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**Prototype Repository – Sensor
data report (Period 010917–130101)
Report No 25**

Reza Gourdazi, Clay Technology AB

March 2014

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Abstract

The Prototype Repository Test consists of two sections. The installation of the first Section of Prototype Repository was made during summer and autumn 2001 and Section 2 was installed in spring and summer 2003. The retrieval of the outer section started at the end of November 2010.

After the retrieval of the outer section, validation tests of the total pressure sensors of type Geocon were made. It was then discovered that, the up to now used calibration values (linear equation) gave inaccurate readings of the total pressure. The improvements of the readings were large when a polynomial calibration equation was used instead. At the presentation of the data in this report the polynomial equation was used.

This report presents data from measurements in the Prototype Repository during the period 2001-09-17 – 2013-01-01 (stress and strain measurements, Appendix 10, presents during period 2001-09-17 – 2011-01-01). The report is organized so that the actual measured results are shown in Appendix 1–10, where Appendix 8 deals with measurements of canister displacements (by AITEMIN), Appendix 9 deals with geo-electric measurements in the backfill (by GRS), Appendix 10 deals with stress and strain measurement in the rock (by ÅF) and Appendix 11 deals with measurement of water pressure in the rock (by VBB/VIK). The main report and Appendix 1–7 deal with the rest of the measurements.

Section 1

The following measurements are made in the bentonite in each of the two instrumented deposition holes in Section 1 (1 and 3): Temperature is measured in 32 points, total pressure in 27 points, pore water pressure in 14 points and relative humidity in 37 points. Temperature is also measured by all relative humidity gauges. Every measuring point is related to a local coordinate system in the deposition hole.

The following measurements are made in the backfill in Section 1. Temperature is measured in 20 points, total pressure in 18 points, pore water pressure in 23 points and relative humidity in 45 points. Temperature is also measured by all relative humidity gauges. Furthermore, water content is measured by an electric chain in one section. Every measuring point is related to a local coordinate system in the tunnel.

The following measurements are made on the surface of the canisters in Section 1: Temperature is measured every meter along two fiber optic cables. Furthermore, displacements of the canister in hole 3 are measured with 6 gauges.

The following measurements are made in the rock in Section 1: Temperature is measured in 37 points in boreholes in the floor. Water pressure is measured in altogether 64 points in 17 boreholes all around the tunnel.

Section 2

The following measurements are made in the bentonite in each of the two instrumented deposition holes in Section 2 (5 and 6): Temperature is measured in 29 points, total pressure in 27 points, pore water pressure in 14 points and relative humidity in 47 points deposition hole 5 and in 65 points in deposition hole 6. Temperature is also measured by all relative humidity gauges.

The following measurements are made in the backfill in Section 2. Temperature is measured in 16 points, total pressure in 16 points, pore water pressure in 18 points and relative humidity in 32 points. Temperature is also measured by all relative humidity gauges. Furthermore, water content is measured by an electric chain in one section. Every measuring point is related to a local coordinate system in the tunnel.

The following measurements are made on the surface of the canisters in Section 2: Temperature is measured every meter along two fiber optic cables. Additional to this temperature measurement three conventional thermocouples are placed on each canister. Furthermore, displacements of the canister in hole 6 are measured with 6 gauges.

The following measurements are made in the rock in Section 2: Temperature is measured in 24 points in boreholes close to the deposition holes. Relative humidity is also measured in 6 points in the rock close to deposition hole 6.

Conclusions

A general conclusion is that the measuring systems work well, but the number of sensors that has failed is increasing. 275 (excluding water pressure sensors in the rock, geo-electric measurements) out of totally 363 installed sensors in Section 1 are out of order, the majority being RH-sensors that fail at water saturation. 142 (excluding water pressure sensors in the rock, geo-electric measurements, stress and strain in the rock and displacement of canister) out of totally 394 sensors in Section 2 were out of order at start dismantling, November 2010. Furthermore almost all suction sensors placed in the backfill is not giving reliable values due to high degree of saturation (RH 100%).

The drainages of the inner section together with the drainage of the outer plug were closed at the beginning of November 2004. The pressure (pore pressure and total pressure) both in the backfill and in some parts of the buffer in the six deposition holes increased after this date. At the beginning of December 2004 damages on the cables to the installed heaters in two of the canisters (canister No 2 and No 6) were observed. The power to all of the canisters was then switched off and the drainage of the tunnel was opened. The power of canisters was switched on again on December 15 except for canister No 2 where all of the installed heaters were out of order. The drainage of the tunnel was kept open. The increase in pore pressure affected the saturation rate of the backfill and the buffer. The failure of the heaters in canister No 2 and the time when the power was switched off affected also the measurements especially the temperature measurements in the buffer. At the beginning of September 2005 more problems with the power to canister 6 was observed. The power to the canister was switched off for about 2 months. The power to canister 6 was switched on again on November 2 2005. Due to new problems with the heaters in canister No 6 in May and June 2008 the power was reduced to about 1,150 W. A packer installed in the rock in Section 1 was broken around the 18th of April 2006. The broken packer caused an increase in the measured total and pore pressure in the backfill in Section 1. The work with the new tunnel near by the Prototype site which started in April 2007 has affected the pressure, water outflow and saturation of the backfill.

Sammanfattning

Prototypförvaret består av två sektioner. Den första sektionen installerades under sommaren och hösten 2001 och Sektion 2 installerades under våren och sommaren 2003. I slutet av november 2010 började arbetet med att demontera den yttre sektionen av försöket.

Efter demontering av yttre sektionen, utfördes en utvärdering av totaltrycksgivarna av fabrikkatet Geocon. Då upptäcktes att de använda kalibreringsparametrarna och den linear ekvationen för totaltryck inte var optimala. Den alternativa polynoma ekvationen vid redovisning av data används i den här rapporten vilket gav högre tryck.

I denna rapport presenteras data från mätningar i Prototypförvaret för perioden 2001-09-17 – 2013-01-01 (Mätningar av spänning och töjning, Appendix 10, presenteras för perioden 2001-09-17 – 2011-01-01). Rapporten är uppdelad så att själva mätresultaten redovisas i Appendix 1–10, varvid Appendix 8 behandlar mätning av kapselförskjutningar (görs av AITEMIN), Appendix 9 behandlar geoelektriska mätningar i återfyllningen (görs av GRS), Appendix 10 behandlar mätningar av spänning och töjning i berget (handhas av ÅF) och Appendix 11 behandlar vattentrycksmätningar i berget (handhas av VBB/VIK). I själva huvudrapporten och Appendix 1–7 behandlas alla övriga mätningar.

Sektion 1

Följande mätningar görs i bentoniten i vardera av de två instrumenterade deponeringshålen i Sektion 1 (1 och 3): Temperatur mäts i 32 punkter, totaltryck i 27 punkter, porvattentryck i 14 punkter och relativa fuktigheten i 37 punkter. Temperaturen mäts även med relativa fuktighetsmätare. Varje mätpunkt relateras till ett lokalt koordinatsystem i deponeringshålet.

Följande mätningar görs i återfyllningen i Sektion 1: Temperaturen mäts i 20 punkter, totaltryck i 18 punkter, porvattentryck i 23 punkter och relativa fuktigheten i 45 punkter. Temperaturen mäts även med alla relativa fuktighetsmätare. Varje mätpunkt relateras till ett lokalt koordinatsystem i tunneln. Dessutom mäts vatteninnehållet i en sektion med en geoelektrisk mätkedja.

Följande mätningar görs på ytan i kapselns kopparhölje i samtliga 4 kapslar i Sektion 1: Temperaturen mäts varje meter längs två fiberoptiska kablar från två håll. Dessutom mäts förskjutningar av kapseln i hål 3 med 6 givare.

Följande mätningar görs i berget i Sektion 1: Temperatur mäts i borrhål i 37 punkter i golvet. Vattentryck mäts i sammanlagt 64 punkter i 17 borrhål runt hela tunneln.

Sektion 2

Följande mätningar görs i bentoniten i vardera av de två instrumenterade deponeringshålen i Sektion 2 (5 och 6): Temperatur mäts i 29 punkter, totaltryck i 27 punkter, porvattentryck i 14 punkter och relativa fuktigheten i 47 punkter i deponeringshål 5 och 65 punkter i deponeringshål 6. Temperaturen mäts även i alla relativa fuktighetsmätare.

Följande mätningar görs i återfyllningen i Sektion 2: Temperaturen mäts i 16 punkter, totaltryck i 16 punkter, porvattentryck i 18 punkter och relativa fuktigheten i 32 punkter. Temperaturen mäts även med alla relativa fuktighetsmätare. Varje mätpunkt relateras till ett lokalt koordinatsystem i tunneln. Dessutom mäts vatteninnehållet i en sektion med en geoelektrisk mätkedja.

Följande mätningar görs på ytan i kapselns kopparhölje i de två kapslarna i Sektion 2: Temperaturen mäts varje meter längs två fiberoptiska kablar från två håll. Vidare mäts temperaturen i tre punkter på varje kapsel med konventionella termoelement. Även förskjutningen av kapseln i deponeringshål 6 mäts med 6 givare.

Temperatur mäts i berget kring varje kapsel i 24 punkter. Vidare mäts RH i berget kring deponeringshål 6 i 6 punkter.

Slutsatser

En generell slutsats är att mätsystemen tycks fungera bra. 275 av totalt 363 installerade givare i Sektion 1 (med undantag av vattentrycksmätare i berget) fungerar inte. Många av dessa (64 stycken) är RH-mätare som slutar fungera vid vattenmättnad. 142 av 394 givare i Sektion 2 (med undantag av vattentrycksmätare i berget) fungerade inte vid början av demontering av Sektion 2, november 2010. Portrycket och totaltrycket både i återfyllnaden och i bufferten ökade markant efter stängningen av dränaget. Ökningen av portrycket påverkade också vattenmättnaden i vissa delar av buffert och återfyllnade. Skador observerades på kablarna till de installerade värmarna i två av kapslarna i början av december 2004, varefter effekten till samtliga kapslar stängdes av samtidigt som dräneringen av tunneln öppnades. Effekten till alla kapslar utom kapsel nr. 2 sattes på igen den 15:e december. Skadorna på kablarna till värmarna i kapsel 2 var så omfattande att det inte var möjligt att använda dessa. Dräneringen av tunneln förblev öppen. I början av september 2005 uppstod nya problem med kapsel Nr 6. Effekten till kapseln stängdes av under ca 2 månader. Från och med den 2:a november 2005 sattes effekten till kapsel Nr 6 på igen. På grund av nya problem med värmarna i kapsel 6 under maj och juni 2008 reducerades effekten till 1 150 W. En packer installerad i berget i Sektion 1 gick sönder kring den 18:e april 2006. Den läckande packern medförde att totaltrycken och portrycken i återfyllningen i Sektion 1 ökade markant. Arbetet med den nya tunneln nära Prototype-tunneln vilket startade i april 2007 har påverkat tryckte, utflödet ur tunneln samt vattenmättnaden av återfyllningen i de båda tunnelsektionerna.

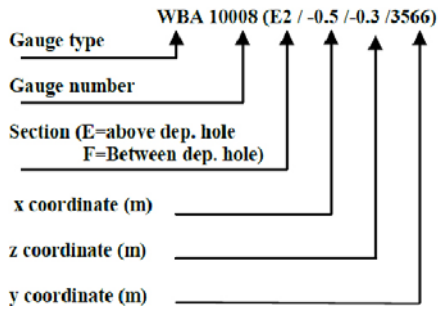
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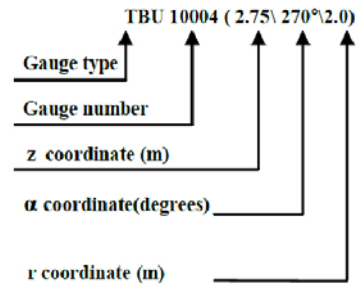
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Quick guide

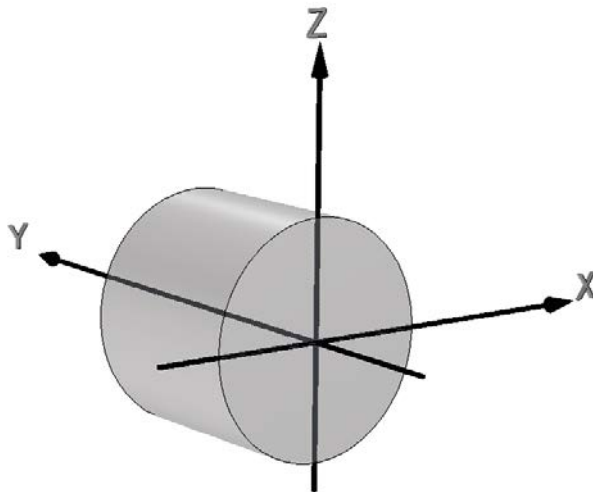
Transducers in the backfill



Transducers in dep. holes 1, 3,5 and 6 and in the rock

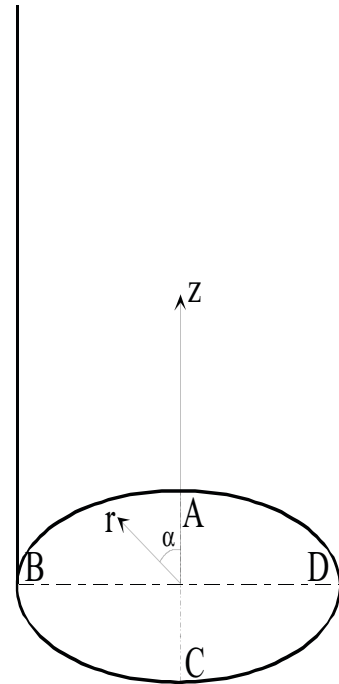


Coordinate system in backfill



| | |
|-----------------------|-------------|
| End of tunnel at | Y=3,599.8 m |
| Center dep.hole 1.at | Y=3,587 m |
| Center dep.hole 2 at | Y=3,581 m |
| Center dep.hole 3 at | Y=3,575 m |
| Center dep.hole 4 at | Y=3,569 m |
| Inner plug surface at | Y=3,561.4 m |
| Center dep.hole 5 at | Y=3,551 m |
| Center dep.hole 6 at | Y=3,545 m |
| Outer plug surface at | Y=3,538.6 m |
| Tunnel radius | Z=X =2.5 m |

Coordinate system in dep. holes



| | |
|----------------------|---------|
| Tunnel direction | C-A |
| Bottom of hole | Z=0 |
| Bottom of canister | Z=0.5 |
| Top of canister | Z=5.400 |
| Upper buffer surface | Z=7.125 |
| Dep. hole radius | r=0.875 |
| Canister radius | r=0.525 |

1 Introduction

The Prototype Repository Test consists of two sections. The installation of the first Section of Prototype Repository was made during summer and autumn 2001 and Section 2 was installed in spring and summer 2003.

Section 1 consists of four full-scale deposition holes, copper canisters equipped with electrical heaters, bentonite blocks and a deposition tunnel backfilled with a mixture of bentonite and crushed rock and ends with a concrete plug as shown in Figure 1-1. Section 2 consists of two full-scale deposition holes with a backfilled tunnel section and ends also with a concrete plug.

The bentonite buffer in deposition holes 1, 3, 5 and 6, the backfill and the surrounding rock are instrumented with gauges for measuring temperature, water pressure, total pressure, relative humidity, resistivity and canister displacement. The instruments are connected to data collection systems by cables protected by tubes, which are led through the rock in watertight lead throughs.

In general the data for Section 1 in this report are presented in diagrams covering the time period 2001-09-17 to 2013-01-01. The time axis in the diagrams represent number of days from start 2001-09-17, which is the day the heating of the canister in hole 1 was started. For Section 2 the date are presented in diagrams covering the time period 2003-05-08 to 2011-01-01, where 2003-05-08 is the day when the heating of the canister in hole 5 was started.

This report consists of several parts. In Chapters 2, 3, 4 and 6 a test overview with the positions of those measuring points and a brief description of the instruments are shown. In Chapter 5 the measured results from all measurements in Section 1, except canister displacement, stress and strain and water pressure in the rock and resistivity in the backfill and buffer, are presented and commented. Corresponding presentations and comments for Section 2 are made in Chapter 7. The diagrams of those measured results are attached in Appendix 1–7. The results and comments of the measurements of canister displacement, resistivity in the backfill, stress and strain in the rock and water pressure in the rock are presented separately in Appendix 8–11.

A quick guide to the position of the instruments in the buffer and backfill is shown on page 9.

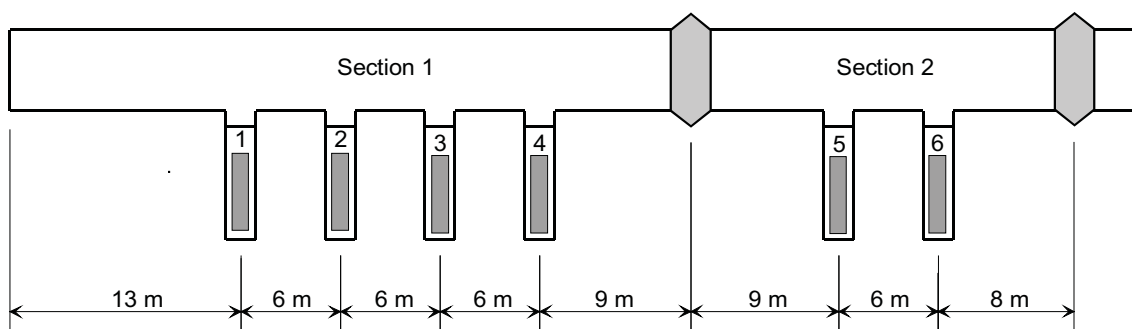


Figure 1-1. Schematic view of the Prototype Repository.

2 Geometry and coordinate systems

The Prototype Repository consists of two sections as shown in Figure 1-1. The geometry and the coordinate system for the sensors are different for the deposition holes and the tunnel. The temperature sensors in the rock are defined with the same coordinate system as the deposition holes.

Deposition holes

In Section 1 the deposition holes are termed 1–4 according to Figure 1-1 and in Section 2 the deposition holes are termed 5 and 6. The coordinate system for these holes is shown in Figure 2-1. With the z -axis starting from the cement casting and the angle α counted anti-clockwise from direction A. Measurements are mainly made in four vertical sections A, B, C and D according to Figure 2-1. Direction A and C are placed in the tunnels axial direction with A headed against the end of the tunnel i.e. almost towards West.

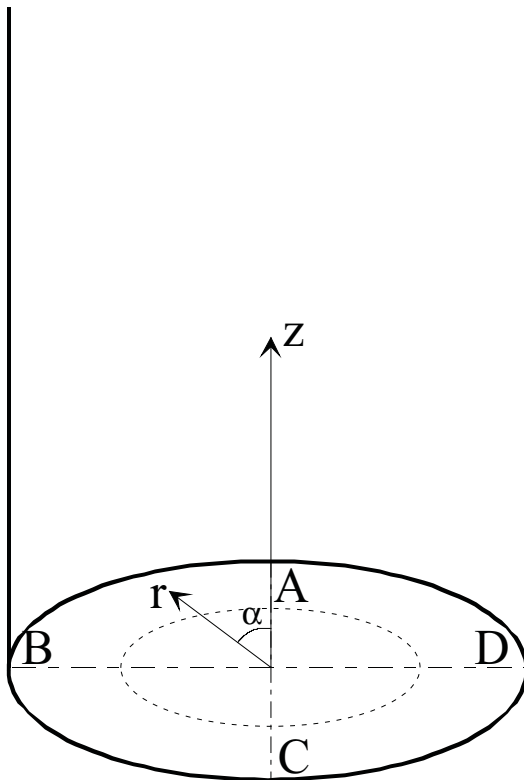


Figure 2-1. Figure describing the instrument planes (A-D) and the coordinate system used when describing the instrument positions.

Tunnel

The coordinate system of the backfill in the tunnel is shown in Figure 2-2. The coordinate y starts at the entrance on ground, which means that the tunnel ends at $y = 3,599, 8$. The y -axis runs in the centre of the tunnel, which means that the tunnel walls intersect the z and x -axes at ± 2.5 m. The z -coordinate is determined positive upwards and the x -coordinate is determined positive to the right when facing the end of the tunnel.

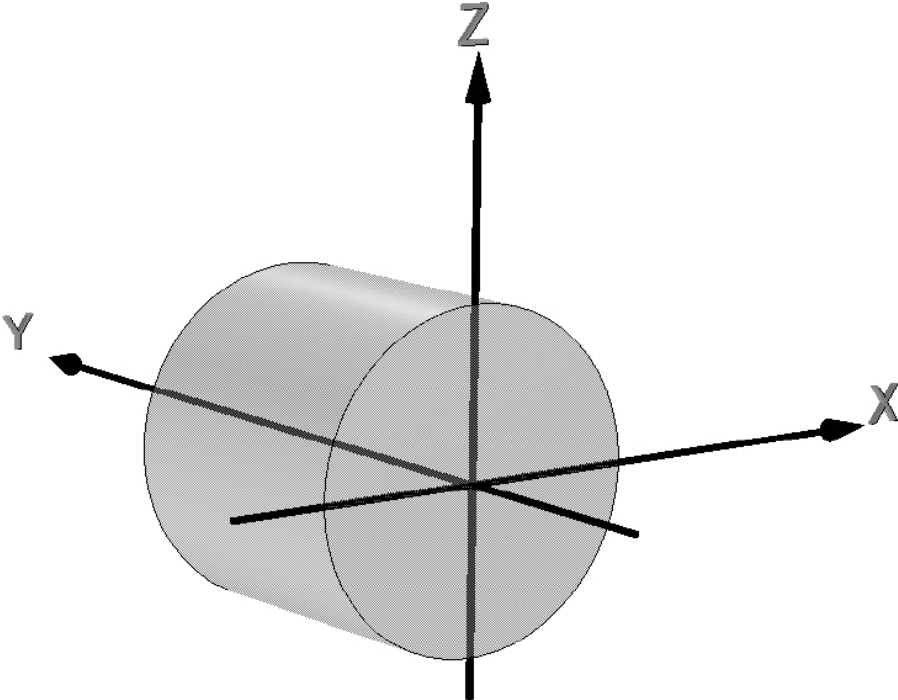


Figure 2-2. Coordinate system of the tunnel.

3 Brief description of the instruments

The different standard instruments that are used in the buffer, backfill and rock (temperature) are briefly described in this chapter.

Measurements of temperature

Buffer, backfill and rock

Thermocouples from Pentronic have been used to measure temperature. Measurements are done in 32 points in each instrumented hole (hole1 and hole 3). In addition, temperature gauges are built into the capacitive relative humidity sensors and some of the other sensor types as well.

Canister

Temperature is measured on the surface of the canister with optical fiber cables. An optical measuring system called FTR (Fiber Temperature Laser Radar) is used. In Section 2 are also three thermocouples of type Pentronic installed on each canister.

Measurement of total pressure in the buffer and backfill

Total pressure is the sum of the swelling pressure and the pore water pressure. It is measured with the following instrument types:

- Geocon total pressure cells with vibrating wire transducers.
- Kulite total pressure cells with piezo resistive transducers.

Measurement of pore water pressure in the buffer and backfill

Pore water pressure is measured with the following instrument types:

- Geocon pore pressure cells with vibrating wire transducer.
- Kulite pore pressure cells with piezo resistive transducer.

Measurement of the water saturation process in the buffer and backfill

The water saturation process is recorded by measuring the relative humidity in the pore system, which can be converted to total suction (negative water pressure). The following techniques and devices are used:

- Vaisala relative humidity sensor of capacitive type. The measuring range is 0–100% RH.
- Rotronic relative humidity sensors of capacitive type. The measuring range is 0–100% RH.
- Wescor soil psychrometer. The sensor is measuring the dry and the wet temperature in the pore volume of the material. The measuring range is 95.5–99.6% RH corresponding to the pore water pressure –0.5 to –6 MPa. Psychrometers are placed in the backfill in both sections and in the buffer in the two deposition holes in Section 2.

4 Location of instruments in Section 1

4.1 Strategy for describing the position of each device in the bentonite and rock in and around the deposition holes

The same principles are used for describing the position of all sensors in the bentonite inside the deposition holes as well as the thermocouples in the rock around the deposition holes. The principles are described in the quick guide inserted as a folded A3 page at the end of the report.

The type of instruments and their locations are described in detail in Börgesson and Sanden (2001).

Every instrument is named with a unique name consisting of 1 letter describing the type of measurement, 2 letters describing where the measurement takes place (buffer, backfill, rock or canister), 1 figure denoting the deposition hole (1–4) and 4 figures specifying the instrument according to a separate list (see Table 4-1 to 4-10). Every instrument position is then described with three coordinates according to Figure 4-1.

The r -coordinate is the horizontal distance from the centre of the hole and the z -coordinate is the height from the surface of the bottom casting of the hole (the block height is set to 500 mm). The α -coordinate is the angle from the vertical direction A (almost West).

Figure 4-1 shows an overview of the instruments in the buffer. The bentonite blocks are called cylinders and rings. The cylinders are numbered C1–C4 and the rings R1–R10 respectively.

- pore water pressure + temp.
- total pressure + temp.
- × temp.
- △ relative humidity (+ temp.)

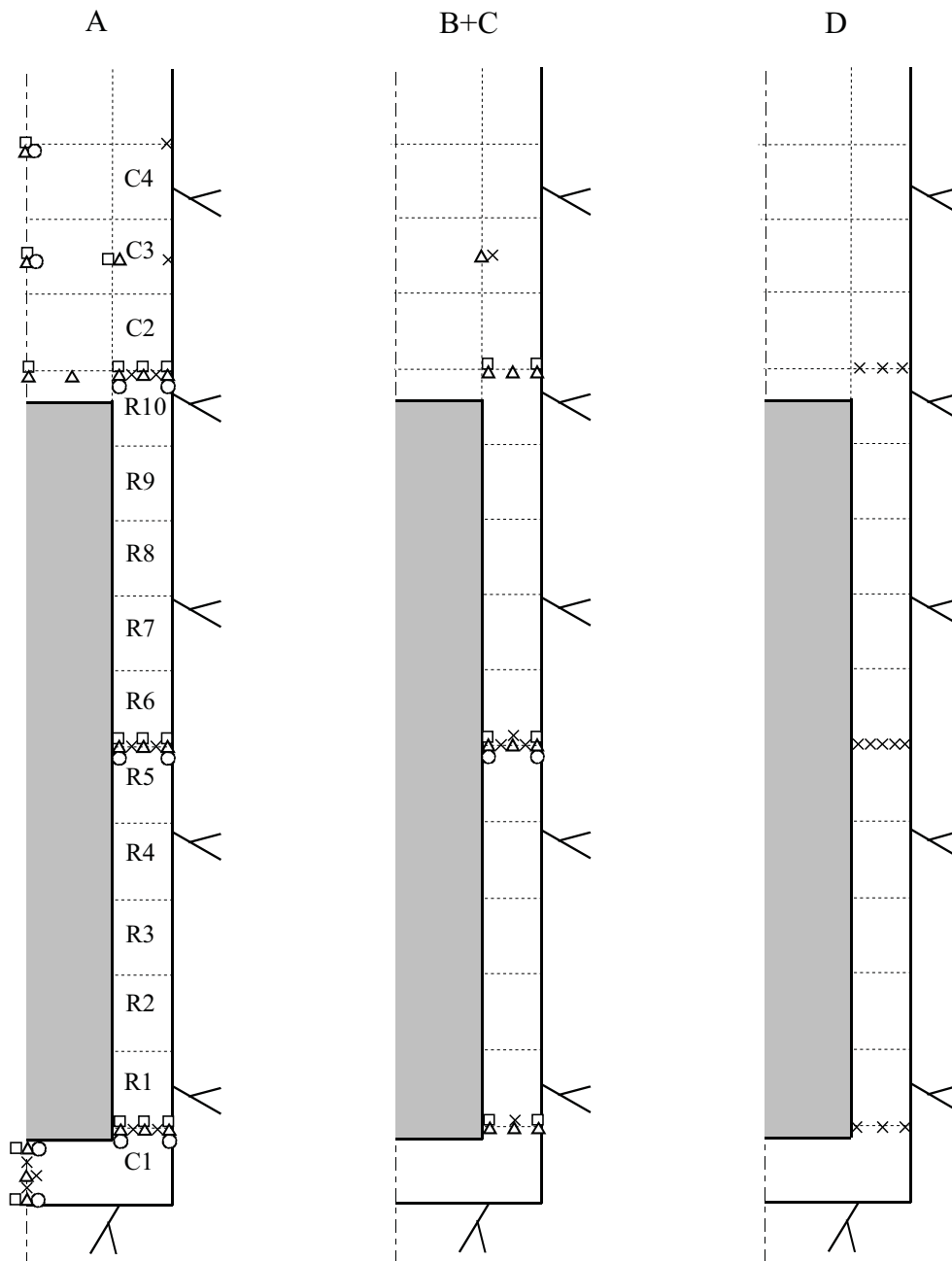
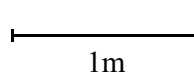


Figure 4-1. Schematic view over the instruments in four vertical sections and the block designation.

4.2 Position of each instrument in the bentonite in hole 1 (DA3587G01)

The instruments are located in three main levels in the blocks, 50 mm, 160 mm and 250 mm, from the upper surface. The thermocouples are mostly placed in the 50 mm level and the other gauges in the 160 mm level except for the Geokon type 1 pressure sensors and the Rotronic humidity sensors, which are placed in the 250 mm level depending on the size of the sensor house.

Exact positions of the sensors are described in Tables 4-1 to 4-4.

Table 4-1. Numbering and position of instruments for measuring temperature (T) in the buffer in hole 1.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|----------------------------------|---------------------|--------------------|--------|--------|-----------|-----------|
| | | Direction | α degree | r m | Z m | | |
| TBU10001 | Cyl. 1 | Center | 270 | 0.050 | 0.054 | Pentronic | |
| TBU10002 | Cyl. 1 | Center | 270 | 0.050 | 0.254 | Pentronic | |
| TBU10003 | Cyl. 1 | Center | 270 | 0.050 | 0.454 | Pentronic | |
| TBU10004 | Cyl. 1 | A | 355 | 0.635 | 0.454 | Pentronic | |
| TBU10005 | Cyl. 1 | A | 355 | 0.735 | 0.454 | Pentronic | |
| TBU10006 | On top of the canister in hole 2 | | | | | | Pentronic |
| TBU10007 | Cyl. 1 | C | 175 | 0.685 | 0.454 | Pentronic | |
| TBU10008 | Cyl. 1 | D | 270 | 0.585 | 0.454 | Pentronic | |
| TBU10009 | Cyl. 1 | D | 270 | 0.685 | 0.454 | Pentronic | |
| TBU10010 | Cyl. 1 | D | 270 | 0.785 | 0.454 | Pentronic | |
| TBU10011 | Ring 5 | A | 0 | 0.635 | 2.980 | Pentronic | |
| TBU10012 | Ring 5 | A | 0 | 0.735 | 2.980 | Pentronic | |
| TBU10013 | Ring 5 | B | 90 | 0.585 | 2.980 | Pentronic | |
| TBU10014 | Ring 5 | B | 90 | 0.685 | 2.980 | Pentronic | |
| TBU10015 | Ring 5 | B | 90 | 0.785 | 2.980 | Pentronic | |
| TBU10016 | Ring 5 | C | 175 | 0.585 | 2.980 | Pentronic | |
| TBU10017 | Ring 5 | C | 175 | 0.685 | 2.980 | Pentronic | |
| TBU10018 | Ring 5 | C | 175 | 0.735 | 2.980 | Pentronic | |
| TBU10019 | Ring 5 | D | 270 | 0.585 | 2.980 | Pentronic | |
| TBU10020 | Ring 5 | D | 270 | 0.635 | 2.980 | Pentronic | |
| TBU10021 | Ring 5 | D | 270 | 0.685 | 2.980 | Pentronic | |
| TBU10022 | Ring 5 | D | 270 | 0.735 | 2.980 | Pentronic | |
| TBU10023 | Ring 5 | D | 270 | 0.785 | 2.980 | Pentronic | |
| TBU10024 | Ring 10 | A | 0 | 0.635 | 5.508 | Pentronic | |
| TBU10025 | Ring 10 | A | 0 | 0.735 | 5.508 | Pentronic | |
| TBU10026 | Ring 10 | D | 270 | 0.585 | 5.508 | Pentronic | |
| TBU10027 | Ring 10 | D | 270 | 0.685 | 5.508 | Pentronic | |
| TBU10028 | Ring 10 | D | 270 | 0.785 | 5.508 | Pentronic | |
| TBU10029 | Cyl. 3 | A | 0 | 0.785 | 6.317 | Pentronic | |
| TBU10030 | Cyl. 3 | B | 95 | 0.585 | 6.317 | Pentronic | |
| TBU10031 | Cyl. 3 | C | 185 | 0.585 | 6.317 | Pentronic | |
| TBU10032 | Cyl. 4 | A | 0 | 0.785 | 7.026 | Pentronic | |

Table 4-2. Numbering and position of instruments for measuring total pressure (P) in the buffer in hole 1.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|---------|---------------------|-----------------|-------|-------|-----------|-------------|
| | | Direction | α degree | r m | Z m | | |
| PBU10001 | Cyl. 1 | Center | 0 | 0.000 | 0.000 | Geokon | In cement |
| PBU10002 | Cyl. 1 | Center | 0 | 0.100 | 0.504 | Geokon | |
| PBU10003 | Cyl. 1 | A | 5 | 0.585 | 0.504 | Kulite | Vertical |
| PBU10004 | Cyl. 1 | A | 5 | 0.685 | 0.504 | Kulite | Vertical |
| PBU10005 | Cyl. 1 | A | 5 | 0.785 | 0.504 | Kulite | Vertical |
| PBU10006 | Cyl. 1 | B | 95 | 0.635 | 0.504 | Geokon | |
| PBU10007 | Cyl. 1 | B | 105 | 0.735 | 0.504 | Geokon | |
| PBU10008 | Cyl. 1 | C | 185 | 0.635 | 0.504 | Geokon | |
| PBU10009 | Cyl. 1 | C | 195 | 0.735 | 0.504 | Geokon | |
| PBU10011 | Ring 5 | A | 5 | 0.685 | 2.780 | Geokon I | |
| PBU10012 | Ring 5 | A | 5 | 0.785 | 3.030 | Kulite | In the slot |
| PBU10013 | Ring 5 | B | 95 | 0.585 | 2.780 | Geokon I | |
| PBU10014 | Ring 5 | B | 95 | 0.785 | 2.780 | Geokon I | |
| PBU10015 | Ring 5 | C | 185 | 0.535 | 3.030 | Geokon I | In the slot |
| PBU10016 | Ring 5 | C | 185 | 0.825 | 2.870 | Kulite | In the slot |
| PBU10017 | Ring 10 | Center | 0 | 0.050 | 5.558 | Geokon | |
| PBU10019 | Ring 10 | A | 5 | 0.685 | 5.558 | Kulite | Vertical |
| PBU10020 | Ring 10 | A | 5 | 0.785 | 5.558 | Kulite | Vertical |
| PBU10021 | Ring 10 | B | 90 | 0.635 | 5.558 | Geokon | |
| PBU10022 | Ring 10 | B | 100 | 0.735 | 5.558 | Geokon | |
| PBU10023 | Ring 10 | C | 190 | 0.735 | 5.558 | Geokon | |
| PBU10024 | Ring 10 | C | 180 | 0.635 | 5.558 | Geokon | |
| PBU10025 | Cyl. 3 | Center | 0 | 0.050 | 6.317 | Kulite | Vertical |
| PBU10026 | Cyl. 3 | A | 5 | 0.585 | 6.567 | Geokon | |
| PBU10027 | Cyl. 4 | Center | 0 | 0.050 | 7.076 | Kulite | Vertical |

Table 4-3. Numbering and position of instruments for measuring pore water pressure (U) in the buffer in hole 1.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|---------|---------------------|-----------------|-------|-------|-----------|-------------|
| | | Direction | α degree | r m | Z m | | |
| UBU10001 | Cyl. 1 | Center | 90 | 0.050 | 0.054 | Kulite | |
| UBU10002 | Cyl. 1 | Center | 90 | 0.050 | 0.254 | Geokon | Horizontal |
| UBU10003 | Cyl. 1 | A | 355 | 0.585 | 0.344 | Geokon | |
| UBU10004 | Cyl. 1 | A | 355 | 0.785 | 0.344 | Kulite | |
| UBU10005 | Ring 5 | A | 355 | 0.585 | 2.780 | Geokon | |
| UBU10006 | Ring 5 | A | 355 | 0.785 | 2.870 | Kulite | |
| UBU10007 | Ring 5 | B | 85 | 0.535 | 2.870 | Kulite | In the slot |
| UBU10008 | Ring 5 | B | 85 | 0.825 | 2.870 | Kulite | In the slot |
| UBU10009 | Ring 5 | C | 175 | 0.535 | 2.780 | Geokon | In the slot |
| UBU10010 | Ring 5 | C | 175 | 0.825 | 2.780 | Geokon | In the slot |
| UBU10011 | Ring 10 | A | 355 | 0.585 | 5.398 | Kulite | |
| UBU10012 | Ring 10 | A | 355 | 0.785 | 5.308 | Geokon | |
| UBU10013 | Cyl. 3 | Center | 90 | 0.050 | 6.317 | Geokon | |
| UBU10014 | Cyl. 4 | Center | 90 | 0.050 | 6.916 | Geokon | |

Table 4-4. Numbering and position of instruments for measuring water content (W) in the buffer in hole 1.

| Type and number | Block | Instrument position | | | Z m | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | | | |
| WBU10001 | Cyl. 1 | Center | 180 | 0,050 | 0,054 | Rotronic | |
| WBU10002 | Cyl. 1 | Center | 0 | 0,400 | 0,254 | Rotronic | |
| WBU10003 | Cyl. 1 | Center | 180 | 0,100 | 0,254 | Rotronic | Horizontal |
| WBU10004 | Cyl. 1 | A | 350 | 0,785 | 0,344 | Vaisala | |
| WBU10005 | Cyl. 1 | A | 350 | 0,685 | 0,344 | Vaisala | |
| WBU10006 | Cyl. 1 | A | 350 | 0,585 | 0,344 | Vaisala | |
| WBU10007 | Cyl. 1 | B | 80 | 0,585 | 0,344 | Vaisala | |
| WBU10008 | Cyl. 1 | B | 80 | 0,685 | 0,254 | Rotronic | |
| WBU10009 | Cyl. 1 | B | 80 | 0,785 | 0,254 | Rotronic | |
| WBU10010 | Cyl. 1 | C | 170 | 0,585 | 0,254 | Rotronic | |
| WBU10011 | Cyl. 1 | C | 170 | 0,685 | 0,254 | Rotronic | |
| WBU10012 | Cyl. 1 | C | 170 | 0,785 | 0,254 | Rotronic | |
| WBU10013 | Ring 5 | A | 350 | 0,585 | 2,870 | Vaisala | |
| WBU10014 | Ring 5 | A | 350 | 0,685 | 2,870 | Vaisala | |
| WBU10015 | Ring 5 | A | 350 | 0,785 | 2,870 | Vaisala | |
| WBU10016 | Ring 5 | B | 80 | 0,535 | 2,780 | Rotronic | In the slot |
| WBU10017 | Ring 5 | B | 80 | 0,685 | 2,780 | Rotronic | |
| WBU10018 | Ring 5 | B | 80 | 0,785 | 2,780 | Rotronic | |
| WBU10019 | Ring 5 | C | 180 | 0,535 | 2,870 | Vaisala | In the slot |
| WBU10020 | Ring 5 | C | 180 | 0,685 | 2,870 | Vaisala | |
| WBU10021 | Ring 5 | C | 180 | 0,785 | 2,780 | Rotronic | |
| WBU10022 | Ring 10 | Center | 0 | 0,050 | 5,418 | Vaisala | |
| WBU10023 | Ring 10 | A | 180 | 0,362 | 5,428 | Vaisala | |
| WBU10024 | Ring 10 | A | 350 | 0,585 | 5,398 | Vaisala | |
| WBU10025 | Ring 10 | A | 350 | 0,685 | 5,398 | Vaisala | |
| WBU10026 | Ring 10 | A | 350 | 0,785 | 5,398 | Vaisala | |
| WBU10027 | Ring 10 | B | 80 | 0,585 | 5,308 | Rotronic | |
| WBU10028 | Ring 10 | B | 80 | 0,685 | 5,308 | Rotronic | |
| WBU10029 | Ring 10 | B | 80 | 0,785 | 5,308 | Rotronic | |
| WBU10030 | Ring 10 | C | 170 | 0,585 | 5,398 | Vaisala | |
| WBU10031 | Ring 10 | C | 170 | 0,785 | 5,308 | Rotronic | |
| WBU10032 | Cyl. 3 | Center | 270 | 0,050 | 6,317 | Vaisala | |
| WBU10033 | Cyl. 3 | A | 350 | 0,585 | 6,317 | Vaisala | |
| WBU10034 | Cyl. 3 | B | 90 | 0,585 | 6,317 | Vaisala | |
| WBU10035 | Cyl. 3 | C | 180 | 0,585 | 6,317 | Rotronic | |
| WBU10036 | Cyl. 4 | Center | 180 | 0,050 | 6,916 | Vaisala | |
| WBU10037 | Cyl. 4 | Center | 270 | 0,050 | 6,756 | Vaisala | |

4.3 Position of each instrument in the bentonite in hole 3 (DA3575G01)

The instruments are located according to the same system as those in hole 1.

The positions of each instrument are described in Tables 4-5 to 4-9.

Table 4-5. Numbering and position of instruments for measuring temperature (T) in the buffer in hole 3.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|--------|-----------|-------------------------|
| | | Direction | α degree | r m | Z m | | |
| TBU30001 | Cyl. 1 | Center | 270 | 0,050 | 0,095 | Pentronic | |
| TBU30002 | Cyl. 1 | Center | 270 | 0,050 | 0,295 | Pentronic | |
| TBU30003 | Cyl. 1 | Center | 270 | 0,050 | 0,445 | Pentronic | |
| TBU30004 | Cyl. 1 | A | 355 | 0,635 | 0,445 | Pentronic | |
| TBU30005 | Cyl. 1 | A | 355 | 0,735 | 0,445 | Pentronic | |
| TBU30006 | Cyl. 1 | B | 85 | 0,685 | 0,445 | Pentronic | |
| TBU30007 | Cyl. 1 | C | 175 | 0,685 | 0,445 | Pentronic | |
| TBU30008 | Cyl. 1 | D | 270 | 0,585 | 0,445 | Pentronic | |
| TBU30009 | Cyl. 1 | D | 270 | 0,685 | 0,445 | Pentronic | |
| TBU30010 | Cyl. 1 | D | 270 | 0,785 | 0,445 | Pentronic | |
| TBU30011 | Ring 5 | A | 0 | 0,635 | 2,971 | Pentronic | |
| TBU30012 | Ring 5 | A | 0 | 0,735 | 2,971 | Pentronic | |
| TBU30013 | Ring 5 | B | 90 | 0,585 | 2,971 | Pentronic | |
| TBU30014 | Ring 5 | B | 90 | 0,685 | 2,971 | Pentronic | |
| TBU30015 | Ring 5 | B | 90 | 0,785 | 2,971 | Pentronic | |
| TBU30016 | Ring 10 | A | 329 | 0,410 | 5,394 | Pentronic | Just above canister lid |
| TBU30017 | Ring 5 | C | 175 | 0,685 | 2,971 | Pentronic | |
| TBU30018 | Ring 5 | C | 175 | 0,735 | 2,971 | Pentronic | |
| TBU30019 | Ring 5 | D | 270 | 0,585 | 2,971 | Pentronic | |
| TBU30020 | Ring 5 | D | 270 | 0,635 | 2,971 | Pentronic | |
| TBU30021 | Ring 5 | D | 270 | 0,685 | 2,971 | Pentronic | |
| TBU30022 | Ring 5 | D | 270 | 0,735 | 2,971 | Pentronic | |
| TBU30023 | Ring 5 | D | 270 | 0,785 | 2,971 | Pentronic | |
| TBU30024 | Ring 10 | A | 0 | 0,635 | 5,504 | Pentronic | |
| TBU30025 | Ring 10 | A | 0 | 0,735 | 5,504 | Pentronic | |
| TBU30026 | Ring 10 | D | 270 | 0,585 | 5,504 | Pentronic | |
| TBU30027 | Ring 10 | D | 270 | 0,685 | 5,504 | Pentronic | |
| TBU30028 | Ring 10 | D | 270 | 0,785 | 5,504 | Pentronic | |
| TBU30029 | Cyl. 3 | A | 0 | 0,785 | 6,314 | Pentronic | |
| TBU30030 | Cyl. 3 | B | 95 | 0,585 | 6,314 | Pentronic | |
| TBU30031 | Cyl. 3 | C | 185 | 0,585 | 6,314 | Pentronic | |
| TBU30032 | Cyl. 4 | A | 0 | 0,785 | 7,015 | Pentronic | |

Table 4-6. Numbering and position of instruments for measuring total pressure (P) in the buffer in hole 3.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | Z m | | |
| PBU30001 | Cyl. 1 | Center | 0 | 0 | 0 | Geokon | In cement |
| PBU30002 | Cyl. 1 | Center | 0 | 100 | 495 | Geokon | |
| PBU30003 | Cyl. 1 | A | 5 | 585 | 495 | Kulite | Vertical |
| PBU30004 | Cyl. 1 | A | 5 | 685 | 495 | Kulite | Vertical |
| PBU30005 | Cyl. 1 | A | 5 | 785 | 495 | Kulite | Vertical |
| PBU30006 | Cyl. 1 | B | 95 | 635 | 495 | Geokon | |
| PBU30007 | Cyl. 1 | B | 105 | 735 | 495 | Geokon | |
| PBU30008 | Cyl. 1 | C | 185 | 635 | 495 | Geokon | |
| PBU30009 | Cyl. 1 | C | 195 | 735 | 495 | Geokon | |
| PBU30010 | Ring 5 | A | 5 | 535 | 3021 | Kulite | In the slot |
| PBU30011 | Ring 5 | A | 5 | 685 | 2771 | Geokon I | |
| PBU30012 | Ring 5 | A | 5 | 825 | 3021 | Kulite | In the slot |
| PBU30013 | Ring 5 | B | 95 | 585 | 2771 | Geokon I | |
| PBU30014 | Ring 5 | B | 95 | 785 | 2771 | Geokon I | |
| PBU30015 | Ring 5 | C | 185 | 535 | 3021 | Geokon I | In the slot |
| PBU30016 | Ring 5 | C | 185 | 825 | 2971 | Kulite | In the slot |
| PBU30017 | Ring 10 | Center | 0 | 50 | 5556 | Geokon | |
| PBU30018 | Ring 10 | A | 5 | 585 | 5556 | Kulite | Vertical |
| PBU30019 | Ring 10 | A | 5 | 685 | 5556 | Kulite | Vertical |
| PBU30020 | Ring 10 | A | 5 | 785 | 5556 | Kulite | Vertical |
| PBU30021 | Ring 10 | B | 90 | 635 | 5556 | Geokon | |
| PBU30022 | Ring 10 | B | 100 | 735 | 5556 | Geokon | |
| PBU30023 | Ring 10 | C | 180 | 735 | 5556 | Geokon | |
| PBU30024 | Ring 10 | C | 190 | 635 | 5556 | Geokon | |
| PBU30025 | Cyl. 3 | Center | 0 | 50 | 6314 | Kulite | Vertical |
| PBU30026 | Cyl. 3 | A | 5 | 585 | 6564 | Geokon | |
| PBU30027 | Cyl. 4 | Center | 0 | 50 | 7065 | Kulite | Vertical |

Table 4-7. Numbering and position of instruments for measuring pore water pressure (U) in the buffer in hole 3.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | Z m | | |
| UBU30001 | Cyl. 1 | Center | 90 | 50 | 45 | Kulite | |
| UBU30002 | Cyl. 1 | Center | 90 | 100 | 245 | Geokon | Horizontal |
| UBU30003 | Cyl. 1 | A | 355 | 585 | 335 | Geokon | |
| UBU30004 | Cyl. 1 | A | 355 | 785 | 335 | Kulite | |
| UBU30005 | Ring 5 | A | 355 | 585 | 2771 | Geokon | |
| UBU30006 | Ring 5 | A | 355 | 785 | 2861 | Kulite | |
| UBU30007 | Ring 5 | B | 85 | 535 | 2861 | Kulite | In the slot |
| UBU30008 | Ring 5 | B | 85 | 825 | 2861 | Kulite | In the slot |
| UBU30009 | Ring 5 | C | 175 | 535 | 2771 | Geokon | In the slot |
| UBU30010 | Ring 5 | C | 175 | 825 | 2771 | Geokon | In the slot |
| UBU30011 | Ring 10 | A | 355 | 585 | 5396 | Kulite | |
| UBU30012 | Ring 10 | A | 355 | 785 | 5306 | Geokon | |
| UBU30013 | Cyl. 3 | Center | 90 | 50 | 6314 | Geokon | |
| UBU30014 | Cyl. 4 | Center | 90 | 50 | 6910 | Geokon | |

Table 4-8. Numbering and position of instruments for measuring water content (W) in the buffer in hole 3.

| Type and number | Block | Instrument position | | | Z m | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | | | |
| WBU30001 | Cyl. 1 | Center | 180 | 0.050 | 0.045 | Rotronic | |
| WBU30002 | Cyl. 1 | Center | 0 | 0.400 | 0.215 | Rotronic | |
| WBU30003 | Cyl. 1 | Center | 180 | 0.100 | 0.245 | Rotronic | Horizontal |
| WBU30004 | Cyl. 1 | A | 350 | 0.785 | 0.335 | Vaisala | |
| WBU30005 | Cyl. 1 | A | 350 | 0.685 | 0.335 | Vaisala | |
| WBU30006 | Cyl. 1 | A | 350 | 0.585 | 0.335 | Vaisala | |
| WBU30007 | Cyl. 1 | B | 80 | 0.585 | 0.335 | Vaisala | |
| WBU30008 | Cyl. 1 | B | 80 | 0.685 | 0.245 | Rotronic | |
| WBU30009 | Cyl. 1 | B | 80 | 0.785 | 0.245 | Rotronic | |
| WBU30010 | Cyl. 1 | C | 170 | 0.585 | 0.245 | Rotronic | |
| WBU30011 | Cyl. 1 | C | 170 | 0.685 | 0.245 | Rotronic | |
| WBU30012 | Cyl. 1 | C | 170 | 0.785 | 0.245 | Rotronic | |
| WBU30013 | Ring 5 | A | 350 | 0.585 | 2.861 | Vaisala | |
| WBU30014 | Ring 5 | A | 350 | 0.685 | 2.861 | Vaisala | |
| WBU30015 | Ring 5 | A | 350 | 0.785 | 2.861 | Vaisala | |
| WBU30016 | Ring 5 | B | 80 | 0.535 | 2.771 | Rotronic | In the slot |
| WBU30017 | Ring 5 | B | 80 | 0.685 | 2.771 | Rotronic | |
| WBU30018 | Ring 5 | B | 80 | 0.785 | 2.771 | Rotronic | |
| WBU30019 | Ring 5 | C | 180 | 0.535 | 2.861 | Vaisala | In the slot |
| WBU30020 | Ring 5 | C | 180 | 0.685 | 2.861 | Vaisala | |
| WBU30021 | Ring 5 | C | 180 | 0.785 | 2.771 | Rotronic | |
| WBU30022 | Ring 10 | Center | 180 | 0.050 | 5.416 | Vaisala | |
| WBU30023 | Ring 10 | A | 352 | 0.262 | 5.396 | Vaisala | |
| WBU30024 | Ring 10 | A | 350 | 0.585 | 5.396 | Vaisala | |
| WBU30025 | Ring 10 | A | 350 | 0.785 | 5.396 | Vaisala | |
| WBU30026 | Ring 10 | A | 350 | 0.685 | 5.396 | Vaisala | |
| WBU30027 | Ring 10 | B | 80 | 0.585 | 5.306 | Rotronic | |
| WBU30028 | Ring 10 | B | 80 | 0.685 | 5.306 | Rotronic | |
| WBU30029 | Ring 10 | B | 80 | 0.785 | 5.306 | Rotronic | |
| WBU30030 | Ring 10 | C | 170 | 0.585 | 5.396 | Vaisala | |
| WBU30031 | Ring 10 | C | 170 | 0.785 | 5.306 | Rotronic | |
| WBU30032 | Cyl. 3 | Center | 180 | 0.050 | 6.314 | Vaisala | |
| WBU30033 | Cyl. 3 | A | 350 | 0.585 | 6.314 | Vaisala | |
| WBU30034 | Cyl. 3 | B | 90 | 0.585 | 6.314 | Vaisala | |
| WBU30035 | Cyl. 3 | C | 180 | 0.585 | 6.314 | Rotronic | |
| WBU30036 | Cyl. 4 | Center | 180 | 0.050 | 6.910 | Vaisala | |
| WBU30037 | Cyl. 4 | Center | 270 | 0.050 | 6.750 | Vaisala | |

Table 4-9. Numbering and position of temperature sensors in the rock.

| Instrument position in rock | | | | |
|---|---------------------------------------|----------------|----------------|------------------|
| Type and number | α degree | r m | Z m | Fabricate |
| Measured from DA3587G01(Hole 1) | | | | |
| TROA0350 | 360 | 9.080 | 7.785 | Pentronic |
| TROA0340 | 360 | 9.080 | 5.785 | Pentronic |
| TROA0330 | 360 | 9.080 | 3.385 | Pentronic |
| TROA0320 | 0 | 9.080 | 0.986 | Pentronic |
| TROA0310 | 0 | 9.081 | -1.714 | Pentronic |
| TROA0650 | 360 | 4.990 | 7.922 | Pentronic |
| TROA0640 | 360 | 4.982 | 5.922 | Pentronic |
| TROA0630 | 360 | 4.972 | 3.522 | Pentronic |
| TROA0620 | 360 | 4.961 | 1.122 | Pentronic |
| TROA0610 | 360 | 4.951 | -1.478 | Pentronic |
| TROA1050 | 359 | 2.014 | 7.663 | Pentronic |
| TROA1040 | 359 | 2.022 | 5.663 | Pentronic |
| TROA1030 | 359 | 2.032 | 3.263 | Pentronic |
| TROA1020 | 359 | 2.042 | 0.863 | Pentronic |
| TROA1010 | 359 | 2.053 | -1.837 | Pentronic |
| Measured from DA3581G01(Hole 2) | | | | |
| TROA1840 | 179 | 2.403 | 7.584 | Pentronic |
| TROA1830 | 179 | 2.427 | 6.084 | Pentronic |
| TROA1820 | 179 | 2.489 | 2.135 | Pentronic |
| TROA1810 | 179 | 2.541 | -1.165 | Pentronic |
| Measured from DA3575G01(Hole 3) | | | | |
| TROA2150 | 134 | 3.287 | 7.956 | Pentronic |
| TROA2140 | 1 | 1.993 | 5.977 | Pentronic |
| TROA2130 | 1 | 1.975 | 4.228 | Pentronic |
| TROA2120 | 2 | 1.961 | 2.838 | Pentronic |
| TROA2110 | 3 | 1.944 | 1.168 | Pentronic |
| TROA1850 | 360 | 2.013 | 7.887 | Pentronic |
| TROA2330 | 90 | 2.192 | 7.922 | Pentronic |
| TROA2320 | 90 | 1.786 | 6.630 | Pentronic |
| TROA2310 | 109 | 7.111 | 4.638 | Pentronic |
| TROA2440 | 124 | 4.090 | 7.172 | Pentronic |
| TROA2430 | 90 | 2.735 | 4.317 | Pentronic |
| TROA2420 | 89 | 3.912 | 1.449 | Pentronic |
| TROA2410 | 89 | 5.86 | -3.297 | Pentronic |
| Measured from DA3569G01 (Hole 4) | | | | |
| TROA3050 | 359 | 2.013 | 7.665 | Pentronic |
| TROA3040 | 359 | 2.020 | 5.665 | Pentronic |
| TROA3030 | 358 | 2.030 | 3.265 | Pentronic |
| TROA3020 | 357 | 2.040 | 0.865 | Pentronic |
| TROA3010 | 357 | 2.051 | -1.784 | Pentronic |

4.4 Instruments on the canister surface in holes 1–4

The canisters are instrumented with optical fiber cables on the copper surface.

Figure 4-2 shows how two optical fiber cables are placed on the canister surface. Both ends of a cable are used for measurements. This means that the two cables are used for four measurements.

With this laying the cables will enter and exit the surface at almost the same position. Curvatures are shaped as a quarter circle with a radius of 20 cm. The cables are placed in a milled out channels on the surface. The channels have a width and a depth of just above 2 mm.

In addition to the optical cables one thermocouple (TBU 10006) is fixed to the lid of the canister in deposition hole 2 (see Table 4-1).

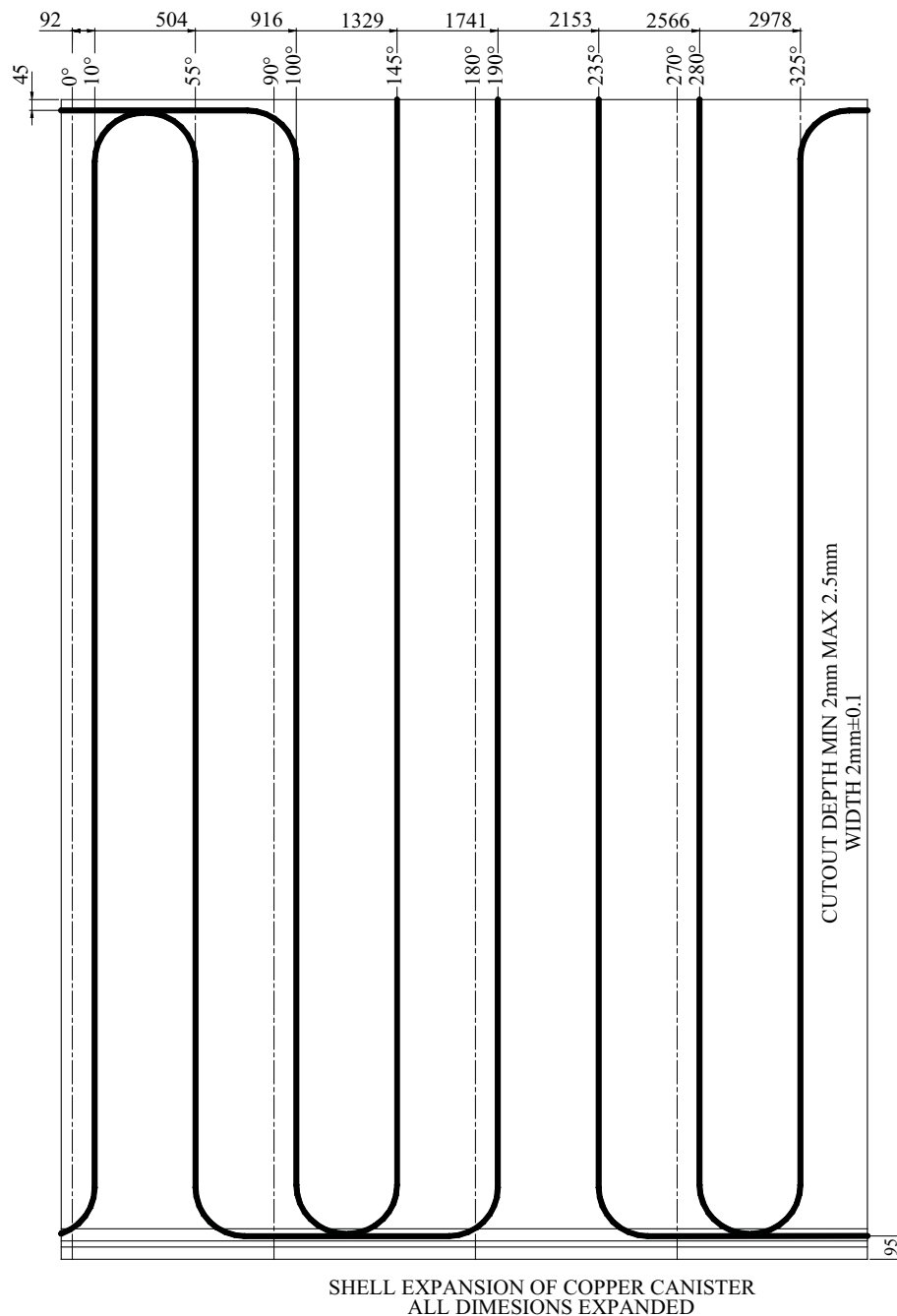


Figure 4-2. Laying of the optical fiber cables with protection tube of Inconel 625 (outer diameter 2 mm) for measurement of the canister surface temperature (surface unfolded).

4.5 Position of temperature sensors in the rock

The positions of the temperature sensors in the rock are termed in the same way as the sensors in the buffer in the deposition holes. Figure 4-3 shows an overview of the temperature sensors placed in the rock. The sensors are assigned to the closest deposition hole. The positions are described in Table 4-9.

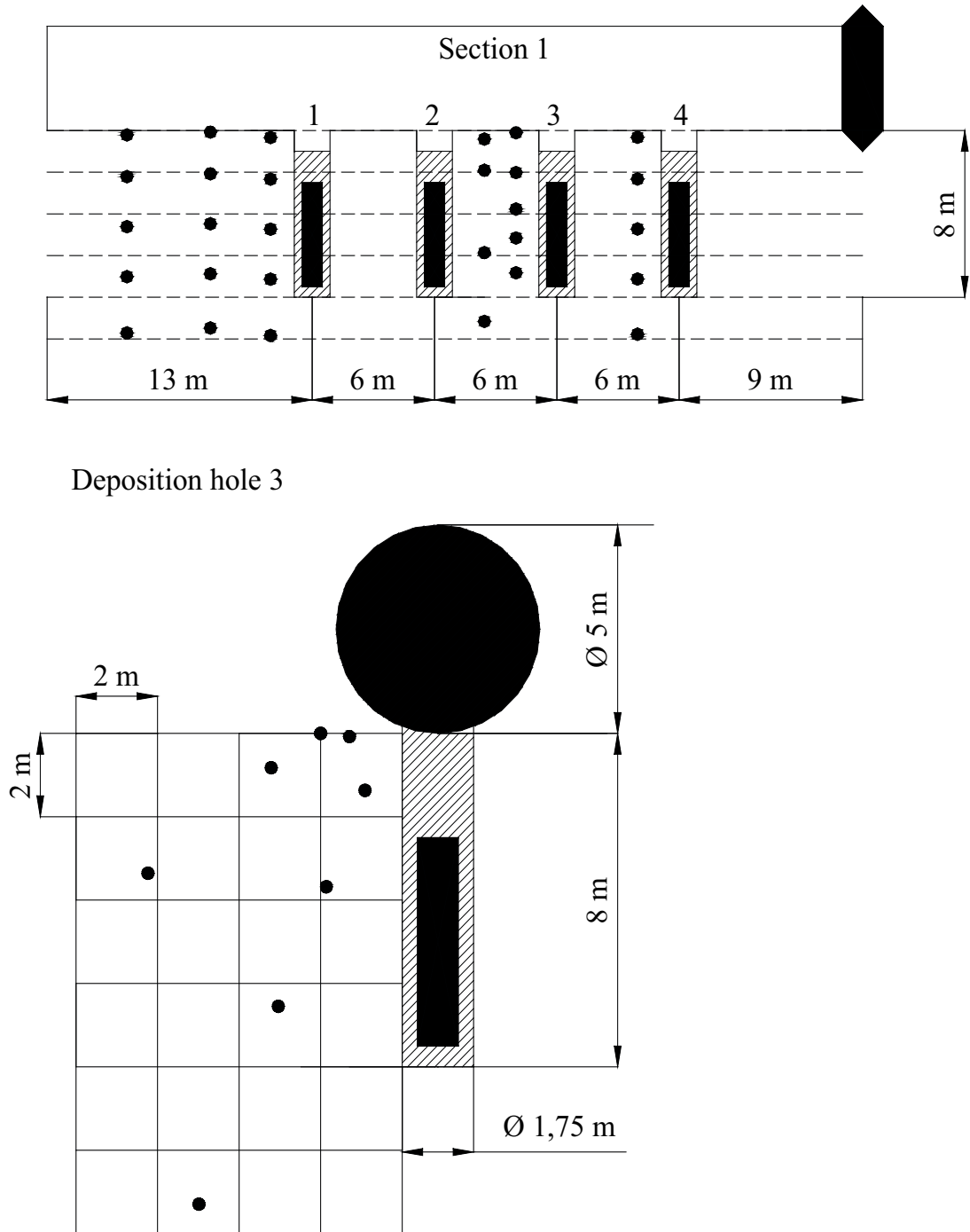


Figure 4-3. Overview of the temperature sensors in the rock. Length section (upper) and cross section (towards the end of the tunnel).

4.6 Strategy for describing the position of each device in the backfill in Section 1

The principles of terming the instruments are described in the quick guide inserted as a folded A3 page at the end of the report.

Every instrument is named with a unique name consisting of 1 letter describing the type of measurement, 2 letters describing where the measurement takes place (buffer, backfill, rock or canister) and 5 figures specifying the instrument according to separate lists (see Tables 4-10 to 4-13). Every instrument position is then described with three coordinates according to Figure 2-2. The x -coordinate is the horizontal distance from the centre of the tunnel and the z -coordinate is the vertical distance from the centre of the tunnel. The y -coordinate is the same as in the tunnel coordinate system, i.e. $y=3,599$ corresponds to the end of the tunnel.

The backfill is mainly instrumented in vertical sections straight above and between the deposition holes (Figures 4-4 and 4-5).

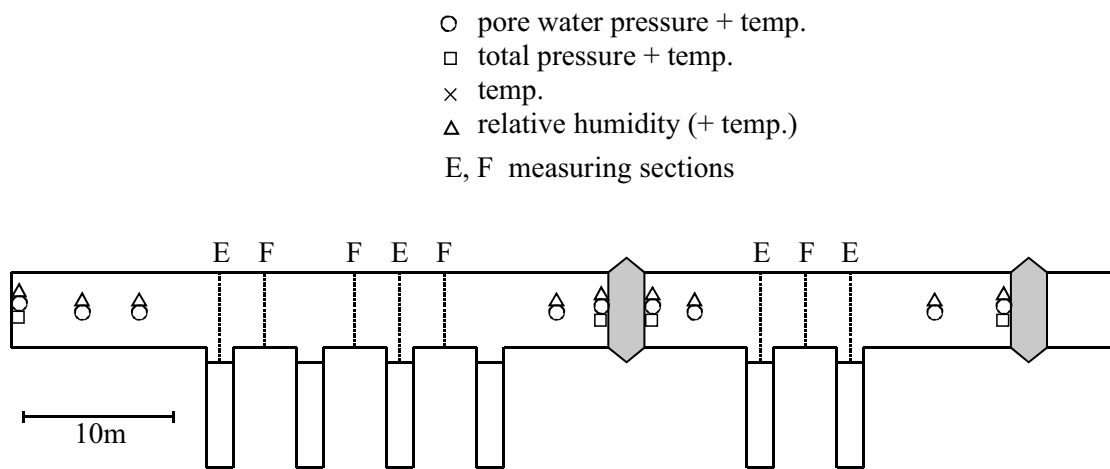


Figure 4-4. Schematic view over the instrumentation of the backfill.

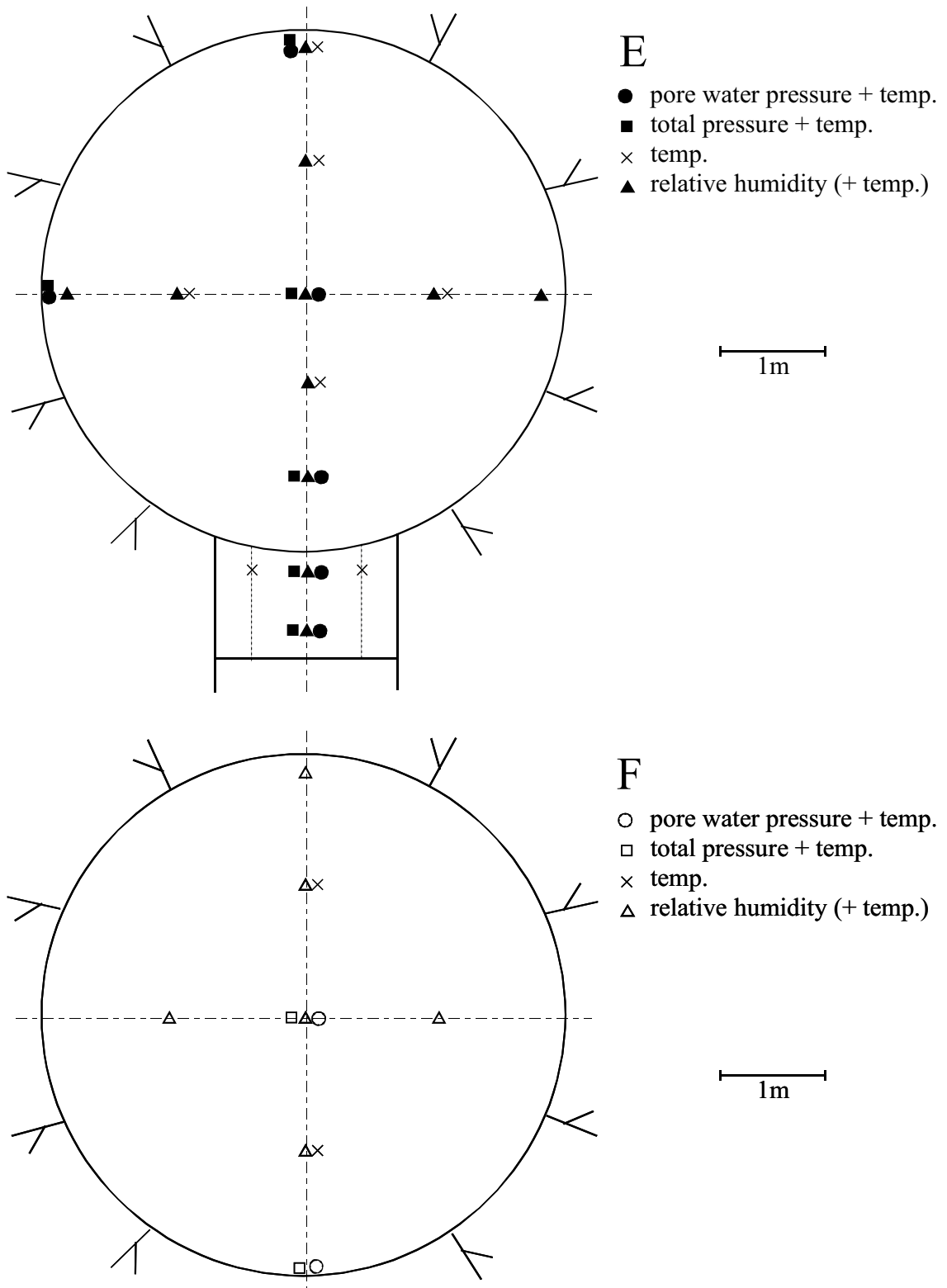


Figure 4-5. Schematic view over the sensors positions in the different sections.

4.7 Position of each instrument in the backfill

The positions of each instrument are described in Tables 4-10 to 4-13.

Table 4-10. Numbering and position of instruments for measuring temperature (T) in the backfill.

| Type and number | Instrument position Section | x | z | y | Fabricate | Remark |
|-----------------|--------------------------------|------|------|-------|-----------|--------|
| | | m | m | m | | |
| TBA10001 | E, over dep.hole 1 | -1.3 | -0.1 | 3 587 | Pentronic | |
| TBA10002 | E, over dep.hole 1 | 0.1 | 1.3 | 3 587 | Pentronic | |
| TBA10003 | E, over dep.hole 1 | 0.0 | -0.8 | 3 587 | Pentronic | |
| TBA10004 | E, over dep.hole 1 | -0.5 | -2.6 | 3 587 | Pentronic | |
| TBA10005 | E, over dep.hole 1 | 0.5 | -2.6 | 3 587 | Pentronic | |
| TBA10006 | E, over dep.hole 1 | -0.1 | 2.3 | 3 587 | Pentronic | |
| TBA10007 | E, over dep.hole 1 | 1.3 | -0.1 | 3 587 | Pentronic | |
| TBA10008 | F, between dep.hole 1 and 2 | 0.0 | 1.3 | 3 584 | Pentronic | |
| TBA10009 | F, between dep.hole 1 and 2 | -0.1 | -1.3 | 3 584 | Pentronic | |
| TBA10010 | F, between dep.hole 2 and 3 | 0.0 | 1.2 | 3 578 | Pentronic | |
| TBA10011 | F, between dep.hole 2 and 3 | 0.0 | -1.2 | 3 578 | Pentronic | |
| TBA10012 | E, over dep.hole 3 | -0.1 | 2.3 | 3 575 | Pentronic | |
| TBA10013 | E, over dep.hole 3 | 0.0 | 1.3 | 3 575 | Pentronic | |
| TBA10014 | E, over dep.hole 3 | 0.0 | -0.9 | 3 575 | Pentronic | |
| TBA10015 | E, over dep.hole 3 | -0.5 | -2.6 | 3 575 | Pentronic | |
| TBA10016 | E, over dep.hole 3 | 0.5 | -2.6 | 3 575 | Pentronic | |
| TBA10017 | E, over dep.hole 3 | -1.3 | 0.0 | 3 575 | Pentronic | |
| TBA10018 | E, over dep.hole 3 | 1.3 | 0.0 | 3 575 | Pentronic | |
| TBA10019 | F, between dep.hole 3 and 4 | 0.0 | 1.2 | 3 572 | Pentronic | |
| TBA10020 | F, between dep.hole 3 and 4 | 0.0 | -1.3 | 3 572 | Pentronic | |

Table 4-11. Numbering and position of instruments for measuring total pressure (P) in the backfill.

| Type and number | Instrument position Section | x m | z m | y m | Fabricate | Remark |
|-----------------|--------------------------------|--------|--------|--------|-----------|--------|
| | | | | | | |
| PBA10001 | Inner part | 0.2 | 0.1 | 3589 | Kulite | |
| PBA10002 | E, over dep.hole 1 | 0.0 | 0.0 | 3587 | Geokon | |
| PBA10003 | E, over dep.hole 1 | 0.0 | -1.8 | 3587 | Geokon | |
| PBA10004 | E, over dep.hole 1 | 0.0 | -2.6 | 3587 | Geokon | |
| PBA10005 | E, over dep.hole 1 | 0.0 | -3.1 | 3587 | Kulite | |
| PBA10006 | E, over dep.hole 1 | -2.3 | 0.1 | 3587 | Kulite | |
| PBA10007 | E, over dep.hole 1 | 0.2 | 2.3 | 3587 | Kulite | |
| PBA10008 | F, between dep.hole 1 and 2 | 0.0 | 0.0 | 3584 | Geokon | |
| PBA10009 | F, between dep.hole 1 and 2 | -0.1 | -1.8 | 3584 | Geokon | |
| PBA10010 | F, between dep.hole 2 and 3 | 0.0 | -0.2 | 3578 | Kulite | |
| PBA10011 | F, between dep.hole 2 and 3 | 0.0 | -2.3 | 3578 | Kulite | |
| PBA10013 | E, over dep.hole 3 | 0.0 | -1.8 | 3575 | Kulite | |
| PBA10015 | E, over dep.hole 3 | 0.0 | -3.1 | 3575 | Geokon | |
| PBA10016 | E, over dep.hole 3 | -2.3 | 0.0 | 3575 | Geokon | |
| PBA10017 | E, over dep.hole 3 | 0.0 | 0.0 | 3575 | Geokon | |
| PBA10018 | F, between dep.hole 3 and 4 | 0.0 | 0.0 | 3572 | Geokon | |
| PBA10019 | F, between dep.hole 3 and 4 | 0.0 | -2.3 | 3572 | Geokon | |
| PBA10020 | In front of plug | 0.0 | 0.0 | 3561 | Kulite | |

Table 4-12. Numbering and position of instruments for measuring pore water pressure (U) in the backfill.

| Type and number | Instrument position Section | x m | z m | y m | Fabricate | Remark |
|-----------------|--------------------------------|--------|--------|--------|-----------|--------|
| | | | | | | |
| UBA10001 | Inner part | -0.2 | -0.1 | 3589 | Kulite | |
| UBA10002 | Inner part | 0.0 | 0.0 | 3592 | Geokon | |
| UBA10003 | Inner part | -0.2 | -0.1 | 3590 | Geokon | |
| UBA10004 | E, over dep.hole 1 | 0.0 | -0.1 | 3587 | Geokon | |
| UBA10005 | E, over dep.hole 1 | -0.2 | -1.8 | 3587 | Kulite | |
| UBA10006 | E, over dep.hole 1 | 0.1 | -2.6 | 3587 | Kulite | |
| UBA10007 | E, over dep.hole 1 | 0.4 | -3.2 | 3587 | Kulite | |
| UBA10008 | E, over dep.hole 1 | -2.3 | 0.0 | 3587 | Geokon | |
| UBA10009 | E, over dep.hole 1 | 0.0 | 2.3 | 3587 | Geokon | |
| UBA10010 | F, between dep.hole 1 and 2 | 0.0 | 0.0 | 3584 | Kulite | |
| UBA10011 | F, between dep.hole 1 and 2 | 0.1 | -1.8 | 3584 | Kulite | |
| UBA10012 | F, between dep.hole 2 and 3 | 0.0 | -0.2 | 3578 | Kulite | |
| UBA10013 | F, between dep.hole 2 and 3 | 0.0 | -2.3 | 3578 | Kulite | |
| UBA10014 | E, over dep.hole 3 | 0.0 | 0.0 | 3575 | Kulite | |
| UBA10015 | E, over dep.hole 3 | 0.0 | -1.8 | 3575 | Geokon | |
| UBA10016 | E, over dep.hole 3 | 0.3 | -2.6 | 3575 | Geokon | |
| UBA10017 | E, over dep.hole 3 | -0.1 | -3.1 | 3575 | Geokon | |
| UBA10018 | E, over dep.hole 3 | -2.3 | 0.0 | 3575 | Geokon | |
| UBA10019 | E, over dep.hole 3 | 0.0 | 0.0 | 3575 | Geokon | |
| UBA10020 | F, between dep.hole 3 and 4 | 0.0 | 0.0 | 3572 | Kulite | |
| UBA10021 | F, between dep.hole 3 and 4 | 0.0 | -2.3 | 3572 | Kulite | |
| UBA10022 | In front of plug | 0.0 | 0.0 | 3565 | Kulite | |
| UBA10023 | In front of plug | 0.1 | 0.0 | 3562 | Kulite | |

Table 4-13. Numbering and position of instruments for measuring relative humidity (W) in the backfill.

| Type and number | Instrument position Section | x | z | y | Fabricate | Remark |
|-----------------|--------------------------------|------|------|------|-----------|--------|
| | | m | m | m | | |
| WBA10001 | Inner part | 0.0 | 0.0 | 3589 | Wescor | |
| WBA10002 | Inner part | 0.0 | 0.0 | 3592 | Wescor | |
| WBA10003 | Inner part | 0.1 | -0.1 | 3590 | Wescor | |
| WBA10004 | E, over dep.hole 1 | 0.3 | 2.3 | 3587 | Wescor | |
| WBA10005 | E, over dep.hole 1 | 0.0 | 1.3 | 3587 | Wescor | |
| WBA10006 | E, over dep.hole 1 | 0.0 | 0.1 | 3587 | Wescor | |
| WBA10007 | E, over dep.hole 1 | 0.1 | -0.8 | 3587 | Wescor | |
| WBA10008 | E, over dep.hole 1 | 0.0 | -1.7 | 3587 | Wescor | |
| WBA10009 | E, over dep.hole 1 | -0.1 | -2.6 | 3587 | Wescor | |
| WBA10010 | E, over dep.hole 1 | -0.5 | -3.1 | 3587 | Wescor | |
| WBA10011 | E, over dep.hole 1 | -2.3 | -0.1 | 3587 | Wescor | |
| WBA10012 | E, over dep.hole 1 | -1.3 | 0.0 | 3587 | Wescor | |
| WBA10013 | E, over dep.hole 1 | 1.3 | 0.0 | 3587 | Wescor | |
| WBA10014 | E, over dep.hole 1 | 2.3 | 0.0 | 3587 | Wescor | |
| WBA10015 | F, between dep.hole 1 and 2 | 0.0 | 1.3 | 3584 | Wescor | |
| WBA10016 | F, between dep.hole 1 and 2 | 0.0 | 2.3 | 3584 | Wescor | |
| WBA10017 | F, between dep.hole 1 and 2 | 0.0 | 0.0 | 3584 | Wescor | |
| WBA10018 | F, between dep.hole 1 and 2 | 0.0 | -1.3 | 3584 | Wescor | |
| WBA10019 | F, between dep.hole 1 and 2 | -1.3 | 0.0 | 3584 | Wescor | |
| WBA10020 | F, between dep.hole 1 and 2 | 1.3 | 0.0 | 3584 | Wescor | |
| WBA10021 | F, between dep.hole 2 and 3 | 0.0 | 2.3 | 3578 | Wescor | |
| WBA10022 | F, between dep.hole 2 and 3 | 0.0 | 1.2 | 3578 | Wescor | |
| WBA10023 | F, between dep.hole 2 and 3 | 0.0 | -0.2 | 3578 | Wescor | |
| WBA10024 | F, between dep.hole 2 and 3 | 0.0 | -1.2 | 3578 | Wescor | |
| WBA10025 | F, between dep.hole 2 and 3 | -1.3 | 0.0 | 3578 | Wescor | |
| WBA10026 | F, between dep.hole 2 and 3 | 1.3 | 0.0 | 3578 | Wescor | |
| WBA10027 | E, over dep.hole 3 | 0.0 | 2.5 | 3575 | Wescor | |
| WBA10028 | E, over dep.hole 3 | 0.0 | 1.3 | 3575 | Wescor | |
| WBA10029 | E, over dep.hole 3 | 0.0 | 0.0 | 3575 | Wescor | |
| WBA10030 | E, over dep.hole 3 | 0.0 | -0.9 | 3575 | Wescor | |
| WBA10031 | E, over dep.hole 3 | 0.0 | -1.6 | 3575 | Wescor | |
| WBA10032 | E, over dep.hole 3 | -0.3 | -2.6 | 3575 | Wescor | |
| WBA10033 | E, over dep.hole 3 | 0.1 | -3.1 | 3575 | Wescor | |
| WBA10034 | E, over dep.hole 3 | -2.3 | 0.0 | 3575 | Wescor | |
| WBA10035 | E, over dep.hole 3 | -1.3 | 0.0 | 3575 | Wescor | |
| WBA10036 | E, over dep.hole 3 | 1.3 | 0.0 | 3575 | Wescor | |
| WBA10037 | E, over dep.hole 3 | 2.3 | 0.0 | 3575 | Wescor | |
| WBA10038 | F, between dep.hole 3 and 4 | 0.0 | 2.3 | 3572 | Wescor | |
| WBA10039 | F, between dep.hole 3 and 4 | 0.0 | 1.2 | 3572 | Wescor | |
| WBA10040 | F, between dep.hole 3 and 4 | 0.0 | 0.0 | 3572 | Wescor | |
| WBA10041 | F, between dep.hole 3 and 4 | 0.0 | -1.3 | 3572 | Wescor | |
| WBA10042 | F, between dep.hole 3 and 4 | -1.3 | 0.0 | 3572 | Wescor | |
| WBA10043 | F, between dep.hole 3 and 4 | 1.3 | 0.0 | 3572 | Wescor | |
| WBA10044 | In front of plug | 0.0 | 0.0 | 3565 | Wescor | |
| WBA10045 | In front of plug | -0.1 | 0.0 | 3562 | Wescor | |

5 Results and comments for Section 1

5.1 General

In this chapter short comments on general trends in the measurements are given. Sensors that are not delivering reliable data or no data at all are noted and comments on the data collection in general are given.

The heating of the canister in hole1 started with an applied constant power of 1,800 W at 010917. This date is also marked as start date for the test. The backfilling started 010903 and was finished 011120 and the plug was cast at 011214. In order to simulate the radioactive decay, the power was decreased 20 W one year after start of the first heater. At the beginning of September 2004 the power was decreased with about 30 W to 1,710 W in deposition holes 1–4. Table 5-1 shows some important dates for Section 1. At the beginning of November 2004 the drainage of the inner part of Section 1 and the drainage trough the outer plug were closed. At the beginning of December 2004 damages on the cables for the installed heaters in one of the canisters in Section 1 (No 1) and one in Section 2 (No 6) were observed. The damages were probably caused by the high water pressure in the buffer and backfill. It was then decided to switch off the power to all canisters. This was done on December 2. The drainage of the tunnel was opened on December 6 and investigations of the damaged cables were initialized. The power to all the canisters, except for canister 2, was on December 15 switched on. The damages on heaters in canister 2 were so severe that it was impossible to apply any power on this canister. The drainage of the tunnel was kept open.

In December 2005, 2006, 2007 and in January 2009 and 2010 the power to the canisters was reduced with about 30 W. The applied power after the latest reduction is about 1,560 W.

Beside the above reported power reductions a change in power was made June 23 2003 due to additional calculations of the power from measurement of the energy. The power of the canisters was adjusted to 1,800 W. The most significant change was made for canister 2 (See Section 5.4.1 and Appendix 3 page 109).

Table 5-1. Key dates for Section 1.

| Activity | Date |
|---|------------|
| Start backfilling | 3/9 2001 |
| Start heating canister 1 | 17/9 2001 |
| Start heating canister 2 | 24/9 2001 |
| Start heating canister 3 | 11/10 2001 |
| Start heating canister 4 | 22/10 2001 |
| Finish backfilling | 20/11 2001 |
| Plug casting | 14/12 2001 |
| Decreased power (-20 W) | 17/9 2002 |
| Decreased power (-40 W) | 5/9 2003 |
| Decreased power (-30 W) | 8/9 2004 |
| The drainage of tunnel was closed | 1/10 2004 |
| The power to all canisters was switched off | 2/12 2004 |
| The drainage of the tunnel was opened | 6/12 2004 |
| The power to the canisters was switched on | 15/12 2004 |
| Decreased power (-30 W) | 2/12 2005 |
| A packer installed in the rock was broken | 18/5 2006 |
| Decreased power (-30 W) | 21/12 2006 |
| Decreased power (-30 W) | 11/12 2007 |
| Decreased power (-30 W) | 29/1 2009 |
| Decreased power (-30 W) | 21/1 2010 |
| Start of the dismantling of the outer plug | 29/11 2010 |

At the end of November 2010 the dismantling of the outer plug in Section II started. This work was preceded by leakage tests of the outer plug.

After the retrieval of the outer section, validation tests of the total pressure sensors of type Geocon were made. It was then discovered that, the up to now used calibration values (linear equation) gave inaccurate readings of the total pressure. The improvements of the readings were large when a polynomial calibration equation was used instead. At the presentation of the data in this report the polynomial equation was used.

At present about 275 (excluding water pressure sensors in the rock and the displacement sensors for the canister) out of totally 363 installed sensors are out of order. In Figure 5-1 the numbers of still working sensors in the buffer and the backfill of Section 1 are plotted as function of time from September 2001. The figure shows that the majority of the broken sensors are RH-sensors and thermocouples (in deposition hole 3). The figure also shows that the numbers of broken sensors increased after the closing of the drainage of the tunnel.

The measured processes were slow up to about 20 days after the drainage of the tunnel was closed. Very small changes of the measured parameters occurred up to that date. After that the readings from some of the total and pore pressure sensors placed in the buffer reacted strongly (quick increase in pressure). Also the total and pore pressure sensors placed in the backfill recorded high pressures caused by the closing of the drainage. After the reopening of the drainage of the tunnel, both the pore pressures and the total pressures in the backfill were stabilized on almost the same level as before the closing of the drainage. At around day 1,670 both the total pressure sensors and the pore pressure sensors are measuring an increase in pressure. This is caused by a failure in one packer placed in the rock at the inner part of the tunnel causing an increase in out flow of water from the inner section from about 1.5 l/min to more than 9 l/min.

So far hole 1 has been strongly wetted and a very slowly wetting is observed in hole 3. A slow but obvious wetting of the backfill is noted until about 20 days after the closing of the drainage. After that a strong increase of the wetting rate was monitored by several psychrometers. The measurement of the temperature on the canister surface with the optical system has stopped functioning.

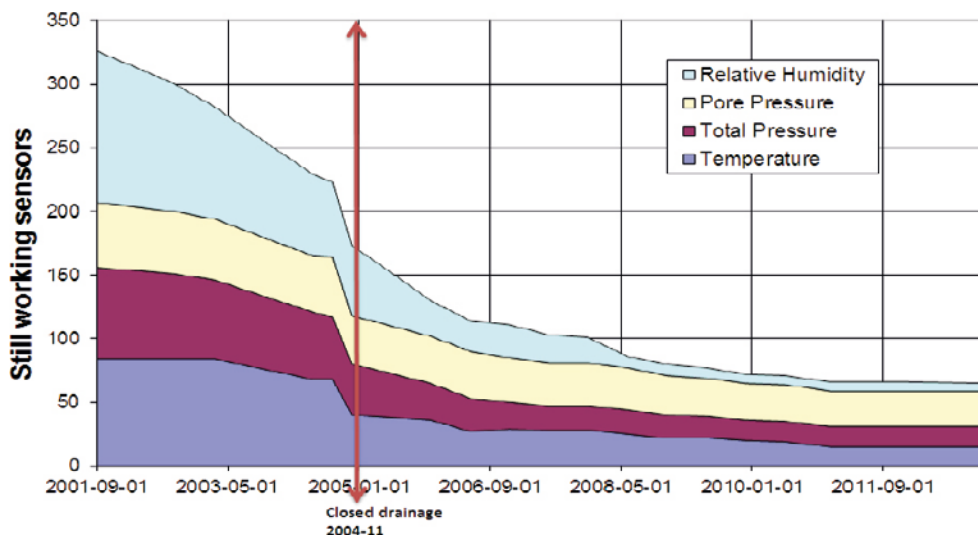


Figure 5-1. The number of still working sensors placed in the buffer and backfill in Section 1 as function of date. The coloured fields are representing the four types of installed sensors.

5.2 Deposition hole 1

5.2.1 Total pressure

Geokon (App. 1\pages 79–80)

The measured pressure range is from 1.4 to 8.5 MPa. The highest pressure is indicated from the peripheral sensors in the bottom block (C1). Four sensors in block R5 and block R10 yielded a high increase in total pressure when the drainage of the tunnel was closed. Most of the sensors yielded a drop in pressure when the heaters were switched off and the drainage of the tunnel was opened again and an increase in pressure when the heaters were switched on again.

All of the installed sensors are out of order.

Kulite (App. 1\page 80)

The highest pressure 7 MPa is indicated from the peripheral sensor (PBU 10012) in block R5. Three of the installed sensors indicated a rapid increase in pressure when the drainage of the tunnel was closed followed by a drop in pressure when the power was switched off and the drainage was reopened. After the power was switched on the pressure increased to the same level as before the closing of the drainage.

Two sensors were not installed and six of the installed sensors are out of order.

5.2.2 Relative humidity

Vaisala (App. 1\pages 81–82)

Since temperature is also measured with all relative humidity sensors, the diagrams include those measured temperatures. The temperature measurements start at about 16 degrees while the RH measurements start at about 70%RH.

The relative humidity measured in the buffer has not changed very much during the last 6 months, except for the sensors placed above the canister (in Cylinder 3 and 4) which are indicating a slowly wetting. The sensors have not reached 100 RH. The temperature measurements were effected when the power to the heaters was switched off but reached the same levels as before when the power was switched on again. A slow decrease in temperature is measured by all of the still working sensors

Sixteen sensors are out of order, most of them due to high water saturation of the buffer.

Rotronic (App. 1\pages 83–85)

All Rotronic sensors placed between the canister and the rock measured RH higher than 90% within 200 days after the start of the test. Two of the sensors placed in the central part of block C1 indicated a drying of the bentonite (decreasing in RH from about 75%) up to the time when they stopped working (after about 1,000 days).

All of the installed sensors have stopped giving reliable RH values, most of them due to high water saturation of the buffer. One of the temperature sensors is still working.

5.2.3 Pore water pressure

Geokon (App. 1\page 85)

The highest pressures 500–1,600 kPa are measured near the canister surface in block R5 (UBU10005) and in the periphery of block R5 (UBU10010). Two sensors in block C1 are also recording an increasing pressure (UBU10002, UBU10003) while the rest of the sensors are measuring very low pressures at the last reading before they were broken (day 3,639).

All sensors are out of order.

Kulite (App. 1\page 86)

Rather high water pressures have been measured by three sensors located in block R5 (1,200–3,500 kPa). One sensor placed in the outer slot started to react about 50 days after the start of the measurement. The pore pressure measured with two of the sensors reacted strongly during the period when the drainage of the tunnel was closed and during the period when the power to the canister was switched off. The sensors measured an increase of the pressure with about 100 kPa after the middle of May 2007. This change in pressure is probably caused by the preparation work done for a new tunnel near by the Prototype tunnel.

All of the installed sensors have stopped giving reliable values.

5.2.4 Temperature in the buffer (App. 1\pages 86–89)

The measured temperature after the power to the canister was switched on again ranges from 28.0°C (in the periphery of the upper bentonite cylinder C4) to 70.0°C in block R5 close to the canister. The highest temperature gradient measured in the buffer is 0.57°C/cm (block R5).

Thirty-two sensors are out of order.

The temperature in the buffer is also measured with the Geokon sensors (from day 1,350). The maximum temperature recorded with these sensors is about 51°C at the end of this measuring period (UBU10010 placed in block R5).

5.2.5 Canister power in dep. hole 1 (App. 1\page 91)

The power of the canister in whole 1 was kept constant during one year at 1,800 W since the start 010917. After one year the power was decreased with about 20 W. After another year the power was decreased with about 40 W. The next reduction of power was made at the beginning of September year 2004 (about 30 W). The power of the canister in hole 1 was about 1,710 W after this reduction. During the period between December 6 and December 15 2004 the power to the canister was switched off. After that period the power was adjusted to about 1,710 W again. At the beginning of December 2005, 2006, 2007 and January 2009 and 2010 the power was decreased with 30 W. After the latest reduction the power is now about 1,560 W.

5.2.6 Temperature on the canister surface (App. 1\pages 92)

The first diagram shows the maximum temperature, measured with the optical cables placed on the surface of the canister, plotted as function of time. The maximum measured temperature on the canister surface is about 75°C. With no damages on the optical cables this plot should have four curves. Only one curve with relevant values is presented here up to December 24 which indicates that the optical cables are damaged. The second diagram shows the distribution of the temperature along the optical cables at December 1 2004. The length of the cables on the canister surface is about 20 m. The variation of a few degrees is caused by the difference in temperature in the centre and ends of the canister. At December 15 2004 the optical system for measuring the temperature on this canister stopped functioning.

5.3 Deposition hole 3

5.3.1 Total pressure

Geokon (App. 2\pages 93–94)

Most of the sensors placed in block C1 and block R10 yielded an increase in total pressure when the drainage of the tunnel was closed.

The total pressures measured in this deposition hole are significantly lower than those measured in deposition hole 1. The maximum pressure registered so far is 3 MPa (PBU30023). This value was obtained when the drainage was closed. The sensor is placed in block R10.

Twelve sensors are out of order.

Kulite (App. 2\pages 94–95)

The highest pressure, 2.0 MPa, is indicated from the peripheral placed sensors in block C1. Also two sensor placed in block R10 have measured a pressure higher than 1.5 MPa. The sudden change in pressure which occurred around day 180 was probably caused by early data logger problems.

Eleven sensors are out of order.

5.3.2 Relative humidity

Vaisala (App. 2\pages 95–97)

A significant drying of the bentonite close to the top of the canister was observed by the two sensors WBU30022 and WBU30023. After the closing of the drainage both sensors indicated an instant and significant increasing in relative humidity. The still working sensor (WBU30022) is measuring a slowly increasing in humidity, implying a wetting of the buffer close to the canister lid.

An increased wetting of the bentonite can be observed by sensors place in block R10 between the canister and the rock. One sensor placed in block R5 showed an increase in relative humidity from about 70% to 82% after the closing of the drainage.

Two sensors (WBU30019 and WBU30020) placed in block R5 measured a decrease in relative humidity (indicating a drying of the buffer) after the power was switched on again. During this measuring period the still working sensors (WBU30020, WBU30033) are measuring a slowly increase in relative humidity.

Seventeen sensors are out of order.

Rotronic (App. 2\pages 97–99)

All Rotronic sensors in hole 3 have failed or increased the measured RH to 100%. The reason for this is unclear. Since there are no other signs of strong wetting, malfunction are more probable than strong wetting. One sensor (WBU30016) placed close to the canister in block R5 was indicating a drying of the bentonite until it failed.

5.3.3 Pore water pressure.

Geokon (App. 2\page 100)

One sensor UBU30014 placed in C4 yields increasing to 230 kPa during this measuring period. All sensors yield very low pressures except for one sensor below the canister that yields a sudden increase to 220 kPa around day 300.

Kulite (App. 2\page 100)

UBU30004 yielded a maximum pressure of 440 kPa. This sensor is placed near the rock surface at the bottom of the deposition hole. The rest of the sensors yield low pressures.

5.3.4 Temperature in the buffer (App. 2\pages 101–104)

The measured temperature ranges from 38°C (in the periphery of the upper bentonite cylinder C4) to a temperature of 83.2°C in the centre close to the canister. These measurements are from the period just before the power to the canisters where switched off. The highest temperature gradient measured with the sensors is 0.59°C/cm (block R5). There have appeared some problems with some data scan units, which explains the noise in some curves.

30 sensors are out of order.

The temperature in the buffer is also measured with the Geokon sensors (from day 1,350). The maximum temperature recorded at the end of this measuring period with these sensors is about 72°C (UBU30009 placed in block R5 close to the canister). The maximum temperature gradient determined at mid height of the canister and at the end of this measuring period is 0.49°C/cm.

5.3.5 Canister power (App. 2\page 106)

The power of the canister in hole 3 was kept constant at 1,800 W from the start 011011 until 020917, when the power was decreased with about 20 W. The power has been stepwise decreased according to Table 5-1. During the period between December 6 and December 15 the power of all canisters was switched off. After that period the power was adjusted to about 1,710 W. At the beginning of December 2005, 2006, 2007 and January 2009 and 2010 the power was decreased with 30 W. After the latest reduction the power is now about 1,560 W.

5.3.6 Temperature on the canister surface (App. 2\pages 106–107)

The first diagram shows the maximum temperature plotted as a function of time. The maximum measured temperature on the canister surface was about 100°C just before the power to the canisters was switched off. The temperature recovered, but only to about 93°C after the power was switched on again and after that a slightly decrease in temperature was measured until the sensor stopped functioning at the end of August 2005. The second diagram shows the distribution of the temperature along the cables. See also Section 5.2.6.

5.4 Deposition hole 2

5.4.1 Canister power (App. 3\page 109)

The power of the canister in hole 2 was kept constant at 1,800 W from the start 010924 until 020917, when the power was decreased with about 20 W. After two years (September 2003) the power was decreased with about 40 W to 1,740 W. The interruption in the curve between days 409 and 456 is caused by data collection problems. At the beginning of September 2004 the power was decreased with about 40 W to 1,710 W. Since permanent damages on the heaters in the canister were observed on December 1 2004 the power to this canister has been switched off and not been restarted.

5.4.2 Temperature on the canister surface (App. 3\pages 110–111)

See Section 5.2.6. The maximum measured temperature on the canister surface was just before the power was switched off about 96°C. The reason for the unexpected increase in temperature after 450 days is the difficulties with the measurement of the power (see Section 5.2.5). The actual power at that time was probably higher than 1,800 W. After the power was switched off the temperature on the canister surface was stabilized on about 30°C. The sensor stopped giving reliable data at the beginning of June 2005.

5.5 Deposition hole 4

5.5.1 Canister power (App. 3\page 112)

The power of the canister in hole 3 was kept constant at 1,800 W from the start 011011 until 020917, when the power was decreased with about 20 W. Some initial problems with the control system for the power have been overcome. The power has been stepwise decreased according to Table 5-1. During the period between December 6 and December 15 the power of all canisters was switched off. After that period the power was adjusted to about 1,710 W. At the beginning of December 2005, 2006, 2007 and January 2009 and 2010 the power was decreased with 30 W. After the latest reduction the power is now about 1,560 W.

5.5.2 Temperature on the canister surface (App. 3\pages 112–113)

See Section 5.2.6. The maximum measured temperature on the canister surface after the power was switched on again was 88°C. The sensor stopped giving reliable data at the beginning of April 2005.

5.6 Backfill in Section1

5.6.1 Total pressure in the backfill

Geokon (App. 4\pages 115)

All these sensors yielded high increase in total pressure in connection with closing of the tunnel drainage. The maximum measured pressure was about 2.5 MPa. After the opening of the drainage the total pressure was stabilized on the same level as before the closing of the drainage (maximum pressure about 0.2 MPa). At around the 20th of April 2006, a packer placed in a borehole in Section I of the tunnel started to leak resulting in an increase of water drained out from the inner section from about 1.5 l/min to about 9 l/min. The damaged packer caused also an increase in the measured total pressure of about 300 kPa (around day 1,660). At the beginning of April 2007 some of the sensors indicated an increase in the measured pressure. The change in the measure pressures was probably related to the work with the excavation of a new tunnel near by the Prototype-tunnel which was initialized at that time. The measured total pressures at the end of this measuring period vary between 700–1,200 kPa at the end of this measuring period.

Three sensors are out of order.

Kulite (App.4 \pages 116)

These measurements yielded rather small increase in total pressure until the drainage of the tunnel was closed. The maximum pressure recorded is with PBA10013, about 350 kPa. The sensor stopped functioning during a period of about 100 day after the rapid increase in pressure when the tunnel drainage was closed. Sensor PBA10013 is placed 1.7 m above the bentonite surface in hole 3.

All sensors are out of order.

5.6.2 Suction in the backfill (App. 4\pages 117–120)

The suction in the backfill is measured with Wescor psychrometers. The steady but slow wetting (decrease in suction) observed in about 50% of the sensors continues. 7 sensors close to the roof and walls of the tunnel and one sensor just above the buffer in hole 1 indicate fast wetting that has gone close to water saturation (less than 1,000 kPa suction). Also the sensor placed just inside the plug has reached a suction value that indicates saturation. In connection with the closing of the drainage, a very rapid decrease in suction was recorded by the installed psychrometers. Six of these sensors placed in the central part of the tunnel section yielded an increase in suction, after the reopening of the drainage, to the same level as before the closing. Seven of the sensors measured a decrease in suction after the packer was damaged.

All of these sensors have stopped giving reliable values due to high water saturation of the backfill.

5.6.3 Pore water pressure in the backfill

Geokon (App. 4\pages 120–121)

All these sensors yielded high increase in pore pressure when the drainage of the tunnel was closed. Many of the sensors recorded pressures up to 2.5 MPa. After the opening of the drainage the pore pressure was stabilized at low pressures (below 0.1 MPa). Also these sensors reacted when the packer was broken by measuring an increase in pore pressure of about 200 kPa. At the beginning of April 2007 some of the sensors are indicating an increase in the measured pressure. The change in the measure pressures is probably related to the work with the excavation of a new tunnel near by the Prototype-tunnel which was initialized at that time. The measured pore pressures vary between 600–800 kPa at the end of this measuring period.

Kulite (App. 4\pages 121–122)

Also some of these sensors recorded very high water pressure after the closing of the drainage. The still functioning sensors measured an increase in pore pressure of about 200 kPa at the time when the packer installed in the rock was broken. The sensors reacted also when the excavation of the nearby tunnel was initialized. Eight sensors are out of order.

5.6.4 Temperature in the backfill (App. 4\pages 122–124)

The measured temperature in the backfill over the whole test period ranges from 16 to 35°C. The highest temperature was as expected measured above the buffer in hole 3 just before the drainage was opened. Also these sensors reacted when the packer was broken (a decrease in temperature). The measured temperatures at the end of this measuring period vary between 16 and 30°C.

5.7 Temperature in the rock

5.7.1 Near hole 1 (App. 1\pages 90–91)

The maximum temperature measured in the rock is 38.6°C. This temperature was measured with the thermocouple TROA1030 located 2.038 m from the centre of the canister in deposition hole 1. The temperature in the rock close to the deposition hole decreased when the power to the canisters was switched off but increased again when the power was switched on to a temperature about 1°C lower than before the power was switched off. The temperature is continuing to drop and the maximum temperature at the end of this measuring period is about 34°C.

5.7.2 Near hole 2 (App. 3\page 109)

The maximum temperature in the rock (46.8°C) was measured by TROA1820 located 2.490 m from the centre of the canister in deposition hole 2 just before the power to the canisters was switched off. Since no power is applied to this canister anymore the temperature in the rock around the deposition hole is continuing to decrease and the maximum temperature at the end of this measuring period is about 32°C.

5.7.3 Near hole 3 (App. 2\pages 104–105)

The maximum temperature in the rock (48.8°C) was measured by TROA2120 located 1.967 m from the centre of the canister in deposition hole 3 just before the power to the canisters was switched off. Although the power was switched on again the temperature around the deposition hole is continuing to drop. This is most obvious for the sensors installed in the direction towards deposition hole 2. The maximum temperature measured temperature at the end of this measuring period is about 40°C.

5.7.4 Near hole 4 (App. 3\page 111)

The maximum temperature in the rock (46.5°C) is measured by TROA3030 located 2.034 m from the centre of the canister in deposition hole 4. Also for this deposition hole there was a drop in the temperature in the rock when the power was switched off. After the power was switched on again the temperature in the rock increased to almost the same level as before the power was switched off and has been remained relatively constant since then.

5.8 Analyze of data from Section 1

5.8.1 Deposition hole 1

Before the drainage of the tunnel was closed and the power of the canister was switched off the saturation of the buffer at mid height of the canister in block R5 was considered (indicated both by the relative humidity sensors and total pressure sensors) to be high even close to the canister (PBU10015). Also installed pore pressure sensors placed in block R5 (e.g. UBU 10007) are measuring high pressures close to the canister which also is indicating that the bentonite is saturated. This was not changed when the drainage was opened and the power of the canister was switched on again. The degree of saturation in the solid blocks both under (Block C1) and above the canister (Blocks C2–C4) is much lower. However the degree of saturation interpretable from measurements of relative humidity, swelling pressure and pore pressure is increasing with time. This trend is continuing with the same rate after the drainage was opened and the power was switched on.

In Figure 5-2 the temperature in the buffer is plotted as function of the radius from the centre of the deposition hole. The measurements are made with different type of sensors in block R5 (at mid height of the canister). A straight line is fitted to the measured values. The temperature gradient is determined from the fitted line in the figure. This gradient together with the temperature on the canister surface and the temperature in the buffer close to the outer radius of the ring shaped block ($r = 785$ mm) are plotted as function of time in Figure 5-4. The shaded part of the plot represents the time when the power to the canister was switched off at the beginning of December 2004. The plot shows that the temperature after this is somewhat lower than before, probably due to the fact that no power is applied to canister 2 after December 2 2004. However the temperature gradient over the buffer is similar before and after the switch on/off the power of the canisters. The determination of the gradient was made up to the beginning of December 2005. After that the number of still working sensors are too few, to be able to determine the temperature gradient.

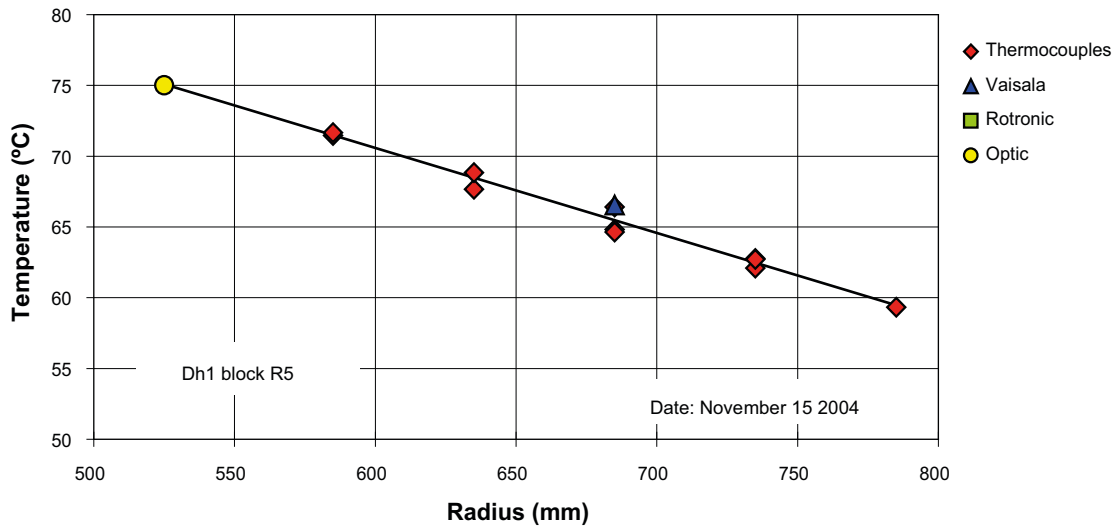


Figure 5-2. The temperature in block R5 in Dh 1 as function of radius from the centre of the deposition hole on November 15, 2004.

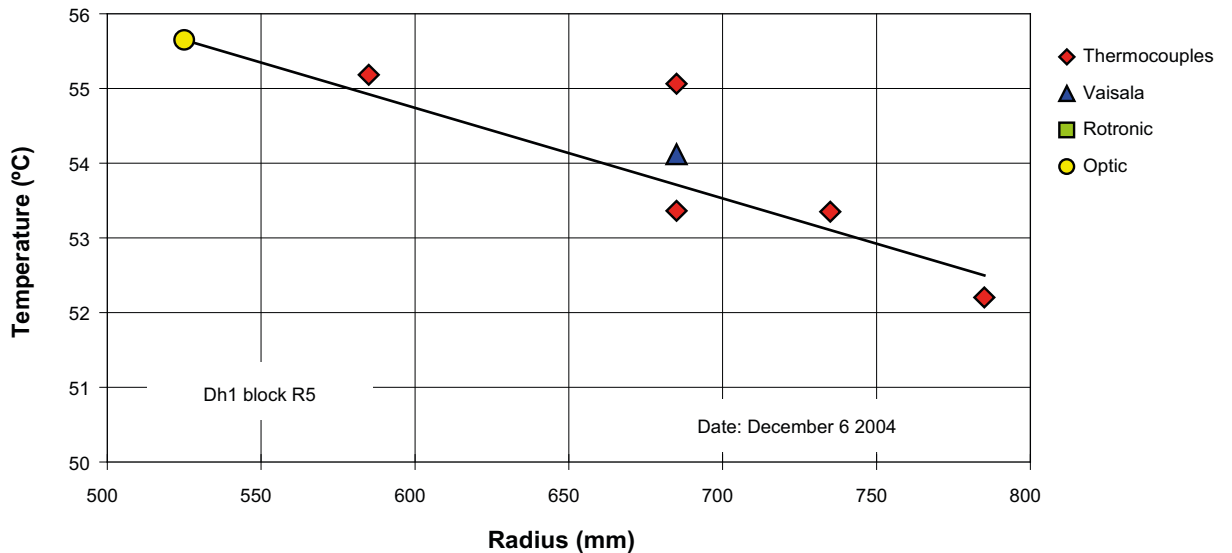


Figure 5-3. The temperature in block R5 in Dh 1 as function of radius from the centre of the deposition hole on December 6, 2004.

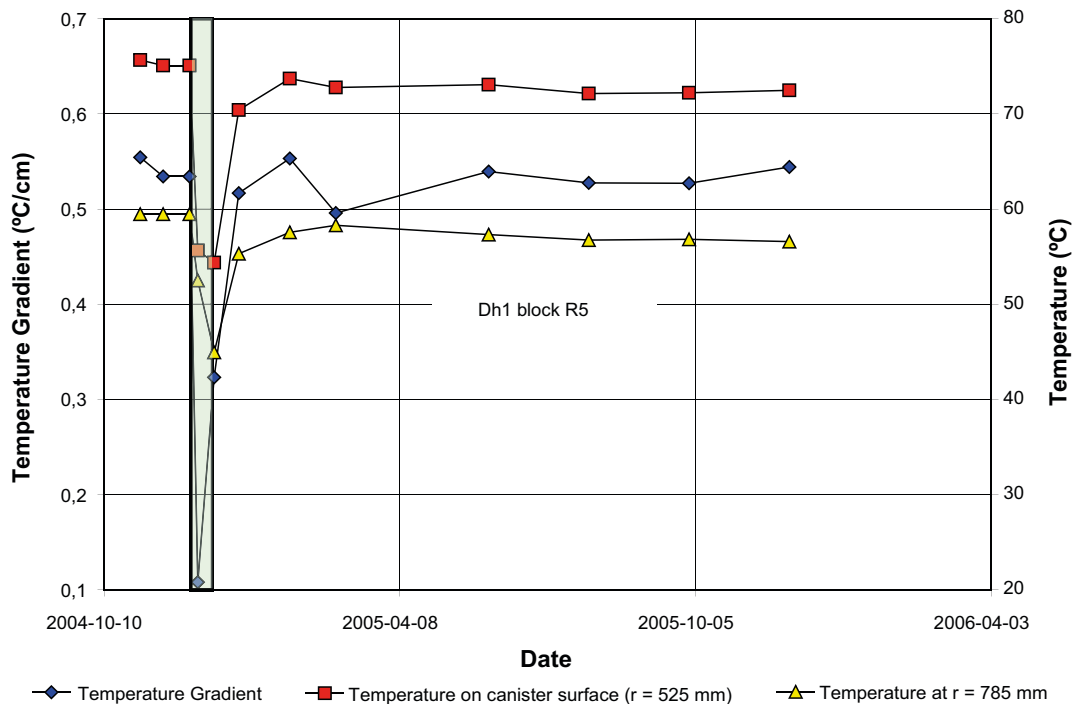


Figure 5-4. The temperature and temperature gradient plotted as function the date in deposition hole 1 block R5.

5.8.2 Deposition hole 3

The saturation of the buffer, as an average, indicated by both RH-transducers and total pressure transducers was before the closing of the drainage much lower compared to the buffer in deposition hole 1, although some total pressure sensors placed above and under the canister indicated rather high total pressures. When the drainage was closed those total pressure sensors which before had indicated high total pressure reacted with a rapid increase in pressure while the rest of the transducers did not react at all. When the drainage was opened again and the power to the canisters was switched off there was a decrease in the pressure. For most of the transducers the pressure went down to the same level as before the closing of the drainage. One RH sensor placed in block R5 at a radius of 785 mm reacted with a significant increase in RH (from 70% to 82%) when the drainage was closed. The RH was maintained on the higher level even after the opening of the drainage. Also some transducers placed in the buffer but close the canister top reacted with an increase in RH of about 5%. These transducers had before the closing of the drainage indicated a drying of the buffer. The rest of the RH transducers reacted very little at the closing/opening of the drainage. The buffer is today far from saturated (indicated both by RH-sensors, total pressure sensors and pore pressure sensors).

In Figure 5-5 the temperature in deposition hole 3 is plotted as function of the radial distance from the centre of the deposition hole. Compared with the corresponding plot for deposition hole 1 this plot shows a significant drop in temperature between the surface of the canister and the buffer (inner diameter of the ring). This indicates that the initial slot (of about 10 mm) between the canister and the buffer was still open.

The temperature gradient over the inner slot together with the temperature on the canister and the temperature on the inner radius of the ring shaped block are plotted as function of time in Figure 5-6. The shaded part of the plot represents the time when the power to canisters was switched off. Immediately after the power was switched off the temperature gradient increased which indicate that the slot was isolating the canister resulting in a much faster drop in temperature of the buffer than the canister surface. When the power was switched on again the temperature gradient over the slot reached the same level as before the closing of the drainage indicating an open slot between the canister and the buffer. The figure also shows that the gradient is decreasing with time which might be an indication that the gap is getting smaller. The sensors for measuring the temperature on the canister surface stopped functioning of August 2005. The temperature gradient over the inner slot could not be calculated after that date.

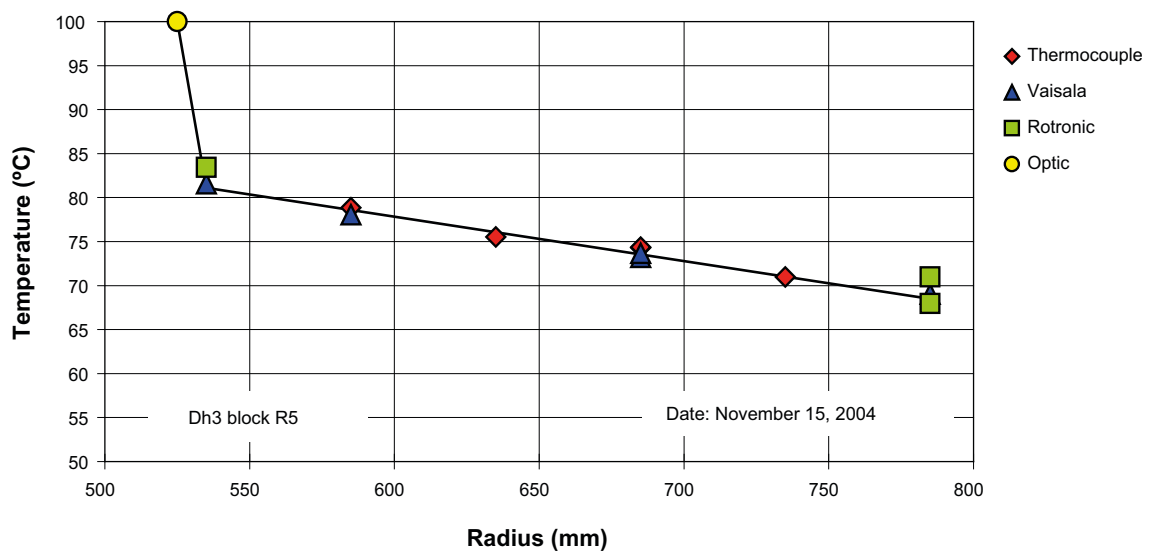


Figure 5-5. The temperature in block R5 in Dh 3 as function of radius from the centre of the deposition hole on November 15, 2004.

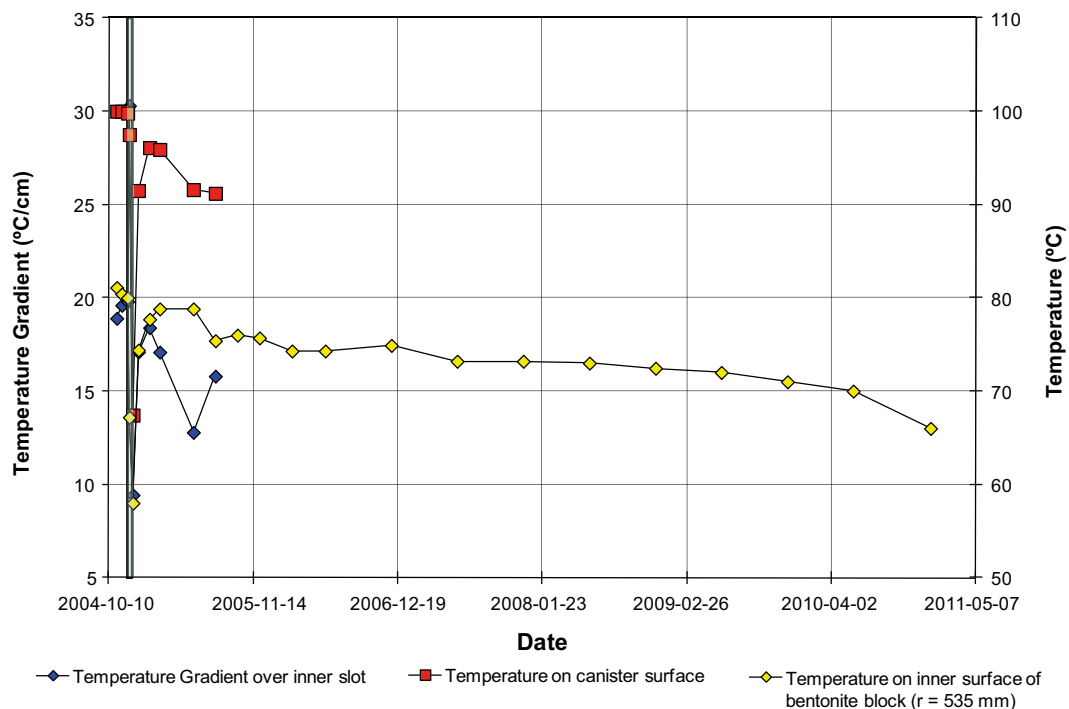


Figure 5-6. The temperature and temperature gradient over the inner slot plotted as function the date in deposition hole 3 block R5.

The temperature gradient over the buffer is plotted in Figure 5-7 together with the temperature on the inner surface of the block and the temperature at the radius of $r = 785$ mm. After the power was switched on again also this gradient stabilized on the same level as before the power was switched off.

A conclusion of the analyses is that even though the pressure in the backfill and in the surrounding rock was high (more than 2 MPa) when the drainage was closed, water did not enter the inner slot between the buffer and the canister. The fact that no water pressure acted directly on the canister surface can also explain the large vertical displacement of the canister measured when the drainage was closed (see Figure 5-8). If the increased pore pressure (2.5 MPa) would act directly on the canister surface the deformation should be much smaller than what was measured. The measured deformation was probably caused by large deformations of the solid bentonite block below the canister.

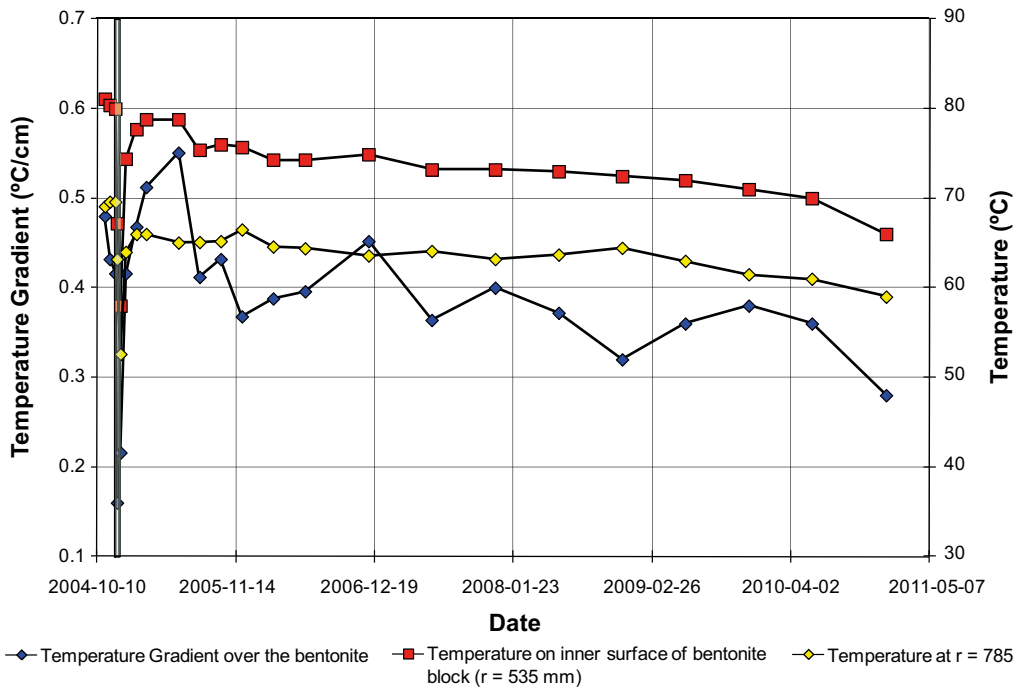


Figure 5-7. The temperature and temperature gradient over the buffer plotted as function the date in deposition hole 3 block R5.

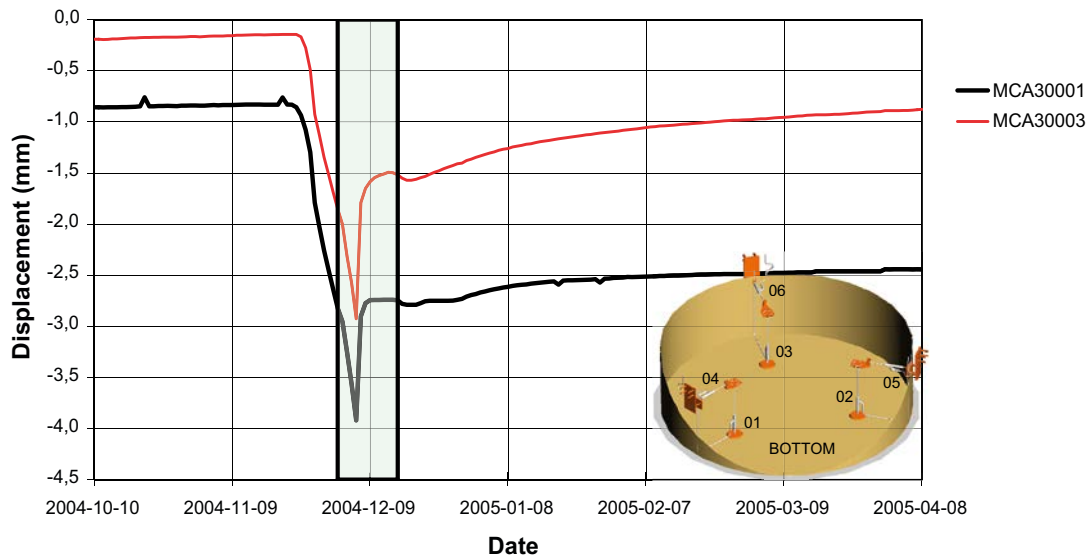


Figure 5-8. Vertical displacement of the canister in Dh 3. Negative sign on the displacement means that the canister is moving downwards.

5.8.3 Backfill

The pore pressure in the backfill increased fast from a low level when the drainage of the tunnel was closed. This affected the rate in which the backfill was saturated measured both with soil psychrometers and with resistivity measurements made by GRS. After the drainage was reopened the pore pressure stabilized on the same level as before it was close. The saturation rate (measured with both psychrometers and resistivity measurements) decreased to the same rate as before the closing of the drainage for most of the sensors.

When a packer placed in a borehole in Section I was broken (at the middle of April 2006) the pressure in the backfill (both total pressure and pore pressure) increased with about 300 kPa.

An increase of the total pressure and the pore pressure can also be observed around day 2040 (corresponding to the date 2007-04-19). The increase in pressure is probably related to the work with the excavation of a new tunnel nearby the Prototype-tunnel which was initialized at that time. The pore pressure and total pressure are continuing to increase and the total pressure has at the end of this measuring period reach a maximum of about 900 kPa.

The change in pressure affected also the measured suction values (measured with soil psychrometers). Eight of the sensors measured a decrease in suction of about 500 kPa due to the broken packer. All of the installed sensors have stopped giving reliable values after most of them have reached a suction value less than 1,000 kPa which is indicating that the backfill is saturated.

The outflow from the inner section of the Prototype tunnel as function of time is shown in Figure 5-9. The figure is showing that the outflow from Section I increased from about 1.8 l/min to about 9 l/min when the installed packer was broken. The large scatter and the increase in the outflow starting at the beginning of summer 2007 are probably caused by the work with the new tunnel placed close to the Prototype tunnel.

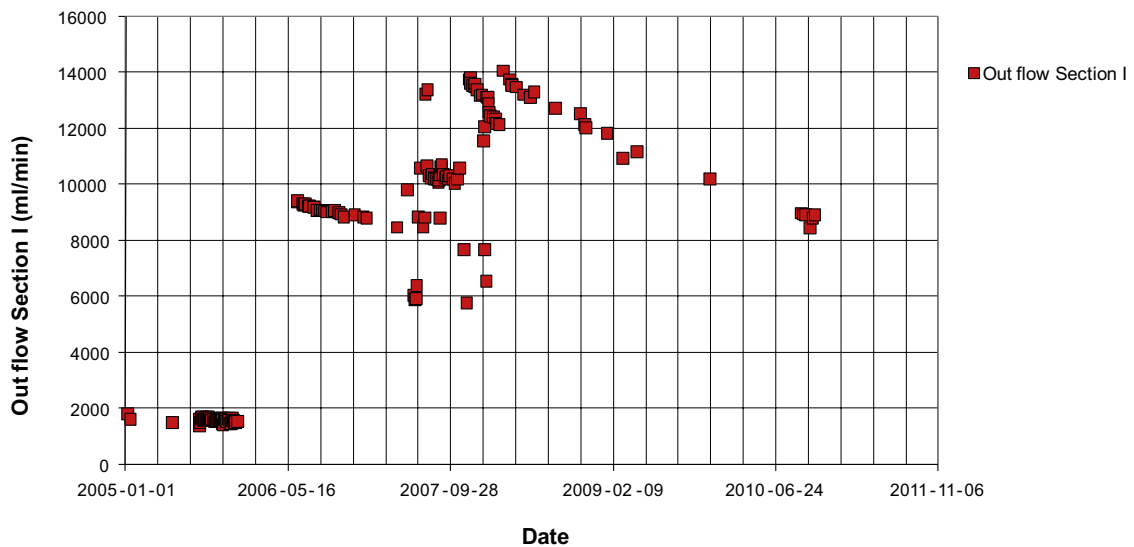


Figure 5-9. The measured outflow from the inner section of the Prototype tunnel.

6 Location of instruments in Section 2

6.1 Strategy for describing the position of each device in the bentonite and rock in and around the deposition holes

The deposition holes in Section 2 are termed DA3551G01 and DA3545G01, hole number 5 and 6 respectively according to Figure 1-1.

Deposition hole 5 has been instrumented in the same way as the two inner deposition holes, 1 and 3 i.e. measurements have been done in four vertical sections A, B, C and D according to Figure 4-1. (See Section 4.1)

Deposition hole 6 has, however, been instrumented according to another strategy. The instruments have been placed in eight directions, where four directions are represented in each instrumented block, see Figure 6-1.

The type of instruments and their locations are described in detail in Börgesson and Sanden (2003).

Direction A and C are placed in the tunnels axial direction with A headed against the end of the tunnel i.e. almost to the West, see Figure 2-1.

Every instrument placed in the buffer is named with a unique name consisting of 1 letter describing the type of measurement, 1 letter describing where the measurement takes place (buffer, rock), 1 figure denoting the deposition hole (5-6) and 2 figures specifying the instrument according to separate lists (see Table 6-1 to 6-11). Every instrument position is then described with three coordinates according to Figure 2-1.

The bentonite blocks are called cylinders and rings. The cylinders are numbered C1–C4 and the rings R1–R10 respectively, see Figure 4-1.

Thermocouples in the rock are placed on 3 levels in each deposition hole (bottom, 3 m and 6 m level). Thermocouples are placed in the bottom of the deposition holes in a vertical hole at the centre of the deposition hole. On level 3 m and 6 m the thermocouples are placed in two vertical directions perpendicular to each other.

6.2 Position of each instrument in the bentonite in hole 5 (DA3551G01)

The instruments are located according to the same system as those in hole 1 and hole 3.

The positions of each instrument are described in Tables 6-1 to 6-4. These tables have been updated since the last data report (Sensors data report No 7).

The positions of 10 Wescor psychrometer sensors were determined after inflow measurement on the wall of the deposition hole. The position of these sensors are described in Table 6-5.

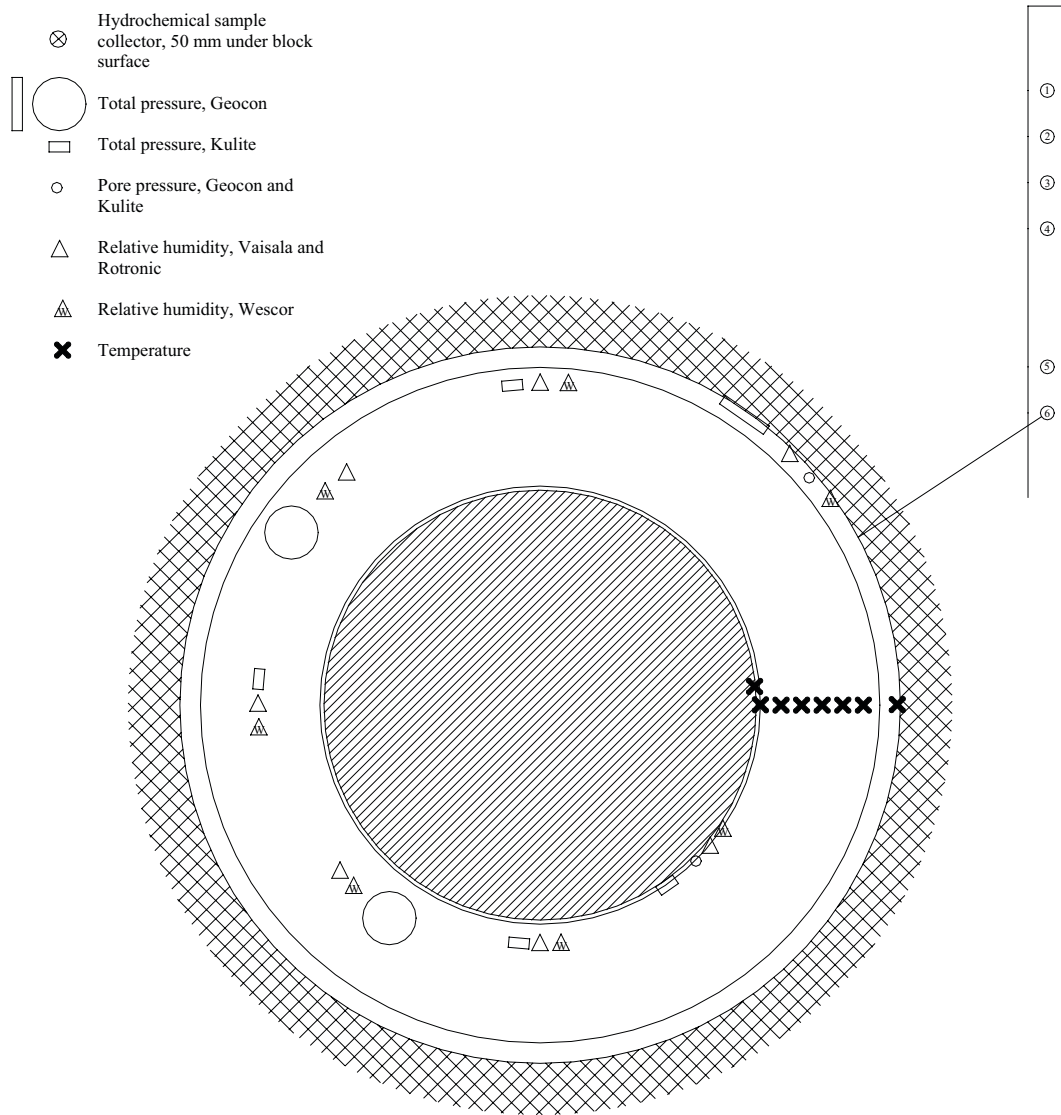


Figure 6-1. Schematic view over the instruments positions in deposition hole 6. The instruments are placed in eight vertical sections, where four sections are represented in each instrumented block.

Table 6-1. Numbering and position of instruments for measuring temperature (T) in the buffer in hole 5.

| Type and number | Block | Instrument position | | | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|-----------|-----------------------|
| | | Direction | α degree | r m | | |
| TB501 | Cyl. 1 | Center | 270 | 0.050 | 0.080 | Pentronic |
| TB502 | Cyl. 1 | Center | 270 | 0.060 | 0.250 | Pentronic |
| TB503 | Cyl. 1 | Center | 270 | 0.070 | 0.450 | Pentronic |
| TB504 | Cyl. 1 | A | 355 | 0.525 | 0.450 | Pentronic On canister |
| TB505 | Cyl. 1 | A | 355 | 0.685 | 0.450 | Pentronic |
| TB506 | Cyl. 1 | B | 85 | 0.685 | 0.450 | Pentronic |
| TB507 | Cyl. 1 | C | 175 | 0.685 | 0.450 | Pentronic |
| TB508 | Cyl. 1 | D | 270 | 0.585 | 0.450 | Pentronic |
| TB509 | Cyl. 1 | D | 270 | 0.685 | 0.450 | Pentronic |
| TB510 | Cyl. 1 | D | 270 | 0.785 | 0.450 | Pentronic |
| TB511 | Ring 5 | A | 0 | 0.525 | 2.950 | Pentronic On canister |
| TB512 | Ring 5 | A | 0 | 0.685 | 2.986 | Pentronic |
| TB513 | Ring 5 | B | 85 | 0.585 | 2.986 | Pentronic |
| TB514 | Ring 5 | B | 85 | 0.685 | 2.986 | Pentronic |
| TB515 | Ring 5 | B | 85 | 0.785 | 2.986 | Pentronic |
| TB516 | Ring 5 | C | 175 | 0.585 | 2.986 | Pentronic |
| TB517 | Ring 5 | C | 175 | 0.685 | 2.986 | Pentronic |
| TB518 | Ring 5 | C | 175 | 0.735 | 2.986 | Pentronic |
| TB519 | Ring 5 | D | 270 | 0.585 | 2.986 | Pentronic |
| TB520 | Ring 5 | D | 270 | 0.635 | 2.986 | Pentronic |
| TB521 | Ring 5 | D | 270 | 0.685 | 2.986 | Pentronic |
| TB522 | Ring 5 | D | 270 | 0.735 | 2.986 | Pentronic |
| TB523 | Ring 5 | D | 270 | 0.785 | 2.986 | Pentronic |
| TB524 | Ring 10 | A | 0 | 0.525 | 5.150 | Pentronic On canister |
| TB525 | Ring 10 | A | 0 | 0.685 | 5.543 | Pentronic |
| TB526 | Ring 10 | D | 270 | 0.585 | 5.543 | Pentronic |
| TB527 | Ring 10 | D | 270 | 0.685 | 5.543 | Pentronic |
| TB528 | Ring 10 | D | 270 | 0.785 | 5.543 | Pentronic |
| TB529 | Cyl. 3 | A | 0 | 0.785 | 6.353 | Pentronic |
| TB530 | Cyl. 3 | B | 95 | 0.585 | 6.353 | Pentronic |
| TB531 | Cyl. 3 | C | 185 | 0.585 | 6.353 | Pentronic |
| TB532 | Cyl. 4 | A | 0 | 0.785 | 7.060 | Pentronic |

Table 6-2. Numbering and position of instruments for measuring total pressure (P) in the buffer in hole 5.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | Z m | | |
| PB501 | Cyl. 1 | Center | 0 | 0.000 | 0.000 | Geokon | Bottom |
| PB502 | Cyl. 1 | Center | 0 | 0.100 | 0.500 | Geokon | |
| PB503 | Cyl. 1 | A | 5 | 0.585 | 0.340 | Kulite | Vertical |
| PB504 | Cyl. 1 | A | 5 | 0.685 | 0.340 | Kulite | Vertical |
| PB505 | Cyl. 1 | A | 5 | 0.785 | 0.340 | Kulite | Vertical |
| PB506 | Cyl. 1 | B | 95 | 0.635 | 0.500 | Geokon | |
| PB507 | Cyl. 1 | B | 105 | 0.735 | 0.500 | Geokon | |
| PB508 | Cyl. 1 | C | 185 | 0.635 | 0.500 | Geokon | |
| PB509 | Cyl. 1 | C | 195 | 0.735 | 0.500 | Geokon | |
| PB510 | Ring 5 | A | 10 | 0.535 | 2.876 | Kulite | In the slot |
| PB511 | Ring 5 | A | 10 | 0.685 | 3.036 | Geokon | |
| PB512 | Ring 5 | A | 5 | 0.825 | 2.876 | Kulite | In the slot |
| PB513 | Ring 5 | B | 95 | 0.635 | 3.036 | Geokon | |
| PB514 | Ring 5 | B | 105 | 0.785 | 3.036 | Geokon | |
| PB515 | Ring 5 | C | 190 | 0.635 | 3.036 | Geokon | |
| PB516 | Ring 5 | C | 190 | 0.825 | 2.876 | Kulite | In the slot |
| PB517 | Ring 10 | Center | 0 | 0.050 | 5.593 | Geokon | |
| PB518 | Ring 10 | A | 10 | 0.585 | 5.433 | Kulite | Vertical |
| PB519 | Ring 10 | A | 10 | 0.685 | 5.433 | Kulite | Vertical |
| PB520 | Ring 10 | A | 10 | 0.785 | 5.433 | Kulite | Vertical |
| PB521 | Ring 10 | B | 95 | 0.635 | 5.593 | Geokon | |
| PB522 | Ring 10 | B | 105 | 0.735 | 5.593 | Geokon | |
| PB523 | Ring 10 | C | 180 | 0.635 | 5.593 | Geokon | |
| PB524 | Ring 10 | C | 190 | 0.735 | 5.593 | Geokon | |
| PB525 | Cyl. 3 | Center | 0 | 0.100 | 6.603 | Geokon | |
| PB526 | Cyl. 3 | A | 5 | 0.585 | 6.603 | Geokon | |
| PB527 | Cyl. 4 | Center | 0 | 0.100 | 7.110 | Geokon | |

Table 6-3. Numbering and position of instruments for measuring pore water pressure (U) in the buffer in hole 5.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|--------|-----------|---------------|
| | | Direction | α degree | r m | Z m | | |
| UB501 | Cyl. 1 | Center | 90 | 0.050 | 0.250 | Kulite | |
| UB502 | Cyl. 1 | Center | 90 | 0.100 | 0.050 | Geokon | |
| UB503 | Cyl. 1 | A | 355 | 0.585 | 0.250 | Geokon | |
| UB504 | Cyl. 1 | A | 355 | 0.785 | 0.340 | Kulite | |
| UB505 | Ring 5 | A | 355 | 0.585 | 2.786 | Geokon | |
| UB506 | Ring 5 | A | 355 | 0.785 | 2.876 | Kulite | |
| UB507 | Ring 5 | B | 85 | 0.535 | 2.876 | Kulite | In the slot |
| UB508 | Ring 5 | B | | | | | Not installed |
| UB509 | Ring 5 | C | 175 | 0.535 | 2.786 | Geokon | In the slot |
| UB510 | Ring 5 | C | 175 | 0.825 | 2.786 | Geokon | In the slot |
| UB511 | Ring 10 | A | 355 | 0.585 | 5.433 | Kulite | |
| UB512 | Ring 10 | A | 355 | 0.785 | 5.433 | Kulite | |
| UB513 | Cyl. 3 | Center | | | | | Not installed |
| UB514 | Cyl. 4 | Center | 90 | 0.100 | 6.860 | Geokon | |

Table 6-4. Numbering and position of instruments for measuring water content (W) in the buffer in hole 5.

| Mark | Block | Instrument position | | | Z m | Fabricate | Remark |
|-------|---------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | | | |
| WB501 | Cyl. 1 | Center | 180 | 0.050 | 0.250 | Rotronic | |
| WB502 | Cyl. 1 | Center | 180 | 0.100 | 0.050 | Rotronic | |
| WB503 | Cyl. 1 | Center | 0 | 0.400 | 0.250 | Rotronic | |
| WB504 | Cyl. 1 | A | 350 | 0.585 | 0.340 | Vaisala | |
| WB505 | Cyl. 1 | A | 350 | 0.685 | 0.340 | Vaisala | |
| WB506 | Cyl. 1 | A | 350 | 0.785 | 0.340 | Vaisala | |
| WB507 | Cyl. 1 | B | 80 | 0.585 | 0.340 | Vaisala | |
| WB508 | Cyl. 1 | B | 80 | 0.685 | 0.250 | Rotronic | |
| WB509 | Cyl. 1 | B | 80 | 0.785 | 0.250 | Rotronic | |
| WB510 | Cyl. 1 | C | 170 | 0.585 | 0.250 | Rotronic | |
| WB511 | Cyl. 1 | C | 170 | 0.685 | 0.250 | Rotronic | |
| WB512 | Cyl. 1 | C | 170 | 0.785 | 0.250 | Rotronic | |
| WB513 | Ring 5 | A | 350 | 0.585 | 2.876 | Vaisala | |
| WB514 | Ring 5 | A | 350 | 0.685 | 2.876 | Vaisala | |
| WB515 | Ring 5 | A | 350 | 0.785 | 2.876 | Vaisala | |
| WB516 | Ring 5 | B | 80 | 0.535 | 2.786 | Rotronic | In the slot |
| WB517 | Ring 5 | B | 80 | 0.685 | 2.786 | Rotronic | |
| WB518 | Ring 5 | B | 80 | 0.785 | 2.786 | Rotronic | |
| WB519 | Ring 5 | C | 180 | 0.535 | 2.876 | Vaisala | In the slot |
| WB520 | Ring 5 | C | 180 | 0.685 | 2.876 | Vaisala | |
| WB521 | Ring 5 | C | 180 | 0.785 | 2.786 | Rotronic | |
| WB522 | Ring 10 | Center | 180 | 0.050 | 5.433 | Vaisala | |
| WB523 | Ring 10 | A | 0 | 0.262 | 5.433 | Vaisala | |
| WB524 | Ring 10 | A | 350 | 0.585 | 5.433 | Vaisala | |
| WB525 | Ring 10 | A | 350 | 0.685 | 5.433 | Vaisala | |
| WB526 | Ring 10 | A | 350 | 0.785 | 5.433 | Vaisala | |
| WB527 | Ring 10 | B | 80 | 0.585 | 5.343 | Rotronic | |
| WB528 | Ring 10 | B | 80 | 0.685 | 5.343 | Rotronic | |
| WB529 | Ring 10 | B | 80 | 0.785 | 5.343 | Rotronic | |
| WB530 | Ring 10 | C | 170 | 0.585 | 5.433 | Vaisala | |
| WB531 | Ring 10 | C | 170 | 0.785 | 5.343 | Rotronic | |
| WB532 | Cyl. 3 | Center | 270 | 0.100 | 6.353 | Vaisala | |
| WB533 | Cyl. 3 | A | 350 | 0.585 | 6.353 | Vaisala | |
| WB534 | Cyl. 3 | B | 90 | 0.585 | 6.353 | Vaisala | |
| WB535 | Cyl. 3 | C | 180 | 0.585 | 6.353 | Rotronic | |
| WB536 | Cyl. 4 | Center | 180 | 0.100 | 6.790 | Vaisala | |
| WB537 | Cyl. 4 | Center | 270 | 0.100 | 6.950 | Vaisala | |

Table 6-5. Numbering and position of instruments for measuring water content (W) in the buffer in hole 5. The positions were determined after inflow measurements.

| Mark | Block | Instrument position | | | Z m | Fabricate | Remark |
|-------|--------|---------------------|--------------------|--------|--------|-----------|--------|
| | | Direction | α degree | r m | | | |
| WB538 | Ring 3 | C-D | 225 | 0.775 | 1.624 | Wescor | |
| WB539 | Ring 3 | C-D | 235 | 0.68 | 1.624 | Wescor | |
| WB540 | Ring 3 | C-D | 245 | 0.585 | 1.624 | Wescor | |
| WB541 | Ring 3 | C-D | 255 | 0.68 | 1.624 | Wescor | |
| WB542 | Ring 3 | C-D | 265 | 0.775 | 1.624 | Wescor | |
| WB543 | Ring 8 | C-D | 225 | 0.775 | 4.173 | Wescor | |
| WB544 | Ring 8 | C-D | 235 | 0.68 | 4.173 | Wescor | |
| WB545 | Ring 8 | C-D | 245 | 0.585 | 4.173 | Wescor | |
| WB546 | Ring 8 | C-D | 255 | 0.68 | 4.173 | Wescor | |
| WB547 | Ring 8 | C-D | 265 | 0.775 | 4.173 | Wescor | |

6.3 Position of each instrument in the bentonite in hole 6 (DA3545G01)

The instruments are located in one main level in the blocks, 250 mm, from the upper surface. The upper blocks, C2, C3 and C4 are instrumented in the same way as those in deposition hole 5. The positions of each instrument are described in Tables 6-6 to 6-9. These tables have been updated since the last data report (Sensors data report No 7).

The position of 10 Wescor psychrometers and 5 Vaisala relative humidity sensors were determined after inflow measurement. The positions of these transducers are described in Table 6-10.

Table 6-6. Numbering and position of instruments for measuring temperature (T) in the buffer in hole 6.

| Type and number | Block | Instrument position | | | Fabricate | Remark |
|-----------------|--------|---------------------|-----------------|-------|-----------|-----------------------|
| | | Direction | α degree | r m | | |
| TB601 | Cyl. 1 | Center | 45 | 0.050 | 0.385 | Pentronic |
| TB602 | Cyl. 1 | Center | 315 | 0.050 | 0.260 | Pentronic |
| TB603 | Cyl. 1 | Center | 0 | 0.050 | 0.135 | Pentronic |
| TB604 | Ring 1 | D | 270 | 0.535 | 0.770 | Pentronic |
| TB605 | Ring 1 | D | 270 | 0.585 | 0.770 | Pentronic |
| TB606 | Ring 1 | D | 270 | 0.635 | 0.770 | Pentronic |
| TB607 | Ring 1 | D | 270 | 0.685 | 0.770 | Pentronic |
| TB608 | Ring 1 | D | 270 | 0.735 | 0.770 | Pentronic |
| TB609 | Ring 1 | D | 270 | 0.785 | 0.770 | Pentronic |
| TB610 | Ring 1 | D | 270 | 0.825 | 0.753 | Pentronic On rock |
| TB611 | Ring 1 | D | 0 | 0.525 | 0.753 | Pentronic On canister |
| TB612 | Ring 5 | D | 270 | 0.535 | 2.795 | Pentronic |
| TB613 | Ring 5 | D | 270 | 0.585 | 2.795 | Pentronic |
| TB614 | Ring 5 | D | 270 | 0.635 | 2.795 | Pentronic |
| TB615 | Ring 5 | D | 270 | 0.685 | 2.795 | Pentronic |
| TB616 | Ring 5 | D | 270 | 0.735 | 2.795 | Pentronic |
| TB617 | Ring 5 | D | 270 | 0.785 | 2.795 | Pentronic |
| TB618 | Ring 5 | D | 270 | 0.825 | 2.753 | Pentronic On rock |
| TB619 | Ring 5 | D | 0 | 0.525 | 2.753 | Pentronic On canister |
| TB620 | Ring 8 | D | 270 | 0.535 | 4.324 | Pentronic |
| TB621 | Ring 8 | D | 270 | 0.585 | 4.324 | Pentronic |
| TB622 | Ring 8 | D | 270 | 0.635 | 4.324 | Pentronic |
| TB623 | Ring 8 | D | 270 | 0.685 | 4.324 | Pentronic |
| TB624 | Ring 8 | D | 270 | 0.735 | 4.324 | Pentronic |
| TB625 | Ring 8 | D | 270 | 0.785 | 4.324 | Pentronic |
| TB626 | Ring 8 | D | 270 | 0.825 | 4.253 | Pentronic On rock |
| TB627 | Ring 8 | D | 0 | 0.525 | 4.253 | Pentronic On canister |
| TB628 | Cyl. 3 | A | 0 | 0.785 | 6.366 | Pentronic |
| TB629 | Cyl. 3 | B | 95 | 0.585 | 6.366 | Pentronic |
| TB630 | Cyl. 3 | C | 185 | 0.585 | 6.366 | Pentronic |
| TB631 | Cyl. 4 | Center | 225 | 0.100 | 7.071 | Pentronic |
| TB632 | Cyl. 4 | A | 0 | 0.785 | 7.071 | Pentronic |

Table 6-7. Numbering and position of instruments for measuring total pressure (P) in the buffer in hole 6.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|--------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | Z m | | |
| PB601 | Cyl. 1 | Center | 315 | 0.210 | 0.510 | Geokon | |
| PB602 | Cyl. 1 | B | 80 | 0.685 | 0.260 | Kulite | Vertical |
| PB603 | Ring 1 | A | 10 | 0.785 | 0.770 | Kulite | Vertical |
| PB604 | Ring 1 | B | 80 | 0.685 | 0.770 | Kulite | Vertical |
| PB605 | Ring 1 | C | 170 | 0.585 | 0.770 | Kulite | Vertical |
| PB606 | Ring 2 | AB | 55 | 0.735 | 1.534 | Geokon | |
| PB607 | Ring 2 | BC | 145 | 0.635 | 1.534 | Geokon | |
| PB608 | Ring 2 | CD | 215 | 0.535 | 1.284 | Kulite | In the slot |
| PB609 | Ring 2 | DA | 325 | 0.875 | 1.253 | Geokon | At rock |
| PB610 | Ring 5 | A | 10 | 0.785 | 2.795 | Kulite | Vertical |
| PB611 | Ring 5 | B | 80 | 0.685 | 2.795 | Kulite | Vertical |
| PB612 | Ring 5 | C | 170 | 0.585 | 2.795 | Kulite | Vertical |
| PB613 | Ring 6 | AB | 55 | 0.785 | 3.550 | Geokon | |
| PB614 | Ring 6 | BC | 145 | 0.635 | 3.550 | Geokon | |
| PB615 | Ring 6 | CD | 215 | 0.535 | 3.300 | Kulite | In the slot |
| PB616 | Ring 6 | DA | 325 | 0.875 | 3.253 | Geokon | At rock |
| PB617 | Ring 8 | A | 10 | 0.785 | 4.324 | Kulite | Vertical |
| PB618 | Ring 8 | B | 80 | 0.685 | 4.324 | Kulite | Vertical |
| PB619 | Ring 8 | C | 170 | 0.585 | 4.324 | Kulite | Vertical |
| PB620 | Ring 9 | AB | 55 | 0.735 | 5.084 | Geokon | |
| PB621 | Ring 9 | BC | 145 | 0.635 | 5.084 | Geokon | |
| PB622 | Ring 9 | CD | 215 | 0.535 | 4.834 | Kulite | In the slot |
| PB623 | Ring 9 | DA | 325 | 0.875 | 4.753 | Geokon | At rock |
| PB624 | Cyl. 4 | Center | 135 | 0.585 | 7.121 | Kulite | |
| PB625 | Cyl. 3 | Center | 0 | 0.100 | 6.616 | Geokon | |
| PB626 | Cyl. 3 | A | 5 | 0.585 | 6.616 | Geokon | |
| PB627 | Cyl. 4 | Center | 0 | 0.100 | 7.121 | Geokon | |

Table 6-8. Numbering and position of instruments for measuring pore water pressure (U) in the buffer in hole 6.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|--------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | Z m | | |
| UB601 | Cyl. 1 | Center | 280 | 0.210 | 0.260 | Kulite | |
| UB602 | Cyl. 1 | B | 95 | 0.685 | 0.260 | Geokon | |
| UB603 | Ring 2 | CD | 225 | 0.535 | 1.284 | Geokon | In the slot |
| UB604 | Ring 2 | DA | 310 | 0.875 | 1.253 | Kulite | At the rock |
| UB605 | Ring 5 | C | 190 | 0.585 | 2.795 | Geokon | |
| UB606 | Ring 5 | A | 350 | 0.785 | 2.795 | Kulite | |
| UB607 | Ring 6 | AB | 35 | 0.735 | 3.300 | Kulite | |
| UB608 | Ring 6 | BC | 125 | 0.635 | 3.300 | Kulite | |
| UB609 | Ring 6 | CD | 225 | 0.535 | 3.300 | Geokon | In the slot |
| UB610 | Ring 6 | DA | 310 | 0.875 | 3.253 | Geokon | At the rock |
| UB611 | Ring 9 | CD | 225 | 0.535 | 4.834 | Geokon | In the slot |
| UB612 | Ring 9 | DA | 310 | 0.875 | 4.753 | Kulite | At the rock |
| UB613 | Cyl. 3 | Center | 135 | 0.100 | 6.366 | Kulite | |
| UB614 | Cyl. 4 | Center | 90 | 0.100 | 6.961 | Kulite | |

Table 6-9. Numbering and position of instruments for measuring water content (W) in the buffer in hole 6.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|---------|---------------------|--------------------|--------|--------|-----------|-------------|
| | | Direction | α degree | r m | Z m | | |
| WB601 | Cyl. 1 | Center | 135 | 0.050 | 0.250 | Rotronic | |
| WB602 | Cyl. 1 | Center | 225 | 0.050 | 0.250 | Wescor | |
| WB603 | Cyl. 1 | Center | 260 | 0.210 | 0.250 | Wescor | |
| WB604 | Cyl. 1 | Center | 270 | 0.210 | 0.250 | Rotronic | |
| WB605 | Cyl. 1 | B | 90 | 0.685 | 0.250 | Wescor | |
| WB606 | Cyl. 1 | B | 100 | 0.685 | 0.250 | Rotronic | |
| WB607 | Ring 1 | B | 90 | 0.685 | 0.750 | Vaisala | |
| WB608 | Ring 1 | B | 95 | 0.685 | 0.750 | Wescor | |
| WB609 | Ring 1 | C | 180 | 0.585 | 0.750 | Vaisala | |
| WB610 | Ring 1 | C | 185 | 0.585 | 0.750 | Wescor | |
| WB611 | Ring 1 | A | 355 | 0.785 | 0.750 | Wescor | |
| WB612 | Ring 1 | A | 360 | 0.785 | 0.750 | Wescor | |
| WB613 | Ring 2 | AB | 40 | 0.735 | 1.250 | Rotronic | |
| WB614 | Ring 2 | AB | 45 | 0.735 | 1.250 | Wescor | |
| WB615 | Ring 2 | BC | 130 | 0.635 | 1.250 | Rotronic | |
| WB616 | Ring 2 | BC | 135 | 0.635 | 1.250 | Wescor | |
| WB617 | Ring 2 | CD | 230 | 0.535 | 1.250 | Rotronic | In the slot |
| WB618 | Ring 2 | CD | 235 | 0.535 | 1.250 | Wescor | In the slot |
| WB619 | Ring 2 | DA | 305 | 0.875 | 1.250 | Wescor | At rock |
| WB620 | Ring 2 | DA | 315 | 0.875 | 1.250 | Rotronic | At rock |
| WB621 | Ring 5 | B | 90 | 0.685 | 2.750 | Rotronic | |
| WB622 | Ring 5 | B | 95 | 0.685 | 2.750 | Wescor | |
| WB623 | Ring 5 | C | 180 | 0.585 | 2.750 | Rotronic | |
| WB624 | Ring 5 | C | 185 | 0.585 | 2.750 | Wescor | |
| WB625 | Ring 5 | A | 355 | 0.785 | 2.750 | Wescor | |
| WB626 | Ring 5 | A | 360 | 0.785 | 2.750 | Rotronic | |
| WB627 | Ring 6 | AB | 40 | 0.735 | 3.250 | Vaisala | |
| WB628 | Ring 6 | AB | 45 | 0.735 | 3.250 | Wescor | |
| WB629 | Ring 6 | BC | 130 | 0.635 | 3.250 | Vaisala | |
| WB630 | Ring 6 | BC | 135 | 0.635 | 3.250 | Wescor | |
| WB631 | Ring 6 | CD | 230 | 0.535 | 3.250 | Vaisala | In the slot |
| WB632 | Ring 6 | CD | 235 | 0.535 | 3.250 | Wescor | In the slot |
| WB633 | Ring 6 | DA | 305 | 0.875 | 3.250 | Wescor | At rock |
| WB634 | Ring 6 | DA | 315 | 0.875 | 3.250 | Vaisala | At rock |
| WB635 | Ring 8 | B | 90 | 0.685 | 4.250 | Rotronic | |
| WB636 | Ring 8 | B | 95 | 0.685 | 4.250 | Wescor | |
| WB637 | Ring 8 | C | 180 | 0.585 | 4.250 | Rotronic | |
| WB638 | Ring 8 | C | 185 | 0.585 | 4.250 | Wescor | |
| WB639 | Ring 8 | A | 355 | 0.785 | 4.250 | Wescor | |
| WB640 | Ring 8 | A | 360 | 0.785 | 4.250 | Rotronic | |
| WB641 | Ring 9 | AB | 40 | 0.735 | 4.750 | Rotronic | |
| WB642 | Ring 9 | AB | 45 | 0.735 | 4.750 | Wescor | |
| WB643 | Ring 9 | BC | 130 | 0.635 | 4.750 | Vaisala | |
| WB644 | Ring 9 | BC | 135 | 0.635 | 4.750 | Wescor | |
| WB645 | Ring 9 | CD | 230 | 0.535 | 4.750 | Vaisala | In the slot |
| WB646 | Ring 9 | CD | 235 | 0.535 | 4.750 | Wescor | In the slot |
| WB647 | Ring 9 | DA | 305 | 0.875 | 4.750 | Wescor | At rock |
| WB648 | Ring 9 | DA | 315 | 0.875 | 4.750 | Vaisala | At rock |
| WB649 | Ring 10 | Center | 90 | 0.050 | 5.340 | Vaisala | |
| WB650 | Ring 10 | Center | 270 | 0.210 | 5.340 | Vaisala | |
| WB651 | Cyl. 3 | Center | 225 | 0.100 | 6.250 | Rotronic | |
| WB652 | Cyl. 3 | B | 90 | 0.585 | 6.250 | Vaisala | |
| WB653 | Cyl. 3 | C | 180 | 0.585 | 6.250 | Rotronic | |
| WB654 | Cyl. 3 | A | 350 | 0.585 | 6.250 | Vaisala | |
| WB655 | Cyl. 4 | Center | 180 | 0.100 | 6.680 | Rotronic | |
| WB656 | Cyl. 4 | Center | 270 | 0.100 | 6.750 | Vaisala | |

Table 6-10. Numbering and position of instruments for measuring water content (W) in the buffer in hole 6. The positions were determined after inflow measurements.

| Type and number | Block | Instrument position | | | | Fabricate | Remark |
|-----------------|--------|---------------------|--------------------|--------|--------|-----------|--------|
| | | Direction | α degree | r m | Z m | | |
| WB657 | Ring 6 | C | 190 | 0.625 | 3.300 | Wescor | |
| WB658 | Ring 6 | C | 190 | 0.725 | 3.300 | Wescor | |
| WB659 | Rock | C | 190 | 0.900 | 3.100 | Wescor | |
| WB660 | Rock | C | 190 | 0.925 | 3.250 | Wescor | |
| WB661 | Rock | C | 190 | 0.975 | 3.400 | Wescor | |
| WB662 | Ring 8 | D | 280 | 0.625 | 4.324 | Wescor | |
| WB663 | Ring 8 | D | 280 | 0.725 | 4.324 | Wescor | |
| WB664 | Rock | D | 280 | 0.900 | 4.100 | Wescor | |
| WB665 | Rock | D | 280 | 0.925 | 4.250 | Wescor | |
| WB666 | Rock | D | 280 | 0.975 | 4.400 | Wescor | |
| WB667 | Cyl.1 | D | 280 | 0.685 | 0.260 | Vaisala | |
| WB668 | Ring 6 | C | 200 | 0.625 | 3.300 | Vaisala | |
| WB669 | Ring 6 | C | 200 | 0.725 | 3.300 | Vaisala | |
| WB670 | Ring 8 | D | 290 | 0.625 | 4.324 | Vaisala | |
| WB671 | Ring 8 | D | 290 | 0.725 | 4.324 | Vaisala | |

6.4 Instruments on the canister surface in holes 5–6

A system for measuring the temperature with optical cables on the surface of the canisters is used in the same way as for the canisters in Section 1. The system is described in Section 4.4.

In addition to the optical cables three thermocouples (TB504, TB511 and TB524) in deposition hole 5 and three thermocouples (TB611, TB619 and TB627) in deposition hole 6 are fixed to the surface of the canister (see Table 6-1 and 6-6).

6.5 Position of temperature sensors in the rock

Thermocouples are placed on 3 levels in each deposition hole (bottom, 3 m and 6 m level). On level 3 m and 6 m the thermocouples are placed in two directions perpendicular to each other.

The positions are described in Table 6-11.

Table 6-11. Numbering and position of temperature sensors in the rock.

| Type and number | Distance from rock surface (m) | α degree | r m | Z m | Remark |
|--|--------------------------------|--------------------|--------|--------|--------|
| Measured from DA3551G01(Hole 5) | | | | | |
| TR5011 | 1.000 | 0 | 0.000 | -1.000 | Bottom |
| TR5012 | 0.500 | 0 | 0.000 | -0.500 | Bottom |
| TR5013 | 0.200 | 0 | 0.000 | -0.200 | Bottom |
| TR5014 | 0.000 | 0 | 0.000 | 0.000 | Bottom |
| TR5021 | 2.200 | 171 | 3.075 | 6.000 | East |
| TR5022 | 1.100 | 171 | 1.975 | 6.000 | East |
| TR5023 | 0.600 | 171 | 1.475 | 6.000 | East |
| TR5024 | 0.200 | 171 | 1.075 | 6.000 | East |
| TR5025 | 0.000 | 171 | 0.875 | 6.000 | East |
| TR5031 | 2.200 | 80 | 3.075 | 6.000 | South |
| TR5032 | 1.100 | 80 | 1.975 | 6.000 | South |
| TR5033 | 0.600 | 80 | 1.475 | 6.000 | South |
| TR5034 | 0.200 | 80 | 1.075 | 6.000 | South |
| TR5035 | 0.000 | 80 | 0.875 | 6.000 | South |
| TR5041 | 2.200 | 170 | 3.075 | 3.000 | East |
| TR5042 | 1.100 | 170 | 1.975 | 3.000 | East |
| TR5043 | 0.600 | 170 | 1.475 | 3.000 | East |
| TR5044 | 0.200 | 170 | 1.075 | 3.000 | East |
| TR5045 | 0.000 | 170 | 0.875 | 3.000 | East |
| TR5051 | 2.200 | 80 | 3.075 | 3.000 | South |
| TR5052 | 1.100 | 80 | 1.975 | 3.000 | South |
| TR5053 | 0.600 | 80 | 1.475 | 3.000 | South |
| TR5054 | 0.200 | 80 | 1.075 | 3.000 | South |
| TR5055 | 0.000 | 80 | 0.875 | 3.000 | South |
| Measured from DA3545G01(Hole 6) | | | | | |
| TR6011 | 1.000 | 0 | 0.000 | -1.000 | Bottom |
| TR6012 | 0.500 | 0 | 0.000 | -0.500 | Bottom |
| TR6013 | 0.200 | 0 | 0.000 | -0.200 | Bottom |
| TR6014 | 0.000 | 0 | 0.000 | 0.000 | Bottom |
| TR6021 | 2.200 | 79 | 3.075 | 6.000 | South |
| TR6022 | 1.100 | 79 | 1.975 | 6.000 | South |
| TR6023 | 0.600 | 79 | 1.475 | 6.000 | South |
| TR6024 | 0.200 | 79 | 1.075 | 6.000 | South |
| TR6025 | 0.000 | 79 | 0.875 | 6.000 | South |
| TR6031 | 2.200 | 349 | 3.075 | 6.000 | West |
| TR6032 | 1.100 | 349 | 1.975 | 6.000 | West |
| TR6033 | 0.600 | 349 | 1.475 | 6.000 | West |
| TR6034 | 0.200 | 349 | 1.075 | 6.000 | West |
| TR6035 | 0.000 | 349 | 0.875 | 6.000 | West |
| TR6041 | 2.200 | 79 | 3.075 | 3.000 | South |
| TR6042 | 1.100 | 79 | 1.975 | 3.000 | South |
| TR6043 | 0.600 | 79 | 1.475 | 3.000 | South |
| TR6044 | 0.200 | 79 | 1.075 | 3.000 | South |
| TR6045 | 0.000 | 79 | 0.875 | 3.000 | South |
| TR6051 | 2.200 | 347 | 3.075 | 3.000 | West |
| TR6052 | 1.100 | 347 | 1.975 | 3.000 | West |
| TR6053 | 0.600 | 347 | 1.475 | 3.000 | West |
| TR6054 | 0.200 | 347 | 1.075 | 3.000 | West |
| TR6055 | 0.000 | 347 | 0.875 | 3.000 | West |

6.6 Strategy for describing the position of each device in the backfill in Section 2

The strategy for instrumentation of the backfill in Section 2 is the same as in Section 1 and is described in Section 4.6.

6.7 Position of each instrument in the backfill in Section 2

The positions of each instrument are described in Tables 6-12 to 6-15.

Table 6-12. Numbering and position of instruments for measuring temperature (T) in the backfill in Section 2.

| Type and number | Instrument position Section | x | z | y | Fabricate | Remark |
|-----------------|--------------------------------|-------|-------|--------|-----------|--------|
| | | m | m | m | | |
| TFA01 | E, over dep.hole 5 | 0.0 | 2.3 | 3551.0 | Pentronic | |
| TFA02 | E, over dep.hole 5 | 0.0 | 1.25 | 3551.0 | Pentronic | |
| TFA03 | E, over dep.hole 5 | 0.0 | -0.8 | 3551.0 | Pentronic | |
| TFA04 | E, over dep.hole 5 | -0.5 | -2.6 | 3551.0 | Pentronic | |
| TFA05 | E, over dep.hole 5 | 0.5 | -2.6 | 3551.0 | Pentronic | |
| TFA06 | E, over dep.hole 5 | -1.25 | 0.0 | 3551.0 | Pentronic | |
| TFA07 | E, over dep.hole 5 | 1.25 | 0.0 | 3551.0 | Pentronic | |
| TFA08 | F, between dep.hole 5 and 6 | 0.0 | 1.0 | 3548.0 | Pentronic | |
| TFA09 | F, between dep.hole 5 and 6 | 0.0 | -1.25 | 3548.0 | Pentronic | |
| TFA10 | E, over dep.hole 6 | 0.0 | 2.3 | 3545.0 | Pentronic | |
| TFA11 | E, over dep.hole 6 | 0.0 | 1.25 | 3545.0 | Pentronic | |
| TFA12 | E, over dep.hole 6 | 0.0 | -0.8 | 3545.0 | Pentronic | |
| TFA13 | E, over dep.hole 6 | -0.5 | -2.6 | 3545.0 | Pentronic | |
| TFA14 | E, over dep.hole 6 | 0.5 | -2.6 | 3545.0 | Pentronic | |
| TFA15 | E, over dep.hole 6 | -1.25 | 0.0 | 3545.0 | Pentronic | |
| TFA16 | E, over dep.hole 6 | 1.25 | 0.0 | 3545.0 | Pentronic | |

Table 6-13. Numbering and position of instruments for measuring total pressure (P) in the backfill in Section 2.

| Type and number | Instrument position Section | x m | z m | y m | Fabricate | Remark |
|-----------------|--------------------------------|--------|--------|--------|-----------|--------|
| | | | | | | |
| PFA01 | Inner part | 0.0 | 0.0 | 3555.8 | Kulite | |
| PFA02 | E, over dep.hole 5 | 0.0 | 0.0 | 3551.0 | Geokon | |
| PFA03 | E, over dep.hole 5 | 0.0 | -1.75 | 3551.0 | Geokon | |
| PFA04 | E, over dep.hole 5 | 0.0 | -2.6 | 3551.0 | Geokon | |
| PFA05 | E, over dep.hole 5 | 0.0 | -3.15 | 3551.0 | Kulite | |
| PFA06 | E, over dep.hole 5 | -2.3 | 0.0 | 3551.0 | Kulite | |
| PFA07 | E, over dep.hole 5 | 0.0 | 2.3 | 3551.0 | Kulite | |
| PFA08 | F, between dep.hole 5 and 6 | 0.0 | 0.0 | 3548.0 | Geokon | |
| PFA09 | F, between dep.hole 5 and 6 | 0.0 | -2 | 3548.0 | Geokon | |
| PFA10 | E, over dep.hole 6 | 0.0 | 0.0 | 3545.0 | Kulite | |
| PFA11 | E, over dep.hole 6 | 0.0 | -1.75 | 3545.0 | Kulite | |
| PFA12 | E, over dep.hole 6 | 0.0 | -2.6 | 3545.0 | Kulite | |
| PFA13 | E, over dep.hole 6 | 0.0 | -3.15 | 3545.0 | Geokon | |
| PFA14 | E, over dep.hole 6 | -2.3 | 0.0 | 3545.0 | Geokon | |
| PFA15 | E, over dep.hole 6 | 0.0 | 2.3 | 3545.0 | Geokon | |
| PFA16 | In front of plug | 0.0 | 0.0 | 3539.0 | Kulite | |

Table 6-14. Numbering and position of instruments for measuring pore water pressure (U) in the backfill in Section 2.

| Type and number | Instrument position Section | x m | z m | y m | Fabricate | Remark |
|-----------------|--------------------------------|--------|--------|--------|-----------|--------|
| | | | | | | |
| UFA01 | Inner part | 0.0 | 0.0 | 3555.8 | Kulite | |
| UFA02 | Inner part | 0.0 | 0.0 | 3554.1 | Geokon | |
| UFA03 | E, over dep.hole 5 | 0.0 | 0.0 | 3551.0 | Geokon | |
| UFA04 | E, over dep.hole 5 | 0.0 | -1.75 | 3551.0 | Kulite | |
| UFA05 | E, over dep.hole 5 | 0.0 | -2.6 | 3551.1 | Kulite | |
| UFA06 | E, over dep.hole 5 | 0.0 | -3.15 | 3551.0 | Kulite | |
| UFA07 | E, over dep.hole 5 | 0.0 | -1.75 | 3551.0 | Geokon | |
| UFA08 | E, over dep.hole 5 | 0.0 | 2.3 | 3551.0 | Geokon | |
| UFA09 | F, between dep.hole 5 and 6 | 0.0 | 0.0 | 3548.0 | Geokon | |
| UFA10 | F, between dep.hole 5 and 6 | 0.0 | -2.0 | 3548.0 | Geokon | |
| UFA11 | E, over dep.hole 6 | 0.0 | 0.0 | 3545.0 | Geokon | |
| UFA12 | E, over dep.hole 6 | 0.0 | -1.75 | 3545.0 | Geokon | |
| UFA13 | E, over dep.hole 6 | 0.0 | -2.6 | 3545.0 | Geokon | |
| UFA14 | E, over dep.hole 6 | 0.0 | -3.15 | 3545.0 | Geokon | |
| UFA15 | E, over dep.hole 6 | -2.3 | 0.0 | 3545.0 | Geokon | |
| UFA16 | E, over dep.hole 6 | 0.0 | 2.3 | 3545.0 | Geokon | |
| UFA17 | In front of plug | -2.3 | 0.0 | 3551.0 | Geokon | |
| UFA18 | In front of plug | 0.0 | 0.0 | 3539.0 | Geokon | |

Table 6-15. Numbering and position of instruments for measuring relative humidity (W) in the backfill in Section 2.

| Type and number | Instrument position Section | x | z | y | Fabricate | Remark |
|-----------------|--------------------------------|-------|-------|--------|-----------|-----------|
| | | m | m | m | | |
| WFA01 | Inner part | 0.0 | 0.0 | 3555.8 | Wescor | |
| WFA02 | Inner part | 0.0 | 0.0 | 3554.1 | Wescor | |
| WFA03 | E, over dep.hole 5 | 0.0 | 2.3 | 3551.0 | Wescor | |
| WFA04 | E, over dep.hole 5 | 0.0 | 1.25 | 3551.0 | Wescor | |
| WFA05 | E, over dep.hole 5 | 0.0 | 0.0 | 3551.0 | Wescor | |
| WFA06 | E, over dep.hole 5 | 0.0 | -0.8 | 3551.0 | Wescor | |
| WFA07 | E, over dep.hole 5 | 2.3 | 0.0 | 3545.0 | Wescor | |
| WFA08 | E, over dep.hole 5 | 0.0 | -2.6 | 3550.9 | Wescor | |
| WFA09 | E, over dep.hole 5 | 0.0 | -3.15 | 3551.0 | Wescor | |
| WFA10 | E, over dep.hole 5 | -2.3 | 0.0 | 3551.0 | Wescor | |
| WFA11 | E, over dep.hole 5 | -1.25 | 0.0 | 3551.0 | Wescor | |
| WFA12 | E, over dep.hole 5 | 1.25 | 0.0 | 3551.0 | Wescor | |
| WFA13 | E, over dep.hole 5 | 2.3 | 0.0 | 3551.0 | Wescor | |
| WFA14 | F, between dep.hole 5 and 6 | | | | Wescor | Not clear |
| WFA15 | F, between dep.hole 5 and 6 | 0.0 | 1.0 | 3548.0 | Wescor | |
| WFA16 | F, between dep.hole 5 and 6 | 0.0 | 0.0 | 3548.0 | Wescor | |
| WFA17 | F, between dep.hole 5 and 6 | 0.0 | -0.55 | 3548.0 | Wescor | |
| WFA18 | F, between dep.hole 5 and 6 | -1.25 | 0.0 | 3548.0 | Wescor | |
| WFA19 | F, between dep.hole 5 and 6 | 1.25 | 0.0 | 3548.0 | Wescor | |
| WFA20 | E, over dep.hole 6 | 0.0 | 2.3 | 3545.0 | Wescor | |
| WFA21 | E, over dep.hole 6 | 0.0 | 1.25 | 3545.0 | Wescor | |
| WFA22 | E, over dep.hole 6 | 0.0 | 0.0 | 3545.0 | Wescor | |
| WFA23 | E, over dep.hole 6 | 0.0 | -0.8 | 3545.0 | Wescor | |
| WFA24 | E, over dep.hole 6 | 0.0 | -1.75 | 3545.0 | Wescor | |
| WFA25 | E, over dep.hole 6 | 0.0 | -2.6 | 3545.0 | Wescor | |
| WFA26 | E, over dep.hole 6 | 0.0 | -3.15 | 3545.0 | Wescor | |
| WFA27 | E, over dep.hole 6 | -2.3 | 0.0 | 3545.0 | Wescor | |
| WFA28 | E, over dep.hole 6 | -1.25 | 0.0 | 3545.0 | Wescor | |
| WFA29 | E, over dep.hole 6 | 1.25 | 0.0 | 3545.0 | Wescor | |
| WFA30 | E, over dep.hole 6 | 0.0 | 2.3 | 3548.0 | Wescor | |
| WFA31 | In front of plug | 0.0 | 0.0 | 3540.0 | Wescor | |
| WFA32 | In front of plug | 0.0 | 0.0 | 3539.0 | Wescor | |

7 Results and comments for Section 2

7.1 General

In this chapter short comments on general trends in the measurements are given. Sensors that are not delivering reliable data or no data at all are noted and comments on the data collection in general are given.

The heating of the canister in hole 5 started with an applied constant power of 1,800 W at 030508. This date is also marked as start date. The backfilling started 030429 and was finished 030625 and the plug was cast at 030911. Table 7-1 shows some important dates for Section 2. At the beginning of November 2004 the drainage of the inner part of Section 1 and the drainage trough the outer plug were closed. At the beginning of December 2004 damages on the cables for the installed heaters in one of the canisters in Section 1 (No 1) and one in Section 2 (No 6) were observed. The damages were probably caused by the high water pressure in the buffer and backfill. It was then decided to switch off the power to all canisters. This was done on December 2. The drainage of the tunnel was opened on December 6 and investigations on the damaged canisters were initialized. The power to all the canisters, except for canister 2, was on December 15 switched on. The drainage of the tunnel was kept open. Additional problems with the heaters in canister 6 were observed September 2005 and the power to the canister was switched off for about 2 months.

Since the start of the test, the power to the two canisters has been reduced with 30 W at four occasions and the power was about 1,680 W at the beginning of May 2008. Then, the power for canister 6 was reduced with about 200 W due to new problems with the heaters. Another reduction of the power for canister 6 was made at the beginning of June 2008 also due to heater problems. After the latest reduction the power to canister 6 was about 1,150 W. The power to canister 5 was reduced with 30 W in January 2009 and 2010. The power to the canister was after the latest reduction about 1,620 W.

The retrieval of the outer section started at the end of November 2010. This work was preceded by leakage tests of the outer plug.

The power to canister 6 was switched off at 16 February 2011 and the power to canister 5 was switched off at 15 July 2011.

After the retrieval of the outer section, validation tests of the total pressure sensors of type Geocon were made. It was then discovered that, the up to now used calibration values (linear equation) gave inaccurate readings of the total pressure. The improvements of the readings were large when a polynomial calibration equation was used instead. At the presentation of the data in this report the polynomial equation was used.

At present about 142 (excluding water pressure sensors in the rock and the displacement sensors for the canister) out of totally 394 installed sensors are out of order. In Figure 7-1 the numbers of still working sensors in the backfill and the buffer of Section 2 are plotted as function of time from June 2004. The figure shows that the majority of the broken sensors are RH-sensors and that the numbers of broken sensors increased after the closing of the drainage of the tunnel.

The measured processes in the buffer and the backfill were slow up to about 20 days after the drainage of the tunnel was closed. Very small changes of the measured parameters have occurred up to that date. After that the readings from some of the total and pore pressure sensors placed in the buffer have reacted strongly (quick increase in pressure). Also the total and pore pressure sensors placed in the backfill have recorded high pressures caused by the closing of the drainage. After the opening of the drainage of the tunnel, both the pore pressures and the total pressures were stabilized on a higher level than before the closing of the drainage.

Table 7-1. Key dates for Section 2.

| Activity | Date |
|---|------------|
| Start backfilling | 29/4 2003 |
| Start heating canister 5 | 8/5 2003 |
| Start heating canister 6 | 23/5 2003 |
| Finished backfilling | 25/6 2003 |
| Plug casting | 11/9 2003 |
| Decreased power (-30 W) | 8/9 2004 |
| The power to all canisters was switched off | 2/12 2004 |
| The drainage of the tunnel was opened | 6/12 2004 |
| The power to the canisters was switched on | 15/12 2004 |
| The power to canister 6 was switched off | 6/9 2005 |
| The power to canister 6 was switched on | 2/11 2005 |
| Decreased power (-30 W) | 2/12 2005 |
| Decreased power (-30 W) | 21/12 2006 |
| Decreased power (-30 W) | 11/12 2007 |
| The power to canister 6 was decreased with about 200 W due to problems with the heaters | 8/4 2008 |
| The power to canister 6 was decreased with about 300 W due to problems with the heaters | 5/6 2008 |
| Decreased power to canister 5 (-30 W) | 29/1 2009 |
| Decreased power to canister 5 (-30 W) | 21/1 2010 |
| Start of the dismantling of the outer plug | 29/11 2010 |
| The power to canister 6 was switched off | 16/2 2011 |
| The power to canister 5 was switched off | 15/7 2011 |

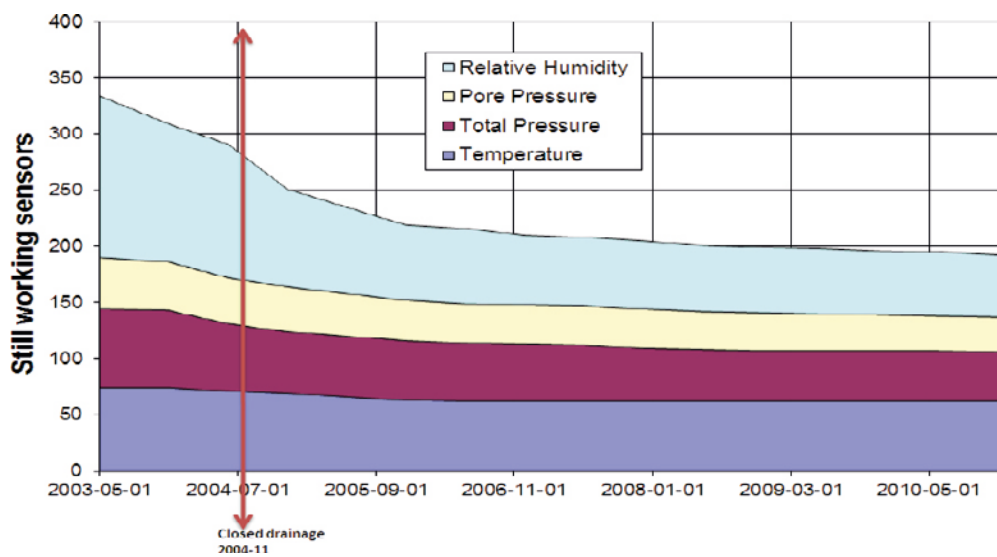


Figure 7-1. The numbers of still working sensors placed in the buffer and backfill in Section 2 as function of date. The coloured fields are representing the four types of installed sensors.

7.2 Deposition hole 5

7.2.1 Total pressure

Geokon (App. 5\pages 125–126)

The measured pressure range is from 0 to 11 MPa. PB506 placed in block C1 shows a strong increasing of the total pressure since day 200. Two sensors (PB508 and PB509) placed in block C1 at the direction of about 180° both started to measure an increase of the pressure around day 700. Pressures were about 6 MPa at the starting of dismantling.

High pressures are also indicated by sensors in block R5 and R10. PB511 in block R5 showed a very quick increase in pressure from day 520 up to the day when the power was switched off. After that a drop in pressure of 2 MPa was observed and then an increase in pressure to about 8 MPa. The pressure dropped then to about 4 MPa during a period of 200 days. The pressure was then stabilized on that level for about 250 days. After that period is the sensor showing an increasing pressure with the time. The pressure increased to about 6 MPa at around day 1,500 when the sensor failed. The two other sensors in block R5 are measuring pressures 6.5–10.5 MPa at the starting of dismantling of outer section.

Two sensors placed in block R10 (PB521 and PB522) showed a drop in total pressure at around day 300 and then they were stabilized on a pressure of about 1.5 MPa. The two sensors measured an increase in pressure when the drainage was closed. When the power to the canister was switched off the measured pressures decreased quickly with about 1 MPa. After the power was switched on again the measured pressures increased very quickly to the same level as before the power was switched off. A drop in pressure of about 1 MPa was observed at the end of previous measuring period. This is probably caused by activities at the dismantling of the outer plug. The measured pressures at the starting of dismantling deposition hole5 were about 3.3 MPa. Two sensors (of totally three installed sensors) placed in block C4 are measuring a pressure higher than 1.0 MPa.

The power to canister 5 was switched off at 15 July 2011 (day 2,990). This caused a drop in pressure at the end of the measuring period.

Five sensors were out of order.

Kulite (App. 5\page 127)

One sensor placed in block C1 is measuring low pressures, lower than 500 kPa. The measured pressures have continuing to increase during this measuring period.

One sensor placed at the inner surface of block R5 (PB510) started to measure an increase in pressure around day 250 which might indicate that water entered the inner slot at that time. The sensor measured a maximum pressure of about 2.5 MPa just before it was broken.

Two sensors PB519 and PB520, placed in block R10 are measuring pressures higher than 2.3 MPa at the end of this measuring period and a third sensor in block R5 (PB518) is measuring a pressure of about 1.3 MPa. The power to canister 5 was switched off at 15 July 2011 (day 2,990) therefore the pressure drop after this day.

Three sensors are out of order.

7.2.2 Relative humidity/suction in dep. hole 5

Vaisala (App. 5\pages 127–129)

Since temperature is also measured with all relative humidity sensors, the diagrams include those measured temperatures. The temperature measurements start at about 16 degrees while the RH measurements start at about 70% RH.

The sensors placed in the bottom block C1 show very small changes in RH with time. The measured relative humidity varies between 80–90%.

One sensor placed in block R5 close to the canister (WB519) indicated a very strong drying of the bentonite until day 170 when it stopped to give reliable values. Sensor WB520 placed in the middle of block R5 indicated also an initial drying of the bentonite. The rest of the sensors in block R5 indicate a slowly wetting of the buffer (increase in RH) up to day 1,300 when they stopped giving reliable values.

Two sensors in block R10 placed close to the top of the canister (WB522, WB523) indicated a drying of the bentonite up to day 350 and after that a slowly wetting. The rest of the sensors in block R10 indicate initially a wetting of the buffer. The relative humidity at the end of this measuring period varies between 75% close to the canister lid and 85% at the periphery of the bentonite block.

Two still working sensors placed in block C3 and C4 indicate a slowly wetting of the buffer and are measuring a RH of about 90% at the end of this measuring period.

Twelve sensors are out of order.

Rotronic (App. 5\pages 130–132)

Seven of the sensors placed in the bottom block C1 show a slow increase in RH with the time. The measured RH in block C1 varies between 85–100% at the end of this measuring period.

One sensor placed in block R5 close to the canister (WB516) indicated a very strong drying of the bentonite for the first 60 days. The sensor indicated then a wetting for the next 60 days and after that another period of drying until day 230. After that the sensor is measuring an increase in Relative Humidity indicating a wetting of the buffer until it stopped giving reliable values.

All the sensors in block R10 have stopped giving reliable values.

One sensor placed in block C3 indicated a slow wetting of the bentonite during the first 600 days. The sensor recorded a Relative Humidity of 100% after about 1,400 days.

Nine sensors are out of order.

Wescor Psychrometers (App. 5\page 132)

The Wescor sensors can measure suction between 200 and 6,000 kPa.

Four of totally ten sensors have started to measure a decrease in suction of the buffer. These sensors (WB538, WB539, WB541 and WB542) are placed near the periphery of block R3. All of these sensors have stopped giving reliable values.

7.2.3 Pore water pressure

Geokon (App. 5\page 133)

All sensors yield very low pressures.

Kulite (App. 5\page 133)

Sensors UB508 was out of order from start and it is not plotted in this report.

One sensor placed in block R5 yields a pressure of about 0.5 MPa at the end of this measuring period. The rest of the installed sensors are measuring very low pressures.

Three sensors are out of order.

7.2.4 Temperature in the buffer (App. 5\pages 134–139)

Three thermocouples (TB504, TB511 and TB524) are placed on the surface of the canister. TB504 placed closed to the bottom of the canister shows a temperature of about 65°C, TB511 placed at the middle of canister about 70°C and TB524 placed close to the top of the canister shows a temperature of about 64°C.

High temperatures are measured with thermocouples placed in the centre of block C1 and just below the canister (TB503, 62°C) and in block R5 (TB513, 68°C). The temperature gradient over block R5 (between the radius 585 mm and 785 mm) is at the end of this measuring period about 0.58°C/cm.

The temperature in the buffer is also measured with the Geokon sensors. The maximum temperature recorded with these sensors is about 62°C at the end of this measuring period (PBU502 placed in the centre of block C1 close to the canister).

The temperature in the buffer is also measured with the Wescor sensors. The maximum temperature recorded at the end of this measuring period with these sensors is about 65°C.

The power to canister 5 was switched off at 15 July 2011 (day 2,990). This caused a drop in temperature at the end of the measuring period.

7.2.5 Canister power (App. 5\page 141)

The power of the canister in hole 5 was kept constant at 1,800 W from the start 2003-05-08 until the beginning of September 2004 when the power was decreased to about 1,770 W. During the period between December 6 (day 575) and December 15 (day588) the power to the canister was switched off. After that period the power was adjusted to about 1,770 W again. At the beginning of December 2005, 2006, 2007 and 2008 the power was decreased with 30 W. In January 2009 and 2010 the power was reduced with about 30 W. After the latest reduction the power of the canister is about 1,620 W.

Due to problems with the data collection system, data is missing for the first 45 days of the heating. The power to canister 5 was switched off 15 July 2011.

7.2.6 Temperature on the canister surface (App. 5\pages 142–143)

The first diagram shows the maximum temperature, measured with the optical cables placed on the surface of the canister, plotted as function of time. The maximum measured temperature on the canister surface is about 88°C. With no damages on the optical cables this plot should have four curves. Only one curve with relevant values is presented here up to May 2007 which indicates that the optical cables are damaged. The second diagram shows the distribution of the temperature along the optical cables at December 1 2006. The length of the cables on the canister surface is about 20 m. The variation of a few degrees is caused by the difference in temperature in the centre and ends of the canister. In May 2007 the optical system for measuring the temperature on this canister stopped functioning.

7.3 Deposition hole 6

7.3.1 Total pressure

Geokon and Kulite (App. 6\pages 145–146)

The results from two types of sensors are presented in the same plot.

The measured pressure range is from 0 to 11 MPa. Two sensors, PB624 and PB627 placed in the top block (C4) showed an increase in pressure with about 1.5 MPa when the drainage of the tunnel was closed. Two sensors in block C3 and C4 are measuring pressures between 1.5–1.8 MPa at the end of previous measuring period. A drop in pressure of about 1 MPa was observed at the end of previous measuring period (day 2,764). This is probably caused by activities at the dismantling of the outer plug. One sensor placed in block C1 (PB601) is measuring a pressure of about 6 MPa at the starting of dismantling of outer section.

Three sensors placed in Block R1 and R2, PB603, PB606 and PB607, showed an increase in pressure up to the point where the power to the canister was reduced to ~1,500 W when a drop in the measured pressures was observed. The sensor recorded another drop in pressure when the power was reduced to ~1,250 W at around day 1,840. The three sensors are measuring a pressure between 10 and 11 MPa at the starting of dismantling of the outer section.

Three sensors placed in Block R5 and R6 are measuring a pressure between 7.5 and 9 MPa at the starting of dismantling of the outer section.

Three of the sensors placed in Block R8 and R9 (PB620, PB621 and PB623) showed a strong increase in pressure after the power was switched on again at the end of year 2004. All the sensors reacted also with a rapid decrease in pressure when the power to canister 6 was switched off for the second time. After the drop in pressure most of the sensors started to measure an increase in pressure even though the power was not switched on. The measured total pressure in Block R8 and R9 varies between 4 and 8.5 MPa at starting of dismantling of the outer section.

The power to canister 6 was switched off at 2 February 2011 (day 2,841). This caused a drop in pressure at the end of the measuring period.

Thirteen sensors (eight Kulite and five Geokon) were out of order.

7.3.2 Relative humidity/Suction

Vaisala and Rotronic (App. 6\pages 147–150)

The results from two types of sensors are presented in the same plot.

The sensors placed in the bottom block C1 showed small changes in RH with the time. At the end of this measuring period two sensors are measuring a relative humidity of about 100%.

Two sensors placed in block R1 and R2 indicated a very quick increase in RH when the drainage was closed.

All sensors placed in block R5 and R6 stopped giving reliable values of the RH after the drainage was closed.

One sensor placed close to the canister in block R9 (WB645) indicates a drying of the buffer. The rest of the sensors in block R8 and R9 indicated a slowly wetting of the buffer up to the time when the drainage was closed. At that point a quick increase in RH was measured by several sensors and most of them stopped give reliable values after that period.

Two sensors (WB649, WB650) placed in block R10 and at the top of the canister indicated an initial wetting of the bentonite and then a continuing drying. The two sensors stopped giving reliable values around day 600 (when the drainage of the tunnel was closed).

The sensors placed in block C3 and C4 show very small changes in RH with the time.

Sensors WB606, WB634 and WB648 were out of order at the start of the heating phase and are not plotted in this report.

34 of the initial 37 installed sensors are out of order.

Wescor Psychrometers (App. 6\pages 150–153)

Seven of totally nine sensors installed in the rock wall have measured suction in the rock since the start of the test. Three of totally 26 sensors installed in the buffer are giving reliable values at the end of this measuring period.

7.3.3 Pore water pressure

Geokon and Kulite (App. 6\pages 153–154)

Four installed sensors yield pressures higher than 0.5 MPa. Two of the sensors are placed in block R6, one is placed in block R5 60 mm from the surface of the canister, and the fourth is placed in Block R2 close to the canister.

Three sensors (Kulite) are out of order.

7.3.4 Temperature in the buffer (App. 6\pages 155–161)

Due to problems with the heaters in the canister the power was reduced with about 200 W around day 1,800 and with about 300 W around day 1,860 (see Section 7.3.5). These reductions affected the measured temperatures in the buffer.

Three thermocouples (TB611, TB619 and TB627) are placed on the surface of the canister. TB611 placed close to the bottom of the canister showed a temperature at the end of this measuring period of about 51°C while TB619 placed at the middle of canister showed a temperature of 56°C. TB627 placed close to the top of the canister was measuring a temperature of about 54°C.

The maximum temperature in the buffer recorded at the end of this measuring period is 55°C. It was measured in block R5, close to the canister (TB612). The temperature plot for this sensor indicates that the thermocouple is in contact with the canister. When this sensor is excluded the maximum temperature gradient over block R5 is about 0.31°C/cm.

Eleven thermocouples are out of order.

The temperature in the buffer is also measured by the installed Geokon sensors. The maximum temperature recorded with these sensors at the end of this measuring period is about 56°C (UB609 placed in block R2 close to the canister). Five sensors are out of order.

The temperature in the buffer is also measured with the Wescor sensors. The maximum temperature recorded with these sensors is about 57°C at the end of this measuring period. The sensor is placed in block R5 close to the canister surface.

The power to canister 6 was switched off at 2 February 2011 (day 2,841). This caused a drop in temperature at the end the measuring period.

7.3.5 Canister power (App. 6\page 163)

The power of the canister in hole 6 has been kept constant at 1,800 W from the start 2003-05-08 to the beginning of September 2004 when the power was decreased to about 1,770 W. During the period between December 6 (day 575) and December 15 (day 588) the power to the canister was switched off. After that period the power was adjusted to about 1,770 W. During a period of about 2 months (from August 2) the power was switched off again and after that the power was adjusted to 1,770 W again. At the beginning of December 2005, 2006 and 2007 the power was decreased with 30 W. Due to problems with the heaters the power was reduced with about 200 W at the beginning of May 2008. Another reduction of the power was made at the beginning of June 2008 also due to heater problems. After the latest reduction the power was about 1,150 W.

Due to problems with the data collection system, data is missing for the first 30 days of the heating phase.

The power to canister 6 was switched off at 2 February 2011 (day 2,841).

7.3.6 Temperature on the canister surface (App. 6\pages 164–165)

The first diagram shows the maximum temperature plotted as a function of time. The average maximum measured temperature on the canister surface at the end of this measuring period is about 76°C. The second diagram shows the distribution of the temperature along the optical cables at the end of this measuring period. The maximum temperature has decreased with about 9°C after the switch off/switch on of the power at the end of year 2004. The temperature has all about recovered from the latest period when the power was switched off. With no damages on the optical cables this plot should have four curves. Only two curves with relevant values are available which indicates that the optical cables are damaged. The length of the cables on the canister surface is about 20 m. The variation of a few degrees is caused by the difference in temperature at the centre and ends of the canister. The optical system stopped giving reliable values at around day 1,300.

7.4 Backfill in Section 2

7.4.1 Total pressure

Geokon (App. 7\page 167)

All the total pressure sensors measured an increase pressure, of about 1.5 MPa, after the drainage of the tunnel was closed. The highest total pressures before the closing of the drainage, 400 kPa, was measured by the sensor PFA13. This sensor is placed just above the bentonite surface in the deposition hole 6. The rest of the total pressure sensors measured very low pressures before the closing of the drainage. However, all installed sensors indicated a decrease in pressure when the drainage was opened again. The maximum measured pressure just after the opening of the drainage was about 0.4 MPa. All the sensors recorded a slow increase in pressure although the drainage was kept open. Just before the power to canister 6 was switched off again at the beginning of September 2005 the maximum recorded pressure was about 1 MPa. All the sensors indicated a decrease in pressure when the power to canister 6 was switched off. When the power was switched on the pressure started to slowly increase again and the maximum pressure recorded at around day 1,450 was about 1.2 MPa. After that all the sensors were measuring an increase in pressure of about 0.3 MPa. This increase in pressure is caused by the initial hydraulic tests made for the construction of a new tunnel close to the Prototype-tunnel. The maximum recorded pressure just before the dismantling of the outer plug started was about 1.9 MPa. This pressure is in the same range as the pressure measured at the closing of the drainage of the tunnel. During the work with the dismantling of the outer plug, at the end of this measuring period, a general decrease in pressure of about 0.8 MPa was recorded.

The power to canister 6 and canister 5 were switched off at day 2,841 and day 2,990 respectively. This caused a drop in pressure at the end of the measuring period.

Kulite (App.7 \page 167)

These sensors measured also an increase in total pressure of about 1.5 MPa due to the closing of the drainage. The highest pressure before the closing of the drainage was measured by the sensor PFA12, about 0.4 MPa. This sensor is placed just above the bentonite surface in deposition hole 6. The rest of the total pressure sensors measured very small pressures before the drainage closing. After the reopening of the drainage, all the sensors recorded a drop in total pressure. The measured pressure started to slowly increase although the drainage was kept open. When the power to canister 6 was switched off again at the beginning of September 2005 the maximum recorded pressure decreased to 0.6 MPa and after that the pressure started to slowly increase again and the maximum pressure recorded at around day 1,450 was about 1.2 MPa. Also these sensors were measuring an increase in pressure of about 0.3 MPa when tests made for the new tunnel closed to the Prototype-tunnel started. The maximum measured pressure just before the dismantling of the outer plug started was about 1.9 MPa. During the work with the dismantling of the outer plug, at the end of this measuring period, a general decrease in pressure of about 0.8 MPa was recorded.

The power to canister 6 (day 2,841) and canister 5 (day 2,990) were switched off therefore a drop in pressure at the end of measurement.

7.4.2 Suction (App. 7 \pages 168–171)

The suction in the backfill is measured with Wescor psychrometers. Most of the psychrometers yield suction values between 2,500 and 3,500 kPa at the start of the test, which correspond to the initial suction at a water ratio in the backfill of 12%. Some sensors have clearly being wetted to almost fully saturation (suction below 1,500 kPa) very short after the start of the test. These sensors (WFA12, WFA20, and WFA27) are placed close the rock surface. A decrease in suction and thus a wetting of the backfill was indicated by the rest of the sensors until the closing of drainage of the tunnel. All of the still working sensors were after this event showing a quicker decrease in suction. None of the installed sensors are giving reliable values.

The position of WFA14 is not clear and the sensor is not plotted in this report.

7.4.3 Pore water pressure

Geokon (App. 7\pages 171–172)

All the sensors, except one (UFA11), showed an increase in pore pressure, about 1.5 MPa, after the closing of the tunnel drainage. The sensors recorded very low pressures before this event. After the drainage was reopening all sensors placed close to the tunnel surface indicated a slow increase in pore pressure. Just before the power to canister 6 was switched off again at the beginning of September 2005 the average recorded pressure was 0.5 MPa. The pressure dropped then with about 0.2 MPa with a subsequent slowly increase in pressure. The average pressure for these sensors was about 0.5 MPa around day 1,450. Also these sensors were measuring an increase in pressure of about 0.3 MPa when the tests for the new tunnel started. The maximum measured pressure just before the dismantling of the outer plug started was about 1.4 MPa. During the work with the dismantling of the outer plug, at the end of this measuring period, a general decrease in pore pressure of about 0.8 MPa was recorded

The power to canister 6 and canister 5 were switched off at day 2,841 and day 2,990 respectively. This caused a drop in pressure at the end of the measuring period.

Kulite (App. 7\page 173)

Three of the sensors showed an increase in pore pressure, about 1.5 MPa, after the closing of the tunnel drainage. The sensors recorded very low pressures before this event. After the drainage was reopened again, the two still working sensors measured maximum values of about 0.55 MPa. When the power to canister 6 was switched off again the pressures dropped with about 0.2 MPa. The still working sensor measured a pressure of about 0.5 MPa around day 1,450. The measured pressure increased then with about 0.3 MPa caused by the work with the new tunnel. The work with the new tunnel has also affected this sensor during about 2.5 years and the maximum measured pore pressure just before the dismantling of the outer plug started was about 1.2 MPa. During the work with the dismantling of the outer plug, at the end of this measuring period, a decrease in pore pressure of about 0.8 MPa was recorded.

The power to canister 6 (day 2,841) and canister 5 (day 2,990) were switched off therefore a drop in pressure at the end of measurement.

Three sensors are out of order.

7.4.4 Temperature (App. 7\pages 173–174)

The temperature in the backfill ranges from 20 to 31°C. The highest temperatures is as expected measured just above the buffer in hole 5. When the power to canister 6 was switched off at the beginning of September 2005 the temperature in the backfill close to upper surface of the buffer in deposition hole 6 dropped with about 2°C but increased when the power was switched on again. A decrease in temperature is also recorded during this measuring period due to the reduction of the power to canister 6.

The power to canister 6 and canister 5 were switched off at day 2,841 and day 2,990 respectively. This caused a drop in temperature at the end of the measuring period.

7.5 Temperature in the rock

7.5.1 Near hole 5 (App. 5\pages 140–141)

The maximum temperature in the rock (54°C) was measured by TROA5045 located at rock surface near the centre of the canister in deposition hole 5.

7.5.2 Near hole 6 (App. 6\pages 162–163)

The maximum temperature in the rock just before the power to canister 6 was switched off (54°C) was measured by TROA6055. The sensor is located at rock surface near the centre of the canister in deposition hole 6. All the sensors placed close to deposition hole measured a drop in temperature when the power was switched off at three occasions since the start of the test. After the two latest reduction of the power to the canister with about 200 and 300 W the temperature measured by the sensor placed at mid height of the canister and at the surface of the deposition hole dropped with about 8°C to a maximum temperature of about 45°C.

7.6 Analyze of data from Section 2

7.6.1 Deposition hole 5

The saturation of the buffer in deposition hole 5 indicated by both RH sensors and total pressure sensors is complex. Some total pressure sensors indicate rather high total pressures (higher than 6 MPa) while others measure very low pressures. The sensors giving high pressures are placed in block C1, R5 and R10. There are also some RH-sensors which are measuring relative humidity of ~100%, indicating a high saturation of the buffer. In other parts of the buffer most of the sensors (both RH-sensors and total pressure sensors) indicate a slow wetting of the buffer with time. Although the sensors reacted rather strongly just before and after the power was switched on and off at the beginning of December 2004, the saturation rate indicated by the sensors is not changed radically over the time. One sensor (PB510), measuring the total pressure in block R5 at the inner slot towards the canister, measured a maximum pressure of about 2,600 kPa before it stopped giving reliable values. This sensor started to react around day 200 which might be an indication of the time when the inner slot was closed.

In Figure 7-2 the temperature for deposition hole 5 is plotted as function of the radial distance from the centre of the deposition hole at mid height of the canister. Compared the corresponding plots for deposition hole 3 these plots do not show a drop in temperature between the surface of the canister and the buffer (inner diameter of the ring) although the temperature gradient is higher close to the canister surface. The temperature on the canister surface is also much lower compared to canister 3. These measurements indicate that the initial slot between the buffer and the canister of about 10 mm is not present anymore, but the closing of the slot is not associated with the high pressures generated in the buffer and backfill at the closing of the tunnel drainage.

The temperature gradient over the inner part of the buffer together with the temperature on the canister and the temperature at the radius of 600 mm in the ring shaped block R5 are plotted as function of time in Figure 7-3. The shaded part of the plot is representing the time when the power to the canisters was switched off. The plot shows that both the temperature and the temperature gradient were affected very little by the switch off/on of the power. The plot is indicating that there is decrease in the temperature gradient after the power was switched on again. The plot is also showing that the temperature gradient is decreasing towards a value similar as for the outer part of the buffer (about 0.5°C/cm).

The temperature gradient over the outer part of the buffer is plotted in Figure 7-4. After the power was switched on again this gradient is also stabilized on about the same level as before the power was switched off.

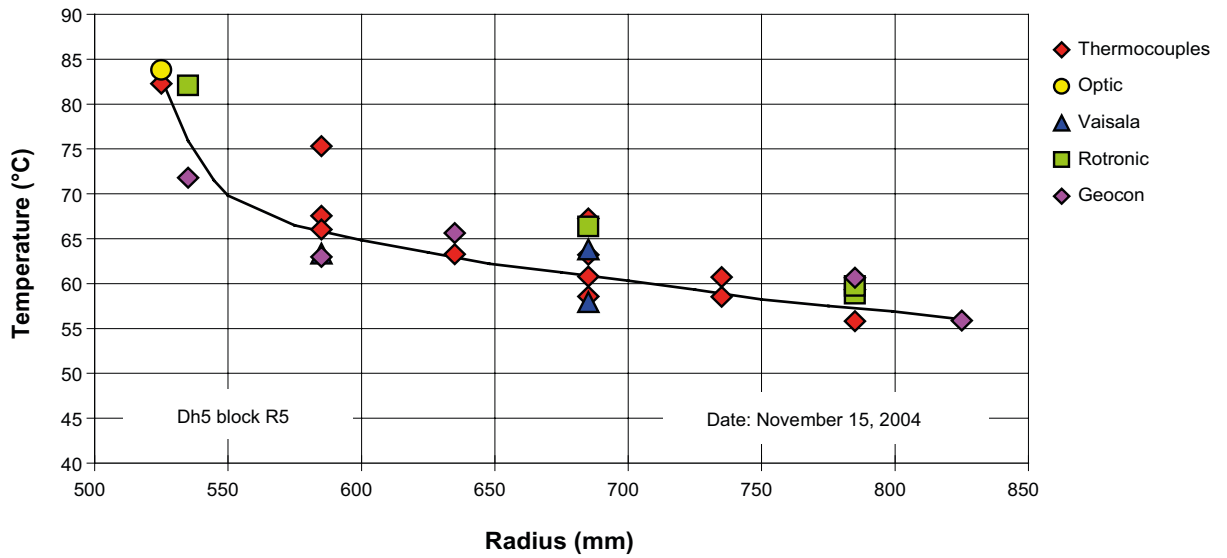


Figure 7-2. The temperature in block R5 in Dh 5 as function of radius from the centre of the deposition hole on November 15, 2004.

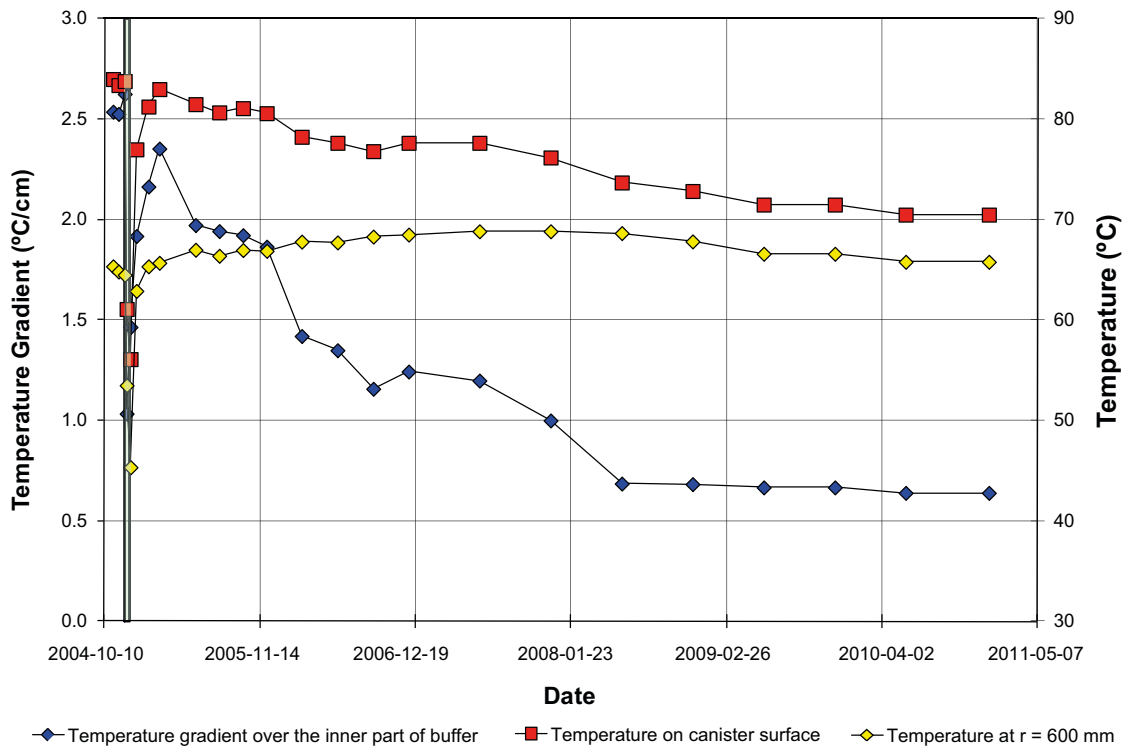


Figure 7-3. The temperature and temperature gradient over the inner par of the buffer plotted as function the date in deposition hole 5 block R5.

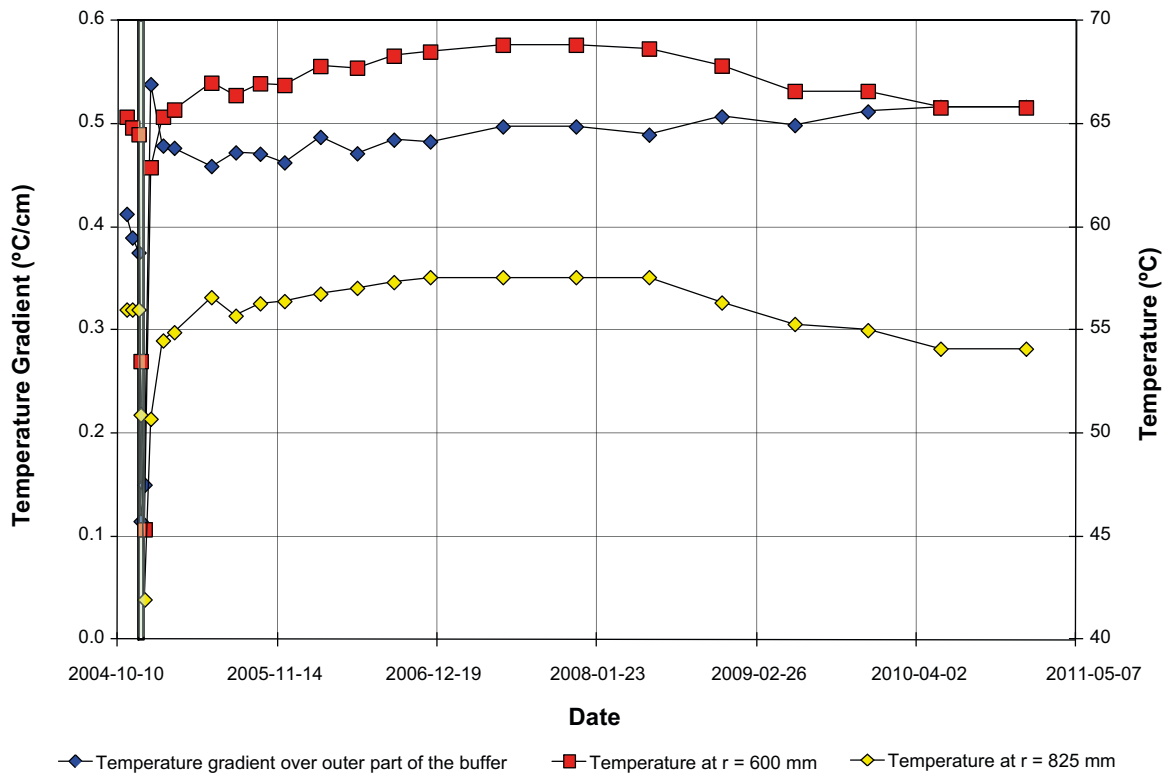


Figure 7-4. The temperature and temperature gradient over the outer part of the buffer plotted as function the date in deposition hole 5 block R5.

7.6.2 Deposition hole 6

The saturation of the buffer in deposition hole 6 was affected by the quick increase in pressure when the drainage of the tunnel was closed, indicated by both RH sensors and total pressure sensors. The total pressure was also affected when the power was switched off again at the beginning of September 2005. The drop in total pressure was very large and rapid and the pressure started to increase before the power to the canister was switched on again. When the power was switched on the pressure increased very fast to the same level as before the power was switched off. This course of events is indicating that the change in total pressure is an effect of the changes in water volume in the bentonite caused by variation in temperature.

The temperature in the buffer for deposition hole 6 is plotted as function of the radial distance from the centre of the deposition hole at mid height of the canister in Figure 7-5 at November 15, 2004 which was before the high pore pressure in the tunnel was observed. Compared to the corresponding plots for deposition hole 5 these plots indicate a drop in temperature between the surface of the canister and the buffer (inner diameter of the ring). The temperature on the canister surface measured with the optical system is also rather high compared to measurements made on canister 1. The measurements indicate that the initial slot between the buffer and the canister of about 10 mm was still open when the drainage was closed. Corresponding plot of the temperature some time after the drainage was opened again shows that the temperature on the surface of the canister has dropped with about 10°C, see Figure 7-6.

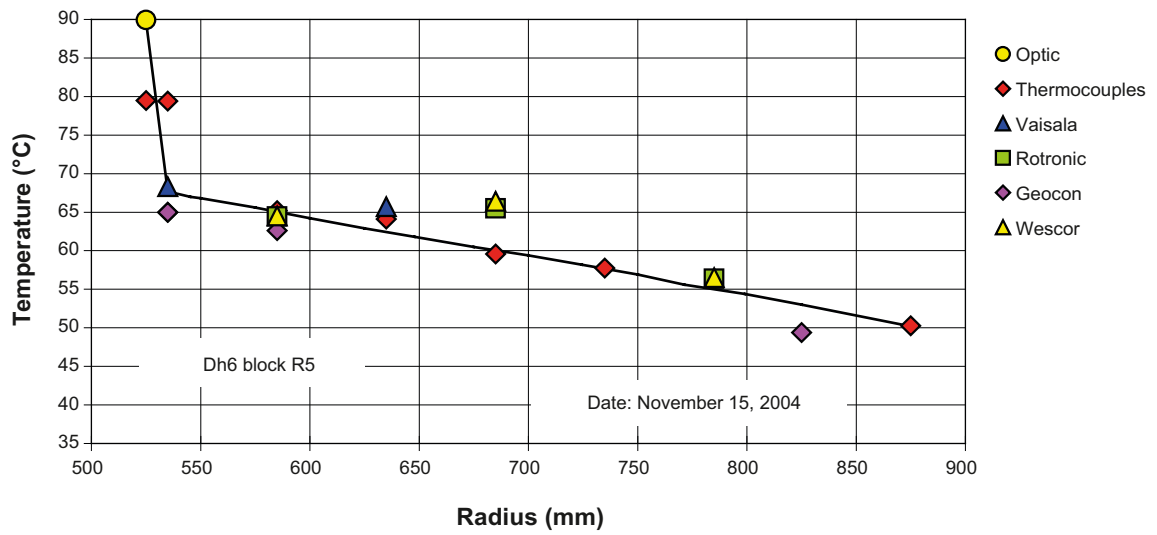


Figure 7-5. The temperature in block R5 in Dh 6 as function of radius from the centre of the deposition hole on November 15, 2004.

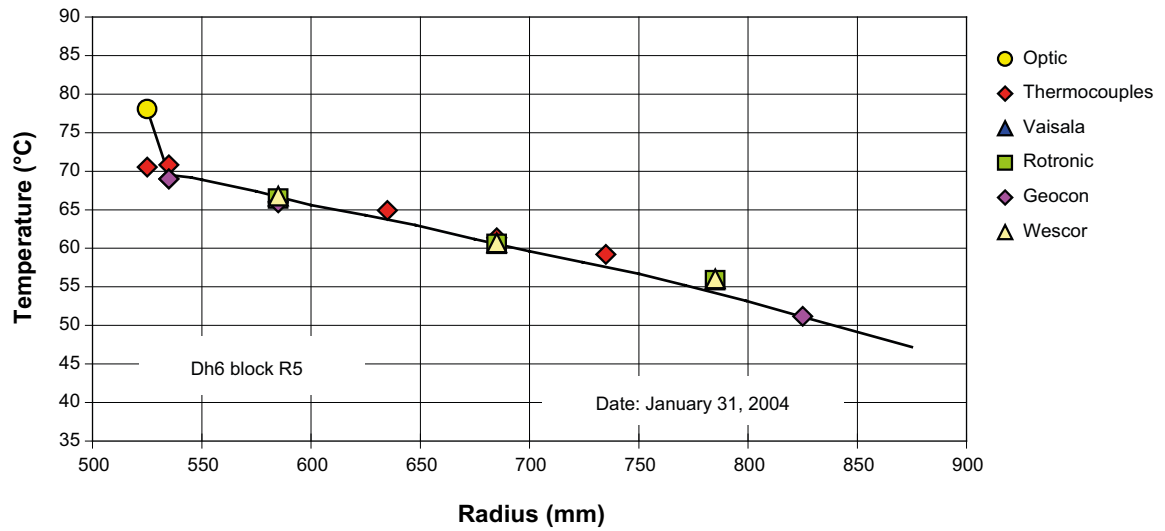


Figure 7-6. The temperature in block R5 in Dh 6 as function of radius from the centre of the deposition hole on January 31, 2005.

The temperature gradient over the inner slot is shown in Figure 7-7 as function of time. The shaded parts of the plot represents the time when the power to the canister was switched off. The plot shows that both the temperatures and the temperature gradient were affected very much by the closing/opening of the drainage which is indicating that the inner slot was closed when water entered the slot. The temperatures and the gradient were also affected when the power to the canister was switched off for the second time. Both the temperatures and the gradient have reached the same levels as before the power was switched off the second time. The measured temperatures in the buffer were also affected by the two reduction of the power to the canister with about 200 W and 300 W due to problems with the installed heaters. Many of the sensors installed close to the canister surface have stopped giving reliable values and the temperature on the canister and the gradient over the inner part of the buffer are thus less accurate.

The closing of the gap is also affecting the temperature development in different part of the buffer since the relation between the heat leaving the end parts of the canister and the heat leaving the cylindrical part of the canister was changed when the gap was closed. Directly after the installation, the buffer was in good contact with the ends of the canister while the slot was isolating the rest of canister surface from the buffer. When the gap was closed, more of the generated heat was leaving the cylindrical part of the canister resulting in a higher temperature in the buffer at the central part of the deposition hole and a lower temperature in the buffer at the ends of the canister.

The temperature gradient over the outer part of the buffer is plotted in Figure 7-8. This gradient was also affected when the power was switched off. After the power was switched on again this gradient was stabilized on the same level as before the power was switched off. Due to the reduction of the power to the canister, both the temperature and the temperature gradient over the buffer decreased.

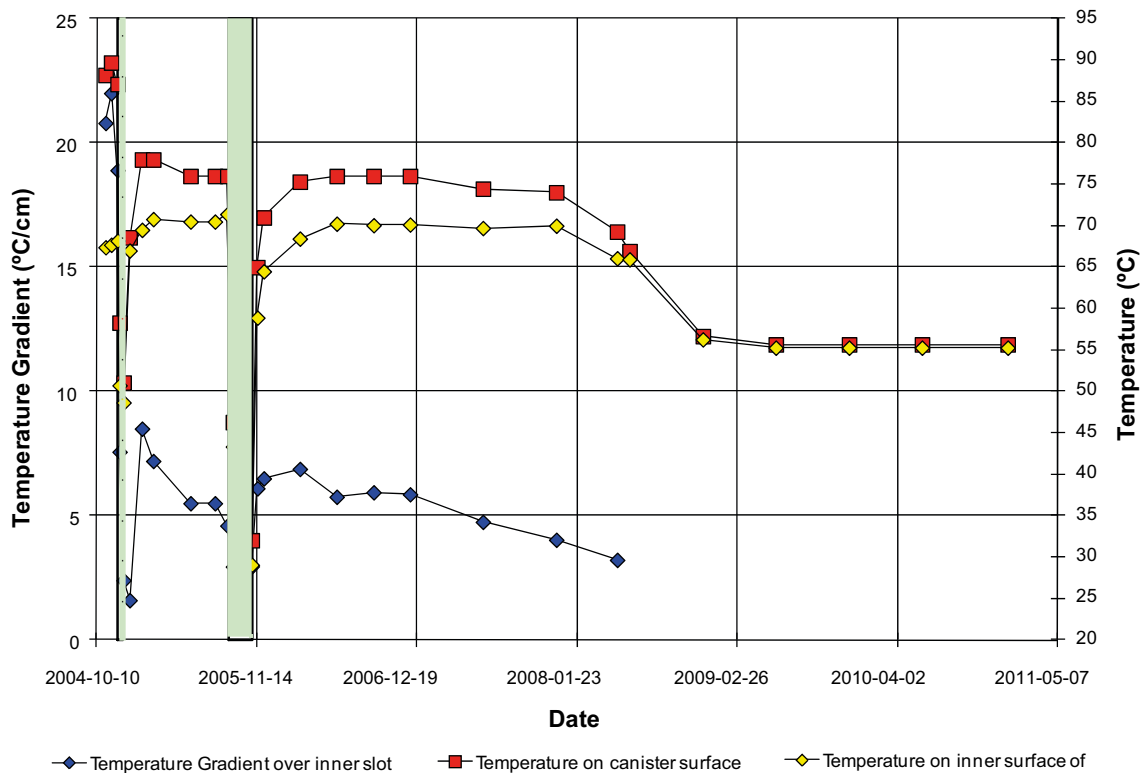


Figure 7-7. The temperature and temperature gradient over the inner slot plotted as function the date in deposition hole 6 block R5.

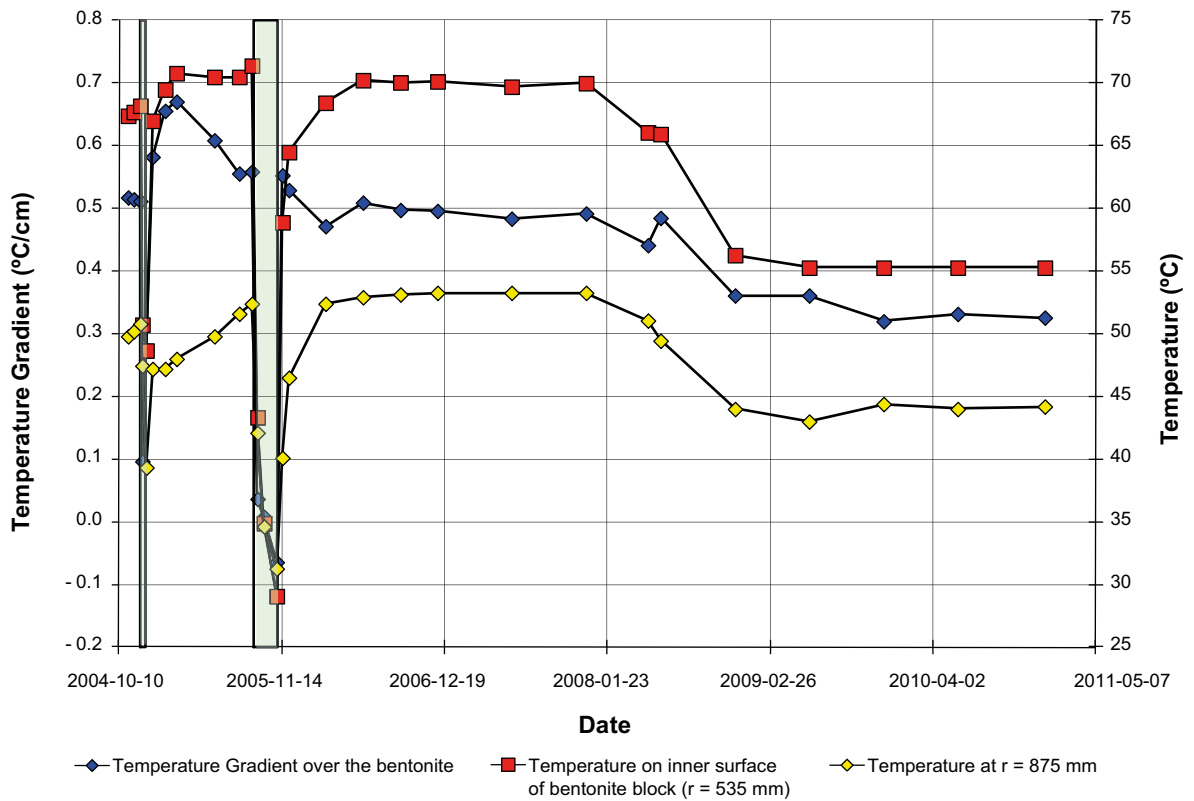


Figure 7-8. The temperature and temperature gradient over the buffer plotted as function the date in deposition hole 6 block R5.

7.6.3 Backfill

The pore pressure, measured both with total and pore pressure transducers placed in the backfill, increased fast from a low level when the drainage of the tunnel was closed. This affected the rate in which the backfill was saturated measured both with soil psychrometers and with resistivity measurements in the backfill. After the drainage was opened again the pore pressure stabilized on a higher level than before the drainage was closed. Both the total pressure and the water pressure are continuing to increase although the drainage is kept open. The outflow from the drainage of the outer section is plotted in Figure 7-9. During this measuring period most of the pore pressure and total pressure sensors are indicating a relatively constant pressure except for the last month where a significant drop in pressure can be seen. The drop in pressure is caused by the work with dismantling of the outer plug in the deposition tunnel. Most of the installed soil psychrometers measure very low suction values after the closing/opening of the drainage which indicate that the backfill is close to fully saturated.

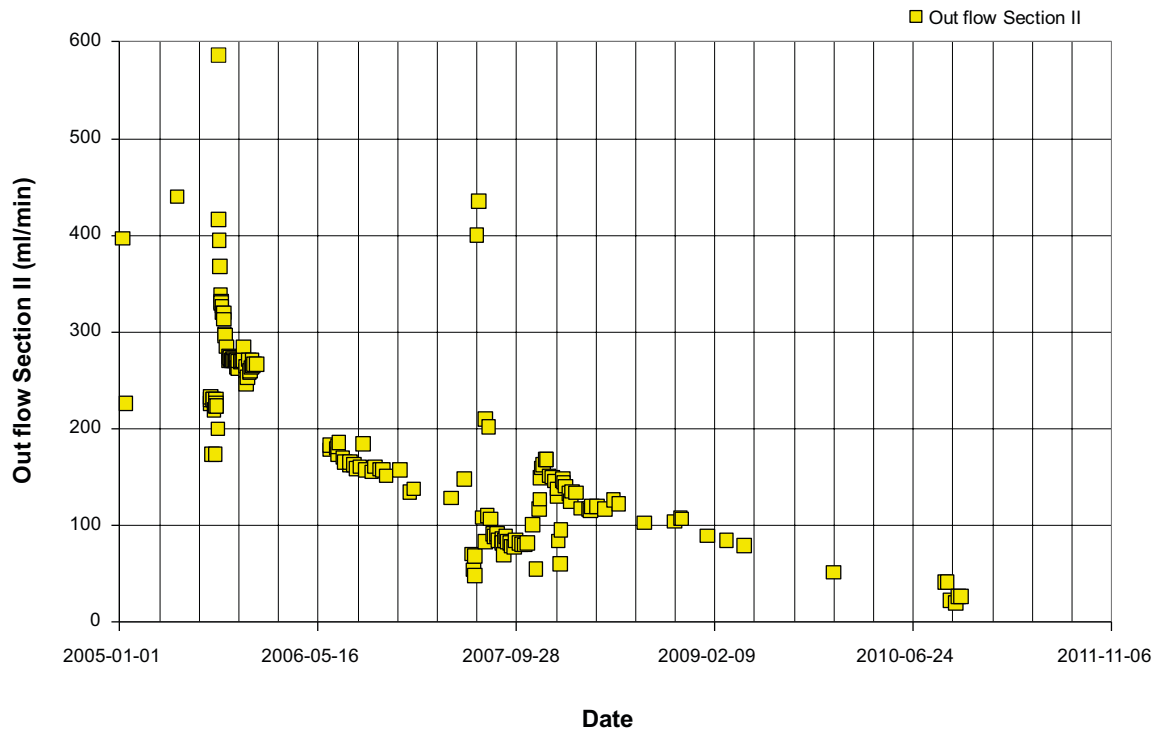


Figure 7-9. The measured outflow from the outer section of the Prototype tunnel.

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Börgesson L, Sandén T, 2001. Äspö Hard Rock Laboratory. Prototype Repository. Report on instrument positions in buffer/backfill and preparation of bentonite blocks for instruments and cables in section I. SKB IPR-01-20, Svensk Kärnbränslehantering AB.

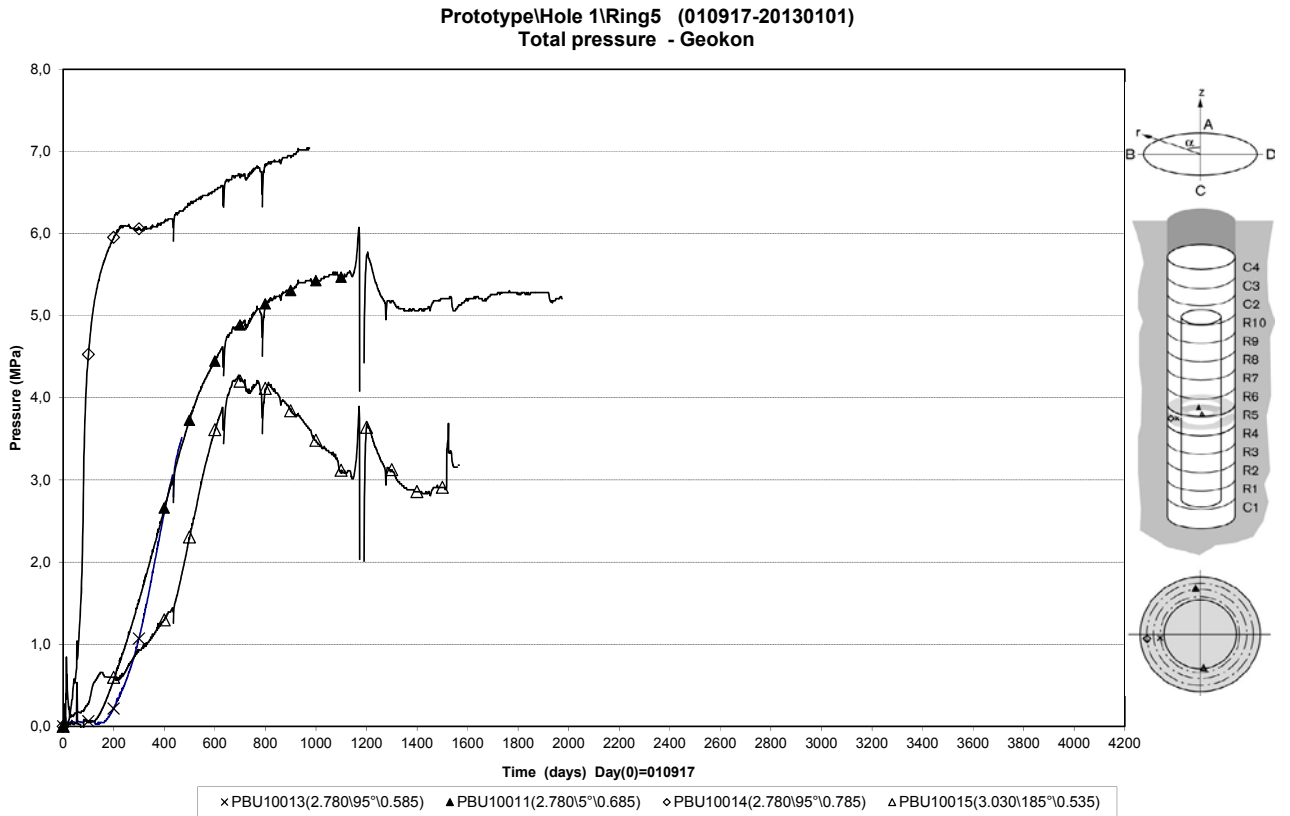
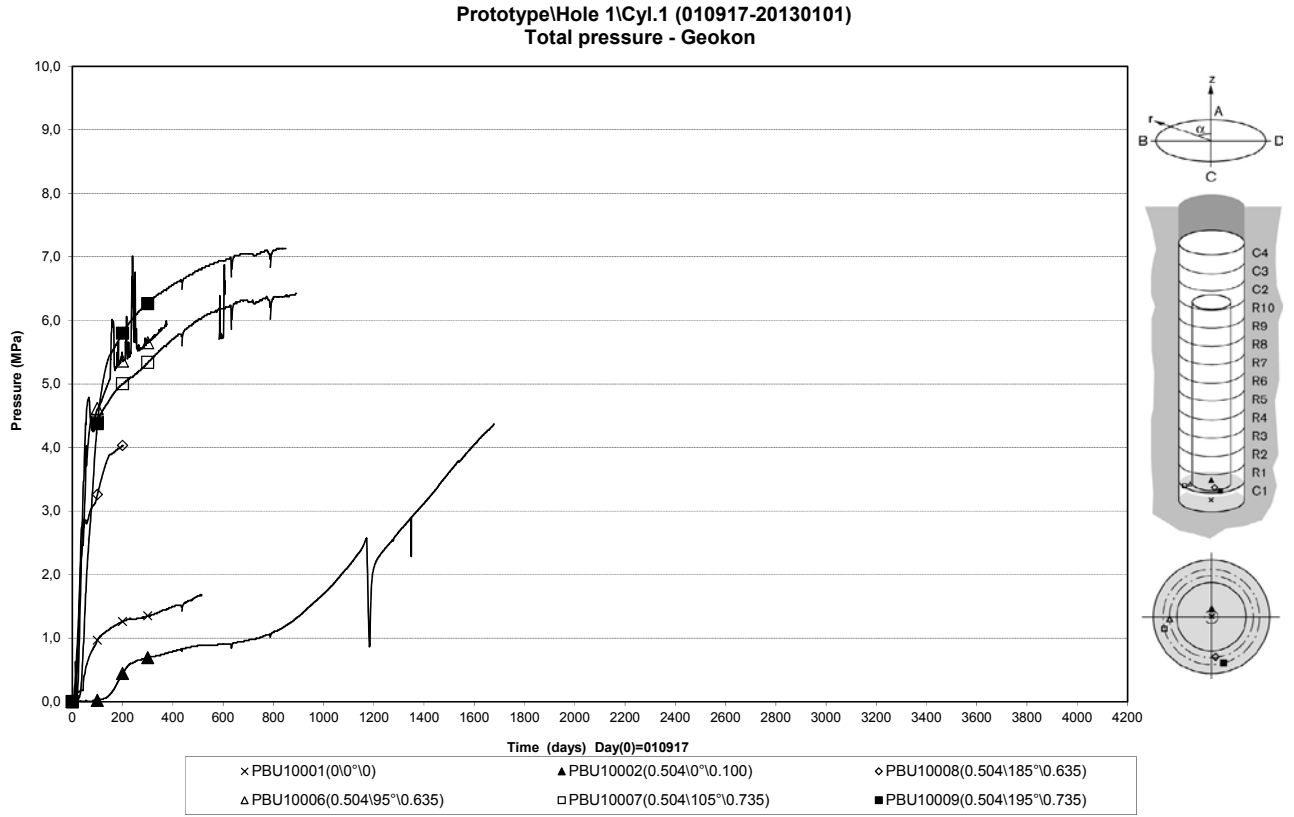
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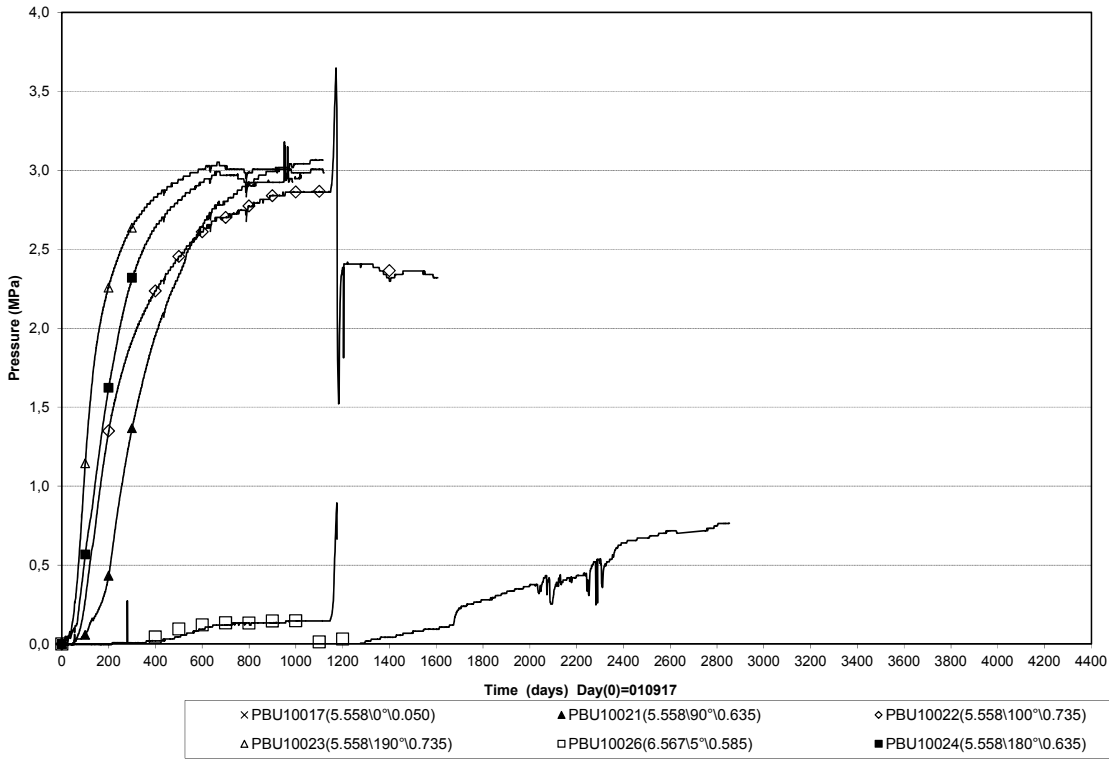
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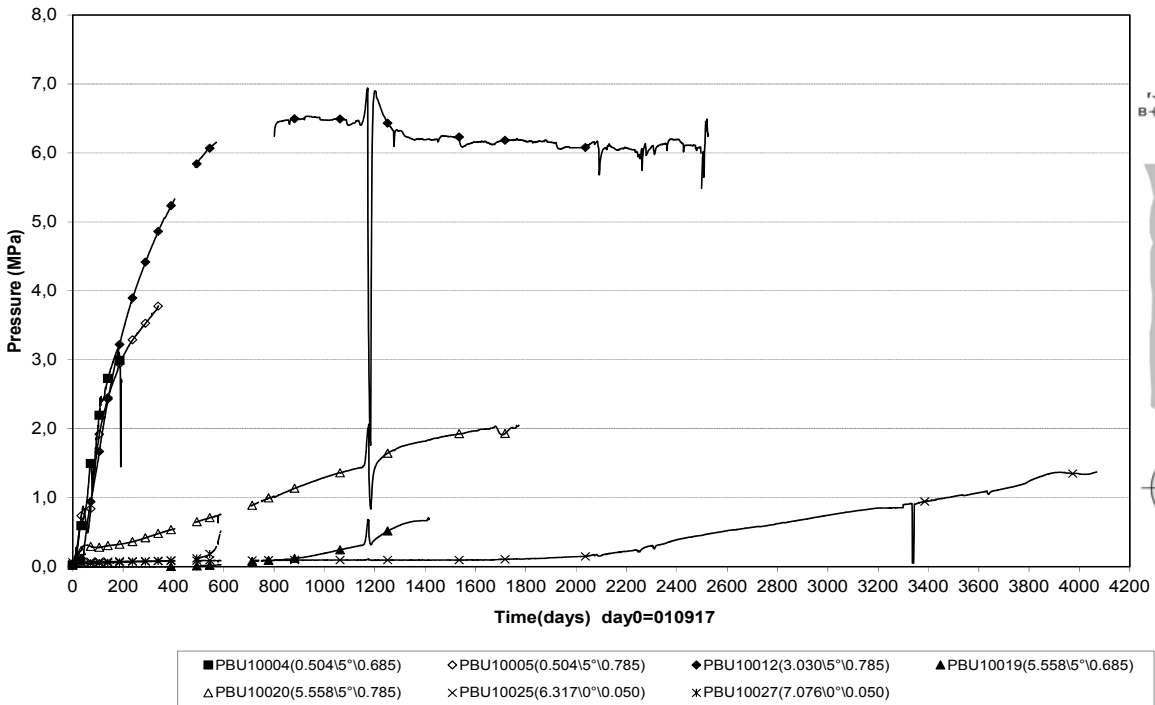
Dep. hole 1



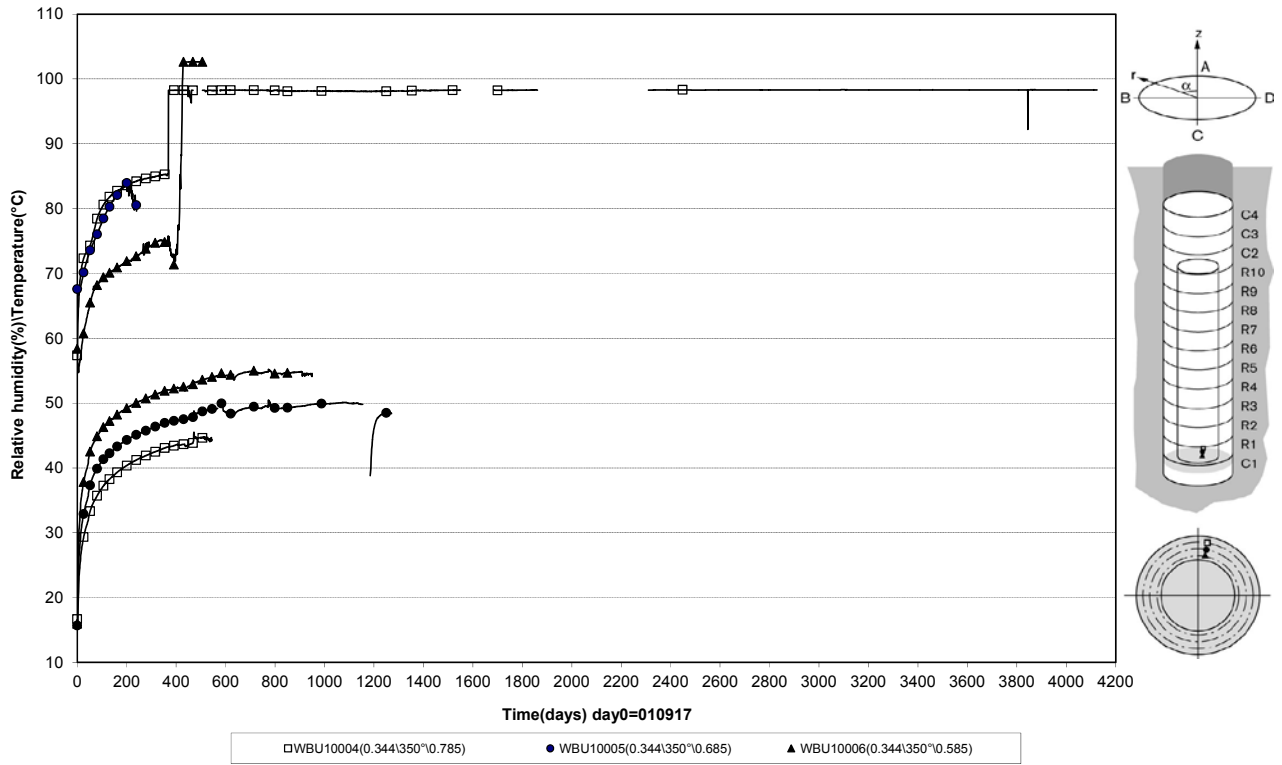
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Total pressure - Geokon



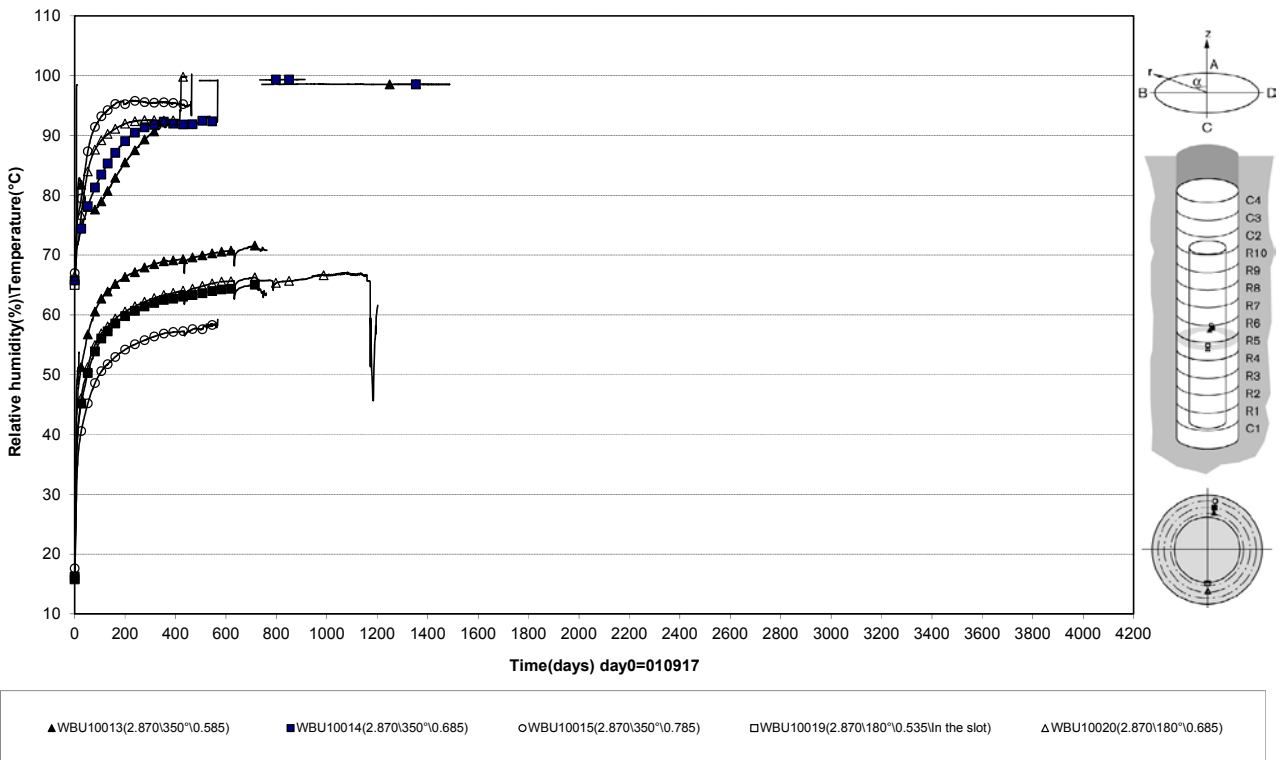
Prototype\ Hole 1 (010917-20130101)
Total pressure - Kulite



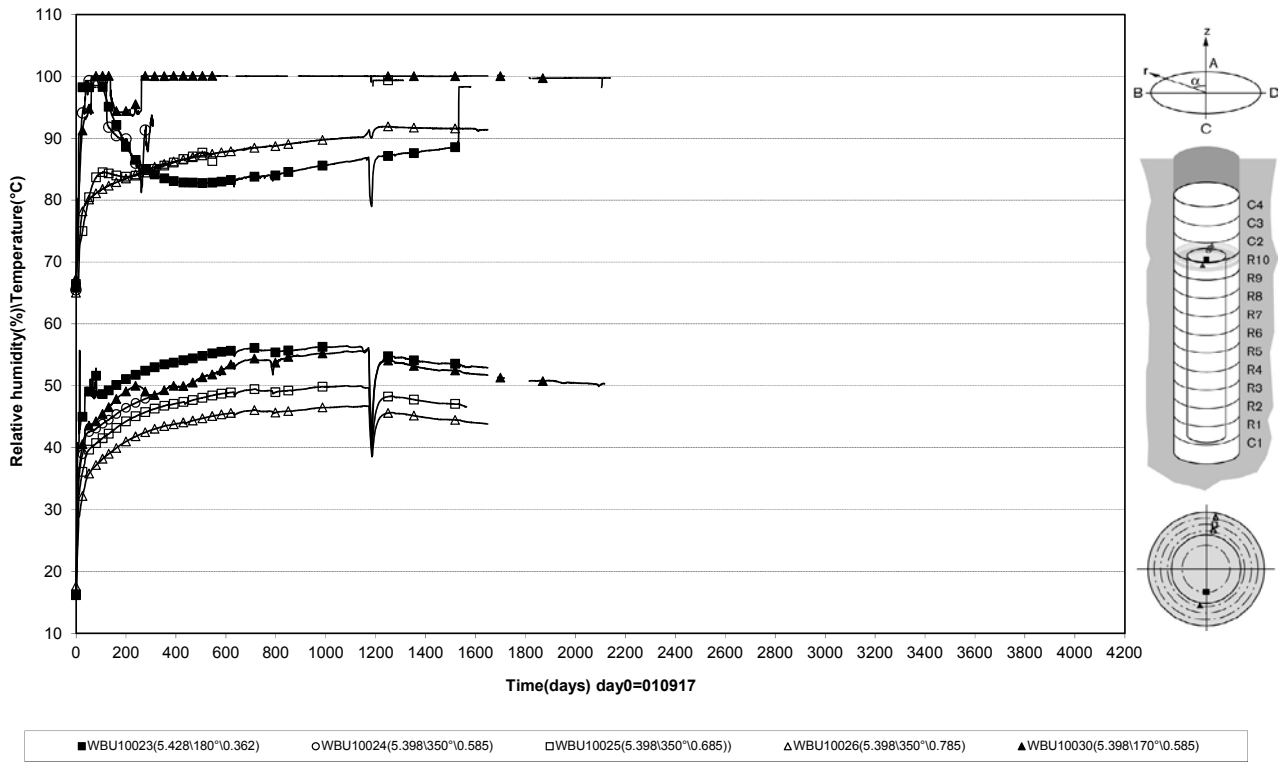
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Relative humidity - Vaisala



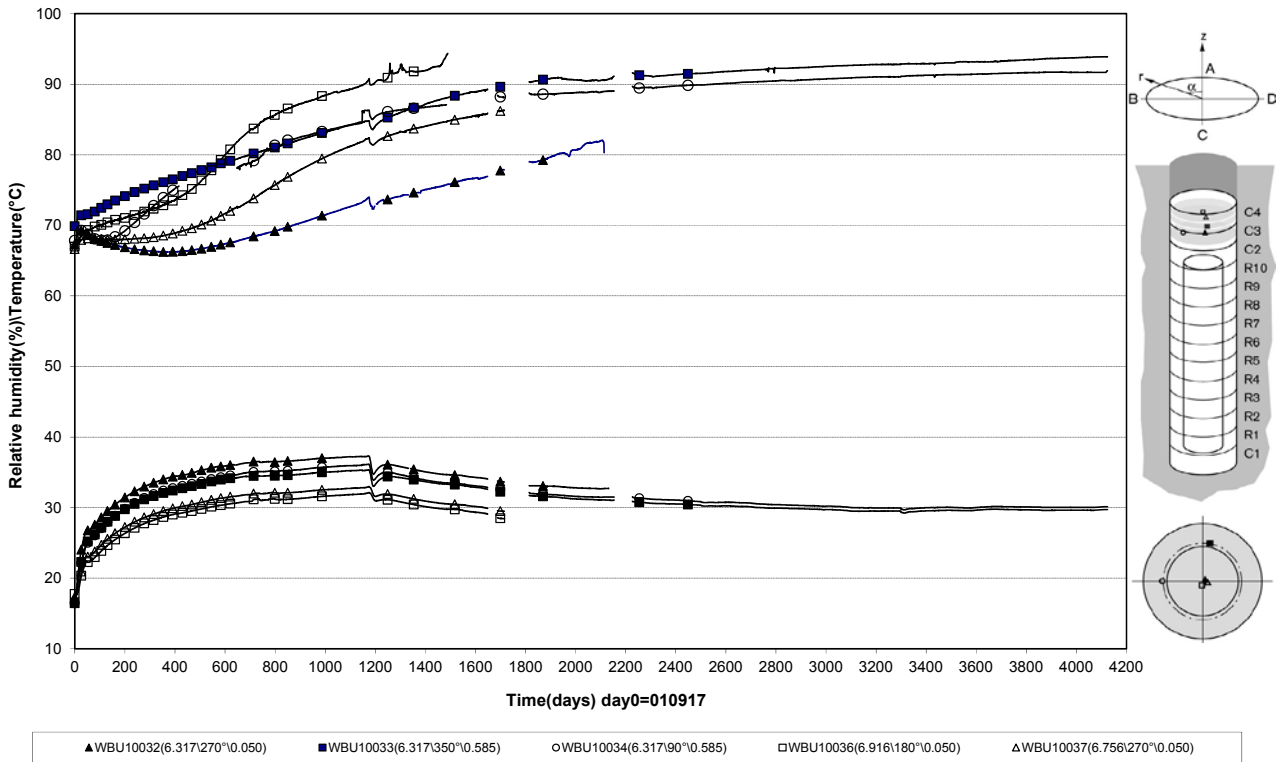
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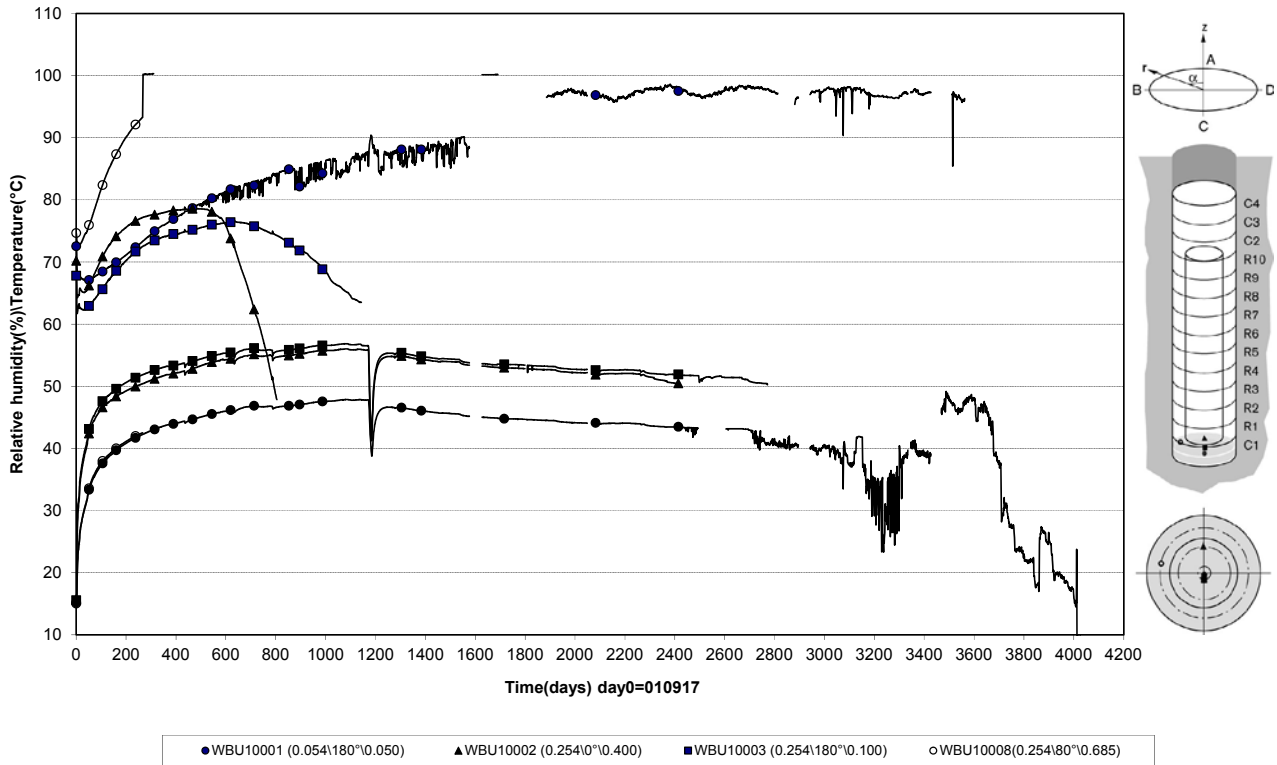
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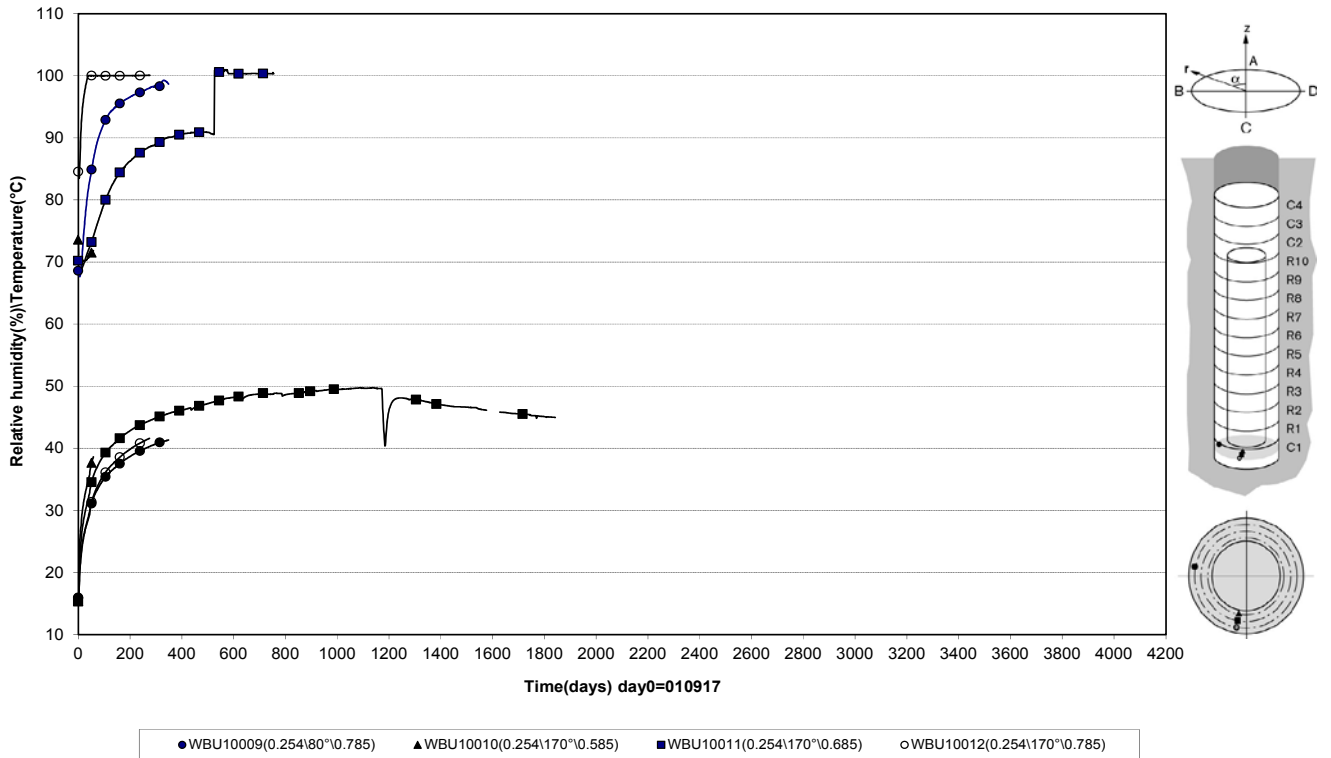
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Relative humidity - Vaisala



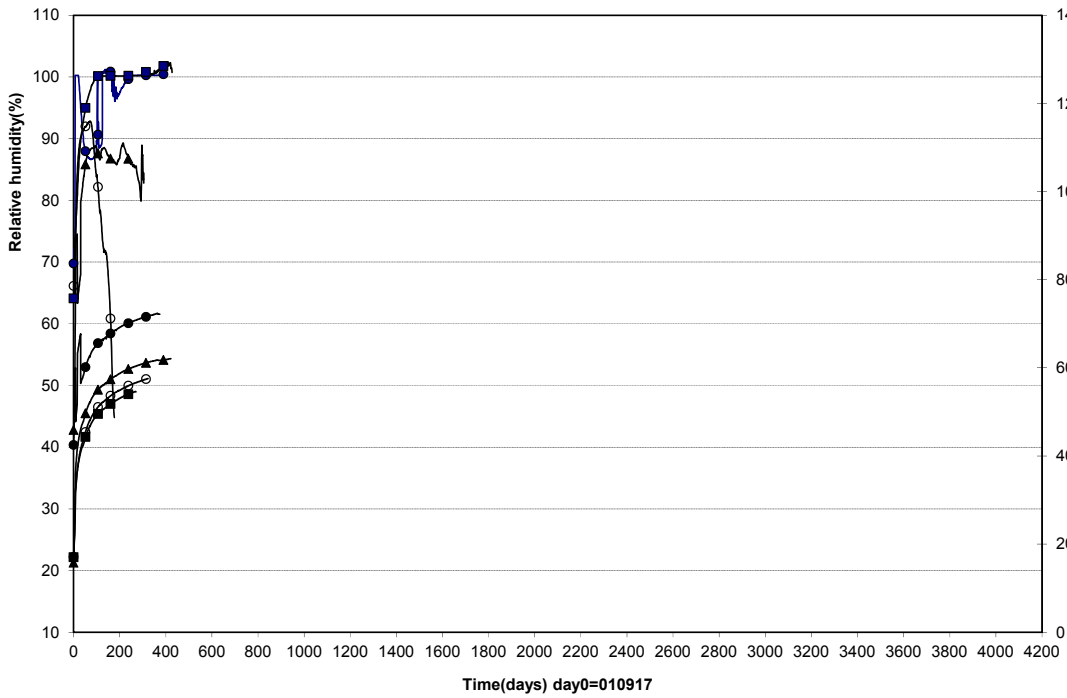
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Relative humidity - Rotronic



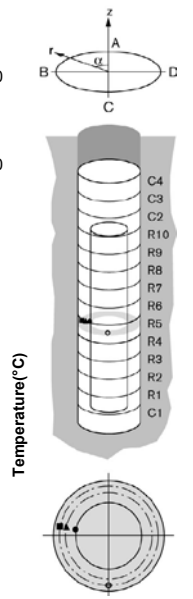
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Relative humidity - Rotronic



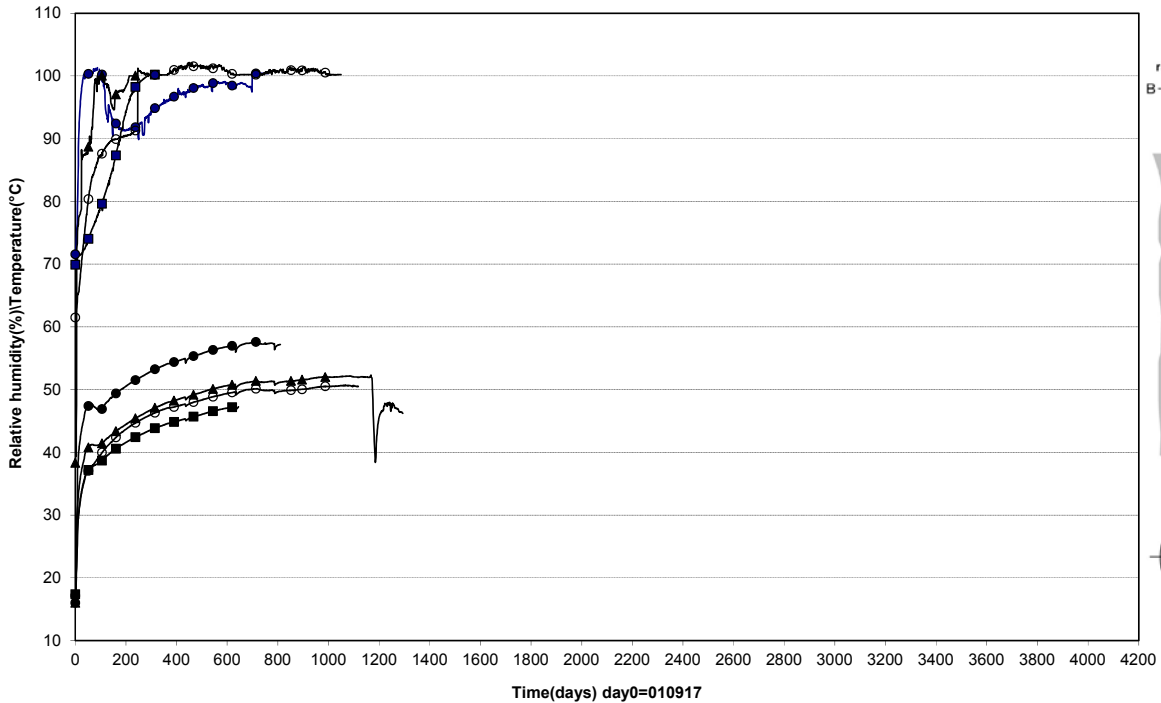
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Relative humidity - Rotronic



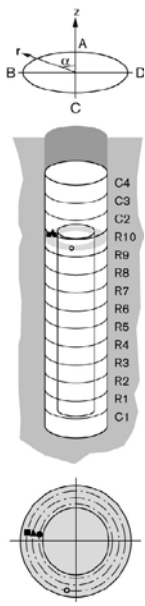
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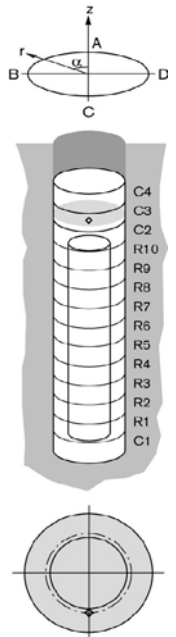
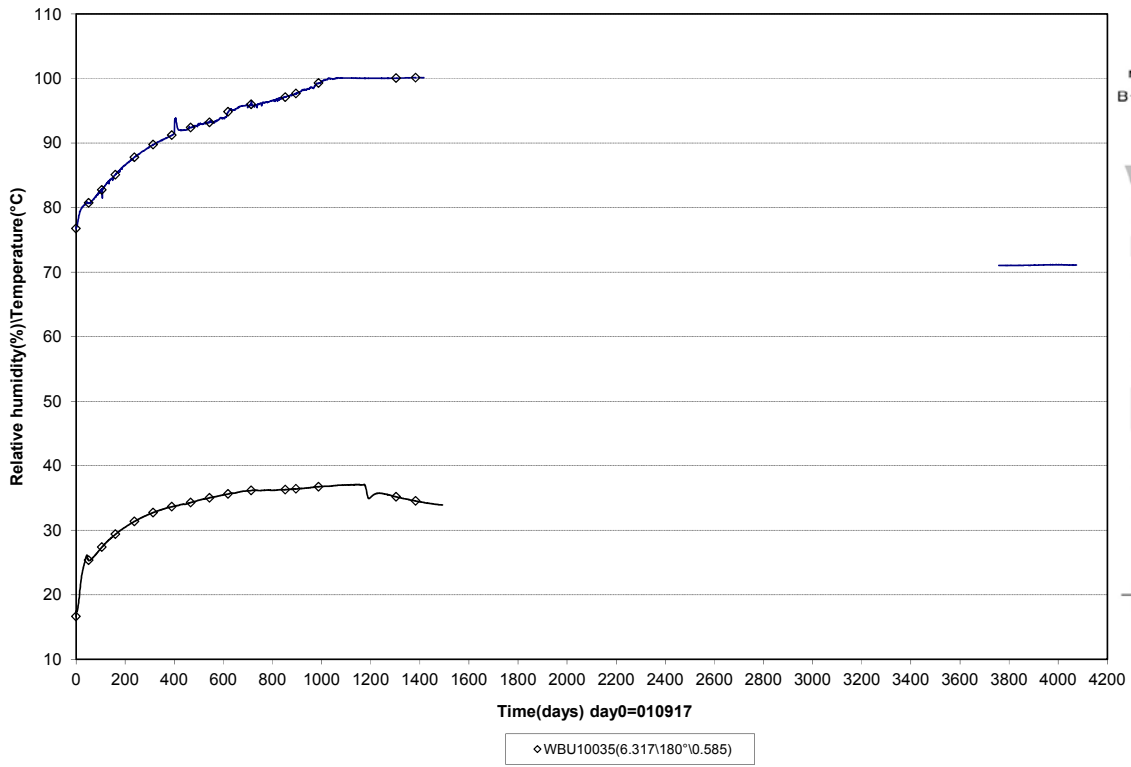
Prototyp\Hole 1\Ring10 (010917-20130101)
Relative humidity - Rotronic



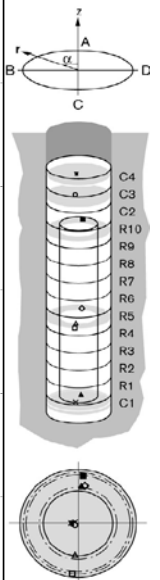
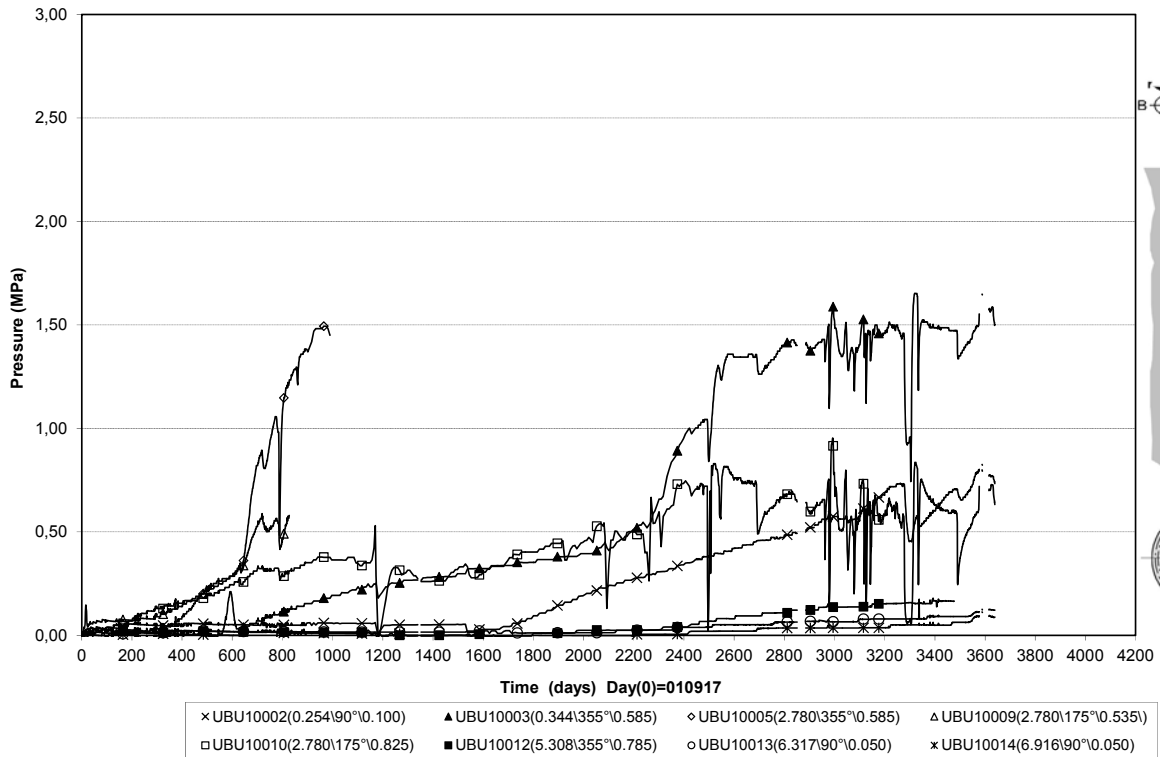
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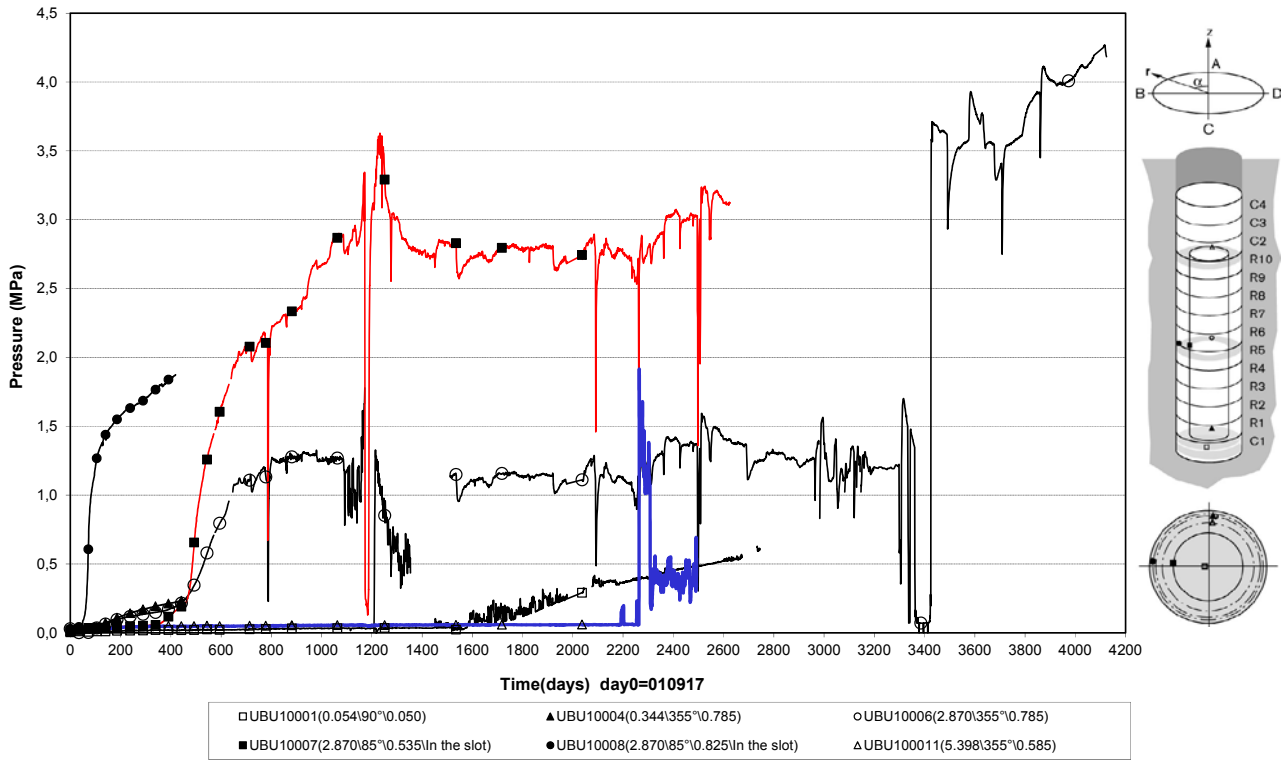
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Relative humidity - Rotronic



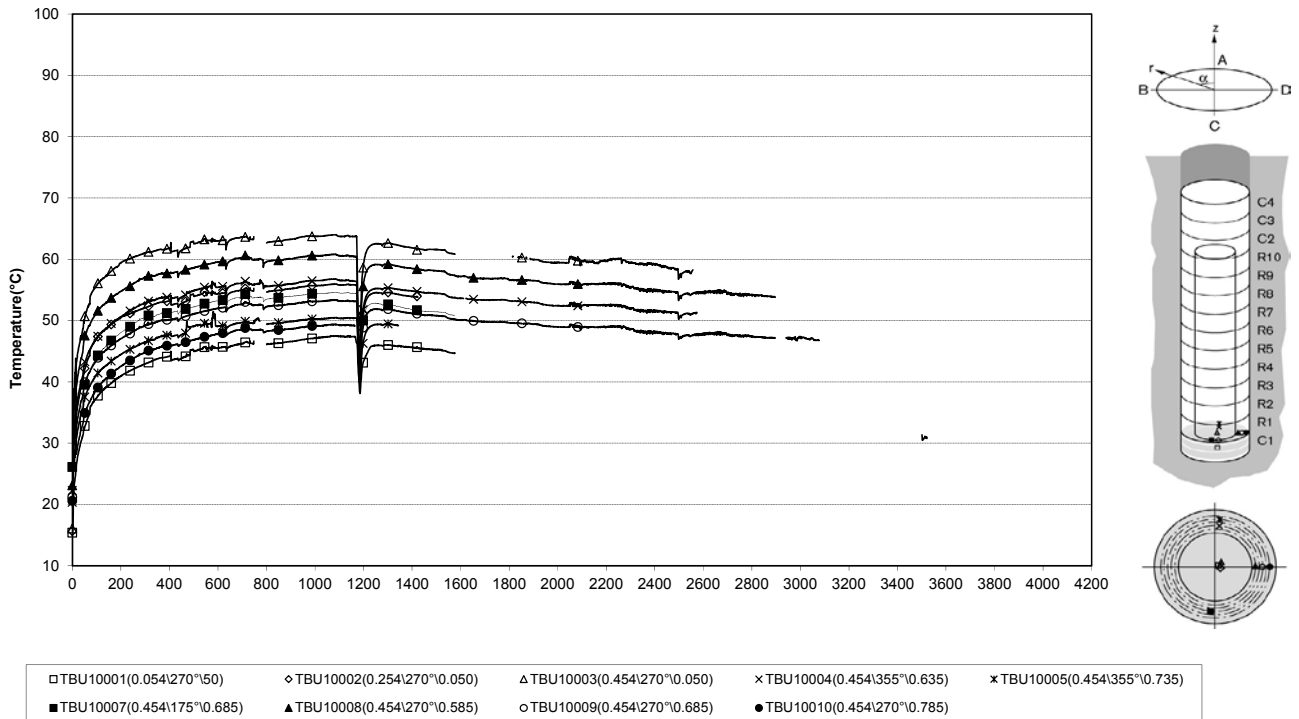
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Pore pressure - Geokon



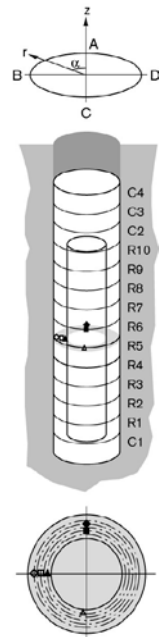
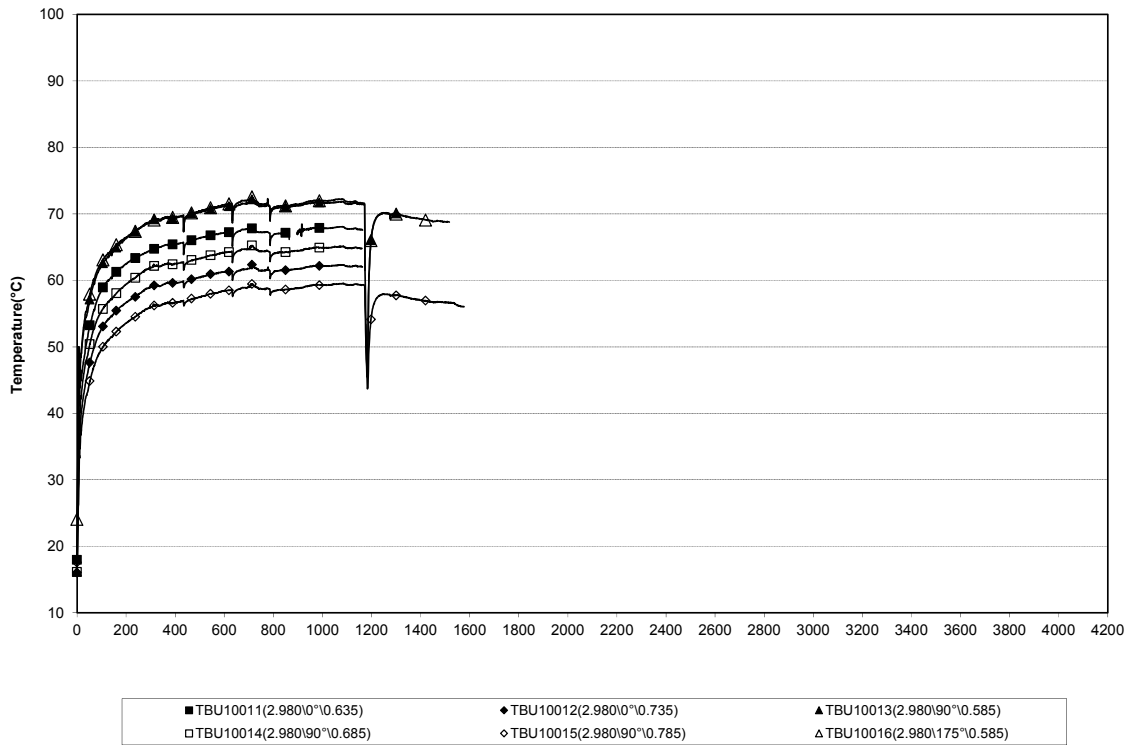
Prototype Hole 1 (010917-20130101)
Pore pressure - Kulite



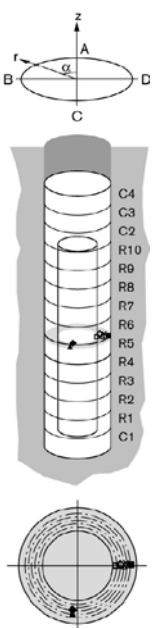
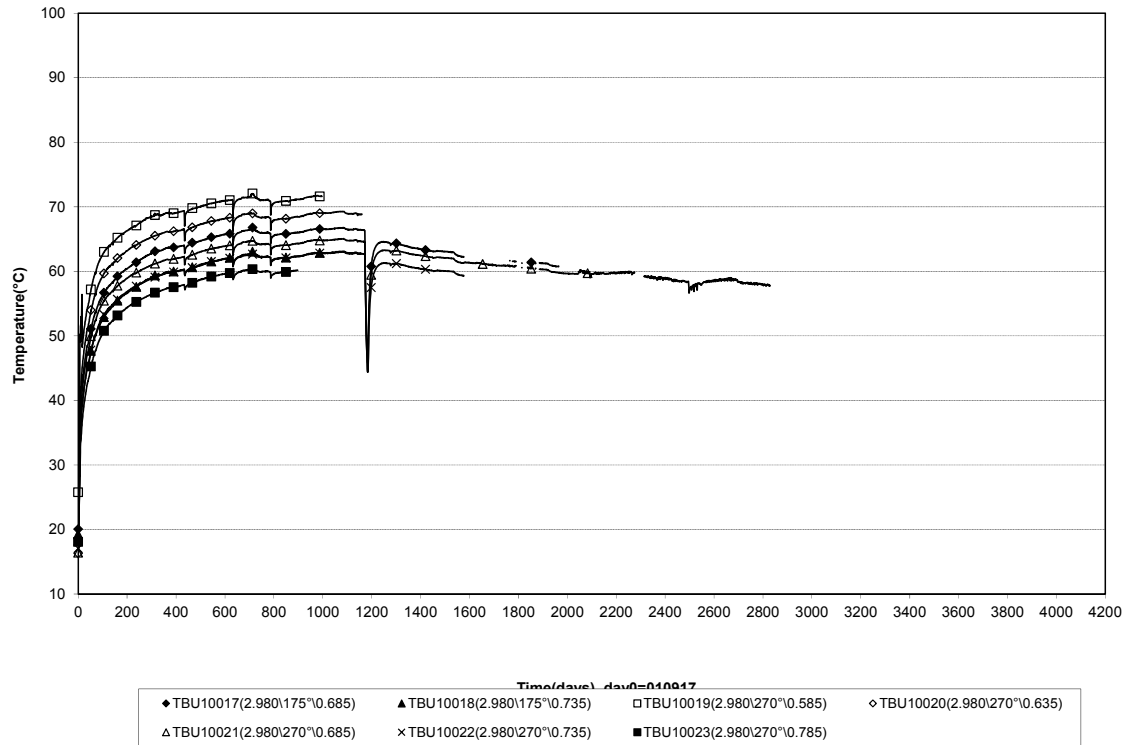
Prototype Hole 1\Cyl.1 (010917-20130101)
Temperature - Pentronic



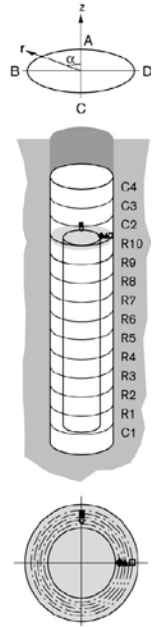
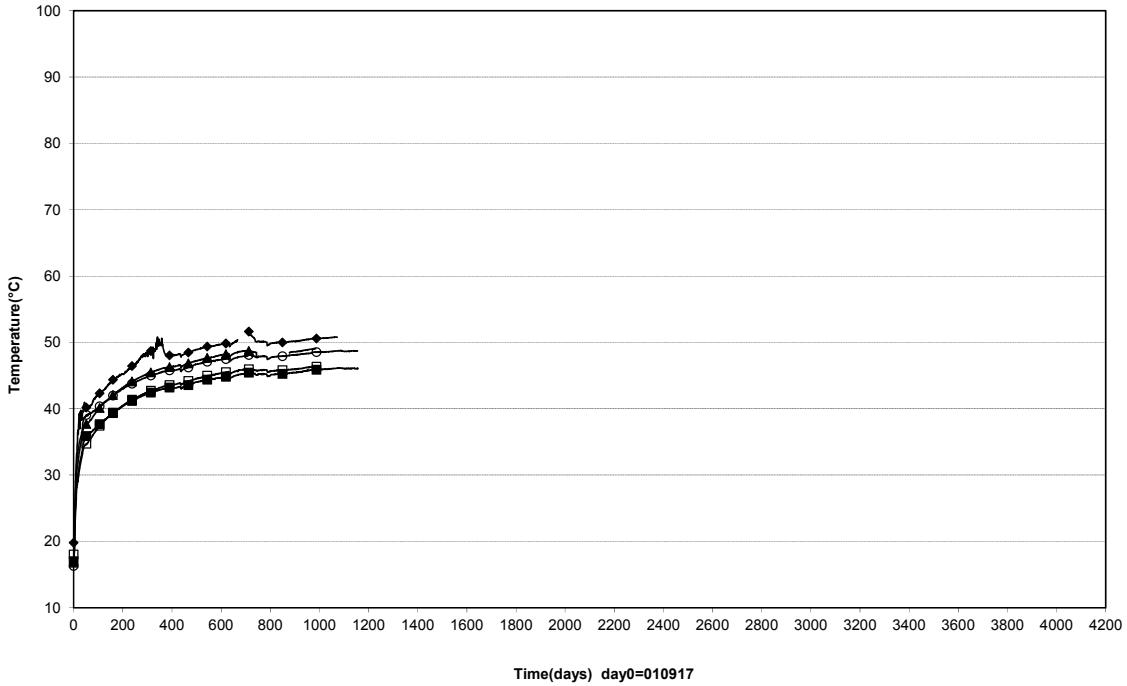
Prototype\Hole 1 \Ring5 (010917-20130101)
Temperature - Pentronic



Prototype\Hole 1 \Ring5 (010917-20130101)
Temperature - Pentronic

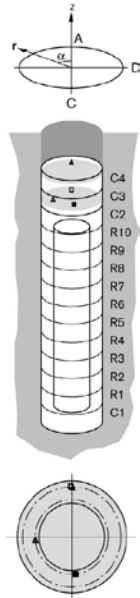
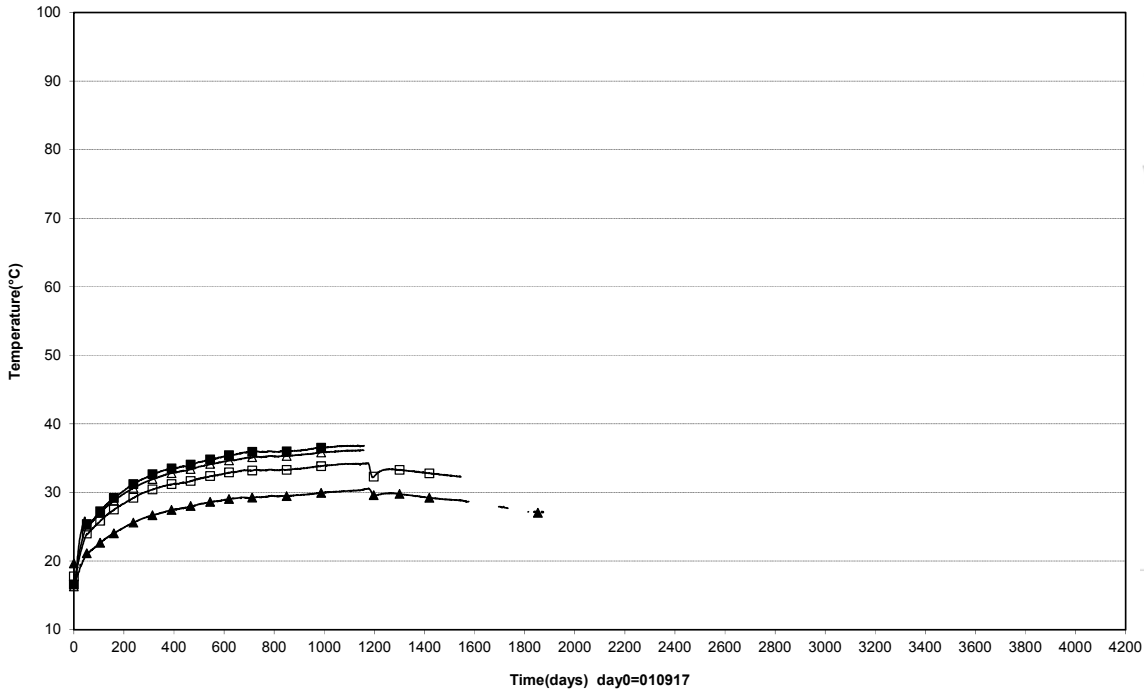


Prototype\Hole 1 \Ring10 (010917-20130101)
Temperature - Pentronic

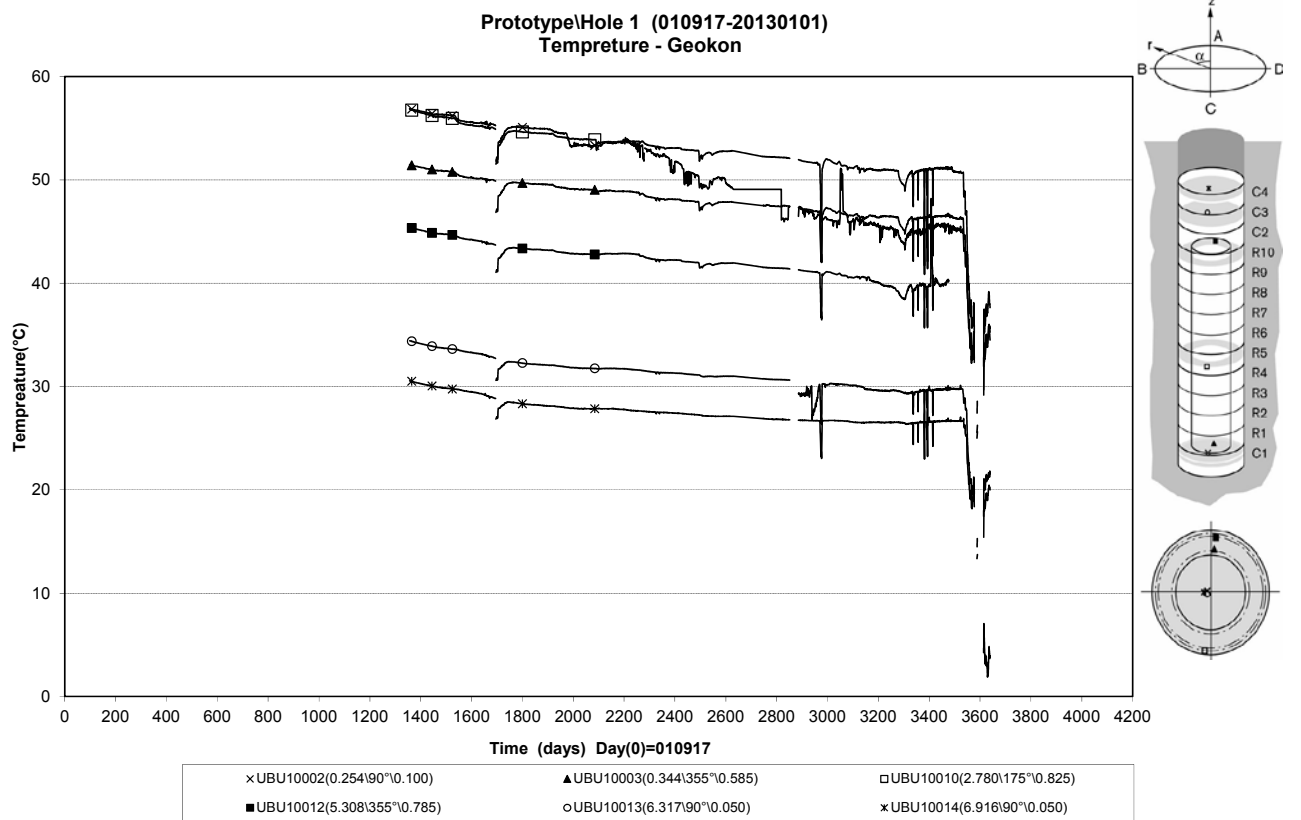
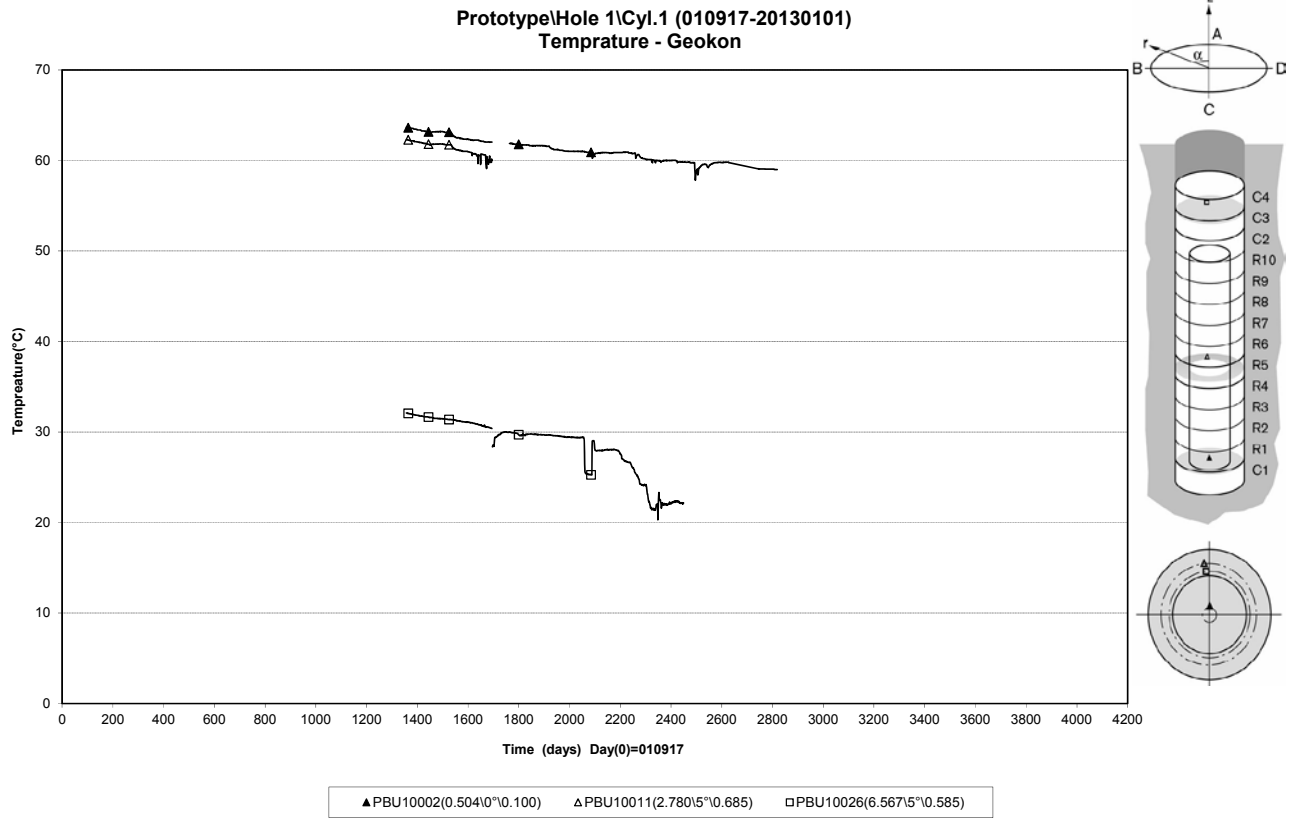


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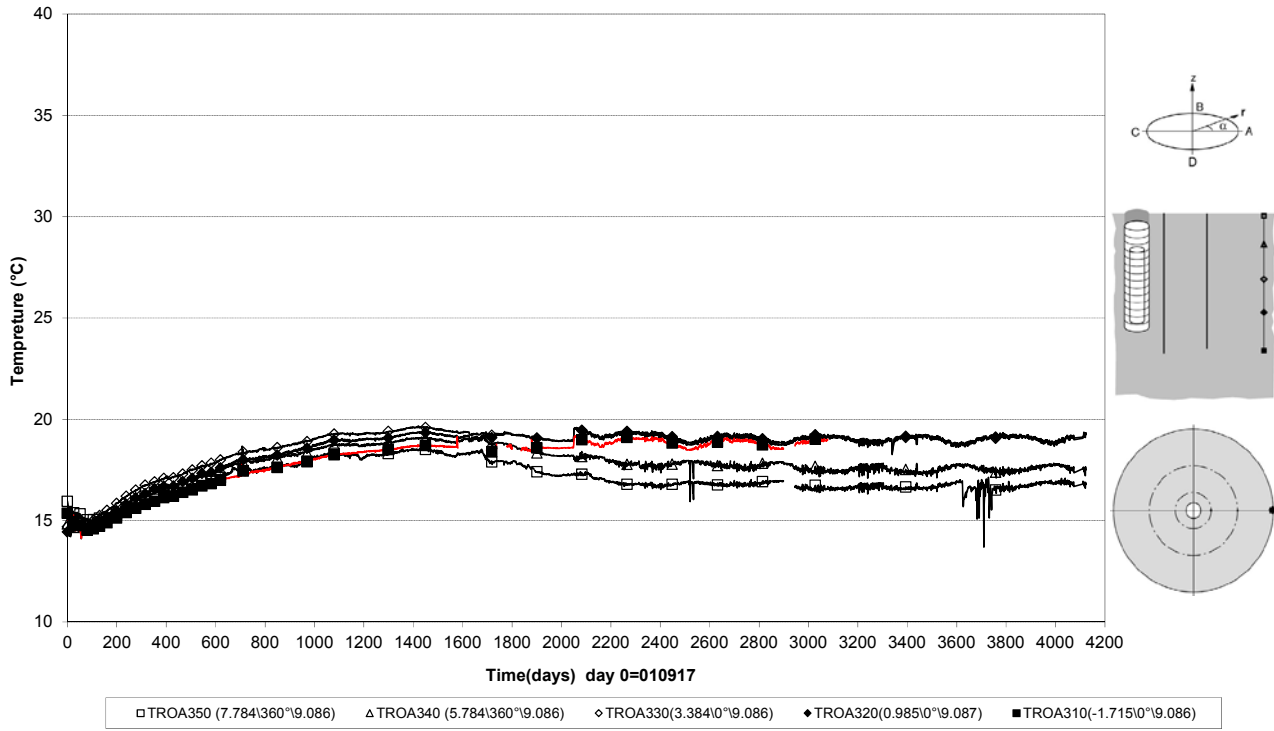
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Temperature - Pentronic



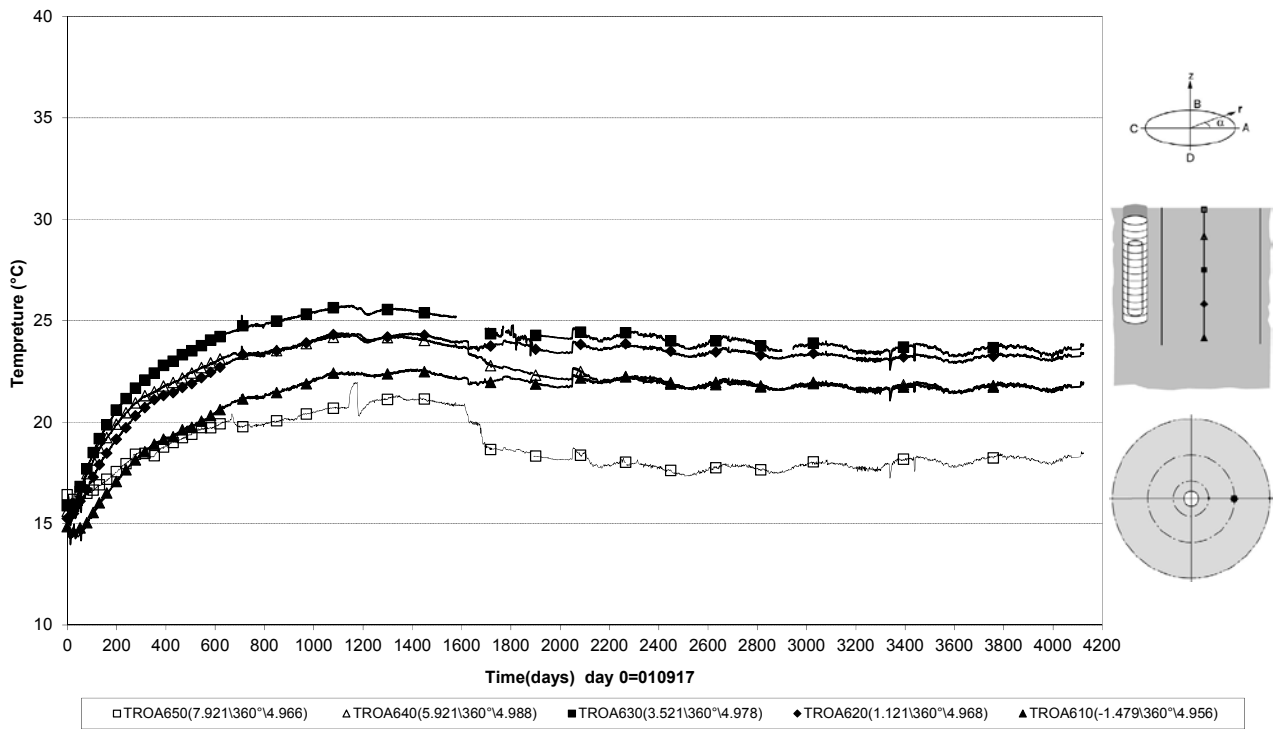
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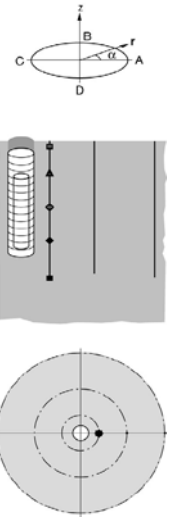
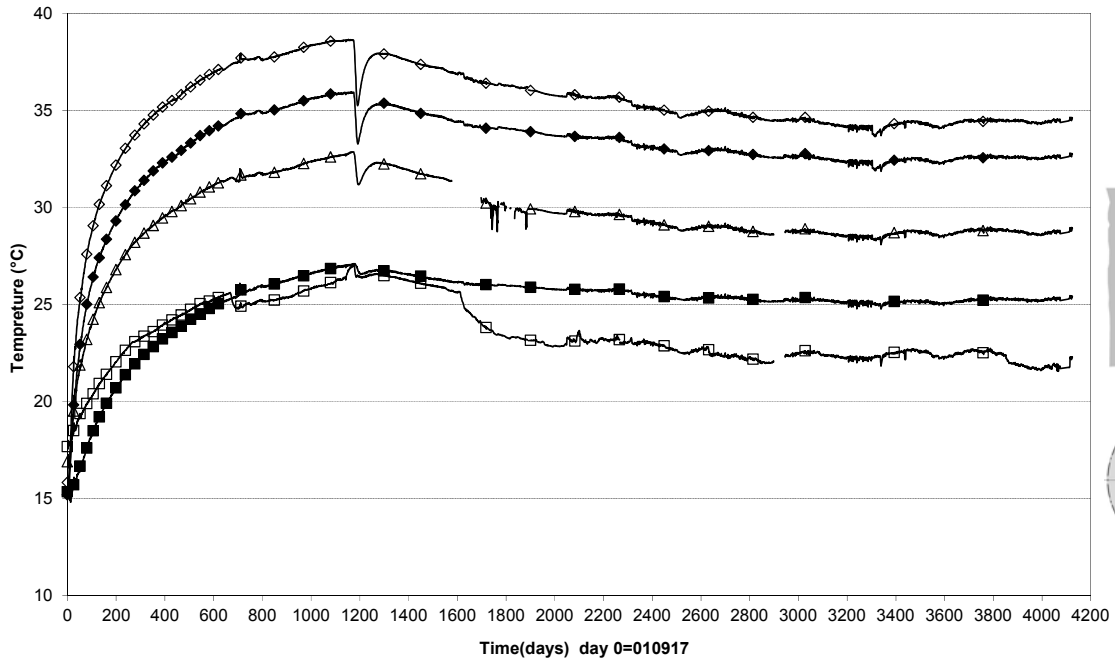
Prototype\Rock\Hole 1 (010917-20130101)
Temperature - Pentronic



Prototype\Rock\Hole 1 (010917-20130101)
Temperature - Pentronic

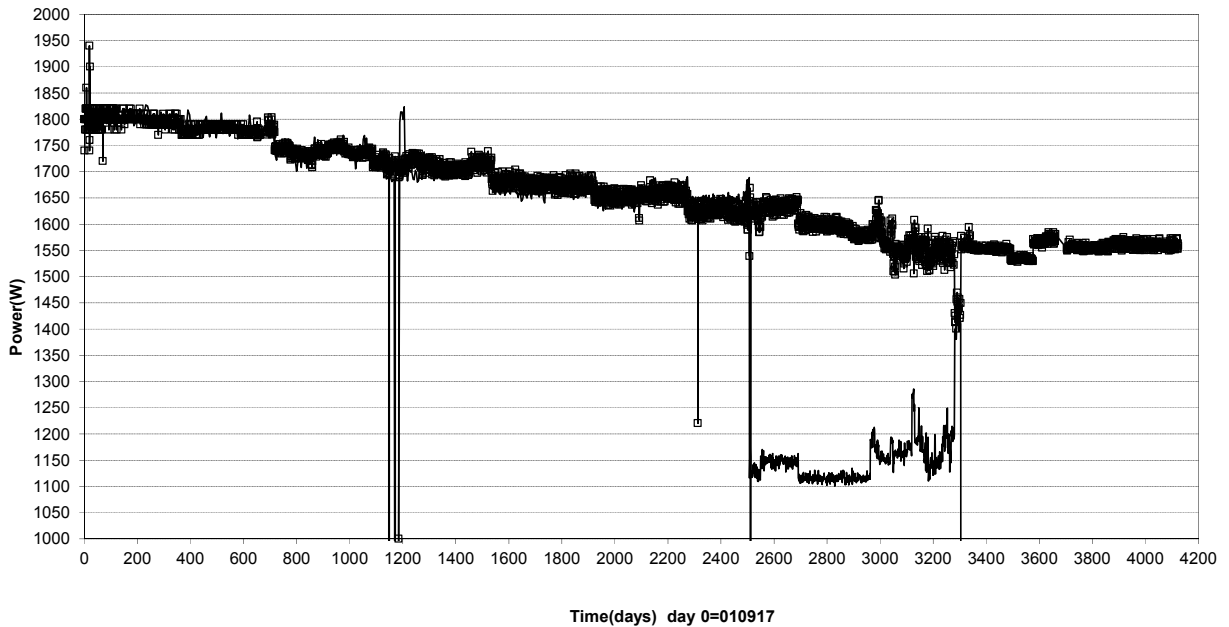


Prototype\Rock\Hole 1 (010917-20130101)
Temperature - Pentronic



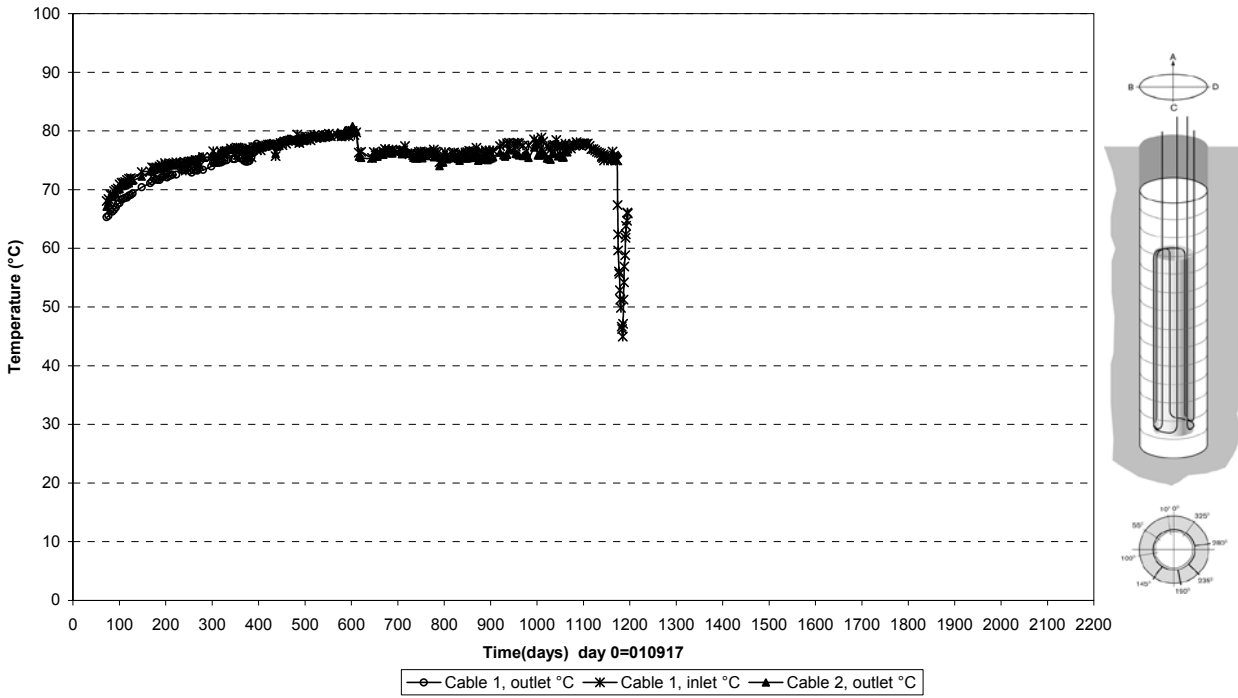
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Prototype\ Hole 1 (20010917-20130101)
Canister power

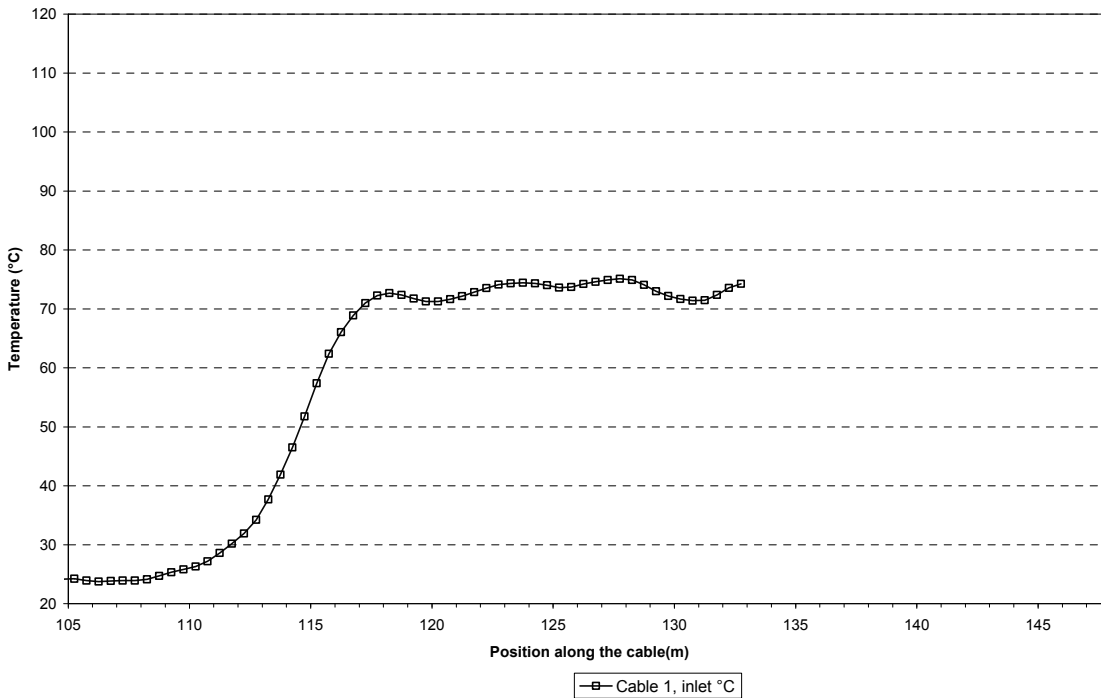


— Measured power (W) □ Power-used energy (W)

Prototypel Hole 1 \ Canister (010917-070601)
 Max. temperature on the canister surface - Optical fiber cables



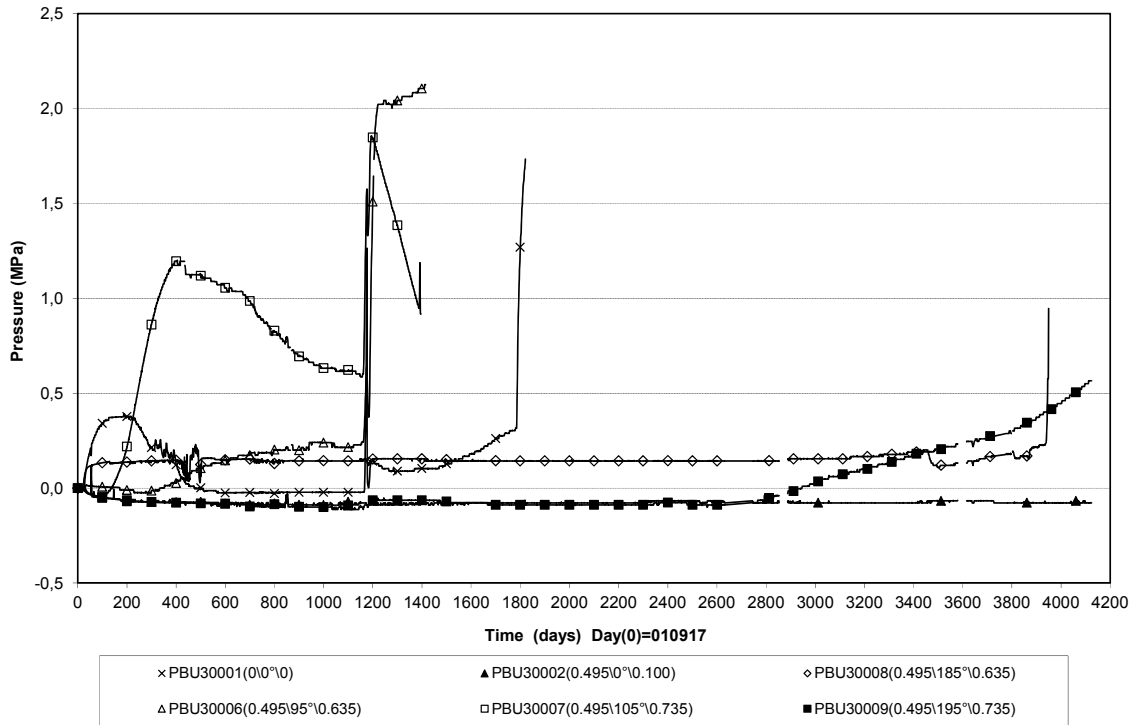
Prototypel Hole 1 \ Canister (041201)
 Temperature profile on the canister surface - Optical fiber cables



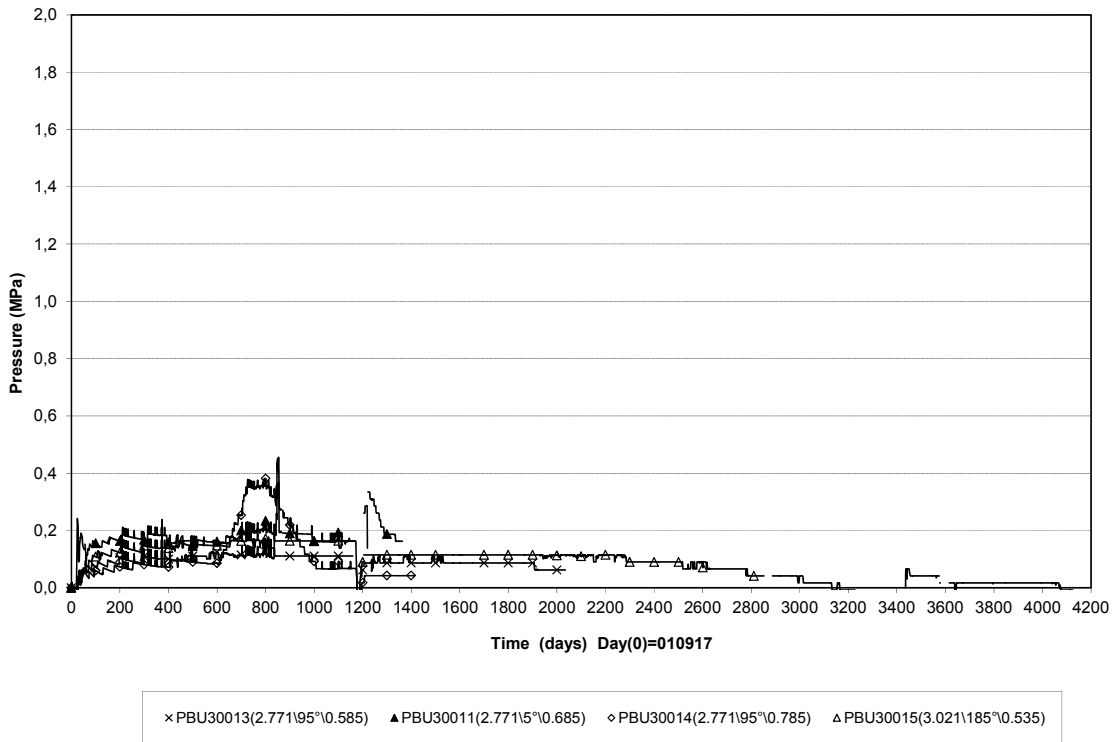
Appendix 2

Dep.hole 3

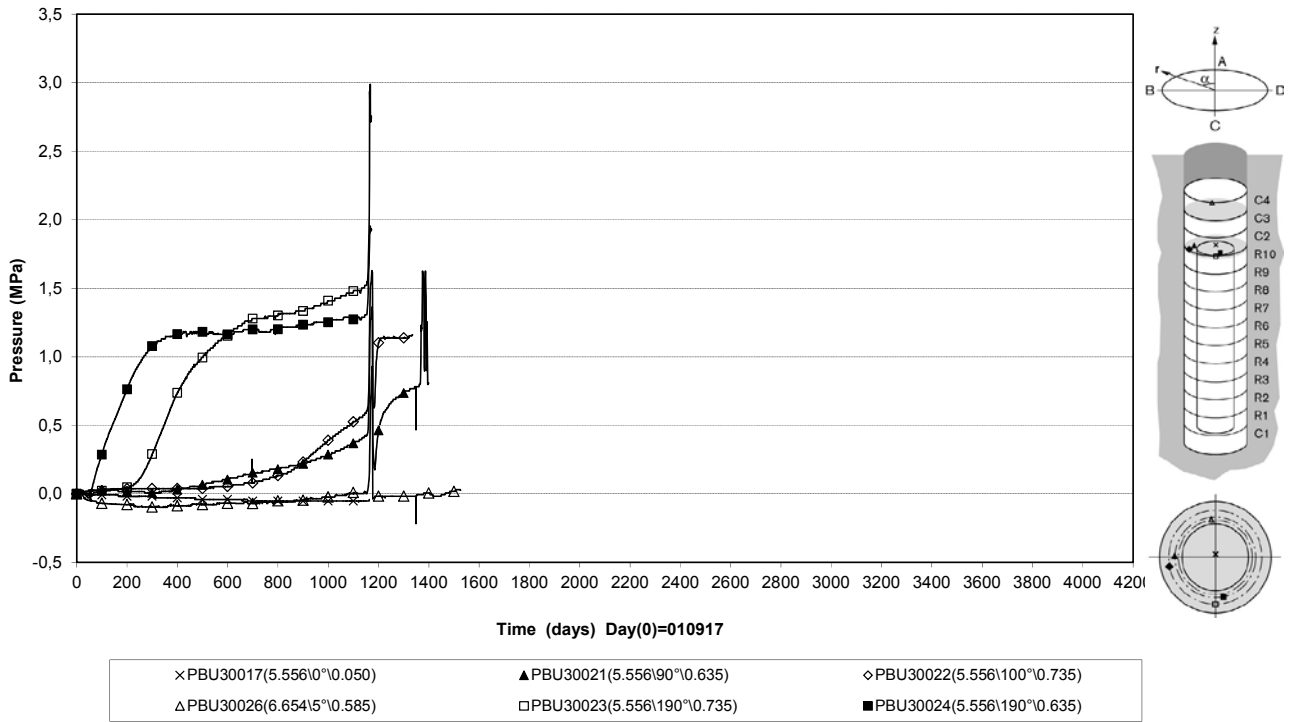
Prototype\Hole 3\Cyl.1 (010917-20130101)
Total pressure - Geokon



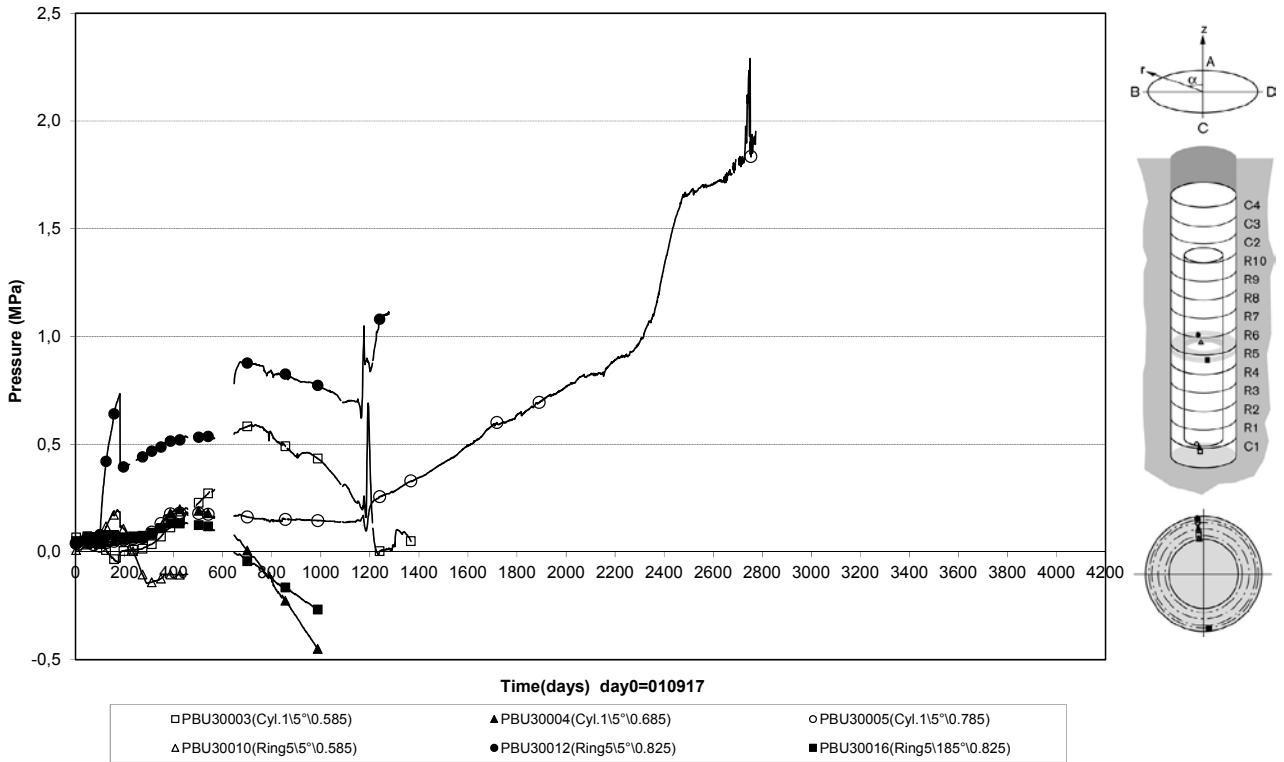
Prototype\Hole 3 \Ring5 (010917-20130101)
Total pressure - Geokon



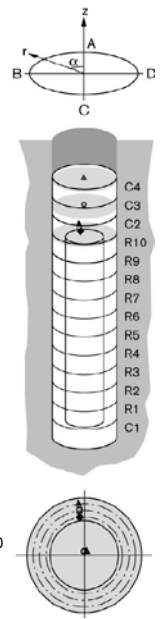
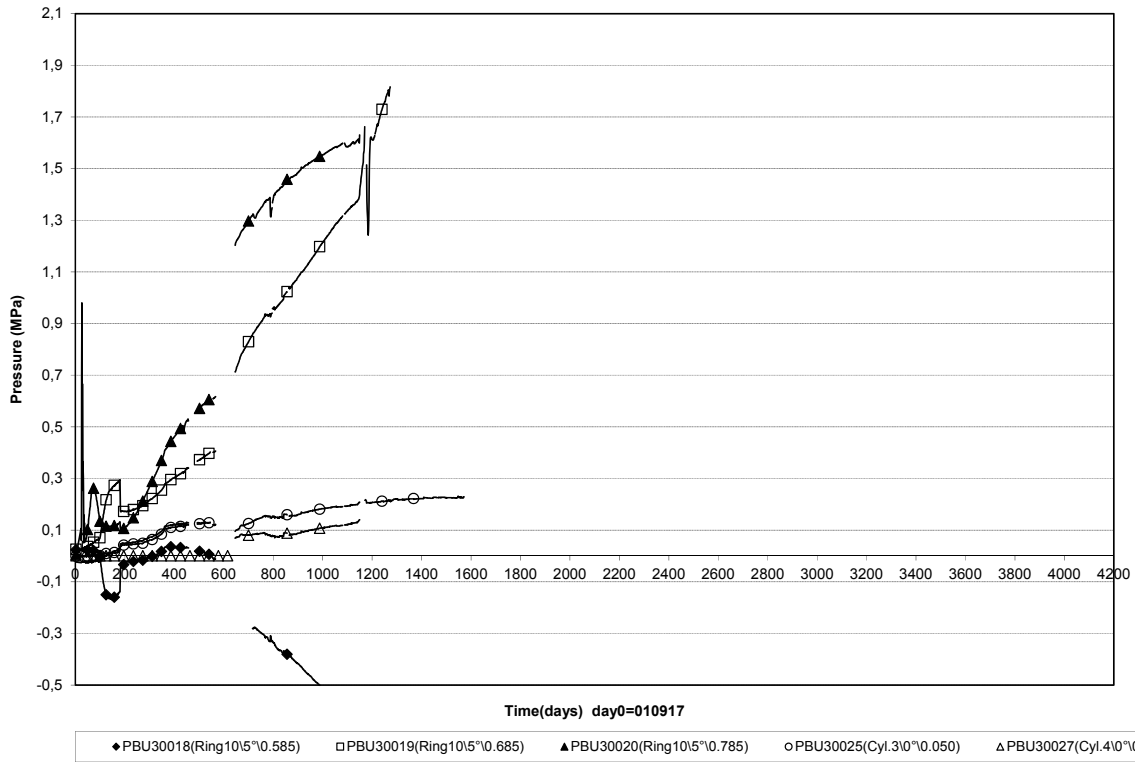
Prototype\Hole 3\Ring10 and Cyl.3 (010917-20130101)
Total pressure - Geokon



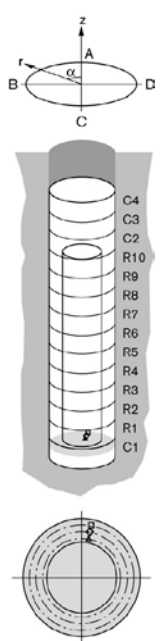
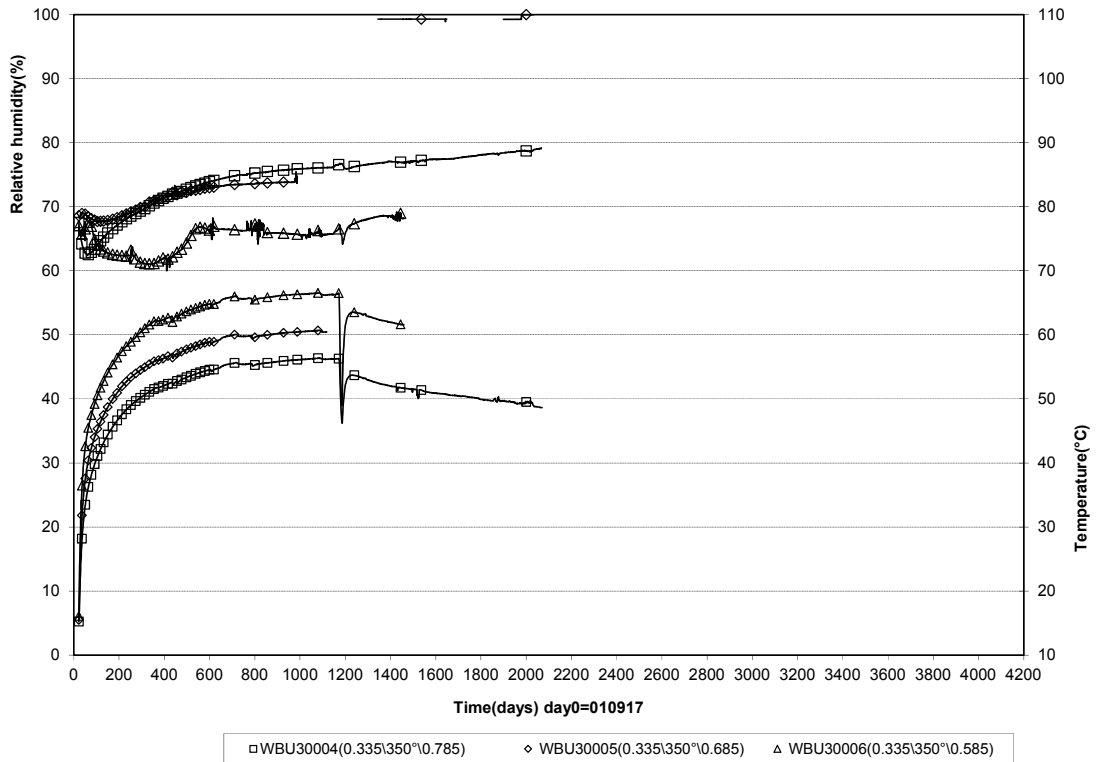
Prototype\Hole 3\Cyl.1 and Ring5 (010917-20130101)
Total pressure - Kulite



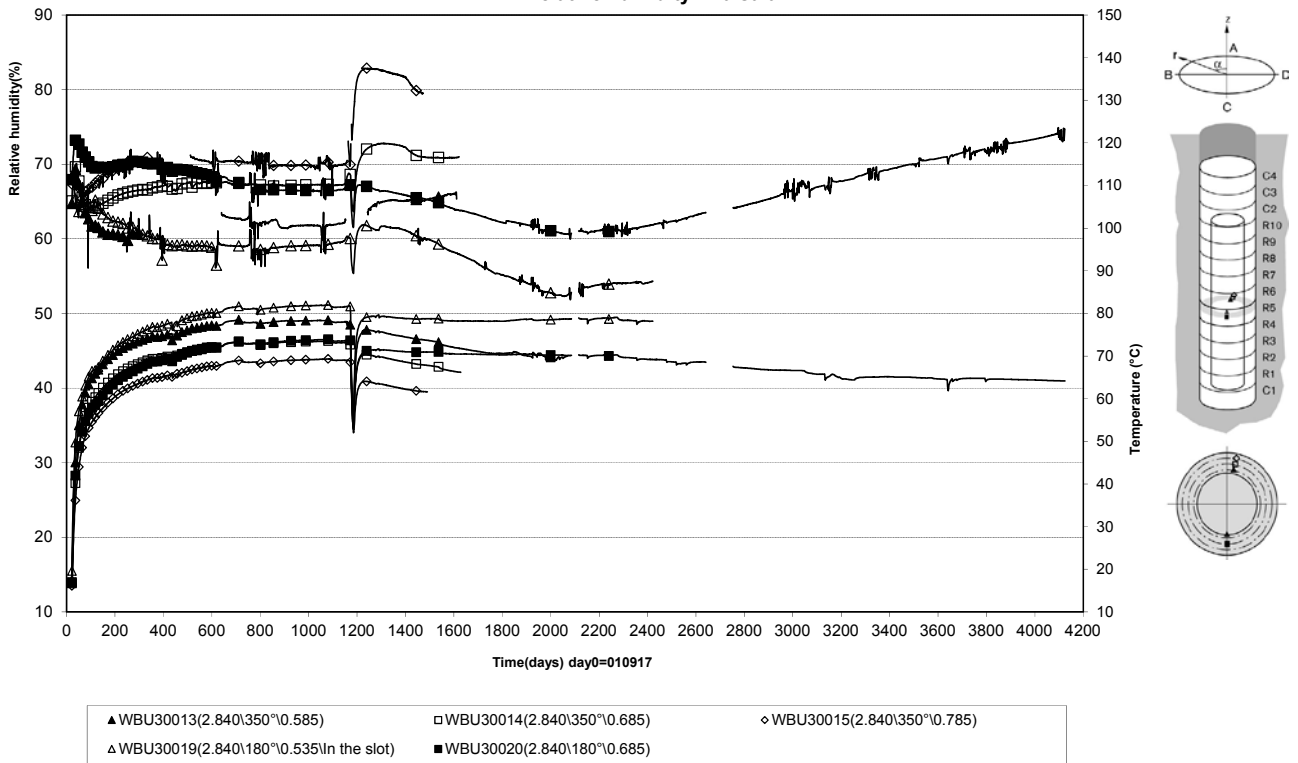
Prototype\Hole 3\Ring10 and Cyl.3-4 (010917-20130101)
Total pressure - Kulite



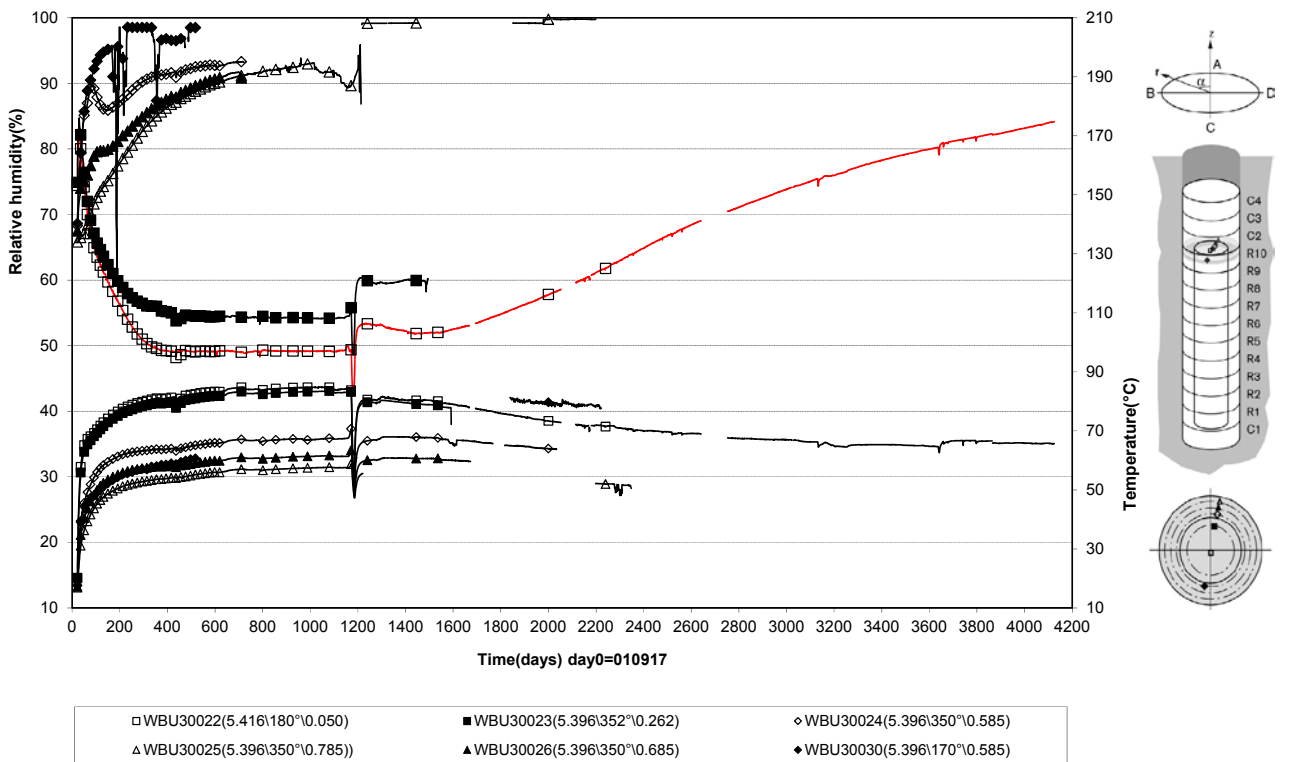
Prototype\Hole 3\Cyl.1 (010917-20130101)
Relative humidity - Vaisala



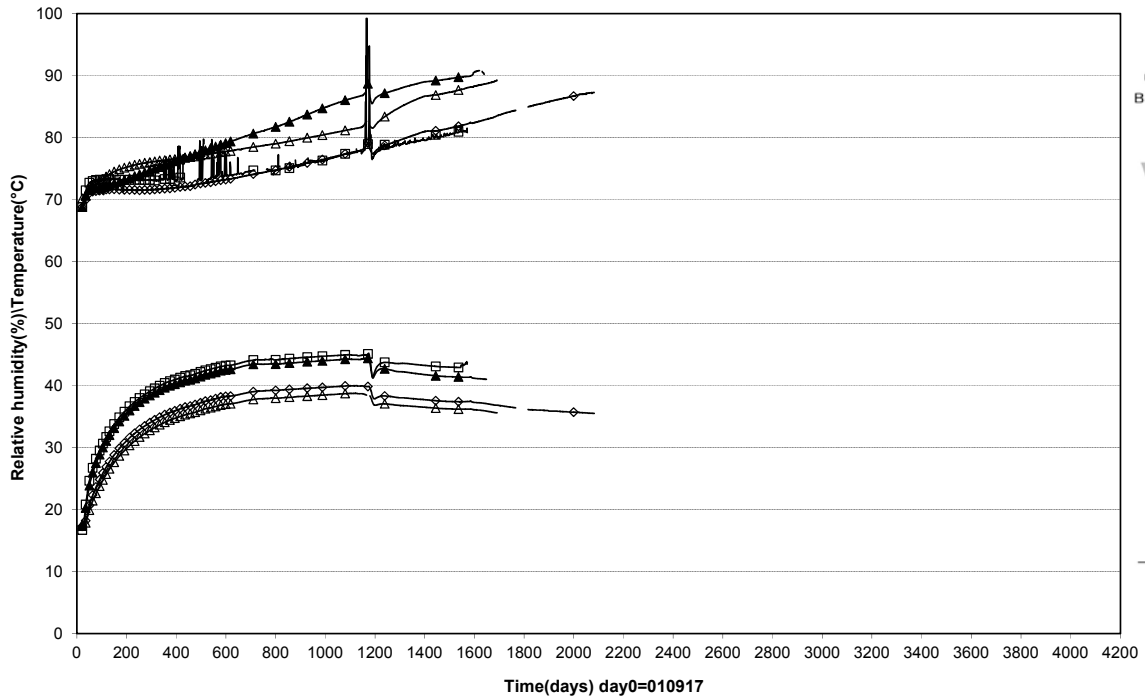
Prototype\Hole 3\Ring 5 (010917-20130101)
Relative humidity - Vaisala



Prototype\Hole 3\Ring 10 (010917-20130101)
Relative humidity - Vaisala

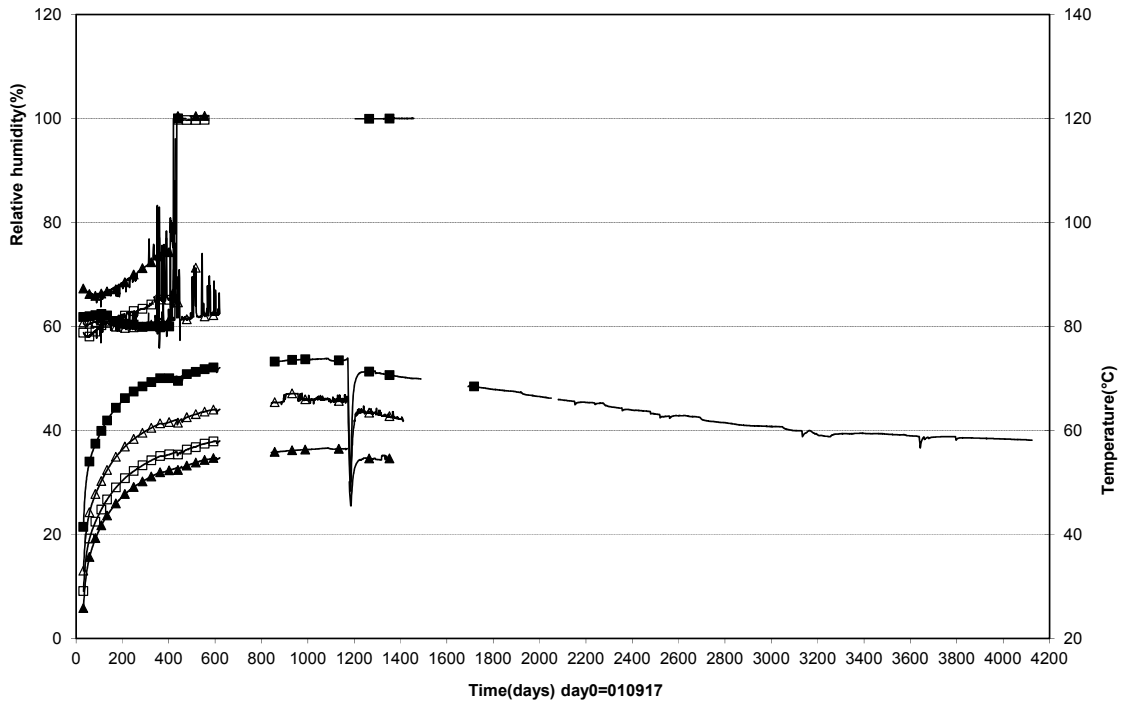


Prototype\Hole 3\Cyl.3 and Cyl.4 (010917-20130101)
Relative humidity - Vaisala



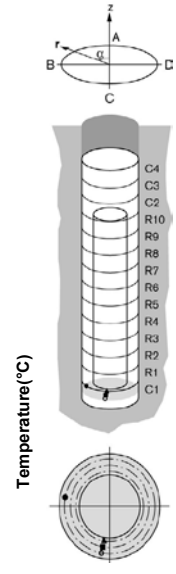
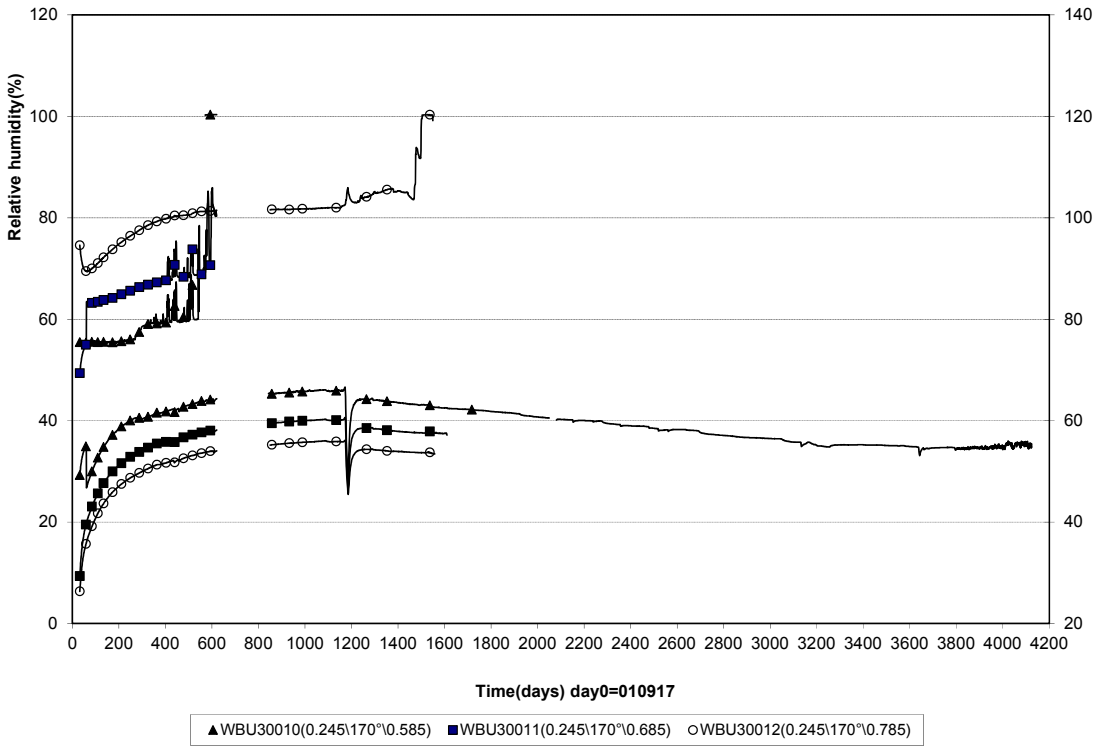
□WBU30032(6.314\180°\0.050) ▲WBU30033(6.314\350°\0.585) △WBU30036(6.680\180°\0.050) ◇WBU30037(6.840\270°\0.050)

Prototype\Hole 3\Cyl.1 (010917-20130101)
Relative humidity - Rotronic

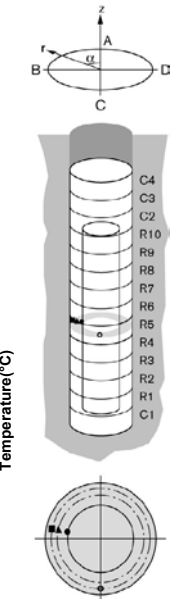
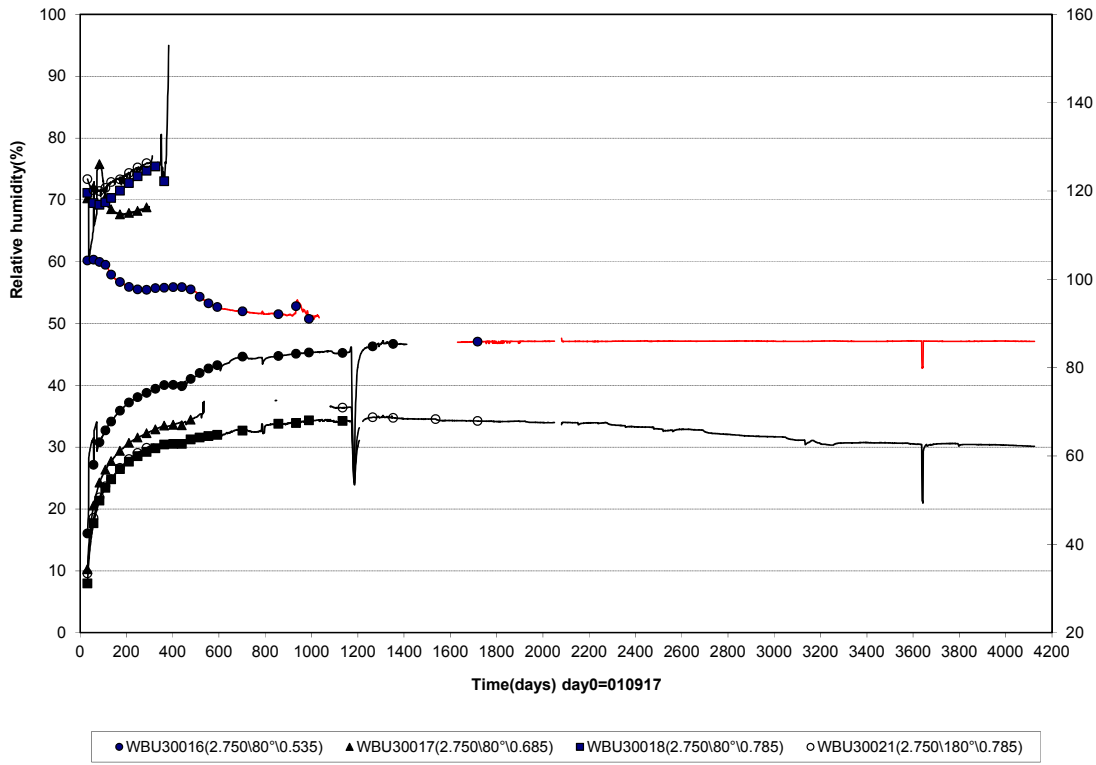


□WBU30001(0.045\180°\0.050) △WBU30002(0.215\0°\0.400) ■WBU30003(0.245\180°\0.100) ▲WBU30008(0.245\80°\0.685)

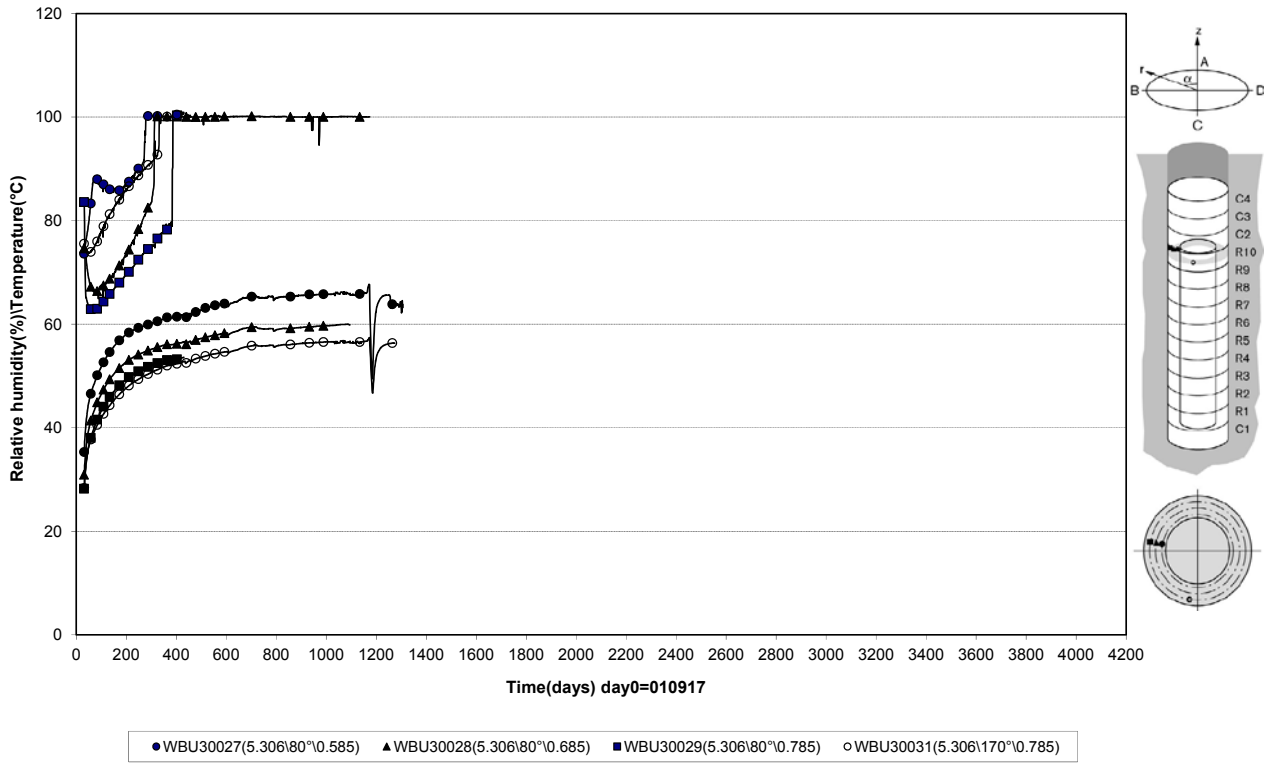
Prototype\Hole 3\Cyl.1 (010917-20130101)
Relative humidity - Rotronic



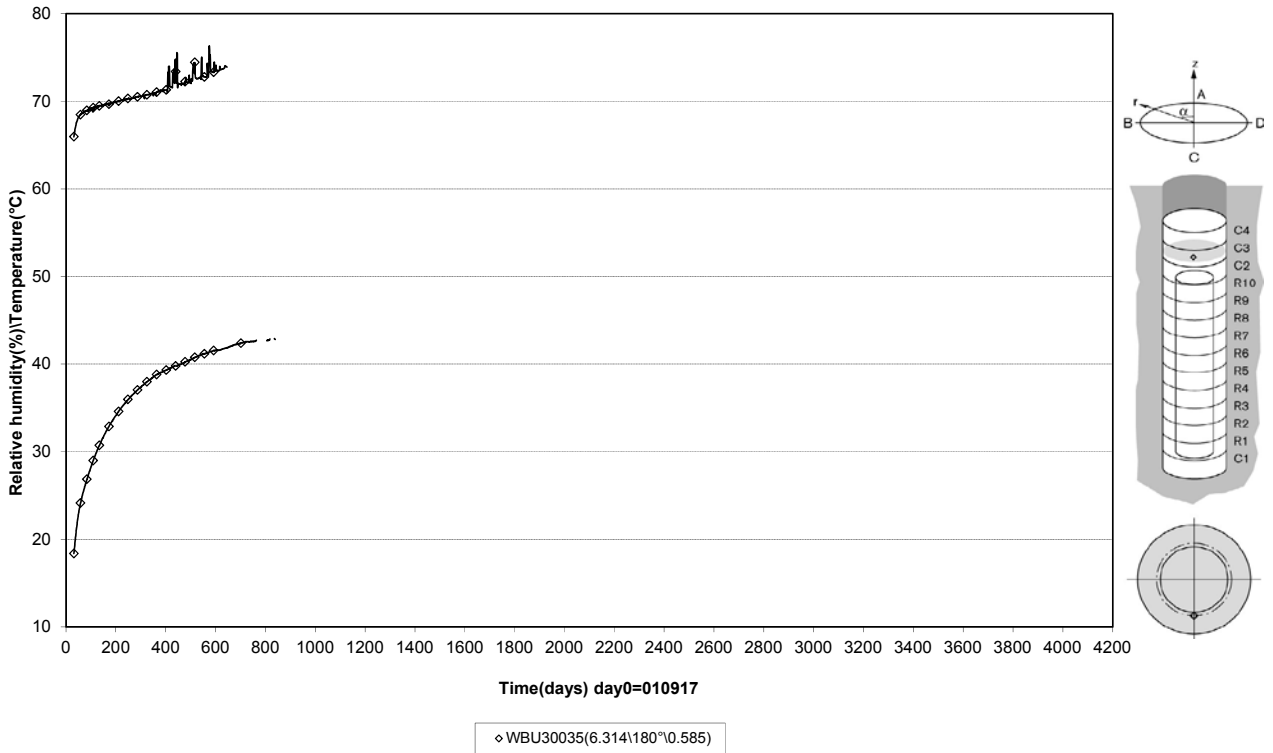
Prototype\Hole 3\Ring 5 (010917-20130101)
Relative humidity - Rotronic



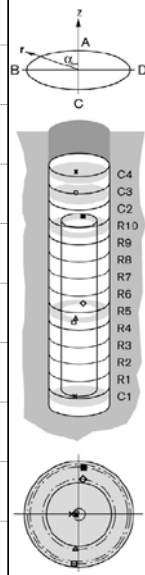
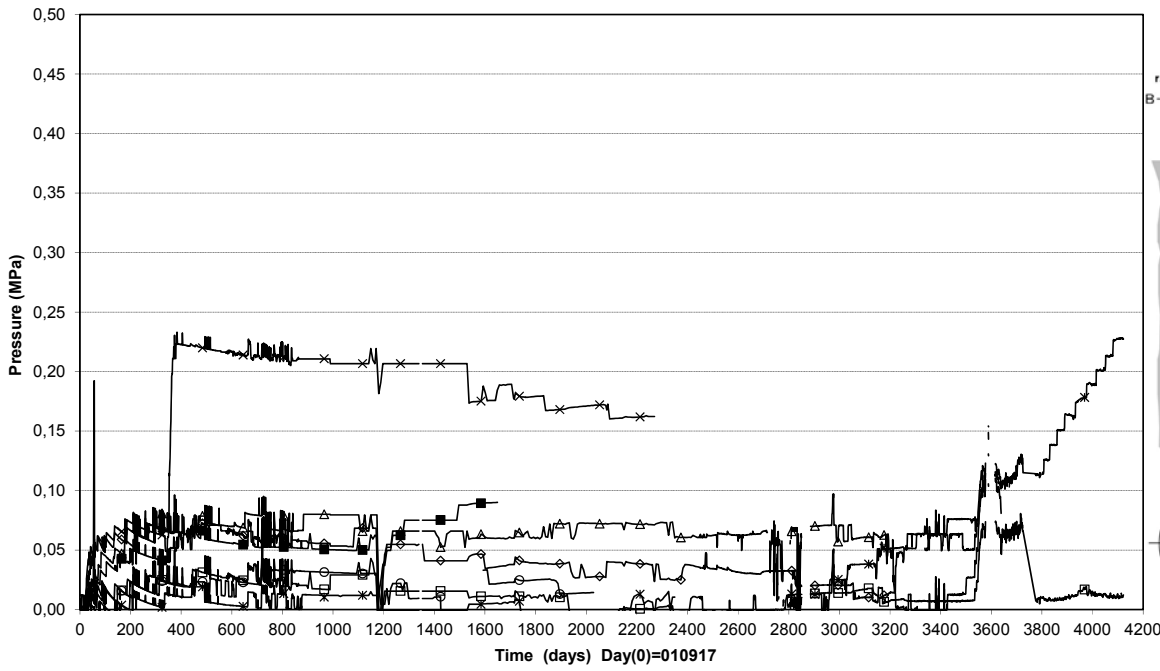
Prototype\Hole 3\Ring 10 (010917-20130101)
Relative humidity - Rotronic



Prototype\Hole 3\Cyl.3 (010917-20130101)
Relative humidity - Rotronic

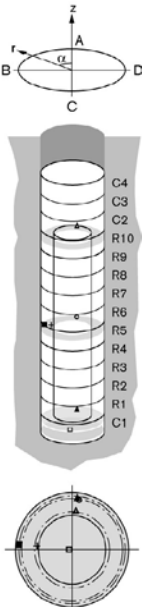
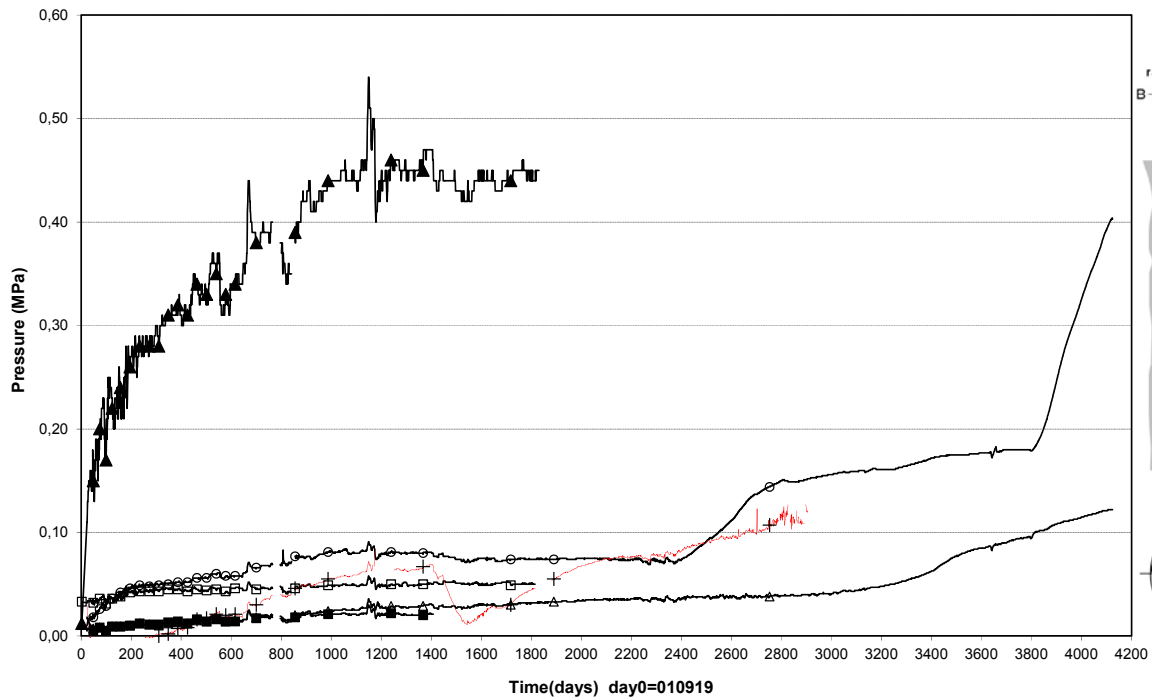


PrototypeHole 3 (010917-20130101)
Pore pressure - Geokon



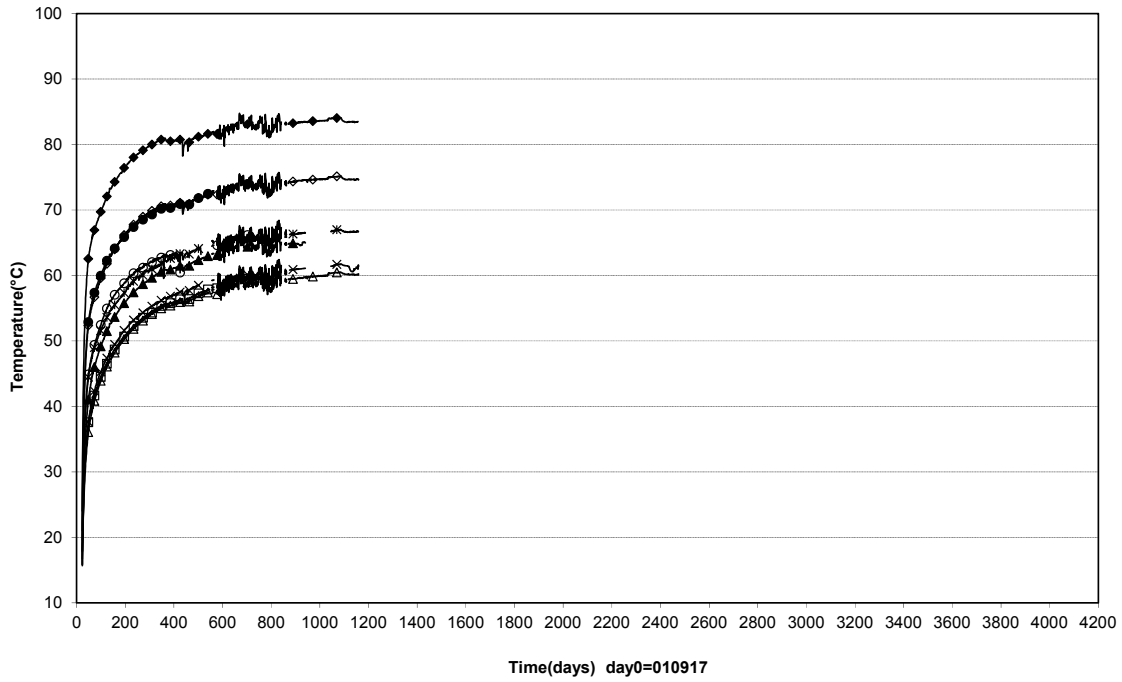
- | | | | |
|-----------------------------|-----------------------------|---|---|
| ×UBU30002(0.245\190°\0.100) | ◇UBU30005(2.771\355°\0.585) | △UBU30009(2.771\175°\0.535\in the slot) | □UBU30010(2.771\175°\0.825\in the slot) |
| ■UBU30012(5.306\355°\0.785) | ○UBU30013(6.314\90°\0.050) | ×UBU30014(6.910\90°\0.050) | |

PrototypeHole 3 (010917-20130101)
Pore pressure - Kulite



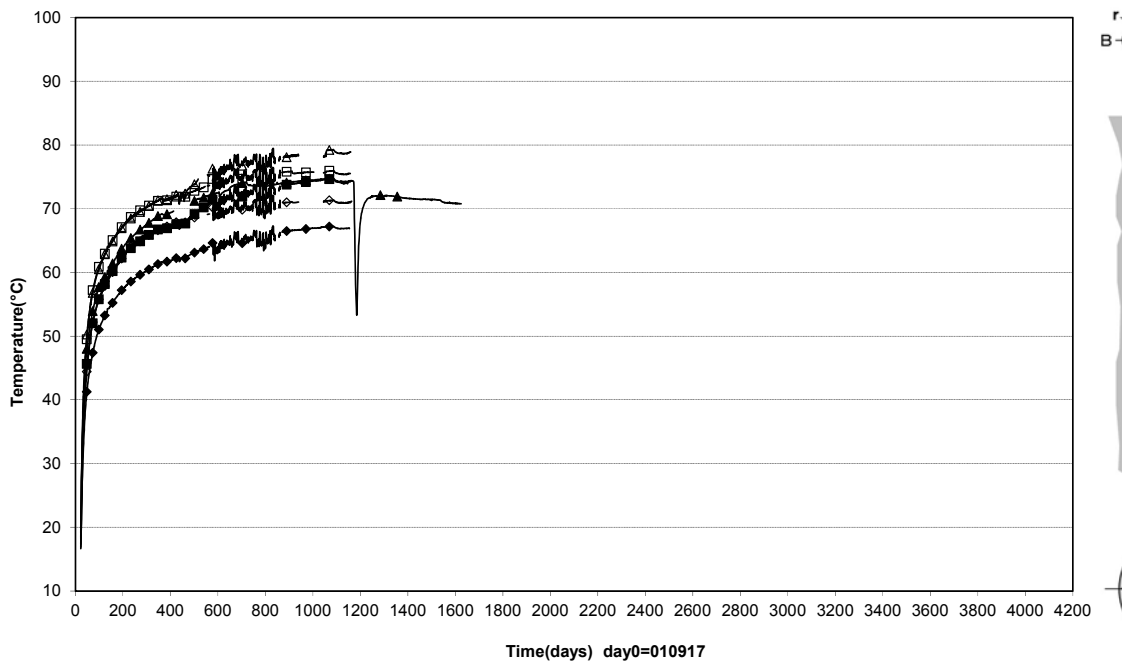
- | | | |
|---|---|------------------------------|
| □UBU30001(Cyl.1\90°\0.050) | ▲UBU30004(Cyl.1\355°\0.785) | ○UBU30006(Ring5\355°\0.785) |
| +UBU30007(Ring.5\85°\0.535\in the slot) | ■UBU30008(Ring.5\85°\0.825\in the slot) | △UBU30011(Ring10\355°\0.585) |

Prototype\Hole 3\Cyl.1 (010917-20130101)
Temperature - Pentronic



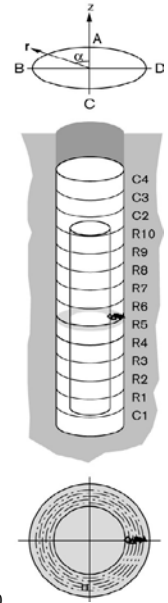
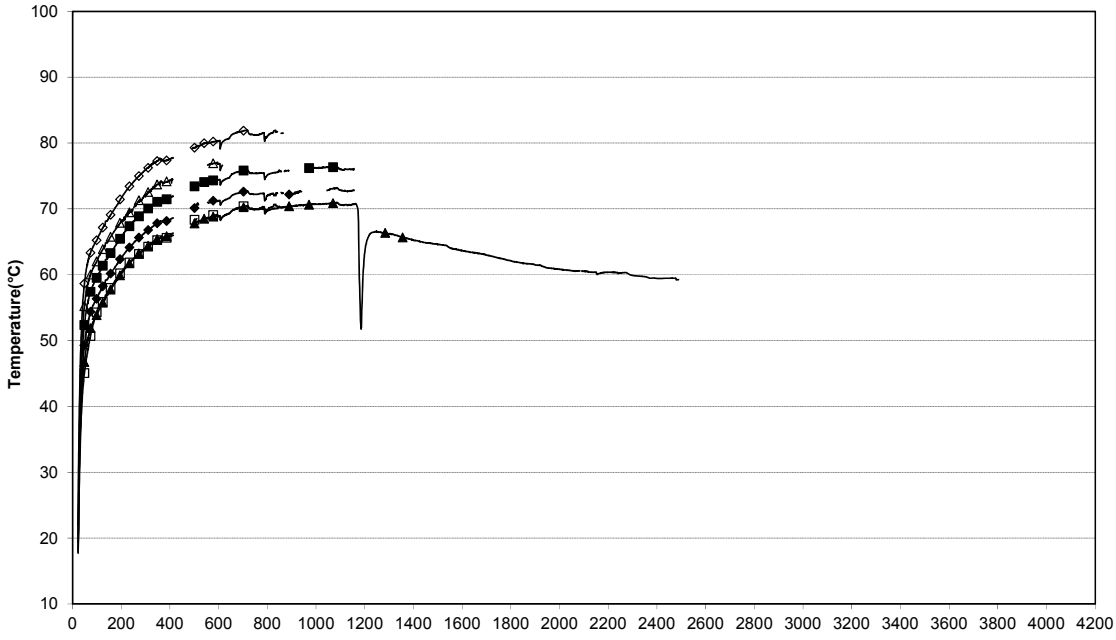
| | | | | |
|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| □ TBU30001(0.095\270°\0.050) | ◇ TBU30002(0.295\270°\0.050) | ◆ TBU30003(0.445\270°\0.050) | ▲ TBU30004(Cyl.1\355°\0.635) | △ TBU30005(Cyl.1\355°\0.735) |
| × TBU30006(Cyl.1\85°\0.685) | ○ TBU30007(Cyl.1\175°\0.685) | ● TBU30008(Cyl.1\270°\0.585) | × | × TBU30009(Cyl.1\270°\0.685) |

Prototype\Hole 3\Ring5 (010917-20130101)
Temperature - Pentronic



| | | |
|-----------------------------|-----------------------------|------------------------------|
| □ TBU30011(2.971\90°\0.635) | ◇ TBU30012(2.971\90°\0.735) | △ TBU30013(2.971\90°\0.585) |
| ■ TBU30014(2.971\90°\0.685) | ◆ TBU30015(2.971\90°\0.785) | ▲ TBU30017(2.971\175°\0.685) |

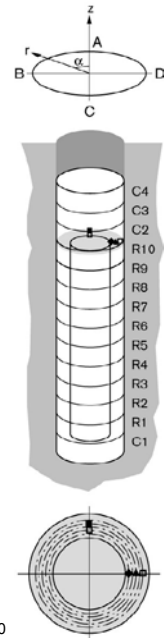
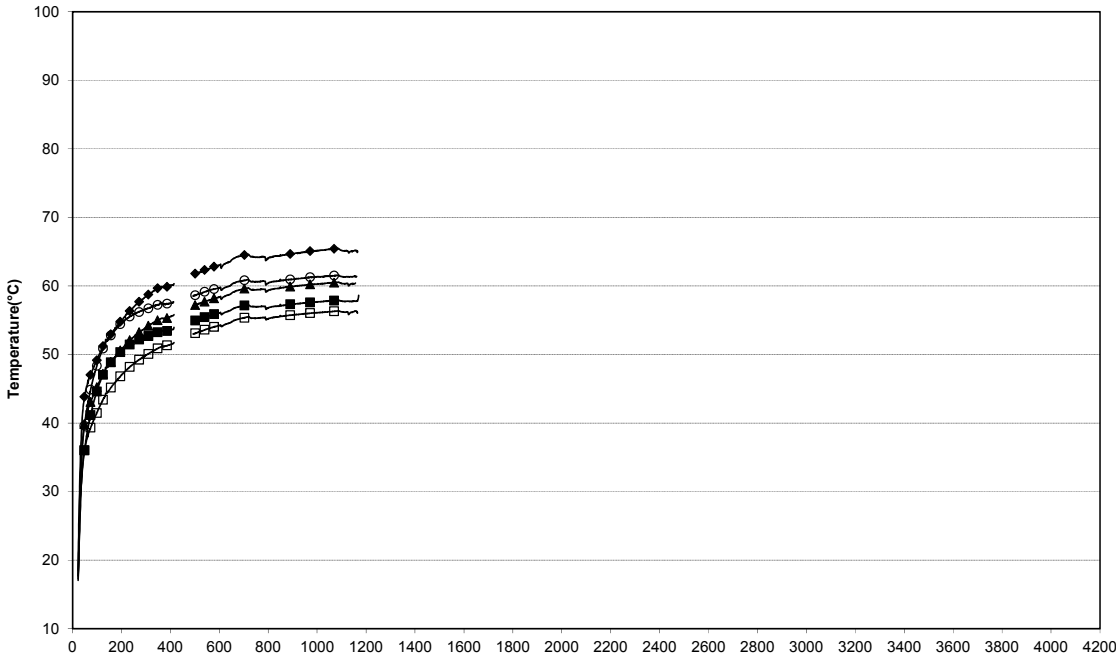
Prototype\Hole 3\Ring5 (010917-20130101)
Temperature - Pentronic



Time(days) day0=010917

- | | | |
|------------------------------|------------------------------|------------------------------|
| □ TBU30018(2.971\175°\0.735) | ◇ TBU30019(2.971\270°\0.585) | △ TBU30020(2.971\270°\0.635) |
| ■ TBU30021(2.971\270°\0.685) | ◆ TBU30022(2.971\270°\0.735) | ▲ TBU30023(2.971\270°\0.785) |

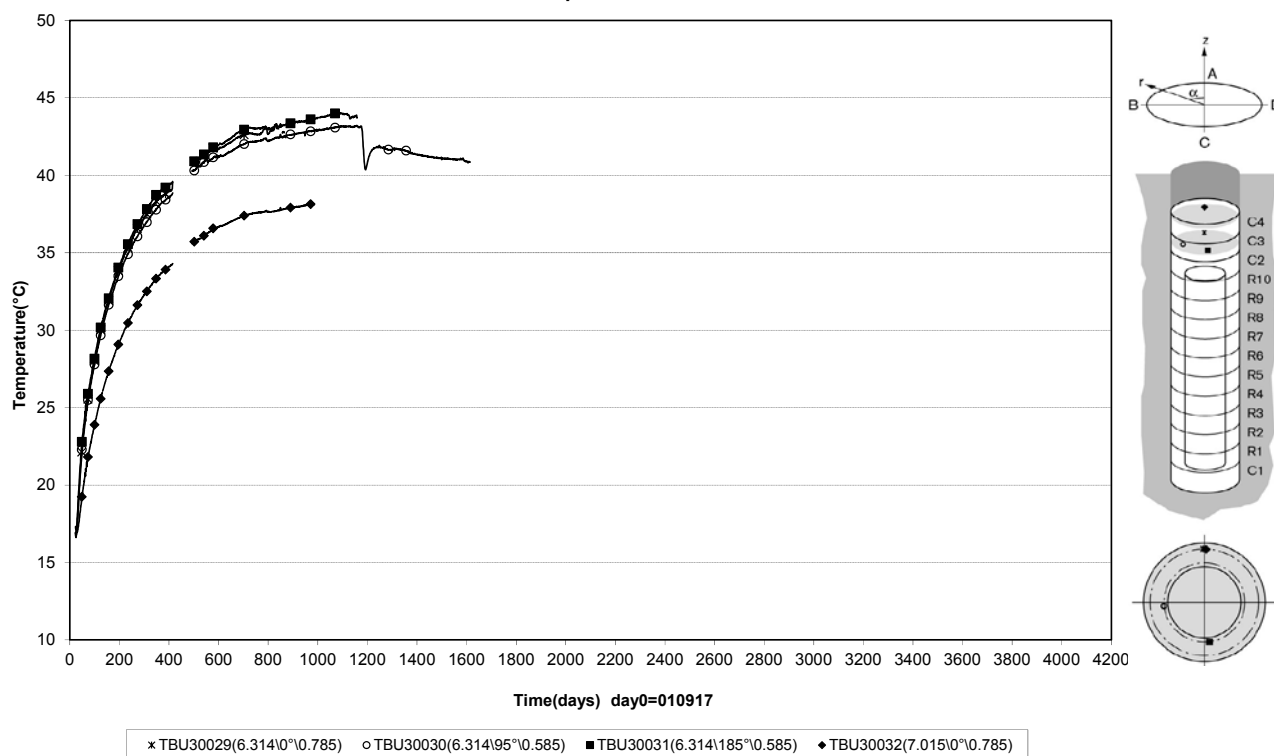
Prototype\Hole 3\Ring10 (010917-20130101)
Temperature - Pentronic



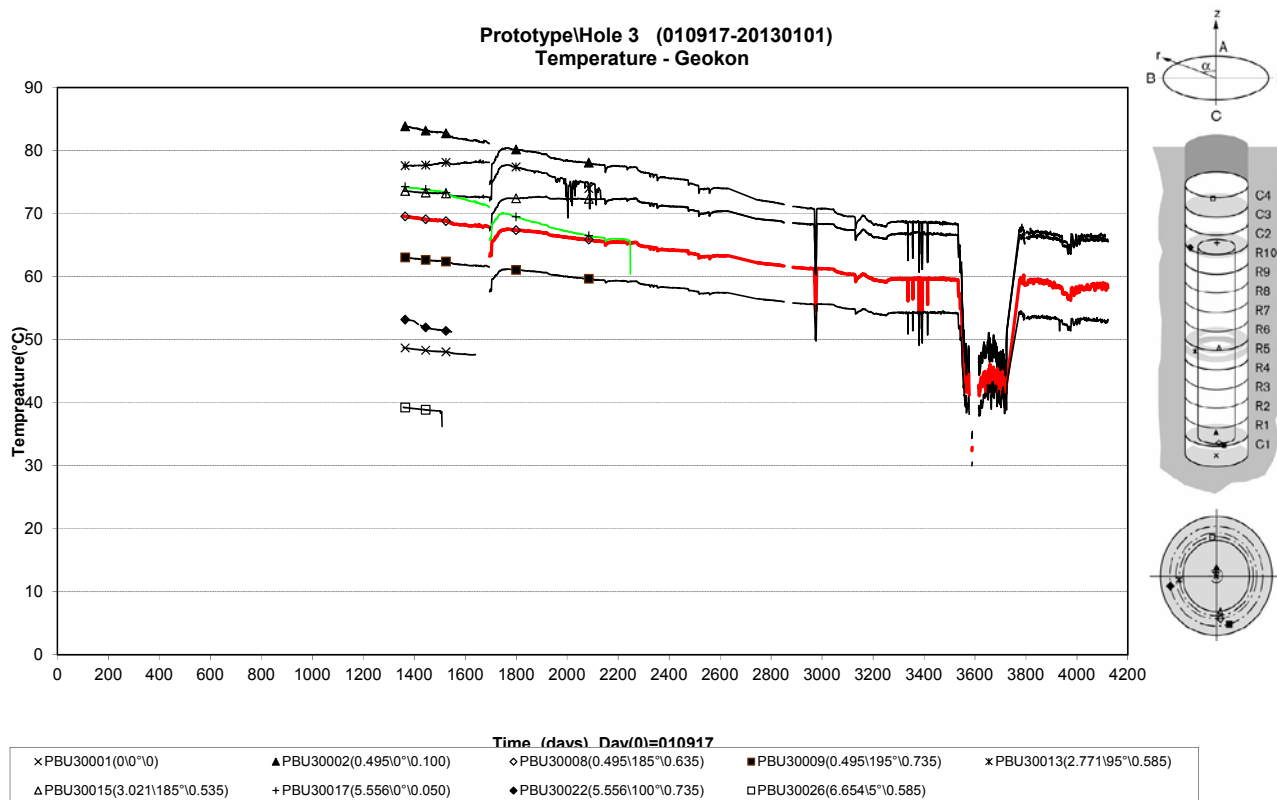
Time(days) day0=010917

- | | | | | |
|----------------------------|----------------------------|------------------------------|------------------------------|------------------------------|
| ○ TBU30024(5.504\0°\0.635) | ■ TBU30025(5.504\0°\0.735) | ◆ TBU30026(5.504\270°\0.585) | ▲ TBU30027(5.504\270°\0.685) | □ TBU30028(5.504\270°\0.785) |
|----------------------------|----------------------------|------------------------------|------------------------------|------------------------------|

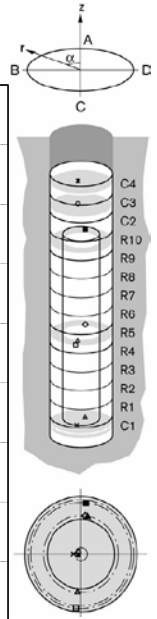
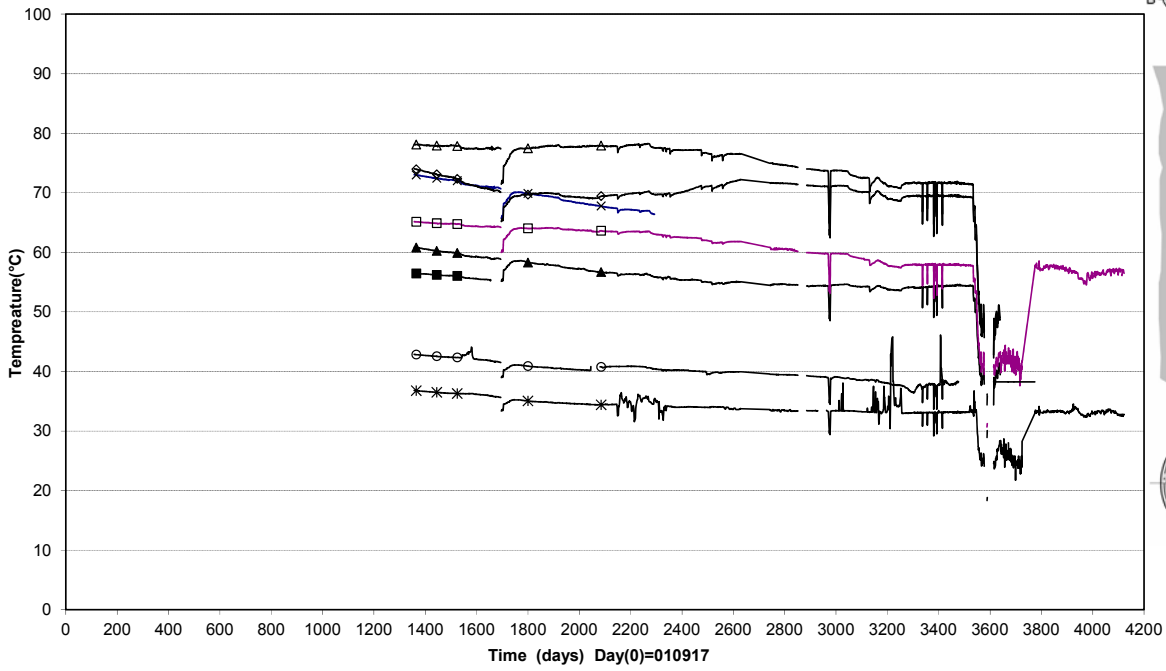
Prototype\Hole 3\Cyl.3 and Cyl.4 (010917-20130101)
Temperature - Pentronic



Prototype\Hole 3 (010917-20130101)
Temperature - Geokon

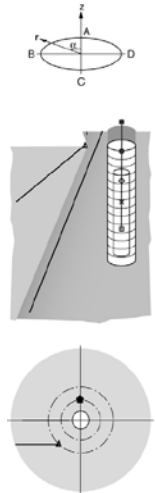
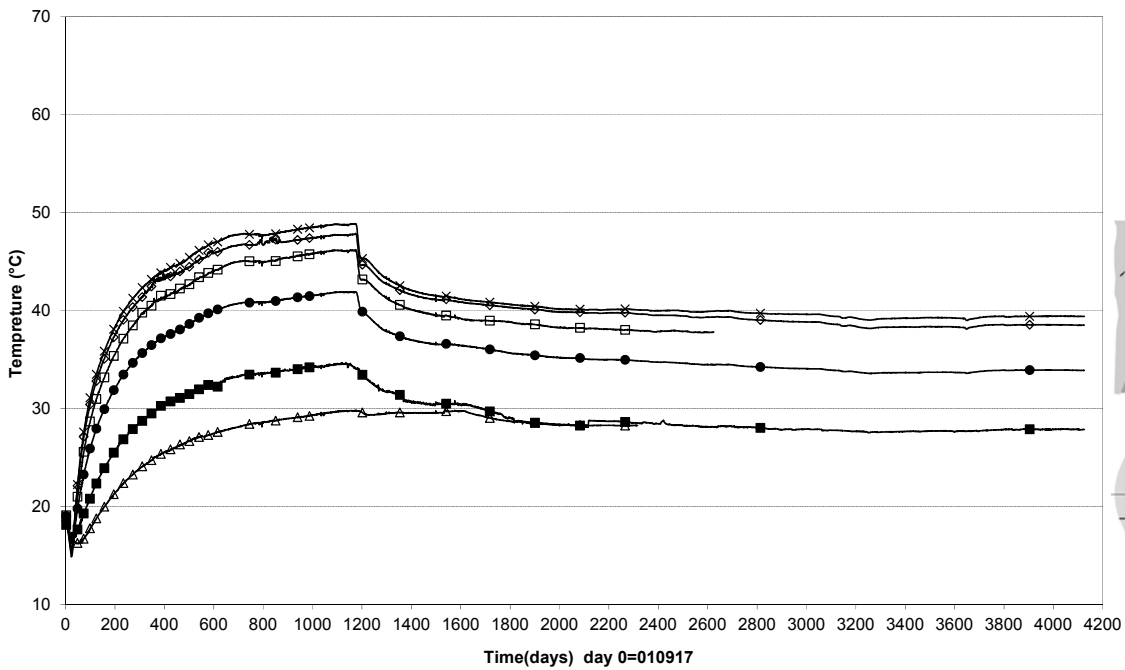


PrototypeHole 3 (010917-20130101)
Temperature - Geokon



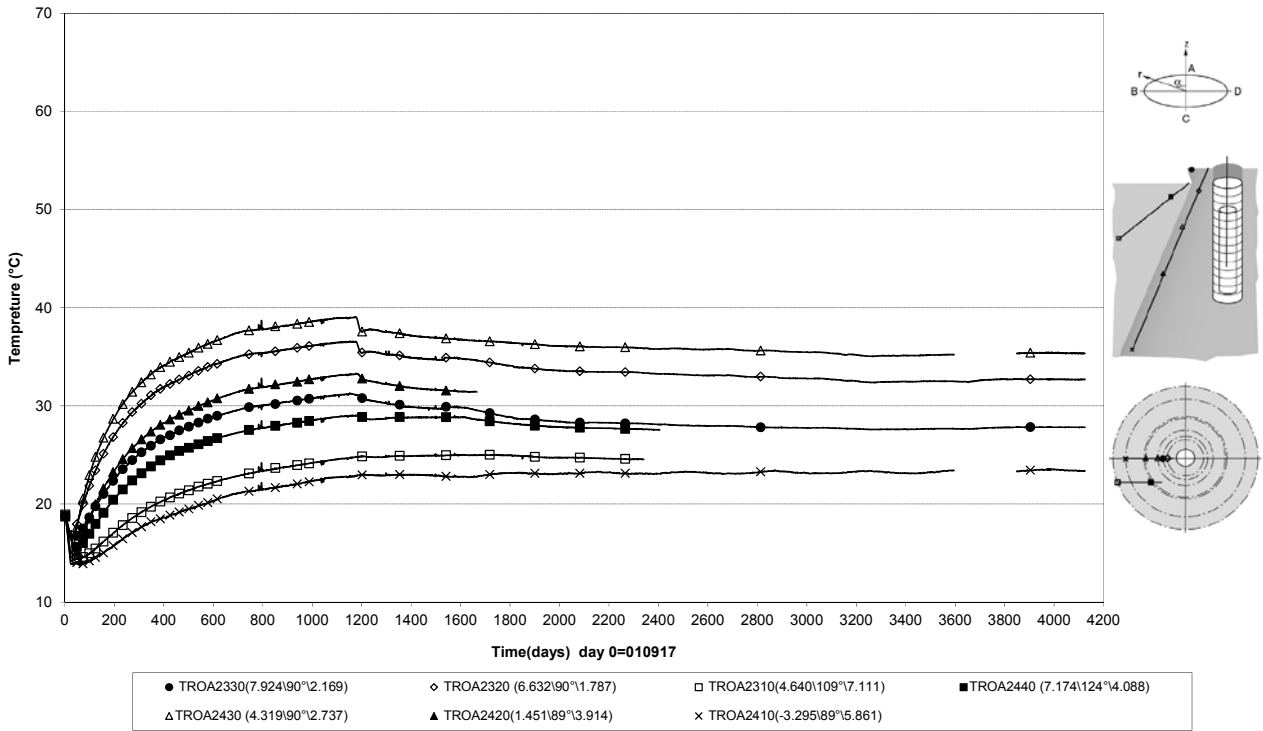
| | | | |
|--|------------------------------|------------------------------|--|
| x UBU30002(0.245\90°\0.100) | ▲ UBU30003(0.335\355°\0.585) | ◇ UBU30005(2.771\355°\0.585) | △ UBU30009(2.771\175°\0.535\in the slot) |
| □ UBU30010(2.771\175°\0.825\in the slot) | ■ UBU30012(5.306\355°\0.785) | ○ UBU30013(6.314\90°\0.050) | x UBU30014(6.910\90°\0.050) |

PrototypeRock\Hole 3 (20010917-20130101)
Temperature - Pentronic

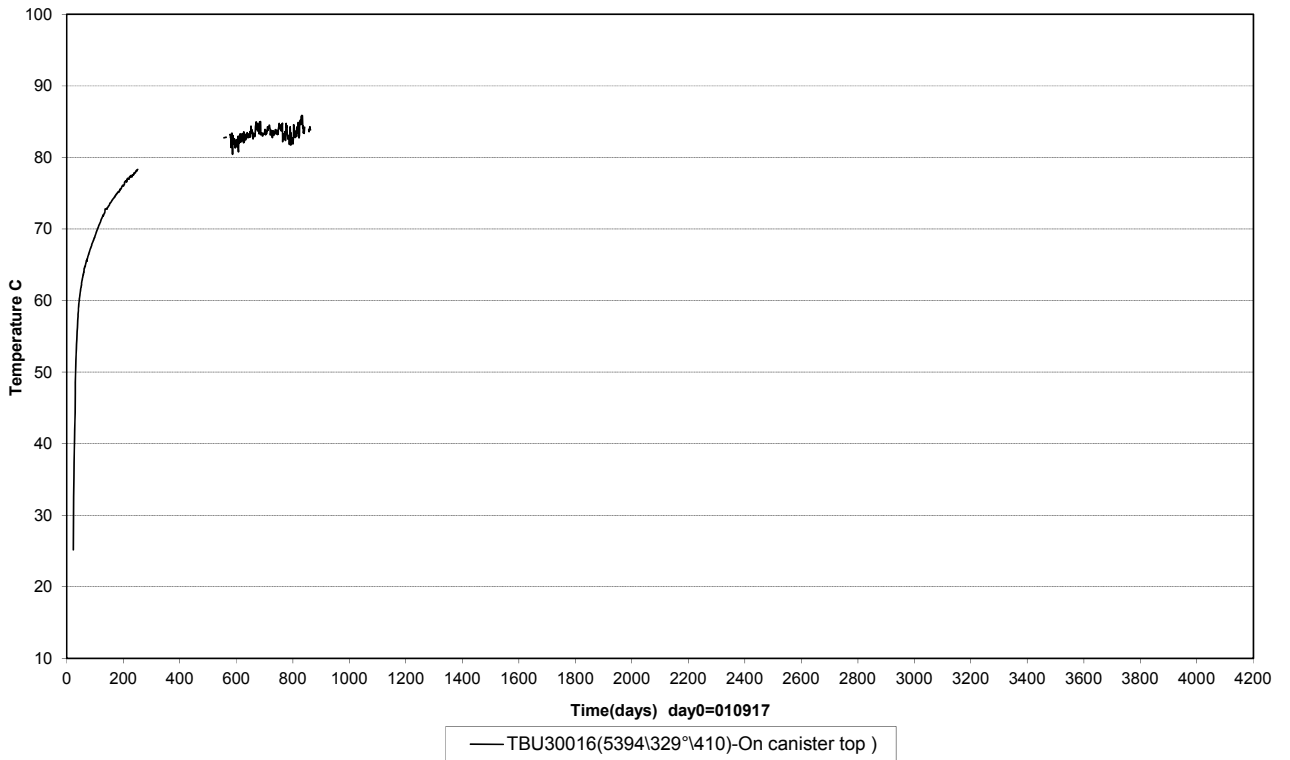


| | | |
|------------------------------|-----------------------------|-----------------------------|
| △ TROA2150(7.958\134°\3.284) | ● TROA2140 (5.979\1°\1.999) | ◇ TROA2130(4.230\2°\1.981) |
| x TROA2120(2.840\2°\1.967) | □ TROA2110(1.170\3°\1.950) | ■ TROA1850 (7.889\0°\2.019) |

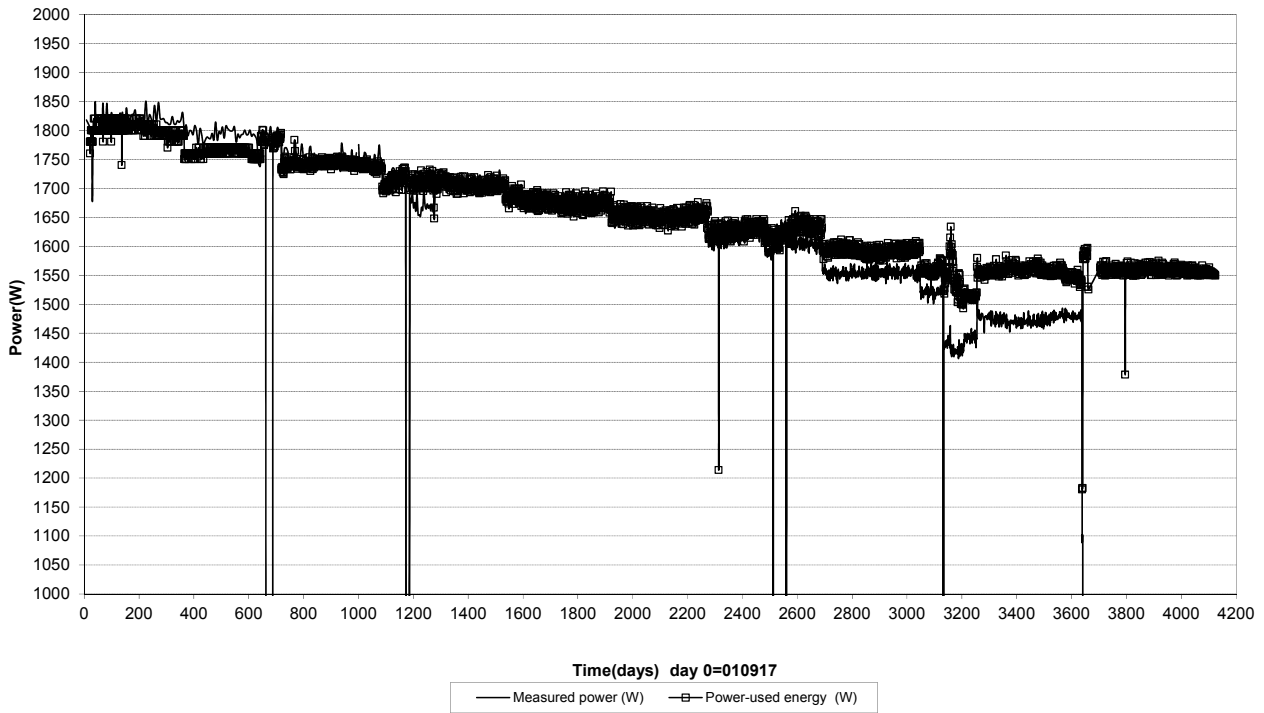
Prototype\Rock\Hole 3 (20010917-20130101)
Temperature - Pentronic



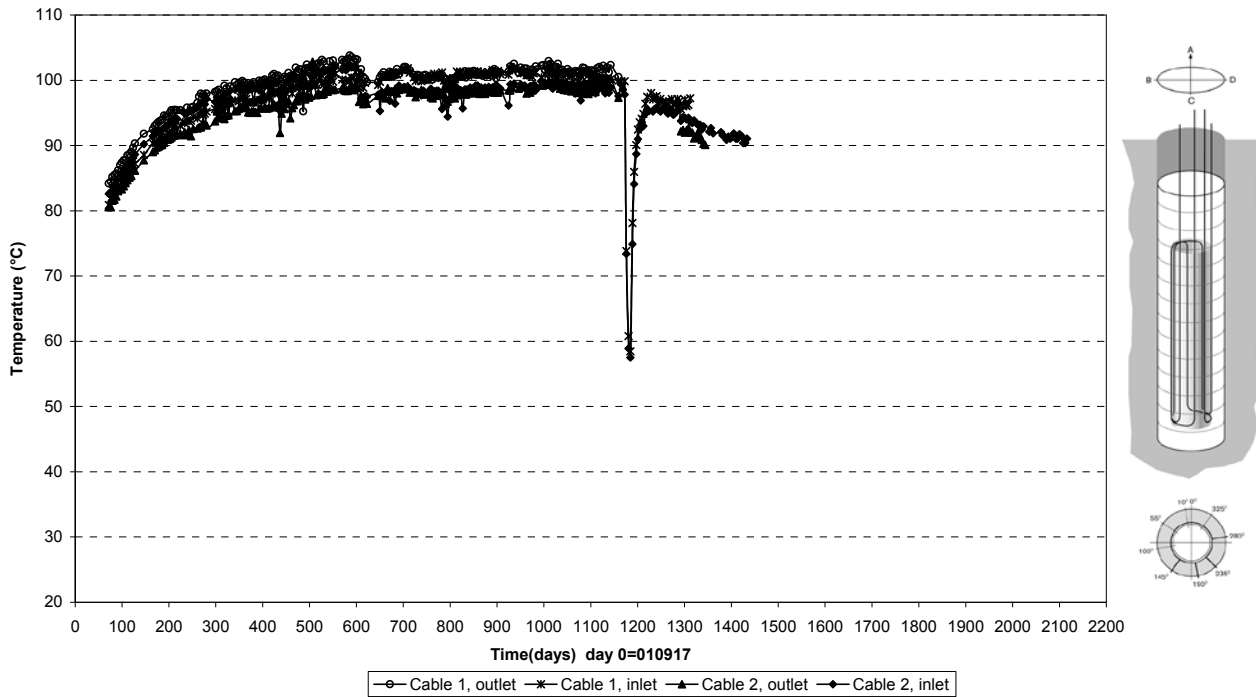
Prototype\Hole 3\ On canister top (010917-20130101)
Temperature - Pentronic



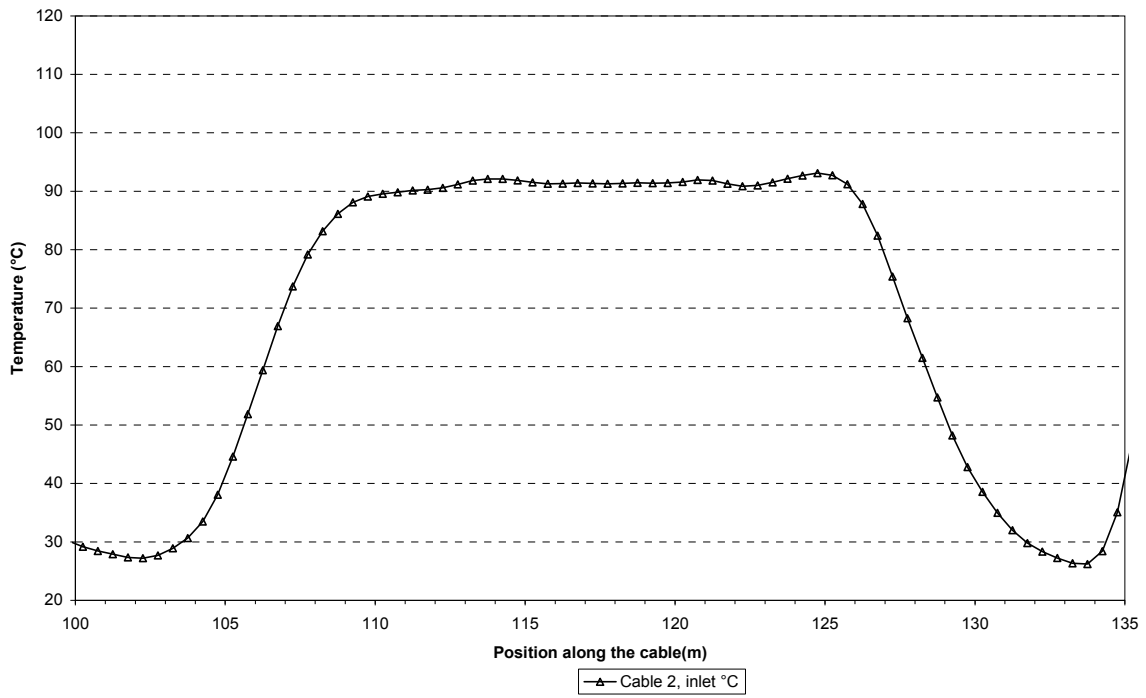
Prototype\ Hole 3 (20010917-20130101)
Canister power



Prototype\ Hole 3 \Canister (010917-070601)
Max. temperature on the canister surface - Optical fibre cables

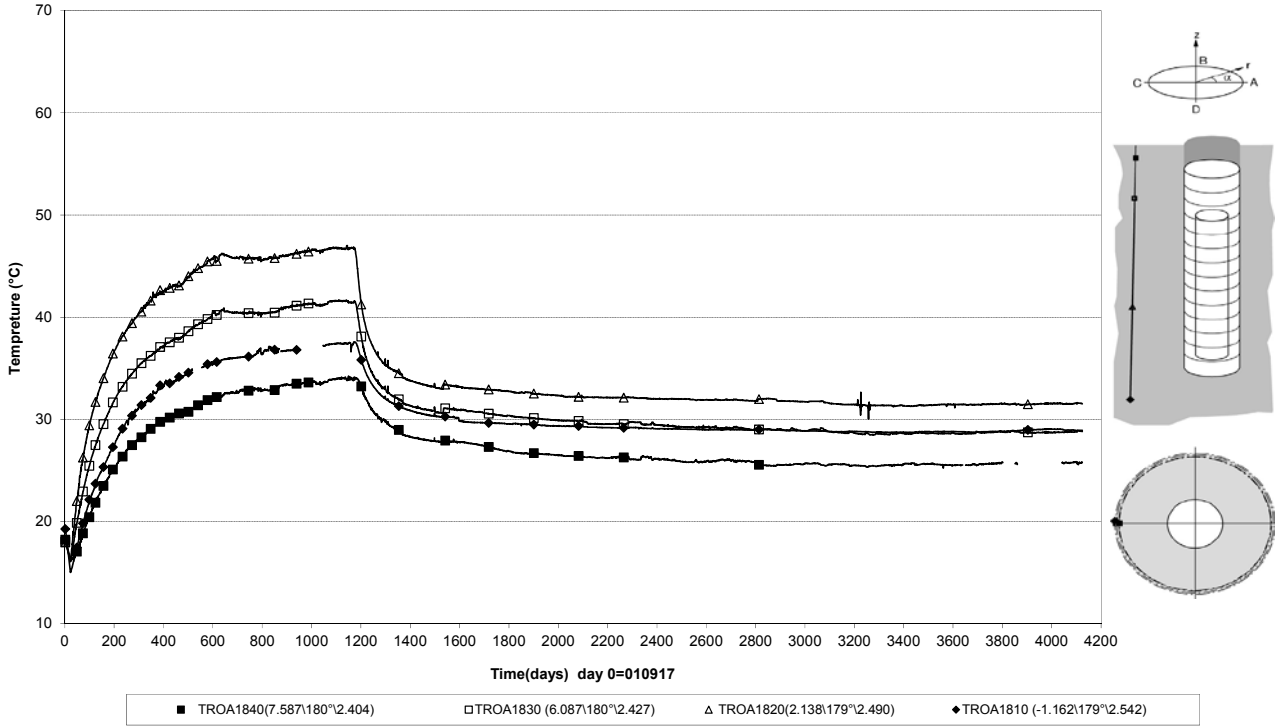


Prototypel Hole 3 \Canister (050601)
Temperature profile on the canister surface - Optical fiber cables

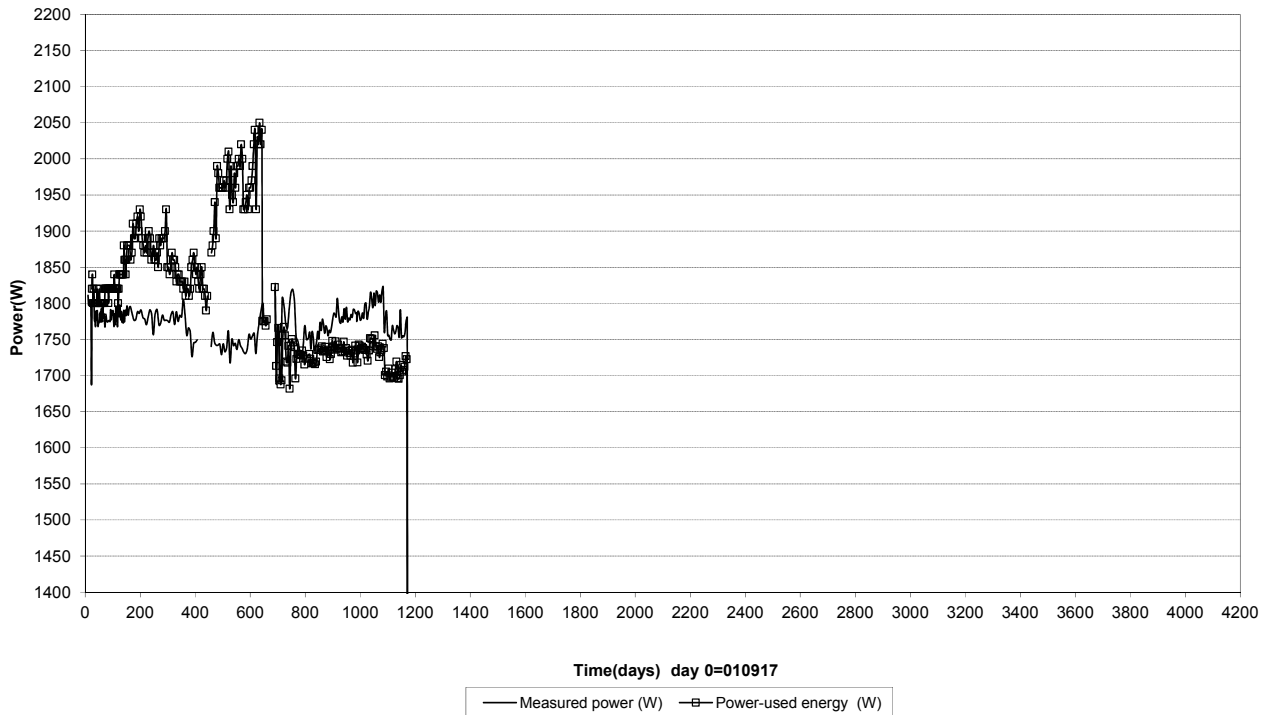


Dep. hole 2 and 4

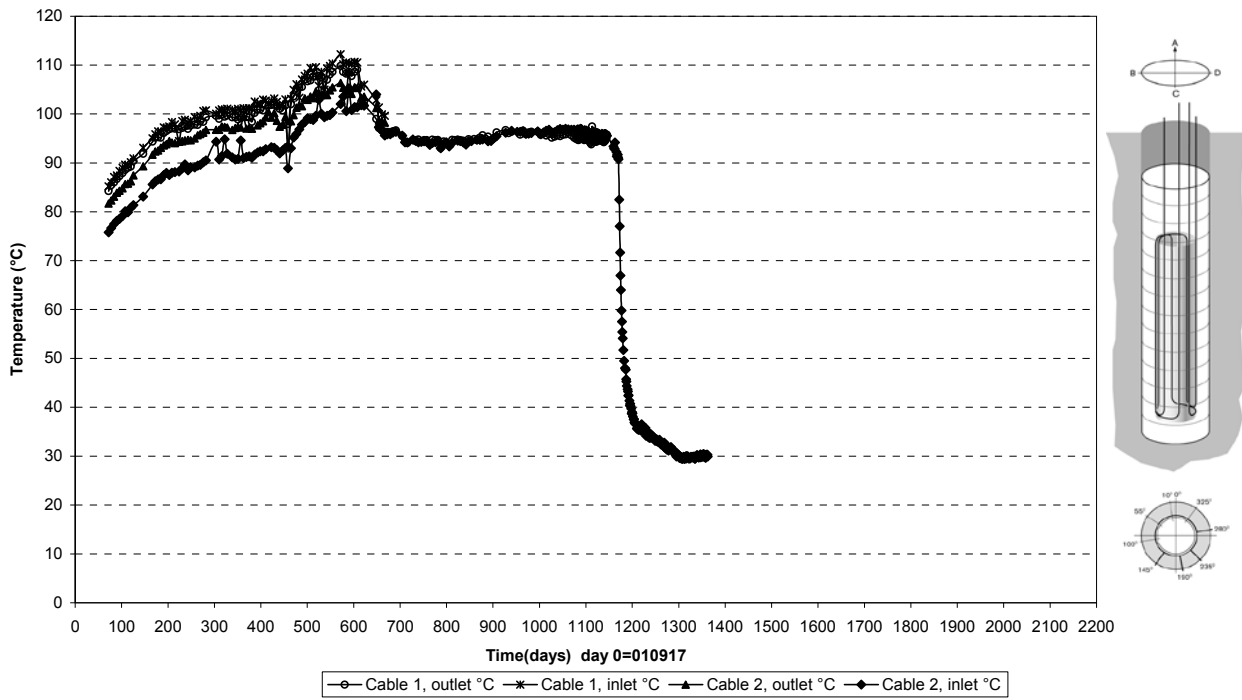
Prototype\Rock\Hole 2 (20010917-20130101)
Temperature - Pentronic



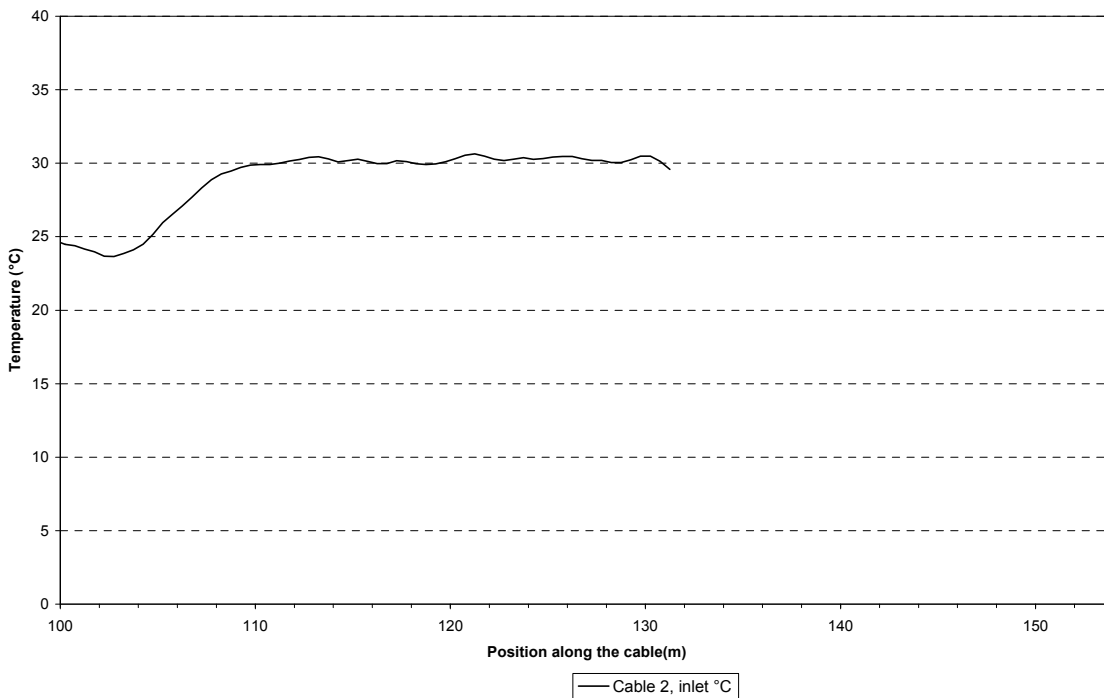
Prototype Hole 2 (20010917-20130101)
Canister power



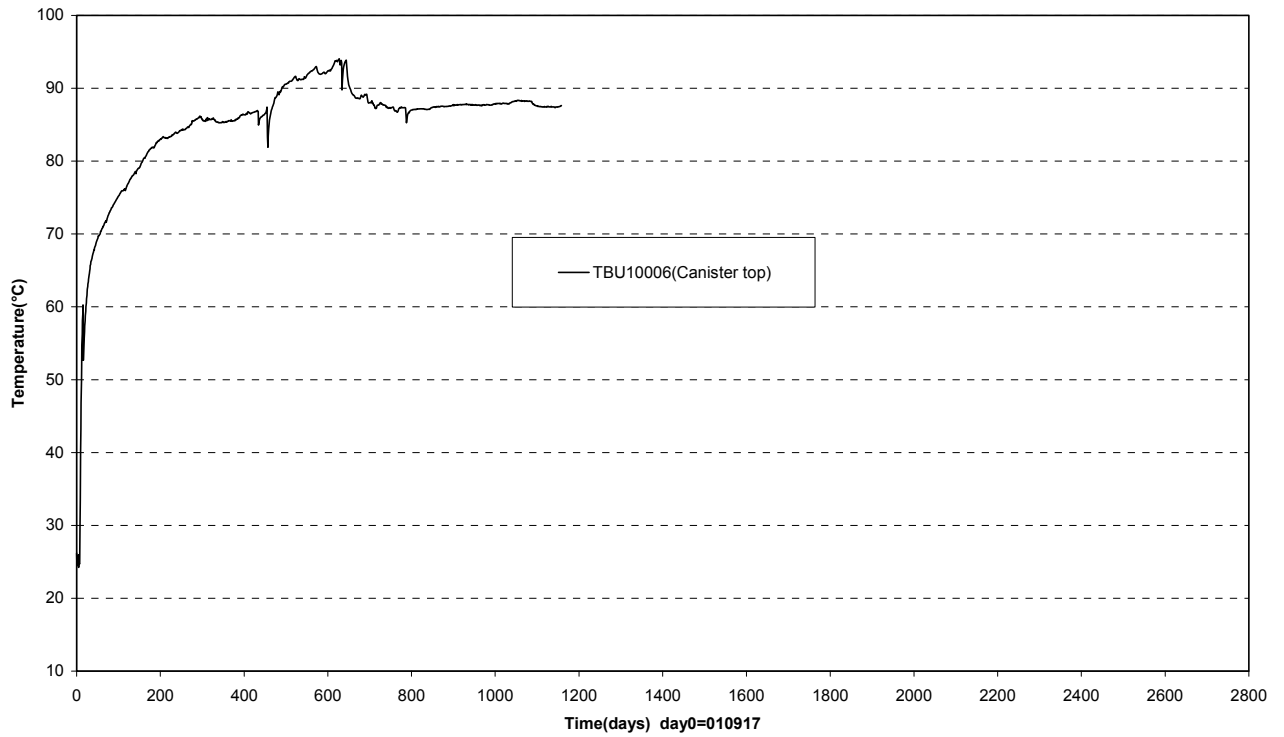
Prototypel Hole 2 \Canister (010917-070601)
Max. temperature on the canister surface - Optical fiber cables



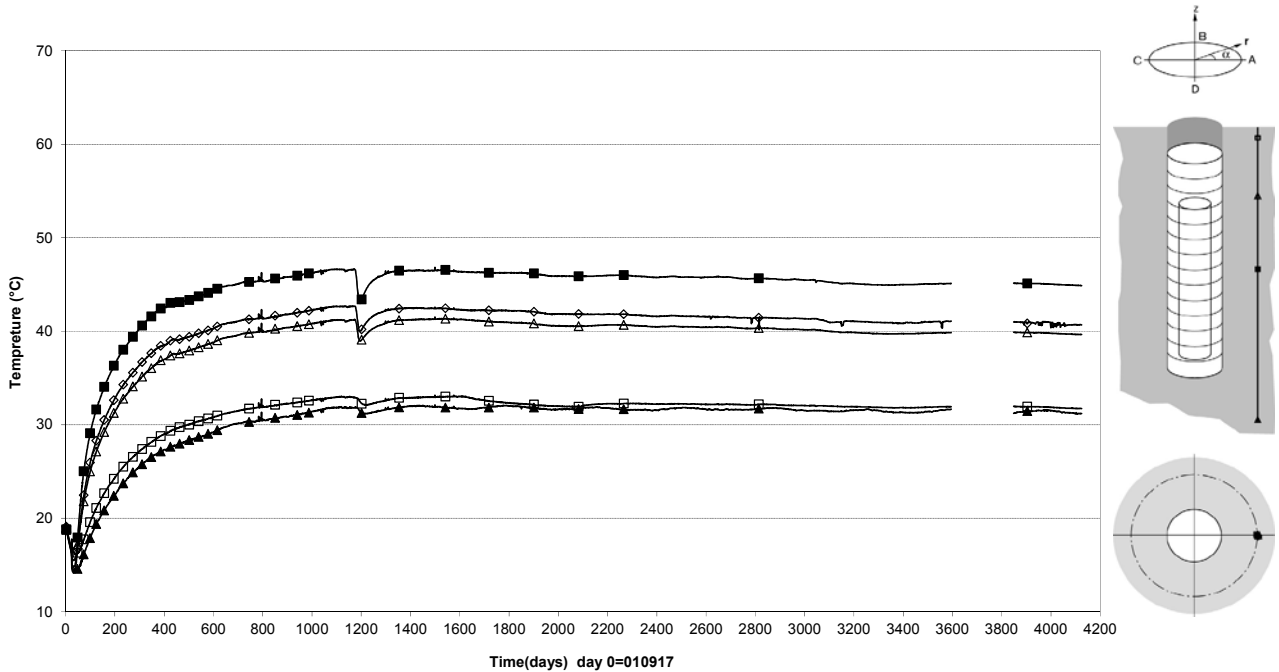
Prototypel Hole 2 \Canister (050601)
Temperature profile on the canister surface - Optical fiber cables



Prototype\Hole 2 \Canister top (010917-081201)
Temperature - Pentronic

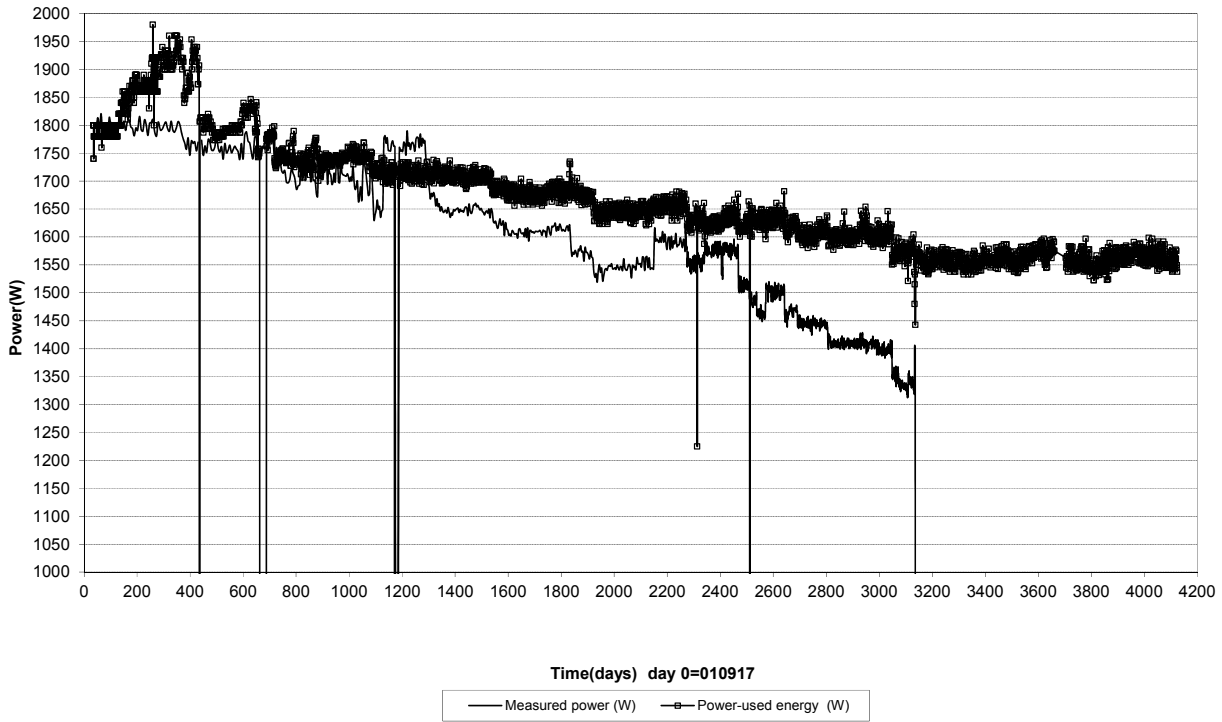


Prototype\Rock\Hole 4 (20010917-20130101)
Temperature - Pentronic

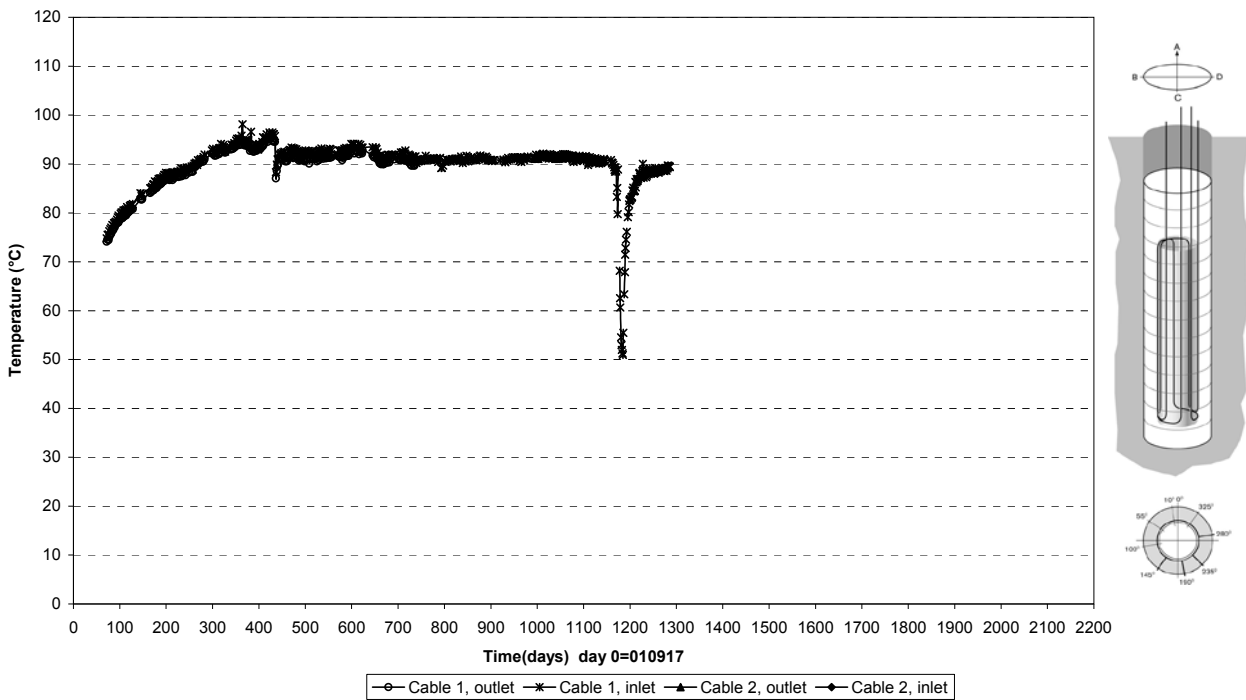


□ TROA3050 (7.671\360°\2.017) Δ TROA3040 (5.671\359°\2.025) ■ TROA3030(3.271\358°\2.034) ◇ TROA3020(0.871\358°\2.045) ▲ TROA3010(-1.778\357°\2.056)

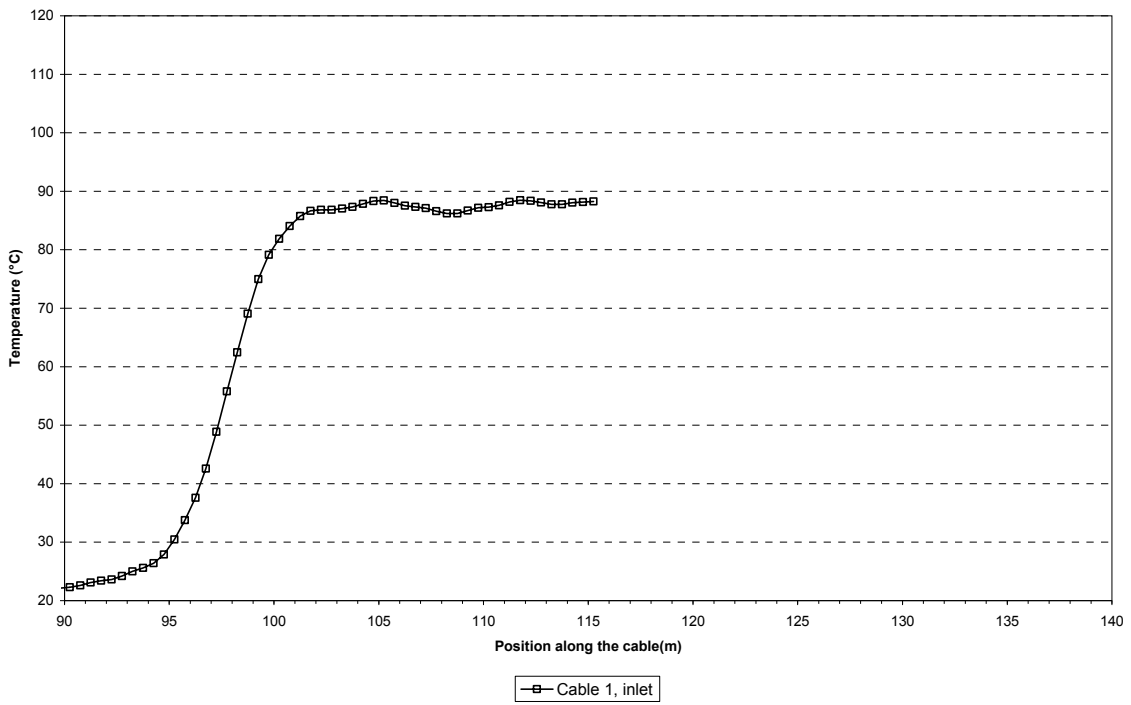
Prototype\Hole 4 (20010917-20130101)
Canister power



Prototype\ Hole 4 \Canister (010917-070601)
Max. temperature on the canister surface - Optical fiber cables

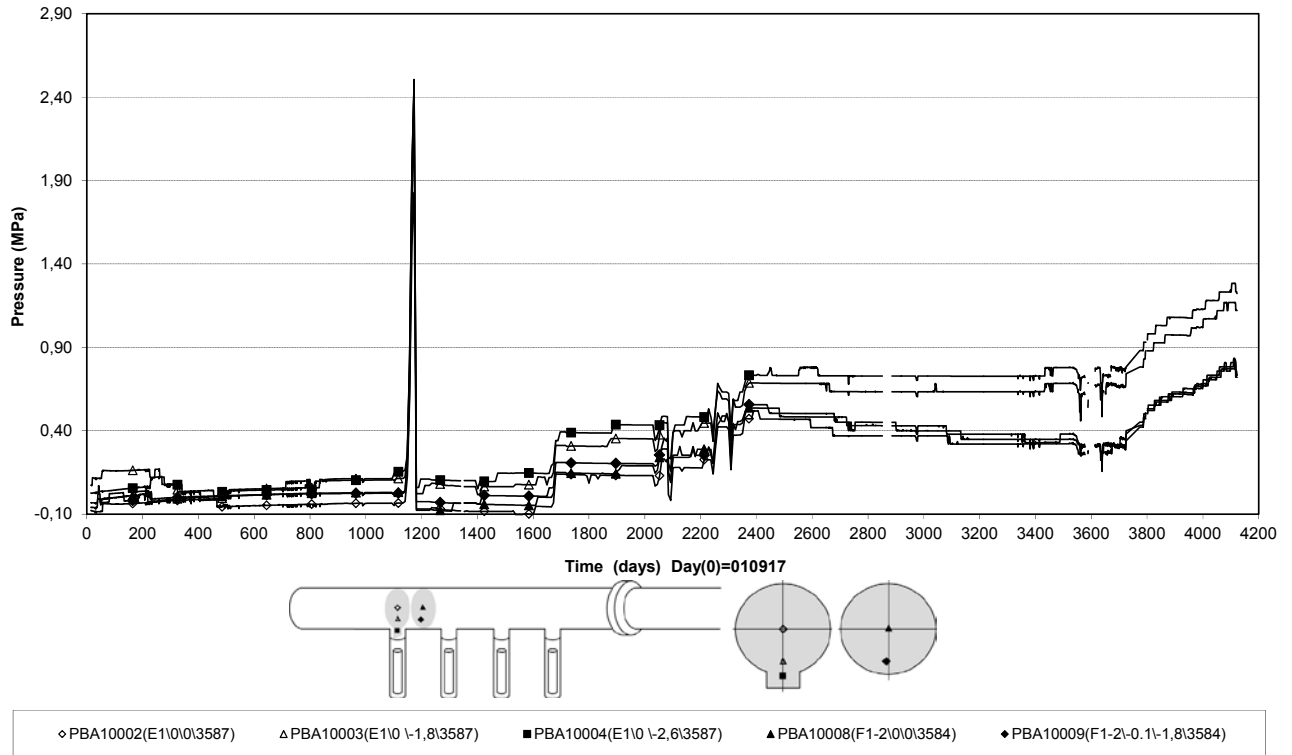


Prototype\ Hole 4\Canister (041130)
Temperature profile on the canister surface - Optical fiber cables

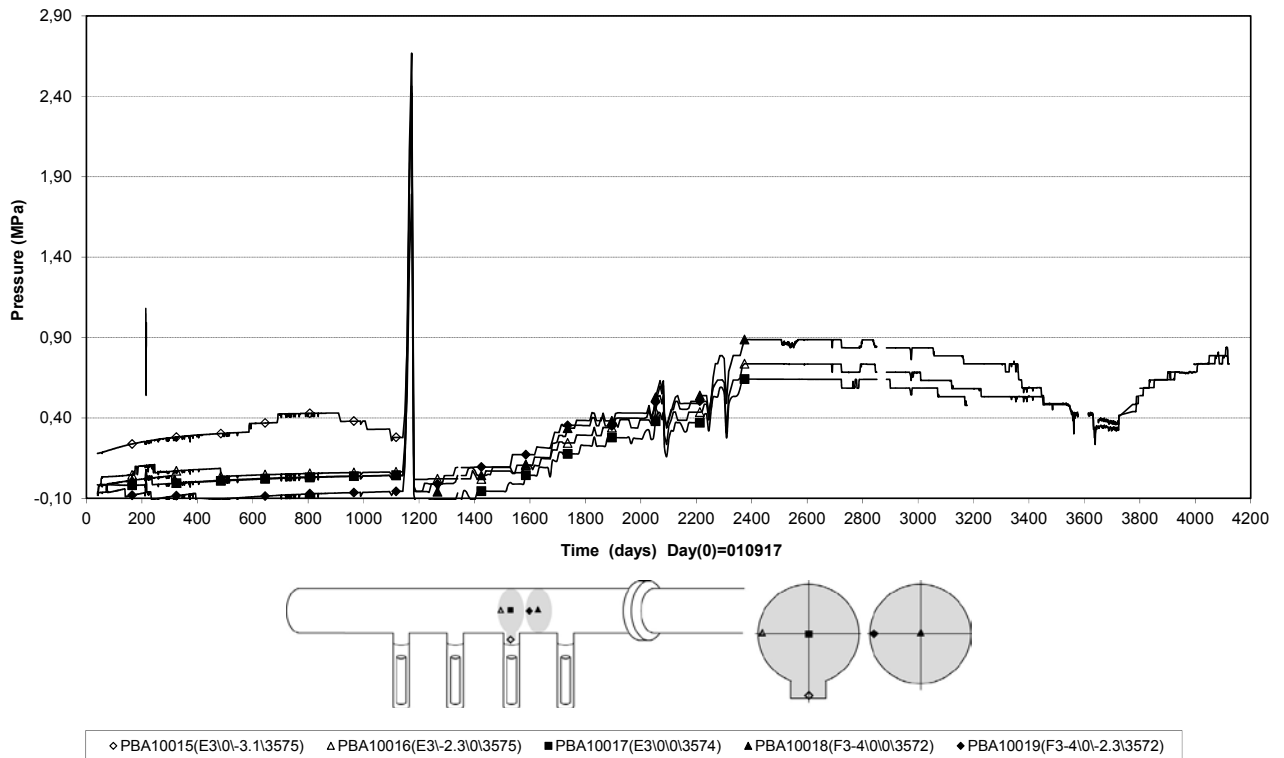


Backfill in Section 1

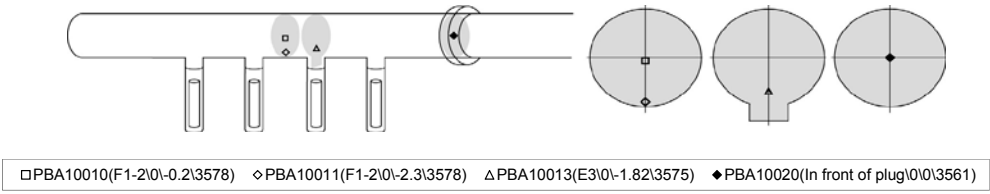
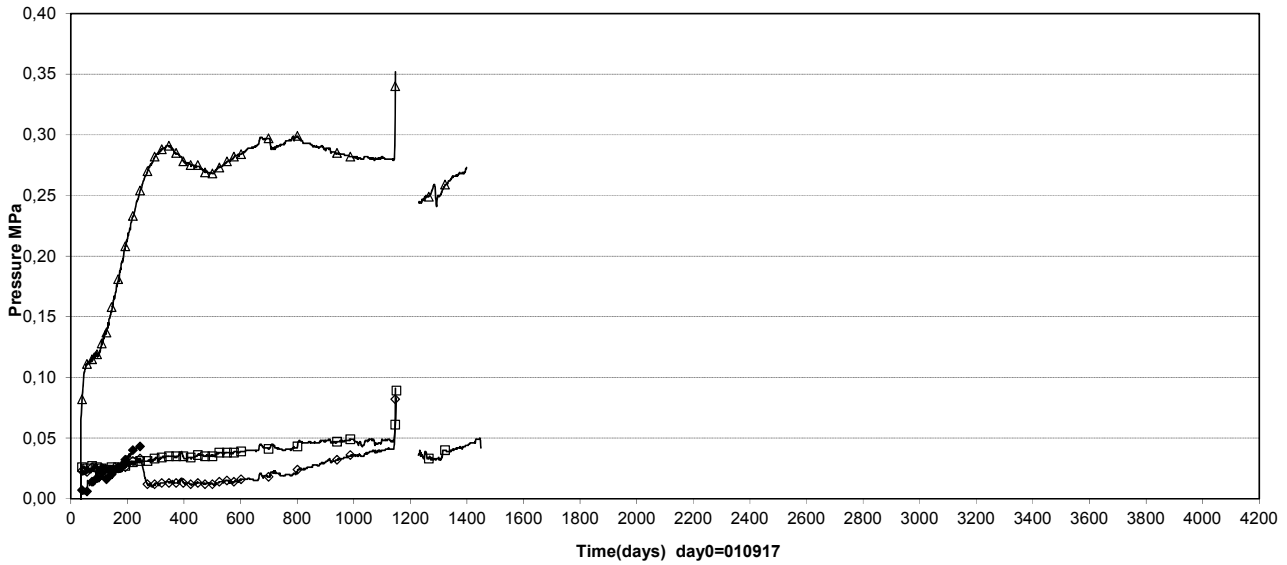
Prototype\Backfill\Section 1 (010917-20130101)
Total pressure - Geokon



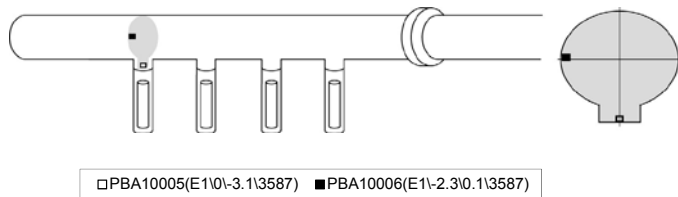
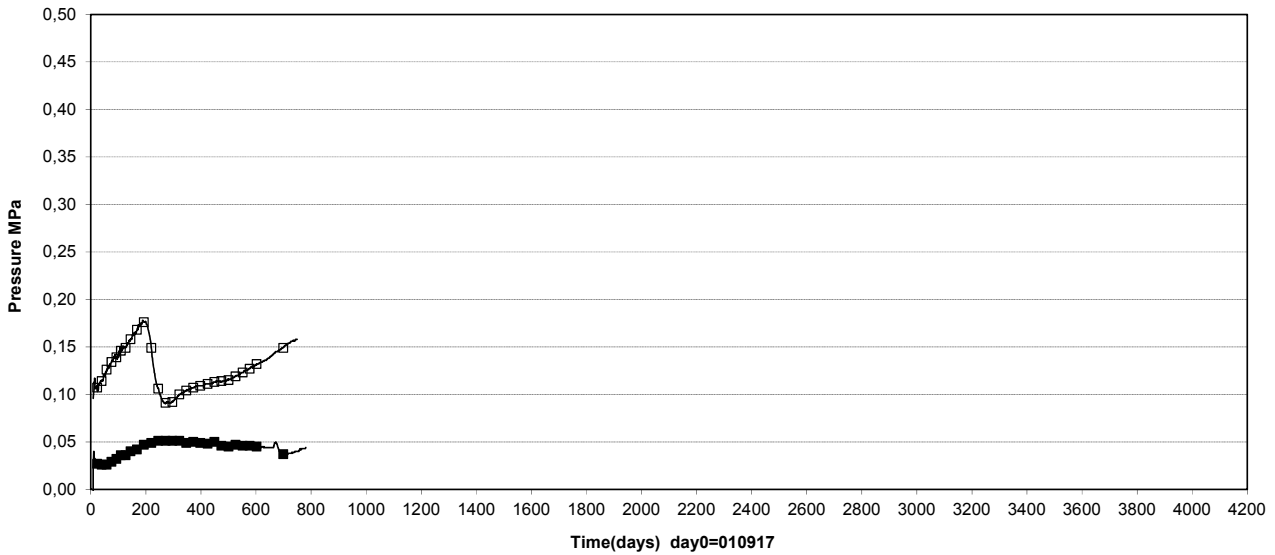
Prototype\Backfill\ Section 1 (010917-20130101)
Total pressure - Geokon



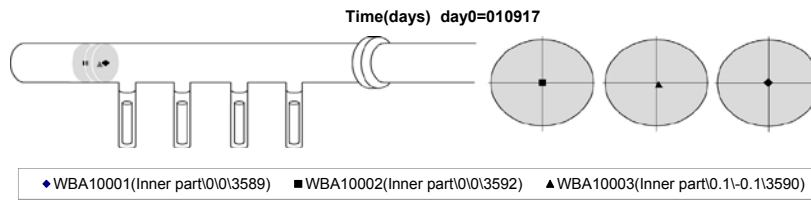
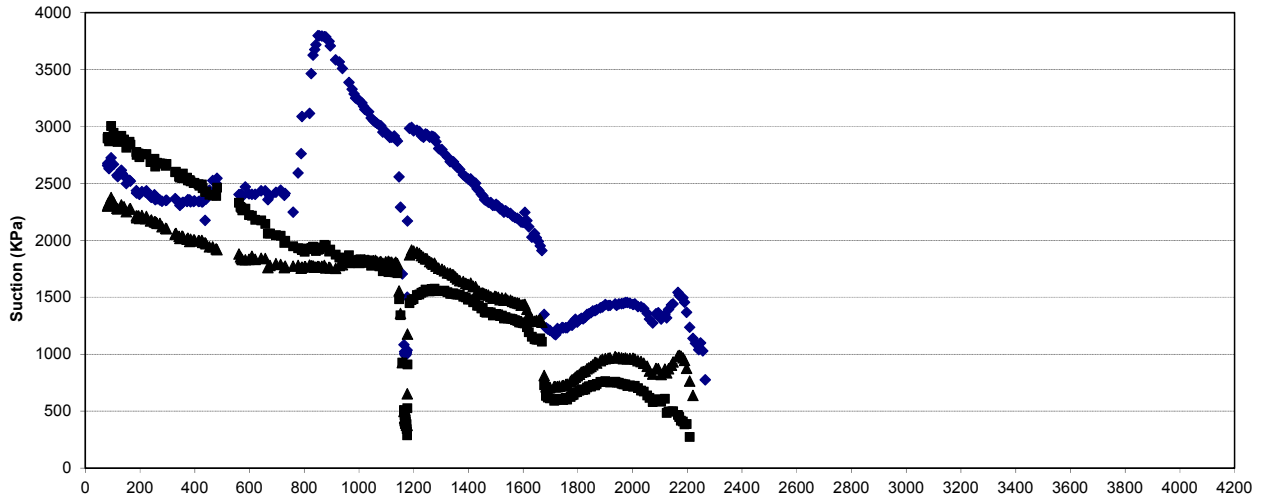
Prototype\Backfill\Section 1 (041015-20130101)
Total pressure - Kulite



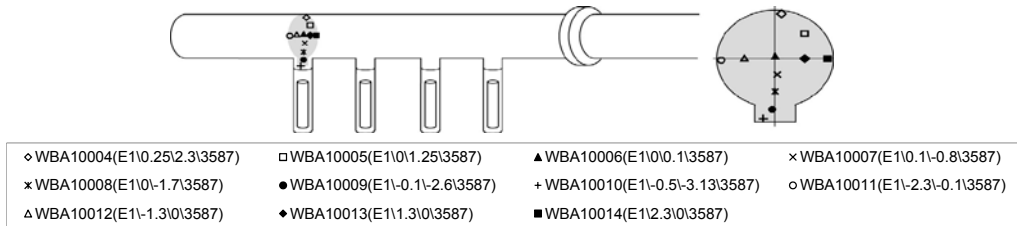
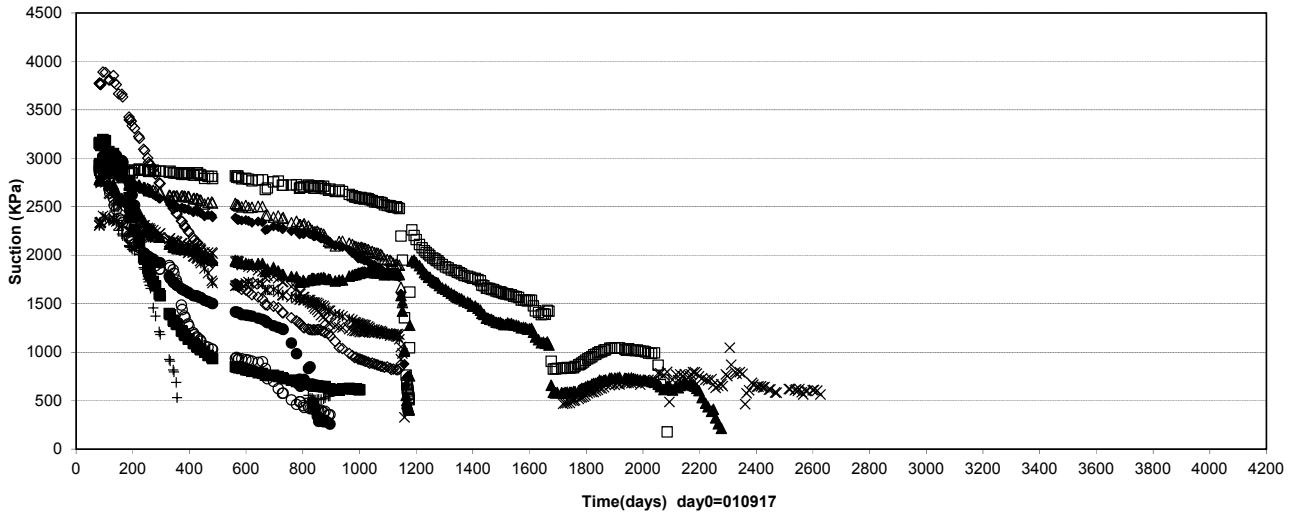
Prototype\Backfill\Section 1 (010917-20130101)
Total pressure - Kulite



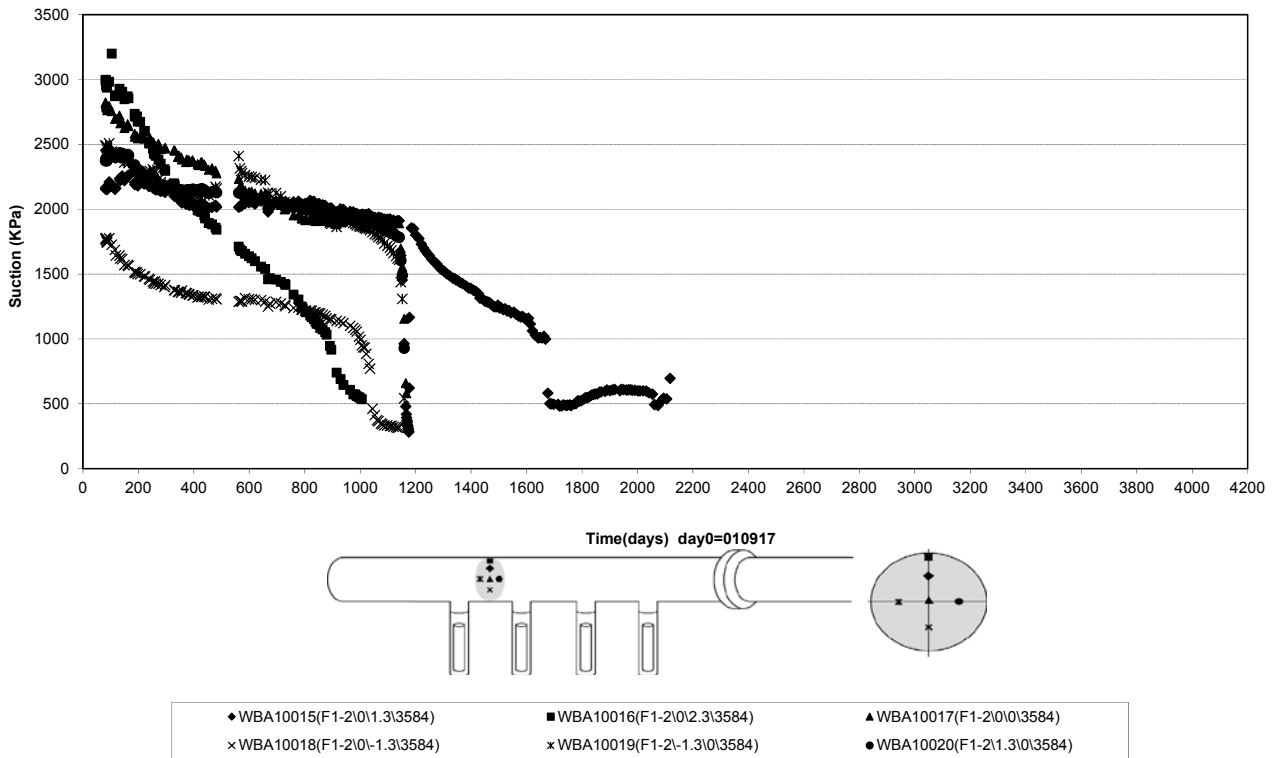
Prototype\Backfill \ Inner part (20010917-20130101)
Suction - Wescor



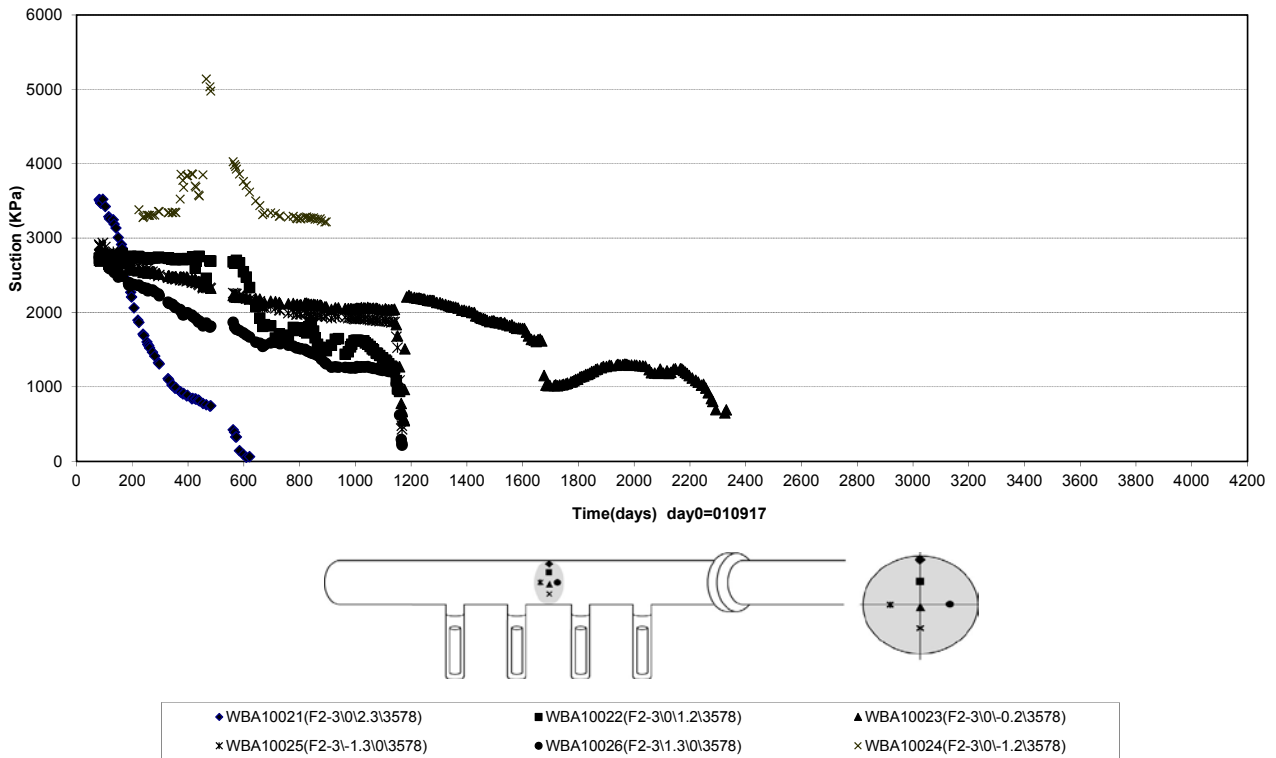
Prototype\Backfill Above dep.hole 1 (20010917-20130101)
Suction - Wescor



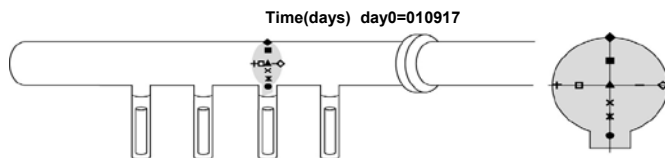
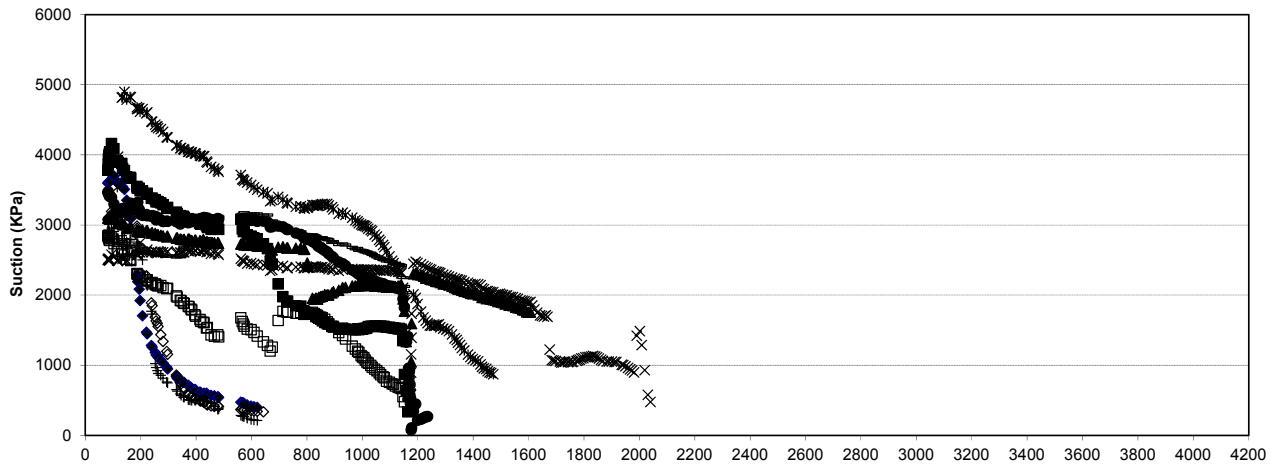
Prototype\Backfill \ Between dep.hole 1 and hole 2 (20010917-20130101)
Suction - Wescor



Prototype\Backfill \ Between dep.hole 2 and hole 3 (20010917-20130101)
Suction - Wescor

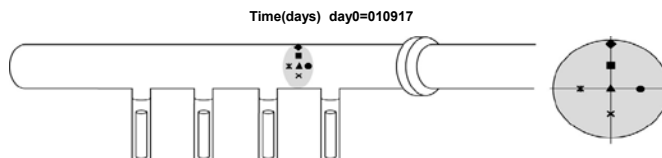
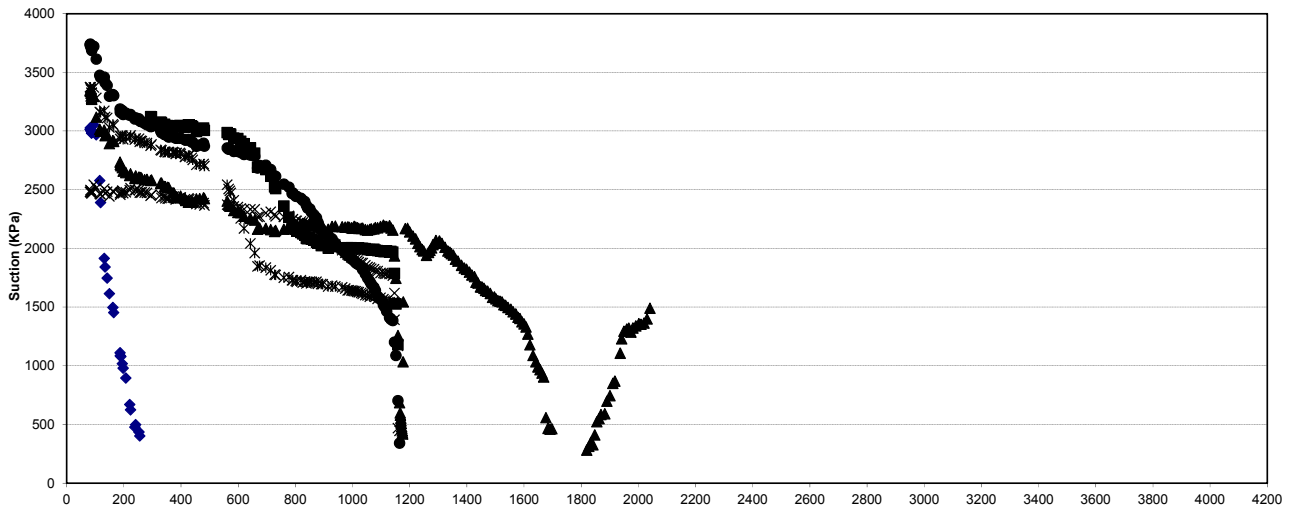


Prototype\Backfill\ Above dep.hole 3 (20010917-20130101)
Suction - Wescor



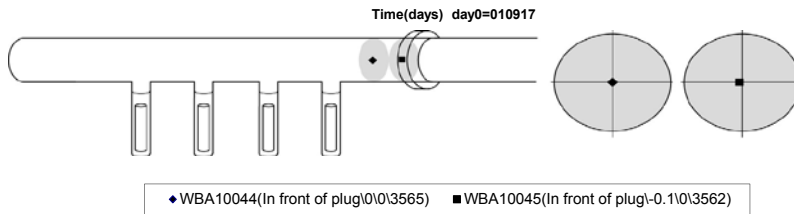
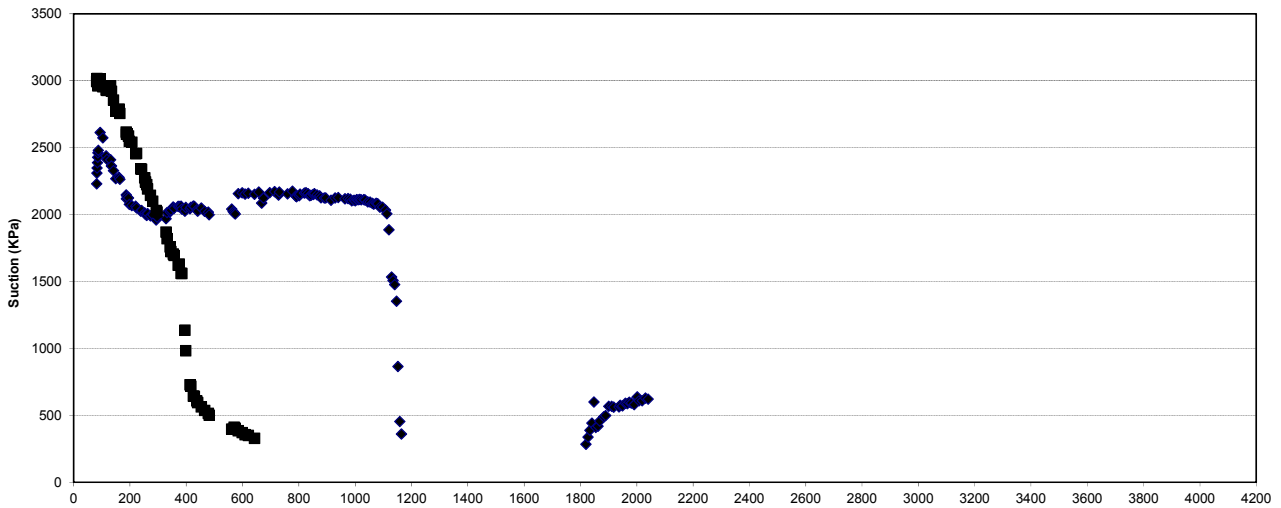
- | | | | | |
|-----------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| ◆ WBA10027(E3\0\2.5\3574) | ■ WBA10028(E3\0\1.3\3575) | ▲ WBA10029(E3\0\0\3575) | × WBA10030(E3\0\0.9\3575) | × WBA10031(E3\0\1.6\3575) |
| ● WBA10032(E3\0.3\2.6\3575) | + WBA10034(E3\1.2\3\3575) | □ WBA10035(E3\1.3\0\3575) | - WBA10036(E3\1.3\0\3575) | ◇ WBA10037(E3\2.3\0\3575) |

Prototype\Backfill\ Between dep.hole 3 and hole 4 (20010917-20130101)
Suction - Wescor

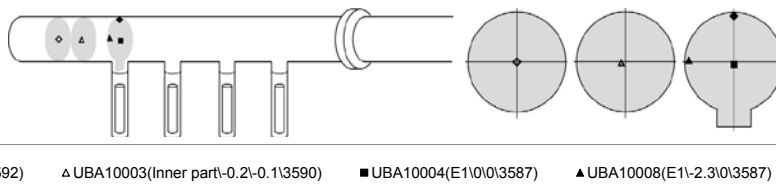
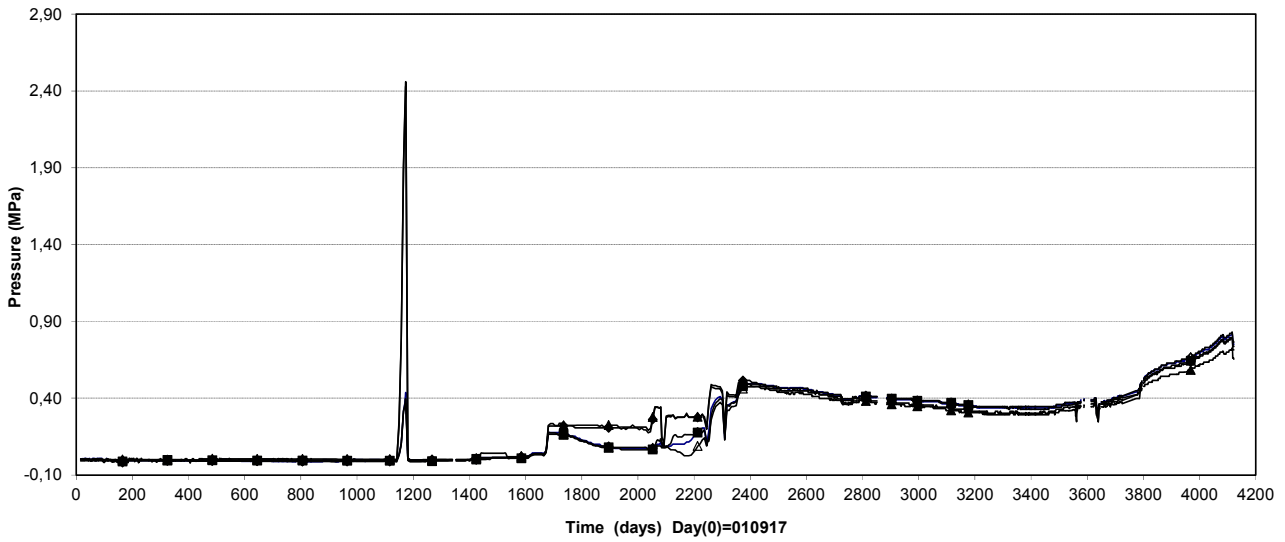


- | | | |
|------------------------------|------------------------------|------------------------------|
| ◆ WBA10038(F3- 4\0\2.3\3572) | ■ WBA10039(F3- 4\0\1.2\3572) | ▲ WBA10040(F3- 4\0\0\3572) |
| × WBA10041(F3- 4\0\1.3\3572) | × WBA10042(F3- 4\1.3\0\3572) | ● WBA10043(F3- 4\1.3\0\3572) |

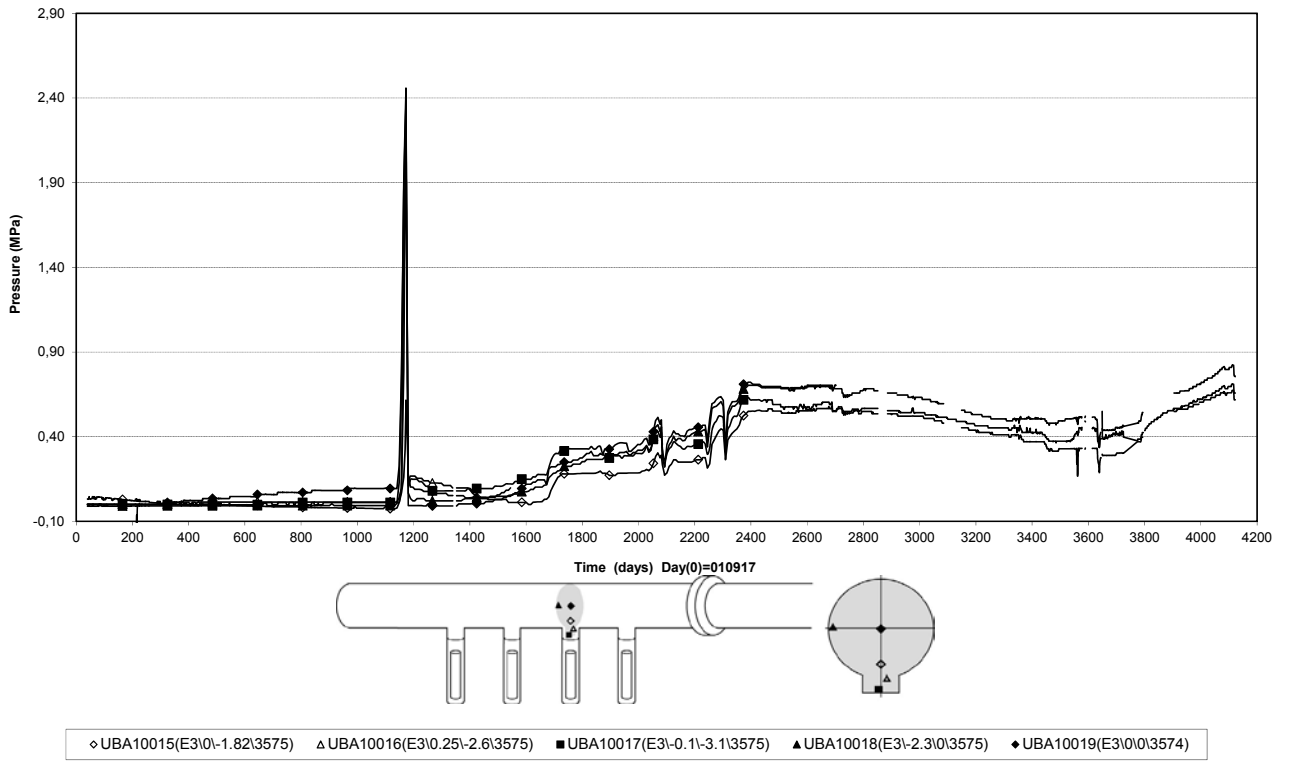
Prototype\Backfill \ In front of plug (20010917-20130101)
Suction - Wescor



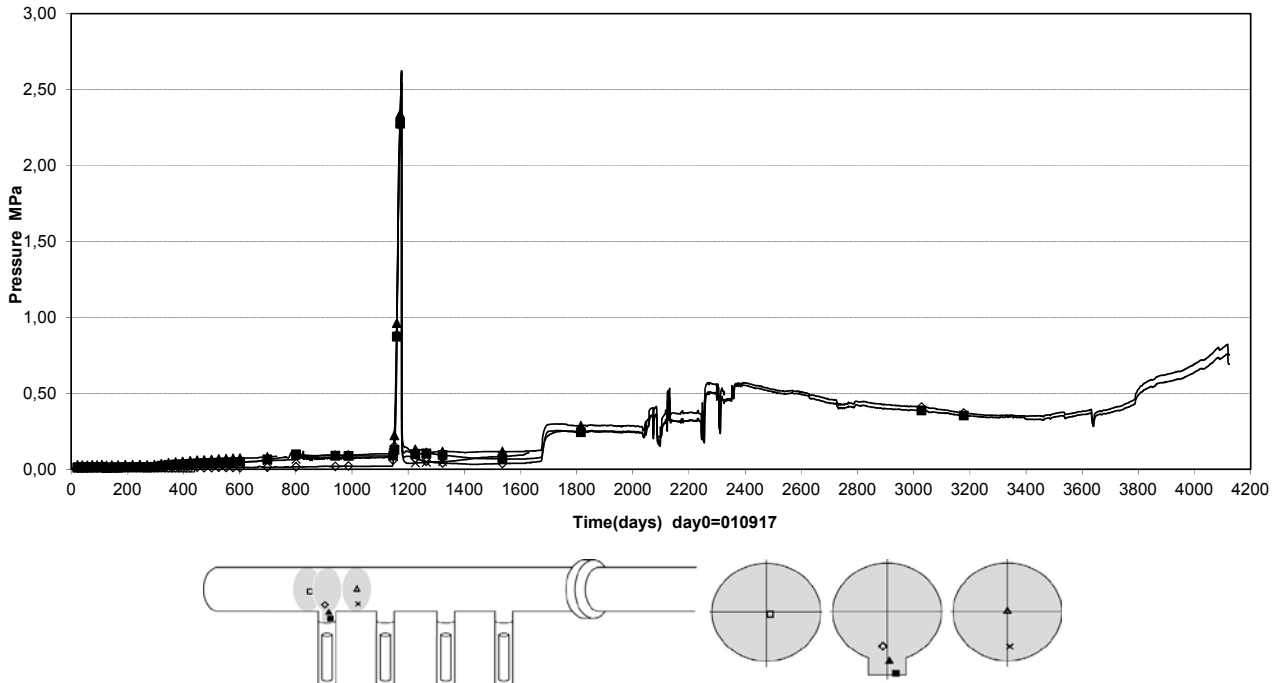
Prototype\Backfill\Section 1 (010917-20130101)
Pore pressure - Geokon



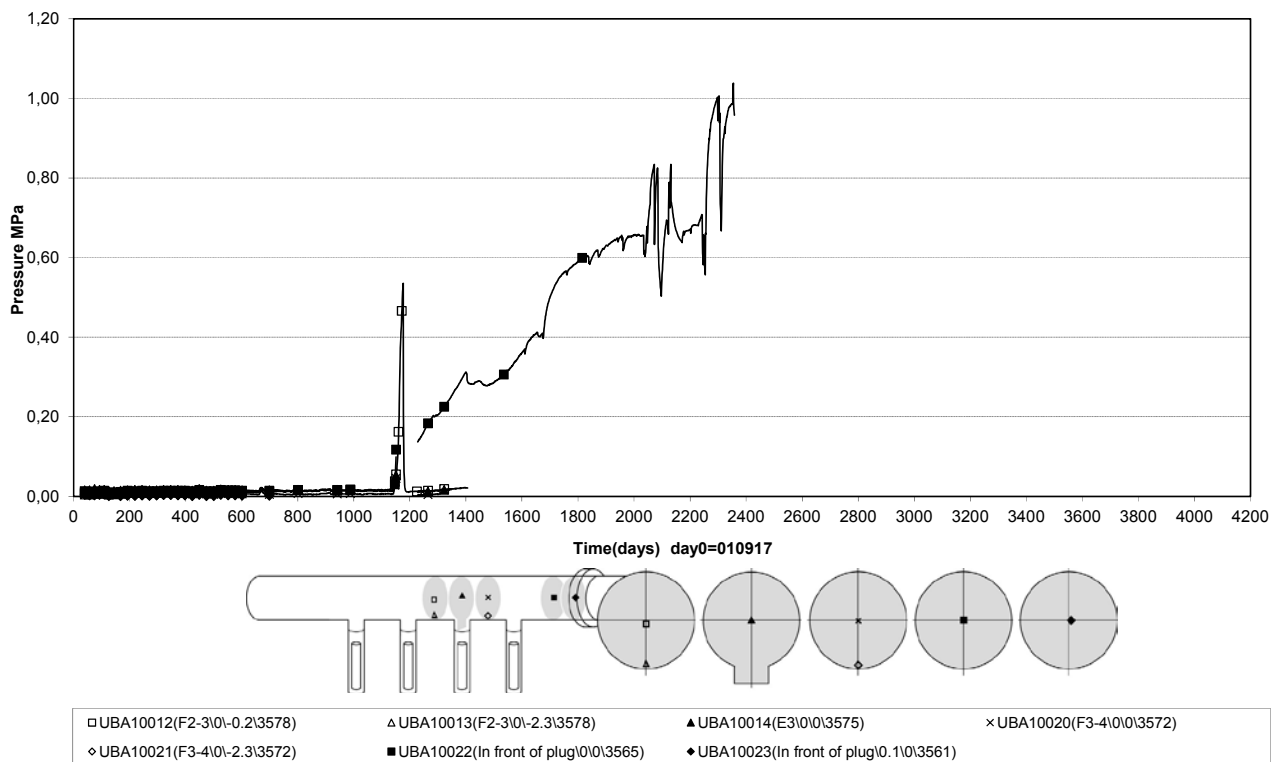
Prototype\Backfill \ Section 1 (010917-20130101)
Pore pressure - Geokon



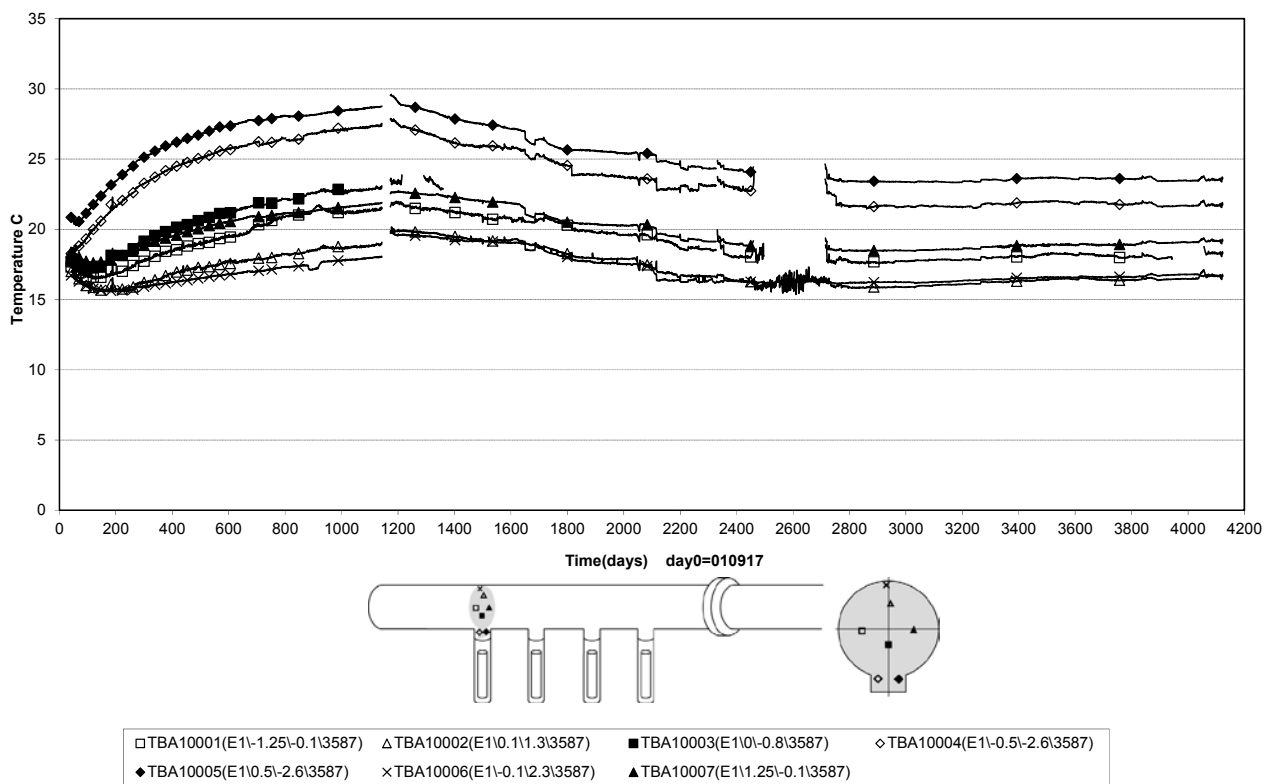
Prototype\Backfill \ Section 1 (010917-20130101)
Pore pressure - Kulite



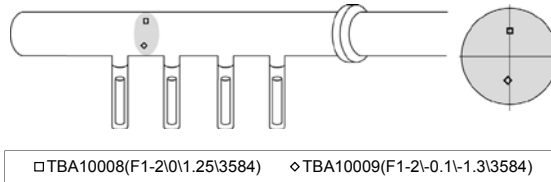
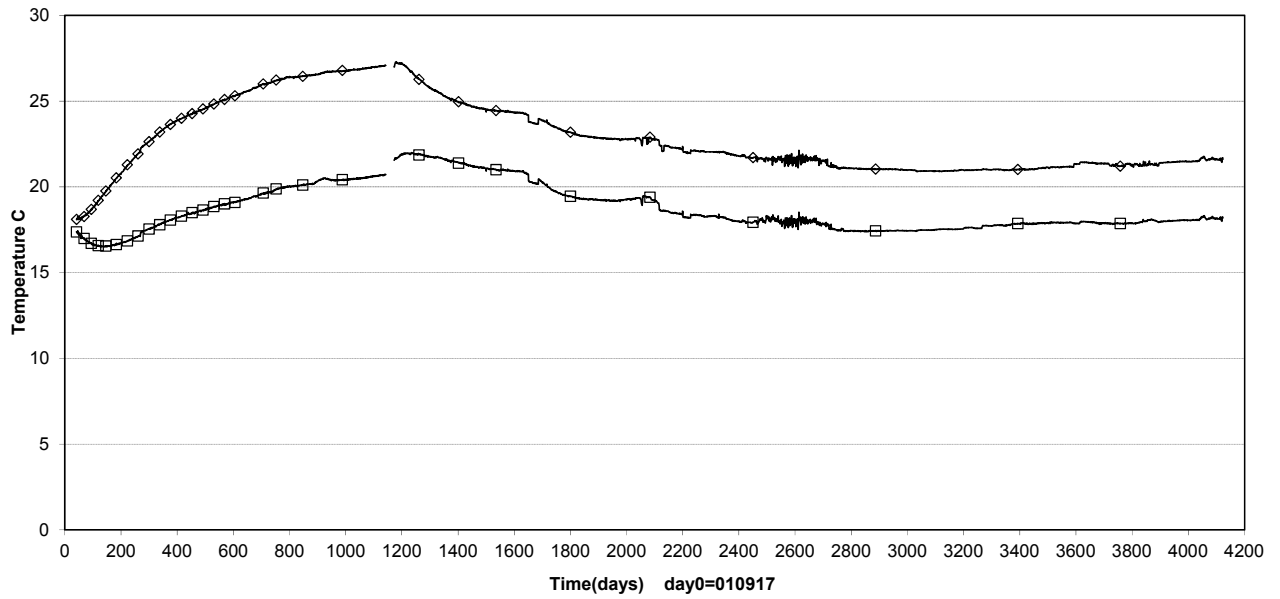
Prototype\Backfill \Section 1 (041015-20130101)
Pore pressure - Kulite



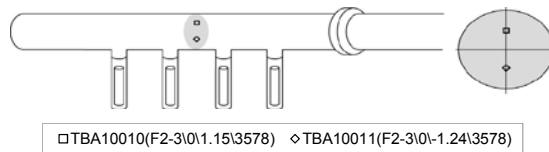
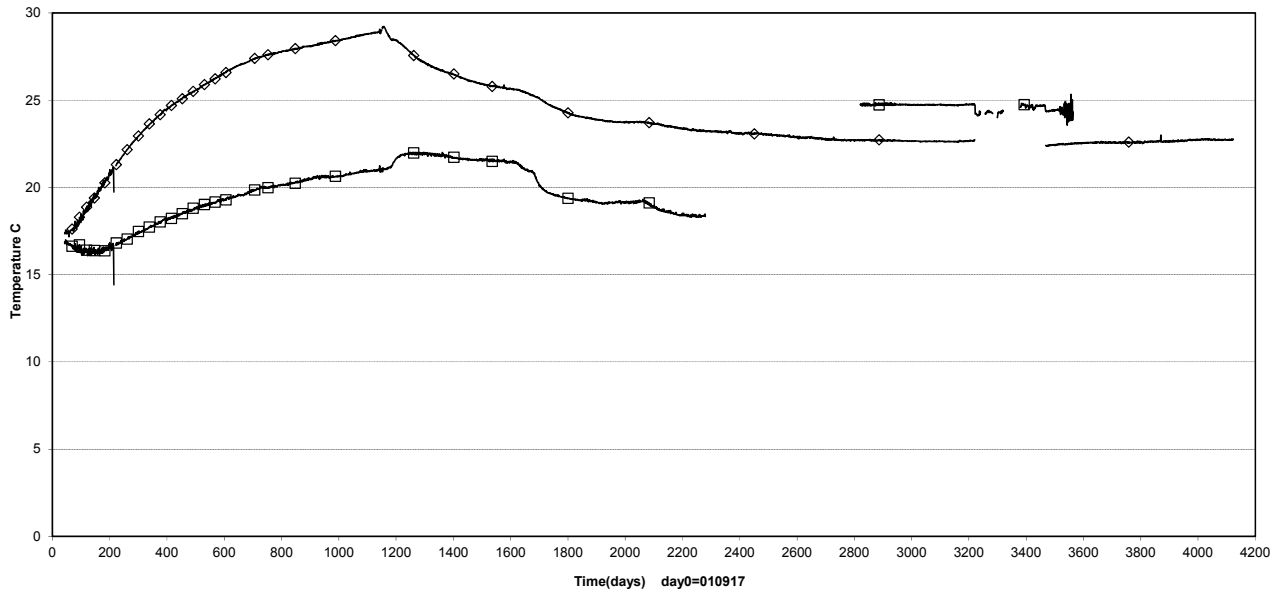
Prototype\ Backfill \ Above dep.hole1 (010917-20130101)
Temperature - Pentronic



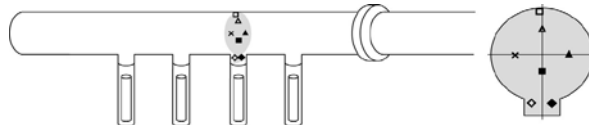
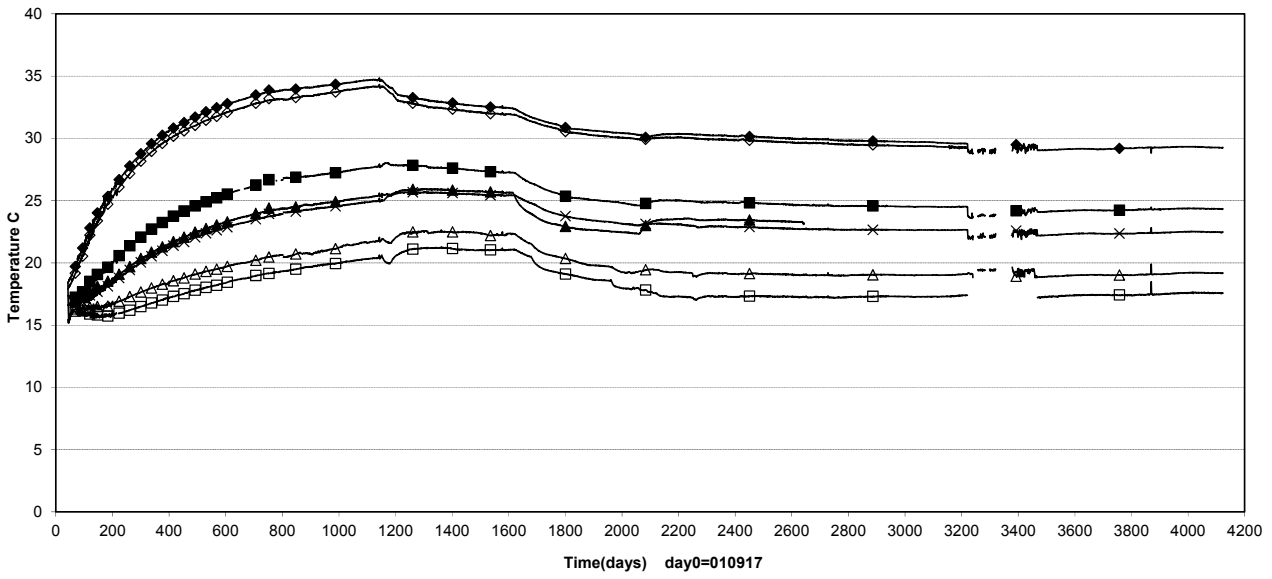
Prototype\ Backfill \ Between dep.hole 1-2 (010917-20130101)
 Temperature - Pentronic



Prototype\ Backfill \ Between dep.hole 2-3 (010917-20130101)
 Temperature -Pentronic

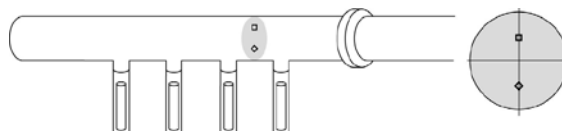
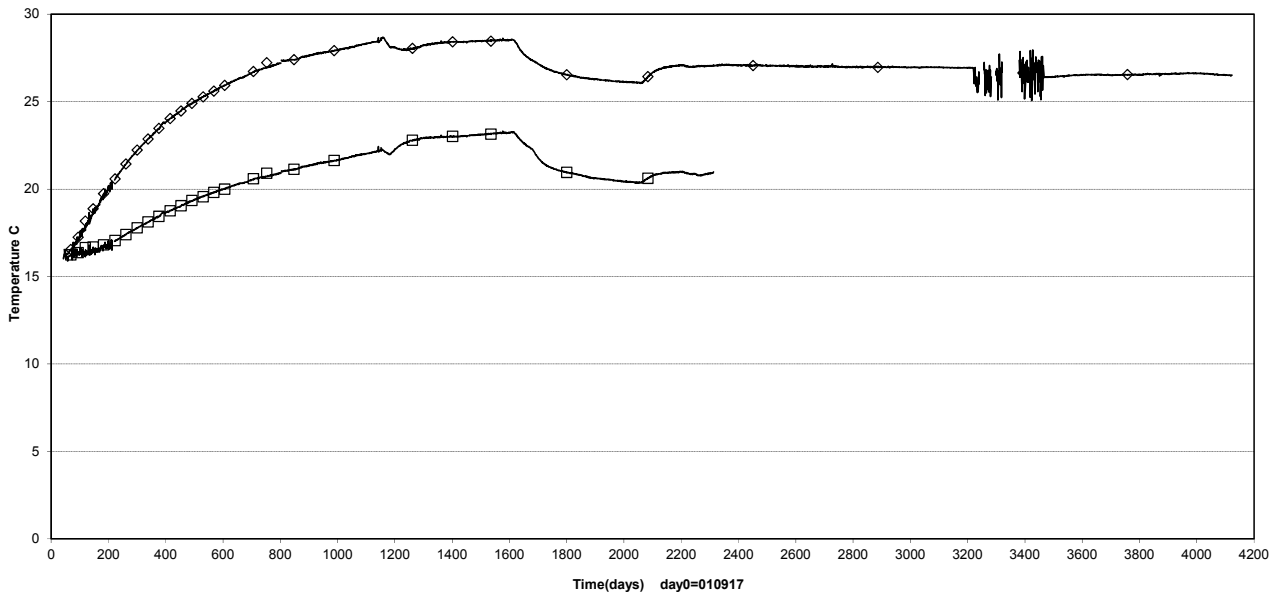


Prototype\ Backfill \ Above dep.hole3 (010917-20130101)
Temperature - Pentronic



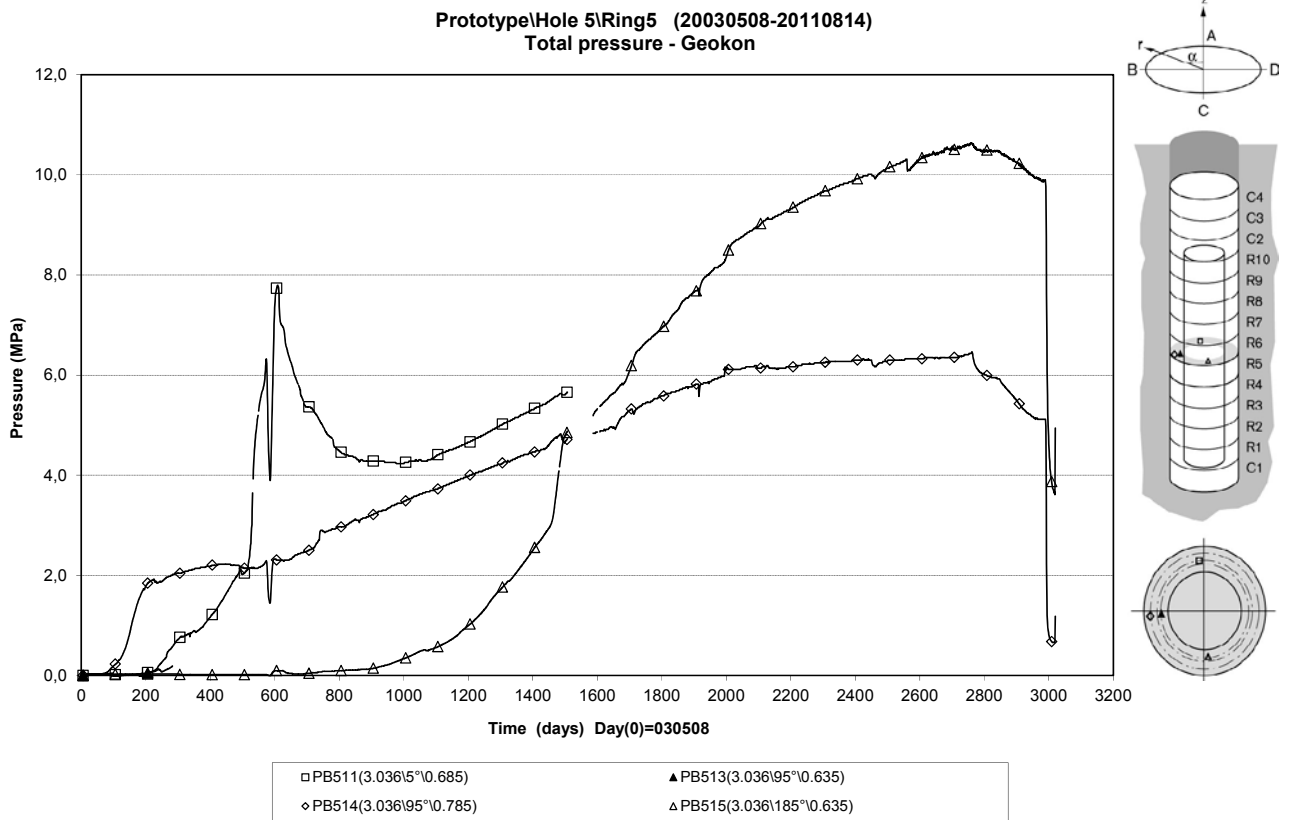
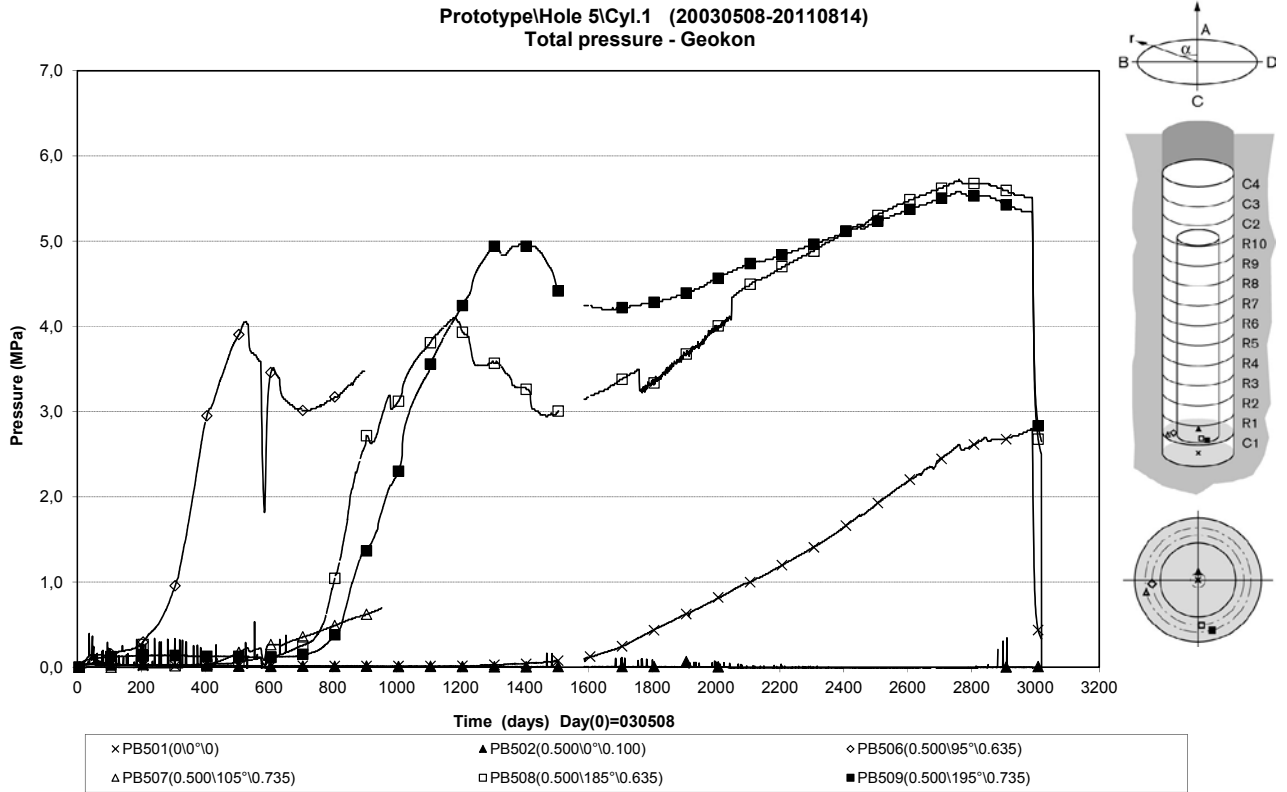
- | | | | |
|-----------------------------|---------------------------|-----------------------------|-----------------------------|
| □ TBA10012(E3\0.1\2.3\3575) | △ TBA10013(E3\0.1\3\3575) | ■ TBA10014(E3\0.9\0.9\3575) | ◇ TBA10015(E3\0.5\2.6\3575) |
| ◆ TBA10016(E3\0.5\2.6\3575) | × TBA10017(E3\1.3\0\3575) | ▲ TBA10018(E3\1.3\0\3575) | |

Prototype\ Backfill \ Between dep.hole 3-4 (010917-20130101)
Temperature - Pentronic

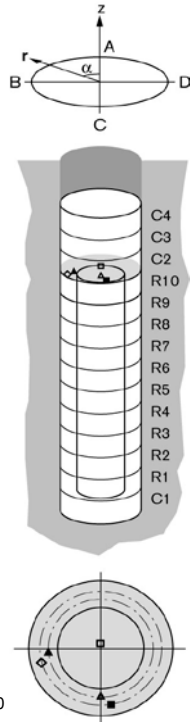
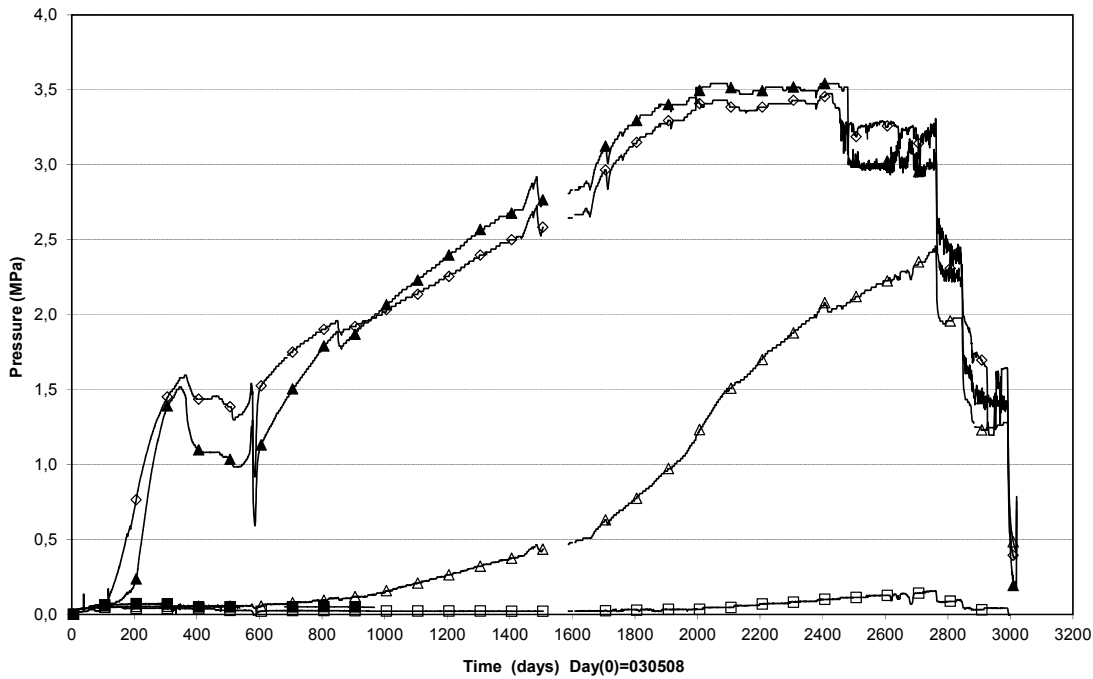


- | | |
|-----------------------------|-----------------------------|
| □ TBA10019(F3-4\0.1\2\3572) | ◇ TBA10020(F3-4\0.1\3\3572) |
|-----------------------------|-----------------------------|

Dep. hole 5

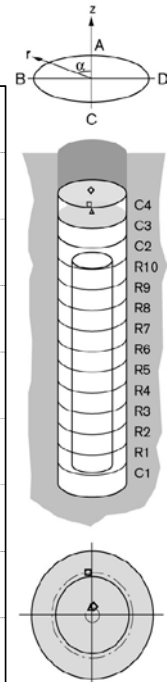
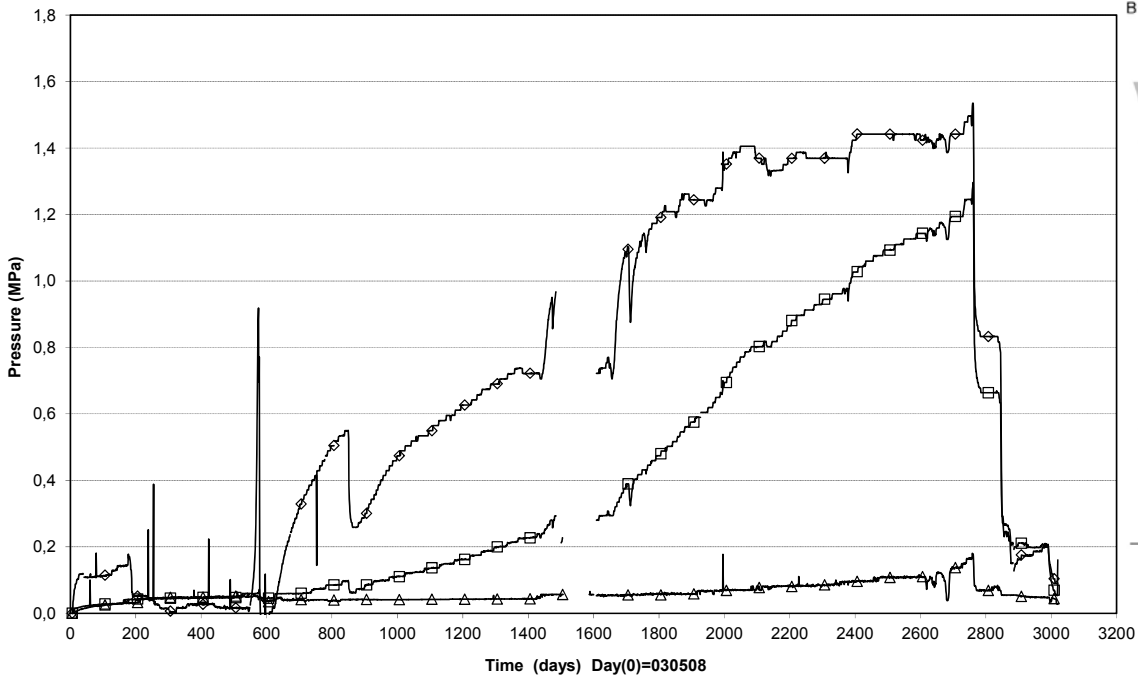


Prototype\Hole 5\Ring10 (20030508-20110814)
Total pressure - Geokon



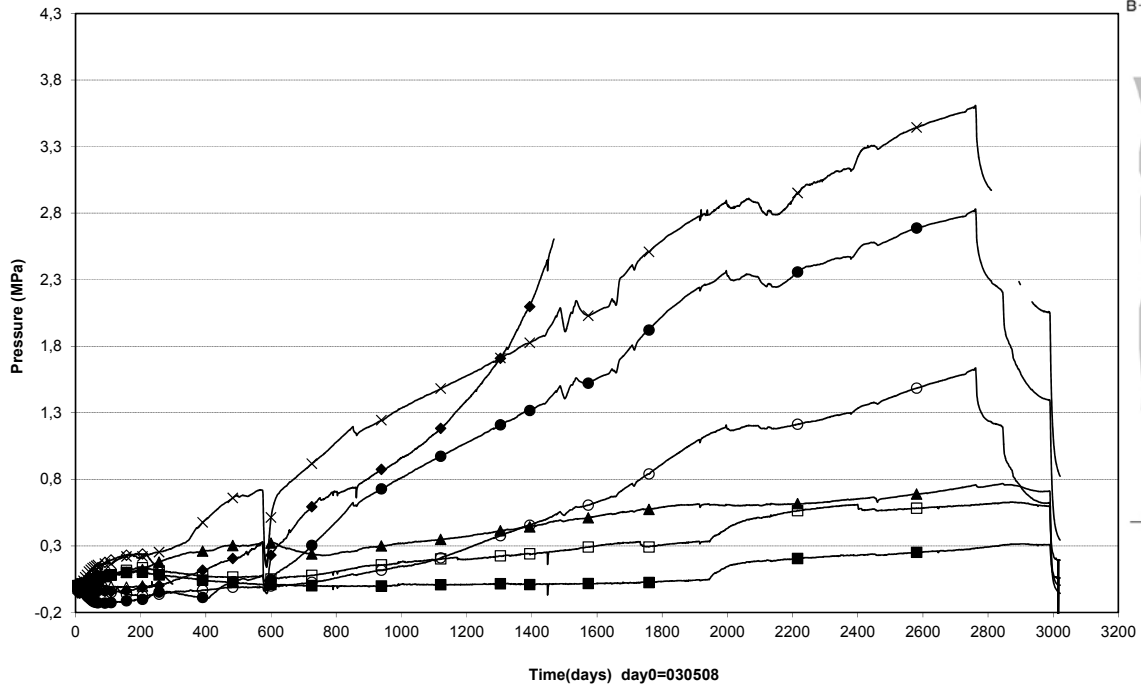
| | | |
|---------------------------|---------------------------|---------------------------|
| □ PB517(5.593\0°\0.050) | ▲ PB521(5.593\95°\0.635) | ◇ PB522(5.593\105°\0.735) |
| △ PB523(5.593\180°\0.635) | ■ PB524(5.593\190°\0.735) | |

Prototype\Hole 5\Cyl.3 and Cyl.4 (20030508-20110814)
Total pressure - Geokon



| | | |
|-------------------------|-------------------------|-------------------------|
| △ PB525(6.603\0°\0.100) | □ PB526(6.603\5°\0.585) | ◇ PB527(7.110\0°\0.100) |
|-------------------------|-------------------------|-------------------------|

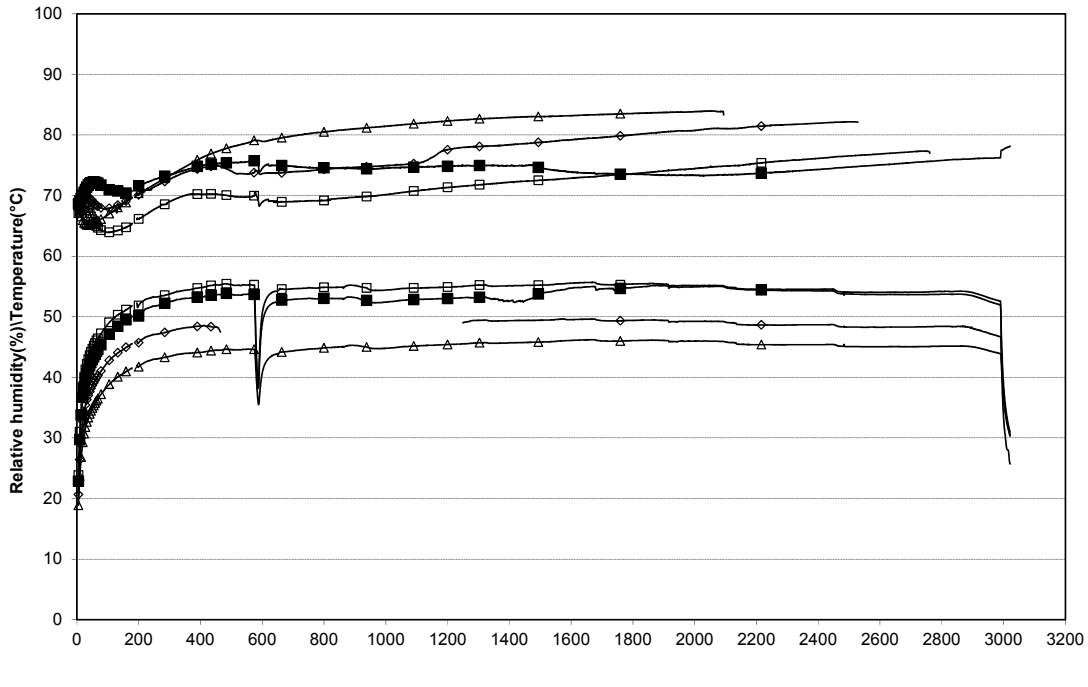
Prototype\Hole 5 (20030508-20110814)
Total pressure - Kulite



Time(days) day0=030508

| | | | | |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|----------------------------|
| □ PB503(0.340 \15^\ 0.585) | ■ PB504(0.340 \15^\ 0.685) | ◇ PB505(0.340 \15^\ 0.785) | ◆ PB510(2.876 \110^\ 0.535) | △ PB512(2.876 \15^\ 0.825) |
| ▲ PB516(2.876 \190^\ 0.825) | ○ PB518(5.433 \110^\ 0.585) | ● PB519(5.433 \110^\ 0.685) | × PB520(5.433 \110^\ 0.785) | |

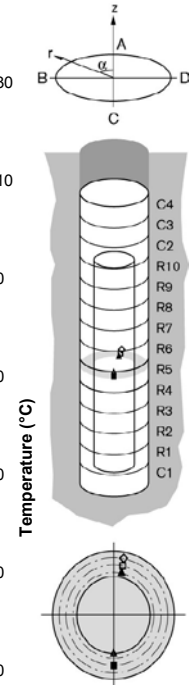
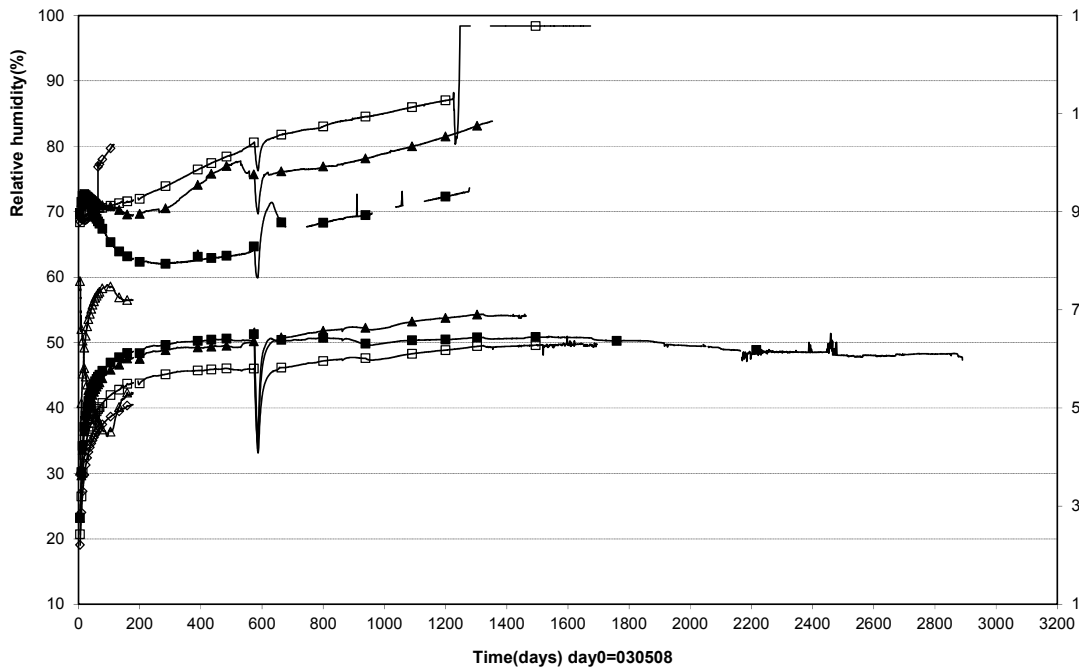
Prototype\Hole 5\Cyl.1 (20030508-20110814)
Relative humidity - Vaisala



Time(days) day0=030508

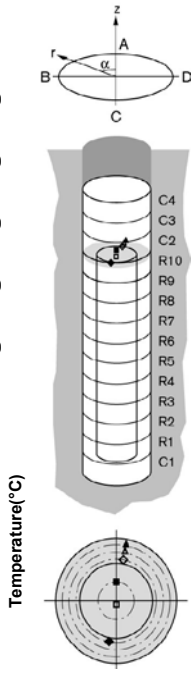
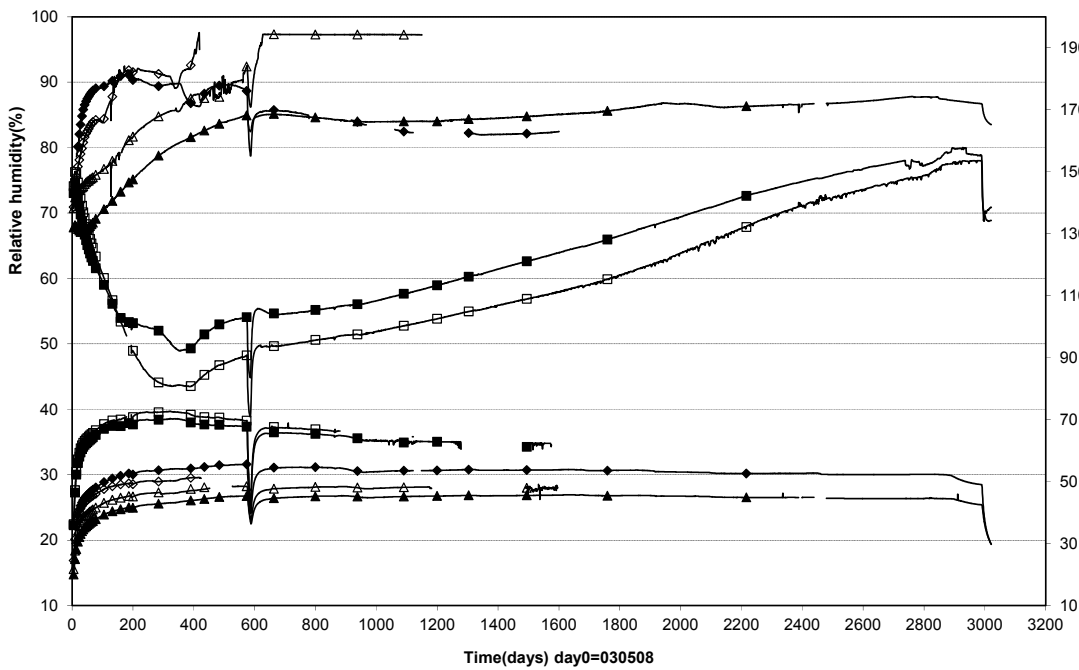
| | | | |
|----------------------------|----------------------------|----------------------------|---------------------------|
| □ WB504(0.340\350^\ 0.585) | ◇ WB505(0.340\350^\ 0.685) | △ WB506(0.340\350^\ 0.785) | ■ WB507(0.340\80^\ 0.585) |
|----------------------------|----------------------------|----------------------------|---------------------------|

Prototype\Hole 5\Ring 5 (20030508-20110814)
Relative humidity - Vaisala



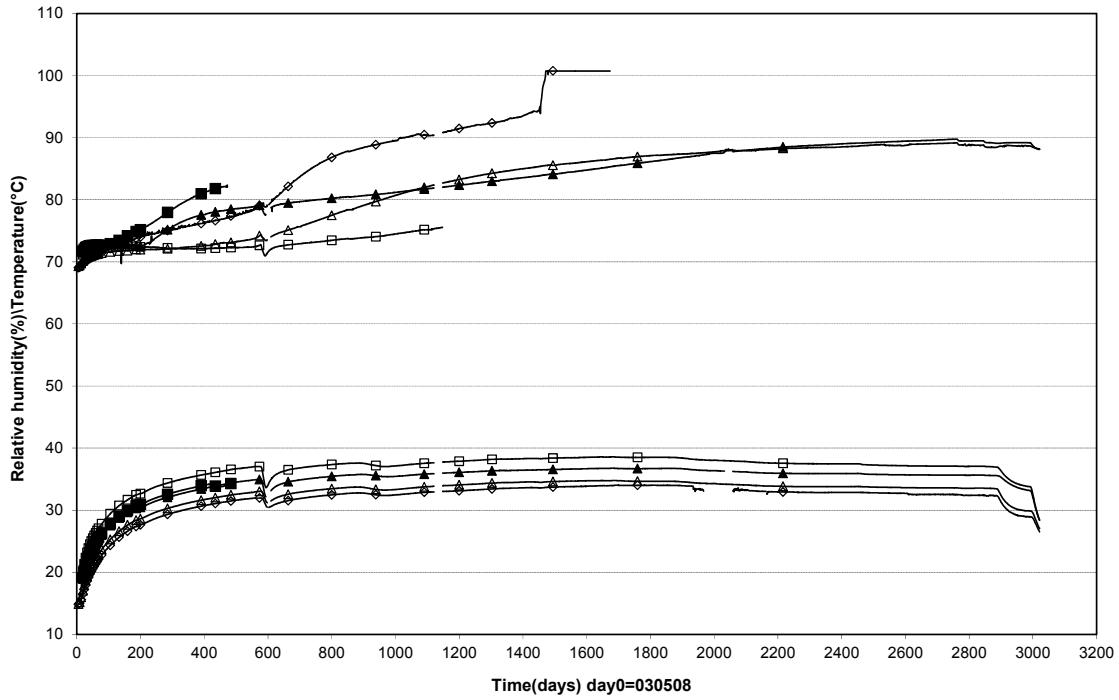
▲ WB513(2.876\350°\0.585) □ WB514(2.876\350°\0.685) ◇ WB515(2.876\350°\0.785) ▲ WB519(2.876\180°\0.535)In the slot ■ WB520(2.876\180°\0.685)

Prototype\Hole 5\Ring 10 (20030508-20110814)
Relative humidity - Vaisala



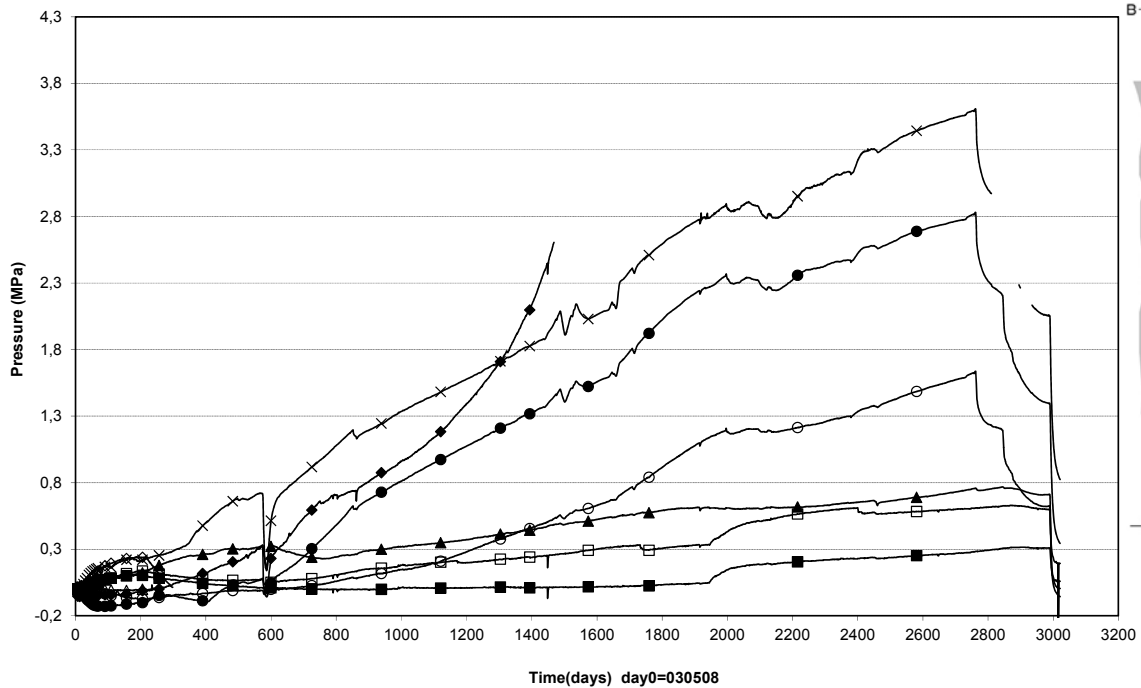
□ WB522(5.433\180°\0.050) ■ WB523(5.433\ 0° \0.262) ◇ WB524(5.433\350°\0.585) ▲ WB525(5.433\350°\0.685) ▲ WB526(5.433\350°\0.785) ◆ WB530(5.433\170°\0.585)

Prototype\Hole 5\Cyl.3 and Cyl.4 (20030508-20110814)
Relative humidity - Vaisala



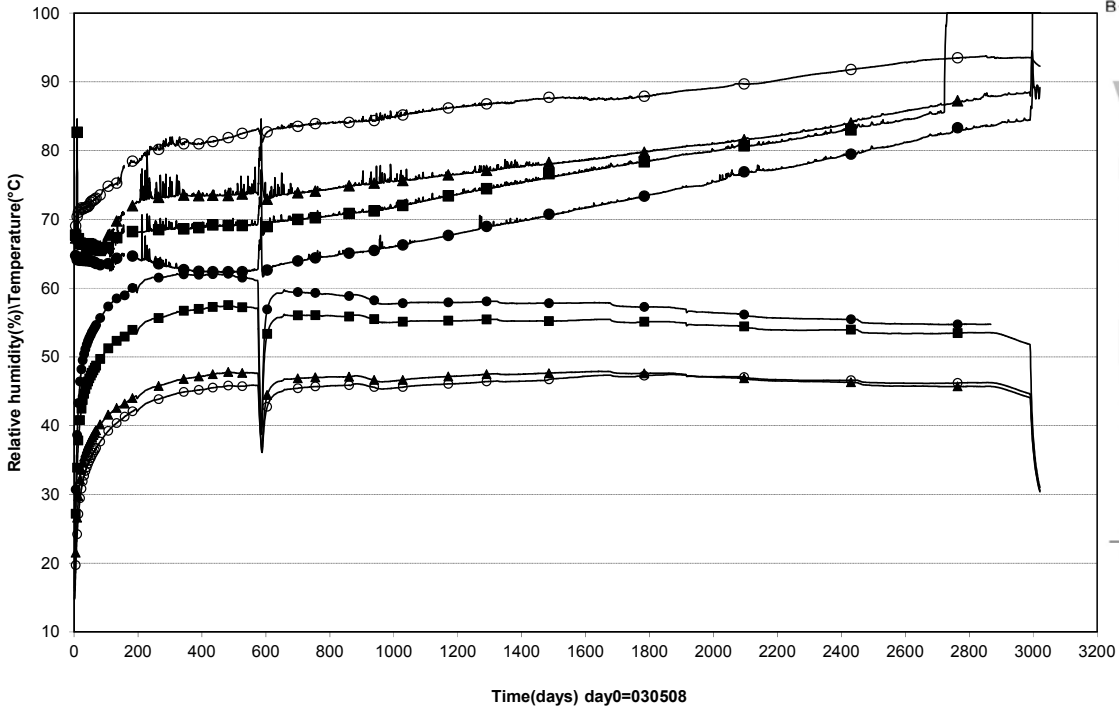
□WB532(6.353\270°\0.100) ▲WB533(6.353\350°\0.585) ■WB534(6.353\90°\0.585) △WB536(6.790\180°\0.100) ◇WB537(6.950\270°\0.100)

Prototype\ Hole 5 (20030508-20110814)
Total pressure - Kulite

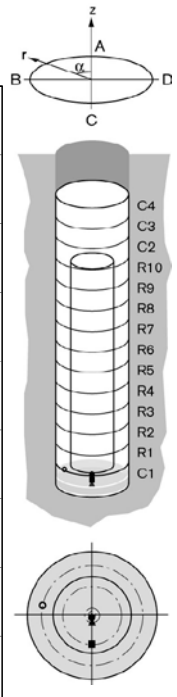


□PB503(0.340 \5°\ 0.585) ■PB504(0.340 \5°\0.685) ◇PB505(0.340 \5°\ 0.785) ◆PB510(2.876 \10°\ 0.535) △PB512(2.876 \5°\ 0.825)
▲PB516(2.876 \190°\ 0.825) ○PB518(5.433 \10°\ 0.585) ●PB519(5.433 \10°\ 0.685) ×PB520(5.433 \10°\ 0.785)

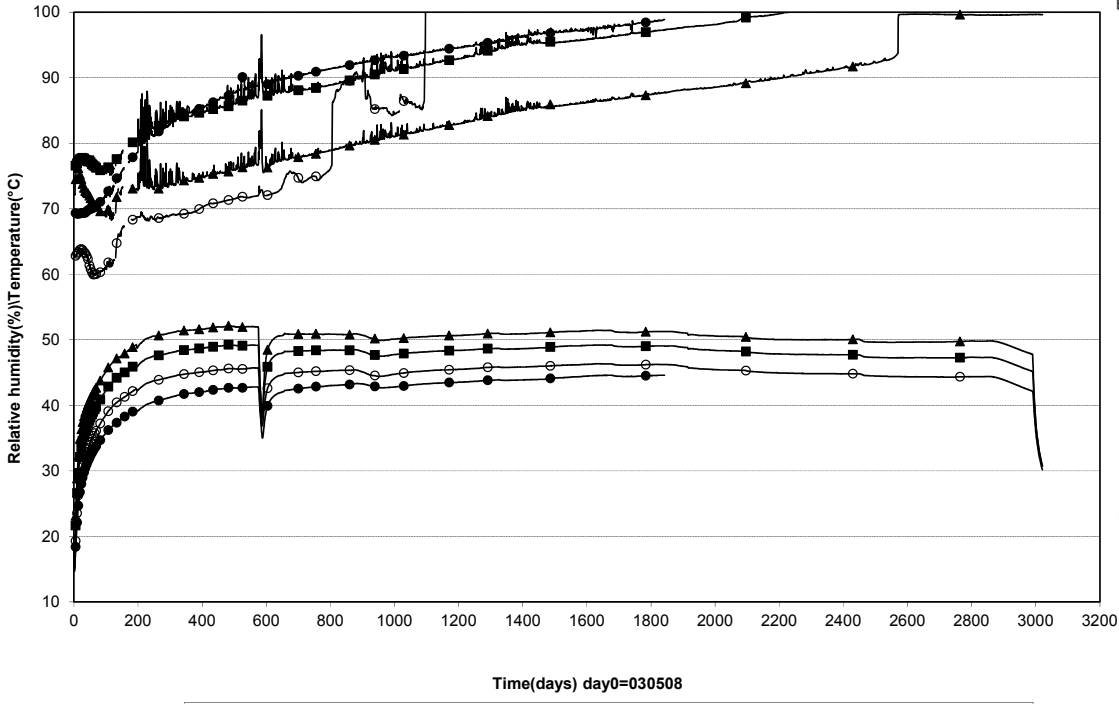
Prototyp\Hole 5\Cyl.1 (20030508-20110814)
Relative humidity - Rotronic



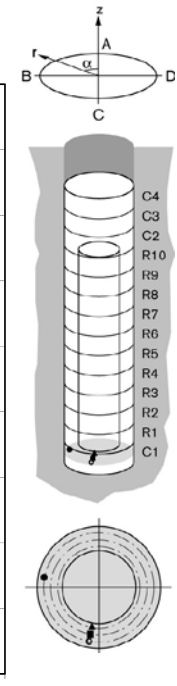
● WB501 (0.250\180°\0.050) ▲ WB502 (0.05\180°\0.100) ■ WB503 (0.250\180°\0.400) ○ WB508(0.250\80°\0.685)



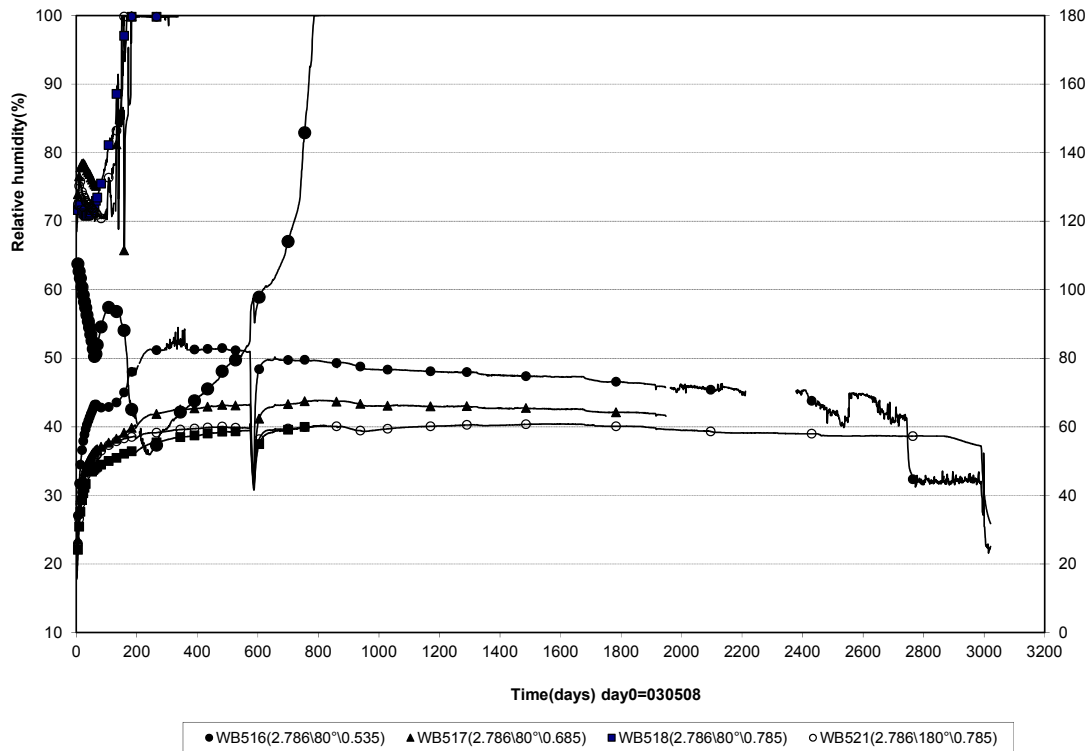
Prototyp\Hole 5\Cyl.1 (20030508-20110814)
Relative humidity - Rotronic



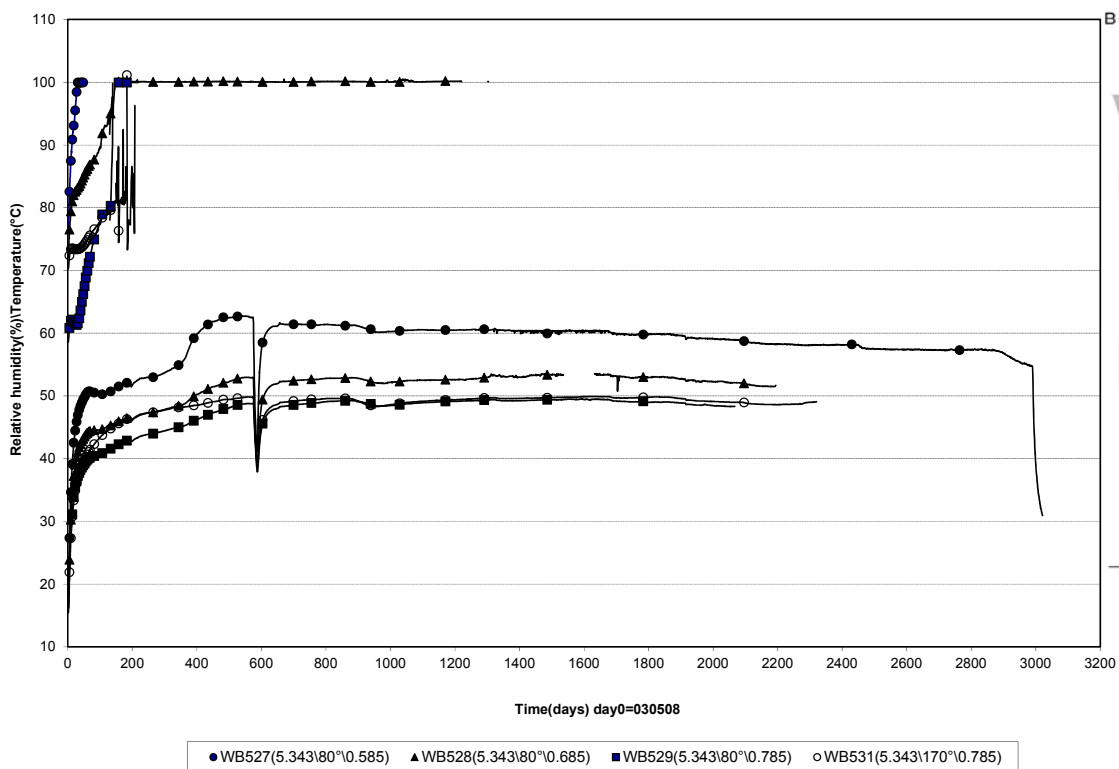
● WB509(0.250\80°\0.785) ▲ WB510(0.250\170°\0.585) ■ WB511(0.250\170°\0.685) ○ WB512(0.250\170°\0.785)

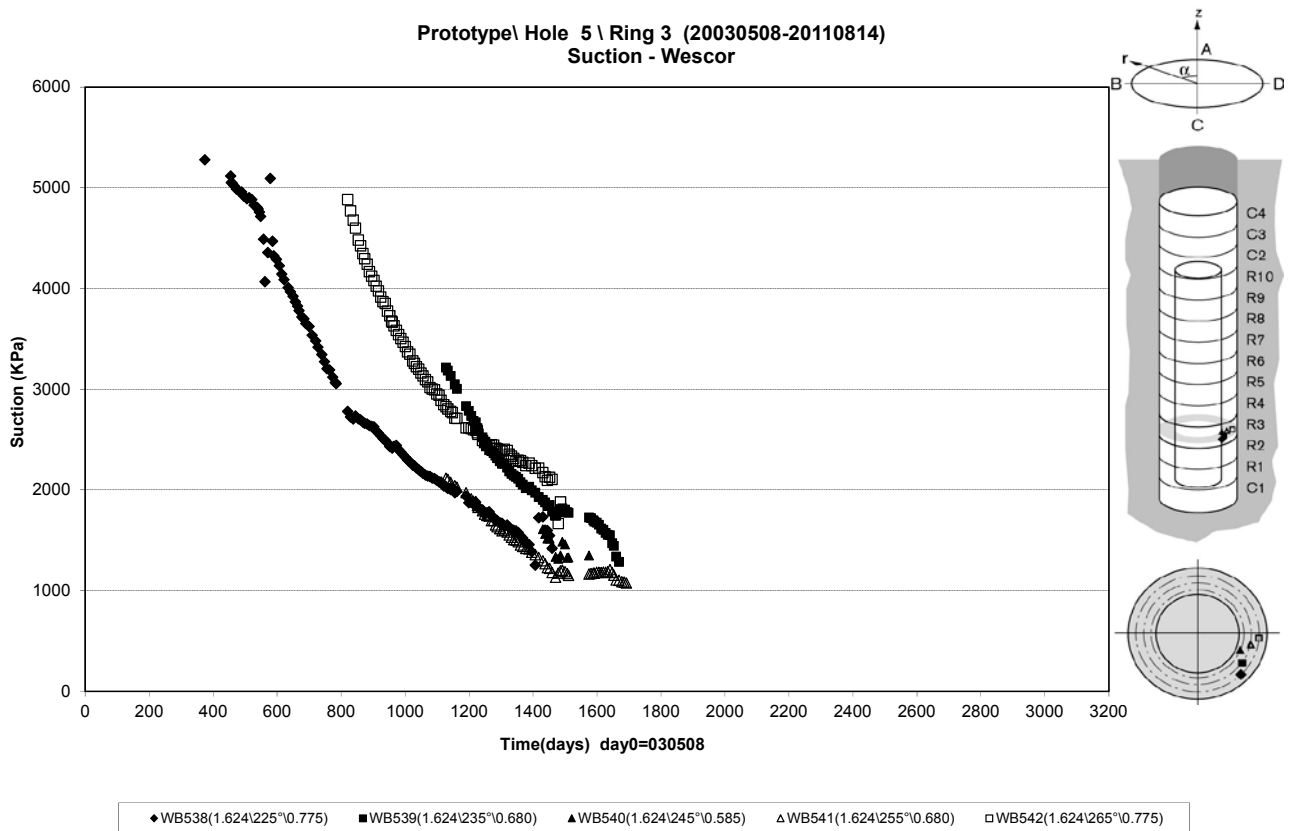
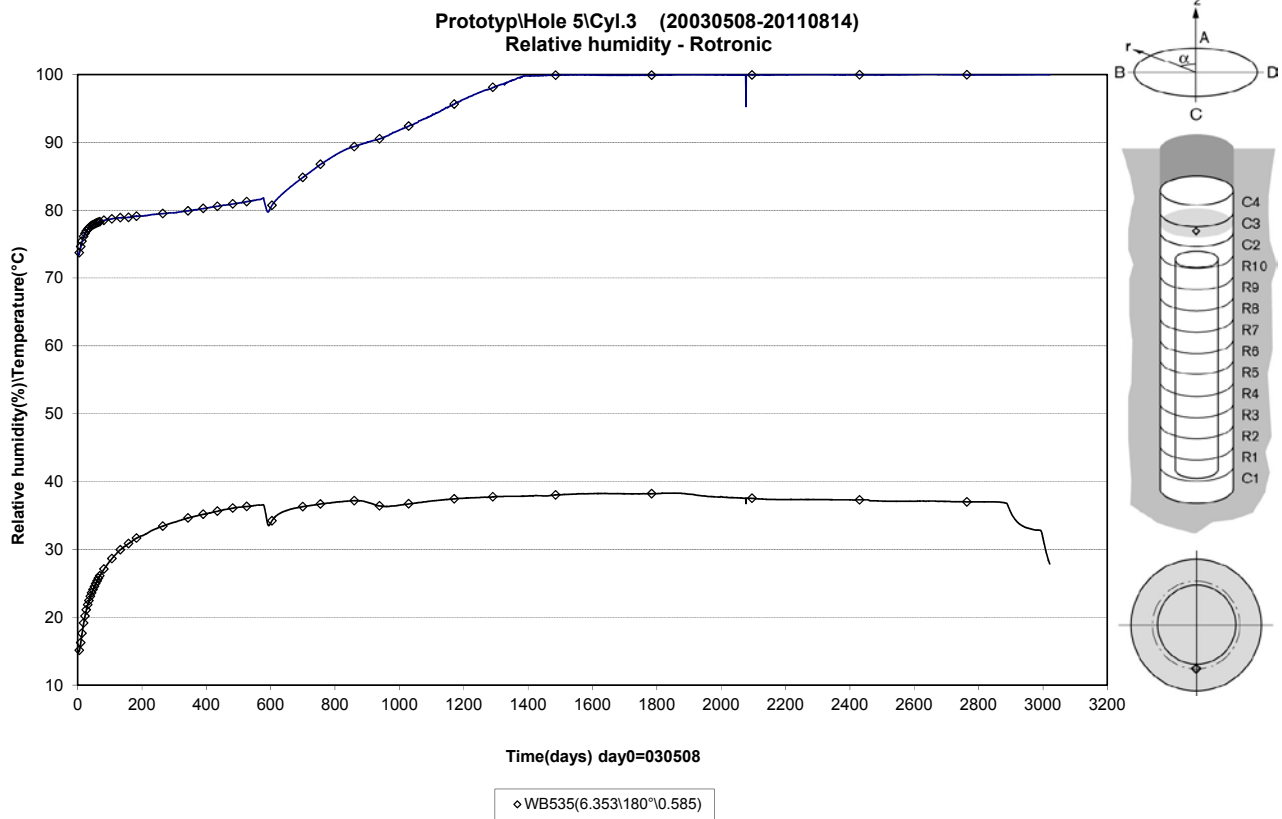


Prototyp\Hole 5\Ring5 (20030508-20110814)
Relative humidity - Rotronic

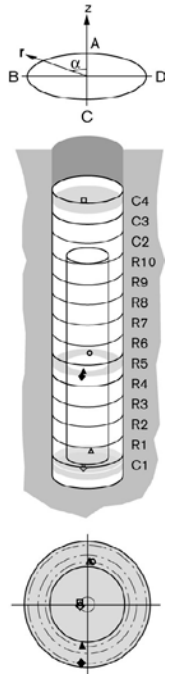
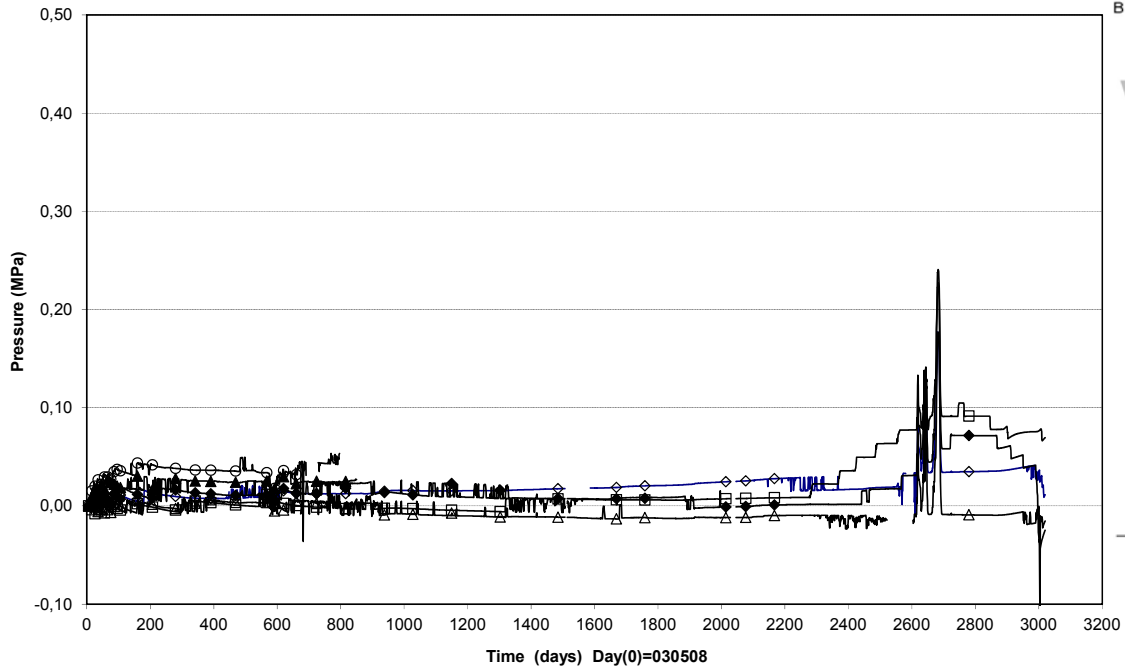


Prototyp\Hole 5\Ring10 (20030508-20110814)
Relative humidity - Rotronic

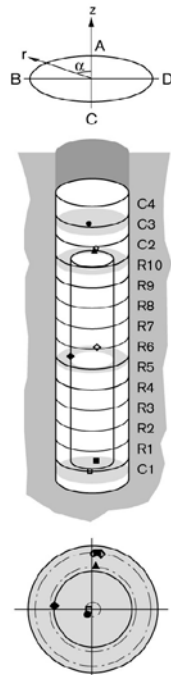
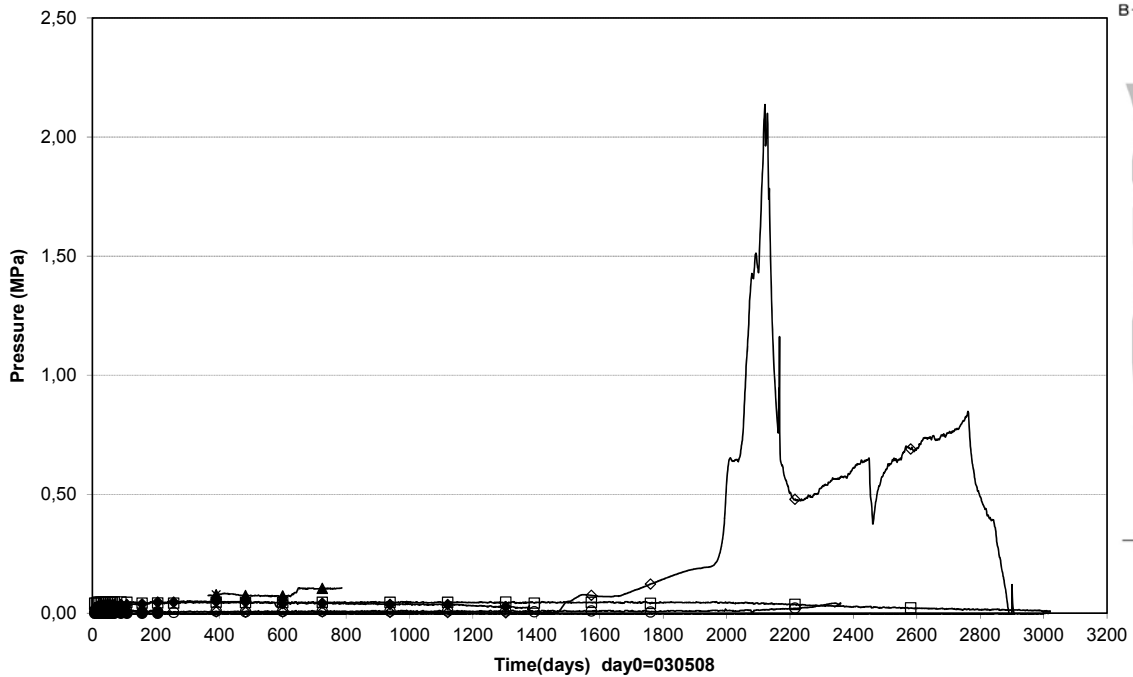




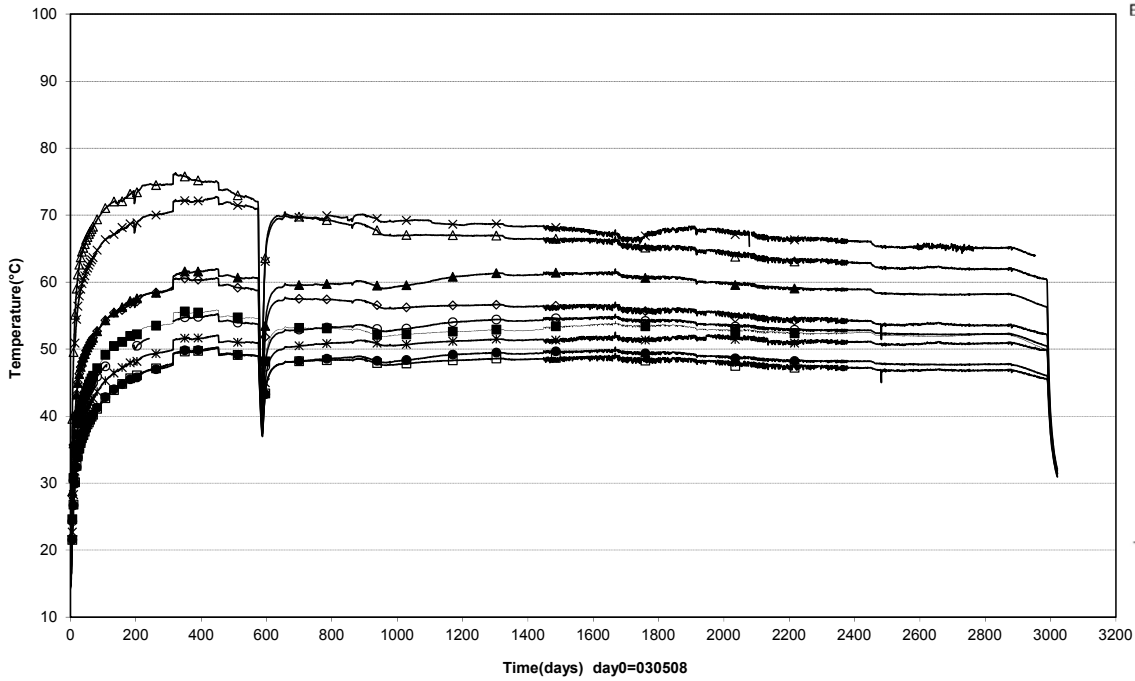
Prototype\Hole5 (20030508-20110814)
Pore pressure - Geokon



Prototipe\ Hole 5 (20030508-20110814)
Pore pressure - Kulite

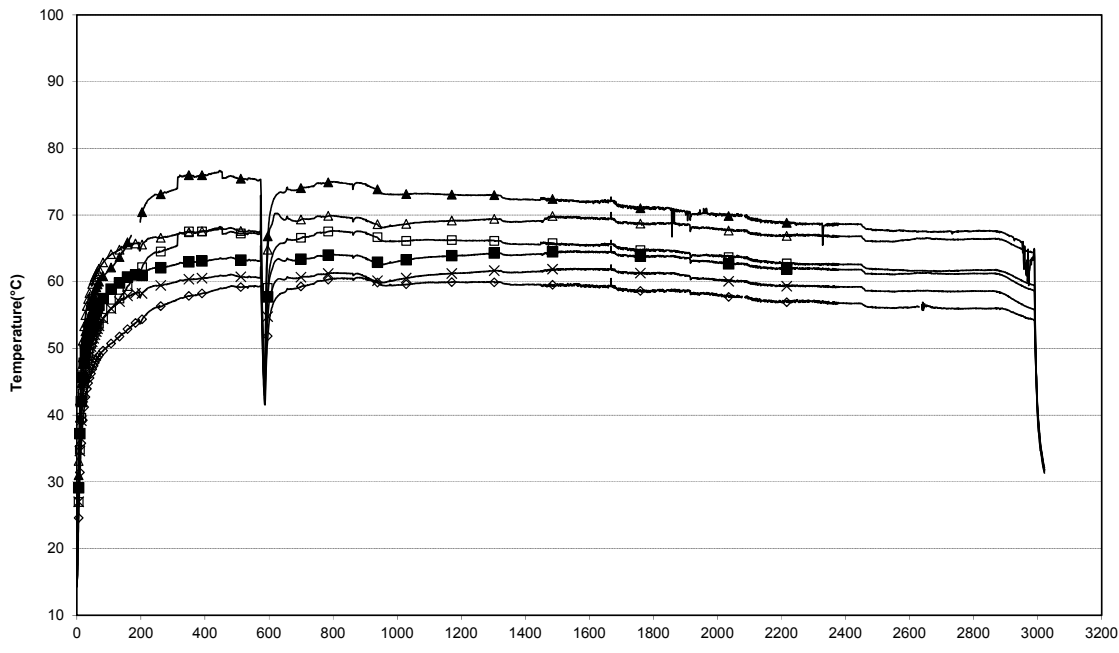


Prototype\Hole 5\Cyl.1 (20030508-20110814)
Temperature - Pentronic



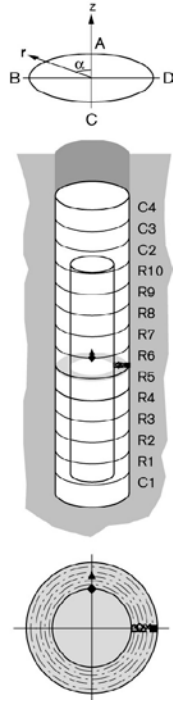
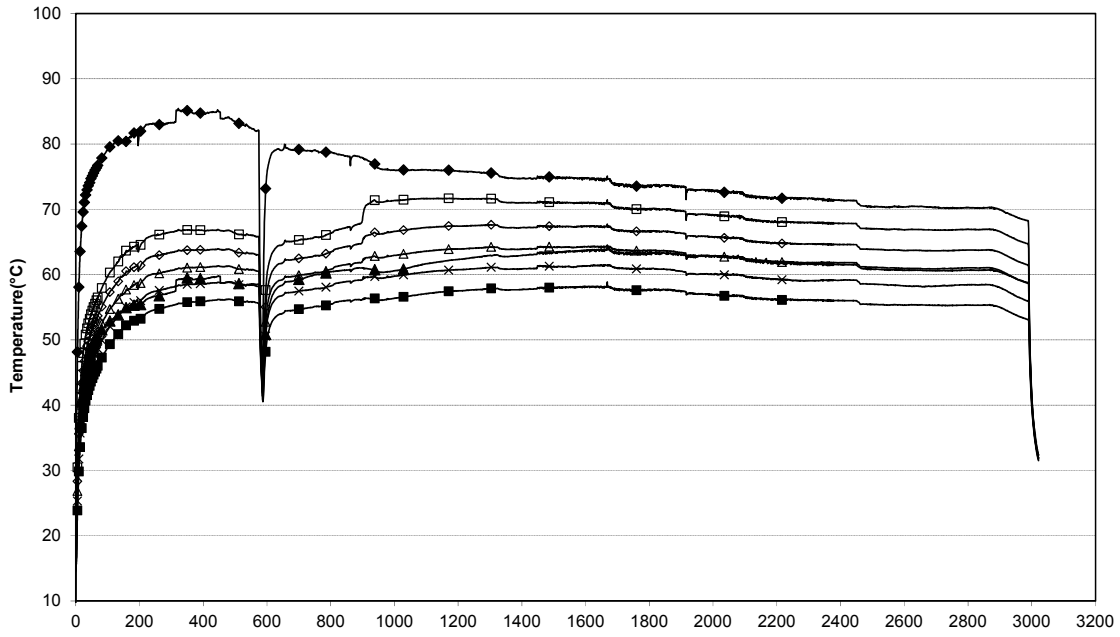
- | | | | | |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| □ TB501(0.080\270°\0.050) | ◇ TB502(0.250\270°\0.060) | △ TB503(0.450\270°\0.070) | × TB504(0.450\355°\0.525) | × TB505(0.450\355°\0.685) |
| + TB506(0.450\85°\0.685) | ■ TB507(0.450\175°\0.685) | ▲ TB508(0.450\270°\0.585) | ○ TB509(0.450\270°\0.685) | ● TB510(0.450\270°\0.785) |

Prototype\Hole 5 \Ring5 (20030508-20110814)
Temperature - Pentronic



- | | | |
|---------------------------|---------------------------|---------------------------|
| ▲ TB513(2.986\85°\0.585) | □ TB514(2.986\85°\0.685) | ◇ TB515(2.986\85°\0.785) |
| △ TB516(2.986\175°\0.585) | ■ TB517(2.986\175°\0.685) | × TB518(2.986\175°\0.735) |

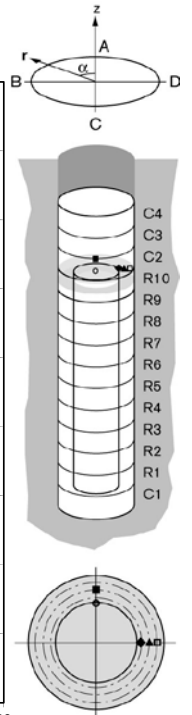
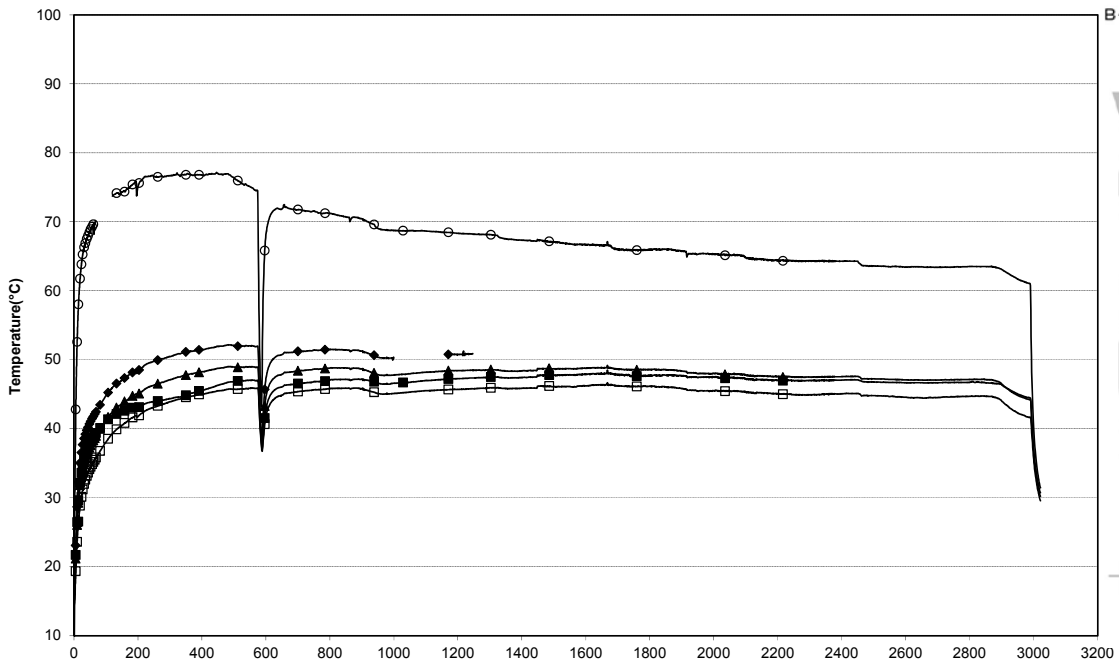
Prototype\Hole 5 \Ring5 (20030508-20110814)
Temperature - Pentronic



Time(days) day0=030508

| | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|
| □ TB519(2.986\270\0.585) | ◇ TB520(2.986\270\0.635) | △ TB521(2.986\270\0.685) | × TB522(2.986\270\0.735) |
| ■ TB523(2.986\270\0.785) | ◆ TB511(2.950\0\0.525) | ▲ TB512(2.986\0\0.685) | |

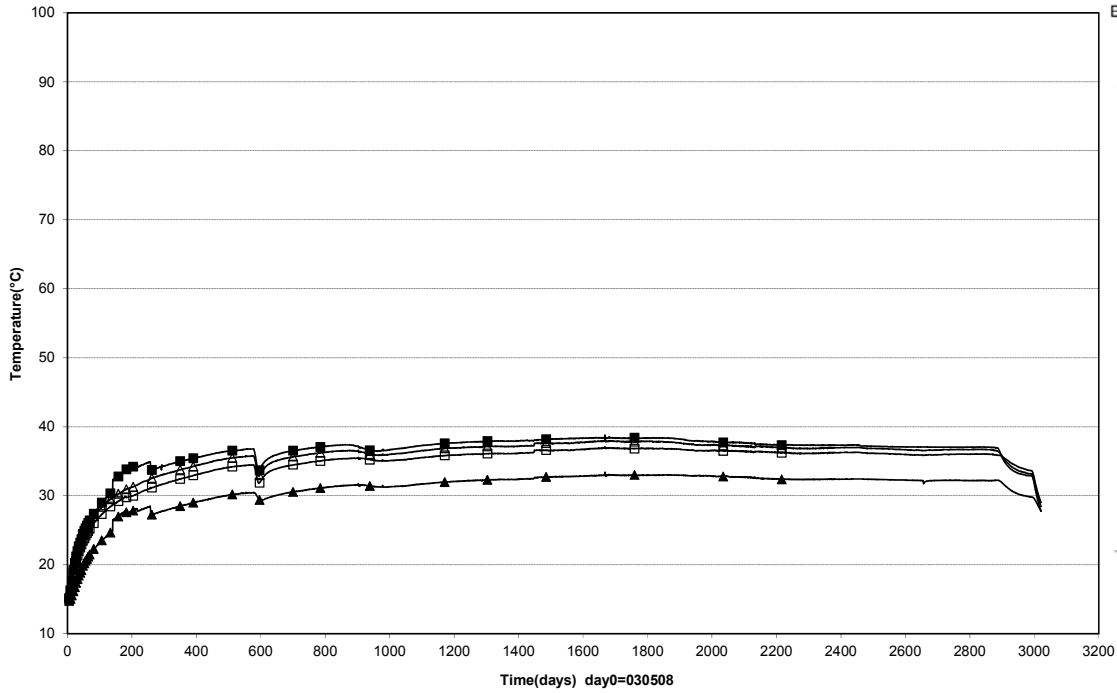
Prototype\Hole 5 \Ring10 (20030508-20110814)
Temperature - Pentronic



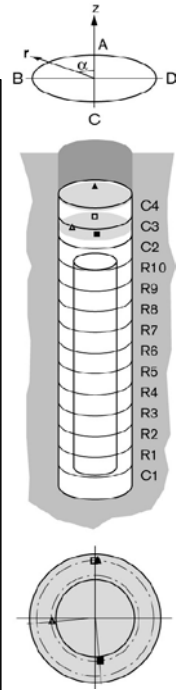
Time(days) day0=030508

| | | | | |
|-------------------------|-------------------------|---------------------------|---------------------------|---------------------------|
| ○ TB524(5.150\ 0\0.525) | ■ TB525(5.543\ 0\0.685) | ◆ TB526(5.543\ 270\0.585) | ▲ TB527(5.543\ 270\0.685) | □ TB528(5.543\ 270\0.785) |
|-------------------------|-------------------------|---------------------------|---------------------------|---------------------------|

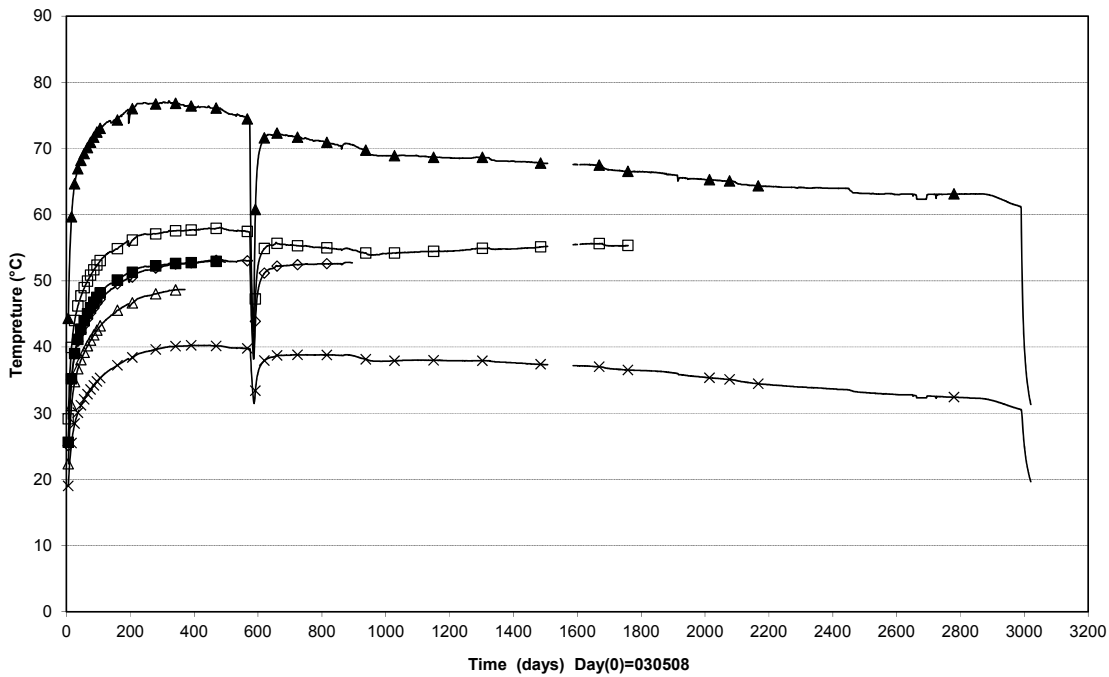
Prototype\Hole 5 \Cyl.3 and Cyl.4 (20030508-20110814)
Temperature - Pentronic



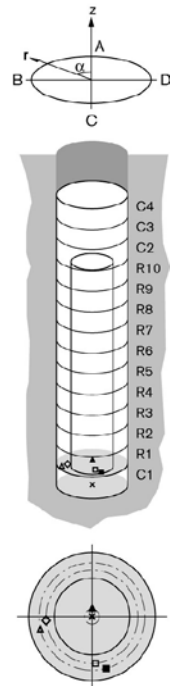
□ TB529(6.353\0°\0.785) △ TB530(6.353\95°\0.585) ■ TB531(6.353\185°\0.585) ▲ TB532(7.060\0°\0.785)



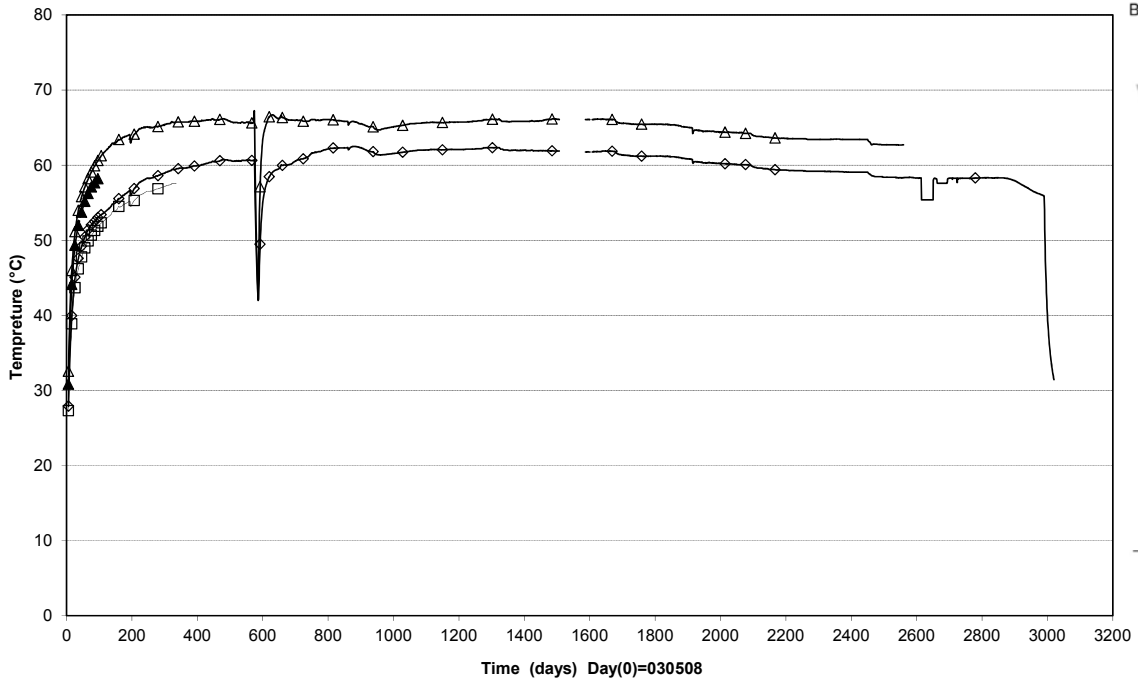
Prototype\Hole 5\Cyl.1 (20030508-20110814)
Temperature - Geokon



× PB501T(0\0°\0) ▲ PB502T(0.500\0°\0.100) ◇ PB506T(0.500\95°\0.635)
△ PB507T(0.500\105°\0.735) □ PB508T(0.500\185°\0.635) ■ PB509T(0.500\195°\0.735)

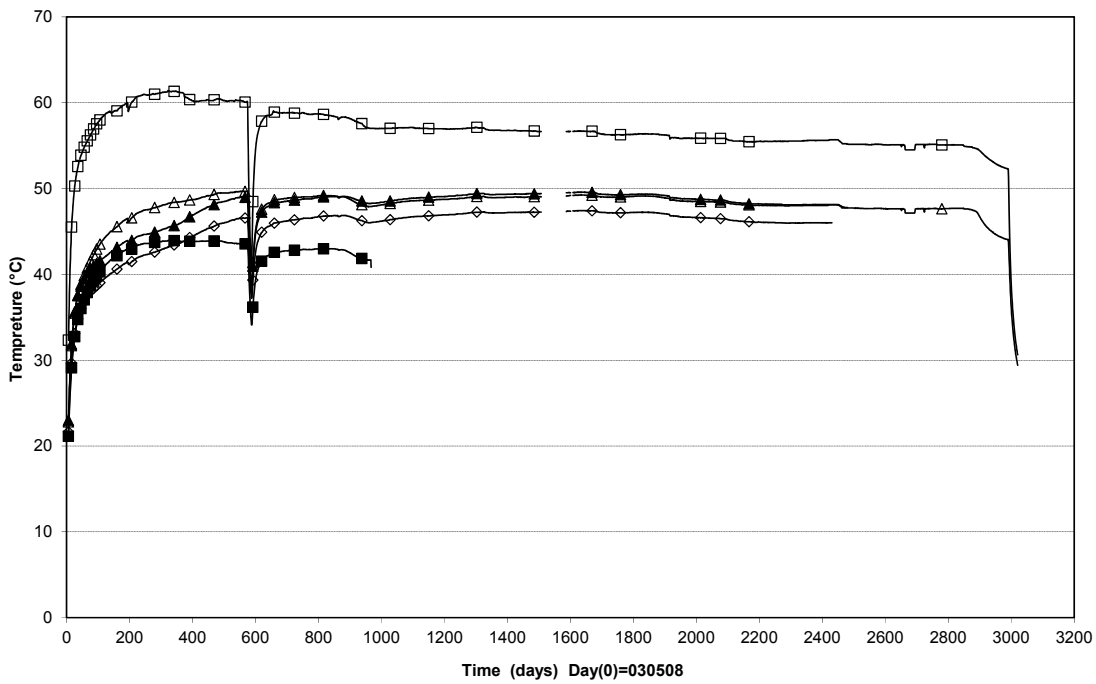


Prototype\Hole 5\Ring5 (20030508-20110814)
Temperature - Geokon



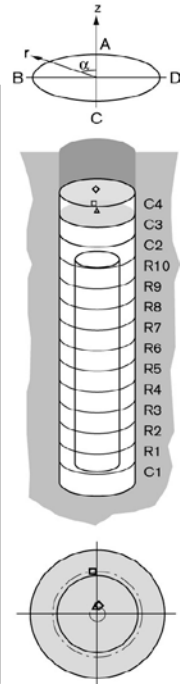
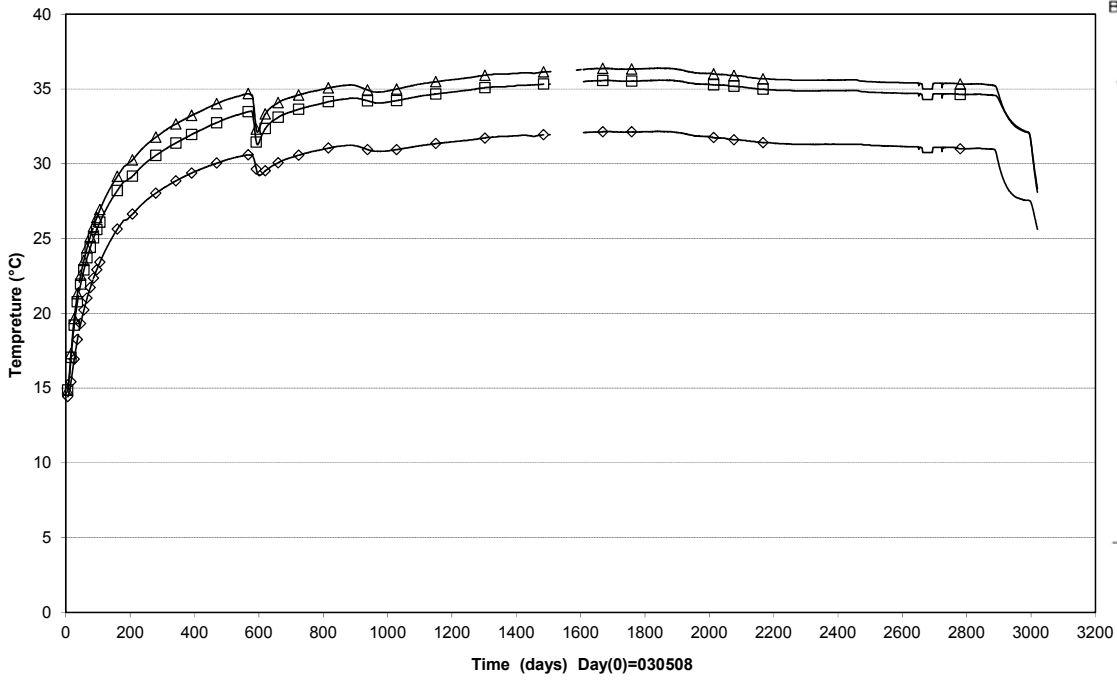
| | |
|---------------------------|----------------------------|
| □ PB511T(3.036\5°\0.685) | ▲ PB513T(3.036\95°\0.635) |
| ◇ PB514T(3.036\95°\0.785) | △ PB515T(3.036\185°\0.635) |

Prototype\Hole 5\Ring10 (030508-20110814)
Temperature - Geokon



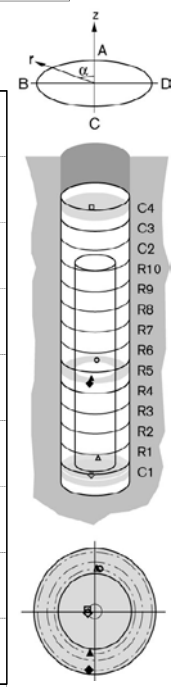
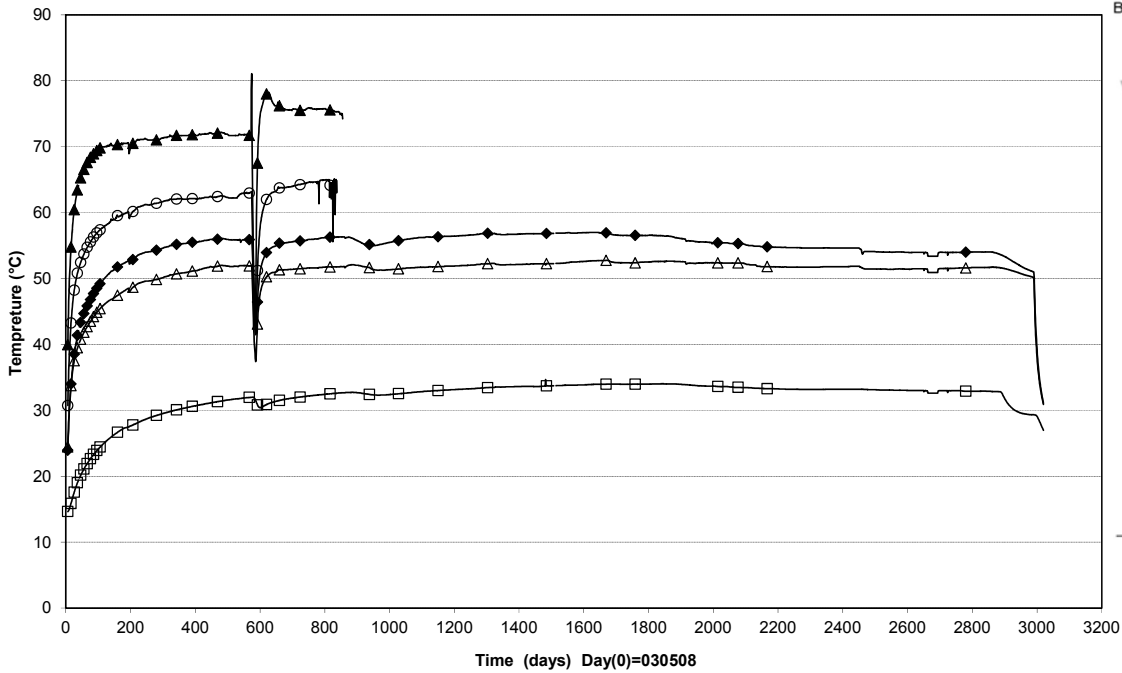
| | | |
|----------------------------|----------------------------|----------------------------|
| □ PB517T(5.593\0°\0.050) | ▲ PB521T(5.593\95°\0.635) | ○ PB522T(5.593\105°\0.735) |
| △ PB523T(5.593\180°\0.635) | ◆ PB524T(5.593\190°\0.735) | |

Prototype\Hole 5\Cyl.3 and Cyl.4 (20030508-20110814)
Temperature - Geokon



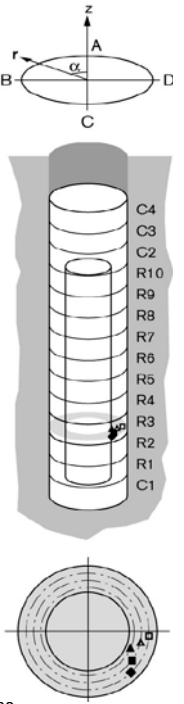
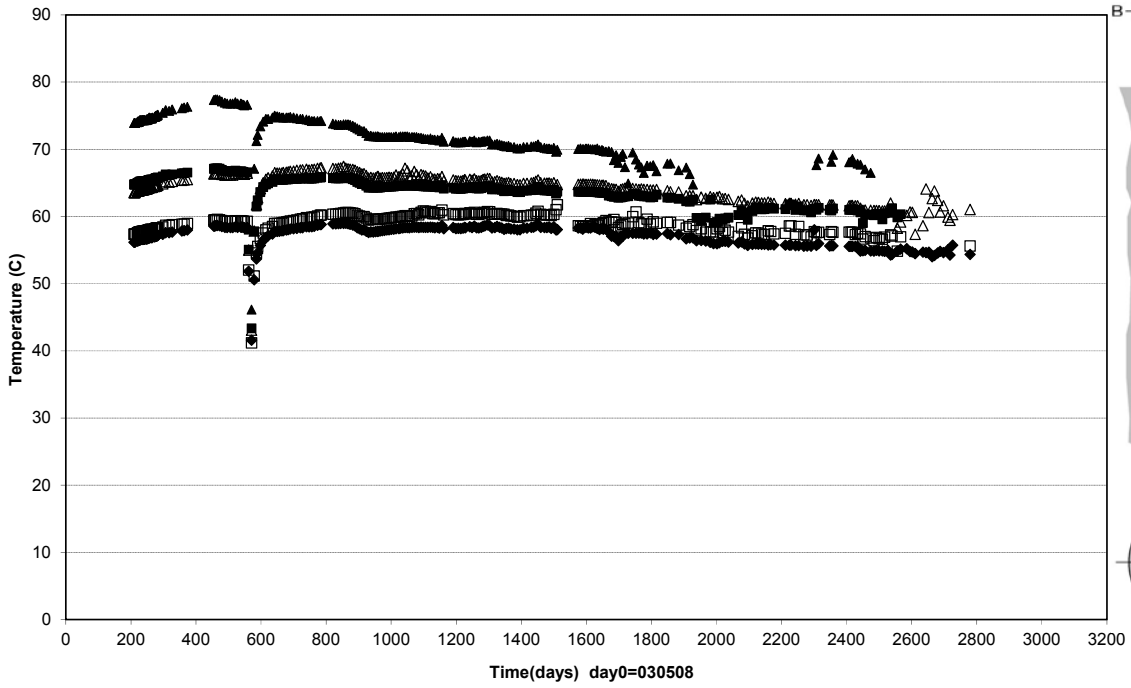
△ PB525T(6.603|0°|0.100)
□ PB526T(6.603|5°|0.585)
◇ PB527T(7.110|0°|0.100)

Prototype\Hole5 (20030508-20110814)
Temperature - Geokon

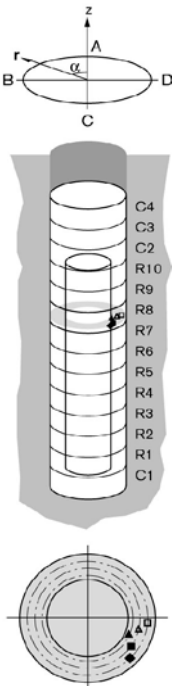
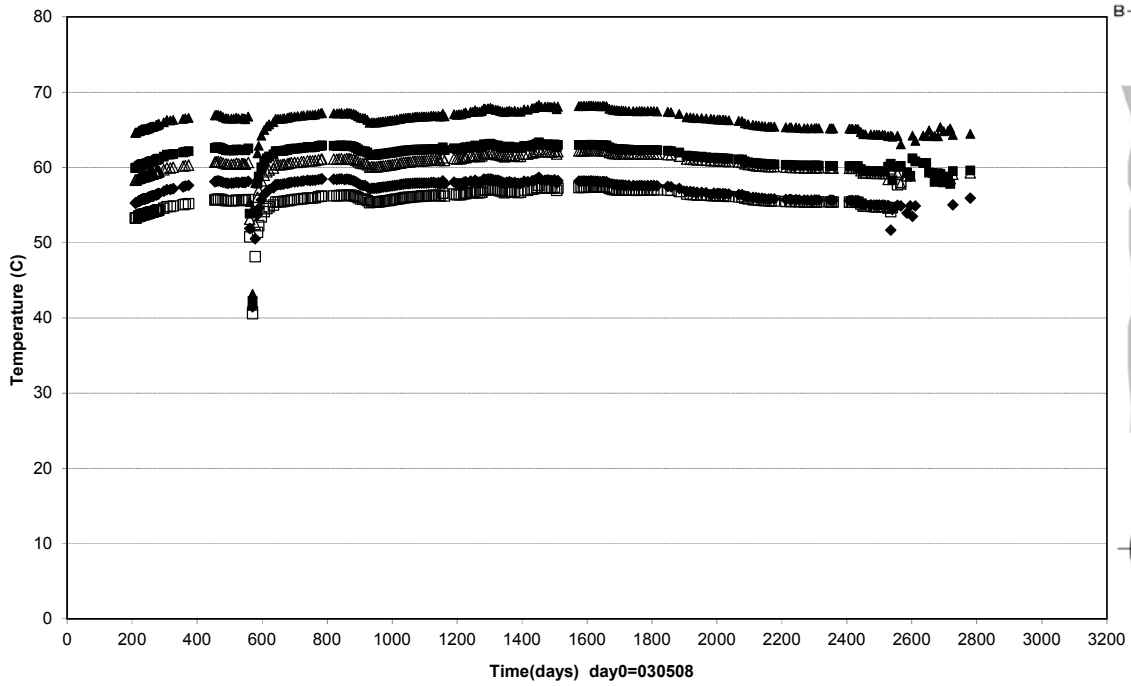


◇ UB502T(0.050|90°|0.100)
△ UB503T(0.250|355°|0.585)
○ UB505T(2.786|355°|0.585)
▲ UB509T(2.786|175°|0.535)
◆ UB510T(2.786|175°|0.825)
□ UB514T(6.860|90°|0.100)

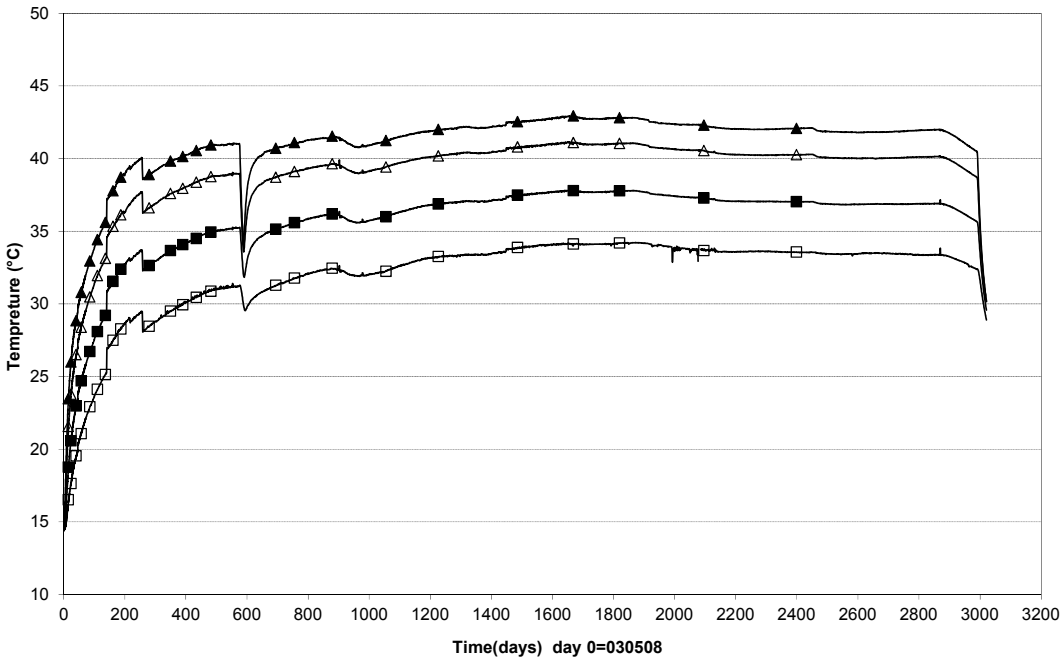
Prototype Hole 5 \ Ring 3 (20030508-20110814)
Temperature - Wescor



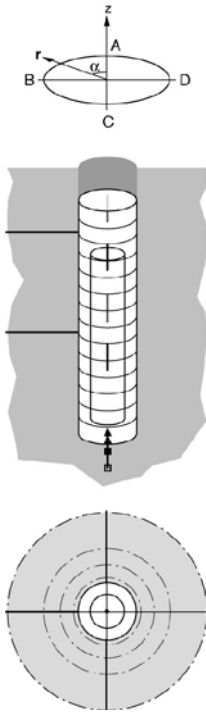
Prototype Hole 5 \ Ring 8 (20030508-20110814)
Temperature - Wescor



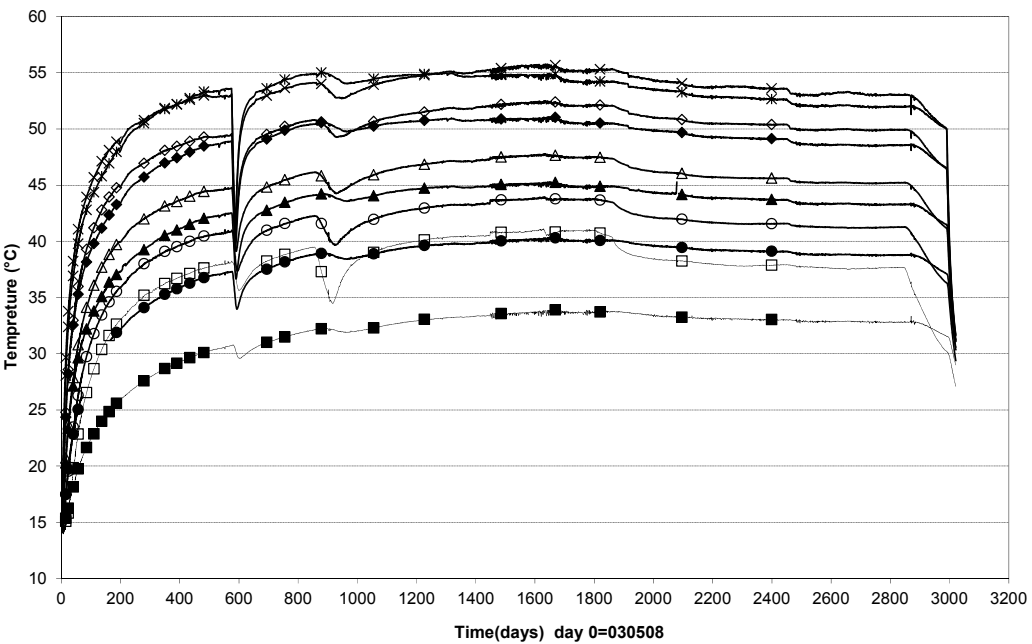
PrototypelRock\Hole 5\ Bottom (20030508-20110814)
Temperature - Pentronic



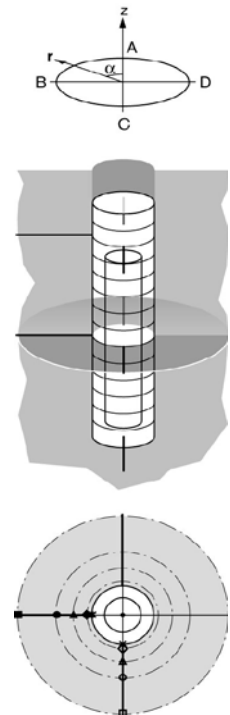
□TR5011(-1,0\0°\0,0\Bottom) ■TR5012(-0,5\0°\0,0\Bottom) △TR5013(-0,2\0°\0,0\Bottom) ▲TR5014(0,0\0°\0,0\Bottom)



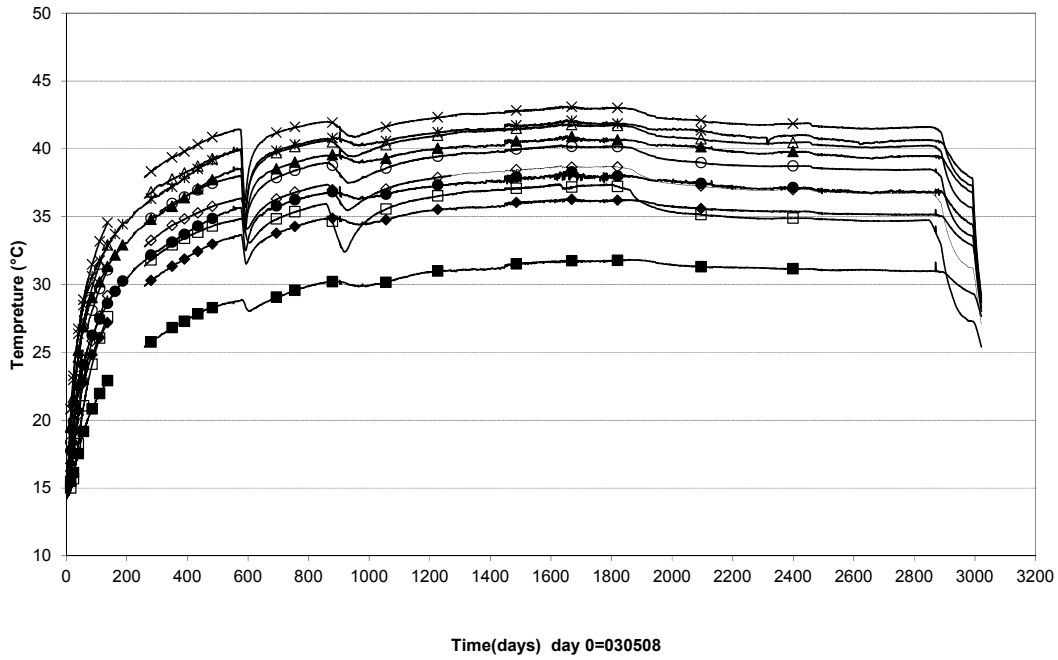
PrototypelRock\Hole 5 \Level 3,0 m (20030508-20110814)
Temperature - Pentronic



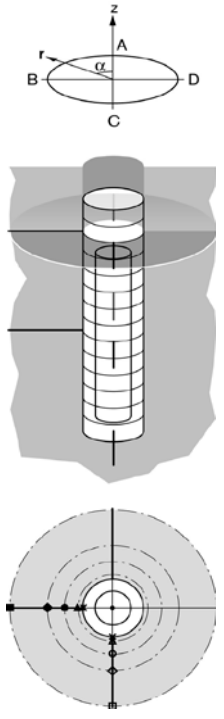
□TR5041 (3,0\170°\3,075) ○TR5042 (3,0\170°\1,975) △TR5043 (3,0\170°\1,475) ◇TR5044 (3,0\170°\1,075) ×TR5045 (3,0\170°\0,875)
■TR5051 (3,0\80°\3,075) ●TR5052 (3,0\80°\1,975) ▲TR5053 (3,0\80°\1,475) ◆TR5054 (3,0\80°\1,075) ×TR5055 (3,0\80°\0,875)



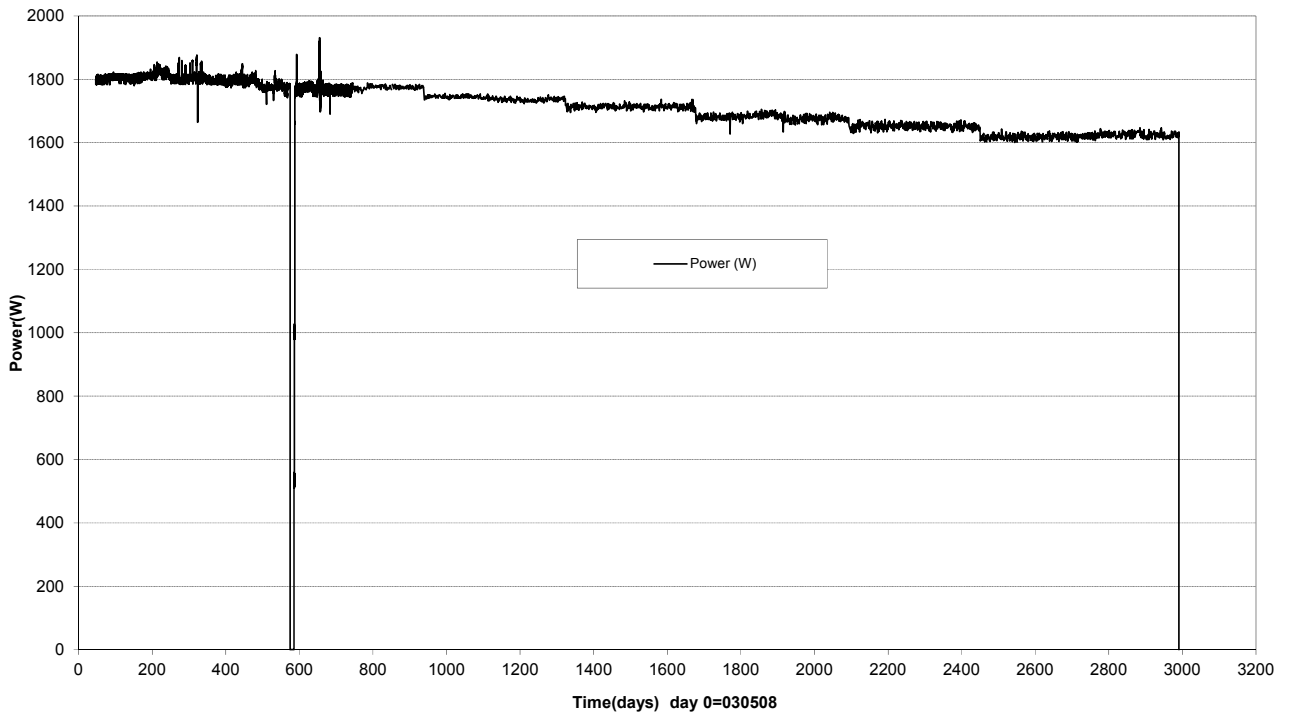
Prototype\Rock\Hole 5 \Level 6,0 m (20030508-20110814)
Temperature - Pentronic



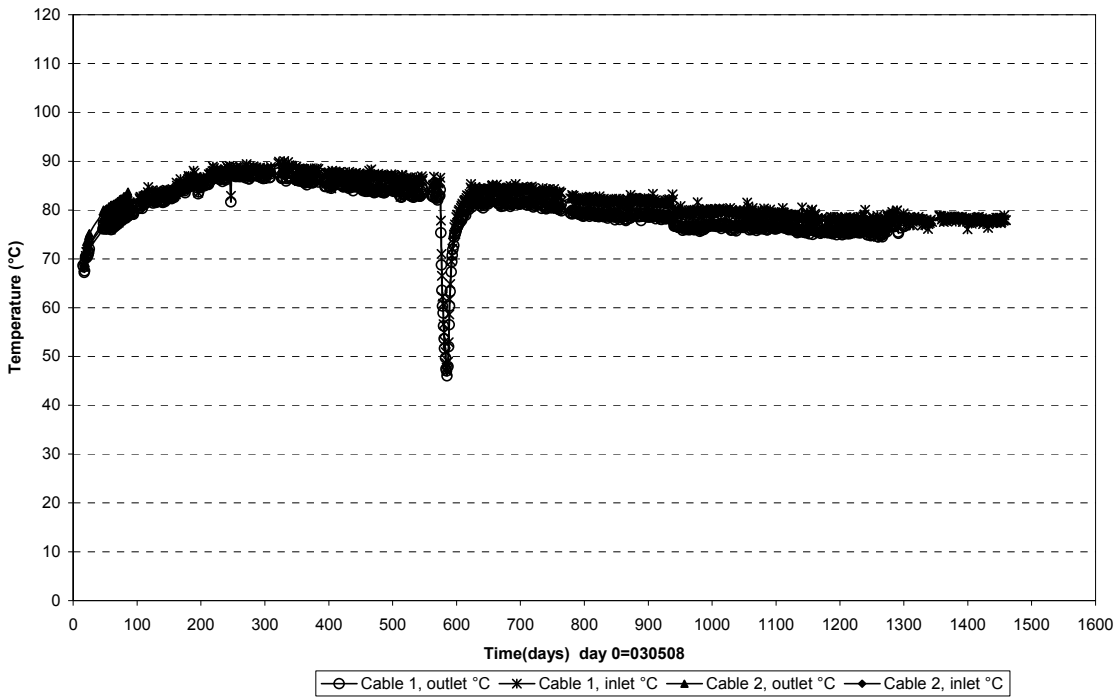
- TR5021 (6,0\171°\3,075) ◇ TR5022 (6,0\171°\1,975) ○ TR5023 (6,0\171°\1,475) △ TR5024 (6,0\171°\1,075) × TR5025 (6,0\171°\0,875)
- TR5031 (6,0\80°\3,075) ◆ TR5032 (6,0\80°\1,975) ● TR5033 (6,0\80°\1,475) ▲ TR5034 (6,0\80°\1,075) × TR5035 (6,0\80°\0,875)



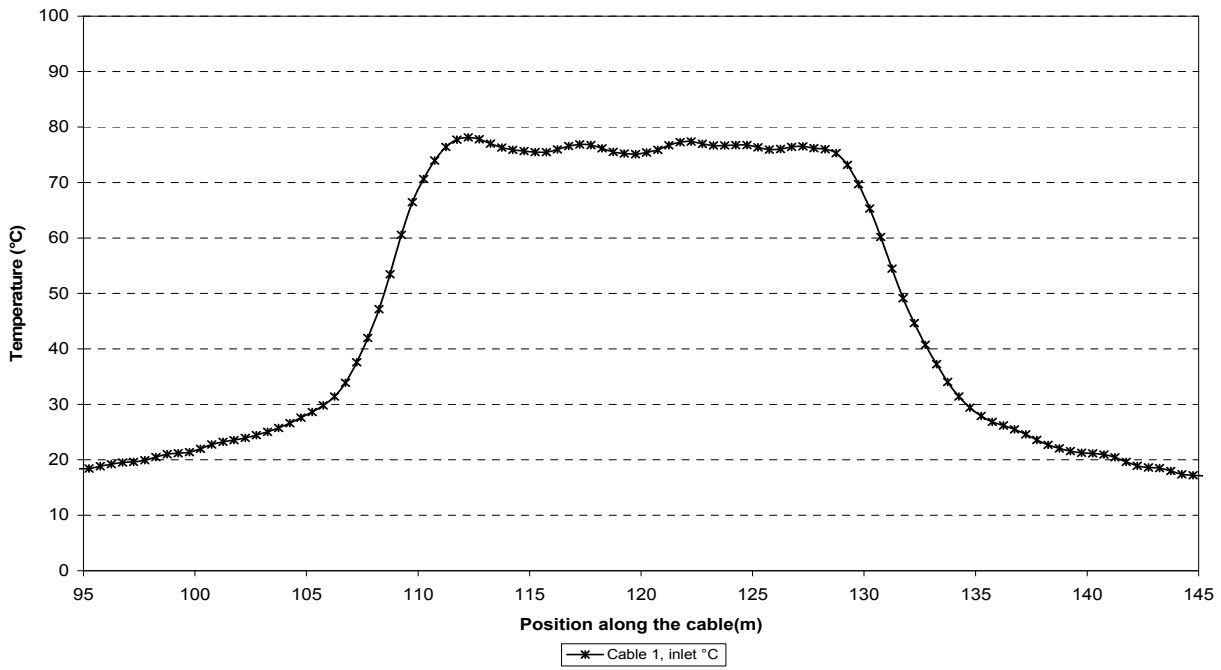
Prototype\Hole 5 (20030508-20110814)
Canister power



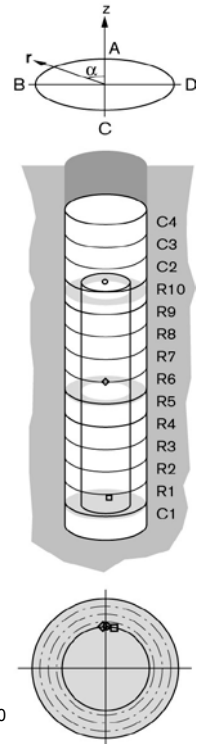
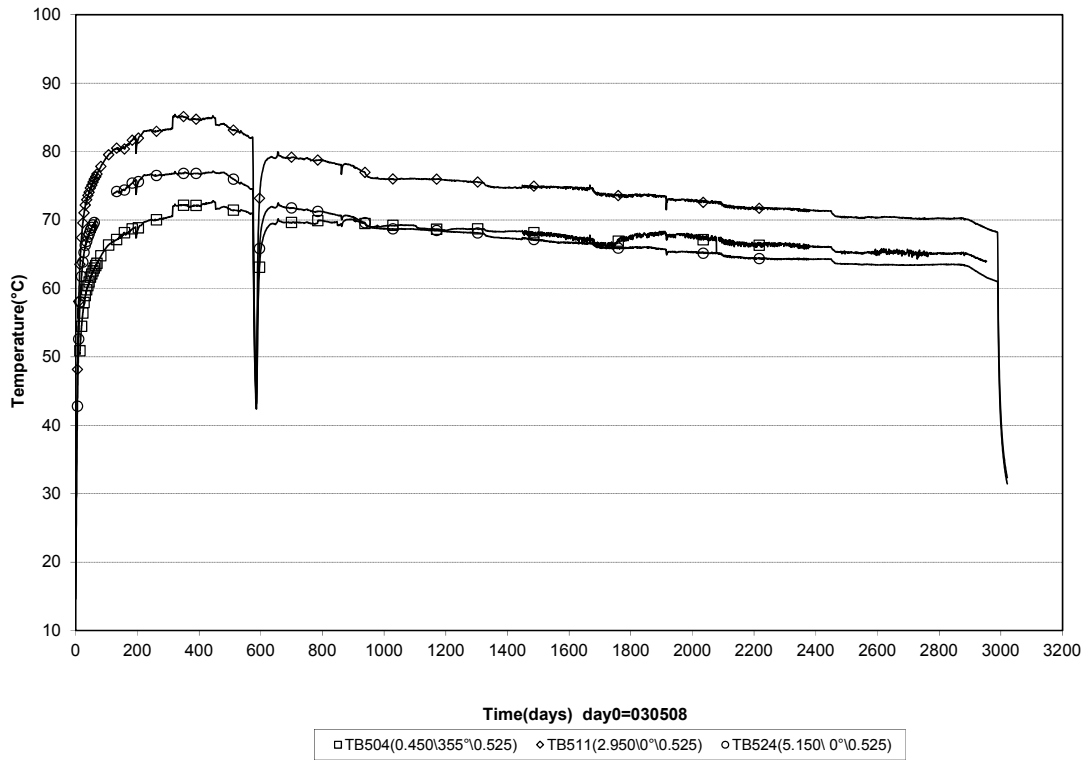
Prototypel Hole 5 \Canister (030508-070601)
Max. temperature on the canister surface - Optical fiber cables



Temperature profile on the canister surface-No5 (061201)
Optical fiber cables

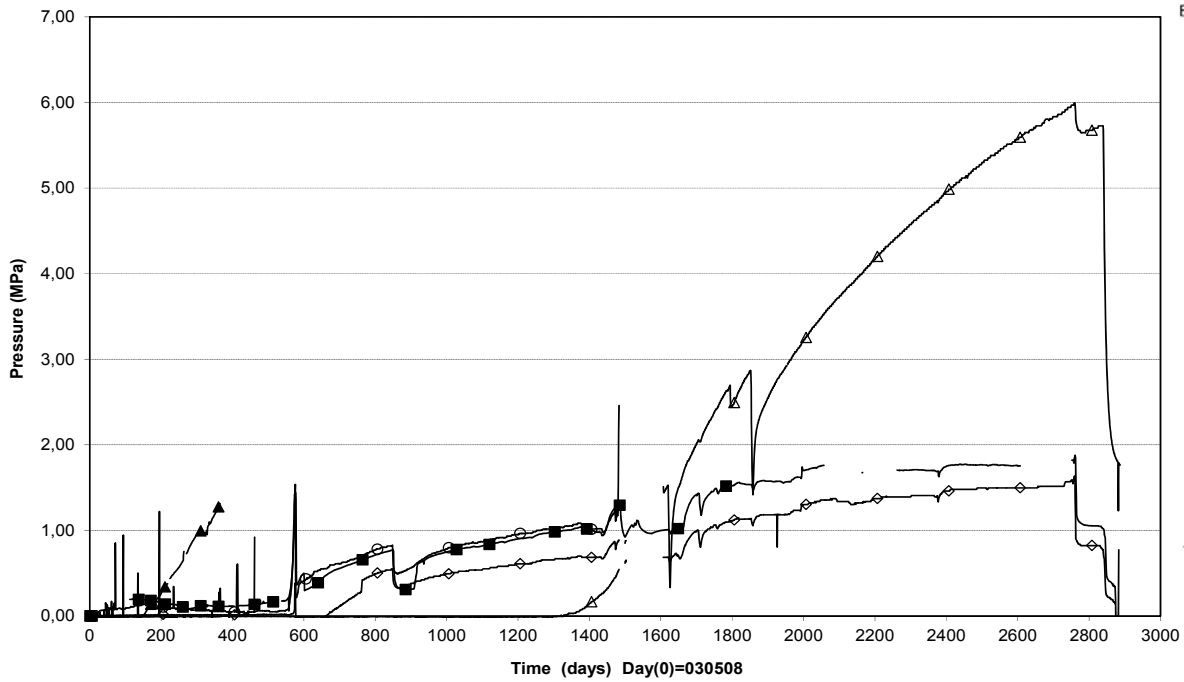


Prototype Hole 5 \On the canister surface (20030508-20110814)
 Temperature - Pentronic



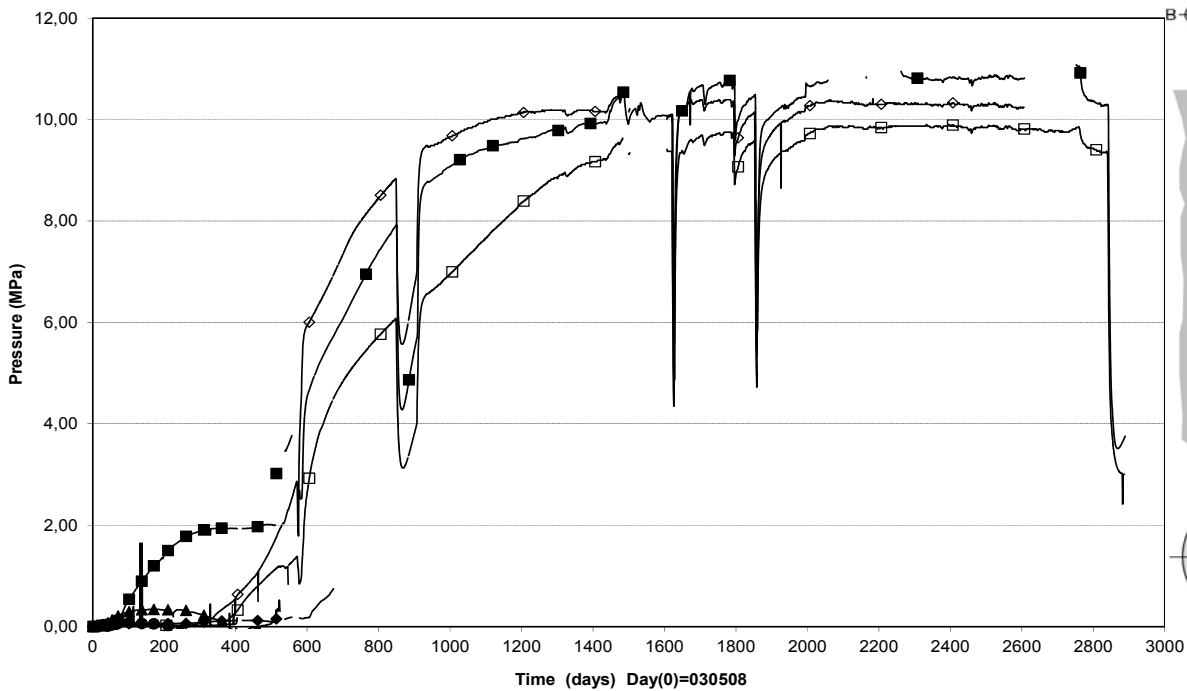
Dep. hole 6

PrototypeHole 6\Cyl.1 , Cyl.3 and Cyl.4 (20030508-20110405)
Total pressure



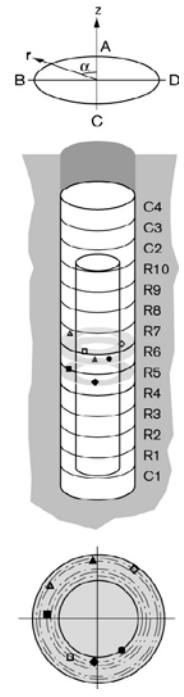
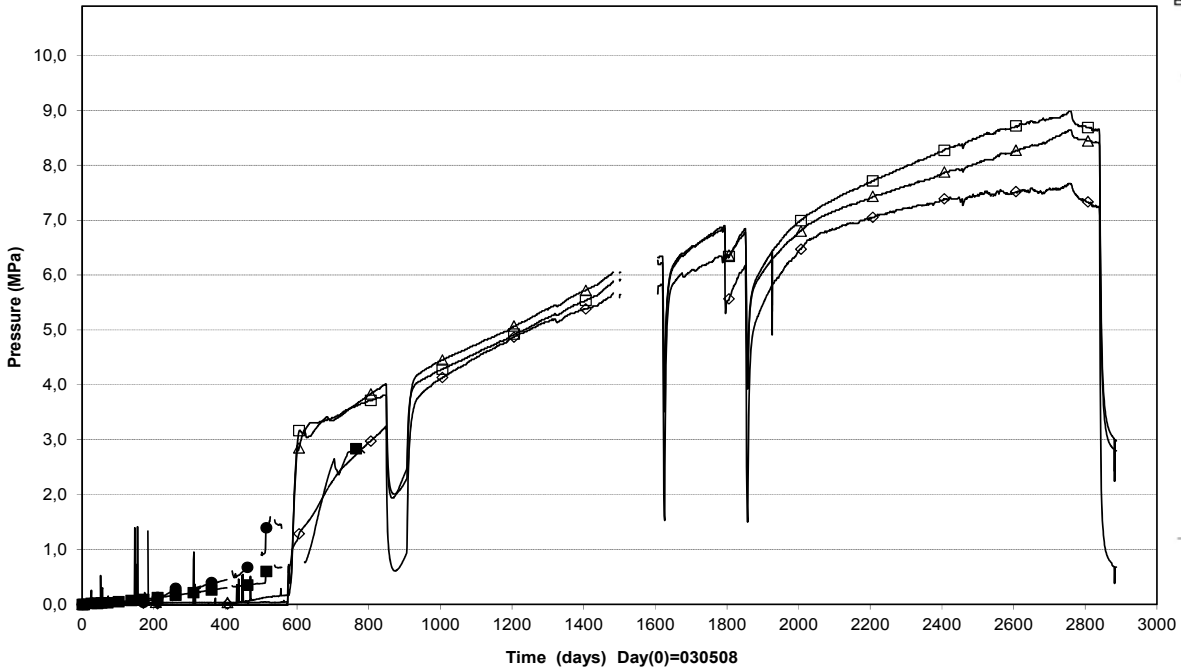
- | | | |
|---------------------------|--------------------------|---------------------------|
| ▲ PB601(0.510\315°\0.210) | ▲ PB602(0.260\80°\0.685) | ■ PB624(7.121\135°\0.585) |
| □ PB625(6.616\0°\0.100) | ◇ PB626(6.616\5°\0.585) | ○ PB627(7.121\0°\0.100) |

PrototypeHole 6\ Ring1 and Ring 2 (20030508-20110405)
Total pressure



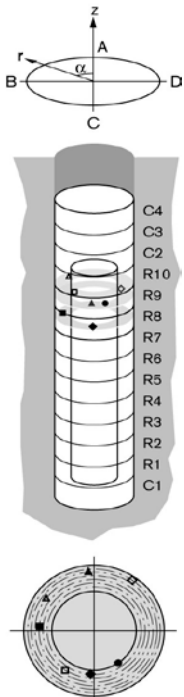
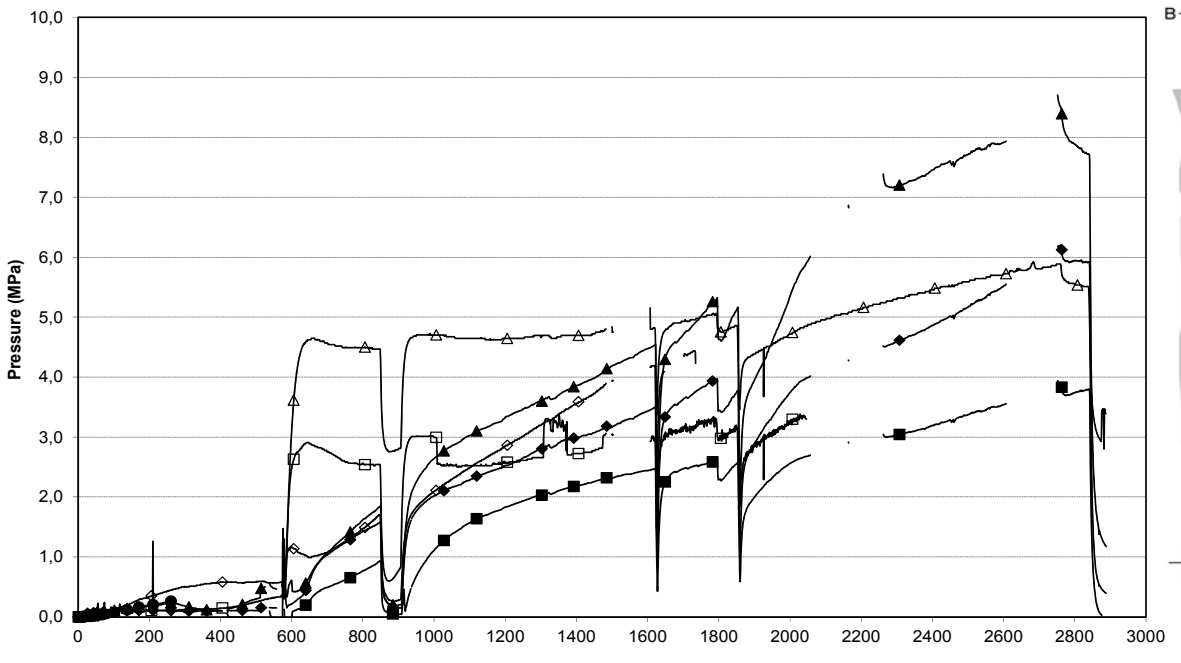
- | | | |
|--------------------------|---------------------------|---------------------------|
| ■ PB603(0.770\10°\0.785) | ◆ PB604(0.770\80°\0.685) | ● PB605(0.770\170°\0.585) |
| □ PB606(1.534\55°\0.735) | ◇ PB607(1.534\145°\0.635) | ▲ PB608(1.284\215°\0.535) |

PrototypeHole 6\ Ring 5 and Ring 6 (20030508-20110405)
Total pressure

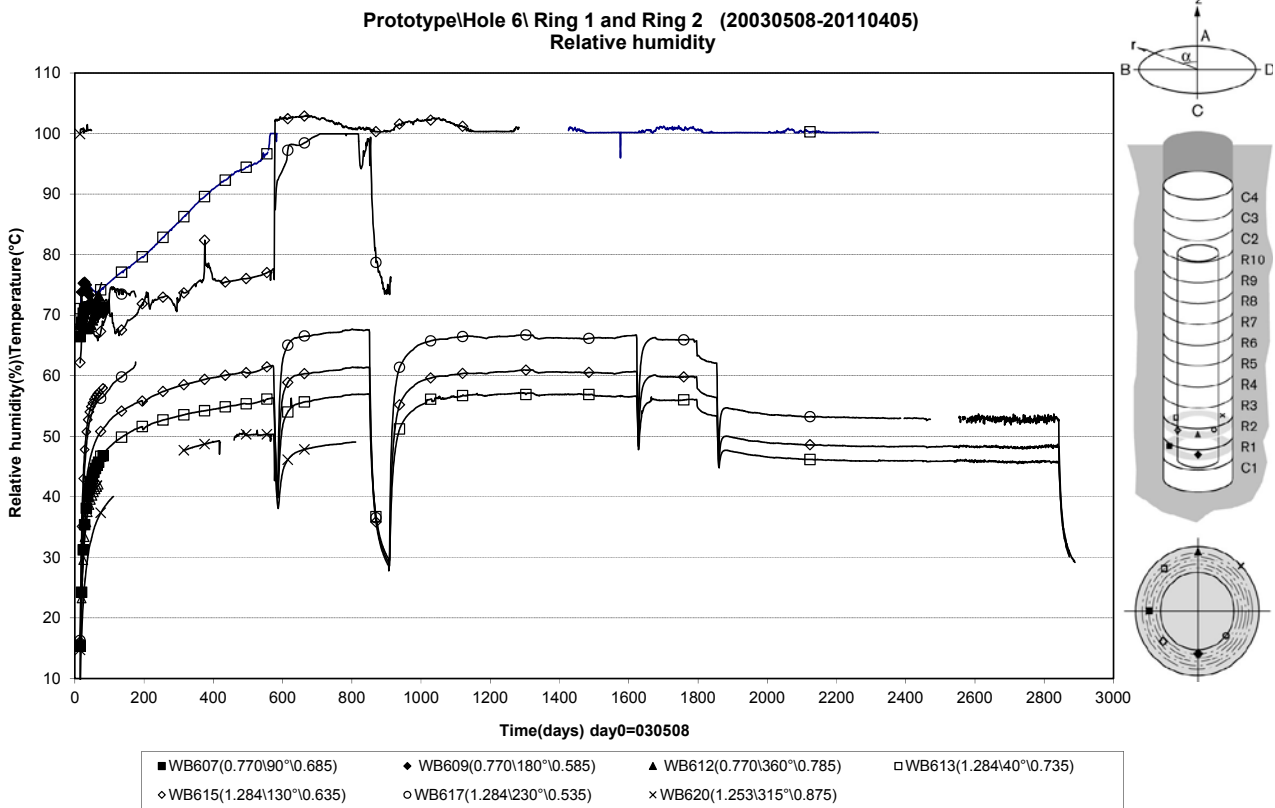
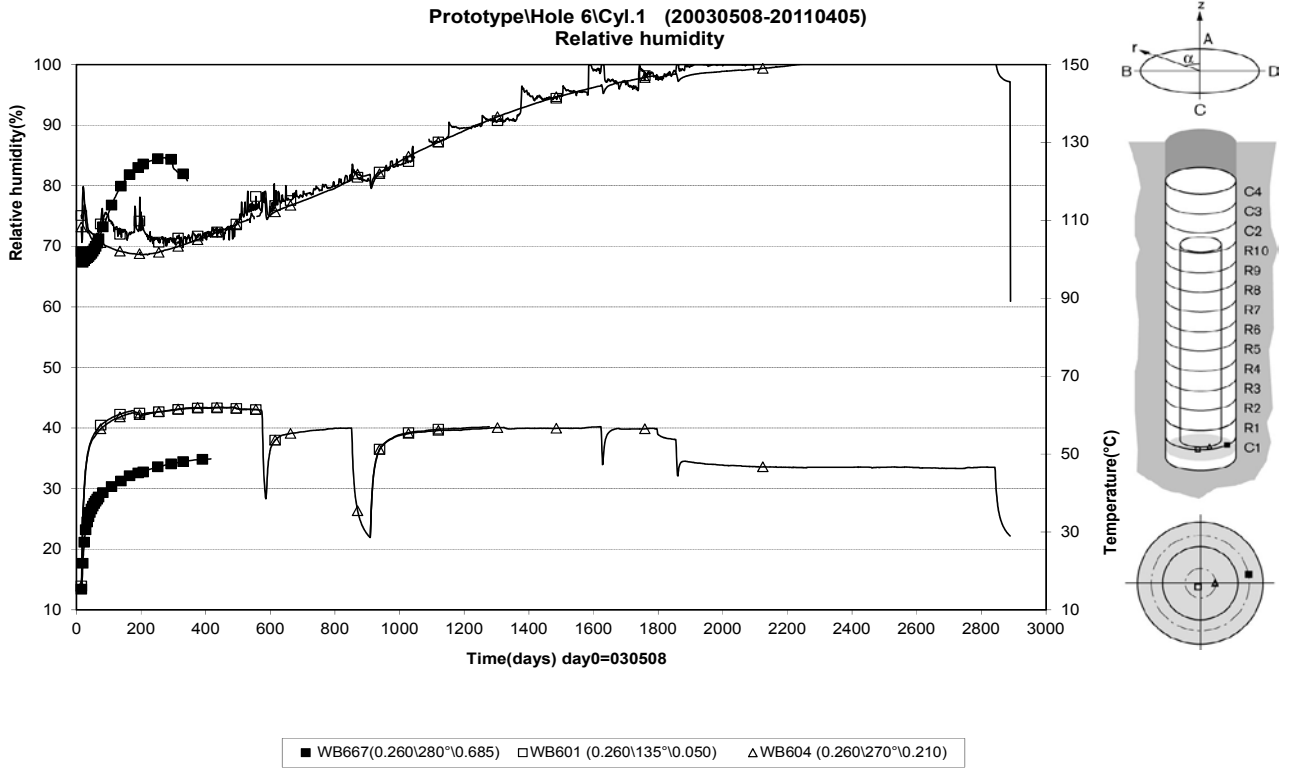


- Time (days) Day(0)=030508
- ▲ PB610(2.795 \10^\ 0.785)
 - PB611(2.795 \80^\ 0.685)
 - ◆ PB612(2.795 \170^\ 0.585)
 - △ PB613(3.550\55^\ 0.785)
 - PB614(3.550\145^\ 0.635)
 - PB615(3.300 \215^\ 0.535)
 - ◇ PB616(3.253\325^\ 0.875)

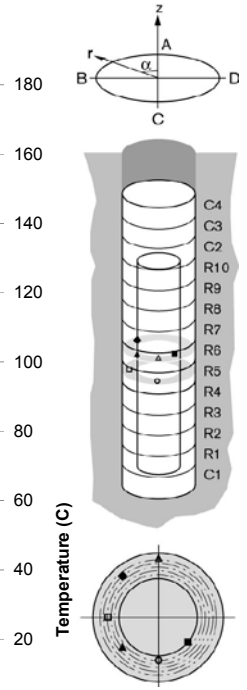
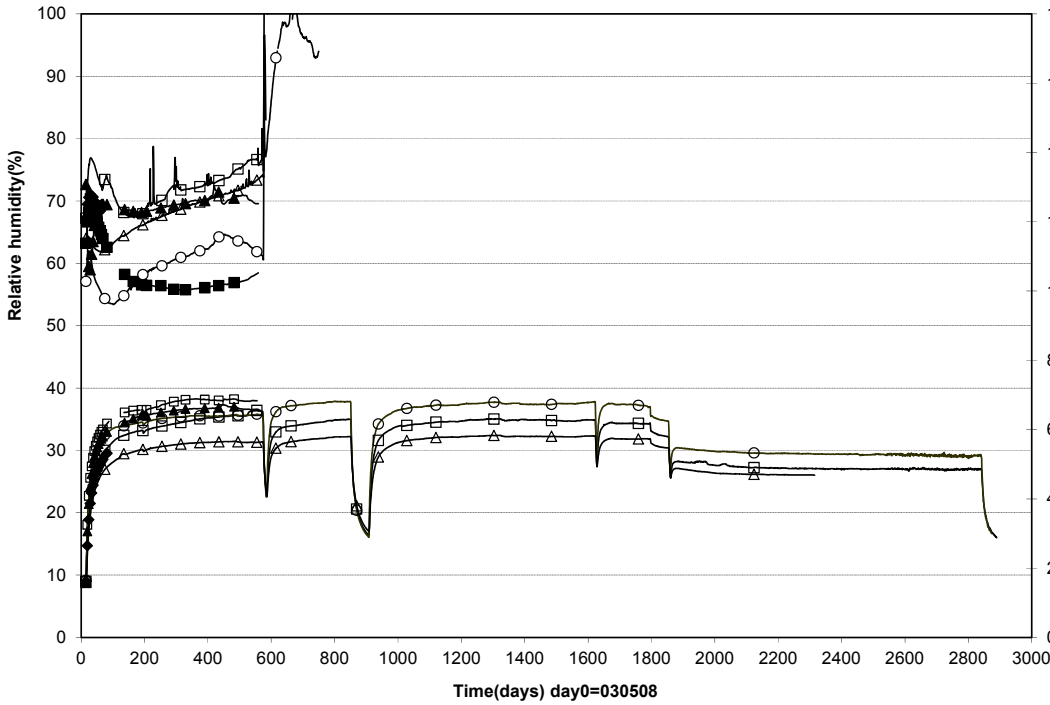
PrototypeHole 6\ Ring 8 and Ring 9 (20030508-20110405)
Total pressure



- Time (days) Day(0)=030508
- ▲ PB617(4.324 \10^\ 0.785)
 - PB618(4.324 \80^\ 0.685)
 - ◆ PB619(4.324 \170^\ 0.585)
 - △ PB620(5.084\55^\ 0.735)
 - PB621(5.084\145^\ 0.635)
 - PB622(4.834 \215^\ 0.535)
 - ◇ PB623(4.753\325^\ 0.875)

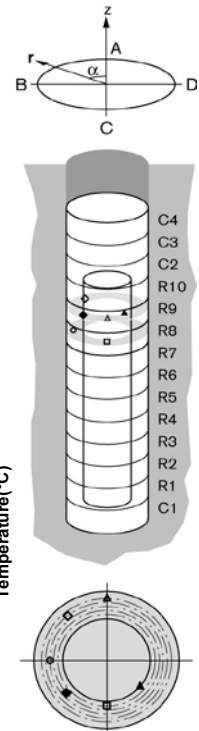
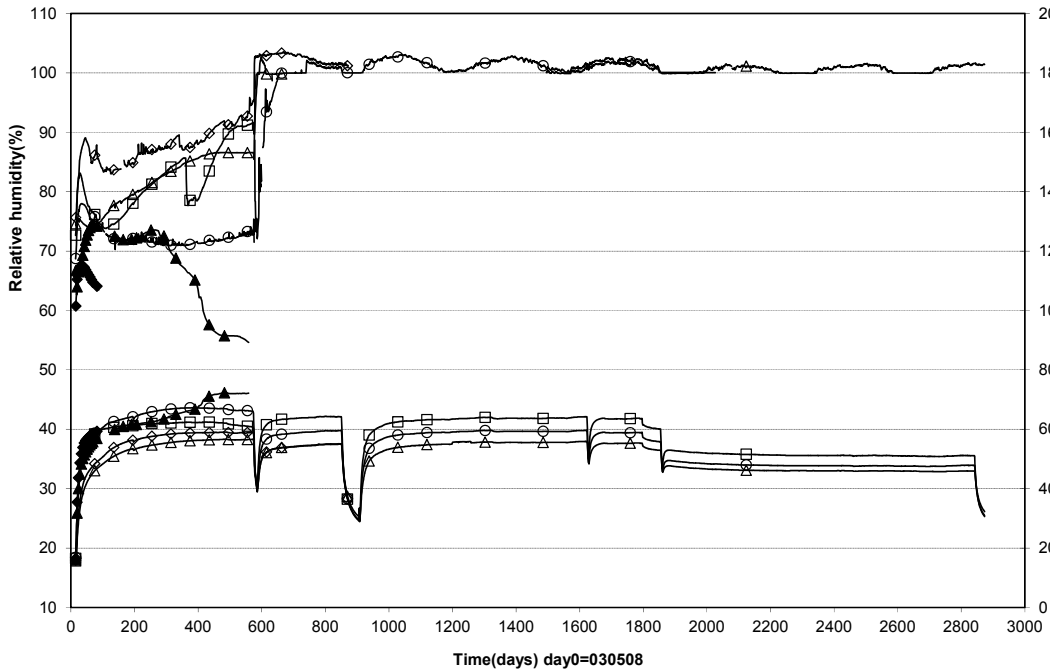


Prototype\Hole 6\Ring 5 and Ring 6 (20030508-20110405)
Relative humidity



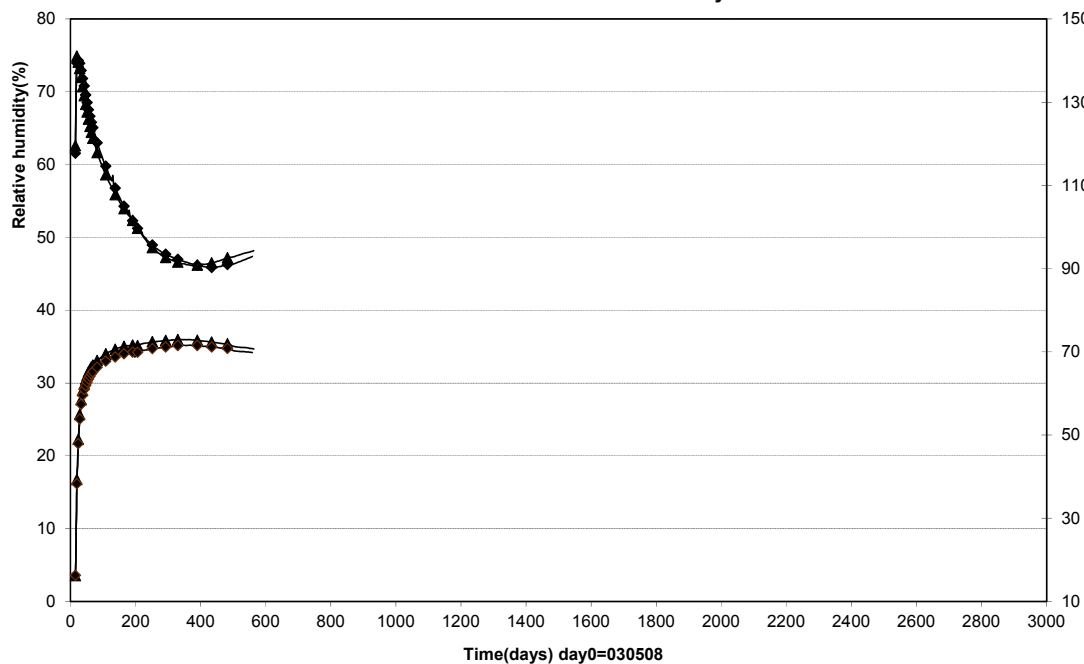
▲ WB629(3.300\130°\0.635) ■ WB631(3.300\230°\0.535) ◆ WB627(3.300\40°\0.735) □ WB621(2.795\90°\0.685) ○ WB623(2.795\180°\0.585) △ WB626(2.795\360°\0.785)

Prototype\Hole 6\ Ring 8 and Ring9 (20030508-20110405)
Relative humidity

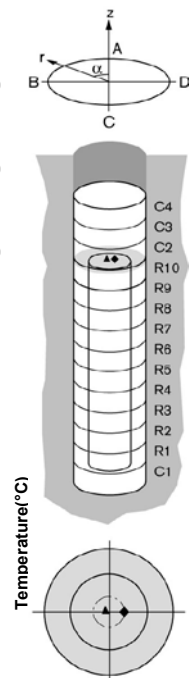


◆ WB643(4.834\130°\0.635) ▲ WB645(4.834\230°\0.535) ○ WB635(4.324\90°\0.685) □ WB637(4.324\180°\0.585) △ WB640(4.324\360°\0.785) ◆ WB641(4.834\40°\0.735)

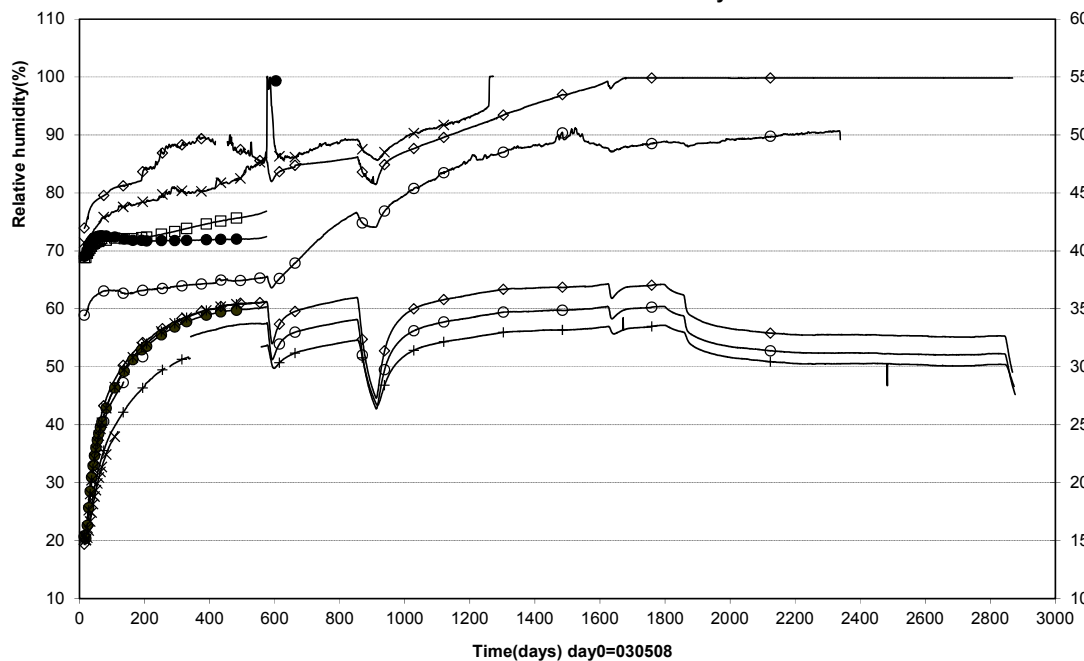
Prototype\Hole 6\ Ring10 (20030508-20110405)
Relative humidity



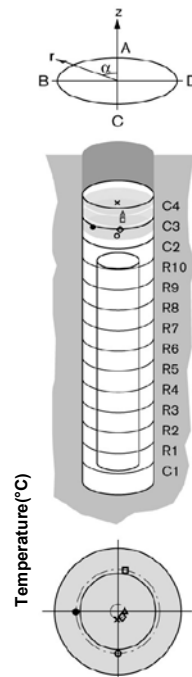
▲ WB649(5.439\90°\0.50) ◆ WB650(5.439\270°\0.210)



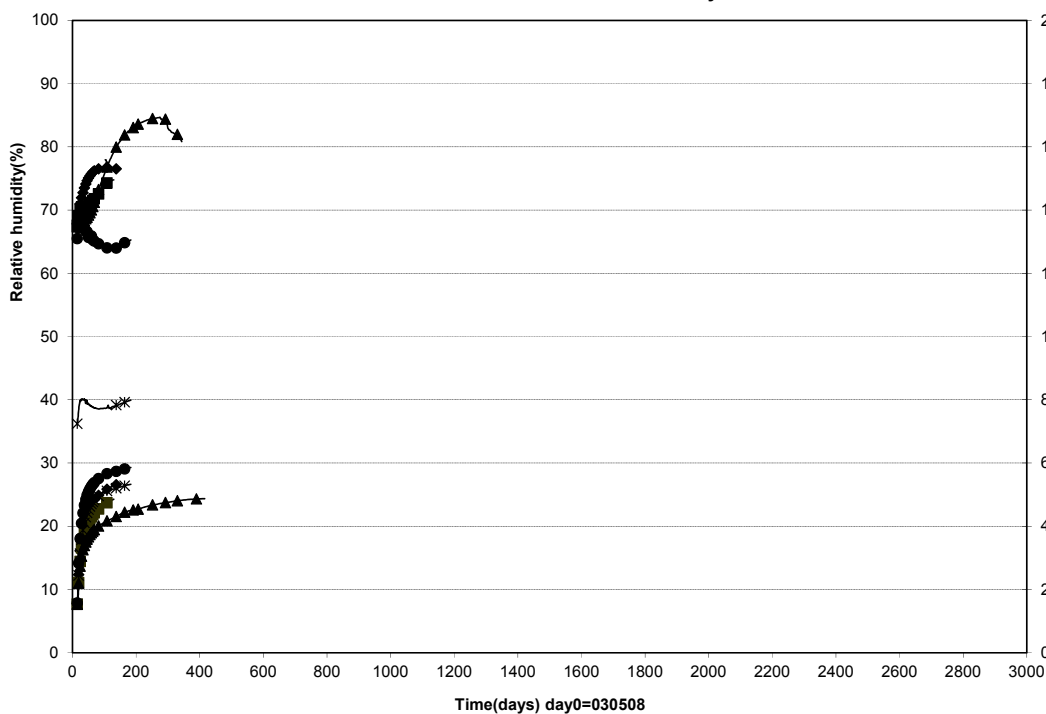
Prototype\Hole 6\Cyl.3 and Cyl.4 (20030508-20110405)
Relative humidity



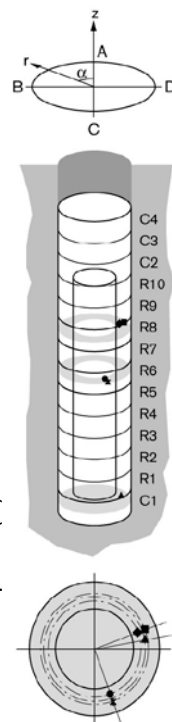
● WB652(6.366\90°\0.585) □ WB654(6.366\350°\0.585) △ WB656(6.961\270°\0.100) ◇ WB651(6.366\225°\0.100) ○ WB653(6.366\180°\0.585) × WB655(6.801\180°\0.100)



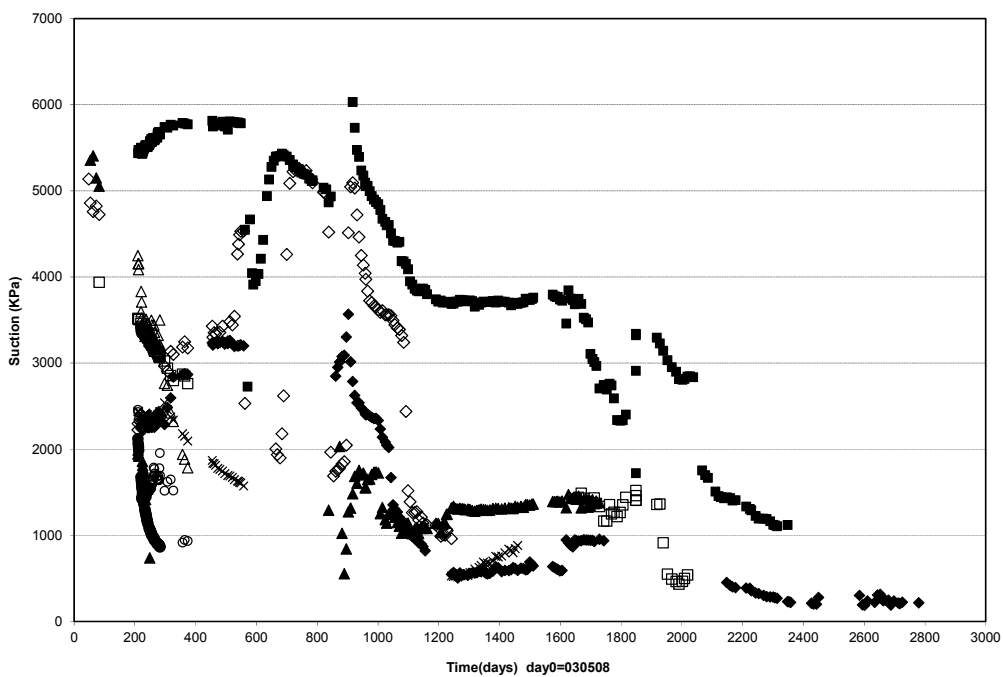
Prototype\Hole 6\Cyl.1 , Ring 6 and Ring8 (20030508-20110405)
Relative humidity



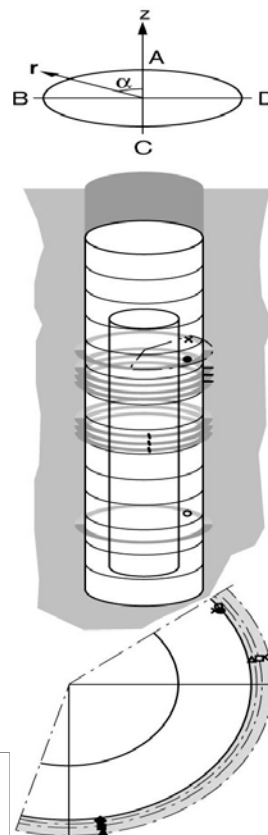
- ▲ WB667(0.260\280°\0.685)
- WB668(3.300\200°\0.625)
- × WB669(3.300\200°\0.725)
- ◆ WB670(4.324\290°\0.625)
- WB671(4.324\290°\0.725)



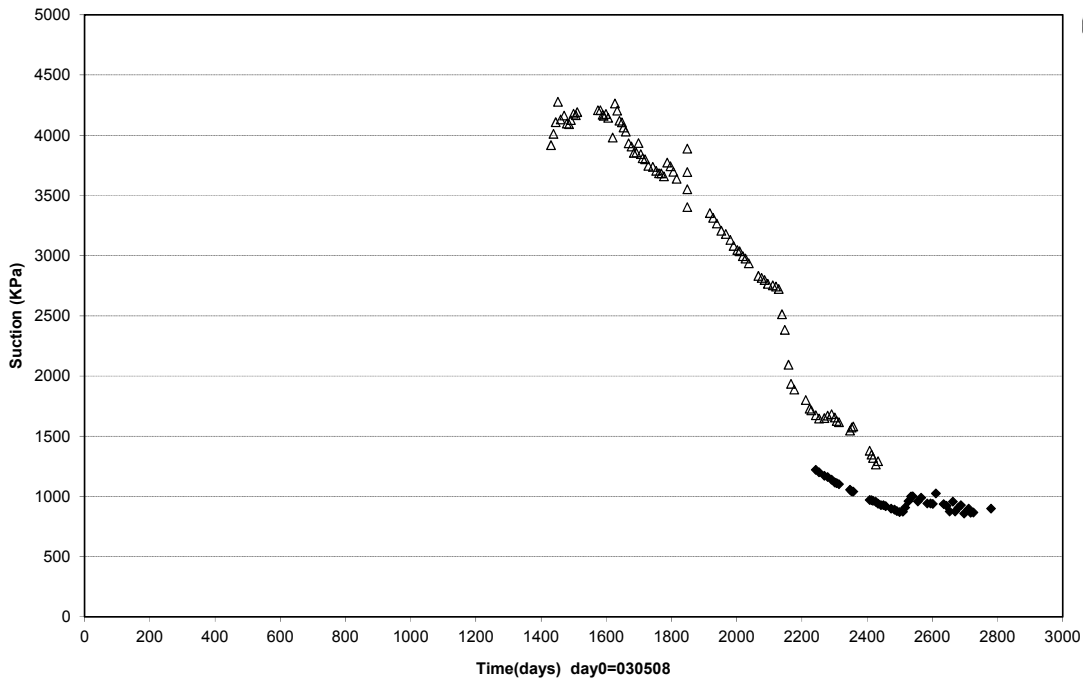
Prototype\ Hole 6 \Rock (030508-20110405)
Suction - Wescor



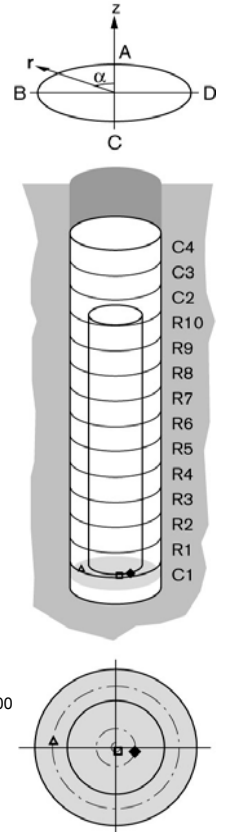
- ◆ WB659(3.100\190°\0.900\Rock)
- ▲ WB661(3.400\190°\0.975\Rock)
- △ WB664(4.100\280°\0.900\Rock)
- WB660(3.250\190°\0.925\Rock)
- WB665(4.250\280°\0.925\Rock)
- ◊ WB666(4.400\280°\0.975\Rock)
- WB619(1.253\305°\0.875\Rock)
- WB633(3.253\305°\0.875\Rock)
- × WB647(4.753\305°\0.875\Rock)



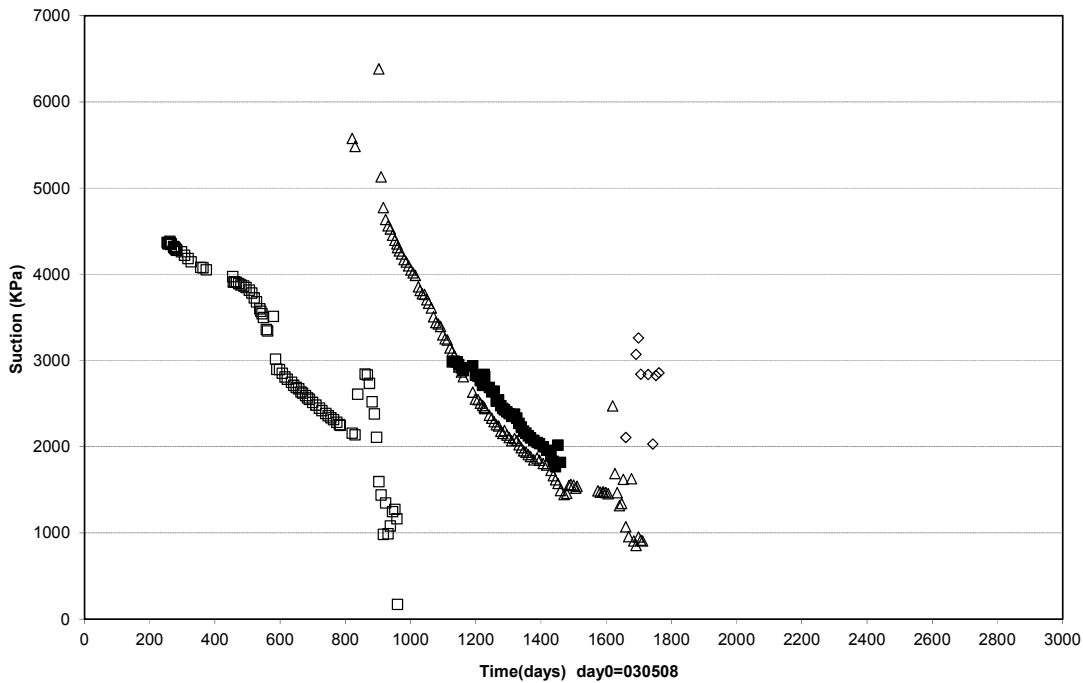
Prototypel Hole 6 \ Cyl1 (20030508-20110405)
Suction - Wescor



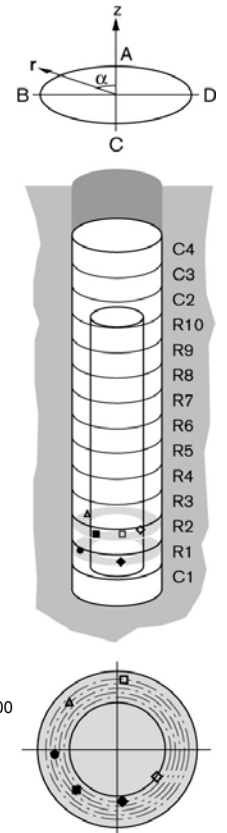
□WB602(0.260\225°\0.050) ◆WB603(0.260\260°\0.210) △WB605(0.260\90°\0.685)



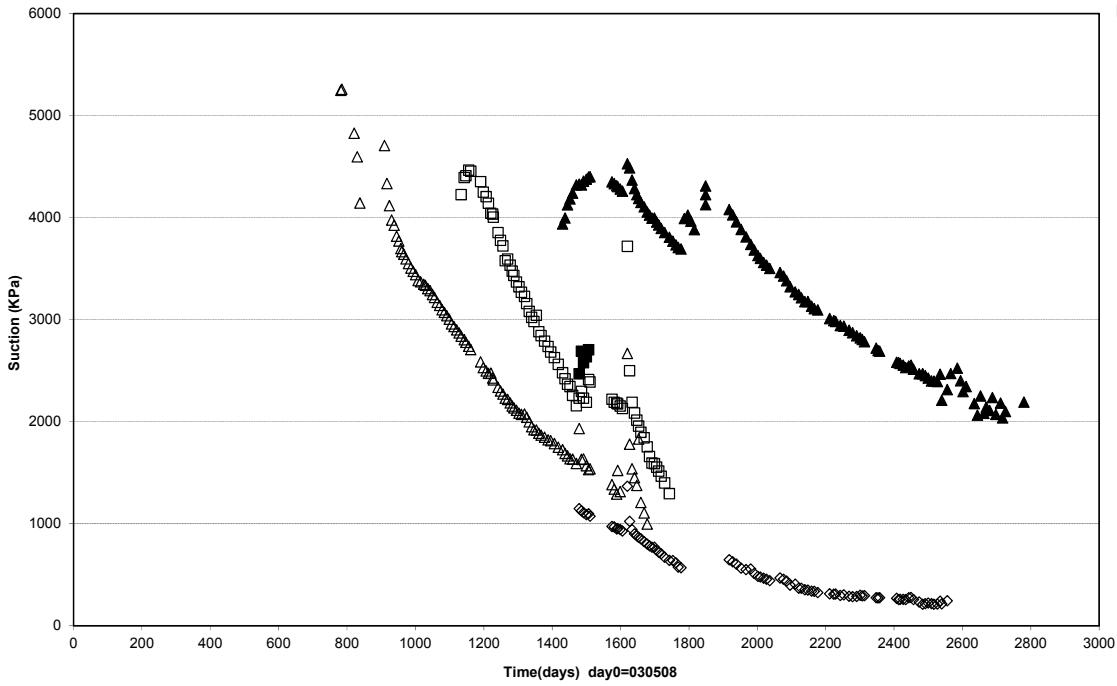
Prototypel Hole 6 \ Ring 1 and Ring 2 (20030508-20110405)
Suction - Wescor



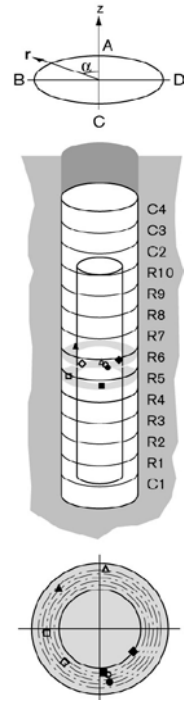
●WB608(0.770\95°\0.685) ◆WB612(0.750\185°\0.585) □WB611(0.770\355°\0.785)
△WB614(1.284\45°\0.735) ■WB616(1.284\135°\0.635) ◇WB618(1.284\235°\0.535)



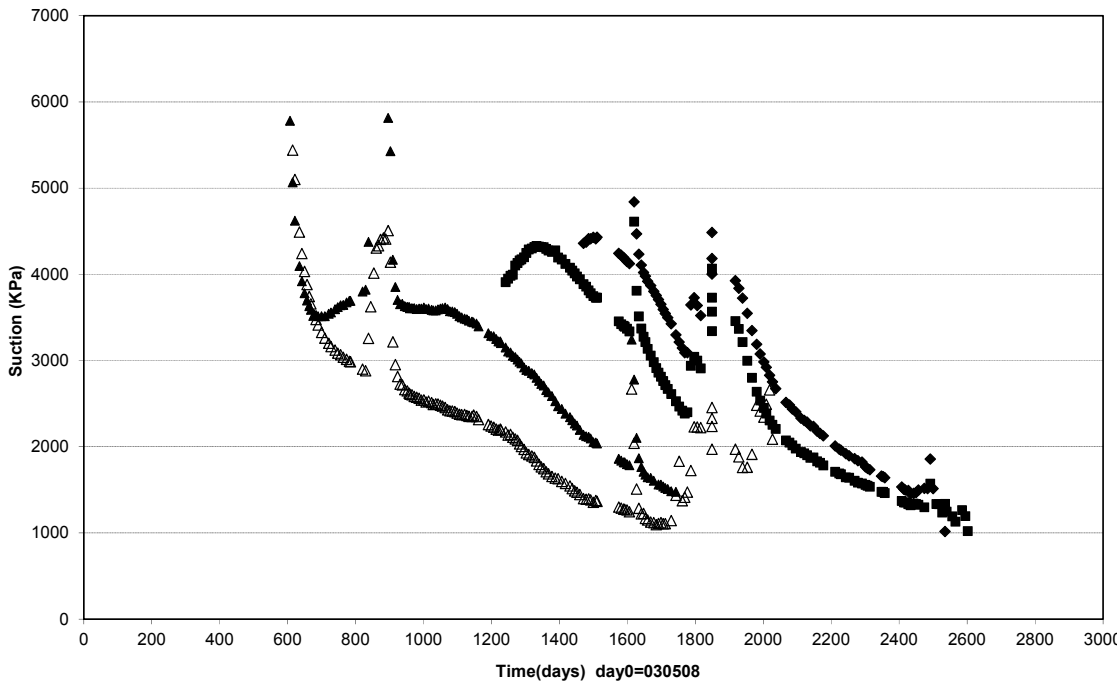
Prototype\ Hole 6 \ Ring 5 and Ring 6 (20030508-20110405)
Suction - Wescor



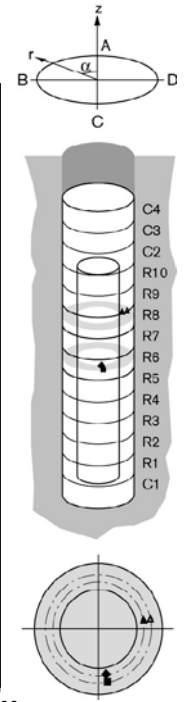
| | | |
|-------------------------|--------------------------|--------------------------|
| □WB622(2.795\95°\0.685) | ■WB624(2.795\185°\0.585) | △WB625(2.795\355°\0.785) |
| ▲WB628(3.300\45°\0.735) | ◇WB630(3.300\135°\0.635) | ◆WB632(3.300\235°\0.535) |



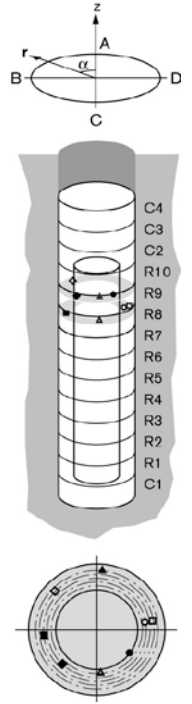
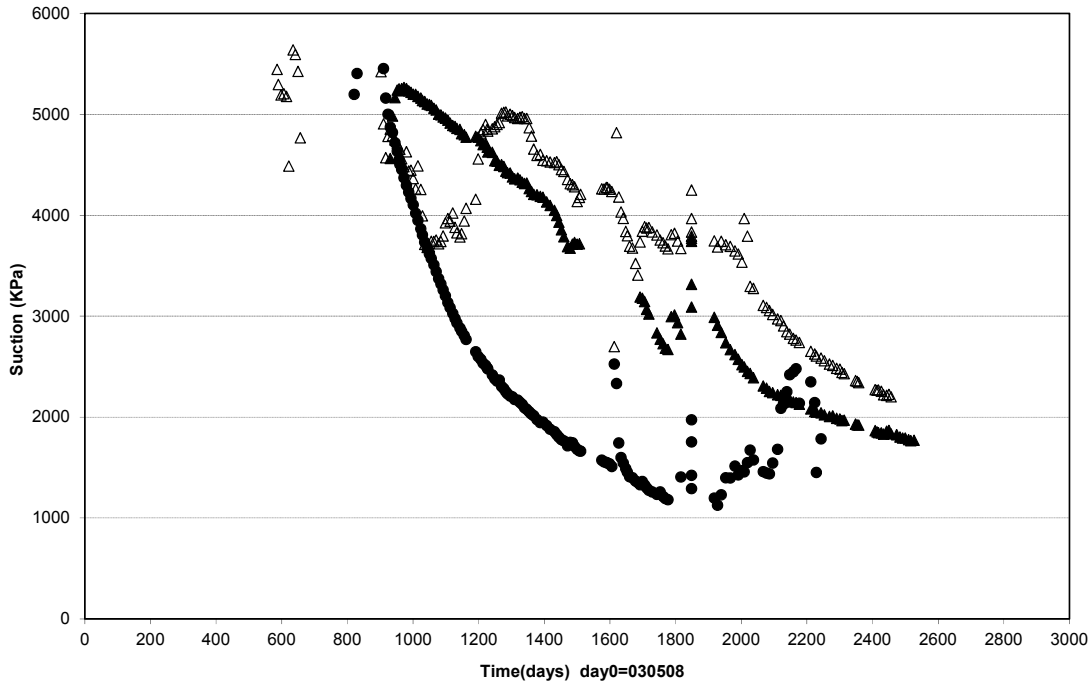
Prototype\ Hole 6 \ Ring 6 and Ring 8 (20030508-20110405)
Suction - Wescor



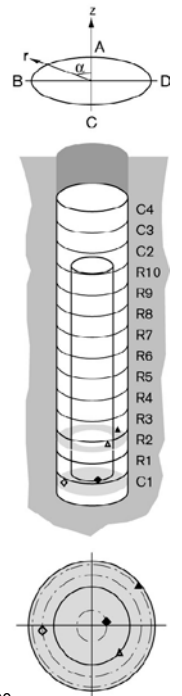
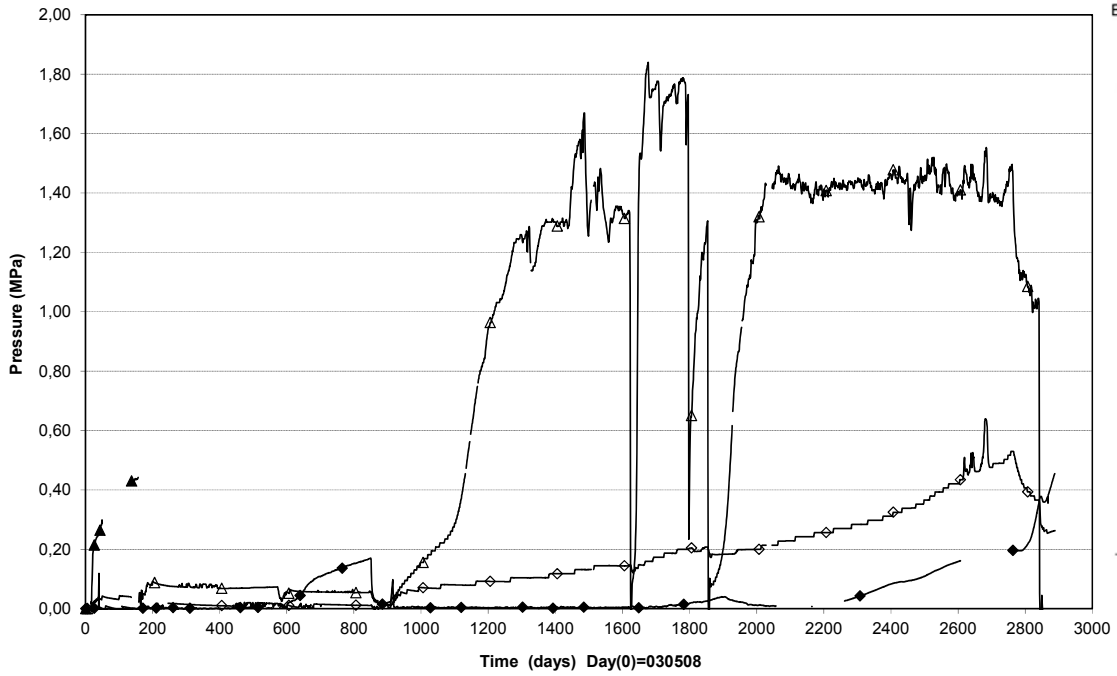
| | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|
| ◆WB657(3.300\190°\0.625) | ■WB658(3.300\190°\0.725) | ▲WB662(4.324\280°\0.625) | △WB663(4.324\280°\0.725) |
|--------------------------|--------------------------|--------------------------|--------------------------|



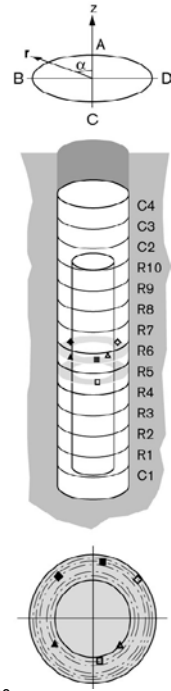
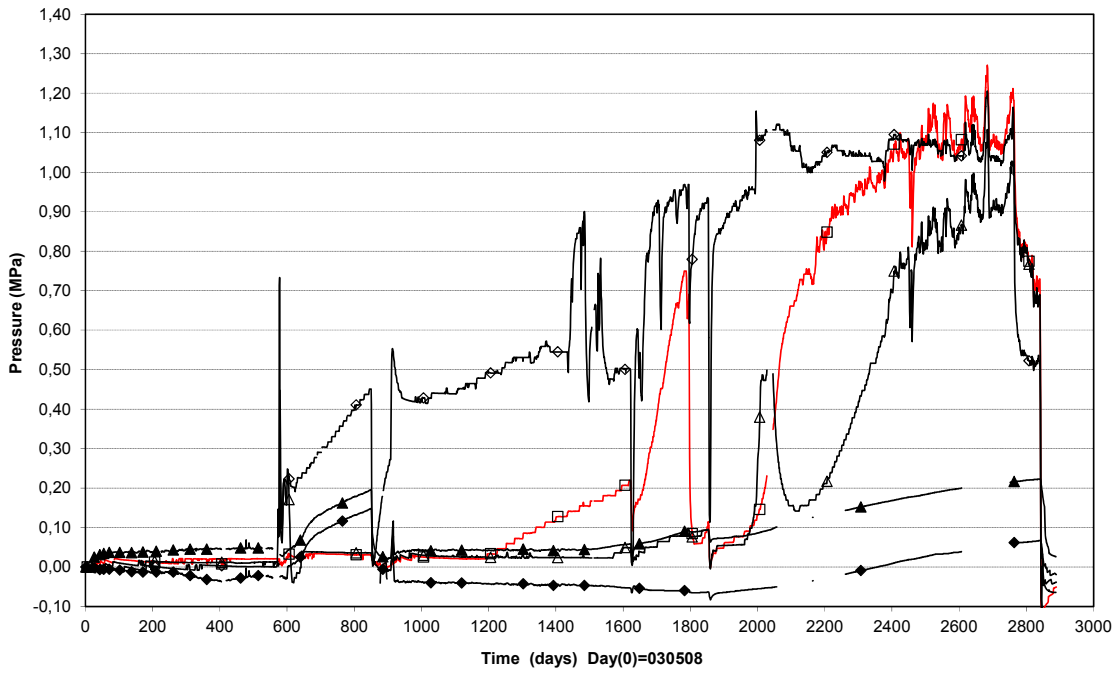
Prototype\ Hole 6 \ Ring 8 and Ring 9 (20030508-20110405)
Suction - Wescor



Prototype\Hole6 \Cyl.1 and Ring2 (20030508-20110405)
Pore pressure

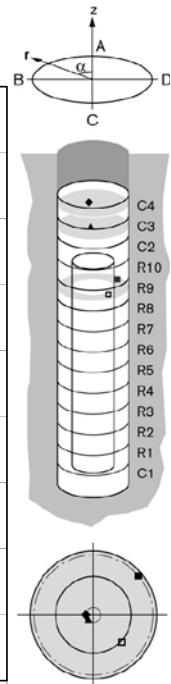
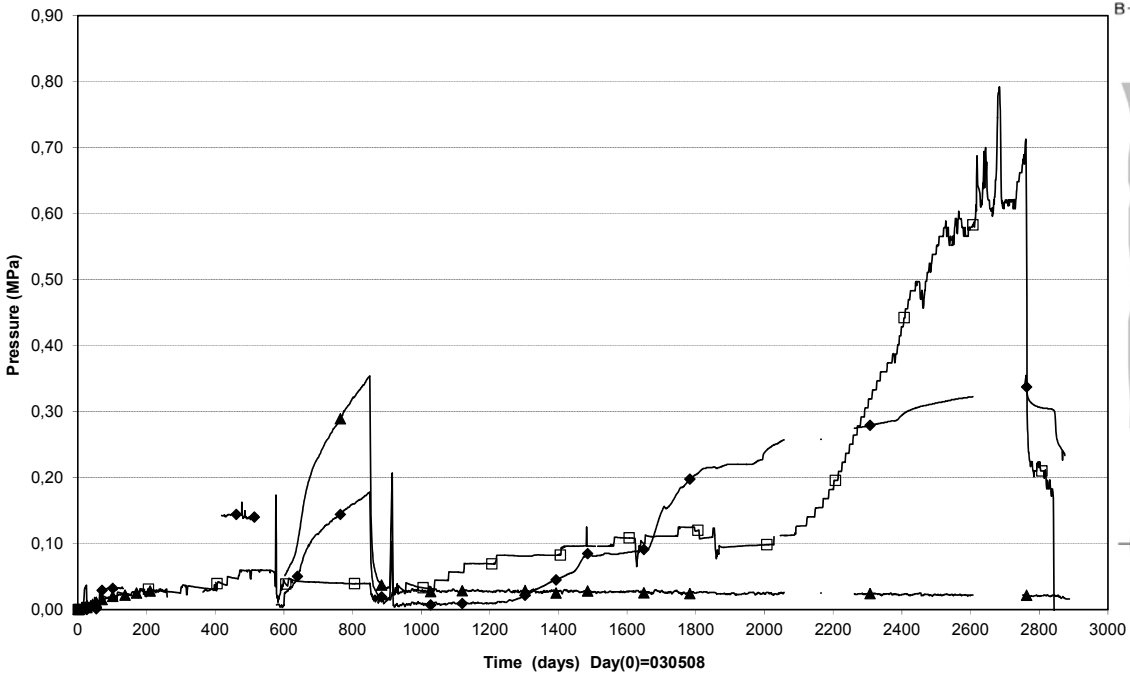


Prototype\Hole6 \ Ring 5 and Ring 6 (20030508-20110405)
Pore pressure



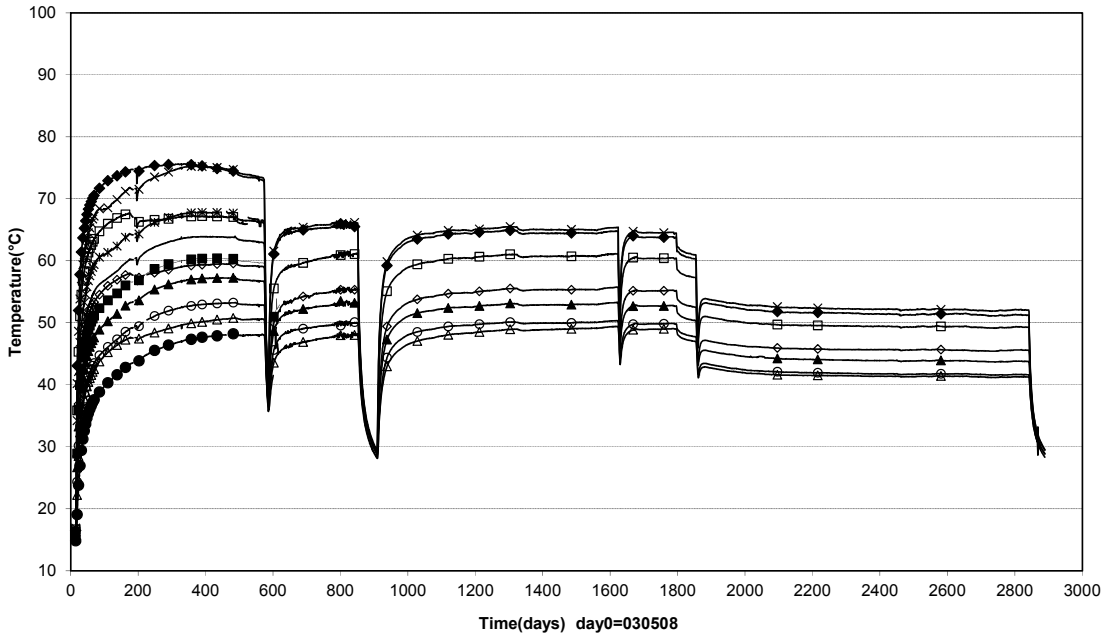
| | | |
|---------------------------|---------------------------|---------------------------|
| □ UB605(2.795\190°\0.585) | ■ UB606(2.795\350°\0.785) | ◆ UB607(3.300\35°\0.735) |
| ▲ UB608(3.300\125°\0.635) | △ UB609(3.300\225°\0.535) | ◇ UB610(3.253\310°\0.875) |

Prototype\Hole6\Ring 9 , Cyl.3 and Cyl.4 (20030508-20110405)
Pore pressure



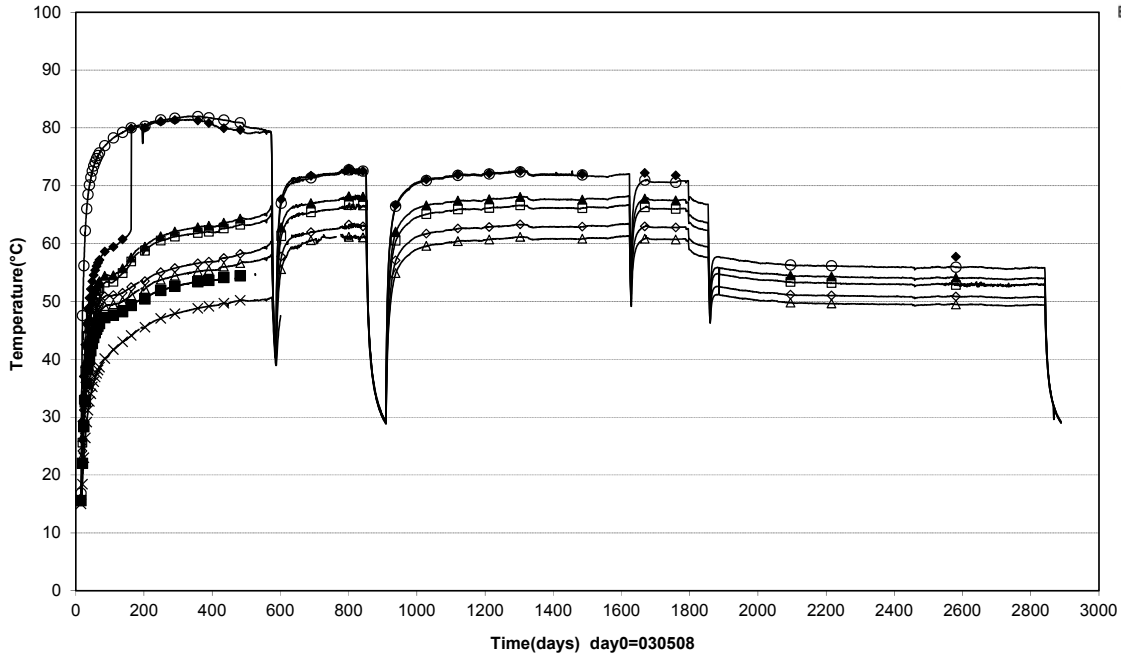
| | | | |
|---------------------------|---------------------------|---------------------------|--------------------------|
| □ UB611(4.834\225°\0.535) | ■ UB612(4.753\310°\0.875) | ▲ UB613(6.366\135°\0.100) | ◆ UB614(6.961\90°\0.100) |
|---------------------------|---------------------------|---------------------------|--------------------------|

Prototype\Hole 6\Cyl.1 and Ring1 (20030508-20110405)
Temperature - Pentronic



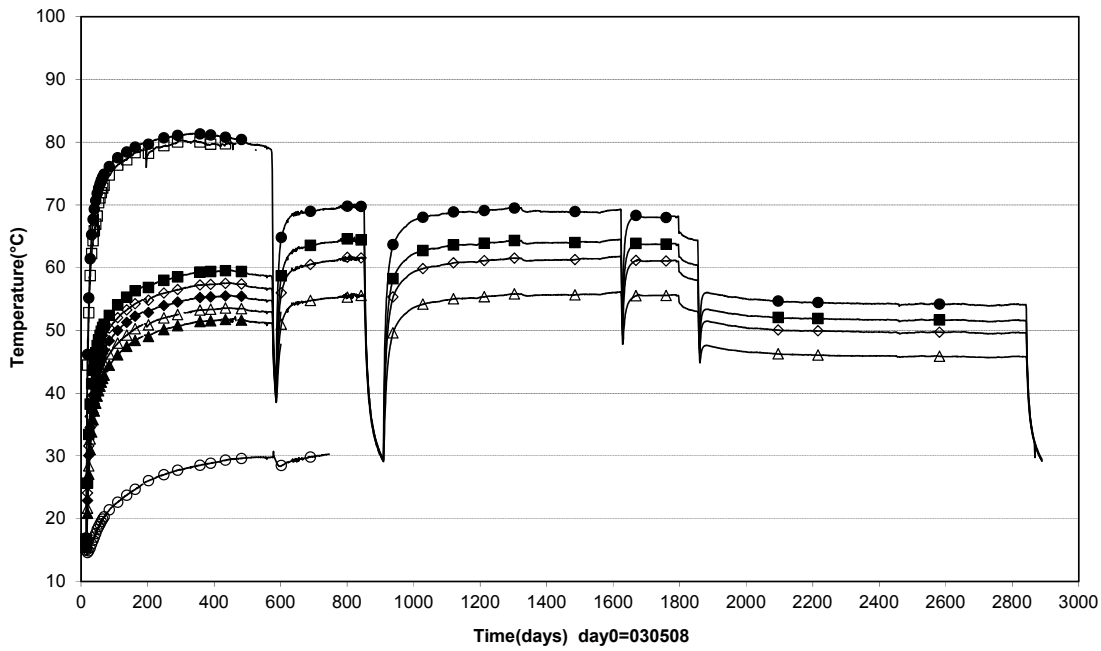
- | | | | |
|---------------------------|---------------------------|---------------------------|---------------------------|
| □ TB601(0.385\45°\0.050) | ◇ TB602(0.260\315°\0.050) | △ TB603(0.135\0°\0.050) | × TB604(0.770\270°\0.535) |
| × TB605(0.770\270°\0.585) | ■ TB607(0.770\270°\0.685) | ▲ TB608(0.770\270°\0.735) | ○ TB609(0.770\270°\0.785) |
| ● TB610(0.753\270°\0.875) | ◆ TB611(0.753\ 0°\0.525) | — TB606(0.750\270°\0.635) | |

Prototype\Hole 6 \Ring5 (20030508-20110405)
Temperature - Pentronic



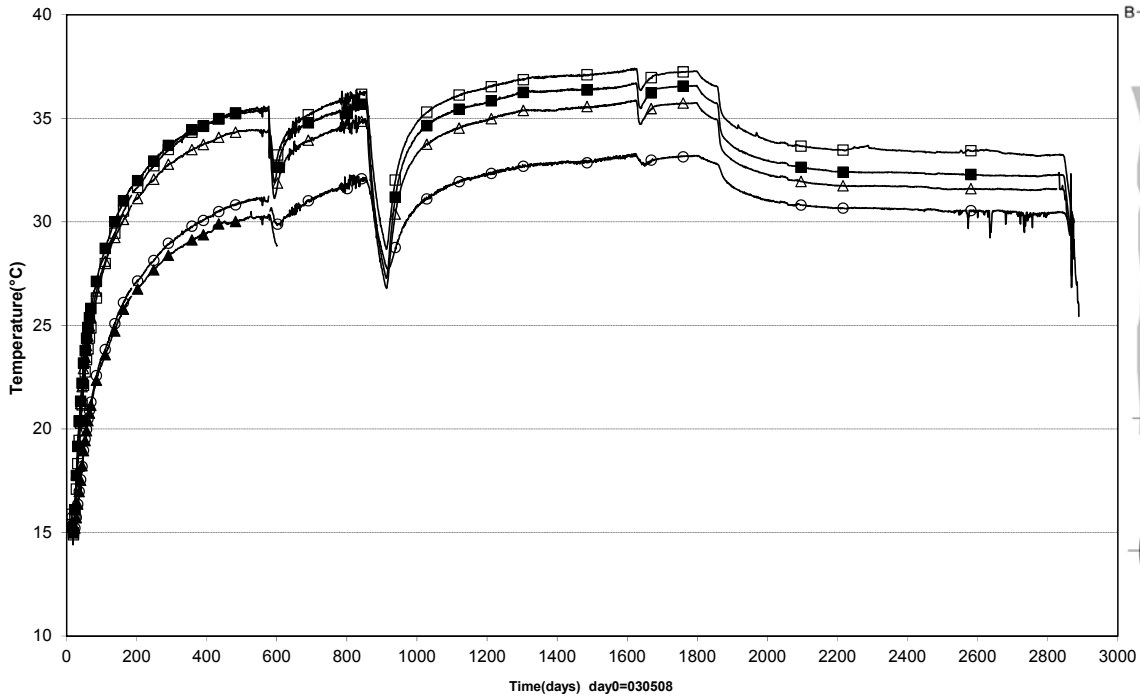
- | | | | |
|---------------------------|---------------------------|---------------------------|---------------------------|
| ◆ TB612(2.795\270°\0.535) | ▲ TB613(2.795\270°\0.585) | □ TB614(2.795\270°\0.635) | ◇ TB615(2.795\270°\0.685) |
| △ TB616(2.795\270°\0.735) | ■ TB617(2.795\270°\0.785) | × TB618(2.753\270°\0.875) | ○ TB619(2.753\ 0°\0.525) |

Prototype\Hole 6 \Ring8 (20030508-20110405)
Temperature - Pentronic



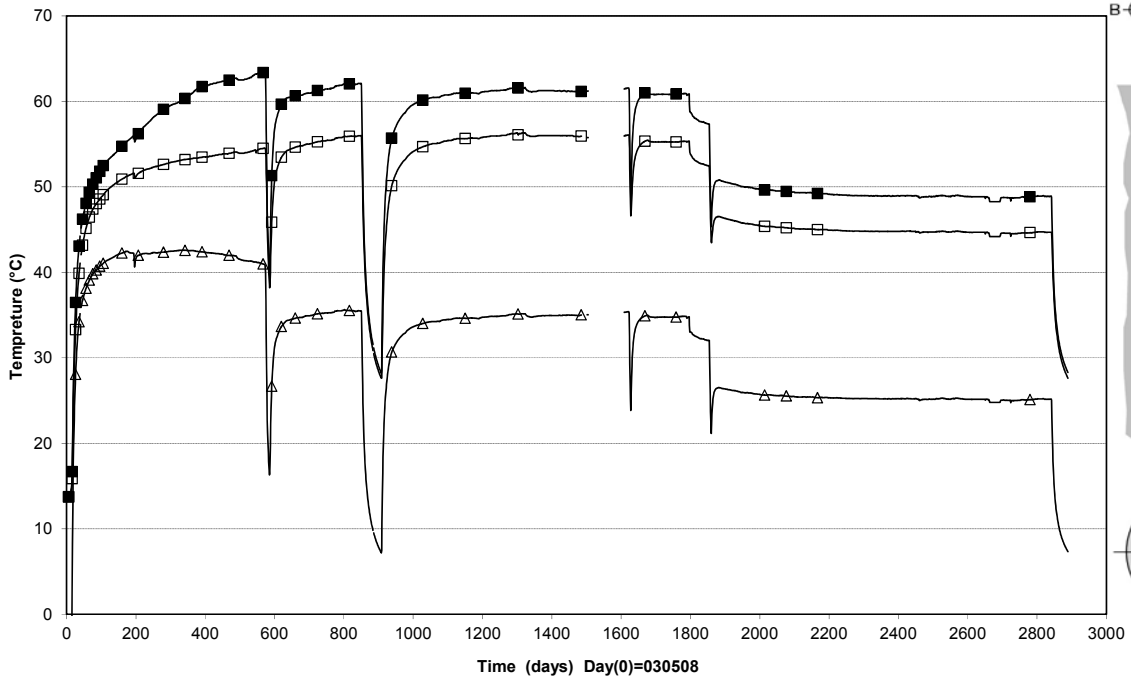
- TB620(4.324\270°\0.535) ■ TB621(4.324\270°\0.585) ◇ TB622(4.324\270°\0.635) ◆ TB623(4.324\270°\0.685)
- △ TB624(4.324\270°\0.735) ▲ TB625(4.324\270°\0.785) ○ TB626(4.253\270°\0.875) ● TB627(4.253\0°\0.525)

Prototype\Hole 6 \Cyl.3 and Cyl.4 (20030508-20110405)
Temperature - Pentronic

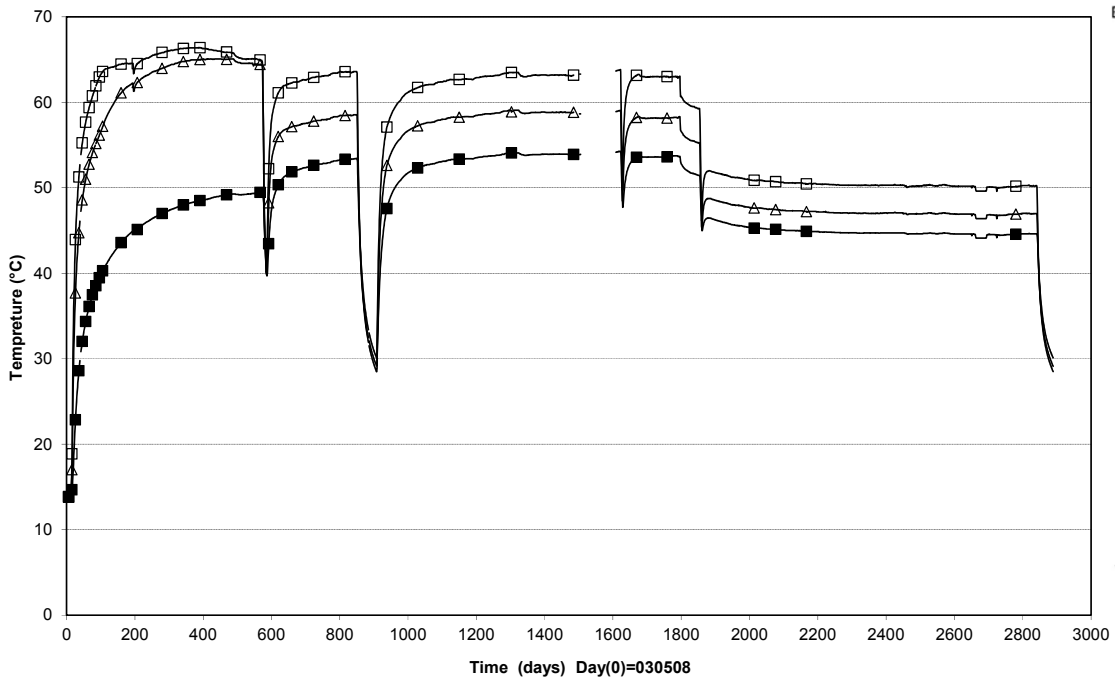


- TB628(6.366\0°\0.785) ■ TB629(6.366\95°\0.585) △ TB630(6.366\185°\0.585) ▲ TB631(7.071\225°\0.100) ○ TB632(7.071\0°\0.785)

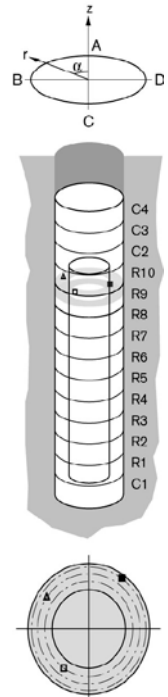
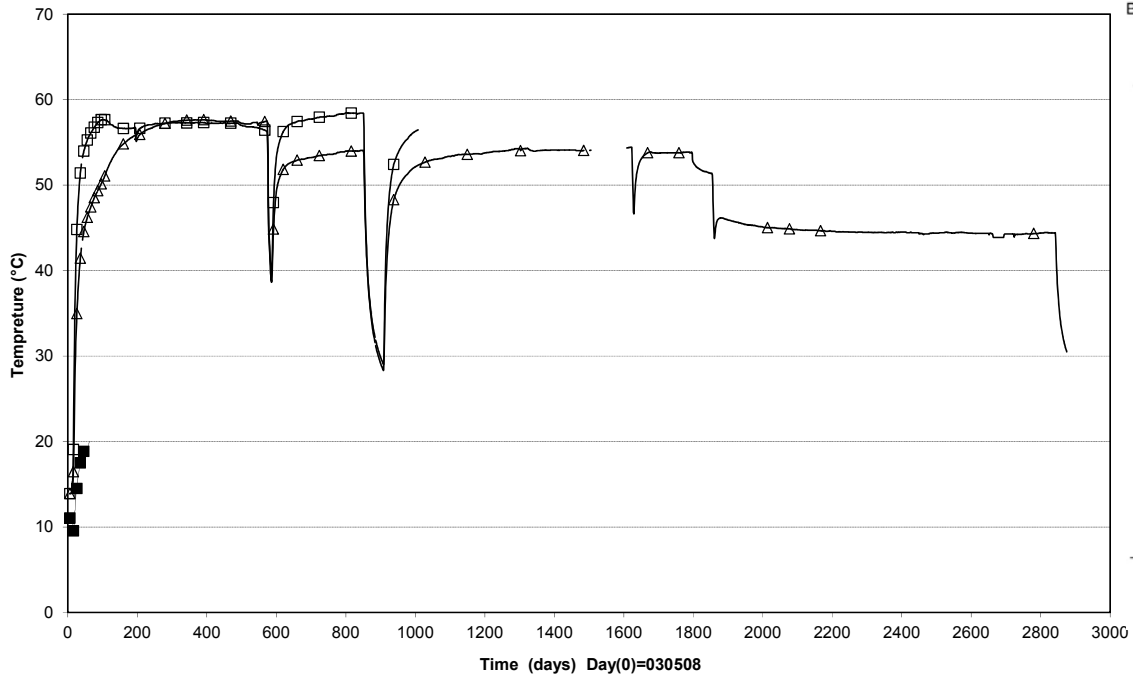
Prototype\Hole 6\Cyl.1 and Ring2 (20030508-20110405)
Temperature - Geokon



Prototype\Hole 6\ Ring6 (030508-20110405)
Temperature - Geokon

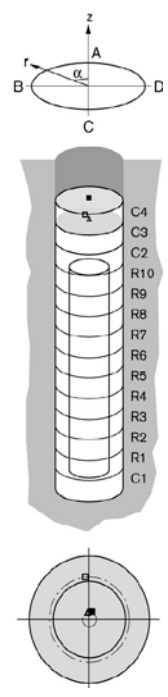
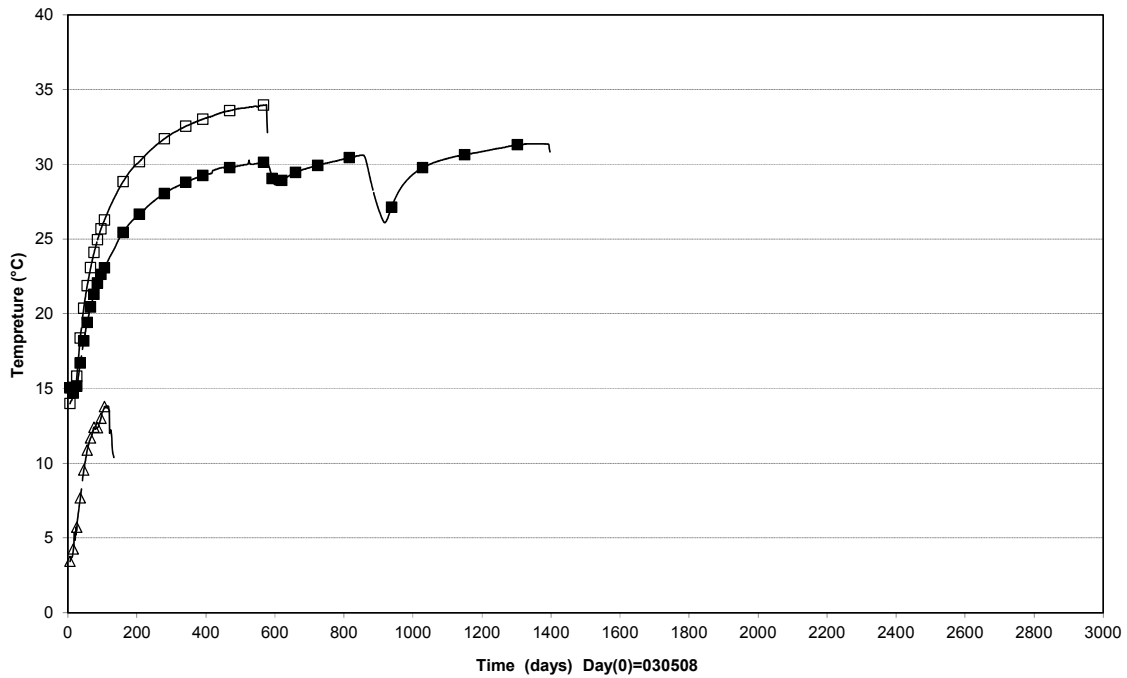


Prototype\Hole 6\ Ring9 (20030508-20110405)
Temperature - Geokon



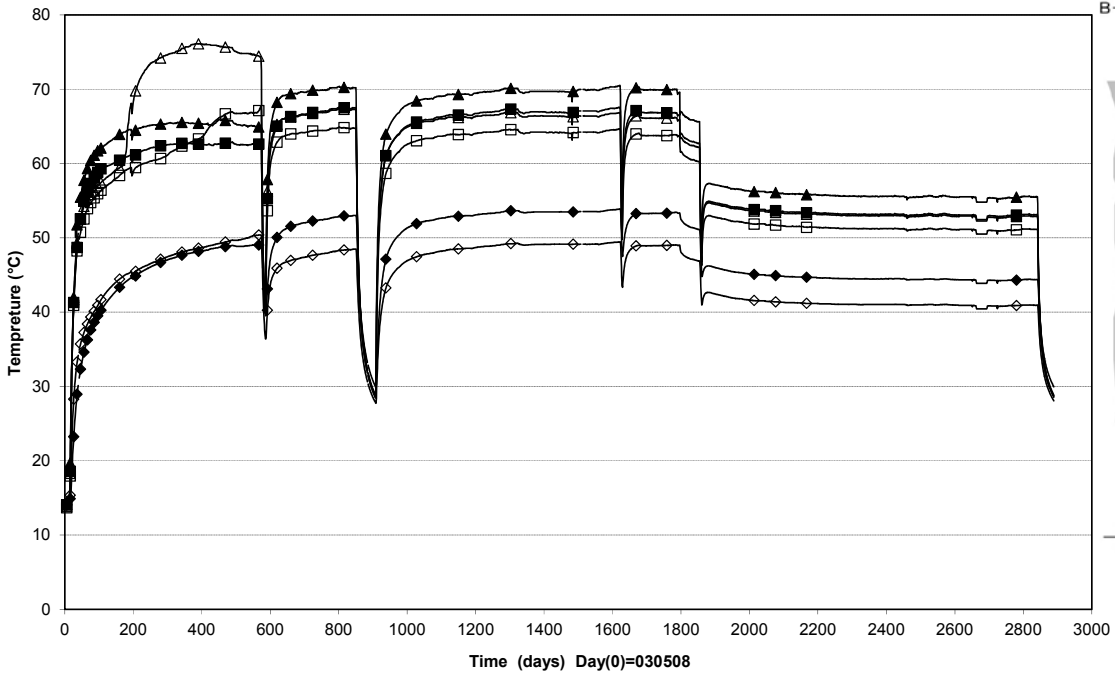
▲ PB620T(5.084\55°\0.735)
□ PB621T(5.084\145°\0.635)
■ PB623T(4.753\325°\0.875)

Prototype\Hole 6\Cyl.3 and Cyl.4 (20030508-20110405)
Temperature - Geokon

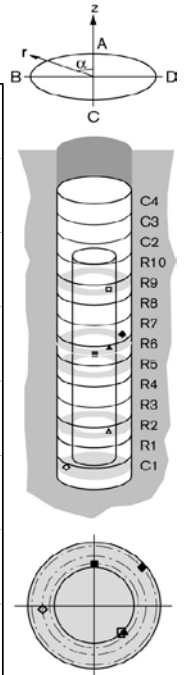


▲ PB625T(6.616\0°\0.100)
□ PB626T(6.616\5°\0.585)
■ PB627T(7.121\0°\0.100)

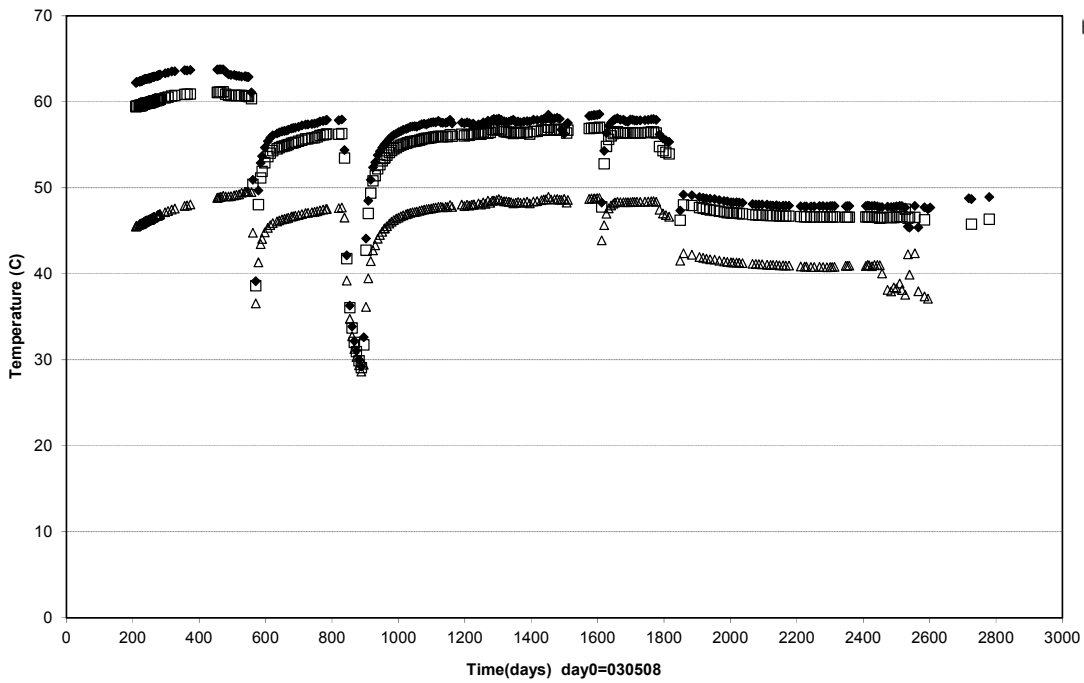
Prototype\Hole6 (20030508-20110405)
Temperature- Geokon



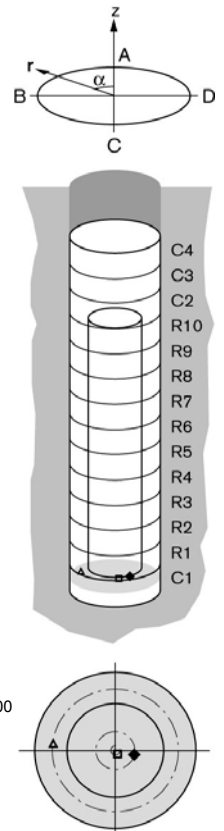
- | | | |
|----------------------------|----------------------------|----------------------------|
| ◇ UB602T(0.260\95°\0.685) | △ UB603T(1.284\225°\0.535) | ■ UB605T(2.795\190°\0.585) |
| ▲ UB609T(3.300\225°\0.535) | ◆ UB610T(3.253\310°\0.875) | □ UB611T(4.834\225°\0.535) |



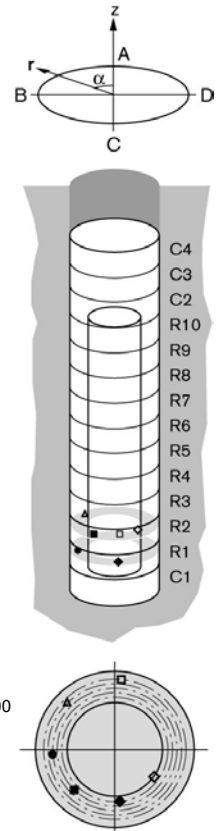
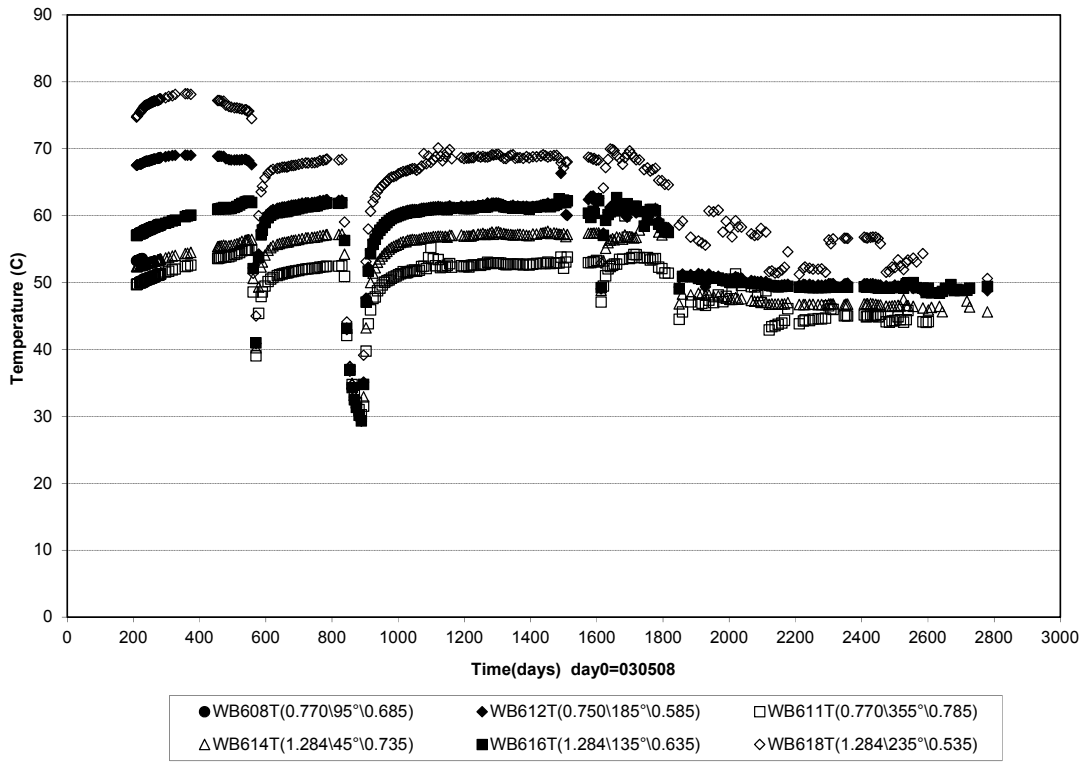
Prototype\ Hole 6 \ Cyl1 (20030508-20110405)
Temperature - Wescor



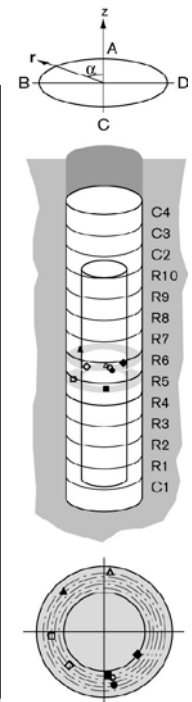
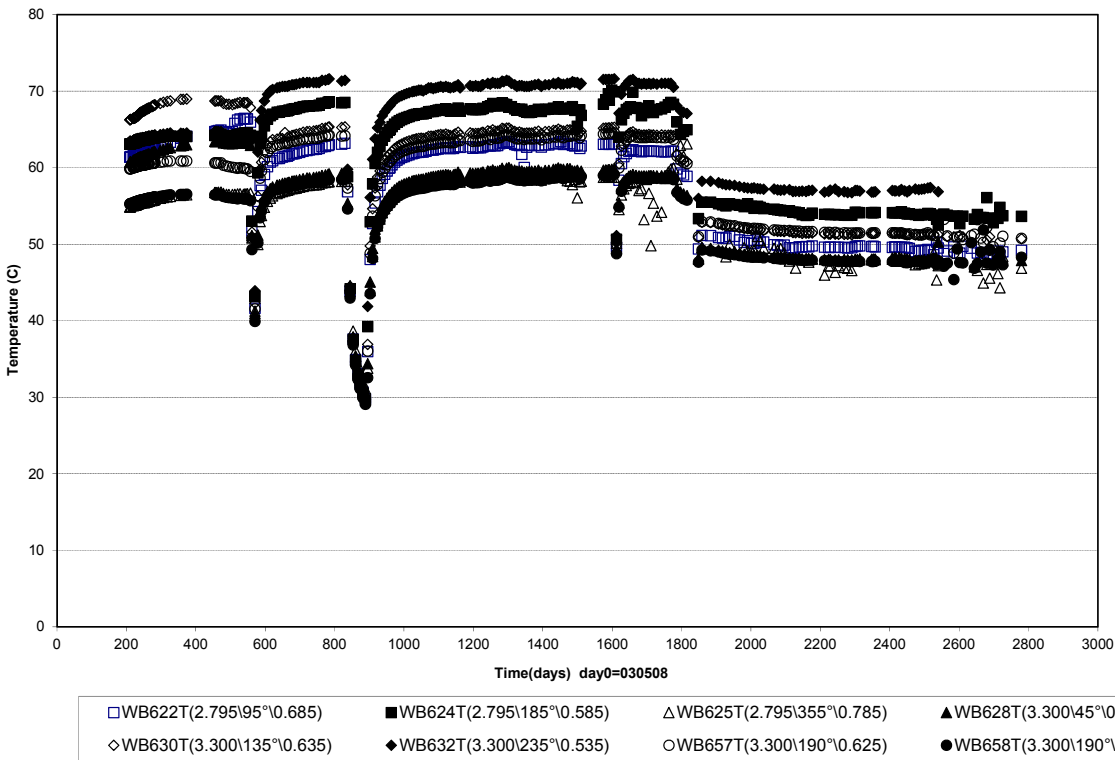
- | | | |
|----------------------------|----------------------------|---------------------------|
| □ WB602T(0.260\225°\0.050) | ◆ WB603T(0.260\260°\0.210) | △ WB605T(0.260\90°\0.685) |
|----------------------------|----------------------------|---------------------------|



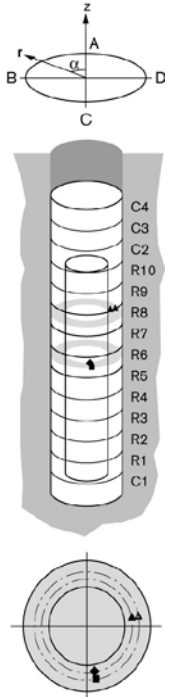
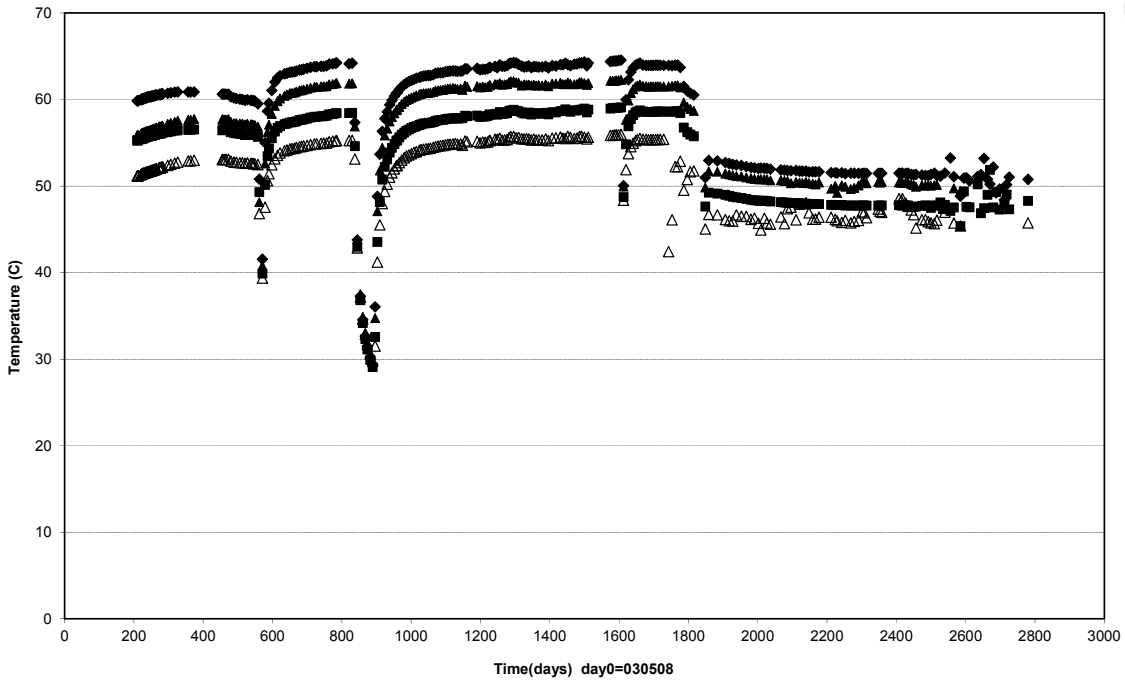
Prototype\ Hole 6 \ Ring 1 and Ring 2 (20030508-20110405)
Temperature - Wescor



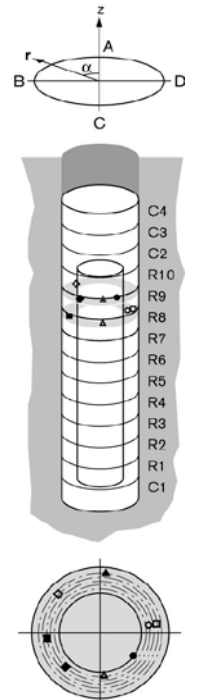
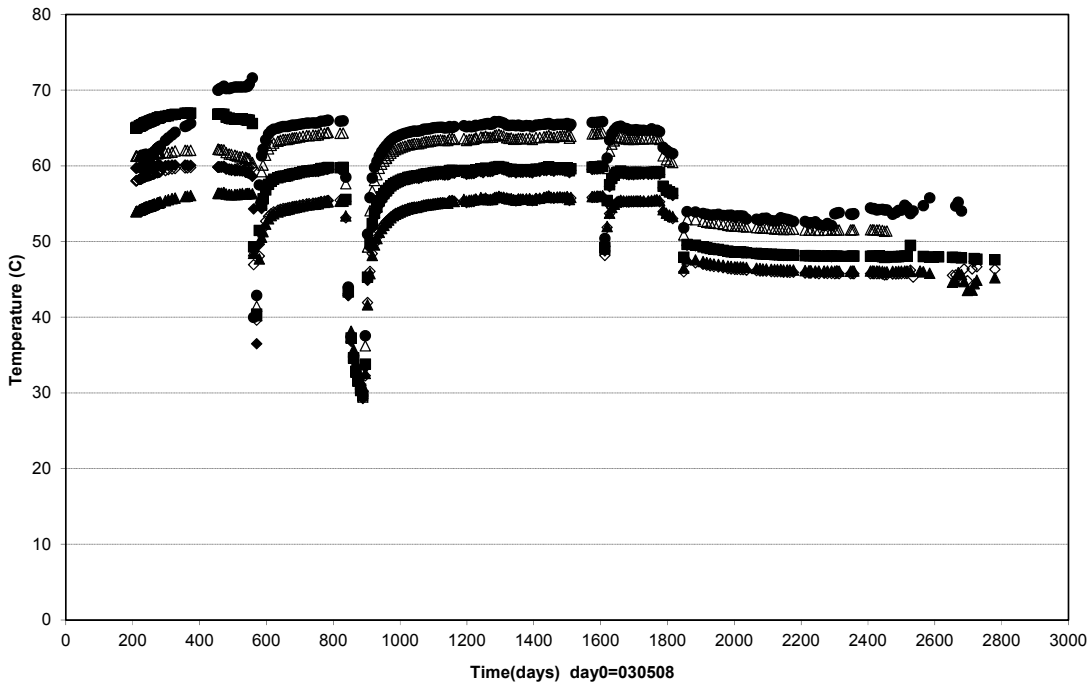
Prototype\ Hole 6 \ Ring 5 and Ring 6 (20030508-20110405)
Temperature - Wescor



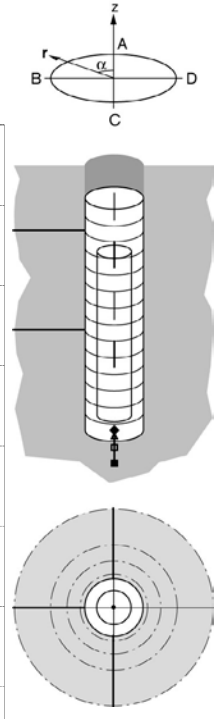
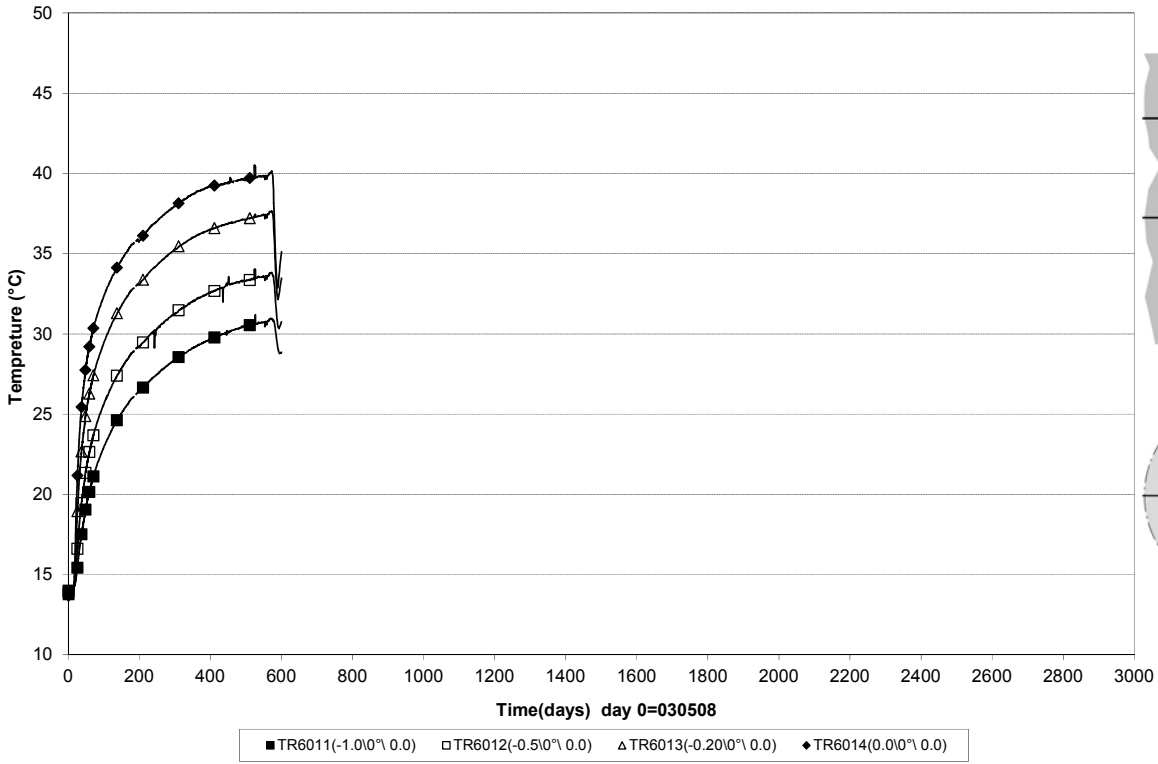
Prototype\ Hole 6 \ Ring 6 and Ring 8 (20030508-20110405)
Temperature - Wescor



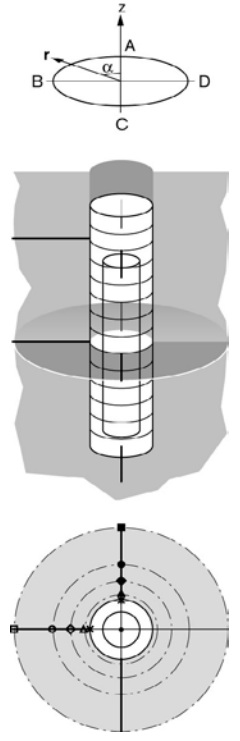
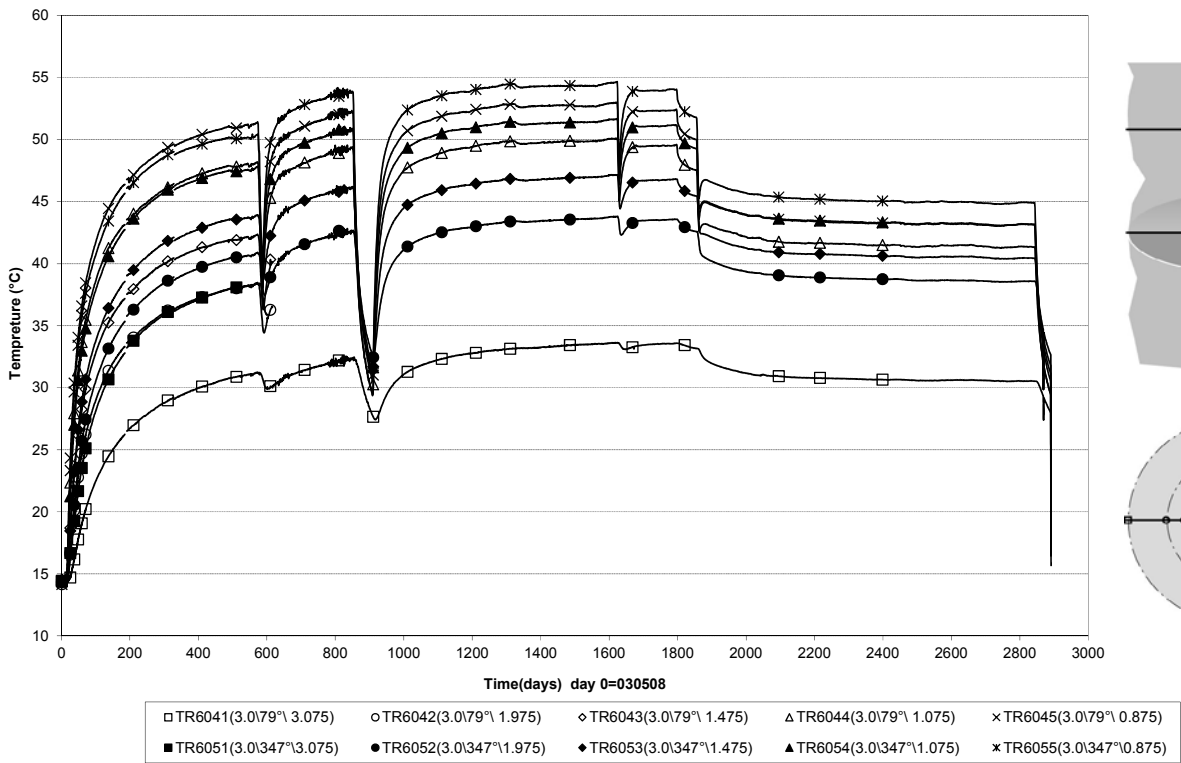
Prototype\ Hole 6 \ Ring 8 and Ring 9 (20030508-20110405)
Temperature - Wescor



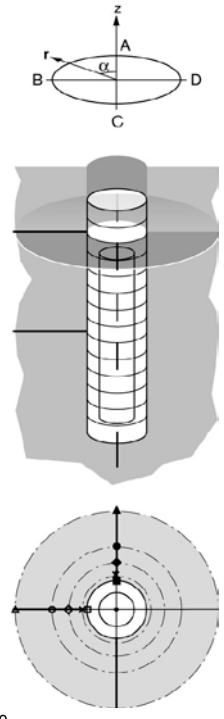
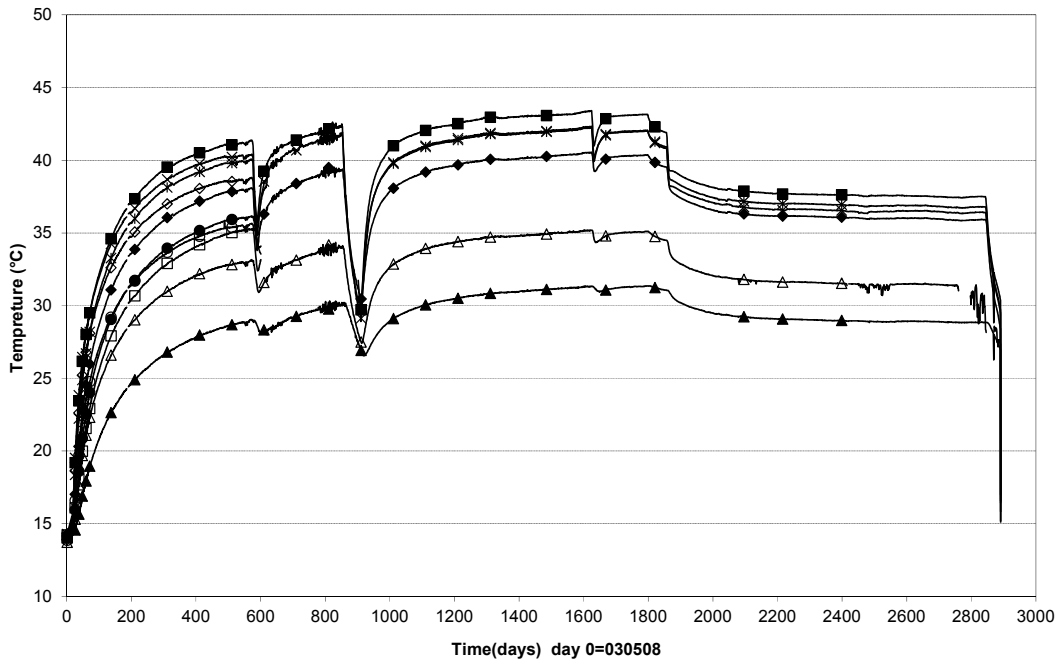
Prototype\Rock\Hole 6 \ Level bottom (20030508-20110405)
Temperature - Pentronic



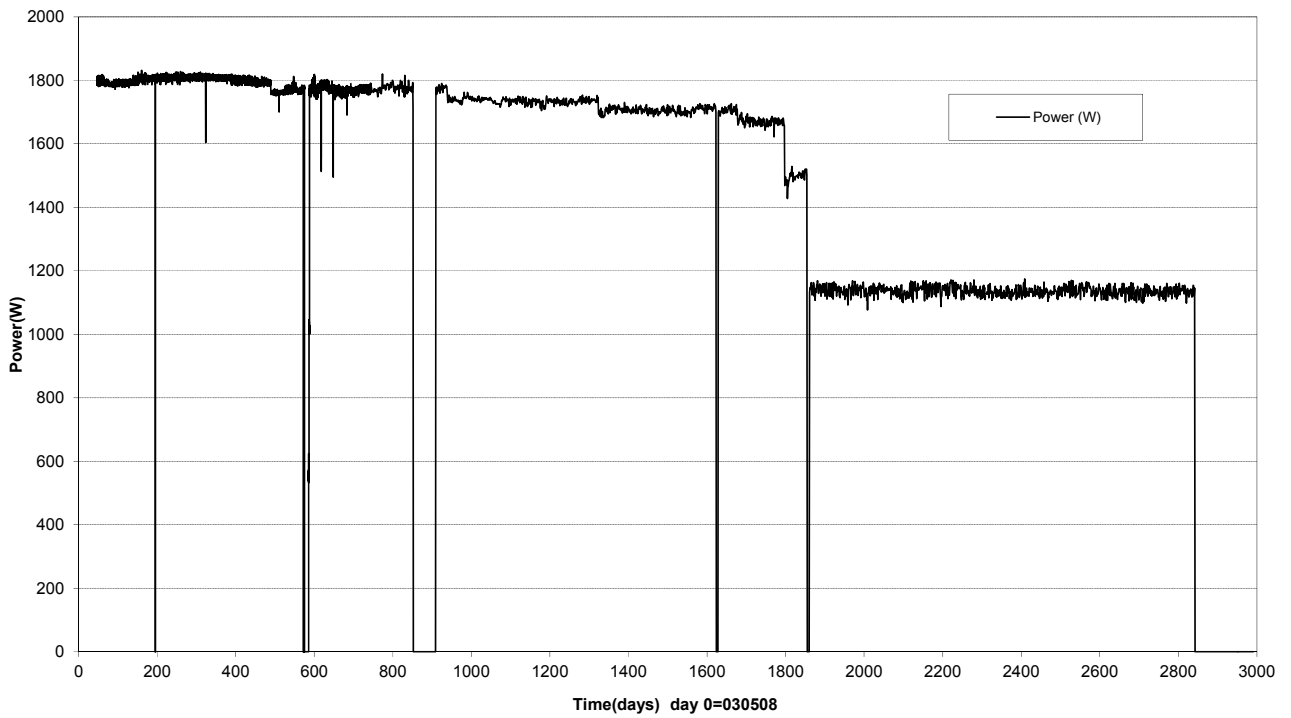
Prototype\Rock\Hole 6 \ Level 3,0 m (20030508-20110405)
Temperature - Pentronic



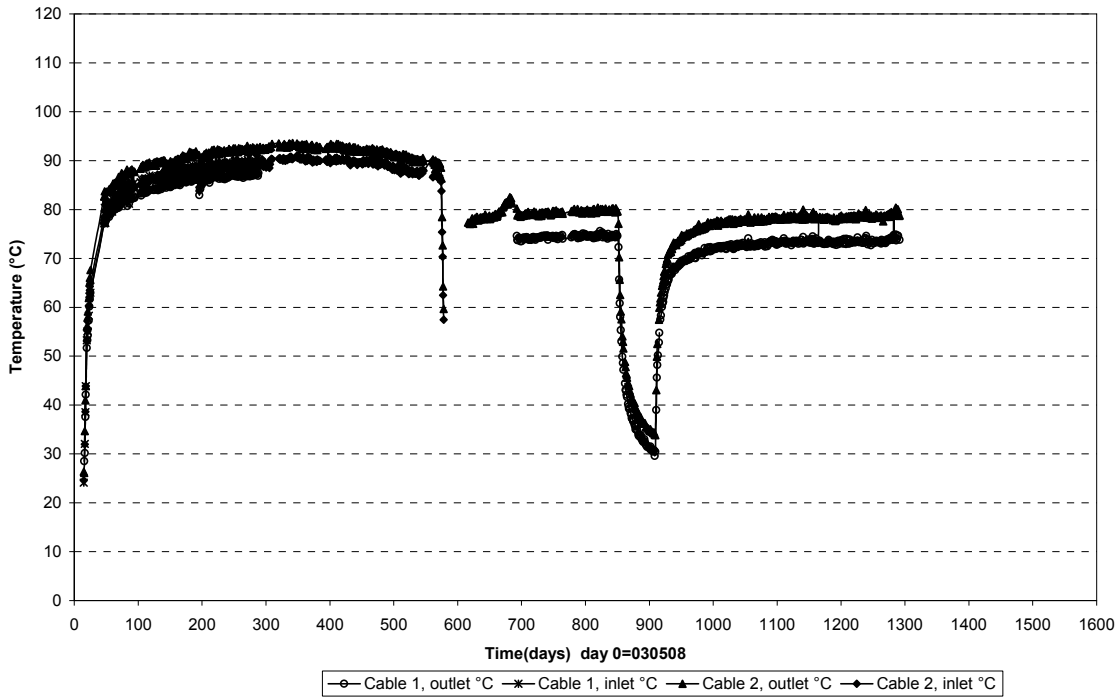
Prototype\Rock\Hole 6\ Level 6,0 m (20030508-20110405)
Temperature - Pentronic



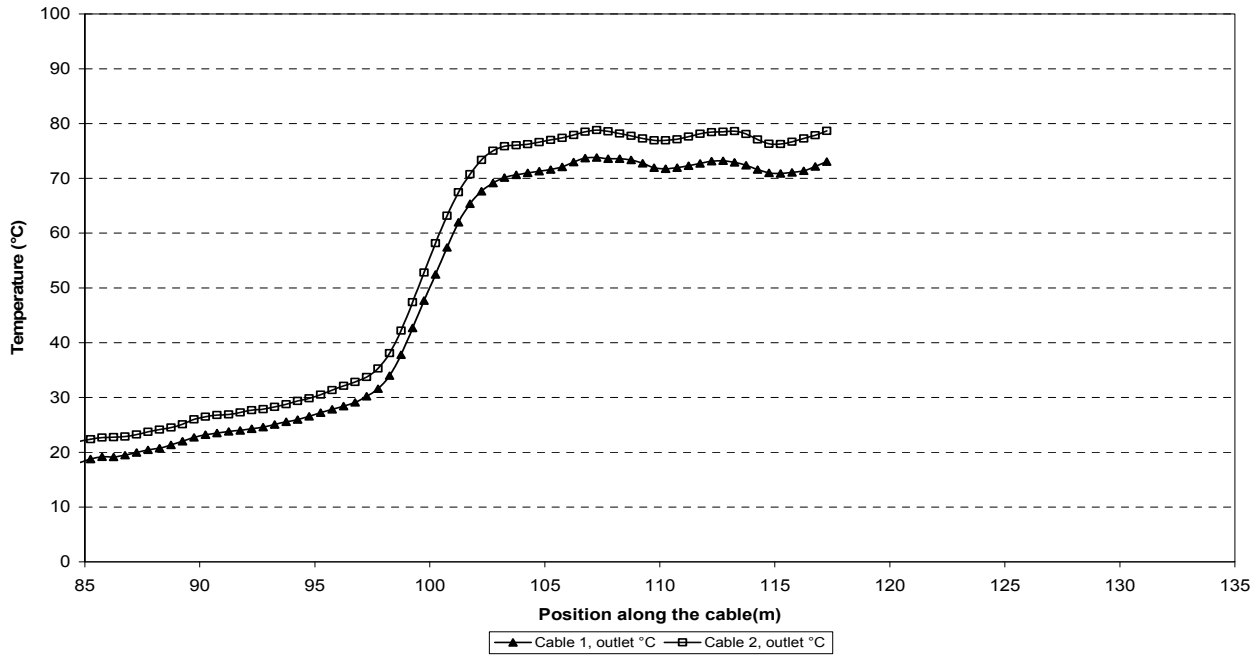
Prototype\Hole 6 (20030508-20110405)
Canister power



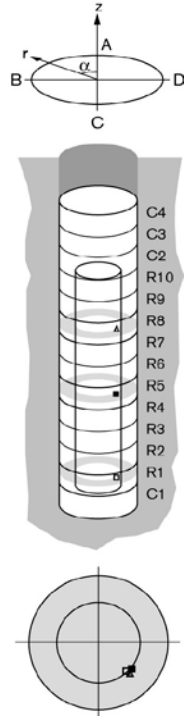
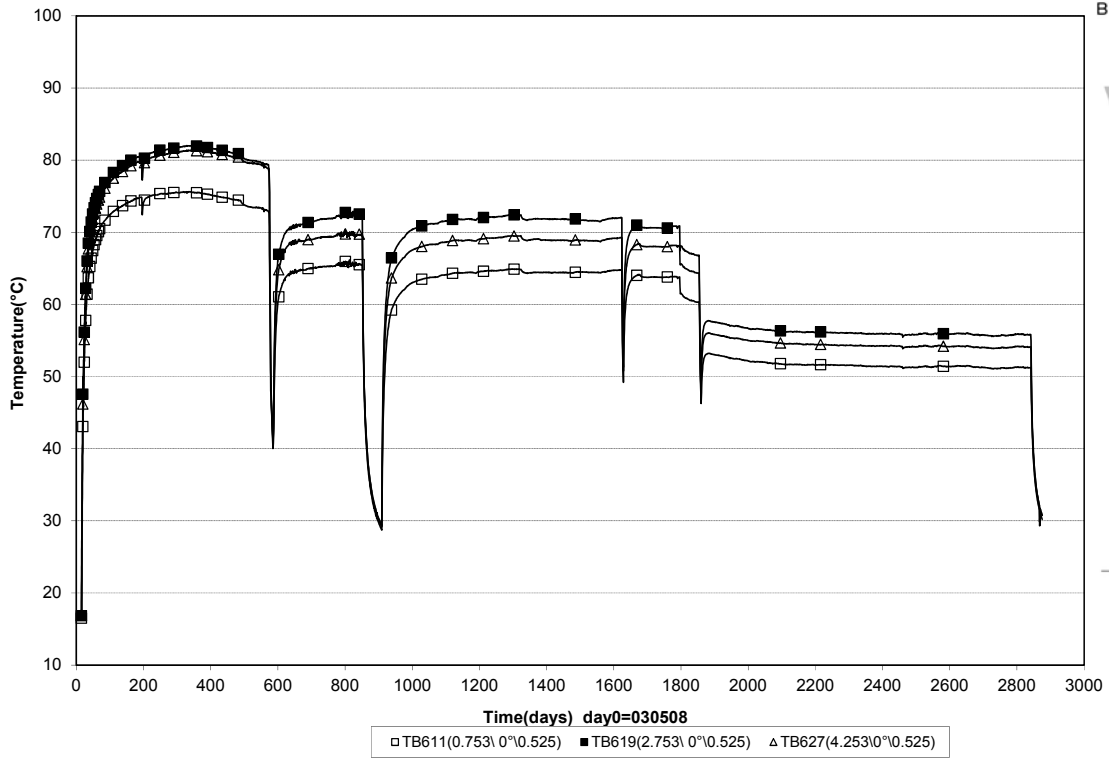
Prototype Hole 6 \Canister (030508-070601)
 Max. temperature on the canister surface - Optical fiber cables



Temperature profile on the canister surface-No6 (061119)
 Optical fiber cables

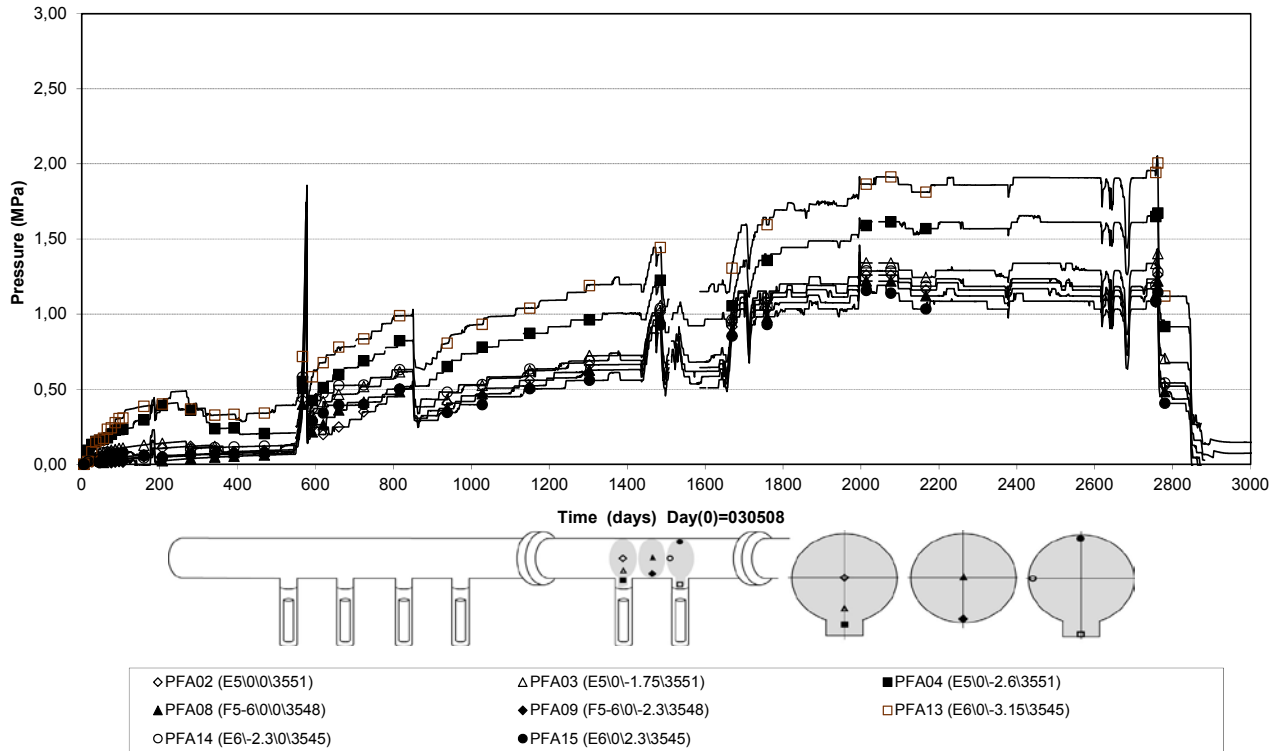


Prototype\Hole 6 \On the canister surface (20030508-20110405)
 Temperature - Pentronic

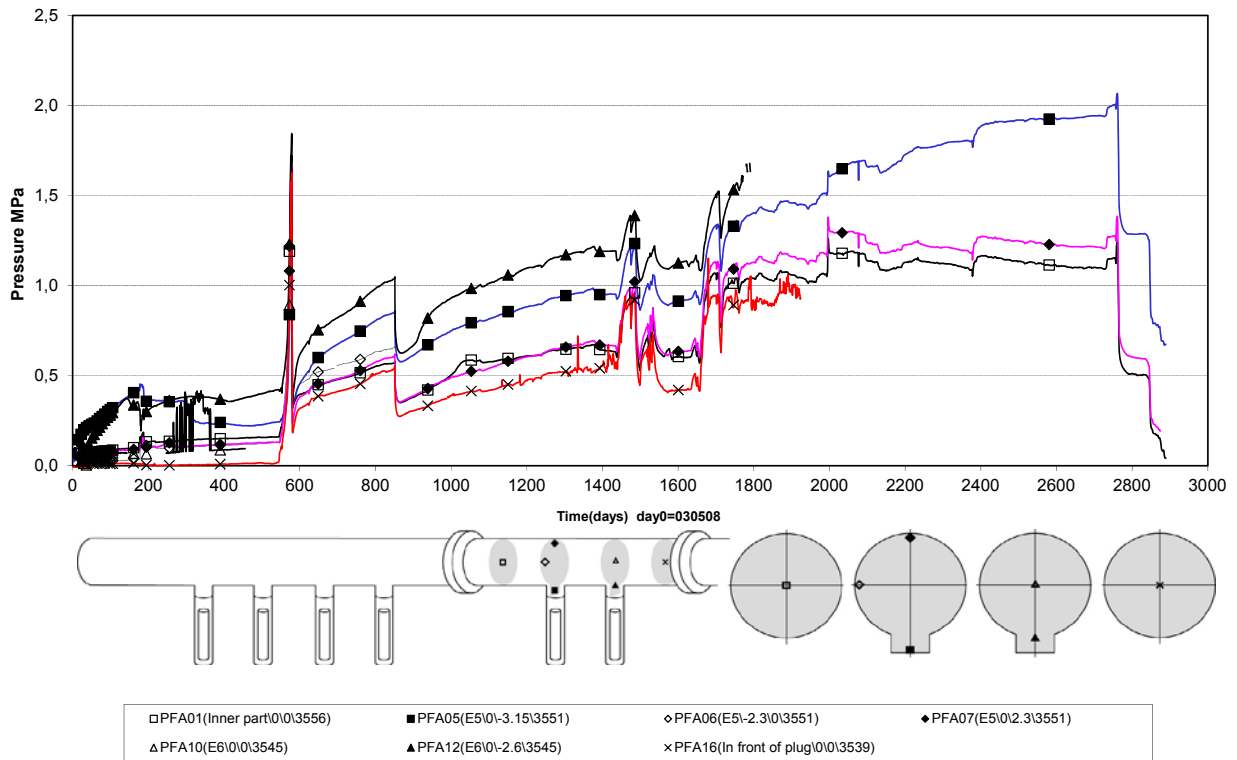


Backfill in Section 2

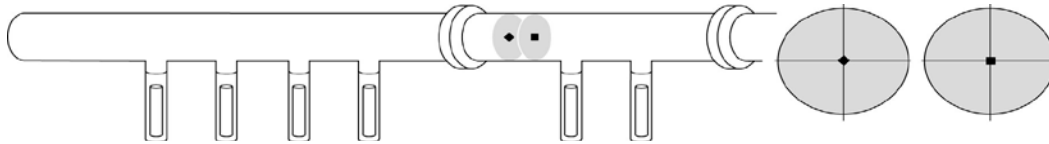
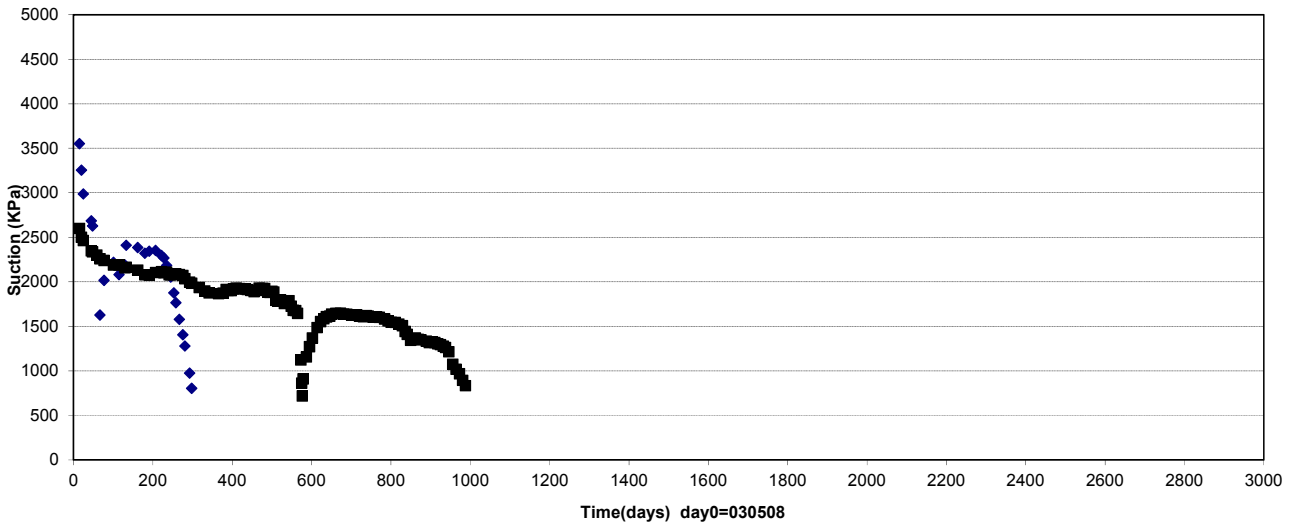
Total pressure\ Backfill \ Section 2 (20030508-20110405)
Geokon



Prototype\ Backfill \ Section 2 (20030508-20110405)
Total pressure - Kulite

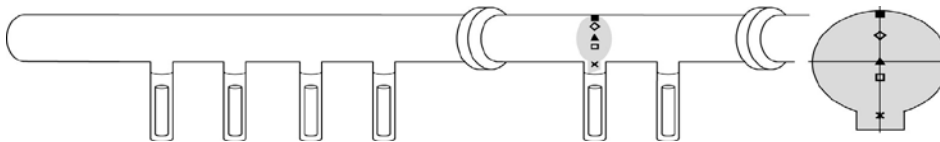
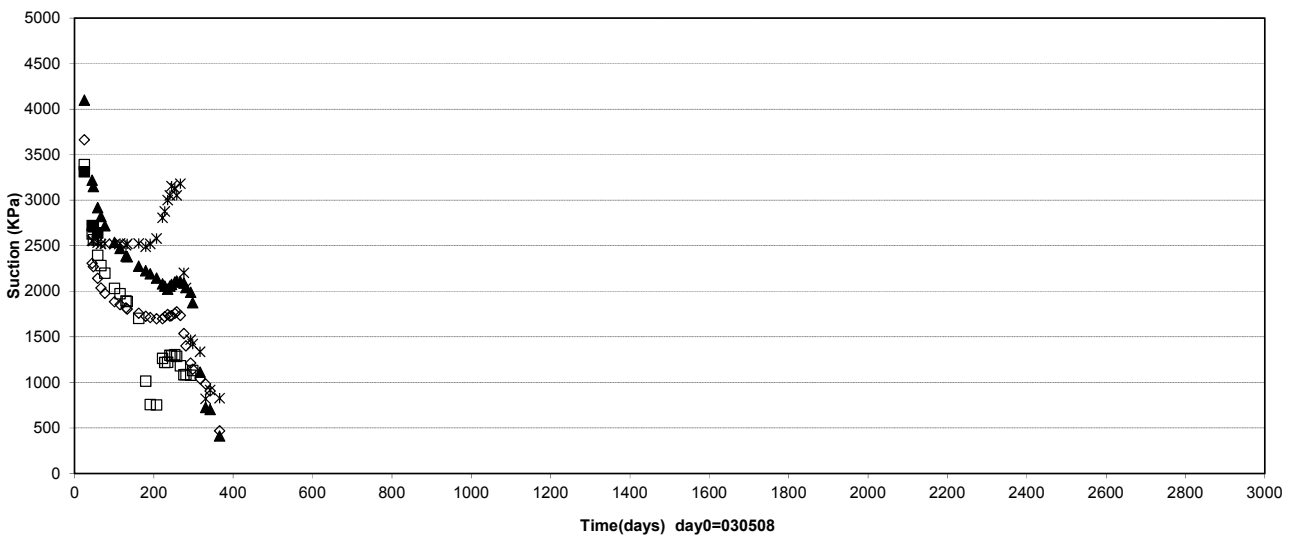


Prototype\Backfill \Section2\ Inner part (20030508-20110405)
Suction - Wescor



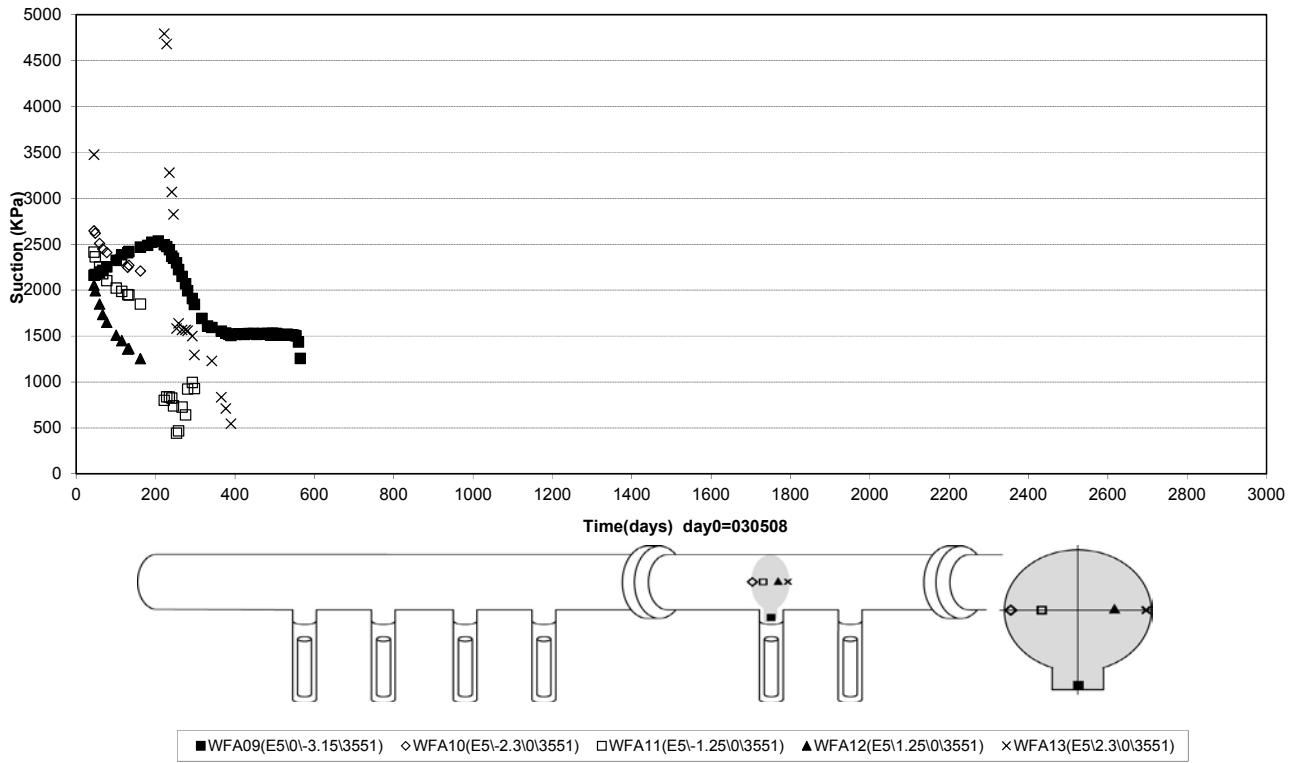
◆ WFA01(Inner part\0\0\3556) ■ WFA02(Inner part\0\0\3554)

Prototype\Backfill\ Above dep.hole 5 (20030508-20110405)
Suction - Wescor

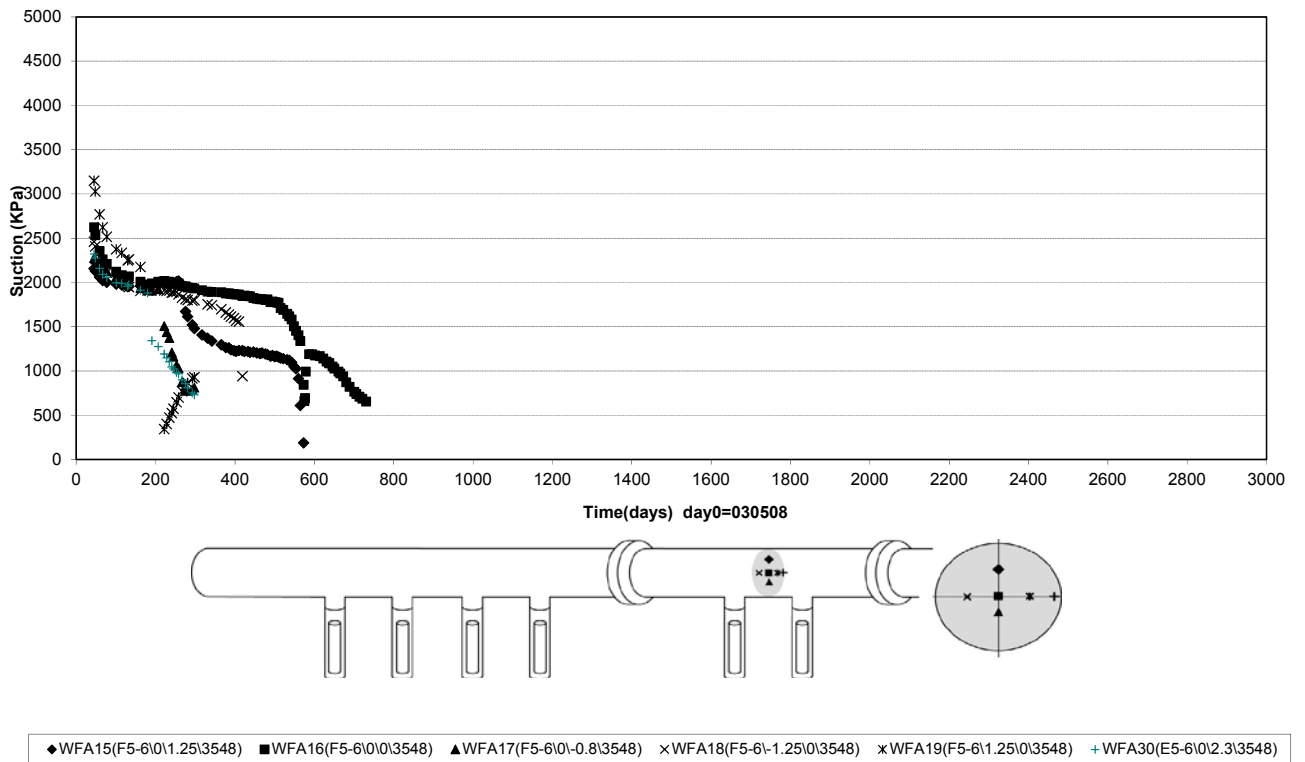


■ WFA03(E5\0\2.3\3551) ◇ WFA04(E5\0\1.25\3551) ▲ WFA05(E5\0\0\3551) □ WFA06(E5\0\0.8\3551) × WFA08(E5\0\2.6\3551)

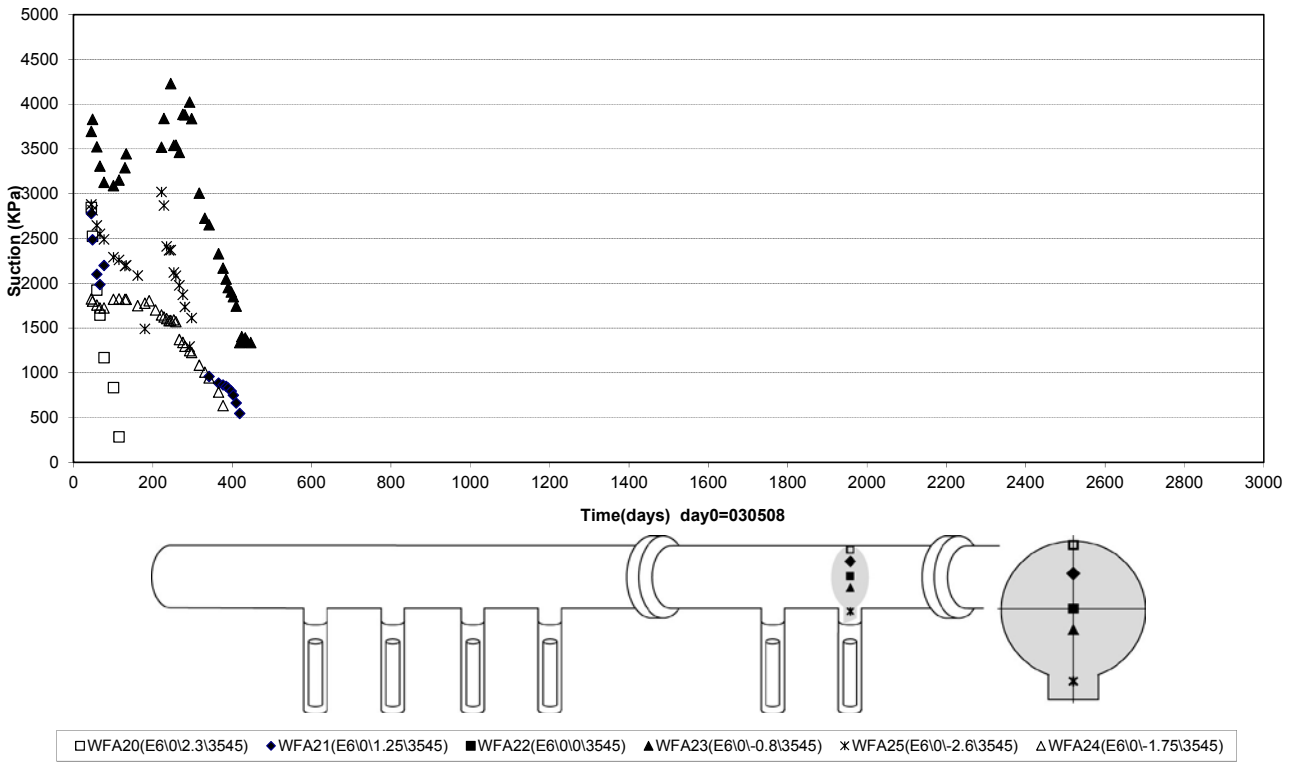
Prototype\Backfill\ Above dep.hole 5 (20030508-20110405)
Suction - Wescor



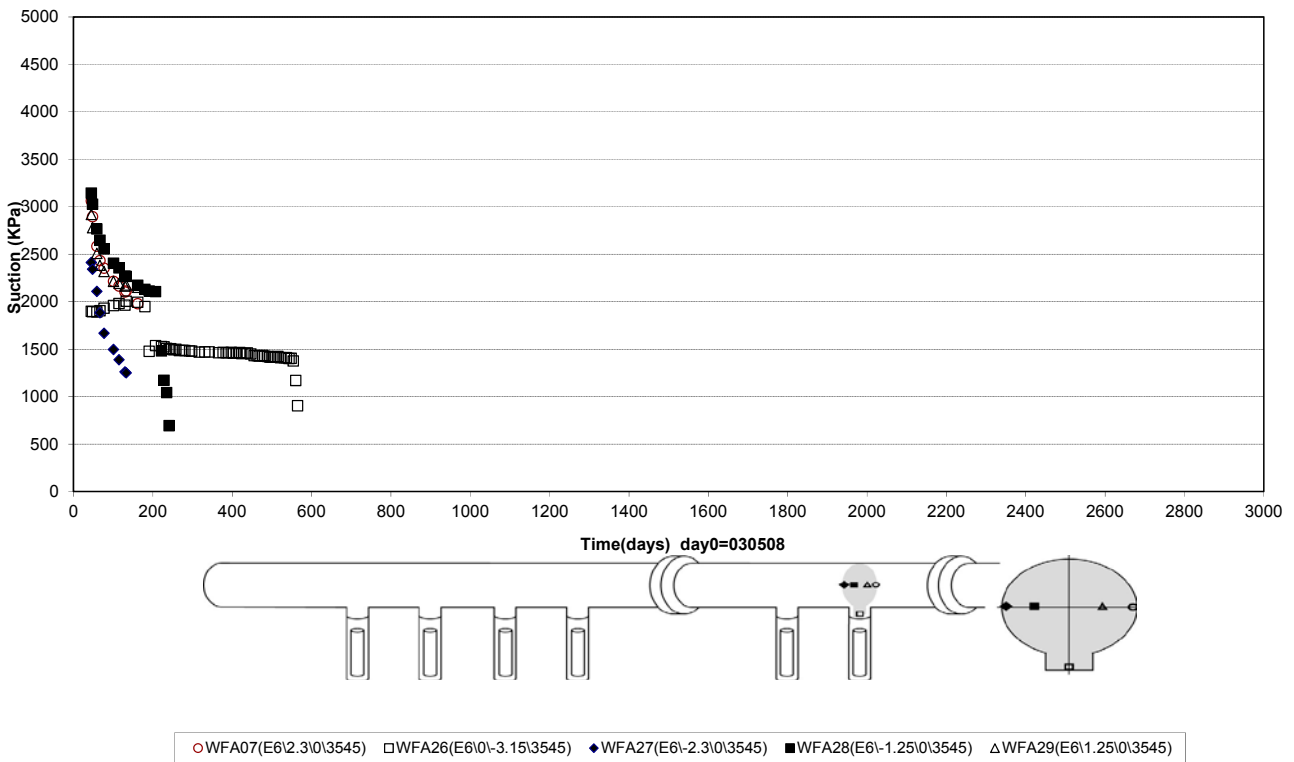
Prototype\Backfill\ Between dep.hole 5 and hole 6 (20030508-20110405)
Suction - Wescor



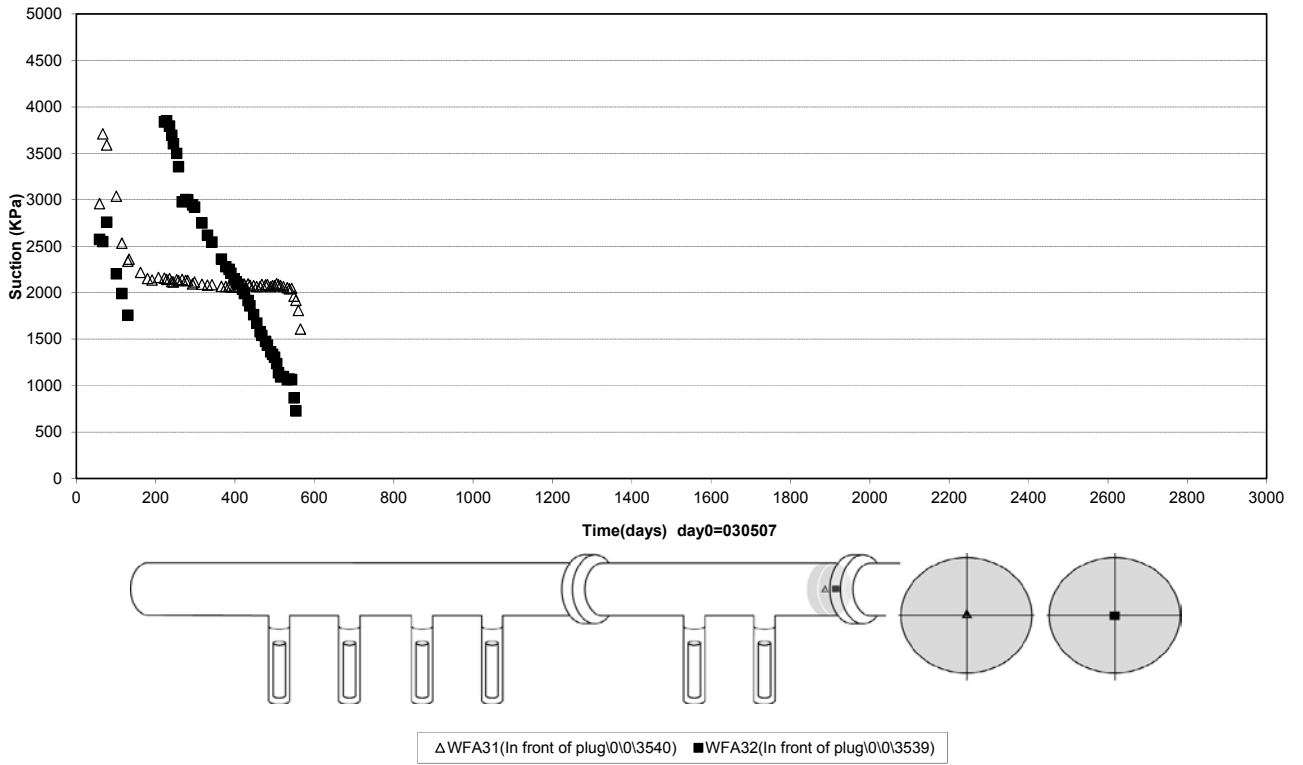
Prototype\Backfill \Section2\ Above dep.hole 6 (20030508-20110405)
Suction - Wescor



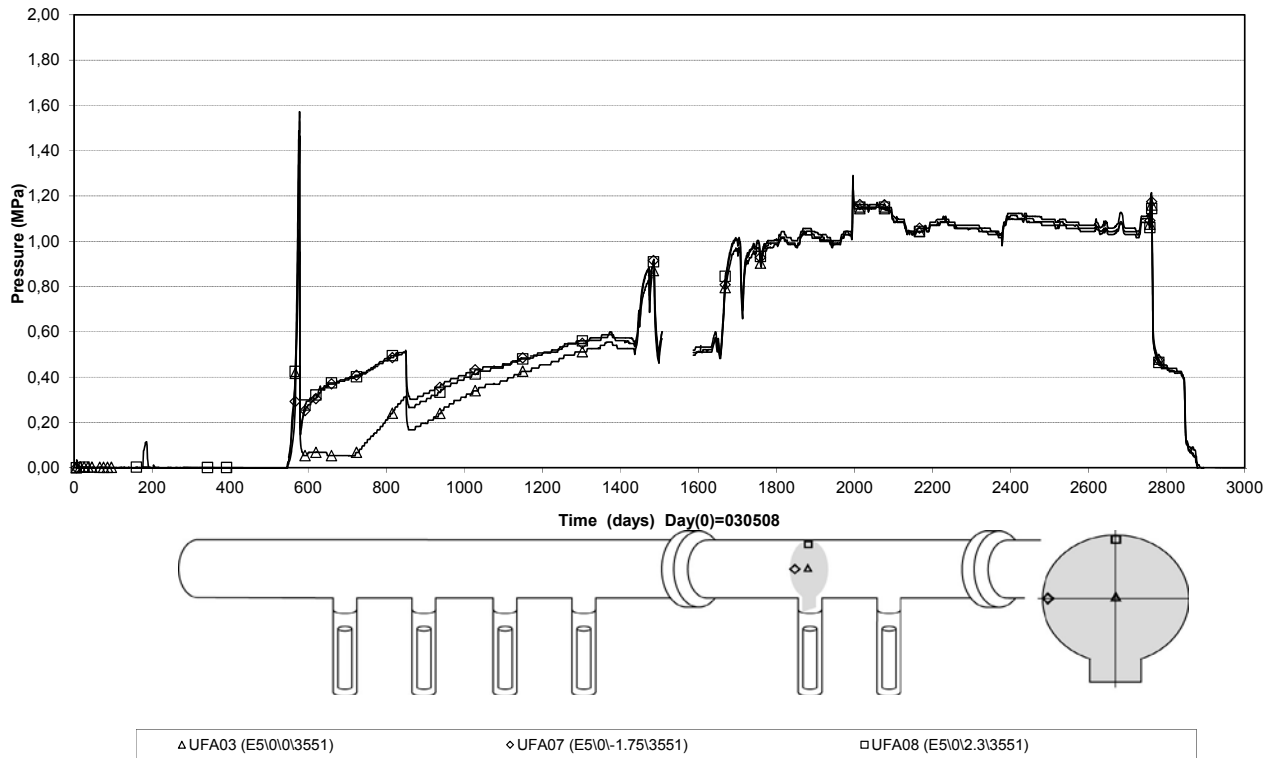
Prototype\Backfill \Section2\ Above dep.hole 6 (20030508-20110405)
Suction - Wescor



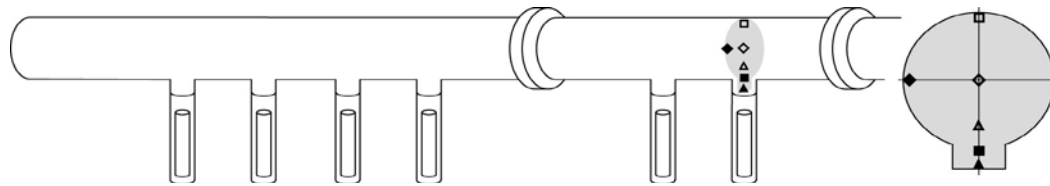
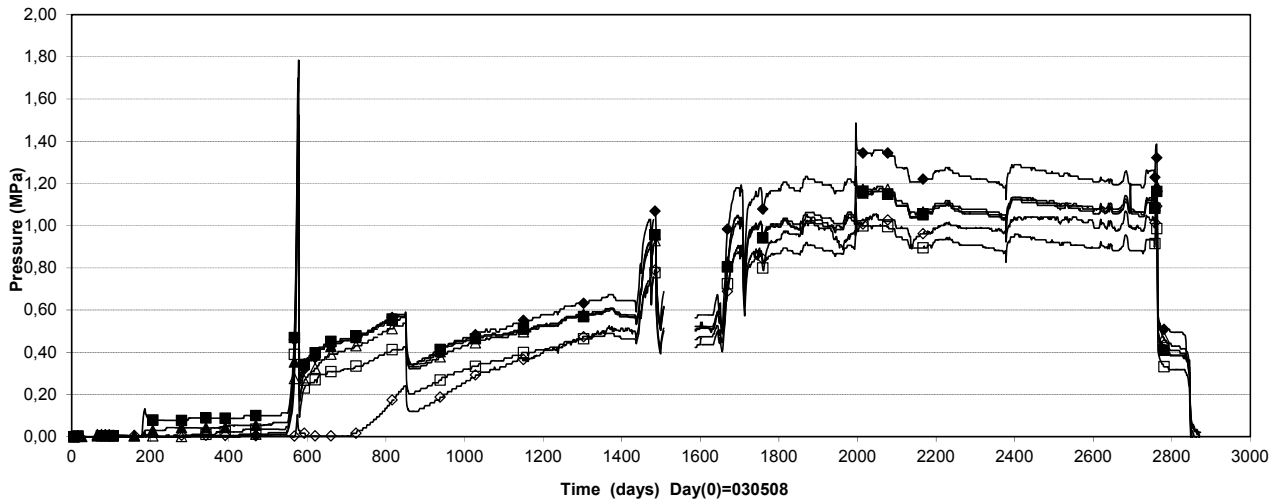
Prototype\Backfill \Section2 \ In front of plug (20030508-20110405)
Suction - Wescor



Prototype\Backfill \Over hole 5 (20030508-20110405)
Pore pressure - Geokon

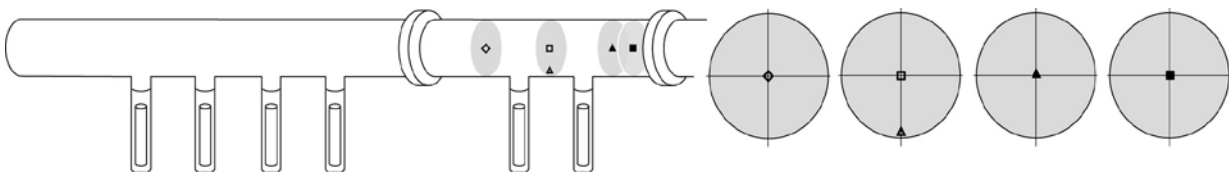
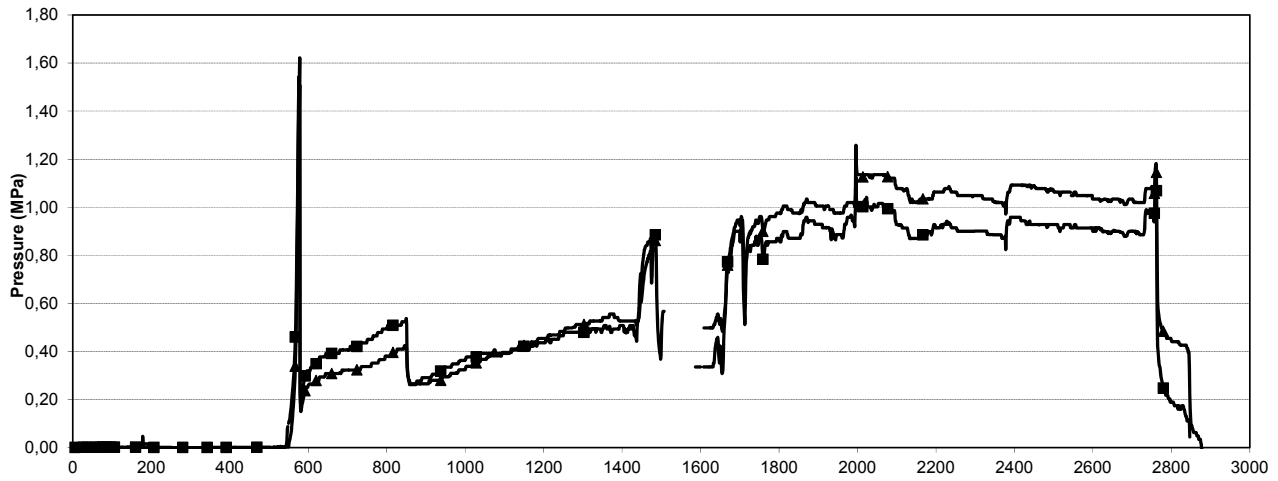


Prototype \Backfill \ Over hole 6 (20030508-20110405)
Pore pressure - Geokon



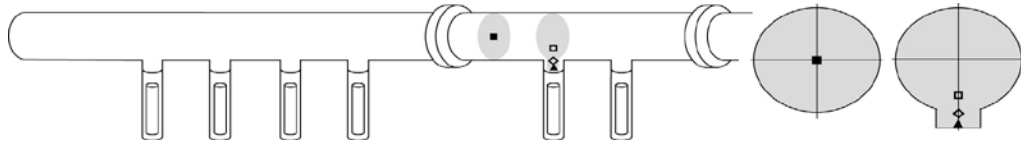
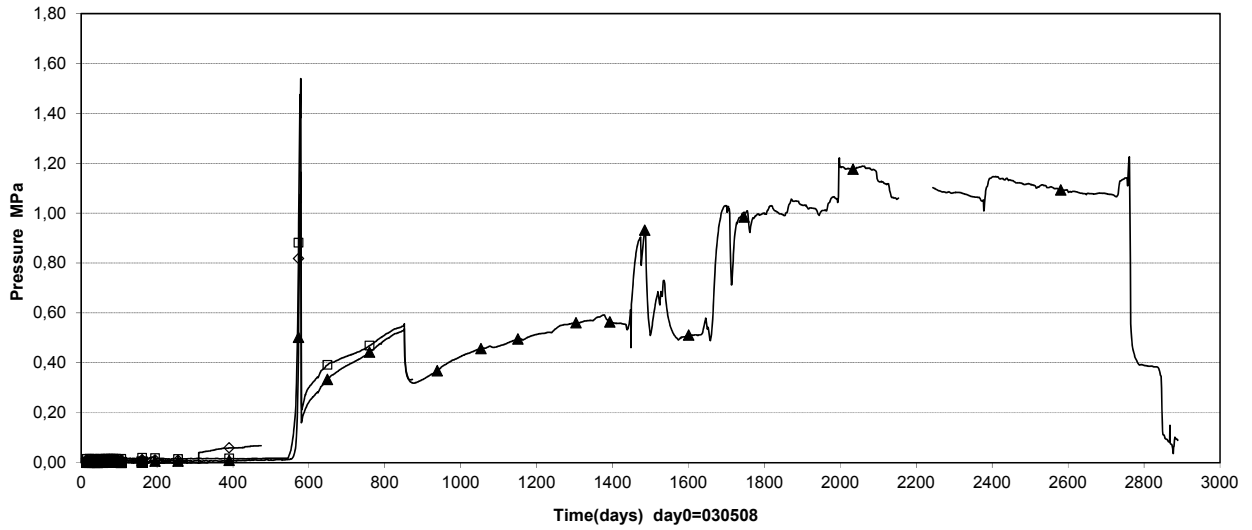
- ◇ UFA11 (E6\0\0\3545)
- ▲ UFA14 (E6\0\3.15\3545)
- △ UFA12 (E6\0\1.75\3545)
- ◆ UFA15 (E6\2.3\0\3545)
- UFA13 (E6\0\2.6\3545)
- UFA16 (E6\0\2.3\3545)

Prototype\Backfill \ Section2 (20101120-20110405)
Pore pressure - Geokon



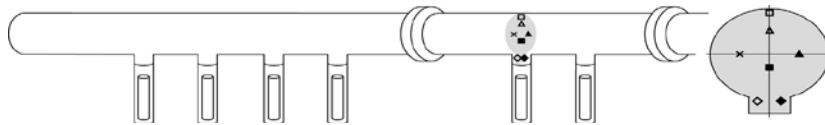
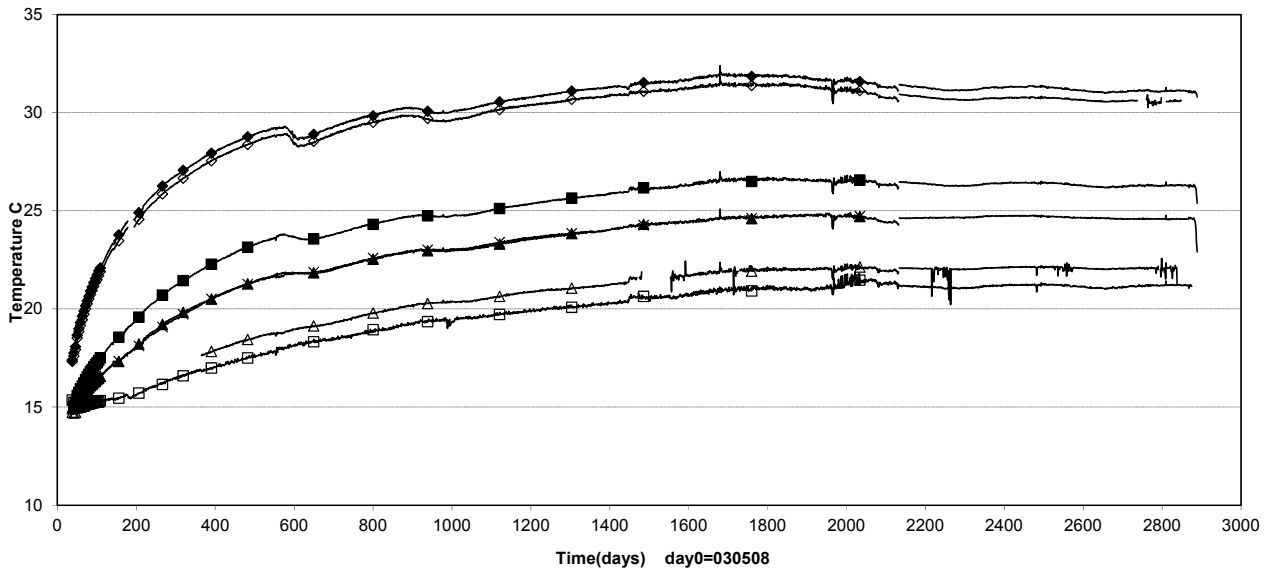
- ▲ UFA17(E5\2.3\0\3551)
- UFA18 (In front of plug\0\0\3539)

Prototype\ Backfill \ Section 2 (20030508-20110405)
 Pore pressure - Kulite



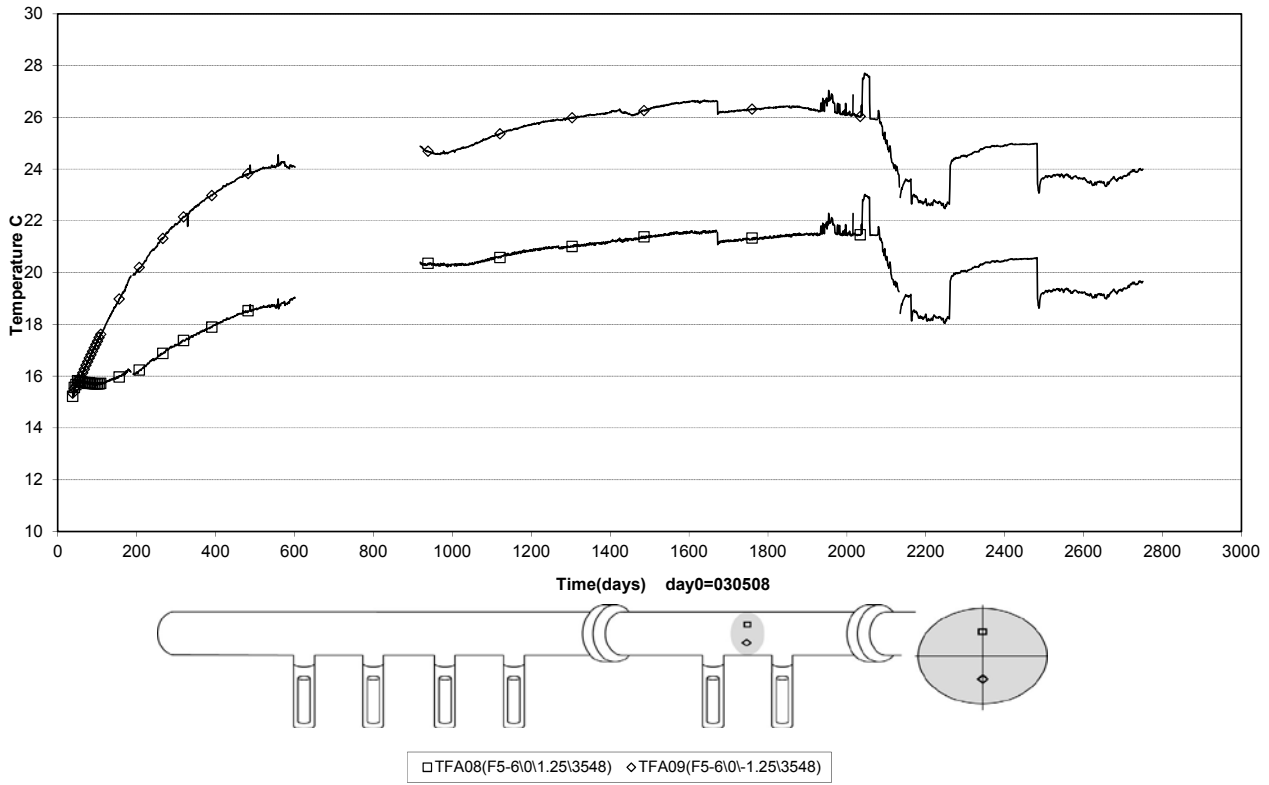
■ UFA01(Inner part\0\3556) □ UFA04(E5\0-1.75\3551) ◇ UFA05(E5\0-2.6\3551) ▲ UFA06(E5\0-3.15\3551)

Prototype\ Backfill \ Above dep.hole5 (20030508-20110405)
 Temperature - Pentronic

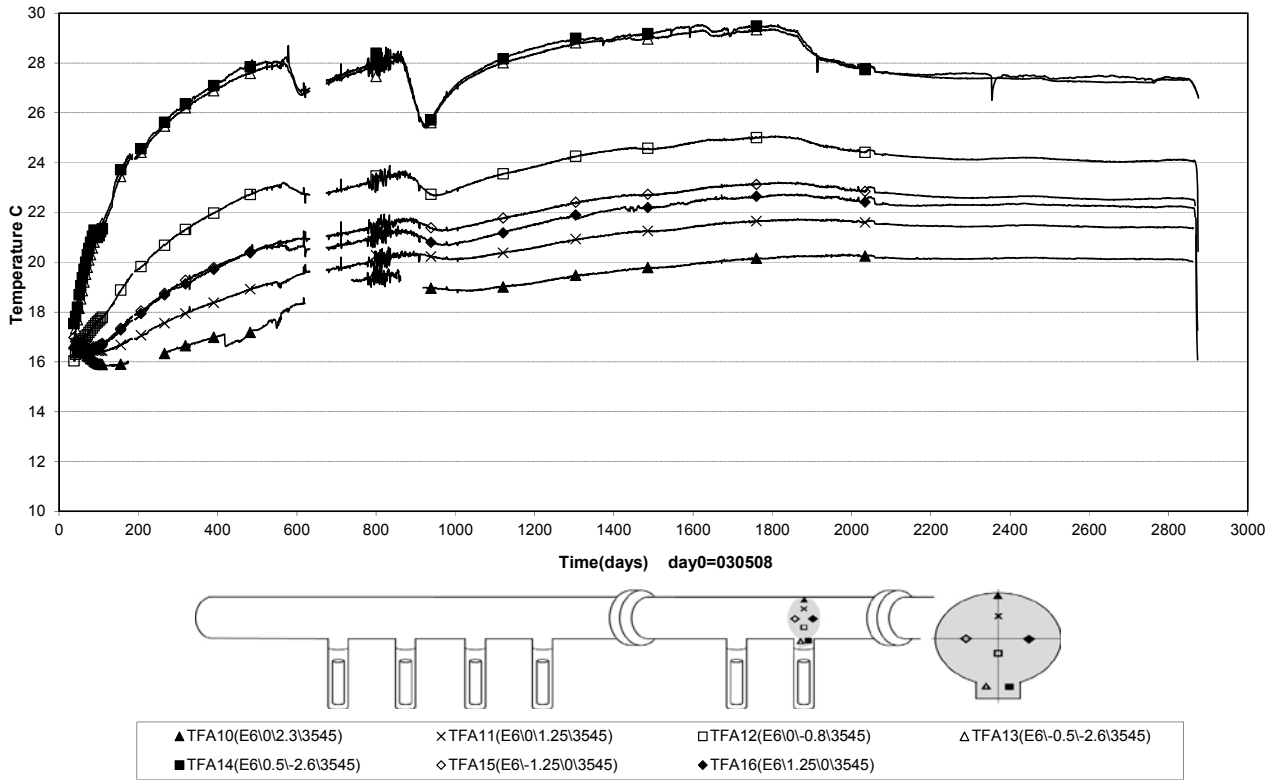


□ TFA01(E5\0\2.3\3551) △ TFA02(E5\0\1.25\3551) ■ TFA03(E5\0-0.8\3551) ◇ TFA04(E5\0-0.5\2.6\3551)
 ◆ TFA05(E5\0.5\2.6\3551) × TFA06(E5\1.25\0\3551) ▲ TFA07(E5\1.25\0\3551)

Prototype\ Backfill \ Between dep.hole 5-6 (20030508-20110405)
Temperature - Pentronic



Prototype\ Backfill \ Above dep.hole6 (20030508-20110405)
Temperature - Pentronic



Canister displacement tracking

A8.1 Layout

Section 2 of the experiment was dismantled in February 2011, including the removal and decommissioning of sensors MCA60001 to MCA60006 in deposition hole 6. Therefore, those sensors are not considered any more in the data reports.

The measurement of displacements is carried out in Section 1 on the canister in deposition hole 3. Sensors are grouped into one measuring section at the bottom of the canister, as shown in Figure A8-1.

Three sensors, named MCA30001 to MCA30003, have been placed in vertical position into holes drilled into the bottom bentonite block. These three sensors determine the vertical displacement of the canister, as well as any possible tilt. The points where the sensors are attached to the canister are the same as for the horizontal sensors.

The other three displacement sensors, named MCA30004 to MCA30006, are placed horizontally at the top of the lower bentonite block, close to the lower lid of the canister and attached to it, in a 120° radial disposition. Thus, the sensors will be always in a horizontal position, so that the horizontal displacement of the canister can be measured. The sensors have been placed so as to avoid interfering with other sensors installed in the block. Figure A8-2 illustrates the position of the six sensors.

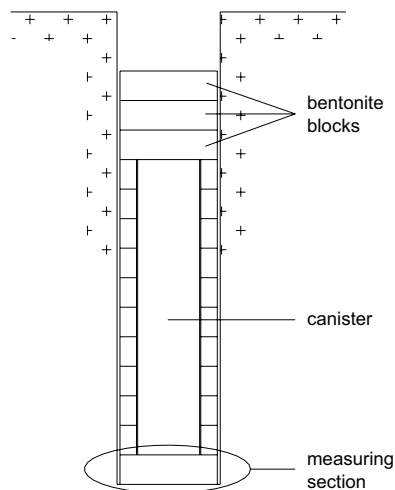


Figure A8-1. Location of measuring section for deposition hole 3.

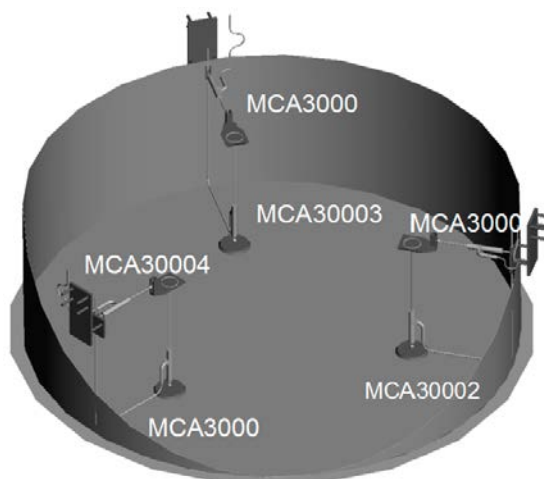


Figure A8-2. General view of sensors in deposition hole 3.

A8.2 General comments

This is the seventeenth “Prototype Repository in Operation” report issued for SKB, and the second annual one, and contains data up to 130101 (day 4,124 for dep. hole 3).

Monitoring is carried out since 010623 in deposition hole 3, and day 0 corresponds to 010917. Negative values correspond to a retraction of the transducer, which means vertical sinking or horizontal approaching to the rock surface, depending on the transducer position.

During the installation, it can be clearly noticed the moment when the protection plastic sheet was removed, right before the backfilling of the tunnel. At that point, the sensors started registering displacements due to the bentonite swelling.

The tunnel drainage was closed on 041101 (day 1,141) and re-opened on day 041206 (day 1,176). There was a power cut in all the canisters from 041202 (day 1,172) to 041215 (day 1,185).

The closure and subsequent re-opening of the tunnel drainage seemed to have a high influence. In comparison, the power cut had little effect in general in this hole.

A major problem was detected in the computer of the Data Acquisition System in September 2005. As a consequence, no data could be registered from 050925 (day 1,469) to 060207 (day 1,604), when the computer was checked “in situ” and put again in operation. On 060408 (day 1,664) the computer failed again, so no data was registered from that date until the problem was fixed on 060616 (day 1,733) by replacing the computer’s full hard drive. Other fails in the computer resulted in data loss from 070813 (day 2,156) to 070930 (day 2,204) and from 080425 (day 2,412) to 080513 (day 2,430).

The computer failed again in September 2008, so no data could be registered from 080930 (day 2,570) until 090225 (day 2,718), when the computer was replaced by a new one.

The data acquisition unit failed on 110225 (day 3,448). After some in situ checking to determine the problem, the unit came back to normal operation on 110419 (day 3,501).

The data acquisition unit failed again on 120108 (day 3,785). This time, in situ actions were not sufficient and unit had to be sent to reparation. The unit was installed back on 120917 (day 4,018).

One sensor out of the 6 installed in deposition hole 3 failed permanently on 020112 (day 117) during the monitoring phase until the end of this period: vertical sensor MCA30002.

The results obtained are described hereafter. Monitoring screens correspond to data of 130101 (day 4,124).

A8.3 Deposition hole 3

A8.3.1 Vertical sensors

Two vertical sensors are still in operation in this deposition hole. After an initial small rise of about 0.5 mm, the sensors showed a fast canister sinking that reached about 2 mm below the initial level, when, most likely due to the re-equilibration of pressures below and above the canister, the decrease ceased and the canister started to rise again.

From day 1,163 (041123), a fast sink of the canister could be noticed, in both vertical sensors at the same time. This could be due to the increase of pressure on top of the canister caused by the closure of the tunnel drainage, which was done 23 days before, on day 1,141 (041101). The canister sank 3 mm in two weeks, until day 1,176 (041206) when the drainage was opened again. On that point the canister experienced a fast rise, of one mm in one day.

Afterwards one of the vertical sensors (MCA30003) kept showing an elongation at a similar slow rate as before the events, while in the other vertical sensor still operative (MCA30001) the trend changed to a slight retraction. This could indicate that a small canister tilting had taken place, although the third value for defining the plane of the canister base is unavailable, and no clear signs of tilting were noticed in the corresponding horizontal sensors during that period.

The retraction trend of sensor MCA30001 stopped more than two years ago, being this sensor in a nearly constant value since. The elongation of sensor MCA30003 seemed to have stopped too, but in the last three years it can be noticed that the elongation continues in both sensors at a very slow rate, which again could indicate a very slight tilting, that cannot be confirmed without the third vertical sensor.

A8.3.2 Horizontal sensors

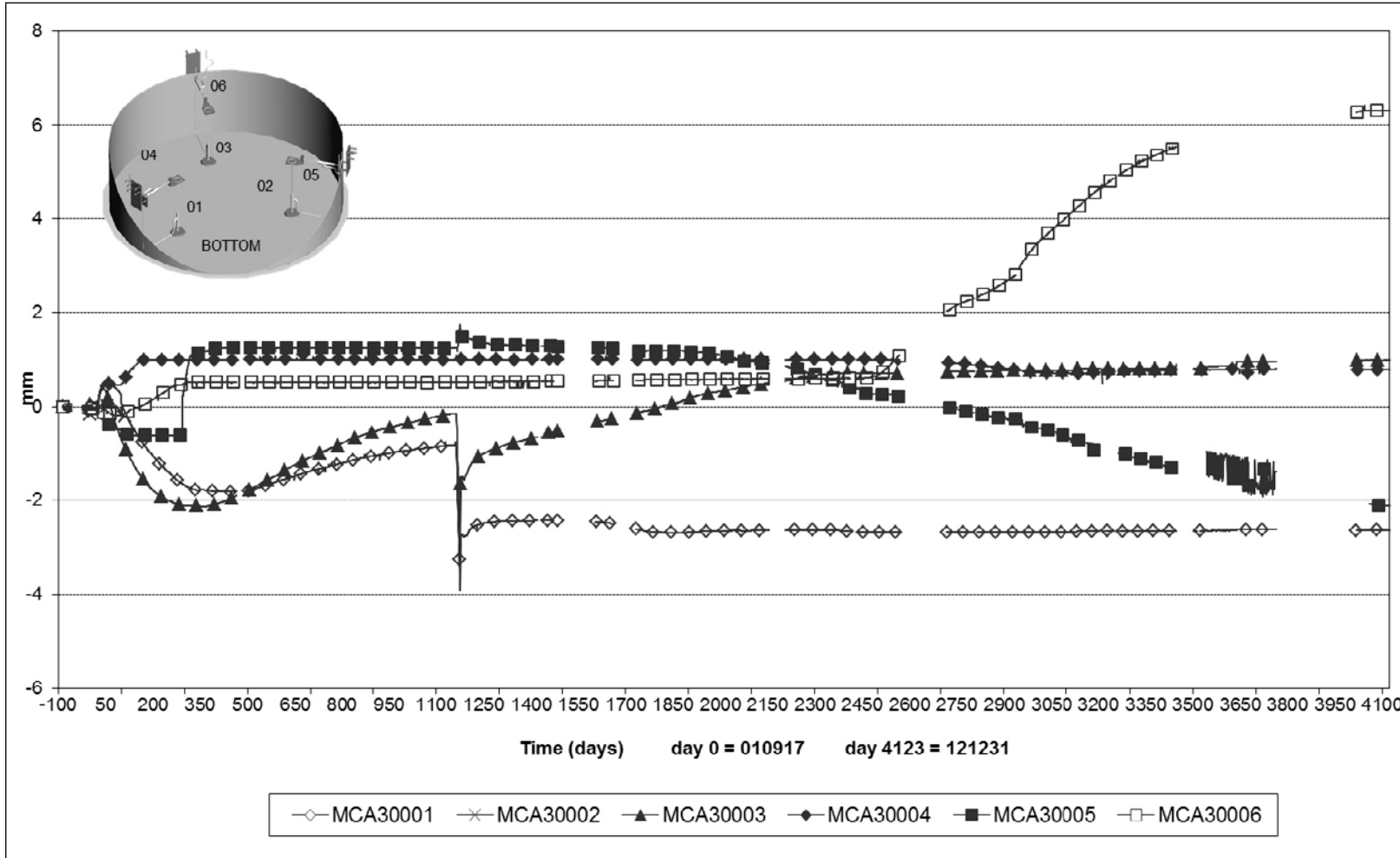
At the start of the monitoring phase, two of the horizontal sensors registered an initial small retraction, while the third one registered a similar elongation, all in the order of half of millimetre. This could indicate a horizontal displacement of the canister. Afterwards, the two sensors showing retraction changed to elongations of about 0.5 mm and 1.5 mm. One of the changes was very fast. No changes were registered in the third sensor, so it is not clear that this is due to a horizontal displacement of the canister. A possible explanation for this behaviour is that it is due to the vertical movement of the canister, although in principle the anchoring points of the horizontal sensors were conceived not to be affected by vertical displacements of the canister.

No changes were registered afterwards until 041127 (day 1,167 for dep. hole 3), when one of the horizontal sensors showed a fast elongation, followed by a retraction. This behaviour could reflect again the vertical displacement of the canister detected in the same dates, given that the shape of the plot matched exactly the vertical movement and that the other two horizontal sensors showed no displacement.

The retraction trend maintained during the last four years by sensor MCA30005 is very clear during the last three years, although values are fluctuating lately so its reliability might be compromised. MCA30004 seems to have now a stable pattern, and MCA30006 was lost after the DMI incident in February. In former periods, correlating the three sensors' trends, there seemed to be a slow horizontal displacement of the canister towards a point located between sensors MCA30004 and MCA30005, and quite closer to the latter, given its higher retraction rate. As MCA30006 kept rising significantly before its end, the same explanation could be drawn. As pointed out in the previous section, this displacement could be combined with a tiny tilting of the canister.

After the reparation of the unit on 2012, it seems that trends are maintained in general. Nonetheless, in particular for MCA30006, it seems that movements have reached a fairly stable behaviour so it seems the canister is decreasing or even stopping tilting. Given the few data available in this period, this should be further assessed in next reports.

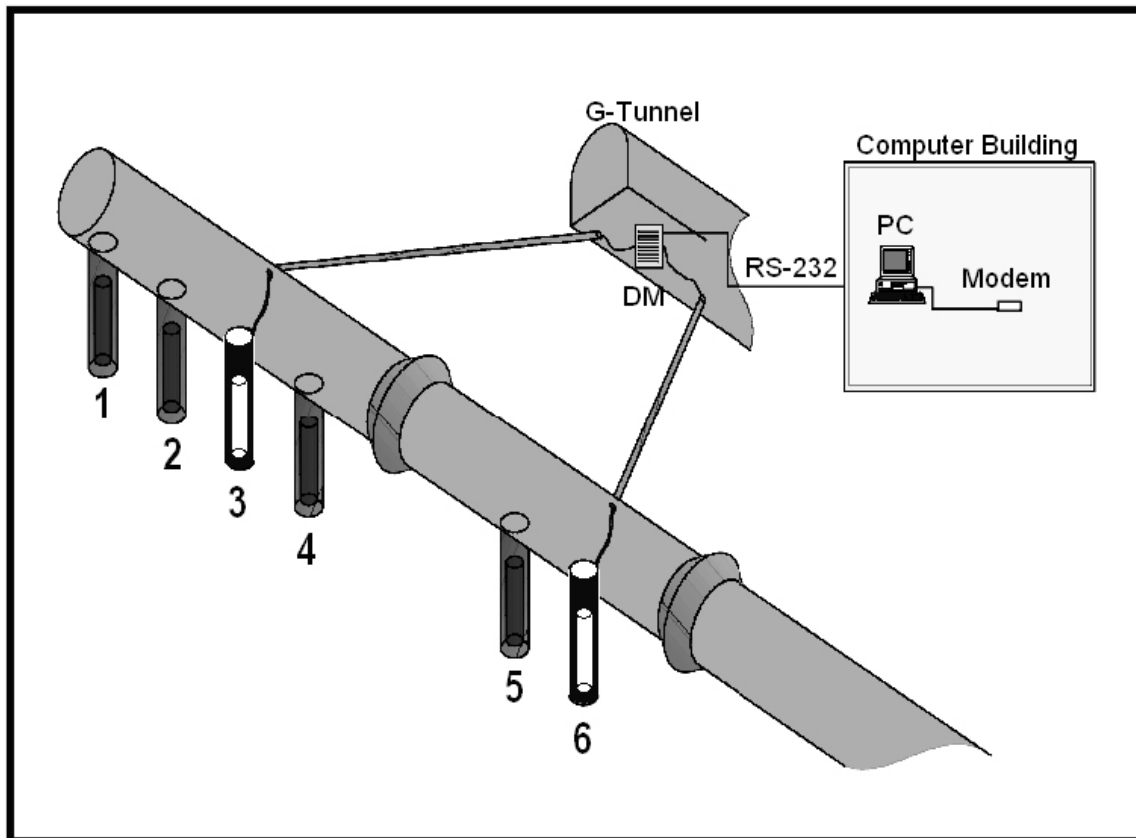
A8.4 Data plot deposition hole 3



A8.5 Monitoring screens



PROTOTYPE REPOSITORY



Signal Displacement

Rel. Displ.

Deposition Hole 3

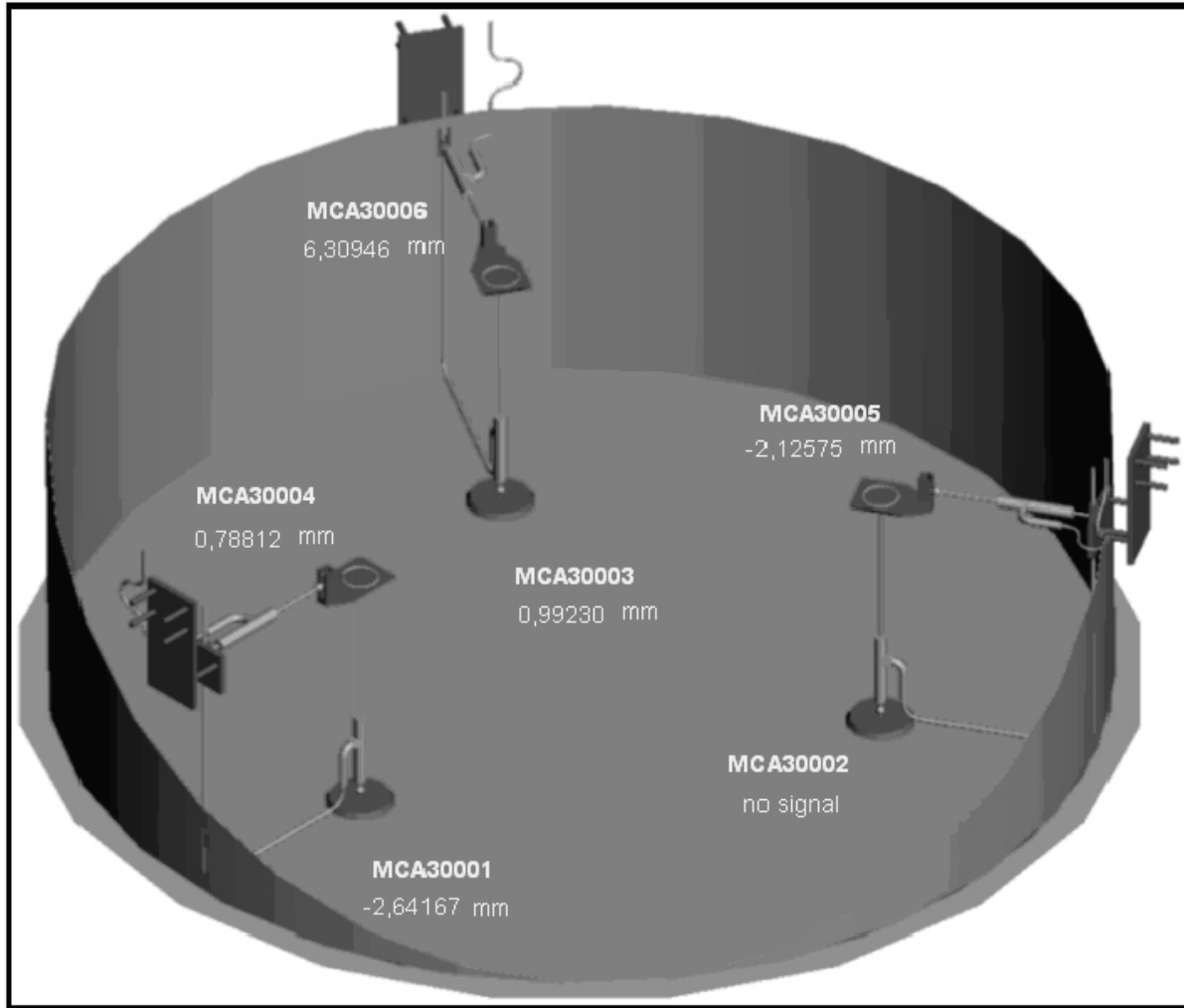
| | |
|----------|-------------|
| MCA30001 | -2,64167 mm |
| MCA30002 | no signal |
| MCA30003 | 0,99230 mm |
| MCA30004 | 0,78812 mm |
| MCA30005 | -2,12575 mm |
| MCA30006 | 6,30946 mm |

Deposition Hole 6

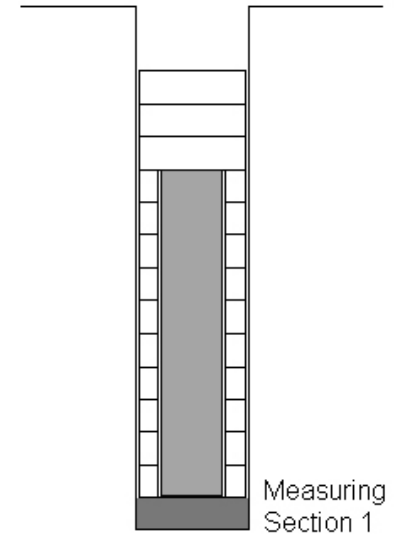
| | |
|----------|-----------|
| MCA60001 | no signal |
| MCA60002 | no signal |
| MCA60003 | no signal |
| MCA60004 | no signal |
| MCA60005 | no signal |
| MCA60006 | no signal |

14:49:57 31/12/2012

DEPOSITION HOLE 3



Signal Displacement
Rel. Displ.



BACK

14:49:57 31/12/2012

Geoelectric monitoring

Introduction

Within the frame of research activities in the prototype repository at Äspö GRS employs measurements of electrical resistivity to monitor water uptake in the drift backfill, the borehole buffer, and desaturation effects around one of the deposition boreholes.

The electrical resistivities in the buffer, the backfill, and around the boreholes are determined by use of multi-electrode arrays. The arrays consist of electrode chains. The resistivity distribution in the areas between the chains is determined by means of tomographic dipole-dipole measurements. The recording unit for these arrays is controlled remotely from Braunschweig / Germany via a telephone connection, which allows daily measurements of the in situ resistivity distribution. From the measured apparent resistivity values the “true” resistivity distributions in the different parts are computed applying the latest inversion software.

In the geoelectric measurements advantage is taken of the dependence of the electrical resistivity in materials on the water (solution) content. In order to interpret the resistivity values in terms of water content the data are to be compared with laboratory calibration results which are available for the different materials.

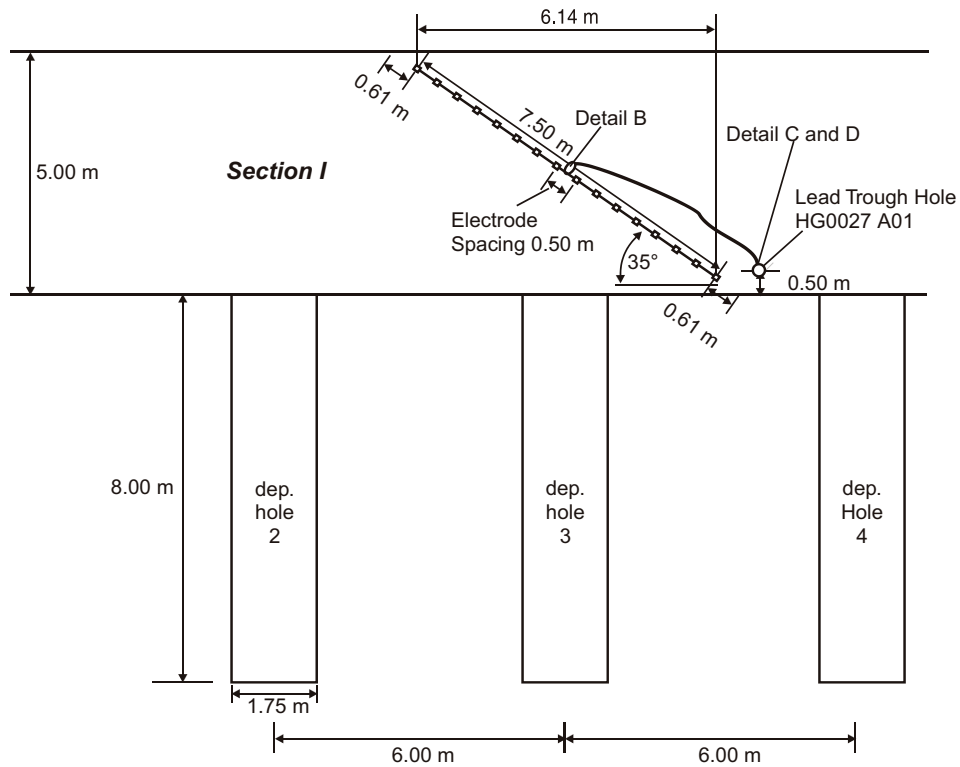
In the following, the calculated inversion data for the different arrays are provided in the form of tomograms. Additional data for smaller time periods can be made available on demand.

All geoelectric measurements in Section 2 of the Prototype Repository were stopped in the course of the dismantling of the Section in 2011. Since then, only the measurements in the backfill of Section 1 have been continued.

A9.1 Backfill Section 1

A9.1.1 Layout of electrode array in the backfill of Section 1

A) Vertical Cross section



B) Plan View

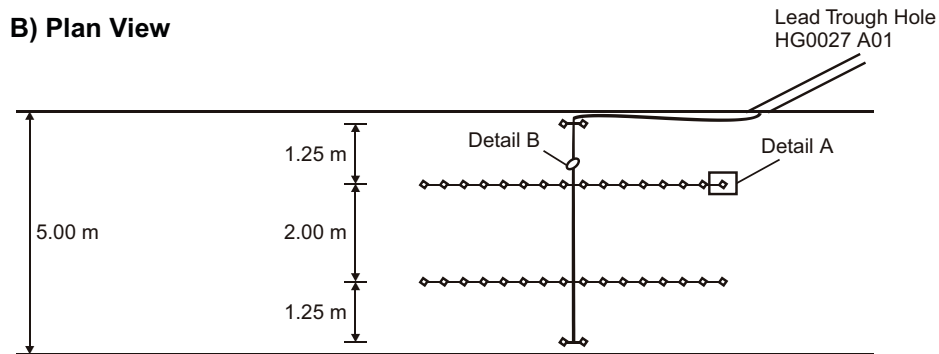
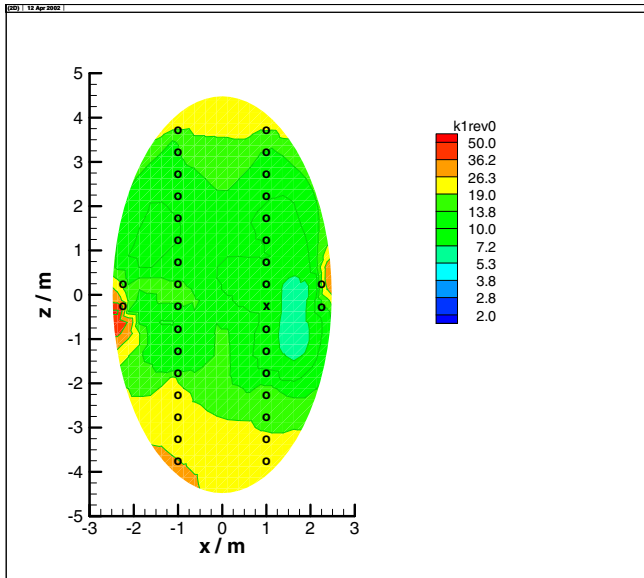
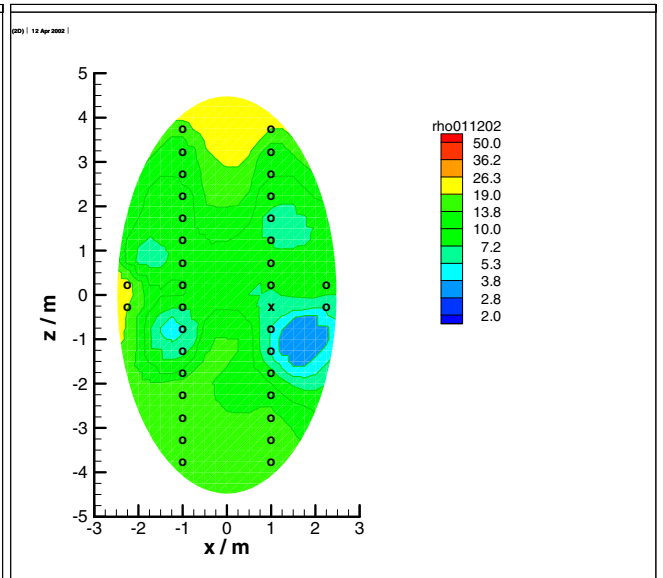


Figure A9-1. Electrode array in the backfill in Section 1.

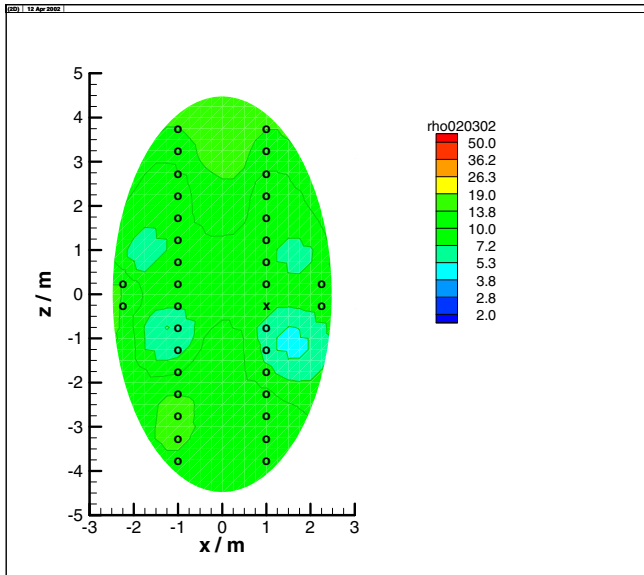
A9.1.2 Tomograms of the backfill array in Section 1



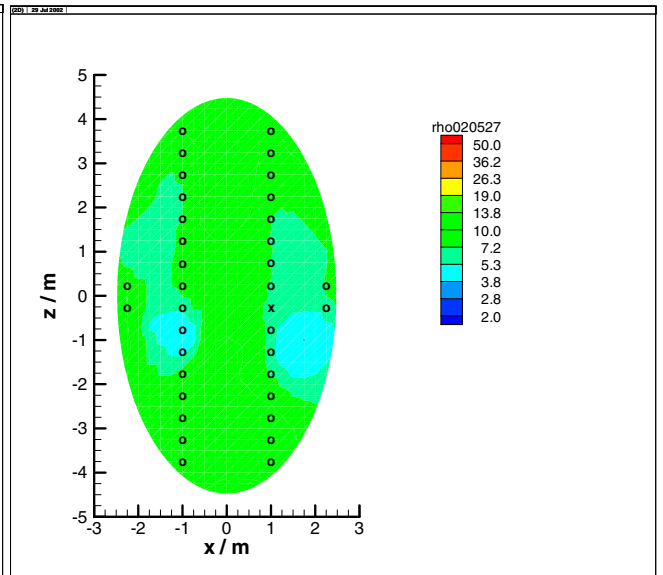
2001-10-27



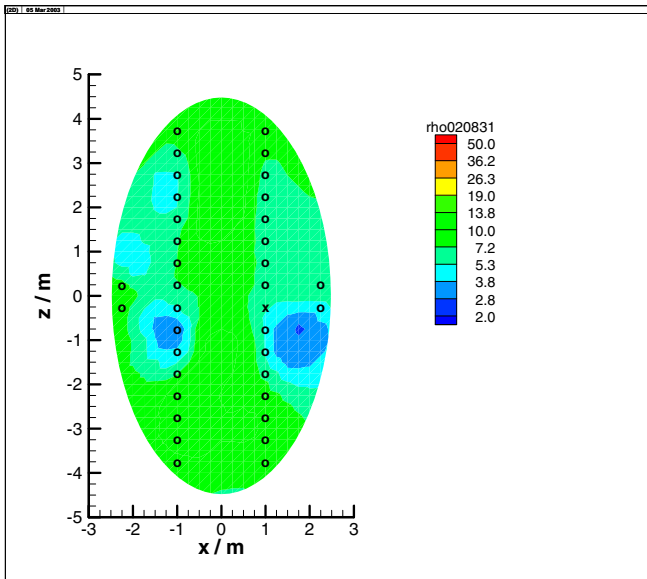
2001-12-02



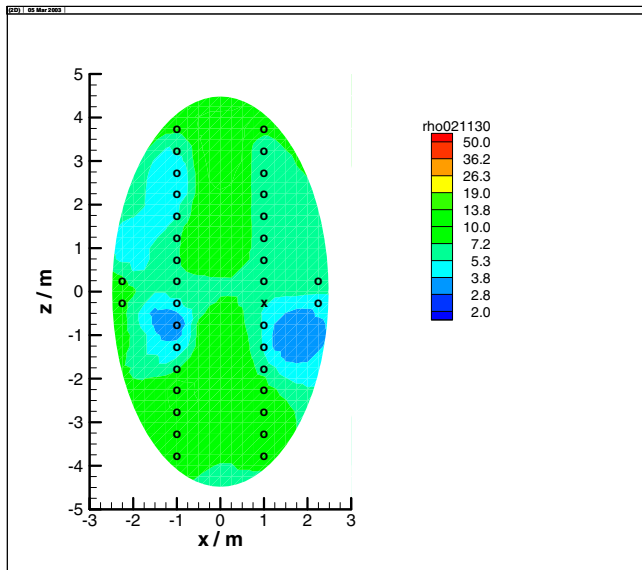
2002-03-02



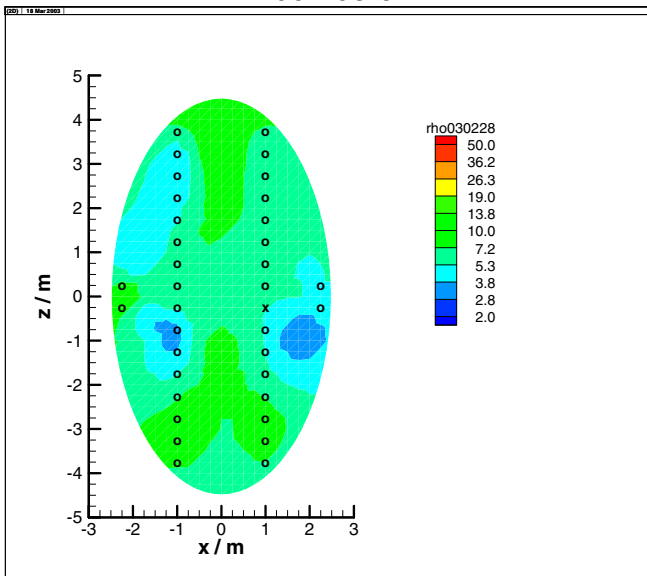
2002-05-27



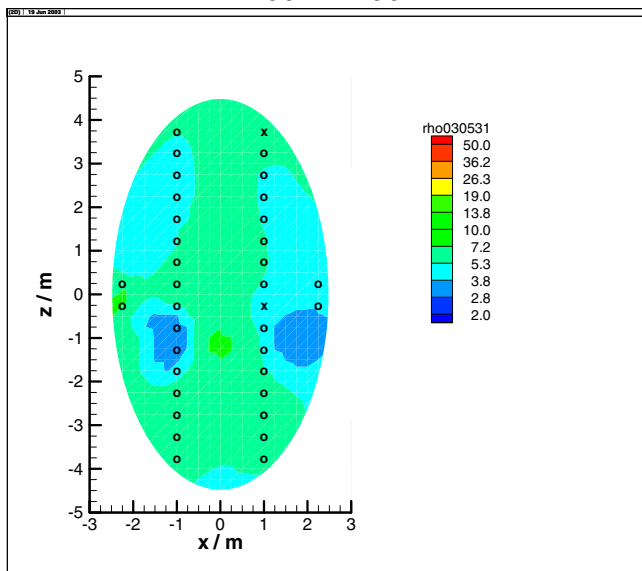
2002-08-31



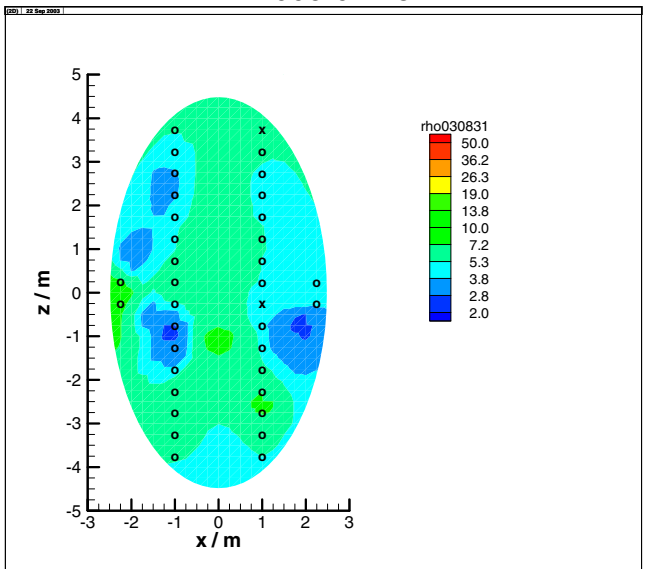
2002-11-30



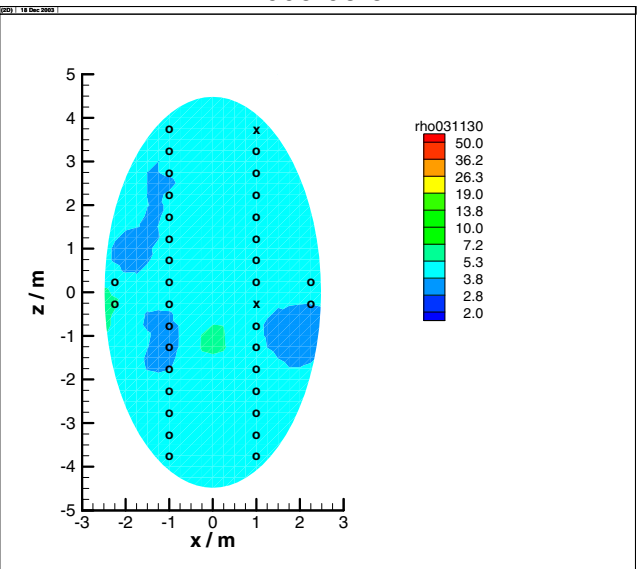
2003-02-28



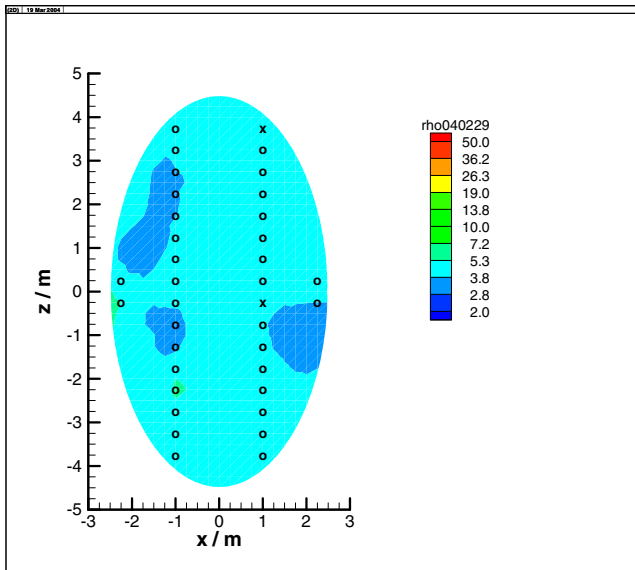
2003-05-31



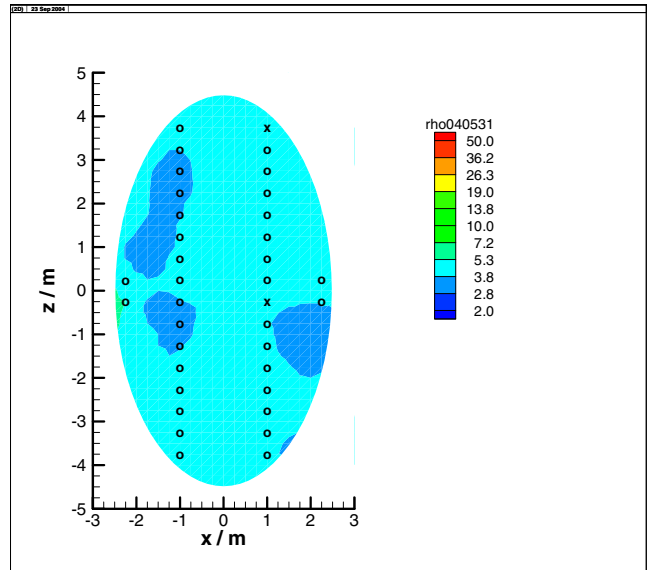
2003-08-31



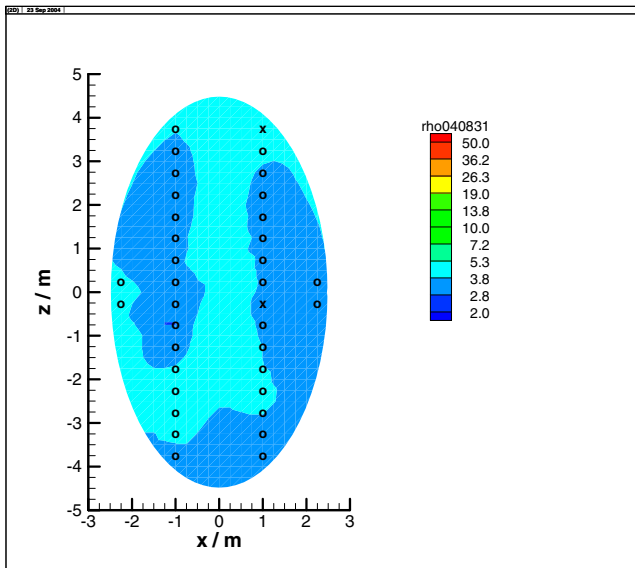
2003-11-30



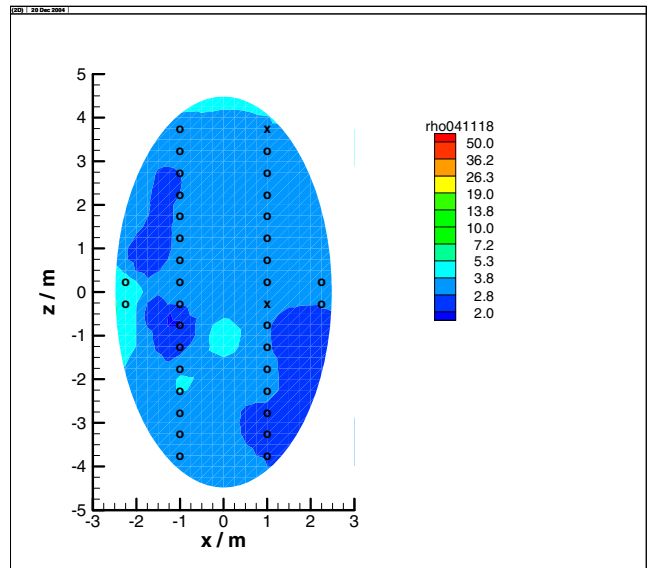
2004-02-29



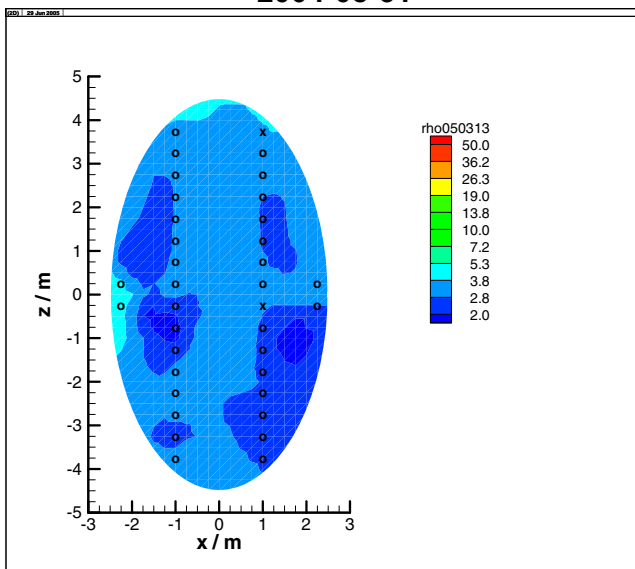
2004-05-31



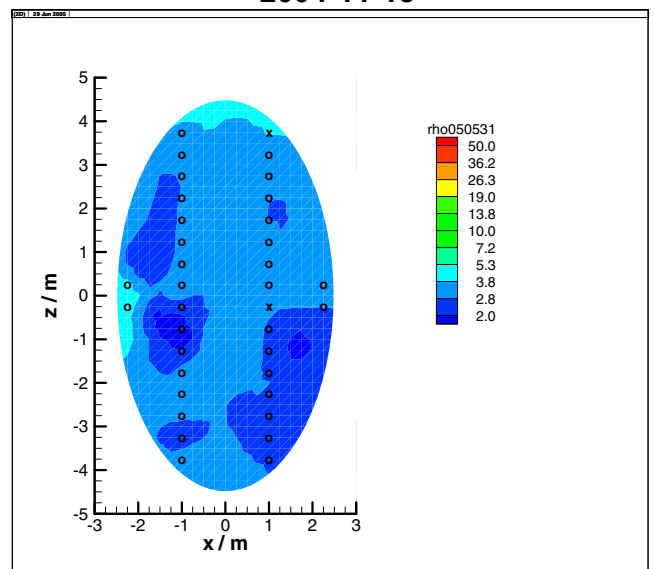
2004-08-31



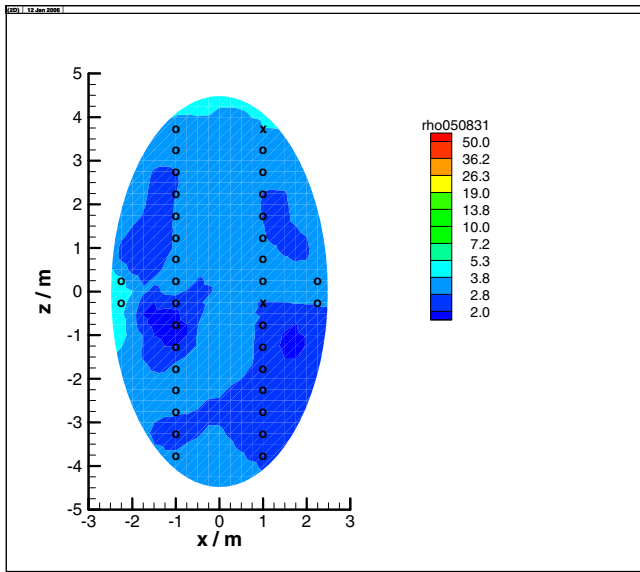
2004-11-18



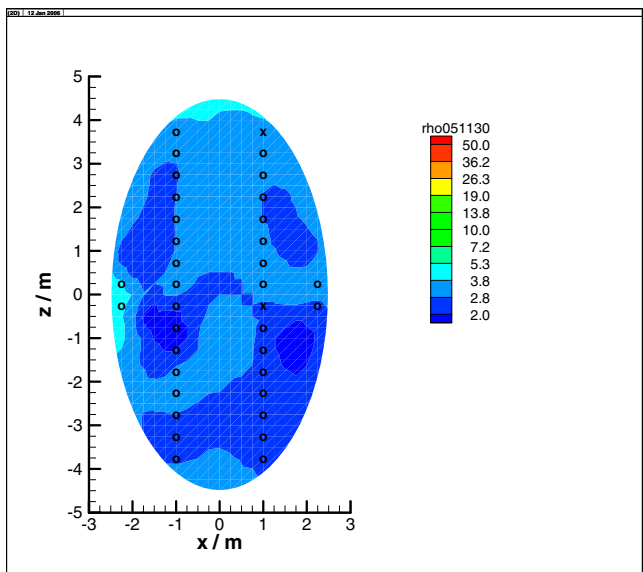
2005-03-13



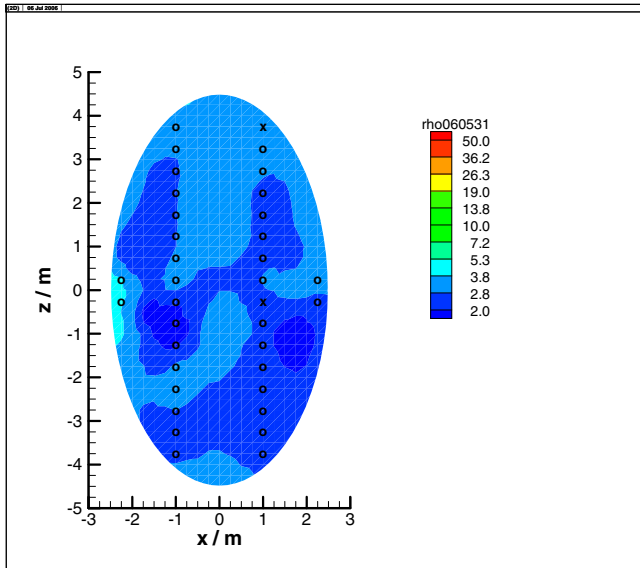
2005-05-31



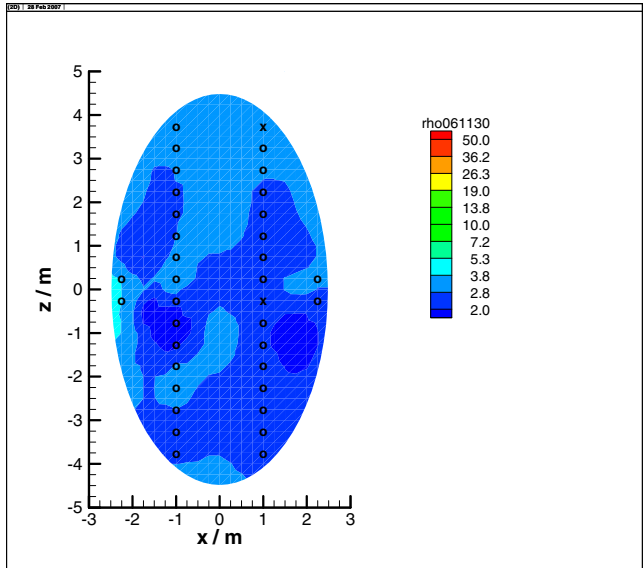
2005-08-31



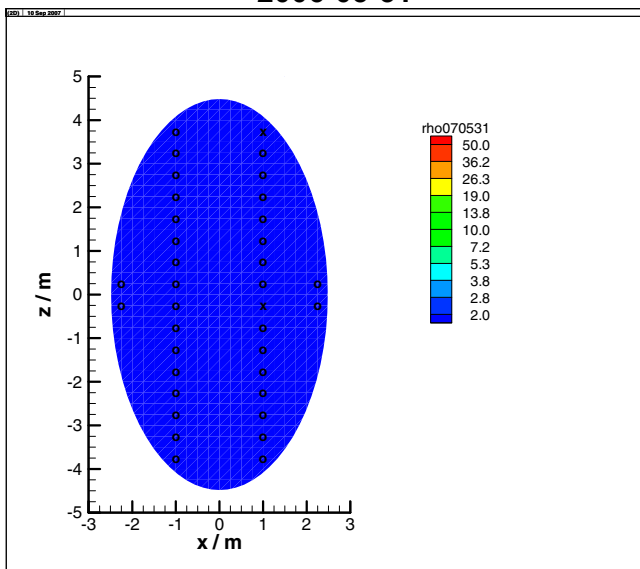
2005-11-30



2006-05-31



2006-11-30



2007-05-31

A9.1.3 Actual Interpretation

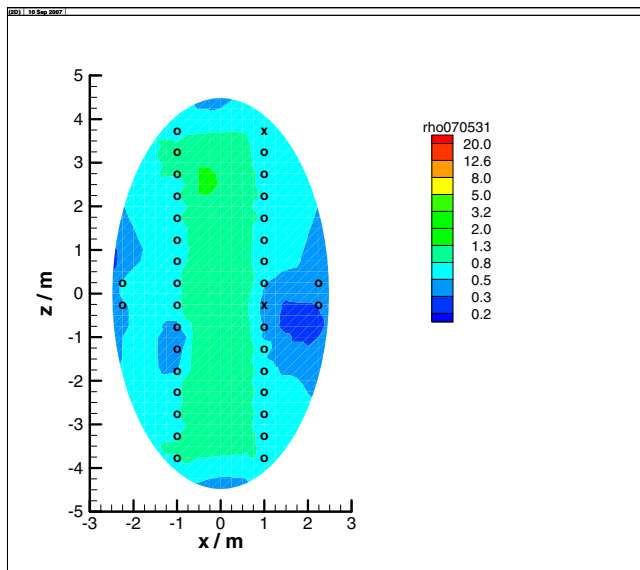
The initial resistivity value of the backfill in October 2001 is about 10 to 14 Ωm corresponding to a water content of 13 to 14%. In the following month the resistivity reduces to about 7 to 10 Ωm which corresponds to a water content of about 14 to 16%. However, this reduction in resistivity is most likely generated by the wet (light blue) areas close to the electrode chains. These wet areas are the consequence of moistened backfill used during installation of the electrodes for better covering of the electrode chains. From then on, the resistivity decreases continuously, starting near the drift walls and progressing into the drift centre. From November 2004 on, a very homogeneous resistivity distribution was reached; with a value around 3 Ωm corresponding to a water content of 21–22%.

Besides the overall trend, minor changes in the tomograms from month to month are visible near the edges of the gallery, especially a light blue area on the right side of the tomograms is more or less pronounced. These are no real anomalies, but are caused by the fact that inaccuracies in the measurements can lead to the accumulation of “ghost” anomalies in areas of lower sensitivity. The areas of lower sensitivity are typically the edges of the model. In case of the blue area on the right side of the tomograms, the sensitivity is more reduced because one of the electrodes (marked with an “x” in the tomograms) is not active, as its cable broke after installation during backfilling.

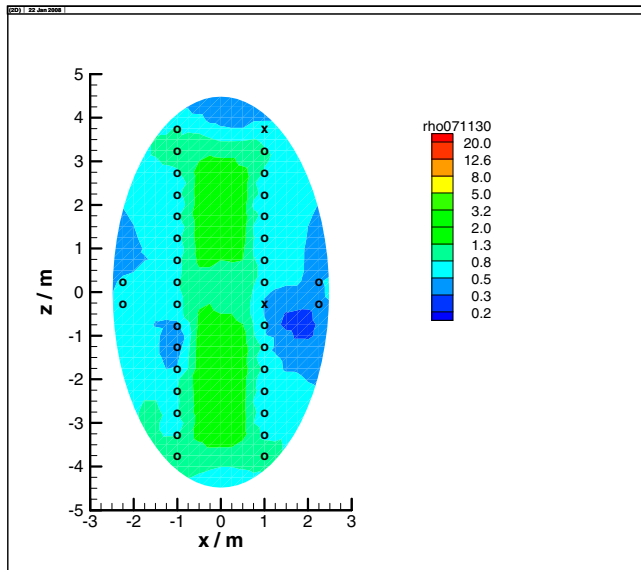
The resistivity is also slightly decreased by the temperature increase in the backfill. The temperature increase can result in a resistivity reduction by not more than 1 Ωm .

On May 2, 2003, the upper right electrode (also marked with an “x” in the tomogram from May 31, 2003) was lost. The reason is probably a cable failure. It is not clear whether this is already a corrosion effect.

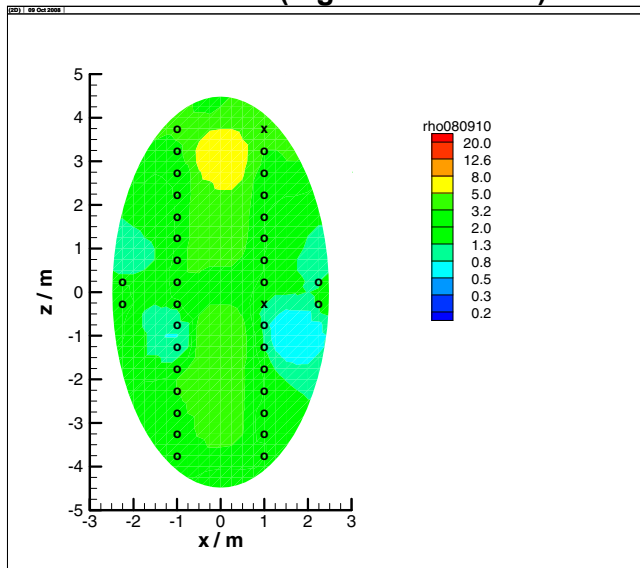
The tomogram of May 2007 shows that the resistivity was below 2.8 Ωm everywhere in the backfill then. To get more detailed information, the tomograms below show the resistivity distributions since May 2007 in a higher resolution. Resistivity was in fact below 2 Ωm in all of the backfill during 2007, with the values near the walls being slightly lower than in the center. From 2008, however, resistivity seems to have increased again. The respective tomograms show a slight increase in the entire cross section and a center of elevated resistivity above 5 Ωm near the tunnel roof. A possible reason for this may be the continuous pumping of water out of section I, which may have led to a slight desaturation or a settling of the backfill, which resulted in a degradation of the electrode coupling. What is interesting in this context is that in the last tomogram from 2013 the high resistivity near the roof is no longer observed, which may be a hint to resaturation of the near-roof part.



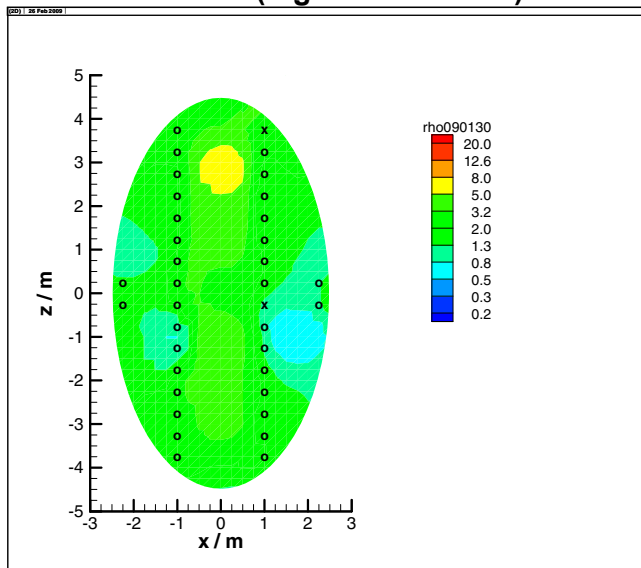
2007-05-31 (higher resolution)



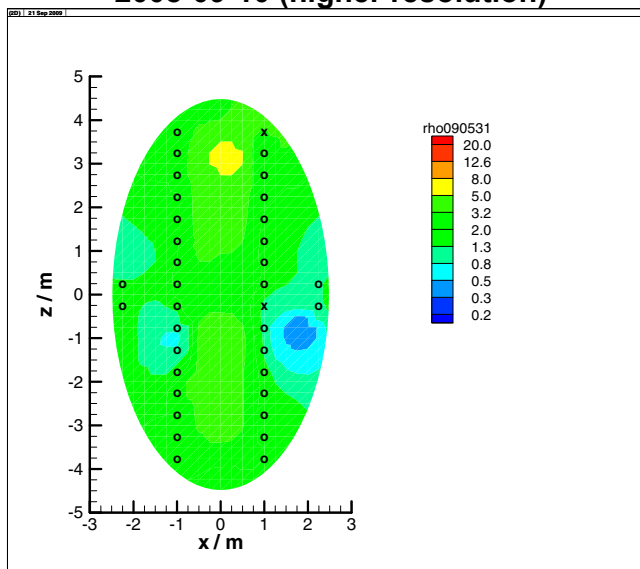
2007-11-30 (higher resolution)



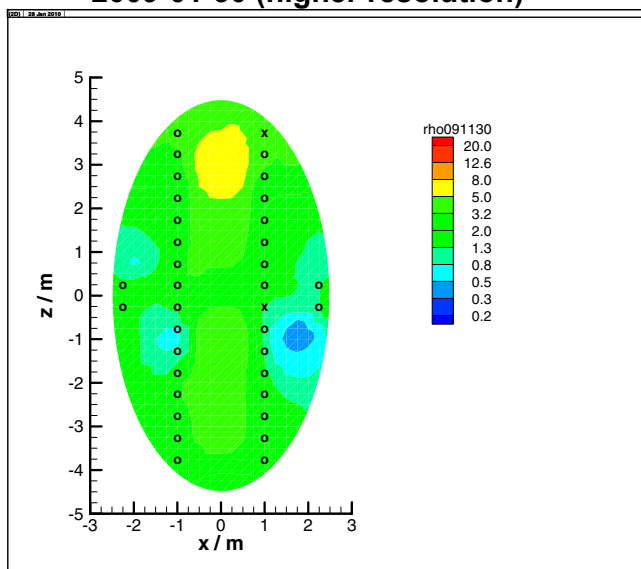
2008-09-10 (higher resolution)



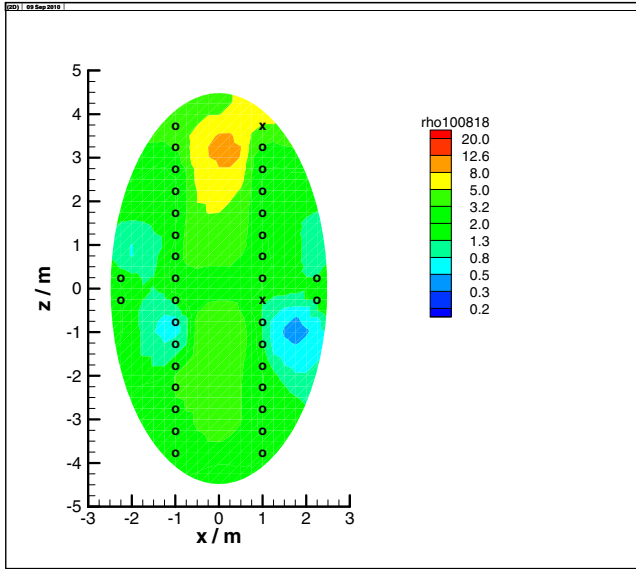
2009-01-30 (higher resolution)



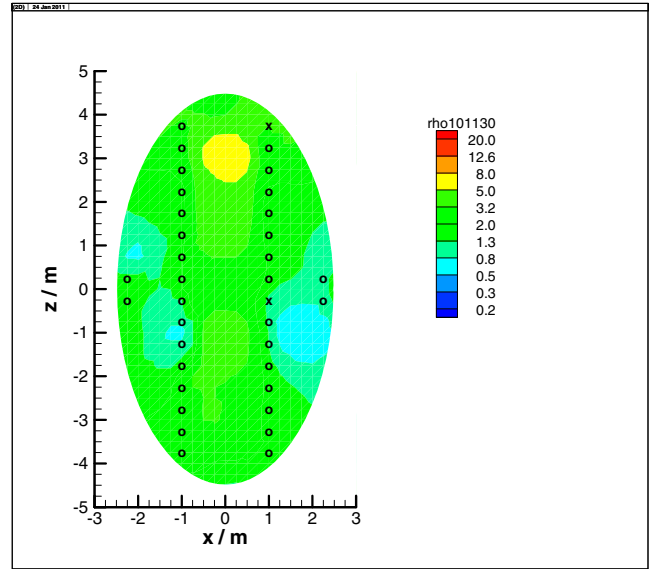
2009-05-31 (higher resolution)



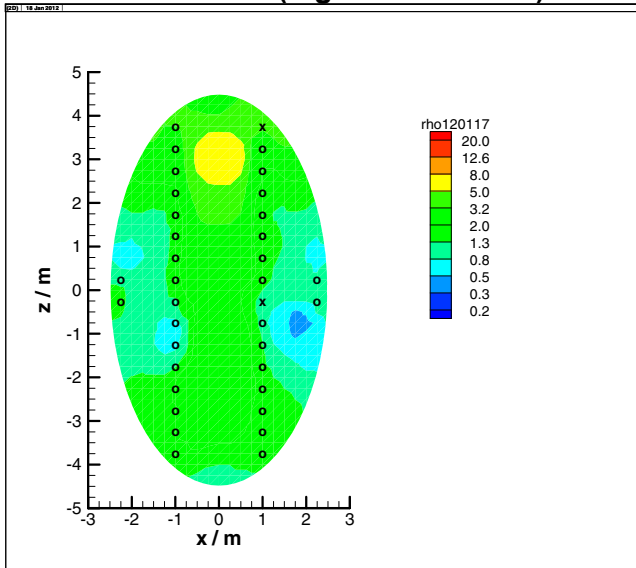
2009-11-30 (higher resolution)



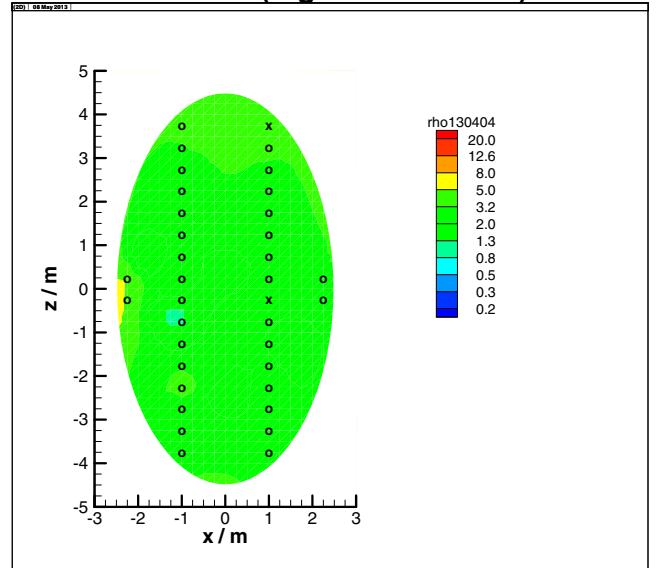
2010-08-18 (higher resolution)



2010-11-30 (higher resolution)



2012-01-17 (higher resolution)



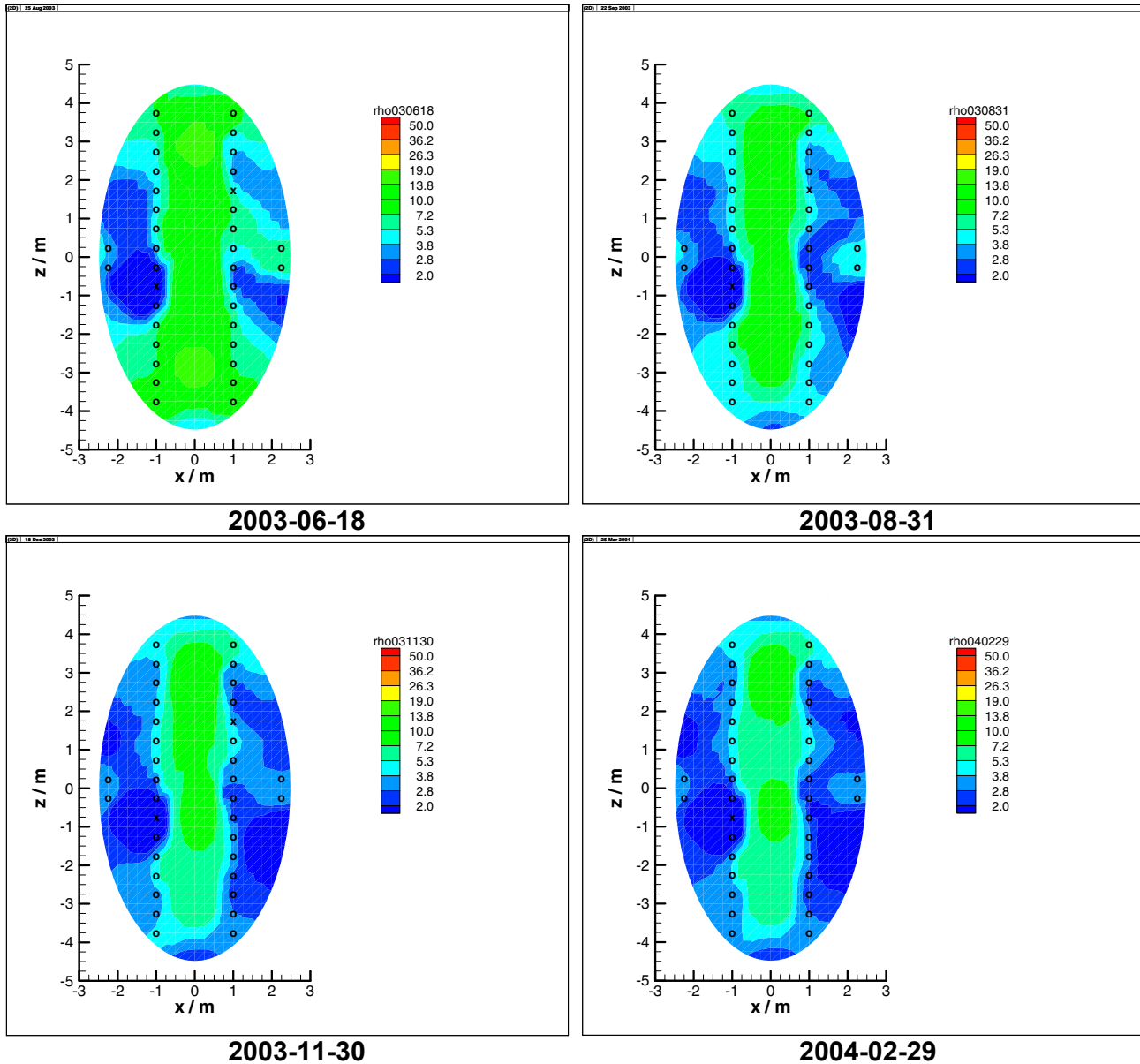
2013-04-04 (higher resolution)

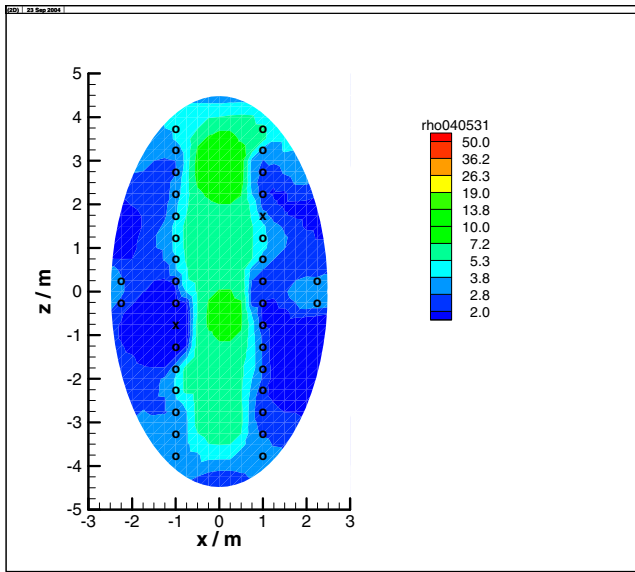
A9.2 Backfill Section 2

A9.2.1 Layout of electrode array in the backfill of Section 2

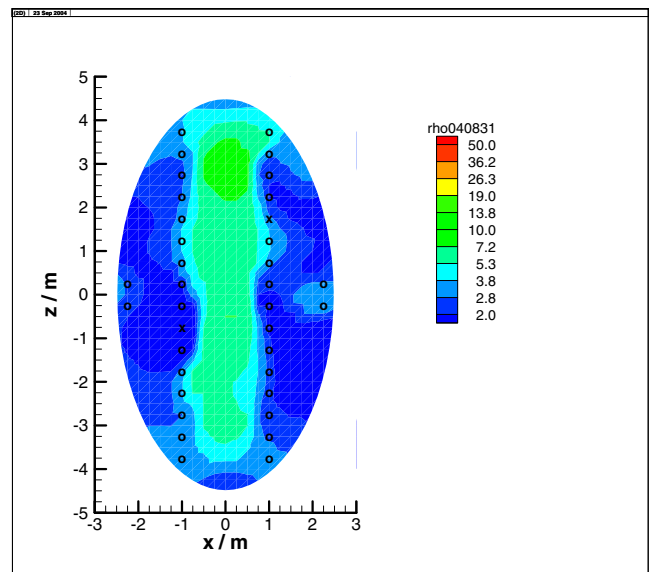
The array layout in the backfill of Section 2 is identical to that located in Section 1, except for the fact that the array has been placed above deposition borehole #6 instead of #3.

A9.2.2 Tomograms of the backfill array in Section 2

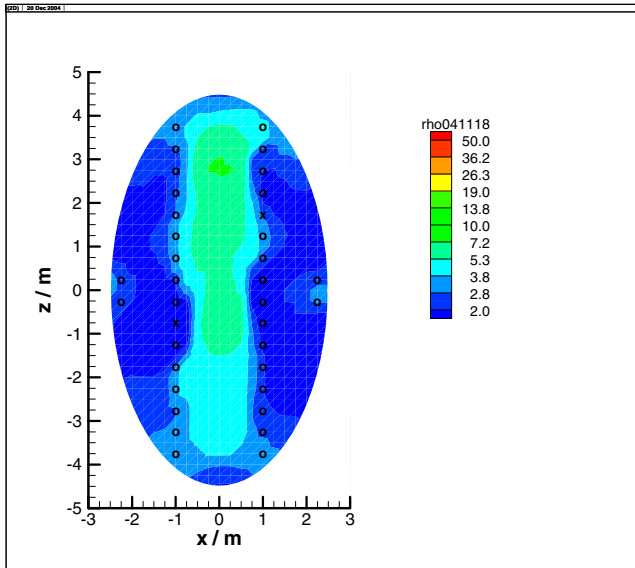




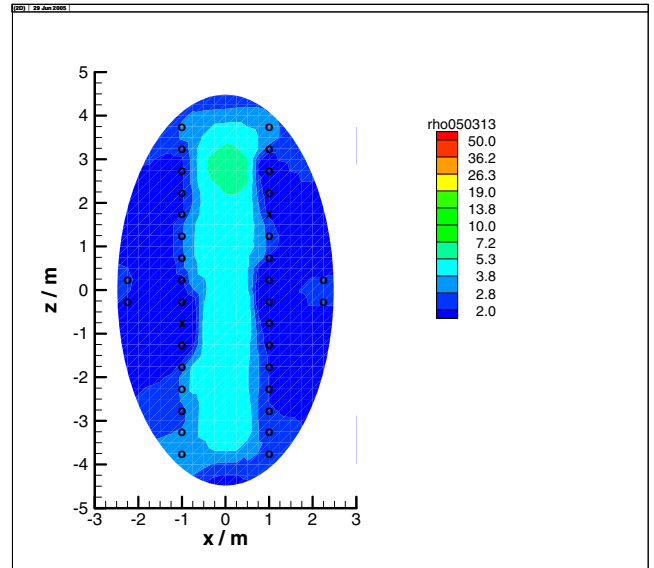
2004-05-31



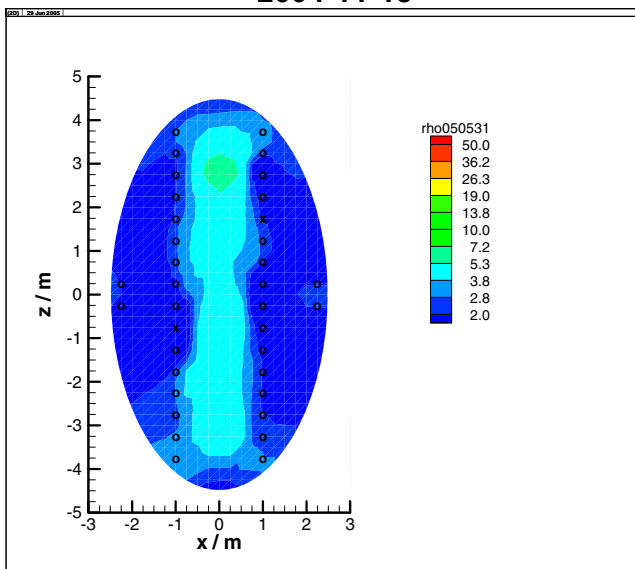
2004-08-31



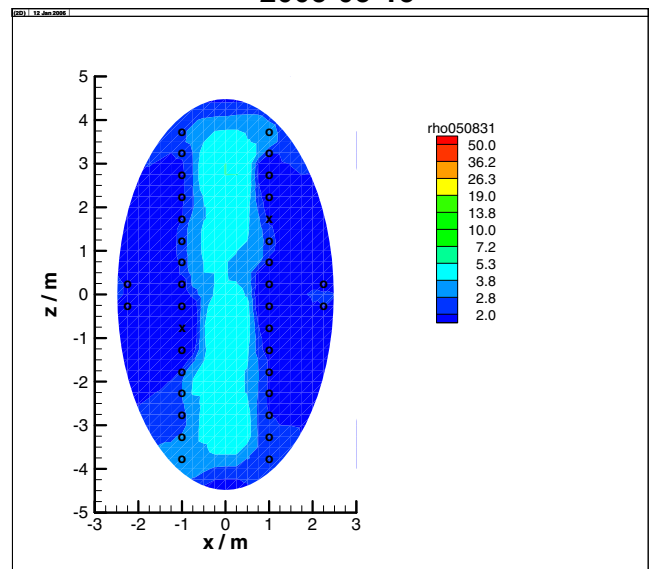
2004-11-18



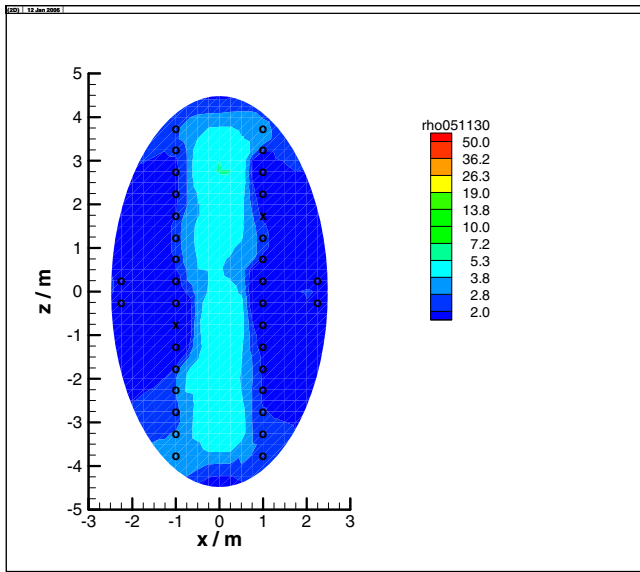
2005-03-13



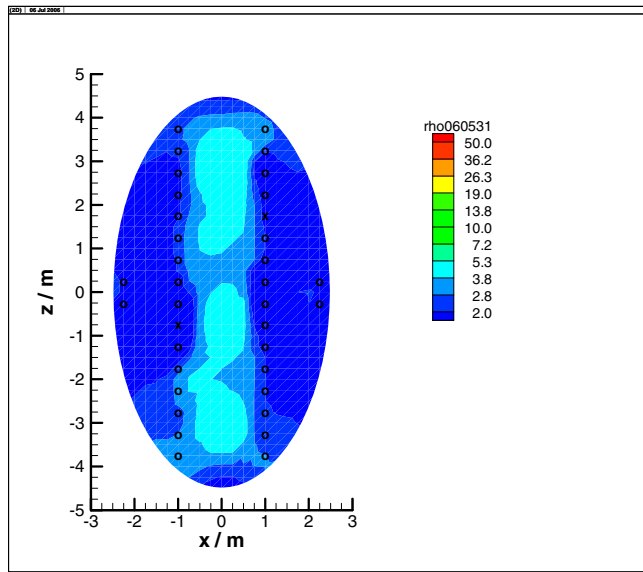
2005-05-31



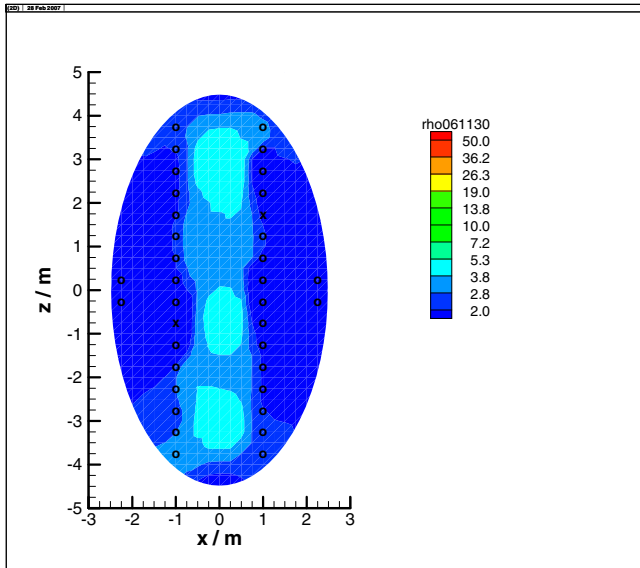
2005-08-13



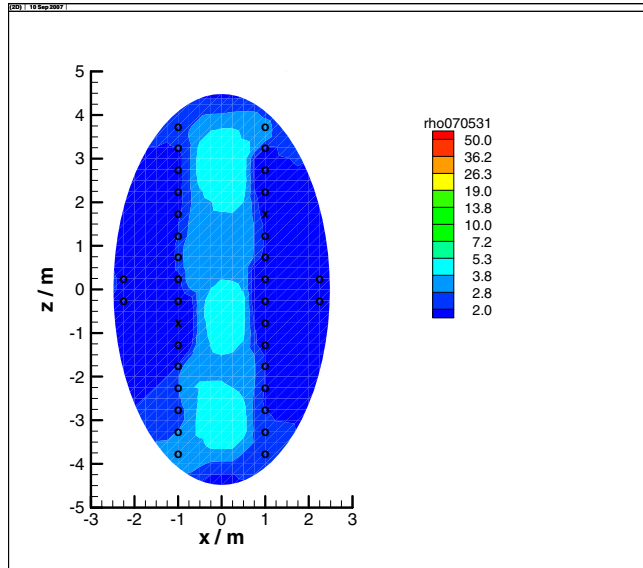
2005-11-30



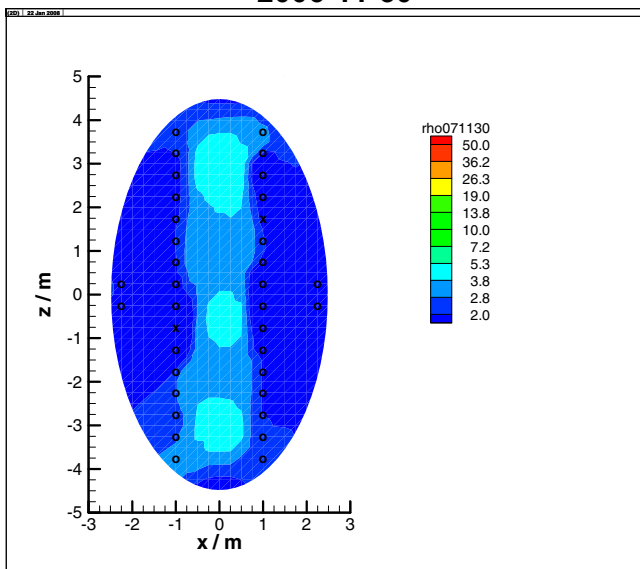
2006-05-31



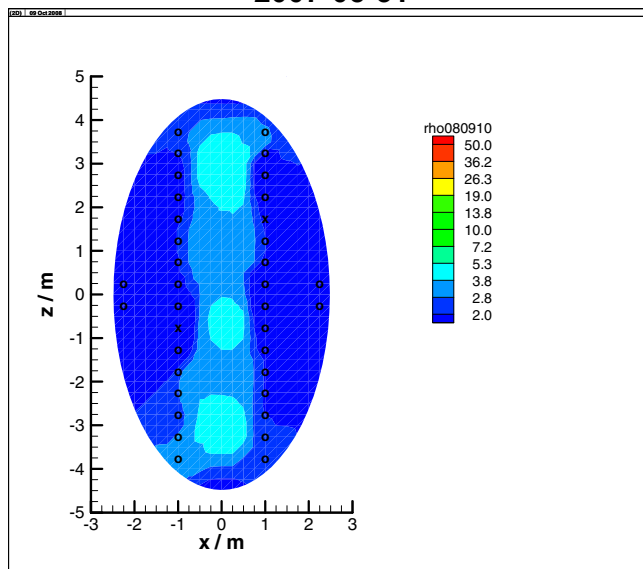
2006-11-30



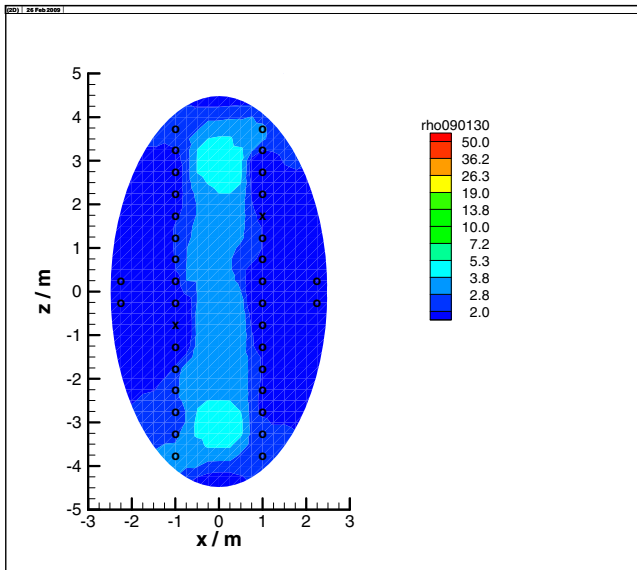
2007-05-31



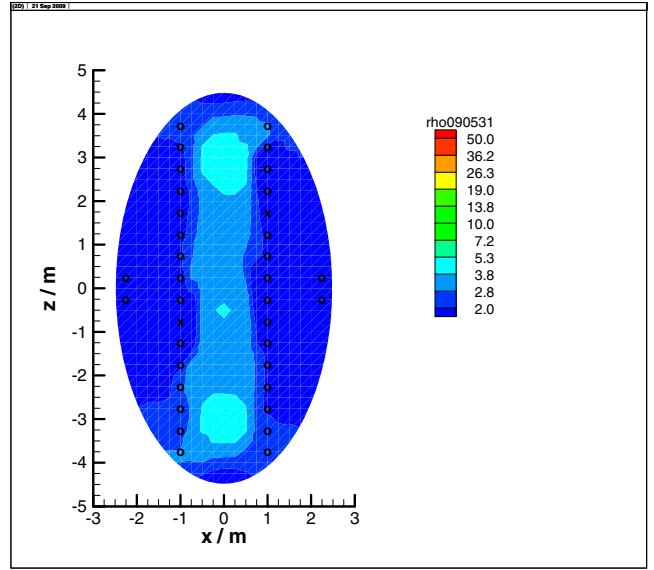
2007-11-30



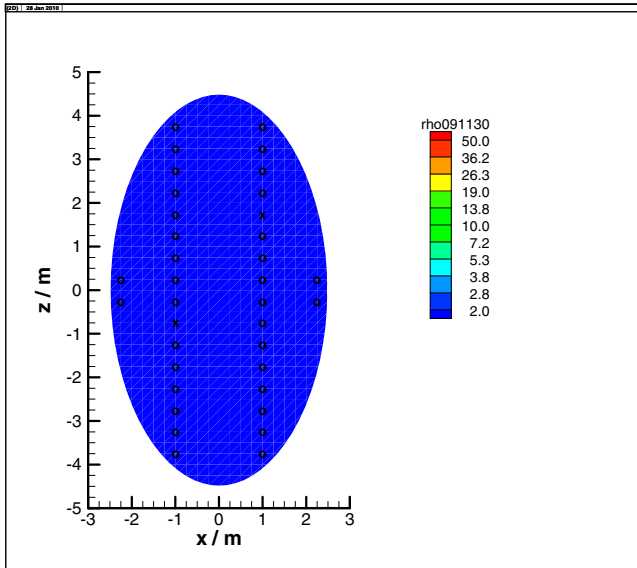
2008-09-10



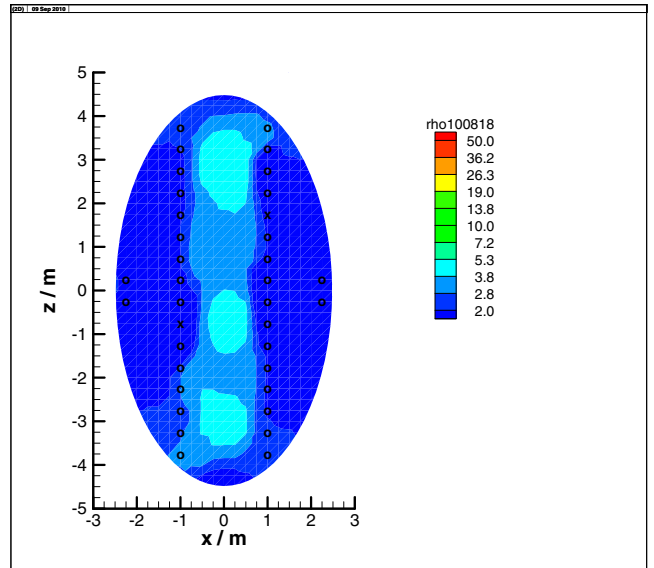
2009-01-30



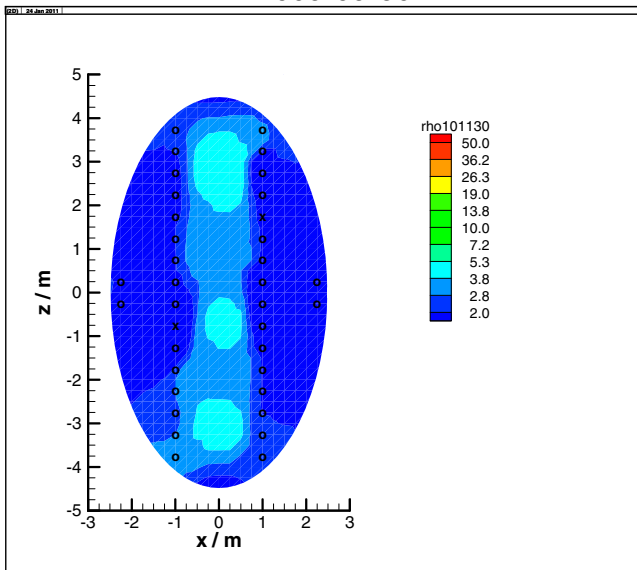
2009-01-30



2009-09-30



2010-08-18



2010-11-30

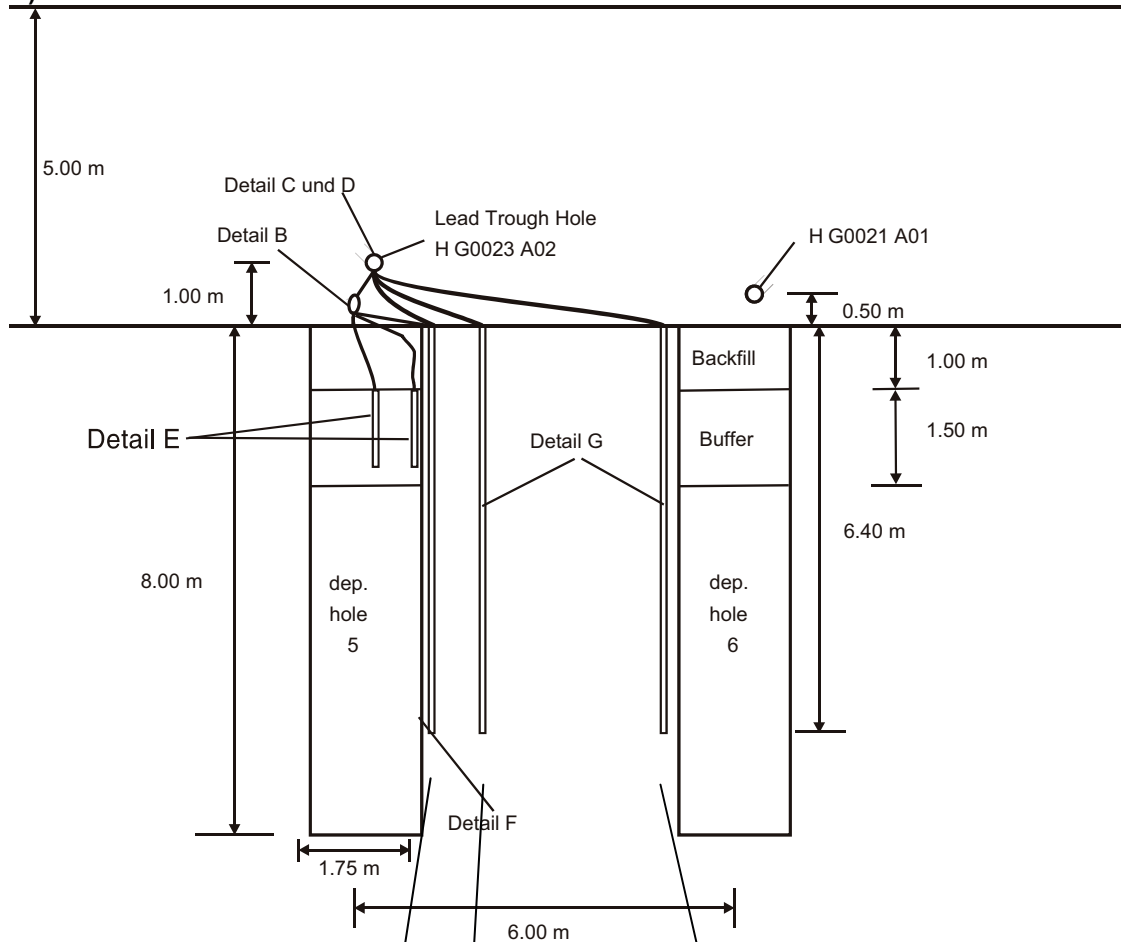
A9.2.3 Actual Interpretation

The first measurement performed on June 18, 2003 in Section 2 shows a much lower resistivity than the early measurements in Section 1. Obviously, the backfill had a considerably higher water content already during installation. This observation was also made during instrumentation. Resistivity has been decreasing further from the drift walls. The central area of higher resistivity has been continuously decreasing in size. In particular, the evolution encountered in section I has not been found here. At the end of 2009, resistivity has reached values around $2 \Omega\text{m}$ everywhere in the cross section. The backfill in section II could be considered fully saturated at that time. Since then there has been a slight increase in resistivity to a distribution comparable to the one encountered at the end of 2008. In 2011, the measurement was stopped due to the dismantling of Section 2.

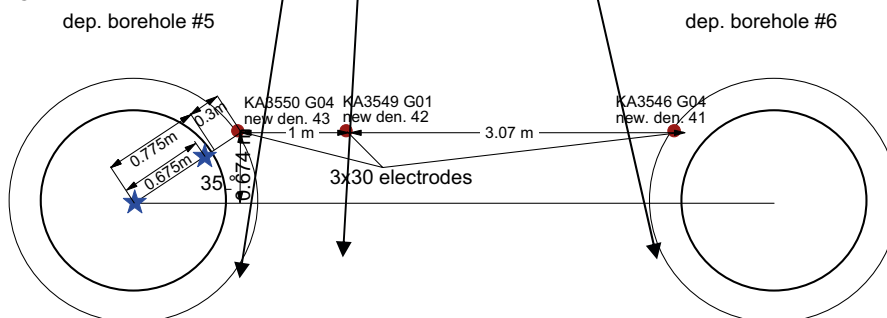
A9.3 Rock Section 2

A9.3.1 Layout of electrode array in the rock between deposition boreholes 5 and 6

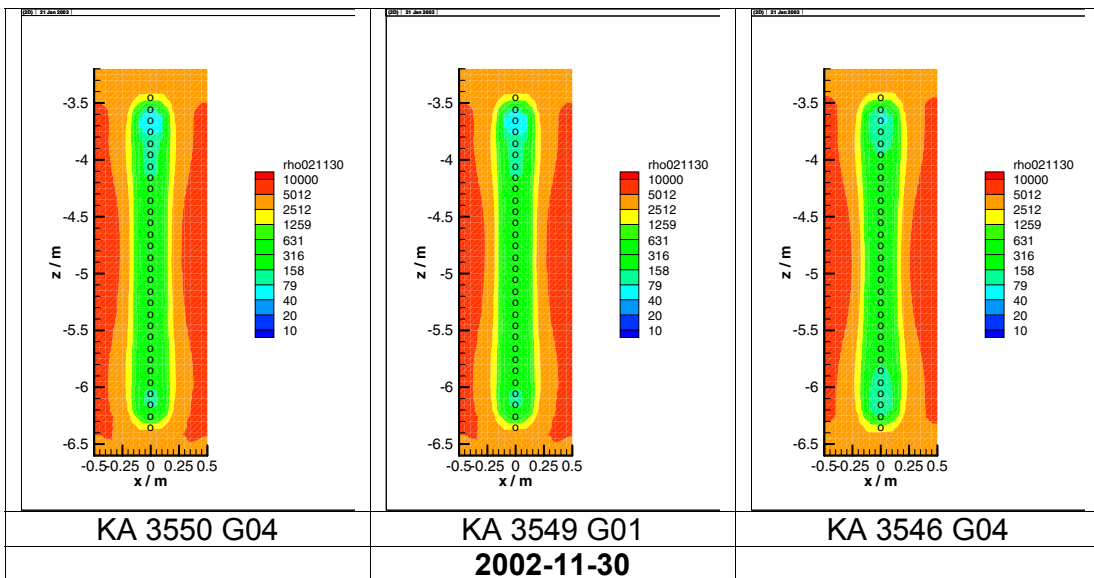
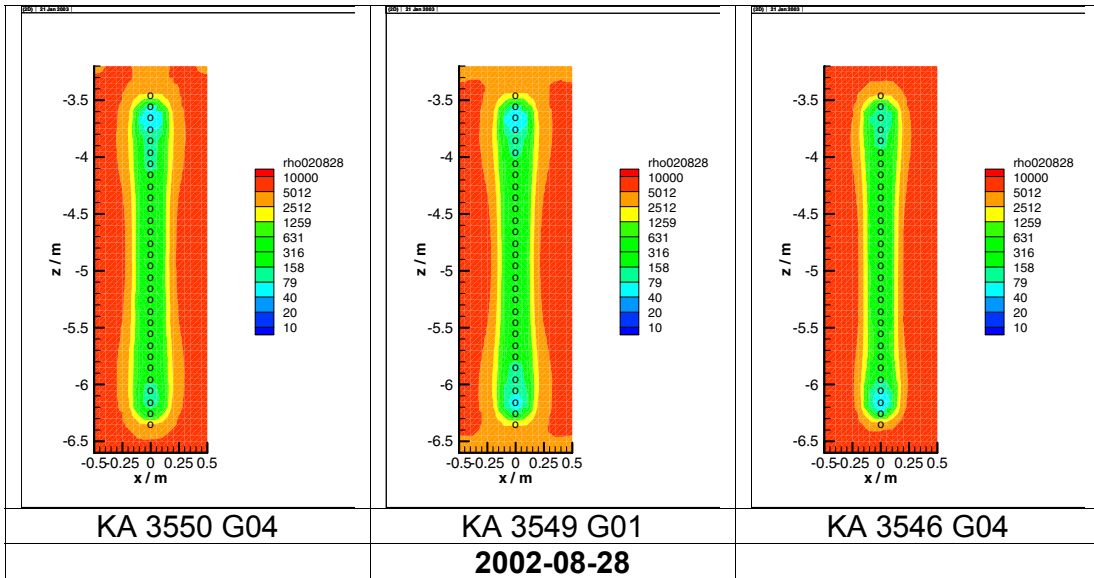
A) Vertical cross section

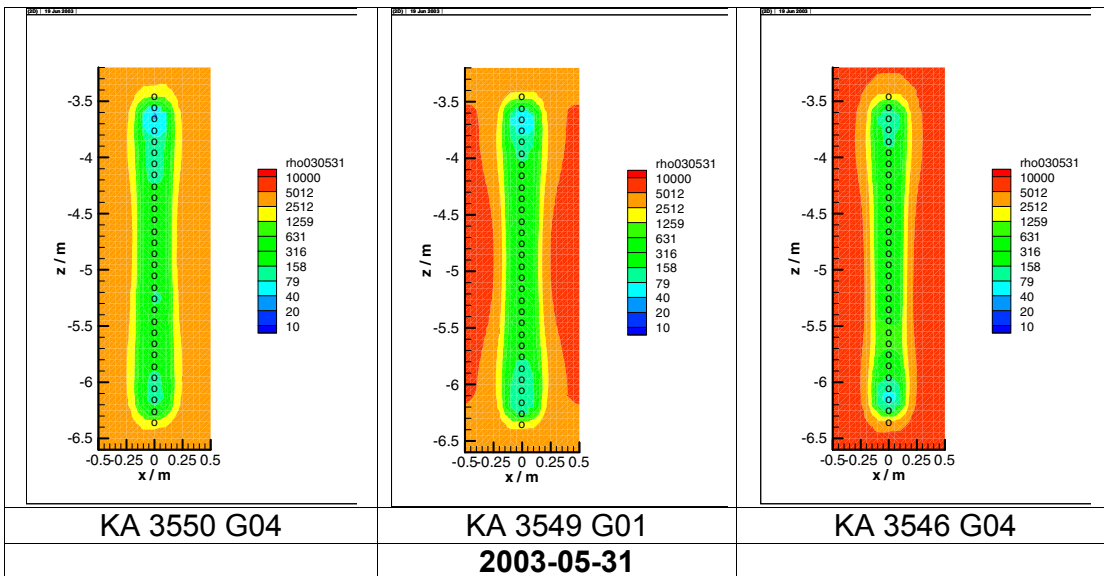
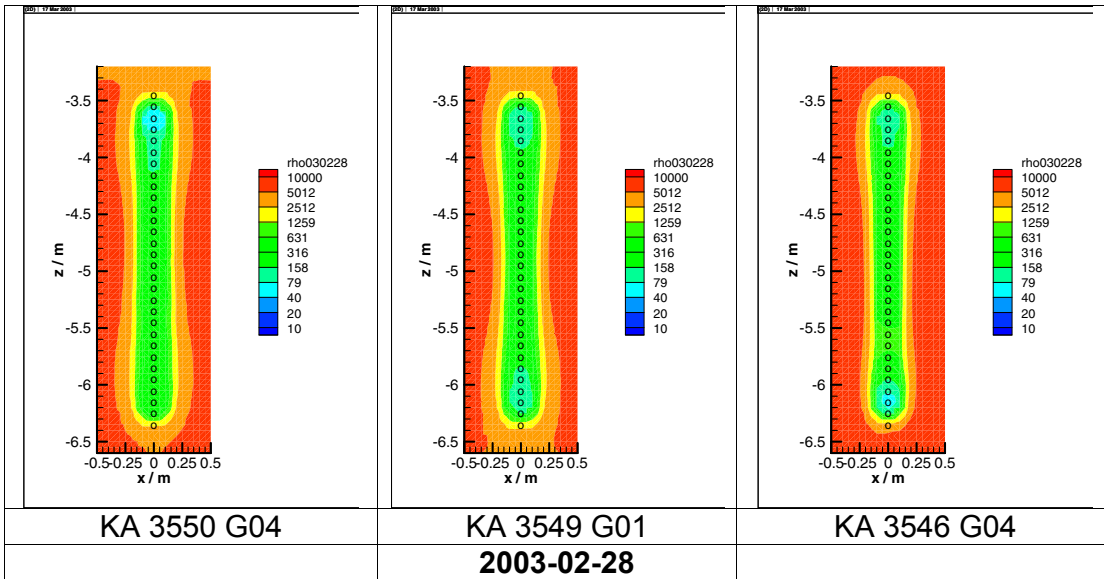


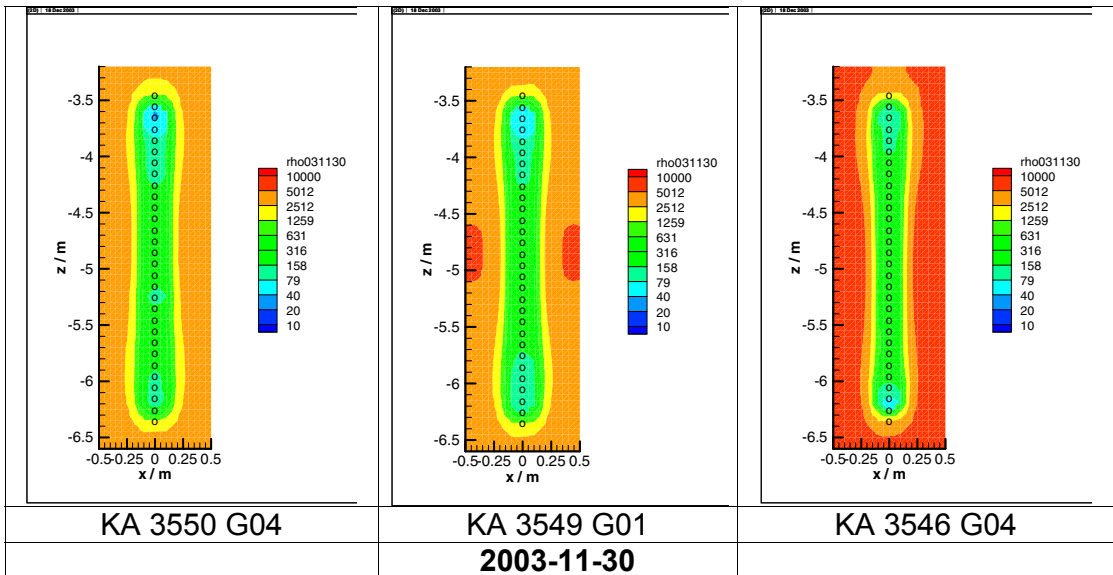
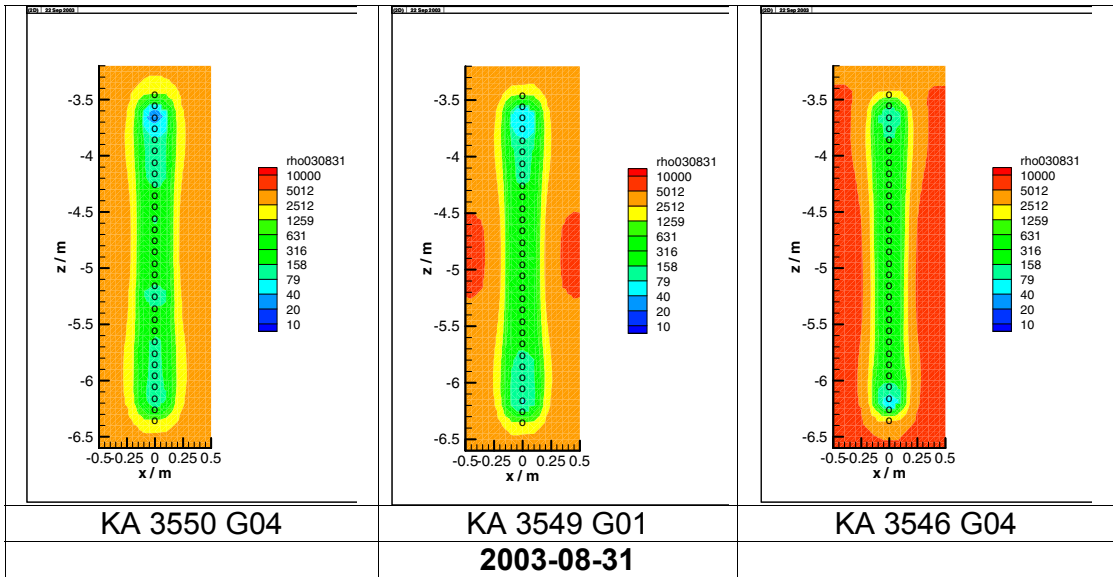
B) Plan view

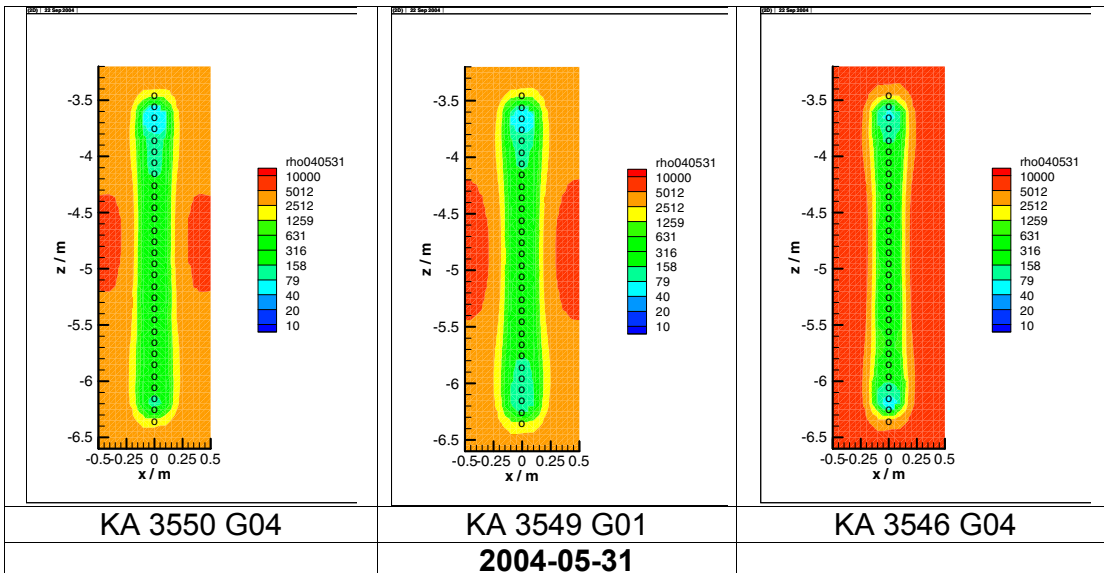
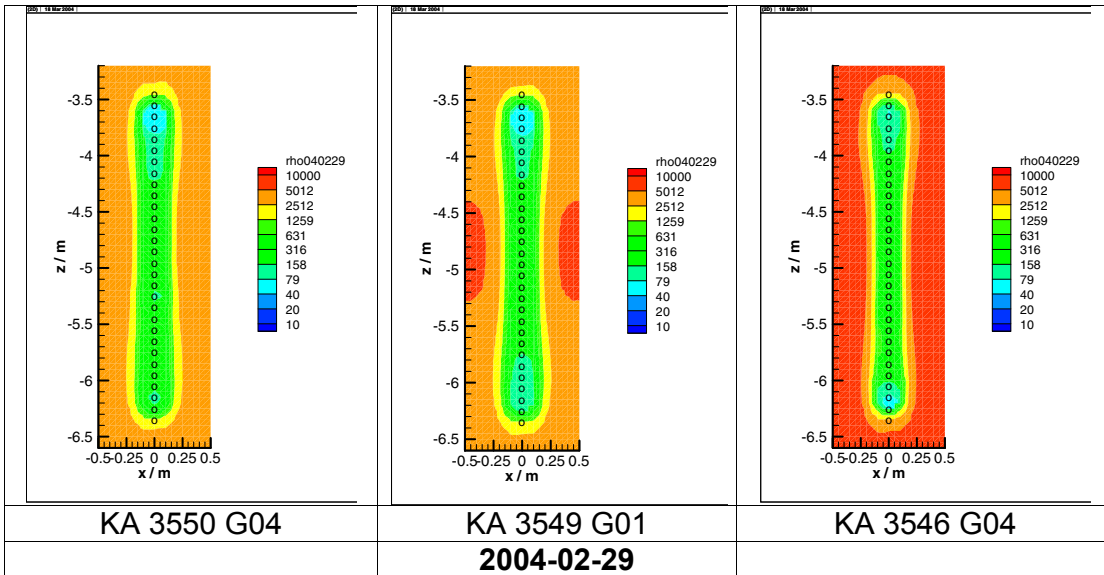


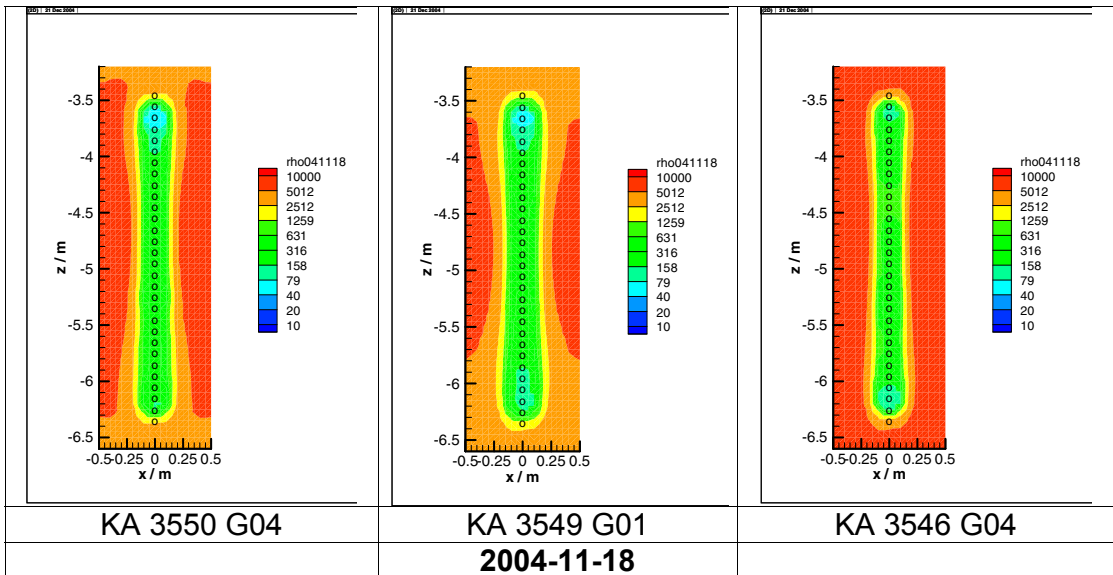
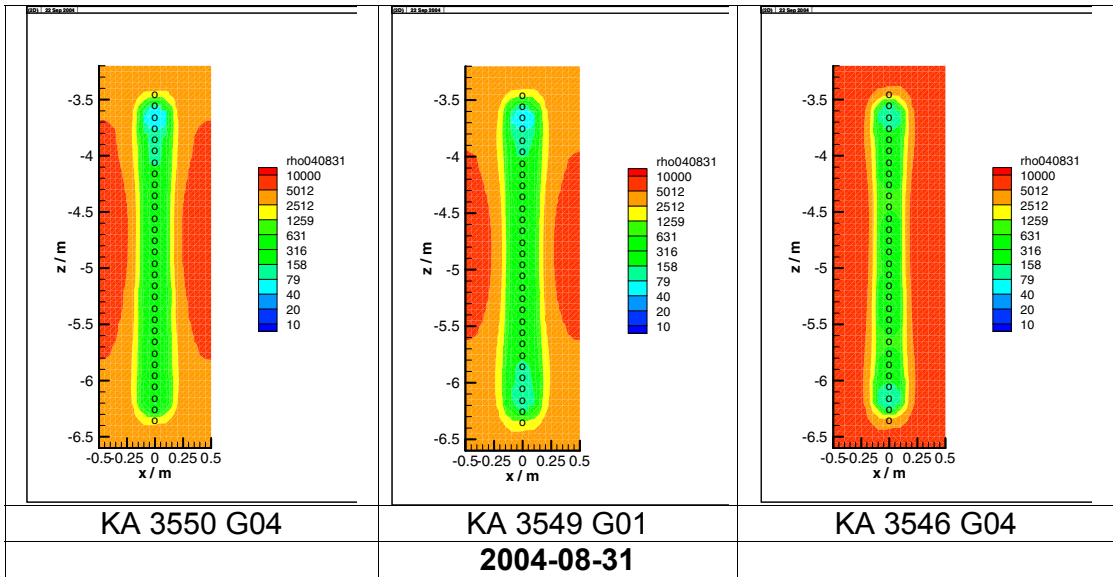
A9.3.2 Tomograms of electrode arrays in the rock

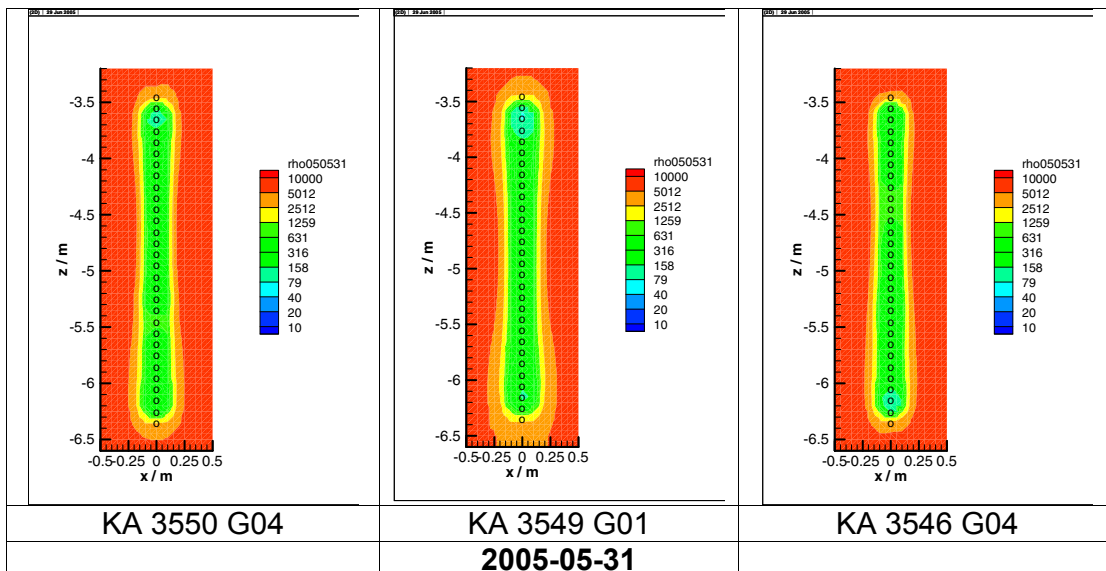
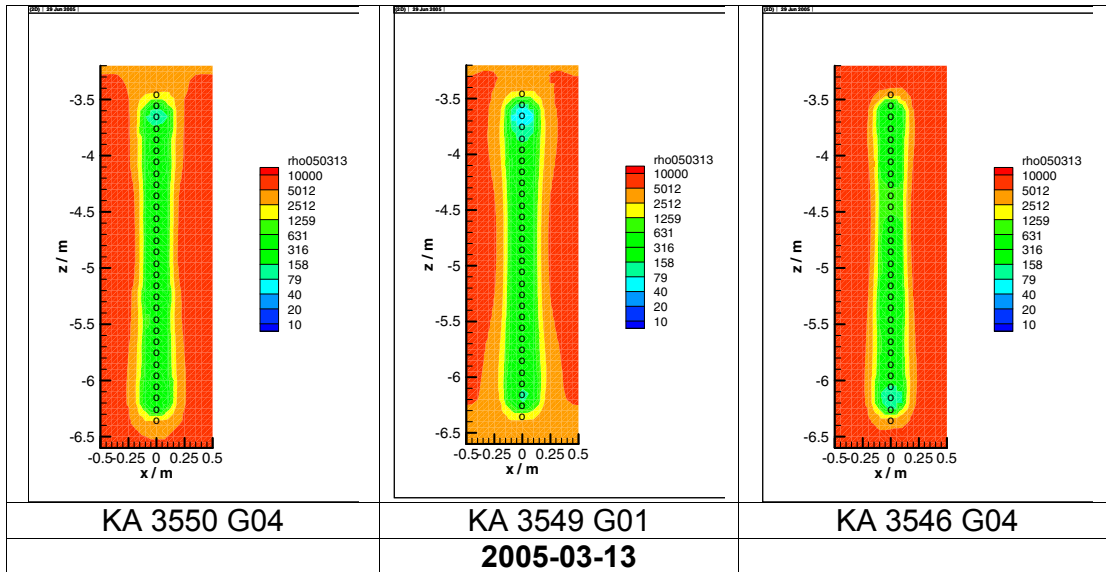


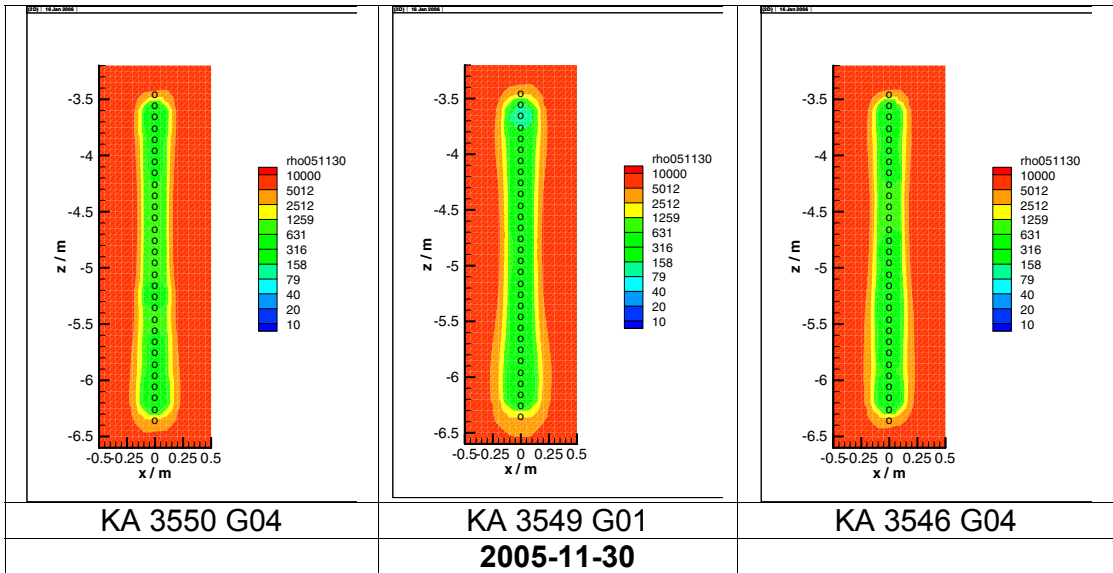
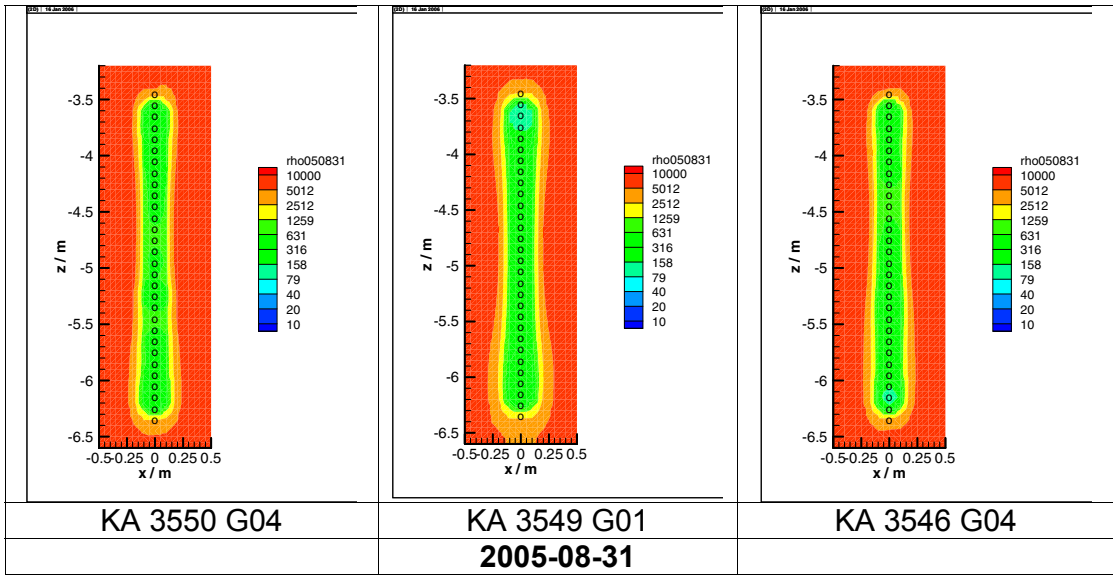


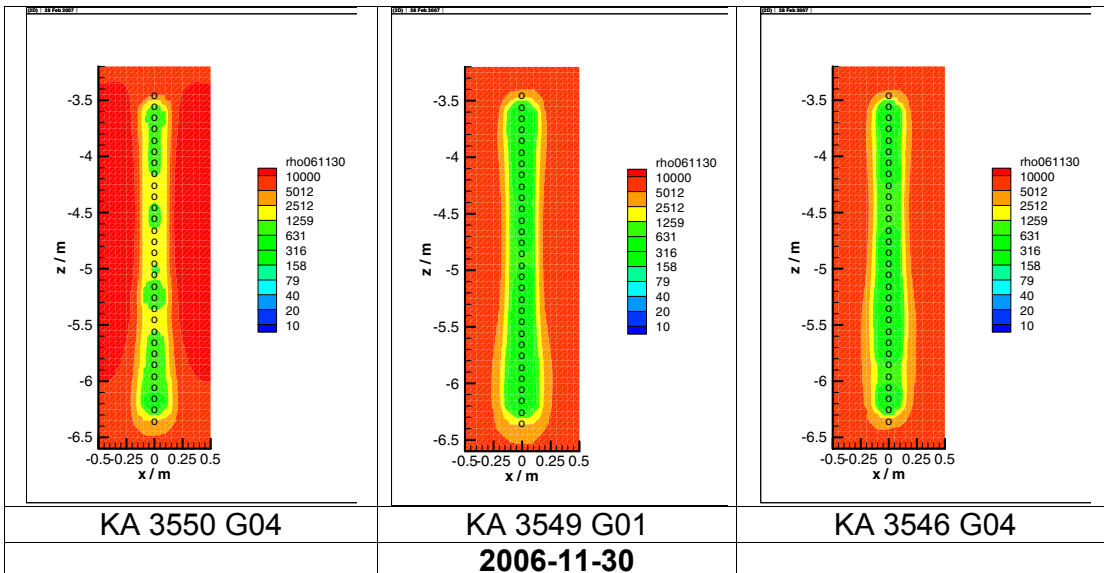
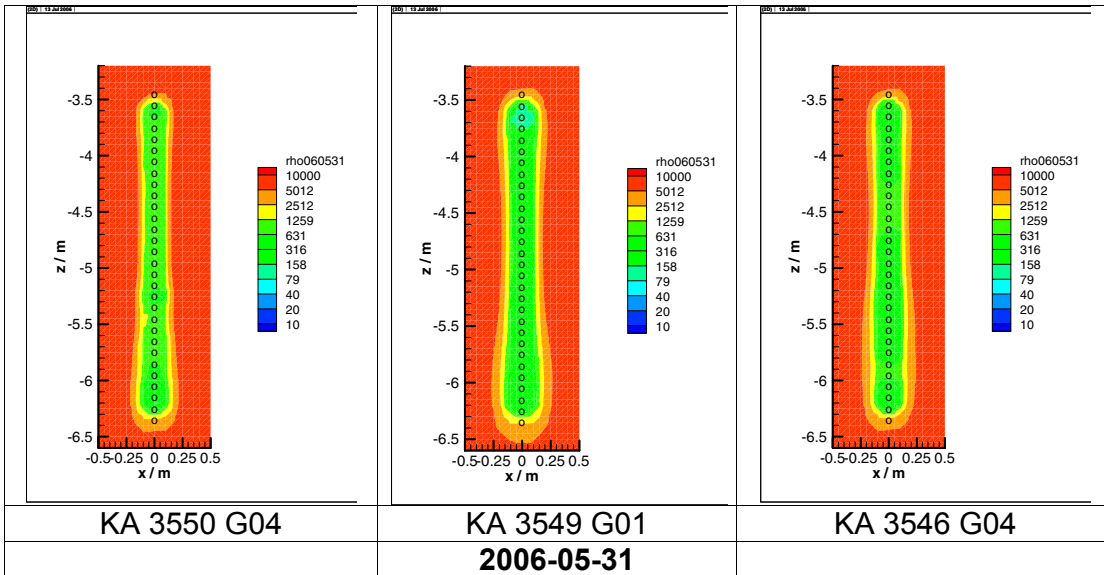


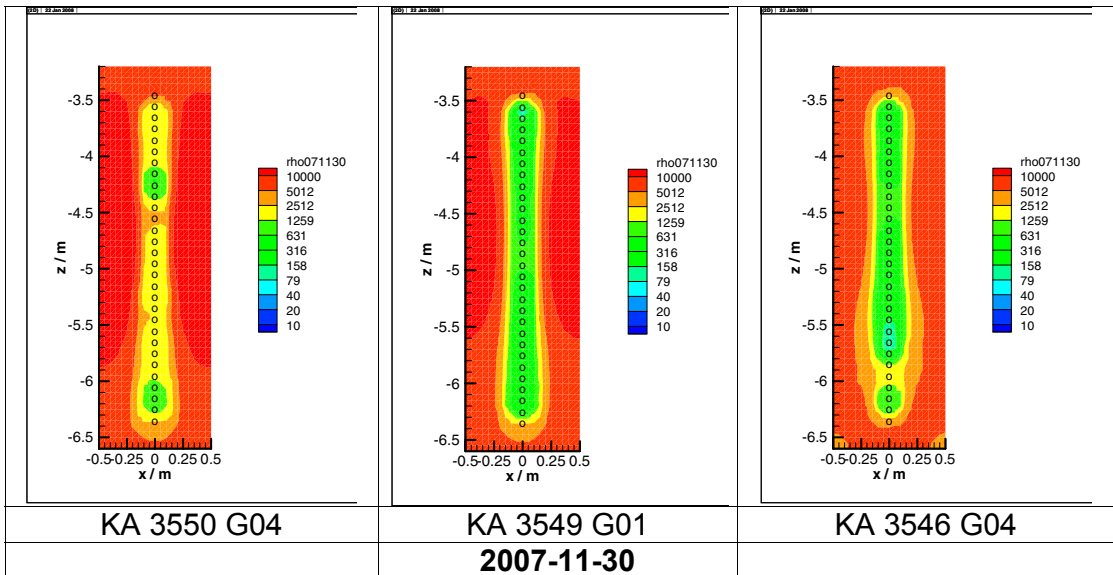
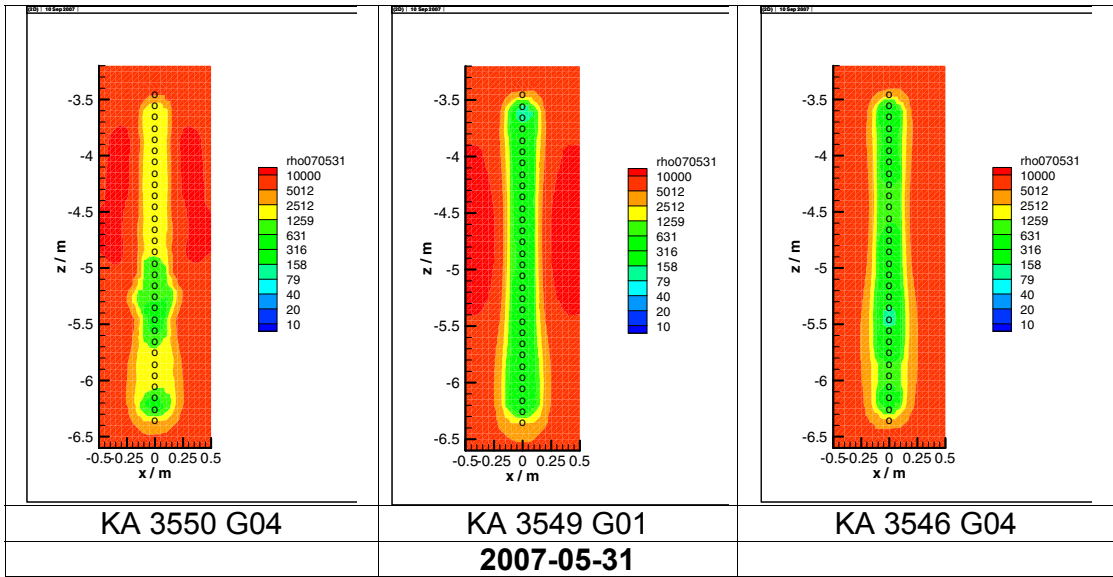


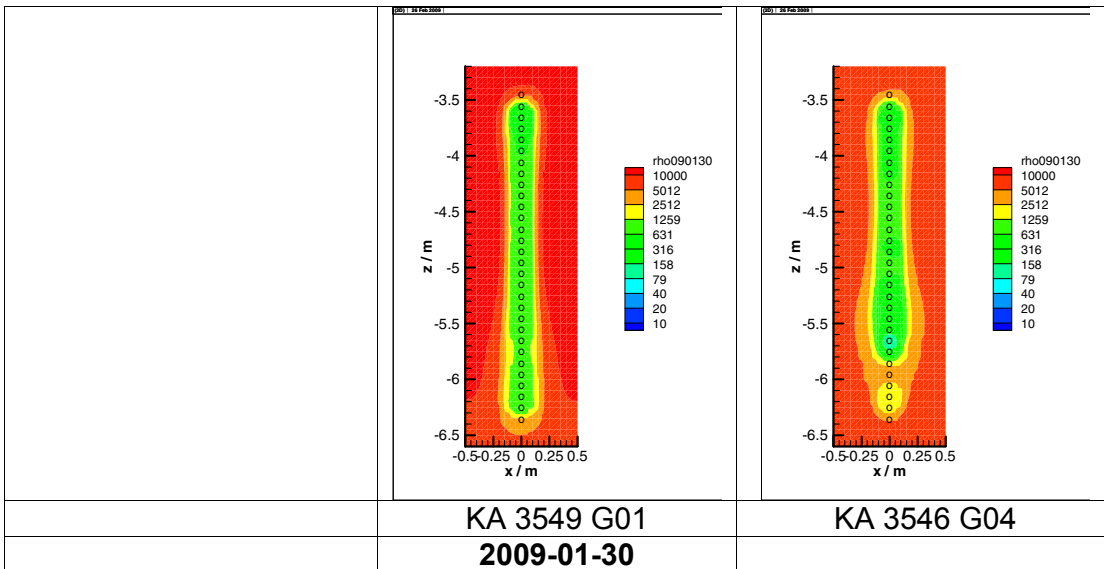
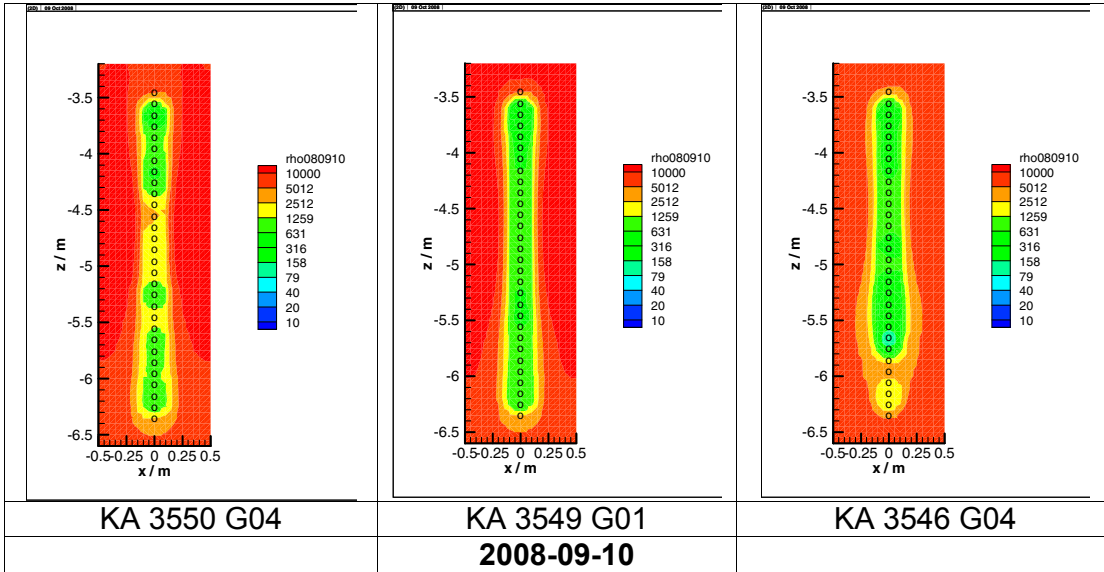


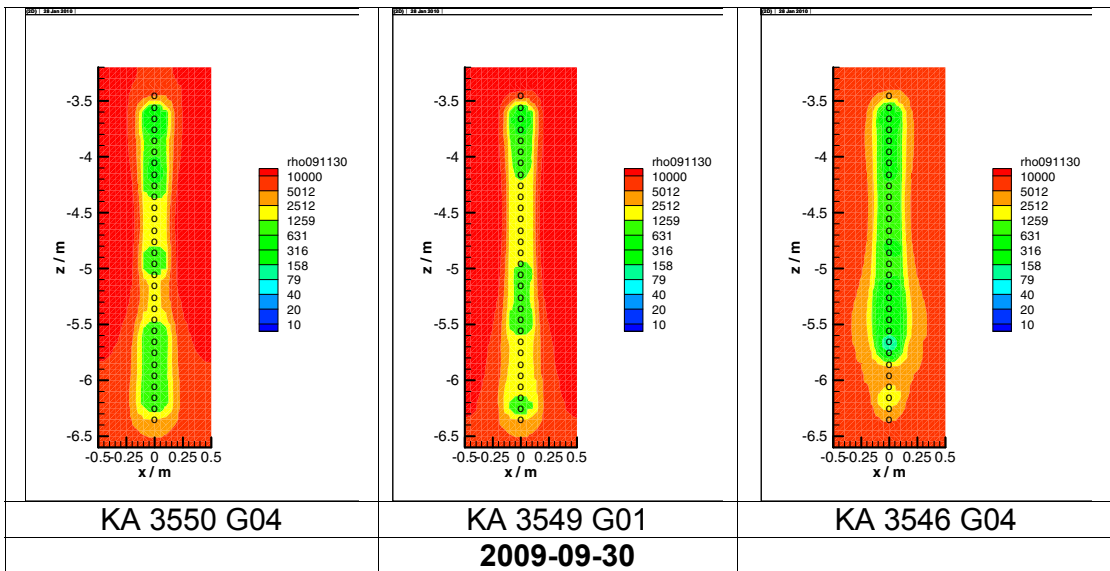
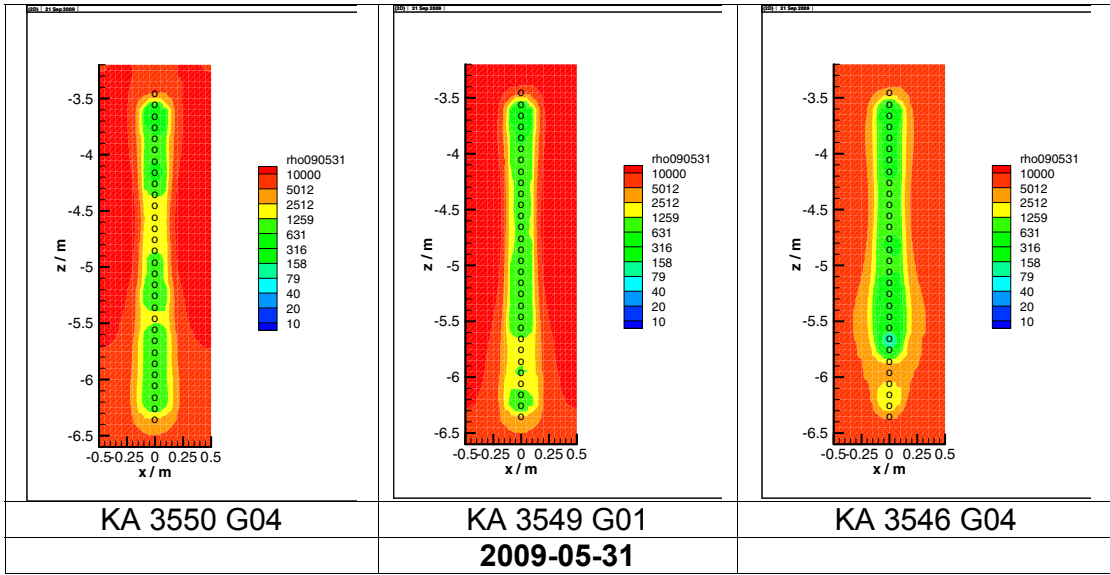


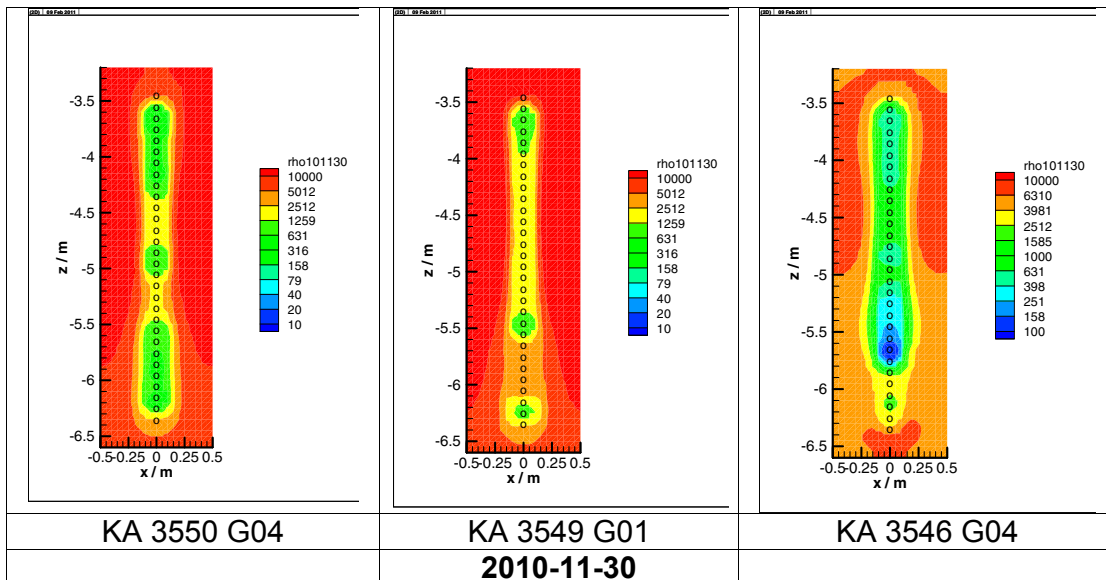
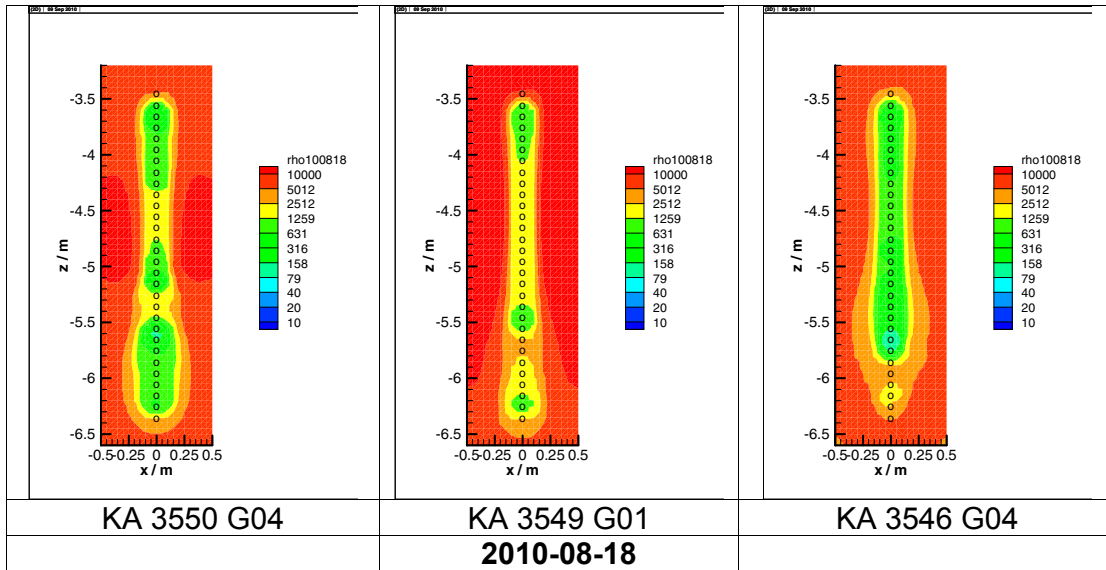












A9.3.3 Actual Interpretation

The resistivity distributions along the three electrode chains installed in the rock are quite similar to each other and show no significant variation in time until April 2003. Close to the electrodes, the resistivity ranges around 200 Ωm . This value characterizes the water-saturated concrete used for backfilling the electrode boreholes. Further away from the boreholes, the resistivity rises to values of 2,000 to 7,000 Ωm which is characteristic for water-saturated granite.

From April 2003 on, there is a slight decrease in resistivity in the rock near deposition hole #5. This coincides with installation of the buffer which also stopped the pumping of water from the open deposition hole. Apparently, this had caused a slight desaturation of the rock which recovered. From February 2004, resistivity seems to increase again. This becomes very visible from May 2006 on and might be caused by a drying of the concrete backfill of the electrode hole and possibly of the surrounding rock. Near the deposition hole #6, no such effect was detected.

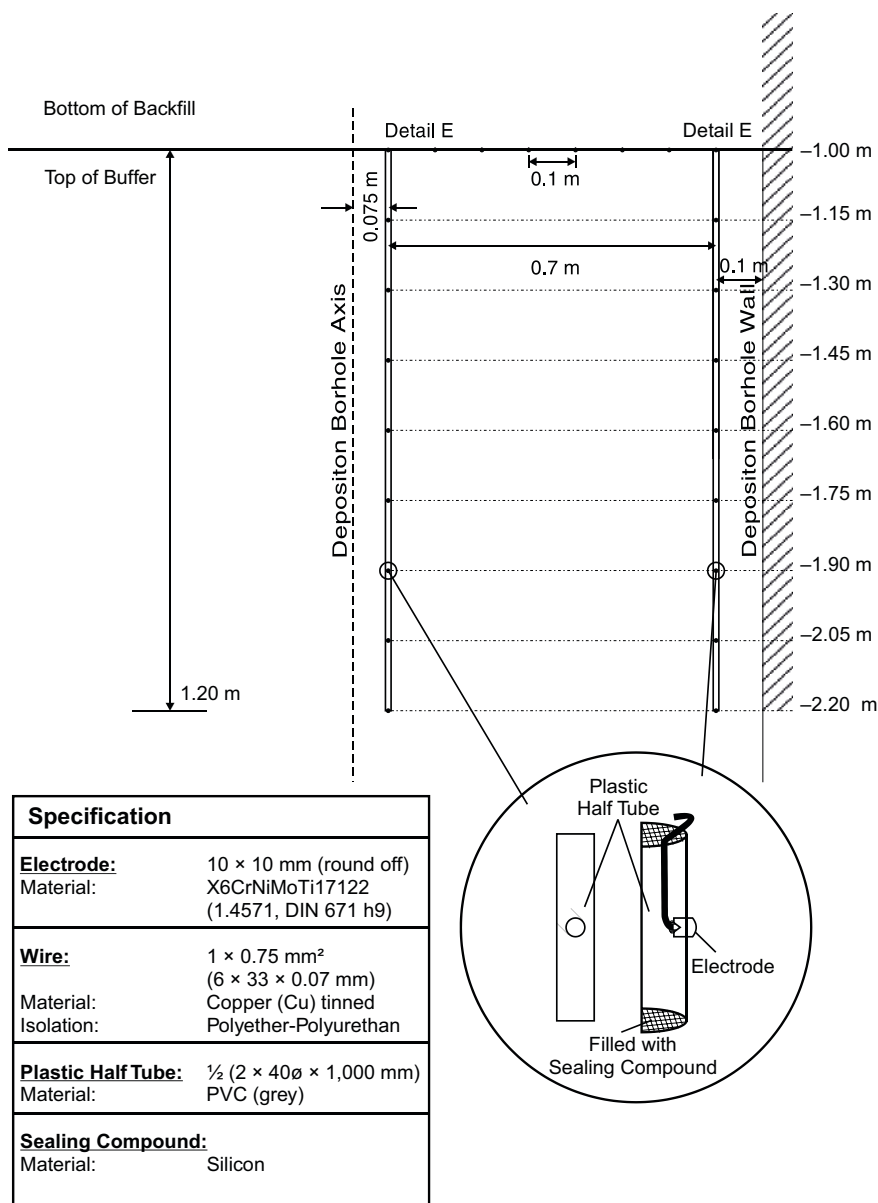
At the end of 2008, the complete electrode chain near deposition hole #5 failed. Therefore, no tomogram of January 2009 is shown for this chain. In the meantime, the failure was fixed (see following tomograms).

A new development seems to have taken place in 2010 when the resistivity near deposition hole #5 showed a clear decrease at a depth around 5.7 m below the tunnel floor. This is visible in the tomogram of KA 3546 G04 from November 2010. In 2011, the measurement was stopped due to the dismantling of Section 2.

A9.4 Buffer in borehole 5 in Section 2

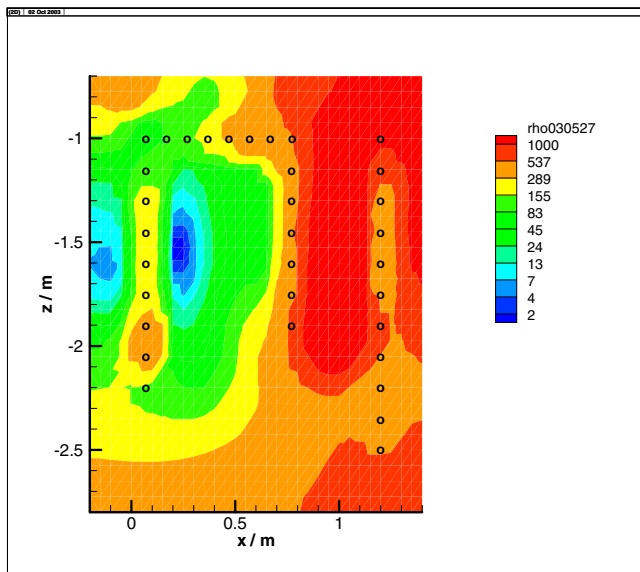
A9.4.1 Layout of electrode array in the buffer of deposition boreholes 5

The array is made up of the electrodes located in the buffer at the top of deposition hole #5 (see figure) and of the electrodes in the upper part of borehole KA 3550 G04 in the rock (see figure in Section A9.4.1).

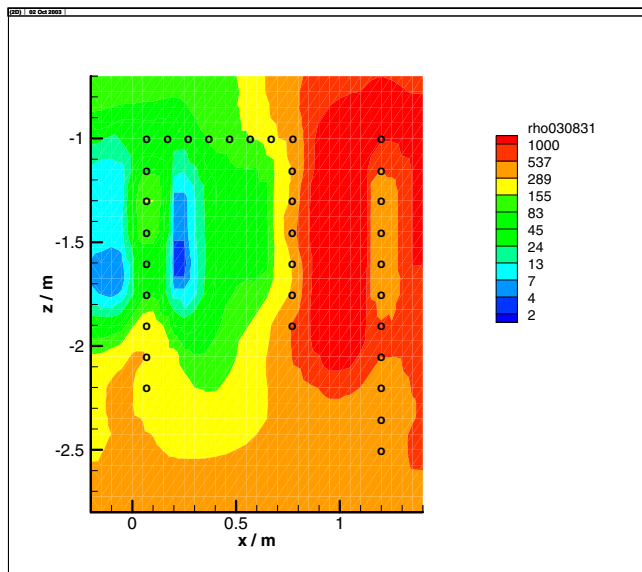


ELECTRODE DETAIL E VERS.01.CDR

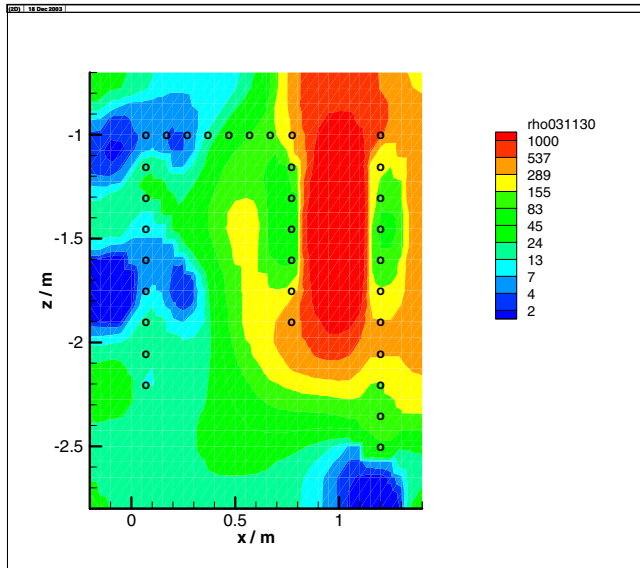
A9.4.2 Tomograms of electrode array in the buffer



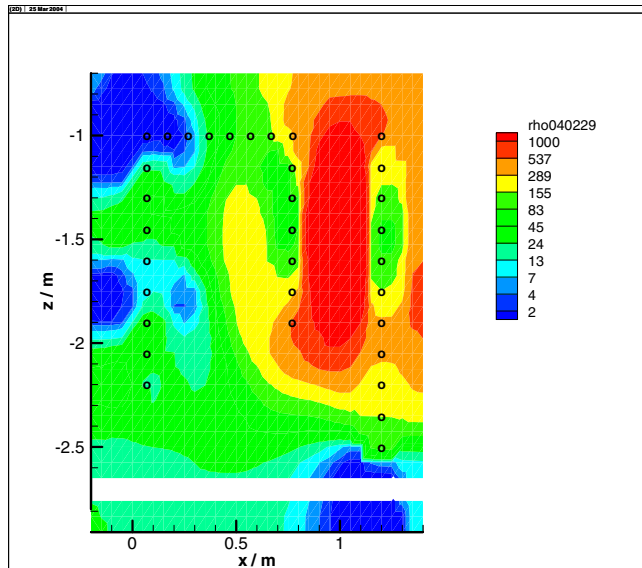
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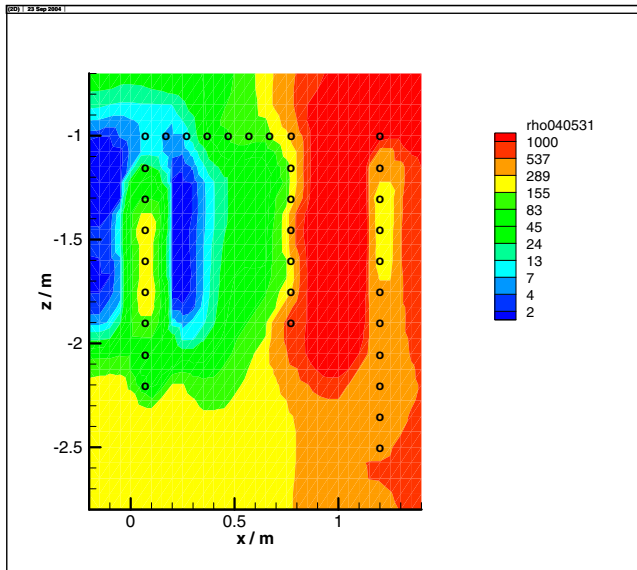
2003-08-31



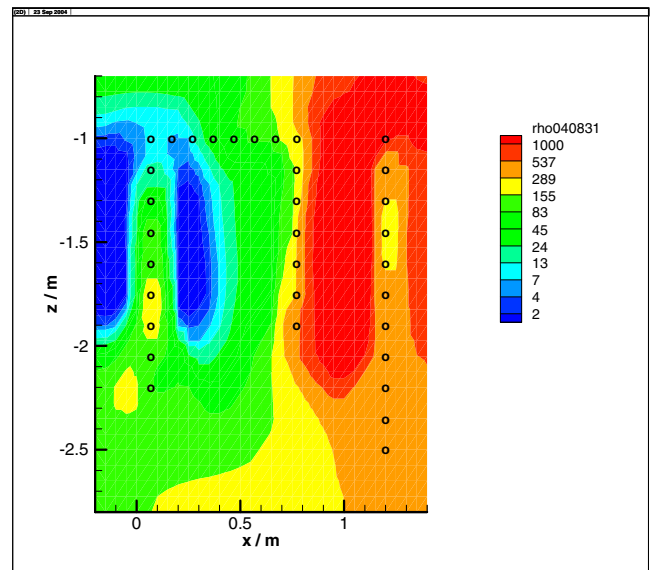
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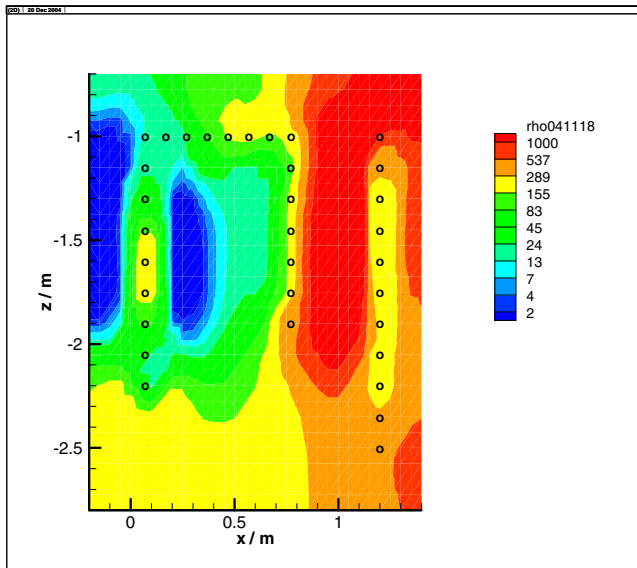
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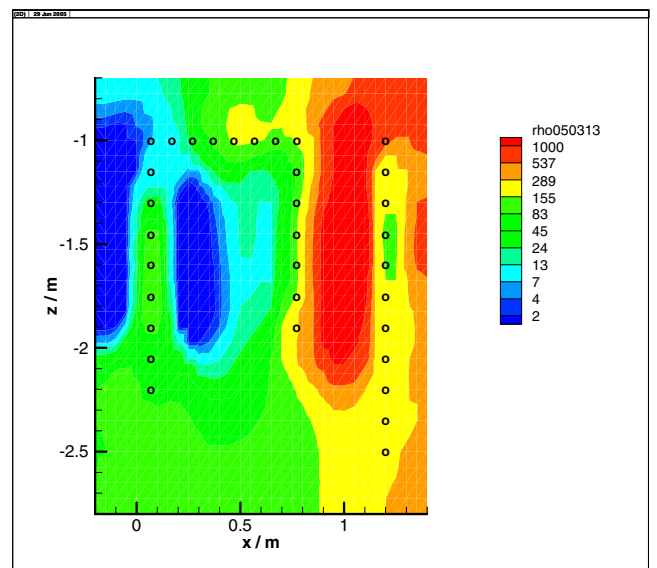
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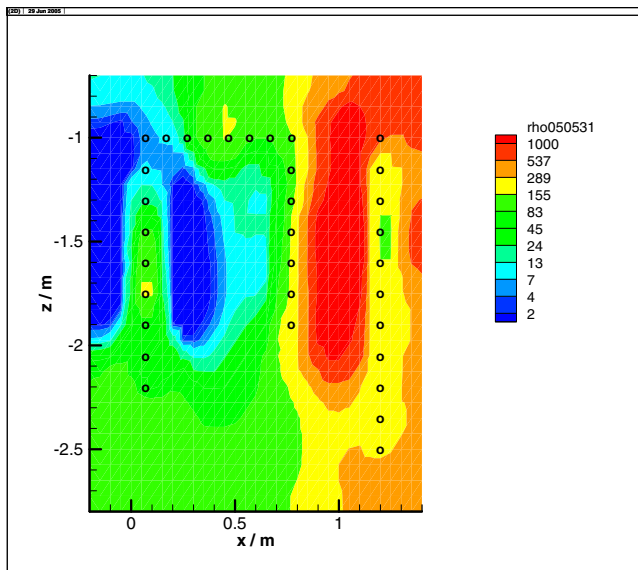
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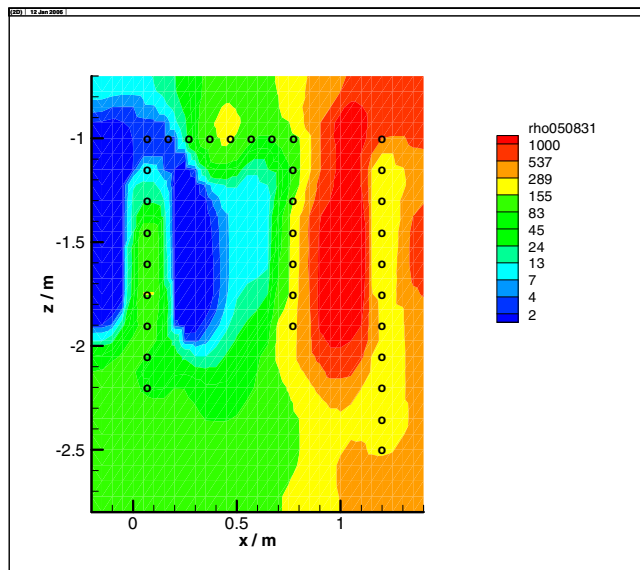
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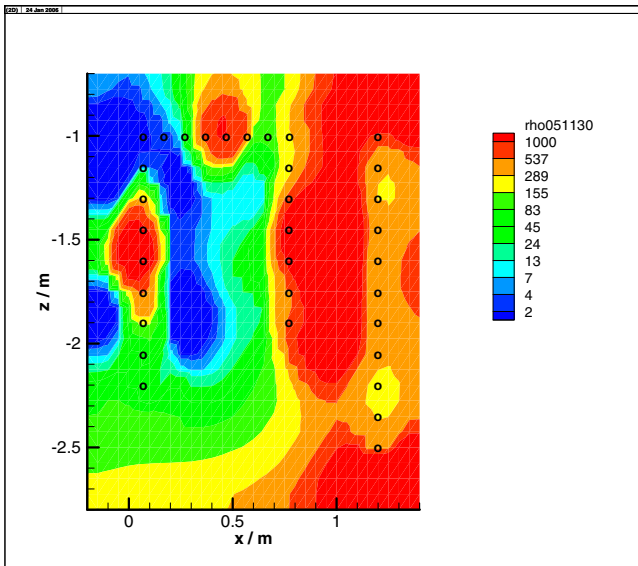
2005-03-13



2005-05-31



2005-08-31



2005-11-30

A9.4.3 Actual Interpretation

The tomogram of May 2003 (first measurement) shows the high resistivity (above 1,000 Ωm) of the rock on the right side and the low resistivity of the buffer (below 80 Ωm). The picture is somewhat distorted by the fact that along the electrode chains the resistivity is increased compared to the undisturbed buffer. The increased resistivity along the electrode chains can be attributed to the refilling of the electrode boreholes with bentonite powder produced during borehole drilling. It was, however, expected that the difference would diminish with time, especially if the buffer takes up water. The tomograms of the following months show a progressing decrease of resistivity in the buffer. While the overall behaviour is rather clear, it is difficult to interpret buffer resistivity in terms of water content. In nearly all the buffer monitored by the array the resistivity has decreased to values below 24 Ωm by November 2004 and below 13 Ωm by end of May 2005. The tomogram of November 2005 shows two high resistivity anomalies in the buffer. These are not real, but result from the fact that two electrodes have been lost between September and November, 2005. The accuracy of the results is reduced by the loss of electrodes. From November 2005 on, more electrodes failed (possibly due to corrosion) so that a tomographic evaluation was no longer possible. The injection current of the electrode pairs which were still working was still increasing, which was a hint to a further decrease in resistivity, meaning the buffer was still taking up water.

In 2011, Section 2 was dismantled and samples were taken from the tunnel backfill and from the buffer of the deposition holes. In particular, buffer cores containing parts of the electrode chains could be retrieved and analyzed.

Two core samples with embedded electrode chains (see photos below) were retrieved from the buffer, one from the center and one close to the deposition hole wall. It was found that the electrodes were nicely coupled to the buffer and showed little corrosion, but all electrodes were disconnected from their cables.

The reason for the cable failure is a significant upward swelling of the uppermost buffer blocks in the range of decimeters which was found during the post-test investigations of the buffer. This elongation could not be taken by the cables. The volume increase of the buffer blocks during swelling was caused by an insufficient stiffness of the tunnel backfill above the buffer, which had not been foreseen.

Measurement of water content of samples from the buffer cores resulted in values between 21 and 22 wt.% in the center and around 23 wt.% near the deposition hole wall. These values are in good agreement with measurement results achieved by Clay Technology.



Figure A9-1. Core section from top central buffer of deposition hole #5.



Figure A9-2. Buffer electrodes.

Stress and strain in the rock

A10.1 Extent

ÅF Infrastructure AB and NCC Teknik have, on commission of SKB, Äspö Hard Rock Laboratory, performed rock mechanical measurements in the Prototype tunnel at Äspö. The measurement program comprises registration of the stress and strain response around the two deposition holes during drilling and heating of the rock mass.

In the first phase, the response of the rock mass was monitored during the drilling of the two canister holes. The second phase, which is the subject of this report, includes the response registered during a heating phase. The heating experiment started on the 8th of May 2003 and is planned to be finished during 2011.

The goal of the instrumentation is to monitor the stress, strain and deformation changes due to heating of the rock mass surrounding the deposition holes. Instrumentation has been installed to monitor the relative changes in intact rock as well as across fractures.

The commission extends over field measurement and evaluation.

ÅF Infrastructure AB is responsible for measuring equipment, the mobilization, field measurement, and the computer processing. ÅF Infrastructure AB and NCC Teknik are responsible for the interpretation and reporting of the measurements.

This report presents the measurement results during the period of the heating phase from 2010-06-01 to 2010-12-31.

A10.2 Technical background

A10.2.1 Summary of instruments installed

The instrumentation for monitoring rock mechanical response was installed in two stages. The instruments used to monitor the drilling phase of the canister boreholes were installed within vertically drilled boreholes located 0.3 m from the periphery of the deposition hole. These instruments are referred to as primary (Table A10-1) instruments in the following section. Following the drilling of the deposition holes, complementary instruments (Table A10-2) were installed within boreholes extending from the deposition holes.

The following numbers and types of instruments were selected for installation to allow monitoring of stresses and strains within the host rock surrounding the deposition holes.

Table A10-1. Summary of primary instruments.

| Parameter measured | Instrument type | Total number installed |
|--|---------------------------------------|------------------------|
| Compressive stress change in intact rock | Geokon model 4350 biaxial stressmeter | 8 |
| Compressive and tensile stress change in intact rock | Geokon model 4360-1 Soft stress cell | 8 |
| Vertical movements in intact rock, over single fractures and within fracture zones | Geokon model 4430 deformation meter | 17 |
| Vertical strain measurements in intact rock and over single fractures | Geokon model 4200 strain gauge | 7 |

Table A10-2. Summary of complementary instruments.

| Parameter measured | Instrument type | Total number installed |
|---|---|------------------------|
| Horizontal deformation perpendicular to the axis of the deposition hole | Geokon model 4430 displacement transducer | 32 |
| Vertical strains beneath the deposition hole | Geokon model 4200 strain gauge | 8 |

The layout of the primary instruments around the deposition holes is shown in Figures A10-1 and A10-2. A total of eight 60 mm diameter boreholes (four around each of the two deposition holes) were drilled. The majority of the instruments were installed within these boreholes. These holes are designated as A, C, E and G – 5 and 6. In addition, a total of four 76 mm diameter boreholes (two at each deposition hole) were drilled to shallower depths to allow installation of the soft stress cell meters. These larger diameter holes are designated as H and D – 5 and 6.

Installation of the complementary instruments took place following drilling of ten boreholes having about a 75 mm diameter from within the two deposition boreholes. The locations of these ten boreholes are shown schematically as well as in plan and elevation in Figures A10-3 to A10-6. The instruments installed within these boreholes consisted of displacement transducers ranging in length from 0.3 to 1.2 m, and strain gauges which were 0.15 m in length.

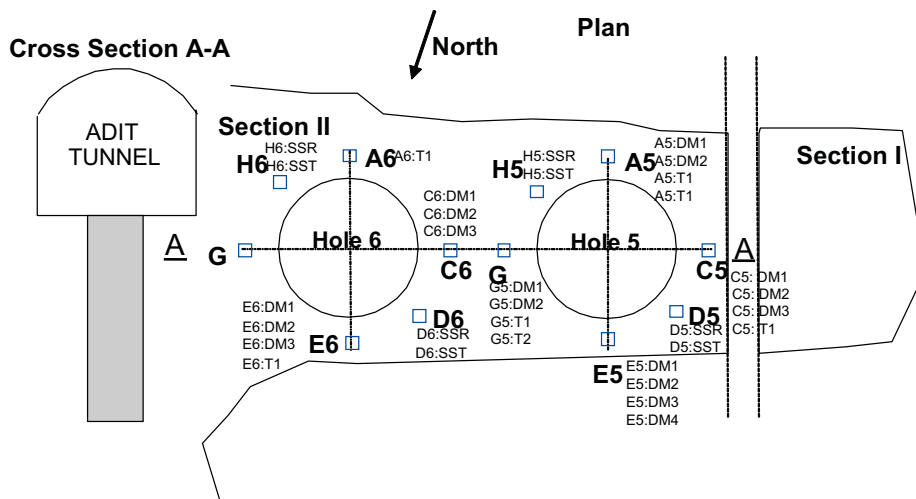


Figure A10-1. Primary instrument locations in plan view.

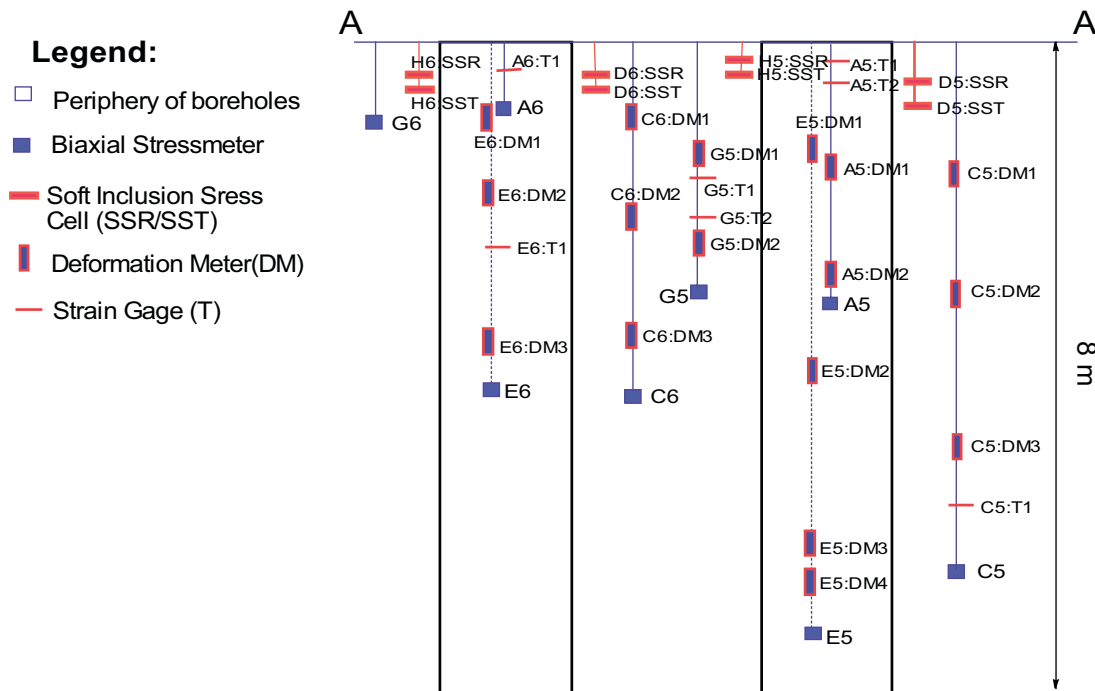


Figure A10-2. Primary instrument locations in elevation view.

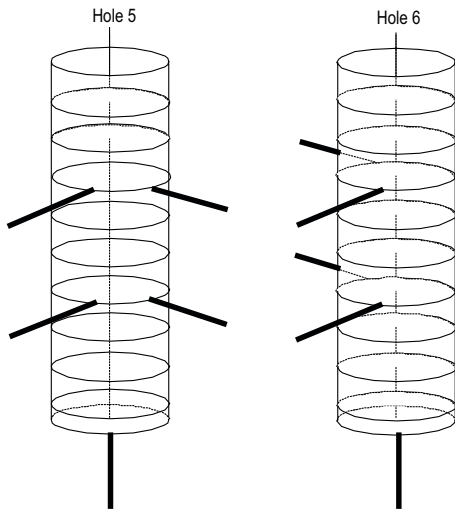


Figure A10-3. Schematic views of complementary boreholes.

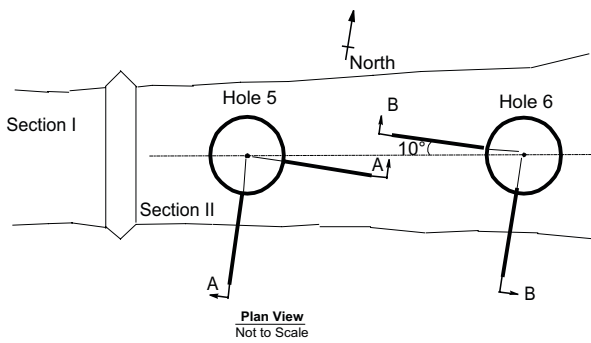


Figure A10-4. Plan views of complementary boreholes.

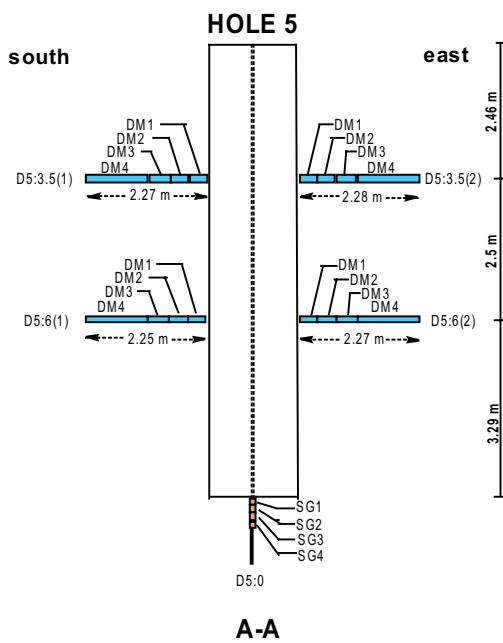


Figure A10-5. Elevation view of complementary instruments in Deposition Hole 5.

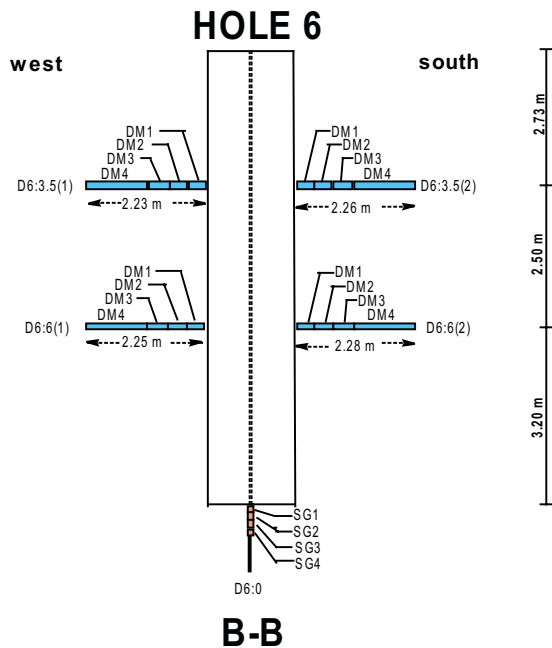


Figure A10-6. Elevation view of complementary instruments in Deposition Hole 6.

A10.2.2 Stress measurements

A10.2.2.1 Vibrating wire embedment biaxial stressmeters

The Geokon model 4350 vibrating wire biaxial stressmeter was installed for monitoring stress changes. This instrument was designed to measure compressive stress changes in rock, salt, concrete or ice. The instrument consists of a stiff high-strength steel cylinder, which is grouted into a BX (60 mm) size borehole. Stress changes in the host material cause the cylinder to deform, and the deformations in the plane perpendicular to the borehole are measured by means of two sets of three vibrating wire sensors spaced at 60° intervals (measurements are made at two levels within the cylinder). The gauges also include two longitudinal strain sensors and temperature sensors. The deformation of the steel cylinder, and resulting changes in resonate frequency of the vibrating wires, are used to determine both the magnitude and orientation of the change in stress in the host material.

Installation of the stressmeter gauge is accomplished by inserting the gauge into a grout-filled borehole using a setting tool and self-aligning setting rod. The stress cell is orientated so that the first vibrating wire is orientated tangentially to the canister hole. The second wire is orientated 60° from tangential direction and the third wire is orientated 120° from tangential direction.

A10.2.2.2 Vibrating wire soft inclusion stress cell

The Geokon model 4360 soft inclusion stress cell is designed to measure changes in borehole diameters caused by changes in stress in rock and concrete. In use, an instrumented steel ring is installed in a borehole and pre-stressed in place by forcing platens into contact with the borehole walls. A vibrating wire strain gauge measures the deformation of the ring, which is also the deformation of the borehole. Both compressive and tensile measurements can be made. Unlike the biaxial stressmeters that contain sets of 3 vibrating wires, the soft stress cells measure deformation changes in only one direction. For this reason the soft stress cells are installed in pairs to measure stress changes tangential and radial to the deposition holes.

A10.2.3 Deformation gauges

Deformations around the deposition holes are measured with deformation gauges installed both within the same boreholes used for the biaxial stressmeters, as well as in the horizontal complementary boreholes.

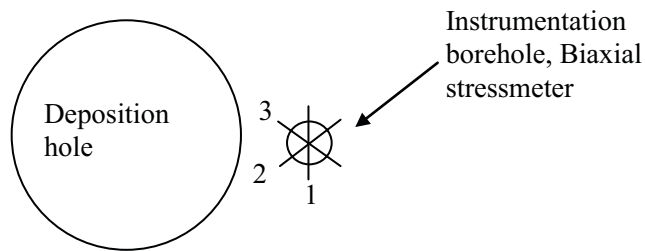


Figure A10-7. Plan view of positioning of instrumentation in boreholes around deposition holes.

The Geokon model 4430 Deformation gauge is designed to measure longitudinal deformations in boreholes. The deformation meter consists of a tube with an anchor at each end. Within the tube a beam of graphite will transfer any distance changes between the two anchors to a vibrating wire sensor. In each deformation meter a temperature sensor is included for temperature corrections.

A10.2.4 Embedded strain gauges

At some particular locations, Geokon model 4200 strain gauges have been installed over single fractures. This model gauge is designed for direct embedment in cast concrete and for installation in grouted boreholes. A steel wire is taut between two end blocks and the strain of the wire is measured using the vibrating wire principle. Deformations in the rock mass induce movements of the hard cement causing the two end blocks to move in relation to each other across a joint, thereby altering the tension in the wire. The tension in the wire is measured by plucking the wire and measuring its resonant frequency of vibration using an electromagnetic coil.

A10.2.5 Cement

Special expansive grout was used to insure that the gauge is in complete contact with the surrounding rock. The instruments are grouted in special cement from Denmark named Densitop T2. This cement is chosen to have as similar properties as the rock as possible. The compression strength is 150 MPa. The coefficient of expansion is approximately 8.5 microstrain/°C and that is similar to hard rock as granite and as 85% of common concrete.

A10.2.6 Registration

Two data loggers type Campbell CR10X have recorded the measurements, which have typically been recorded once every four hours during the period 2010-06-01 to 2010-12-31.

A10.3 Computer processing of field data

A10.3.1 Evaluation of stresses from biaxial stressmeters

The stress changes are evaluated from the measured deformations registered by the vibrating wires.

A10.3.1.1 Radial deformations

Radial deformations for each of the vibrating wires are calculated with the equation:

$$V_r = (R_1 - R_0) \times \text{Gauge factor (mm/digit)}$$

V_r = Radial deformation for each of the vibrating wires

R_1 = Deformation reading in digits (= frequency²/1,000)

R_0 = Deformation zero reading in digits (= frequency²/1,000)

A10.3.1.2 Calculation of deformation to stresses

The magnitude and the direction of the stress changes are determined from the measured radial deformation of the sensor in three directions.

The equations below give the magnitude and the direction of the maximum stress increase and reduction in a plane perpendicular to the borehole axes:

Maximal stress increase

$$p = \frac{1}{2} \left[\frac{1}{3B} \left((2V_{r_1} - V_{r_2} - V_{r_3})^2 + 3(V_{r_2} - V_{r_3})^2 \right)^{1/2} + \frac{1}{3A} (V_{r_1} + V_{r_2} + V_{r_3}) \right]$$

V_{r_1} = Radial deformation for vibrating wire 1

V_{r_2} = Radial deformation for vibrating wire 2

V_{r_3} = Radial deformation for vibrating wire 3

A, B = Coefficients depending on the sensor geometry and the material properties

Maximal stress reduction

$$q = \frac{1}{3A} (V_{r_1} + V_{r_2} + V_{r_3}) - p$$

The angle of the maximal stress increase

The angle in the plane perpendicular to the borehole axes is measured clockwise from the tangential direction of the canister hole.

$$\theta = \frac{1}{2} \cos^{-1} \left[\frac{V_{r_1} - A(p+q)}{B(p-q)} \right]$$

A10.3.2 Evaluation of stress from soft inclusion stress cells

The eight soft inclusion stress cells each contain one vibrating wire which is mounted at a 90° angle from measured direction of stress. Therefore an increase in the readings in digits indicates a reduction on borehole diameter.

The change in the diameter of the borehole is calculated as follows:

$$D = (R_1 - R_0) \times G$$

Where R_1 and R_0 are the current and initial readings respectively, in units of digits (frequency²/1,000), and G is the gauge factor in units of (mm/digit)

A10.3.3 Evaluation of deformation

Deformation measurements taken with the Geokon Model 4430 deformation meters were calculated as temperature compensated deformation with the following equations:

$$\text{Deformation}_{\text{corr}} = ((R_1 - R_0) \times C) + ((T_1 - T_0) \times K) + L_c$$

Where R_1 and R_0 are the current and initial readings respectively, in units of digits (frequency²/1,000),

T_1 and T_0 are the current and initial temperatures respectively in °C,

C is the gauge specific calibration factor

K is the thermal coefficient based on the following equation:

$$K = ((R_1 \times M) + B) \times C$$

Where $M = 0.000295$, and $B = 1.724$

L_c is the gauge length correction based on the following equation:

$$L_c = (17.3 \times 10^{-6}) \times (\text{Length of the deformation meter} - \text{transducer length}) \times (T_1 - T_0)$$

For the gauges installed at the Prototype project the transducer length is 267 mm.

A10.3.4 Evaluation of strain

Strain measurements taken with the Geokon Model 4200 gauges were calculated as temperature compensated strain with the following equation:

$$\mu\epsilon_{true} = (R_1 - R_0) \times GF \times B + (T_1 - T_0)(C_1 - C_2)$$

$\mu\epsilon_{true}$ = temperature compensated microstrain

R_1 and R_0 = Digits reading

GF = theoretical gauge factor

B = batch calibration factor

C_1 and C_2 are the coefficients of expansion of steel and concrete, 12.2 microstrain/°C and 8.5 microstrain/°C.

A10.3.5 Material parameters

Material parameters used in the calculations are as the following:

- Young's modulus of intact rock 69 GPa.
- Poisson's ratio of intact rock 0.25.
- Coefficients of expansion of steel 12.2 microstrain/°C.
- Coefficients of expansion of concrete 8.5 microstrain/°C.

A10.3.6 Processing

The raw data which have been collected using Multilogger software have been processed using Microsoft Excel software.

A10.4 Results

A10.4.1 Overview and comments

The measurement results are presented graphically for each of the sensors in the following sections for the primary and complementary instruments. It should be noted that the readings are currently uncompensated for the temperature effects.

Recording and registration have continuously been taken from all Data loggers and Multiplexers.

During this period the experiment was dismantled, thus many of the recordings have stopped.

A10.4.1.1 Biaxial stressmeter results

Most sensors have stopped giving reliable values during this period. From the time when the sensors give values no or very small changes can be seen in stresses around canister holes 5 and 6. The readings, of the working sensors, are mostly stable. Some problems with noise that were noticed in previous periods can also be seen during this period.

The functioning sensors in G5, A6 and G6 produce stable, useful values (Table A10-3). Similar to previously reported, the sensor C6 continues to produce unreliable readings, whereas the temperature sensors in C5 (T2), E5 (T1, T2) and E6 (T1) still produce reliable readings. A single discrepancies in temperature values can be identified the 18th of September, 2010. Unfortunately, most of the wires in sensors A5, C5, E5 and E6 continuously produce unreliable readings throughout this half year period. Unreliable readings were recorded for sensors 4–6 in G5, and 1–3 and T1 in G6. Noteworthy is that sensors 4–6 in A5 Stopped working the 5th of October (see diagram in Section A10-4.2.1 in this appendix).

Table A10-3. Biaxial stress meter sensors.

| Borehole | Working sensors | Broken/Unreliable sensors | Comments |
|----------|--|--|----------|
| A5 | T1 T2 | Stress inc 1-3 Stress dec 1-3 Stress inc 4-6 Stress dec 4-6 | |
| C5 | T2 | Stress inc 1-3 Stress inc 4-6 Stress dec 1-3 Stress dec 4-6 T1 | |
| E5 | T1 T2 | Stress inc 1-3 Stress inc 4-6 Stress dec 1-3 Stress dec 4-6 | |
| G5 | Stress inc 1-3 Stress dec 1-3 T1 T2 | Stress inc 4-6 Stress dec 4-6 | |
| A6 | Stress inc 1-3 Stress inc 4-6 Stress dec 1-3 Stress dec 4-6 T1 T2 | | |
| C6 | | Stress inc 1-3 Stress inc 4-6 Stress dec 1-3 Stress dec 4-6 T1 T2 | |
| E6 | T1 | Stress inc 1-3 Stress inc 4-6 Stress dec 1-3 Stress dec 4-6 T2 | |
| G6 | Stress inc 4-6 Stress dec 4-6 T2 | Stress inc 1-3 Stress dec 1-3 T1 | |

A10.4.1.2 Soft inclusion stress cell

All stress sensors, with the exception of D6Soft_2 and H6Soft_2 are still working and show relatively stable values throughout this period (Table A10-4). The contact with the sensor in D6Soft_1 is unreliable producing sporadic obviously erroneous values (see diagrams in Section A10-4.2.2 in this appendix). H6Soft_1 is the sole soft inclusion stress cell continuously producing reliable values in connection to deposition hole 6 whereas all the sensors in connection to deposition hole 5 produce reliable values. The temperature is not used for the calculation of changes in diameter from soft inclusion stress cells.

The temperature sensors generally give more unstable readings compared to earlier readings. Noteworthy is that temperature sensor D5Soft_2T stabilise in September and show a stepwise decline of temperature starting in November. Temperature sensors H6Soft_2T produce a behaviour that is within range of the sensor but is probably an effect of the demolition of the experiment i.e. it should be very carefully scrutinized before use just like D5Soft_2T (see diagrams in Section A10.4.2.2 in this appendix).

Table A10-4. Soft inclusion stress cell sensors.

| Borehole | Working sensors | Broken/Unreliable sensors | Comments |
|----------|-----------------------------------|---------------------------|---|
| D5 | D5Soft_1 D5Soft_2 D5Soft_2T | D5Soft_1T | D5Soft_2T shows unstable readings all through the period. |
| H5 | H5Soft_1 H5Soft_2 H5Soft_1T | H5Soft_2T | H5Soft_2T shows unreliable readings throughout the period. |
| D6 | D6Soft_1 (D6Soft_2T) | D6Soft_1T D6Soft_2 | D6Soft_2 shows unreliable readings throughout the whole period. D6Soft_1T shows unreliable readings throughout the whole period. D6Soft_2T shows unreliable readings throughout the whole period. |
| H6 | H6Soft_1 H6Soft_2T | H6Soft_2 H6Soft_1T | H6Soft_2T shows unstable readings all through the period |

A10.4.1.3 Deformation measurements in vertical primary boreholes

The 13 deformation meters that function generally display stable readings with no or small changes with the disparity if sensor E5Def_1. The sensor E5Def_2 stopps sending values abruptly around the 24th of September 2010. Unfortunately, E5Def_4, C5Def_2, C5Def_3 and temperature sensors: C5Def_3T, E5Def_2T, E5Def_4T, G5Def_1T and G5Def_2T are still recording unreliable readings throughout this period (Table A10-5). (see diagrams in Section A10.4.2.3 in this appendix).

As the temperature sensor (A5Def_2T) for sensor A5Def_2 has been out of order since 2004-10-24, the temperature reading from sensor C5Def_2T was used for the calculation. The temperature sensor C5Def_2T has also been used for the calculations for E5Def_2 as well as for sensor C5Def_2. Unfortunately temperature sensor C5Def_2T stops functioning the 4th of december 2010. Temperature sensors from strain-sensors G5Strain_1T and G5Strain_2T replace sensors G5Def_1T and G5Def_2T for the calculations of deformation from sensors G5Def_1 and G5Def_2 respectively.

The replacing temperatures have been derived from temperature sensors in the vicinity of the deformation sensor.

The sensors around Deposition hole 6 still function.

Table A10-5. Deformation sensors in primary vertical boreholes.

| Borehole | Working sensors | Broken/Unreliable sensors | Comments |
|----------|---|---|----------|
| A5 | A5Def_1 A5Def_2 A5Def_1T | A5Def_2T | |
| C5 | C5Def_1 C5Def_1T | C5Def_2 C5Def_2T(from 4th Dec 2011) C5Def_3 C5Def_3T | |
| E5 | E5Def_1 E5Def_3 E5Def_1T E5Def_2T E5Def_3T | E5Def_2 E5Def_4 E5Def_4T | |
| G5 | G5Def_1 G5Def_2 | G5Def_1T G5Def_2T | |
| C6 | C6Def_1 C6Def_2 C6Def_3 C6Def_1T C6Def_2T C6Def_3T | | |
| E6 | E6Def_1 E6Def_2 E6Def_3 E6Def_1T E6Def_2T E6Def_3T | | |

A10.4.1.4 Strain measurements in vertical primary boreholes

The strain sensors are still working except the temperature sensor A5Strain_1T (Table A10-6). This half year period shows a similar stable pattern to last period (see diagrams in Section A10.4.2.4 in this appendix). For sensors A6Strain_1, E6Strain_1 and G5Strain_2 the unstable nature of the temperature readings is the sole cause of the unstable appearance of the strain in the diagram. These three sensors are perhaps candidates for using temperature values from different temperature sensors. A similar pattern can be observed for sensors A5Strain_1 and G5Strain_1 although here the variations seen in the strain values are not depending on the temperature.

The results for A5Strain_1 have been calculated using the temperature values from A5Strain_2T as the temperature sensor A5Strain_1T produce unreliable values. The temperature values from A5Strain_2T are applied from the time A5Strain_1T started producing unreliable values (from 2009-12-12).

A10.4.1.5 Deformation measurements in D5 horizontal complementary boreholes

In the horizontal complementary boreholes around deposition hole 5, six sensors out of 16 are still generating reliable values (Table A10-7).

On level 3.5 (as seen in Figure A10-5) there is one sensor (located in borehole 1) out of eight generating reliable values for deformation, whereas there are five out of eight deformation sensors producing reliable deformation values on level 6 (see diagrams in Section A10.4.2.5 in this appendix).

All the temperature sensors give reliable values contrary to several of the deformation sensors. In borehole 2 on level 3.5 all the deformation sensors are out of order whereas their respective temperature sensor function.

As seen in Table A10-7 there are several sensors where the temperature sensors have been replaced from other sensors. This is of course due to malfunctioning temperature sensors. The temperature readings from Clay Technology sensors installed juxtaposed to our sensors in the borehole has been used for: D5_6_1Def2, D5_6_1Def3, D5_6_2Def2 and D5_6_2Def3. As the number of readings from the Clay-temperature sensors differs from the readings taken by our sensors, the temporally closest value have been used, thus the same temperature value may be used for several sensory readings.

Many of the sensors in the horizontal complementary boreholes for deposition hole 6 is in a similar but interchanged state levelwise to the sensors around deposition hole 5. On level 3.5 (as seen in Figure A10-6) there are five sensors in borehole generating reliable values for deformation, whereas there are 1 out of 8 deformation sensors producing reliable deformation values on level 6 (Table A10-7).

The stable temperature sensor D6_6_2Def1_T is used to calculate results from both sensor D6_6_2Def1 and D6_6_2Def2. Similar to the sensors around deformation hole 5 the unreliable temperature values have been replaced with values from temperatures sensors in the vicinity. For sensor D6_6_2Def3 temperature values from the juxtaposed temperature sensor installed by Clay Technology were used.

Table A10-6. Strain sensors in primary vertical boreholes.

| Borehole | Working sensors | Broken/Unreliable sensors | Comments |
|----------|--|---------------------------|----------|
| A5 | A5Strain_1 A5Strain_2 A5Strain_2T | A5Strain_1T | |
| C5 | C5Strain_1 C5Strain_1T | | |
| G5 | G5Strain_1 G5Strain_2 G5Strain_1T G5Strain_2T | | |
| A6 | A6Strain_1 A6Strain_1T | | |
| E6 | E6Strain_1 E6Strain_1T | | |

Table A10-7. Deformation sensors in complementary horizontal boreholes in D5 and D6.

| Borehole | Working sensors | Broken/Unreliable sensors | Comments |
|-----------|---|---|---|
| D5:3.5(1) | D5_35_1Def_2 D5_35_1Def_1T D5_35_1Def_3T D5_35_1Def_4T | D5_35_1Def_1 D5_35_1Def_3 D5_35_1Def_4 D5_35_1Def_2T | D5_35_1Def_1T was used to calculate D5_35_1Def_2. |
| D5:3.5(2) | D5_35_2Def2T D5_35_2Def3T D5_35_2Def4T | D5_35_2Def1 D5_35_2Def2 D5_35_2Def3 D5_35_2Def4 D5_35_2Def1T | Temperature sensor TR5044 was used to calculate both D5_6_2Def_2 and D5_6_2Def_3. |
| D5:6(1) | D5_6_1Def2 D5_6_1Def3 D5_6_1Def4 D5_6_1Def4T | D5_6_1Def1 D5_6_1Def1T D5_6_1Def2T D5_6_1Def3T | Temperature sensor TR5054 was used to calculate D5_6_1Def_2 and TR5053 was used for D5_6_1Def_3. |
| D5:6(2) | D5_6_2Def3 D5_6_2Def4 D5_6_2Def3T D5_6_2Def4T | D5_6_2Def1 D5_6_2Def2 D5_6_2Def1T D5_6_2Def2T | |
| D6:3.5(1) | D6_35_1Def2 D6_35_1Def3 D6_35_1Def1T D6_35_1Def2T D6_35_1Def3T D6_35_1Def4T | D6_35_1Def1 D6_35_1Def4 | |
| D6:3.5(2) | D6_35_2Def2 D6_35_2Def3 D6_35_2Def4 D6_35_2Def1T D6_35_2Def2T D6_35_2Def3T D6_35_2Def4T | D6_35_2Def1 | |
| D6:6(1) | D6_6_1Def2 D6_6_1Def3 D6_6_1Def1T D6_6_1Def4T | D6_6_1Def1 D6_6_1Def4 D6_6_1Def2T D6_6_1Def3T | Temperature sensor TR6055 was used to calculate D6_6_1Def2. |
| D6:6(2) | D6_6_2Def1T | D6_6_2Def1 D6_6_2Def2 D6_6_2Def3 D6_6_2Def4 D6_6_2Def2T D6_6_2Def3T D6_6_2Def4T | Throughout the period D6_6_2Def1T is stable, D6_6_2Def3T is unstable and the other two temperature sensors are broken. D6_6_2Def1T was used to calculate D6_6_2Def2 and temperature sensor TR6044 was used for D6_6_2Def3. |

A10.4.1.6 Strain measurements in complementary boreholes

The readings from the functioning strain gauges (strain-gage D5_0Str_2 (partially), D5_0Str_4) in deposition hole 5 are stable with a rather steady temperature (decreasing with 0.5°C). Sensor D5_0Str_2 display a rather remarkable behaviour during this half year period, thus this sensor is now considered out of service. The sensors D5_0Str_1 and D5_0Str_3 are still showing unreliable values, and have been doing so since the beginning of the experiment 2003-04-30, respectively (Table A10-8).

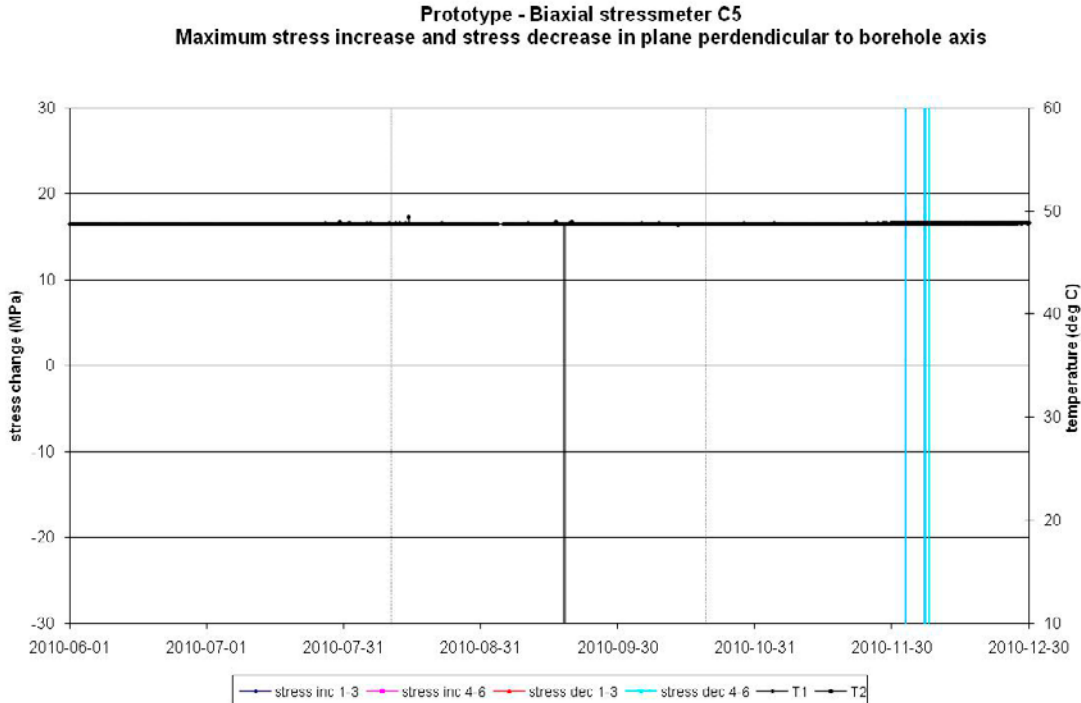
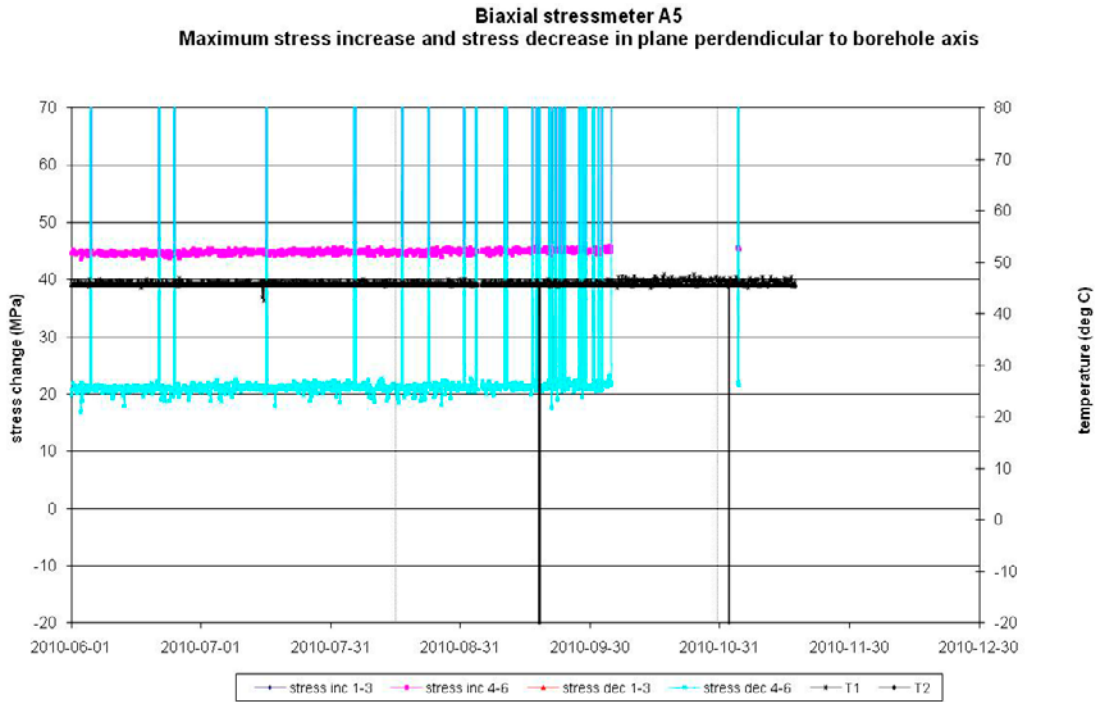
Regarding deposition hole 6 the general tendency shows unstable readings.

Table A10-8. Strain sensors in complementary vertical boreholes in D5 and D6.

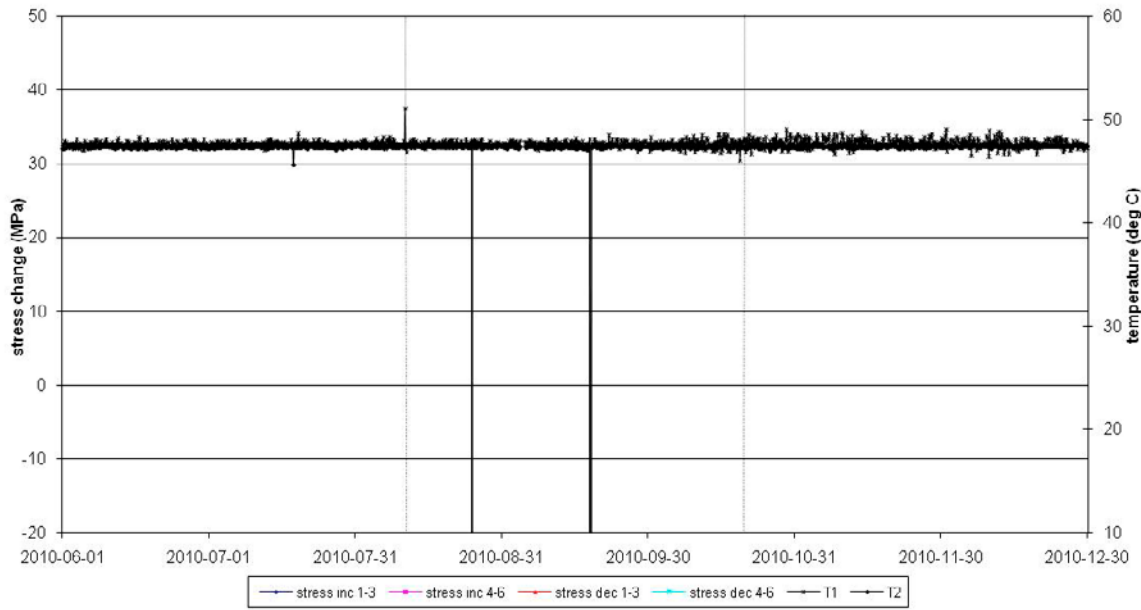
| Borehole | Working sensors | Broken/Unreliable sensors | Comments |
|----------|--|---------------------------|---|
| D5 (0) | (D5_0Str_2) D5_0Str_4 D5_0Str_1T D5_0Str_2T D5_0Str_3T D5_0Str_4T | D5_0Str_1 D5_0Str_3 | D5_0Str_2 stops functioning during this period. |
| D6 (0) | D6_0Str_1 D6_0Str_2 D6_0Str_3 D6_0Str_4 D6_0Str_1T D6_0Str_2T D6_0Str_3T D6_0Str_4T | | |

A10.4.2 Graphical presentation of results

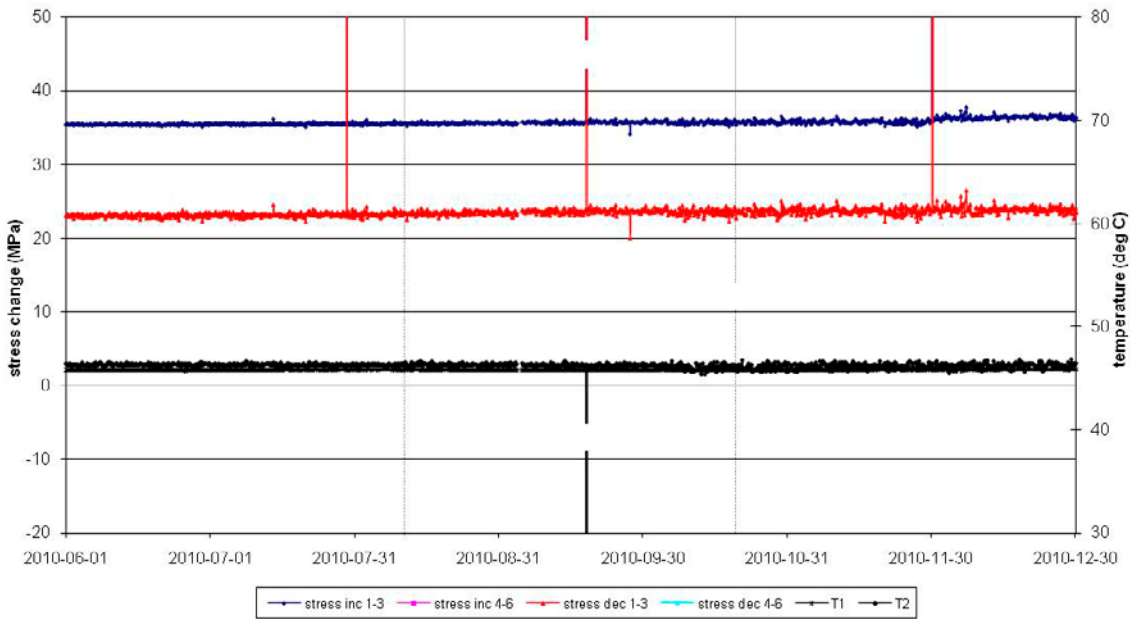
A10.4.2.1 Biaxial Stressmeter results



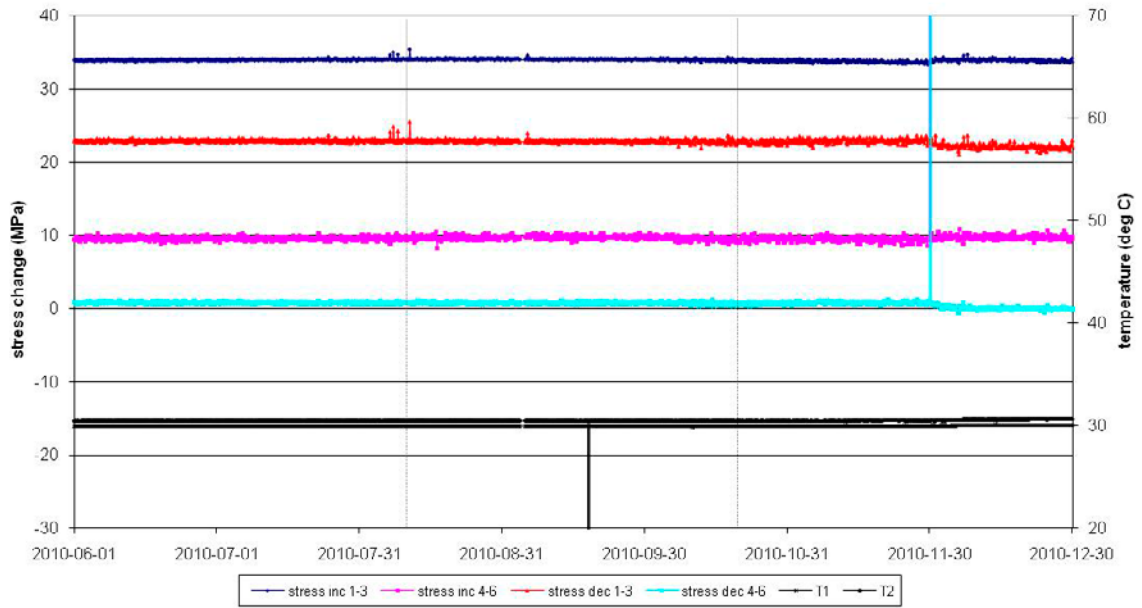
Biaxial stressmeter E5
 Maximum stress increase and stress decrease in plane perpendicular to borehole axis



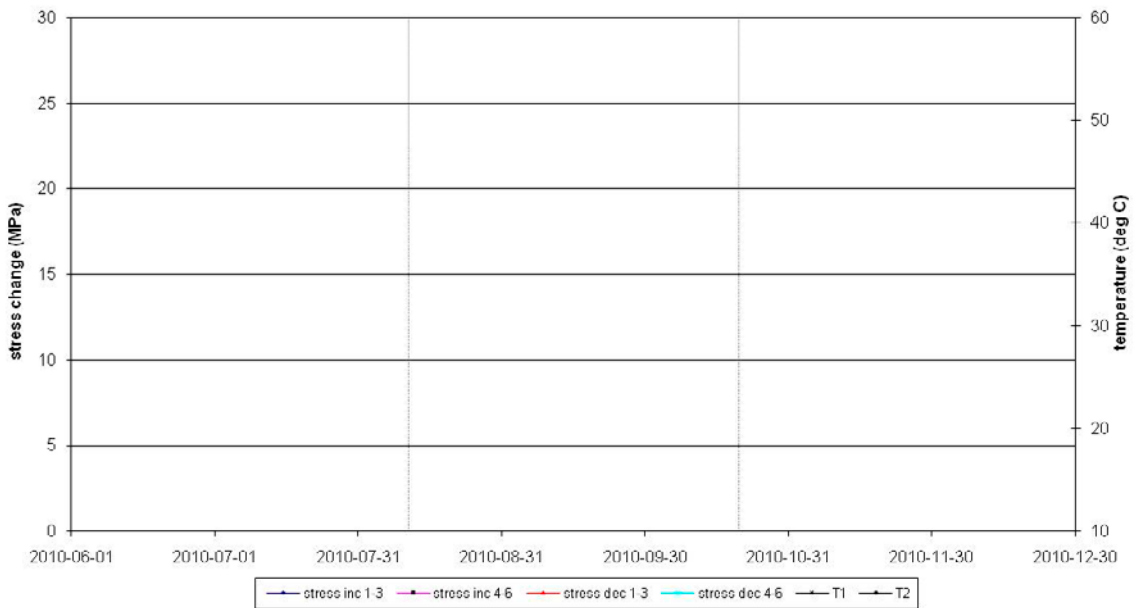
Biaxial stressmeter G5
 Maximum stress increase and stress decrease in plane perpendicular to borehole axis



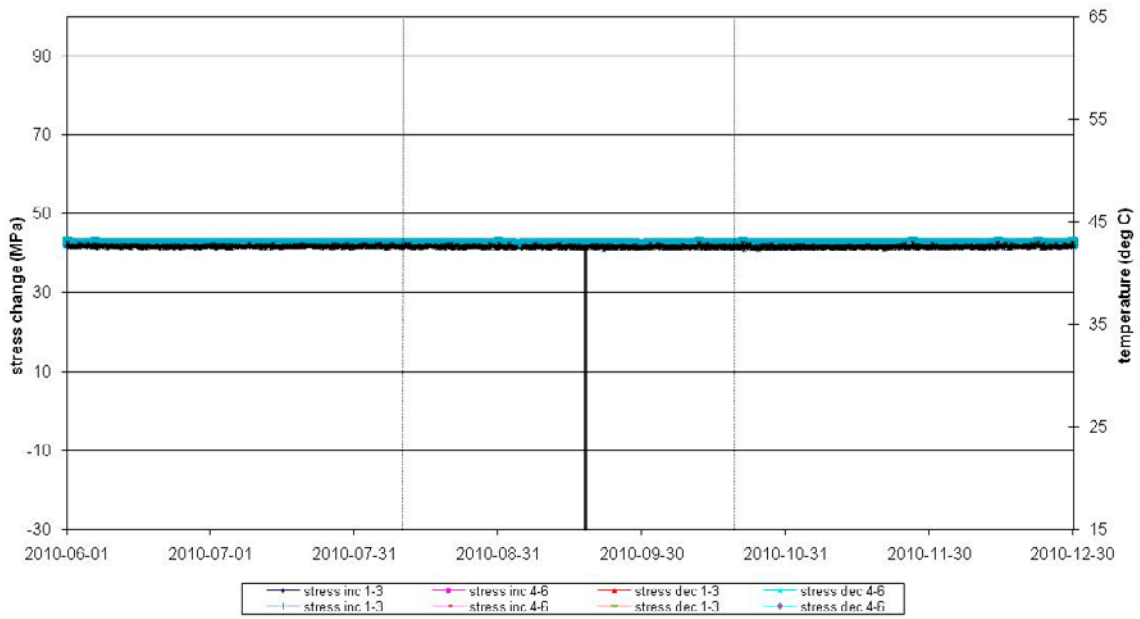
Biaxial stressmeter A6
Maximum stress increase and stress decrease in plane perpendicular to borehole axis



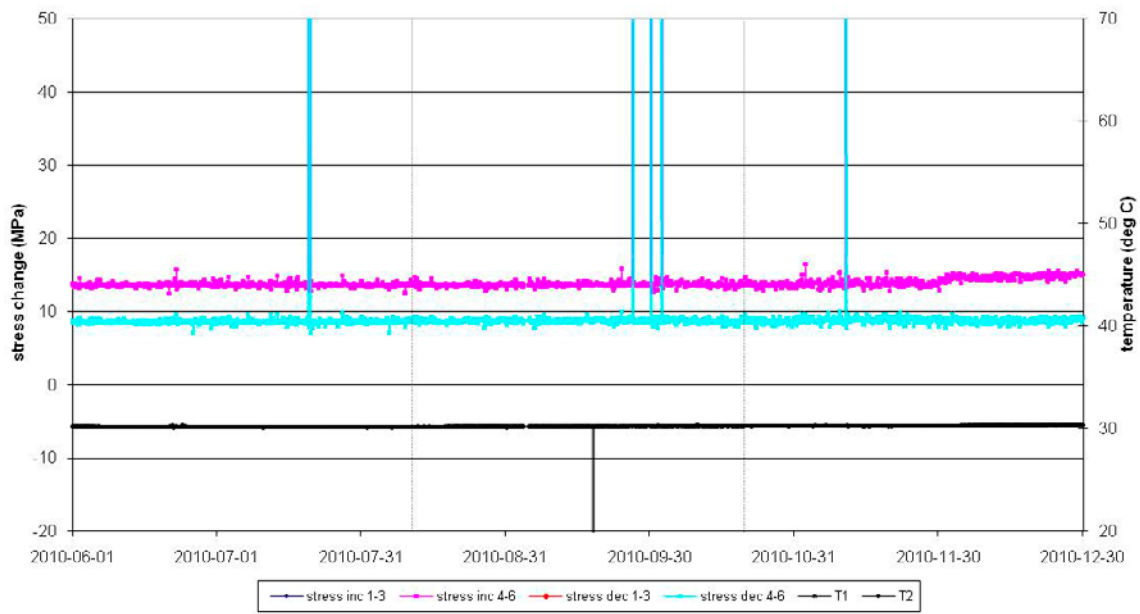
Biaxial stressmeter C6
Maximum stress increase and stress decrease in plane perpendicular to borehole axis



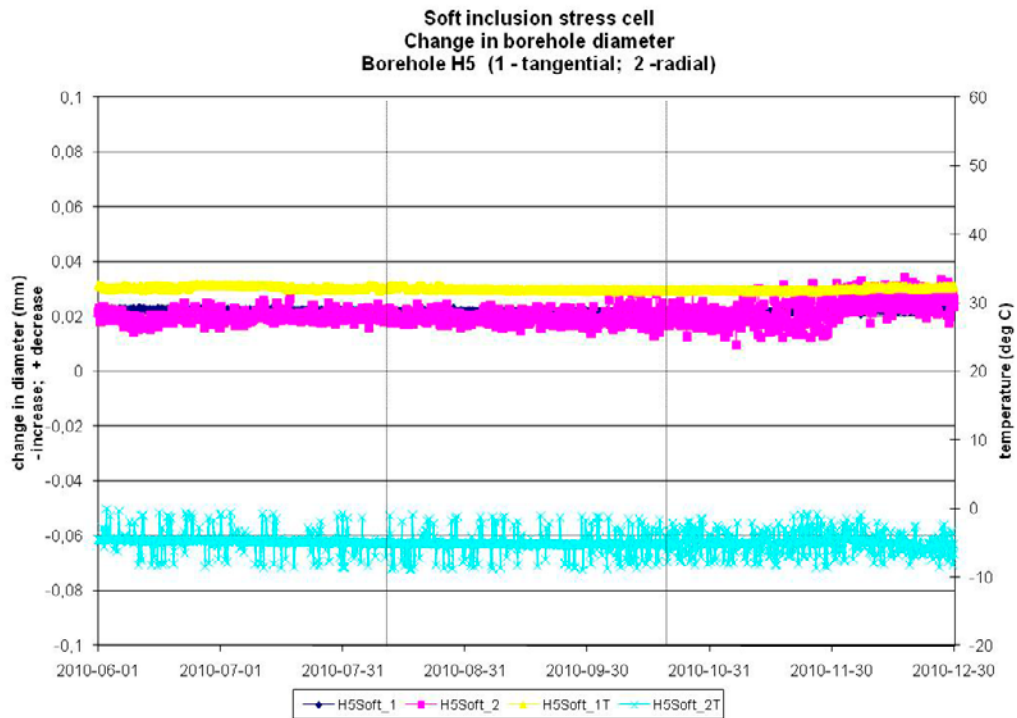
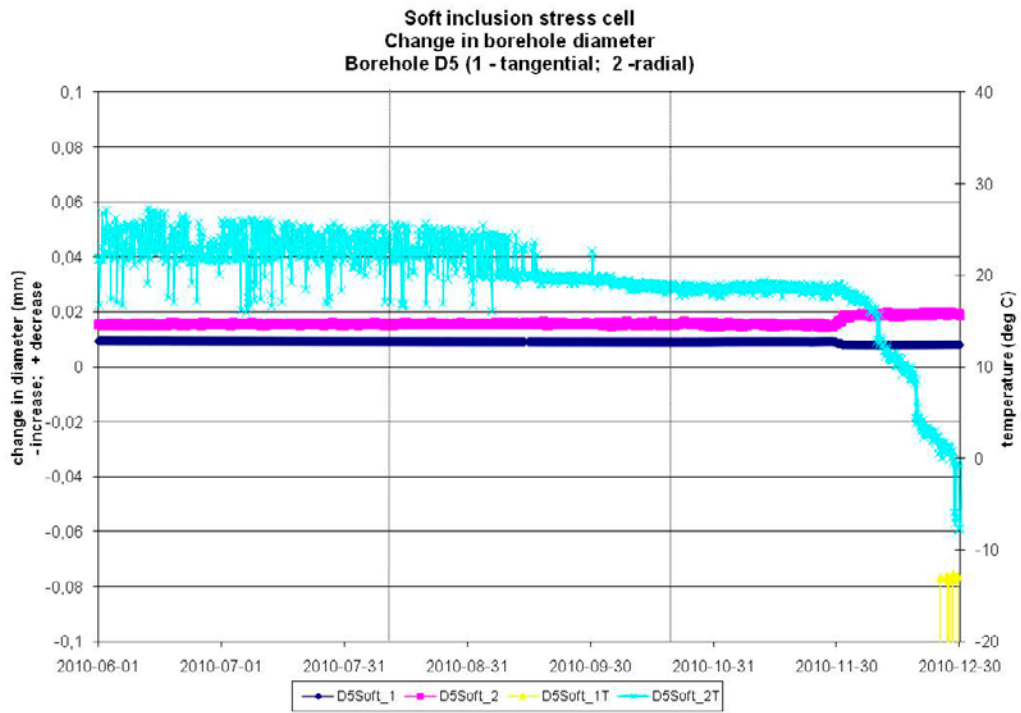
Biaxial stressmeter E6
Maximum stress increase and stress decrease in plane perpendicular to borehole axis

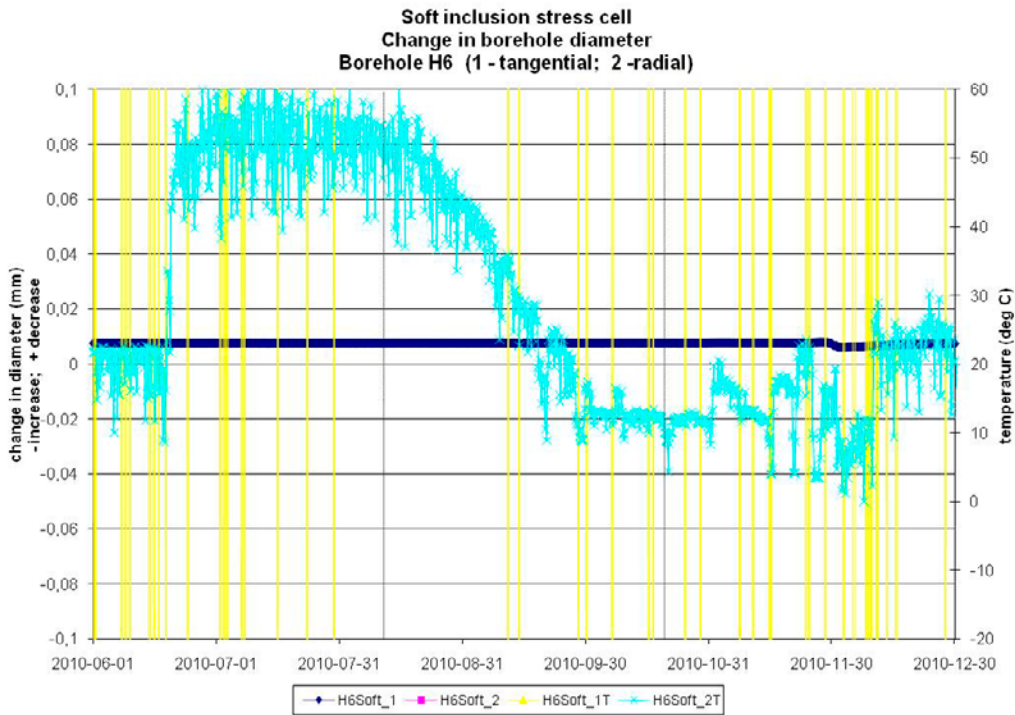
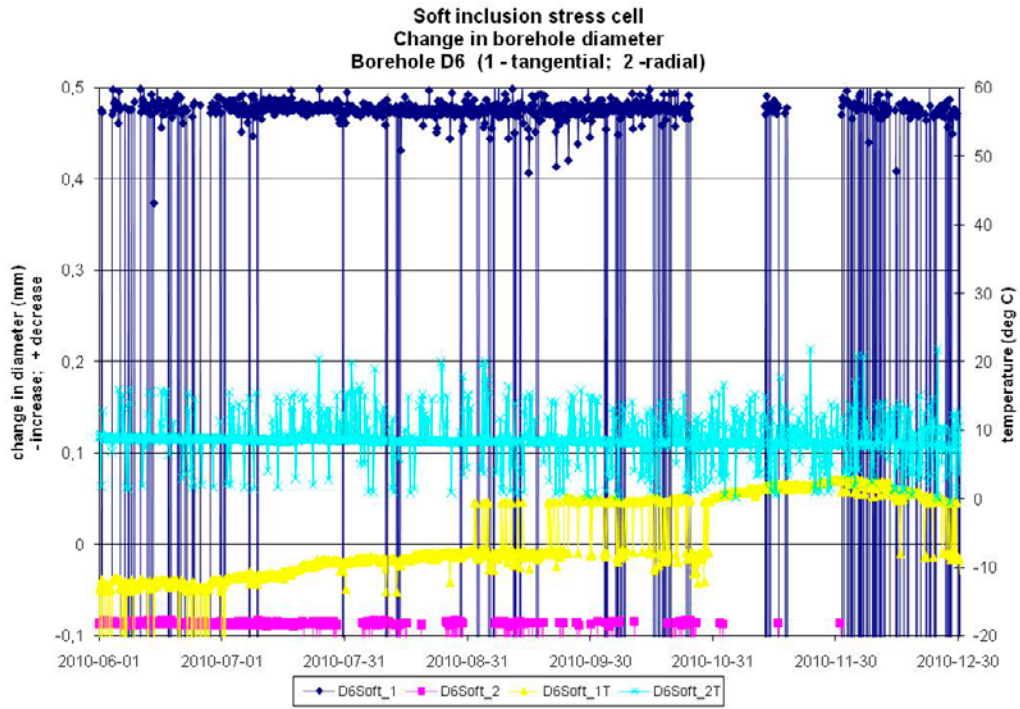


Biaxial stressmeter G6
Maximum stress increase and stress decrease in plane perpendicular to borehole axis



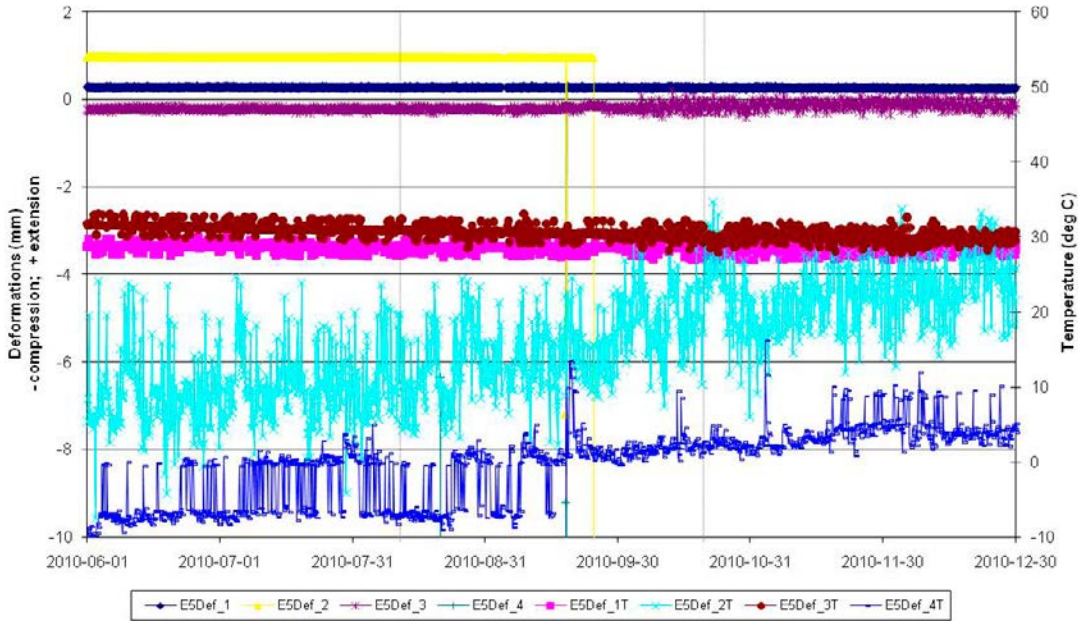
A10.4.2.2 Soft inclusion stress cell results



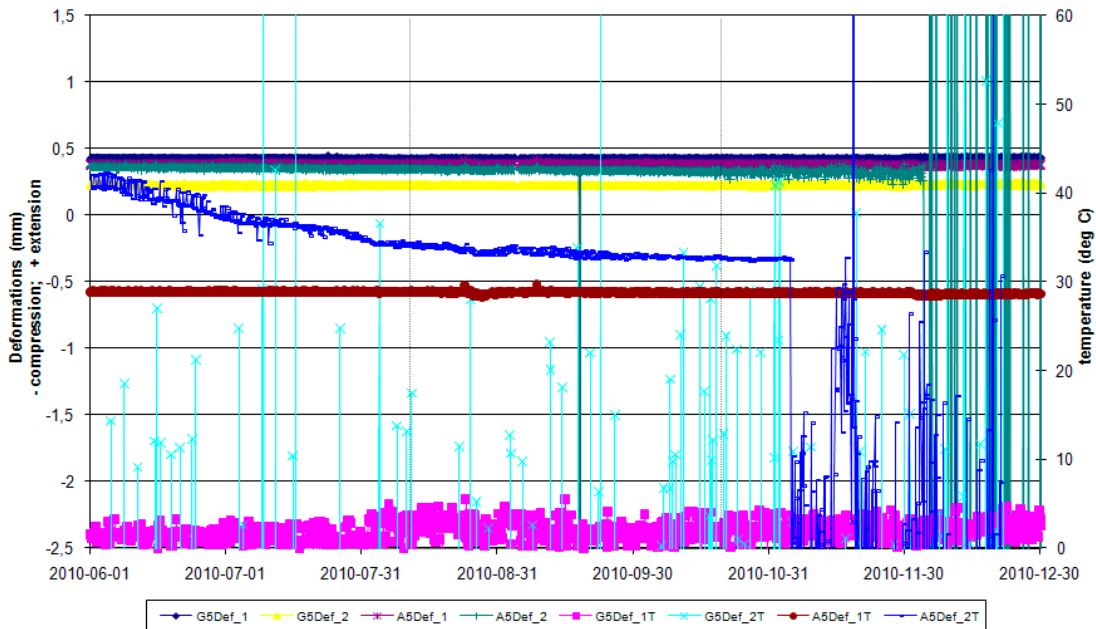


A10.4.2.3 Deformation measurements in vertical primary boreholes

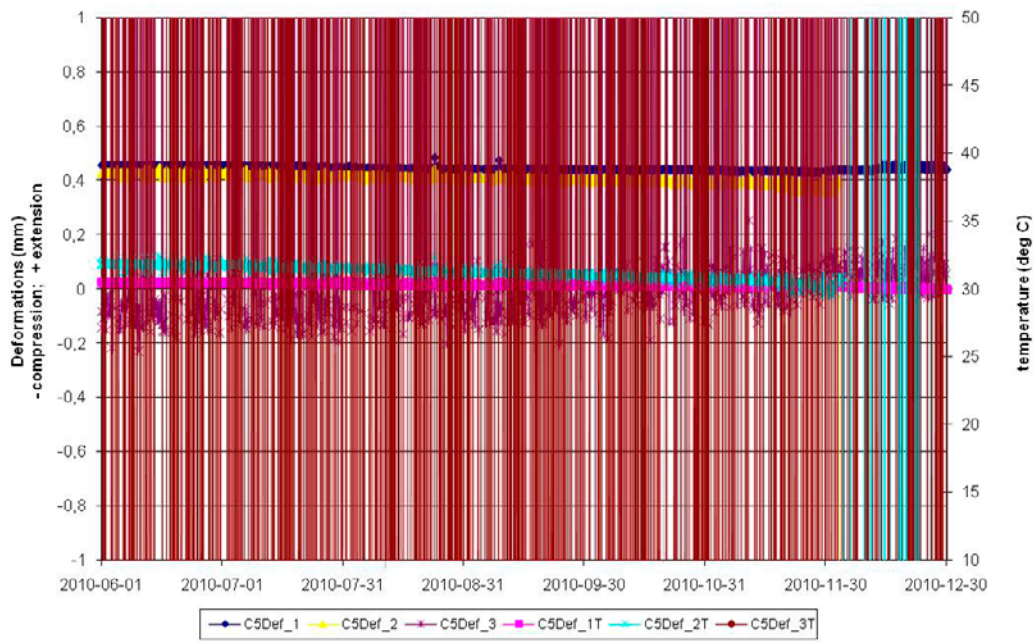
Vertical deformations adjacent to Deposition Hole 5
in Borehole E5



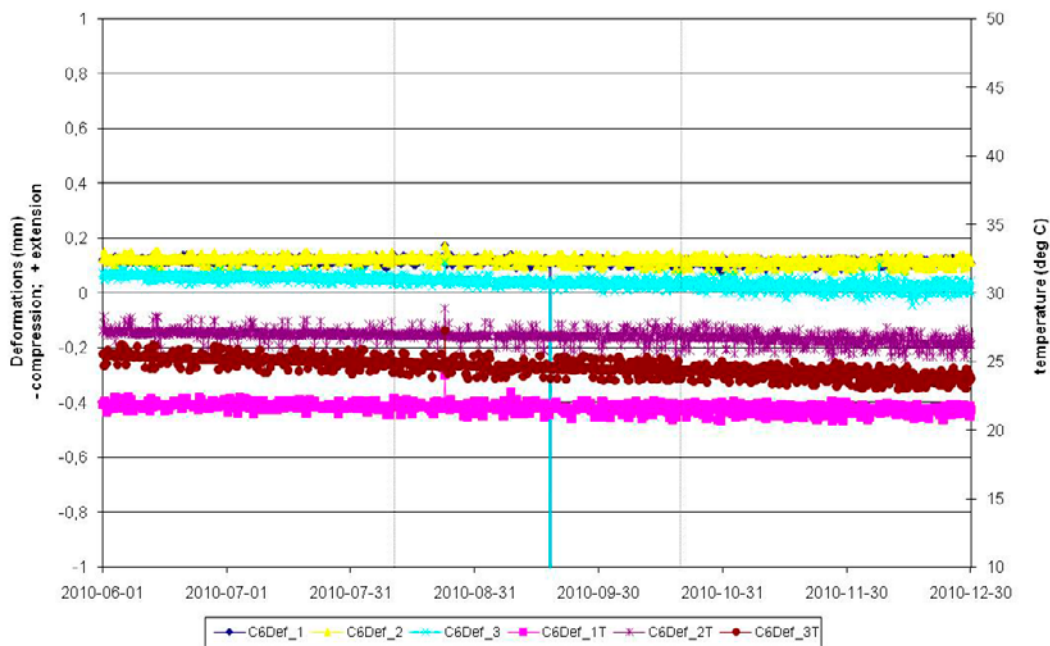
Vertical deformations adjacent to Deposition Hole 5
in Boreholes G5 and A5



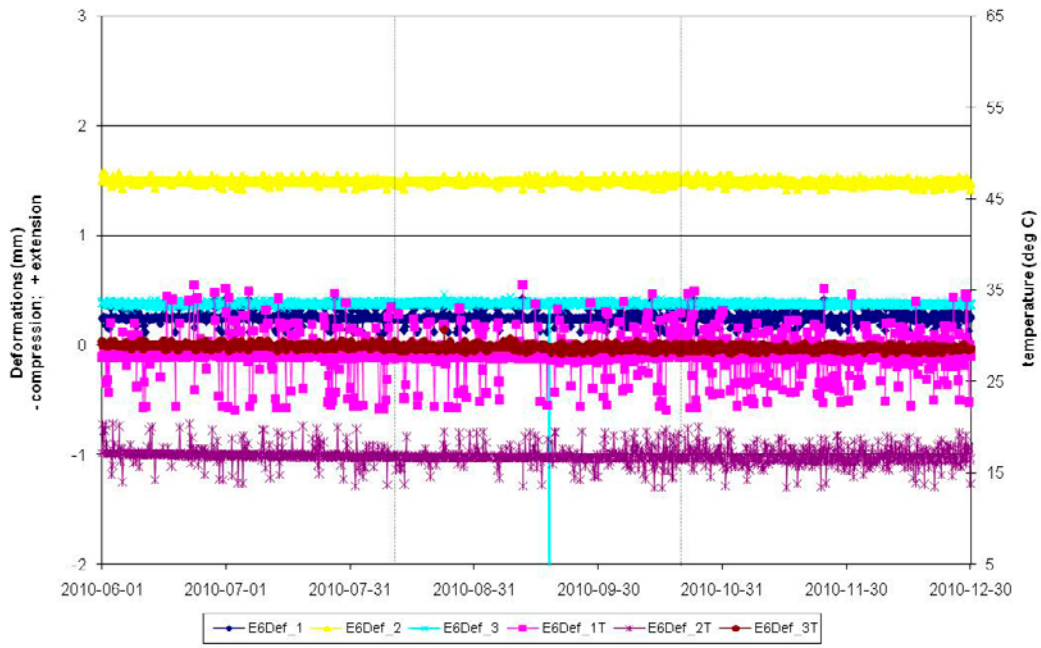
Vertical deformations adjacent to Deposition Hole 5
in borehole C5



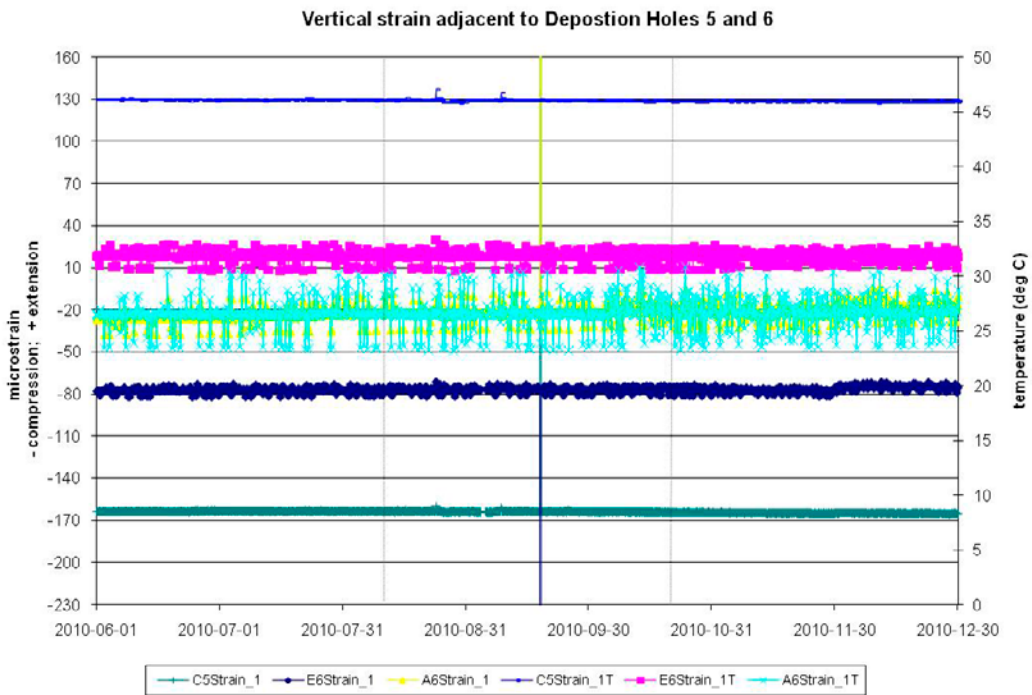
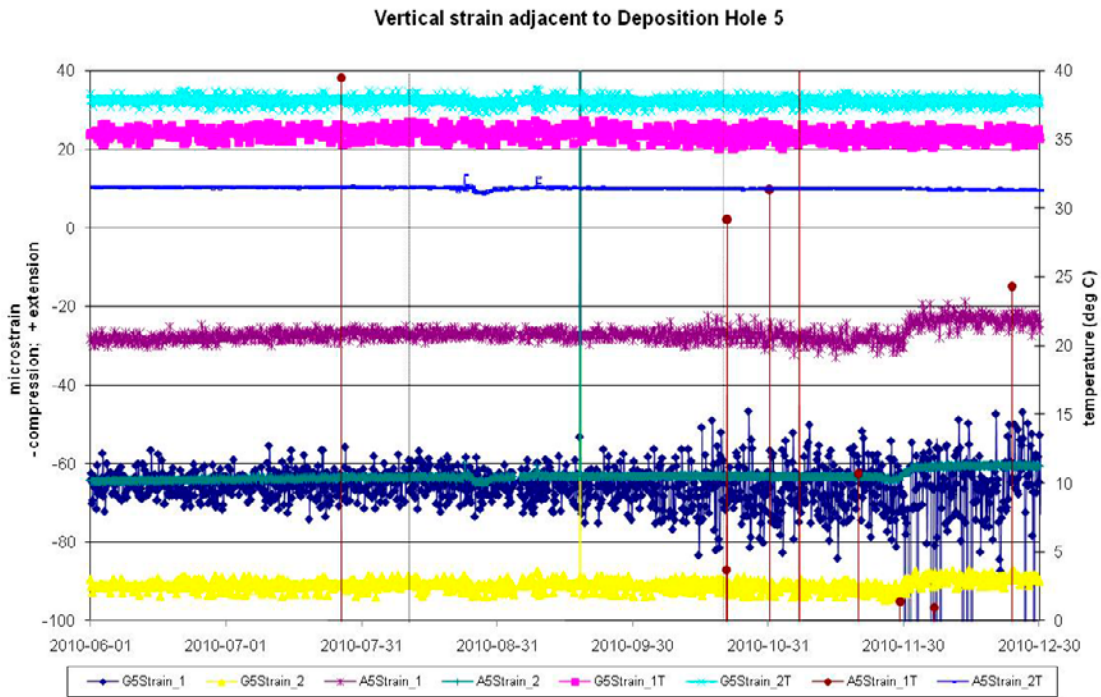
Vertical deformations adjacent to Deposition Hole 6
in borehole C6



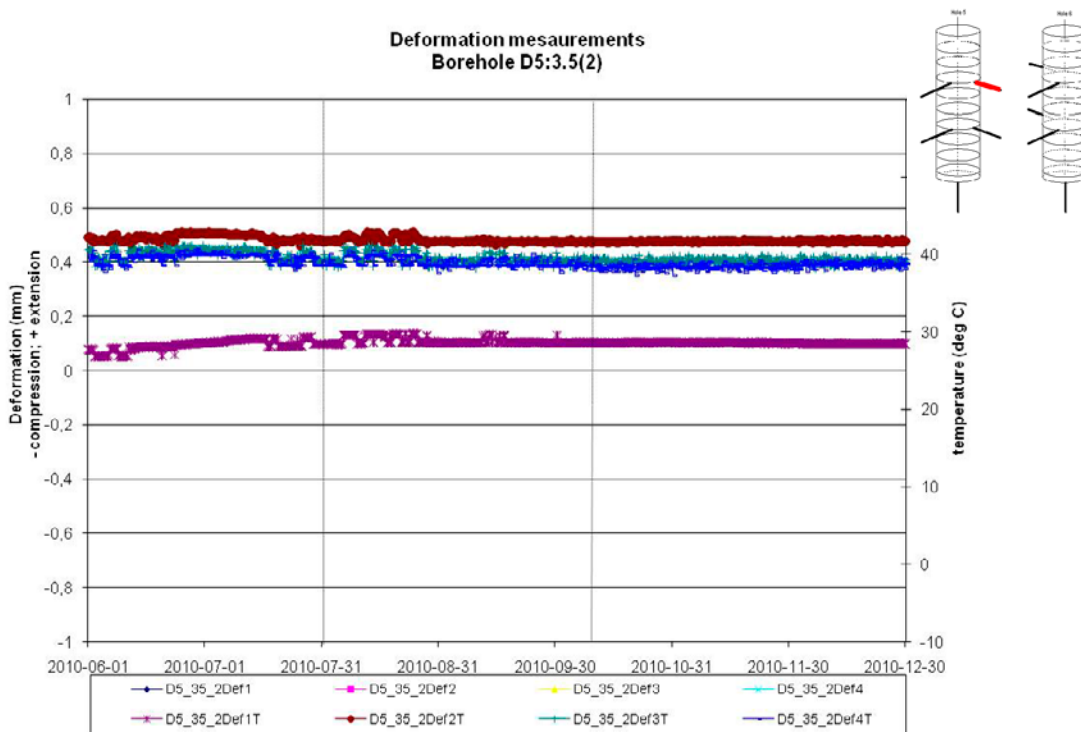
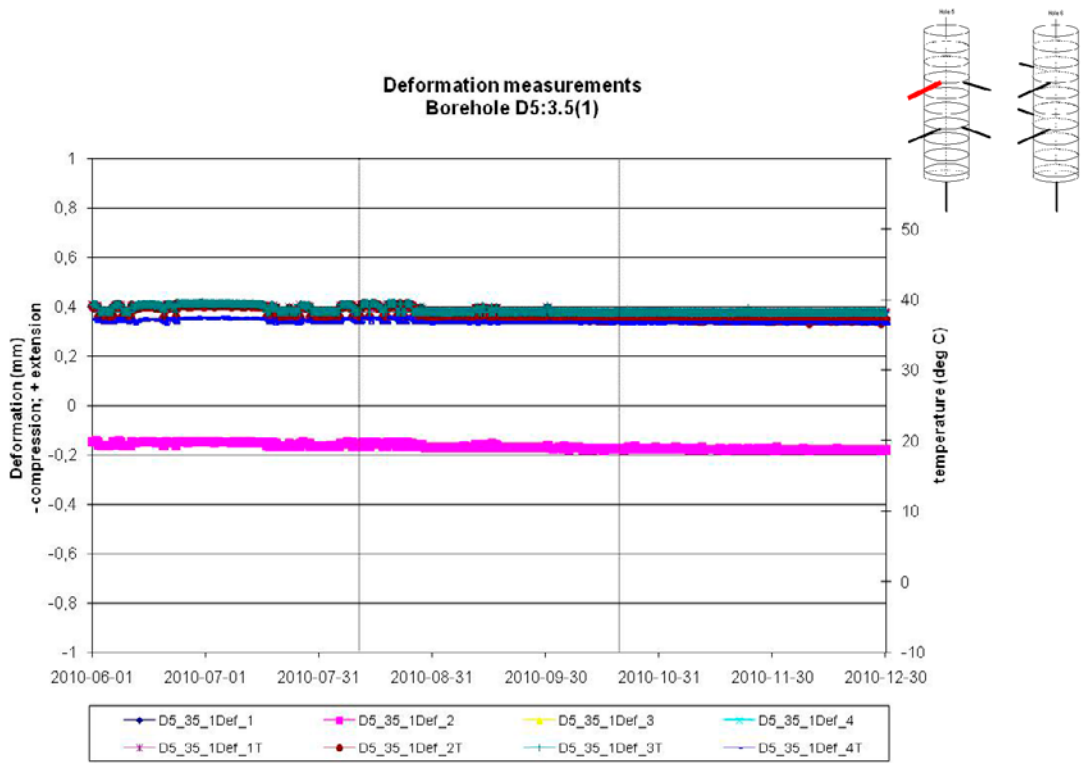
Vertical deformations adjacent to Deposition Hole 6
in borehole E6

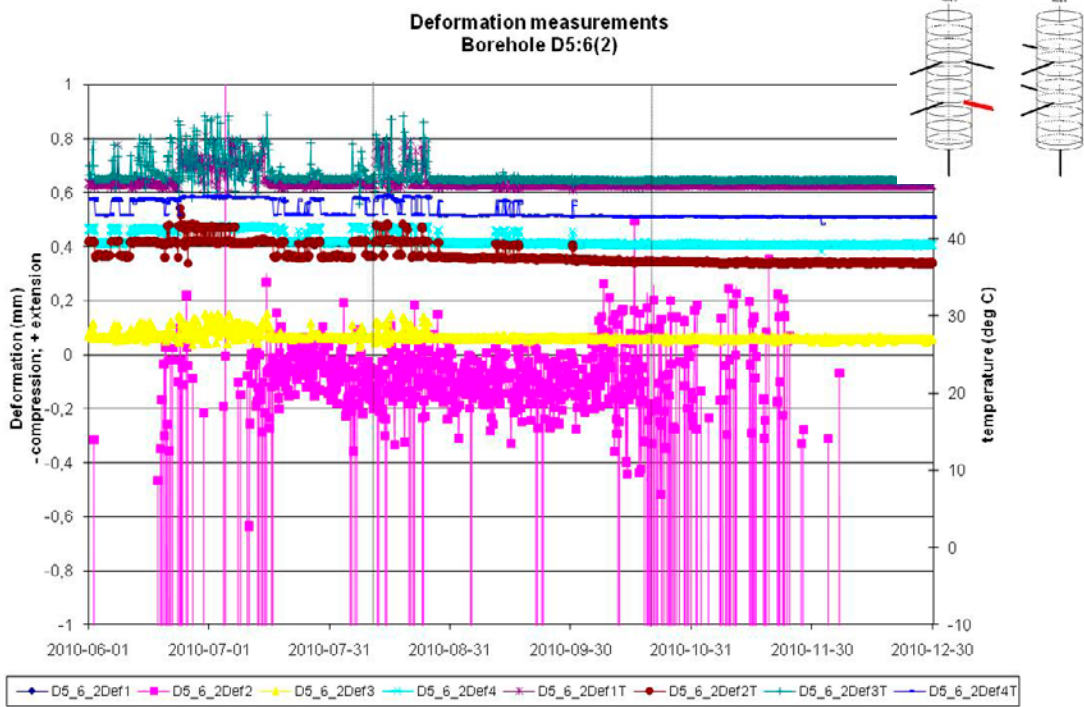
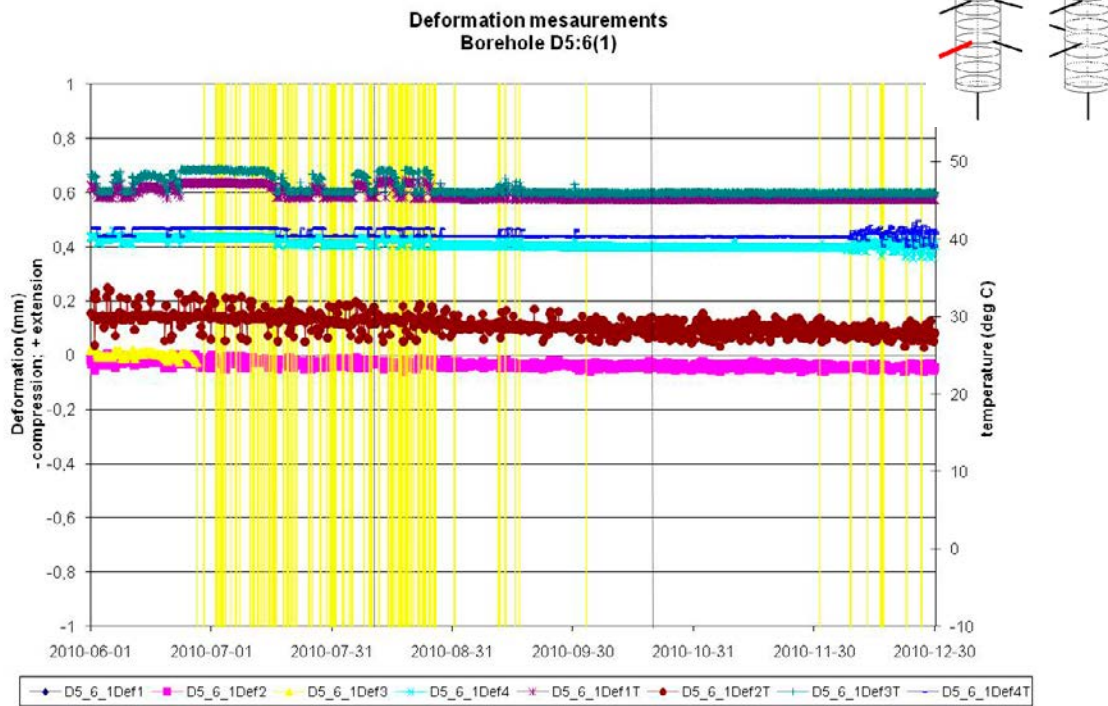


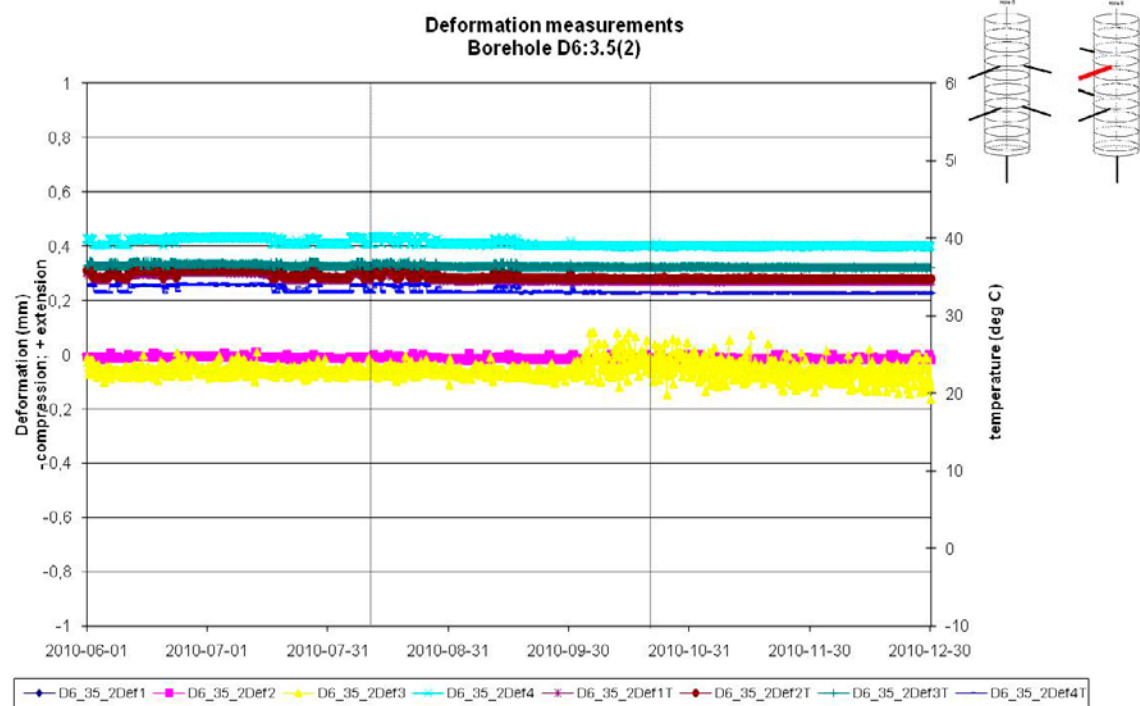
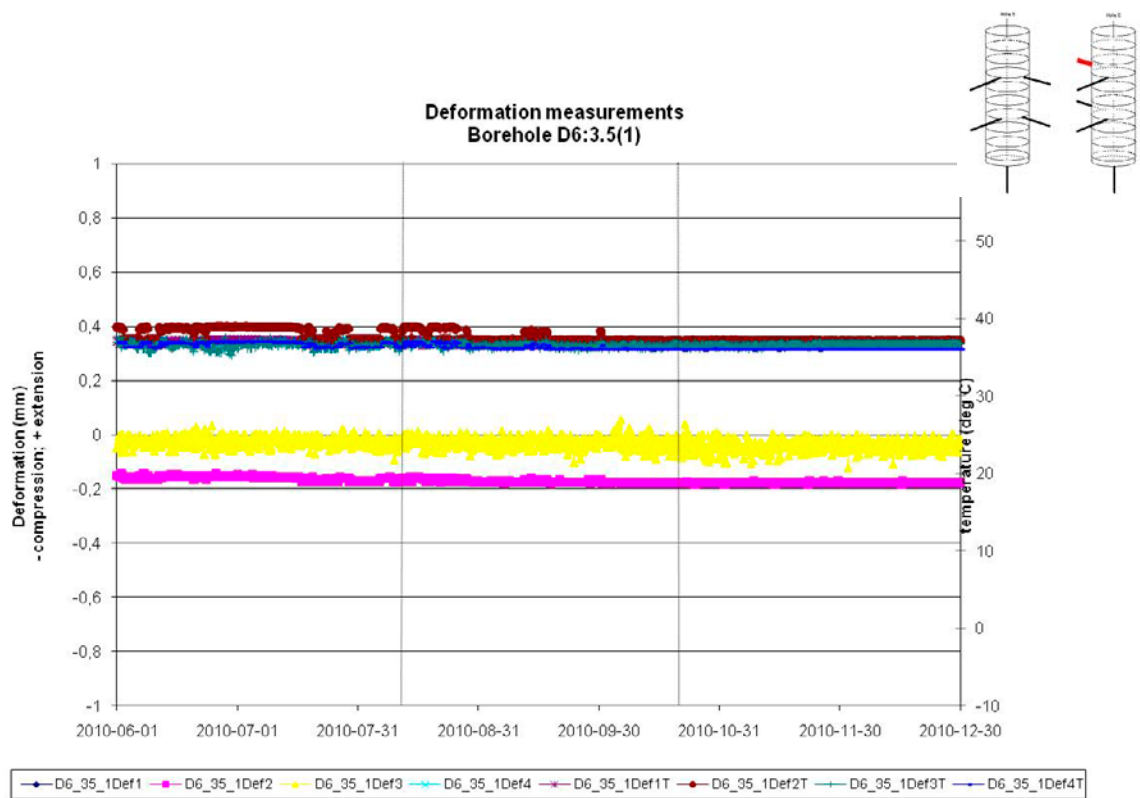
A10.4.2.4 Strain measurements in vertical primary boreholes

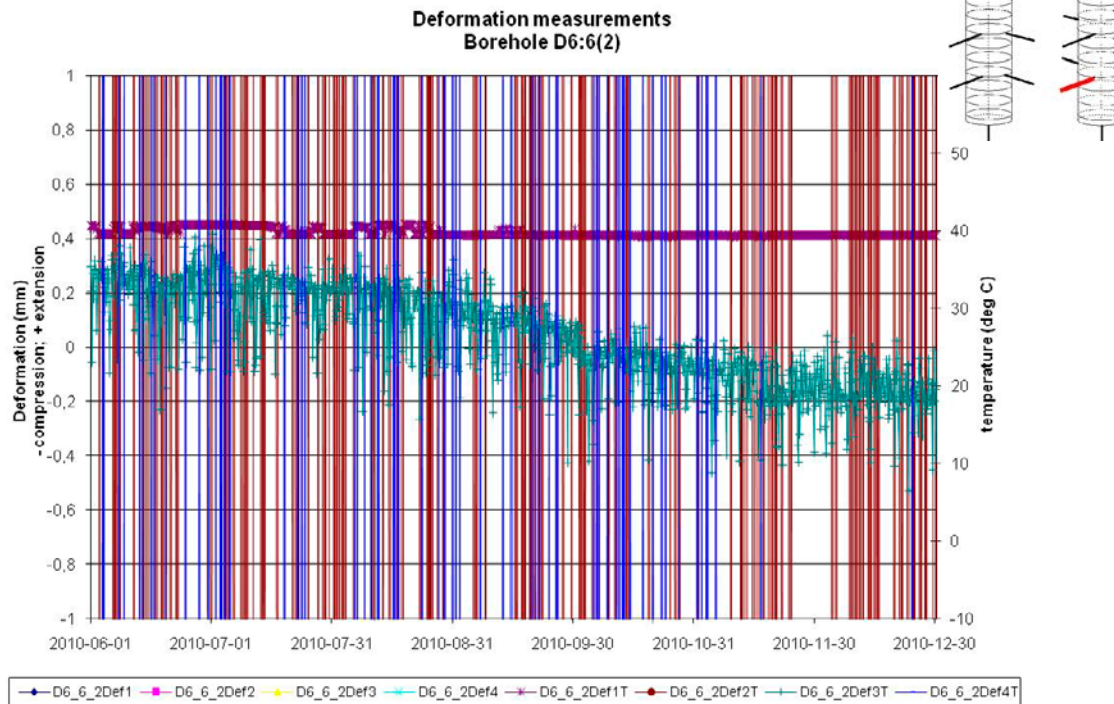
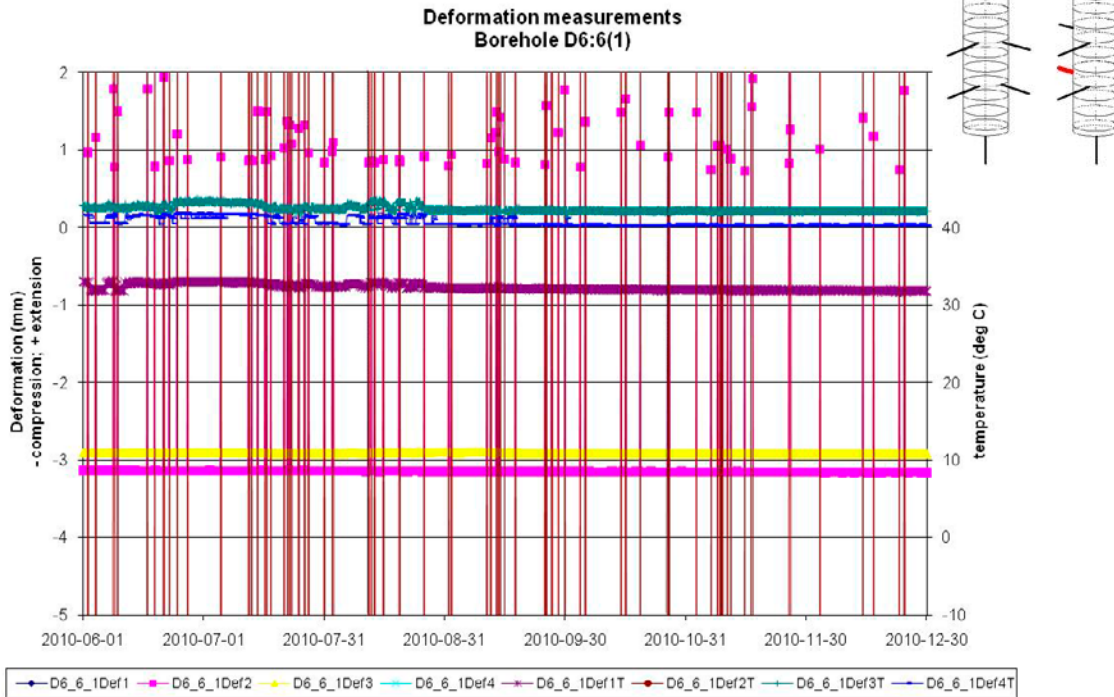


A10.4.2.5 Deformation measurements in horizontal complementary boreholes

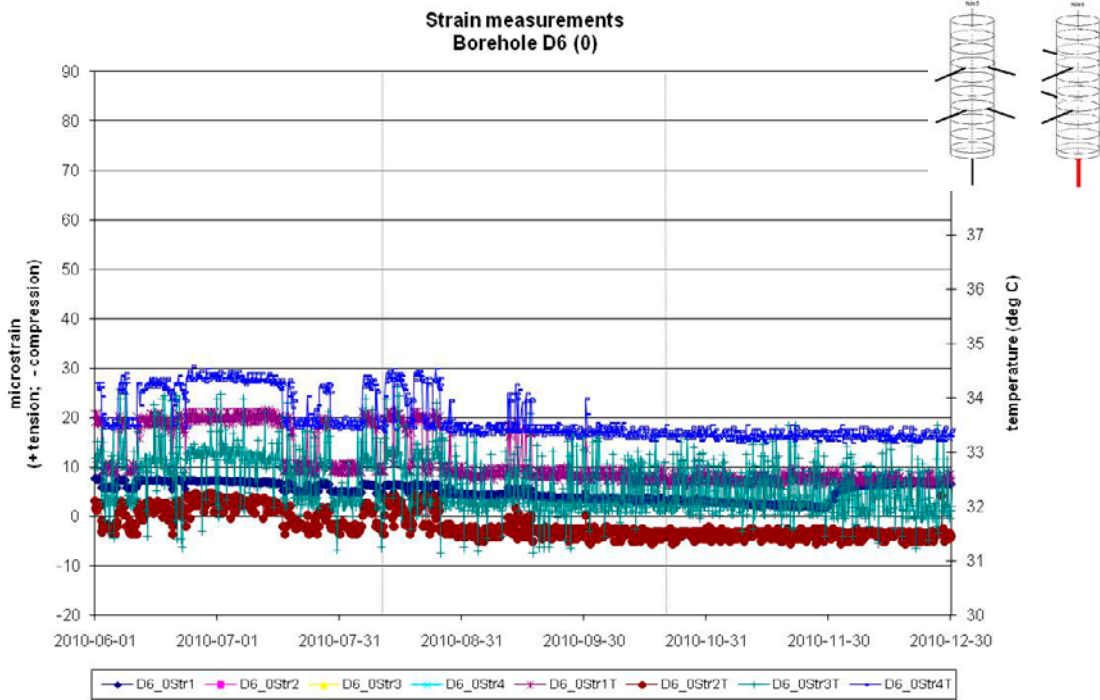
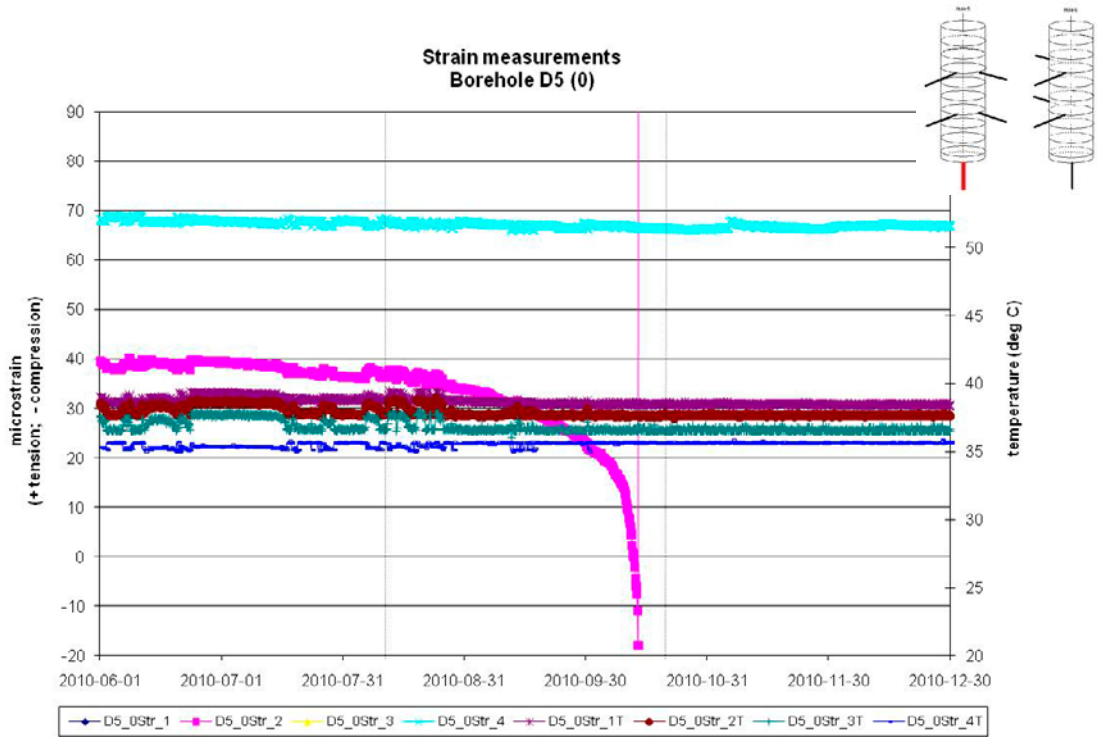








A10.4.2.6 Strain measurements in complementary boreholes



Water pressure in the rock and flow measurements

A11.1 Water pressure measurements in the rock mass

A11.1.1 Introduction

The hydraulic properties of the rock, geometry of tunnels and depositions holes, water pressure far away from the tunnels and the hydro-mechanical properties of the backfill and buffer govern the saturation of the buffer and backfill. It is important to measure the water pressure in the rock for the interpretation of the measurements in the buffer and backfill and to sample data useful for the modelling of the saturation process.

A short summary of the instrumentation follows below. For more details, see Rhén et al. (2001).

A11.1.2 Measurements in the boreholes

A large number of boreholes are instrumented with one or several packers. In all packed-off sections, the water pressure is measured. Each borehole section is connected to a tube of polyamide that via lead-through holes ends in the G-tunnel. All pressure transducers are placed in the G-tunnel to facilitate easy calibration and exchange of transducers that are out of order. The transducers are connected to the HMS system at Äspö Laboratory and it is a flexible system for changing the logging frequency. The maximum scan frequency is 1/second. During periods with no hydraulic tests, preliminary the logging (storing a value in the data base) frequency is 2/hour with an automatic increase of the sampling frequency if the pressure change since last registration is larger than 2 kPa. During hydraulic tests, the sampling frequency is up to 1 logging every 3rd second (maximum logging rate possible).

A11.1.3 Instrumentation with bentonite packers in Section I

Section I will be in operation for a long time, possibly up to 20 years, and there will be no access to the instruments in the boreholes for a long period. It was decided to develop a new type of packer that was not dependent of an external pressure to seal-off the borehole sections. These packers are made of compacted bentonite with rubber coverage. For chemical reasons the bentonite is not allowed to be in contact with the surrounding water in the rock mass and therefore the packers have a cover made of polyurethane (PUR-rubber). This rubber also protected the packers against unwanted wetting during transport and installation. After installing all packers in a borehole, the compacted bentonite was wetted to make it swell and expanded against the borehole wall. This packer system is used in 14 boreholes with a length between 12 and 50 meters in the tunnel floor and the walls, see Rhén et al. (2001).

Due to the expected high temperature near the deposition holes two boreholes (KA3574A and KA3576A) were equipped with stainless steel pipes instead of polyamide tubes.

In some sections used for circulation or hydrochemistry sampling purposes in Section I, a dummy is installed to reduce the water-filled volume of the section. Depending on the purpose the dummies were made either by high-density polyethylene (circulation sections) or PEEK (hydrochemistry sections) material. The dummy consists of two parts, positioned around the centre rod.

The packers were inserted into the borehole with Ø 20 mm massive stainless steel rods. A special designed manual-hoisting rig was used to insert the equipment into the boreholes. When the packers were at their correct position the equipment was attached to a locking device mounted on the tunnel wall at the borehole collar. Before insertion, the equipment was cleaned with a cleaner delivering hot steam (100°C) at high pressure.

The instrument configuration for the boreholes provided with bentonite packers is summarised in Table A11-1 and illustrated in Figures A11-1 and A11-2.

Table A11-1. Instrumentation configuration in Section I. “Lead-through”: pipes between the packers.

| Borehole:sec | Sec. length (m) | Type of section | Type of dummy | Packer length | Lead-through (no:diameter:type) |
|--------------|-----------------|-----------------|---------------|---------------|---------------------------------|
| KA3563G:1 | 15–30.01 | P | | 2 m | 1:6/4:PA |
| KA3563G:2 | 10–13 | P | | 2 m | 2:6/4:PA |
| KA3563G:3 | 4–8 | P | | 1 m | 3:6/4:PA |
| KA3563G:4 | 1.5–3 | P, C | HD | 1 m | 6:6/4:PA |
| KA3566G01:1 | 23.5–30.01 | P | | 2 m | 1:6/4:PA |
| KA3566G01:2 | 20–21.5 | P, C | HD | 2 m | 4:6/4:PA |
| KA3566G01:3 | 12–18 | P | | 2 m | 5:6/4:PA |
| KA3566G01:4 | 7.3–10 | P | | 1 m | 6:6/4:PA |
| KA3566G01:5 | 1.5–6.3 | P, F | | 1 m | 8:6/4:PA |
| KA3566G02:1 | 19–30.1 | P | | 1 m | 1:6/4:PA |
| KA3566G02:2 | 16–18 | P, C | HD | 2 m | 4:6/4:PA |
| KA3566G02:3 | 12–14 | P | | 1 m | 5:6/4:PA |
| KA3566G02:4 | 8–11 | P | | 2 m | 6:6/4:PA |
| KA3566G02:5 | 1.3–6 | P, F | | 1 m | 8:6/4:PA |
| KA3572G01:1 | 7.3–12.03 | P | | 2 m | 1:6/4:PA |
| KA3572G01:2 | 2.7–5.3 | P, C | HD | 2 m | 4:6/4:PA |
| KA3573A:1 | 26–40.07 | P | | 2 m | 1:6/4:PA |
| KA3573A:2 | 21–24 | P, F | | 2 m | 3:6/4:PA |
| KA3573A:3 | 14.5–19 | P | | 2 m | 4:6/4:PA |
| KA3573A:4 | 10.5–12.5 | P, F | | 2 m | 6:6/4:PA |
| KA3573A:5 | 1.3–8.5 | P | | 1 m | 7:6/4:PA |
| KA3574G01:1 | 8–12.03 | P | | 1 m | 1:6/4:ST |
| KA3574G01:2 | 5.1–7 | P | | 1 m | 2:6/4:ST |
| KA3574G01:3 | 1.8–4.1 | P, C | HD | 1 m | 5:6/4:ST |
| KA3576G01:1 | 8–12.01 | P | | 2 m | 1:6/4:ST |
| KA3576G01:2 | 4–6 | P, HC | PE | 1 m | 2:6/4:ST, 1:1/8"/2:PE |
| KA3576G01:3 | 1.3–3 | P | | 1 m | 3:6/4:ST, 1:1/8"/2:PE |
| KA3578G01:1 | 6.5–12.58 | P | | 1 m | 1:6/4:PA |
| KA3578G01:2 | 4.3–5.5 | P, HC | PE | 2 m | 2:6/4:PA, 1:1/8"/2:PE |
| KA3579G:1 | 14.7–22.65 | P | | 1 m | 1:6/4:PA |
| KA3579G:2 | 12.5–13.7 | P | | 1 m | 2:6/4:PA |
| KA3579G:3 | 2.3–11.5 | P | | 2 m | 3:6/4:PA |
| KA3584G01:1 | 7–12 | P | | 2 m | 1:6/4:PA |
| KA3584G01:2 | 1.3–5 | P | | 1 m | 2:6/4:PA |
| KA3590G01:1 | 16–30 | P | | 1 m | 1:6/4:PA |
| KA3590G01:2 | 7–15 | P, F, F | | 1 m | 4:6/4:PA |
| KA3590G01:3 | 1.3–6 | P, HC | | 1 m | 5:6/4:PA, 1:1/8"/2:PE |
| KA3590G02:1 | 25.5–30.01 | P, F | | 2 m | 2:6/4:PA |
| KA3590G02:2 | 15.2–23.5 | P | | 2 m | 3:6/4:PA |
| KA3590G02:3 | 11.9–13.2 | P, HC | PE | 2 m | 4:6/4:PA, 1:1/8"/2:PE |
| KA3590G02:4 | 1.3–9.9 | P | | 1 m | 5:6/4:PA, 1:1/8"/2:PE |
| KA3593G:1 | 25.2–30.02 | P | | 1 m | 1:6/4:PA |
| KA3593G:2 | 23.5–24.2 | P, HC | PE | 1 m | 2:6/4:PA, 1:1/8"/2:PE |
| KA3593G:3 | 9–22.5 | P | | 2 m | 3:6/4:PA, 1:1/8"/2:PE |
| KA3593G:4 | 3–7 | P, F | | 2 m | 5:6/4:PA, 1:1/8"/2:PE |
| KA3600F:1 | 43–50.1 | P | | 1 m | 1:6/4:PA |
| KA3600F:2 | 40.5–42 | P, HC | PE | 1 m | 2:6/4:PA, 1:1/8"/2:PE |
| KA3600F:3 | 20–39.5 | P | | 2 m | 3:6/4:PA, 1:1/8"/2:PE |
| KA3600F:4 | 1.3–18 | P | | 1 m | 4:6/4:PA, 1:1/8"/2:PE |

| Borehole:sec | Sec. length (m) | Type of section | Type of dummy | Packer length | Lead-through (no:diameter:type) |
|--------------|-----------------|-----------------|---------------|---------------|---------------------------------|
| KA3510A:1 | 125–150 | P | | 1 m | 1:6/4:PA |
| KA3510A:2 | 110–124 | P, F | | 1 m | 3:6/4:PA |
| KA3510A:3 | 75–109 | P | | 1 m | 4:6/4:PA |
| KA3510A:4 | 51–74 | P | | 1 m | 5:6/4:PA |
| KA3510A:5 | 4.5–50 | P | | 1 m | 6:6/4:PA |
| KG0021A01:1 | 42.5–48.82 | P, HC | | 1 m | 1:6/4:ST, 1:1/8"/2:PE |
| KG0021A01:2 | 37–41.5 | P | | 1 m | 2:6/4:PA, 1:1/8"/2:PE |
| KG0021A01:3 | 35–36 | P, C | HD | 1 m | 5:6/4:PA, 1:1/8"/2:PE |
| KG0021A01:4 | 19–34 | P | | 1 m | 6:6/4:PA, 1:1/8"/2:PE |
| KG0021A01:5 | 5–18 | P | | 1 m | 7:6/4:PA, 1:1/8"/2:PE |
| KG0048A01:1 | 49–54.69 | P, HC | | 1 m | 1:6/4:ST, 1:1/8"/2:PE |
| KG0048A01:2 | 34.8–48 | P | | 1 m | 2:6/4:PA, 1:1/8"/2:PE |
| KG0048A01:3 | 32.8–33.8 | P, C | HD | 1 m | 5:6/4:PA, 1:1/8"/2:PE |
| KG0048A01:4 | 13–31.8 | P | | 1 m | 6:6/4:PA, 1:1/8"/2:PE |
| KG0048A01:5 | 5–12 | P | | 1 m | 7:6/4:PA, 1:1/8"/2:PE |

Type of section:

P Pressure measurement
C Circulation possible
HC Hydrochemistry sampling
F Flow

Materials:

PA Polyamide
ST Steel
PE PEEK
HD HD1000 (High Density Polyethylene)

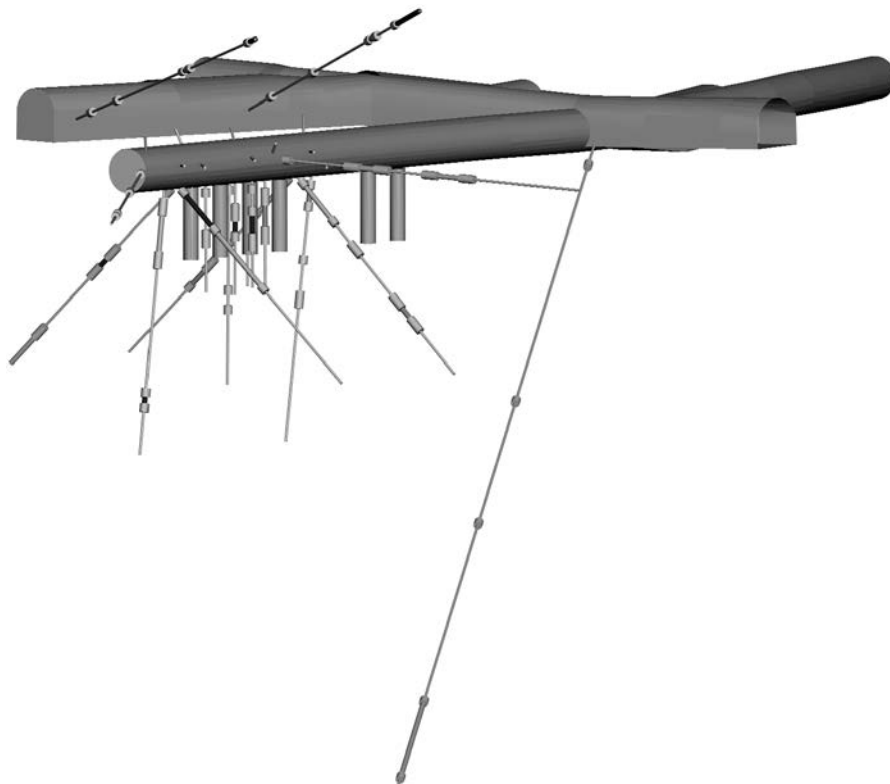


Figure A11-1. View of the drilled core holes in the Prototype Repository Section I. The length from the I-tunnel to the end of the TBM-tunnel is 90 m. The diameter of the TBM tunnel is 5 m and the diameter of the deposition holes is 1.75 m. The depth of the deposition holes is 8.37 m in the centre and 8.15 m along the deposition hole wall. The diameter of the core holes is 76 mm except for the short core holes in the roof of the TBM tunnel that have a diameter of 56 mm. The monitoring boreholes used in the presentation in this report are located in the inner part of the tunnel surrounding the area with the four innermost canister holes. Also included are two holes drilled from the G-tunnel and the long hole KA3510A drilled from the main tunnel.

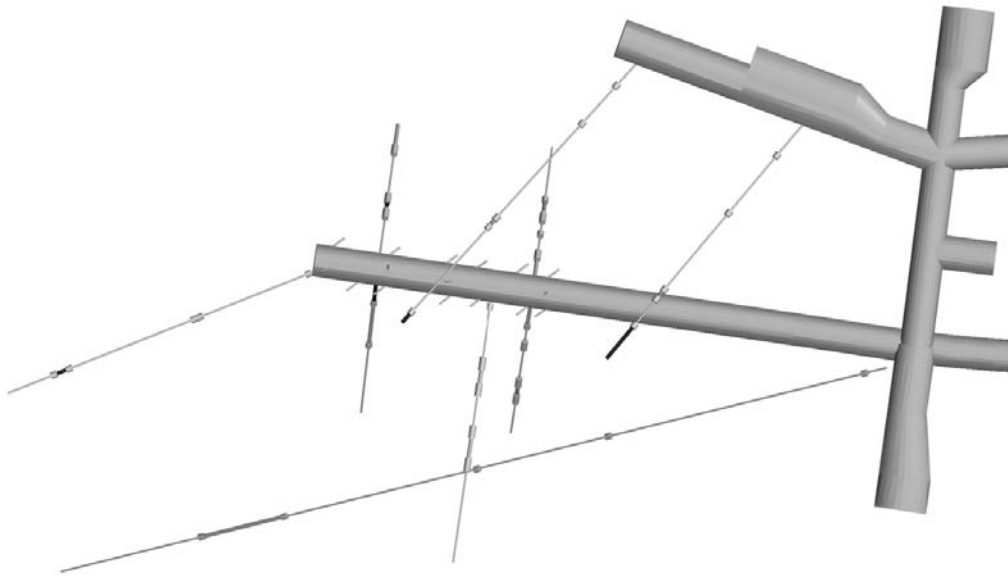


Figure A11-2. Overview of Section I in Prototype Repository.

A11.1.4 Instrumentation with hydraulic packers in Section II

Fifteen boreholes are equipped with hydraulically expanded packers of one meters length to seal off at most five sections in one borehole. In ten of these boreholes one section also is instrumented with hydro-mechanical equipment adapted to measure small deformations in the solid rock and over selected fractures. Another borehole in the G-tunnel is instrumented with HM equipment as a reference. The borehole was drilled in the north tunnel wall and is not expected to be influenced by the stress changes around the Prototype tunnel.

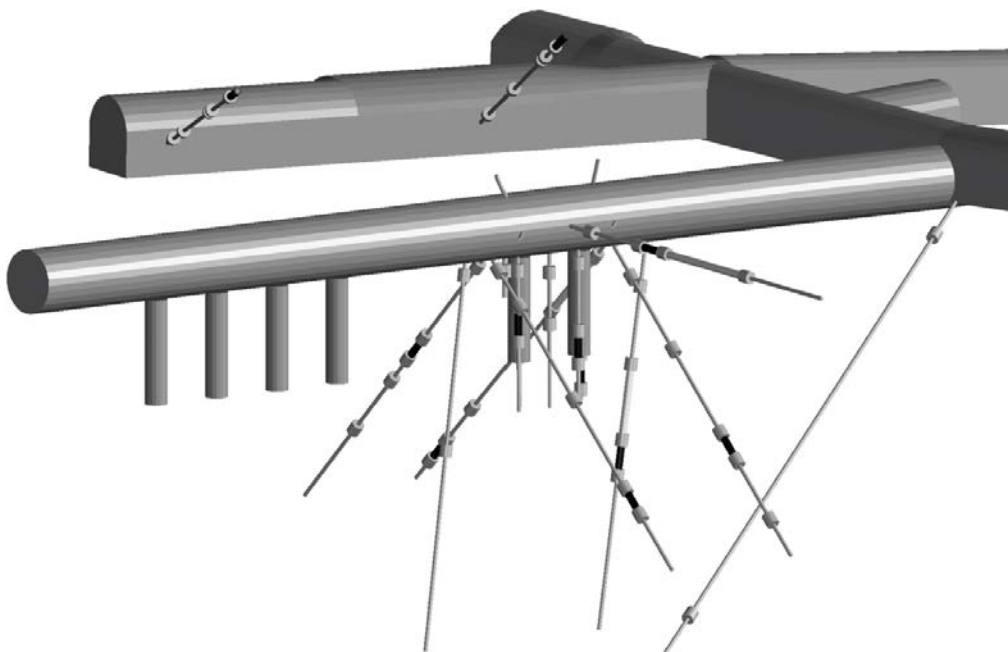


Figure A11-3. View of the drilled core holes in the Prototype Repository Section II. The length from the I-tunnel to the end of the TBM-tunnel is 90 m. The diameter of the TBM-tunnel is 5 m and the diameter of the deposition holes is 1.75 m. The depth of the deposition holes is 8.37 m in the centre and 8.15 m along the deposition hole wall. The diameter of the core holes is 76 mm except for the short core holes in the roof of the TBM tunnel that have a diameter of 56 mm. The monitoring boreholes used in the presentation in this report are located in the inner part of the tunnel surrounding the area with the four innermost canister holes. Also included are two holes drilled from the G-tunnel and the long hole KA3510A drilled from the main tunnel.

Table A11-2. Instrumentation configuration in Section II. “Lead-through”: pipes between the packers.

| Borehole:sec | Sec. length (m) | Type of section | Tubes/pipes (no:diameter:type) |
|--------------|-----------------|-----------------|--|
| KA3539G:1 | 18.6–30 | P | 1:4/2:PA, 1:6/4:PA |
| KA3539G:2 | 15.85–17.6 | P, HM, C | 2:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3539G:3 | 10–14.85 | P, F | 3:4/2:PA, 4:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3539G:4 | 4–9 | P | 4:4/2:PA, 4:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3542G01:1 | 27–30 | P | 1:4/2:PA, 1:6/4:PA |
| KA3542G01:2 | 21.3–26 | P | 2:4/2:PA, 1:6/4:PA |
| KA3542G01:3 | 18.6–20.3 | P, HM, C | 3:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3542G01:4 | 10.5–17.6 | P | 4:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3542G01:5 | 3.5–9.5 | P | 5:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3542G02:1 | 28.2–30.01 | P | 1:4/2:PA, 1:6/4:PA |
| KA3542G02:2 | 25.6–27.2 | P, HM, C | 2:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3542G02:3 | 21.5–24.6 | P | 3:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3542G02:4 | 9–20.5 | P | 4:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3542G02:5 | 2–8 | P, F | 5:4/2:PA, 4:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3544G01:1 | 11.65–12 | P | 1:4/2:ST, 1:6/4:ST |
| KA3544G01:2 | 8.9–10.65 | P, HM, C | 5:4/2:ST, 3:6/4:ST, 2:8/6:ST |
| KA3544G01:3 | 3.5–7.9 | P | 6:4/2:ST, 3:6/4:ST, 2:8/6:ST |
| KA3546G01:1 | 9.3–12 | P | 1:4/2:ST, 1:6/4:ST |
| KA3546G01:2 | 6.75–8.3 | P, HM, C | 5:4/2:ST, 3:6/4:ST, 2:8/6:ST |
| KA3546G01:3 | 1.5–5.75 | P | 6:4/2:ST, 3:6/4:ST, 2:8/6:ST |
| KA3548A01:1 | 21.5–30 | P | 1:4/2:PA, 1:6/4:PA |
| KA3548A01:2 | 11.75–20.5 | P, F | 2:4/2:PA, 2:6/4:PA |
| KA3548A01:3 | 8.8–10.75 | P, HM, C | 3:4/2:PA, 4:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3548A01:4 | 3–7.8 | P | 4:4/2:PA, 4:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3548G01:1 | 6–12 | P | 2:6/4:PA |
| KA3548G01:2 | 2–5 | P | 3:6/4:PA |
| KA3550G01:1 | 8.3–12.03 | P | 1:4/2:ST, 1:6/4:ST |
| KA3550G01:2 | 5.2–7.3 | P, HM, C | 5:4/2:ST, 3:6/4:ST, 2:8/6:ST |
| KA3550G01:3 | 1.8–4.2 | P | 6:4/2:ST, 3:6/4:ST, 2:8/6:ST |
| KA3550G05:1 | 1.5–3 | P | 1:4/2:ST, 1:6/4:ST |
| KA3551G05:1 | 1.5–3.1 | P | 1:4/2:ST, 1:6/4:ST |
| KA3552G01:1 | 7.05–12 | P | 1:4/2:ST, 1:6/4:ST |
| KA3552G01:2 | 4.35–6.05 | P, HM, C | 5:4/2:ST, 3:6/4:ST, 2:8/6:ST |
| KA3552G01:3 | 1.5–3.35 | P | 6:4/2:ST, 3:6/4:ST, 2:8/6:ST |
| KA3554G01:1 | 25.15–30.01 | P | 1:4/2:PA, 1:6/4:PA |
| KA3554G01:2 | 22.6–24.15 | P, HM, C | 2:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3554G01:3 | 14–21.6 | P | 3:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3554G01:4 | 5–13 | P | 4:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3554G01:5 | 1.5–4 | P | 5:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3554G02:1 | 22–30.01 | P | 1:4/2:PA, 1:6/4:PA |
| KA3554G02:2 | 15.9–21 | P | 2:4/2:PA, 1:6/4:PA |
| KA3554G02:3 | 13.2–14.9 | P | 3:4/2:PA, 1:6/4:PA |
| KA3554G02:4 | 10.5–12.2 | P, HM, C | 4:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3554G02:5 | 1.5–9.5 | P | 5:4/2:PA, 3:6/4:PA, 3:4/2:ST, 2:8/6:ST |
| KA3557G:1 | 15–30.04 | P | 1:4/2:PA, 1:6/4:PA |
| KA3557G:2 | 1.5–14 | P | 2:4/2:PA, 1:6/4:PA |
| KG0010B01:1 | 2.8–4.35 | HM | 3:4/2:ST, 2:8/6:ST |

Type of section:

P Pressure measurement

C Circulation possible

HM Hydro-mechanical measurements

Materials:

PA Polyamide tube

ST Stainless steel pipe

F Flow

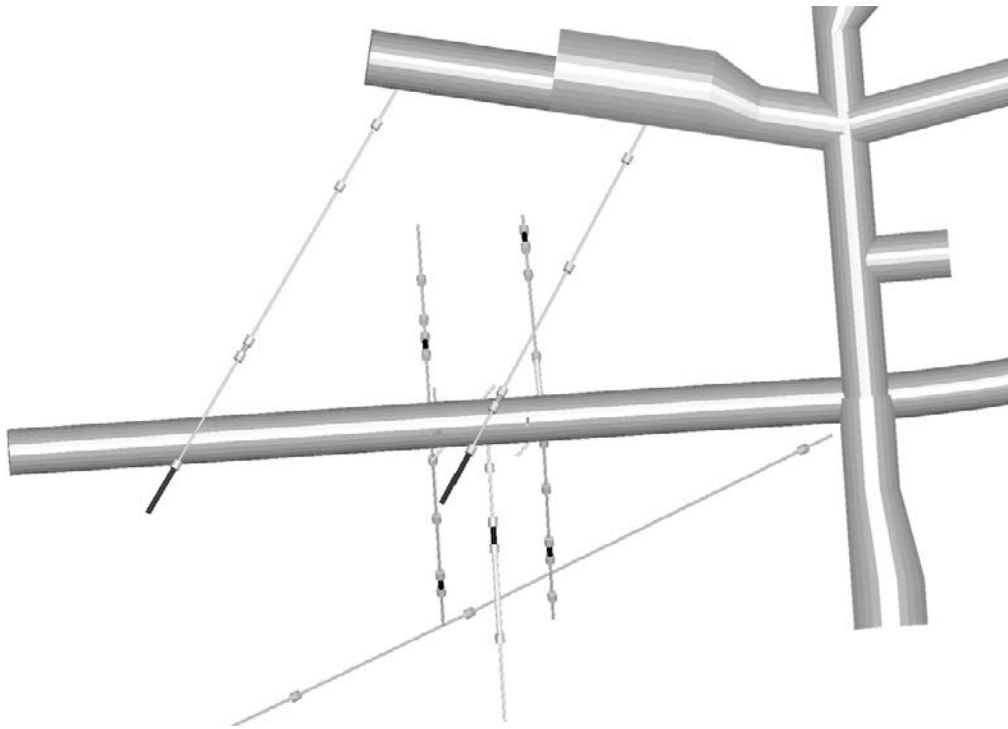


Figure A11-4. Overview of Sektion II in Prototype Repository.

A11.1.5 Instrumentation with mechanical packers

Twenty-two short boreholes (2 m) in the tunnel roof and walls are equipped with mechanical packers, see Table A11-3. After insertion into the hole, the pulling of a nut on the centre pipe expanded the packer. Since these holes are directed upwards, the de-aeration required an extra lead-through connected to a tube ending in the innermost part of the borehole. The de-aeration was made during the backfilling and in boreholes with very little flow the de-aeration was made by filling water through the outer tube.

A11.1.6 Calibration intervals

Recalibration of pressure transducers are made a couple of times every year.

A11.1.7 Pressure measurements

In this section pressure measurement of all monitored holes in the Prototype repository is shown in plots below. The pressure values plotted are daily mean values. The definition of day 0 is the day the heating of canister 1 started, i.e. 2001-09-17. In Table A11-4 the dates of the starting of the heaters in all canisters are presented.

The position of pressure measurement is indicated for all observation sections. In general sections close to the prototype rock wall indicate lower pressure head than further away from the prototype.

In the longer holes the section closest to the wall has a lower head than sections deeper into the rock mass.

A pressure drop 2002-05-07 for most of the observation sections are shown in the plots. The most major pressure change happens in the lowest section of KA3566G02 (approx. 70 m) but are also clearly visible for Section 2-4 of the same borehole. The pressure recovered during the evening of 2002-12-02. The cause for the pressure change is unknown.

Several sections have had a slight decreasing trend since the summer of 2002. This trend was in most cases discontinued after 2004-11-01 when the draining of Section I was closed down.

Table A11-3. Boreholes instrumented with mechanical packers (“Inclination”: inclination of the borehole).

| Borehole | Borehole length (m) | Inclination (°) |
|-----------|---------------------|-----------------|
| KA3543A01 | 2.06 | -0.8 |
| KA3543I01 | 2.06 | 70.5 |
| KA3548D01 | 2.06 | 2.7 |
| KA3552A01 | 2.06 | -2.8 |
| KA3552H01 | 2.1 | 58.2 |
| KA3553B01 | 2.02 | -37.7 |
| KA3563A01 | 2.06 | -7.7 |
| KA3563D01 | approx. 2 | 2.8 |
| KA3563I01 | 2.15 | 73 |
| KA3566C01 | 2.1 | 3.5 |
| KA3568D01 | 2.3 | -2.3 |
| KA3573C01 | 2.05 | 34.9 |
| KA3574D01 | 2.05 | 12.6 |
| KA3578C01 | 2.09 | -5.4 |
| KA3578H01 | 1.9 | 59.1 |
| KA3579D01 | 2 | -1 |
| KA3588C01 | 2.04 | -4 |
| KA3588D01 | 1.9 | -1.8 |
| KA3588I01 | 1.96 | 65.6 |
| KA3592C01 | 2.1 | 4.4 |
| KA3597D01 | 2.22 | 3.1 |
| KA3597H01 | 2.06 | 55.1 |

Table A11-4. Starting of heaters in canisters.

| Canister in deposition hole | Date |
|-----------------------------|------------|
| 1 (DA3587G) | 2001-09-17 |
| 2 (DA3581G) | 2001-09-24 |
| 3 (DA3575G) | 2001-11-10 |
| 4 (DA3569G) | 2001-11-24 |
| 5 (DA3551G) | 2003-05-08 |
| 6 (DA3545G) | 2003-05-23 |

The instrumentation of boreholes in Section II started 2002-11-06 and continued until the beginning of December 2002. Several sections indicate a pressure drop around 2002-11-11 which probably is caused by the installation work.

The sections of KA3510A show a drop of pressure during the first week of December 2002. The pressure is quickly re-established. Probably the cause for this was the on-going monitoring work in Section II.

During the period 2003-05-08 until 2003-05-15 a total of 19 hydraulic tests (TC 1) were done in several of the boreholes in Section I and II. The tests caused groundwater pressure interference in the whole of the prototype repository area. Since the tests were mostly short-time tests it is only shown in some of the borehole section plots.

During the summer 2003 (2003-07-13 to 2003-08-05) no pressure data was recorded. In some of the long boreholes inclined to the south of the prototype show a pressure drop in mid-August.

The packers in KA3550G01 were deflated 2003-08-18 and have not been possible to re-inflate again. The reason is probably a tube leakage.

Hydraulic single hole tests were done in nine boreholes during 2003-10-21 to 10-23 (TC 2). The tests caused groundwater pressure interference in the whole of the prototype repository area. Since the tests were mostly short-time tests it is only shown in some of the borehole section plots.

The packers in five boreholes were deflated around Oct 30–Nov 1, 2003. This was probably generated by a tube leakage which in its turn emptied the water in the pressure vessel and finally emptied the gas tube connected to it. The boreholes whose packers were deflated were KA3542G01, KA3542G02, KA3544G01 and KA3548A01. It was possible to inflate the packers in three of the four boreholes on 2003-11-10. It was not possible to restore the status of KA3544G01. This pressure drop is observed in several other borehole observation sections.

Hydraulic single hole tests were done in eight boreholes during 2004-02-02 to 02-04 (TC 3). The tests caused groundwater pressure interference in the whole of the prototype repository area. Since the tests were mostly short-time tests it is only shown in some of the borehole section plots.

A pressure drop of around 700 kPa in KA3566G01:4 is observed 2004-02-25. It remained so for some weeks before recovering, but dropped again in May and remains that way at the end of the month. This pattern was observed in this section during the spring 2003. The following investigation showed a faulty data-scan coupling (corrosion) which were replaced 2004-08-10.

Hydraulic single hole tests were done in eight boreholes during 2004-08-11 to 08-18 (TC 4). The tests caused groundwater pressure interference in the whole of the prototype repository area. Since the tests were mostly short-time tests it is only shown in some of the borehole section plots.

During the period 2005-01-19 until 2005-01-28 a total of 26 hydraulic tests (TC 5) were done in several of the boreholes in Section I and II. The tests caused groundwater pressure interference in the whole of the prototype repository area. Since the tests were mostly short-time tests it is only shown in some of the borehole section plots.

During week 36, starting 2005-09-05, several boreholes have a rather sudden drop in pressure which does not recover immediately. The reason is not known yet.

During week 39, starting 2005-10-01, pressure in KA3557G decreased rather suddenly. This was due to an empty gas pressure vessel, which has been replaced by now (January 2006).

Hydraulic single hole tests were done in eight boreholes during 2005-11-28 to 12-02 (TC 6). A total of 17 tests were done. The tests caused groundwater pressure interference in the whole of the prototype repository area. Since the tests were mostly short-time tests it is only shown in some of the borehole section plots.

In KA3573A the pressure in Section 3 suddenly decreases around 200 kPa 2006-02-12/13. This is the initial phase as it turned out later, see below, of the total pressure loss of that section.

In KA3566G01 Sections 2 and 3, and 4 and 5 respectively are short-cut from 2006-03-03. The reason is not known.

A pressure drop in several borehole sections on the south side of the prototype repository is observed from approximately 2006-04-18. At the same time the drainage from Section 1 increases from 1.5 to 9 L/min. Section KA3573A:3 which lost most of its pressure head is believed to lead groundwater, together with sections KA3573A:2 & 4, into the Section 1 backfill. In earlier investigations this borehole had flow rates over 50 L/min (Rhén and Forsmark 2001). The following borehole/sections are affected by this pressure drop event: KA3510A:3-5, KA3539G, KA3542G01, KA3548A01, KA3554G01, KA3566G01:1, KA3573A:2-4, KA3590G01:1-2, KG0021A01:1-4 and KG0048A01:1-4. The pressure decrease is probably a result of a leaking tube or a tube coupling from KA3573A:3. The pressure in KA3573A:3 is now at the same level as the pressure in the backfill (around 500 kPa).

The pressure drop in KA3557G in July 2006 is due to HMS maintenance work.

Hydraulic single hole tests were done in eight boreholes during 2006-09-25 to 09-29 (TC 7). A total of 17 tests were done. The tests caused groundwater pressure interference in the whole of the prototype repository area. Since the tests were mostly short-time tests it is only shown in some of the borehole section plots.

In November/December 2006, dilution measurements were made in KA3539G:2, KA3542G01:3, KA3542G02:2, KA3546G01:2, KA3548A01:3, KA3552G01:2, KA3554G01:2, KA3554G02:4, KA3563G:4, KA3566G01:2, KA3566G02:2, KA3572G01:2, KA3574G01:3, KG0021A01:3 and KG0048A01:3.

The work with excavating a new tunnel niche from I-niche, for sealing experiments, commenced in March 2007. The project is called “Sealing of Tunnel at Great Depth”. Since it is situated rather close to the Prototype Repository it is expected to influence the pressure levels around the prototype.

During the period March – December 2007, the drilling and testing of three boreholes in niche I, KI0010B01, KI0014B01 and KI0016B01 causes major pressure head fluctuations in most of the observation sections in the prototype repository. The overall groundwater head level decreases during this period but late in the period seems to recover. The new boreholes are drilled within the project “Sealing of Tunnel at Great Depth”.

The pressure transducers in KA3510A were taken out of operation 2007-08-20. The reason is the on-going tunnel construction works in the I-niche. They were taken in operation again in August 2008.

KA3566G02 transducers does not seem to work properly since the start of the “Sealing of Tunnel at Great Depth” project in the summer of 2007.

Hydraulic single hole tests were done in eight boreholes during 2007-10-15 to 10-19 (TC 8). A total of 17 tests were done. The tests caused some groundwater pressure interference in the prototype repository area.

Fan grouting have been done within the project “Sealing of Tunnel at Great Depth” during several periods November 2007 until May 2008. Especially the fan grouting campaign 2007-11-26 to 2007-11-29 result in pressure level increase in several of the boreholes in the prototype repository including KA3542G01, KA3542G02, KA3548A01, KA3554G01 and KA3554G02.

The pressure in KA3574G01:2 suddenly start rising from 2008-08-30.

Hydraulic single hole tests were done in eight boreholes during 2008-10-20 to 10-24 (TC 9). A total of 17 tests were done. During testing of KA3552G01 a sudden flow rate increase occurred together with a pressure increase. This was caused by a probable tube failure. The packers are now deflated and the hole cannot be used further on. The pressure increase is noticed in KA3542G01, KA3543A01, KA3548D01, KA3544G01, KA3546G01, KA3548G01, KA3550G01 and KA3553B01.

Fan grouting were done in the project “Sealing of Tunnel at Great Depth” during several periods during the spring 2009.

There is a sudden pressure decrease in KA3510A:1 and :2 2009-04-16 which last until 2009-05-07.

The pressure in KA3546G01:1 start rising from 2009-04-28.

No pressure recordings are made in HMS between 2009-05-23 and 2009-06-11.

During the period 2009-11-09 until 2009-11-19 six interference-tests (TC 10) were done in boreholes KA3539G:2, KA3542G02:5, KA3554G01:2, KA3590G02:1, KG0021A01:3 and KG0048A01:3. Flowing periods were 6 hours for each of the boreholes.

The general pressure trend is decreasing pressures since January 2008.

Pressure increases occurs in KA3546G01:1, KA3588C01:1 and KA3588D01 during the months of January and February 2010. It decreases after a while. The reason is unknown.

Preparations for demolition of the outer plug, Section II, started at the end of November 2010. During 2010-11-23 and 2010-11-24 groundwater sampling is made from several boreholes within the prototype Section I and II. A pressure decrease is clearly seen in the plots for several of the observation sections in both sections.

Demolition work of the outer plug of Section II started during December 2010 and was finalized during February 2011. The work was done by drilling several boreholes into the concrete plug continued by mechanical impact with a hydraulic hammer and a hydraulic breaker.

The backfill material was then carefully excavated with a lot of material samples taken every 2 meter to determine amongst other parameters water content and density. The heating canister in deposition hole 6 was retrieved 2011-07-14 and the same was done with the canister in deposition hole 5 2011-12-07. All demolition work in the tunnel section II was finalized by 2011-12-15.

The boreholes in Section I closest to the plug between Section I and II show an obvious pressure drop during 2011 due to the demolition of Section II. The pressure recovers during 2012.

In Table A11-5 the pressure sensor status 2013-01-01 is estimated based on pressure head data.

Table A11-5. Apparent pressure sensor status.

| Borehole:sec | Secup (m) | Seclow (m) | Pressure status 2013-01-01 | Comment |
|--------------|-----------|------------|----------------------------|-----------------------------------|
| KA3510A:1 | 125.00 | 150.00 | OK | |
| KA3510A:2 | 110.00 | 124.00 | OK | |
| KA3510A:3 | 75.00 | 109.00 | OK | |
| KA3510A:4 | 51.00 | 74.00 | Not OK | Pressure very low since June 2010 |
| KA3510A:5 | 4.50 | 50.00 | OK | |
| KA3539G:1 | 18.60 | 30.00 | Not OK | Prototype Section II demolished |
| KA3539G:2 | 15.85 | 17.60 | Not OK | Prototype Section II demolished |
| KA3539G:3 | 10.00 | 14.85 | Not OK | Prototype Section II demolished |
| KA3539G:4 | 4.00 | 9.00 | Not OK | Prototype Section II demolished |
| KA3542G01:1 | 27.00 | 30.00 | Not OK | Prototype Section II demolished |
| KA3542G01:2 | 21.30 | 26.00 | Not OK | Prototype Section II demolished |
| KA3542G01:3 | 18.60 | 20.30 | Not OK | Prototype Section II demolished |
| KA3542G01:4 | 10.50 | 17.60 | Not OK | Prototype Section II demolished |
| KA3542G01:5 | 3.50 | 9.50 | Not OK | Prototype Section II demolished |
| KA3542G02:1 | 28.20 | 30.01 | Not OK | Prototype Section II demolished |
| KA3542G02:2 | 25.60 | 27.20 | Not OK | Prototype Section II demolished |
| KA3542G02:3 | 21.50 | 24.60 | Not OK | Prototype Section II demolished |
| KA3542G02:4 | 9.00 | 20.50 | Not OK | Prototype Section II demolished |
| KA3542G02:5 | 2.00 | 8.00 | Not OK | Prototype Section II demolished |
| KA3543A01:1 | 0.65 | 2.06 | Not OK | Prototype Section II demolished |
| KA3543I01:1 | 0.65 | 2.06 | Not OK | Prototype Section II demolished |
| KA3544G01:1 | 11.65 | 12.00 | Not OK | Prototype Section II demolished |
| KA3544G01:2 | 8.90 | 10.65 | Not OK | Prototype Section II demolished |
| KA3544G01:3 | 3.50 | 7.90 | Not OK | Prototype Section II demolished |
| KA3546G01:1 | 9.30 | 12.00 | Not OK | Prototype Section II demolished |
| KA3546G01:2 | 6.75 | 8.30 | Not OK | Prototype Section II demolished |
| KA3546G01:3 | 1.50 | 5.75 | Not OK | Prototype Section II demolished |
| KA3548A01:1 | 21.50 | 30.00 | Not OK | Prototype Section II demolished |
| KA3548A01:2 | 11.75 | 20.50 | Not OK | Prototype Section II demolished |
| KA3548A01:3 | 8.80 | 10.75 | Not OK | Prototype Section II demolished |
| KA3548A01:4 | 3.00 | 7.80 | Not OK | Prototype Section II demolished |
| KA3548D01:1 | 0.65 | 2.06 | Not OK | Prototype Section II demolished |
| KA3548G01:1 | 6.00 | 12.00 | Not OK | Prototype Section II demolished |
| KA3548G01:2 | 2.00 | 5.00 | Not OK | Prototype Section II demolished |
| KA3550G01:1 | 8.30 | 12.03 | Not OK | Prototype Section II demolished |
| KA3550G01:2 | 5.20 | 7.30 | Not OK | Prototype Section II demolished |
| KA3550G01:3 | 1.80 | 4.20 | Not OK | Prototype Section II demolished |
| KA3550G05:1 | 1.50 | 3.00 | Not OK | Prototype Section II demolished |
| KA3551G05:1 | 1.50 | 3.10 | Not OK | Prototype Section II demolished |
| KA3552A01:1 | 0.65 | 2.06 | Not OK | Prototype Section II demolished |
| KA3552G01:1 | 7.05 | 12.00 | Not OK | Prototype Section II demolished |
| KA3552G01:2 | 4.35 | 6.05 | Not OK | Prototype Section II demolished |
| KA3552G01:3 | 1.50 | 3.35 | Not OK | Prototype Section II demolished |

| Borehole:sec | Secup (m) | Seclow (m) | Pressure status 2013-01-01 | Comment |
|--------------|-----------|------------|----------------------------|--|
| KA3552H01:1 | 0.65 | 2.10 | Not OK | Prototype Section II demolished |
| KA3553B01:1 | 0.65 | 2.02 | Not OK | Prototype Section II demolished |
| KA3554G01:1 | 25.15 | 30.01 | Not OK | Prototype Section II demolished |
| KA3554G01:2 | 22.60 | 24.15 | Not OK | Prototype Section II demolished |
| KA3554G01:3 | 14.00 | 21.60 | Not OK | Prototype Section II demolished |
| KA3554G01:4 | 5.00 | 13.00 | Not OK | Prototype Section II demolished |
| KA3554G01:5 | 1.50 | 4.00 | Not OK | Prototype Section II demolished |
| KA3554G02:1 | 22.00 | 30.01 | Not OK | Prototype Section II demolished |
| KA3554G02:2 | 15.90 | 21.00 | Not OK | Prototype Section II demolished |
| KA3554G02:3 | 13.20 | 14.90 | Not OK | Prototype Section II demolished |
| KA3554G02:4 | 10.50 | 12.20 | Not OK | Prototype Section II demolished |
| KA3554G02:5 | 1.50 | 9.50 | Not OK | Prototype Section II demolished |
| KA3557G:1 | 15.00 | 30.04 | Not OK | Prototype Section II demolished |
| KA3557G:2 | 1.50 | 14.00 | Not OK | Prototype Section II demolished |
| KA3563A01:1 | 0.65 | 2.06 | OK | |
| KA3563D01:1 | 0.65 | 2.01 | OK | |
| KA3563G:1 | 15.00 | 30.01 | OK | |
| KA3563G:2 | 10.00 | 13.00 | OK | |
| KA3563G:3 | 4.00 | 8.00 | OK | |
| KA3563G:4 | 1.50 | 3.00 | OK | |
| KA3563I01:1 | 0.65 | 2.15 | OK | |
| KA3566C01:1 | 0.65 | 2.1 | OK | |
| KA3566G01:1 | 23.50 | 30.01 | OK | |
| KA3566G01:2 | 20.00 | 21.50 | OK | |
| KA3566G01:3 | 12.00 | 18.00 | OK | |
| KA3566G01:4 | 7.30 | 10.00 | Not OK | Shortcut between Sections 4 and 5 |
| KA3566G01:5 | 1.50 | 6.30 | Not OK | Shortcut between Sections 4 and 5 |
| KA3566G02:1 | 19.00 | 30.10 | Not OK | Pressure drop May 2007. All sections shortcut! |
| KA3566G02:2 | 16.00 | 18.00 | Not OK | Pressure drop May 2007. All sections shortcut! |
| KA3566G02:3 | 12.00 | 14.00 | Not OK | Pressure drop May 2007. All sections shortcut! |
| KA3566G02:4 | 8.00 | 11.00 | Not OK | Pressure drop May 2007. All sections shortcut! |
| KA3566G02:5 | 1.30 | 6.00 | Not OK | Pressure drop May 2007. All sections shortcut! |
| KA3568D01:1 | 0.65 | 2.30 | OK | |
| KA3572G01:1 | 7.30 | 12.03 | OK | |
| KA3572G01:2 | 2.70 | 5.30 | OK | |
| KA3573A:1 | 26.00 | 40.07 | Not OK | Probable tube failure in Section 3 |
| KA3573A:2 | 21.00 | 24.00 | Not OK | Probable tube failure in Section 3 |
| KA3573A:3 | 14.50 | 19.00 | Not OK | Probable tube or tube coupling failure |
| KA3573A:4 | 10.50 | 12.50 | Not OK | Probable tube failure in Section 3 |
| KA3573A:5 | 1.30 | 8.50 | Not OK | Probable tube failure in Section 3 |
| KA3573C01:1 | 0.65 | 2.05 | OK | |
| KA3574D01:1 | 0.65 | 2.05 | OK | |
| KA3574G01:1 | 8.00 | 12.03 | OK | |
| KA3574G01:2 | 5.10 | 7.00 | Not OK? | Sudden pressure increase 2008-08-30 |
| KA3574G01:3 | 1.80 | 4.10 | OK | |
| KA3576G01:1 | 8.00 | 12.01 | OK | |
| KA3576G01:2 | 4.00 | 6.00 | Not OK? | Pressure decrease starting Jan. 2009 |
| KA3576G01:3 | 1.30 | 3.00 | OK | |
| KA3578C01:1 | 0.65 | 2.09 | OK | |
| KA3578G01:1 | 6.50 | 12.58 | OK? | Shortcut between sections |
| KA3578G01:2 | 4.30 | 5.50 | OK? | Shortcut between sections |
| KA3578H01:1 | 0.65 | 1.90 | OK | |
| KA3579D01:1 | 0.65 | 2.00 | Not OK | Air in borehole section? |

| Borehole:sec | Secup (m) | Seclow (m) | Pressure status 2013-01-01 | Comment |
|--------------|-----------|------------|----------------------------|------------------------------|
| KA3579G:1 | 14.70 | 22.65 | OK? | Shortcut between sections |
| KA3579G:2 | 12.50 | 13.70 | OK? | Shortcut between sections |
| KA3579G:3 | 2.30 | 11.50 | Not OK | Air in borehole section? |
| KA3584G01:1 | 7.00 | 12.00 | OK | |
| KA3584G01:2 | 1.30 | 5.00 | OK | |
| KA3588C01:1 | 0.65 | 2.04 | OK | |
| KA3588D01:1 | 0.65 | 1.90 | Not OK | Not in operation any longer? |
| KA3588I01:1 | 0.65 | 1.96 | OK | |
| KA3590G01:1 | 16.00 | 30.00 | Not OK? | Shortcut between sections. |
| KA3590G01:2 | 7.00 | 15.00 | Not OK? | Shortcut between sections. |
| KA3590G01:3 | 1.30 | 6.00 | OK | |
| KA3590G02:1 | 25.50 | 30.01 | OK | |
| KA3590G02:2 | 15.20 | 23.50 | OK | |
| KA3590G02:3 | 11.90 | 13.20 | OK | |
| KA3590G02:4 | 1.30 | 9.90 | OK | |
| KA3592C01:1 | 0.65 | 2.01 | Not OK? | Air in borehole section? |
| KA3593G:1 | 25.20 | 30.02 | Not OK | Very low pressure in section |
| KA3593G:2 | 23.50 | 24.20 | OK | |
| KA3593G:3 | 9.00 | 22.50 | OK | |
| KA3593G:4 | 3.00 | 7.00 | OK | |
| KA3597D01:1 | 0.65 | 2.22 | Not OK? | Air in borehole section? |
| KA3597H01:1 | 0.65 | 2.06 | OK | |
| KA3600F:1 | 43.00 | 50.10 | OK | |
| KA3600F:2 | 40.50 | 42.00 | OK | |
| KA3600F:3 | 20.00 | 39.50 | OK | |
| KA3600F:4 | 1.30 | 18.00 | OK | |
| KG0021A01:1 | 42.50 | 48.82 | OK | |
| KG0021A01:2 | 37.00 | 41.50 | OK | |
| KG0021A01:3 | 35.00 | 36.00 | OK | |
| KG0021A01:4 | 19.00 | 34.00 | OK | |
| KG0021A01:5 | 5.00 | 18.00 | OK | |
| KG0048A01:1 | 49.00 | 54.69 | OK | |
| KG0048A01:2 | 34.8 | 48 | OK | |
| KG0048A01:3 | 32.80 | 33.80 | OK | |
| KG0048A01:4 | 13.00 | 31.80 | OK | |
| KG0048A01:5 | 5.00 | 12.00 | OK | |

A11.1.8 Drainage of Section I

The drainage system in Section I was shut down 2004-11-01. It resulted in a major pressure increase in most borehole sections close to the prototype tunnel. The pressure increased until 2004-12-06.

The drained water amount was approximately 2.5 L/min. The flow rate of weir MG0004G decreased accordingly with the same order of magnitude after November 1.

The drainage system was re-opened 2004-12-06 due to electrical problems with the canister heaters. It is still open (2009-06-01). The pressure in most borehole sections within Section I decreased rapidly again after the re-opening while the pressures in Section II decreased more slowly.

In mid-April 2006 the flow rate from Section 1 rather suddenly increases to 9 L/min, while pressure decreases in several boreholes on the south side of the prototype. This is a result of tube failure in borehole section KA3573A:3.

The flow rate from Section I was still around 9 L/min at the end of 2010.

A11.1.9 Packer functionality status in Section II

The packers are of the type PU53 or PU72. All packers have an inflation length of one meter and the minimum and maximum packer expansion pressure is 6.5 bar and 65 bar respectively. They are expanded by means of water, pressurised by nitrogen gas in a pressure vessel. A regulator controls the magnitude of the inflation pressure. The stainless steel pressure vessel is connected to the packers by a high-pressure 6/4-mm polyamide tube, type Tecalan. A check valve unit with a manometer is mounted on the packer inflation line. In order to avoid accidental deflation the check valve unit also includes a stop valve.

In Table A11-6 below are listed the borehole packers that have ceased to function for some reason. During 2011 section II was excavated and all packers were disconnected from the pressure transducers.

A11.1.10 Deformation measurements in Section II

Deformation measurements of fractures in borehole sections with Hydro-Mechanical anchors in Section II have stopped due to the demolition of Section II. No results have yet been published.

A11.1.11 Flow measurements

Earlier estimations and measurements of inleaking ground water amounts to the tunnel system are presented in Forsmark et al. (2001) and Rhén and Forsmark (2001).

Data from eight flow weirs are presented in this data report.

A weir at the tunnel G opening measures the inleaking amounts from this tunnel. The weir was taken in operation in January 2002-01-21 and is named MG0004G. The water from MG0004G is led to PG5. The pumped water amounts from Section I mentioned above was prior to November 1, 2004, when the drainage of Section I was closed down, included in the rates from this weir station which is clearly shown in the diagram below. The packer or tube failure of KA3573A:3 2006-04-18 resulted in an increase of water being drained from Section 1 due to the fact that groundwater in the rock got contact with the backfill in Section 1 via the borehole. Until the beginning of 2006 the trend was decreasing.

The weir MF0061G halfway down tunnel F measures today the inleaking amounts from the first half of tunnel F, see plot of this weir. Earlier, until autumn 2001, inleaking water from tunnel G was led to tunnel F and weir MF0061G thereby to some extent explaining the high flow rate during that period. The inleaking water in tunnel J+ is included in the flow rate of MF0061G.

Table A11-6. Packer functionality status in Section II.

| Packer tube label | Borehole | Status 2013-01-01 |
|-------------------|-----------|-------------------|
| XRA1100 | KA3539G | Not in operation |
| XRA1200 | KA3542G01 | Not in operation |
| XRA1300 | KA3542G02 | Not in operation |
| XRA1600 | KA3544G01 | Not in operation |
| XRA1700 | KA3546G01 | Not in operation |
| XRA1800 | KA3548A01 | Not in operation |
| XRA2000 | KA3548G01 | Not in operation |
| XRA2100 | KA3550G01 | Not in operation |
| XRA2200 | KA3550G05 | Not in operation |
| XRA2300 | KA3551G05 | Not in operation |
| XRA2500 | KA3552G01 | Not in operation |
| XRA2800 | KA3554G01 | Not in operation |
| XRA2900 | KA3554G02 | Not in operation |
| XRA3000 | KA3557G | Not in operation |

The weir MA3426G measures the flow rates from the south part of tunnel J and tunnel A chainage 3,426–3,514 m. Until December 2003 the inleaking amounts from tunnel Section 3,515–3,600 was included in the presented flow rate. The inleaking water in tunnel I is included in this weir's flow rate.

In December 2003 three new flow measurement weirs were constructed in the A-tunnel outside Section II plug. They are called MA3515G, MA3525G and MA3535G (in operation 2003-12-10). The water from these three weirs is led to MA3426G. Continuous measurement is done since the spring of 2004. Manual measurements done in December 2003 show a flow rate for MA3515G of 0.175–0.19 L/min, for MA3525G of 1.15–1.25 L/min and for MA3535G of 0.38–0.45 L/min. The increase of flow during October 2004 was caused by yet unknown causes, but it is believed that the final grouting that was done around Plug 2 October 8, 2004 is the cause to it. The flow rates have now decreased once again.

Two weirs have, during the winter 2004/2005, been constructed inside niches I and J+. They are called MI0008G (in operation 2005-01-20) and MJ0033G (in operation 2005-01-20) respectively. The water from MI0008G is led to MA3426G. The water from MJ0033G is led to MF0061G. MI0008G is included in the continuously measurement program (HMS) while MJ0033G is measured manually approximately every fortnight. The readings from MI0008G have however not been correct since August 2005 and therefor no readings are presented since then. Manual readings will be made in the future. A manual reading 2006-06-26 shows a flow of 2.85 L/min which is within the same order of magnitude as the flow readings of the pre-August 2005 period.

MI0008G was plugged 2007-08-02 during the preparations of the construction of Tunnel S which will start inside niche I and the water is led to MA3426G.

The automatic registration of flow in MA3515G, MA3525G and MA3535G were cancelled during autumn 2007 due to the on-going tunnel construction work in the I-niche. The registration was resumed in April 2008 and continued until November 2010 when preparation started for the demolishing work of Prototype Section II.

The flow rate in MA3426G has been extremely high during the period June until November 2007. This is due to that inleaking water from the new boreholes KI0010B01 and KI0016B01 together with the water previously measured in MI0008G is led to MA3426G. A single rate measurement 2007-10-18 gives a flow rate from KI0010B01 of 44 L/min and from KI0016B01 of 7 L/min.

The pre-investigations for TASS resulted in major in-leaking amounts through the three long core holes drilled in the planned direction of TASS. During this period the in-leaking accumulated initial flow rates from the three boreholes was approximately 230 L/min, but the overall flow rate during the period until they were grouted was approximately 65 L/min which is the increase of flow in weir MA3426G where the water was directed.

A11.1.12 Water sampling

Water sampling for chemical analysis have been done at several occasions, see Table A11-7. Each one of them may have a short-lived effect on the hydrostatic pressure in the rock mass. In some cases the flowing of a section continued for several days and the following pressure response is clearly shown in the subsequent plot.

Table A11-7. Water sampling dates in boreholes close to the Prototype Repository. Start and stop of times are for the flowing of the section.

| Borehole | Start date/time | Stop date/time | Secup | Seclow | Section number |
|-----------|---------------------|---------------------|--------|--------|----------------|
| KA3600F | 2001-10-15 10:30:00 | 2001-10-15 10:45:00 | 40.50 | 42.00 | 2 |
| KA3600F | 2001-10-15 10:45:00 | 2001-10-15 11:15:00 | 43.00 | 50.10 | 1 |
| KA3573A | 2002-09-24 10:30:00 | 2002-09-24 11:00:00 | 26.00 | 40.07 | 1 |
| KA3573A | 2002-09-24 11:40:00 | 2002-09-24 13:40:00 | 21.00 | 24.00 | 2 |
| KA3600F | 2002-09-25 11:00:00 | 2002-09-25 13:40:00 | 40.50 | 42.00 | 2 |
| KA3600F | 2002-09-25 11:25:00 | 2002-09-25 11:44:00 | 43.00 | 50.01 | 1 |
| KA3510A | 2002-12-12 08:30:00 | 2002-12-12 08:50:00 | 4.50 | 50.00 | 5 |
| KA3510A | 2002-12-12 08:30:00 | 2002-12-12 08:52:00 | 110.00 | 124.00 | 2 |
| KA3510A | 2002-12-12 10:30:00 | 2002-12-12 11:04:00 | 75.00 | 109.00 | 3 |
| KA3539G | 2003-05-23 09:48:00 | 2003-05-23 09:53:00 | 15.85 | 17.60 | 2 |
| KA3542G01 | 2003-06-02 09:28:00 | 2003-06-02 09:54:00 | 18.60 | 20.30 | 3 |
| KA3548A01 | 2003-06-02 09:57:00 | 2003-06-02 10:15:00 | 8.80 | 10.75 | 3 |
| KG0048A01 | 2003-06-03 10:06:00 | 2003-06-03 10:12:00 | 32.80 | 33.80 | 3 |
| KA3554G01 | 2003-06-03 10:31:00 | 2003-06-03 10:38:00 | 22.60 | 24.15 | 2 |
| KA3542G02 | 2003-06-04 11:09:00 | 2003-06-04 12:49:00 | 25.60 | 27.20 | 2 |
| KA3566G02 | 2003-06-04 12:30:00 | 2003-06-04 17:30:00 | 16.00 | 18.00 | 2 |
| KG0021A01 | 2003-06-30 11:03:00 | 2003-06-30 11:09:00 | 35.00 | 36.00 | 3 |
| KA3554G02 | 2003-06-30 15:23:00 | 2003-06-30 21:40:00 | 10.50 | 12.20 | 4 |
| KA3600F | 2003-07-03 13:51:00 | 2003-07-03 13:53:00 | 40.50 | 42.00 | 2 |
| KA3572G01 | 2003-08-11 15:28:00 | 2003-08-28 15:00:00 | 2.70 | 5.30 | 2 |
| KG0021A01 | 2003-09-18 09:40:00 | 2003-09-18 09:55:00 | 35.00 | 36.00 | 3 |
| KG0048A01 | 2003-09-18 09:45:00 | 2003-09-18 09:55:00 | 32.80 | 33.80 | 3 |
| KA3542G01 | 2003-09-24 09:15:00 | 2003-09-24 09:30:00 | 18.60 | 20.30 | 3 |
| KA3539G | 2003-09-24 09:20:00 | 2003-09-24 09:35:00 | 15.85 | 17.60 | 2 |
| KA3548A01 | 2003-09-24 09:30:00 | 2003-09-24 10:00:00 | 8.80 | 10.75 | 3 |
| KA3554G01 | 2003-09-24 09:30:00 | 2003-09-24 10:00:00 | 22.60 | 24.15 | 2 |
| KA3573A | 2003-09-25 09:00:00 | 2003-09-25 10:00:00 | 26.00 | 40.07 | 1 |
| KA3600F | 2003-09-25 09:00:00 | 2003-09-25 09:45:00 | 43.00 | 50.10 | 1 |
| KA3600F | 2003-09-25 09:30:00 | 2003-09-25 10:00:00 | 40.50 | 42.00 | 2 |
| KA3542G02 | 2003-09-26 11:20:00 | 2003-09-26 11:35:00 | 2.00 | 8.00 | 5 |
| KA3573A | 2003-09-29 10:20:00 | 2003-09-29 10:40:00 | 21.00 | 24.00 | 2 |
| KA3566G02 | 2003-09-29 11:00:00 | 2003-09-29 13:50:00 | 16.00 | 18.00 | 2 |
| KA3590G01 | 2003-09-30 09:00:00 | 2003-09-30 12:45:00 | 16.00 | 30.00 | 2 |
| KA3539G | 2004-02-16 10:50:00 | 2004-03-22 11:26:00 | 15.85 | 17.60 | 2 |
| KA3548A01 | 2004-02-16 12:13:00 | 2004-02-16 12:31:00 | 8.80 | 10.75 | 3 |
| KA3600F | 2004-02-17 09:55:00 | 2004-02-17 10:11:00 | 40.50 | 42.00 | 2 |
| KG0021A01 | 2004-02-17 10:27:00 | 2004-02-17 10:43:00 | 35.00 | 36.00 | 3 |
| KA3539G | 2004-02-17 11:30:00 | 2004-02-17 11:31:00 | 15.85 | 17.60 | 2 |
| KG0048A01 | 2004-03-02 09:24:00 | 2004-03-02 09:40:00 | 32.80 | 33.80 | 3 |
| KA3554G01 | 2004-03-02 10:04:00 | 2004-03-02 10:17:00 | 22.60 | 24.15 | 2 |
| KA3542G02 | 2004-03-02 10:22:00 | 2004-03-02 13:15:00 | 2.80 | 8.00 | 5 |
| KA3590G01 | 2004-03-03 21:36:00 | 2004-03-03 21:36:00 | 7.00 | 15.00 | 2 |
| KA3572G01 | 2004-04-02 10:35:00 | 2004-04-07 10:15:00 | 2.70 | 5.30 | 2 |
| KA3573A | 2004-09-21 09:23:00 | 2004-09-22 09:54:00 | 26.00 | 40.07 | 1 |
| KA3600F | 2004-09-21 09:23:00 | 2004-09-22 10:03:00 | 43.00 | 50.10 | 1 |
| KA3573A | 2004-09-22 09:2200 | 2004-09-22 10:03:00 | 21.00 | 24.00 | 2 |
| KA3600F | 2004-09-22 09:18:00 | 2004-09-22 09:44:00 | 40.50 | 42.00 | 2 |
| KA3542G01 | 2004-11-09 09:02:00 | 2004-11-09 10:11:00 | 18.60 | 20.30 | 3 |
| KA3590G01 | 2004-11-15 11:16:00 | 2005-01-20 09:40:00 | 7.00 | 15.00 | 2 |
| KA3554G02 | 2004-11-19 08:30:00 | 2004-11-22 16:50:00 | 10.50 | 12.20 | 4 |

| Borehole | Start date/time | Stop date/time | Secup | Seclow | Section number |
|-----------|---------------------|---------------------|--------|--------|----------------|
| KA3566G02 | 2004-11-19 08:30:00 | 2004-11-22 09:53:00 | 16.00 | 18.00 | 2 |
| KA3566G02 | 2005-02-03 10:20 | 2005-03-10 14:00 | 16.00 | 18.00 | 2 |
| KA3573A | 2005-09-26 10:58:00 | 2005-09-26 10:58:00 | 21.00 | 24.00 | 2 |
| KA3600F | 2005-09-26 10:42:00 | 2005-09-26 10:42:00 | 40.50 | 42.00 | 2 |
| KA3510A | 2005-10-03 09:24:00 | 2005-10-03 09:29:00 | 110.00 | 124.00 | 2 |
| KA3573A | 2005-10-05 10:30:00 | 2005-10-05 11:05:00 | 26.00 | 40.07 | 1 |
| KA3600F | 2005-10-07 09:20:00 | 2005-10-07 10:03:00 | 43.00 | 50.10 | 1 |
| KA3510A | 2005-10-07 12:15:00 | 2005-10-07 12:38:00 | 110.00 | 124.00 | 2 |
| KA3554G01 | 2006-07-11 14:45:00 | 2006-07-12 14:45:00 | 22.60 | 24.15 | 2 |
| KA3539G | 2006-07-11 16:08:00 | 2006-07-11 18:35:00 | 15.85 | 17.60 | 2 |
| KA3548A01 | 2006-07-11 17:35:00 | 2006-07-11 18:15:00 | 8.80 | 10.75 | 3 |
| KA3600F | 2006-07-12 09:37:00 | 2006-07-12 10:04:00 | | | 2 |
| KA3572G01 | 2006-07-12 10:00:00 | 2006-07-18 15:35:00 | | | 2 |
| KA3542G01 | 2006-07-12 10:52:00 | 2006-07-12 11:17:00 | 18.60 | 20.30 | 3 |
| KG0021A01 | 2006-07-12 13:40:00 | 2006-07-12 14:29:00 | 35.00 | 36.00 | 3 |
| KG0048A01 | 2006-07-12 14:42:00 | 2006-07-12 15:36:00 | 32.80 | 33.80 | 3 |
| KA3590G01 | 2006-07-13 09:55:00 | 2006-07-13 16:00:00 | | | 2 |
| KA3566G02 | 2006-07-13 10:10:00 | 2006-07-13 19:25:00 | 16.00 | 18.00 | 2 |
| KA3542G02 | 2006-07-13 14:37:00 | 2006-07-13 17:13:00 | 2.80 | 8.00 | 5 |
| KA3554G02 | 2006-07-14 13:00:00 | 2006-07-17 16:30:00 | 10.50 | 12.20 | 4 |
| KA3510A | 2006-09-20 08:30:00 | 2006-09-20 08:35:00 | | | |
| KA3542G02 | 2006-09-20 08:35:00 | 2006-09-20 08:40:00 | 25.60 | 27.20 | 2 |
| KA3554G01 | 2006-09-20 08:35:00 | 2006-09-20 08:40:00 | 22.60 | 24.15 | 2 |
| KA3573A | 2006-10-02 10:15:00 | 2006-10-02 10:37:00 | 21.00 | 24.00 | 2 |
| KA3600F | 2006-10-02 09:50:00 | 2006-10-02 10:10:00 | 40.50 | 42.00 | |
| KA3573A | 2006-10-03 09:50:00 | 2006-10-03 10:17:00 | 26.00 | 40.07 | 1 |
| KA3600F | 2006-10-03 09:50:00 | 2006-10-03 10:13:00 | 43.00 | 51.10 | |
| KA3554G01 | 2007-01-09 09:05:00 | 2007-01-09 09:57:00 | | | |
| KA3600F | 2007-01-09 14:32:00 | 2007-01-09 14:58:00 | | | |
| KA3548A01 | 2007-01-09 15:03:00 | 2007-01-09 15:30:00 | | | |
| KA3539G | 2007-01-09 16:08:00 | 2007-01-09 16:53:00 | | | |
| KA3572G01 | 2007-01-10 09:30:00 | 2007-01-16 10:33:00 | | | |
| KA3542G01 | 2007-01-10 10:25:00 | 2007-01-10 10:49:00 | | | |
| KA3566G02 | 2007-01-11 08:57:00 | 2007-01-11 16:35:00 | | | |
| KA3590G01 | 2007-01-15 09:07:00 | 2007-01-15 14:37:00 | | | |
| KA3554G02 | 2007-01-15 09:12:00 | 2007-01-16 10:39:00 | | | |
| KA3542G02 | 2007-01-15 09:30:00 | 2007-01-15 11:13:00 | | | |
| KA3542G01 | 2007-03-28 09:49:00 | 2007-03-29 10:13:00 | 18.60 | 20.30 | 3 |
| KA3542G01 | 2007-03-29 09:15:00 | 2007-03-29 09:45:00 | 21.30 | 26.00 | 2 |
| KG0021A01 | 2007-01-10 09:50:00 | 2007-01-10 10:21:00 | 35.00 | 36.00 | 3 |
| KG0048A01 | 2007-01-10 13:59:00 | 2007-01-10 14:26:00 | 32.80 | 33.80 | 3 |