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Äspö Hard Rock Laboratory

Temperature Buffer Test

Sensors data report (Period 030326-040101) Report No:2

Reza Goudarzi
Lennart Börgesson
Torbjörn Sandén

Clay Technology AB

Ignacio Barcena

AITEMIN

January 2004

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

Äspö Hard Rock Laboratory

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Author	Date
Reza Goudarzi Lennart Börgesson Torbjörn Sandén Ignacio Barcena	Jan. 2004
Checked by	Date
Approved	Date
Christer Svemar Bertrand Vignal	

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Résumé

TBT (Test de Barrière ouvragée en Température) est une expérience menée conjointement par SKB et l'ANDRA; ENRESA et DBE. Ce projet simule le stockage de déchets fortement exo-thermiques où la température du colis pourrait dépasser 100°C. Cet essai est conduit dans le HRL d'Äspö dans une cellule de type KBS-3 de 8 m de profondeur et 1,75 m de diamètre. Deux colis (3 m de long, 0,6 m de diamètre) sont entourés d'argiles gonflantes et coiffés par un bouchon de confinement ancré sur 9 barres. L'essai fonctionne depuis le printemps 2003. Les colis chauffent avec une puissance nominale de 1500w chacun et un système d'hydratation artificielle fournit de l'eau avec une pression de 800 kPa.

Ce rapport présente les données de TBT enregistrées depuis son début le 26 mars 2003 jusqu'au premier janvier 2004.

Dans la bentonite sont mesurées la température en 89 points, la pression totale en 29 points, la pression de pore en 8 et l'humidité relative en 35. Outre les 89 thermomètres déjà cités, tous les autres capteurs possèdent une mesure de température interne pour compensation.

De plus la température est mesurée en 40 points du rocher environnant, en 11 points à la surface et 6 à l'intérieur des colis. La force sur le bouchon de confinement est mesurée sur trois des barres d'ancrage et son déplacement en trois points de sa périphérie. Le flux et la pression d'eau fournie sont aussi mesurés.

L'ensemble des mesures s'opère de façon satisfaisante mis à part les mesures d'humidité relative au droit du colis inférieur où plusieurs capteurs sont hors service.

La température maximale atteinte sur le colis du bas est de 143°C et de 157°C sur celui du haut. L'hydratation est sensible sur toute la périphérie de l'argile gonflante ; elle est mesurée par les capteurs d'humidité relative ainsi que par les capteurs de pression totale.

Abstract

TBT (Temperature Buffer Test) is a joint project between SKB/ANDRA, ENRESA and DBE that simulates a part of a repository for strongly exothermic waste, where the temperature on the canisters may exceed 100 ˚C. The test is carried out in Äspö HRL in a 8 meters deep and 1.75 m diameter deposition hole, with two canisters (3 m long, 0.6 m diameter), surrounded by a bentonite buffer and a confining plug on top anchored with 9 rods. It was installed during spring 2003. The canisters are heated with 1500 W power and an artificial wetting with a water pressure of 800 kPa is in progress. This report presents data from the measurements in the Temperature Buffer Test from 030326 to 040101 (26 March 2003 to 01 January 2004).

The following measurements are made in the bentonite: Temperature is measured in 89 points, total pressure in 29 points, pore water pressure in 8 points and relative humidity in 35 points. Temperature is also measured by all gauges as an auxiliary measurement used for compensation.

The following additional measurements are done: Temperature is measured in 40 points in the rock in 11 points on the surface of each canister and in 6 points inside each canister. The force on the confining plug is measured in 3 of the 9 rods and its vertical displacement is measured in three points. The water inflow and water pressure in the outer sand filter is also measured.

A general conclusion is that the measuring systems and transducers work well and almost all sensors deliver reliable values. The only exception is the Relative Humidity sensors in the high temperature area around the lower canister, where several sensors have failed.

The highest temperature measured on the canister surfaces is 143 ˚C on the lower canister and 157 ˚C on the upper. Strong wetting with measured high RH (>90%) and high swelling pressure (>3 MPa) has reached about 20 cm into the buffer everywhere with exception of the top blocks between the plug and heater 2.

Sammanfattning

TBT (Temperature Buffer Test) är ett gemensamt projekt mellan SKB/ANDRA, ENRESA och DBE som simulerar delar av ett slutförvar för starkt exotermiskt radioaktivt avfall där temperaturen på kapslarna kan överstiga 100 ˚C. Försöket görs på 420-metersnivån i Äspö HRL i ett 8 m djupt deponeringshål med diametern 1.75 m, där två kapslar, omgivande bentonitbuffert och en ovanliggande plugg, som förankrats med 9 stag, installerades våren 2003. Uppvärmning av kapslarna med effekten 1500 W och konstgjord bevätning med vattentrycket 800 kPa i sandfiltret pågår. I denna rapport presenteras data från mätningar i TBT under perioden 030326-040101.

Följande mätningar görs i bentoniten: Temperaturen mäts i 89 punkter, totaltryck i 29 punkter, porvattentryck i 8 punkter och relativa fuktigheten i 35 punkter. Temperaturen mäts även i alla relativa fuktighetsmätare, för att kompensera för temperaturens inverkan på mätresultaten.

Följande övriga mätningar görs: Temperaturen mäts i 40 punkter i berget, i 11 punkter på ytan av varje kapsel och i 6 punkter inne varje kapsel. Kraften på den ovanliggande pluggen mäts i 3 av de 9 stagen och vertikala förskjutningen av pluggen mäts i tre punkter. Vatten inflödet och vattentrycket i den yttre sandfyllda spalten mäts också.

En generell slutsats är att mätsystemen och givarna fungera bra och i stort sett alla givare leverar pålitliga mätvärden. Enda undantaget är mätningarna av relativa fuktigheten i högtemperaturområdet runt den undre kapseln, där ett flertal givare inte fungerar.

Högsta temperaturen som mäts på kapselytorna är 143 ˚C på nedre kapseln respektive 157 ˚C på övre. Stark bevätning med mätta höga RH (>90%) och höga svälltryck (>3 MPa) har nått cirka 20 cm in i bufferetn överallt utom i de översta blocken mellan pluggen och kapsel 2.

Contents

1 Introduction

The installation of the Temperature Buffer Test was made during spring 2003 in Äspö Hard Rock Laboratory, Sweden.

The Temperature Buffer Test, TBT, is a full-scale experiment that ANDRA and SKB carry out at the SKB Äspö Hard Rock Laboratory. In addition DBE has installed a number of optic pressure sensors. When storing strongly exothermic waste in addition to spent fuel, which is the case for ANDRA, the buffer material may be subjected to temperatures exceeding 100°C unless long waiting time is allowed before storage. No other full scales tests have been carried out with temperatures of the buffer exceeding 100°C so far.

The test consists of a full-scale KBS3 deposition hole, 2 steel canisters equipped with electrical heaters simulating the power of radioactive decay and a mechanical plug at the top. Figure 1-1 shows the layout and denomination of blocks and canisters. The canisters are embedded in dense clay buffer consisting of blocks (cylindrical and ring shaped) of compacted bentonite powder.

An artificial water pressure is applied in the outer slot between the buffer and the rock, which is filled with compacted sand and functions as a filter.

The upper canister is surrounded by sand in order to reduce the temperature in the bentonite.

The buffer material is instrumented with pressure cells (total and water pressure), thermocouples and moisture gauges. Thermocouples are also installed in the rock.

A retaining plug is built in order to confine the buffer swelling.

Measured results and general comments concerning the collected data are given in chapter 2. A test overview with the positions of the measuring points and a brief description of the instruments are presented in chapters 3 and 4.

In general the data in this report are presented in diagrams covering the time period 030326 to 040101[1]. The time axis in the diagrams represents days from 030326. The diagrams are attached in Appendix A. Results regarding DBE´s sensors will be included in the next TBT sensor data report.

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[1] YYMMDD (Swedish way of expressing dates implying that the first two numbers are the year, the next two numbers are the month abd the final two numbers are the date)

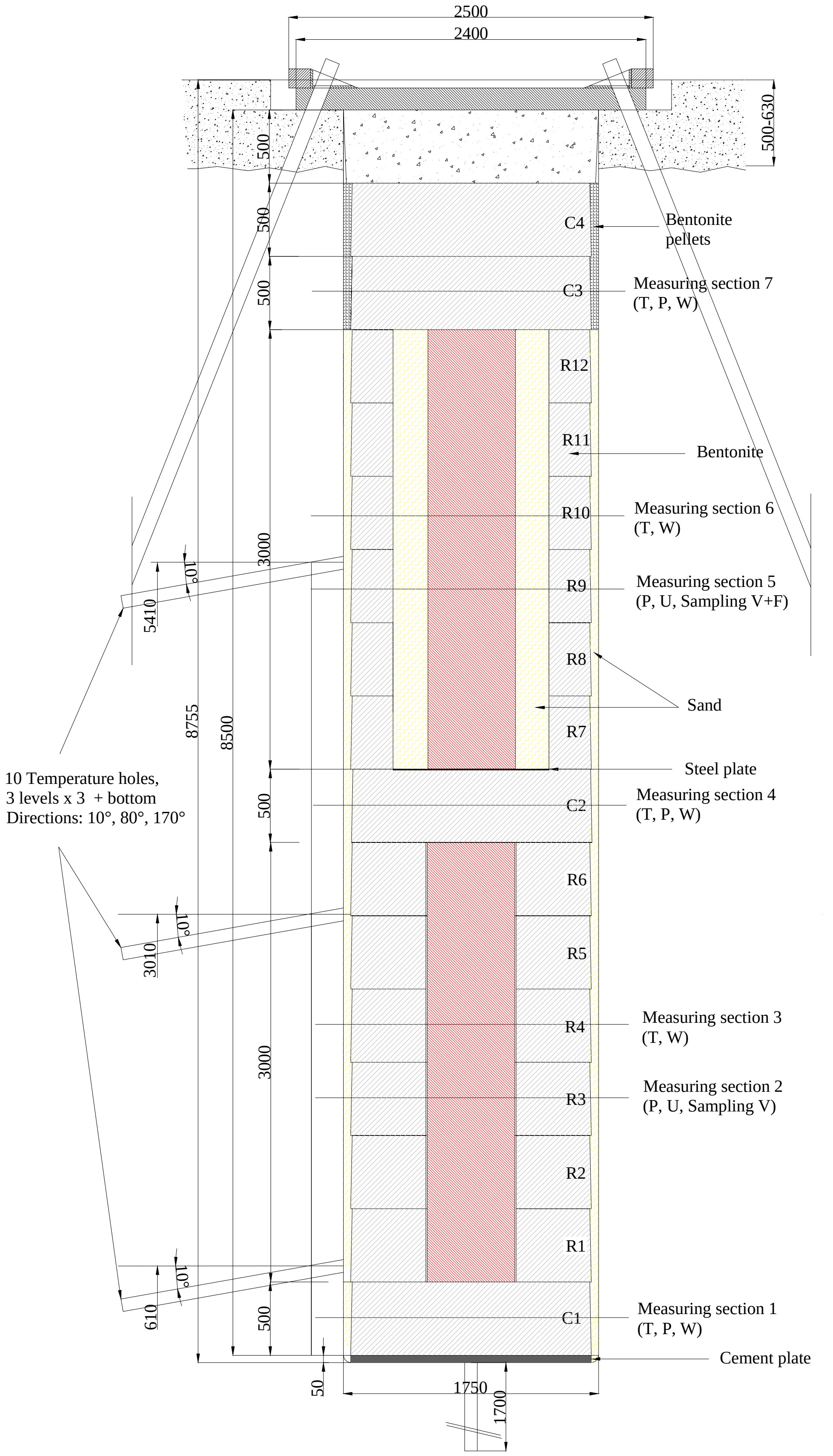


***Figure 1-1**. Schematic view showing the layout of the experiment and the numbering of bentonite blocks. The lower heater is denominated No. 1 and the upper heater is No. 2.*

2 Comments

2.1 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 in general are given but no evaluation or comparison with predictions will be given here.

The heating of both canisters started with an initially applied constant power of 900 W on 030326. This date is also marked as start date. The power was raised to 1200 W on 030403. The power was further raised to 1500 W on 030410. Several power failures have occurred. Important events and dates are shown in Table 2-1.

Table 2-1. Key dates for TBT

Activity	Date (time)	Day No.
900 W power applied	030326	0
Start water filling of filter	030327	1
1200 W power applied	030403	8
1500 W power applied	030410	15
Finished water filling	~030604	~70
Power failure heater 1	030423 (~20.00)-030424 (~10.00)	27-28
Power failure heater 1	030527 (~01.00)-030527 (~12.00)	62
Power failure heater 1	030603 (~12.00)-030603 (~14.00)	69
Power failure heater 1	030606 (~19.00)-030609 (~10.00)	72-75
Power failure heater 1	030612 (~12.00)-030612 (~14.00)	78
Power failure heaters 1 and 2	030923 (~12.00[1)])-030923 (~18.00[1)])	181
Power failure heaters 1 and 2	031028 (~18.00[1)])-031029 (~11.00[1)])	216

1) The duration of the power loss is not known since no data was recorded between the times noted.

The water filling was done through four tubes leading to the bottom of the sand filter. The filling was slow due to flow resistance in the sand and the rate was increased by pressurizing the water (see chapter 2.6). The filling was completed after 60-80 days. The water pressure in the bottom of the sand filter has been kept with periodical interruptions (see chapter 2.6) but the valves to the 4 upper tubes leading out water from the top of the sand filter have been open at all times.

This report is the second one and covers the results up to 040101.

2.2 Total pressure, Geocon (App. A, pages 35-43)

The measured pressure ranges from 0 to 8.0MPa. The start of the pressure increase takes place shortly after the water filling has reached the level of the different transducer. Only one transducer measures very low pressure (~200 kPa). This transducer measures radial pressure above the upper canister (PB228)

The latest power supply failure from 031028 (day 216) with decreased temperature is noted as a very small temporary drop in pressure. Notable is that one transducer around heater 1 and eight transducers around heater 2 are recording decreasing total pressure. The reason for this is not clear.

One transducer (PB207) has failed.

2.3 Suction, Wescore Psychrometers (App. A, pages 44-48)

Wescor psychrometers are only working at suction below ~5000 kPa, which correspond to high relative humidity (higher than 96%).

Ten transducers have started yielding interpretable values, which means that they are close to water saturation. Two of them have ceased functioning. Notable is that two transducers around heater 2 are yielding increasing suction during the last 80 days, which is consistent with the measured decrease in total pressure.

2.4 Relative humidity, Vaisala and Rotronic (App. A, pages 49-54)

Relative humidity and temperature measured with Vaisala and Rotronic transducers are shown on pages 53-58. For most transducers RH starts to increase just after the filling of water has reached the sensor level. Only one sensor in the buffer shows an obvious reduction in RH, namely WB206, which is located in the high temperature zone close to the lower heater. Sensors WB221 and WB222 are located in the sand in contact with the bentonite rings 9 and 10. The high initial RH measured by WB221 may be caused by the free water in the sand that had the water content of about 1% from start.

6 of 23 sensors are presently out of order for other reasons than high degree of saturation. Five of those are sensors in ring 4.

One transducer (WB231) has been revived during this measuring period.

2.5 Pore water pressure, Geocon (App. A, pages 55-56)

All water pressure sensors yield pressure close to zero.

2.6 Water flow and water pressure in the sand (App. A, pages 57-58)

Water filling and measurement of water inflow into the sand started on 030327. The total inflow to the sand has since that date been 1336 litre. The total volume of voids in the sand filter was initially about 790 litres. The inflow rate has been in average about 0.3 l/day since day 110.

There is also an outflow that started after completed filling since the valves from the top of the sand filter was kept open. The total outflow of water has since that date been 44 litre. Today there is almost no water outflow in spite of the high water pressure in the bottom.

The water pressure in the bottom of the sand filter is shown on page 46. The water pressure was increased to 800 – 900 kPa during the first 50 days and then kept "constant". However, problems with the water pump have lead to many interruptions in the applied pressure. During the last 50 days a rather constant pressure without interruptions has been kept.

2.7 Forces on the plug (App. A, page 59)

The forces on the plug have been measured since 030404.The total force is about 5325 kN at 040101.

During the first about 15 days the plug was only fixed with 3 rods. When the total force exceeded 1100 kN the rest of the 9 rods were fixed in a prescribed manner. This procedure took place 10-11 April 2003 that is 15-16 days after test start. From that time only every third anchor is measured and the results should thus be multiplied with 3. The diagram shows both the actual measurements and after multiplication with 3.

2.8 Displacement of the plug (App. A, page 60)

The three displacement gauges were placed and started to measure displacements from 030409 (day 14) (except for zero reading that was done day 0). One of them (DP201) did not work well and was replaced on 030923 with a new transducer.

2.9 Canister power (App A, page 61-62)

The heating of both canisters started with an initially applied constant power of 900 W on 030326 and was raised to 1500 W according to Table 2-1. Only one out of three heaters in each canister is presently used (RAH1 and RAH2).

2.10 Temperature in the buffer (App. A, pages 63-71)

Temperature is measured in a large number of points. The plotting of results is done so that the effect of wetting and cracking can be traced, since sensors placed close to each other are collected in the same diagrams.

The highest measured temperature in the bentonite is 136 °C by sensor TB215 located in the midplane of canister 1 at the distance 15 mm from the canister surface. The corresponding temperature on the canister surface is 143 °C, which shows that the temperature drop at the slot between the canister and the bentonite ring is very small.

Temperature is also measured in the sand around canister 2 (page 72), where the temperature drop is rather large (~3.2 °C/cm)

2.11 Temperature in the rock (App. A, pages 72-75)

The maximum temperature measured in the rock (72 degrees) is measured in the central section on the surface of the deposition hole. The deviation from axial symmetry of the temperature measured in the rock is caused by the influence from the heating of the neighbouring Canister Retrieval Test.

2.12 Temperature on the canister surface (App. A, pages 76-77)

The maximum temperature measured on the surface of canister 1 is about 143 °C and on the surface of canister 2 about 157 °C on 040101. There are strong temperature differences in the canisters, both radial and axial. The highest difference on the surface is 27 °C on canister 1 and 37 °C on canister 2.

The steady increase in temperature of heater 1 has turned into a slow decrease. The temperature of heater 2 has decreased since day 50.

2.13 Temperature inside the canister (App. A, pages 78-79)

The maximum temperature measured inside canister 1 is about 166 °C and about 211 °C in canister 2 on 040101. However, the very high value 211 °C may be questioned since it deviates from all other values measured in canister 2. The other sensor at the same level (upper part of the canister) measures only about 175 °C, which is consistent with the other measurements in canister 2.

3 Coordinate system

Measurements will be done in 7measuring sections placed on different levels (see Figure 1-1). On each level, sensors are placed in eight main directions A, AB, B, BC, C, CD, D and DA according to Figure 3-1. 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 South (see Figure 1-1, 3-1 and 4-1). The angle α is counted anti-clockwise from direction A. The z-coordinate is counted from the bottom of the deposition hole (the cement base).

The bentonite blocks are called cylinders and rings. The cylinders are numbered C1-C4 and the rings R1-R12 respectively (see Figure 1-1).

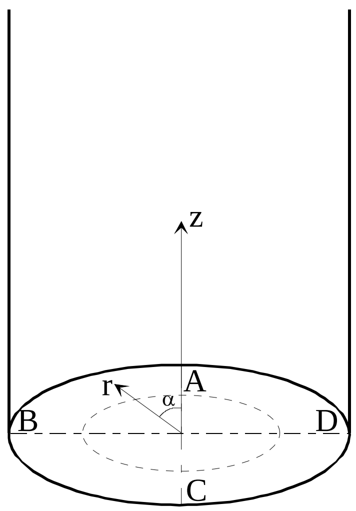


Figure 3-1*Figure describing the coordinate system used when determining the instrument positions.*

4 Location of instruments

4.1 Brief description of the instruments

The different instruments that are used in the experiment are briefly described in this chapter.

Measurements of temperature

Buffer

Thermocouples from Pentronic have been installed for measuring temperature in the buffer. Measurements are done in 89 points in the test hole. In addition, temperature gauges are built in into the capacitive relative humidity sensors (23 sensors) as well as in the pressure gauges of vibrating wire type (37 gauges). Temperature is also measured in the psychrometers.

Canister

Temperature is measured in 11 points on the surface of the each canister. Temperature is also measured in each canister insert in 6 points.

Rock

Temperature in the rock and on the rock surface of the hole is measured in 40 points with thermocouples from Pentronic.

Measurement of total pressure in the buffer

Total pressure is the sum of the swelling pressure and the pore water pressure. It is measured with Geocon total pressure cells with vibrating wire transducers. 29 cells of this type have been installed.

Measurement of pore water pressure in the buffer

Pore water pressure is measured with Geocon pore pressure cells with vibrating wire transducer. 8 cells of this type have been installed.

Measurement of the water saturation process

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

- Vaisala relative humidity sensor of capacitive type. 29 cells of this type have been installed. The measuring range is 0-100 % RH.

- Wescor psychrometers measure the dry and the wet temperature in the pore system. The measuring range is 95.5-99.6 % RH corresponding to the pore water pressure -0.5 to -6MPa. 12 cells of this type have been installed.

Measurements of forces on the plug

The force on the plug caused by the swelling pressure of the bentonite is measured in 3 of the 9 anchors. The force transducers are of the type GLÖTZL.

Measurements of plug displacement

Due to straining of the anchors the swelling pressure of the bentonite will cause not only a force on the plug but also displacement of the plug. The displacement is measured in three points with transducers of the type LVDT with the range 0 – 50 mm.

Measurement of water flow into the sand

An artificial water pressure is applied in the outer slot, which is filled with sand. Titanium tubes equipped with filter tips are placed in the sand on two levels, 250 mm and 6750 mm from bottom (four at each level).

4.2 Strategy for describing the position of each device

Every instrument is named with a unique name consisting of 1 letter describing the type of measurement, (T-Temperature, P-Total Pressure, U-Pore Pressure, W-Relative Humidity, C-Chemical sampling, D-Displacement and A-Artificial water), 1 letter describing where the measurement takes place (B-Buffer, H-Heater, S-Sand, R-Rock and P-plug), 1 figure denoting the deposition hole (1 is used for the CRT test and 2 is used for this experiment), and 2 figures specifying the position in the buffer according to a separate list (see Table 4-1 to 4-7). Every instrument position is described with three coordinates according to Figure 3-1. The r-coordinate is the horizontal distance from the center of the hole and the z-coordinate is the height from the bottom of the hole (the block height is set to 500mm). The coordinate is the angle from the vertical direction A (almost South).

The position of each instrument is described in the legend in the diagrams according to the following strategy:

Buffer: Three positions according to Figure 3-1: (z \ α \ r) meaning (z-coordinate in m. from the bottom \ the angle α \ the radius in m.)

The cells measuring total pressure have been installed in three different directions in order to measure the radial stress (R), the axial stress (A) and the tangential stress (T). The direction of the pressure measurement is added in Table 4-2 and in the legend for each cell.

Rock: Three positions with the following meaning: (distance in meters from the bottom \ α according to Fig 3-1 \ distance in meters from the rock surface)

The bentonite blocks are called cylinders and rings. The cylinders are numbered C1-C4 and the rings R1-R12 respectively (Figure 1-1).

Canister: The denomination of the instruments in the canister differs a little from the other instruments. At first there are two letters and one figure describing the type of measurement and the place (TH for temperature and heater) and which heater (1 for lower heater and 2 for upper). Then there are again two letters describing if it is an external or internal sensor (SE or SI) and one figure describing the position on the canister (0-4 according to Figure 4-2). Finally the angle clockwise from direction A is written.

4.3 Position of each instrument in the bentonite

Measurements are done in 7measuring sections placed on different levels (see Figure 1-1). On each level, sensors are placed in eight main directions A, AB, B, BC, C, CD, D and DA according to Figure 4-1. The bentonite blocks are called cylinders and rings. The cylinders are numbered C1-C4 and the rings R1-R12 respectively (see Figure 1-1).

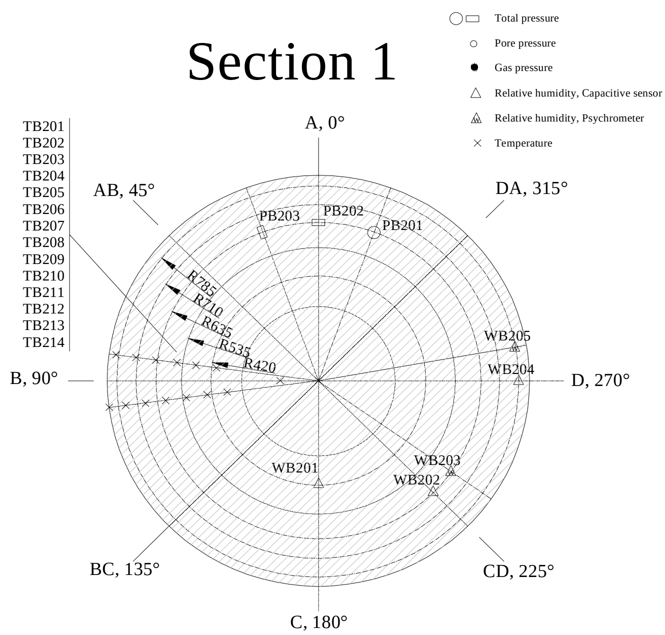


Figure 4-1 *Schematic view, showing the main directions of the instrument positioning. The drawing shows the instrumentation in measuring section 1.*

An overview of the positions of the instruments is shown in Fig 1-1 and 4-1. Exact positions are described in Tables 4-1 to 4-6.

The instruments are located in three main levels in each instrumented block, the surface of the block (only total pressure cells measuring the horizontal pressure) and 50 mm and 250 mm from the upper block surface. The thermocouples and the total pressure cells are placed in the 50 mm level by practical reasons and the other sensors in the 250 mm level.

Table 4-1 Numbering and position of instruments for measuring temperature (T)

Type and number	Measuring section	Block	Instrument position in block				Instrument Fabricate
			Direction	α	r	z	
				degree	m	m	
TB201	1	Cyl. 1	B	90	0,150	0,450	Pentronic
TB202	1	Cyl. 1	B	95	0,360	0,450	Pentronic
TB203	1	Cyl. 1	B	85	0,400	0,450	Pentronic
TB204	1	Cyl. 1	B	95	0,440	0,450	Pentronic
TB205	1	Cyl. 1	B	85	0,480	0,450	Pentronic
TB206	1	Cyl. 1	B	95	0,520	0,450	Pentronic
TB207	1	Cyl. 1	B	85	0,560	0,450	Pentronic
TB208	1	Cyl. 1	B	95	0,600	0,450	Pentronic
TB209	1	Cyl. 1	B	85	0,640	0,450	Pentronic
TB210	1	Cyl. 1	B	95	0,680	0,450	Pentronic
TB211	1	Cyl. 1	B	85	0,720	0,450	Pentronic
TB212	1	Cyl. 1	B	95	0,760	0,450	Pentronic
TB213	1	Cyl. 1	B	85	0,780	0,450	Pentronic
TB214	1	Cyl. 1	B	95	0,825	0,450	Pentronic
TB215	3	Ring 4	B	97,5	0,320	2,450	Pentronic
TB216	3	Ring 4	B	82,5	0,360	2,450	Pentronic
TB217	3	Ring 4	B	97,5	0,390	2,450	Pentronic
TB218	3	Ring 4	B	92,5	0,420	2,450	Pentronic
TB219	3	Ring 4	B	87,5	0,435	2,450	Pentronic
TB220	3	Ring 4	B	82,5	0,450	2,450	Pentronic
TB221	3	Ring 4	B	97,5	0,465	2,450	Pentronic
TB222	3	Ring 4	B	92,5	0,480	2,450	Pentronic
TB223	3	Ring 4	B	87,5	0,495	2,450	Pentronic
TB224	3	Ring 4	B	82,5	0,510	2,450	Pentronic
TB225	3	Ring 4	B	97,5	0,525	2,450	Pentronic
TB226	3	Ring 4	B	92,5	0,540	2,450	Pentronic
TB227	3	Ring 4	B	87,5	0,555	2,450	Pentronic
TB228	3	Ring 4	B	82,5	0,570	2,450	Pentronic
TB229	3	Ring 4	B	97,5	0,585	2,450	Pentronic
TB230	3	Ring 4	B	92,5	0,600	2,450	Pentronic
TB231	3	Ring 4	B	87,5	0,615	2,450	Pentronic
TB232	3	Ring 4	B	82,5	0,630	2,450	Pentronic
TB233	3	Ring 4	B	97,5	0,645	2,450	Pentronic
TB234	3	Ring 4	B	92,5	0,660	2,450	Pentronic
TB235	3	Ring 4	B	87,5	0,690	2,450	Pentronic
TB236	3	Ring 4	B	92,5	0,720	2,450	Pentronic
TB237	3	Ring 4	B	87,5	0,750	2,450	Pentronic
TB238	3	Ring 4	B	92,5	0,780	2,450	Pentronic
TB239	3	Ring 4	B	87,5	0,810	2,450	Pentronic
TB240	4	Cyl. 2	B	90	0,150	3,950	Pentronic
TB241	4	Cyl. 2	B	95	0,360	3,950	Pentronic
TB242	4	Cyl. 2	B	85	0,400	3,950	Pentronic
TB243	4	Cyl. 2	B	95	0,440	3,950	Pentronic
TB244	4	Cyl. 2	B	85	0,480	3,950	Pentronic
TB245	4	Cyl. 2	B	95	0,520	3,950	Pentronic

Type and number	Measuring section	Block	Instrument position in block				Instrument Fabricate
			Direction	α	r	z	
				degree	m	m	
TB246	4	Cyl. 2	B	85	0,560	3,950	Pentronic
TB247	4	Cyl. 2	B	95	0,600	3,950	Pentronic
TB248	4	Cyl. 2	B	85	0,640	3,950	Pentronic
TB249	4	Cyl. 2	B	95	0,680	3,950	Pentronic
TB250	4	Cyl. 2	B	85	0,720	3,950	Pentronic
TB251	4	Cyl. 2	B	95	0,760	3,950	Pentronic
TB252	4	Cyl. 2	B	85	0,780	3,950	Pentronic
TB253	4	Cyl. 2	B	95	0,825	3,950	Pentronic
TB254	6	Ring 10	B	90	0,360	5,950	Pentronic
TB255	6	Ring 10	B	90	0,420	5,950	Pentronic
TB256	6	Ring 10	B	90	0,480	5,950	Pentronic
TB257	6	Ring 10	B	97,5	0,540	5,950	Pentronic
TB258	6	Ring 10	B	92,5	0,555	5,950	Pentronic
TB259	6	Ring 10	B	87,5	0,570	5,950	Pentronic
TB260	6	Ring 10	B	82,5	0,585	5,950	Pentronic
TB261	6	Ring 10	B	97,5	0,600	5,950	Pentronic
TB262	6	Ring 10	B	92,5	0,615	5,950	Pentronic
TB263	6	Ring 10	B	87,5	0,630	5,950	Pentronic
TB264	6	Ring 10	B	82,5	0,645	5,950	Pentronic
TB265	6	Ring 10	B	97,5	0,660	5,950	Pentronic
TB266	6	Ring 10	B	92,5	0,675	5,950	Pentronic
TB267	6	Ring 10	B	87,5	0,690	5,950	Pentronic
TB268	6	Ring 10	B	82,5	0,705	5,950	Pentronic
TB269	6	Ring 10	B	97,5	0,720	5,950	Pentronic
TB270	6	Ring 10	B	92,5	0,735	5,950	Pentronic
TB271	6	Ring 10	B	87,5	0,750	5,950	Pentronic
TB272	6	Ring 10	B	82,5	0,765	5,950	Pentronic
TB273	6	Ring 10	B	97,5	0,780	5,950	Pentronic
TB274	6	Ring 10	B	92,5	0,795	5,950	Pentronic
TB275	6	Ring 10	B	87,5	0,810	5,950	Pentronic
TB276	7	Cyl. 3	B	90	0,150	7,450	Pentronic
TB277	7	Cyl. 3	B	95	0,360	7,450	Pentronic
TB278	7	Cyl. 3	B	85	0,400	7,450	Pentronic
TB279	7	Cyl. 3	B	95	0,440	7,450	Pentronic
TB280	7	Cyl. 3	B	85	0,480	7,450	Pentronic
TB281	7	Cyl. 3	B	95	0,520	7,450	Pentronic
TB282	7	Cyl. 3	B	85	0,560	7,450	Pentronic
TB283	7	Cyl. 3	B	95	0,600	7,450	Pentronic
TB284	7	Cyl. 3	B	85	0,640	7,450	Pentronic
TB285	7	Cyl. 3	B	95	0,680	7,450	Pentronic
TB286	7	Cyl. 3	B	85	0,720	7,450	Pentronic
TB287	7	Cyl. 3	B	95	0,760	7,450	Pentronic
TB288	7	Cyl. 3	B	85	0,780	7,450	Pentronic
TB289	7	Cyl. 3	B	95	0,825	7,450	Pentronic

Table 4-2 Numbering and position of instruments measuring total pressure (P)

Type and number	Measuring section	Block	Instrument position in block: Direction	α	r	Z	Instrument Fabricate	Direction of pressure measurement
				degree	m	m		
PB201	1	Cyl. 1	A	340	0,635	0,500	Geokon	Axial
PB202	1	Cyl. 1	A	0	0,635	0,450	Geokon	Radial
PB203	1	Cyl. 1	A	20	0,635	0,450	Geokon	Tangential
PB204	2	R3	D	250	0,420	1,950	Geokon	Radial
PB205	2	R3	D	290	0,420	2,000	Geokon	Axial
PB206	2	R3	A	0	0,535	1,950	Geokon	Radial
PB207	2	R3	A	20	0,535	1,950	Geokon	Tangential
PB208	2	R3	AB	45	0,585	2,000	Geokon	Axial
PB209	2	R3	B	100	0,635	1,950	Geokon	Tangential
PB210	2	R3	C	170	0,710	1,950	Geokon	Tangential
PB211	2	R3	C	180	0,710	1,950	Geokon	Radial
PB212	2	R3	D	260	0,770	2,000	Geokon	Axial
PB213	2	R3	D	270	0,875	1,950	Geokon	Radial on rock
PB214	4	Cyl. 2	A	340	0,635	4,000	Geokon	Axial
PB215	4	Cyl. 2	A	0	0,635	3,950	Geokon	Radial
PB216	4	Cyl. 2	A	20	0,635	3,950	Geokon	Tangential
PB217	5	Ring 9	D	270	0,535	5,450	Geokon	Radial,against sand
PB218	5	Ring 9	A	340	0,635	5,500	Geokon	Axial
PB219	5	Ring 9	A	0	0,635	5,450	Geokon	Radial
PB220	5	Ring 9	A	20	0,635	5,450	Geokon	Tangential
PB221	5	Ring 9	B	70	0,710	5,500	Geokon	Axial
PB222	5	Ring 9	B	110	0,710	5,450	Geokon	Radial
PB223	5	Ring 9	C	160	0,770	5,500	Geokon	Axial
PB224	5	Ring 9	C	180	0,770	5,450	Geokon	Radial
PB225	5	Ring 9	C	200	0,770	5,450	Geokon	Tangential
PB226	5	Ring 9	D	270	0,875	5,450	Geokon	Radial on rock
PB227	7	Cyl. 3	A	340	0,635	7,500	Geokon	Axial
PB228	7	Cyl. 3	A	0	0,635	7,450	Geokon	Radial
PB229	7	Cyl. 3	A	20	0,635	7,450	Geokon	Tangential
PB230	2	R3	C	180	0,315	1,950	DBE	Radial
PB231	5	R9	C	180	0,535	5,450	DBE	Radial

Table 4-3 Numbering and position of instruments measuring pore pressure (U)

Type and number	Measuring section	Block	Instrument position in block: Direction	α	r	Z	Instrument Fabricate	Remark
				degree	m	m		
UB201	2	Ring 3	D	270	0,420	1,750	Geokon	
UB202	2	Ring 3	A	350	0,535	1,750	Geokon	
UB203	2	Ring 3	B	90	0,635	1,750	Geokon	
UB204	2	Ring 3	D	280	0,785	1,750	Geokon	
US205	5	Ring 9	D	270	0,420	5,250	Geokon	In sand
UB206	5	Ring 9	DA	315	0,635	5,250	Geokon	
UB207	5	Ring 9	B	90	0,710	5,250	Geokon	
UB208	5	Ring 9	CD	225	0,785	5,250	Geokon	
UB209	2	Ring 3	C	190	0,315	1,750	DBE	
UB210	5	Ring 9	C	160	0,420	5,250	DBE	

Table 4-4 Numbering and position of instruments measuring water content (W)

Type and number	Measuring section	Block	Instrument position in block				Instrument Fabricate	Remark
			Direction	α	r	Z		
				degree	m	m		
WB201	1	Cyl.1	C	180	0,420	0,250	Rotronic	
WB202	1	Cyl.1	CD	225	0,635	0,250	Vaisala	
WB203	1	Cyl.1	CD	235	0,635	0,250	Wescor	
WB204	1	Cyl.1	D	270	0,760	0,250	Rotronic	
WB205	1	Cyl.1	D	280	0,760	0,250	Wescor	
WB206	3	Ring 4	BC	135	0,360	2,250	Vaisala	
WB207	3	Ring 4	C	180	0,420	2,250	Rotronic	
WB208	3	Ring 4	CD	225	0,485	2,250	Vaisala	
WB209	3	Ring 4	D	270	0,560	2,250	Rotronic	
WB210	3	Ring 4	DA	315	0,635	2,250	Vaisala	
WB211	3	Ring 4	DA	325	0,635	2,250	Wescor	
WB212	3	Ring 4	A	0	0,710	2,250	Rotronic	
WB213	3	Ring 4	A	10	0,710	2,250	Wescor	
WB214	3	Ring 4	AB	45	0,785	2,250	Vaisala	
WB215	3	Ring 4	AB	55	0,785	2,250	Wescor	
WB216	4	Cyl.2	C	180	0,420	3,750	Rotronic	
WB217	4	Cyl.2	CD	225	0,635	3,750	Vaisala	
WB218	4	Cyl.2	CD	235	0,635	3,750	Wescor	
WB219	4	Cyl.2	D	270	0,760	3,750	Rotronic	
WB220	4	Cyl.2	D	280	0,760	3,750	Wescor	
WS221	5	Ring 9	BC	135	0,525	5,250	Vaisala	In sand
WS222	6	Ring 10	BC	135	0,525	5,750	Vaisala	In sand
WB223	6	Ring 10	C	180	0,585	5,750	Rotronic	
WB224	6	Ring 10	CD	225	0,635	5,750	Vaisala	
WB225	6	Ring 10	D	270	0,685	5,750	Rotronic	
WB226	6	Ring 10	D	280	0,685	5,750	Wescor	
WB227	6	Ring 10	DA	315	0,735	5,750	Vaisala	
WB228	6	Ring 10	DA	325	0,735	5,750	Wescor	
WB229	6	Ring 10	A	0	0,785	5,750	Rotronic	
WB230	6	Ring 10	A	10	0,785	5,750	Wescor	
WB231	7	Cyl.3	C	180	0,420	7,250	Rotronic	
WB232	7	Cyl.3	CD	225	0,635	7,250	Vaisala	
WB233	7	Cyl.3	CD	235	0,635	7,250	Wescor	
WB234	7	Cyl.3	D	270	0,760	7,250	Rotronic	
WB235	7	Cyl.3	D	280	0,760	7,250	Wescor	

4.4 Instruments in the rock

Temperature measurements

40 thermocouples are located in ten boreholes in the rock (see Figure 1-1). The depth of each borehole is 1.5 m. In each borehole 4 thermocouples are placed at different distances from the rock surface. Observe that the coordinate system does not count the radius but the radial distance from the rock surface of the deposition hole. The position of each instrument is described in Table 4-5.

Table 4-5 Numbering and positions of thermocouples in the rock

Mark	Level	Direction	Distance from rock surface	Instrument Fabricate
	m	degree	m	
TR201	0	Center	0,000	Pentronic
TR202	0	Center	0,375	Pentronic
TR203	0	Center	0,750	Pentronic
TR204	0	Center	1,500	Pentronic
TR205	0,61	10°	0,000	Pentronic
TR206	0,61	10°	0,375	Pentronic
TR207	0,61	10°	0,750	Pentronic
TR208	0,61	10°	1,500	Pentronic
TR209	0,61	80°	0,000	Pentronic
TR210	0,61	80°	0,375	Pentronic
TR211	0,61	80°	0,750	Pentronic
TR212	0,61	80°	1,500	Pentronic
TR213	0,61	170°	0,000	Pentronic
TR214	0,61	170°	0,375	Pentronic
TR215	0,61	170°	0,750	Pentronic
TR216	0,61	170°	1,500	Pentronic
TR217	3,01	10°	0,000	Pentronic
TR218	3,01	10°	0,375	Pentronic
TR219	3,01	10°	0,750	Pentronic
TR220	3,01	10°	1,500	Pentronic
TR221	3,01	80°	0,000	Pentronic
TR222	3,01	80°	0,375	Pentronic
TR223	3,01	80°	0,750	Pentronic
TR224	3,01	80°	1,500	Pentronic
TR225	3,01	170°	0,000	Pentronic
TR226	3,01	170°	0,375	Pentronic
TR227	3,01	170°	0,750	Pentronic
TR228	3,01	170°	1,500	Pentronic
TR229	5,41	10°	0,000	Pentronic
TR230	5,41	10°	0,375	Pentronic
TR231	5,41	10°	0,750	Pentronic
TR232	5,41	10°	1,500	Pentronic
TR233	5,41	80°	0,000	Pentronic
TR234	5,41	80°	0,375	Pentronic
TR235	5,41	80°	0,750	Pentronic
TR236	5,41	80°	1,500	Pentronic
TR237	5,41	170°	0,000	Pentronic
TR238	5,41	170°	0,375	Pentronic
TR239	5,41	170°	0,750	Pentronic
TR240	5,41	170°	1,500	Pentronic

4.5 Instruments in the canister

Temperature is measured both on the canister surface and inside the canister. Eleven thermocouples are installed on each canisters surface. Three groups of three thermocouples are installed 100 mm from each heater end, and in the middle of the heater, with a distribution of 120°. Two additional thermocouples are installed in the centre of the bottom lid and the top cover. Temperature inside the canister insert is measured at 6 points with thermocouples.

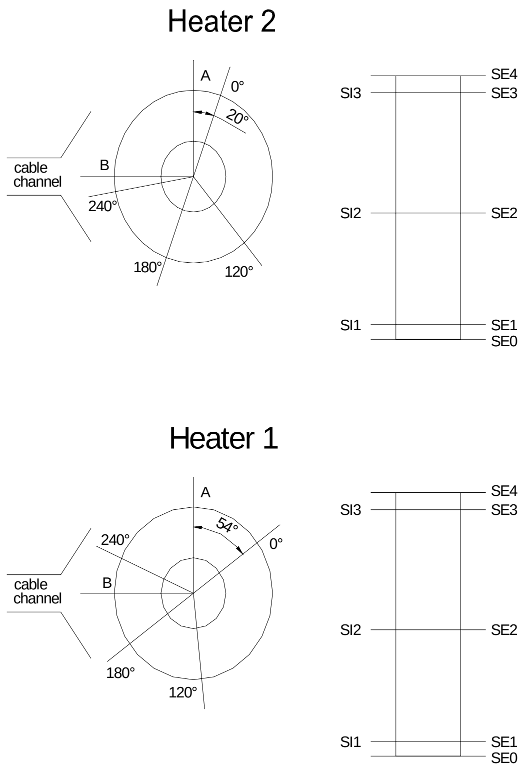
Figure 4-2 shows how these thermocouples are placed (see also chapter 4.2). Table 4-6 and 4-7 show the positions.

Table 4-6 Numbering and position of instruments for measuring the temperature on the heaters surface (T)

Type and number	Heater	Instruments coordinates				Instrument	Remark
		Position	α	r	z	Fabricate	
			degree	m	m		
TH1 SE0	1	Bottom	0	0,000	0,500		
TH1 SE1 0º	1	Lower sec.	0	0,305	0,600		
TH1 SE1 240º	1	Lower sec.	240	0,305	0,600		
TH1 SE1 120º	1	Lower sec.	120	0,305	0,600		
TH1 SE2 0º	1	Middle sec.	0	0,305	2,000		
TH1 SE2 240º	1	Middle sec.	240	0,305	2,000		
TH1 SE2 120º	1	Middle sec.	120	0,305	2,000		
TH1 SE3 0º	1	Upper sec.	0	0,305	3,400		
TH1 SE3 240º	1	Upper sec.	240	0,305	3,400		
TH1 SE3 120º	1	Upper sec.	120	0,305	3,400		
TH1 SE4	1	Top	0	0,000	3,500		
TH2 SE0	2	Bottom	0	0,000	4,000		
TH2 SE1 0º	2	Lower sec.	0	0,305	4,100		
TH2 SE1 240º	2	Lower sec.	240	0,305	4,100		
TH2 SE1 120º	2	Lower sec.	120	0,305	4,100		
TH2 SE2 0º	2	Middle sec.	0	0,305	5,500		
TH2 SE2 240º	2	Middle sec.	240	0,305	5,500		
TH2 SE2 120º	2	Middle sec.	120	0,305	5,500		
TH2 SE3 0º	2	Upper sec.	0	0,305	6,900		
TH2 SE3 240º	2	Upper sec.	240	0,305	6,900		
TH2 SE3 120º	2	Upper sec.	120	0,305	6,900		
TH2 SE4	2	Top	0	0,000	7,000		

Table 4-7 Numbering and position of instruments for measuring the temperature inside the heaters (T)

Type and number	Heater	Instruments coordinates			Instrument Fabricate	Remark
		Position	α	Z		
			degree	m		
TH1 SI1 0º	1	Lower sec.	0	0,60		
TH1 SI1 180º	1	Lower sec.	180	0,60		
TH1 SI2 0º	1	Middle sec.	0	2,00		
TH1 SI2 180º	1	Middle sec.	180	2,00		
TH1 SI3 0º	1	Upper sec.	0	3,40		
TH1 SI3 180º	1	Upper sec.	180	3,40		
TH2 SI1 0º	2	Lower sec.	0	0,60		
TH2 SI1 180º	2	Lower sec.	180	0,60		
TH2 SI2 0º	2	Middle sec.	0	2,00		
TH2 SI2 180º	2	Middle sec.	180	2,00		
TH2 SI3 0º	2	Upper sec.	0	3,40		
TH2 SI3 180º	2	Upper sec.	180	3,40		



Figur 4-2. *Location of thermocouples inside (SI) and on (SE) the canisters*

4.6 Instruments on the plug

Three force transducers and three displacement transducers have been placed on the plug to measure the force of the anchors and the displacement of the plug. The location of these transducers can be described in relation to Fig 4-3, which shows a schematic view of the plug with the slots, rods and cables.

The rods are numbered 1-9 anti-clockwise and number 1 is the northern rod 18 degrees from direction A. The force transducers are placed on rods 3, 6, and 9. The displacement transducers are placed between the rods on the steel ring in the periphery of the plug. They are fixed on the rock surface and measure thus the displacement relative to the rock.

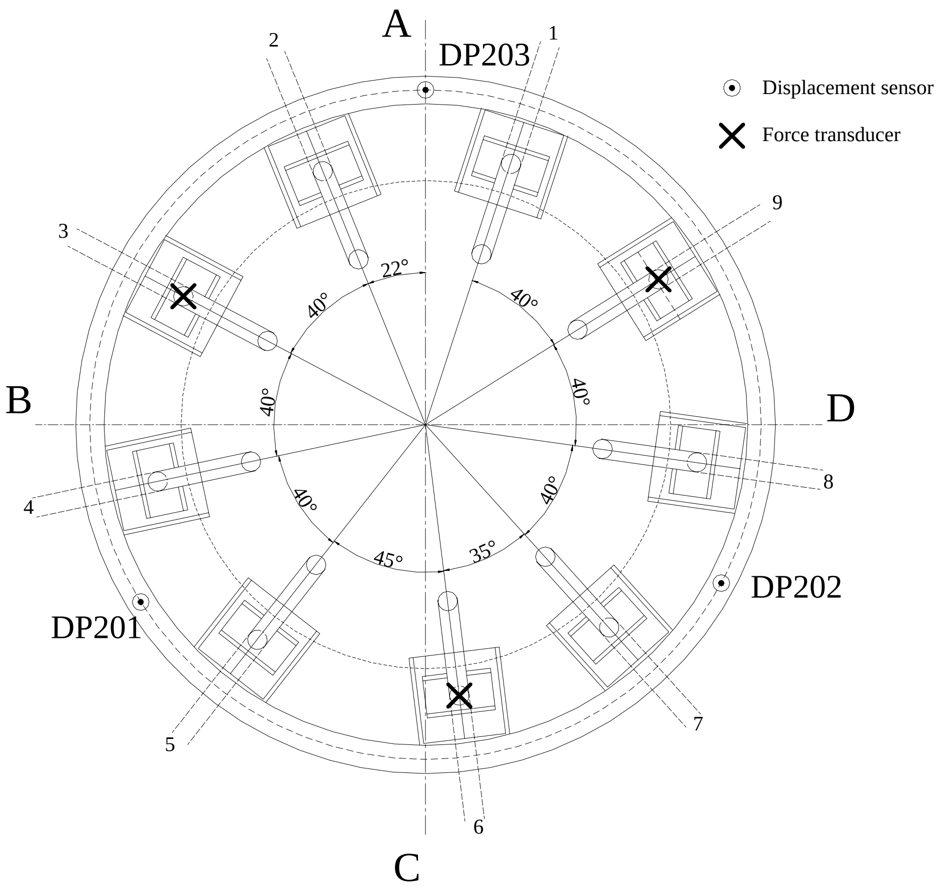


Figure 4-3. *Schematic view showing the positions of the rods and the displacement and force transducers on the retaining plug.*

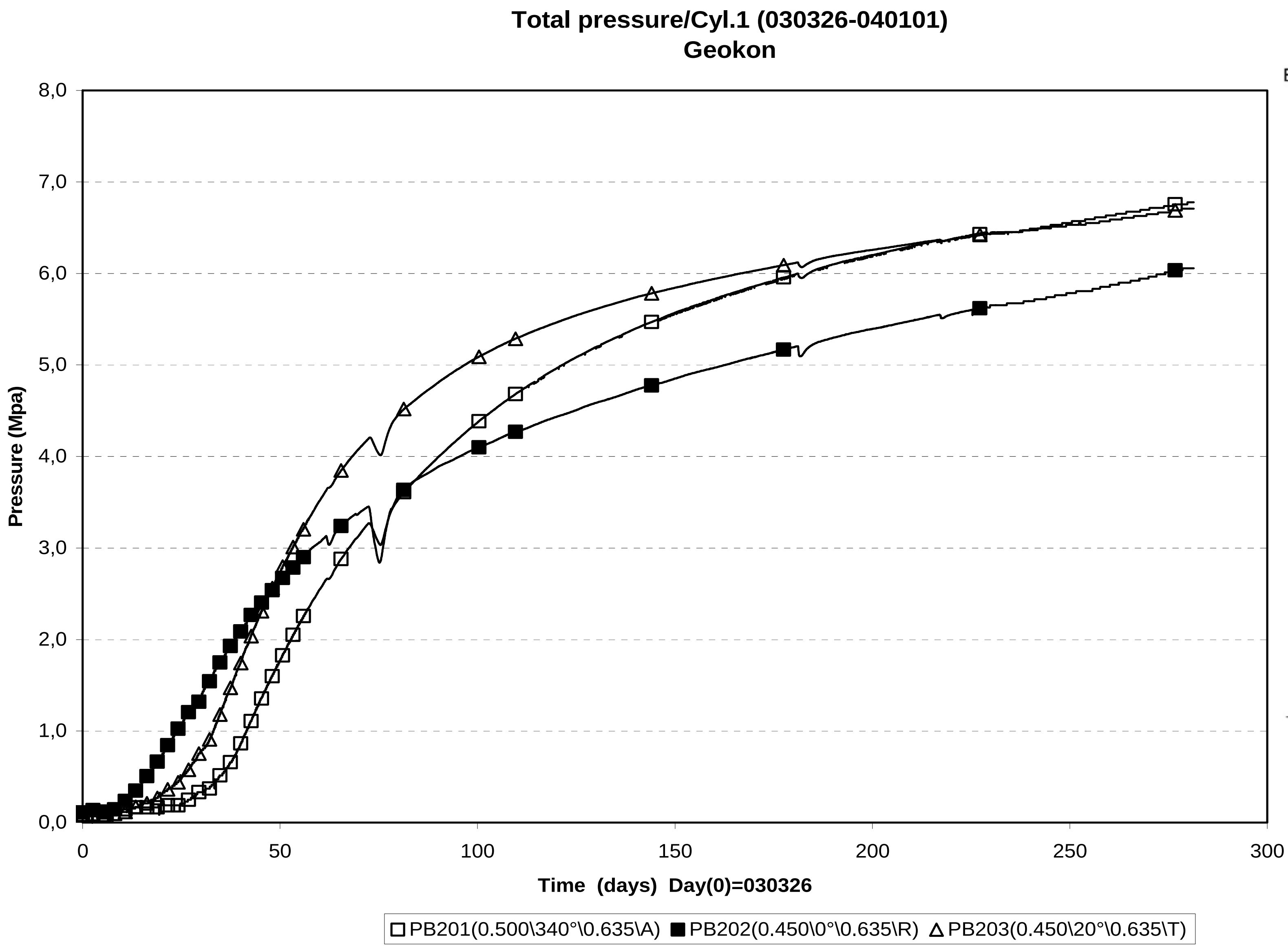
5 References

/1-1/ Sandén T and Börgesson L. Report on instruments and their positions for THM measurements in buffer and rock and preparation of bentonite blocks for instruments and cables. Temperature Buffer Test, Report R5 , 2002. SKB ITD-02-05

/2-1/ Garcia-Sineriz, J.L and Fuentes- Cantillana. Feasibility study for the heating system at the TBT test carried out at the Äspö HRL in Sweden. Temperature Buffer Test , October 2002. SKB IPR-03-18

6 Appendix A

Measured data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2,0
1,0
0,0
0
50
100
150
200
250
300
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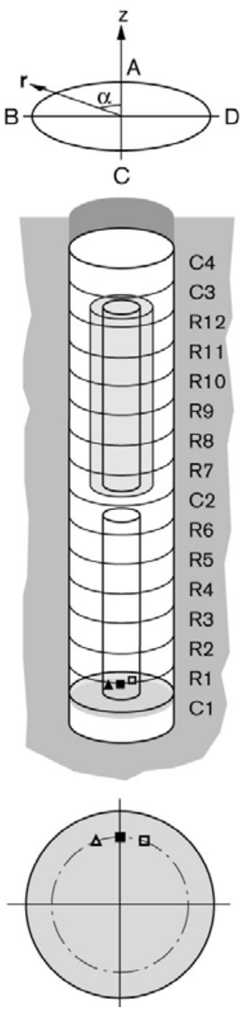
z
A
r
α
B
D
C
C4
C3
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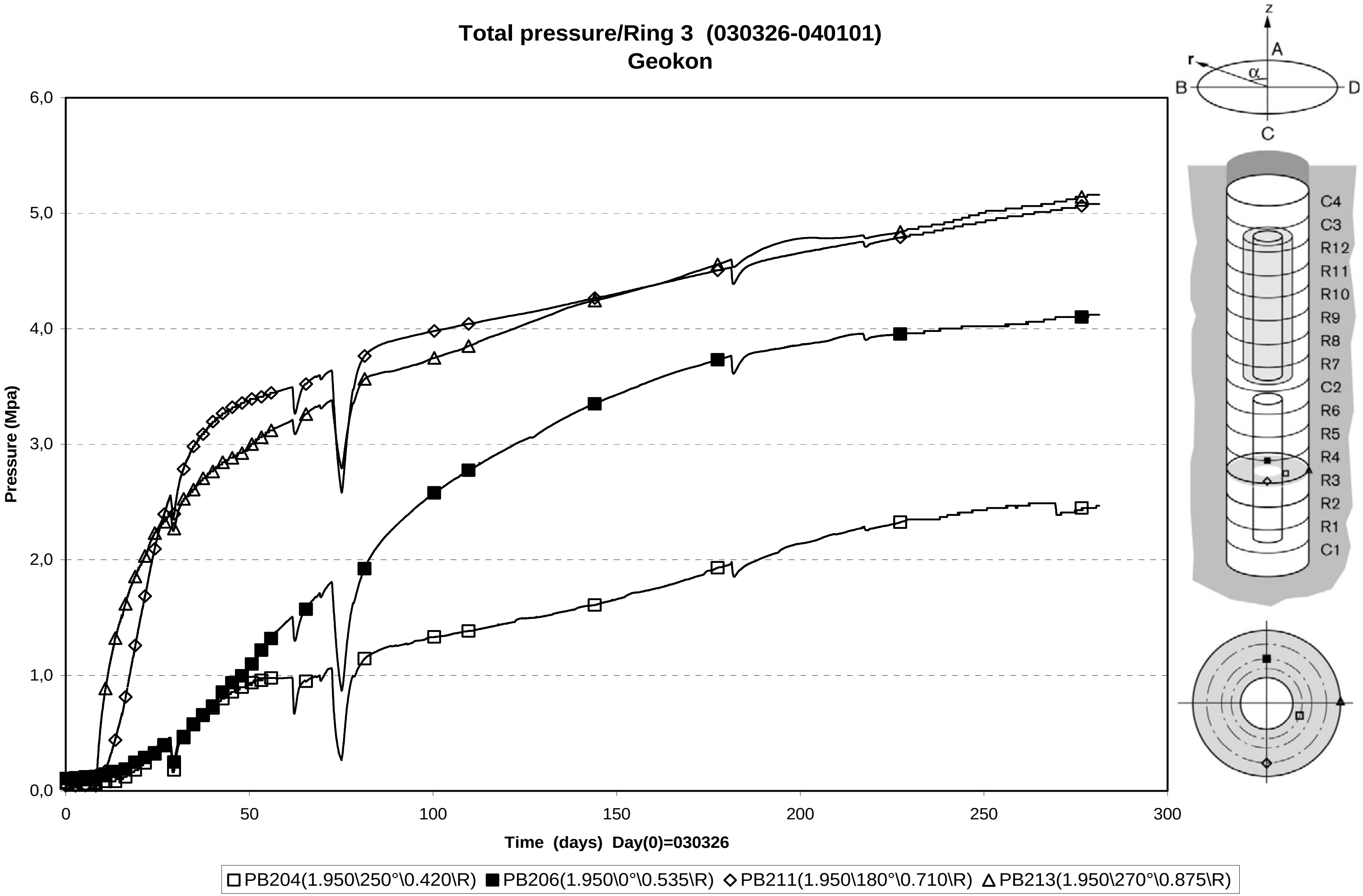
R3
R2
R1
C1



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Geokon
Pressure (Mpa)
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4,0
3,0
2,0
1,0
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0
50
100
150
200
250
300
Time (days) Day(0)=030326
PB204(1.950\250°\0.420\R)
PB206(1.950\0°\0.535\R)
PB211(1.950\180°\0.710\R)
PB213(1.950\270°\0.875\R)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
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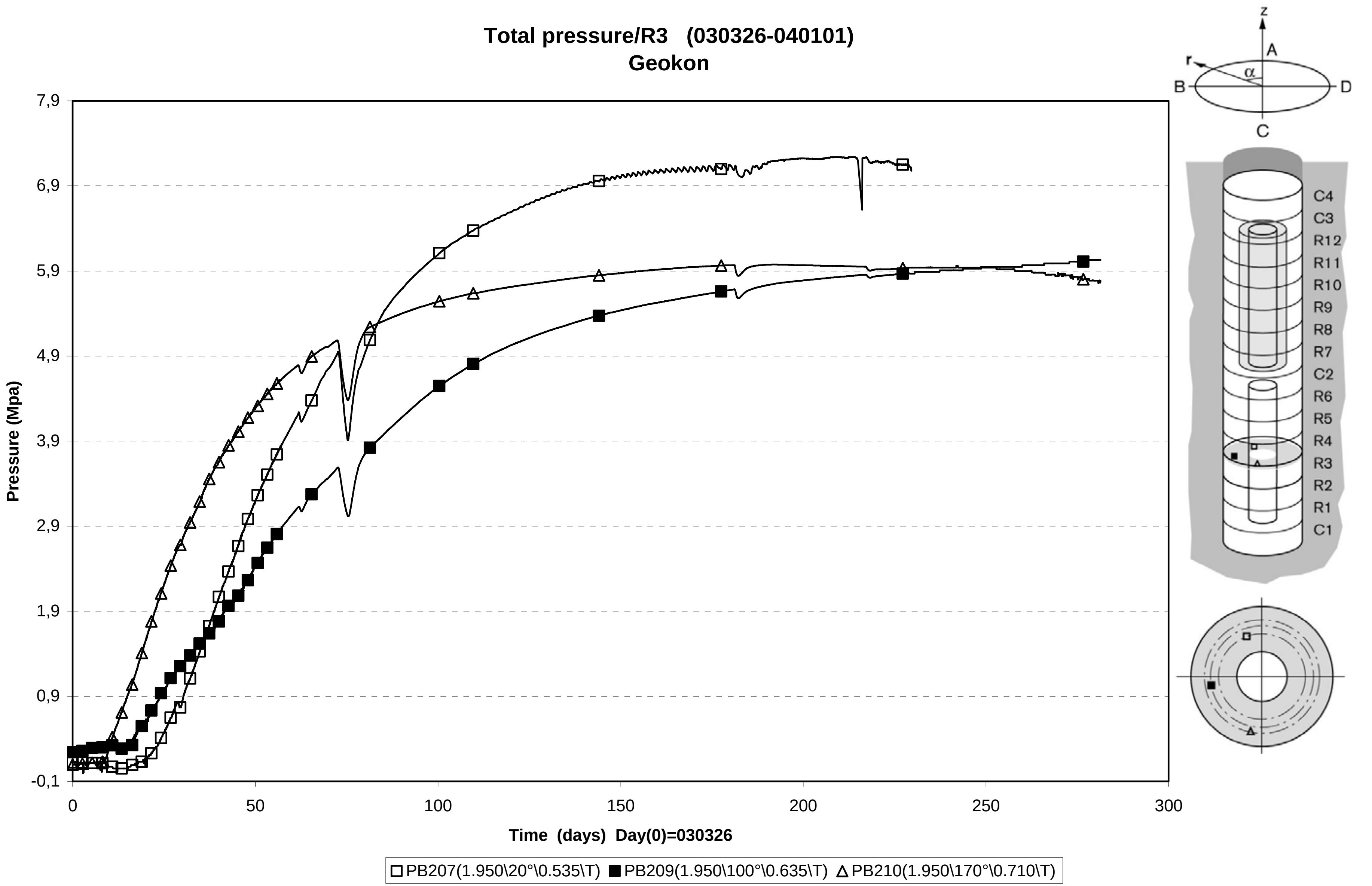
R3
R2
R1
C1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3,9
2,9
1,9
0,9
-0,1
0
50
100
150
200
250
300
Time (days) Day(0)=030326
PB207(1.950\20°\0.535\T)
PB209(1.950\100°\0.635\T)
PB210(1.950\170°\0.710\T)
z
A
r
α
B
D
C
C4
C3
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C2
R6
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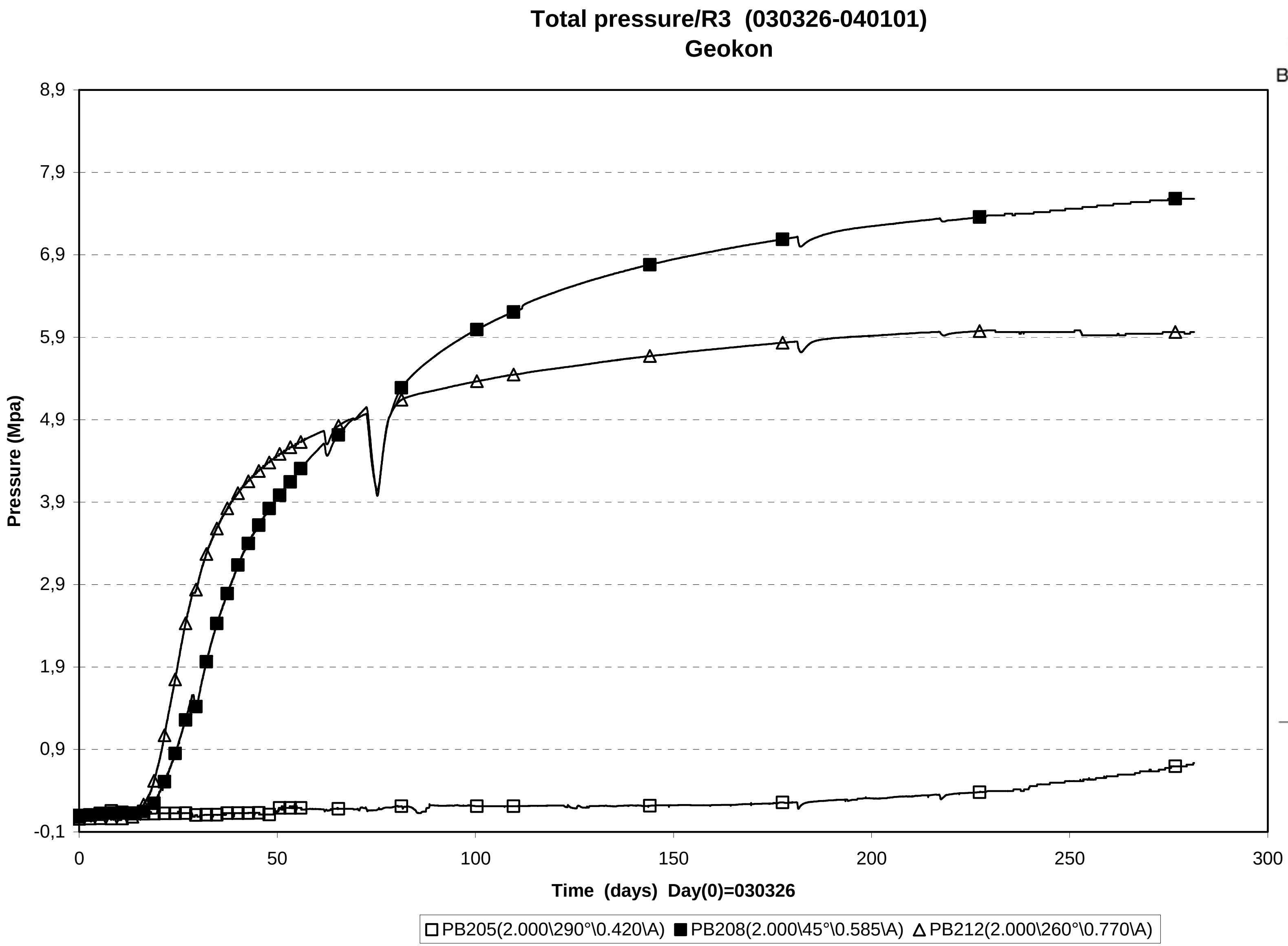
R3
R2
R1
C1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0,9
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0
50
100
150
200
250
300
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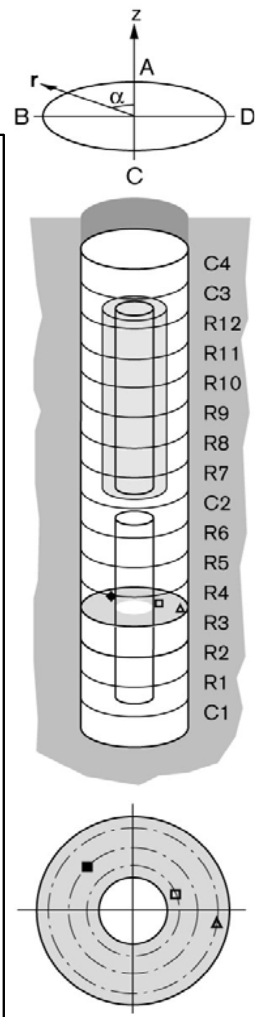
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r
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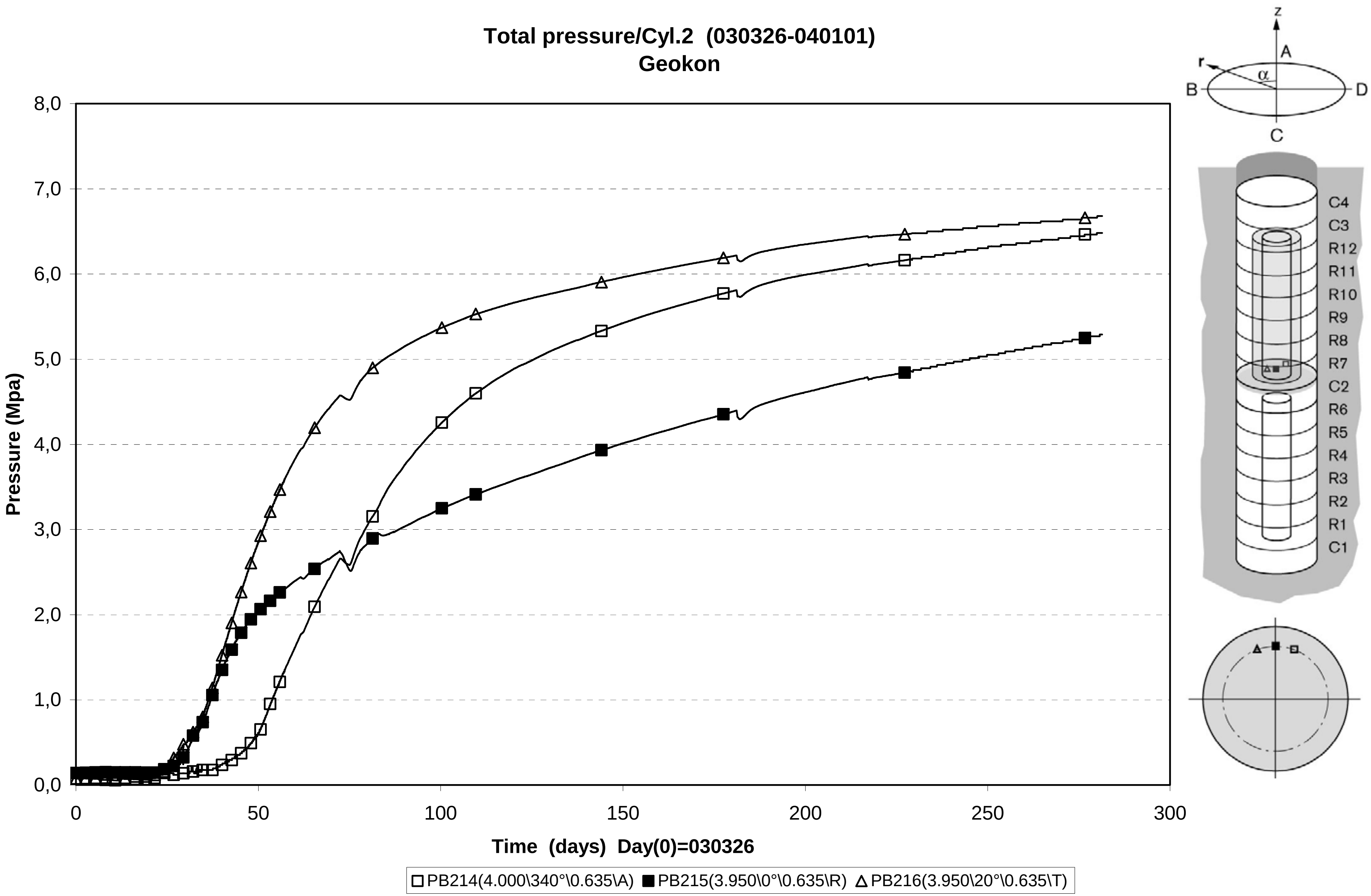
R3
R2
R1
C1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1,0
0,0
0
50
100
150
200
250
300
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PB214(4.000\340°\0.635\A)
PB215(3.950\0°\0.635\R)
PB216(3.950\20°\0.635\T)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
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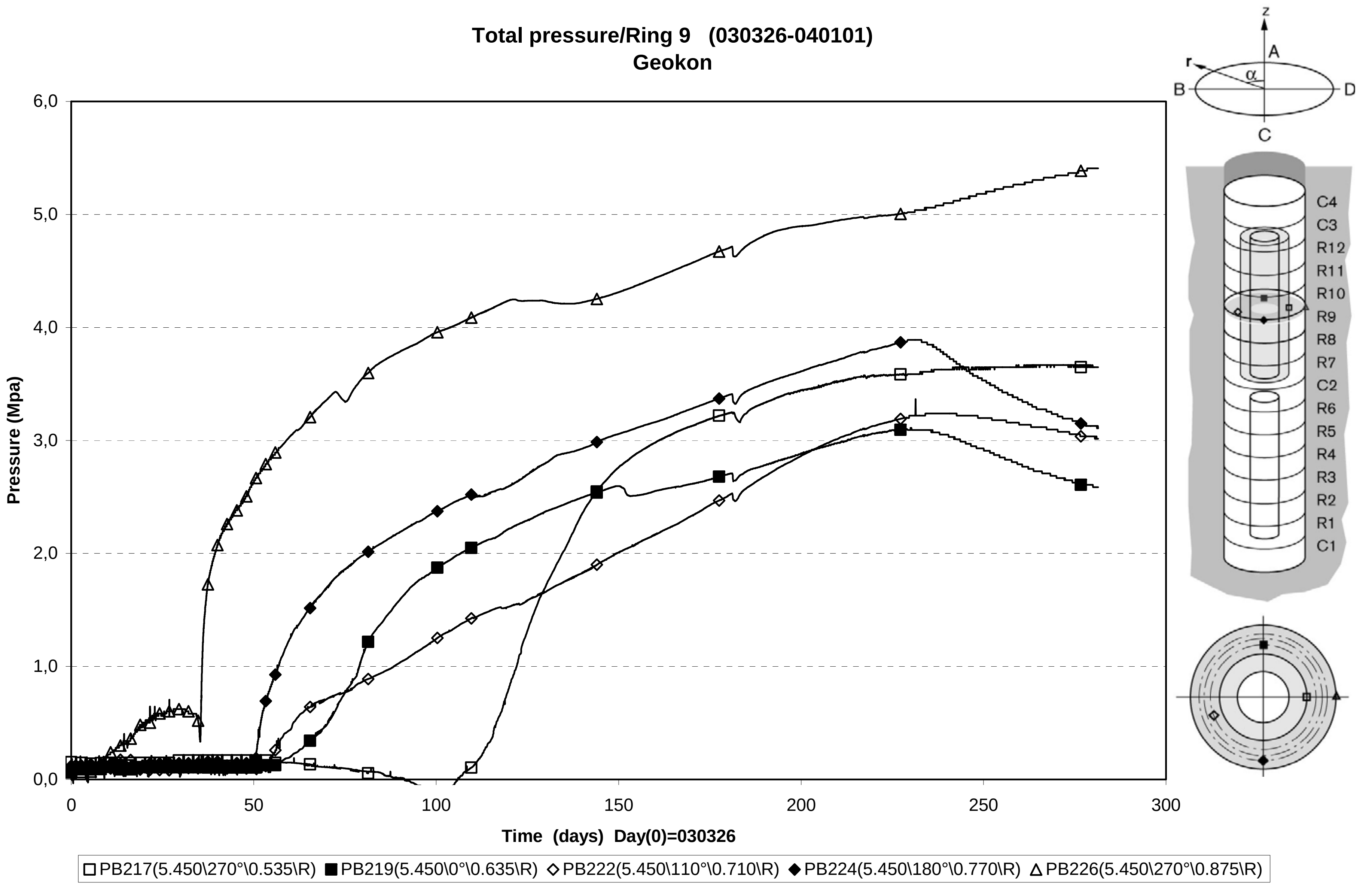
R4
R3
R2
R1
C1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Geokon
Pressure (Mpa)
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4,0
3,0
2,0
1,0
0,0
0
50
100
150
200
250
300
Time (days) Day(0)=030326
□PB217(5.450\270°\0.535\R) ■PB219(5.450\0°\0.635\R) ◇PB222(5.450\110°\0.710\R) ◆PB224(5.450\180°\0.770\R) △PB226(5.450\270°\0.875\R)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
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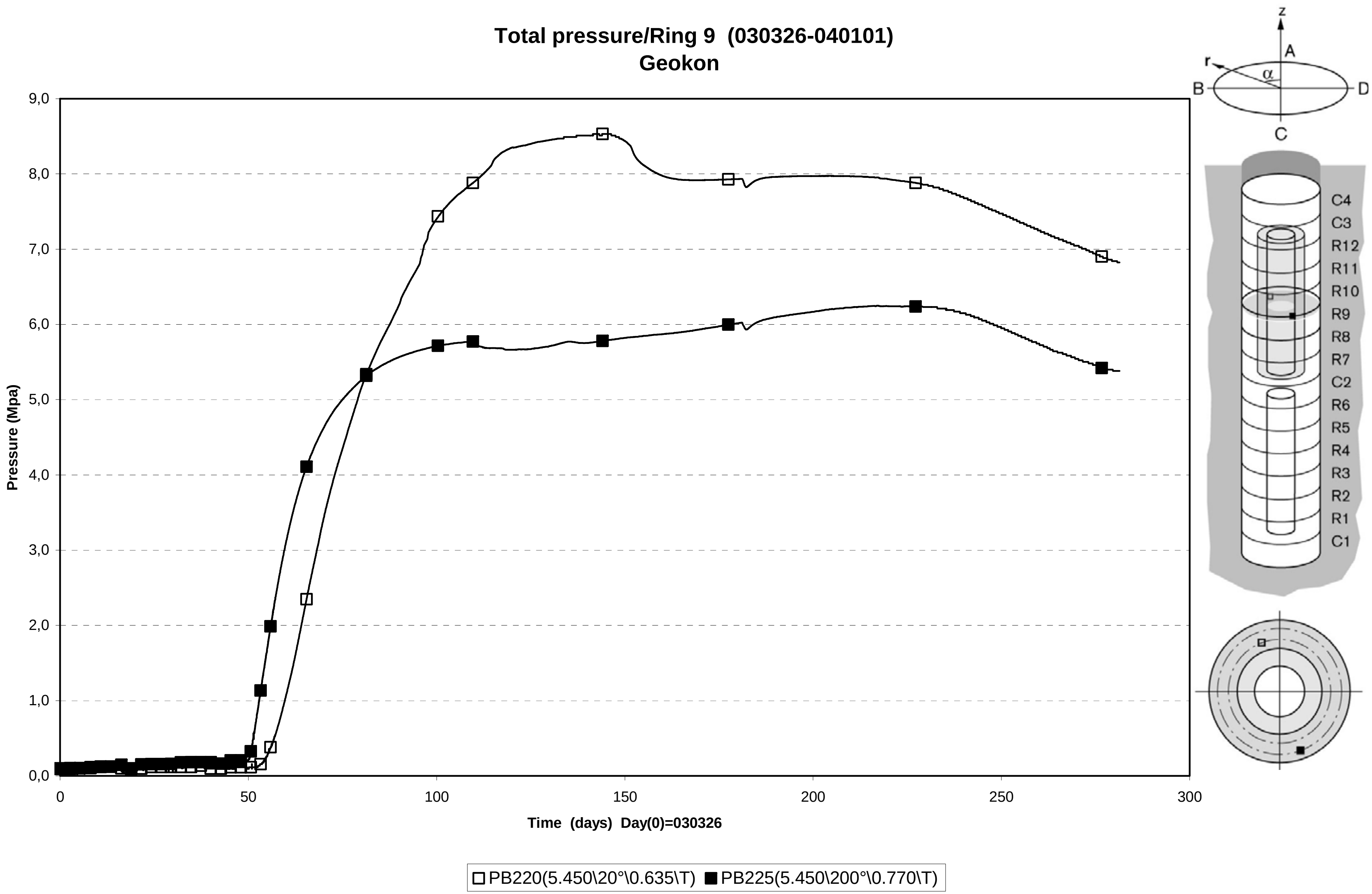
R3
R2
R1
C1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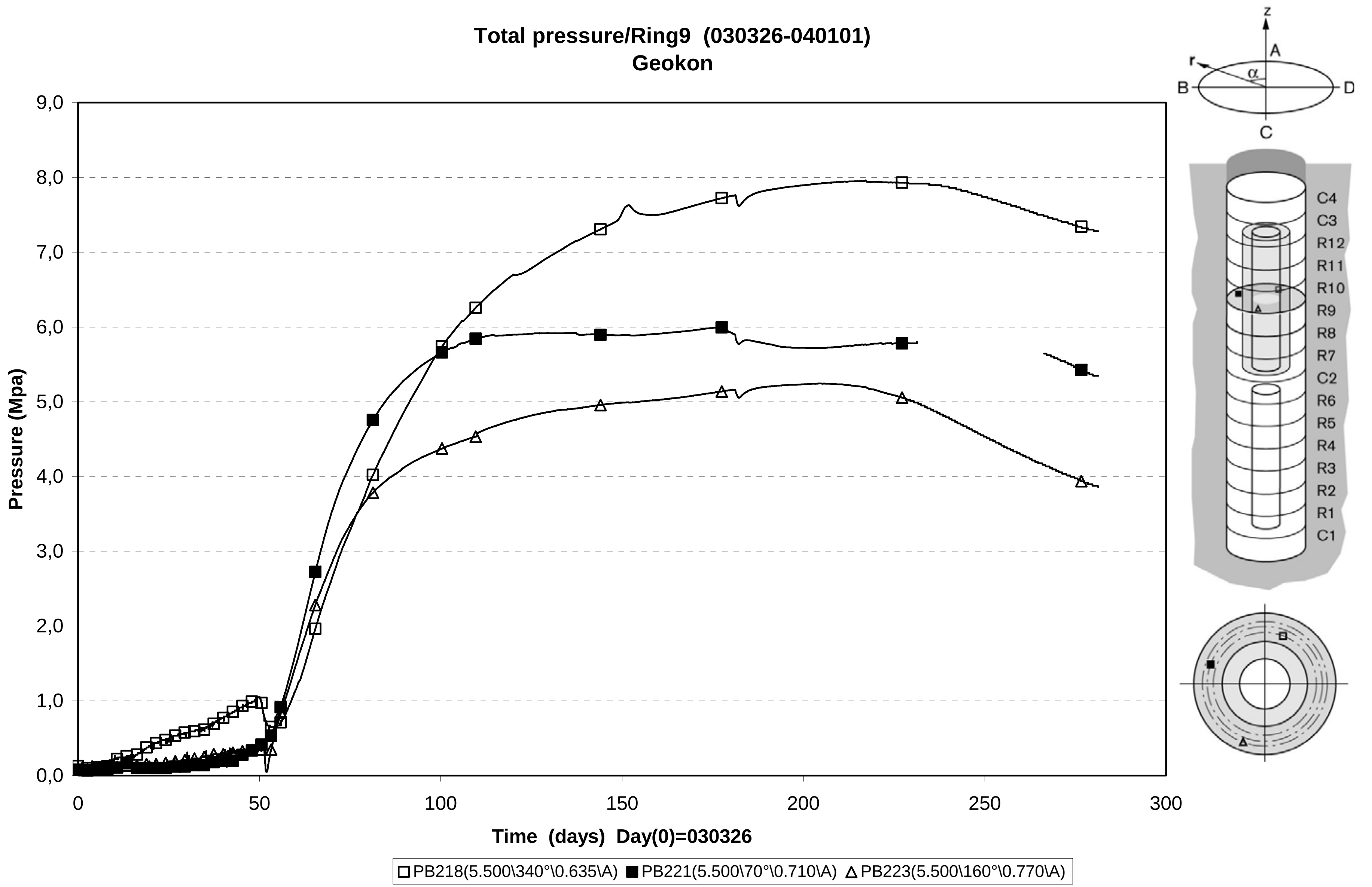
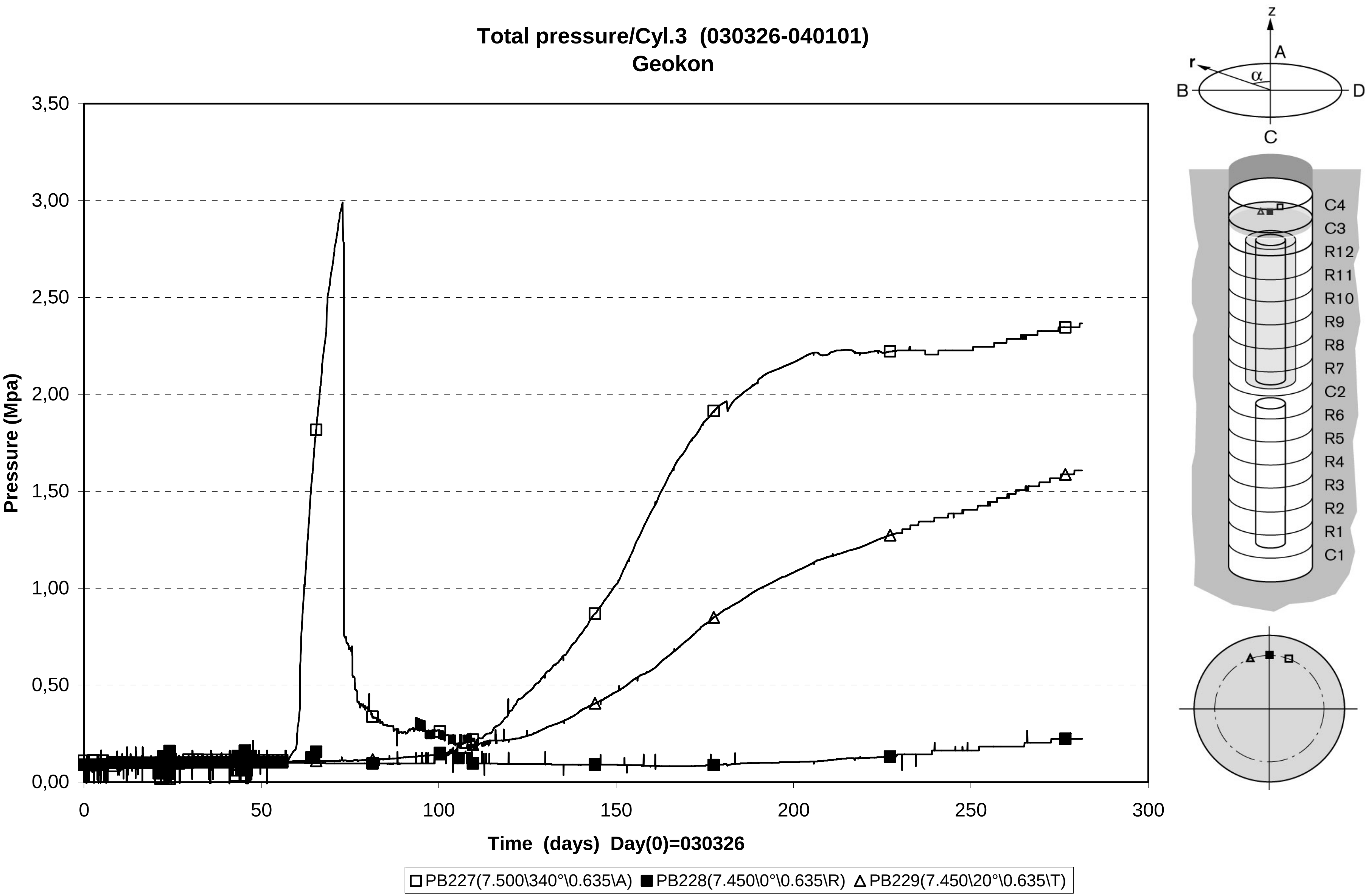
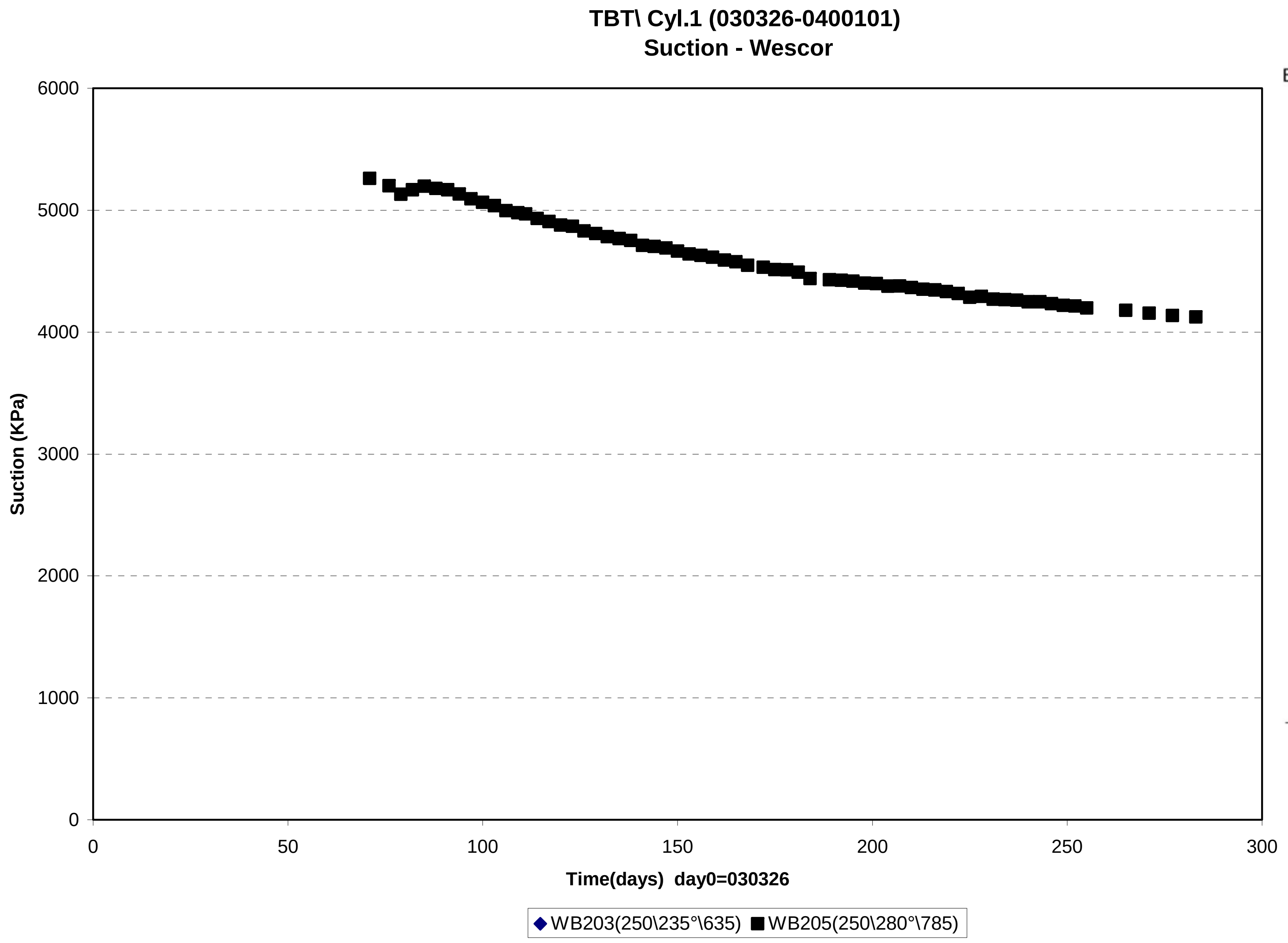
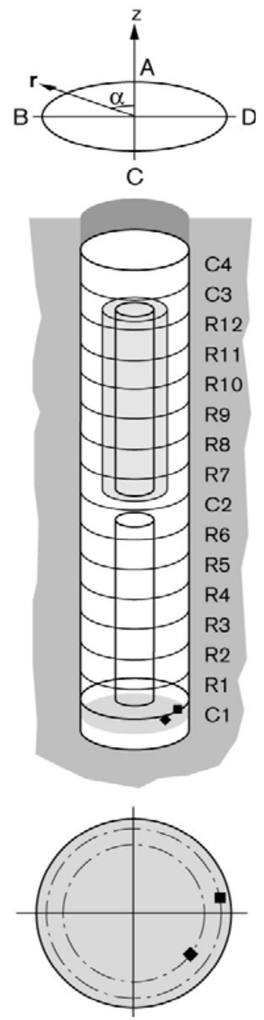
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
0
50
100
150
200
250
300
Time (days) Day(0)=030326
PB220(5.450\20°\0.635\T)
PB225(5.450\200°\0.770\T)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

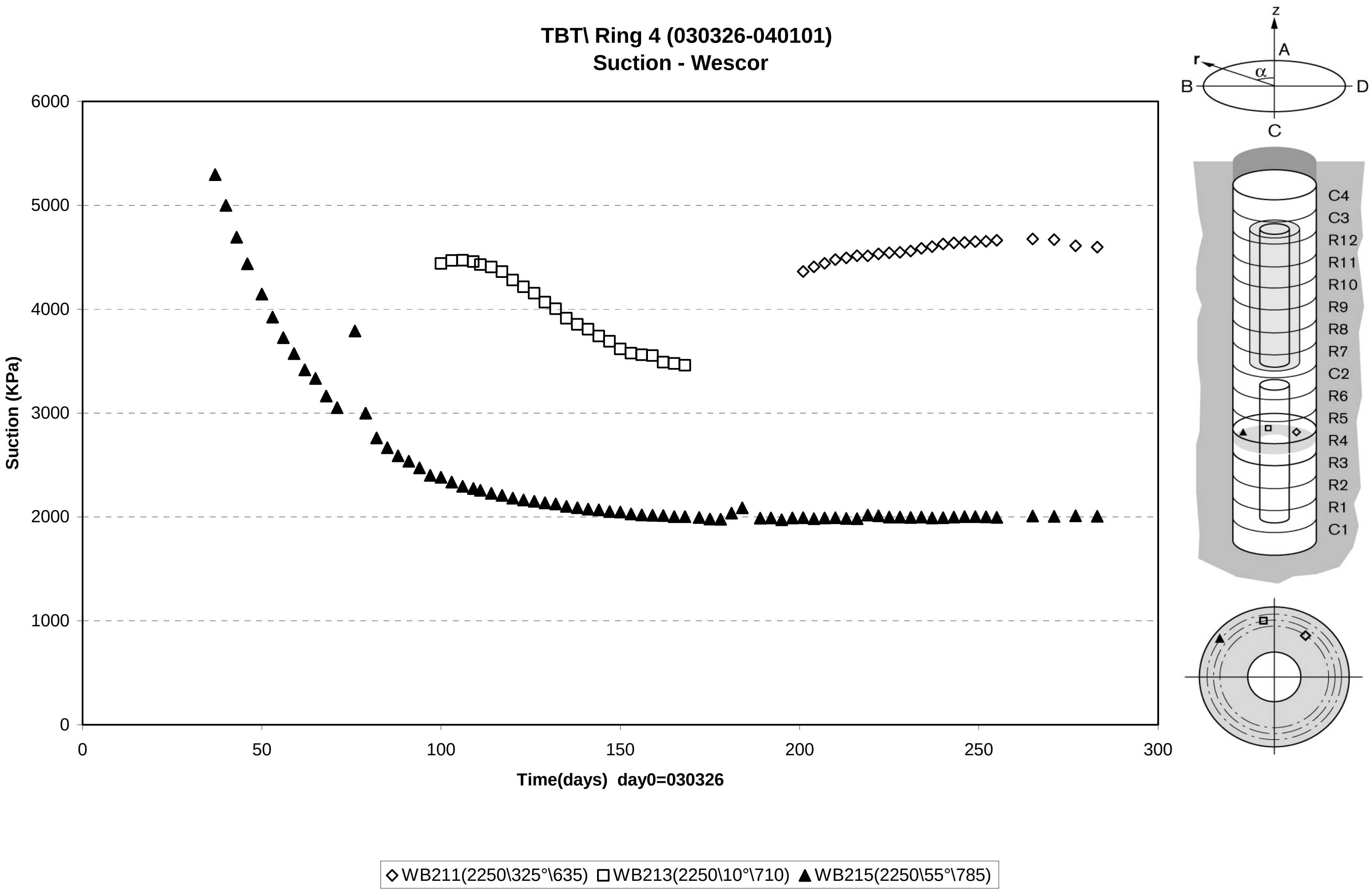

Total pressure/Ring9 (030326-040101)
Geokon
Pressure (Mpa)
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
0
50
100
150
200
250
300
Time (days) Day(0)=030326
PB218(5.500\340°\0.635\A)
PB221(5.500\70°\0.710\A)
PB223(5.500\160°\0.770\A)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

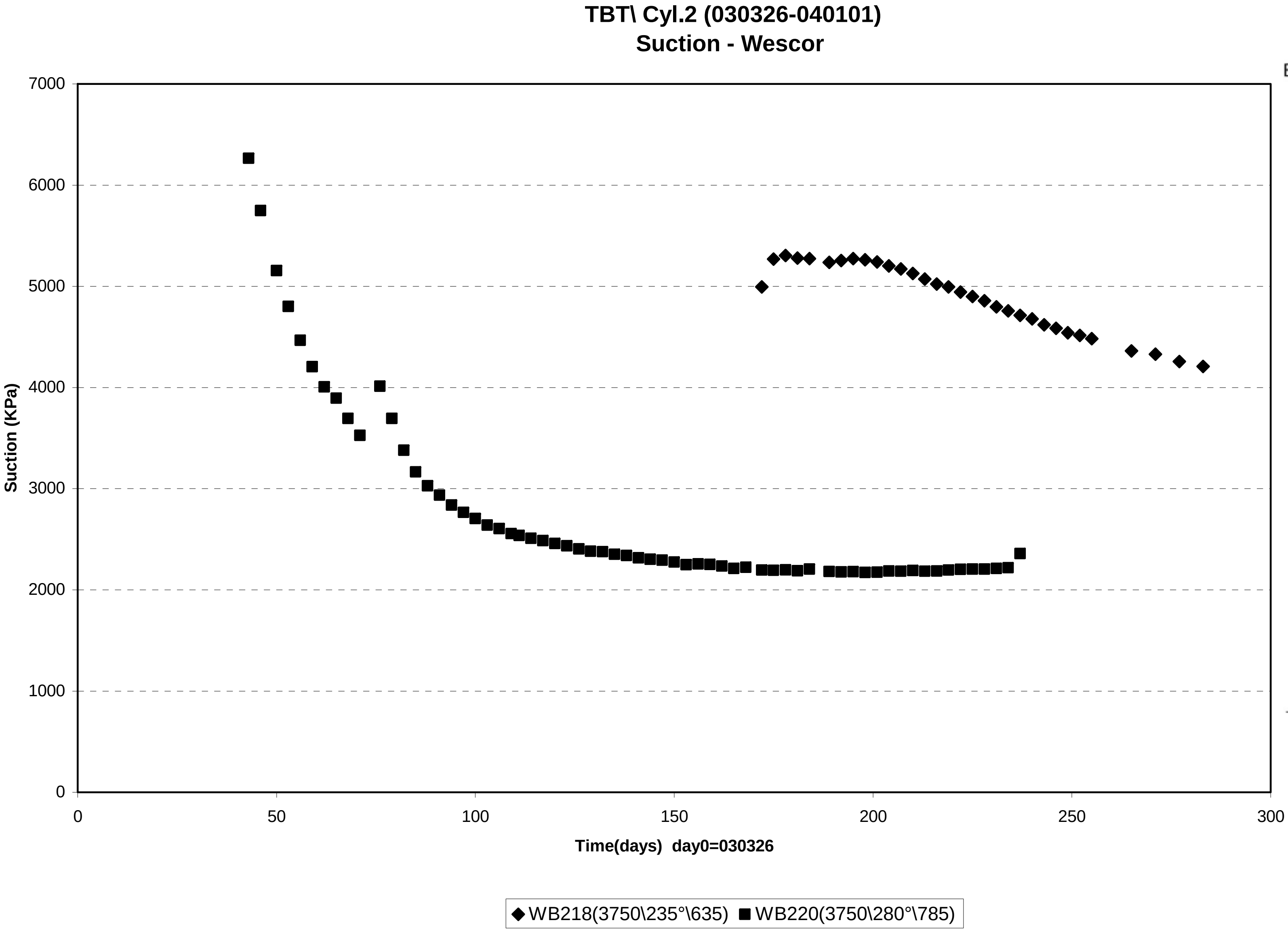


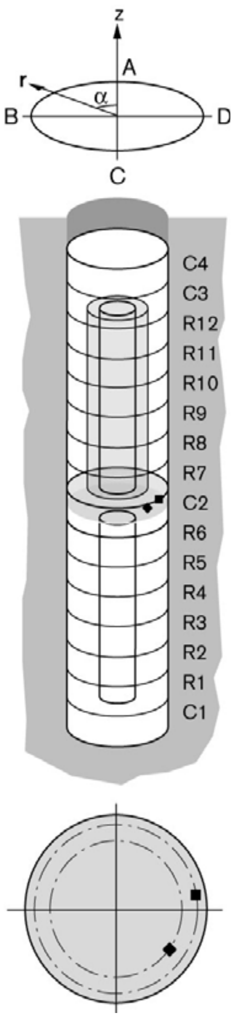
Total pressure/Cyl.3 (030326-040101)
Geokon
Pressure (Mpa)
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
0
50
100
150
200
250
300
Time (days) Day(0)=030326
PB227(7.500\340°\0.635\A)
PB228(7.450\0°\0.635\R)
PB229(7.450\20°\0.635\T)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

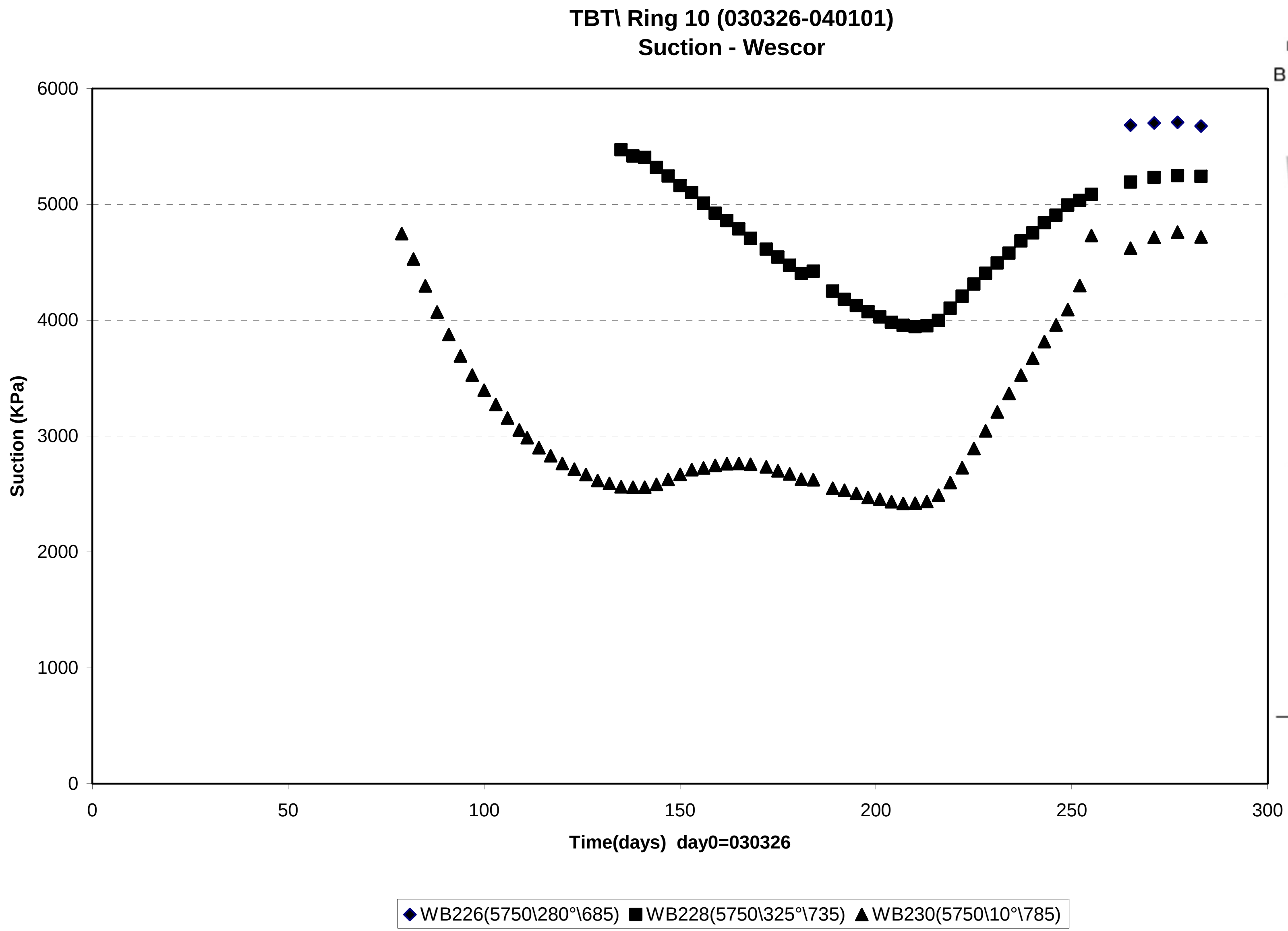

TBT\ Cyl.1 (030326-0400101)
Suction - Wescor
6000
5000
4000
3000
2000
1000
0
Suction (KPa)
0
50
100
150
200
250
300
Time(days) day0=030326
WB203(250\235°\635)
WB205(250\280°\785)


z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

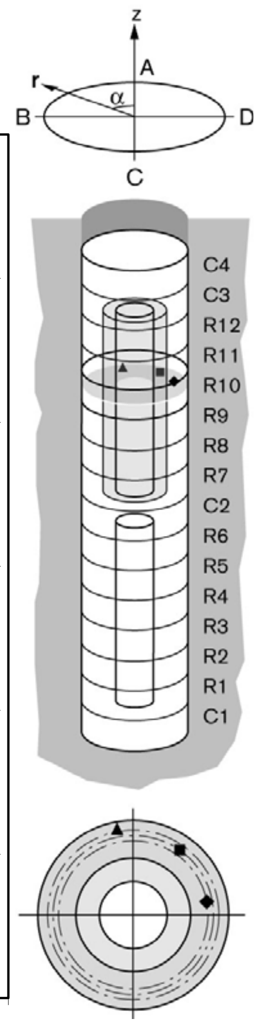

TBT\ Ring 4 (030326-040101)
Suction - Wescor
Suction (KPa)
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
300
Time(days) day0=030326
WB211(2250\325°\635)
WB213(2250\10°\710)
WB215(2250\55°\785)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1


TBT\ Cyl.2 (030326-040101)
Suction - Wescor
Suction (KPa)
7000
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
300
Time(days) day0=030326
WB218(3750\235°\635)
WB220(3750\280°\785)

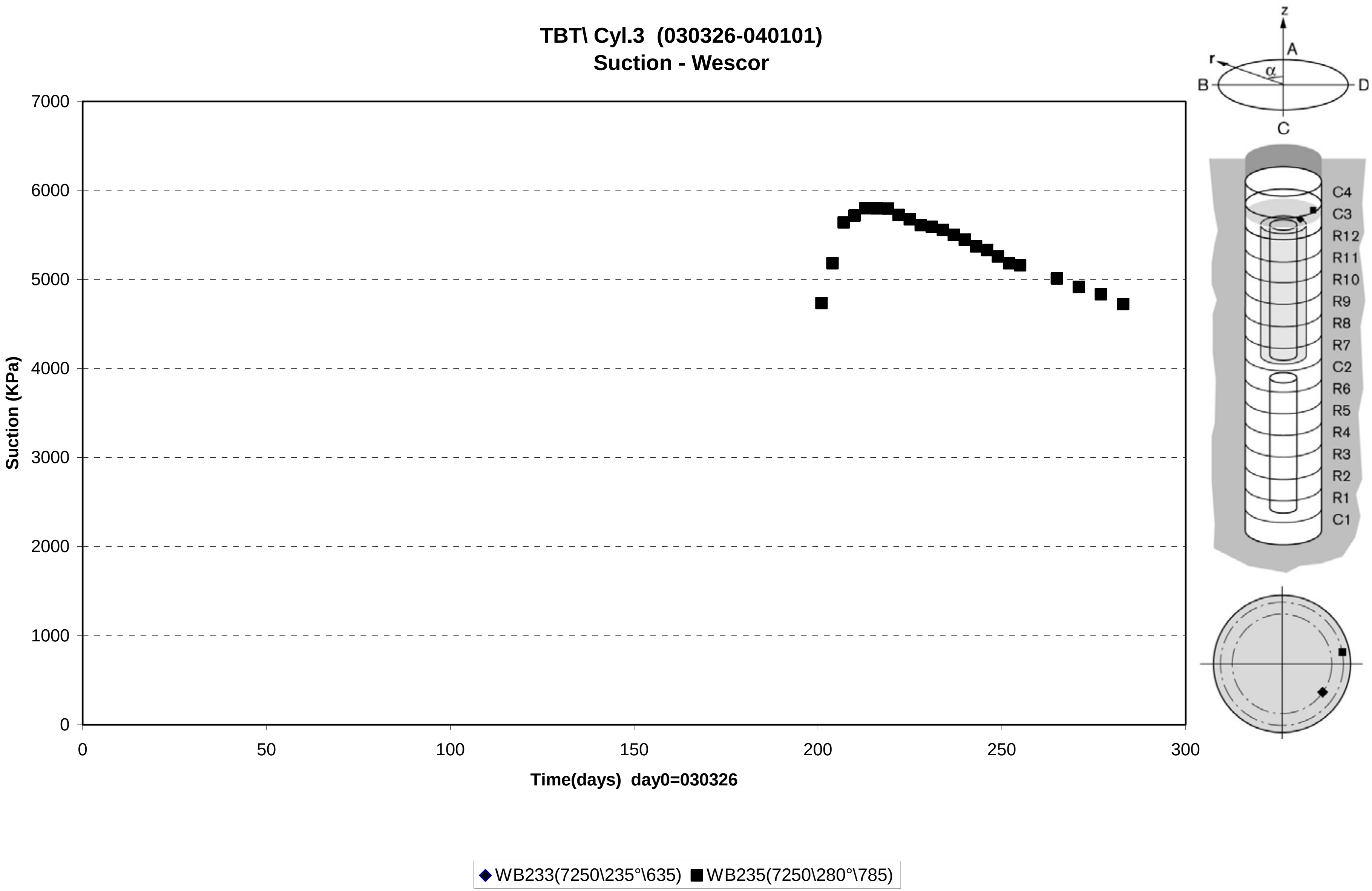

z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

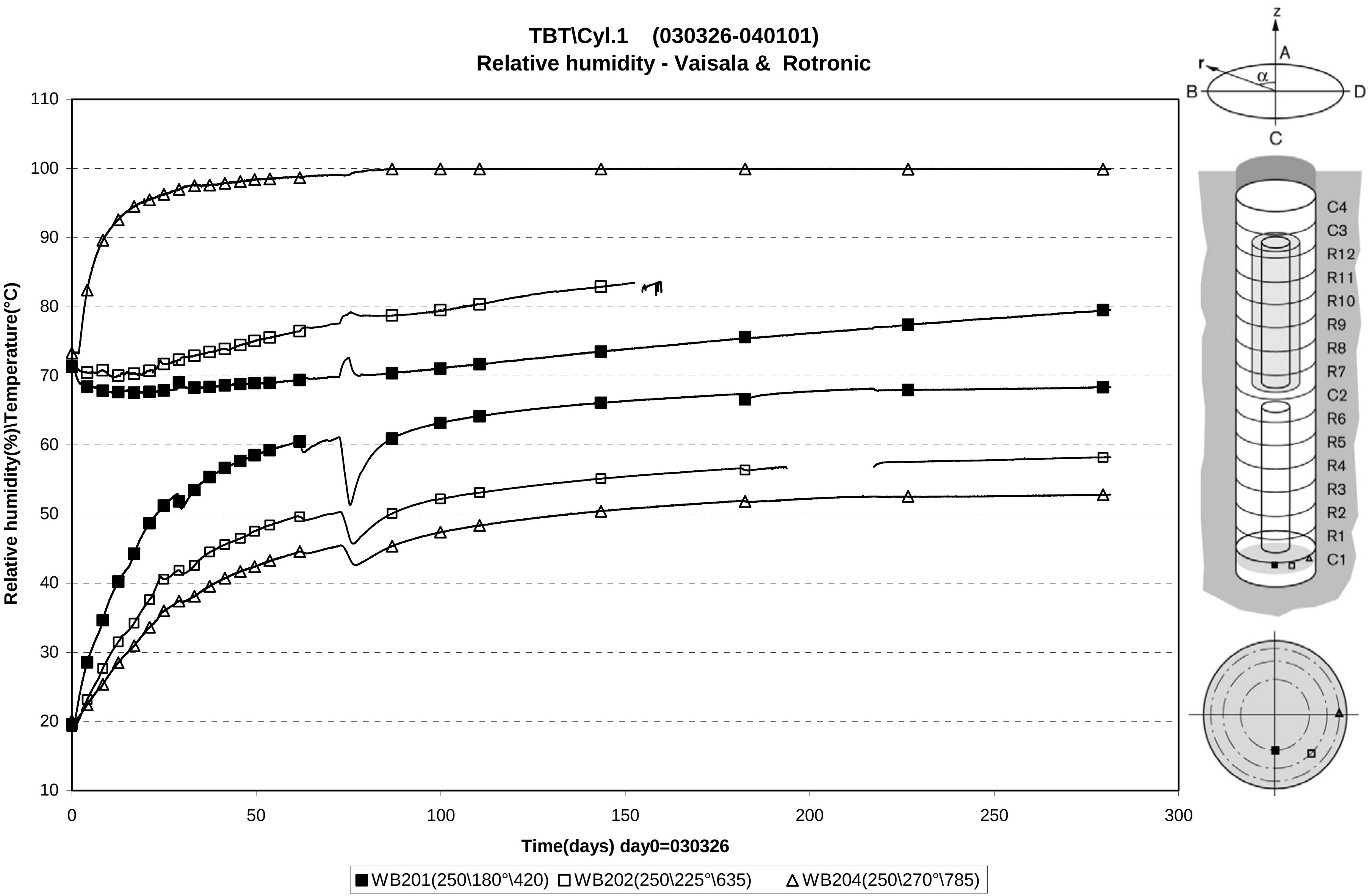


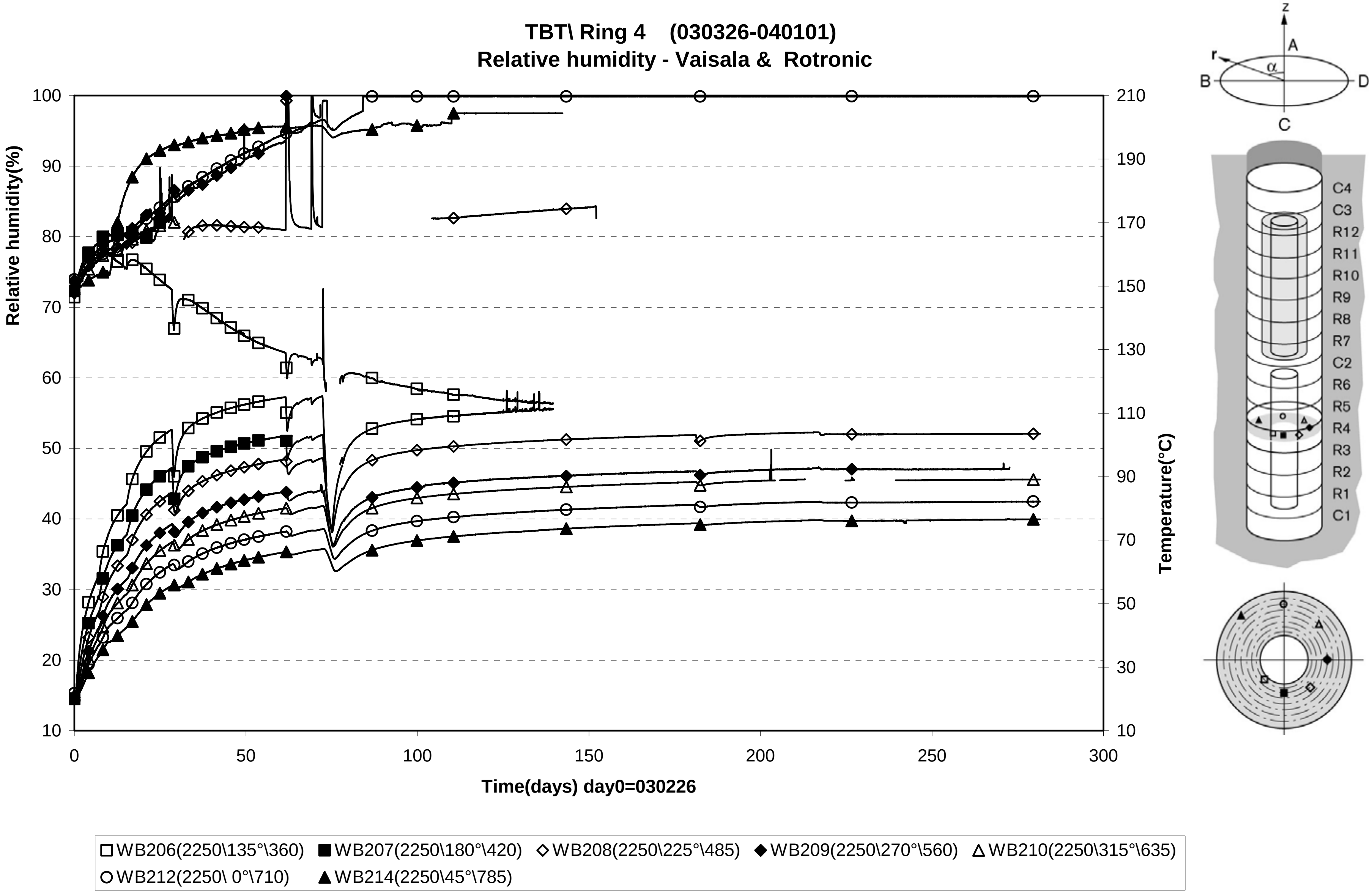
TBT\ Ring 10 (030326-040101)
Suction - Wescor
Suction (KPa)
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
300
Time(days) day0=030326
WB226(5750\280°\685)
WB228(5750\325°\735)
WB230(5750\10°\785)



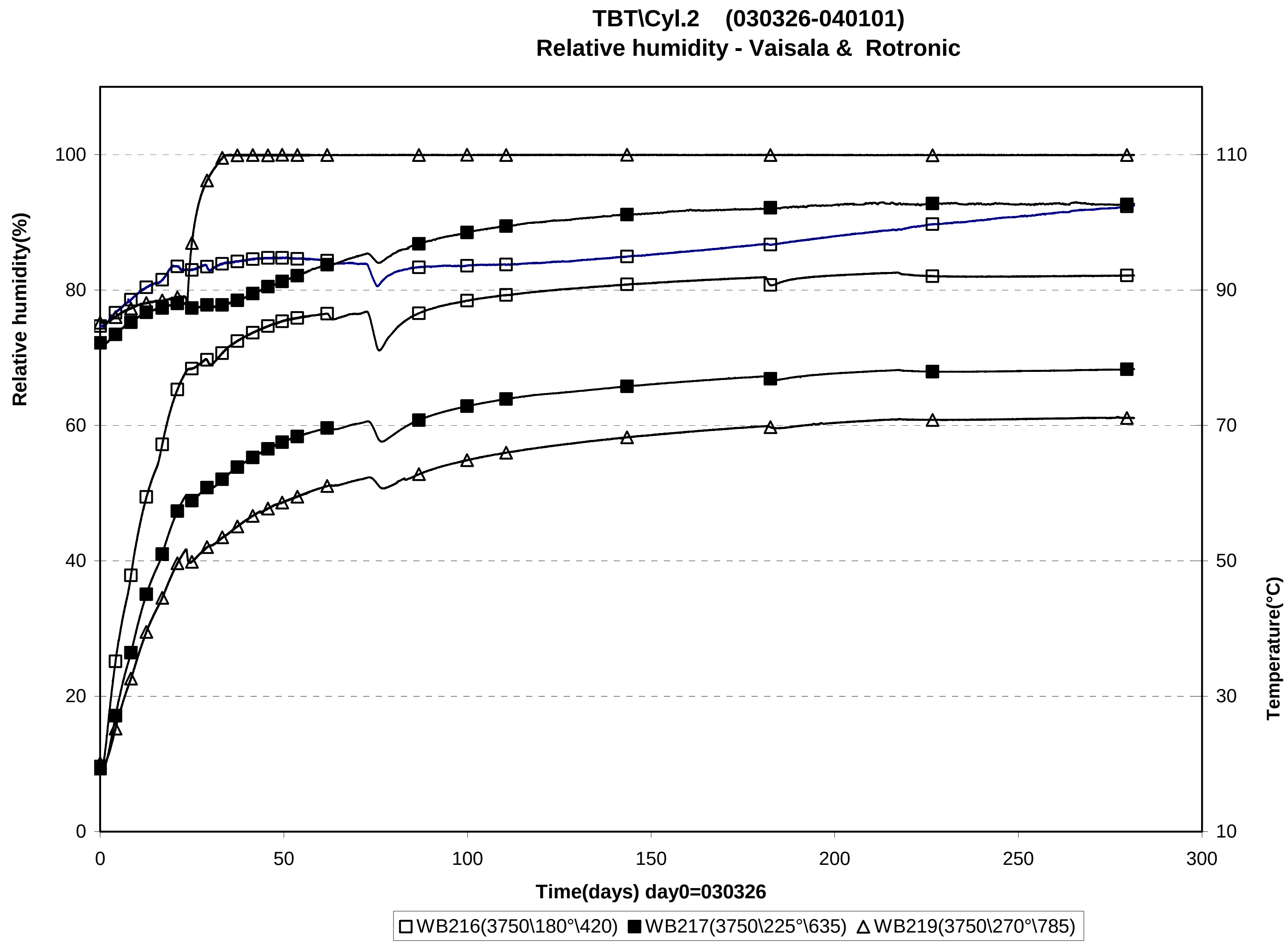
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

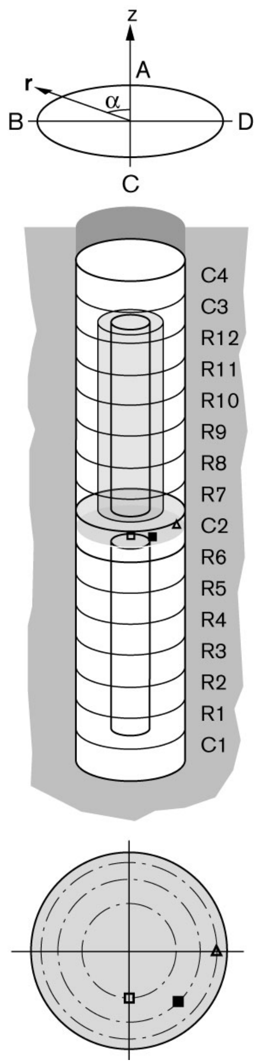

TBT\ Cyl.3 (030326-040101)
Suction - Wescor
Suction (KPa)
7000
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
300
Time(days) day0=030326
WB233(7250\235°\635)
WB235(7250\280°\785)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

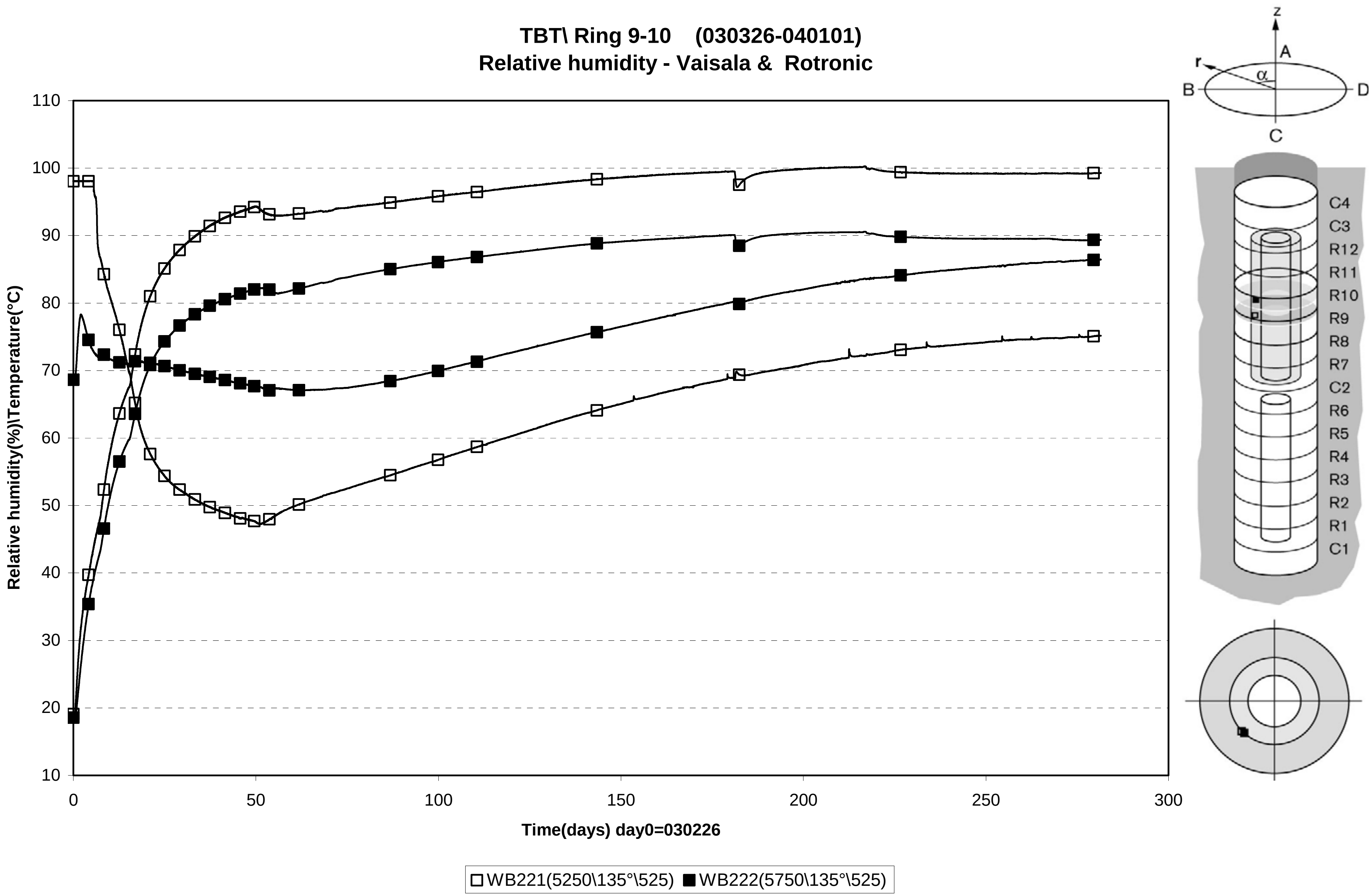

TBT\Cyl.1 (030326-040101)
Relative humidity - Vaisala & Rotronic
Relative humidity(%)\Temperature(°C)
Time(days) day0=030326
WB201(250\180°\420)
WB202(250\225°\635)
WB204(250\270°\785)
z
A
B
C
D
r
α
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1



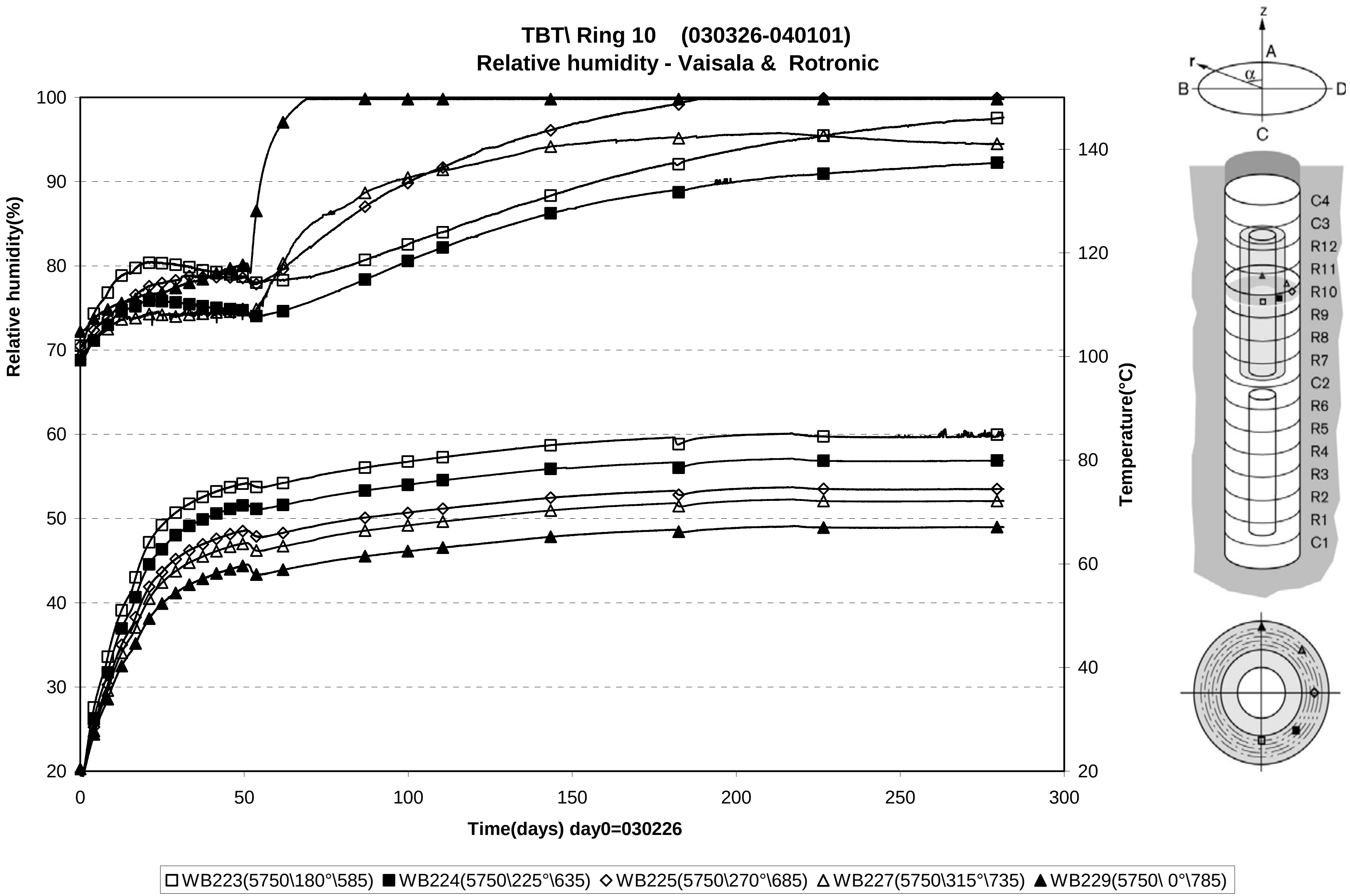
TBT\ Ring 4 (030326-040101)
Relative humidity - Vaisala & Rotronic
Relative humidity(%)
Temperature(°C)
Time(days) day0=030226
□WB206(2250\135°\360) ■WB207(2250\180°\420) ◇WB208(2250\225°\485) ◆WB209(2250\270°\560) △WB210(2250\315°\635)
○WB212(2250\ 0°\710) ▲WB214(2250\45°\785)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

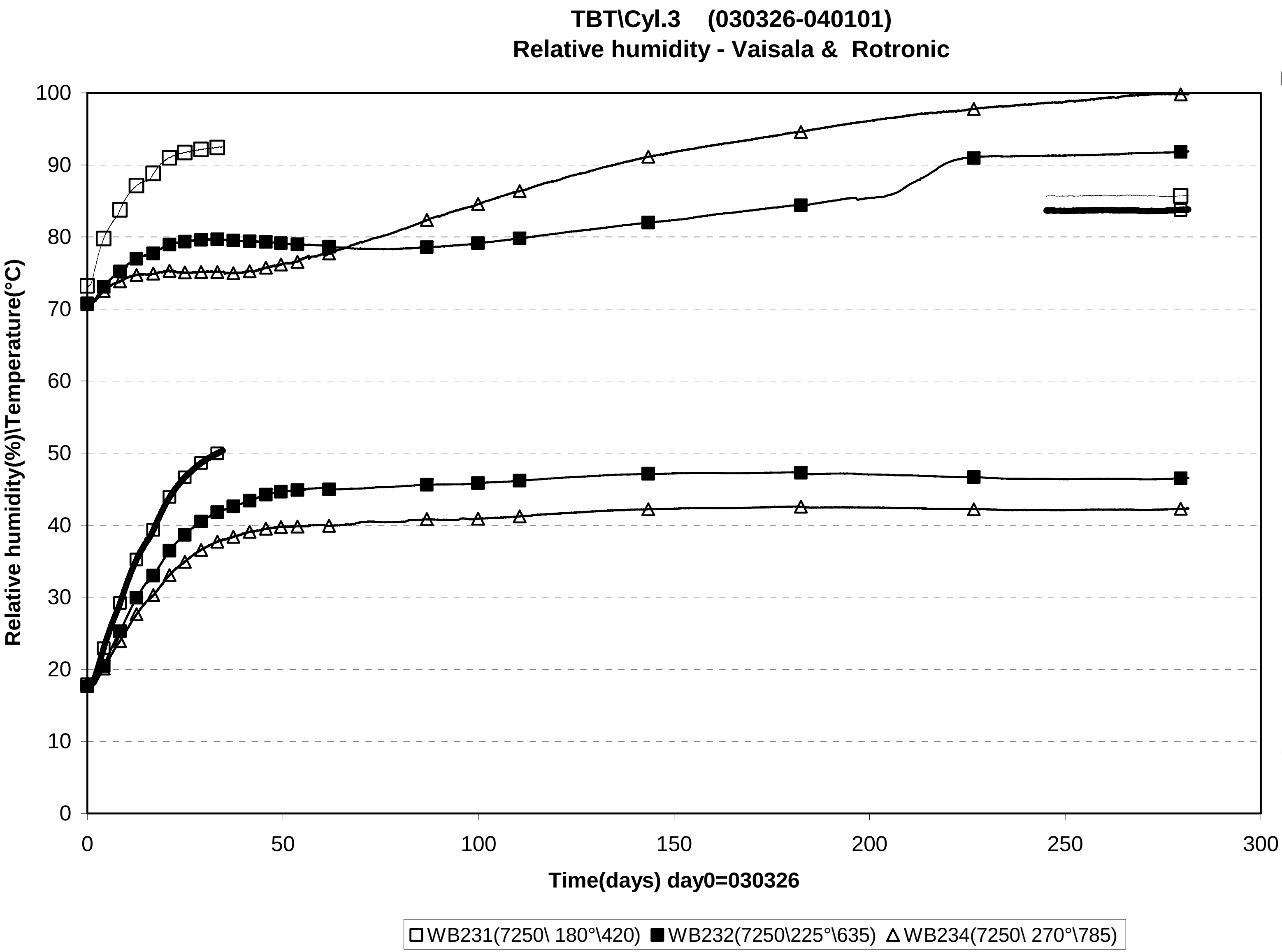

TBT\Cyl.2 (030326-040101)
Relative humidity - Vaisala & Rotronic
Relative humidity(%)
Temperature(°C)
Time(days) day0=030326
WB216(3750\180°\420)
WB217(3750\225°\635)
WB219(3750\270°\785)
0
20
40
60
80
100
10
30
50
70
90
110
0
50
100
150
200
250
300

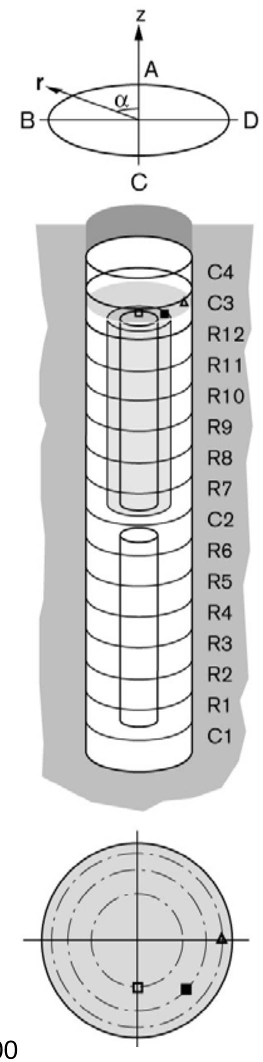

z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

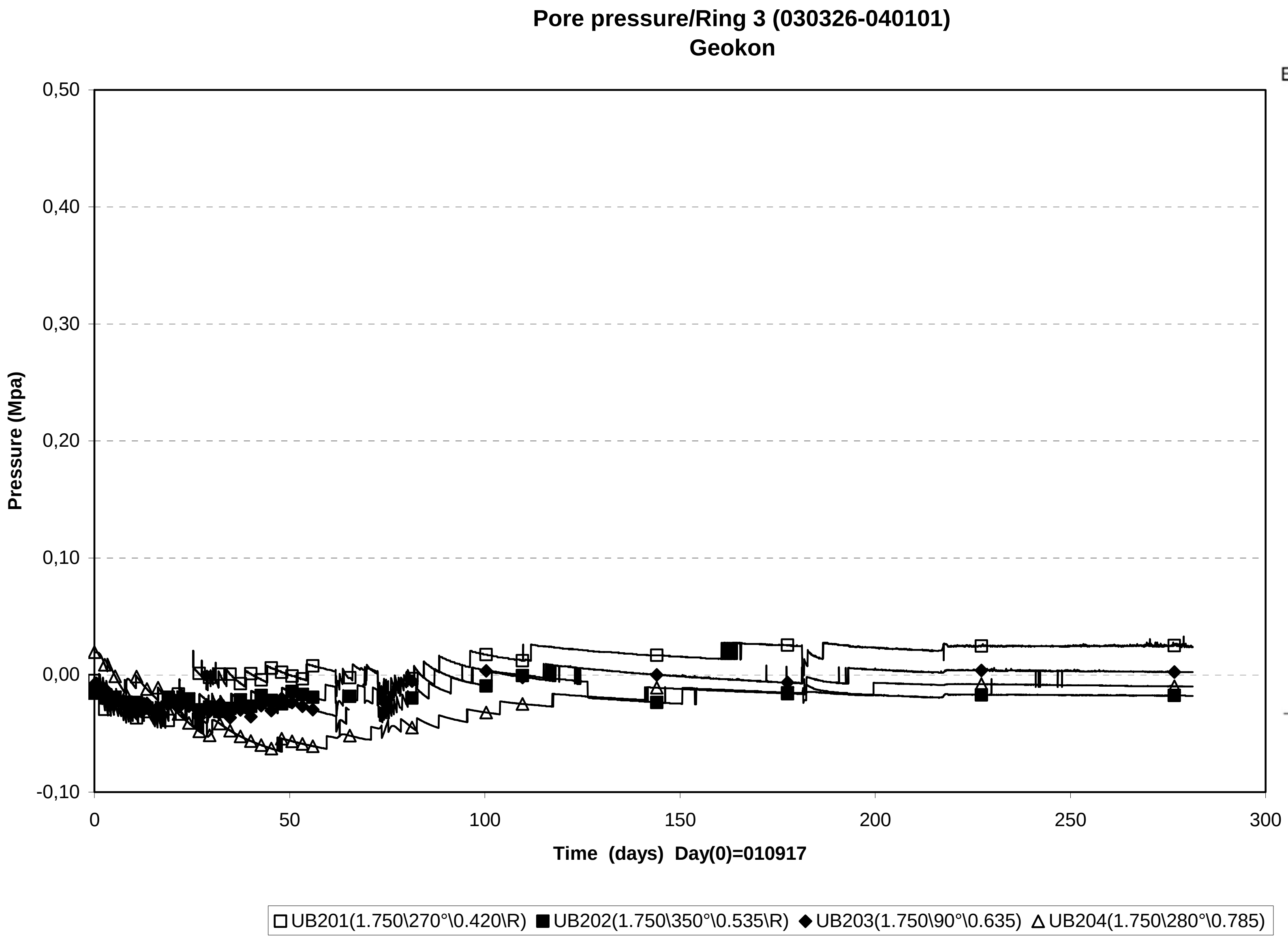


TBT\ Ring 9-10 (030326-040101)
Relative humidity - Vaisala & Rotronic
Relative humidity(%)\Temperature(°C)
Time(days) day0=030226
WB221(5250\135°\525)
WB222(5750\135°\525)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

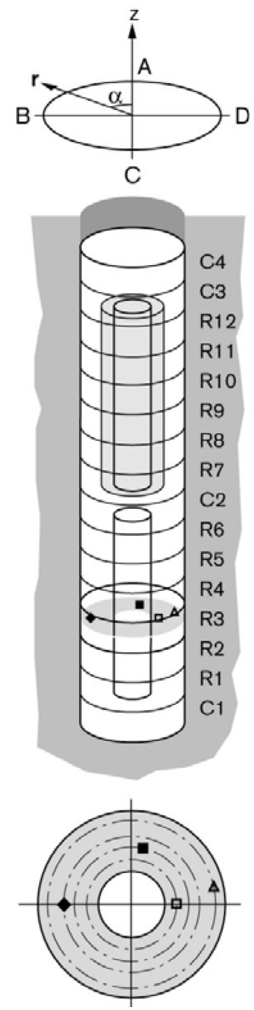

TBT\ Ring 10 (030326-040101)
Relative humidity - Vaisala & Rotronic
Relative humidity(%)
Temperature(°C)
Time(days) day0=030226
WB223(5750\180°\585)
WB224(5750\225°\635)
WB225(5750\270°\685)
WB227(5750\315°\735)
WB229(5750\ 0°\785)
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1


TBT\Cyl.3 (030326-040101)
Relative humidity - Vaisala & Rotronic
Relative humidity(%)\Temperature(°C)
Time(days) day0=030326
WB231(7250\ 180°\420)
WB232(7250\225°\635)
WB234(7250\ 270°\785)

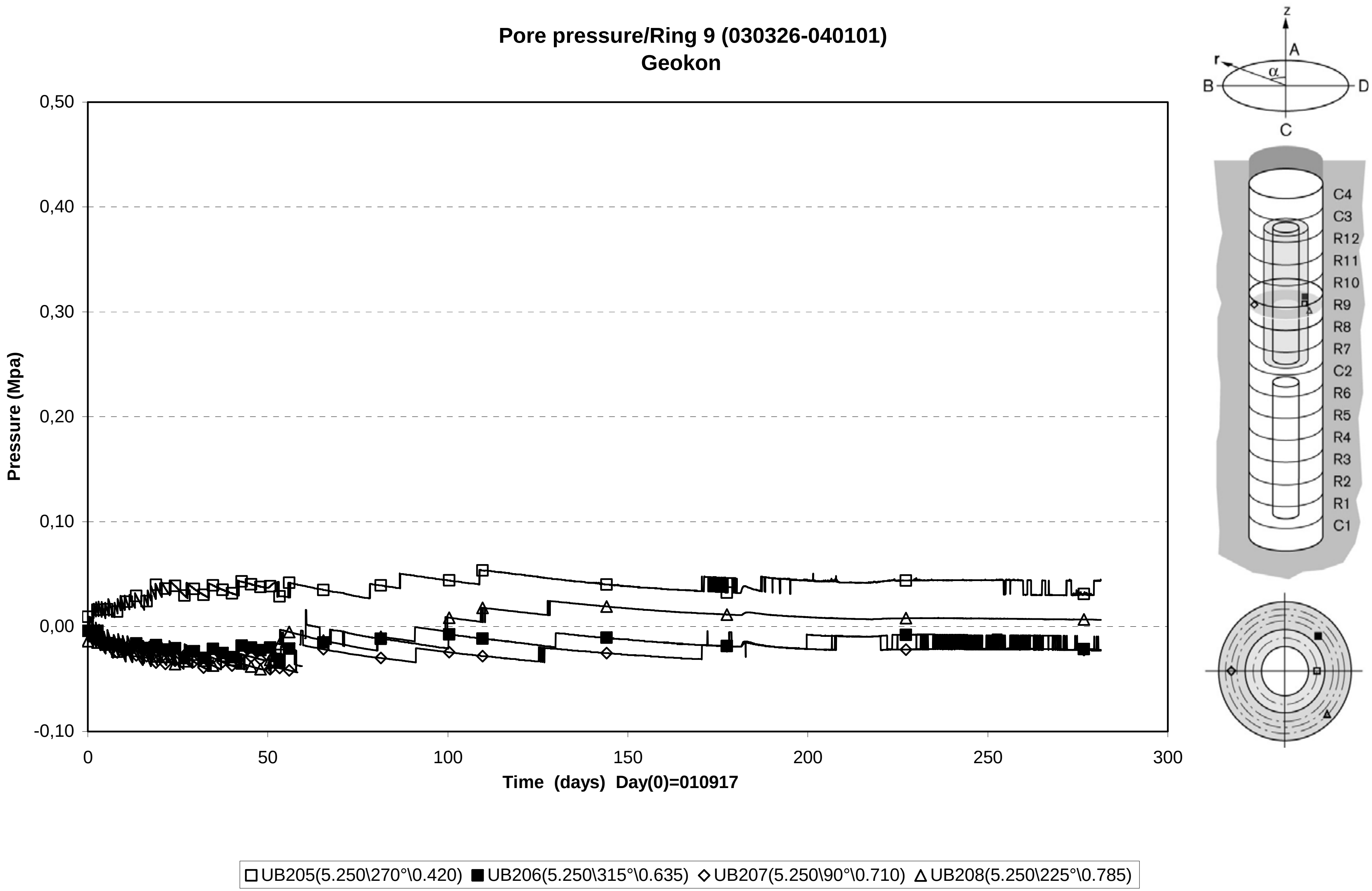

z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1



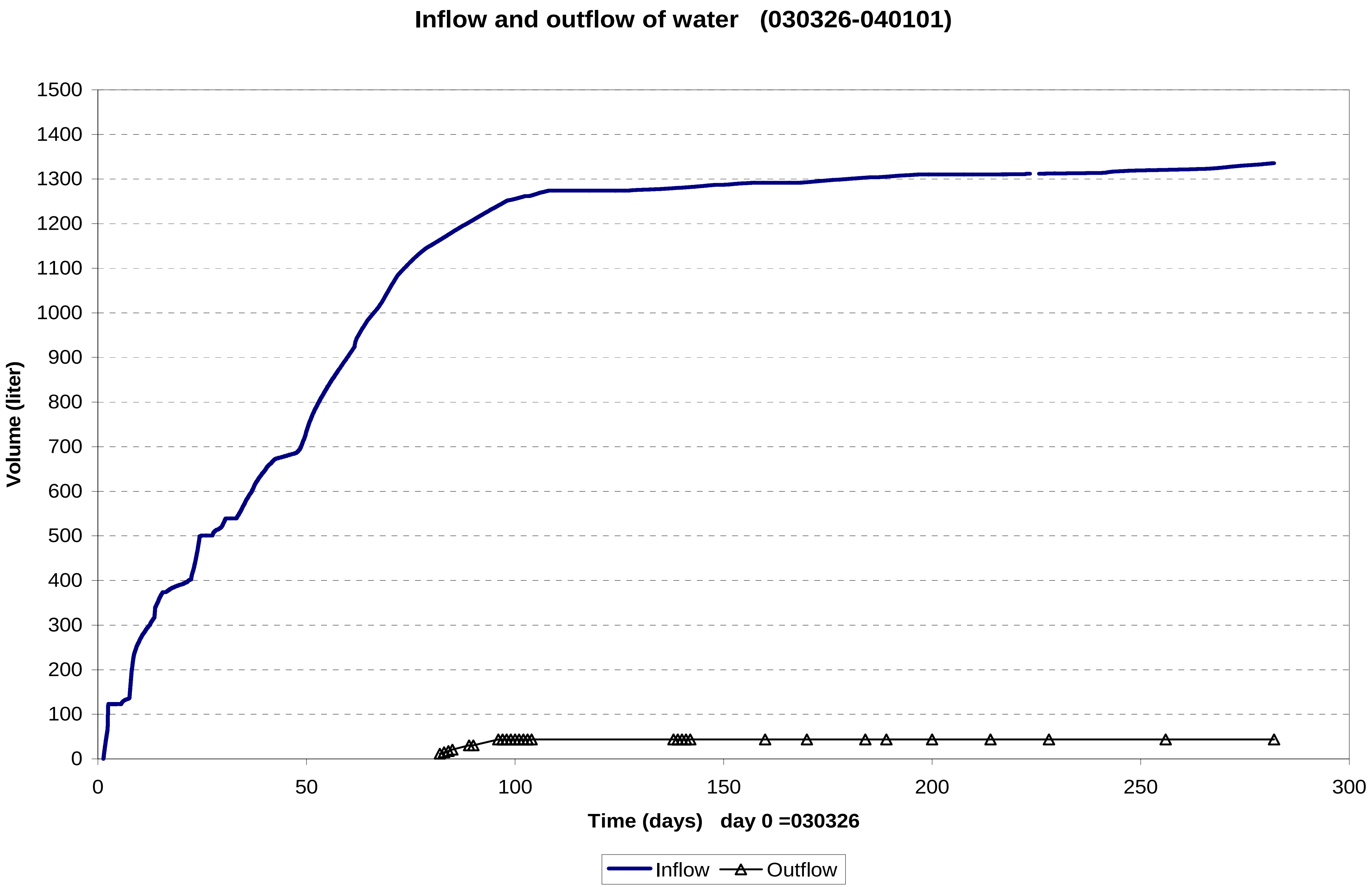
Pore pressure/Ring 3 (030326-040101)
Geokon
Pressure (Mpa)
0,50
0,40
0,30
0,20
0,10
0,00
-0,10
0
50
100
150
200
250
300
Time (days) Day(0)=010917
UB201(1.750\270°\0.420\R)
UB202(1.750\350°\0.535\R)
UB203(1.750\90°\0.635)
UB204(1.750\280°\0.785)

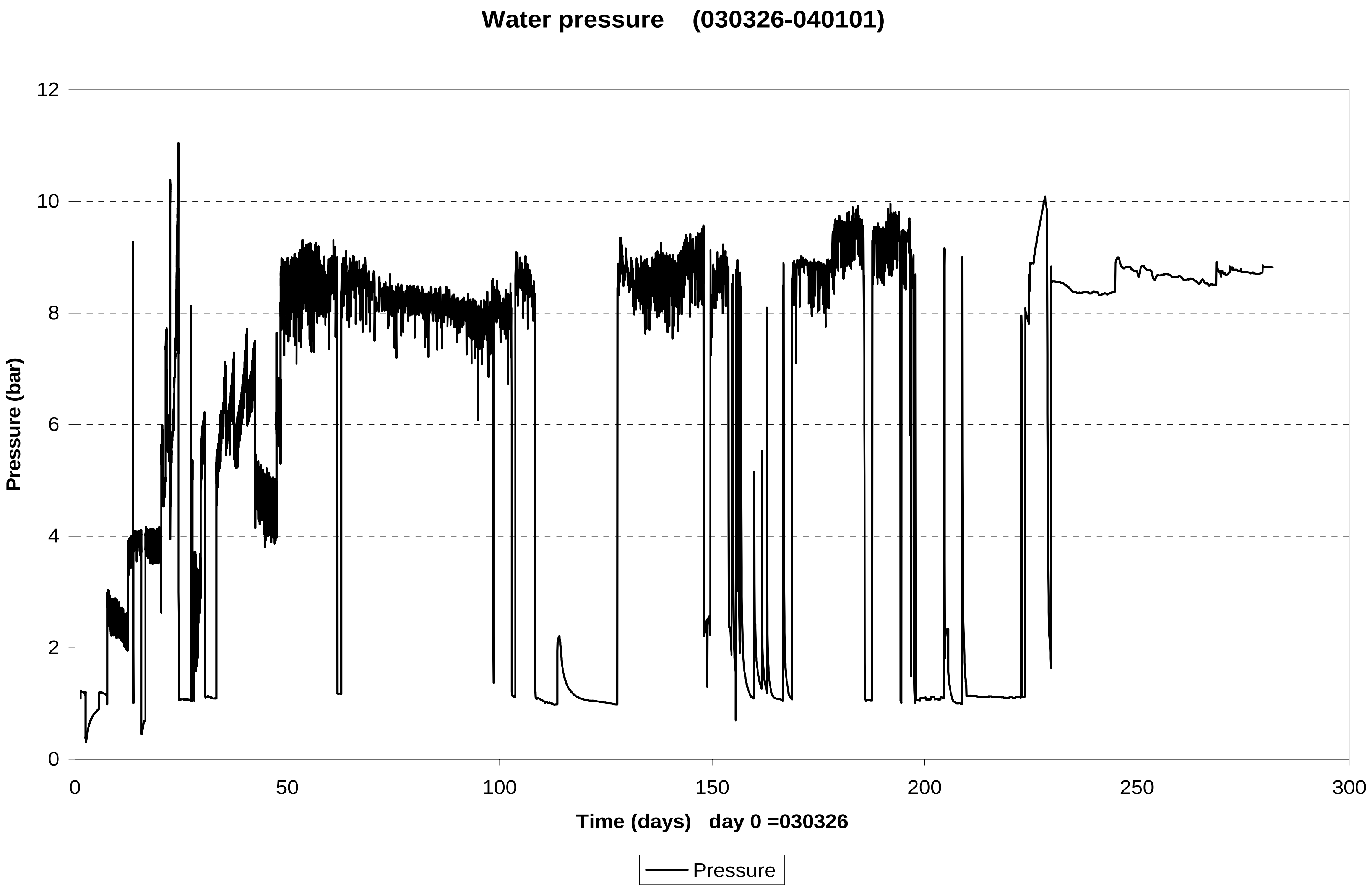


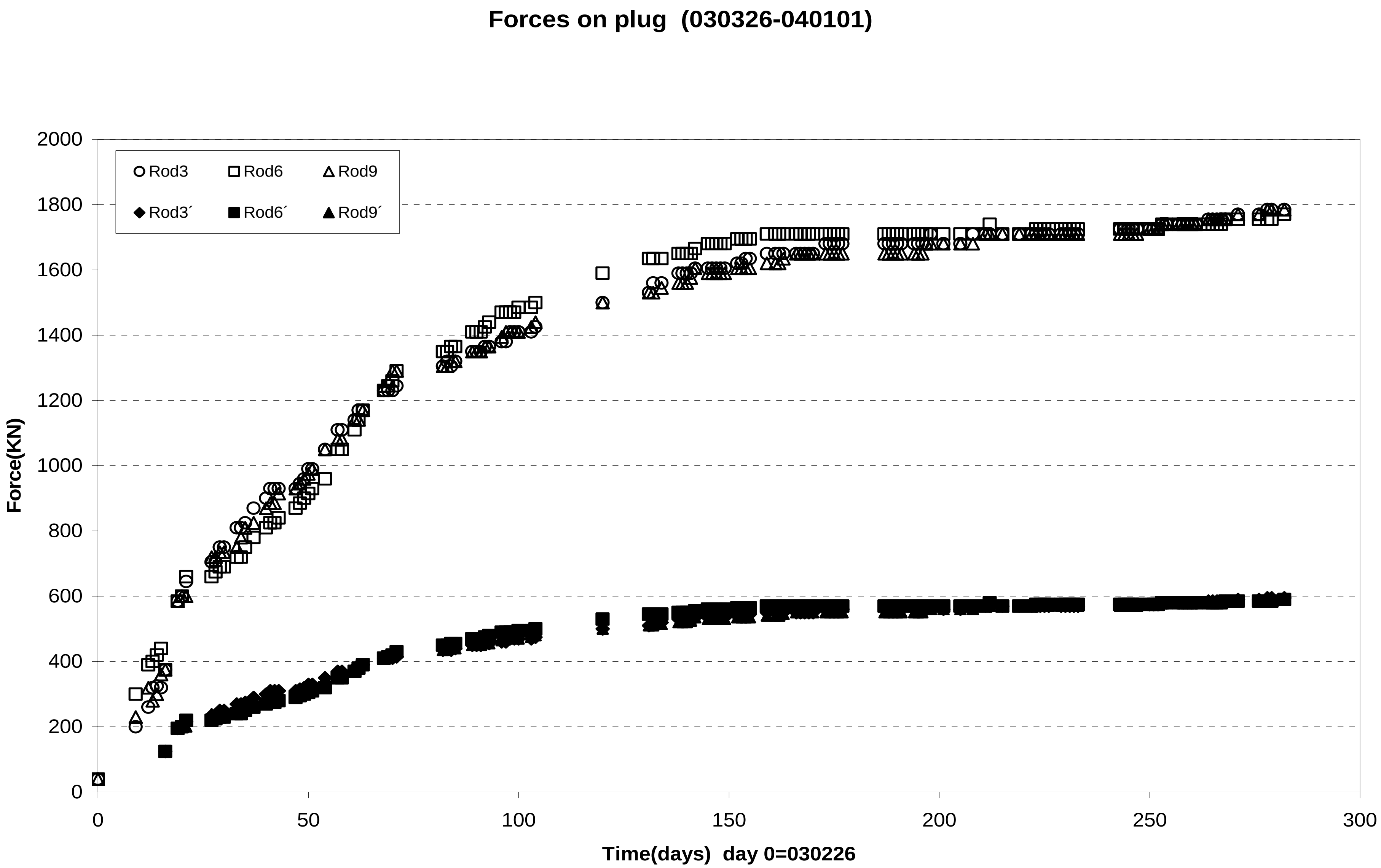
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

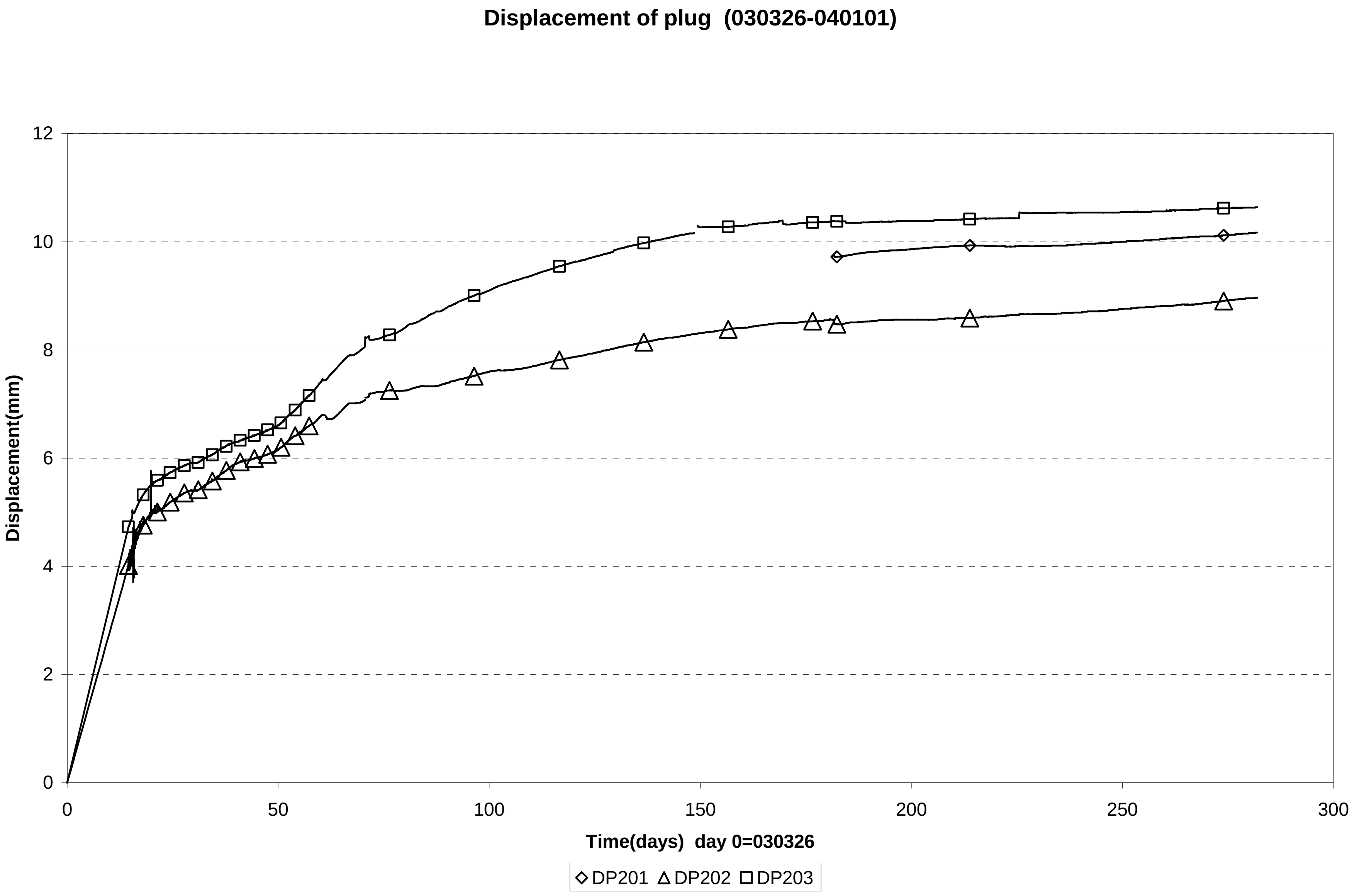


Pore pressure/Ring 9 (030326-040101)
Geokon
Pressure (Mpa)
0,50
0,40
0,30
0,20
0,10
0,00
-0,10
0
50
100
150
200
250
300
Time (days) Day(0)=010917
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1
UB205(5.250\270°\0.420)
UB206(5.250\315°\0.635)
UB207(5.250\90°\0.710)
UB208(5.250\225°\0.785)

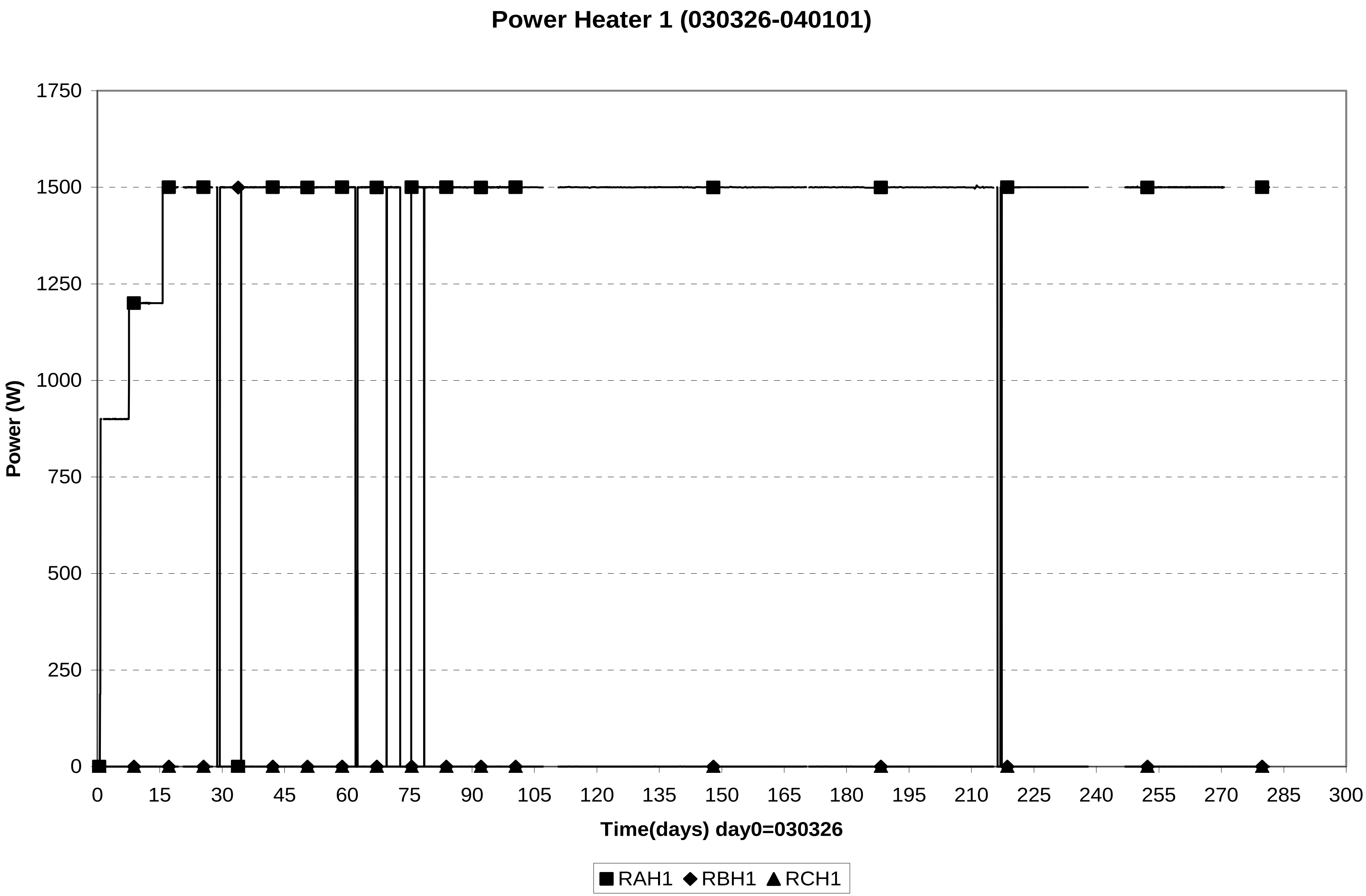

Inflow and outflow of water (030326-040101)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Volume (liter)
0
50
100
150
200
250
300
Time (days) day 0 =030326
Inflow
Outflow

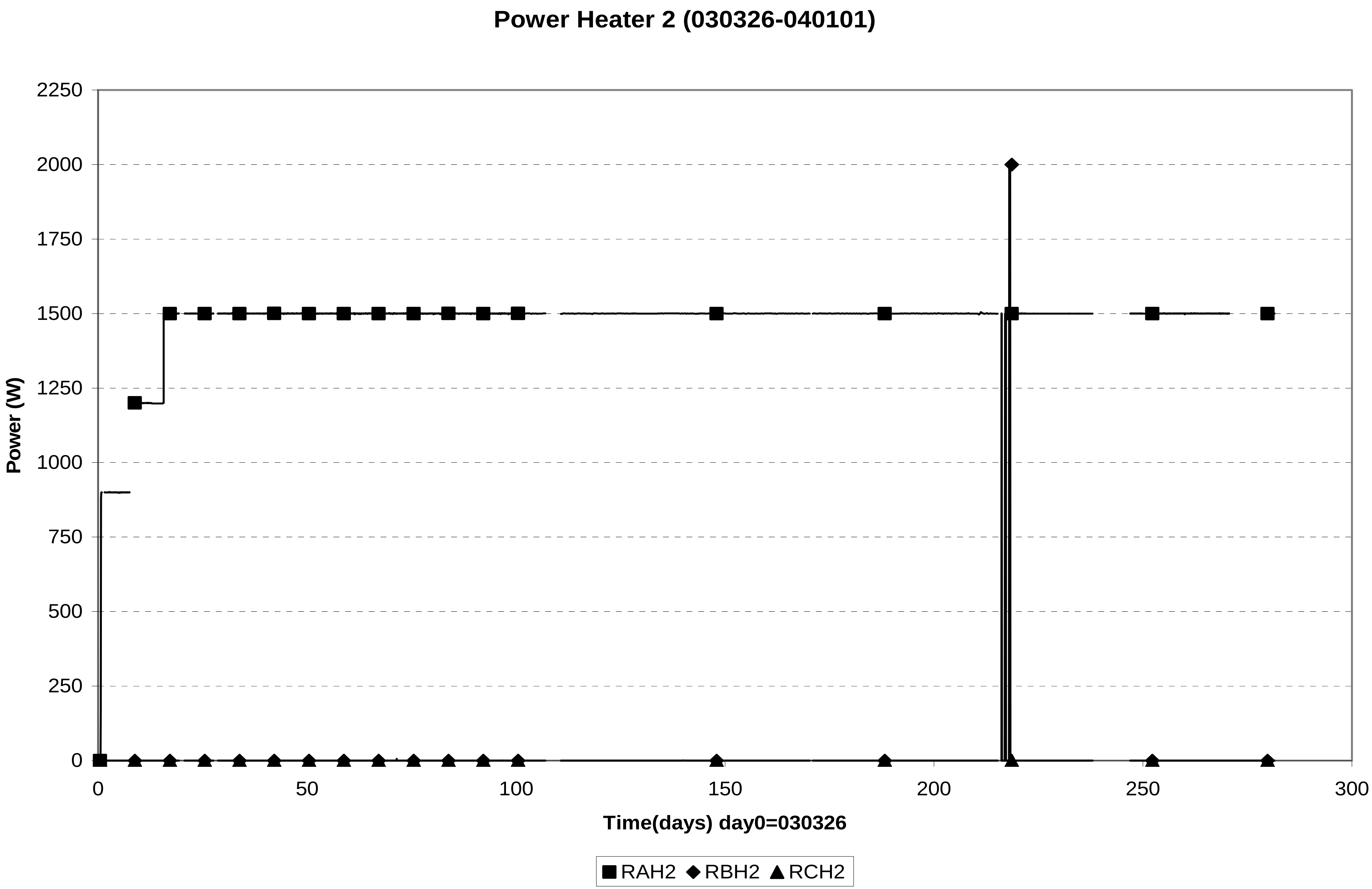

Water pressure (030326-040101)
Pressure (bar)
12
10
8
6
4
2
0
0
50
100
150
200
250
300
Time (days) day 0 =030326
Pressure

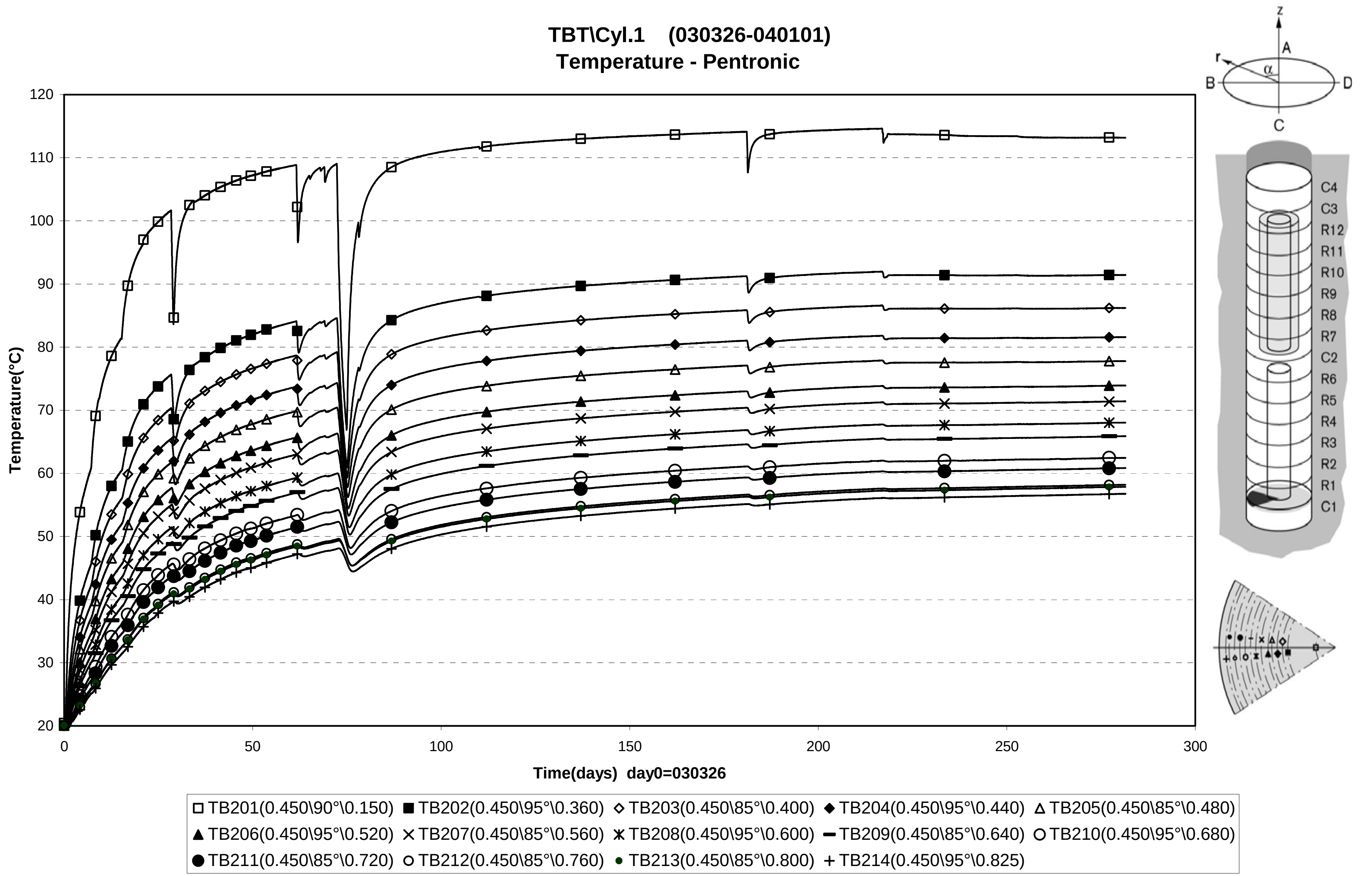

Forces on plug (030326-040101)
Rod3
Rod6
Rod9
Rod3´
Rod6´
Rod9´
Force(KN)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200
250
300
Time(days) day 0=030226

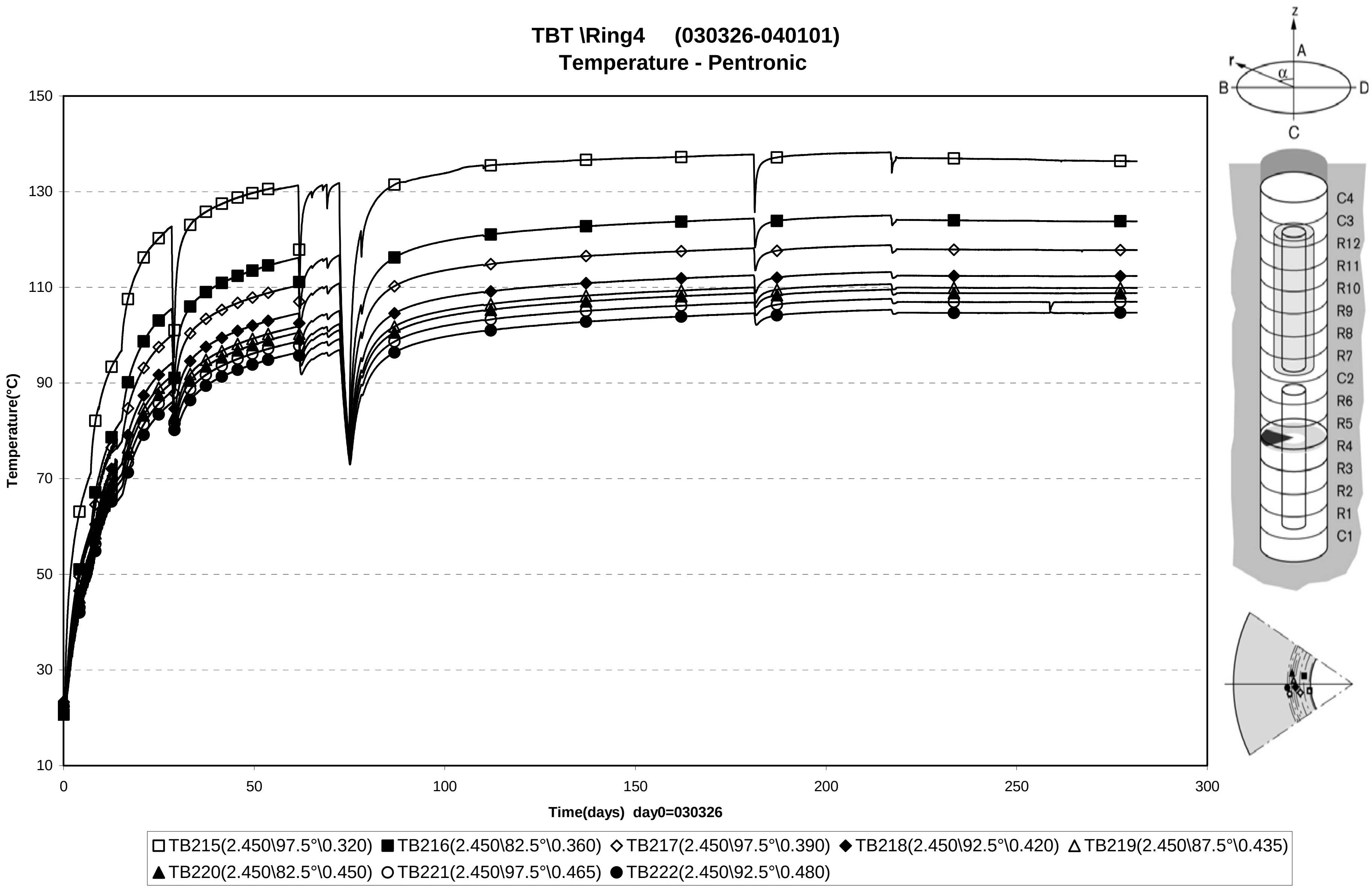


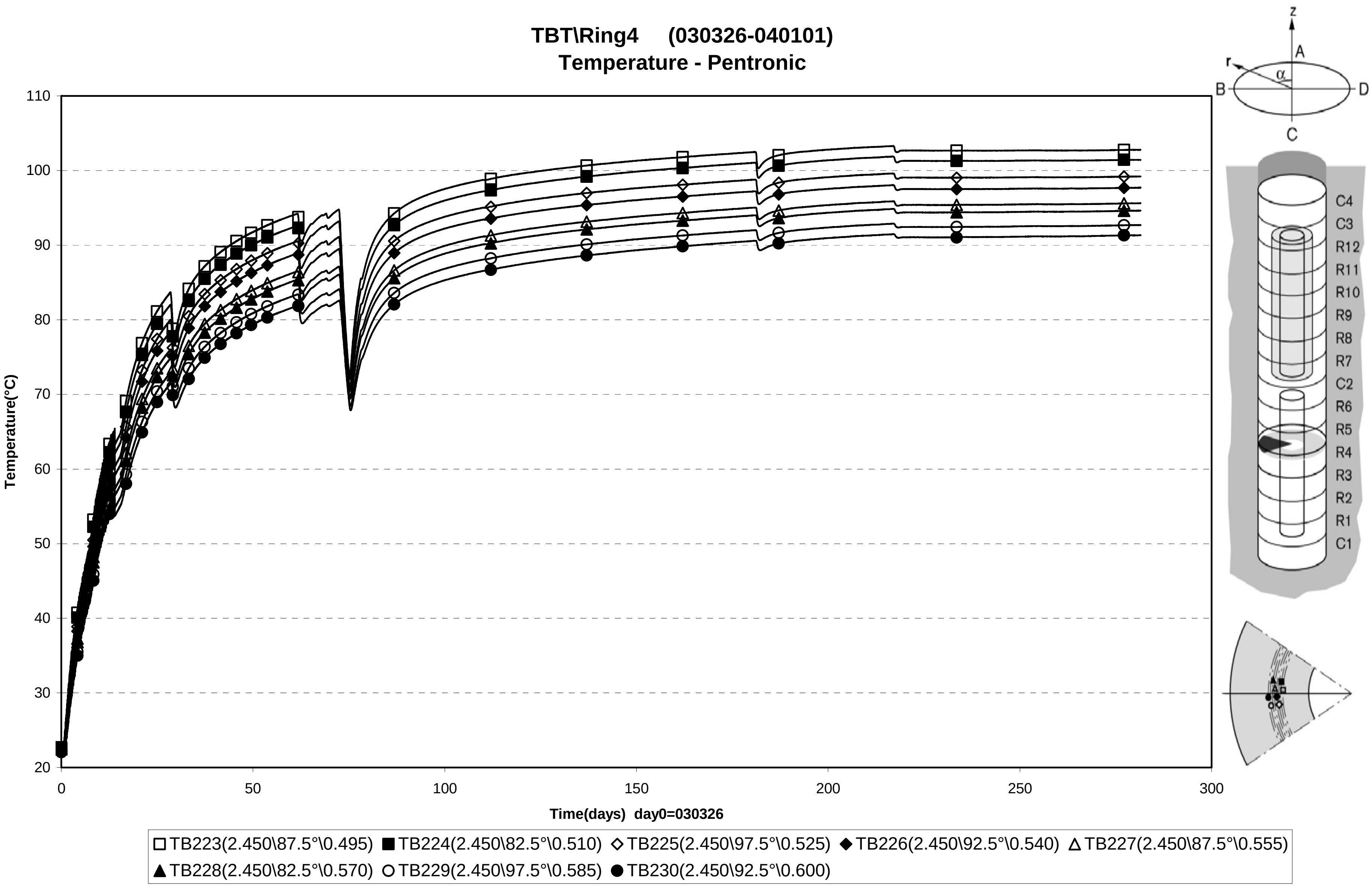
Displacement of plug (030326-040101)
Displacement(mm)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
Time(days) day 0=030326
DP201
DP202
DP203

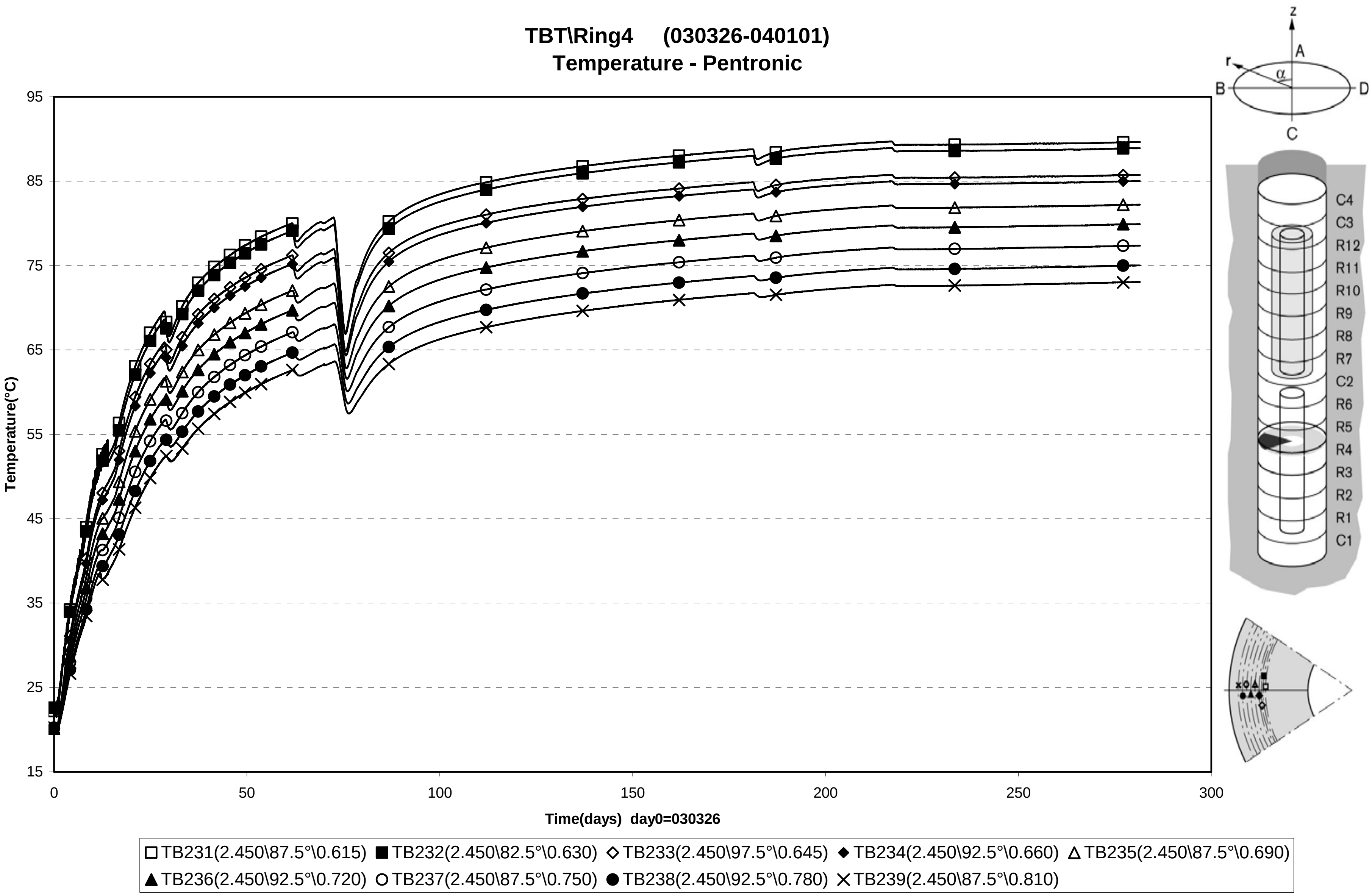

Power Heater 1 (030326-040101)
1750
1500
1250
1000
750
500
250
0
Power (W)
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
Time(days) day0=030326
RAH1
RBH1
RCH1


Power Heater 2 (030326-040101)
2250
2000
1750
1500
1250
1000
750
500
250
0
Power (W)
0
50
100
150
200
250
300
Time(days) day0=030326
RAH2
RBH2
RCH2

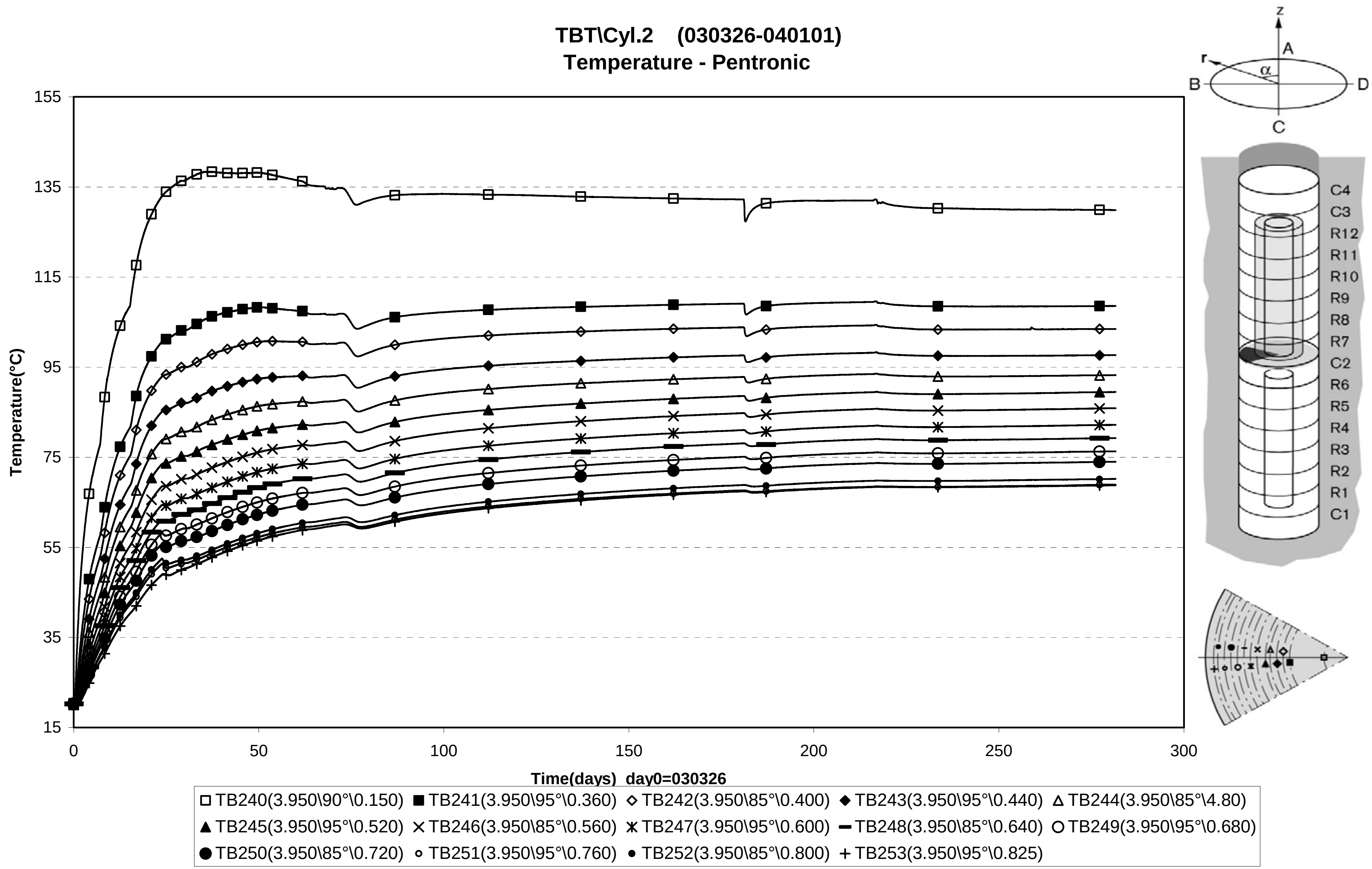

TBT\Cyl.1 (030326-040101)
Temperature - Pentronic
Temperature(°C)
Time(days) day0=030326
TB201(0.450\90°\0.150)
TB202(0.450\95°\0.360)
TB203(0.450\85°\0.400)
TB204(0.450\95°\0.440)
TB205(0.450\85°\0.480)
TB206(0.450\95°\0.520)
TB207(0.450\85°\0.560)
TB208(0.450\95°\0.600)
TB209(0.450\85°\0.640)
TB210(0.450\95°\0.680)
TB211(0.450\85°\0.720)
TB212(0.450\85°\0.760)
TB213(0.450\85°\0.800)
TB214(0.450\95°\0.825)
z
A
B
C
D
r
α
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

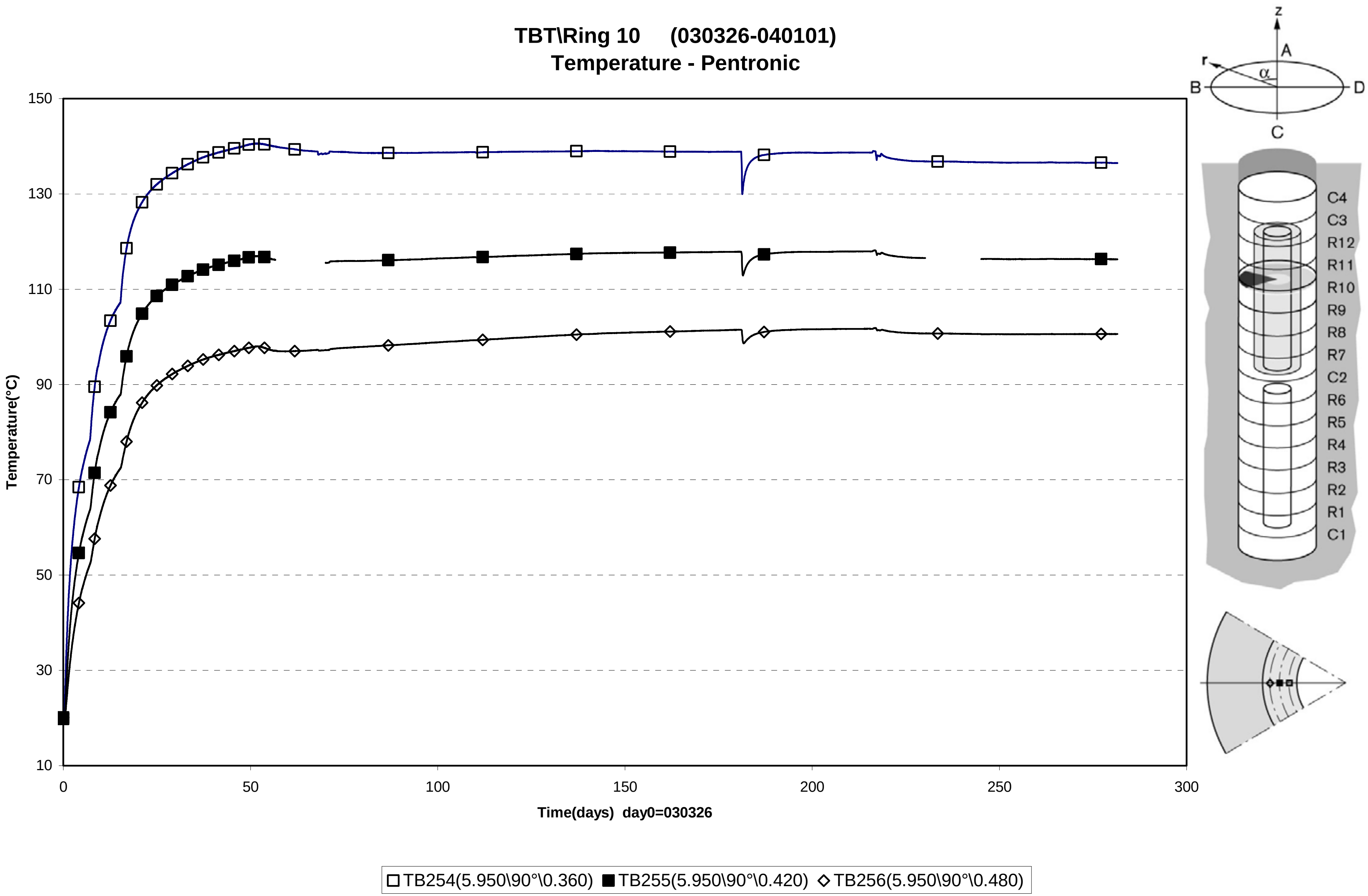

TBT \Ring4 (030326-040101)
Temperature - Pentronic
Temperature(°C)
Time(days) day0=030326
150
130
110
90
70
50
30
10
0
50
100
150
200
250
300
TB215(2.450\97.5°\0.320)
TB216(2.450\82.5°\0.360)
TB217(2.450\97.5°\0.390)
TB218(2.450\92.5°\0.420)
TB219(2.450\87.5°\0.435)
TB220(2.450\82.5°\0.450)
TB221(2.450\97.5°\0.465)
TB222(2.450\92.5°\0.480)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

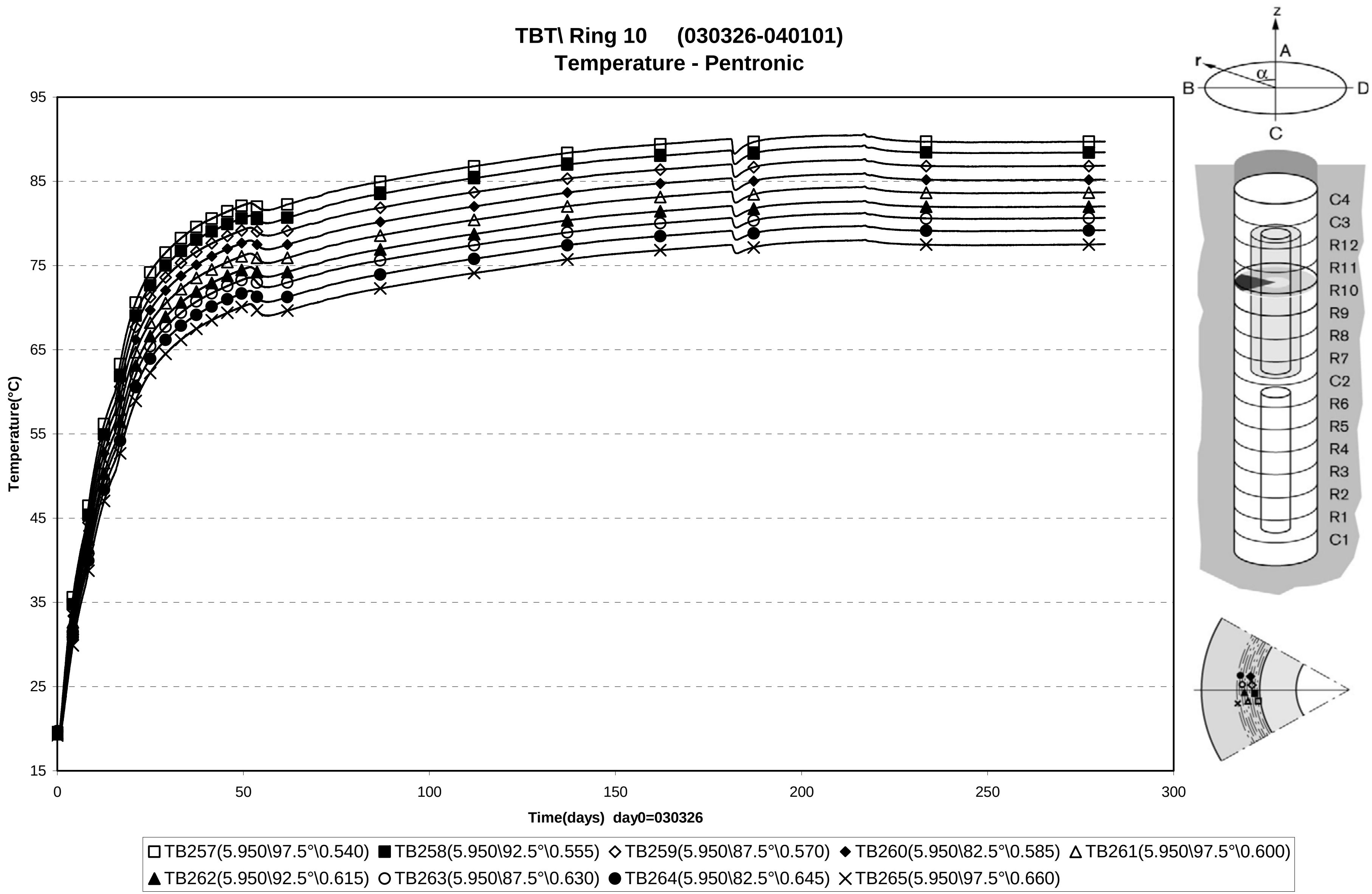

TBT\Ring4 (030326-040101)
Temperature - Pentronic
Temperature(°C)
Time(days) day0=030326
110
100
90
80
70
60
50
40
30
20
0
50
100
150
200
250
300
TB223(2.450\87.5°\0.495) TB224(2.450\82.5°\0.510) TB225(2.450\97.5°\0.525) TB226(2.450\92.5°\0.540) TB227(2.450\87.5°\0.555)
TB228(2.450\82.5°\0.570) TB229(2.450\97.5°\0.585) TB230(2.450\92.5°\0.600)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

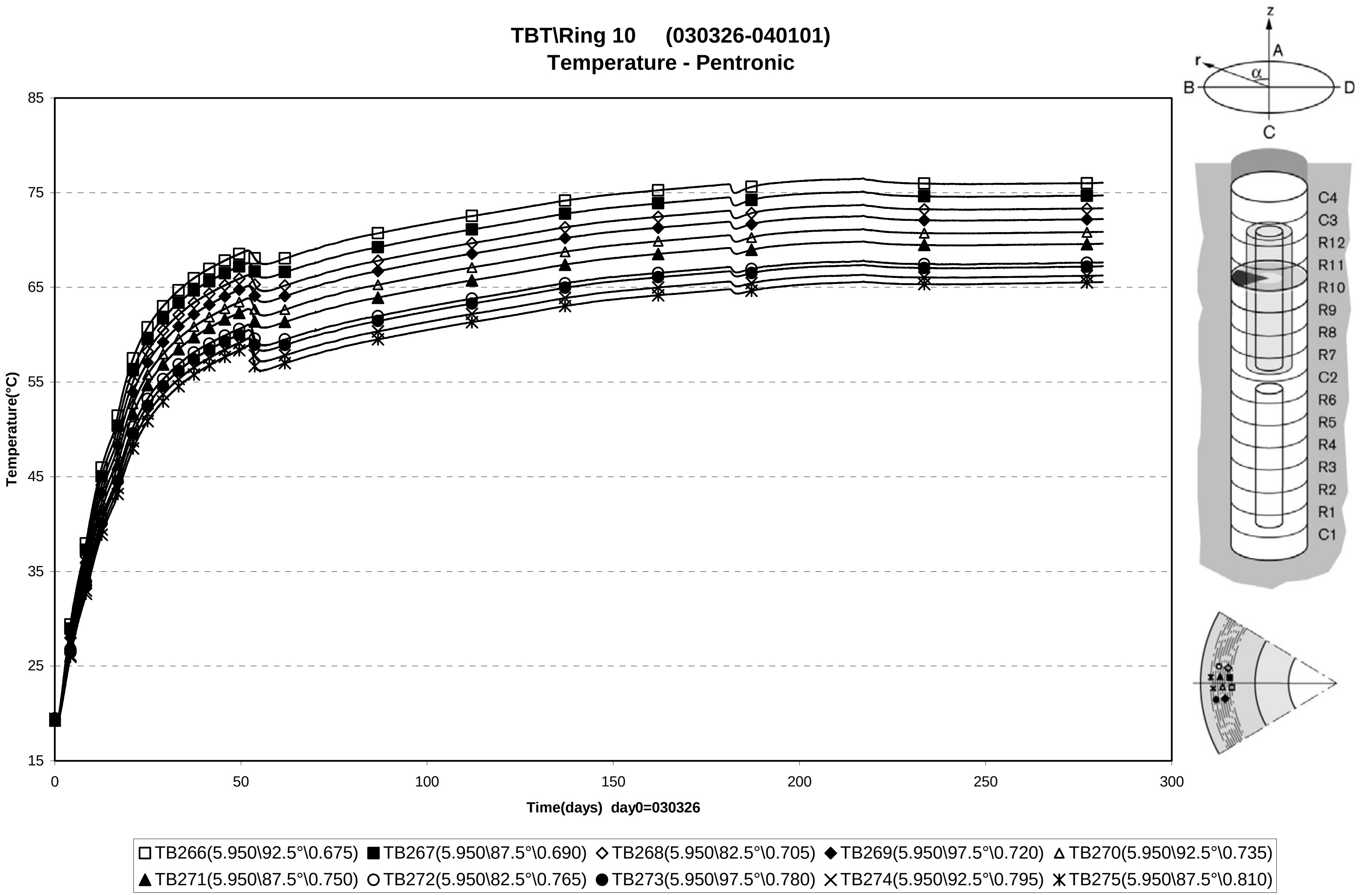


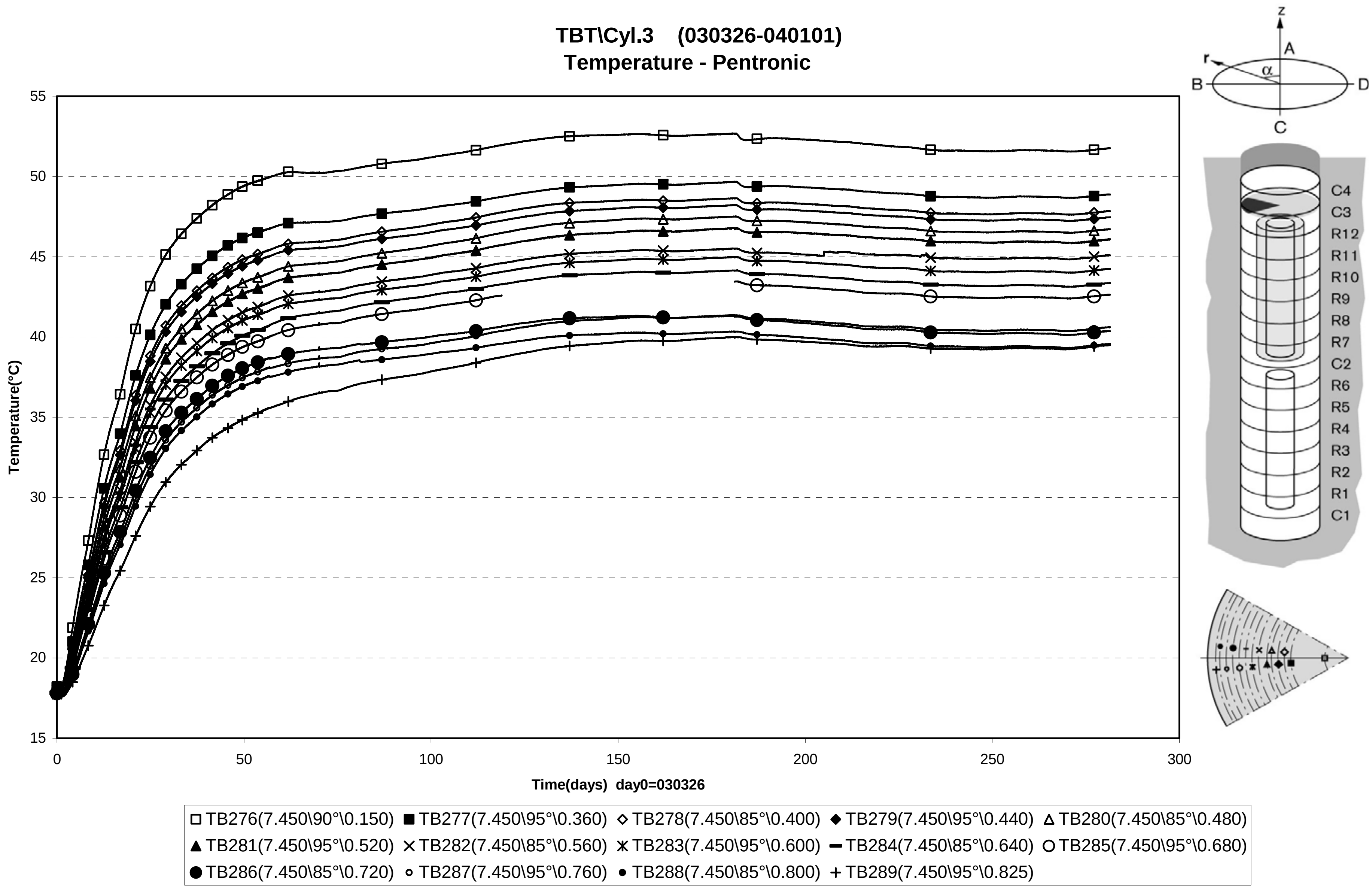
TBT\Ring4 (030326-040101)
Temperature - Pentronic
Temperature(°C)
Time(days) day0=030326
TB231(2.450\87.5°\0.615)
TB232(2.450\82.5°\0.630)
TB233(2.450\97.5°\0.645)
TB234(2.450\92.5°\0.660)
TB235(2.450\87.5°\0.690)
TB236(2.450\92.5°\0.720)
TB237(2.450\87.5°\0.750)
TB238(2.450\92.5°\0.780)
TB239(2.450\87.5°\0.810)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

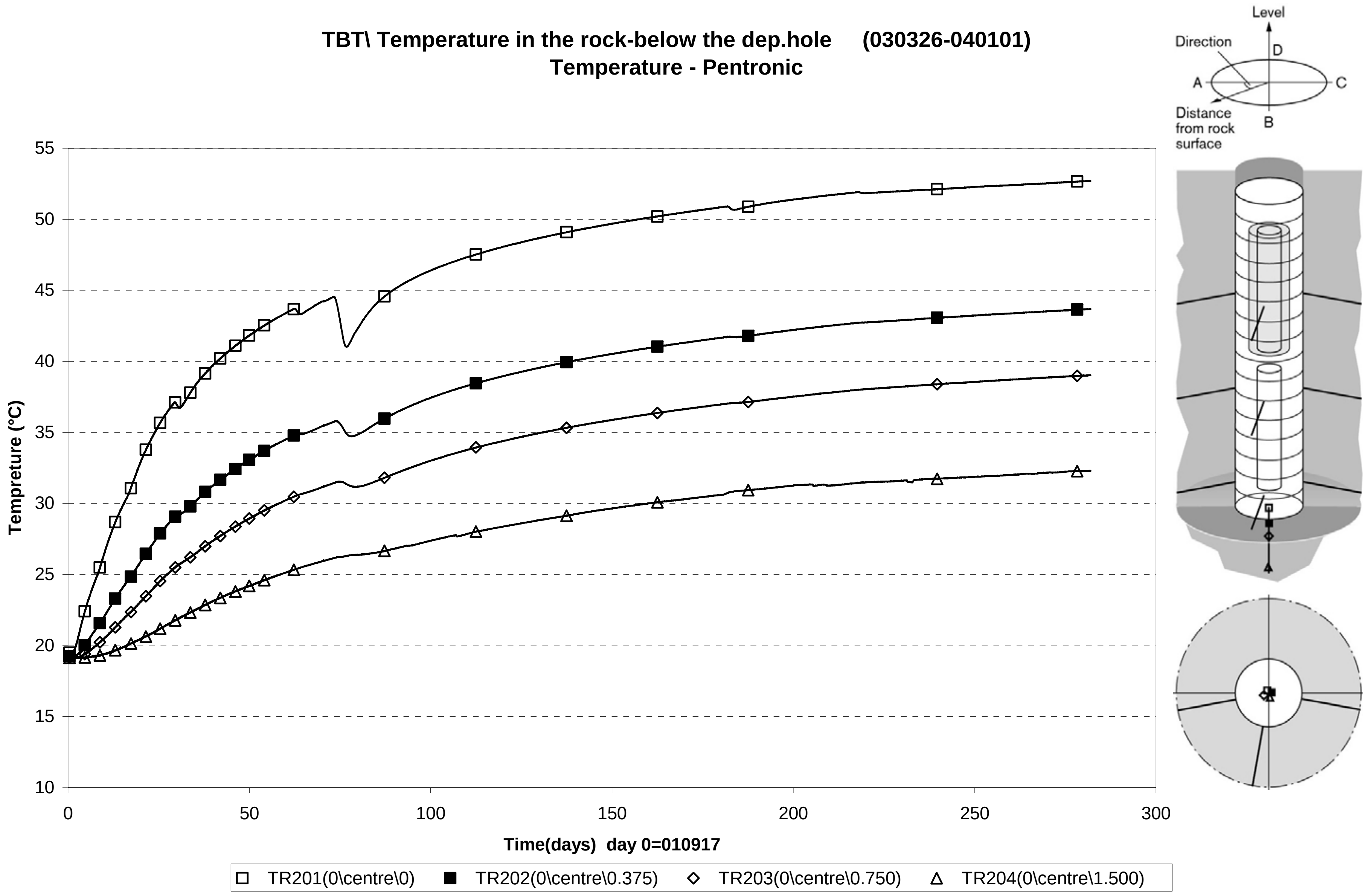

TBT\Cyl.2 (030326-040101)
Temperature - Pentronic
Temperature(°C)
155
135
115
95
75
55
35
15
0
50
100
150
200
250
300
Time(days) day0=030326
TB240(3.950\90°\0.150)
TB241(3.950\95°\0.360)
TB242(3.950\85°\0.400)
TB243(3.950\95°\0.440)
TB244(3.950\85°\4.80)
TB245(3.950\95°\0.520)
TB246(3.950\85°\0.560)
TB247(3.950\95°\0.600)
TB248(3.950\85°\0.640)
TB249(3.950\95°\0.680)
TB250(3.950\85°\0.720)
TB251(3.950\95°\0.760)
TB252(3.950\85°\0.800)
TB253(3.950\95°\0.825)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

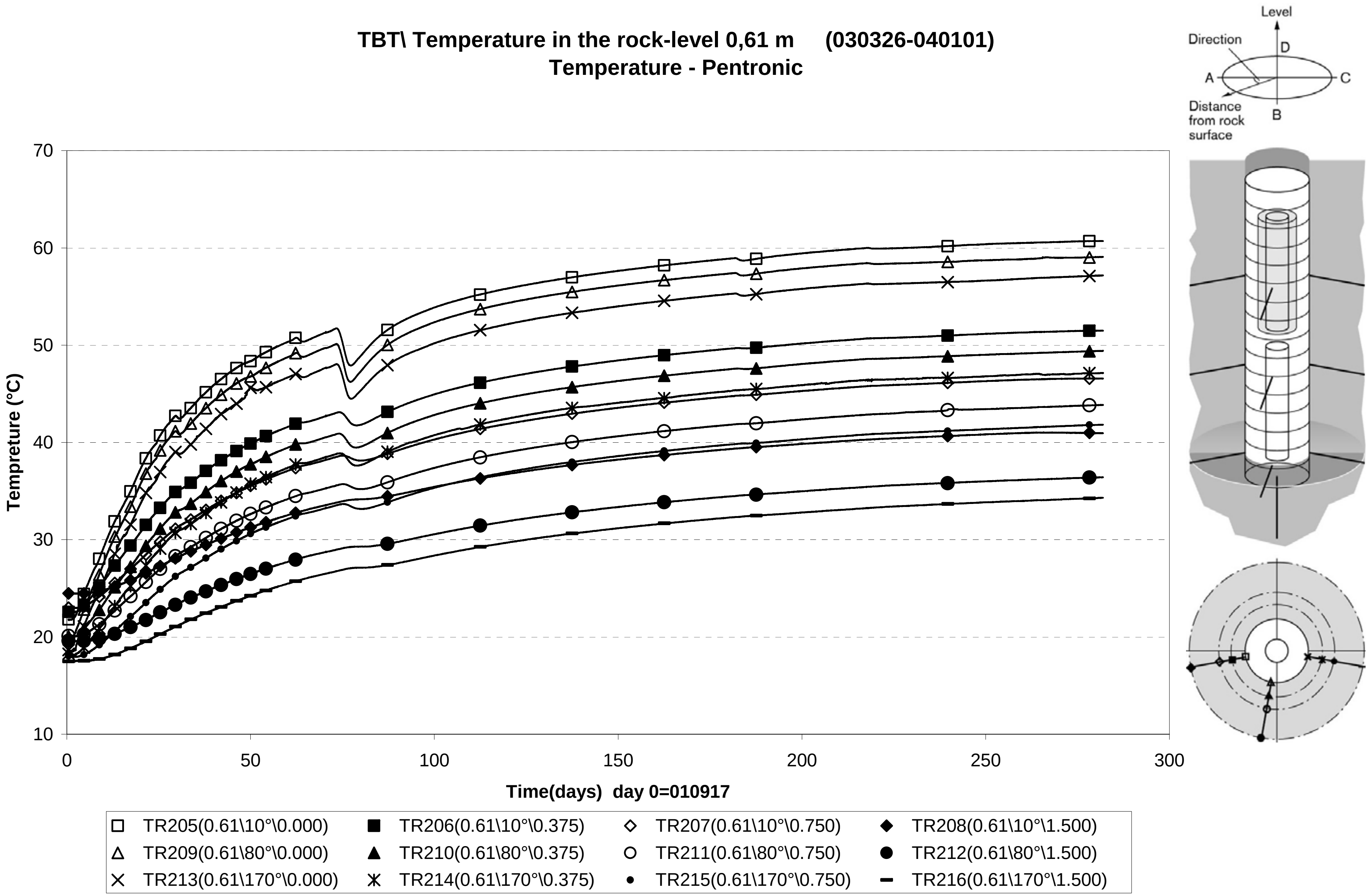

TBT\Ring 10 (030326-040101)
Temperature - Pentronic
Temperature(°C)
150
130
110
90
70
50
30
10
0
50
100
150
200
250
300
Time(days) day0=030326
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1
□ TB254(5.950\90°\0.360) ■ TB255(5.950\90°\0.420) ◇ TB256(5.950\90°\0.480)

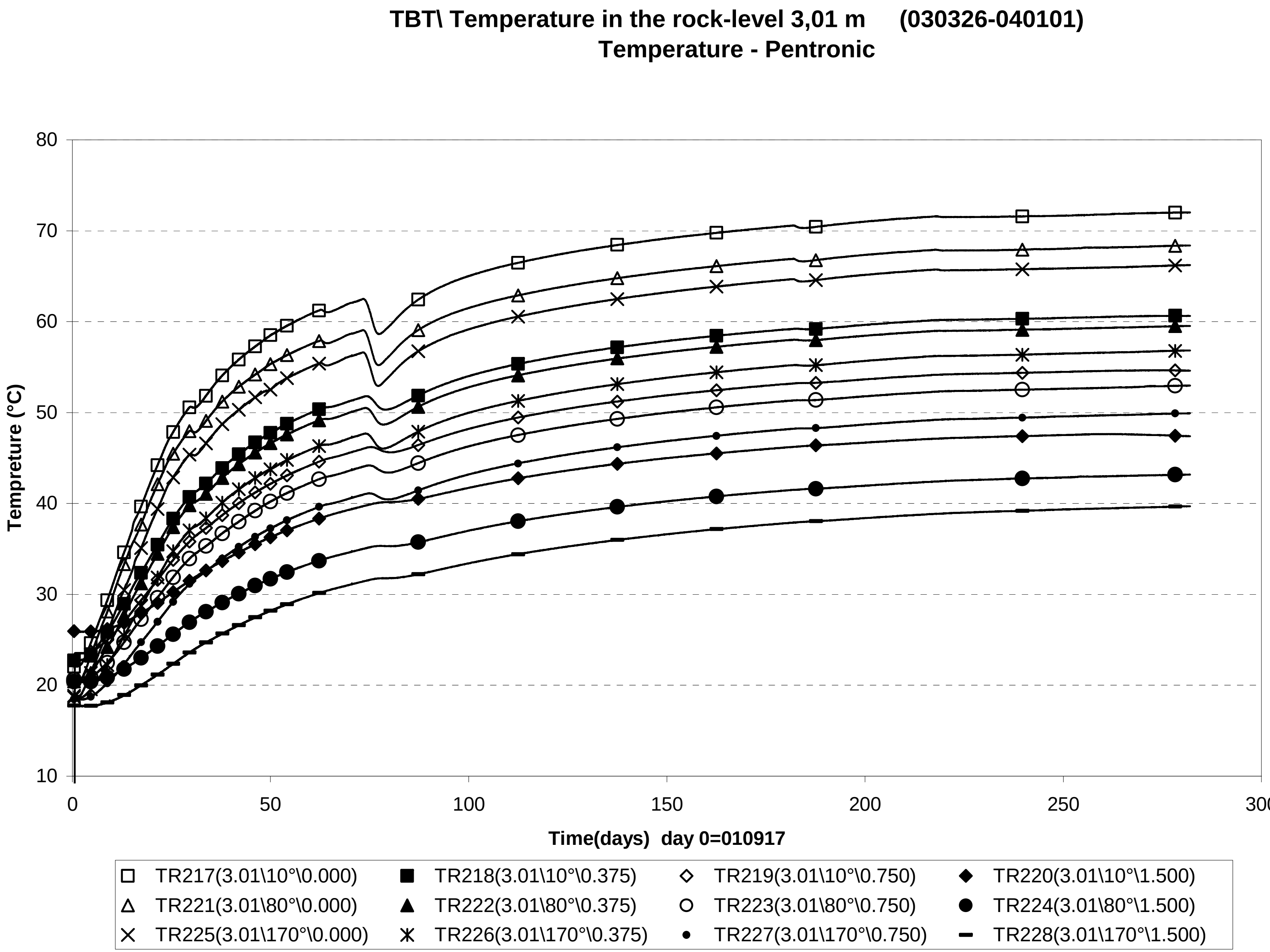

TBT\ Ring 10 (030326-040101)
Temperature - Pentronic
Temperature(°C)
95
85
75
65
55
45
35
25
15
0
50
100
150
200
250
300
Time(days) day0=030326
TB257(5.950\97.5°\0.540)
TB258(5.950\92.5°\0.555)
TB259(5.950\87.5°\0.570)
TB260(5.950\82.5°\0.585)
TB261(5.950\97.5°\0.600)
TB262(5.950\92.5°\0.615)
TB263(5.950\87.5°\0.630)
TB264(5.950\82.5°\0.645)
TB265(5.950\97.5°\0.660)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

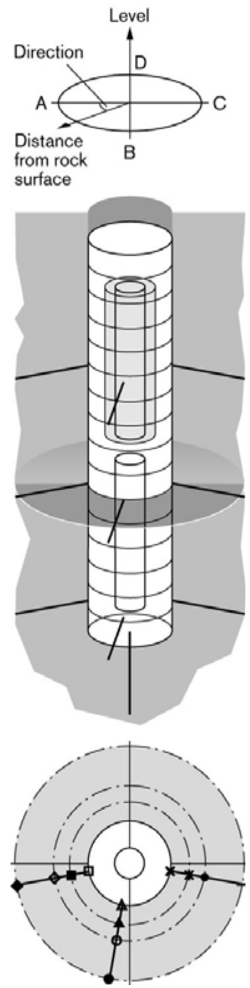

TBT\Ring 10 (030326-040101)
Temperature - Pentronic
Temperature(°C)
Time(days) day0=030326
85
75
65
55
45
35
25
15
0
50
100
150
200
250
300
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1
TB266(5.950\92.5°\0.675) TB267(5.950\87.5°\0.690) TB268(5.950\82.5°\0.705) TB269(5.950\97.5°\0.720) TB270(5.950\92.5°\0.735)
TB271(5.950\87.5°\0.750) TB272(5.950\82.5°\0.765) TB273(5.950\97.5°\0.780) TB274(5.950\92.5°\0.795) TB275(5.950\87.5°\0.810)

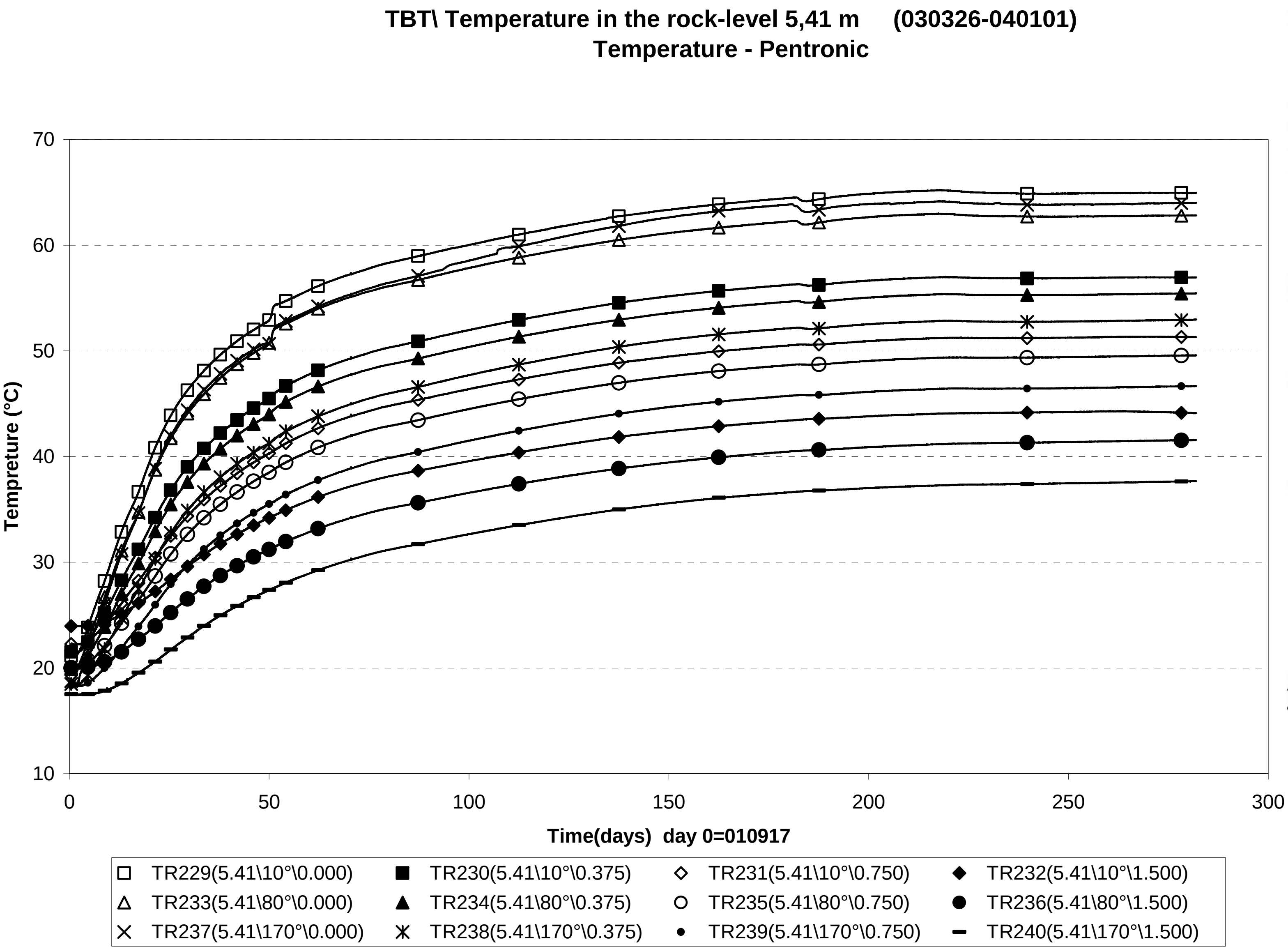

TBT\Cyl.3 (030326-040101)
Temperature - Pentronic
Temperature(°C)
55
50
45
40
35
30
25
20
15
0
50
100
150
200
250
300
Time(days) day0=030326
TB276(7.450\90°\0.150)
TB277(7.450\95°\0.360)
TB278(7.450\85°\0.400)
TB279(7.450\95°\0.440)
TB280(7.450\85°\0.480)
TB281(7.450\95°\0.520)
TB282(7.450\85°\0.560)
TB283(7.450\95°\0.600)
TB284(7.450\85°\0.640)
TB285(7.450\95°\0.680)
TB286(7.450\85°\0.720)
TB287(7.450\95°\0.760)
TB288(7.450\85°\0.800)
TB289(7.450\95°\0.825)
z
A
r
α
B
D
C
C4
C3
R12
R11
R10
R9
R8
R7
C2
R6
R5
R4
R3
R2
R1
C1

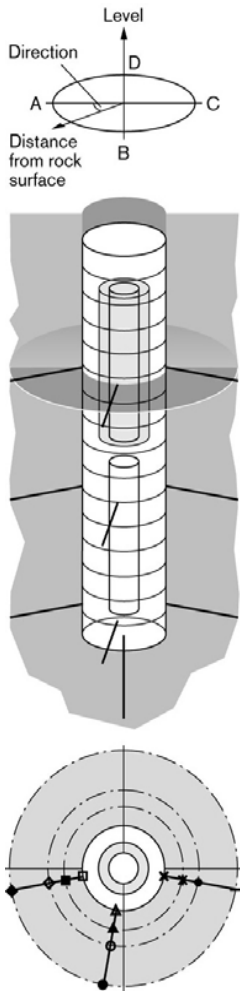

TBT\ Temperature in the rock-below the dep.hole (030326-040101)
Temperature - Pentronic
Tempreture (°C)
Time(days) day 0=010917
TR201(0\centre\0)
TR202(0\centre\0.375)
TR203(0\centre\0.750)
TR204(0\centre\1.500)
Level
Direction
Distance from rock surface
A
B
C
D

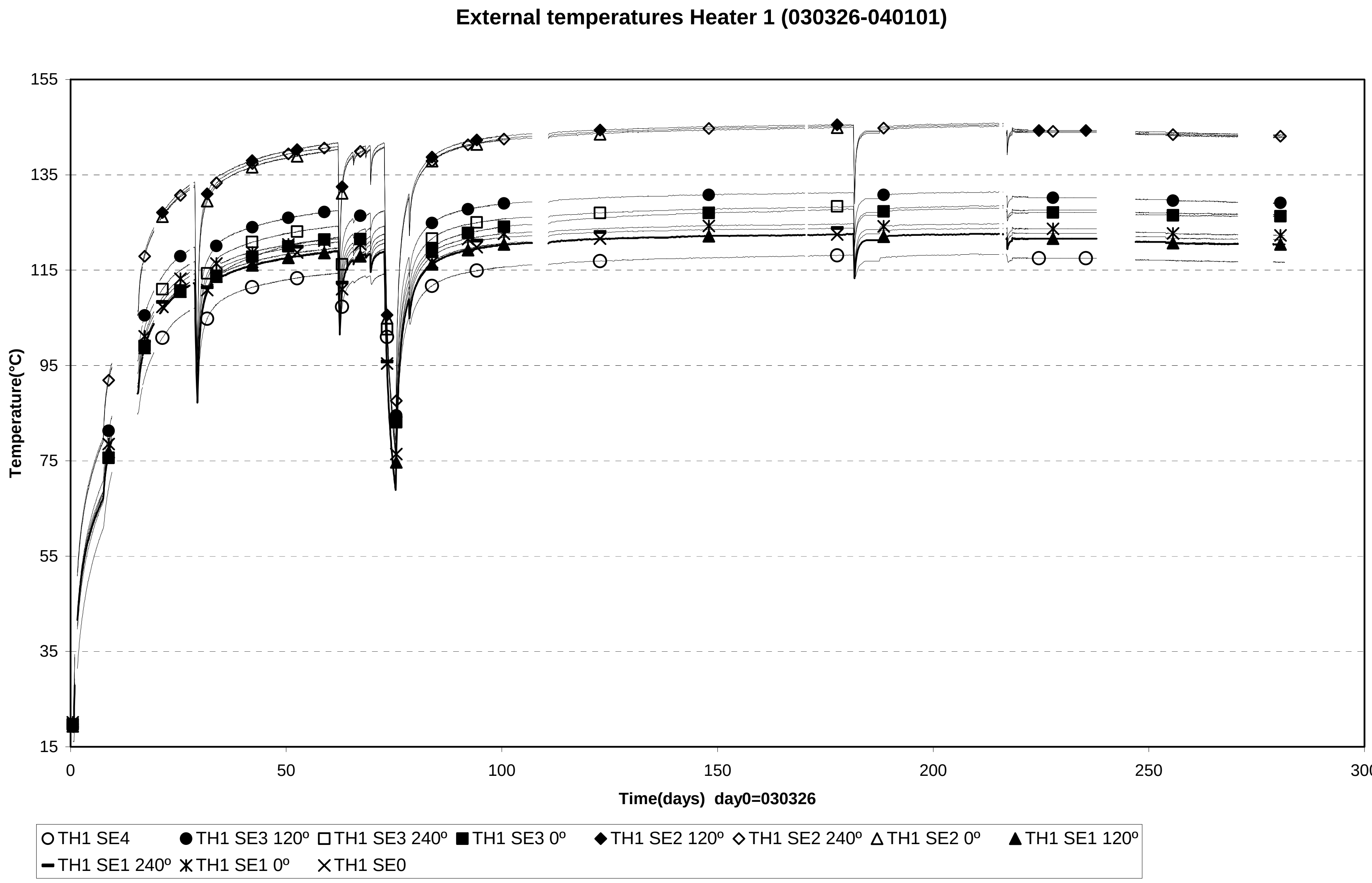

TBT\ Temperature in the rock-level 0,61 m (030326-040101)
Temperature - Pentronic
Tempreture (°C)
Time(days) day 0=010917
70
60
50
40
30
20
10
0
50
100
150
200
250
300
Level
Direction
A
B
C
D
Distance from rock surface
TR205(0.61\10°\0.000)
TR206(0.61\10°\0.375)
TR207(0.61\10°\0.750)
TR208(0.61\10°\1.500)
TR209(0.61\80°\0.000)
TR210(0.61\80°\0.375)
TR211(0.61\80°\0.750)
TR212(0.61\80°\1.500)
TR213(0.61\170°\0.000)
TR214(0.61\170°\0.375)
TR215(0.61\170°\0.750)
TR216(0.61\170°\1.500)

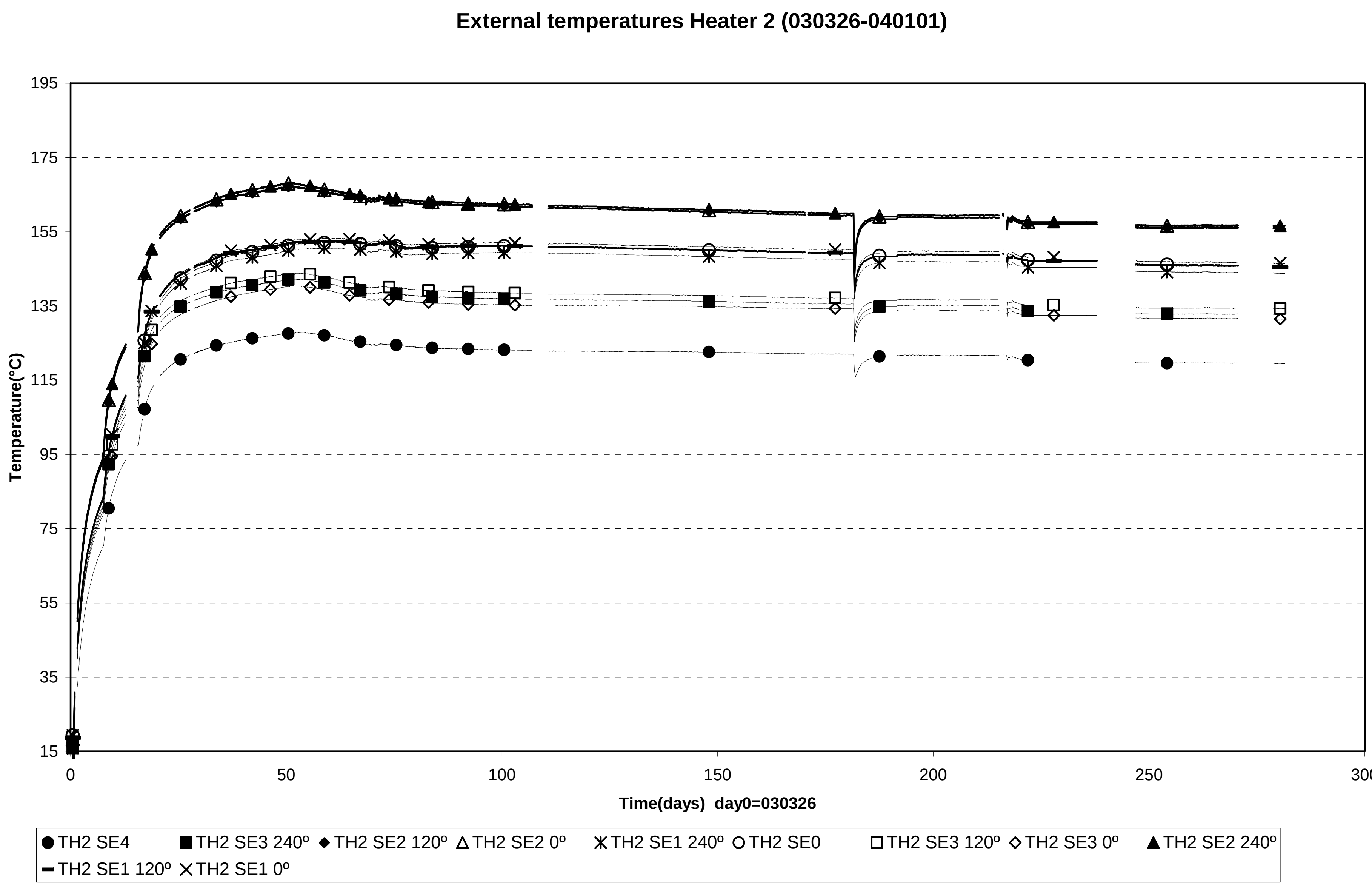

TBT\ Temperature in the rock-level 3,01 m (030326-040101)
Temperature - Pentronic
80
70
60
50
40
30
20
10
Tempreture (°C)
0
50
100
150
200
250
300
Time(days) day 0=010917
TR217(3.01\10°\0.000)
TR218(3.01\10°\0.375)
TR219(3.01\10°\0.750)
TR220(3.01\10°\1.500)
TR221(3.01\80°\0.000)
TR222(3.01\80°\0.375)
TR223(3.01\80°\0.750)
TR224(3.01\80°\1.500)
TR225(3.01\170°\0.000)
TR226(3.01\170°\0.375)
TR227(3.01\170°\0.750)
TR228(3.01\170°\1.500)

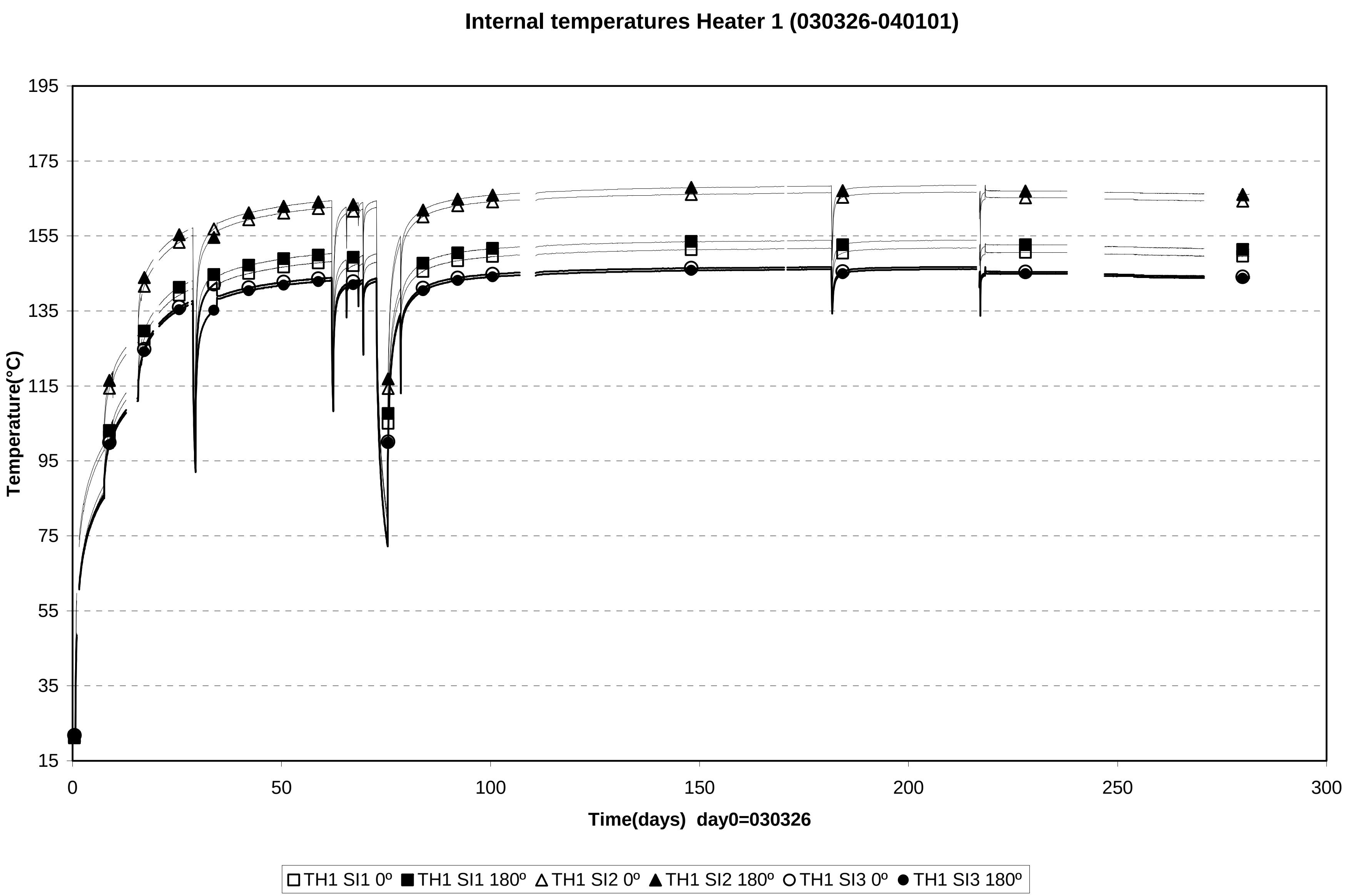

Level
Direction
D
A
C
Distance from rock surface
B

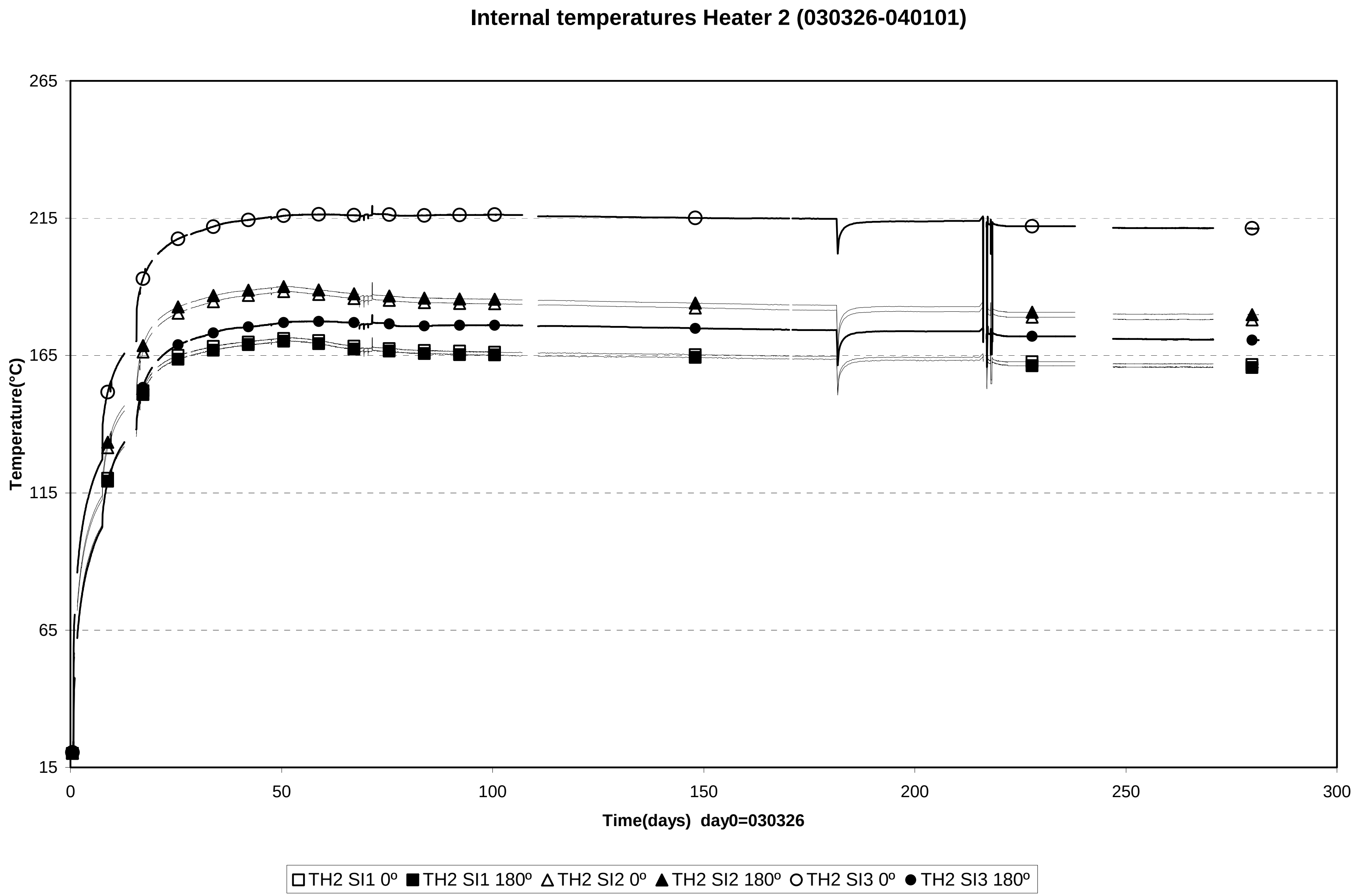

TBT\ Temperature in the rock-level 5,41 m (030326-040101)
Temperature - Pentronic
Tempreture (°C)
70
60
50
40
30
20
10
0
50
100
150
200
250
300
Time(days) day 0=010917
TR229(5.41\10°\0.000)
TR230(5.41\10°\0.375)
TR231(5.41\10°\0.750)
TR232(5.41\10°\1.500)
TR233(5.41\80°\0.000)
TR234(5.41\80°\0.375)
TR235(5.41\80°\0.750)
TR236(5.41\80°\1.500)
TR237(5.41\170°\0.000)
TR238(5.41\170°\0.375)
TR239(5.41\170°\0.750)
TR240(5.41\170°\1.500)


Level
Direction
D
A
C
Distance from rock surface
B


External temperatures Heater 1 (030326-040101)
Temperature(°C)
155
135
115
95
75
55
35
15
0
50
100
150
200
250
300
Time(days) day0=030326
TH1 SE4
TH1 SE3 120º
TH1 SE3 240º
TH1 SE3 0º
TH1 SE2 120º
TH1 SE2 240º
TH1 SE2 0º
TH1 SE1 120º
TH1 SE1 240º
TH1 SE1 0º
TH1 SE0


External temperatures Heater 2 (030326-040101)
195
175
155
135
115
95
75
55
35
15
Temperature(°C)
0
50
100
150
200
250
300
Time(days) day0=030326
TH2 SE4
TH2 SE3 240º
TH2 SE2 120º
TH2 SE2 0º
TH2 SE1 240º
TH2 SE0
TH2 SE3 120º
TH2 SE3 0º
TH2 SE2 240º
TH2 SE1 120º
TH2 SE1 0º


Internal temperatures Heater 1 (030326-040101)
Temperature(°C)
195
175
155
135
115
95
75
55
35
15
0
50
100
150
200
250
300
Time(days) day0=030326
TH1 SI1 0º
TH1 SI1 180º
TH1 SI2 0º
TH1 SI2 180º
TH1 SI3 0º
TH1 SI3 180º


Internal temperatures Heater 2 (030326-040101)
265
215
165
115
65
15
Temperature(°C)
0
50
100
150
200
250
300
Time(days) day0=030326
TH2 SI1 0º
TH2 SI1 180º
TH2 SI2 0º
TH2 SI2 180º
TH2 SI3 0º
TH2 SI3 180º