions</b>	<b>Number</b>	<b>Version</b>
Metodbeskrivning för hydrokemisk loggning	SKB MD 422.001	1.0

## 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 KLX04. The technique used for sampling is fast and simple even at great depth.

The analysis program has previous been carried out according to SKB chemistry class 3 (excluding options) and reported in a previous report /1/. The isotopes reported in this report were sent to be analysed approximately three months after the sampling occasion i.e. in the beginning of October. Until they were sent for analyses, the samples were stored in a freezer (tritium in a refrigerator). The conducted isotope determinations include tritium, deuterium and  $\delta^{18}\text{O}$ .

## **3 Performance**

### **3.1 Hydrochemical logging**

The hydrochemical logging in KLX04 was performed July 8, 2004, according to the controlling documents for the activity (see Table 1-1).

The performance of the activity is described in a previous report regarding the hydrochemical logging in KLX04 /1/.

### **3.2 Sample treatment and chemical analysis**

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

An overview showing the samples obtained at the logging occasion is given in Table 3-1. The sample portions for isotope analyses were stored in a freezer at SKB (tritium in a refrigerator) at the time of the hydrochemical logging. Samples collected for determination of tritium,  $\delta^{18}\text{O}$  and deuterium were analysed at the consulted laboratories approximately three months after the sampling occasion. Remaining isotope samples collected at the logging occasion are still stored in a freezer at SKB. The data from the hydrochemical logging are stored in the database SICADA. The SKB sample numbers are 7574 to 7593.

The upper most tube unit was not completely filled, see Section 3.1. Water intended for archive samples in the second unit were used to fill sample bottles for  $\delta\text{D}$  and  $\delta^{18}\text{O}$ ,  $^{87}\text{Sr}/^{86}\text{Sr}$ , and  $\delta^{34}\text{S}$  from the first section (0–35 m).



**Table 3-1. Overview of samples collected at the hydrochemical logging in KLX04. Filled cells represent collected samples. Yellow filling represents isotope samples that has been analysed, blue filling represent samples reported in a previous report /1/, dashed yellow filling represents samples stored in freezer and purple dashed cells represents archive samples.**

Sample information			Collected sample portions											Archive
Tube unit	Length (m)	SKB no	Cond, pH, alk	Major Comp	Uranine	Anions	<sup>3</sup> H	δD/ δ <sup>18</sup> O	δ <sup>37</sup> Cl	<sup>10</sup> B	<sup>87</sup> Sr	δ <sup>34</sup> S	Carbon isotopes	Filtered 2×250 mL
1	0	7574				ω	Ж	Ж			Ж			
	35													
2		7575												
	85													
3		7576												
	135													
4		7577												
	185													
5		7578												
	235													
6		7579												
	285													
7		7580												
	335													
8		7581												
	385													
9		7582												
	435													
10		7583												
	485													
11		7584												
	535													
12		7585												
	585													
13		7586												
	635													
14		7587												
	685													
15		7588												
	735													
16		7589												
	785													
17		7590												
	835													
18		7591												
	885													
19		7592												
	935													
20		7593												
	985													

Ж filled with sample water from tube unit two.

ω partly filled with sample water from tube unit two.

### 3.3 Data handling

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

Several constituents are determined by more than one method and/or laboratory. Moreover, control analyses by an independent laboratory are performed as a standard procedure on each fifth or tenth collected sample.

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 on basic water analyses are inserted into 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. 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  $\pm 10\%$ ).

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

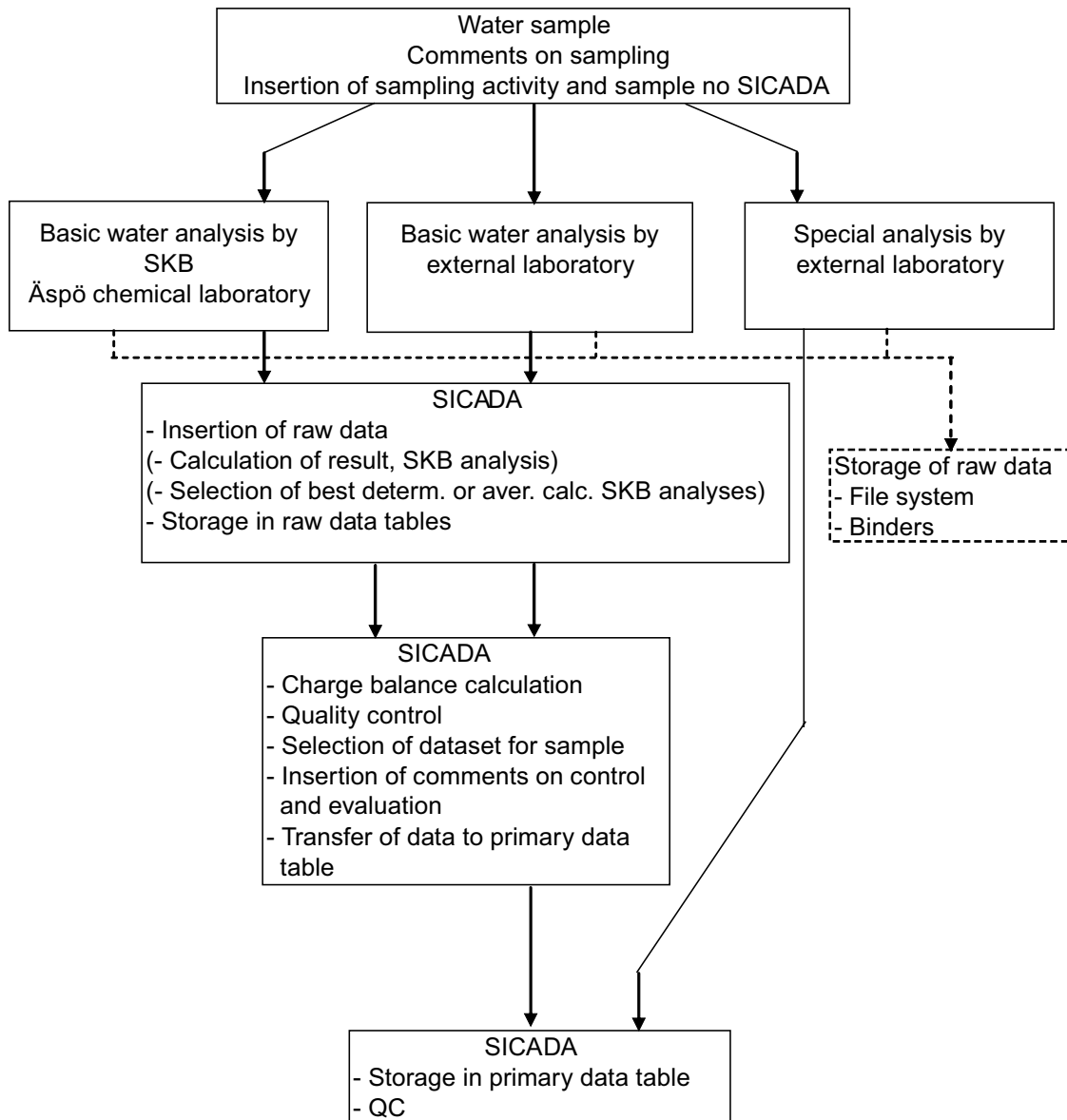
- General expert judgement of plausibility based on earlier results and experiences.

All results from special analyses of trace metals and isotopes are inserted directly into primary data tables. In those 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 3-1.

### 3.4 Nonconformities

The activity was performed without any deviations from the controlling documents.

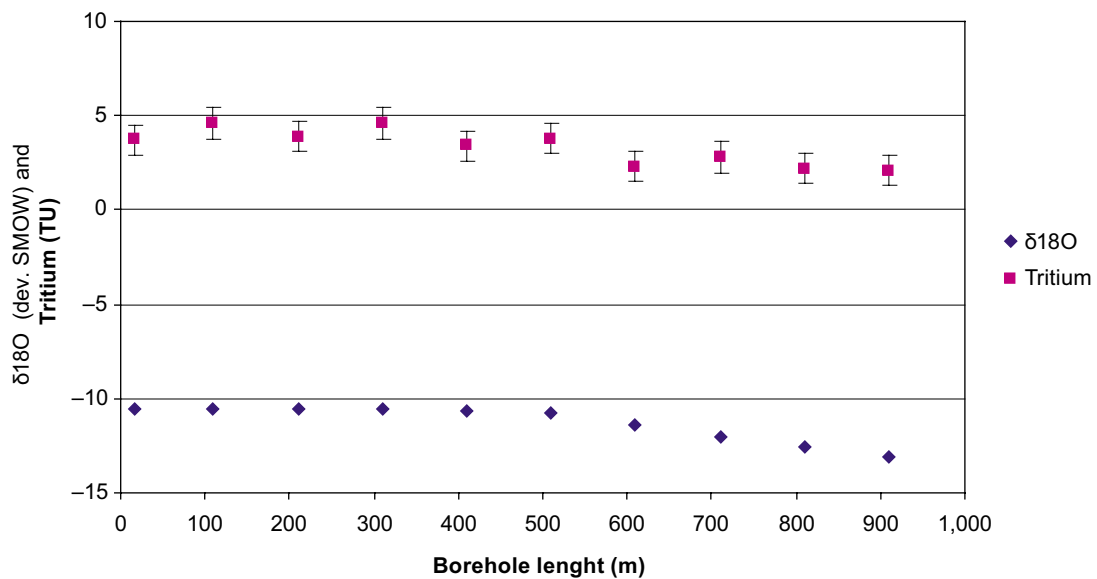


**Figure 3-1.** Overview of data management for hydrogeochemical data. This report only handles the “Special analyses by external laboratory”. (The basic water analyses are reported in the previous report /1/).

## 4 Results

### 4.1 Analysis results

The results from the conducted isotope determinations are given in Appendix 2. Diagrams showing the tritium and  $\delta^{18}\text{O}$  values along the borehole received from the hydrochemical logging are presented in Figure 4-1. Results are plotted for the mid-length of each tube unit. Results from deuterium determinations are shown in Table 4-1.



**Figure 4-1.** Tritium and  $\delta^{18}\text{O}$  data from samples collected in the core drilled borehole KLX04 at the hydrochemical logging.

**Table 4-1. Deuterium determinations for samples collected at the hydrochemical logging in KLX04.**

Sample SKB no	$\delta\text{D}$ (dev SMOW)
7574	-79.4
7576	-78.2
7578	-78.6
7580	-78.7
7582	-77.9
7584	-78.7
7586	-84.2
7588	-88.4
7590	-93.6
7592	-99.3

## 5 References

- /1/ **Berg C, 2004.** Oskarshamn site investigation. Hydrochemical logging in KLX04A. SKB P-04-219, Svensk Kärnbränslehantering AB.
- /2/ **SKB, 2001.** Generellt genomförande program för platsundersökningar. SKB R-01-10, Svensk Kärnbränslehantering AB.

## Sampling and analysis methods

Table A1-1. Overview of general sample handling routines and analysis methods.

Component group	Component/element	Sample container (material)	Volume (mL)	Filtering	Preparation/conservation*	Analysis method	Laboratory***	Analysis within – or delivery time to lab
Anions 1	HCO <sub>3</sub> pH(lab) cond (lab)	Plastic	250	No	No	Titration Pot meas, Cond meas	Åspö's chemistry lab	The same day – maximum 24 hours
Anions 2	Cl, SO <sub>4</sub> , Br <sup>-</sup> , F <sup>-</sup> , I <sup>-</sup>	Plastic	250	Yes (not in the field)	No	Titration (Cl <sup>-</sup> ) IC (Cl <sup>-</sup> , SO <sub>4</sub> , Br <sup>-</sup> , F <sup>-</sup> ) ISE (F <sup>-</sup> )	Åspö's chemistry lab	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	Analytica AB	Not critical (month)
Environmental isotopes	<sup>2</sup> H, <sup>18</sup> O	Plastic	100	No	–	MS	IFE	Not critical (month)
Tritium,	<sup>3</sup> H (enhanced)	Plastic (dry bottle)	500	No	–	LSC	Univ Of Waterfoo	Not critical (month)
Chlorine-37	Chlorine-37	Plastic	500	No	–	ICP MS	Univ Of Waterfoo	Not critical (month)
Carbon isotopes	<sup>13</sup> C, <sup>14</sup> C	Glass (brown)	100×2	No	–	(A)MS	Univ Of Waterfoo The Ångström laboratory, Uppsala	A few days
Sulphur isotopes	<sup>34</sup> S	Plastic	500–1,000	No	–	Combustion, ICP MS	IFE	No limit
Strontium-isotopes	<sup>87</sup> Sr/ <sup>86</sup> Sr	Plastic	100	No	–	TIMS	IFE	Days or Week
Boron isotopes	<sup>10</sup> B	Plastic	100	Yes	Yes (1 mL HNO <sub>3</sub> )	ICP – MS	Analytica AB	No limit
Archive samples without acid	–	Plastic	250×2**	Yes	No	–	–	Storage in freeze

\* Suprapur acid is used for conservation of samples.

\*\* Minimum number, the number of archive samples can vary depending on how many similar samples that are collected at the same occasion.

\*\*\* Full name and address is given in Table A1-2.

**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
INAA	Instrumental Neutron Activation Analysis
MS	Mass Spectrometry
LSC	Liquid Scintillation Counting
(A)MS	(Accelerator) Mass Spectrometry
GC	Gas Chromatography

**Table A1-2. Consulted laboratories, full name and address.**

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Äspö waterchemical laboratory (SKB)
Analytica AB
Aurorum 10
977 75 Luleå
(Nytorsvägen 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
The Ångström laboratory
Box 534
SE-751 21 Uppsala

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## Isotopes, compilation of H-, and O-isotopes

Compilation May 2005

Idcode	Secup	Seclow	Sample	$\delta D$	$^3H$	$d^{18}O$	$\delta^{37}Cl$	$^{10}B/^{11}B$	$^{87}Sr/^{86}Sr$	$\delta^{34}S$	$\delta^{13}C$	$^{14}C$
	m	m	no	dev SMOW	TU	dev SMOW	dev SMOC	no unit	no unit	dev CDT	dev PDB	pmC
KLX04	0	35	7574	-79.4	3.7	-10.5	xxx	xxx	xxx	-	-	-
KLX04	35	85	7575	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	85	135	7576	-78.2	4.6	-10.6	xxx	xxx	xxx	-	-	-
KLX04	135	185	7577	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	185	235	7578	-78.6	3.9	-10.6	xxx	xxx	xxx	-	-	-
KLX04	235	285	7579	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	285	335	7580	-78.7	4.6	-10.6	xxx	xxx	xxx	-	-	-
KLX04	335	385	7581	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	385	435	7582	-77.9	3.4	-10.7	xxx	xxx	xxx	-	-	-
KLX04	435	485	7583	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	485	535	7584	-78.7	3.8	-10.8	xxx	xxx	xxx	-	-	-
KLX04	535	585	7585	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	585	635	7586	-84.2	2.3	-11.4	xxx	xxx	xxx	-	-	-
KLX04	635	685	7587	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	685	735	7588	-88.4	2.8	-12.0	xxx	xxx	xxx	-	-	-
KLX04	735	785	7589	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	785	835	7590	-93.6	2.2	-12.6	xxx	xxx	xxx	-	-	-
KLX04	835	885	7591	-	-	-	-	-	-	xxx	xxx	xxx
KLX04	885	935	7592	-99.3	2.1	-13.1	xxx	xxx	xxx	-	-	-
KLX04	935	985	7593	-	-	-	-	-	-	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 = Stored in a freezer

&lt; "value" = result below detection limit