

SKB

**TECHNICAL
REPORT**

86-17

**Analysis of groundwater from
deep boreholes in Klipperås**

Sif Laurent
IVL, Swedish Environmental
Research Institute

Stockholm, 1986-09-22

ERRATA SKB TR 86-17, 1986-09-22

1. In Table 10 the Chloride content is missing. It should be as follows:

| Borehole | Length(m) | Date | Cl mg/l |
|----------|-----------|----------|---------|
| K1 01 | 0406 | 85-06-23 | 42 |
| | | 06-25 | 43 |
| | | 06-25 | 43 |
| | | 06-26 | 45 |
| | | 06-27 | 48 |
| | | 07-02 | - |
| K1 09 | 0696 | 85-08-14 | 6.0 |
| | | 08-15 | 6.0 |
| | | 08-16 | 5.9 |
| | | 08-17 | 6.2 |
| | | 08-18 | 6.1 |
| | | 08-19 | 6.2 |
| | | 08-20 | 6.2 |
| | | 08-21 | 6.1 |
| | | 08-23 | 6.0 |
| | | 08-26 | |
| | | 08-27 | 5.9 |
| | | 08-28 | 5.8 |
| | | 08-29 | 5.9 |
| | | 08-30 | 5.8 |
| 08-02 | 5.7 | | |
| 08-03 | 5.5 | | |
| 08-04 | 5.5 | | |
| 08-05 | 6.3 | | |

2. The parameter "pH,y" in table 4 and 6 is calculated from the measured potential using temperature correction.

The parameter "pH,y" in tables 8 and 11 is a momentary reading of the potential, and the pH is evaluated from a calibration graph without temperature correction. The difference is usually 0.1-0.2 pH-units.

During the first period of automatic readings (1984) the sond-electrode was checked by "momentary readings". The table-head "pH,y" in table 11 is therefore correct only for 860 m. For the other zones the head should be "pH,b".

In the SKB-database, the parameter "pH,y" in tables 8 and 11 will be replaced by "pH,y-average", which is the average of the automatic pH,y-readings during the day.

ANALYSIS OF GROUNDWATER FROM DEEP BOREHOLES IN KLIPPERÅS

Sif Laurent
IVL, Swedish Environmental Research Institute

September 22, 1986

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author(s) and do not necessarily coincide with those of the client.

A list of other reports published in this series during 1986 is attached at the end of this report. Information on KBS technical reports from 1977-1978 (TR 121), 1979 (TR 79-28), 1980 (TR 80-26), 1981 (TR 81-17), 1982 (TR 82-28), 1983 (TR 83-77), 1984 (TR 85-01) and 1985 (TR 85-20) is available through SKB.

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| | | 08-17 | 6.2 |
| | | 08-18 | 6.1 |
| | | 08-19 | 6.2 |
| | | 08-20 | 6.2 |
| | | 08-21 | 6.1 |
| | | 08-23 | 6.0 |
| | | 08-26 | |
| | | 08-27 | 5.9 |
| | | 08-28 | 5.8 |
| | | 08-29 | 5.9 |
| | | 08-30 | 5.8 |
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**Analysis of Groundwater from
Deep Boreholes in Klipperås**

Sif Laurent
IVL, Swedish Environmental Research Institute
Stockholm, 1986-09-22

SUMMARY

Groundwater from three boreholes in granitic rock at an investigation site in Klipperås has been sampled and analysed. This is part of a larger program of geological, geophysical and hydrogeological investigations aimed at finding a suitable site for a high level radioactive waste repository.

Water-bearing levels in the boreholes down to the deepest at 777 m were selected. Prior to sampling, the water-bearing level is isolated between packer sleeves. The water is then pumped to the surface where sensitive parameters such as redox potential, pH, sulphide and oxygen content are measured electrochemically on the flowing water in a system isolated from the air. Water, filter and gas samples are sent to several laboratories for further analysis.

During the site investigations in Klipperås a new mobile field laboratory was introduced with the capability to measure certain sensitive parameters such as Eh and pH downhole and to perform rapid, on site analyses of several other groundwater constituents.

The present report is a presentation of the results of the groundwater analyses. The reliability of the results is discussed but there is no evaluation in relation to geology and hydrogeology. This report presents the basic results from the groundwater analyses to be further evaluated by experts in different fields.

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1 INTRODUCTION

Groundwater from three core drilled boreholes in Klipperås: Kl 1, Kl 2 and Kl 9 has been sampled and analyzed. The sampling levels have been chosen on the basis of hydrological measurements in the boreholes.

All field work has been carried out by personnel from Industrins Processkonsult AB (IPK). The sampling in Klipperås has been carried out in a period of transition between old and new technology.

One level - 406 m - has been sampled in Kl 1. The first sampling there was carried out in Nov.-Dec. 1983 using the old technique (KBS TR 83-44 and 83-70). The results of the chemical water analyses exhibited an abnormally large variation. A more recent reanalysis of two frozen samples has shed doubt on the correctness of the previous analyses for a number of the parameters. The analyses are therefore not reported here. In June 1985, sampling was repeated at the same level, but now with new technology, i.e. new measuring equipment, automatic recording of the measured values and chemical analyses in our own computer-equipped field laboratory (to be published as SKB TR 86-16).

Kl 2 was sampled for the first time in Oct.-Dec. 1984. Five levels were sampled on this occasion: 326, 623, 741, 761 and 777 m. At the four greatest depths, it was found that drilling water admixture was around 5% and did not decrease during sampling. The work was therefore interrupted after a relatively short time at each level. The measured values have been recorded automatically with the computer unit, Chemmac, which recorded the measured values in units of one-half mV. In order to permit all the measurement results to be treated uniformly, the measured values in the filed computer tables have been divided by two. The chemical analyses were performed in the field laboratory, where the analysis results were calculated manually and recorded on test reports. In May 1985, a new sampling was carried out, this time at 860 m and with the new equipment. At this level as well, such high concentrations of drilling water were found that the sampling was interrupted after a week or so.

Kl 9 was sampled during Aug.-Sept. 1985. Only the 696 m level was investigated. New technology was used throughout.

Control analyses are performed about once a week by AB IVL, Stockholm, to verify the results of the field laboratory. A number of laboratories are used for special analyses (see Sections 6-8).

The present report consists mainly of a presentation of the results of the groundwater analyses. The reliability of the results is subjected to some scrutiny. No further evaluation in relation to geology or hydrology is made here, but the material in the report will be further analyzed by experts in different fields.

The geology and hydrology of the study area are described in KBS TR 86-06 and 86-08.

The fracture mineralogy at the Klipperås study site has been investigated by E-L Tullborg (SKB TR 86-10). The relations between the chemical and isotopical composition of the groundwater and the fracture minerals are described in that work.

The importance of groundwater composition in relation to final disposal of radioactive waste is discussed in the final report KBS-3, Volume 2 and 3 (Final storage of Spent Nuclear Fuel - KBS-3; 2 Geology Volume and 3 Barriers Volume) Stockholm, May 1983.

The previously used sampling equipment is described in KBS TR 83-44 and a description of the new mobile field laboratory will be presented in the technical report SKB TR 86-16.

2 SAMPLING

The sampled boreholes are core-drilled with a diameter of 56 mm. Kl 1 and Kl 2 are virtually vertical while Kl 9 slopes about 60°. Normally, borehole length is given in the tables, but the corresponding vertical depth is also indicated in Tables 1-2.

Before sampling starts in a borehole, it is first cleaned by means of gas-lift pumping three times with compressed nitrogen. Gas-lift pumping is repeated prior to each new sampling sequence in a borehole.

The sampling equipment (see Section 2.2) is lowered to the level selected for water sampling and is allowed to work there for 3-4 days before sampling starts. Successive sampling for at least 8-9 days makes it possible to follow changes in the composition of the water, which can be due to activities in the borehole and/or changing conditions in the rock.

The changes may be due to many factors. They may, for example, derive from drilling water or accidental contamination during the drilling procedure. Slowly declining Eh values may be due to the fact that there was adsorbed oxygen on the surface of the sampling equipment (hose, probe etc.). An example of changes due to natural causes is the fact that several aquifers with different composition can be tapped during the pumping procedure.

In interpreting the analysis results, it is important to know whether the water is subject to external influence or whether the results stem from unaffected groundwater. The sampling periods are therefore made longer than before in order that stable conditions can be achieved.

2.1 DRILLING WATER

Drilling water used in the core drilling of the sampling holes is taken from percussion boreholes within the study area and is filtered through mechanical filters of cellulose material (18 CMC 3-2), which separate particles with a diameter greater than 5 µm. The drilling water can penetrate into fractures in the rock and

contaminate the groundwater. In order to get rid of the drilling water to as great an extent as possible, the borehole is gas-lift-pumped both before the hydrological survey and immediately prior to installation of the sampling equipment.

The drilling water for Kl 2 and Kl 9 was marked with 0.5 g/m³ of uranine AP (Na fluorescein, C₂₀H₁₀Na₂O₅) in order to permit traces of drilling water in the sampled waters to be traced. The amount of drilling water found in the analyzed water is reported in Tables 1-2. The measured uranine content in Kl 1 only shows the background. It is calculated as "Drilling water" in order to facilitate comparison with other concentrations.

2.2 SAMPLING EQUIPMENT

The sampling zone is 5 m long and is sealed off by 1 m wide rubber packers that are expanded to a pressure that is 0.7-0.8 MPa above the groundwater pressure. During sampling of some deeper levels, the measuring zone is only sealed off by an upper packer. This is the case in Kl 1, 406 m and in Kl 2, 761, 777 and 860 m. The sampling equipment consists of a 2 m long measuring probe and a 3 m long pump. The water intake is thus 5 m below the upper packer. Given borehole lengths refer to the upper packer. The pump, which is made of steel and equipped with teflon seals, has a maximum capacity of 0.12 l/stroke and can pump 200-250 ml/min (about 300 l/d). The water flow is often lower than the pump capacity (Tables 1 and 2), which is due to the fact that the hydraulic conductivity of the rock limits the flow. A schematic illustration of sampling pump, packers and probe is shown in Figure 2-1.

The water is pumped through the probe and then through polyamide hose up to the ground surface, where it goes directly into a measuring chamber located in a refrigerator. The temperature of the refrigerator is approximately the same as that of the pumped-up water. The temperature, pH, pS and redox potential of the water are registered both in the probe and in the measuring chamber. The conductivity and oxygen content of the water are measured in the measuring chamber. A detailed description of the sampling equipment is provided in SKB TR 86-16.

In the measurements in Kl 1 during Nov.-Dec. 1983, the probe had not yet been put into use.

2.3 SAMPLING FOR LABORATORY ANALYSES AND FREEZING

Sampling is performed via a filter cartridge (Pall/Ultipor 0.45 µm) and a PVC hose immediately after the water has passed through the refrigerator (2.2). The sample bottles, which are made of uncoloured polyethylene, are filled from the bottom via a poly-

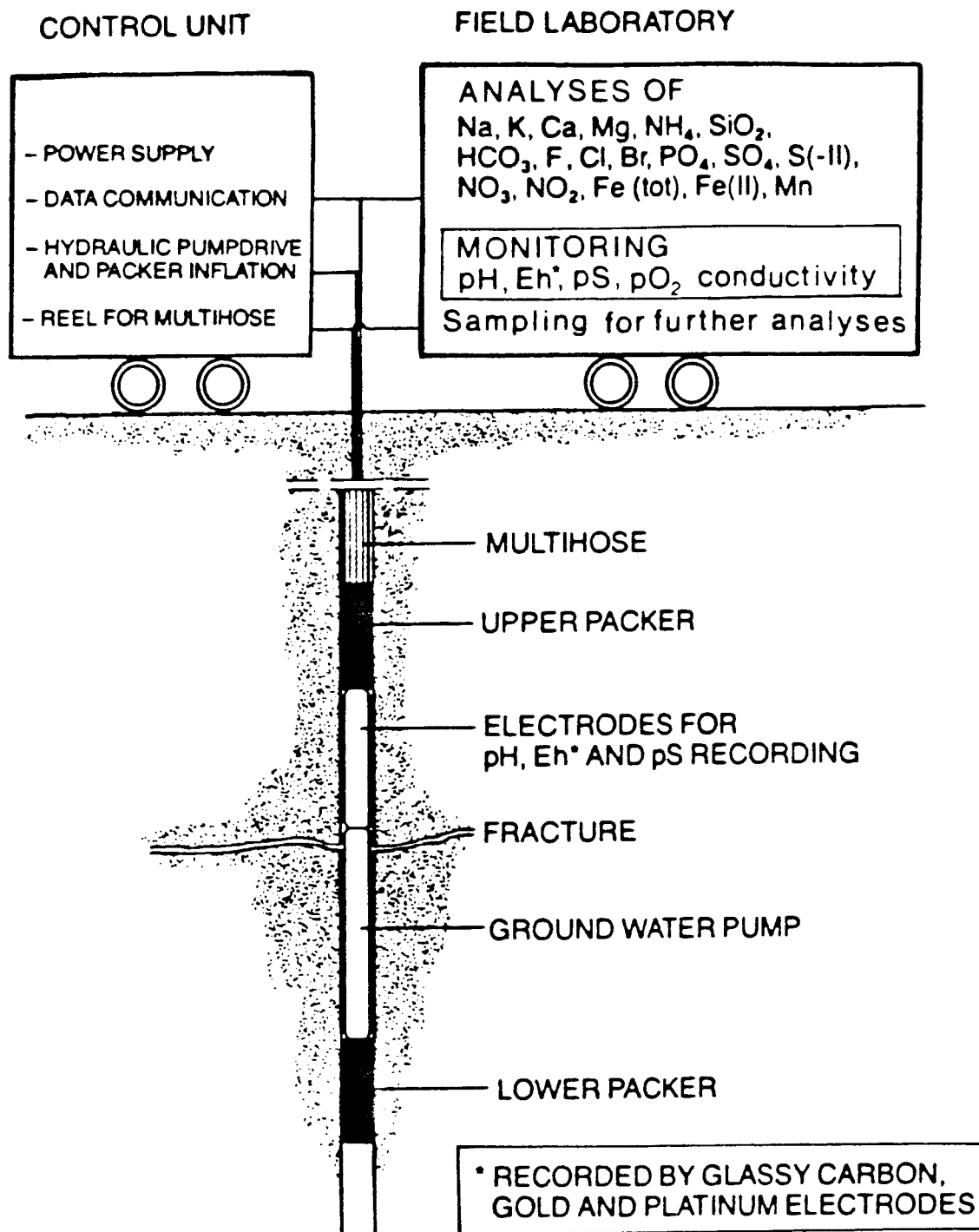


Figure 2-1

ethylene tube. Unpreserved and acid-preserved reference samples are frozen and kept in cold storage to permit supplementary analyses. For the analyses presented in Table 8-16, as well as for the frozen samples, a couple of bottles of water are allowed to overflow before the brim-filled bottle is sealed. The water that is analyzed in the field laboratory is not bottled.

2.3.1 Sampling number

Each sampling occasion is assigned a unique sampling number, which is the same for all samples taken during a 24-hour period. The number, which is given in Tables 1-2, is indicated on each individual sample bottle by means of printed and different-coloured labels. Red labels are used for acid-preserved samples intended for metal analysis (1 ml concentrated hydrochloric acid (super-pure) per 100 ml sample).

3 AUTOMATICALLY RECORDED MEASUREMENTS

The measurements of the water's redox properties and pH are reported in Tables 4-7 and the E° values obtained from the field calibrations are reported in Table 3. pH and conductivity recorded simultaneously in laboratory analyses are presented in Tables 8 and 11.

Conductivity and dissolved oxygen are only recorded at the surface. From 1984 onwards Eh, pH and pS are recorded both at the bottom and at the surface. Glassy carbon, platinum and gold electrodes are used for the Eh measurements. A detailed description of the older measuring equipment is provided in KBS TR 83-44 and of the new equipment in SKB TR 86-16.

3.1 CALIBRATION

All calibration solutions, except the one used for the conductivity cell, are prepared freshly from concentrate from ampules and deaerated purified water (ion exchanger). In the calibration procedure, the solutions are circulated through the measuring chamber. Bottom probe and surface electrodes are calibrated separately.

For calibration of the pH electrodes, three buffer solutions are prepared with pH 4, 7 and 10. Quinhydrone is added to the buffer solutions with pH 4 and 7 for simultaneous calibration of the Eh electrodes. For calibration of the sulphide electrode, alkaline solutions are prepared that are 0.01 and 0.05 molar with respect to sulphide ion. Recording during the calibration is done automatically. Calculated E° values are presented in Table 3.

The oxygen probe is calibrated against air-saturated purified water (ion exchanger) and the conductivity cell against 0.01 and 0.1 mol/l KCl.

3.2 MEASUREMENT

At least one value per hour is recorded automatically with the aid of a computer.

It takes some time after each calibration before the water in the measuring chambers is representative of the borehole water and then before the Eh and pS values have stabilized. Values measured 72 hours after calibration are reported for Kl 2, 761 m. In other cases, more than a week has passed between calibration and reporting of results. Values resulting from samplings that have obviously failed due to operating disturbances in the field are not reported.

3.2.1 Temperature measurement

The temperature is measured in the measuring chambers in order to permit calibration and calculation of the electrode potentials. Only the temperature measured in the bottom probe is representative of the groundwater. It is reported in Tables 4 and 6.

3.2.2 Measurement of pH, pS and Eh

The pH and pS measurements are presented in Tables 4 and 6 and the Eh measurements in Tables 5 and 7. pH measurements (surface) simultaneous with the laboratory analyses are also presented in Tables 8 and 11. The electrodes are normally cleaned in connection with calibration. The system normally needs to be undisturbed about one week before the Eh and pS values approach stable levels. The pH value normally stabilizes much faster. Periods with very rapid potential fluctuations are not reported in the tables.

3.2.3 Oxygen measurement with probe

The oxygen probe should be calibrated more often than is possible with respect to other electrodes. The quality of the measured oxygen concentrations is therefore always difficult to judge. In this case, however, the values have been considered to be so uncertain that they have not been reported.

4 MAIN COMPONENTS OF THE WATER

The analysis results are presented in Tables 8-13 - pH, conductivity, organic carbon and silicon in Tables 8 and 11, metal ions in Tables 9 and 12, anions and ammonium in Tables 10 and 13. pH and conductivity marked with "y" are recorded in the measuring chamber simultaneously with sampling for laboratory analyses.

The chemical analyses confirm that conditions within the sampling area are uniform. Conductivity varies between 23 and 38 mS/m. The sodium concentration is higher than the calcium concentration in the deep water from Kl 9 and in Kl 2, 741 m and 860 m. The opposite situation prevails in the shallower waters from Kl 2, 326 m and Kl 1, 406 m - as well as in the intervening levels (761 m and 777 m) in Kl 2. In Kl 1, the chloride ions dominate, while bicarbonate dominates in all other waters.

4.1 LABORATORY ANALYSES

Starting in 1984, the analyses have primarily been carried out in the mobile field laboratory. Control analysis of approximately one sample per week has been carried out at AB IVL in Stockholm.

Bromide and the redox-sensitive parameters ion(II), nitrite, sulphide and sulphate have only been analyzed in the field laboratory and aluminium, lithium, strontium, iodide and organic carbon (TOC) only by IVL.

The following analysis methods have been used:

- pH and conductivity. Values marked with "b" and "y" in Tables 8 and 11 have been recorded automatically from the in-situ probe ("b") and the measuring chamber in field laboratory ("y") before it has come into contact with the air (see Section 3). The control analyses, which were performed in accordance with Swedish Standard (SS), are marked with "1".
- Metal ions. In the field laboratory, sodium and potassium are determined by means of ion chromatography, calcium and magnesium titrimetrically in accordance with SS, iron and manga-

nese spectrophotometrically - iron with ferrozine and manganese with periodate oxidation. At IVL, all metals are determined by means of atomic absorption spectrophotometry.

- Fluoride, chloride, bromide and sulphate have been determined in the field laboratory by means of ion chromatography, while IVL has determined chloride titrimetrically in accordance with Mohr (SS) and fluoride by means of potentiometric titration (SS).
- Nutrients and sulphide photometrically in accordance with SS.
- Silicon has been determined at IVL by means of atomic absorption, while the field laboratory has determined SiO₂ photometrically (yellow silicon molybdate complex).
- Bicarbonate has been determined titrimetrically as alkalinity at pH 5.4 in accordance with SS.
- TOC has been determined with a carbon analyzer from Astro.
- Iodide has been determined photometrically by means of the "Leuco Crystal Violet Method".

4.2 SAMPLING

The water samples are taken through a valve immediately after the refrigerator (2.2). All sampling water passes a filter cartridge with a pore diameter of 0.45 μm before it is sampled except in sampling for determination of iron and manganese where a polycarbonate membrane (0.4 μm) is used as from July 1985. Analysis of the particulate matter (Table 14) shows that a considerable portion of the iron can consist of small particles, which can be smaller than 0.4 μm .

4.3 TRANSPORT OF SAMPLES

Samples to the control laboratory are packed in specially made cases. The cases are mailed "express" on the afternoon of the sampling day and delivered to the laboratory the following morning. No samples were sent on Fridays or Saturdays, since the samples could then not be taken care of by the laboratory until the following Monday.

5 ASSESSMENT OF ANALYSIS RESULTS

The judgement below is given only from an analytical viewpoint based on available information on the analyses - double values, scatter and previous experience. Evaluation of the results from other viewpoints will be performed in connection with their use by experts within different fields.

In general, it can be said that the measurements with the new in-situ probe, as well as the analyses in the mobile field laboratory, have succeeded beyond expectation.

5.1 AUTOMATIC RECORDINGS

Equilibrium is achieved in the in-situ probe faster than at the surface, which is probably because there is adsorbed oxygen in lines etc. that affects the water during its transport to the surface. After a few days' pumping, the differences have generally been evened out, and after a longer period of measurement, the agreement between in-situ ("b") and the surface ("y") is very good, as is shown in Tables 4-7. Obviously incorrect results are not reported.

5.1.1 pH and conductivity

The pH of all waters is around 8. The highest value, pH 8.7, was measured in the deepest water (K1 2, 860 m).

There is a small difference between pH measured at the in-situ and at the surface, which is probably due to differences in the carbon dioxide balance. Laboratory verifications show good agreement with the values recorded at the surface.

5.1.2 Redox potential

The redox potential was measured simultaneously with platinum, gold and glassy carbon electrodes placed in the in-situ probe and in the measuring chamber at the surface. All Eh values are approximately -300 mV. The good agreement between the measurements makes it probable that they reflect the actual state of the water. Observe, however, the unusually high contamination with drilling water at the deeper levels in Kl 2. The extent of contamination with drilling water in Kl 1 is not known (2.1).

5.1.3 pS

The pS value depends on total content of sulphide and pH. However, at low sulphide contents the sulphide electrode measures Eh instead of pS. Therefore pS has to be compared to Eh. It is recommended that the laboratory values of sulphide content are used first hand.

5.1.4 Measurement of conductivity

The conductivity measurements (Tables 8 and 11) have been consistently stable and exhibit good agreement with the control analysis in Kl 2, 860 m (Table 14).

5.2 **MOBILE FIELD LABORATORY**

In the field laboratory, double analyses are performed of all analysis parameters. Approximately once a week samples are sent to AB IVL in Stockholm for control analysis of the stable ions. Iron(II), sulphate, sulphide, bromide and nitrite are only analyzed in the field laboratory and TOC, strontium, aluminium and lithium only at IVL.

The analyses where the results of the field laboratory and the control laboratory do not agree are commented on below. For the sake of continuity in the measurement series, the results of the field laboratory are given unless otherwise specified.

5.2.1 Potassium

The concentration is uniformly low, around 1 mg/l. For Kl 9, IVL's analyses are consistently 0.1-0.2 mg/l lower than the mobile laboratory's.

5.2.2 Calcium and magnesium

The determination is performed titrimetrically with EDTA in the field laboratory. In the analysis, both the sum of calcium and magnesium and calcium alone are determined. The latter analysis is the more difficult of the two. Magnesium is determined as the difference between the two results.

The scatter in the analysis results is relatively great and the largest relative deviation from the control laboratory is found, naturally enough, in the magnesium concentration. If the mole sum (Ca + Mg) is considered, the scatter is acceptable and the agreement with the control laboratory good.

5.2.3 Iron

The colorimetric determination in the field laboratory shows that the dissolved iron is present as ferrous iron, i.e. iron(II). The control analysis of the total concentration performed by means of atomic absorption spectrophotometry shows good agreement in Kl 9, but gives roughly twice the value in Kl 1 and Kl 2. The analyses of particulate matter (Table 14) show that a considerable portion of the particulate iron in Kl 1 and Kl 2 is present in the form of particles smaller than 0.4 μm .

One explanation for the difference in the analysis results is that the particulate matter has not been completely dissolved in the colorimetric analysis. This assumption is confirmed by the unusually great scatter in the results from the field laboratory. The analyses are performed in acid solution, but the sample has not been heat-treated in an autoclave, as is prescribed in Swedish Standard. In other words, the scatter could be due to the fact that a varying portion of the particulate iron has been undissolved during the analysis, owing to the fact that the sample has been acidified for varying lengths of time prior to the analysis.

Another explanation for the scatter in the results could be the column filter (0.45 μm) that has been used for all sample water in the field laboratory. The same filter is used a couple of days in succession, and the longer it is used the more particles with pore diameter less than 0.45 μm can be assumed to be retained in the filter. In order to avoid this source of error, water for iron and manganese analysis has been filtered through a polycarbonate membrane with a pore diameter of 0.4 μm since July 1985.

5.2.4 Fluoride

In the ion chromatographic analysis, the fluoride peak comes right at the beginning of the chromatogram and is therefore difficult to evaluate. In cases of poor agreement, IVL's results are therefore reported.

5.2.5 Ammonium and nitrate

The concentrations are too low for the ion chromatograph. IVL's results have therefore been reported. As of 85-08-23 (K1 9), the field laboratory also analyzes ammonium photometrically in accordance with Swedish Standard.

6 PARTICULATE MATTER

For determination of the chemical composition of the particulate matter, the water has been filtered through three membrane filters of polycarbonate with successively decreasing pore size - nominal pore diameter 0.4, 0.2 and 0.05 μm . Scandlab in Sollentuna has determined aluminium, calcium, iron, manganese, silicon and sulphur on the membranes. The results are reported as $\mu\text{g/l}$ of filtered sample in Table 14.

7 ISOTOPE ANALYSIS

Isotope analysis of light elements in the water is performed primarily in order to permit calculations of the age and origin of the water. The heavy radioactive elements are determined because the natural background levels are of great interest for the SKB project.

The analyses were performed at the following laboratories: Laboratory for Isotope Geology, Stockholm (see Section 7.1 and 7.2), Department of Physical Geography, Uppsala University (see Section 7.3), Studsvik Energiteknik, Nyköping (see Section 7.4).

7.1 TRITIUM

Owing to its short half-life (about 12 years), tritium is an important isotope in hydrological studies. The amount of tritium in the atmosphere has increased drastically due to experiments with nuclear fission. However, the results are becoming increasingly difficult to interpret the longer the weapons tests continue. At the sampling in Kl 1 during December 1983, the tritium concentration lay at or below the detection limit. When the samplings were resumed in June 1985, 6-7 TU tritium was measured.

The results of sampling in Kl 1 and Kl 2 are presented in the Table below. The tritium concentration is given in the unit TU, which is the number of tritium atoms per 10^{18} hydrogen atoms.

Isotopes of hydrogen, oxygen and sulphur

| Bore-hole | Length m | Date sampling | D o/∞ | Tr TU | O-18 o/∞ | O-18* o/∞ | S-34 o/∞ |
|-----------|-------------|------------------|----------|----------|-------------|--------------|-------------|
| Kl 1 | 406 | 83-11-30 | -85.7 | 3 | | -11.96 | |
| Kl 1 | 406 | 83-12-02 | | 3 | | | |
| Kl 1 | 406 | 83-12-06 | -86.3 | 3 | | -12.02 | |
| Kl 1 | 406 | 83-12-08 | | 3 | | | |
| Kl 1 | 406 | 83-12-12 | -86.5 | | | -12.11 | |
| Kl 1 | 406 | 83-12-13 | | | | | 7.0 |
| Kl 1 | 406 | 83-12-14 | | 3 | | | |
| Kl 1 | 406 | 83-12-15 | | 3 | | | 9.0 |
| Kl 1 | 406 | 85-06-26 | | 7 | | | |
| Kl 1 | 406 | 85-06-29 | | | -11.90 | | |
| Kl 1 | 406 | 85-07-01 | | 6 | | | |
| Kl 2 | 326 | 84-12-06 | | | -12.35 | | |
| Kl 2 | 326 | 84-12-10 | | 3 | | | |
| Kl 2 | 741 | 84-11-06 | | 13 | -11.31 | | |
| Kl 2 | 761 | 84-10-18 | | 25 | | | |
| Kl 9 | 696 | 85-08-19 | | 3 | | | |
| Kl 9 | 696 | 85-08-29 | | 2 | | | |
| Kl 9 | 696 | 85-09-03 | | | -11.93 | | |

7.2

CARBON ISOTOPES

The determination was used for dating by means of the carbon-14 method. The water's contents of carbon dioxide and carbonate have to be concentrated prior to the determination. It is of the utmost importance that the concentrate not be contaminated by carbon-containing chemicals or by contact with air.

The age determination is reported in the Table below as "age BP" and the age after correction for carbon-13 content as "age BP, corr".

Groundwater age

| Bore-hole | Length m | Date sampling | Age BP year | Age BP corr | C-13 o/∞ |
|-----------|-------------|------------------|----------------|----------------|-------------|
| Kl 1 | 406 | 83-12-06 | 28375 | 28500 | -17.0 |
| Kl 9 | 696 | 85-09-03 | 30795 | 30295 | -15.7 |

7.2.1 Sample preparation

A polyethylene barrel holding 130 l and filled from the start with nitrogen is filled with water. Hydrochloric acid is added in order to break down carbonates in the water to carbon dioxide. A nitrogen gas stream is then used to drive the carbon dioxide over to a wash bottle containing carbonate-free sodium hydroxide.

7.3 DEUTERIUM, OXYGEN AND SULPHUR

The analyses provide information on the age of the water and on the climatic conditions prevailing at the time of infiltration (see the table in Section 7.1).

The concentrations in the table of Section 7.1 refer to deviations in per mill from SMOW (Standard Mean Oceanic Water).

7.4 URANIUM, THORIUM, RADIUM AND RADON

The natural concentration of these elements in the groundwater is of great interest to the project. The analyses are reported in Table 15. The concentrations for U, Ra and Rn are given in Bq/l. The following relationships apply: 39.4 μg U per Bq, 2.74×10^{-5} μg Ra-226 per Bq, 1.76×10^{-10} μg Rn-222 per Bq.

8 GAS ANALYSIS

In the samples from K1 1 and K1 2, nitrogen, oxygen, hydrogen, carbon dioxide, helium, argon and methane were determined in the gas that spontaneously leaves the water on passage through a Horst bottle. AGA SpecialGas, Lidingö, performed the analyses.

Gas analysis

| Bore-hole | Length m | Date sampling | Water- vol l | Gas- vol ml | N2 % | O2 % | H2 % | CO2 % | He % | Ar % | CH4 % |
|-----------|-------------|------------------|--------------------|-------------------|---------|---------|---------|----------|---------|---------|----------|
| K1 1 | 406 | 83-12-07 | 9 | 105 | 94.5 | | | .03 | .30 | | |
| K1 1 | 406 | 83-12-15 | | | 96.8 | | | .03 | .21 | | |
| K1 1 | 406 | 85-06-29 | 1 | 205 | 97.2 | .12 | .002 | .01 | .07 | .08 | .016 |
| K1 2 | 326 | 84-12-09 | | | 96.0 | .10 | .050 | .10 | .22 | 1.40 | .120 |

Besides the gas phase's percentage content of the analyzed gases, the table below also shows the amount of water that has passed through the Horst bottle and the gas volume obtained. The concentrations cannot be related directly to the water volume, since the conditions of degassing are uncertain.

Table 1

| Bore-hole | Length m | Depth m | Date | Sampling No | W. flow ml/min | Drilling water, % |
|-----------|-------------|------------|----------|----------------|-------------------|----------------------|
| KL01 | 0406 | 0398 | 83-11-23 | 1001 | 52.0 | |
| | | | 83-11-24 | 1002 | 46.0 | |
| | | | 83-11-29 | 1003 | | |
| | | | 83-11-30 | 1004 | | |
| | | | 83-12-01 | 1005 | | |
| | | | 83-12-02 | 1006 | | |
| | | | 83-12-05 | 1007 | | |
| | | | 83-12-06 | 1008 | | |
| | | | 83-12-07 | 1009 | | |
| | | | 83-12-08 | 1010 | 50.0 | |
| | | | 83-12-12 | 1011 | | |
| | | | 83-12-13 | 1012 | 45.0 | |
| | | | 83-12-14 | 1013 | | |
| | | | 83-12-15 | 1014 | | |
| | | | 85-06-17 | 1156 | 45.5 | |
| | | | 85-06-17 | 1157 | | |
| | | | 85-06-18 | 1158 | 25.0 | |
| | | | 85-06-22 | 1160 | 35.0 | |
| | | | 85-06-23 | 1161 | 28.0 | .03 |
| | | | 85-06-25 | 1162 | 26.0 | |
| | | | 85-06-25 | 1163 | 32.0 | .02 |
| | | | 85-06-26 | 1164 | 20.0 | .02 |
| | | | 85-06-27 | 1165 | 30.0 | .02 |
| KL09 | 0696 | 0581 | 85-08-13 | 1170 | 203.0 | .01 |
| | | | 85-08-14 | 1171 | 207.0 | |
| | | | 85-08-15 | 1172 | 202.0 | |
| | | | 85-08-16 | 1173 | 208.0 | |
| | | | 85-08-18 | 1174 | 195.0 | |
| | | | 85-08-18 | 1175 | 194.0 | |
| | | | 85-08-19 | 1176 | 194.0 | |
| | | | 85-08-20 | 1177 | 188.0 | |
| | | | 85-08-21 | 1178 | 186.0 | |
| | | | 85-08-22 | 1178 | 185.0 | .01 |
| | | | 85-08-23 | 1179 | 180.0 | |
| | | | 85-08-26 | 1182 | 205.0 | |
| | | | 85-08-27 | 1183 | 205.0 | |
| | | | 85-08-28 | 1184 | 197.0 | |
| | | | 85-08-29 | 1185 | 204.0 | |
| | | | 85-08-30 | 1186 | 203.0 | |
| | | | 85-09-02 | 1188 | 202.0 | .01 |
| | | | 85-09-03 | 1189 | 200.0 | |
| | | | 85-09-04 | 1190 | 202.0 | |
| | | | 85-09-05 | 1191 | 195.0 | |

Table 2

| Bore-hole | Length m | Depth m | Date | Sampling No | W. flow ml/min | Drilling water, % | | | |
|-----------|-------------|------------|----------|----------------|-------------------|----------------------|------|-------|------|
| KL02 | 0326 | 0320 | 84-11-15 | 1099 | 47.0 | 5.32 | | | |
| | | | 84-11-16 | 1100 | 54.0 | 1.81 | | | |
| | | | 84-11-17 | 1101 | 50.0 | .83 | | | |
| | | | 84-11-19 | 1103 | 47.0 | .42 | | | |
| | | | 84-11-20 | 1104 | 43.0 | .32 | | | |
| | | | 84-11-21 | 1105 | 44.0 | .27 | | | |
| | | | 84-11-22 | 1106 | 43.0 | .24 | | | |
| | | | 84-11-24 | 1108 | 40.0 | .20 | | | |
| | | | 84-11-26 | 1110 | 41.0 | .16 | | | |
| | | | 84-11-27 | 1111 | 45.0 | .15 | | | |
| | | | 84-11-28 | 1112 | 43.0 | .13 | | | |
| | | | 84-11-29 | 1113 | 45.0 | .13 | | | |
| | | | 84-11-30 | 1114 | 43.0 | .12 | | | |
| | | | 84-12-03 | 1117 | 52.0 | .10 | | | |
| | | | 84-12-04 | 1118 | 48.0 | .11 | | | |
| | | | 84-12-05 | 1119 | 48.0 | .09 | | | |
| | | | 84-12-06 | 1120 | 41.0 | .08 | | | |
| | | | 84-12-07 | 1121 | 43.0 | .08 | | | |
| | | | KL02 | 0741 | 0727 | 84-10-25 | 1081 | 70.0 | 4.45 |
| | | | | | | 84-10-26 | 1082 | 71.0 | 6.44 |
| 84-10-27 | 1083 | 76.0 | | | | 6.86 | | | |
| 84-10-28 | 1084 | 73.0 | | | | 7.69 | | | |
| 84-10-29 | 1085 | 71.0 | | | | 7.21 | | | |
| 84-10-30 | 1086 | 73.0 | | | | 7.18 | | | |
| 84-10-31 | 1087 | 76.0 | | | | 7.01 | | | |
| 84-11-01 | 1088 | 74.0 | | | | 6.97 | | | |
| 84-11-02 | 1089 | 75.0 | | | | 6.90 | | | |
| 84-11-03 | 1090 | 75.0 | | | | 7.06 | | | |
| 84-11-04 | 1091 | 73.0 | | | | 6.60 | | | |
| 84-11-05 | 1092 | 72.0 | | | | 6.47 | | | |
| 84-11-06 | 1093 | 71.0 | | | | 5.99 | | | |
| KL02 | 0761 | 0746 | | | | 84-10-11 | 1069 | 170.0 | 5.32 |
| | | | 84-10-12 | 1070 | 165.0 | 3.15 | | | |
| | | | 84-10-13 | 1071 | 175.0 | 4.39 | | | |
| | | | 84-10-14 | 1072 | 175.0 | 4.74 | | | |
| | | | 84-10-15 | 1073 | 172.0 | 6.02 | | | |
| | | | 84-10-16 | 1074 | 172.0 | 6.87 | | | |
| | | | 84-10-17 | 1075 | 173.0 | 4.78 | | | |
| | | | 84-10-18 | 1076 | 170.0 | 5.23 | | | |
| | | | 84-10-19 | 1077 | 170.0 | 5.09 | | | |
| | | | KL02 | 0777 | 0762 | 84-10-08 | 1066 | 95.0 | |
| 84-10-09 | 1067 | 170.0 | | | | 4.20 | | | |
| 84-10-22 | 1078 | 186.0 | | | | 4.56 | | | |
| 84-10-23 | 1079 | 187.0 | | | | 4.39 | | | |
| 84-10-24 | 1080 | 187.0 | | | | 5.01 | | | |
| KL02 | 0860 | 0843 | 85-05-20 | 1150 | | 4.54 | | | |
| | | | 85-05-21 | 1151 | 79.0 | | | | |
| | | | 85-05-22 | 1152 | 84.0 | 4.17 | | | |
| | | | 85-05-23 | 1153 | 80.0 | 3.80 | | | |
| | | | 85-06-05 | 1155 | | 3.50 | | | |

E^o-values (mV) obtained from the field calibrations

| Bore-hole | Calibr. date | Used until or from | pH _b | pH _y | C _b | Pt _b | Au _b | C _y | Pt _y | Au _y | C _y error | pS _b | pS _y |
|-----------|--------------|--------------------|-----------------|-----------------|----------------|-----------------|-----------------|----------------|-----------------|-----------------|----------------------|-----------------|-----------------|
| KL01 | 83-11-22 | | | 435 | | | | 254 | 254 | | | | - 860 |
| | 83-12-19 | 11-23 | | 435 | | | | 254 | 251 | | | | - 860 |
| | 85-06-13 | | 206 | 380 | 179 | 207 | 198 | 256 | 256 | 258 | 221 | - 656 | - 902 |
| | 85-07-03 | 06-20 | 213 | 373 | 193 | 191 | 193 | 262 | 262 | 265 | 239 | - 663 | - 894 |
| KL02 | 84-10-05 | | 28 | | 392 | 392 | 392 | | | | | | - 998 |
| | 84-10-09 | 11-13 | | 366 | | | | 270 | 269 | 273 | 208 | | - 915 |
| | 84-12-13 | 11-14 | 18 | 370 | 404 | 401 | 402 | 266 | 267 | 269 | 248 | -1009 | - 504 |
| | 85-05-09 | 05-23 | 21 | 384 | 394 | 391 | 390 | 252 | 251 | 251 | 211 | -1028 | - 893 |
| | 85-05-29 | | -114 | | 389 | 389 | 391 | | | | | | - 847 |
| KL09 | 85-08-09 | | 17 | 379 | 382 | 382 | 385 | 259 | 259 | 259 | 240 | -1052 | - 895 |
| | 85-09-06 | 08-22 | 25 | 369 | 386 | 386 | 386 | 266 | 266 | 267 | 268 | -1025 | - 850 |

Table 4

FIELD MEASUREMENT - Temp, pH and pS
(b = bottom, y = surface)

| Bore-hole | Length m | Datum | Kl. | Temp, b oC | pH, b | pH, y | pS, b | pS, y | | |
|-----------|-------------|----------|-------|---------------|-------|-------|-------|-------|-------|-------|
| KL 01 | 0406 | 83-11-30 | 08:04 | | | 8.42 | | 11.27 | | |
| | | 83-12-01 | 08:06 | | | 8.47 | | 11.38 | | |
| | | 83-12-02 | 06:35 | | | 8.45 | | 11.45 | | |
| | | 83-12-05 | 08:45 | | | 8.45 | | 11.18 | | |
| | | 83-12-06 | 08:10 | | | 8.43 | | 11.03 | | |
| | | 83-12-07 | 07:57 | | | 8.50 | | 10.96 | | |
| | | 83-12-08 | 08:12 | | | 8.48 | | 10.96 | | |
| | | 83-12-09 | 10:10 | | | 8.48 | | 10.95 | | |
| | | 83-12-12 | 08:15 | | | 8.45 | | 10.71 | | |
| | | 83-12-13 | 08:17 | | | 8.50 | | 10.53 | | |
| | | 83-12-14 | 08:00 | | | 8.53 | | 10.63 | | |
| | | 83-12-15 | 07:58 | | | 8.49 | | 10.51 | | |
| | | 83-12-16 | 06:53 | | | 8.53 | | 10.38 | | |
| | | 83-12-19 | 07:53 | | | 8.48 | | 10.28 | | |
| | | 85-06-24 | 08:12 | | 12.20 | | 8.36 | | 11.92 | |
| | | 85-06-25 | 08:12 | | 12.20 | | 8.51 | | 11.62 | |
| | | 85-06-26 | 08:25 | | 12.21 | | 8.51 | | 11.65 | |
| | | 85-06-27 | 08:25 | | 12.21 | | 8.57 | | 11.64 | |
| | | 85-06-28 | 09:21 | | 12.22 | | 8.15 | 8.60 | 5.62 | 11.68 |
| | | 85-06-29 | 08:21 | | 12.22 | | 8.07 | 8.60 | 5.65 | 11.68 |
| | | 85-06-30 | 08:21 | | 12.21 | | 8.12 | 8.57 | 5.47 | 11.60 |
| | | 85-07-01 | 08:21 | | 12.22 | | 8.12 | 8.60 | 5.40 | 11.62 |
| | | 85-07-02 | 08:21 | | 12.21 | | 8.22 | 8.65 | 5.14 | 11.79 |
| | | KI 09 | 0696 | 85-08-23 | 08:00 | 14.94 | 7.50 | 8.04 | 13.38 | 12.00 |
| | | | | 85-08-24 | 08:00 | 14.94 | 7.52 | 8.05 | 13.33 | 12.03 |
| | | | | 85-08-25 | 08:00 | 14.95 | 7.55 | 8.02 | 13.21 | 12.03 |
| | | | | 85-08-26 | 08:00 | 14.95 | 7.59 | 8.04 | 13.09 | 12.05 |
| 85-08-27 | 08:00 | | | 14.95 | 7.70 | 8.04 | 12.77 | 12.03 | | |
| 85-08-28 | 08:02 | | | 14.95 | 7.78 | 8.07 | 12.53 | 12.07 | | |
| 85-08-29 | 08:00 | | | 14.95 | 7.78 | 8.03 | 12.46 | 12.00 | | |
| 85-08-30 | 08:18 | | | 14.95 | 7.62 | 8.09 | 12.79 | 12.05 | | |
| 85-08-31 | 08:18 | | | 14.95 | 7.60 | 8.06 | 12.81 | 12.00 | | |
| 85-09-01 | 08:18 | | | 14.96 | 7.60 | 8.03 | 12.80 | 12.04 | | |
| 85-09-02 | 08:13 | | | 14.96 | 7.59 | 8.07 | 12.80 | 12.11 | | |
| 85-09-03 | 08:13 | | | 14.96 | 7.60 | 8.07 | 12.82 | 12.13 | | |
| 85-09-04 | 08:13 | | | 14.96 | 7.60 | 8.04 | 12.84 | 12.11 | | |
| 85-09-05 | 08:13 | | | 14.95 | 7.60 | 8.06 | 12.84 | 12.12 | | |

Table 5

FIELD MEASUREMENT - Eh
(bottom, y = surface)

| Bore-hole | Length m | Datum | K1 | Eh-C, b mV | Eh-Pt, b mV | Eh-Au, b mV | Eh-C, y mV | Eh-Pt, y mV | Eh-Au, y mV | Eh-C, y ex. mV | | |
|-----------|-------------|----------|-------|---------------|----------------|----------------|---------------|----------------|----------------|-------------------|------|------|
| KL01 | 0406 | 83-11-30 | 08 04 | | | | -179 | | | | | |
| | | 83-12-01 | 08 06 | | | | -217 | | | | | |
| | | 83-12-02 | 06 35 | | | | -232 | | | | | |
| | | 83-12-05 | 08 45 | | | | -300 | | | | | |
| | | 83-12-06 | 08 10 | | | | -303 | | | | | |
| | | 83-12-07 | 07 57 | | | | -308 | | | | | |
| | | 83-12-08 | 08 12 | | | | -308 | -389 | | | | |
| | | 83-12-09 | 10 10 | | | | -306 | -335 | | | | |
| | | 83-12-12 | 08 15 | | | | -310 | -283 | | | | |
| | | 83-12-13 | 08 17 | | | | -313 | -295 | | | | |
| | | 83-12-14 | 08 00 | | | | -312 | -271 | | | | |
| | | 83-12-15 | 07 58 | | | | -313 | -289 | | | | |
| | | 83-12-16 | 06 53 | | | | -315 | -305 | | | | |
| | | 83-12-19 | 07 53 | | | | -312 | -305 | | | | |
| | | 85-06-24 | 08 12 | | | | -244 | -285 | | | -154 | |
| | | 85-06-25 | 08 12 | | | | -309 | -303 | | | -222 | |
| | | 85-06-26 | 08 25 | | | | -314 | -311 | | | -252 | |
| | | 85-06-27 | 08 25 | | | | -318 | -314 | | | -308 | |
| | | 85-06-28 | 09 21 | | | -311 | -195 | -223 | -318 | -316 | -230 | -319 |
| | | 85-06-29 | 08 21 | | | -304 | -197 | -265 | -319 | -318 | -236 | -323 |
| | | 85-06-30 | 08 21 | | | -306 | -273 | -295 | -320 | -319 | -295 | -327 |
| | | 85-07-01 | 08 21 | | | -305 | -288 | -299 | -320 | -320 | -296 | -330 |
| | | 85-07-02 | 08 21 | | | -309 | -303 | -312 | -320 | -321 | -297 | -329 |
| KL09 | 0696 | 85-08-23 | 08 00 | | | | - 35 | -126 | | | -111 | |
| | | 85-08-24 | 08 00 | | | | -186 | -213 | | | -134 | |
| | | 85-08-25 | 08 00 | | | | -207 | -274 | | | -149 | |
| | | 85-08-26 | 08 00 | | | | -211 | -280 | | | -187 | |
| | | 85-08-27 | 08 00 | | | | -220 | -297 | | | -207 | |
| | | 85-08-28 | 08 02 | | | | -228 | -324 | | | -256 | |
| | | 85-08-29 | 08 00 | | | | -273 | -340 | | | -281 | |
| | | 85-08-30 | 08 18 | | | | -268 | -283 | | | -287 | |
| | | 85-08-31 | 08 18 | | | | -268 | -274 | | | -289 | |
| | | 85-09-01 | 08 18 | | | | -270 | -274 | | | -289 | |
| | | 85-09-02 | 08 13 | | | | -271 | -274 | | | -291 | |
| | | 85-09-03 | 08 13 | | | | -273 | -276 | | | -292 | |
| | | 85-09-04 | 08 13 | | | | -274 | -276 | | | -293 | |
| | | 85-09-05 | 08 13 | | | | -275 | -278 | | | -294 | |

Table 6

FIELD MEASUREMENT - Temp, pH and pS
(b = bottom, y = surface)

| Bore-hole | Length m | Datum | K1 | Temp, b oC | pH, b | pH, y | pS, b | pS, y |
|-----------|-------------|----------|-------|---------------|-------|-------|-------|-------|
| KL02 | 0326 | 84-11-16 | 08:00 | 11.31 | 7.76 | 8.16 | 9.66 | 10.94 |
| | | 84-11-17 | 08:00 | 11.31 | 7.71 | 8.12 | 9.73 | 11.17 |
| | | 84-11-18 | 08:00 | 11.31 | 7.71 | 8.13 | 9.83 | 11.51 |
| | | 84-11-19 | 08:00 | 11.32 | 7.68 | 8.14 | 9.92 | 11.80 |
| | | 84-11-20 | 08:00 | 11.32 | 7.67 | 8.09 | 10.05 | 11.89 |
| | | 84-11-21 | 08:00 | 11.33 | 7.66 | 8.06 | 10.08 | 11.93 |
| | | 84-11-22 | 07:00 | 11.32 | 7.65 | 8.07 | 10.15 | 11.98 |
| | | 84-11-23 | 08:00 | 11.32 | 7.65 | 8.04 | 10.17 | 12.00 |
| | | 84-11-24 | 08:00 | 11.33 | 7.64 | 8.00 | 10.22 | 11.97 |
| | | 84-11-25 | 08:00 | 11.32 | 7.64 | 7.97 | 10.20 | 11.93 |
| | | 84-11-26 | 08:00 | 11.33 | 7.63 | 7.99 | 10.22 | 11.96 |
| | | 84-11-27 | 08:00 | 11.33 | 7.63 | 8.12 | 10.22 | 12.11 |
| | | 84-11-28 | 08:46 | 11.33 | 7.62 | 8.06 | 10.36 | 12.00 |
| | | 84-11-29 | 08:00 | 11.33 | 7.62 | 8.03 | 10.49 | 11.97 |
| | | 84-11-30 | 08:00 | 11.34 | 7.62 | 8.03 | 10.51 | 11.97 |
| | | 84-12-01 | 08:00 | 11.34 | 7.61 | 8.05 | 10.66 | 11.99 |
| | | 84-12-02 | 08:00 | 11.33 | 7.61 | 8.07 | 10.66 | 12.03 |
| | | 84-12-04 | 08:00 | 11.34 | 7.60 | 8.08 | 10.58 | 11.98 |
| | | 84-12-05 | 08:00 | 11.34 | 7.60 | 8.12 | 10.66 | 12.03 |
| | | 84-12-07 | 08:00 | 11.34 | 7.59 | 8.11 | 10.77 | 11.98 |
| | | 84-12-08 | 08:00 | 11.34 | 7.60 | 8.04 | 10.79 | 11.90 |
| 84-12-09 | 08:00 | 11.34 | 7.60 | 8.07 | 10.77 | 11.95 | | |
| 84-12-10 | 08:00 | 11.34 | 7.60 | 8.11 | 10.77 | 11.99 | | |
| 84-12-11 | 08:00 | 11.34 | 7.60 | 8.12 | 10.75 | 11.99 | | |
| KL02 | 0623 | 84-11-08 | 08:00 | 15.49 | 7.91 | 7.69 | 9.13 | 12.48 |
| | | 84-11-09 | 08:00 | 15.50 | 7.99 | 7.73 | 8.94 | 11.78 |
| | | 84-11-10 | 08:00 | 15.51 | 8.02 | 7.86 | 8.82 | 11.49 |
| | | 84-11-11 | 08:00 | 15.51 | 8.04 | 7.88 | 8.78 | 11.32 |
| | | 84-11-12 | 12:00 | 15.51 | 8.05 | 7.90 | 8.69 | 11.29 |
| | | 84-11-13 | 08:00 | 15.52 | 8.04 | 8.04 | 8.69 | 11.30 |
| | | 84-11-14 | 07:00 | 15.53 | 8.03 | 7.96 | 8.75 | 11.05 |
| KL02 | 0741 | 84-10-27 | 08:00 | 17.19 | 8.04 | 7.97 | 10.17 | 11.82 |
| | | 84-10-28 | 08:00 | 17.20 | 8.06 | 8.11 | 9.91 | 11.62 |
| | | 84-10-29 | 08:00 | 17.20 | 8.09 | 8.16 | 9.63 | 11.47 |
| | | 84-10-30 | 08:00 | 17.21 | 8.11 | 8.15 | 9.39 | 11.32 |
| | | 84-10-31 | 08:00 | 17.20 | 8.14 | 8.11 | 9.16 | 11.24 |
| | | 84-11-01 | 08:00 | 17.21 | 8.15 | 8.17 | 8.99 | 11.26 |
| | | 84-11-01 | 15:00 | 17.21 | 8.16 | 8.12 | 8.96 | 11.21 |
| | | 84-11-02 | 08:00 | 17.22 | 8.16 | 8.19 | 8.87 | 11.30 |
| | | 84-11-03 | 08:00 | 17.21 | 8.17 | 8.24 | 8.73 | 11.29 |
| | | 84-11-04 | 08:00 | 17.22 | 8.17 | 8.24 | 8.70 | 11.30 |
| | | 84-11-05 | 08:00 | 17.21 | 8.17 | 8.24 | 8.63 | 11.28 |
| 84-11-06 | 08:00 | 17.22 | 8.16 | 8.24 | 8.56 | 11.27 | | |
| KL02 | 0761 | 84-10-12 | 08:00 | 17.51 | 7.94 | 7.94 | 11.43 | 13.33 |
| | | 84-10-13 | 08:00 | 17.51 | 7.87 | 7.98 | 11.55 | 13.25 |
| | | 84-10-14 | 08:00 | 17.51 | 7.86 | 7.96 | 11.53 | 13.25 |
| | | 84-10-15 | 08:00 | 17.52 | 7.91 | 8.01 | 11.41 | 13.13 |
| | | 84-10-16 | 08:00 | 17.53 | 7.96 | 8.04 | 11.25 | 13.08 |
| | | 84-10-17 | 08:00 | 17.54 | 8.02 | 7.99 | 11.08 | 13.00 |
| | | 84-10-18 | 08:00 | 17.53 | 8.08 | 8.03 | 10.92 | 12.96 |
| | | 84-10-19 | 08:00 | 17.54 | 8.11 | 8.02 | 10.78 | 12.87 |
| KL02 | 0777 | 84-10-21 | 08:00 | 17.77 | 8.13 | 8.11 | 10.60 | 12.92 |
| | | 84-10-22 | 08:00 | 17.78 | 8.17 | 8.15 | 10.45 | 12.85 |
| | | 84-10-23 | 15:00 | 17.77 | 8.18 | 8.11 | 10.38 | 12.72 |
| | | 84-10-24 | 11:00 | 17.78 | 8.18 | 8.13 | 10.29 | 12.68 |
| KL02 | 0860 | 85-05-18 | 08:44 | 18.88 | 7.93 | 8.43 | 12.58 | 12.07 |
| | | 85-05-19 | 08:44 | 18.88 | 8.01 | 8.56 | 12.48 | 11.76 |
| | | 85-05-20 | 08:44 | 18.88 | 8.07 | 8.58 | 12.30 | 11.34 |
| | | 85-05-21 | 08:44 | 18.88 | 8.11 | 8.63 | 12.17 | 11.33 |
| | | 85-05-22 | 08:56 | 18.89 | 8.15 | 8.72 | 12.06 | 11.24 |
| | | 85-05-23 | 08:22 | 18.88 | 8.12 | 8.73 | 12.10 | 11.08 |

Table 7

FIELD MEASUREMENT - Eh
(bottom, y = surface)

| Bore-hole | Length m | Datum | K1 | Eh-C. b mV | Eh-Pt. b mV | Eh-Au. b mV | Eh-C. y mV | Eh-Pt. y mV | Eh-Au. y mV | Eh-C. y ex. mV |
|-----------|-------------|----------|-------|---------------|----------------|----------------|---------------|----------------|----------------|-------------------|
| KL 02 | 0326 | 84-11-16 | 08:00 | -339 | -347 | -345 | -316 | -353 | -281 | -314 |
| | | 84-11-17 | 08:00 | -335 | -343 | -340 | -304 | -323 | -276 | -310 |
| | | 84-11-18 | 08:00 | -330 | -340 | -336 | -288 | -300 | -272 | -306 |
| | | 84-11-19 | 08:00 | -326 | -336 | -332 | -265 | -280 | -270 | -302 |
| | | 84-11-20 | 08:00 | -321 | -331 | -325 | -259 | -280 | -269 | -301 |
| | | 84-11-21 | 08:00 | -321 | -327 | -322 | -258 | -280 | -271 | -300 |
| | | 84-11-22 | 07:00 | -318 | -323 | -317 | -258 | -279 | -273 | -300 |
| | | 84-11-23 | 08:00 | -318 | -319 | -314 | -258 | -279 | -276 | -300 |
| | | 84-11-24 | 08:00 | -317 | -316 | -311 | -261 | -280 | -277 | -302 |
| | | 84-11-25 | 08:00 | -317 | -314 | -310 | -260 | -278 | -277 | -304 |
| | | 84-11-26 | 08:00 | -319 | -313 | -309 | -259 | -280 | -277 | -305 |
| | | 84-11-27 | 08:00 | -319 | -312 | -308 | -261 | -279 | -274 | -302 |
| | | 84-11-28 | 08:46 | -311 | -306 | -302 | -260 | -281 | -277 | -305 |
| | | 84-11-29 | 08:00 | -305 | -298 | -296 | -260 | -282 | -276 | -307 |
| | | 84-11-30 | 08:00 | -307 | -297 | -297 | -260 | -282 | -276 | -309 |
| | | 84-12-01 | 08:00 | -298 | -287 | -287 | -261 | -282 | -278 | -310 |
| | | 84-12-02 | 08:00 | -301 | -287 | -288 | -261 | -282 | -275 | -310 |
| | | 84-12-04 | 08:00 | -303 | -289 | -288 | -262 | -282 | -274 | -311 |
| | | 84-12-05 | 08:00 | -303 | -287 | -287 | -263 | -284 | -269 | -310 |
| | | 84-12-07 | 08:00 | -300 | -283 | -285 | -262 | -283 | -268 | -312 |
| | | 84-12-08 | 08:00 | -300 | -282 | -283 | -264 | -285 | -270 | -314 |
| | | 84-12-09 | 08:00 | -302 | -284 | -285 | -263 | -284 | -265 | -314 |
| | | 84-12-10 | 08:00 | -303 | -284 | -286 | -263 | -284 | -266 | -313 |
| 84-12-11 | 08:00 | -303 | -285 | -286 | -263 | -284 | -263 | -313 | | |
| KL 02 | 0623 | 84-11-08 | 08:00 | -352 | -357 | -360 | -254 | -274 | -257 | -326 |
| | | 84-11-09 | 08:00 | -358 | -365 | -367 | -284 | -344 | -274 | -333 |
| | | 84-11-10 | 08:00 | -362 | -369 | -369 | -295 | -360 | -279 | -341 |
| | | 84-11-11 | 08:00 | -362 | -370 | -370 | -301 | -362 | -281 | -347 |
| | | 84-11-12 | 12:00 | -364 | -371 | -372 | -303 | -357 | -280 | -351 |
| | | 84-11-13 | 08:00 | -365 | -371 | -371 | -306 | -353 | -275 | -349 |
| | | 84-11-14 | 07:00 | -363 | -370 | -369 | -310 | -351 | -278 | -353 |
| | | KL 02 | 0741 | 84-10-27 | 08:00 | -311 | -327 | -313 | -265 | -348 |
| 84-10-28 | 08:00 | | | -320 | -321 | -315 | -275 | -367 | -281 | -318 |
| 84-10-29 | 08:00 | | | -328 | -322 | -318 | -281 | -376 | -287 | -325 |
| 84-10-30 | 08:00 | | | -337 | -325 | -321 | -289 | -382 | -292 | -328 |
| 84-10-31 | 08:00 | | | -345 | -328 | -325 | -289 | -386 | -294 | -333 |
| 84-11-01 | 08:00 | | | -350 | -332 | -330 | -289 | -387 | -296 | -338 |
| 84-11-01 | 15:00 | | | -351 | -333 | -331 | -293 | -386 | -296 | -341 |
| 84-11-02 | 08:00 | | | -354 | -337 | -336 | -290 | -386 | -294 | -343 |
| 84-11-03 | 08:00 | | | -357 | -342 | -351 | -291 | -386 | -294 | -347 |
| 84-11-04 | 08:00 | | | -359 | -354 | -358 | -292 | -386 | -295 | -348 |
| 84-11-05 | 08:00 | | | -361 | -359 | -363 | -296 | -384 | -292 | -351 |
| 84-11-06 | 08:00 | -362 | -364 | -368 | -297 | -383 | -294 | -353 | | |
| KL02 | 0761 | 84-10-12 | 08:00 | -282 | -199 | -240 | -245 | -270 | 19 | -33 |
| | | 84-10-13 | 08:00 | -284 | -249 | -263 | -252 | -275 | 61 | -146 |
| | | 84-10-14 | 08:00 | -288 | -268 | -272 | -254 | -278 | -159 | -213 |
| | | 84-10-15 | 08:00 | -293 | -280 | -281 | -258 | -281 | -144 | -276 |
| | | 84-10-16 | 08:00 | -298 | -290 | -289 | -259 | -282 | -169 | -288 |
| | | 84-10-17 | 08:00 | -303 | -299 | -297 | -261 | -285 | -246 | -296 |
| | | 84-10-18 | 08:00 | -308 | -307 | -304 | -261 | -285 | -255 | -300 |
| | | 84-10-19 | 08:00 | -311 | -313 | -309 | -262 | -287 | -262 | -302 |
| KL02 | 0777 | 84-10-21 | 08:00 | -314 | -320 | -315 | -261 | -285 | -266 | -300 |
| | | 84-10-22 | 08:00 | -317 | -325 | -320 | -263 | -286 | -270 | -303 |
| | | 84-10-23 | 15:00 | -318 | -328 | -322 | -265 | -288 | -274 | -305 |
| | | 84-10-24 | 11:00 | -319 | -329 | -323 | -265 | -288 | -276 | -307 |
| KL02 | 0860 | 85-05-18 | 08:44 | -200 | -240 | -235 | -231 | -246 | | -178 |
| | | 85-05-19 | 08:44 | -242 | -284 | -297 | -296 | -310 | | -242 |
| | | 85-05-20 | 08:44 | -278 | -291 | -306 | -309 | -314 | | -359 |
| | | 85-05-21 | 08:44 | -291 | -298 | -311 | -316 | -317 | -249 | -340 |
| | | 85-05-22 | 08:56 | -297 | -296 | -313 | -323 | -325 | -309 | -337 |
| | | 85-05-23 | 08:22 | -297 | -295 | -306 | -329 | -327 | -317 | -337 |

KLIPPERASEN - Field parameters and sundries

| Bore-hole | Length m | Date | pH, y | Cond, y mS/m | Cond. lab mS/m | TDC mg/l | Si mg/l |
|-----------|-------------|----------|-------|-----------------|-------------------|-------------|------------|
| KL01 | 0406 | 85-06-23 | | 28.8 | | | 4.1 |
| | | 85-06-25 | 8.2 | 30.2 | | | 4.1 |
| | | 85-06-25 | 8.3 | 31.0 | 30.9 | 3.7 | 4.2 |
| | | 85-06-26 | 8.3 | 31.6 | | | 4.4 |
| | | 85-06-27 | 8.4 | 31.8 | | | 4.3 |
| | | 85-07-02 | | | | 32.5 | |
| KL09 | 0696 | 85-08-14 | 7.9 | 22.9 | 23.0 | .5 | 9.6 |
| | | 85-08-15 | 7.9 | 22.9 | | | 9.7 |
| | | 85-08-16 | 7.9 | 22.9 | | | 9.7 |
| | | 85-08-17 | 7.9 | 23.0 | | | 9.7 |
| | | 85-08-18 | 7.9 | 23.0 | | | 10.0 |
| | | 85-08-19 | 7.9 | 23.0 | 22.9 | .5 | 9.8 |
| | | 85-08-20 | 7.9 | 23.0 | | | 10.0 |
| | | 85-08-21 | 8.0 | 23.0 | | | 10.0 |
| | | 85-08-23 | 8.0 | 22.9 | | | 10.0 |
| | | 85-08-26 | 8.0 | 23.0 | | | 10.0 |
| | | 85-08-27 | 8.0 | 23.0 | 22.9 | 1.2 | 9.7 |
| | | 85-08-28 | 8.0 | 23.0 | | | 9.9 |
| | | 85-08-29 | 8.0 | 23.0 | | | 9.9 |
| | | 85-08-30 | 8.0 | 23.0 | | | 9.9 |
| | | 85-09-02 | 8.0 | 23.0 | 22.8 | 5 | |
| | | 85-09-03 | 8.0 | 23.0 | | | 9.6 |
| | | 85-09-04 | 8.0 | 23.0 | | | 10.0 |
| 85-09-05 | 8.0 | 23.0 | | | 10.0 | | |

Table 9

KLIPPERASEN - Metal ions

| Bore-hole | Length m | Date | Na mg/l | K mg/l | Li mg/l | Ca mg/l | Mg mg/l | Sr mg/l | Al mg/l | Mn mg/l | Fe. tot mg/l | Fe2+ mg/l | |
|-----------|-------------|----------|------------|-----------|------------|------------|------------|------------|------------|------------|-----------------|--------------|------|
| KL01 | 0406 | 85-06-23 | 45 | .9 | | 14 | 2.6 | | | .05 | .013 | .012 | |
| | | 85-06-25 | 46 | .9 | | 14 | 2.2 | | | .04 | .021 | .021 | |
| | | 85-06-25 | 46 | 1.1 | .01 | 14 | 2.6 | .28 | .01 | .04 | .016 | .012 | |
| | | 85-06-26 | 47 | .9 | | 14 | 2.3 | | | .03 | .006 | .002 | |
| | | 85-06-27 | 48 | .9 | | 14 | 2.3 | | | .04 | .010 | .007 | |
| | | 85-07-02 | 48 | 1.1 | .01 | 15 | | .35 | .04 | .03 | | | |
| | | | | | | | | | | | | | |
| KL09 | 0696 | 85-08-14 | 15 | 1.1 | .015 | 28 | 2 | | .021 | .03 | .074 | .066 | |
| | | 85-08-15 | 16 | 1.4 | | | | | | | .084 | .071 | |
| | | 85-08-16 | 16 | 1.4 | | | | | | | .03 | .071 | .063 |
| | | 85-08-17 | 16 | | | | | | | | | .077 | .069 |
| | | 85-08-18 | 16 | 1.2 | | | | | | | | .081 | .071 |
| | | 85-08-19 | 16 | 1.3 | .020 | | | | .024 | .03 | .080 | | |
| | | 85-08-20 | | | | | | | | .03 | .085 | .079 | |
| | | 85-08-21 | 16 | 1.2 | | 29 | 3 | | | .04 | .088 | .082 | |
| | | 85-08-23 | 16 | 1.2 | | 28 | 3 | | | | .092 | .094 | |
| | | 85-08-26 | 15 | 1.3 | | 29 | 3 | | | | .04 | .092 | .087 |
| | | 85-08-27 | 15 | 1.3 | .002 | 29 | 3 | | .025 | .04 | .100 | .096 | |
| | | 85-08-28 | 16 | 1.3 | | 29 | 3 | | | .03 | .098 | .097 | |
| | | 85-08-29 | 16 | 1.3 | | 29 | 3 | | | .04 | .096 | .092 | |
| | | 85-08-30 | 16 | 1.3 | | 29 | 3 | | | .04 | .096 | .094 | |
| | | 85-09-02 | 16 | 1.1 | .001 | 29 | 3 | | | .05 | .098 | .082 | |
| | | 85-09-03 | 16 | 1.0 | | 30 | 2 | | | .04 | .098 | .091 | |
| | | 85-09-04 | 15 | 1.0 | | 29 | 3 | | | .04 | .092 | .085 | |
| | | 85-09-05 | 15 | 1.0 | | 30 | 2 | | | .04 | .090 | .082 | |

Table 10

KLIPPERÅSEN - Anions + NH4-N

| Bore-hole | Length m | Date | HCO3 mg/l | Cl mg/l | F mg/l | Br mg/l | I mg/l | PO4-P mg/l | SO4 mg/l | S-2, mg/l | NO2-N mg/l | NO3-N mg/l | NH4-N mg/l |
|-----------|-------------|----------|--------------|------------|-----------|------------|-----------|---------------|-------------|--------------|---------------|---------------|---------------|
| KL01 | 0406 | 85-06-23 | 73 | | 3.3 | .32 | | .001 | 2.3 | .01 | .001 | | |
| | | 85-06-25 | 77 | | 3.6 | .34 | | .001 | 2.3 | .01 | .001 | | |
| | | 85-06-25 | 78 | | 3.8 | .38 | .006 | .001 | 1.8 | .15 | .001 | .005 | .01 |
| | | 85-06-26 | 80 | | | .39 | | .001 | 1.5 | .11 | .001 | | |
| | | 85-06-27 | 80 | | | .40 | | .001 | 1.3 | .13 | .001 | | |
| | | 85-07-02 | 79 | | 3.9 | | .008 | | | .09 | | | |
| | | | | | | | | | | | | | |
| KL09 | 0696 | 85-08-14 | 119 | | 3.6 | | .002 | | 4.4 | .01 | .001 | .01 | |
| | | 85-08-15 | 120 | | | | | | 4.5 | .01 | .001 | | |
| | | 85-08-16 | 120 | | | | | | 4.4 | .01 | .001 | | |
| | | 85-08-17 | 120 | | | | | | 4.1 | .01 | .001 | | |
| | | 85-08-18 | 120 | | | | | | 4.1 | .01 | .001 | | |
| | | 85-08-19 | 119 | | 3.5 | | .002 | .003 | | .01 | .001 | .01 | .01 |
| | | 85-08-20 | 121 | | | | | | 4.0 | .01 | .001 | | |
| | | 85-08-21 | 120 | | 3.2 | | | | 4.5 | .01 | .001 | | |
| | | 85-08-23 | 119 | | 3.2 | | | | 4.4 | .01 | | | |
| | | 85-08-26 | 120 | | | | | | 4.4 | .01 | | | |
| | | 85-08-27 | 120 | | 3.2 | | .002 | .003 | 4.4 | .01 | .001 | .04 | .01 |
| | | 85-08-28 | 120 | | 3.1 | | | | 4.3 | .02 | .001 | | .01 |
| | | 85-08-29 | 120 | | 2.9 | | | | 4.1 | .02 | | | .01 |
| | | 85-08-30 | 120 | | 3.0 | .05 | | | 4.0 | .02 | .001 | | .01 |
| | | 85-09-02 | 121 | | 2.9 | .05 | .002 | .001 | 3.9 | .01 | .001 | .02 | .01 |
| | | 85-09-03 | 121 | | | .05 | | | 4.0 | .01 | .001 | | .01 |
| | | 85-09-04 | 121 | | 3.0 | .04 | | | 4.3 | .01 | .001 | | .02 |
| 85-09-05 | 119 | | 3.1 | .05 | | | 4.4 | .01 | .001 | | .02 | | |

KLIPPERASEN - Field parameters and sundries

| Bore-hole | Length m | Datum | pH _y | Cond. _y mS/m | Cond. lab mS/m | TOC mg/l | Si mg/l | |
|-----------|-------------|----------|-----------------|----------------------------|-------------------|-------------|------------|-----|
| KL02 | 0326 | 84-11-15 | 7.6 | 25.5 | | | | |
| | | 84-11-16 | 7.6 | 27.1 | | 11.0 | | |
| | | 84-11-17 | 7.6 | 27.7 | | | | |
| | | 84-11-19 | 7.6 | 27.9 | | | | |
| | | 84-11-20 | 7.6 | 27.8 | | 3.0 | | |
| | | 84-11-21 | 7.6 | 27.9 | | | 7.0 | |
| | | 84-11-22 | 7.6 | 28.0 | | 2.0 | | |
| | | 84-11-24 | 7.6 | 28.0 | | | | |
| | | 84-11-26 | 7.6 | 28.1 | | | 7.3 | |
| | | 84-11-27 | 7.5 | 28.2 | | 8 | 7.9 | |
| | | 84-11-28 | 7.5 | 28.1 | | | 7.5 | |
| | | 84-11-29 | 7.5 | 28.1 | | | 7.6 | |
| | | 84-11-30 | 7.5 | 28.1 | | | 7.8 | |
| | | 84-12-03 | 7.5 | 28.1 | | | 7.6 | |
| | | 84-12-04 | 7.5 | 28.1 | | | 1.2 | 7.6 |
| | | 84-12-05 | 7.5 | 28.2 | | | | 7.4 |
| | | 84-12-06 | 7.5 | 28.2 | | | 2.0 | 7.5 |
| 84-12-07 | 7.5 | 28.1 | | | | 7.6 | | |
| KL02 | 0741 | 84-10-25 | 8.6 | 20.6 | | | 3.3 | |
| | | 84-10-26 | | | | | 3.4 | |
| | | 84-10-27 | 7.9 | 24.0 | | | 3.8 | |
| | | 84-10-28 | 7.9 | 25.0 | | | 3.8 | |
| | | 84-10-29 | 8.0 | 24.3 | | | 4.2 | |
| | | 84-10-30 | 8.0 | 24.8 | | | 3.8 | |
| | | 84-10-31 | 8.0 | 25.2 | | | 4.0 | |
| | | 84-11-01 | 8.1 | 25.5 | | 12.0 | 4.0 | |
| | | 84-11-02 | 8.1 | 25.8 | | | 4.3 | |
| | | 84-11-03 | 8.1 | 26.2 | | | 4.1 | |
| | | 84-11-04 | 8.1 | 26.5 | | | 4.5 | |
| | | 84-11-05 | 8.1 | 26.8 | | | 4.4 | |
| | | 84-11-06 | 8.1 | 27.0 | | | 12.0 | 4.4 |
| | | KL02 | 0761 | 84-10-11 | | | | |
| 84-10-12 | | | | | | | 2.8 | |
| 84-10-13 | | | | | | | 2.8 | |
| 84-10-14 | | | | | | | 2.7 | |
| 84-10-15 | | | | | | | 2.7 | |
| 84-10-16 | | | | | | | 2.5 | |
| 84-10-17 | | | | | | | 2.5 | |
| 84-10-18 | 8.0 | | | 20.4 | | | 2.4 | |
| 84-10-19 | 8.0 | | | 20.5 | | | 2.6 | |
| KL02 | 0777 | 84-10-08 | | | | | | |
| | | 84-10-09 | | | | | 3.0 | |
| | | 84-10-22 | 8.1 | 20.7 | | | 2.6 | |
| | | 84-10-23 | 8.1 | 20.8 | | | 2.5 | |
| | | 84-10-24 | | | | | 2.6 | |
| KL02 | 0860 | 85-05-20 | | | | | 3.9 | |
| | | 85-05-21 | 8.6 | 34.0 | 33.5 | 5.3 | 3.8 | |
| | | 85-05-22 | 8.6 | 35.0 | | | 4.9 | |
| | | 85-05-23 | 8.6 | 36.6 | | | 5.0 | |
| | | 85-06-05 | 8.7 | 38.5 | | | 4.9 | |

Table 12

KLIPPERASEN - Metal ions

| Bore-hole | Length m | Datum | Na mg/l | K mg/l | Li mg/l | Ca mg/l | Mg mg/l | Sr mg/l | Al mg/l | Mn mg/l | Fe. tot mg/l | Fe2+ mg/l | | |
|-----------|-------------|----------|------------|-----------|------------|------------|------------|------------|------------|------------|-----------------|--------------|------|-----|
| KL02 | 0326 | 84-11-15 | 19 | 1.6 | | 29.0 | 2.0 | | | 25 | | | | |
| | | 84-11-16 | | | | 30.0 | 2.0 | | .17 | 14 | .212 | 209 | | |
| | | 84-11-17 | 29 | 1.5 | | 31.0 | 1.0 | | | | | | | |
| | | 84-11-19 | 29 | | | 31.0 | 1.2 | | | | | .231 | 217 | |
| | | 84-11-20 | 29 | 1.5 | | 31.0 | 2.0 | | .07 | .06 | | .230 | 200 | |
| | | 84-11-21 | 29 | 1.3 | | 31.0 | 2.0 | | | | .06 | .171 | 176 | |
| | | 84-11-22 | 29 | 1.0 | | 31.0 | 1.0 | | .08 | .05 | | | | |
| | | 84-11-24 | | | | 31.0 | 1.0 | | | | | .203 | 162 | |
| | | 84-11-26 | 33 | .8 | | 30.0 | 2.0 | | | | .05 | .145 | 138 | |
| | | 84-11-27 | 28 | .9 | | 31.0 | 1.0 | | .09 | .05 | | .147 | 141 | |
| | | 84-11-28 | 27 | .9 | | 31.0 | 1.0 | | | | .05 | .133 | 130 | |
| | | 84-11-29 | 29 | 1.1 | | 31.0 | 1.0 | | | | .06 | .140 | 134 | |
| | | 84-11-30 | 31 | 1.1 | | 31.0 | 1.0 | | | | .06 | .130 | 123 | |
| | | 84-12-03 | 26 | | | 31.0 | 1.0 | | | | .05 | .128 | 125 | |
| | | 84-12-04 | 24 | 1.1 | | 31.0 | 1.0 | | | .08 | .05 | .126 | 126 | |
| | | 84-12-05 | 26 | | | 31.0 | 1.0 | | | .09 | .05 | .107 | 102 | |
| | | 84-12-06 | 27 | 1.1 | | 30.0 | 1.0 | | | .07 | .04 | .105 | 102 | |
| | | 84-12-07 | | | | 31.0 | 1.0 | | | | .04 | .092 | 088 | |
| | | KL02 | 0741 | 84-10-25 | 14 | 2.0 | | 23.0 | 4.0 | | | .88 | .199 | 151 |
| | | | | 84-10-26 | | | | 18.0 | 4.0 | | | | .113 | 107 |
| 84-10-27 | 27 | | | 2.0 | | 17.0 | 3.0 | | | .27 | | | | |
| 84-10-28 | 28 | | | 1.1 | | 16.0 | 2.0 | | | | | | | |
| 84-10-29 | 34 | | | 1.4 | | 16.0 | 2.0 | | | | .17 | .088 | 079 | |
| 84-10-30 | 36 | | | 2.0 | | 16.0 | 1.0 | | | | .16 | | | |
| 84-10-31 | 35 | | | 1.8 | | 16.0 | 1.0 | | | | .16 | | | |
| 84-11-01 | 35 | | | 1.6 | | 16.0 | 1.0 | | .15 | .14 | | .058 | 048 | |
| 84-11-02 | 38 | | | 1.1 | | 16.0 | 1.0 | | | | .12 | .045 | 039 | |
| 84-11-03 | | | | | | 16.0 | 1.0 | | | | .13 | .045 | 038 | |
| 84-11-04 | 39 | | | 1.6 | | 16.0 | 1.0 | | | | .11 | .068 | 067 | |
| 84-11-05 | 41 | | | 1.8 | | 16.0 | | | | | .11 | | | |
| 84-11-06 | 41 | | | 1.5 | | 16.0 | 1.0 | | | .15 | .10 | .060 | 059 | |
| KL02 | 0761 | | | 84-10-11 | | | | 23.0 | 5.0 | | | .86 | .430 | 410 |
| | | 84-10-12 | 11 | 3.1 | | 23.0 | 4.0 | | | .77 | .365 | 365 | | |
| | | 84-10-13 | | | | | | | | | | .435 | 445 | |
| | | 84-10-14 | 12 | 3.0 | | 23.0 | 4.0 | | | | .73 | .430 | 430 | |
| | | 84-10-15 | 13 | 3.3 | | 23.0 | 4.0 | | | | .72 | .405 | 410 | |
| KL02 | 0777 | 84-10-16 | 13 | 3.4 | | 23.0 | 4.0 | | | .69 | .340 | 320 | | |
| | | 84-10-17 | 13 | 3.3 | | 22.0 | 4.0 | | | .63 | .310 | 285 | | |
| | | 84-10-18 | 13 | 2.5 | | 22.0 | 4.0 | | | .57 | .350 | 345 | | |
| | | 84-10-19 | 13 | 3.1 | | 22.0 | 4.0 | | | .60 | .259 | 253 | | |
| | | 84-10-08 | 9 | 2.2 | | 24.0 | 5.5 | | | 1.10 | | | | |
| 84-10-09 | 9 | 2.0 | | 24.0 | 5.5 | | | | .94 | | | | | |
| 84-10-22 | 15 | 3.1 | | 23.0 | 4.0 | | | | .54 | | | | | |
| 84-10-23 | | | | 22.0 | 4.0 | | | | | .209 | 201 | | | |
| 84-10-24 | 16 | 3.1 | | 22.0 | 4.0 | | | | .51 | .173 | 159 | | | |
| KL02 | 0860 | 85-05-20 | 57 | 1.6 | | 8.4 | 1.9 | | | | .11 | .043 | 031 | |
| | | 85-05-21 | 59 | 1.7 | .02 | 8.6 | 1.8 | .16 | .09 | .10 | .050 | .045 | | |
| | | 85-05-22 | 63 | 1.6 | | 8.3 | 1.8 | | | .10 | .043 | .041 | | |
| | | 85-05-23 | 65 | 1.6 | | 8.2 | 1.8 | | | .07 | .042 | .037 | | |
| | | 85-06-05 | 72 | 1.4 | | 7.9 | 1.9 | | | .06 | .060 | .045 | | |

Table 13

KLIPPERASEN - Anions + NH4-N

| Bore-hole | Length m | Datum | HCO3 mg/l | Cl mg/l | F mg/l | Br mg/l | I mg/l | PO4-P mg/l | SO4 mg/l | S-2. mg/l | NO2-N mg/l | NO3-N mg/l | NH4-N mg/l | | |
|-----------|-------------|----------|--------------|------------|-----------|------------|-----------|---------------|-------------|--------------|---------------|---------------|---------------|-----|--|
| KL02 | 0326 | 84-11-15 | 113 | 14 | 3.5 | .08 | | | .8 | 21 | | | | | |
| | | 84-11-16 | 130 | 15 | 2.8 | | .010 | | .4 | 15 | | | | | |
| | | 84-11-17 | 132 | | | | | | | | 14 | | | | |
| | | 84-11-19 | 132 | 16 | 2.9 | .09 | | | .2 | 11 | | | | | |
| | | 84-11-20 | 132 | 16 | 2.9 | | .010 | | | 07 | | | | | |
| | | 84-11-21 | 138 | | | .02 | | | .2 | 10 | | .001 | .02 | .02 | |
| | | 84-11-22 | 138 | 17 | 2.9 | .05 | .010 | | .1 | 09 | | | | | |
| | | 84-11-24 | | | | | | | | | | | | | |
| | | 84-11-26 | 139 | 16 | 2.9 | .13 | | | .1 | 08 | | .001 | | .08 | |
| | | 84-11-27 | 135 | 16 | 2.8 | .12 | .010 | | .1 | 08 | | | | | |
| | | 84-11-28 | 137 | 17 | 2.9 | .12 | | | .1 | 06 | | .001 | .01 | .08 | |
| | | 84-11-29 | 135 | 17 | 2.8 | .12 | | | .1 | 06 | | | | | |
| | | 84-11-30 | 135 | 17 | 2.5 | .13 | | | .002 | .1 | 05 | | | | |
| | | 84-12-03 | 137 | 16 | | | | | .002 | .1 | 04 | | | | |
| | | 84-12-04 | 136 | 16 | | | | .010 | .002 | | 07 | | | | |
| | | 84-12-05 | 134 | 17 | | | | | .002 | | 05 | .001 | .02 | .08 | |
| | | 84-12-06 | 134 | 18 | | | | .010 | | | 07 | | | | |
| 84-12-07 | 132 | 18 | | | | | .002 | | 02 | | | | | | |
| KL02 | 0741 | 84-10-25 | 102 | 8 | 2.9 | .01 | | | 1.1 | 04 | | | | | |
| | | 84-10-26 | 102 | 14 | 3.6 | .08 | | | .1 | 08 | | | | | |
| | | 84-10-27 | 97 | 15 | 4.0 | .09 | | | .1 | 33 | | | | | |
| | | 84-10-28 | 97 | 19 | 4.2 | .10 | | | .1 | 31 | | | | | |
| | | 84-10-29 | 98 | 20 | 4.3 | .13 | | | .1 | 26 | | | | | |
| | | 84-10-30 | 97 | 20 | 4.7 | .17 | | | .1 | 24 | | | | | |
| | | 84-10-31 | 98 | 21 | 4.4 | .17 | | | .1 | 27 | | | | | |
| | | 84-11-01 | 97 | 22 | 4.6 | .18 | .002 | .001 | .1 | 39 | | .001 | .02 | .03 | |
| | | 84-11-02 | 97 | 23 | 4.4 | .19 | | | .1 | 41 | | | | | |
| | | 84-11-03 | 97 | | | | | | | 41 | | | | | |
| | | 84-11-04 | 97 | 24 | 4.1 | .20 | | | .2 | 40 | | | | | |
| | | 84-11-05 | 99 | 23 | 4.1 | .21 | | | .1 | | | | | | |
| | | 84-11-06 | 99 | 25 | 4.7 | | .002 | .001 | | 36 | | .001 | .02 | .01 | |
| | | KL02 | 0761 | 84-10-11 | 107 | 6 | 2.0 | | | | .8 | 04 | | | |
| 84-10-12 | 106 | | | 6 | | .02 | | | .8 | 04 | | | | | |
| 84-10-13 | | | | 6 | 2.1 | .03 | | | .6 | | | | | | |
| 84-10-14 | 106 | | | 7 | 1.9 | .04 | | | .6 | 03 | | | | | |
| 84-10-15 | 105 | | | 6 | 2.0 | .03 | | | .5 | | | | | | |
| KL02 | 0777 | 84-10-16 | 106 | 7 | 2.3 | .02 | | | .5 | 04 | | | | | |
| | | 84-10-17 | 106 | 8 | 2.7 | .04 | | | .4 | 05 | | | | | |
| | | 84-10-18 | 106 | 7 | 2.5 | .04 | | | .3 | 05 | | | | | |
| | | 84-10-19 | 105 | 7 | 2.4 | .02 | | | .2 | 05 | | | | | |
| | | 84-10-20 | | | | | | | | | | | | | |
| KL02 | 0860 | 85-05-20 | 106 | 37 | 5.4 | .25 | | | 1.6 | 15 | .001 | | | | |
| | | 85-05-21 | 103 | 37 | 5.4 | .25 | .012 | .002 | 1.6 | 15 | .001 | 10 | .02 | | |
| | | 85-05-22 | 102 | 49 | 5.8 | .35 | | | 1.5 | 14 | .001 | | | | |
| | | 85-05-23 | 101 | 51 | 5.3 | .42 | | | 1.5 | 12 | .001 | | | | |
| | | 85-06-05 | 97 | 53 | 4.8 | .48 | | | 1.3 | 11 | .001 | | | | |

Table 14

PARTICULATE MATTER - Chemical composition

| Bore-hole | Length m | Date sampling | Core um | Al, p ug/l | Ca, p ug/l | Fe, p ug/l | Mn, p ug/l | Si, p ug/l | S, p ug/l | Fe-tot mg/l | Fe(II) mg/l |
|-----------|-------------|------------------|------------|---------------|---------------|---------------|---------------|---------------|--------------|----------------|----------------|
| KL01 | 406 | 85-06-27 | 05 | 34.3 | 20.6 | 100.6 | 4 | 41.6 | 24.5 | | |
| | | | 20 | 1 | 5.5 | 1.3 | 2 | 3 | 9.5 | 105 | 100 |
| | | | 40 | 2 | 6.5 | 19.3 | 2 | 3.1 | 9.8 | 106 | 096 |
| KL02 | 326 | 84-11-27 | 05 | 58.4 | 5.4 | 20.9 | 1.0 | 10.2 | 33.4 | | |
| | | | 05 | 28.7 | 6.3 | 2 | 1.6 | 2.0 | 14.7 | | |
| | | | 20 | < 1 | 3.6 | 6 | < 2 | < 1 | < 1 | | |
| | | | 40 | 3.8 | 6.8 | 3 | 2 | 1.7 | 2.9 | | |
| KL02 | 860 | 85-05-23 | 05 | 3.2 | 6.2 | 5.3 | 1 | 7.5 | 11.0 | | |
| | | | 20 | 9 | 4.0 | 4 | 1 | 2.2 | 6.8 | 043 | 002 |
| | | | 40 | 5.5 | 4.2 | 25.6 | 2 | 15.9 | 6.3 | 043 | 002 |
| KL09 | 696 | 85-08-15 | 05 | 3 | 9.9 | 3 | 1 | 3.2 | 11.0 | | |
| | | | 05 | 3 | 4.9 | 3 | 1 | 1.3 | 6.0 | | |
| | | | 20 | 4 | 4 | < 1 | 1 | 2 | 1.7 | 067 | 067 |
| | | | 40 | 7 | 3.7 | 5 | 1 | 2.6 | 6.4 | 067 | 067 |
| KL09 | 696 | 85-09-05 | 05 | 1 | 7.2 | < 1 | 1 | 1.4 | 4.9 | | |
| | | | 05 | 2 | 8.0 | 3.1 | 1 | 8 | 5.2 | | |
| | | | 20 | 1 | 4.6 | 3 | 1 | 8 | 2.9 | 066 | 060 |
| | | | 40 | 2 | 1.3 | < 1 | 1 | 4 | 1.1 | 067 | 079 |

Uranium, thorium, radium and radon

| Bore-hole | Length m | Date sampling | U Bq/l | Th ug/l | Ra-226 Bq/l | Rn-222 Bq/l |
|-----------|-------------|------------------|----------------|----------------|----------------|----------------|
| KL01 | 406 | 83-12-01 | (7.2 + 3.6)E-3 | <1.5 E-2 | (6.03+0.34)E-2 | 1590+50 |
| KL01 | 406 | 83-12-06 | (1.60+0.32)E-2 | <1.6 E-2 | (8.14+0.24)E-2 | 1640+50 |
| KL01 | 406 | 85-06-29 | (4.4+0.7)E-2 | (4.1+1.6)E-3 | (7.25+0.20)E-2 | 252+50 |
| KL02 | 326 | 84-12-10 | (7.0 + 1.1)E-2 | (1.0 + 1.8)E-3 | (2.87+0.10)E-1 | 2710+50 |
| KL09 | 696 | 85-09-03 | (1.43+0.05)E-2 | (5.9 + 3.8)E-3 | (6.3 + 0.3)E-2 | 221 + 5 |

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I: An analogue validation study of natural radionuclide migration in crystalline rock using uranium-series disequilibrium studies

II: A comparison of neutron activation and alpha spectroscopy analyses of thorium in crystalline rocks

JAT Smellie, Swedish Geological Co, A B MacKenzie and RD Scott, Scottish Universities Research Reactor Centre
February 1986

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U Olofsson
Chalmers University of Technology, Gothenburg, Sweden
B Allard
University of Linköping, Sweden
March 26, 1986

TR 86-03

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D Kirk Nordstrom
US Geological Survey, Menlo Park, USA
Ignasi Puigdomenech
Royal Institute of Technology, Stockholm, Sweden
April 1, 1986

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Trygve Eriksen
Royal Institute of Technology, Stockholm, Sweden
Hilbert Christensen
Studsvik Energiteknik AB, Nyköping, Sweden
Erling Bjergbakke
Risø National Laboratory, Roskilde, Denmark
March 1986

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Kaj Ahlbom, Peter Andersson, Lennart Ekman, Erik Gustafsson, John Smellie,
Swedish Geological Co, Uppsala
Eva-Lena Tullborg, Swedish Geological Co. Göteborg
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Andrzej Olkiewicz
Vladislav Stejskal
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**Geophysical investigations at the
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Klipperås study site**
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on core samples from the Klipperås
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Department of Nuclear Chemistry, Chalmers
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Bert Allard
Department of water in environment and
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Kenth Hansson, Olle Olsson, Swedish Geologi-
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Göran Nilsson, Swedish Geological Co, Luleå
Peter Wikberg, Royal Institute of Technology,
Stockholm