

**P-06-16**

## **Oskarshamn site investigation**

### **Hydrochemical logging in KLX07A**

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

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February 2006

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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 core drilled borehole KLX07A. The method is a fast and simple sampling technique to obtain information of the chemical composition of the water along an open borehole. The equipment consists of an approximately 850 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/. The following report 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 four months before they were sent to the consulted laboratories for analyses.

# Sammanfattning

Hydrokemisk loggning, även kallad slangprovtagning, har utförts i kärnborrhålet KLX07A. 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 850 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 fyra månader innan de sändes iväg för analys till de konsulterade laboratorierna.

# Contents

<b>1</b>	<b>Introduction</b>	7
<b>2</b>	<b>Objective and scope</b>	9
<b>3</b>	<b>Performance</b>	11
3.1	Hydrochemical logging	11
3.2	Sample treatment and chemical analysis	11
3.3	Data handling	11
3.4	Nonconformities	13
<b>4</b>	<b>Results</b>	15
4.1	Analysis results	15
<b>5</b>	<b>References</b>	17
	<b>Appendix 1</b> Sampling and analysis methods	19
	<b>Appendix 2</b> Isotopes, compilation of H- and O-isotopes	21

# 1 Introduction

This document reports isotope results from the Hydrochemical logging in borehole KLX07A, 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 400-05-037. In Table 1-1 controlling documents for performance of 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 KLX07A /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 KLX07A	AP PS 400-05-037	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 KLX07A. 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 without isotope options and reported in a previous report /1/. The isotopes reported in this report were sent to be analysed approximately four months after the sampling occasion i.e. in the beginning of October 2005. Until they were sent for analyses they were stored in a freezer (tritium in a refrigerator). The conducted isotope determinations include tritium,  $\delta^{18}\text{O}$  and deuterium.

## 3 Performance

### 3.1 Hydrochemical logging

The hydrochemical logging in KLX07A was performed June 8, 2005, 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 KLX07A /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 four months after the sampling performance. Remaining isotope samples collected are still stored in a freezer. The data from the hydrochemical logging are stored in the database SICADA. The SKB sample numbers are 10330–10346.

Due to the lack of water in the first tube unit, archive samples from the second tube unit were not obtained. Water intended for archive samples in the second unit were used to fill the sample bottle for analyses of anions from the first section (0–40 m).

### 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.

All analytical results are stored in the SICADA database. The applied hierarchy path “Hydrochemistry/Hydrochemical investigation/Analyses/Water in the database” contains two types of tables, raw data tables and primary data tables (final data tables).

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

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

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

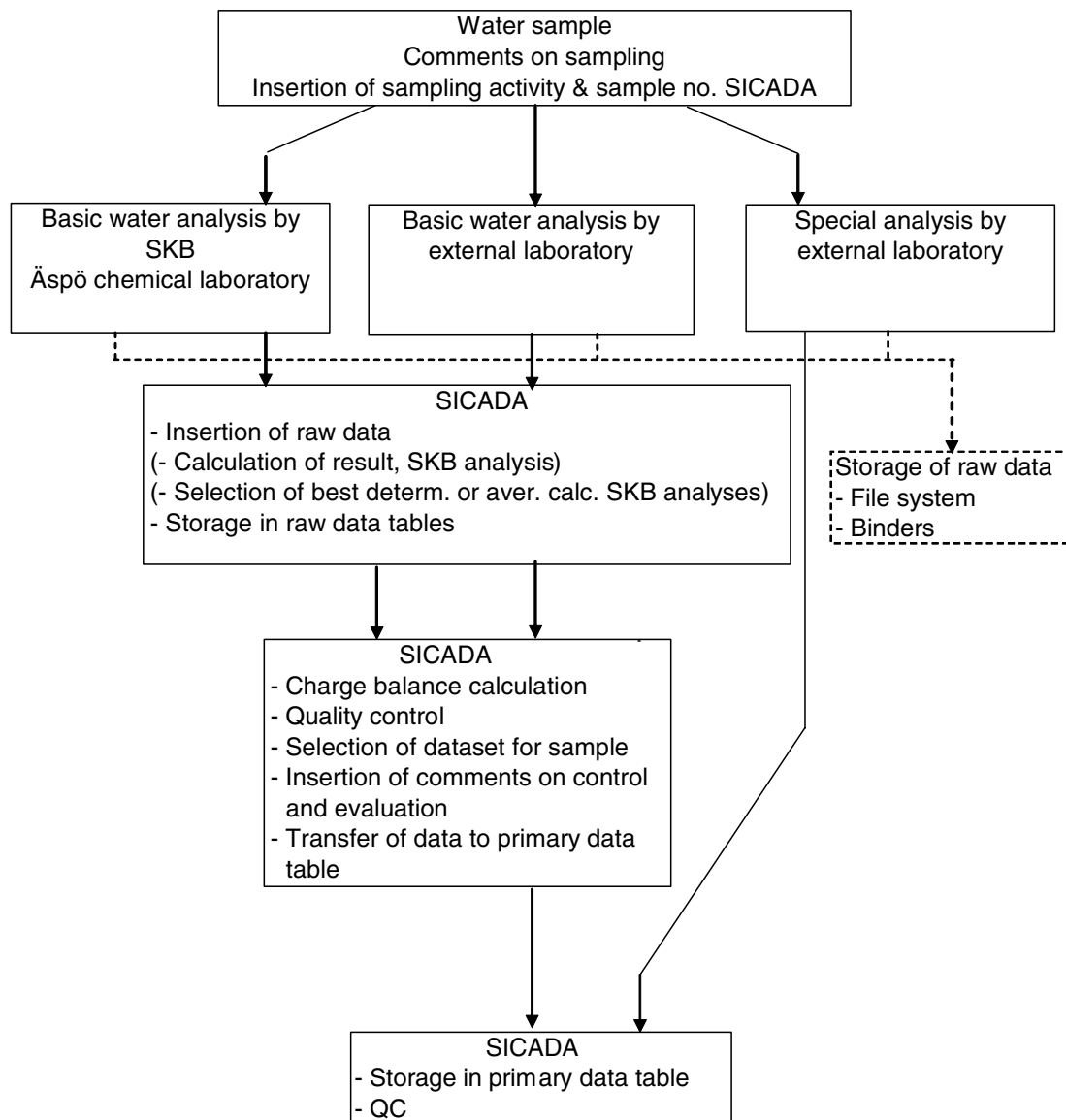
All results from special analyses of **trace metals** and **isotopes** are inserted directly into primary data tables. In those cases where the analyses are repeated or performed by more than one laboratory, a “best choice” notation will indicate those results which are considered most reliable.

An overview of the data management is given in Figure 3-1.

**Table 3-1. Overview of samples collected at the Hydrochemical logging in KLX07A. Filled cells represent collected samples. Yellow filling represent isotope samples that have been analysed, blue filling represents samples reported in a previous report /1/, dashed yellow filling represents samples stored in a freezer (C-isotopes in a refrigerator) and purple dashed celles 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	$\delta D / \delta^{18}O$	$\delta^{37}Cl$	<sup>10</sup> B	<sup>87</sup> Sr	$\delta^{34}S$	C-iso-topes	Filtered 2×250 mL
1	0-30	10330				✱								
2	80	10331												
3	130	10332												
4	180	10333												
5	230	10334												
6	280	10335												
7	330	10336												
8	380	10337												
9	430	10338												
10	480	10339												
11	530	10340												
12	580	10341												
13	630	10342												
14	680	10343												
15	730	10344												
16	780	10345												
17	830	10346												

✱ filled with sample water from tube unit two.



**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 a previous report /1/).

### 3.4 Nonconformities

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

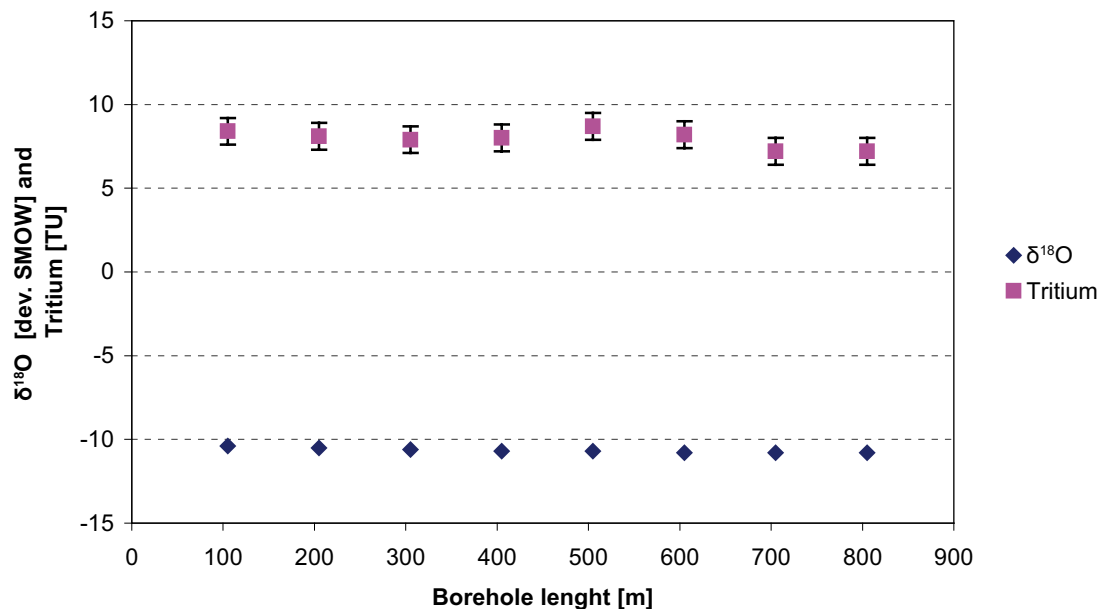
## 4 Results

### 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 from deuterium determinations are shown in Table 4-1. Results are plotted for the mid-length of each tube unit, for example the first sample from section 80–130 m is plotted at 105 metres.

**Table 4-1. Deuterium determinations for samples collected at the hydrochemical logging in KLX07A.**

Sample SKB:no	$\delta\text{D}$ [dev. SMOW]
10332	-76.1
10334	-76.6
10336	-76.8
10338	-76.9
10340	-77.5
10342	-79.5
10344	-78.4
10346	-79.1



**Figure 4-1.** Tritium and  $\delta^{18}\text{O}$  data from samples collected in the core drilled borehole KLX07A at the hydrochemical logging.

## 5 References

- /1/ **Berg C, 2005.** Oskarshamn site investigation. Hydrochemical logging in KLX07A. SKB P-05-226, 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 <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> )	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	Yes (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 Waterloo	Not critical (month)
Chlorine-37	Chlorine-37	Plastic	500	No	–	ICP MS	Univ. Of Waterloo	Not critical (month)
Carbon isotopes	<sup>13</sup> C, <sup>14</sup> C	Glass (brown), or plastic	100×4	No	–	(A)MS	Univ. Of Waterloo The Ångström laboratory, Uppsala	A few days
Sulphur isotopes	<sup>34</sup> S	Plastic	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 chromatography
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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<b>Äspö waterchemical laboratory (SKB)</b>
Analytica AB Aurorum 10 977 75 Luleå (Nytorpsvägen 16 Box 511 183 25 Täby)
Environmental Isotope Laboratory Dep. Of earth sciences University of Waterloo Waterloo, Ontario N2L 3G1 CANADA
Institutt for energiteknik (IFE) Instituttveien 18 P.O Box 40 2027 Kjeller NORGE
The Ångström laboratory Box 534 Se-751 21 Uppsala

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## Appendix 2

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

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
KLX07A	0	30	10330	-	-	-	-	-	-	-	-	-
KLX07A	30	80	10331	-	-	-	-	-	-	XXX	XXX	XXX
KLX07A	80	130	10332	-76.1	-10.4	8.4	XXX	XXX	XXX	-	-	-
KLX07A	130	180	10333	-	-	-	-	-	-	XXX	XXX	XXX
KLX07A	180	230	10334	-76.6	-10.5	8.1	XXX	XXX	XXX	-	-	-
KLX07A	230	280	10335	-	-	-	-	-	-	XXX	XXX	XXX
KLX07A	280	330	10336	-76.8	-10.6	7.9	XXX	XXX	XXX	-	-	-
KLX07A	330	380	10337	-	-	-	-	-	-	XXX	XXX	XXX
KLX07A	380	430	10338	-76.9	-10.7	8.0	XXX	XXX	XXX	-	-	-
KLX07A	430	480	10339	-	-	-	-	-	-	XXX	XXX	XXX
KLX07A	480	530	10340	-77.5	-10.7	8.7	XXX	XXX	XXX	-	-	-
KLX07A	530	580	10341	-	-	-	-	-	-	XXX	XXX	XXX
KLX07A	580	630	10342	-79.5	-10.8	8.2	XXX	XXX	XXX	-	-	-
KLX07A	630	680	10343	-	-	-	-	-	-	XXX	XXX	XXX
KLX07A	680	730	10344	-78.4	-10.8	7.2	XXX	XXX	XXX	-	-	-
KLX07A	730	780	10345	-	-	-	-	-	-	XXX	XXX	XXX
KLX07A	780	830	10346	-79.1	-10.8	7.2	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 freezer/refrigerator