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Äspö Hard Rock Laboratory

Prototype Repository

Hydrogeology – injection test campaign 1

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September 2000

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Abstract

The Prototype Repository Test is focused on testing and demonstrating the function of the SKB 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 in the project but are also part of other projects.

The characterisation 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 the boundary and rock conditions needed for the interpretation of the experimental data.

This report describes the injection test campaign 1 made before the drilling of the repository boreholes. A second test campaign will be made after the drilling of those boreholes.

During the test campaign, 39 injection tests in 13 different boreholes were made. In each of the boreholes, three tests were made in the uppermost part of the borehole.

The results from the tests show that the tested borehole sections, with the exception of one section, are very low conductive. The range, of the hydraulic conductivity of these sections, is within the range $4 \cdot 10^{-12} – 1.6 \cdot 10^{-9}$ m/s.

The one section differing from the rest, is the top section of KA3554G01, 0.25-0.75 m . This section has an estimated hydraulic conductivity of $4.6 \cdot 10^{-8}$ m/s. No mapped fracture, however, exist in this section.

The initial pressure for the test sections was within the interval 110 kPa – 160 kPa. One section differed from this, KA3542G02, 1.25 – 1.75 m. This section had an initial pressure of 3056 kPa. A constant outflow test methodology was used in this section instead, resulting in a hydraulic conductivity value of $7.0 \cdot 10^{-10}$ m/s.

Sammanfattning

Huvudsyftet med prototypförvaret är att testa och demonstrera funktionen av en del av SKB's djupförvars system. Aktiviteter som syftar till utveckling och försök av praktiska och ingenjörsmässiga lösningar, som krävs för att på ett rationellt sätt kunna stegvis utföra deponeringen av kapslar med kärnbränsle, är inkluderade i projektet för prototyp förvaret men även i andra projekt.

Karakteriseringen av bergmassan genomförs i tre steg. Varje steg syftar till att bidra med mer detaljer som skall vara användbara för att kunna lokalisera deposition hål och för att också kunna bestämma randvillkor och bergegenskaper som behövs för att kunna tolka experimentella data.

Denna rapport behandlar de injektionstester som genomförts innan dess att de sex depositionshålen i prototypförvaret borrats. En andra testomgång är planerad efter att borrningarna genomförts.

Under testperioden genomfördes 39 injektionstester i 13 olika borrhål. I vart och ett av borrhålen genomfördes 3 tester i den översta delen av hålet.

Resultaten från testerna visar att de undersökta borrhålssektionerna, med undantag för en sektion är mycket låg-konduktiva. Den hydrauliska konduktiviteten för dessa sektioner ligger i intervallet $4 \cdot 10^{-12} – 1.6 \cdot 10^{-9}$ m/s.

Den sektion som avviker från detta mönster är den översta sektionen i KA3554G01. Den hydrauliska konduktiviteten för denna sektion är $4.6 \cdot 10^{-8}$ m/s. Ingen öppen spricka förekommer inom detta intervall.

Det ostörda bakgrundstrycket för sektionerna innan teststart låg inom intervallet 110 kPa – 160 kPa. En sektion avvek från detta mönster, KA3542G02, 1.25 – 1.75 m. Det ostörda bakgrundstrycket i denna sektion var 3056 kPa. Istället för en injektionstest utfördes ett konstant utflödestest i denna sektion istället. Den hydrauliska konduktiviteten i denna sektion är $7.0 \cdot 10^{-10}$ m/s.

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1.1 Äspö Hard Rock Laboratory

In order to prepare for the siting and licensing of a spent fuel repository SKB has constructed an underground research laboratory.

In the autumn of 1990, SKB began the construction of the Äspö Hard Rock Laboratory (Äspö HRL) near Oskarshamn in the southeastern part of Sweden, see *Figure 1-1*. A 3.6-km long tunnel was excavated in crystalline rock down to a depth of approximately 460 meters.

The laboratory was completed in 1995 and research concerning the disposal of nuclear waste in crystalline rock has since then been carried out.

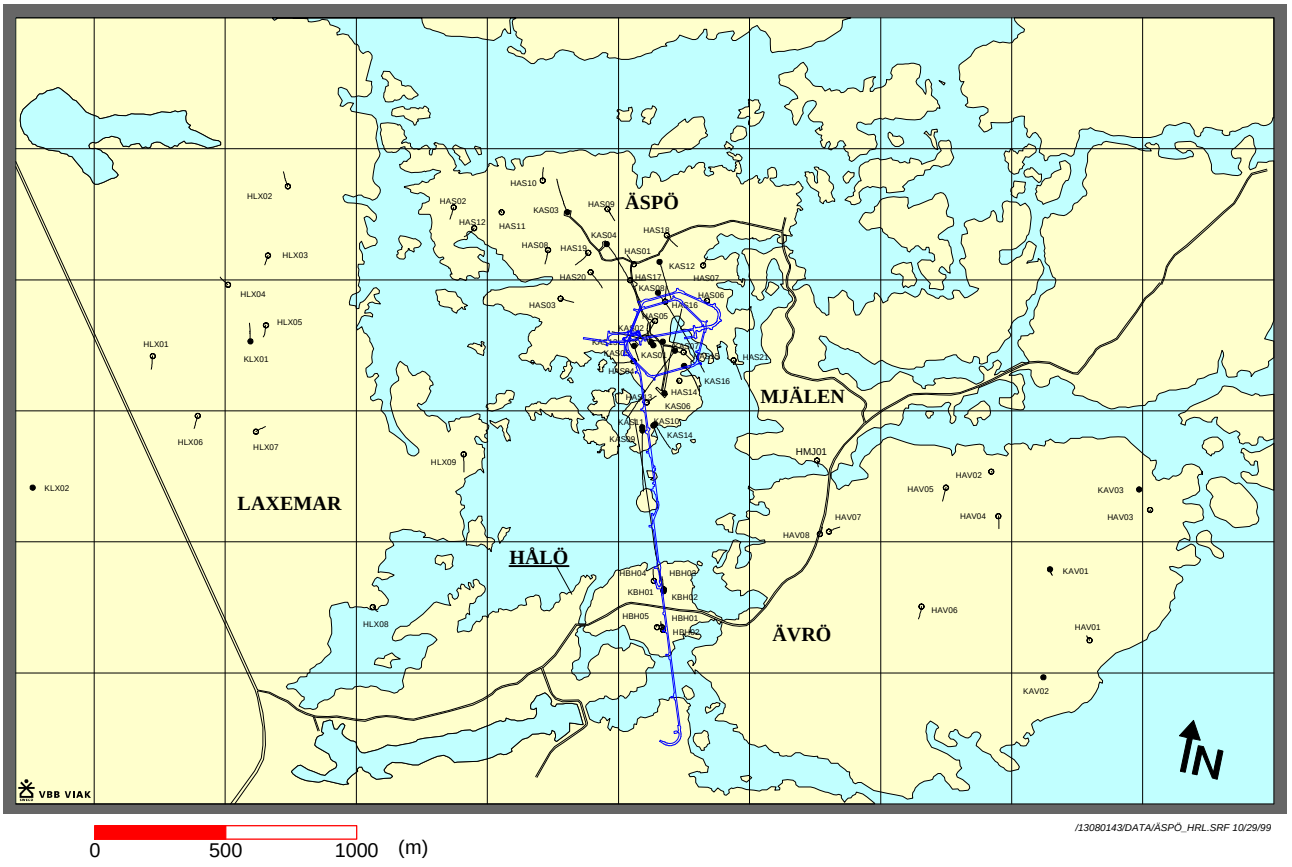


Figure 1-1 Äspö Hard Rock Laboratory

1.2 Prototype repository

The Äspö Hard Rock Laboratory is an essential part of the research, development, and demonstration work performed by SKB in preparation for construction and operation of the deep repository for spent fuel. Within the scope of the SKB program for RD&D 1995, SKB has decided to carry out a project with the designation “Prototype Repository Test“. The aim of the project is to test important components in the SKB deep repository system in full scale and in a realistic environment.

The Prototype Repository Test is focused on testing and demonstrating the function of the SKB 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.

1.2.1 General objectives

The Prototype Repository should simulate as many aspects as possible a real repository, for example 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 for the Prototype Repository are:

- To test and demonstrate the integrated function of the repository components under realistic conditions in full scale and to compare results with models and assumptions.
- To develop, test and demonstrate appropriate engineering standards and quality assurance methods.
- To simulate appropriate parts of the repository design and construction process.

The objectives for the characterisation program are:

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

1.2.2 Characterisation stages

The characterisation 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 the boundary and rock conditions needed for the interpretation of the experimental data. The three stages are:

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 bore holes
3. Drilling of exploratory holes - long bore holes

This report describes the results of 39 injection tests in 13 of the exploratory boreholes. The report is to be regarded as a result report. No conclusions are made in this report.

2 OBJECTIVE

The objectives of the exploratory bore holes is to obtain data for prediction of the characteristics in the deposition holes, data for modelling and to quantify the criteria needed for validation of the suitability of the position for canister deposition. Acceptance of a canister position is based on scrutinization of characterisation data such as fracturing, permeability and stability of the bore hole wall.

The main objectives for the injection tests in the exploratory boreholes 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.

- Data shall constitute together with the geological and other investigations a basis for interpretation of changes, of the rock characteristics, around the upper part of the rock volume due to drilling of the deposition holes.

3 SCOPE

The injection tests were performed, *Gentzschein*, 1999, in 13 boreholes located in the TBM drilled part of the tunnel between section 3/542 meter and section 3/578 meter. Nine of the boreholes are vertical or subvertical; four have an inclination of 45 degrees. The nominal diameter is 76 mm. The borehole lengths and the dates of drilling are presented in *Table 3-1*.

The Underground Hydraulic Test system, UHT, *see Appendices 1 and 2*, was used. Prior to the injection tests, UHT 1 was mobilised. The mobilisation included transfer to the test site, calibration of flow meters and transducers and evacuation of air from the flow system. The preparations were conducted 16-17th of December 1998 and 7-8th of January 1999.

Table 3-1 Drilling data and borehole data of the 13 boreholes.

Borehole	Drilling Completed (Date)	Borehole length (m)	Comment
KA3542G01	980623	30.04	inclination 45º
KA3542G02	980616	30.01	“
KA3544G01	980324	12.00	
KA3546G01	980323	12.00	
KA3548G01	980323	12.01	
KA3550G01	980322	12.03	
KA3552G01	980321	12.01	
KA3554G01	980623	30.01	inclination 45º
KA3554G02	980616	30.01	“
KA3572G01	980320	12.00	
KA3574G01	980425	12.00	
KA3576G01	980426	12.01	
KA3578G01	980319	12.58	

Four tests were planned, with section length 0.5 m in the interval 0.25 to 2.25 m in each borehole. However, since the length of the packer tool specially made for this occasion was too short, only three tests down to 1.75 meters depth in each borehole were conducted. Consequently 39 sections were tested, see *Table 3-2*. The test period started 8th of January and ended 16th of January 1999.

The demobilisation of the UHT 1 system was carried out January 16th and 20th.

A plan view of the test area is shown in Figure 3-1 and a length section is shown in *Figure 3-2.*

Table 3-2 A list of injection tests conducted in exploratory boreholes in January 1999.

Borehole	Date of test	Test No	Section	Start of test (hh.mm)	Valve open (hh:mm:ss)	Valve closed (hh:mm:ss)	End of test (hh.mm)
KA3542G02	990108	1	0.25 - 0.75	19.23(7/1)	11:19.14	11:41.15	13.09
KA3542G02	990108	2	0.75 -.1.25	13.21	14:06.21	14:27.52	14.19
KA3542G02	990108	3	1.25 - 1.75	15.36	17:03.45	17:50.04	09.20 (9/1)
KA3542G01	990109	4	0.25 - 0.75	11.36	12:02.47	12:43.56	14.47
KA3542G01	990109	5	0.75 -.1.25	14.51	15:22.46	15:55.03	16.14
KA3542G01	990109	6	1.25 - 1.75	16.45	17:22.20	17:52.35	09.23 (10/1)
KA3544G01	990110	7	0.25 - 0.75	10.58	11:40.57	12:07.46	14.05
KA3544G01	990110	8	0.75 -.1.25	14.16	14:48.22	15:17.26	15.38
KA3544G01	990110	9	1.25 - 1.75	15.41	16:13.03	16:33.51	17.14
KA3546G01	990111	10	0.25 - 0.75	17.20(10/1)	10:28.08	10:54.42	11.10
KA3546G01	990111	11	0.75 -.1.25	11.18	11:54.56	12:15.26	13.29
KA3546G01	990111	12	1.25 - 1.75	13.24	14:11.10	14:32.29	14.55
KA3548G01	990111	13	0.25 - 0.75	15.22	16:02.46	16:31.37	16.49
KA3548G01	990111	14	0.75 -.1.25	16.55	17:26.18	17:49.02	18.06
KA3548G01	990111	15	1.25 - 1.75	18.12	18:46.08	19:08.12	08.18
KA3550G01	990112	16	0.25 - 0.75	08.57	09:39.05	10:03.51	10.17
KA3550G01	990112	17	0.75 -.1.25	10.25	11:08.56	11:31.39	13.42
KA3550G01	990112	18	1.25 - 1.75	13.52	14:39.27	15:01.00	15.15
KA3552G01	990112	19	0.25 - 0.75	15.40	16:30.13	16:51.41	17.12
KA3552G01	990112	20	0.75 -.1.25	17.35	18:05.07	18:25.10	18.37
KA3552G01	990112	21	1.25 - 1.75	18.44	19:16.47	19:36.43	08.27 (13/1)
KA3554G02	990113	22	0.25 - 0.75	09.10	09:53.51	10:20.09	10.32
KA3554G02	990113	23	0.75 -.1.25	10.40	11:17.33	11:43.04	12.59
KA3554G02	990113	24	1.25 - 1.75	13.08	14:55.09	15:17.11	15.33
KA3554G01	990113	25	0.25 - 0.75	16.17	16:52.47	17:14.04	17.29
KA3554G01	990113	26	0.75 -.1.25	17.40	18:15.17	18:37.15	18.49
KA3554G01	990113	27	1.25 - 1.75	19.05	19:38.52	20:12.58	08.00 (14/1)
KA3572G01	990114	28	0.25 - 0.75	10.24	11:47.58	12:10.42	13.22
KA3572G01	990114	29	0.75 -.1.25	13.30	14:14.25	14:34.25	14.51
KA3572G01	990114	30	1.25 - 1.75	14.58	15:48.31	16:19.31	16.33
KA3574G01	990114	31	0.25 - 0.75	16.55	17:35.01	17:58.14	18.11
KA3574G01	990114	32	0.75 -.1.25	18.25	19:04.21	19:31.13	08.17 (15/1)
KA3574G01	990115	33	1.25 - 1.75	08.26	09:01.50	09:33.59	09.52
KA3576G01	990115	34	0.25 - 0.75	10.17	10:53.43	11:14.23	12.31
KA3576G01	990115	35	0.75 -.1.25	12.39	13:28.13	13:50.54	14.05
KA3576G01	990115	36	1.25 - 1.75	14.14	15:01.26	15:23.44	15.35
KA3578G01	990115	37	0.25 - 0.75	16.10	16:55.33	17:16.14	17.29
KA3578G01	990115	38	0.75 -.1.25	17.36	18:12.13	18:32.27	18.45
KA3578G01	990115	39	1.25 - 1.75	18.51	19:25.22	19:46.10	09.31 (16/1)

Start Test - The time when the pressure registration starts
Valve open - The time when the water injection period starts
Valve closed - The time when the water injection period stops
End of test - The time when the pressure registration ended

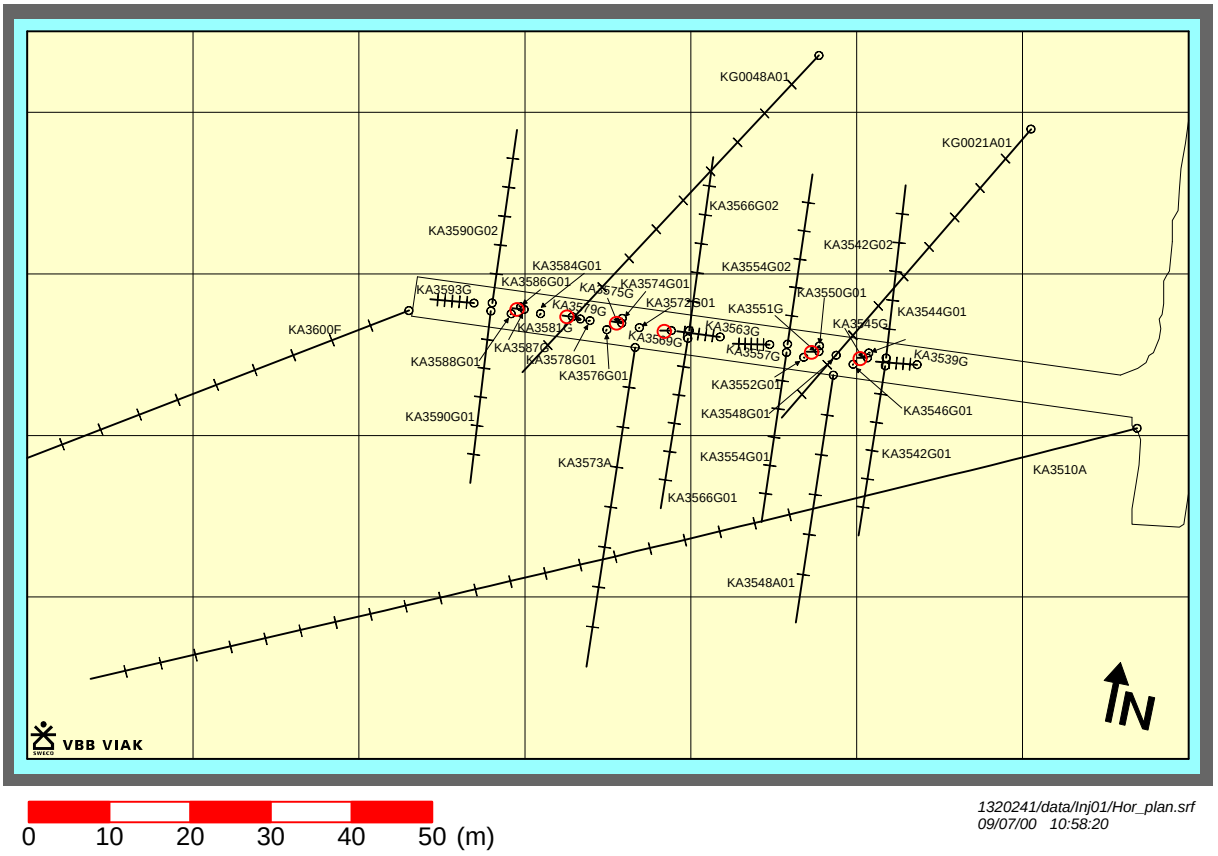


Figure 3-1 Plan ov the Prototype Repository Test Area

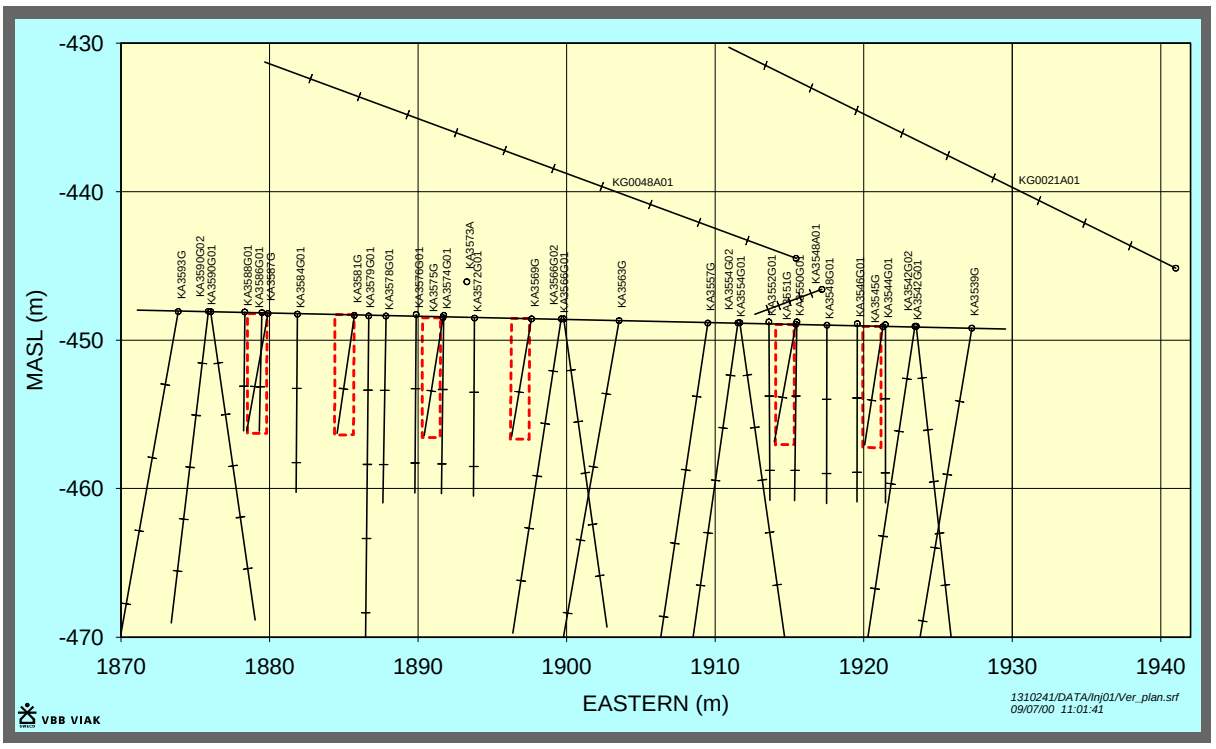


Figure 3-2 Section of the Prototype Repository Area

4 RESULTS

The tests were performed as constant pressure injection-tests. During the flow (injection) phase the ambient pressure of the test section was generally increased with 0.2 – 0.4 MPa. Subsequently the test section was shut in and the pressure was allowed to recover to ambient pressure. The pressure of the injection section was registered both during and after the flow (injection) phase. A low injection pressure was used in order not to widen any fractures.

In the test section 1.25 m – 1.75 m in borehole KA3542G02 the borehole pressure was higher than the maximum pressure of the injection pump. Therefor a constant pressure outflow test was done in this section.

In *Table 4-1* a summary of the results from the injection-tests are presented. The parameters shown in the table are:

- Borehole — Borehole name
- Secup — Upper section limit in metres
- Seclow — Lower section limit in metres
- Inj. time — Injection time in minutes
- Vtot — Total injected volume of water in m^3
- Q_p — Flowrate of the test section at the end of the injection period in m^3/s
- Rec. time — Pressure recovery period in minutes
- P_0 — Pressure head of the test section before start of injection in kPa
- P_p — Pressure head a moment before ending the injection period in kPa
- P_f — Pressure head at the end of the recovery in kPa
- P_{ref} — Pressure head at the injection pump in kPa
- K_{MOYE} — Steady state value of hydraulic conductivity (Moye) in m/s, see *App.2*.
- Q_p/dp (K_{MOYE}) — Steady state value of specific capacity based on K_{MOYE} in $m^3/s \cdot m$
- Q_p/dp (INJ) — Steady state value of specific capacity, $Q_p/(P_p-P_0)$, from injection period in $m^3/s \cdot m$

Table 4-1 Result of the injection tests

Injection tests - Prototype repository January 1999													
Borehole	Secup (m)	Seclow (m)	Inj. time (min)	V_{tot} (m^3)	Q_p (m^3/s)	Rec time (min)	P_0 (kPa)	P_p (kPa)	P_f (kPa)	P_{ref} (kPa)	K_{MOYE} (m/s)	$Q_p/dp(K_{MOYE})$	$Q_p/dp(INJ)$ (m^3/s m)
KA3542G02	0.25	0.75	22	2.28E-04	-3.23E-10	87.1	119	309.8	346.6	303.3	-		
	0.75	1.25	21.5	2.37E-05	-1.67E-10	29.9	120.2	315.8	368.8	308.5	-		
	1.25	1.75	46.5	2.46E-04	8.87E-08	929.3	3056.3	1042.7	3130.5	1042	3.5E-10	3.8E-10	4.4E-10
KA3542G01	0.25	0.75	41.2	3.26E-04	6.60E-09	118.1	137.4	512.3	474.7	500	1.1E-10	1.1E-10	1.8E-10
	0.75	1.25	32.3	3.26E-04	9.63E-10	18.6	119.1	524.1	546.9	500	2.2E-11	2.4E-11	2.4E-11
	1.25	1.75	30.3	3.09E-04	4.99E-09	928.7	118.8	540.5	742.6	500	7.7E-11	8.4E-11	1.2E-10
KA3544G01	0.25	0.75	26.8	1.39E-04	4.80E-10	116.5	162	690.9	500.1	500	6.0E-12	6.5E-12	9.1E-12
	0.75	1.25	29.1	2.54E-04	1.24E-08	13.9	126.7	574.8	613.6	500	2.8E-10	3.1E-10	2.8E-10
	1.25	1.75	30.3	1.95E-04	4.81E-10	928.7	131.4	529.5	652.9	500	1.3E-11	1.4E-11	1.2E-11
KA3546G01	0.25	0.75	26.6	2.70E-04	1.58E-10	14.5	124.5	694.5	619	500	2.6E-12	2.8E-12	2.8E-12
	0.75	1.25	20.5	2.05E-04	3.19E-08	71.9	127.3	520.1	403.9	520	7.9E-10	8.6E-10	8.1E-10
	1.25	1.75	21.2	2.57E-04	2.25E-09	10.6	130.8	579.2	562.5	550	5.0E-11	5.5E-11	5.0E-11
KA3548G01	0.25	0.75	28.7	2.26E-04	5.15E-09	16.4	122.8	518.6	489.2	500	1.3E-10	1.4E-10	1.3E-10
	0.75	1.25	22.8	2.86E-04	1.28E-09	16	124	820.4	701.4	500	1.5E-11	1.7E-11	1.8E-11
	1.25	1.75	22.1	2.73E-04	1.28E-09	788.5	126.9	527.9	308.1	500	3.3E-11	3.6E-11	3.2E-11
KA3550G01	0.25	0.75	24.8	2.59E-04	1.11E-08	11.6	121.5	520	386	500	2.9E-10	3.2E-10	2.8E-10
	0.75	1.25	22.7	1.98E-04	3.54E-09	129.9	130.1	563.5	505.7	500	8.2E-11	8.9E-11	8.2E-11
	1.25	1.75	21.6	-3.93E-07	-1.59E-10	11.9	126.9	679.6	663.2	500	-		
KA3552G01	0.25	0.75	21.5	2.27E-04	2.09E-09	20	127.2	560.7	538.4	540	5.0E-11	5.4E-11	4.8E-11
	0.75	1.25	20.1	2.17E-04	1.12E-09	11.2	125.1	788.3	762.8	500	1.5E-11	1.6E-11	1.7E-11
	1.25	1.75	20	1.97E-04	-6.50E-10	769.8	129.1	528.4	552.9	500	-		
KA3554G02	0.25	0.75	26.3	2.61E-04	2.66E-08	11.2	116.5	600.2	452.8	590	5.49E-10	6.0E-10	5.5E-10
	0.75	1.25	25.5	2.37E-04	1.12E-09	74.5	117.6	517.4	653.4	500	2.87E-11	3.1E-11	2.8E-11
	1.25	1.75	22.1	2.65E-04	2.25E-09	14.8	118.1	571.2	574.7	500	6.06E-11	6.6E-11	5.0E-11
KA3554G01	0.25	0.75	21.3	1.42E-03	9.00E-07	14.2	117.1	514.2	120.5	500	2.30E-08	2.5E-08	2.3E-08
	0.75	1.25	22	2.45E-04	3.06E-09	10.8	114.6	607.4	573.7	550	6.53E-11	7.1E-11	6.2E-11
	1.25	1.75	34.1	2.43E-04	1.77E-09	706.6	116.9	520.8	2466.4	500	4.54E-11	4.9E-11	4.4E-11
KA3572G01	0.25	0.75	22.8	3.02E-04	4.02E-09	70.4	129.1	519.5	380.1	500	1.05E-10	1.1E-10	1.0E-10
	0.75	1.25	20	2.60E-04	9.34E-09	15.8	122.1	974.1	883.7	500	1.19E-10	1.3E-10	1.1E-10
	1.25	1.75	31	1.36E-05	3.38E-09	12.1	136.1	529.5	522.2	500	6.56E-11	7.1E-11	8.6E-11
KA3574G01	0.25	0.75	23.2	2.95E-04	3.38E-09	11.7	123.7	539.9	535.7	500	8.28E-11	9.0E-11	8.1E-11
	0.75	1.25	26.9	3.31E-04	3.06E-09	764.3	123.4	524.7	337.6	500	8.04E-11	8.8E-11	7.6E-11
	1.25	1.75	32.2	3.09E-04	9.61E-10	15.1	123.4	560.6	556.8	500	2.23E-11	2.4E-11	2.2E-11
KA3576G01	0.25	0.75	20.7	2.55E-04	1.53E-10	75.8	122.3	519.9	396.7	500	4.26E-12	4.6E-12	3.9E-12
	0.75	1.25	22.7	2.45E-04	1.12E-09	13.6	127.9	524.4	517.3	500	2.90E-11	3.2E-11	2.8E-11
	1.25	1.75	21.3	2.50E-04	2.25E-09	10.3	134.8	529.4	523.9	500	5.92E-11	6.4E-11	5.7E-11
KA3578G01	0.25	0.75	20.7	2.15E-04	-1.69E-10	12	133.7	543.3	520	500	-		
	0.75	1.25	20.3	2.57E-04	1.03E-08	12.3	122.8	563	543.3	500	2.35E-10	2.6E-10	2.3E-10
	1.25	1.75	20.8	1.83E-04	1.29E-09	823.6	130.2	529.9	241.5	500	3.25E-11	3.5E-11	3.2E-11

Radial flow did not occur during the recovery phase in any of the tests. Accordingly, no Jacob semi-logarithmic evaluation of the transmissivity of any of the tested sections was possible to do. One section (KA3554G01, 0.25-0.75 m) is more conductive than the rest of the sections. Its final injection flowrate, Qp, is the only one larger than $1 \cdot 10^{-7}$ m^3/s.

Two different specific capacity values are presented in *Table 4-1*. The first one, Q_p/dp (K_{MOYE}), is calculated from the K_{MOYE} value, using the equation below

$$Q_p/dp\ (K_{MOYE}) = 2 \cdot \pi \cdot K_{MOYE} \cdot L / [1 + \ln (L / 2 \cdot r_w)]$$

The second one is calculated from the injection phase, Q_p/dp (INJ). The two values differ slightly, but indicate the same order of magnitude.

Details of each test are found in *Appendix 3*. The flowrate data curve, in *Appendix 3*, shows a sudden increase in most of the tests (in diagram C4) after approximately 10 seconds. The

reason for this is unknown; the most probable reason is that it is generated by the test equipment. The Q_p value in *Table 4-1* is the best estimate of the injection flow rate.

The transmissivity have been estimated from the specific capacity calculated from the injection phase. The following relationship have been used, *Rhén et al /1997/:*

3 meter injection tests : $$\text{Log}_{10}\, T = 1.52 + 1.18 \cdot \text{Log}_{10}\,(Q_p/dp\ (INJ)) \qquad (4\text{-}1)$$

In this series of injection tests the packer distance have been 0.5 m. Still it is believed that the relationship above will give a good estimation of the actual transmissivity of the tested sections. In *Table 4-2* the estimated transmissivity of the sections are detailed.

Table 4-2 Estimated transmissivity and hydraulic conductivityaccording to equation 4-1.

Borehole	Secup	Seclow	LOG_{10} T	K_{INJ}
	(m)	(m)	(m^2/s)	(m/s)
KA3542G02	0.25	0.75	-	-
	0.75	1.25	-	-
	1.25	1.75	3.0E-10	6.0E-10
KA3542G01	0.25	0.75	1.0E-10	2.0E-10
	0.75	1.25	9.6E-12	1.9E-11
	1.25	1.75	6.4E-11	1.3E-10
KA3544G01	0.25	0.75	3.1E-12	6.2E-12
	0.75	1.25	1.7E-10	3.5E-10
	1.25	1.75	4.3E-12	8.7E-12
KA3546G01	0.25	0.75	7.6E-13	1.5E-12
	0.75	1.25	6.2E-10	1.2E-09
	1.25	1.75	2.3E-11	4.6E-11
KA3548G01	0.25	0.75	7.2E-11	1.4E-10
	0.75	1.25	7.1E-12	1.4E-11
	1.25	1.75	1.4E-11	2.7E-11
KA3550G01	0.25	0.75	1.8E-10	3.5E-10
	0.75	1.25	4.1E-11	8.3E-11
	1.25	1.75	-	-
KA3552G01	0.25	0.75	2.2E-11	4.4E-11
	0.75	1.25	6.5E-12	1.3E-11
	1.25	1.75	-	-
KA3554G02	0.25	0.75	3.9E-10	7.8E-10
	0.75	1.25	1.2E-11	2.3E-11
	1.25	1.75	2.3E-11	4.6E-11
KA3554G01	0.25	0.75	3.2E-08	6.3E-08
	0.75	1.25	3.0E-11	6.0E-11
	1.25	1.75	2.0E-11	4.0E-11
KA3572G01	0.25	0.75	5.4E-11	1.1E-10
	0.75	1.25	5.8E-11	1.2E-10
	1.25	1.75	4.4E-11	8.8E-11
KA3574G01	0.25	0.75	4.1E-11	8.2E-11
	0.75	1.25	3.8E-11	7.6E-11
	1.25	1.75	8.8E-12	1.8E-11
KA3576G01	0.25	0.75	1.1E-12	2.3E-12
	0.75	1.25	1.2E-11	2.4E-11
	1.25	1.75	2.7E-11	5.4E-11
KA3578G01	0.25	0.75	-	-
	0.75	1.25	1.4E-10	2.9E-10
	1.25	1.75	1.4E-11	2.8E-11

As shown in the table above the range of the transmissivity is $1 \cdot 10^{-12} – 6 \cdot 10^{-10}$ m^2/s, with the exception of the KA3554G01, 0.25 – 0.75 m where the estimated transmissivity is $3.2 \cdot 10^{-8}$ m^2/s.

5 SUMMARY OF RESULTS

A total of 39 injection tests were made during the test campaign. The results from the tests show that the tested borehole sections, with the exception of one section, are very low conductive. The range, of the hydraulic conductivity of these sections, is within the range $4 \cdot 10^{-12} – 1.6 \cdot 10^{-9}$ m/s.

The one section differing from the rest, is the top section of KA3554G01. This section has an estimated hydraulic conductivity of $4.6 \cdot 10^{-8}$ m/s. No mapped open fracture exist in this section.

The initial pressure for the test sections was within the interval 110 kPa – 160 kPa. One section differed from this, KA3542G02, 1.25 – 1.75 m. This section had an initial pressure of 3056 kPa. A constant outflow test methodology was used in this section instead, resulting in a hydraulic conductivity value of $7.0 \cdot 10^{-10}$ m/s.

REFERENCES

Gentzschein B, 1999. Äspö Hard Rock Laboratory. Prototype repository. Hydraulic tests in exploratory holes. Injection tests. SKB Technical Document, SKB TD 99-56, May 1999.

Rhén I, Gustafson G, Stanfors R, Wikberg P, 1997. Äspö HRL – Geoscientific evaluation 1997/5. Models based on site characterisation 1986 – 1995. SKB TR 97-06.

APPENDIX 1

Equipment used

Parts of the underground hydraulic test system (UHT 1) were used for the injection tests. This was the first occasion when injection tests were performed using the UHT 1 equipment.

UHT 1, developed by SKB (Almén and Hansson, 1996) is constructed for underground hydraulic testing in boreholes with 56 mm and 76 mm diameter. Maximum borehole length is 300 m and the maximum working depth is 500 metres below sea level.

The main parts of the system (*Figure A1-1*) are :

- Down-hole equipment with packers and pipe string
- Hoisting rig
- Mini container including a system control unit, a measurement control unit and a data export and plotting unit

When conducting the injection tests only the mini container was utilised. The ordinary inflatable polyurethane packers and the pipe string were replaced by a specially made mechanical packer, which was lowered manually in the borehole and not by the rig. The packer was fixed in position with the help of a pipe wrench.

The mechanical double packer was manufactured by LIVINSTONE AB. The length of the packer is 2.3 m, see *Figure A1-2*. The test interval of 50 cm is limited by rubbers on both sides. The rubber length is 0.10 m. At the top the packer pipe is branched into two pipe ends. One is connected to the test interval between the sealing rubbers, the second pipe end is in hydraulic contact with the space below the lower packer.

On the pipe end connected to the test section a valve arrangement, consisting of a three-way coupling, a number of quick couplings and a valve, was mounted. To this device the injection hose and a hose to a pressure transducer (P) positioned in the mini container could be connected. The valve was used as a test valve. When opened, the injection started (after a delay due to the start of the regulation valves in UHT 1). The test interval was shut in and the injection stopped by closing the valve. The second pipe end was connected to a pressure line establishing hydraulic contact between the borehole interval below the packer and a pressure transducer (P_a) in the container.

The mini container is made of steel and has the outer dimension 2.5 x 1.7 x 2.6 m. Its walls are insulated using covered white plates and the floor is covered with an aluminium sheet. It is furnished with a table, cupboards and shelves for keeping tools, spare parts etc. The container accommodates the monitoring equipment the computers and the printer necessary to retrieve and plot data, respectively.

The electrical system of the container is connected to 16 A three-phase AC. The inside of the container is supplied with two 230 V electrical systems. One of them is directly connected to the power net, the second, which feeds the measurement instruments is also connected to an UPS-unit (auxiliary power supply) to avoid data losses during a power failure

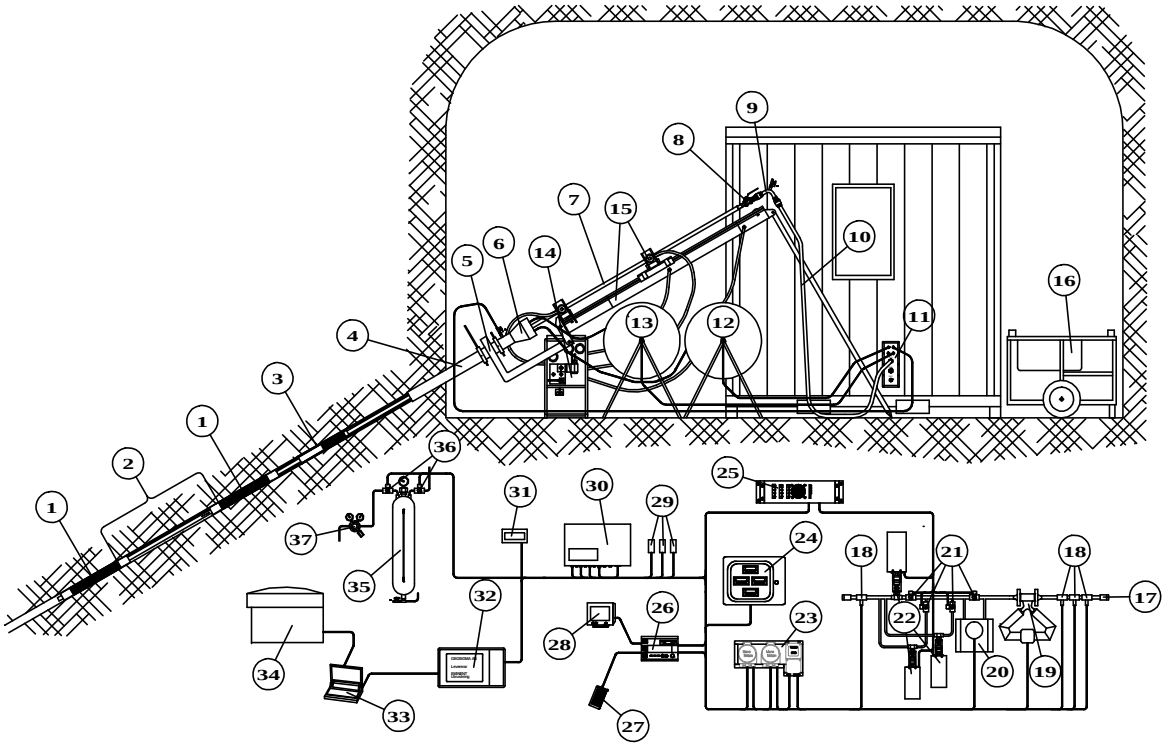


Figure A1-1 Overview of the UHT 1-system

1. Packer
2. Measurement section
3. Test valve
4. Casing
5. Extension beam
6. Sealing device
7. Pipe string
8. Adapter
9. Tube bend with air evacuation valve
10. Measurement hose from borehole
11. Wall lead-in
12. Hose reel, packer
13. Hose reel, section pressure
14. Control board, hoisting rig
15. Feed beam, hoisting rig
16. Power unit, hoisting rig
17. Inlet to container
18. Sensors, pressure, temperature, electrical conductivity
19. Flow meter BIG
20. Flow meter small
21. Valves
22. Regulation valves
23. Amplifier to Flow meter unit
24. Display for Flow meter unit
25. Stepping motor
26. Regulation computer
27. Regulation computer, key board
28. Regulation computer, monitor
29. Pressure transducers
30. Data scan box
31. External display
32. Measurement computer (SPC Rabbit)
33. Evaluation computer (Compaq)
34. Laser Jet printer
35. Pressure tank, packer inflation
36. Solenoid valves
37. N_2-gas governor

The pipe system within the container is connected to a lead-through in the wall. On the outside of the lead-through, different hoses from the borehole are connected with the help of quick-couplings. The standard UHT 1 equipment includes an injection hose of polyurethane with a steel inforced cord (Φ=3/4 “). During the injection tests polyamide hoses (Tecalan 6/4 mm) were used as injection hoses as well as for pressure conducting.

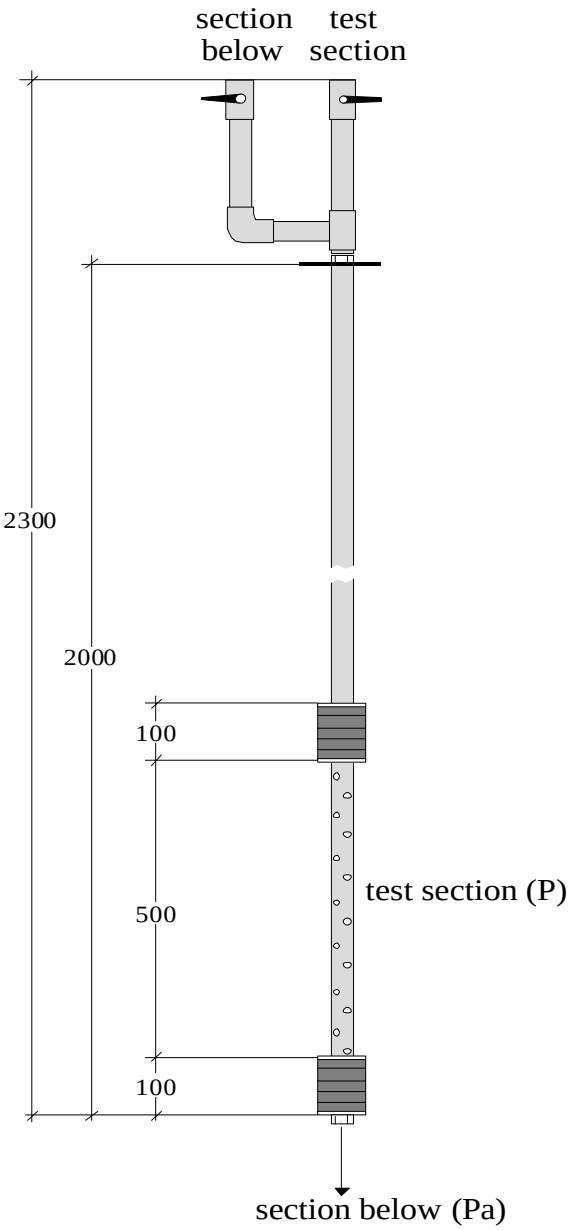


Figure A1-2 Mechanical double packer used in the Injection tests of 13 exploratory boreholes of the Prototype Repository, January 1999.

The maximum injection pressure of the UHT 1 is 10 bar. If the undisturbed ambient pressure exceeds 10 bar injection tests using UHT 1 are not possible to perform.

The pressure transducers, of type Druck PTX 630, monitoring absolute pressure, are mounted on a board on one of the container walls. Two sets of transducers with different pressure ranges are operable. The standard set of pressure transducers are,

Interval/packer	**Number**	**Transducer id**	**Range (alternative)**
Test section	2	P and P_b	6 MPa (1 MPa)
Borehole	1	P_a	6 MPa (1 MPa)
Packers	1	P_{pack}	8 MPa (2 MPa)

6 MPa transducers were used for P, P_b and P_a. P_{pack} was not used at all.

The pressure transducers are connected to the borehole through cannula tubes, hydraulic hoses and polyamide hoses.

The technical specifications of the pressure transducers are:

Type :	Druck Transmitter PTX 630 abs.
Supply voltage:	9 - 30 VDC
Output current:	4 - 20 mA
Linearity and hysteresis:	± 0.1 % of full scale
Temperature error :	± 0.3 % of full scale in the range -2 ^{o}C - +30 ^{o}C

The flow meter unit enables monitoring and regulation of the flow during constant pressure tests and constant flow tests, respectively. The flow regulation is operated and controlled using a digital computer. The main parts of the flow meter unit are:

- Two mass flow meters of type Coriolis-meters, flow range: 0.001-100 l/min
- Valves to regulate the flow rate
- A water filter
- Two pressure transducers, measuring the pressure at the inlet and the outlet of water, respectively.
- A temperature sensor.

Further components are:
- A display unit with four displays
- A cylinder with an electric conductivity sensor
- An amplifier to the flow meter unit and the conductivity sensor.

The water flow is conducted via the large flow meter (Q_{big}) irrespective if the small flow meter (Q_{small}) is in use or not. The measurement system selects flow data from one of the two flow meters according to the following criteria:

Q_{small} is selected if
(Q_{big} <Q2L2 and Q1L1< Q_{small} ≤Q1L2) or (Q_{big} ≤Q2L1 and Q_{small} >Q1L1).

Q_{big} is selected if
(Q_{small} ≤Q1L1 and Q_{big} >Q2L1) or (Q_{small} >Q1L2 and Q_{big} >Q2L1)

QIL1 = Low limit for Q_{small} connected, set to $-5.0 * 10^{-7}$ during the injection tests.
Q1L2 = Upper measure limit for $Q_{small,}$ set to $1.18 * 10^{-5}$ during the injection tests.
Q2L1 = Low limit for Q_{big} connected, set to $-5.0 * 10^{-5}$ during the injection tests.
Q2L2 = Lower measure limit for Q_{big}, set to $1.16 * 10^{-5}$ during the injection tests.

The system changes between the two flow meters during a test, depending on the variation of the flow rate. Which one used is known only by opening the *HT2 data file.

The technical data of the main components of the flow meter unit are as follows:

Flow meter Q_{small}

Type :	Micro Motion mass flow meter
Range:	0 - 1.00 kg/minute
Accuracy:	±0.4 % of current value ± zero stability (0.0001 Kg/minute)
Pressure drop at max.flow:	c. 500 kPa
Maximum working pressure:	7 MPa

Flow meter Q_{big}

Type :	Micro Motion mass flow meter
Range:	0 - 100 kg/ minute
Accuracy:	± 0.15 % of current value ± zero stability (0.003 Kg/minute)
Hysteresis:	< 0.1 %
Pressure drop at max. flow:	c. 500 kPa
Maximum working pressure:	5 MPa

Pressure transducers, inlet and outlet

Type : Druck Transmitter PTX 1400
Range: 0 - 6 Mpa
Linearity and hysteresis: ± 0.15 % typical value
± 0.25% maximum, Best Straight Line Definition

Temperature sensors

Type : GEOSIGMA BG01
Semiconductor type
Range: 0 - +32 ^{o}C
Accuracy: ±0.25 ^{o}C

Electrical Conductivity meter

Type : Kemotron 2911
Sensor: Kemotron 9221, 4-electrode
Range: Adjustable, 14 intervals within the range
0 - 20 000 mS/m
Accuracy, amplifier: ±0.25 % of current value
Accuracy, cell constant: ±0.5 %
Maximum working pressure: 5 MPa
Temperature sensor: Pt 1000

When performing constant pressure injection tests, the constant pressure is maintained by a standard PC (Intel 486, 100 MHz, 4MB RAM and 200 MB HDD, CRT monitor). The pressure is kept constant by regulating the water flow rate. Specially designed software opens and shuts regulation valves such that a constant pressure according to a pre-set value is achieved. The program is written in TURBO-C and runs on a DOS platform.

The UHT 1 measurement system is controlled by, and operated from a 120 MHz Pentium laptop computer. The software used is DM2 (Datascan Technology) , which also constitutes the platform for the Hydro Monitoring System (HMS) at the Äspö HRL. DM2 is a standard program, but has been supplemented with additional programs.

All sensors are connected to the AD-converter unit (Datascan 7320)
In addition there is a Datascan-unit for digital I/O (Datascan 7035).

The data produced by UHT 1 are evaluated in a second computer, a portable Compaq 100 MHz Pentium. The operating system is Windows 95, but the evaluation programs run on a DOS platform. Data files from the test are transferred to the evaluation computer during or after each test.

The UHT 1-system also includes a HP Laser Jet 5p, which is printing either evaluation plots from the evaluation computer, or display images from the measurement computer.

APPENDIX 2

Performance of injection tests

A2.1 TEST PRINCIPLES

The tests were performed as constant-pressure injection tests. During the flow phase the ambient pressure in the test section was generally increased with c. 0.2 MPa to 0.4 MPa. Subsequently the test section was shut in and the pressure was allowed to recover to ambient pressure.

In the test section 1.25 m – 1.75 m in borehole KA2542G02 the borehole pressure was higher than the maximum pressure of the injection pump. Therefore, a constant pressure outflow test was performed in this section.

The pressure was measured within the test section as well as in the borehole interval below the packers. The surrounding boreholes were packed of and closed during the test period.

A2.2 TEST CYCLE AND PROCEDURES

The test cycle was performed as follows:

- The double packer was lowered into position and the sealing rubbers were expanded to delimit the test interval.
- The measurement section and the packer pipes were filled up with water.
- The injection hose and the pressure hoses (all filled up with water) were connected via quick-couplings.
- The measurement system of UHT 1 was started.
- The undisturbed pressure was measured for at least 20 minutes.
- The injection was started, by opening the test valve.
- Regulation of a constant injection pressure for 20 minutes.
- The injection was stopped, by closing the test valve.
- Pressure recovery during 10 minutes.
- The UHT 1 measurement was ended and the packer released.
- Transfer to next borehole section.

The different stages of a test were regulated and controlled from the measurement computer in the UHT 1 container. The flow phase was started according to the following procedure:

- The injection pump was started.
- The data processing system was initiated to begin the flow phase
- Within 45 seconds, the test valve was manually opened .

The recovery period was initiated in a corresponding way. In the diagrams the start of the flow and recovery periods, respectively, are determined by pre-set criteria.

During the injection, the pressure initially increased far more than the pre-set value. Since most of the test sections were low conductive or impermeable, the pressure was decreasing during the entire flow period without reaching down to the reference level.

To achieve a more constant pressure the automatic regulation was interrupted when the pressure was close to the pre-set value, and then restarted after c. 30 seconds. In some cases, if the initial pressure value did not deviate too much, the reference level was changed to be equal to the actual pressure.

The constant pressure during the injection was achieved prior to the injection start by pre-setting a reference pressure on the display of the regulation computer. The display value P_{ref} was not compensated for the vertical distance between the transducer and the test section as was the case with the pressures P, P_a and P_b.

A2.3 CALIBRATION

The flow meters Q_{small} and Q_{big} were calibrated using graduated cylinders and a stopwatch. Two flow values were measured for each flow meter for the purpose of calibration, and each level was measured twice.

The pressure transducers P, P_b and P_a were calibrated with the help of the reference pressure system established in the Äspö HRL tunnel. The transducers were connected to two hoses, filled with water of known density. The water column of each hose ends at a well-defined reference water level (at KK0120 and KK2850) enabling calculation of the calibration constants. The position of the pressure sensors and the barometric pressure are also used in the calibration process. The elevation of the sensors were surveyed prior to the tests and the barometric pressure was measured with a Druck DPI 700 digital pressure indicator, which have a factory-listed accuracy of 0.05% of full scale (2 bar).

The temperature sensor and the electric conductivity sensor were only zero-point calibrated. The temperature sensor was compared with a high-accuracy portable spirit thermometer of good quality (the accuracy was ±0.2 °C in the range -10 °C - +50°C). The conductivity sensor was calibrated using a liquid solution with a well-determined electric conductivity.

The results of the calibrations were entered into the measurement computer and the calibration constants were automatically calculated.

A2.4 DATA PROCESSING

The parameters, measured by the UHT-1 measurement system are:

P	Pressure of the test section
P_a	Pressure of the borehole intervals above and/or below the test section
P_{pack}	Packer pressure
T_{surf}	Water temperature (surface)
Q_1	Water flow rate Q_{small}
Q_2	Water flow rate Q_{big}
P_b	Pressure of the test section (same as P)
Elcond	Electrical conductivity

Since a mechanical packer was used, P_{pack} was not measured during the injection tests. P_a was equal to the pressure of the borehole interval below the test section, see *Figure A1-2 in Appendix 1*.

The operative system of the measurement computer is OS9000. The measurement program is based on a program called
- DM2-386

Additionally there are three modules (standard programs):

- CALC-386 (for special transformation of data)
- SEQ-386 (creates automatic sequences of measurements, data storing.)
- MIMICMAN (creates graphical interfaces with process images)
- CONTR-386 (controller for regulation of flow/pressure)

These programs are supplemented with a number of application programs.

- Menu programs for entering data (calibration constants, background data)
- Report generator that creates an out put file (MIO-format)
- Drive routine for extra display
- Calibration programs

The program ”KERMIT” is used to transfer data from the measurement computer to the evaluation computer.

The program SHELL.EXE starts all the programs in the evaluation computer. SHELL.EXE is a commercial program from WordPerfect. The data file transferred from the measurement computer has an MIO-format. This file is converted to a number of files, which enables plotting of the different diagrams. The same plot program creates plots both on the screen and on the printer. The programs in the evaluation computer are:

- IPPLOT.EXE Conversion program from ERGO-data (B. Johansson)
- SKBPLOT.EXE Plot program from ERGO-data (B. Johansson)
- PLTCNV.EXE File selection program. From GEOSIGMA (G. Nyberg)
- RUNBAT.EXE File selection program and start of BATCH file. From GEOSIGMA (G. Nyberg)

The plot program generates three types of diagrams :

- A diagrams (**A1 - A5**) illustrating pressure, flow and temperature variations during the whole test cycle. **A0** is a flyleaf displaying background data as well as measured and calculated data from the test.

- B diagrams (**B1 - B6**) representing pressure and flow variations during the flow phase in logarithmic and semi-logarithmic scale. In addition, other parameter transformations are plotted.

- C diagrams (**C1 - C9**) showing pressure and flow variations during the pressure build-up phase in logarithmic and semi-logarithmic scale. In addition, other transformations of parameters and time are plotted.

The pressure values of the diagrams are corrected for the vertical distance between the transducer and the test section (upper limit). This is achieved by entering basic data such as length to the test section, borehole inclination and the height of the transducer, into the measurement computer, before each test.

The format of the section limits in the diagrams only allows one decimal, which entails that the section limits 0.25 m, 0.75 m, 1.25 m and 1.75 m are written 0.3 m, 0.8 m, 1.3 m and 1.8 m respectively

A2.5 PRELIMINARY EVALUATION

The UHT 1 system automatically calculates a steady-state value of the hydraulic conductivity of the test sections using Moye´s formula (Moye 1967):

$$K = \frac{Q_p \times 1000 \times 9.81}{L \times dP_{om}} \cdot C$$

where

Qp = flow rate of the test section at the end of the flow phase(m^3/s)
dP_{om} = Average of $P - P_o$ during the flow phase (kPa)
P = hydraulic head of the test section
P_o = hydraulic head of the test section before flow start.
$C = [1 + \ln(L/2r_w)]/ 2\pi$
L = Length of the test section (m)
r_w = borehole radius (m)

The steady-state hydraulic conductivity is printed on the flyleaf of each test section. In the main report it is reported as K_{MOYE}.

A2.6 SOURCES OF ERROR

The accuracy of the pressure transducers, the flow meters, the temperature sensor and the electrical conductivity sensor is described in *Appendix 1*.

The zero stability of the "small " flow meter is $\pm 1.67 \cdot 10^{-9}$ m^3/s (0.0001 kg/min), see chapter 4. In the majority of the injection tests the flow rates are close to or less than the zero stability and often negative. In most tests, the flow values are scattered around the zero flow line. This means that in many tests the flow values and the calculated conductivity values, chapter 5.5, have low accuracy.

In a number of tests, the pressure increases after the injection stop. This could be an effect of a too short pressure stabilisation period or possibly, due to high pressure in the borehole interval below the packers, which influences the section pressure.

APPENDIX 3

Details and diagrams from transient injection tests in 39 borehole sections

Of the diagrams from each test the 1st one presents the measured flowrate, the 2nd one the groundwater pressure in the test section and the section below the test section, the 3rd and 4th ones the recovery period after the injection phase.

In the diagrams the following abbreviations are used:

P - groundwater pressure of the test section (kPa)

P_a - groundwater pressure of the borehole interval below the test section (kPa)

P_b - groundwater pressure of the test section (kPa)

P_p - groundwater pressure average of the last five values before the injection period (kPa)

Q - the flowrate (m^3/s)

The flowrate data curve shows a sudden increase in most of the tests (in diagram C4) after approximately 10 seconds. The reason for this is unknown; the most probable reason is that it is generated by the test equipment.

Borehole KA3542G02, section 0.25 m - 0.75 m

Date: 99-01-08 Field Crew: B. Gentzschein

Valve opened: 990108 111914 Valve closed: 990108 114115
Total flowing time: 22.0 min. Tot. Pr. Build-up time: 87.1 min.

Pressure before injection start (P_0, kPa) : 119.0
Pressure just before closing the valve (P_p, kPa) : 309.8
Pressure at the end of the recovery (P_f, kPa) : 346.6

Pre-set section pressure (during injection) (P_{ref}, kPa) : 303.3

Initially the pressure increases to >320 kPa. Thereafter it decreases to a level below the pre-set value! Approximately 25 minutes after the valve closing the pressure increases, possibly due to the high pressure in the borehole interval below the packer.

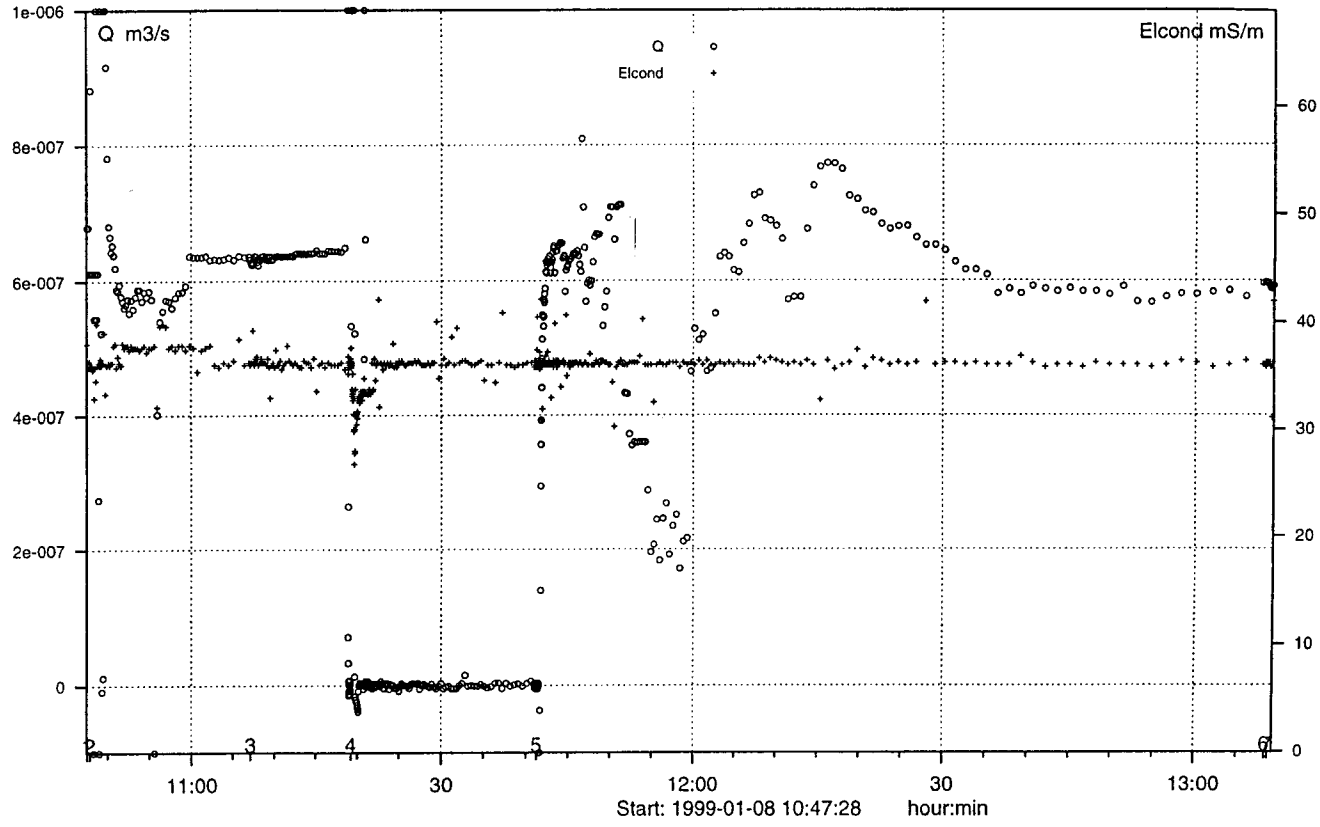
The measured flow rate before and after the injection phase is internal within the flow meter system and does not impact the test section (since the test valve is closed). It is probably an effect of air in the flow meter system. The flow at the end, Qp, is negative ($-3.22 \cdot 10^{-10}$ m^3/s). This is within the limits of the zero stability, $\pm 1.67 \cdot 10^{-9}$ m^3/s (0.0001 kg/min).

Borehole: 3542G02

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-08 10:47:07



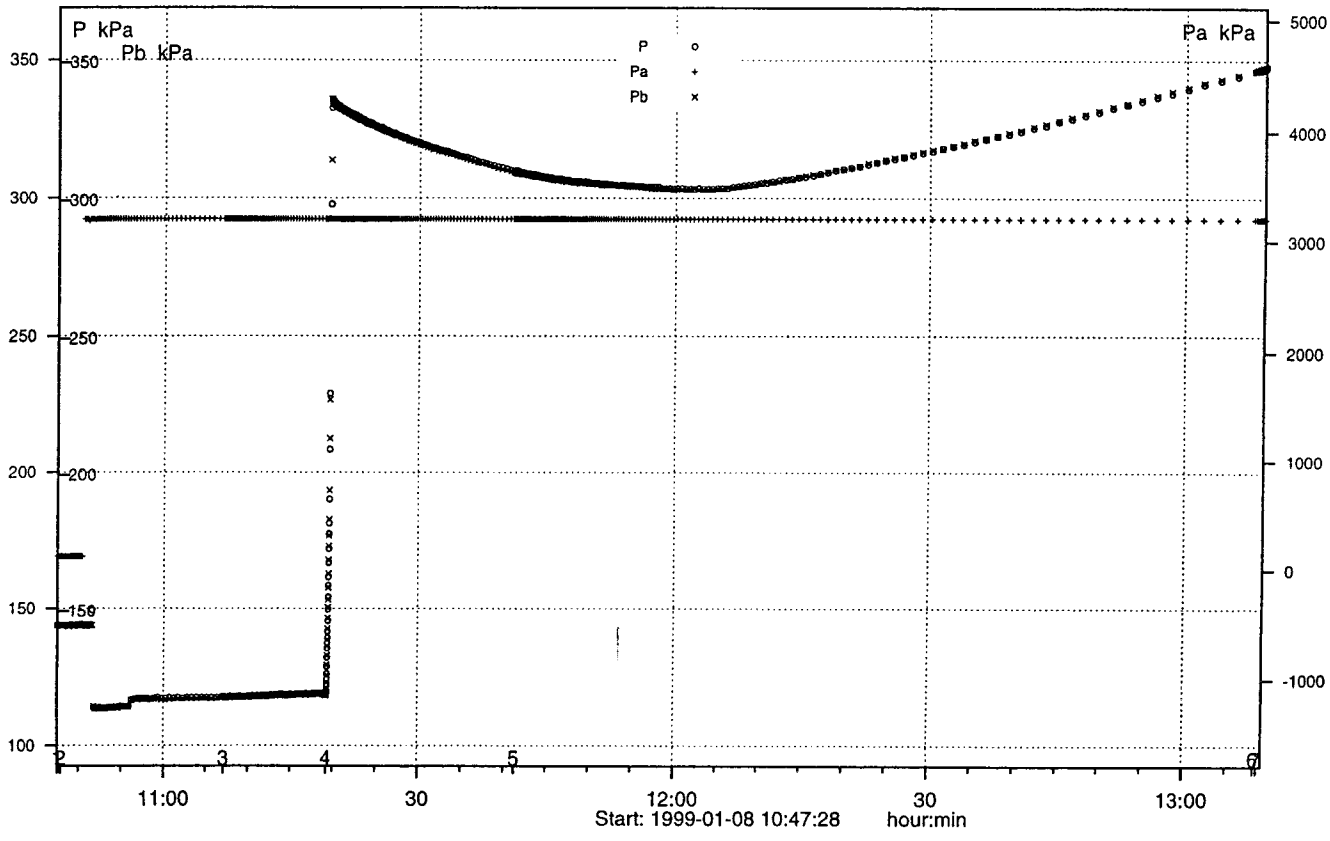
Thu Apr 29 14:51:31 1999

Borehole: 3542G02

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-08 10:47:07



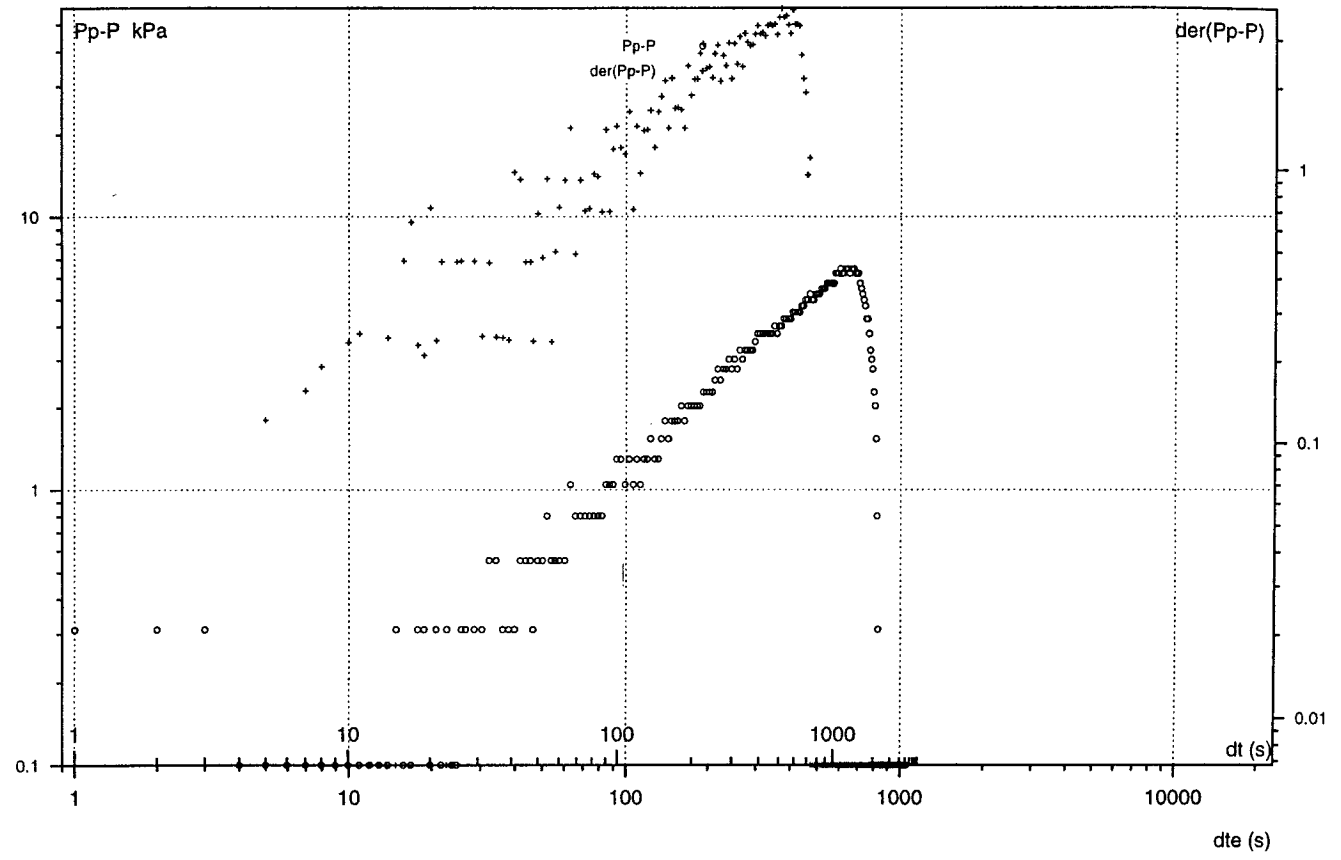
Thu Apr 29 14:26:22 1999

Borehole: 3542G02

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-08 10:47:07



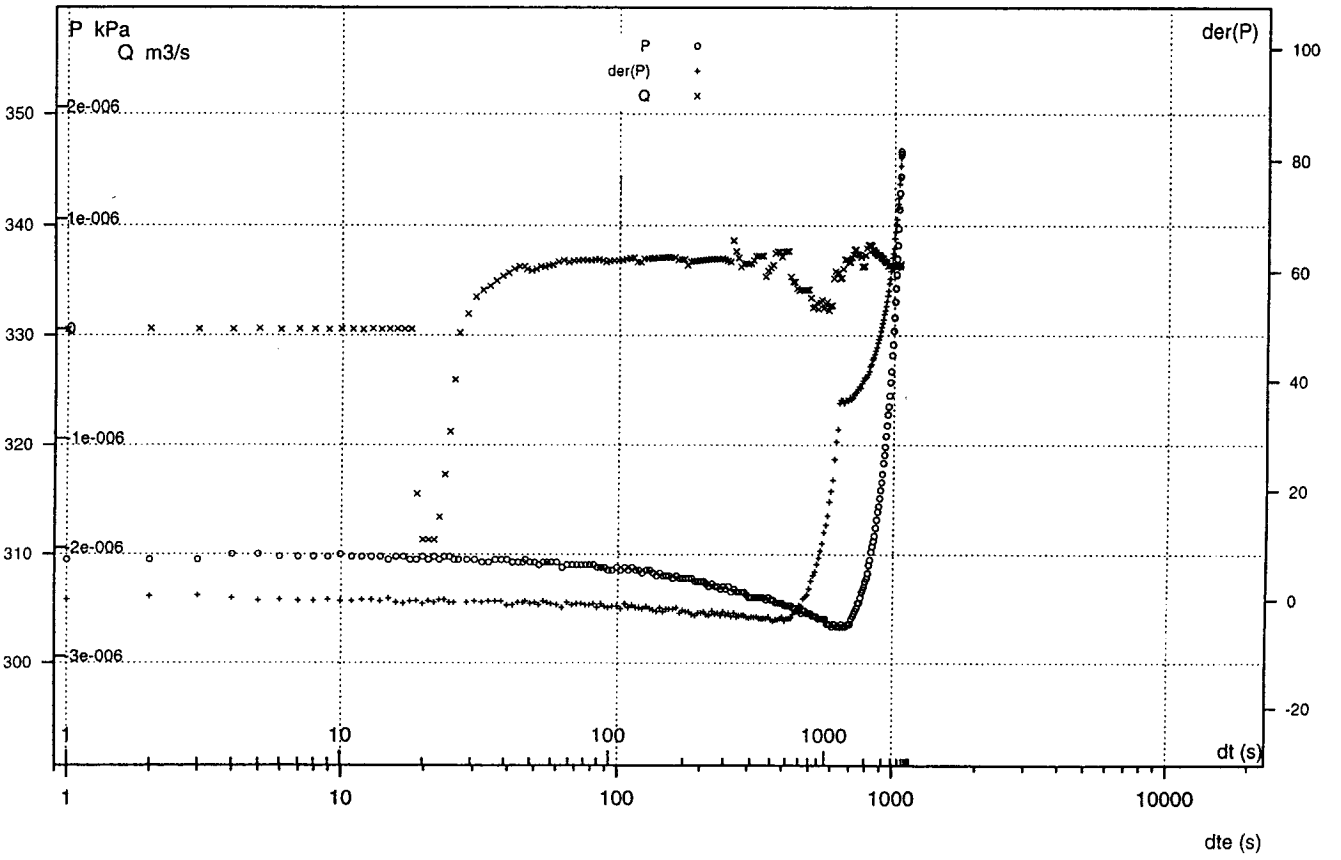
Thu Apr 29 14:26:22 1999

Borehole: 3542G02

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-08 10:47:07



Thu Apr 29 14:26:22 1999

Borehole KA3542G02, section 0.75 m – 1.25 m

Date: 99-01-08 Field Crew: B. Gentzschein

Valve opened: 990108 140621 Valve closed: 990108 142752
Total flowing time: 21.5 min. Tot. Pr. Build-up time: 29.9 min.

Pressure before injection start (P_0, kPa) : 120.2
Pressure just before closing the valve (P_p, kPa) : 315.8
Pressure at the end of the recovery (P_f, kPa) : 368.8

Pre-set section pressure (during injection) (P_{ref}, kPa) : 308.5

Initially the pressure increased to >570 kPa. By opening a valve, the pressure fell to a level close to the pre-set value.

As in the preceding test the pressure increased after valve closing

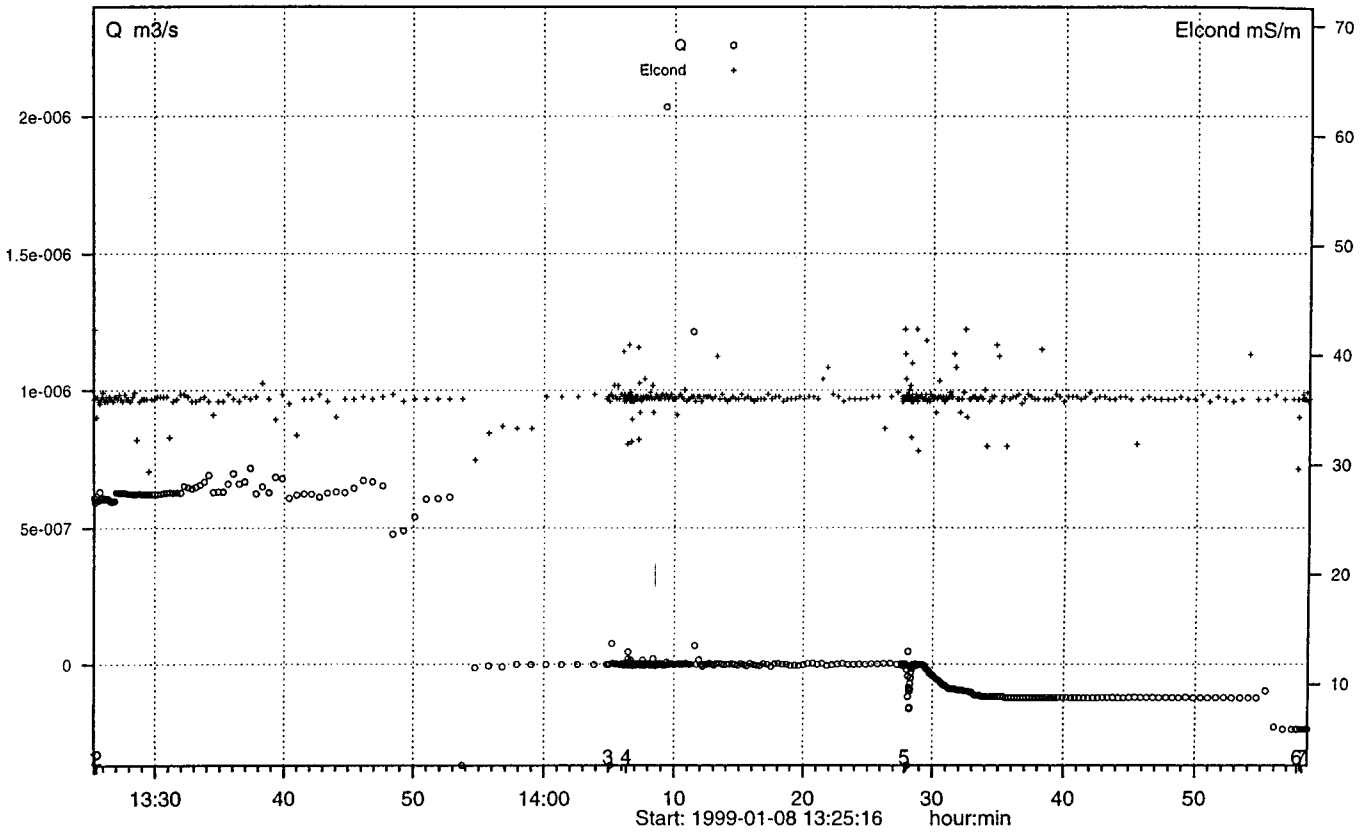
The measured flow rate before the injection phase is of internal nature, see section 0.25 – 0.75 m.

Borehole: 3542G02

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-08 13:25:02



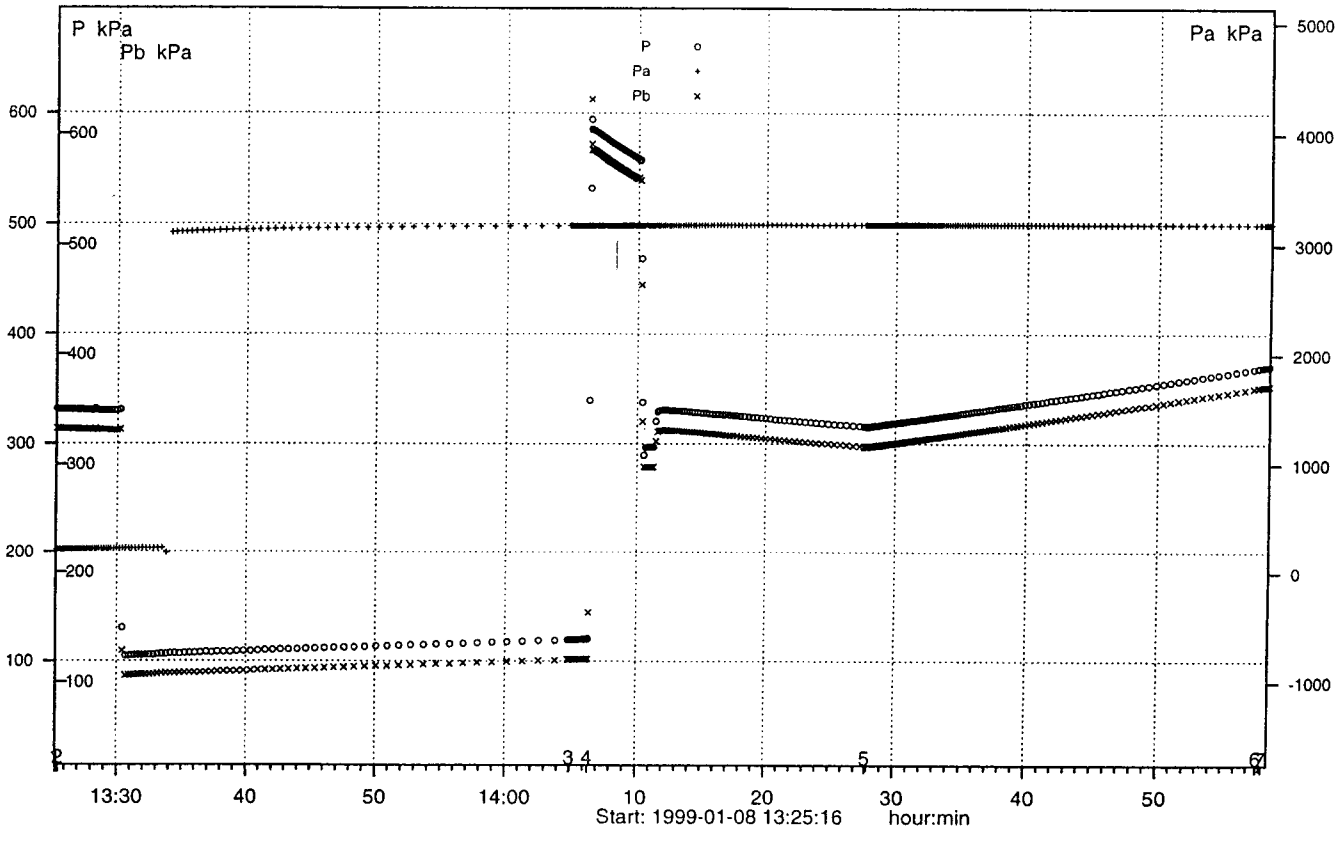
Thu Apr 29 15:12:05 1999

Borehole: 3542G02

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-08 13:25:02



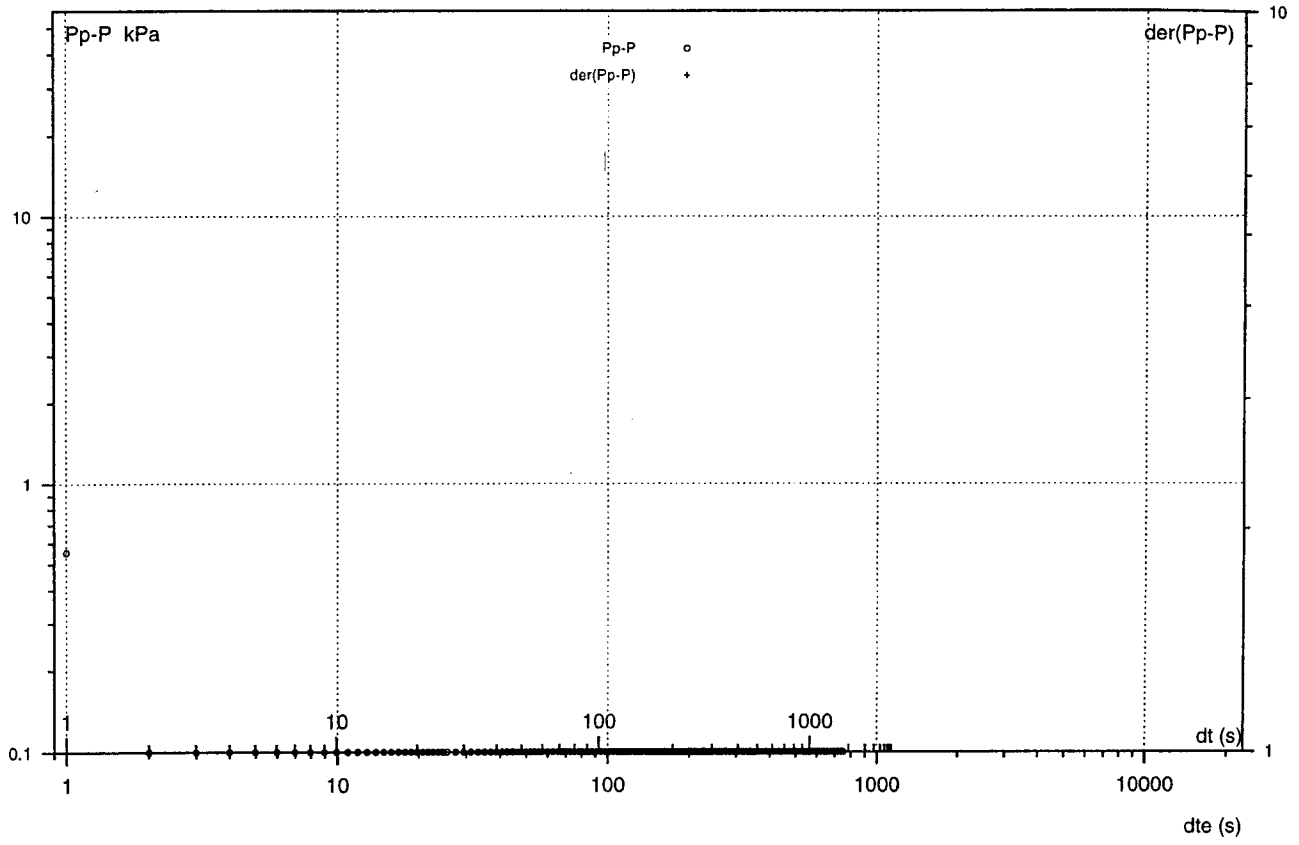
Thu Apr 29 15:12:05 1999

Borehole: 3542G02

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-08 13:25:02



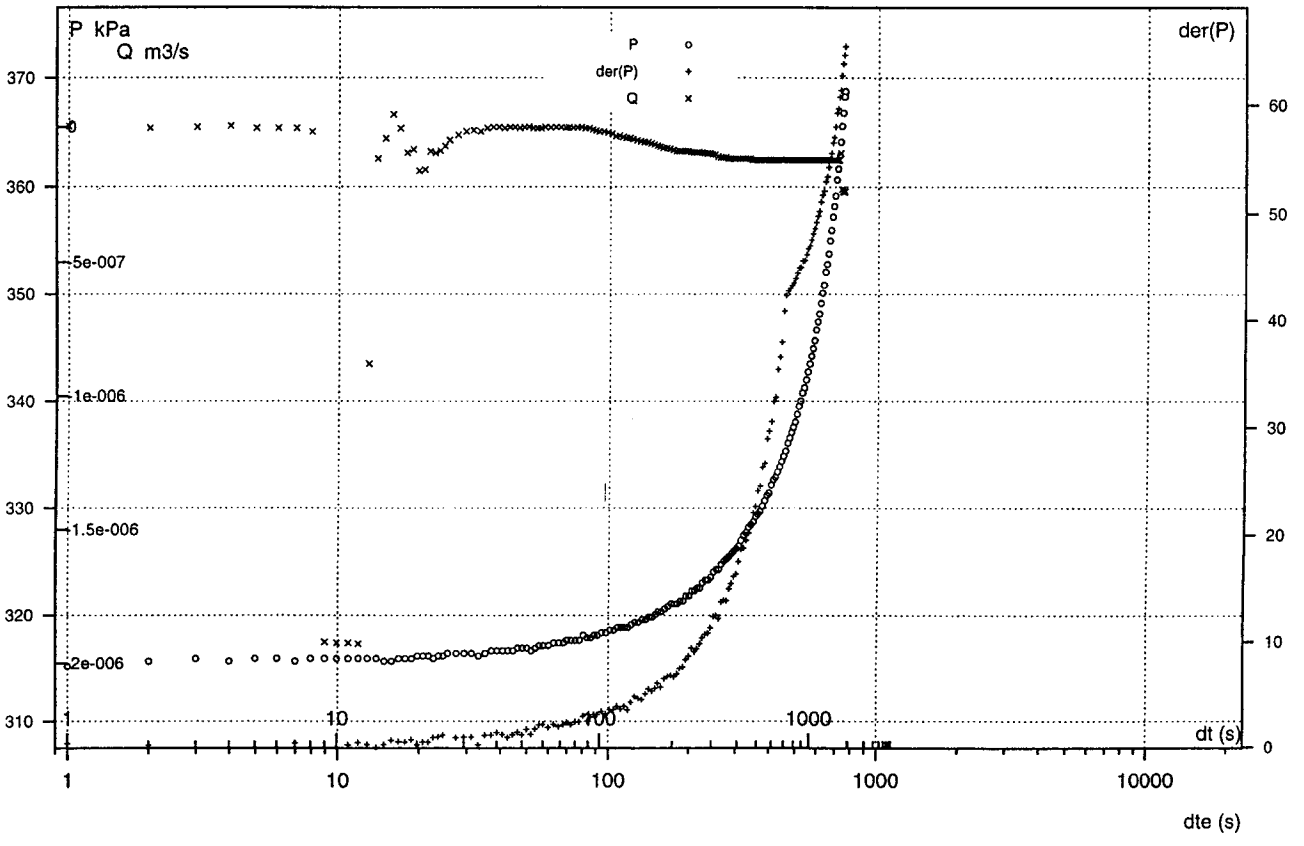
Thu Apr 29 15:20:28 1999

Borehole: 3542G02

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-08 13:25:02



Thu Apr 29 15:21:00 1999

Borehole KA3542G02, section 1.25 m – 1.75 m

Date: 99-01-08 Field Crew: B. Gentzschein

Valve opened: 990108 170345 Valve closed: 990108 175004
Total flowing time: 46.5 min. Tot. Pr. Build-up time: 929.3 min.

Pressure before valve opening (P_0, kPa) : 3056.3
Pressure just before closing the valve (P_p, kPa) : 1045.7
Pressure at the end of the recovery (P_f, kPa) : 3130.5
Pre-set section pressure (during injection) (P_{ref}, kPa) : 1042

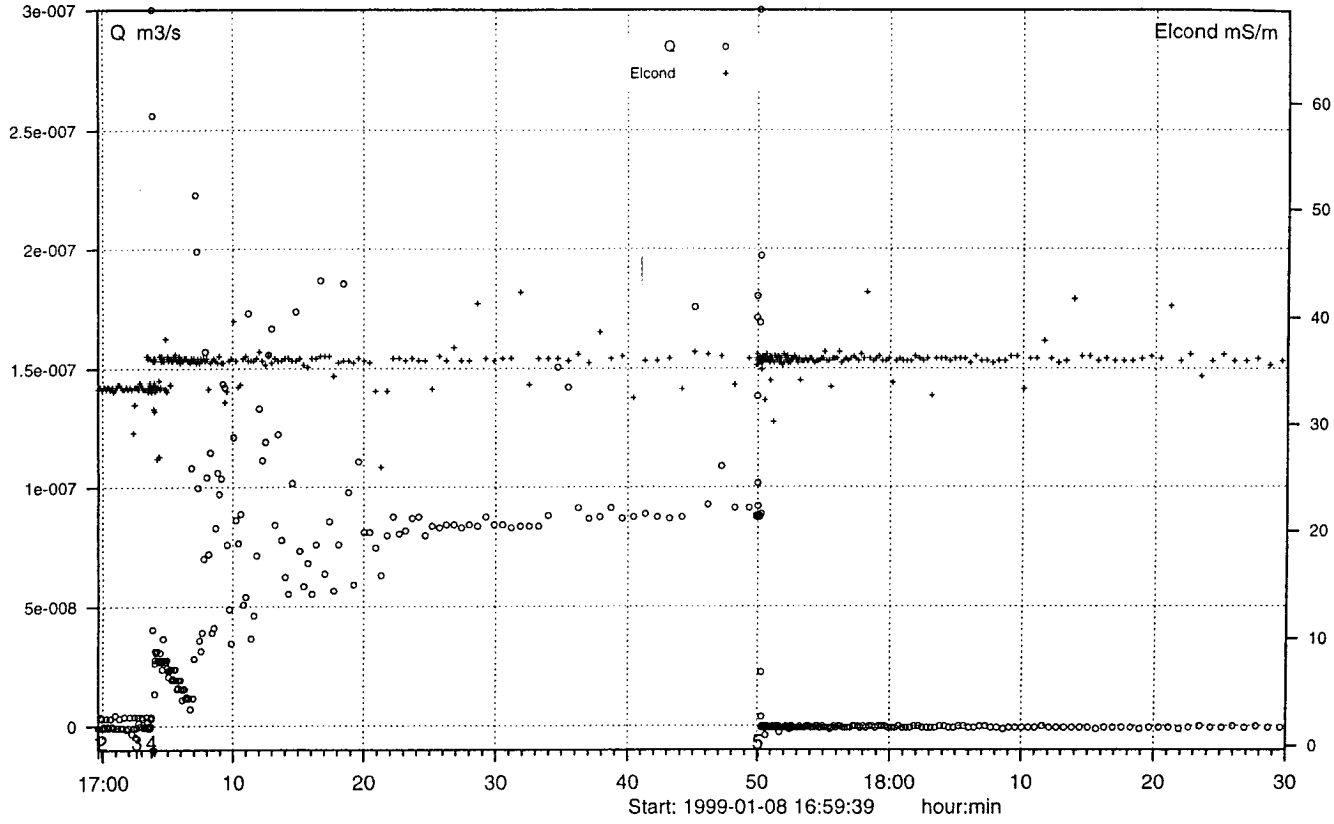
Because of the high section pressure, the test was performed as a constant-pressure outflow test. The recovery lasted over night.

Borehole: 3542G02

Section : 1.3 - 1.8 m

A2 (Pump const P) constant pressure outflow test

Start : 1999-01-08 16:59:01



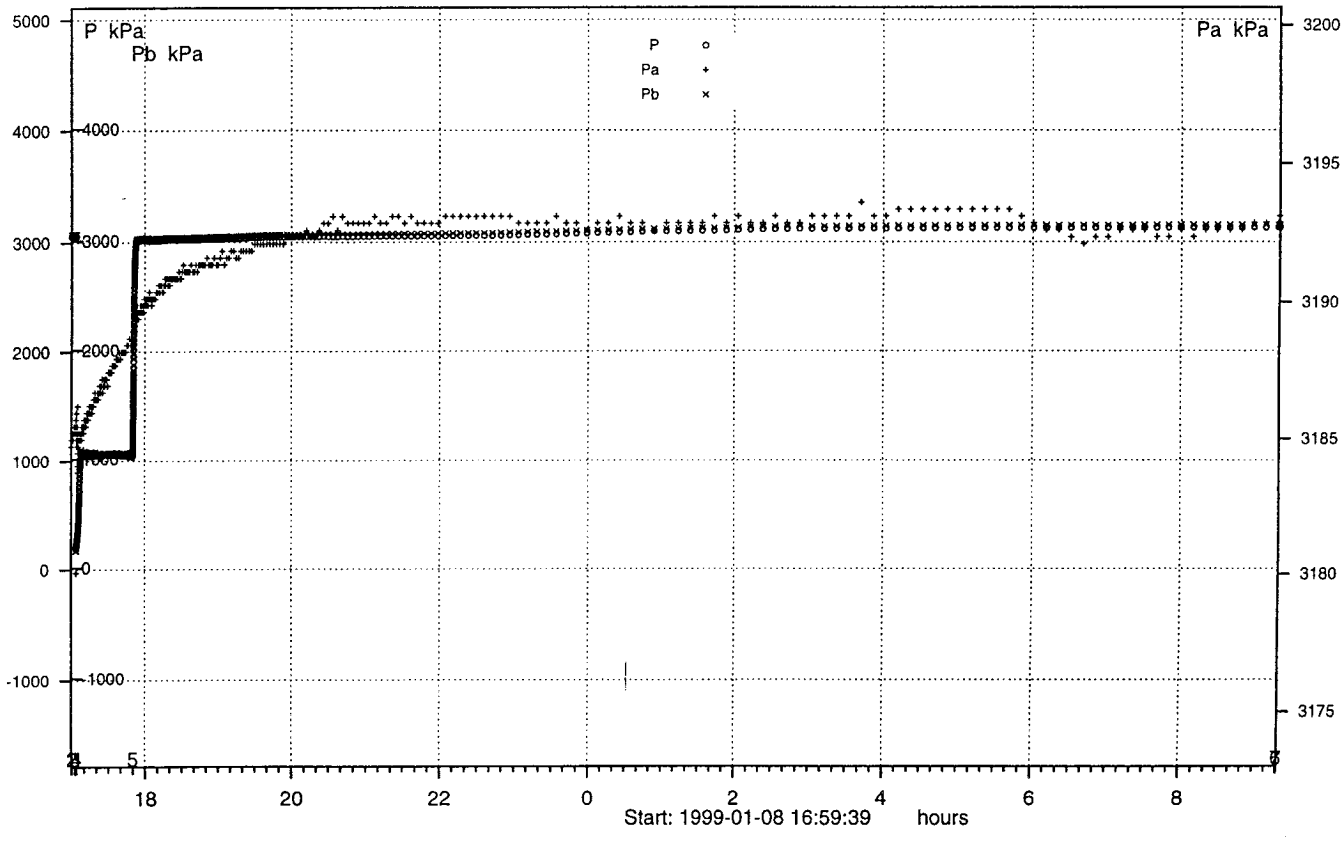
Thu Apr 29 17:33:24 1999

Borehole: 3542G02

Section : 1.3 - 1.8 m

A3 (Pump const P) constant pressure outflow test

Start : 1999-01-08 16:59:01



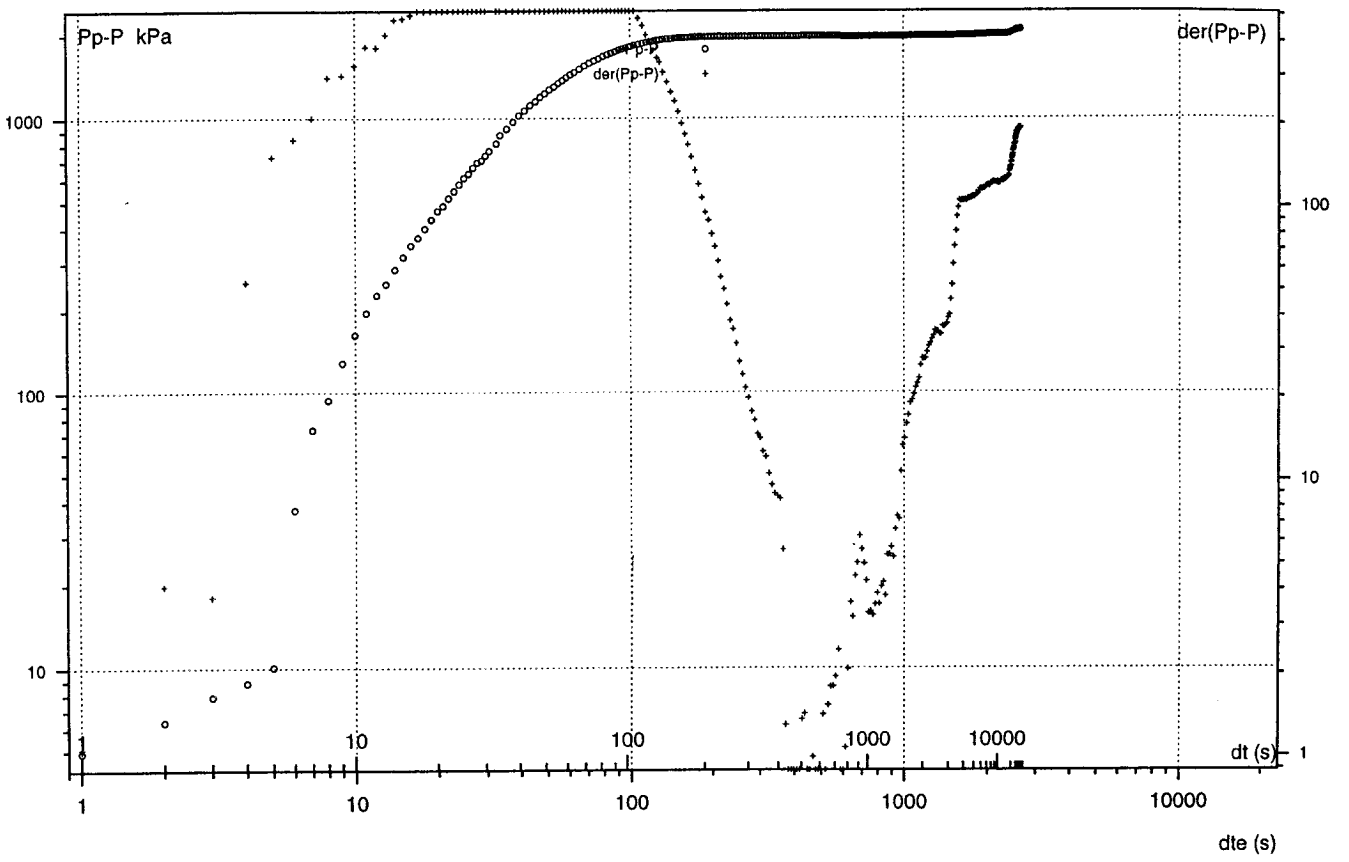
Thu Apr 29 17:24:53 1999

Borehole: 3542G02

Section : 1.3 - 1.8 m

C6 (Pump const P) constant pressure outflow test

Start : 1999-01-08 16:59:01



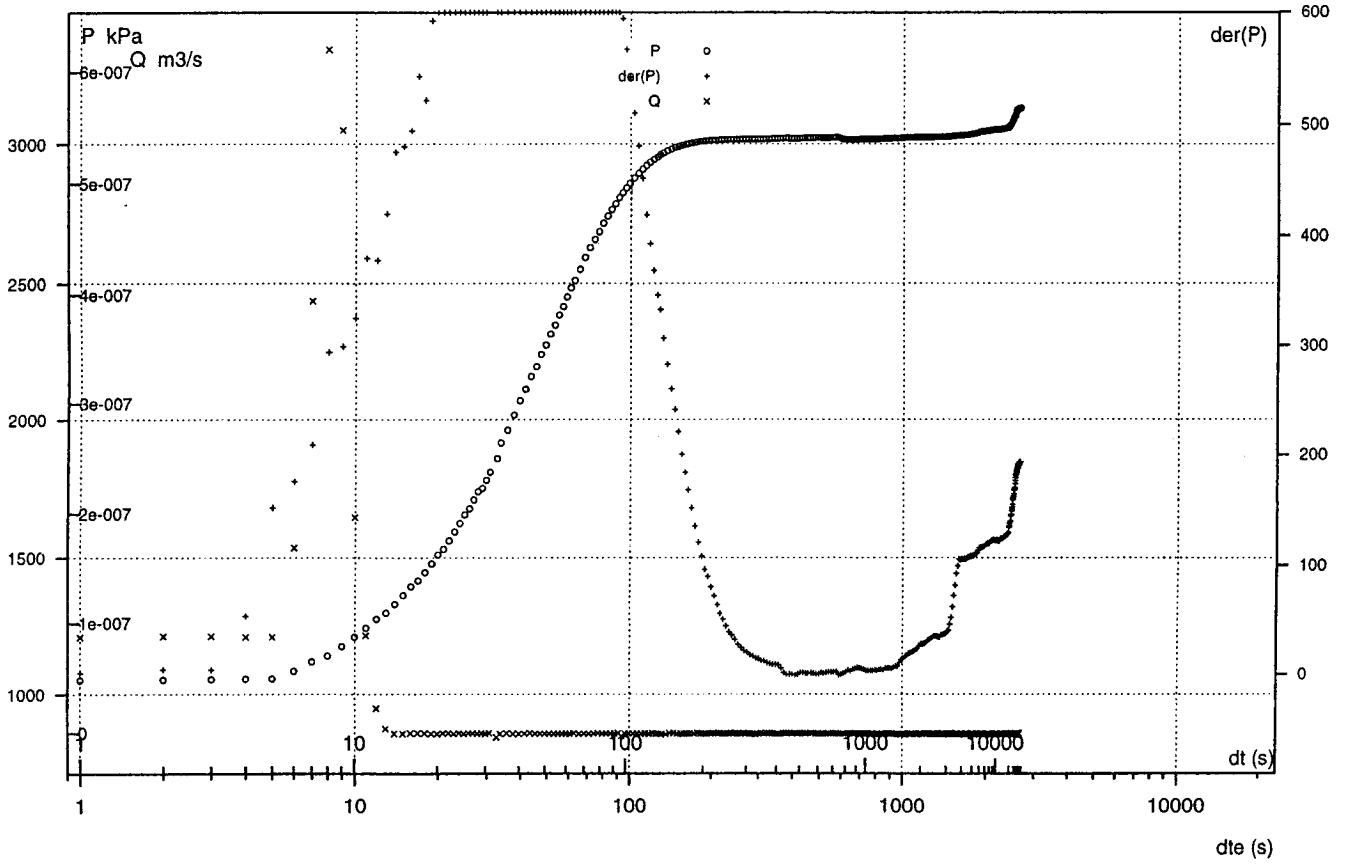
Thu Apr 29 17:24:53 1999

Borehole: 3542G02

Section : 1.3 - 1.8 m

C4 (Pump const P) constant pressure outflow test

Start : 1999-01-08 16:59:01



Thu Apr 29 17:24:53 1999

Borehole KA3542G01, section 0.25 m - 0.75 m

Date: 99-01-09 Field Crew: B. Gentzschein

Valve opened: 990109 120247 Valve closed: 990109 124356
Total flowing time: 41.2 min. Tot. Pr. Build-up time: 118.1 min.

Pressure before injection start (P_0, kPa) : 137.4
Pressure just before closing the valve (P_p, kPa) : 512.3
Pressure at the end of the recovery (P_f, kPa) : 474.7

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

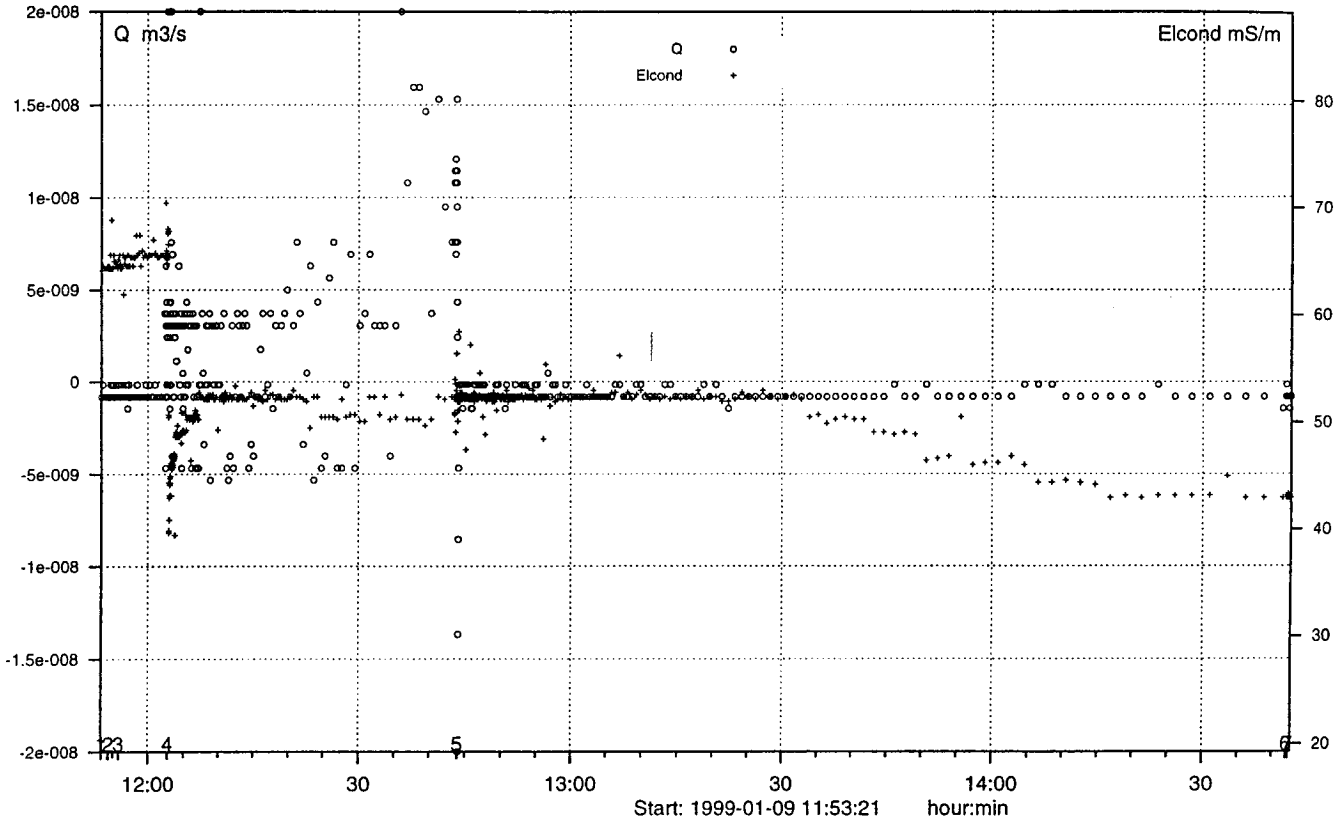
Initially the pressure increased to >1000 kPa, then it slowly decreased to the pre-set value. During the recovery the pressure initially fell off, then increased slowly.

Borehole: 3542G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-09 11:53:04



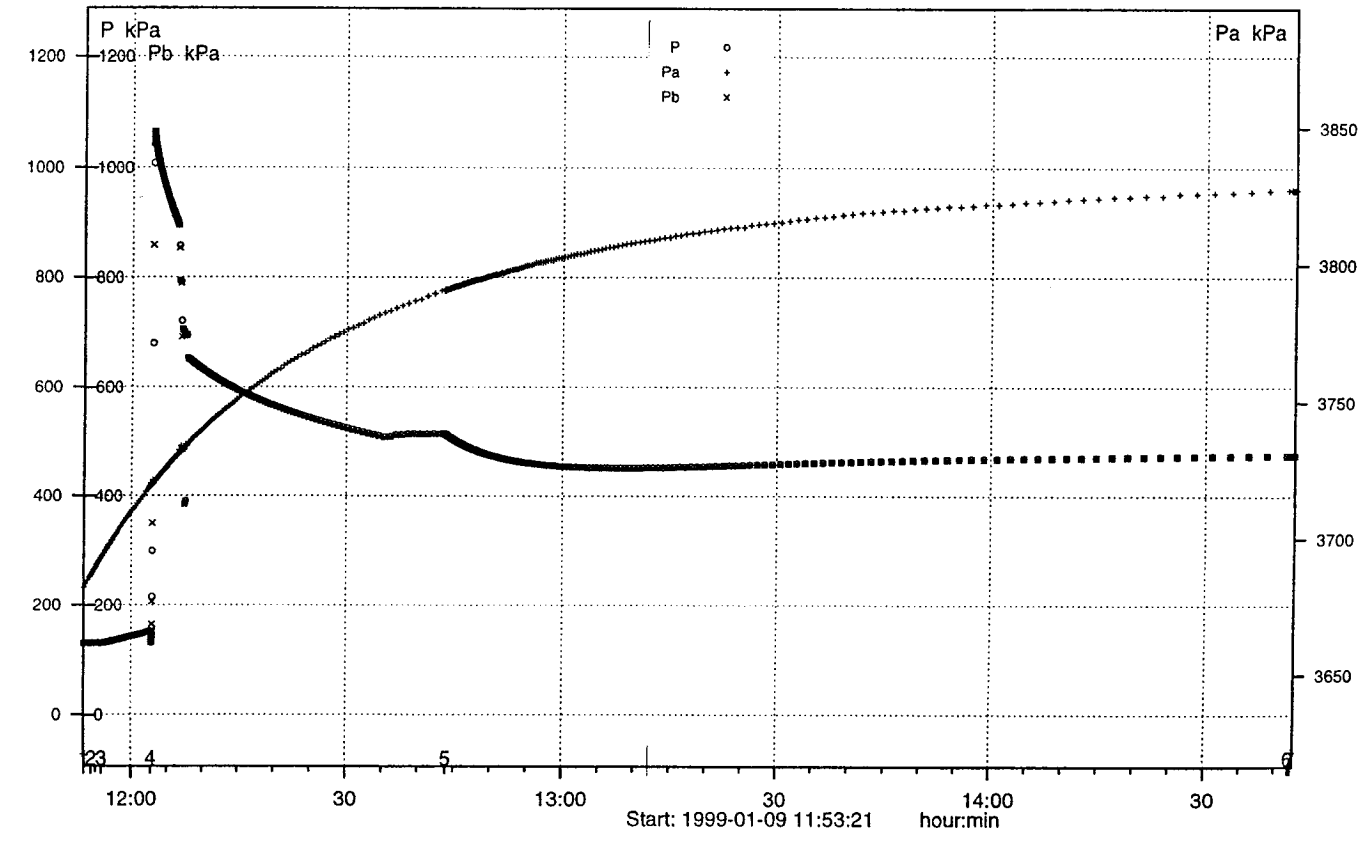
Thu Apr 29 17:47:12 1999

Borehole: 3542G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-09 11:53:04



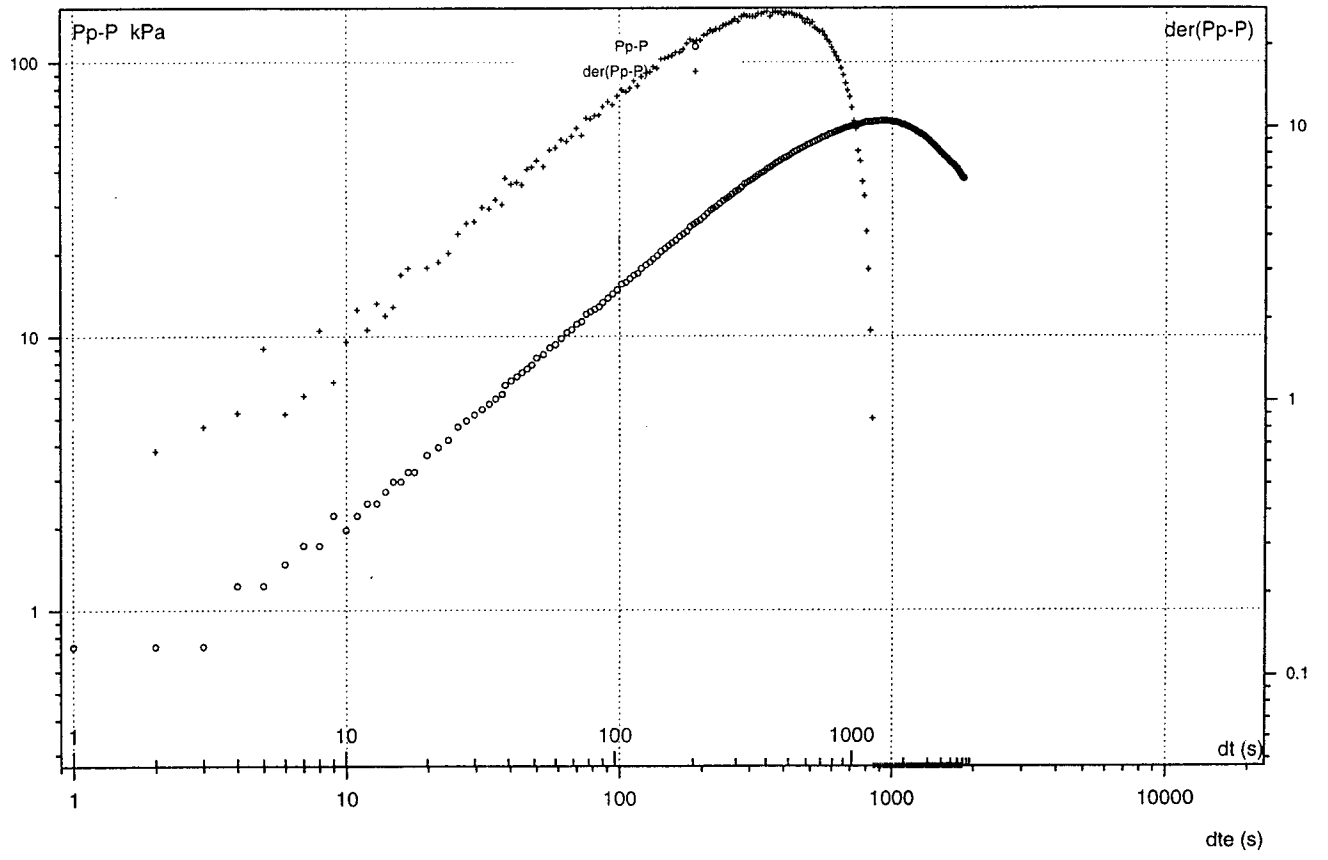
Thu Apr 29 17:42:52 1999

Borehole: 3542G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-09 11:53:04



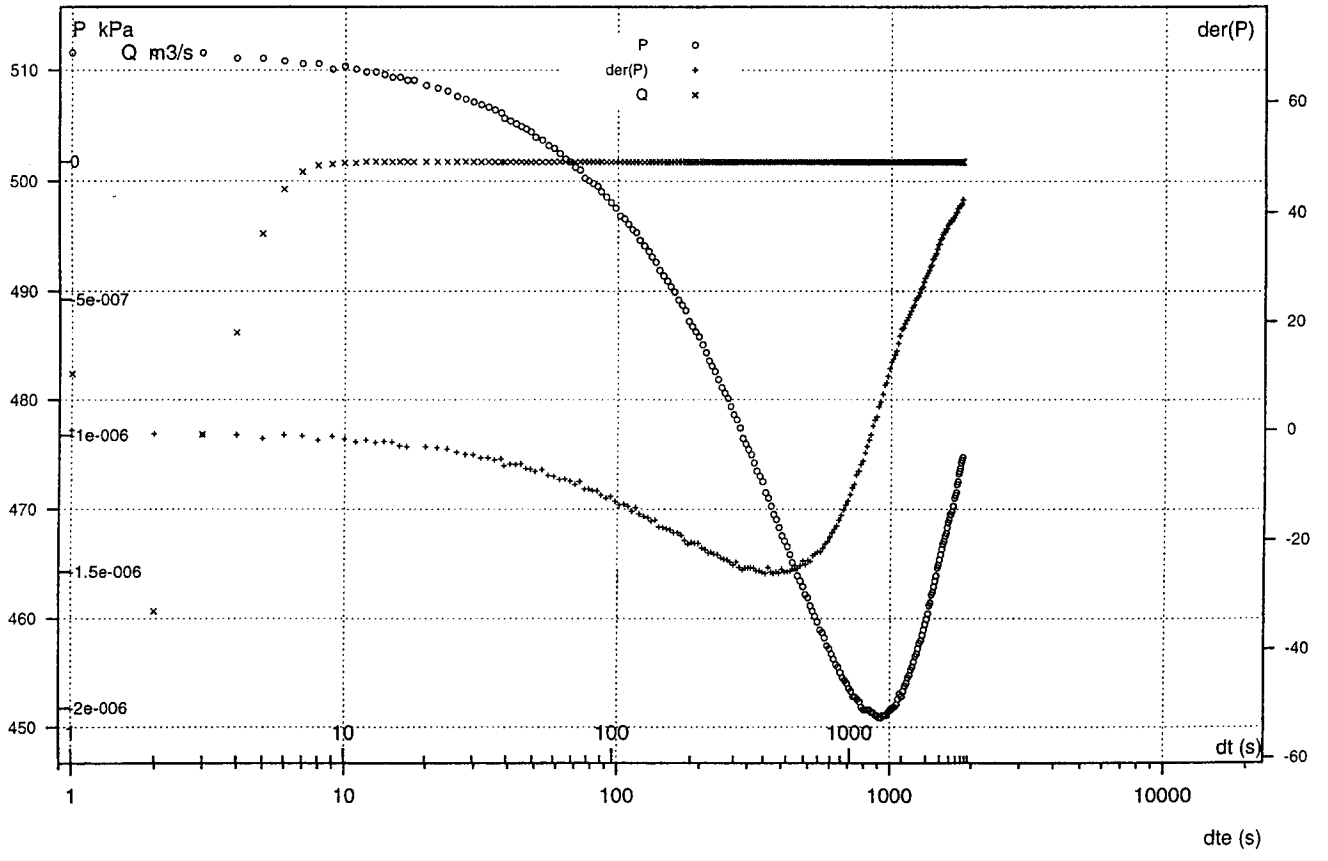
Thu Apr 29 17:52:50 1999

Borehole: 3542G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-09 11:53:04



Thu Apr 29 17:52:42 1999

Borehole KA3542G01, section 0.75 m – 1.25 m

Date: 99-01-09 Field Crew: B. Gentzschein

Valve opened: 990109 152246 Valve closed: 990109 155503
Total flowing time: 32.3 min. Tot. Pr. Build-up time: 18.6 min.

Pressure before injection start (P_0, kPa) : 119.1
Pressure just before closing the valve (P_p, kPa) : 524.1
Pressure at the end of the recovery (P_f, kPa) : 546.9

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

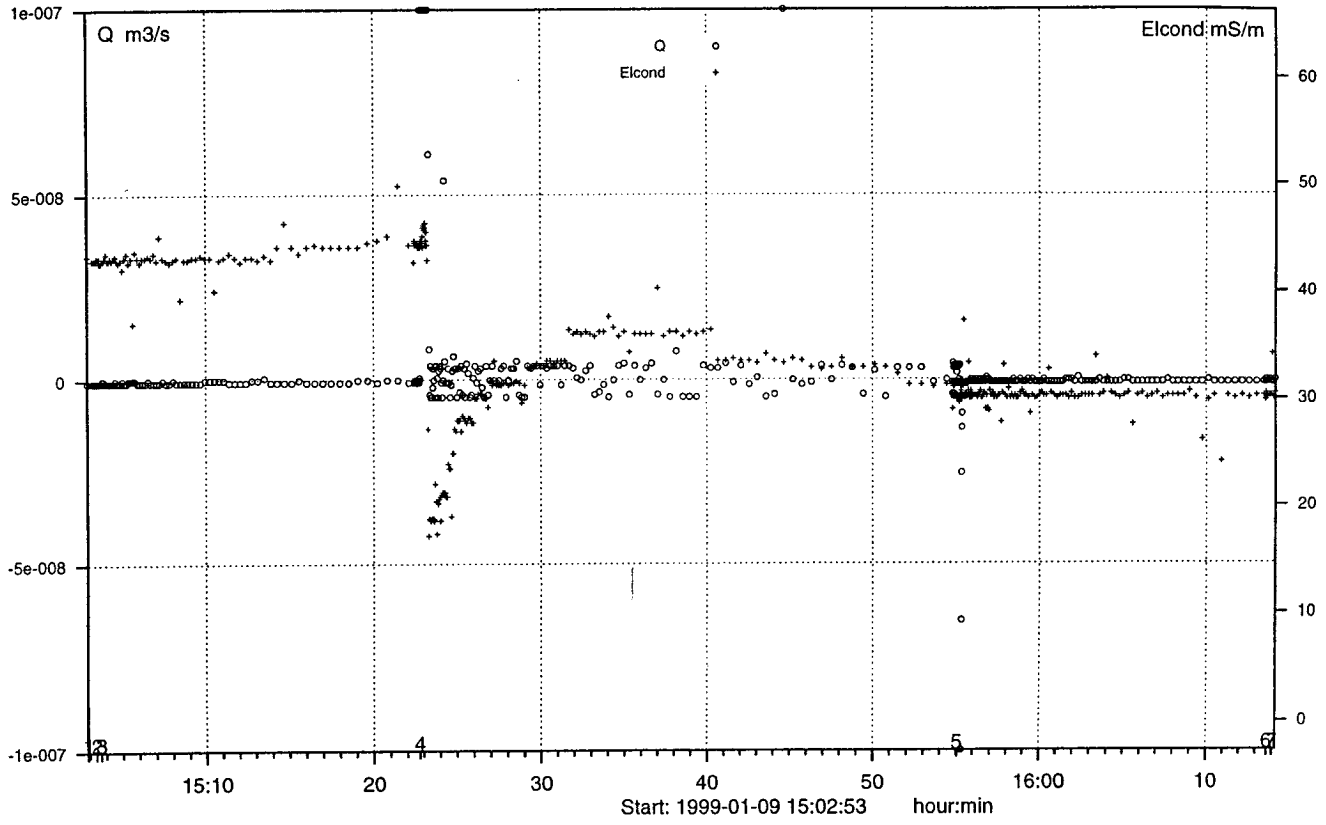
Initially the pressure increased to c. 600 kPa. Then it didn't reach the pre-set value before recovery start. After valve closing the pressure didn't fall, but increased, possibly due to the high pressure in the borehole interval below the packer.

Borehole: 3542G01

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-09 15:02:43



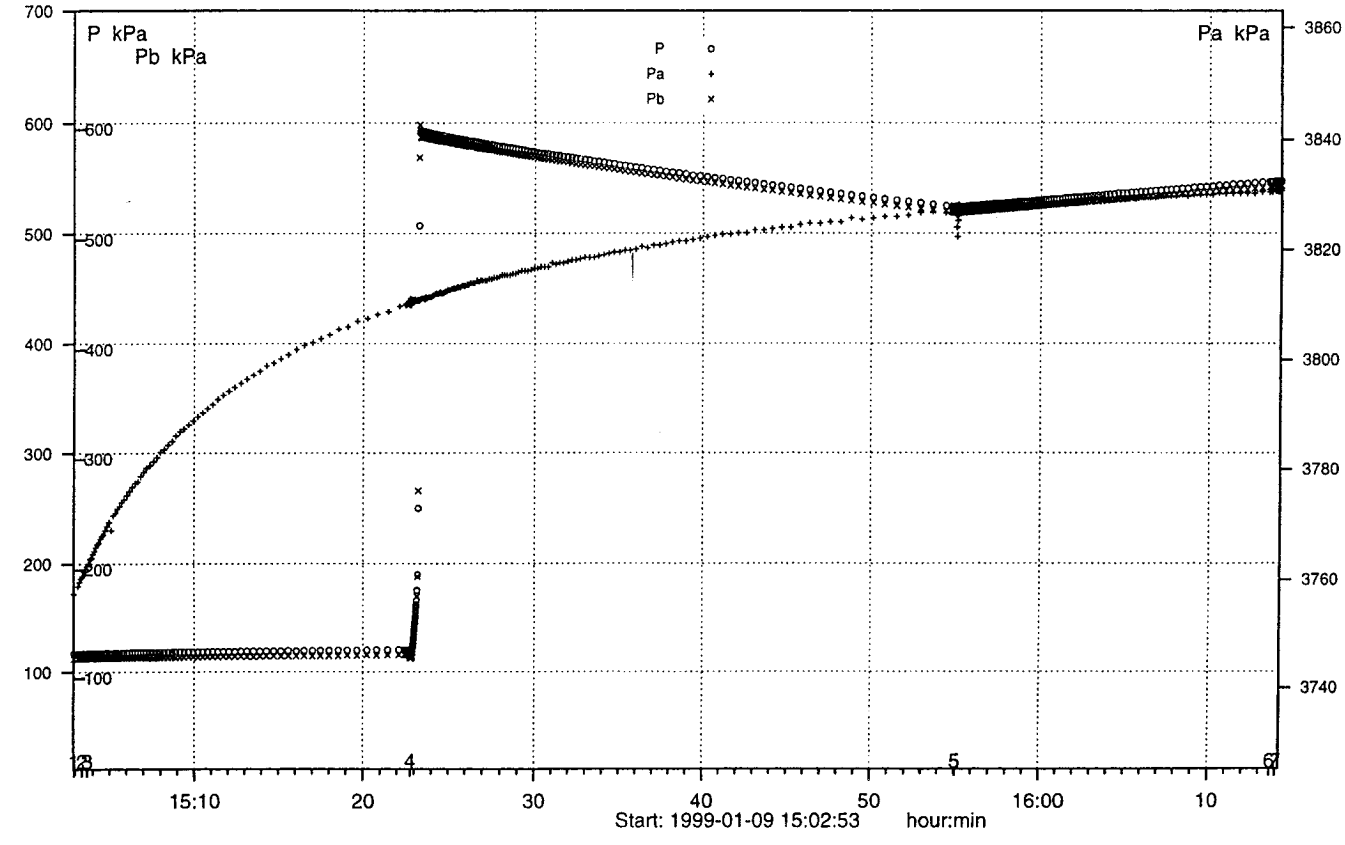
Thu Apr 29 18:03:31 1999

Borehole: 3542G01

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-09 15:02:43



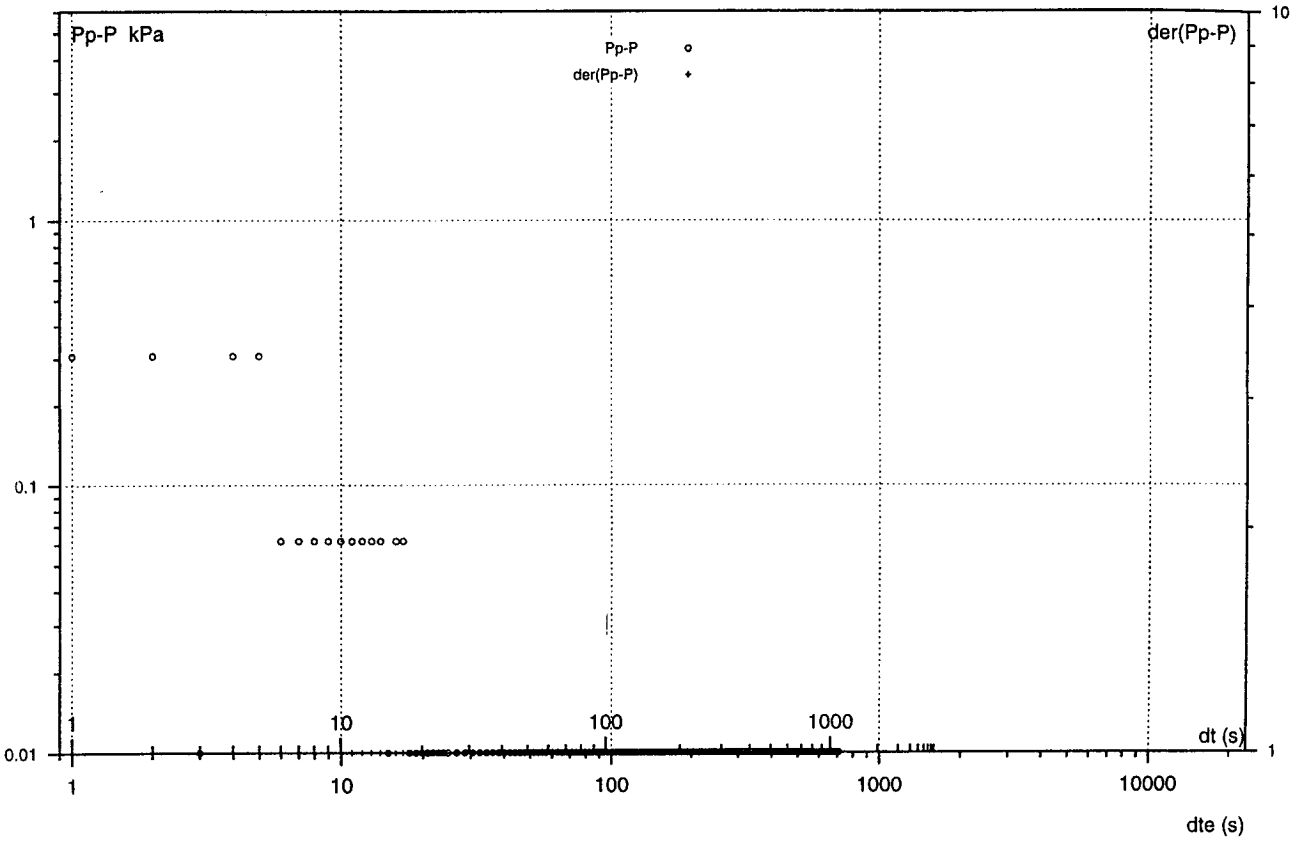
Thu Apr 29 17:58:49 1999

Borehole: 3542G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-09 15:02:43



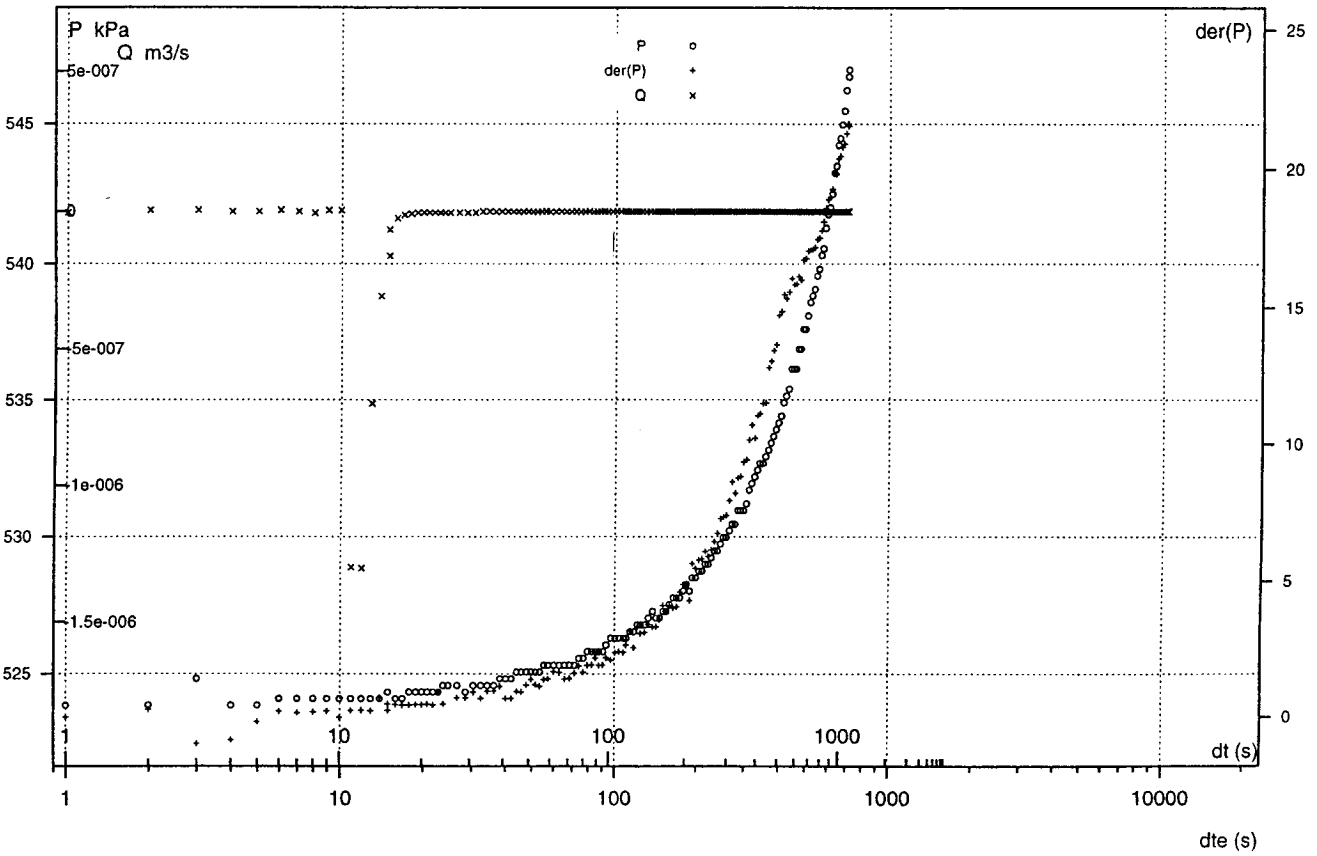
Thu Apr 29 18:05:44 1999

Borehole: 3542G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-09 15:02:43



Thu Apr 29 17:58:49 1999

Borehole KA3542G01, section 1.25 m – 1.75 m

Date: 99-01-09 Field Crew: B. Gentzschein

Valve opened: 990109 172220 Valve closed: 990109 175235
Total flowing time: 30.3 min. Tot. Pr. Build-up time: 928.7 min.

Pressure before injection start (P_0, kPa) : 118.8
Pressure just before closing the valve (P_p, kPa) : 540.5
Pressure at the end of the recovery (P_f, kPa) : 742.6

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

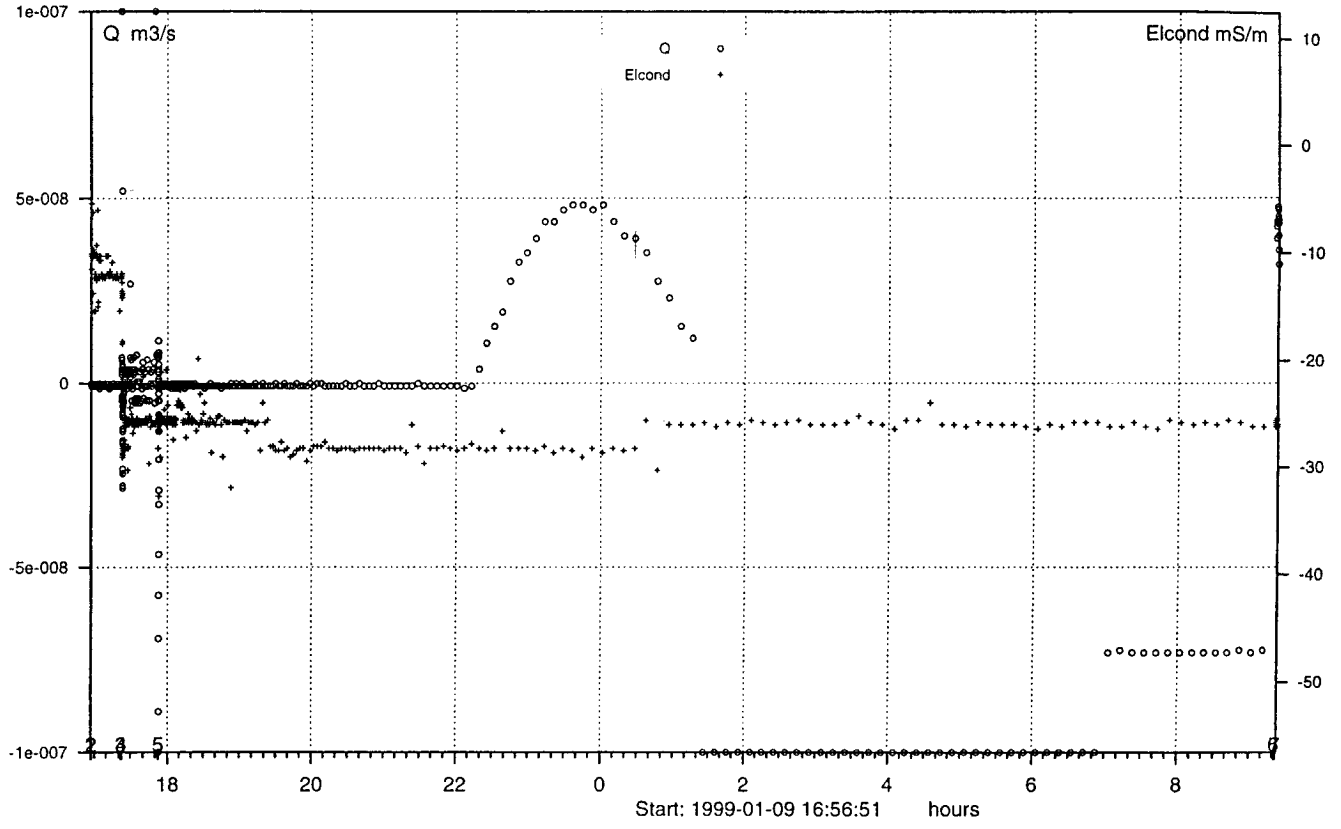
Initially the pressure increased to >1000 kPa. By opening a valve the pressure decreased. Again the pressure increased during the recovery (over night).

Borehole: 3542G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-09 16:56:39



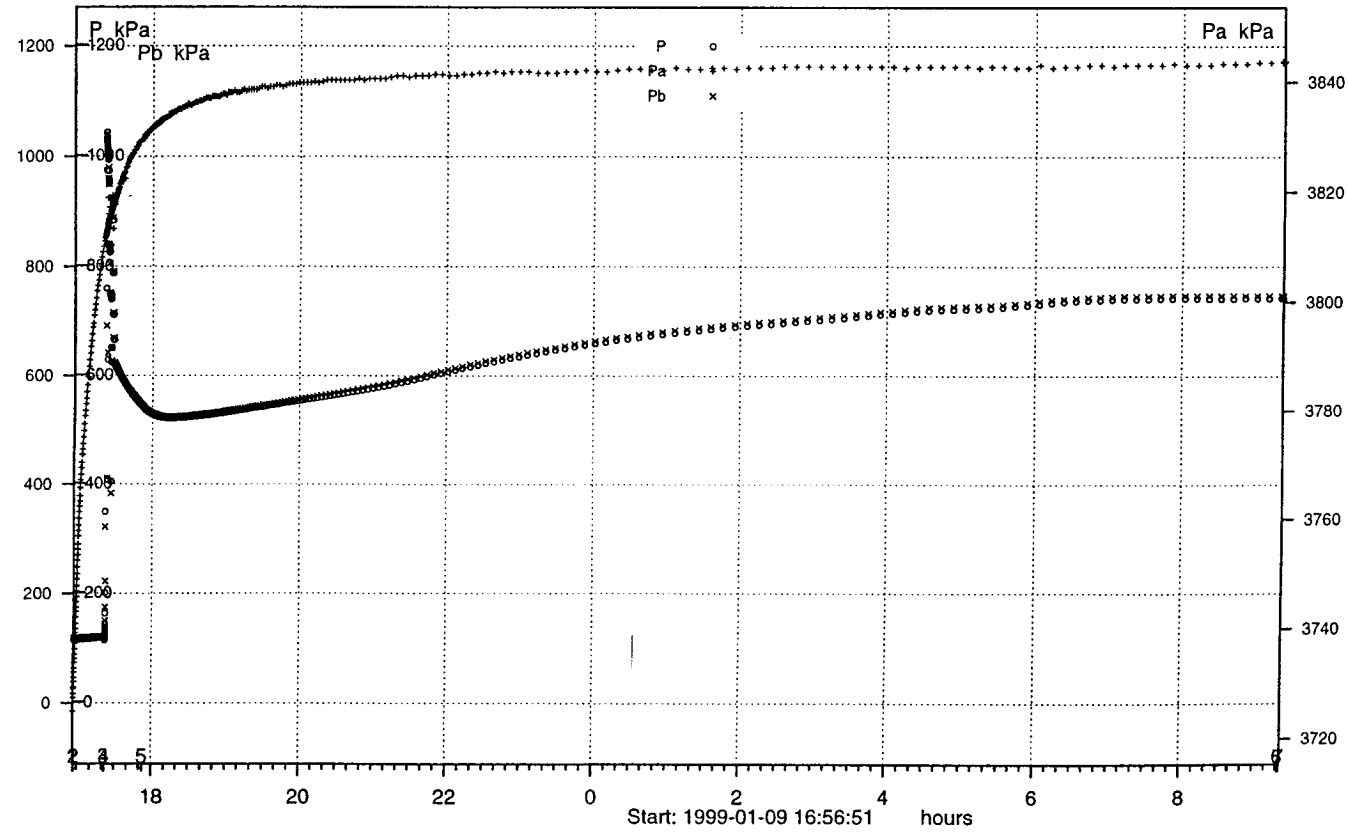
Thu Apr 29 18:25:48 1999

Borehole: 3542G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-09 16:56:39



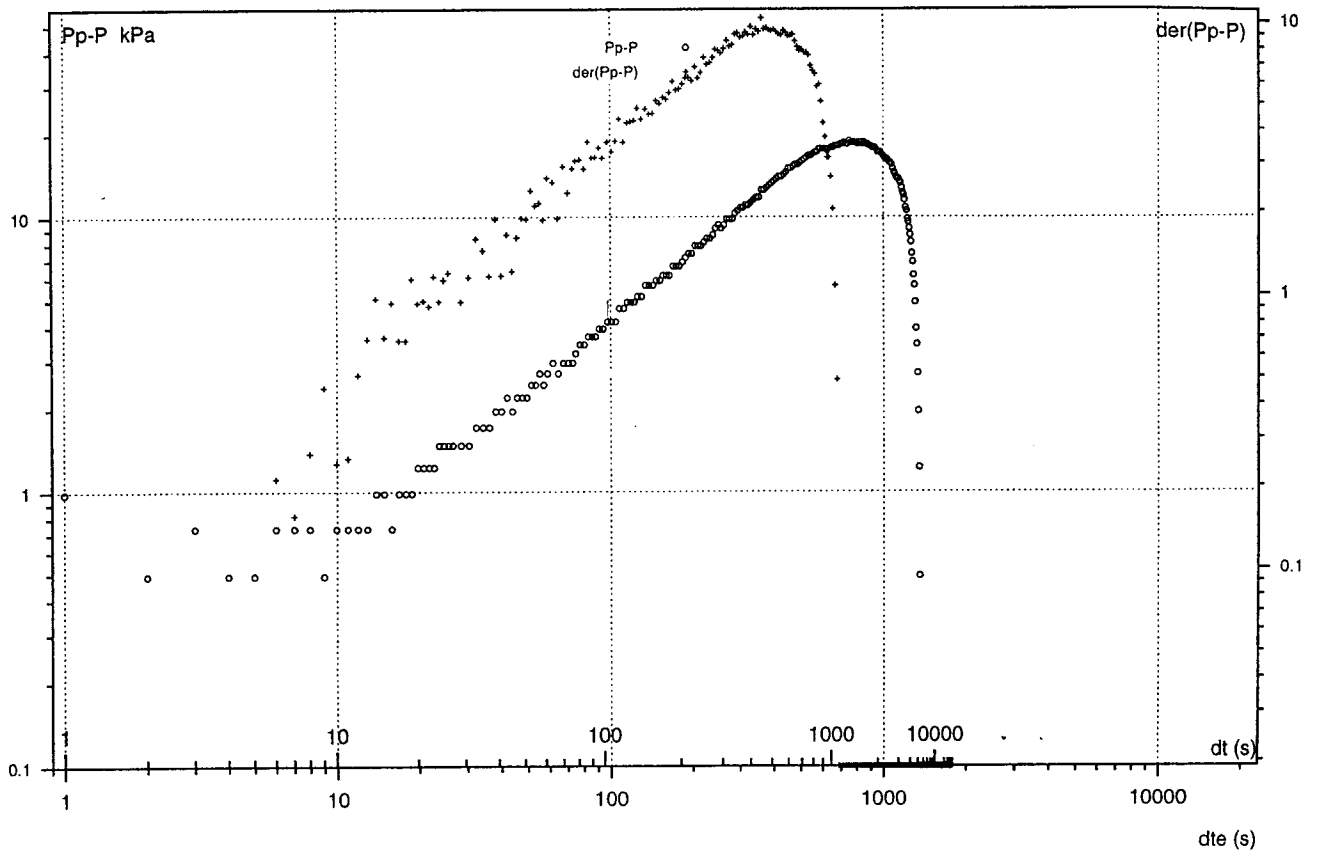
Thu Apr 29 18:20:51 1999

Borehole: 3542G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-09 16:56:39



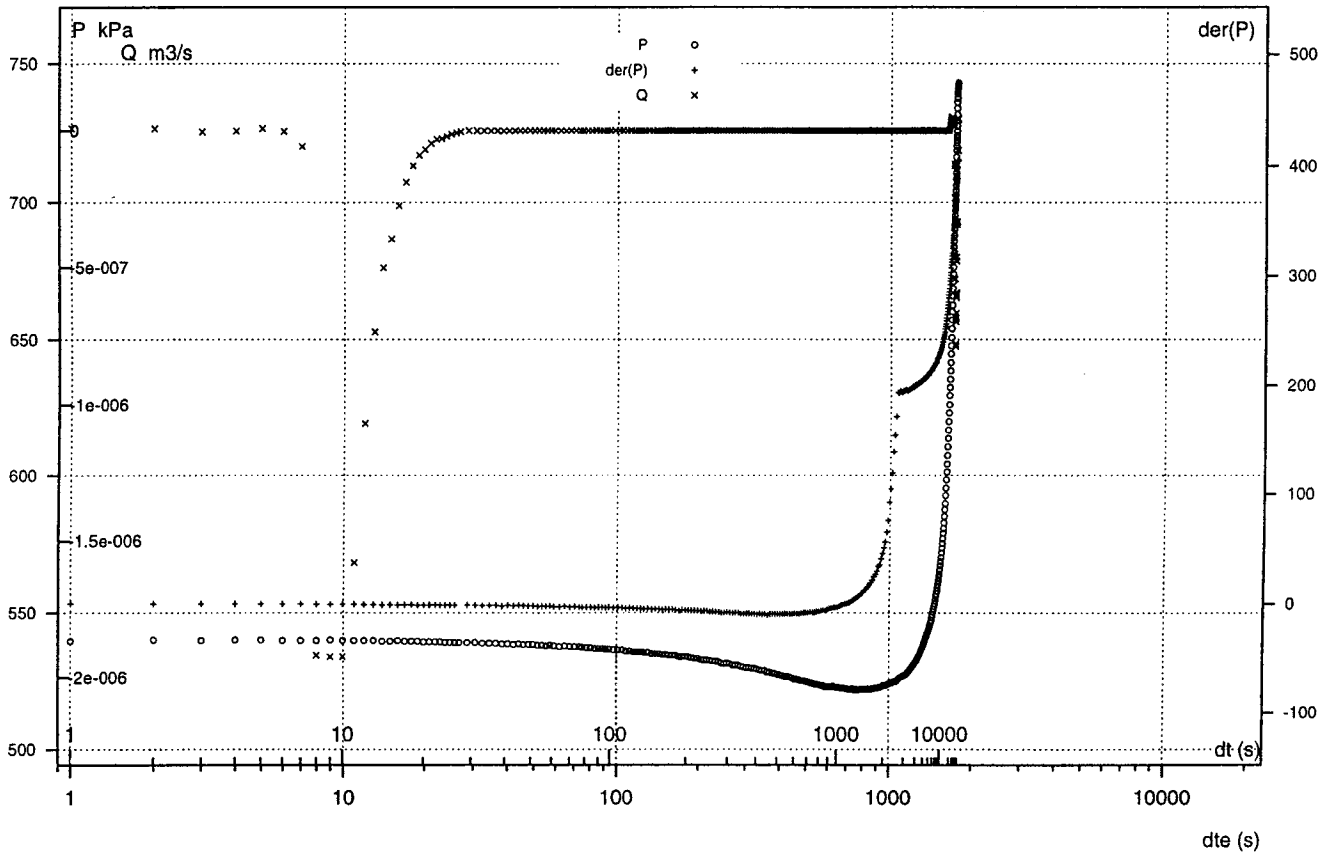
Thu Apr 29 18:22:11 1999

Borehole: 3542G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-09 16:56:39



Thu Apr 29 18:22:18 1999

Borehole KA3544G01, section 0.25 m - 0.75 m

Date: 99-01-10 Field Crew: B. Gentzschein

Valve opened: 990110 114057 Valve closed: 990110 120746
Total flowing time: 26.8 min. Tot. Pr. Build-up time: 116.5 min.

Pressure before injection start (P_0, kPa) : 162.0
Pressure just before closing the valve (P_p, kPa) : 690.9
Pressure at the end of the recovery (P_f, kPa) : 500.1

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

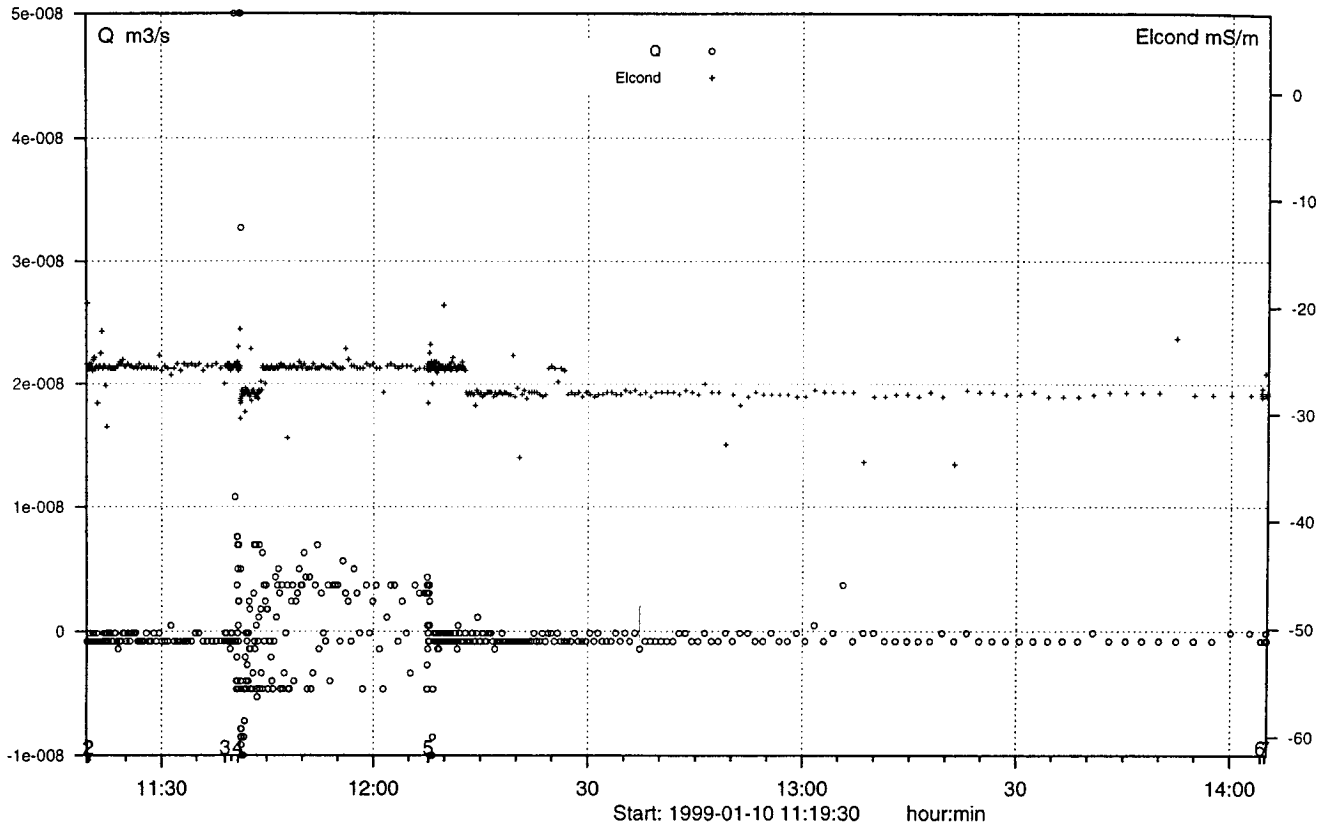
Initially the pressure increased to >1100 kPa. By opening a valve the pressure decreased.

Borehole: 3544G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-10 11:19:17



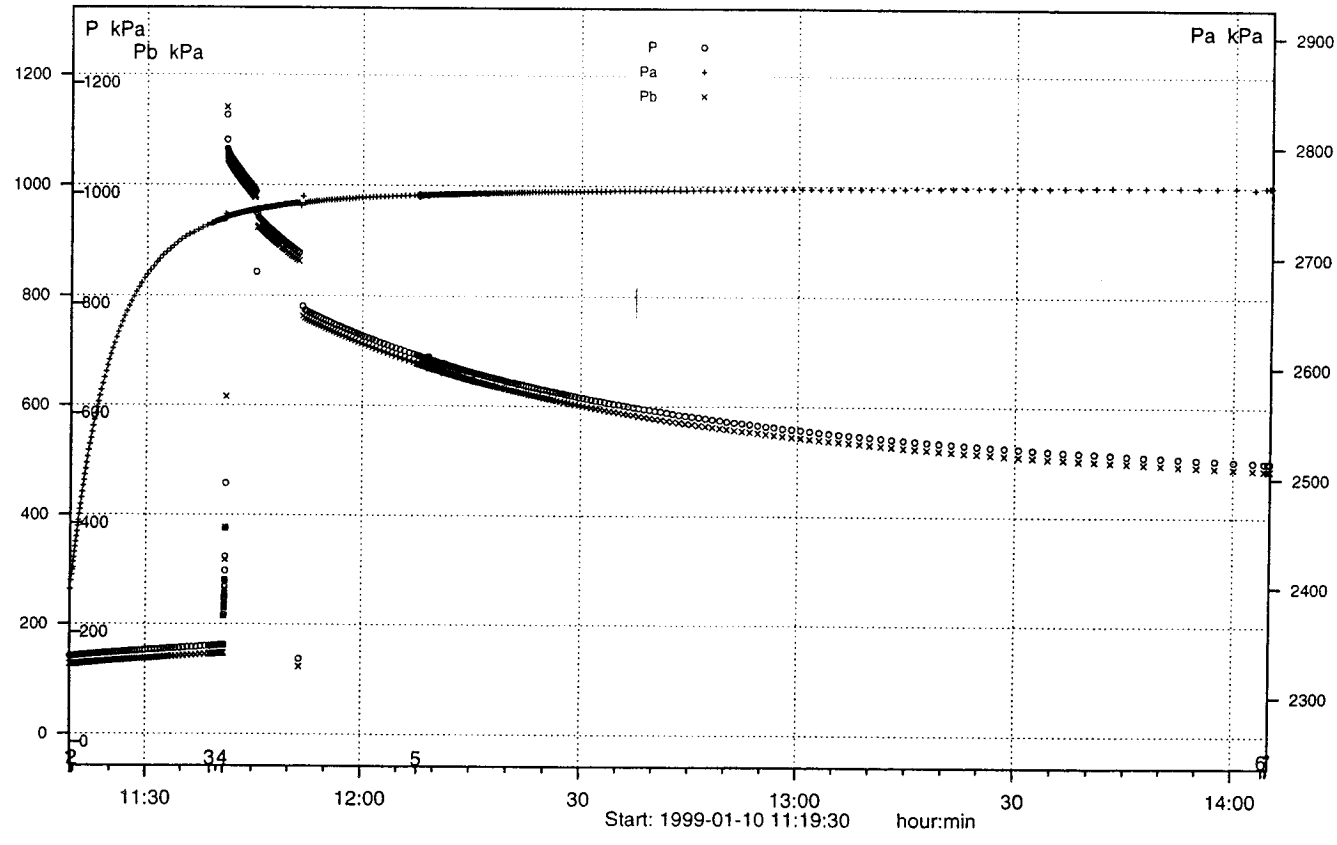
Fri Apr 30 09:14:35 1999

Borehole: 3544G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-10 11:19:17



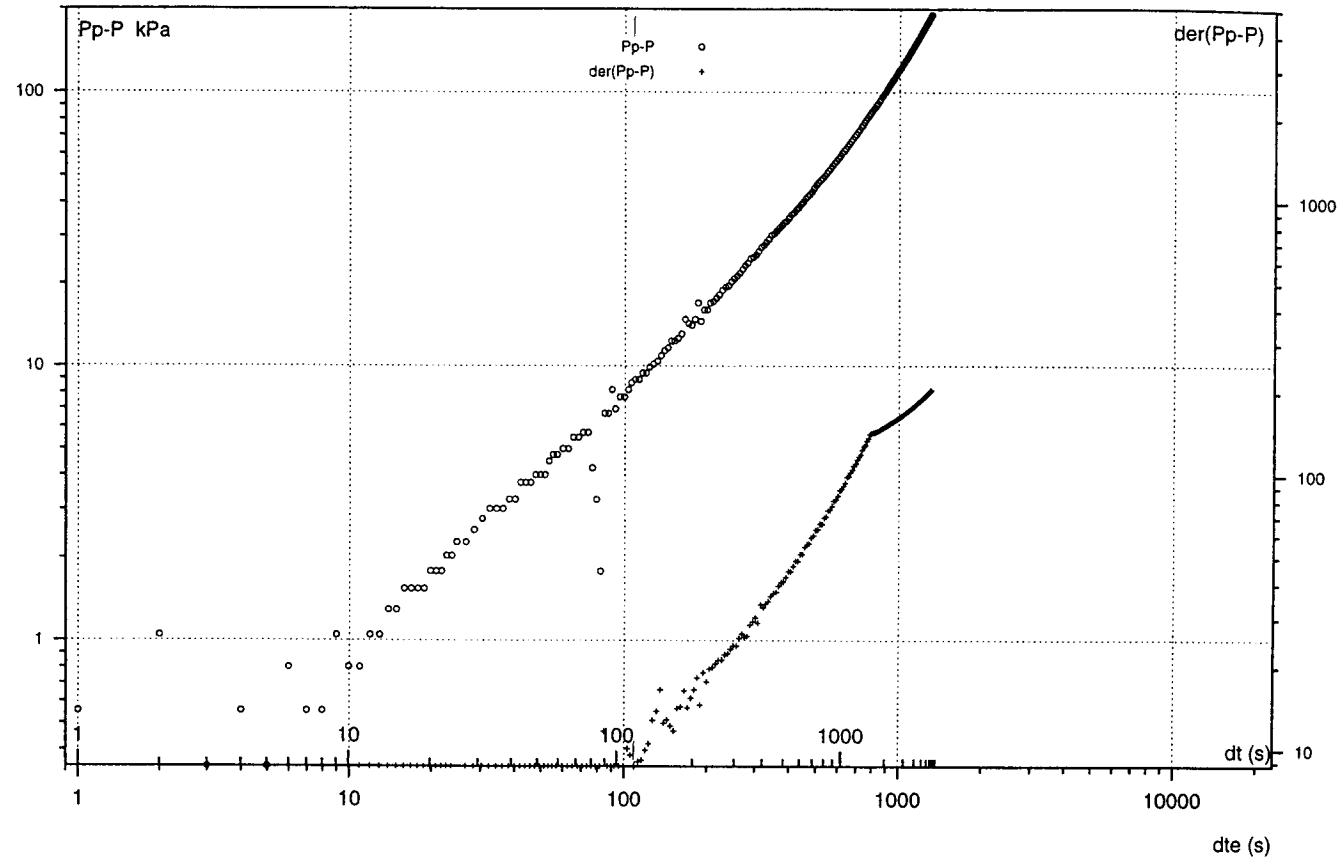
Fri Apr 30 09:06:13 1999

Borehole: 3544G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-10 11:19:17



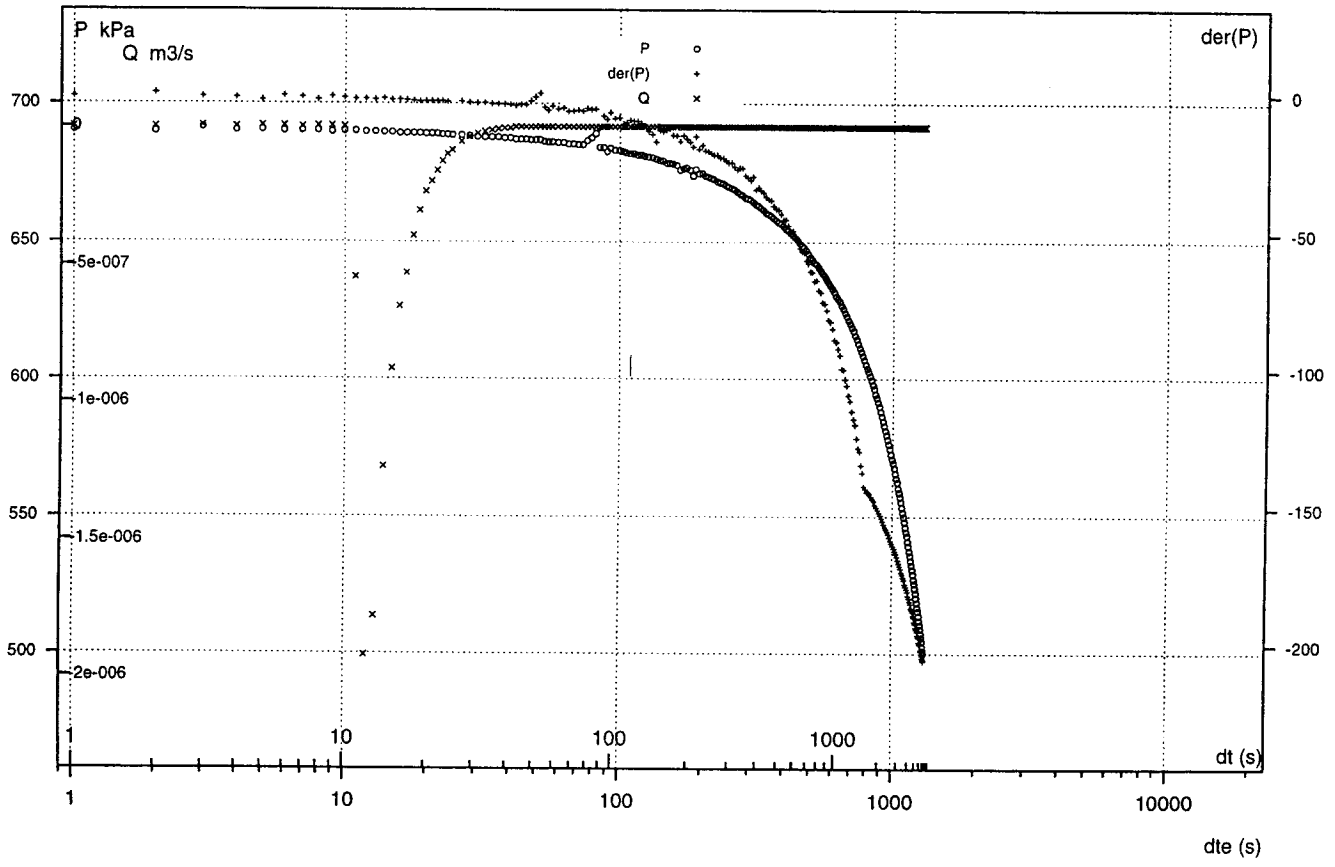
Fri Apr 30 09:06:15 1999

Borehole: 3544G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-10 11:19:17



Fri Apr 30 09:06:14 1999

Borehole KA3544G01, section 0.75 m – 1.25 m

Date: 99-01-10 Field Crew: B. Gentzschein

Valve opened: 990110 144822 Valve closed: 990110 151726
Total flowing time: 29.1 min. Tot. Pr. Build-up time: 13.9 min.

Pressure before injection start (P_0, kPa) : 126.7
Pressure just before closing the valve (P_p, kPa) : 574.8
Pressure at the end of the recovery (P_f, kPa) : 613.6

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

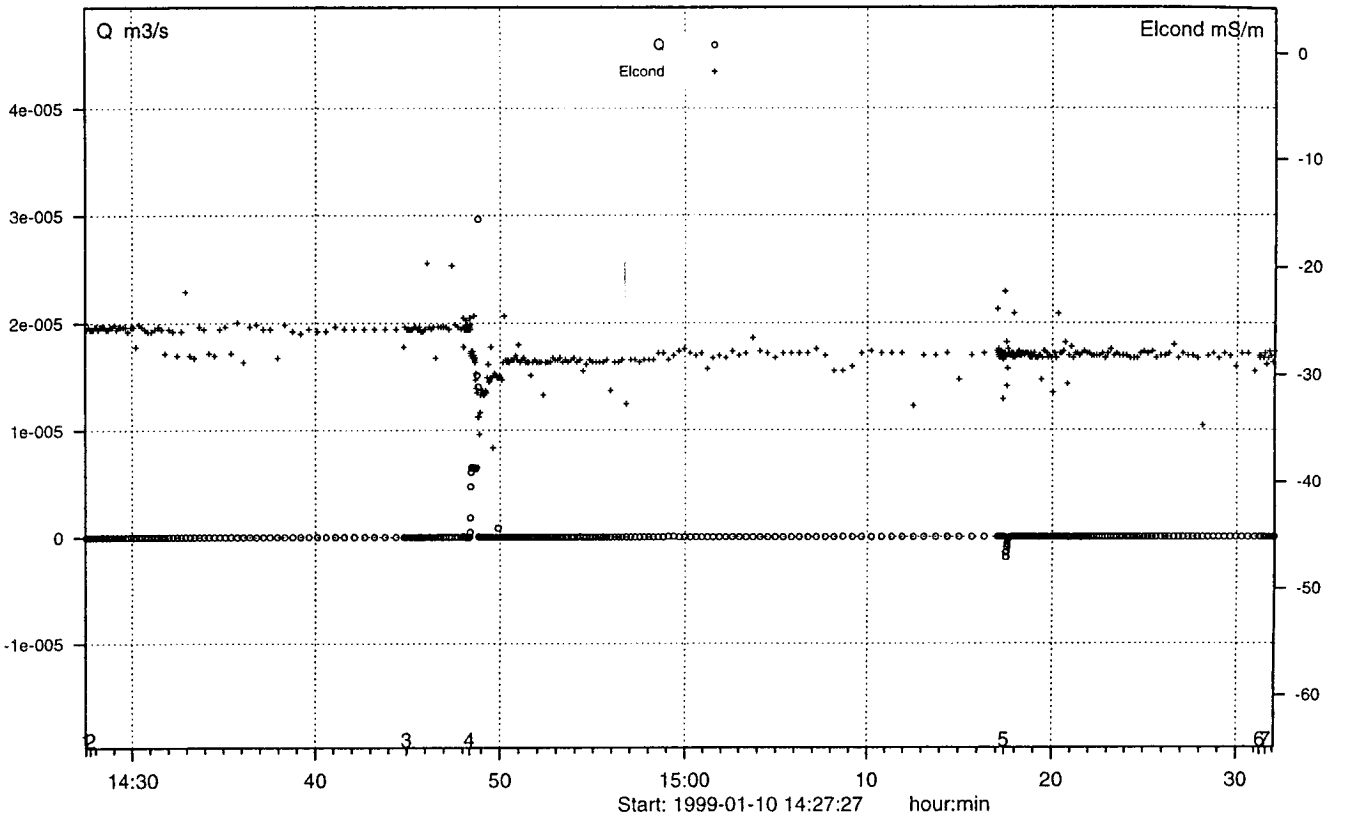
Initially the pressure increased to c. 550 kPa. Shortly after the injection start, P_{ref} was changed to 550 kPa. The pressure increased during the recovery.

Borehole: 3544G01

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-10 14:27:01



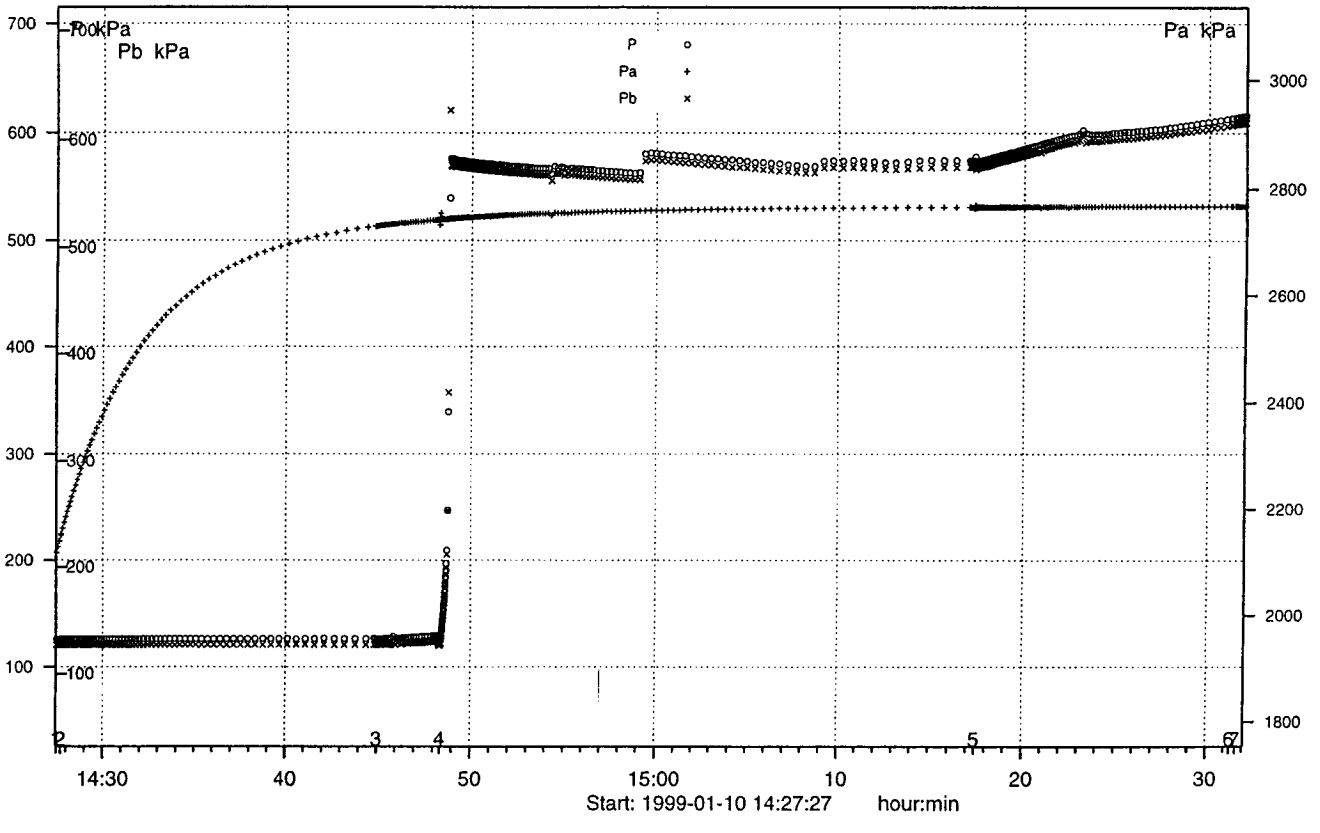
Fri Feb 12 09:24:12 1999

Borehole: 3544G01

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-10 14:27:01



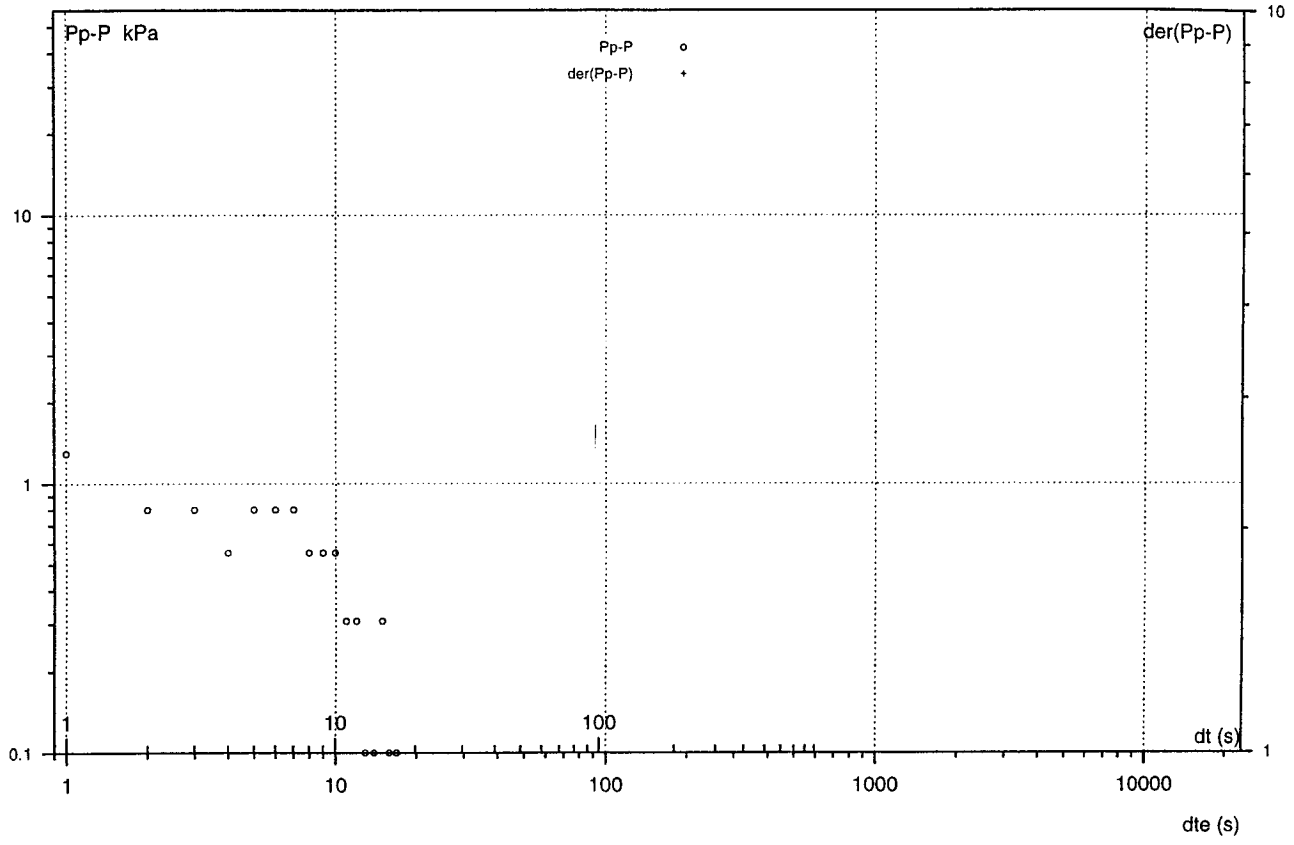
Fri Feb 12 09:24:12 1999

Borehole: 3544G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-10 14:27:01



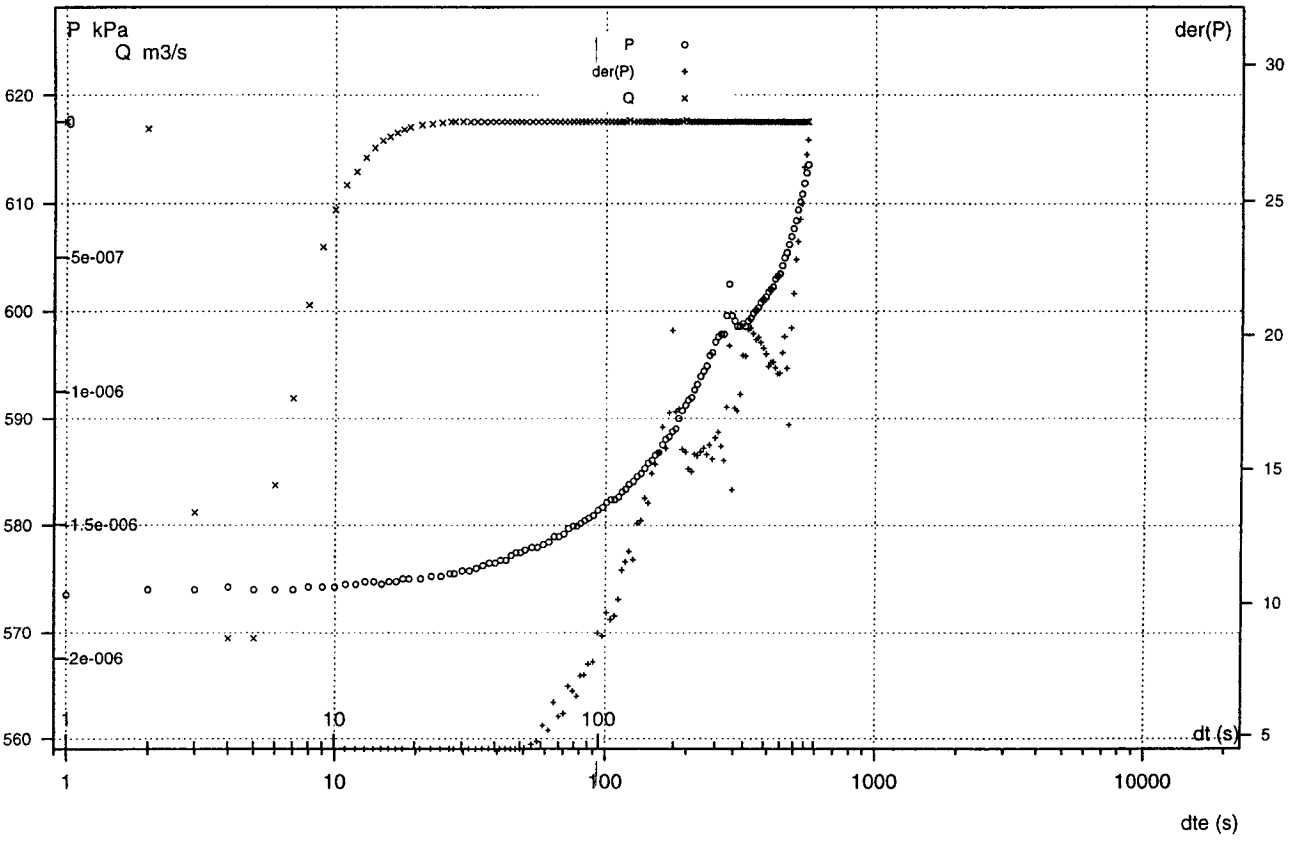
Fri Feb 12 09:24:12 1999

Borehole: 3544G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-10 14:27:01



Fri Feb 12 09:24:12 1999

Borehole KA3544G01, section 1.25 m – 1.75 m

Date: 99-01-10 Field Crew: B. Gentzschein

Valve opened: 990110 161303 Valve closed: 990110 163351
Total flowing time: 30.3 min. Tot. Pr. Build-up time: 928.7 min.

Pressure before injection start (P_0, kPa) : 131.4
Pressure just before closing the valve (P_p, kPa) : 529.5
Pressure at the end of the recovery (P_f, kPa) : 652.9

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

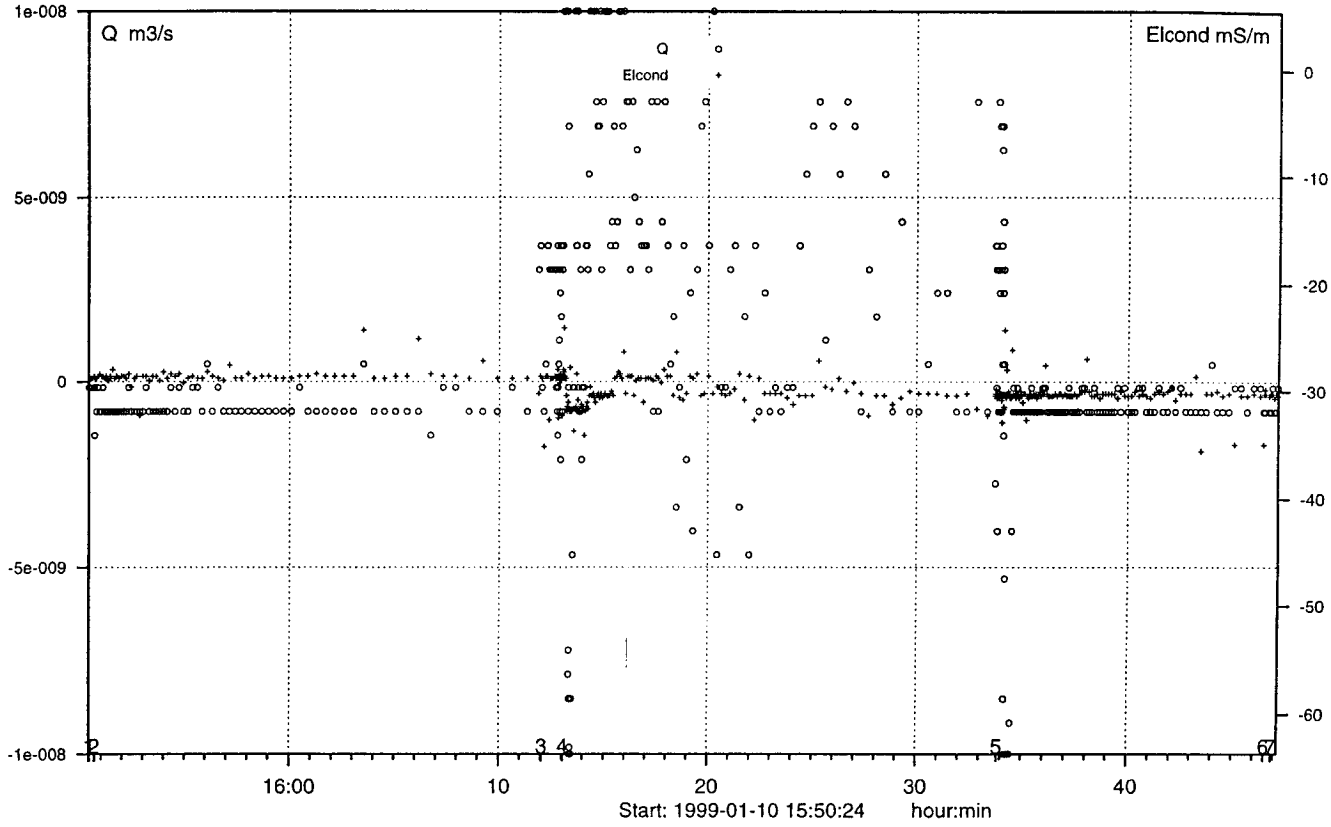
Pressure increase during recovery!

Borehole: 3544G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-10 15:50:11



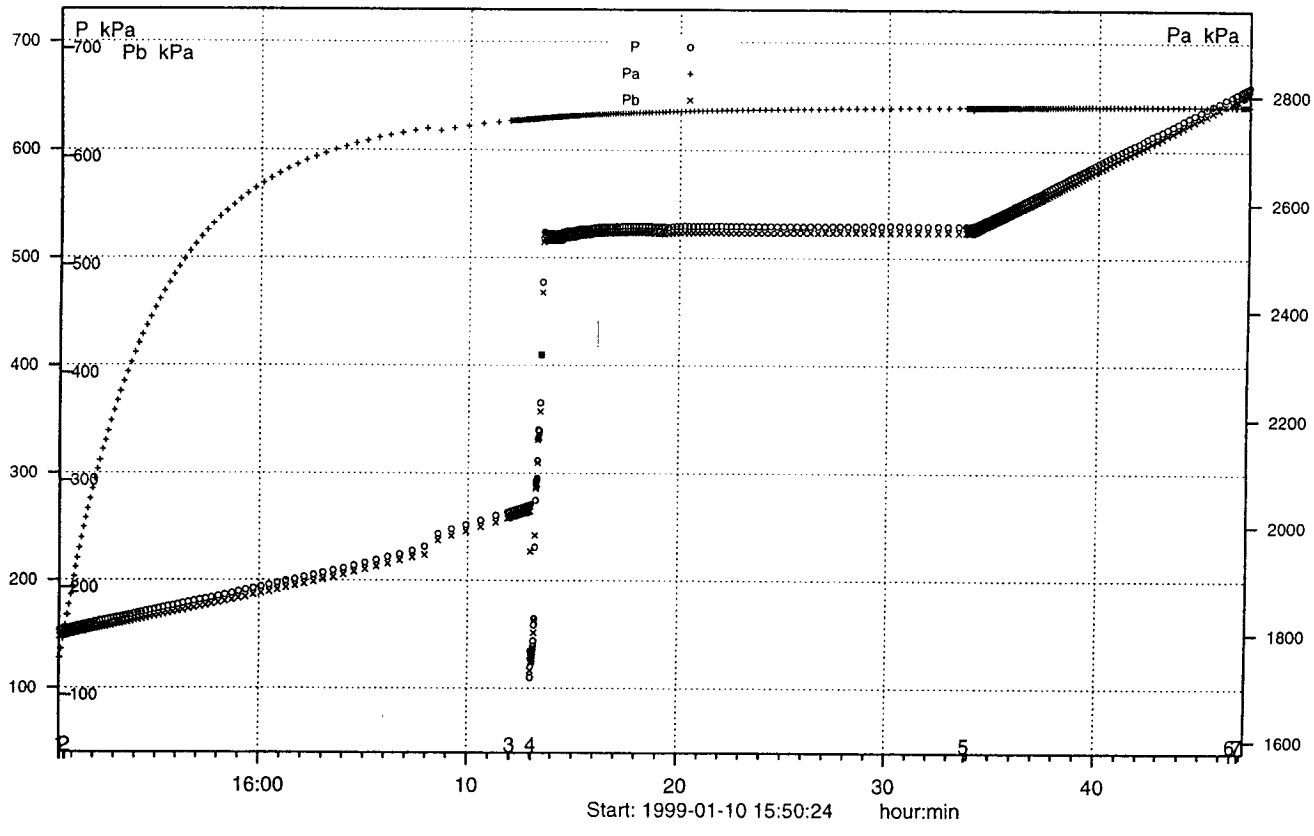
Fri Feb 12 10:12:31 1999

Borehole: 3544G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-10 15:50:11



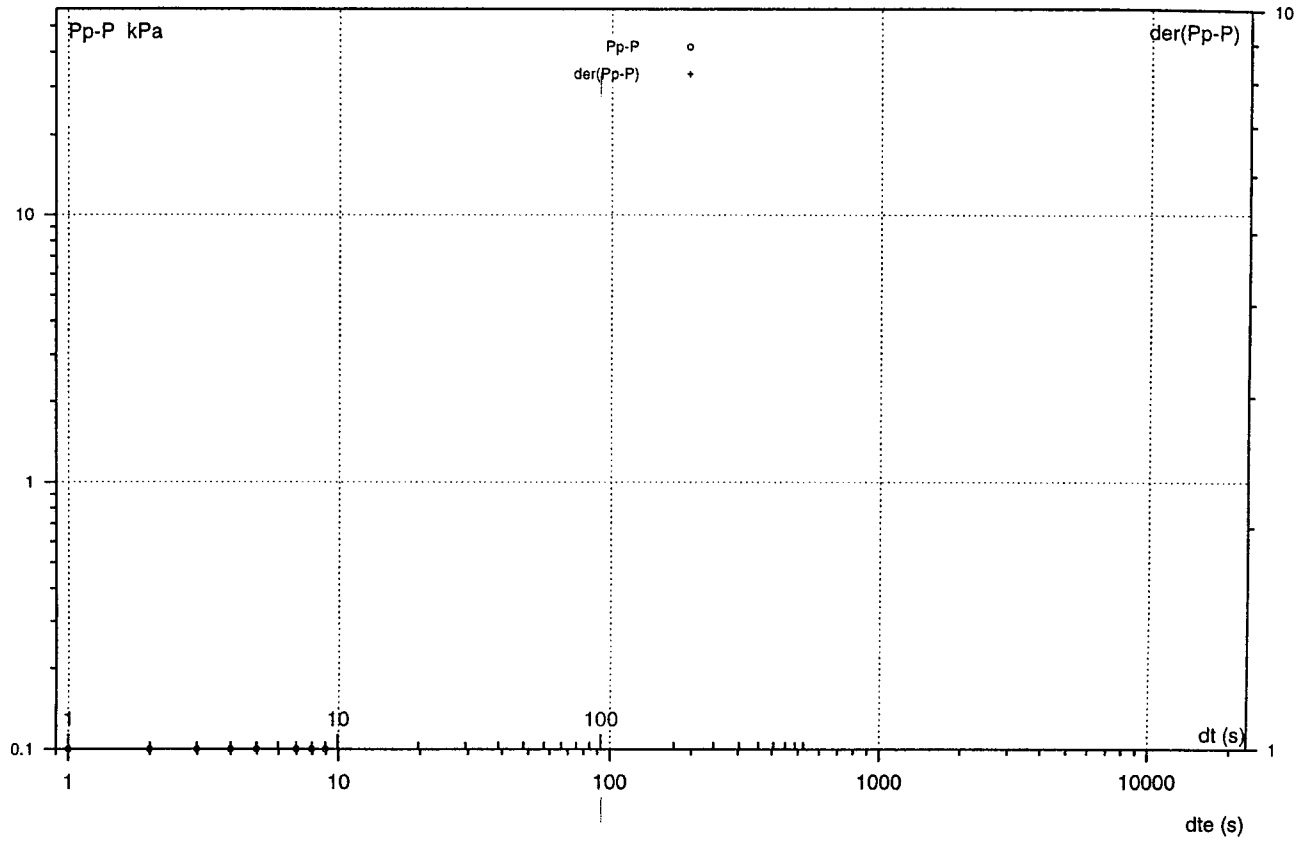
Fri Feb 12 10:10:21 1999

Borehole: 3544G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-10 15:50:11



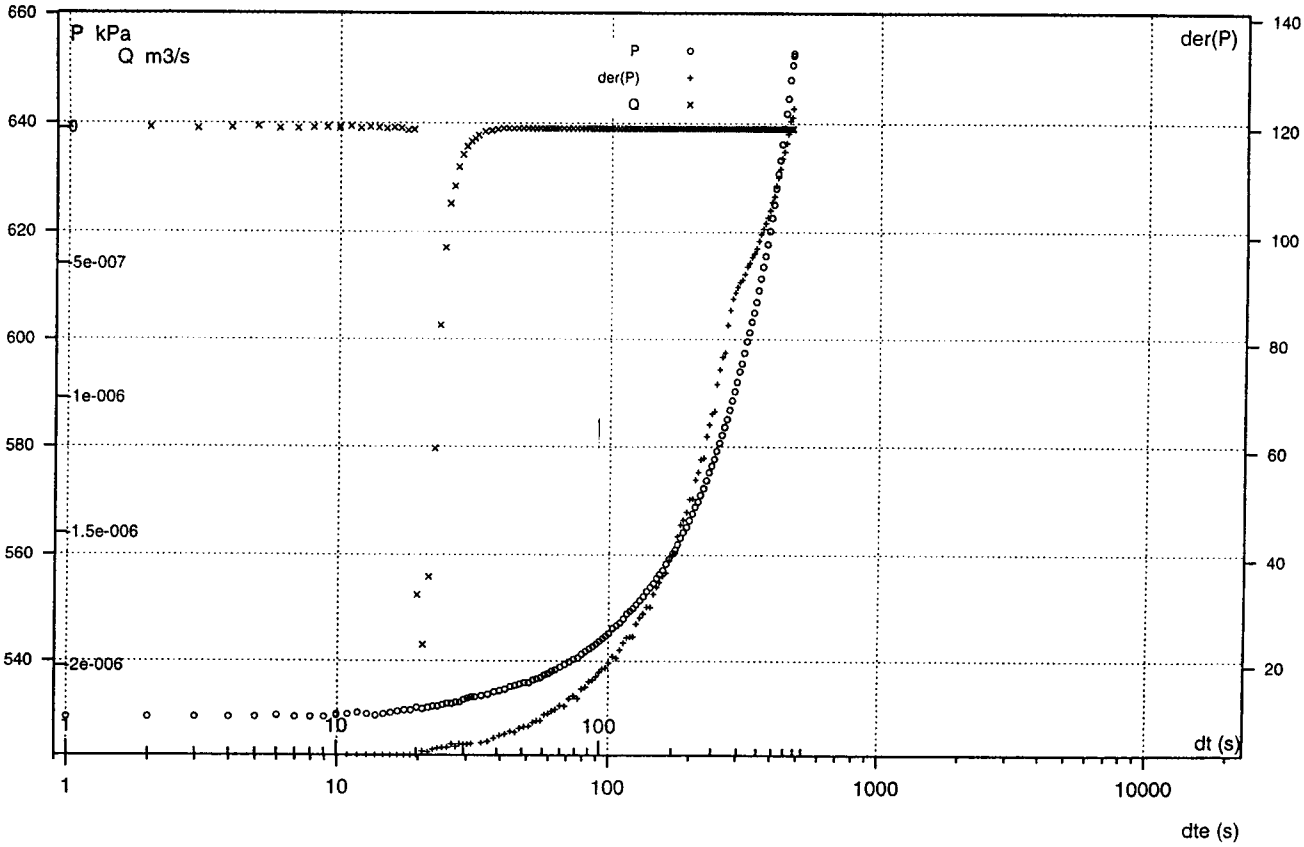
Fri Feb 12 10:10:21 1999

Borehole: 3544G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-10 15:50:11



Fri Feb 12 10:10:21 1999

Borehole KA3546G01, section 0.25 m - 0.75 m

Date: 99-01-11 Field Crew: B. Gentzschein

Valve opened: 990111 102808 Valve closed: 990111 105442
Total flowing time: 26.6 min. Tot. Pr. Build-up time: 14.5 min.

Pressure before injection start (P_0, kPa) : 124.5
Pressure just before closing the valve (P_p, kPa) : 694.5
Pressure at the end of the recovery (P_f, kPa) : 619.0

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

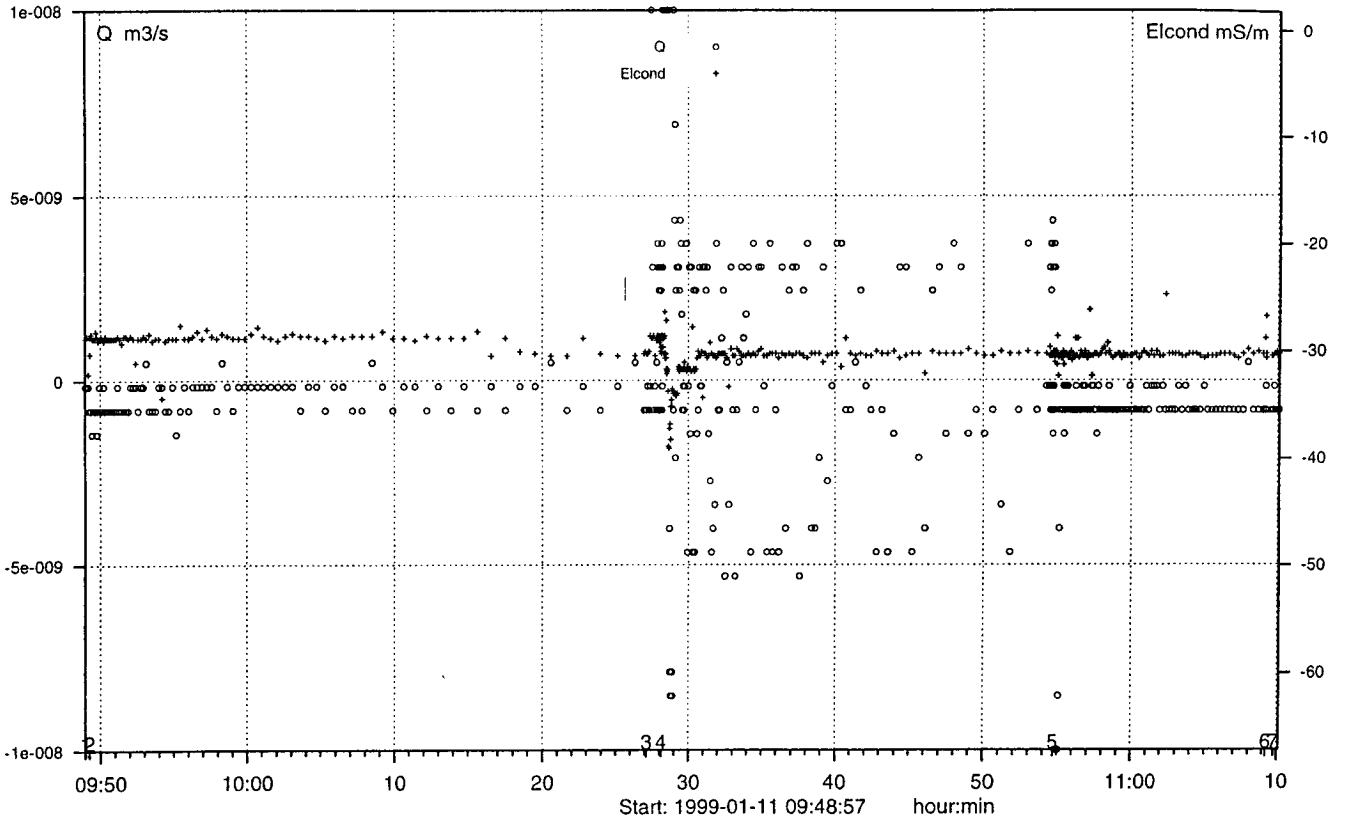
Initially the pressure increased to >800 kPa. Thereafter it decreased, but the pre-set value was not reached before the end of the flowing period.

Borehole: 3546G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-11 09:48:41



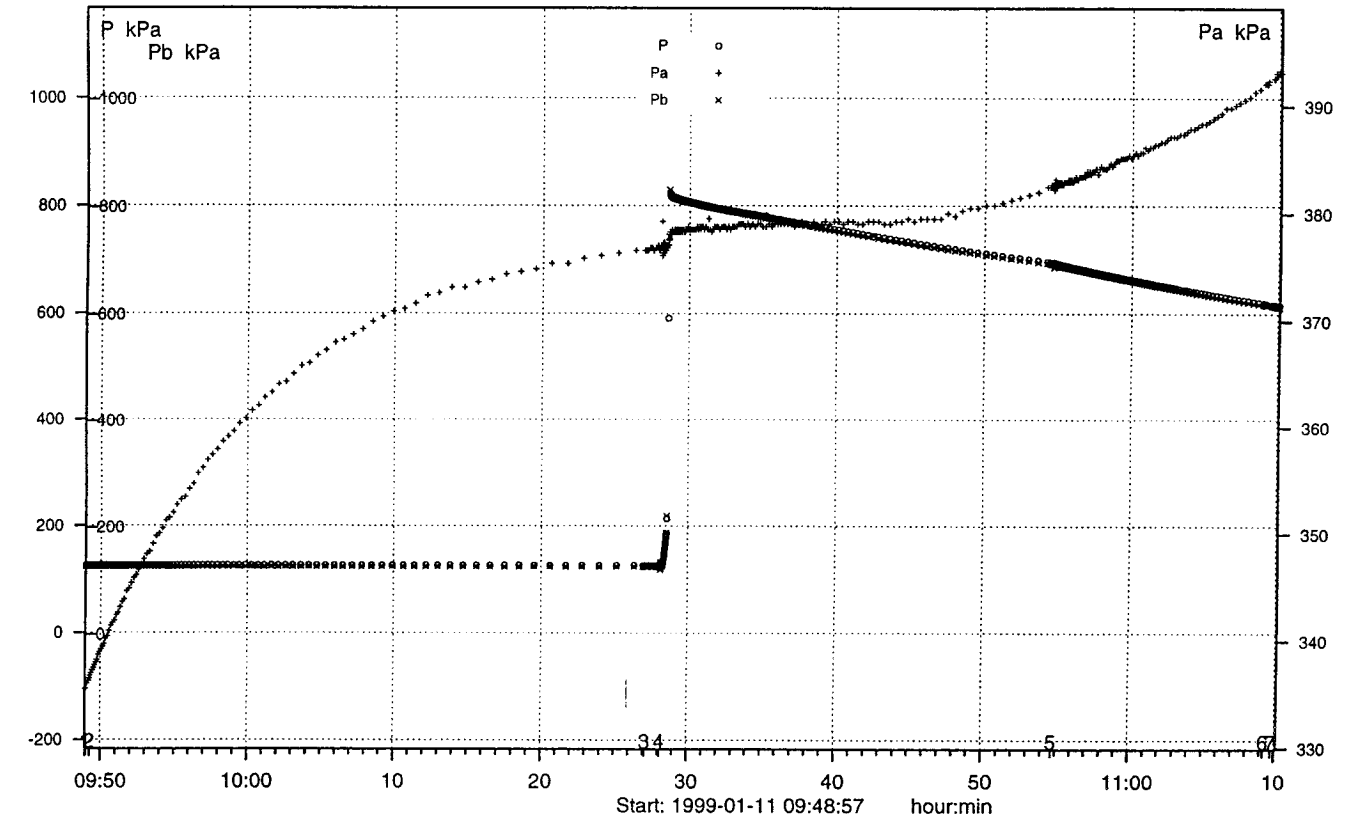
Fri Feb 12 10:34:14 1999

Borehole: 3546G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-11 09:48:41



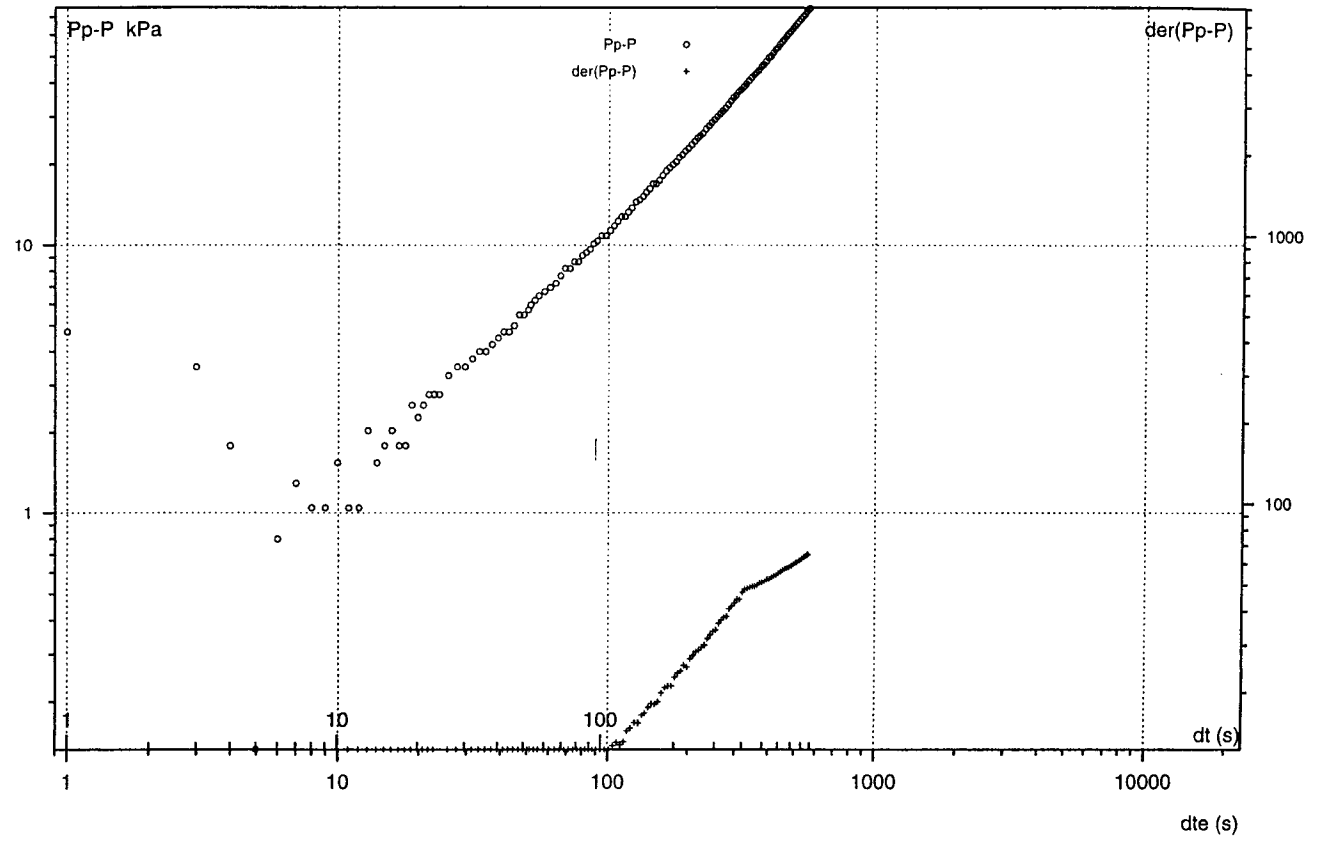
Fri Feb 12 10:23:23 1999

Borehole: 3546G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-11 09:48:41



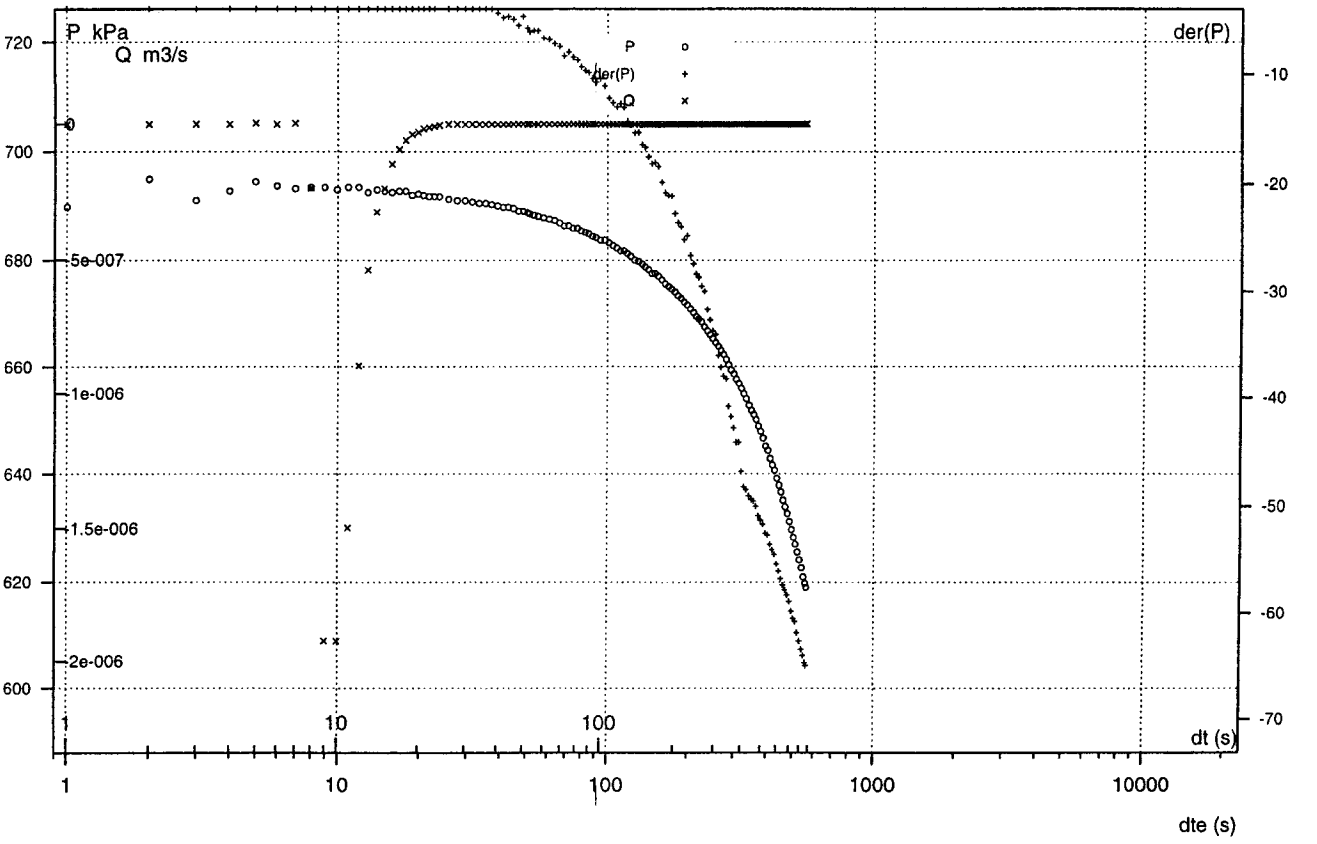
Fri Feb 12 10:23:24 1999

Borehole: 3546G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-11 09:48:41



Fri Feb 12 10:23:24 1999

Borehole KA3546G01, section 0.75 m – 1.25 m

Date: 99-01-11 Field Crew: B. Gentzschein

Valve opened: 990111 115456 Valve closed: 990111 121526
Total flowing time: 20.5 min. Tot. Pr. Build-up time: 71.9 min.

Pressure before injection start (P_0, kPa) : 127.3
Pressure just before closing the valve (P_p, kPa) : 520.1
Pressure at the end of the recovery (P_f, kPa) : 403.9

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

Shortly after the injection start P_{ref} was changed to 520 kPa.

Borehole KA3546G01, section 1.25 m – 1.75 m

Date: 99-01-11 Field Crew: B. Gentzschein

Valve opened: 990111 141110 Valve closed: 990111 143229
Total flowing time: 21.2 min. Tot. Pr. Build-up time: 10.6 min.

Pressure before injection start (P_0, kPa) : 130.8
Pressure just before closing the valve (P_p, kPa) : 579.2
Pressure at the end of the recovery (P_f, kPa) : 562.5

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

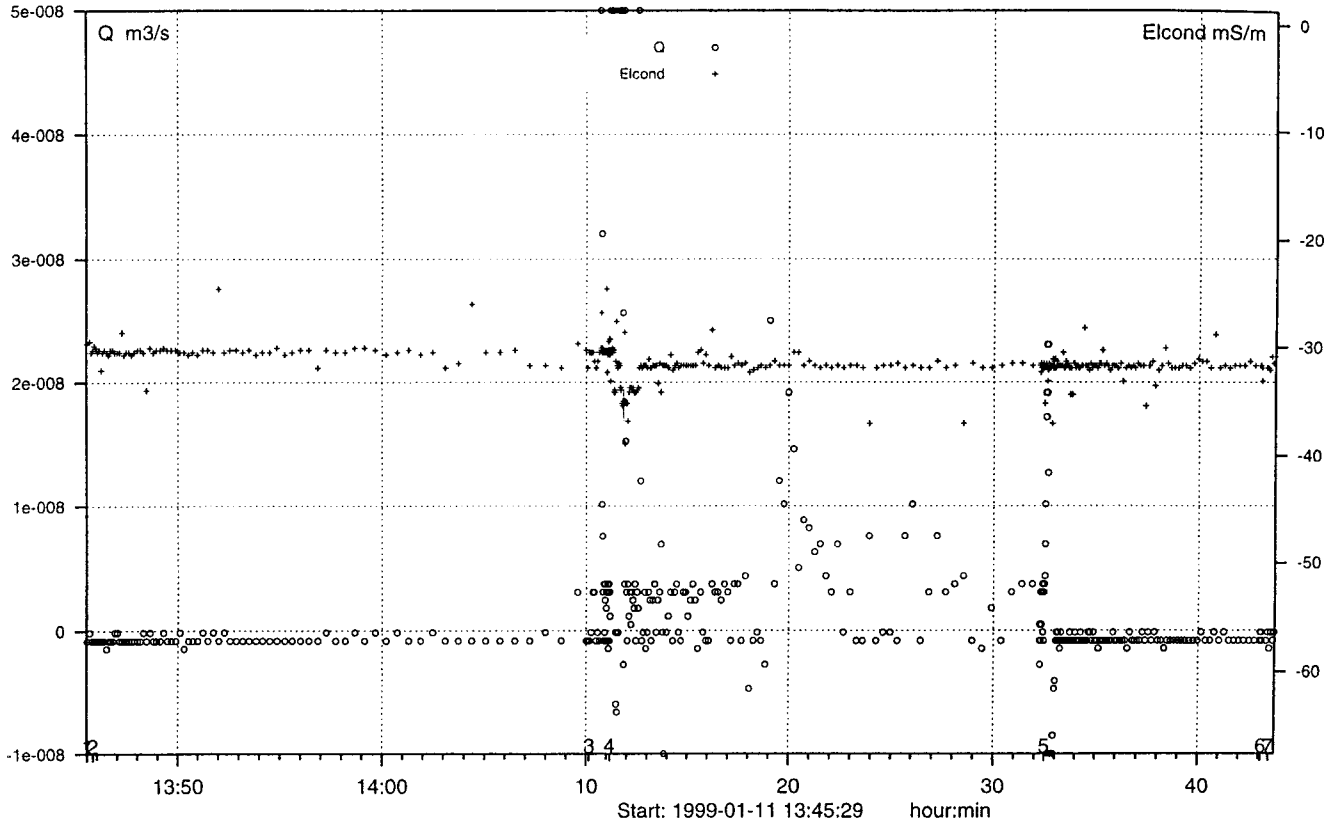
Shortly after the injection start, P_{ref} was changed to 550 kPa.

Borehole: 3546G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-11 13:45:20



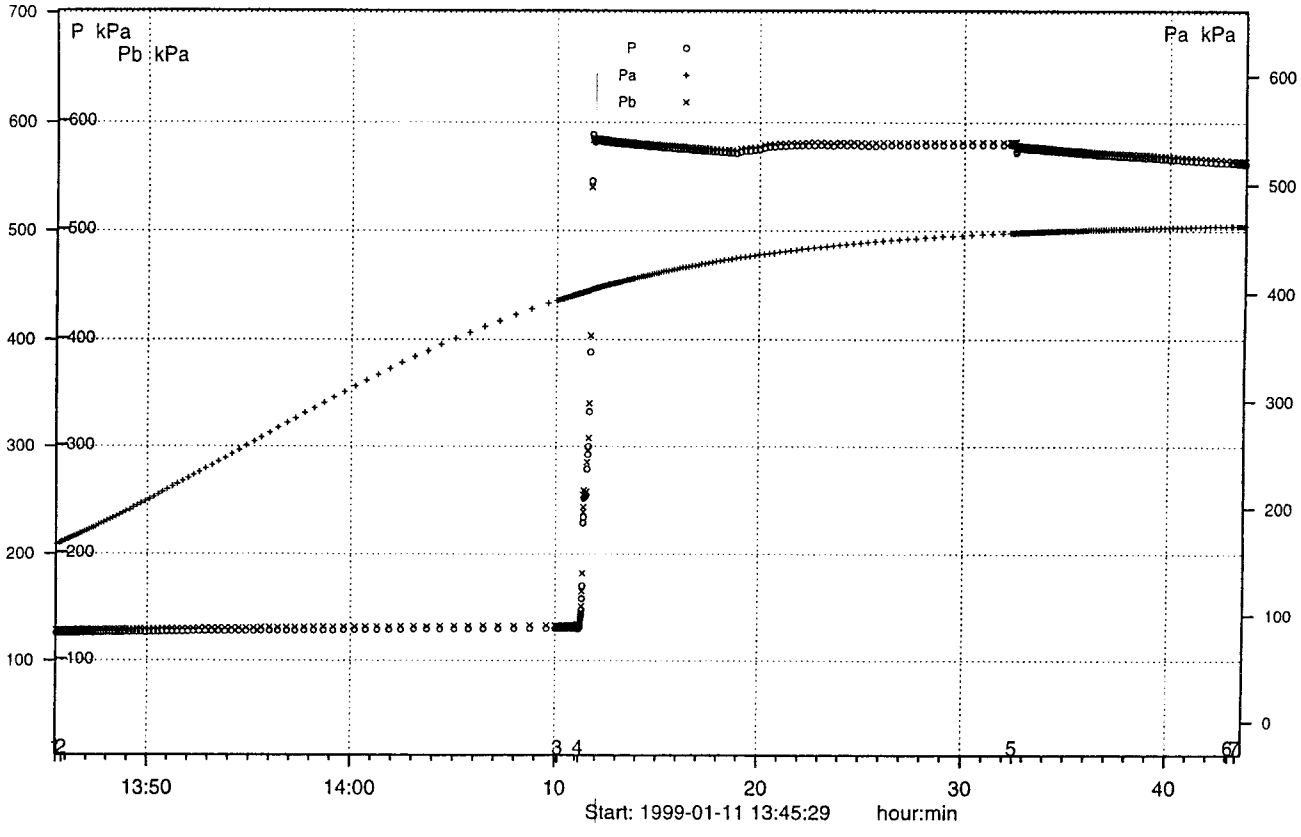
Fri Feb 12 10:53:56 1999

Borehole: 3546G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-11 13:45:20



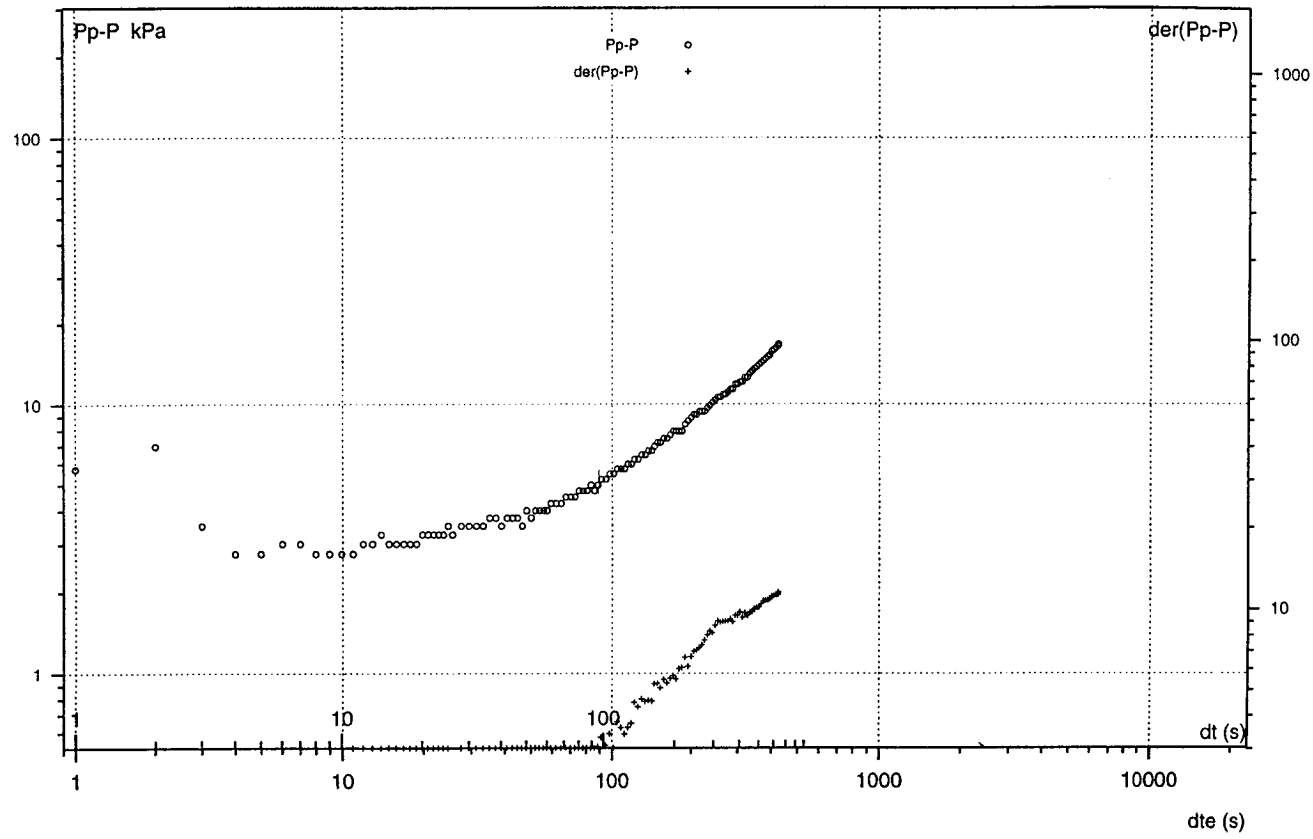
Fri Feb 12 10:52:17 1999

Borehole: 3546G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-11 13:45:20



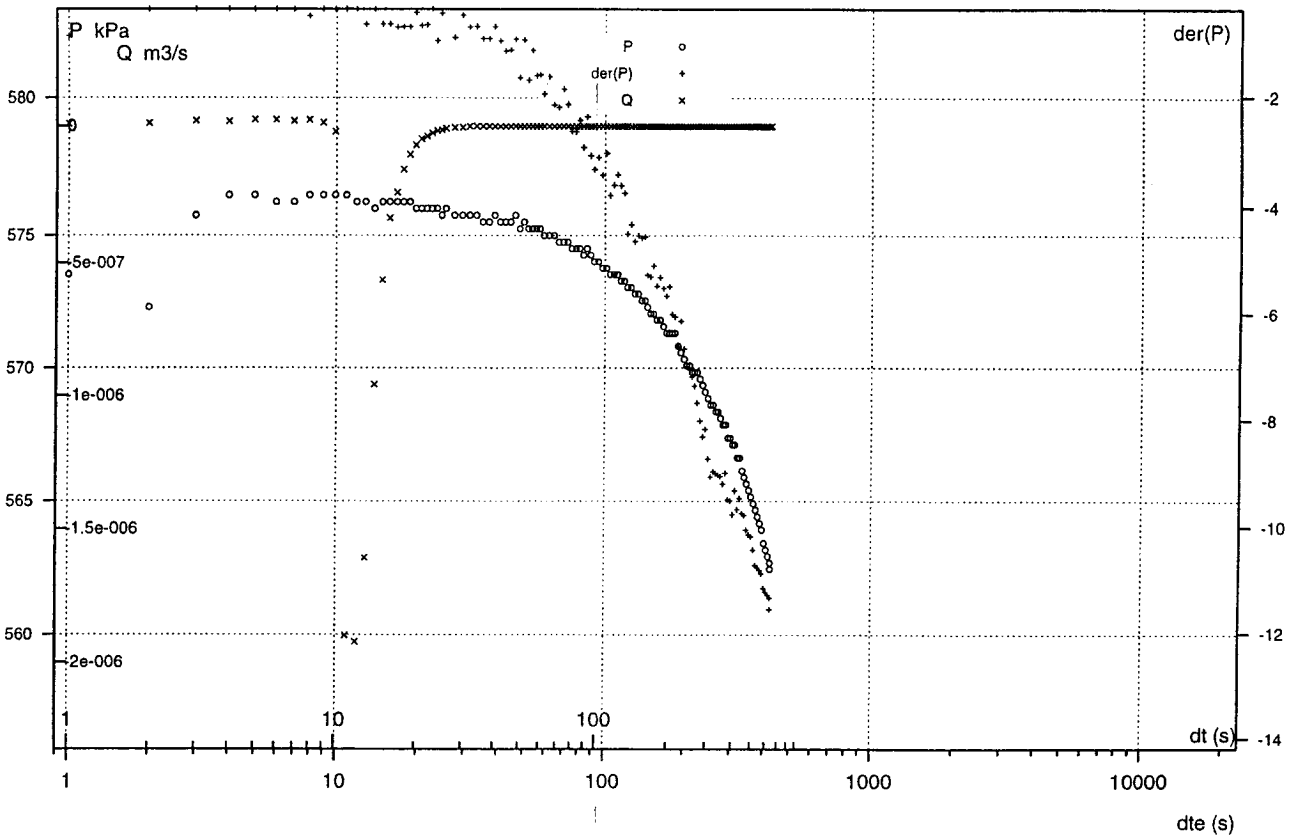
Fri Feb 12 10:52:18 1999

Borehole: 3546G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-11 13:45:20



Fri Feb 12 10:52:18 1999

Borehole KA3548G01, section 0.25 m - 0.75 m

Date: 99-01-11 Field Crew: B. Gentzschein

Valve opened: 990111 160246 Valve closed: 990111 163137
Total flowing time: 28.7 min. Tot. Pr. Build-up time: 16.4 min.

Pressure before injection start (P_0, kPa) : 122.8
Pressure just before closing the valve (P_p, kPa) : 518.6
Pressure at the end of the recovery (P_f, kPa) : 489.2

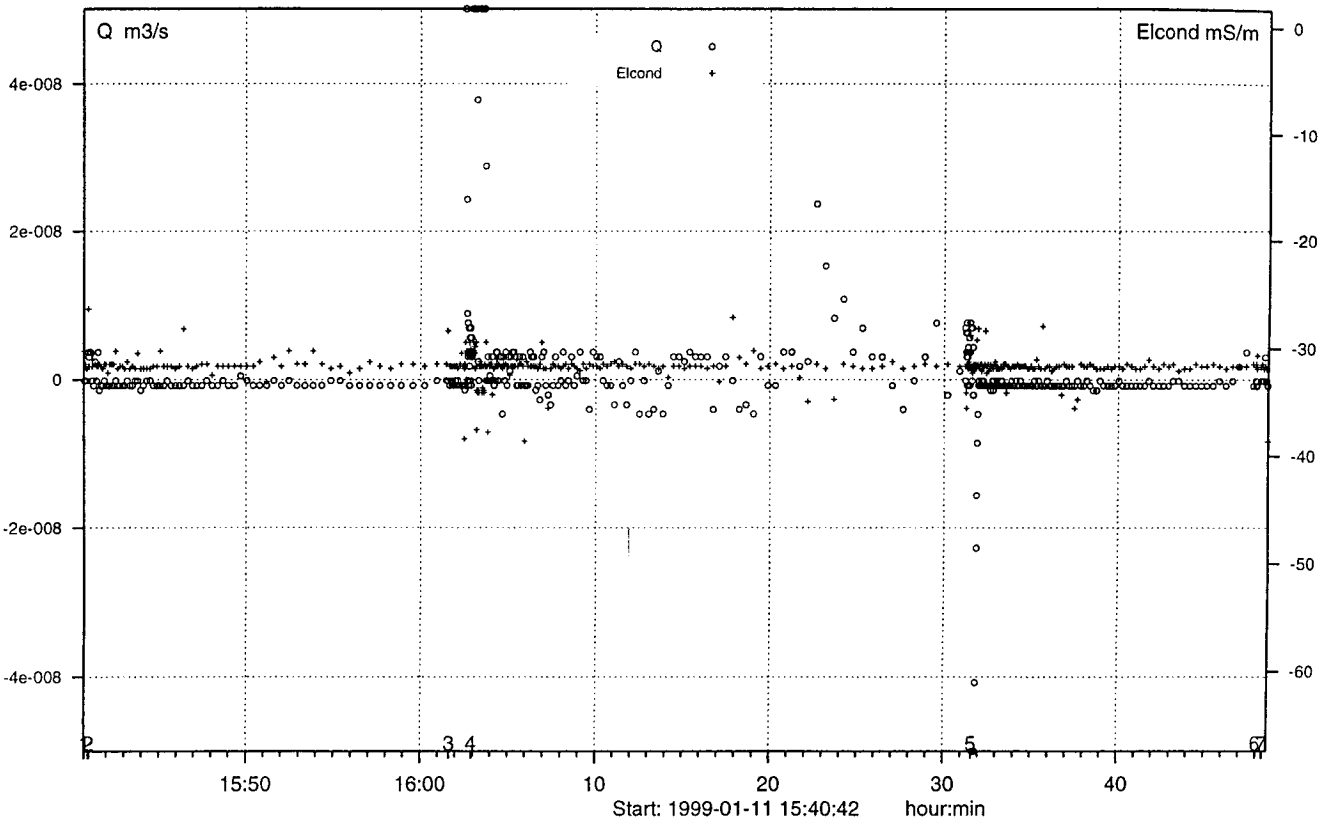
Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

Borehole: 3548G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-11 15:40:28



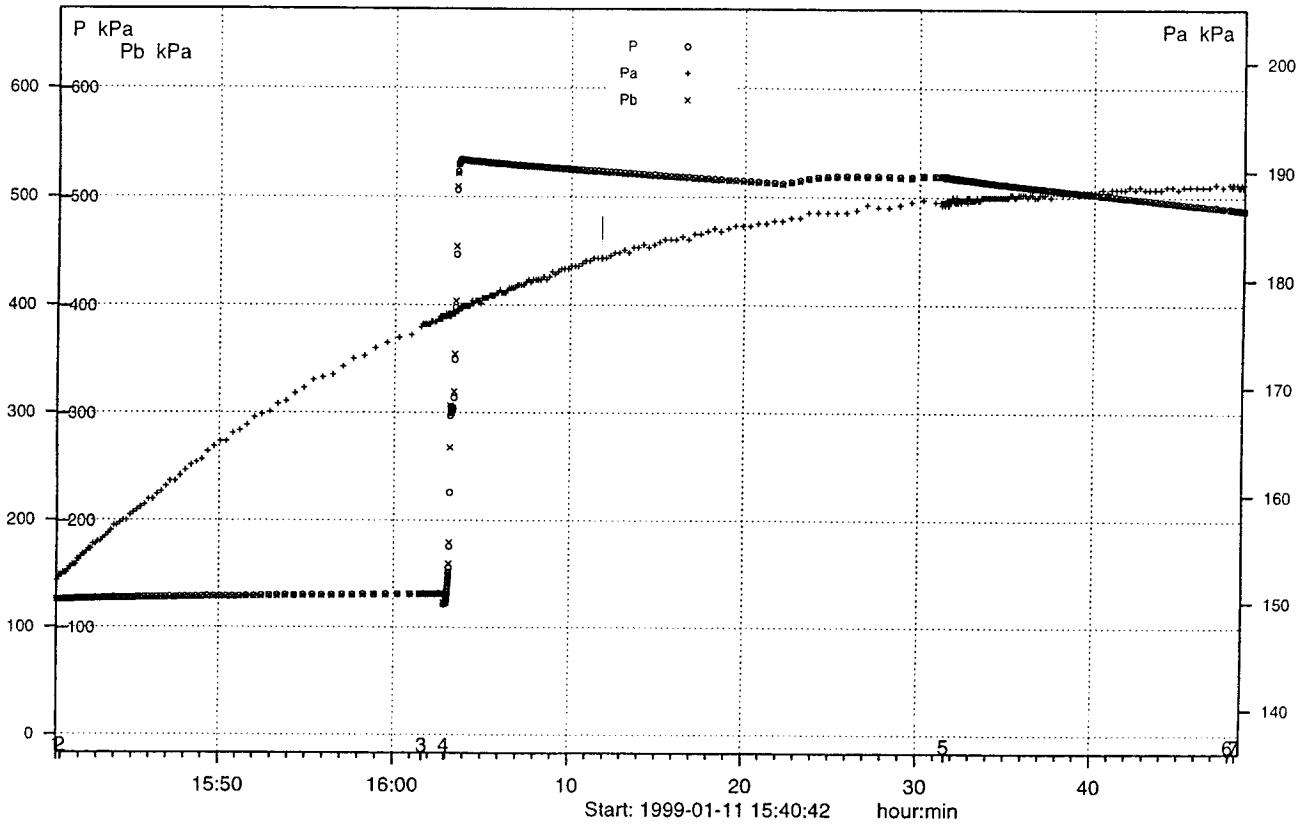
Fri Feb 12 11:08:35 1999

Borehole: 3548G01

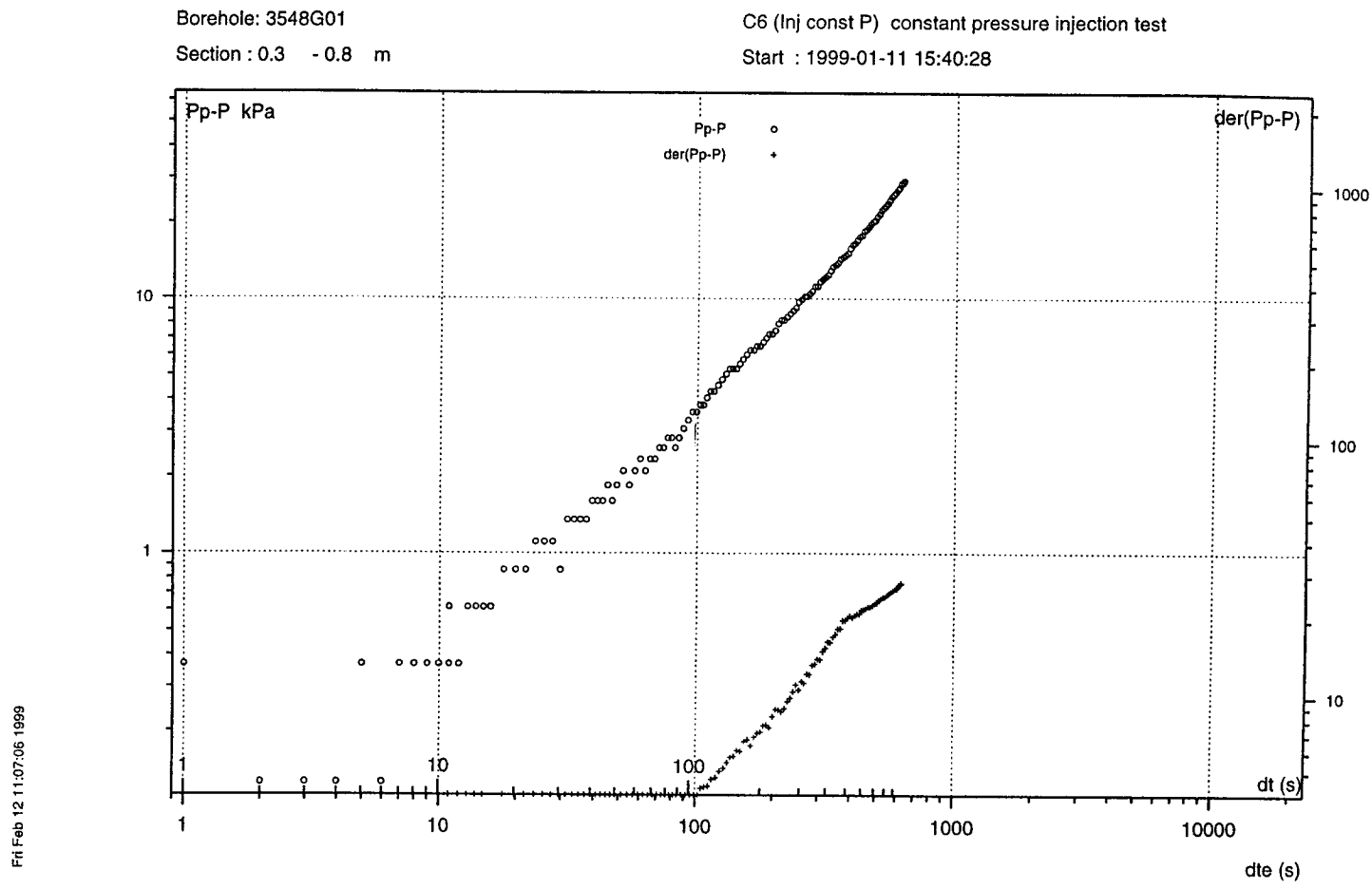
Section : 0.3 - 0.8 m

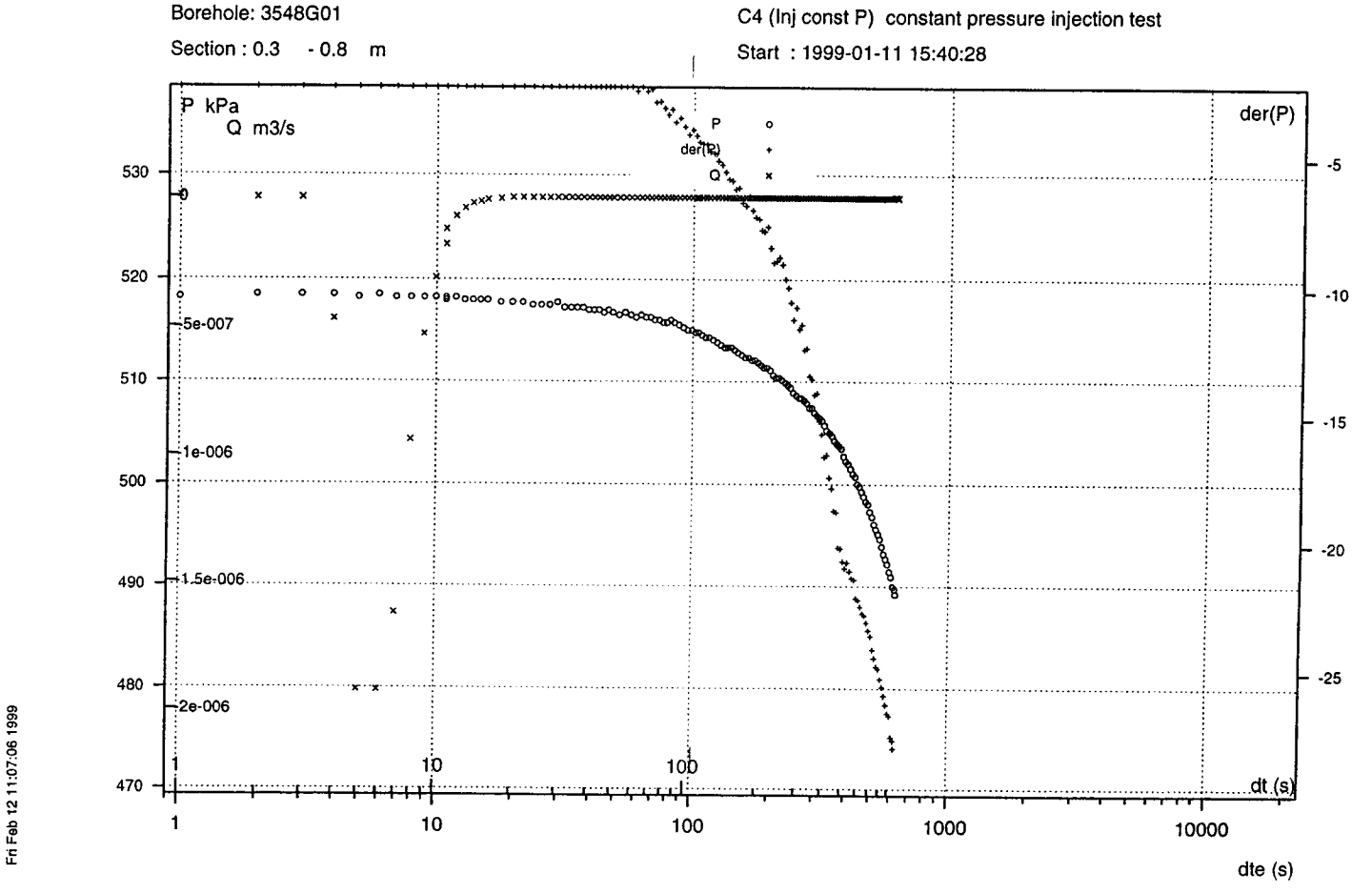
A3 (Inj const P) constant pressure injection test

Start : 1999-01-11 15:40:28



Fri Feb 12 11:07:05 1999


Borehole: 3548G01
Section : 0.3 - 0.8 m
C6 (Inj const P) constant pressure injection test
Start : 1999-01-11 15:40:28
Pp-P kPa
der(Pp-P)
Pp-P
der(Pp-P)
dt (s)
dte (s)
Fri Feb 12 11:07:06 1999


Borehole: 3548G01
Section : 0.3 - 0.8 m
C4 (Inj const P) constant pressure injection test
Start : 1999-01-11 15:40:28
P kPa
Q m3/s
der(P)
P
der(P)
Q
dt (s)
dte (s)
Fri Feb 12 11:07:06 1999

Borehole KA3548G01, section 0.75 m – 1.25 m

Date: 99-01-11 Field Crew: B. Gentzschein

Valve opened: 990111 172618 Valve closed: 990111 174902
Total flowing time: 22.8 min. Tot. Pr. Build-up time: 16.0 min.

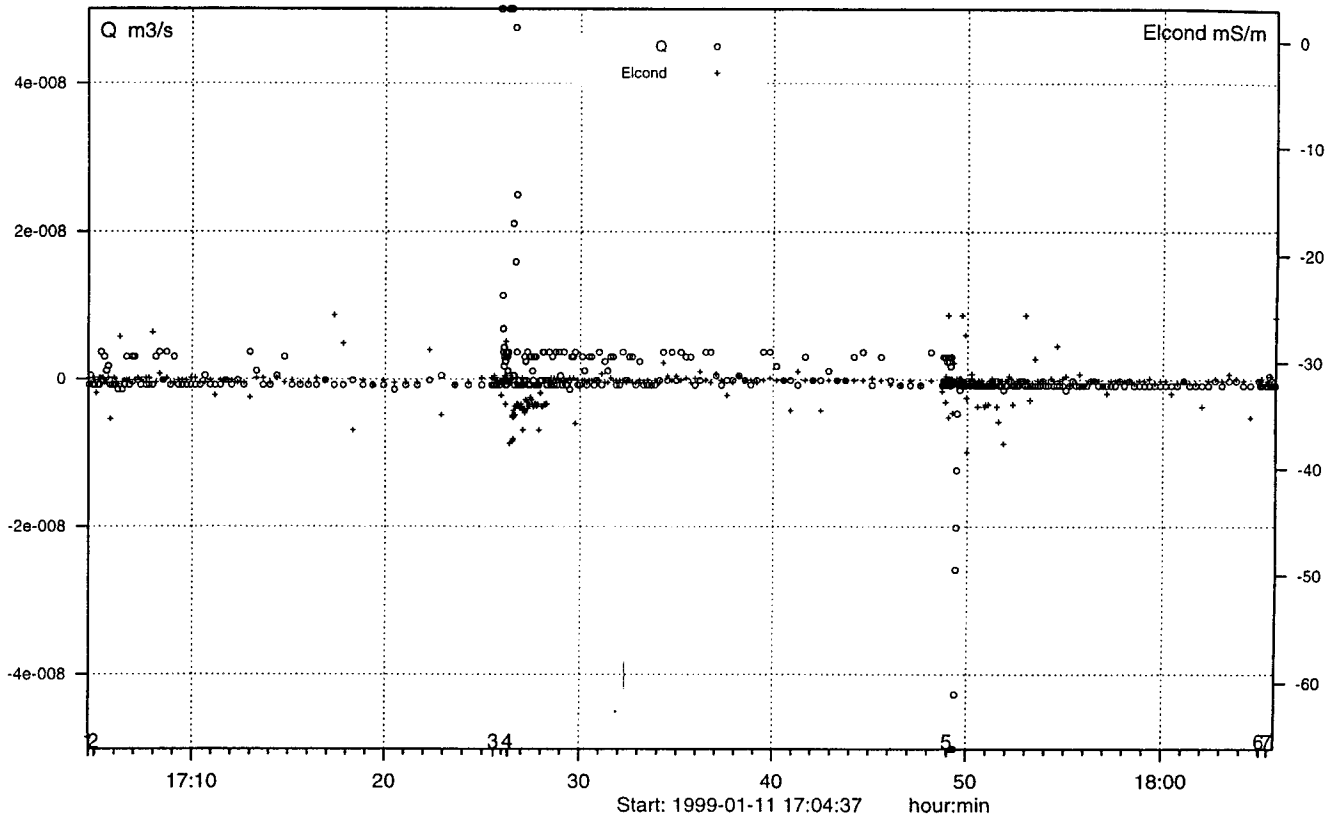
Pressure before injection start (P_0, kPa) : 124.0
Pressure just before closing the valve (P_p, kPa) : 820.4
Pressure at the end of the recovery (P_f, kPa) : 701.4

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

Initially the pressure increased to >800 kPa. Then it didn't reach down to the pre-set value before recovery start.

Borehole: 3548G01
Section : 0.8 - 1.3 m

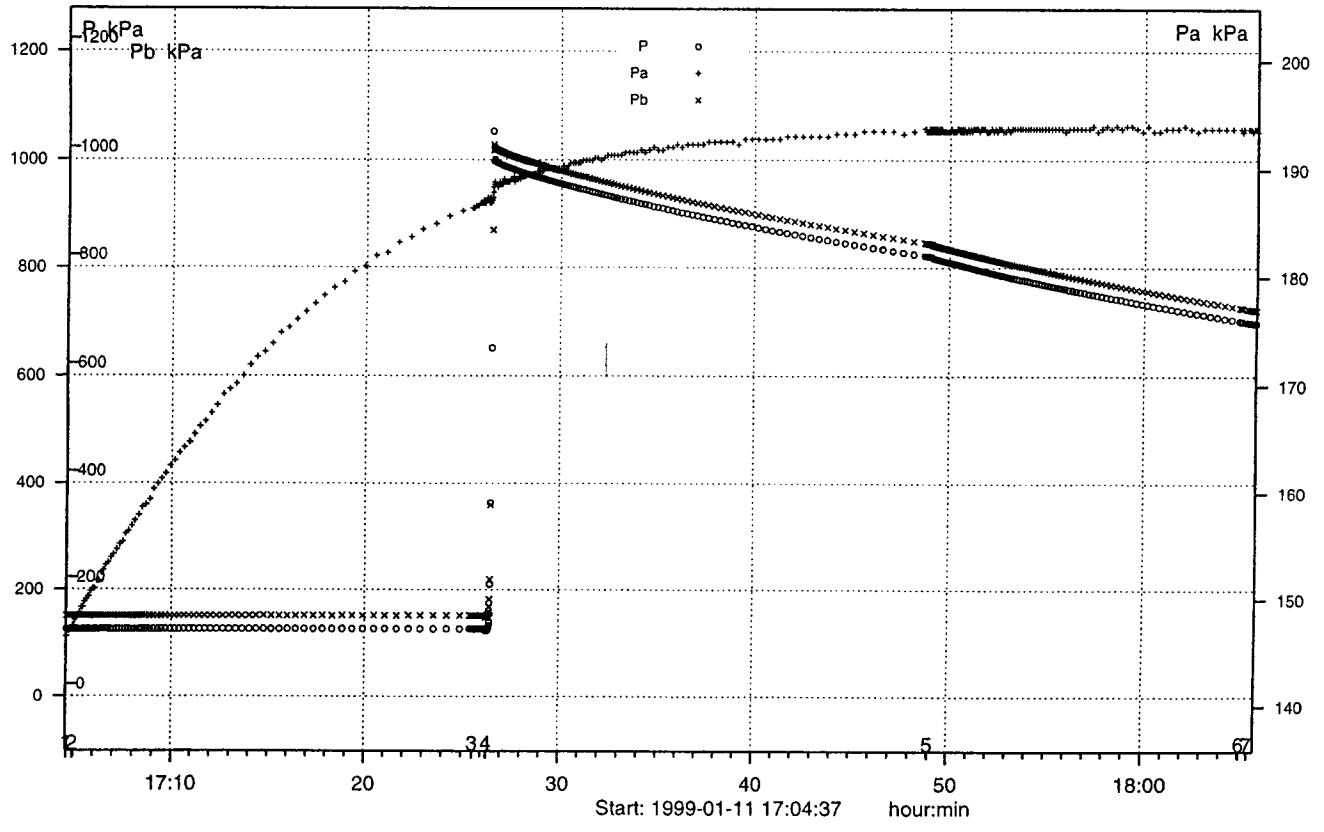
A2 (Inj const P) constant pressure injection test
Start : 1999-01-11 17:04:24



Fri Feb 12 11:33:58 1999

Borehole: 3548G01
Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test
Start : 1999-01-11 17:04:24



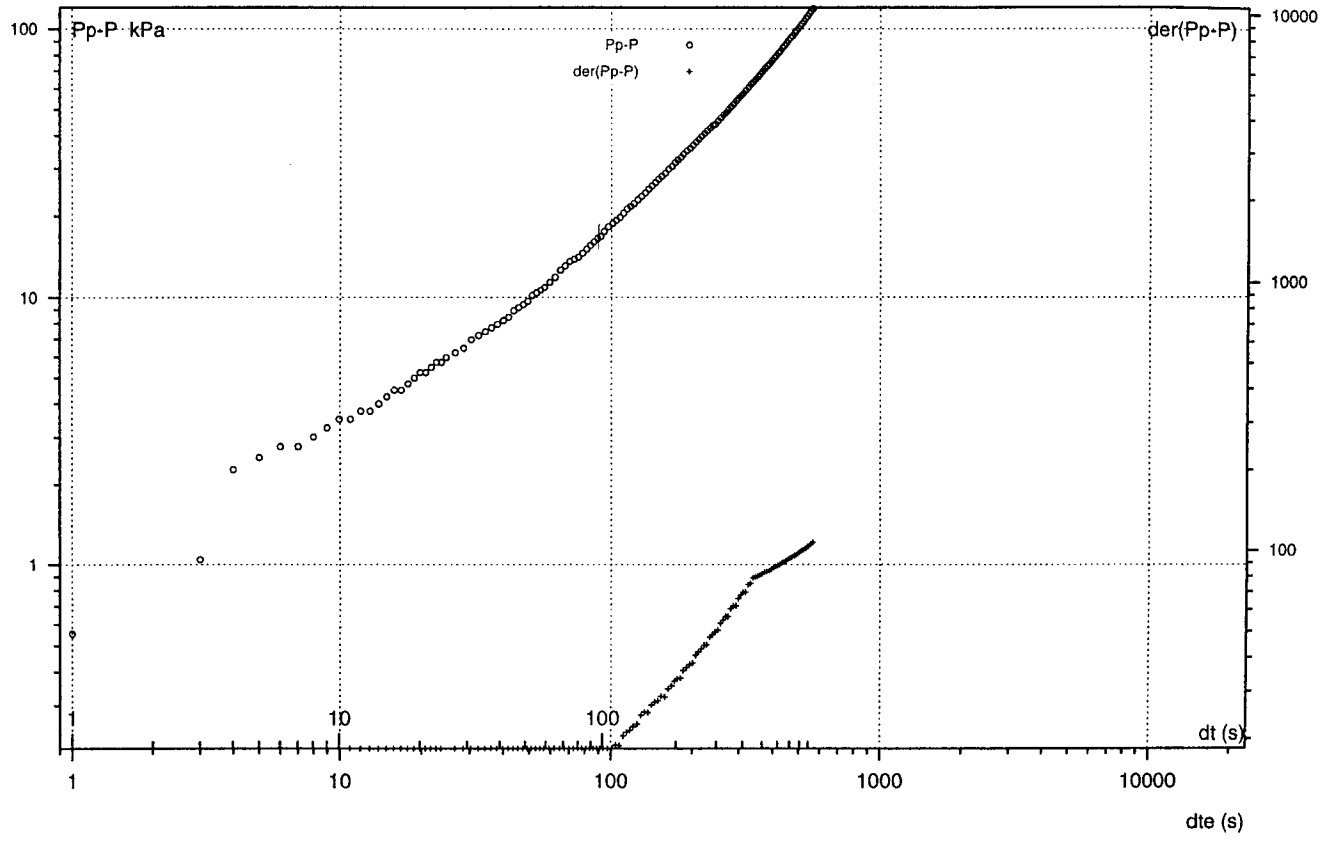
Fri Feb 12 11:31:48 1999

Borehole: 3548G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-11 17:04:24



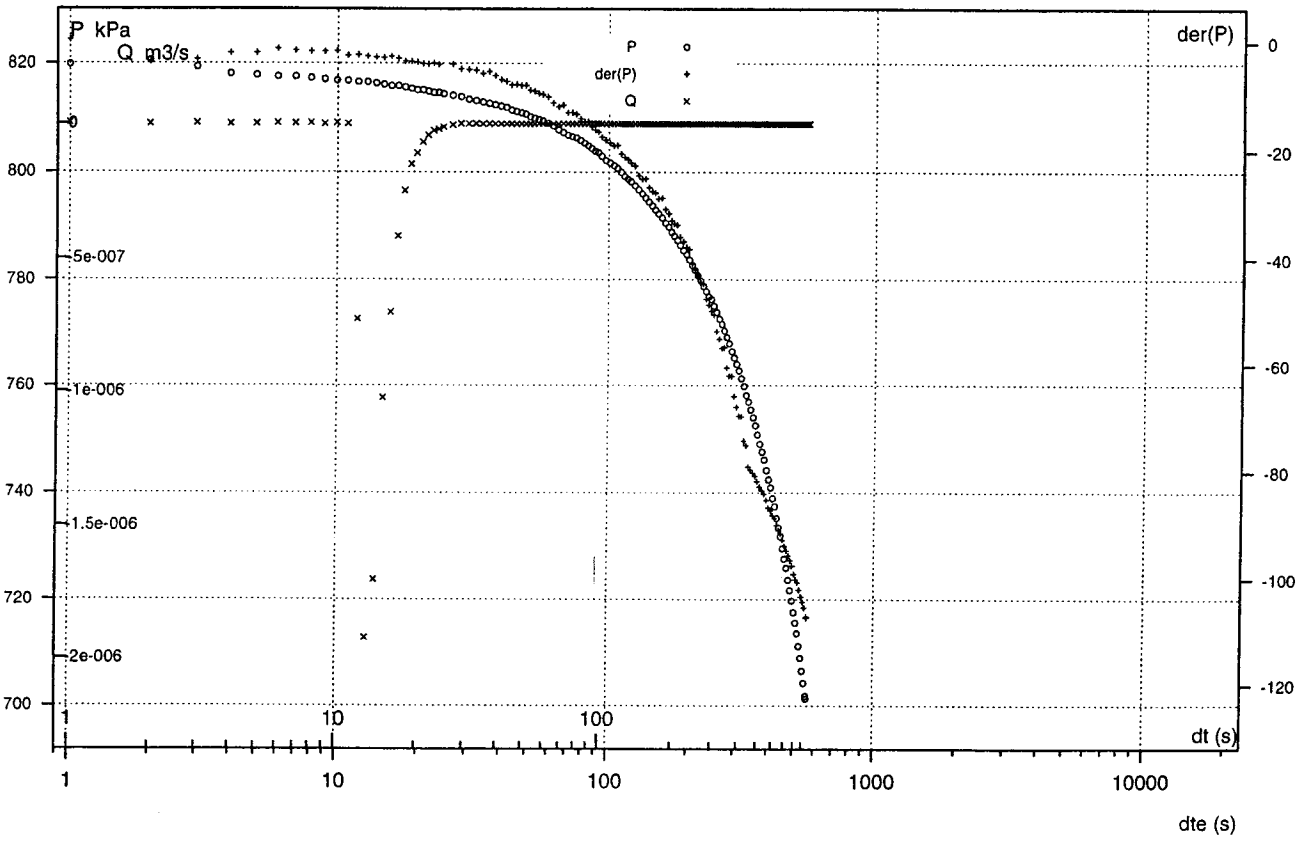
Fri Feb 12 11:31:48 1999

Borehole: 3548G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-11 17:04:24



Fri Feb 12 11:31:48 1999

Borehole KA3548G01, section 1.25 m – 1.75 m

Date: 99-01-11 Field Crew: B. Gentzschein

Valve opened: 990111 184608 Valve closed: 990111 190812
Total flowing time: 22.1 min. Tot. Pr. Build-up time: 788.5 min.

Pressure before injection start (P_0, kPa) : 126.9
Pressure just before closing the valve (P_p, kPa) : 527.9
Pressure at the end of the recovery (P_f, kPa) : 308.1

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

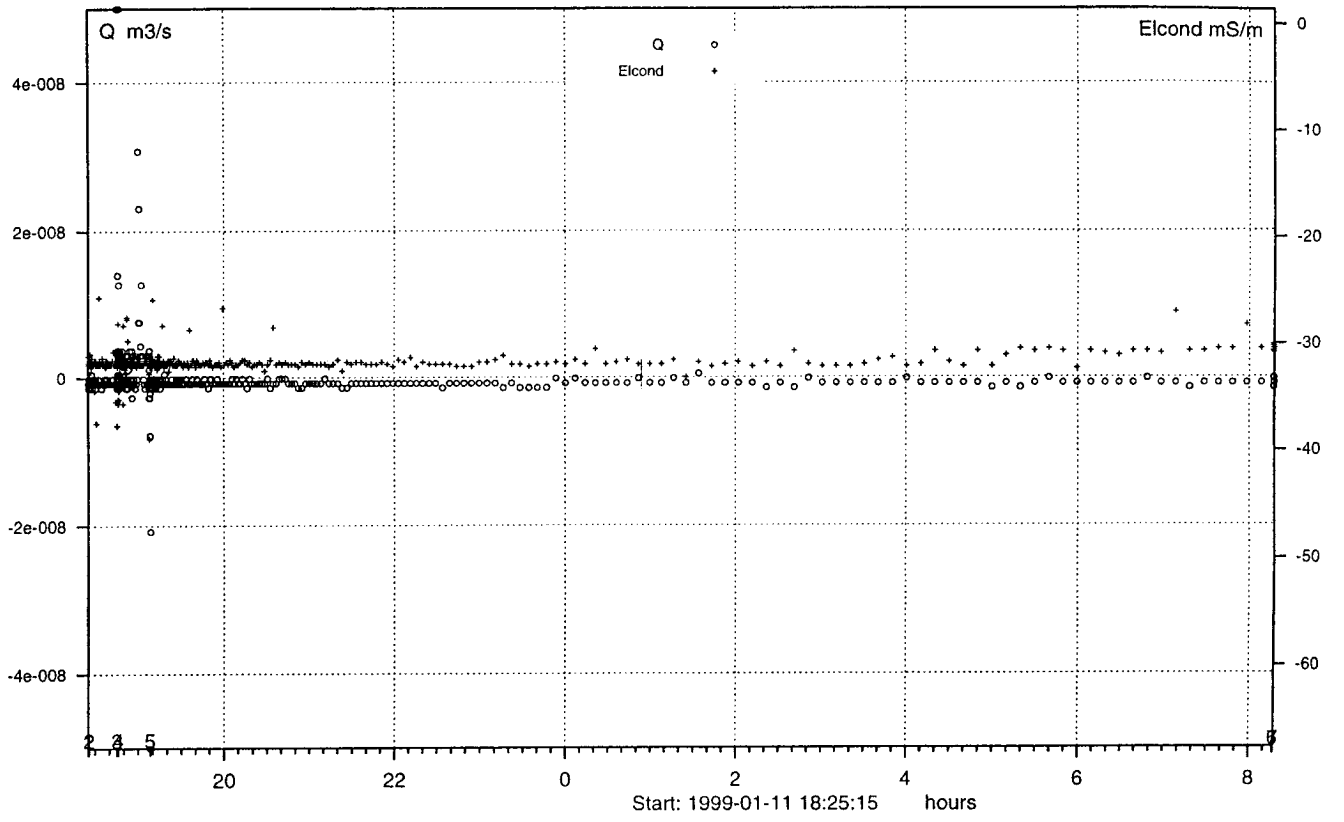
The recovery lasted over the night.

Borehole: 3548G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-11 18:25:01



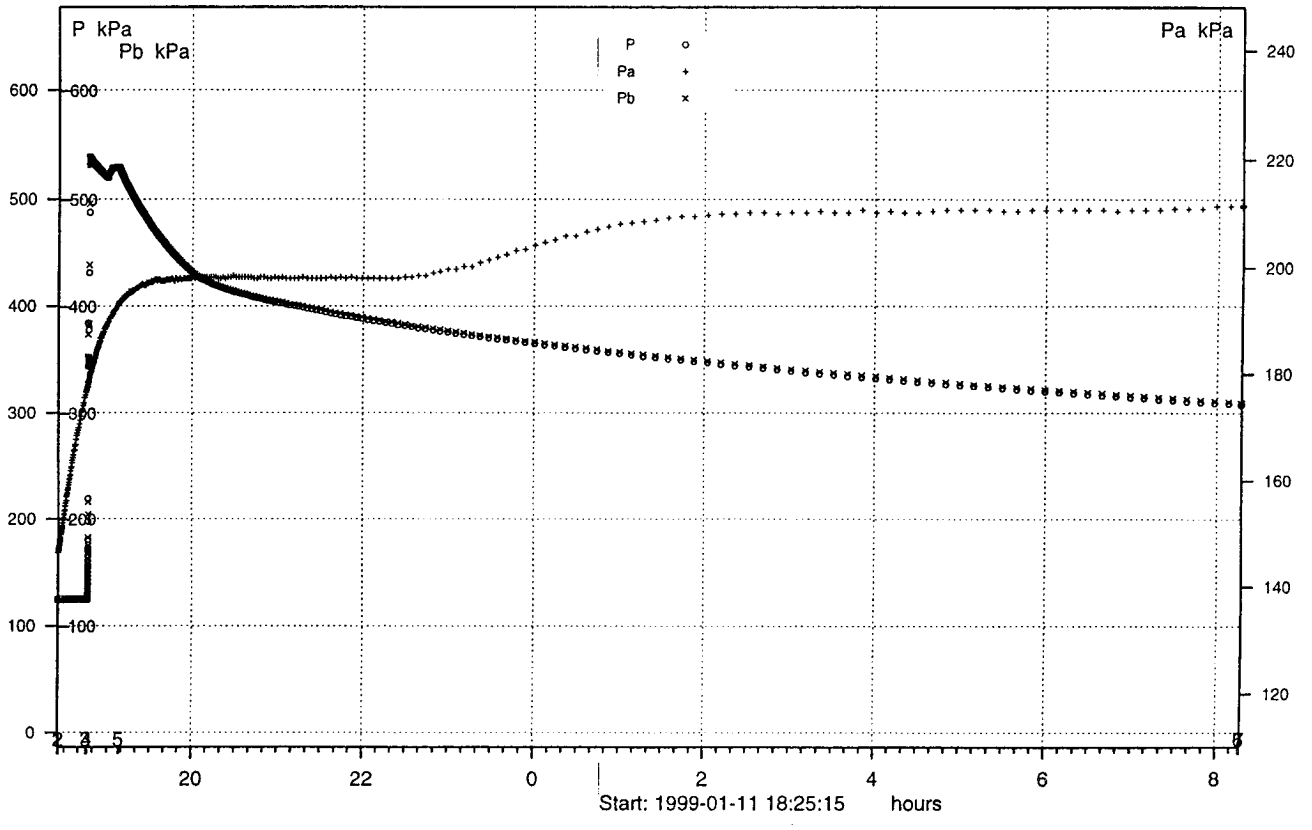
Fri Feb 12 11:46:30 1999

Borehole: 3548G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-11 18:25:01



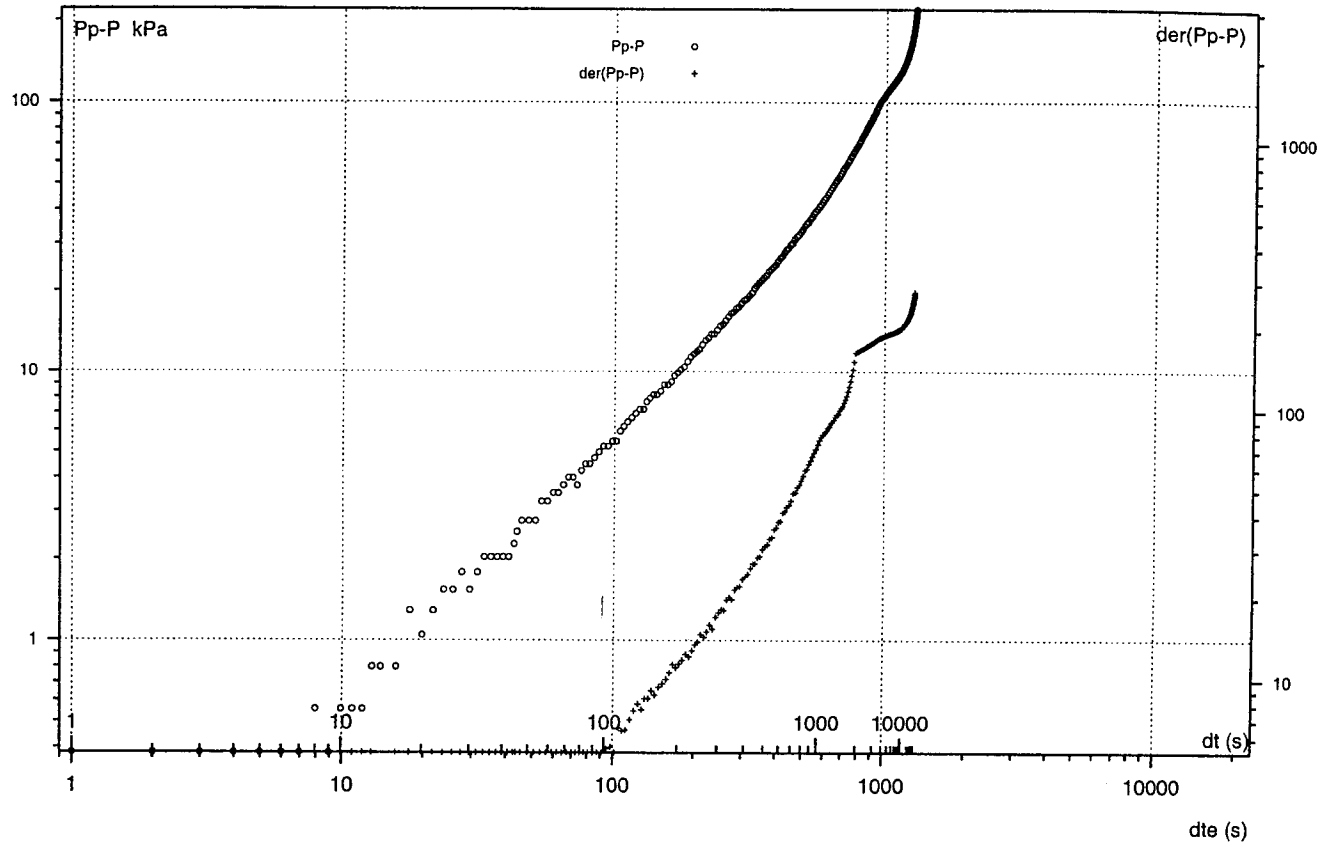
Fri Feb 12 11:41:20 1999

Borehole: 3548G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-11 18:25:01



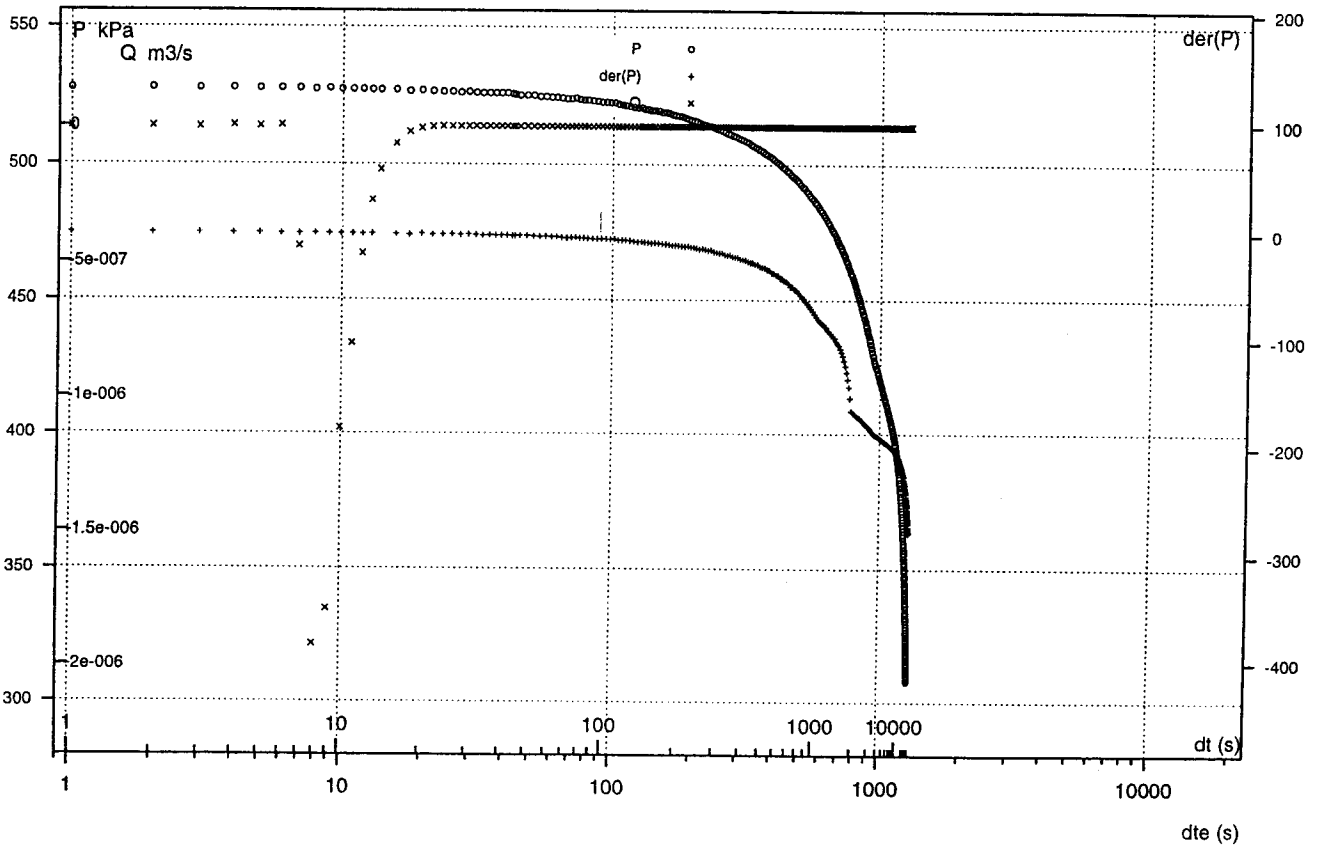
Fri Feb 12 11:41:20 1999

Borehole: 3548G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-11 18:25:01



Fri Feb 12 11:41:20 1999

Borehole KA3550G01, section 0.25 m - 0.75 m

Date: 99-01-12 Field Crew: B. Gentzschein

Valve opened: 990112 093905 Valve closed: 990112 100351
Total flowing time: 24.8 min. Tot. Pr. Build-up time: 11.6 min.

Pressure before injection start (P_0, kPa) : 121.5
Pressure just before closing the valve (P_p, kPa) : 520.0
Pressure at the end of the recovery (P_f, kPa) : 386.0

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

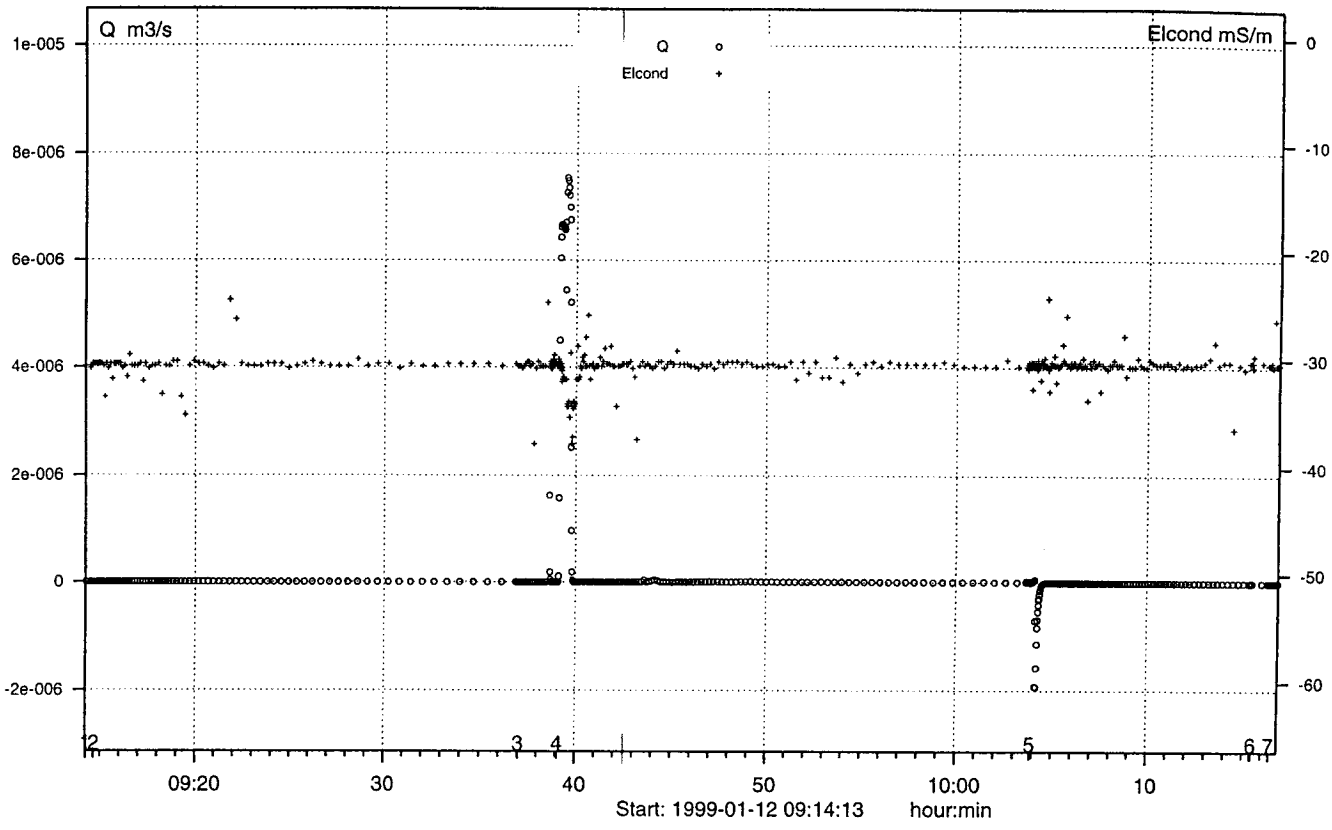
The injection pressure is relatively stable and the recovery is c. 34 %

Borehole: 3550G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-12 09:14:01



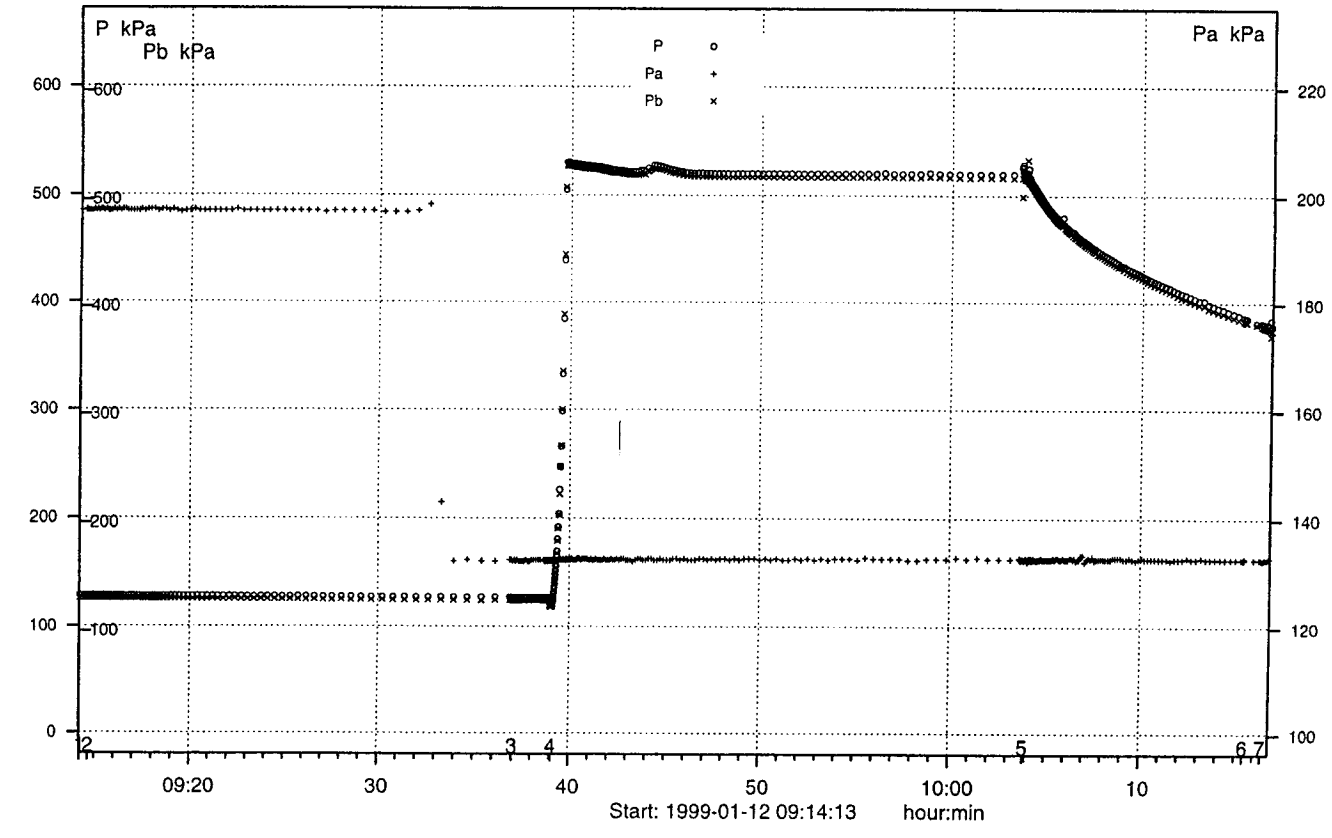
Fri Feb 12 13:28:34 1999

Borehole: 3550G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-12 09:14:01



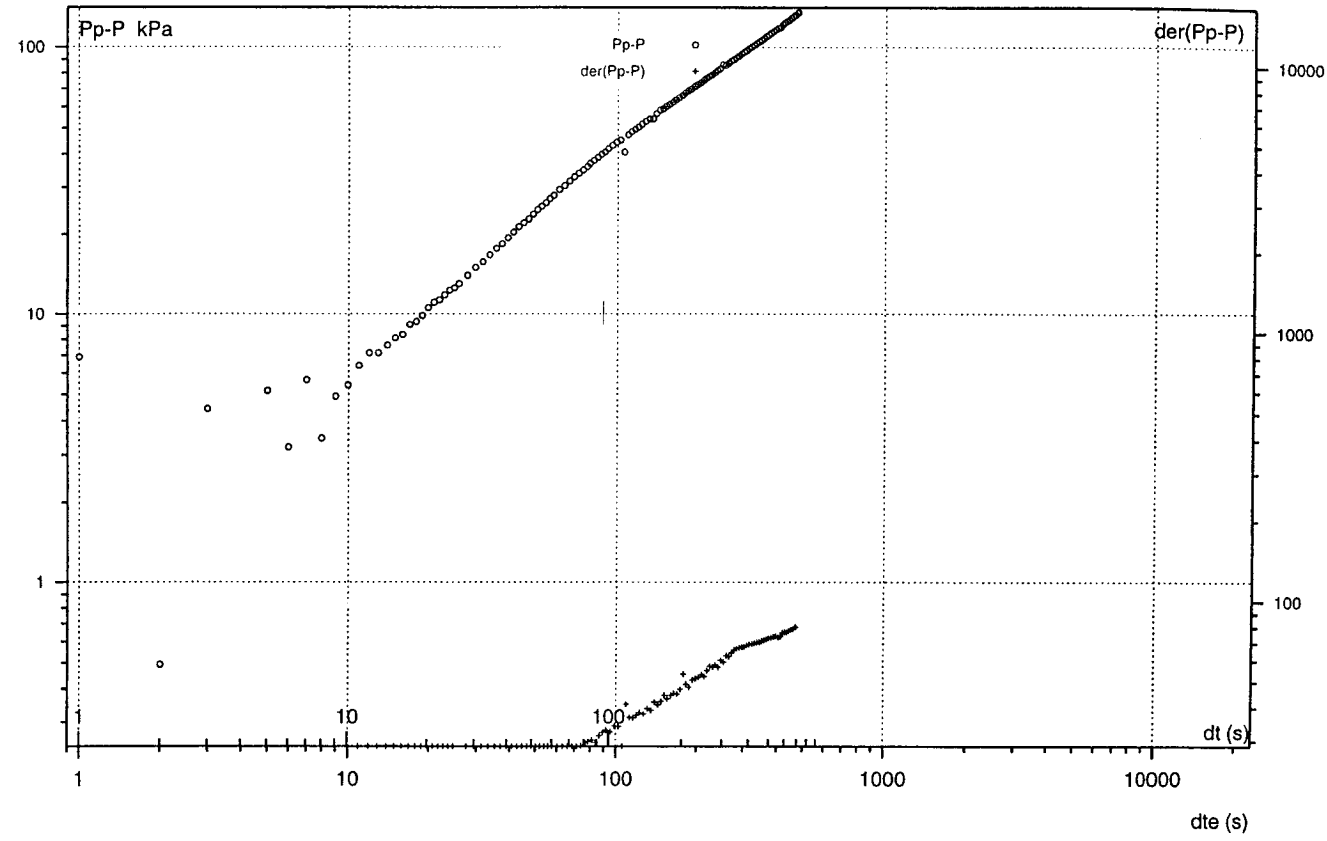
Fri Feb 12 13:28:34 1999

Borehole: 3550G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-12 09:14:01



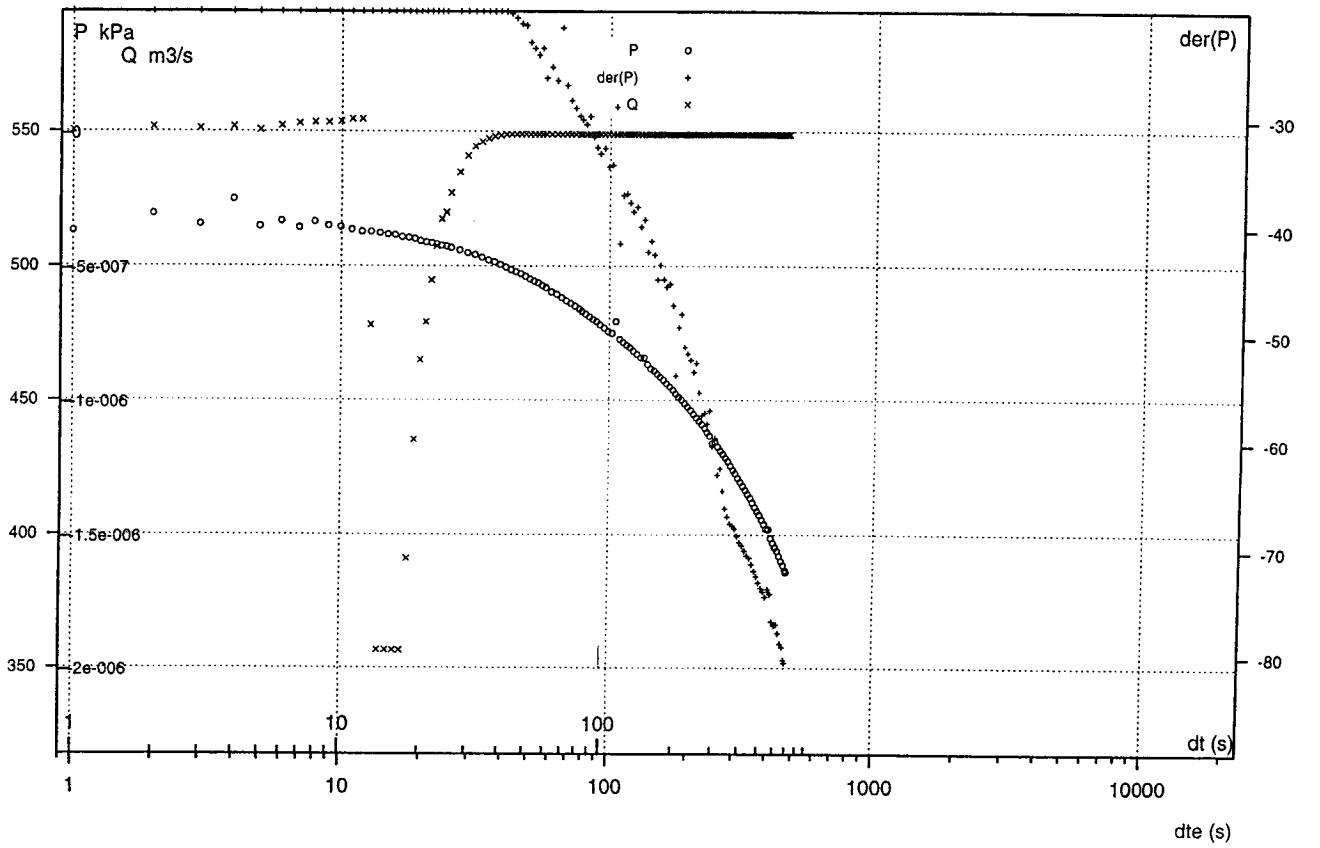
Fri Feb 12 13:28:35 1999

Borehole: 3550G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-12 09:14:01



Fri Feb 12 13:28:34 1999

Borehole KA3550G01, section 0.75 m – 1.25 m

Date: 99-01-12 Field Crew: B. Gentzschein

Valve opened: 990112 110856 Valve closed: 990112 113139
Total flowing time: 22.7 min. Tot. Pr. Build-up time: 129.9 min.

Pressure before injection start (P_0, kPa) : 130.1
Pressure just before closing the valve (P_p, kPa) : 563.5
Pressure at the end of the recovery (P_f, kPa) : 505.7

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

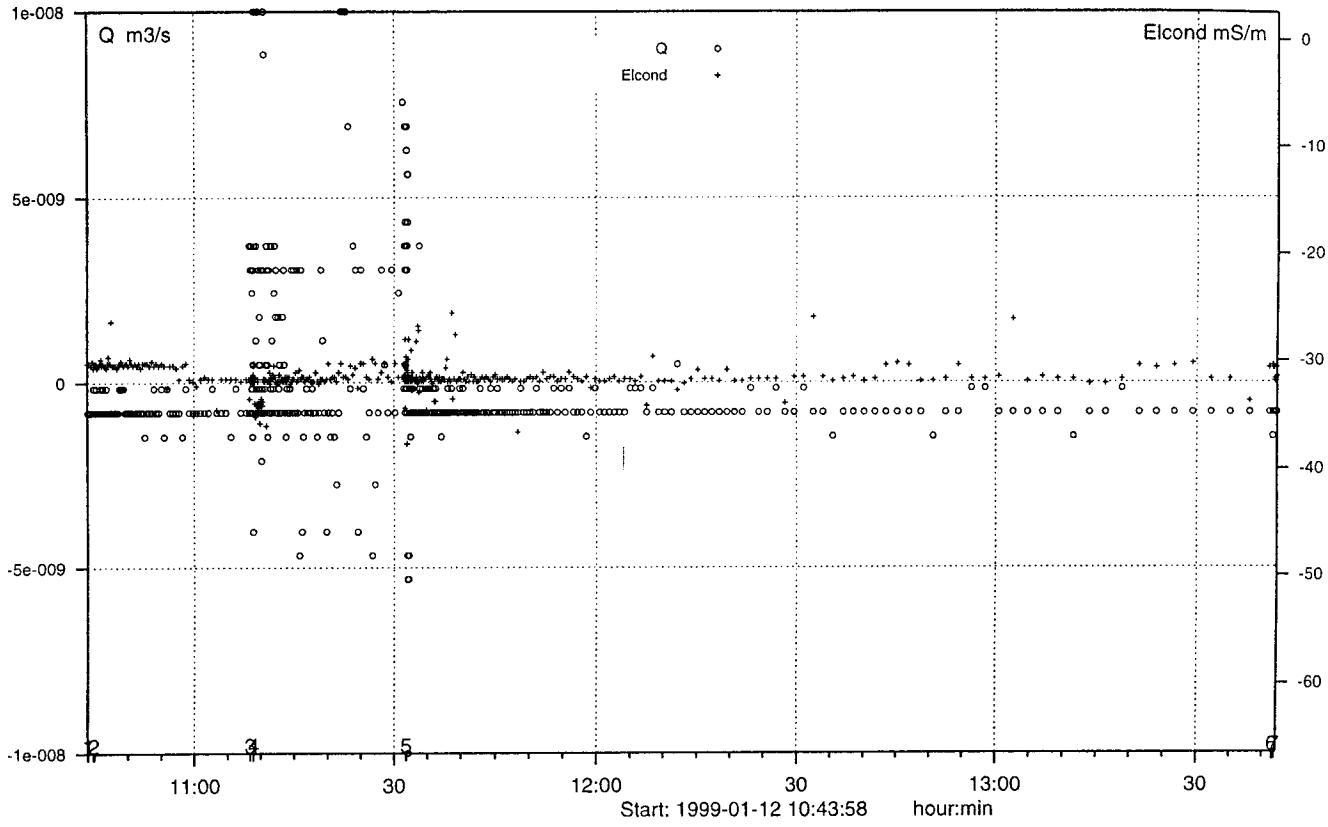
P_{ref} was changed to 540 kPa at 11:10.30:

Borehole: 3550G01

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-12 10:43:45



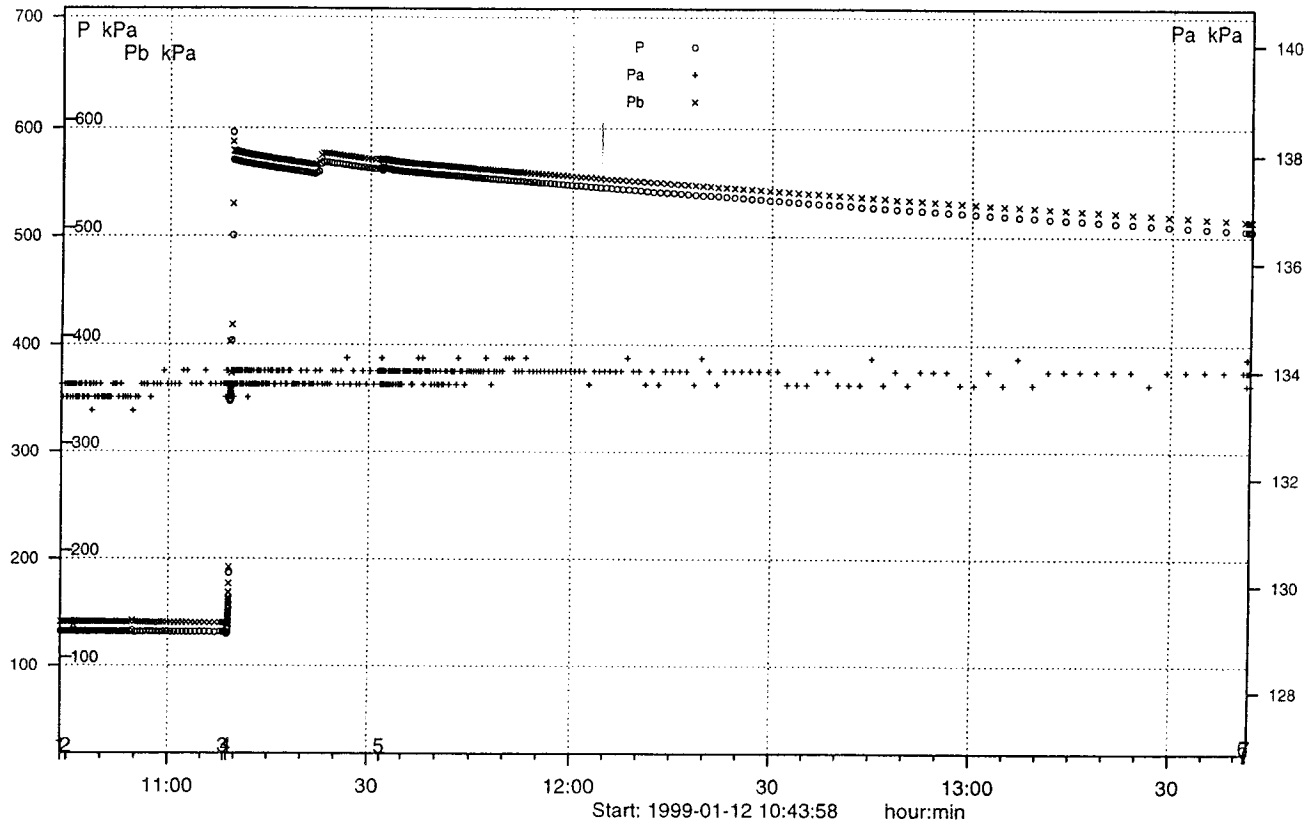
Fri Feb 12 14:01:29 1999

Borehole: 3550G01

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-12 10:43:45



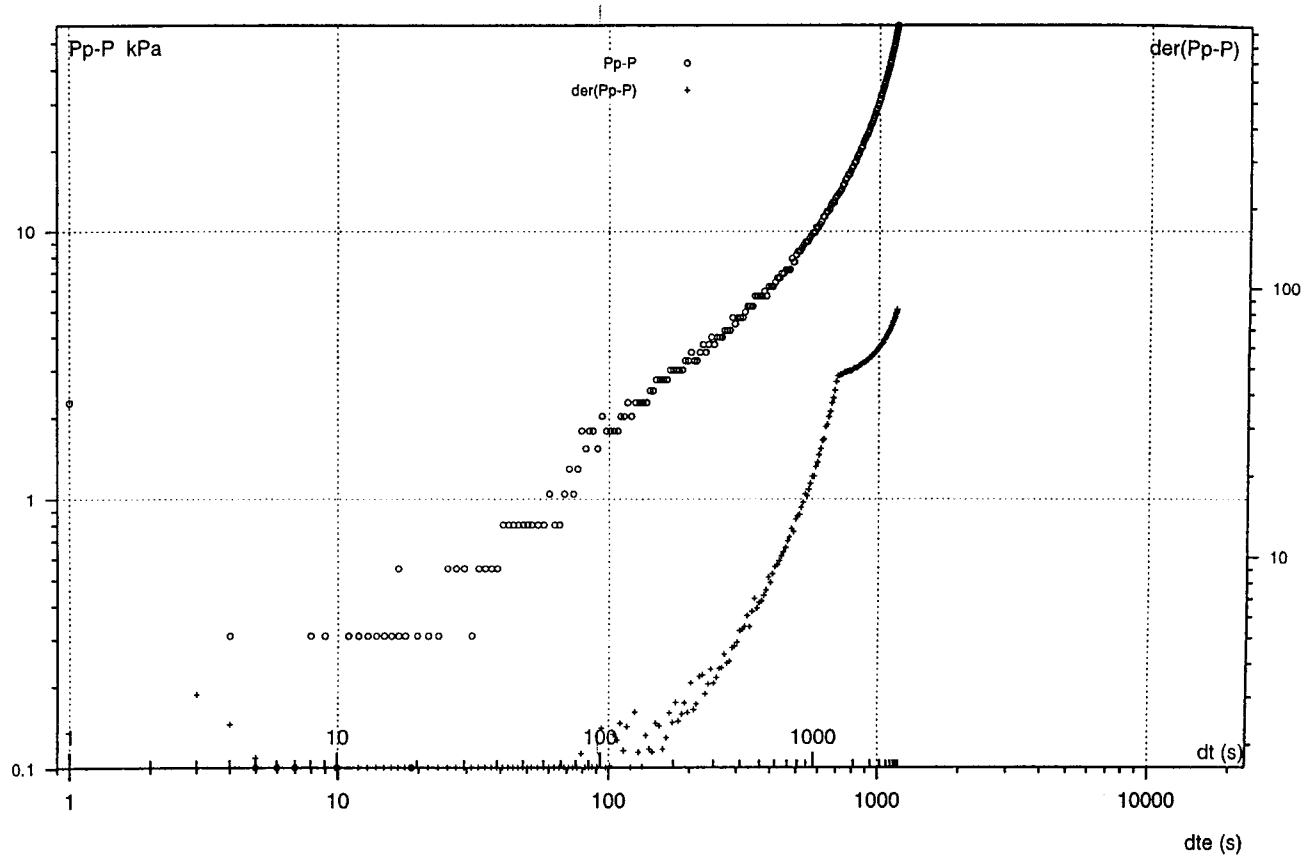
Fri Feb 12 13:58:54 1999

Borehole: 3550G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-12 10:43:45



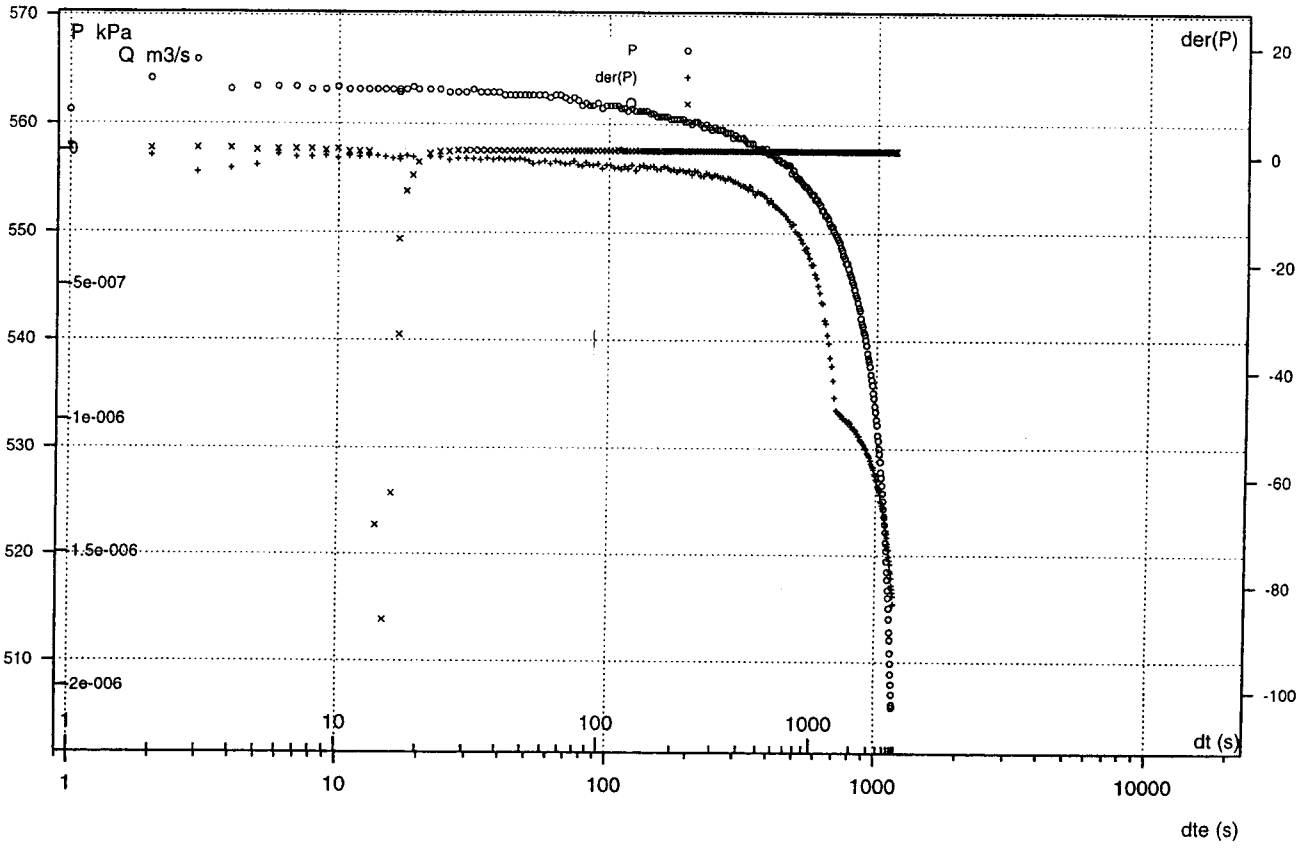
Fri Feb 12 13:58:54 1999

Borehole: 3550G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-12 10:43:45



Fri Feb 12 13:58:54 1999

Borehole KA3550G01, section 1.25 m – 1.75 m

Date: 99-01-12 Field Crew: B. Gentzschein

Valve opened: 990112 143927 Valve closed: 990112 150100
Total flowing time: 21.6 min. Tot. Pr. Build-up time: 11.9 min.

Pressure before injection start (P_0, kPa) : 126.9
Pressure just before closing the valve (P_p, kPa) : 679.6
Pressure at the end of the recovery (P_f, kPa) : 663.2

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

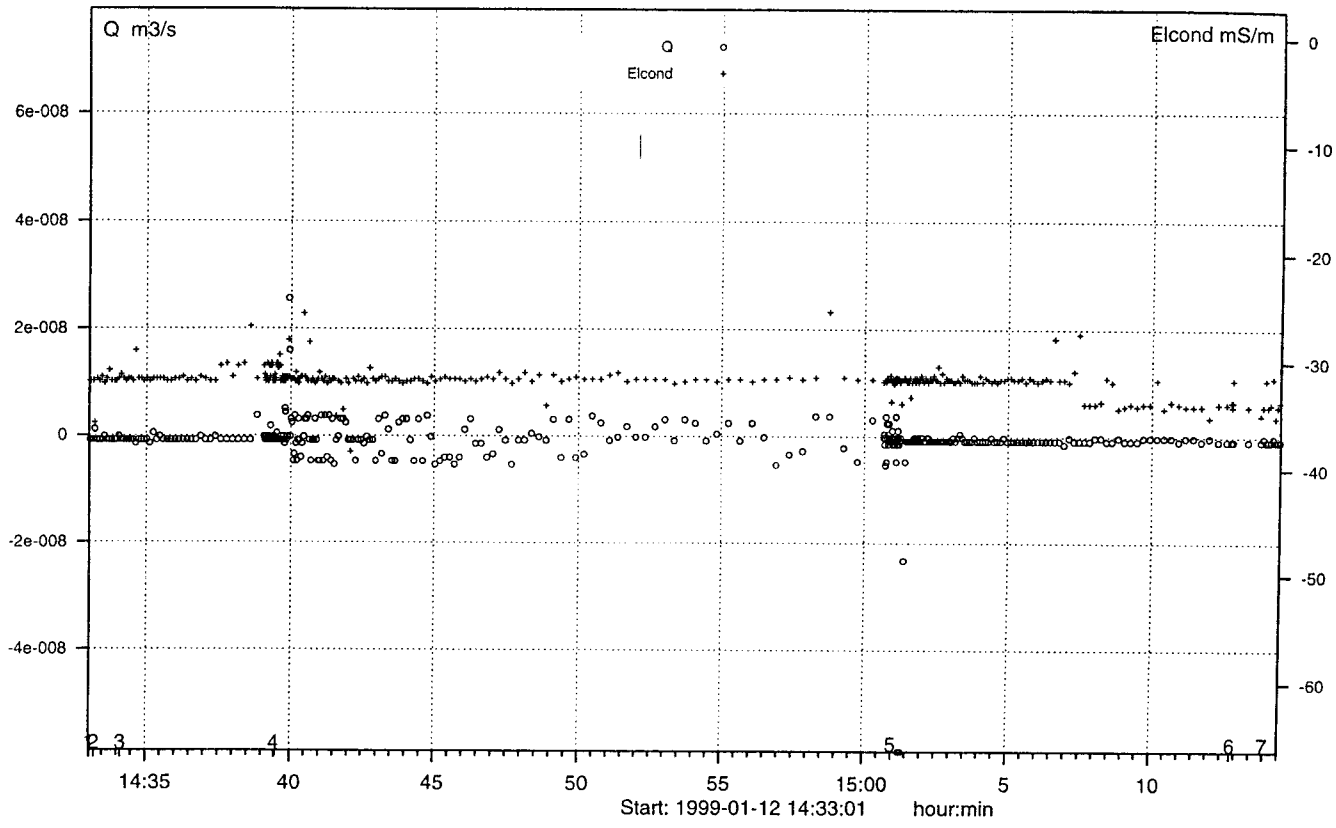
Initially the pressure increased to >700 kPa. Thereafter it decreased, but the pre-set value was not reached before the end of the flowing period

Borehole: 3550G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-12 14:32:51



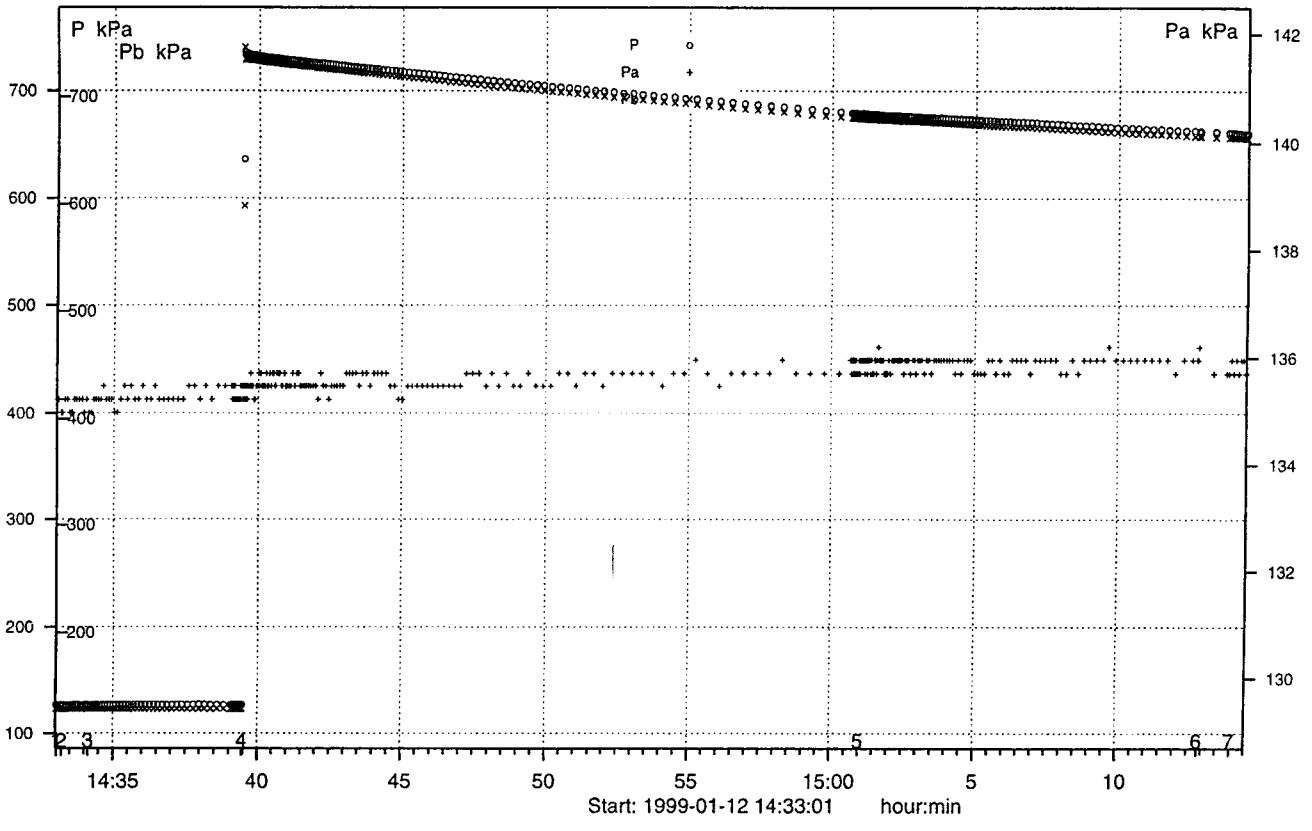
Fri Feb 12 14:11:11 1999

Borehole: 3550G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-12 14:32:51



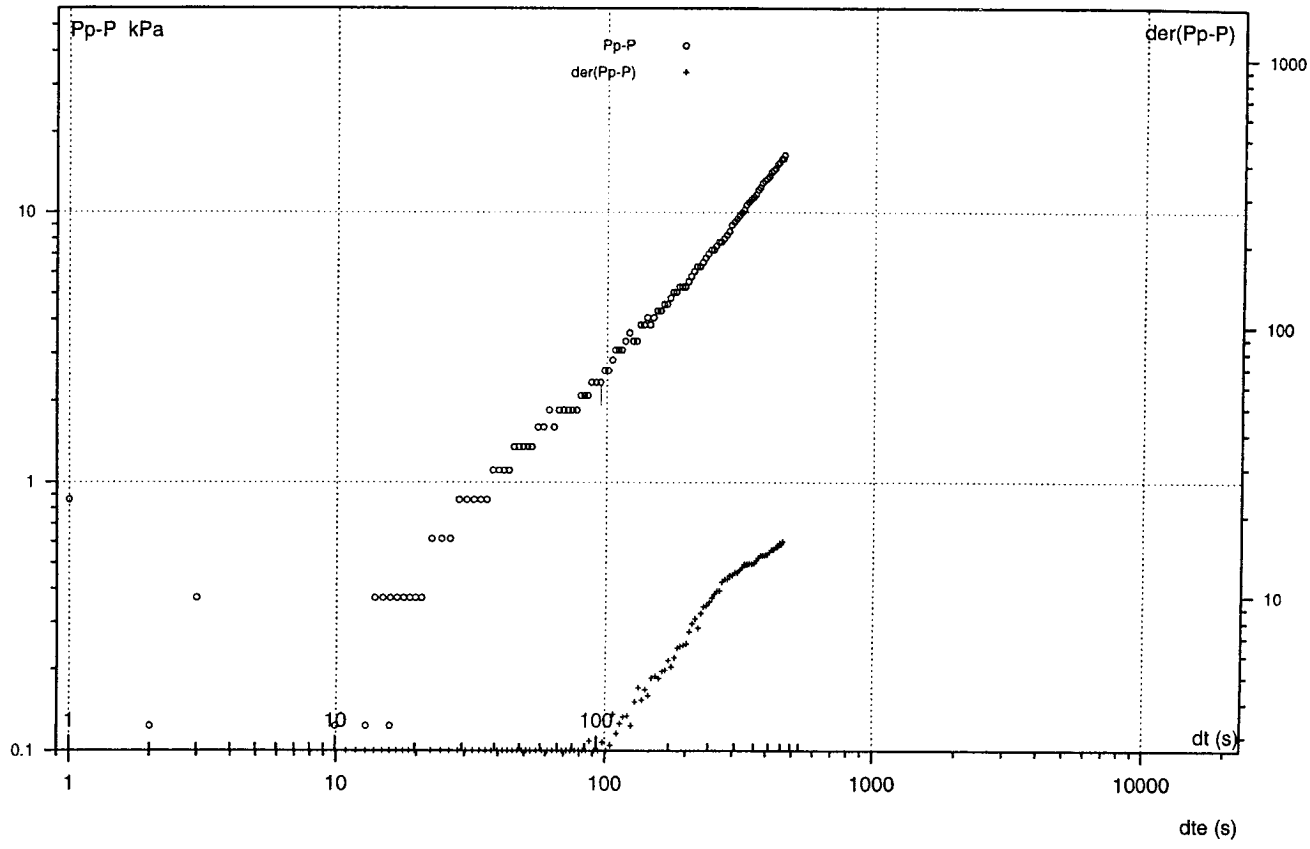
Fri Feb 12 14:11:11 1999

Borehole: 3550G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-12 14:32:51



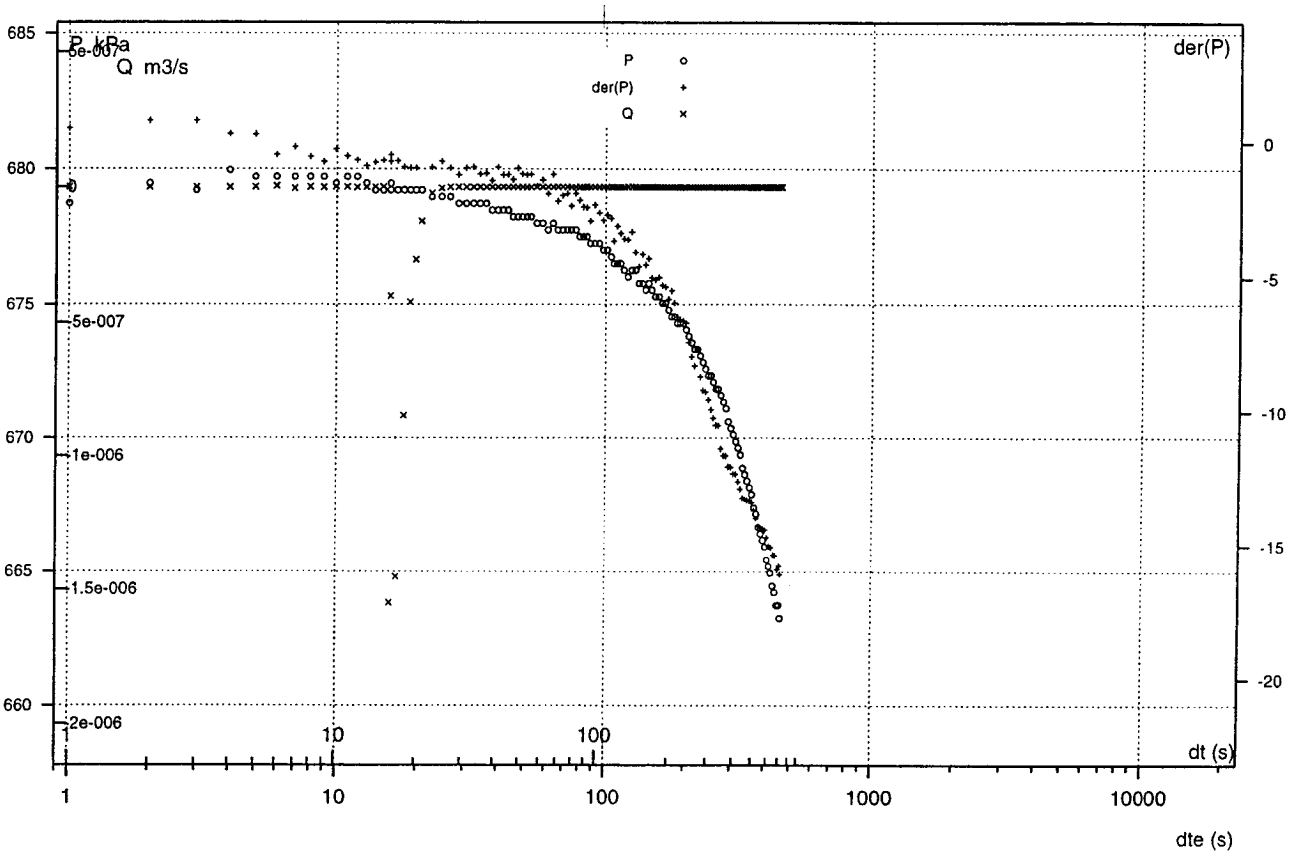
Fri Feb 12 14:11:12 1999

Borehole: 3550G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-12 14:32:51



Fri Feb 12 14:11:12 1999

Borehole KA3552G01, section 0.25 m - 0.75 m

Date: 99-01-12 Field Crew: B. Gentzschein

Valve opened: 990112 163013 Valve closed: 990112 164151
Total flowing time: 21.5 min. Tot. Pr. Build-up time: 20.0 min.

Pressure before injection start (P_0, kPa) : 127.2
Pressure just before closing the valve (P_p, kPa) : 560.7
Pressure at the end of the recovery (P_f, kPa) : 538.4

Pre-set section pressure (during injection) (P_{ref}, kPa) : 540

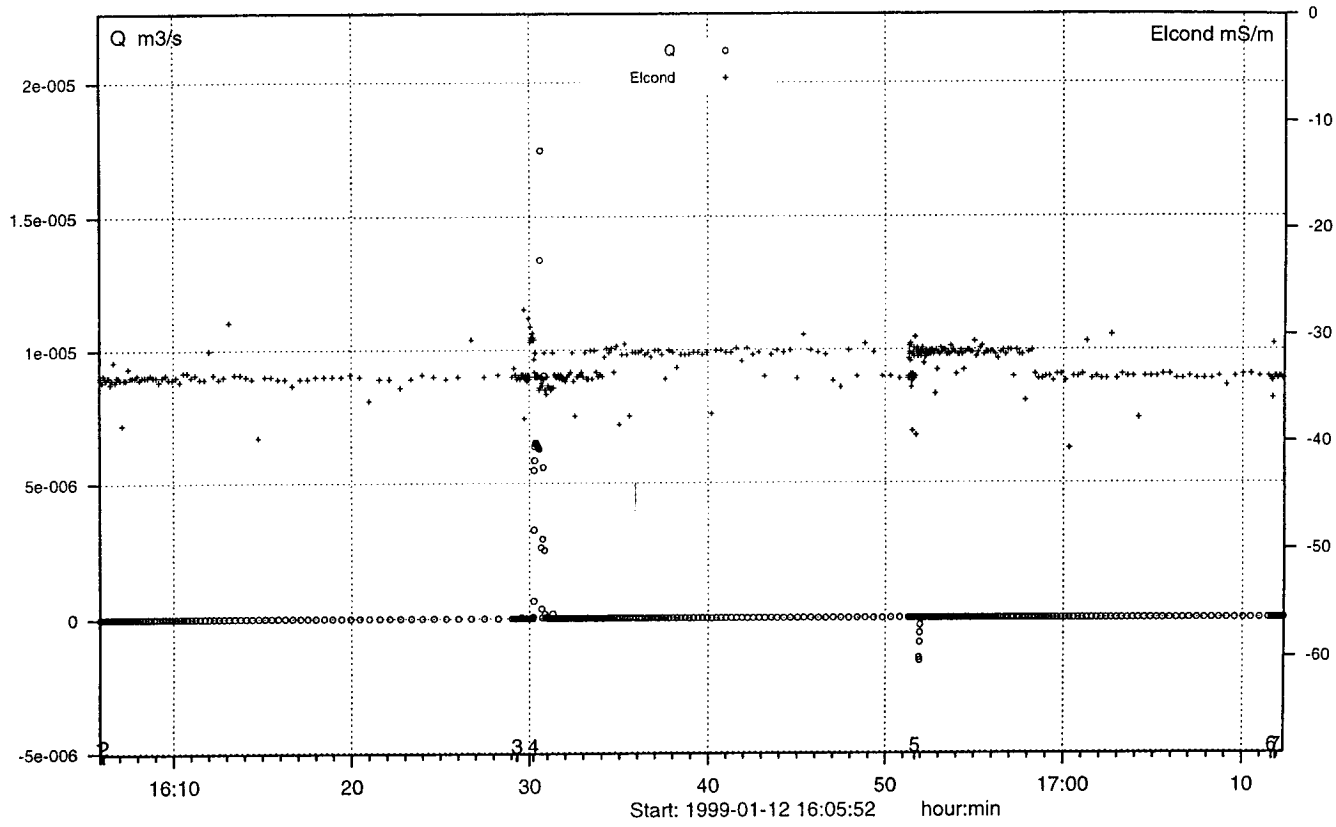
The injection pressure is relatively stable, but the recovery is only c. 5%.

Borehole: 3552G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-12 16:05:43



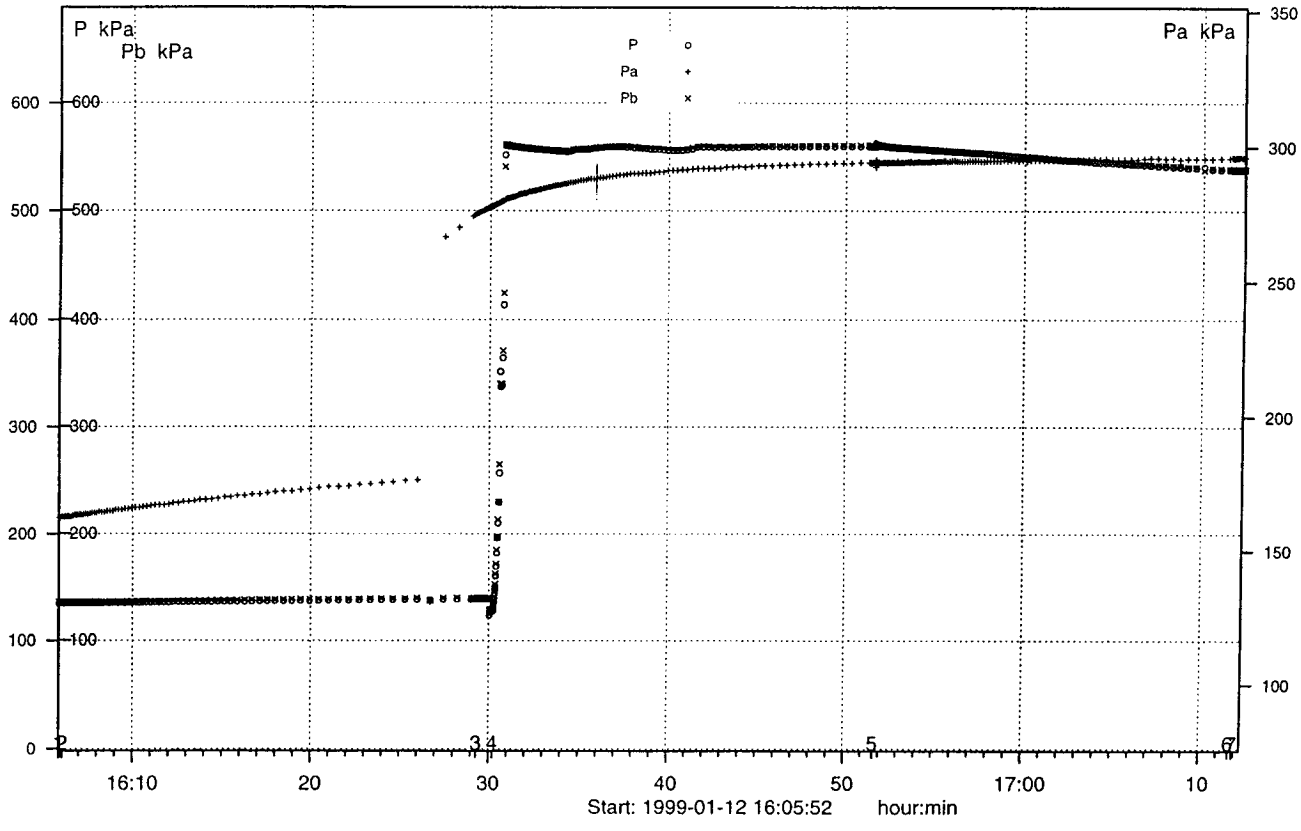
Fri Feb 12 14:20:43 1999

Borehole: 3552G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-12 16:05:43



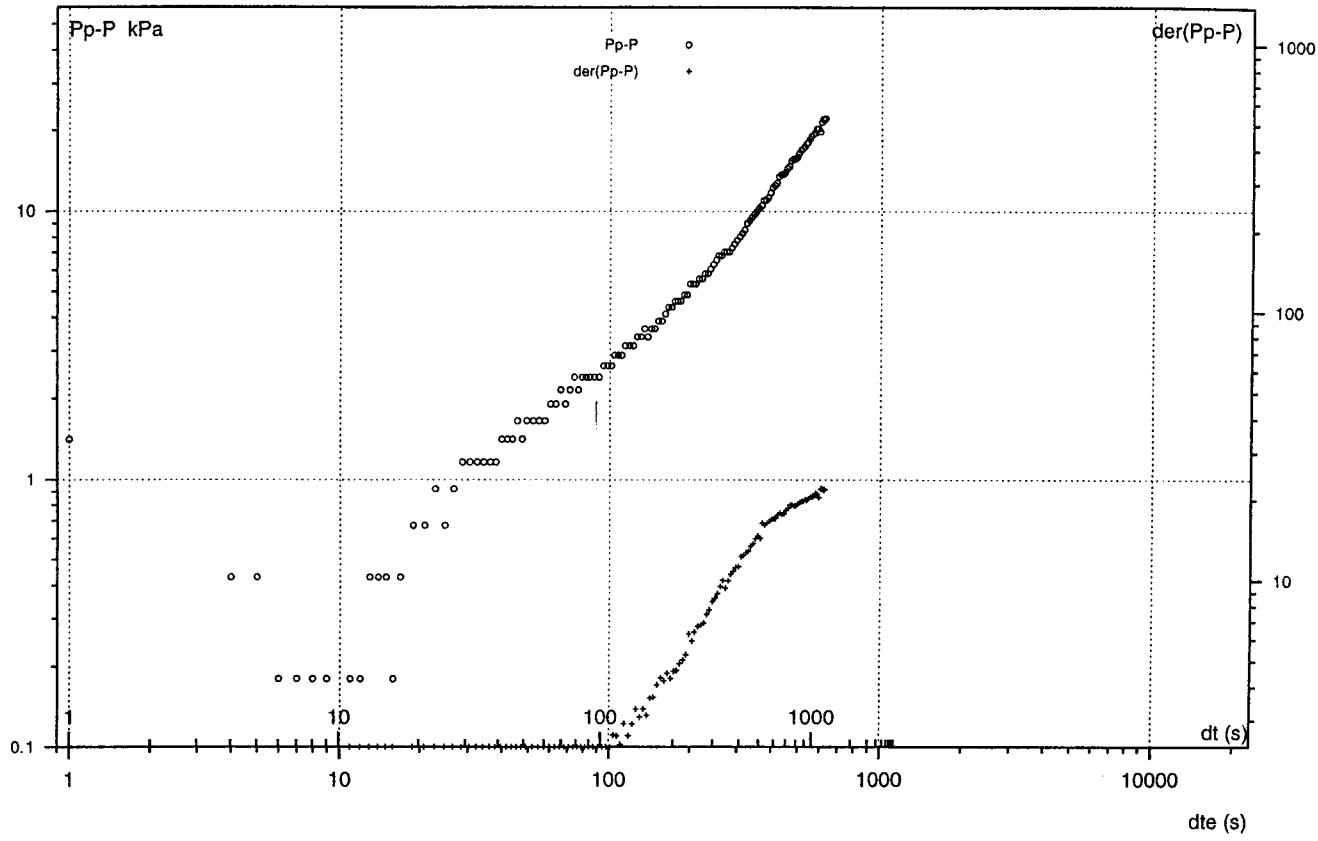
Fri Feb 12 14:20:43 1999

Borehole: 3552G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-12 16:05:43



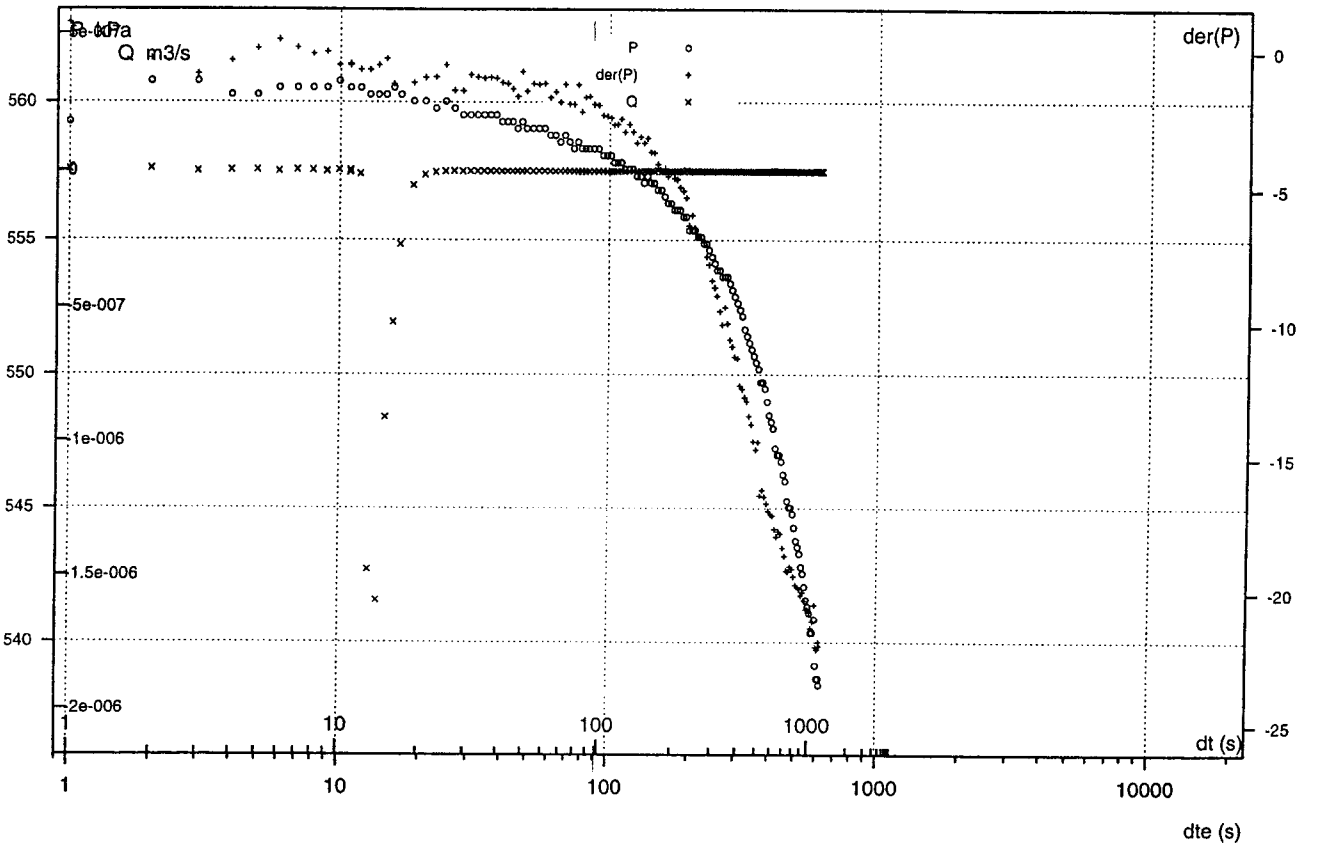
Fri Feb 12 14:20:43 1999

Borehole: 3552G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-12 16:05:43



Fri Feb 12 14:20:43 1999

Borehole KA3552G01, section 0.75 m – 1.25 m

Date: 99-01-12 Field Crew: B. Gentzschein

Valve opened: 990112 180507 Valve closed: 990112 182510
Total flowing time: 20.1 min. Tot. Pr. Build-up time: 11.2 min.

Pressure before injection start (P_0, kPa) : 125.1
Pressure just before closing the valve (P_p, kPa) : 788.3
Pressure at the end of the recovery (P_f, kPa) : 762.8

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

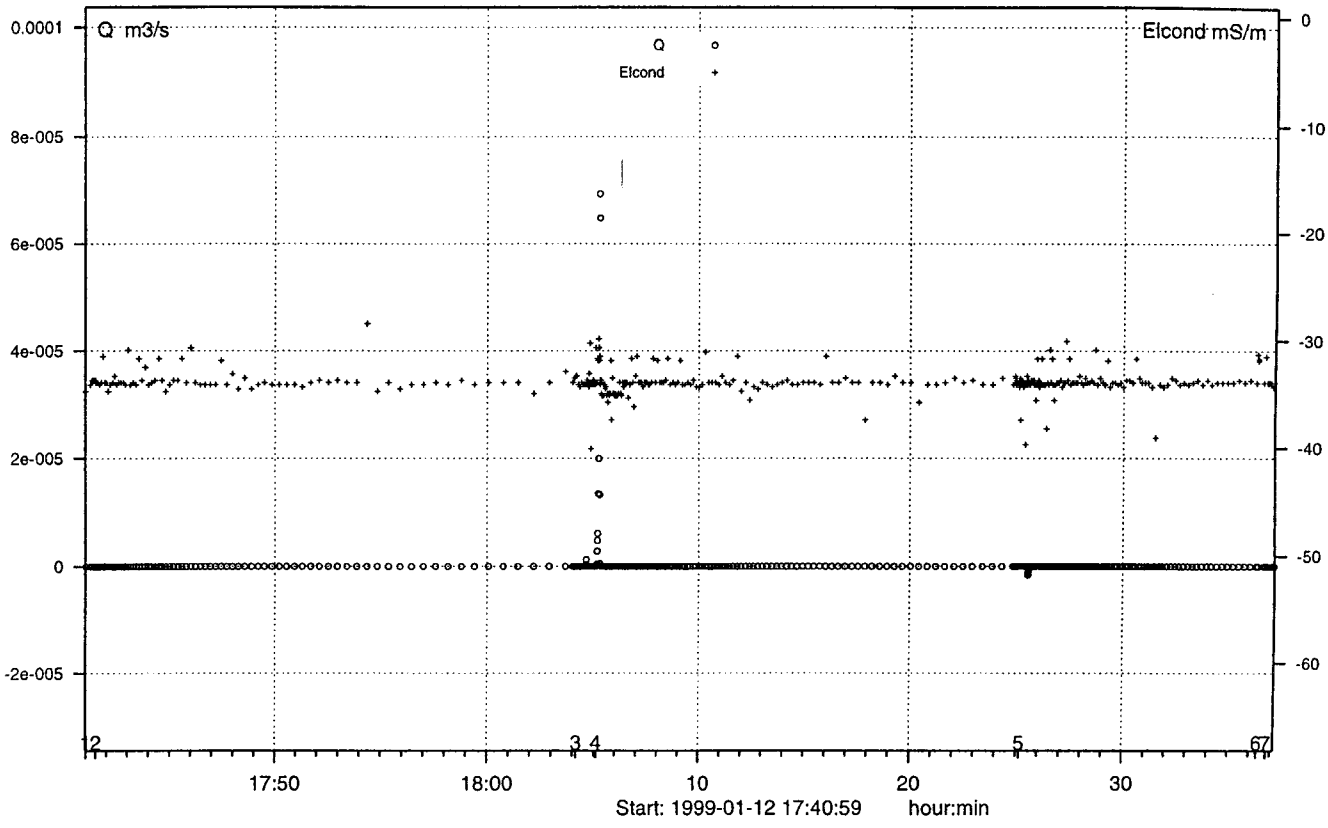
Initially the pressure increased to >870 kPa. Then it didn't reach down to the pre-set value before the injection stop.

Borehole: 3552G01

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-12 17:40:48



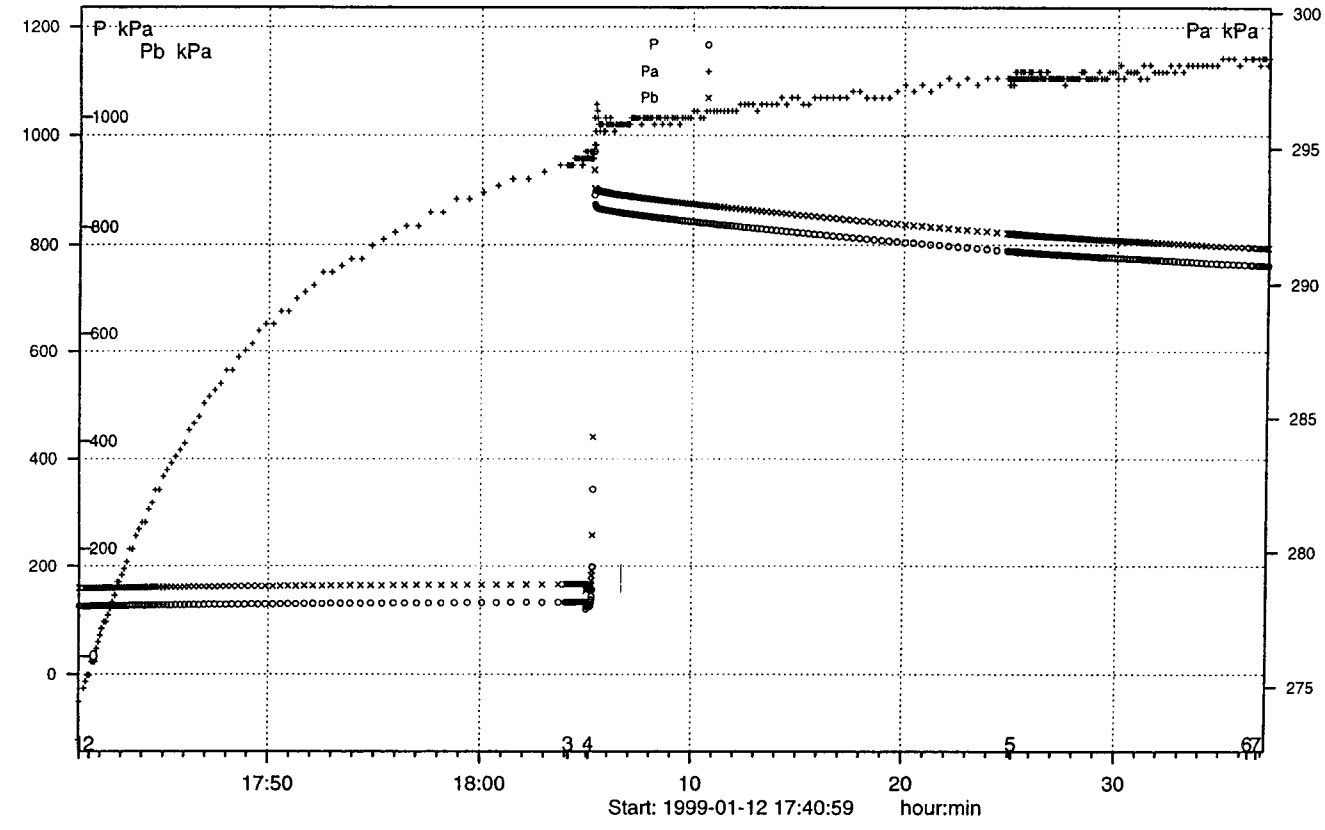
Fri Feb 12 14:27:03 1999

Borehole: 3552G01

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-12 17:40:48



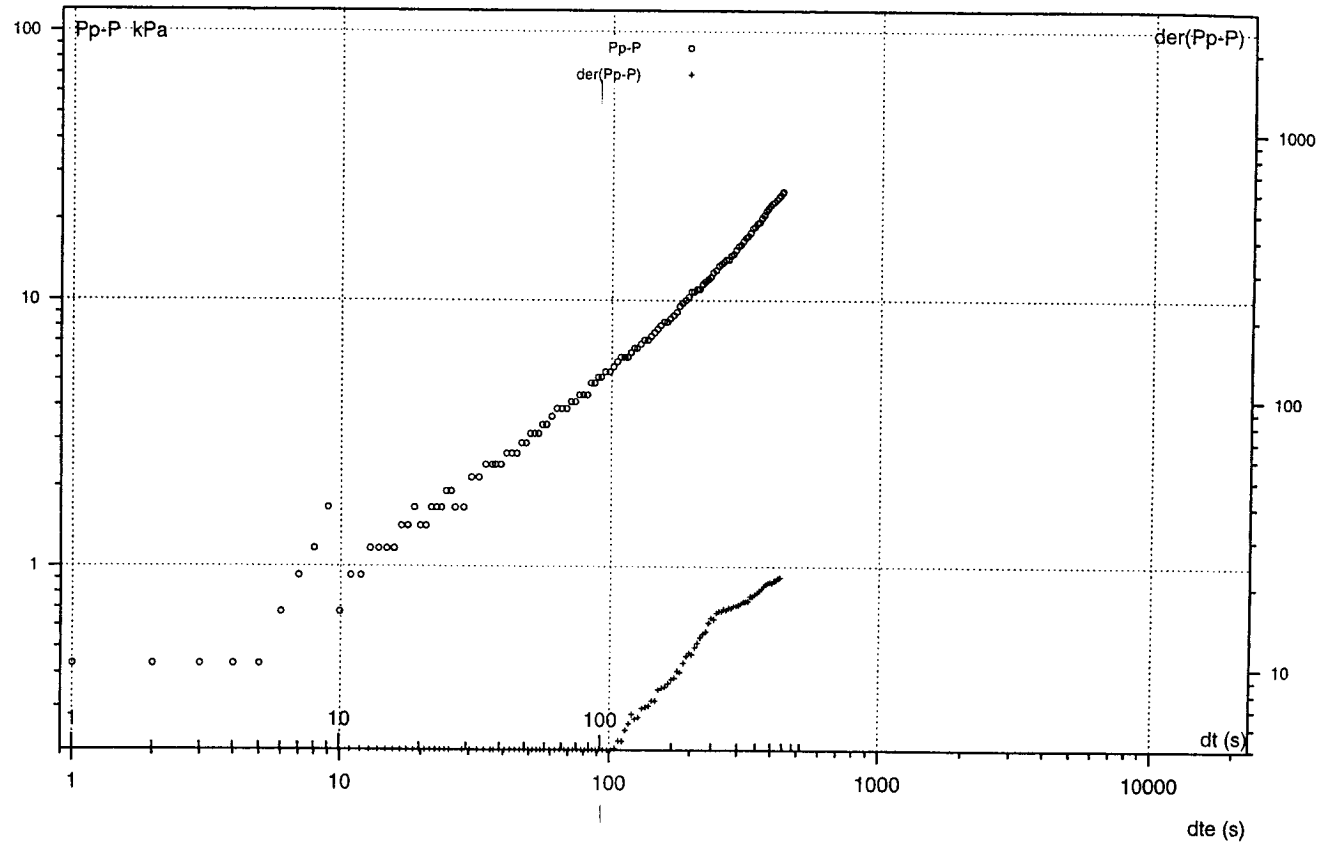
Fri Feb 12 14:27:03 1999

Borehole: 3552G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-12 17:40:48



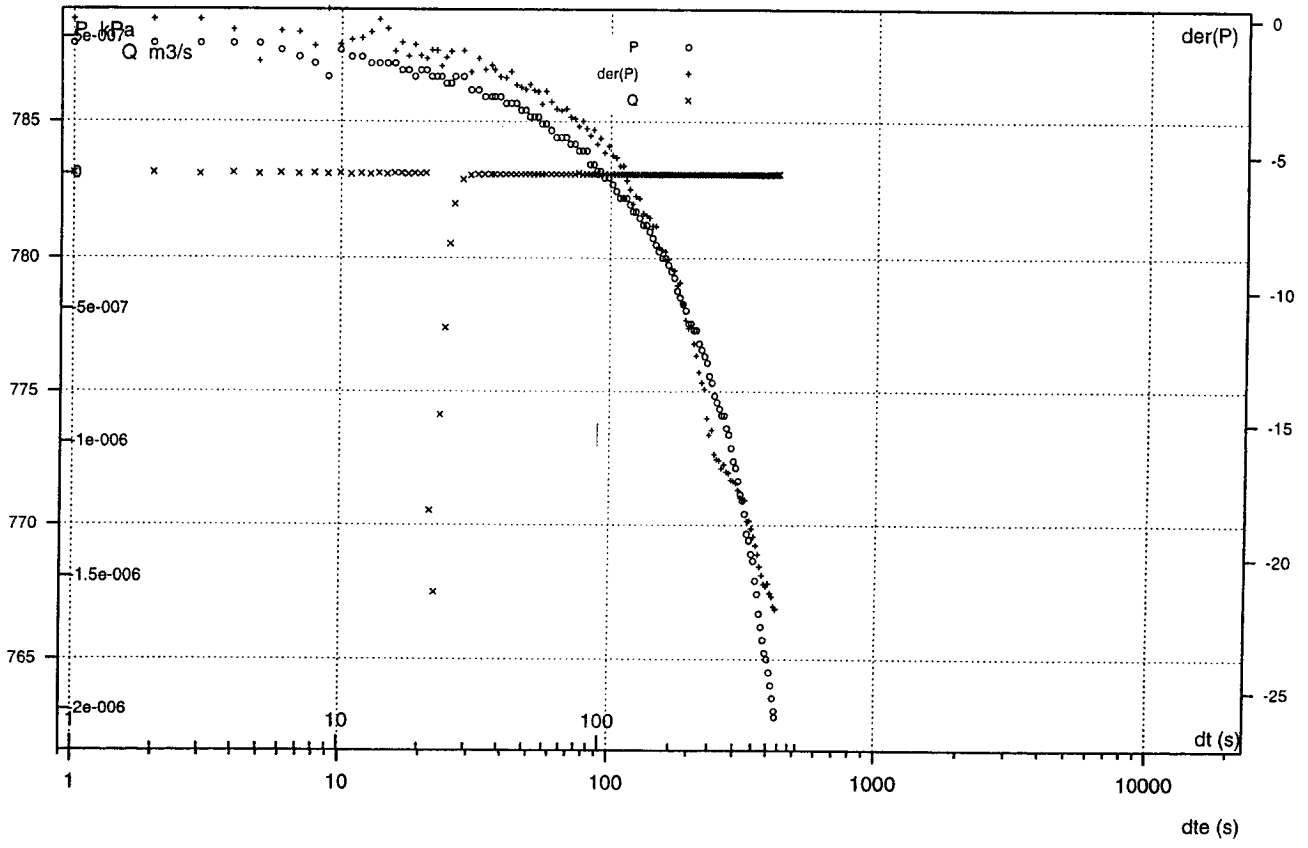
Fri Feb 12 14:27:04 1999

Borehole: 3552G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-12 17:40:48



Fri Feb 12 14:27:03 1999

Borehole KA3552G01, section 1.25 m – 1.75 m

Date: 99-01-12 Field Crew: B. Gentzschein

Valve opened: 990112 191647 Valve closed: 990112 193643
Total flowing time: 20.0 min. Tot. Pr. Build-up time: 769.8 min.

Pressure before injection start (P_0, kPa) : 129.1
Pressure just before closing the valve (P_p, kPa) : 528.4
Pressure at the end of the recovery (P_f, kPa) : 552.9

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

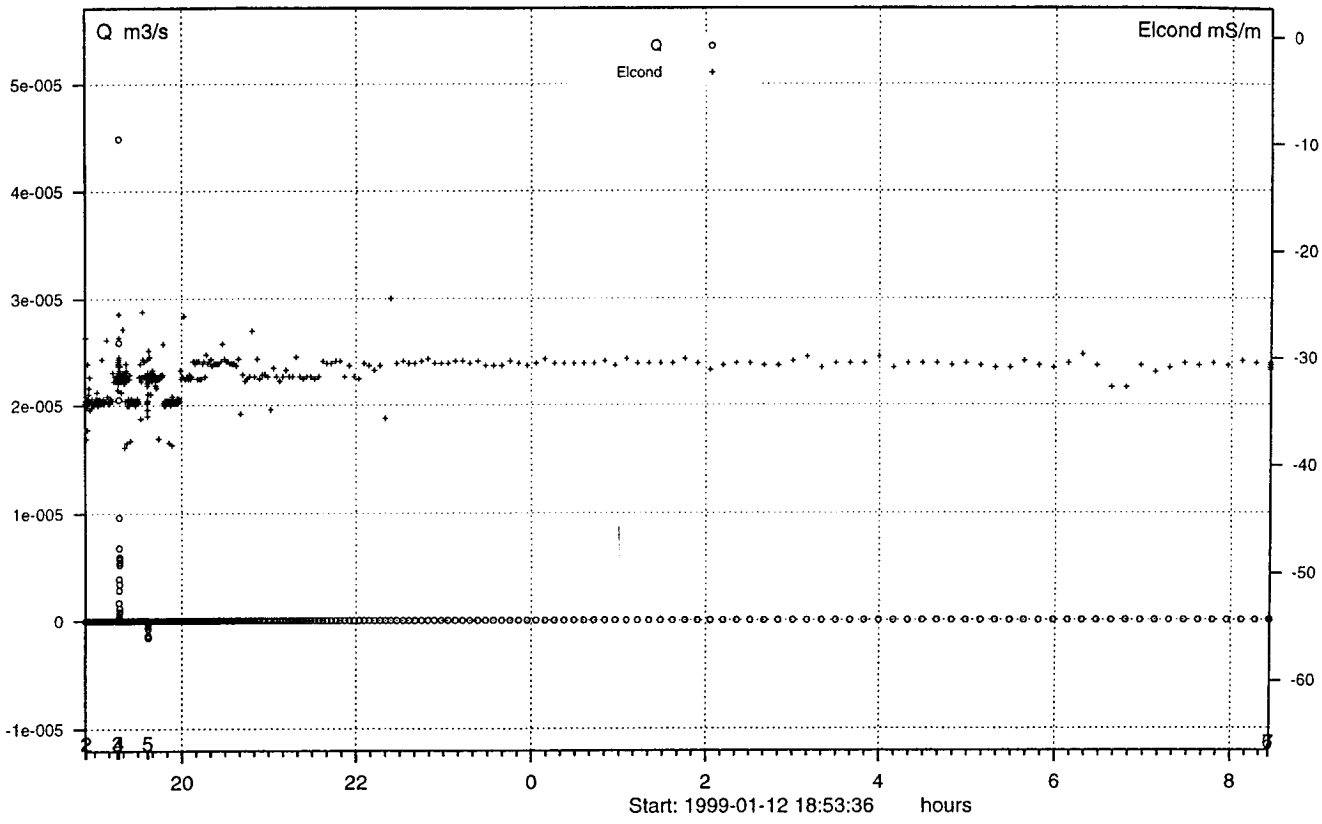
The flow at the end, Qp, is negative (-6.496e-10 m^3/s). This is within the limits of the zero stability, $\pm 1.67 \cdot 10^{-9}$ m^3/s (0.0001 kg/min), see chapter 4. During the recovery, lasting over night, the pressure is increasing.

Borehole: 3552G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-12 18:53:27



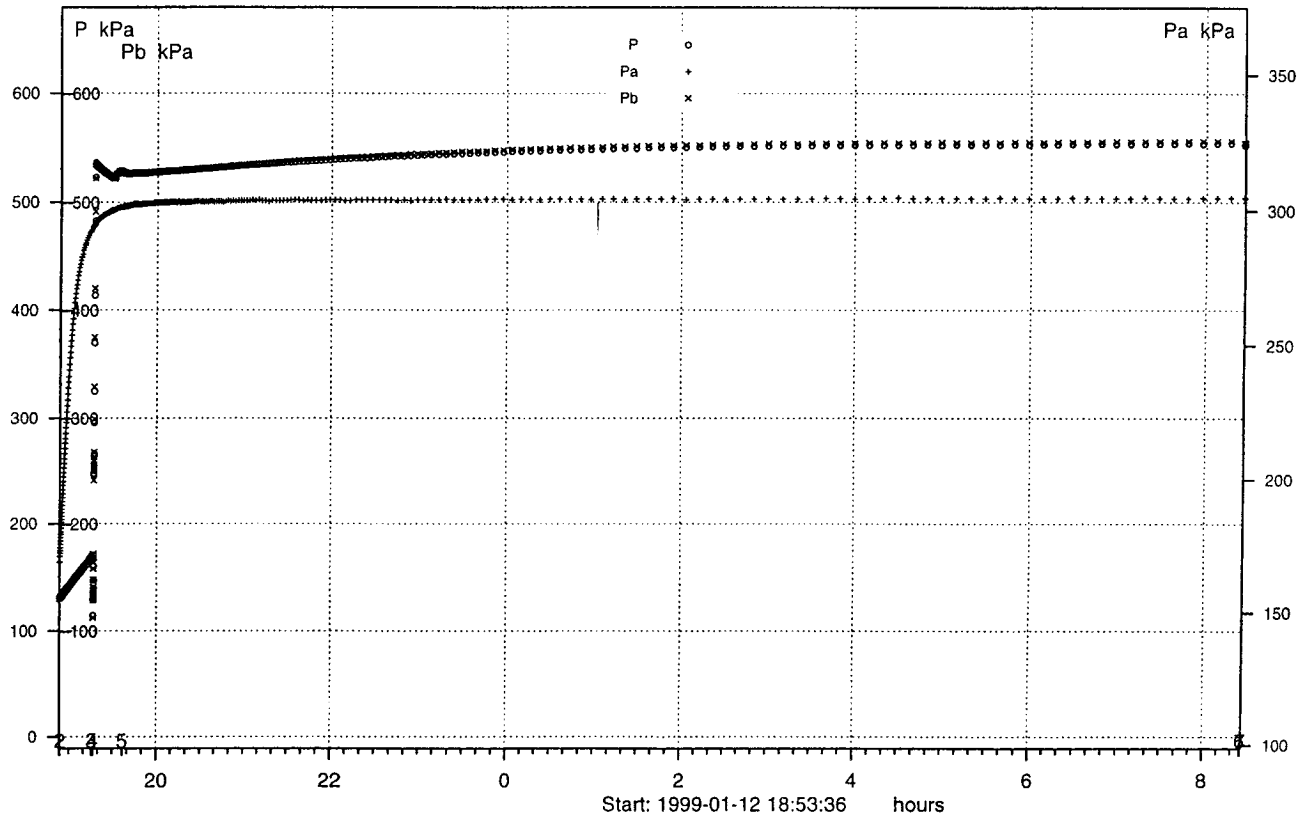
Fri Feb 12 14:35:33 1999

Borehole: 3552G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-12 18:53:27



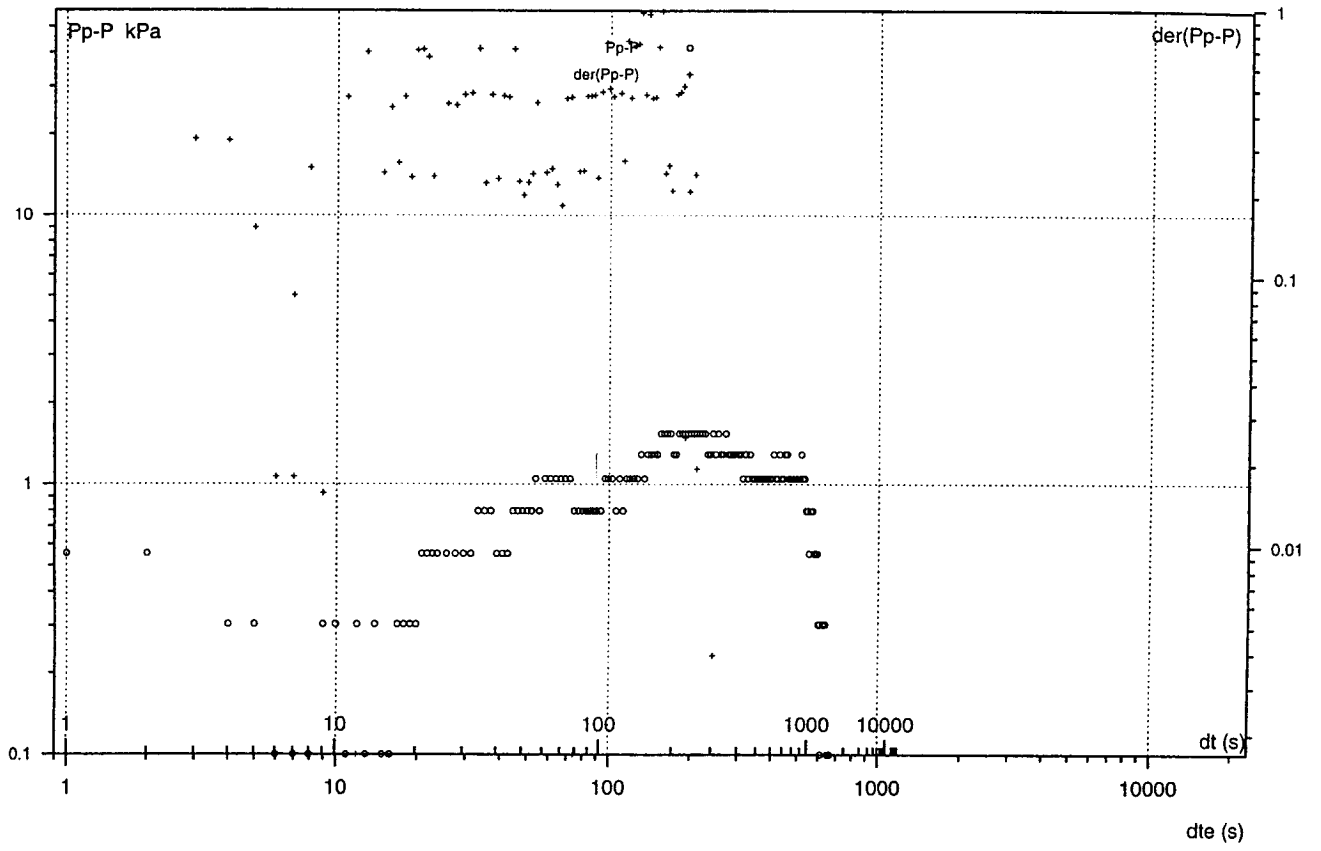
Fri Feb 12 14:35:33 1999

Borehole: 3552G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-12 18:53:27



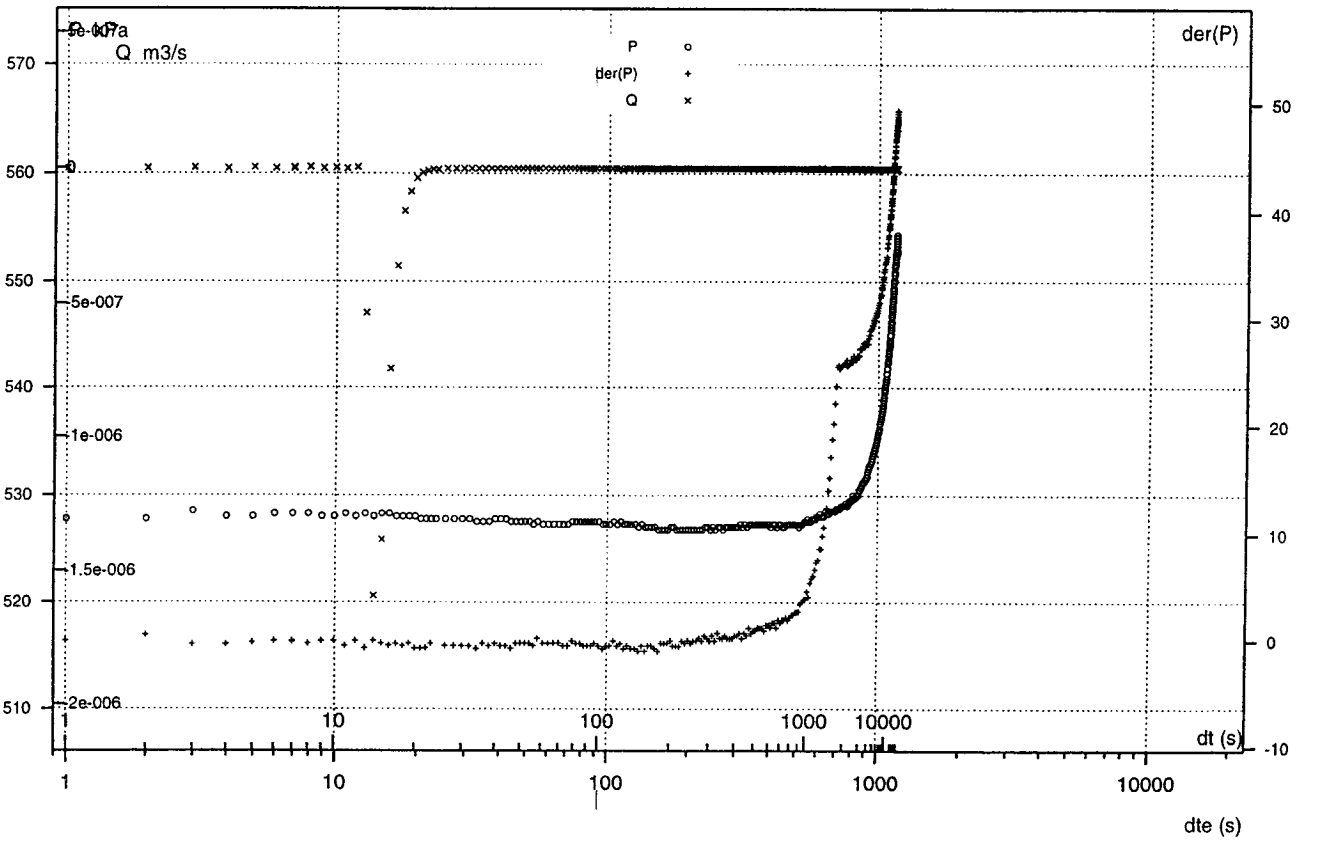
Fri Feb 12 14:35:34 1999

Borehole: 3552G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-12 18:53:27



Fri Feb 12 14:35:34 1999

Borehole KA3554G02, section 0.25 m - 0.75 m

Date: 99-01-13 Field Crew: B. Gentzschein

Valve opened: 990113 095351 Valve closed: 990113 102009
Total flowing time: 26.3 min. Tot. Pr. Build-up time: 11.2 min.

Pressure before injection start (P_0, kPa) : 116.5
Pressure just before closing the valve (P_p, kPa) : 600.2
Pressure at the end of the recovery (P_f, kPa) : 452.8

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

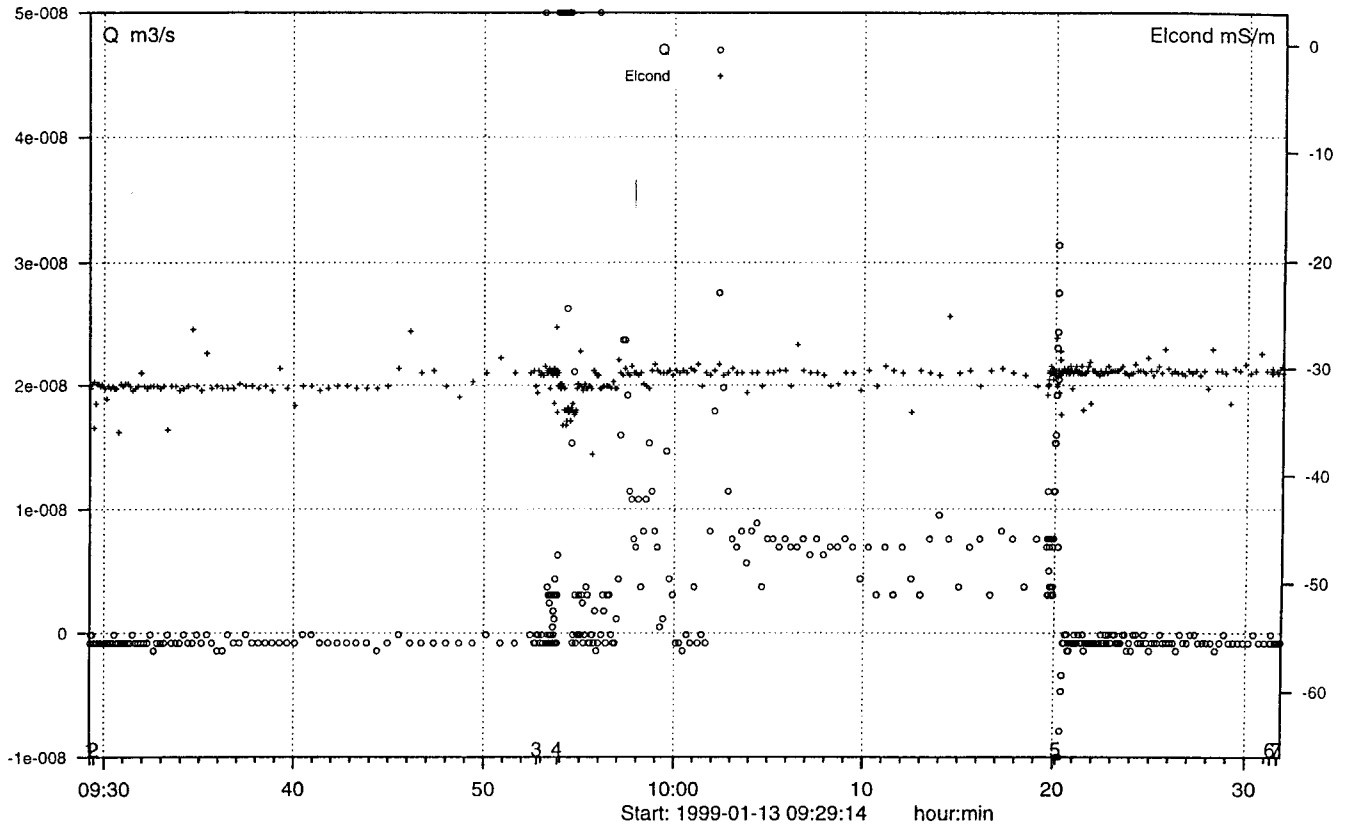
P_{ref} was increased to 590 kPa.

Borehole: 3554G02

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-13 09:29:04



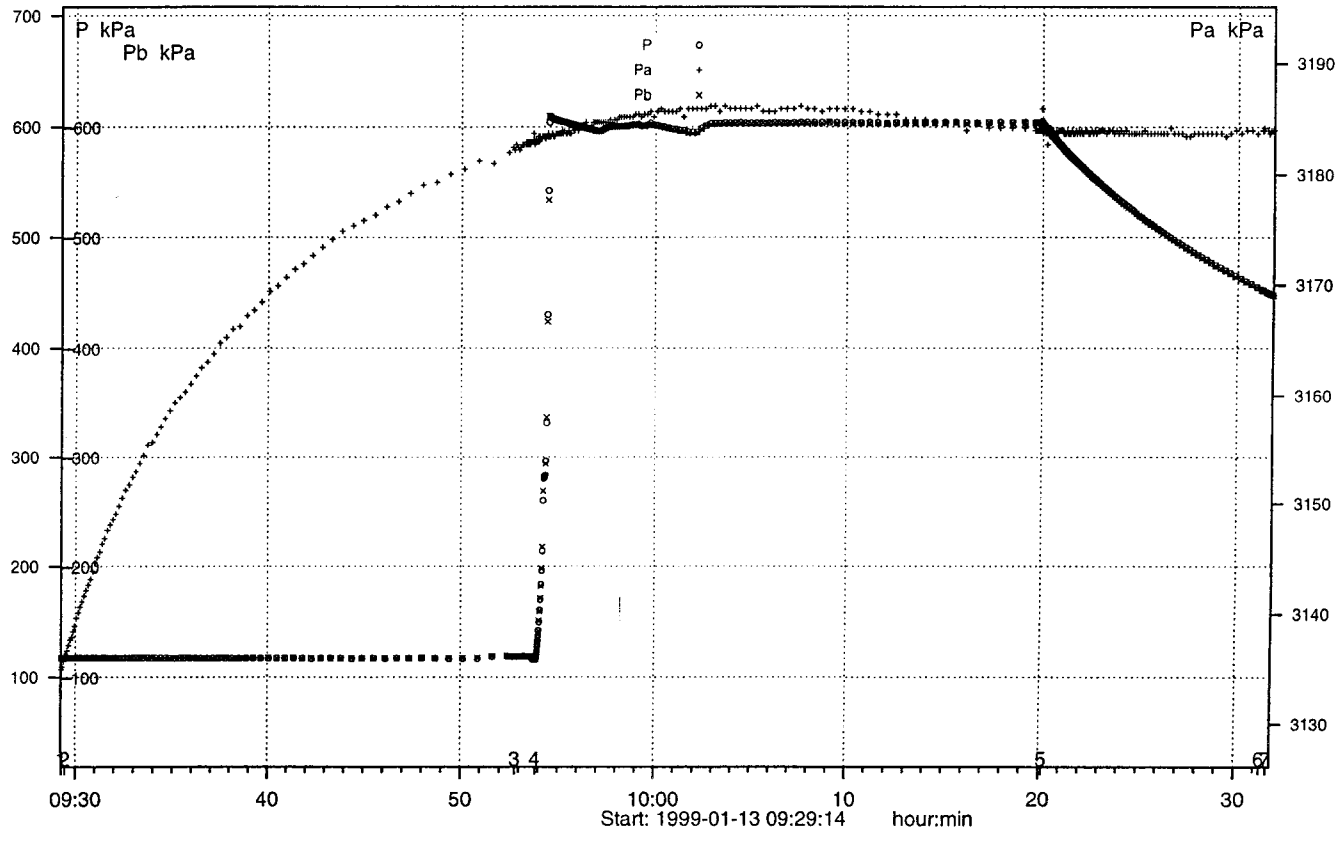
Mon May 03 09:07:06 1999

Borehole: 3554G02

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-13 09:29:04



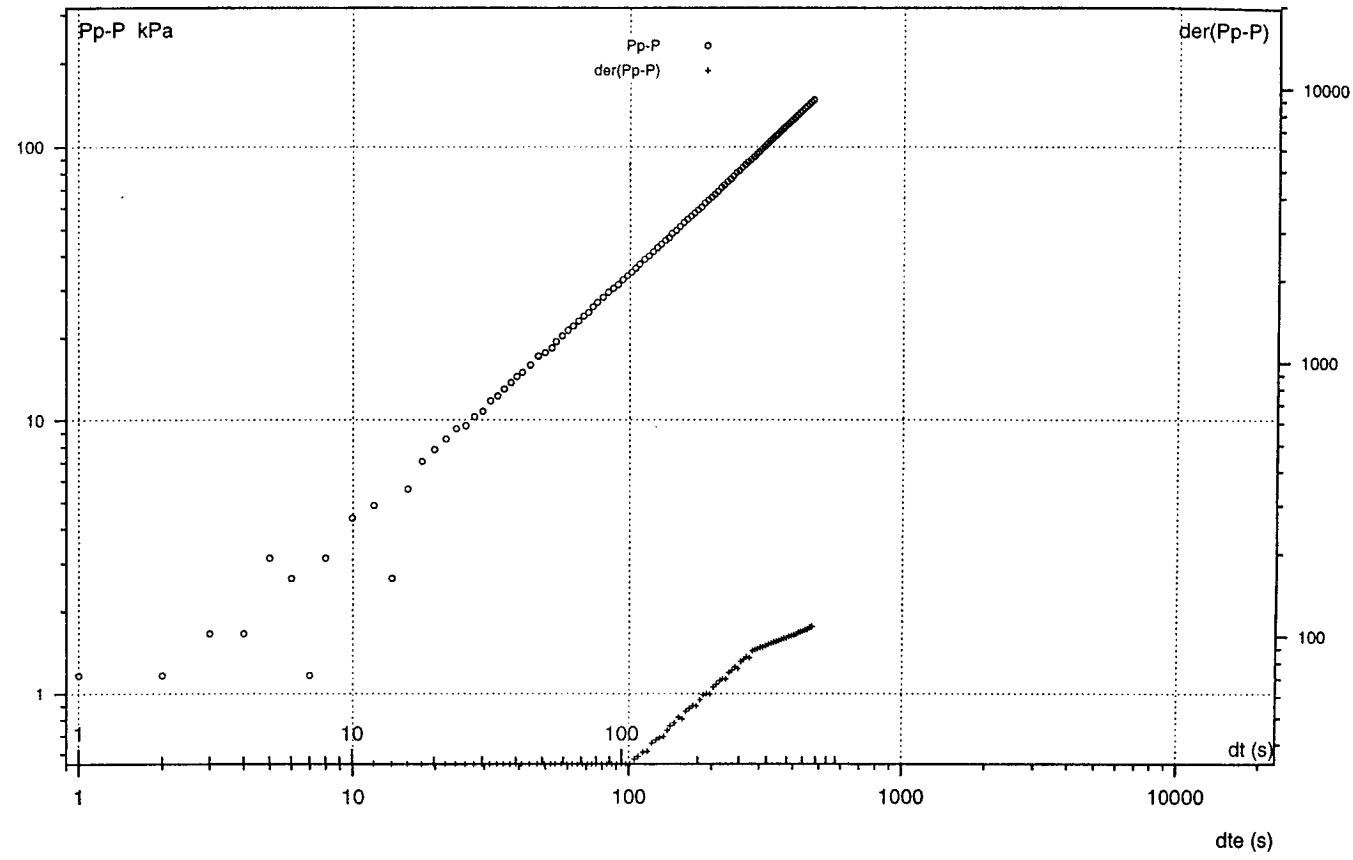
Mon May 03 09:45:55 1999

Borehole: 3554G02

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-13 09:29:04



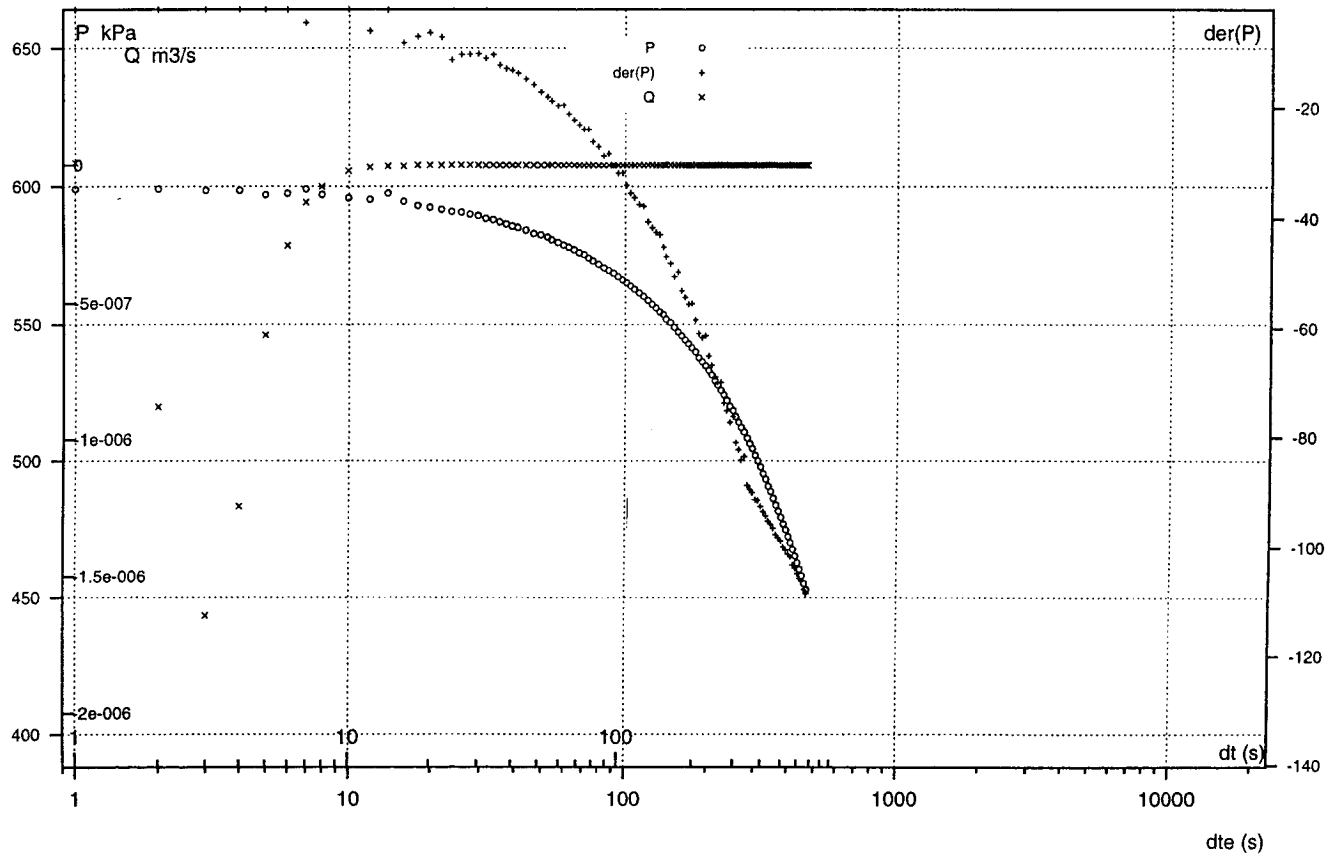
Mon May 03 09:48:13 1999

Borehole: 3554G02

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-13 09:29:04



Mon May 03 09:48:20 1999

Borehole KA3554G02, section 0.75 m – 1.25 m

Date: 99-01-13 Field Crew: B. Gentzschein

Valve opened: 990113 111733 Valve closed: 990113 114304
Total flowing time: 25.5 min. Tot. Pr. Build-up time: 74.5 min.

Pressure before injection start (P_0, kPa) : 117.6
Pressure just before closing the valve (P_p, kPa) : 517.4
Pressure at the end of the recovery (P_f, kPa) : 653.4

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

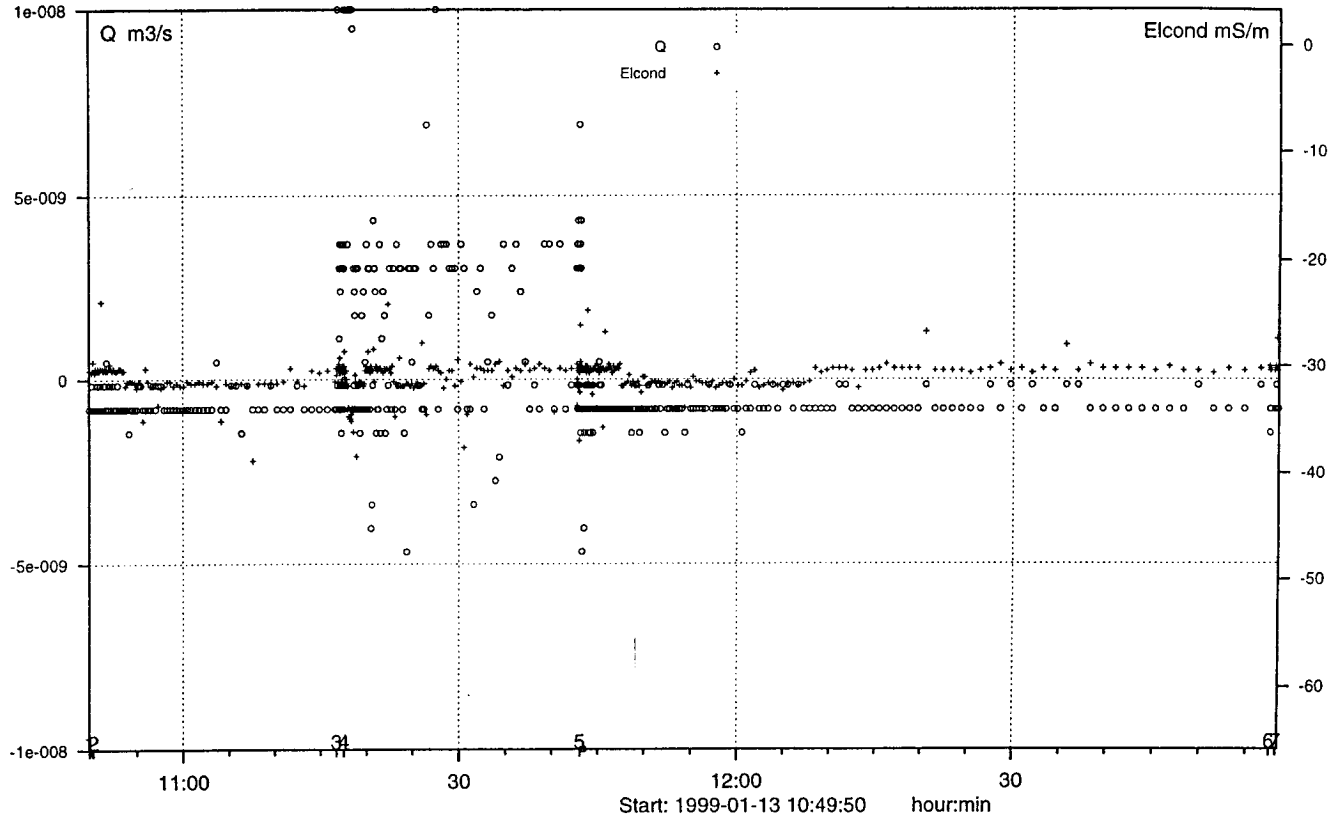
The pressure increased during the recovery period, possibly due to the high pressure in the borehole interval below the packers

Borehole: 3554G02

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-13 10:49:37



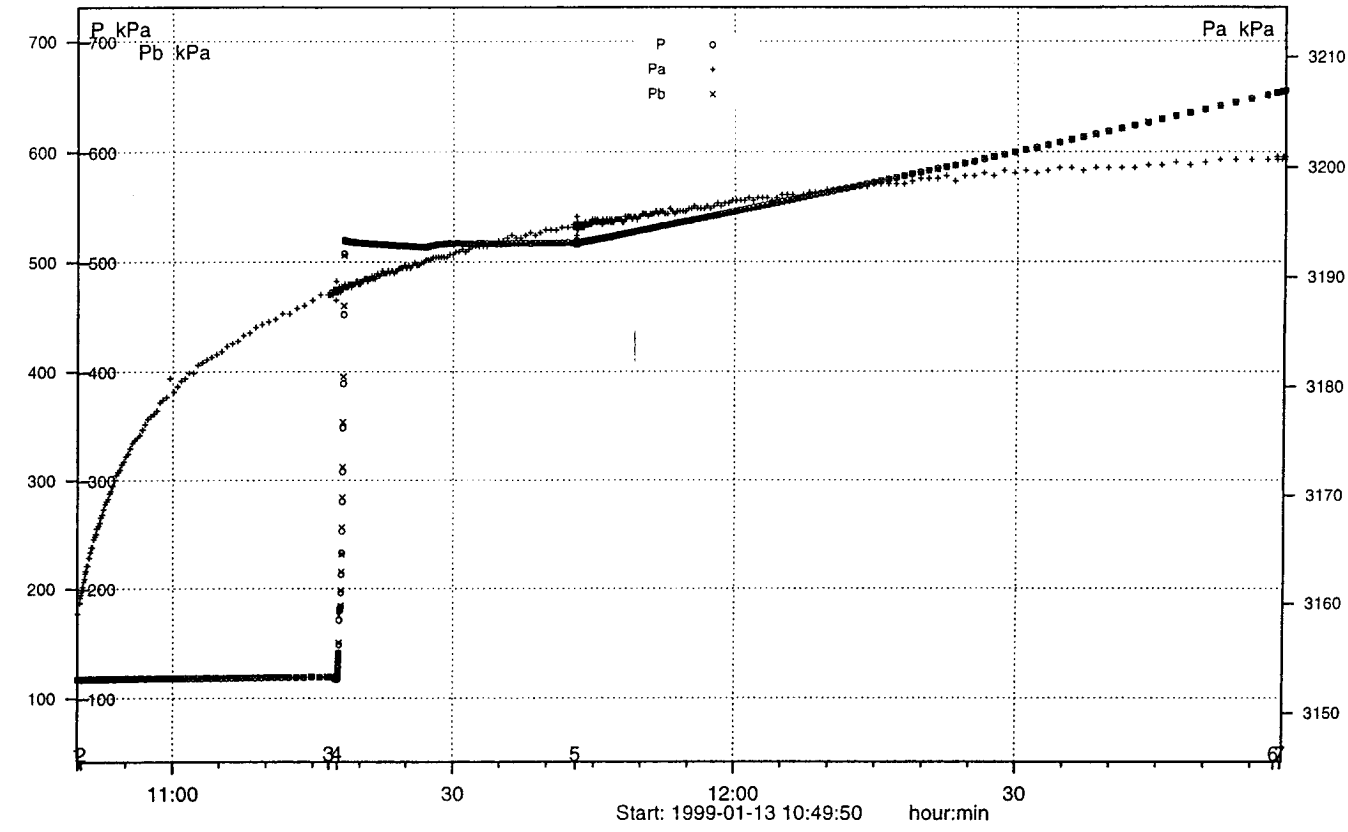
Mon May 03 09:57:25 1999

Borehole: 3554G02

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-13 10:49:37



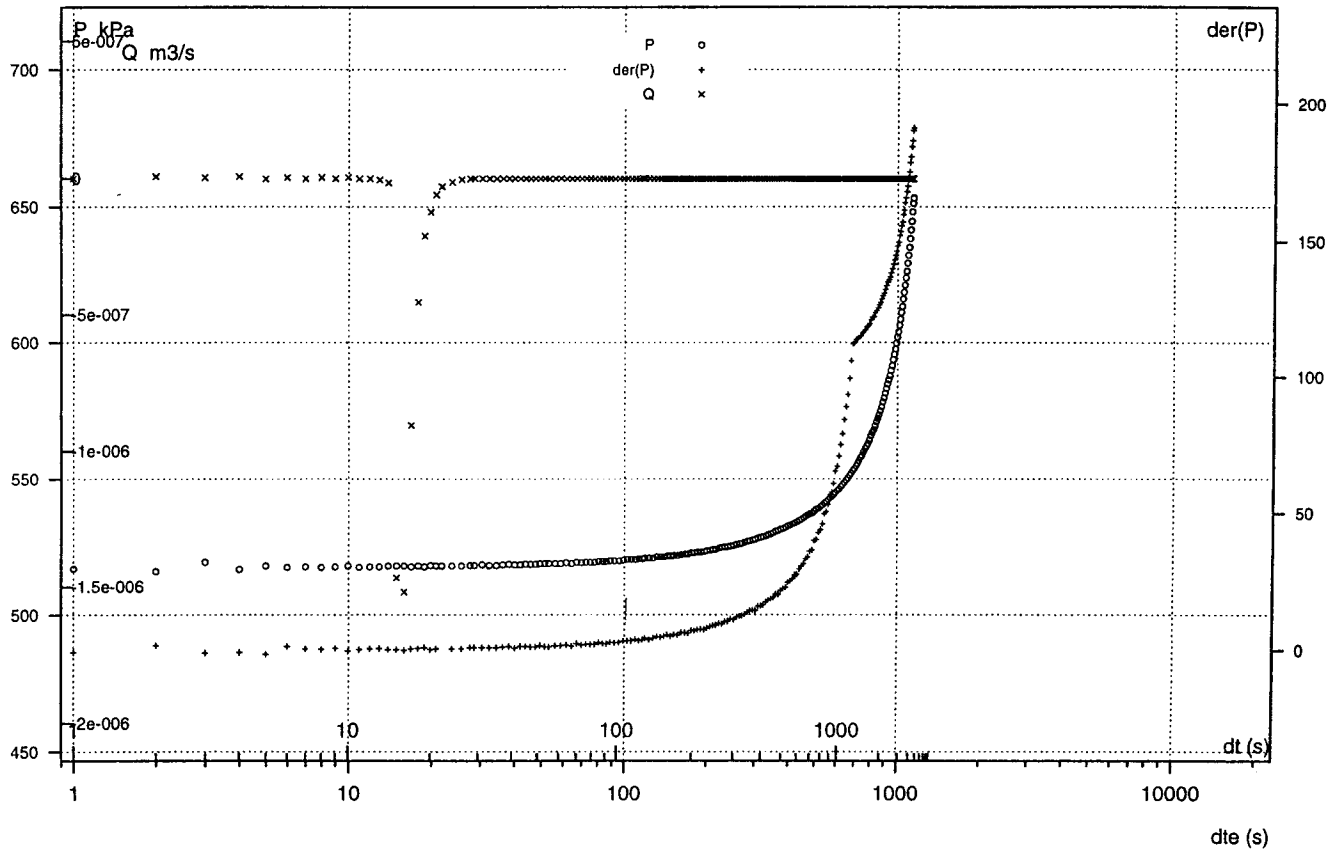
Mon May 03 09:57:36 1999

Borehole: 3554G02

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-13 10:49:37



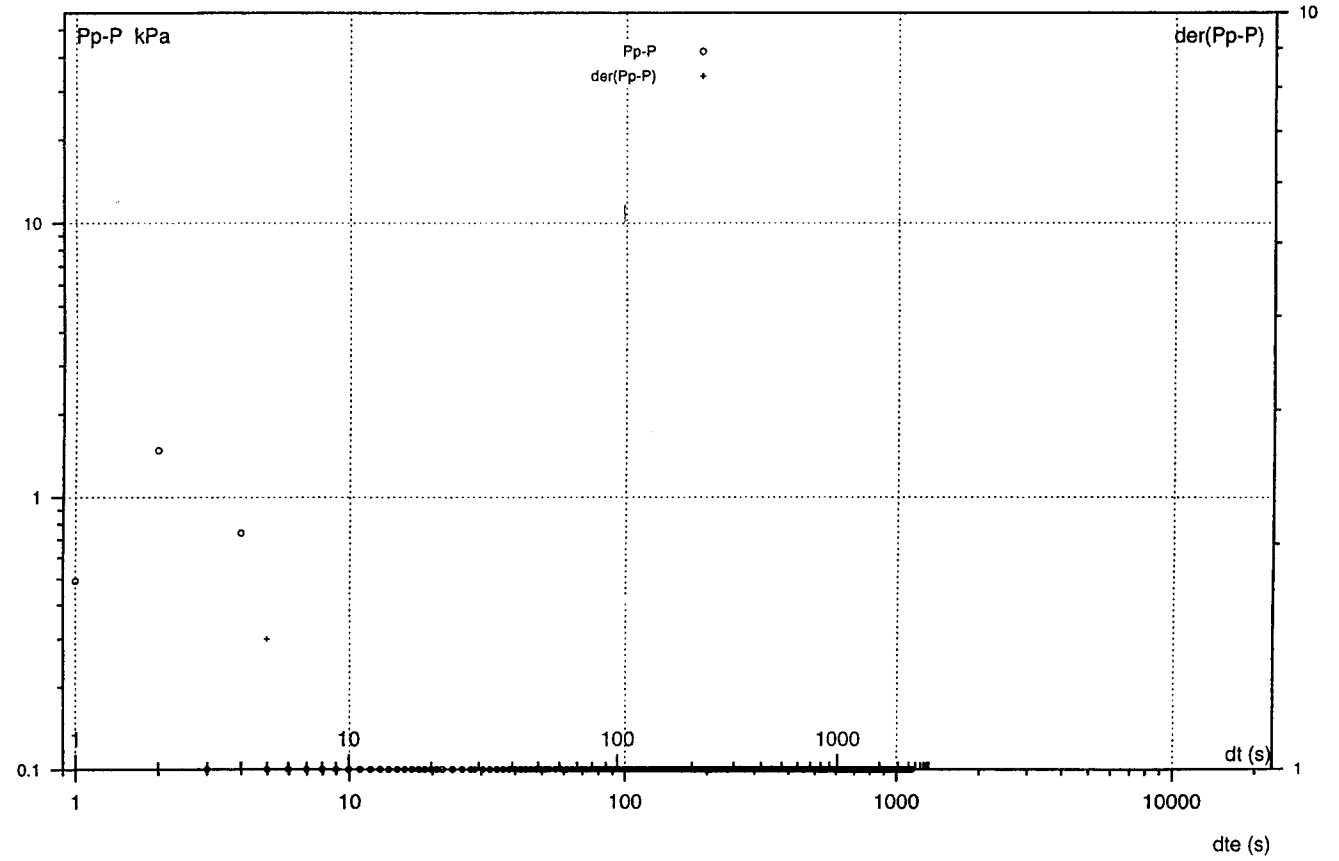
Mon May 03 09:59:41 1999

Borehole: 3554G02

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-13 10:49:37



Mon May 03 09:59:36 1999

Borehole KA3554G02, section 1.25 m – 1.75 m

Date: 99-01-13 Field Crew: B. Gentzschein

Valve opened: 990113 145509 Valve closed: 990113 151711
Total flowing time: 22.1 min. Tot. Pr. Build-up time: 14.8 min.

Pressure before injection start (P_0, kPa) : 118.1
Pressure just before closing the valve (P_p, kPa) : 571.2
Pressure at the end of the recovery (P_f, kPa) : 574.7

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

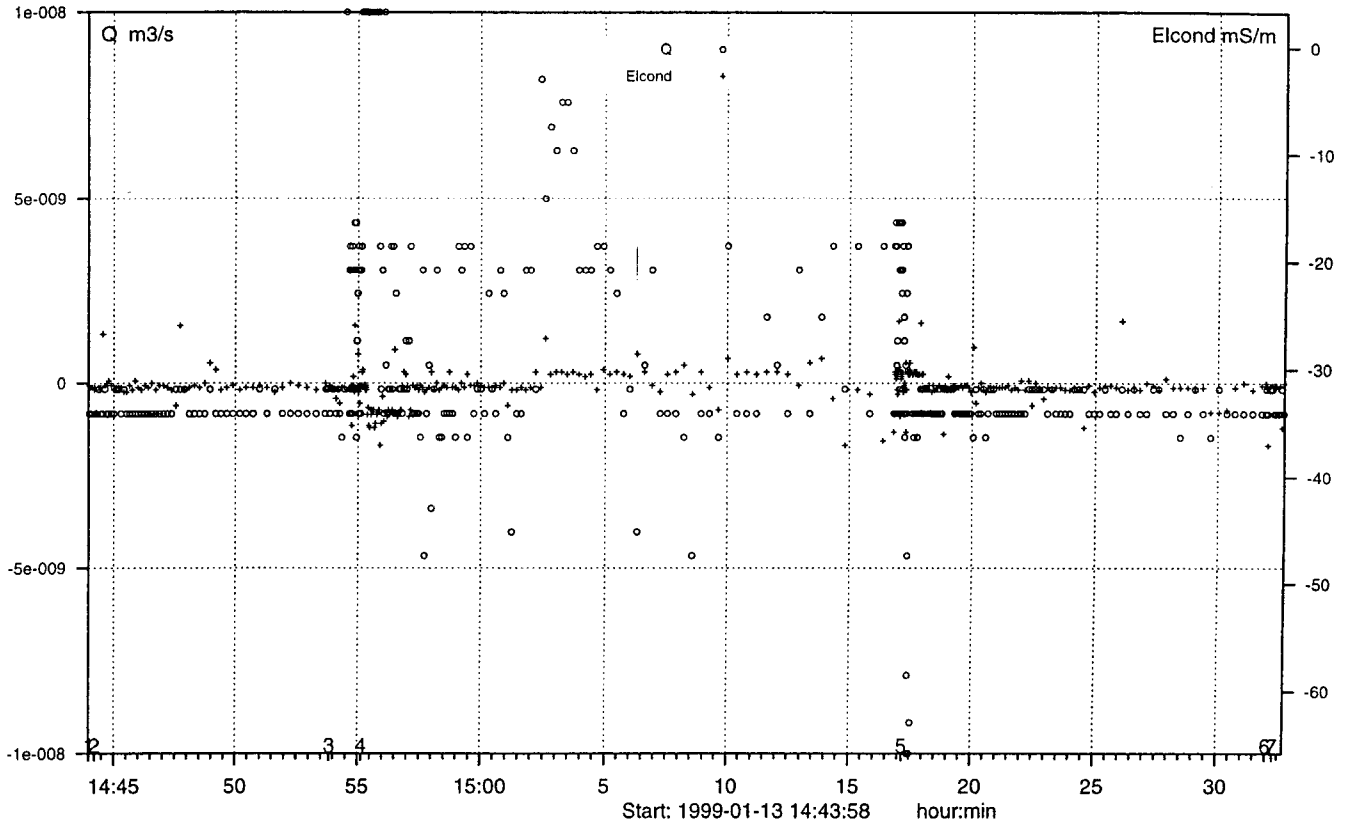
P_{ref} was increased to 550 kPa. A small pressure increase occurred during the recovery period.

Borehole: 3554G02

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-13 14:43:46



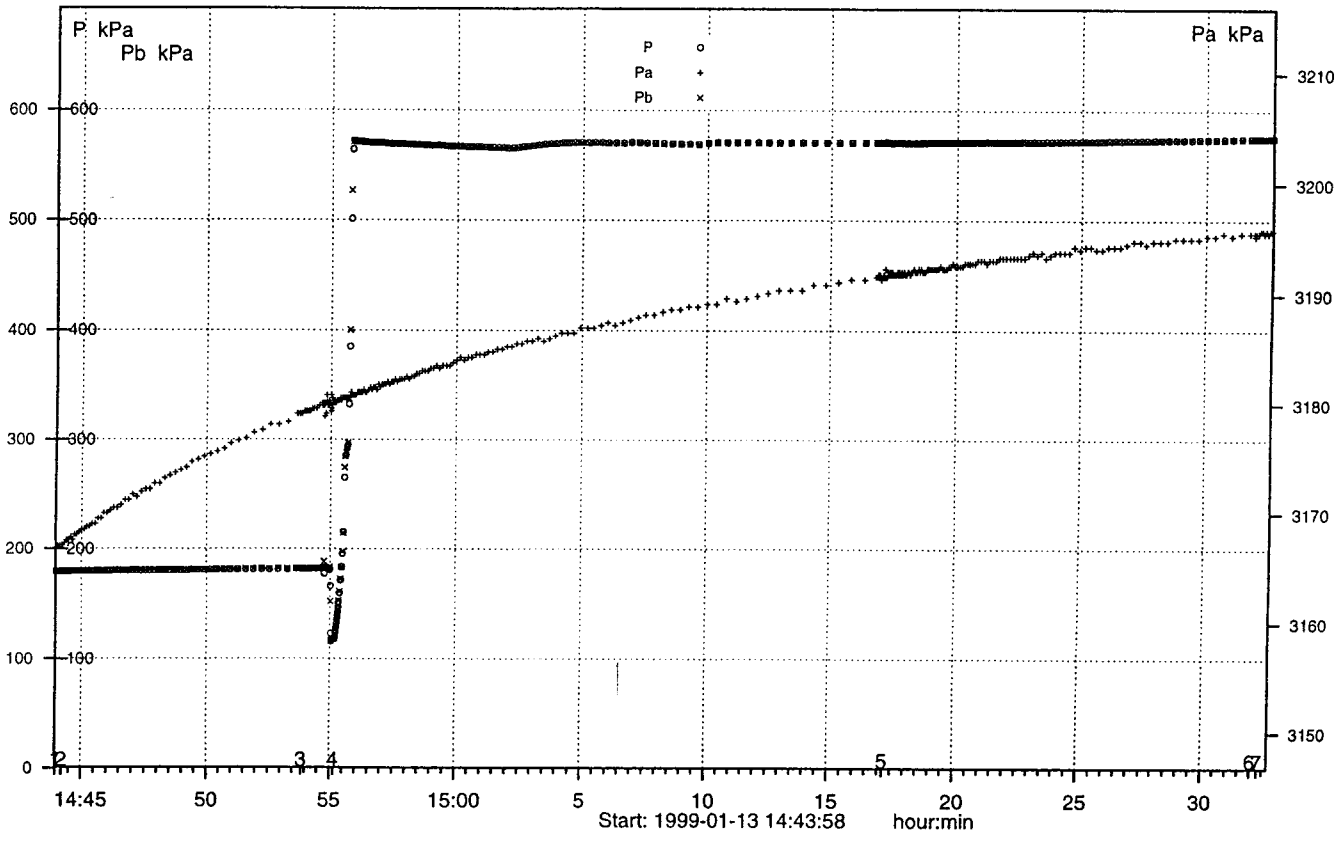
Mon May 03 10:14:13 1999

Borehole: 3554G02

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-13 14:43:46



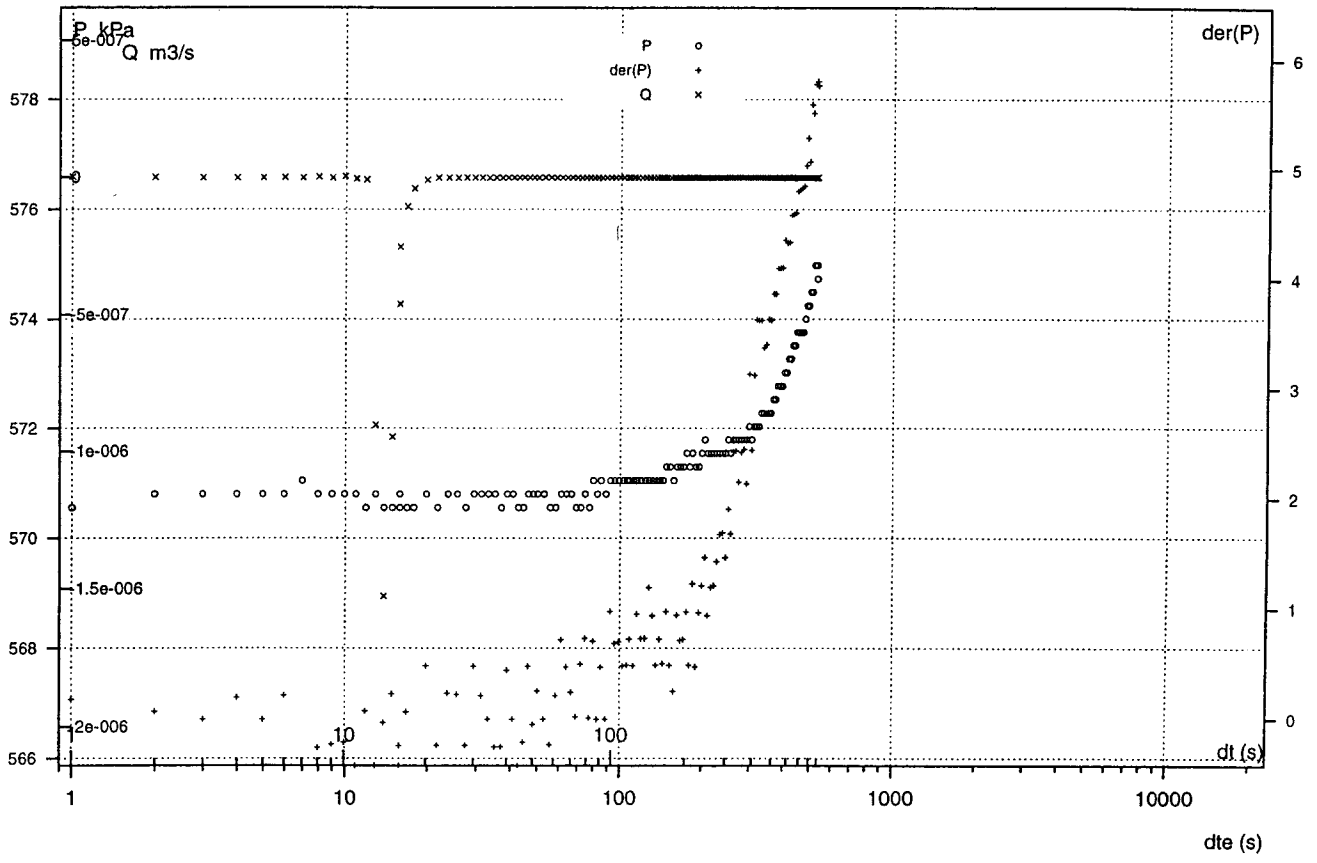
Mon May 03 10:09:46 1999

Borehole: 3554G02

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-13 14:43:46



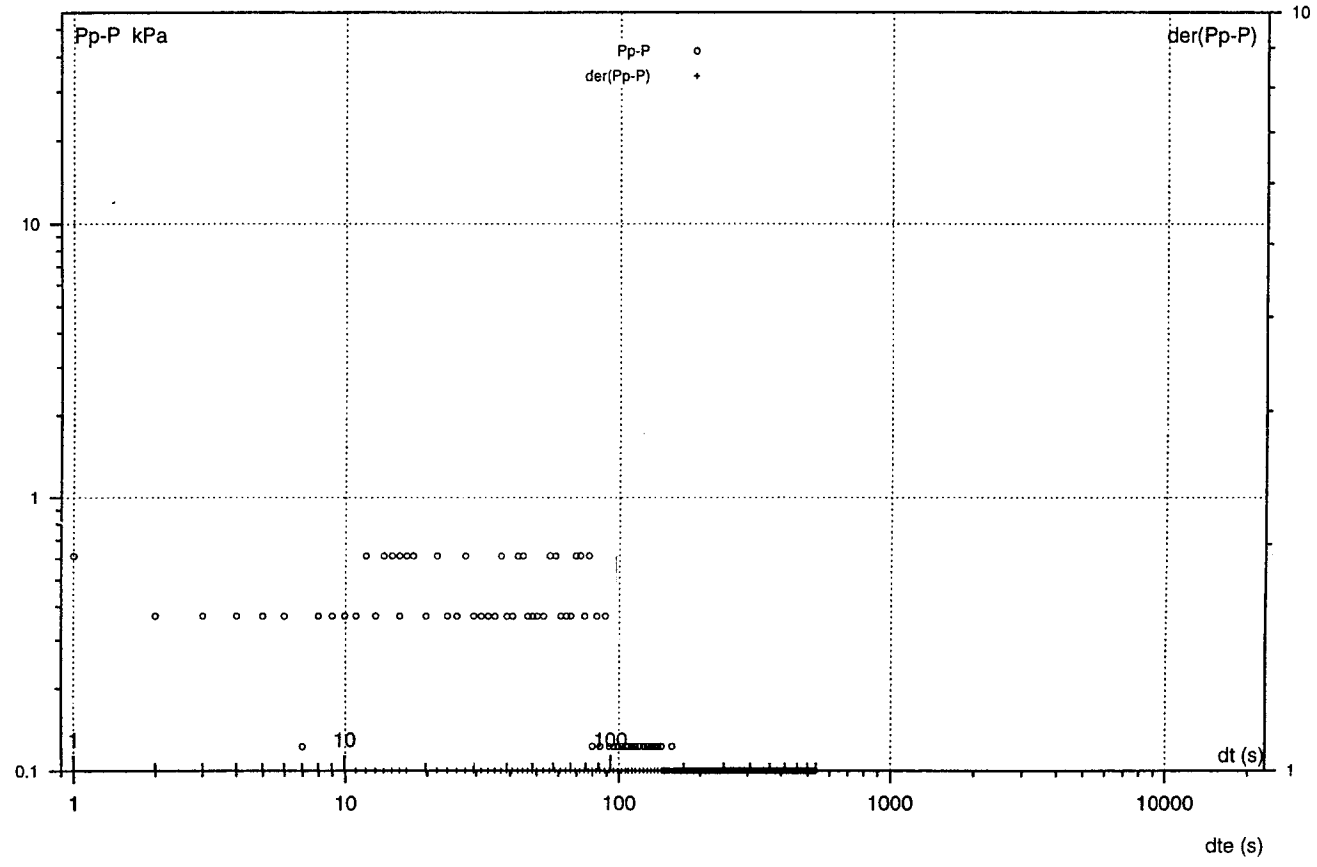
Mon May 03 10:09:47 1999

Borehole: 3554G02

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-13 14:43:46



Mon May 03 10:09:47 1999

Borehole KA3554G01, section 0.25 m - 0.75 m

Date: 99-01-13 Field Crew: B. Gentzschein

Valve opened: 990113 165247 Valve closed: 990113 171404
Total flowing time: 21.3 min. Tot. Pr. Build-up time: 14.2 min.

Pressure before injection start (P_0, kPa) : 117.1
Pressure just before closing the valve (P_p, kPa) : 514.2
Pressure at the end of the recovery (P_f, kPa) : 120.5

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

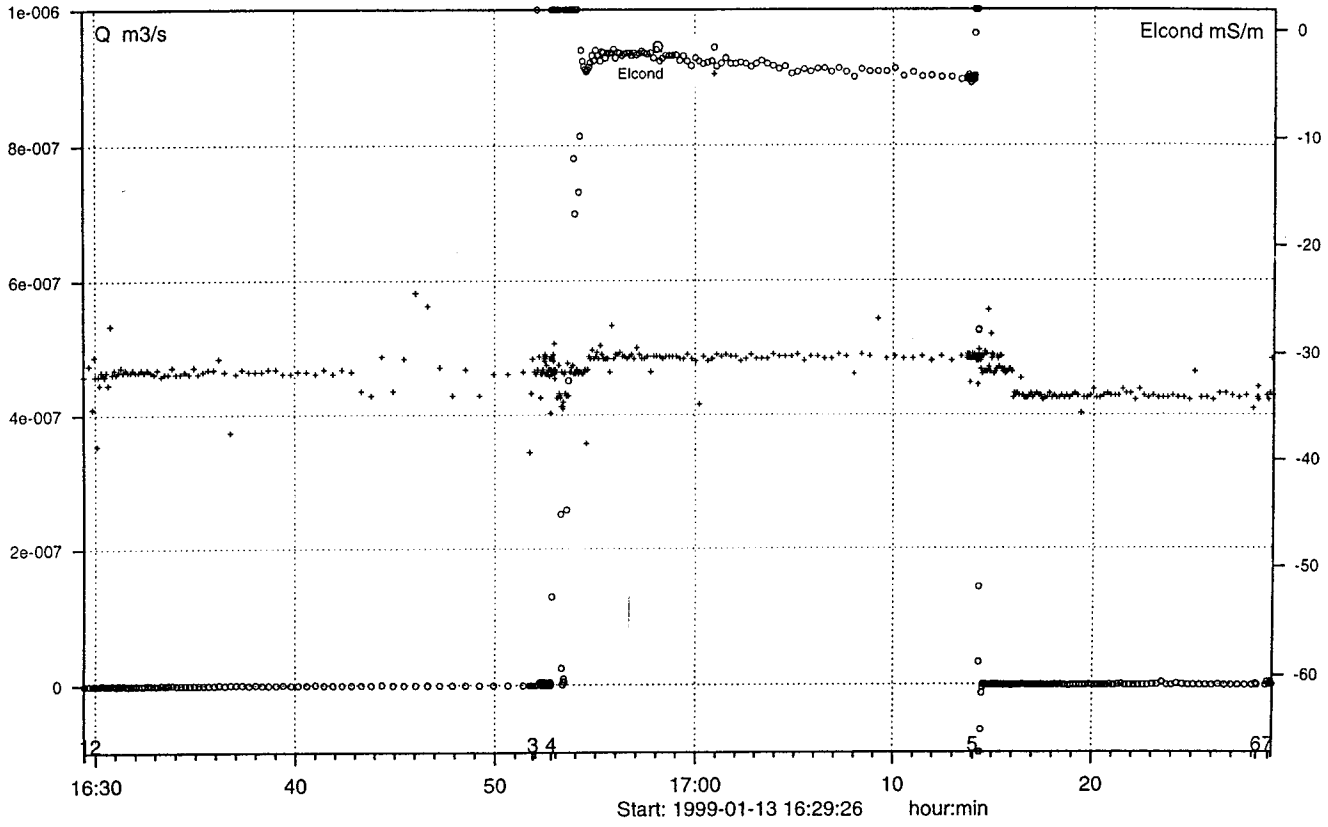
A stable flow and pressure and a nice recovery!

Borehole: 3554G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-13 16:29:14



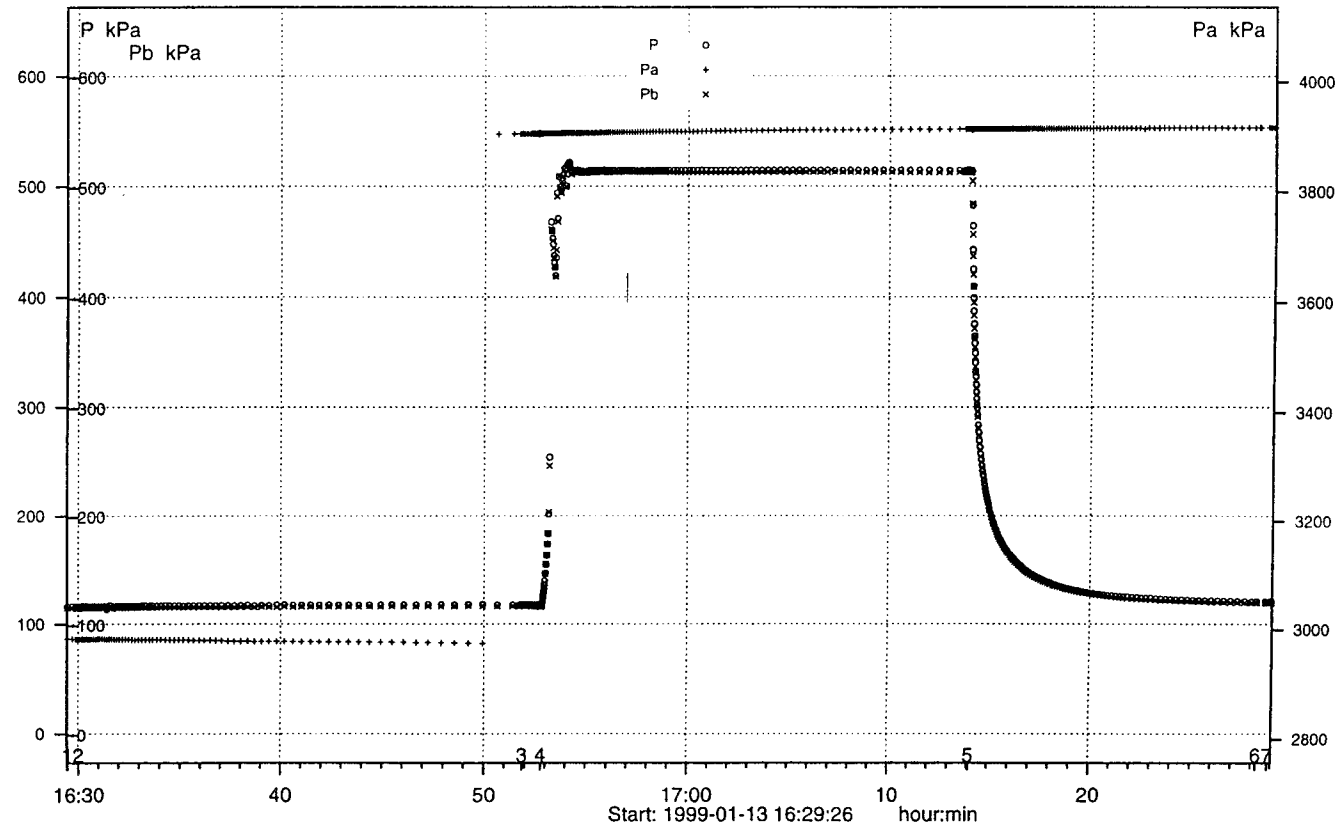
Mon May 03 10:27:25 1999

Borehole: 3554G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-13 16:29:14



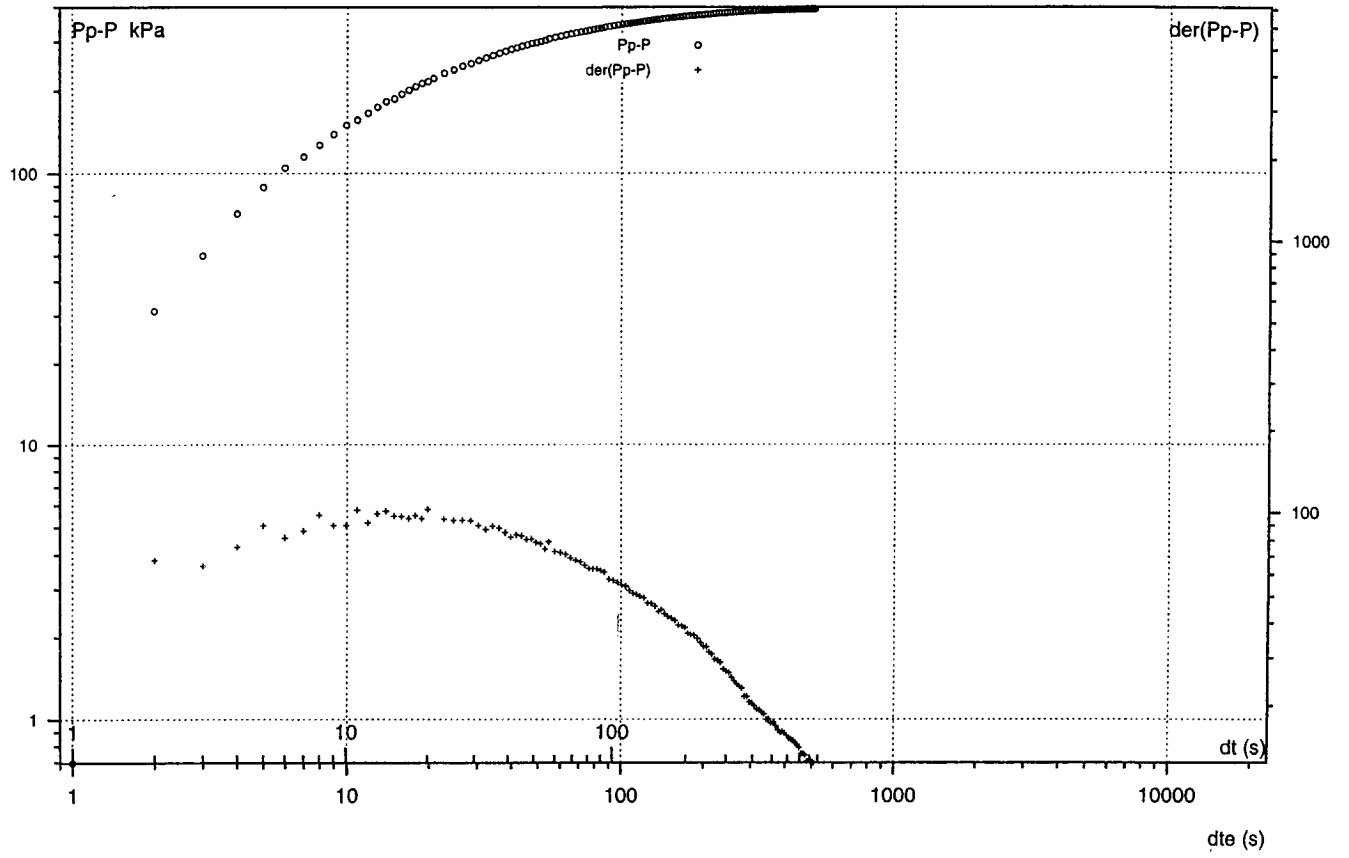
Mon May 03 10:28:51 1999

Borehole: 3554G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-13 16:29:14



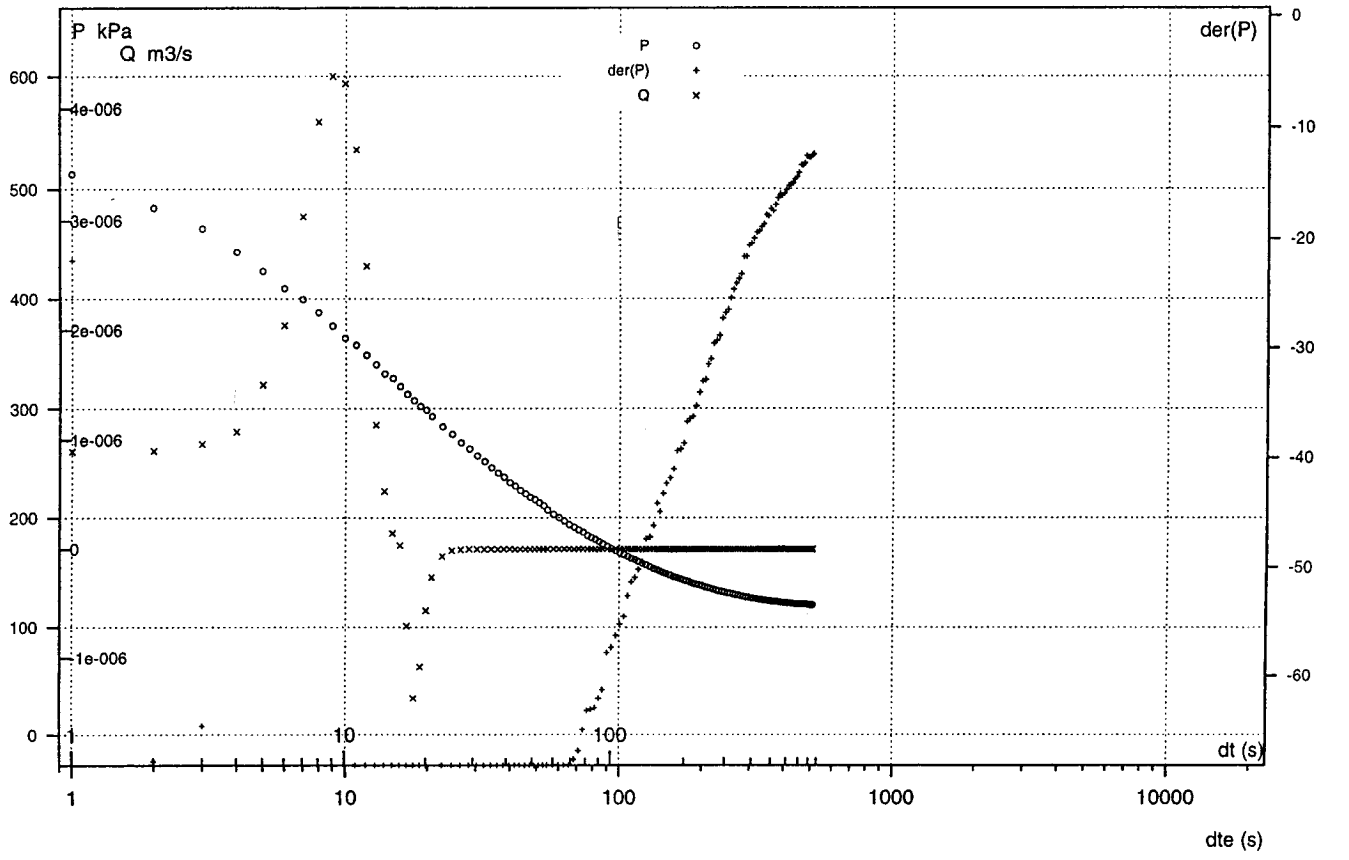
Mon May 03 10:29:15 1999

Borehole: 3554G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-13 16:29:14



Mon May 03 10:29:24 1999

Borehole KA3554G01, section 0.75 m – 1.25 m

Date: 99-01-13 Field Crew: B. Gentzschein

Valve opened: 990113 181517 Valve closed: 990113 183715
Total flowing time: 22.0 min. Tot. Pr. Build-up time: 10.8 min.

Pressure before injection start (P_0, kPa) : 114.6
Pressure just before closing the valve (P_p, kPa) : 607.4
Pressure at the end of the recovery (P_f, kPa) : 573.7

Pre-set section pressure (during injection) (P_{ref}, kPa) : 550

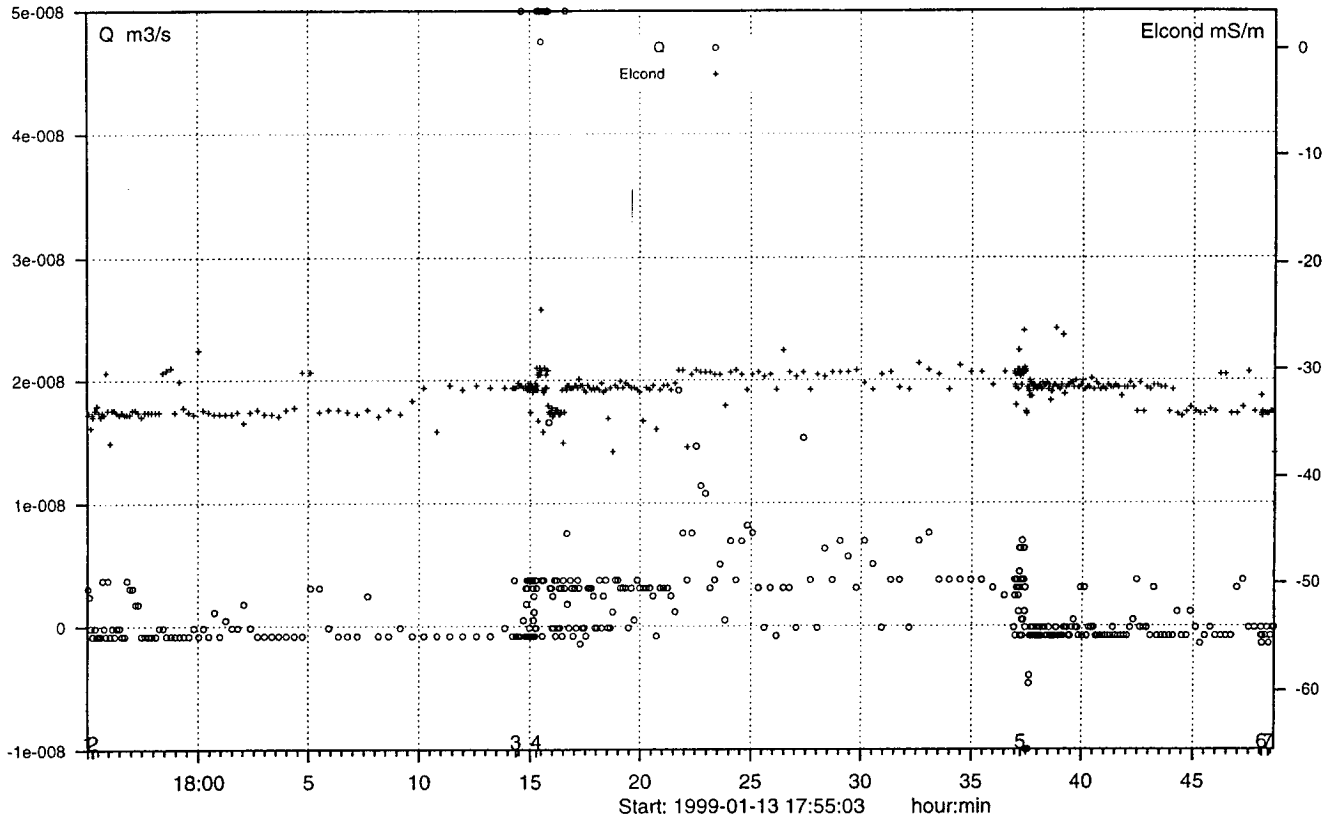
P_{ref} was increased to 590 kPa. A small pressure increase during the recovery.

Borehole: 3554G01

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-13 17:54:48



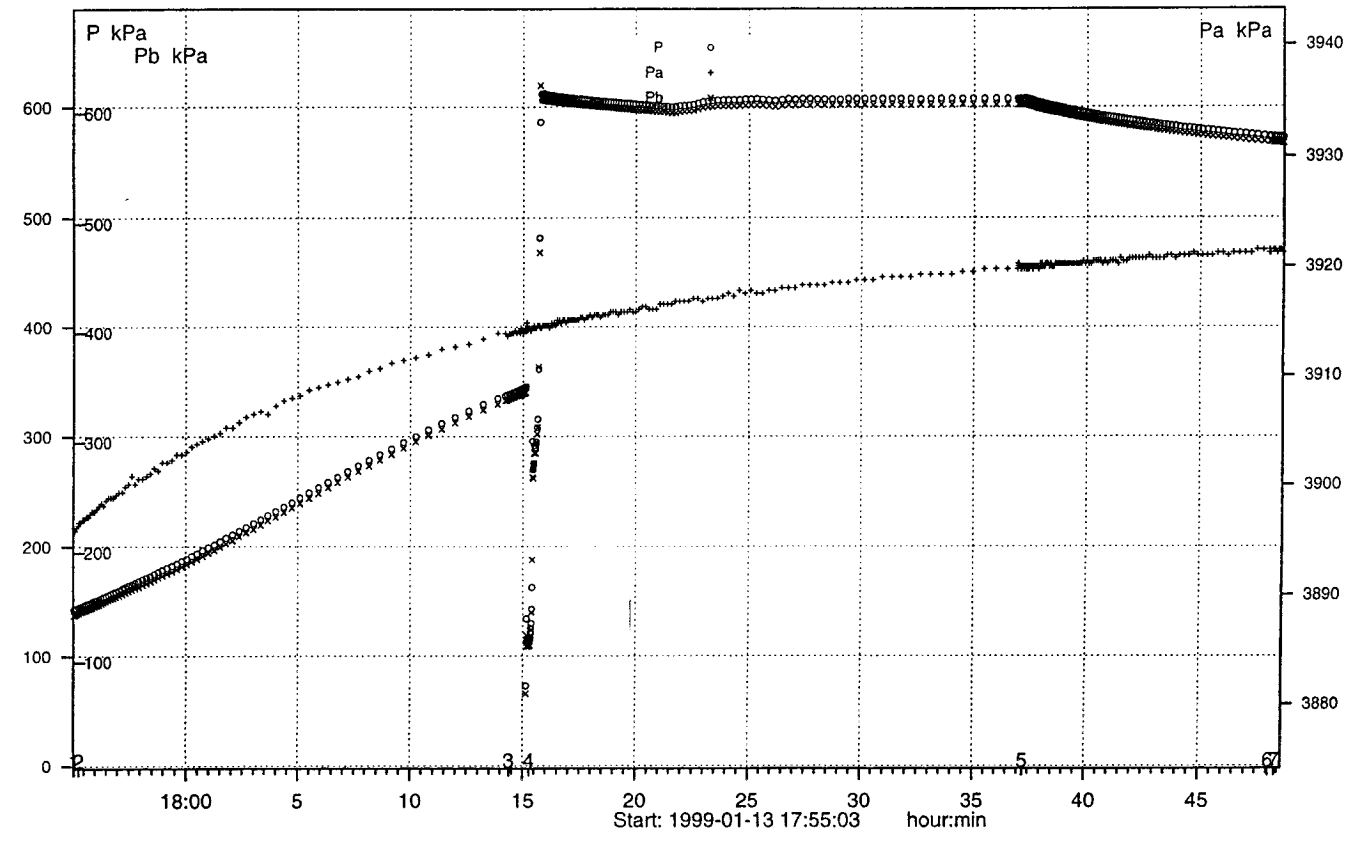
Mon May 03 10:36:49 1999

Borehole: 3554G01

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-13 17:54:48



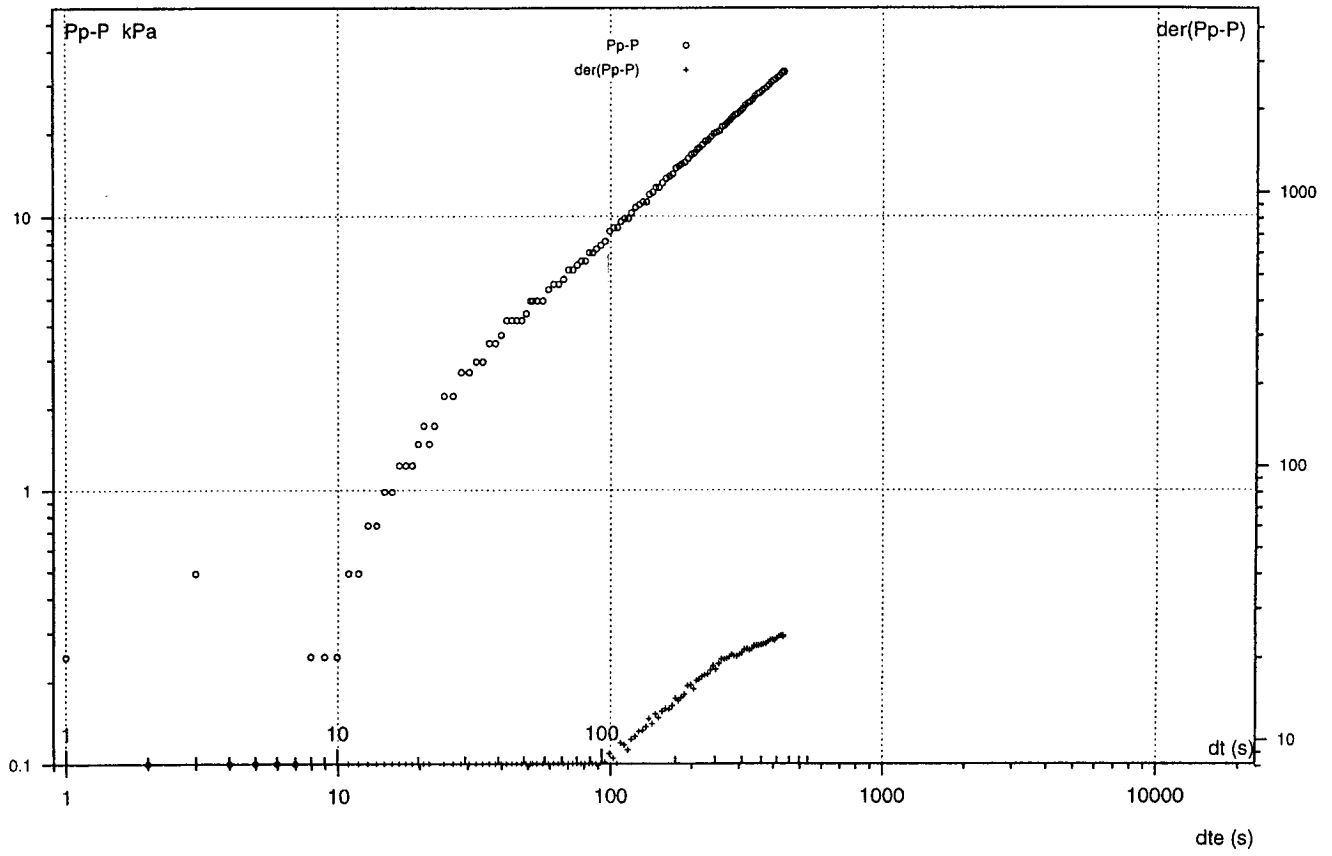
Mon May 03 10:35:34 1999

Borehole: 3554G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-13 17:54:48



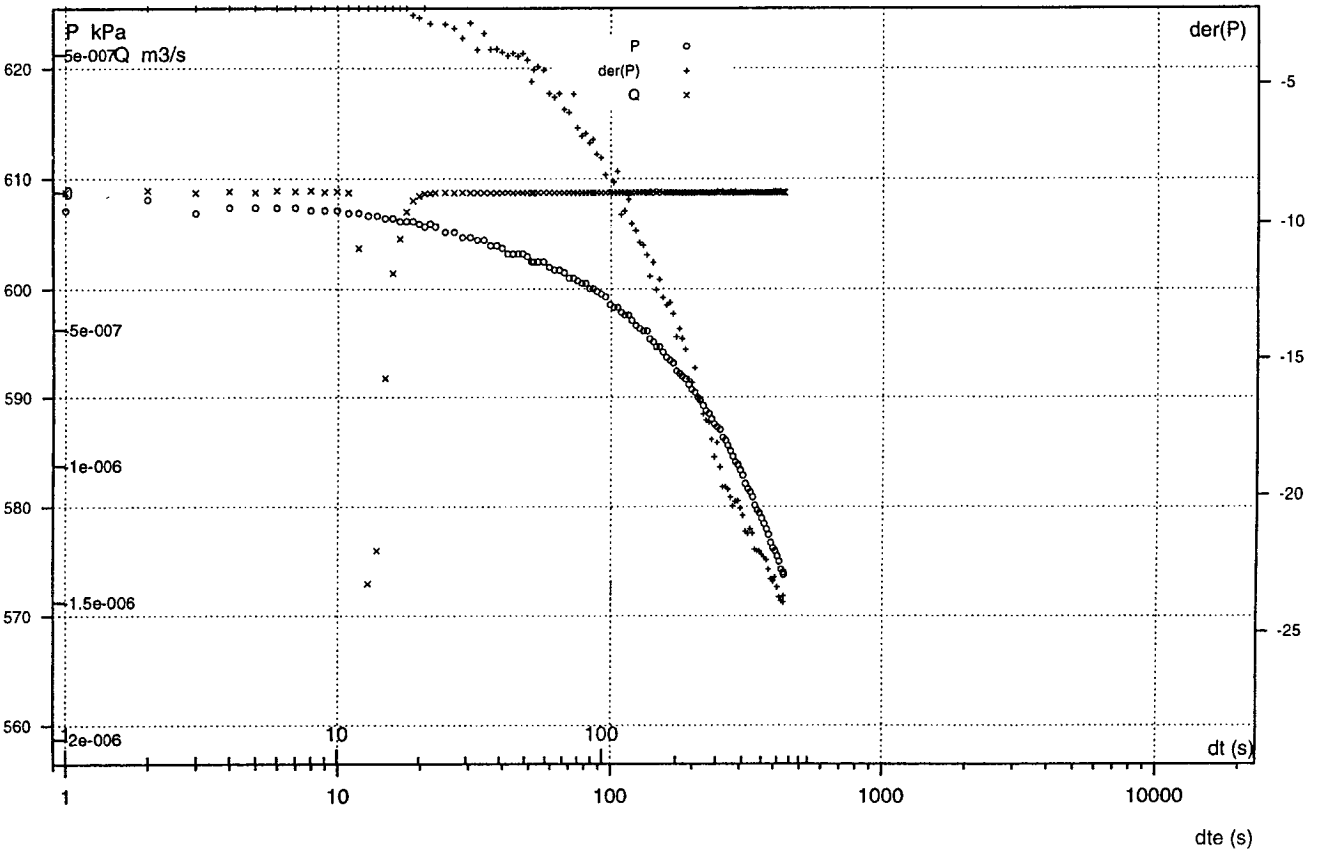
Mon May 03 10:35:35 1999

Borehole: 3554G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-13 17:54:48



Mon May 03 10:35:34 1999

Borehole KA3554G01, section 1.25 m – 1.75 m

Date: 99-01-13 Field Crew: B. Gentzschein

Valve opened: 990113 193852 Valve closed: 990113 201258
Total flowing time: 34.1 min. Tot. Pr. Build-up time: 706.6 min.

Pressure before injection start (P_0, kPa) : 116.9
Pressure just before closing the valve (P_p, kPa) : 520.8
Pressure at the end of the recovery (P_f, kPa) : 2466.4

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

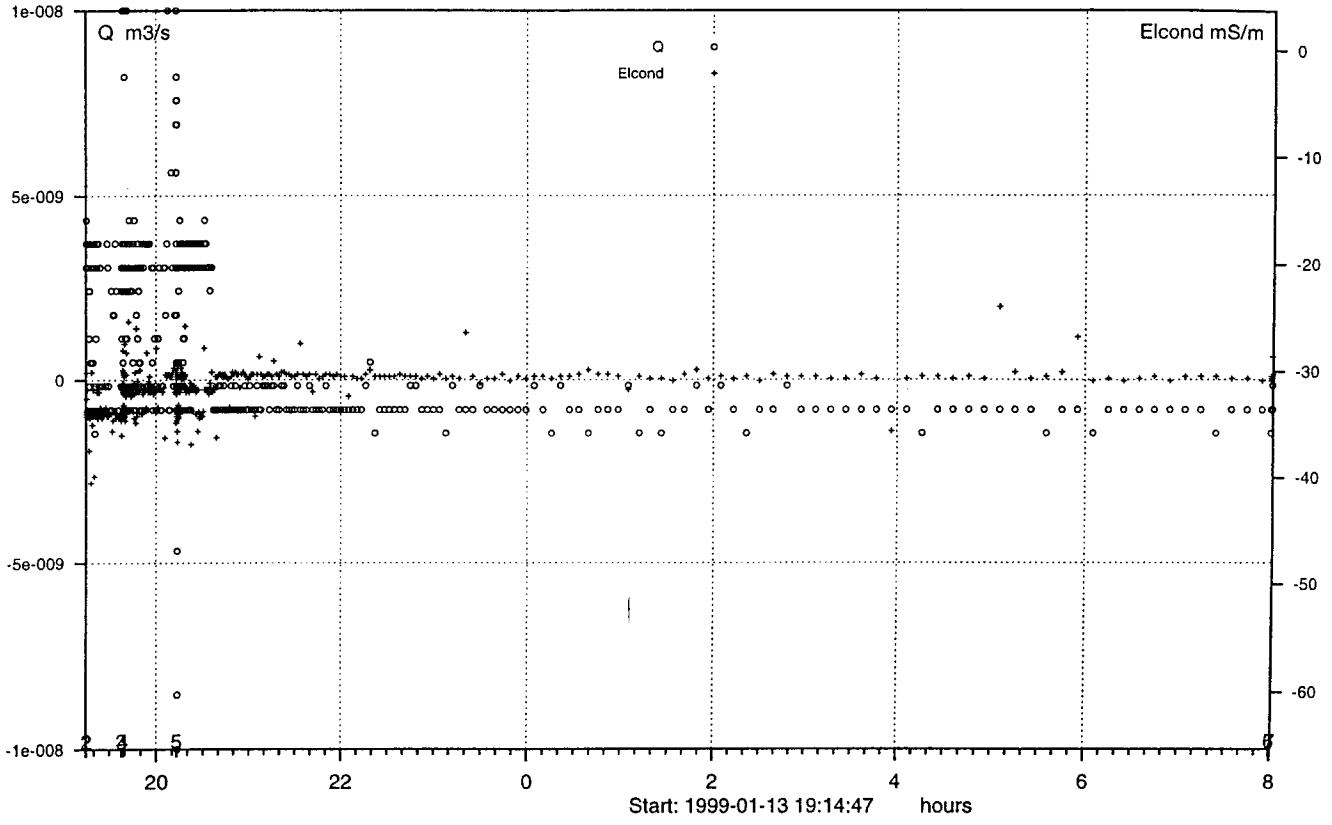
The pressure increased during the long recovery period. After c. nine hours of recovery, the pressure below the packers declined. It is unknown why.

Borehole: 3554G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-13 19:14:30



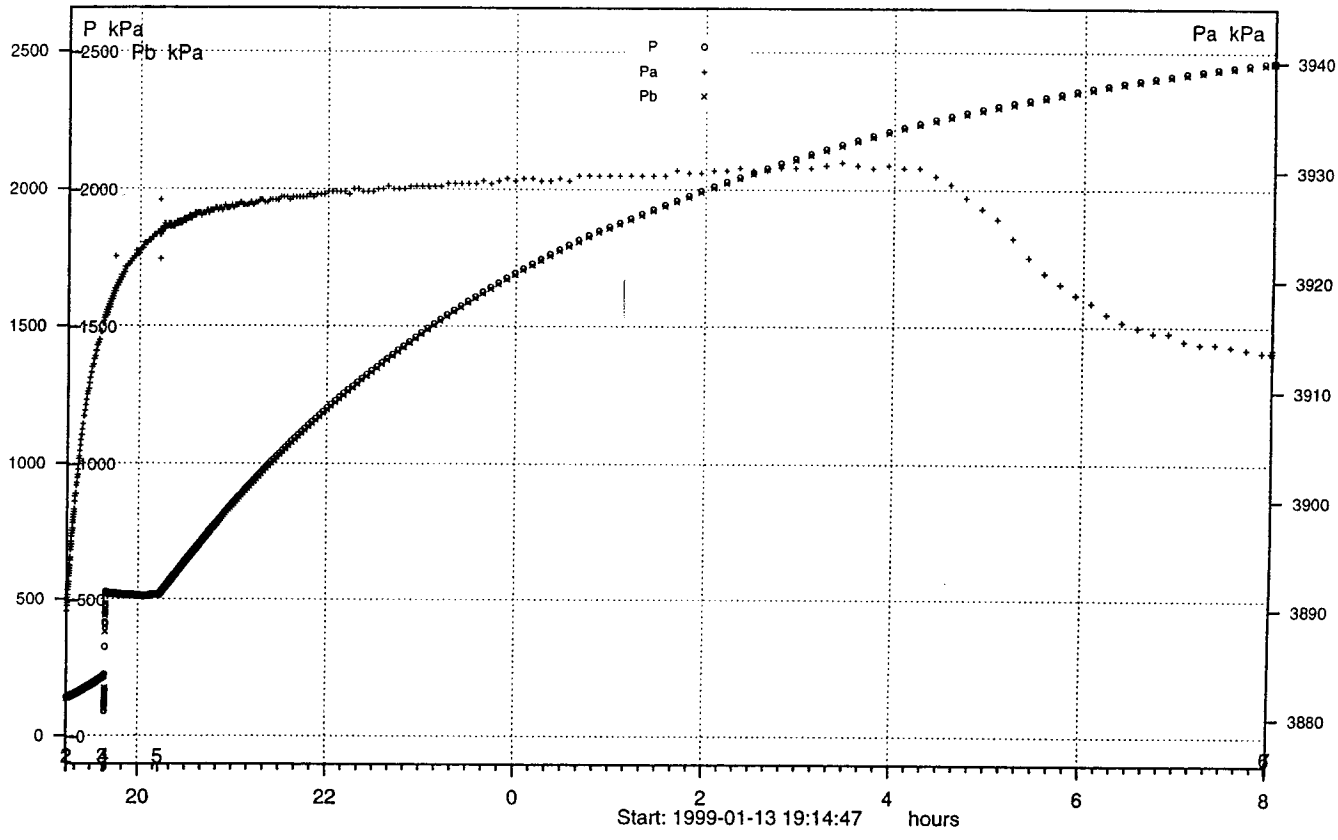
Mon May 03 10:44:42 1999

Borehole: 3554G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-13 19:14:30



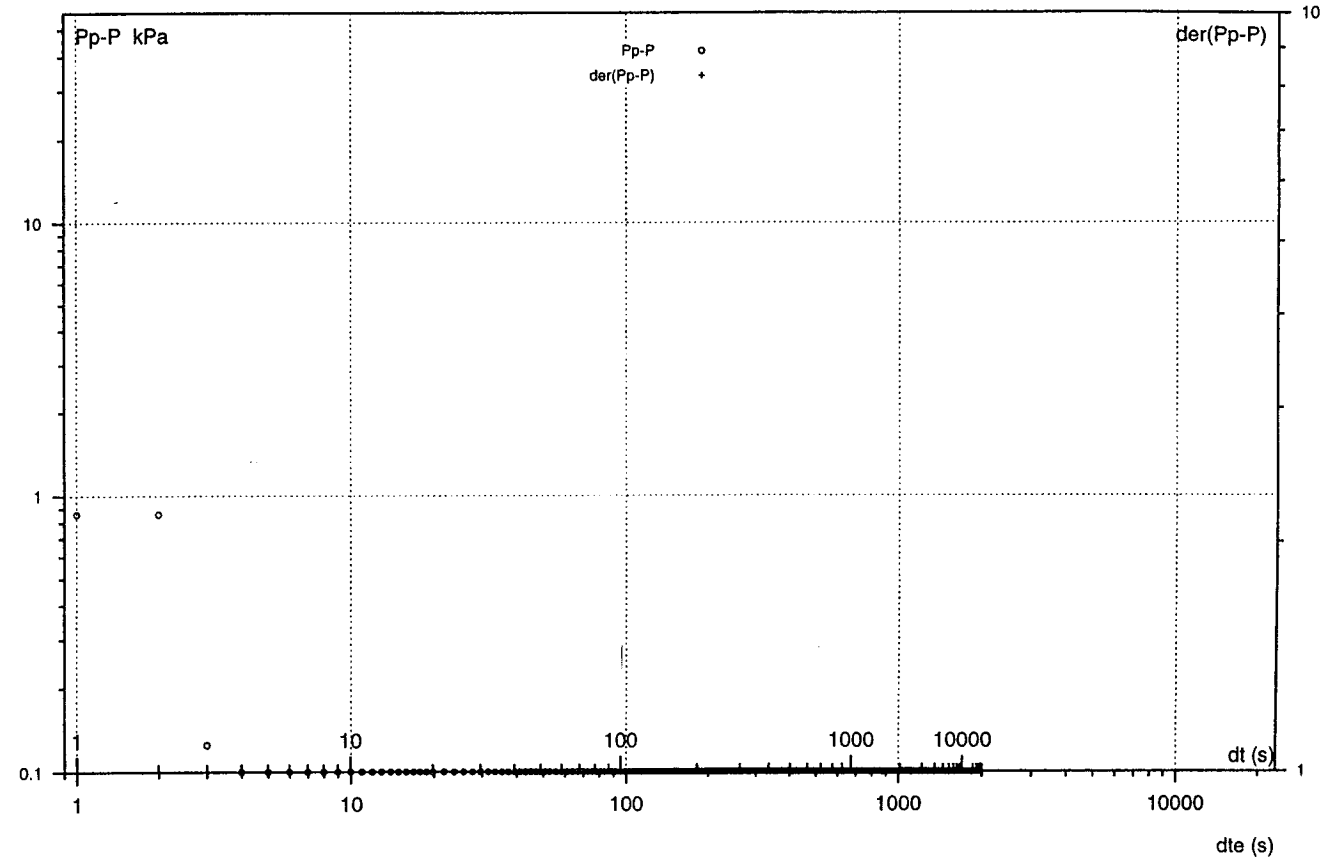
Mon May 03 10:47:25 1999

Borehole: 3554G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-13 19:14:30



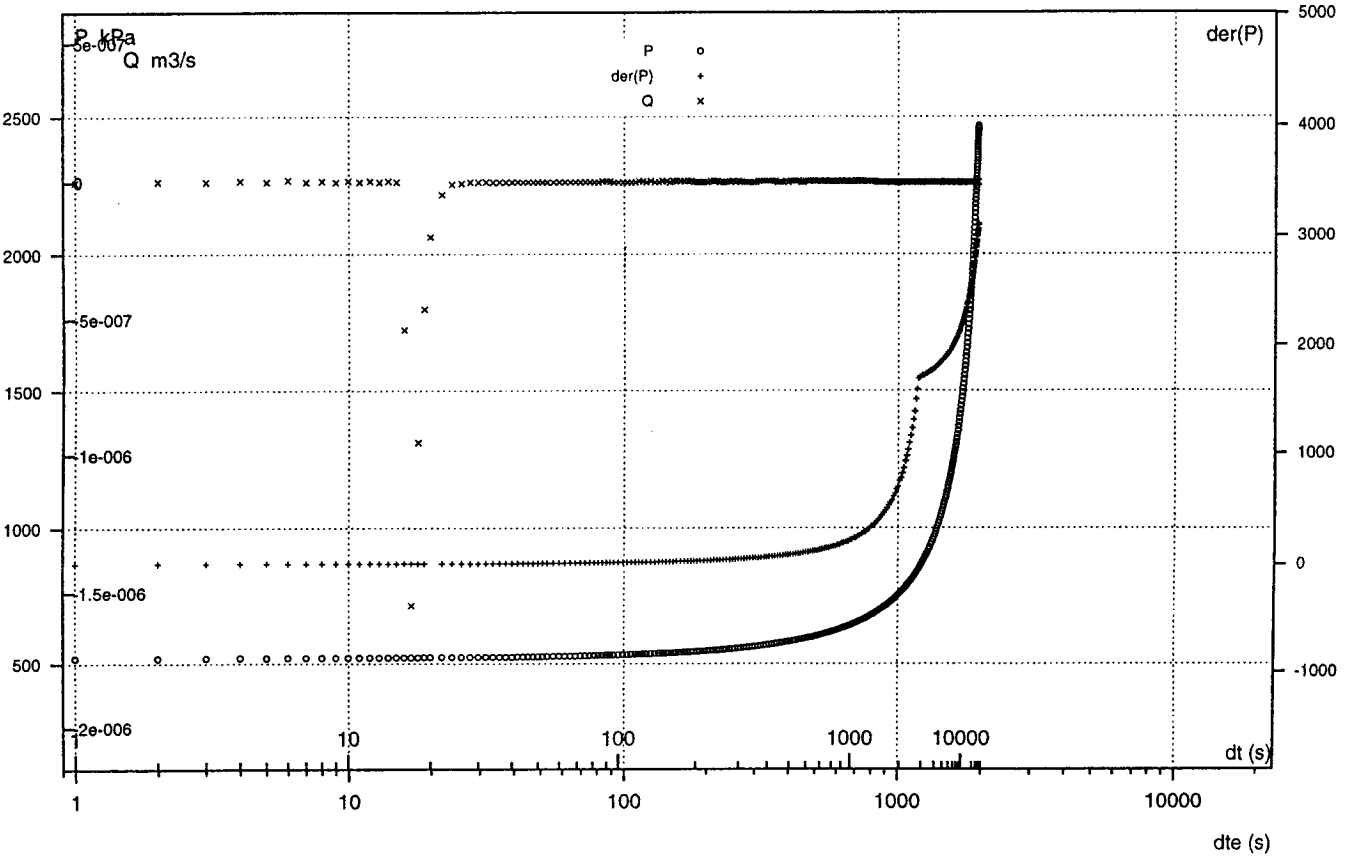
Mon May 03 10:47:03 1999

Borehole: 3554G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-13 19:14:30



Mon May 03 10:47:11 1999

Borehole KA3572G01, section 0.25 m - 0.75 m

Date: 99-01-14 Field Crew: B. Gentzschein

Valve opened: 990114 114758 Valve closed: 990114 121042
Total flowing time: 22.8 min. Tot. Pr. Build-up time: 70.4 min.

Pressure before injection start (P_0, kPa) : 129.1
Pressure just before closing the valve (P_p, kPa) : 519.5
Pressure at the end of the recovery (P_f, kPa) : 380.1

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

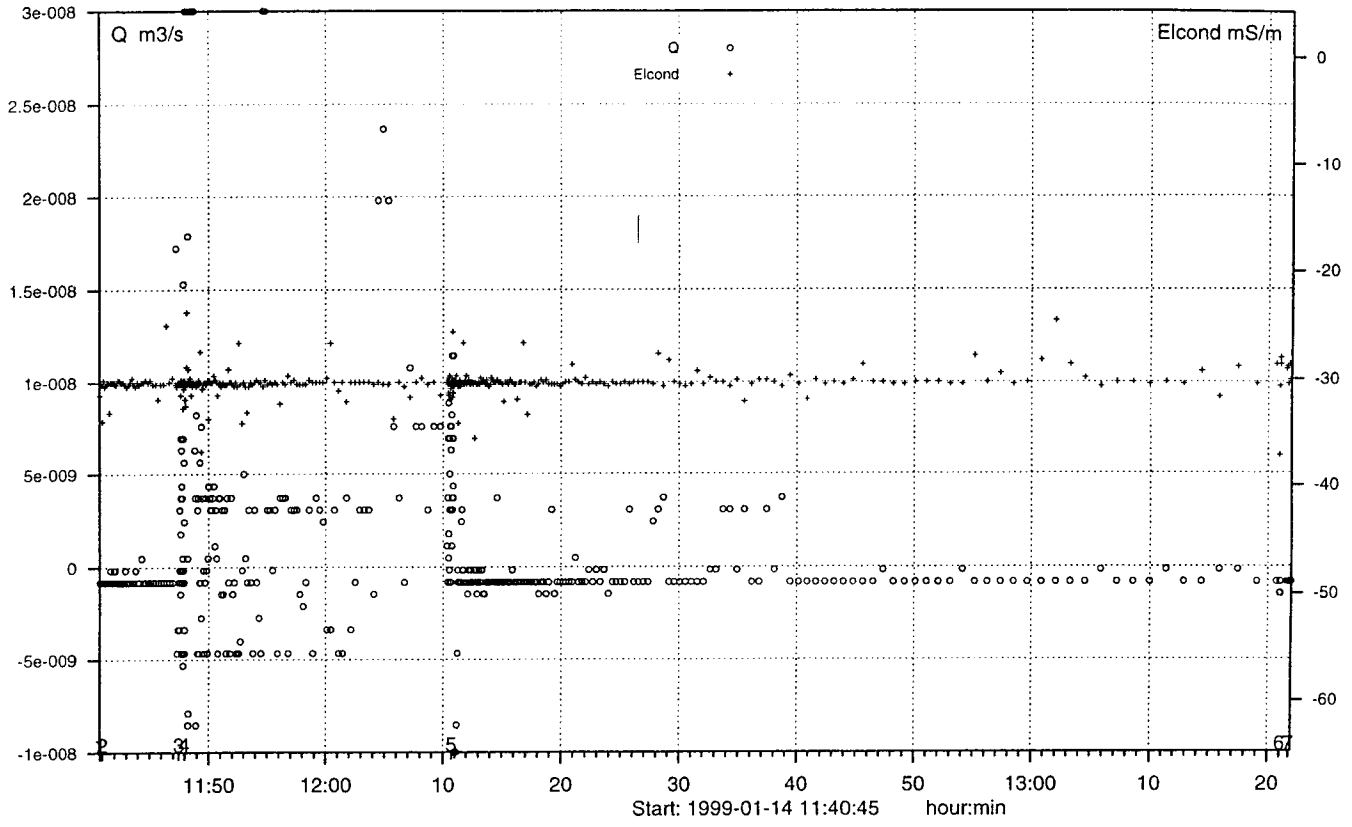
A constant injection pressure was achieved after more than 16 minutes.

Borehole: 3572G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-14 11:40:16



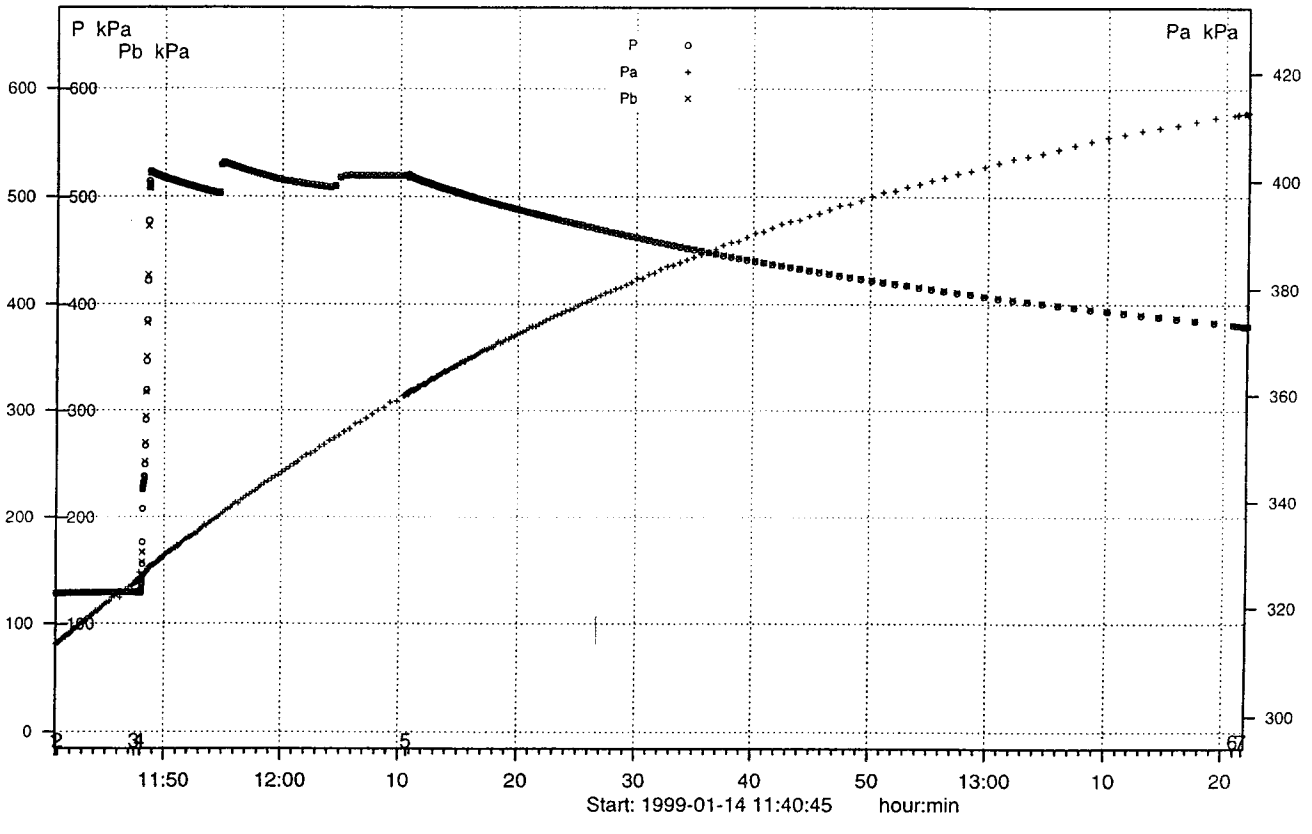
Fri Feb 12 16:18:46 1999

Borehole: 3572G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-14 11:40:16



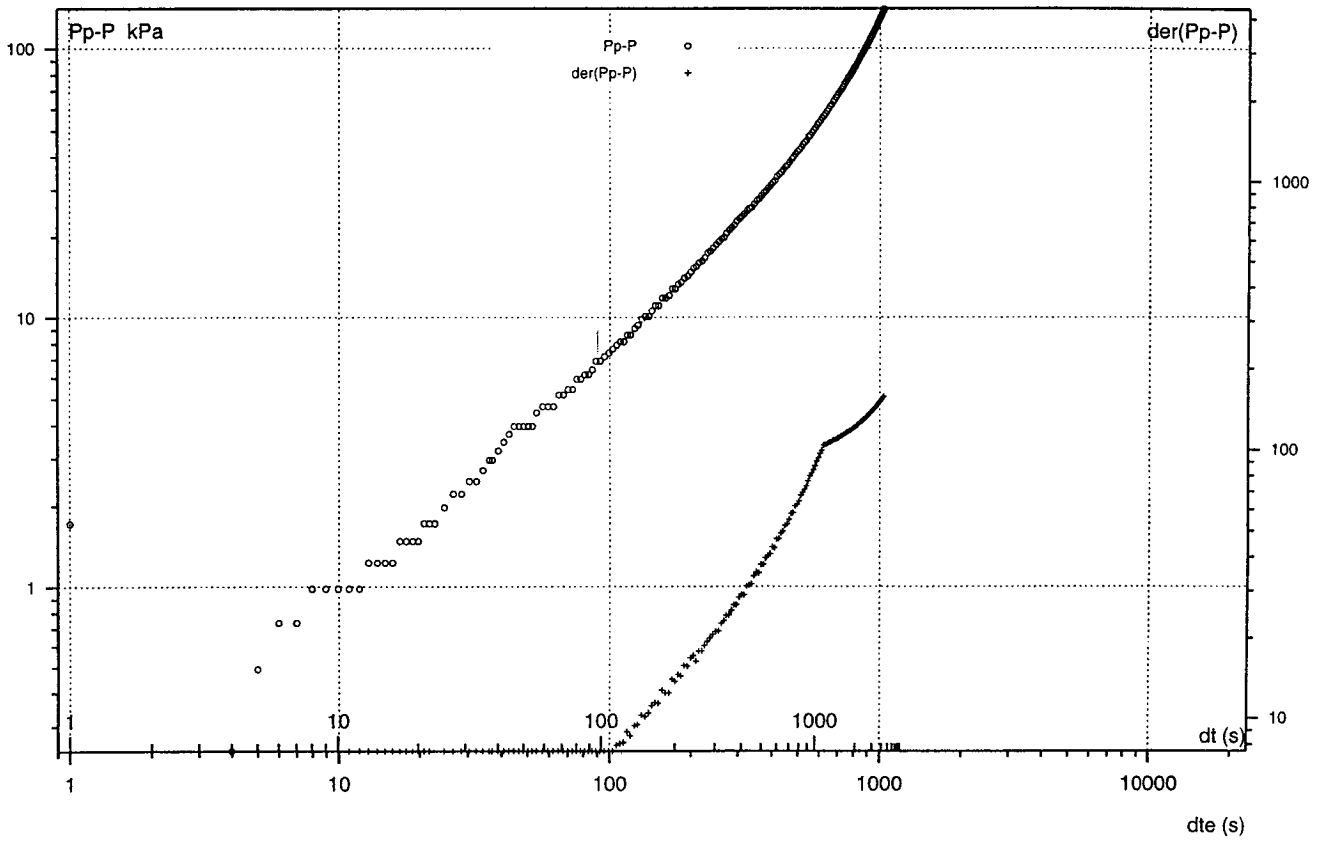
Fri Feb 12 16:17:24 1999

Borehole: 3572G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-14 11:40:16



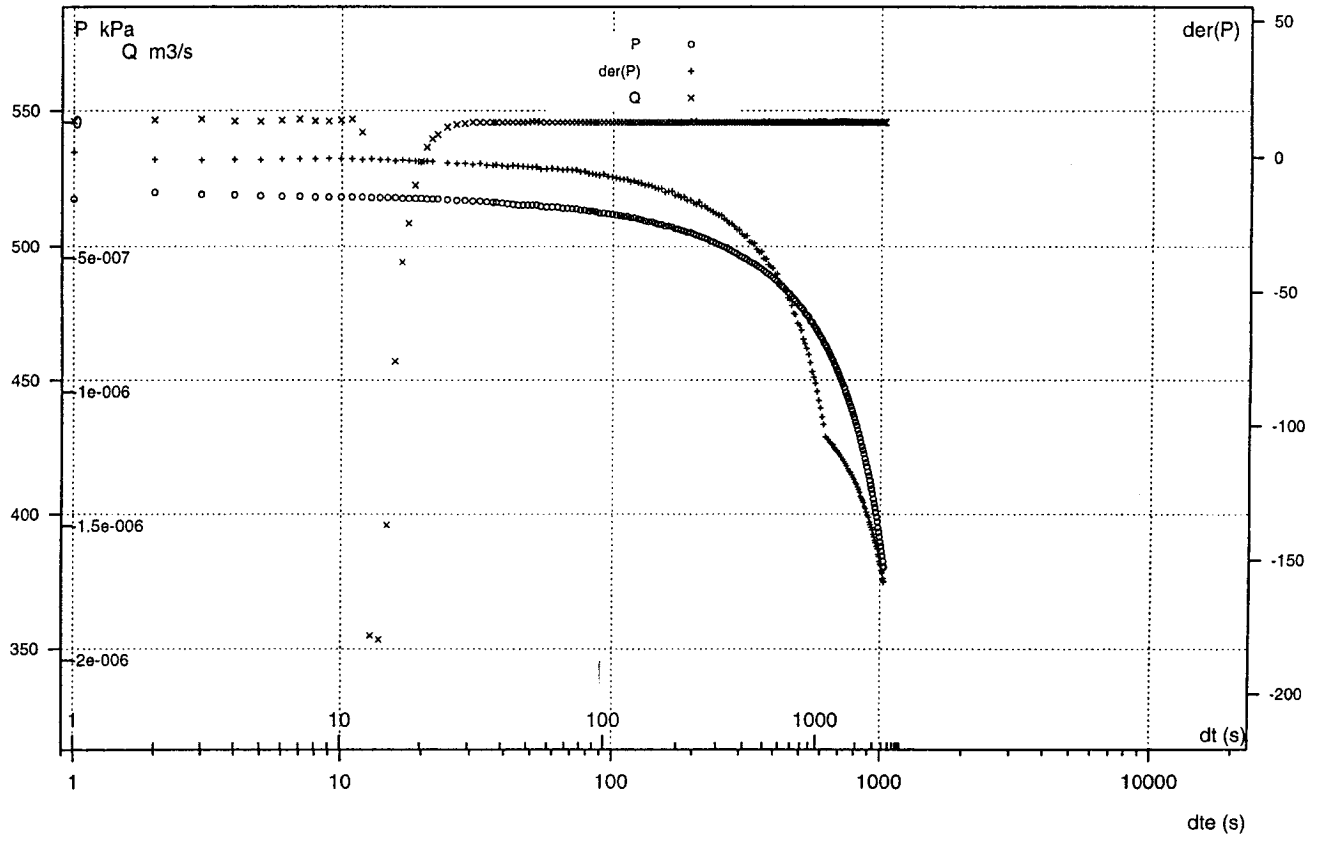
Fri Feb 12 16:17:25 1999

Borehole: 3572G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-14 11:40:16



Fri Feb 12 16:17:25 1999

Borehole KA3572G01, section 0.75 m – 1.25 m

Date: 99-01-14 Field Crew: B. Gentzschein

Valve opened: 990114 141425 Valve closed: 990114 143425
Total flowing time: 20.0 min. Tot. Pr. Build-up time: 15.8 min.

Pressure before injection start (P_0, kPa) : 122.1
Pressure just before closing the valve (P_p, kPa) : 974.1
Pressure at the end of the recovery (P_f, kPa) : 883.7

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

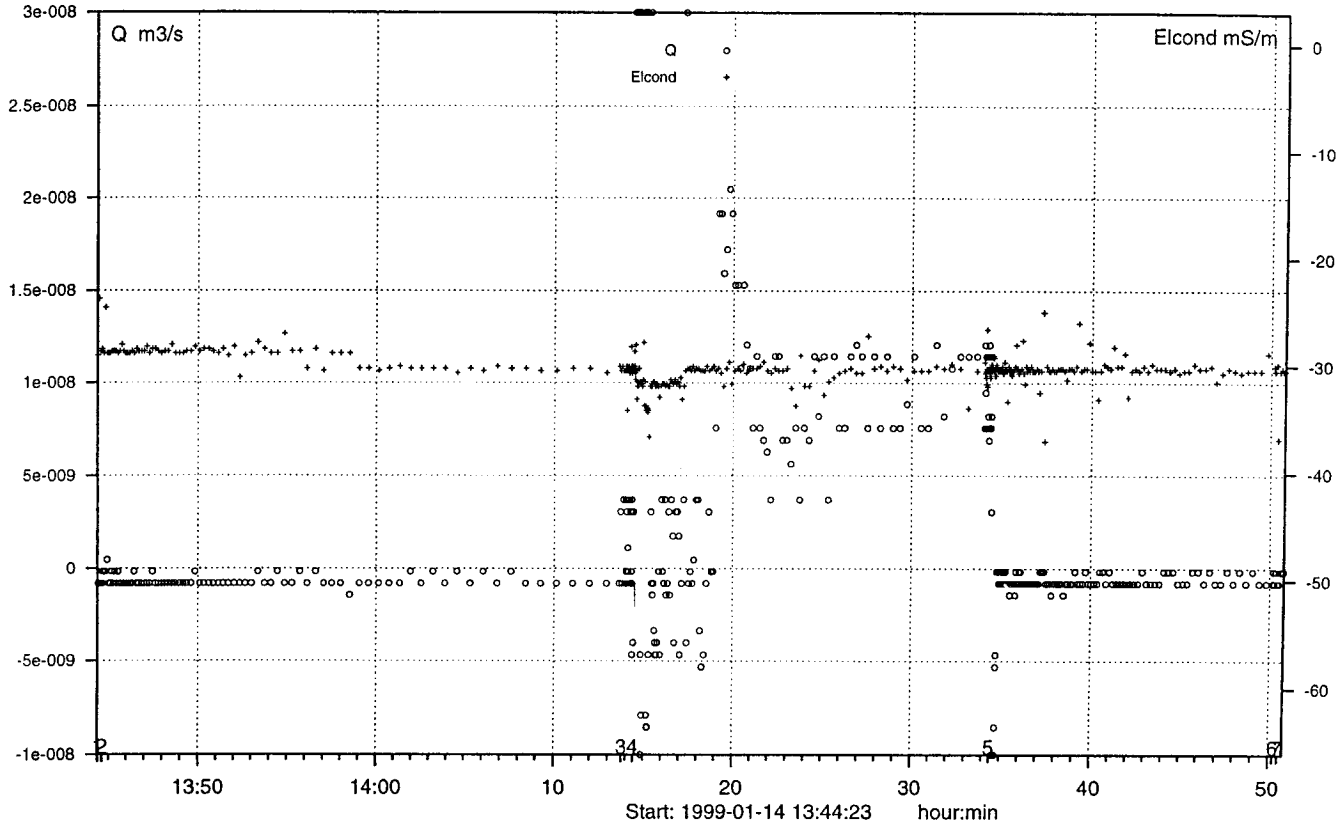
P_{ref} was changed to 950 kPa

Borehole: 3572G01

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-14 13:44:15



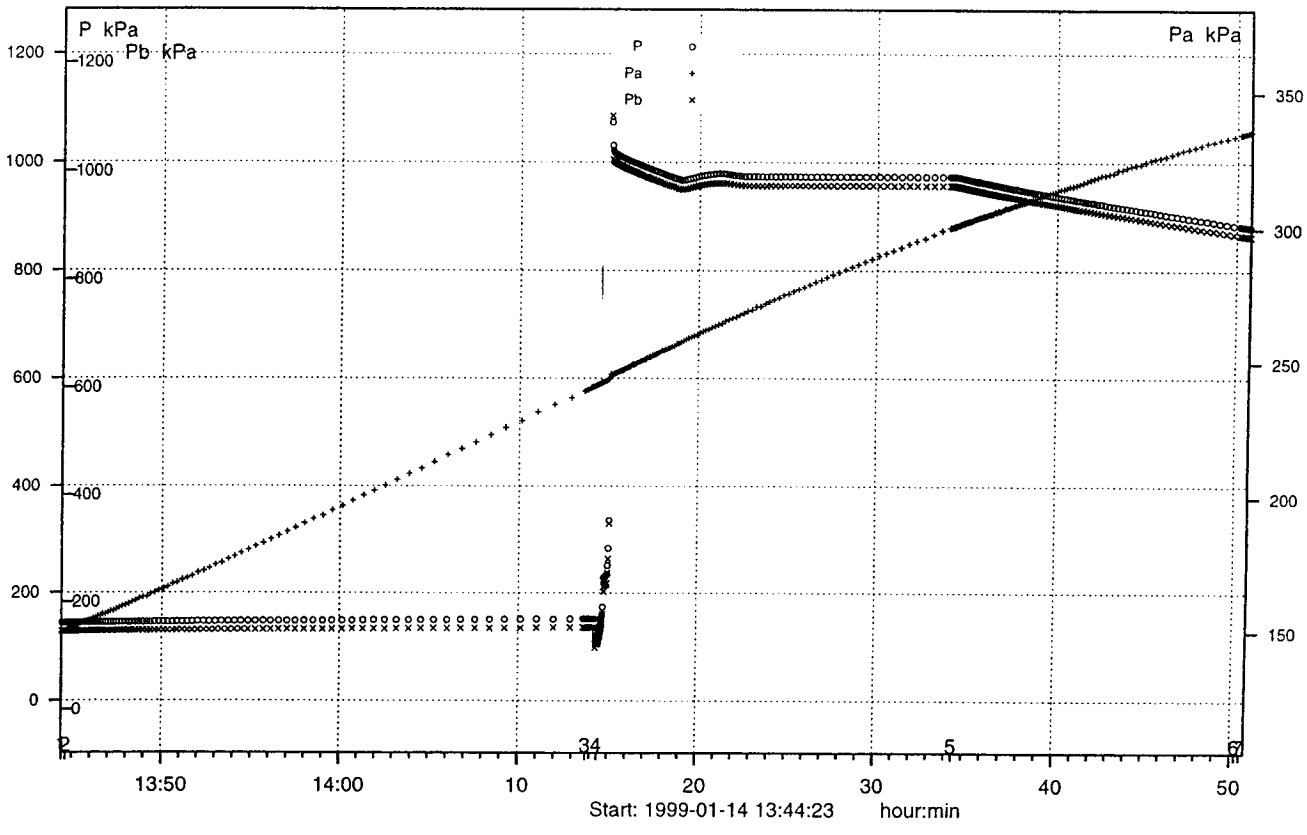
Fri Feb 12 16:27:54 1999

Borehole: 3572G01

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-14 13:44:15



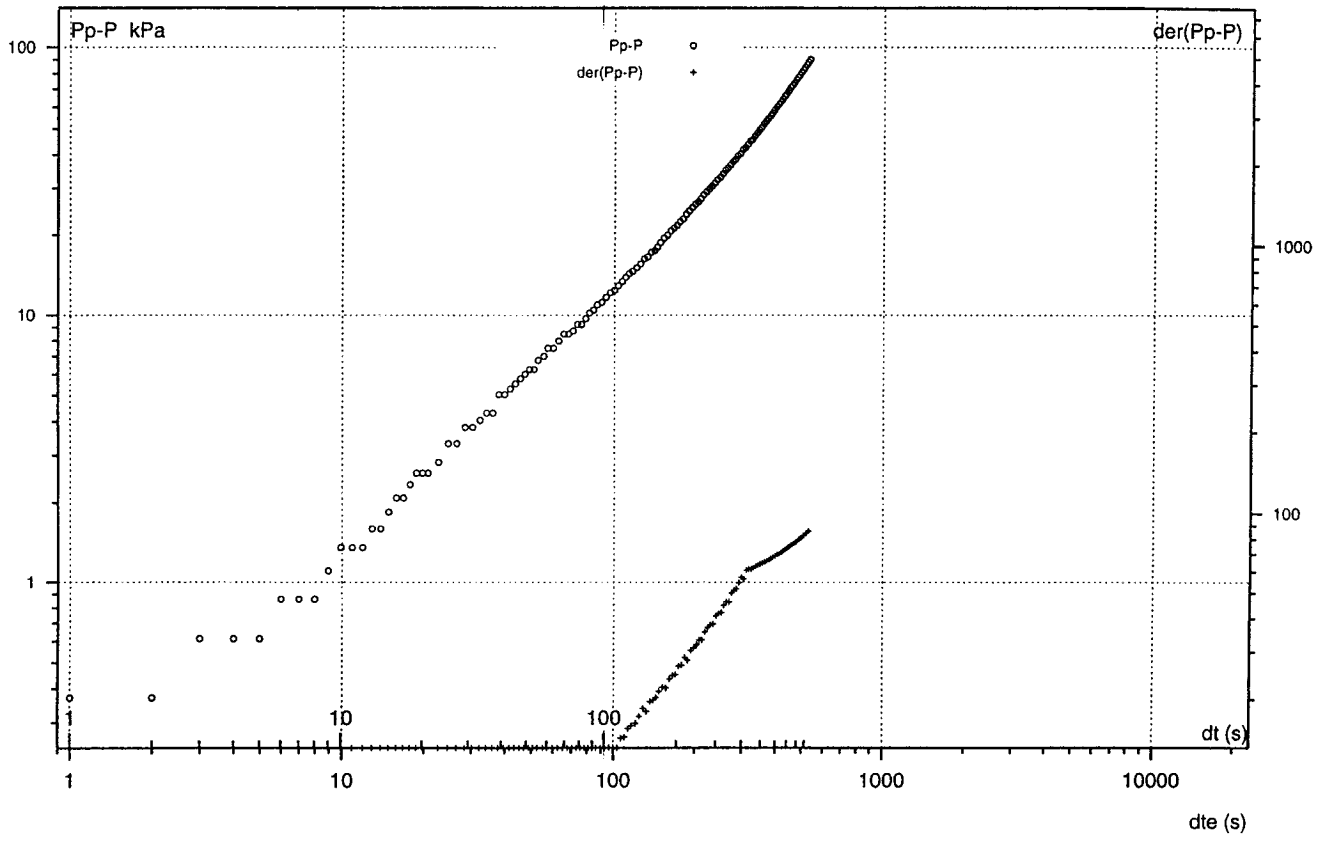
Fri Feb 12 16:27:16 1999

Borehole: 3572G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-14 13:44:15



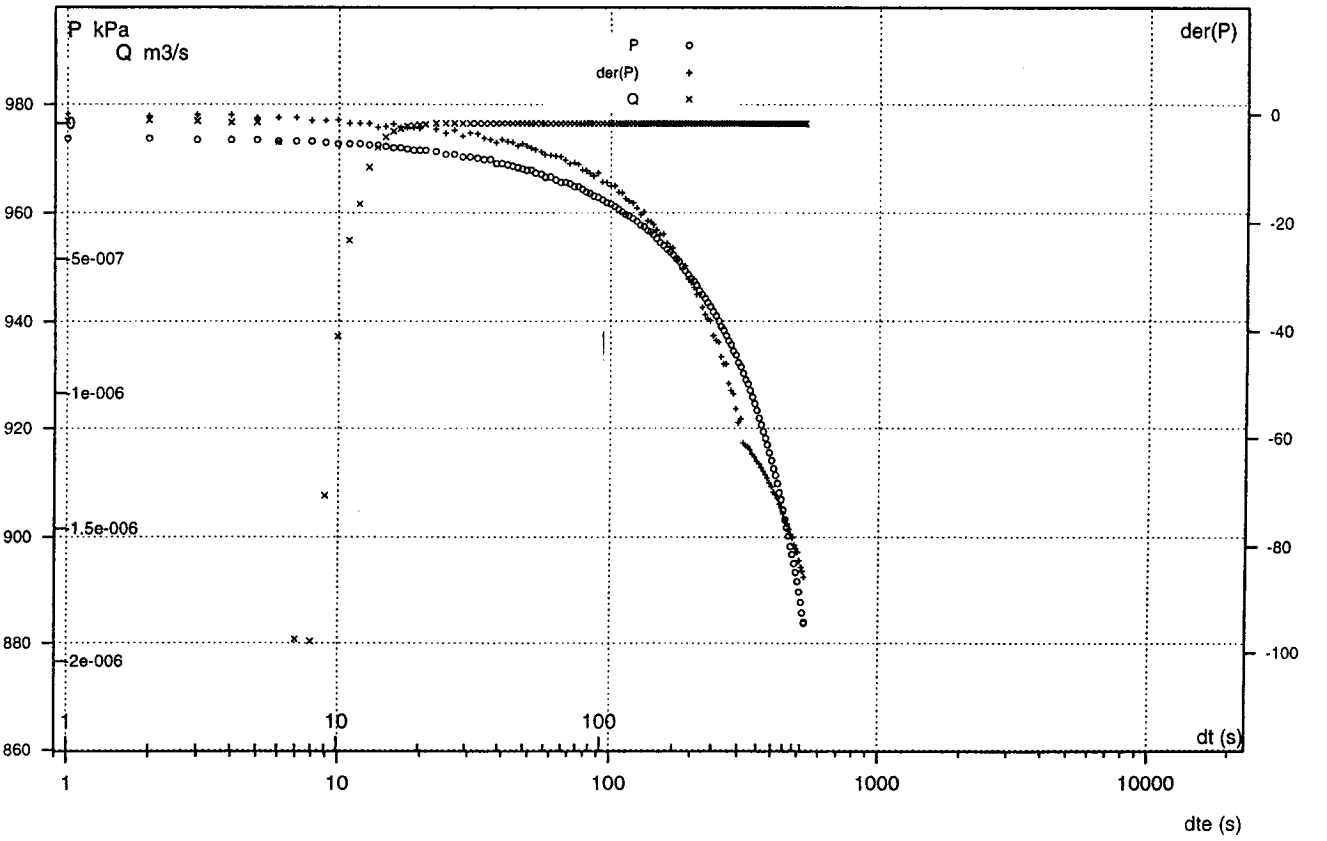
Fri Feb 12 16:27:17 1999

Borehole: 3572G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-14 13:44:15



Fri Feb 12 16:27:17 1999

Borehole KA3572G01, section 1.25 m – 1.75 m

Date: 99-01-14 Field Crew: B. Gentzschein

Valve opened: 990114 154831 Valve closed: 990114 161931
Total flowing time: 31.0 min. Tot. Pr. Build-up time: 12.1 min.

Pressure before injection start (P_0, kPa) : 136.1
Pressure just before closing the valve (P_p, kPa) : 529.5
Pressure at the end of the recovery (P_f, kPa) : 522.2

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

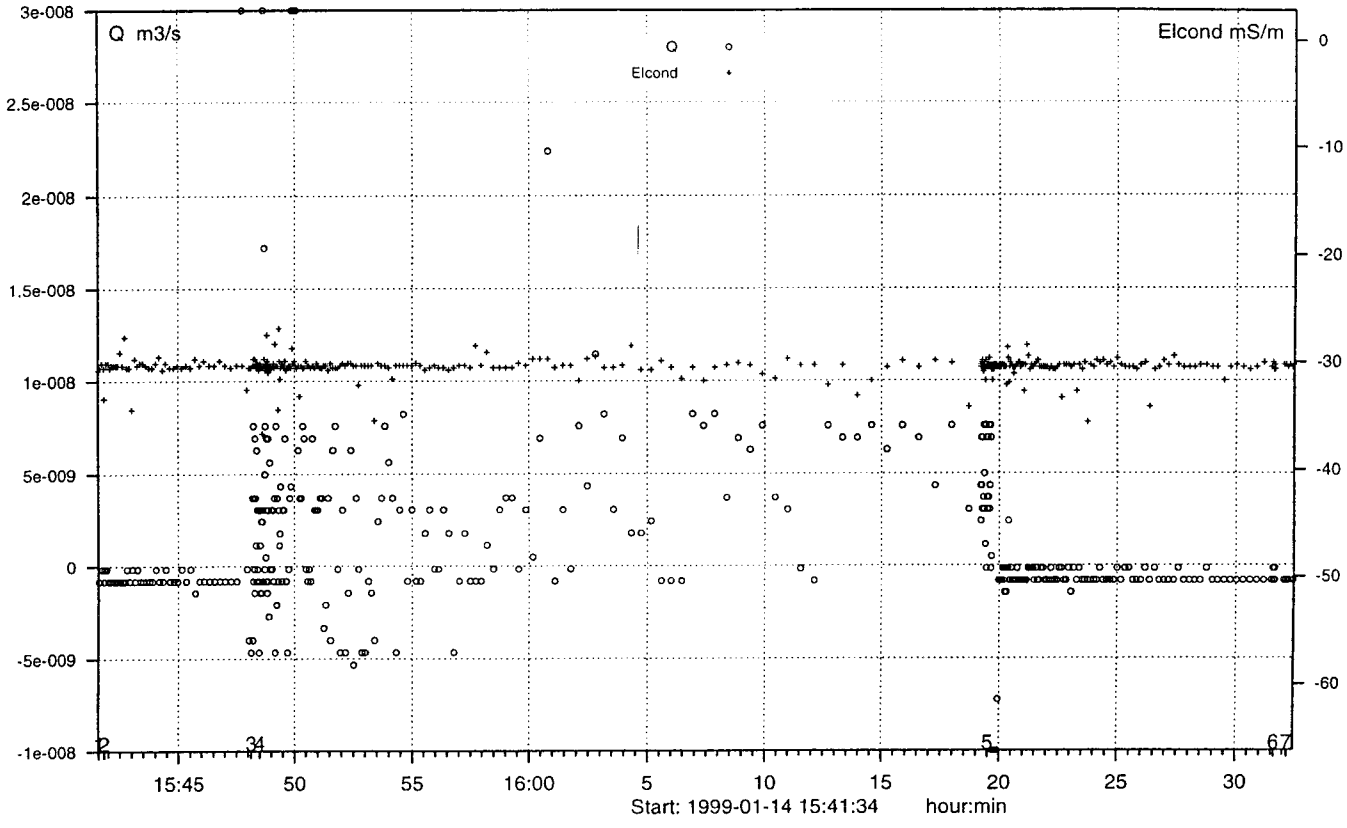
The recovery is less than 10 kPa.

Borehole: 3572G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-14 15:41:24



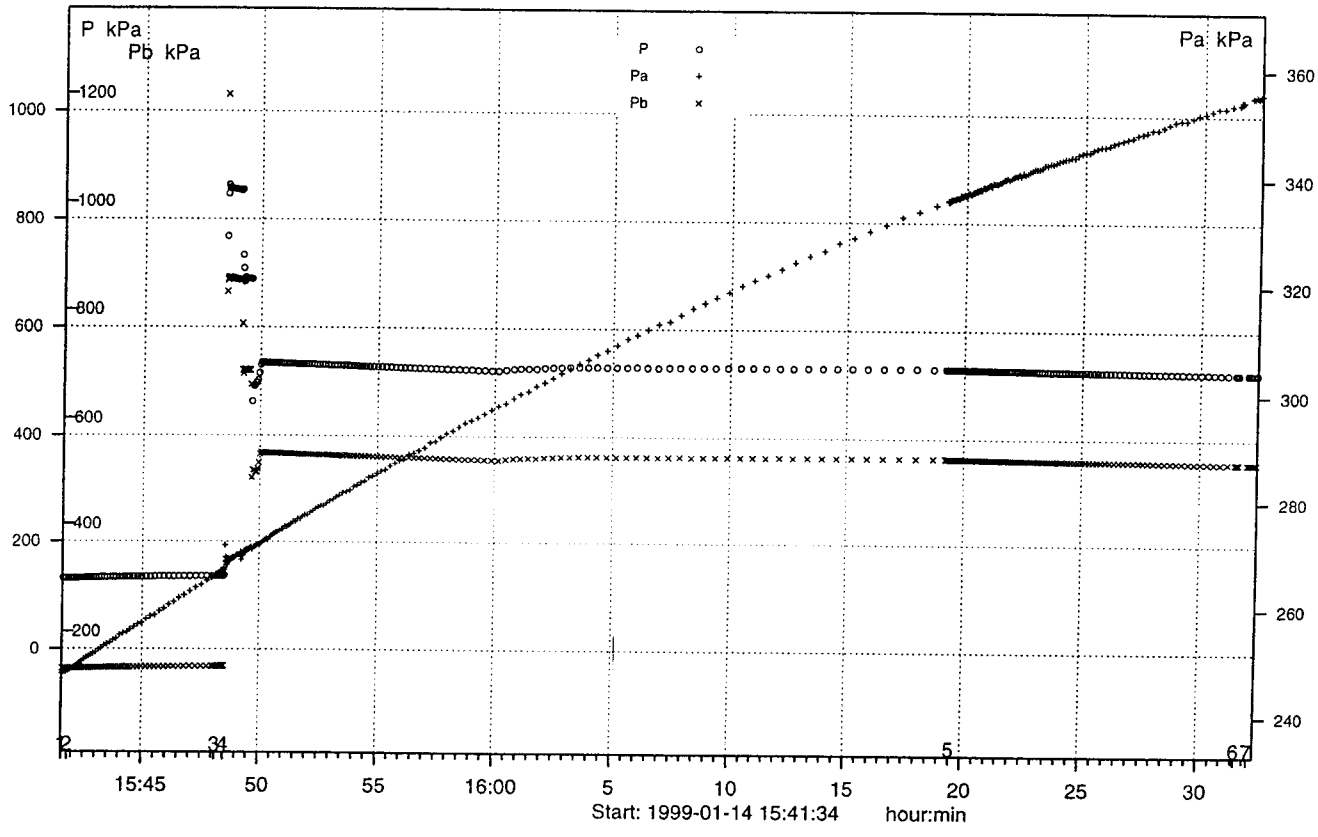
Fri Feb 12 16:33:20 1999

Borehole: 3572G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-14 15:41:24



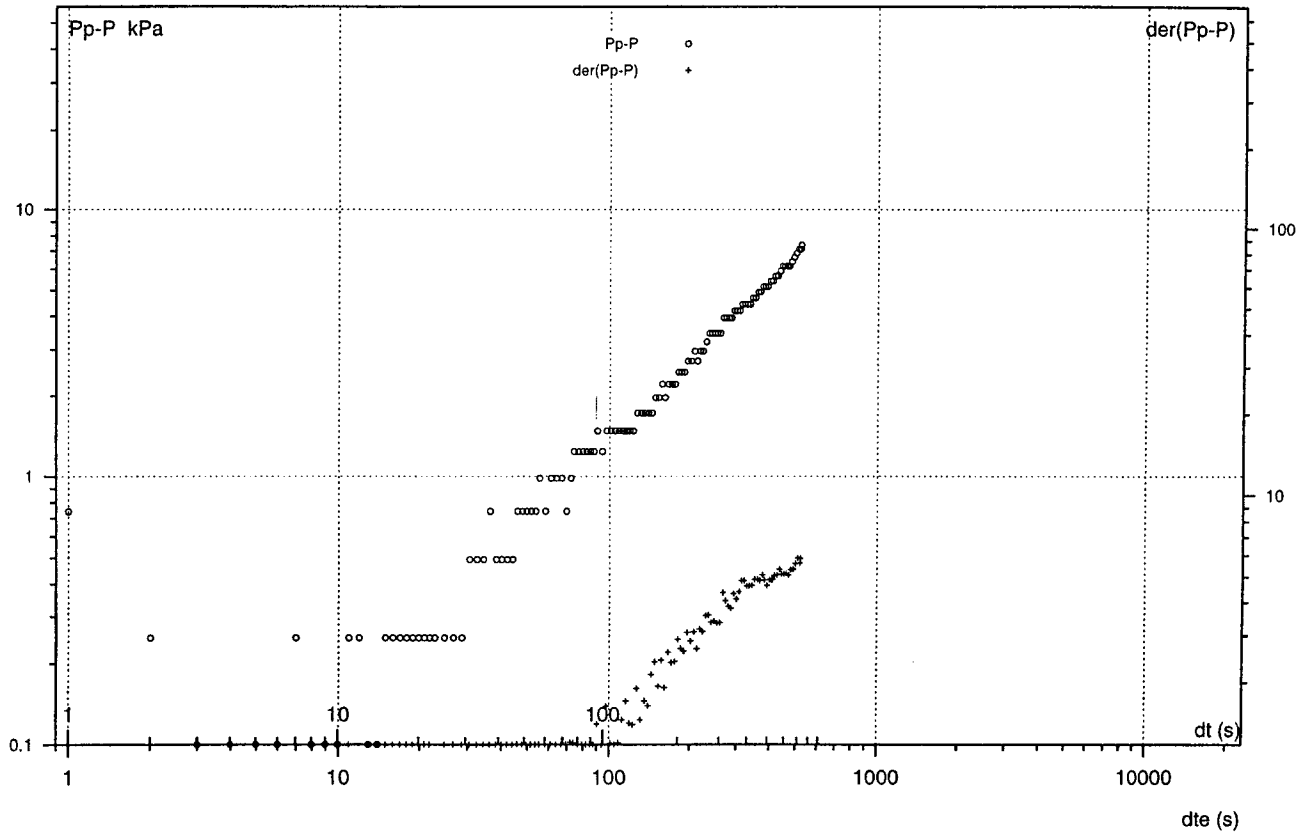
Fri Feb 12 16:32:48 1999

Borehole: 3572G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-14 15:41:24



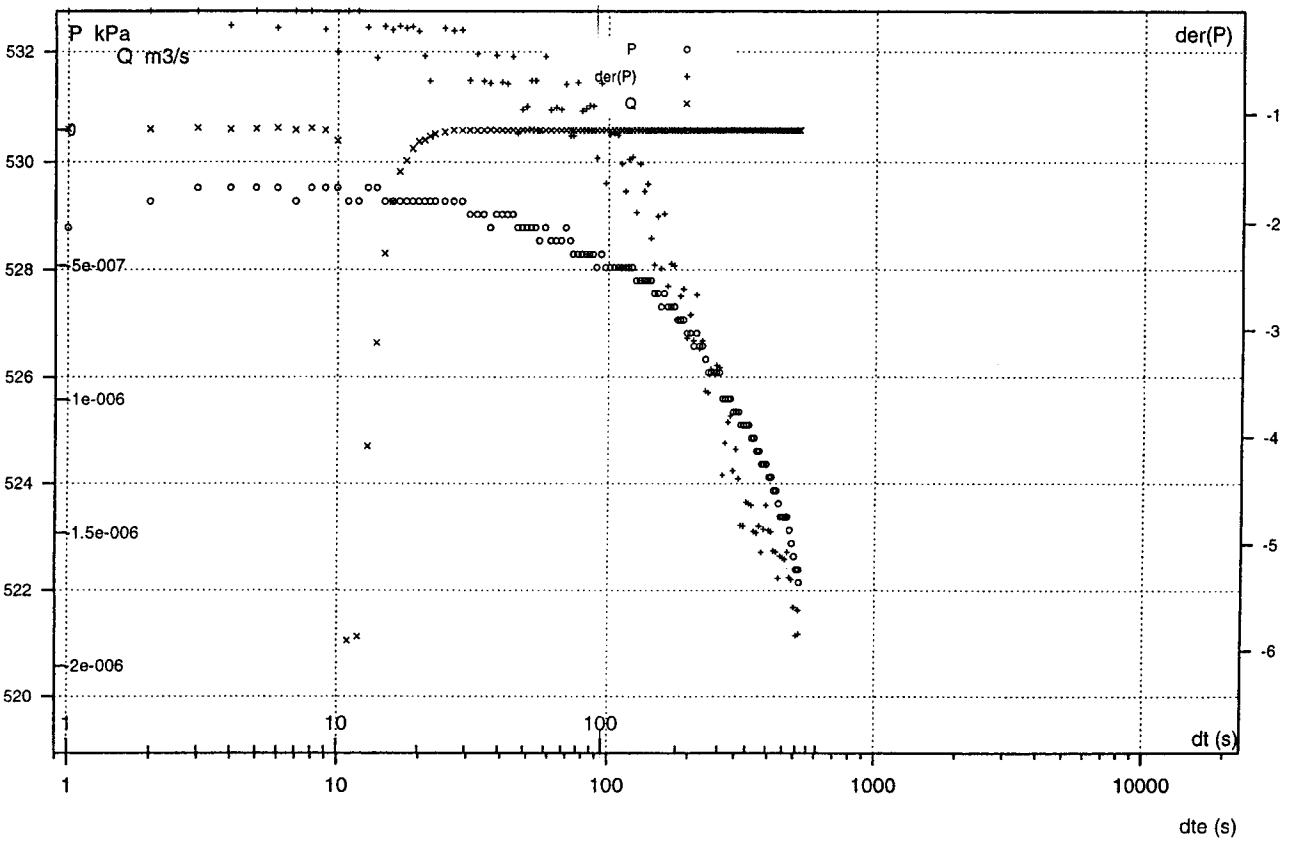
Fri Feb 12 16:32:49 1999

Borehole: 3572G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-14 15:41:24



Fri Feb 12 16:32:49 1999

Borehole KA3574G01, section 0.25 m - 0.75 m

Date: 99-01-14 Field Crew: B. Gentzschein

Valve opened: 990114 173501 Valve closed: 990114 175814
Total flowing time: 23.2 min. Tot. Pr. Build-up time: 11.7 min.

Pressure before injection start (P_0, kPa) : 123.7
Pressure just before closing the valve (P_p, kPa) : 539.9
Pressure at the end of the recovery (P_f, kPa) : 535.7

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

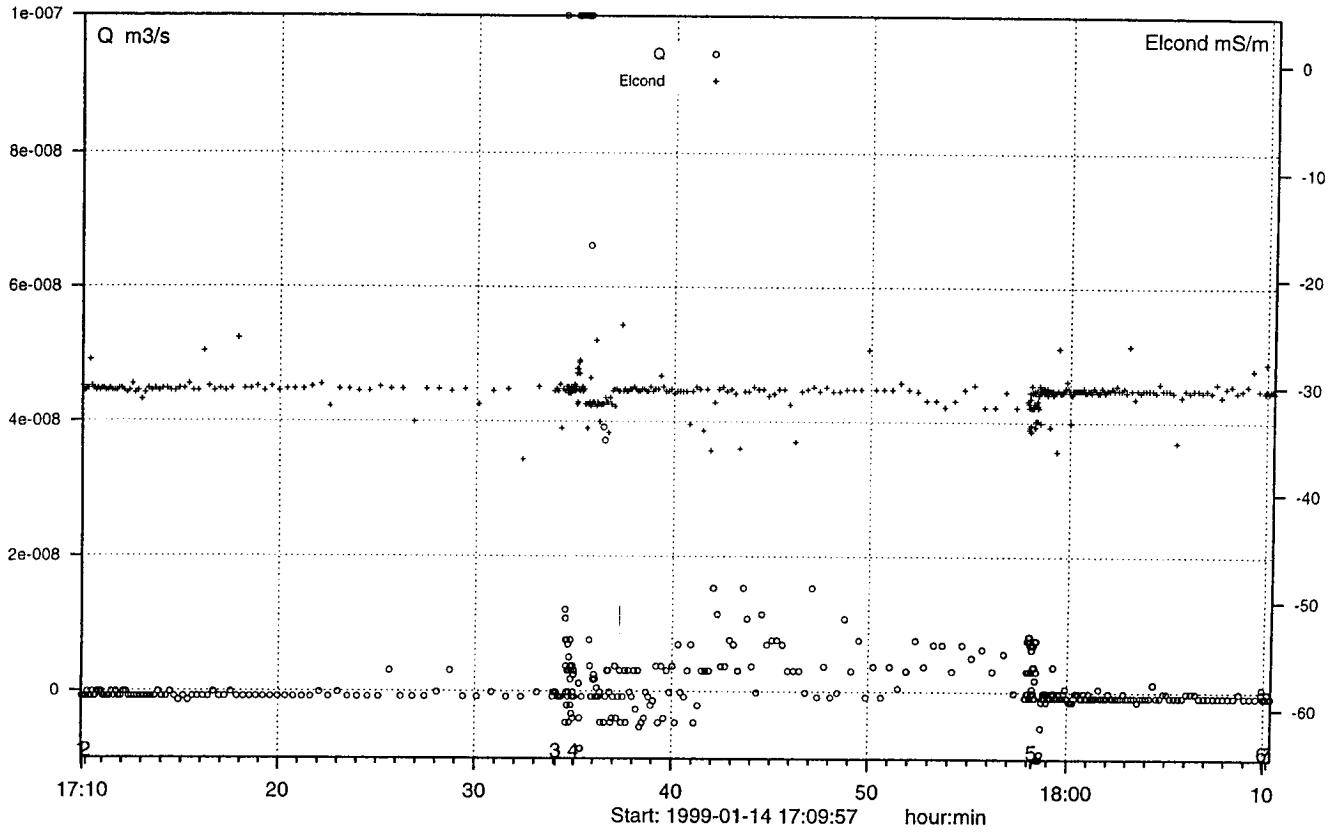
P_{ref} was changed to 520 kPa. The recovery is less than five kPa.

Borehole: 3574G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-14 17:09:48



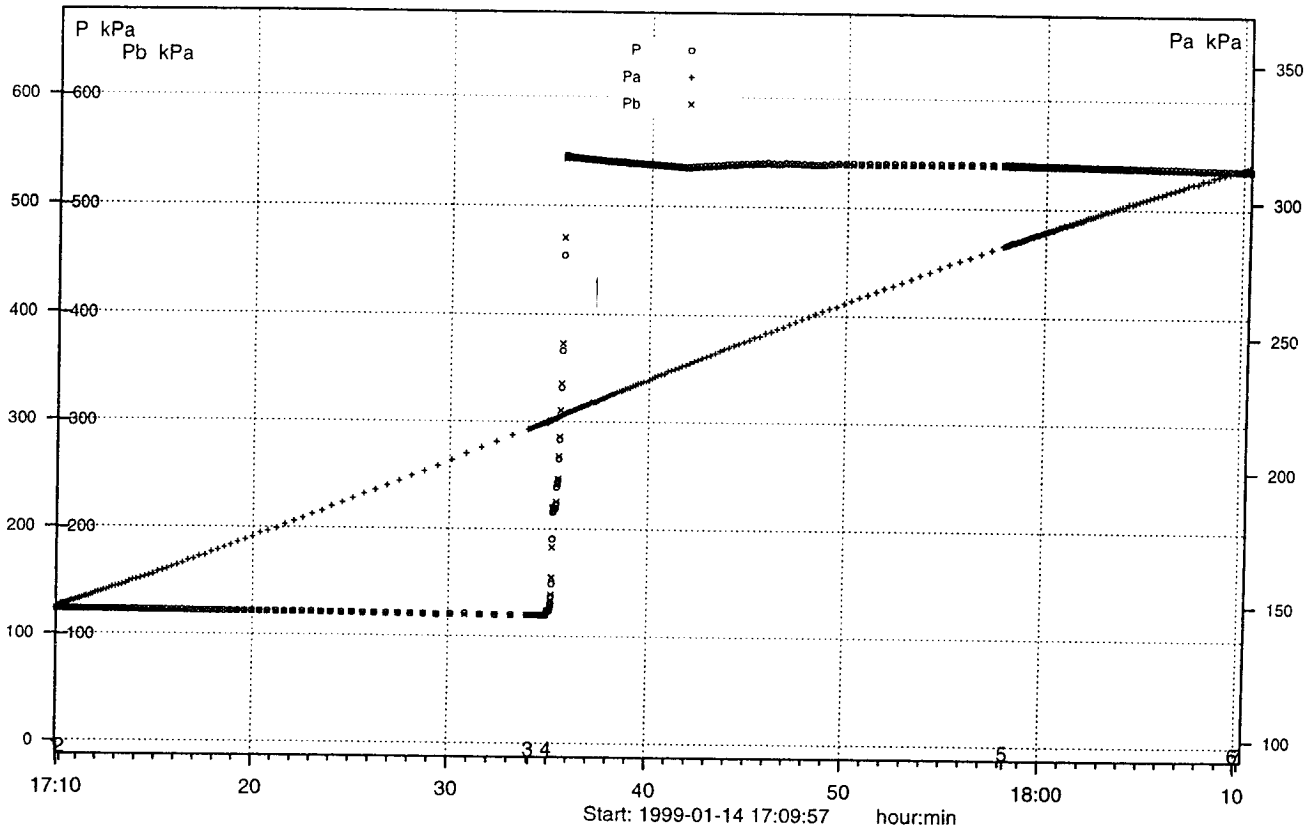
Mon Feb 15 08:47:53 1999

Borehole: 3574G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-14 17:09:48



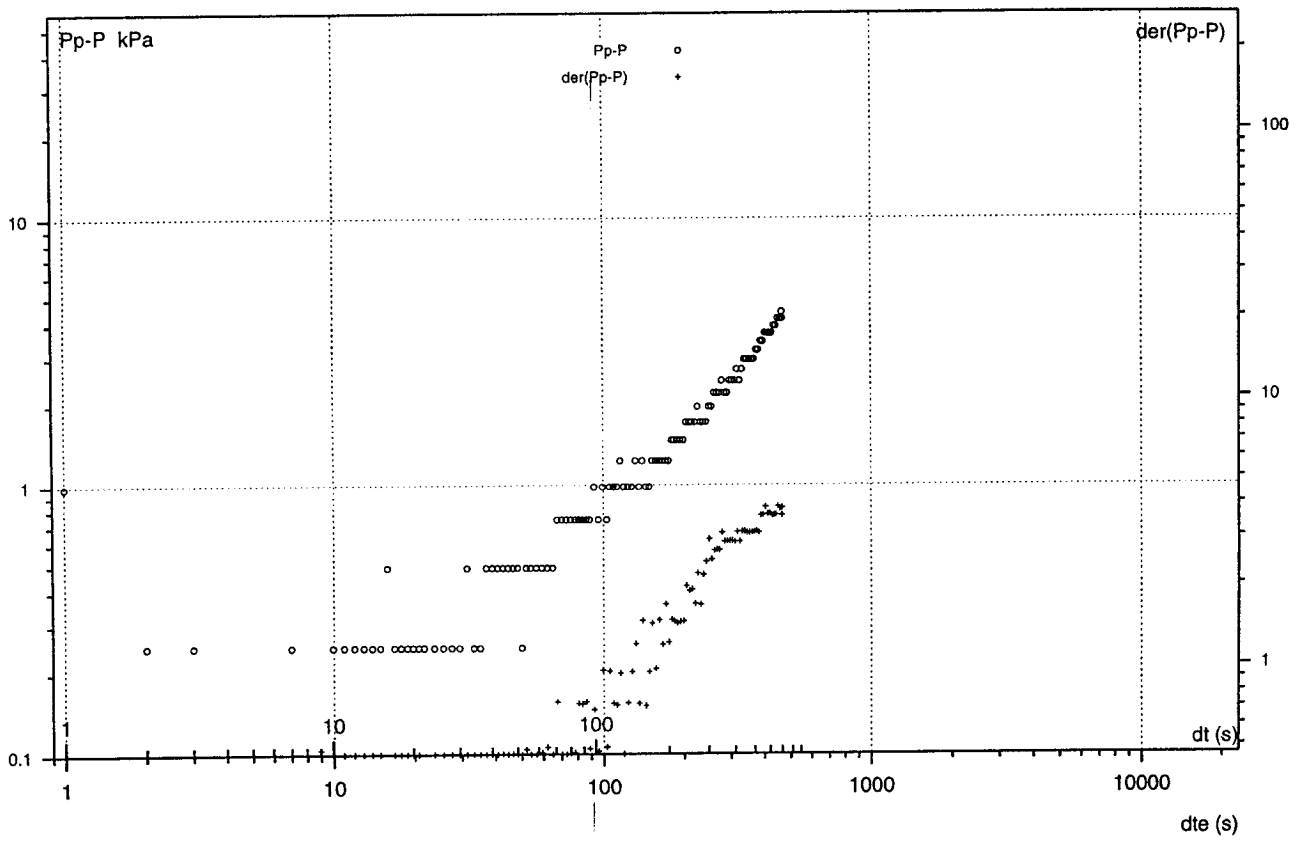
Mon Feb 15 08:45:59 1999

Borehole: 3574G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-14 17:09:48



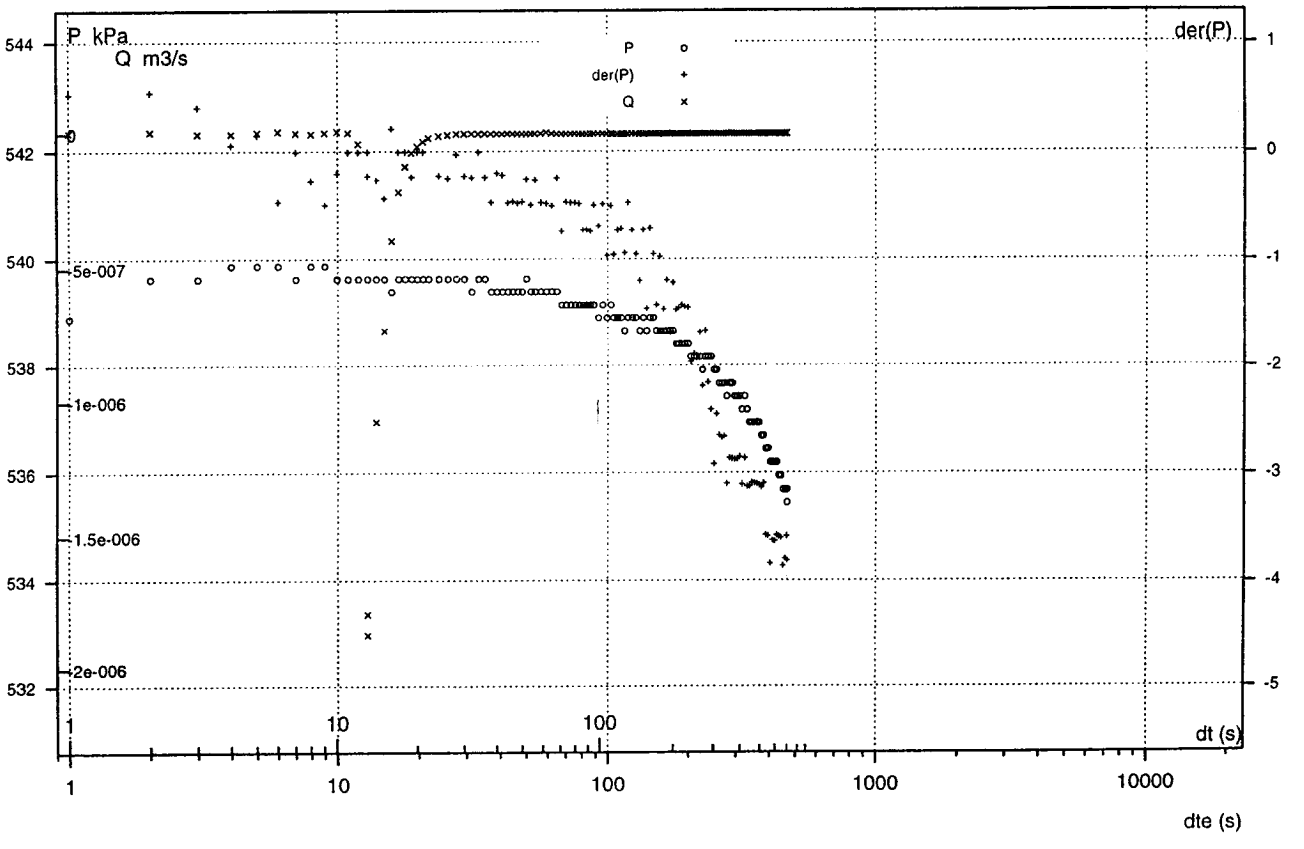
Mon Feb 15 08:46:00 1999

Borehole: 3574G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-14 17:09:48



Mon Feb 15 08:46:00 1999

Borehole KA3574G01, section 0.75 m – 1.25 m

Date: 99-01-14 Field Crew: B. Gentzschein

Valve opened: 990114 190421 Valve closed: 990114 193113
Total flowing time: 26.9 min. Tot. Pr. Build-up time: 764.3 min.

Pressure before injection start (P_0, kPa) : 123.4
Pressure just before closing the valve (P_p, kPa) : 524.7
Pressure at the end of the recovery (P_f, kPa) : 337.6

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

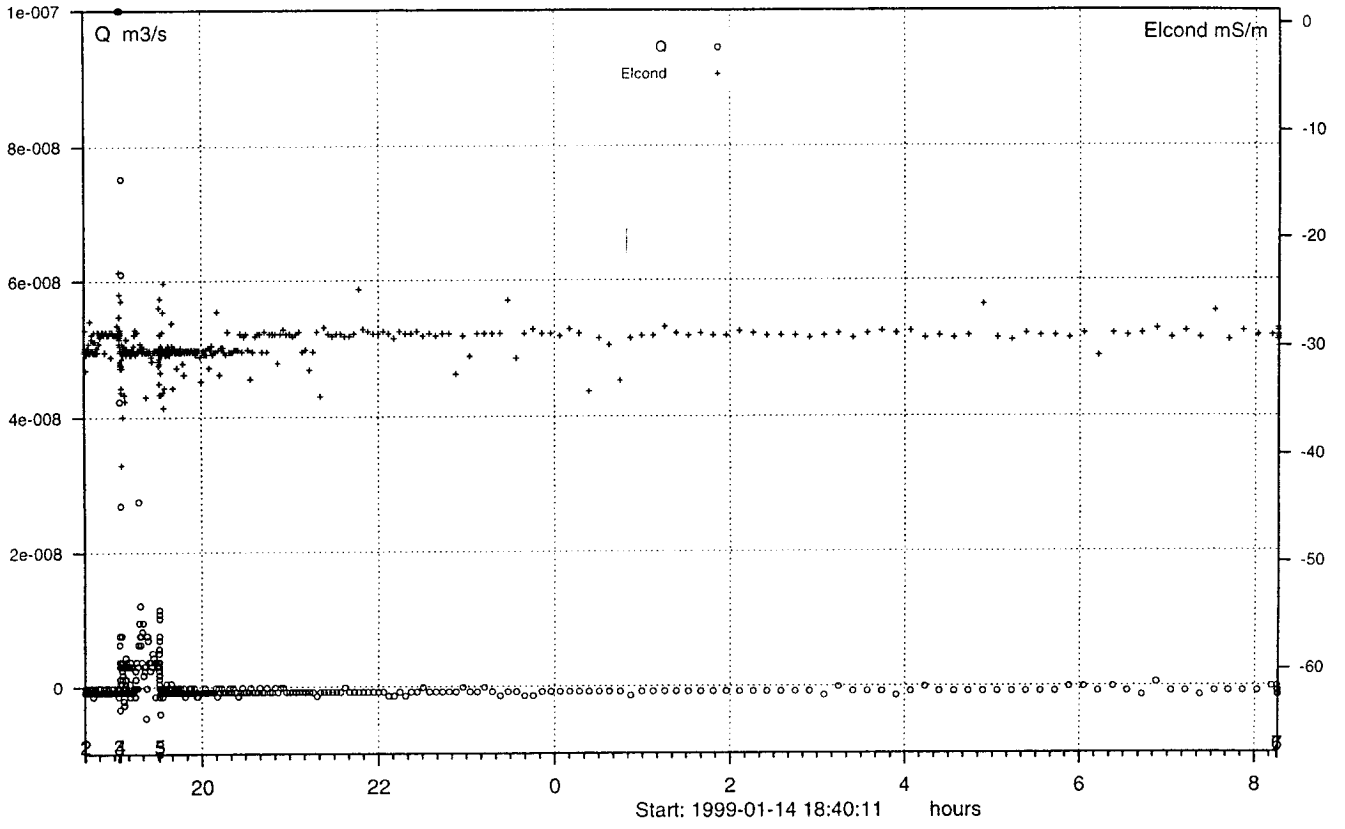
The recovery lasted over night.

Borehole: 3574G01

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-14 18:40:00



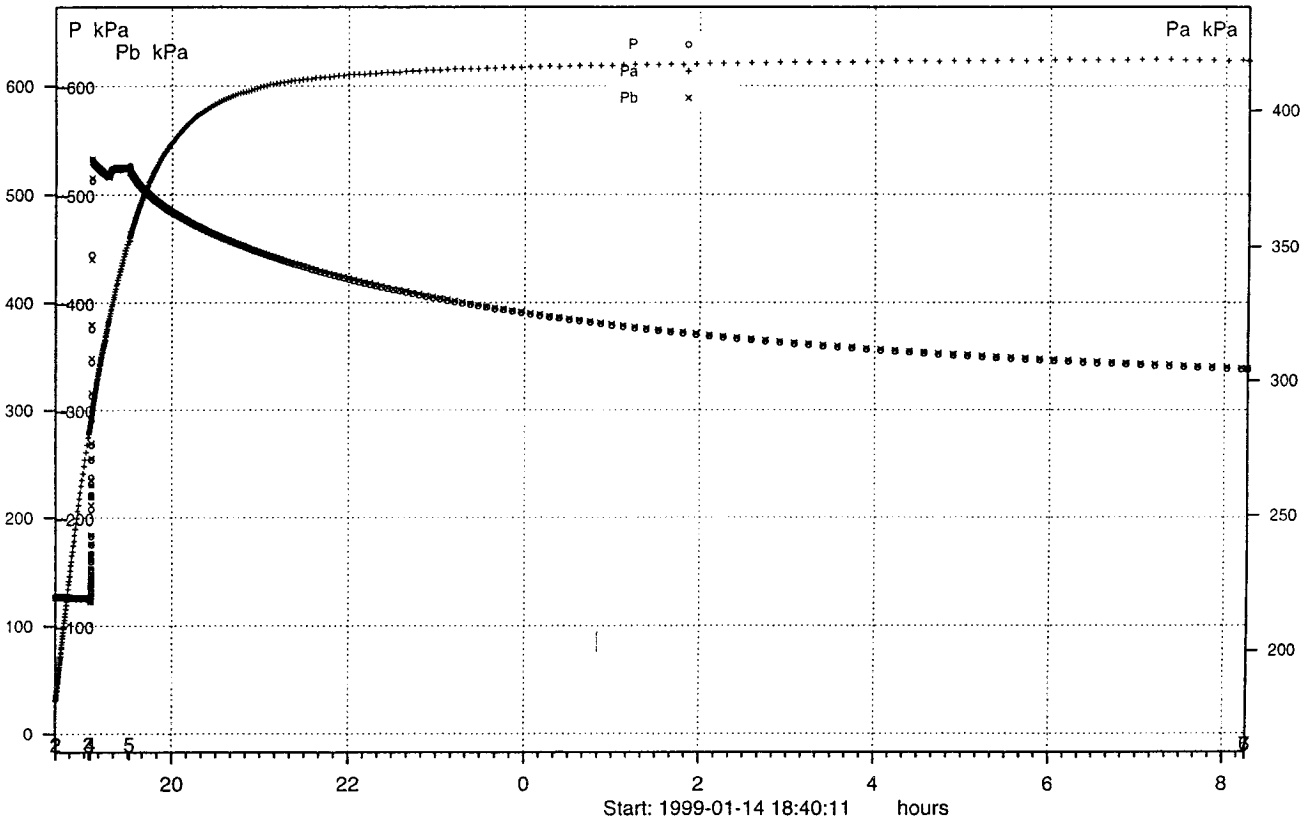
Mon Feb 15 09:04:28 1999

Borehole: 3574G01

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-14 18:40:00



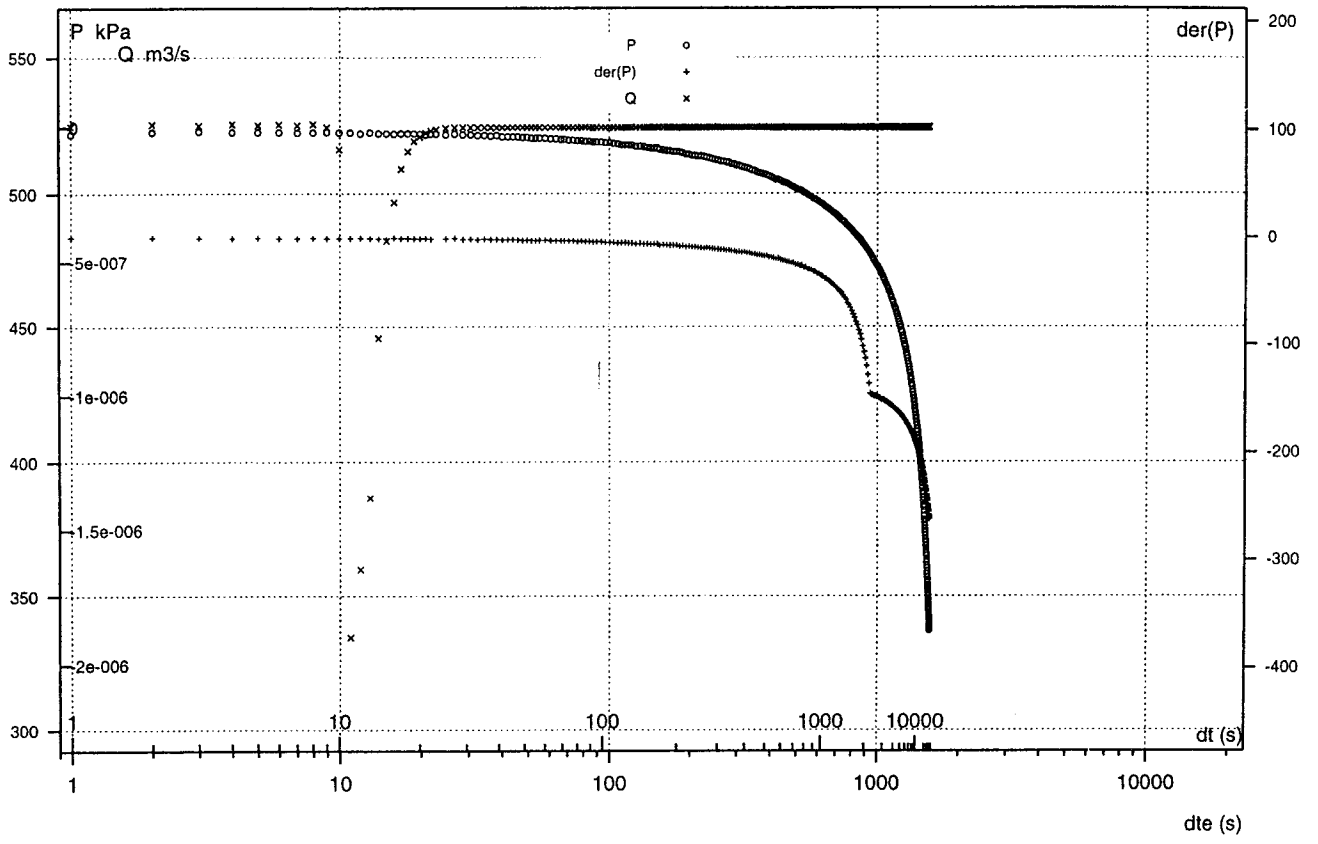
Mon Feb 15 09:03:25 1999

Borehole: 3574G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-14 18:40:00



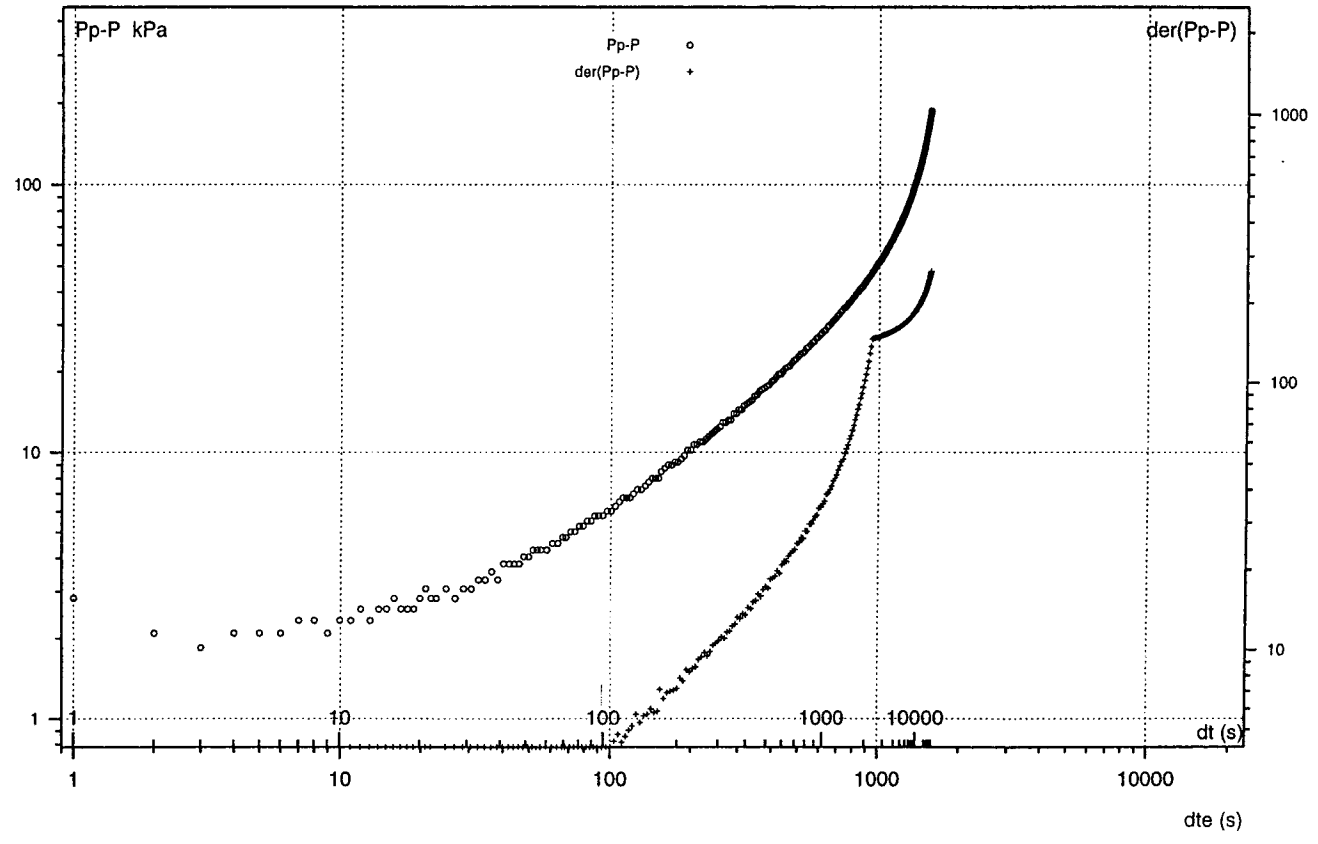
Mon Feb 15 09:03:26 1999

Borehole: 3574G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-14 18:40:00



Mon Feb 15 09:03:26 1999

Borehole KA3574G01, section 1.25 m – 1.75 m

Date: 99-01-15 Field Crew: B. Gentzschein

Valve opened: 990115 090150 Valve closed: 990115 093359
Total flowing time: 32.2 min. Tot. Pr. Build-up time: 15.1 min.

Pressure before injection start (P_0, kPa) : 123.4
Pressure just before closing the valve (P_p, kPa) : 560.6
Pressure at the end of the recovery (P_f, kPa) : 556.8

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

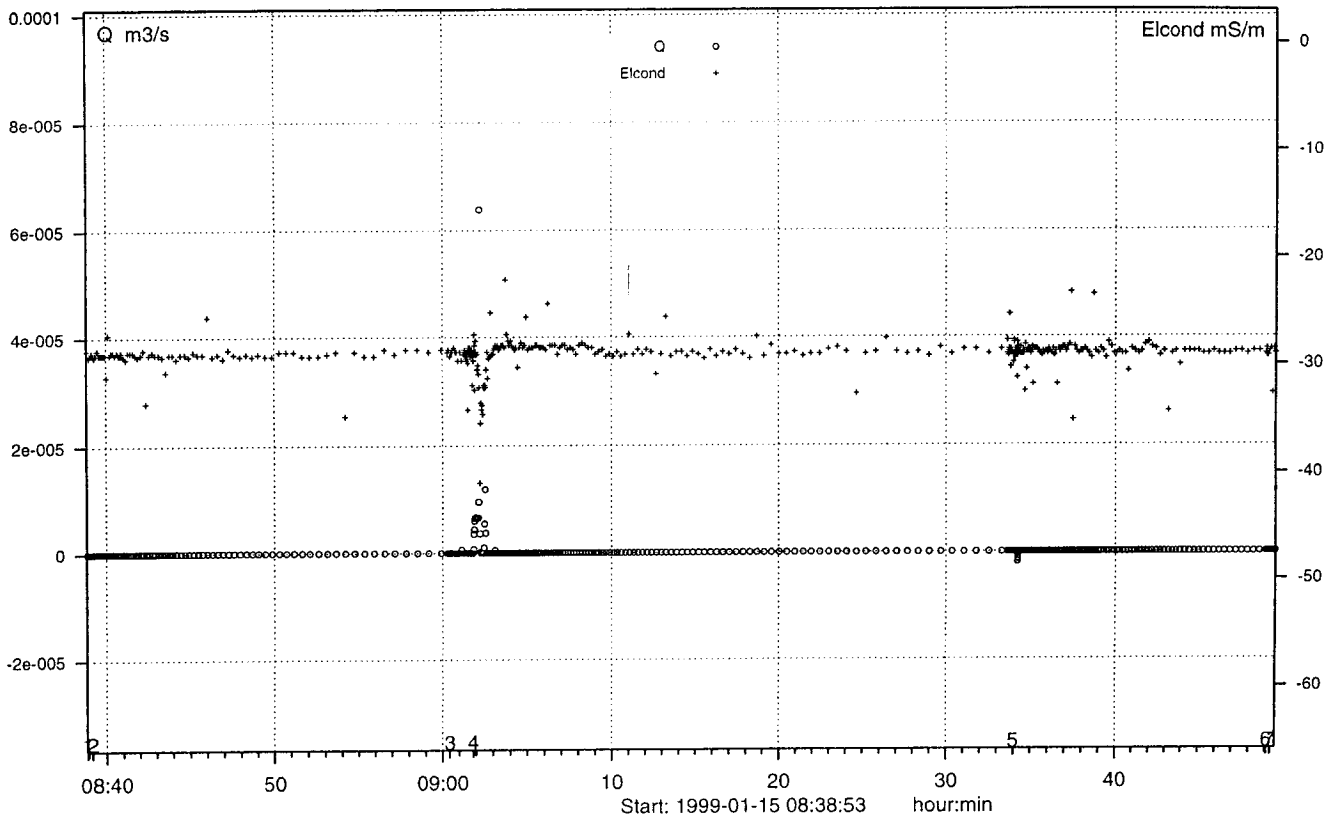
P_{ref} was changed to 530 kPa. The recovery is less than five kPa.

Borehole: 3574G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-15 08:38:37



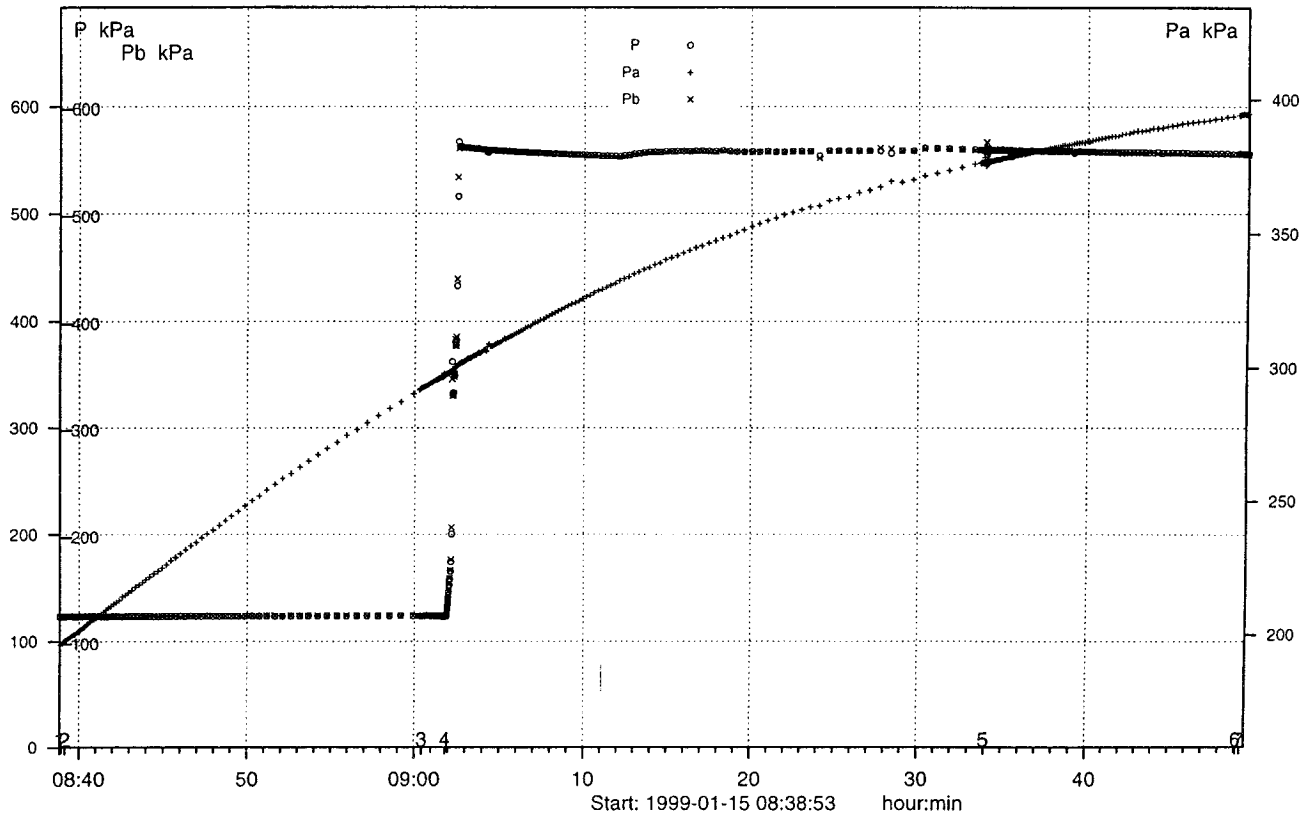
Mon Feb 15 09:22:04 1999

Borehole: 3574G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-15 08:38:37



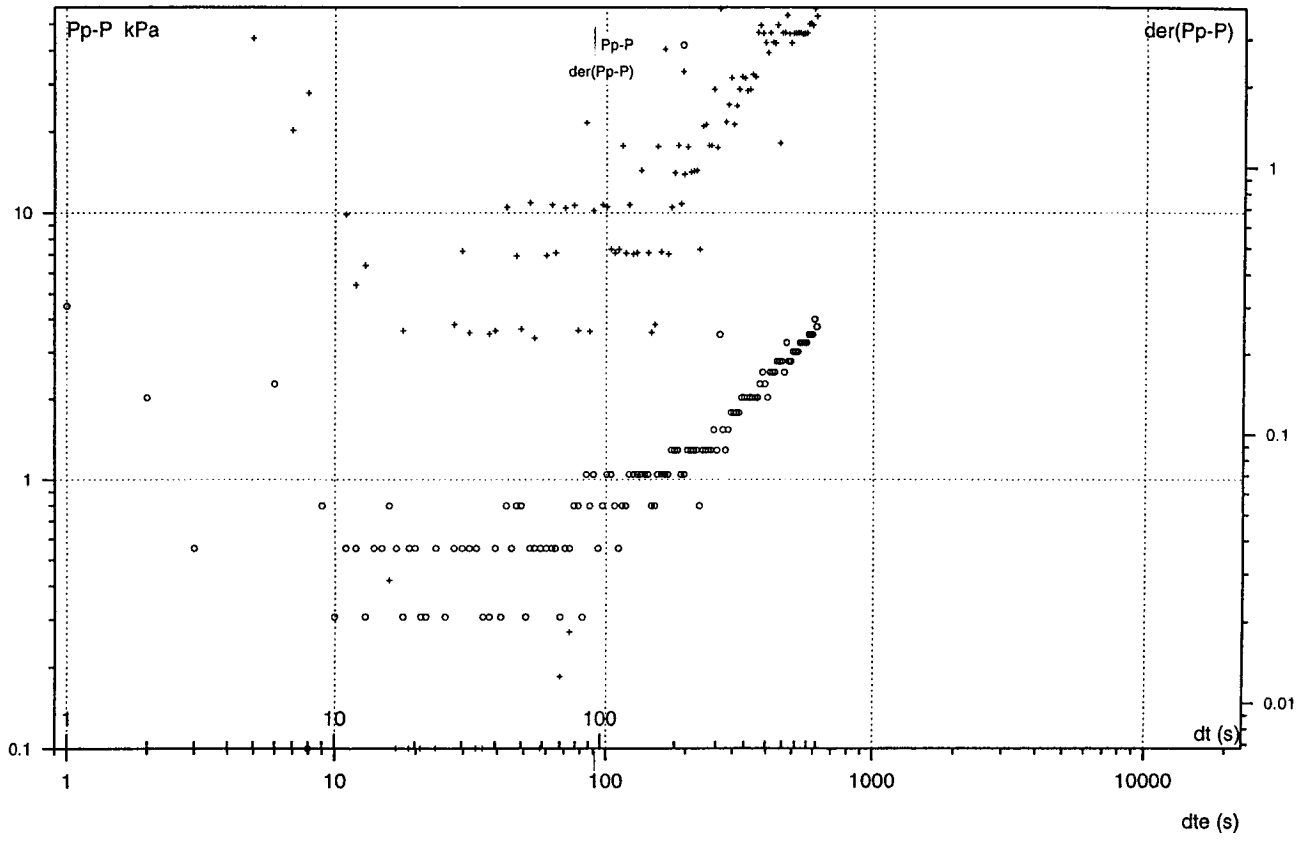
Mon Feb 15 09:22:04 1999

Borehole: 3574G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-15 08:38:37



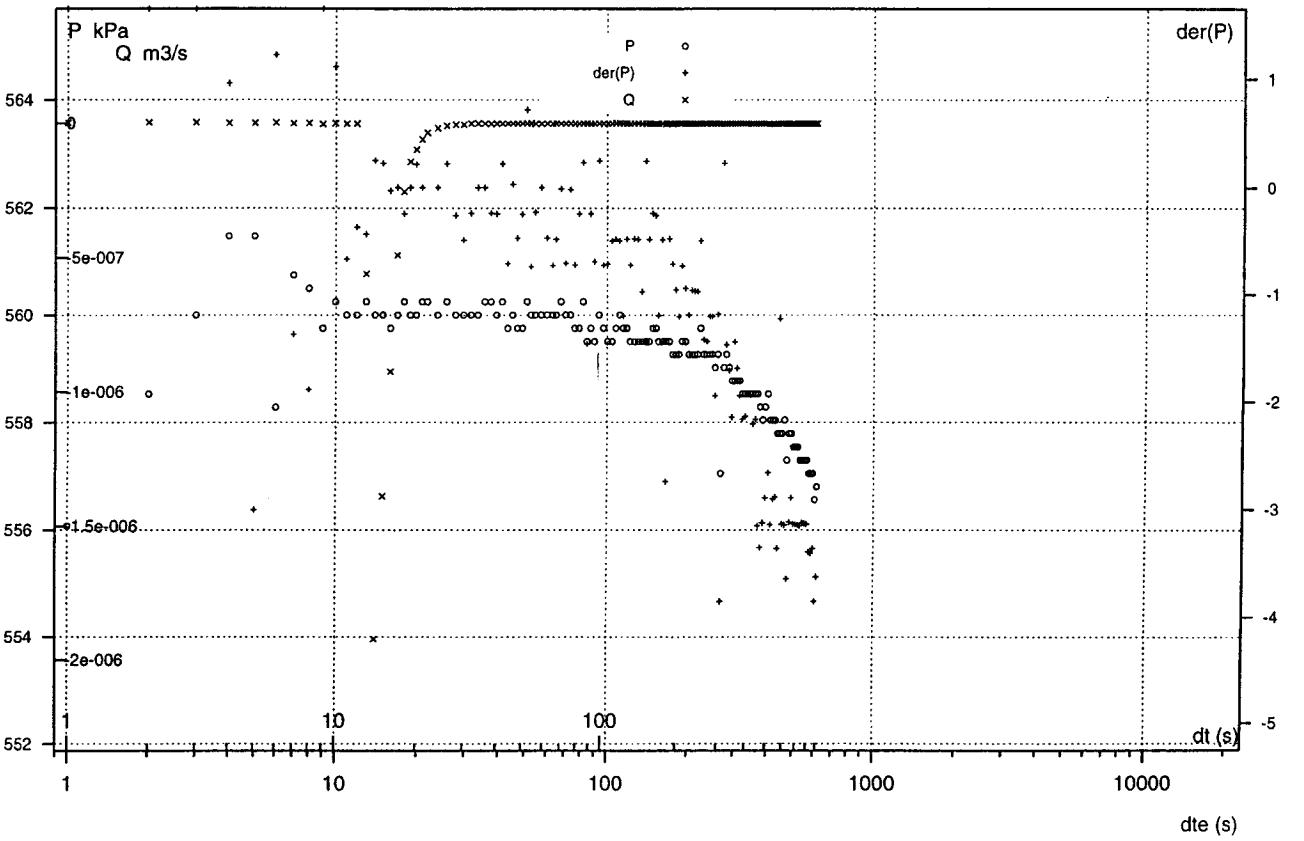
Mon Feb 15 09:22:05 1999

Borehole: 3574G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-15 08:38:37



Mon Feb 15 09:22:05 1999

Borehole KA3576G01, section 0.25 m - 0.75 m

Date: 99-01-15 Field Crew: B. Gentzschein

Valve opened: 990115 105343 Valve closed: 990115 111423
Total flowing time: 20.7 min. Tot. Pr. Build-up time: 75.8 min.

Pressure before injection start (P_0, kPa) : 122.3
Pressure just before closing the valve (P_p, kPa) : 519.9
Pressure at the end of the recovery (P_f, kPa) : 396.7

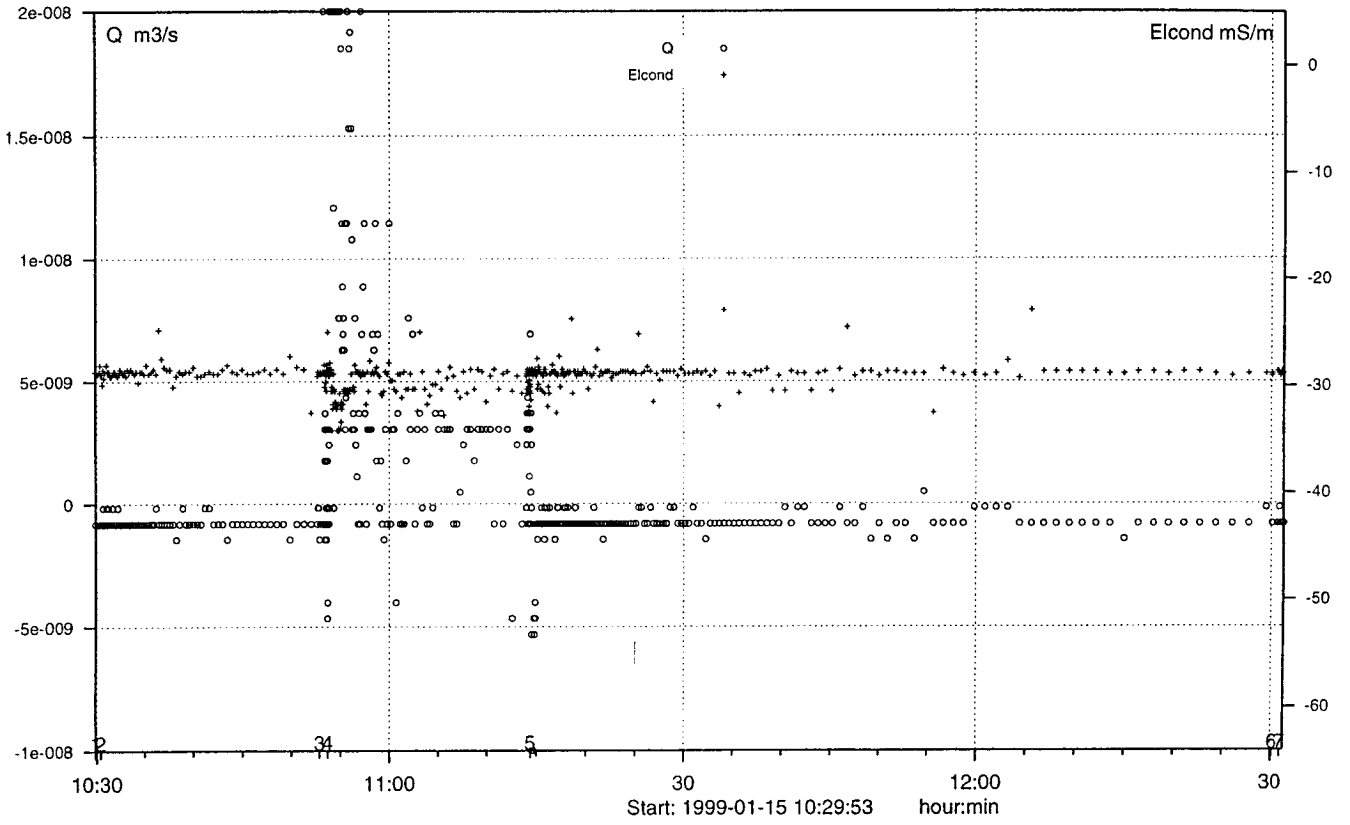
Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

Borehole: 3576G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-15 10:29:40



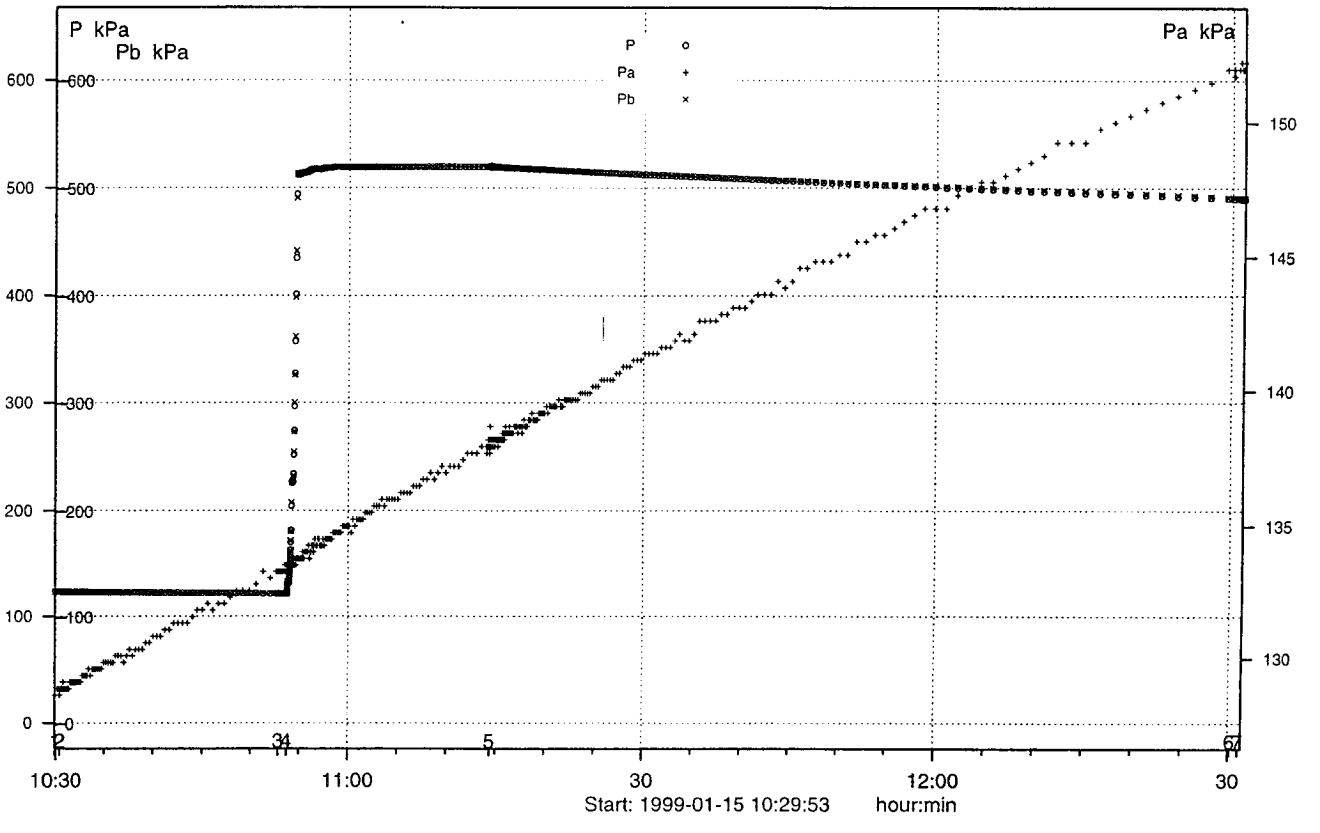
Mon Feb 15 09:50:20 1999

Borehole: 3576G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-15 10:29:40



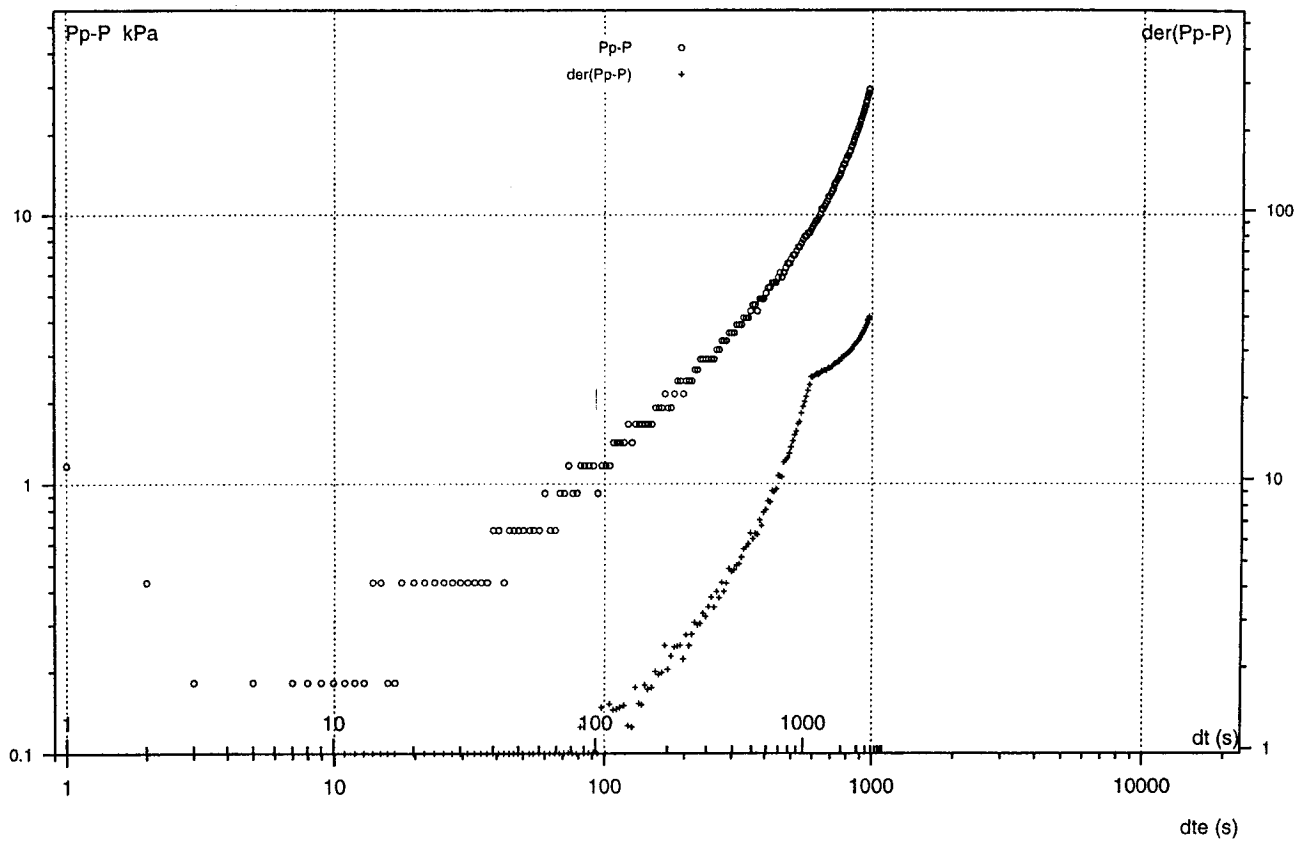
Mon Feb 15 09:49:17 1999

Borehole: 3576G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-15 10:29:40



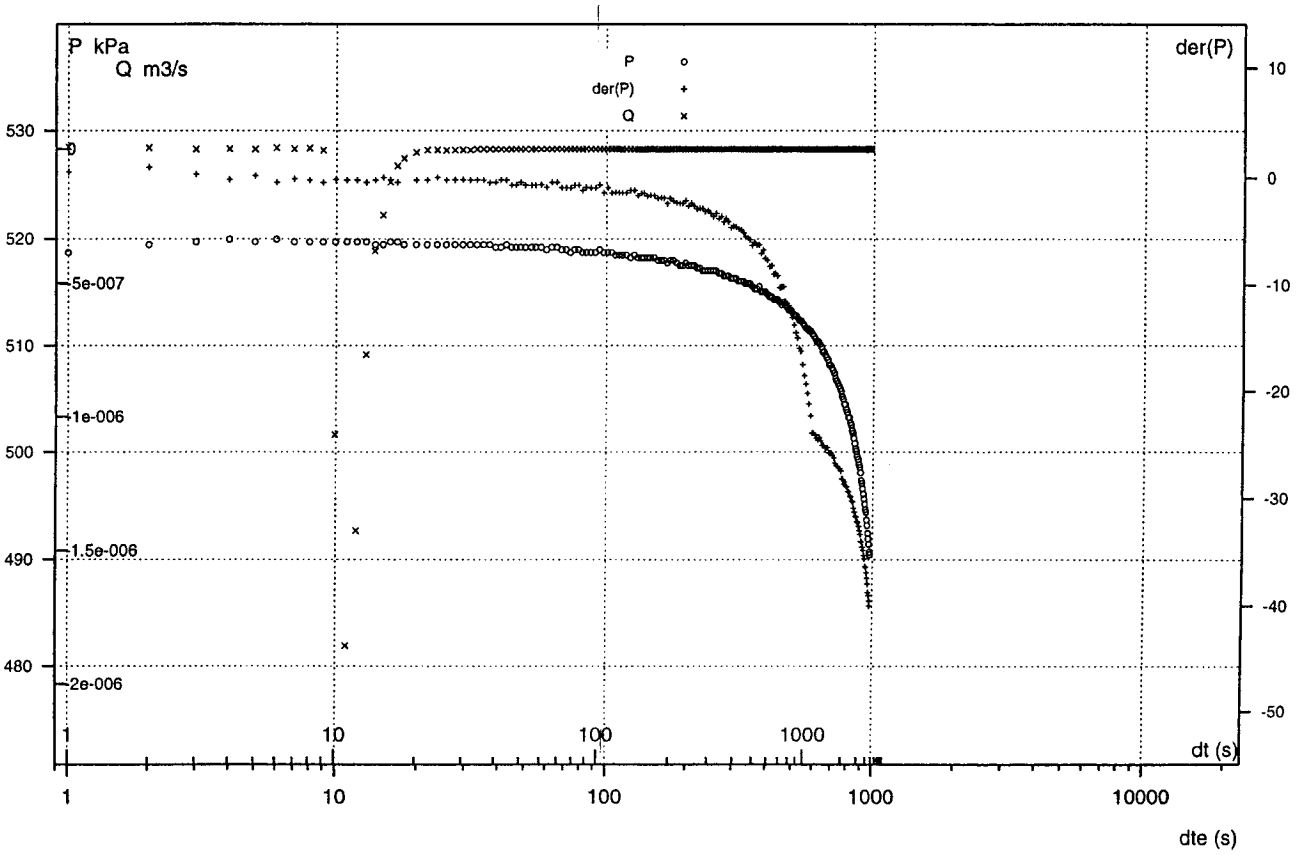
Mon Feb 15 09:49:18 1999

Borehole: 3576G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-15 10:29:40



Mon Feb 15 09:49:18 1999

Borehole KA357601, section 0.75 m – 1.25 m

Date: 99-01-15 Field Crew: B. Gentzschein

Valve opened: 990115 132813 Valve closed: 990115 135054
Total flowing time: 22.7 min. Tot. Pr. Build-up time: 13.6 min.

Pressure before injection start (P_0, kPa) : 127.9
Pressure just before closing the valve (P_p, kPa) : 524.4
Pressure at the end of the recovery (P_f, kPa) : 517.3

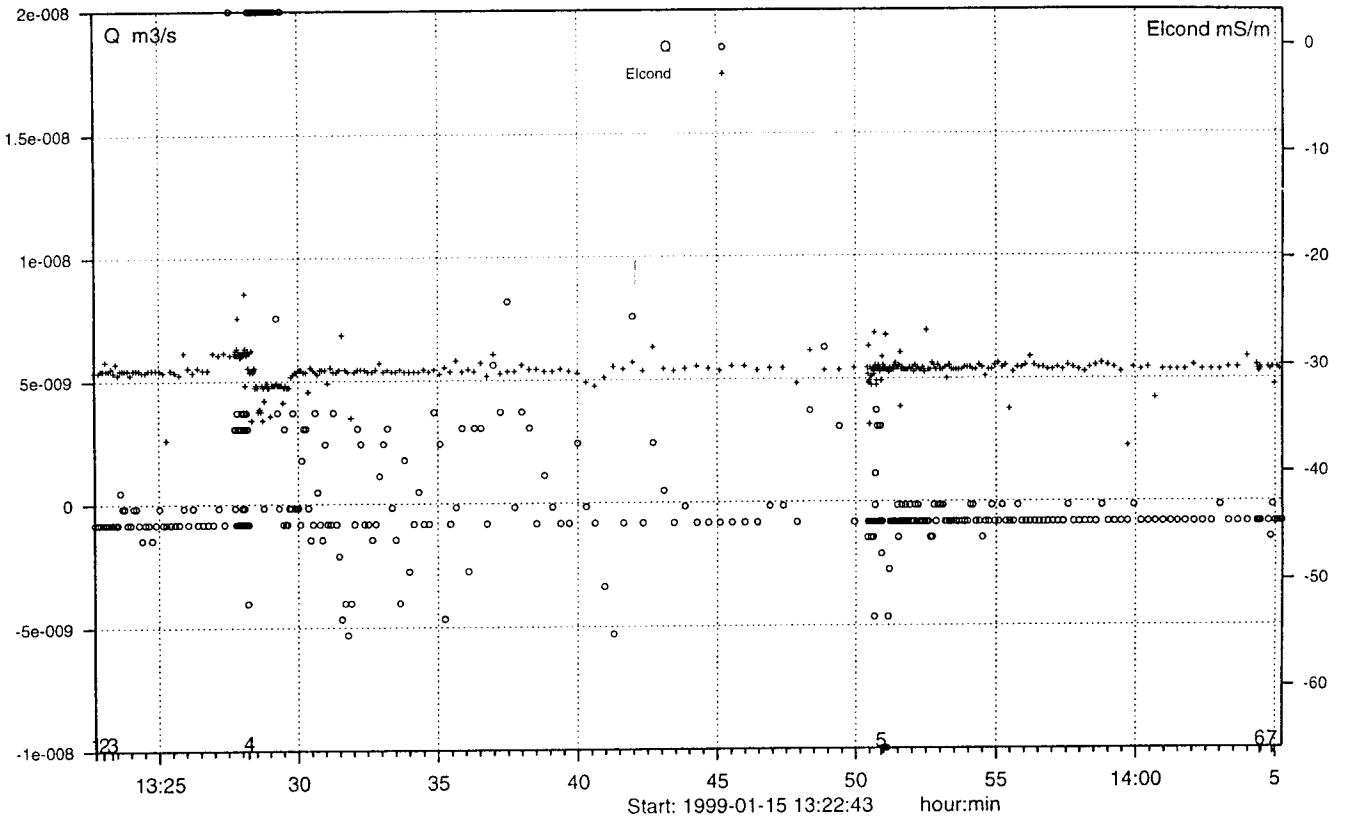
Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

Borehole: 3576G01

Section : 0.8 - 1.3 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-15 13:22:31



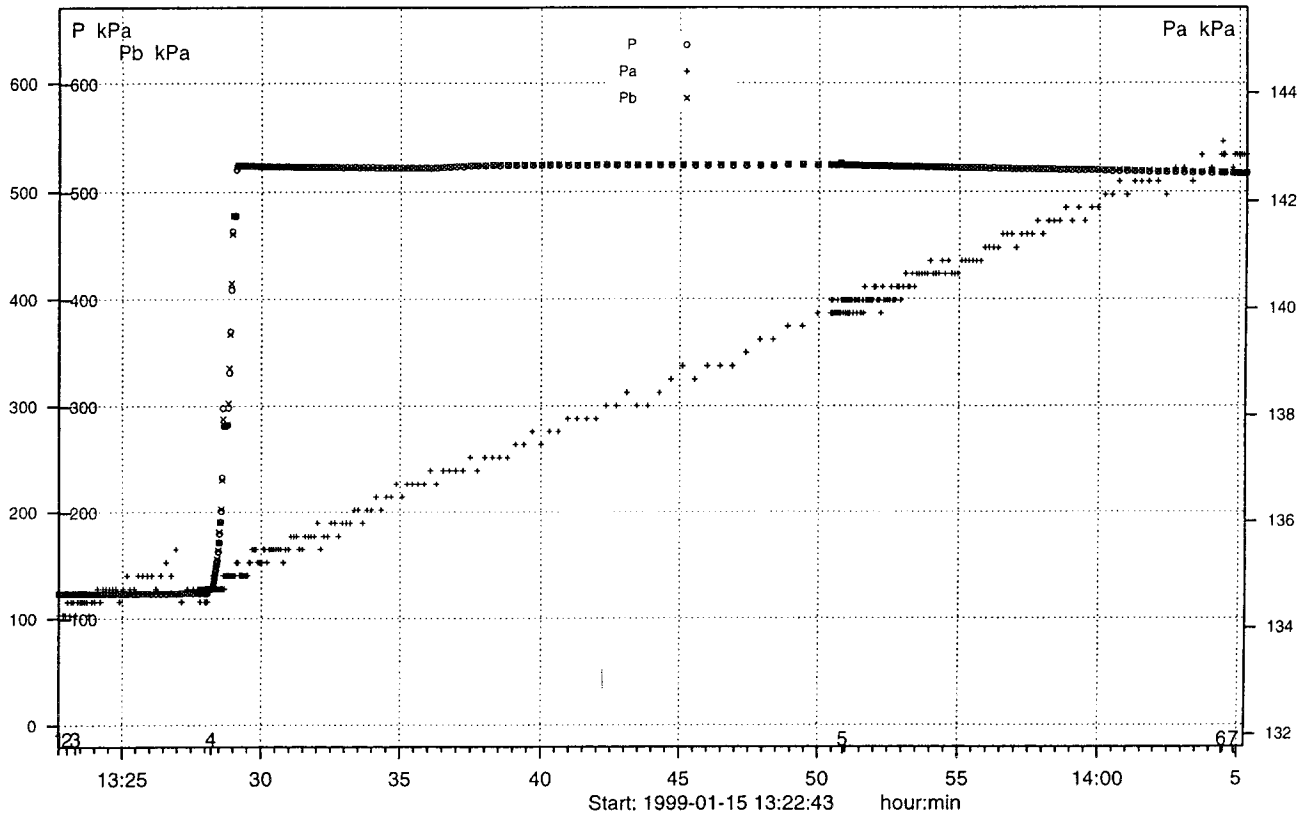
Mon Feb 15 10:02:13 1999

Borehole: 3576G01

Section : 0.8 - 1.3 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-15 13:22:31



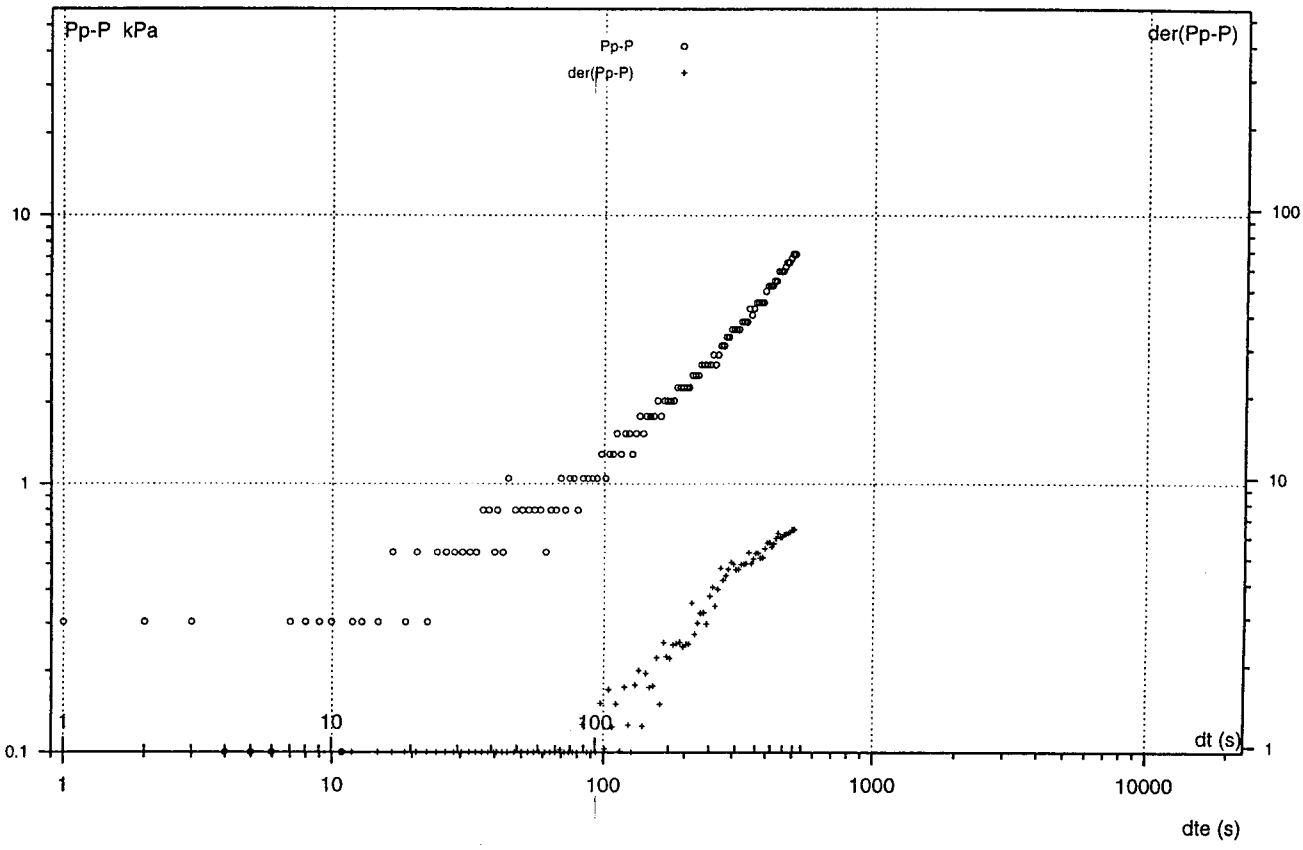
Mon Feb 15 10:01:29 1999

Borehole: 3576G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-15 13:22:31



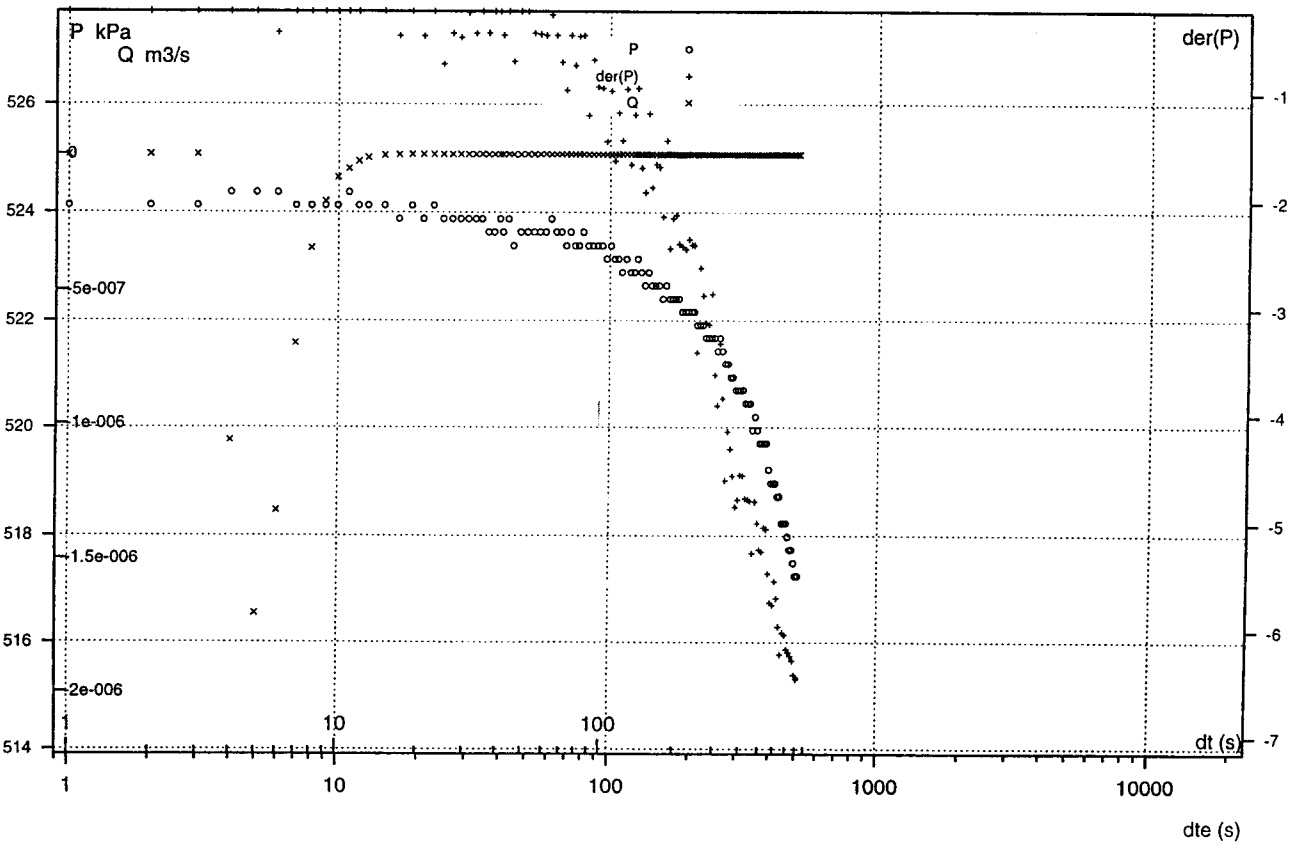
Mon Feb 15 10:01:30 1999

Borehole: 3576G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-15 13:22:31



Mon Feb 15 10:01:29 1999

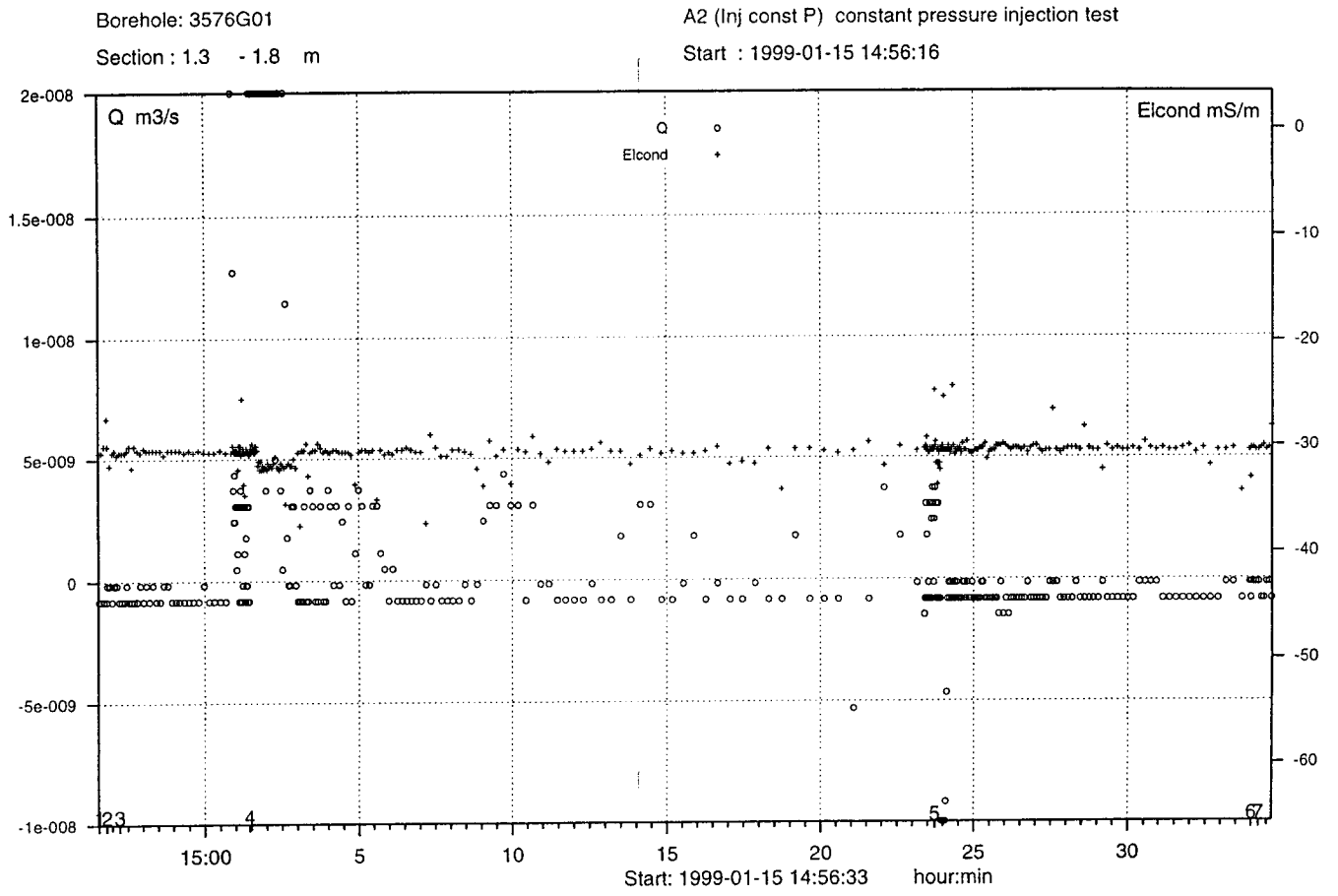
Borehole KA357601, section 1.25 m – 1.75 m

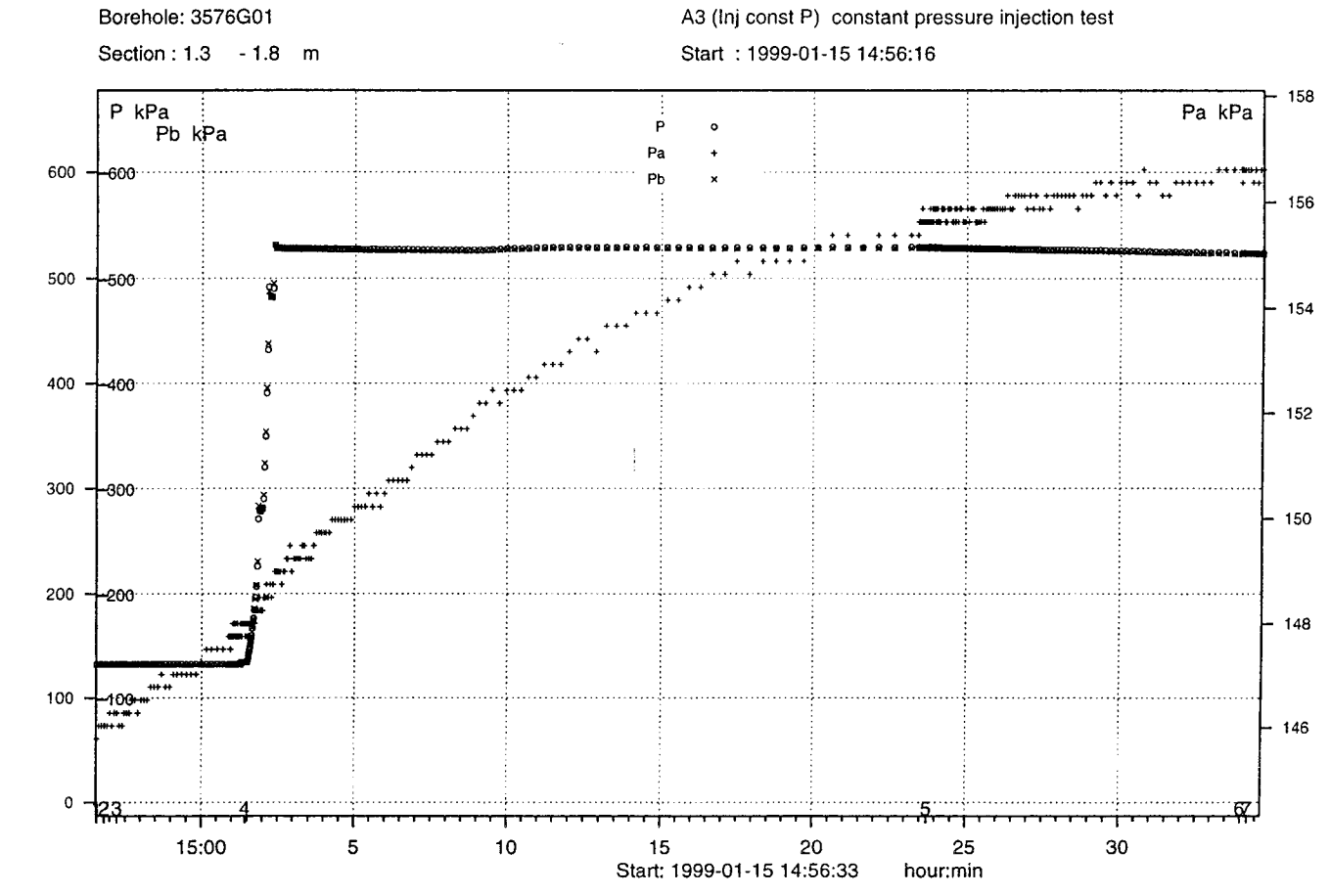
Date: 99-01-15 Field Crew: B. Gentzschein

Valve opened: 990115 150126 Valve closed: 990115 152344
Total flowing time: 21.3 min. Tot. Pr. Build-up time: 10.3 min.

Pressure before injection start (P_0, kPa) : 134.8
Pressure just before closing the valve (P_p, kPa) : 529.4
Pressure at the end of the recovery (P_f, kPa) : 523.9

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500


Borehole: 3576G01
Section : 1.3 - 1.8 m
A2 (Inj const P) constant pressure injection test
Start : 1999-01-15 14:56:16
Q m3/s
Elcond mS/m
Q
Elcond
2e-008
1.5e-008
1e-008
5e-009
0
-5e-009
-1e-008
0
-10
-20
-30
-40
-50
-60
15:00
5
10
15
20
25
30
Start: 1999-01-15 14:56:33
hour:min
Mon Feb 15 10:46:36 1999

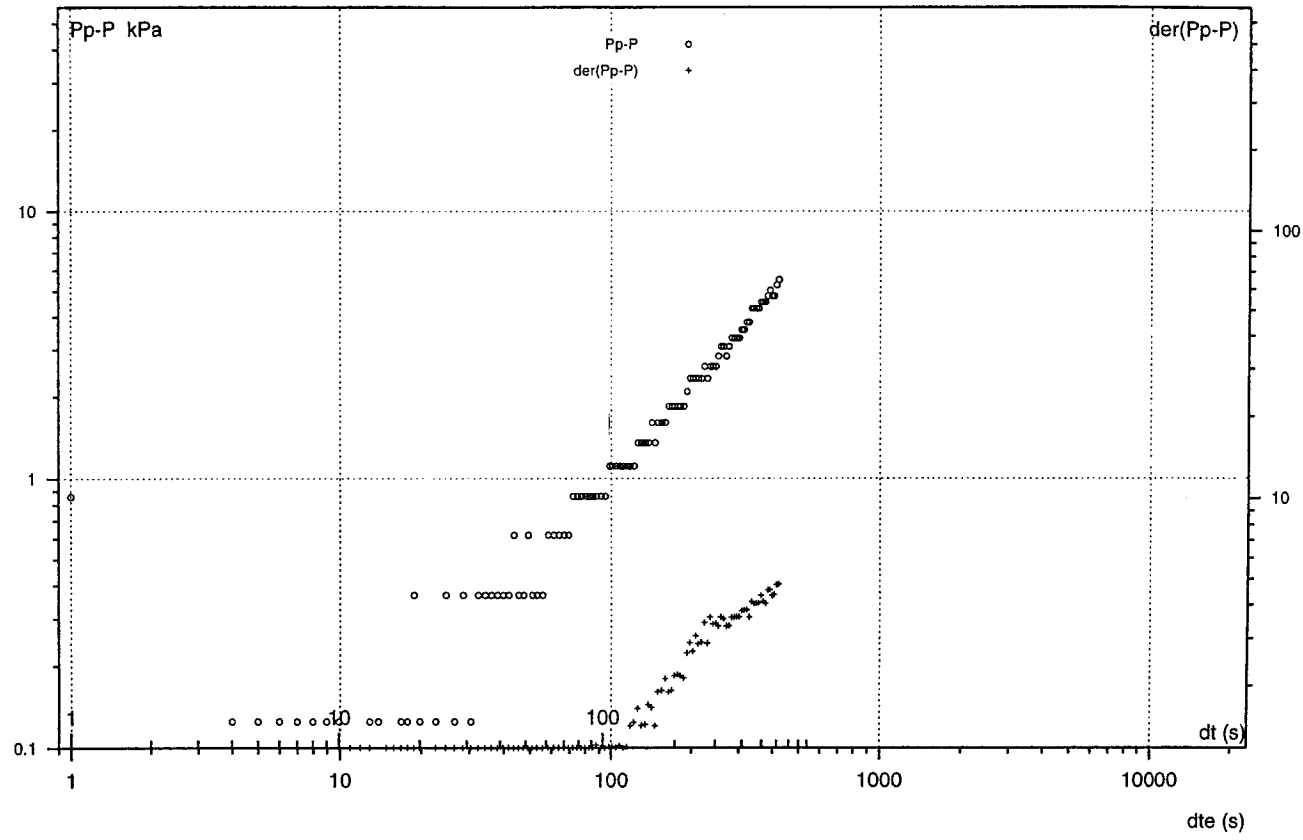

Borehole: 3576G01
Section : 1.3 - 1.8 m
A3 (Inj const P) constant pressure injection test
Start : 1999-01-15 14:56:16
P kPa
Pb kPa
Pa kPa
P
Pa
Pb
600
500
400
300
200
100
0
158
156
154
152
150
148
146
15:00
5
10
15
20
25
30
Start: 1999-01-15 14:56:33
hour:min
Mon Feb 15 10:24:12 1999

Borehole: 3576G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-15 14:56:16



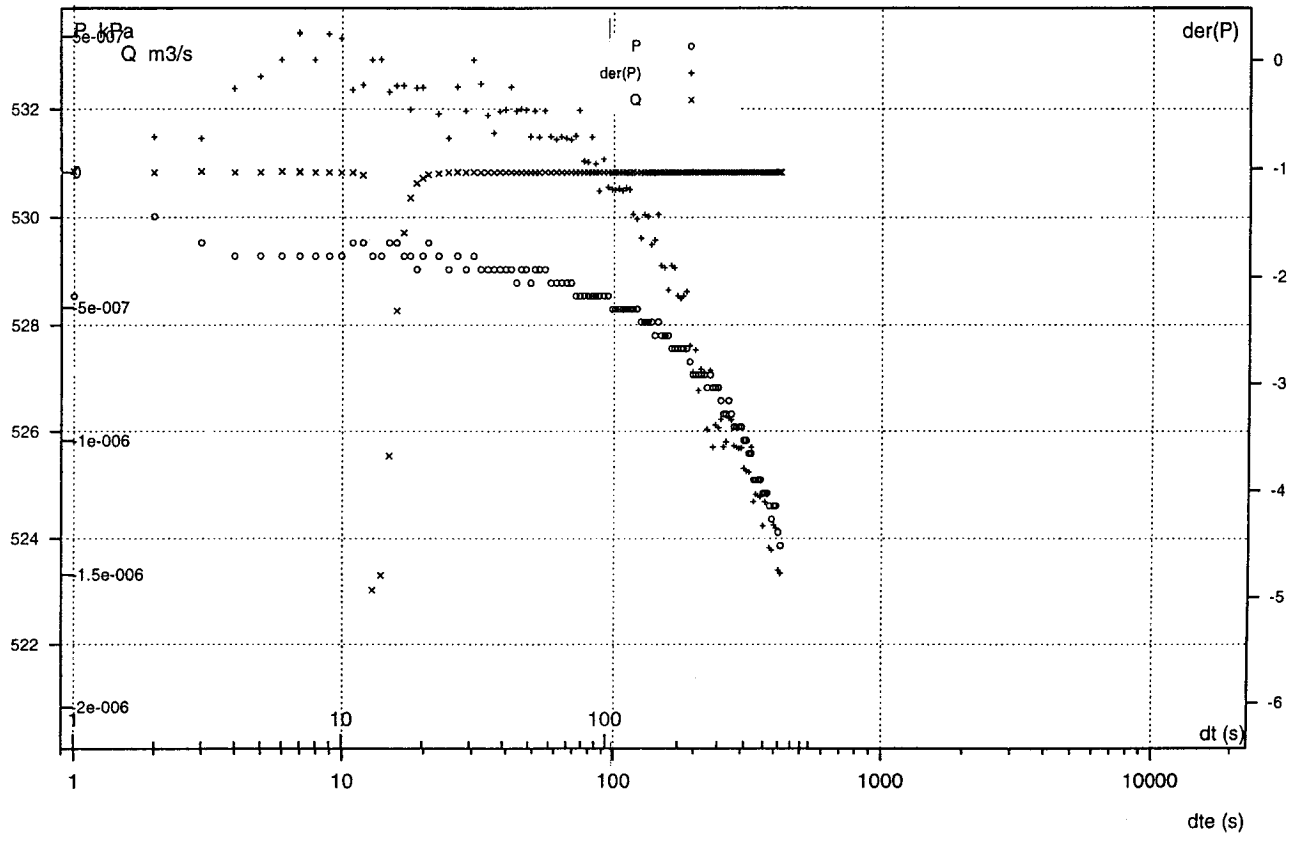
Mon Feb 15 10:24:13 1999

Borehole: 3576G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-15 14:56:16



Mon Feb 15 10:24:13 1999

Borehole KA3578G01, section 0.25 m - 0.75 m

Date: 99-01-15 Field Crew: B. Gentzschein

Valve opened: 990115 165533 Valve closed: 990115 171614
Total flowing time: 20.7 min. Tot. Pr. Build-up time: 12.0 min.

Pressure before injection start (P_0, kPa) : 133.7
Pressure just before closing the valve (P_p, kPa) : 543.3
Pressure at the end of the recovery (P_f, kPa) : 520.0

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

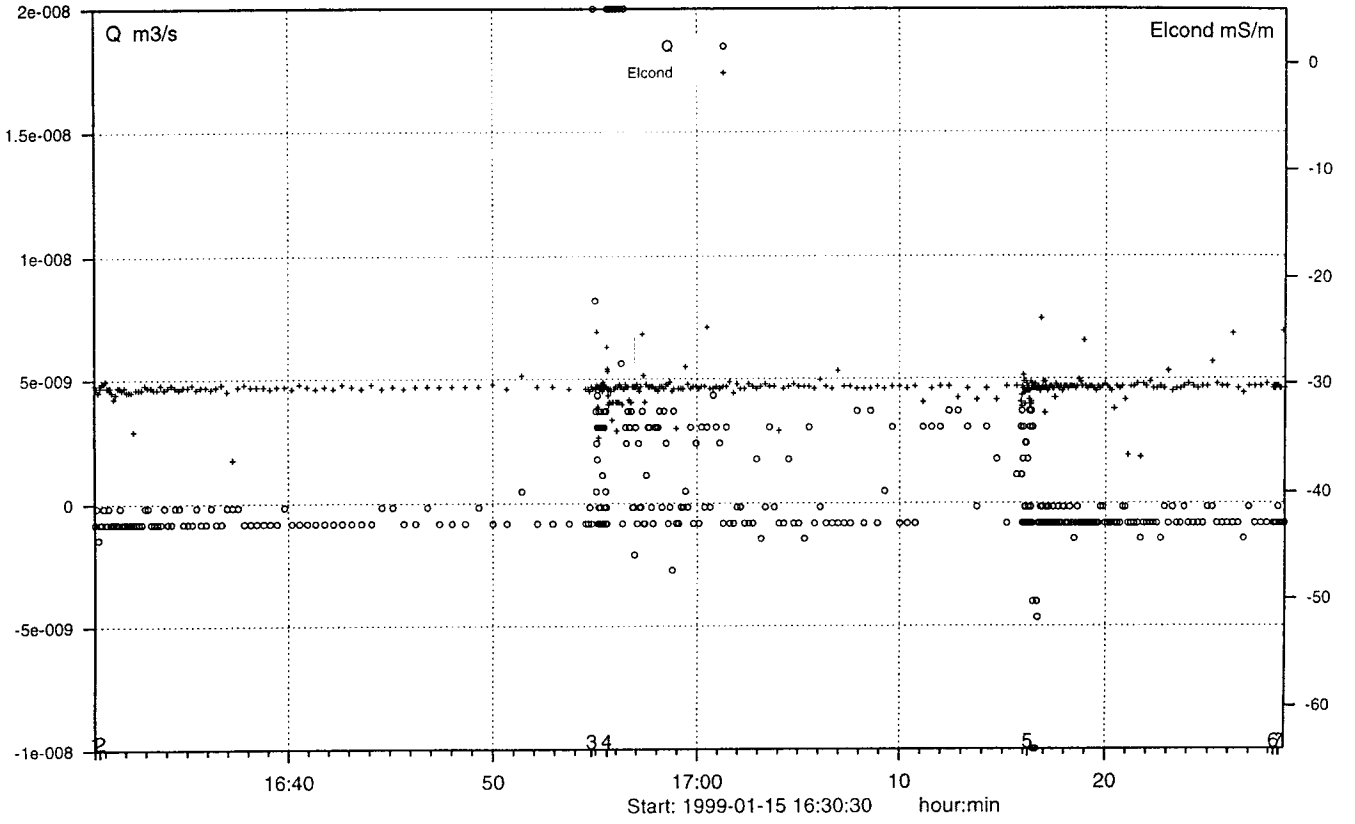
P_{ref} was changed to 524 kPa. The flow at the end, Qp, is negative (-1.689e-10 m^3/s).
This is within the limits of the zero stability, $\pm 1.67 \cdot 10^{-9}$ m^3/s (0.0001 kg/min).

Borehole: 3578G01

Section : 0.3 - 0.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-15 16:30:17



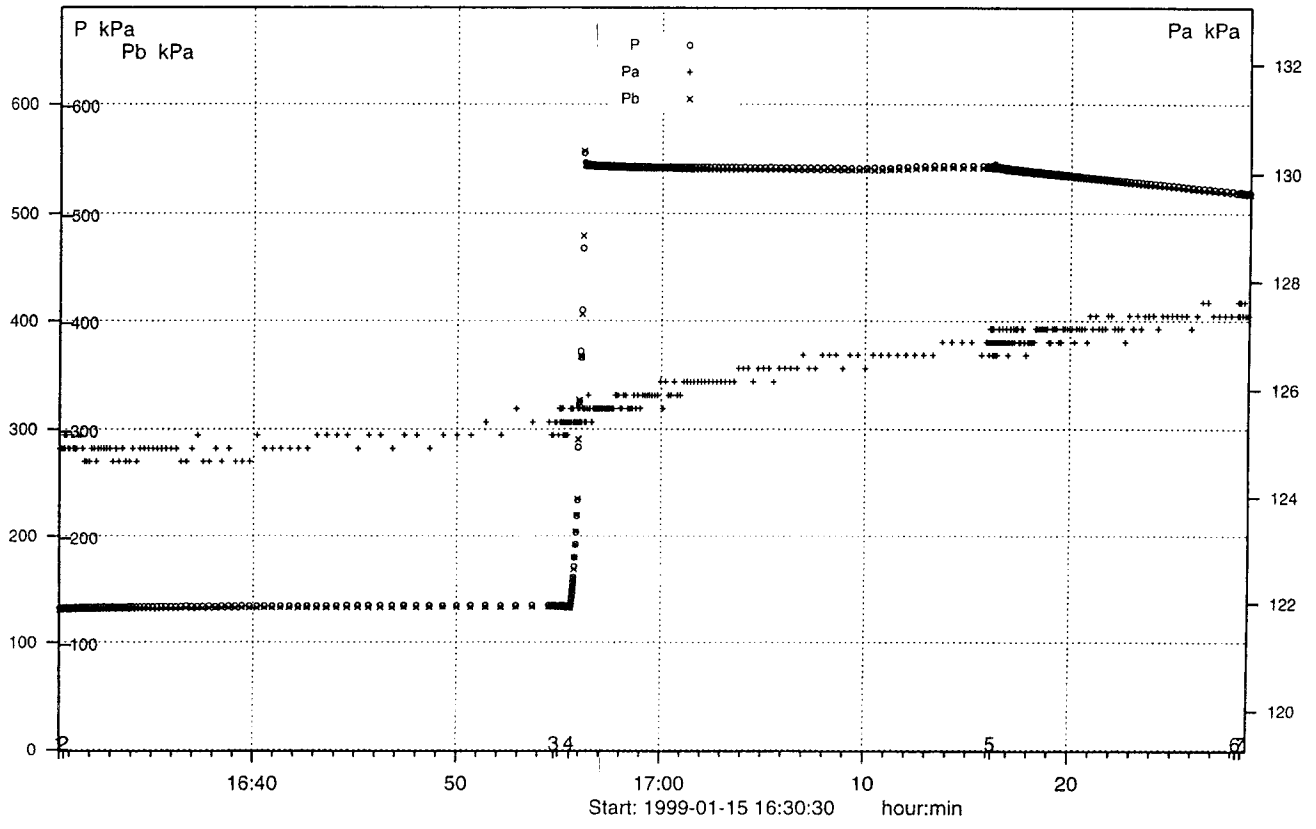
Mon Feb 15 10:55:21 1999

Borehole: 3578G01

Section : 0.3 - 0.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-15 16:30:17



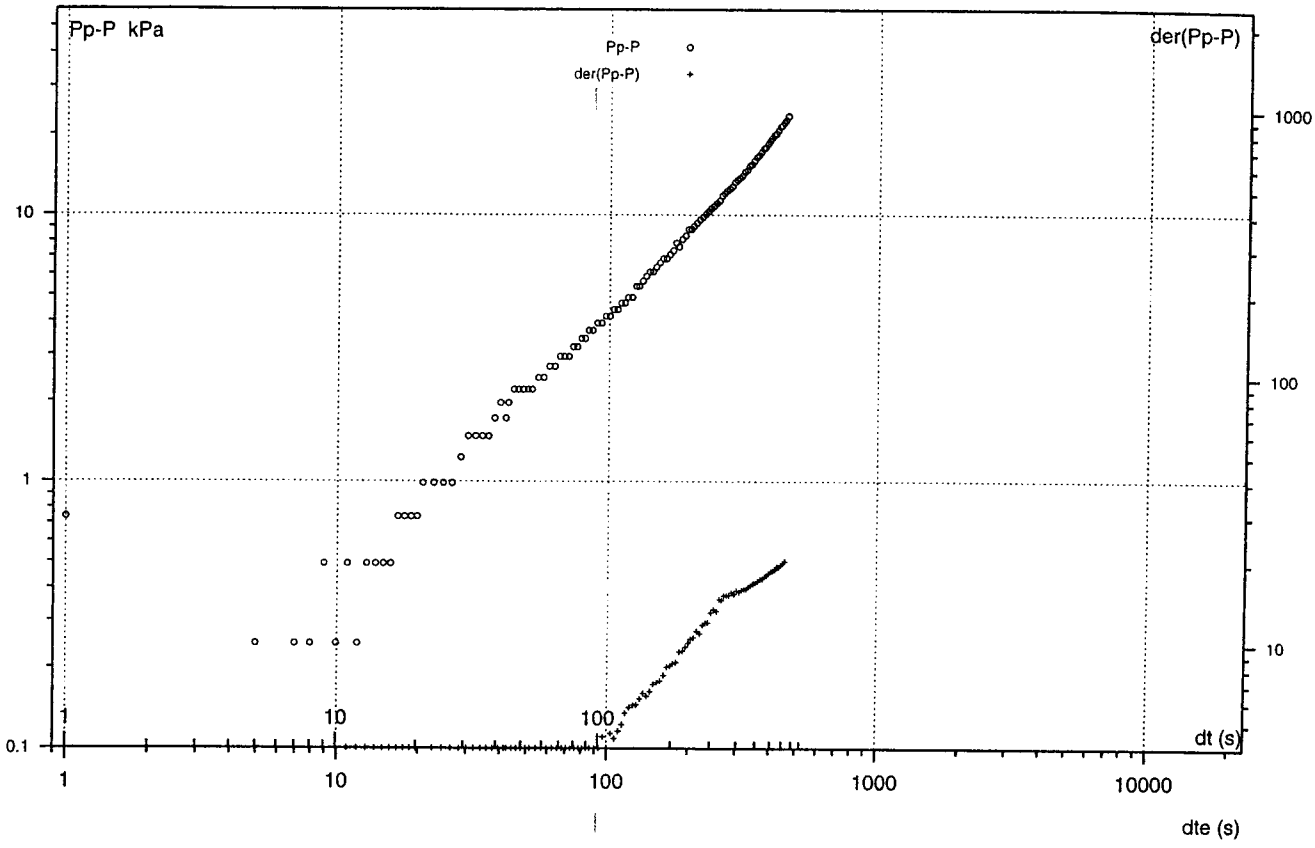
Mon Feb 15 10:55:28 1999

Borehole: 3578G01

Section : 0.3 - 0.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-15 16:30:17



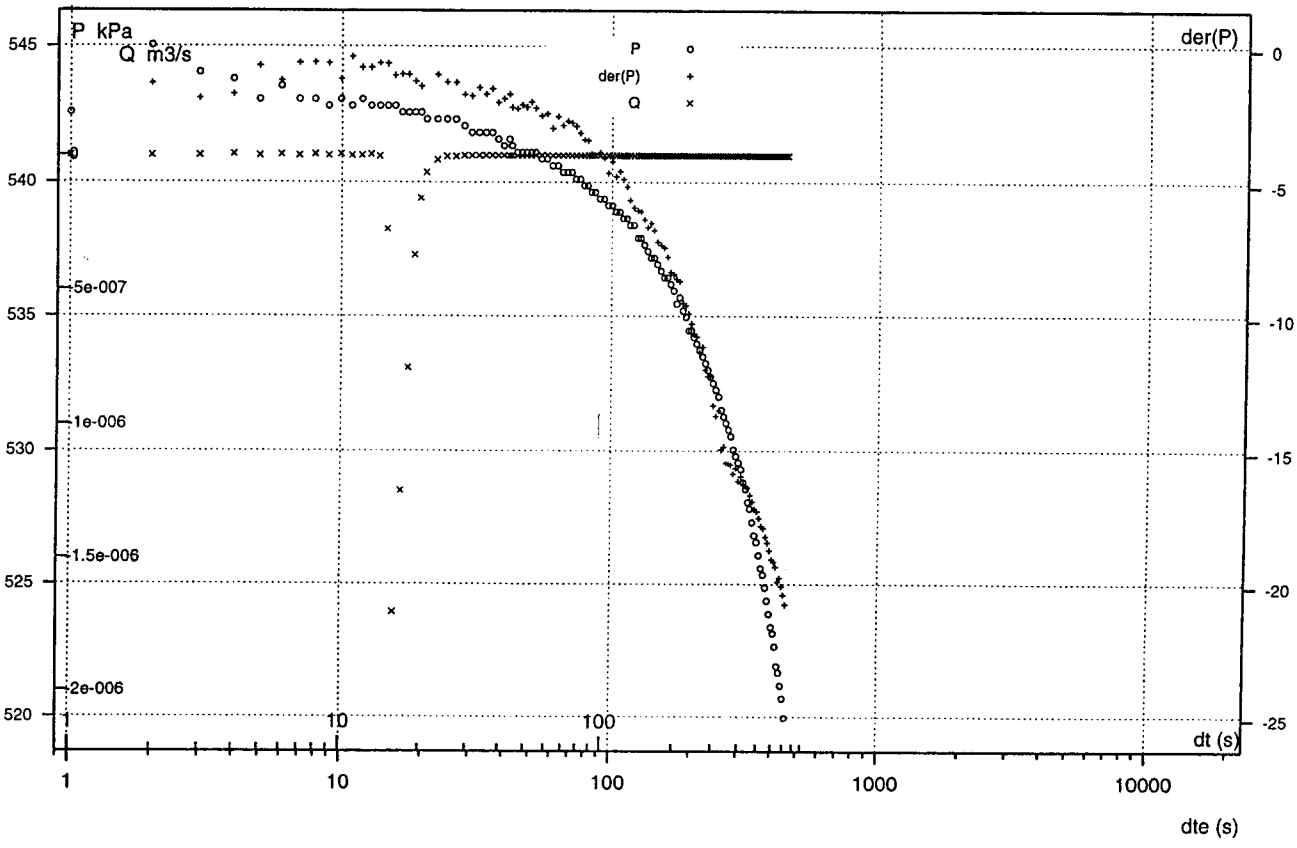
Mon Feb 15 10:55:29 1999

Borehole: 3578G01

Section : 0.3 - 0.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-15 16:30:17



Mon Feb 15 10:55:29 1999

Borehole KA357801, section 0.75 m – 1.25 m

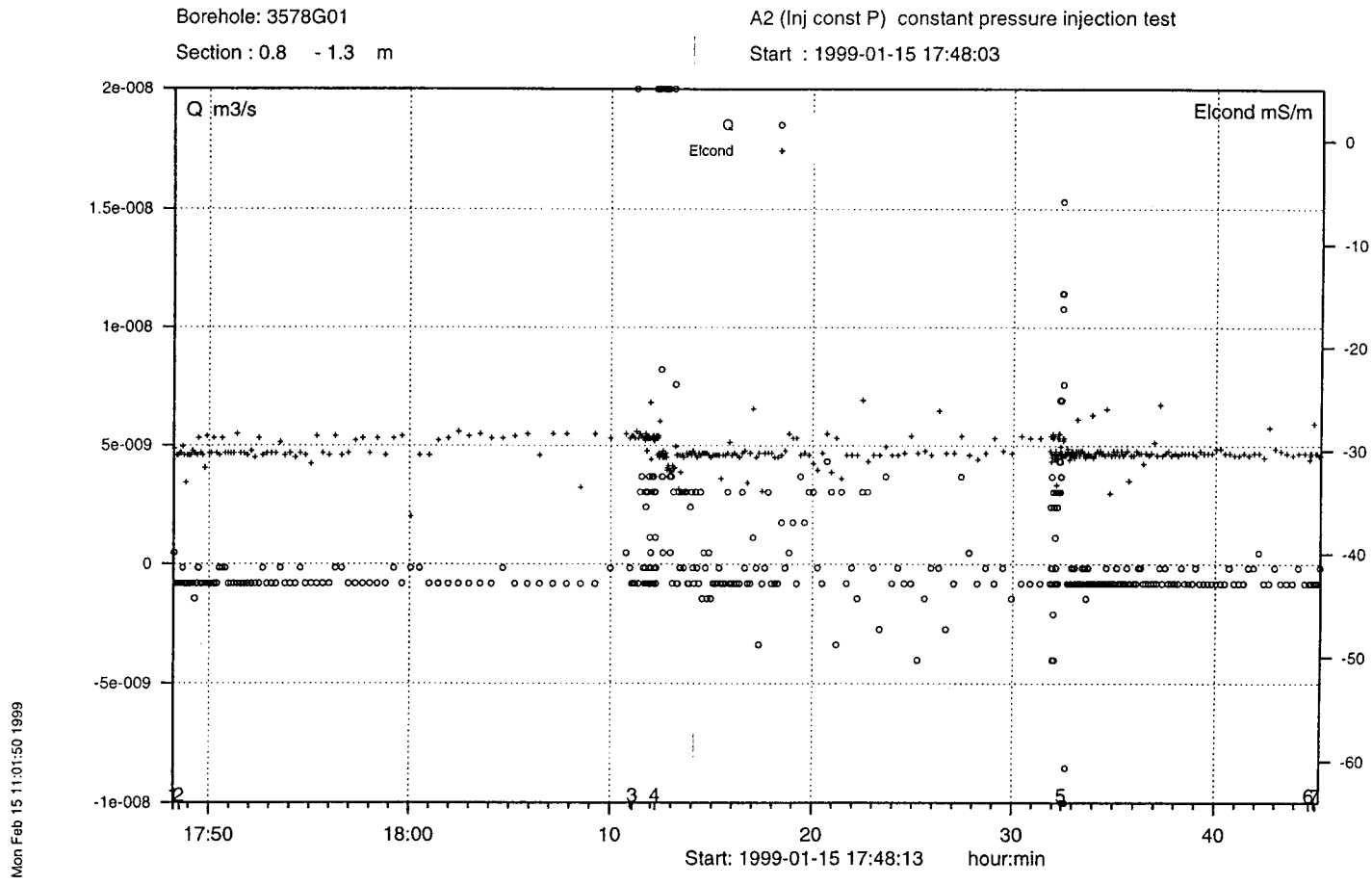
Date: 99-01-15 Field Crew: B. Gentzschein

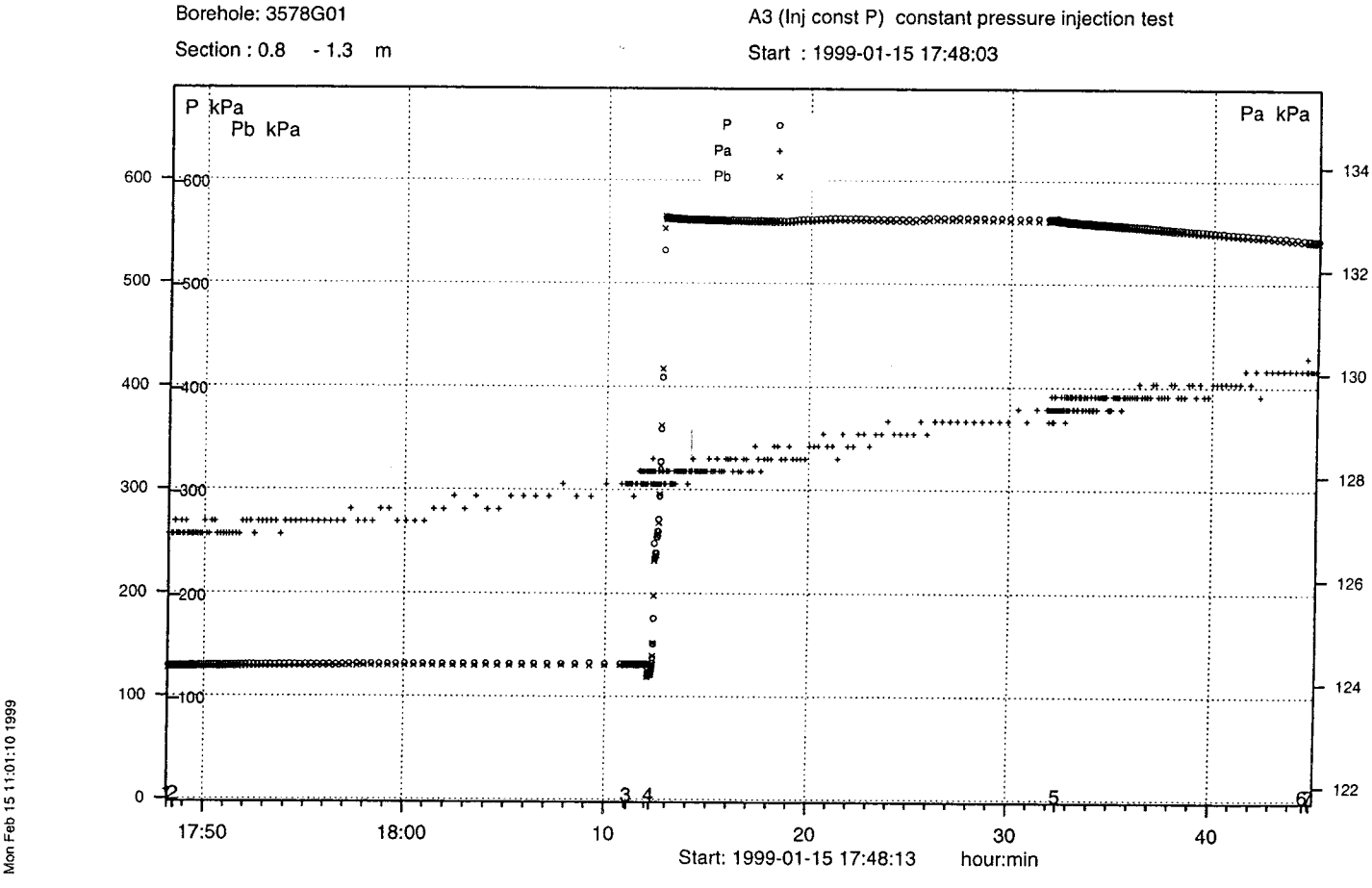
Valve opened: 990115 181213 Valve closed: 990115 183227
Total flowing time: 20.3 min. Tot. Pr. Build-up time: 12.3 min.

Pressure before injection start (P_0, kPa) : 122.8
Pressure just before closing the valve (P_p, kPa) : 563.0
Pressure at the end of the recovery (P_f, kPa) : 543.3

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

P_{ref} was changed to 540 kPa.


Borehole: 3578G01
Section : 0.8 - 1.3 m
A2 (Inj const P) constant pressure injection test
Start : 1999-01-15 17:48:03
Q m3/s
Elcond mS/m
Q
Elcond
2e-008
1.5e-008
1e-008
5e-009
0
-5e-009
-1e-008
0
-10
-20
-30
-40
-50
-60
17:50
18:00
10
20
30
40
Start: 1999-01-15 17:48:13
hour:min
Mon Feb 15 11:01:50 1999

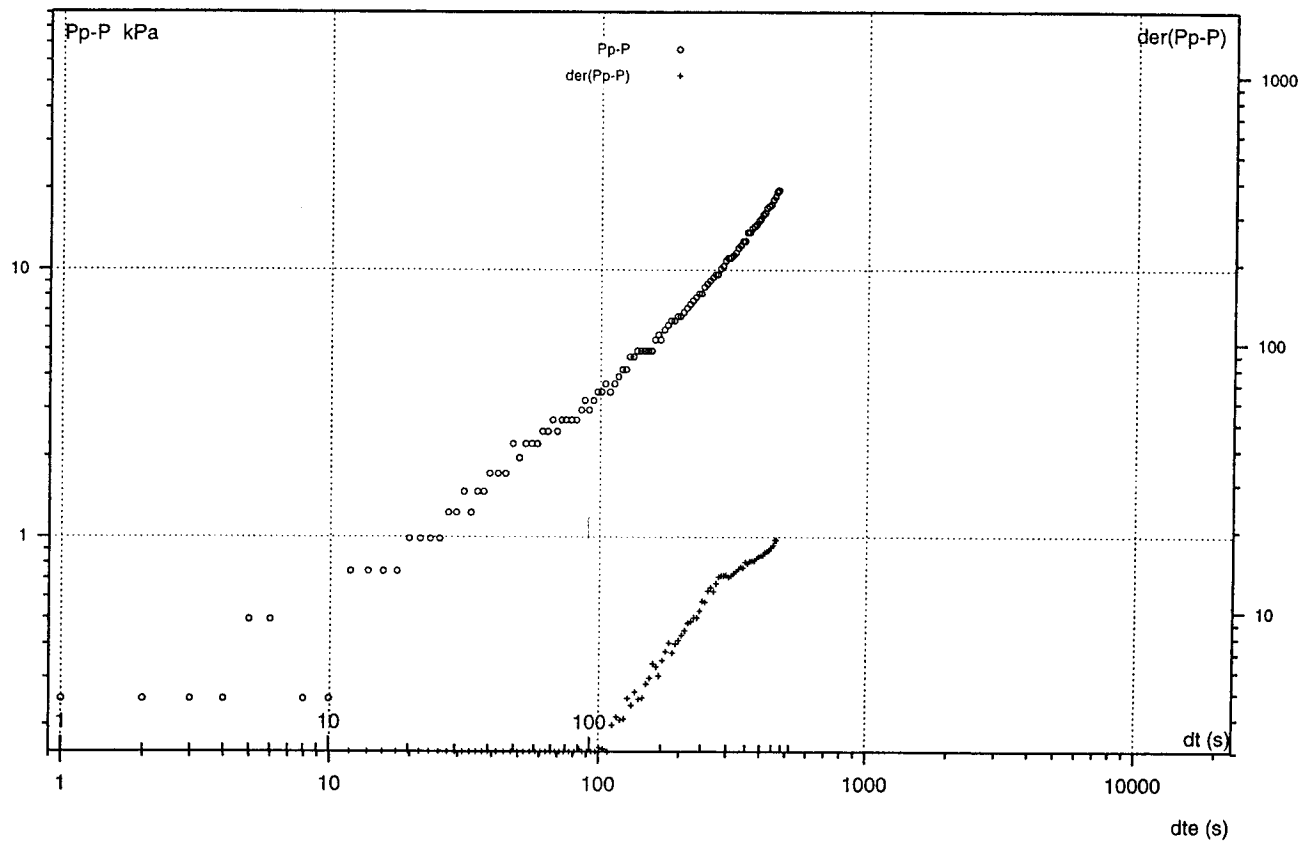

Borehole: 3578G01
Section : 0.8 - 1.3 m
A3 (Inj const P) constant pressure injection test
Start : 1999-01-15 17:48:03
P kPa
Pb kPa
Pa kPa
P
Pa
Pb
600
500
400
300
200
100
0
134
132
130
128
126
124
122
17:50
18:00
10
20
30
40
Start: 1999-01-15 17:48:13
hour:min
Mon Feb 15 11:01:10 1999

Borehole: 3578G01

Section : 0.8 - 1.3 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-15 17:48:03



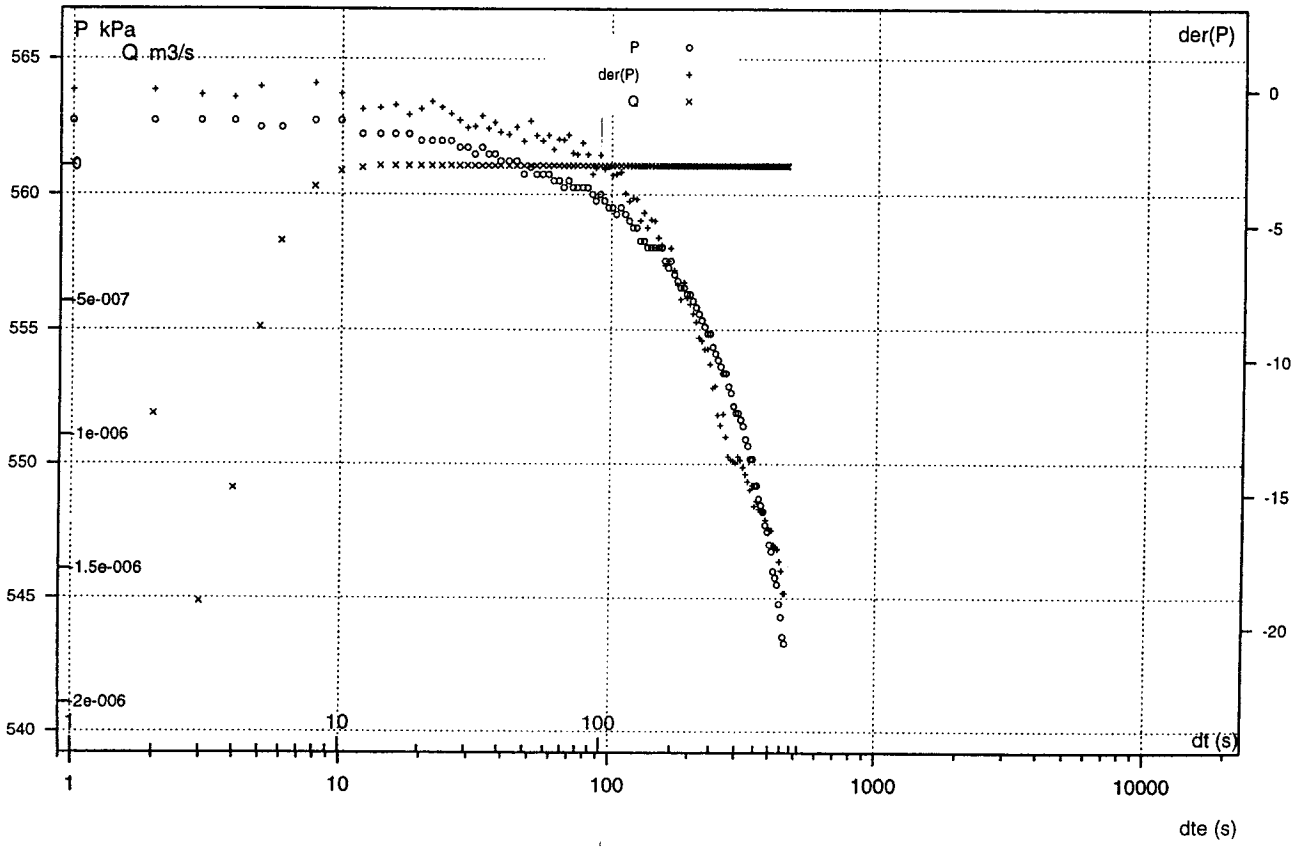
Mon Feb 15 11:01:10 1999

Borehole: 3578G01

Section : 0.8 - 1.3 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-15 17:48:03



Mon Feb 15 11:01:10 1999

Borehole KA3578G01, section 1.25 m – 1.75 m

Date: 99-01-15 Field Crew: B. Gentzschein

Valve opened: 990115 192522 Valve closed: 990115 194610
Total flowing time: 20.8 min. Tot. Pr. Build-up time: 823.6 min.

Pressure before injection start (P_0, kPa) : 130.2
Pressure just before closing the valve (P_p, kPa) : 529.9
Pressure at the end of the recovery (P_f, kPa) : 241.5

Pre-set section pressure (during injection) (P_{ref}, kPa) : 500

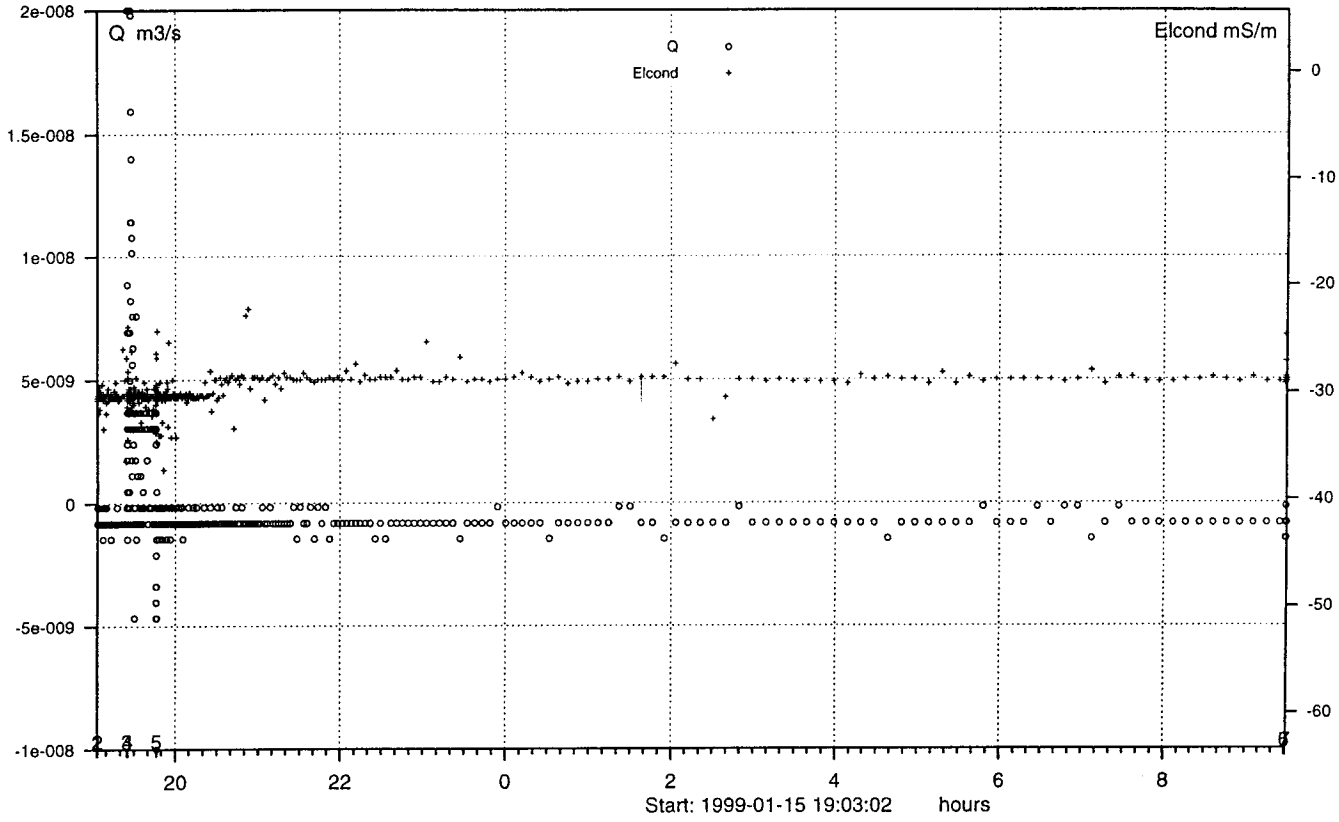
Recovery over night!

Borehole: 3578G01

Section : 1.3 - 1.8 m

A2 (Inj const P) constant pressure injection test

Start : 1999-01-15 19:02:48



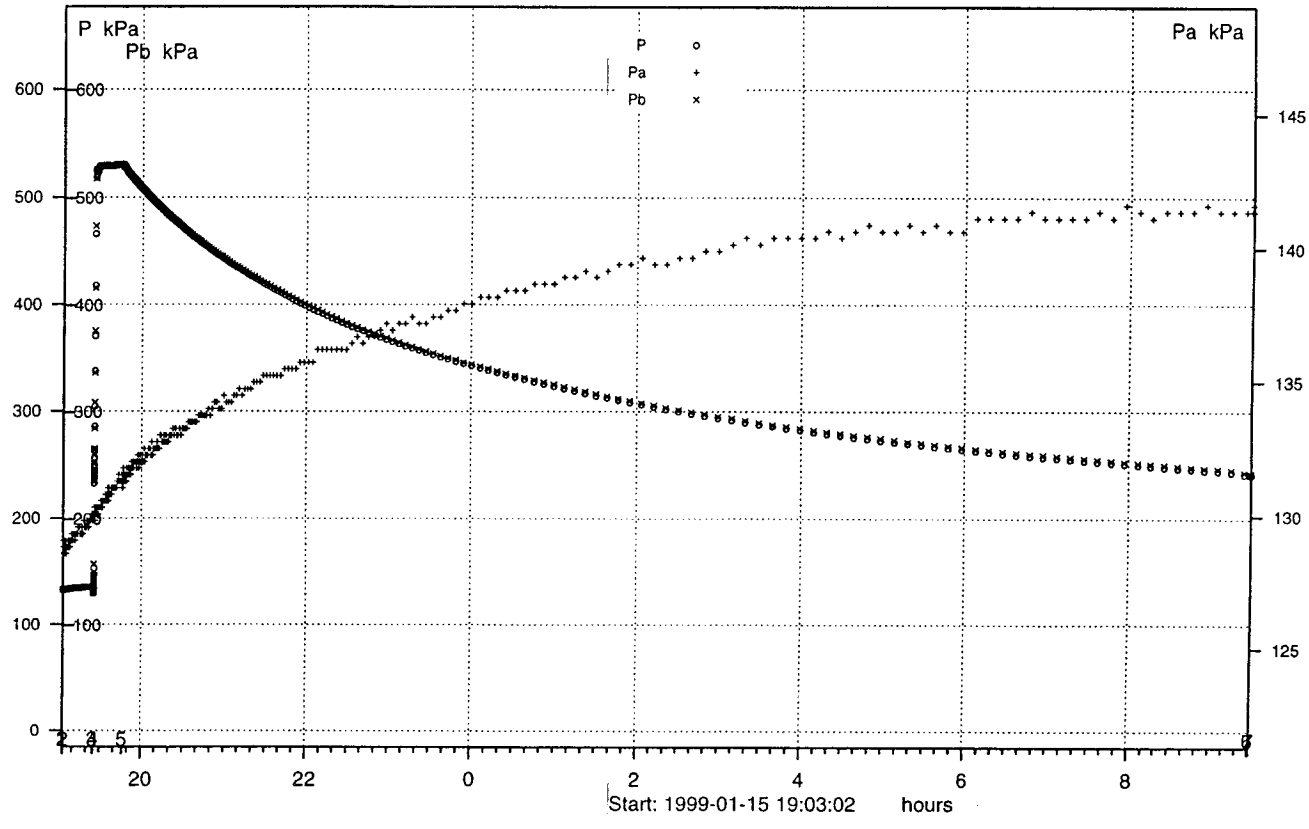
Mon Feb 15 11:11:29 1999

Borehole: 3578G01

Section : 1.3 - 1.8 m

A3 (Inj const P) constant pressure injection test

Start : 1999-01-15 19:02:48



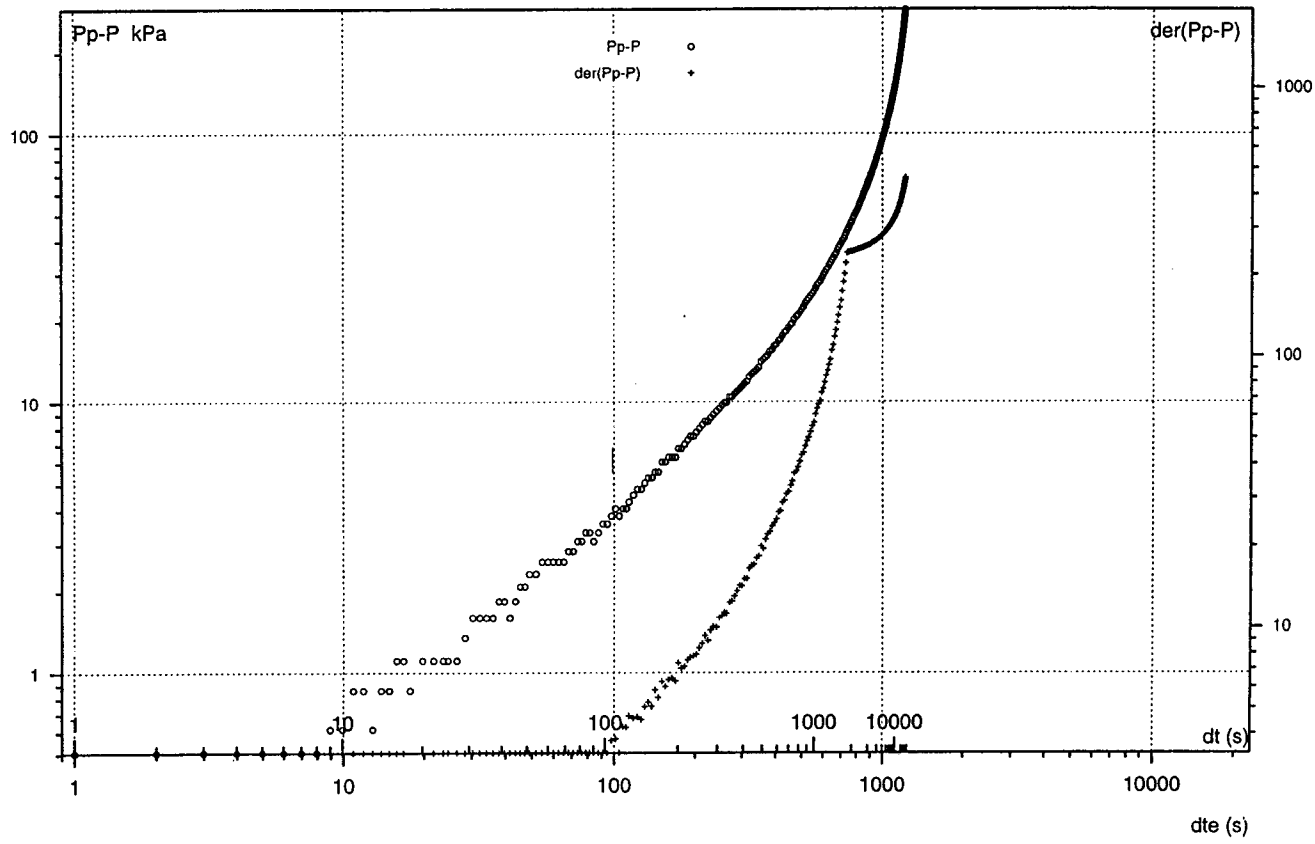
Mon Feb 15 11:09:25 1999

Borehole: 3578G01

Section : 1.3 - 1.8 m

C6 (Inj const P) constant pressure injection test

Start : 1999-01-15 19:02:48



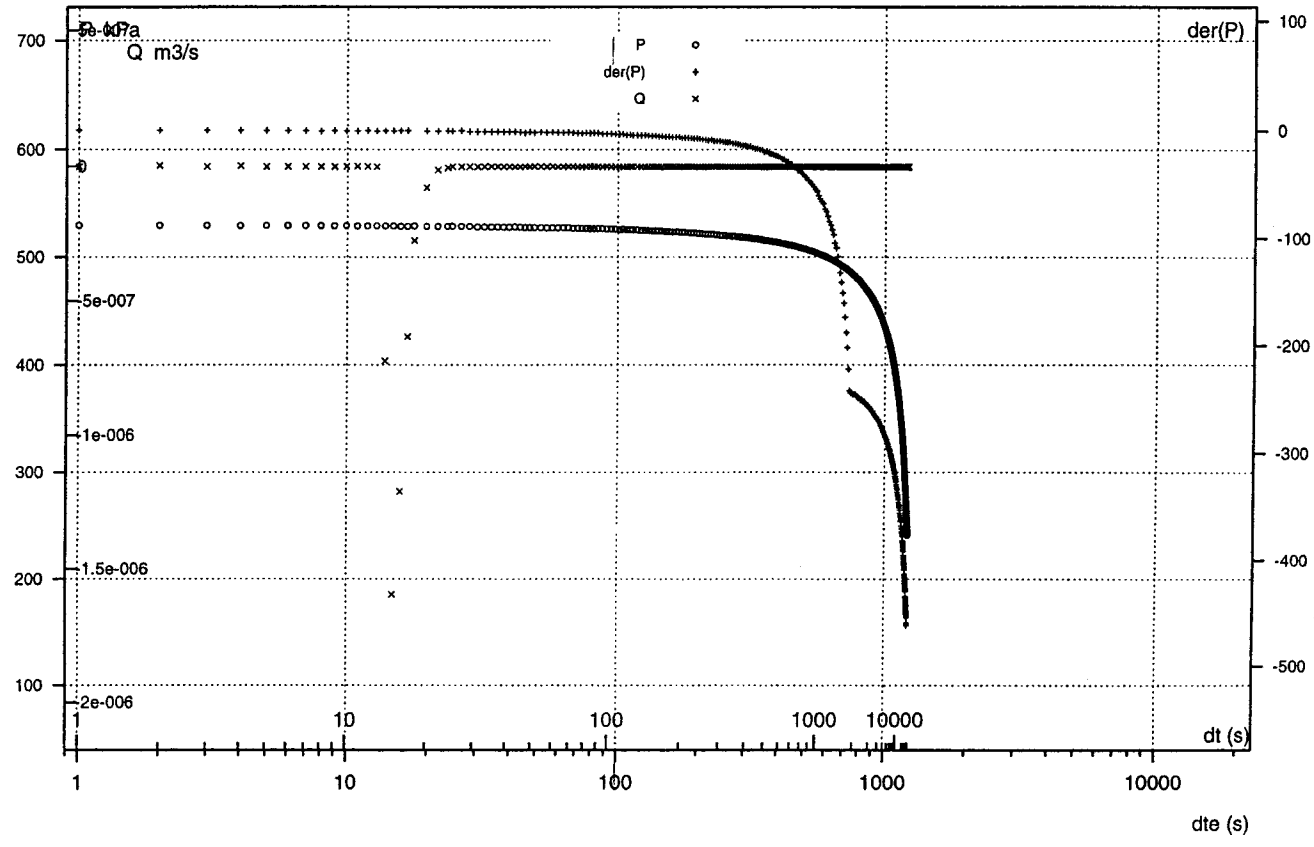
Mon Feb 15 11:09:26 1999

Borehole: 3578G01

Section : 1.3 - 1.8 m

C4 (Inj const P) constant pressure injection test

Start : 1999-01-15 19:02:48



Mon Feb 15 11:09:26 1999