

Data set of mini-frac tests at the Bedretto Lab (SB boreholes)

Dataset**Author(s):**

[Bröker, Kai](#) ; [Klee, Gerd](#); [Ma, Xiaodong](#) 

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ETH-06 19-1 - Creating a hierarchy of fracture network in enhanced geothermal systems (EGS) through innovative hydraulic fracturing stimulation (ETHZ)

Stress magnitudes of all vertical SB boreholes

SB1-1

Depth z [m]	Shmin [MPa]	SD Shmin [MPa]	SHmax [MPa]	SD SHmax [MPa]	Pore pressure P _p [MPa]
14.5	13.4	0.2	20.9	2.5	
17.5	16.1	0.6	27.1	3.2	3.2
19.9	13.5	0.3	24.1	2.8	
24.0	13.1	0.5	23.3	4.2	3.9

SD = standard deviation

SB2-1

Depth z [m]	Shmin [MPa]	SD Shmin [MPa]	SHmax [MPa]	SD SHmax [MPa]	Pore pressure P _p [MPa]
12.5	16.1	0.1	26.9	1.9	2.0
15.5	13.5	0.4	23.3	3.2	
17.5	13.7	0.8	23.9	3.8	2.7
23.3	11.2	0.3	20.4	2.8	
25.2	13.9	1.4	27.9	8.7	

SB3-1

Depth z [m]	Shmin [MPa]	SD Shmin [MPa]	SHmax [MPa]	SD SHmax [MPa]	Pore pressure P _p [MPa]
12.0	16.4	0.4	26.5	3.1	
16.0	16.2	0.3	26.5	2.9	
20.0	16.3	0.4	27.6	3.1	
24.0	15.1	0.7	26.1	4.1	
28.0	14.7	0.2	23.4	2.2	5.6

SB4-1

Depth z [m]	Shmin [MPa]	SD Shmin [MPa]	SHmax [MPa]	SD SHmax [MPa]	Pore pressure P _p [MPa]
12.0	15.1	0.5	26.7	3.5	
16.0	15.1	0.5	26.6	3.5	
20.0	15.4	0.3	27.6	3.0	
24.0	14.6	0.3	26.8	2.3	2.6
28.0	14.5	0.3	26.2	2.9	

All boreholes

Mean	14.6	0.4	25.4	3.3	3.3
SD	1.36		2.27		1.28
Min	11.2	0.1	20.4	1.9	2.0
Max	16.4	1.4	27.9	8.7	5.6

Vertical stress magnitude

Overburden [m]	1000	1030	1050
Density granite [g/cm ³]	2.62	2.62	2.62
Sv [MPa]	25.7	26.5	27.0

Calculated and picked pressure parameters for all vertical SB boreholes

The hydrostatic pressure was added to all pressure parameters below because the measurements were conducted at the surface.

SB1-1

Depth z [m]	Hydrostatic pressure P_{hyd} [MPa]	Breakdown pressure P_b [MPa]	Hydraulic reopening pressure P_r [MPa]	Inflection point method P_{si} [MPa]	Closure pressure tangent method P_{cl} [MPa]	Closure pressure compliance method P_{cl} [MPa]	Bilinear decay rate method P_{si} [MPa]	Jacking pressure $P_{jacking}$ [MPa]	Pore pressure P_p [MPa]	Hydraulic tensile strength [MPa]	Longest shut-in time [min]	Comment
14.5	0.1	24.3	15.8	13.4	n.a.	10.5	11.8	14.6	-	8.5	4.1	only short shut-ins
17.5	0.2	26.1	17.7	16.1	7.6	12.3	14.4	17.6	3.2	8.4	809.1	
19.9	0.2	20.1	12.8	13.5	n.a.	n.a.	12.5	13.2	-	7.3	3.3	only short shut-ins
24.0	0.2	20.5	15.9	13.1	6.5	9.5	11.9	14.5	3.9	4.6	776.2	weird pressure decline with strong "kink" for F, RF1
Mean		22.8	15.6	14.0	7.0	10.8	12.6	15.0	3.6	8.1		
SD		2.92	2.03	1.41	0.82	1.41	1.23	1.85		0.7		

* potential packer bypass

* only one pick per interval possible (no SD)

* underestimated, due to high reopening pressure

SB2-1

Depth z [m]	Hydrostatic pressure P_{hyd} [MPa]	Breakdown pressure P_b [MPa]	Hydraulic reopening pressure P_r [MPa]	Inflection point method P_{si} [MPa]	Closure pressure tangent method P_{cl} [MPa]	Closure pressure compliance method P_{cl} [MPa]	Bilinear decay rate method P_{si} [MPa]	Jacking pressure $P_{jacking}$ [MPa]	Pore pressure P_p [MPa]	Hydraulic tensile strength [MPa]	Longest shut-in time [min]	Comment
12.5	0.1	25.5	19.2	16.1	8.3	14.7	15.4	16.6	2.0	6.3	801.1	
15.5	0.2	25.2	14.9	13.5	7.3	10.8	12.3	14.5	-	10.3	15.1	
17.5	0.2	24.6	14.8	13.7	8.2	10.7	12.8	-	2.7	9.8	800.1	
23.3	0.2	21.3	11.0	11.2	7.0	9.3	10.4	10.7	-	10.3	15.1	large P drop, closure hard to determine
25.2	0.2	20.7	17.9	13.9	n.a.	13.3	13.6	13.7	-	2.8	15.1	all values drop quickly after frac cycle
Mean		23.5	15.6	13.7	7.7	11.8	12.9	13.9	2.3	9.2		
SD		2.25	3.19	1.74	0.63	2.20	1.82	2.44		1.9		

* overestimated, because the fracture developed entirely below the lower packer

* only one pick per interval possible (no SD)

* underestimated, due to high reopening pressure

SB3-1

Depth z [m]	Hydrostatic pressure P_{hyd} [MPa]	Breakdown pressure P_b [MPa]	Hydraulic reopening pressure P_r [MPa]	Inflection point method P_{si} [MPa]	Closure pressure tangent method P_{cl} [MPa]	Closure pressure compliance method P_{cl} [MPa]	Bilinear decay rate method P_{si} [MPa]	Jacking pressure $P_{jacking}$ [MPa]	Pore pressure P_p [MPa]	Hydraulic tensile strength [MPa]	Longest shut-in time [min]	Comment
12.0	0.1	27.4	17.0	16.4	n.a.	15.6	15.8	16.0	-	10.4	2.8	only short shut-ins
16.0	0.2	27.0	16.4	16.2	n.a.	15.3	15.6	15.6	-	10.6	2.9	only short shut-ins
20.0	0.2	25.7	15.7	16.3	n.a.	15.5	15.7	15.9	-	10.0	2.6	only short shut-ins
24.0	0.2	19.1	13.7	15.1	n.a.	11.5	14.3	15.2	-	5.4	2.5	only short shut-ins
28.0	0.3	22.5	15.1	14.7	10.7	12.9	13.8	14.8	5.6	7.5	833.0	quite constant values
Mean		24.3	15.6	15.7		14.2	15.0	15.5	5.6	8.4		
SD		3.48	1.26	0.77		1.86	0.91	0.50		2.4		

SB4-1

Depth z [m]	Hydrostatic pressure P_{hyd} [MPa]	Breakdown pressure P_b [MPa]	Hydraulic reopening pressure P_r [MPa]	Inflection point method P_{si} [MPa]	Closure pressure tangent method P_{cl} [MPa]	Closure pressure compliance method P_{cl} [MPa]	Bilinear decay rate method P_{si} [MPa]	Jacking pressure $P_{jacking}$ [MPa]	Pore pressure P_p [MPa]	Hydraulic tensile strength [MPa]	Longest shut-in time [min]	Comment
12.0	0.1	26.5	16.0	15.1	n.a.	13.9	14.4	14.7	-	10.5	3.5	only short shut-ins
16.0	0.2	26.3	16.0	15.1	n.a.	14.8	14.8	14.6	-	10.3	2.2	only short shut-ins
20.0	0.2	27.6	16.0	15.4	n.a.	14.7	14.9	14.7	-	11.6	2.7	only short shut-ins
24.0	0.2	25.5	14.4	14.6	9.4	12.9	14.3	13.7*	2.6	11.1	896.9	P increases with time during overnight shut-in (3.1 MPa at end of shut-in, given P_p is minimum)
28.0	0.3	25.1	14.6	14.5	10.1	13.5	14.0	15.0	-	10.5	15.2	Pressure drops to 0.5 MPa in 15 Min!
Mean		26.2	15.4	14.9	9.7	14.0	14.5	14.7	2.6	10.9		
SD		0.97	0.82	0.39	0.55	0.78	0.37	0.17		0.6		

* Step-rate test seems to have propagated fracture

All boreholes

	Breakdown pressure P_b [MPa]	Hydraulic reopening pressure P_r [MPa]	Inflection point method P_{si} [MPa]	Closure pressure tangent method P_{cl} [MPa]	Closure pressure compliance method P_{cl} [MPa]	Bilinear decay rate method P_{si} [MPa]	Jacking pressure $P_{jacking}$ [MPa]	Pore pressure P_p [MPa]	Hydraulic tensile strength [MPa]
Mean	24.3	15.5	14.6	8.3	12.9	13.8	14.8	3.3	9.3
SD	2.68	1.86	1.36	1.45	2.08	1.51	1.48	1.27	1.79
Min	19.1	11.0	11.2	6.5	9.3	10.4	10.7	2.0	5.4
Max	27.6	19.2	16.4	10.7	15.6	15.8	17.6	5.6	11.6

SB1-1 14.5 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	0.9	0.59	0.17	2.5	24.2	13.3	n.a.	n.a.	11.9	11.9	12.6	
RF1	1.0	1.33	0.11	2.1	15.7	13.4	n.a.	n.a.	11.0	11.0	12.0	
RF2	1.6	1.80	0.09	4.1	16.0	13.4	n.a.	n.a.	9.5	9.7	11.7	
RF3	2.0	2.54	0.08	3.8	16.1	13.2	n.a.	n.a.	9.6	9.7	11.1	
RF4	0.4	1.19	0.10	1.6	-	13.0	n.a.	n.a.	10.3	10.4	11.4	
SR	0.9	7.25	0.15	3.6	-	12.8	n.a.	n.a.	9.7	9.8	11.1	15.0
	1.3											15.4
	2.2											16.1
	2.9											16.3
Sum		14.70	0.70							Jacking pressure P_{jack} [MPa]		14.5
Mean					15.9	13.2			10.3	10.4	11.7	
SD						0.24			0.95	0.89	0.58	
						Combined mean			10.4			
						SD			0.88			

SB1-1 17.5 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	0.8	0.78	0.17	2.7	25.9	16.4	n.a.	n.a.	n.a.	n.a.	14.8	
RF1	1.2	1.52	0.10	2.9	17.5	16.6	n.a.	n.a.	n.a.	n.a.	15.3	
RF2	1.5	2.04	0.16	2.8	17.7	15.4	n.a.	n.a.	12.2	12.3	13.7	
RF3	2.1	3.15	0.15	3.3	17.3	15.4	n.a.	n.a.	12.0	12.0	13.6	
SR	0.7	7.03	0.16	3.0	-	16.0	n.a.	n.a.	n.a.	n.a.	13.9	17.7
	1.2											18.3
	2.0											18.8
	2.6											18.9
RF4	1.70	11.36	-	809.1	-	14.6	7.5	7.4	9.4	9.6	12.6	
Sum		25.88	0.74							Jacking pressure P_{jack} [MPa]		17.4
Mean					17.5	16.0	7.5	7.4	12.1	12.2	14.3	
SD						0.55	-	-	0.14	0.21	0.75	
						Combined mean	7.5		12.1			
						SD			0.15			

SB1-1 19.9 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]	
F	0.9	0.48	0.14	3.3	19.9	13.2	n.a.	n.a.	n.a.	n.a.	12.3		
RF1	0.9	1.05	0.09	3.3	12.6	13.0	n.a.	n.a.	n.a.	n.a.	12.0		
RF2	1.7	2.49	0.13	3.0	12.9	13.3	n.a.	n.a.	n.a.	n.a.	12.2		
RF3	2.1	3.07	0.13	2.9	13.0	13.7	n.a.	n.a.	n.a.	n.a.	12.3		
SR	0.5	5.15	0.13	2.6	-	13.2	n.a.	n.a.	n.a.	n.a.	12.6	13.4	
	1.0											14.0	
	1.8											15.0	
	2.5											15.4	
Sum		12.24	0.62									Jacking pressure P_{jack} [MPa]	13.0
Mean					12.8	13.3					12.3		
SD						0.26					0.22		
						Combined mean							
						SD							

SB1-1 17.5 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	0.6	0.45	0.02	2.6	20.3	13.6	n.a.	n.a.	n.a.	n.a.	12.4	
RF1	0.9	1.25	0.08	3.8	15.7	13.1	n.a.	n.a.	n.a.	n.a.	11.8	
RF2	1.4	1.80	0.12	4.8	15.4	12.8	n.a.	n.a.	n.a.	n.a.	11.4	
RF3	1.6	2.02	0.07	3.2	15.2	12.5	n.a.	n.a.	n.a.	n.a.	11.2	
SR	0.5	4.61	0.15	2.8	-	12.3	n.a.	n.a.	n.a.	n.a.	11.3	14.4
	1.1											14.7
	1.7											14.8
	2.2											15.0
RF4	2.2	12.28	0.05	776.2	21.3	14.9	7.4	7.4	10.0	10.2	13.3	
RF5	1.5	10.25	0.05	60.0	16.5	15.2	5.0	5.1	8.4	8.5	13.1	
Sum		32.66	0.54							Jacking pressure P_{jack} [MPa]		14.3
Mean					15.4	12.9	6.2	6.3	9.2	9.4	11.6	
SD						0.51	1.70	1.63	1.13	1.20	0.49	
						Combined mean	6.2		9.3			
						SD	1.36		0.96			

SB2-1 12.5 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.8	1.23	0.21	1.9	25.4	16.2	n.a.	n.a.	n.a.	n.a.	15.5	
RF1	1.5	1.14	0.20	3.0	19.1	16	n.a.	n.a.	n.a.	n.a.	15.4	
RF2	1.6	2.04	0.20	2.4	18.9	16.1	n.a.	n.a.	14.5	14.5	15.3	
RF3	1.9	2.63	0.19	2.2	18.6	15.9	n.a.	n.a.	14.6	14.5	15.0	
SR	0.7	3.48	0.18	2.1	-	15.9	n.a.	n.a.	14.7	14.6	15.0	16.8
	1.4											17.1
	2											17.4
	2.4											17.5
RF4	2.0	9.96	0.13	15.0	17.5	14.8	8.7	8.8	10.8	10.7	14.2	
RF5	1.9	2.04	0.09	801.1	18.7	14.6	7.6	7.5	13.5	13.4	13.9	
Sum		22.52	1.20							Jacking pressure P_{jack} [MPa]		16.5
Mean					18.9	16.0	8.2	8.2	14.6	14.5	15.2	
SD						0.13	0.78	0.92	0.10	0.06	0.23	
						Combined mean	8.2		14.6			
						SD	0.70		0.08			

SB2-1 15.5 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.2	0.53	0.09	2.9	25	13.5	n.a.	n.a.	n.a.	n.a.	12.6	
RF1	1.2	1.12	0.09	2.2	14.7	13.8	n.a.	n.a.	n.a.	n.a.	12.5	
RF2	1.6	2.06	0.14	2.5	15.2	13.6	n.a.	n.a.	10.2	10.6	12.0	
RF3	2.6	2.76	0.13	2.5	15.9	13.1	n.a.	n.a.	10.4	10.6	11.7	
SR	0.5	3.75	0.17	2.3	-	12.8	n.a.	n.a.	10.8	10.7	11.9	14.4
	1.5											15.3
	2.0											15.5
	3.0											15.8
RF4	2	9.90	0.06	15.1	13.8	12.0	7.1	7.2	10.9	10.9	11.3	
Sum		20.12	0.68							Jacking pressure P_{jack} [MPa]		14.3
Mean					15.3	13.4	7.1	7.2	10.6	10.7	12.1	
SD						0.40	-	-	0.33	0.14	0.39	
						Combined mean	7.2		10.6			
						SD			0.24			

SB2-1 17.5 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	0.9	0.49	0.02	800.1	24.4	14.4	8.8	8.6	11.7	11.6	13.7	
RF1	1.7	10.26	0.06	63.4	14.6	12.5	7.2	7.4	9.9	9.9	11.9	
RF2	1.8	1.29	0.11	2.5	14.6	13.6	n.a.	n.a.	n.a.	n.a.	12.8	
RF3	2.4	1.18	0.13	2.5	14.5	13.6	n.a.	n.a.	n.a.	n.a.	12.0	
RF4	2.1	10.55	0.08	15.0	13.8	11.4	n.a.	n.a.	10.1	10.1	11.1	
Sum		23.77	0.40							Jacking pressure P_{jack} [MPa]		n.a.
Mean					14.6	13.5	8.0	8.0	10.6	10.5	12.6	
SD						0.78	1.13	0.85	0.99	0.93	0.84	
						Combined mean	8.0		10.6			
						SD	0.82		0.86			

SB2-1 23.3 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.5	0.58	0.20	2.5	21.1	10.6	n.a.	n.a.	n.a.	n.a.	9.8	
RF1	1.7	2.05	0.06	2.9	10.8	10.9	7	n.a.	n.a.	n.a.	10.1	
RF2	2.4	2.23	0.13	2.3	10.1	11.3	n.a.	n.a.	10.2	10.2	10.5	
RF3	2.8	2.85	0.09	2.7	10.2	11.1	n.a.	n.a.	7.9	7.8	10.0	
SR	0.8	4.69	0.08	2.0	-	11.2	6.8	6.5	n.a.	n.a.	10.4	10.9
	1.6											11.3
	2.5											11.7
	3.6											12.2
RF4	2.1	10.53	0.03	15.1	7.6	10.4	6.7	6.9	n.a.	n.a.	10.1	
Sum		22.93	0.59								Jacking pressure P_{jack} [MPa]	10.5
Mean					10.4	11.0	6.8	6.7	9.1	9.0	10.2	
SD						0.28	0.15	0.28	1.63	1.70	0.29	
						Combined mean	6.8		9.0			
						SD	0.19		1.36			

SB2-1 25.2 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.4	0.41	0.17	2.5	20.5	16.0	n.a.	n.a.	15.1	15.1	15.5	
RF1	1.5	1.68	0.08	2.9	17.7	14.0	n.a.	n.a.	n.a.	n.a.	13.7	
RF2	1.9	2.20	0.08	2.7	17.5	12.7	n.a.	n.a.	n.a.	n.a.	12.3	
RF3	2.7	2.94	0.06	3.2	15.6	12.6	n.a.	n.a.	11.0	11.1	12.3	
SR	0.6	4.96	0.13	2.6	-	13.1	n.a.	n.a.	n.a.	n.a.	12.9	14.5
	1.4											13.8
	2.3											14.1
	3.2											14.2
RF4	2.1	-	-	15.1	19.9	12.4	n.a.	n.a.	n.a.	n.a.	12.2	
Sum		12.19	0.52								Jacking pressure P_{jack} [MPa]	13.5
Mean					16.9	13.7			13.1	13.1	13.3	
SD						1.41			2.90	2.83	1.34	
						Combined mean			13.1			
						SD			2.34			

SB3-1 12.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.4	0.74	0.36	2.6	27.3	16.7	n.a.	n.a.	16.3	16.3	16.5	
RF1	1.4	1.32	0.40	2.7	16.9	16.5	n.a.	n.a.	15.8	15.8	16.0	
RF2	2.0	2.09	0.73	2.8	15.9	16.1	n.a.	n.a.	15.2	15.2	15.6	
RF3	2.7	2.40	1.00	2.7	16	15.8	n.a.	n.a.	14.5	14.5	14.6	
SR	0.5	4.31	1.06	2.0	-	16.1	n.a.	n.a.	n.a.	n.a.	15.7	14.0
	0.6											15.8
	1.0											16.0
	2.0											16.4
	3.4											16.7
Sum		10.86	3.55							Jacking pressure P_{jack} [MPa]		15.9
Mean					16.3	16.2			15.5	15.5	15.7	
SD						0.36			0.78	0.78	0.70	
						Combined mean			15.5			
						SD			0.72			

SB3-1 16.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.1	0.73	0.27	2.1	26.8	16.5	n.a.	n.a.	16.0	16.0	16.1	
RF1	1.4	1.33	0.30	2.9	16.2	16	n.a.	n.a.	15.3	15.3	15.4	
RF2	2.0	1.68	0.38	2.5	14.5	16	n.a.	n.a.	15.1	15.1	15.4	
RF3	2.6	2.13	0.88	2.5	15.1	15.9	n.a.	n.a.	15.0	15.0	15.1	
SR	0.6	5.71	1.48	2.3	-	15.7	n.a.	n.a.	14.5	14.4	15.1	15.6
	1.4											16.1
	2.1											16.0
	3.2											16.5
Sum		11.58	3.31							Jacking pressure P_{jack} [MPa]		15.5
Mean					15.3	16.0			15.2	15.2	15.4	
SD						0.29			0.54	0.58	0.41	
						Combined mean			15.2			
						SD			0.53			

SB3-1 20.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.2	0.69	0.43	2.0	25.5	16.5	n.a.	n.a.	16.2	16.2	16.2	
RF1	1.3	1.45	0.41	2.6	15.5	15.9	n.a.	n.a.	15.2	15.2	15.4	
RF2	1.9	1.86	0.65	2.5	13.8	16.3	n.a.	n.a.	15.1	15.1	15.4	
RF3	2.2	1.95	0.69	2.5	13.6	16.3	n.a.	n.a.	16.2	16.2	16.2	
SR	0.8	4.94	1.50	1.9	-	15.6	n.a.	n.a.	14.6	14.6	14.9	15.8
	1.5											16.1
	2.3											16.1
Sum		10.89	3.68							Jacking pressure P_{jack} [MPa]		15.7
Mean					14.3	16.1			15.3	15.3	15.5	
SD						0.36			0.67	0.67	0.54	
						Combined mean			15.3			
						SD			0.62			

SB3-1 24.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]	
F	1.2	0.53	0.22	2.1	18.9	14.1	n.a.	n.a.	11.3	11.2	13.3		
RF1	1.2	1.33	0.15	2.5	13.5	14.3	n.a.	n.a.	n.a.	n.a.	13.5		
RF2	1.9	1.96	0.23	2.5	13.4	14.9	n.a.	n.a.	n.a.	n.a.	14.2		
RF3	2.5	1.90	0.08	2.5	13.0	15.5	n.a.	n.a.	n.a.	n.a.	14.5		
SR	0.6	4.24	0.20	2.0	-	15.7	n.a.	n.a.	n.a.	n.a.	14.9	15.2	
	1.2											16.3	
	2.5											16.8	
Sum		9.96	0.88									Jacking pressure P_{jack} [MPa]	15.0
Mean					13.3	14.9			11.3	11.2	14.1		
SD						0.71			-	-	0.67		
						Combined mean			11.3				
						SD			0.07				

SB3-1 28.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]	
F	1.1	0.73	0.12	833.0	22.3	14.1	10.6	9.9	n.a.	n.a.	12.7		
RF1	1.3	2.04	0.12	60.0	14.8	14.4	10.5	10.8	12.8	12.9	13.7		
RF2	2.0	1.86	0.19	2.5	14.7	14.3	n.a.	n.a.	12.3	12.3	13.5		
RF3	2.3	2.17	0.15	2.5	9.6	14.7	n.a.	n.a.	12.6	12.6	13.9		
SR	0.5	3.95	0.20	2.0	-	14.6	n.a.	n.a.	12.8	12.7	13.8	14.0	
	0.6											14.5	
	1.1											15.0	
	2.0											15.4	
	3.2											15.9	
Sum		10.75	0.78									Jacking pressure P_{jack} [MPa]	14.5
Mean					14.8	14.4	10.6	10.4	12.6	12.6	13.5		
SD						0.24	0.07	0.64	0.24	0.25	0.48		
						Combined mean	10.5		12.6				
						SD	0.39		0.23				

SB4-1 12.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.1	0.57	0.19	3.0	26.4	15.6	n.a.	n.a.	15.1	15.1	15.4	
RF1	1.2	0.87	0.23	2.1	15.9	15.4	n.a.	n.a.	14.8	14.8	15.0	
RF2	1.7	1.36	0.25	2.1	15.8	14.8	n.a.	n.a.	13.4	13.4	13.8	
RF3	2.1	1.90	0.27	2.3	15.5	14.5	n.a.	n.a.	12.0	11.9	13.5	
SR	0.7	4.50	0.24	3.5	-	14.6	n.a.	n.a.	11.0	11.1	13.8	15.1
	1.5											15.6
	2.0											16.0
Sum		9.20	1.18							Jacking pressure P_{jack} [MPa]	14.6	
Mean					15.7	15.0			13.8	13.8	14.3	
SD						0.49			1.42	1.47	0.84	
						Combined mean			13.8			
						SD			1.34			

SB4-1 16.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.4	0.65	0.27	2.0	26.1	15.5	n.a.	n.a.	15.2	15.2	15.2	
RF1	1.4	1.64	0.34	2.2	15.8	14.8	n.a.	n.a.	14.4	14.4	14.5	
RF2	1.7	2.27	0.72	2.0	15.1	14.8	n.a.	n.a.	14.3	14.3	14.5	
RF3	2.2	2.16	1.24	2.0	14.4	15.2	n.a.	n.a.	n.a.	n.a.	15.1	
SR	0.5	6.40	1.18	2.1	-	14.2	n.a.	n.a.	n.a.	n.a.	13.8	14.5
	1.4											14.5
	2.3											14.8
Sum		13.12	3.75							Jacking pressure P_{jack} [MPa]		14.4
Mean					15.1	14.9			14.6	14.6	14.6	
SD						0.49			0.49	0.49	0.56	
						Combined mean			14.6			
						SD			0.44			

SB4-1 20.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.4	0.72	0.25	2.7	27.4	15.8	n.a.	n.a.	15.5	15.4	15.5	
RF1	1.5	1.46	0.33	2.3	15.8	15.2	n.a.	n.a.	14.7	14.6	14.8	
RF2	1.9	2.42	0.58	2.3	15.3	15.1	n.a.	n.a.	13.7	13.6	14.4	
RF3	2.3	1.72	0.59	2.0	15.2	14.9	n.a.	n.a.	14.2	14.2	14.4	
SR	0.7	2.81	0.50	2.0	-	15.1	n.a.	n.a.	n.a.	n.a.	14.4	14.9
	1.2											15.2
	2											15.6
Sum		9.13	2.25							Jacking pressure P_{jack} [MPa]		14.5
Mean					15.4	15.2			14.5	14.5	14.7	
SD						0.34			0.77	0.75	0.48	
						Combined mean			14.5			
						SD			0.71			

SB4-1 24.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.3	0.56	0.10	2.0	25.3	14.1	n.a.	n.a.	12.8	12.6	13.7	
RF1	1.3	1.49	0.20	2.1	14.2	14.2	n.a.	n.a.	13.6	13.5	13.9	
RF2	1.9	1.88	0.56	2.1	14.1	14.4	n.a.	n.a.	14.2	14.2	14.3	
RF3	2.5	2.10	0.93	2.1	13.7	14.7	n.a.	n.a.	14.3	14.3	14.5	
SR	0.7	7.48	1.18	2.2	-	13	n.a.	n.a.	n.a.	n.a.	12.8	13.6
	1.3											13.4
	2.2											13.6
RF4	1.4	1.25	0.09	896.9	10.6	12.4	8.7	8.7	12.2	12.0	n.a.	
RF5	1.8	1.79	0.10	60.0	12	13.1	9.6	9.5	12.5	12.5	n.a.	
Sum		16.55	3.16								Jacking pressure P_{jack} [MPa]	13.5
Mean					14.0	14.4	9.2	9.1	12.8	12.7	14.1	
SD						0.26	0.64	0.57	0.60	0.62	0.37	
						Combined mean	9.1		12.7			
						SD	0.49		0.57			

SB4-1 28.0 m

Cycle	Flow rate Q [L min ⁻¹]	Injected volume V _{in} [L]	Retrieved volume V _{out} [L]	Pressure Decline Observation Time [Min]	Breakdown pressure P _b & Reopening pressure P _r [MPa]	ISIP P _{si} [MPa]	Closure pressure tangent method sqrt(t). P _{cl} [MPa]	Closure pressure tangent method G- fct. P _{cl} [MPa]	Closure pressure compliance method sqrt(t). P _{cl} [MPa]	Closure pressure compliance method G-fct. P _{cl} [MPa]	Bilinear decay rate method P _{dPdt} [MPa]	Pressure step- rate test [MPa]
F	1.4	0.58	0.28	2.1	24.8	14.7	n.a.	n.a.	13.3	13.2	14.0	
RF1	1.4	1.49	0.13	3.3	14.3	14.2	10.3	10.1	13.4	13.2	13.7	
RF2	1.6	2.74	0.08	4.0	14.5	14.0	10.3	10.2	13.4	13.1	13.6	
RF3	1.8	2.57	0.08	2.8	14.7	14.0	9.5	9.6	13.4	13.0	13.5	
SR	0.9	4.35	0.03	2.3	-	14.1	9.2	9.7	13.3	13.2	13.7	15.0
	1.7											15.5
	2.7											15.8
RF4	1.4	1.39	0.03	15.2	12.5	12.8	7.6	7.7	12.0	11.9	12.4	
Sum		13.12	0.63								Jacking pressure P_{jack} [MPa]	14.7
Mean					14.5	14.2	9.8	9.9	13.4	13.1	13.7	
SD						0.29	0.56	0.29	0.05	0.09	0.19	
						Combined mean	9.9		13.3			
						SD	0.42		0.14			