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Äspö Hard Rock Laboratory

Prototype Repository

Hydraulic tests in exploratory holes
Drill campaign 3B

Bengt Gentzschein

Geosigma

June 1999

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Foreword

This International Progress Report is one out of seven reports presenting the results from the hydrogeological field characterisation work prior to boring of the six deposition holes in the Prototype Repository tunnel in the Äspö Hard Rock Laboratory. The field investigations have been conducted in seven test campaigns between November 1997 and August 1999. The results from each campaign are described in a separate report and the following seven ones have been published.

Gentzschein, B. 1997: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Pilot Holes. Drill campaign 1. SKB International Progress Report IPR 99-27, December 1997.

Gentzschein, B. 1998: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Drill campaign 2. SKB International Progress Report IPR 99-28, May 1998.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Drill campaign 3a. SKB International Progress Report IPR 99-29, June 1999.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Drill campaign 3b. SKB International Progress Report IPR 99-30, June 1999.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Injection Tests. SKB International Progress Report IPR 99-31 , May 1999.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Interference Tests A after drill campaign 3. SKB International Progress Report IPR 99-32, May 1999.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Interference Tests B after drill campaign 3. SKB International Progress Report IPR 99-33, November 1999.

The reports include technical specifications and description of the equipment used, measurement procedures, results of the flow and pressure measurements, relevant test data and all the background data necessary for interpretation and evaluation of field data.

Each test produces a great number of diagrams showing responses in test sections or observation boreholes caused by pressure draw-downs. Each report comprises between 120 and 600 diagrams sorted in appendices after the describing text. Due to the great number, the diagrams are not included in the printed versions of the reports. But the reports, including the diagrams are also stored as Word documents on a CD-R. In addition each diagram is stored as a file (GIF – format). The Word-documents, converted to PDF-format, as well as the diagram-files are available at the Äspö Hard Rock Laboratory.

Abstract

The Prototype Repository in the Äspö Hard Rock Laboratory aims at simulating conditions in the future Deep Repository as realistically as possible. Some of many tasks are to observe the water saturation and homogenisation of the bentonite buffer and the backfill, and their interaction with the rock as well as to compare developed codes and material models with the observations. These tasks among other things need information on the hydraulic properties of the rock. The geohydraulic characterisation of the rock around the Prototype Repository is made in three stages. Each stage is intended to contribute to more details useful for determination of the localisation of the deposition holes and the boundary and rock conditions needed for the interpretation of the experimental data. The three stages are focused on:

Mapping of the tunnel
Pilot and exploratory holes
Deposition holes

This International Progress Report is report number 4 out of seven in a series which presents the results from stage 2, i e hydrogeological characterisation in pilot and exploratory holes, which have been obtained during seven test campaigns between November 1997 and August 1999. More precisely the present International Progress Report presents the results from the hydraulic tests in two approx. 50 m long holes drilled from the adjacent G-tunnel and one approx. 20 m deep vertical hole, used for rock stress measurements (The first three reports concerned studies in the 10 pilot holes and 21 both short and long exploratore drillholes in the Prototype Repository tunnel)

Packers were installed in the three studied holes as well as in 10 pilot holes and the 21 earlier drilled exploratory holes. The groundwater pressure was measured in the 13 30 m long exploratory holes and the two new 50 m long holes only. The result was readings between 0 and 3.8 MPa. Interference tests were conducted in one of the 50 m holes and pressure responses in some ten holes. Flow logging was measured in 15 sections in the two 50 m long holes and in meter-sections down to 12 m in the 20 m deep vertical rock stress measurement hole. Pressure build-up was measured in the 15 sections in one of the 50 m long holes.

Sammanfattning

Prototypförvaret i Äspölaboratoriet byggs för att simulera förhållandena så naturnära som möjligt i det framtida djupförvaret. Några av många uppgifter är att observera bentonitbuffertens och återfyllens vattenmättnad och homogenisering liksom den interaktion mellan materialen och berget som sker. samt att jämföra utvecklade koder och materialmodeller med de gjorda observationerna. För dessa uppgifter behöver bl a bergets hydrauliska egenskaper kunna beskrivas. Denna geohydrauliska karakteriseringen av berget omkring Prototypförvaret görs i tre steg. Varje steg ska bidra med mer användbar detaljinformation om lokalisering av deponeringshål samt randvillkor och bergegenskaper som behövs för tolkning av framtida observationer. De tre stegen inriktas på:

Kartering av tunneln
Pilot-och undersökningshål
Deponeringshål

Denna International Progress Report utgör rapport nummer 4 av sju i en serie som presenterar resultaten från Steg 2, dvs de hydrogeologiska karakteriseringar i pilot-och undersökningshål som gjorts i sju testkampanjer mellan november 1997 och augusti 1999. Mer precist redovisar föreliggande International Progress Report resultaten från mätningar i 11 nya hål, 2 korta, dvs 12 m, och 9 långa, dvs 30 m, undersökningshål samt i 4 gamla som förlängts till 30 m. De nya hålen borrades under april-juni 1998. (Den tre första rapporterna redovisade resultaten från testerna i de 10 pilothålen respektive i de därefter borrade 10 korta hålen.)

Manschetter installerades i alla 31 hålen och grundvattentrycket i hela hålet mättes flera gånger. Tryck mellan 0 och 3,8 MPa erhölls. Interferenstester gjordes i ett av de 50 m långa hålet och tryckrespons i 10 hål. Inflödet mättes i 15 sektioner i de två 50-metershålen i hela hålet och i enmeterssektioner ner till 12 m i det 20 m djupa, vertikala hålet för bergspänningsmätning. Tryckuppbyggnaden mättes i de 15 sektionerna i ett av 50-metershålen.

Table of Contents

Foreword i

Abstracts ii

Sammansfattning iii

Table of Contents iv

List of Figures v

List of Tables v

1 Background 1

2 Objectives 2
2.1 General Objectives 2
2.2 Objectives for the Hydraulic Tests - Drill Campaign 3b 2

3 Scope 3

4 Equipment Used 6

5 Performance 9
5.1 Pressure Measurements 9
5.2 Pressure Build-Up Tests of the Entire Exploratory Holes 9
5.3 Flow Meter Logging with Double Packers 10
5.4 Pressure Build-Up Tests of Features in the Exploratory Holes 11
5.5 Data Processing 11

6 Results 12
6.1 Pressure Measurements 12
6.2 Pressure Build-Up Tests and Interference Tests of the Entire Exploratory Holes 13
6.3 Flow Meter Logging with Double Packers 18
6.4 Pressure Build-Up Tests of Features in The Exploratory Holes 22

7 References 64

8 Appendices 65

List of Figures

Figure 4-1 Generated flow caused by inflation of double packers PUR 72. Elapsed time from start of inflation, from Lindström 1997. 8

List of Tables

Table 3-1 Drilling data and section limits for the exploratory holes, while testing in KG0048A01 and KG0021A01. 3

Table 3-2 A list of hydraulic tests conducted in the boreholes KG0021A01, KG0048A01 and KA3579G. Prototype Repository , drill campaign 3b, October 1998-January 1999. 4

Table 4-1 Level of pressure transducers above the tunnel floor during pressure measurements of the entire exploratory holes, October - December 1998. 6

Table 4-2 Generated flow caused by inflation of double packers PUR 72. Laboratory tests 98-04-02. 8

Table 6-1 Borehole pressures (kPa) measured pressure transducer and data Logger in exploratory holes for Prototype Repository, drill campaign 3b. 12

Table 6-2. Results of flow logging of the boreholes KG0021A01, KG0048A01 and KA3579G for the Prototype Repository, drill campaign 3b. 18

1. BACKGROUND

Within the scope of SKB's program for R&D 1995, SKB has decided to carry out a project named "Prototype Repository " at the Äspö Hard Rock Laboratory. The aim of the project is to test important components in SKB's deep repository system in full scale and in a realistic environment.

The Prototype Repository is focused on testing and demonstrating the function of SKB's deep repository system. Activities aimed at contributing to development and testing of the practical engineering measures required to rationally perform the steps of a deposition sequence are also included. However, efforts in this direction are limited, since these matters are addressed in the Demonstration of Repository Technology project and to some extent in the Backfill and Plug test.

The characterisation of the test site, located in the TBM-drilled part of the Äspö HRL-tunnel, will be made in three stages. Each stage is intended to contribute to more details useful for the determination of the localization of the deposition holes and also the boundary and rock conditions needed for the interpretation of the experimental data. The three stages are focused on:

1. Mapping of the tunnel
2. Pilot and exploratory holes
3. Deposition holes

Stage 1 is completed and stage 2 has been divided into three drilling campaigns:

1. Drilling of pilot holes
2. Drilling of exploratory holes-short boreholes
3. Drilling of exploratory holes-long boreholes

Ten pilot holes were drilled between during October 1997. in the tunnel interval 3/539 m - 3/593 m. Ten of the short exploratory boreholes were drilled in the tunnel interval 3/544 m - 3/588 m during March 1998. Hydraulic tests were performed in the short exploratory boreholes in November 1997 and in April 1998.

Another two short exploratory holes were drilled April 25th and 26th. Nine long exploratory (30 m) boreholes were drilled June 3rd - June 28th. Further more four of the older boreholes were extended to 30 m depth during May. Hydraulic tests and flow measurements were performed in these boreholes during the summer 1998.

July and August 1998 two c. 50 m long boreholes, KG0021A01 and KG0048A01, were drilled from the G-tunnel towards and above the prototype tunnel. This report describes the flow logging and the hydraulic tests performed in these two boreholes and in the borehole KA3579G, drilled for rock stress measurements in October 1997. The tests and the flow logging were conducted during autumn and winter 1998-1999. The last measurements were completed in January 1999.

2. OBJECTIVES

2.1 General objectives

The Prototype Repository should simulate a real repository in as many aspects as possible, regarding geometry **,** materials, and rock environment. The as possible. The Prototype Repository is a demonstration of the integrated function of the repository components. Results will be compared with models and assumptions to their validity.

The major objectives for the Prototype Repository are:

- To demonstrate the integrated function of a full-scale prototype of the repository system .
- To provide a full-scale reference for testing/scrutinization of models, experiments and assumptions.
- To develop, test and demonstrate appropriate engineering standards and quality standards and quality assurance systems.
- To demonstrate technology for monitoring of the repository system.

The objectives for the characterization program are:

- To provide a basis for determination of localization of the deposition holes.
- To provide data on boundary and rock conditions to enable interpretation of the experimental data.

2.2 Objectives of hydraulic tests - drill campaign 3b

The objectives of the long exploratory boreholes are to obtain data mainly for the geological and hydrogeological models but also for prediction of the characteristics in the deposition holes and quantify the criteria needed for validation the suitability of the position of canister deposition. Acceptance of canister position is based on scrutinization of characterization data such as fracturing, permeability and stability of the borehole wall.

The objectives of the hydraulic tests in the long exploratory boreholes are:

- The hydraulic tests of the long exploratory boreholes shall provide hydrogeological data useful for setting up a hydrogeological model of the rock volume around the TBM tunnel up to a distance of approximately 30 m from the TBM tunnel.
- Data shall together with the geological interpretation be a base for designing specific interference tests with several packed off sections in a number of boreholes and to choose sections for flow measurements during natural conditions and during interference tests.
- The tests shall partly be of similar character as for drill campaign 1 and 2 in order to provide data for statistical treatment.
- Take water samples useful for the hydrochemical characterization of the rock volume around the prototype repository.

3. SCOPE

The lengths of the boreholes KG0021AG01 and KG0048A01 are 48.82 m and 54.69 m respectively. The boreholes were drilled upwards approximately 20 degrees. The vertical borehole KA3579G was drilled for rock stress measurements to a depth of 22.65 m. The nominal diameters of the three boreholes are 76 mm., the dates of drilling are presented in Table 3-1

Prior to the hydraulic tests mechanical packers were installed in the exploratory holes of the TBM tunnel. Packers were also installed in the earlier drilled pilot boreholes. The groundwater pressure was measured both in the exploratory holes of 30 m length in the TBM-tunnel and in the two holes in the G-tunnel.

Table 3-1 Drilling data and section limits for the exploratory holes, while testing in KG0048A01 and KG0021A01.

Borehole	Drilling completed (Date)	Measurement section (m)	Comment
KA3579G	971008	0.50 - 22.65	
KA3510A	960909	0 - 150.06	during tests in KG0048A01
KA3510A:1	960909	122.02-150.06	during tests in KG0021A01
KA3510A:2	“	114.02-121.02	“
KA3510A:3	“	4.52-113.02	“
KA3573A:1	970924	18.00-40.00	
KA3573A:2	“	4.50-17.00	
KA3600F:1	970911	22.00-50.01	
KA3600F:2	“	4.50-21.00	
KA3548A01:1	980628	15.00– 30.00	(horizontal)
KA3548A01:2	“	10.00-14.00	
KA3590G01	980623	0.39 – 30.06	(inclin.=45°)
KA3590G02	980616	0.39 – 30.05	“
KA3566G01	980623	0.39 – 30.01	“
KA3566G02	980616	0.39 – 30.01	“
KA3554G01	980623	0.39 – 30.01	“
KA3554G02	980616	0.39 – 30.01	“
KA3542G01	980623	0.39 – 30.04	“
KA3542G02	980616	0.39 – 30.01	“
KG0021A01:1	980708	26.0 - 48.82	980810-981016
KG0021A01:2	“	9.0 - 25.0	“ “
KG0048A01:1	980804	49.00-54.69	during tests in KG0021A01
KG0048A01:2	“	41.00-48.00	“
KG0048A01:3	“	30.00-40.00	“
KG0048A01:4	“	13.00-29-00	“
KG0048A01:5	“	4.00-12.00	“

After the packer installation the ground-water pressure of the boreholes stabilized during one to four days

Interference tests of the entire KG0048A01 were carried out the 6tst and 7th of October. The pressure responses in ten boreholes in TBM-tunnel and in the G-tunnel were monitored. Further more the ground water pressure of the three boreholes KA3510B, KA3573A and KA3600A was measured. The first test in KG0048A01 failed due to leakage and has not been evaluated.

An interference test in KG0021A01 was carried out October 16th . However the resulting data was of bad quality due to too much air in the borehole and the test was be performed again November 30th .

Flow logging of KG0048A01 using double-packers was carried out between October 8th and October 16th. In 15 sections the flow measurements were extended to pressure build-up tests (PBT).

In borehole KG0021A01 the flow measurements were performed December 1st to December 15th. 26 PBT's were executed.

In borehole KA3579G the flow logging was carried out the 16th and 17th of December. January 16th a PBT of the entire borehole was started, and completed two days later.

A list of tests is shown in Table 3-2.

Table 3-2 A list of hydraulic tests conducted in the boreholes KG0021A01, KG0048A01 and KA3579G. Prototype Repository, drill campaign 3b, October 1998-January 1999.

Borehole	Date of test	Test No	Test Typ	Section	Start Test (kl.)	V. 0pen (kl.)	V Close (kl.)	End of Test (kl.)
KG0048A01	981006	1a	I	0-54.69		18.35	19.09	07.45
KG0048A01	981007	1b	I	0-54.69		13.19	14.22	(8/10)
KG0048A01	981008	2	PBT	5.00-8.00	14.32	14.44	16.23	18.39
KG0048A01	981009	3	PBT	17.00-20.00	09.22	09.31	10.34	12.34
KG0048A01	981009	4	PBT	20.00-23.00		12.58	13.57	16.02
KG0048A01	981009	5	PBT	23.00-24.00	19.09	19.18	20.19	07.16
KG0048A01	981010	6	PBT	24.00-25.00	07.57	08.08	09.11	11.13
KG0048A01	981010	7	PBT	27.00-28.00	13.29	13.39	14.39	16.43
KG0048A01	981011	8	PBT	33.00-34.00	13.25	13.34	14.36	16.47
KG0048A01	981012	9	PBT	41.00-42.00	16.50	17.05	c. 18	(13/10)
KG0048A01	981013	10	PBT	43.00-44.00	09.54	10.07	11.07	13.07
KG0048A01	981013	11	PBT	44.00-45.00	13.27	13.39	14.37	16.37
KG0048A01	981013	12	PBT	45.00-46.00	16.48	16.57	17.57	07.14 (14/10)
KG0048A01	981014	13	PBT	46.00-47.00	08.24	08.38	09.38	11.38
KG0048A01	981014	14	PBT	47.00-48.00	12.18	12.30	13.27	15.18
KG0048A01	981014	15	PBT	50.00-51.00	17.19	17.27	18.31	07.1 1 (15/10)
KG0048A01	981015	16	PBT	53.00-54.69	16.25	16.30	17.31	(16/10)
KG0021A01	981016	17	I	0 – 48.82		19.20	20.24	07.52 (17/10)

Borehole	Date of test	Test No	Test Typ	Section	Start Test (kl.)	V. 0pen (kl.)	V Close (kl.)	End of Test (kl.)
KG0021A01	981130	18	I	0.00-48.82	17.40	17.40	19.05	07.52 (1/12)
KG0021A01	981202	19	PBT	7.00-10.00	12.25	12.36	13.36	15.36
KG0021A01	981202	20	PBT	10.00-13.00	15.45	15.55	16.55	09.05 (3/12)
KG0021A01	981204	21	PBT	19.00-20.00	16.58(3/12)	08.34	09.37	12.03.36
KG0021A01	981204	22	PBT	20.00-21.00	12.14	12.26	13.26	16.16
KG0021A01	981205	23	PBT	21.00-22.00	09.23	09.39	10.39	12.39 (5/12)
KG0021A01	981205	24	PBT	22.00-23.00	12.51	13.02	14.02	16.02
KG0021A01	981205	25	PBT	23.00-24.00	16.09	16.20	17.21	08.31 (6/12)
KG0021A01	981206	26	PBT	24.00-25.00	08.58	09.12	10.15	12.26
KG0021A01	981206	27	PBT	25.00-26.00	15.22	15.33	16.33	18.33
KG0021A01	981206	28	PBT	2600- 27.00	18.39	18.51.36	19.52	08.12 (7/12)
KG0021A01	981207	29	PBT	27.00-28.00	09.36	09.49	10.50	12.50
KG0021A01	981207	30	PBT	28.00-29.00	13.12	13.22	14.24	16.17
KG0021A01	981207	31	PBT	29.00-30.00	16.50	17.04	18.04	08.04 (8/12)
KG0021A01	981208	32	PBT	30.00-31.00	09.23	09.34	10.34	12.34
KG0021A01	981208	33	PBT	31.00-32.00	13.03	13.13	14.15	16.15
KG0021A01	981208	34	PBT	32.00-33.00	16.20	16.31	17.32	19.32
KG0021A01	981209	35	PBT	33.00-34.00	09.58	10.08	11.08	13.09
KG0021A01	981209	36	PBT	35.00-36.00	13.55	14.13	15.19	17.24
KG0021A01	981209	37	PBT	36.00-37.00	17.38	17.50	18.52	19.51
KG0021A01	981210	38	PBT	37.00-38.00	08.20	08.30	09.31	12.06
KG0021A01	981210	39	PBT	38.00-39.00	12.11	12.21	13.22	15.22
KG0021A01	981210	40	PBT	40.00-41.00	16.20	16.31	17.33	07.33 (11/12)
KG0021A01	981211	41	PBT	42.00-43.00	09.51	10.02	11.03	13.03
KG0021A01	981214	42	PBT	43.00-44.00	13.34	14.30	15.30	17.30
KG0021A01	981214	43	PBT	44.00-45.00	17.35	17.46	18.48	18.13 (15/12)
KG0021A01	981215	44	PBT	45.00-46.00	08.24	08.35	09.39	11.54
KA3579G	990116	45	PBT	0.50 –22.65	09:26.30	09:26.30	12:30	13:50 (18/1)

PBT = Pressure Build-Up Test. I =Interference Test

4. EQUIPMENT USED

When measuring the borehole, most of the observation boreholes were shut in by mechanically operated packers manufactured by Livinstone AB. The sealing rubber length of the packers was 0.15 m. The length of the packer system was c. 1.5 m.
A valve arrangement, including a pressure gauge for manual reading, and a sealing BAT rubber disc mounted in a nozzle, was connected on the inner packer pipe

In some of the boreholes a new type of mechanical packer was installed. It has no packer pipe outside the borehole, and reaches 280 mm into the hole. The sealing length is 135 mm.

In KA3548A01, KA3573A, KA3600F and KG0021A01 inflatable packers (PUR 72) were used.

The pressure transducers used were Druck PTX 1400. The pressure range was 60 bar. The transducers were positioned on top of the packers or on the tunnel floor, see Table 4-1.

Table 4-1 Level of pressure transducers above the tunnel floor during pressure measurements of the entire exploratory holes, October - December 1998.

Borehole	Level above tunnel floor (m)	Comment
KA3600	c. 1.80	
KA3573A	0.49/0.42	
KA3510A	0.17	
KA3539G	0	
KA3593G	1.45	
KA3548A01	c. 1.8	
KA3590G01	0	
KA3590G02	0	
KA3566G01	0	
KA3566G02	0	
KA3554G01	0	
KA3554G02	0	
KA3542G01	0	
KA3542G02	0	
KG0048A01	0.45	
KG0021A01	0/0	

Pressure data were stored using the data logger BORRE MDL ver. 2.2, manufactured by IPA-konsult AB. The software of the logger is very flexible concerning sampling intervals etc. A measurement sequence can be started either by a temporarily connected computer or by using the key pad at the front of the data logger. Pressure values are shown on the computer screen during the measurements. The key pad enables three measurement options. The option ”SLOW” initiates one hour interval measurements and ”FAST” a 5 minutes interval. The ”SEQUENCE”-option is usually used during hydraulic testing. This option has stepwise increase in measurement intervals starting with 2 seconds (if one channel is used). After 30 minutes and onwards the measurement interval is three minutes. These ”SLOW”-, ”FAST”- and ”SEQUENCE” -options can easily be reprogrammed from the computer.

During the interference tests to five data loggers and 18 pressure transducers were used in the exploratory boreholes.

Water flow rates higher than 1-2 ml/min were measured using graduated cylinders of different sizes and a stop watch. Lower rates were achieved by letting the water flow through a vertical mounted Tecalan hose and measure the rise of the water level. A Tecalan hose with the inner diameter 4 mm was used.

The down-hole equipment used for the flow logging and the PBT’s of a feature in KG0021A01 and KG0048A01 consisted of two inflatable polyurethane packers, separated by a pipe, a pipe string and two pressure lines. The sealing length of each packer is 1.0 m and they are inflated using water pressurized by nitrogen. The pipe between the packers and a by-pass opening at the upper gable of the outer packer was able to equalize the ground water pressure on both sides of the measurement section. However, during the tests in KG0021A01 and KG0048A01 this by-pass was closed. Two of the three pressure hoses (polyamide) are connecting the packers and the pressurizing system. It was possible to inflate the packers separately. The third pressure hose establishes hydraulic contact between the measurement chamber and a transducer positioned outside the borehole.

The pipe string is made of aluminum with threaded pipe joints of stainless steel. The outer/inner diameter is 33/21 mm and the length of individual pipe segments is 1 m or 3 m. The groundwater pressure of the entire borehole was shut in by a sealing device at the casing.

The test tool and the pipe string were transferred in the borehole using a rig.

The packer inflation influences the accuracy of the flow measurements. The generated flow in a double packer section caused by the packers used in the exploratory hole tests have been tested in the laboratory, cf. Lindström (1997). The results show that after 30 minutes of inflation, the flow is c. 0.5 ml/min. and after 40 minutes the generated flow is c.0.4ml/min. Consequently, the effect of packer creep induced flow is most pronounced for low-conductive test sections., see Figure 4-1.

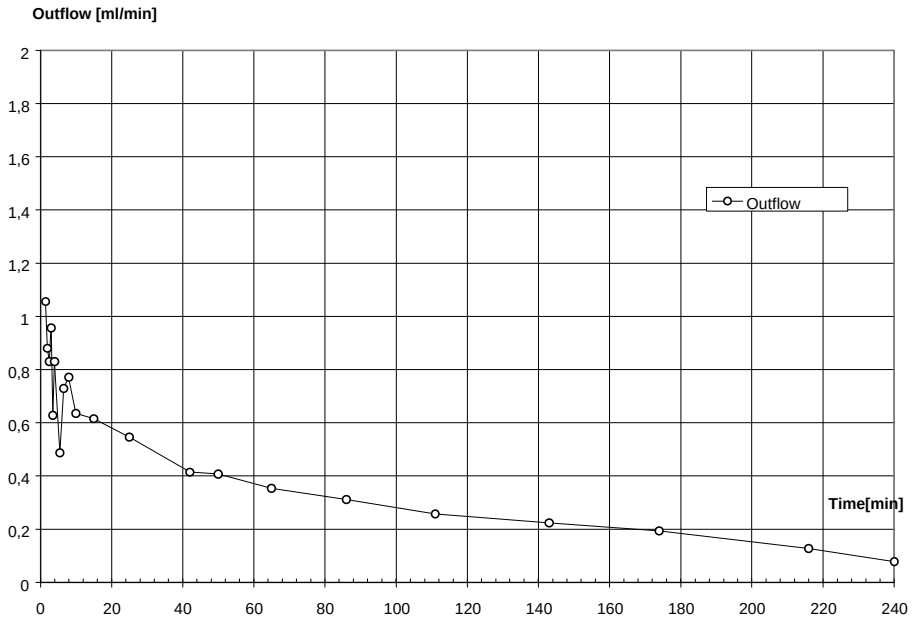

Figure 4-1 Generated flow caused by inflation of double packers PUR 72. Elapsed time from start of inflation, from Lindström 1997.

When flow logging the pilot holes in November 1997 flow rates lower than the minimum rates of the laboratory tests were observed. This was somewhat confusing and not easy to explain. In order to study if the function of the packers had been changed by age or by use, the laboratory tests were repeated in April 1998. The same packers used in the November measurements and later used in the exploratory holes were tested in the laboratory. However the result of the new tests was similar to the data achieved at the first test. After 30 to 40 minutes of packer inflation the flow generated by the packer expansion was measured to 0.48 - 0.44 ml/min. see Table 4-2.

Table 4-2 Generated flow caused by inflation of double packers PUR 72. Laboratory tests 98-04-02.

Elapsed Time (min)	Squeezed volume (cumulative) (ml)	Flow (ml/ min)	Elapsed Time (min)	Squeezed volume (cumulative) (ml)	Flow (ml/ min)
0	0	0	8	59.42	0.57
2	56.00	28.00	9	59.94	0.53
2.5	56.26	0.53	10	60.50	0.55
3	56.58	0.63	15	63.08	0.52
3.5	56.87	0.58	20	65.61	0.50
4	57.16	0.58	30	70.37	0.48
4.5	57.44	0.58	40	74.80	0.44
5	57.75	0.60	50	78.95	0.41
6	58.31	0.57	60	82.84	0.39
7	58.85	0.54			

5. PERFORMANCE

5.1 Pressure measurements

The ground-water pressure of the exploratory holes was at one occasion measured using the connected pressure transducers, data loggers and a portable PC. The transducer was connected to the ”BAT-connection” of the boreholes respectively and the logger value, displayed on the PC-screen, was noted. The pressure was calculated using the calibration constants. Before the measurements, the borehole pressures were stabilized for one to four days.

5.2 Pressure build-up tests of the entire boreholes and interference tests.

Before the measurements, the borehole pressures were stabilized for about four days

The test cycle was performed as follows:

- the pressure transducers and the data loggers were connected, see chapter 4, to the flowing borehole and the observation boreholes.
- the logarithmic scanning option (”SEQ”) of the logger was initiated.
- The valve of the flowing borehole was opened and the flow was measured during 1 – 3 hours.
- the logarithmic scanning option (”SEQ”) of the loggers was restarted.
- the valve was closed and the pressure build-up was registered during 12 hours or more 1090.
- The data loggers were switched off.

The flow rate was measured using graduated cylinders or a Tecalan hose, see chapter 4.

The data loggers were programmed to measure with the highest sample rate during the first three minutes of the flow phase and recovery phase respectively. Thereafter the sampling interval was 20 seconds. Since 1-5 transducers were connected to each data logger the lowest measurement interval was 2-6 seconds.

The tests in KG0048A01 and KG0021A01 were performed as interference tests, while only a pressure build up test was conducted in KA3579G.

The flow of KG0021A01 was reduced in order to stop air to enter the borehole. The pressure was manually kept at a constant level.

5.3 Flow meter logging with double packers in borehole KA3579G

Shortly before the measurements the mechanical packer was removed and the double packer section was assembled.

In KA3579G the flow rate of all the test interval was less than 10 ml/min.
A measurement cycle was performed as follows:

- The double packer section was lowered to the first position.
- Start of the packer inflation and data logger (SEQ)
- The packers stabilised for 30 minutes
- The packer pipe was filled with water and a Tecalan hose was mounted on the top of the packer pipe
- Flow measurements during 5 minutes
- Packer deflation
- Transfer to next borehole section

The flow logging started in the uppermost test interval of the boreholes (1.0-2.0 m). Thereafter the packers were lowered 1 m for the next test. The flow rate was measured down to the depth of 12 m. No single packer measurement was performed.

5.4 Flow logging and pressure build-up test of a feature in KG0048A01 and KG0021A01

If the flow of a measurement section exceeded 10 ml/min a pressure bild-up test (PBT) was carried out. If the flow was less only a flow measurement was performed. Prior to the measurements the borehole pressure was shut in by the sealing device at the casing, see chapter 4. A measurement/test cycle was performed as follows:

- The double packer section was transferred to the measurement interval. The sealing device was somewhat unsealed to make the transfer easier. When the pipe string was lengthened (every third meter) the entire borehole was opened for some minutes.
- The inflation of the outer packer was started and the "SEQUENCE-option" of the data logger was initiated.
- The borehole volume above the outer packer was filled up with water for approximately five minutes.
- The inflation of the inner (upper) packer was started.
- The packers stabilized for c. five minutes.
- The valve at the end of the pipe string was opened.
- If only **flow measurements** were performed the flow was measured after 30 minutes If a **PBT** was conducted the flow was measured during c. 60 minutes
- The logarithmic scanning option ("SEQ") of the loggers was restarted (only **PBT**)
- The valve was closed and the pressure build-up was registered during two hours **(**only **PBT**).
- Packer deflation
- Transfer to next borehole section

In order to stop air to enter the measurement interval the flow was reduced and the pressure was manually kept at a constant level.

5.5 Data processing

Raw data files from the Borre data loggers ("*.BOR-files") were converted to "*.HYF-files", see Gentzschein 1994.

Pressure data was plotted in diagrams (see chapters 6.2 and 6.4) using the programs PUMPKONV and SKBPLOT, see Ergodata 1997 and 1998.

Pressure data and flow data has also been tabulated in text-files, specified in the QA-plan of this test campaign, see Rhén 1998 and Appendix C1.

All the data files are listed in Appendix C1.

6. RESULTS

6.1 Pressure measurements

The results of the pressure measurement are listed in Table 6.1

Table 6-1 Borehole pressures (kPa) measured pressure transducer and data logger, exploratory holes for Prototype Repository - drill campaign 3b.

Borehole	Date, Time	Leve of trans-ducer above floor (m)	Pressure (kPa)
KA3539G	981006; 17:41	0	3 125
KA3542G01	981006; 18:03	0	3 760
KA3542G02	981006; 18:03	0	3 187
KA3548A01: 1	981006; 18:03	1.8	3819
KA3548A01: 2	981006; 18:03	1.8	3755
KA3554G01	981006; 17:59	0	3837
KA3554G02	981006; 18:03	0	3231
KA3557G	981006; 17:45	1.45	0
KA3563G	981006; 17:50	1.45	0
KA3566G01	981006; 17:59	0	2199
KA3566G02	981006; 17:59	0	3305
KA3590G01	981006; 17:57	0	1875
KA3590G02	981006; 17:57	0	3696
KA3593G	981006; 17:50	1.45	2277
KG0048A01	981006; 18:24	0.45	3811
KG0021A01:1	981006; 18:12	0	3702
KG0021A01:2	981006; 18:12	0	3666

6.2 Pressure build-up tests of the entire boreholes and interference tests.

Appendices A1, A7 and A13 contain the diagrams of the three tested boreholes KG0048A01, KG0021A01 and KA3579G respectively. Appendices A2 – A6 show the pressure responses in the observation boreholes during the test in KG0048A01 and the diagrams showing the responses of the test in KG0021A01 are found in appendices A8-A12.

The different types of diagrams are:

- Lin-Lin plots for the whole test sequence
- Lin-Log plots for the draw-down phase and the Pressure build-up
- Log-Log plots for the draw-down phase and the Pressure build-up
- Derivative plots for the recovery

The pressure build-up is plotted versus the equivalent time, dt_e, in minutes. The equivalent time is defined as:

$$dt_e = \frac{t_p \cdot dt}{t_p + dt}$$ where

t_p = time in minutes when the test section was open
dt = elapsed time after shutting the valve to the test section.

In the following details and important test data for each test are described
The abbreviations used are

- Po = Initial pressure before opening of the valve
- Pp = Pressure just before closing the valve
- Pf = Pressure at the end of the pressure build-up period

Borehole KG0048A0, section 0.0 m - 54.69 m

Date: 98-10-07 Field Crew: S. Jönsson/J. Onkenhout
Borehole length: 54.69 m Borehole diameter: 76 mm

Flowing borehole: KG0048A01
Valve opened: 981007 131459 Valve closed: 981007 142147
Total flowing time : 65.8 min Tot. Pr. Build-up time 1090.2 min.

The test was performed as an Interference test. Pressure responses were monitored in boreholes KA3590G01, KA3590G02, KA3566G01, KA3566G02, KA3554G01, KA3554G02, KA3548A01, KA3542G01, KA3542G02, KG0021A01, KA3510B, KA3573A and KA3600F.

Pressure data

Borehole	Po (kPa)	Pp(kPa)	Pf(kPa)
KG0048A01	3813.0	0.08	3819.9
KA3590G01	1886.8	1130.2	1759.1
KA3590G02	3454 2	3107.2	3446.0
KA3566G01	2239.9	1466.8	2186.6
KA3566G02	3369.7	2984.9	3364.6
KA3554G01	3775.1	2152.2	3576.1
KA3554G02	2146.3	1829.6	2146.8
KA3548A01:1	3805.3	1264.5	2536.2
KA3548A01:2	3761.7	2435.9	3719.8
KA3542G01	3787.7	2500.8	3768.3
KA3542G02	3216.3	2718.1	3214.8
KA3510B	4136.8	4029.1	4132.2
KA3573A:1	4051.4	3226.7	3888.8
KA3573A:2	3745.2	612.9	1427.1
KA3600F:1	4118.9	4065.0	4121.0
KA3600F:2	4094.5	3927.9	4053.3
KG0021A01:1	3709.1	3115.8	3589.5
KG0021A01:2	3676.3	1421.7	3116.8

Manually measured flow rates of KG0048A01 are presented below.

Time	Flow rate (l/min)
13:17	146.0
13:24:30	107.5
13:33	96.9
13:43	92.5
13:55	89.8
14:07	88.0
14:13	87.0

Borehole KG0021A01, section 0.0 m - 48.82 m

Date: 98-11-30 Field Crew: Bengt Gentzschein
Borehole length: 48.82 m Borehole diameter: 76 mm

Flowing borehole: KG0021A01
Valve opened: 981130 17:39.59 Valve closed: 981130 19:04.57
Total flowing time : 85 min Tot. Pr. Build-up time 769 min.

The test was performed as an interference test. Pressure responses were monitored in boreholes KA3590G01, KA3566G01, KA3566G02, KA3554G01, KA3554G02, KA3548A01, KA3542G01, KA3542G02, KG0048A01, KA3510B, KA3573A and KA3600F.

Manually measured flow rates of KG0021A01 are presented below.

Pressure data

Borehole	Po (kPa)	Pp(kPa)	Pf(kPa)
KG0021A01	3394.5	247.0	3360.0
KA3590G01	-	-	-
KA3590G02	3586.0	2781.6	3574.3
KA3566G01	2153.7	2110.3	2155.5
KA3566G02	3246.8	2592.9	3247.7
KA3554G01	3075.3	1500.2	3128.7
KA3554G02	2480.0	2401.2	2481.3
KA3548A01:1	3814.0	3700.1	3818.8
KA3548A01:2	3735.0	3571.0	3745.1
KA3542G01	3764.9	3605.2	3774.3
KA3542G02	3016.8	1465.4	3084.3
KA3510A:1	3835.3	3831.8	3843.5
KA3510A:2	4148.3	4142.5	4148.9
KA3510A:3	3868.1	3747.4	3878.8
KA3573A:1	4052.9	4010.9	4055.4
KA3573A:2	3926.7	3813.2	3932.1
KA3600F:1	4115.7	4103.5	4116.4
KA3600F:2	4092.7	4074.5	4093.9
KG0048A01:1	3807.8	3692.7	3811.7
KG0048A01:2	3629.7	3436.9	3636.6
KG0048A01:3	3655.9	3142.7	3660.9
KG0048A01:4	3567.4	2276.7	3540.7
KG0048A01:5	3243.1	1216.7	3216.5

No monitoring was carried out in borehole KA3590G01 due to shortage of pressure transducers.

The draw-down of KA3554G02 is less than that of KA3554G01. This was not expected since the distance to KA3554G02 from KG0021A01 is shorter. As a comparison the draw-downs in KA3542G02 and KA3566G02 are larger than the drawdowns of KA3542G01 and KA3566G01 respectively.

Possibly but not confirmed is that the two boreholes have been mixed up when connecting the pressure transducers.

Manually measured flow rates during interference test in KG0021A01 are presented below.

Time	Flow rate (l/min)
17:42:30	83.7
17:47:15	37.9
17:56:30	31.4
18:06	30.1
18:21	21.8
18:32:30	27.0
18:40	27.3
18:50	27.1
19:00	26.8

In order to prevent the borehole from gas intrusion the flow rate was reduced and the borehole pressure was kept at an approximate constant level (c. 250 kPa)

Borehole KA3579G , section 0.50 m – 22.65 m

Date: 99-01-16 Field Crew: B. Gentzschein
Borehole length: 22.65 m Borehole diameter: 76 mm

Flowing borehole: KA3579G
Valve opened: 99-01-16 09:26.30 Valve closed: 99-01-18 12:30.00
Total flowing time : 183.5 min Tot. Pr. Build-up time 2 960 min.

The test was performed as a pressure build-up test. The groundwater pressure was measured only in borehole KA3579G

Pressure data

Borehole	Po (kPa)	Pp(kPa)	Pf(kPa)
KA3579G	1687.2	0.06	1534.3

The flow rate of KA3579G was determined by measuring the rise of the water level in a 6/4 mm Tecalan tube (during 5-6 minutes), see the table below.

Time Start	Stop	Start level (mm)	Stop level (mm)	Flow rate (l/min)
09:28:30	09:33:30	20	139	3.0×10^{-4}
09:51	09:56.30	15	99	1.9×10^{-4}
10:30.30	10:35.30	25	92	1.7×10^{-4}
10:59	11:04	16	79	1.6×10^{-4}
11:34	11:39	16	79	1.6×10^{-4}
12:03	12:08	13	72	1.5×10^{-4}
12:23	12:28	15	71	1.4×10^{-4}

The pressure transducer was located c. 1.2 m above the floor.

6.3 Flow meter logging with double packers

The result of the flow logging is presented in Table 6.2. The table includes an approximate value of the average pressure during the flow phase, estimated from the diagrams.

Table 6-2. Results of flow logging of the boreholes KG0021A01, KG0048A01 and KA3579G for the Prototype Repository, drill campaign 3b.

Flowing Borehole	Date of Test	Section (m)	Flow rate (l/min)	Estimated pressure during the flow phase (bar)	Comment
KG0048A01	981008	5.00-8.00	5.2	0.1 - 12	PBT #2, The pressure during the flow phase varies due to water sampling.
KG0048A01	981008	8.00-11.00	4.2×10^{-4}	0.2	
KG0048A01	981009	11.00-14.00	4.1×10^{-4}	0.6	
KG0048A01	981009	14.00-17.00	2.4×10^{-3}	0.2	
KG0048A01	981009	17.00-20.00	0.078	0.2	PBT #3
KG0048A01	981009	20.00-23.00	0.106	0.2	PBT #4
KG0048A01	981009	23.00-24.00	0.097	0.2	PBT #5
KG0048A01	981010	24.00-25.00	0.624	0.25	PBT #6
KG0048A01	981010	25.00-26.00	5.8×10^{-4}	0.2	
KG0048A01	981010	26.00-27.00	1.3×10^{-4}	0.2	
KG0048A01	981010	27.00-28.00	0.025	0.2	PBT #7
KG0048A01	981011	28.00-29.00	5.8×10^{-3}	0.2	
KG0048A01	981011	29.00-30.00	8.7×10^{-5}	0.2	
KG0048A01	981011	30.00-31.00	2.3×10^{-4}	0.2	
KG0048A01	981011	31.00-32.00	2.3×10^{-4}	0.2	
KG0048A01	981011	32.00-33.00	3.6×10^{-4}	0.2	
KG0048A01	981011	33.00-34.00	1.67	0.4	PBT #8
KG0048A01	981011	34.00-35.00	1.0×10^{-4}	0.2	
KG0048A01	981012	35.00-36.00	6.0×10^{-4}	0.2	
KG0048A01	981012	36.00-37.00	1.3×10^{-4}	0.2	

Flowing Borehole	Date of Test	Section (m)	Flow rate (l/min)	Estimated pressure during the flow phase (bar)	Comment
KG0048A01	981012	37.00-38.00	1.7×10^{-4}	0.2	
KG0048A01	981012	38.00-39.00	1.4×10^{-4}	0.2	
KG0048A01	981012	39.00-40.00	6.0×10^{-5}	0.2	
KG0048A01	981012	40.00-41.00	2.0×10^{-5}	0.25	
KG0048A01	981012	41.00-42.00	0.024	0.3	PBT # 9
KG0048A01	981013	42.00-43.00	2.5×10^{-3}	0.3	
KG0048A01	981013	43.00-44.00	0.080	6.3	PBT #10
KG0048A01	981013	44.00-45.00	0.204	4.2	PBT #11
KG0048A01	981013	45.00-46.00	21.9	0.6	PBT #12
KG0048A01	981014	46.00-47.00	15.0	0.4	PBT #13
KG0048A01	981014	47.00-48.00	0.164	6.5	PBT #14
KG0048A01	981014	48.00-49.00	1.4×10^{-4}	1.5	
KG0048A01	981014	49.00-50.00	7.1×10^{-4}	1	
KG0048A01	981014	50.00-51.00	0.561	0.9	PbT #15
KG0048A01	981014	51.00-5200	1.7×10^{-4}	0.9	
KG0048A01	981014	52.00-53.00	7.6×10^{-6}	6	
KG0048A01	981014	53.00-54.69	62.9	3.5	Single packer test, PBT # 16
KG0048A01	981006	0.00-54.69	87.2		PBT #1b/ Interference test
KG0021A01	981202	4.00-7.00	0.0096	0	
KG0021A01	981202	7.00-10.00	0.078	0.2	PBT #19
KG0021A01	981202	10.00-13.00	5.9	0	PBT #20
KG0021A01	981203	13.00-16.00	0.0064	0	
KG0021A01	981203	16.00-19.00	0.0024	0	
KG0021A01	981204	19.00-20.00	0.017	6,2	PBT #21
KG0021A01	981204	20.00-21.00	0.021	5,8	PBT #22
KG0021A01	981205	21.00-22.00	0.021	5,6	PBT #23

Flowing Borehole	Date of Test	Section (m)	Flow rate (l/min)	Estimated pressure during the flow phase (bar)	Comment
KG0021A01	981205	22.00-23.00	0.027	5,7	PBT #24
KG0021A01	981205	23.00-24.00	0.038	5,7	PBT #25
KG0021A01	981206	24.00-25.00	0.022	5,8	PBT #26
KG0021A01	981206	25.00-26.00	0.513	5,6	PBT #27
KG0021A01	981206	26.00-27.00	0.066	5,7	PBT #28
KG0021A01	981207	27.00-28.00	17.9	4,6	PBT #29
KG0021A01	981207	28.00-29.00	16.4	4,7	PBT #30
KG0021A01	981207	29.00-30.00	12.9	4,6	PBT #31
KG0021A01	981208	30.00-31.00	6.9	4,5	PBT #32
KG0021A01	981208	31.00-32.00	0.044	5,8	PBT #33
KG0021A01	981208	32.00-33.00	0.082	5,7	PBT #34
KG0021A01	981209	33.00-34.00	0.010	5,8	PBT #35
KG0021A01	981209	34.00-35.00	0.009	5,4	
KG0021A01	981209	35.00-36.00	0.688	5,2	PBT #36
KG0021A01	981209	36.00-37.00	0.056	5,2	PBT #37
KG0021A01	981210	37.00-38.00	0.012	6,2	PBT #38
KG0021A01	981210	38.00-39.00	0.320	6,2	PBT #39
KG0021A01	981210	39.00-40.00	2.5×10^{-4}	5,2	
KG0021A01	981210	40.00-41.00	1.01	6,2	PBT #40
KG0021A01	981211	41.00-42.00	5.5×10^{-4}	7	
KG0021A01	981211	42.00-43.00	0.050	6,2	PBT #41
KG0021A01	981214	43.00-44.00	0.315	6,2	PBT #42
KG0021A01	981214	44.00-45.00	0.015	5,4	PBT #43
KG0021A01	981215	45.00-46.00	0.010	6,1	PBT #44
KG0021A01	981215	46.00-47.00	0.0085	6,2	
KG0021A01	981215	47.00-48.82	3.2×10^{-4}	4,7	

Flowing Borehole	Date of Test	Section (m)	Flow rate (l/min)	Estimated pressure during the flow phase (bar)	Comment
KG0021A01	981130	0.00-48.82	27	2.5	PBT #18/ Interference test
KA3579G	981216	1.00- 2.00	5.3×10^{-5}		
KA3579G	981216	2.00- 3.00	1.1×10^{-4}		
KA3579G	981216	3.00- 4.00	7.8×10^{-5}		
KA3579G	981216	4.00- 5.00	7.3×10^{-5}		
KA3579G	981216	5.00- 6.00	6.3×10^{-5}		
KA3579G	981216	6.00- 7.00	7.0×10^{-5}		
KA3579G	981216	7.00- 8.00	5.5×10^{-5}		
KA3579G	981216	8.00- 9.00	9.0×10^{-5}		
KA3579G	981216	9.00-10.00	6.8×10^{-4}		
KA3579G	981217	10.00-11.00	9.6×10^{-5}		
KA3579G	981217	11.00-12.00	1.5×10^{-4}		

6.4.1 Pressure build-up test of a feature in exploratory boreholes

In 41 of the flow logged sections flow rates equal to or greater than 0.010 l/minute were measured. In these sections the measurements were extended to pressure build-up tests.

Appendices B1 – B41 contain the diagrams for each test. The different types of diagrams are:

- Lin-Lin plots for the whole test sequence
- Lin-Log plots for the Pressure build-up
- Log-Log plots for the Pressure build-up
- Derivative plots for the recovery

In the Lin-Log and Log-Log plots a time correction has been performed, see section 6.2.

In the following details and important test data for each test are described.

Packer inflation 1) = Time of inflation of the outer (lower) packer.
Packer inflation 2) = Time of inflation of the inner (upper) packer.

Borehole KG0048A01, section 5.0 m - 8.0 m. Test #2

Date:	98-10 -08	Field Crew:	B. Gentzschein/J. Onkenhout
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981008 14:32.20	2) 981008 14:37.20	
Valve opened:	981008 14:44.45	Valve closed:	981008 16:23.00
Flowing time :	98.25 min	Tot. Pr. Build-up time:	136 min

Pressure just before opening the valve (Po, kPa) : 2901.0
Pressure just before closing the valve (Pp, kPa) : 24.7
Pressure at the end of the recovery (Pf, kPa): 2699.9

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 5.0 - 8.0 m, are presented below.

Time	Flow rate (l/min)	Comment
14:47	8.28	
14:54	7.16	
15:03	6.14	
15:12	5.72	
15:20	5.38	
15:32	5.08	
15:43	4.93	
15:51	4.62	reduced capacity
16.12	1.70	reduced capacity
16:20	5.2	

Water sampling was carried out between 15:55 and 16:13.

Borehole KG0048A01, section 17.0 m - 20.0 m. Test #3

Date:	98-10 - 09	Field Crew:	B. Gentzschein/J. Onkenhout
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981009 09:22.34	2) 981009 09:25.35	
Valve opened:	981008 09:31.00	Valve closed:	981009 10:34.00
Flowing time :	63 min	Tot. Pr. Build-up time:	120 min

Pressure just before opening the valve (Po, kPa) : 3723.8
Pressure just before closing the valve (Pp, kPa) : 21.5
Pressure at the end of the recovery (Pf, kPa): 3732.8

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 17.0 - 20.0 m, are presented below.

Time	Flow rate (l/min)
09:33	0.099
09:39	0.082
09:45	0.081
09:51	0.081
09:59	0.079
10:07	0.079
10:15	0.079
10:23	0.079
10.31	0.078

Borehole KG0048A01, section 20.0 m - 23.0 m. Test #4

Date: 98-10 – 09(10) Field Crew: B. Gentzschein/J. Onkenhout
Borehole length: 54.69 m Borehole diameter: 76 mm

Packer inflation: 1) 981009 12:46.17 2) 981009 12:51.43
Valve opened: 981009 12:57.38 Valve closed: 981009 13:58.00
Flowing time : 60.4 min Tot. Pr. Build-up time: 124 min

Pressure just before opening the valve (Po, kPa) : 3730.7
Pressure just before closing the valve (Pp, kPa) : 20.4
Pressure at the end of the recovery (Pf, kPa): 3749.4

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 20.0 - 23.0 m, are presented below.

Time	Flow rate (l/min)
12:59.30	0.135
13:06	0.112
13:11	0.112
13:19	0.111
13:29	0.108
13:37	0.106
13:45	0.108
13:53	0.106

Borehole KG0048A01, section 23.0 m - 24.0 m. Test #5

Date:	98-10 - 09	Field Crew:	B. Gentzschein/J. Onkenhout
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981009 19:09.35	2) 981009 19:12.24	
Valve opened:	981009 19:18.30	Valve closed:	981009 20:19.01
Flowing time :	60.5 min	Tot. Pr. Build-up time:	656 min

Pressure just before opening the valve (Po, kPa) : 3266.2
Pressure just before closing the valve (Pp, kPa) : 24.7
Pressure at the end of the recovery (Pf, kPa): 3769.7

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2.4 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 23.0 - 24.0 m, are presented below.

Time	Flow rate (l/min)
19:21	0.113
19:28	0.111
19:35	0.102
19:43	0.100
19:50	0.096
19:59	0.098
20:06.30	0.097
20:13	0.097

Borehole KG0048A01, section 24.0 m - 25.0 m. Test #6

Date:	98-10 - 10	Field Crew:	B. Gentzschein/J. Onkenhout
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981010 07:57.45	2) 981010 08:02.51	
Valve opened:	981010 08:08.50	Valve closed:	981010 09:12.00
Flowing time :	63.2 min	Tot. Pr. Build-up time:	120 min

Pressure just before opening the valve (Po, kPa) : 3746.6
Pressure just before closing the valve (Pp, kPa) : 23.8
Pressure at the end of the recovery (Pf, kPa): 3765.7

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 24.0 - 25.0 m, are presented below.

Time	Flow rate (l/min)
08:11	0.674
08:17	0.650
08:25	0.652
08:33	0.639
08:41	0.671
08:49	0.634
08:59	0.637
09:05	0.624
09:08	0.624

Borehole KG0048A01, section 27.0 m - 28.0 m. Test #7

Date:	98-10 - 10	Field Crew:	B. Gentzschein/J. Onkenhout
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981010 13:28.53	2) 981010 13:32.50	
Valve opened:	981010 13:39.00	Valve closed:	981010 14:39.01
Flowing time :	60.0 min	Tot. Pr. Build-up time:	124.3 min

Pressure just before opening the valve (Po, kPa) : 3303.6
Pressure just before closing the valve (Pp, kPa) : 21.1
Pressure at the end of the recovery (Pf, kPa): 3658.6

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 27.0 - 28.0 m, are presented below.

Time	Flow rate (l/min)
13:43	0.030
13:50	0.0285
13:57	0.0275
14:05	0.0295
14:12	0.0262
14:20	0.0285
14:27	0.0251
14:35	0.0253

Borehole KG0048A01, section 33.0 m - 34.0 m. Test #8

Date:	98-10 - 11	Field Crew:	B. Gentzschein/J. Onkenhout
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981011 13:25.20	2) 981011 13:29.40	
Valve opened:	981011 13:34.35	Valve closed:	981011 14:36.00
Flowing time :	61.4 min	Tot. Pr. Build-up time:	130 min

Pressure just before opening the valve (Po, kPa) : 3724.3
Pressure just before closing the valve (Pp, kPa) : 41.8
Pressure at the end of the recovery (Pf, kPa): 3783.5

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 33.0 - 34.0 m, are presented below.

Time	Flow rate (l/min)
13:38	1.823
13:45	1.72
13:53	1.698
14:00.30	1.697
14:08	1.682
14:15	1.678
14:23	1.679
14:30	1.655
14:35	1.670

Water sampling was carried out at the end of the flow period.

Borehole KG0048A01, section 41.0 m - 42.0 m. Test #9

Date:	98-10 – 12(13)	Field Crew:	B. Gentzschein/T.Tammela
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981012 16:50.18	2) 981012 16:55.20	
Valve opened:	981012 17:05.30	Valve closed:	981012 18:01.00
Flowing time :	55.5 min	Tot. Pr. Build-up time:	816 min

Pressure just before opening the valve (Po, kPa) : 3577.5
Pressure just before closing the valve (Pp, kPa) : 29.1
Pressure at the end of the recovery (Pf, kPa): 3696.8

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 41.0 - 42.0 m. , are presented below.

Time	Flow rate (l/min)
17:19	0.0265
17:21	0.027
17:26	0.0265
17:34	0.024

Borehole KG0048A01, section 43.0 m - 44.0 m. Test #10

Date:	98-10 – 13	Field Crew:	B. Gentzschein/T.Tammela
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981013 09:53.36	2) 981013 10:00.25	
Valve opened:	981013 10:06.30	Valve closed:	981013 11:06.56
Flowing time :	60.4 min	Tot. Pr. Build-up time:	119.7 min

Pressure just before opening the valve (Po, kPa) : 3661.1
Pressure just before closing the valve (Pp, kPa) : 635.3
Pressure at the end of the recovery (Pf, kPa): 3748.5

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 43.0 - 44.0 m, are presented below.

Time	Flow rate (l/min)
10:23	0.070
10:35	0.081
10:43	0.081
10:50	0.081
10:58	0.080
11:05	0.080

Borehole KG0048A01, section 44.0 m - 45.0 m. Test #11

Date:	98-10 – 13	Field Crew:	B. Gentzschein/T.Tammela
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981013 13:27.10	2) 981013 13:34.00	
Valve opened:	981013 13:39.00	Valve closed:	981013 14:37.00
Flowing time :	58 min	Tot. Pr. Build-up time:	120 min

Pressure just before opening the valve (Po, kPa) : 3770.6
Pressure just before closing the valve (Pp, kPa) : 425.4
Pressure at the end of the recovery (Pf, kPa): 3813.9

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 44.0 - 45.0 m, are presented below.

Time	Flow rate (l/min)
13:45	0.210
13:52	0.207
14:02	0.204
14:10	0.204
14:17	0.204
14:26	0.204
14:32	0.204
14:35.30	0.204

Borehole KG0048A01, section 45.0 m - 46.0 m. Test #12

Date:	98-10 – 13(14)	Field Crew:	B. Gentzschein/T.Tammela
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981013 16:47.48	2) 981013 16:51.33	
Valve opened:	981013 16:56.35	Valve closed:	981013 17:56.58
Flowing time :	60.4 min	Tot. Pr. Build-up time:	796 min

Pressure just before opening the valve (Po, kPa) : 3584.4
Pressure just before closing the valve (Pp, kPa) : 54.2
Pressure at the end of the recovery (Pf, kPa): 3692.0

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 45.0 - 46.0 m, are presented below.

Time	Flow rate (l/min)
17:05	23.48
17:12	22.50
17:19	21.89
17:25	22.19
17:32	22.19
17:40	22.19
17:47	22.28
17:55	21.89

Borehole KG0048A01, section 46.0 m - 47.0 m. Test #13

Date:	98-10 – 14	Field Crew:	B. Gentzschein/T.Tammela
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981014 08:24.19	2) 981014 08:30.38	
Valve opened:	981014 08:38.10	Valve closed:	981014 09:38.00
Flowing time :	59.8 min	Tot. Pr. Build-up time:	120 min

Pressure just before opening the valve (Po, kPa) : 3458.6
Pressure just before closing the valve (Pp, kPa) : 37.4
Pressure at the end of the recovery (Pf, kPa): 3634.9

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 46.0 - 47.0 m, are presented below.

Time	Flow rate (l/min)
08:44	16.04
08:54	15.28
09:02	15.0
09:10	15.28
09:21	14.73
09:26.45	15.14
09:36	15.0

Borehole KG0048A01, section 47.0 m - 48.0 m. Test #14

Date:	98-10 – 14	Field Crew:	B. Gentzschein/T.Tammela
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981014 12:18.21	2) 981014 12:24.25	
Valve opened:	981014 12:30.00	Valve closed:	981014 13:26.59
Flowing time :	57 min	Tot. Pr. Build-up time:	111 min

Pressure just before opening the valve (Po, kPa) : 3702.6
Pressure just before closing the valve (Pp, kPa) : 657.0
Pressure at the end of the recovery (Pf, kPa): 3816.2

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 47.0 - 48.0 m, are presented below.

Time	Flow rate (l/min)
12:36	0.165
12:43	0.164
12:51	0.164
12:58	0.164
13:05	0.164
13:12	0.164
13:20	0.1635
13:25	0.164

Borehole KG0048A01, section 50.0 m - 51.0 m. Test #15

Date:	98-10 – 14 (15)	Field Crew:	B. Gentzschein/T.Tammela
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	1) 981014 17:19.20	2) 981014 17:22.01	
Valve opened:	981014 17:27.00	Valve closed:	981014 18:29.57
Flowing time :	64 min	Tot. Pr. Build-up time:	760 min

Pressure just before opening the valve (Po, kPa) : 3736.5
Pressure just before closing the valve (Pp, kPa) : 911.8
Pressure at the end of the recovery (Pf, kPa): 3826.1

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 50.0 - 51.0 m, are presented below.

Time	Flow rate (l/min)
17:37	0.562
17:48	0.562
17:53	0.561
18:00	0.560
18:08	0.562
18:15	0.560
18:22	0.562
18:29	0.561

Borehole KG0048A01, section 53.0 m - 54.69 m. Test #16

Date:	98-10 – 15 (16)	Field Crew:	B. Gentzschein/T.Tammela
Borehole length:	54.69 m	Borehole diameter:	76 mm
Packer inflation:	981015 16:25.12		
Valve opened:	981015 16:30.11	Valve closed:	981015 17:30.56
Flowing time :	60.8 min	Tot. Pr. Build-up time:	861 min

A single packer was used to delimit the test interval.

Pressure just before opening the valve (Po, kPa)	:	3700.5
Pressure just before closing the valve (Pp, kPa)	:	307.2
Pressure at the end of the recovery (Pf, kPa)	:	3591.6

The pressure transducer used was positioned 0.45 m above the tunnel floor.
The height of the water flow outlet was c. 2 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0048A01, 53.0 - 54.69 m, are presented below.

Time	Flow rate (l/min)
16:34	93.5
16:40	76.7
16:44	68.2
16:50	67.1
16:57	67.0
17:02.30	65.5
17:11	65.5
17:19	63.5
17:26.30	62.9

Borehole KG0021A01, section 7.0 m -10.0 m. Test #19

Date: 98-12 -02 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981202 12:24.39 2) 981202 12:31.05

Valve opened: 981202 12:35.57 Valve closed: 981202 13:36.00
Flowing time : 60 min Tot. Pr. Build-up time: 120 min

Pressure just before opening the valve (Po, kPa) : 3229.2
Pressure just before closing the valve (Pp, kPa) : 21.6
Pressure at the end of the recovery (Pf, kPa): 3368.8

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 7.0 - 10.0 m, are presented below.

Time	Flow rate (l/min)	Comment
12:39.30	0.083	
12:42	0.081	
12:49	0.080	
12:56	0.079	
13:04	0.078	
13:11	0.078	
13:19	0.0785	
13:26	0.078	
13.34	0.078	

Shortly after the closing of the pressure valve it was discovered that the pressure transducer was not properly connected to the pressure hose. The transducer was reconnected immediately, but the pressure values from the first 2 minutes of the recovery phase are not correct.

Borehole KG0021A01, section 10.0 m -13.0 m. Test #20

Date: 98-12 -02 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981202 15:44.44 2) 981202 15:50.02

Valve opened: 981202 15:54.58 Valve closed: 981202 16:54.58
Flowing time : 60 min Tot. Pr. Build-up time: 970 min

Pressure just before opening the valve (Po, kPa) : 2950.0
Pressure just before closing the valve (Pp, kPa) : 6.4
Pressure at the end of the recovery (Pf, kPa): 2839.0

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 10.0 - 13.0 m, are presented below.

Time	Flow rate (l/min)	Comment
15:57.28	10.08	
16:00.45	9.84	
16:08.30	7.66	
16:15.30	6.90	
16:22.	6.70	
16:31.	6.22	
16:37.30	6.08	
16:45.	5.88	
16:52.	5.78	

The valve was not opened momentarily but during a period of c. one minute.
After the recovery period the test interval was opened for water sampling between 09:07.40 and 09:45, 3rd of December.

Borehole KG0021A01, section 19.0 m -20.0 m. Test #21

Date: 98-12 -04 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981203 16:58.00 2) 981204 08:27.52

Valve opened: 981204 08:33.57 Valve closed: 981204 09:36.58
Flowing time : 63 min Tot. Pr. Build-up time: 146.5 min

Pressure just before opening the valve (Po, kPa) : 3388.1
Pressure just before closing the valve (Pp, kPa) : 607.7
Pressure at the end of the recovery (Pf, kPa): 3390.8

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 19.0 - 20.0 m, are presented below.

Time	Flow rate (l/min)	Comment
08:53	0.017	
08:59	0.012	
09:10	0.0145	
09:18	0.022	
09:31	0.017	

In order to avoid gas intrusion into the borehole, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 600 - 630 kPa). However, in spite of these measures the recovery data indicate that gas intrusion really occurred.

Borehole KG0021A01, section 20.0 m -21.0 m. Test #22

Date: 98-12 -04 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981204 12:14.12 2) 981204 12:20.26

Valve opened: 981204 12:25.56 Valve closed: 981204 13:25.54
Flowing time : 60 min Tot. Pr. Build-up time: 170.1 min

Pressure just before opening the valve (Po, kPa) : 3344.9
Pressure just before closing the valve (Pp, kPa) : 577.9
Pressure at the end of the recovery (Pf, kPa): 3388.8

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Table: Manually measured flow rates in pressure build-up test in KG0021A01, 20.0 - 21.0 m, are presented below.

Time	Flow rate (l/min)	Comment
12:36	0.019	
12:46	0.020	
12:53	0.022	
13:01	0.0205	
13:11	0.020	
13:19	0.0205	
13:24	0.0205	

In order to avoid gas intrusion into the borehole, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 550 - 585 kPa).

Borehole KG0021A01, section 21.0 m -22.0 m. Test #23

Date: 98-12 -05 Field Crew: B. Gentzschein/J. Onkenhout
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981205 09:23.20 2) 981205 09:31.48

Valve opened: 981205 09:38.58 Valve closed: 981205 10:38.57
Flowing time : 60 min Tot. Pr. Build-up time: 120 min

Pressure just before opening the valve (Po, kPa) : 3222.5
Pressure just before closing the valve (Pp, kPa) : 587.5
Pressure at the end of the recovery (Pf, kPa): 3389.2

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 21.0 - 22.0 m, are presented below.

Time	Flow rate (l/min)	Comment
09:44	0.022	
09:52	0.022	
10:03	0.020	
10:12	0.022	
10:21	0.022	
10:29.30	0.0215	
10:36	0.0212	

In order to avoid gas intrusion into the borehole, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 550 - 590 kPa).

Borehole KG0021A01, section 22.0 m -23.0 m. Test #24

Date: 98-12 -05 Field Crew: B. Gentzschein/J. Onkenhout
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981205 12:51.08 2) 981205 12:56.24

Valve opened: 981205 13:02.00 Valve closed: 981205 14:01.56
Flowing time : 60 min Tot. Pr. Build-up time: 120 min

Pressure just before opening the valve (Po, kPa) : 3377.7
Pressure just before closing the valve (Pp, kPa) : 575.3
Pressure at the end of the recovery (Pf, kPa): 3388.5

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 22.0 - 23.0 m, are presented below.

Time	Flow rate (l/min)	Comment
13:07	0.0301	
13:14	0.0288	
13:21	0.0285	
13:28	0.028	
13:37	0.0273	
13:46.30	0.0275	
13:53	0.028	
14:00	0.0272	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 560 - 580 kPa).

Borehole KG0021A01, section 23.0 m -24.0 m. Test #25

Date: 98-12 -05 Field Crew: B. Gentzschein/J. Onkenhout
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981205 16:09.12 2) 981205 16:14.30

Valve opened: 981205 16:20.00 Valve closed: 981205 17:20.56
Flowing time : 61 min Tot. Pr. Build-up time: 910 min

Pressure just before opening the valve (Po, kPa) : 3372.4
Pressure just before closing the valve (Pp, kPa) : 576.0
Pressure at the end of the recovery (Pf, kPa): 3399.8

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 23.0 - 24.0 m, are presented below.

Time	Flow rate (l/min)	Comment
16:24	0.070	
16:30	0.044	
16:37	0.0425	
16:43	0.041	
16:51	0.039	
16:59	0.039	
17:07	0.038	
17:15	0.038	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 540 - 580 kPa).

Borehole KG0021A01, section 24.0 m -25.0 m. Test #26

Date: 98 - 12 - 06 Field Crew: B. Gentzschein/J. Onkenhout
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981206 08:57.41 2) 981206 09:04.49

Valve opened: 981206 09:12.00 Valve closed: 981206 10:14.57
Flowing time : 63 min Tot. Pr. Build-up time: 131 min

Pressure just before opening the valve (Po, kPa) : 3165.5
Pressure just before closing the valve (Pp, kPa) : 598.6
Pressure at the end of the recovery (Pf, kPa): 3393.8

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 24.0 - 25.0 m, are presented below.

Time	Flow rate (l/min)	Comment
09:16	0.021	
09:22	0.021	
09:28	0.0225	
09:36	0.022	
09:46	0.022	
09:55	0.022	
10:05	0.022	
10:12	0.0215	

The pressure data show a pressure decrease shortly before the valve opening (09:08) The origin of this pressure drop is not known.

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 540 - 600 kPa).

Borehole KG0021A01, section 25.0 m -26.0 m. Test #27

Date: 98 - 12 - 06 Field Crew: B. Gentzschein/J. Onkenhout
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981206 15:21.40 2) 981206 15:27.34

Valve opened: 981206 15:33.05 Valve closed: 981206 16:32.57
Flowing time : 59.9 min Tot. Pr. Build-up time: 120 min

Pressure just before opening the valve (Po, kPa) : 2956.0
Pressure just before closing the valve (Pp, kPa) : 552.6
Pressure at the end of the recovery (Pf, kPa): 3397.5

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 25.0 - 26.0 m, are presented below.

Time	Flow rate (l/min)	Comment
15:41	0.500	
15:47.30	0.493	
15:54	0.493	
16:09	0.500	
16:15	0.500	
16:22	0.509	increasing flow !
16:30	0.513	" "

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 540 - 600 kPa).

This borehole interval was shut in again December 7th (08:17 – 09:27) and the interval was open for water sampling 09:01 – 09:25.

Borehole KG0021A01, section 26.0 m -27.0 m. Test #28

Date:	98 - 12 - 06	Field Crew:	B. Gentzschein/J. Onkenhout
Borehole length:	48.82 m	Borehole diameter:	76 mm

Packer inflation: 1) 981206 18:38.44 2) 981206 18:45.39

Valve opened:	981206 18:51.36	Valve closed:	981206 19:51.57
Flowing time :	60.4 min	Tot. Pr. Build-up time:	740 min

Pressure just before opening the valve (Po, kPa) : 3345.3
Pressure just before closing the valve (Pp, kPa) : 576.0
Pressure at the end of the recovery (Pf, kPa): 3397.5

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 26.0 - 27.0 m, are presented below.

Time	Flow rate (l/min)	Comment
18:58.30	0.068	
19:04	0.068	
19:10	0.0675	
19:17	0.067	
19:25	0.067	
19:33	0.066	
19:42	0.066	
19:50	0.066	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 560 - 590 kPa).

Borehole KG0021A01, section 27.0 m -28.0 m. Test #29

Date: 98 - 12 - 07 Field Crew: B. Gentzschein/J. Onkenhout
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981207 09:36.23 2) 981207 09:42.56

Valve opened: 981207 09:48.56 Valve closed: 981207 10:49.54
Flowing time : 61 min Tot. Pr. Build-up time: 120.1 min

Pressure just before opening the valve (Po, kPa) : 3383.1
Pressure just before closing the valve (Pp, kPa) : 453.0
Pressure at the end of the recovery (Pf, kPa): 3500.7

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 27.0 - 28.0 m, are presented below.

Time	Flow rate (l/min)	Comment
09:55	20.1	
10:03	18.8	
10:12	18.6	
10:21	18.3	
10:31	18.1	
10:41	18.0	
10:47.40	17.9	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 440 - 480 kPa).

Between 12:51 and 13:07 the test interval was opened again for water sampling.

Borehole KG0021A01, section 28.0 m -29.0 m. Test #30

Date: 98 - 12 - 07 Field Crew: B. Gentzschein/J. Onkenhout
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981207 13:11.46 2) 981207 13:16.49

Valve opened: 981207 13:22.00 Valve closed: 981207 14:23.55
Flowing time : 61.9 min Tot. Pr. Build-up time: 113 min

Pressure just before opening the valve (Po, kPa) : 3445.1
Pressure just before closing the valve (Pp, kPa) : 473.2
Pressure at the end of the recovery (Pf, kPa): 3481.9

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 28.0 - 29.0 m, are presented below.

Time	Flow rate (l/min)	Comment
13:28	18.34	
13:39	17.40	
13:47	16.98	
13:55.30	16.89	
14:09	16.61	
14:16.30	16.41	
14:22	16.41	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 440 - 490 kPa).

Between 16:18 and 16:42 the test interval was opened again for water sampling.

Borehole KG0021A01, section 29.0 m -30.0 m. Test #31

Date: 98 - 12 - 07 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981207 16:50.11 2) 981207 16:55.43

Valve opened: 981207 17:03.30 Valve closed: 981207 18:04.05
Flowing time : 60.6 min Tot. Pr. Build-up time: 839.1 min

Pressure just before opening the valve (Po, kPa) : 3160.0
Pressure just before closing the valve (Pp, kPa) : 456.4
Pressure at the end of the recovery (Pf, kPa): 3257.7

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 29.0 - 30.0 m, are presented below.

Time	Flow rate (l/min)	Comment
17:06.40	17.97	
17:15	14.92	
17:24.30	14.17	
17:32.30	13.62	
17:43	13.42	
17:52	13.08	
18:02	12.94	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 440 - 490 kPa).

The valve was not opened momentarily but during a period of c. one minute.

Between 08:54 and 09:13 (December 8th) the test interval was opened again for water sampling.

Borehole KG0021A01, section 30.0 m -31.0 m. Test #32

Date: 98 - 12 - 08 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981208 09:22.30 2) 981208 09:28.58

Valve opened: 981208 09:33.55 Valve closed: 981208 10:33.54
Flowing time : 60 min Tot. Pr. Build-up time: 120 min

Pressure just before opening the valve (Po, kPa) : 3110.8
Pressure just before closing the valve (Pp, kPa) : 446.6
Pressure at the end of the recovery (Pf, kPa): 3200.7

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 30.0 - 31.0 m, are presented below.

Time	Flow rate (l/min)	Comment
09:39.20	7.70	
09:46	7.42	
09:51.20	7.25	
09:59.30	7.16	
10:09	7.04	
10:17	7.03	
10:25	7.01	
10:32	6.88	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 440 - 500 kPa).

After the end of the recovery period, the test interval was opened again for water sampling (between 12:36 and 12:57).

Borehole KG0021A01, section 31.0 m -32.0 m. Test #33

Date: 98 - 12 - 08 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981208 13:03:25 2) 981208 13:08.25

Valve opened: 981208 13:12.55 Valve closed: 981208 14:14.55
Flowing time : 62 min Tot. Pr. Build-up time: 120 min

Pressure just before opening the valve (Po, kPa) : 3305.3
Pressure just before closing the valve (Pp, kPa) : 578.8
Pressure at the end of the recovery (Pf, kPa): 3378.0

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 31.0 - 32.0 m, are presented below.

Time	Flow rate (l/min)	Comment
13:17.20	0.048	
13:24	0.046	
13:30	0.047	
13:37	0.0472	
13:46	0.047	
13:53	0.0462	
14:01	0.046	
14:08	0.044	
14:12	0.044	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 540 - 590 kPa).

Borehole KG0021A01, section 32.0 m -33.0 m. Test #34

Date: 98 - 12 - 08 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981208 16:19:40 2) 981208 16:25.32

Valve opened: 981208 16:30.55 Valve closed: 981208 17:31.54
Flowing time : 61 min Tot. Pr. Build-up time: 120 min

Pressure just before opening the valve (Po, kPa) : 3356.1
Pressure just before closing the valve (Pp, kPa) : 576.5
Pressure at the end of the recovery (Pf, kPa): 3355.0

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 32.0 - 33.0 m, are presented below.

Time	Flow rate (l/min)	Comment
16:37	0.096	
16:43	0.100	
16:50	0.083	
16:56.10	0.082	
17:04	0.082	
17:13	0.082	
17:21	0.083	
17:30	0.0815	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 550 - 580 kPa).

After the end of the recovery period (19:33), he test interval was opened again for water sampling. The interval was flowing over the night until 09:45 in the morning December 9th.

Borehole KG0021A01, section 33.0 m -34.0 m. Test #35

Date: 98 - 12 - 09 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981209 09:58:15 2) 981209 10:03.20

Valve opened: 981209 10:07.55 Valve closed: 981209 11:08.25
Flowing time : 60.5 min Tot. Pr. Build-up time: 120.5 min

Pressure just before opening the valve (Po, kPa) : 3352.2
Pressure just before closing the valve (Pp, kPa) : 576.9
Pressure at the end of the recovery (Pf, kPa): 3260.9

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 33.0 - 34.0 m, are presented below.

Time	Flow rate (l/min)	Comment
10:11	0.013	
10:14	0.0127	
10:21.30	0.012	
10:29	0.0105	
10:33	0.0085	
10:37	0.0105	
10:41	0.0102	
10:53	0.0085	
10:57	0.0092	
11:04	0.010	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 440 - 600 kPa).

Borehole KG0021A01, section 35.0 m -36.0 m. Test #36

Date: 98 - 12 - 09 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981209 13:55:25 2) 981209 14:04.10

Valve opened: 981209 14:12 Valve closed: 981209 15:18.56
Flowing time : c. 65 min Tot. Pr. Build-up time: 125.1 min

Pressure just before opening the valve (Po, kPa) : 3371.1
Pressure just before closing the valve (Pp, kPa) : 462.7
Pressure at the end of the recovery (Pf, kPa): 3353.8

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 35.0 - 36.0 m, are presented below.

Time	Flow rate (l/min)	Comment
14:20.10	1.98	
14:24	1.60	
14:28.30	1.54	
14:35	1.49	
14:43	1.34	
14:50	1.37	
15:08	1.40	
15:17	1.38	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 440 - 510 kPa).

The valve was not opened momentarily but during a period of c. two minutes.

Water sampling was performed during the flow period, between 14:56 and 15:06.

Borehole KG0021A01, section 36.0 m -37.0 m. Test #37

Date: 98 - 12 - 09 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981209 17:38:13 2) 981209 17:43.10

Valve opened: 981209 17:49.58 Valve closed: 981209 18:51.55
Flowing time : 62 min Tot. Pr. Build-up time: 59 min

Pressure just before opening the valve (Po, kPa) : 3065
Pressure just before closing the valve (Pp, kPa) : 505.7
Pressure at the end of the recovery (Pf, kPa): 3347.6

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 36.0 - 37.0 m, are presented below.

Time	Flow rate (l/min)	Comment
17:54	0.063	
18:00	0.060	
18:08	0.0597	
18:14	0.060	
18:20	0.059	
18:26	0.056	
18:33	0.058	
18:40	0.057	
18:47	0.056	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 410 - 510 kPa).

The pressure data show a pressure decrease shortly before the valve opening from c. 3300 kPa to c. 1320 Kpa. Then the pressure increased to 3065 kPa. The origin of this pressure drop is not known.

The recovery period is only 59 minutes due to problems with the transducer - connection.

Borehole KG0021A01, section 37.0 m -38.0 m. Test #38

Date: 98 - 12 - 10 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981210 08:19:30 2) 981210 08:24.27

Valve opened: 981210 08:29.55 Valve closed: 981210 09:30.55
Flowing time : 61 min Tot. Pr. Build-up time: 155.1 min

Pressure just before opening the valve (Po, kPa) : 3388.3
Pressure just before closing the valve (Pp, kPa) : 511.4
Pressure at the end of the recovery (Pf, kPa): 3365.5

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 37.0 - 38.0 m, are presented below.

Time	Flow rate (l/min)	Comment
08:34	0.0235	
08:39	0.0221	
08:47	0.0216	
08:57	0.014	!
09:03.30	0.0129	
09:12	0.012	
09:19	0.012	
09:25	0.012	
09:28.30	0.012	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 500 - 550 kPa).

A pressure drop was observed shortly before nine o'clock. At the same time the flow rate decreased. The origin of this anomaly is unknown

Borehole KG0021A01, section 38.0 m -39.0 m. Test #39

Date: 98 - 12 - 10 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981210 12:11:09 2) 981210 12:16.18

Valve opened: 981210 12:21.25 Valve closed: 981210 13:21.55
Flowing time : 60.5 min Tot. Pr. Build-up time: 120.1 min

Pressure just before opening the valve (Po, kPa) : 3349.2
Pressure just before closing the valve (Pp, kPa) : 552.6
Pressure at the end of the recovery (Pf, kPa): 3344.2

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 38.0 - 39.0 m, are presented below.

Time	Flow rate (l/min)	Comment
12:25.25	0.35	
12:35.30	0.334	
12:43	0.335	
12:51	0.3295	
12:59	0.324	
13:07	0.323	
13:13	0.320	
13:20	0.320	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 510 - 570 kPa).

Borehole KG0021A01, section 40.0 m -41.0 m. Test #40

Date: 98 - 12 - 10 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981210 16:20:10 2) 981210 16:25.13

Valve opened: 981210 16:31.05 Valve closed: 981210 17:32.55
Flowing time : 62.8 min Tot. Pr. Build-up time: 840 min

Pressure just before opening the valve (Po, kPa) : 3439.4
Pressure just before closing the valve (Pp, kPa) : 637.4
Pressure at the end of the recovery (Pf, kPa): 3441.4

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 40.0 - 41.0 m, are presented below.

Time	Flow rate (l/min)	Comment
16:38.15	1.170	
16:43.45	1.122	
16:55	1.075	
17:01	1.066	
17:08.55	1.056	
17:16	1.018	
17:23	1.013	
17:31.30	1.0104	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 530 - 650 kPa).

After the end of the recovery period the test interval was opened again between 07:38 and 09:00 (December 11th)for water sampling.

Borehole KG0021A01, section 42.0 m -43.0 m. Test #41

Date: 98 - 12 - 11 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981211 09:51:16 2) 981211 09:56.42

Valve opened: 981211 10:01.55 Valve closed: 981211 11:02.55
Flowing time : 61 min Tot. Pr. Build-up time: 120.1 min

Pressure just before opening the valve (Po, kPa) : 3105.2
Pressure just before closing the valve (Pp, kPa) : 616.5
Pressure at the end of the recovery (Pf, kPa): 3377.0

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 42.0 - 43.0 m, are presented below.

Time	Flow rate (l/min)	Comment
10:05	0.047	
10:11	0.0455	
10:18.10	0.0469	
10:26	0.046	
10:36	0.049	
10:46	0.050	
10:52	0.0502	
11:00	0.050	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 560 - 620 kPa).

Borehole KG0021A01, section 43.0 m -44.0 m. Test #42

Date: 98 - 12 - 14 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981214 13:34:21 2) 981214 13:39.25

Valve opened: 981214 14:29.55 Valve closed: 981214 15:29.54
Flowing time : 60 min Tot. Pr. Build-up time: 120.1 min

Pressure just before opening the valve (Po, kPa) : 3132.0
Pressure just before closing the valve (Pp, kPa) : 549.6
Pressure at the end of the recovery (Pf, kPa): 3495.7

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 43.0 - 44.0 m, are presented below.

Time	Flow rate (l/min)	Comment
14:32	0.375	
14:39	0.340	
14:47	0.329	
14:54	0.324	
15:00	0.322	
15:07	0.319	
15:15	0.316	
15:22	0.312	
15:28	0.315	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 550 - 640 kPa).

Borehole KG0021A01, section 44.0 m -45.0 m. Test #43

Date: 98 - 12 - 14 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981214 17:35:18 2) 981214 17:40.47

Valve opened: 981214 17:45.54 Valve closed: 981214 18:47.54
Flowing time : 62 min Tot. Pr. Build-up time: 865 min

Pressure just before opening the valve (Po, kPa) : 3479.8
Pressure just before closing the valve (Pp, kPa) : 572.8
Pressure at the end of the recovery (Pf, kPa): 3285.3

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 44.0 - 45.0 m, are presented below.

Time	Flow rate (l/min)	Comment
17:48.30	0.0205	
17:55.30	0.018	
18:03 30	0.018	
18:10	0.0171	
18:17	0.0162	
18:25	0.0154	
18:32	0.0149	
18:39	0.0149	
18:46	0.0146	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. After the first minutes of pressure regulation, the section pressure was kept at an approximate constant level (c. 520 - 590 kPa).

The pressure was recovering over the night. However the pressure decreased c. 65 kPa between c. 20:00 and 08:13. This possibly was caused by a pressure drop in borehole KG0048A01, due to packer failure.

Borehole KG0021A01, section 45.0 m - 46.0 m. Test #44

Date: 98 - 12 - 15 Field Crew: B. Gentzschein/J. Olausson
Borehole length: 48.82 m Borehole diameter: 76 mm

Packer inflation: 1) 981215 08:24:14 2) 981215 08:29.39

Valve opened: 981215 08:34.55 Valve closed: 981215 09:38.52
Flowing time : 64 min Tot. Pr. Build-up time: 135.1 min

Pressure just before opening the valve (Po, kPa) : 3616.8
Pressure just before closing the valve (Pp, kPa) : 620.9
Pressure at the end of the recovery (Pf, kPa): 3168.7

The pressure transducer used was positioned 0.71 m above the tunnel floor.
The height of the water flow outlet was c. 1.5 m above the tunnel floor.

Manually measured flow rates in pressure build-up test in KG0021A01, 45.0 - 46.0 m, are presented below.

Time	Flow rate (l/min)	Comment
08:45	0.008	
08:59	0.011	
09:06	0.0108	
09:14	0.0128	
09:21	0.0115	
09:29	0.0105	
09:34	0.0098	
09:38	0.0112	

In order to avoid gas intrusion into the test interval, the flow rate was reduced during the flow period. In this low permeable section it was initially difficult to regulate the pressure at a constant level. After the first 11- 12 minutes of the recovery, the section pressure varied between c. 550 and 620 Kpa.

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APPENDICES

The following appendices are not included as hard copies in the report, but stored on CD-ROM which is available at Äspö Hard Rock Laboratory.

APPENDIX A1 Interference test in the exploratory hole **KG0048A01, 0 – 54.69 m**
Diagrams of borehole **KG0048A01**

APPENDIX A2 Interference test in the exploratory hole **KG0048A01, 0 – 54.69 m**
Diagrams of borehole **KA3510A,**

APPENDIX A3 Interference test in the exploratory hole **KG0048A01, 0 – 54.69 m**
Diagrams of borehole **KA3548A01, KA3542G01, KA3542G02** and **KA3554G02**

APPENDIX A4 Interference test in the exploratory hole **KG0048A01, 0 – 54.69 m**
Diagrams of borehole **KA3573A, KA3566G01, KA3566G02** and **KA3554G01**

APPENDIX A5 Interference test in the exploratory hole **KG0048A01, 0 – 54.69 m**
Diagrams of borehole **KA3600F, KA3590G01, and KA3590G02**.

APPENDIX A6 Interference test in the exploratory hole **KG0048A01, 0 – 54.69 m**
Diagrams of borehole **KG0021A01**.

APPENDIX A7 Interference test in the exploratory hole **KG0021A01, 0 – 48.82 m**
Diagrams of borehole **KG0021A01**

APPENDIX A8 Interference test in the exploratory hole **KG0021A01, 0 – 48.82 m**
Diagrams of borehole **KA3510A,**

APPENDIX A9 Interference test in the exploratory hole **KG0021A01, 0 – 48.82 m**
Diagrams of borehole **KA3548A01, KA3542G01, KA3542G02** and **KA3554G02**

APPENDIX A10 Interference test in the exploratory hole **KG0021A01, 0 – 48.82 m**
Diagrams of borehole **KA3573A, KA3566G01, KA3566G02** and **KA3554G01**

APPENDIX A11 Interference test in the exploratory hole **KG0021A01, 0 – 48.82 m**
Diagrams of borehole **KA3600F and KA3590G02**.

APPENDIX A12 Interference test in the exploratory hole **KG0021A01, 0 – 48.82 m**
Diagrams of borehole **KG0048A01**.

APPENDIX A13 Diagrams of the pressure build-up test in the exploratory hole **KA3579G, 0.50 - 22.65 m**

APPENDIX B1 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **5.00 - 8.00 m**

APPENDIX B2 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **17.00 - 20.00 m**

APPENDIX B3 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **20.00 - 23.00 m**

APPENDIX B4 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **23.00 - 24.00 m**

APPENDIX B5 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **24.00 - 25.00 m**

APPENDIX B6 Diagrams of the pressure build-up test in the exploratory hole

KG0048A01, section **27.00 - 28.00 m**
APPENDIX B7 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **33.00 - 34.00 m**
APPENDIX B8 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **41.00 - 42.00 m**
APPENDIX B9 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **43.00 - 44.00 m**
APPENDIX B10 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **44.00 - 45.00 m**
APPENDIX B11 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **45.00 - 46.00 m**

APPENDIX B12 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **46.00 - 47.00 m**
APPENDIX B13 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **47.00 - 48.00 m**
APPENDIX B14 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **50.00 - 51.00 m**
APPENDIX B15 Diagrams of the pressure build-up test in the exploratory hole **KG0048A01,** section **53.00 - 54.69 m**
APPENDIX B16 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **7.00 - 10.00 m**
APPENDIX B17 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **10.00 - 13.00 m**
APPENDIX B18 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **19.00 - 20.00 m**
APPENDIX B19 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **20.00 - 21.00 m**
APPENDIX B20 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **21.00 - 22.00 m**
APPENDIX B21 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **22.00 - 23.00 m**
APPENDIX B22 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **23.00 - 24.00 m**
APPENDIX B23 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **24.00 - 25.00 m**
APPENDIX B24 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **25.00 - 26.00 m**
APPENDIX B25 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **26.00 - 27.00 m**
APPENDIX B26 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **27.00 - 28.00 m**
APPENDIX B27 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **28.00 - 29.00 m**
APPENDIX B28 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **29.00 - 30.00 m**
APPENDIX B29 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **30.00 - 31.00 m**

APPENDIX B30 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **31.00 - 32.00 m**
APPENDIX B31 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **32.00 - 33.00 m**
APPENDIX B32 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **33.00 - 34.00 m**
APPENDIX B33 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **35.00 - 36.00 m**
APPENDIX B34 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **36.00 - 37.00 m**
APPENDIX B35 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **37.00 - 38.00 m**
APPENDIX B36 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **38.00 - 39.00 m**
APPENDIX B37 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **40.00 - 41.00 m**
APPENDIX B38 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **42.00 - 43.00 m**
APPENDIX B39 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **43.00 - 44.00 m**
APPENDIX B40 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **44.00 - 45.00 m**
APPENDIX B41 Diagrams of the pressure build-up test in the exploratory hole **KG0021A01,** section **45.00 - 46.00 m**

APPENDIX C1

List of data files

Table 1 A list of data files of data stored by the Borre data loggers, during Interference Tests and Pressure Build-up Tests conducted in the exploratory boreholes KG0021A01, KG0048A01 and KA3579G. Prototype Repository, drill campaign 3b. October 1998 – January 1999.

Borehole /Section (m)	Start Date	Start time	Stop Time	Test No	Observation Borehole	"*.HYF-file"	"*.BOR-file"	Calibration File
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KG0048A01	PR3BFLO4.HYF	PR3BFLO4.BOR	Borre45.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3600F	PR3B4_38.HYF	PR3B4_38.BOR	Borre381.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3590G01	PR3B4_38.HYF	PR3B4_38.BOR	Borre381.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3590G02	PR3B4_38.8YF	PR3B4_38.BOR	Borre38.1Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3566G01	PR3B4_36.HYF	PR3B4_36.BOR	Borre36.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3566G02	PR3B4_36.HYF	PR3B4_36.BOR	Borre36.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3573A	PR3B4_36.HYF	PR3B4_36.BOR	Borre36.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3554G01	PR3B4_36.HYF	PR3B4_36.BOR	Borre36.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3548A01	PR3B4_39.HYF	PR3B4_39.BOR	Borre39.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3542G01	PR3B4_39.HYF	PR3B4_39.BOR	Borre39.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3542G02	PR3B4_39.HYF	PR3B4_39.BOR	Borre39.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3554G02	PR3B4_39.HYF	PR3B4_39.BOR	Borre39.Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KG0021A01	PR3B4_44.HYF	PR3B4_44.BOR	Borre44.1Cal
KG0048A01/ 0-54.69	981007	12:00	08:32	1b	KA3510A	PR3B_ 37.HYF	PR3B-37.BOR	Borre37.Cal
KG0021A01/ 0-48.82	981130	17:22	07:54	18	KG0021A01	PR3B6FLO.HYF	PR3B6FLO.BOR	Borre45.Cal
KG0021A01/ 0-48.82	981130	16:56	07:54	18	KA3600F	PR3B1838.HYF	PR3B1838.BOR	Borre382.Cal
KG0021A01/ 0-48.82	981130	16:56	07:54	18	KA3590G02	PR3B1838.HYF	PR3B1838.BOR	Borre382.Cal
KG0021A01/ 0-48.82	981130	16:48	07:54	18	KA3566G01	PR3B6_36.HYF	PR3B6_36.BOR	Borre36.Cal
KG0021A01/ 0-48.82	981130	16:48	07:54	18	KA3566G02	PR3B6_36.HYF	PR3B6_36.BOR	Borre36.Cal
KG0021A01/ 0-48.82	981130	16:48	07:54	18	KA3573A	PR3B6_36.HYF	PR3B6_36.BOR	Borre36.Cal
KG0021A01/ 0-48.82	981130	16:48	07:54	18	KA3554G01	PR3B6_36.HYF	PR3B6_36.BOR	Borre36.Cal
KG0021A01/ 0-48.82	981130	16:14	07:54	18	KA3548A01	PR3B6_39.HYF	PR3B6_39.BOR	Borre39.Cal
KG0021A01/ 0-48.82	981130	16:14	07:54	18	KA3542G01	PR3B6_39.HYF	PR3B6_39.BOR	Borre39.Cal
KG0021A01/ 0-48.82	981130	16:14	07:54	18	KA3542G02	PR3B6_39.HYF	PR3B6_39.BOR	Borre39.Cal
KG0021A01/ 0-48.82	981130	16:14	07:54	18	KA3554G02	PR3B6_39.HYF	PR3B6_39.BOR	Borre39.Cal
KG0021A01/ 0-48.82	981130	17:22	07:54	18	KG0048A01	PR3B8_44.HYF	PR3B8_44.BOR	Borre44.2Cal
KA3779G / 0.5- 22.65	990116	09:25	13:50	45	KA3579G	KA3579G.HYF	KA3579G.BOR	Borre45.Cal

The end dates of the tests in KG0048A01, KG0021A01 and KA3579G were 981007, 981201 and 990118 respectively.

During the tests in KG0021A01 borehole KA3510A was monitored by the Hydro Monitoring System of Äspö HRL

Table 2 Data files of the test sections stored by the Borre data loggers, during Pressure Build-up Tests of features conducted in the boreholes KG0021A01, KG0048A01 and KA3579G. (Calibration file = Borre452cal) Prototype Repository, drill campaign 3b. October 1998 - January 1999.

Borehole Section (m)	Date	Start Time	Stop Time	Test No	".HYF-file"	".BOR-file"	Calibration File
KG0048A01 5.00-8.00	981008	15:46	19:12	2	PR3B0245.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 17.0-20.0	981009	10:19	13:47	3	PR3B0345.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 20.0-23.0	981009	14:19	17:29	4	PR3B0445.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 23.0-24.0	981009	17:35	20:40	5	PR3B0545.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 24.0-25.0	981010	10:35	13:35	6	PR3B0645.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 27.0-28.0	981010	14:54	17:59	7	PR3B0745.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 33.0-34.0	981011	09:25	12:29	8	PR3B0845.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 41.0-42.0	981012	18:03	08:00	9	PR3B0945.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 43.0-44.0	981013	12:11	15:23	10	PR3B1045.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 44.0-45.0	981013	10:44	13:49	11	PR3B1145.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 45.0-46.0	981013	13:58	17:11	12	PR3B1245.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 46.0-47.0	981014	17:17	20:22	13	PR3B1345.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 47.0-48.0	981014	10:57	14:09	14	PR3B1445.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 50.0-51.0	981014	14:21	17:27	15	PR3B1545.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0048A01 53.0-54.69	981015	17:31	21:17	16	PR3B1645.HYF	PR3BFLO4.BOR	Borre451.Cal
KG0021A01 7.0-10.0	981202	10:49	15:59	19	PR3B1945.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 10.0-13.0	981202	16:06	19:44	20	PR3B2045.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 19.0-20.0	981204	08:10	11:23	21	PR3B2145.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 20.0-21.0	981204	14:36	14:52	22	PR3B2245.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 21.0-22.0	981205	13:28	16:34	23	PR3B2345.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 22.0-23.0	981205	16:40	19:50	24	PR3B2445.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 23.0-24.0	981205	19:56	08:44	25	PR3B2545.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 24.0-25.0	981206	10:58	14:13	26	PR3B2645.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 25.0-26.0	981206	10:32	15:03	27	PR3B2745.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 26.0- 27.0	981206	15:09	18:49	28	PR3B2845.HYF	PR3B6FLO.BOR	Borre452.Cal
KG0021A01 27.0-28.0	981207	19:44	08:32	29	PR3B2945.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 28.0-29.0	981207	11:15	14:22	30	PR3B3045.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 29.0-30.0	981207	14:25	18:00	31	PR3B3145.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 30.0-31.0	981208	18:54	08:03	32	PR3B3245.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 31.0-32.0	981208	08:09	11:20	33	PR3B3345.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 32.0-33.0	981208	11:24	14:30	34	PR3B3445.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 33.0-34.0	981209	15:13	18:22	35	PR3B3545.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 35.0-36.0	981209	16:01	19:14	36	PR3B3645.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 36.0-37.0	981209	19:17	08:00	37	PR3B3745.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 37.0-38.0	981210	09:37	13:05	38	PR3B3845.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 38.0-39.0	981210	13:10	16:58	39	PR3B3945.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 40.0-41.0	981210	18:39	19:48	40	PR3B4045.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 42.0-43.0	981211	19:54	21:13	41	PR3B4145.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 43.0-44.0	981214	11:22	14:40	42	PR3B4245.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 44.0-45.0	981214	15:33	18:40	43	PR3B4345.HYF	PR3B9FLO.BOR	Borre452.Cal
KG0021A01 45.0-46.0	981215	18:42	08:13	44	PR3B4445.HYF	PR3B9FLO.BOR	Borre452.Cal

Table 3 Data files of the observation boreholes stored by the Borre data loggers, during Pressure Build-up Tests of features conducted in the boreholes KG0021A01 and KG0048A01. Prototype Repository, drill campaign 3b. October 1998 - December 1998.

Borehole (m)	Date	Test No's	Observation Boreholes	".HYF-file"	".BOR-file"	Calibration File
KG0048A01	981006-981017	2– 16	KA3600F	PR3B4_38.HYF	PR3B4_38.BOR	Borre381.Cal
			KA3590G01	PR3B4_38.HYF	PR3B4_38.BOR	Borre381.Cal
			KA3590G02	PR3B4_38.HYF	PR3B4_38.BOR	Borre381.Cal
			KA3573A	PR3B4_36.HYF	PR3B4_36.BOR	Borre36.Cal
			KA3566G01	PR3B4_36.HYF	PR3B4_36.BOR	Borre36.Cal
			KA3566G02	PR3B4_36.HYF	PR3B4_36.BOR	Borre36.Cal
			KA3554G01	PR3B4_36.HYF	PR3B4_36.BOR	Borre36.Cal
			KA3548A01	PR3B4_39.HYF	PR3B4_39.BOR	Borre39.Cal
			KA3542G01	PR3B4_39.HYF	PR3B4_39.BOR	Borre39.Cal
			KA3542G02	PR3B4_39.HYF	PR3B4_39.BOR	Borre39.Cal
			KA3554G02	PR3B4_39.HYF	PR3B4_39.BOR	Borre39.Cal
			KA3510A	PR3B_37.HYF	PR3B_37.BOR	Borre37.Cal
			KG0021A01	PR3B_44.HYF	PR3B_44.BOR	Borre441.Cal
KG0021A01	981202-981205	19– 25	KA3600F	PR3B8_38.HYF	PR3B8_38.BOR	Borre381.Cal
			KA3590G01	PR3B8_38.HYF	PR3B8_38.BOR	Borre381.Cal
			KA3590G02	PR3B8_38.HYF	PR3B8_38.BOR	Borre381.Cal
			KA3573A	PR3B6_36.HYF	PR3B6_36.BOR	Borre36.Cal
			KA3566G01	PR3B6_36.HYF	PR3B6_36.BOR	Borre36.Cal
			KA3566G02	PR3B6_36.HYF	PR3B6_36.BOR	Borre36.Cal
			KA3554G01	PR3B6_36.HYF	PR3B6_36.BOR	Borre36.Cal
			KA3548A01	PR3B6_39.HYF	PR3B6_39.BOR	Borre39.Cal
			KA3542G01	PR3B6_39.HYF	PR3B6_39.BOR	Borre39.Cal
			KA3542G02	PR3B6_39.HYF	PR3B6_39.BOR	Borre39.Cal
			KA3554G02	PR3B6_39.HYF	PR3B6_39.BOR	Borre39.Cal
			KG0048A01	PR3B8_44.HYF	PR3B8_44.BOR	Borre442.Cal
KG0021A01	981206-981217	26– 44	KA3600F	PR3B8_38.HYF	PR3B8_38.BOR	Borre381.Cal
			KA3590G01	PR3B8_38.HYF	PR3B8_38.BOR	Borre381.Cal
			KA3590G02	PR3B8_38.HYF	PR3B8_38.BOR	Borre381.Cal
			KA3573A	PR3B8_36.HYF	PR3B8_36.BOR	Borre36.Cal
			KA3566G01	PR3B8_36.HYF	PR3B8_36.BOR	Borre36.Cal
			KA3566G02	PR3B8_36.HYF	PR3B8_36.BOR	Borre36.Cal
			KA3554G01	PR3B8_36.HYF	PR3B8_36.BOR	Borre36.Cal
			KA3548A01	PR3B8_39.HYF	PR3B8_39.BOR	Borre39.Cal
			KA3542G01	PR3B8_39.HYF	PR3B8_39.BOR	Borre39.Cal
			KA3542G02	PR3B8_39.HYF	PR3B8_39.BOR	Borre39.Cal
			KA3554G02	PR3B8_39.HYF	PR3B8_39.BOR	Borre39.Cal
			KG0048A01	PR3B8_44.HYF	PR3B8_44.BOR	Borre442.Cal

TEXT FILES

All the datafiles of the test intervals have been transformed to textfiles (.TXT). The format of the files is described in the QA-document of test campaign 3b (Ingvar Rhén 1998-06-21)

The files are named according to:
NNVPLLLL.TXT

where

NN = Test No
V = Test parameter; P = pressure, Q= Flow
P = Test Phase; D = draw down, B = recovery
LLLL = Borehole ID (position in the tunnel)

(example: 12PD3542.TXT)