P-04-47

Forsmark site investigation

Hydrochemical logging of KFM04A

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March 2004

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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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Summary

Hydrochemical logging has been performed in the borehole KFM04A. Hydrochemical logging or so called tube sampling is a fast and simple sampling technique to obtain information on the chemical composition of the water column along an open borehole. The equipment consists of an approximately 1000-m long polyamide tube divided into units of 50 m length.

In most cases the water content of one tube unit constituted one sample and each second tube unit/sample was analysed. Three samples (in the beginning, in the middle and at the end of the tube array) were concatenated from two tube units in order to allow analyses of all SKB class 3 isotope options. The content of flushing water remaining in the borehole after drilling was acceptable (below 25%) in the first 300 m and the SKB class 3 isotopes will be determined in the first three samples. Beneath 300 m, the flushing water content showed a steady increase and ended at 53% in the last sample from 895–995 m. Accordingly, the isotope analyses were omitted in these samples. The relative charge balance error did not exceed the acceptable limit of ± 5% in any of the nine samples.

Due to the high content of remaining flushing water, the analysis data obtained from the activity will be less useful for chemical modelling work.

Sammanfattning

Hydrokemisk loggning har utförts i borrhålet KFM04A. Hydrokemisk loggning eller så kallad slangprovtagning är en snabb och enkel provtagningsteknik för att få information om den kemiska sammansättningen av vattenpelaren längs ett öppet borrhål. Utrustningen består av en ungefär 1000 m lång slang, uppdelad på 50 m långa slang-enheter.

I de flesta fall utgjorde vattnet i en slangenhet ett prov och var annan slangenhet/prov analyserades. Tre prov (i början, i mitten och i slutet av slangraden) bestod av vatten-volymen från två slangenheter. Detta för att ge tillräcklig volym för analys av samtliga isotoptillval enligt SKB klass 3. Halten kvarvarande spolvatten i borrhålet efter borrning var acceptabel (under 25 %) i de första 300 m och SKB klass 3 isotoper kommer att analyseras i de tre första proven. Under 300 m, visade spollvattenhalten en stadig ökning och slutade vid 53 % i det sista provet från 895–995 m. Isotopanalyserna fick därför utgå för dessa prov. Det relativa jonbalansfelet överskred inte godkännande-gränsen på ± 5 % i något av de nio proven.

På grund av den höga spolvattenhalten är de analysdata som erhållits från aktiviteten inte fullt ut användbara för hydrokemisk modellering.

Contents

1 Introduction

This document reports performance of and results from the activity "Hydrochemical logging in KFM04A" performed within the site investigation at Forsmark /1/. The work was conducted according to the Activity Plan AP PF 400-03-99 (SKB internal controlling document).

Borehole KFM04A is the fourth deep telescopic borehole drilled at the site investigations in the Forsmark area /2/. The location of the borehole and the drilling site DS4 within the investigation area is shown in Figure 1-1, whereas Figure 1-2 displays a zooming in towards drilling site DS4 with KFM04A and nearby situated percussion drilled boreholes in rock and soil. Borehole KFM04A is inclined 60° from the horizontal plane and penetrates the altered zone at the border of the candidate area. The borehole section 0–107.4 m is percussion drilled, and at the logging occasion it was cased with a stainless steel casing with the internal diameter 200 mm, whereas section 107.4–1001.42 m is core drilled with a diameter of 77 mm. The borehole is 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). A borehole being of SKB chemical type entails cleaning procedures of all in-hole equipment to be used in the borehole during and after drilling according to level 2 in the cleaning instructions in MD 600.004 (Instruction for cleaning borehole equipment and certain surface equipment). The Method Descriptions and Instructions mentioned are SKB internal controlling documents. Basic borehole information is given in Table 1-1 below and the design of the borehole is presented in Appendix 1.

Table 1-1. Borehole information, KFM04A at drilling site DS4.

Activities performed	Date of completion	Length (m)	Comment
Percussion drilling	2003-05-27	0–107.42	–
BIPS-logging	2003-06-02	0–106.5	–
Core drilling	2003-11-19	107.42–1001.42	HFM10 served as source of flushing water for drilling the cored part of KFM04A. HFM10 is a SKB chemical type of borehole The flushing water volume used was 655 m^3.
Mammoth pumping during/ after core drilling	–	–	Pumped volume: 3466 m^3.
BIPS logging	2003-12-06	108–1000	–
Radar logging	2003-12-07	100–998	–
Hydrochemical logging	2003-12-08	100–1000	Described in this report.

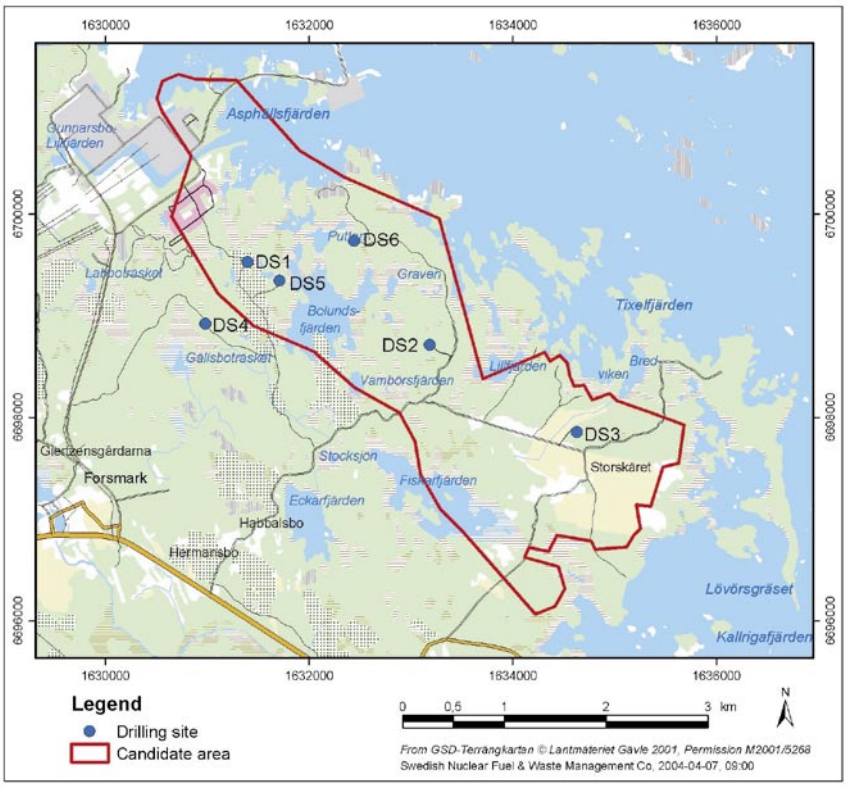


Figure 1-1. *The investigation area at Forsmark (approximately the area inside the black square) including the candidate area selected for more detailed investigations. The six drilling sites for deep boreholes, DS1-6 are marked with blue circles. Borehole KFM04A is situated at drilling site DS4. Map design: Helena Nyman.*

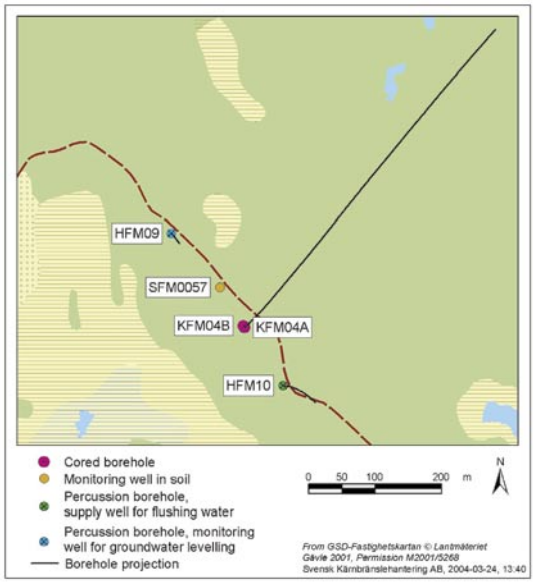


Figure 1-2. *Locations of the telescopic borehole KFM04A (inclined 60°) as well as percussion boreholes and a shallow monitoring well at drilling site DS4. Map design: Helena Nyman.*

2 Objective and scope

Hydrochemical logging is performed in order to obtain an overview of the initial chemical composition of the water column along the open borehole KFM04A. The sampling technique is fast and simple even at great depth.

The analysis program is carried out according to SKB chemistry class 3 including isotope options. However, if the content of drilling water in a sample exceeds 25%, the isotope determinations are omitted.

3 Sampling equipment

The sampling equipment used for the hydrochemical logging consists of an approximately 1000-m long polyamide tube divided into units of 50 m length. The equipment is described in the method description SKB MD 422.001 (Metodbeskrivning för hydrokemisk loggning, SKB internal controlling document).

A schematic illustration of the equipment used for hydrochemical logging is shown in Figure 3-1. The tube units are connected with metal couplings. The length of each tube unit is given in Table 3-1. The external and internal diameters of the tube units are 10 and 8 mm respectively. The water content in each tube unit will constitute one sample and the volume of each sample will amount to at least two litres. A check valve and a weight are mounted at the bottom of the tube array to prevent water outflow and to keep it stretched in the borehole. At both ends of each tube unit there is a manual shut off valve.

Table 3-1. Length of tube units.

Unit	Length [m]
1	49.71
2	50.08
3	49.77
4	49.28
5	49.97
6	50.01
7	49.85
8	49.87
9	49.57
10	49.72
11	49.67
12	50.25
13	50.62
14	49.70
15	49.22
16	49.20
17	49.30
18	49.63
19	49.62
20	49.87
Sum:	994.91
Coupling length:	2.812
Weight length	0.817
Total tube length:	**998.539**

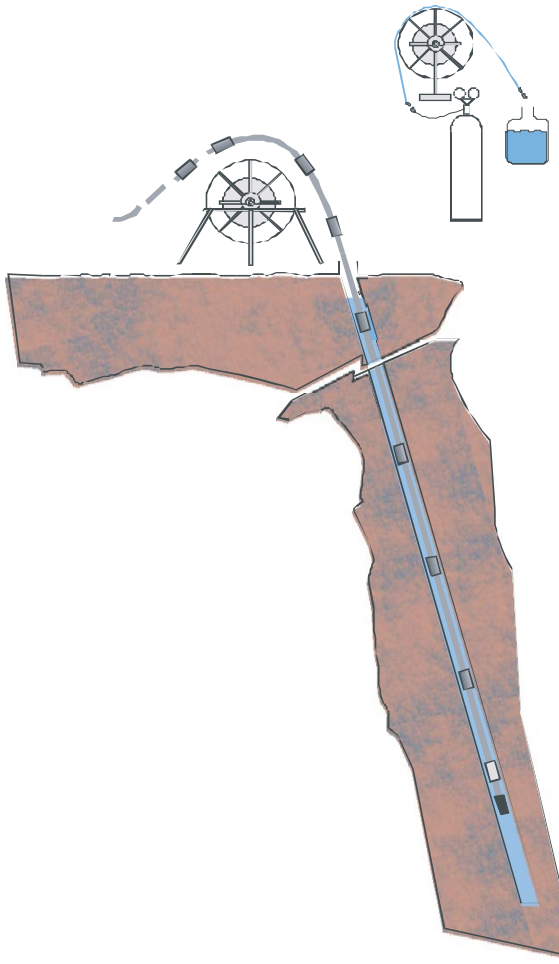


Figure 3-1. *Equipment for hydrochemical logging in boreholes. At the lower end of the tube array there is a check valve and a weight connected. Each tube unit is approximately 50 m long.*

4 Performance

4.1 Hydrochemical logging

Sampling of the telescopic borehole KFM04A was performed according to activity plan AP PF 400-03-99 (SKB internal controlling document) following the method described in SKB MD 422.001 (Metodbeskrivning för hydrokemisk loggning).

The hydrochemical logging was performed on the 8:th of December to a borehole length of 995 m. The tube array was not lowered all the way down to the bottom at 1001.42 m in order to decrease the risk of getting stuck and also to avoid suspending drilling debris sedimented at the bottom of the borehole. The lowering of the tubes started at 09:12 and the retrieval of the tube units started at 13:50. The first tube unit at the top of the array was lowered to 45 m of its length. Since the ground water table was situated about 7 m below top of casing, altogether about 12 m of the upper tube unit was not water filled. The tube units were emptied using pressurized nitrogen gas and the water was portioned into plastic bottles to be analysed at different laboratories. In most cases one tube unit constitutes one sample. However, SKB samples number 8171, 8177 and 8185 were concatenated from two tube units in order to allow analyses of all SKB class 3 isotope options.

The exact level of the ground water table in the borehole prior to logging was 7.04 m below top of casing.

4.2 Sample treatment and chemical analyses

An overview of sample treatment and analysis routines is given in Appendix 2. The routines are applicable independent of sampling method or sampling object. An overview showing the filled sample portions at the logging occasion is given in Table 4-1. The samples SKB no 8175 to 8185 were collected but not sent to the laboratories for isotope analyses due to their high content of flushing water remaining from drilling (more than 25%). The data from the hydrochemical logging are stored in the database SICADA in field note no Forsmark 243. The SKB sample numbers are 8169–8185.

Table 4-1. Overview of samples collected at hydrochemical logging in KFM04A. Filled cells represent collected samples.

Sample information			Collected sample portions												
Tube unit	Length [m]	SKB no.	Cond., pH, alk.	Major comp.	Br^-/I^-	Anions	Uranine	^3H	$\delta^2H/\delta^{18}O$	$\delta^{37}Cl$	^{87}Sr	C isotope	$\delta^{34}S$	Left overs*
1	0 45	8169												
2	95	8170												
3&4	195	8171												
5	245	8172												
6	295	8173												
7	345	8174												
8	395	8175						x	x	x	x	x		
9	445	8176												
10&11	545	8177						x	x	x	x	x	x	
12	595	8178												
13	645	8179						x	x	x	x	x		
14	695	8180												
15	745	8181						x	x	x	x	x		
16	795	8182												
17	845	8183						x	x	x	x	x		
18	895	8184												
19&20	995	8185						x	x	x	x	x	x	

Even sample numbers are archive samples, i.e. dark grey cells.

x = samples were collected but not analysed due to high flushing water content.

4.3 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 components 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 ± 5% are considered acceptable (in surface waters ± 10%).

  $$\text{Rel. Error (\%)} = 100 \times \frac{(\sum \text{cations(equivalents)} - \sum \text{anions(equivalents)})}{(\sum \text{cations(equivalents)} + \sum \text{anions(equivalents)})}$$

- 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 4-1.

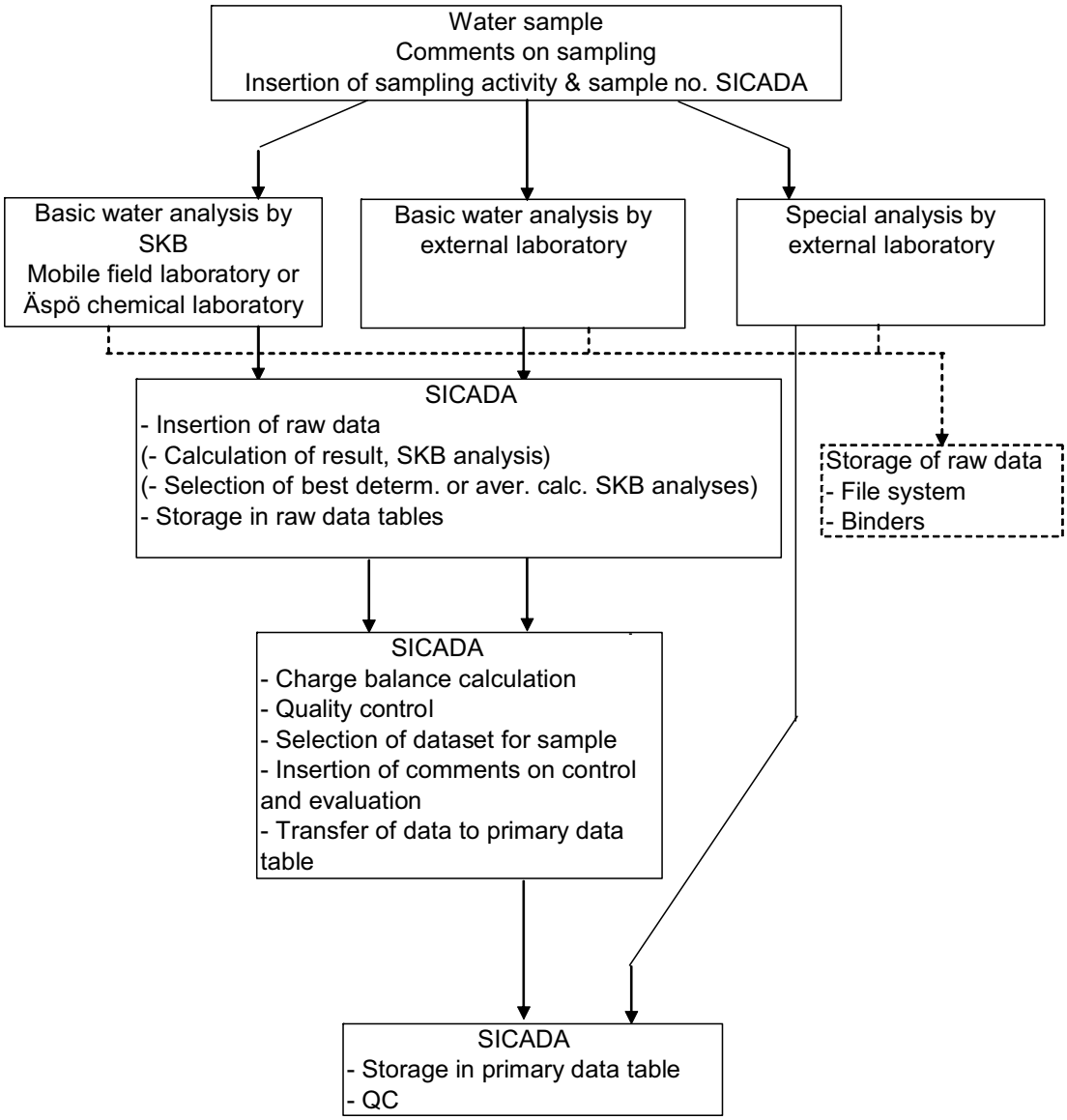


Figure 4-1. *Overview of data management for hydrogeochemical data.*

4.4 Nonconformities

The activity was performed according to the Activity Plan AP PF 400-03-99 and the Method Description SKB MD 422.001 without any deviations that can affect the quality of the data.

5 Results

5.1 Analysis results

The analysis data from the hydrochemical logging in borehole KFM04A are presented in Appendix 3 and 4. Diagrams showing the flushing water content and the electric conductivity plotted versus borehole length are presented in Figure 5-1 and 5-2 below. The results have been plotted for the mid-point of each tube unit, for example tube number 1 from borehole length 0–45 m is plotted at 22.5 m and so on. Isotope results are not available from 300 m and downwards to the bottom of the borehole as the flushing water content in these samples exceeded the acceptable level of 25%, see Figure 5-1.

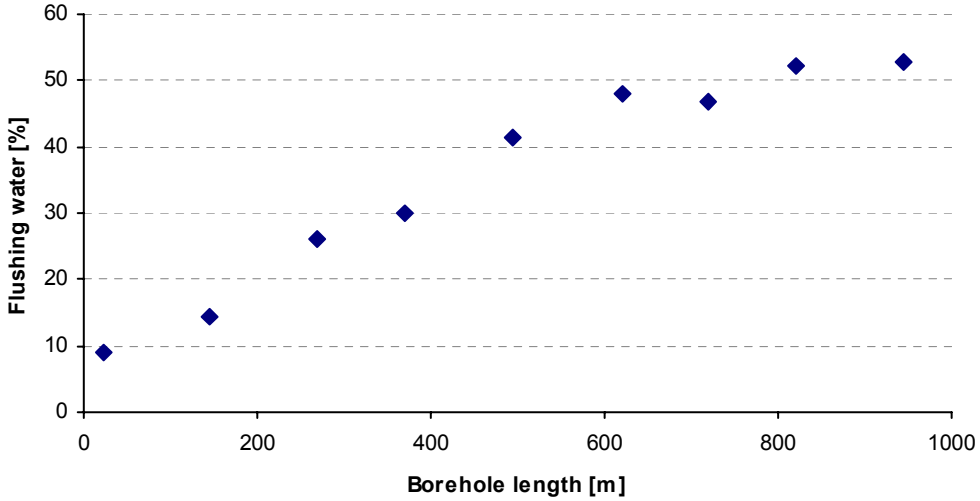


Figure 5-1. *Flushing water content versus borehole length.*

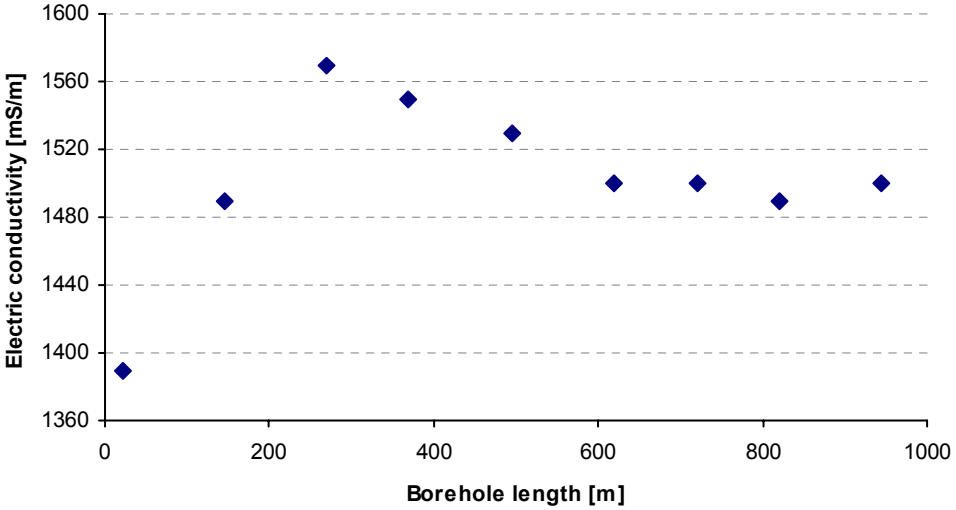


Figure 5-2. *Electric conductivity versus borehole length.*

5.2 Quality of the analyses

The relative charge balance errors give an indication of the quality and uncertainty of the analyses of the major components. The calculated relative charge balance errors for the selected sets of data do not in any case exceed the acceptable level of ± 5%, see Appendix 3.

6 Conclusions

The hydrochemical logging in KFM04A revealed the high content of flushing water in the water column along the open borehole. Accordingly, the analysis data obtained, will be less useful for chemical modelling work due to this fact. The main conclusions that can be drawn from the activity are:

- The content of flushing water remaining in the borehole after drilling was acceptable in the first 300 m and due to this, class 3 isotope options were included for the first three samples. Beneath 300 m, the flushing water content showed a steady increase and ended at 53% in the last sample from 895–995 m.
- The relative charge balance error did not exceed the acceptable limit of ± 5% in any case.
- At the sampling occasion, the difference flow logging was not performed yet. The electric conductivity and the flushing water content along the borehole indicate that the water yielding fractures are located in the upper part of the borehole (down to approx. 300 or 400 m).
- In order to obtain representative samples during the chemical characterisation activity, it may be necessary to conduct extra “clean up” pumping in the borehole prior to sampling.

7 References

/1/ SKB, 2001. Site investigations. Investigation methods and general execution programme. SKB TR-01-29, Svensk Kärnbränslehantering AB.

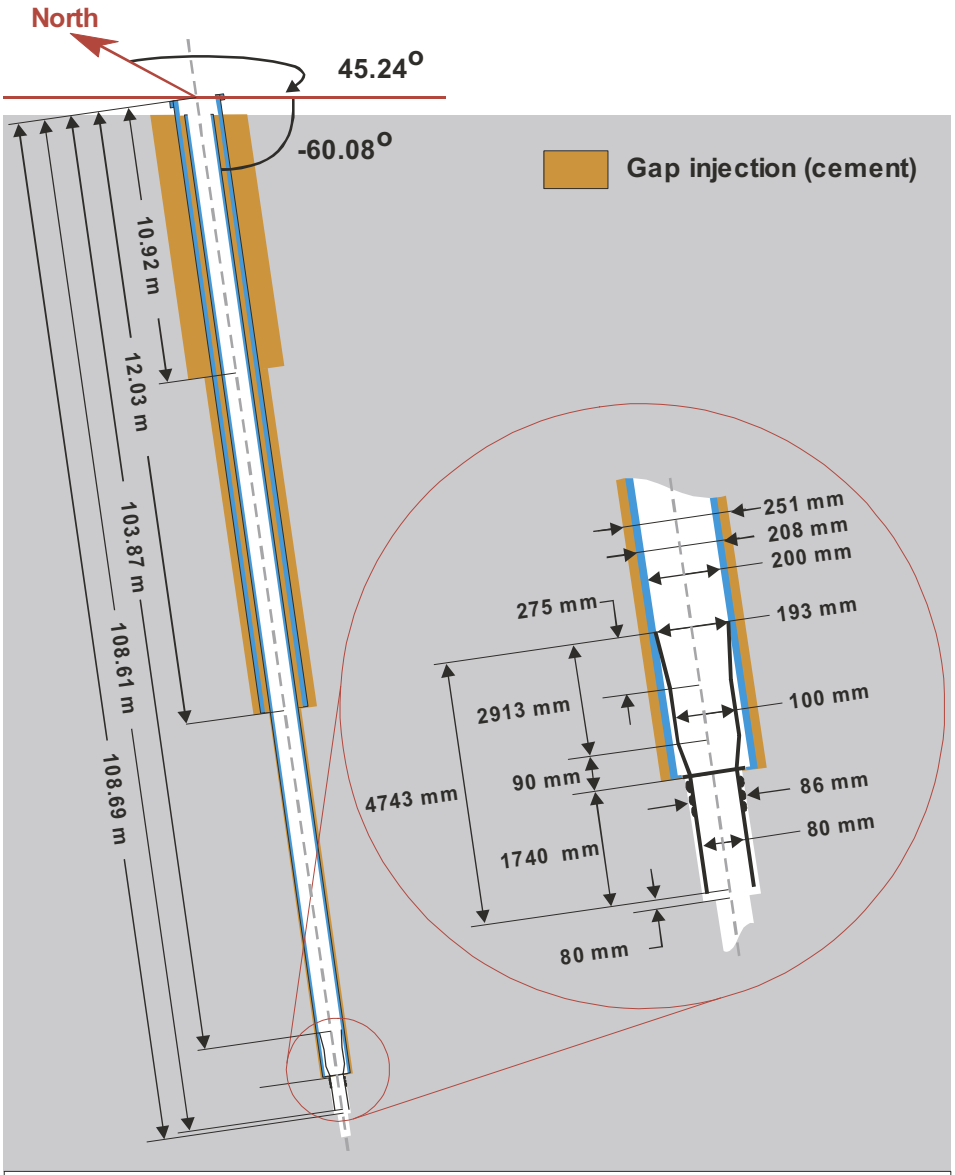
/2/ Claesson L-Å, Nilsson G, 2003. Forsmark site investigation. Drilling of the telescopic borehole KFM04A at drilling site DS4 (in progress), Svensk Kärnbränslehantering AB

Appendix 1

Design of the telescopic borehole KFM04A

Technical data

Borehole KFM04A



Drilling reference point		
Northing:	6698921.74	(m), RT90 2,5 gon V 0:-15
Easting:	1630978.96	(m), RT90 2,5 gon V 0:-15
Elevation:	8.77	(m), RHB70
Drilling period		
Drilling start date:	2003-05-20	
Drilling stop date:	2003-11-19	
Borehole		
Lenght:	1001.42 m	

Appendix 2

Sampling and analysis methods

Table A2-1. 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	Mobile field lab. AnalyCen	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^-, SO4, Br^-, F^-) ISE (F^-)	Äspö:s chemistry lab. AnalyCen	Not critical (month)
	Br, I	Plastic	100	Yes (not in the field)	No	ICP MS	Paavo Ristola OY Analytica AB,	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, AlnalyCen	Not critical (month)
Cations, Si and S according to SKB class 4 and 5	Na, K, Ca, Mg, S(tot), Si(tot), Fe, Mn, Li, Sr	Plastic (Acid washed)	100	Yes (immediately in the field)	Yes (1mL HNO_3)	ICP-AES ICP-MS	Analytica AB, AlnalyCen	Not critical (month)
Fe(II), Fe(tot)	Fe(II), Fe(tot)	Plastic (Acid washed)	500	Yes	Yes (5 mL HCl))	Spectrophotometry Ferrozine method	Mobile field lab.	As soon as possible the same day
Hydrogen sulphide	HS^-	Glass (Winkler)	About 120×2	No	Ev 1 mL 1 M NaOH + 1 mL 1M ZnAc	Spectrophotometry	AlnalyCen l Äspö:s chemistry lab.	Immediately or if conserved, a few days
Nutrient salts	NO_2, NO_3+NO_2, NH_4, PO_4	Plastic	250	No	No	Spectrophotometry	Äspö:s chemistry lab. AlnalyCen l	Maximum 24 hours
Environmental metals	Al, As, Ba, B, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn	Plastic	100	Yes	Yes (1 mL HNO_3)	ICP-AES ICP-MS	Analytica AB, AnalyCen	Not critical (month)
Lantanoids, U, Th and so on.	Sc, Rb, Y, Zr, I, Sb, Cs, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, U, Th	Plastic	100	Yes	Yes (1 mL HNO_3)	ICP-AES ICP-MS	SGAB Analytica, AnalyCen	Not critical (month)

Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Laboratory***	Analysis within - or delivery time to lab.
Dissolved organic Carbon, dissolved inorganic Carbon	DOC, DIC	Plastic	250 25	Yes	Frozen, transported in isolated bag	UV oxidation, IR Carbon analysator Shimadzu TOC5000	Paavo Ristola OY Dept. of System ecology, SU	Short transportation time
Total organic Carbon	TOC	Plastic	250 25	No	Frozen, transported in isolated bag	UV oxidation, IR Carbon analysator Shimadzu TOC5000	Paavo Ristola OY Dept. of System ecology, SU	Short transportation time
Environmental isotopes	∂^2H, $\partial^{18}O$	Plastic	100	No	- -	MS	IFE	Not critical (month)
Tritium, Chlorine-37	^3H (enhanced.) $\partial^{37}Cl$	Plastic (dry bottle) Plastic	500 100	No No	- -	LSC ICP MS	Univ. of Waterloo	Not critical (month)
Carbon isotopes	$\partial^{13}C$, pmC (^{14}C)	Glass (brown)	100×2	No	-	(A)MS	Univ. of Waterloo	A few days
Sulphur isotopes	$\partial^{34}S$	Plastic	500 –1000	Yes	-	Combustion, ICP MS	IFE	No limit
Strontium-isotopes	$^{87}Sr/^{86}Sr$	Plastic	100	Yes	-	TIMS	IFE	Days or Week
Uranium and Thorium isotopes	^{234}U, ^{235}U, ^{238}U, ^{232}Th, ^{230}Th,	Plastic	50	Nej	-	Chemical separat. Alfa/gamma spectrometry	IFE	No limit
Boron isotopes	$^{10}B/^{11}B$	Plastic	100	Yes	Yes (1 mL HNO_3)	ICP – MS	Analytica AB	No limit
Radon and Radium isotopes	^{222}Rn, ^{226}Ra	Plastic	500	No	No	EDA, RD-200	IFE	Immediate transport
Dissolved gas (content and composition)	Ar, N_2, CO_2, O_2, CH_4, H_2, CO, C_2H_2, C_2H_4, C_2H_6, C_3H_8	Cylinder of stainless steel	200	No	No	GC	Paavo Ristola OY	Immediate transport
Colloids	Filter series and fractionation (see below)	Polycarbonate filter	0.45, 0.2 and 0.05 μm	-	N_2 atmosphere	ICP-AES ICP-MS	Analytica AB	Immediate transport
Humic and fulvic acids	Fractionation	Fractions are collected in plastic bottles	250	-	N_2 atmosphere	UV oxidation, IR (DOC)	Paavo Ristola OY	Immediate transport
Archive samples with acid	-	Plast (washed in acid)	100×2 **	Yes	Yes (1 mL HNO_3)	-	-	Storage in freeze container
Archive samples without acid	-	Plastic	250×2 **	Yes	No	-	-	Storage in freeze container

Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Laboratory***	Analysis within - or delivery time to lab.
Carbon isotopes in humic and fulvic acids	$\partial^{13}C$, pmC (^{14}C)	DEAE cellulose (anion exchanger)	-	-	-	(A)MS	The Ångström Laboratory, Uppsala	A few days

* 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 A2-3.

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 A2-2. Reporting limits and measurement uncertainties.

Component	Method	Detection limit	Reporting limit or range	Unit	Measurement uncertainty[2]	"Total" uncertainty[3]
HCO_3	Alkalinity titration	0.2	1	mg/L	4 %	<10 %
Cl^- Cl^-	Mohr titration IC	5 0.2	70 0.5	mg/L	5 % 6 %	<10 % 10 %
SO_4	IC	0.2	0.5	mg/L	6 %	15 %
Br^- Br^-	IC ICP	0.2 -	0.7 0.001 – 0.010[1]	mg/L	9 % 15 %	20 %
F^- F^-	IC Potentiometri	0.2 -	0.6 -	mg/L	10 % -	20 % -
I^-	ICP	-	0.001 – 0.010[1]	mg/L	15 %	20 %
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	10 %	15 %
Si(tot)	ICP	-	0.03	mg/L	4 %	15 %
Sr	ICP	-	0.002	mg/L	4 %	15 %
Li	ICP	-	0.2 - 2[1]	µg/L	10 %	20 %
DOC	See tab. 1	-	0.5	Mg/L	8 %	30 %
TOC	See tab. 1	-	0.5	Mg/L	10 %	30 %
δ^2H	MS	-	2	‰ SMOW[4]	1.0 ‰	-
$\delta^{18}O$	MS	-	0.1	‰ SMOW[4]	0.2 ‰	-
^3H	LSC	-	0.8 or 0.1	TU[5]	0.8 or 0.1 TU	-
$\delta^{37}Cl$	ICP MS	-	0.2 ‰ (20 mg/L)	‰ SMOC[6]	-	-
$\delta^{13}C$	A (MS)	-	>20 mg Carbon	‰ PDB[7]	-	-
pmC (^{14}C)	A (MS)	-	>20 mg kol	PmC[8]	-	-

Component	Method	Detection limit	Reporting limit or range	Unit	Measurement uncertainties [2]	"Total" uncertainties [3]
δ^{34} S	ICP MS	-	0.2 ‰	‰ CDT[9]	0.2 ‰	-
$^{87}Sr/^{86}Sr$	MS	-	-	No unit (ratio) [10]	0.000020	-
$^{10}B/^{11}B$	ICP MS	-	-	No unit (ratio) [10]	0,0020	-

1. Reporting limits at salinity ≤ 0.4 % (520 mS/m) and ≤ 3.5 % (3810 mS/m) respectively.
2. Measurement uncertainty reported by consulted laboratory.
3. Estimated total uncertainty by experience (includes effects of sampling and sample handling).
4. Per mill deviation[11] from SMOW (Standard Mean Oceanic Water).
5. TU=Tritium Units, where one TU corresponds to a Tritium/hydrogen ratio of 10^{-18} (1 Bq/L Tritium = 8.45 TU).
6. Per mill deviation[11] from SMOC (Standard Mean Oceanic Chloride).
7. Per mill deviation[11] from PDB (the standard PeeDee Belemnite).
8. The following relation is valid between pmC (percent modern carbon) and Carbon-14 age: $pmC = 100 \times e^{((1950-y-1.03t)/8274)}$
   where y = the year of the C-14 measurement and t = C-14 age.
9. Per mill deviation[11] from CDT (the standard Canyon Diablo Troilite).
10. Isotope ratio without unit.
11. Isotopes are often reported as per mill deviation from a standard. The deviation is calculated as:
    $\delta^{y}I = 1000\times(K_{sample}-K_{standard})/K_{standard}$, where K= the isotope ratio and $^{y}I = ^{2}H$, ^{18}O, ^{37}Cl, ^{13}C or ^{34}S etc.

Table A2-3. Participant laboratories

Äspö water chemical laboratory (SKB) Mobile field laboratory, Forsmark (SKB)
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Environmental Isotope Laboratory Dep. of earth sciences University of Waterloo Waterloo, Ontario N2L 3G1 CANADA
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AlnalyCen Nordic AB Box 905 531 19 Lidköping
The Ångström laboratory Box 534 Se-751 21 Uppsala

Appendix 3

Water composition, compilation of basic water analysis data

Idcode	Secup m	Seclow m	Sample no.	Date	Time	Charge Bal %	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	HCO_3^- mg/L	Cl^- mg/L	SO_4^{2-} mg/L	SO_4-S mg/L	Br mg/l	F^- mg/L	Si mg/L	Li mg/L	Sr mg/L	pH	ElCond mS/m	DrillWater %	I^- mg/L
KFM04A	0	45	8169	2003-12-08	09:12-13:50	-2,6	1570	20,4	1070	192	148	4690	449	144	18,1	2,00	6,5	0,049	11,6	7,20	1390	9,09	0,041
KFM04A	45	95	8170	2003-12-08	09:12-13:50																	xxx	
KFM04A	95	195	8171	2003-12-08	09:12-13:50	-2,5	1680	21,9	1170	204	124	5080	477	151	19,3	0,65	6,2	0,050	12,5	7,17	1490	14,5	0,043
KFM04A	195	245	8172	2003-12-08	09:12-13:50																	xxx	
KFM04A	245	295	8173	2003-12-08	09:12-13:50	-2,4	1780	23,5	1250	211	95	5410	501	156	21,2	<0.2	5,3	0,053	13,5	6,98	1570	26,1	0,051
KFM04A	295	345	8174	2003-12-08	09:12-13:50																	xxx	
KFM04A	345	395	8175	2003-12-08	09:12-13:50	-2,5	1780	23,2	1240	208	82	5410	493	155	21,1	<0.2	5,1	0,053	13,7	6,87	1550	29,9	0,050
KFM04A	395	445	8176	2003-12-08	09:12-13:50																	xxx	
KFM04A	445	545	8177	2003-12-08	09:12-13:50	-2,3	1750	23,1	1230	198	70	5300	490	151	21,3	<0.2	4,5	0,052	13,7	6,76	1530	41,3	0,048
KFM04A	545	595	8178	2003-12-08	09:12-13:50																	xxx	
KFM04A	595	645	8179	2003-12-08	09:12-13:50	-2,4	1720	23,0	1200	193	59	5200	478	148	21,2	0,4	4,2	0,051	13,5	6,69	1500	47,9	0,046
KFM04A	645	695	8180	2003-12-08	09:12-13:50																	xxx	
KFM04A	695	745	8181	2003-12-08	09:12-13:50	-2,1	1720	23,2	1200	192	55	5180	473	147	20,3	<0.2	4,1	0,051	13,5	6,59	1500	46,8	0,044
KFM04A	745	795	8182	2003-12-08	09:12-13:50																	xxx	
KFM04A	795	845	8183	2003-12-08	09:12-13:50	-2,7	1710	23,3	1190	191	53	5210	471	145	20,9	<0.2	4,2	0,051	13,4	6,52	1490	52,2	0,045
KFM04A	845	895	8184	2003-12-08	09:12-13:50																	xxx	
KFM04A	895	995	8185	2003-12-08	09:12-13:50	-2,0	1710	23,8	1210	191	51	5170	472	145	20,6	<0.2	4,5	0,051	13,5	6,50	1500	52,7	0,046

- = Archive sample
xxx = not collected
< "value" = result less than detection limit
ChargeBal % = Relative charge balance error %

SICADA: water_composition, 040225

Appendix 4

Isotopes, compilation of H-, O-, B-, S-, Cl- and C-isotopes

Idcode	Secup m	Seclow m	Sample no	Date	Time	δ^2H dev SMOW	^3H TU	$\delta^{18}O$ dev SMOW	$\delta^{34}S$ dev CDT	$\delta^{37}Cl$ dev SMOC	$\delta^{13}C$ dev PDB	$^{87}Sr/^{86}Sr$ no unit	^{14}C pmC
KFM04A	0	45	8169	2003-12-08	09:12-13:50	-74,3	A	-9,30	_	A	_	_	_
KFM04A	95	195	8171	2003-12-08	09:12-13:50	-73,7	A	-9,20	A	A	A	A	A
KFM04A	245	295	8173	2003-12-08	09:12-13:50	-70,9	A	-9,00	_	A	A	A	A

- = Not analysed
A = results will be reported later
x = No result due to sampling problems
xx = No result due to analytical problems
SICADA: h_o_isotopes, b_s_cl_sr_isotopes, c_s_isotopes 040405