P-04-304

Oskarshamn site investigation

Hydrochemical logging in KAV04A

Results from isotope determinations (^3H, δ^2H and $\delta^{18}O$)

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November 2004

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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 KAV04A. 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 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 (options excluded). The performance of the sampling and results from the analysis mentioned above has been reported in a previous report /1/. Samples for isotope determionations were collected and stored in a freezer at the sampling occasion (tritium in a refrigerator). The following report gives the results from the performed isotope determinations (tritium, deuterium and $\delta^{18}O$). Odd numbered tube units were analysed for $\delta^{18}O$ and deuterium while even numbered tube units were analysed for tritium. The samples for the isotope determinations were sent to the consulted laboratories approximately one month after the sampling occasion.

Sammanfattning

Hydrokemisk loggning, även kallad slangprovtagning, har utförts i kärnborrhålet KAV04A. *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. Var annan 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 har rapporterats i en tidigare primärdatarapport /1/. Denna rapport redovisar resultaten från utförda isotopanalyser (tritium, deuterium and $\delta^{18}O$). Isotopprover togs ut i samband med provtagningen och sparades i frys respektive kyl (tritium) innan de sändes iväg för analys. Udda slangenheter, räknat från den översta enheten, analyserades med avseende på $\delta^{18}O$ och deuterium medan jämna enheter analyserades på tritium. Proverna för isotopbestämningar sändes iväg till de konsulterade laboratorierna cirka en månad efter provtagningstillfället.

Contents

1 Introduction

This document reports isotope results from the *hydrochemical logging* in borehole KAV04A, 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 PS 400-04-032. 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 KAV04A /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 SICADA in field note no Simpevarp 356.

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

Activity plan	**Number**	**Version**
Hydrokemisk loggning i KAV04	AP PS 400-04-032	1.0
Method descriptions	**Number**	**Version**
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 KAV04A. 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 one month after the sampling occasion i.e. in the beginning of July. Until they were sent for analyses they were store in freezer (tritium in refrigerator). The conducted isotope determinations include tritium, $\delta^{18}O$ and deuterium.

3 Performance

3.1 Hydrochemical logging

The hydrochemical logging in KAV04A was performed June 8, 2004, according to the controlling documents for the activity, see Table 1-1.

Performance of the logging is described in P-04-220 /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, $\delta^{18}O$ and deuterium were analysed at the consulted laboratories approximately one month 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 in field note no Simpevarp 356. The SKB sample numbers are 7442 to 7461.

Table 3-1. Overview of samples collected at the *hydrochemical logging* in KAV04A. Filled cells represent collected samples. Light yellow filling represents isotope samples sent for analysis, blue filling represents samples reported in a previous report /1/, dashed yellow filling represents samples stored in a 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	$\delta^{34}S$	$\delta^{2}H$ /$\delta^{18}O$	^{10}B	^{87}Sr	^{3}H	$\delta^{37}Cl$	Carbon isotopes	Filtered 2×250 mL
1	0	7442					ω	ж	ж	ж				
	45													
2		7443												
	95													
3		7444												
	145													
4		7445												
	195													
5		7446												
	245													
6		7447												
	295													
7		7448												
	345													
8		7449												
	395													
9		7450												
	445													
10		7451												
	495													
11		7452												
	545													
12		7453												
	595													
13		7454												
	645													
14		7455												
	695													
15		7456												
	745													
16		7457												
	795													
17		7458												
	845													
18		7459												
	895													
19		7460												
	945													
20		7461												
	995													

ж filled with sample water from tube unit two.

ω partly filled with sample water from tube unit two.

The upper most tube unit was not completely filled. Water intended for archive samples in the second unit were used to fill sample bottles for $\delta^{2}H/\delta^{18}O$, $^{87}Sr/^{86}Sr$, $^{10}B/^{11}B$ and $\delta^{34}S$ from the first section (0–45 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 ± 5% are considered acceptable (in surface waters ± 10%).

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

- 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.

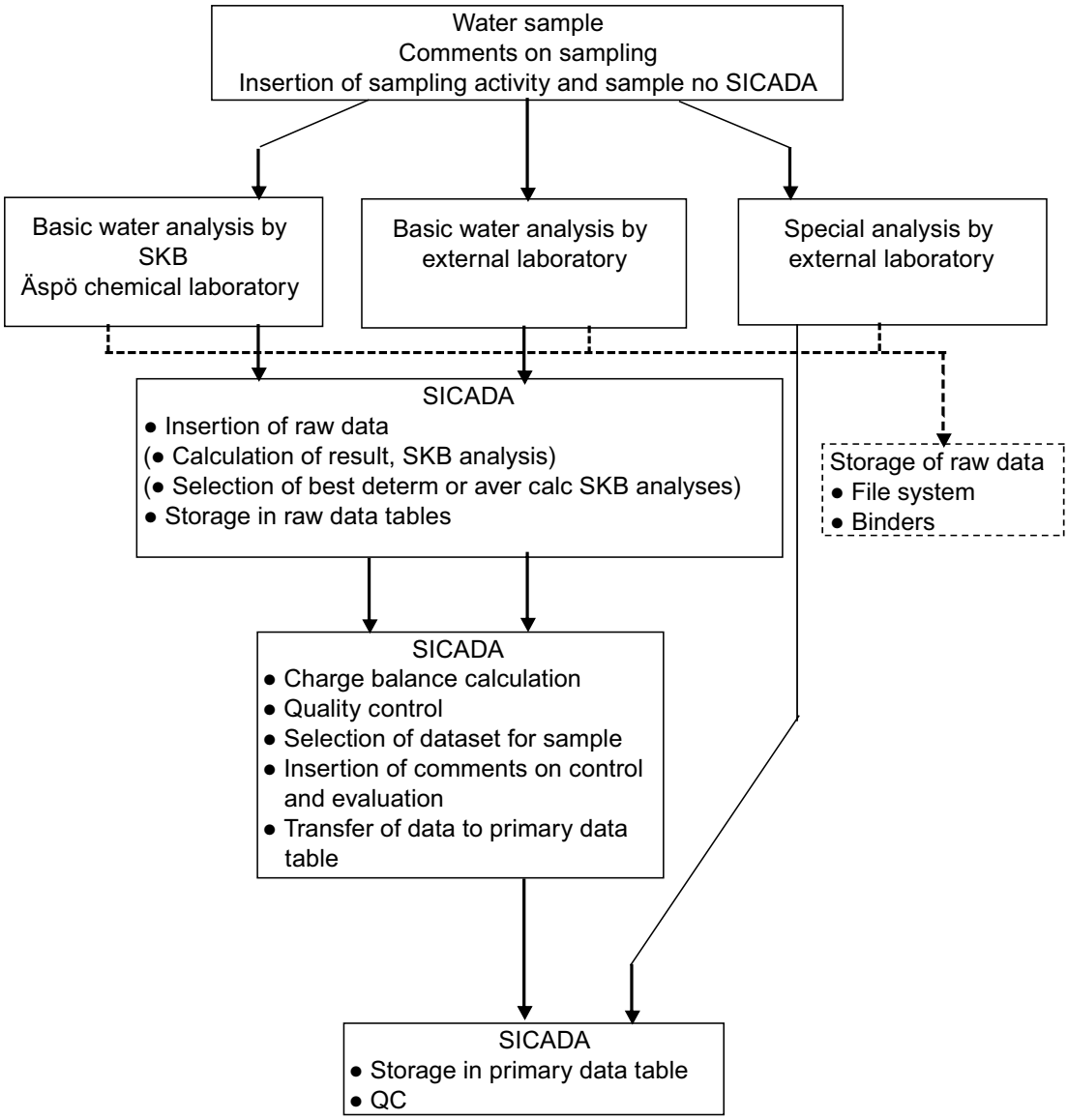

Figure 3-1. *Overview of data management for hydrogeochemical data.*

3.4 Nonconformities

The activity was performed without any deviations from 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 $\delta^{18}O$ 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 tube is plotted at 22.5 metres.

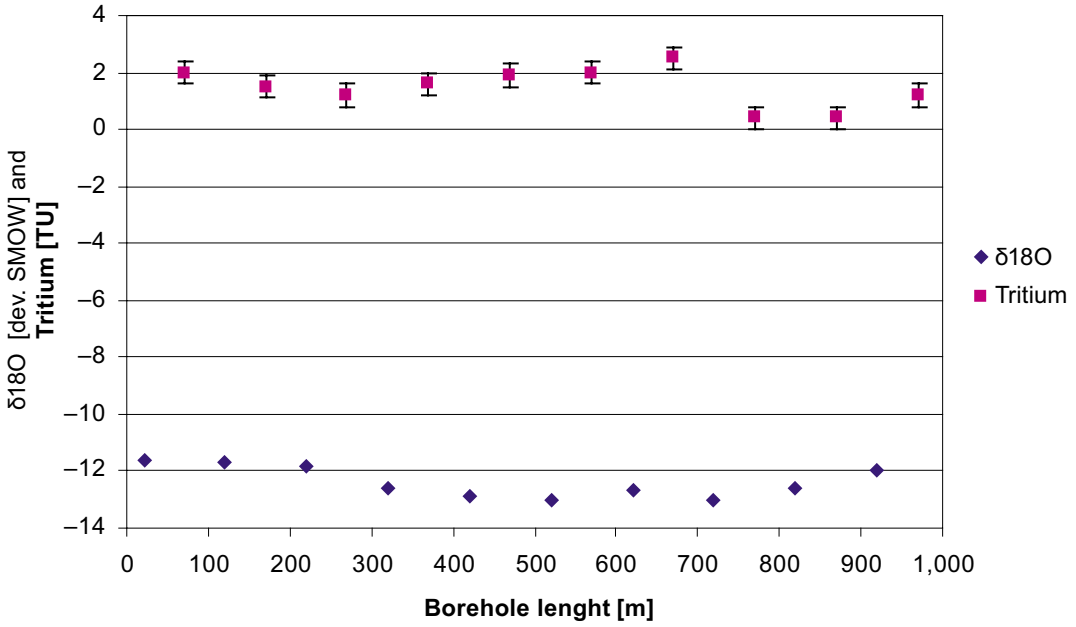

Figure 4-1. *Tritium and $\delta^{18}O$ data from samples collected in the core drilled borehole KAV04A at the hydrochemical logging.*

Table 4-1. Deuterium determinations for samples collected at the *hydrochemical logging* in KAV04A.

Sample SKB no	Deuerium [dev SMOW]
7442	–84.5
7444	–84.2
7446	–84.9
7448	–92.8
7450	–96.3
7452	–94.7
7454	–90.7
7456	–92.2
7458	–87.2
7460	–87.7

5 References

/1/ **Berg C, 2004.** Oskarshamn site investigation. Hydrochemical logging in KAV04A. SKB P-04-220, Svensk Kärnbränslehantering AB.

/2/ **SKB, 2001.** Generellt genomförande program för platsundersökningar. SKB R-01-10, Svensk Kärnbränslehantering AB.

Appendix 1

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_3 pH(lab) cond (lab)	Plastic	250	Yes (not in the field)	No	Titration Pot meas, cond meas	Äspö's chemistry lab	The same day – maximum 24 hours
Anions 2	Cl, SO_4, Br^-, F^-, I^-	Plastic	100	Yes (not in the field)	No	Titration (Cl^-) IC (Cl^-, SO_4, Br^-, F^-) ISE (F^-)	Äspö'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_3)	ICP-AES ICP-MS	Analytica AB	Not critical (month)
Environmental isotopes	^2H, ^{18}O	Plastic	100	No	– –	MS	IFE	Not critical (month)
Tritium,	^3H (enhanced.)	Plastic (dry bottle)	500	No	–	LSC	Univ Of Waterloo	Not critical (month)
Chlorine-37	Chlorine-37	Plastic	100	No	–	ICP MS		
Carbon isotopes	^{13}C, ^{14}C	Glass (brown)	100×2	No	–	(A)MS	Univ Of Waterloo The Ångström laboratory, Uppsala	A few days
Sulphur isotopes	^{34}S	Plastic	500–1,000	Yes	–	Combustion, ICP MS	IFE	No limit
Strontium-isotopes	$^{87}Sr/^{86}Sr$	Plastic	100	Yes	–	TIMS	IFE	Days or week
Boron isotopes	^{10}B	Plastic	100	Yes	Yes (1 mL HNO_3)	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.

** Minimu□

*** 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.

Äspö waterchemical laboratory (SKB)
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) Insituttveien 18 P.O Box 40 2027 Kjeller NORGE
The Ångström laboratory Box 534 Se-751 21 Uppsala

Appendix 2

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

Compilation November 2004

Idcode	Secup m	Seclow m	Sample no	d2H dev SMOW	3H TU	d18O dev SMOW	δ37Cl dev SMOC	10B/11B no unit	87Sr/86Sr no unit	δ34S dev CDT	δ13C dev PDB	14C pmC
KAV04A	0	45	7442	–84.5	–	–11.6	–	xxx	xxx	xxx	–	–
KAV04A	45	95	7443	–	2.0	–	xxx	–	–	–	xxx	xxx
KAV04A	95	145	7444	–84.2	–	–11.7	–	xxx	xxx	xxx	–	–
KAV04A	145	195	7445	–	1.5	–	xxx	–	–	–	xxx	xxx
KAV04A	195	245	7446	–84.9	–	–11.8	–	xxx	xxx	xxx	–	–
KAV04A	245	295	7447	–	1.2	–	xxx	–	–	–	xxx	xxx
KAV04A	295	345	7448	–92.8	–	–12.6	–	xxx	xxx	xxx	–	–
KAV04A	345	395	7449	–	1.6	–	xxx	–	–	–	xxx	xxx
KAV04A	395	445	7450	–96.3	–	–12.9	–	xxx	xxx	xxx	–	–
KAV04A	445	495	7451	–	1.9	–	xxx	–	–	–	xxx	xxx
KAV04A	495	545	7452	–94.7	–	–13.0	–	xxx	xxx	xxx	–	–
KAV04A	545	595	7453	–	2.0	–	xxx	–	–	–	xxx	xxx
KAV04A	595	645	7454	–90.7	–	–12.7	–	xxx	xxx	xxx	–	–
KAV04A	645	695	7455	–	2.5	–	xxx	–	–	–	xxx	xxx
KAV04A	695	745	7456	–92.2	–	–13.0	–	xxx	xxx	xxx	–	–
KAV04A	745	795	7457	–	<0.8	–	xxx	–	–	–	xxx	xxx
KAV04A	795	845	7458	–87.2	–	–12.6	–	xxx	xxx	xxx	–	–
KAV04A	845	895	7459	–	<0.8	–	xxx	–	–	–	xxx	xxx
KAV04A	895	945	7460	–87.7	–	–12.0	–	xxx	xxx	xxx	–	–
KAV04A	945	995	7461	–	1.2	–	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 a freezer
< “value” = result below detection limit