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Äspö Hard Rock Laboratory

Canister Retrieval test

**Sensor data report
(Period: 001026 - 010501)
Report No: 2**

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May 2001

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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author(s) and do not necessarily coincide with those of the client.

Abstract

This report presents data from the measurements in the Canister Retrieval Test from 001026 to 010501.

The following measurements are made in the bentonite: Temperature is measured in 32 points, total pressure in 27 points, pore water pressure in 14 points and relative humidity in 55 points. Temperature is also measured by all relative humidity gauges. The positions of the measuring points in the bentonite are related to a coordinate system in the deposition hole.

The following measurements are made in the rock: Temperature is measured in 40 points, stresses are measured in 8 points and strain is measured in 9 points. Results from the two latter measurements are not shown in this report.

The following measurements are made in the canister: Temperature is measured every meter along two fiber optic cables and strain is measured in 76 points on the surface of the copper envelop. Temperature is measured in the steel insert in 18 points.

The following measurements are made on the plug: Force is measured in 3 of the 9 anchors and vertical displacement is measured in three points.

The water inflow to the filter mats on the rock surface is also measured.

The general conclusion is that the measuring systems and transducers seem to work well but the following problems have been noted: The strain measurements in the canister are not reported due to question marks regarding the relevance of the search. There has been a further delay of the evaluation of stress and strain measurements in the rock and those results are not included. There are still problems with the data collection system for the fiber optical cables, which yielded periods with no data. Some Vaisala relative humidity transducers, located in ring 10, have failed due to water saturation.

Sammanfattning

I denna rapport presenteras data från mätningar i Återtag under perioden 001026-010501.

Följande mätningar görs i bentoniten: Temperaturen mäts i 32 punkter, totaltryck i 27 punkter, porvattentryck i 14 punkter och relativa fuktigheten i 55 punkter. Temperaturen mäts även i alla relativa fuktighetsmätare. Varje mätpunkt relateras till ett koordinatsystem i deponeringshålet.

Följande mätningar görs i berget: Temperaturen mäts i 40 punkter, spänning mäts i 8 punkter och töjning mäts i 9 punkter. Resultat från de två senare visas inte i denna rapport.

Följande mätningar görs på ytan i kapselns kopparhölje: Temperaturen mäts varje meter längs två fiberoptiska kablar och töjning mäts i 76 punkter. Temperaturen mäts i stålinsatsen i kanistern i 18 punkter.

Följande mätningar görs på pluggen: Kraften mäts i 3 av de 9 stagen och vertikala förskjutningen mäts i tre punkter.

Vatteninflödet till filtermattorna mäts också.

En generell slutsats är att mätsystemen och givarna tycks fungera bra, men följande problem har noterats: Töjningsmätningarna i kapselen har inte redovisats p. g. a frågetecken beträffande mätresultatens relevans. Utvärderingen av spännings- och töjningsmätarna i berget har försenats ytterligare och dessa resultat är inte redovisade. Fortsatta problem med datainsamlingssystemet till de fiberoptiska kablarna har medfört att det saknas data under några perioder. Några av Visalas relativa fuktighetsmätare, belägna i ring 10, har slutat fungera p. g. a. vattenmättnad.

Contents

1	Introduction	1
2	Comments	2
2.1	General	2
2.2	Total pressure, Geokon (App. pages 1-3)	2
2.3	Total Pressure, Kulite (App. page 4)	2
2.4	Suction, Wescor Psychrometers (App. pages 5-6)	3
2.5	Relative humidity, Vaisala (App. pages 7-10)	3
2.6	Pore water pressure, Geokon (App. pages 11-12)	3
2.7	Pore water pressure, Kulite (App. page 13)	3
2.8	Water flow into the filters (App. page 14)	3
2.9	Forces on the plug (App. page 15)	4
2.10	Displacement of the plug (App. page 16)	4
2.11	Canister power (App. page 17)	4
2.12	Temperature in the buffer (App. pages 18-22)	4
2.13	Temperature in the rock (App. pages 23-26)	4
2.14	Temperature on the canister surface, Optical fiber cables (App. pages 27-28)	4
2.15	Temperature inside the canister (App. pages 29-30)	5
2.16	Strain in the canister	5
2.16	Rock stresses and strain	5
3	Geometry	6
4	Location of instruments	7
4.1	Brief description of the instruments	7
	Measurements of temperature	7
	Measurement of total pressure in the buffer	7
	Measurement of pore water pressure in the buffer	7
	Measurement of the water saturation process	8
	Measurements of strain in the Canister	8
	Measurements of stresses and strain in the rock	8
	Measurements of forces on the plug	8
	Measurements of plug displacement	8
	Measurement of water flow into the permeable mats	8
4.2	Strategy for describing the position of each device	8
4.3	Position of each instrument in the bentonite	9
4.4	Instruments in the rock	14
	Temperature measurements	14
	Stress and strain measurements	15
4.5	Instruments in the canister	15
4.6	Instruments at the plug	18
	References	19
	Appendix 1	20

1 Introduction

The installation of the Canister Retrieval Test was made during autumn 2000. In general the data in this report are presented in diagrams covering the time period 2000-10-26 to 2001-05-01. The time axis in the diagrams represents days from 2000-10-26. The diagrams are attached in Appendix 1.

A test overview with the positions of the measuring points and a brief description of the instruments is also presented in this report (chapters 3 and 4).

General comments concerning the collection of the data are given in chapter 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 collection in general are given.

The slot between rock and bentonite block was filled with bentonite pellets and water at 001026. This date is also marked as start date.

The saturation of the bentonite started by applying 1 m water head in the water supply tank connected to the filters on 001102.

The heating of the canister started with an initially applied constant power of 700 W at 001027 that is one day after test start. The power was raised to 1700 W on 001113. The power was further raised to 2600 W on 010213

The first report covered the period up to 010201. This report is the second one and covers the results up to 010501.

2.2 Total pressure, Geokon (App. pages 1-3)

The measured pressure range is from 0 to 3.9 MPa. The highest pressure is indicated from P105, P107, P109 and P114. The three first are placed in cylinder 1 and all of them are placed at the same distance from the canister and near the bentonite block periphery. P114 is placed in Ring5 in the slot at the bentonite block periphery. P112 and U106, placed near the bentonite block periphery in ring 5, have increased to 1.0 – 1.5 MPa. Remarkable is that P115, placed close to the canister has increased to 0.7 MPa while P116, placed close to the rock surface, has only increased to about 0.15 MPa.

Sensor P104 was not installed.

U106 was originally intended to be a pore pressure sensor but was replaced by a total pressure sensor.

2.3 Total Pressure, Kulite (App. page 4)

Six total Kulite pressure transducers are installed in the bentonite blocks. Three of them yield questionable data: P222 stopped working properly after 125 days, P224 yields

remarkably high values and P221 yields unreliable reading and it is not plotted in this report. Two of the transducers placed above the center of the canister yield logically very low pressure while the measured value 2 MPa for P223 is difficult to understand since the transducer is placed 29 cm from the rock surface.

2.4 Suction, Wescor Psychrometers (App. pages 5-6)

Wescor psychrometers are only working at suction below 5000 kPa, which correspond to high relative humidity (above about 96%). Three transducer W141, W147 and W124 started yielding values that could be interpreted in the last report. During the last three months another 4 transducers have started yielding interpretable values. Three of the latter ones are placed half way between the rock and the canister in ring 10 while the other 4 are placed close to the ring periphery in rings 5 and 10.

2.5 Relative humidity, Vaisala (App. pages 7-10)

App. pages 7-10 show relative humidity and temperature measured with Vaisala transducers. W112 was not installed. W102 and W125 were out of order from start and they are not plotted in this report. W103 stopped working during the first three months. During the last three months another 5 transducers have stopped working (W150, W138, W136, W137 and W144). All these are placed in ring 10 and it is probable that the malfunction can be explained by a high relative humidity.

2.6 Pore water pressure, Geokon (App. pages 11-12)

U108 and U110 yield a water pressure of 350 kPa and 220 kPa. They are placed in the periphery of Ring 5. U107 and U105 yield 160 kPa and 130 kPa. These sensors are placed in Ring5 but not near the periphery of the bentonite block. The pressure measured by these transducers is most likely a pore gas pressure.

U106 is replaced by a total pressure sensor.

The remaining sensors of this type yield zero pressure.

2.7 Pore water pressure, Kulite (App. page 13)

There are only one sensor of this type in Ring 10 and one in Cylinder 4. Both indicate zero pressure.

2.8 Water flow into the filters (App. page 14)

Measurement of water inflow into the filters started on 001102. The total inflow to the filter has since that date been 211 liter. The inflow is slowly reduced with time and at present about 0.25 l/day.

2.9 Forces on the plug (App. page 15)

The forces on the plug have been measured since 001106. The total force is about 2900 kN at 010501.

During the first about 50 days the plug was only fixed with 3 rods. When the total force exceeded 1500 kN the rest of the 9 rods were fixed in a prescribed manner. This procedure took place 12-14 December that is 46-48 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.

2.10 Displacement of the plug (App. page 16)

The three displacement gauges were placed and started to measure displacements from 001101. The tilting of the plug that could be observed in the beginning of the test has ceased and the displacement in the last three months period seems to be the same in all three points.

2.11 Canister power (App. page 17)

The measurement of the power of the canister was erroneous during the first 20 days, which was the reason for that only 700 W were applied from start.

2.12 Temperature in the buffer (App. pages 18-22)

The temperature ranges from no increase at all (in the periphery of the upper bentonite cylinder C4) to a total temperature of 83 degrees in the center close to the canister. The highest temperature gradient is 0.90 degrees/cm (ring 5).

2.13 Temperature in the rock (App. pages 23-26)

The maximum temperature in the rock (60 degrees) is measured in the central section on the surface of the deposition hole. Almost complete axial symmetry can be observed.

2.14 Temperature on the canister surface, Optical fiber cables (App. pages 27-28)

The first diagram shows the maximum temperature plotted as a function of time. The maximum temperature on the canister surface is 92 degrees. The second diagram shows the distribution of the temperature along the cables at 010511. The length of the cable on the canister surface is only about 20 m and close to the entrances the temperature is affected by the lower surrounding temperatures.

Problems with the data collection system have yielded loss of measurements at long intervals.

2.15 Temperature inside the canister (App. pages 29-30)

The highest temperature (101 degrees) is measured in the center of the canister (P15). In the same central section the temperature on the surface of the steel insert (P5) is about 8 degrees lower, which can be compared to the corresponding temperature on the copper surface, which is still a few degrees lower.

2.16 Strain in the canister

Continuous measurements have been made but so far no results have been produced due to evaluation problems.

2.16 Rock stresses and strain

Continuous measurements have been made but so far no results have been produced due to evaluation problems.

3 Geometry

The test installation consists of a full scale deposition hole, a copper canister equipped with electrical heaters and bentonite blocks (cylindrical and ring shaped). A plug of concrete and steel is anchored to the rock on top of the bentonite.

The saturation of the bentonite is attained artificially by vertical filter stripes. 16 stripes with a width of 0.1 meters and a length of 5.5 meters are applied on the surrounding rock.

Measurements are made in four vertical sections A, B, C and D according to Figure 3-1. Direction A-B is parallel to the tunnels axial with A headed almost against north.

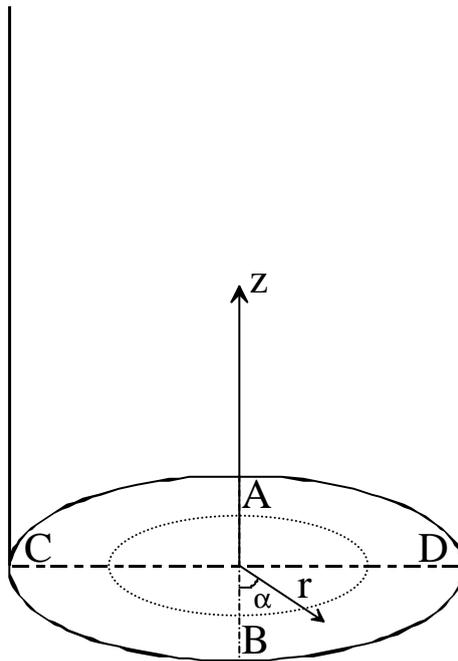


Figure 3-1. Figure describing the instrument planes (A-D) and the coordinate system used when describing the instrument positions.

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 BICC have been installed for measuring temperature in the buffer. Measurements are done in 32 points in the test hole. In addition, temperature gauges are built in into the capacitive relative humidity sensors (29 sensors) as well as in the pressure gauges of vibrating wire type (13 gauges). Temperature is also measured in the psychrometers.

Canister

Temperature is measured inside the canister (on the insert) in 19 points with PT-100 gauges. In addition temperature is measured on the surface of the canister with optical fiber cables. An optical measuring system called FTR (Fiber Temperature Laser Radar) from BICC is used.

Rock

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

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 the following instrument types:

- Geocon total pressure cells with vibrating wire transducers. 15 cells of this type have been installed.
- Kulite total pressure cells with piezo resistive transducers. 6 cells of this type have been installed.

Measurement of pore water pressure in the buffer

Pore water pressure is measured with the following instrument types:

- Geocon pore pressure cells with vibrating wire transducer. 13 cells of this type have been installed.
- Kulite pore pressure cells with piezo resistive transducer. 2 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 model PST-55. The devices measure the relative humidity in the pore system, The measuring range is 95.5-99.6 % RH corresponding to the pore water pressure -0.5 to -6MPa. 26 cells of this type have been installed.

Measurements of strain in the Canister

Measurements of stresses and strain in the rock

These are not reported.

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 permeable mats

Water is supplied to the bentonite with filter strips attached to the rock surface. The water flow into these mats is measured by measuring the water volume in the supply tank with a differential pressure transmitter that measures the difference in pressure between the nitrogen in the top of the tank and the water in the bottom of the tank.

4.2 Strategy for describing the position of each device

Every instrument is named with a short unique name consisting of 1-2 letters describing the type of measurement and 3 figures numbering the device. Every instrument position in the buffer and rock 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 500 mm). The α -coordinate is the angle from the vertical direction B (almost south).

The short description of the positions in the diagrams differs between the buffer and the rock.

Buffer: Three positions with the following meaning: (bentonite block or cylinder number counted from the bottom \ direction A, B, C, or D \ radius in mm from center line)

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

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

4.3 Position of each instrument in the bentonite

Measurements are done in four vertical sections A, B, C and D according to Figure 3-1. Direction A and B are placed in the tunnels axial direction.

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

The instruments are located in two main levels in the blocks, 50 mm and 160 mm, from the upper surface. The thermocouples have mostly placed in the 50mm level and the other gauges in the 160 mm level.

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

1m

A

B+C

D

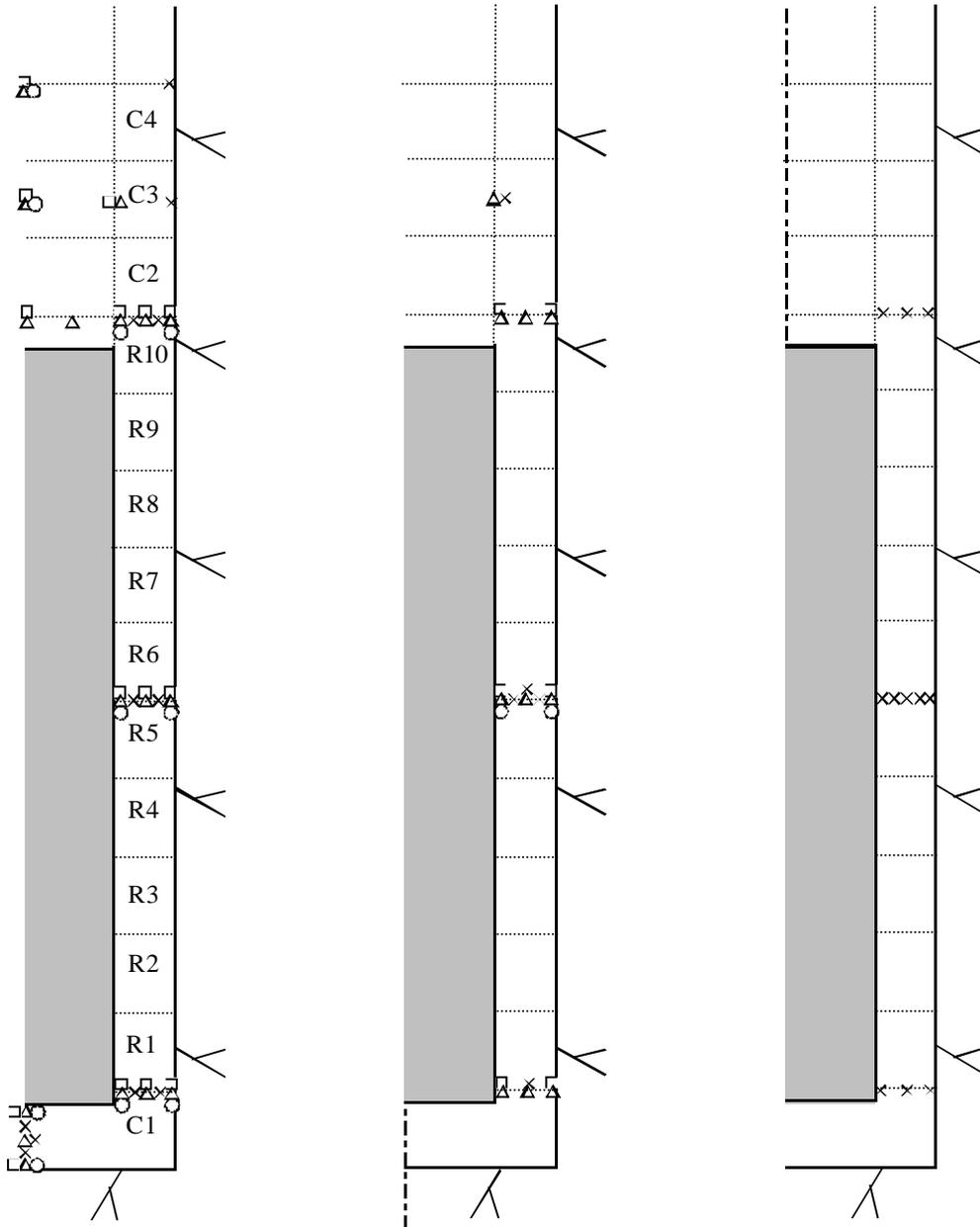


Figure 4-1 Schematic view over the instruments in four vertical sections and the block designation.

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

Type and number	Block	Instrument position in block				Cable pos.		Fabricate	Remark
		Direction	α	r	Z	α			
T101	Cyl. 1	Center	90	50	50	242	BICC		
T102	Cyl. 1	Center	90	50	250	238	BICC		
T103	Cyl. 1	Center	90	50	450	230	BICC		
T104	Cyl. 1	A	180	635	450	206	BICC		
T105	Cyl. 1	A	180	735	450	202	BICC		
T106	Cyl. 1	B	365	685	450	38	BICC		
T107	Cyl. 1	C	275	685	450	274	BICC		
T108	Cyl. 1	D	90	585	450	96	BICC		
T109	Cyl. 1	D	90	685	450	94	BICC		
T110	Cyl. 1	D	90	785	450	92	BICC		
T111	Ring 5	A	180	635	2950	224	BICC		
T112	Ring 5	A	180	735	2950	218	BICC		
T113	Ring 5	B	360	610	2950	318	BICC		
T114	Ring 5	B	360	685	2950	322	BICC		
T115	Ring 5	B	360	735	2950	324	BICC		
T116	Ring 5	C	270	610	2950	258	BICC		
T117	Ring 5	C	270	685	2950	260	BICC		
T118	Ring 5	C	270	735	2950	262	BICC		
T119	Ring 5	D	90	585	2950	44	BICC		
T120	Ring 5	D	90	635	2950	46	BICC		
T121	Ring 5	D	90	685	2950	48	BICC		
T122	Ring 5	D	90	735	2950	50	BICC		
T123	Ring 5	D	90	785	2950	52	BICC		
T124	Ring 10	A	180	635	5450	200	BICC		
T125	Ring 10	A	180	735	5450	194	BICC		
T126	Ring 10	D	90	585	5450	54	BICC		
T127	Ring 10	D	90	685	5450	56	BICC		
T128	Ring 10	D	90	785	5450	58	BICC		
T129	Cyl. 3	A	180	785	6250	166	BICC		
T130	Cyl. 3	B	365	585	6250	358	BICC		
T131	Cyl. 3	C	275	585	6250	280	BICC		
T132	Cyl. 4	A	180	785	6950	66	BICC		

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

Type and number	Block	Instrument position in block				Cable pos.		Fabricate	Remark
		Direction	α	r	Z	α			
P101	Cyl. 1	Center	180	50	50	244	Geocon		
P102	Cyl. 1	Center	180	50	250	232	Geocon		
P103	Cyl. 1	A	185	585	250	208	Geocon		
P104	Cyl. 1	A	185	685	250	204	Geocon		
P105	Cyl. 1	A	185	785	250	186	Geocon		
P106	Cyl. 1	B	365	585	250	40	Geocon		
P107	Cyl. 1	B	365	785	250	2	Geocon		
P108	Cyl. 1	C	275	585	250	278	Geocon		
P109	Cyl. 1	C	275	785	250	270	Geocon		
P110	Ring 5	A	185	585	2750	228	Geocon		
P111	Ring 5	A	185	685	2750	222	Geocon		
P112	Ring 5	A	185	785	2750	188	Geocon		
P113	Ring 5	B	365	535	2750	36	Geocon		
P114	Ring 5	B	365	825	2750	16	Geocon		
P115	Ring 5	C	275	585	2750	296	Geocon		
P116	Ring 5	C	275	785	2750	290	Geocon		
P117	Ring 10	Center	180	50	5250	24	Kulite		
P118	Ring 10	A	180	585	5250	216	Geocon		
P119	Ring 10	A	180	685	5250	198	Geocon		
P120	Ring 10	A	180	785	5250	192	Geocon		
P121	Ring 10	B	365	585	5250	20	Kulite		
P122	Ring 10	B	365	785	5250	18	Kulite		
P123	Ring 10	C	275	585	5250	286	Kulite		
P124	Ring 10	C	275	785	5250	284	Kulite		
P125	Cyl. 3	Center	180	50	6250	158	Geocon		
P126	Cyl. 3	A	180	585	6250	162	Geocon		
P127	Cyl. 4	Center	180	50	6750	64	Kulite		

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

Type and number	Block	Instrument position in block				Cable pos.		Fabricate	Remark
		Direction	α	r	Z	α			
U101	Cyl. 1	Center	270	50	50	246	Geocon		
U102	Cyl. 1	Center	270	50	250	236	Geocon	Horizontal	
U103	Cyl. 1	A	175	585	250	126	Geocon		
U104	Cyl. 1	A	175	785	250	178	Geocon		
U105	Ring 5	A	175	585	2750	138	Geocon		
U106	Ring 5	A	175	785	2750	180	Geocon		
U107	Ring 5	B	355	535	2750	314	Geocon		
U108	Ring 5	B	355	825	2750	348	Geocon		
U109	Ring 5	C	265	585	2750	256	Geocon	In the slot	
U110	Ring 5	C	265	825	2750	264	Geocon	In the slot	
U111	Ring 10	A	175	585	5250	146	Geocon		
U112	Ring 10	A	175	785	5250	152	Geocon		
U113	Cyl. 3	Center	270	50	6250	156	Geocon		
U114	Cyl. 4	Center	270	50	6950	62	Kulite		

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

Type and number	Block	Instrument position in block				Cable pos.		Fabricate	Remark
		Direction	α	r	Z	α			
W101	Cyl. 1	Center	360	50	50	248	Vaisala		
W102	Cyl. 1	Center	360	400	160	240	Vaisala		
W103	Cyl. 1	Center	360	50	450	234	Vaisala	Horizontal	
W104	Cyl. 1	A	180	585	340	128	Vaisala		
W105	Cyl. 1	A	180	685	340	132	Vaisala		
W106	Cyl. 1	A	180	785	340	184	Vaisala		
W107	Cyl. 1	A	170	585	340	124	Wescor		
W108	Cyl. 1	A	170	685	340	130	Wescor		
W109	Cyl. 1	A	170	785	340	134	Wescor		
W110	Cyl. 1	B	360	585	340	304	Vaisala		
W111	Cyl. 1	B	360	785	340	360	Vaisala		
W112	Cyl. 1	B	360	685	340	308	Vaisala		
W113	Cyl. 1	B	355	585	340	302	Wescor		
W114	Cyl. 1	B	355	685	340	306	Wescor		
W115	Cyl. 1	B	355	785	340	310	Wescor		
W116	Cyl. 1	C	270	585	340	250	Wescor		
W117	Cyl. 1	C	270	685	340	252	Wescor		
W118	Cyl. 1	C	270	785	340	254	Vaisala		
W119	Ring 5	A	180	585	2840	226	Vaisala		
W120	Ring 5	A	180	685	2840	220	Vaisala		
W121	Ring 5	A	180	785	2840	182	Vaisala		
W122	Ring 5	A	170	585	2840	136	Wescor		
W123	Ring 5	A	170	685	2840	140	Wescor		
W124	Ring 5	A	170	785	2840	142	Wescor		
W125	Ring 5	B	360	535	2840	316	Vaisala	In the slot	
W126	Ring 5	B	360	685	2840	34	Vaisala		
W127	Ring 5	B	360	785	2840	350	Vaisala		
W128	Ring 5	B	350	535	2840	312	Wescor	In the slot	
W129	Ring 5	B	350	685	2840	320	Wescor		
W130	Ring 5	B	350	785	2840	346	Wescor		
W131	Ring 5	C	270	585	2840	294	Wescor	In the slot	
W132	Ring 5	C	275	685	2840	292	Wescor		
W133	Ring 5	C	270	785	2840	288	Wescor		
W134	Ring 10	Center	360	50	5340	22	Vaisala		
W135	Ring 10	A	180	262	5340	26	Vaisala		
W136	Ring 10	A	180	585	5340	214	Vaisala		
W137	Ring 10	A	180	685	5340	196	Vaisala		
W138	Ring 10	A	180	785	5340	190	Vaisala		
W139	Ring 10	A	170	585	5340	144	Wescor		
W140	Ring 10	A	170	685	5340	148	Wescor		
W141	Ring 10	A	170	785	5340	150	Wescor		
W142	Ring 10	B	360	585	5340	328	Vaisala		
W143	Ring 10	B	360	685	5340	332	Vaisala		
W144	Ring 10	B	360	785	5340	336	Vaisala		
W145	Ring 10	B	355	585	5340	326	Wescor		
W146	Ring 10	B	355	685	5340	330	Wescor		
W147	Ring 10	B	355	785	5340	334	Wescor		
W148	Ring 10	C	270	585	5340	266	Wescor		
W149	Ring 10	C	270	685	5340	268	Wescor		
W150	Ring 10	C	270	785	5340	272	Vaisala		
W151	Cyl. 3	Center	360	50	6250	154	Vaisala		
W152	Cyl. 3	A	180	585	6250	160	Vaisala		
W153	Cyl. 3	B	360	585	6250	356	Vaisala		
W154	Cyl. 3	C	270	585	6250	276	Wescor		
W155	Cyl. 4	Center	360	50	6840	60	Vaisala		

4.4 Instruments in the rock

Temperature measurements

40 thermocouples are placed in the rock and on the rock surface of the deposition hole. Holes have been bored in three directions on three levels and one additional hole has been bored in the bottom of the deposition hole i.e. totally 10 holes. They are led from the rock, over the gap between rock and bentonite and up along the bentonite block periphery. The position of the thermocouples in the rock is shown in Table 4-5.

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

Type and number	Level	Direction	Distance from rock surface	Cable pos. α	Fabricate	Remark
TR101	0	Center	0.000	70°-90°	BICC	
TR102	0	Center	0.375	70°-90°	BICC	
TR103	0	Center	0.750	70°-90°	BICC	
TR104	0	Center	1.500	70°-90°	BICC	
TR105	0.61	10°	0.000	4°-14°	BICC	
TR106	0.61	10°	0.375	4°-14°	BICC	
TR107	0.61	10°	0.750	4°-14°	BICC	
TR108	0.61	10°	1.500	4°-14°	BICC	
TR109	0.61	80°	0.000	70°-90°	BICC	
TR110	0.61	80°	0.375	70°-90°	BICC	
TR111	0.61	80°	0.750	70°-90°	BICC	
TR112	0.61	80°	1.500	70°-90°	BICC	
TR113	0.61	170°	0.000	168°-176°	BICC	
TR114	0.61	170°	0.375	168°-176°	BICC	
TR115	0.61	170°	0.750	168°-176°	BICC	
TR116	0.61	170°	1.500	168°-176°	BICC	
TR117	3.01	10°	0.000	4°-14°	BICC	
TR118	3.01	10°	0.375	4°-14°	BICC	
TR119	3.01	10°	0.750	4°-14°	BICC	
TR120	3.01	10°	1.500	4°-14°	BICC	
TR121	3.01	80°	0.000	70°-90°	BICC	
TR122	3.01	80°	0.375	70°-90°	BICC	
TR123	3.01	80°	0.750	70°-90°	BICC	
TR124	3.01	80°	1.500	70°-90°	BICC	
TR125	3.01	170°	0.000	168°-176°	BICC	
TR126	3.01	170°	0.375	168°-176°	BICC	
TR127	3.01	170°	0.750	168°-176°	BICC	
TR128	3.01	170°	1.500	168°-176°	BICC	
TR129	5.41	10°	0.000	4°-14°	BICC	
TR130	5.41	10°	0.375	4°-14°	BICC	
TR131	5.41	10°	0.750	4°-14°	BICC	
TR132	5.41	10°	1.500	4°-14°	BICC	
TR133	5.41	80°	0.000	70°-90°	BICC	
TR134	5.41	80°	0.375	70°-90°	BICC	
TR135	5.41	80°	0.750	70°-90°	BICC	
TR136	5.41	80°	1.500	70°-90°	BICC	
TR137	5.41	170°	0.000	168°-176°	BICC	
TR138	5.41	170°	0.375	168°-176°	BICC	
TR139	5.41	170°	0.750	168°-176°	BICC	
TR140	5.41	170°	1.500	168°-176°	BICC	

Stress and strain measurements

These are not reported

4.5 Instruments in the canister

The canister is instrumented with optical fiber cables on the copper surface, thermocouples in the steel insert and strain gauge. on the inner and outer surface of the copper envelop in canister.

Optical fiber cables

Figure 4-2 shows how the 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 as four measuring channels as described in Table 4-6.

With this laying the cable 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 cable is placed in a milled out channel on the surface. The channel has a width and a depth of just above 2 mm

Table 4-6. Combination of cables and channels

Channel 1	Outlet of cable 1
Channel 2	Inlet of cable 1
Channel 3	Outlet of cable 2
Channel 4	Inlet of cable 2

Figure 4-3 shows the location of the thermocouples on the steel insert inside the canister.

Thermocouple,PT100

Temperature in the steel insert measured at 18 point of measuring with. thermocouple,of type PT100. Figure 4-4 shows how these thermocouple are placed

4.6 Instruments at 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 4-4, 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 assumed to be the northern rod in direction A. The force transducers are placed on rods 3, 6, and 9. The displacement transducers are placed between the rods 5 cm from the rock surface of the hole and according to Table 4-6. They are fixed on the rock surface and measure thus the displacement relative the rock.

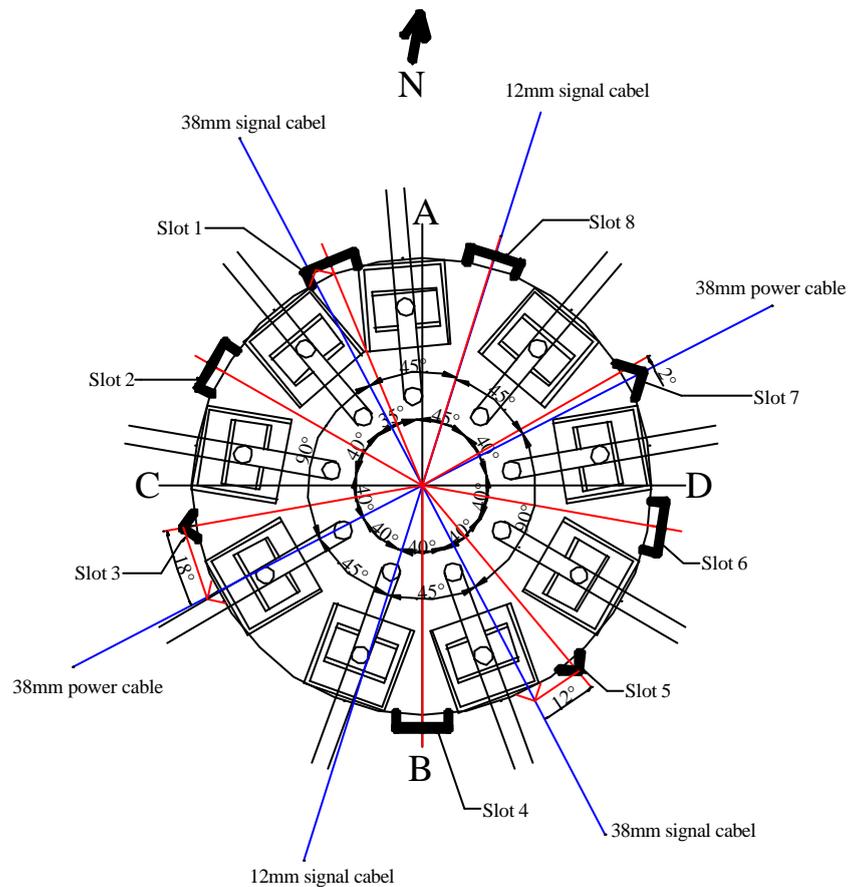


Figure 4-4. Schematic view of the deposition hole, showing the position of the slots, the rods and the cables from the canister.

Table 4-6. Location of displacement transducers

Transducer No.	Located between rods No.
1	4 and 5
2	7 and 8
3	1 and 2

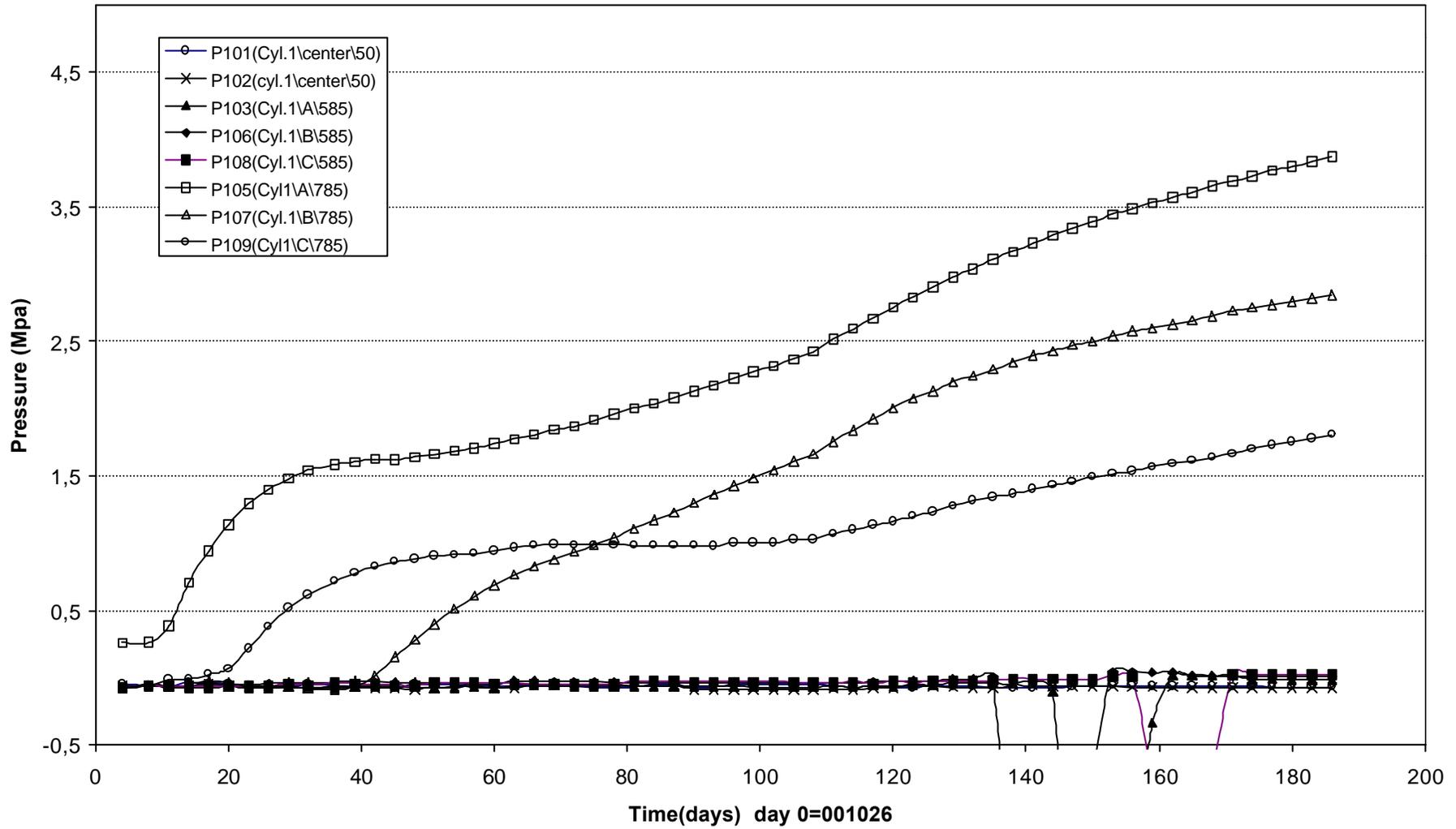
References

/1-1/ Sanden T, Börgesson L. Report on instrument positions and preparation of bentonite blocks for instruments and cables May 2000. SKB IPR-00-14

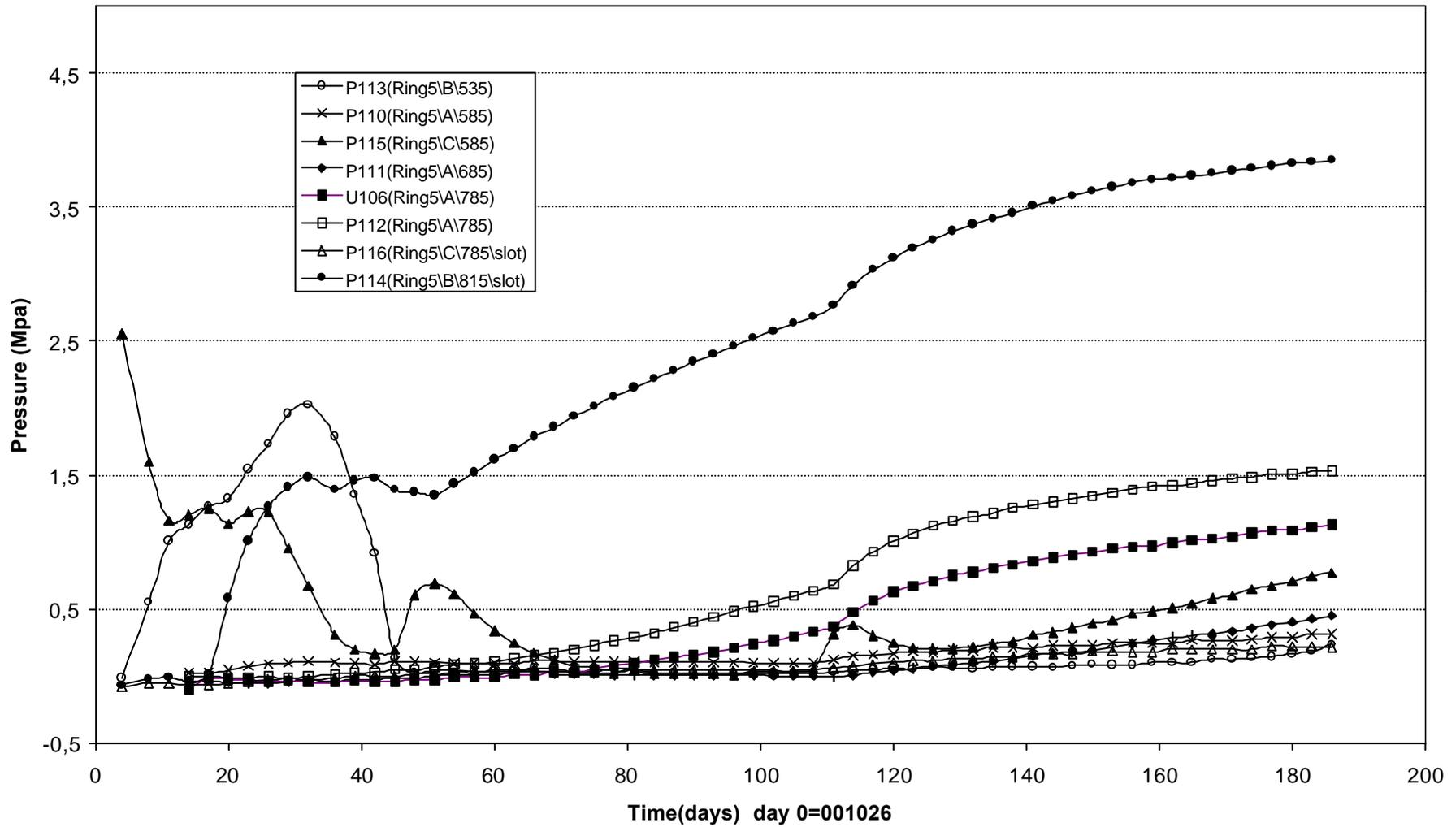
Appendix 1

Measured data

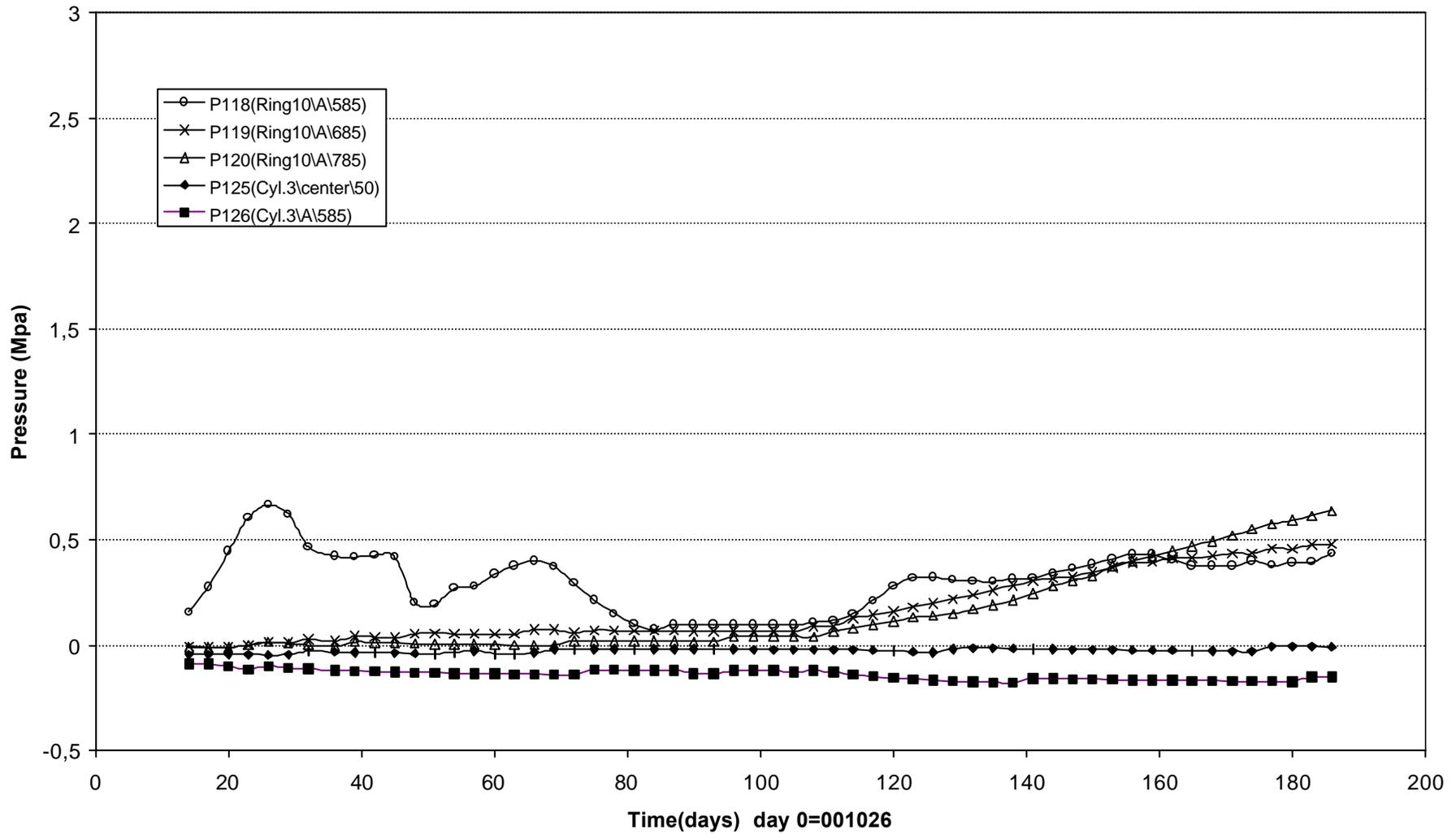
Total pressure - Cylinder 1 (001026-010501)
Geokon



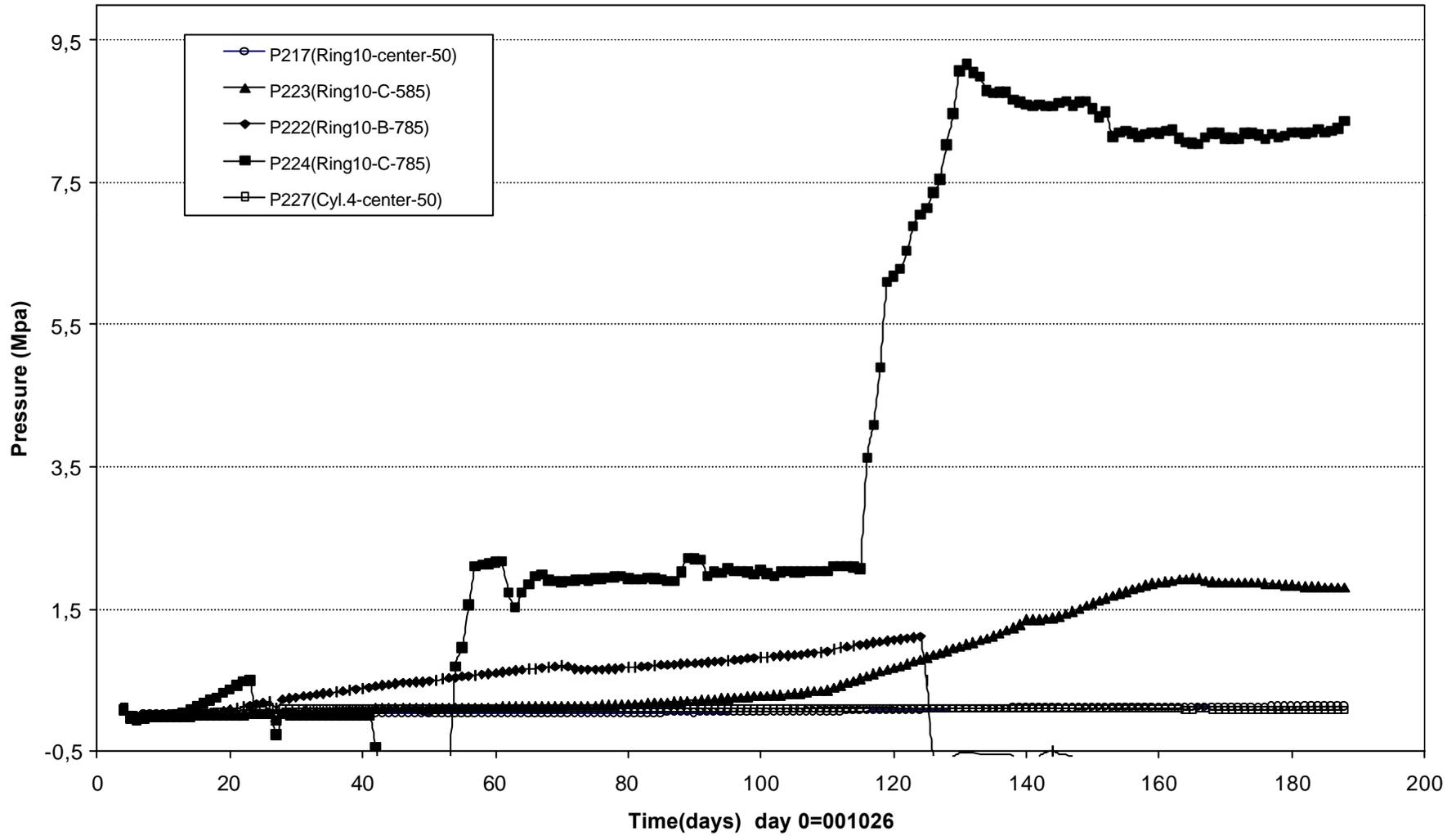
Total pressure - Ring 5 (001026-010501)
Geokon



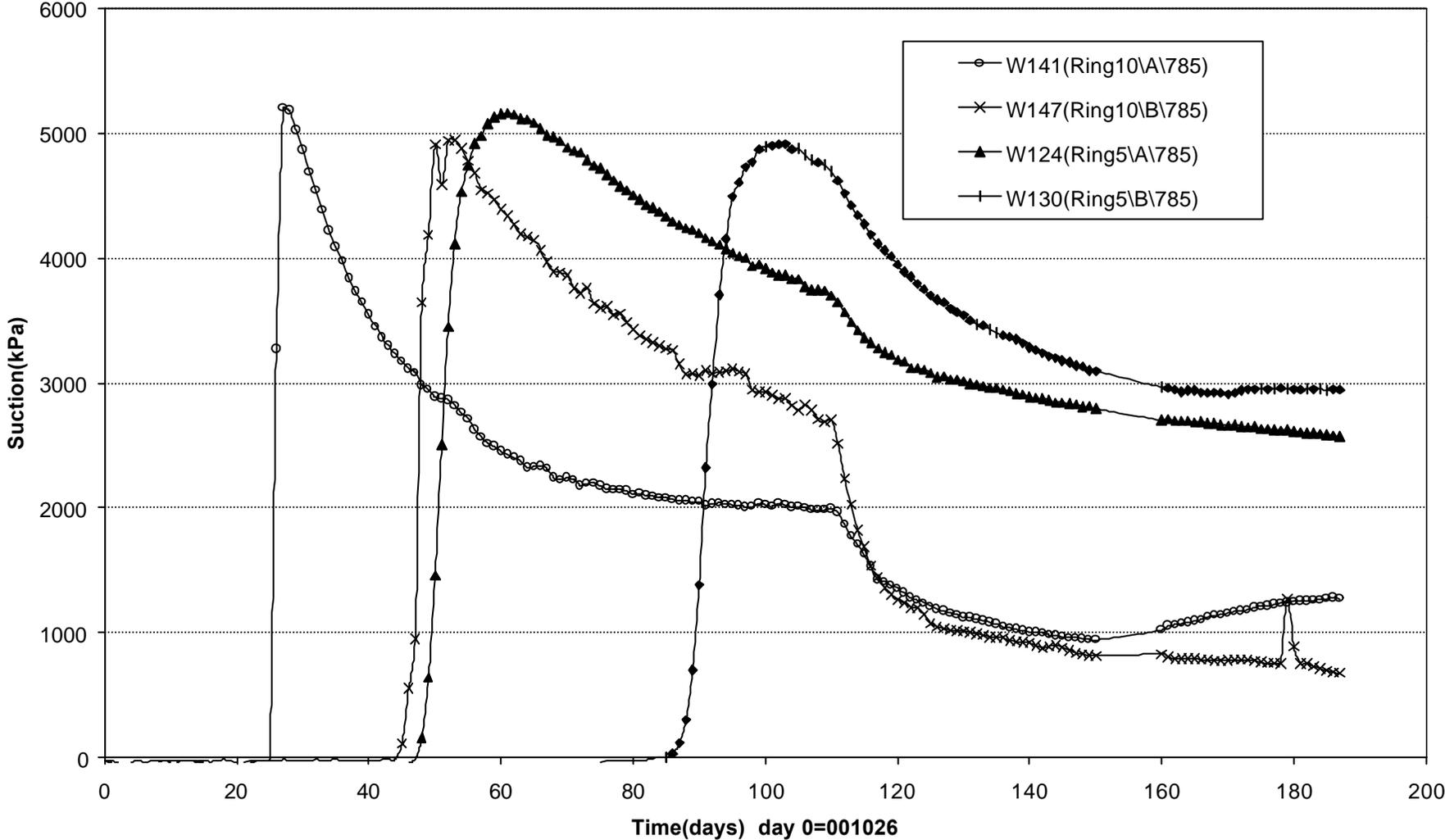
Total pressure - Ring 10 and Cylinder 3 (001026-010501)
Geokon



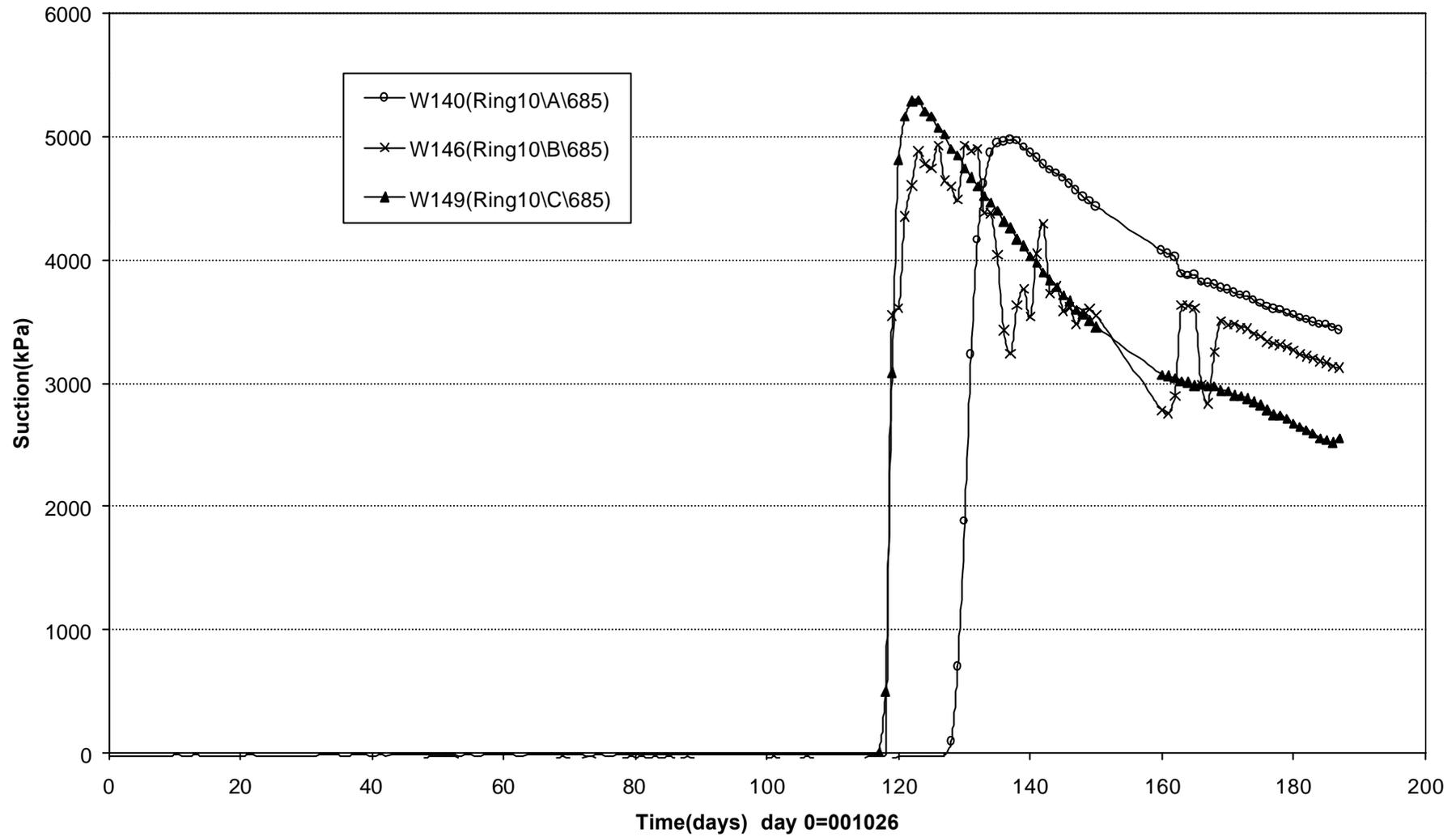
Total pressure - Ring 10 (001026-010501)
Kulite



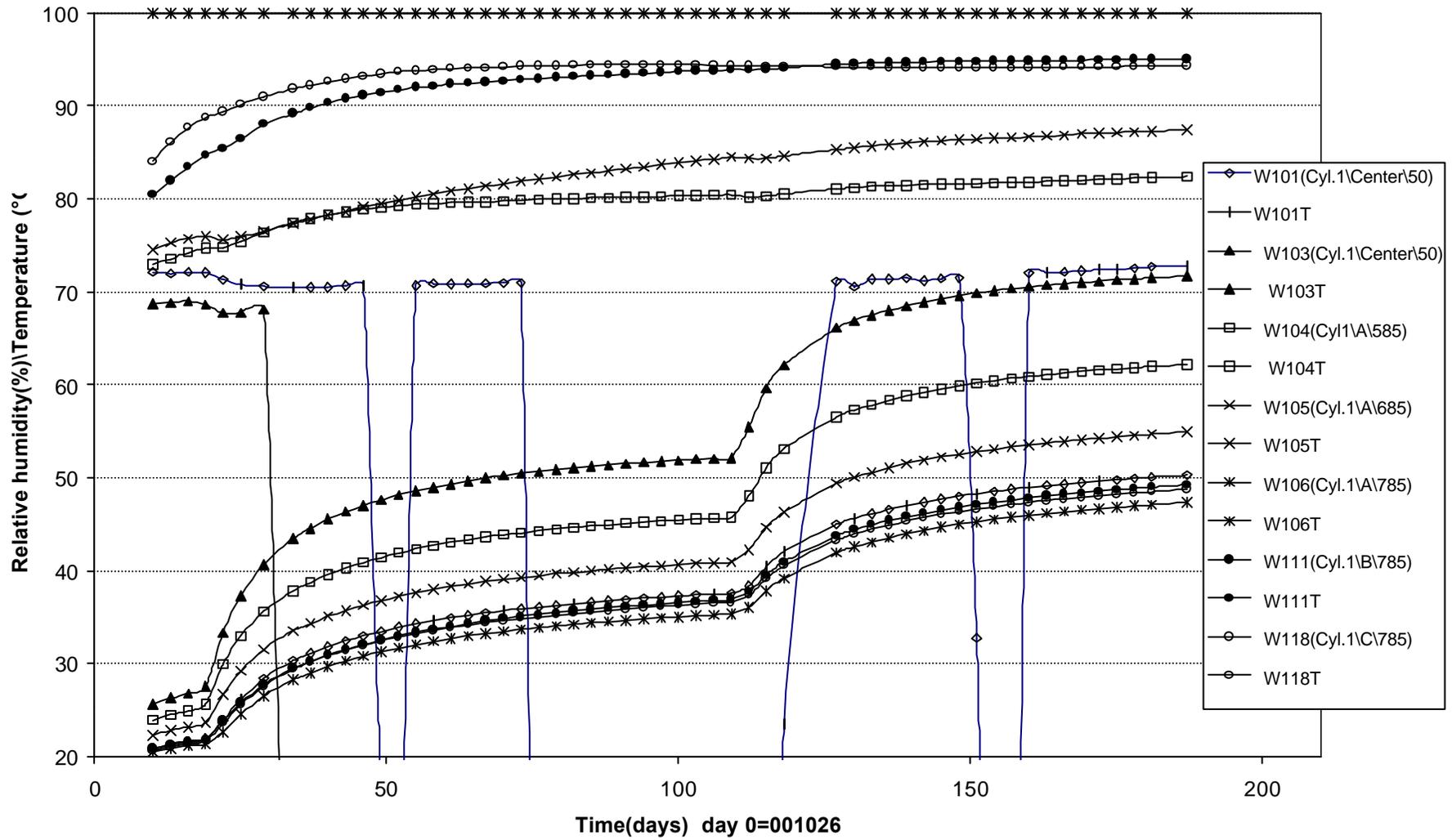
Suction in buffer (001026-010501)
Wescor



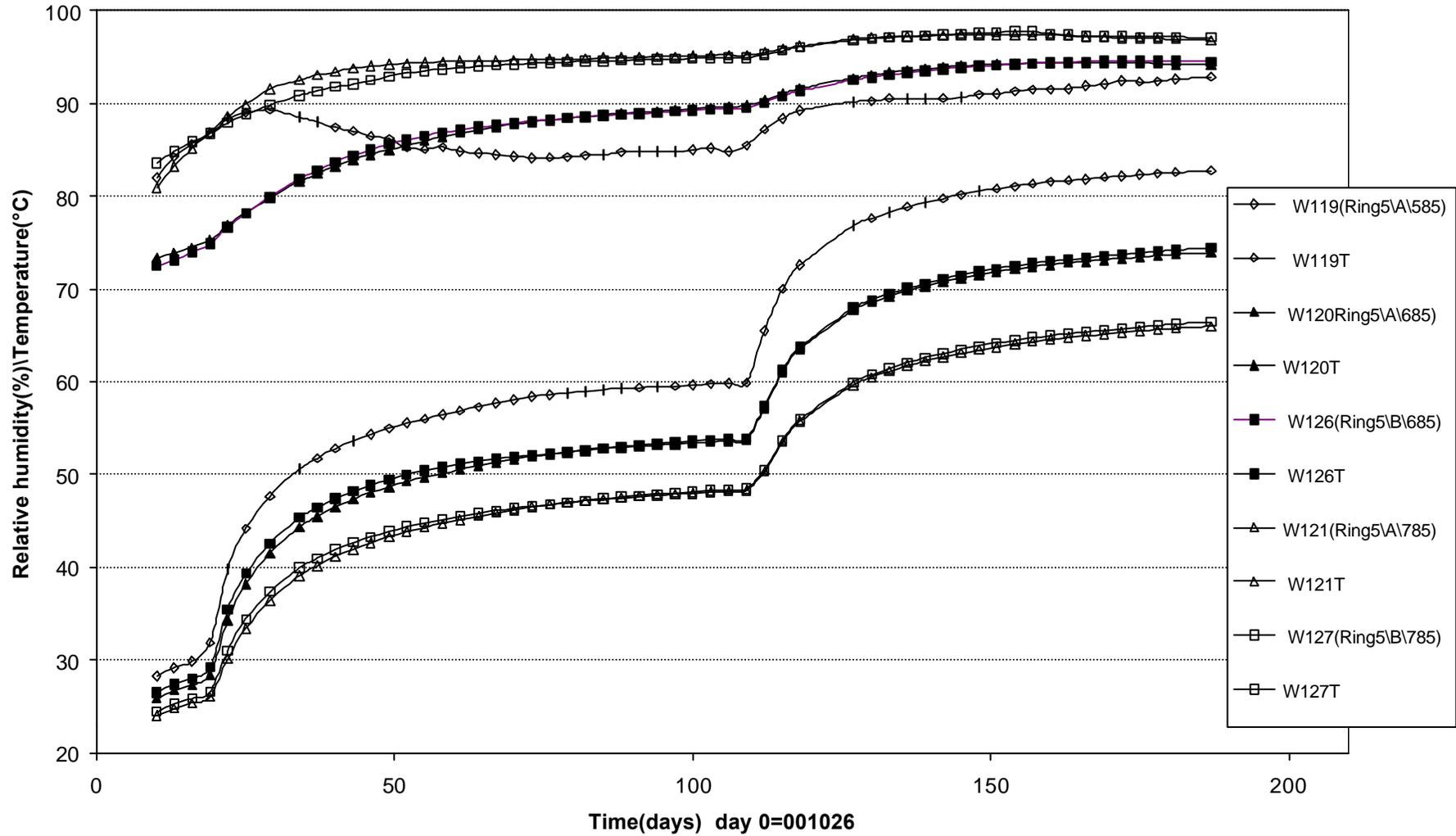
Suction in buffer (001026-010501)
Wescor



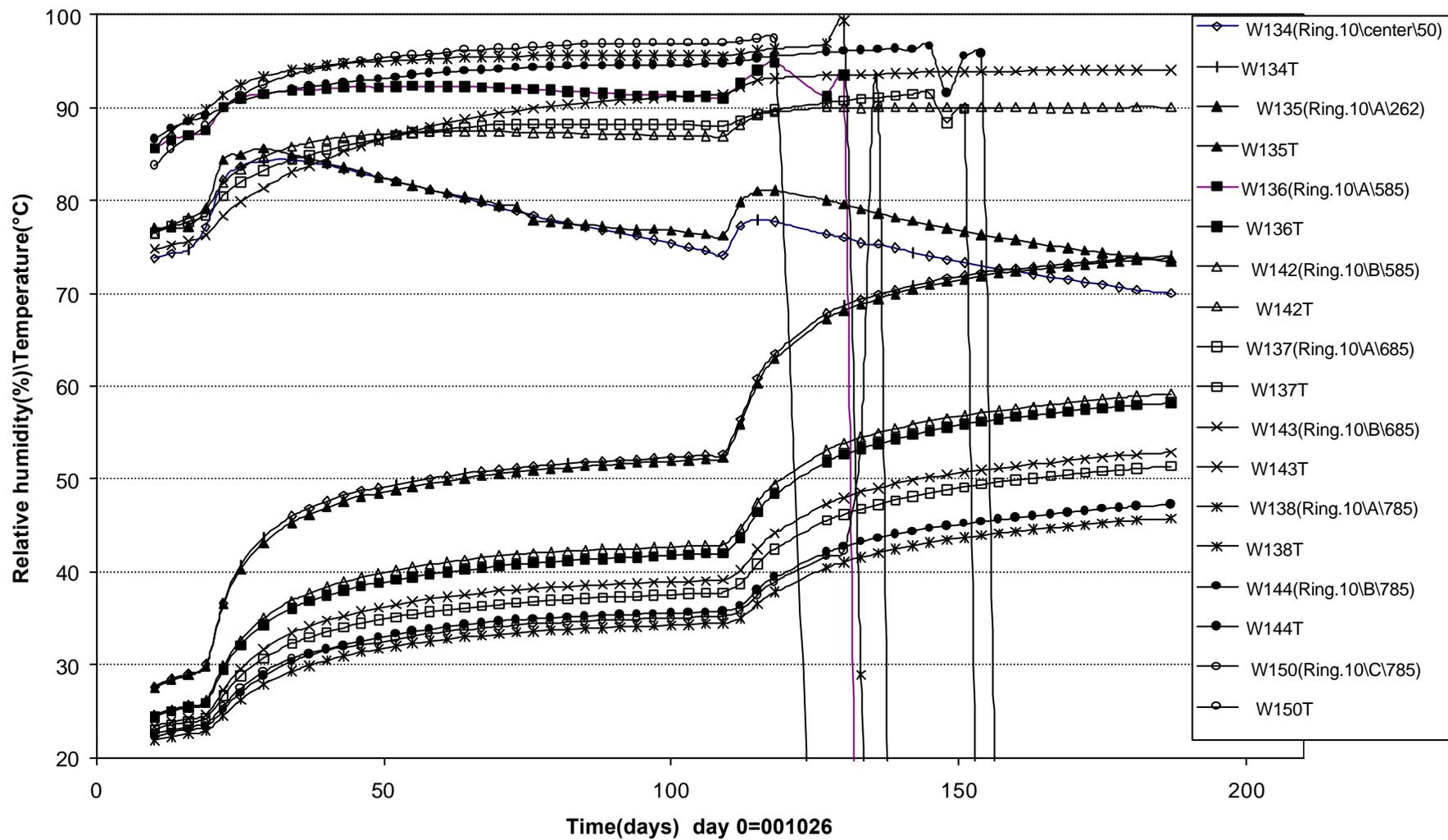
Relative humidity - Cylinder 1 (001026-010501)
Vaisala



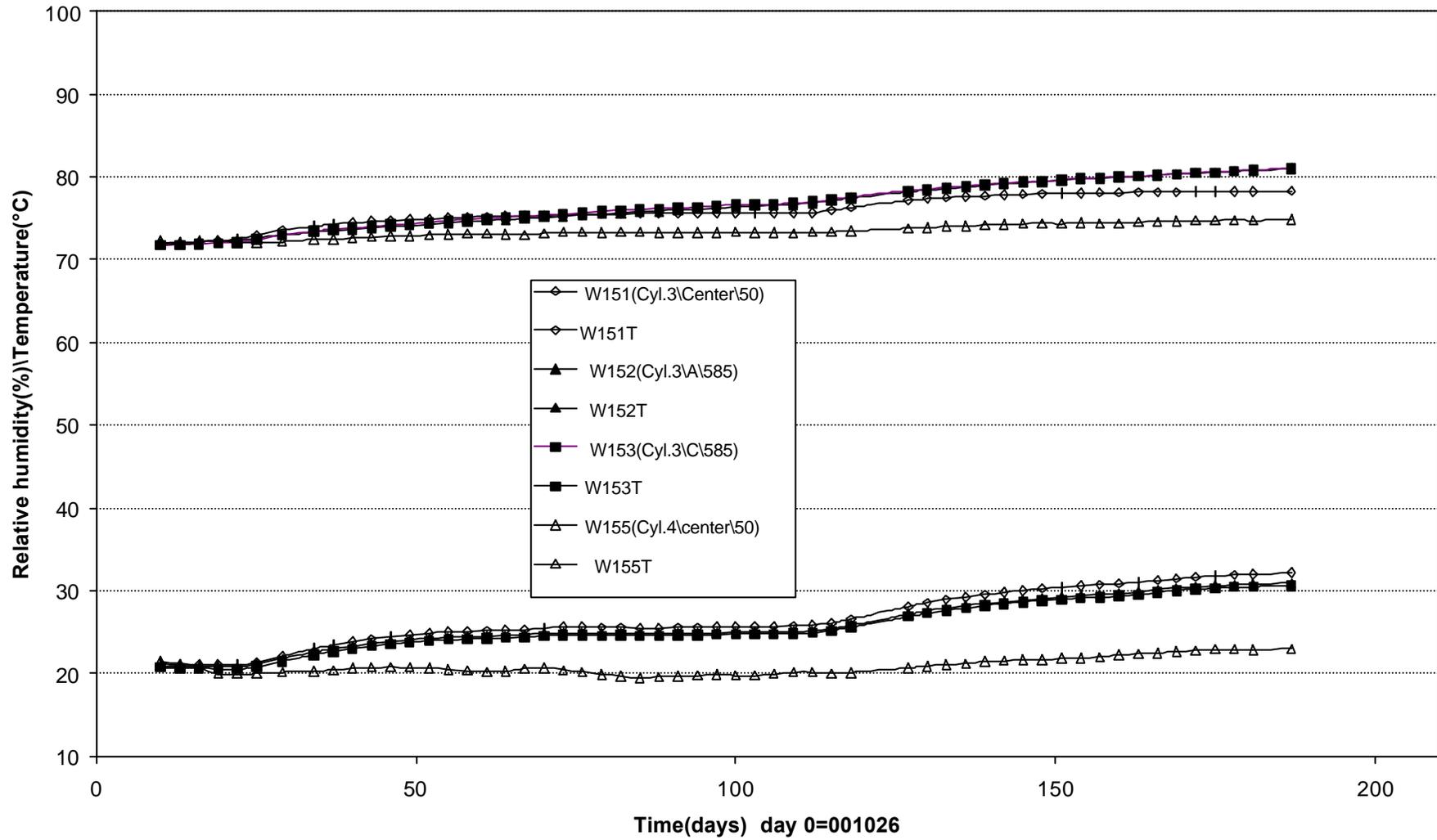
Relative humidity- Ring 5 (001026-010501)
Vaisala



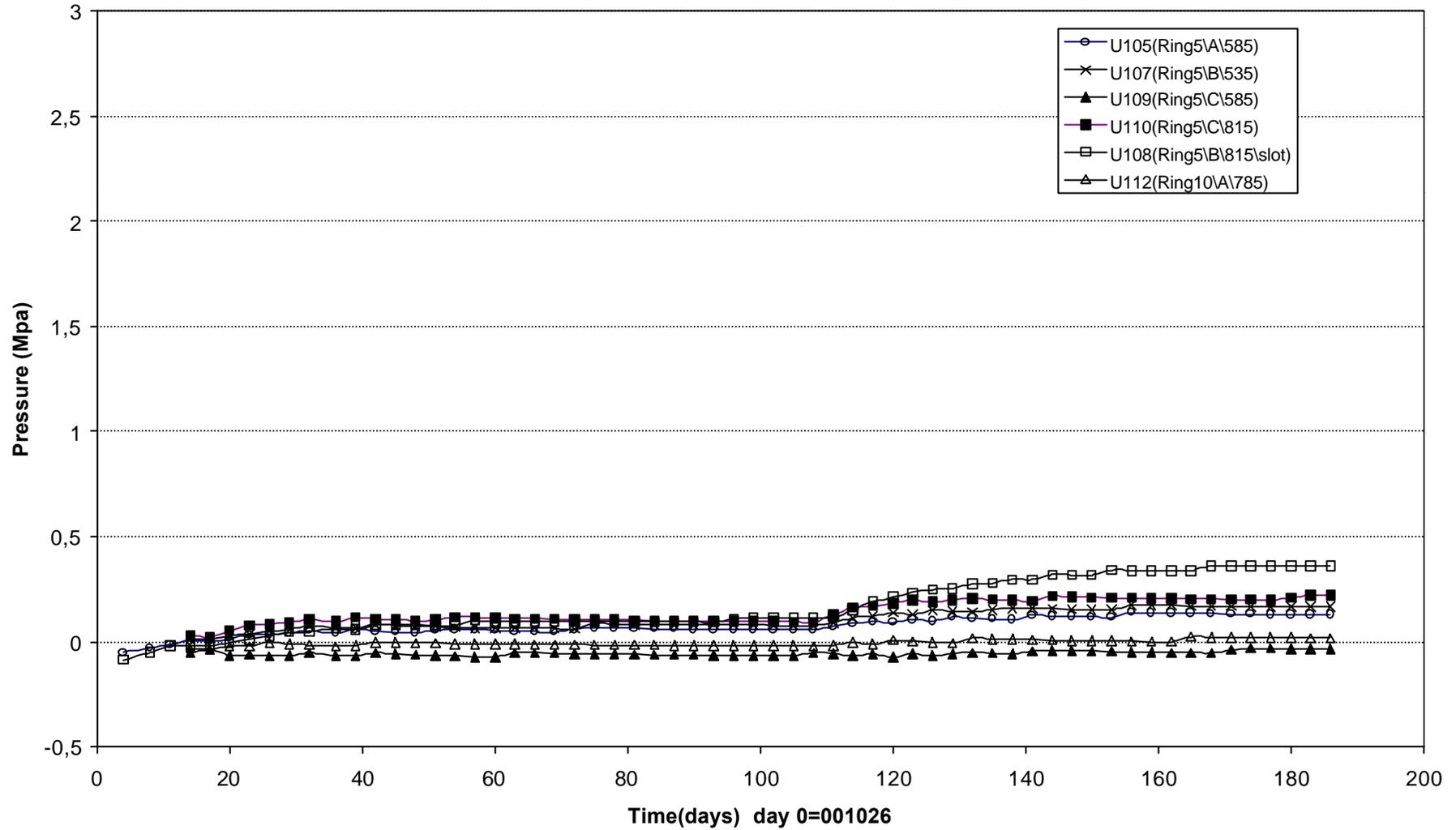
Relative humidity - Ring 10 (001026-010501) Vaisala



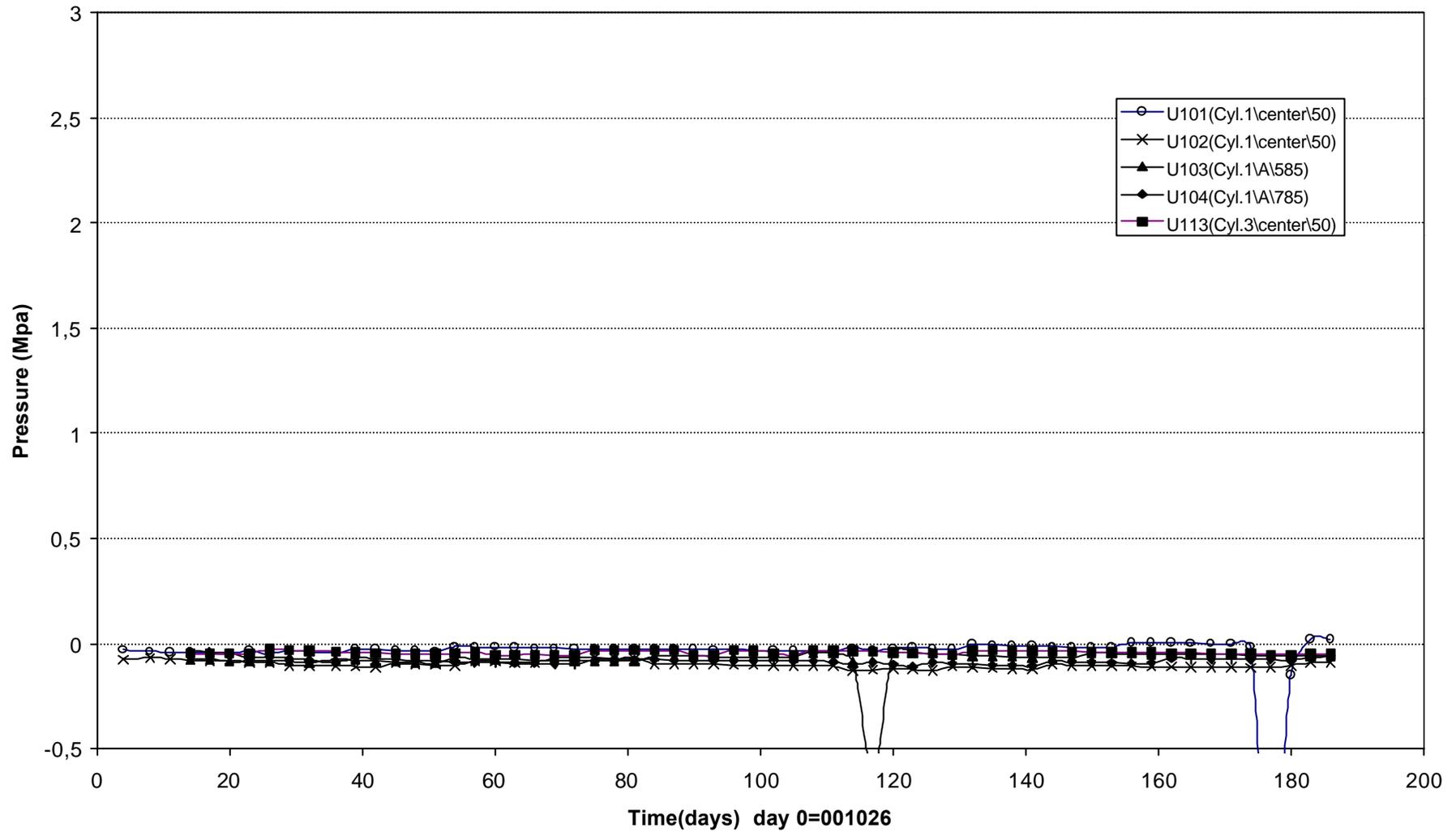
Relative humidity - Cylinder 3 and Cylinder 4 (001026-010501)
Vaisala



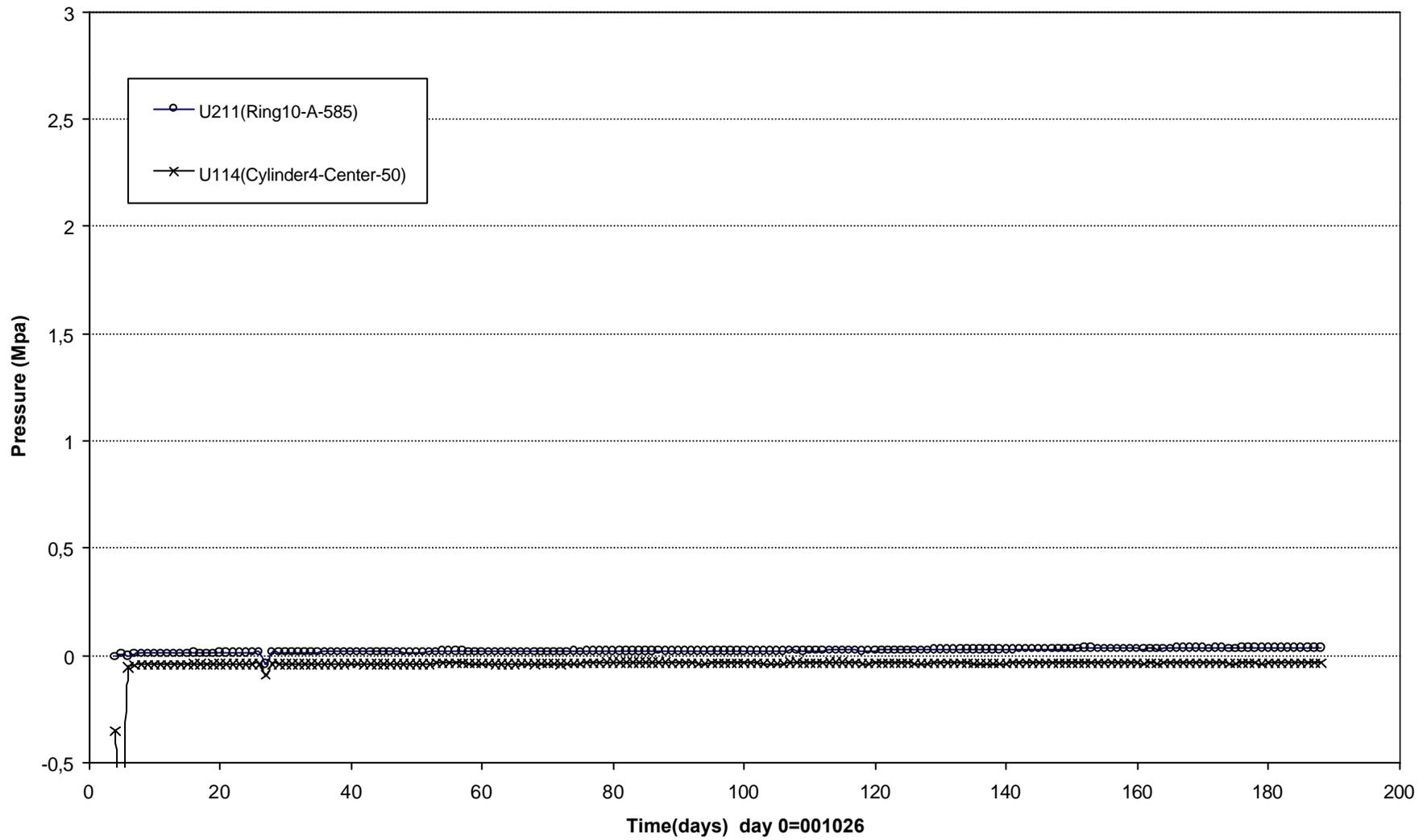
Pore water pressure - Ring 5 and Ring 10 (001026-010501)
Geokon



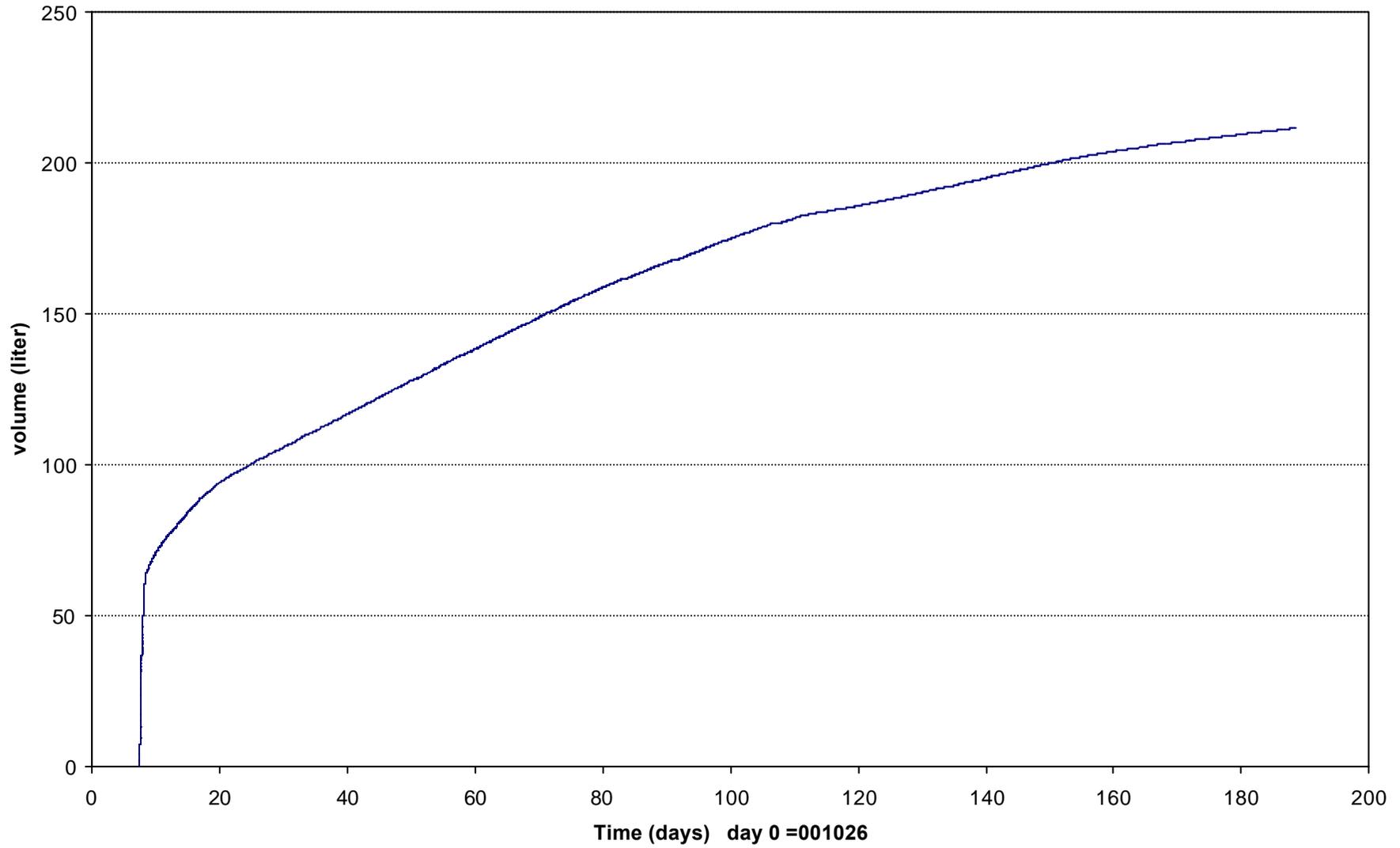
Pore water pressure - Cylinder 1 and Cylinder 3 (001026-010501)
Geokon



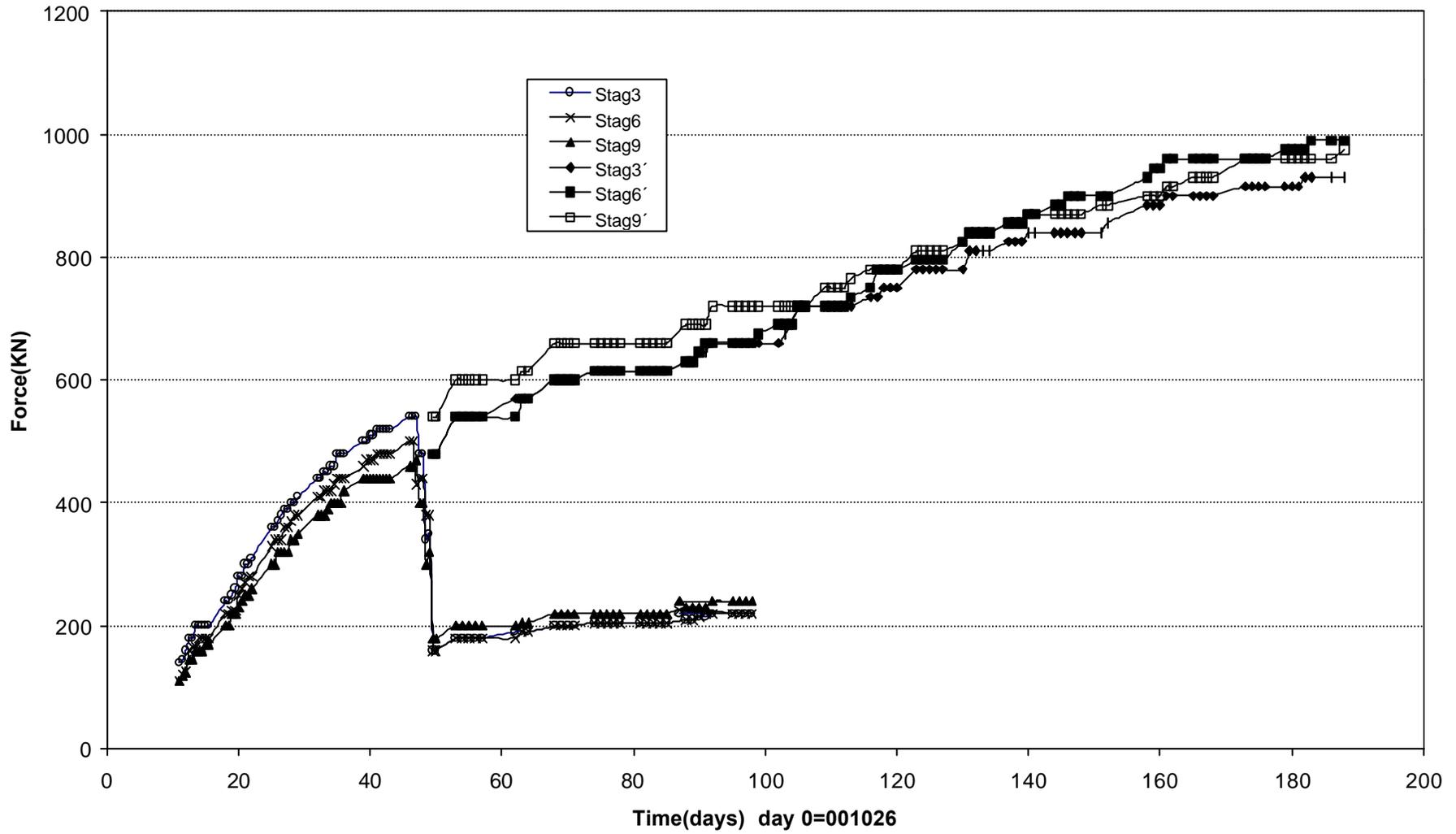
Pore water pressure - Ring 10 and Cylinder 4 (001026-010501)
Kulite



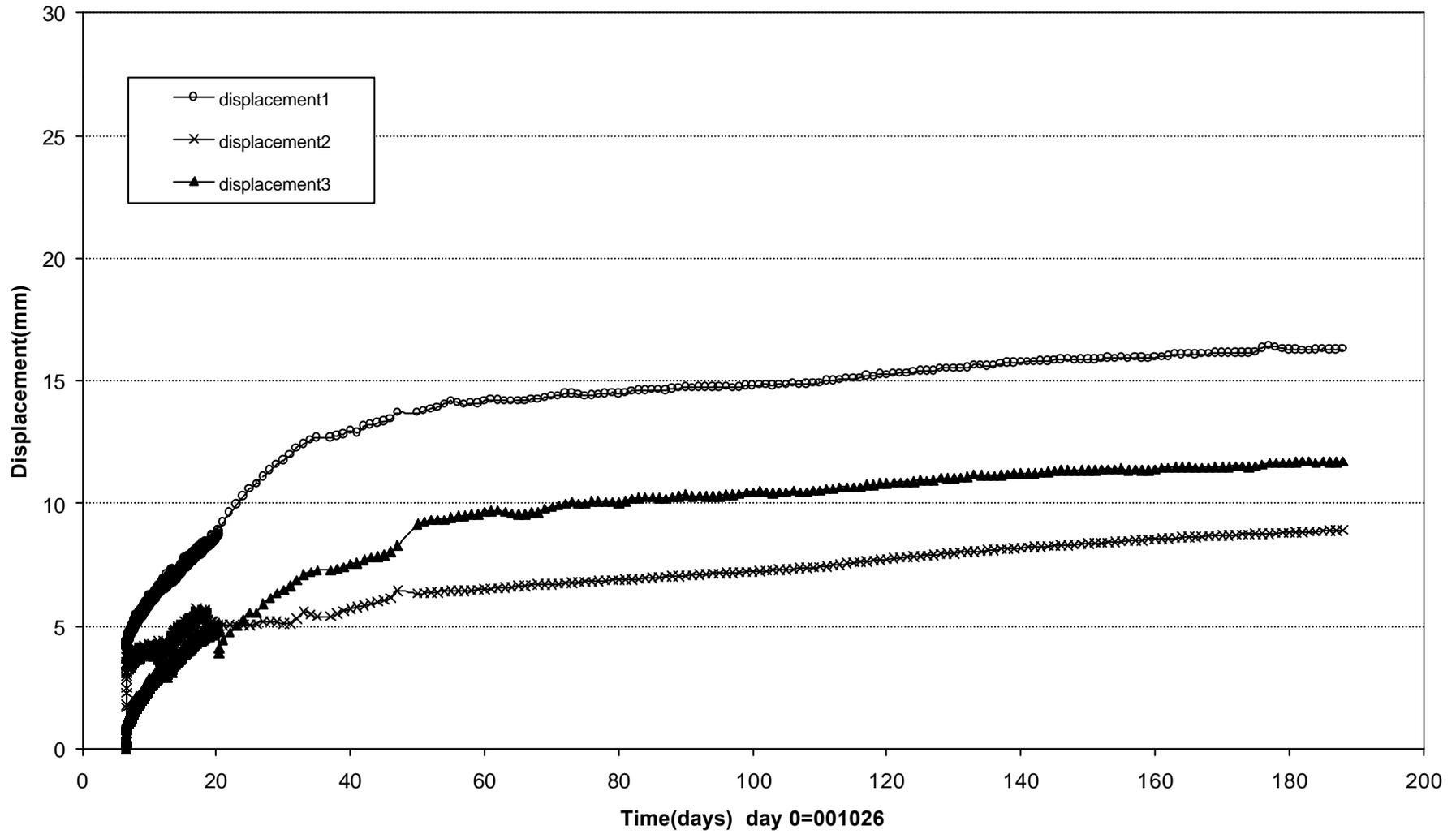
Inflow into filter (001026-010501)



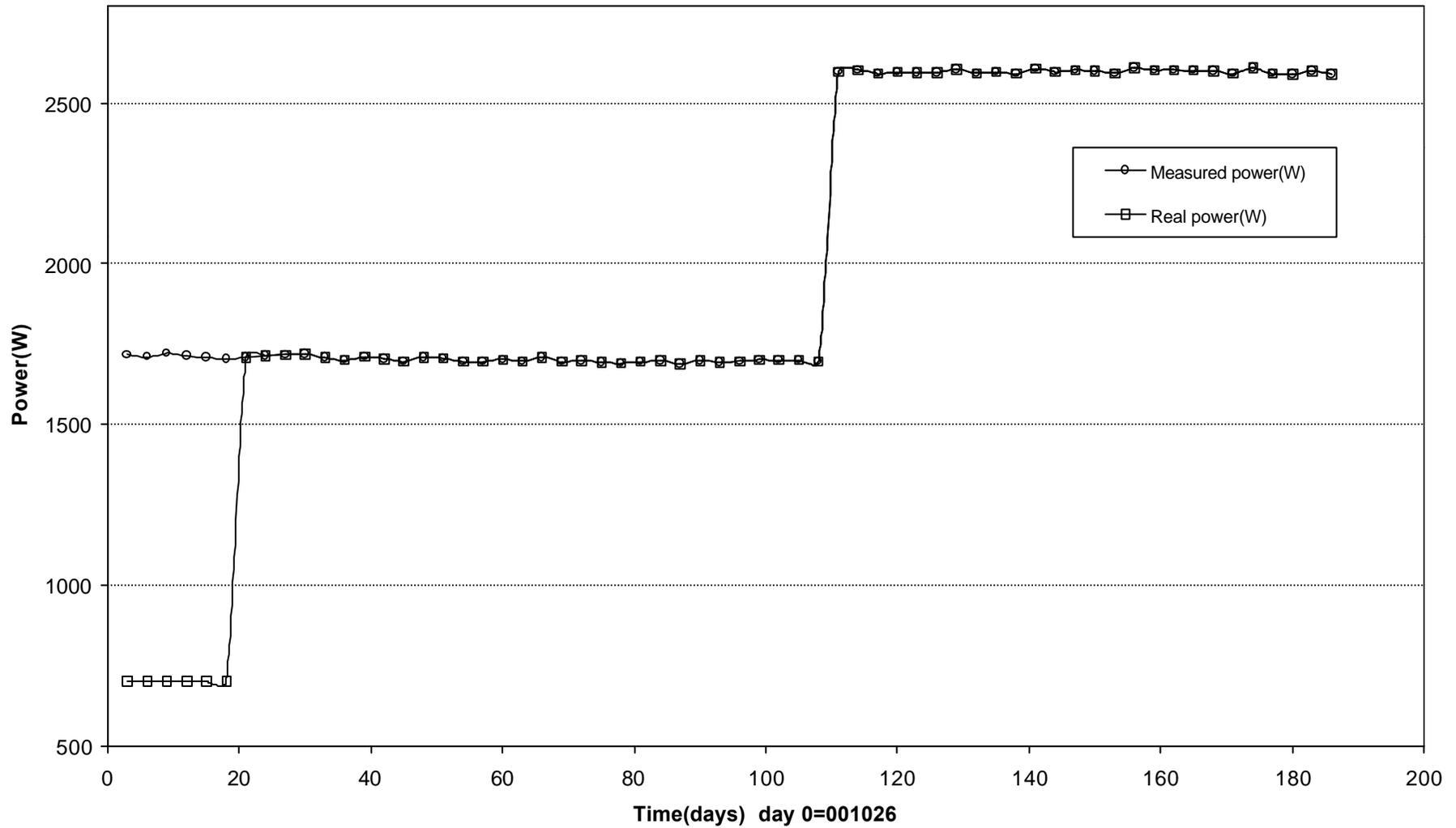
Forces on plug (001026-010501)



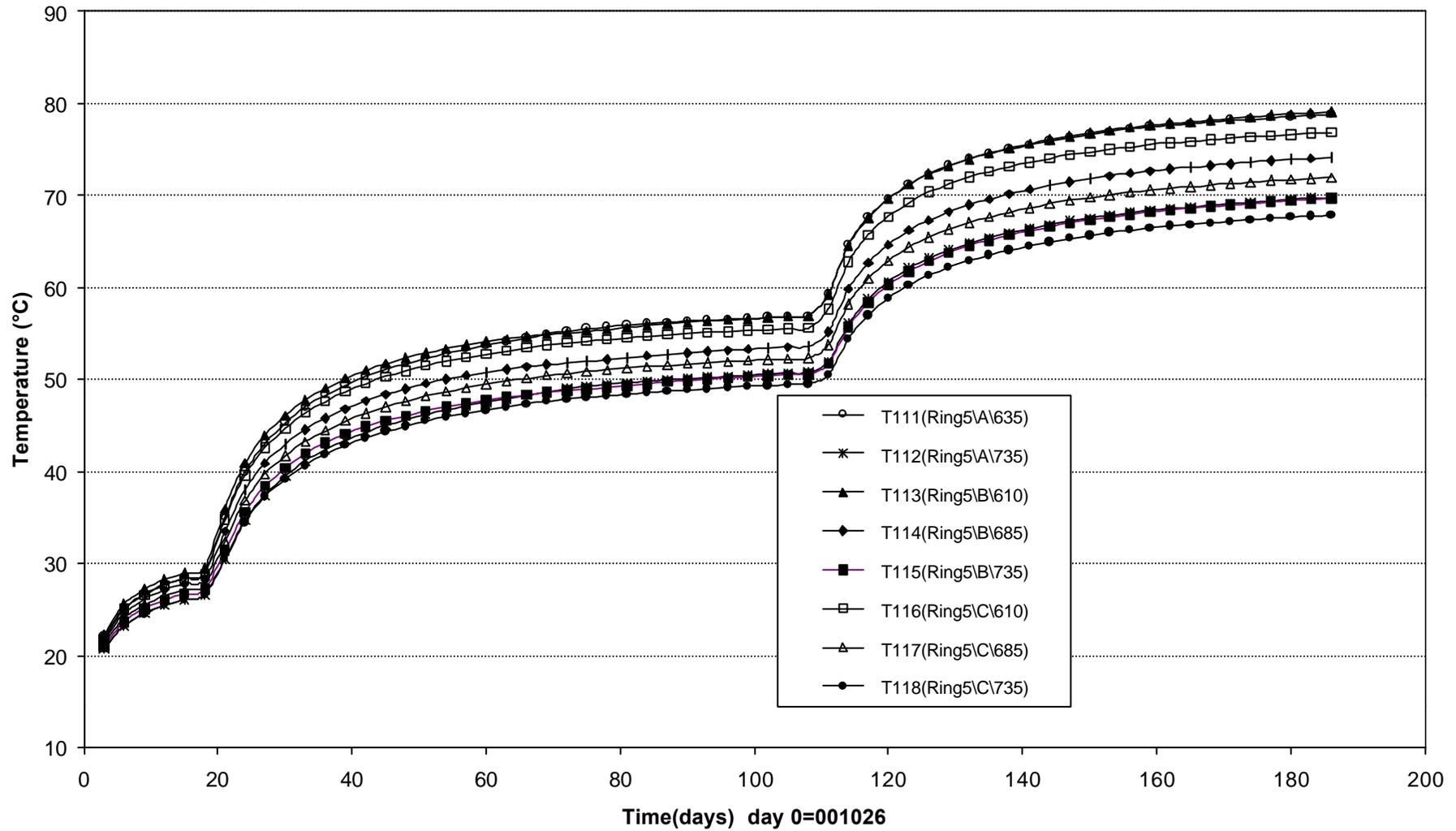
Displacement of plug (001026-010501)



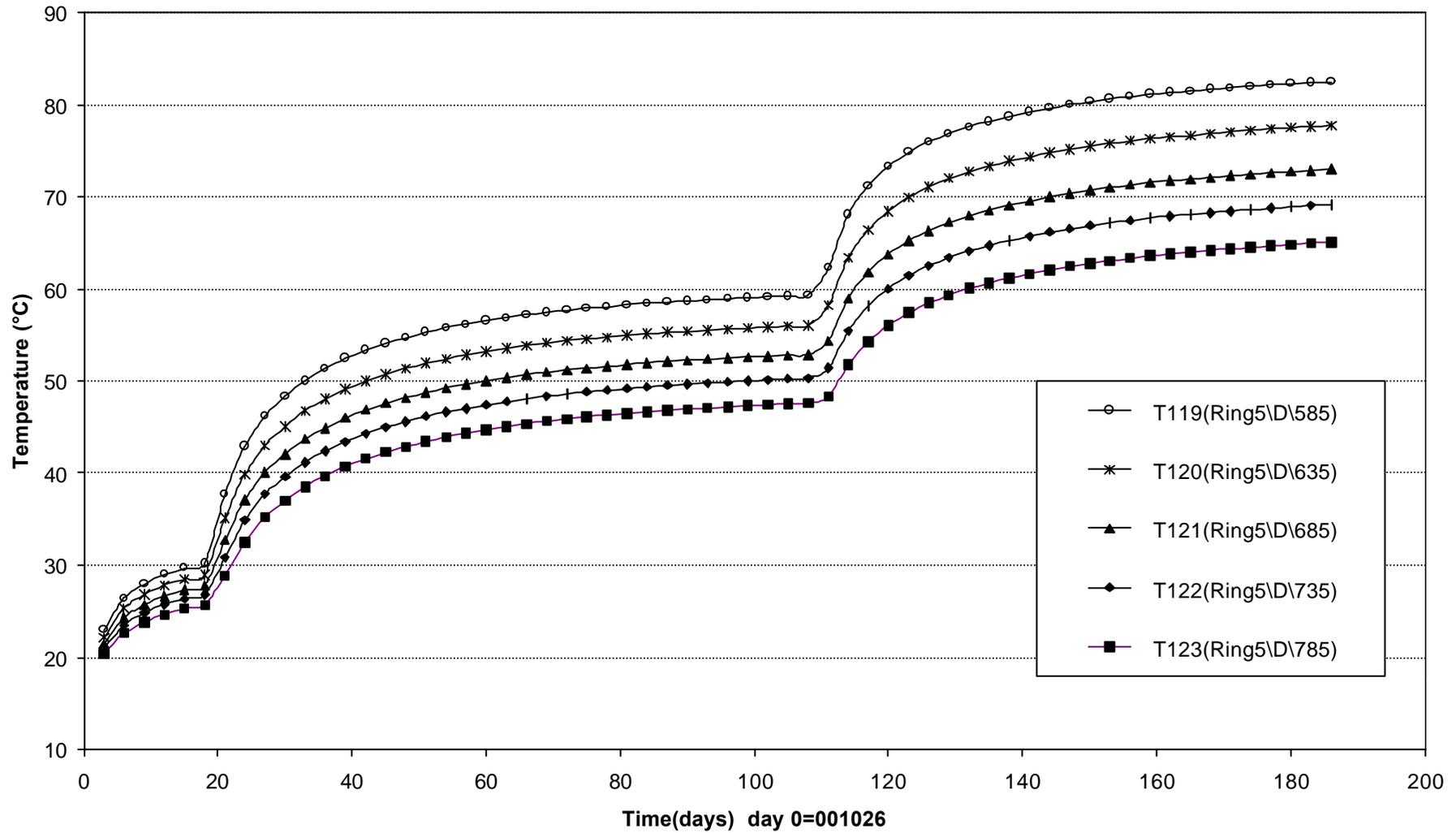
Canister power (001026-010501)



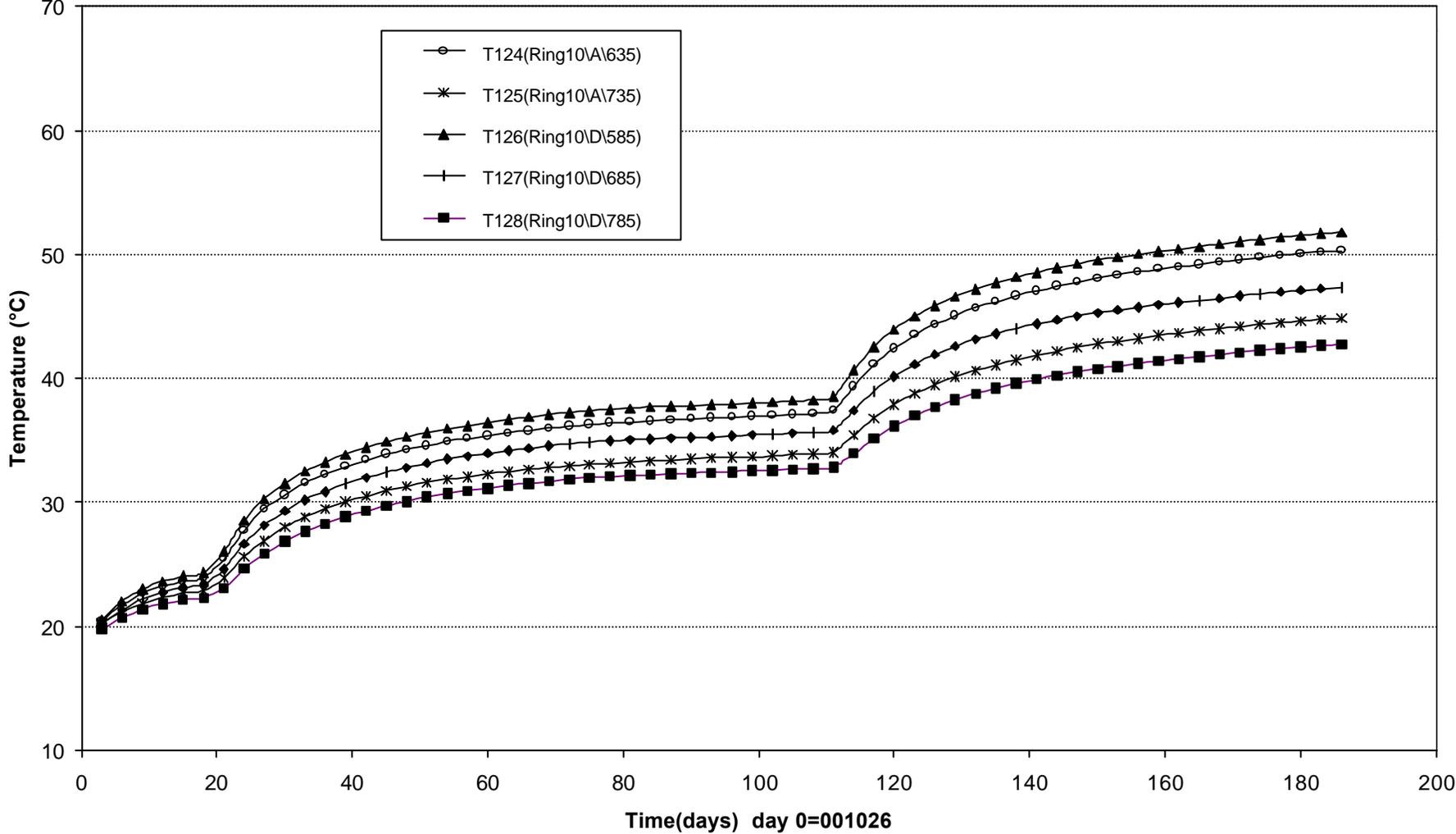
Temperature in the buffer - Ring 5 (001026-010501) Thermocouple



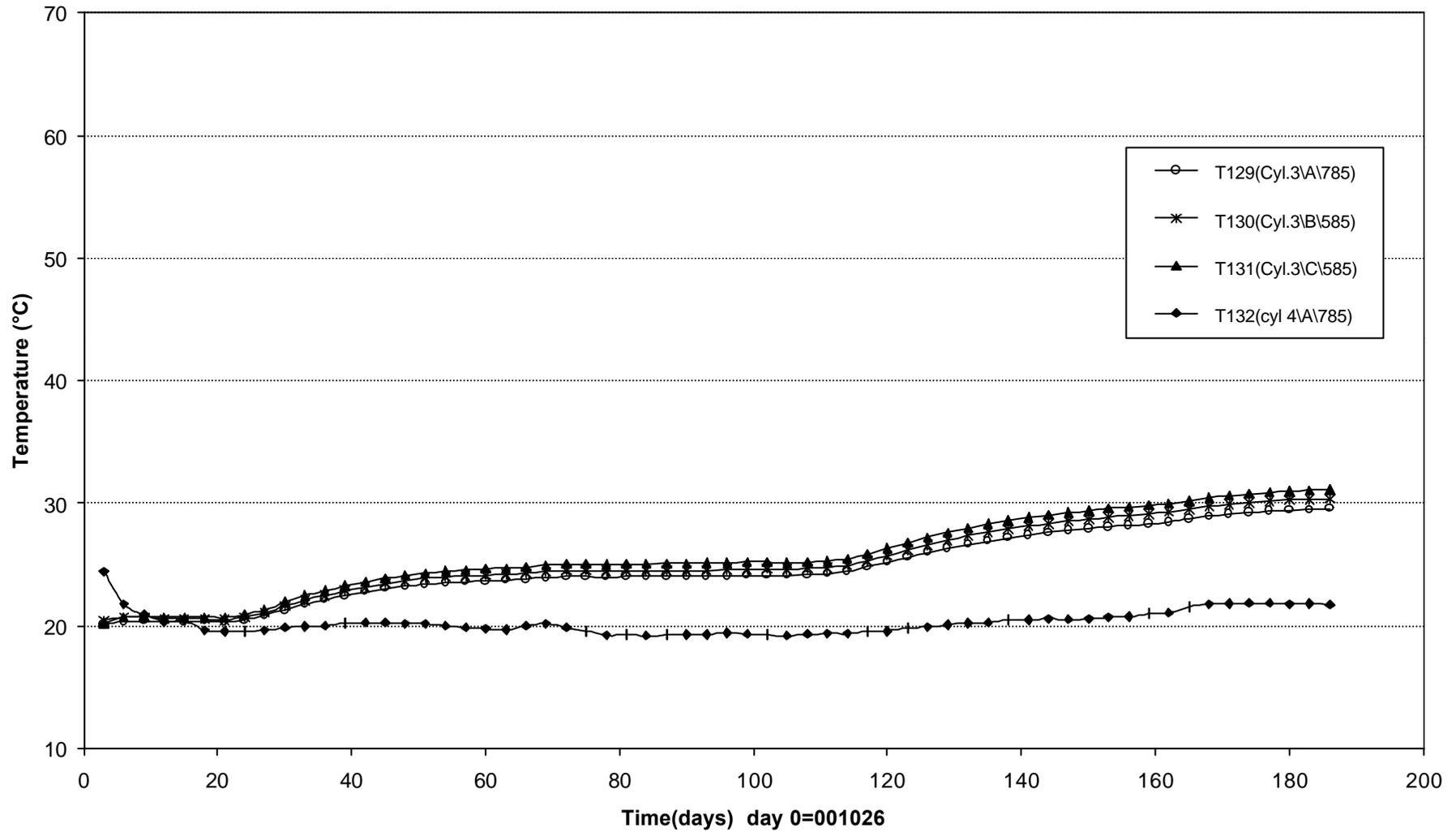
Temperature in the buffer - Ring 5 (001026-010501)
Thermocouple



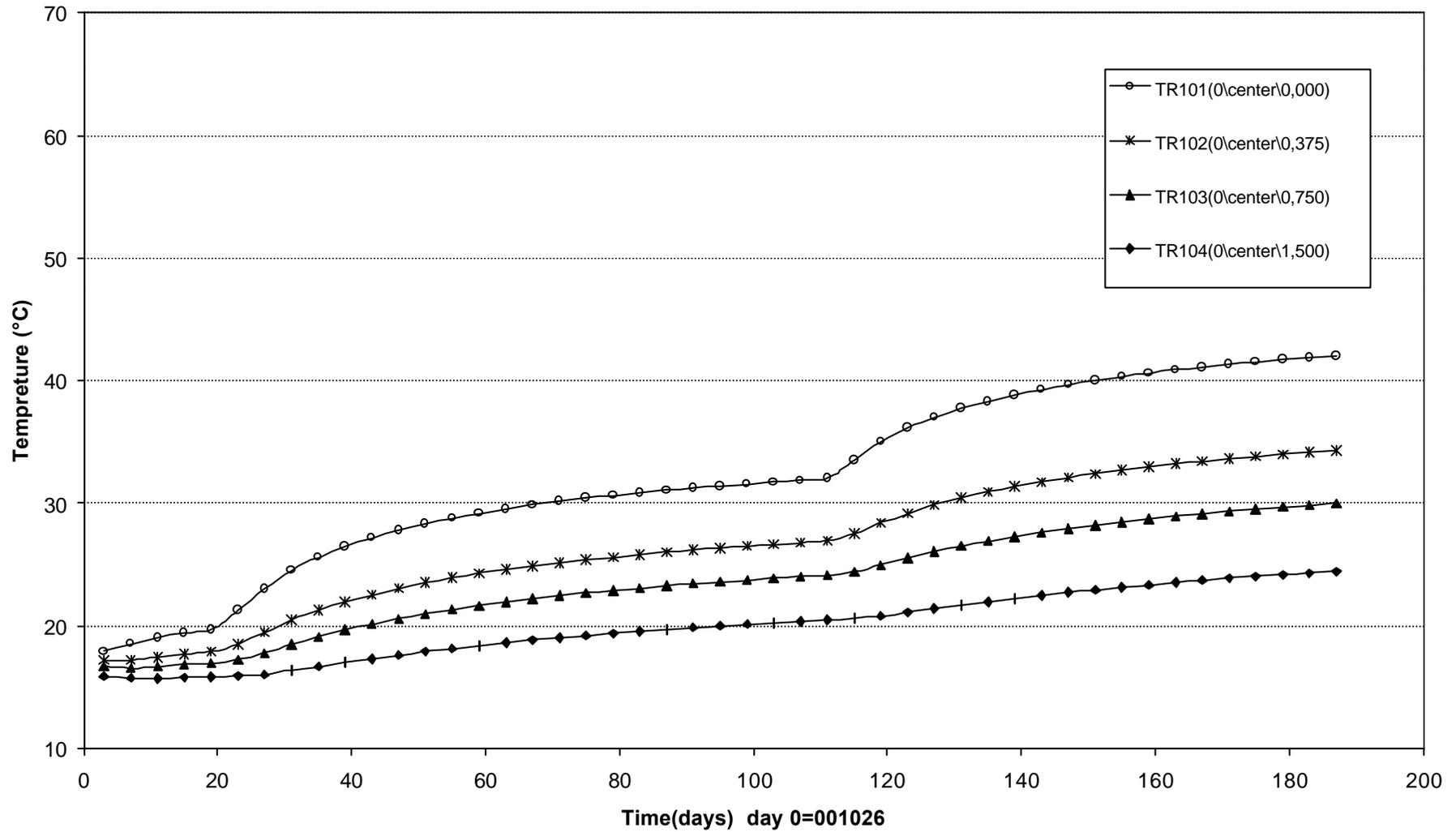
Temperature in the buffer - Ring 10 (001026-010501)
Thermocouple



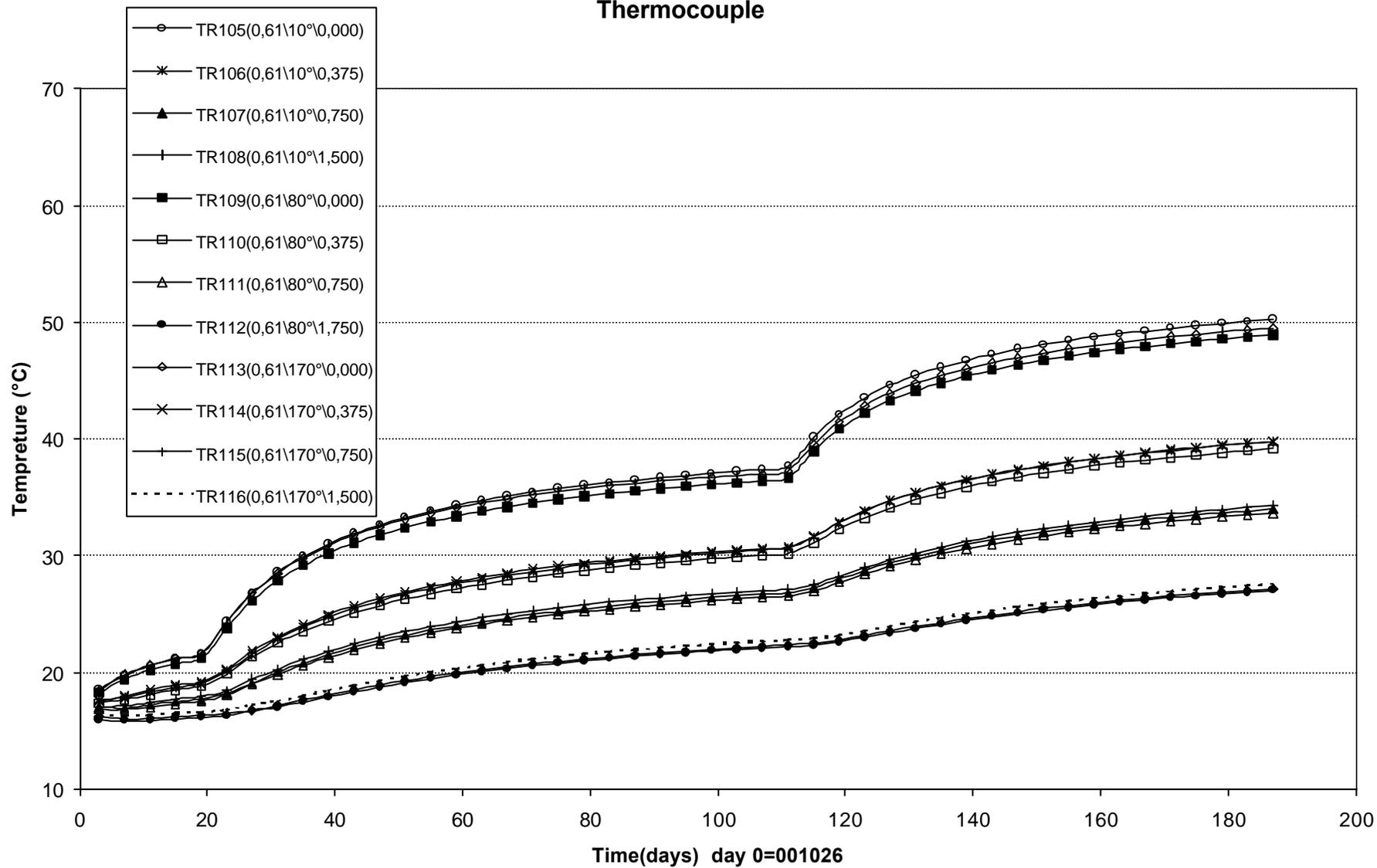
Temperature in the buffer - Cylinder 3 and Cylinder 4 (001026-010501)
Thermocouple



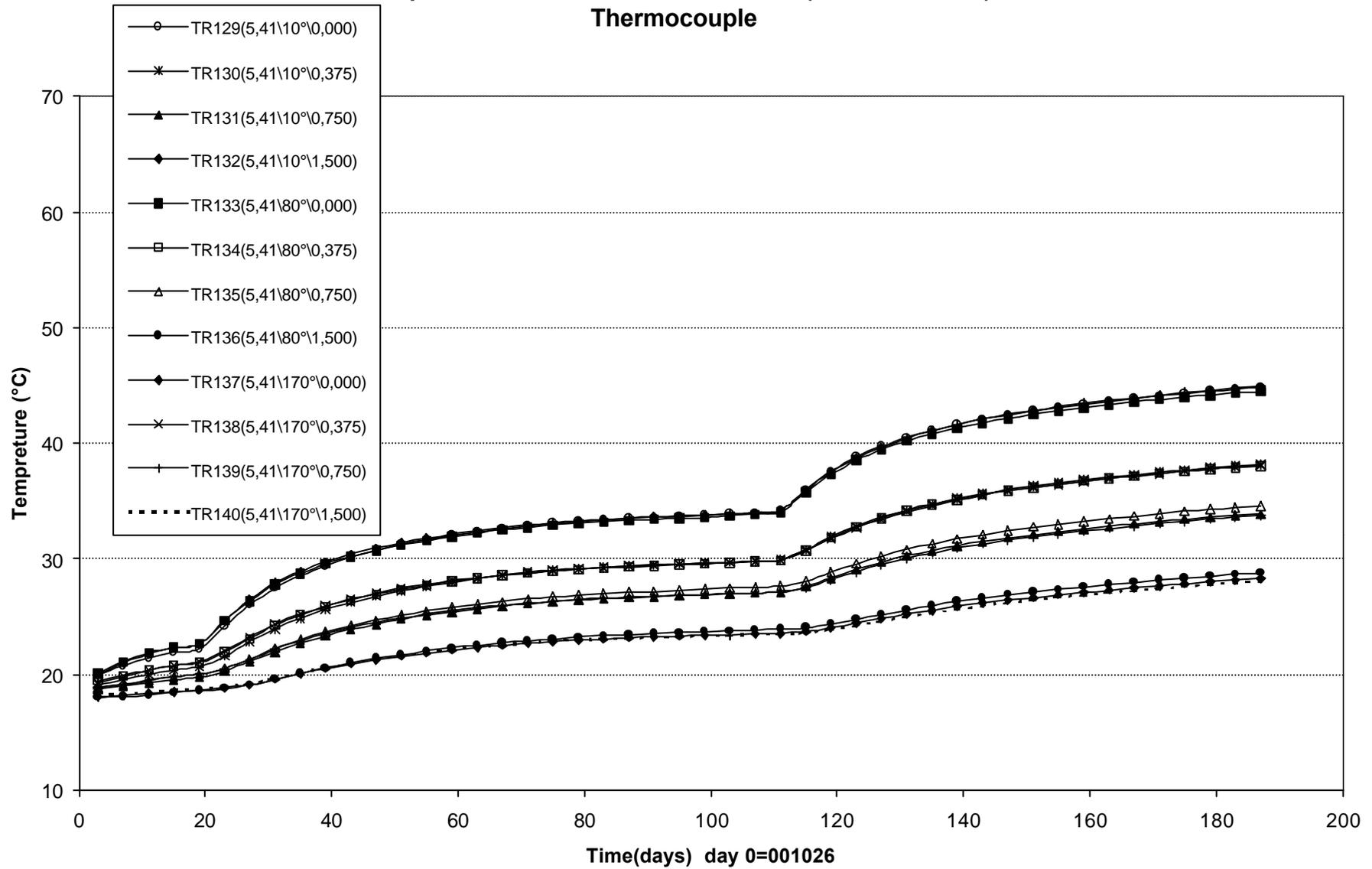
Temperature in the rock- level 0 m (001026-010501)
Thermocouple



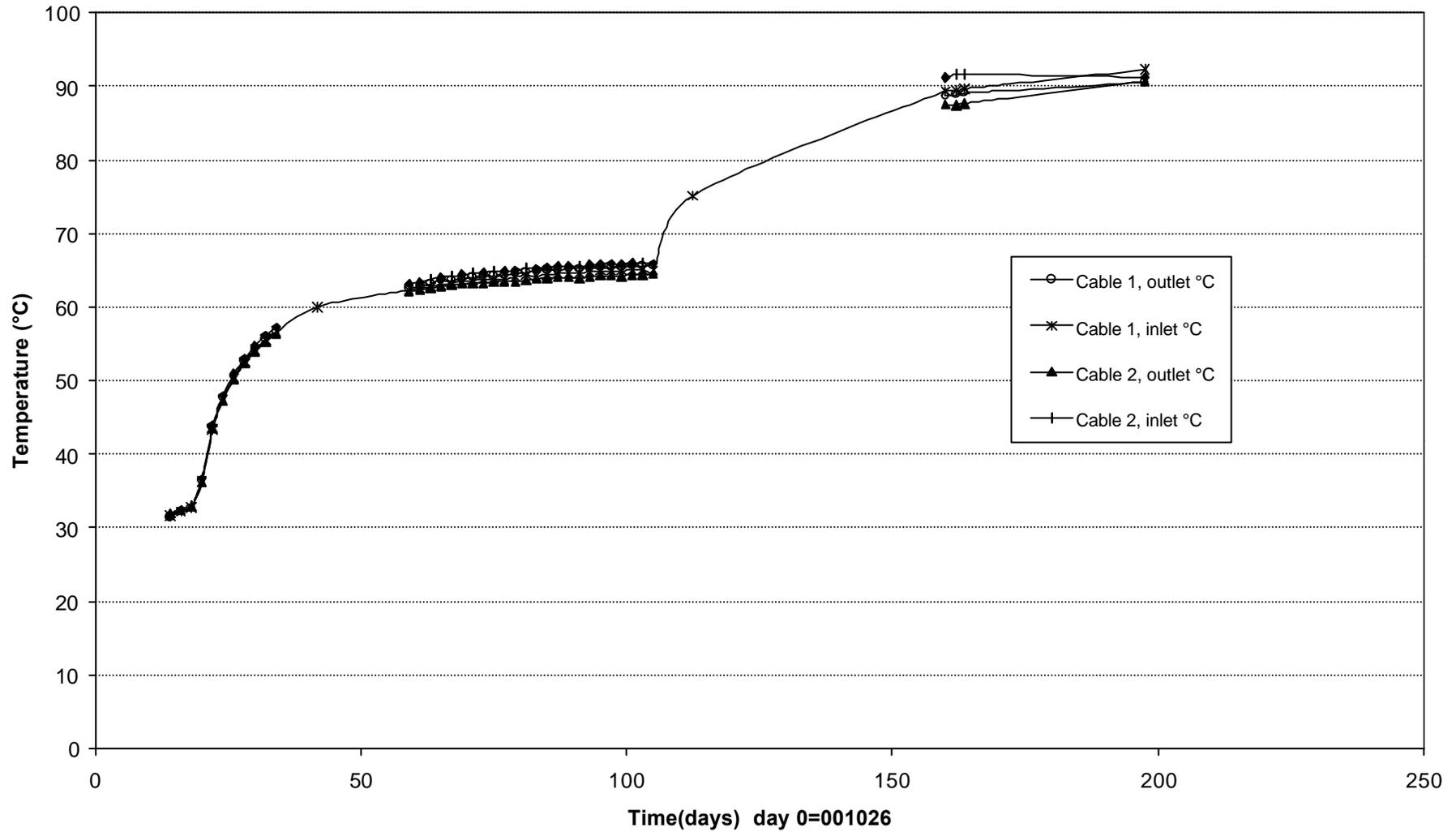
Temperature in the rock - level 0,6 m (001026-010501)
Thermocouple



Temperature in the rock - level 5,40 m (001026-010501)
 Thermocouple



Temperature on the canister surface (001026-010511)
Optical fiber cables



Temperature profile on the canister surface (010511)
Optical fiber cables

