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Äspö Hard Rock Laboratory

Prototype Repository

Hydraulic tests in exploratory holes
Interference tests A after drilling campaign 3

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Geosigma

May 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

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

This International Progress Report is report number 6 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 first batch of interference tests, which were performed in four of the approximately 30 m deep exploratory holes. (The first four reports concerned in-flow and pressure build-up studies in the 33 exploratory drillholes in the Prototype Repository rock volume, supplemented with interference tests in hole sections with high in-flows. The fifth report concerned injection tests in the first 1.75 m of 13 of the altogether 33 exploratory holes.)

Packers were installed in the four holes so that five sections varying from approximately 5 to 10 m in length were obtained. Packers, one to four per hole, were also installed in all other exploratory holes (29 holes) in the Prototype Repository rock volume. Almost all of these 51 bore hole sections were connected to the Hydro Monitoring System, HMS. Flowing of each of the five sections was made in accordance to prepared plans and the data were processed, stored and plotted by the HMS. Two parameters were later processed: groundwater pressure and hydraulic head.

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:

1. Kartering av tunneln
2. Pilot-och undersökningshål
3. Deponeringshål

Denna International Progress Report utgör rapport nummer 6 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 de första interferenstester, vilka utfördes i 4 av de ca 30 m djupa undersökningshålen. (Den fyra första rapporterna redovisade resultaten från inflödes-och tryckuppbyggnadstester i de 33 undersökningshålen i prototypförvarsområdet kompletterade med interferenstester i borrhålssektioner med stort inflöde. Den femte rapporten redovisade resultaten av injektionstester i de första 1,75 m i 13 av de totalt 33 undersökningshålen i prototypförvarsområdet.)

Manschetter installerades i de fyra hålen så att fem sektioner med en längd på mellan ca 5 och 10 m bildades. En till fyra manschetter installerades också i alla de andra undersökningshålen (29 st hål) i prototypförvaret. Nästan alla dessa 51 sektioner anslöts till Äspölaboratoriets hydromoniteteringssytem, HMS. Flödning av all de fem testsektionerna gjordes enligt förberedda planer, och data processades, lagrades och plottades upp av HMS. Två parametrar processades senare: grundvattentrycket och hydrauliska trycket.

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1 BACKGROUND

Within the scope of the SKB 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 localisation 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 is 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 October 14th and October 20th 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 between March 16th and March 24th 1998. Hydraulic tests were performed in these boreholes in November 1997 and in April 1998.

Two short exploratory holes were drilled on April 25th and 26th 1998. 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. In July and August two c 50 m long exploratory boreholes where drilled from the G-tunnel towards and above the prototype tunnel. During the summer and autumn flow measurements and hydraulic tests (PBT’s and interference tests) were performed in the long exploratory holes. The last tests were completed in December 1998. In January 1999 constant pressure injection tests were carried out in 13 exploratory boreholes in the prototype tunnel.

Finally interference tests were carried out in 4 exploratory boreholes in February and April 1999. This report describes objectives, performance and results of these tests.

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 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 of 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 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 the hydraulic tests – interference tests

The objectives of the interference tests in the exploratory bore holes are to obtain data for the geological and hydrogeological models.

The objectives of the hydraulic tests in the long exploratory bore holes are:

- The hydraulic tests in the exploratory holes shall provide hydrogeological data useful for setting up a hydrogeological model of the rock volume around the TBM tunnel. Identification of the positions and properties of larger conductive features are the main objectives.

3. SCOPE

Interference tests were performed in five borehole sections in four of the long exploratory holes of the Prototype Repository tunnel. The tested intervals and basic test data are listed in Table 3-1. Four of the tests were planned before the test period. Test number 4 was accomplished as a function test. Test number 3 was repeated and denominated test number 6, since a leakage around the packers was observed in the test hole during the first test (test #3).

Table 3-1 A list of interference tests conducted in four of the long exploratory boreholes. Prototype Repository, February and April 1999.

Borehole: Section	Section Limits (m)	Date of test	Test No	Start of Test (kl.)	V. 0pen (kl.)	V Close (kl.)	End of Test (kl.)
KA3566G01:2	12.30-19.80	990220	1	00:00 (990220)	14:01	20:05	08:00 (990224)
KA3566G02:2	12.30-18.30	990224	2	07:00	08:26	14:43	08:00 (990225)
KA3590G01:3	1.30 – 6.80	990225	3	07:30	08:20	14:23	07:30 (990226)
KA3590G01:2	7.80 -16.30	990226	4	07:30	07:53	08:03	08.33
KA3590G02:1	23.30-30.05	990226	5	07:30	08:35	16:05	08:00 (990301)
KA3590G01:3	1.30 – 6.80	990406	6	09:00	09:59	16:01	06:30 (990407)

Start/End of test = Start/end of data fetch

Prior to the interference tests, packers were installed in all boreholes in the Prototype Repository tunnel. In some boreholes only one mechanical single packer was installed, in others (16 boreholes) up to four inflatable polyurethane packers were installed, dividing the boreholes in 2 – 4 measurement intervals. Packers were also installed in KG0048A01 in the G-tunnel. Almost all (51) borehole sections in the Prototype Repository tunnel were connected to the Hydro Monitoring System (HMS) of the Äspö HRL.

Many of the confined sections were very low conductive. The pressure hoses connecting the borehole sections with the pressure transducers were long (20 – 110 m). The flow of the borehole sections was too small to fill up the hoses within a reasonable long time. Instead this was done manually. The air in the hoses was evacuated by filling the pressure pipes with water from the “transducer end” towards the packers (deflated).

The boreholes in the G-tunnel, KG0021A01 and KG0048A01, were connected to data loggers BORRE.

After packer installation the ground-water pressure of the borehole sections was permitted to stabilize during three days.

4. EQUIPMENT USED

Two types of packers were used to confine the borehole measurement sections.

1. PUR 72
   Inflatable Polyurethane packers. The sealing length of each packer is 1.0 m. The packers are inflated using water pressurized by nitrogen, cf. Lindström (1997)
   The packer pressure was maintained by means of three pressure vessels located next to borehole KA3510A.

2. Mechanical, 0.28 m (Mech 0.28)
   A new type of mechanical packer, with no packer pipe outside the borehole. The total packer length is 0.28 m. The sealing length is 0.135 m.

The groundwater pressure of the measurement sections in the Prototype tunnel were monitored using the Hydro Monitoring System (HMS) of Äspö HRL (Nyberg et al 1997, Manual för HMS 1994). Via polyamide hoses each section was connected to a pressure transducer mounted on a control board in the I-tunnel. The pressure transducers used were of type Druck PTX 520. The pressure range was 50 bar. The distance between the control board and the boreholes varied between c. 20 m and c. 110 m. The level of each pressure transducer above the tunnel floor is listed in Table 4-1

Pressure data of the two boreholes in the G-tunnel were measured and stored using the pressure transducers Druck PTX 1400 and the data logger BORRE MDL ver. 2.2, manufactured by IPA-konsult AB, cf. Gentzschein, 1994. The transducer of KG0021A01 was connected to a valve on the casing. The transducers of KG0048A01 were positioned c. 3 m east of the borehole.

Water flow rates were measured using graduated cylinders of different sizes and a stopwatch. The outflow level above the tunnel floor for each test is specified in Table 4-3.

The technical specifications of the pressure transducers are:

	PTX 520	**PTX 1400**
Supply voltage:	9 - 30 VDC	9 – 28 VDC
Output current:	4 - 20 mA	4 - 20 mA
Linearity, hysteresis and Repeatability :	± 0.3 % of full scale (typically 0.15 % F.S)	± 0.25 % F.S. (typically 0.15 % F.S)
Best straight line definition:	±0.2 % F.S. (typically ±0.1 % F.S)	±0.2 % F.S. (typically ±0.1 % F.S)
Temperature error :	± 1 % F.S. over -10 ^{o}C to +50 ^{o}C (typically 0.7 % F.S)	± 2 % F.S. over -20 ^{o}C to +80 ^{o}C (typically 1.5 % F.S)

Table 4-1 Level of pressure transducers above the tunnel floor. Interference tests A after drill campaign 3. Prototype Repository, February 1999.

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Idcode	secup	Seclow	z-coordinate	Level above floor (m)
KA3510A:1	122,02	150,00	-447,960	0.81
KA3510A:2	114,02	121,02	-447,960	0.81
KA3510A:3	4,52	113,02	-447,960	0.81
KA3539G:1	0,30	30,01	-448,250	0.52
KA3542G01:1	0,30	30,04	-448,250	0.52
KA3542G02:1	0,30	30,01	-448,250	0.52
KA3548A01:1	15,00	30,00	-448,250	0.52
KA3548A01:2	10,00	14,00	-448,250	0.52
KA3550G01.1	0,30	12,03	-448,250	0.52
KA3552G01:1	0,30	12,01	-448,250	0.52
KA3554G01:1	0,30	30,01	-448,250	0.52
KA3554G02:1	0,30	30,01	-448,250	0.52
KA3557G:1	0,30	30,04	-448,250	0.52
KA3563G011:	9,30	30,00	-447,540	1.23
KA3563G01:2	3,80	8,30	-447,540	1.23
KA3563G01:3	1,30	2,80	-447,540	1.23
KA3566G01:1	20,80	30,01	-447,540	0.52
KA3566G01:2	12,30	19,80	-447,540	1.23
KA3566G01:3	7,30	11,30	-447,540	1.23
KA3566G01:4	1,30	6,30	-447,540	1.23
KA3566G02:1	19,30	30,01	-447,540	1.23
KA3566G02:2	12,30	18,30	-447,540	1.23
KA3566G02:3	7,80	11,30	-447,540	1.23
KA3566G02:4	1,30	6,80	-447,900	0.87
KA3572G01:1	6,30	12,00	-447,900	0.87
KA3572G01:2	1,30	5,30	-447,900	0.87
KA3573A:1	18,00	40,07	-448,250	0.52
KA3573A:2	4,50	17,00	-448,250	0.52
KA3574G01:1	8,80	12,00	-447,900	0.87
KA3574G01:2	5,30	7,80	-447,900	0.87
KA3574G01:3	1,30	4,30	-447,900	0.87
KA3576G01:1	8,80	12,01	-447,900	0.87
KA3576G01:2	3,80	7,80	-447,900	0.87
KA3576G01:3	1,30	2,80	-447,900	0.87
KA3578G01:1	6,80	12,58	-447,900	0.87
KA3578G01:2	1,30	5,80	-447,900	0.87
KA3579G01:1	9,30	22,65	-447,900	0.87
KA3579G01:2	5,30	8,30	-447,900	0.87
KA3579G01:3	1,30	4,30	-447,900	0.87
KA3584G01:1	0,30	12,00	-448,250	0.52
KA3590G01:1	17,30	30,06	-447,900	0.87
KA3590G01:2	7,80	16,30	-447,900	0.87
KA3590G01:3	1,30	6,80	-447,900	0.87
KA3590G02:1	23,30	30,05	-447,900	0.87
KA3590G02:2	17,30	22,30	-447,900	0.87
KA3590G02:3	8,30	16,30	-447,900	0.87

Idcode	secup	Seclow	z-coordinate	Level above floor (m)
KA3590G02:4	1,20	7,20	-447,900	0.87
KA3593G01:1	8,30	30,02	-447,900	0.87
KA3593G01:2	1,30	7,30	-448,250	0.52
KA3600F:1	22,00	50,10	-448,250	0.52
KA3600F:2	4,50	21,00	-448,250	0.52
KG0021A01:1	0	48.82		2.56
KG0048A01:1	49.00	54.69		1.03
KG0048A01:2	41.00	48.00		0.96
KG0048A01:3	30.00	40.00		1.05
KG0048A01:4	4.00	29.00		1.18

Six of the boreholes are supplied with a borehole casing. The lengths are listed in Table 4-2

Table 4-2 Casing lengths in boreholes of the Prototype Repository.

Borehole	Length of casing in borehole (m)
KA3510A	<2.48
KA3548A01	2.20
KA3573A	2.31
KA3600F	2.27
KG0021A01	2.20
KG0048A01	2.42

Any notation of the exact length of the casing in borehole KA3510A does not exist, but the drilling record indicates that the length is less than and probably not far from 2.48 m.

Table 4-3 Outflow level above the floor. Interference tests A in exploratory holes, February - April 1999. Prototype Repository.

Borehole	Section (m)	Date	Test No	Outflow level above floor (m)
KA3566G01:2	12.30-19.80	990220	1	0.2-0.5
KA3566G02:2	12.30-18.30	990224	2	0.2-0.5
KA3590G01:3	1.30 – 6.80	990225	3	0.2-0.5
KA3590G01:2	7.80 -16.30	990226	4	0.2-0.5
KA3590G02:1	23.30-30.05	990226	5	0.2-0.5
KA3590G01:3	1.30 – 6.80	990406	6	0.2-0.5

5. PERFORMANCE

5.1 Packer installations and HMS-connection

The packer installation and the HMS-connection of the boreholes in the Prototype tunnel started on January 27th and was completed on February 17th. In a majority of the boreholes the packers were reconfigured. In a few boreholes the already established packer configuration was used. Two types of packers were installed: PUR 72 and mechanical 0.28 m, see Chapter 4. The mechanical packers were expanded on February 2nd or earlier. Most of the polyurethane packers (PUR 72) were initially inflated 990211-990212, and then occasionally released during the installation work. The packers of the boreholes KA3573A and KA3600F were installed 980305 but were temporarily deflated during two hours on February 15th for equipment completing.

Table 5-1 illustrates packer type and the last packer inflation date of each borehole.

Pressure transducers connected to HMS and positioned in the I-tunnel were measuring the borehole section pressures, one transducer for each section. Polyamide pipes connected the transducers and the measurement sections. If the confined intervals were permeable, the pipes were filled up by the borehole water, but if the sections yielded low flow rates the pipes had to be filled up manually. This was done with the help of nitrogen gas and a pressure vessel from the "transducer end" of the pipes when the packers were deflated. Sections with manually filled up pressure pipes are marked in Table 5-1

Five of the pressure transducers were unstable. The instability was in the range of ±5 kPa. Unfortunately also transducers connected to some sections vital for the interpretation of the interference tests were unstable. These sensors were replaced by transducers from sections of less importance (they were not expected to respond to the draw-downs of the flowing intervals). The shift of sensors was carried out at c. 11:00 February 22nd .

The transducers of the following sections were shifted.

KA3566G02:4 – KA3550G01:1
KA3590G02:3 – KA3539G:1
KA3548A01:1 – KA3557G:1
KA3548A01:2 – KA3552G:01:1

During the five first tests the following borehole sections were monitored with unstable pressure transducers:

KA3539G:1 (0.30 - 30.01 m)
KA3542G02:1 (0.30 – 30.01 m)
KA3550G01:1 (0.30 – 12.03 m)
KA3552G01:1 (0.30 – 12.01 m)
KA3557G:1 (0.30 – 30.04 m)

Prior to test #6 some of the transducers were shifted once more and the sensors of the following sections were more or less unstable:

KA3539G:1 (0.30 - 30.01 m)
KA3542G01:1 (0.30 – 30.04 m)
KA3548A01:2 (10.0 – 14.00 m)
KA3566G02:4 (1.30 – 6.80 m)
KA3584G01:1 (0.30 – 12.00 m)

Table 5-1 Packer type and packer inflation date, interference tests A after drill campaign 3. Prototype Repository, February 1999

Borehole	Packer type	Last date/time of packer inflation	Pipes manually filled up ?
KA3510A	PUR 72	981123	
KA3539G	Mech. 0.28	990202	
KA3542G01	Mech. 0.28	Before 990203	
KA3542G02	Mech. 0.28	Before 990203	
KA3544G01	Mech. 0.28	Before 990203	
KA3545G	Mech. 0.28	Before 990203	
KA3546G01	Mech. 0.28	Before 990203	
KA3548A01	PUR 72	990217 10:20	
KA3550G01	Mech. 0.28	Before 990203	
KA3551G	Mech. 0.28	Before 990203	
KA3552G01	Mech. 0.28	Before 990203	
KA3554G01	Mech. 0.28	Before 990203	
KA3554G02	Mech. 0.28	Before 990203	
KA3557G	Mech. 0.28	Before 990203	
KA3563G	PUR 72	990217 10:20	Yes
KA3566G01	PUR 72	990217 10:30	Yes
KA3566G02	PUR 72	990217 10:30	Yes
KA3569G	Mech. 0.28	990202 10:05	Yes
KA3572G01	PUR 72	990217 10:30	Yes
KA3573A	PUR 72	990215 19:50	Yes
KA3574G01	PUR 72	990217 10:20	Yes
KA3575G	Mech. 0.28	990202 09:00	Yes
KA3576G01	PUR 72	990217 10:20	Yes
KA3578G01	PUR 72	990217 10:20	Yes
KA3579G01	PUR 72	990217 10:30	Yes
KA3581G	Mech. 0.28	990202 09:05	
KA3584G01	PUR 72	990202 09:30	Yes
KA3586G01	Mech. 0.28	990202 09:10	
KA3587G	Mech. 0.28	990202 09:15	
KA3588G01	Mech. 0.28	990202 09:20	
KA3590G01	PUR 72	990217 10:30	Yes
KA3593G01	PUR 72	990217 10:30	Yes
KA3600F	PUR 72	990216 19:50	
KG0048A01	PUR 72	990216 10:48	

5.2 Interference Tests.

Prior to the tests, the boreholes were left undisturbed in order to enable the pressures of the borehole sections to stabilize for about three days

The tests were performed according to the following standard cycle:

- the undisturbed pressure was monitored in all boreholes for at least 1 hour before the start of the flowing period, sampling interval 3 minutes.
- the sampling interval was changed to 5 or 2 seconds
- As soon as possible the valve of the flowing section was opened and the flow was measured 3 times during the first c. 5 minutes. The flow measurements were repeated 4 more times during the first hour
- after 5 minutes or more the sampling interval was changed to 30 seconds and after further 60 minutes to 3 minutes.
- the flowing section was left open for 6 –7 hours
- shortly before the valve was closed the flow was measured 3 times after which the sampling interval again was changed to 5 seconds.
- the test valve was closed and the recovery period started.
- after 5 minutes or more the sampling interval was changed to 30 seconds and after further 60 minutes to 3 minutes. The length of the recovery period was 17 hours

In practice, the duration of the flowing period and the recovery period varied, see Table 3-1

The change of sampling interval of the BORRE data logger was executed by field personnel, while changing of measurement frequency in the HMS-system was usually operated by personnel at the GEOSIGMA office in Uppsala, after call from the field crew.

5.3 Data Processing

Data from the HMS-monitored borehole sections were processed, stored and plotted by the HMS-system, see Nyberg et al, 1997 and Manual för HMS 1994. Two parameters were processed, ground-water pressure (including the barometric pressure) and hydraulic head. The hydraulic head (HH, m.a.s.l.) was determined according to:

$$HH = K1 + K2 \times MV$$

MV = Measured Value (kPa)

$$K1 = (\rho_s \times g \times (Z_{tr} - Z_{mid}) - P_0) / (\rho_0 \times g) + Z_{mid}$$

ρ_s = Density in tube between Pressure Gauge and section midpoint (kg/m^3)
g = 9.81 = Acceleration of Gravity (m/s^2)
Z_{tr} = Level of Pressure Gauge (m.a.s.l.)
Z_{mid} = Level of section midpoint (m.a.s.l.)
P_0 = 101325 = Normal Barometric Pressure at Ground Surface (Pa)
ρ_0 = Density of "fresh water" (kg/m^3)
K2 = 1000 / (ρ_0 x g)

ρ_s was estimated by calculating the values from measured or estimated electric conductivity data. The formula used is:

Density (kg/m^3) = 997.3 + 0.00467 x Electrical conductivity (mS/m)

See also Ingvar Rhén et. Al, 1993, (PR 25-93-13, Appendix 1:5) and Nyberg et al, 1997. (PR HRL-98-19, p 27). ρ_0 was taken from Ingvar Rhén et. al 1993, (PR 25-93-13, Appendix 1:5)

In the hydraulic head calculations for the Prototype Repository boreholes and electrical conductivity of 1000 mS/m was used resulting in a density of 1002 kg/m^3.

Pressure data stored by the Borre data logger were processed by the programs BORRE.EXE (data fetch program) and BORREFIL.EXE, see Gentzschein, 1994. The latter program transfers the raw data file (*.BOR) to a " HYF-file" (*.HYF). The programs PUMPKONV and SKBPLOT are used to create the diagrams, cf. Ergodata, 1998, and Ergodata, 1997. PUMPKONV also ceates text-files (*.OVD), in which pressure and time are listed in TAB-separated files. Appendix 1 presents the data files from the BORRE data logger.

6. RESULTS

6.1 Interference Tests.

Appendices 3 - 8 contain the diagrams for each test respectively. Linear plots of the ground-water pressure and the hydraulic head are included. The plotted intervals are:

Test #1:	99-02-20 00:00 - 99-02-24 08:00	
Test #2:	99-02-24 07:00 - 99-02-25 08:00	
Test: #3:	99-02-25 07:30 - 99-02-26 07:30	
Test #4:	99-02-26 07:30 - 99-02-26 08:33	
Test #5:	99-02-26 07:30 - 99-03-01 08:00	and
	99-02-26 07:30 - 99-03-08 08.00	
Test: #6:	99-04-06 00:00 - 99-04-07 06:30	

No major disturbing activity during the test was identified. However, during the week foregoing the interference tests, flow logging of the cored borehole KA2563A was conducted, which significantly affected the ground water pressure of the Prototype Repository site. The measurements in KA2563A started on February 16th and the borehole was shut in on February 19th at 09:11. The linear diagrams illustrate that in some boreholes the ground water pressure is still recovering the days immediately prior to the interference tests.

Data files (MIO-format) corresponding to the five test periods were created and saved. Data files containing the hydraulic head of the borehole sections for the corresponding time periods have also been created.

Details and important test data for each test are described in sections 6.1.1 – 6.1.6. The abbreviations used are:

- P_0 = Initial pressure before opening of the valve
- P_p = Pressure just before closing the valve
- P_f = Pressure at the end of the pressure build-up period
- Q_p = Flow rate at the end of the flowing period (average of the three last measurements)
- V_{tot} = The integral of the flow rate during the entire flowing period
- Q_{ave} = Average flow rate, calculated according to:

$$Q_{ave} = \frac{V_{tot}}{tp}$$, where tp = length of the flowing period.

6.1.1 Borehole KA3566G01, section 12.30 m –19.80 m, test # 1

Date: 99-02-22 Field Crew: Bengt Gentzschein
Borehole length: 30.01 m Borehole diameter: 76 mm
Flowing borehole: KA3566G01, section #2: 12.30 – 19.80 m

Valve opened: 990222 14:01.10 Valve closed: 990222 20:05.10
End of Test: 990224 08:00
Total flowing time : 364 min Tot. Pr. Build-up time: 2155 min.

The test was performed as an Interference test. Pressure responses were monitored in 51 borehole sections.

Pressure data

Table 6-1 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3566G01, section 12.30 – 19.80 m. Prototype Repository, February 1999

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po – Pp	Pf - Pp
KA3510A:1	4095,4	4095,4	4098,2	0	2,8
KA3510A:2	4132,8	4132,8	4135,2	0	2,4
KA3510A:3	3925,6	3923,7	3928	1,9	4,3
KA3539G:1	3058	3062,9	3036,5	-4,9	-26,4
KA3542G01:1	3782,1	3779	3781,5	3,1	2,5
KA3542G02:1	3195	3196,1	3169,5	-1,1	-26,6
KA3548A01:1	3900,8	3900	3903,3	0,8	3,3
KA3548A01:2	3821,9	3821,2	3823,7	0,7	2,5
KA3550G01:1	147,9	148,9	152,8	-1	3,9
KA3552G01:1	246	250,3	235,9	-4,3	-14,4
KA3554G01:1	3769,9	3768,7	3771,7	1,2	3
KA3554G02:1	3198,6	3202,3	3181,4	-3,7	-20,9
KA3557G:1	98,7	98,9	94,4	-0,2	-4,5
KA3563G01:1	1238,8	1242,5	1273	-3,7	30,5
KA3563G01:2	1239,4	1243,1	1273,4	-3,7	30,3
KA3563G01:3	102,1	102,5	103,1	-0,4	0,6
KA3566G01:1	2726,5	2653,5	2727,8	73	74,3
KA3566G01:2	**2123,1**	**103,3**	**2106,4**	**2019,8**	**2003**
KA3566G01:3	2757,5	2742,6	2859,3	14,9	116,7
KA3566G01:4	2678,9	2665,4	2705,7	13,5	40,3
KA3566G02:1	3364,9	3367,4	3356,3	-2,5	-11,1

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po – Pp	Pf - Pp
KA3566G02:2	3520,7	3521,5	3521,1	-0,8	-0,4
KA3566G02:3	2808	2801	2818,6	7	17,6
KA3566G02:4	312,8	313,6	317,5	-0,8	3,9
KA3572G01:1	1635,5	1641	1690,3	-5,5	49,3
KA3572G01:2	336,3	336,5	340,4	-0,2	3,9
KA3573A:1	4042,7	4042,5	4045	0,2	2,5
KA3573A:2	3906,9	3906,5	3909,8	0,4	3,3
KA3574G01:1	408,5	413,2	440,2	-4,7	27
KA3574G01:2	2029,2	1990,7	1817,6	38,5	-173,1
KA3574G01:3	143,9	139,6	140,4	4,3	0,8
KA3576G01:1	483,2	475,6	446,6	7,6	-29
KA3576G01:2	160,7	160,1	157	0,6	-3,1
KA3576G01:3	1168,2	1125,1	934,5	43,1	-190,6
KA3578G01:1	437,8	444,3	486,5	-6,5	42,2
KA3578G01:2	161,1	160,3	156,8	0,8	-3,5
KA3579G01:1	1738,7	1743,6	1788,7	-4,9	45,1
KA3579G01:2	1110,3	1083,2	647,6	27,1	-435,6
KA3579G01:3	1149,4	1128,1	1029,7	21,3	-98,4
KA3584G01:1	105,7	106,1	106,7	-0,4	0,6
KA3590G01:1	3954,8	3954	3958,5	0,8	4,5
KA3590G01:2	1881,4	1807,9	1877,9	73,5	70
KA3590G01:3	1866	1792,5	1863	73,5	70,5
KA3590G02:1	3662,5	3663,5	3666,8	-1	3,3
KA3590G02:2	3600,1	3601,7	3609,3	-1,6	7,6
KA3590G02:3	2345	2322,3	2346	22,7	23,7
KA3590G02:4	912,9	896,8	866,3	16,1	-30,5
KA3593G01:1	2191,7	2101,8	2189,9	89,9	88,1
KA3593G01:2	2138,6	2111,2	2141,9	27,4	30,7
KA3600F:1	4104,9	4105	4107,1	-0,1	2,1
KA3600F:2	4091,8	4091,6	4094	0,2	2,4
KG0021A01:1	3450,1	3451,2	3457,2	-1,1	6
KG0048A01:1	3899,5	3898,5	3903,1	1	4,6
KG0048A01:2	3690,4	3689,9	3694,5	0,5	4,6
KG0048A01:3	3738,2	3738,7	3742,8	-0,5	4,1
KG0048A01:4	3374,7	3376,3	3382,8	-1,6	6,5

Flow data
Manually measured flow rates of KA3566G01, section 12.30– 19.80 m are presented in the table below, see also Appendix 3a:

Table 6-2 Manually measured flow rates, interference test in KA3566G01, section 12.30 – 19.80 m

Time	Flow rate (l/min)
14:02.30	0.135
14:05:30	0.128
14:09	0.1275
14:12.40	0.127
14:24	0.122
14:43.30	0.1205
15:12	0.1195
19:48	0.115
19:54	0.115
20:03.30	0.1155

Calculated flow data
Flow rate at the end of the flowing period (Q_p, l/min): 0.1152
Average flow rate during the flowing period (Q_{ave}, l/min): 0.1182
Total flow volume during the flowing period (V_{tot}, litres): 43.03

Comments on the diagrams

In several boreholes the ground-water pressure was still recovering from the draw-down caused by the flow logging of KA2563A, see section 6.1.

In the morning before the test start it was observed that the packer pressure of four boreholes, KA3579G, KA3590G01, KA3590G02 and KA3593G, was too low (c. 40 bar). Around ten o'clock the pressure was increased to the proper level (c. 55 bar). Also the packer pressures of the other boreholes were adjusted. At approximately eleven o'clock transducers at the control board were shifted, see section 5.1. Responses to these events can be observed in the diagrams.

In borehole KA3566G01 a sudden pressure response occurred in the sections above and beneath the flowing section when the test valve was opened and closed respectively. The explanation could be that the instant pressure change in the flowing section causes volume changes in the Polyurethane packers or /and in the Tecalan pipes. The magnitude of this response should be permeability-dependent and higher in low permeable sections. This phenomenon was observed during all six tests.

In some low-permeable sections e.g. KA3574G01:2, KA3576G01:3 and KA3579G:2/3 the pressure was declining during the whole test period. Probably the pressure recovered after the pressure increase caused by the packer inflation.

Also sections with increasing pressures (e.g. KA3578G01:1 and KA3579G01:1) were observed during the test period. Probably they were still stabilizing towards the undisturbed pressure level.

The diagram of KA3554G02:1 illustrates several pressure drops during February 23rd. Why this occurred is unknown.

6.1.2 Borehole KA3566G02, section 12.30 m –18.30 m, test # 2

Date: 99-02-24 Field Crew: Bengt Gentzschein
Borehole length: 30.01 m Borehole diameter: 76 mm
Flowing borehole: KA3566G02, section #2: 12.3 – 18.3 m

Valve opened: 990224 08:26.05 Valve closed: 990224 14:43.11
End of Test: 990225 08:00
Total flowing time : 377 min Tot. Pr. Build-up time 1037 min.

The test was performed as an Interference test. Pressure responses were monitored in 51 borehole sections.

Pressure data

Table 6-3 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3566G02, section 12.30 – 18.30 m. Prototype Repository, February 1999

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po – Pp	Pf - Pp
KA3510A:1	4098	4098,4	4099,5	-0,4	1,1
KA3510A:2	4135,2	4134,8	4136,4	0,4	1,6
KA3510A:3	3928	3926,6	3929,9	1,4	3,3
KA3539G:1	3036,3	3038,3	3023,8	-2	-14,5
KA3542G01:1	3781,3	3779,5	3783,4	1,8	3,9
KA3542G02:1	3169,5	3165,6	3136,8	3,9	-28,8
KA3548A01:1	3903,3	3902	3905,7	1,3	3,7
KA3548A01:2	3823,9	3822,1	3826,2	1,8	4,1
KA3550G01:1	150,9	148,9	155	2	6,1
KA3552G01:1	241,9	240,9	251,9	1	11
KA3554G01:1	3771,9	3770,7	3773,8	1,2	3,1
KA3554G02:1	3181,4	3169,8	3156,3	11,6	-13,5
KA3557G:1	98,3	100,7	109,7	-2,4	9
KA3563G01:1	1273,2	1275,6	1285,9	-2,4	10,3

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po – Pp	Pf - Pp
KA3563G01:2	1273,6	1276,3	1286,3	-2,7	10
KA3563G01:3	103,2	102,7	103,4	0,5	0,7
KA3566G01:1	2727,6	2725,3	2728	2,3	2,7
KA3566G01:2	2106,2	2106,2	2106,6	0	0,4
KA3566G01:3	2859,9	2871,3	2906,9	-11,4	35,6
KA3566G01:4	2706,1	2708,4	2720,7	-2,3	12,3
KA3566G02:1	3356,3	3331,6	3349	24,7	17,4
KA3566G02:2	**3520,9**	**103**	**3520,9**	**3417,9**	**3417,9**
KA3566G02:3	2818,8	2762,1	2824,3	56,7	62,2
KA3566G02:4	317,5	311,5	323,4	6	11,9
KA3572G01:1	1690,1	1696,2	1718,1	-6,1	21,9
KA3572G01:2	340,12	340,6	343,7	-0,48	3,1
KA3573A:1	4045	4044,1	4046,8	0,9	2,7
KA3573A:2	3909,8	3908,6	3912	1,2	3,4
KA3574G01:1	440	442,6	459	-2,6	16,4
KA3574G01:2	1815,4	1791	1742,1	24,4	-48,9
KA3574G01:3	140,2	140,2	182,1	0	41,9
KA3576G01:1	446	442,1	441,3	3,9	-0,8
KA3576G01:2	157	156,4	156,2	0,6	-0,2
KA3576G01:3	932,5	907,6	848,5	24,9	-59,1
KA3578G01:1	486,9	494	520,4	-7,1	26,4
KA3578G01:2	156,6	156	155,8	0,6	-0,2
KA3579G01:1	1788,9	1795,2	1813,8	-6,3	18,6
KA3579G01:2	946	926,8	881,6	19,2	-45,2
KA3579G01:3	1028,3	1014,8	957,8	13,5	-57
KA3584G01:1	106,9	106,7	106,9	0,2	0,2
KA3590G01:1	3958,5	3957,9	3963	0,6	5,1
KA3590G01:2	1878,1	1875,8	1875,8	2,3	0
KA3590G01:3	1863,4	1861,3	1861,1	2,1	-0,2
KA3590G02:1	3666,6	3645,9	3677,4	20,7	31,5
KA3590G02:2	3609,3	3589,8	3620,7	19,5	30,9
KA3590G02:3	2346	2344,2	2349,3	1,8	5,1
KA3590G02:4	865,9	862,2	865,7	3,7	3,5
KA3593G01:1	2189,7	2188,5	2189,9	1,2	1,4
KA3593G01:2	2141,9	2141,3	2145,5	0,6	4,2
KA3600F:1	4106,9	4106,1	4108,9	0,8	2,8
KA3600F:2	4094	4093,6	4095,8	0,4	2,2
KG0021A01:1	3457,5	3452,8	3481,4	4,7	28,6

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po – Pp	Pf - Pp
KG0048A01:1	3902,7	3900,8	3904,5	1,9	3,7
KG0048A01:2	3694,3	3692,5	3696,6	1,8	4,1
KG0048A01:3	3742,3	3737,7	3749,9	4,6	12,2
KG0048A01:4	3382,3	3378,2	3402,7	4,1	24,5

Flow data

Manually measured flow rates of KA3566G02, section 12.30 – 18.30 m are presented in the table below: see also Appendix 4a.

Table 6-4 Manually measured flow rates, interference test in KA3566G02, section, 12.30 – 18.30 m

Time	Flow rate (l/min)
08:27.30	0.130
08:29:30	0.113
08:31	0.107
08:40	0.096
08:55	0.091
09:12	0.087
09:25	0.0865
14:32	0.084
14:34.30	0.084
14:41	0.0845

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 0.0842
Average flow rate during the flowing period (Q_{ave}, l/min): 0.0866
Total flow volume during the flowing period (V_{tot}, litres): 32.66

Comments on the diagrams

Some of the comments on the first test concerning pressure trends and instant pressure changes in the sections above and beneath the flowing section are valid for this test as well.

In borehole KA3554G02 the pressure falls and rises normally during the draw-down and at the beginning of the recovery respectively. Then the pressure falls instantly c. 25 kPa. No leakage or any other error was observed at the borehole. Possibly the transmitter is unstable.
The pressure of KA3574G01:1 increases c. 40 Kpa approximately 3 hours after the flow stop.

6.1.3 Borehole KA3590G01, section 1.30 m –6.80 m, test # 3

Date: 99-02-25 Field Crew: Bengt Gentzschein
Borehole length: 30.06 m Borehole diameter: 76 mm
Flowing borehole: KA3590G01, section #3: 1.30 – 6.80 m

Valve opened: 990225 08:20.05 Valve closed: 990225 14:23.05
End of Test: 990226 07:30
Total flowing time : 363 min Tot. Pr. Build-up time 1027 min.

The test was performed as an Interference test. Pressure responses were monitored in 51 borehole sections.

Pressure data

Table 6-5 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3566G01, section 1.30 – 6.80 m. Prototype Repository, February 1999.

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po – Pp	Pf – Pp
KA3510A:1	4099,7	4099,9	4100,9	-0,2	1
KA3510A:2	4136,6	4136,6	4137,3	0	0,7
KA3510A:3	3930,1	3924,5	3931,1	5,6	6,6
KA3539G:1	3025,9	3018,7	3020,7	7,2	2
KA3542G01:1	3783,6	3781,1	3784,6	2,5	3,5
KA3542G02:1	3133,1	3136,8	3140,4	-3,7	3,6
KA3548A01:1	3905,7	3903,7	3907,3	2	3,6
KA3548A01:2	3826,2	3823,8	3827,8	2,4	4
KA3550G01:1	154,8	154,8	155,2	0	0,4
KA3552G01:1	251,7	252,5	257,7	-0,8	5,2
KA3554G01:1	3773,8	3770,5	3775,4	3,3	4,9
KA3554G02:1	3156,3	3152,4	3156,3	3,9	3,9
KA3557G:1	105,6	110,7	111,3	-5,1	0,6
KA3563G01:1	1286,1	1289,1	1298,8	-3	9,7
KA3563G01:2	1286,6	1289,5	1299,4	-2,9	9,9
KA3563G01:3	103,2	103	103	0,2	0
KA3566G01:1	2727,8	2566,4	2707,5	161,4	141,1
KA3566G01:2	2106,4	1881,4	2077,7	225	196,3
KA3566G01:3	2907,5	2913,2	2944,1	-5,7	30,9
KA3566G01:4	2720,9	2722,1	2731,5	-1,2	9,4
KA3566G02:1	3349,4	3346,3	3349,6	3,1	3,3

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po – Pp	Pf – Pp
KA3566G02:2	3521,1	3520,5	3523	0,6	2,5
KA3566G02:3	2824,7	2826,4	2830,3	-1,7	3,9
KA3566G02:4	323,6	324,2	325,3	-0,6	1,1
KA3572G01:1	1718,3	1722,2	1731,8	-3,9	9,6
KA3572G01:2	343,7	343,5	344,5	0,2	1
KA3573A:1	4047	4046,8	4048,2	0,2	1,4
KA3573A:2	3912	3910,4	3914,1	1,6	3,7
KA3574G01:1	459	462,9	473,1	-3,9	10,2
KA3574G01:2	1740,9	1723,9	1678,5	17	-45,4
KA3574G01:3	182,3	181,7	180,9	0,6	-0,8
KA3576G01:1	441,1	440	436,6	1,1	-3,4
KA3576G01:2	156,2	155,8	155,1	0,4	-0,7
KA3576G01:3	847,2	827,6	777,1	19,6	-50,5
KA3578G01:1	521	528,6	549,5	-7,6	20,9
KA3578G01:2	155,8	155,2	155	0,6	-0,2
KA3579G01:1	1814	1816,3	1825,3	-2,3	9
KA3579G01:2	880,6	865,8	827,6	14,8	-38,2
KA3579G01:3	987	977,6	951,4	9,4	-26,2
KA3584G01:1	107,1	107,3	107,5	-0,2	0,2
KA3590G01:1	3963	3962,2	3965,5	0,8	3,3
KA3590G01:2	1876	3886,2	3903	-2010,2	16,8
KA3590G01:3	**1861,1**	**117,3**	**1712,6**	**1743,8**	**1595,3**
KA3590G02:1	3677,6	3677	3678,3	0,6	1,3
KA3590G02:2	3620,7	3618,9	3622,2	1,8	3,3
KA3590G02:3	2349,3	2287,9	2333,3	61,4	45,4
KA3590G02:4	865,5	861,5	857,7	4	-3,8
KA3593G01:1	2189,7	1951,7	2158	238	206,3
KA3593G01:2	2145,5	2069,5	2129,2	76	59,7
KA3600F:1	4108,7	4108,7	4109,6	0	0,9
KA3600F:2	4095,8	4096	4096,6	-0,2	0,6
KG0021A01:1	3481,2	3480,3	3481,2	0,9	0,9
KG0048A01:1	3904,7	3903,3	3906,8	1,4	3,5
KG0048A01:2	3696,6	3695,7	3698,9	0,9	3,2
KG0048A01:3	3749,6	3748,5	3751,2	1,1	2,7
KG0048A01:4	3402,7	3401,8	3402,5	0,9	0,7

Flow data

Manually measured flow rates of KA3590G01, section 1.30 – 6.80 m are presented in the table below, see also Appendix 5a.

Table 6-6 Manually measured flow rates, interference test in KA3590G01, section 1.30 – 6.80 m

Time	Flow rate (l/min)
08:20.45	0.398
08:22:55	0.377
08:25.30	0.370
08:35	0.360
08:50	0.350
09:05	0.349
09:20	0.346
14:14	0.339
14:16	0.341
14:21.40	0.340

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 0.340
Average flow rate during the flowing period (Q_{ave}, l/min): 0.345
Total flow volume during the flowing period (V_{tot}, litres): 125.2

Comments on the diagrams

Some of the comments on the two first tests concerning pressure trends and instant pressure changes in the sections above and beneath the flowing section are valid for this test as well.

The KA3554G02 curve is better than during the preceding test, but still the pressure varies such an extent that an instrument inaccuracy could be suspected.

In borehole KA3590G01 section #2 responded very unexpectedly. Before the test section #2 was c. 15 kPa higher than section #3. But during the pressure drop in section #3, the ground-water pressure in #2 increased almost 2000 kPa ! After flow stop, section #2 continued on the high level while section #3 recovered, however only to c. 1710 kPa. Prior to the test the pressure was 1860 kPa in section #3.

It is difficult to state a final interpretation of these pressure responses but a reasonable explanation is that prior to the test the two sections were connected to each other, either due to leakage in a loose coupling or in an open fracture. When the pressure in section #3 was released, the coupling was tightened or the fracture was closed. Consequently, the section pressures at the end of the recovery period should be more accurate than the initial section pressures.

An interesting observation is that neither in the adjacent borehole KA3593G the section pressures recovered to the initial levels.

Later, on March 23, the packers were hoisted and checked, see Appendix 2. An incompletely tightened coupling on the packer between the section #2 and section #3 was found, indicating that the unexpected pressure responses were caused by equipment insufficiency.

6.1.4 Borehole KA3590G01, section 7.80 m –16.30 m, test # 4

Date: 99-02-26 Field Crew: Bengt Gentzschein
Borehole length: 30.06 m Borehole diameter: 76 mm
Flowing borehole: KA3590G01, section #2: 7.80 – 16.30 m

Valve opened: 990226 07:53.05 Valve closed: 990226 08:03.05
End of Test: 990226 08:33
Total flowing time : 10 min Tot. Pr. Build-up time 30 min.

The test was performed as an Interference test. Pressure responses were monitored in 51 borehole sections.

Pressure data

Table 6-7 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3590G01, section 7.80– 16.30m. Prototype Repository, February 1999

Borehole section	Po (Kpa)	Pp (Kpa)	Pf (Kpa)	Po - Pp	Pf - Pp
KA3510A:1	4100,7	4100,7	4100,9	0	0,2
KA3510A:2	4137	4137	4137,3	0	0,3
KA3510A:3	3931,8	3929,5	3929,5	2,3	0
KA3539G:1	3022	3020,5	3019,7	1,5	-0,8
KA3542G01:1	3784,4	3784,2	3783,4	0,2	-0,8
KA3542G02:1	3138,4	3138,4	3147,4	0	9
KA3548A01:1	3907,3	3905,9	3905,9	1,4	0
KA3548A01:2	3827,4	3827	3826,6	0,4	-0,4
KA3550G01:1	153	154,6	157,7	-1,6	3,1
KA3552G01:1	256,6	260,1	257,4	-3,5	-2,7
KA3554G01:1	3775,4	3774	3774,4	1,4	0,4
KA3554G02:1	3156,1	3156,3	3156,7	-0,2	0,4
KA3557G:1	110,9	110,5	110,3	0,4	-0,2
KA3563G01:1	1299,2	1299	1299,4	0,2	0,4

Borehole section	Po (Kpa)	Pp (Kpa)	Pf (Kpa)	Po - Pp	Pf - Pp
KA3563G01:2	1299,5	1299,6	1299,8	-0,1	0,2
KA3563G01:3	102,7	103	103	-0,3	0
KA3566G01:1	2707,3	2670,5	2708,2	36,8	37,7
KA3566G01:2	2077,7	2013,5	2081,6	64,2	68,1
KA3566G01:3	2944,1	2940	2945,3	4,1	5,3
KA3566G01:4	2731,7	2729,2	2732,1	2,5	2,9
KA3566G02:1	3349,6	3349,6	3349,8	0	0,2
KA3566G02:2	3522,8	3522,5	3522,5	0,3	0
KA3566G02:3	2830,3	2830,3	2830,3	0	0
KA3566G02:4	325,3	325	325,5	0,3	0,5
KA3572G01:1	1731,6	1731,6	1731	0	-0,6
KA3572G01:2	344,3	343,9	344,3	0,4	0,4
KA3573A:1	4048	4047,6	4047,6	0,4	0
KA3573A:2	3913,2	3912,4	3912,7	0,8	0,3
KA3574G01:1	472,5	472,3	471,3	0,2	-1
KA3574G01:2	1676,6	1675,8	1672,8	0,8	-3
KA3574G01:3	180,9	180,9	180,7	0	-0,2
KA3576G01:1	435,8	435,3	433,7	0,5	-1,6
KA3576G01:2	154,9	154,9	154,9	0	0
KA3576G01:3	775,7	775,3	772,8	0,4	-2,5
KA3578G01:1	549,7	549,3	549	0,4	-0,3
KA3578G01:2	154,8	154,8	154,8	0	0
KA3579G01:1	1825,5	1825,7	1825,7	-0,2	0
KA3579G01:2	826,4	825	824,3	1,4	-0,7
KA3579G01:3	950	948,9	946,9	1,1	-2
KA3584G01:1	107,5	107,5	107,5	0	0
KA3590G01:1	3965,3	3875,6	3961,8	89,7	86,2
KA3590G01:2	**3903**	**143,3**	**1861,9**	**3759,7**	**1718,6**
KA3590G01:3	1712,8	354,3	1841,7	1358,5	1487,4
KA3590G02:1	3678,2	3678,1	3677,8	0,1	-0,3
KA3590G02:2	3622,1	3622	3622	0,1	0
KA3590G02:3	2333,5	2333,3	2332,7	0,2	-0,6
KA3590G02:4	856,5	856,3	855,1	0,2	-1,2
KA3593G01:1	2158	2124,3	2156,2	33,7	31,9
KA3593G01:2	2129,2	2127,8	2127,8	1,4	0
KA3600F:1	4109,4	4109,4	4109,4	0	0

Borehole section	Po (Kpa)	Pp (Kpa)	Pf (Kpa)	Po - Pp	Pf - Pp
KA3600F:2	4096,4	4096,6	4096,4	-0,2	-0,2
KG0021A01:1	3481	3481	3480,1	0	-0,9
KG0048A01:1	3907,2	3905	3905,4	2,2	0,4
KG0048A01:2	3699,3	3697,7	3698,2	1,6	0,5
KG0048A01:3	3750,8	3750,5	3750,5	0,3	0
KG0048A01:4	3401,8	3402,4	3401,8	-0,6	-0,6

Flow data

Manually measured flow rates of KA3590G01, section 7.80 m –16.30 m, are presented in the table below, see also Appendix 6a.

Table 6-8 Manually measured flow rates, interference test in KA3590G01, section 7.80 m –16.30 m

Time	Flow rate (l/min)
07:54.15	0.414
07:56:30	0.403
07:58	0.400
08:01	0.398

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 0.398(one value)
Average flow rate during the flowing period (Q_{ave}, l/min): 0.404
Total flow volume during the flowing period (V_{tot}, litres): 4.04

Comments on the diagrams

This test was performed as a function test in order to clarify the pressure responses in borehole KA3590G01 during test #3.

Some of the comments on the preceding tests concerning pressure trends and instant pressure changes in the sections above and beneath the flowing section are valid for this test as well.

During this test section #2 was opened. Section #3 was draw-downed almost to the same level and after the flow stop the curves of the two sections almost coincide again. Probably the connection between them, see section 6.1.3 and Appendix 2, was reopened.

6.1.5 Borehole KA3590G02, section 23.30 m –30.05 m, test # 5

Date: 99-02-26 Field Crew: Bengt Gentzschein
Borehole length: 30.05 m Borehole diameter: 76 mm
Flowing borehole: KA3590G02, section #1: 23.3 – 30.05m

Valve opened: 990226 08:35.05 Valve closed: 990226 16:00.05
End of Test: 990301 08.000
Total flowing time : 445 min Tot. Pr. Build-up time 3840 min.

The test was performed as an Interference test. Pressure responses were monitored in 51 borehole sections.

Pressure data

Table 6-9 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3590G02, section 23.30– 30.05 m. Prototype Repository, February 1999

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Pf2 (Kpa)	Po – Pp	Pf - Pp
KA3510A:1	4100,9	4100,3	4100,4	4109,3	0,6	0,1
KA3510A:2	4137,2	4135,4	4137,7	4135,4	1,8	2,3
KA3510A:3	3930,1	3917,4	3923,3	3927,2	12,7	5,9
KA3539G:1	3022	2975,6	3037,5	3053,0	46,4	61,9
KA3542G01:1	3783,2	3767	3784,2	3774,4	16,2	17,2
KA3542G02:1	3141,3	3079,1	3139,8	3145,6	62,2	60,7
KA3548A01:1	3905,7	3893,4	3907,5	3902,4	12,3	14,1
KA3548A01:2	3826,6	3810,8	3828	3823,1	15,8	17,2
KA3550G01:1	157,3	156,2	159,1	166,3	1,1	2,9
KA3552G01:1	260,5	255	265,2	268,9	5,5	10,2
KA3554G01:1	3774,4	3762,7	3776	3768,5	11,7	13,3
KA3554G02:1	3156,5	3083,7	3164,9	3179.8	72,8	81,2
KA3557G:1	111,8	110,5	114,4	116,7	1,3	3,9
KA3563G01:1	1299,4	1298,4	1329,6	1370,9	1	31,2
KA3563G01:2	1299,8	1298,7	1330	1371,5	1,1	31,3
KA3563G01:3	103	102,5	102,7	104,8	0,5	0,2
KA3566G01:1	2709,4	2718,8	2720,6	2798,2	-9,4	1,8
KA3566G01:2	2083,1	2097,6	2097,2	2151,8	-14,5	-0,4
KA3566G01:3	2945,5	2951,2	2990,8	3008,8	-5,7	39,6
KA3566G01:4	2732,1	2726	2747,9	2758,7	6,1	21,9
KA3566G02:1	3349,6	3136,2	3474,3	3376,1	213,4	338,1

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Pf2 (Kpa)	Po – Pp	Pf - Pp
KA3566G02:2	3322,5	2794,1	3473,9	3535,6	528,4	679,8
KA3566G02:3	2830,3	2502,2	3472,6	2843,8	328,1	970,4
KA3566G02:4	325,5	317,1	886,1	322,2	8,4	569
KA3572G01:1	1731,1	1734	1765,3	1820,1	-2,9	31,3
KA3572G01:2	344,3	343,7	350,8	359,2	0,6	7,1
KA3573A:1	4047,6	4042,1	4048,4	4044,1	5,5	6,3
KA3573A:2	3912,7	3900,2	3914,5	3909,8	12,5	14,3
KA3574G01:1	471,3	473,9	506,4	580,9	-2,6	32,5
KA3574G01:2	1672,8	1649,8	1498,6	1262,3	23	-151,2
KA3574G01:3	180,7	179,2	180,8	184,1	1,5	1,6
KA3576G01:1	433,7	429	411,4	421,8	4,7	-17,6
KA3576G01:2	154,9	154,7	153,5	153,1	0,2	-1,2
KA3576G01:3	772,8	750,3	611,7	414,2	22,5	-138,6
KA3578G01:1	549	555	617,2	748,0	-6	62,2
KA3578G01:2	154,8	154,3	152,9	152,1	0,5	-1,4
KA3579G01:1	1825,7	1829,1	1863,2	1912,7	-3,4	34,1
KA3579G01:2	824,3	807	569,3	1487,3	17,3	-237,7
KA3579G01:3	946,9	932,2	739,1	739,7	14,7	-193,1
KA3584G01:1	107,7	107,3	107,3	109,5	0,4	0
KA3590G01:1	3962	3956	3461,1	3955,8	6	-494,9
KA3590G01:2	1863,1	1869,9	1869,5	1862,9	-6,8	-0,4
KA3590G01:3	1842,7	1852,1	1852,5	1844,2	-9,4	0,4
KA3590G02:1	**3678**	**309,1**	**3680,3**	**3679,5**	**3368,9**	**3371,2**
KA3590G02:2	3622	2466,9	3634	3632,8	1155,1	1167,1
KA3590G02:3	2332,7	2276,3	2340,3	2340,3	56,4	64
KA3590G02:4	855,3	704,5	857,1	863,0	150,8	152,6
KA3593G01:1	2158	2181,9	2183,5	2172,7	-23,9	1,6
KA3593G01:2	2128	2123,3	2145,1	2142,3	4,7	21,8
KA3600F:1	4109,6	4106,9	4110,2	4107,1	2,7	3,3
KA3600F:2	4096,4	4093,4	4097	4092,6	3	3,6
KG0021A01:1	3481	3422,4	3484,4	3421,2	58,6	62
KG0048A01:1	3905,4	3892,1	3905,9	3902,2	13,3	13,8
KG0048A01:2	3698,2	3678,2	3697,5	3692,9	20	19,3
KG0048A01:3	3750,5	3698,6	3751,7	3748,9	51,9	53,1
KG0048A01:4	3402	3346,8	3404,8	3406,4	55,2	58

In Table 6-1 also the section pressure at 08:00 March 8th (Pf2) is shown.

Flow data

Manually measured flow rates of KA3590G02, section 23.30– 30.05 m are presented in the table below, see also Appendix 7a.

Table 6-10 Manually measured flow rates, Interference test in KA3590G02, section 23.30 – 30.05 m

Time	Flow rate (l/min)
08:35.50	2.453
08:37:20	2.306
08:39.22	2.234
08:51	1.971
09:05	1.862
09:21	1.810
09:35	1.789
15:49.30	1.712
15:52	1.718
15:58.30	1.710

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min) : 1.713
Average flow rate during the flowing period (Q_{ave}, l/min): 1.774
Total flow volume during the flowing period (V_{tot}, litres): 789.4

Comments on the diagrams

Some of the comments on the preceding tests concerning pressure trends and instant pressure changes in the sections above and beneath the flowing section are valid for this test as well.

The flowing period of this interference test was about one hour longer than during the preceding four tests. The recovery was prolonged to over the weekend and the pressure monitoring proceeded for another week. However, the packer pressure system started to leak during the recovery period. The leakage effects in a smaller scale is indicated in the diagrams already on February 28th but is more obvious in several boreholes the first days of March. The packers were not inflated again until the morning on March 5th.

During March 3rd to March 5th borehole KA3563A was open for flow logging
In the G-tunnel 5 boreholes were drilled between March 2nd and March 4th .

6.1.6 Borehole KA3590G01, section 1.30 m –6.80 m, test # 6

Date: 99-04-06 Field Crew: Bengt Gentzschein
Borehole length: 30.06 m Borehole diameter: 76 mm
Flowing borehole: KA3590G01, section #3: 1.30 – 6.80 m

Valve opened: 990406 09:59.05 Valve closed: 990406 16:01.05
End of Test: 990407 06:30
Total flowing time : 362 min Tot. Pr. Build-up time 840 min.

The test was performed as an Interference test. Pressure responses were monitored in 51 borehole sections.

Pressure data

Table 6-11 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3590G01, section 1.3 – 6.80 m (test #6). Prototype Repository, April 1999

Borehole section	Po (Kpa)	Pp (Kpa)	Pf (Kpa)	Po - Pp	Pf – Pp
KA3510A:1	4118,1	4117,2	4117,8	0,9	0,6
KA3510A:2	4126	4125,6	4126,6	0,4	1
KA3510A:3	3913,3	3906,1	3913,1	7,2	7
KA3539G:1	3035,8	3034,8	3035	1	0,2
KA3542G01:1	3758,1	3759,9	3764	-1,8	4,1
KA3542G02:1	3132,4	3131,6	3132,2	0,8	0,6
KA3548A01:1	3890,1	3866,1	3890,5	24	24,4
KA3548A01:2	3799,9	3798,6	3798,4	1,3	-0,2
KA3550G01:1	142,2	141,8	141	0,4	-0,8
KA3552G01:1	265,1	264,5	263,9	0,6	-0,6
KA3554G01:1	3735,1	3730,3	3734,7	4,8	4,4
KA3554G02:1	3178,6	3177,8	3178,8	0,8	1
KA3557G:1	122,6	122,4	121,6	0,2	-0,8
KA3563G01:1	1387,1	1385,7	1385,1	1,4	-0,6
KA3563G01:2	1387,7	1386,1	1385,6	1,6	-0,5
KA3563G01:3	108,7	108,7	107,9	0	-0,8
KA3566G01:1	2669,9	2525,7	2672,4	144,2	146,7
KA3566G01:2	2084,5	1881,2	2088	203,3	206,8
KA3566G01:3	3218,4	3214,1	3219,6	4,3	5,5
KA3566G01:4	2796,1	2787,1	2784,9	9	-2,2
KA3566G02:1	3344,7	3343,6	3345,1	1,1	1,5

Borehole section	Po (Kpa)	Pp (Kpa)	Pf (Kpa)	Po - Pp	Pf – Pp
KA3566G02:2	3507,4	3506,2	3508	1,2	1,8
KA3566G02:3	103,7	103,3	102,5	0,4	-0,8
KA3566G02:4	322,1	321,7	318	0,4	-3,7
KA3572G01:1	1878	1874,3	1863,7	3,7	-10,6
KA3572G01:2	102,5	102,3	101,3	0,2	-1
KA3573A:1	4034,5	4033,3	4034,9	1,2	1,6
KA3573A:2	3898,9	3895,5	3899,1	3,4	3,6
KA3574G01:1	821	820,6	823,8	0,4	3,2
KA3574G01:2	1021,7	1017,2	1010,7	4,5	-6,5
KA3574G01:3	182,3	180,7	178,4	1,6	-2,3
KA3576G01:1	1592	1583,4	1566,6	8,6	-16,8
KA3576G01:2	158,2	158	158,4	0,2	0,4
KA3576G01:3	711,9	701,1	679,2	10,8	-21,9
KA3578G01:1	106,5	106,3	105,5	0,2	-0,8
KA3578G01:2	151,9	153,1	154,2	-1,2	1,1
KA3579G01:1	2012,8	2009,4	2005,3	3,4	-4,1
KA3579G01:2	516,3	514,2	511,6	2,1	-2,6
KA3579G01:3	474,3	470,6	466,3	3,7	-4,3
KA3584G01:1	109,8	109,8	108,9	0	-0,9
KA3590G01:1	3951,5	3948,3	3952	3,2	3,7
KA3590G01:2	3891,9	3887,8	3892,3	4,1	4,5
KA3590G01:3	**1641,4**	**117,3**	**1645,1**	**1524,1**	**1527,8**
KA3590G02:1	3662,5	3661,5	3663,5	1	2
KA3590G02:2	3419,1	3410,9	3420,1	8,2	9,2
KA3590G02:3	2556	2508,6	2551,7	47,4	43,1
KA3590G02:4	888,2	883,9	887	4,3	3,1
KA3593G01:1	2114,8	1907,3	2117,9	207,5	210,6
KA3593G01:2	2142,9	2074,8	2137,6	68,1	62,8
KA3600F:1	4098,3	4098,1	4099,1	0,2	1
KA3600F:2	4082,3	4081,3	4082,7	1	1,4
KG0021A01:1	3474,8	3475	3478	-0,2	3
KG0048A01:1	3889,6	3886,1	3890,3	3,5	4,2
KG0048A01:2	3681,7	3679,2	3681,9	2,5	2,7
KG0048A01:3	3737,1	3735,2	3737,7	1,9	2,5
KG0048A01:4	3397,2	3396,8	3399,7	0,4	2,9

Flow data

Manually measured flow rates of KA3590G01, section 1.30 – 6.80 m are presented in the table below, see also Appendix 8a.

Table 6-12 Manually measured flow rates, interference test in KA3590G01, section 1.30 – 6.80 m (test #6)

Time	Flow rate (l/min)
09:59.30	0.432
10:02	0.369
10:04.30	0.352
10:15	0.350
10:30	0.344
10:45	0.341
11:00	0.340
15:50	0.329
15:52	0.330
15:59.30	0.330

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 0.330
Average flow rate during the flowing period (Q_{ave}, l/min): 0.337
Total flow volume during the flowing period (V_{tot}, litres): 122.0

Comments on the diagrams

Test number 6 was performed in the same interval as test #3. But this time the leakage between the sections 2 and 3 had been fixed, see section 6.3 and Appendix 2. .The test was preceded by a five days long period of no activities in the tunnel (Eastern holiday). However, a number of borehole sections were opened prior to or during the test period. Section KA3566G02:3 was opened already on March 29th. The draw down was approximately 2700 kPa and the flow rate was c. 0.006 l /min.

About one hour before test start the bottom section of KA3578G01 and the upper section of KA3572G01 were opened for water sampling. The section pressures fell from c. 950 kPa respectively c. 250 kPa. The flow rates were low (less than or equal to c. 1 ml/min). The sections were kept open during the whole test period. In addition six borehole sections located at a greater distance from the Prototype Repository site were opened for water sampling the same day.

The sections were:

KR0012B 5.0 – 10.57 m, opened at 7:59
KR0015B 19.82 – 30.31 m, opened at 8:58
KAS03 107.0 – 252 m, opened at 8:05
SA2273A 5.8 – 20.0 m, opened at 9:30
KA3385A 7.0 – 31.0 m, opened at 15:10

It is difficult to estimate the effect of the water sampling activities on the ground water conditions of the Prototype site. The diagrams from the surrounding boreholes display no significant responses due to the opened borehole sections. However, it is likely to believe that these responses, if existent, are small and possibly concealed by the much greater ground water level changes caused by the interference tests.

On the seventh of April at c. 06:40 water sampling started in the boreholes KI0025F02 and KA3573A. Responses were instantly observed in several Prototype boreholes. For this reason the recovery period of this test is shorter than the corresponding periods of tests #1, #2, #3 and #5.

6.1.7 Compilation of results

In Table 6-13 important flow- and pressure data are summarized.0

Table 6-13 Summary of the results. Interference tests A after drilling campaign 3. Prototype Repository ,February and April 1999

Borehole: Section	Test No	P_0 (kPa)	P_p, (Kpa)	P_f, (kPa)	Q_p, (l/min)	Q_{ave}, (l/min)	V_{tot}, (l)
KA3566G01:2	1	2123,1	103,3	2106,4	0,115	0.118	43,03
KA3566G02:2	2	3520,9	103,0	3520,9	0,0842	0.0866	32,66
KA3590G01:3	3	1861,1	117,3	1712,6	0,340	0.345	125,2
KA3590G01:2	4	3903,0	143,3	1861,9	0,398	0.404	4,04
KA3590G02:1	5	3678,0	309,1	3608,3	1,713	1.744	789,4
KA3590G01:3	6	1641,4	117,3	1645,1	0,330	0,337	122,0

7. REFERENCES

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APPENDICES

Appendices 3a - 8b are not included as hard copies in the report, but stored on CD-ROM which is available at Äspö Hard Rock Laboratory.

APPENDIX 1: Data files of data stored by the Borre data loggers, boreholes **KG0021A01 and KG0048A01.**

APPENDIX 2: Control of packers in borehole KA3590G01, March 23.

APPENDIX 3a: Flow rate of borehole KA3566G01, section 12.30 – 19.80 m and groundwater pressure of 56 borehole sections during test # 1 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 3b: Hydraulic head of 51 borehole sections during test # 1 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 4a: Flow rate of borehole **KA3566G02**, **section 12.30 – 18.30 m** and groundwater pressure of 56 borehole sections during test # 2 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 4b: Hydraulic head of 51 borehole sections during test # 2 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 5a: Flow rate of borehole **KA3590G01, section 1.30 – 6.80 m** and groundwater pressure of 56 borehole sections during test #3 Prototype Repository, interference tests A after drill campaign 3 b**.**

APPENDIX 5b: Hydraulic head of 51 borehole sections during test # 3 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 6a: Flow rate of borehole **KA3590G01, section 1.30 – 6.80 m** and groundwater pressure of 56 borehole sections during test # 4 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 6b: Hydraulic head of 51 borehole sections during test # 4 Prototype Repository, Interference tests A after drill campaign 3 b.

APPENDIX 7a: Flow rate of borehole **KA3590G02, section 23.30 – 30.05 m** and groundwater pressure of 56 borehole sections during test # 5 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 7b: Hydraulic head of 51 borehole sections during test # 5 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 8a: Flow rate of borehole **KA3590G01, section 1.30 – 16.80 m** and groundwater pressure of 56 borehole sections during test #6 Prototype Repository, interference tests A after drill campaign 3 b.

APPENDIX 8b: Hydraulic head of 51 borehole sections during test # 6 Prototype Repository, interference tests A after drill campaign 3 b.

DATA FILES **APPENDIX 1**

A: A list of data files of data stored by the Borre data loggers, boreholes KG0021A01 and KG0048A01 during interference tests conducted in four of the long exploratory boreholes. Prototype Repository, February and April 1999

Test No	Tested Borehole: Section	Start of Test (kl.)	End of test	Observation Borehole	Data files	Calibration files
1	KA3566G01:2	9902200000	9902240800	KG0021A01	PRINF437.BOR PRINFA37.HYF	BORRE37.CAL
1	KA3566G01:2	9902200000	9902240800	KG0048A01	PRINF444.BOR PRINFA44.HYF	BORRE44.CAL
2	KA3566G02:2	9902240700	990225 0800	KG0021A01	PRINF437.BOR PRINFA37.HYF	BORRE37.CAL
2	KA3566G02:2	9902240700	990225 0800	KG0048A01	PRINF444.BOR PRINFA44.HYF	BORRE44.CAL
3	KA3590G01:3	9902250730	9902260730	KG0021A01	PRINF437.BOR PRINFA37.HYF	BORRE37.CAL
3	KA3590G01:3	9902250730	9902260730	KG0048A01	PRINF444.BOR PRINFA44.HYF	BORRE44.CAL
4	KA3590G01:2	9902260730	9902260833	KG0021A01	PRINF437.BOR PRINFA37.HYF	BORRE37.CAL
4	KA3590G01:2	9902260730	9902260833	KG0048A01	PRINF444.BOR PRINFA44.HYF	BORRE44.CAL
5	KA3590G02:1	9902260730	9903010800	KG0021A01	PRINF437.BOR PRINF537.BOR PRINFA37.HYF	BORRE37.CAL
5	KA3590G02:1	9902260730	9903010800	KG0048A01	PRINF444.BOR PRINF544.BOR PRINFA44.HYF	BORRE44.CAL
6	KA3590G01:3	9904060000	9904070630	KG0021A01	PRINF637.BOR PRINFA37.HYF	BORRE37.CAL
6	KA3590G01:3	9904060000	9904070630	KG0048A01	PRINF644.BOR PRINFA44.HYF	BORRE44.CAL

APPENDIX 1

B. Text- files created of data logger data, boreholes KG0021A01 and KG0048A01 during interference tests conducted in four of the long exploratory boreholes. Prototype Repository, February and April 1999

Test No	Tested Borehole: Section	Start of Test (kl.)	End of test	Observation Borehole	Flow rate-files	Pressure-files
1	KA3566G01:2	9902200000	9902240800	KA3566G01:2	1fd66g21.txt	
1	KA3566G01:2	9902200000	9902240800	KG0021A01		010021A01.OVD
1	KA3566G01:2	9902200000	9902240800	KG0048A01		010048A01_1.OVD 010048A01_2.OVD 010048A01_3.OVD 010048A01_4.OVD
2	KA3566G02:2	9902240700	990225 0800	KA3566G02:2	2fd66g22.txt	
2	KA3566G02:2	9902240700	990225 0800	KG0021A01		002021A01.OVD
2	KA3566G02:2	9902240700	990225 0800	KG0048A01		020048A01_1.OVD 020048A01_2.OVD 020048A01_3.OVD 020048A01_4.OVD
3	KA3590G01:3	9902250730	9902260730	KA3590G01:3	3fd90g13.txt	
3	KA3590G01:3	9902250730	9902260730	KG0021A01		030021A01.OVD
3	KA3590G01:3	9902250730	9902260730	KG0048A01		030048A01_1.OVD 030048A01_2.OVD 030048A01_3.OVD 030048A01_4.OVD
4	KA3590G01:2	9902260730	9902260833	KA3590G01:2	4fd90g12.txt	
4	KA3590G01:2	9902260730	9902260833	KG0021A01		040021A01.OVD
4	KA3590G01:2	9902260730	9902260833	KG0048A01		040048A01_1.OVD 040048A01_2.OVD 040048A01_3.OVD 040048A01_4.OVD
5	KA3590G02:1	9902260730	9903010800	KA3590G02:1	5fd90g21.txt	
5	KA3590G02:1	9902260730	9903010800	KG0021A01		050021A01.OVD
5	KA3590G02:1	9902260730	9903010800	KG0048A01		050048A01_1.OVD 050048A01_2.OVD 050048A01_3.OVD 050048A01_4.OVD
6	KA3590G01:3	9904060000	9904070630	KA3590G01:3	6d90g13.txt	
6	KA3590G01:3	9904060000	9904070630	KG0021A01		060021A01.OVD
6	KA3590G01:3	9904060000	9904070630	KG0048A01		060048A01_1.OVD 060048A01_2.OVD 060048A01_3.OVD 060048A01_4.OVD

APPENDIX 2

Inspection of packers in borehole KA3590G01, March 23.

On March 23 the packer system in borehole KA3590G01 was uplifted. Tubes, packers and fittings were checked.. The tubes were pressurized in order to find leakage. In Figure 1 the packer configuration is illustrated.

A probable leak was found at the connection **I**. The Swagelok tube fitting was incomplete. A part (the front ferrule) was missing. Earlier, shortly after the packer installation, this tube fitting was found to be clogged by plastic and was replaced.

When the tube **E** was pressurized a small leakage was observed from the connector on the cannula tube of the packer at **H**.

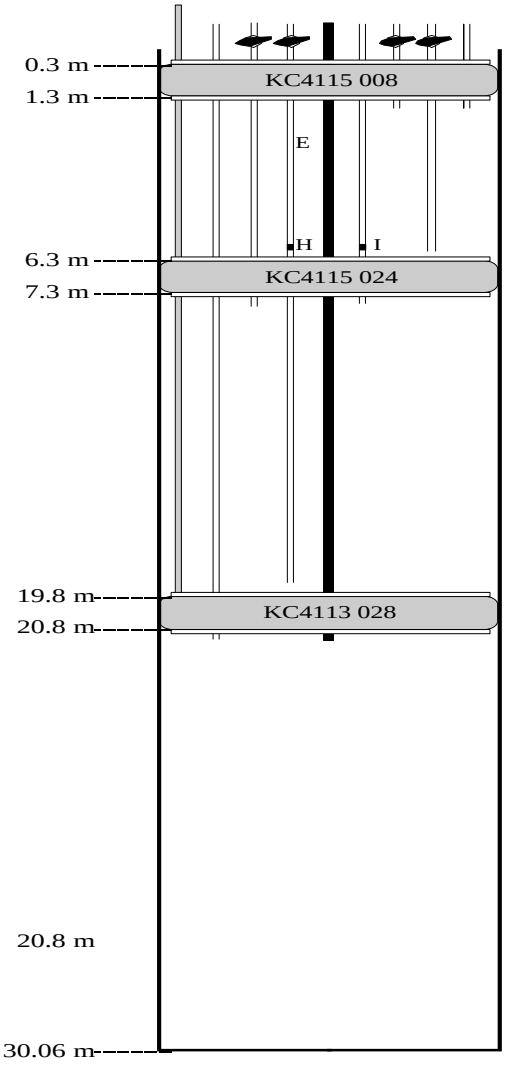

Figure 1 Instrument configuration in borehole KA3590G01