

Pressuremeter testing in Ruritania

**A compilation of the results of ten tests
in a variety of materials, selected to
show what can be derived from careful
pressuremeter testing**

Reference: CIR 2001/11

Part 2 Full results and plots

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A list of tests in this borehole

B1T1	01/04/06	5.0m	Brown Clay
B1T2	05/04/06	6.1m	Clay and gravel
B1T3	05/04/06	8.0m	Clay and gravel
B1T4	07/04/06	10.0m	Coarse sand
B1T5	08/04/06	20.0m	Grey Clay
B1T6	10/04/06	25.0m	Grey Clay
B1T7	12/04/06	37.5m	Silty sand
B1T8	07/05/06	50.8m	Chalk (with flints)
B1T9	10/05/06	67.6m	Limestone
B1T10	11/05/06	80.4m	Phyllite

B1T1 01/04/06 5.0m Brown Clay

- 1. Test record sheet**
- 2. Results summary**
- 3. Plot of expansion versus pressure – all arms**
- 4. Plot of expansion versus pressure – arm average**
- 5. Plot of all pressure cells versus time**
- 6. Plot of Marsland and Randolph procedure**
- 7. Gibson and Anderson plot, giving C_u and P_L from loading curve**
- 8. Jefferies plot, giving C_u from unloading curve**
- 9. Plot of Reload Loop 1, with linear modulus line**
- 10. Plot of Reload Loop 2, with linear modulus line**
- 11. Plot of Reload Loop 3, with linear modulus line**
- 12. Bolton and Whittle plot of reloading part of Loop 1, giving nonlinearity coefficients**
- 13. Ditto for Loop 2**
- 14. And again for Loop 3**
- 15. Plot of Shear modulus versus Shear strain for all reload loops**
- 16. Plot of strain versus pressure, with computed curve and field data**

SITE	DATE	DAY	BOREHOLE	TEST	Depth to test centre
RURITANIA	1-6-06	FRI	1	1	5.0m
MATERIAL: BROWN CLAY			Site Weather:		SUNNY
Water Table	Drilling Start	Drilling End	Distance	Drill rate	Ram Pressure
	11:15	11:25	1.2m	60m	Low
Orientation:					
Water Press.	Probe Dia.	Shoe Dia.	Drill Bit	Bit Location	Probe Ref.
	88mm	89mm	73 RRB	~ FLUSH	DMGAL
Drilling remarks: GOOD FLUSH					
Strain Rate	Press. Rate	Cycle Time	Gas Bottle	Battery V	PPC Type
1 1/2	3 (L)	5 SACS	3600 PSI	12.06	TRUE
Mx. Press.					
13 MPa					
TRANSDUCER DETAILS					
	ARM 1	ARM 2	ARM 3	TPC	PPC A
GL Zero					
Test Depth					
TEST NOTES					
Line No.	Remarks				
42	RATB 4 - A BIT SLOW!				
67	ARM (1) MOVING - ARM (2) SOON AFTER				
135	ARM (1) MOVING				
	SEN ON HOLD! SWITCH TO UP				
	BACK TO RATE (1)				
167	HOLD ⇒ LOOP (1)				
254	HOLD ⇒ LOOP (2) - RATE 4 FOR LOOPS				
328	HOLD ⇒ LOOP (3) - DITTO - BIGGER LOOP				
330	2 1/2 / MIN - PWP DROPPING AWAY				
405	DOWN - RATE 4 - ARM 3 NEAR MAXIMUM				
Test Engineer: <i>[Signature]</i>					
Driller: MIGUEL					
Membrane Correction	Membrane Compression	Arm Cals Ref.	Pressure Cals Ref.		
C0306T2	C0306T1	20-12-05	20-12-05		
GENERAL COMMENTS:					
14-3-06					
START A BIT SLOW - WORK SETTING ON SEN.					
OK AFTER THAT.					

SELF-BORING PRESSUREMETER

RESULTS SUMMARY SHEET

Site:- Ruritania

Test :- B1T1

Test Date :- 1st April 2006

Material :- Brown clay

Depth :- 5.0 mtrs

Water table :- ~11 mtrs

Analysis of Insitu Lateral Stress (Po) :-

		Arm Av.
Marsland and Randolph	kPa	75
Zero offset	mm	0.05

Analysis of Undrained Shear Strength (Cu) :-

Gibson and Anderson	kPa	80
Pressure at failure (P _F)	kPa	102
Limit Pressure (P _L)	kPa	505
Jefferies (unloading)	kPa	48

Analysis of Shear Modulus (G) :-

Initial Modulus (G _i)	MPa	17.0
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Linear Analysis of Reload Loops (G_R) :-

		Loop 1	Loop 2	Loop 3
G _R	Mpa	8.4	9.6	10.2
Co-ordinate :-				
Strain	%	2.1	5.9	11.6
Pressure	MPa	0.15	0.2	0.24
Amplitude :-				
Strain	%	1.2	1.2	1.3
Pressure	MPa	0.10	0.12	0.14

Non-linear Analysis of Reloading data :-

α	MPa	0.87	1.04	1.24
β		0.597	0.605	0.611

Shear Modulus G_S (at 3 levels of shear strain) :-

(0.01%)	MPa	36	40	45
(0.1%)	MPa	14	16	18
(1%)	MPa	5.6	6.4	7.4

Curve matching procedure

P _o	=	106	kPa
O/s	=	1.13	mm

Cu	=	49	kPa
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P _L	=	462	kPa
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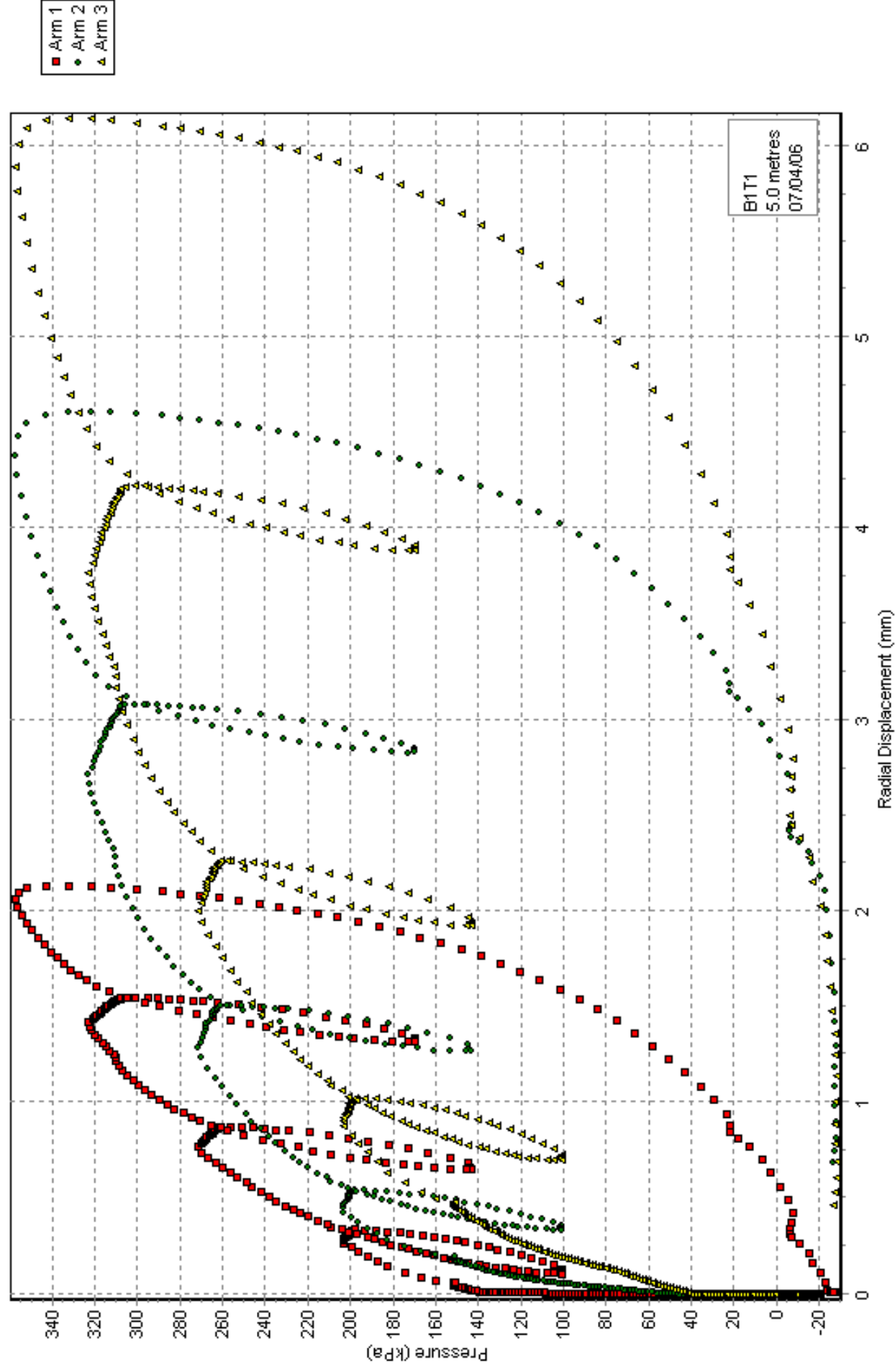
α	=	1.57	MPa
β	=	0.611	

G _{0.01%}	=	56	MPa
G _{0.1%}	=	23	MPa
G _{1%}	=	-	MPa
G _{MIN}	=	14.2	MPa
at 0.3% shear strain			

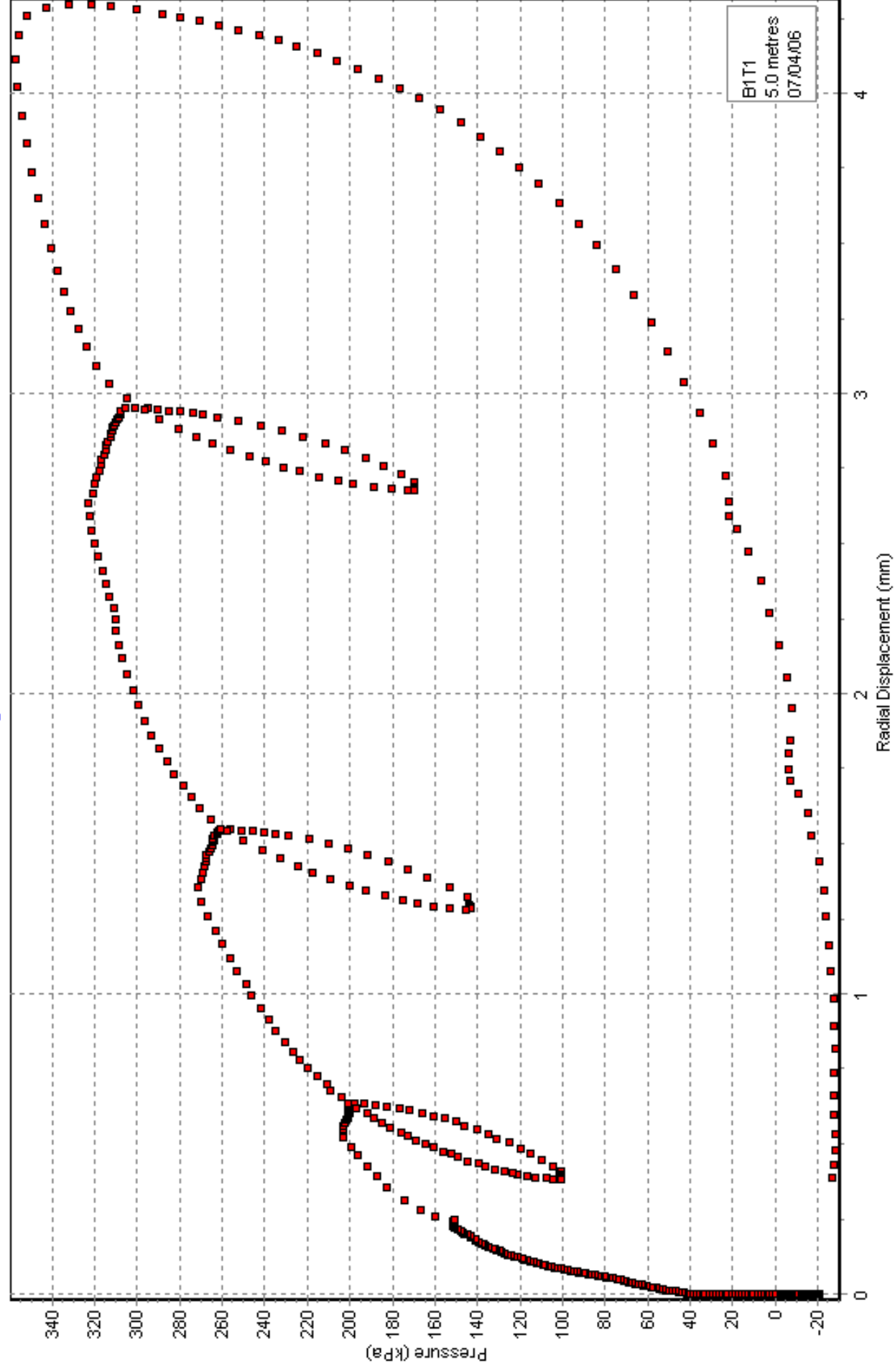
Test Analysed By :- PGH

Date :- April 2006

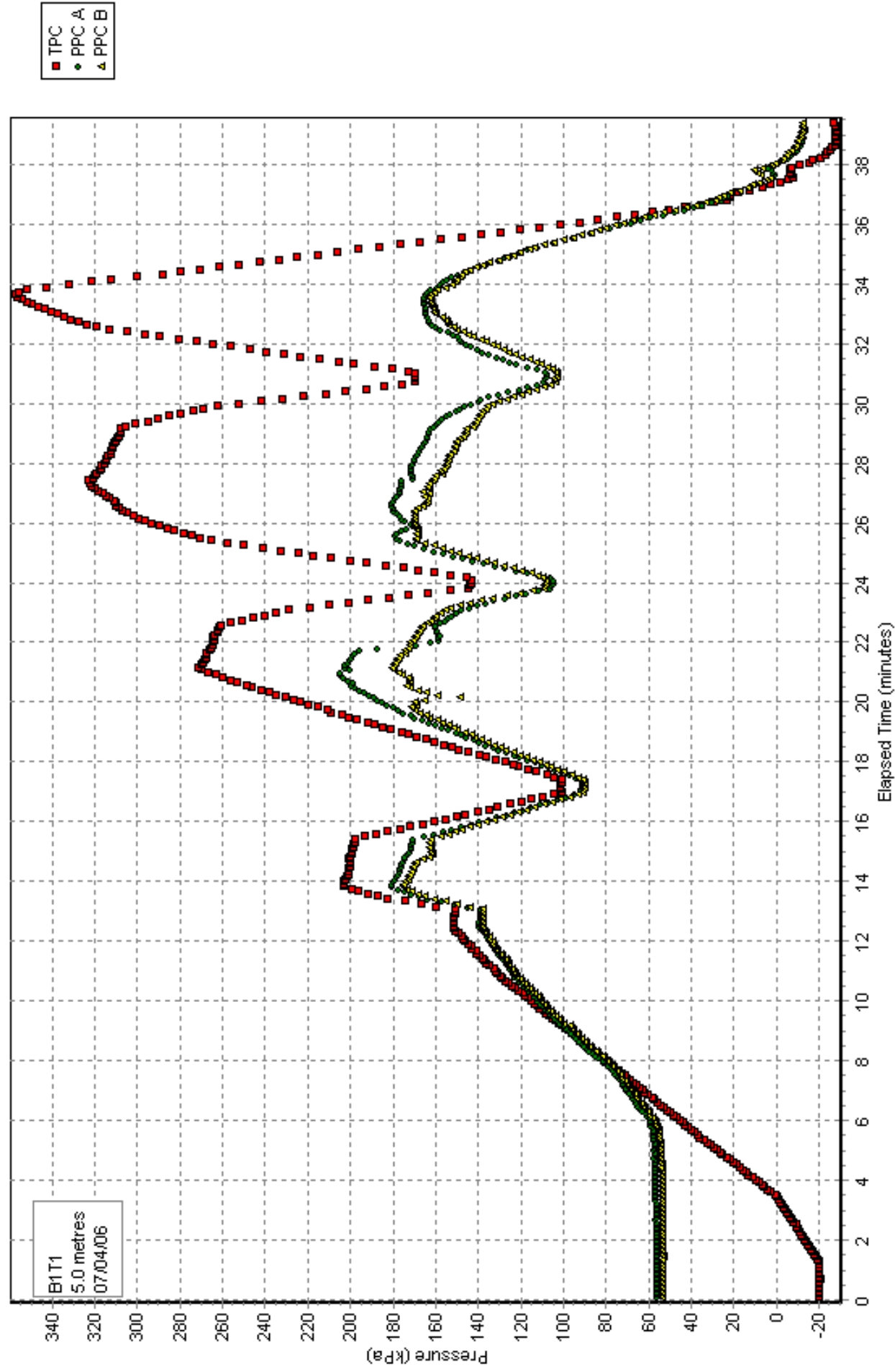
All Arms vs Total Pressure



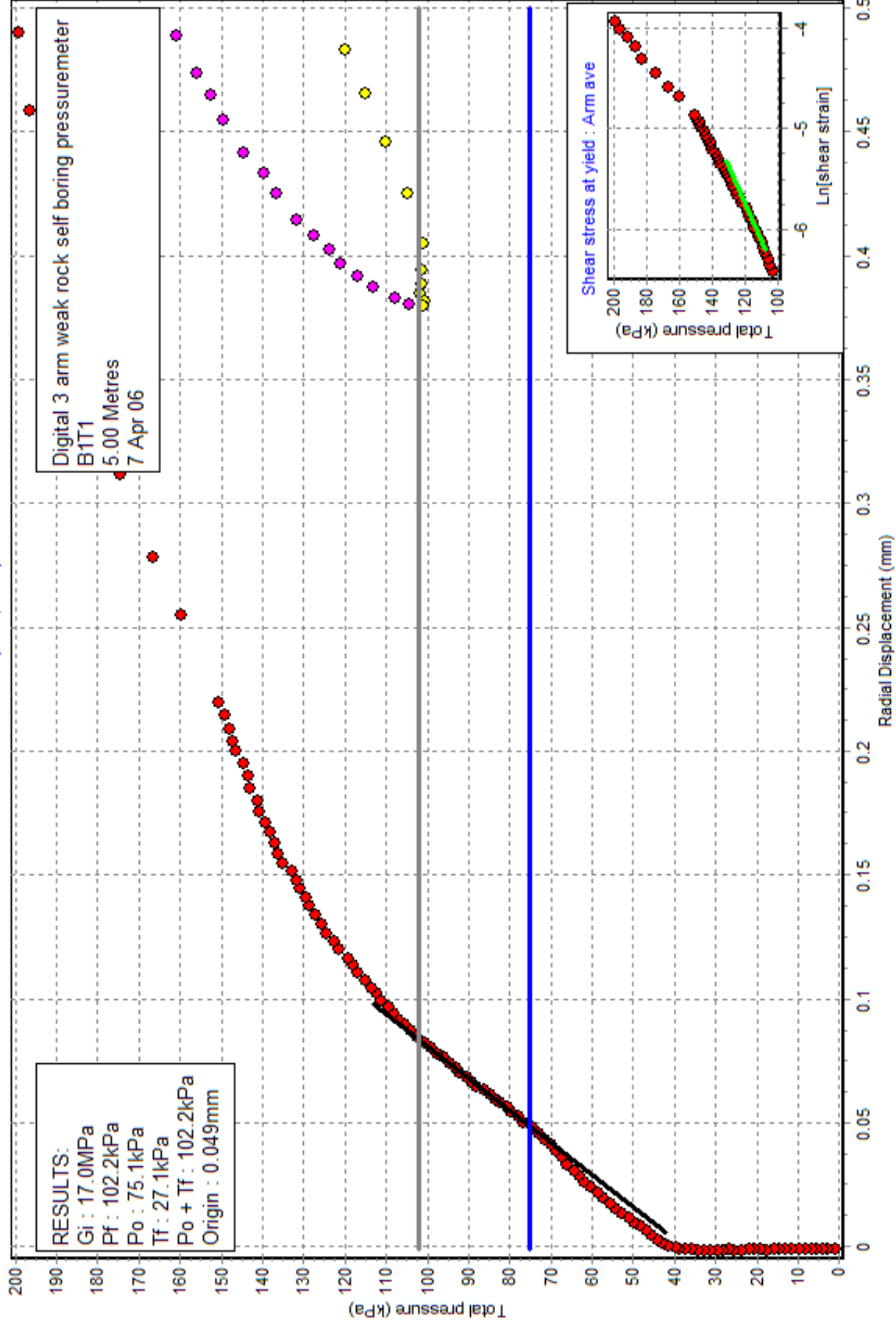
Arm Average vs Total Pressure

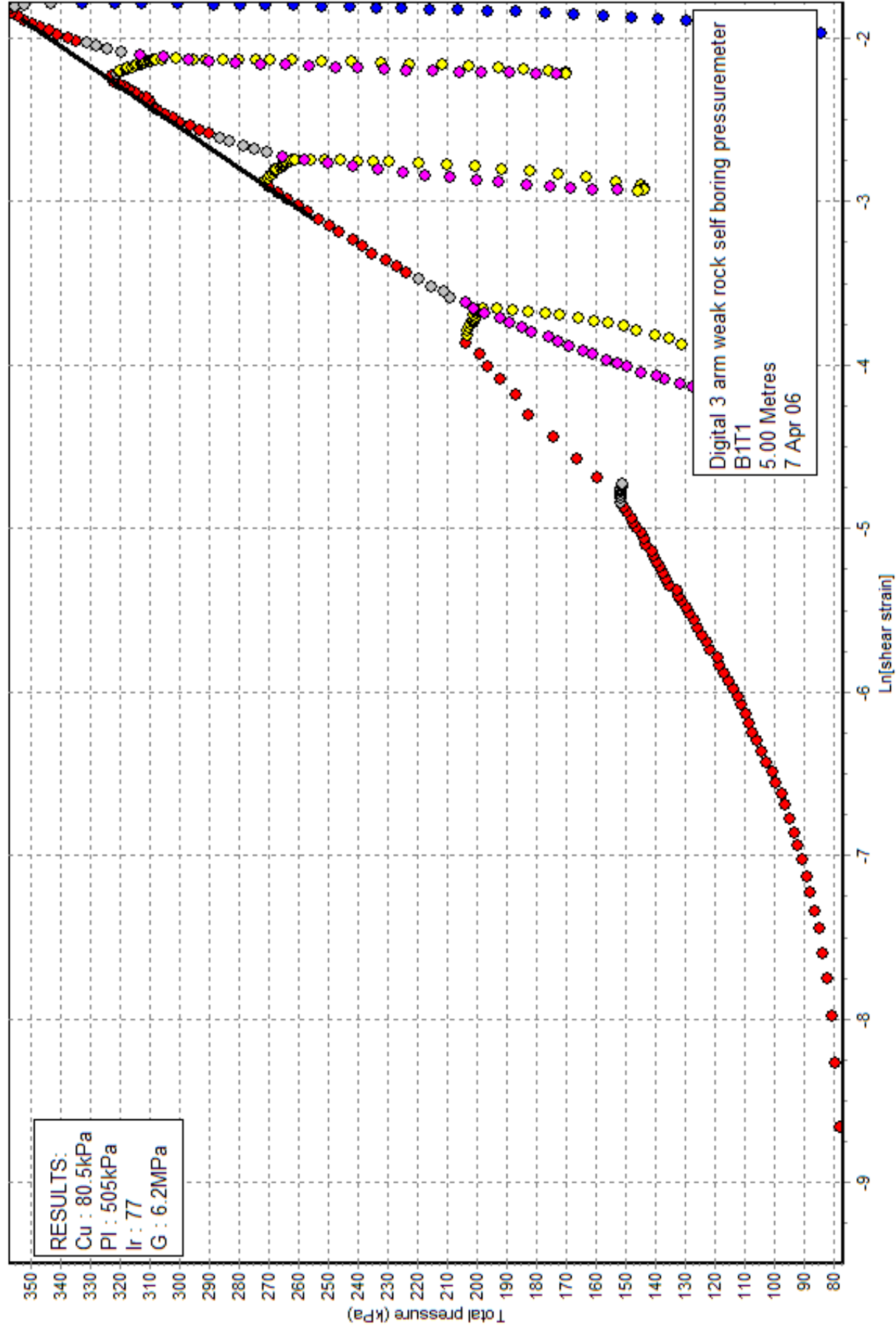


All Pressure Cells vs Time

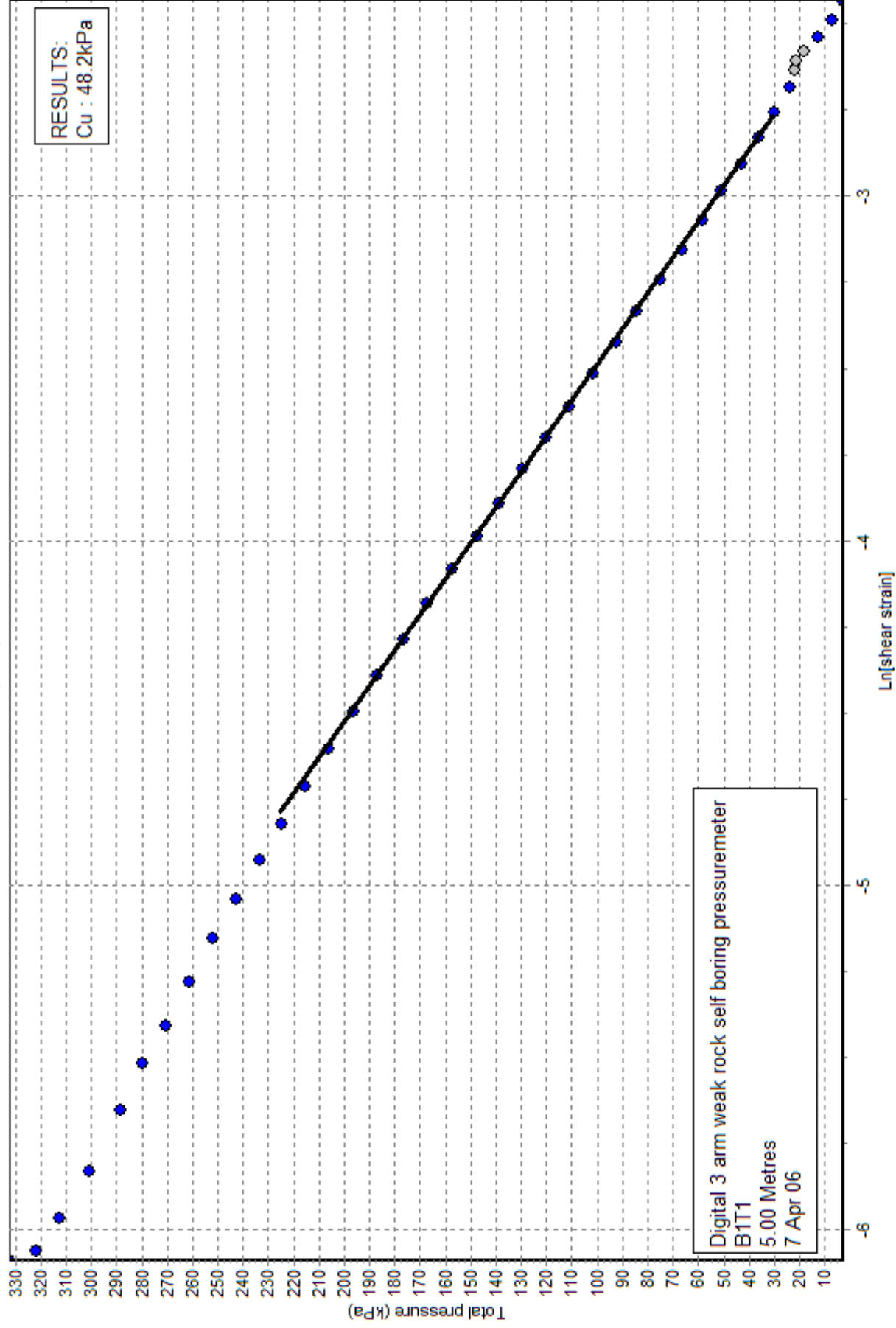


Po of cohesive material (1977, 1990) : Arm ave

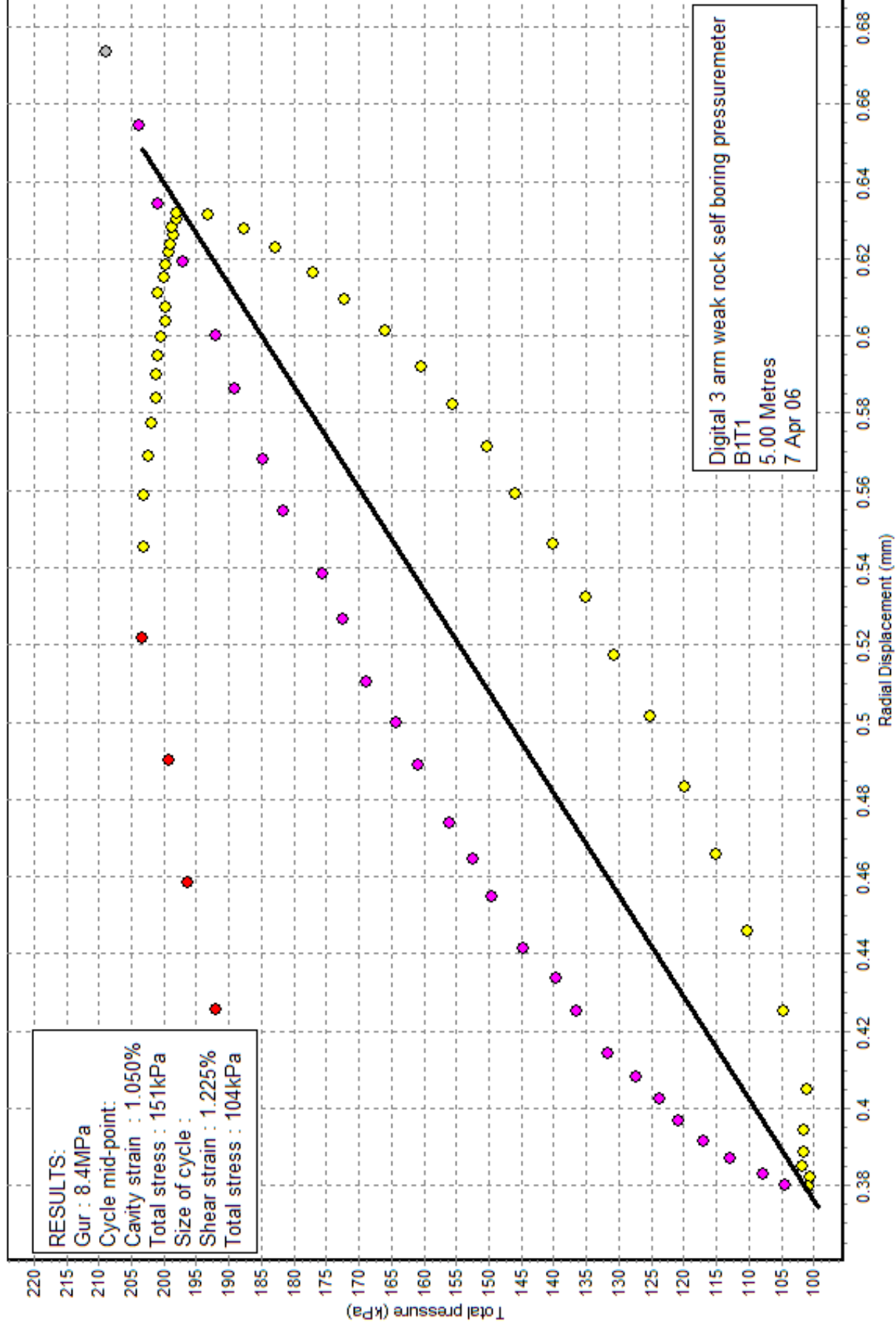




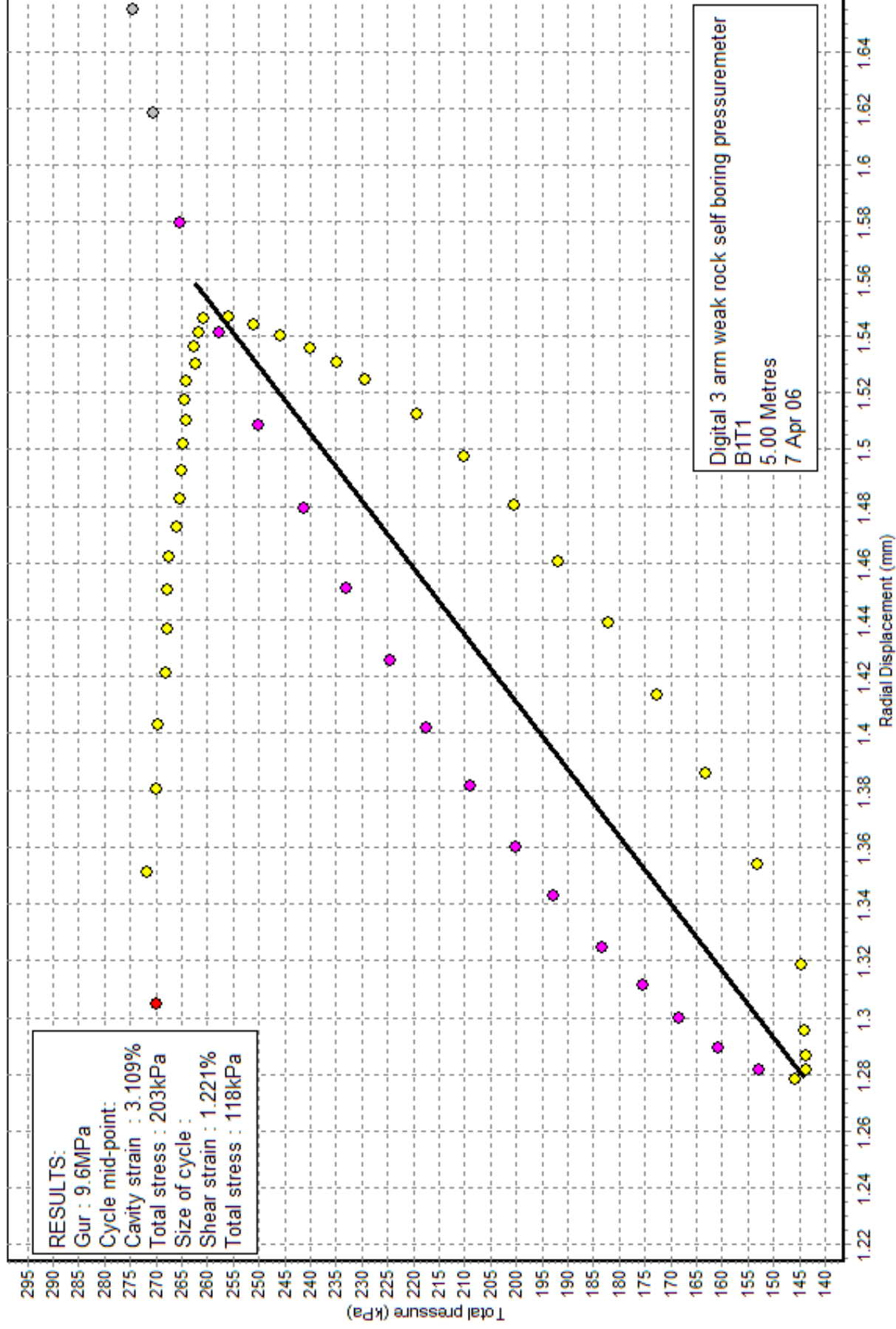
Jefferies (1988) : Arm ave



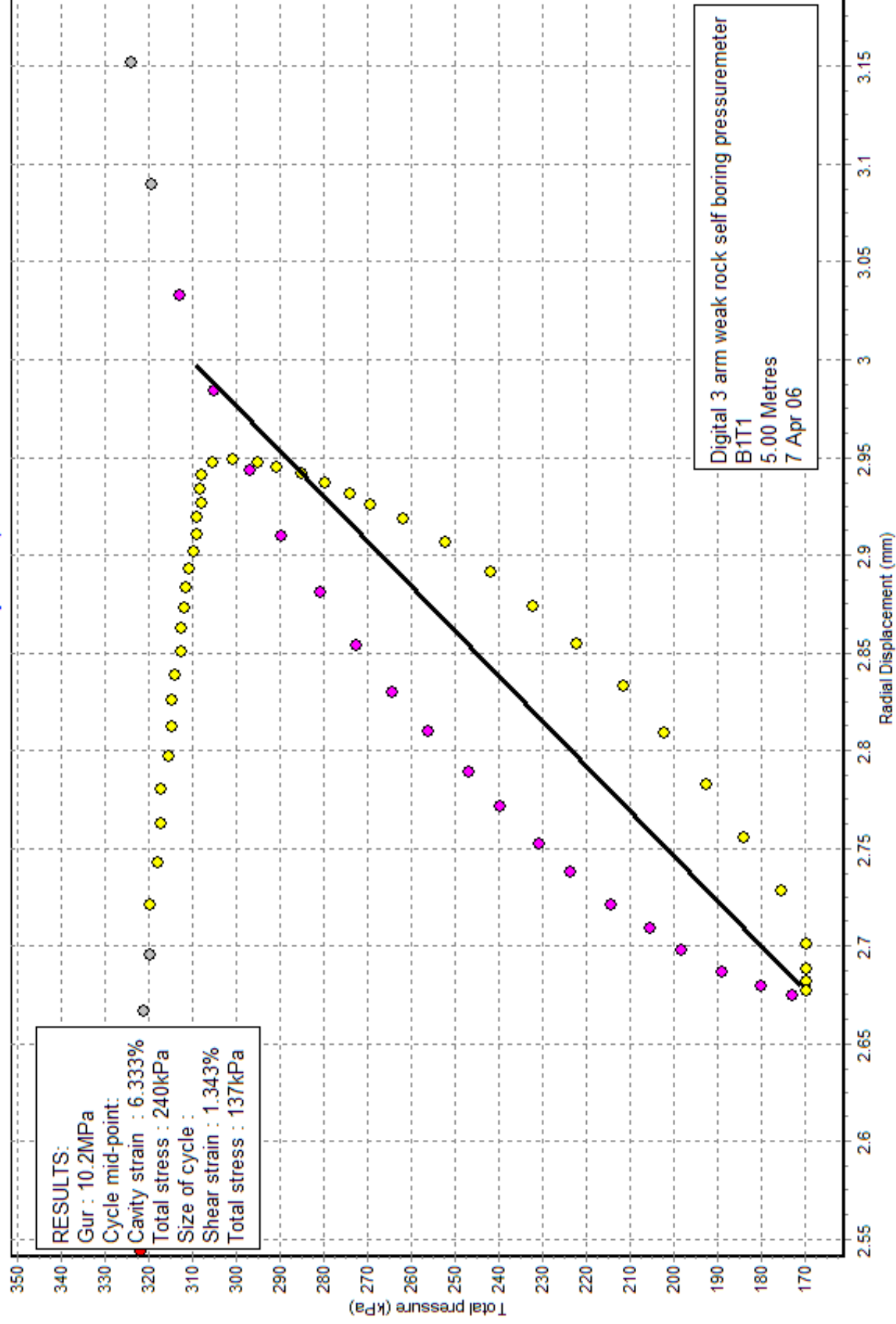
Shear modulus from unload/reload cycles Loop 1 : Arm ave

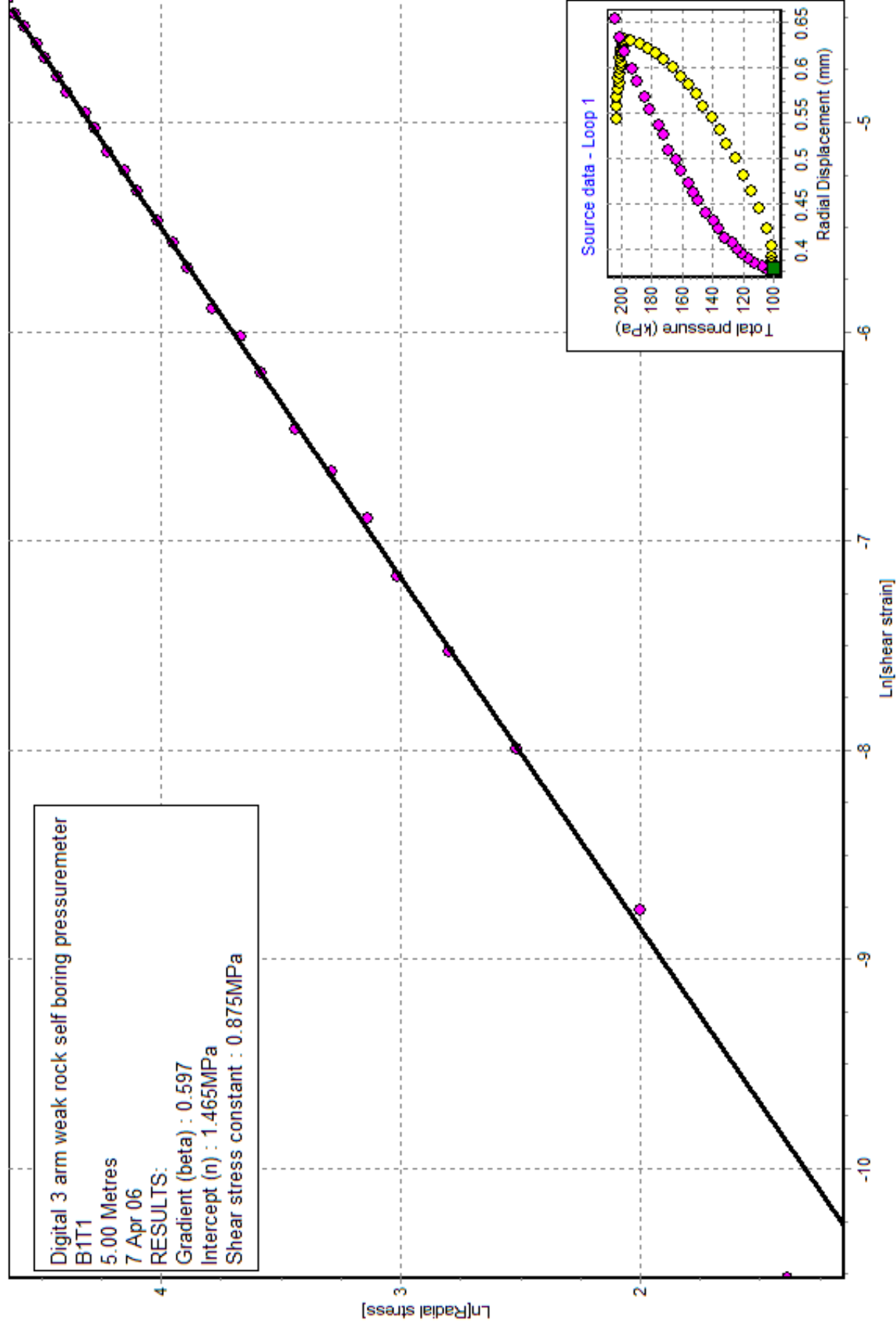


Shear modulus from unload/reload cycles Loop 2 : Arm ave

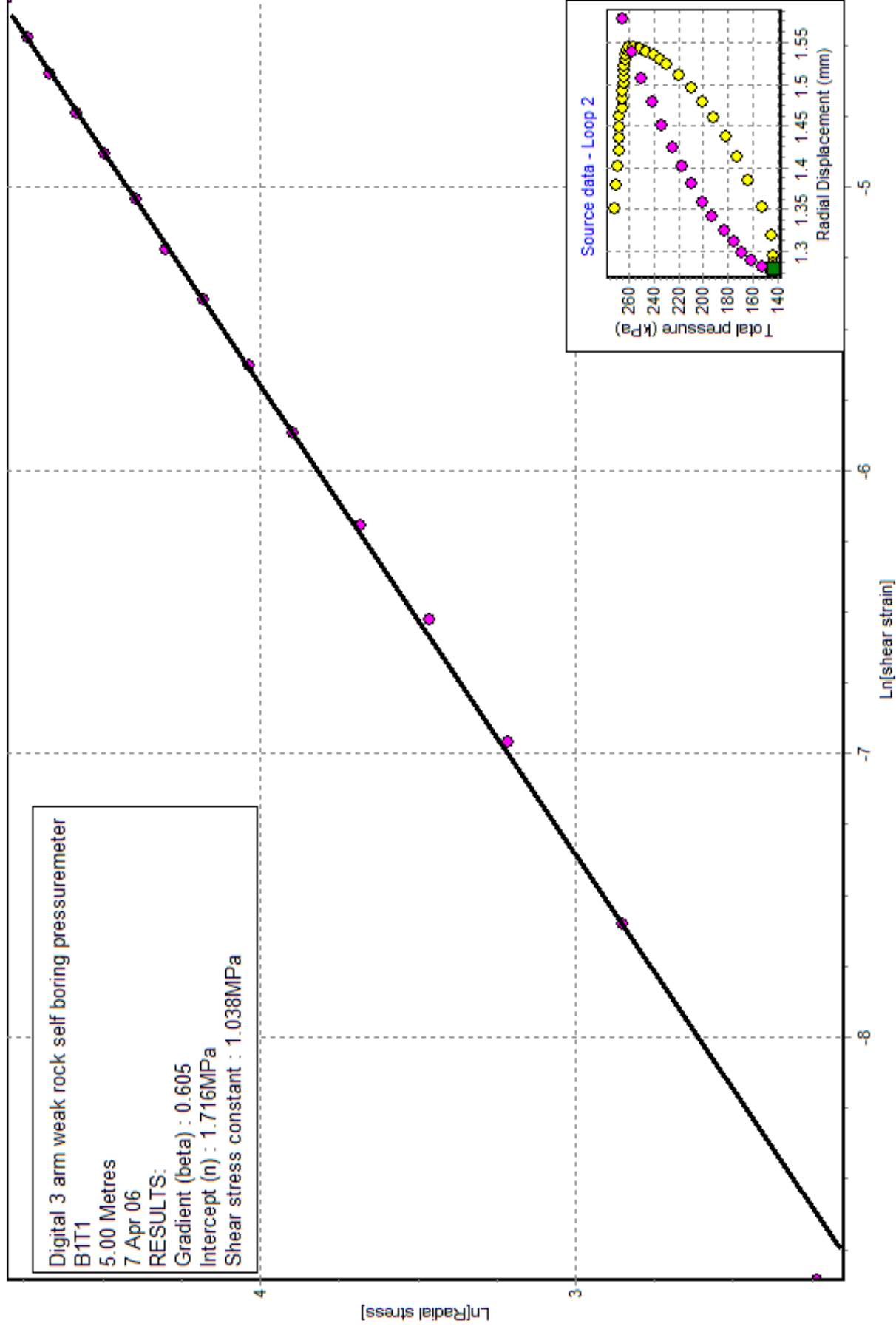


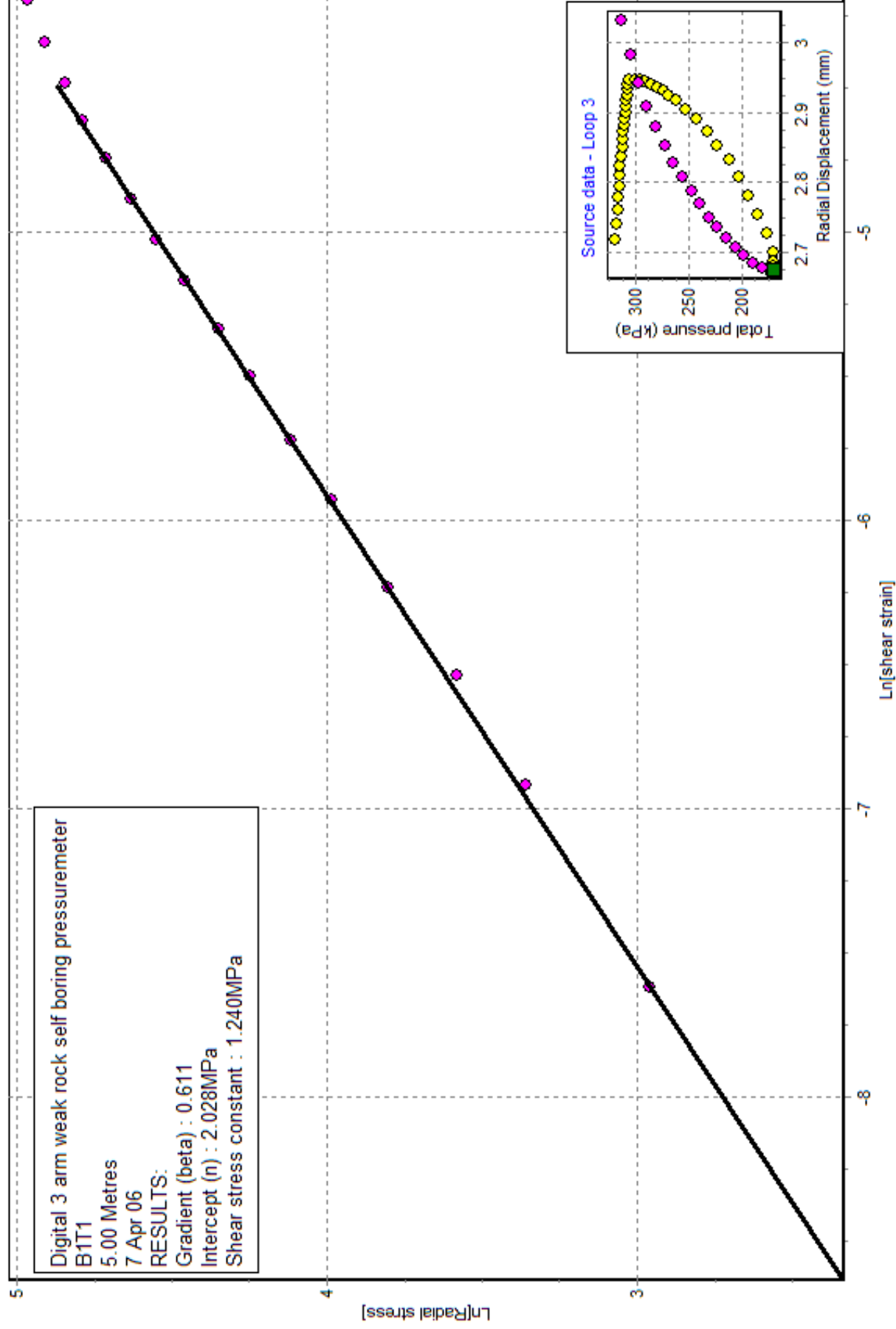
Shear modulus from unload/reload cycles Loop 3 : Arm ave



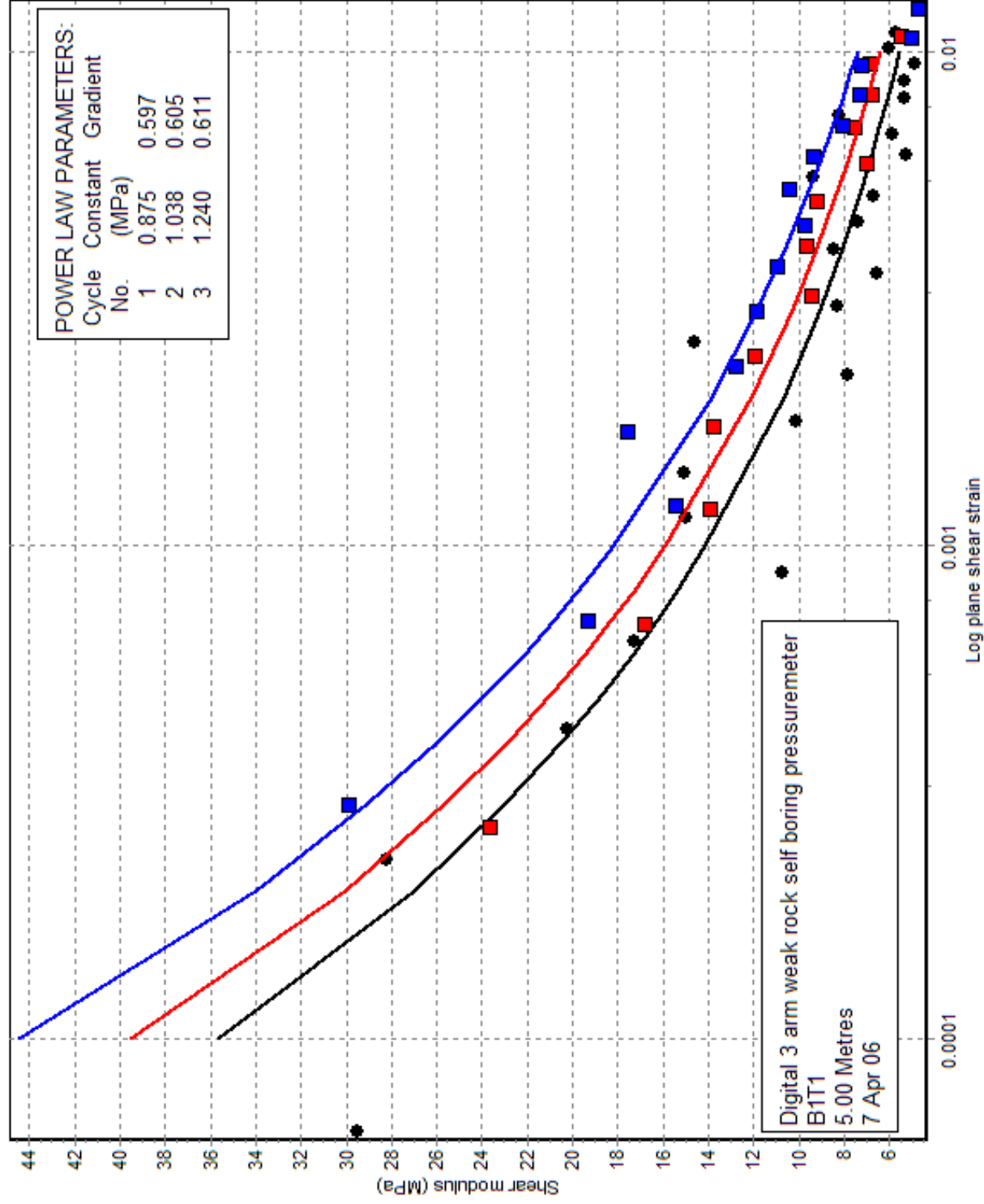


Digital 3 arm weak rock self boring pressuremeter
 B1T1
 5.00 Metres
 7 Apr 06
 RESULTS:
 Gradient (beta) : 0.605
 Intercept (n) : 1.716MPa
 Shear stress constant : 1.038MPa

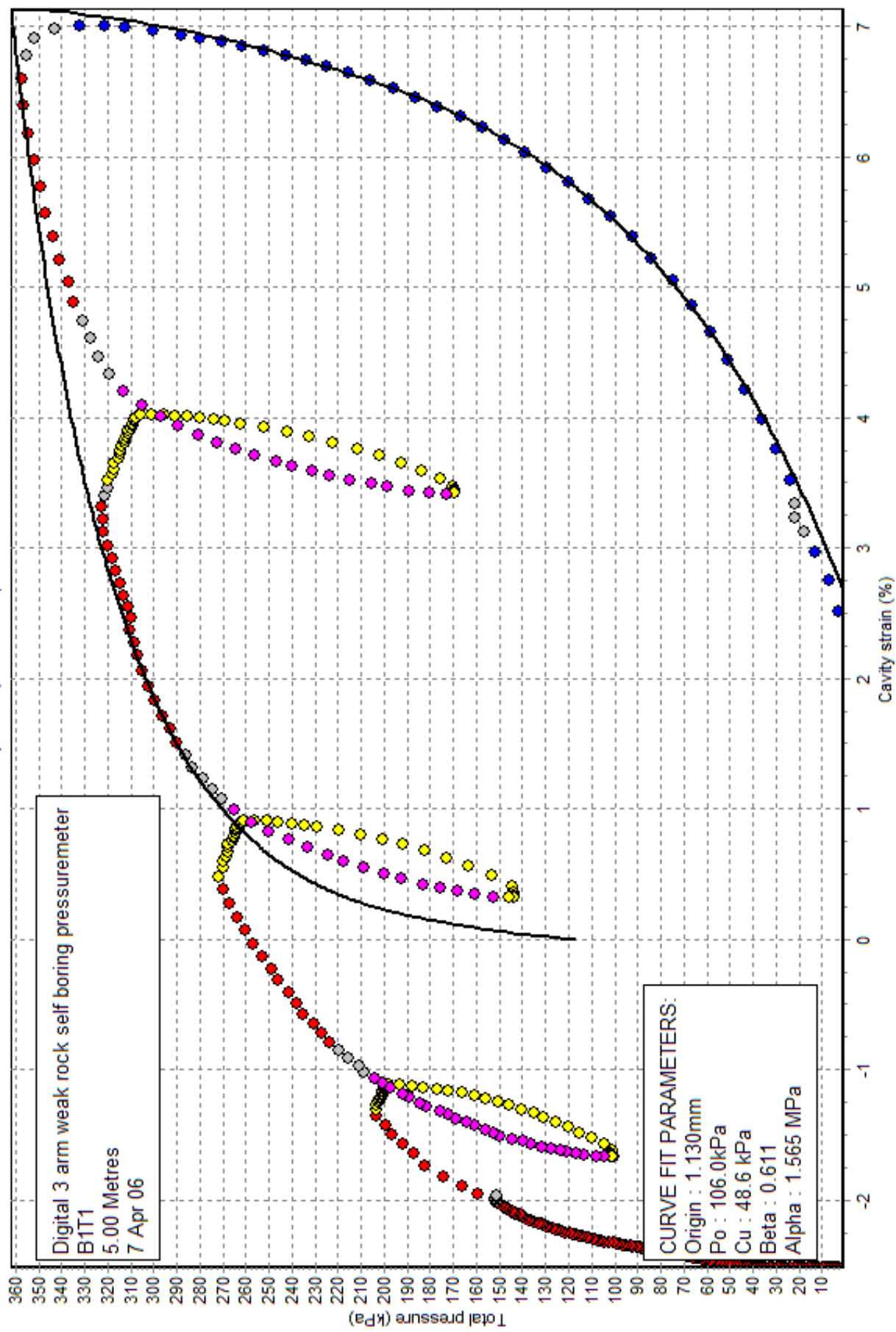




Variation of stiffness with strain, undrained analysis : Arm ave



Curve comparison (Whittle 1999) : Arm ave



B1T2 05/04/06 6.1m Clay and gravel

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- 20. Plot of measured and calculated curves, from Carter et al**

Note that these last two plots are included, even though the results obtained are not shown on the summary sheet. The material is a mixture, and no one model fits properly.

Site	Date	Day	Borehole	Test No.	Depth
RURITANIA	5/4/06	THUR	1	2	6.1m
Material: Glacial till					
Weather	Water Table	Time Now	Drilling End	Orientation	CHL
Clear		11:32	11:15		✓
Drilling: T6H core			Pocket:		
Diameter	Distance	Rate	Core Description		Length
18mm	1.5m		5.5 → 7m		
Wet/Dry	Rig	Driller	Core Quality		Size
			Poor recovery, 100% sand gravel.		
Pres/Incrmntl	Wait Time	Creep Time	Cycle Time	Disc No.	Inst Ref
					SALLX
Zero Readings:			Machine Diameter:		
Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6
-1518	-1084.2	-988.7	-1242.2	-1781.8	-2311.8
					T/Press.
					186.3
					B: 1526
					Battery
					12.18v
Calibrations:					
Strain Arm Calibration Date:			10/1/11		
Total Pressure Cell Calibration Date:			10/1/11		
Membrane Stiffness Calibration Date:			2/2/11		
Mem. Compression Calibration Date:			2/2/11		
New Membrane Filled Date:			2/2/11		
Test Comments: Had to go in with T6H barrel twice after hole collapse.					
Test Starts at: 11:34					
Time	Line No	Notes			
11:42	56	Hold			
11:45	82	loop 1			
11:55	131	Hold			
11:58	158	loop 2			
12:08	217	Hold			
12:11	235	loop 3			
12:20	28	Unload			
12:25	321	loop 4			
Test Ends at: 12:33					
Max. Pressure Reached: 424 MPa.					
General Comments:					
2mm TPC's used. - looks to have tested friable material (caused by drilling) before hitting virgin material. - Free sand loops.					
					Driller: Mark / Ritchie Operator: SDB

Site:- Ruritania

Test :- B1T2

Test Date :- 5th April 2006

Material :- Clay & gravel

Depth :- 6.1 mtrs

Water table :- ~ 11m

Analysis of Insitu Lateral Stress (P_o) :-

		Arm Av.
Marsland and Randolph	kPa	340
Strain zero	mm	8.2

Analysis of Undrained Shear Strength (C_u) :-

Gibson and Anderson	kPa	156
Pressure at failure (P_F)	kPa	500
Limit Pressure (P_L)	kPa	925
Jefferies (unloading)	kPa	77

Strength of Sands Analysis (Hughes, Wroth & Windle)

Friction angle at const. vol.	deg	24	(assumed)
Angle of Friction	deg	24.0	
Angle of Dilation	deg	0	

Analysis of Shear Modulus (G) :-

Initial Modulus (G_i)	MPa	2.3
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Linear Analysis of Reload Loops (G_R) :-

		Loop 1	Loop 2	Loop 3
G_R	MPa	11.1	17.1	16.4
Pressure at start	kPa	285	415	195
Depth of unload	kPa	90	125	-125

Non-linear Analysis of Reloading data :-

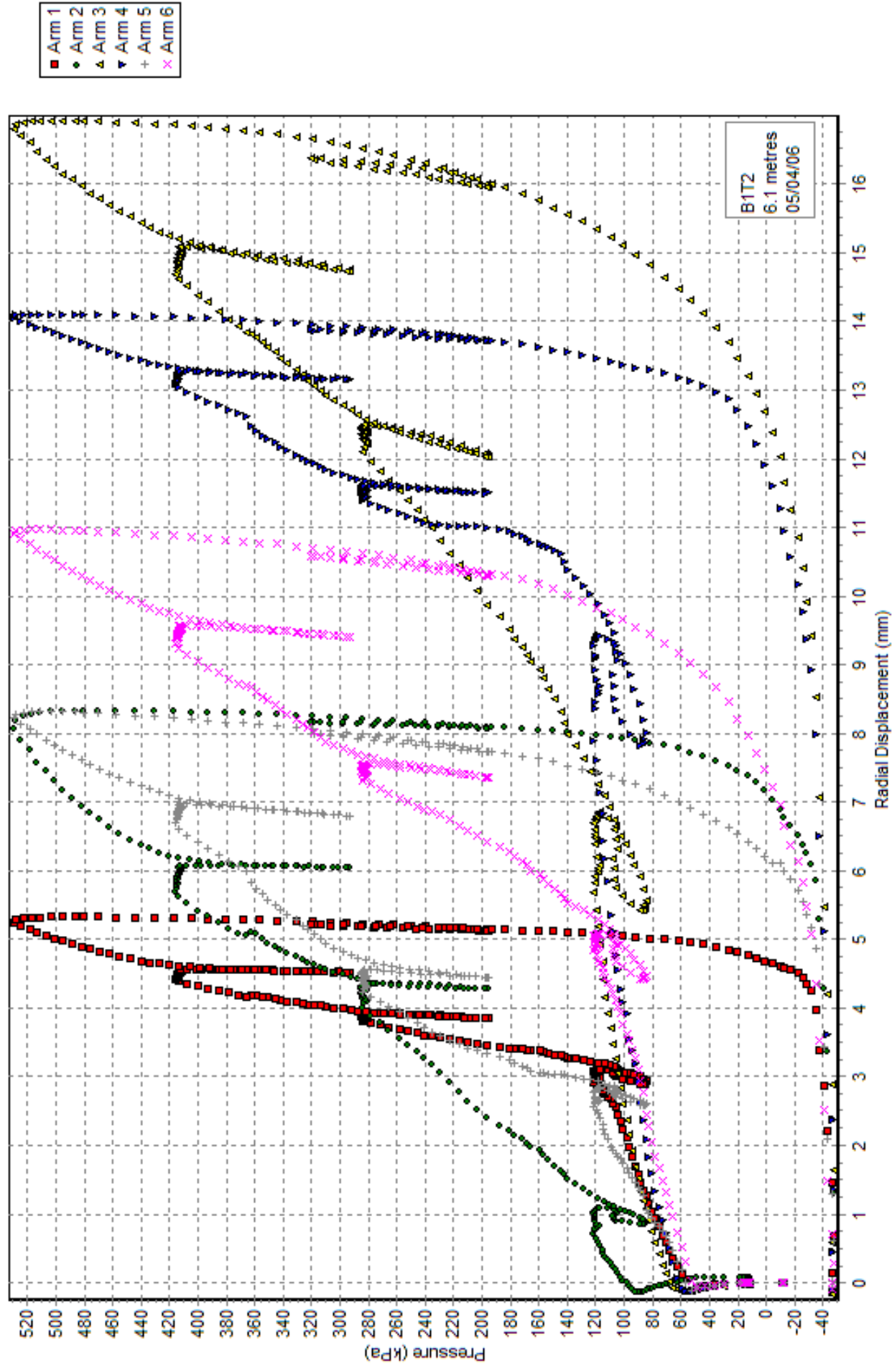
α	MPa	4.32	6.61	5.90
β		0.853	0.833	0.785

Shear Modulus G_S (at 2 levels of shear strain) :-

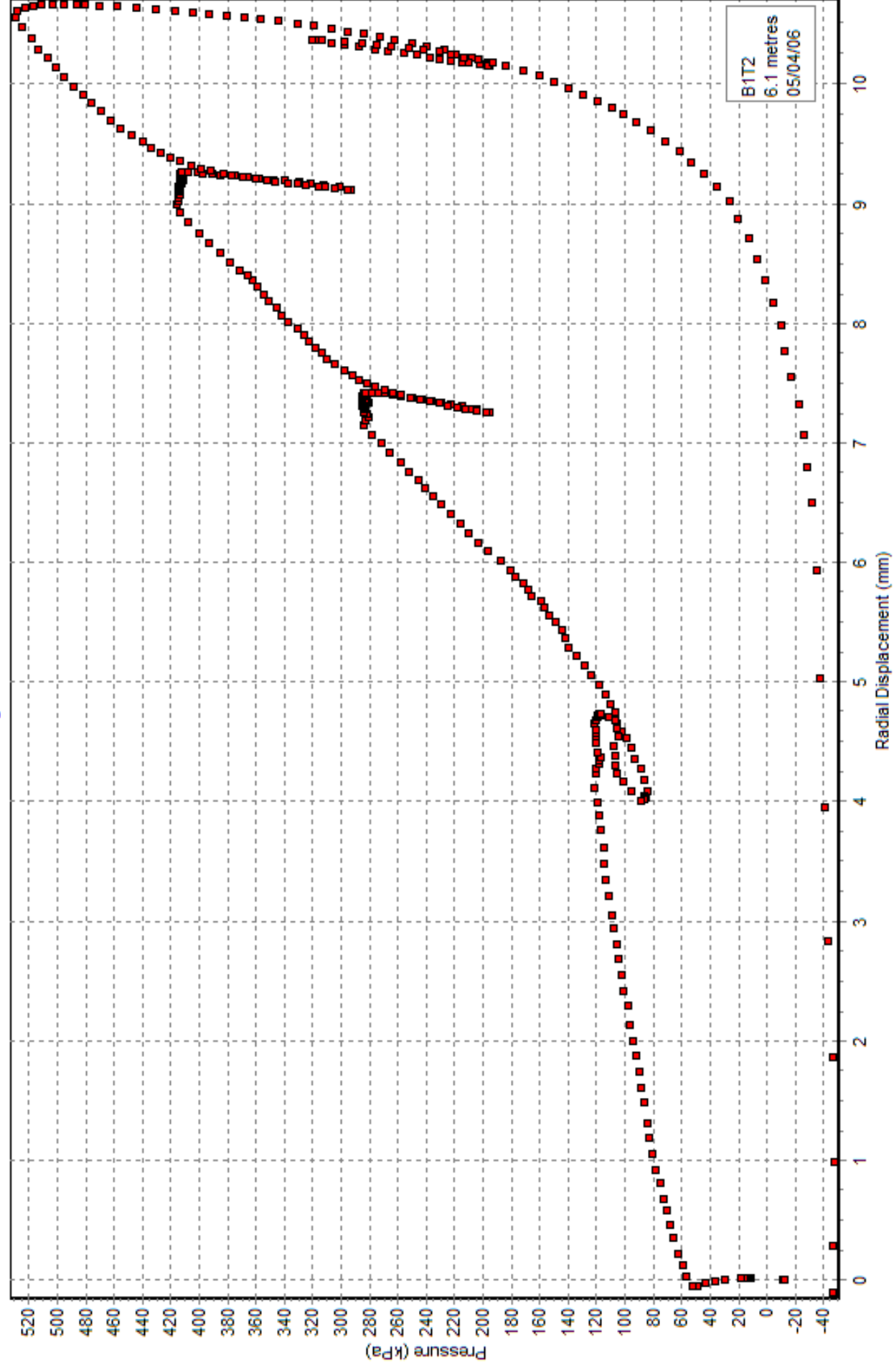
(0.01%)	MPa	16.7	30.8	42.7
(0.1%)	MPa	11.9	21.0	26.0

Test Analysed By :- PGH
Date :- March 2011

All Arms vs Total Pressure

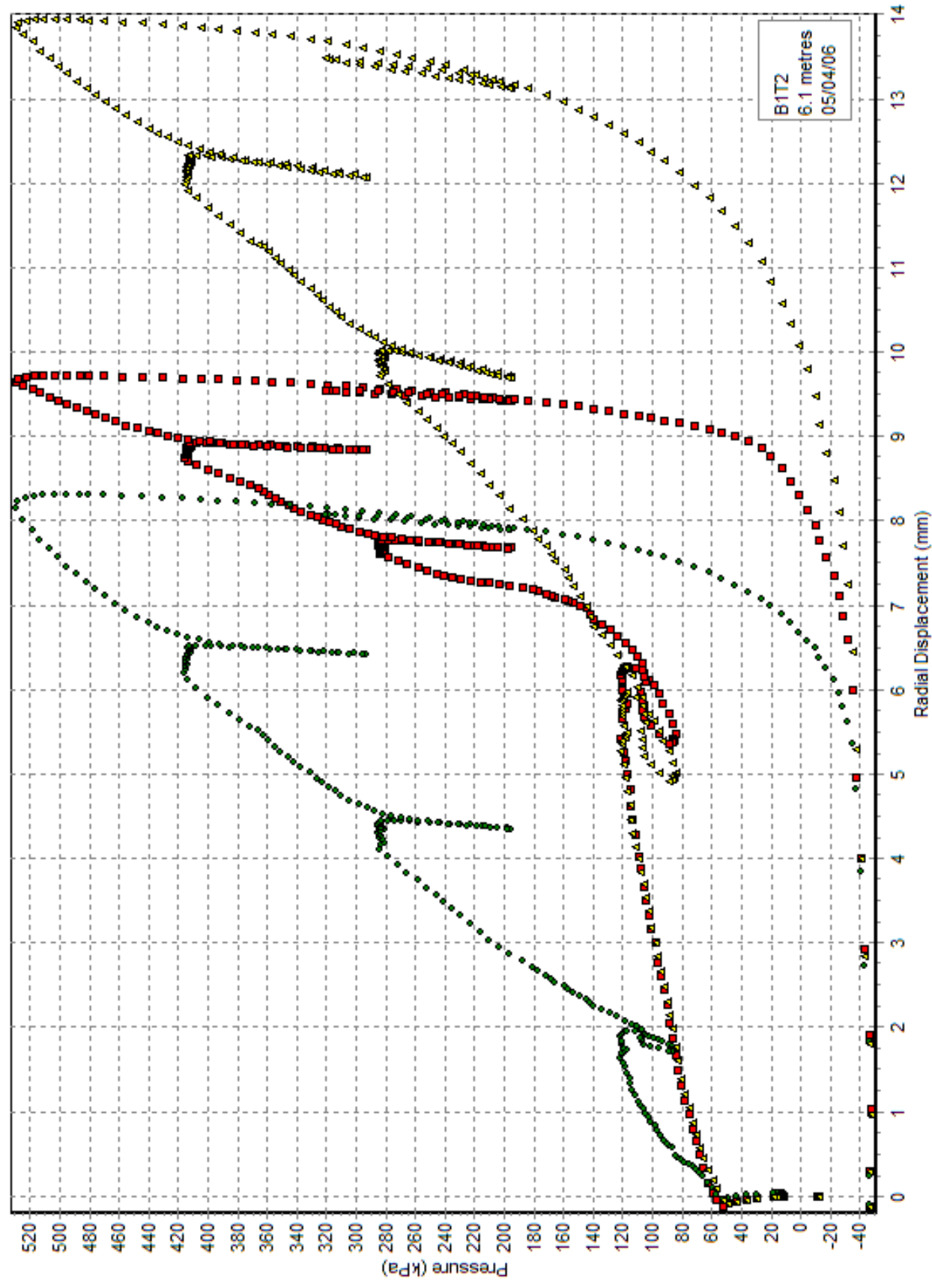


Arm Average vs Total Pressure

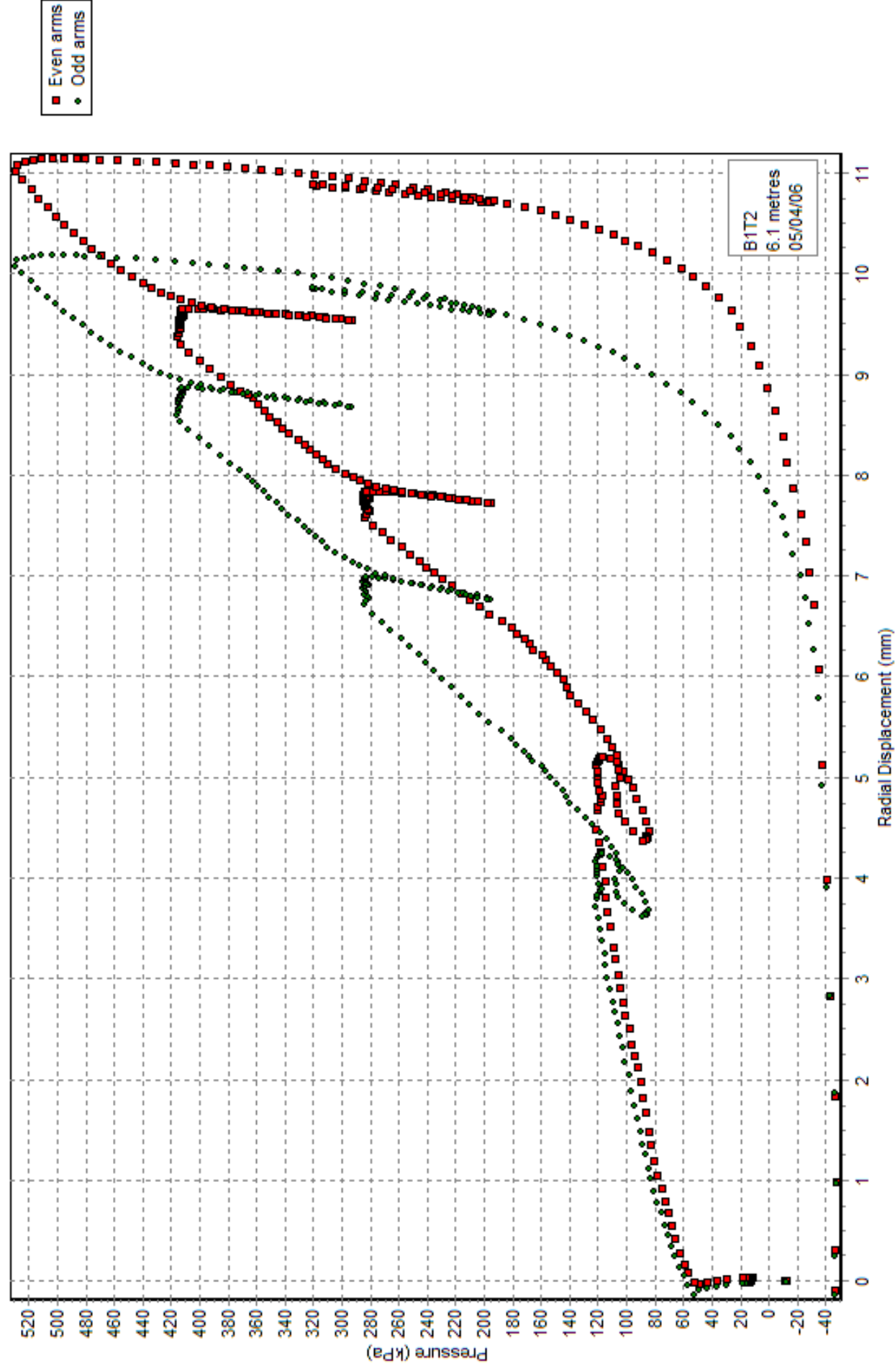


B1T2
6.1 metres
05/04/06

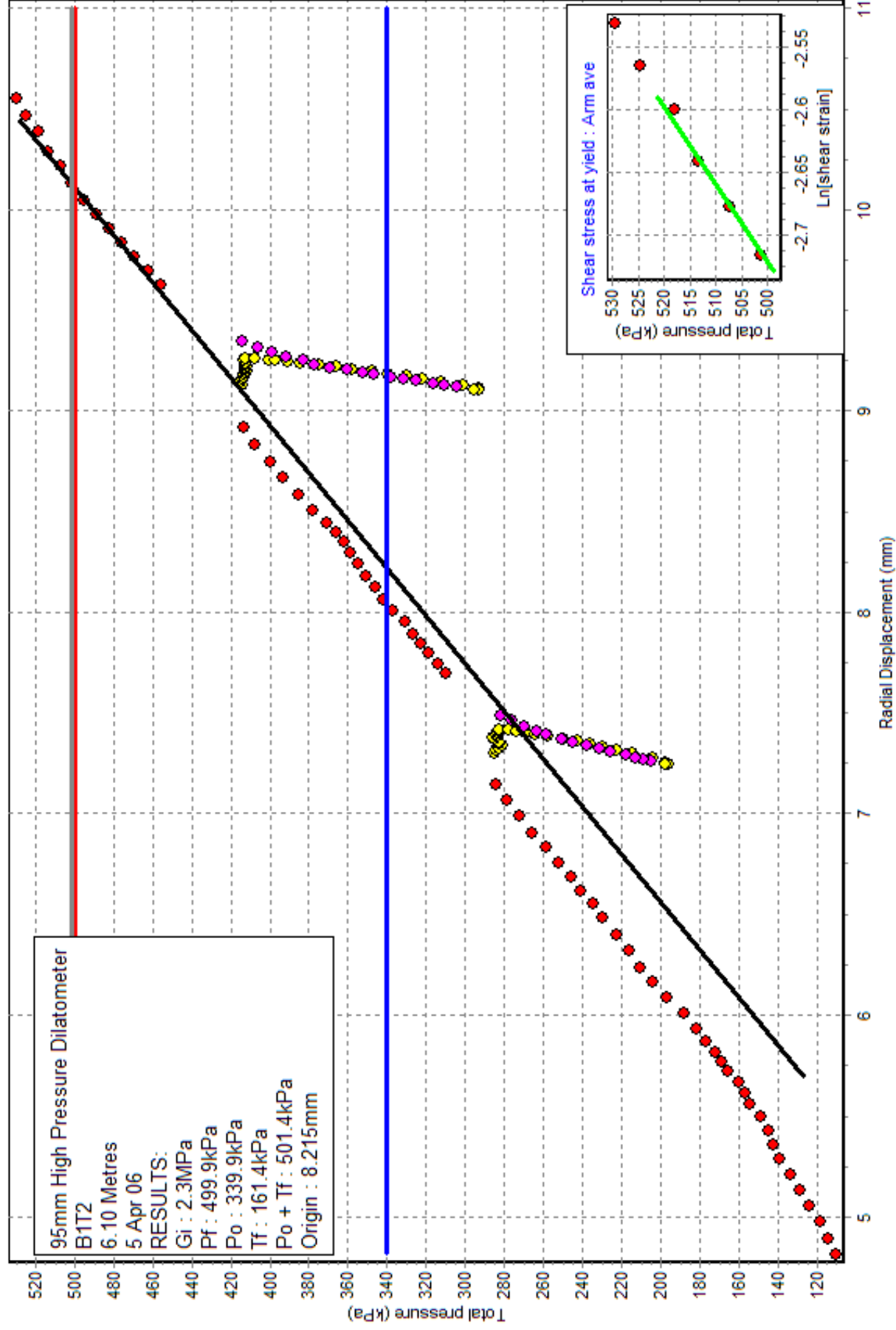
Arm Pairs vs Total Pressure



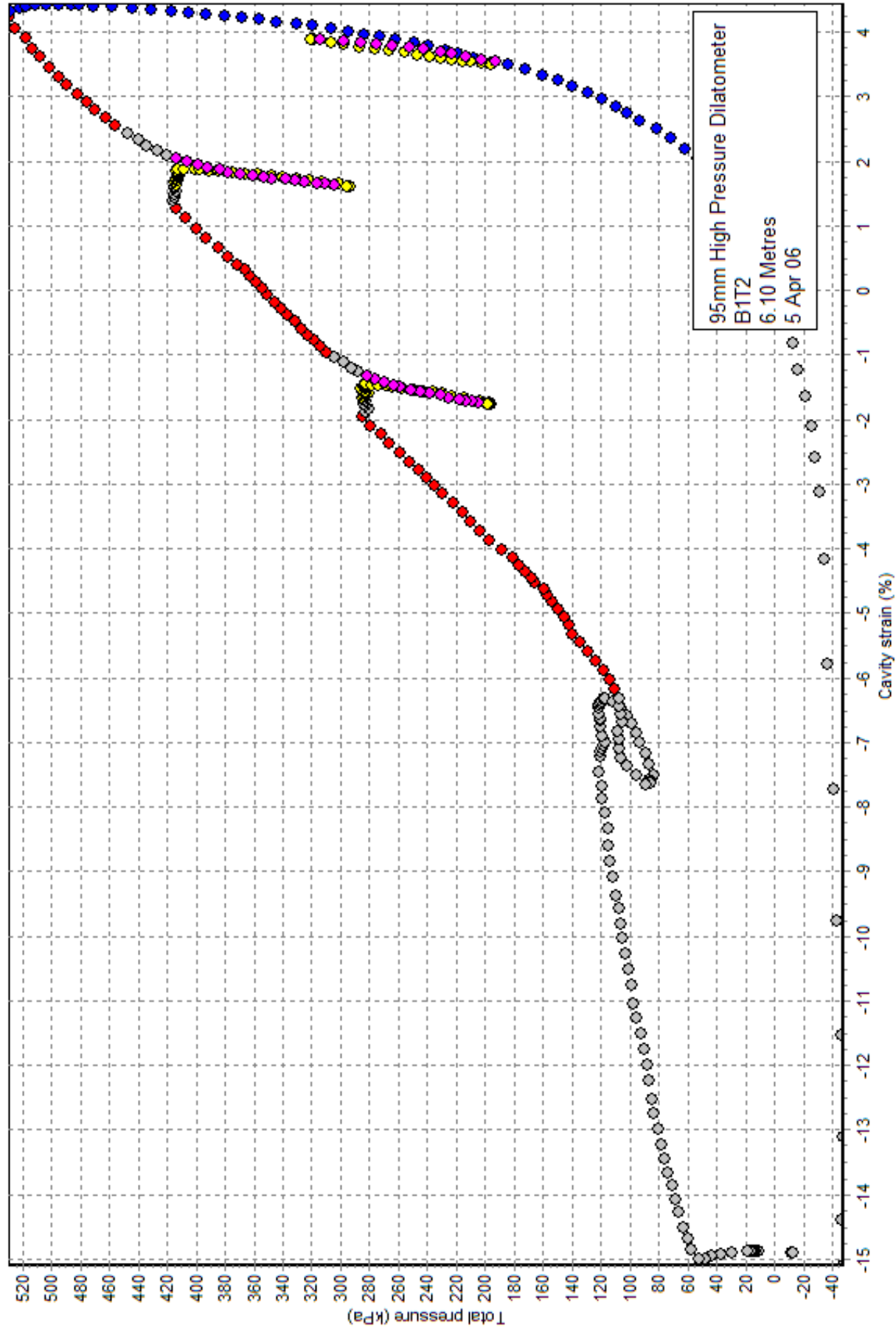
Odd and Even Arms vs Total Pressure

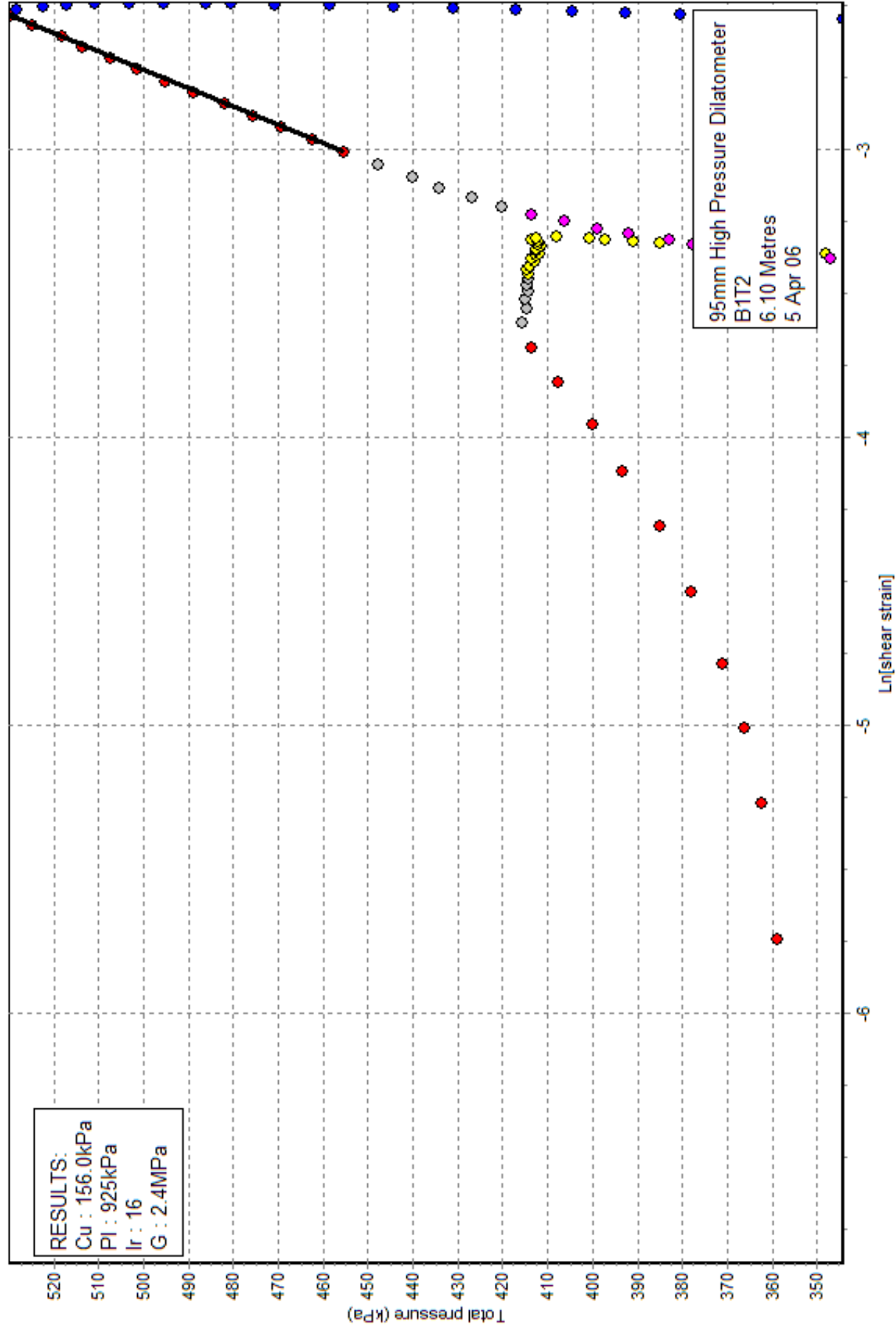


Po of cohesive material (1977, 1990) : Arm ave

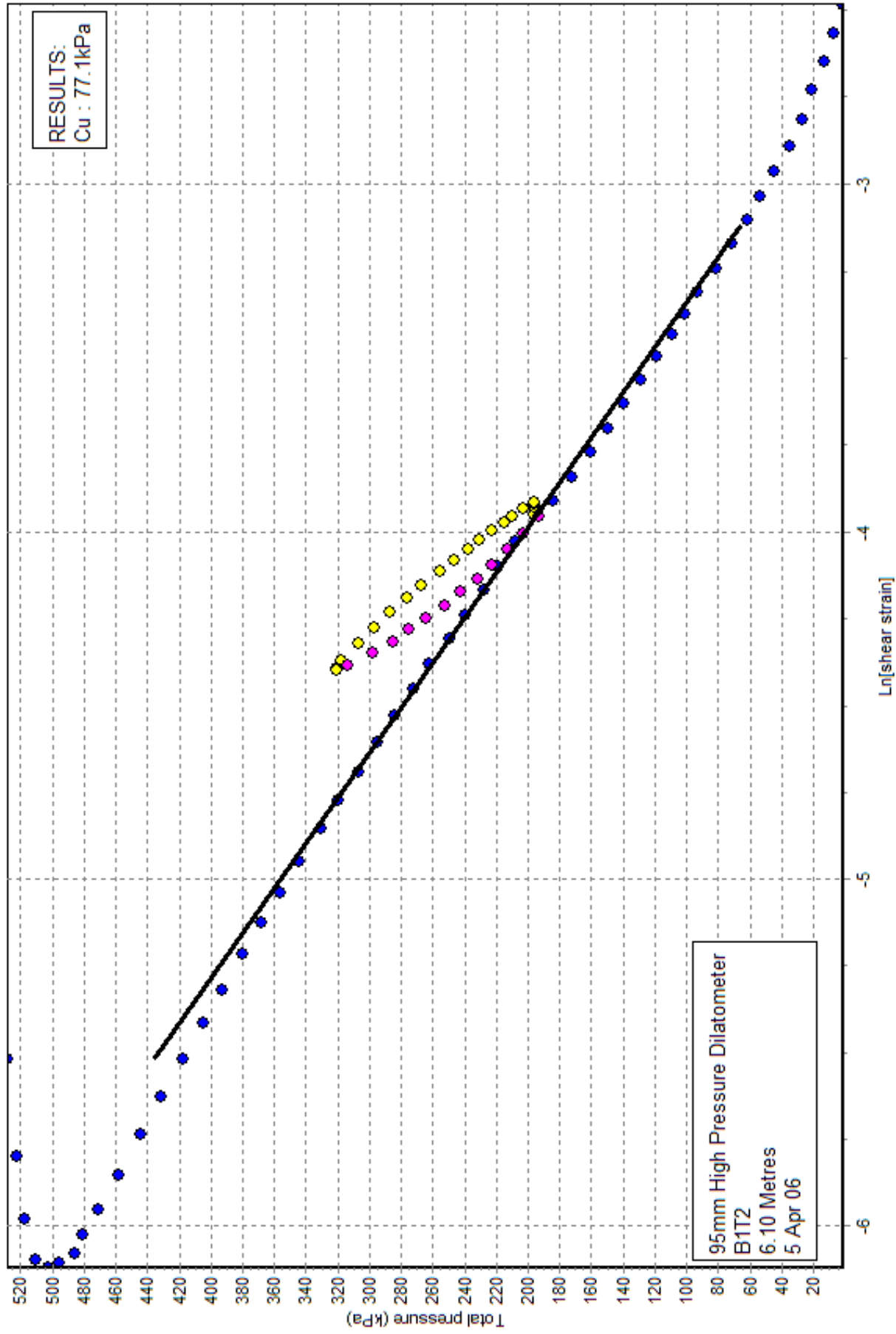


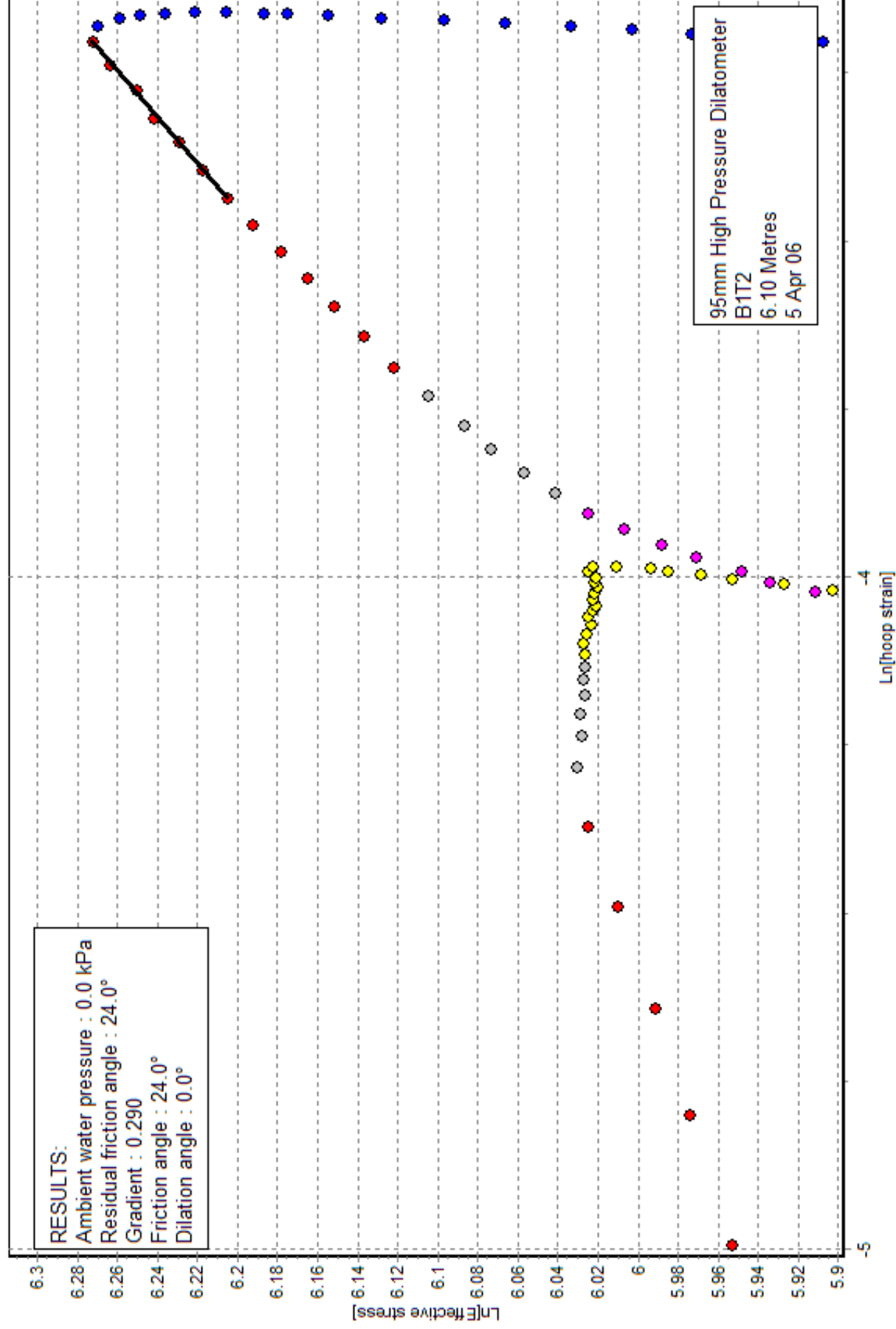
Cavity strain vs Total Pressure : Arm ave



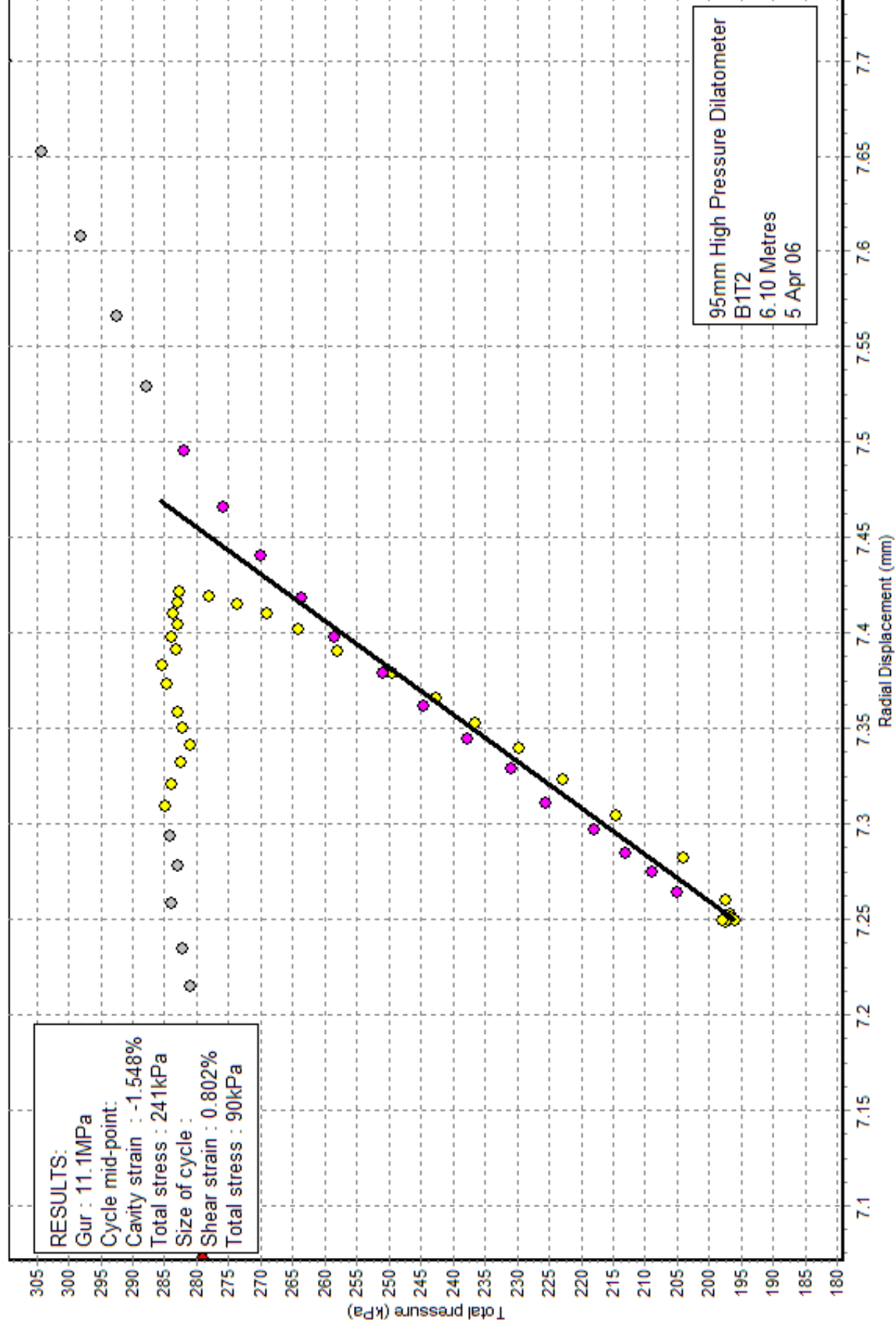


Jefferies (1988) : Arm ave

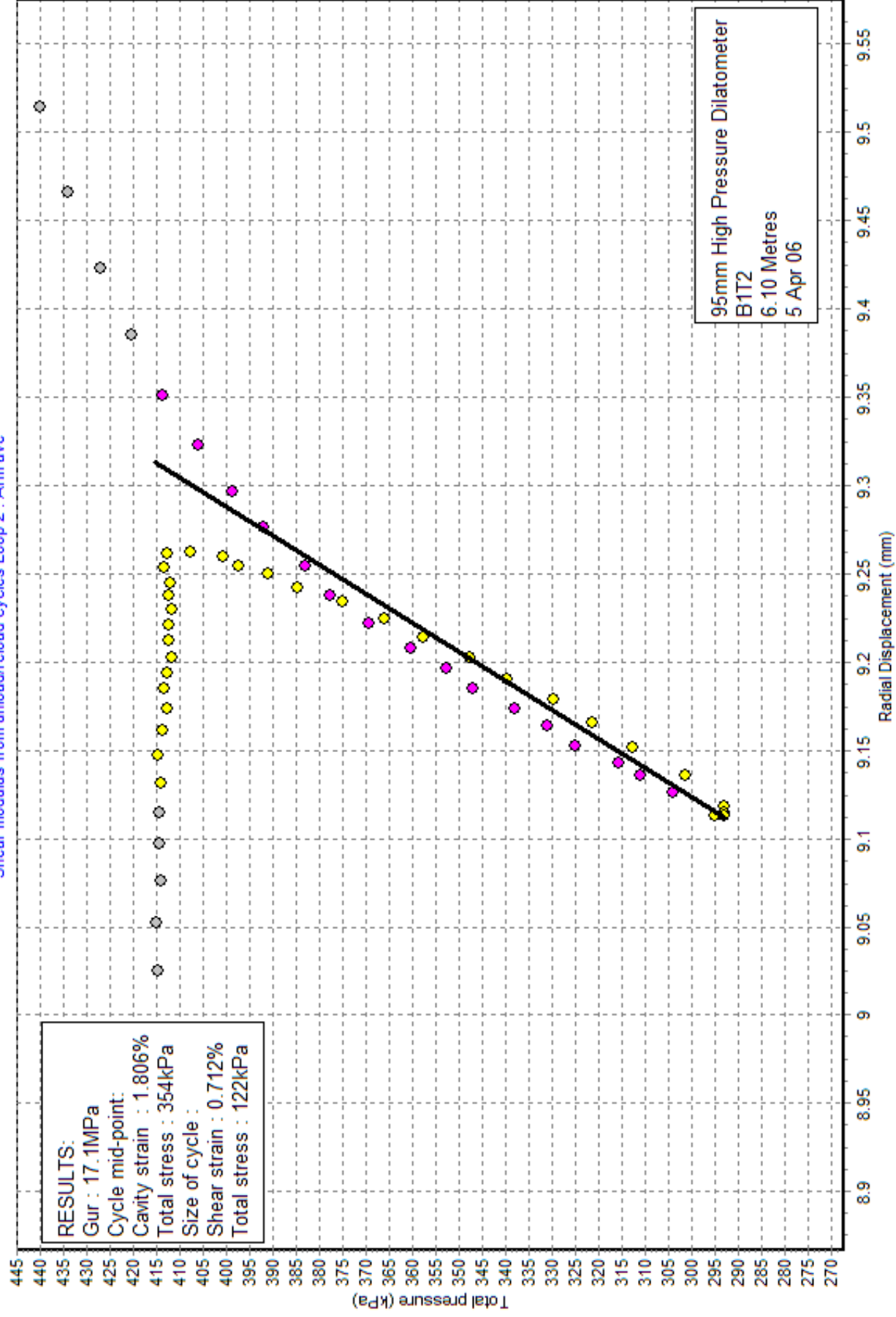




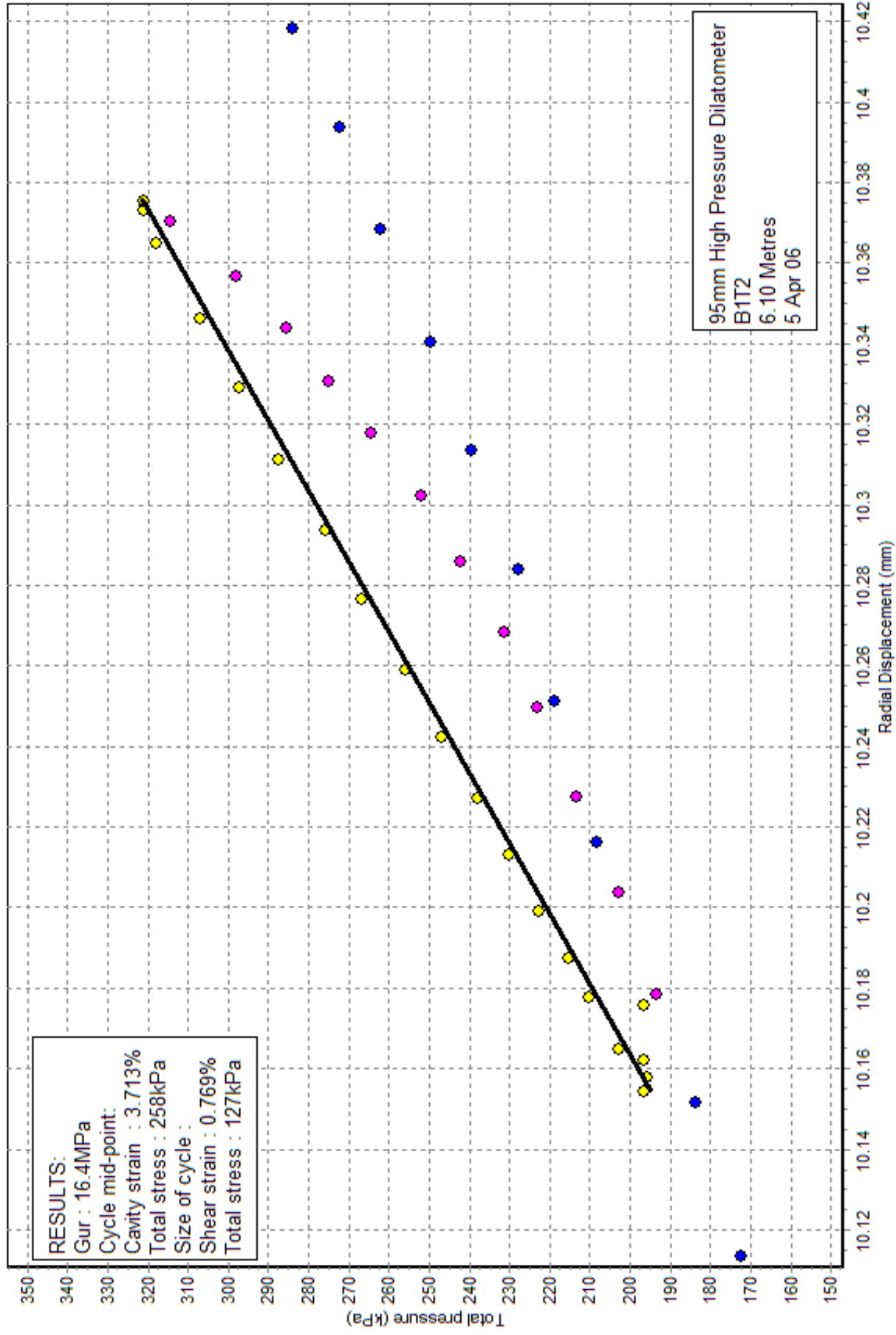
Shear modulus from unload/reload cycles Loop 1 : Arm ave

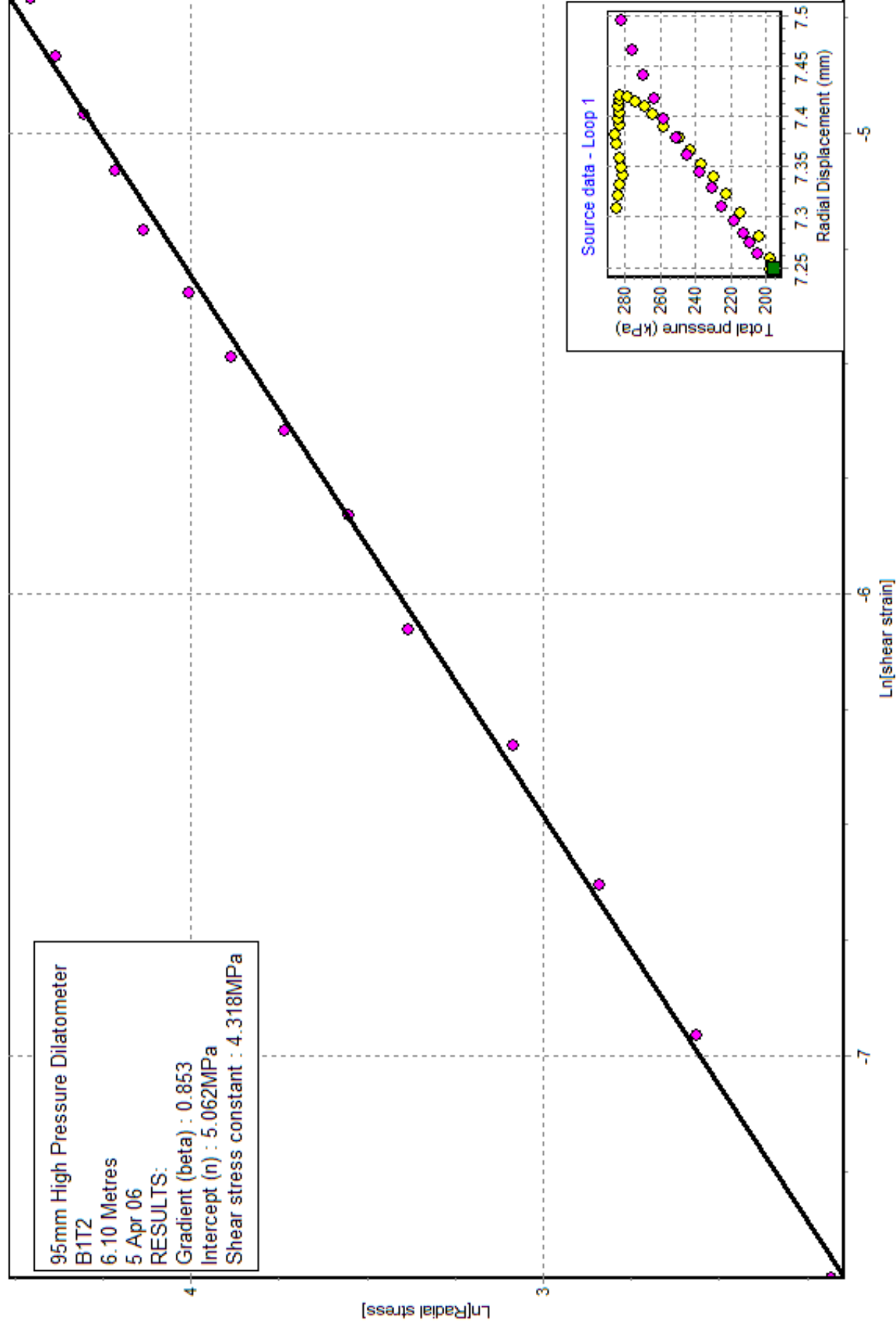


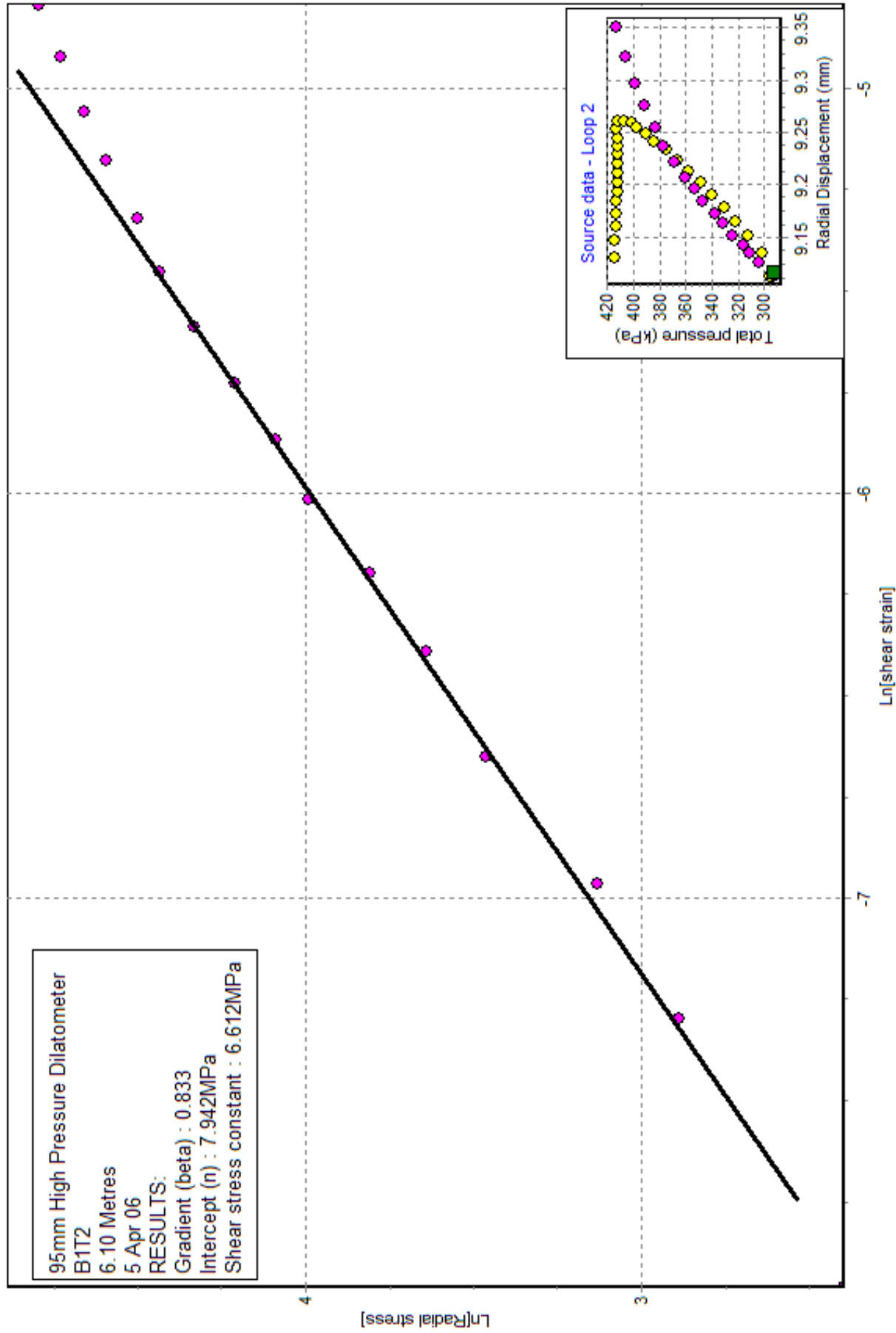
Shear modulus from unload/reload cycles Loop 2 : Arm ave

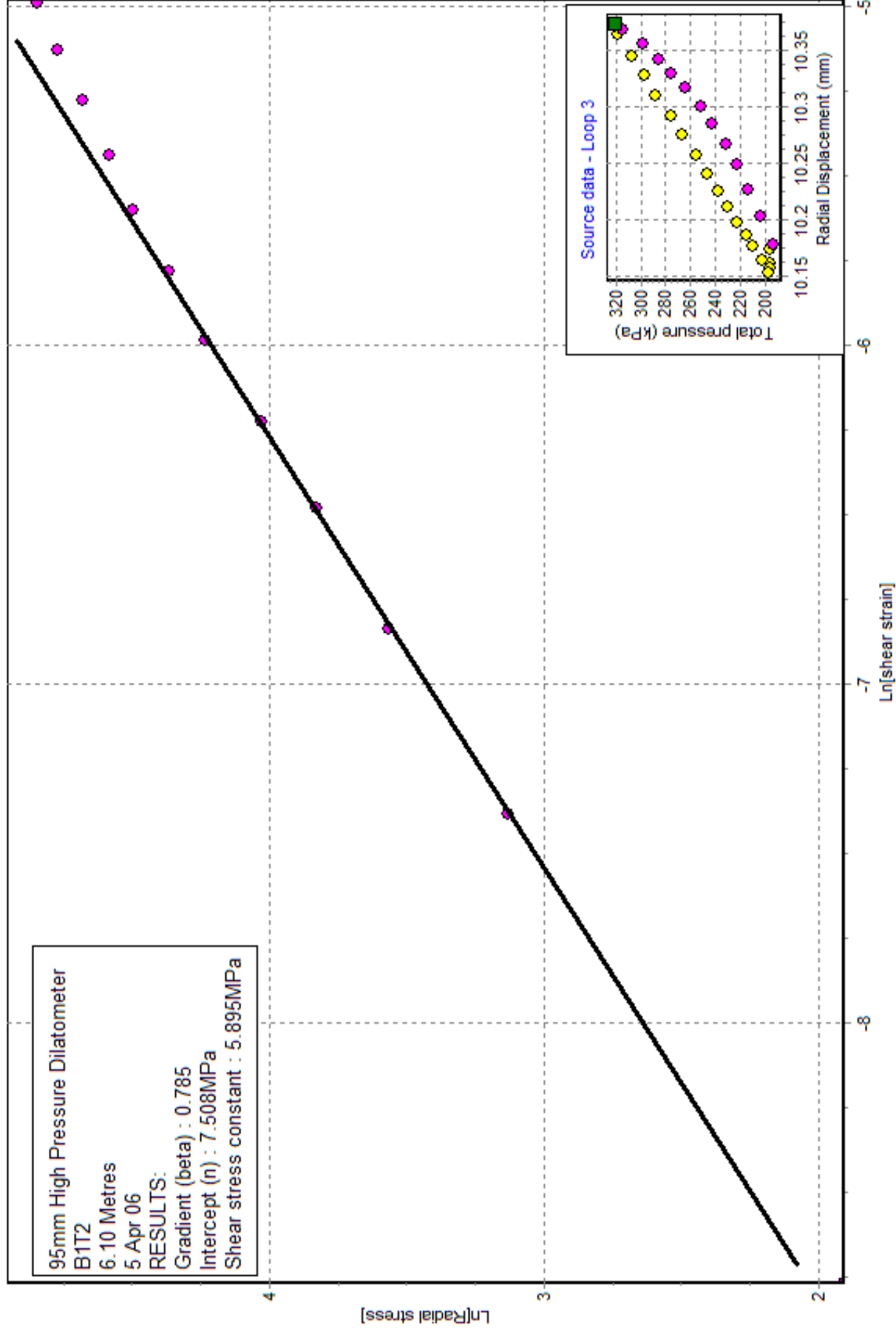


Shear modulus from unload/reload cycles Loop 3 : Arm ave

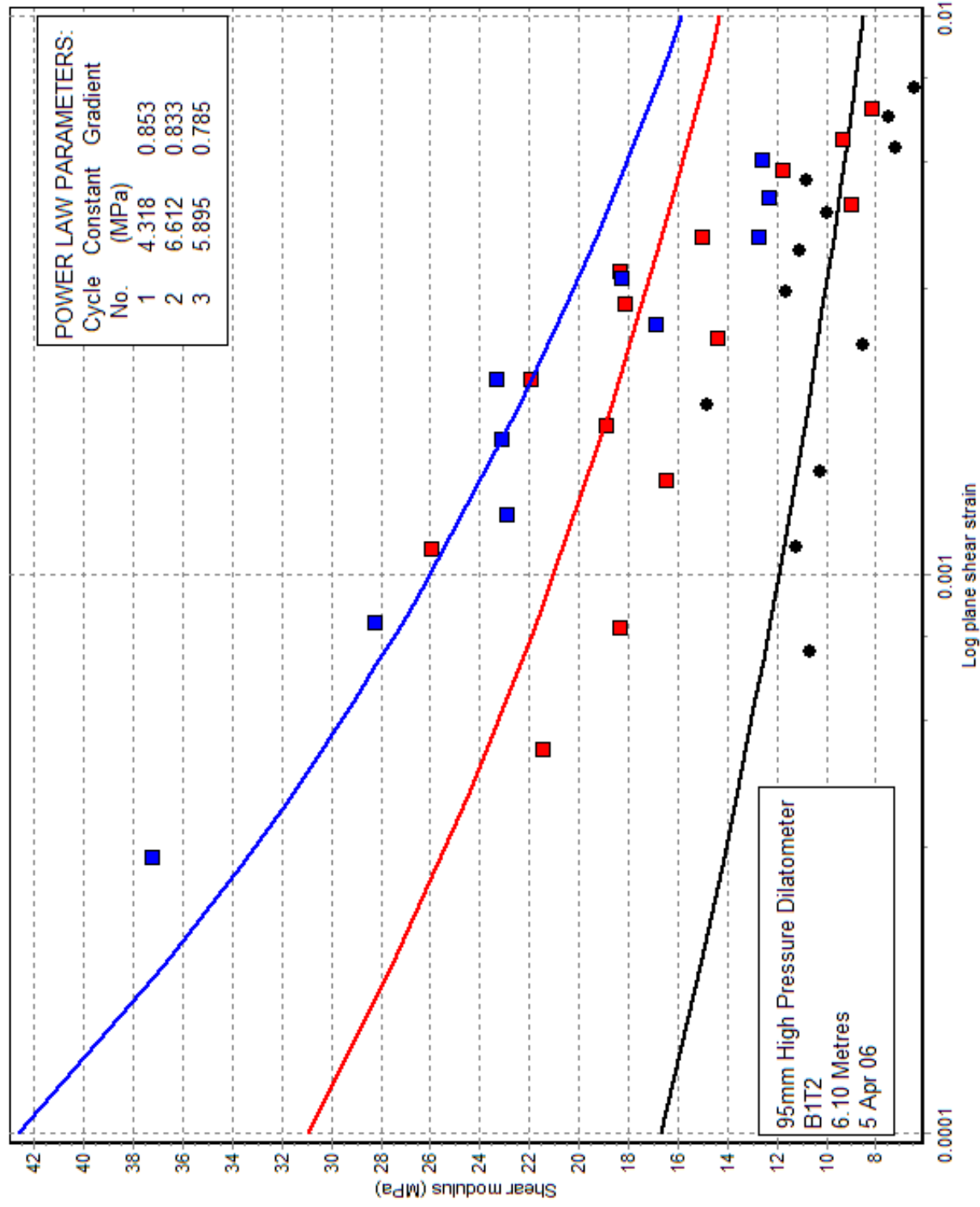




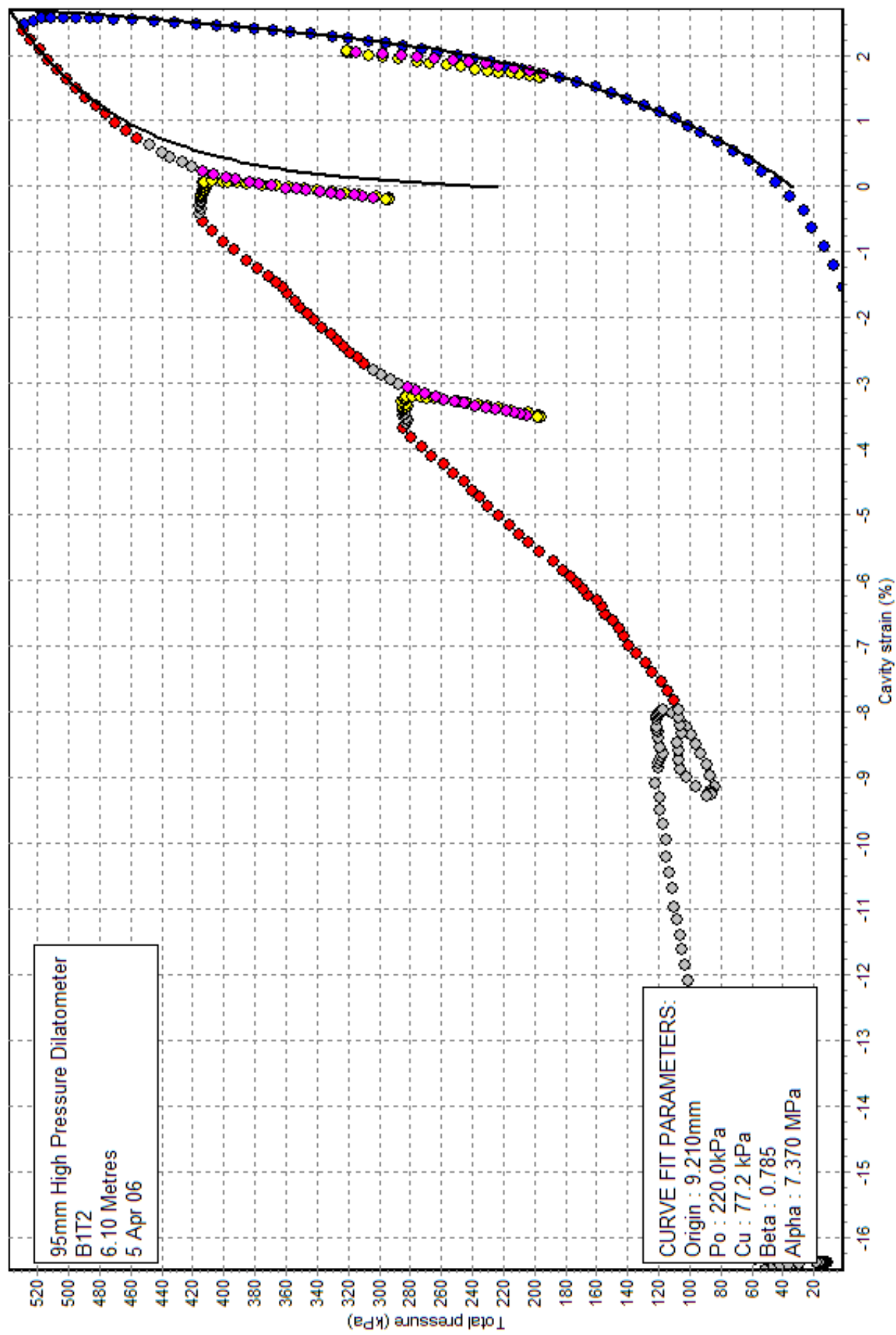




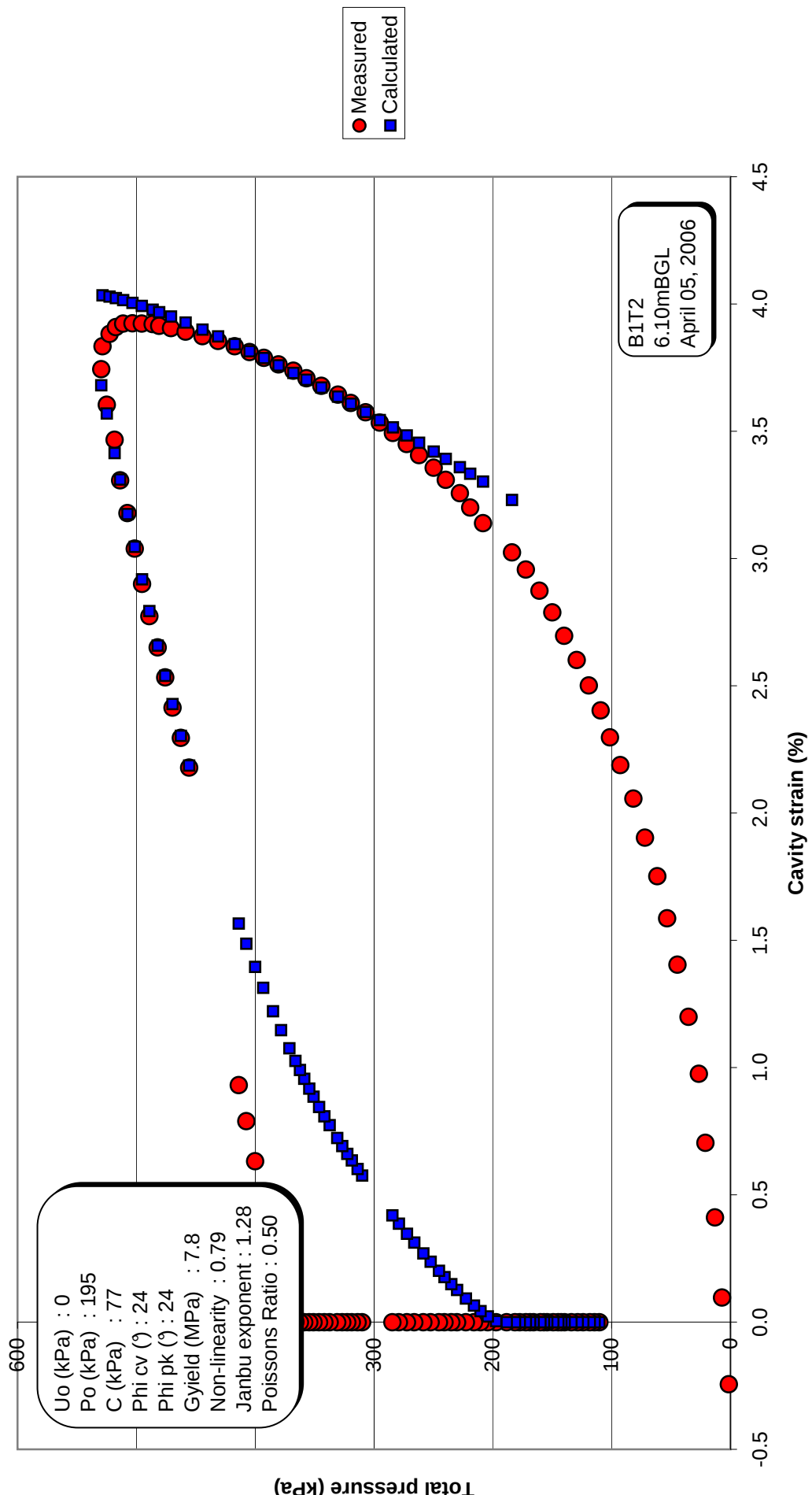
Variation of stiffness with strain, undrained analysis : Arm ave



Curve comparison (Whittle 1999) : Arm ave



Carter et al 1986 - Total pressure vs Cavity strain



B1T3 05/04/06 8.0m Clay and gravel

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Note that these last two plots are included, even though the results obtained are not shown on the summary sheet. The material is a mixture, and no one model fits properly.

Site		Date	Day	Borehole	Test No.	Depth
RURITANIA		5/4/06	TUE	1	3	8m
Material: Glacial Till						
Weather		Water Table	Time Now	Drilling End	Orientation	CHL
Sunny / cold			15:03	15:50		✓
Drilling: TBM core				Pocket: 7 → 8m		
Diameter	Distance	Rate		Core Description		Length
98mm	2m			304r recovery.		
Wet/Dry	Rig	Driller		Core Quality		Size
mod. fresh.						
Pres./Incrmnt	Wait Time	Creep Time		Cycle Time	Disc No.	Inst Ref
						SMLX
Zero Readings:				Machine Diameter:		
Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6	T/Press. Battery
-1522.6	-1690.3	-1744.7	-1752.7	-1781.2	-23135	A: 201.1 B: 1522.7 12.2 ✓
Calibrations:						
Strain Arm Calibration Date:				10/1/11		
Total Pressure Cell Calibration Date:				10/1/11		
Membrane Stiffness Calibration Date:				2/2/11		
Mem. Compression Calibration Date:				2/2/11		
New Membrane Fitted Date:				2/2/11		
Test Comments:						
Test Starts at:				15:05		
Time	Line No	Notes				
15:10	85	Hold. - either large pocket or neck material.				
15:21	101	loop 1				
15:33	171	Hold				
15:36	190	loop 2				
15:45	245	Unload				
15:49	266	loop 3				
Test Ends at:				16:00		
Max. Pressure Reached:				664 kPa		
General Comments:						
• Bore TPT used. • Very large and even expansion. • Very different test curve compared to T1. • Lower section of membrane saw more displacement than upper (after inspecting after test).						

Driller: Mark / Mike /
 Archive
 Operator: SDB

Site:- Ruritania

Test :- B1T3

Test Date :- 5th April 2006

Material :- Clay & gravel

Depth :- 8.0 mtrs

Water table :- ~ 11m

Analysis of Insitu Lateral Stress (P_o) :-

		Arm Av.
Marsland and Randolph	kPa	340
Strain zero	mm	1.4

Analysis of Undrained Shear Strength (C_u) :-

Gibson and Anderson	kPa	323
Pressure at failure (P_F)	kPa	470
Limit Pressure (P_L)	kPa	1086
Jefferies (unloading)	kPa	105

Strength of Sands Analysis (Hughes, Wroth & Windle)

Friction angle at const. vol.	deg	24	(assumed)
Angle of Friction	deg	35.5	
Angle of Dilation	deg	13.1	

Note that the curve matching technique, based on the equations of Carter et al, predicts zero dilation. This is a consequence of the much larger strain zero required to get a reasonable match.

Analysis of Shear Modulus (G) :-

Initial Modulus (G_i)	MPa	1.0
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Linear Analysis of Reload Loops (G_R) :-

		Loop 1	Loop 2	Loop 3
G_R	MPa	16.3	23.4	25.5
Pressure at start	kPa	510	670	370
Depth of unload	kPa	170	215	-185

Non-linear Analysis of Reloading data :-

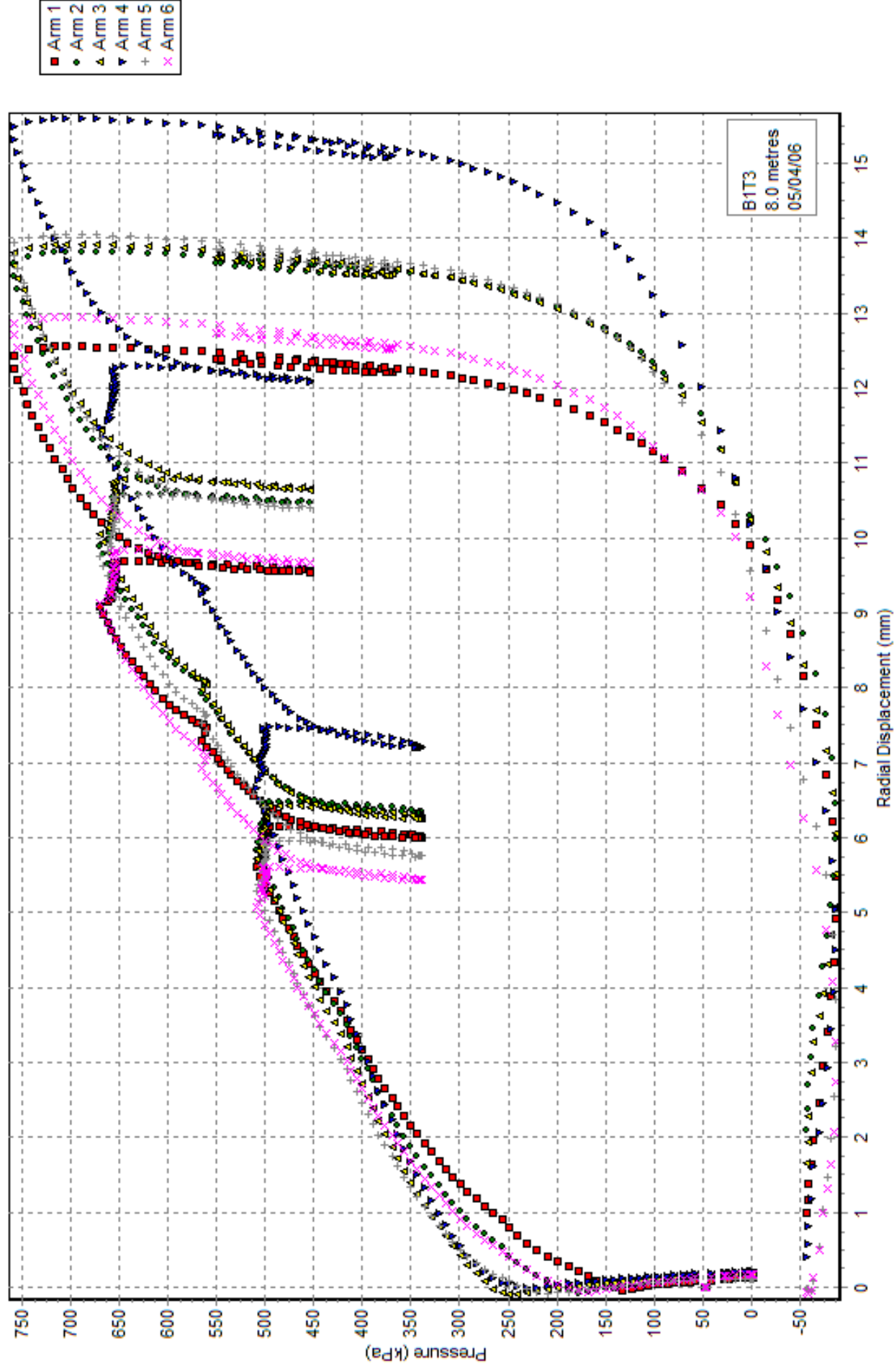
α	MPa	1.91	3.08	3.94
β		0.649	0.670	0.649

Shear Modulus G_S (at 2 levels of shear strain) :-

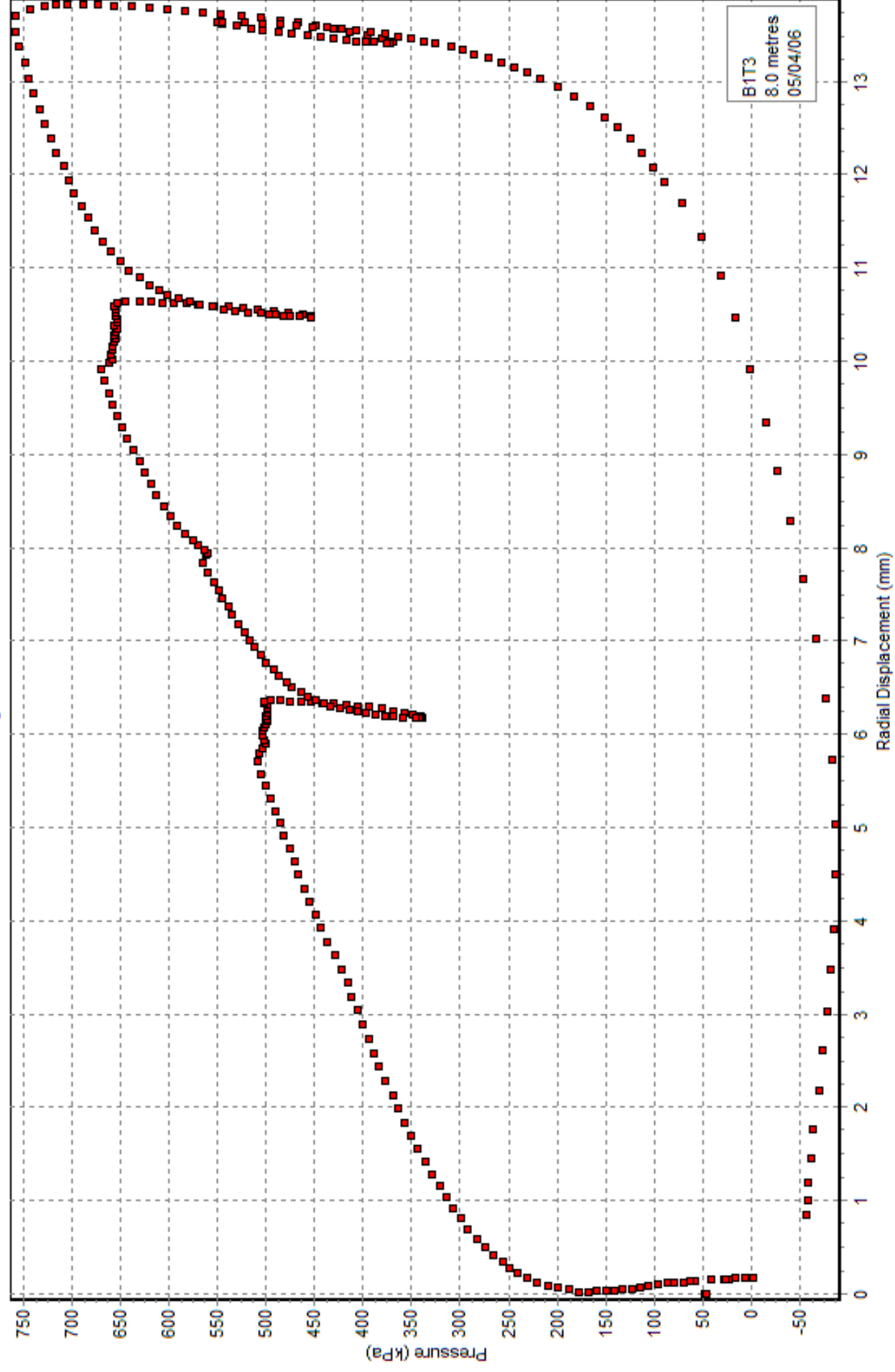
(0.01%)	MPa	48.4	64.5	99.9
(0.1%)	MPa	21.6	30.1	44.5

Test Analysed By :- PGH
Date :- March 2011

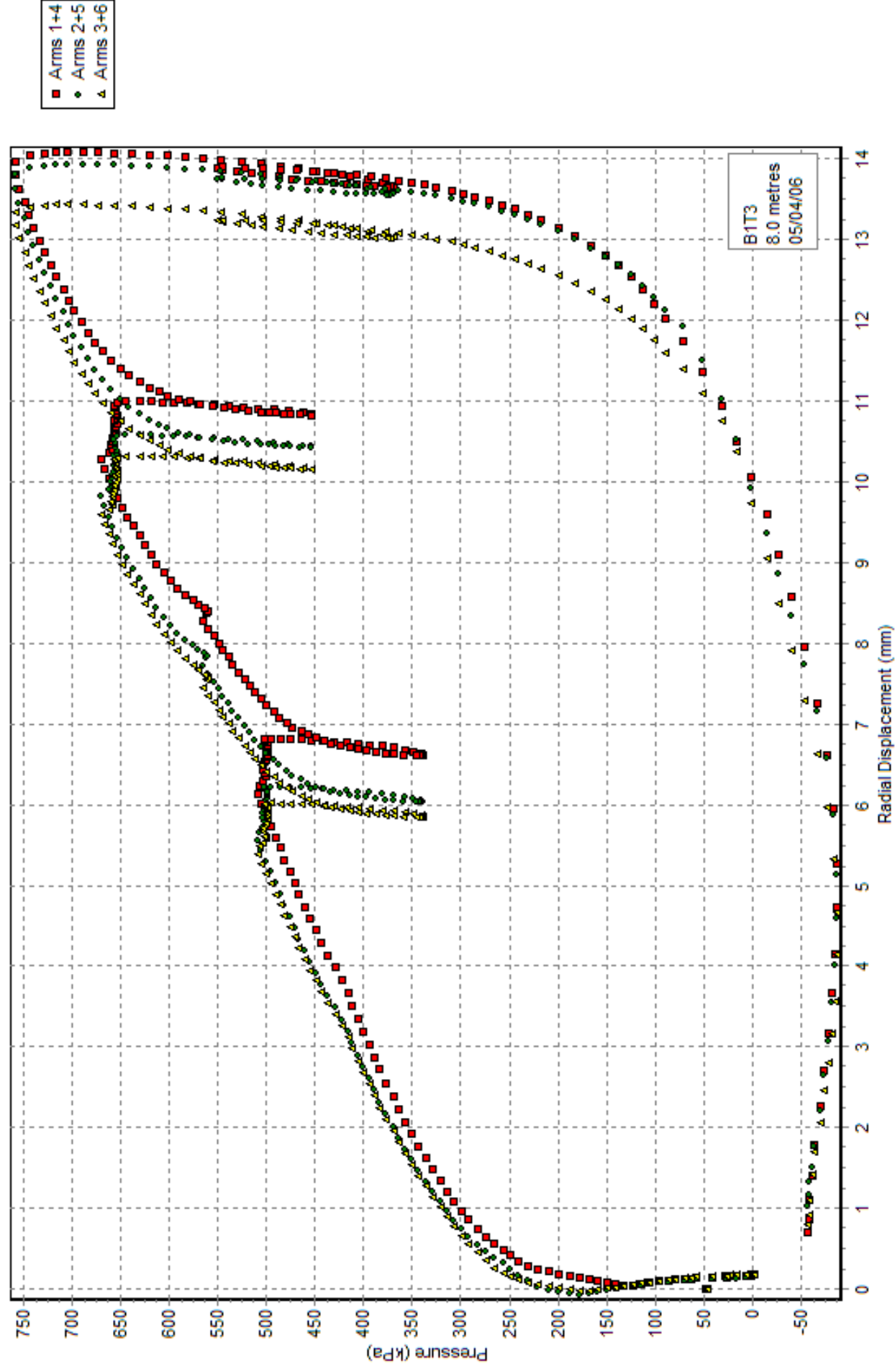
All Arms vs Total Pressure



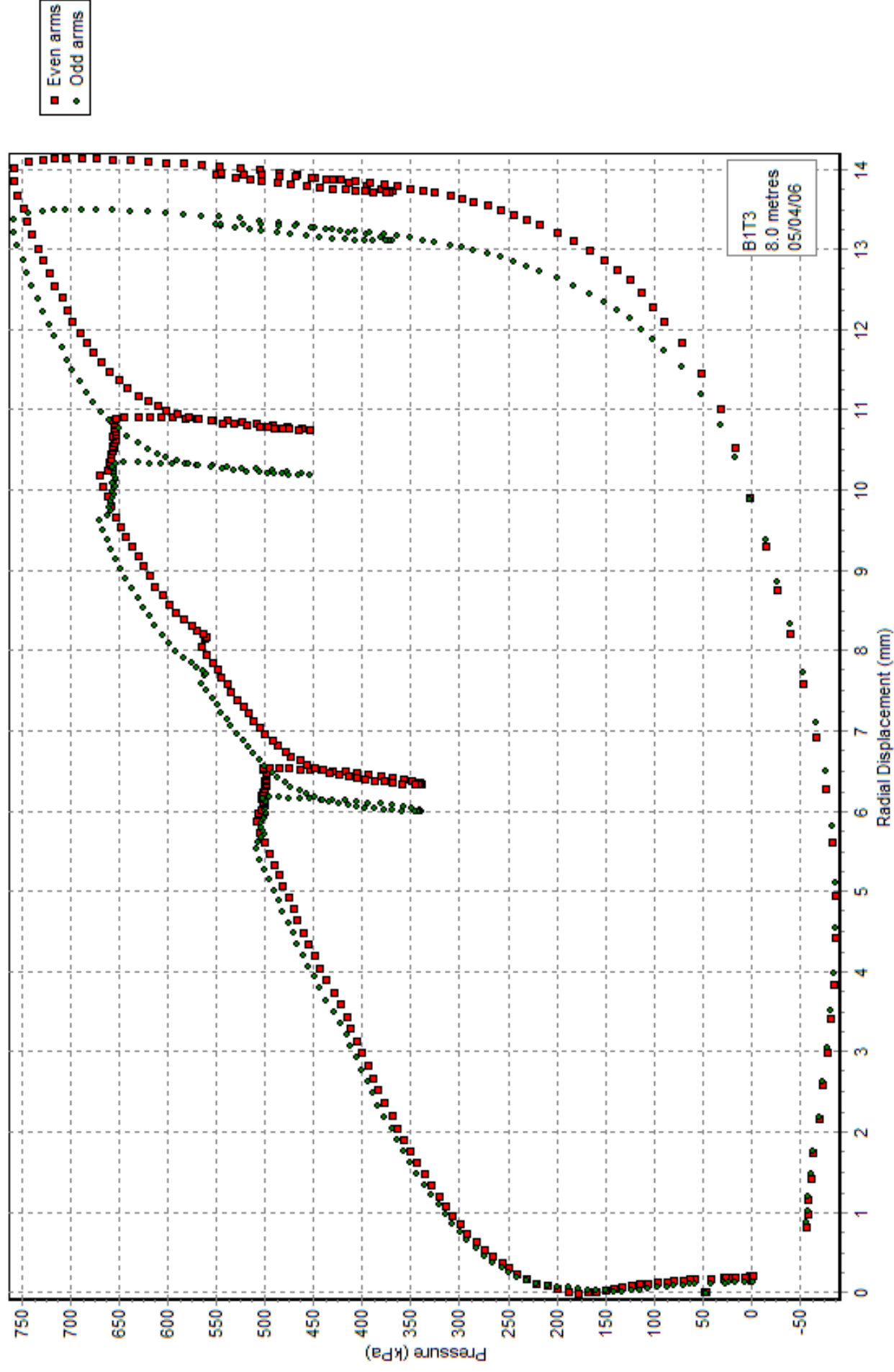
Arm Average vs Total Pressure



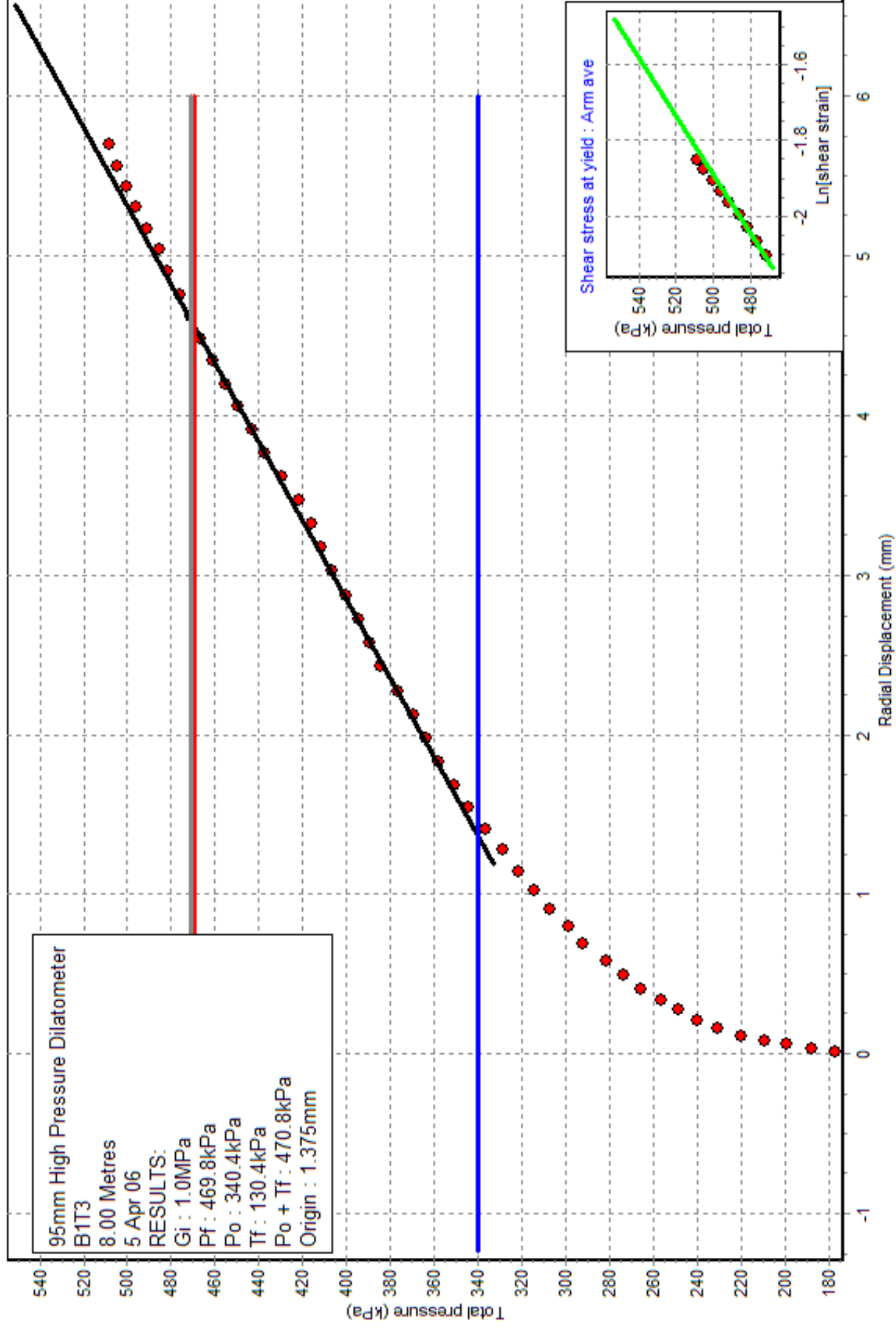
Arm Pairs vs Total Pressure



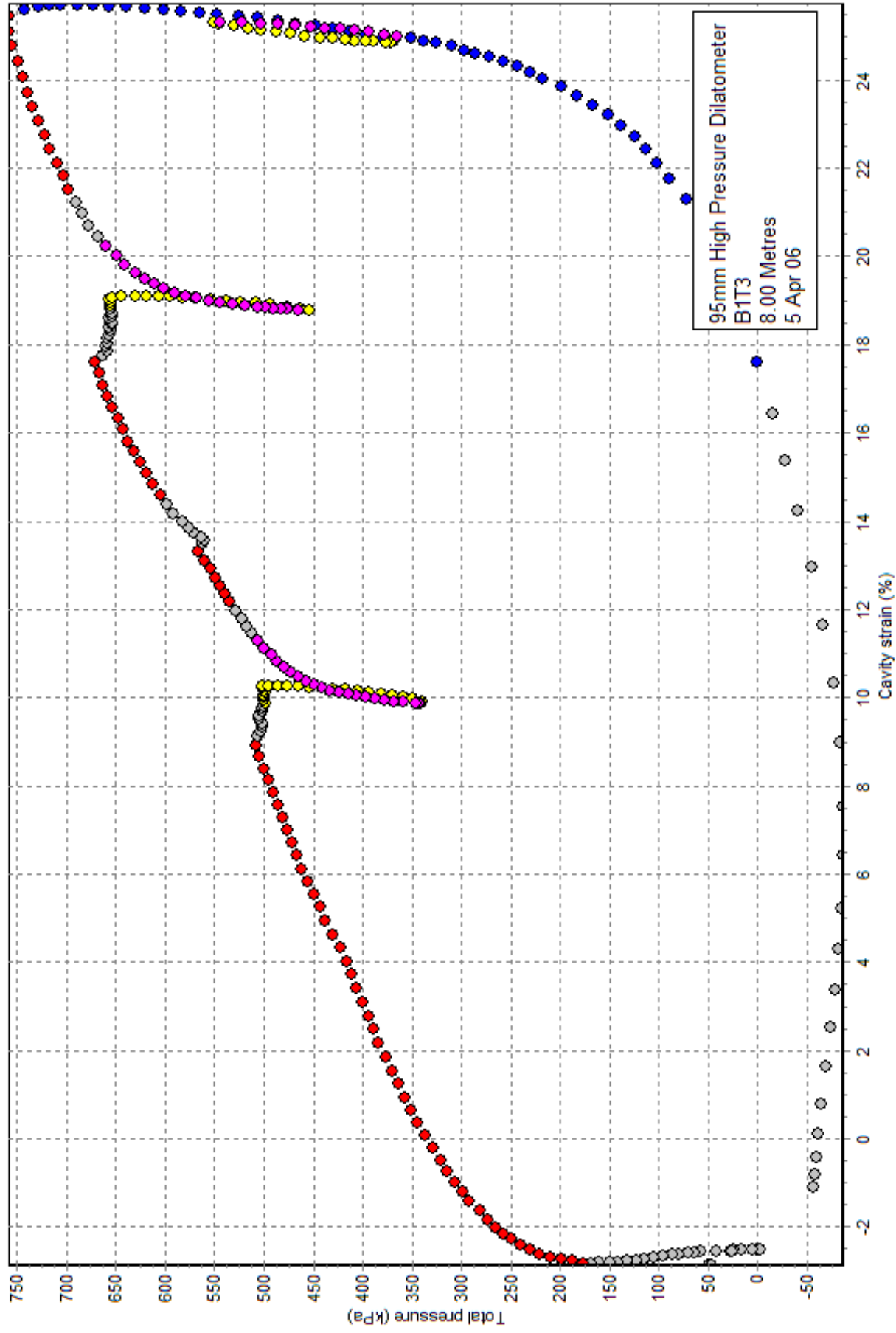
Odd and Even Arms vs Total Pressure

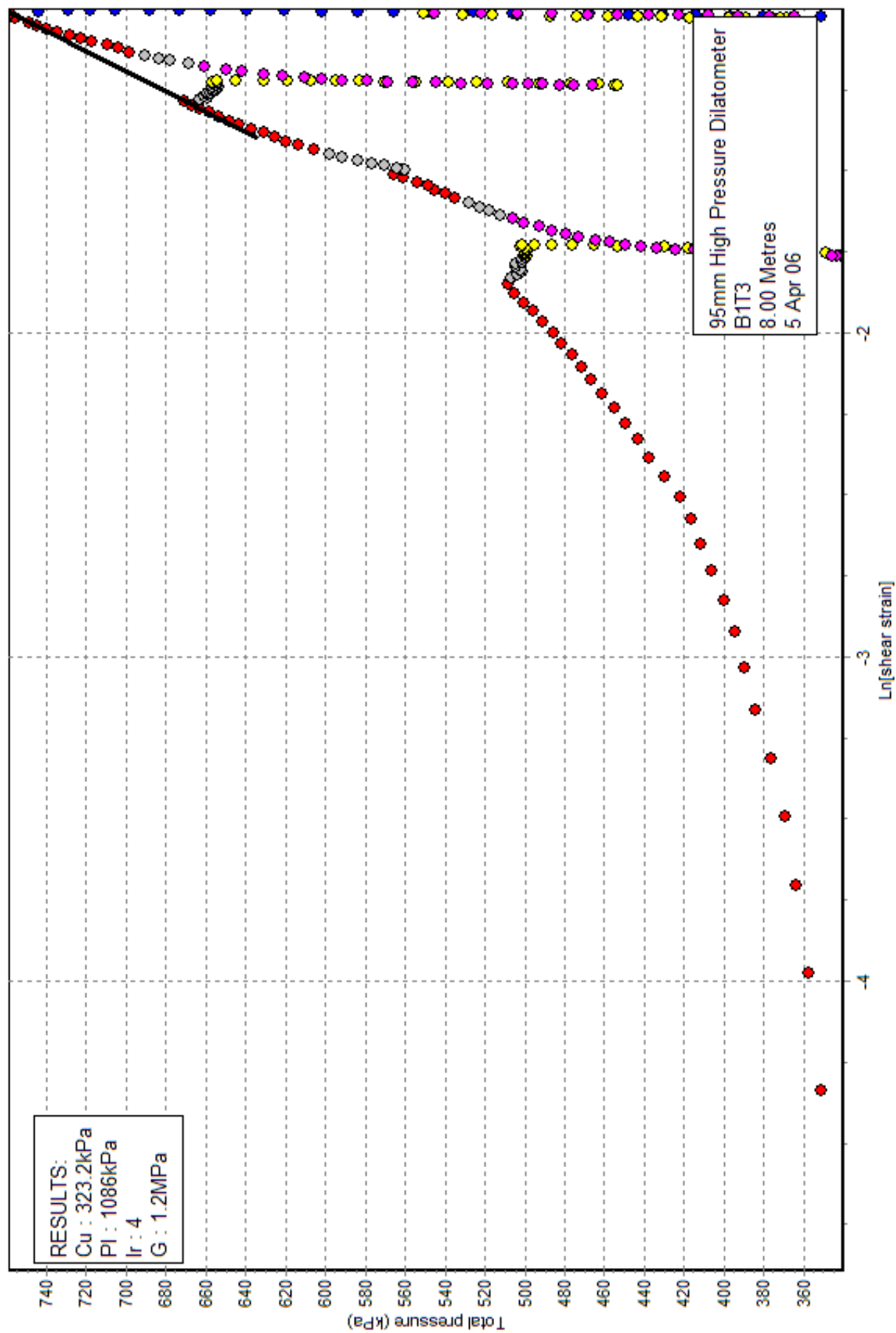


Po of cohesive material (1977, 1990) : Arm ave

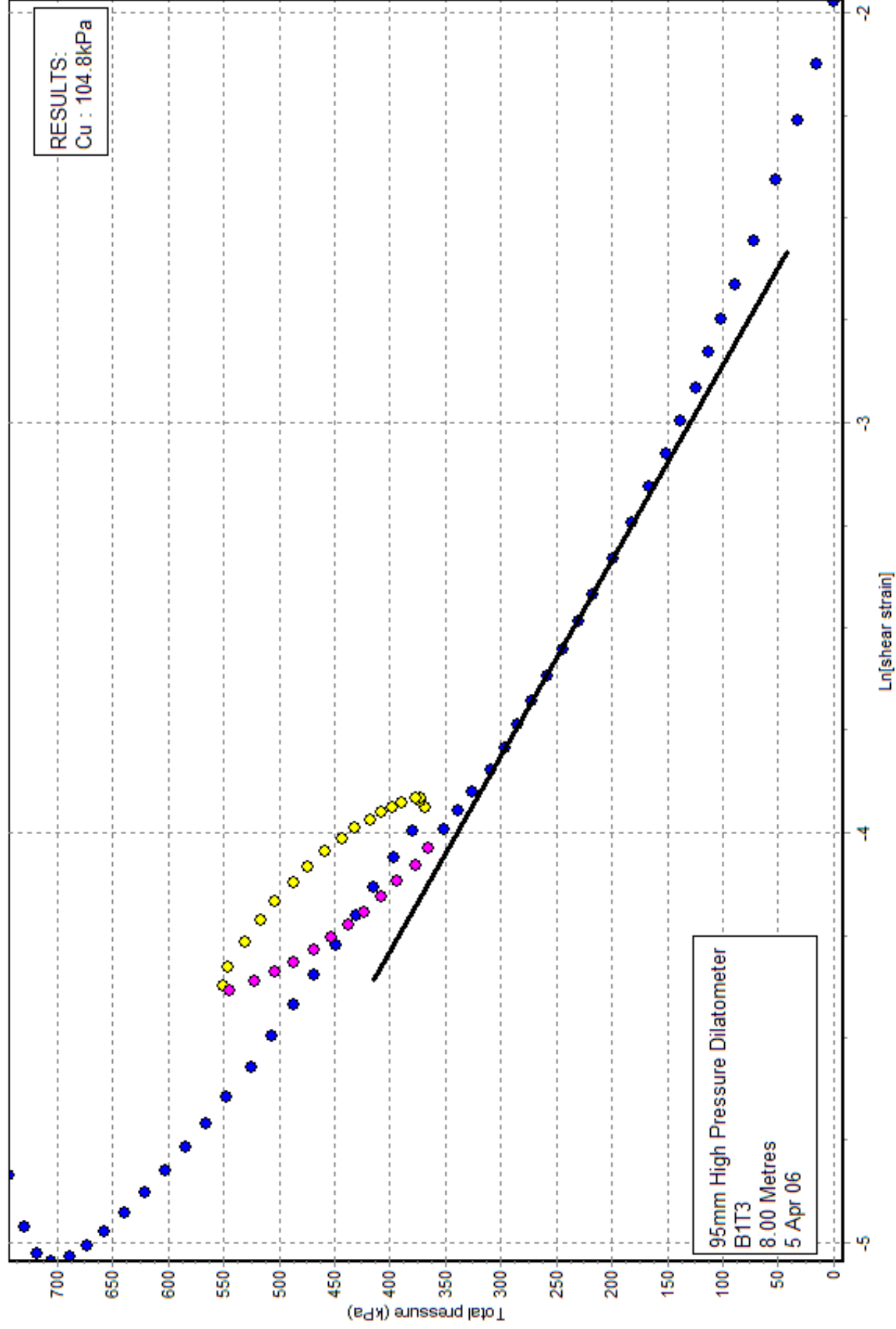


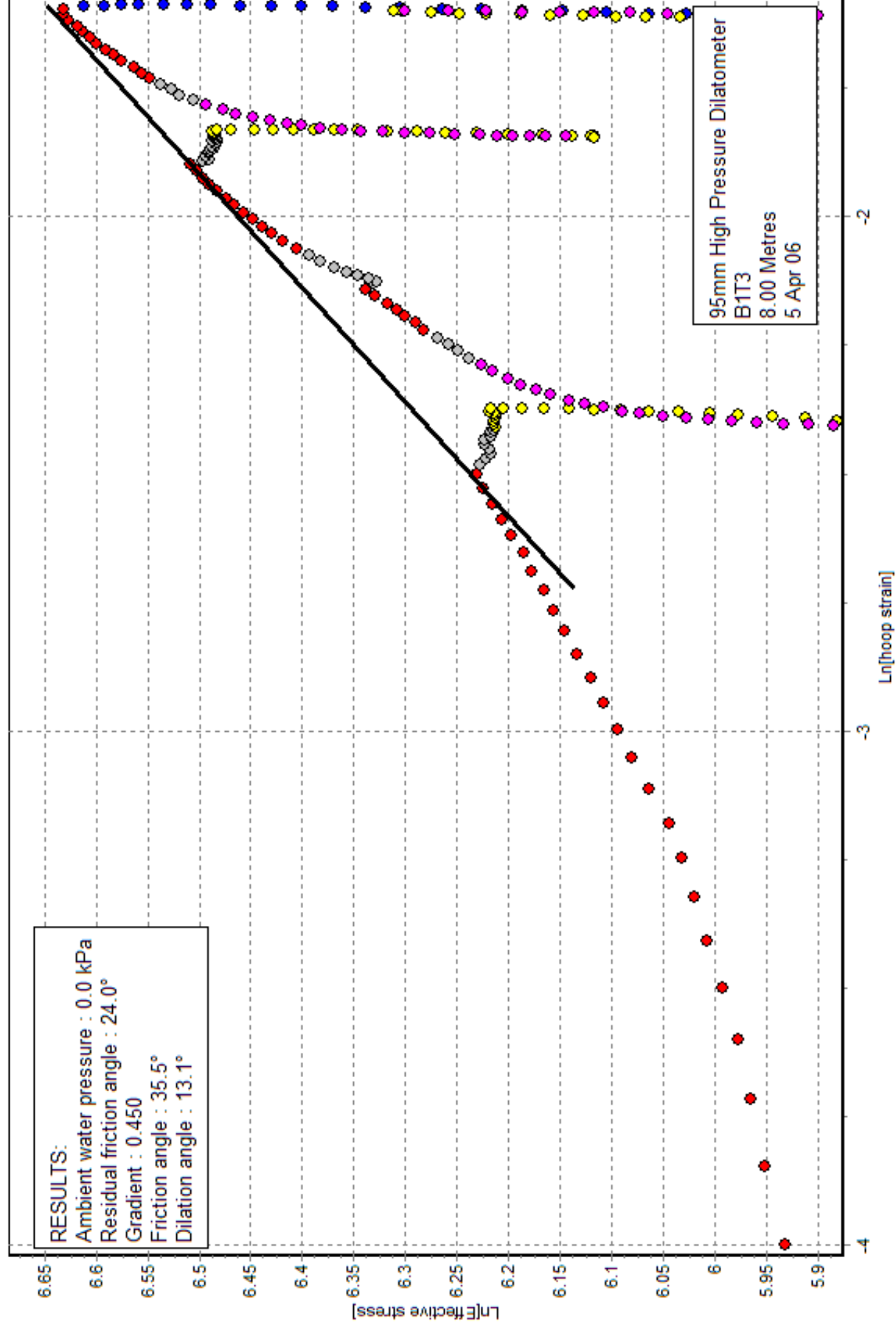
Cavity strain vs Total Pressure : Arm ave



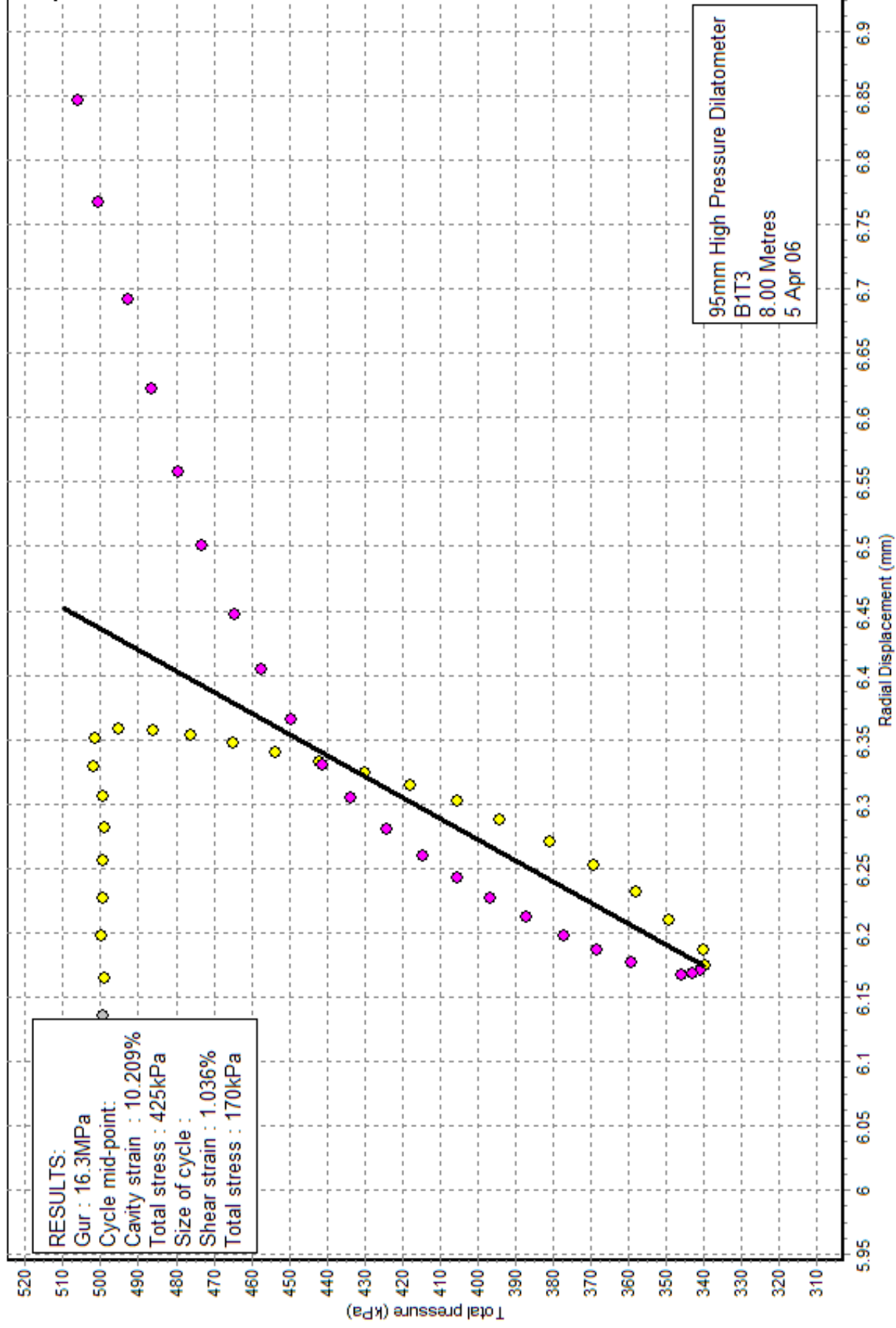


Jefferies (1988) : Arm ave

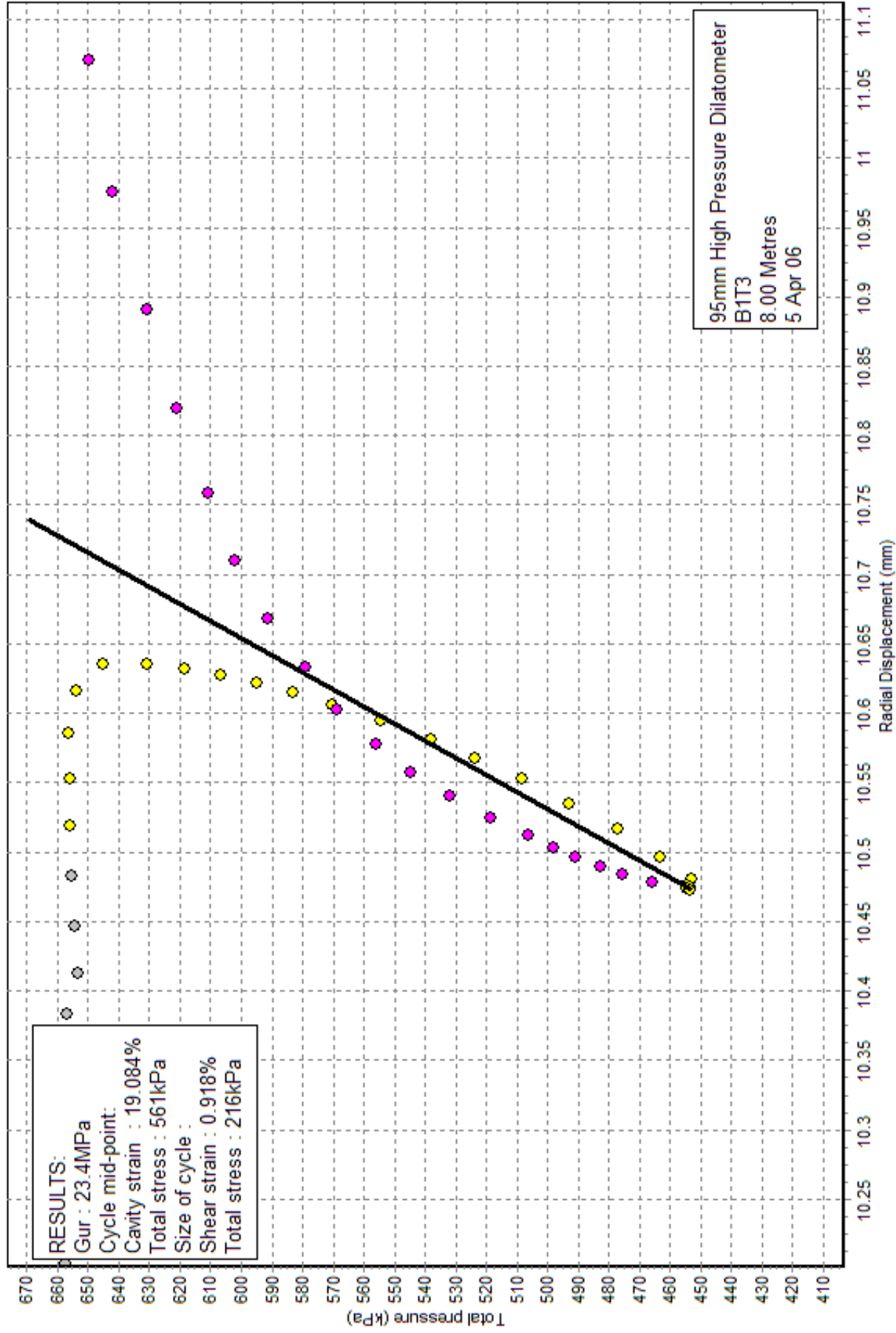




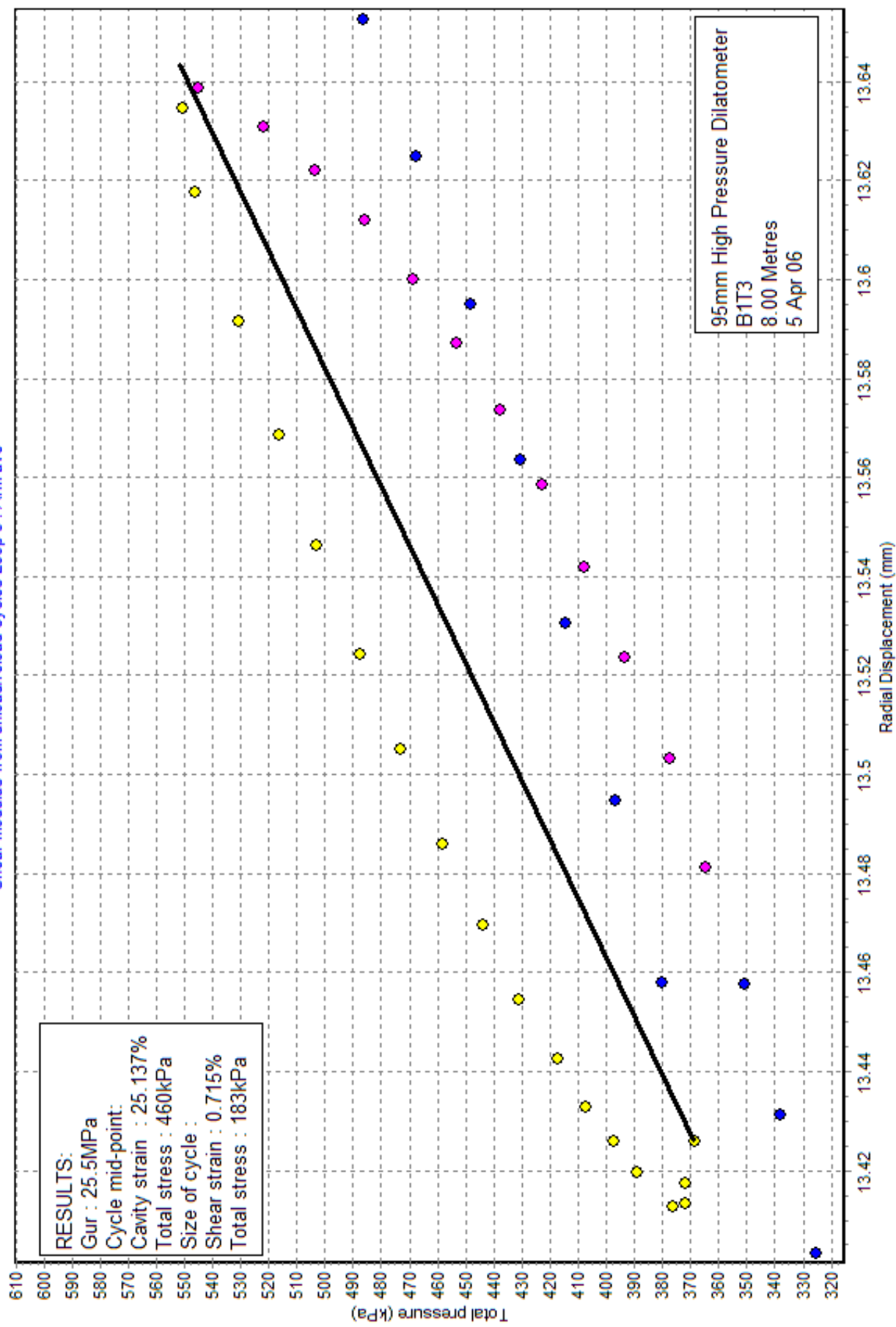
Shear modulus from unload/reload cycles Loop 1 : Arm ave

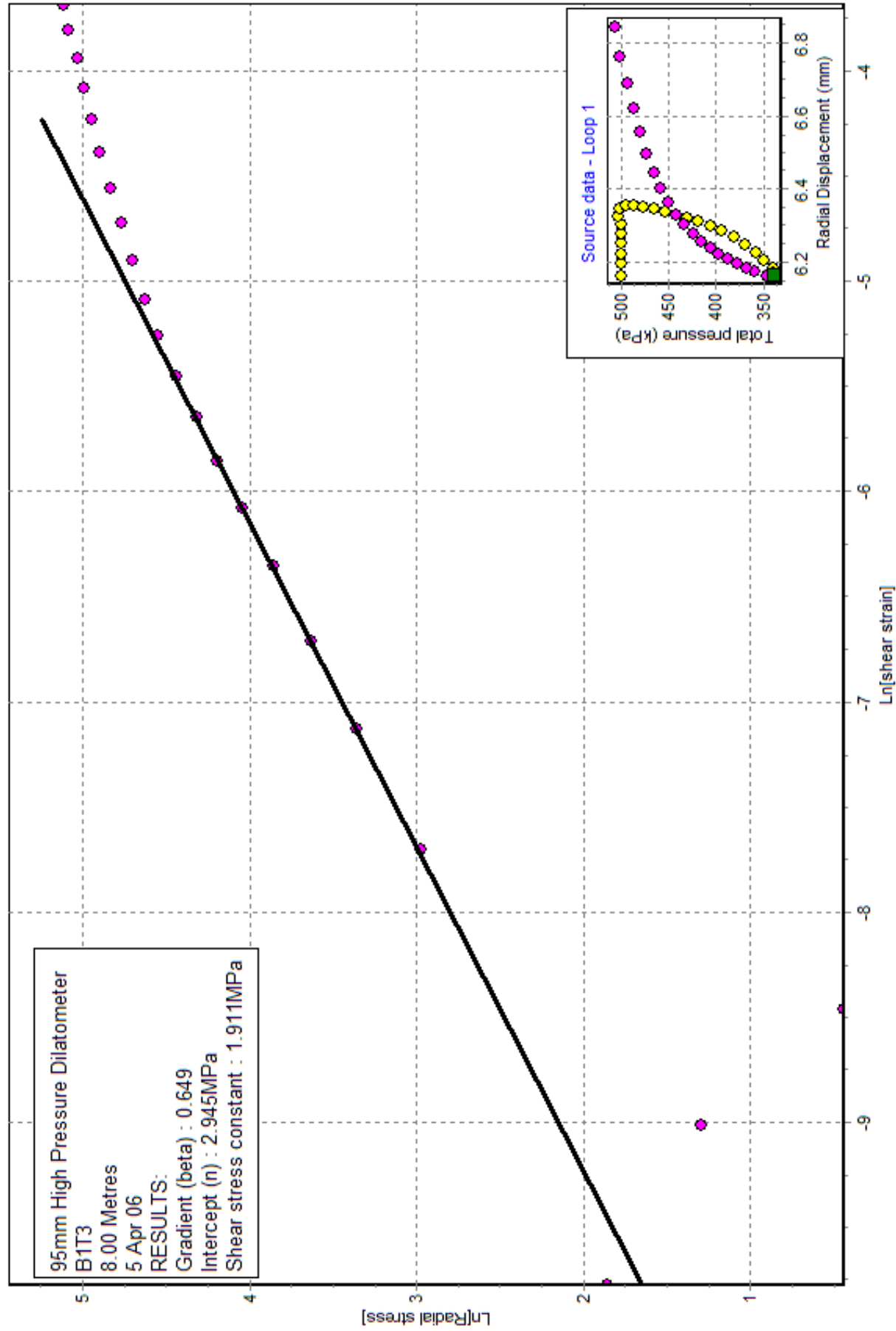


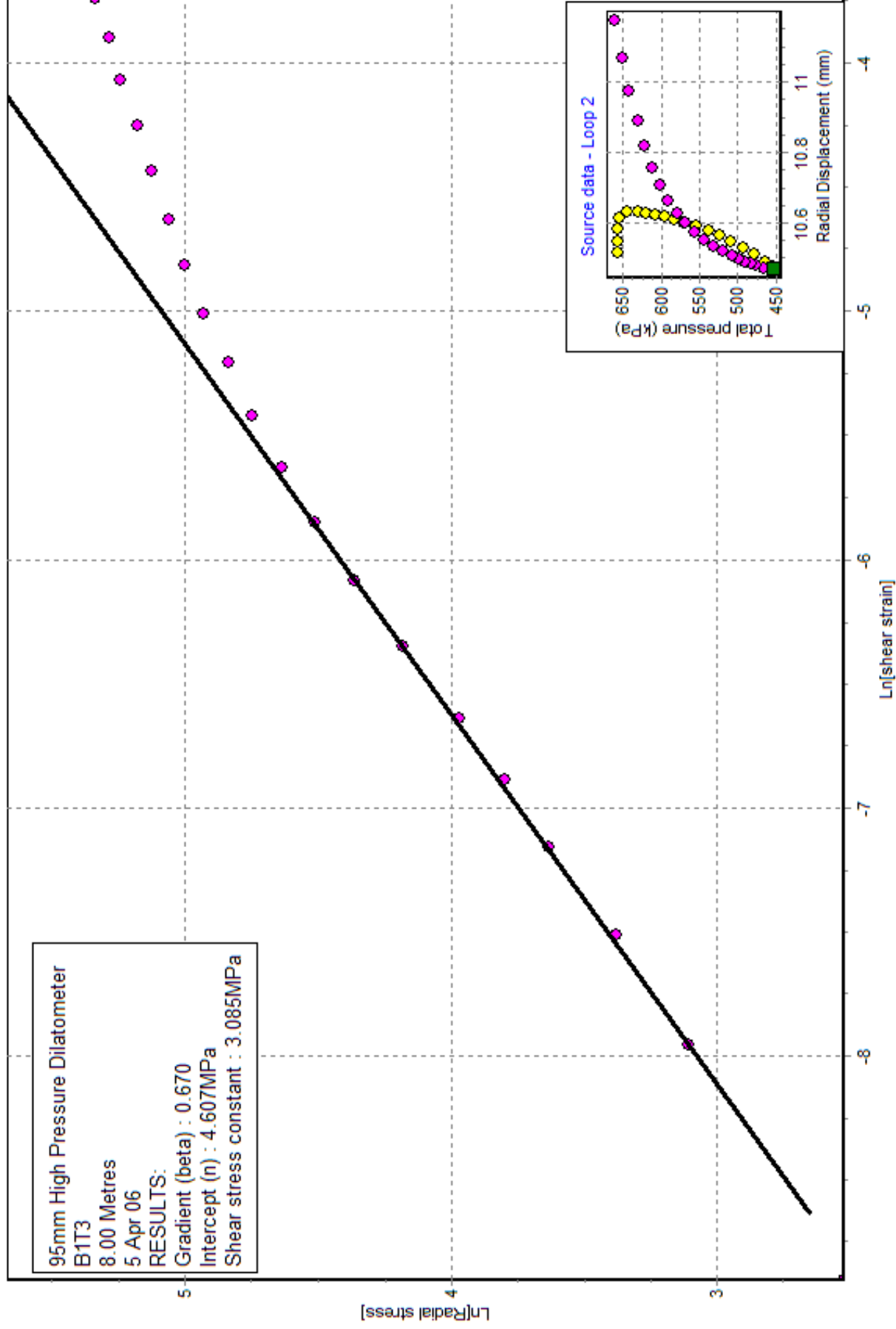
Shear modulus from unload/reload cycles Loop 2 : Arm ave

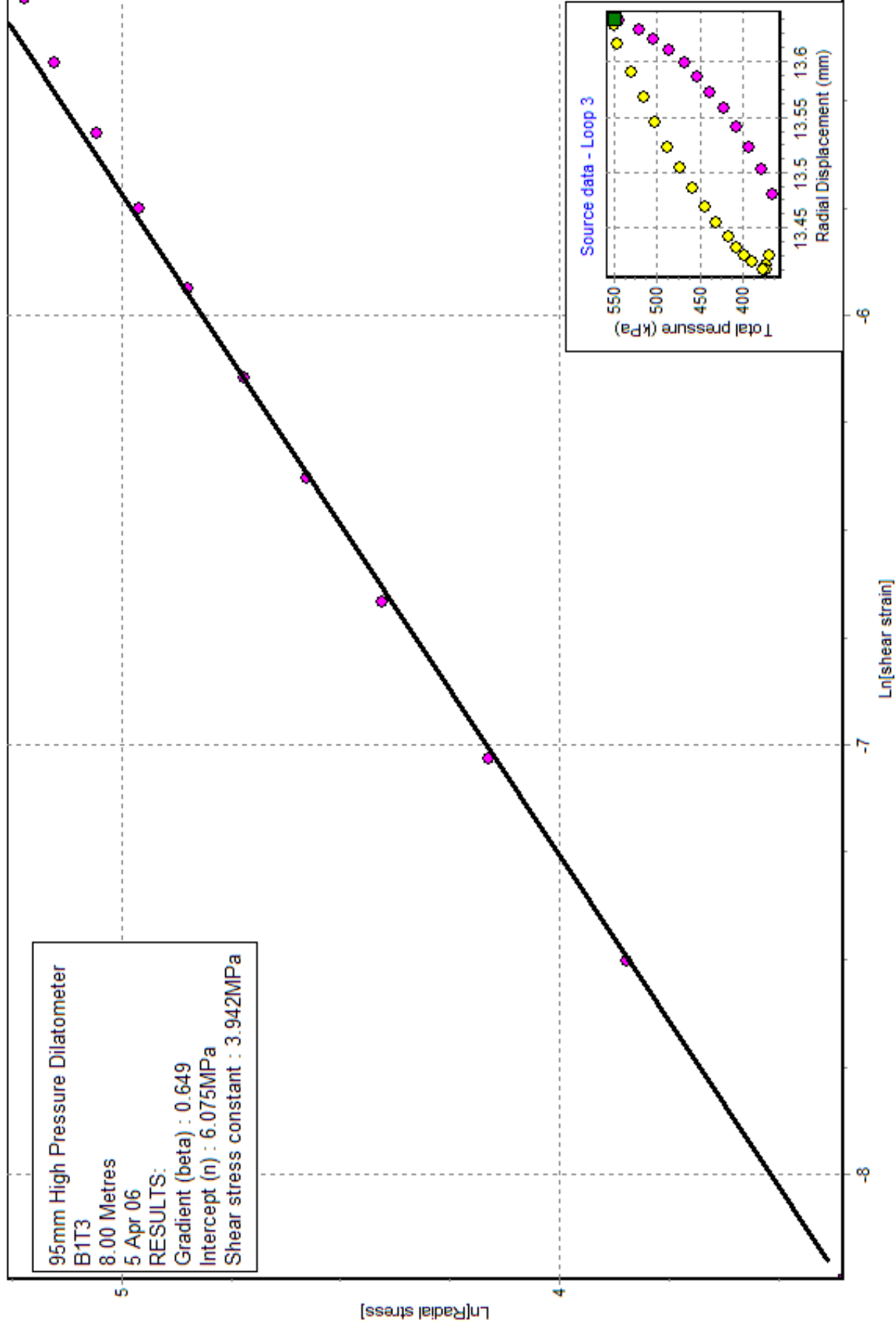


Shear modulus from unload/reload cycles Loop 3 : Arm ave

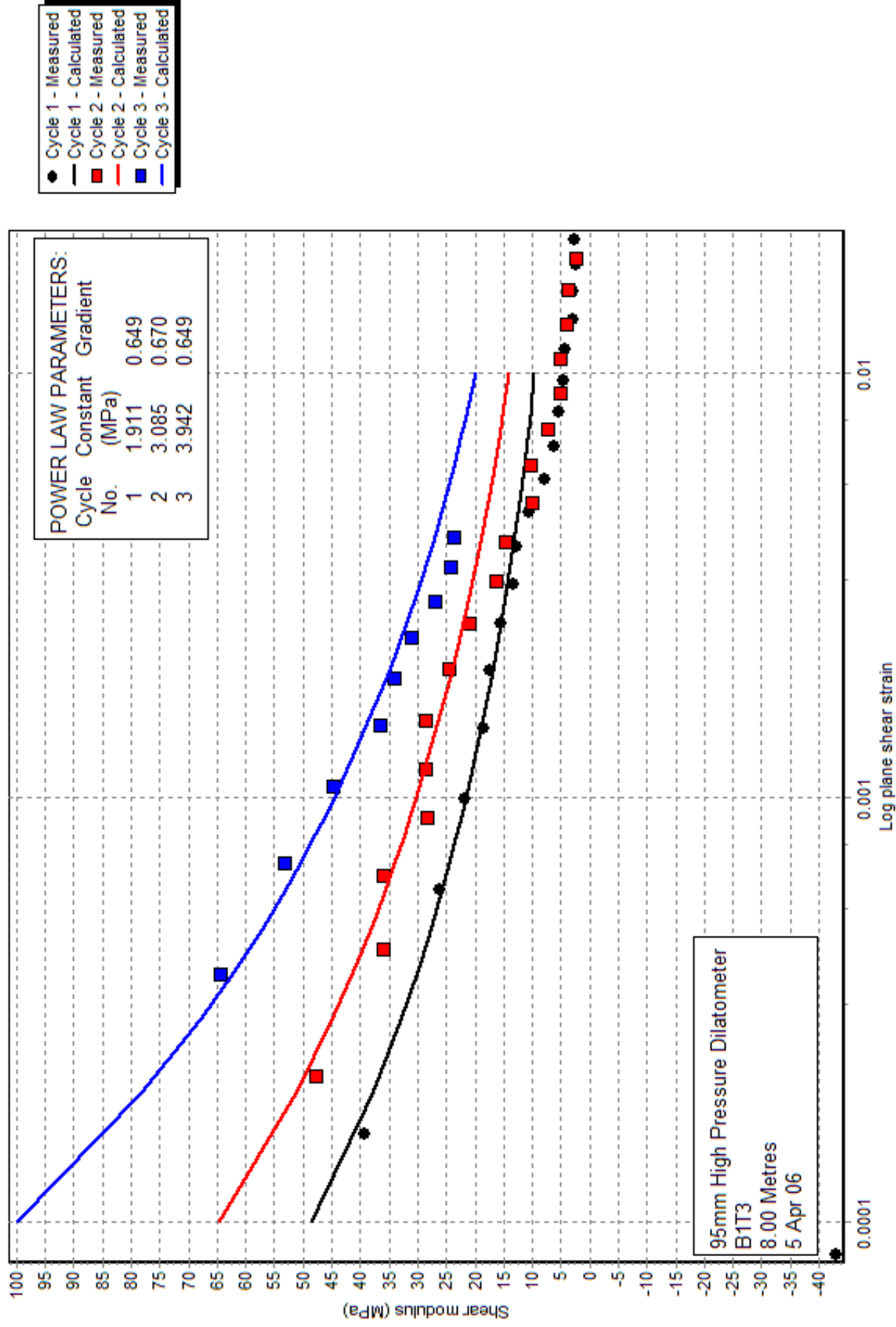




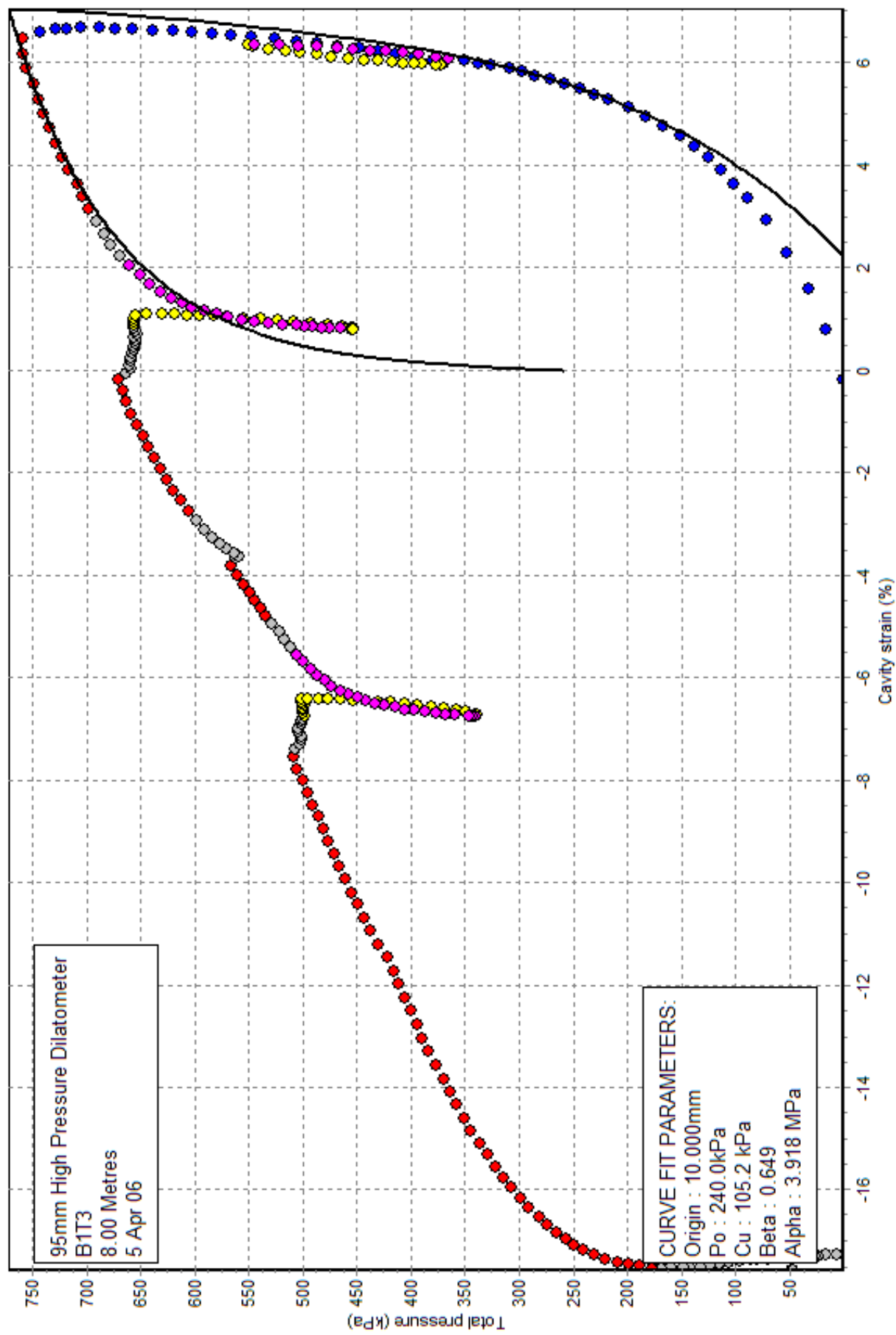




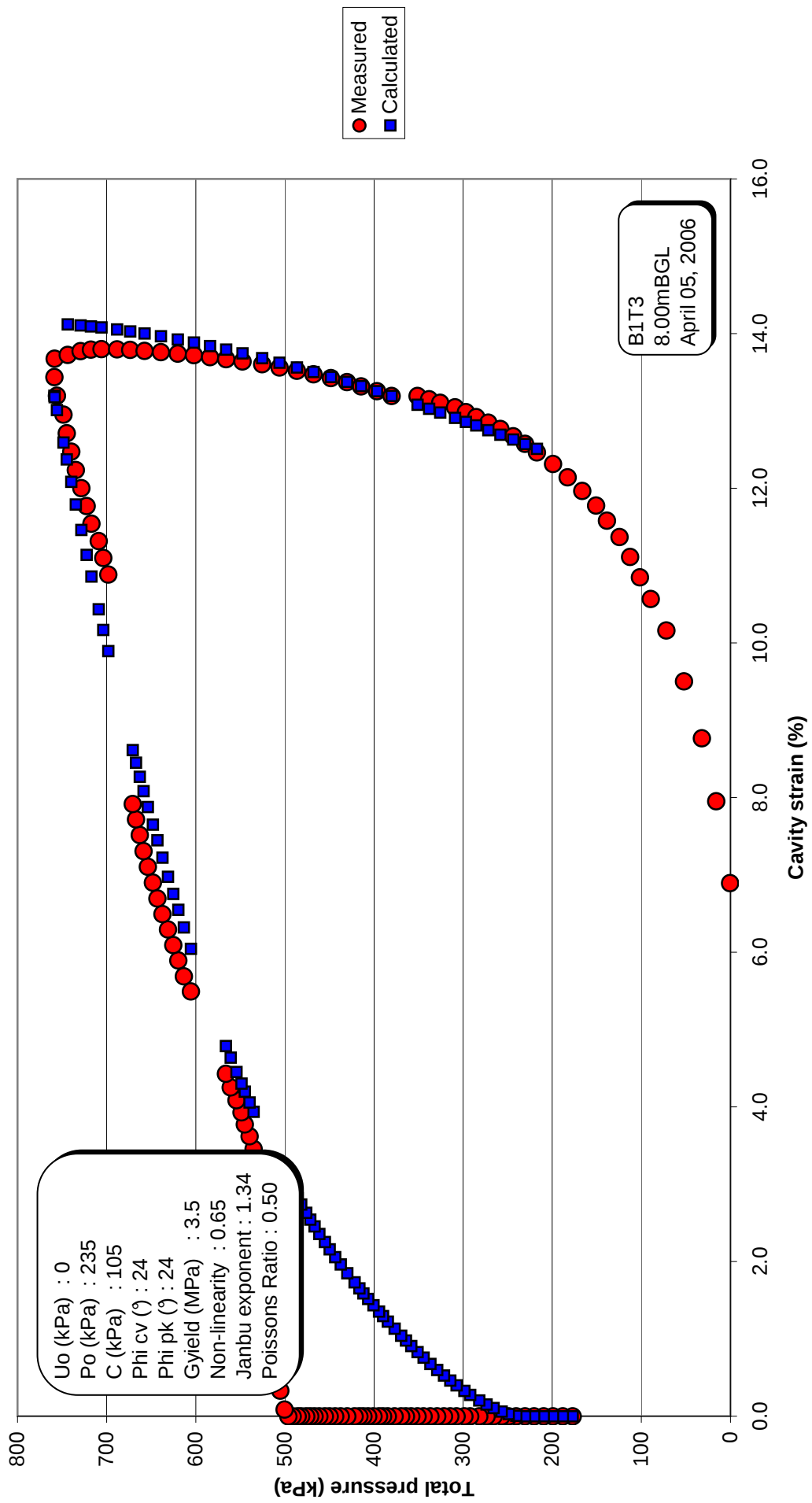
Variation of stiffness with strain, undrained analysis : Arm ave



Curve comparison (Whittle 1999) : Arm ave



Carter et al 1986 - Total pressure vs Cavity strain



B1T4 07/04/06 10.0m Coarse sand

- 1. Test record sheet**
- 2. Results summary**
- 3. Plot of expansion versus pressure – all arms**
- 4. Plot of expansion versus pressure – arm average**
- 5. Plot of all pressure cells versus time**
- 6. Plot of Marsland and Randolph procedure**
- 7. Hughes plot, giving peak friction angle and dilation**
- 8. Jefferies plot, giving C_u from unloading curve**
- 9. Plot of Reload Loop 1, with linear modulus line**
- 10. Plot of Reload Loop 2, with linear modulus line**
- 11. Plot of Reload Loop 3, with linear modulus line**
- 12. Plot of Reload Loop 4, with linear modulus line**
- 13. Bolton and Whittle plot of reloading part of Loop 1, giving nonlinearity coefficients**
- 14. Ditto for Loop 2**
- 15. And again for Loop 3**
- 16. And Loop 4**
- 17. Plot of Shear modulus versus Shear strain for all reload loops**
- 18. Plot of measured and calculated curves, from Carter et al**

Note that this last plot is included, even though the results obtained are not shown on the summary sheet. The friction angle obtained is almost identical to that from the Hughes plot.

CAMBRIDGE INSITU, Little Eversden, Cambridge, CB3 7HE

Site:- Ruritania

Test :- B1T4

Test Date :- 7th April 2006

Material :- Coarse sand

Depth :- 10.0 mtrs

Water table :- ~11 mtrs

Analysis of Insitu Lateral Stress (Po) :-

		Arm Av.
Marsland and Randolph	kPa	147
Zero offset	mm	0.84

Analysis of Undrained Shear Strength (Cu) :-

Pressure at failure (P _F)	kPa	380
Jefferies (unloading)	kPa	195

Strength of Sands Analysis (Hughes, Wroth & Windle)

Friction angle at const. vol.	deg	30	(assumed)
Angle of Friction	deg	44.0	
Angle of Dilation	deg	17.4	

Analysis of Shear Modulus (G) :-

Initial Modulus (G _i)	MPa	9.6
-----------------------------------	-----	-----

Linear Analysis of Reload Loops (G_R) :-

		Loop 1	Loop 2	Loop 3	Loop 4
G _R	MPa	26.6	44.9	51.4	74.8
Co-ordinate :-					
Strain	%	-0.1	1.25	3.8	13.3
Pressure	MPa	0.1	0.2	0.4	0.8
Amplitude :-					
Strain	%	0.37	0.29	0.43	0.38
Pressure	MPa	0.10	0.13	0.22	0.29

Non-linear Analysis of Reloading data :-

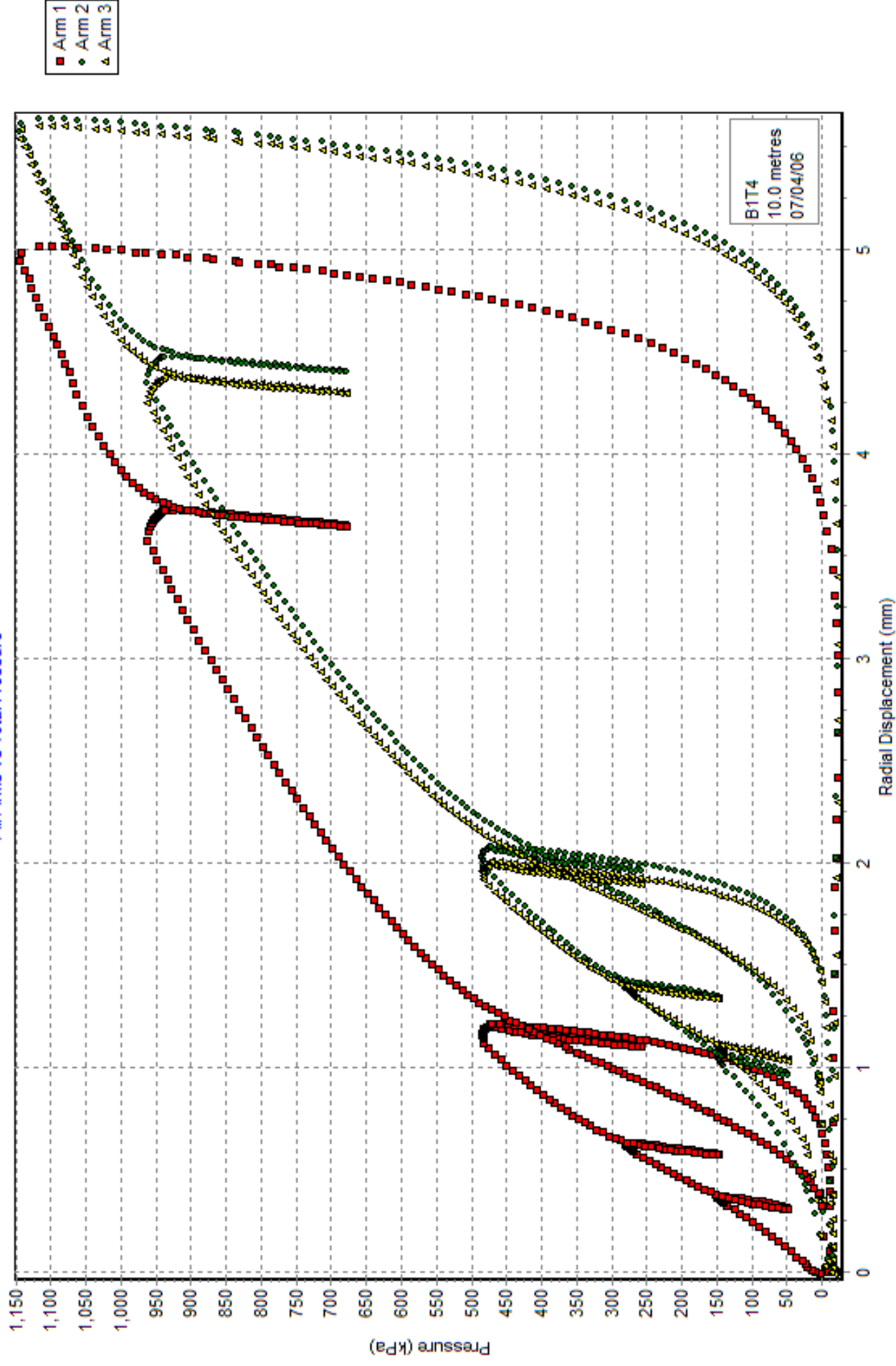
α	MPa	10.4	17.2	22.3	28.8
β		0.858	0.852	0.859	0.845

Shear Modulus G_S (at 3 levels of shear strain) :-

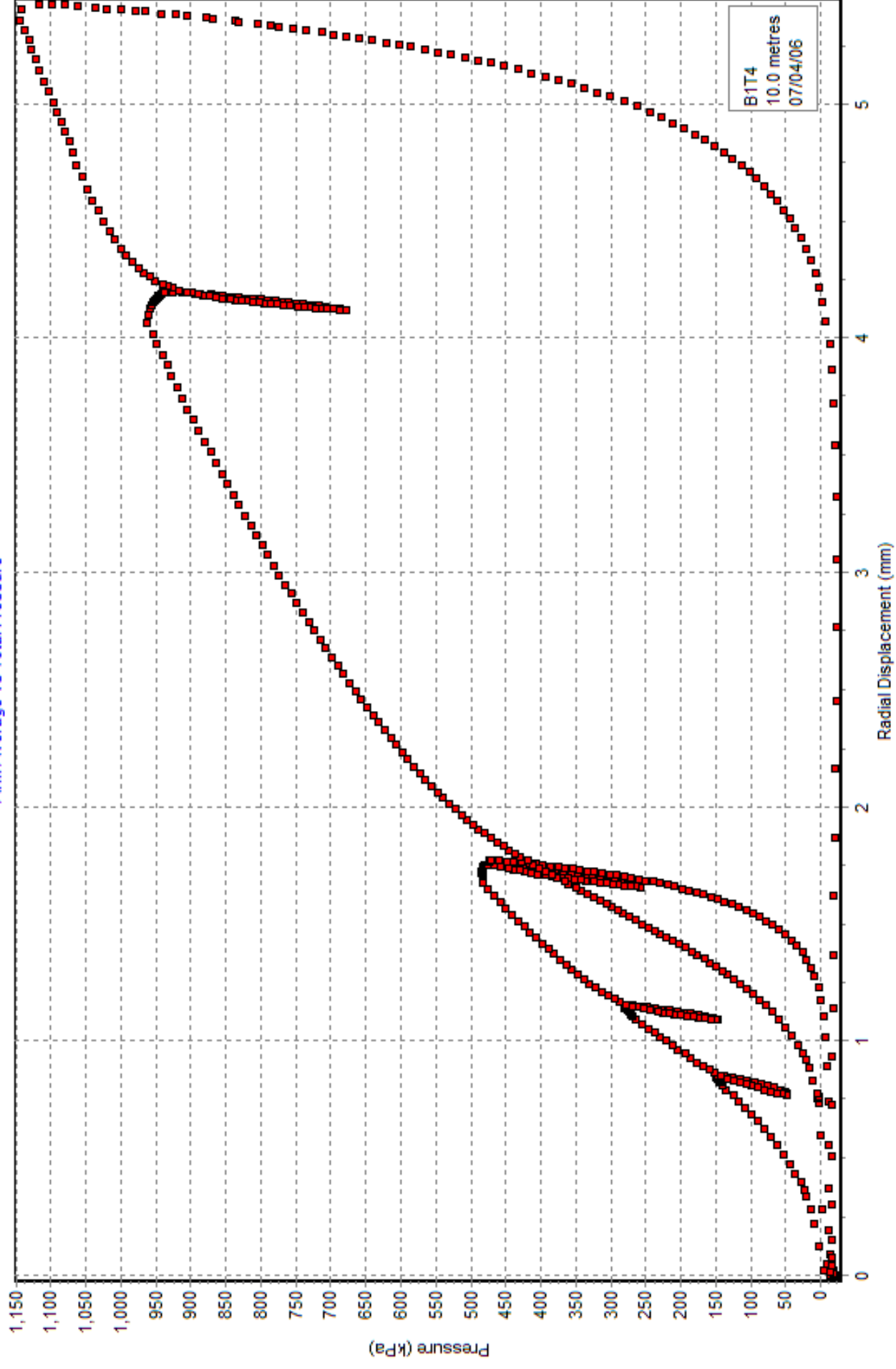
(0.01%)	MPa	39	67	82	120
(0.1%)	MPa	28	48	59	84
(1%)	MPa	20	34	43	59

Test Analysed By :- PGH
Date :- April 2006

All Arms vs Total Pressure

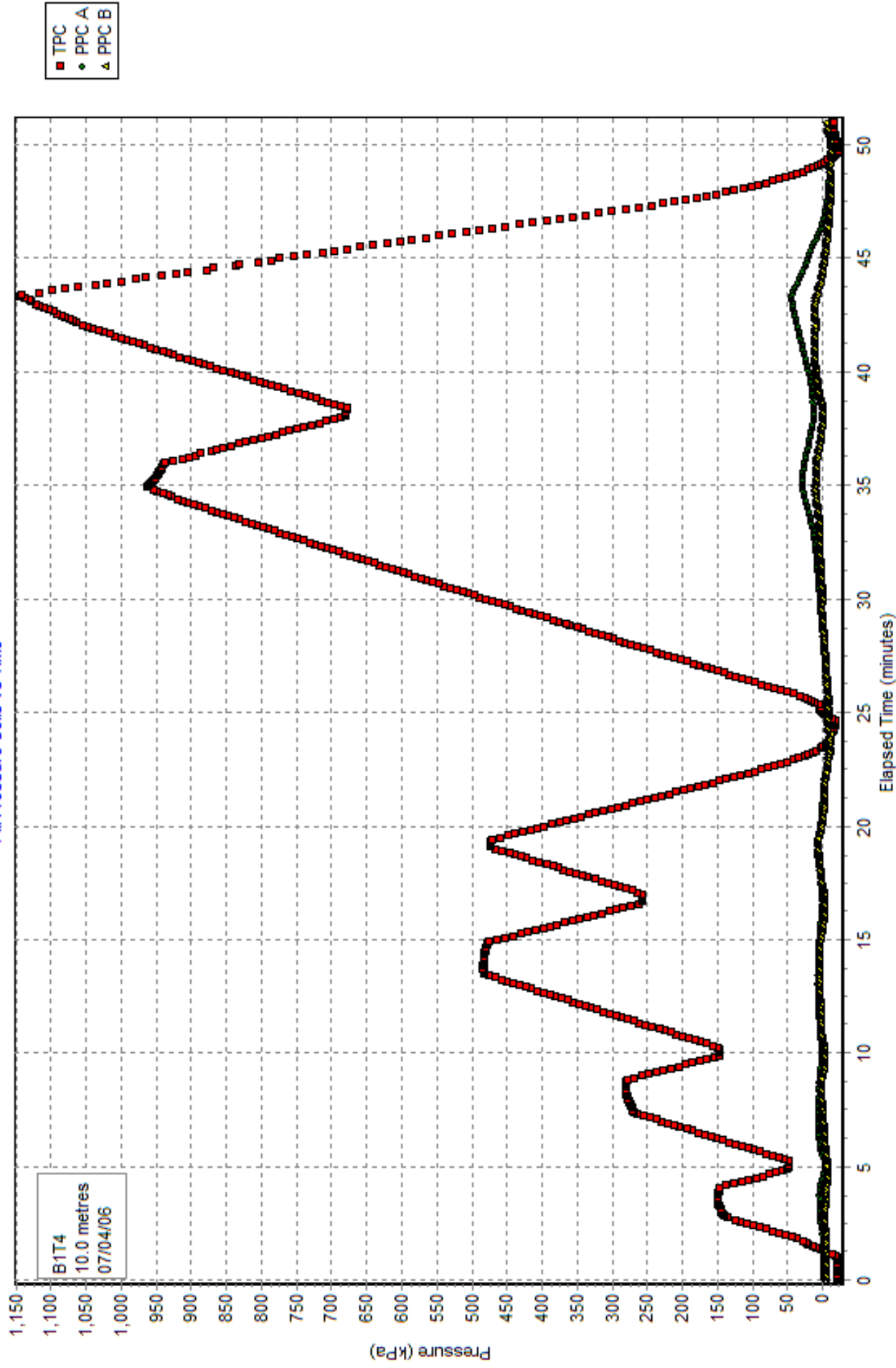


Arm Average vs Total Pressure

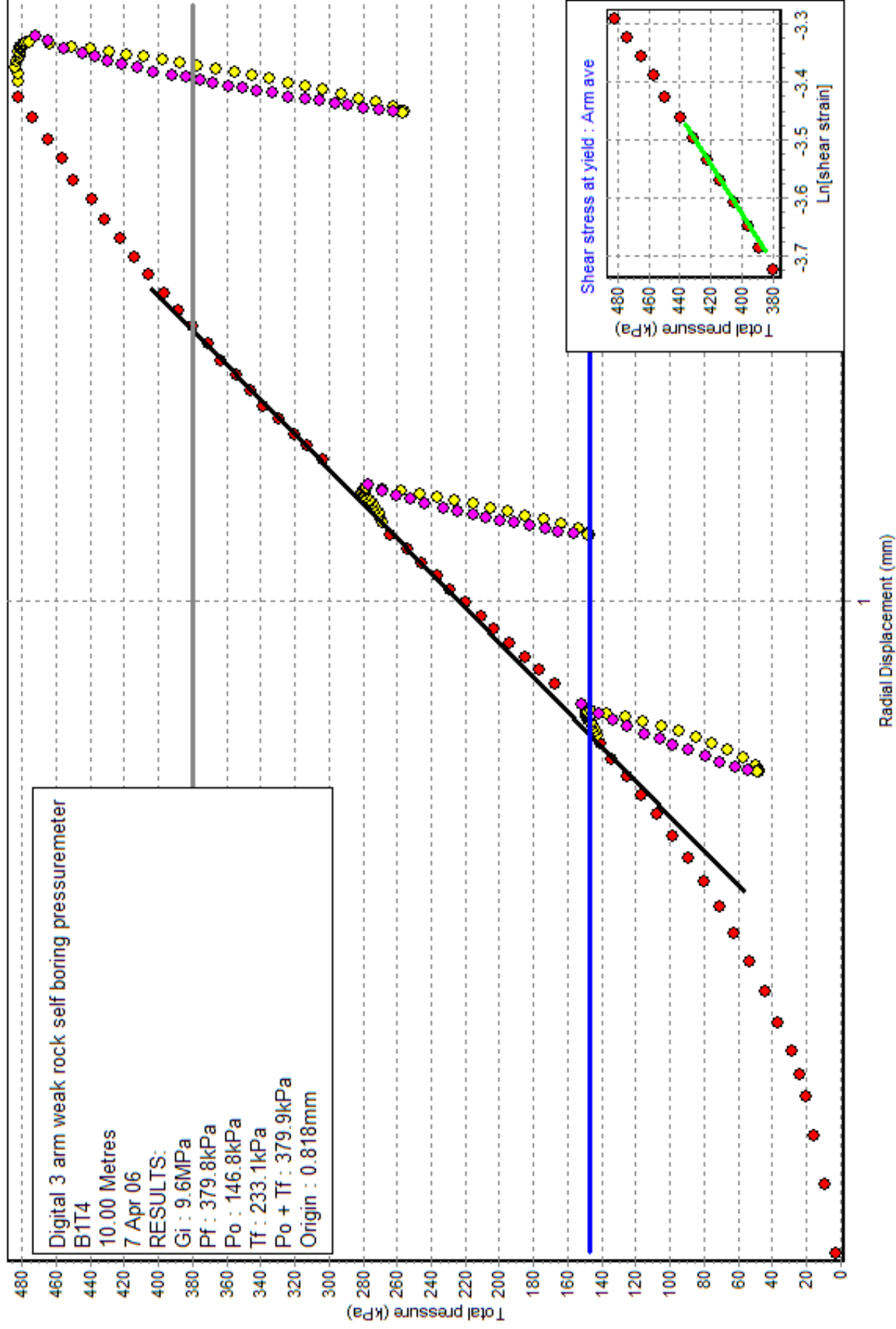


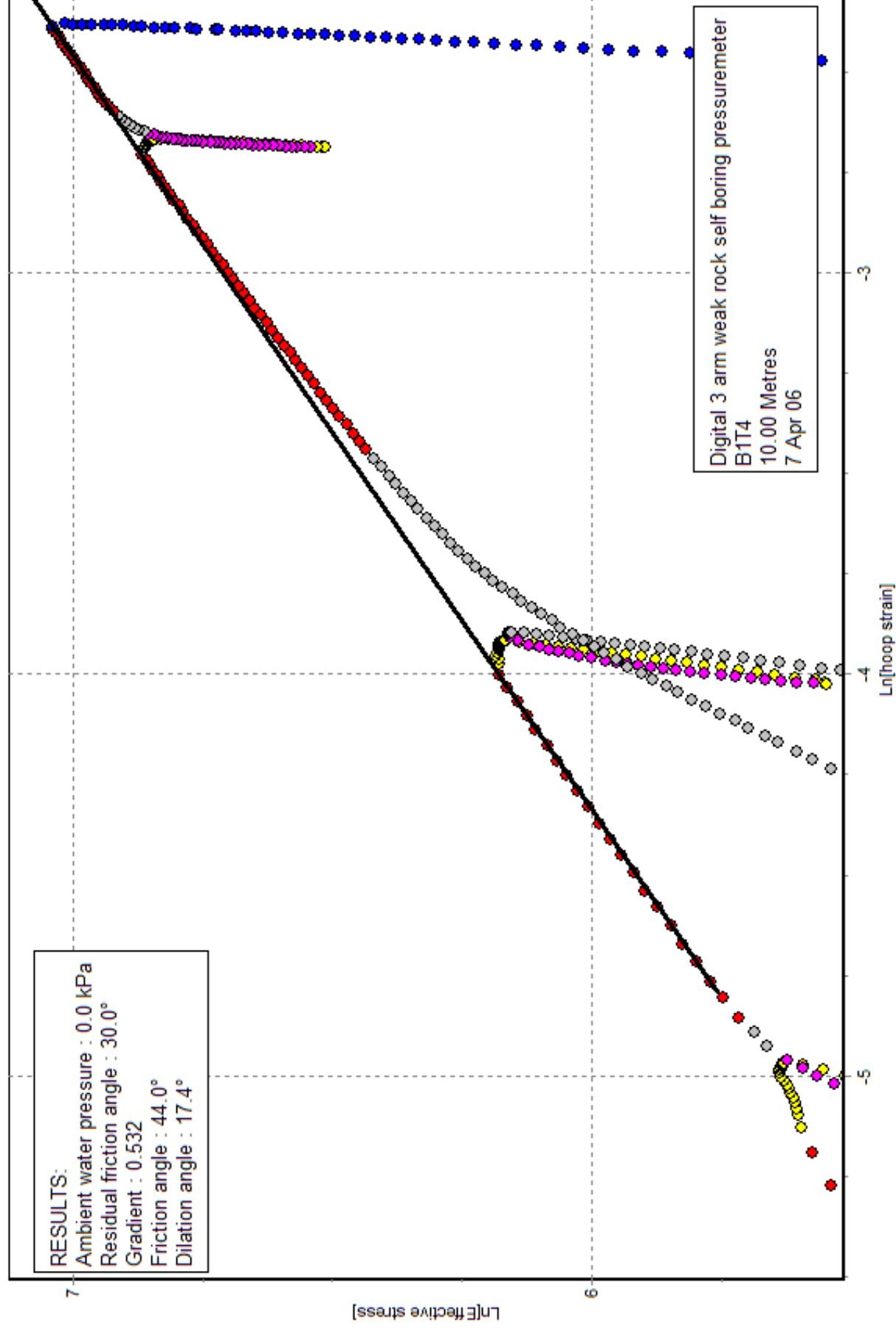
B1T4
10.0 metres
07/04/06

All Pressure Cells vs Time

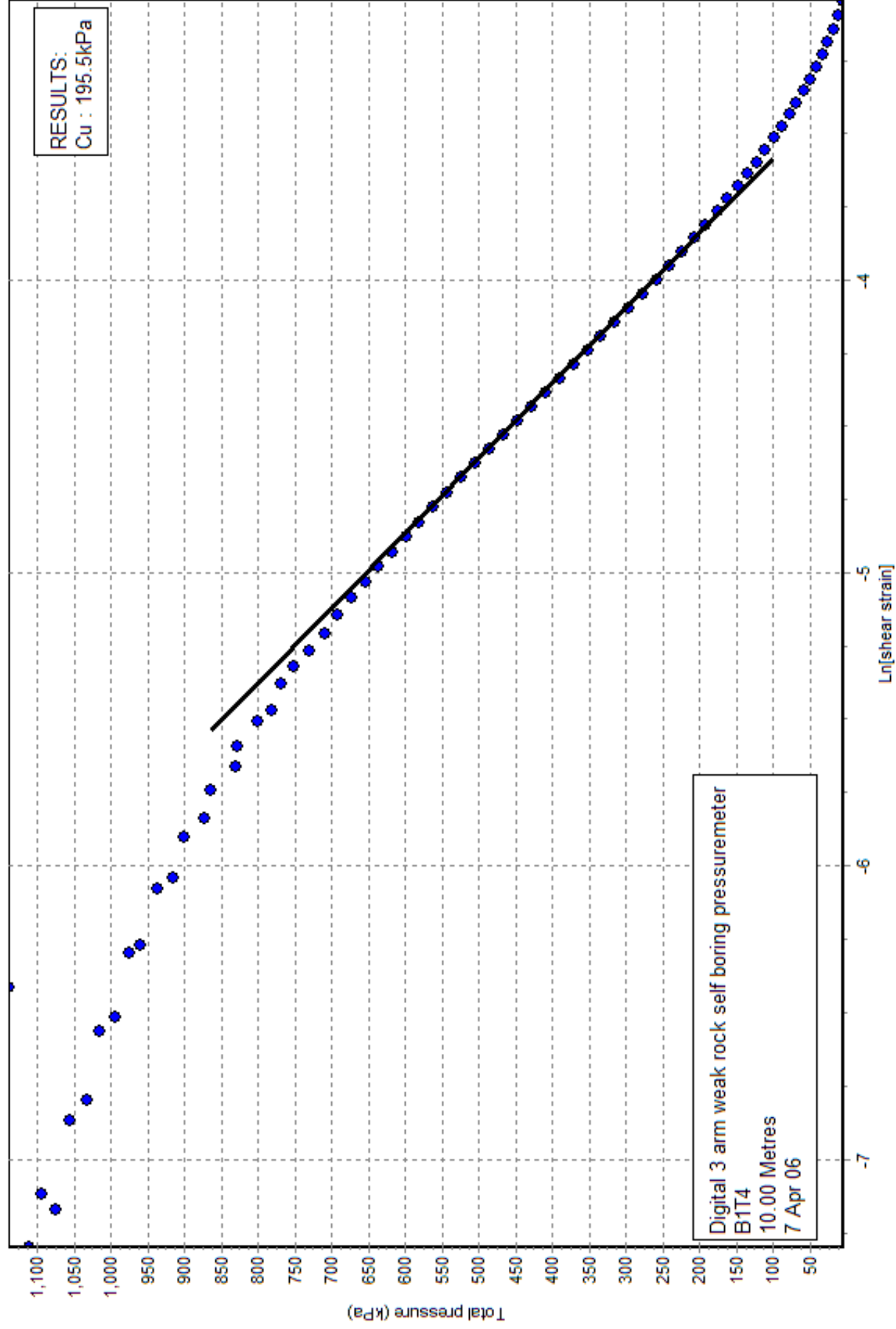


Po of cohesive material (1977, 1990) : Arm ave

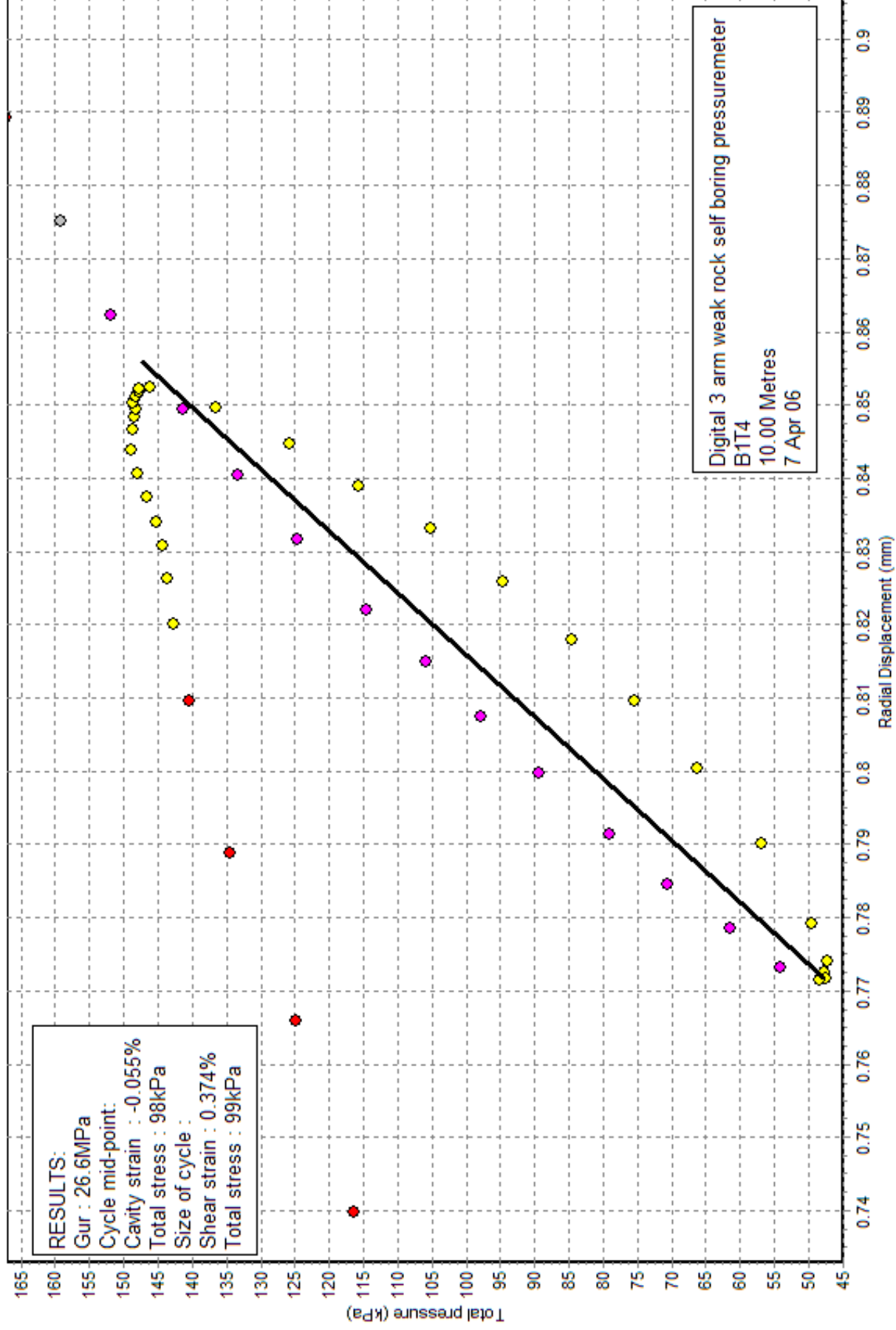




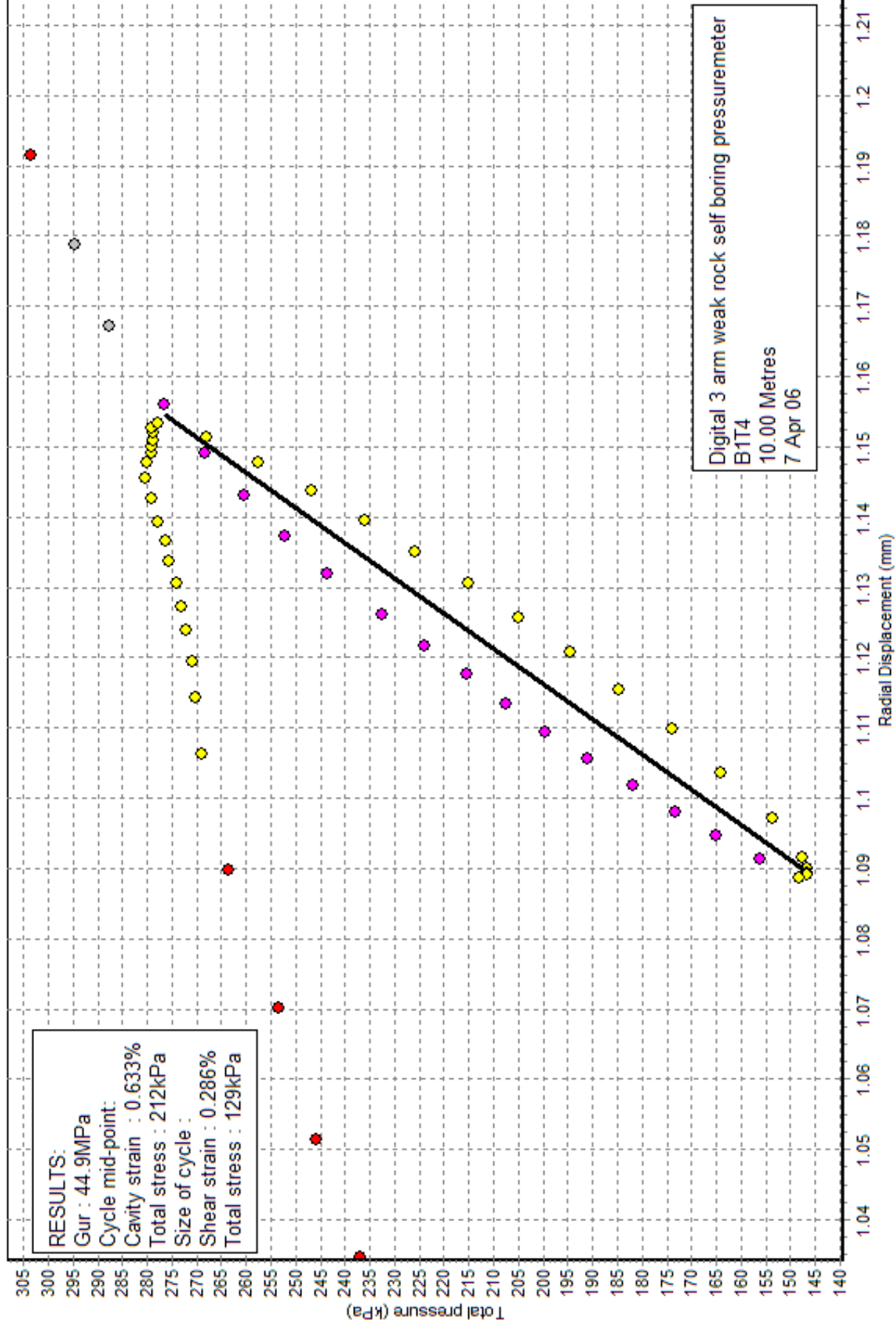
Jefferies (1988) : Arm ave



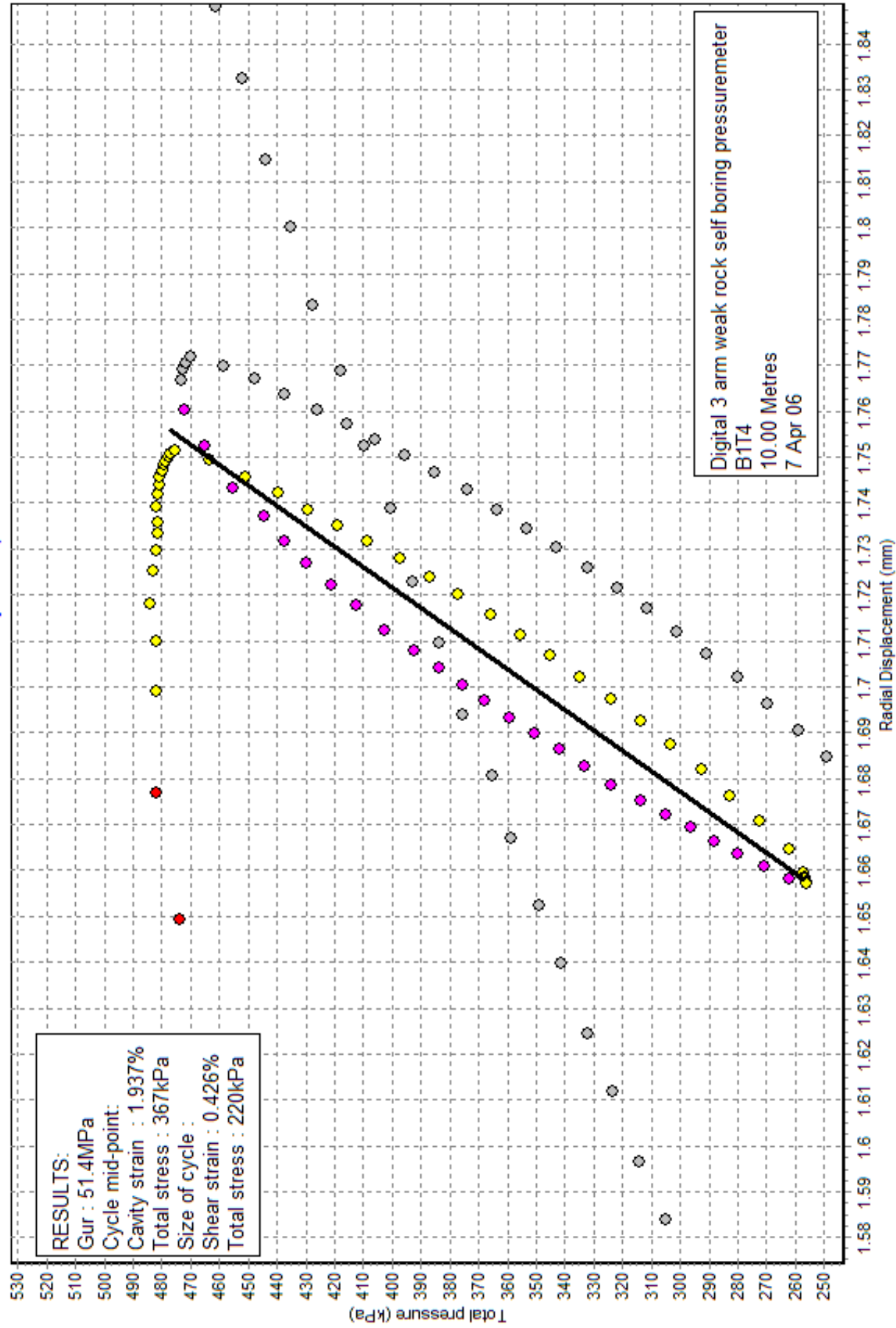
Shear modulus from unload/reload cycles Loop 1 : Arm ave



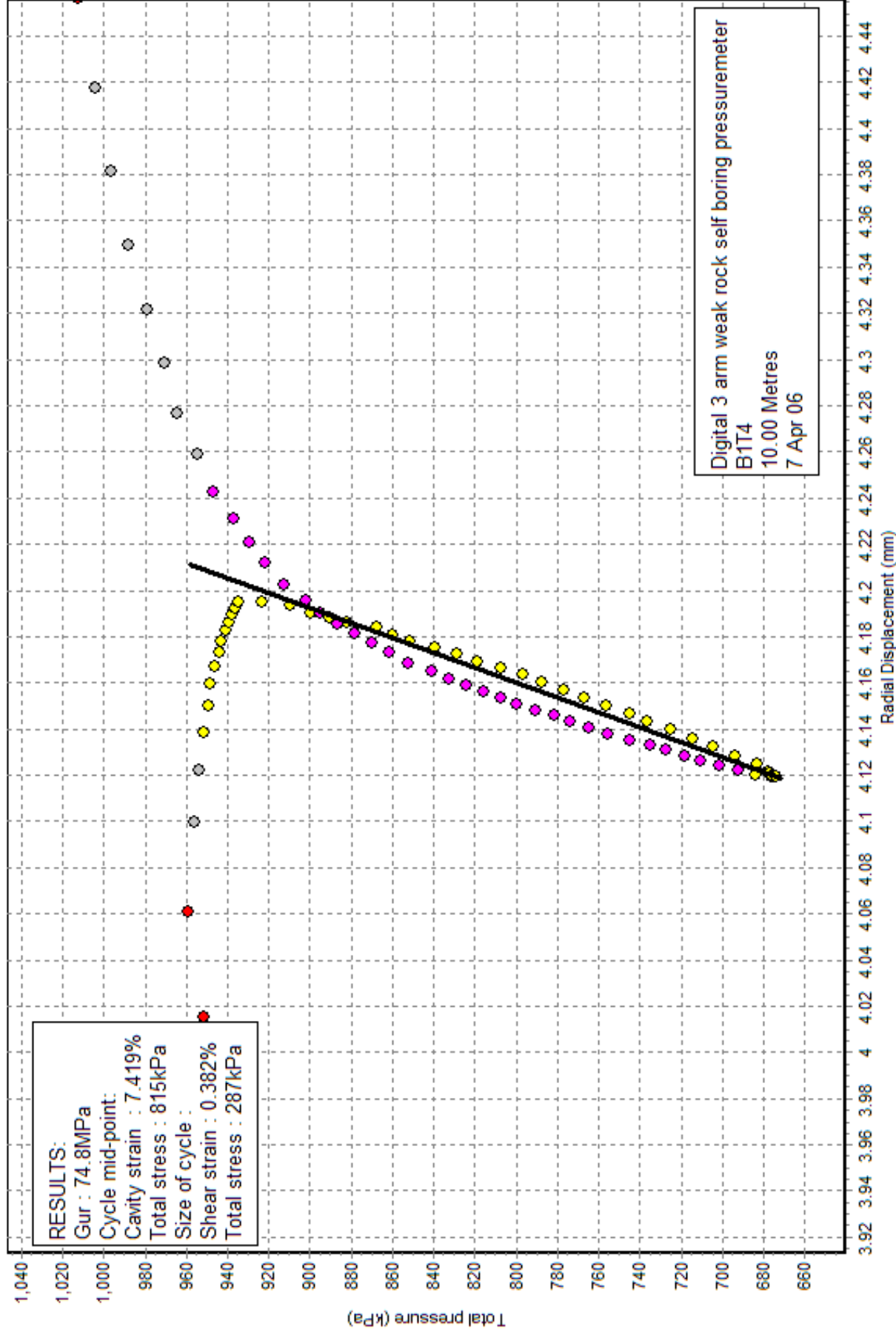
Shear modulus from unload/reload cycles Loop 2 : Arm ave

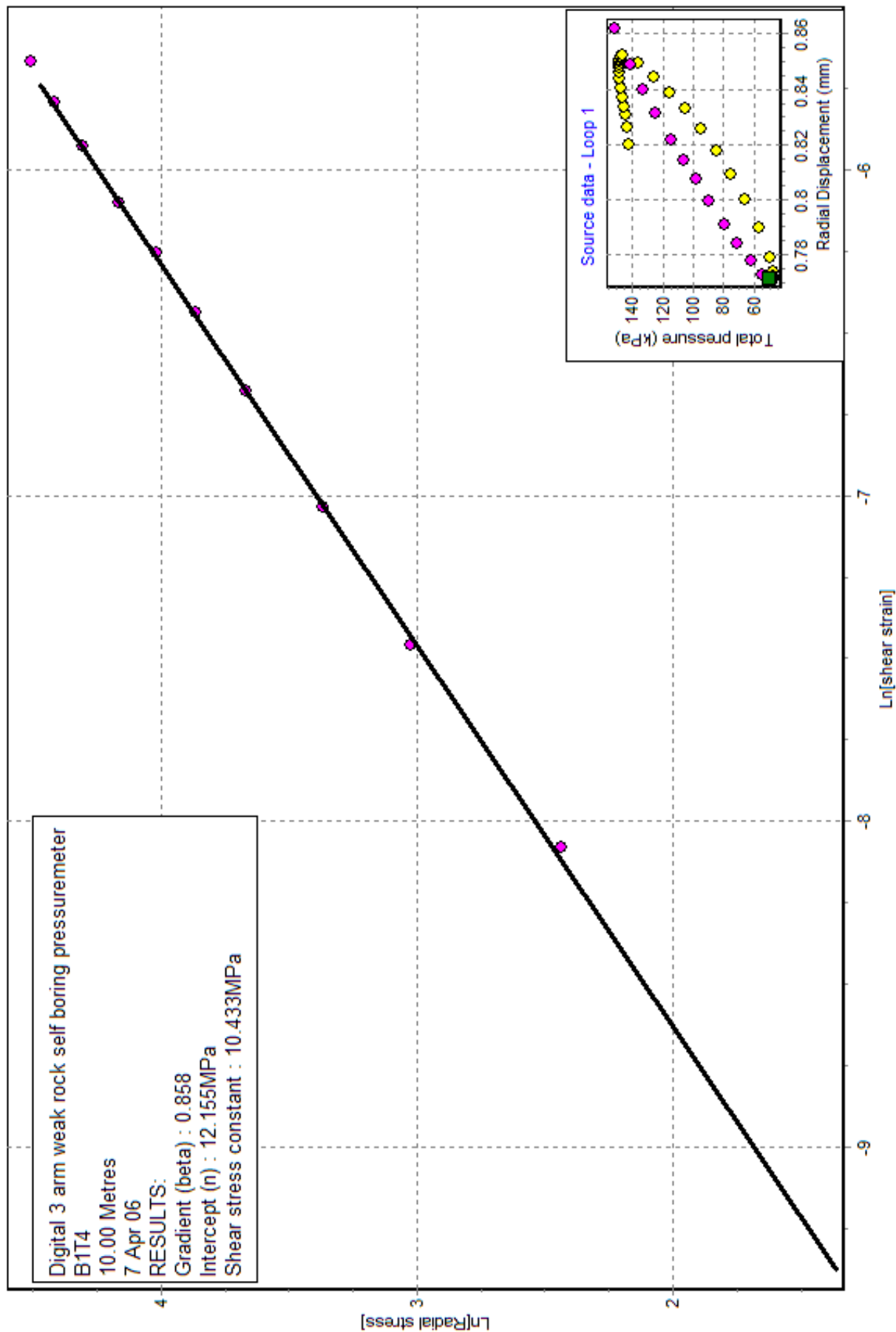


Shear modulus from unload/reload cycles Loop 3 : Arm ave



Shear modulus from unload/reload cycles Loop 4 : Arm ave

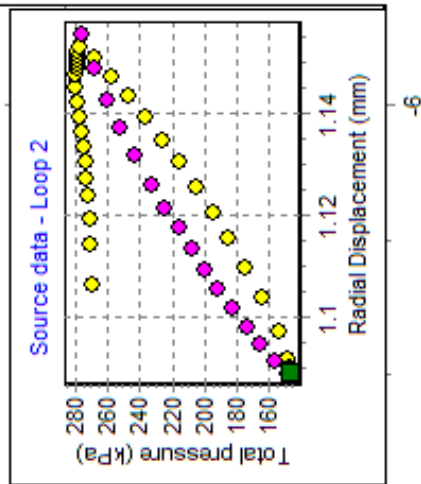


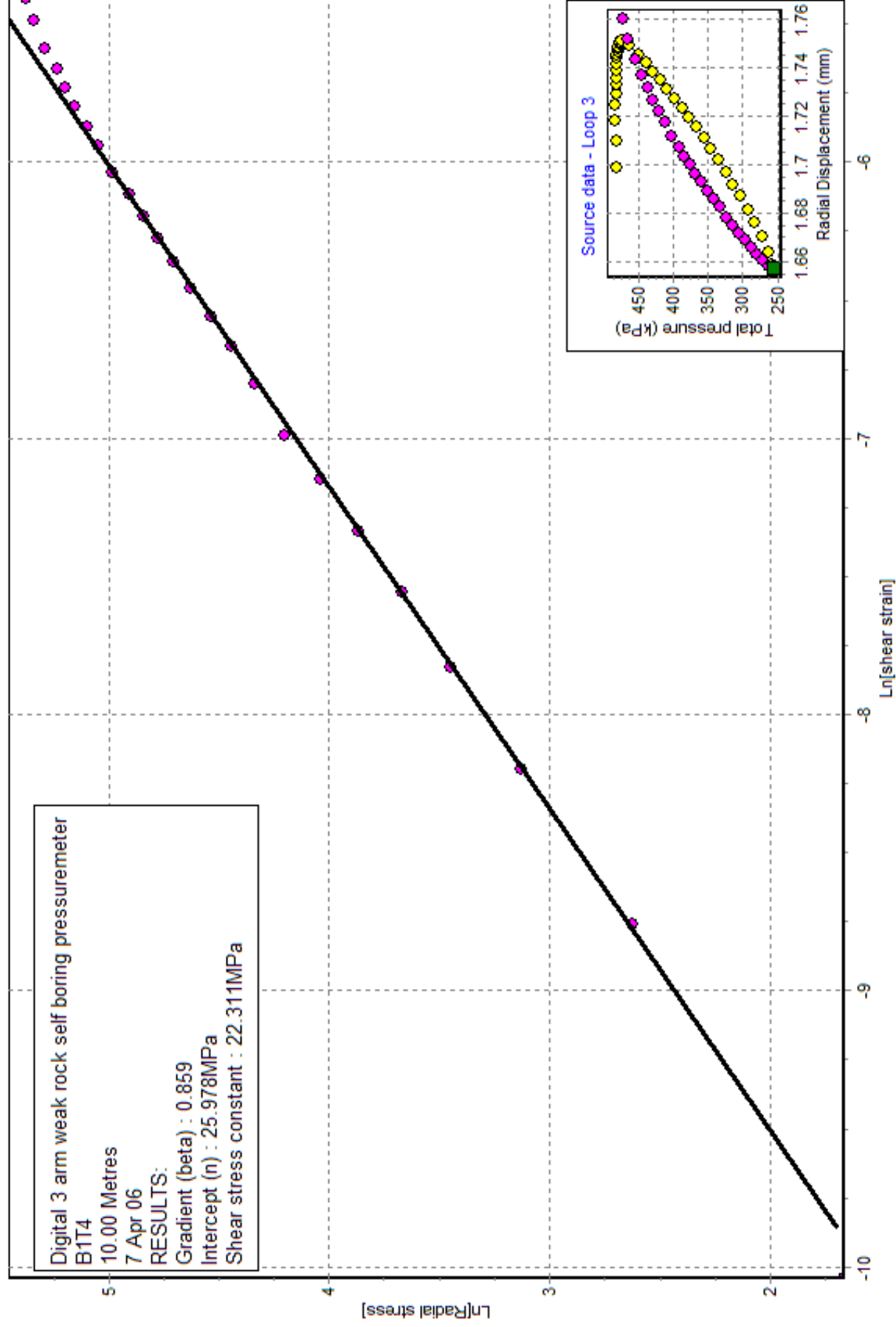


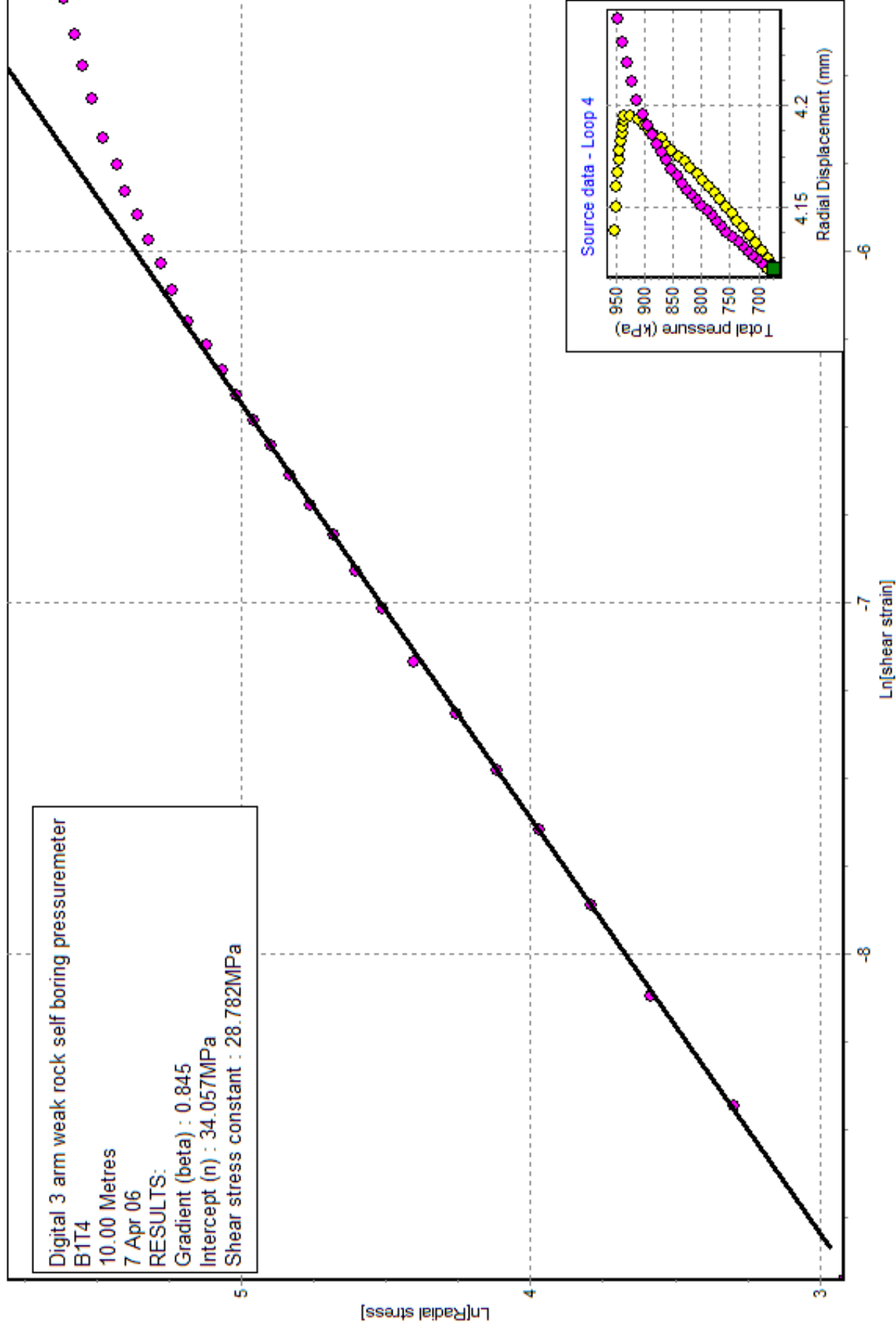
Digital 3 arm weak rock self boring pressuremeter
B1T4
10.00 Metres
7 Apr 06
RESULTS:
Gradient (beta) : 0.852
Intercept (n) : 20.162MPa
Shear stress constant : 17.178MPa

Ln[Radial stress]

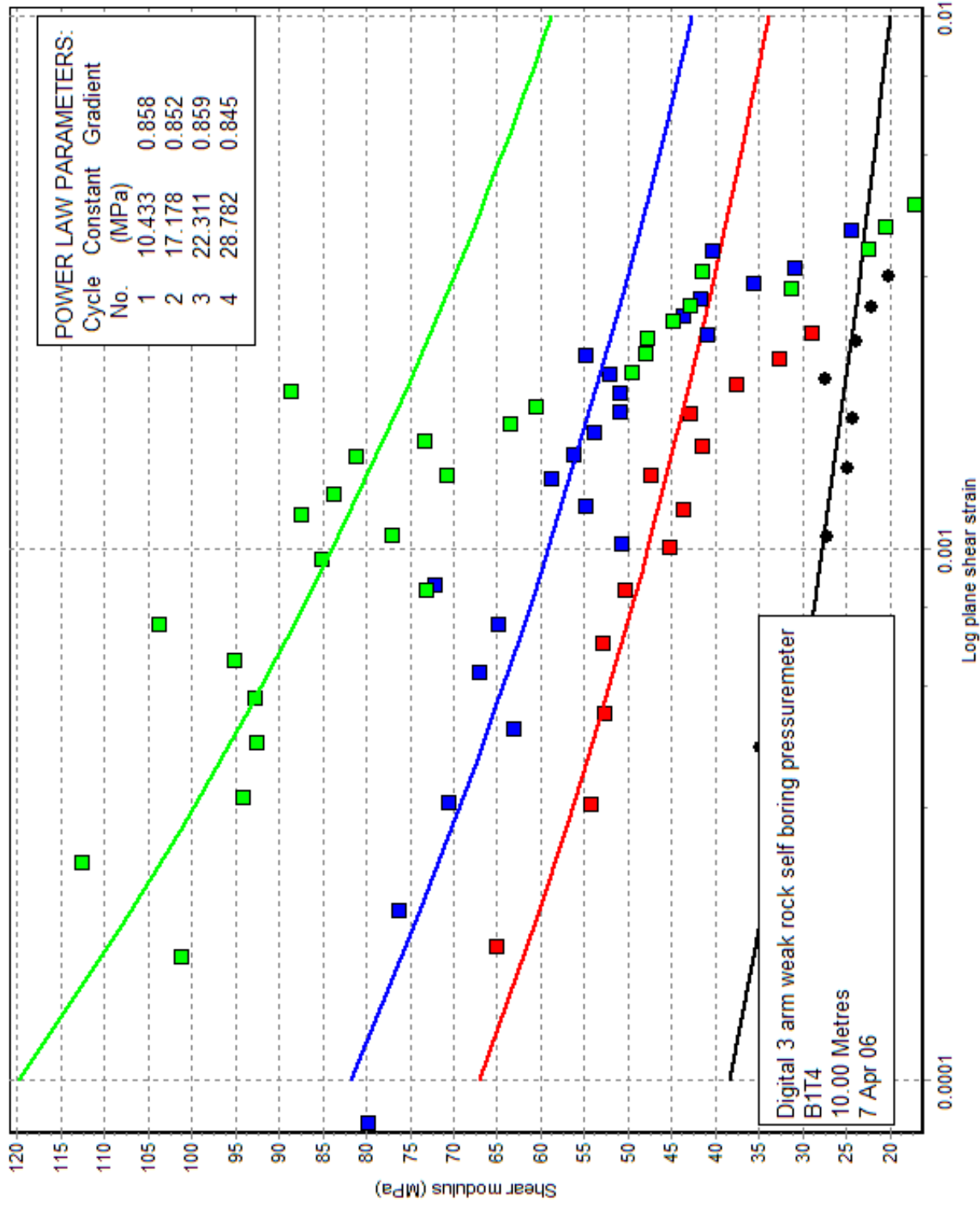
Ln[shear strain]



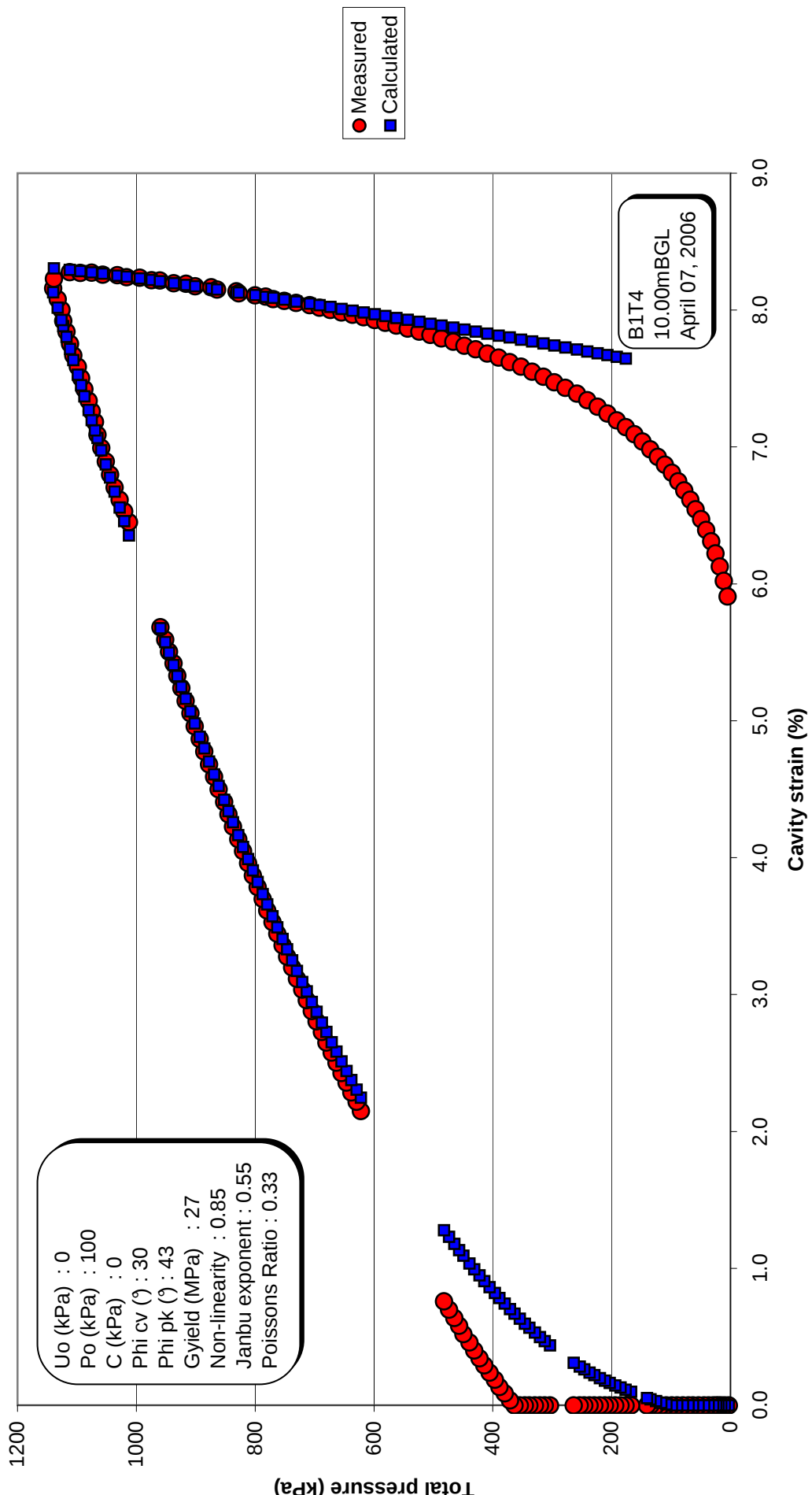




Variation of stiffness with strain, undrained analysis : Arm ave



Carter et al 1986 - Total pressure vs Cavity strain



B1T5 08/04/06 20.0m Grey Clay

- 1. Test record sheet**
- 2. Results summary**
- 3. Plot of expansion versus pressure – all arms**
- 4. Plot of expansion versus pressure – arm average**
- 5. Plot of all pressure cells versus time**
- 6. Plot of Marsland and Randolph procedure**
- 7. Gibson and Anderson plot, giving C_u and P_L from loading curve**
- 8. Jefferies plot, giving C_u from unloading curve**
- 9. Plot of Reload Loop 1, with linear modulus line**
- 10. Plot of Reload Loop 2, with linear modulus line**
- 11. Bolton and Whittle plot of reloading part of Loop 1, giving nonlinearity coefficients**
- 12. Ditto for Loop 2**
- 13. Plot of Shear modulus versus Shear strain for all reload loops**
- 14. Plot of strain versus pressure, with computed curve and field data**
- 15. Holding test simulation plot – matching the start of the decay**
- 16. Ditto – matching the whole decay**

3 ARM SELF BORING PRESSUREMETER

SITE		DATE	DAY	BOREHOLE	TEST	Depth to test centre	
RURITANIA		08/04/06	MON	1	5	20m	
MATERIAL: GREY CLAY				Site Weather:		Cloudy	
Water Table	Drilling Start	Drilling End	Distance	Drill rate	Ram Pressure		
	13:25	13:30	1.2m	OK			
Orientation:							
Water Press.	Probe Dia.	Shoe Dia.	Drill Bit	Bit Location	Probe Ref.		
	89mm	89mm	83R2B	~63mm OUT	JSM 6AL		
Drilling remarks: POOR FLUSH FOR MOST OF DRILL, OK AT END.							
Strain Rate	Press. Rate	Cycle Time	Gas Bottle	Battery V	PPC Type	Mx. Press.	
		5s	✓	✓	TRUE	10MPa	
TRANSDUCER DETAILS							
	ARM 1	ARM 2	ARM 3	TPC	PPC A	PPC B	
GL Zero							
Test Depth							
Test Start Time		Test End Time		Mx Pressure Reached		Disk Reference	
15:29		15:56		1.65 MPa			
TEST NOTES							
Line No.	Remarks						
63	ARM (2) MOVING - THEN STOPPED! ~ 830 KPa						
71	ARM (1) & ARM (2) PROBABLY						
73	ARM (3) MOVING suddenly ~ 1000 KPa						
85	HOLD → LOAD (1)						
140	HOLD → LOAD (2)						
190	HOLD						
450	CONTINUING TEST						
695	DOWN - ARM (3) ~ 5.5 mm						
Test Engineer: <i>P. J. H.</i> Driller: GRANT							
Membrane Correction		Membrane Compression		Arm Cals Ref.		Pressure Cals Ref.	
H2708T5		H2808T1		7-8-08		7-8-08	
GENERAL COMMENTS:							
PPCs NOW WORKING (NEW PPCA)							

CAMBRIDGE INSITU, Little Eversden, Cambridge, CB3 7HE

Telephone: (01223)262361 Fax: (01223) 263947 E-Mail: CamInsitu@AOL.COM

WEAK ROCK SELF-BORING PRESSUREMETER

RESULTS SUMMARY SHEET

Site:- Ruritania
Material :- Grey clay

Test :- B1T5
Depth :- 20.0 mtrs

Test Date :- 8th April 2006
Water table :- ~ 11 mtrs

Initial Pore Water Pressure :-
kPa PPC A PPC B
775 805

Analysis of Insitu Lateral Stress (Po) :-

	Arm 1	Arm 2	Arm 3	Average
Lift-off kPa	960	975	1010	982
Marsland & Randolph kPa				1000
Zero offset mm				-0.01

Analysis of Undrained Shear Strength (Cu) :-

Gibson and Anderson kPa	235
Pressure at failure (P _F) kPa	1090
Limit Pressure (P _L) kPa	2115
Jefferies (unloading) kPa	225

Analysis of Shear Modulus (G) :-

Initial Modulus (G _i) MPa	19.9
<u>Linear Analysis of Reload Loop (G_R) :-</u>	
	Loop 1 Loop 2
G _R MPa	29.8 26.7
<u>Co-ordinate :-</u>	
Strain %	0.7 1.7
Pressure kPa	1070 1175
<u>Amplitude :-</u>	
Strain %	0.87 1.12
Pressure kPa	260 300

Non-linear Analysis of Reloading data :-

α MPa	4.43 4.26
β	0.674 0.672

Shear Modulus G_S (at 3 levels of shear strain) :-

(0.01%) MPa	89 87
(0.1%) MPa	42 41
(1%) MPa	20 19

Analysis of Holding test :-

	Initial	Whole decay
C _H m ² /yr	18.5	25.3
k _H x 10 ⁻¹⁰ m/s	1.1	1.7

Constant flow Permeameter test :-

	0mm	200mm	400mm
k _m x 10 ⁻¹⁰ m/s	1.4 – 2.7	2.7 – 3.7	-

Curve matching procedure

Po = 780 kPa
O/s = 0.01 mm

Cu = 225 kPa

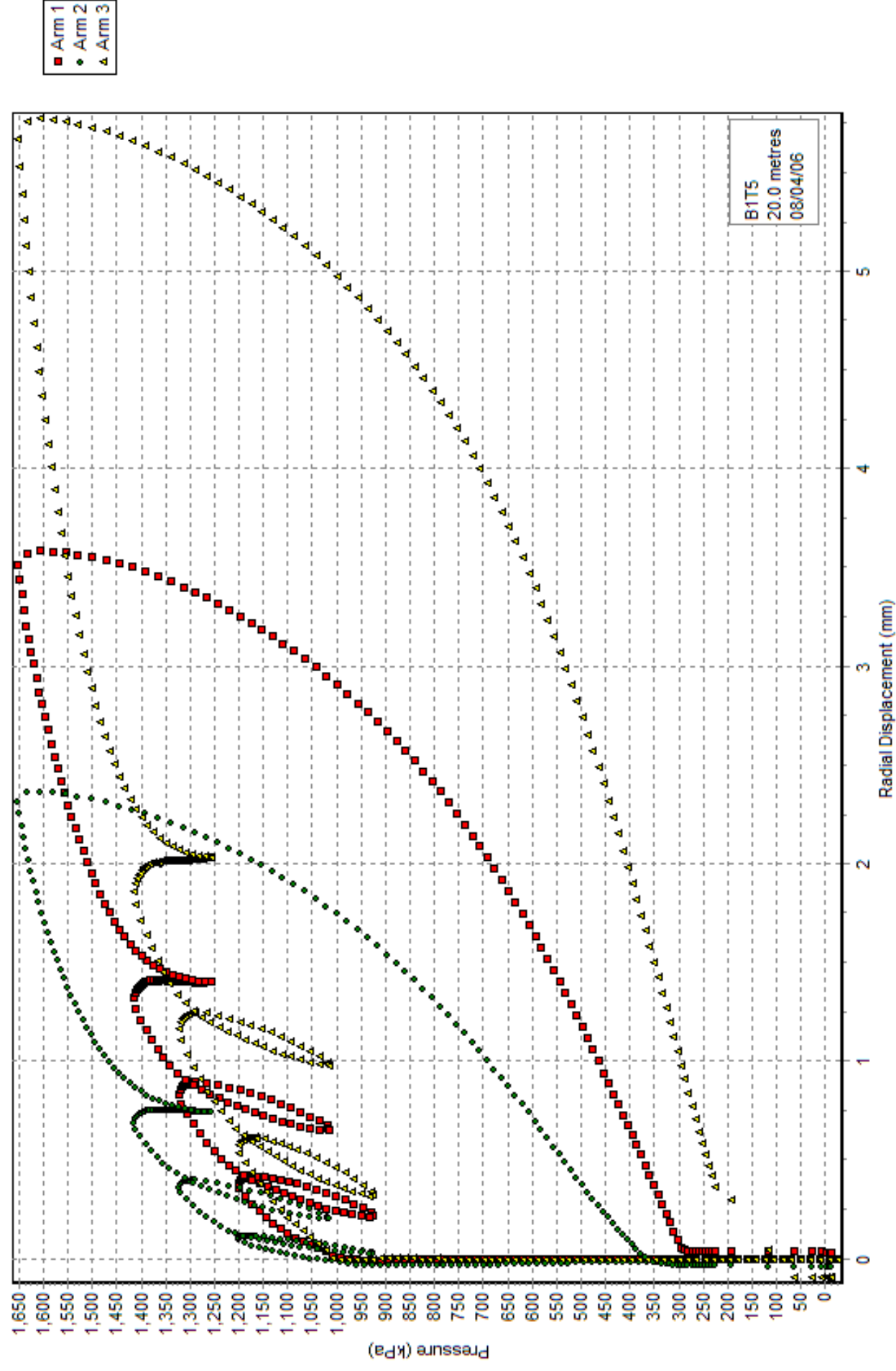
P_L = 2090 kPa

α = 4.17 MPa
β = 0.672

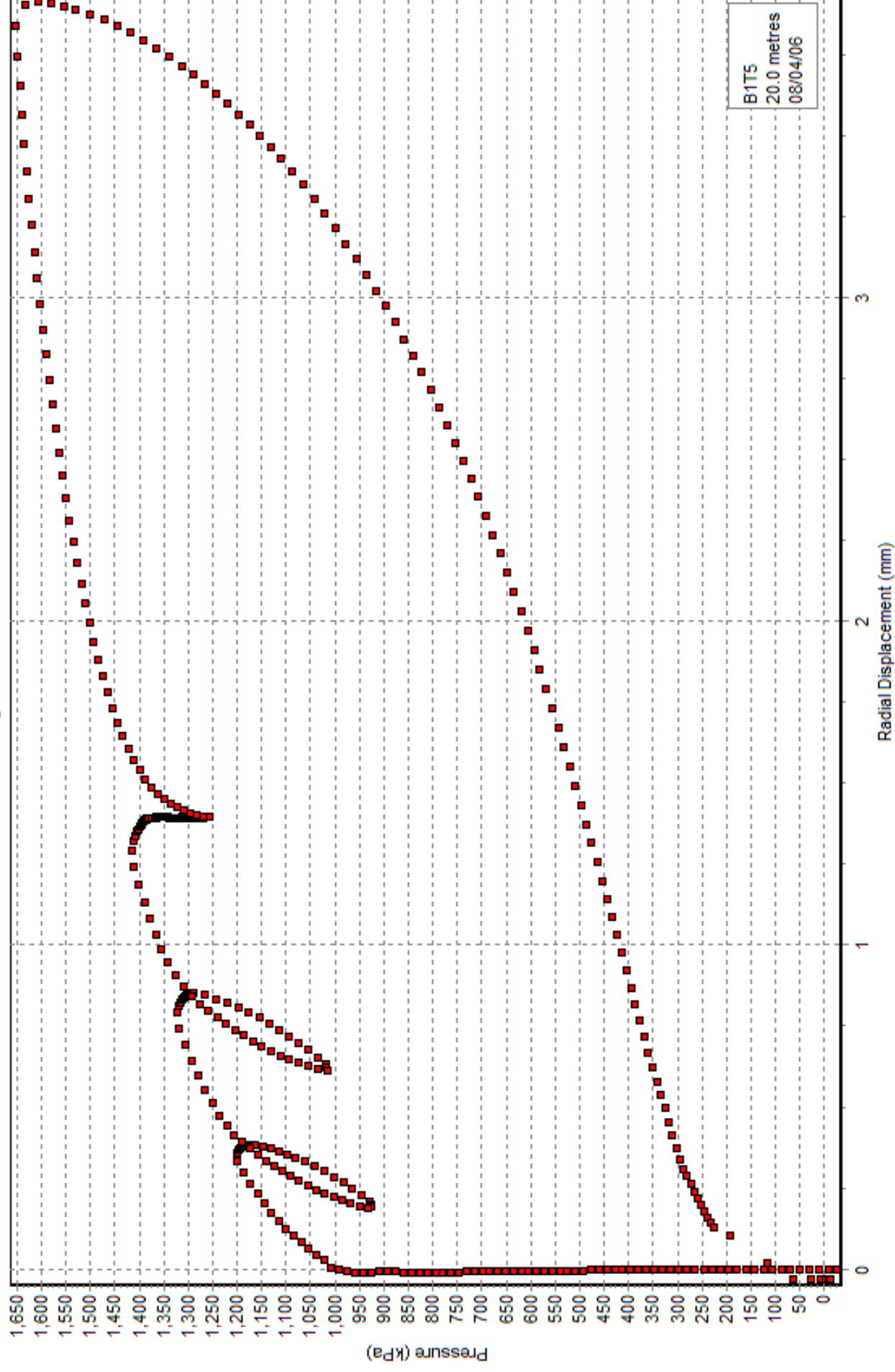
G_{0.01%} = 85 MPa
G_{0.1%} = 40 MPa
G_{1%} = 19 MPa
G_{MIN} = 17.3 MPa
at 1.3 % shear strain

Test Analysed By :- PGH
Date :- August 2006

All Arms vs Total Pressure



Arm Average vs Total Pressure

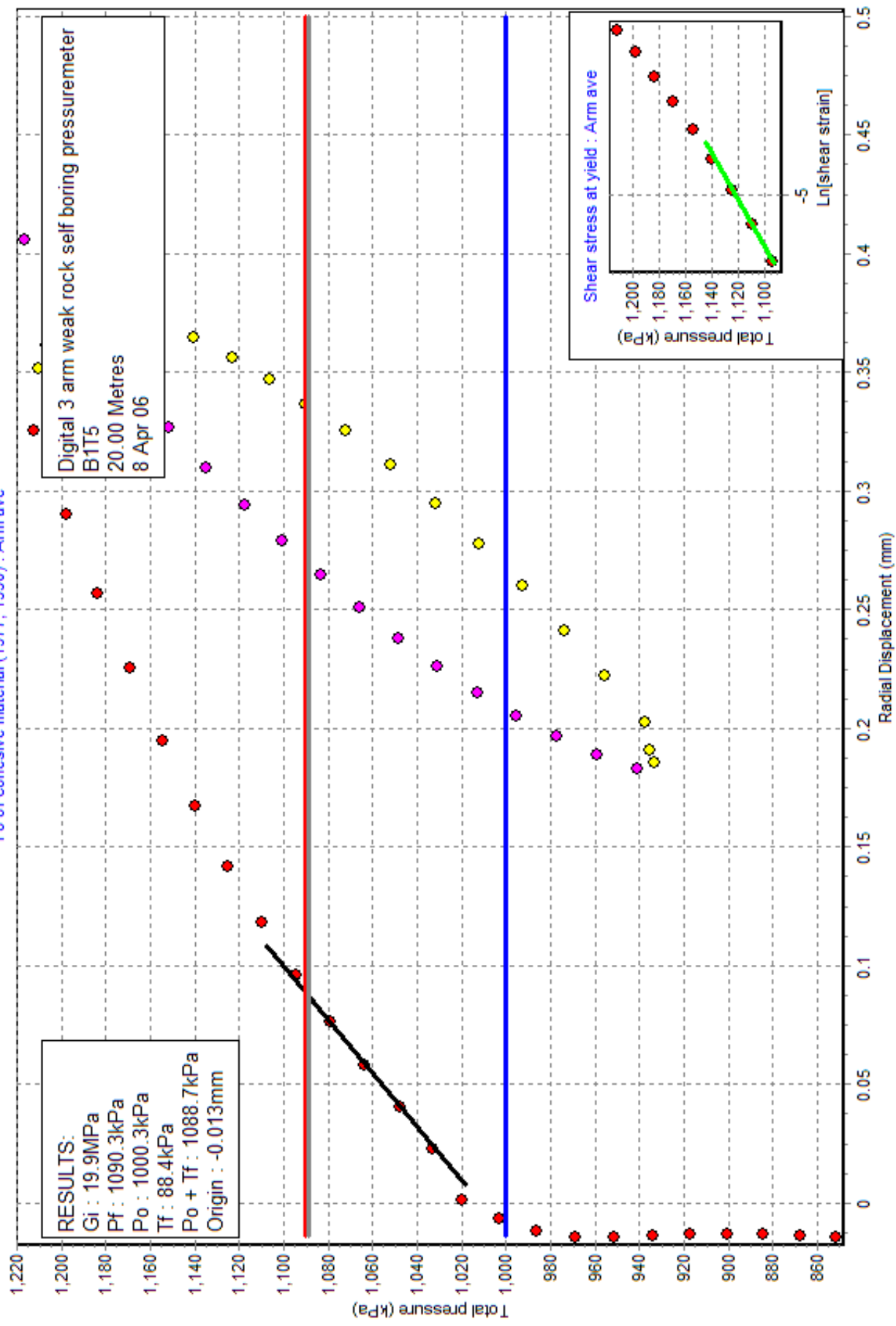


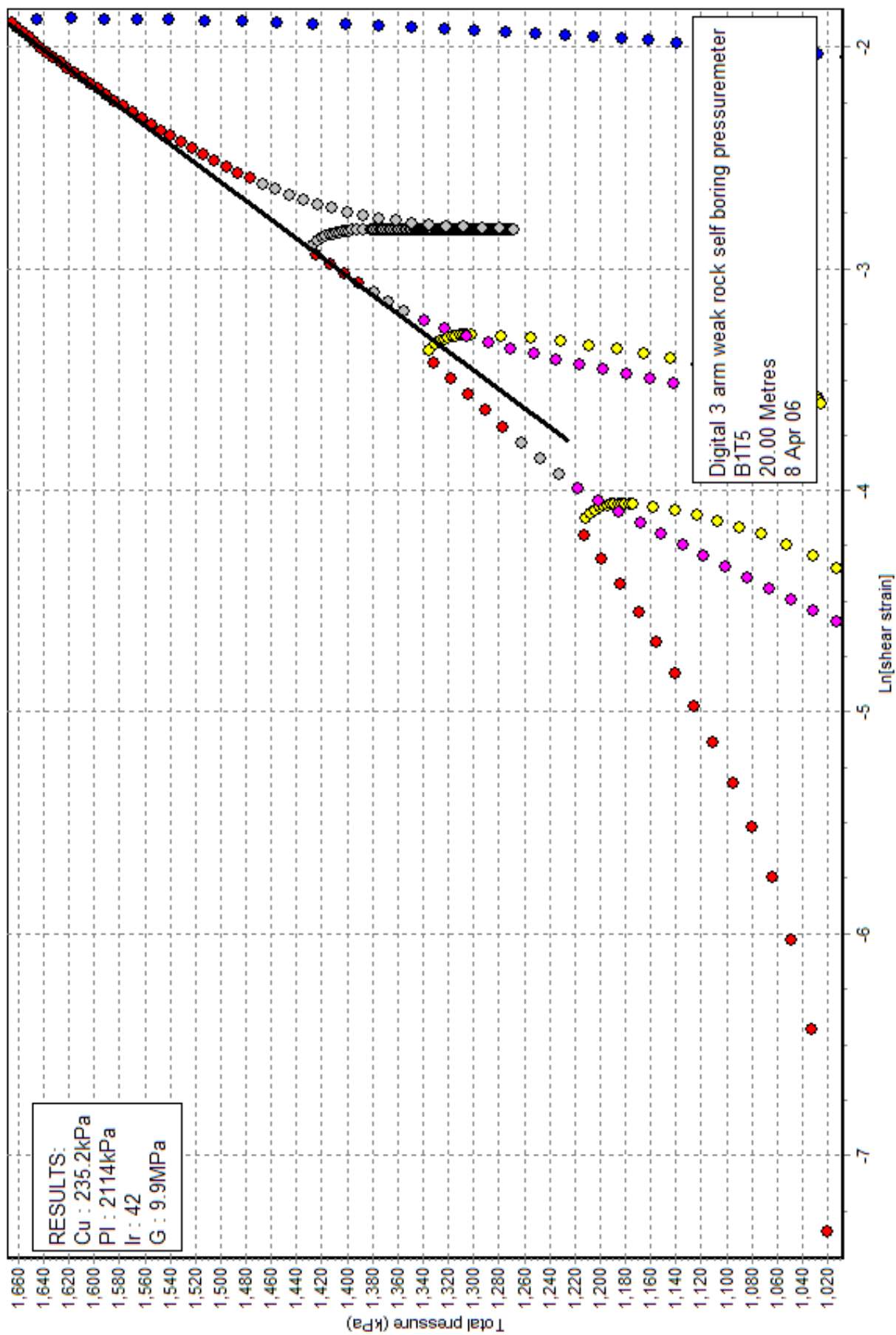
B1T5
20.0 metres
08/04/06

All Pressure Cells vs Time

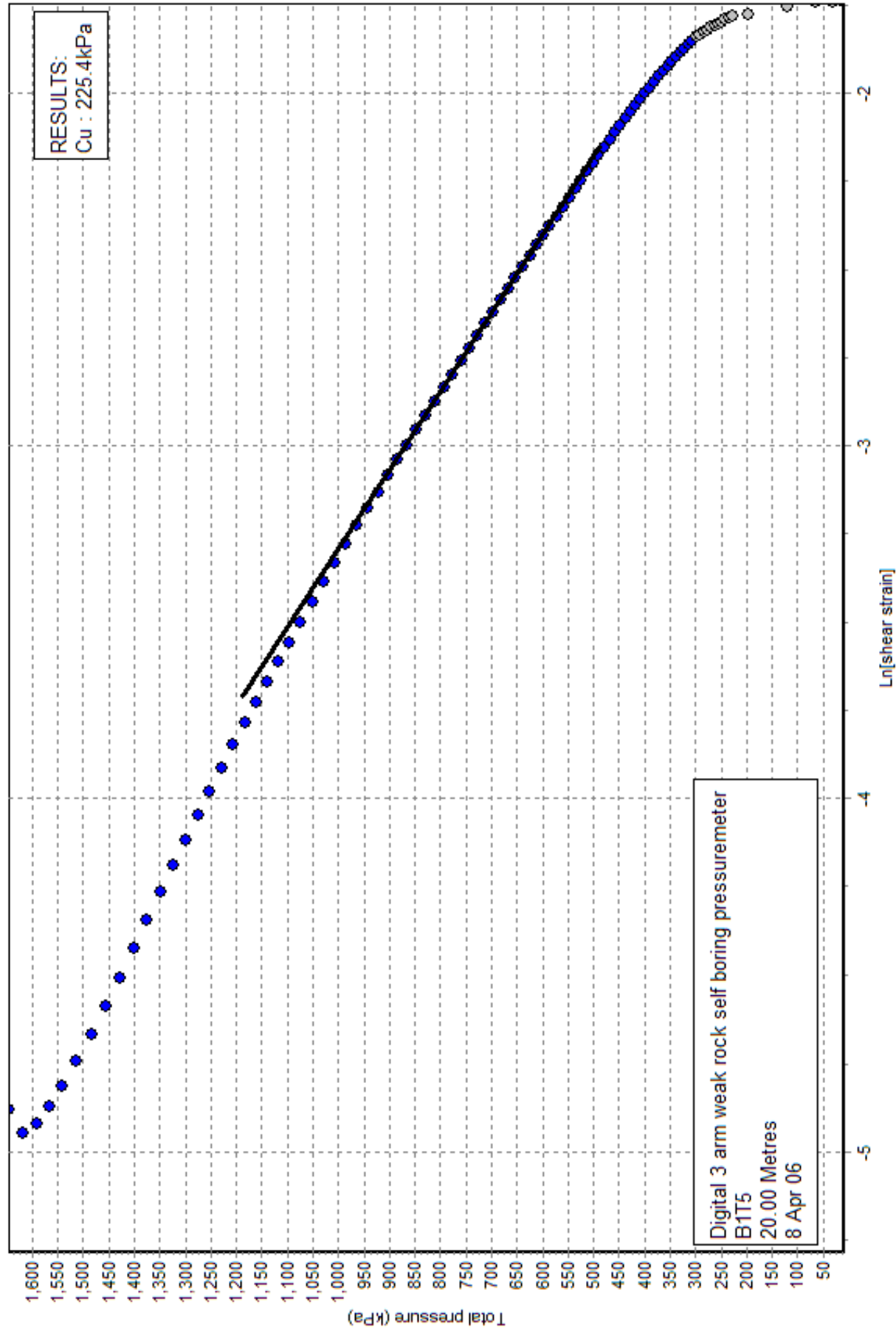


Po of cohesive material (1977, 1990) : Arm ave

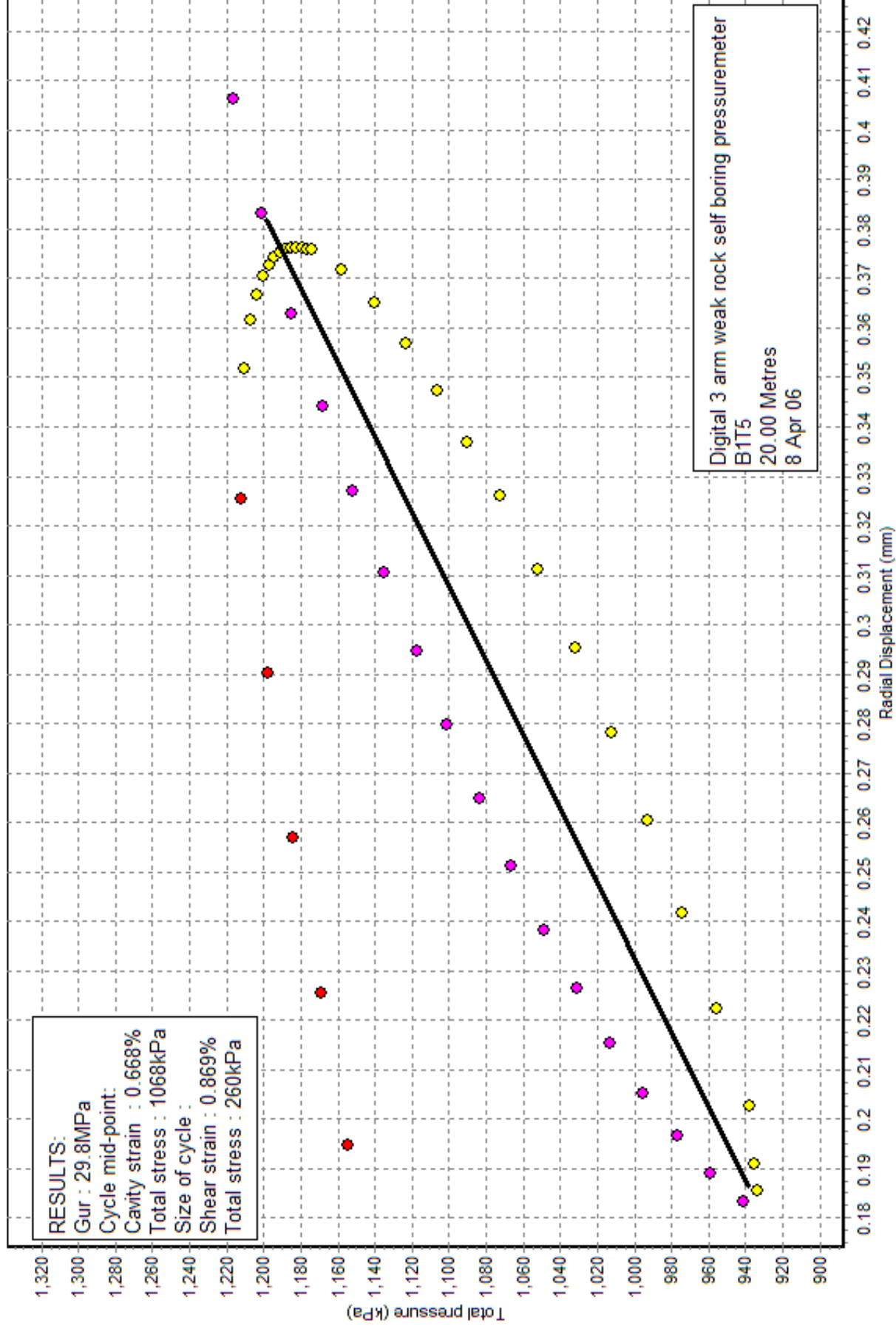




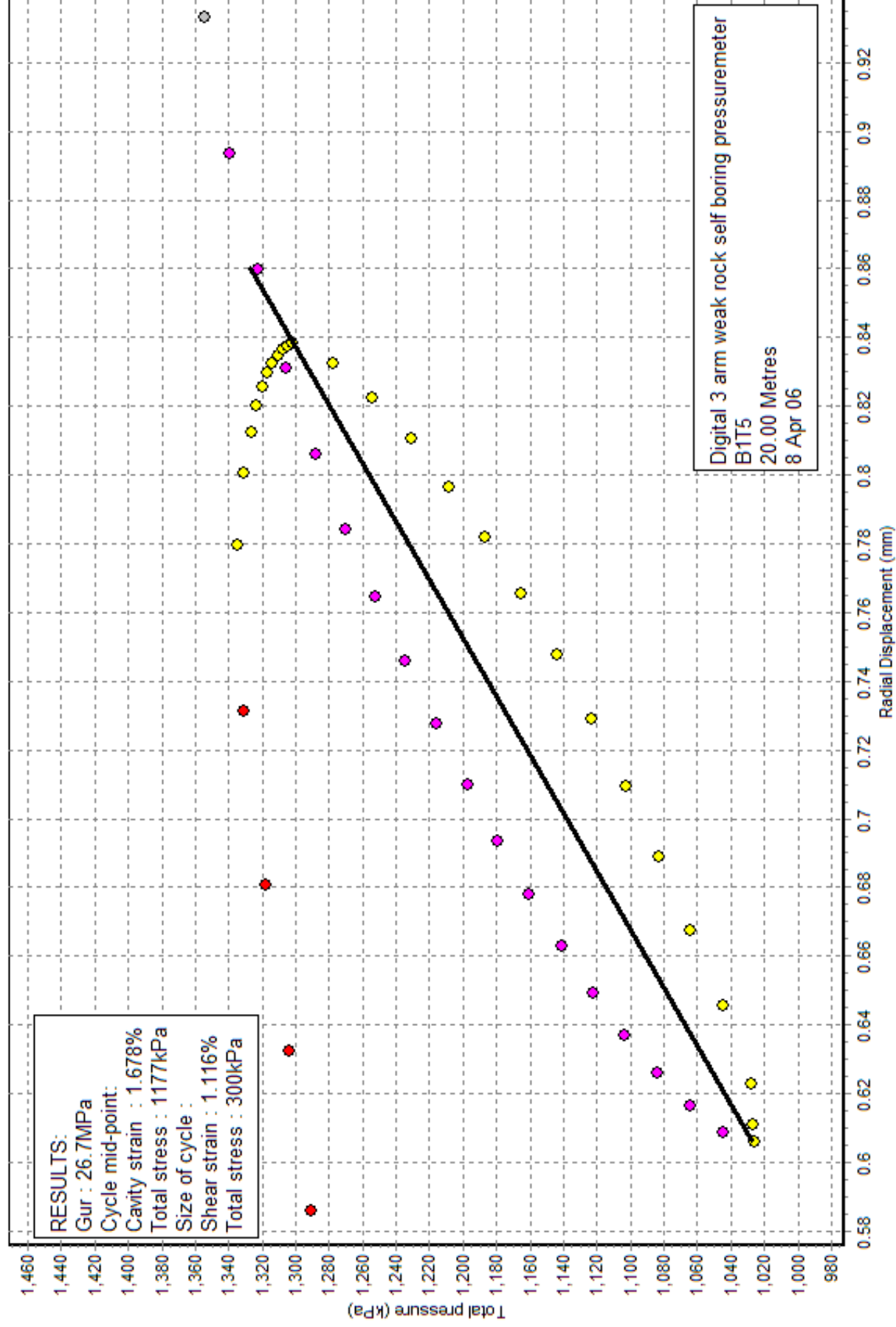
Jefferies (1988) : Arm ave



Shear modulus from unload/reload cycles Loop 1 : Arm ave



Shear modulus from unload/reload cycles Loop 2 : Arm ave



Digital 3 arm weak rock self boring pressuremeter
B1T5
20.00 Metres
8 Apr 06
RESULTS:
Gradient (beta) : 0.674
Intercept (n) : 6.574MPa
Shear stress constant : 4.430MPa

Ln[Radial stress]

4

5

-8

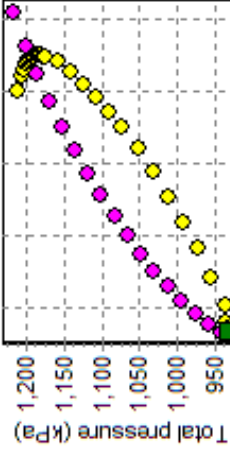
-7

-6

-5

Ln[shear strain]

Source data - Loop 1



Radial Displacement (mm)

Digital 3 arm weak rock self boring pressuremeter

B1T5

20.00 Metres

8 Apr 06

RESULTS:

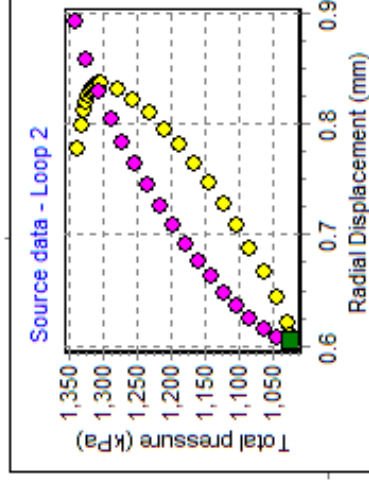
Gradient (beta) : 0.672

Intercept (n) : 6.336MPa

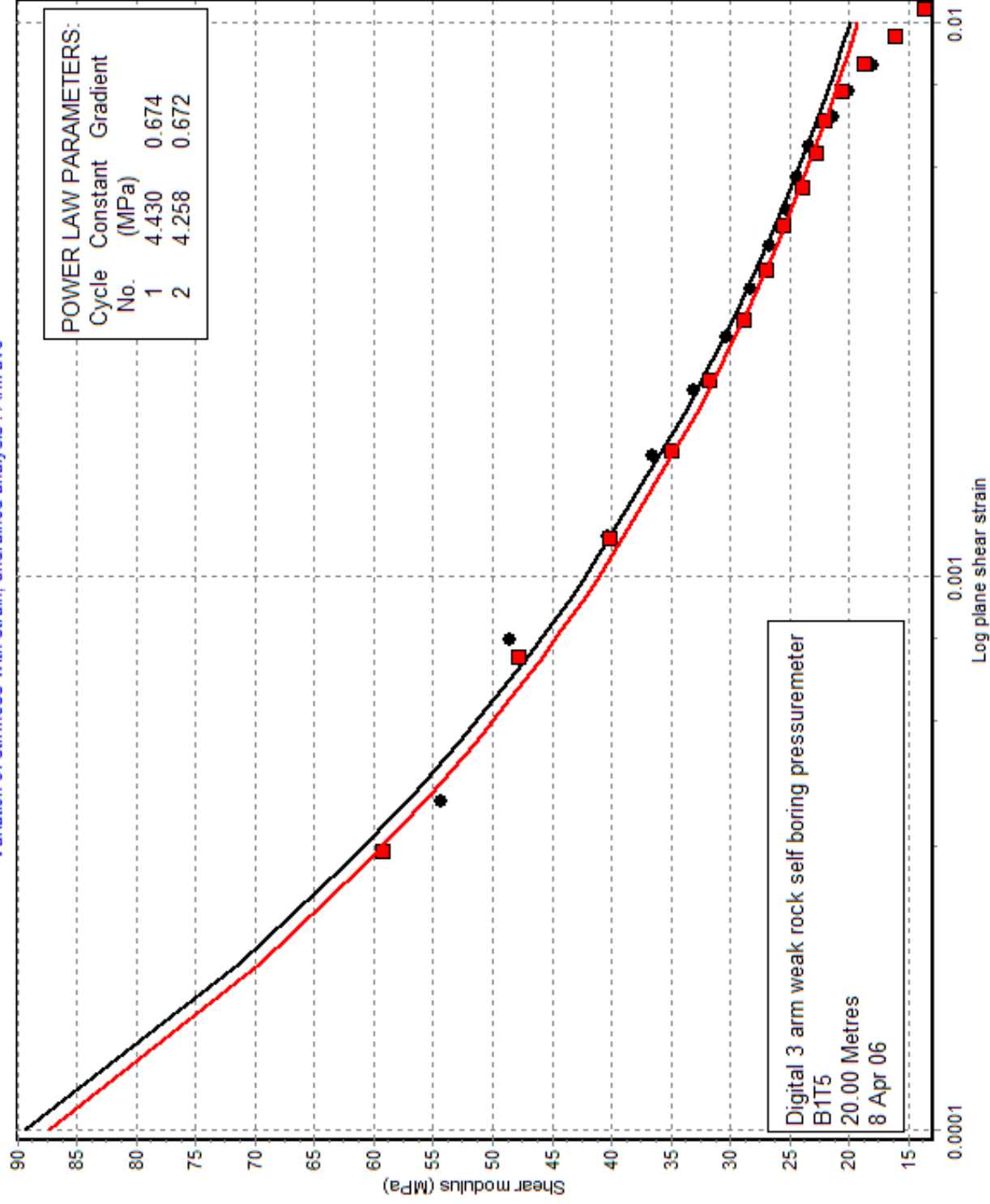
Shear stress constant : 4.258MPa

Ln[Radial stress]

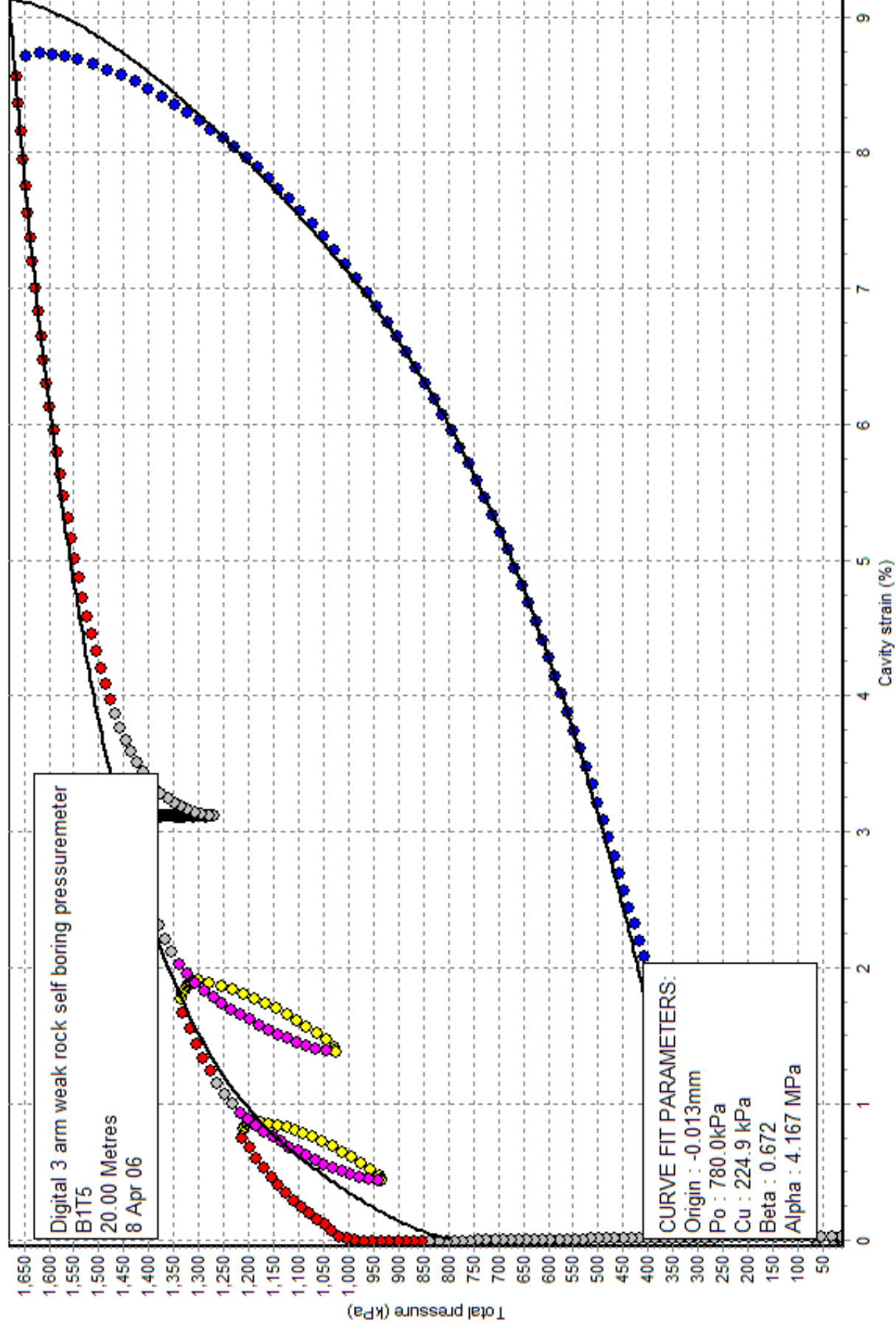
Ln[shear strain]



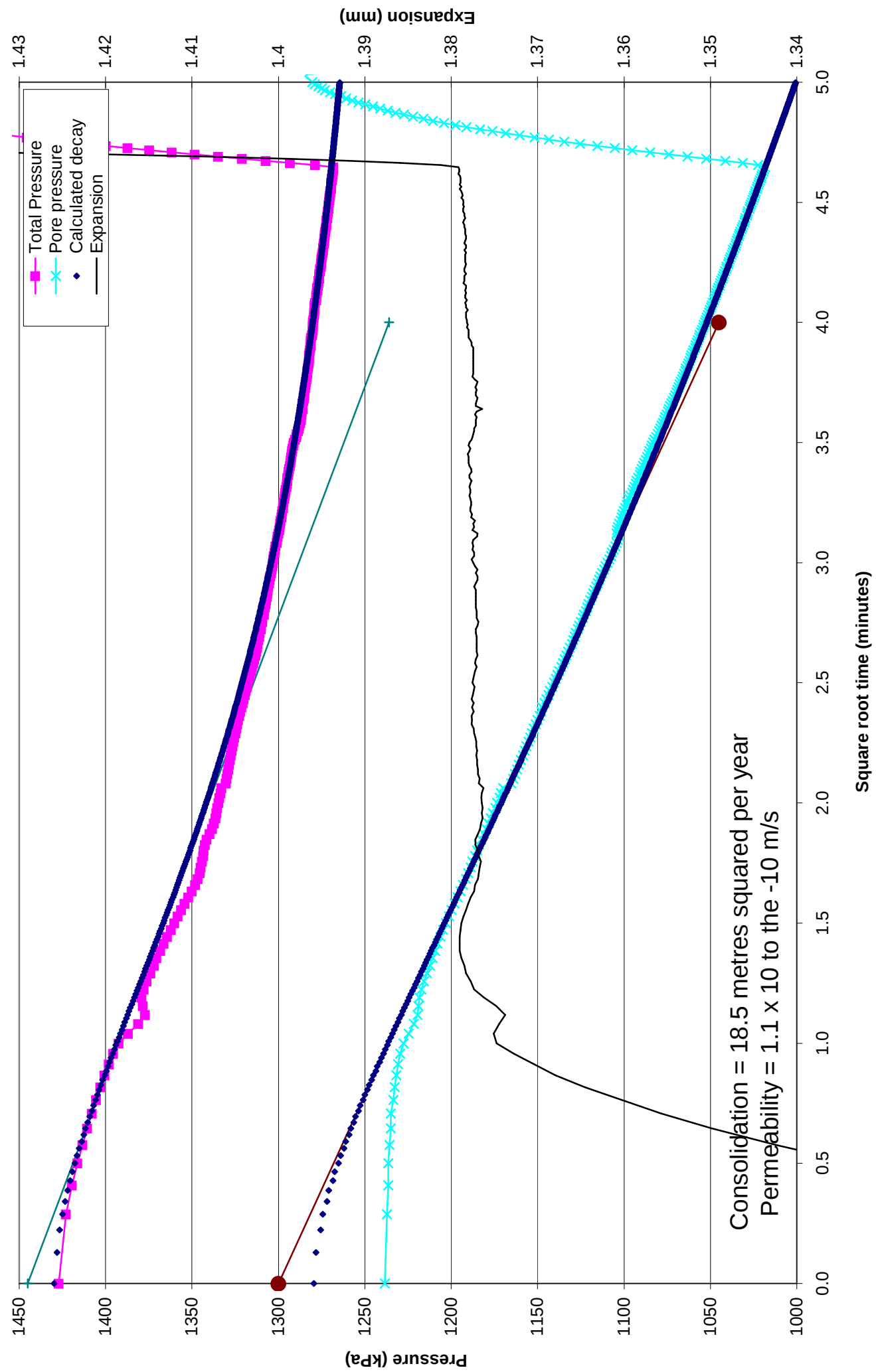
Variation of stiffness with strain, undrained analysis : Arm ave



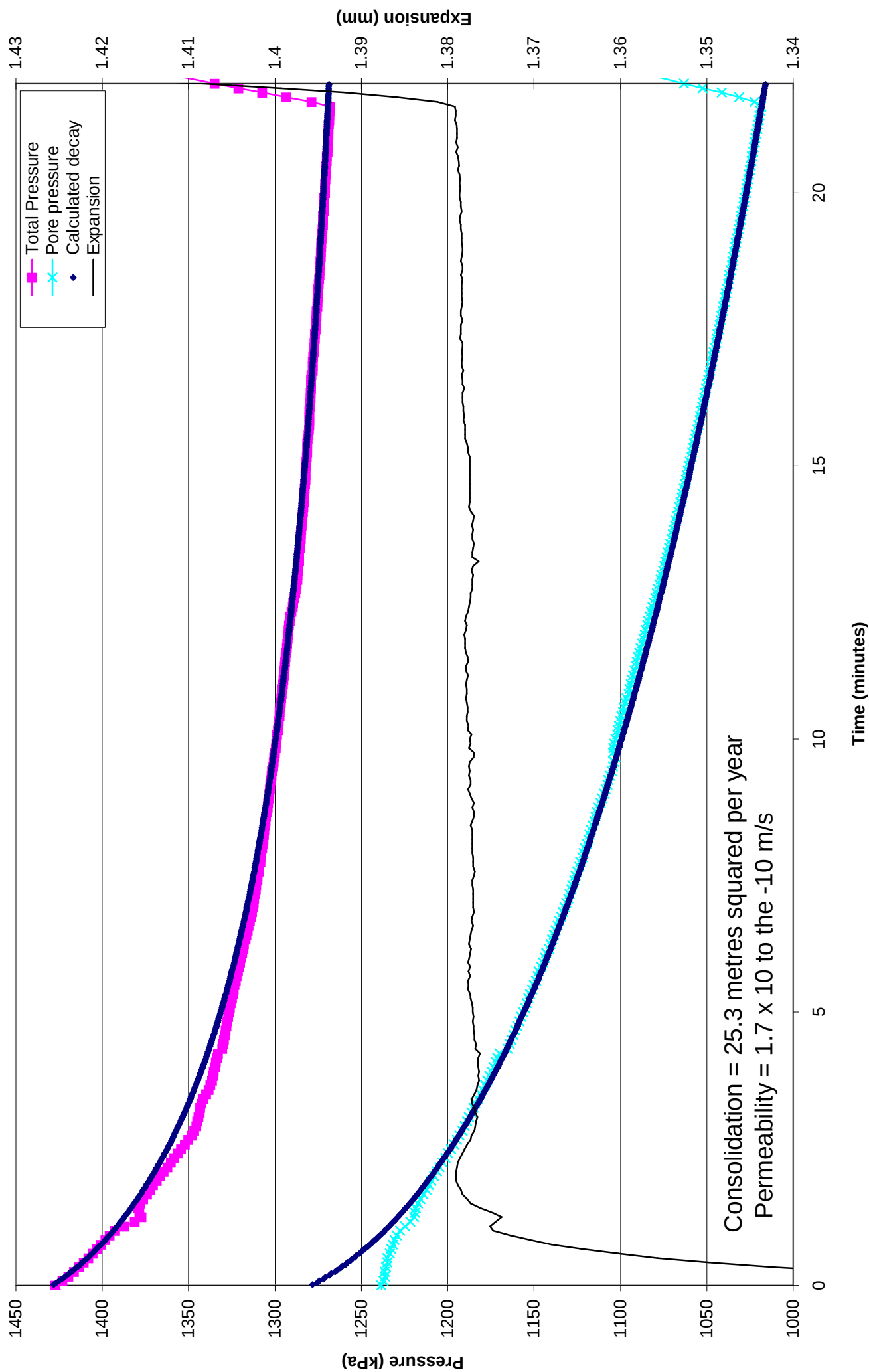
Curve comparison (Whittle 1999) : Arm ave



Holding test simulation - matching the start of the decay
B1T5



Holding test simulation - matching the whole decay
B1T5



B1T6 10/04/06 25.0m Grey Clay

- 1. Test record sheet**
- 2. Results summary**
- 3. Plot of expansion versus pressure – all arms**
- 4. Plot of expansion versus pressure – arm average**
- 5. Plot of all pressure cells versus time**
- 6. Plot of Marsland and Randolph procedure**
- 7. Gibson and Anderson plot, giving C_u and P_L from loading curve**
- 8. Jefferies plot, giving C_u from unloading curve**
- 9. Plot of Reload Loop 1, with linear modulus line**
- 10. Plot of Reload Loop 2, with linear modulus line**
- 11. Plot of Reload Loop 3, with linear modulus line**
- 12. Plot of Reload Loop 4, with linear modulus line**
- 13. Bolton and Whittle plot of reloading part of Loop 1, giving nonlinearity coefficients**
- 14. Ditto for Loop 2**
- 15. And for Loop 3**
- 16. And Loop 4**
- 17. Plot of Shear modulus versus Shear strain for all reload loops**
- 18. Plot of strain versus pressure, with computed curve and field data**
- 19. Plot of Hold 1, showing pressure and expansion**
- 20. Plot of creep against log time, with final trend line for Hold 1**
- 21. Plot of Hold 2, showing pressure and expansion**
- 22. Plot of creep against log time, with final trend line for Hold 2**

3 ARM SELF BORING PRESSUREMETER

TEST RECORD SHEET

SITE	DATE	DAY	BOREHOLE	TEST	Depth to test centre
RURITANIA	10/6/06	WED	1	6	25m
MATERIAL: GREY CLAY			Site Weather: TRYING TO RAIN		
Water Table	Drilling Start	Drilling End	Distance	Drill rate	Ram Pressure
	09:30	10:20	1m	OK	
Orientation:					
Water Press.	Probe Dia.	Shoe Dia.	Drill Bit	Bit Location	Probe Ref.
		89mm	83ARB	~25mm OUT	DSUGAL
Drilling remarks: SLOWLY TOWARDS BED.					
Strain Rate	Press. Rate	Cycle Time	Gas Bottle	Battery V	PPC Type
		5s	DSUGAL	AK	TRUE
Mx. Press.					
TRANSDUCER DETAILS					
	ARM 1	ARM 2	ARM 3	TPC	PPC A
GL Zero					
Test Depth					
Test Start Time	Test End Time	Mx Pressure Reached	Disk Reference		
10:03	10:43	22.9 MPa			
TEST NOTES					
Line No.	Remarks				
30	ARMS (1) & (3) MOVING ~950 kPa				
40	ARM (2) " " ~NO! JUMP ONLY.				
60	ARM (2) MOVING SLOWLY ~1600 kPa				
75	" " " " PROBABLY ~2000 kPa				
85	HOLD				
135	LWR (1)				
185	HOLD - LOT OF CREEP - ARM (2) MOST!				
225	LWR (2) - DISTORTED BY CREEP.				
272	DOWN - ARM (2) 20mm (LIMITING!)				
289	ARM (2) OUT OF LIMITING ~2100 kPa				
300	HOLD → LWR (3)				
370	HOLD → LWR (4) - LONGER HOLD.				
Test Engineer: P. R. J.					
Driller:					
Membrane Correction	Membrane Compression	Arm Cals Ref.	Pressure Cals Ref.		
H270875	H280871	7-8-03	7-8-08		
GENERAL COMMENTS:					

CAMBRIDGE INSITU, Little Eversden, Cambridge, CB3 7HE

Telephone: (01223)262361 Fax: (01223) 263947 E-Mail: CamInsitu@AOL.COM

WEAK ROCK SELF-BORING PRESSUREMETER

RESULTS SUMMARY SHEET

Site:- Ruritania

Test :- B1T6

Test Date :- 10th April 2006

Material :- Grey clay

Depth :- 25.0 mtrs

Water table :- ~11 mtrs

		PPC A	PPC B
<u>Initial water pressure</u>	kPa	102	558

Analysis of Insitu Lateral Stress (Po) :-

		Average
Marsland and Randolph	kPa	1000
Zero offset	mm	0.00

Analysis of Undrained Shear Strength (Cu) :-

Gibson and Anderson	kPa	630
Pressure at failure (P _F)	kPa	1446
Limit Pressure (P _L)	kPa	4498
Jefferies (unloading)	kPa	592

Analysis of Shear Modulus (G) :-

Initial Modulus (G _i)	MPa	70.1
-----------------------------------	-----	------

Linear Analysis of Reload Loops (G_R) :-

		Loop 1	Loop 2	Loop 3	Loop 4
G _R	MPa	79.4	64.7	75.2	66.8
Co-ordinate :-					
Strain	%	2.1	7.1	10	8.7
Pressure	kPa	2000	2330	1980	1370
Amplitude :-					
Strain	%	0.85	1.10	0.78	0.98
Pressure	kPa	680	720	590	660

Non-linear Analysis of Reloading data :-

α	MPa	14.9	13.8	11.2	9.52
β		0.709	0.701	0.668	0.658

Shear Modulus G_S (at 3 levels of shear strain) :-

(0.01%)	MPa	218	217	238	222
(0.1%)	MPa	112	109	111	101
(1%)	MPa	57	55	52	46

Creep :-

		Hold 1	Hold 2
Pressure of hold	MPa	2.3	2.7
Time of hold	mins	4	3
Rate ε _s (=dε/dlogt)	%	0.8	5.2

Curve matching procedure

Po	=	890	kPa
O/s	=	0.02	mm

Cu	=	591	kPa
----	---	-----	-----

P _L	=	4380	kPa
----------------	---	------	-----

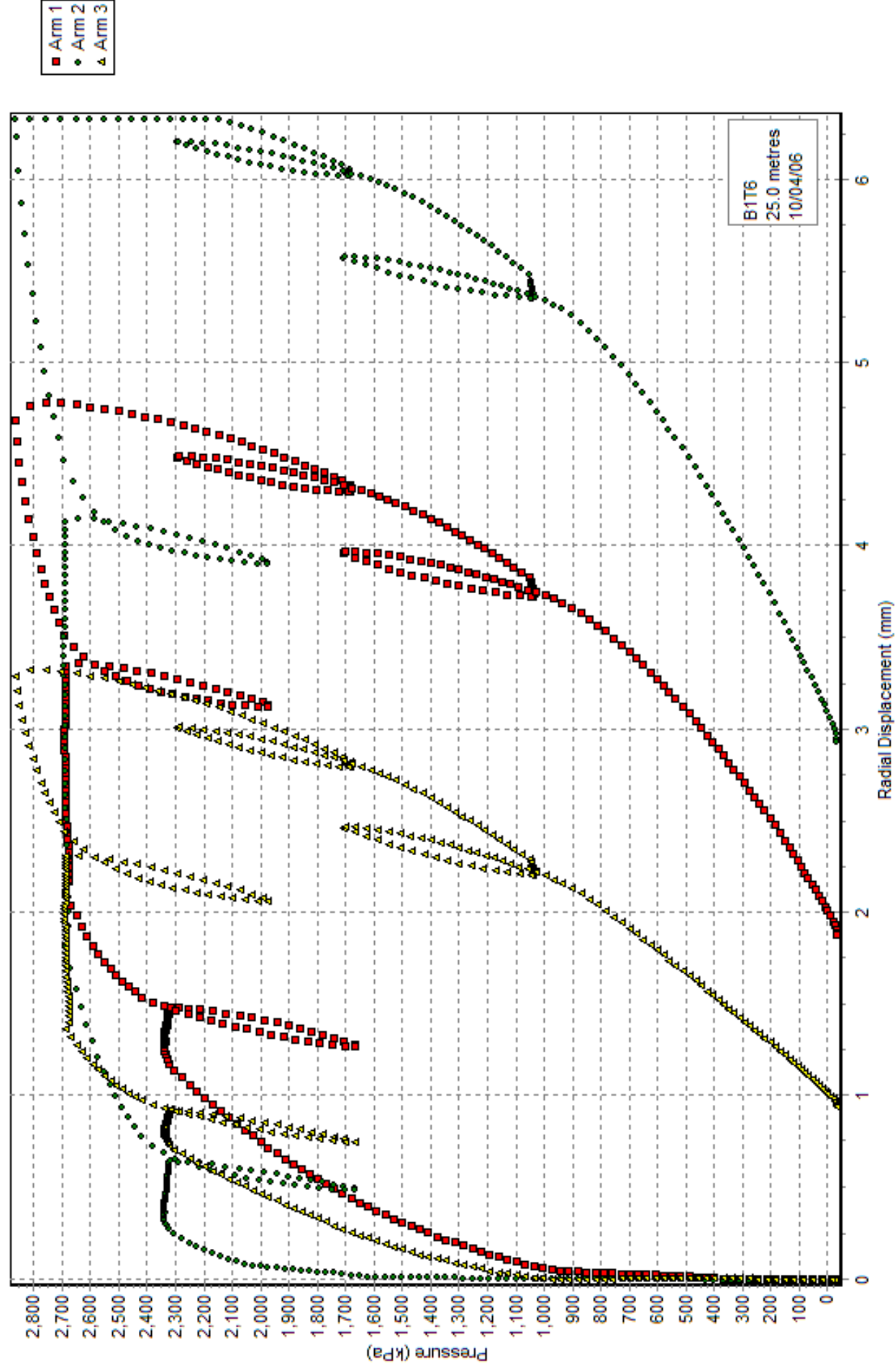
α	=	13.7	MPa
β	=	0.701	

G _{0.01%}	=	215	MPa
G _{0.1%}	=	108	MPa
G _{1%}	=	54	MPa
G _{MIN}	=	52.2	MPa

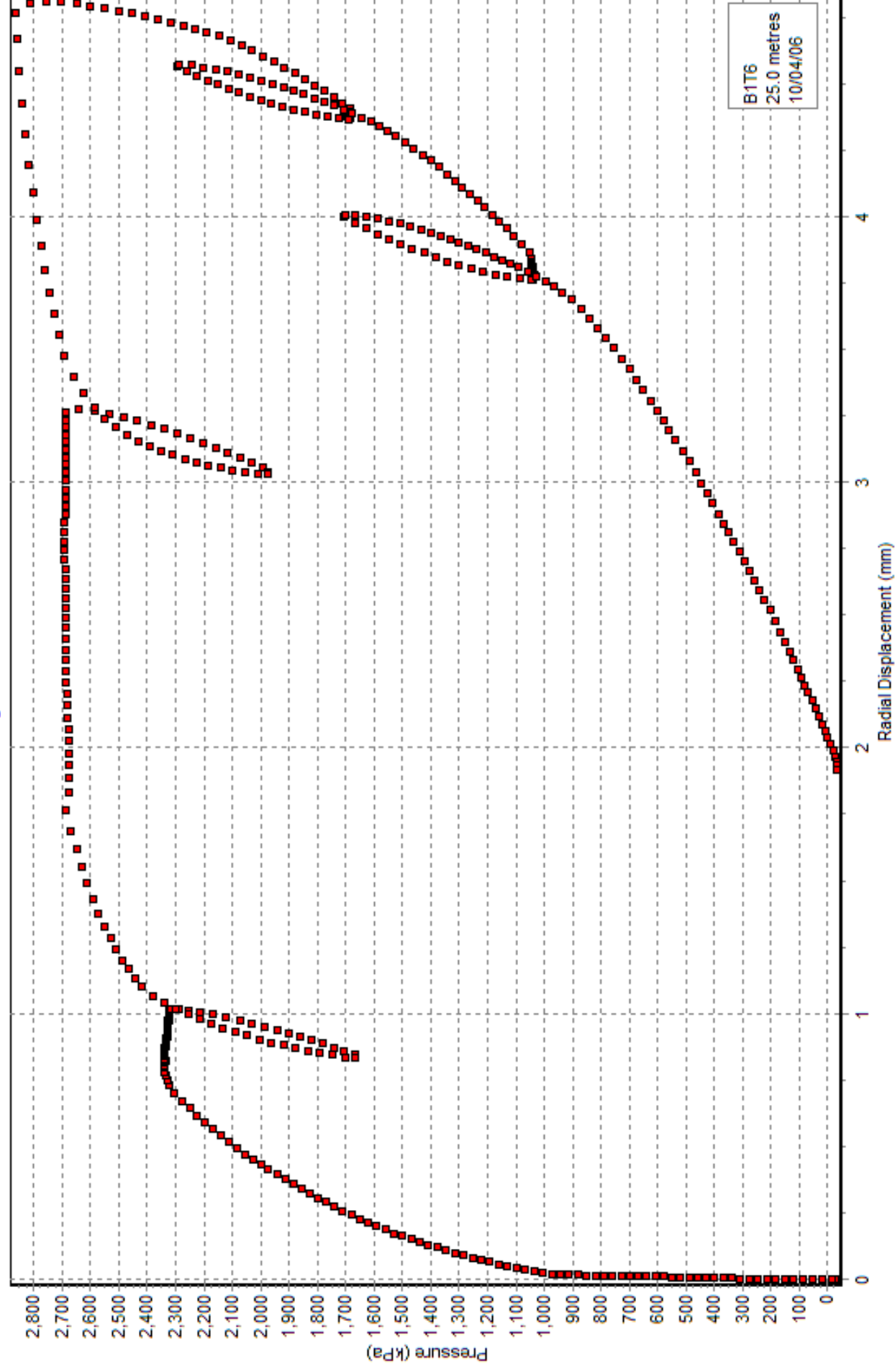
at 1.1% shear strain

Test Analysed By :- PGH
Date :- August 2006

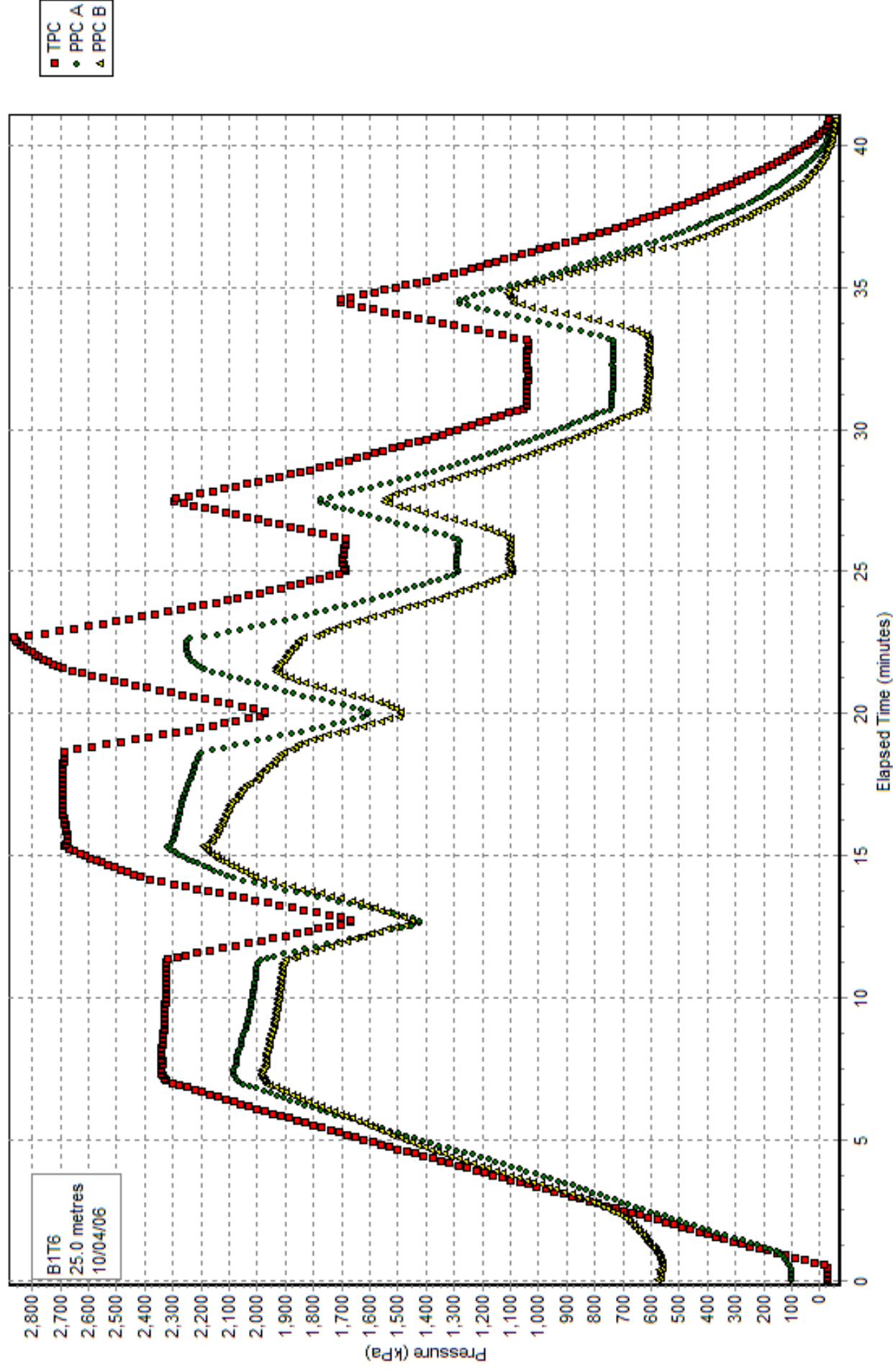
All Arms vs Total Pressure



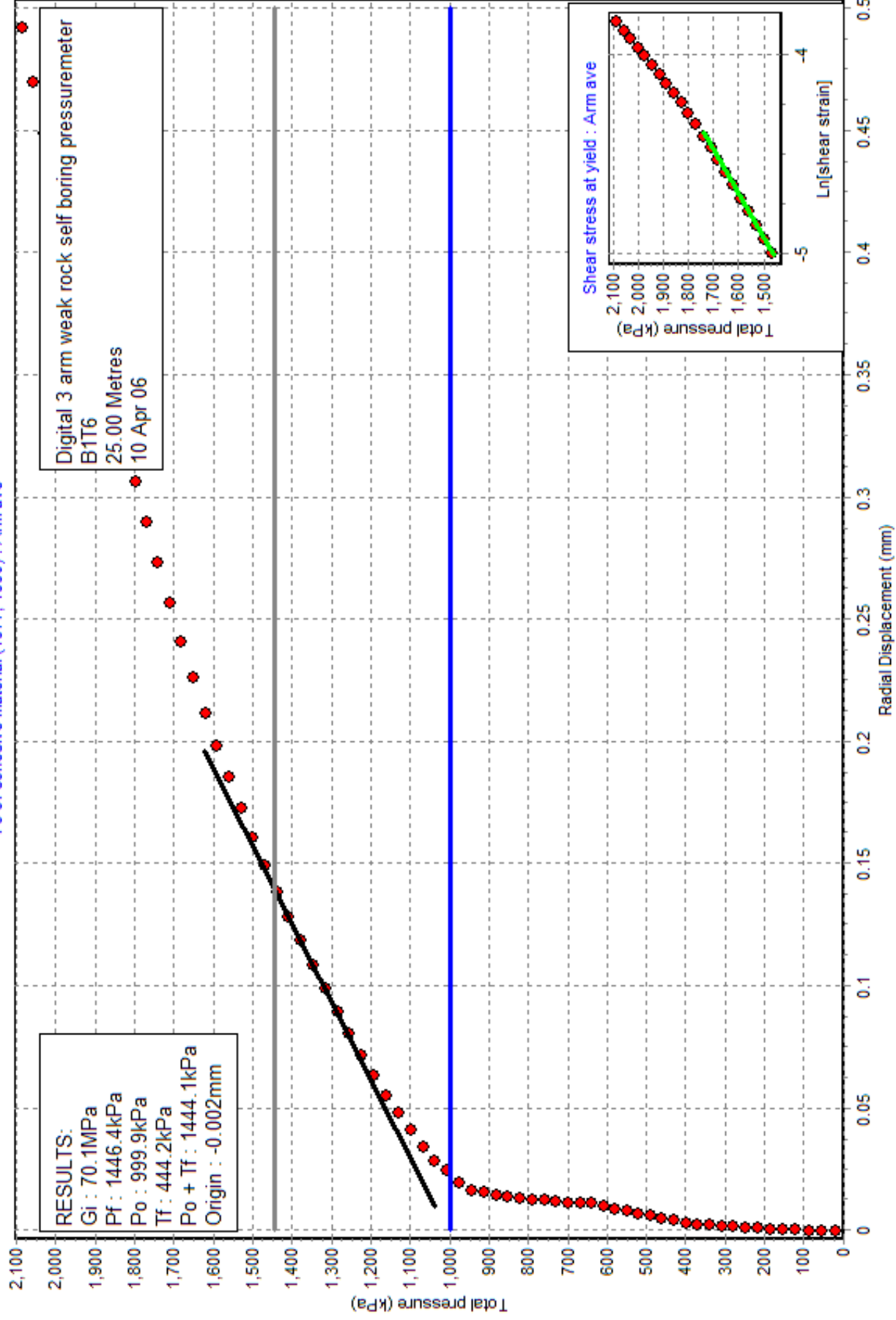
Arm Average vs Total Pressure

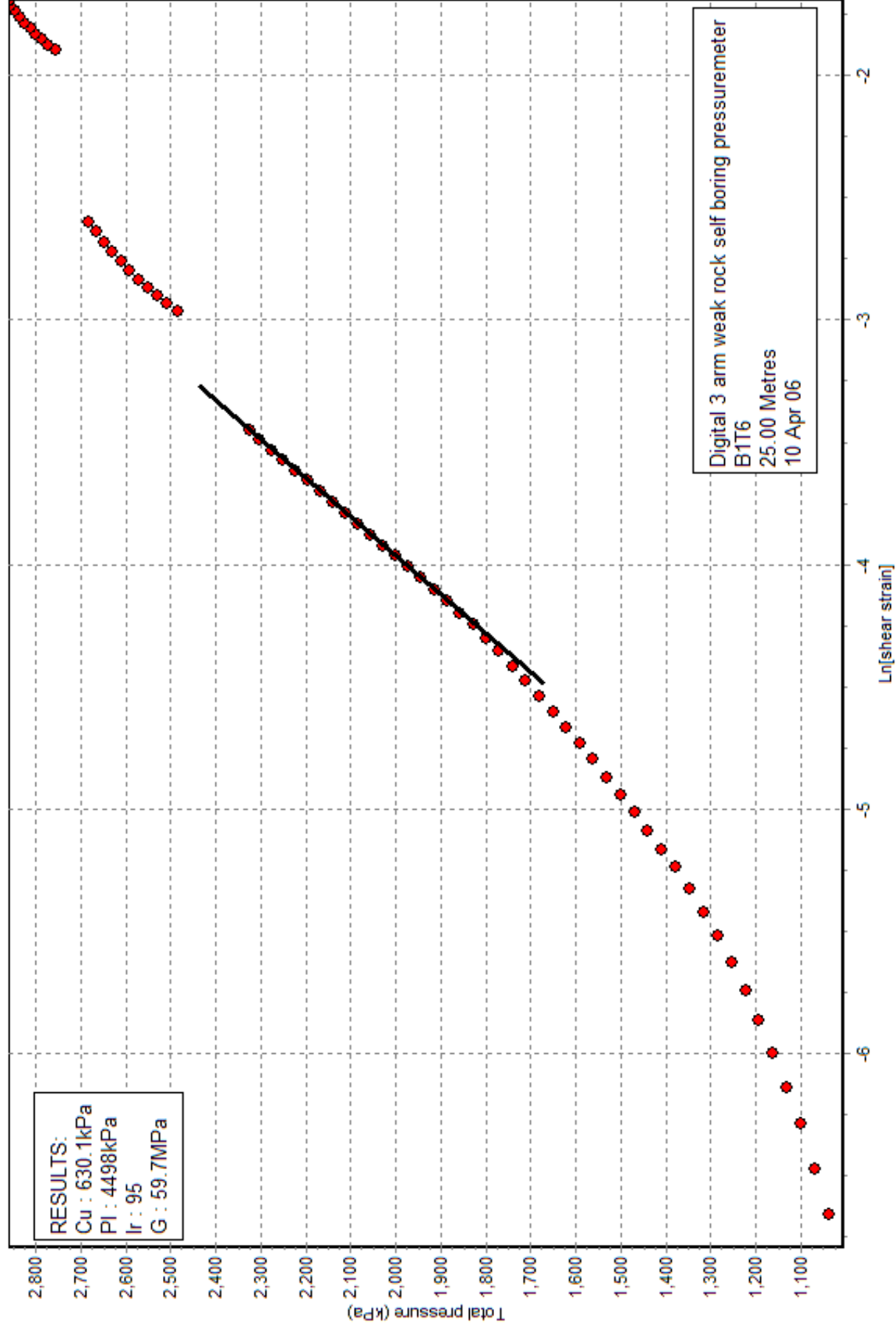


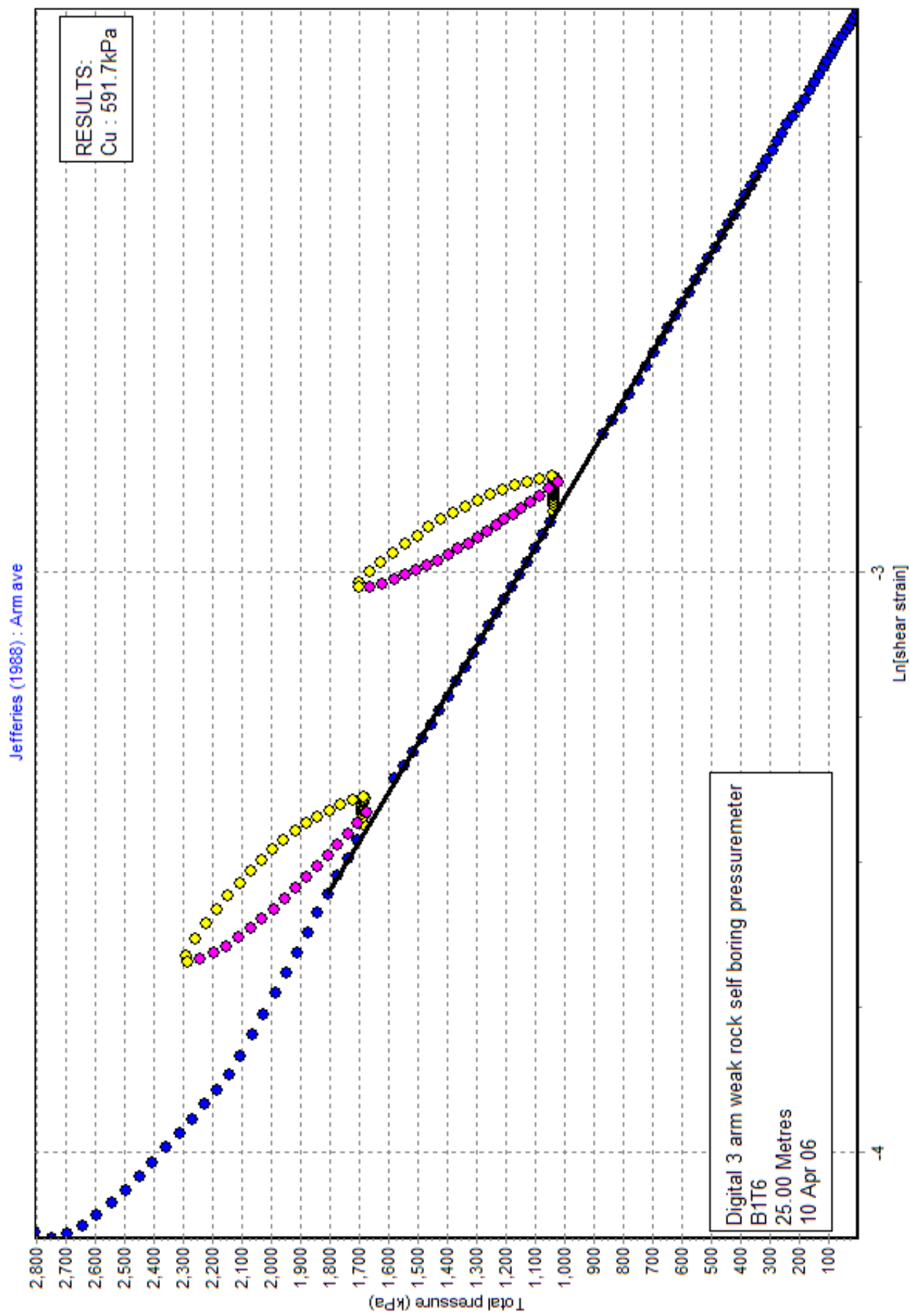
All Pressure Cells vs Time



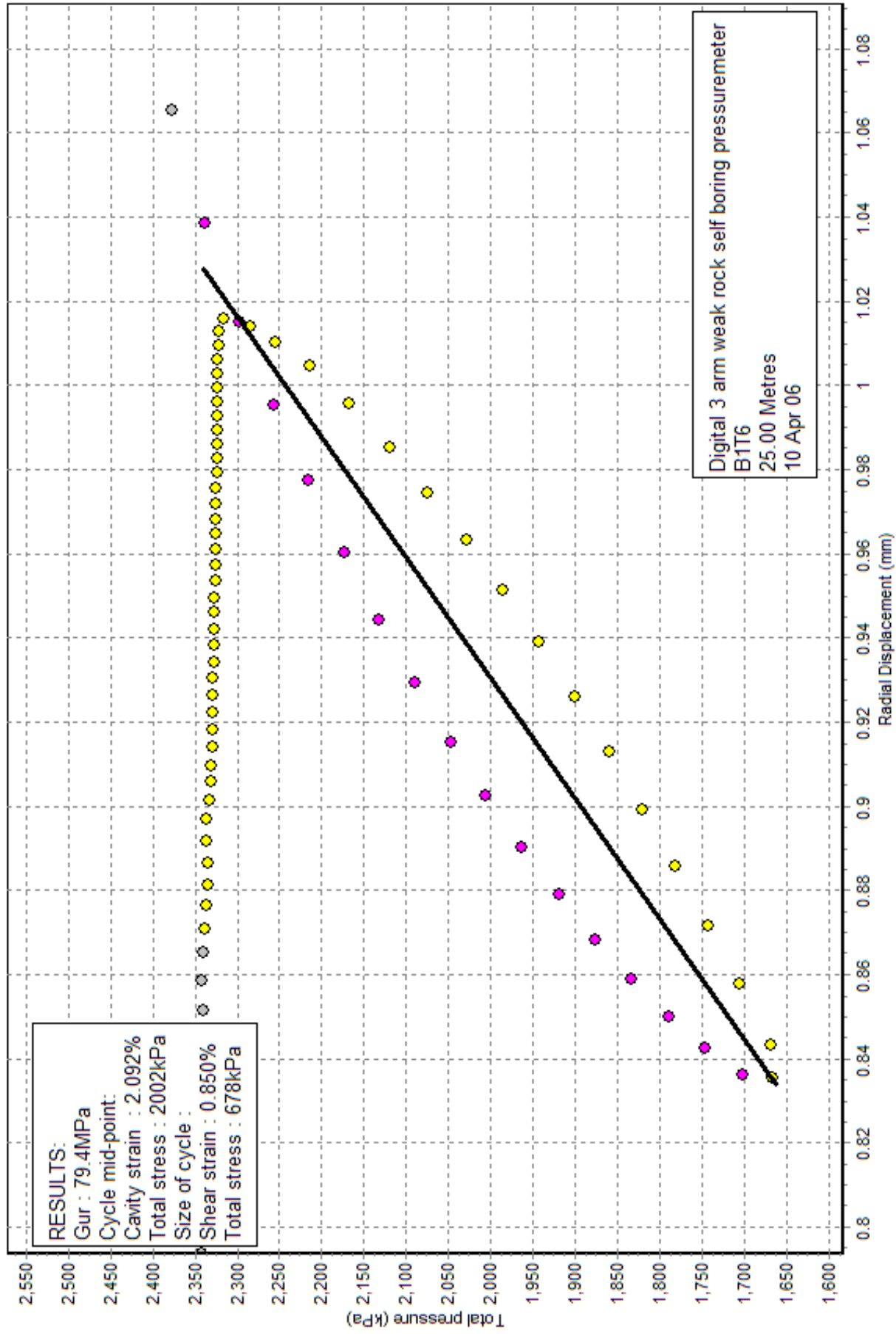
Po of cohesive material (1977, 1990) : Arm ave



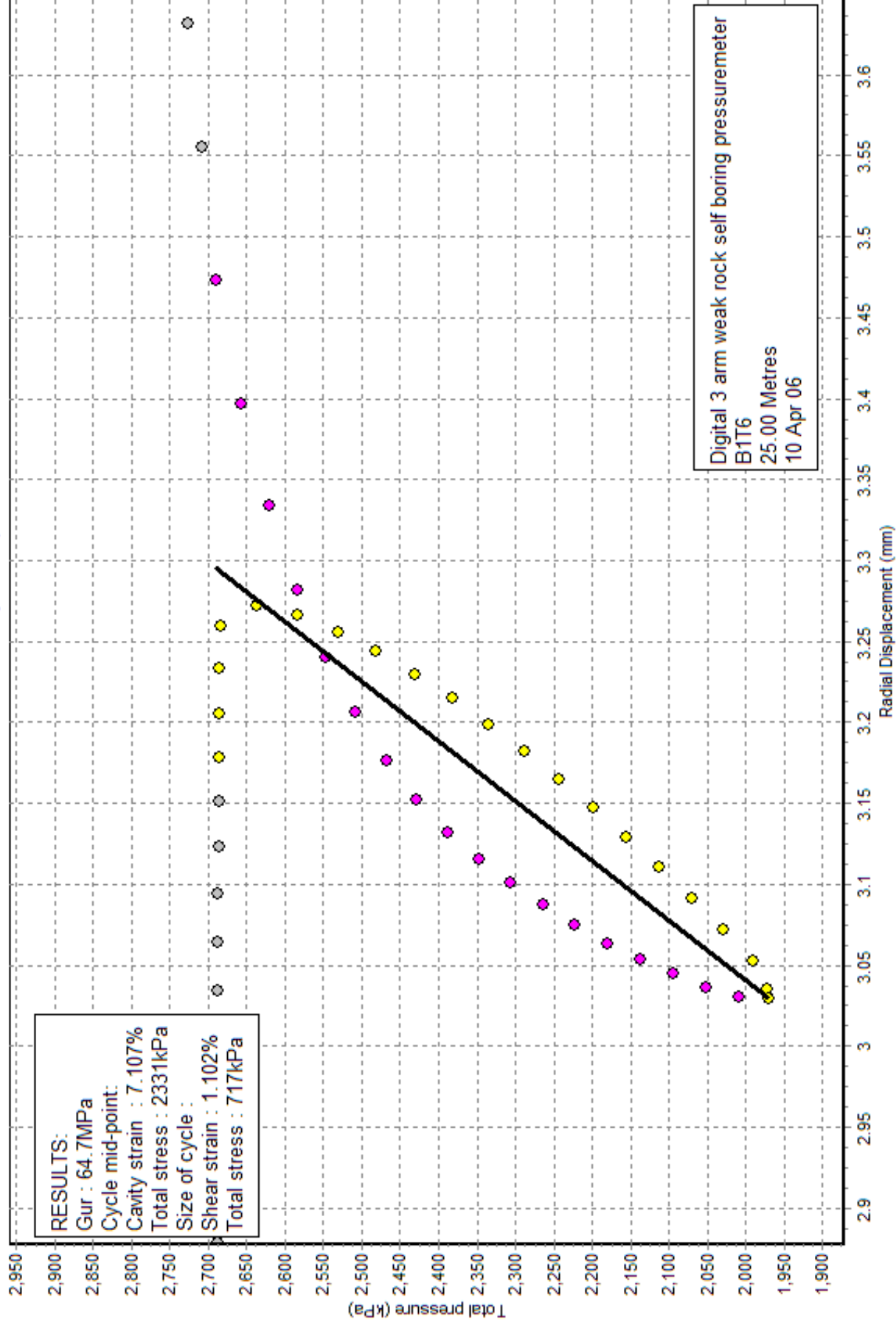




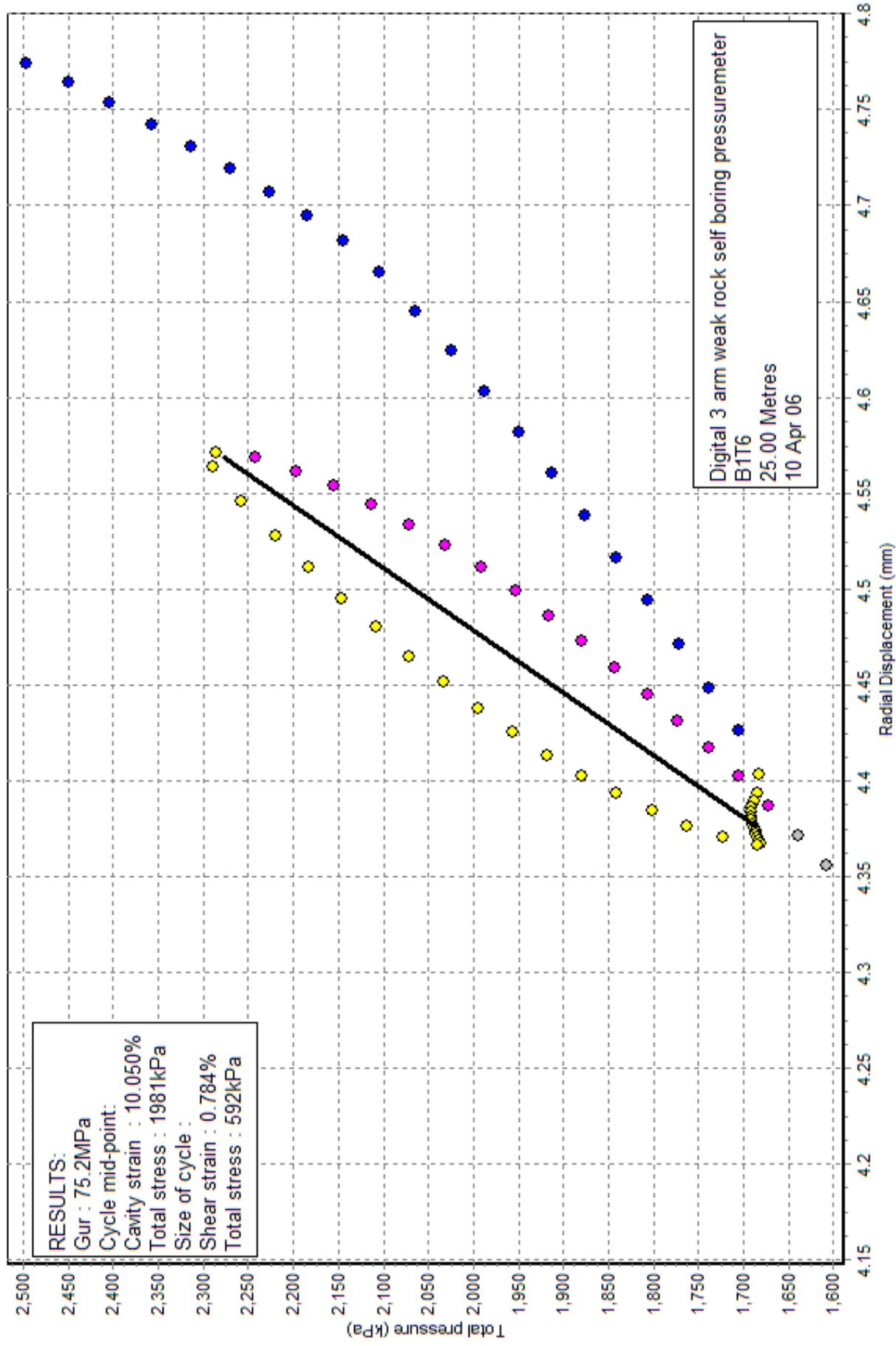
Shear modulus from unload/reload cycles Loop 1 : Arm ave



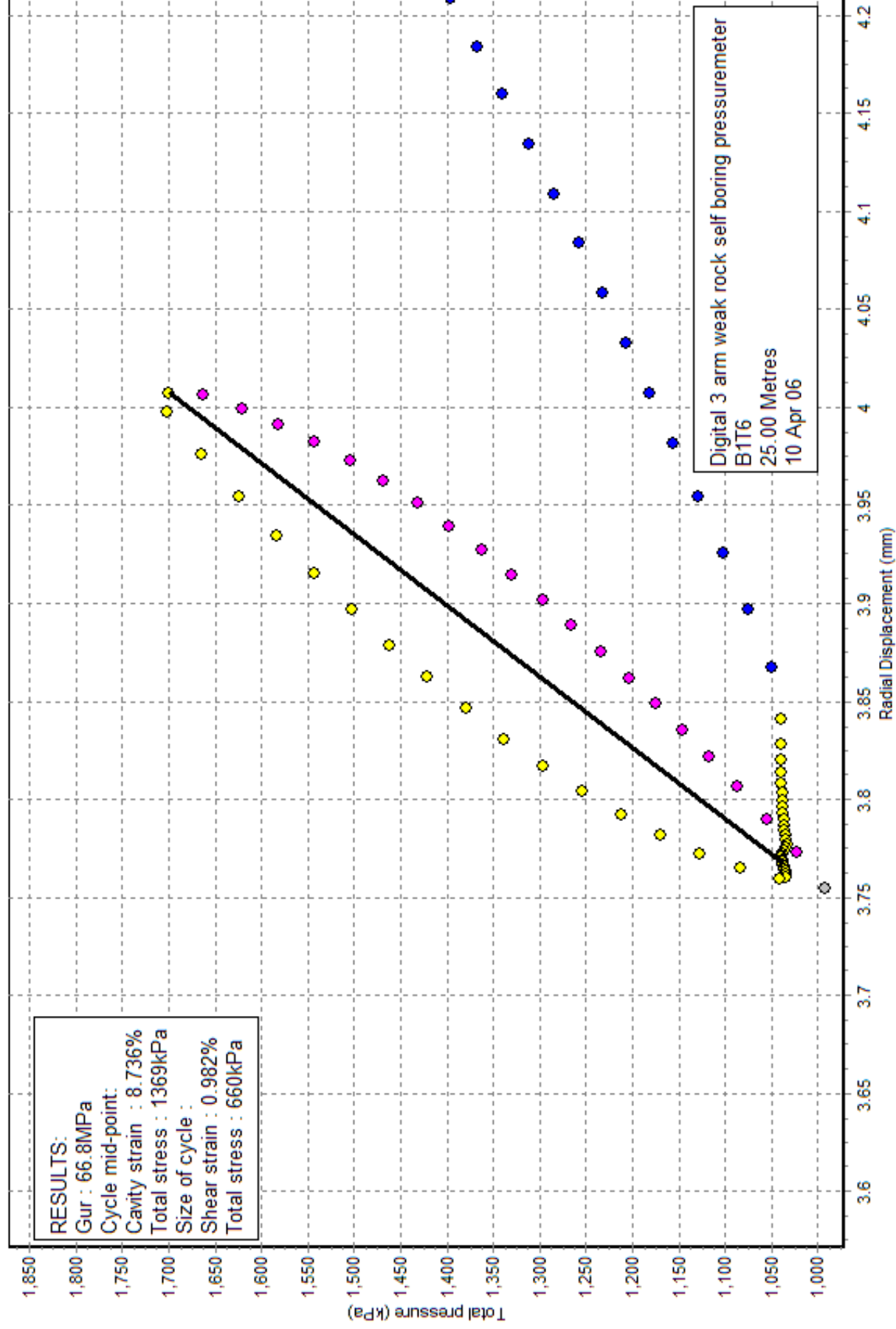
Shear modulus from unload/reload cycles Loop 2 : Arm ave

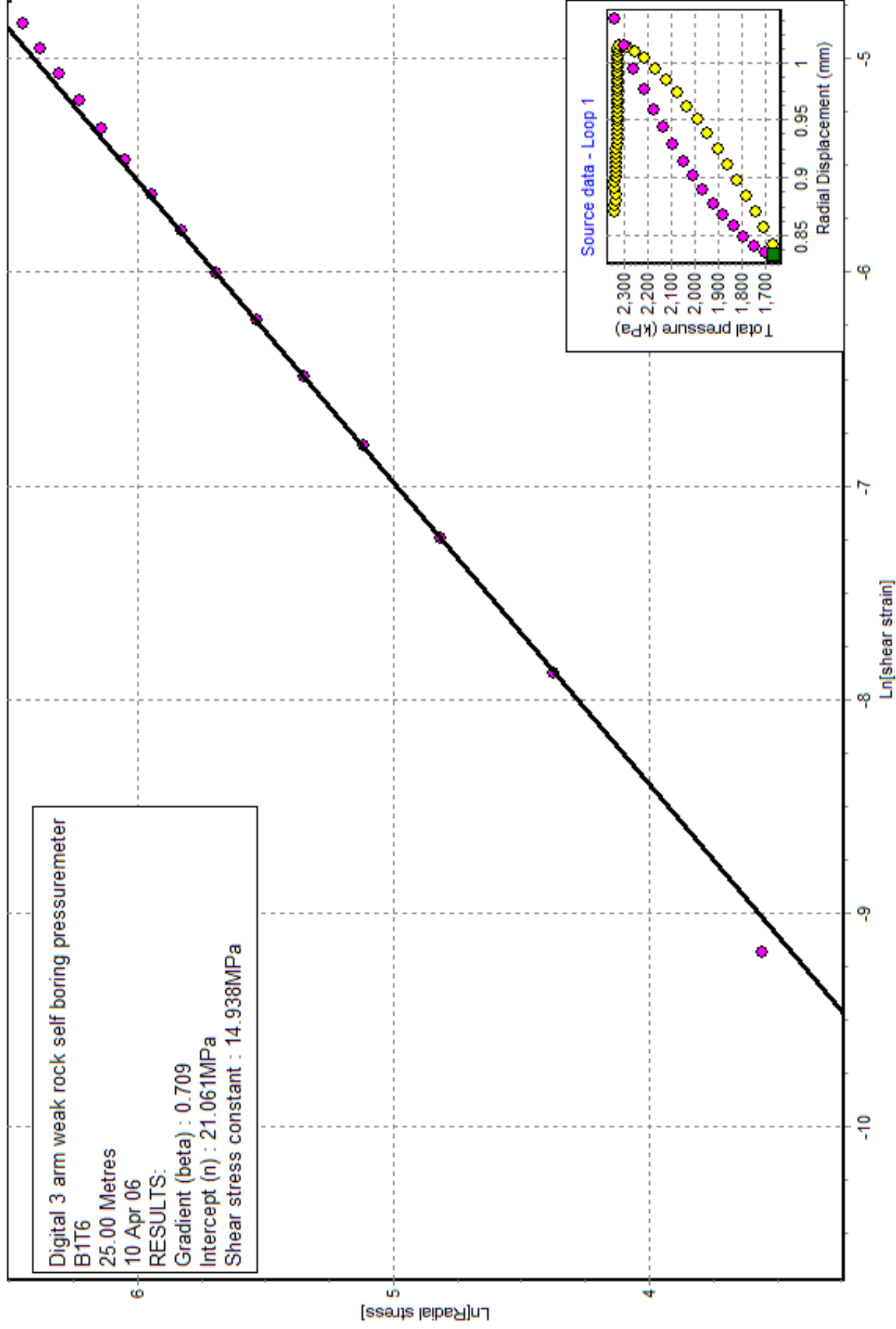


Shear modulus from unload/reload cycles Loop 3 : Arm ave

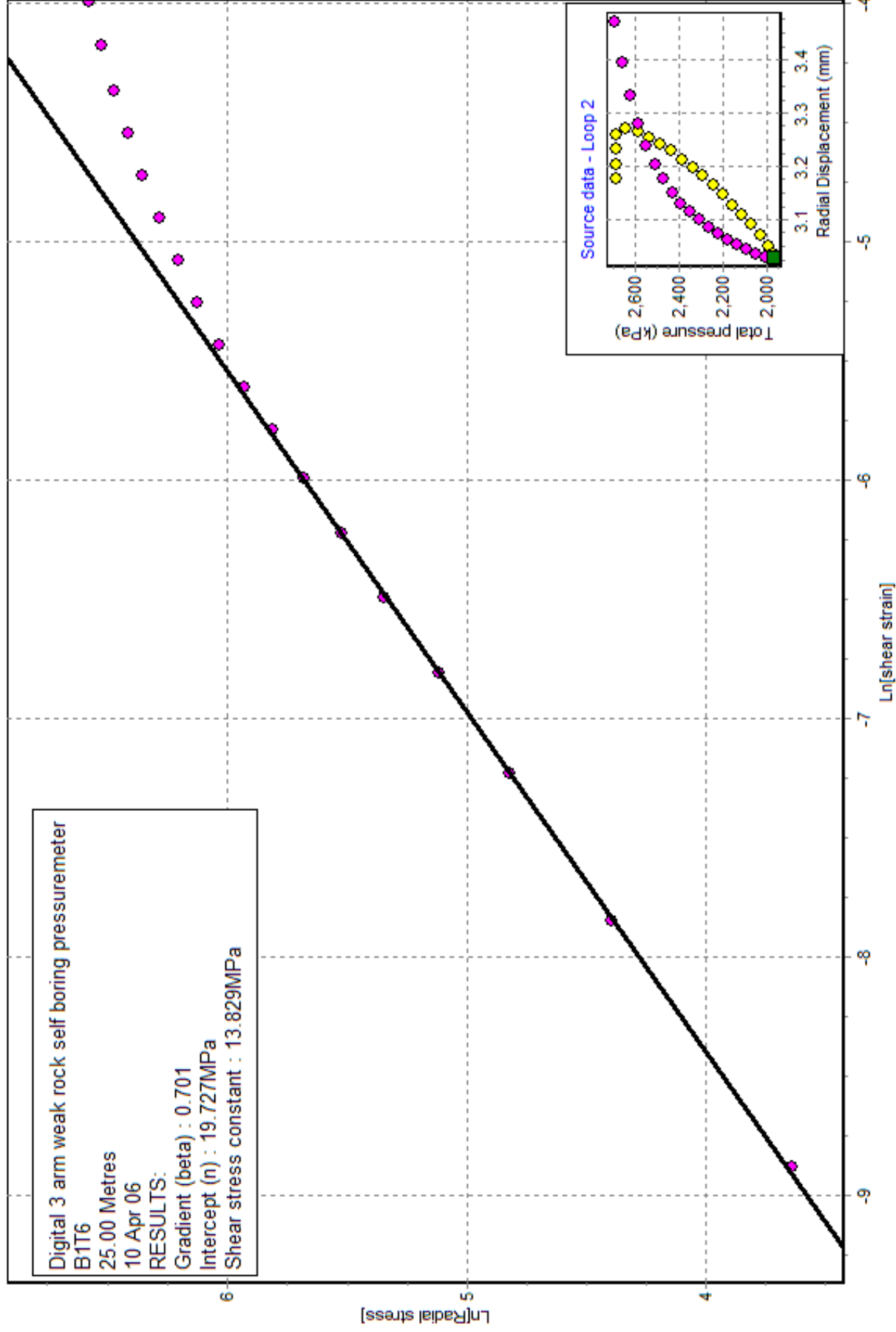


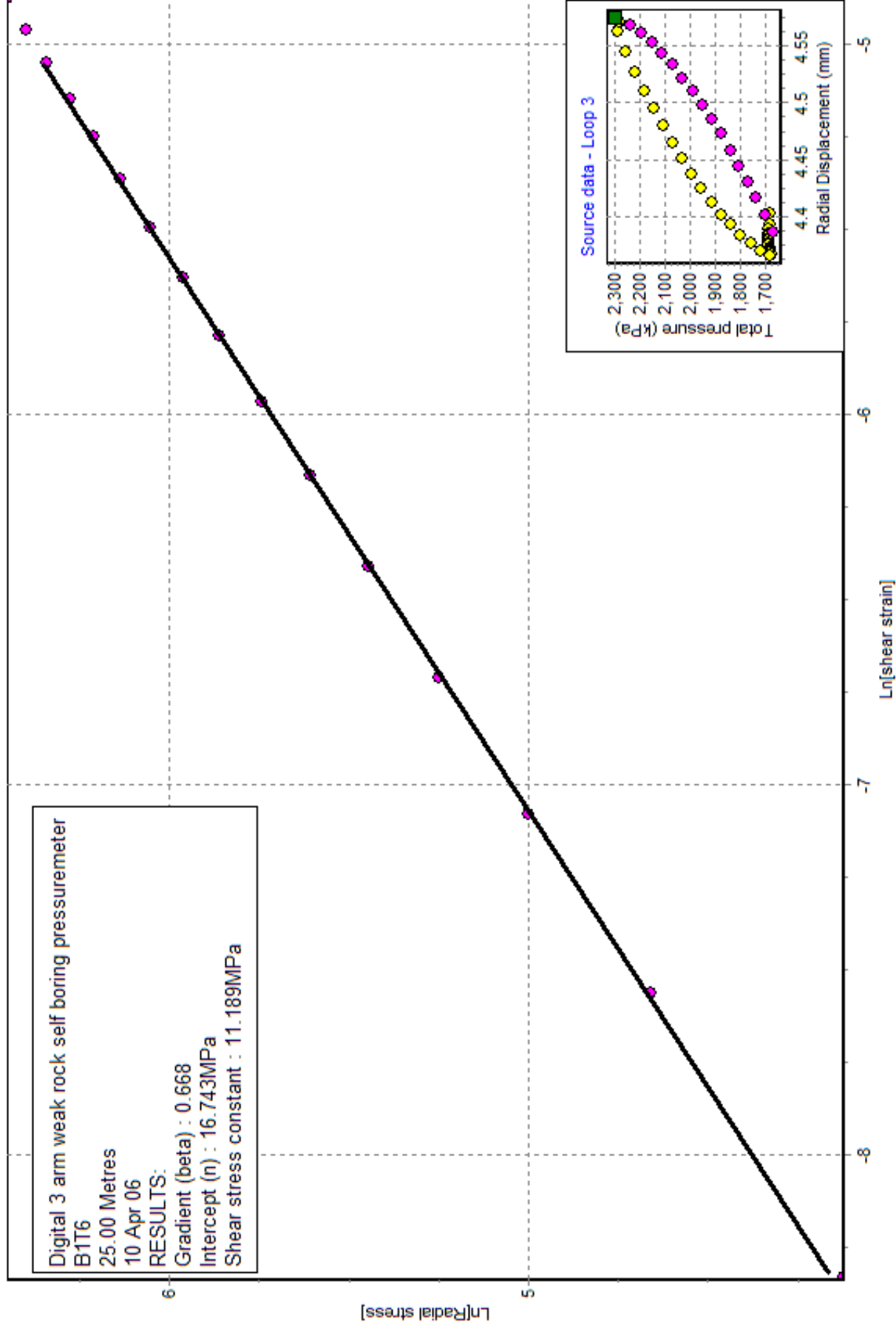
Shear modulus from unload/reload cycles Loop 4 : Arm ave

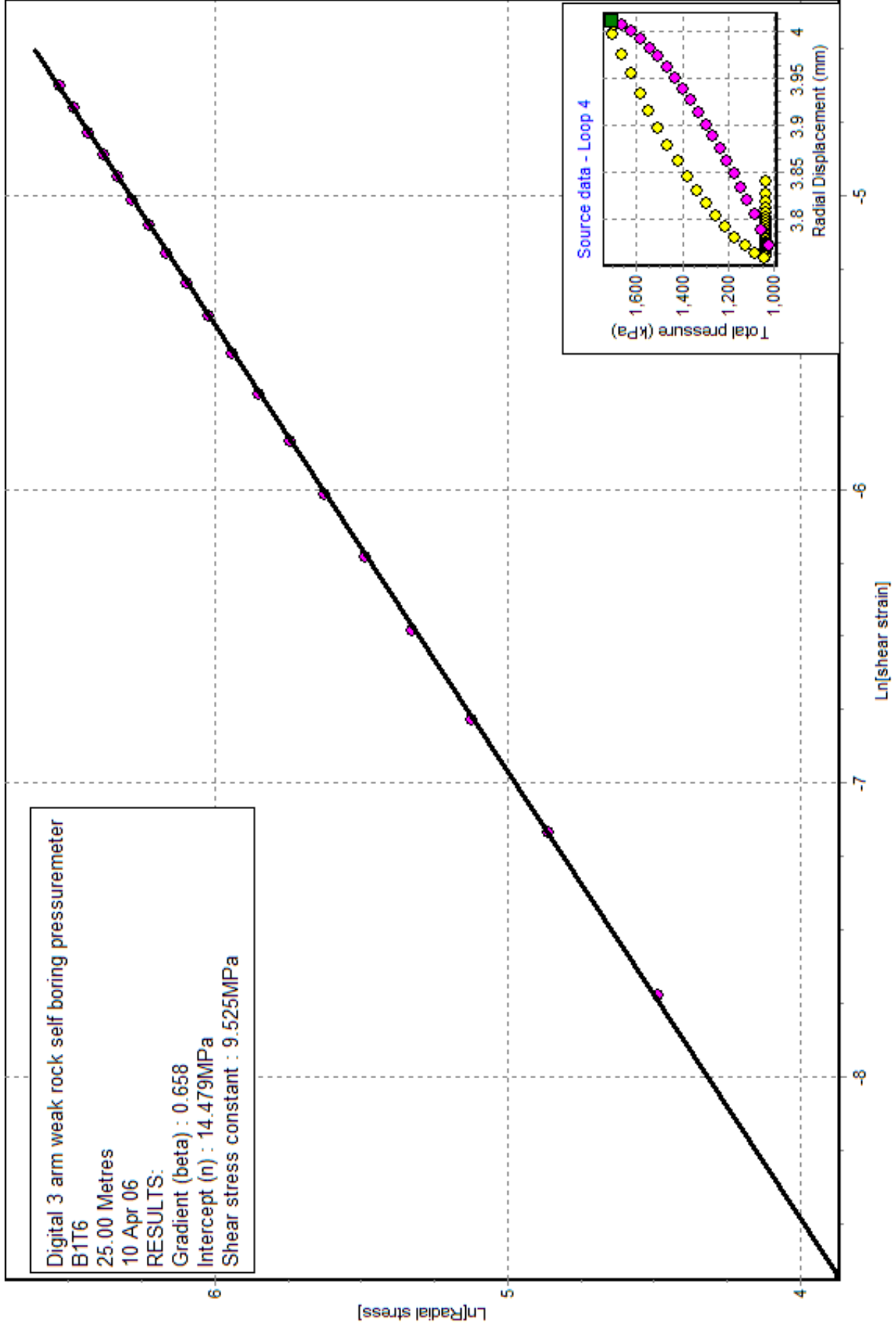




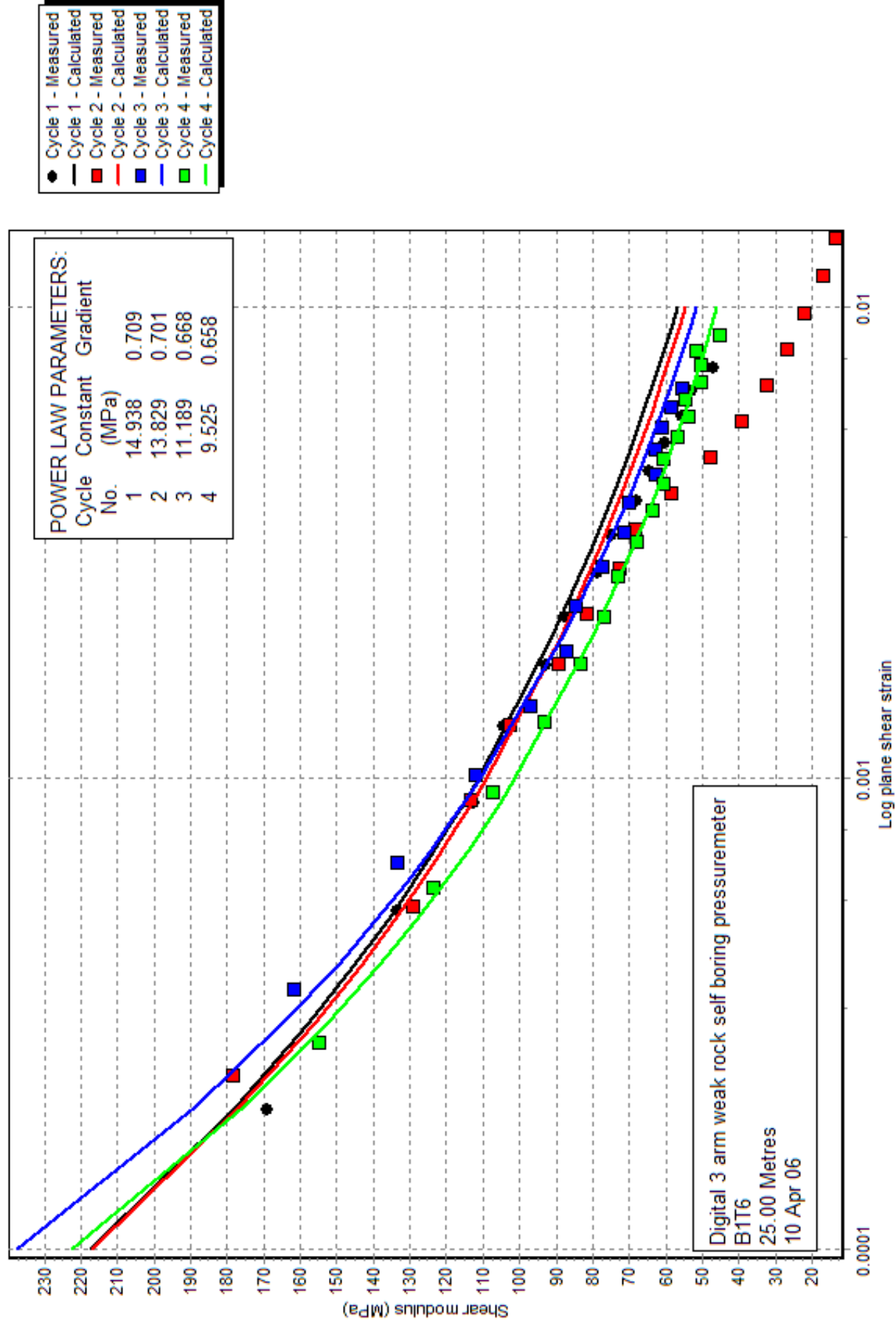
Digital 3 arm weak rock self boring pressuremeter
 B1T6
 25.00 Metres
 10 Apr 06
 RESULTS:
 Gradient (beta) : 0.701
 Intercept (n) : 19.727MPa
 Shear stress constant : 13.829MPa



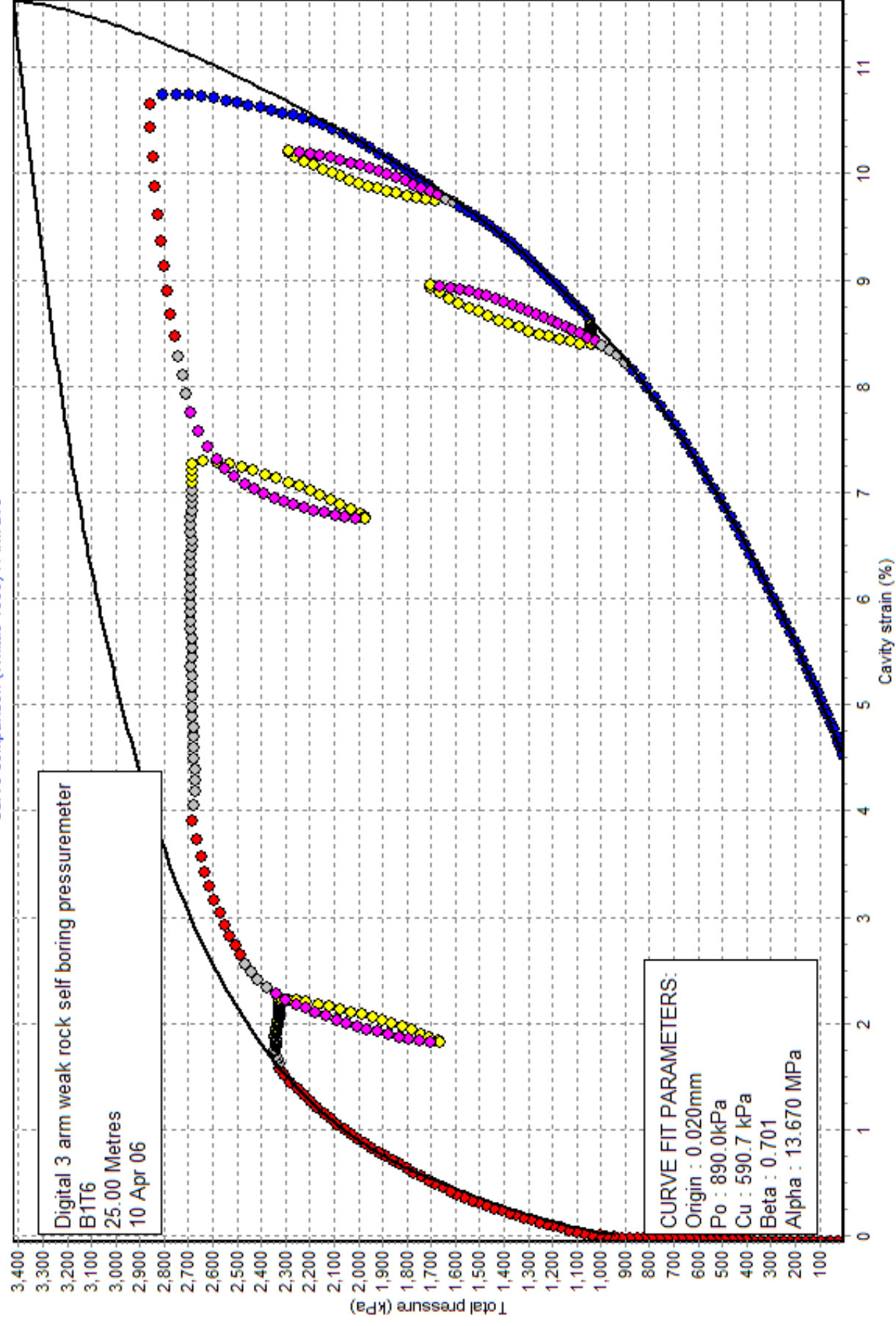




Variation of stiffness with strain, undrained analysis : Arm ave

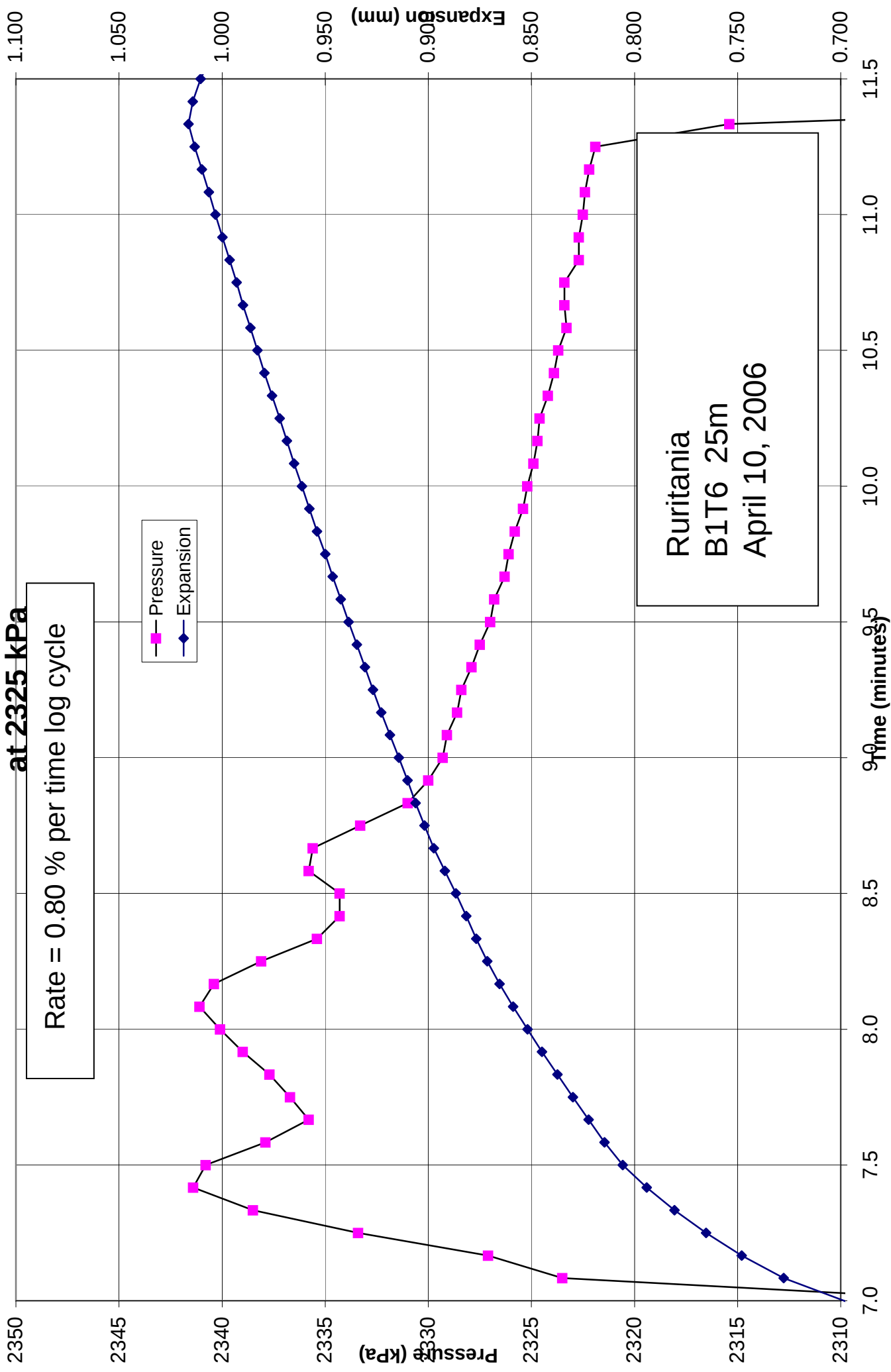


Curve comparison (Whittle 1999) : Arm ave



Hold 1 at 2325 kPa

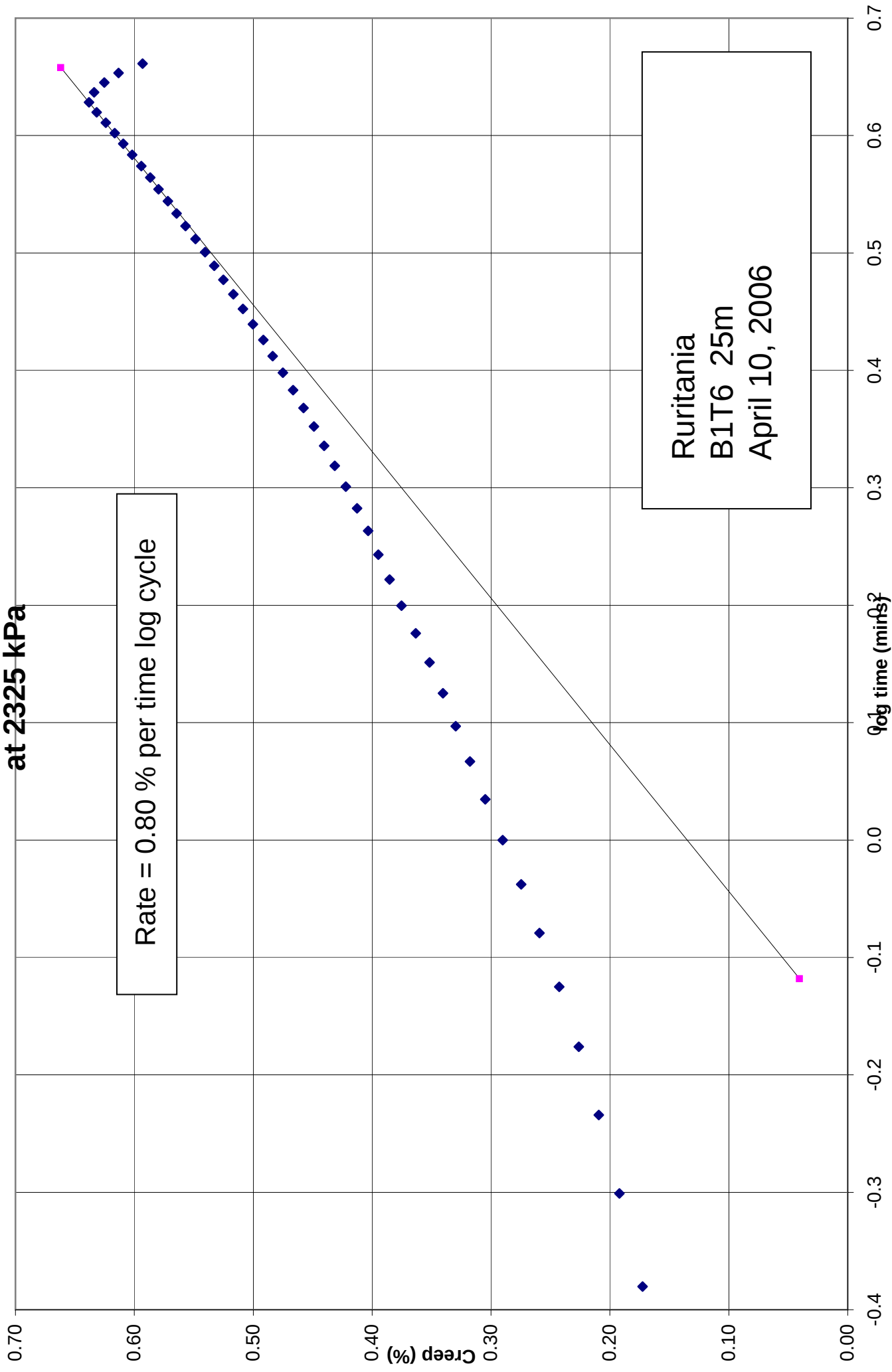
Rate = 0.80 % per time log cycle



Hold 1
at 2325 kPa

Rate = 0.80 % per time log cycle

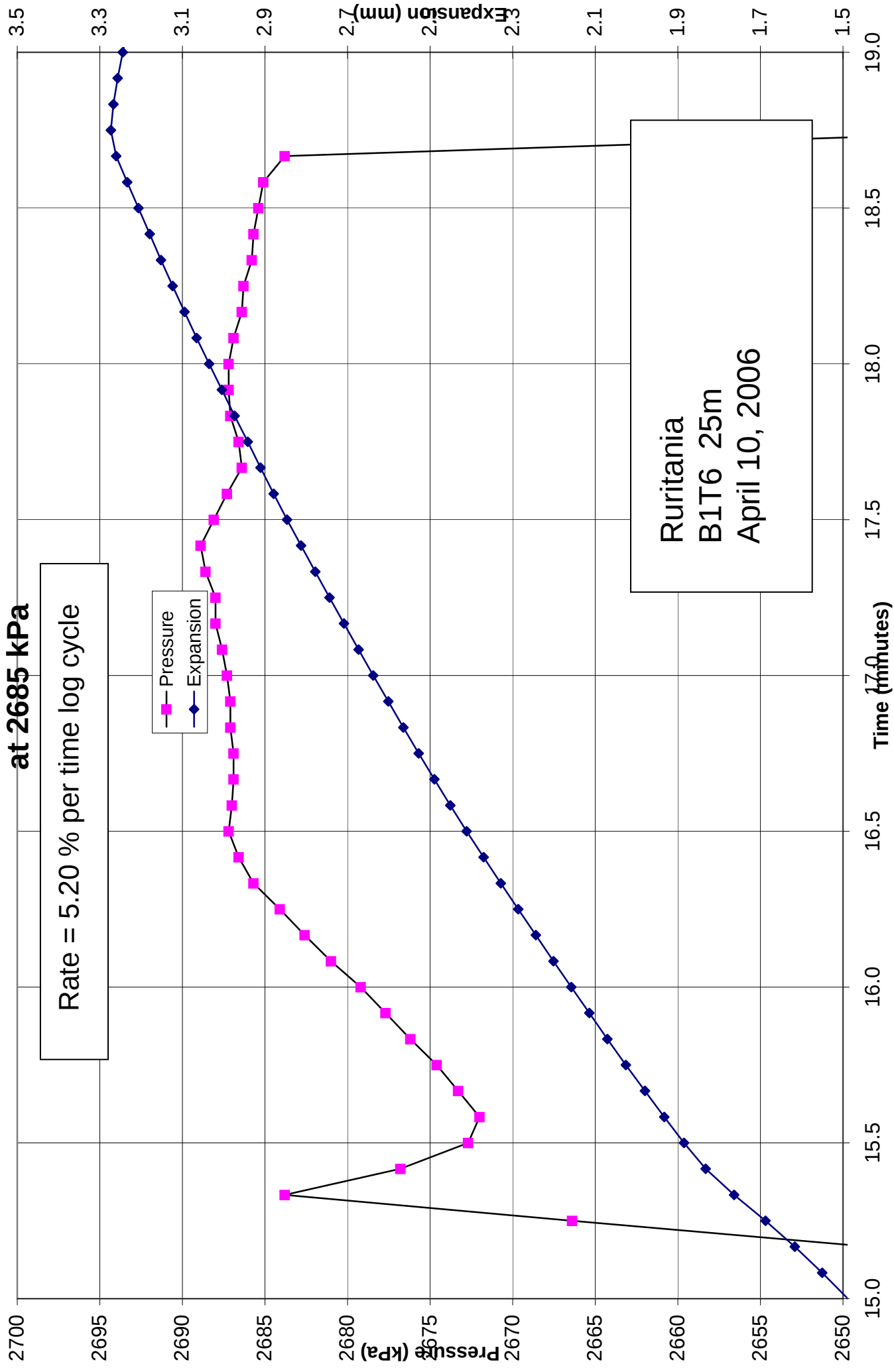
Ruritania
B1T6 25m
April 10, 2006



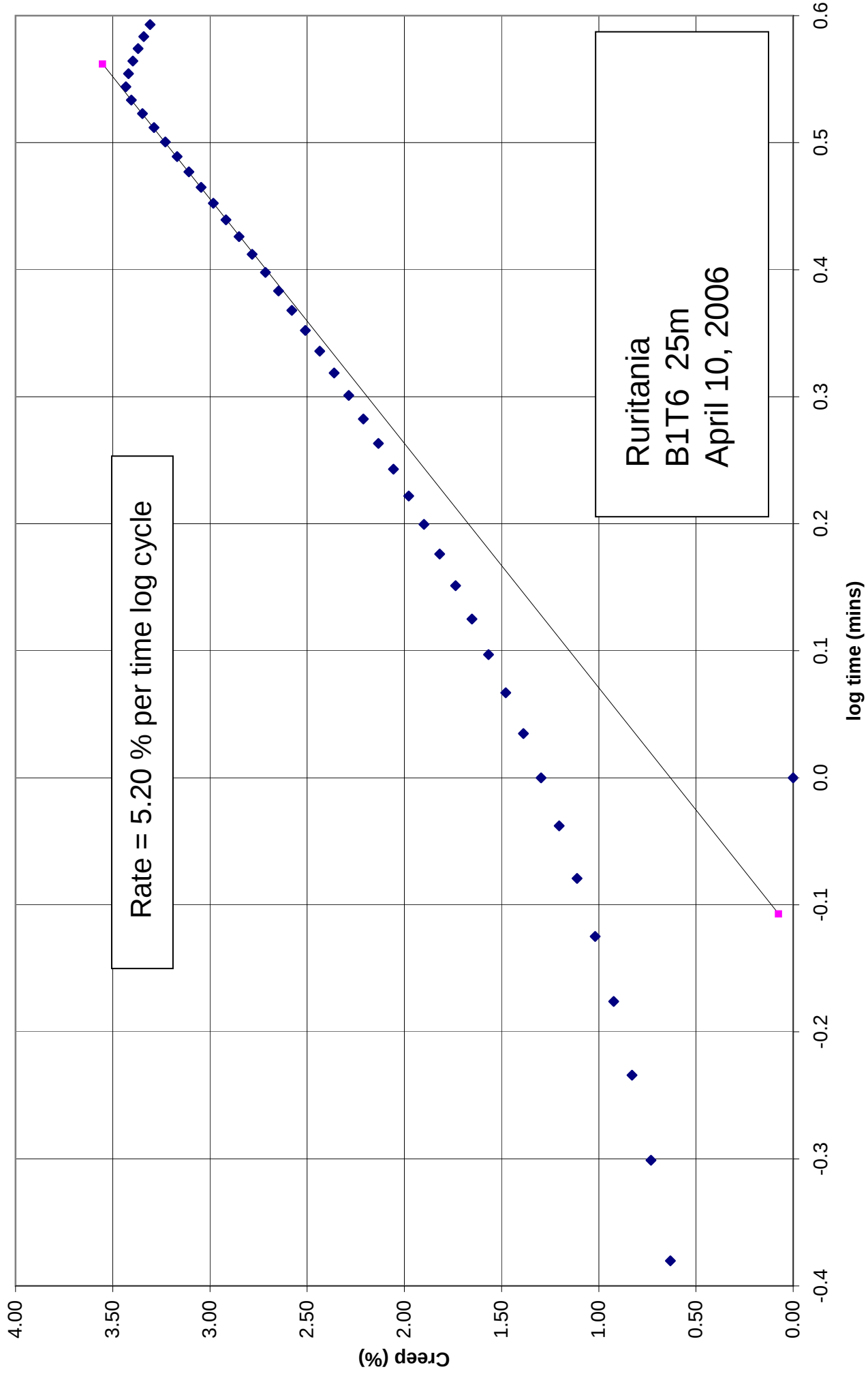
Hold 2

at 2685 kPa

Rate = 5.20 % per time log cycle



Hold 2 at 2685 kPa



B1T7 12/04/06 37.5m Silty sand

- 1. Test record sheet**
- 2. Results summary**
- 3. Plot of expansion versus pressure – all arms**
- 4. Plot of expansion versus pressure – arm average**
- 5. Plot of expansion versus pressure – arm pairs**
- 6. Plot of expansion versus pressure – odd and even arms**
- 7. Plot of all pressure cells versus time**
- 8. Plot of Marsland & Randolph procedure**
- 9. Hughes plot, giving peak friction angle and dilation**
- 10. Jefferies plot, giving Cu from unloading curve**
- 11. Plot of Reload Loop 1, with linear modulus line**
- 12. Plot of Reload Loop 2, with linear modulus line**
- 13. Plot of Reload Loop 3, with linear modulus line**
- 14. Plot of Reload Loop 4 with linear modulus line**
- 15. Plot of Reload Loop 5 with linear modulus line**
- 16. Bolton and Whittle plot of reloading part of Loop 1, giving nonlinearity coefficients**
- 17. Ditto for Loop 2**
- 18. And again for Loop 3**
- 19. And Loop 4**
- 20. And Loop 5**
- 21. Plot of Shear modulus versus Shear strain for all reload loops**
- 22. Plot of measured and calculated curves, from Carter et al**
- 23. Ditto, using different parameters to get a similar match**

This is one of the problems with this procedure.

6 ARM SELF BORING PRESSUREMETER

TEST RECORD SHEET

Site	Date	Day	Borehole	Test	Depth to Test Centre (below ground level)				
RURITANIA	12-4-06	TUE	1	7	37.5 m				
Weather:- OK			Material:- SILTY SAND						
Water table	Drilling Start	Drilling End	Distance	Drill Rate	Ram Pressure				
~11m	15:13	16:03	1 m	SLW AT END	HIGH				
Ground level :-			Orientation:-						
Water Press.	Inst. OD	Shoe OD	Cutter Type	Cutter position	Probe Reference				
✓	88mm	89mm	LARGE ARB.	~20mm OUT	HOLLY				
Drilling Remarks:- UP & DOWN TOWARDS END.									
Strain Rate	Press. Rate	Cycle Time	Gas Bottle	Battery	PPC Type	Max Pressure Cap.			
MANUAL		6 SECS	9.4 MPa	12.5V	TRUE	10 MPa			
Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6	PPC A	PPC B	TPC	Date:-
									Ground Level Zeros
									Pre-drilling Zeros
									Post-drilling Zeros
-0250	0.1575	0.2270	-0551	-0877	-6687	-1.0532	-9007	-2.4920	Pre-test Zeros
									Ground Level Zeros.
Test starts:-		16:06							
Line	Notes								
27	HOLD ⇒ LOOP ① ~1.5 MPa ARMS LEAVING ABOUT								
82	HOLD ⇒ LOOP ② ~2.5 MPa								
127	HOLD ⇒ LOOP ③ ~3.5 MPa								
161	HOLD ⇒ LOOP ④ ~4.7 MPa								
205	CHANGE GAS ⇒ LOOP ⑤ ~7 MPa								
275	DOWN - ARM ② > 5 mm								
Test ends:-		16:46		Max Press:-		9.4 MPa			
Calibrated Data details:									
Mem. Correction		Mem. Compression		Strain Cals.		Pressure Cals.			
C2005 T91		C2005 T92		12-7-05		12-7-05			
TEST REMARKS:									
NICE TEST. EXTRA LOOP AT HIGH PRESSURE - CHANGE OF GAS BOTTLE.									
UNUSUAL TO GO TO MAXIMUM PRESSURE AT MAXIMUM EXPANSION.									
Driller:									Tester: <i>[Signature]</i>
Tester:									

SELF BORING PRESSUREMETER

RESULTS SUMMARY SHEET

Site:- Ruritania

Test :- B1T7

Test Date :- 12th April 2006

Material :- Silty sand

Depth (m) :- 37.5

Water table (m) :- ~11m

Analysis of Insitu Lateral Stress (Po) :-

		Arm Av.
Marsland and Randolph (Iterative Analysis)	MPa	1.70

Analysis of Undrained Shear Strength (Cu) :-

Jefferies (unloading)	MPa	1.85
-----------------------	-----	------

Pressure at failure (Pf)	MPa	4.2
--------------------------	-----	-----

Strength of Sands Analysis (Hughes, Wroth & Windle)

Friction angle at const. vol.	deg	32	(assumed)
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Angle of Friction	deg	47.3
-------------------	-----	------

Angle of Dilation	deg	19.6
-------------------	-----	------

Analysis of Shear Modulus (G) :-

Initial Modulus (Gi)	MPa	130
----------------------	-----	-----

Reload loops :-

Linear analysis		Loop 1	Loop 2	Loop 3	Loop 4	Loop 5
-----------------	--	--------	--------	--------	--------	--------

Reload Modulus (Gr)	MPa	313	354	394	396	454
---------------------	-----	-----	-----	-----	-----	-----

Pressure at start	MPa	1.50	2.51	3.51	4.73	6.97
-------------------	-----	------	------	------	------	------

Depth of unload	MPa	0.60	0.98	1.02	1.25	1.47
-----------------	-----	------	------	------	------	------

Non-linear analysis

Non-linearity coeff. (β)		0.916	0.839	0.809	0.787	0.754
----------------------------------	--	-------	-------	-------	-------	-------

Shear stress coeff. (α)	MPa	157	117	105	100	89.5
----------------------------------	-----	-----	-----	-----	-----	------

Secant shear modulus (Gs)

0.01% shear strain	MPa	340	515	612	710	863
--------------------	-----	-----	-----	-----	-----	-----

0.1% “ “	MPa	280	355	394	435	490
----------	-----	-----	-----	-----	-----	-----

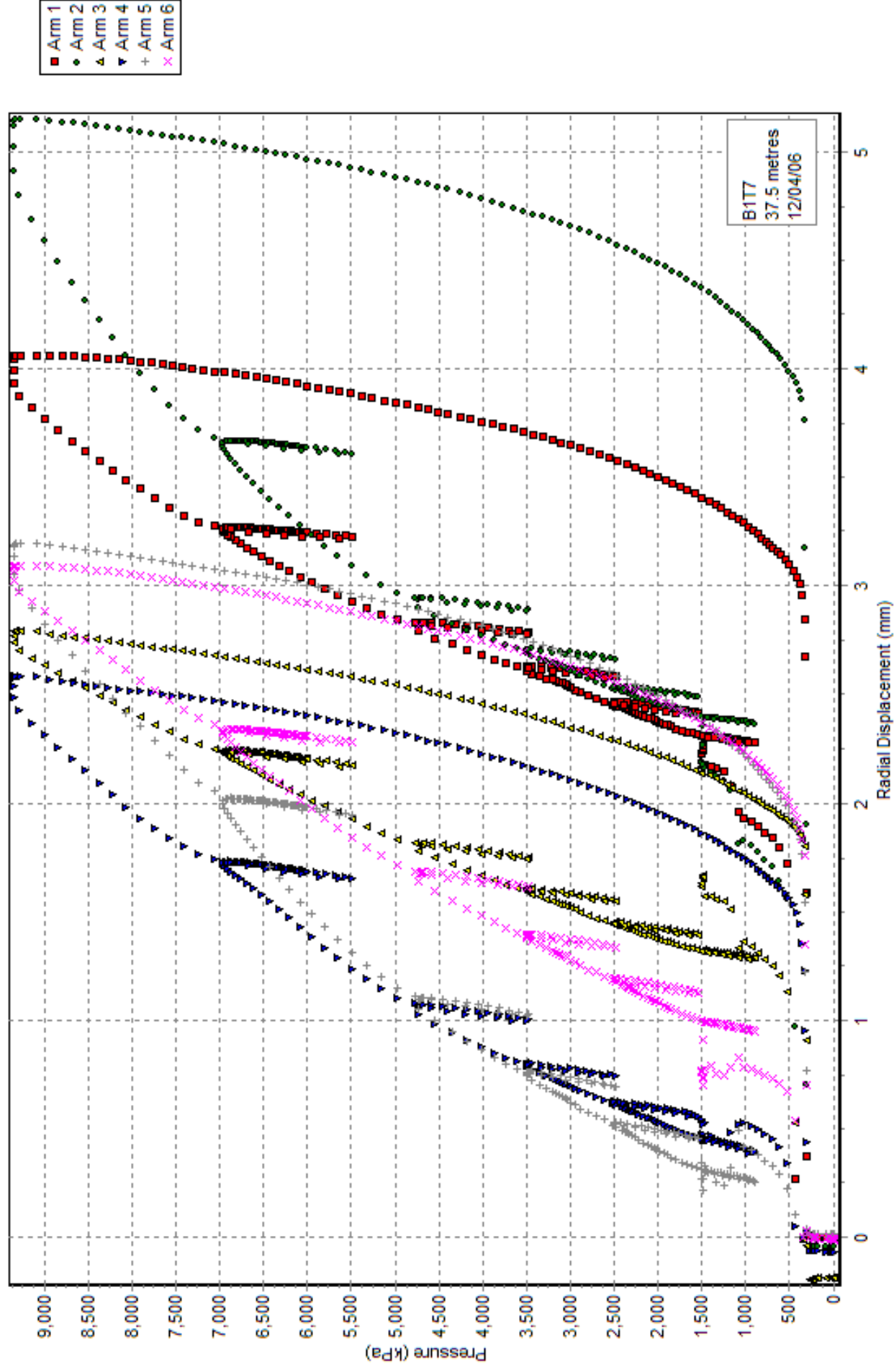
1% “ “	MPa	231	245	254	266	278
--------	-----	-----	-----	-----	-----	-----

Values at 1% are unlikely to be reached because the material will have failed by then.

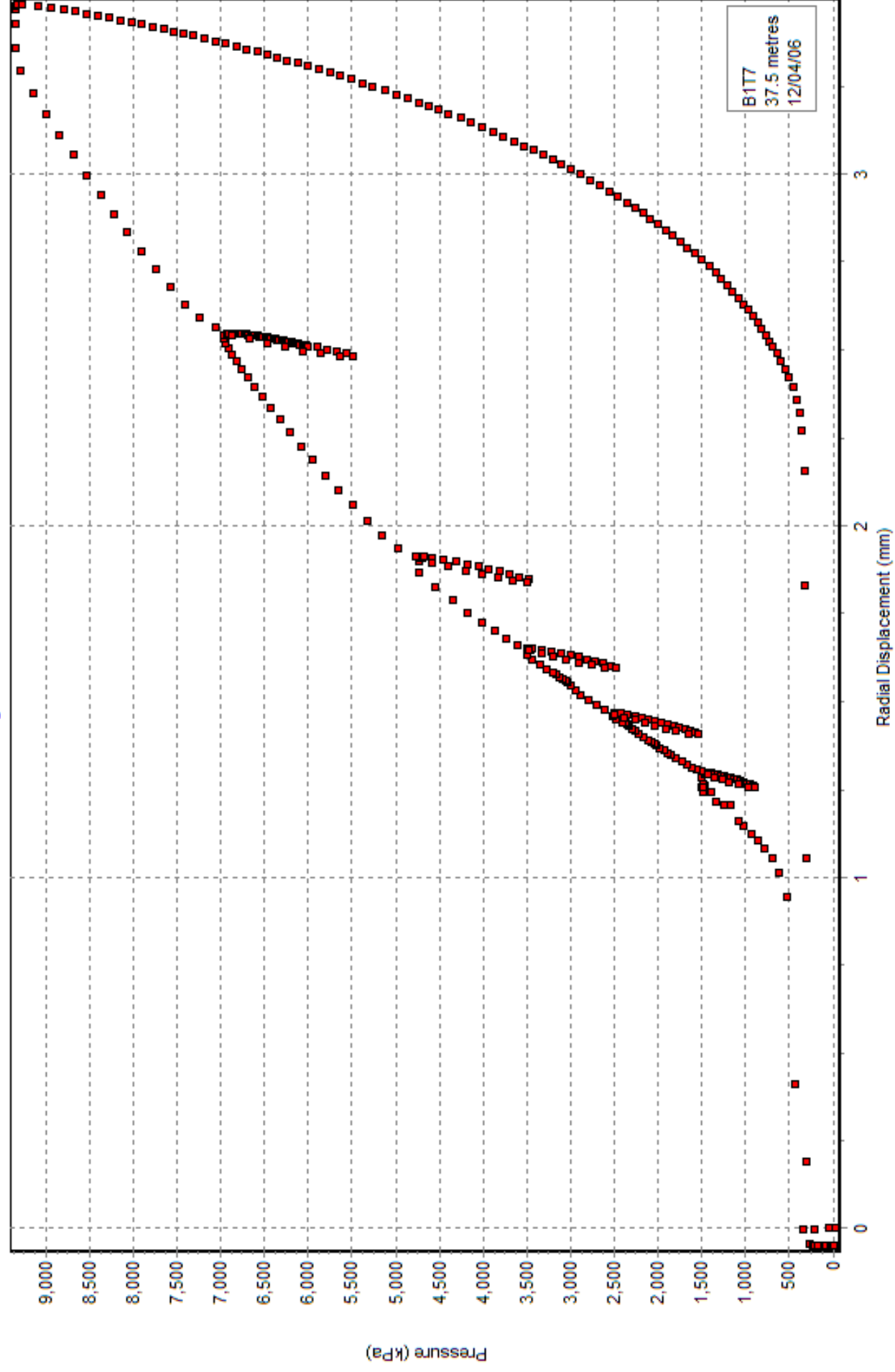
Test Analysed By :- PGH

Date :- February 2011

All Arms vs Total Pressure

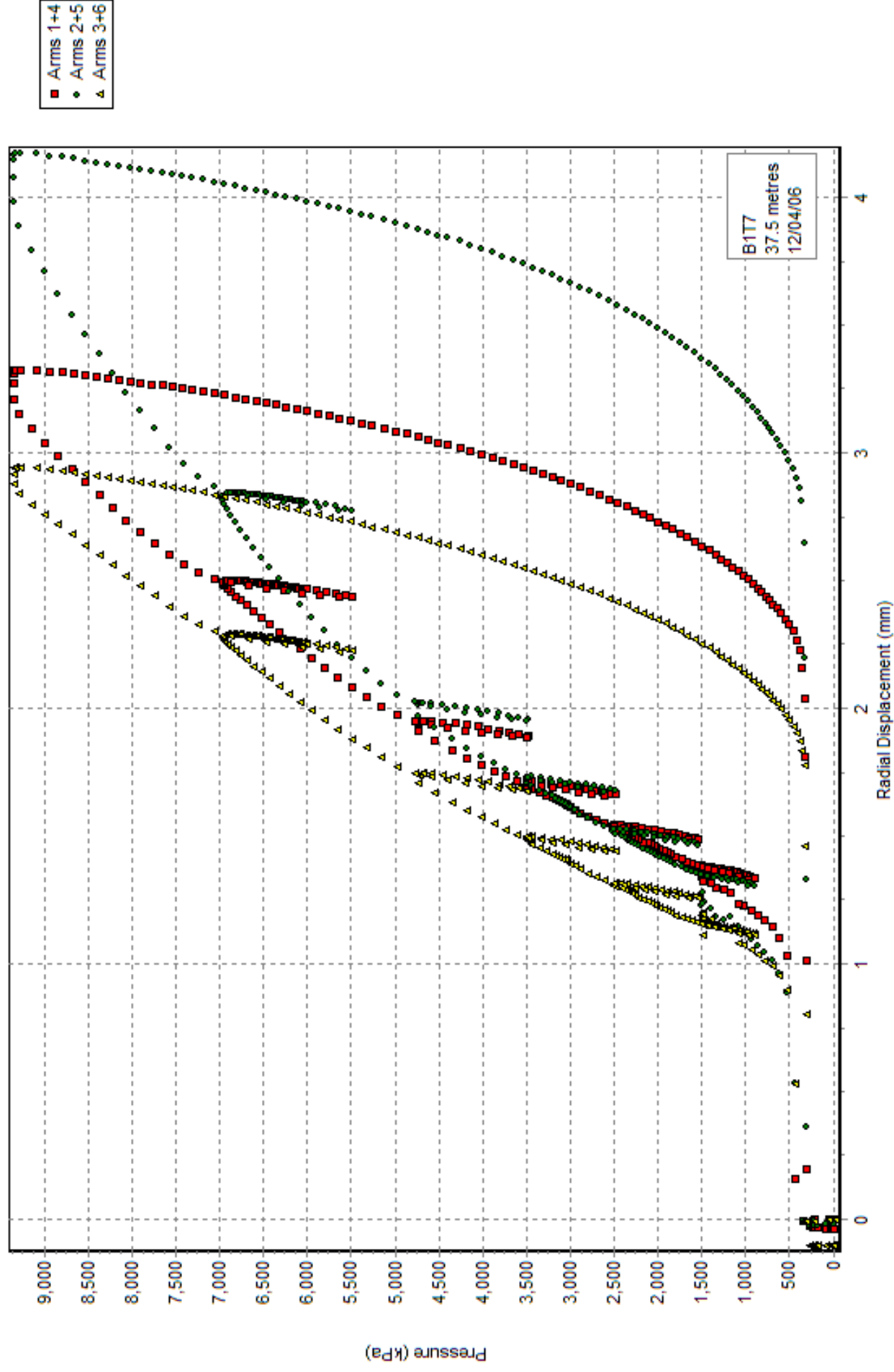


Arm Average vs Total Pressure

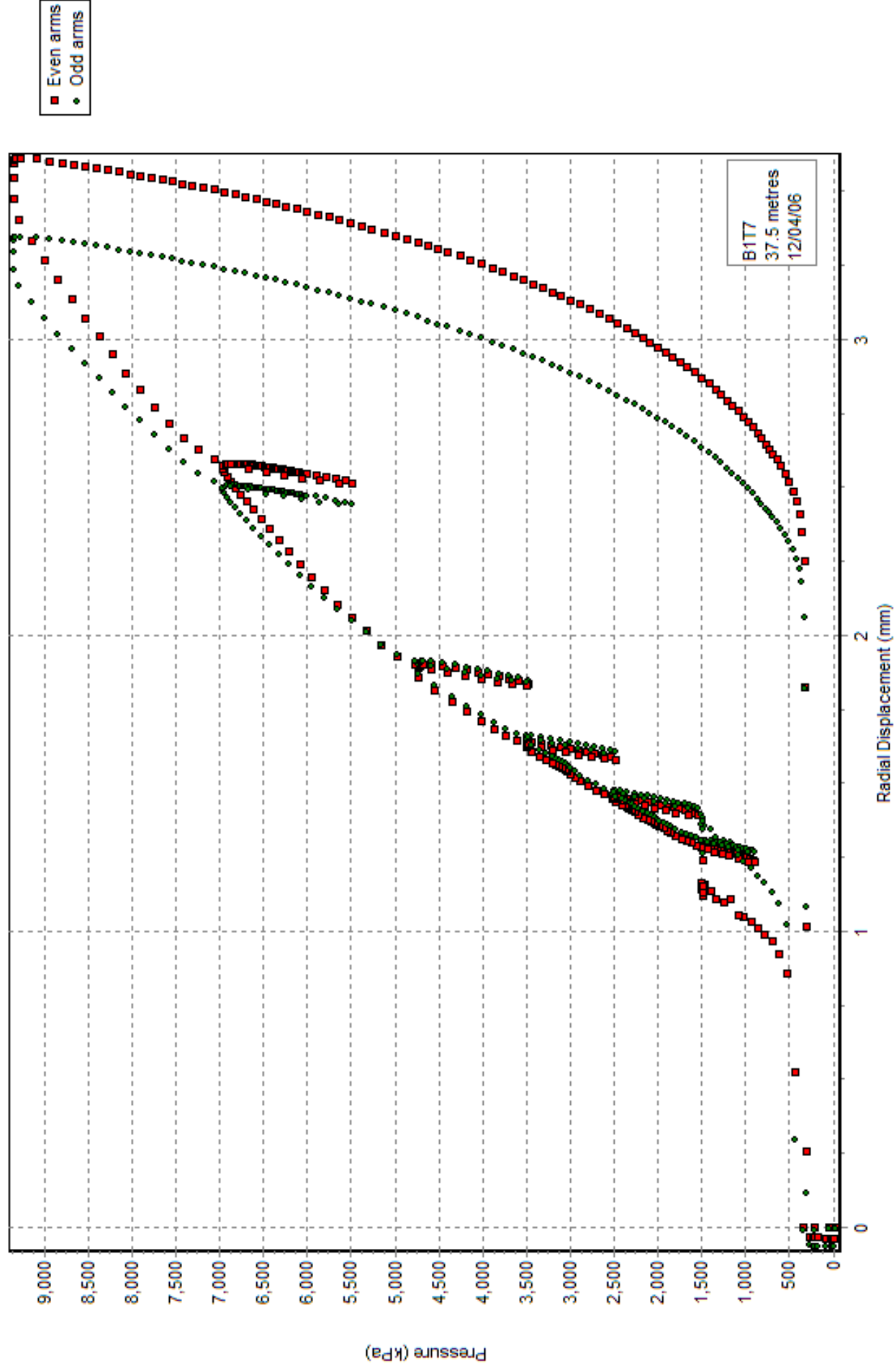


B1T7
37.5 metres
12/04/06

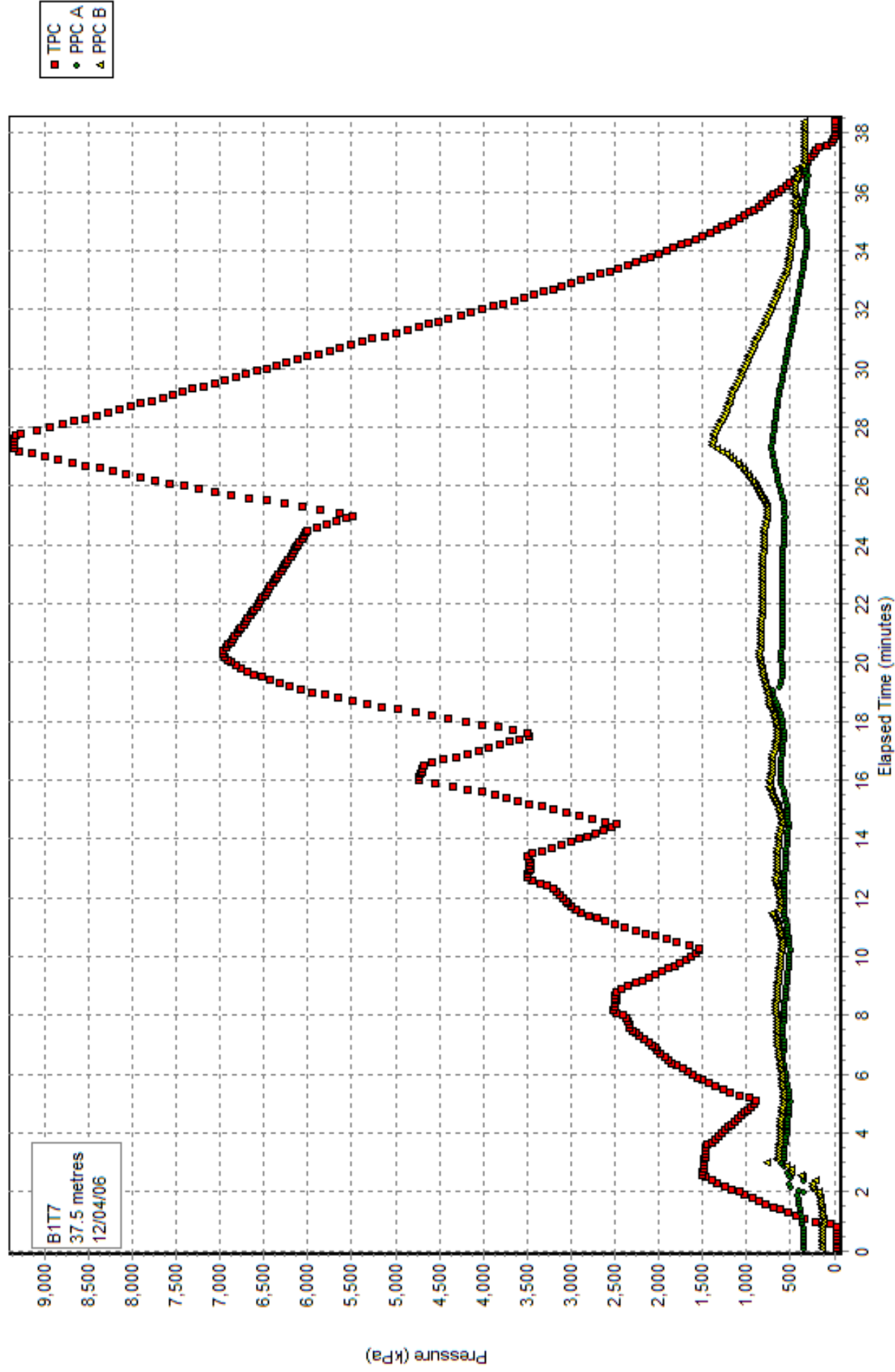
Arm Pairs vs Total Pressure



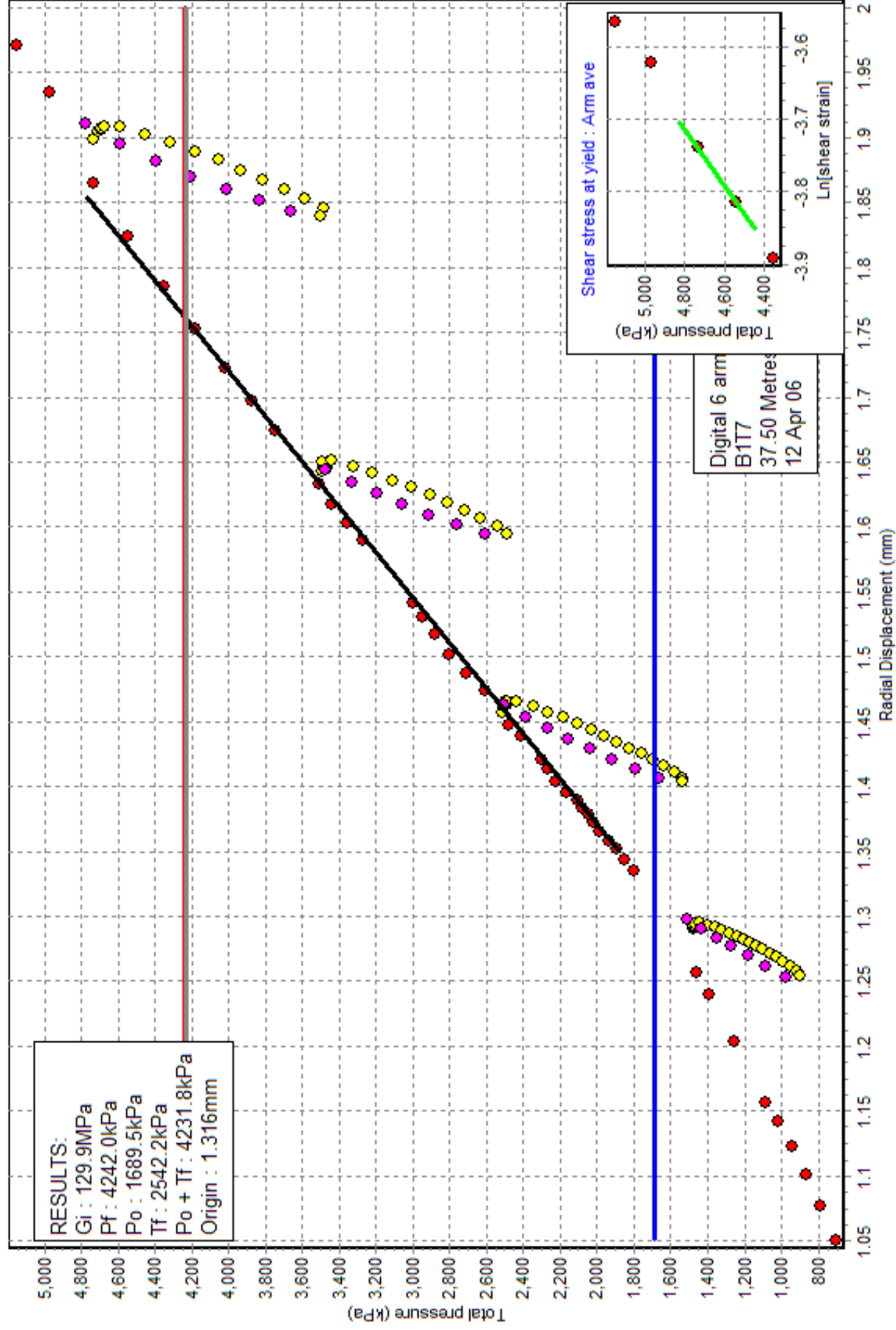
Odd and Even Arms vs Total Pressure

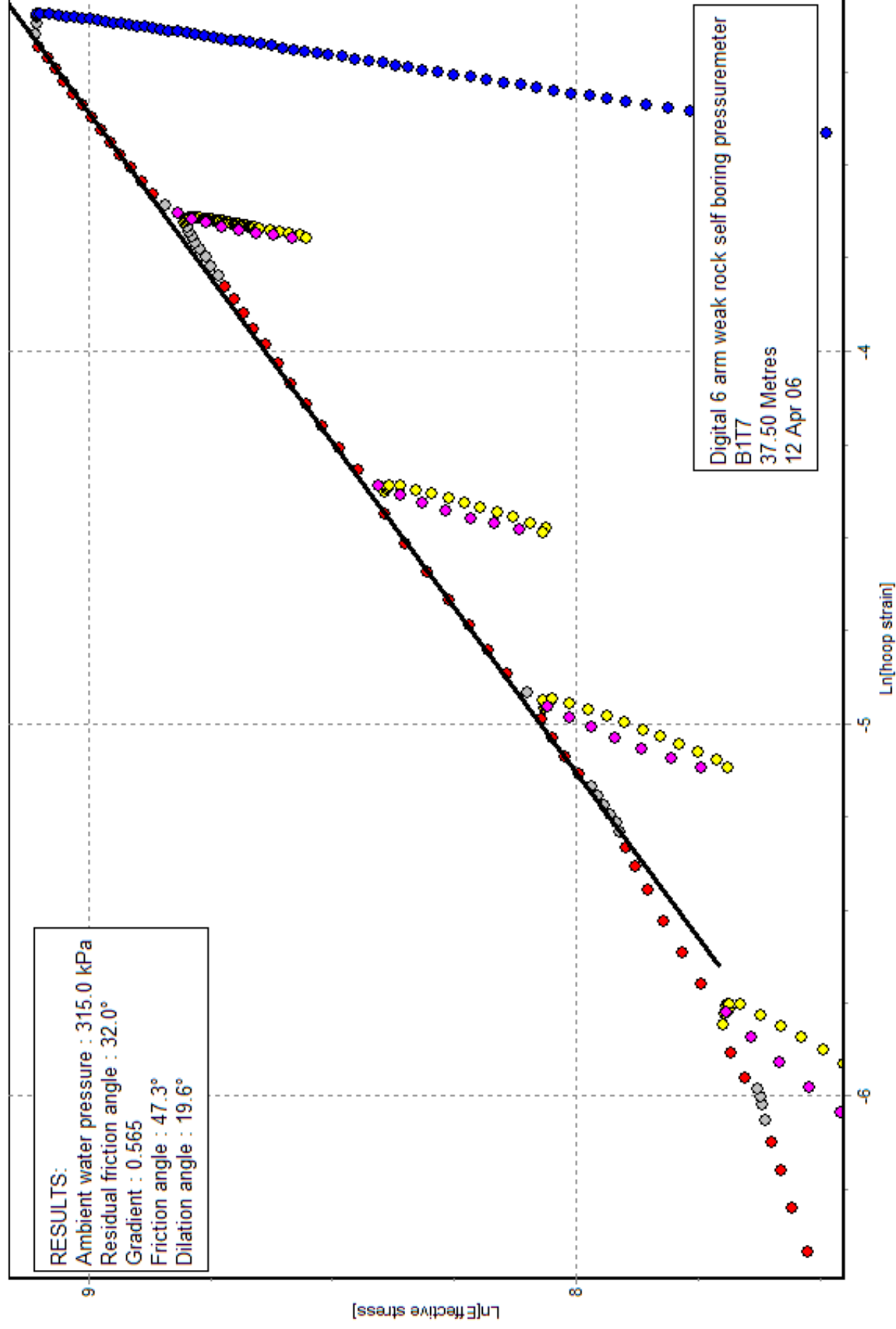


All Pressure Cells vs Time

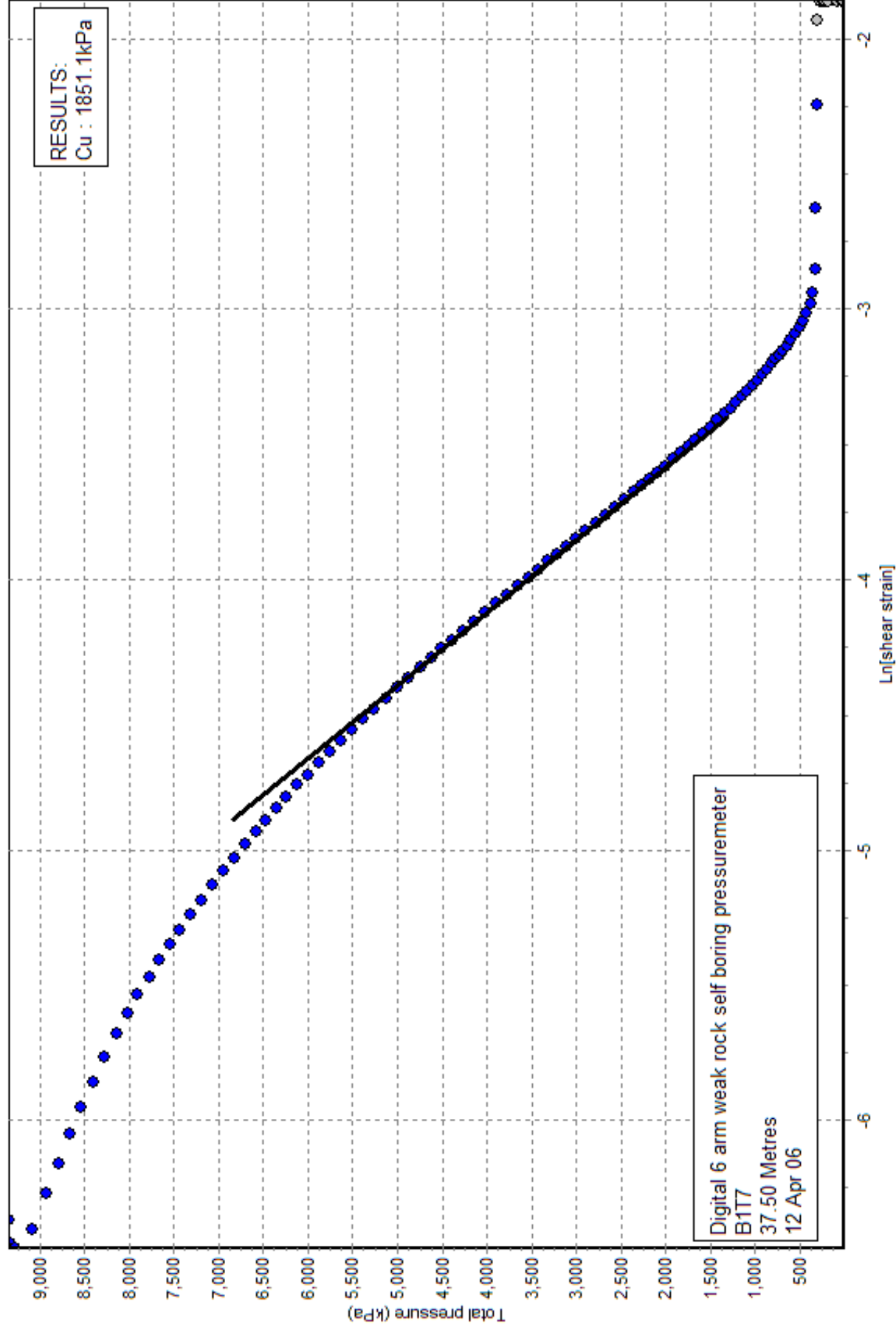


Po of cohesive material (1977, 1990) : Arm ave

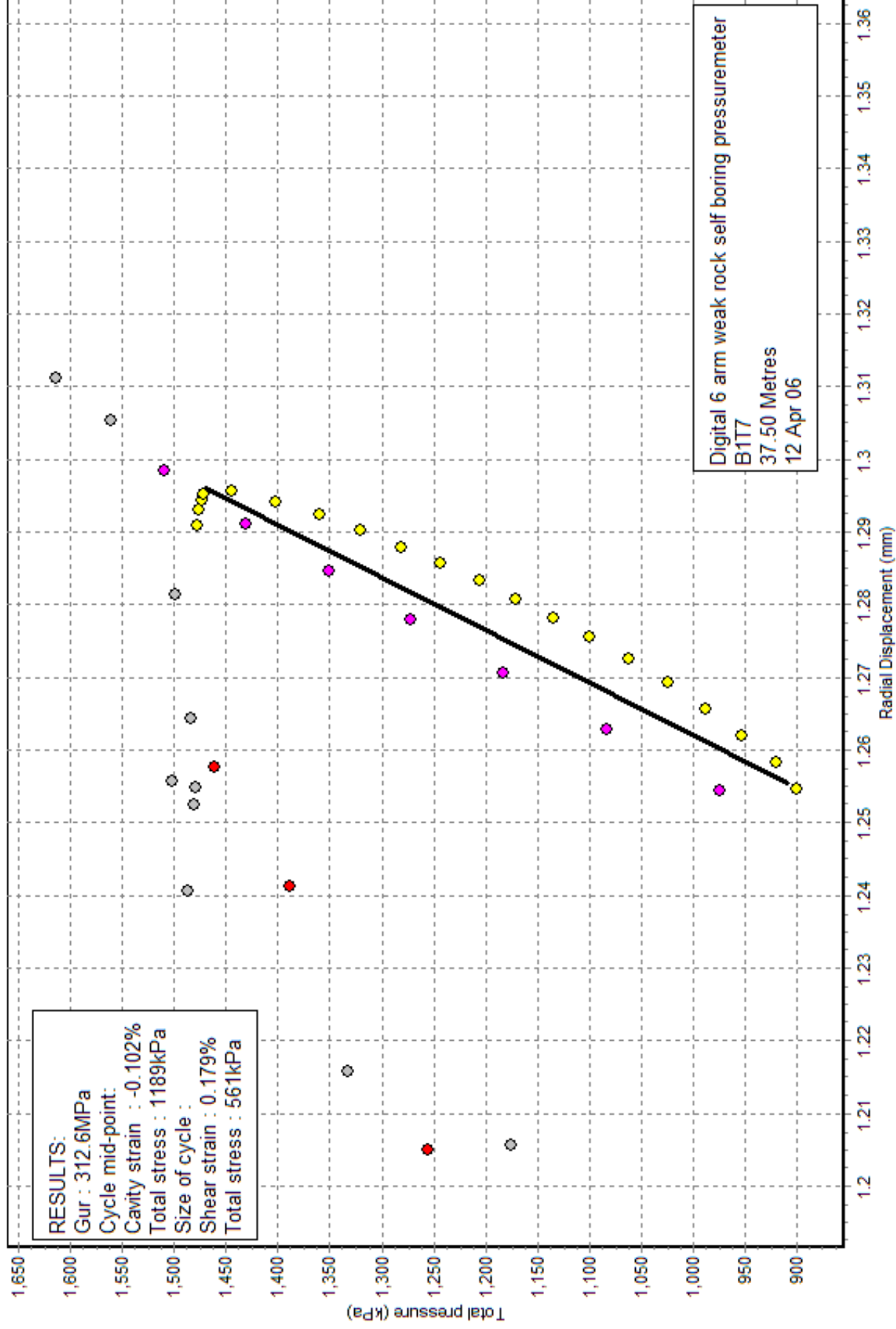




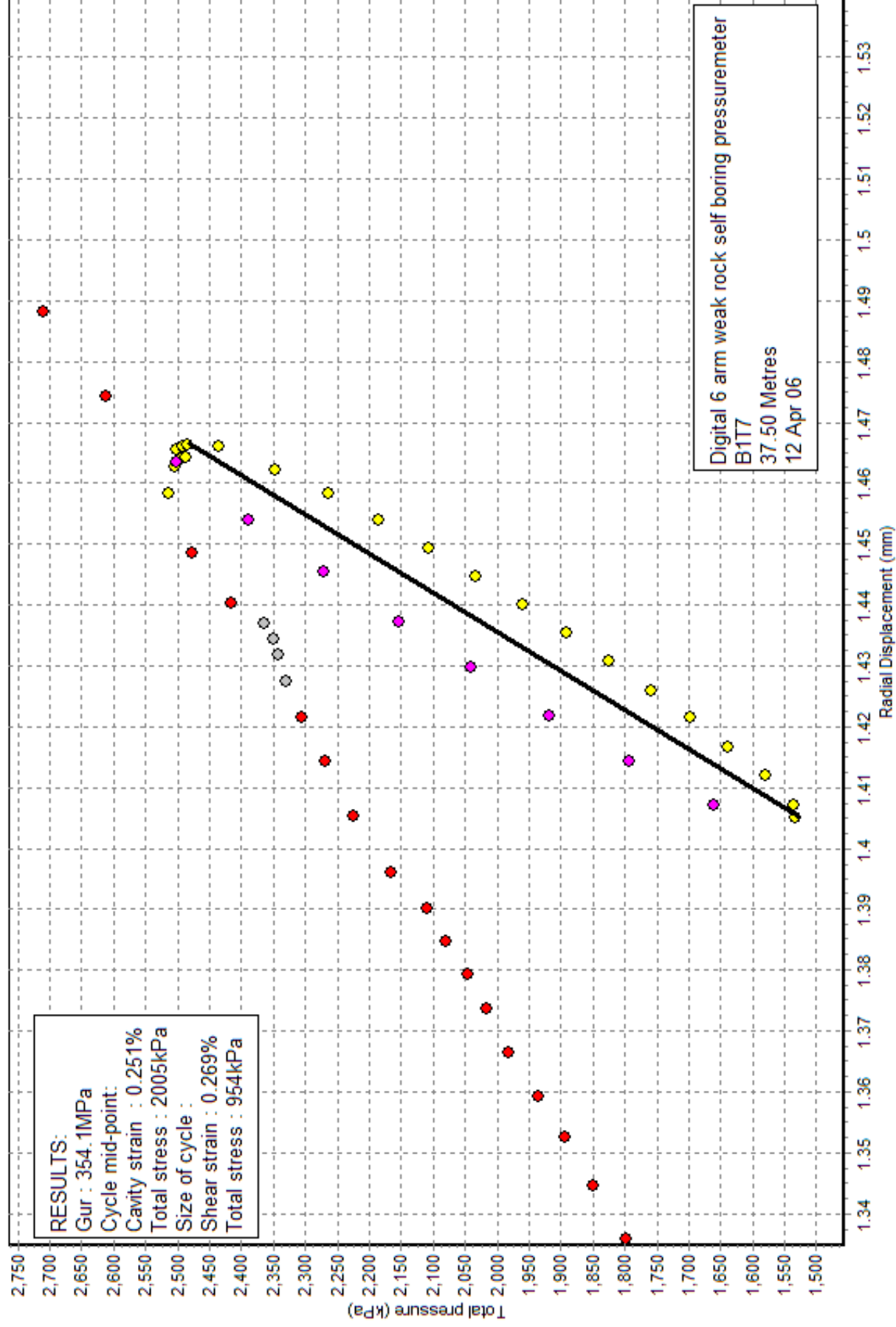
Jefferies (1988) : Arm ave



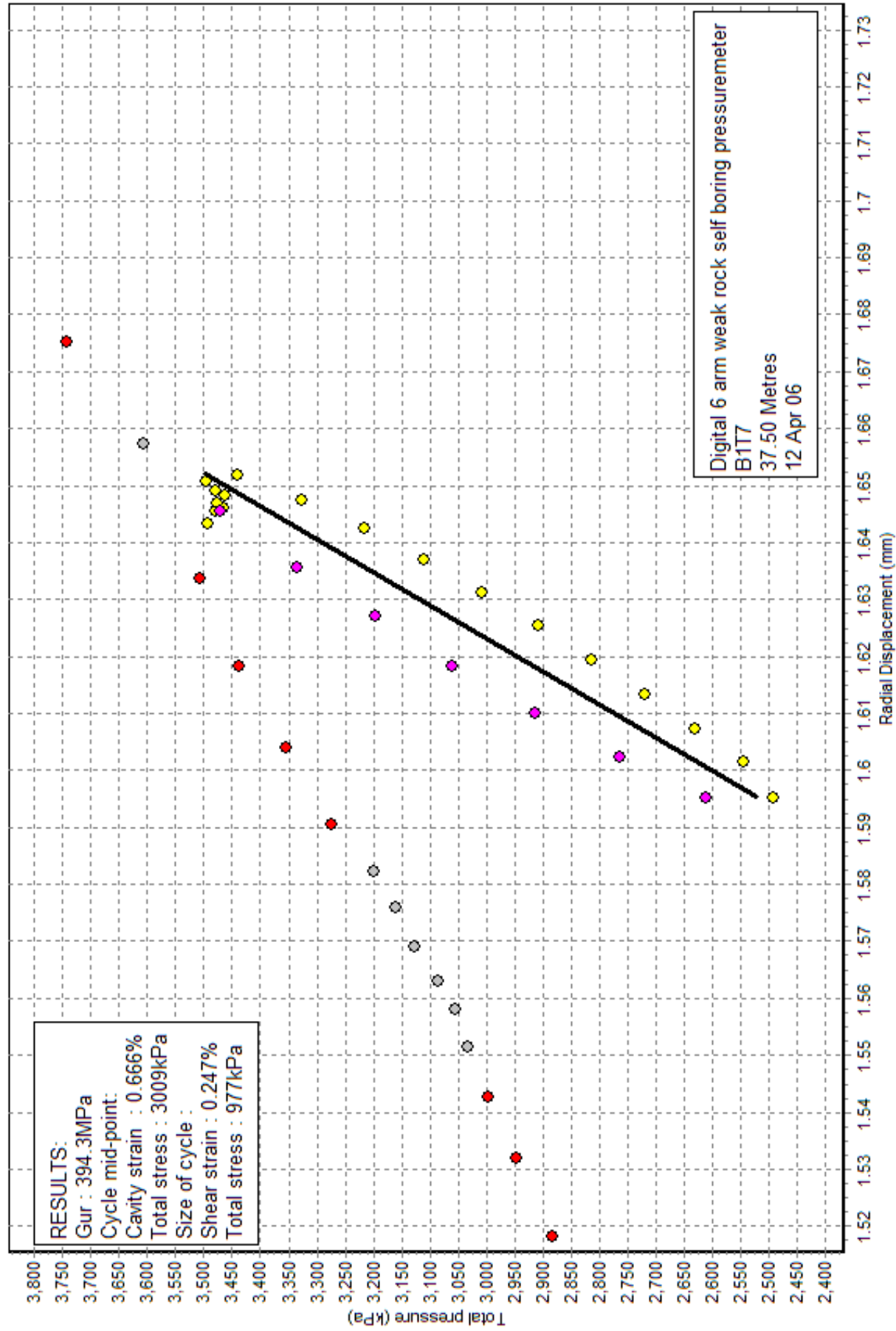
Shear modulus from unload/reload cycles Loop 1 : Arm ave



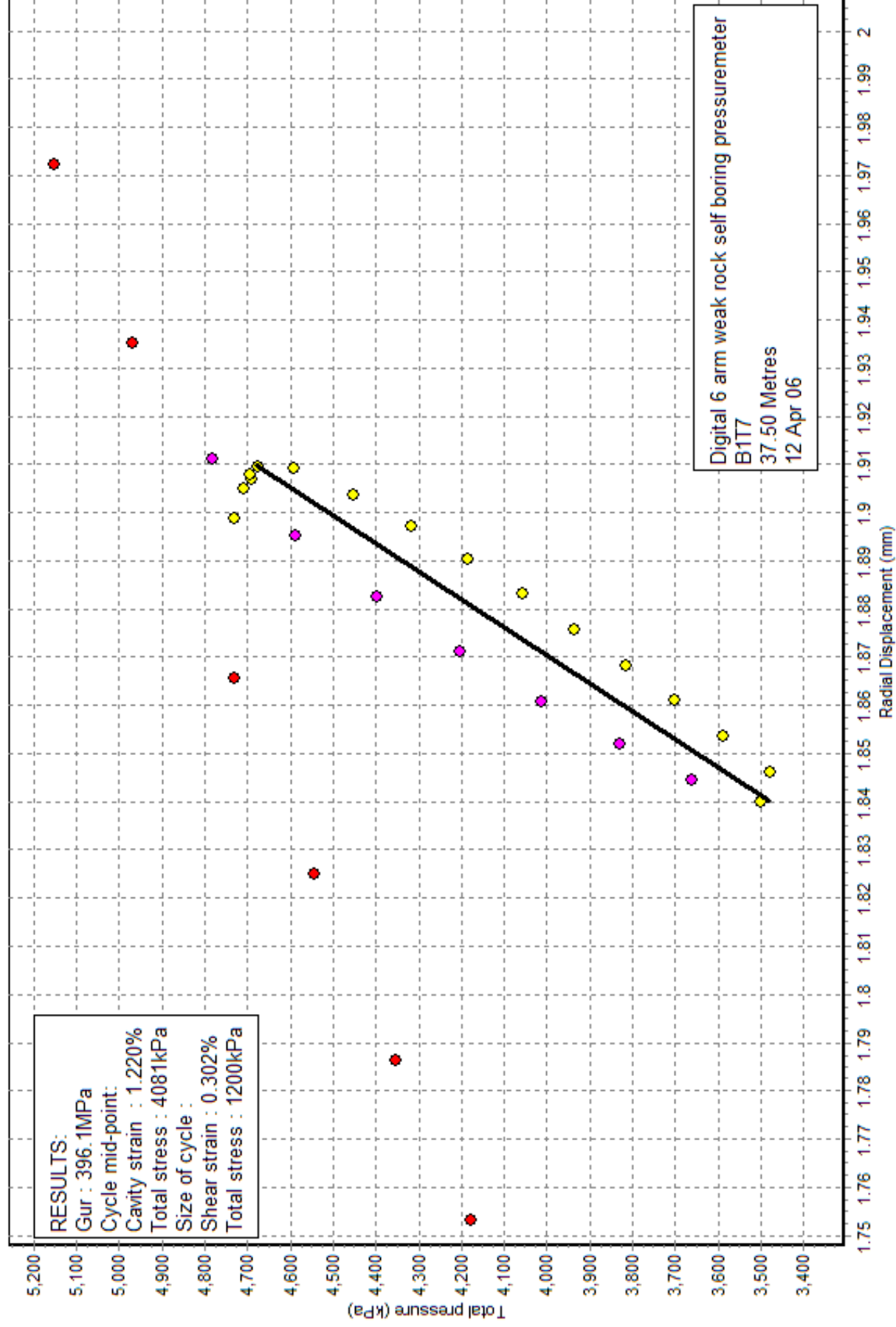
Shear modulus from unload/reload cycles Loop 2 : Arm ave



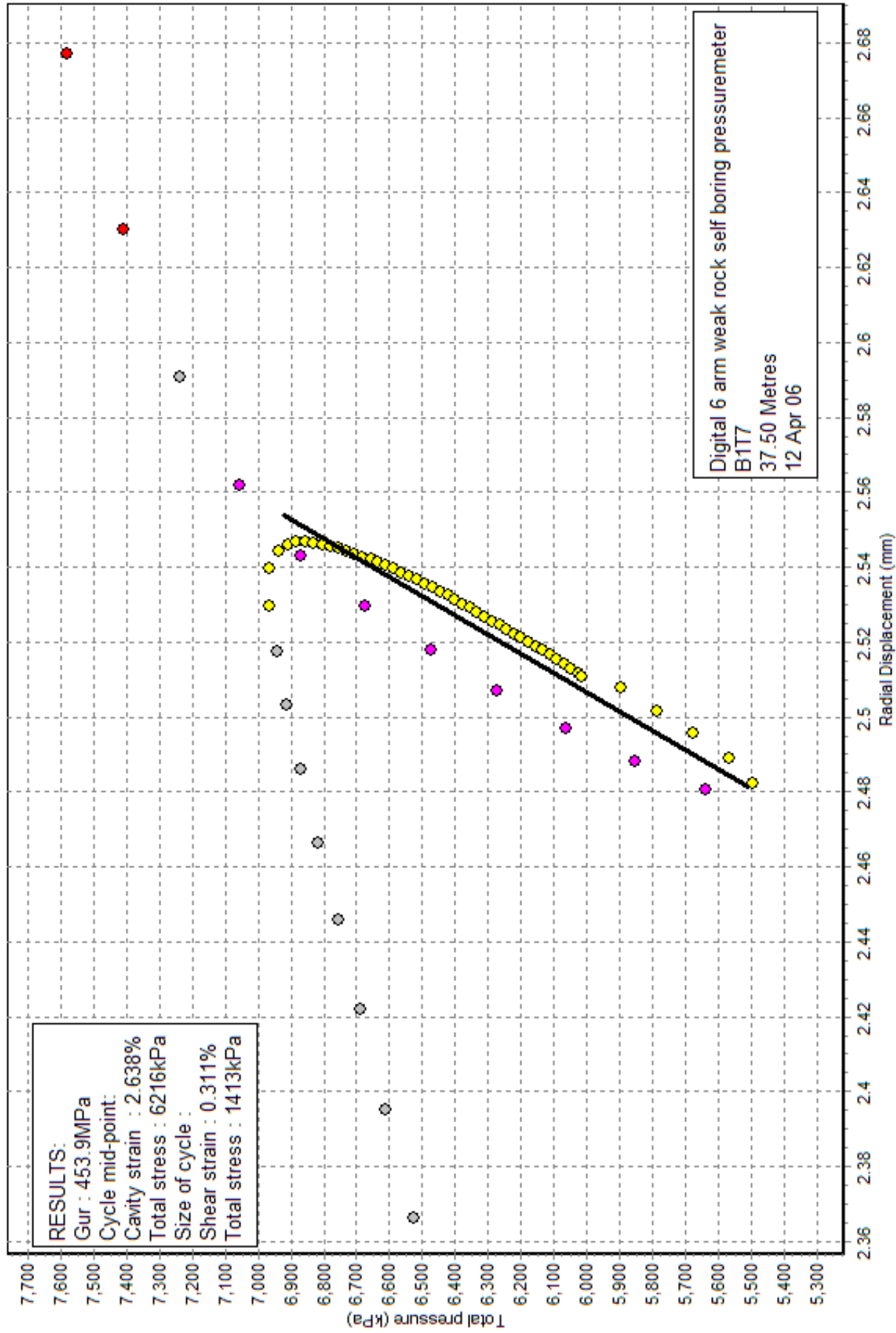
Shear modulus from unload/reload cycles Loop 3 : Arm ave



Shear modulus from unload/reload cycles Loop 4 : Arm ave



Shear modulus from unload/reload cycles Loop 5 : Arm ave



Digital 6 arm weak rock self boring pressuremeter

B1T7

37.50 Metres

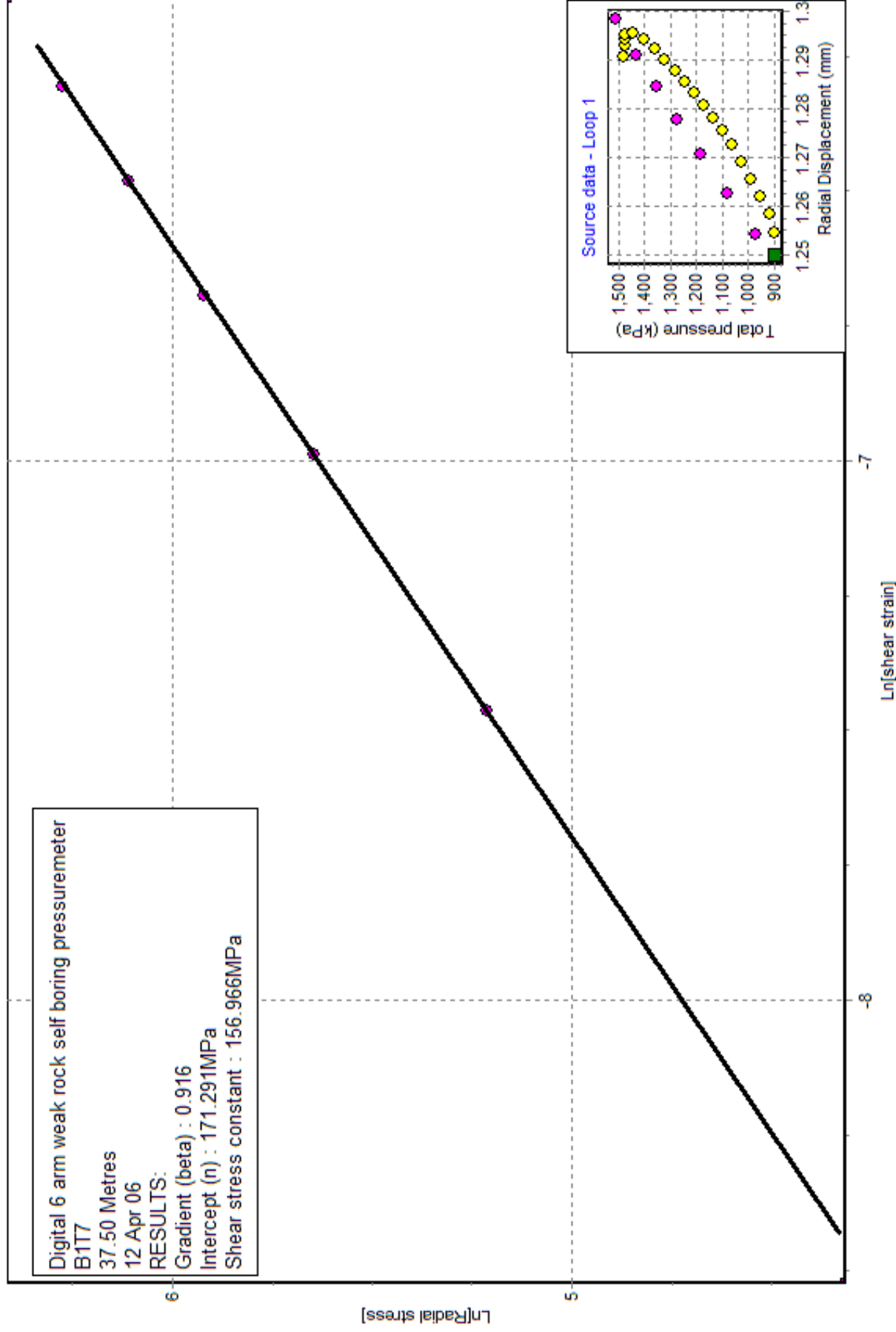
12 Apr 06

RESULTS:

Gradient (beta) : 0.916

Intercept (n) : 171.291MPa

Shear stress constant : 156.966MPa



Digital 6 arm weak rock self boring pressuremeter
 B117
 37.50 Metres
 12 Apr 06
 RESULTS:
 Gradient (beta) : 0.839
 Intercept (n) : 139.231MPa
 Shear stress constant : 116.803MPa

6

Ln[Radial stress]

5

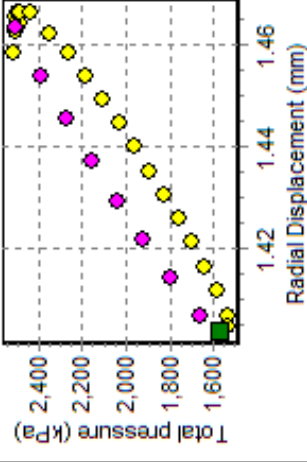
-8

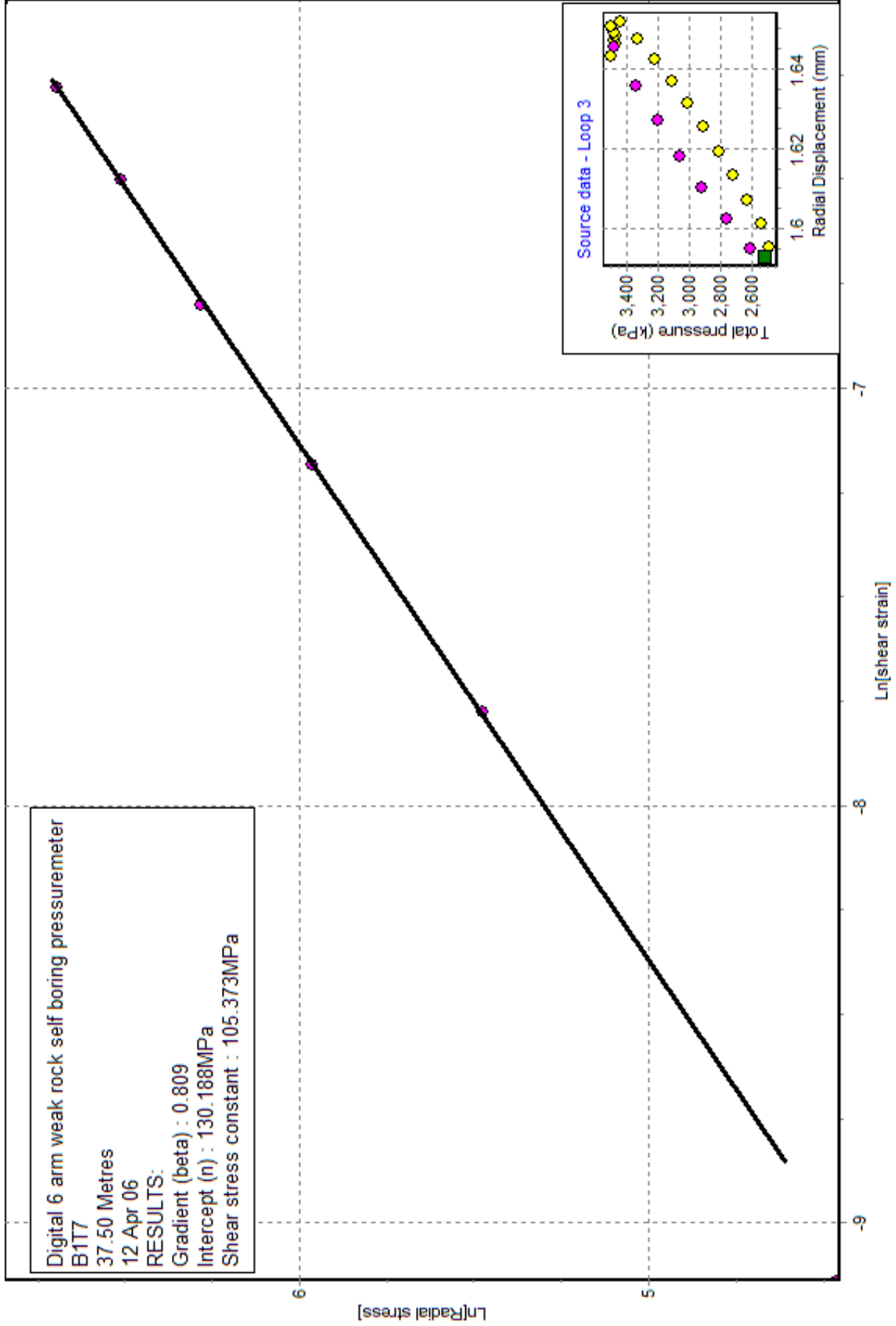
-7

-6

Ln[shear strain]

Source data - Loop 2





Digital 6 arm weak rock self boring pressuremeter

B4177

37.50 Metres

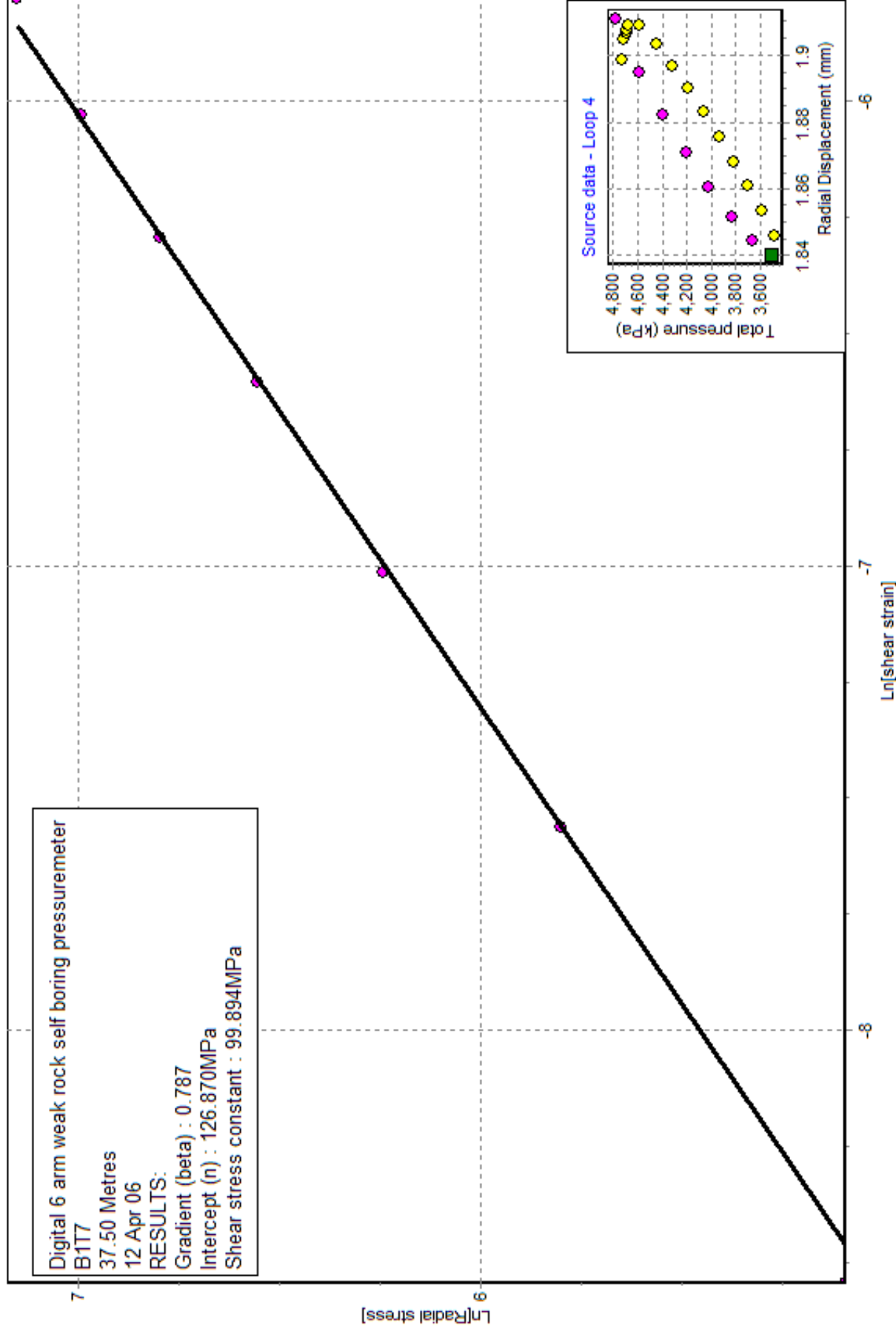
12 Apr 06

RESULTS:

Gradient (beta) : 0.787

Intercept (n) : 126.870MPa

Shear stress constant : 99.894MPa



Digital 6 arm weak rock self boring pressuremeter

B1T7

37.50 Metres

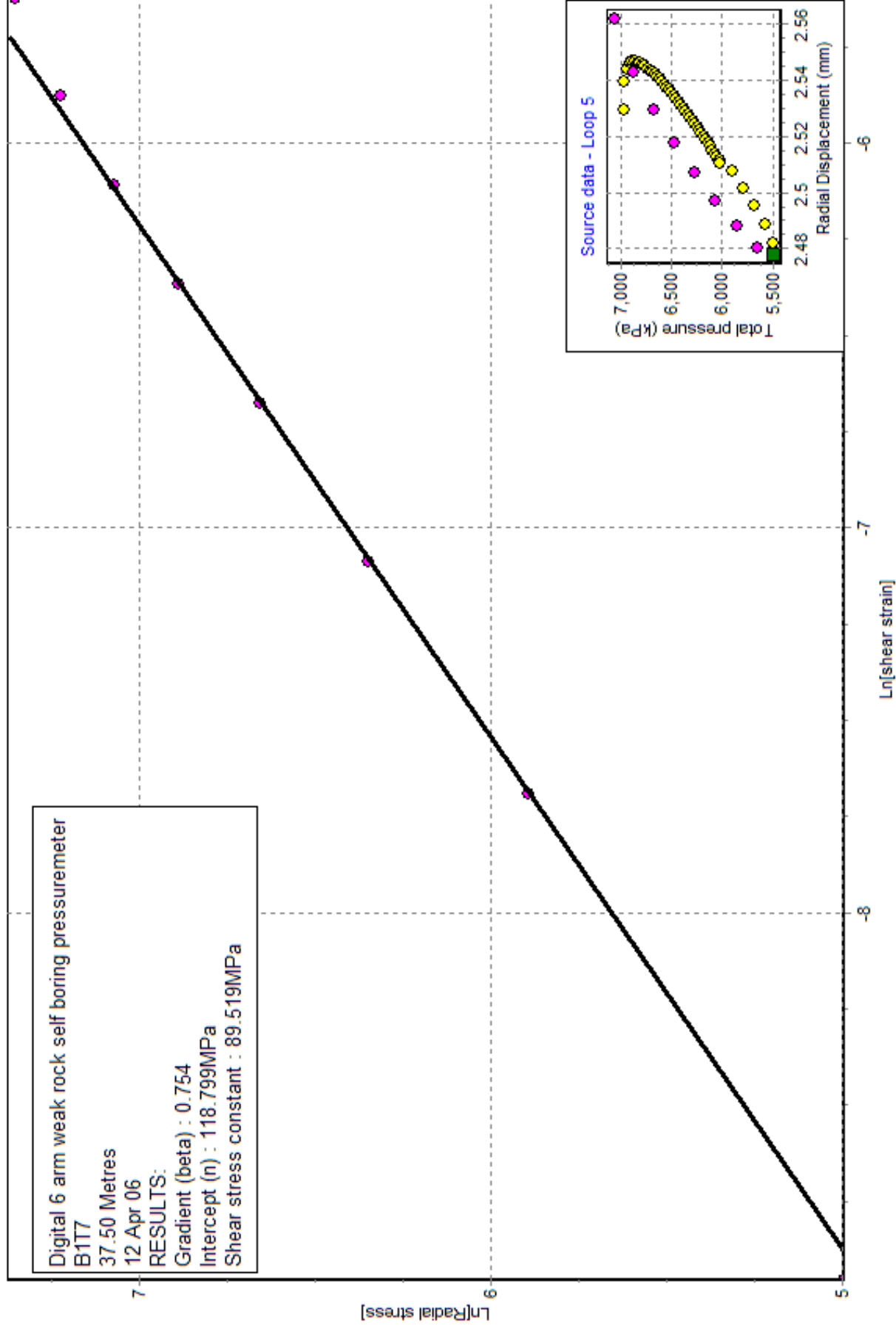
12 Apr 06

RESULTS:

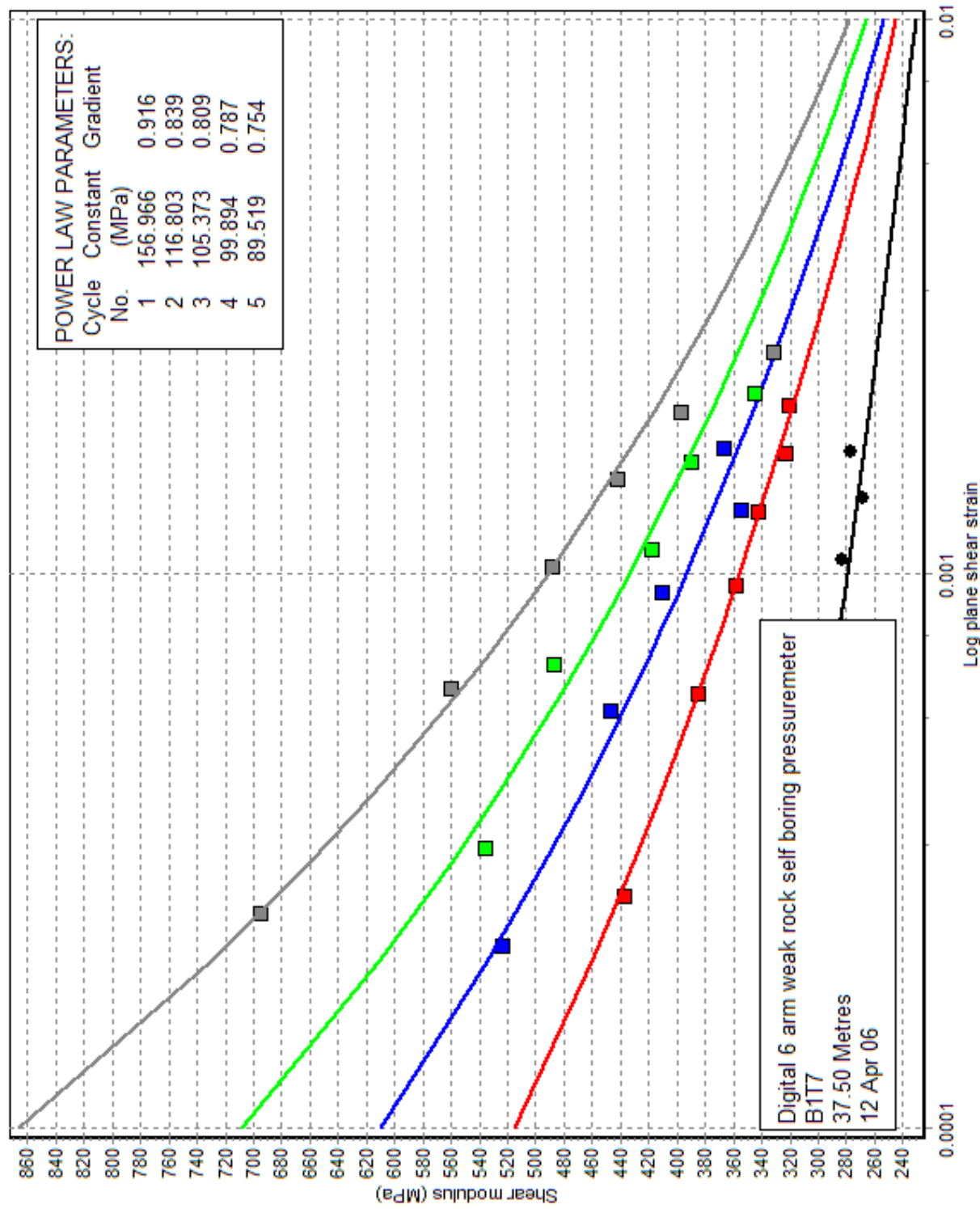
Gradient (beta) : 0.754

Intercept (n) : 118.799MPa

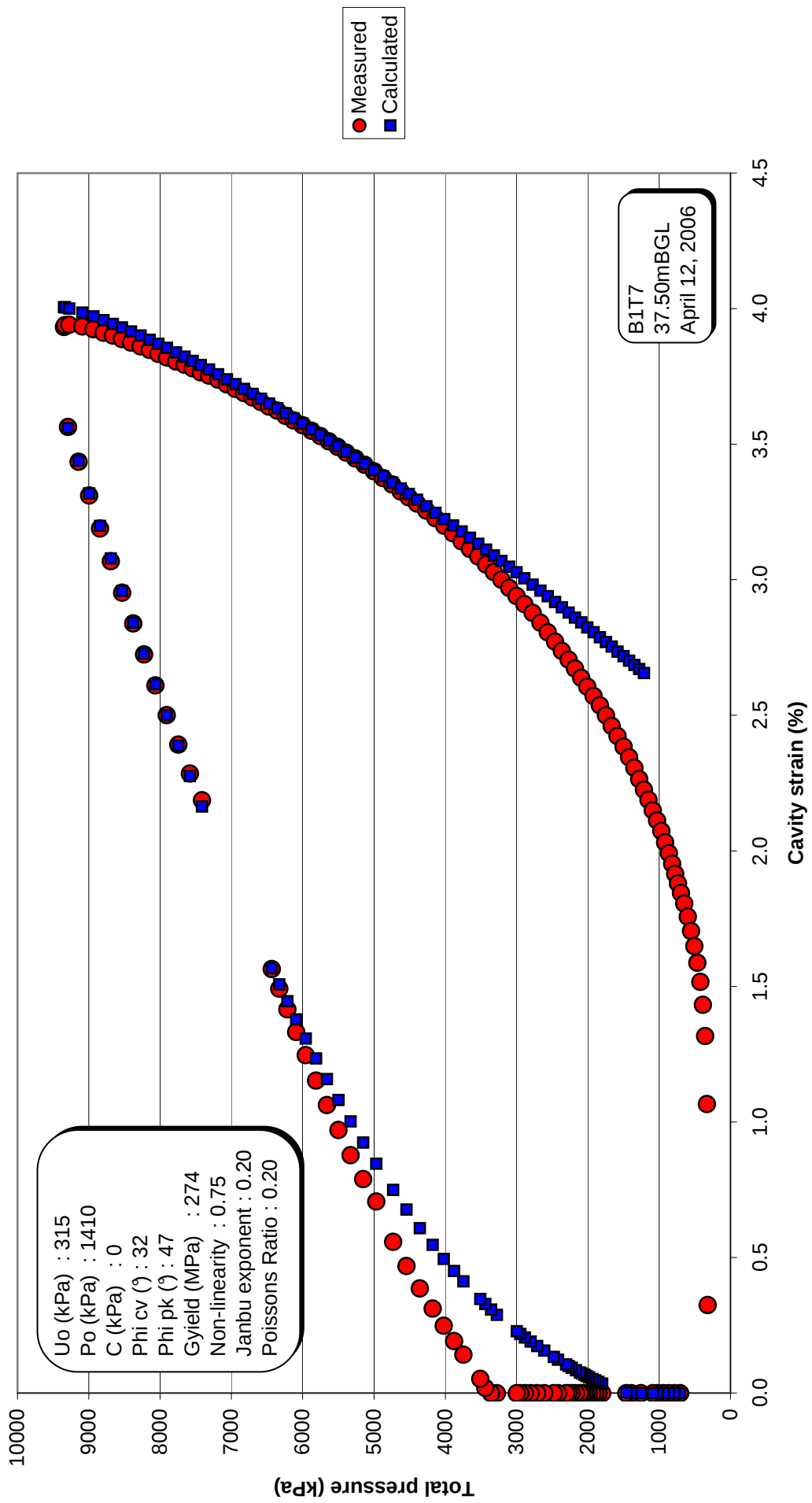
Shear stress constant : 89.519MPa



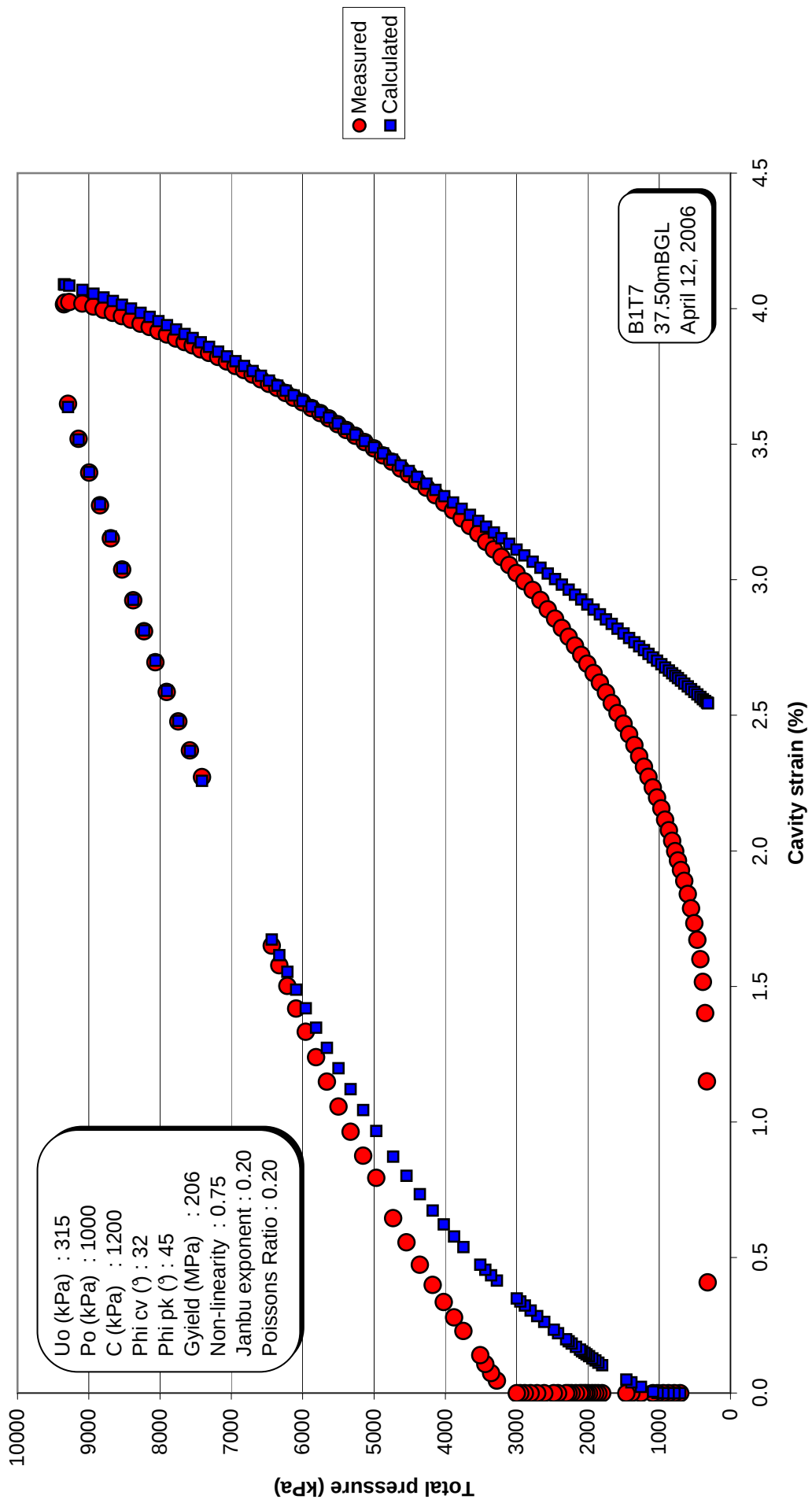
Variation of stiffness with strain, undrained analysis : Arm ave



Carter et al 1986 - Total pressure vs Cavity strain



Carter et al 1986 - Total pressure vs Cavity strain



B1T8 07/05/06 50.8m Chalk (with flints)

- 1. Test record sheet**
- 2. Results summary**
- 3. Plot of expansion versus pressure – all arms**
- 4. Plot of expansion versus pressure – arm average**
- 5. Plot of expansion versus pressure – arm pairs**
- 6. Plot of expansion versus pressure – odd and even arms**
- 7. Plot of Marsland & Randolph procedure**
- 8. Plot of cavity strain versus pressure, using the strain zero from the previous plot**
- 9. Gibson and Anderson plot, giving C_u and P_L from loading curve**
- 10. Jefferies plot, giving C_u from unloading curve**
- 11. Hughes plot, giving peak friction angle and dilation**
- 12. Plot of Reload Loop 1, with linear modulus line**
- 13. Plot of Reload Loop 2, with linear modulus line**
- 14. Plot of Reload Loop 3, with linear modulus line**
- 15. Bolton and Whittle plot of reloading part of Loop 1, giving nonlinearity coefficients**
- 16. Ditto for Loop 2**
- 17. And again for Loop 3**
- 18. Plot of Shear modulus versus Shear strain for all reload loops**
- 19. Hughes plot, showing zero dilation at large strain**

Note that although the material is basically frictional, when it fails it does so at constant volume.

TEST RECORD SHEET - HIGH PRESSURE DILATOMETER

SITE		Date	Day	Borehole	Test No	Depth	
RURITANIA		7-5-06	THU	1	8	50.8	
Material CHALK (+ FLINTS)							
Weather		Water Table	Time Now	Drilling End	Orientation	CHL	
		~11m				✓	
Drilling CORING TCH			Pocket 48.7 - 51.7 m				
Diameter	Distance	Rate		Core Description		Length	
'H'	3m						
Wet/Dry	Rig	Driller		Core Quality		Size	
MUD	T51	N. EVERATT					
Pres/Incrmnt	Wait Time	Creep Time	Cycle Time	Disc No.	Operator	Engineer	
			10 SECS		D.L.		
ZERO READINGS:				Machine Diameter			
Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6	T/Press.	Battery
-2518	-1794	-1443	-1970 -2343	-2343	-2559	A: 16.2 B: -190.2	12.12v
Calibrations:							
Strain Arm Calibration date:				29/04/06		Test No: 125 -	
Total Pressure Cell Calibration date:				"		Test No: -	
Membrane Stiffness Calibration date:				"		Test No: B55730	
Membrane Compression Calibration date:				"		Test No: ?	
New Membrane fitted date:							
Test Comments:							
Time	Line No.	Start Test at: 14:00					
	81	HOLD ~ 6 MPa					
	111	LOAD (1)					
	160	HOLD ~ 10 MPa					
	190	LOAD (2)					
	264	HOLD ~ 13 MPa					
	274	LOAD (3)					
	322	DOWN					
Test Ends at: 15:17							
Max. Pressure reached: 14.7 MPa							
General Comments: FAILING NICELY.							

Site:- Ruritania

Test :- B1T8

Test Date :- 7th May 2006

Material :- Chalk

Depth :- 50.8 mtrs

Water table :- ~ 11m

Analysis of Insitu Lateral Stress (P_o) :-

		Arm Av.
Marsland and Randolph	MPa	3.7
Strain zero	mm	2.1

Analysis of Undrained Shear Strength (C_u) :-

Gibson and Anderson	MPa	4.27
Pressure at failure (P_F)	MPa	5.50
Limit Pressure (P_L)	MPa	26.2
Jefferies (unloading)	MPa	3.68

Strength of Sands Analysis (Hughes, Wroth & Windle)

Friction angle at const. vol.	deg	25	(assumed)
Angle of Friction	deg	37.2	
Angle of Dilation	deg	14.2	

Analysis of Shear Modulus (G) :-

Initial Modulus (G_i)	MPa	330
---------------------------	-----	-----

Linear Analysis of Reload Loops (G_R) :-

		Loop 1	Loop 2	Loop 3
G_R	GPa	1.02	1.07	1.03
Pressure at start	MPa	5.91	10.4	13.4
Depth of unload	MPa	1.96	3.58	4.74

Non-linear Analysis of Reloading data :-

α	MPa	323	367	366
β		0.843	0.842	0.838

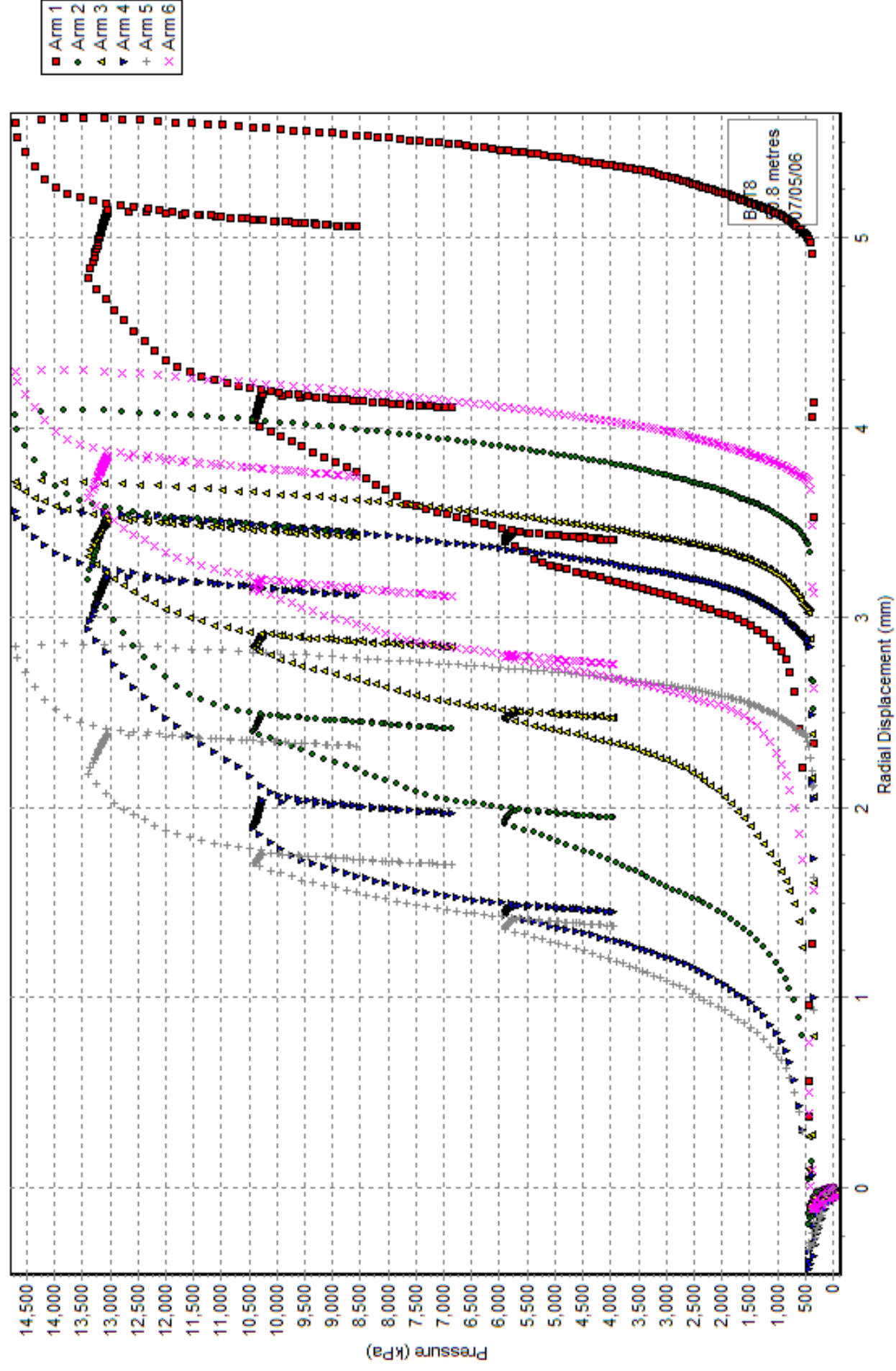
Shear Modulus G_S (at 2 levels of shear strain) :-

(0.01%)	GPa	1.37	1.57	1.63
(0.1%)	GPa	0.96	1.09	1.12

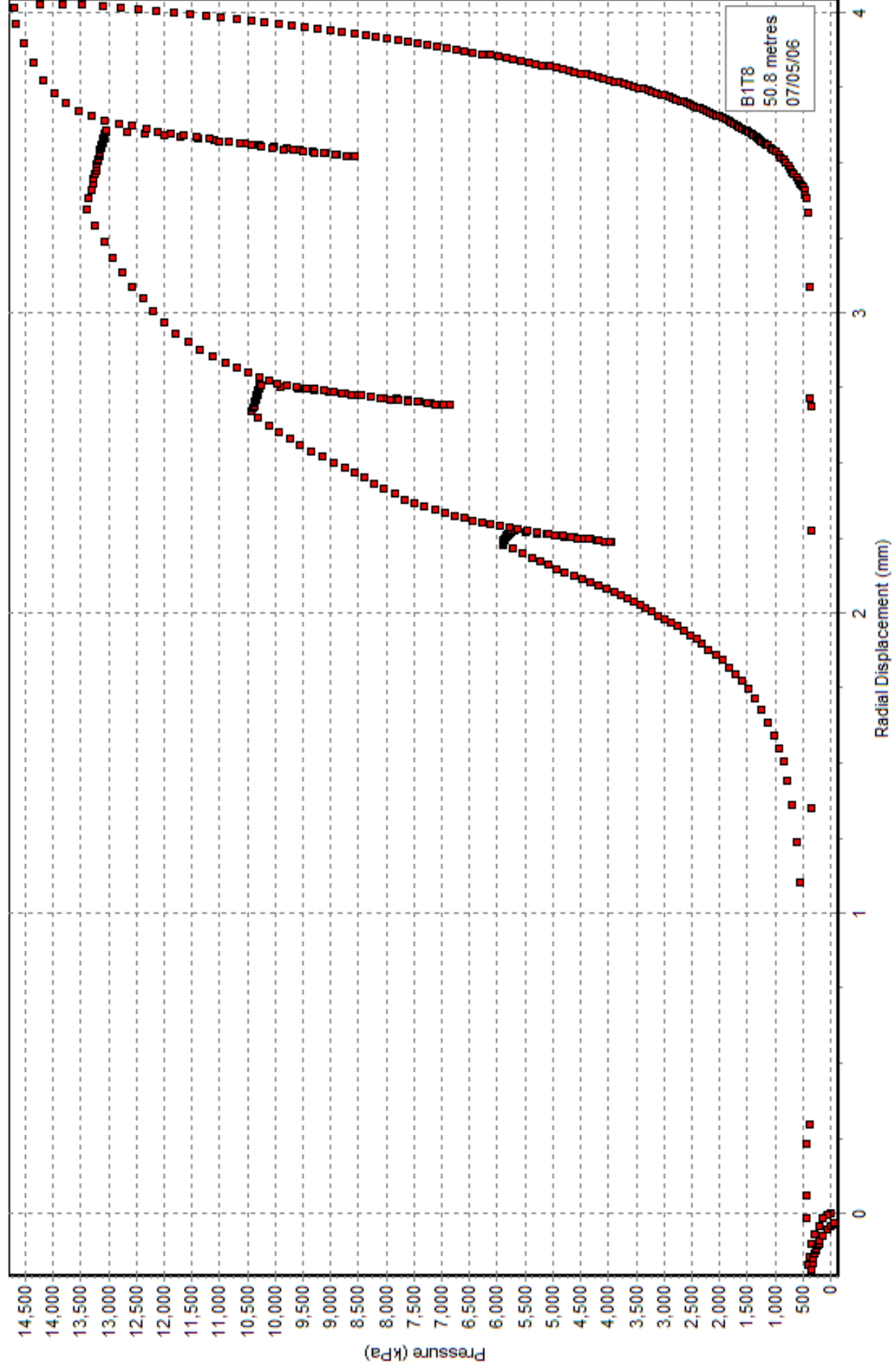
Test Analysed By :- PGH

Date :- Sept 2009

All Arms vs Total Pressure

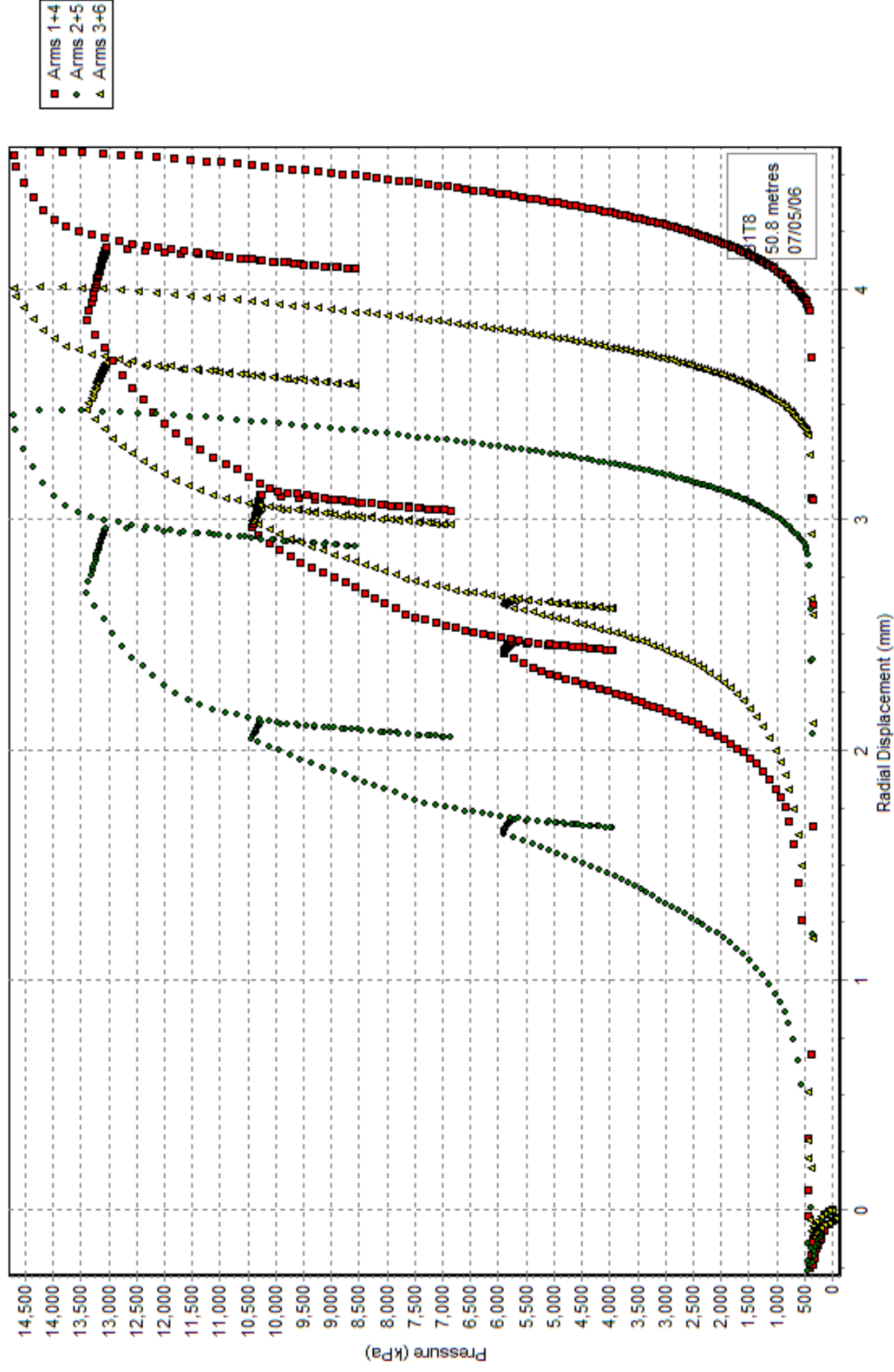


Arm Average vs Total Pressure

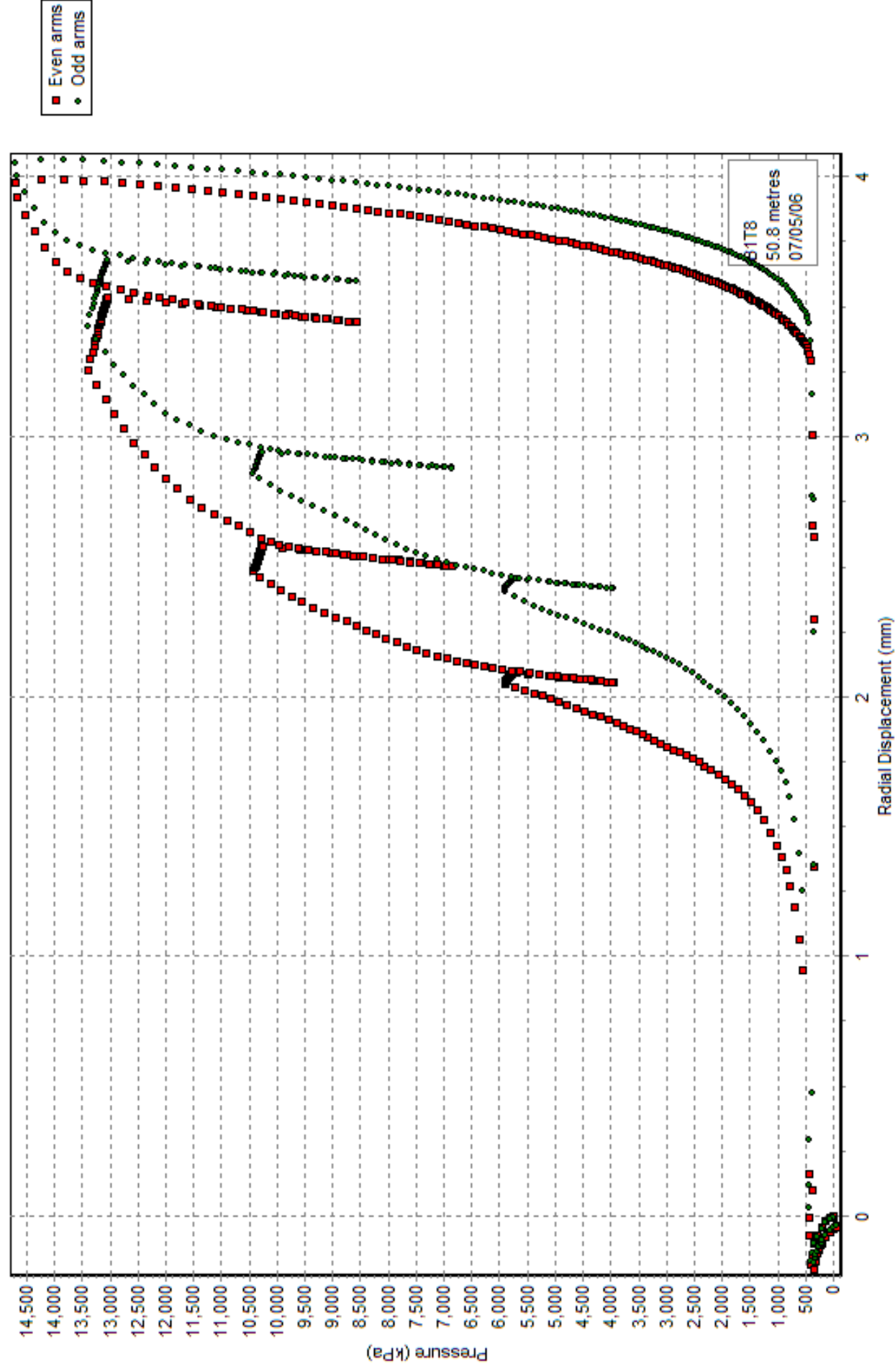


B1T8
50.8 metres
07/05/06

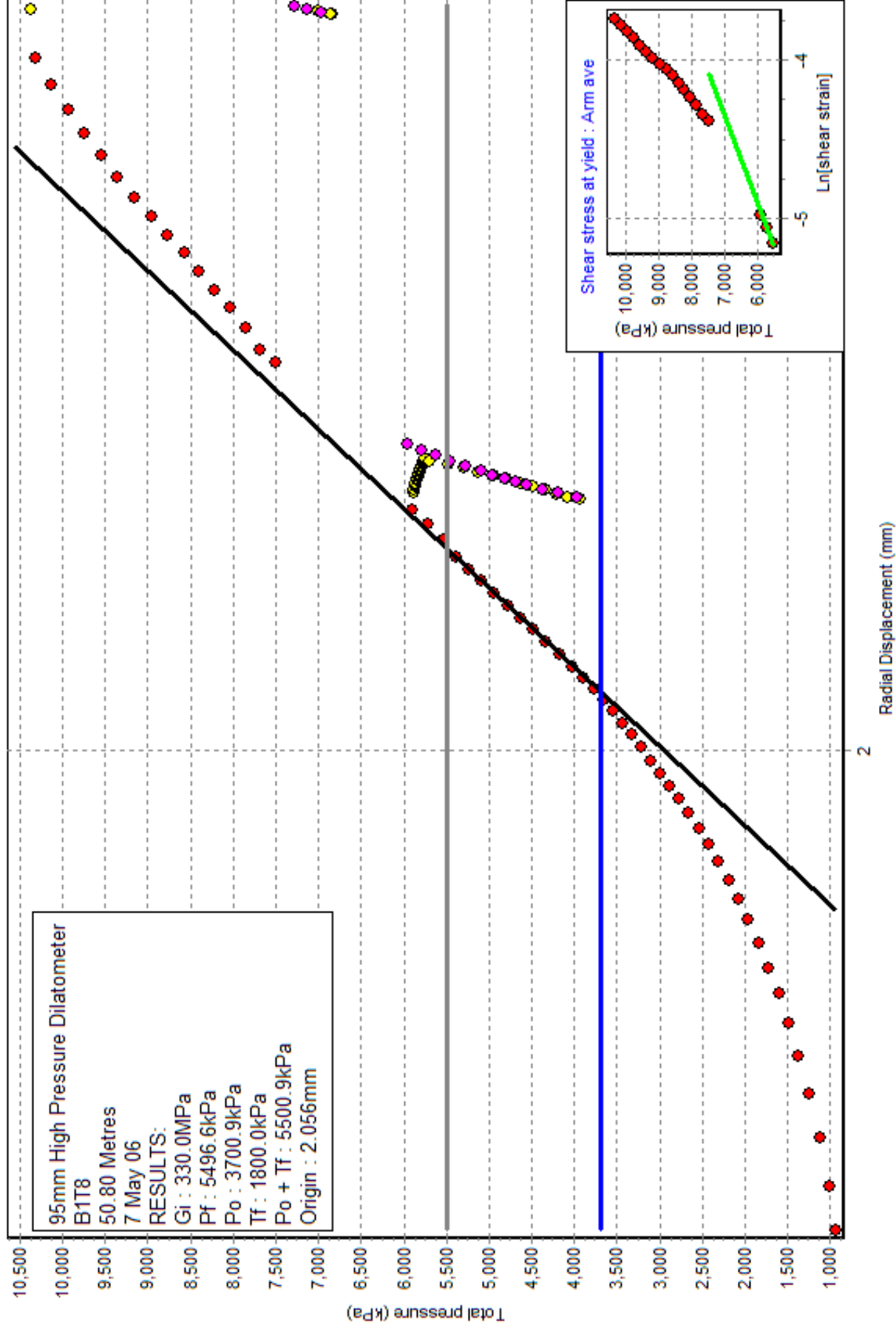
Arm Pairs vs Total Pressure



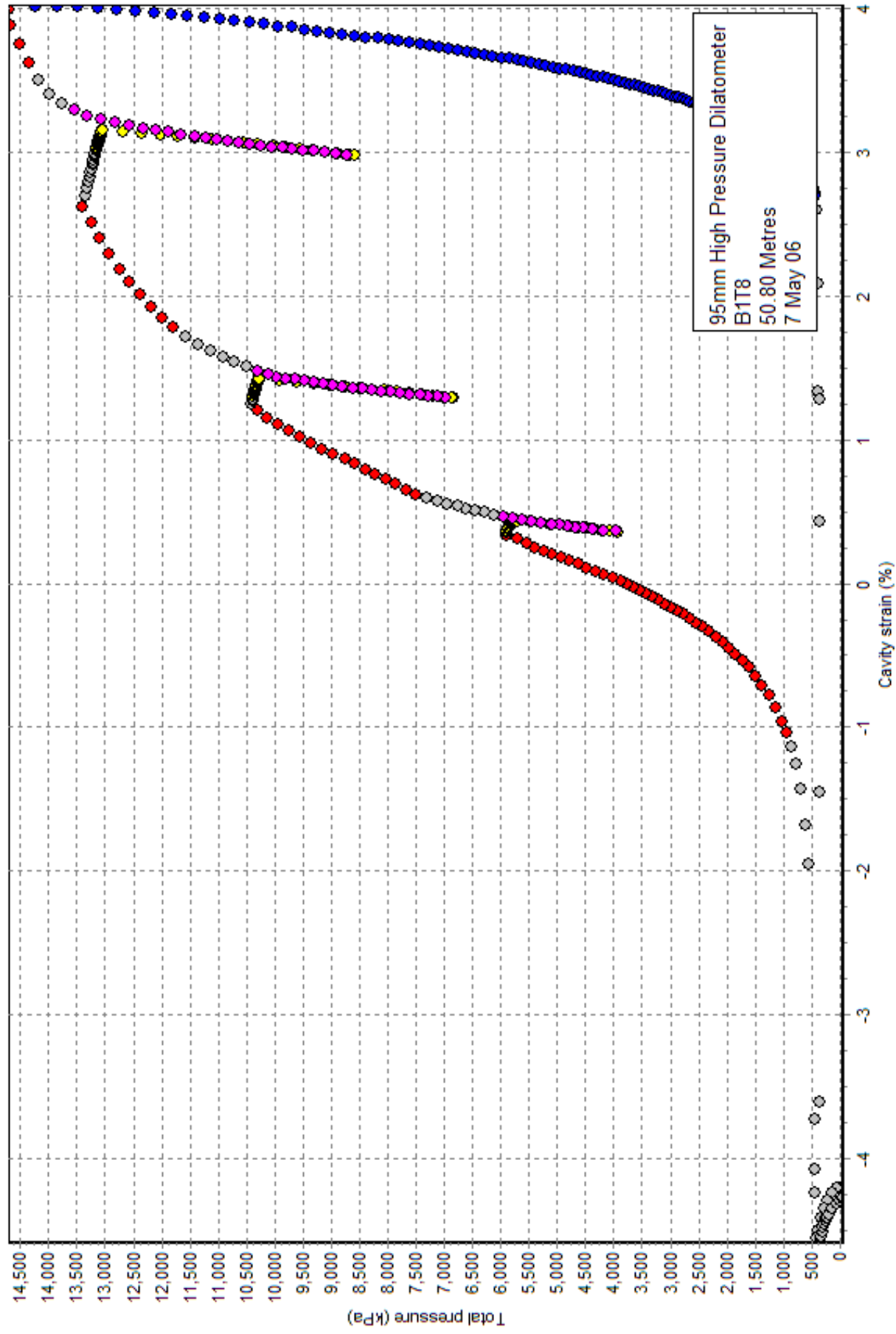
Odd and Even Arms vs Total Pressure

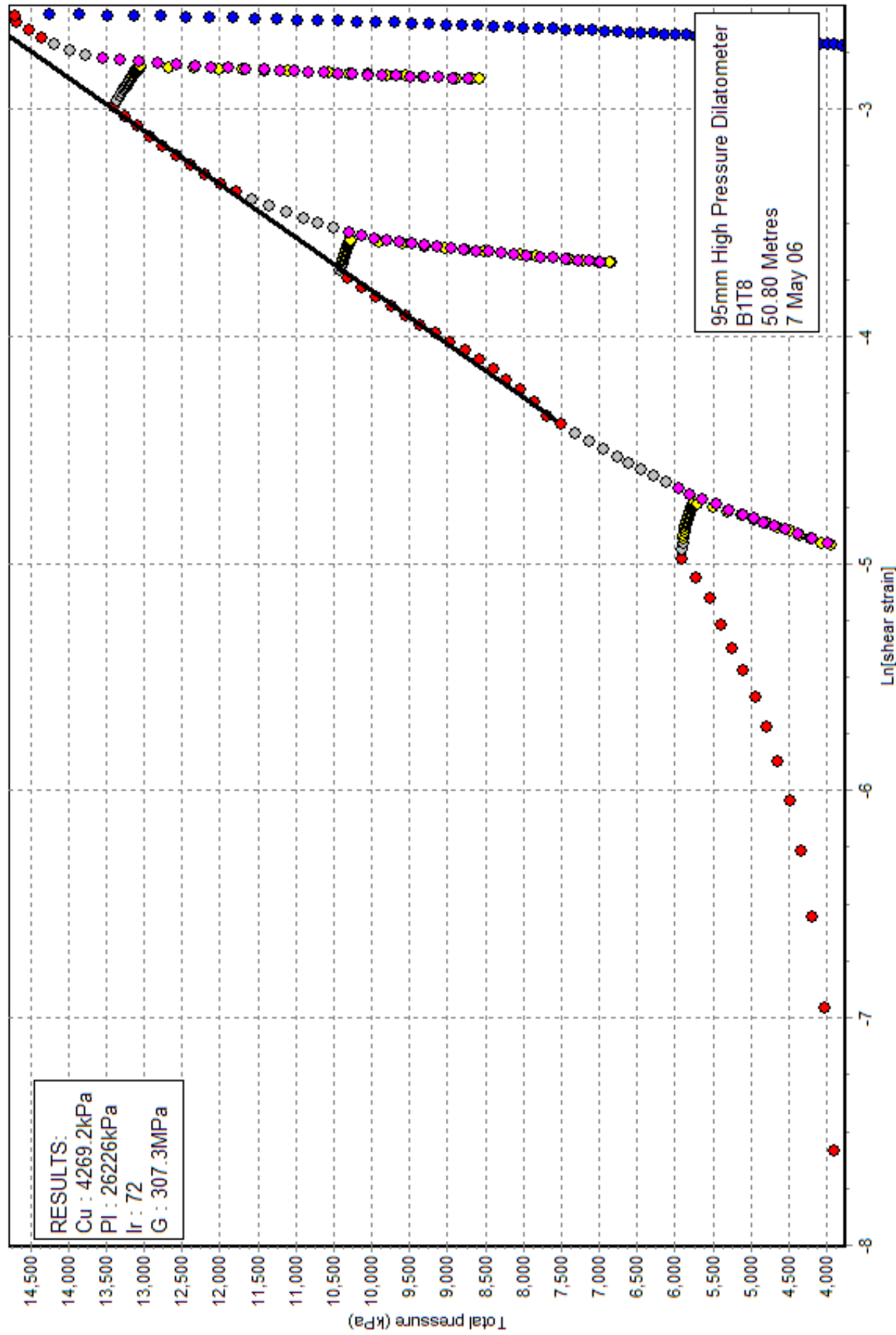


Po of cohesive material (1977, 1990) : Arm ave

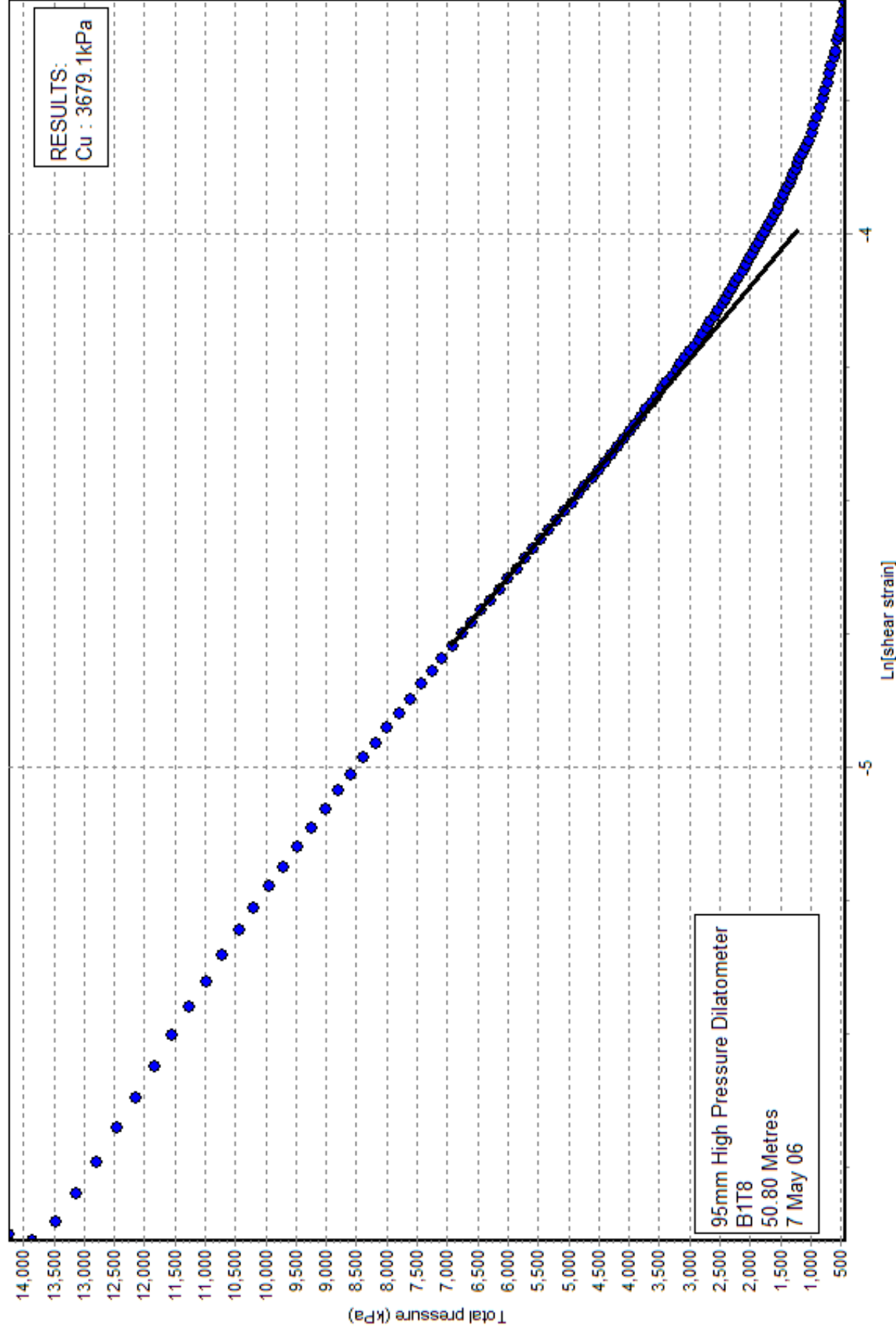


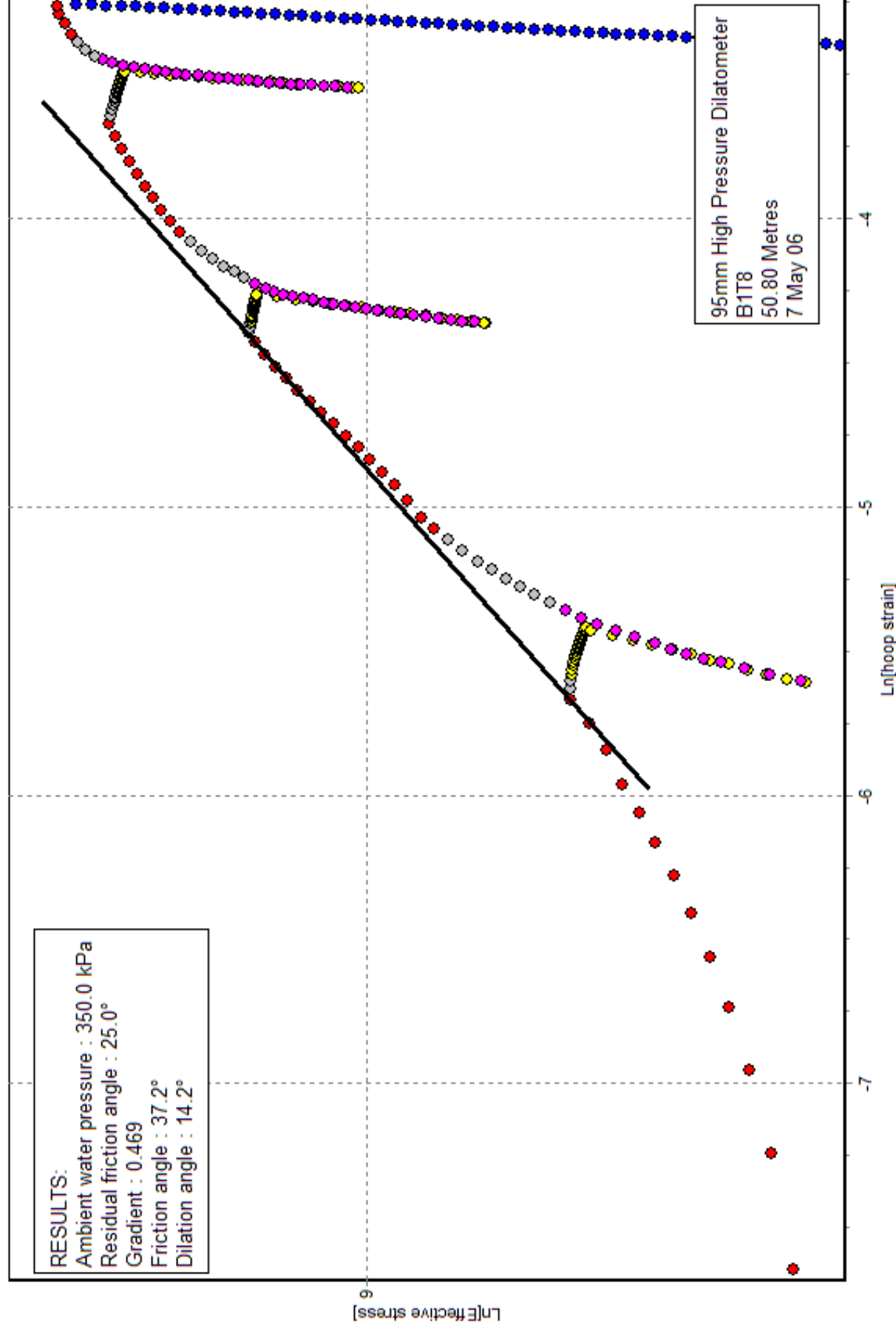
Cavity strain vs Total Pressure : Arm ave



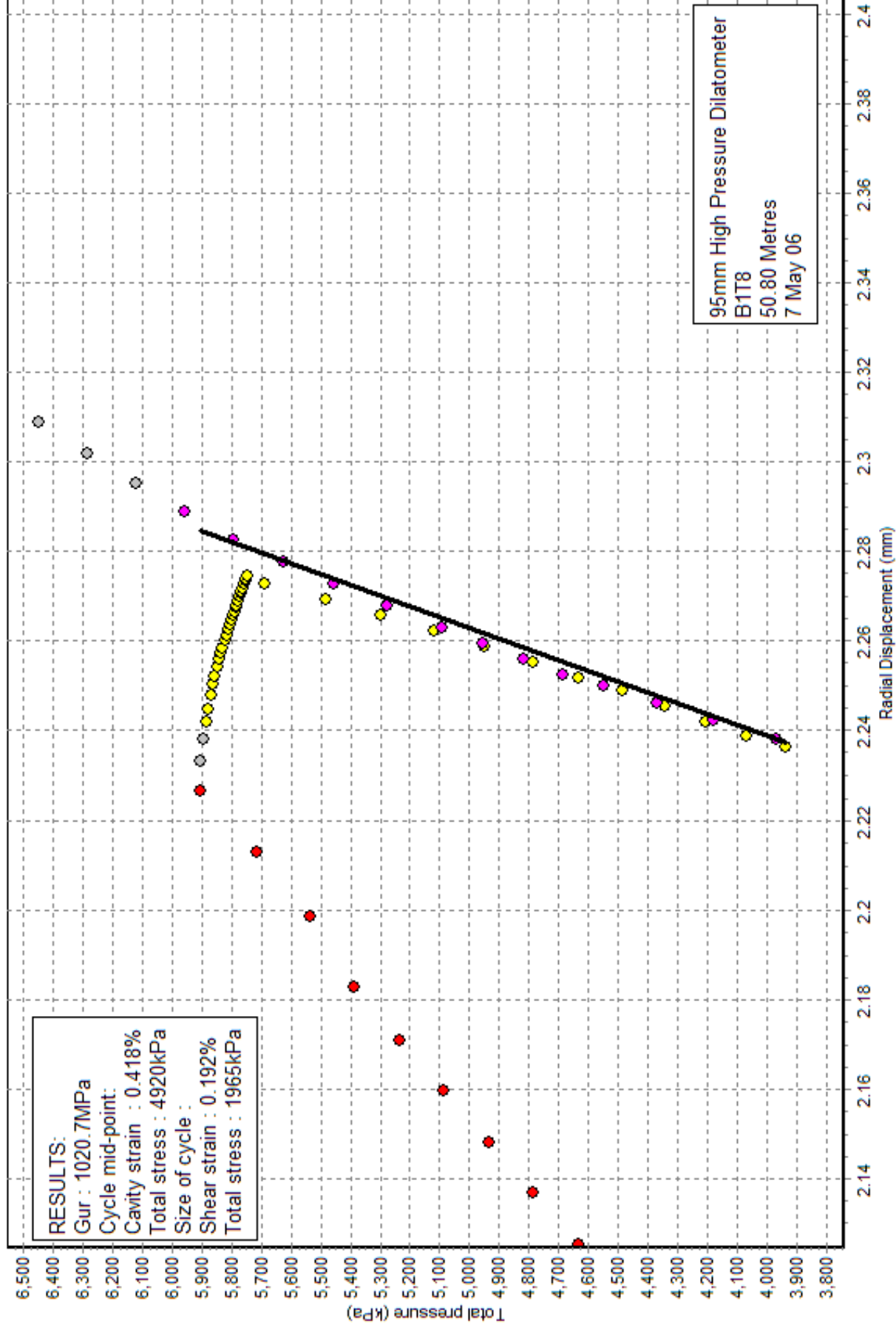


Jefferies (1988) : Arm ave

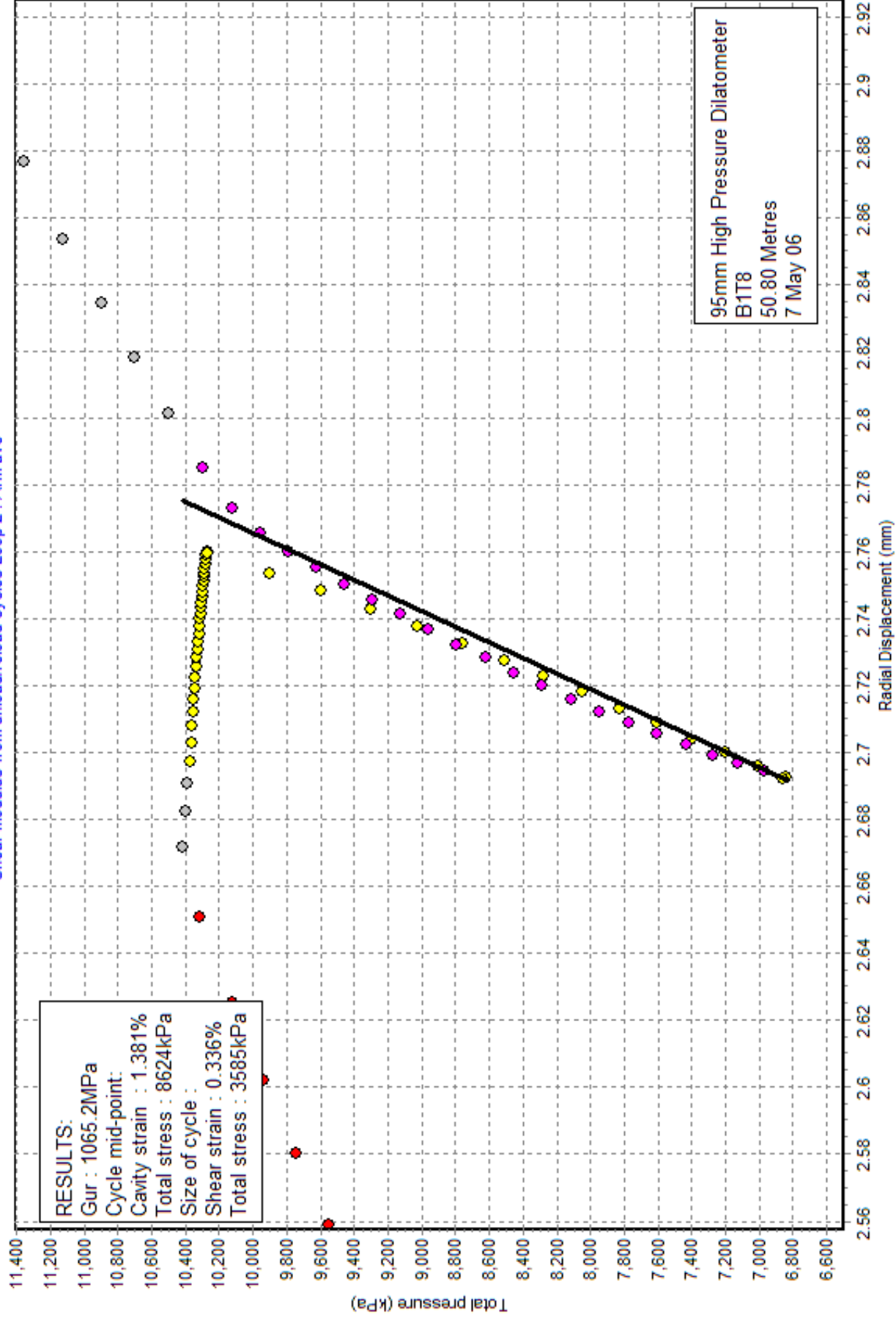




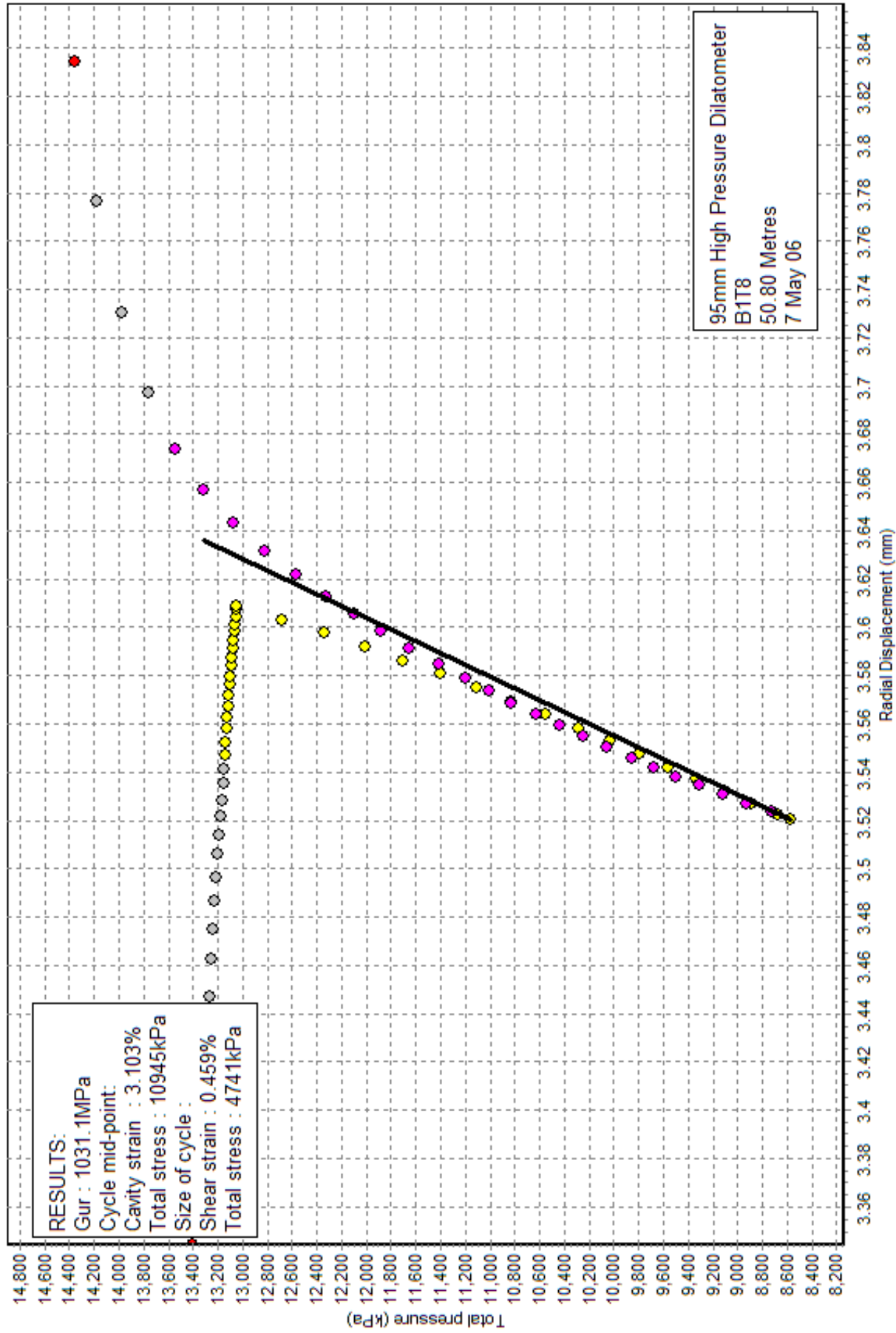
Shear modulus from unload/reload cycles Loop 1 : Arm ave

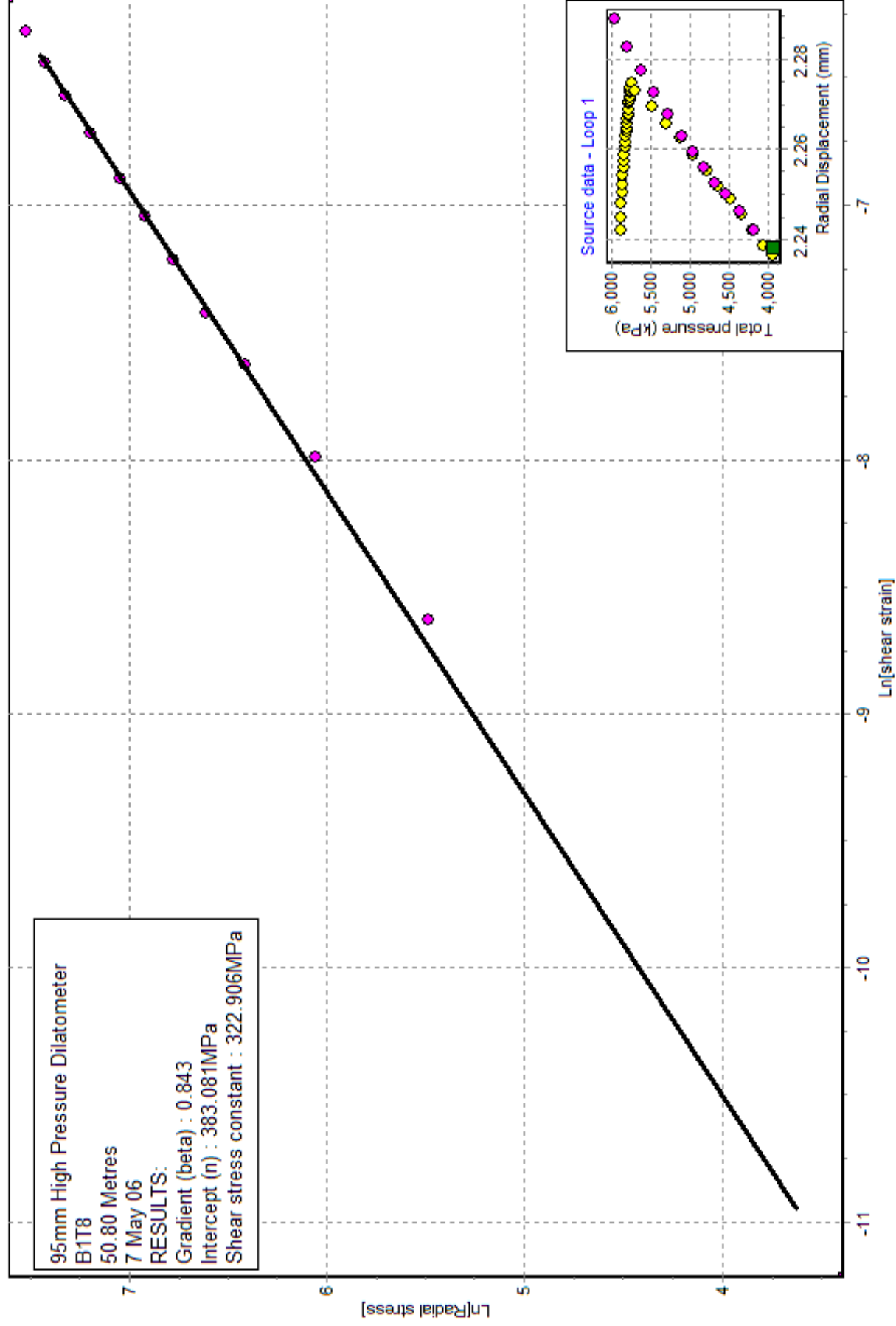


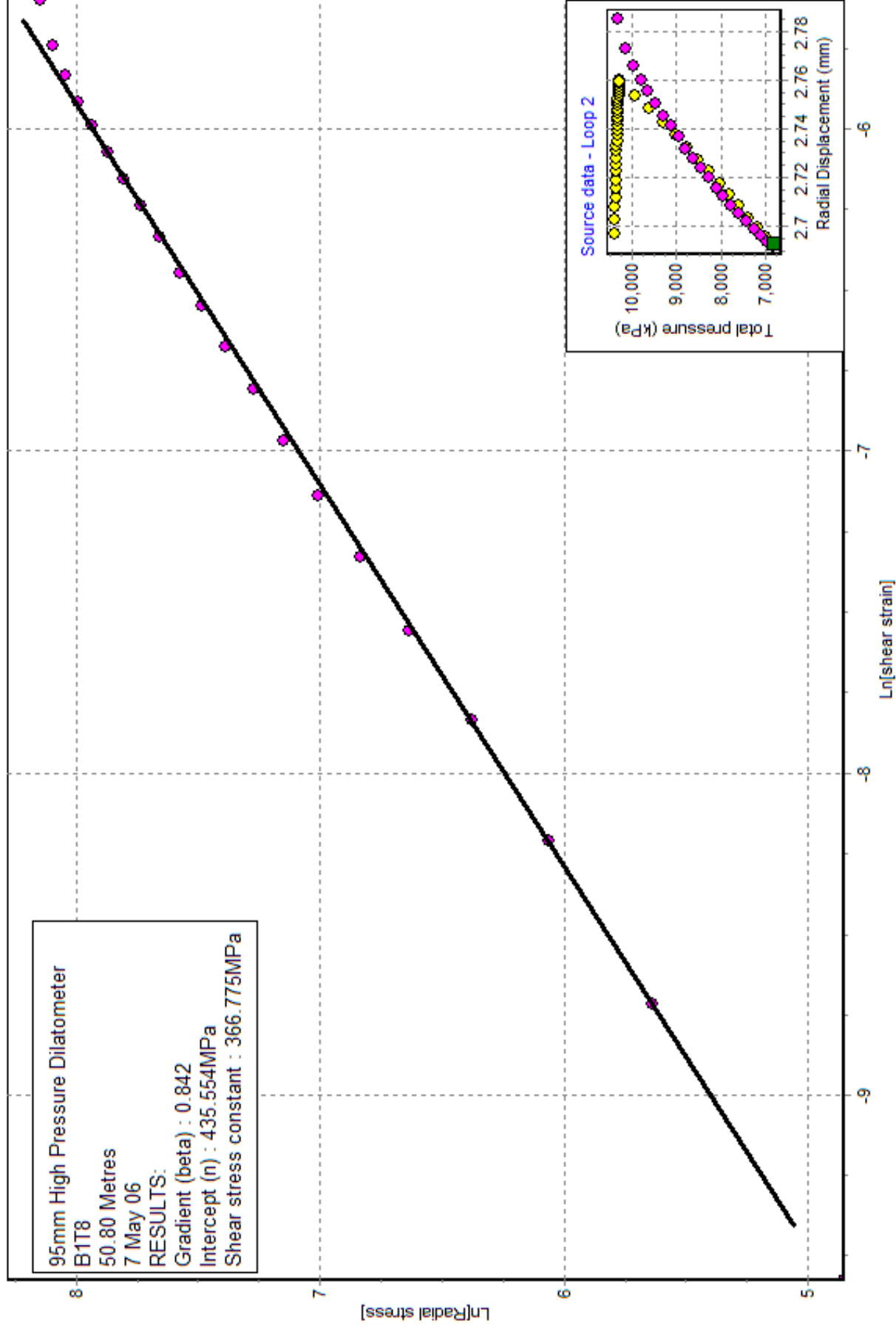
Shear modulus from unload/reload cycles Loop 2 : Arm ave

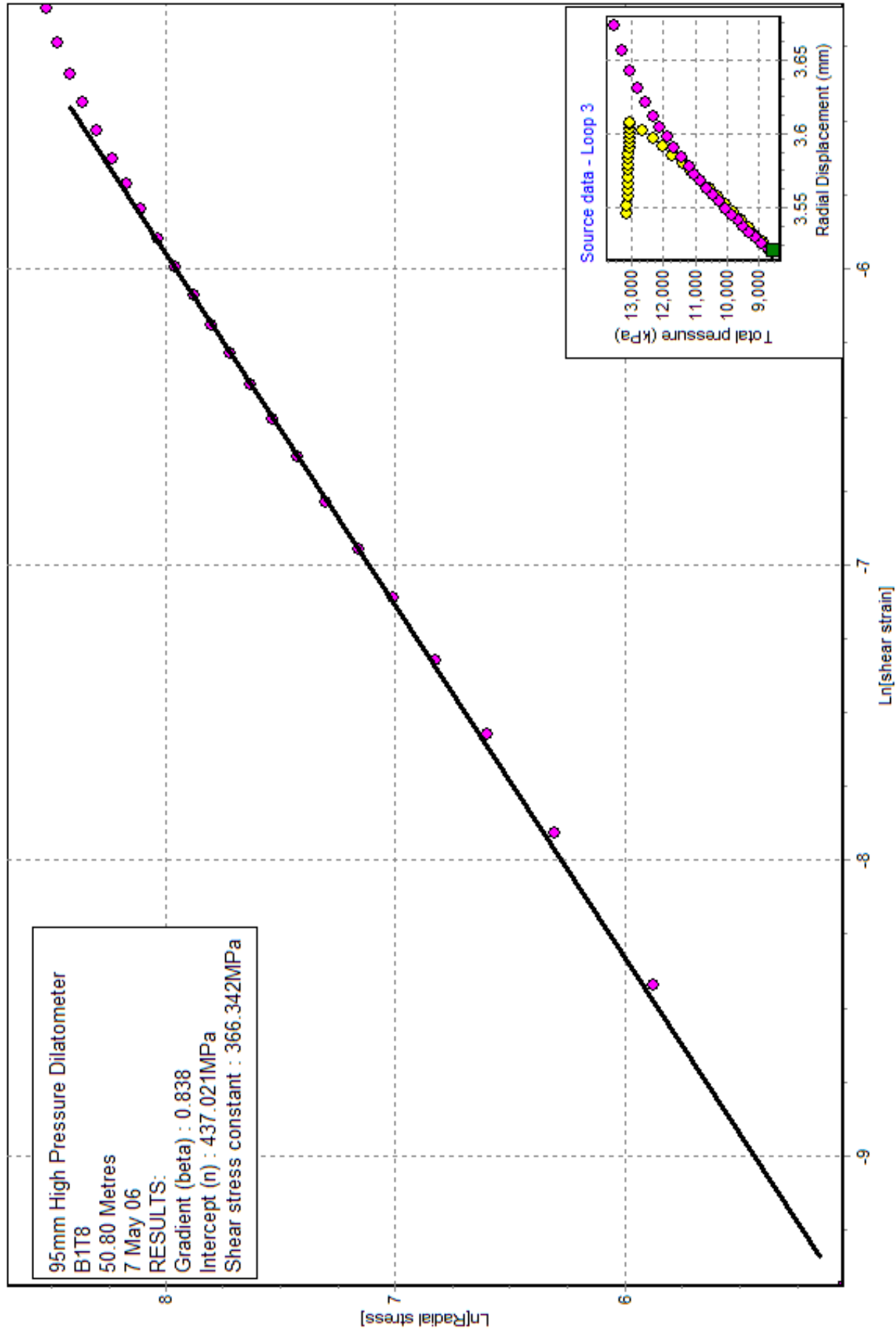


Shear modulus from unload/reload cycles Loop 3 : Arm ave

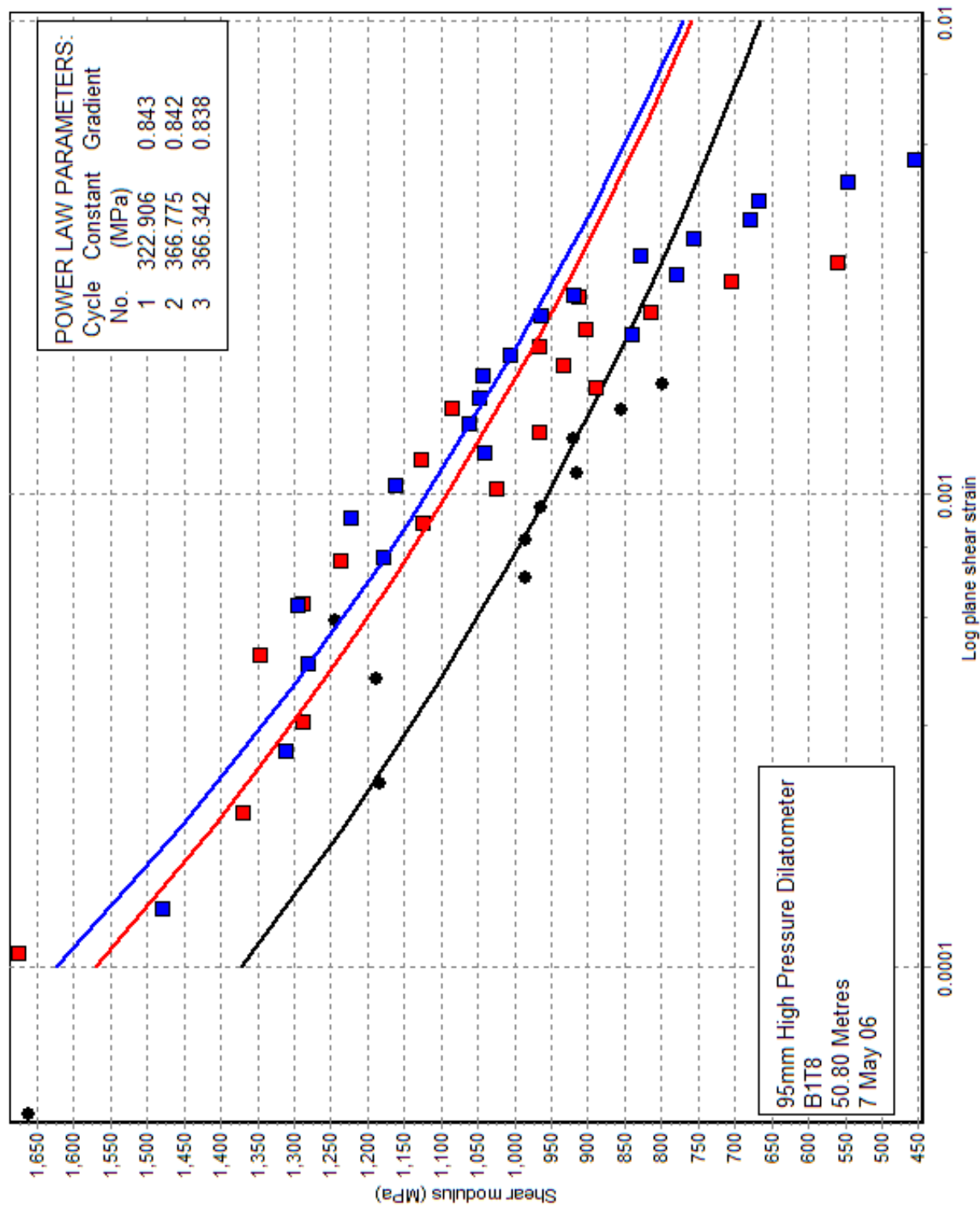


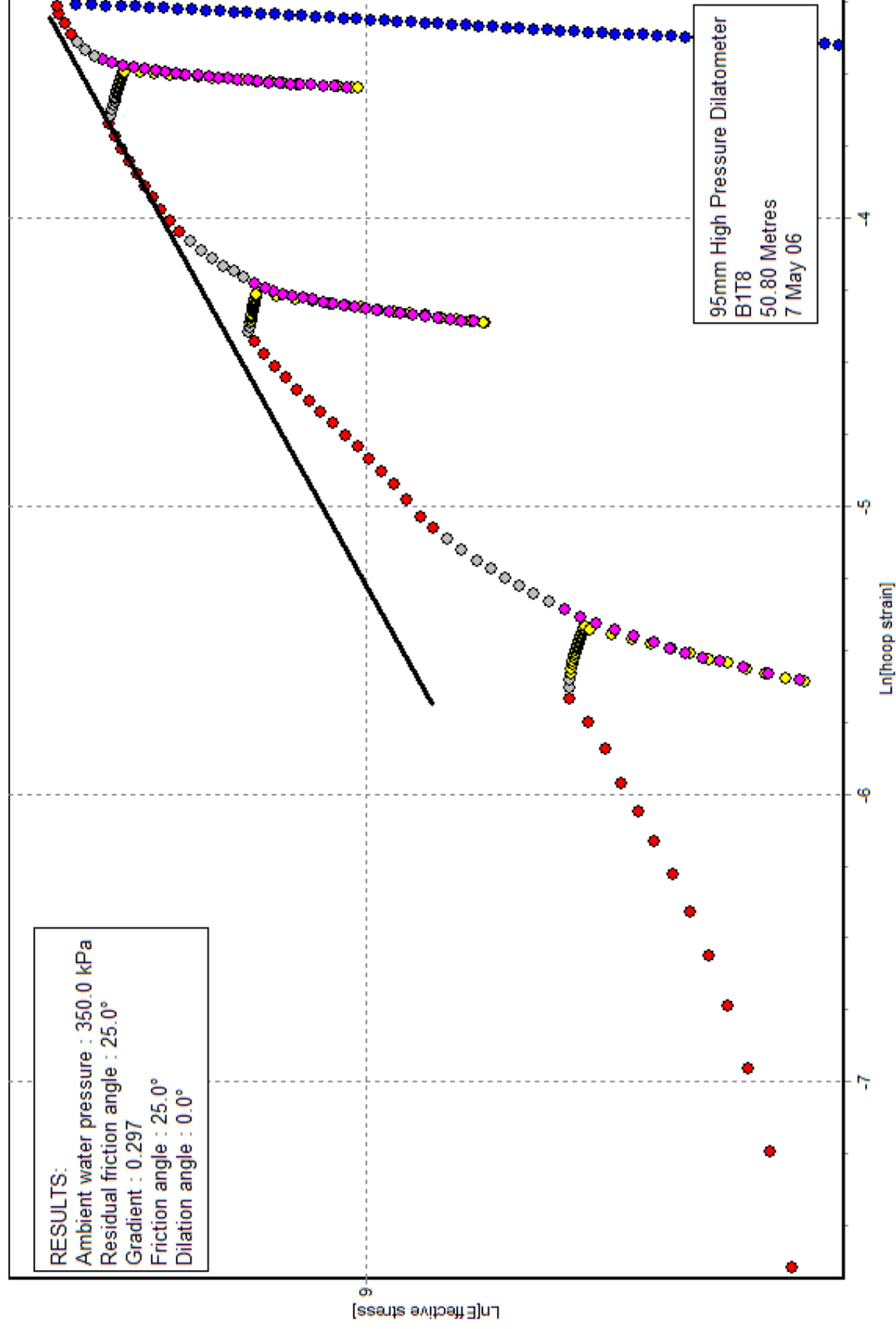






Variation of stiffness with strain, undrained analysis : Arm ave





B1T9 10/05/06 67.6m Limestone

- 1. Test record sheet**
- 2. Results summary**
- 3. Plot of expansion versus pressure – all arms**
- 4. Plot of expansion versus pressure – arm average**
- 5. Plot of expansion versus pressure – arm pairs**
- 6. Plot of expansion versus pressure – odd and even arms**
- 7. Plot of Marsland & Randolph procedure**
- 8. Plot of cavity strain versus pressure**
- 9. Plot of Gibson & Anderson procedure, giving C_u and P_L**
- 10. Jefferies plot, giving C_u from unloading curve**
- 11. Plot of Reload Loop 1, with linear modulus line**
- 12. Plot of Reload Loop 2, with linear modulus line**
- 13. Plot of Reload Loop 3, with linear modulus line**
- 14. Plot of Reload Loop 4 with linear modulus line**
- 15. Plot of Reload Loop 5 with linear modulus line**
- 16. Hughes plot, giving peak friction angle**
- 17. Plot of Shear Stress versus Normal Stress, showing Friction Angle, obtained from the Manassero procedure**
- 18. Plot of measured and calculated curves, from Carter et al**

TEST RECORD SHEET - HIGH PRESSURE DILATOMETER

SITE		Date	Day	Borehole	Test No	Depth	
RURITANIA		10-5-06	TUE	1	9	67.6m	
Material BLACK LIMESTONE							
Weather		Water Table	Time Now	Drilling End	Orientation	CHL	
HUMID				~12:00		✓	
Drilling CURIN 6			Pocket TO 69m				
Diameter	Distance	Rate		Core Description		Length	
'H'							
Wet/Dry	Rig	Driller		Core Quality		Size	
AIR MIST		SEAN		VERY BROKEN			
Pres/Incrmnt	Wait Time	Creep Time	Cycle Time	Disc No.	Operator	Engineer	
			10min		P.F.H.		
ZERO READINGS:			Machine Diameter 95mm				
Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6	T/Press.	Battery
						A:	
						B:	
Calibrations:							
Strain Arm Calibration date:				6-7-10		Test No: -	
Total Pressure Cell Calibration date:				"		Test No: -	
Membrane Stiffness Calibration date:				7-7-10		Test No: 50709T11	
Membrane Compression Calibration date:				"		Test No: "	
New Membrane fitted date:				"			
Test Comments:							
Time	Line No.	Start Test at: 12:30					
	18	HOSE CONNECTION BLOW OFF!					
		BECOMES LEAK (1) ~ 750kPa					
	39	HOLD ⇒ LEAK (2) ~ 1500kPa					
	84	HOLD ⇒ LEAK (3) ~ 2500kPa					
	168	HOLD ⇒ LEAK (4) ~ 5500kPa					
	311	ARM (5) SUDDEN JUMP					
	315	DOWN					
	340	HOLD ⇒ LEAK (5) ON UNLOADING					
Test Ends at: 13:42							
Max. Pressure reached: 13.75 MPa							
General Comments: ONLY ARMS (4) & (5) FAILED AT FIRST.							

CAMBRIDGE INSITU, Little Eversden, Cambridge, England CB3 7HE
 Telephone: 01223 262 361 Fax:- 01223 263 947

Site:- Ruritania

Test :- B1T9

Test Date :- 10th May 2006

Material :- Limestone

Depth :- 67.6 mtrs

Water table :- ~11 mtrs

Analysis of Insitu Lateral Stress (Po) and Cohesion (C) :-

		Po	C	Po + C
Marsland and Randolph	MPa	-	-	5.00
Carter et al	MPa	3.10	1.85	4.95
Borehole diameter	mm	101.7		

Analysis of Undrained Shear Strength (Cu) :-

Pressure at failure (P _F)	MPa	8.01
Jefferies (unloading)	MPa	2.65
Gibson & Anderson (loading)	MPa	4.58
Limit pressure (P _L)	MPa	36.4

Strength of Sands Analysis :-

		ϕ_{cv}	ϕ_{pk}	dilation
Hughes, Wroth & Windle	deg	(43)	45	2.8
Carter et al	deg	"	"	"

Analysis of Shear Modulus (G) :-

Initial Modulus (G _i)	GPa	1.92
Yield Modulus (Carter et al)	GPa	2.15

Linear Analysis of Reload Loops (G_R) :-

		Loop 1	Loop 2	Loop 3	Loop 4	Loop 5 (on unloading)
G _R	GPa	0.23	0.78	1.55	3.01	4.05
Pressure at start	MPa	1.38	2.16	3.10	6.15	7.77
Depth of unload	MPa	0.51	0.59	0.87	1.54	-2.75

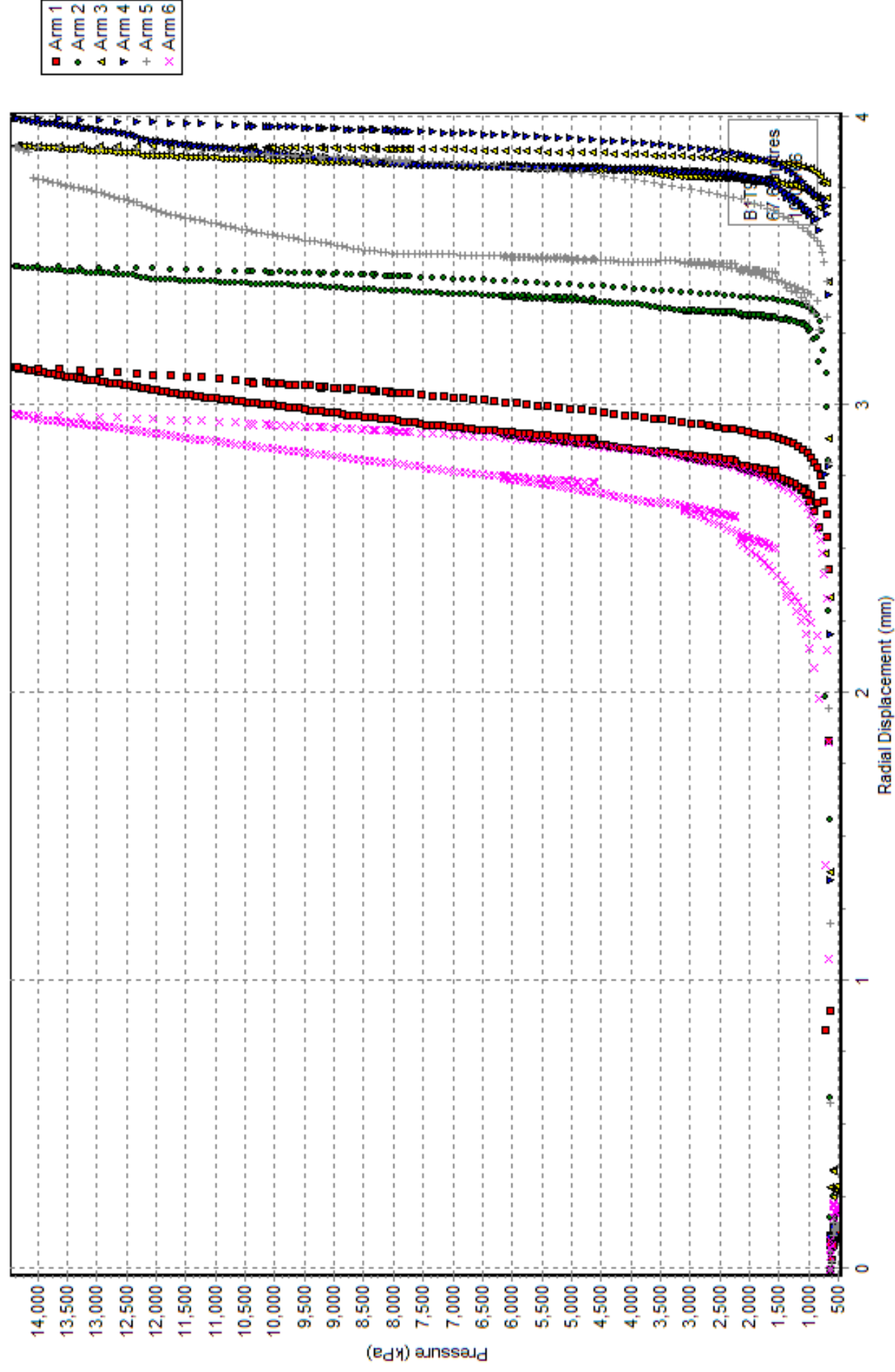
Test Analysed By :- PGH

Date :- July 2010

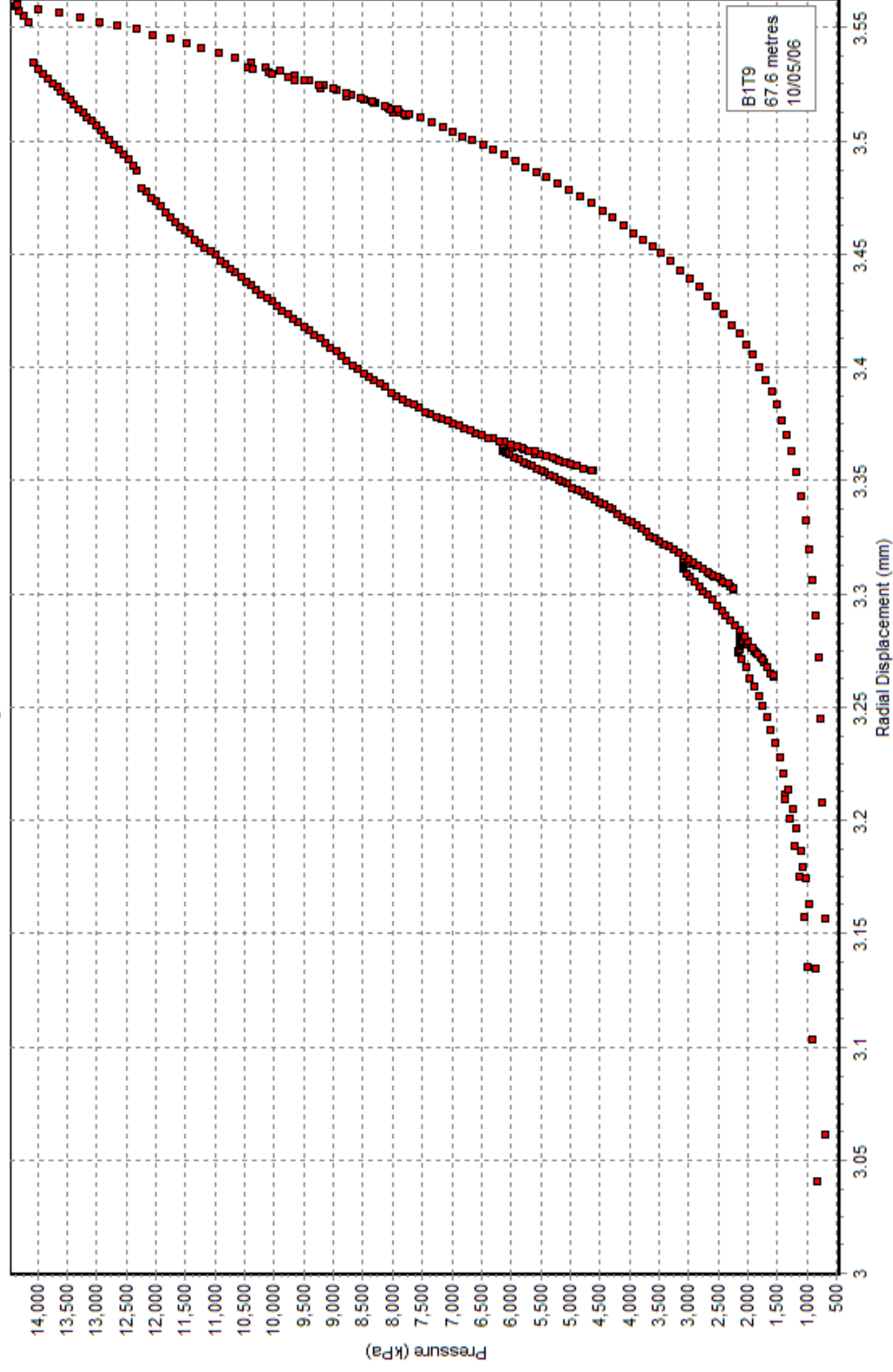
Note that the results of the Carter et al curve matching have been included, because of the good agreement with more traditional methods.

ϕ_{cv} has been estimated from the Manassero plot.

All Arms vs Total Pressure

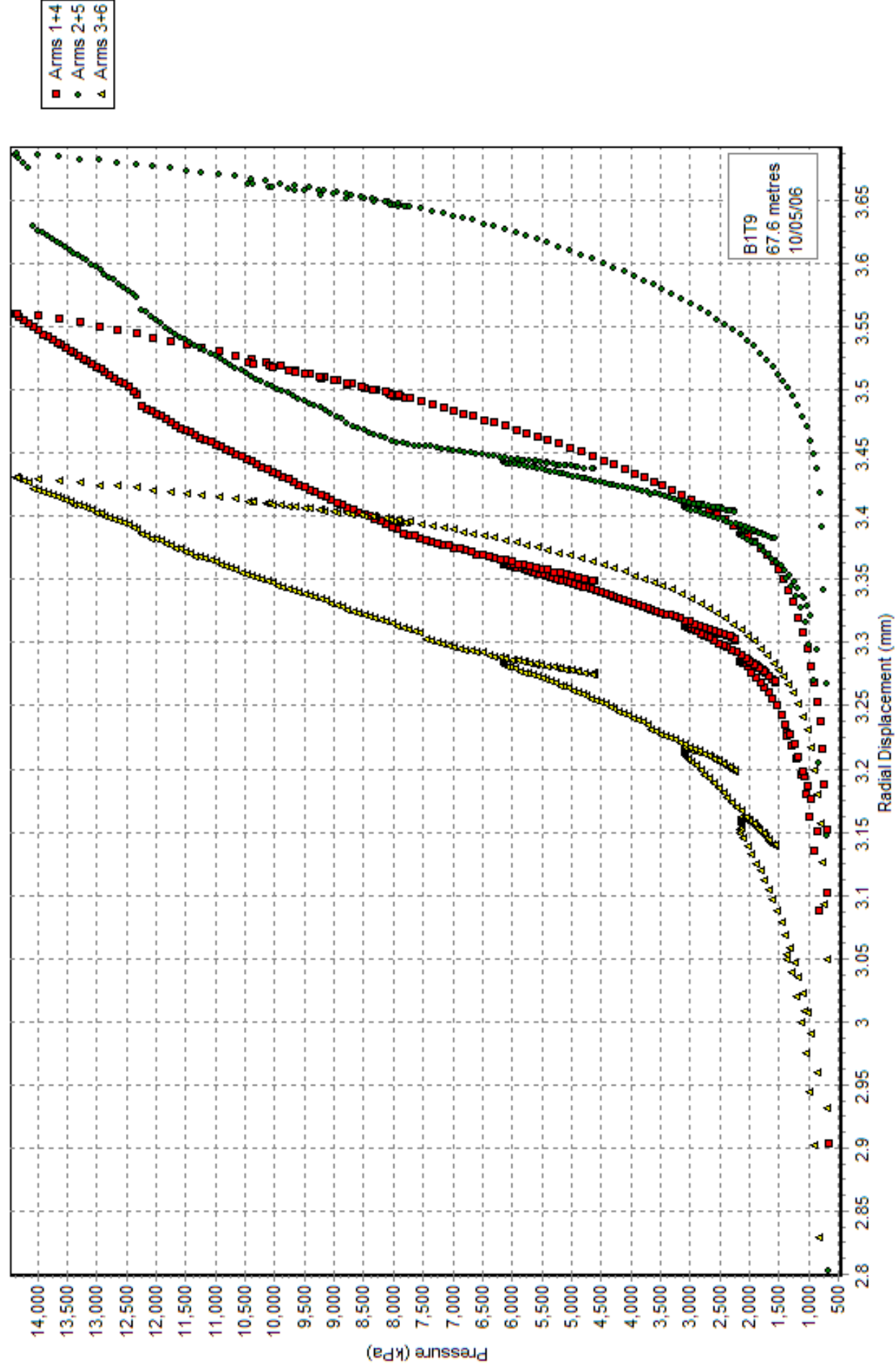


Arm Average vs Total Pressure

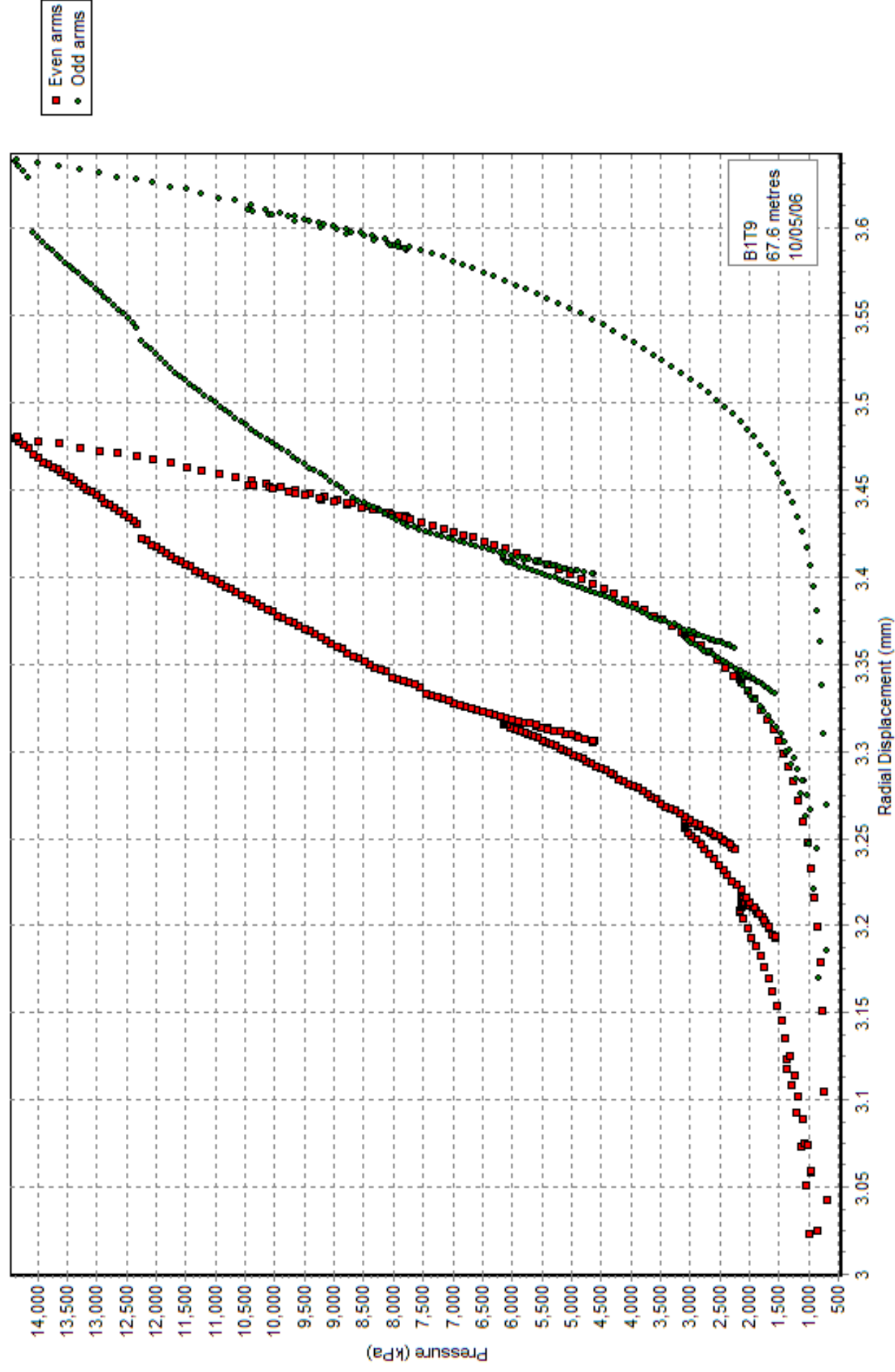


B1T9
67.6 metres
10/05/06

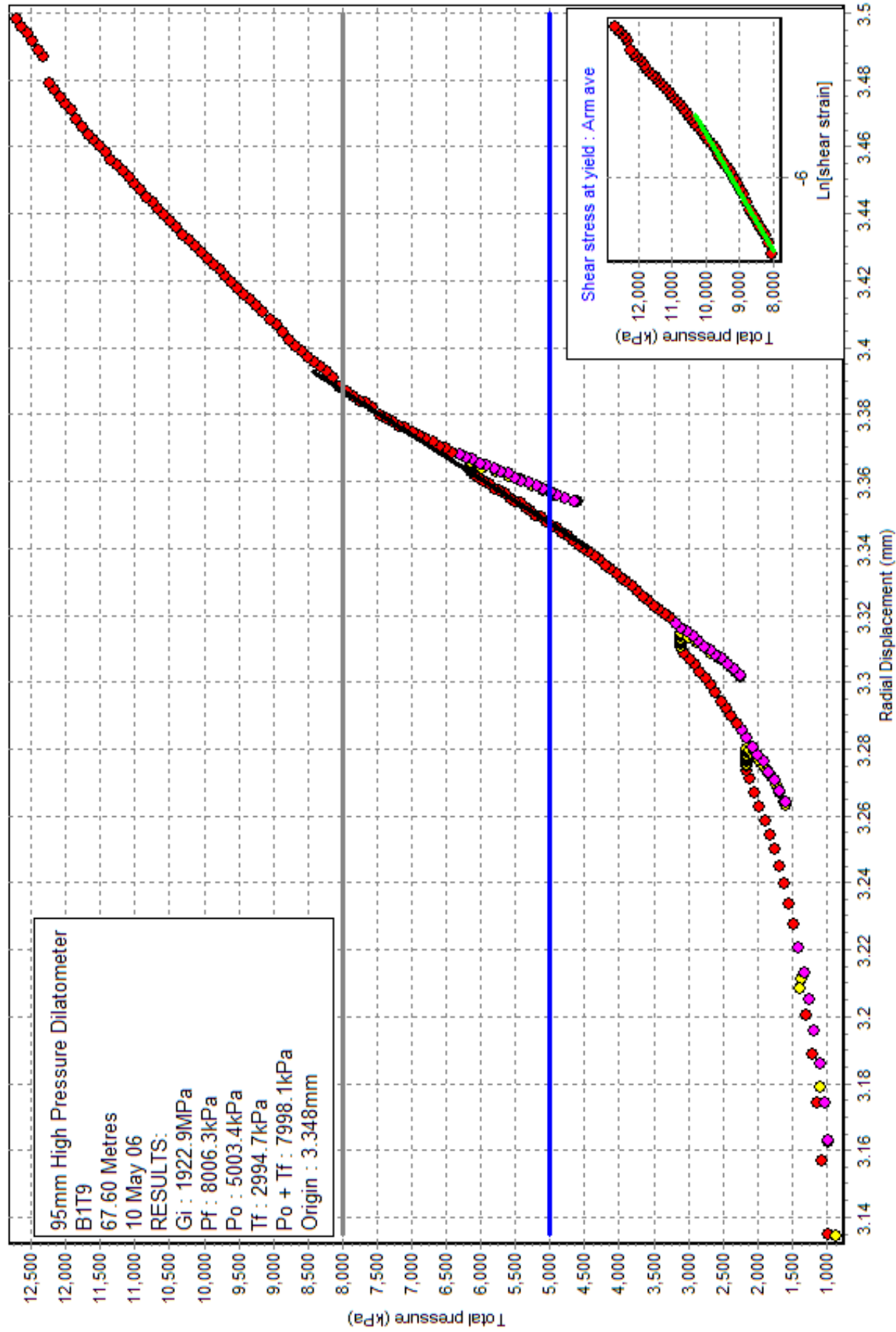
Arm Pairs vs Total Pressure



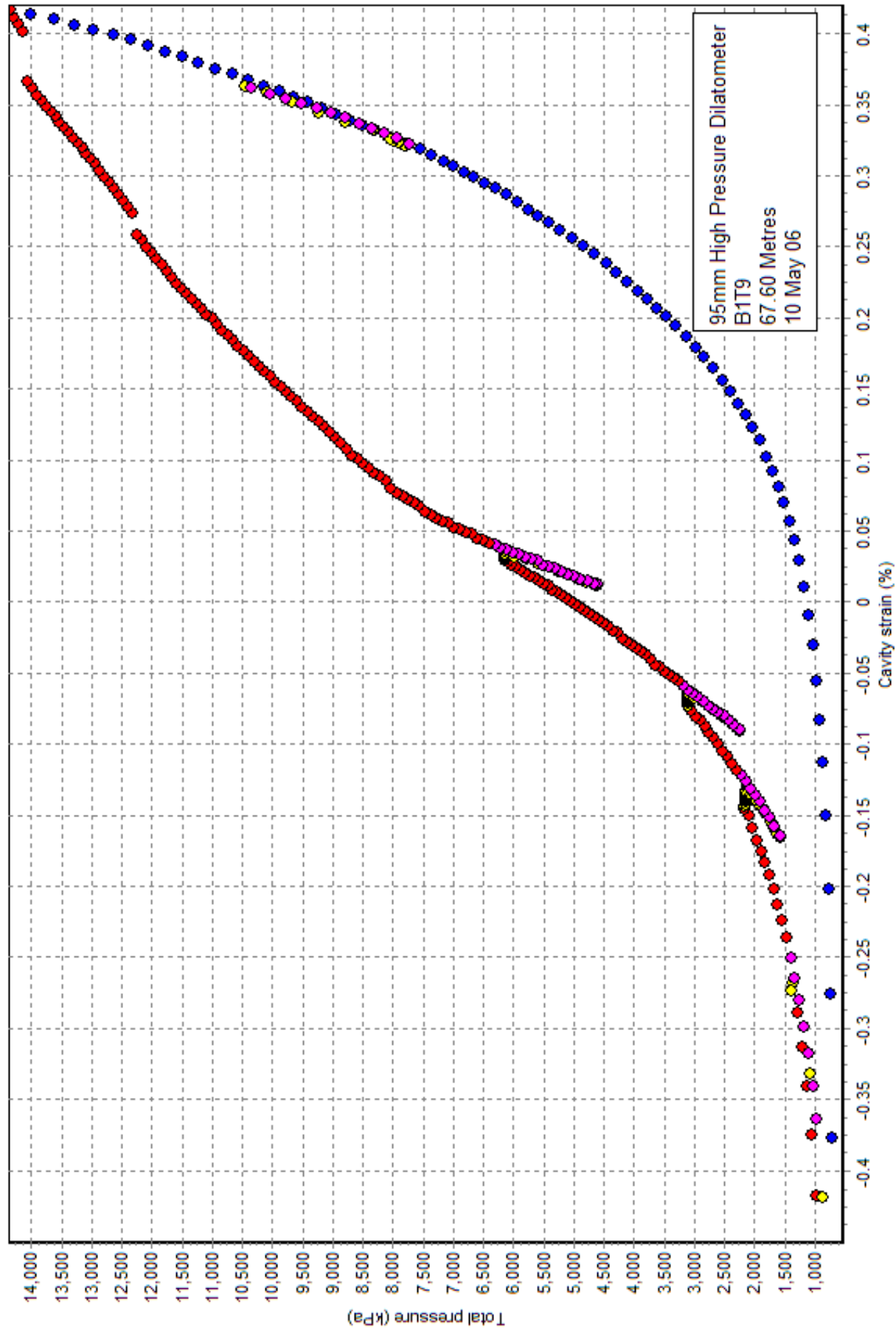
Odd and Even Arms vs Total Pressure

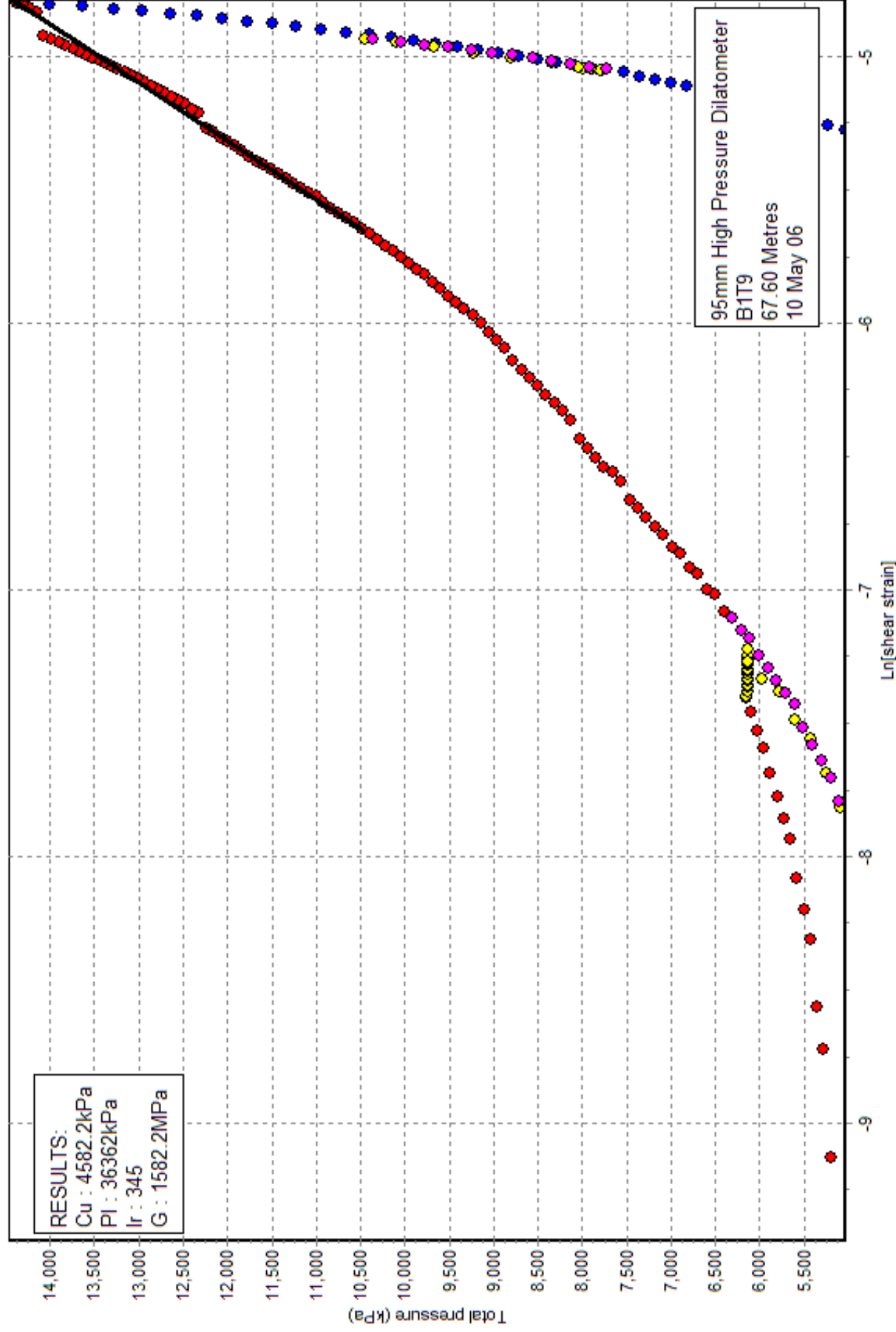


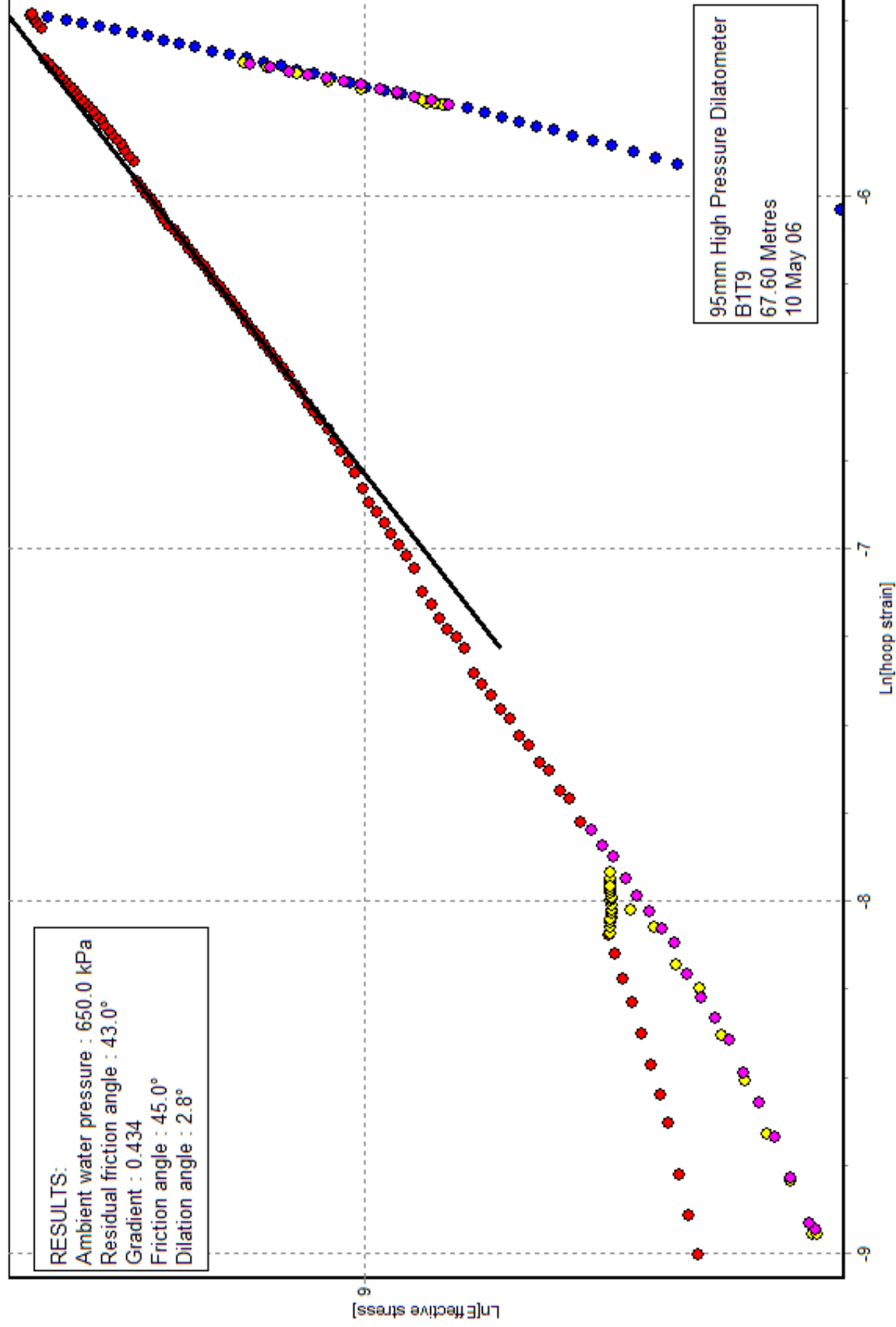
Po of cohesive material (1977, 1990) : Arm ave



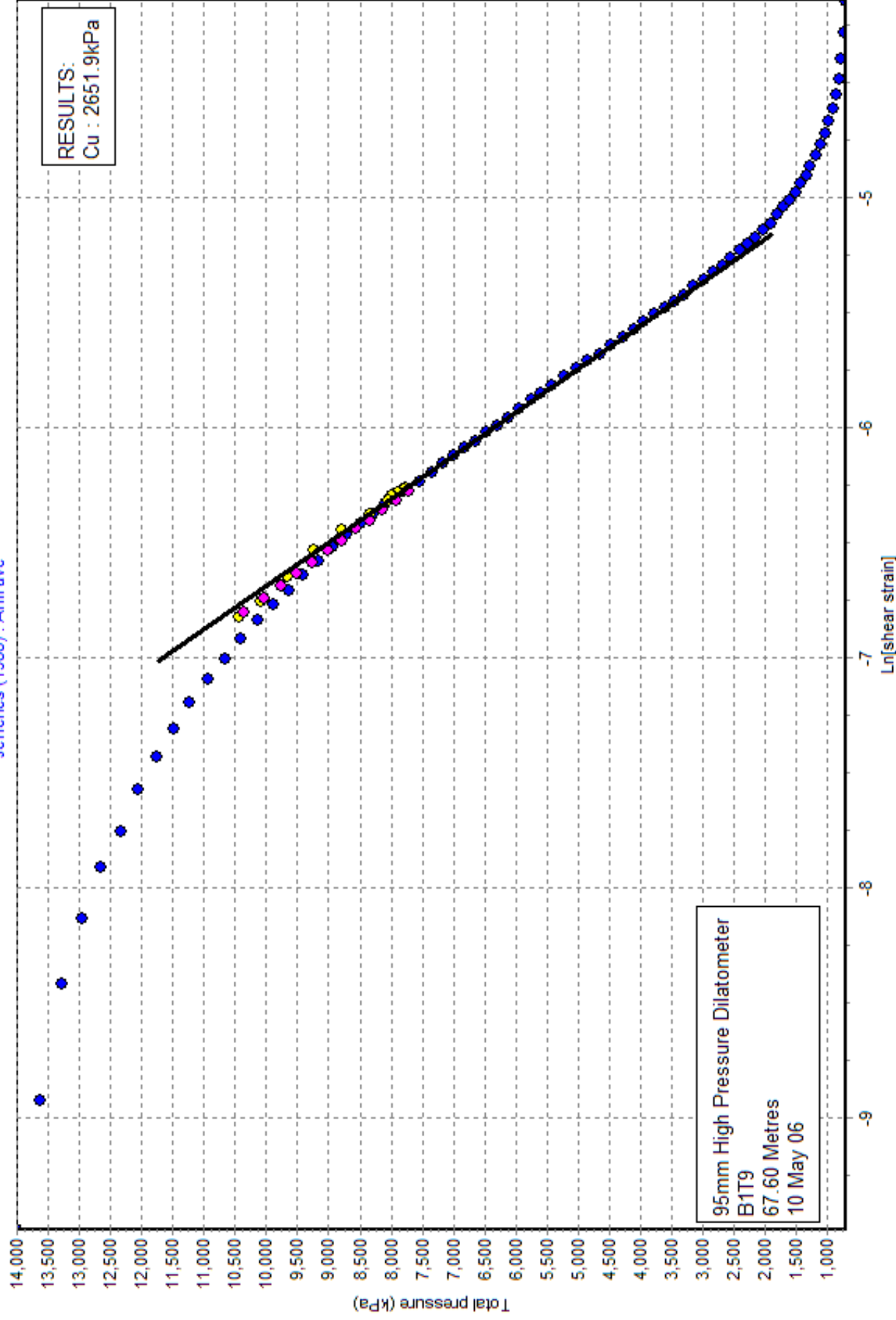
Cavity strain vs Total Pressure : Arm ave



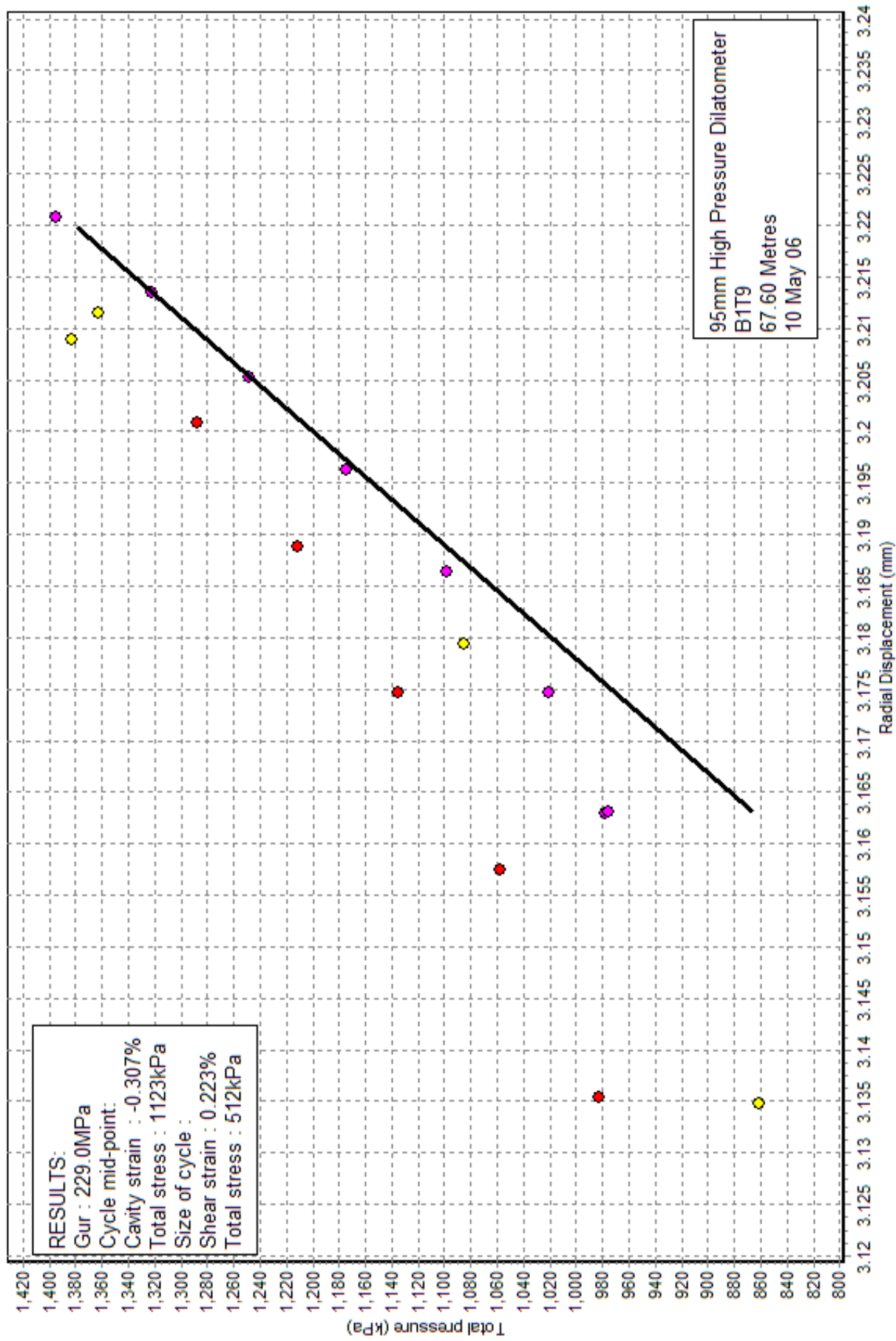




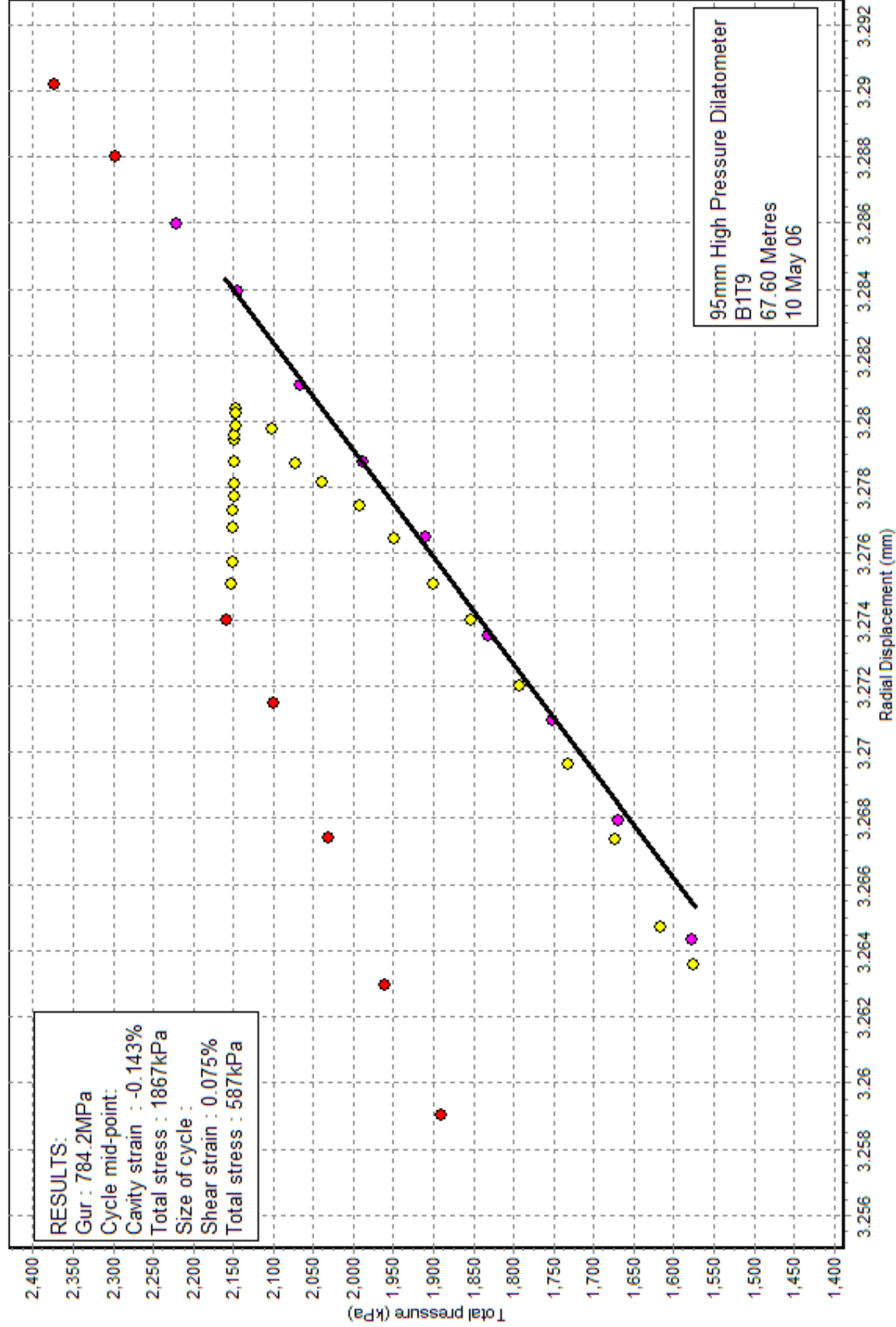
Jefferies (1988) : Arm ave



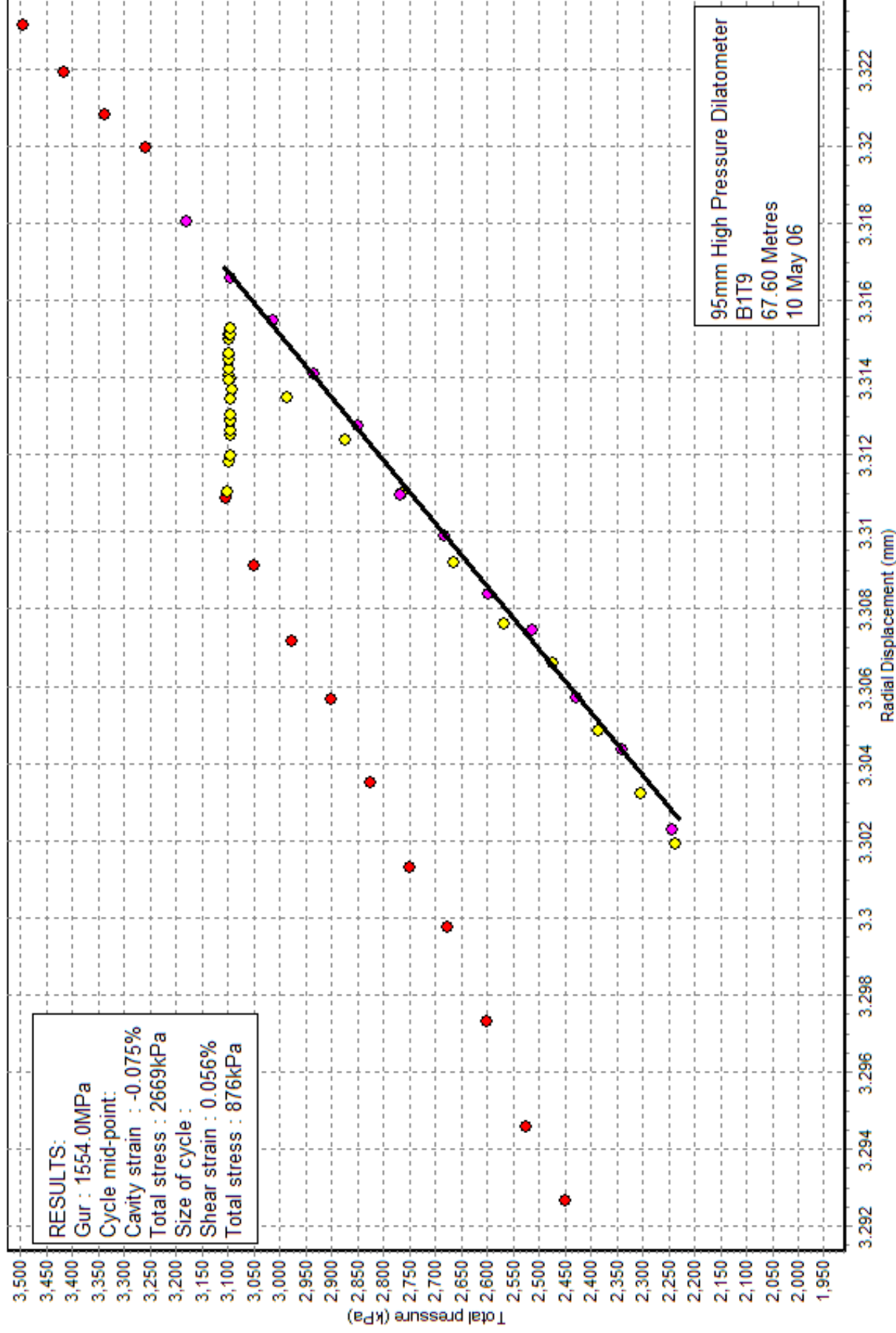
Shear modulus from unload/reload cycles Loop 1 : Arm ave



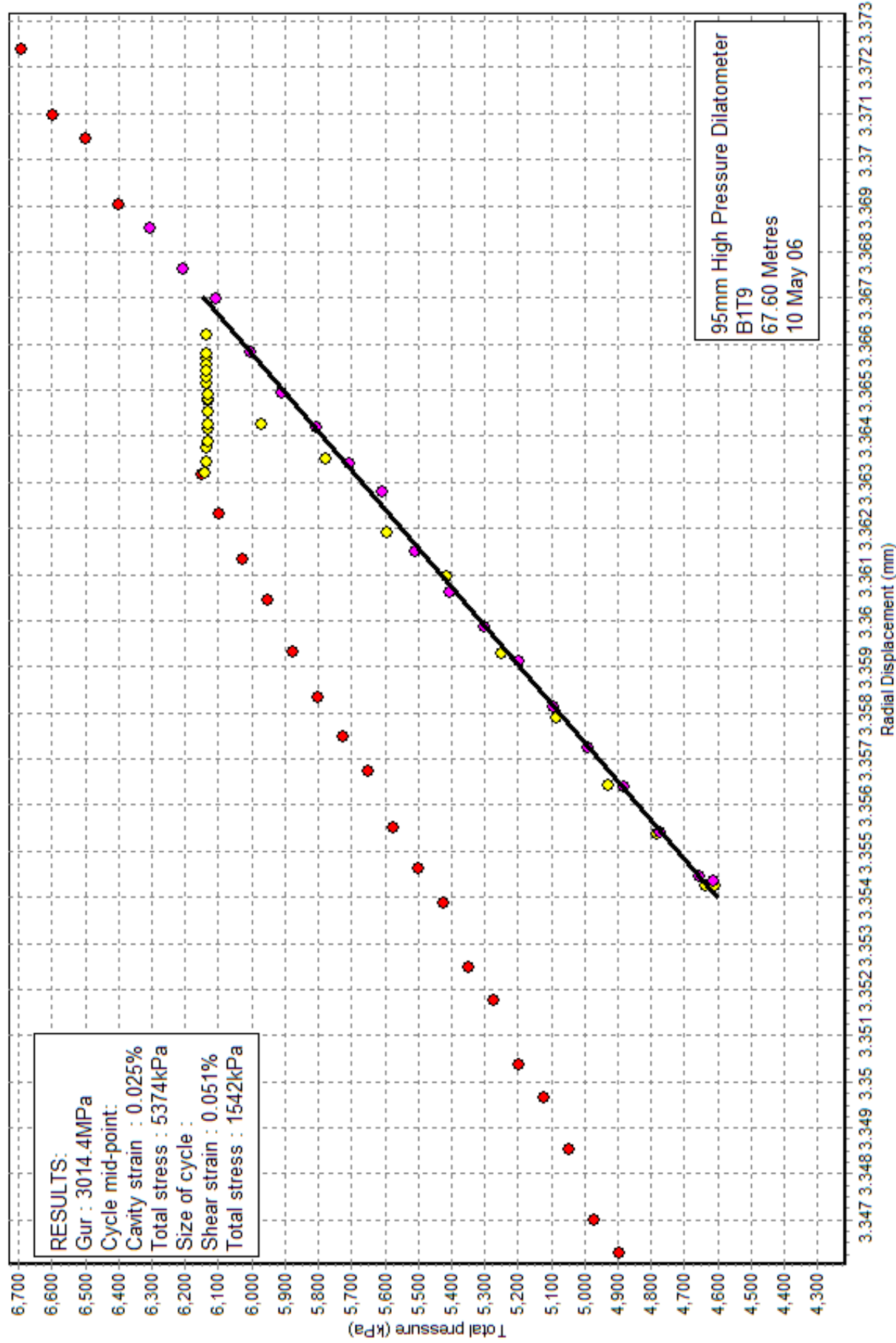
Shear modulus from unload/reload cycles Loop 2 : Arm ave



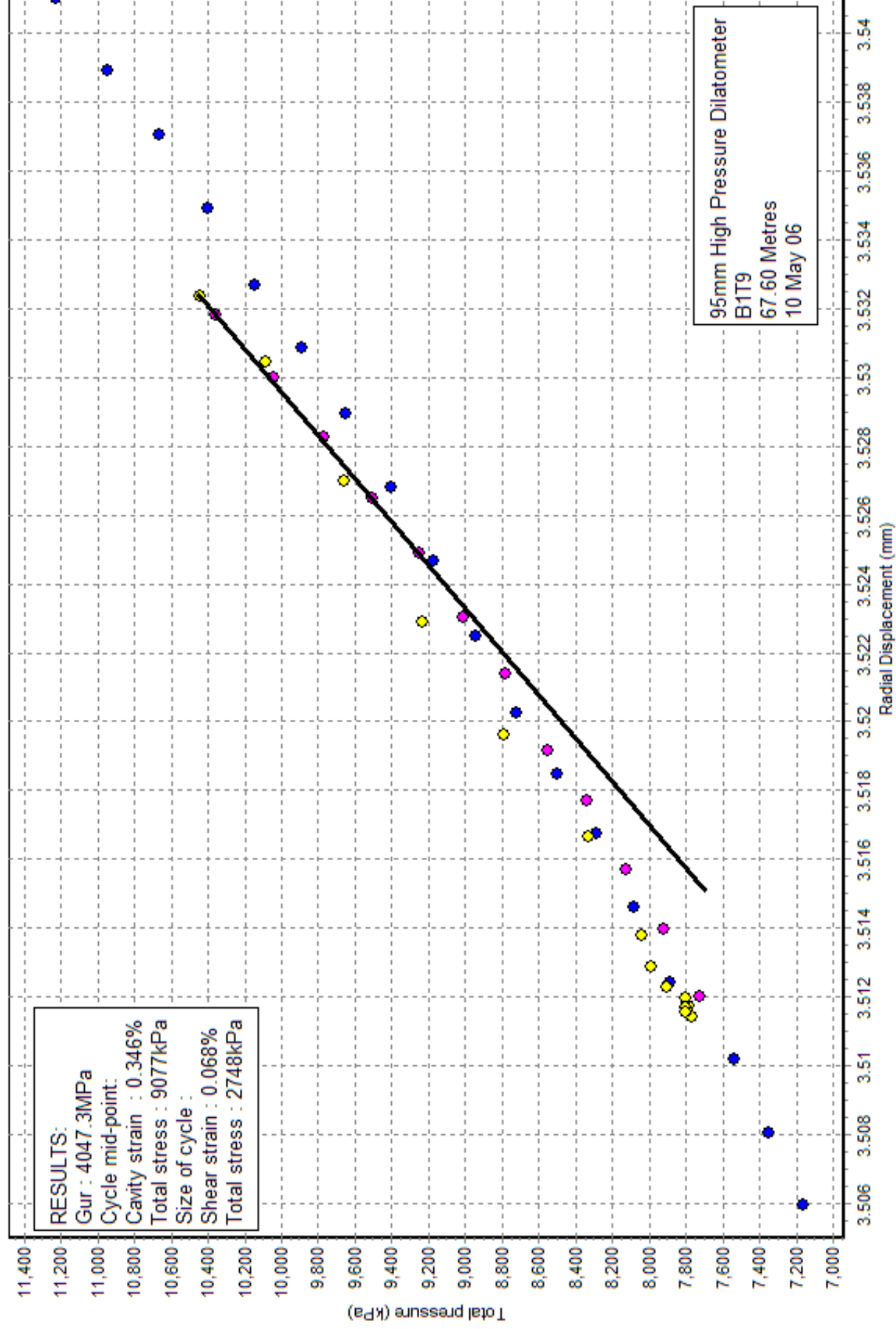
Shear modulus from unload/reload cycles Loop 3 : Arm ave



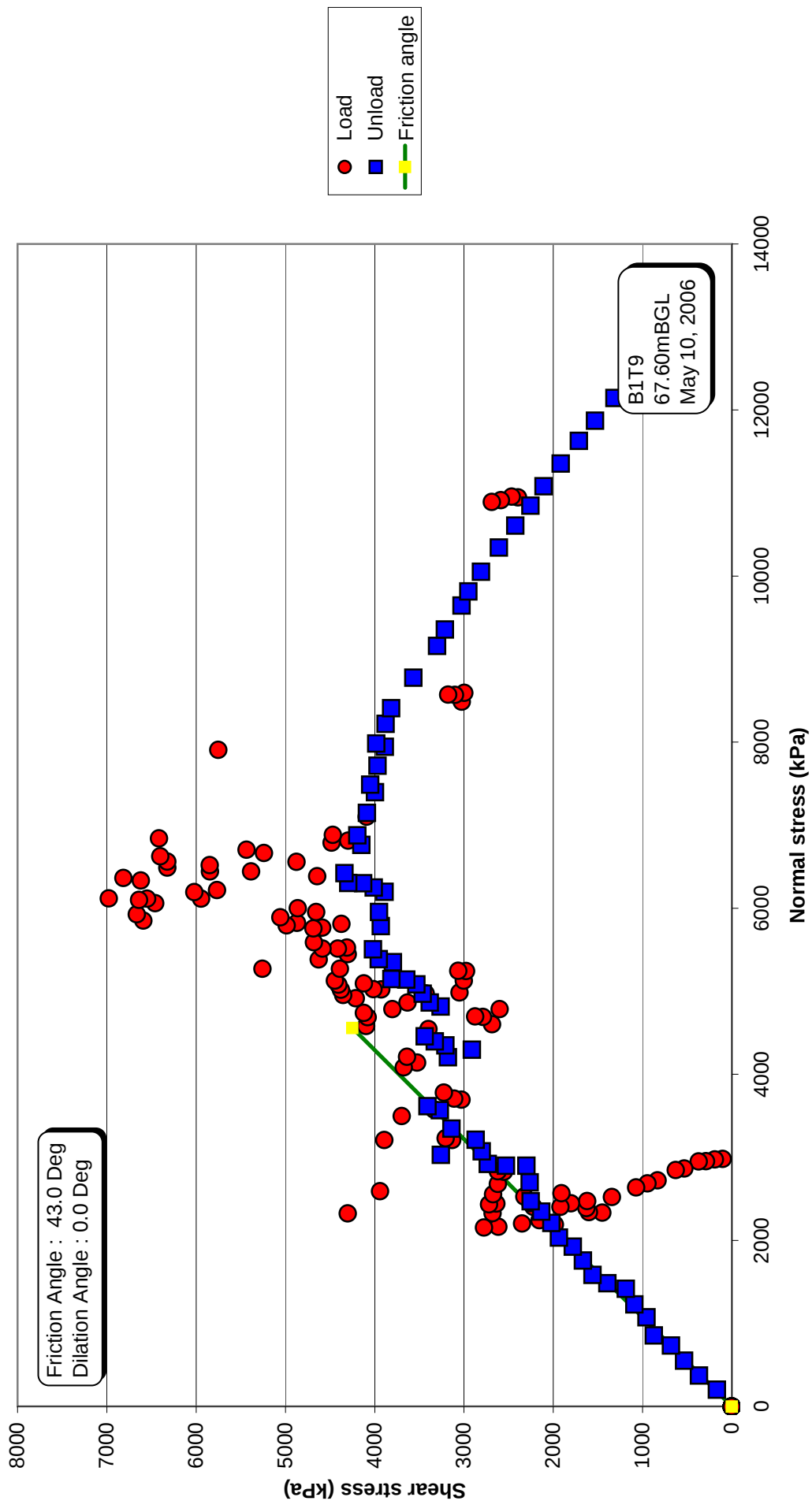
Shear modulus from unload/reload cycles Loop 4 : Arm ave



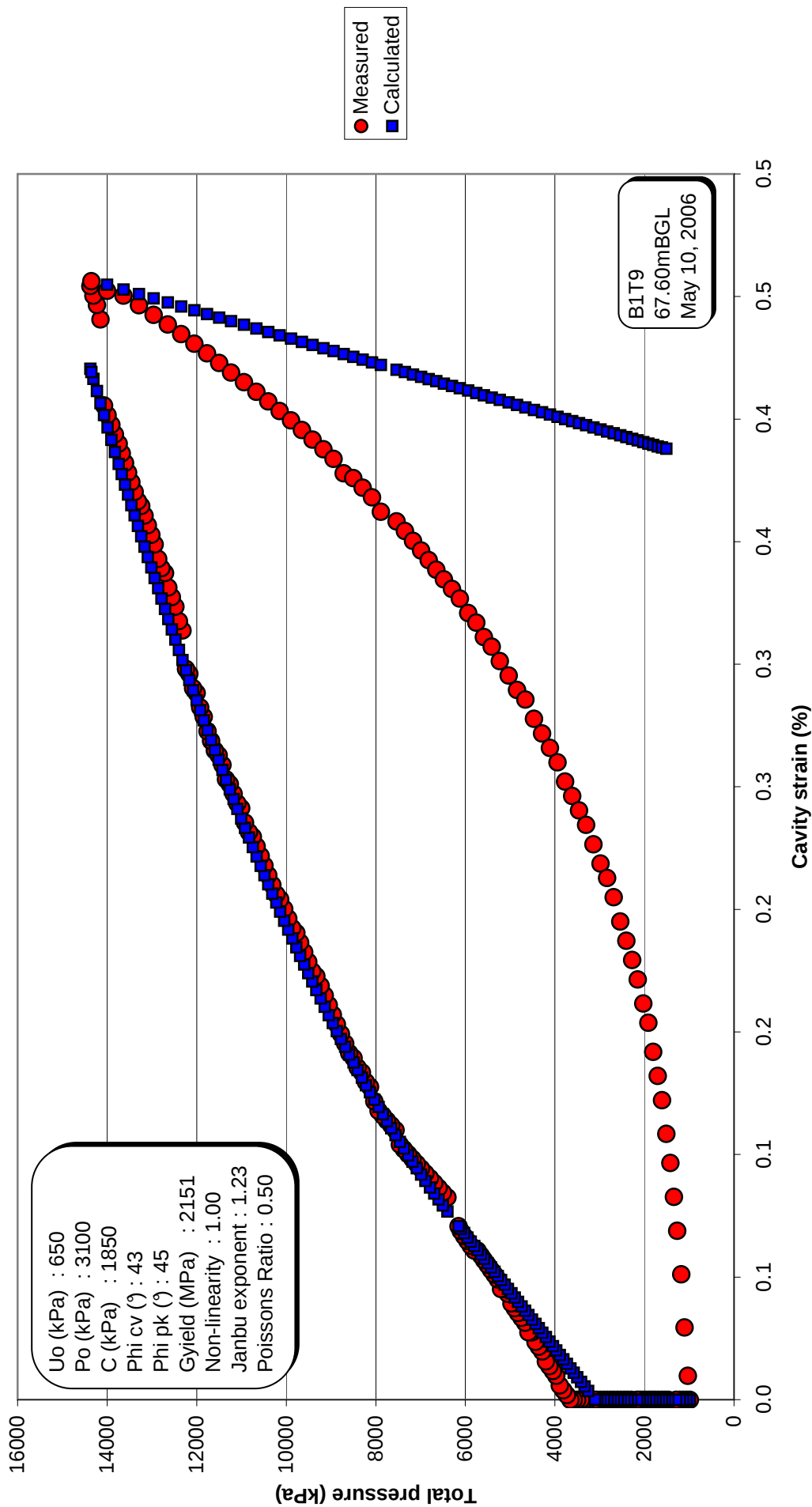
Shear modulus from unload/reload cycles Loop 5 : Arm ave



Shear stress vs Normal stress



Carter et al 1986 - Total pressure vs Cavity strain



B1T10 11/05/06 80.4m Phyllite

- 1. Test record sheet**
- 2. Results summary**
- 3. Plot of expansion versus pressure – all arms**
- 4. Plot of expansion versus pressure – arm average**
- 5. Plot of expansion versus pressure – arm pairs**
- 6. Plot of expansion versus pressure – odd and even arms**
- 7. Plot showing the initial modulus line**
- 8. Plot of Reload Loop 1, with linear modulus line**
- 9. Plot of Reload Loop 2, with linear modulus line**
- 10. Plot of Reload Loop 3, with linear modulus line**

Note that as the material does not fail, this is all that can be determined.

Site RURITANIA	Date 11/5/06	Day SAT	Borehole 1	Test No. 10	Depth 80.4m
Material: Phyllite					
Weather Wet	Water Table	Time Now 05:08	Drilling End 10/5/06 @ 11:00 ~	Orientation	CHL ✓
Drilling: T6H Core			Pocket:		
Diameter 296mm	Distance	Rate	Core Description		Length
Wet/Dry	Rig	Driller	Core Quality		Size
Pres/Incrmm	Wait Time	Creep Time	Cycle Time	Disc No.	Inst Ref SALLY
Zero Readings:			Machine Diameter:		
Arm 1 -1527.1	Arm 2 -1094.5	Arm 3 -999	Arm 4 -1253.6	Arm 5 -1711.4	Arm 6 -2316.5
				T/Press. A: 45.2 B: 1479.2	Battery 12.23v
Calibrations:					
Strain Arm Calibration Date: 19/11/10			Test No:		
Total Pressure Cell Calibration Date: 19/11/10			Test No:		
Membrane Stiffness Calibration Date: 19/11/10			Test No: S1211T11		
Mem. Compression Calibration Date: 19/11/10			Test No: S1211T11		
New Membrane Filled Date: 19/11/10					
Test Comments:					
Test Starts at: 05:11					
Time	Line No	Notes			
	117				
	134				
	195				
	202				
	211 231				
	210				
	325				
	331 251				
	417 420				
	631 638				
Test Ends at: 12:31					
Max. Pressure Reached: 20035 kPa					
General Comments:					
- Good Lvl. - Bore + P.C.					
			Driller: Wayne Operator: SDB		

Site:- Ruritania

Test :- B1T10

Test Date :- 11th May 2006

Material :- Phyllite

Depth (m) :- 80.4

Water table (m) :- ~11m

Analysis of Shear Modulus (G) :-

Initial Modulus (Gi)	GPa	10.5
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Linear Analysis of Reload Loops (G_R) :-

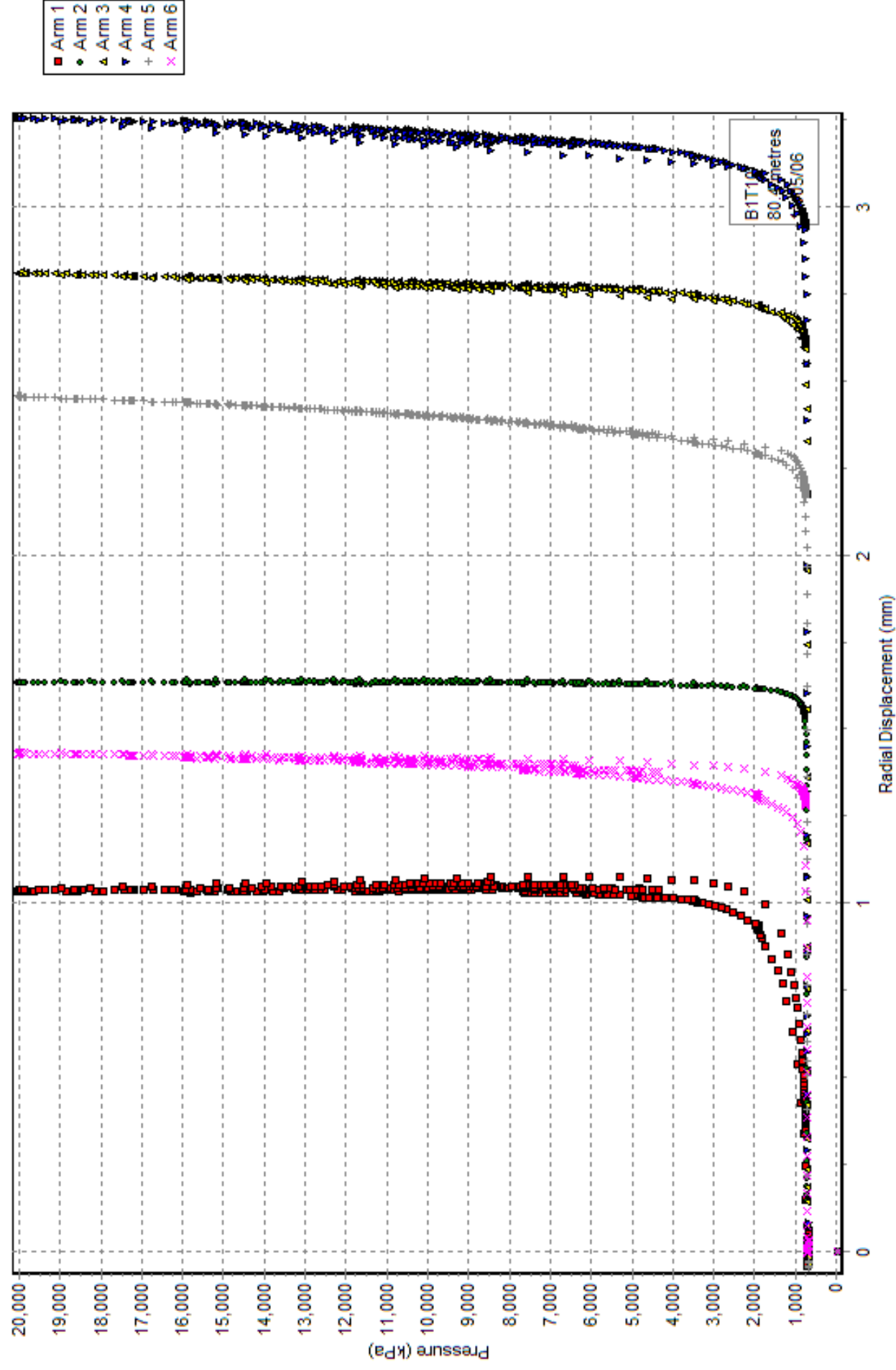
		Loop 1	Loop 2	Loop 3
G _R	GPa	5.22	7.24	9.31
Pressure at start	MPa	7.66	11.75	15.90
Depth of unload	MPa	3.42	5.39	8.01

Reload loops lie on main curve. Linear response after Loop 3.

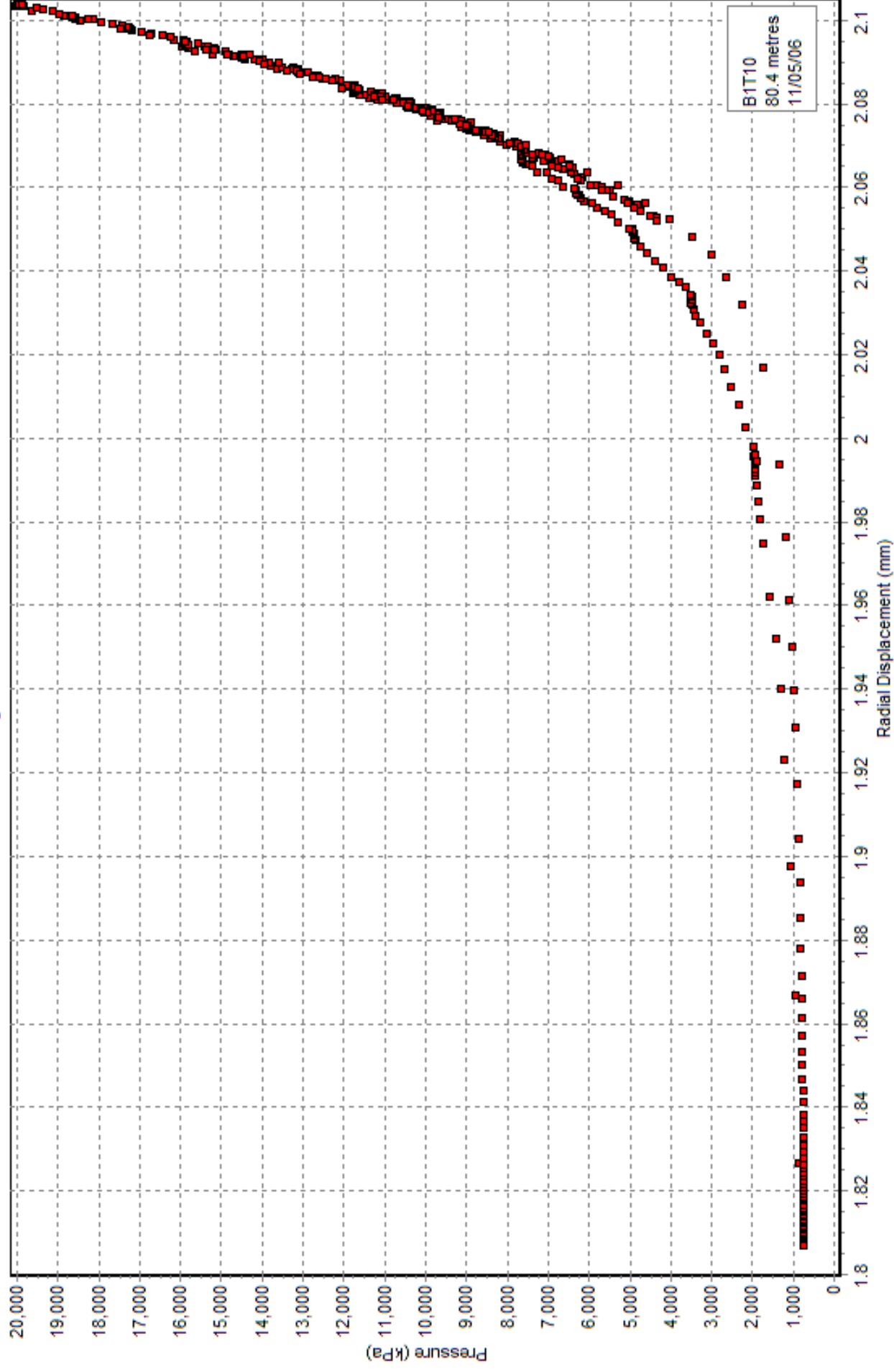
Test Analysed By :- PGH

Date :- February 2011

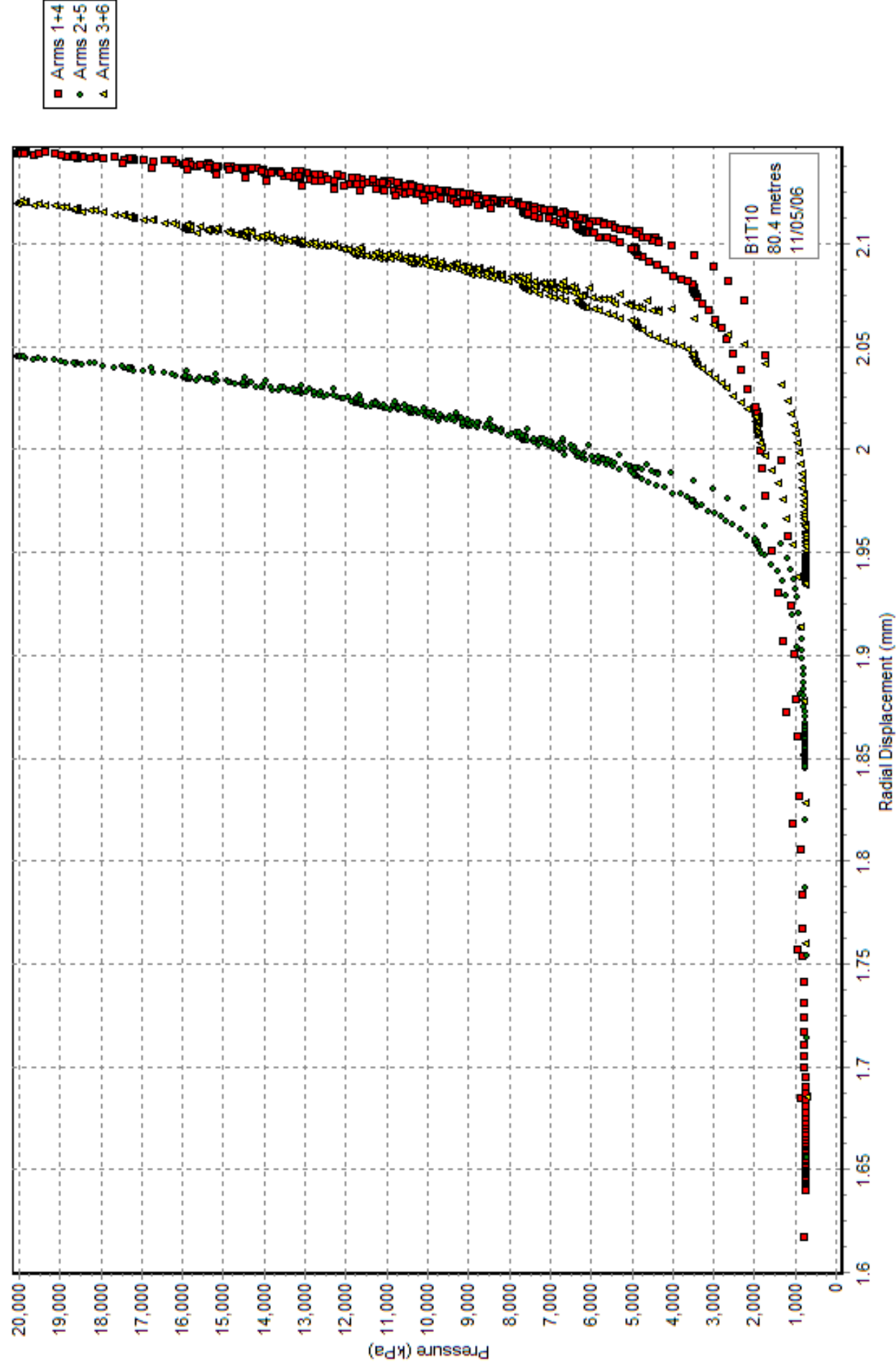
All Arms vs Total Pressure



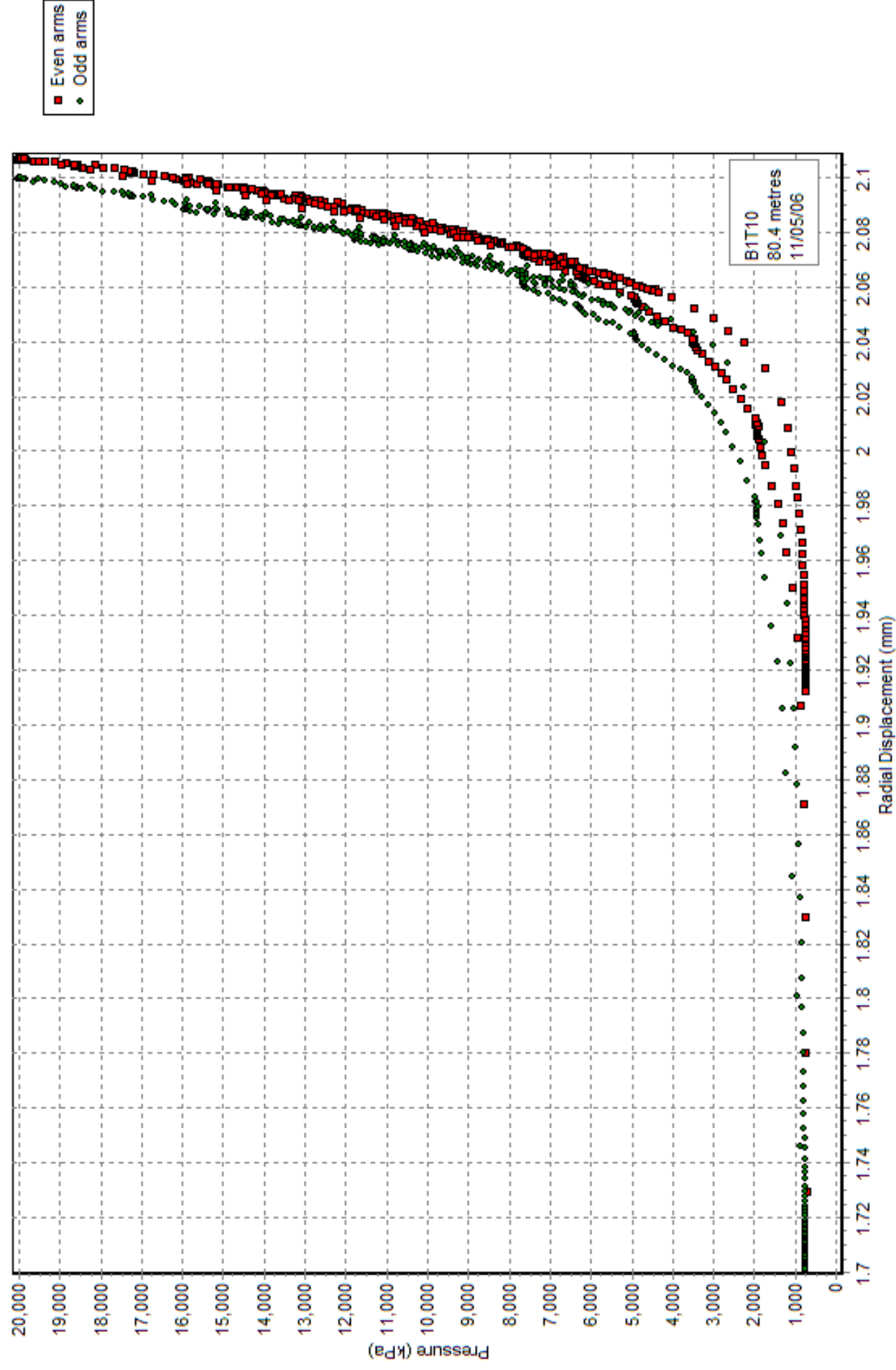
Arm Average vs Total Pressure



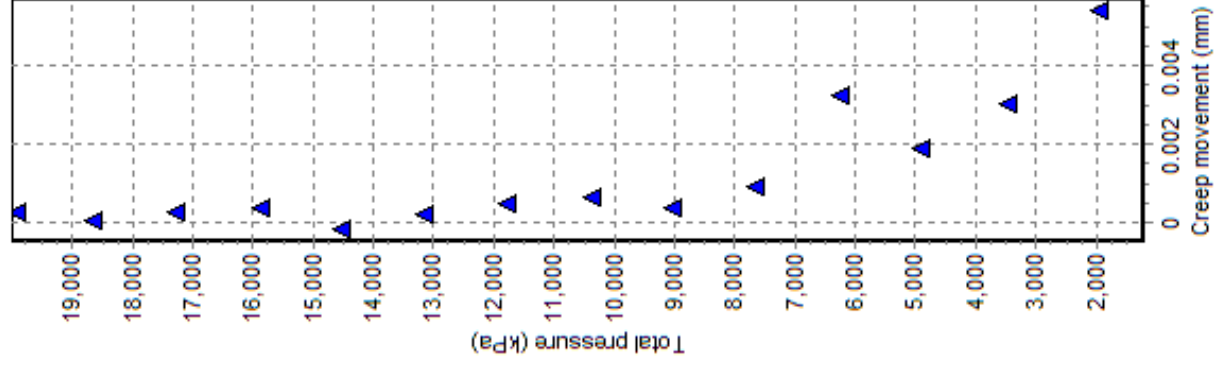
Arm Pairs vs Total Pressure



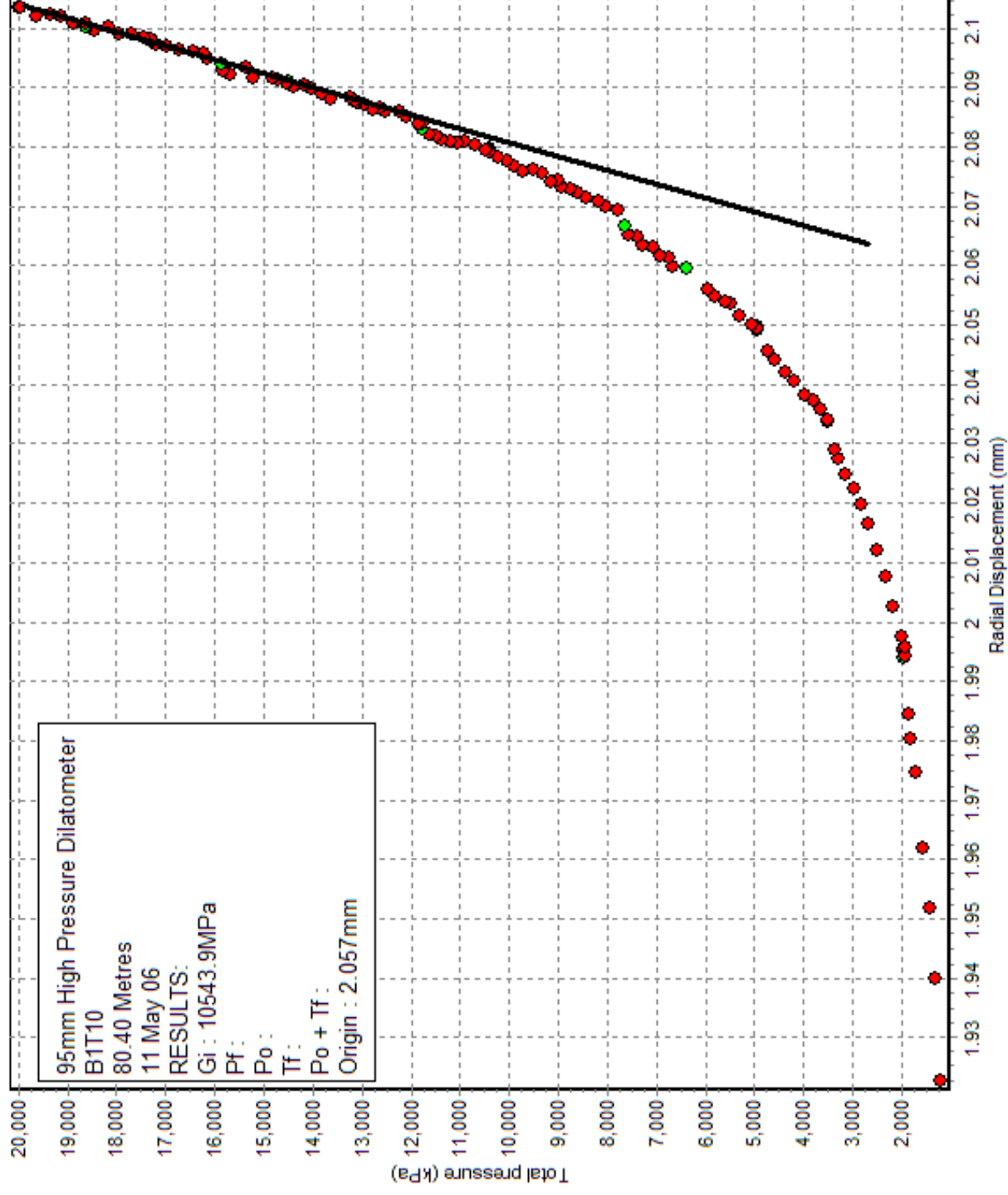
Odd and Even Arms vs Total Pressure



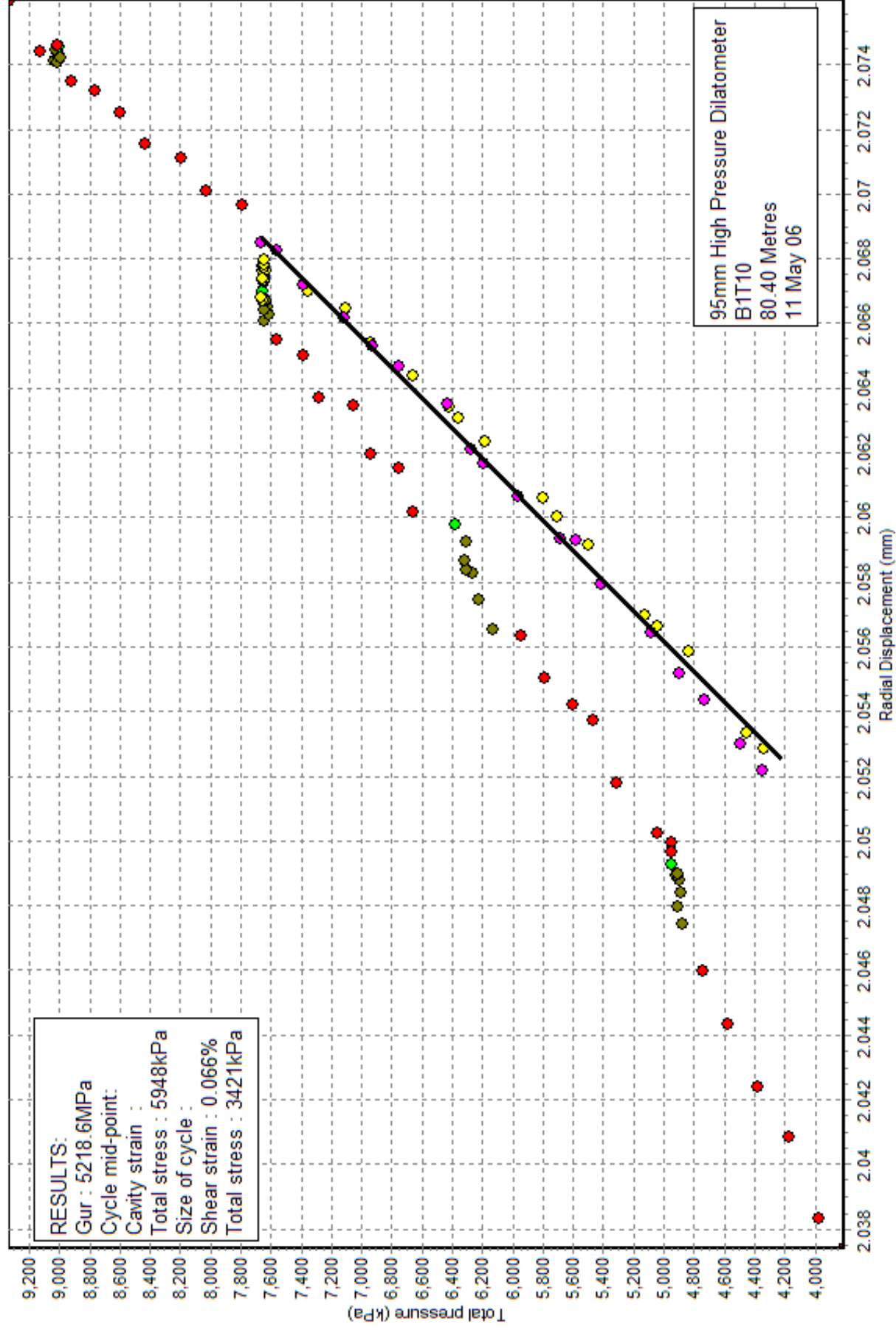
Creep readings



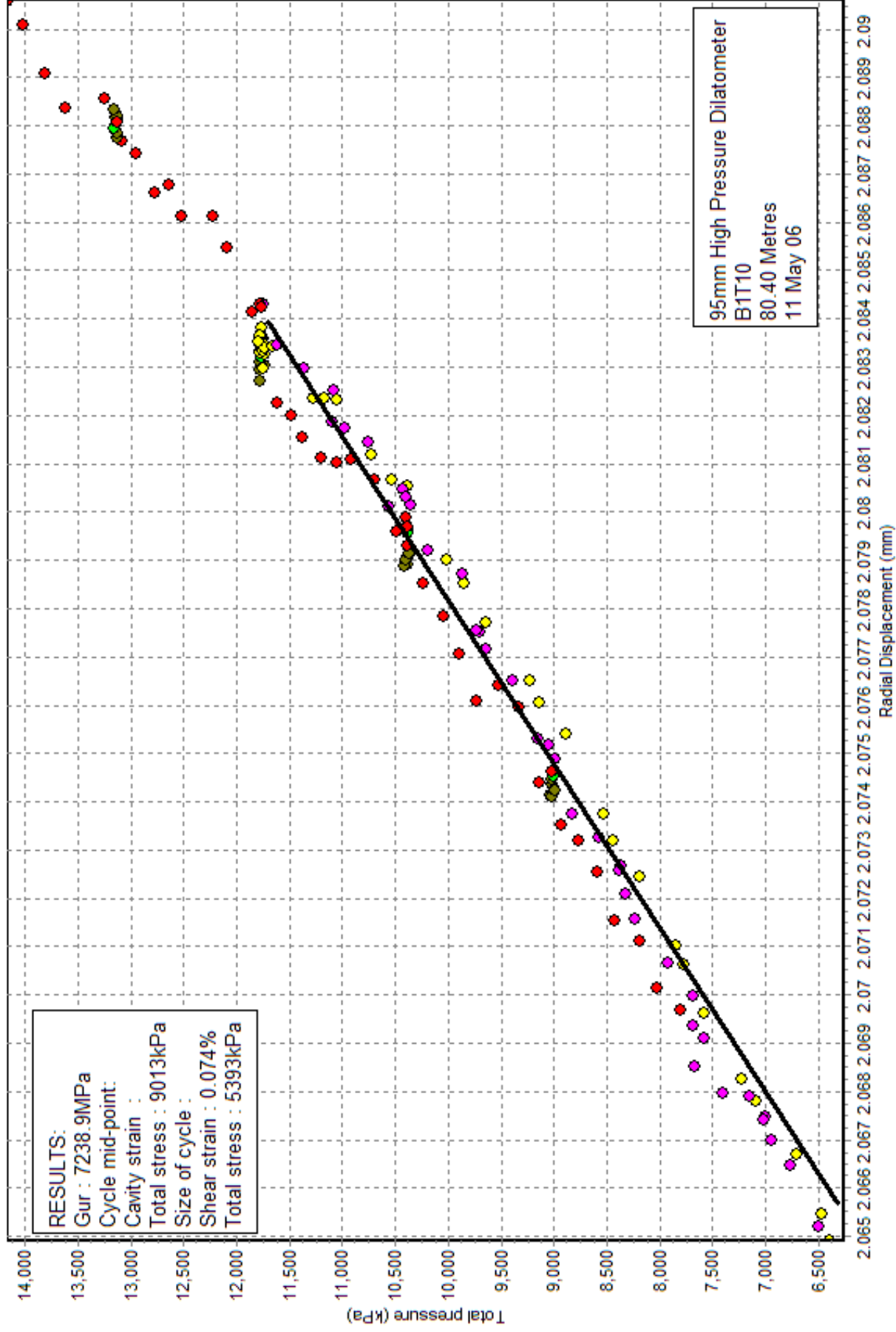
Po of cohesive material (1977, 1990) : Arm ave



Shear modulus from unload/reload cycles Loop 1 : Arm ave



Shear modulus from unload/reload cycles Loop 2 : Arm ave



Shear modulus from unload/reload cycles Loop 3 : Arm ave

