Appendix 7

Mini-Frac Test

MINI-FRAC TESTS AT PENGROWTH LNDBRGH WELL 13-13-58-5W4

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APEGGA Permit of Practice #07814

March 27, 2011

On behalf of Pengrowth Energy Corp., BitCan conducted 4 Mini-Frac tests on Well 13-13-58-5W4:

1) GP zone #3 at 476 m TVD,
2) GP zone #2 at 484 m,
3) GP zone #1 at 493 m,
4) Lloyd at 512 m.

The test locations are denoted on the well log as shown in Figure 1. Objectives of the tests were to assess the in-situ stress conditions. This report will illustrate how the in-situ minimum stress was estimated as well as include a summary of the results.

1. General test procedure

Our tests employ new advancements and improvements to the mini-/micro-hydraulic fracturing stress test protocol currently used in the petroleum industry. Our testing procedure contains modifications tailored specifically for use in the oil sands and heavy oil development.

Before commencing testing, the target interval was perforated. Water was then injected directly down into the casing. Testing began at the lowest depth and a packer was set between two adjacent perforation intervals. Multiple injection and shut-in cycles were used during each test. The injection pressures were monitored on-site via two surface pressure sensors: one close to the pumps and the other at the wellhead.

The current mini-/micro-hydraulic fracturing tests are the most reliable method to assess the in-situ minimum stress. Via controlled well injection, it creates a fracture and propagates it to a sufficient distance from the injection well and into the formation. This ensures the fracture senses the far-field stress condition. Multiple cycles are run to verify the data consistency. The pressure data is analyzed to estimate the fracture closure pressure. The fracture closure pressure can then be equated to the in-situ minimum stress acting perpendicular to the fracture. Figures 2 - 5 plot the recorded pressure and rate history during each of the tests.

A flow-back procedure was also used during each test. For the flow-back, a certain volume of water is manually withdrawn from the injection system (wellbore plus the fracture) during the shut-in period. The fracture is thus able to close quickly and properly due to the manually reduced pressure drop. A plot of BHP vs. cumulative injected volume (called compliance plot), can be used to detect the fracture closure. It is generally agreed that a properly executed and accurately metered flow-back yields better constrained data on the minimum stress. BitCan's mini-frac test system can accurately control and meter the flown-back volume and rate. Figure 6 illustrates an example compliance plot and its interpreted fracture closure pressure.

2. Depth profile of the in-situ minimum stress

The interpreted in-situ minimum stresses (Smin) at the tested depths of Well 13-13 are shown in Figure 1. Their specific values are summarized in the following table:

Pengrowth 1AB/13-13-58-5W4						
	TVD, m	Min. stress		Vert. stress		Stress regime
		MPa	kPa/m	MPa	kPa/m	
Loydminster	512.0	5.94	11.60	10.74	20.98	V. frac
GP zone #1	493.0	7.48	15.17	10.34	20.97	V. frac
GP zone #2	484.0	7.55	15.60	10.15	20.97	V. frac
GP zone #3	476.0	6.80	14.29	9.97	20.95	V. frac

In all the test intervals from 476 to 512 m depths, including the Loydminster reservoir sands and its overlying GP caprock, the measured in-situ minimum stress is smaller than the vertical overburden stress. Thus, at these depths, a vertical fracture stress regime is expected. However, all the immediate caprock zones are stressed more horizontally than the underlying reservoirs. For example, GP zone #1 (493 m TVD) as the caprock to the underlying Loyd sands (512 m) has a Smin=7.48 MPa compared to Smin=5.94 at the 512-m depth. This is beneficial to maintaining the caprock integrity.

3. Analysis of field data

It is BitCan's practices to place great deal of emphasis on acquiring high quality data during testing. As shown in Figures 2 to 5, multiple injection/shut-in cycles were used in each test. In all the tests, obvious formation breakdown occurred in the first injection cycle (Figure 2 to 5), i.e., a fracture was formed. In the subsequent injection cycles during each test, the pressure declined or stayed relatively flat, signalling the continuous fracture propagation.

For each injection/shut-in cycle, the fracture closure pressure was interpreted by a linear flow (or sqrt(t)) plot. A system compliance plot was also used for the interpretations if the flow-back procedure was used. A good compliance plot, such as the one shown in Figure 6, should have two different slopes. Intersection of these two slopes denotes the fracture closure pressure. The initial slope, corresponding to before the fracture closes, is steeper while the second slope, reflecting the post-closure system compliance, is less inclined.

The fracture closure pressures, interpreted as described above, are reconciled in Figures 7 to 10 between the different cycles in each test. In general, a consistent closure pressure is seen in each test among the different cycles. Moreover, different interpretation methods, sqrt(t) or compliance plots, all give a similar closure pressure. Combining these methods serves to enhance the interpretation accuracy. The cycles without the flow-back procedures generally registered a higher closure pressure than the ones flown back. Better clarity can be seen on the flow-back cycles and therefore, their interpreted closure pressures are used to estimate the in-situ stress.

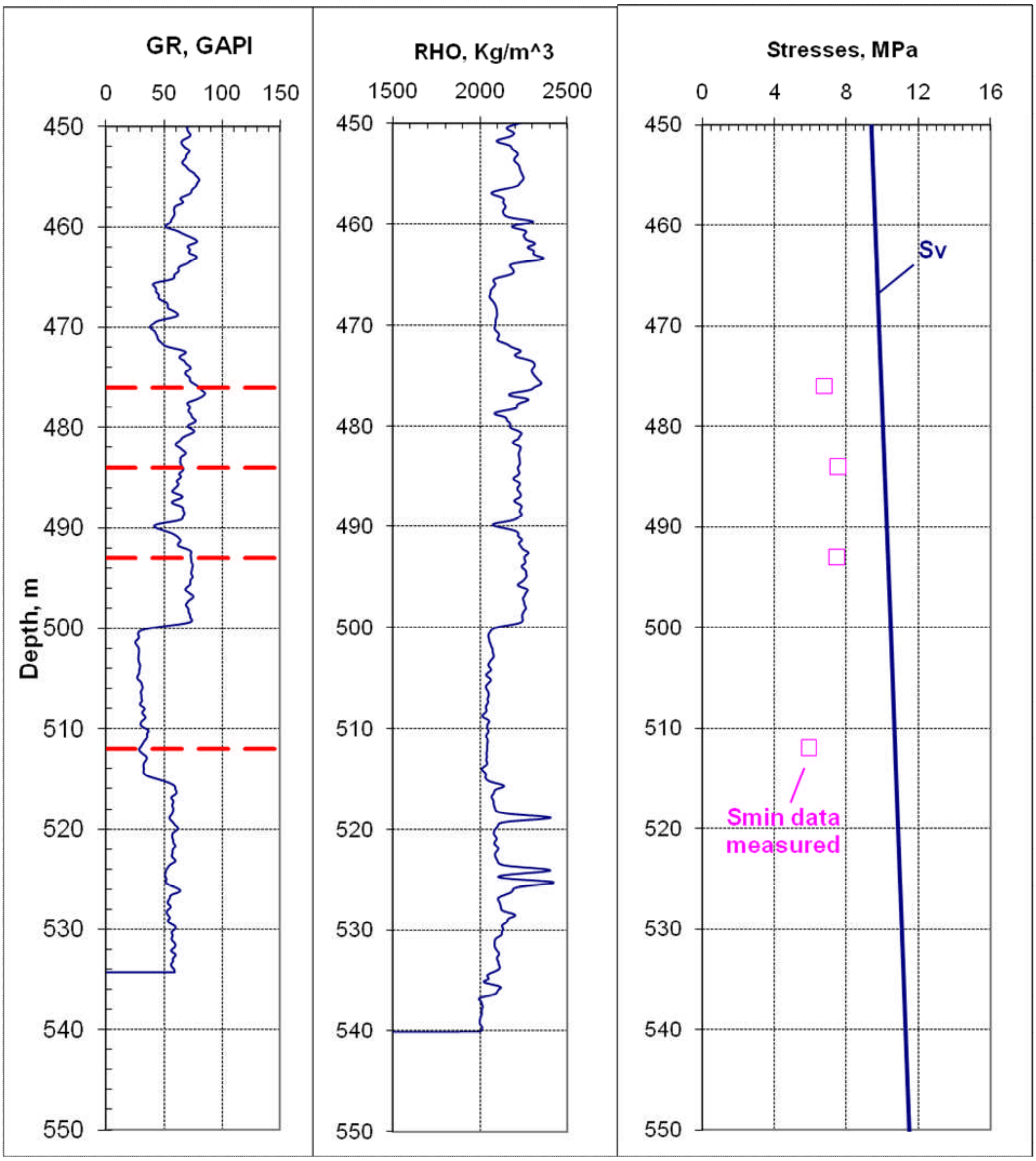


Figure 1: Summary of the in-situ minimum stresses measured from Well 13-13. Red dotted lines on the gamma log denote the mini-frac test intervals. "Sv" denotes the vertical overburden stress calculated from the density log. "Smin" in squares is the interpreted minimum stress from the mini-frac tests.

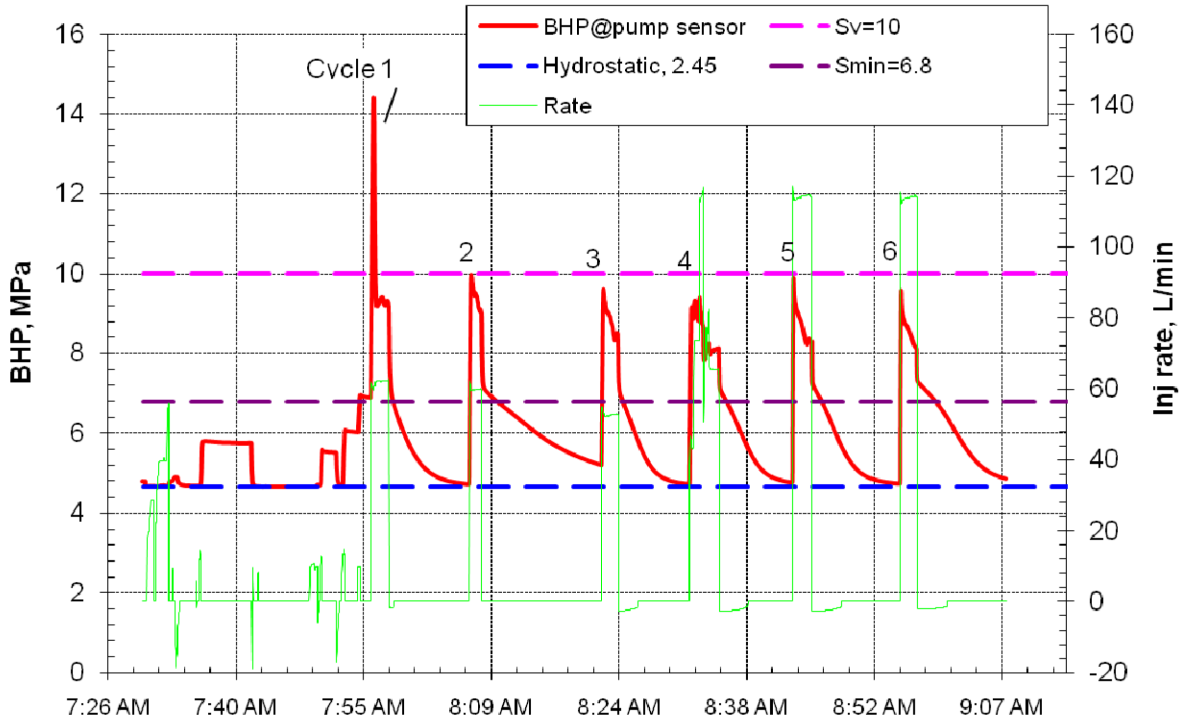


Figure 2: Recorded pressure history during the injection test in the GP zone #3 at 476 m TVD. The bottomhole pressures ("BHP") were calculated from a surface pressure sensor at the pump plus the hydraulic head ("Hydrostatic") from the water column weight. The overburden weight ("Sv") was calculated from the density log. "SHmin" was the in-situ minimum horizontal stress or fracture closure pressure interpreted from the pressure data. Similar conventions are used below unless otherwise specified.

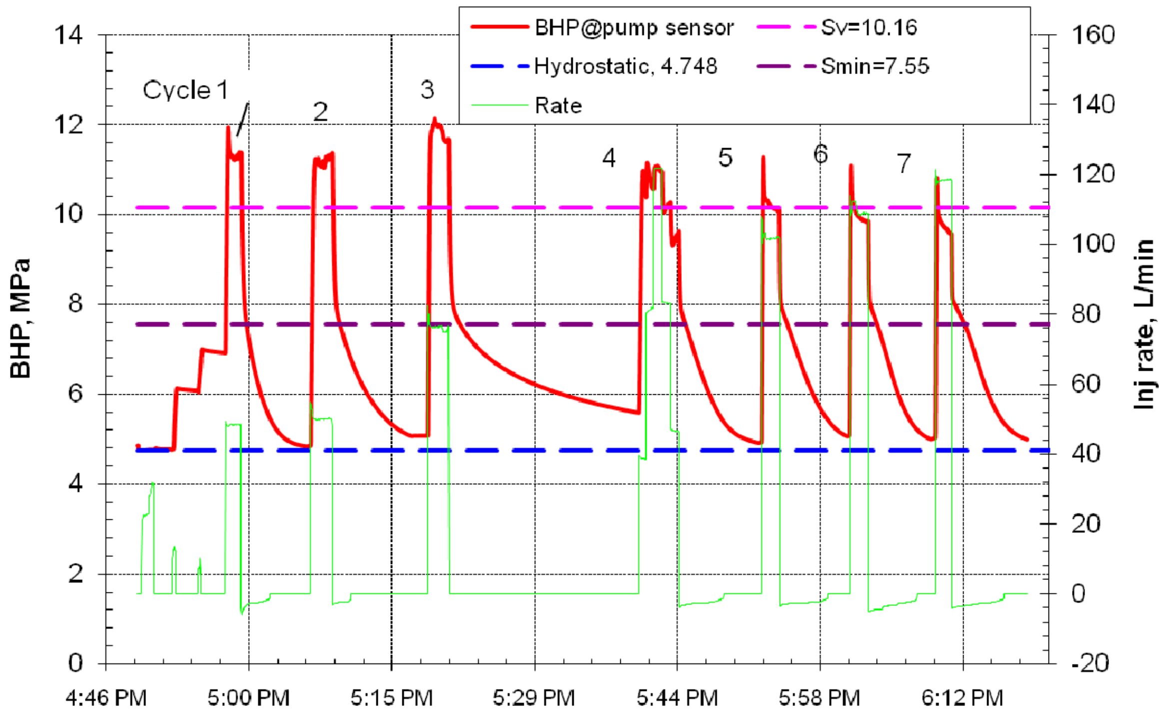


Figure 3: Pressure history during the injection test in the GP zone #2 at 484 m TVD.

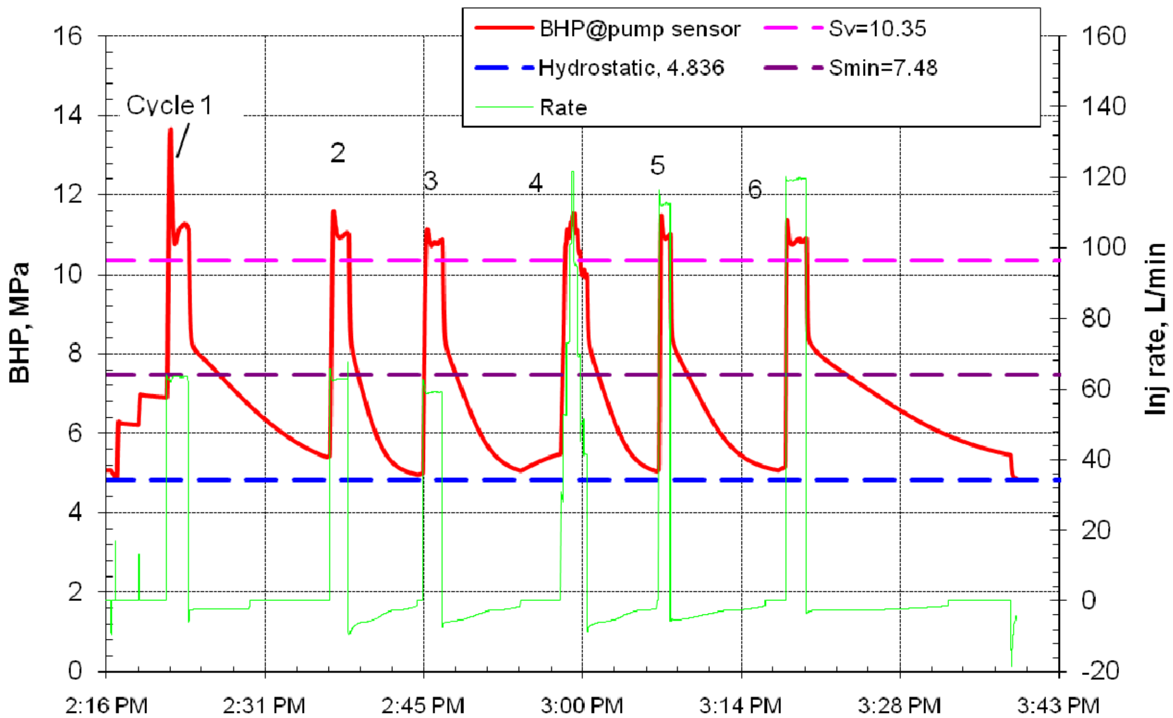


Figure 4: Pressure history during the injection test in the GP zone #1 at 493 m TVD.

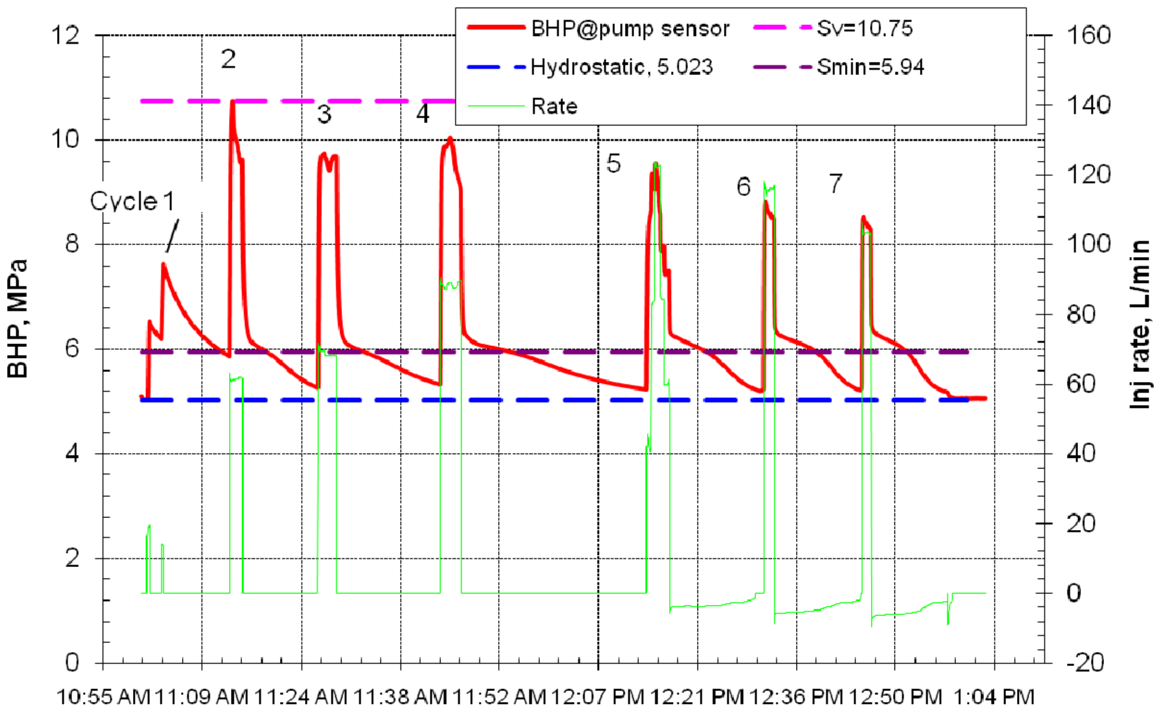


Figure 5: Pressure history during the injection test in the Lloyd sands at 512 m TVD.

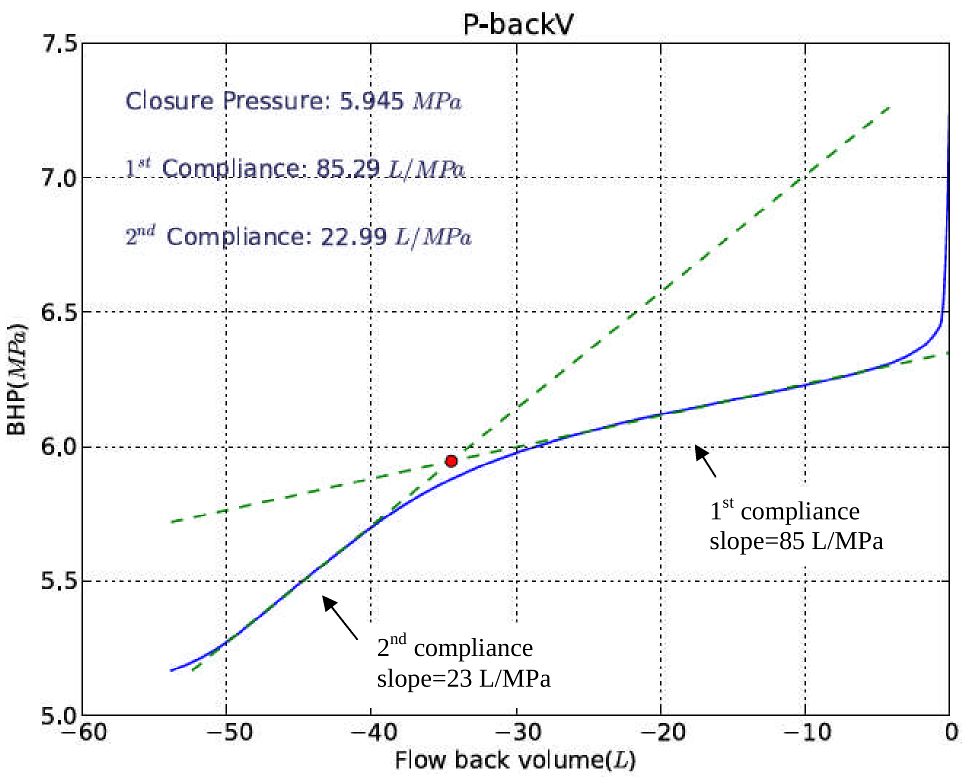
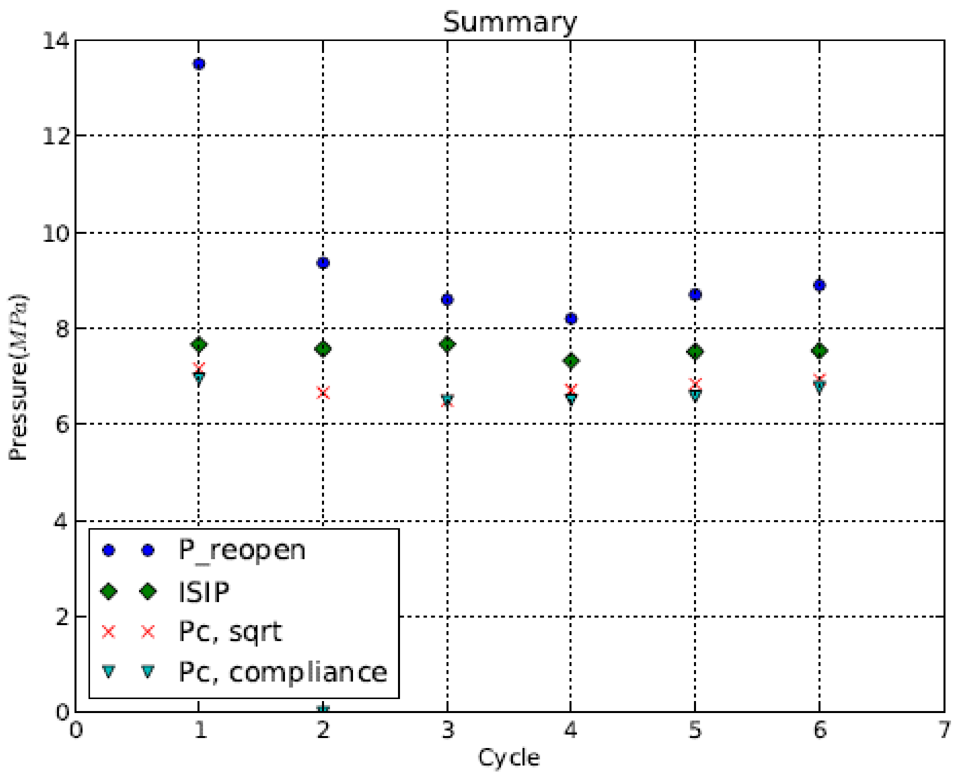


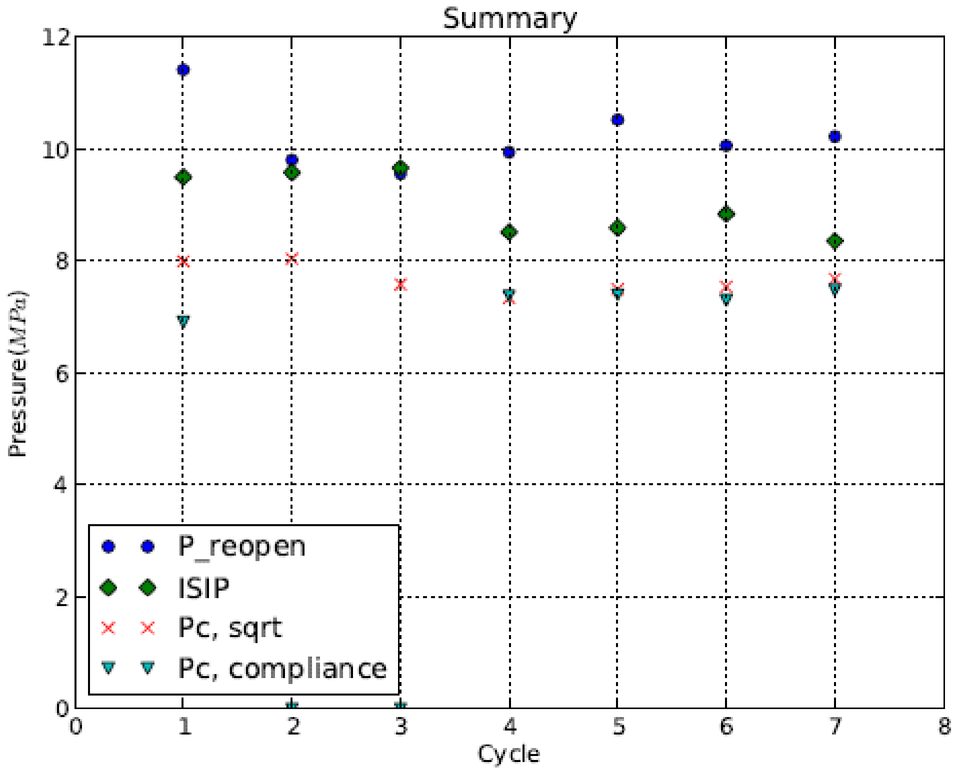
Figure 6: Fracture closure pressure interpreted from the compliance plot for Cycle #6 in the Lyod sand test at 512 m. The negative volume on the x-axis denotes the flown-back volume.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	13.515	7.671	7.165	6.953	2.38	0.93	1.66
2	9.369	7.576	6.664	0.000	2.49	0.00	0.00
3	8.602	7.676	6.498	6.488	2.34	4.42	3.69
4	8.206	7.331	6.717	6.505	2.31	6.63	4.01
5	8.708	7.520	6.844	6.582	2.27	6.30	3.95
6	8.903	7.541	6.935	6.771	2.40	8.57	4.46

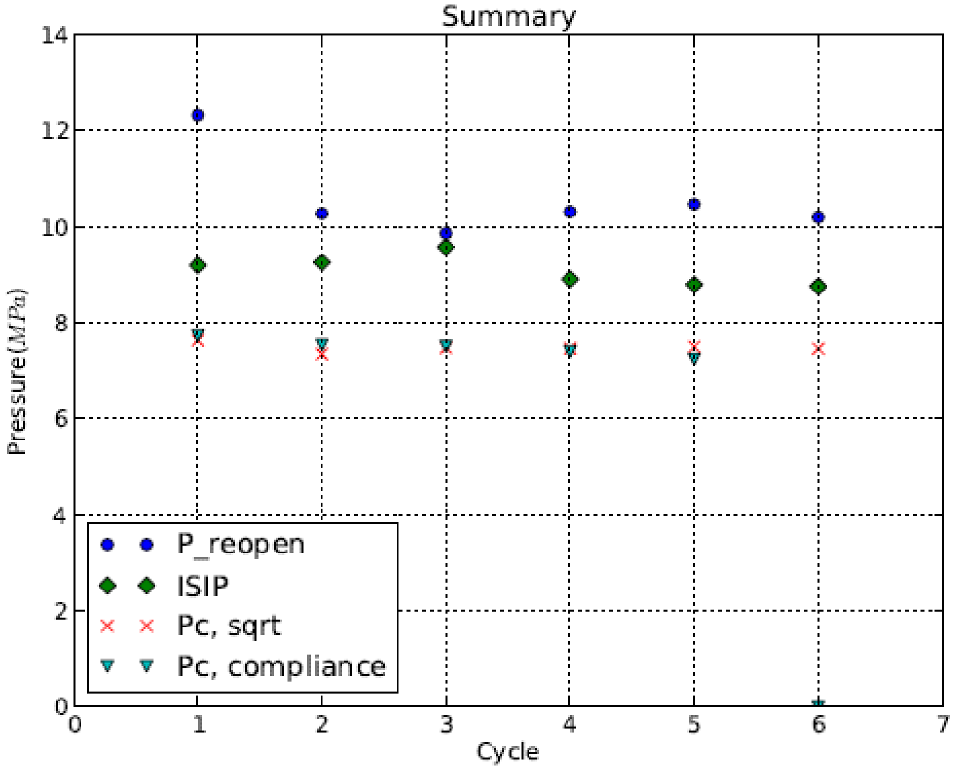
Figure 7: Various characteristic pressures interpreted from the test at 476 m in the GP zone #3. “P_reopen” denotes the fracture reopening pressure where the fracture starts to re-open during the subsequent injection. “ISIP” is the Instantaneous Shut-In Pressure. “Pc, sqrt” refers to the fracture closure pressure extracted by the sqrt(dt)-plot. “Pc, compliance” is the fracture closure pressure extracted by the compliance plot from the flow-back tests. “Cb, inj (Cf, back or Cb, back)” refers to the initial system compliance during the injection (the system compliance before or after the fracture closure during the flowback). Similar convention for the legends holds in this report unless otherwise specified.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	11.413	9.496	7.994	6.908	2.50	2.13	2.56
2	9.802	9.578	8.040	0.000	2.47	0.00	0.00
3	9.558	9.660	7.579	0.000	2.37	0.00	0.00
4	9.940	8.516	7.342	7.370	2.28	4.57	4.13
5	10.519	8.588	7.493	7.395	2.40	4.66	4.05
6	10.058	8.838	7.537	7.298	2.40	7.48	4.46
7	10.221	8.357	7.680	7.477	2.47	8.60	4.06

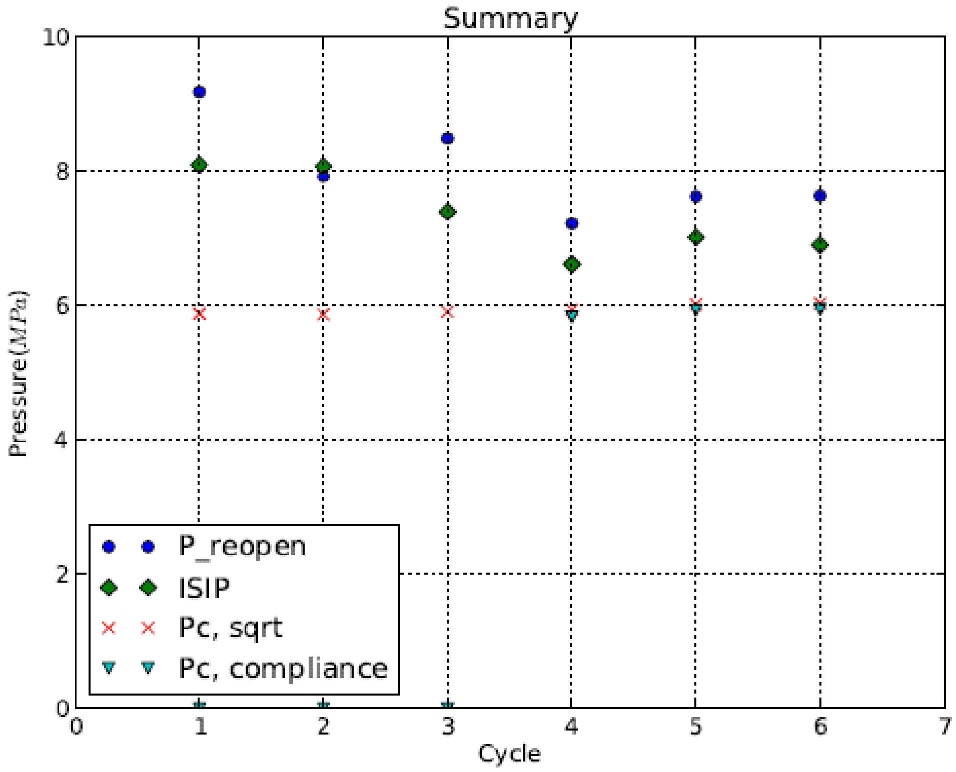
Figure 8: Various characteristic pressures interpreted from the test in the GP formation at 484 m TVD.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	12.326	9.198	7.635	7.730	2.54	9.02	8.11
2	10.279	9.263	7.353	7.536	2.66	6.04	6.13
3	9.865	9.579	7.479	7.509	2.68	7.51	7.62
4	10.316	8.910	7.468	7.405	3.35	7.57	7.24
5	10.472	8.802	7.503	7.248	2.77	9.48	7.93
6	10.202	8.760	7.463	0.000	2.73	0.00	0.00

Figure 9: Various characteristic pressures interpreted from the test in the GP formation at 493 m TVD.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	9.180	8.094	5.881	0.000	2.57	0.00	0.00
2	7.927	8.072	5.872	0.000	2.88	0.00	0.00
3	8.489	7.397	5.909	0.000	3.27	0.00	0.00
4	7.222	6.616	5.940	5.836	3.07	56.57	22.55
5	7.624	7.019	6.017	5.928	3.55	93.86	21.11
6	7.635	6.907	6.032	5.945	3.74	85.29	22.99

Figure 10: Various characteristic pressures interpreted from the test in the Lloyd formation at 512 m TVD.

MINI-FRAC TESTS AT PENGROWTH LNDBRGH WELL 13-13-58-5W4

--- A supplement to the summary report ---

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March 27, 2011

Upon completion of the mini-frac tests, a summary report was written highlighting the test results and discussing their importance to understanding the caprock integrity. The present report describes additional test details including the analysis plots for each of the test cycles in each of the test intervals. It will also describe how to fully utilize the mini-frac test results for designing the field operation. In essence, the mini-frac tests are not merely to satisfy ERCB's requirements. It can be designed, executed and used as a cost-effective geomechanical field test, proactively guiding the field operation.

1. Applications of the test results to the field operation

The interpreted in-situ minimum stresses (Smin) are summarized in the following table:

Pengrowth 1AB/13-13-58-5W4						
	TVD, m	Min. stress		Vert. stress		Stress regime
		MPa	kPa/m	MPa	kPa/m	
Lloydminster	512.0	5.94	11.60	10.74	20.98	V. frac
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GP zone #3	476.0	6.80	14.29	9.97	20.95	V. frac

As the first-order engineering design, the above measurements can be used to guide the field operation designs as follows.

1.1. Operating pressures for Lyod reservoir towards the caprock integrity

Ideally the operating pressures should stay low enough to ensure the caprock integrity. The Smin measured in the caprock provides the first-order engineering design towards this objective. The GP zone #1 caprock shale at 493 m has a Smin=7.48 MPa. Based on this measurement, the margin of safety for various operating pressures in the underlying Lyod reservoir sands is listed below:

OP, MPa	Margin of Safety	% of Smin@cap
3.74	100%	50%
4.49	67%	60%
5.24	43%	70%
5.98	25%	80%
6.73	11%	90%

The Margin of Safety (M.S.) for an Operating Pressure (OP) is defined as follows:

M.S. = Smin@cap/OP - 1

where Smin@cap represents the in-situ minimum stress in the Clwt caprock shale, i.e., equal to 7.48 MPa. It is assumed here that it is unsafe to allow OP to reach Smin in the caprock. This is reasonable for designing the operation against the hydraulically-driven fracture propagation from the reservoir into the caprock. Therefore, a M.S. at zero means failure and larger than zero means no failure. The greater the M.S. the safer the caprock is from failure.

Sometimes, a simple percentage of the Smin in the caprock is used to guide the operation pressure design. At 80%, OP can be 5.98 MPa and its associated M.S. is 25%. At 90%, OP can be 6.73 MPa and its M.S. is 11%.

1.2. Dilation pressures, Llyod reservoir

To promote the geomechanical dilation effect, the reservoir recovery processes should operate at pressures as high as possible. The in-situ minimum stress in the reservoir plays an important role in the dilation. The Lyod reservoir has a Smin=5.94 MPa. The first-order engineering analysis normally suggests that significant dilation should occur if the reservoir operating pressure is close to its Smin, i.e., 5.94 MPa in our situation. At this operating pressure, the Margin of Safety for the caprock integrity is about 25%. This pressure is 79% of the Smin=7.48 MPa in the GP zone #1. These safety measures are favorable for the caprock integrity. Therefore, at the tested well, there is a rare “luxury” where an operating pressure, that is 5.94 MPa, exists which has a M.S. at about 25% for the caprock integrity and meanwhile, promotes dilation in the reservoir.

1.3. A word of caution

It should be noted that caprock integrity as well as reservoir dilation is a very complex issue. For example, many factors contribute and therefore, many mechanisms can potentially compromise the caprock integrity (Yuan, 2008)[1]. The above observations in 1.1 to 1.2 refer to a situation involving hydraulically-driven fracture propagation controlled by high fluid pressures inside the fracture and acting against the original in-situ stresses. It does not consider the mode of shear failure which can potentially compromise the caprock integrity. Dilation is very much shear-controlled. The above discussions do not address impact of

[1] Yuan, Y., 2008, Overburden/casing integrity in SAGD without high operating pressures. Presented at Canadian International Petroleum Conference in June, 2008 in Calgary. Paper # CIPC-2008-206.

reservoir deformation on the caprock. It does not consider thermal stresses. The thermal stresses and reservoir deformation may be significant during the thermal stimulations and should be considered. These issues should be investigated by geomechanical laboratory tests and simulation program.

Furthermore, the above discussions assume that the measured stress condition holds across the region. It may not be true if complex geology is present. Examples include post-depositional collapse structures and large faults. If these conditions are present, caution should be exercised and more tests are warranted.

2. Compilation of the analysis plots

Various appendices to this report compile all the analysis plots for the tests. Each plot occupies a page. They are first organized according to the test intervals. Plots are then grouped according to the test cycles sequentially from the first to the last. For each cycle, the following sequence of plots is arranged:

(1). "BHP and Injection Rate" plots the pressure/rate history, "Relative time" on the x-axis is calculated from the start of the cycle.

(2). "P-V" plot for the pressure vs. injection volume plot to identify "P_reopen".

(3). "P-Δt" plots the pressure decline during the shut-in. "Relative time" on the x-axis is calculated with respect to the start of the shut-in period. This plot determines ISIP.

(4). "lg(ΔP)-lg(Δt)" plots the pressure drop during the shut-in (ongoing pressure minus the pressure at the start of the shut-in) against the shut-in time on the log-log plot. It is used to identify two slopes whose magnitudes are denoted. The 1st or 2nd slopes are counted from the origin to the right.

(5). "P-√Δt" for the p-sqrt(t) plot to identify "Pc, sqrt".

(6). "P-backV" is made only if the flow-back is executed during the test. It plots the pressure vs. fluid volume being flown back. 2 slopes are identified and their intersection is the fracture closure pressure, "Pc, compliance". The slopes are denoted on the plot. The 1st and 2nd slopes are counted from the "0" point on the axis, i.e. the right-hand side end, to the left.

(7). "lg(Δt*dP/dΔt)-lg(Δt)" means the pressure derivative plot on the log-log scale. The y-axis lg(Δt*dP/dΔt) is actually the derivative with respect to the natural log of the incremental time after the shut-in starts, i.e. dP/d(ln(Δt)). 3 slopes are identified to show the flow regimes. They are identified in the legend by "1st" to "3rd" corresponding respectively to fitted lines from the left-most to the right-most. The linear flow period should have a slope of 0.5 while the radial flow has a zero slope.

There are two summary pages after all the cycles are presented: the first plots the characteristic pressures according to the cycle sequences and the second lists their numeric values in a table. The compliance values are also listed: "Cb, inj" refers to the initial system compliance during the injection. "Cf, back or Cb, back" is the system compliance before or after the fracture closure during the flowback.

ANALYSIS PLOTS

WELL: PENGROWTH LINDBERGH WELL 13-13-58-5W4

Test 1: Lloydminster Reservoir Sand at 446 m

Previous View | Main Menu | Search

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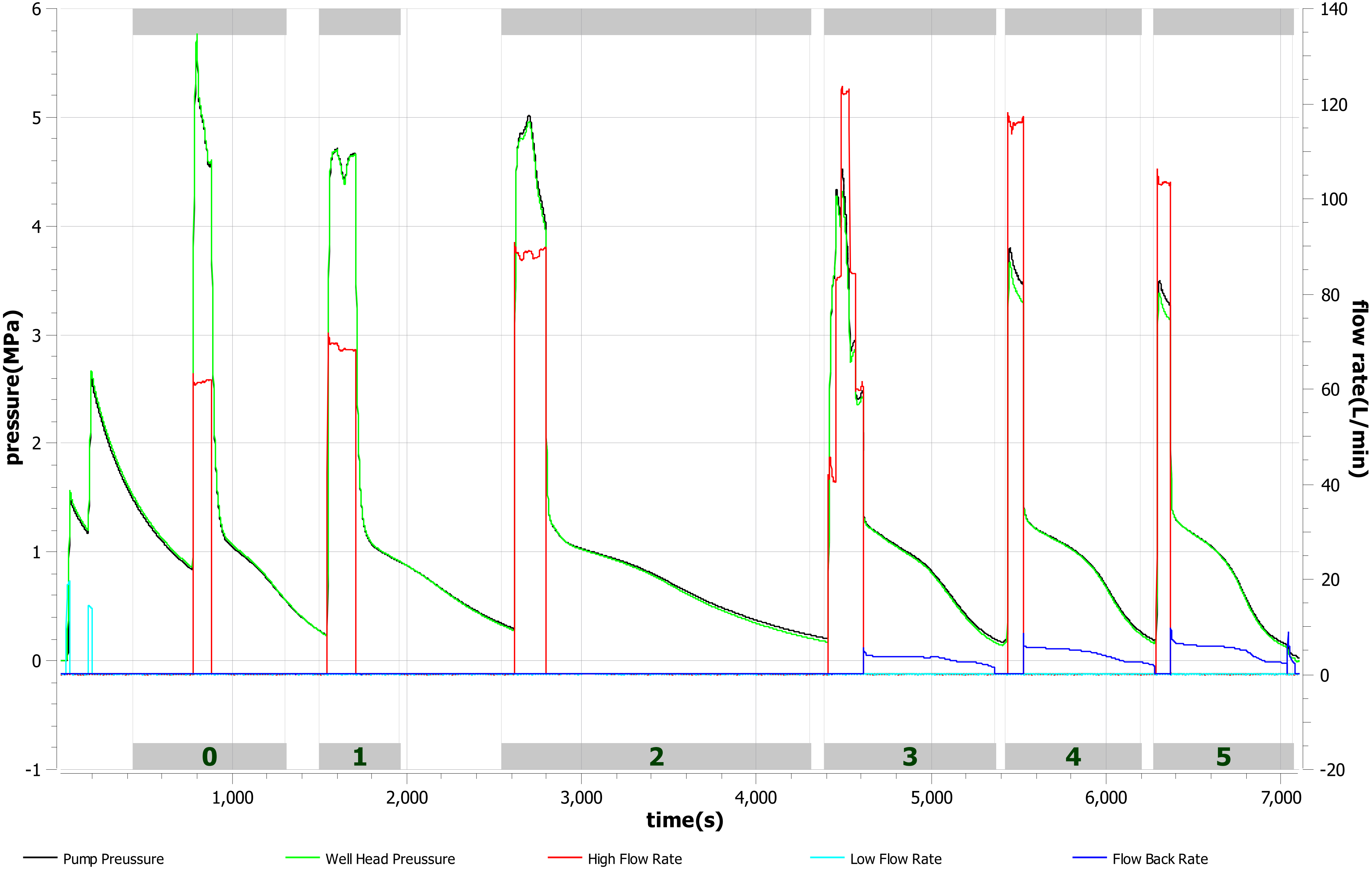
Client: Pengrowth Energy Corp.
Well: 1AB/13-13-58-5W4
Depth: 512
Formation: loyd
Start @: Thu Mar 3 11:00:36 2011

Mini-Frac Test

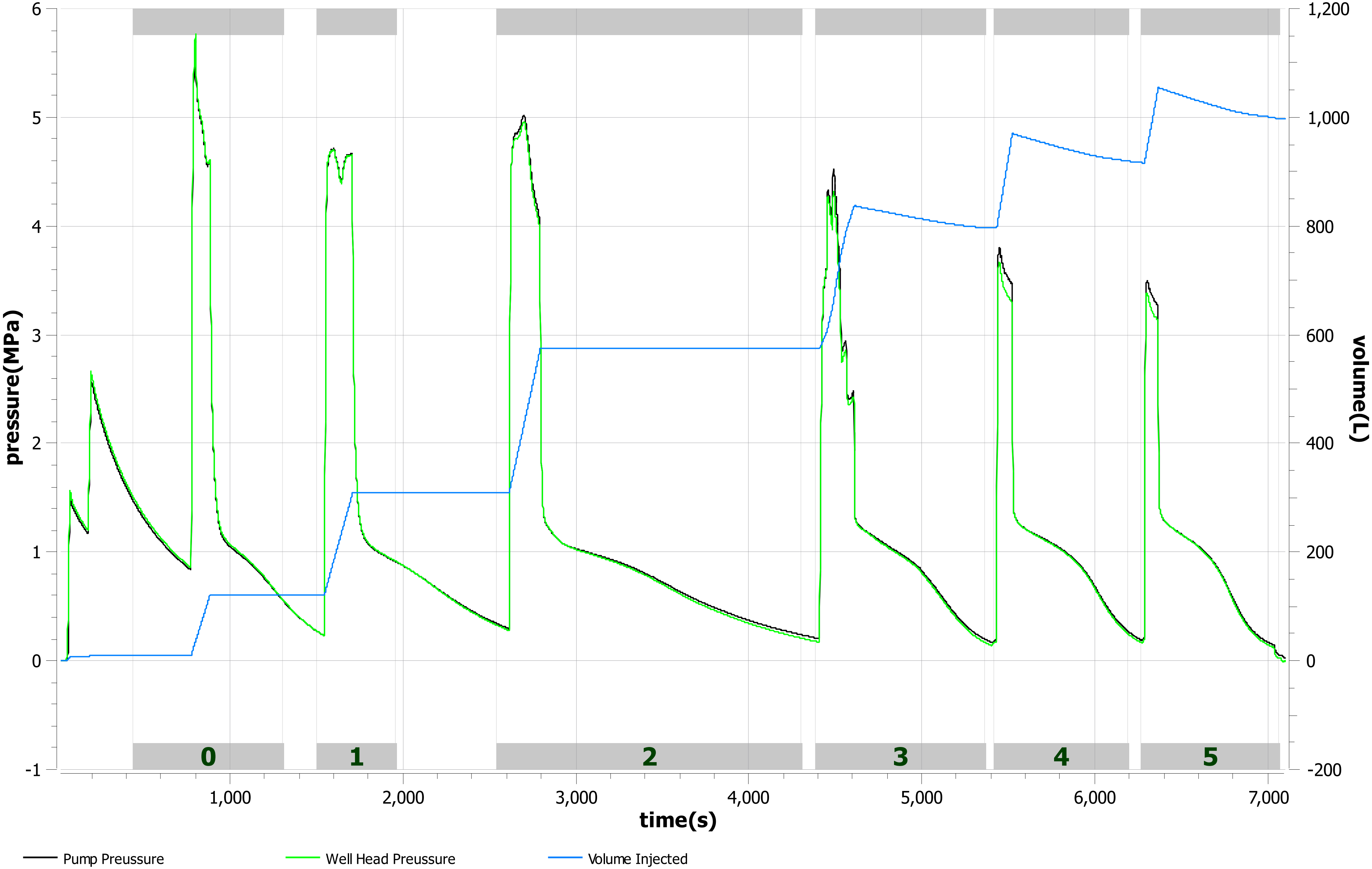


Generated by MiniMonitor

BitCan
Geosciences & Engineering Inc.
www.bitcange.com

Client: Pengrowth Energy Corp.
Well: 1AB/13-13-58-5W4
Depth: 512
Formation: loyd
Start @: Thu Mar 3 11:00:36 2011

Mini-Frac Test



Generated by MiniMonitor

Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 01

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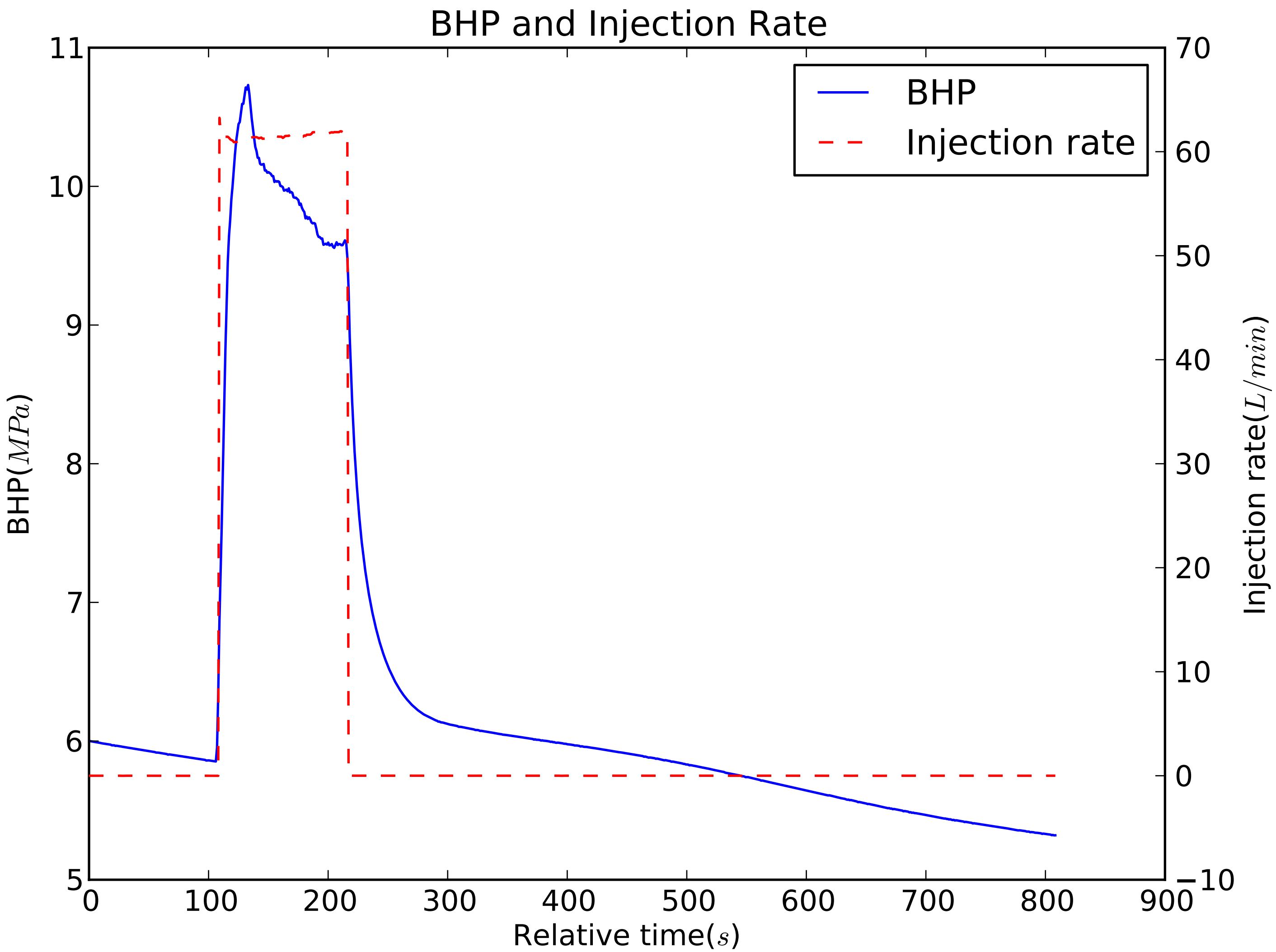

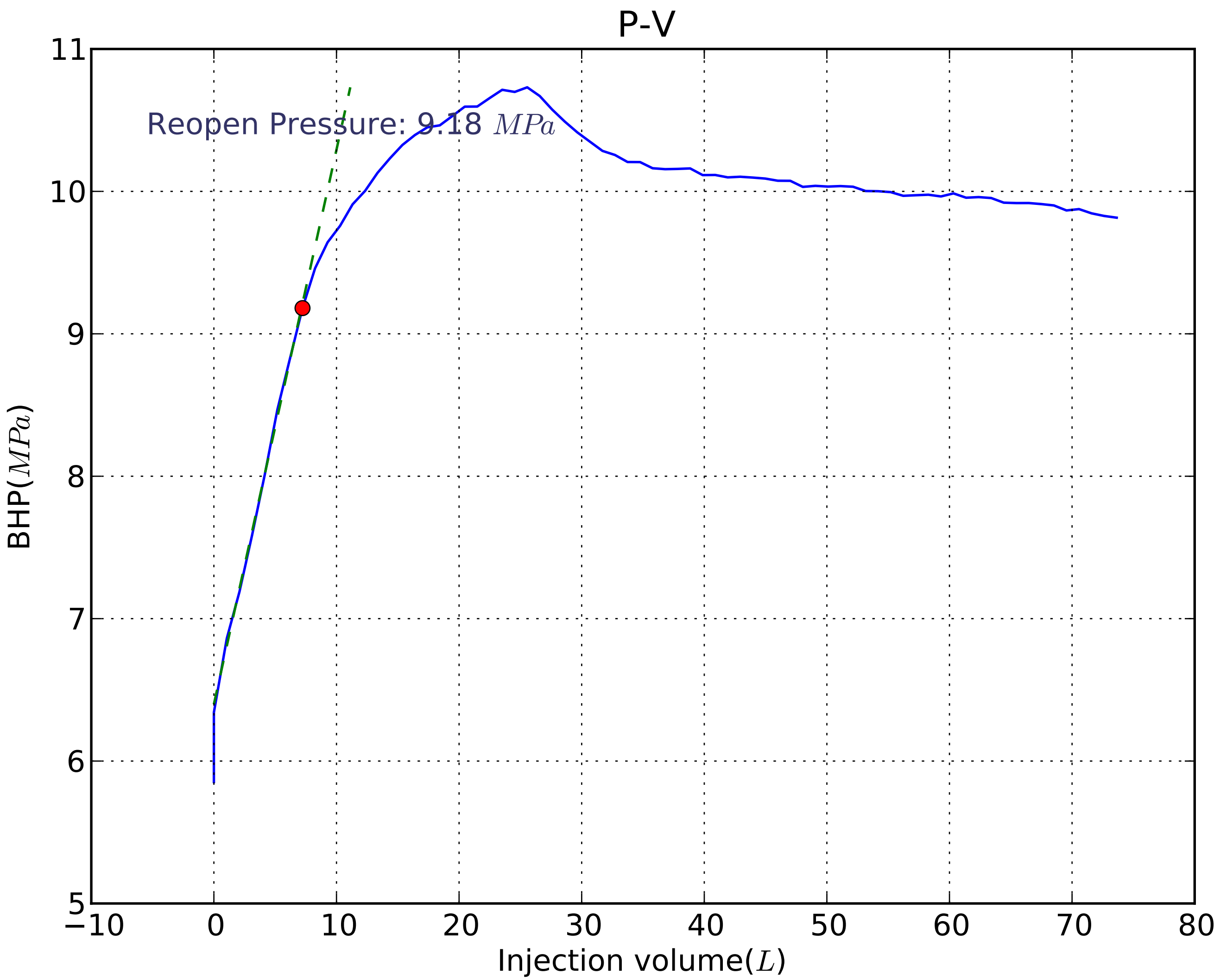
P-V
Reopen Pressure: 9.18 MPa
BHP(MPa)
Injection volume(L)
11
10
9
8
7
6
5
−10
0
10
20
30
40
50
60
70
80

Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 01

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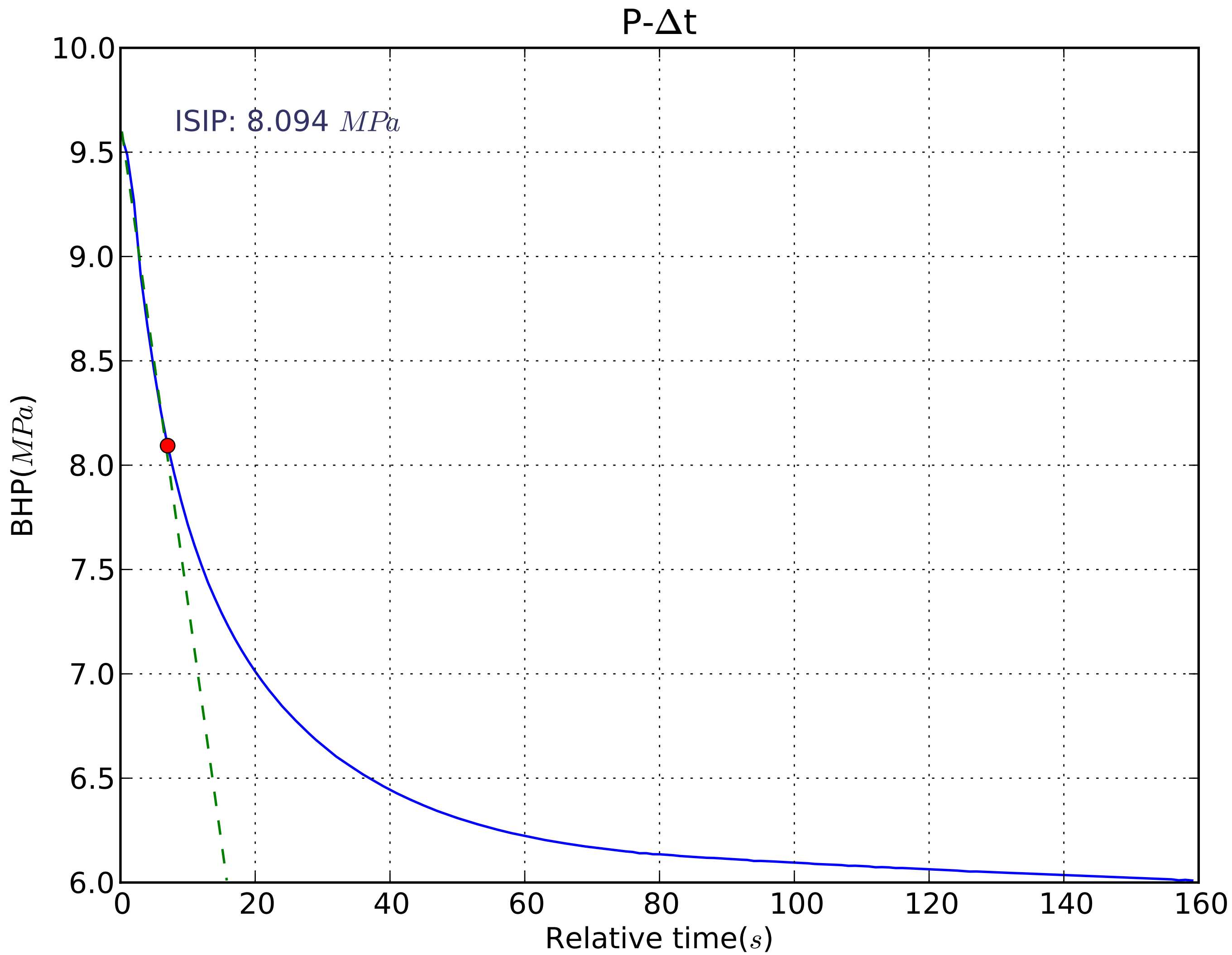

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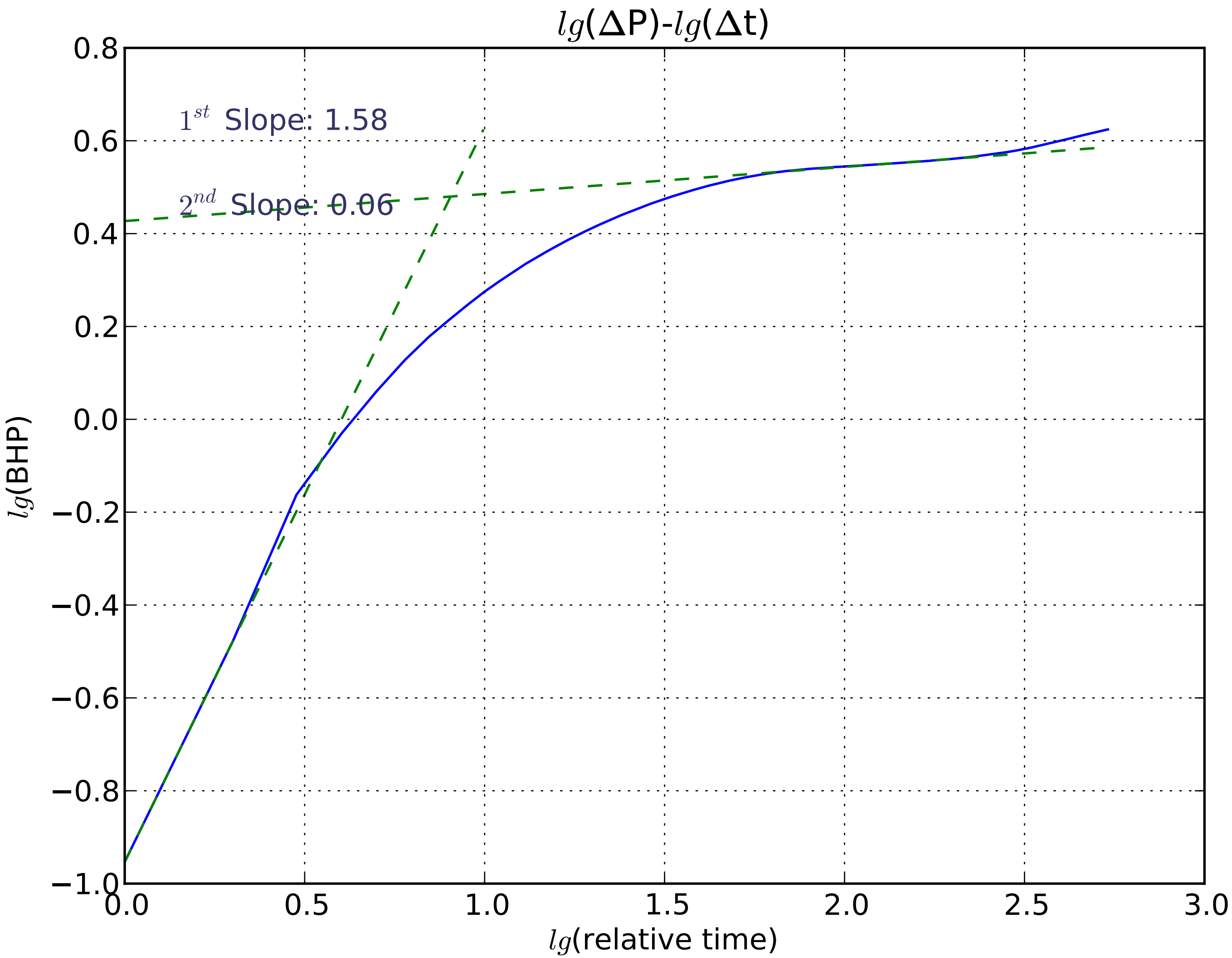
Depth: 512.0m
Formation: LOYD
Cycle: 01



Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 01

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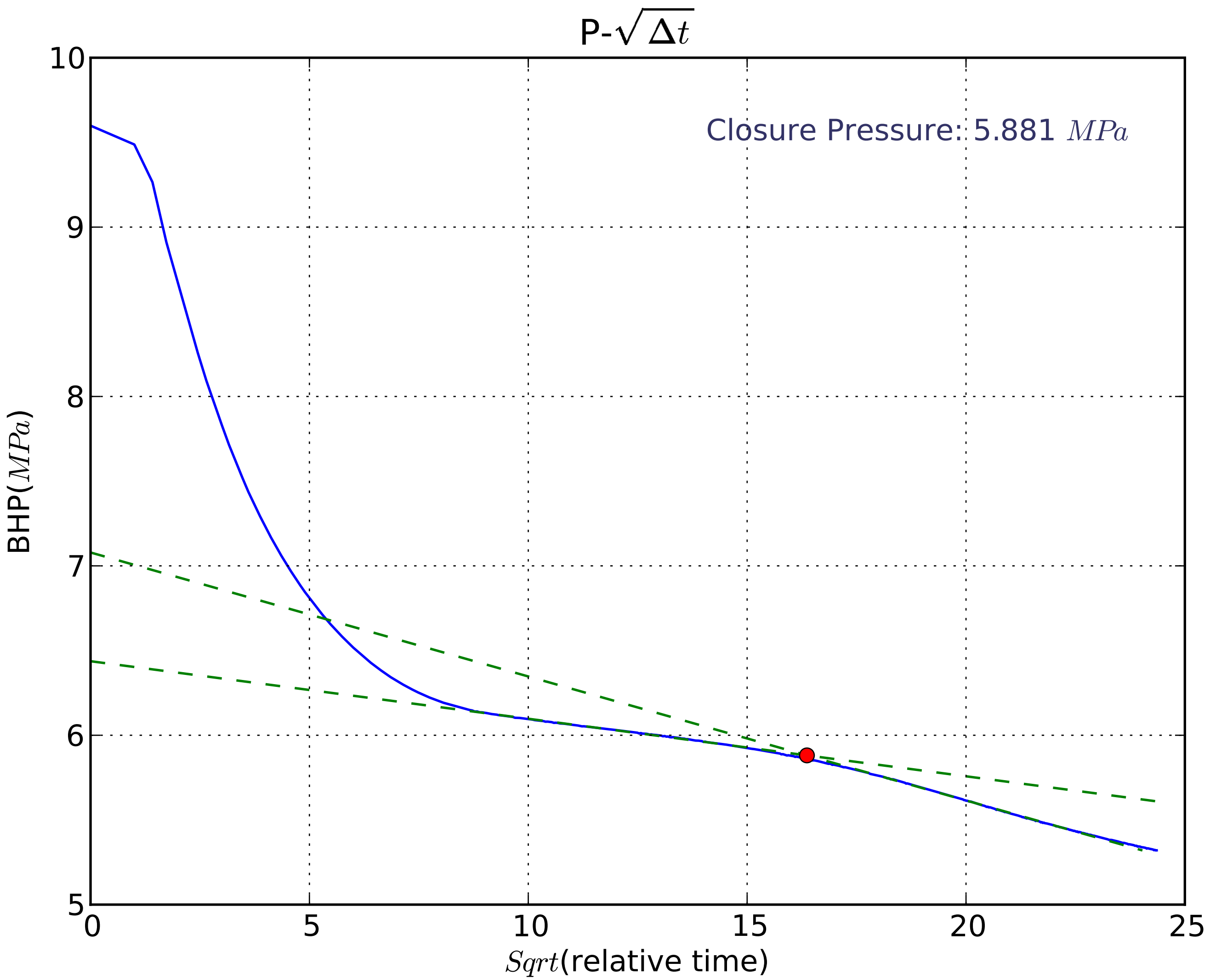

Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 01

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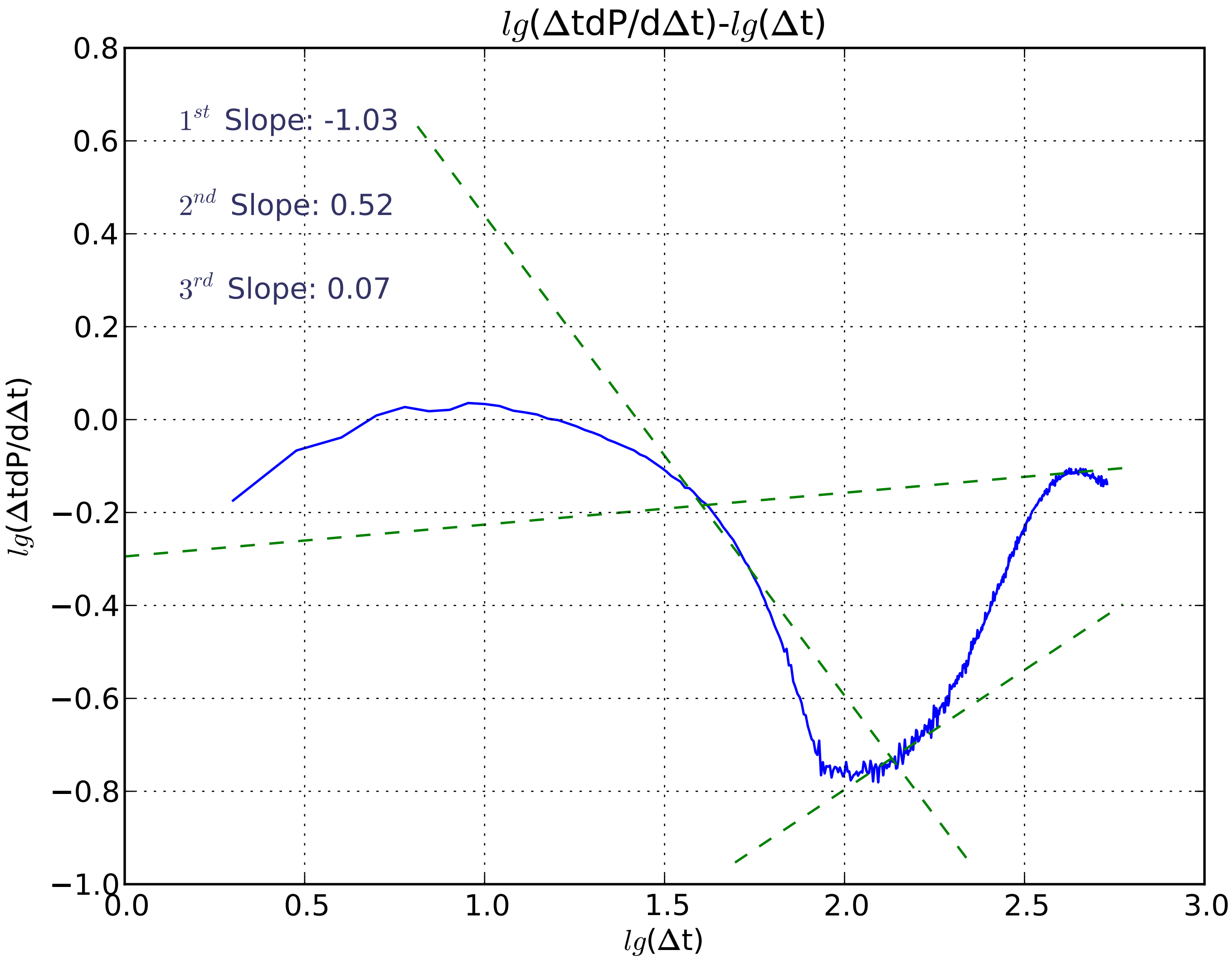
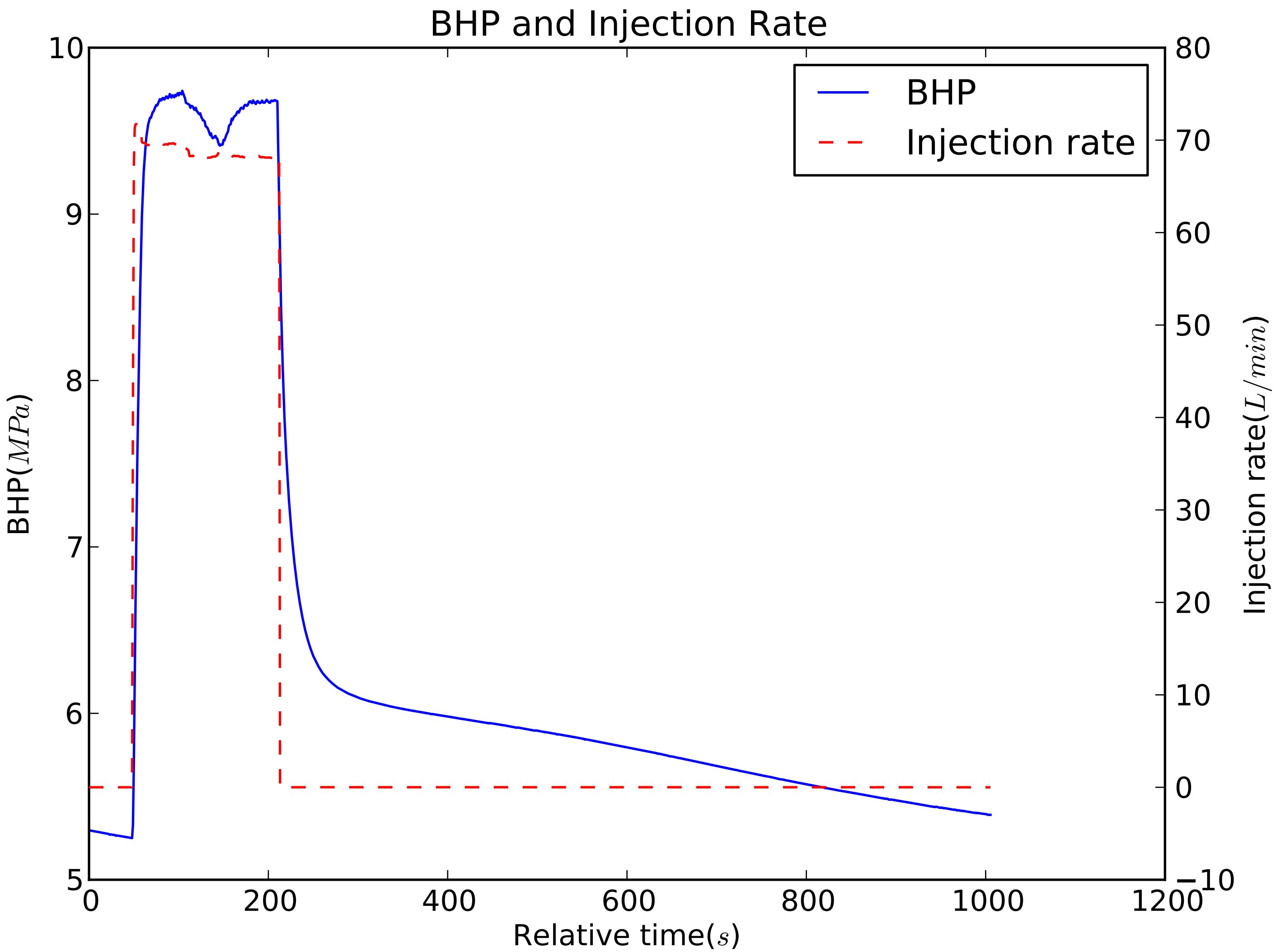


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 02



Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 02

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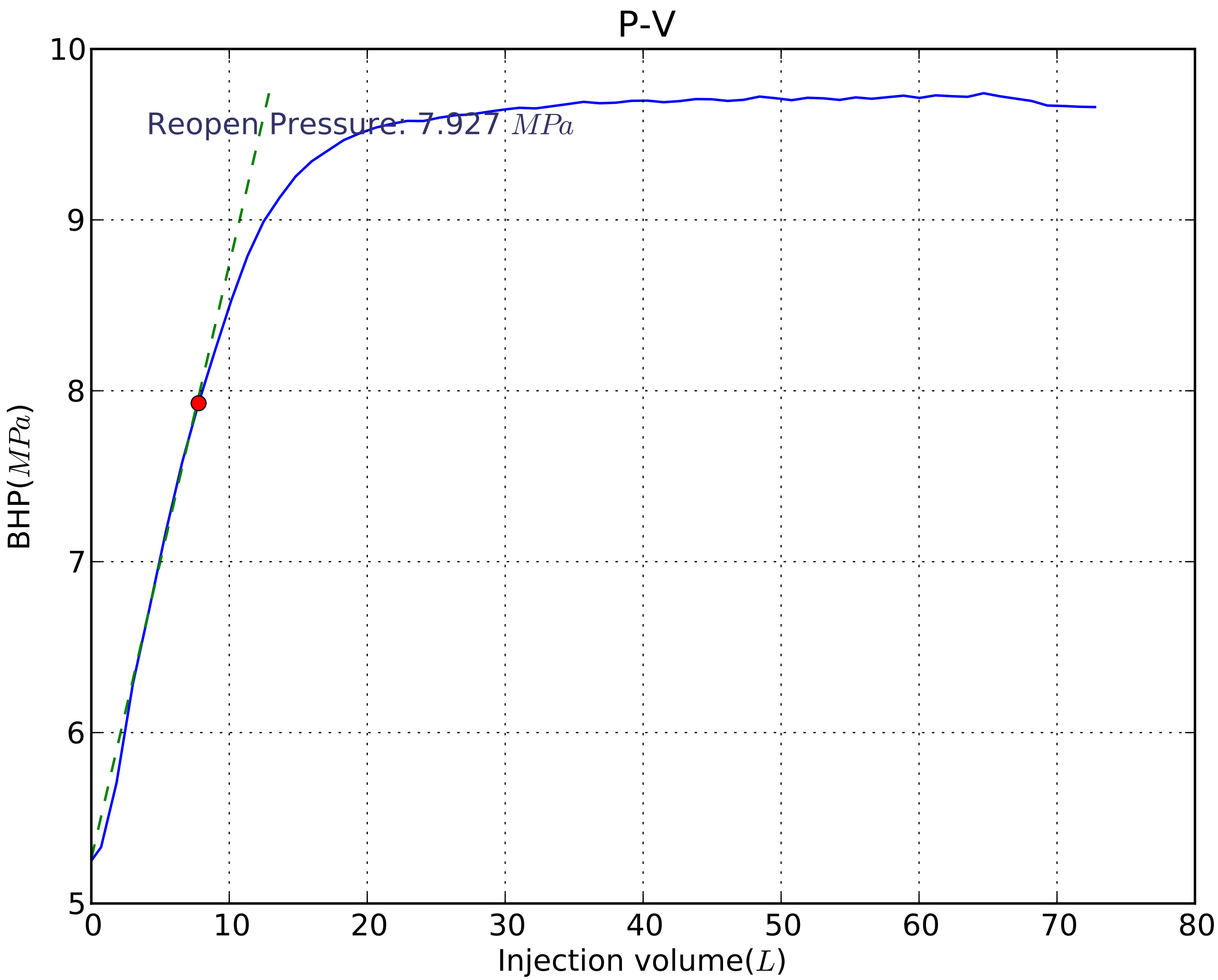
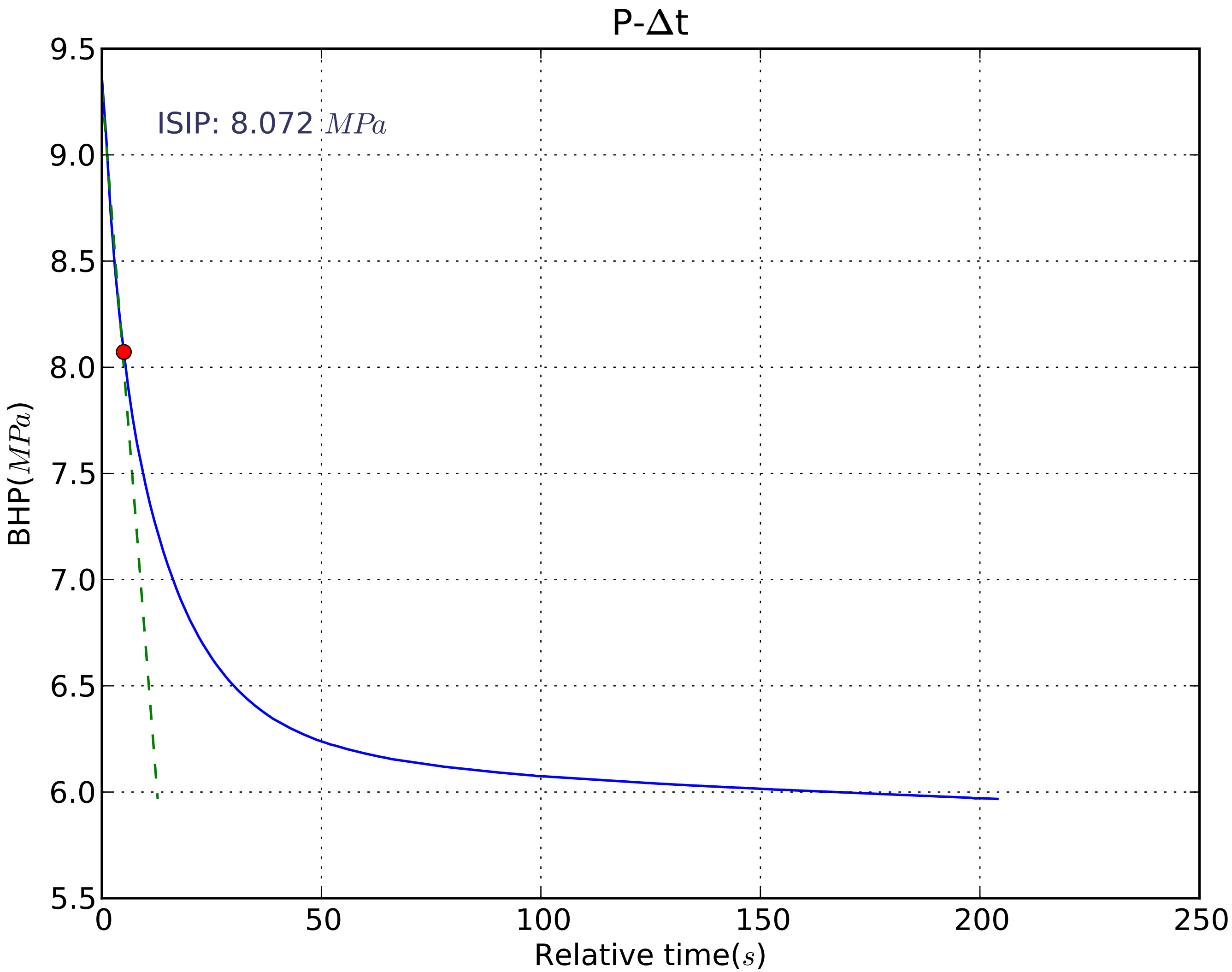


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 02

BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 02

BitCan
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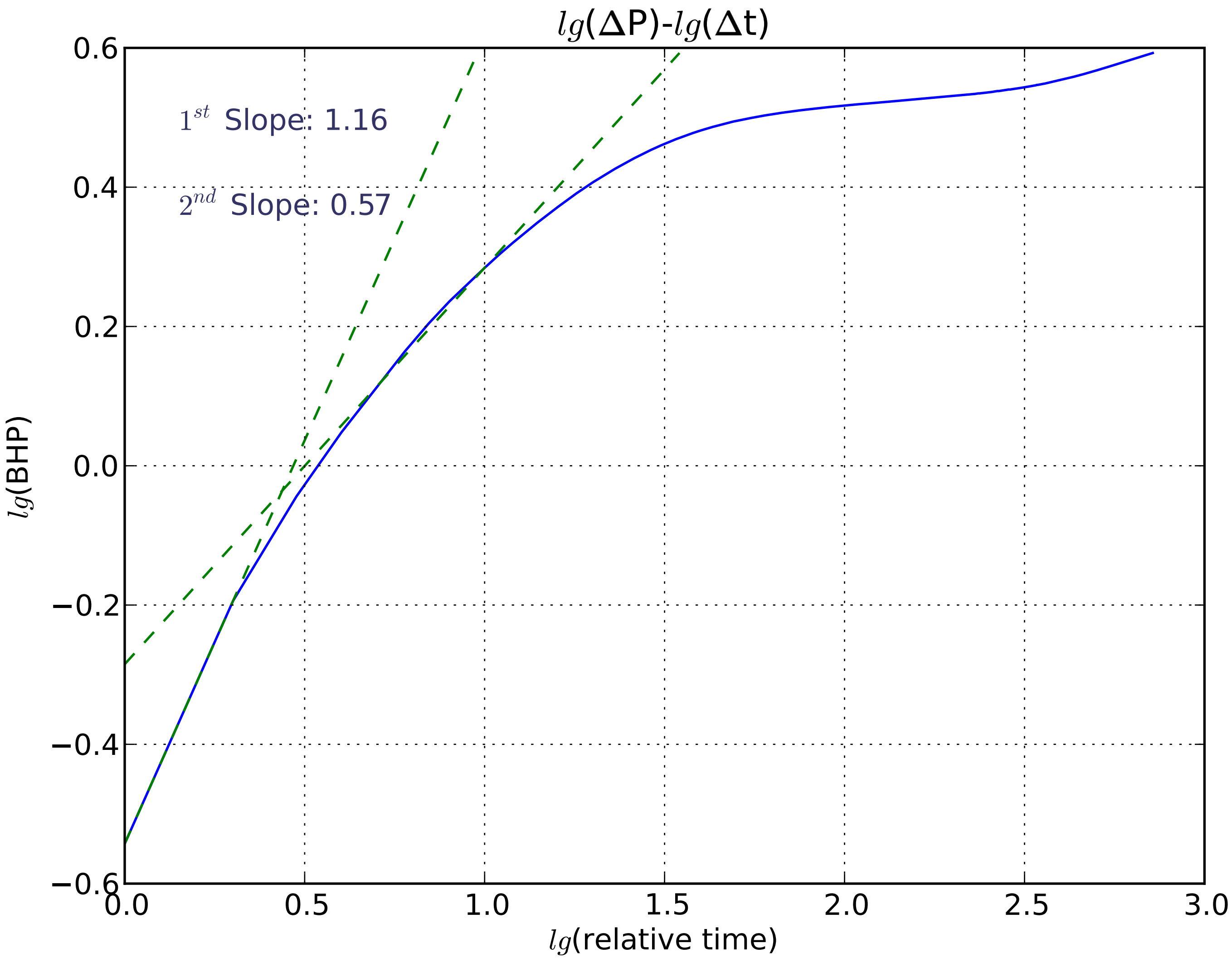
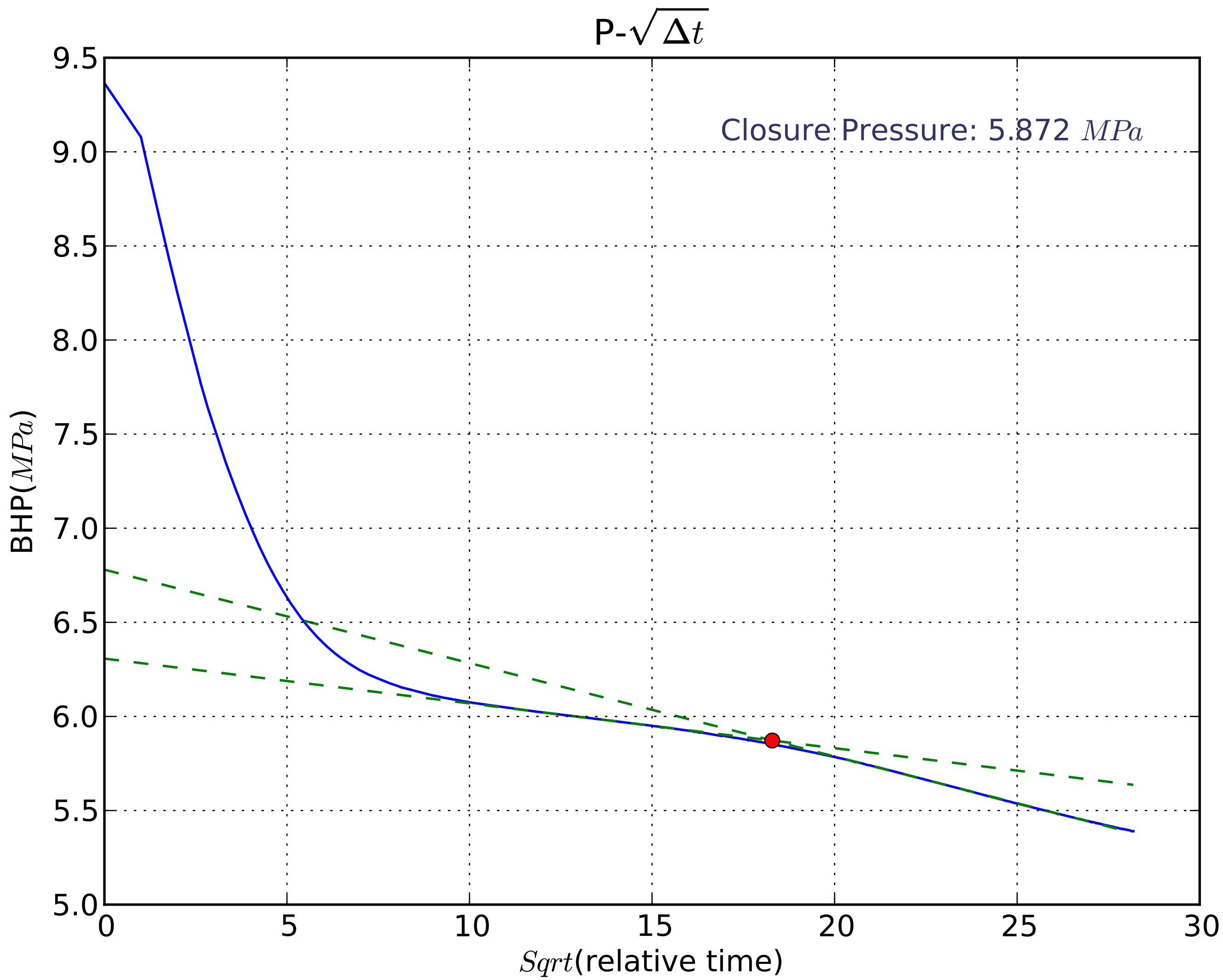
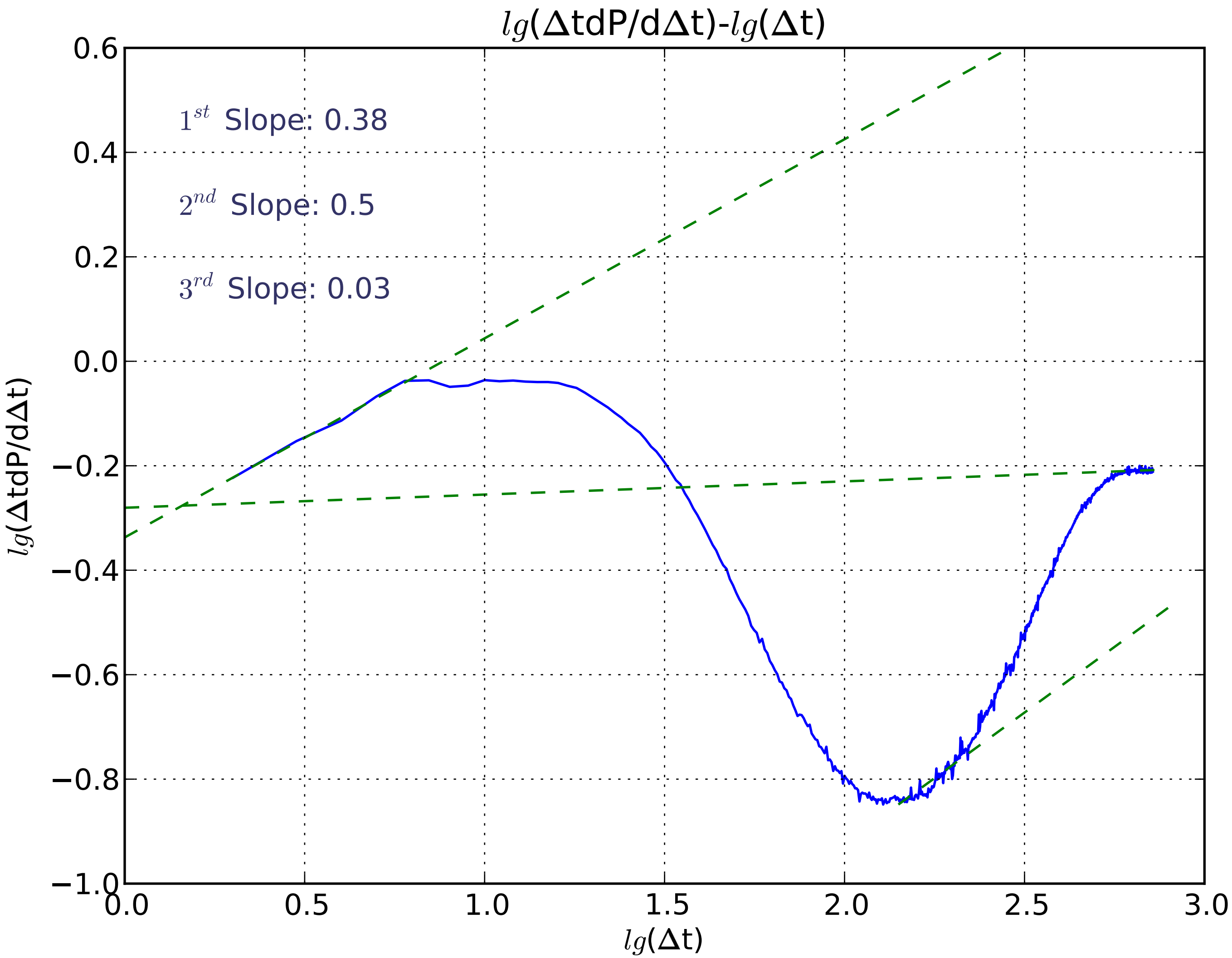


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 02



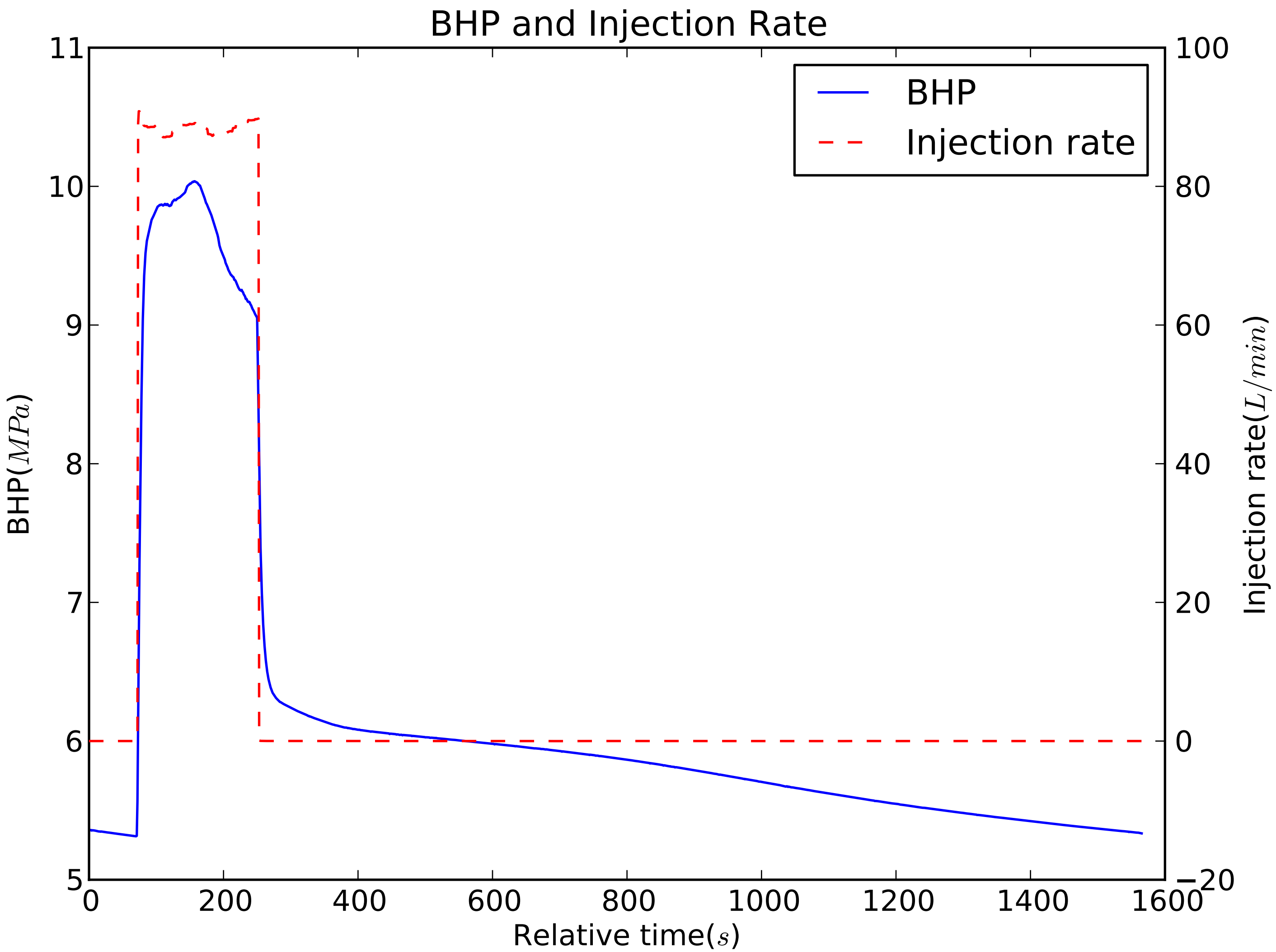
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 02

BitCan
Geosciences & Engineering Inc.

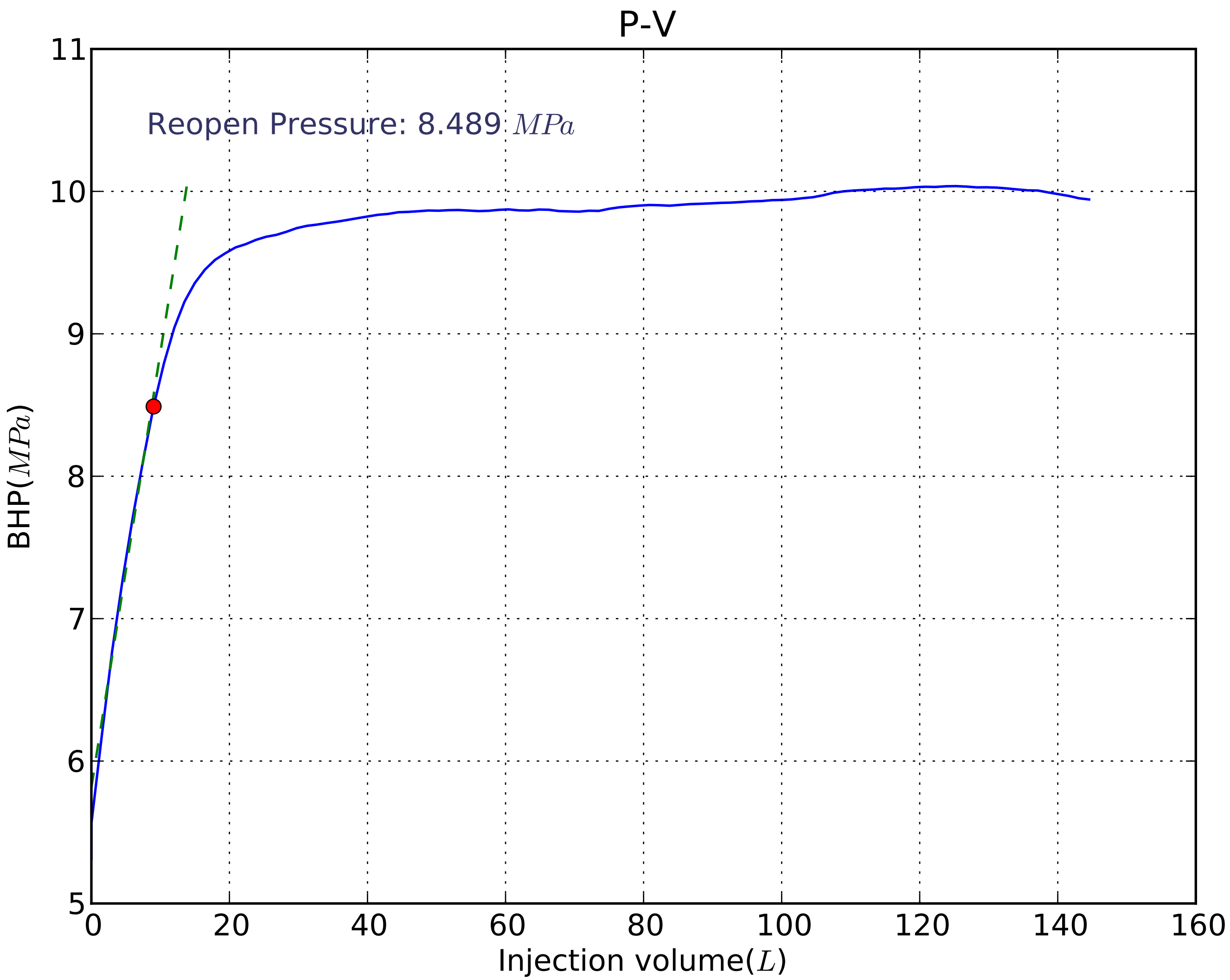


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 03

BitCan
Geosciences & Engineering Inc.

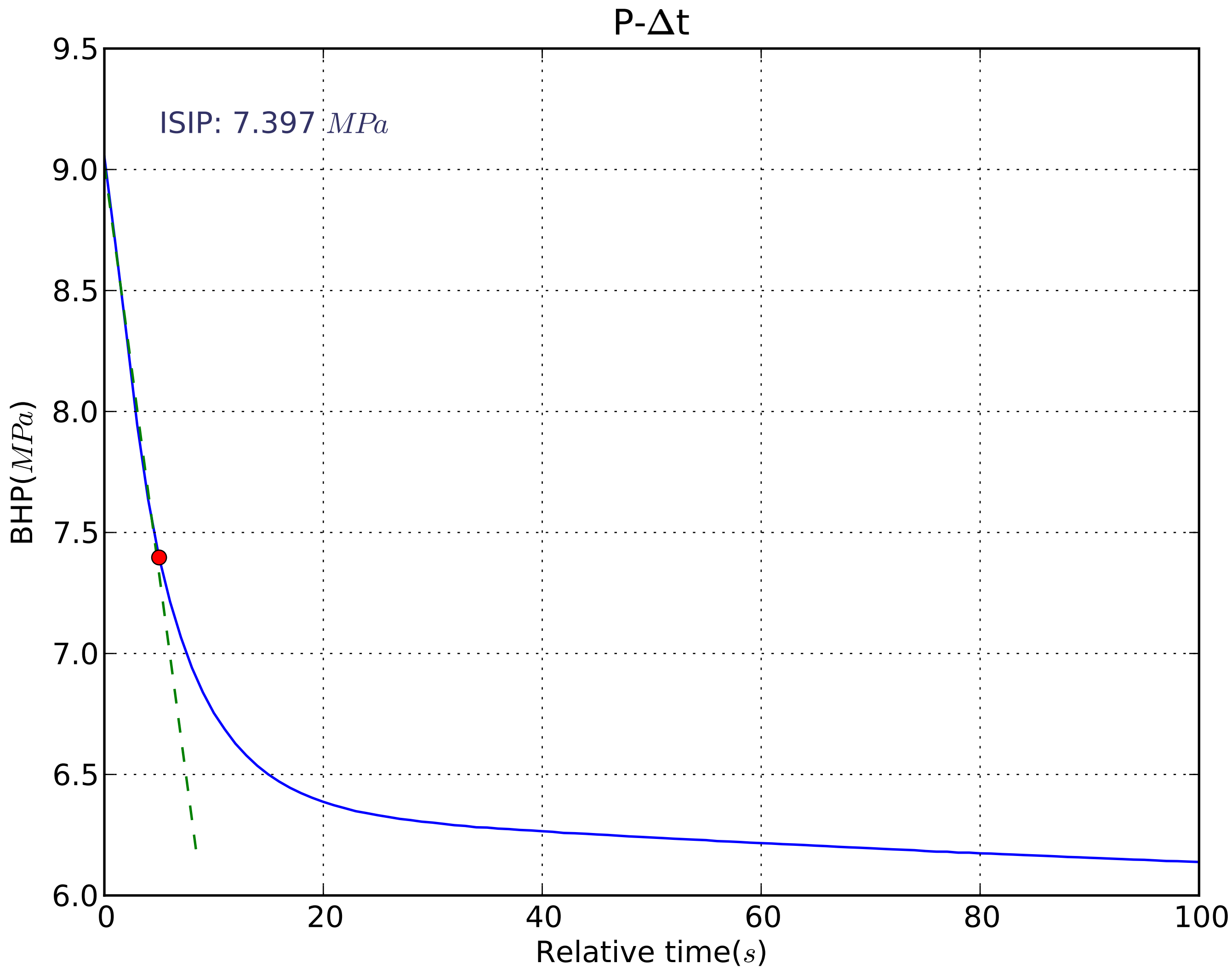


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 03

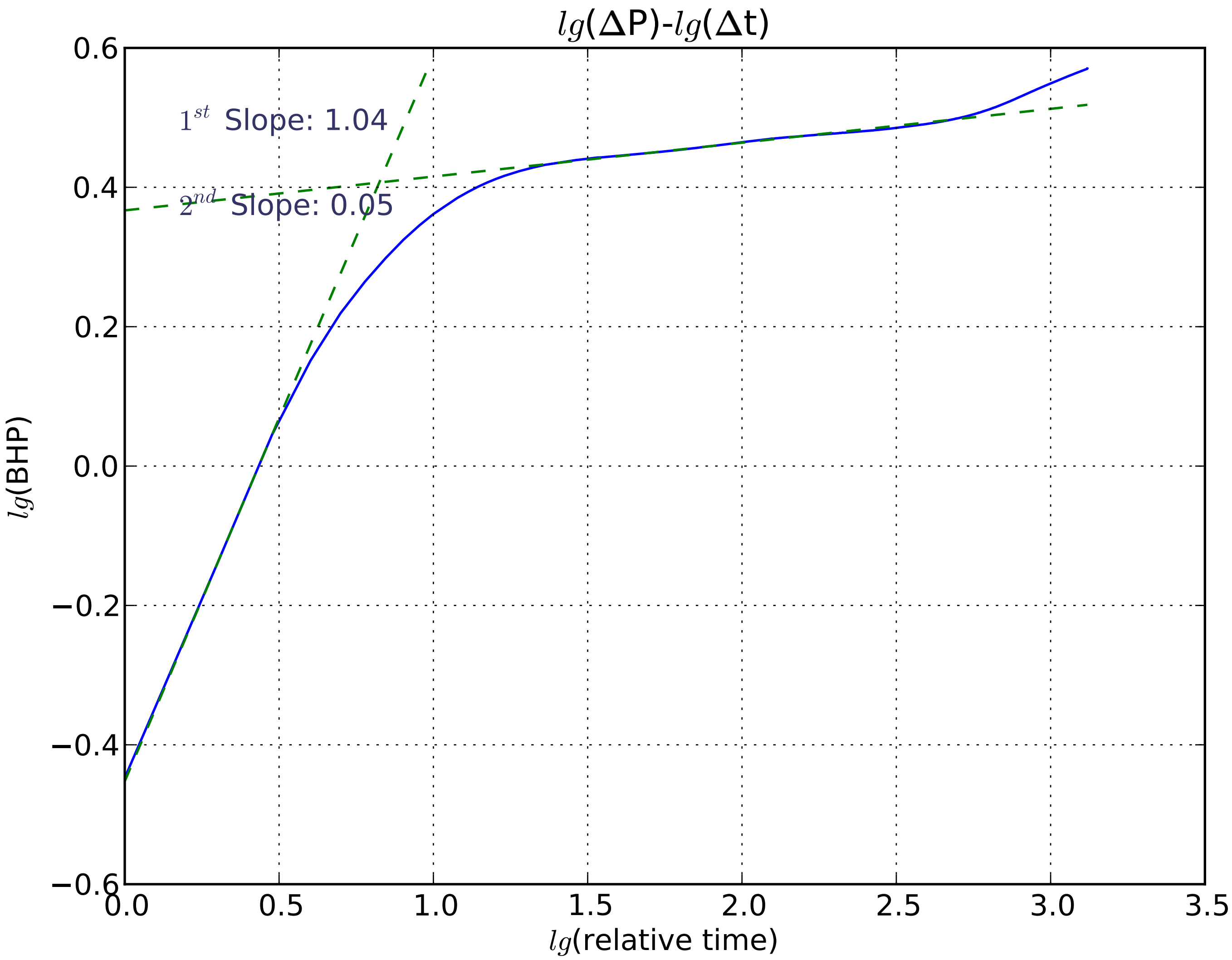


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 03

Geosciences & Engineering Inc.

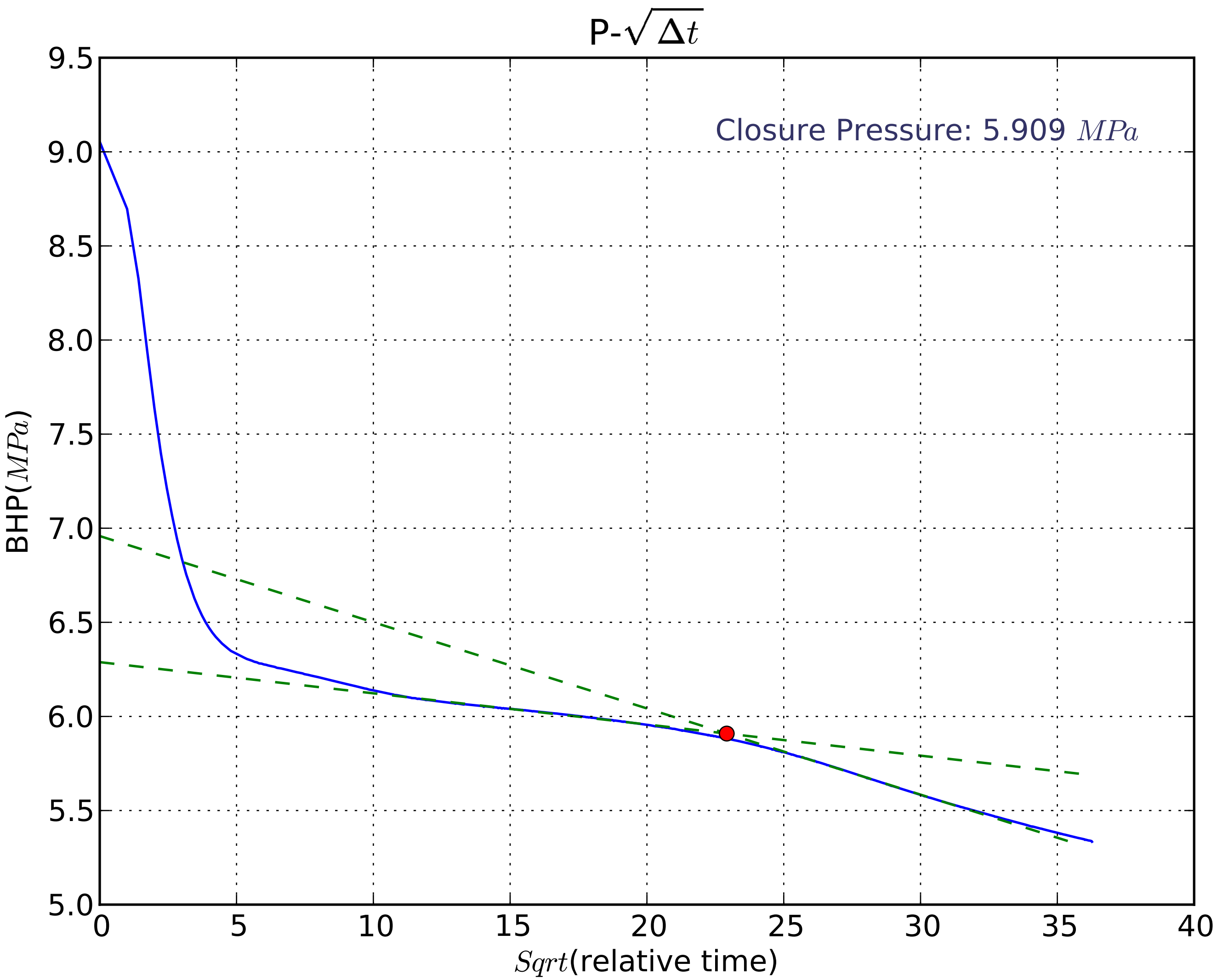


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 03



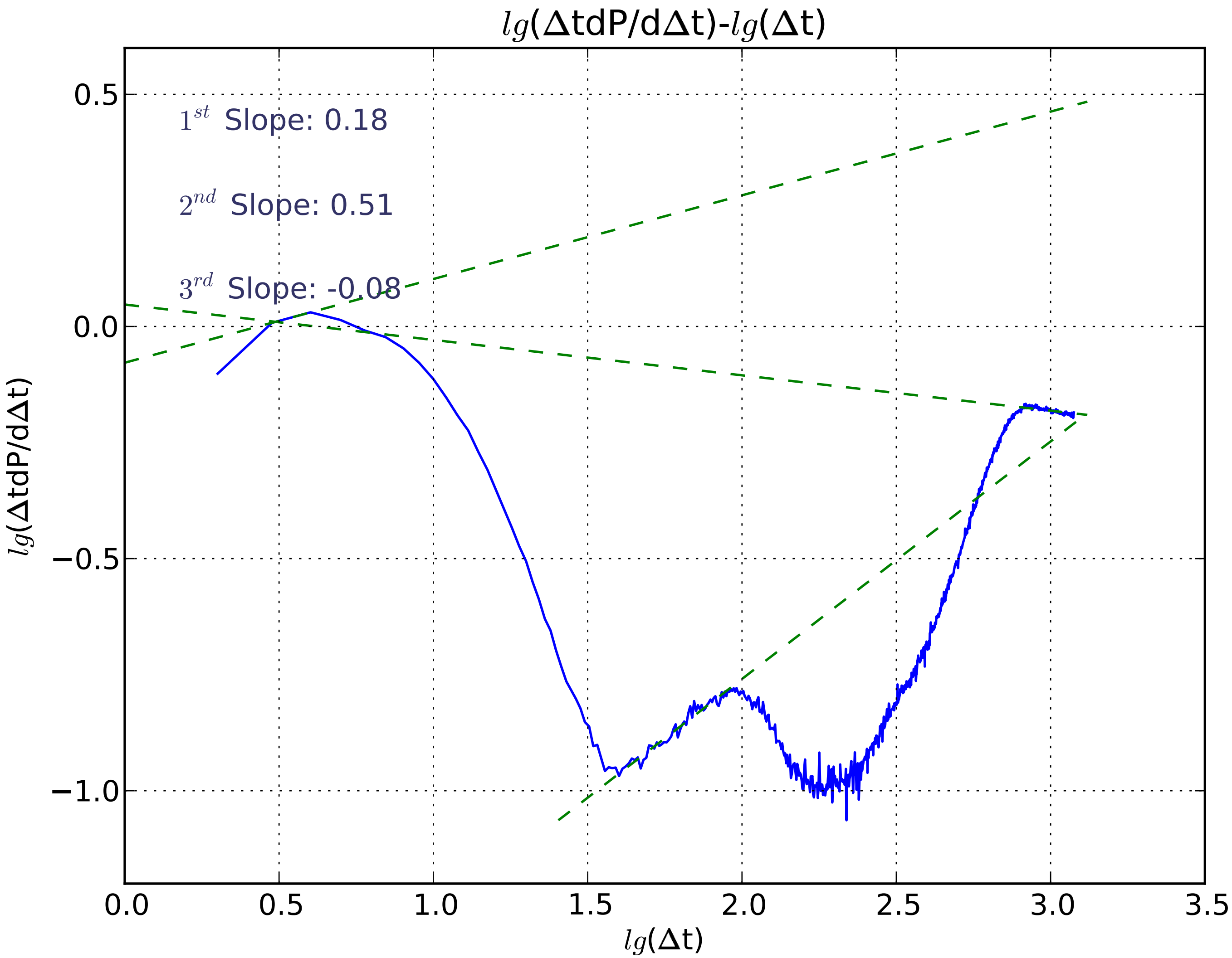
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 03

BitCan
Geosciences & Engineering Inc.



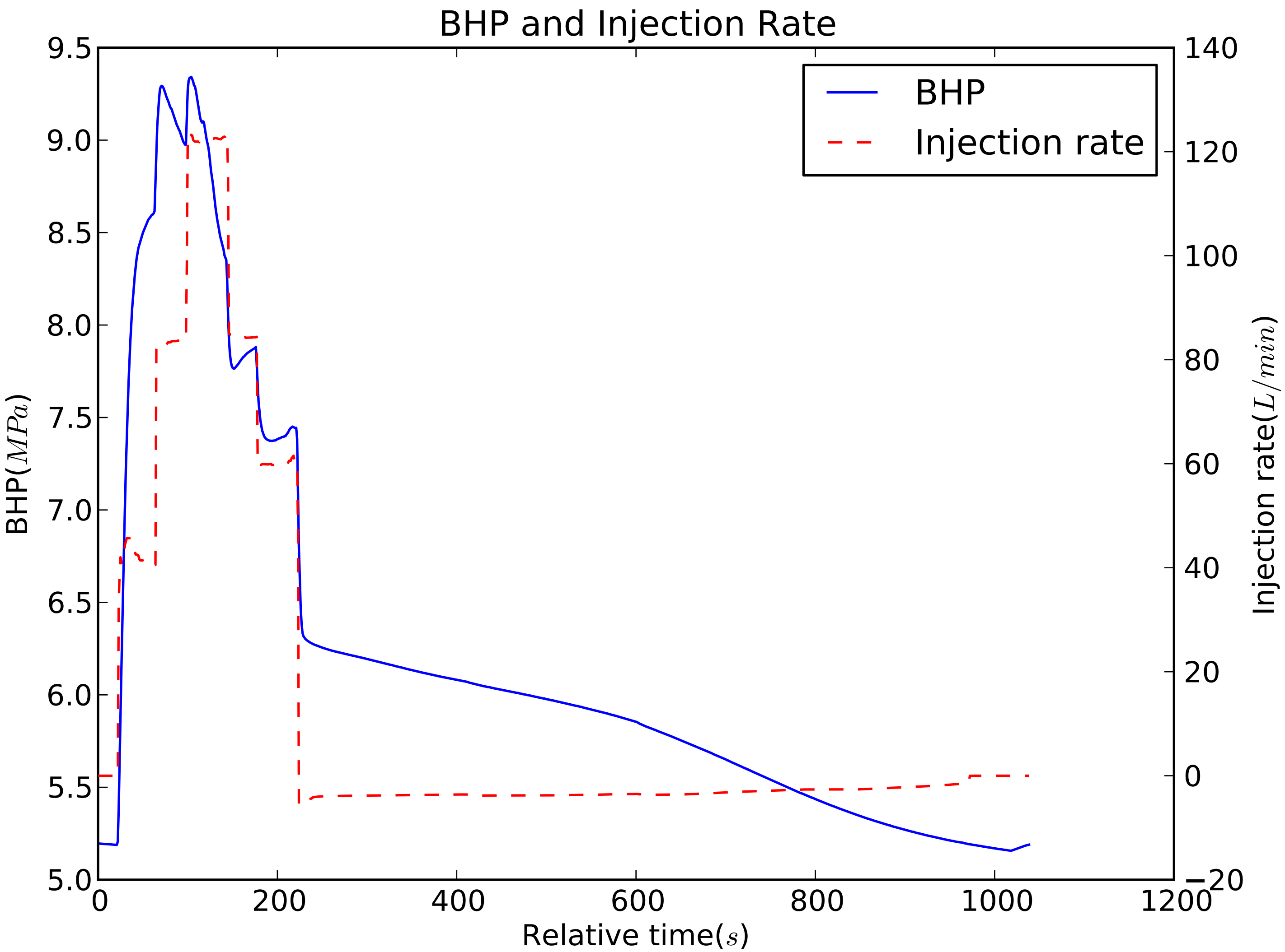
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 03

BitCan
Geosciences & Engineering Inc.

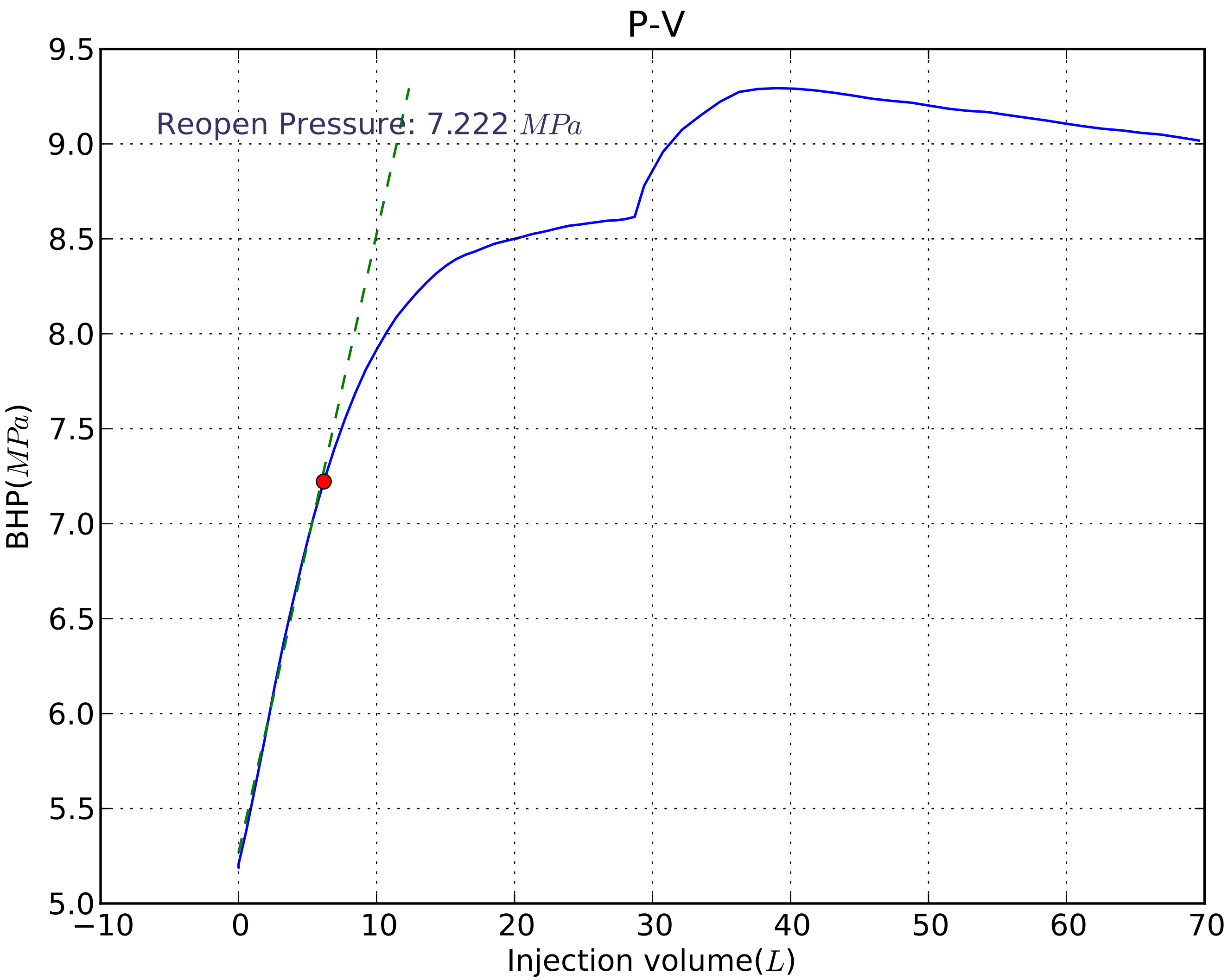


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 04

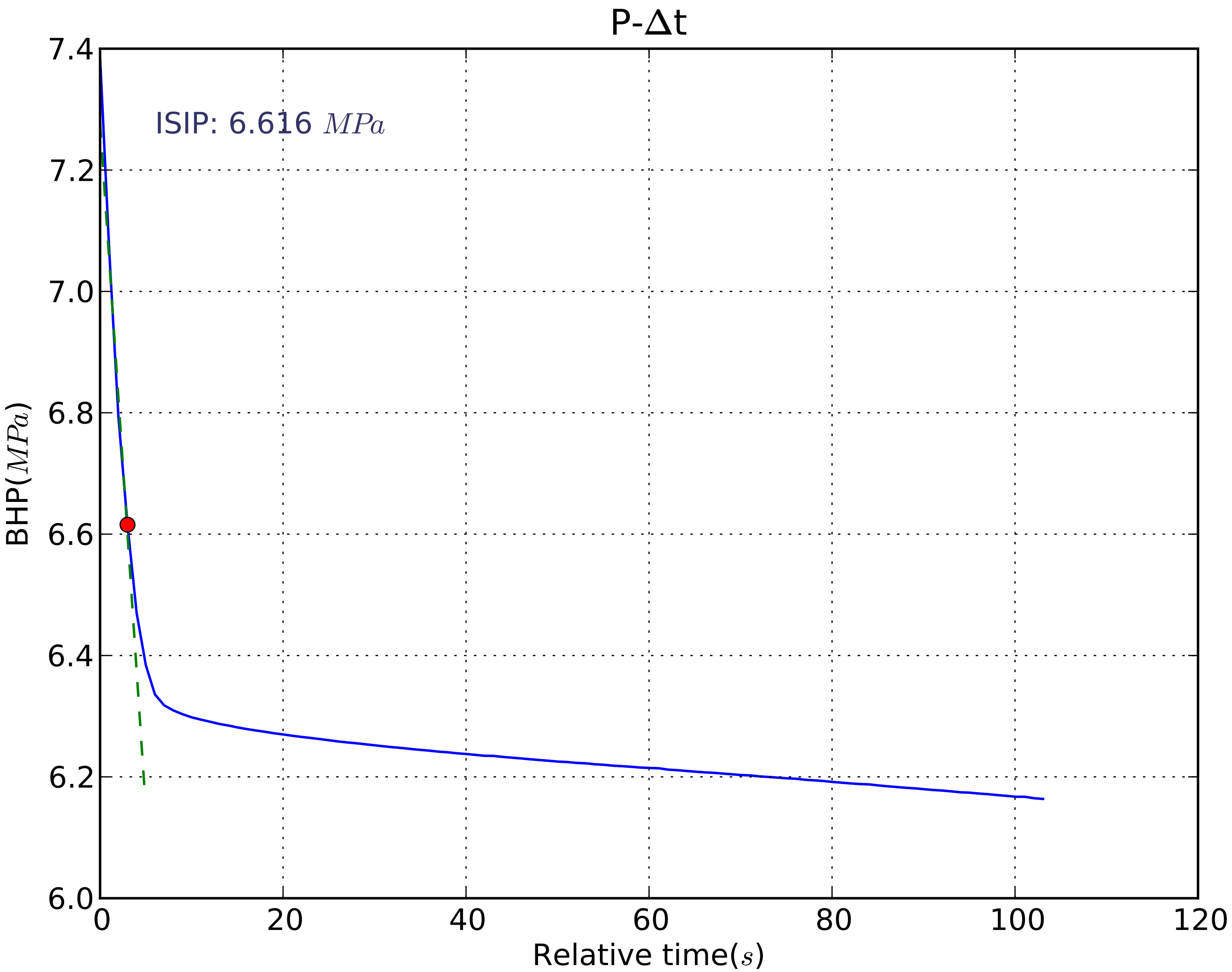
BitCan
Geosciences & Engineering Inc.



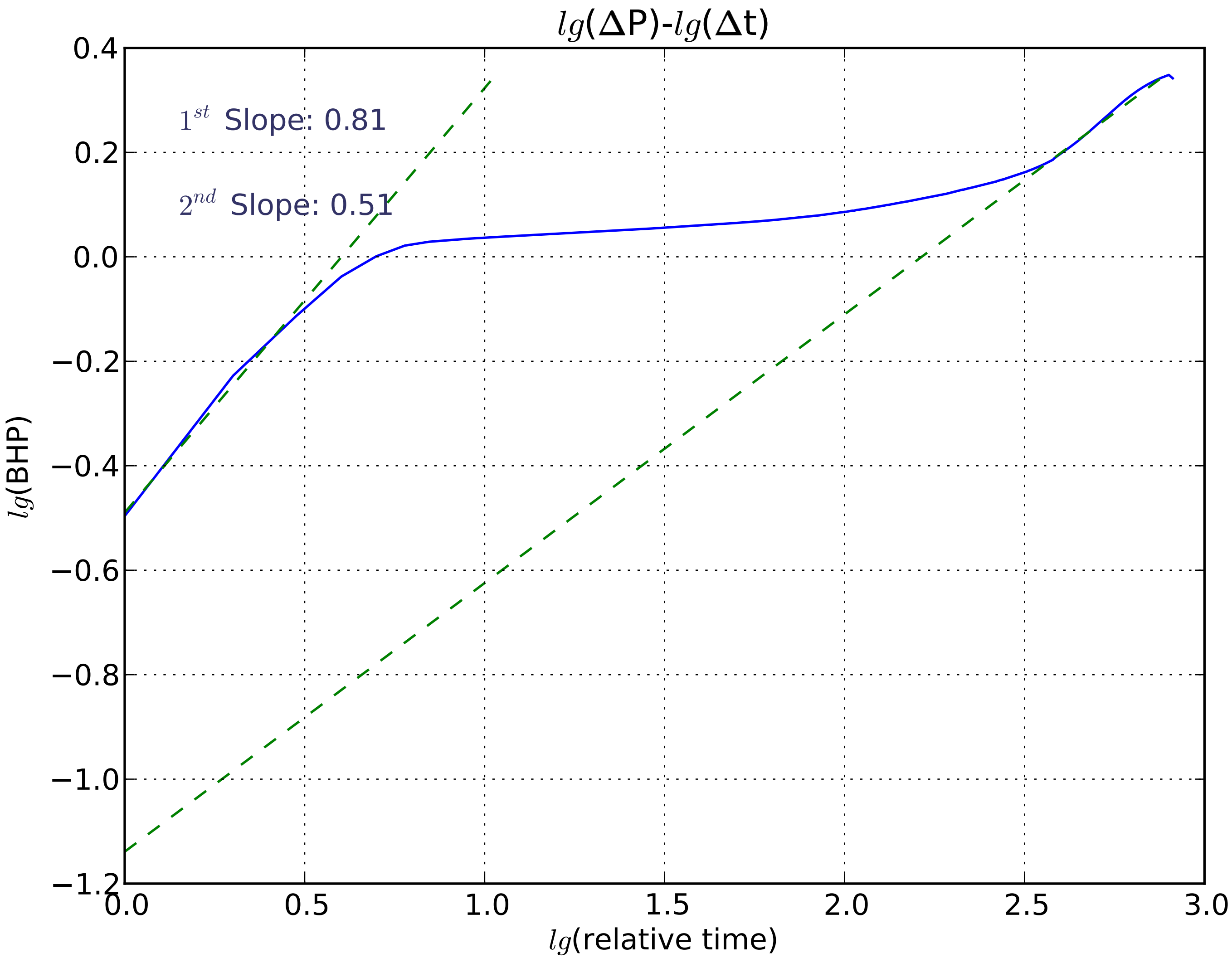
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 04



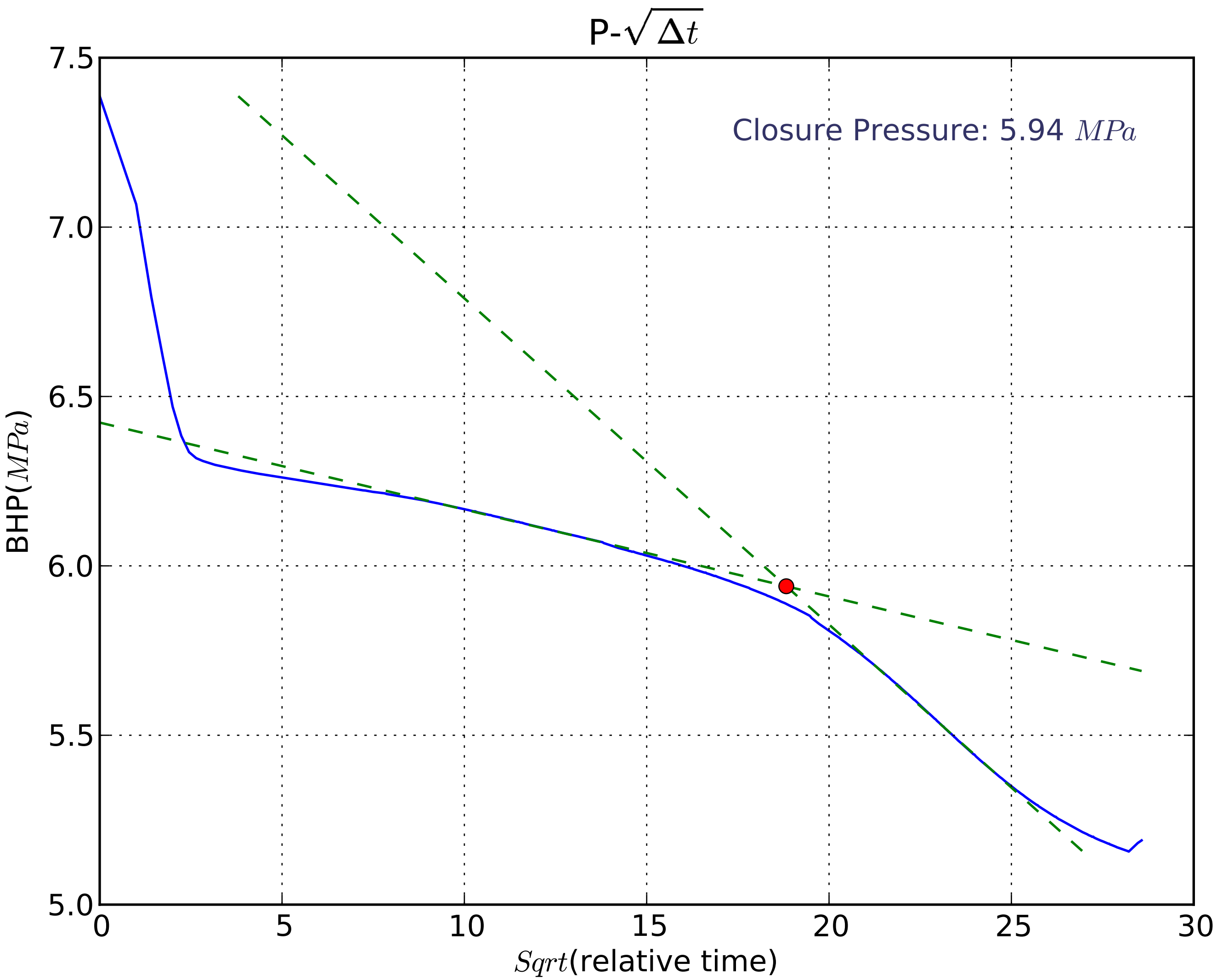
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 04



Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 04

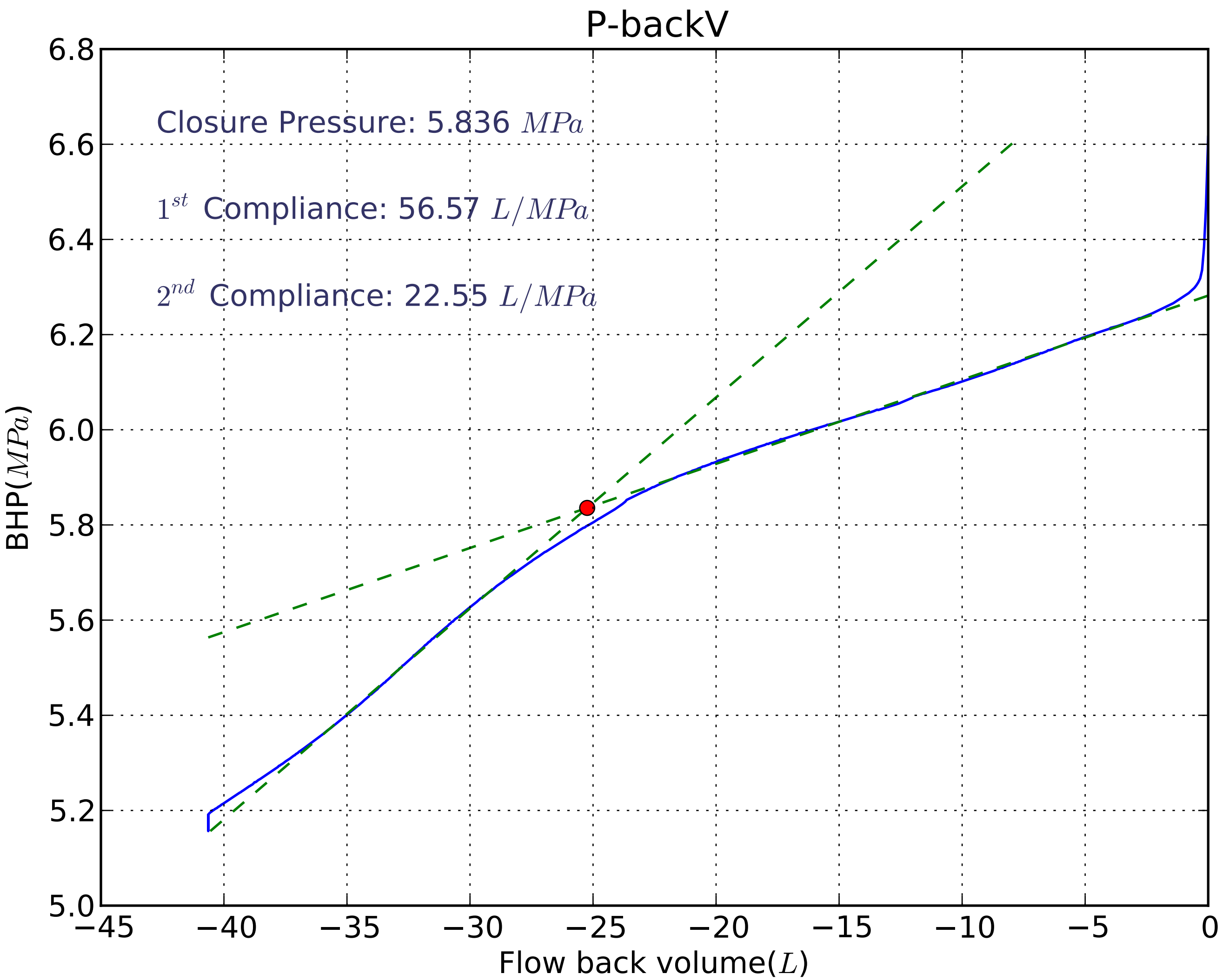


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 04



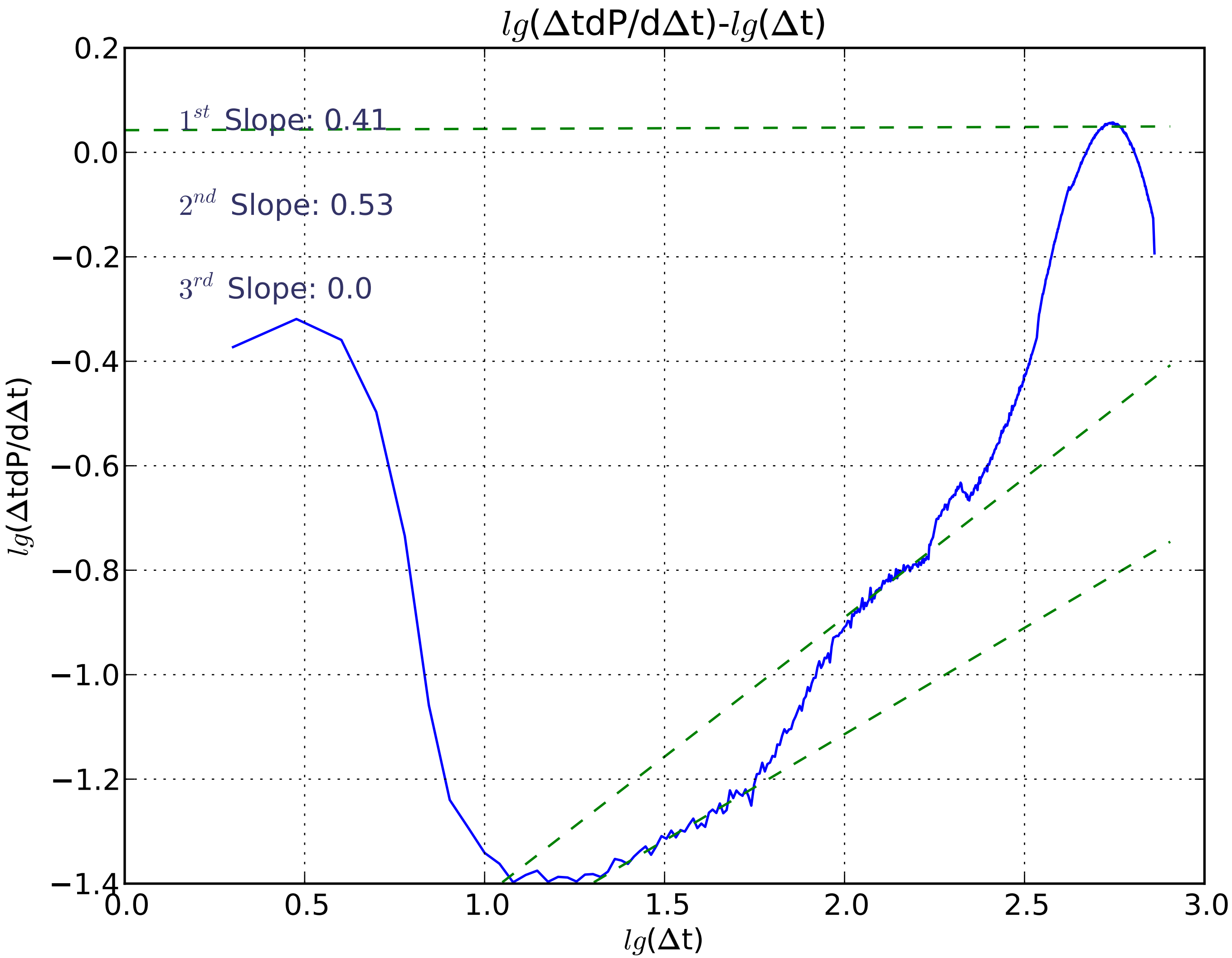
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 04

BitCan
Geosciences & Engineering Inc.



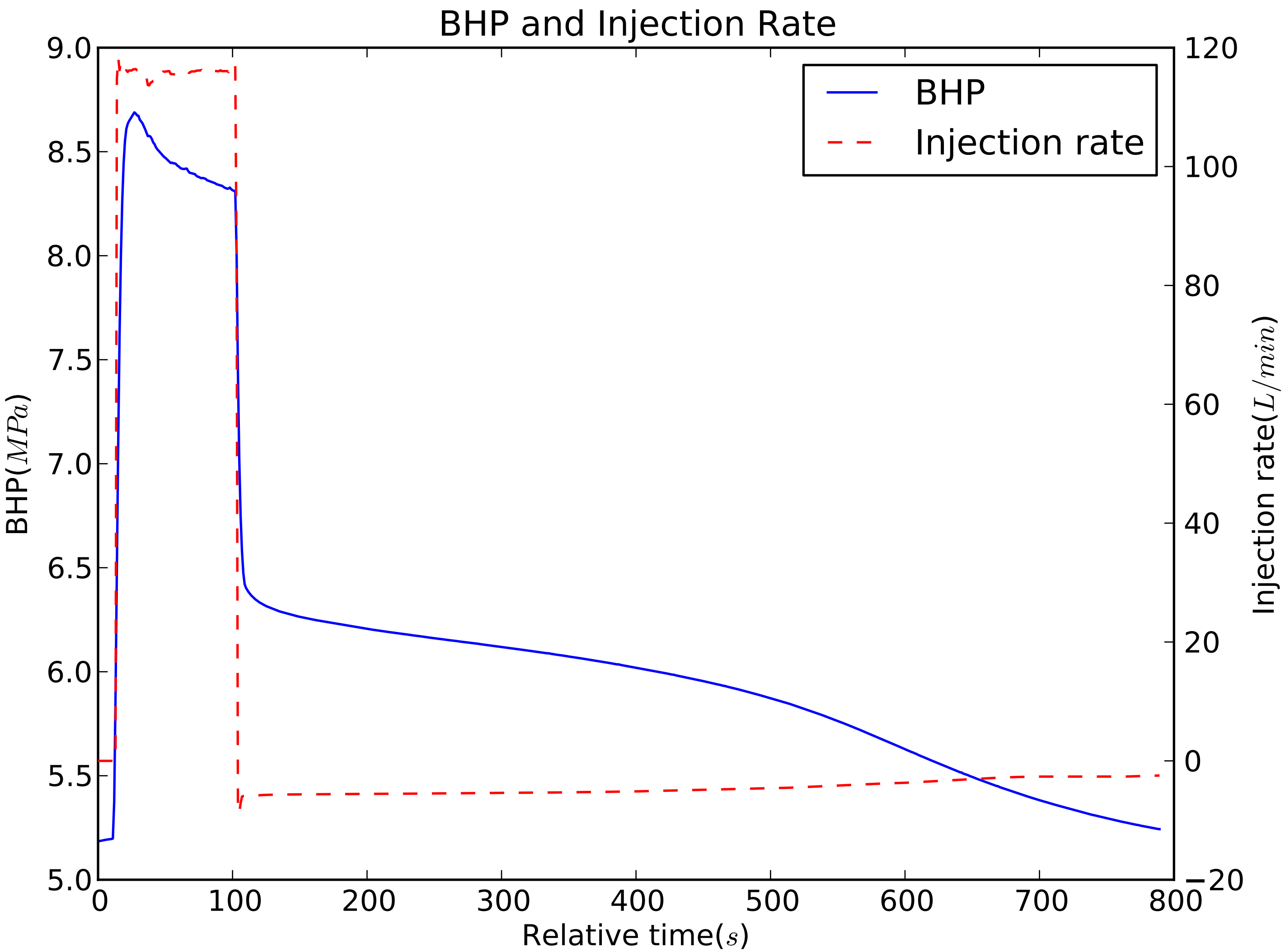
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 04

BitCan
Geosciences & Engineering Inc.



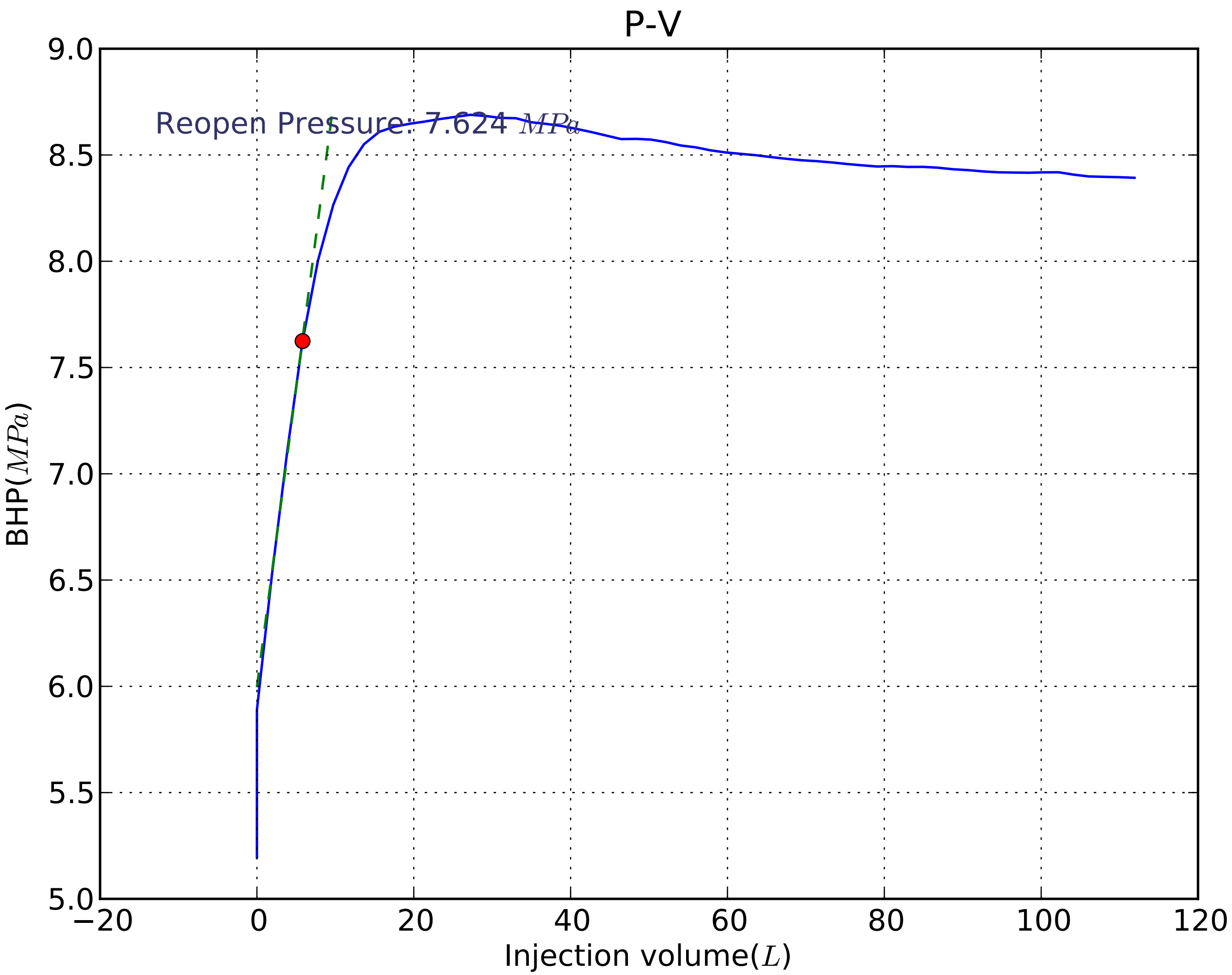
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 05

Geosciences & Engineering Inc.

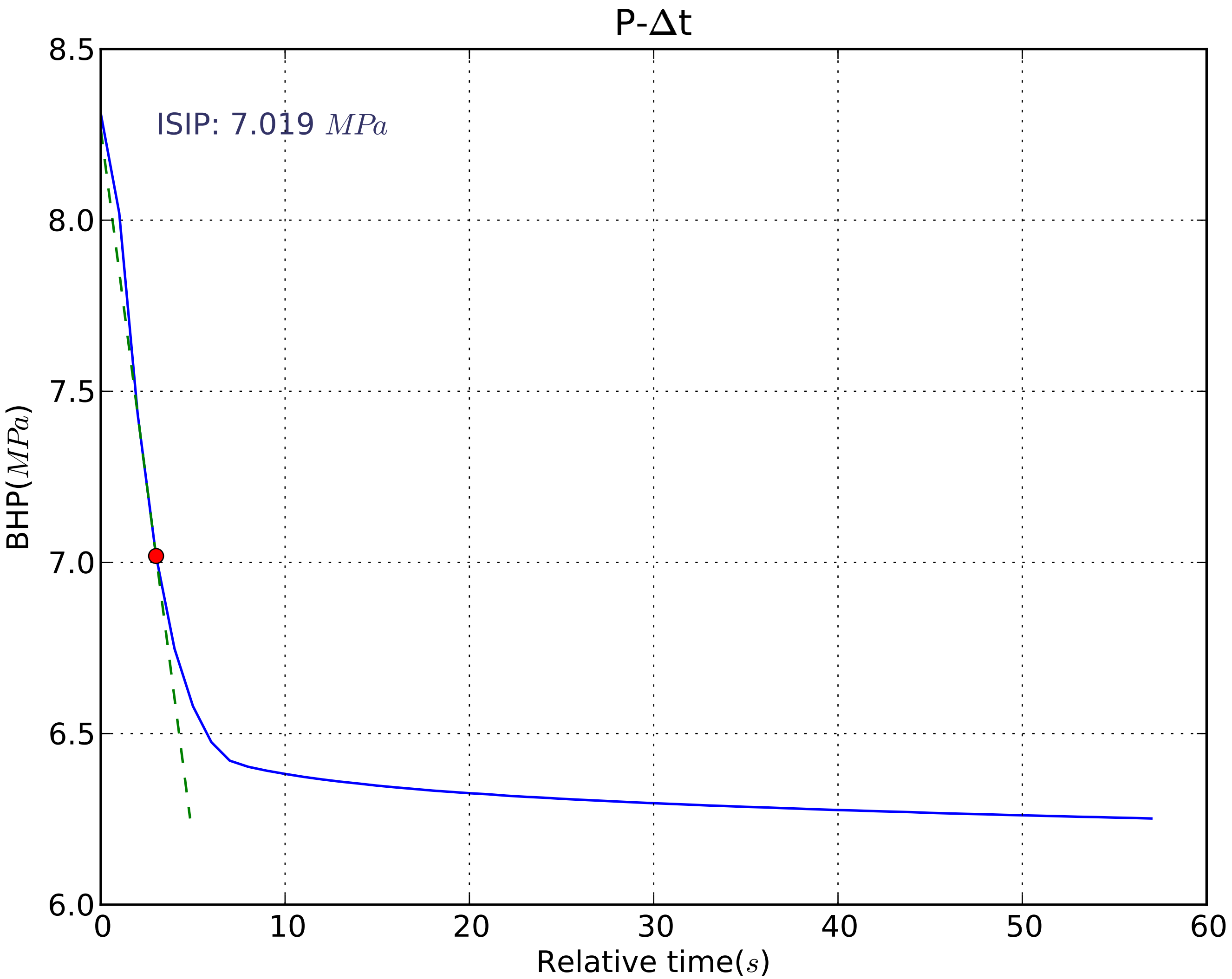


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 05

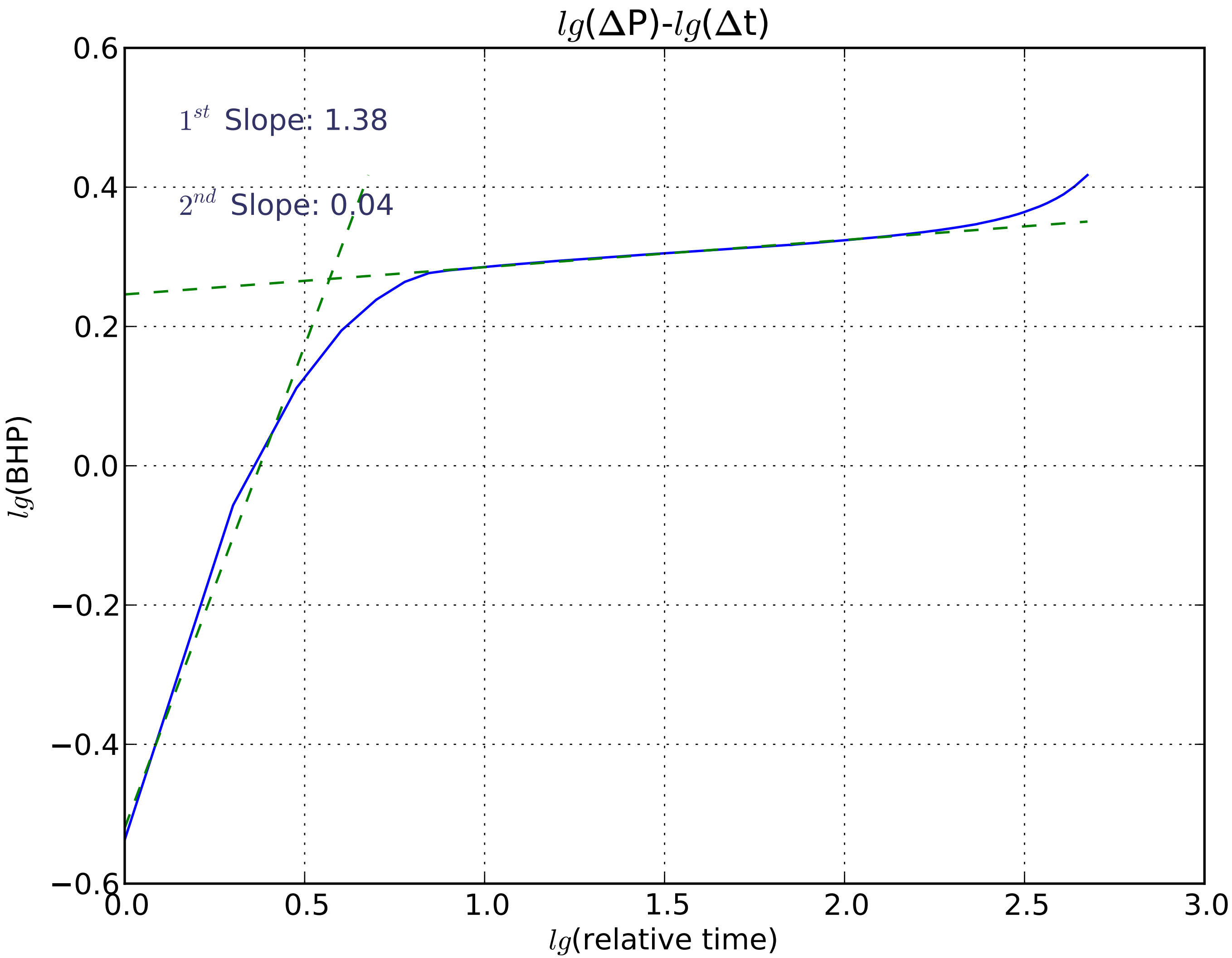
BitCan
Geosciences & Engineering Inc.



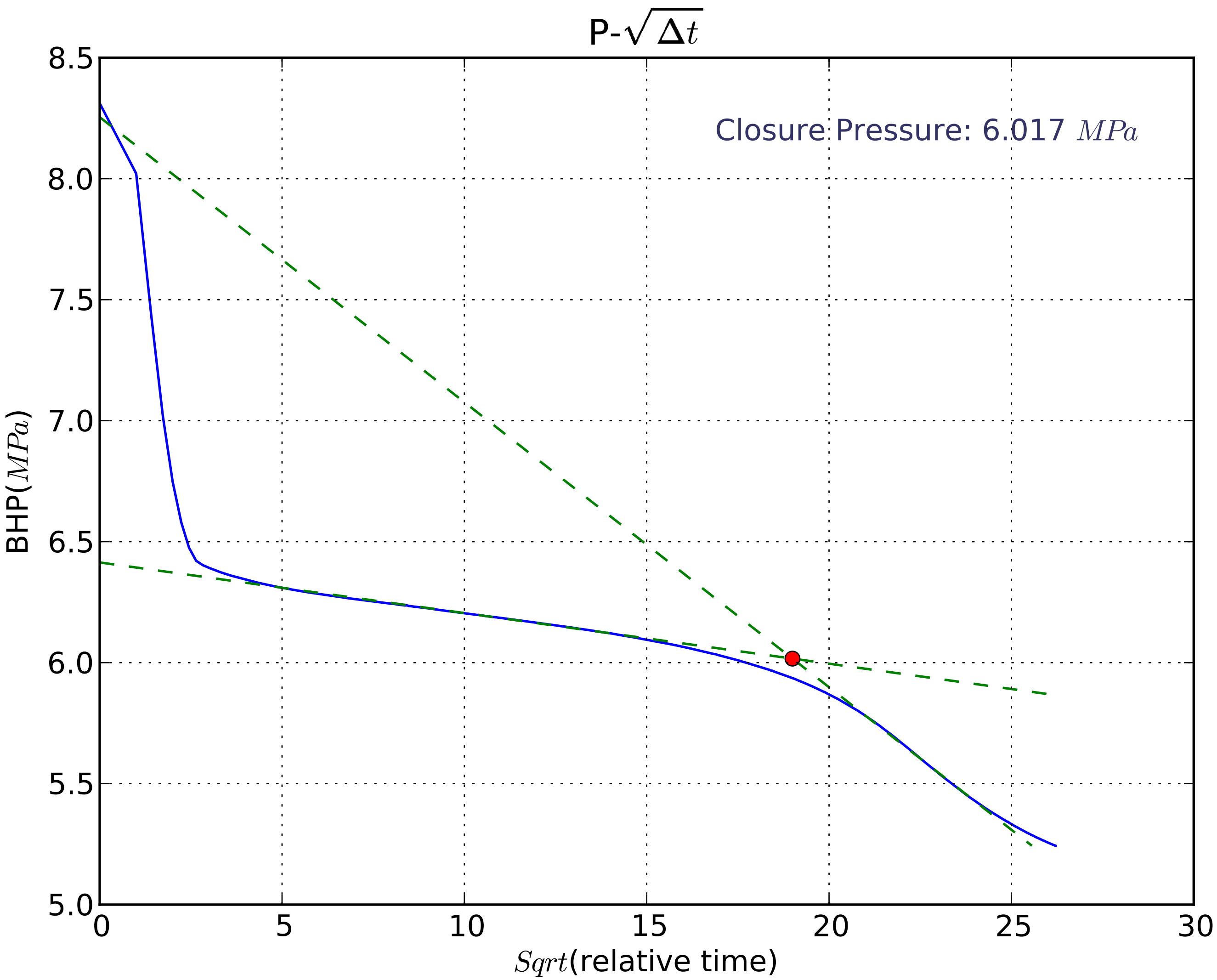
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 05



Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 05

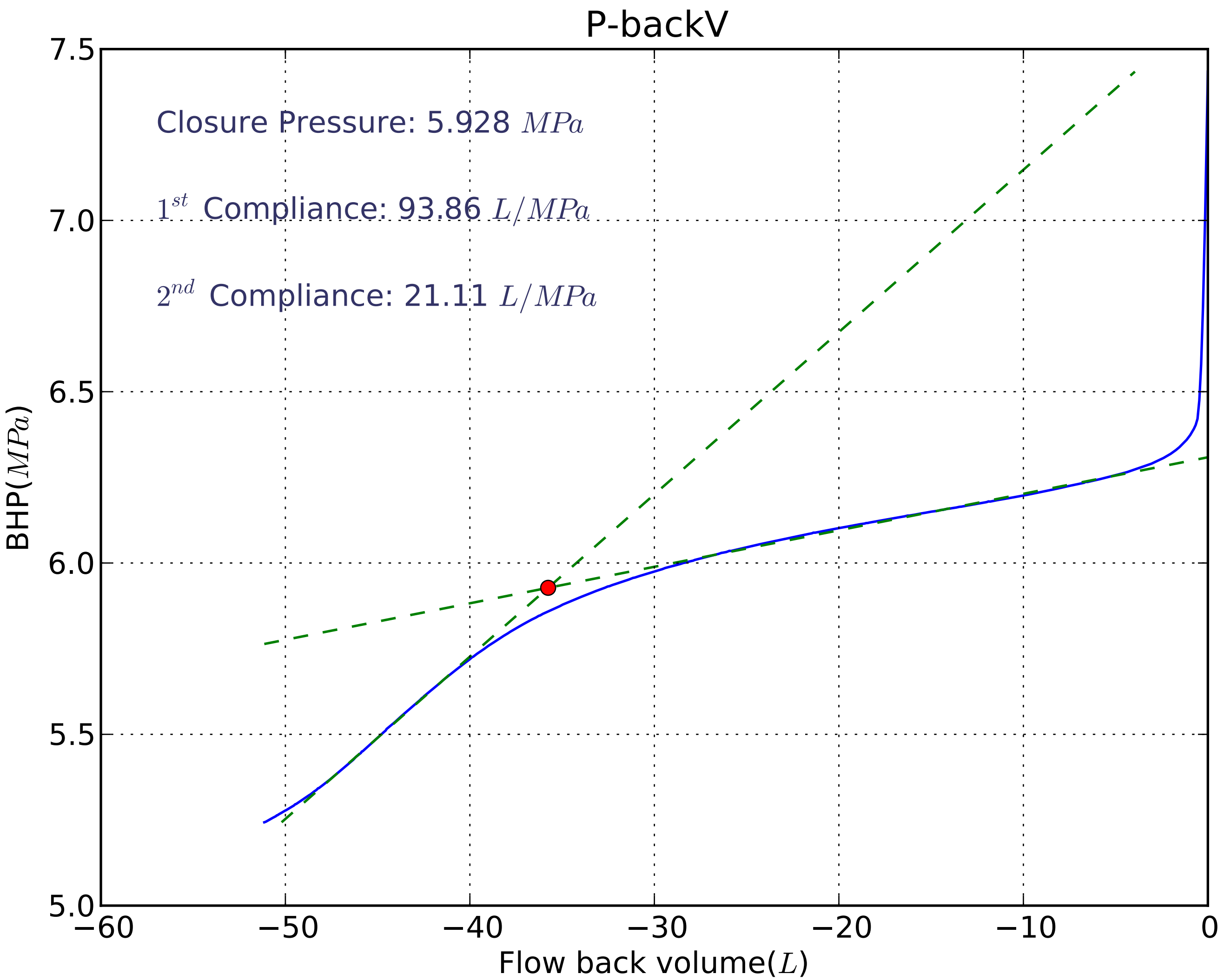


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 05



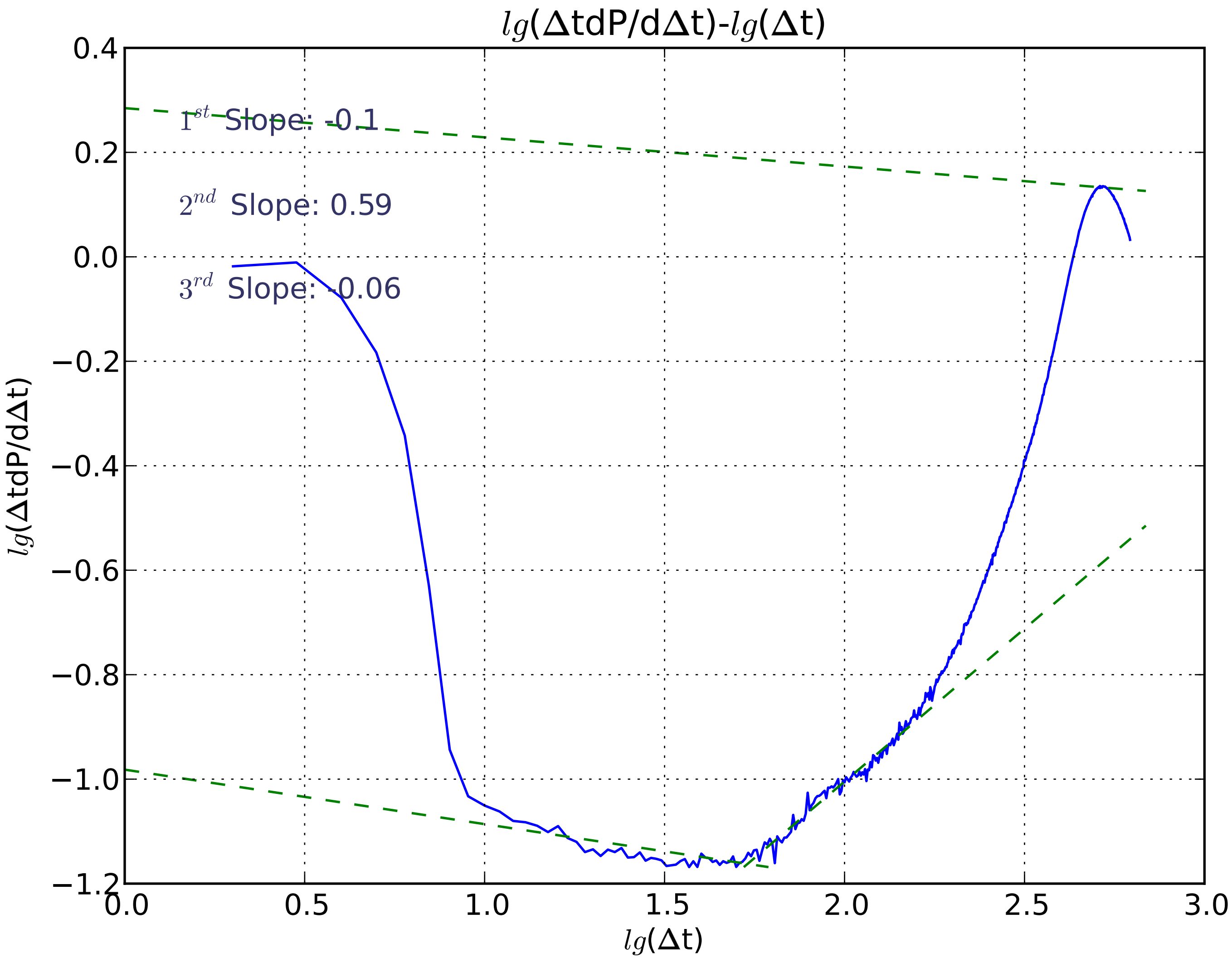
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 05

BitCan
Geosciences & Engineering Inc.



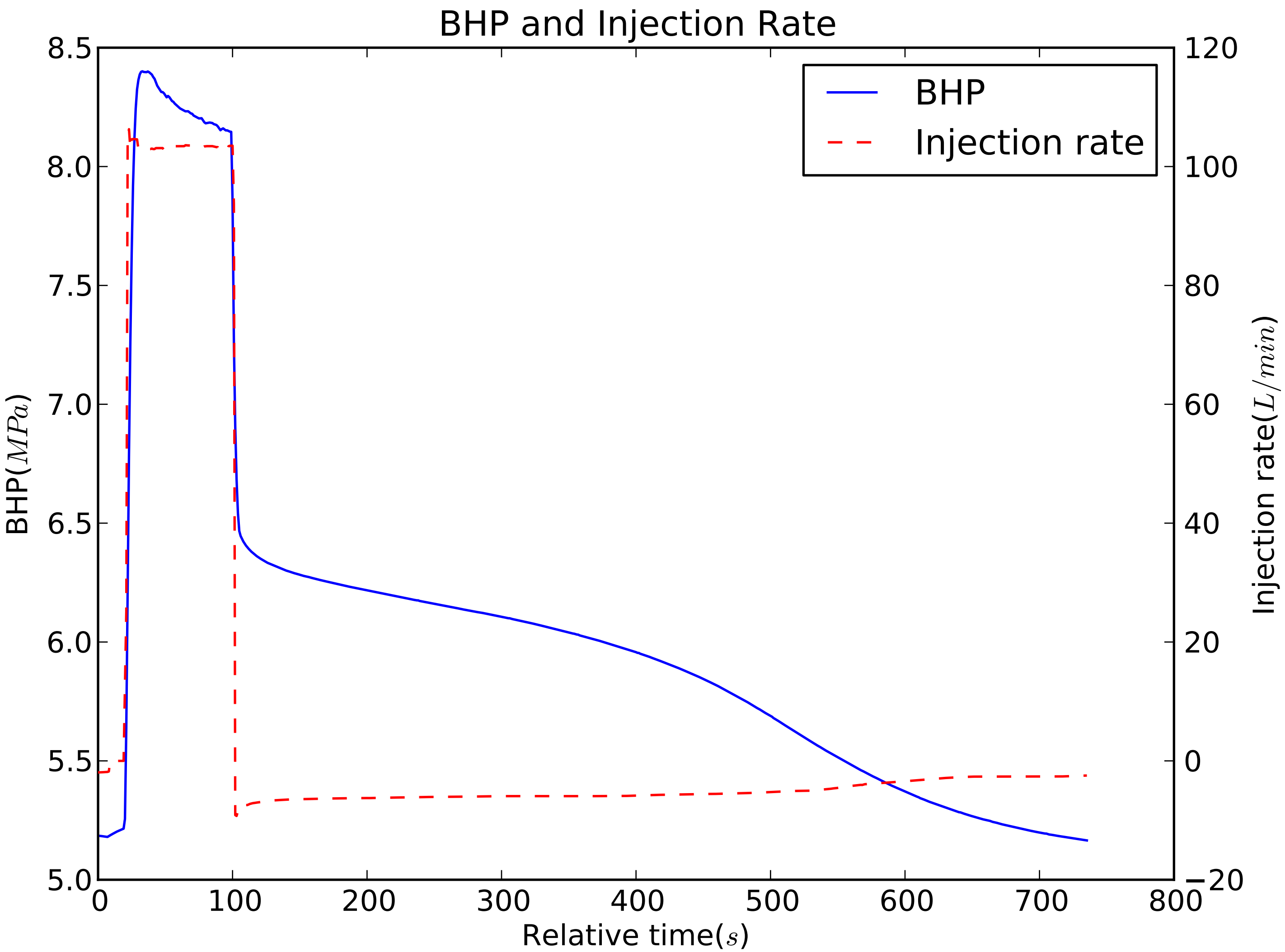
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 05

BitCan
Geosciences & Engineering Inc.

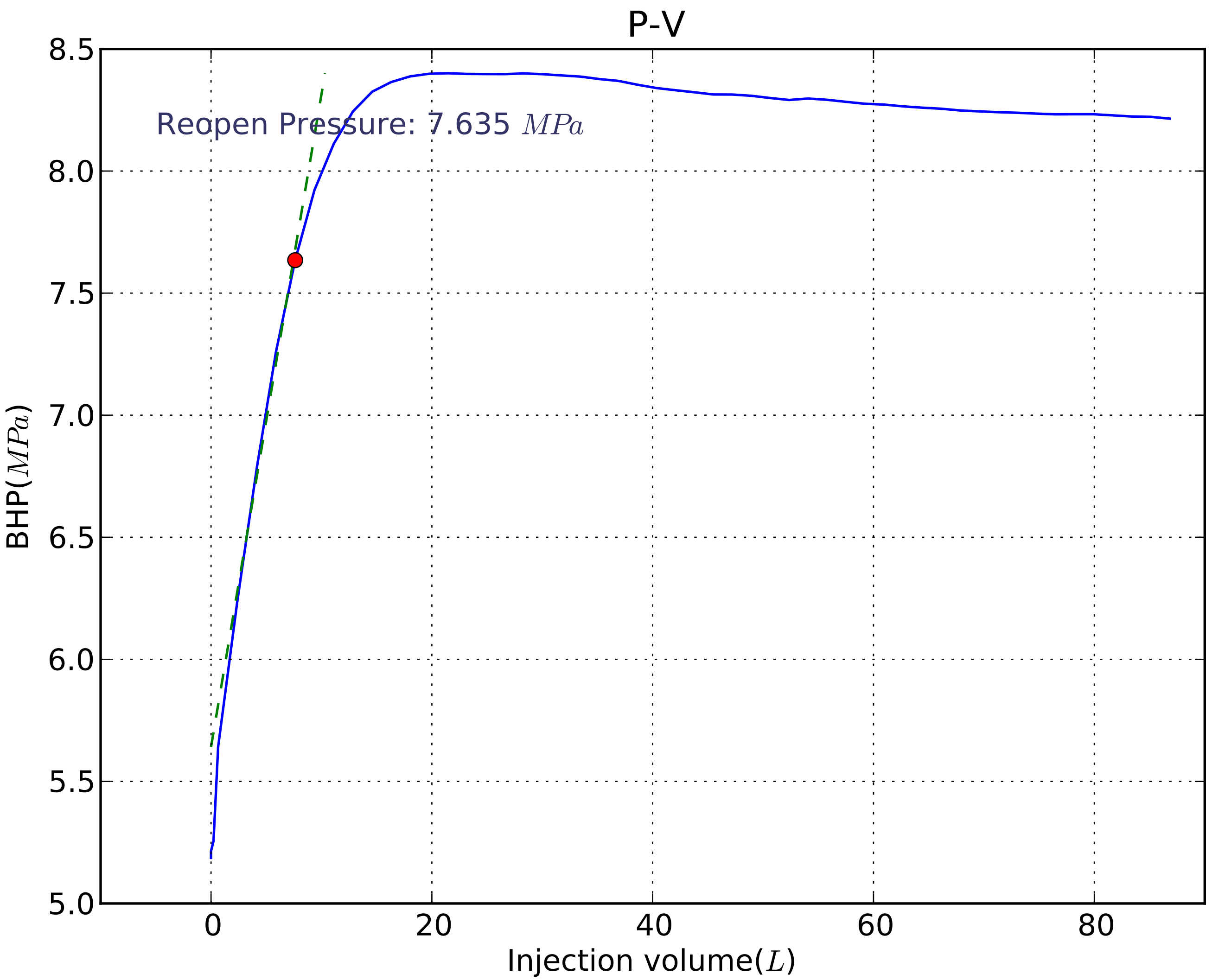


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 06

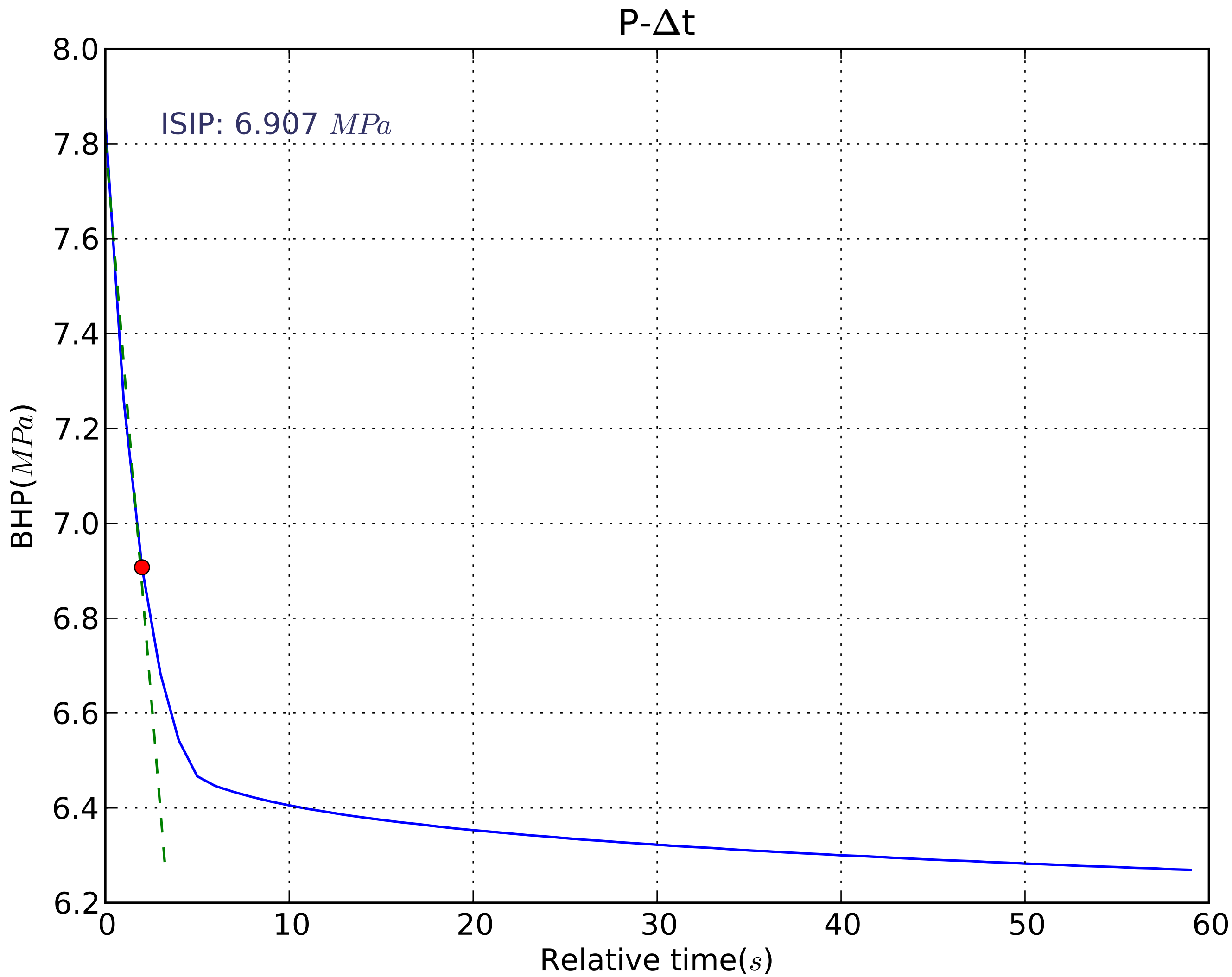
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 06

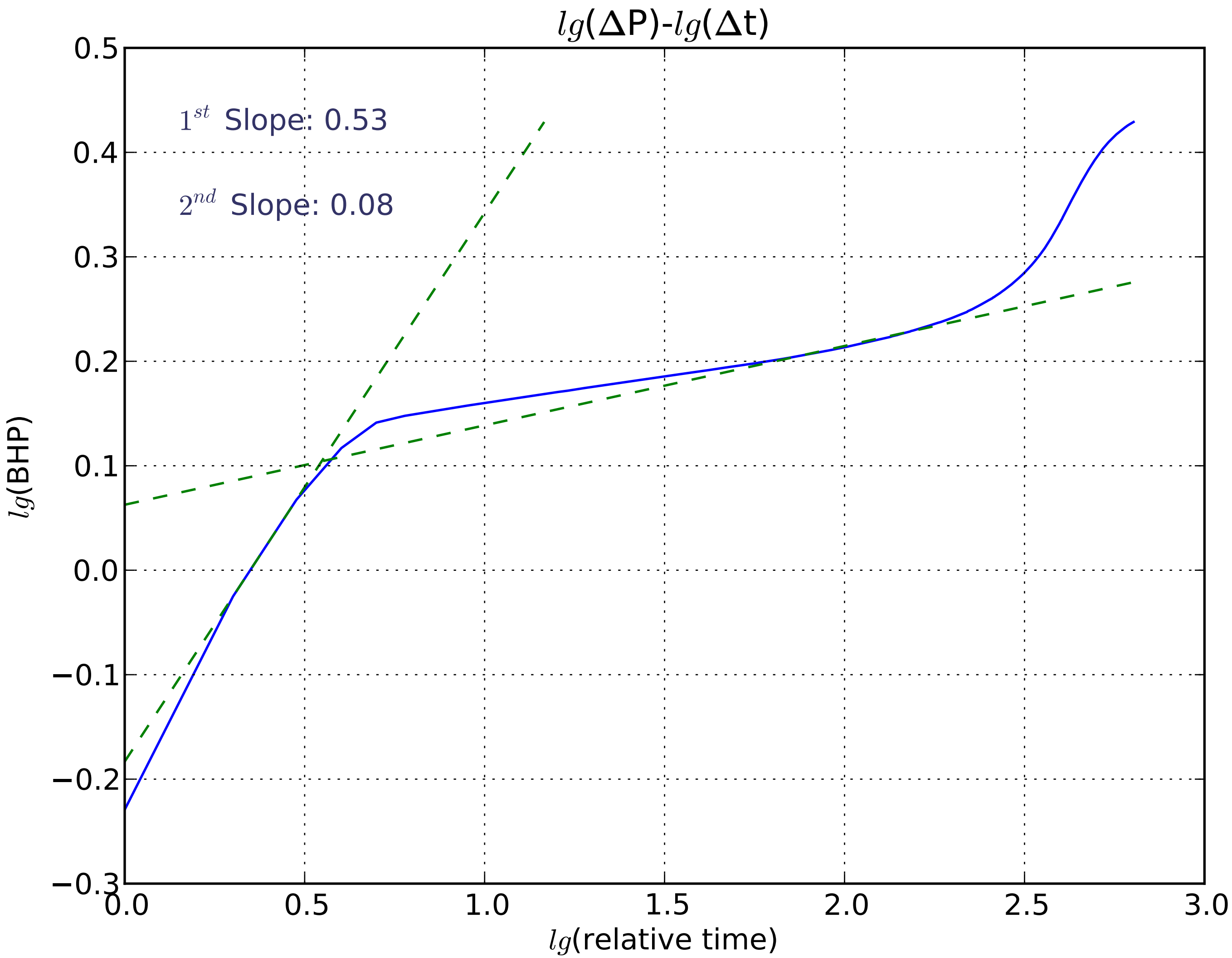


BitCan
Geosciences & Engineering Inc.



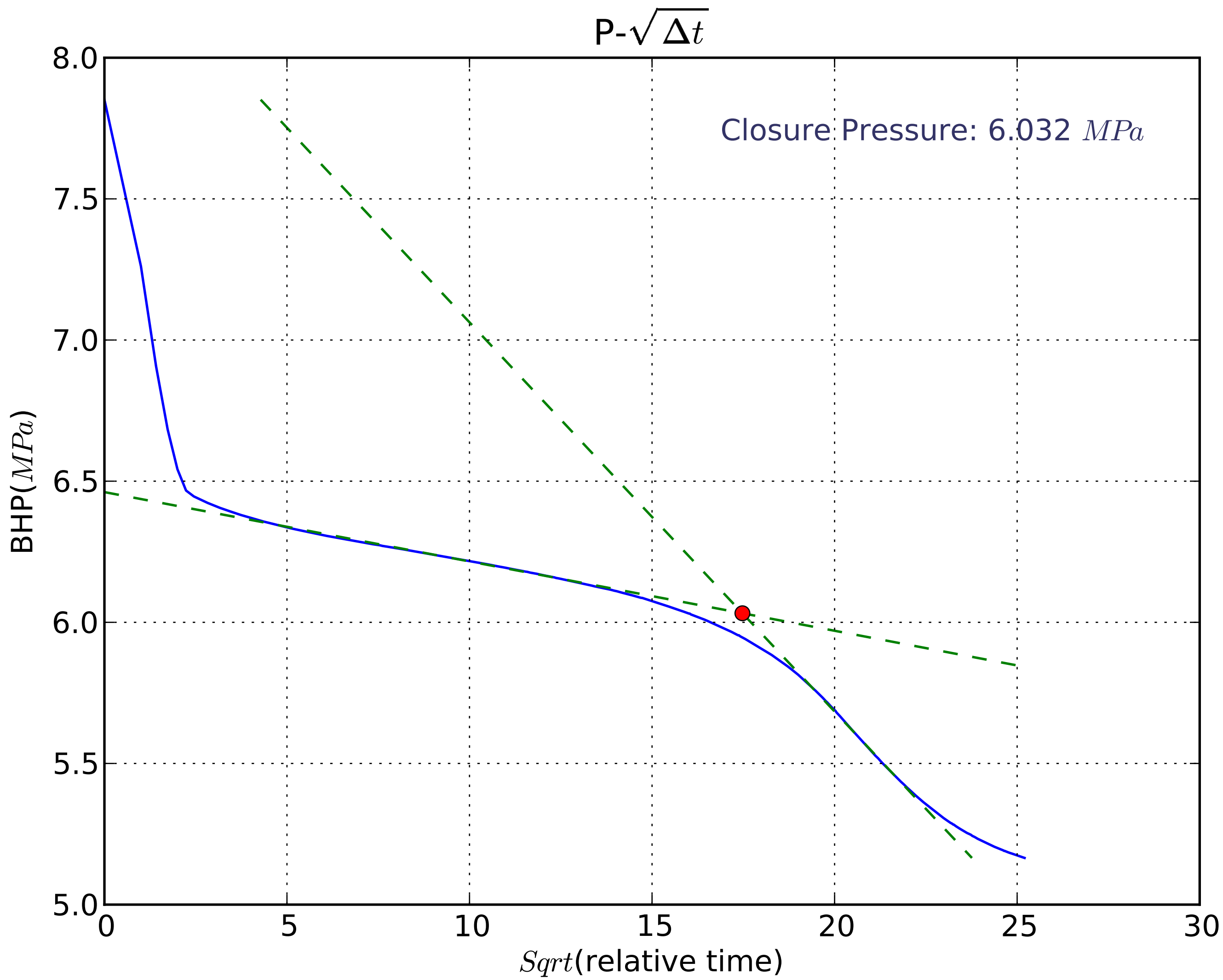
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 06

BitCan
Geosciences & Engineering Inc.



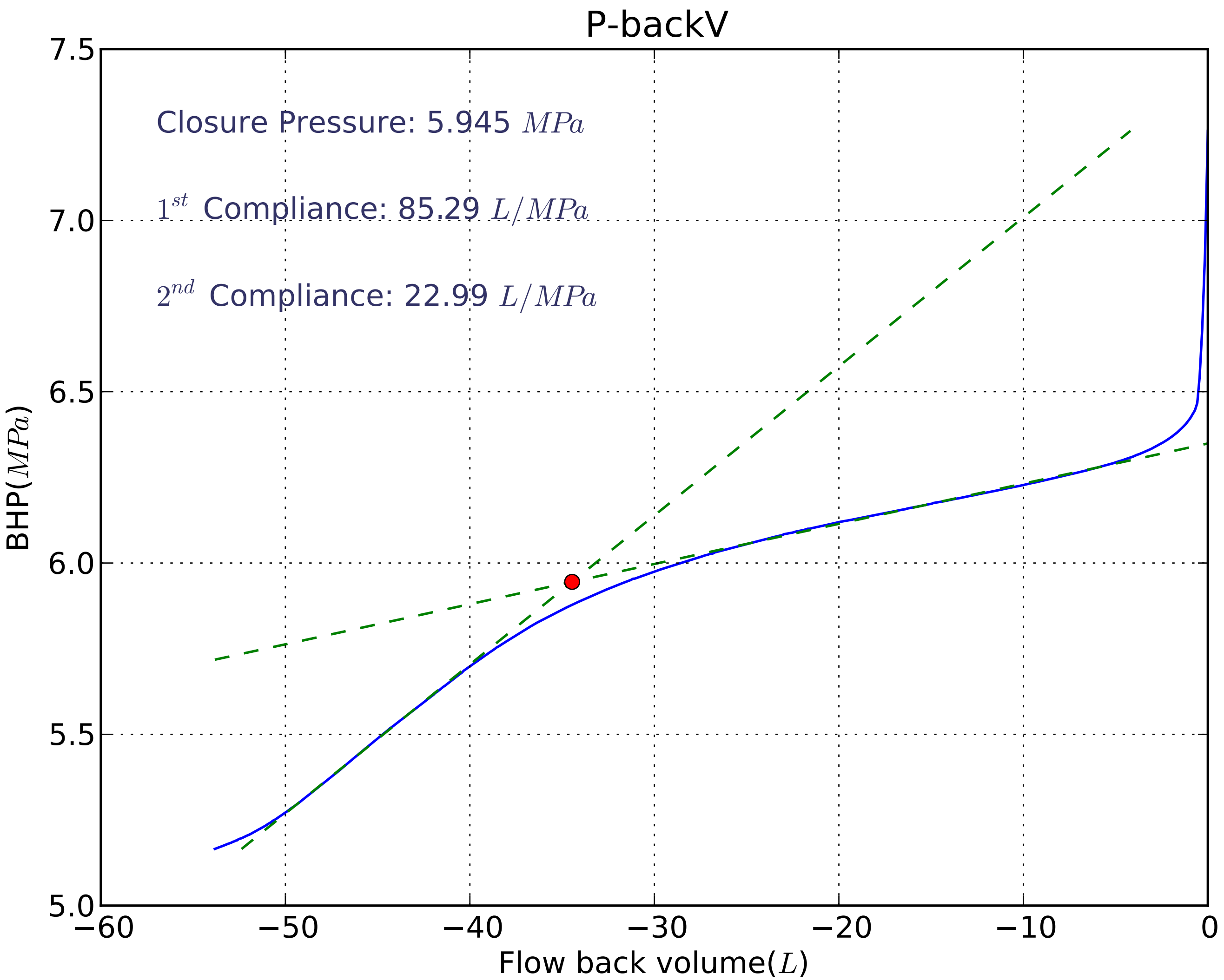
Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 06

BitCan
Geosciences & Engineering Inc.

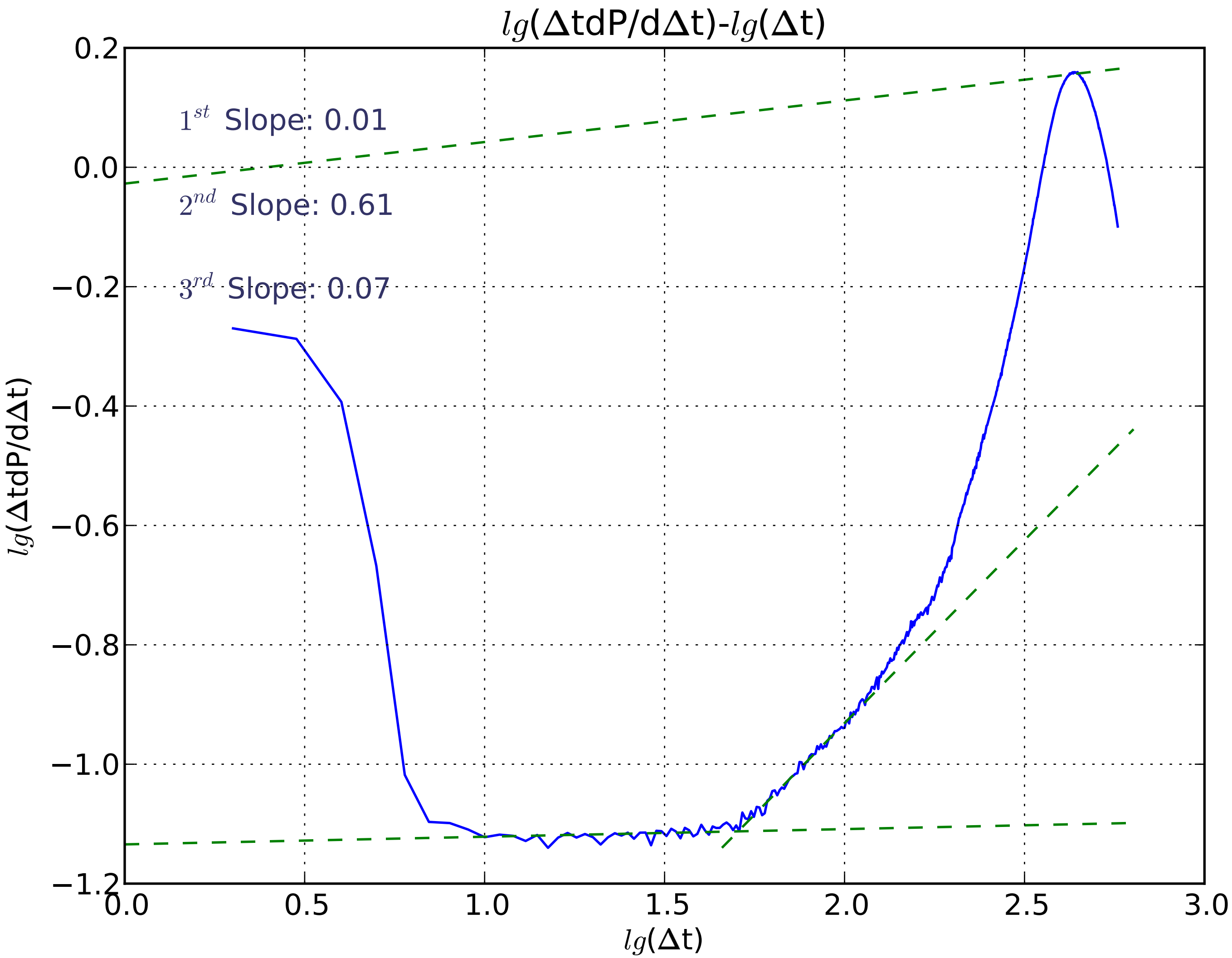


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 06

BitCan
Geosciences & Engineering Inc.

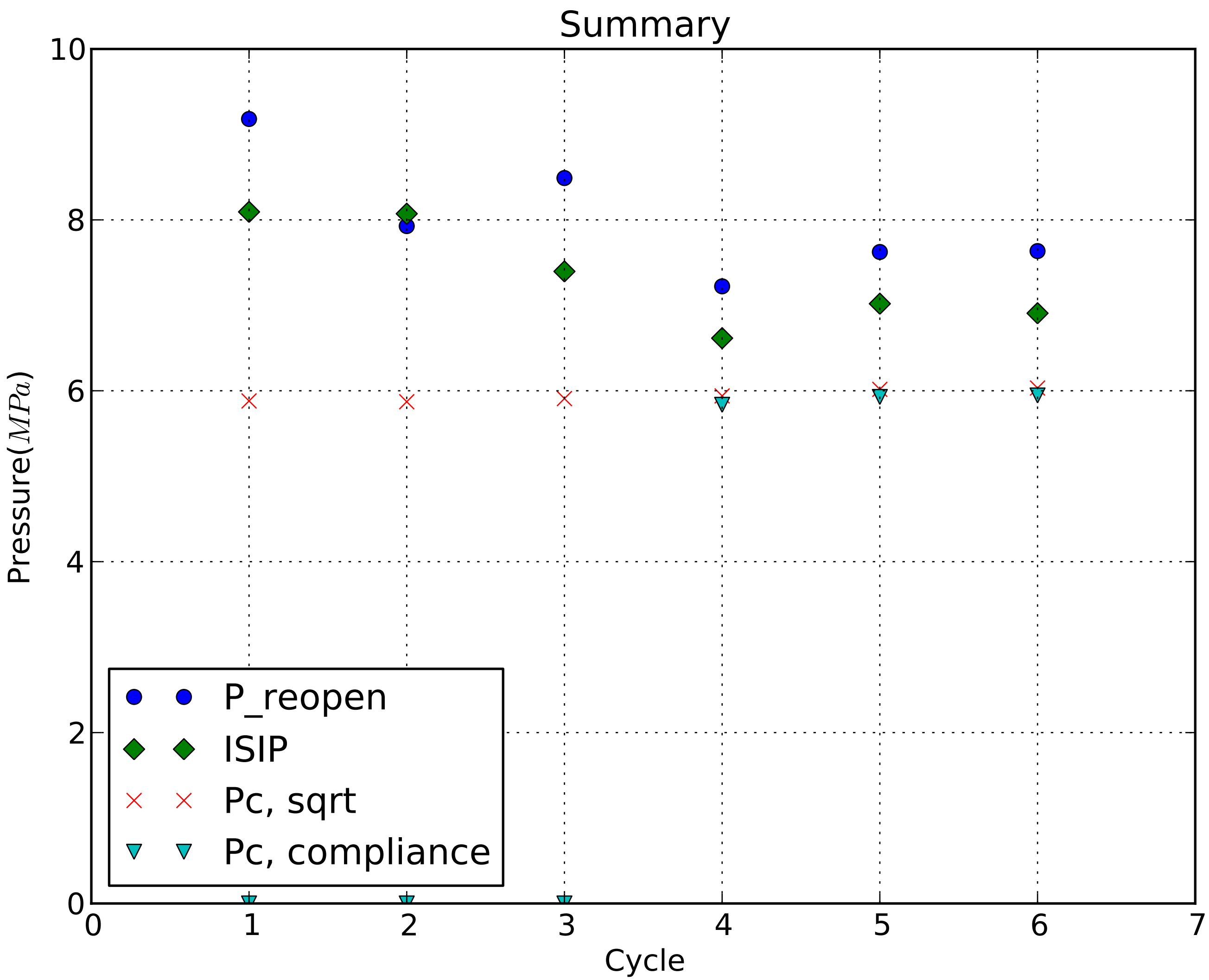


Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 06



Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 1 to 6

BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 512.0m
Formation: LOYD
Cycle: 1 to 6

BitCan
Geosciences & Engineering Inc.

Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	9.180	8.094	5.881	0.000	2.57	0.00	0.00
2	7.927	8.072	5.872	0.000	2.88	0.00	0.00
3	8.489	7.397	5.909	0.000	3.27	0.00	0.00
4	7.222	6.616	5.940	5.836	3.07	56.57	22.55
5	7.624	7.019	6.017	5.928	3.55	93.86	21.11
6	7.635	6.907	6.032	5.945	3.74	85.29	22.99

Previous View

ANALYSIS PLOTS

WELL: PENGROWTH LNDBRGH WELL 13-13-58-5W4

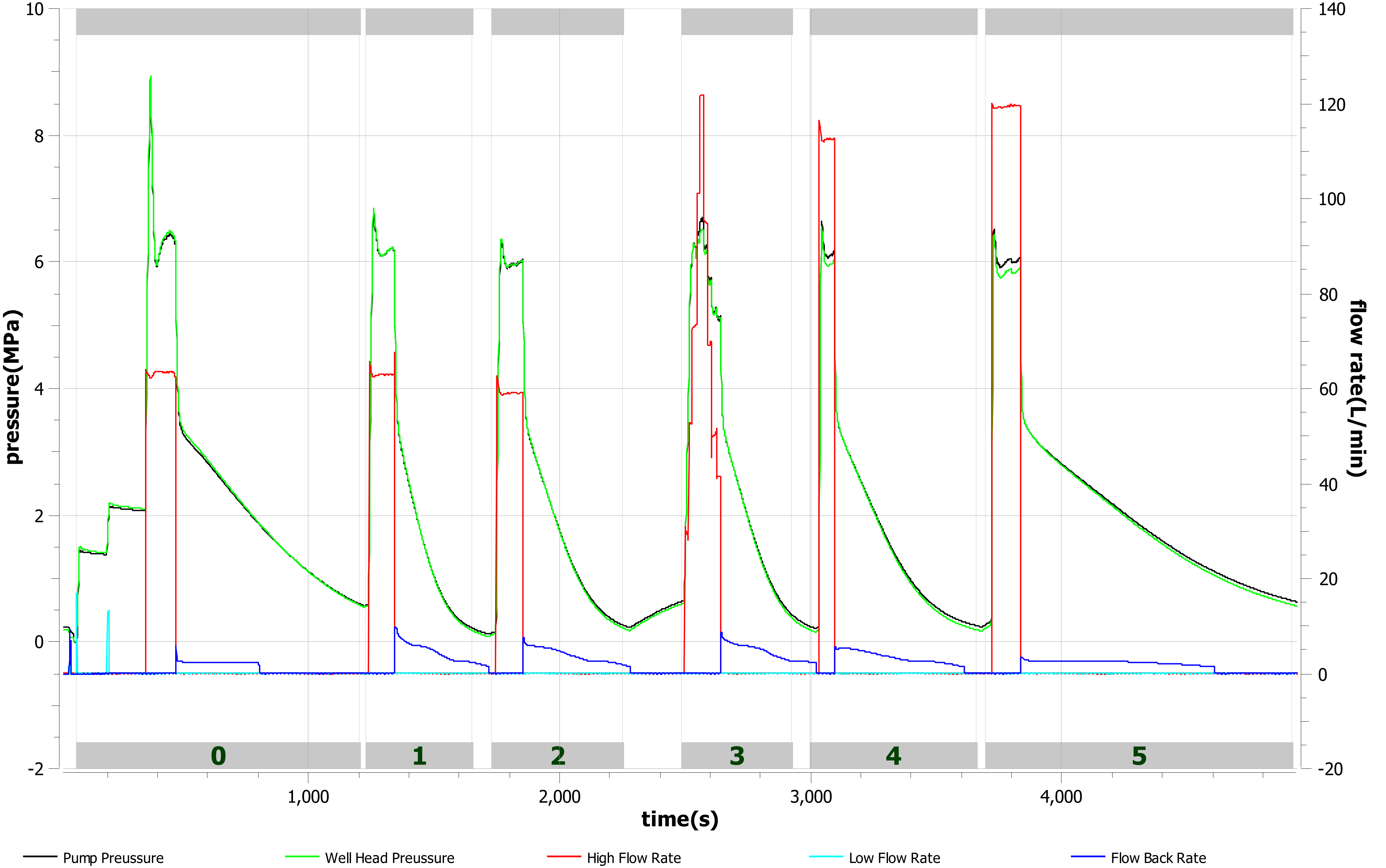
Test 2: GP Zone #1 at 493 m

BitCan Geosciences & Engineering Inc.

www.bitcange.com

Client: Pengrowth Energy Corp
Well: 13-13-58-5W4
Depth: 494
Formation: GP
Start @: Thu Mar 3 14:16:18 2011

Mini-Frac Test

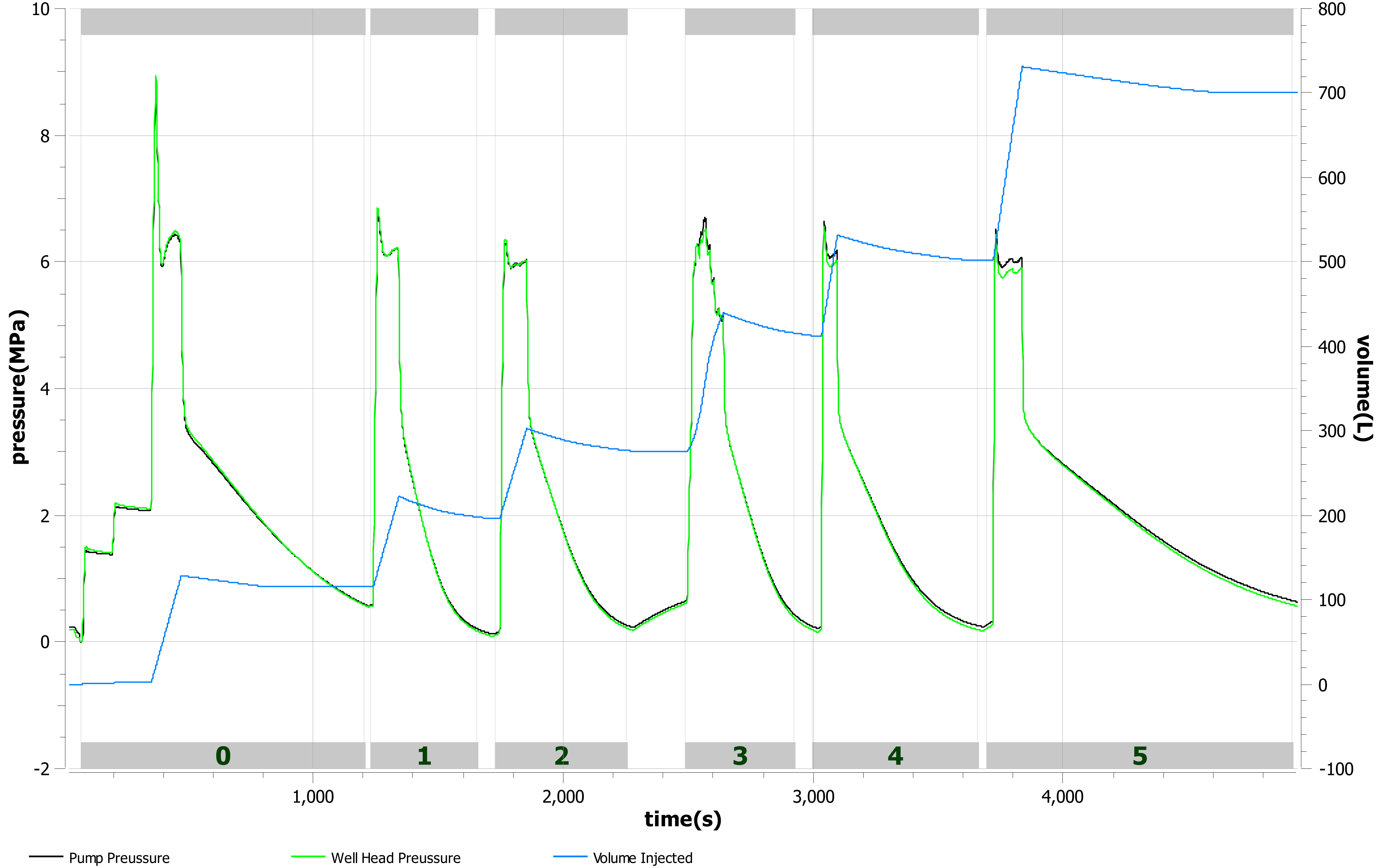


Generated by MiniMonitor

BitCan
Geosciences & Engineering Inc.
www.bitcange.com

Client: Pengrowth Energy Corp
Well: 13-13-58-5W4
Depth: 494
Formation: GP
Start @: Thu Mar 3 14:16:18 2011

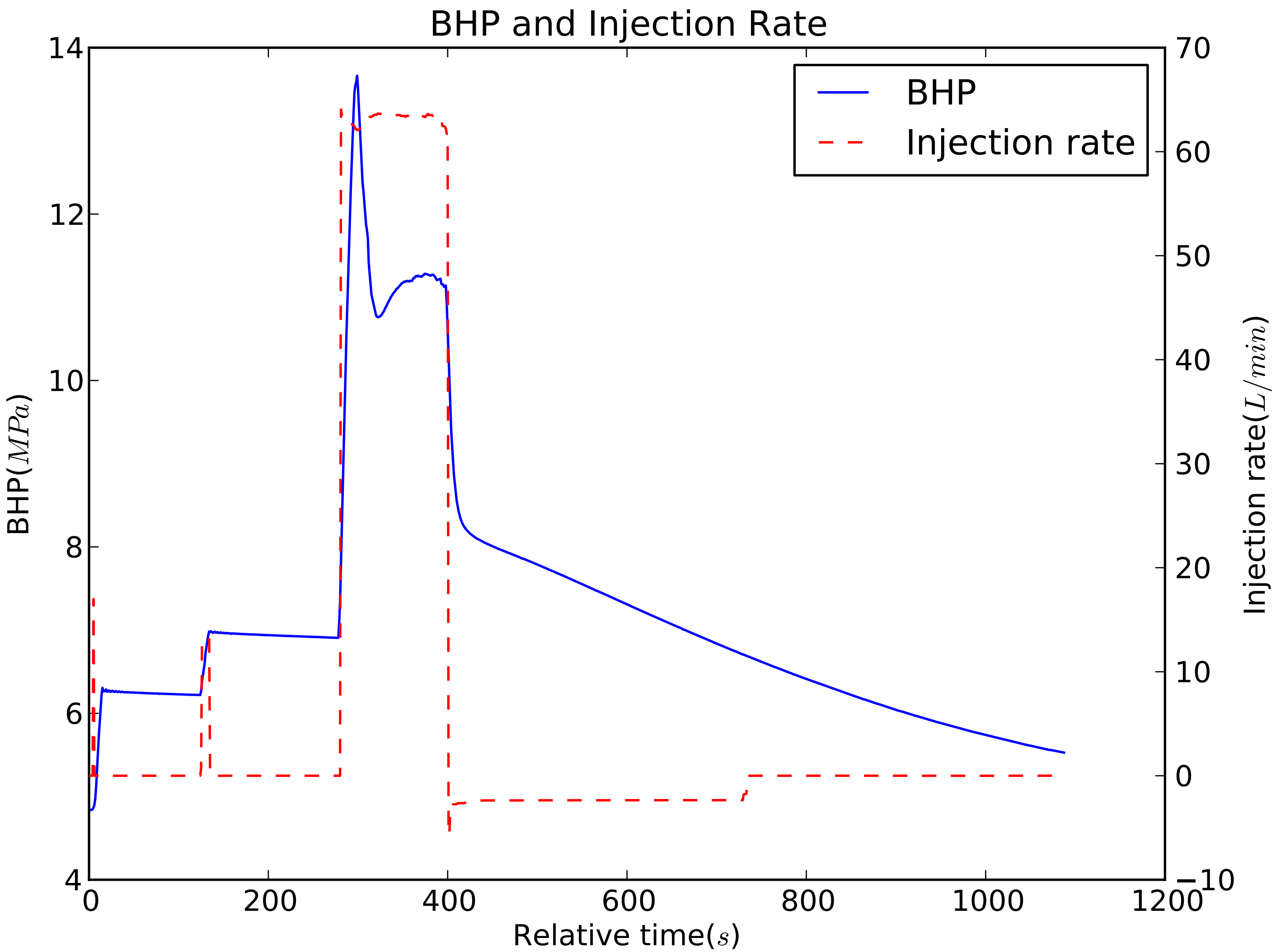
Mini-Frac Test



Generated by MiniMonitor

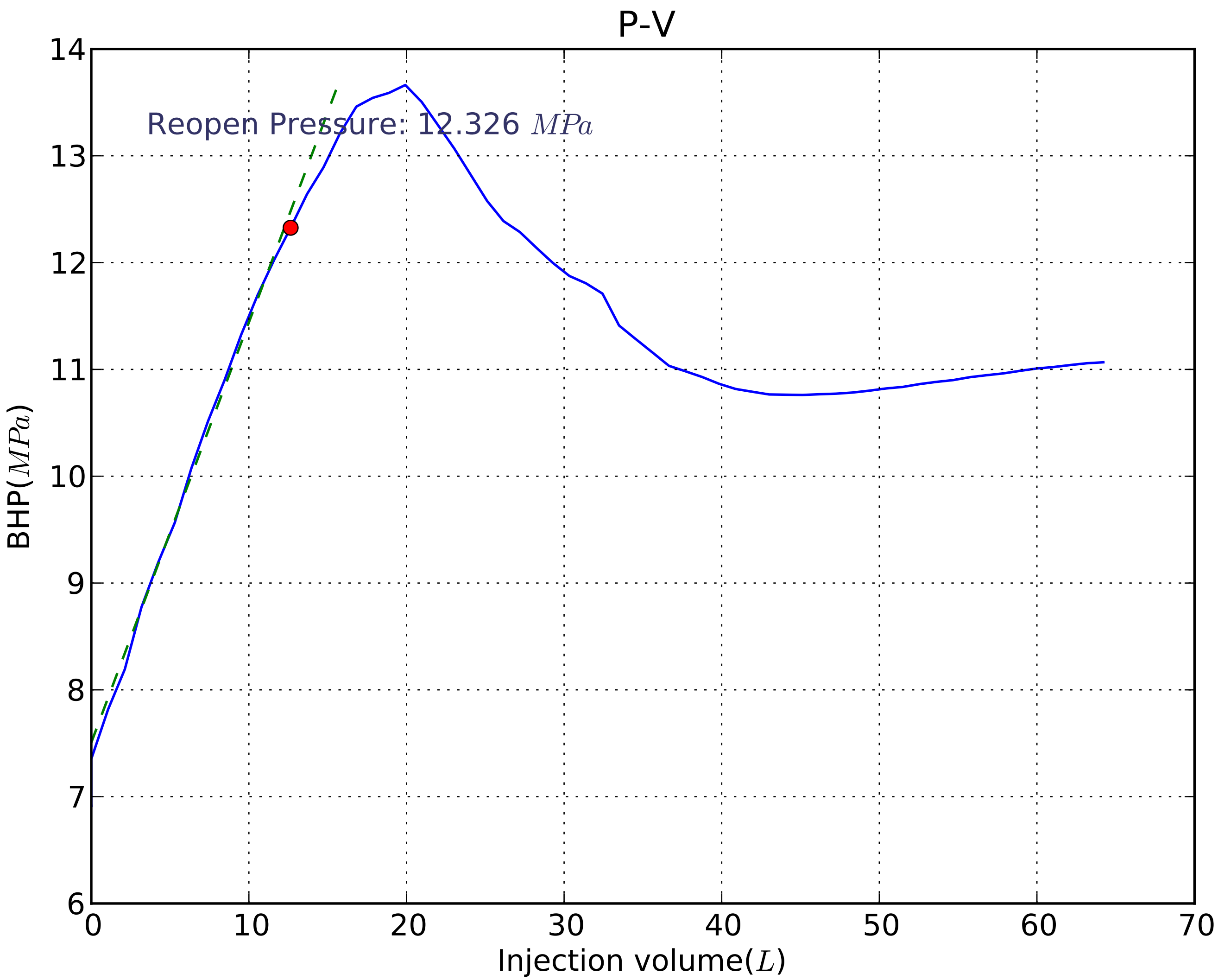
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 01

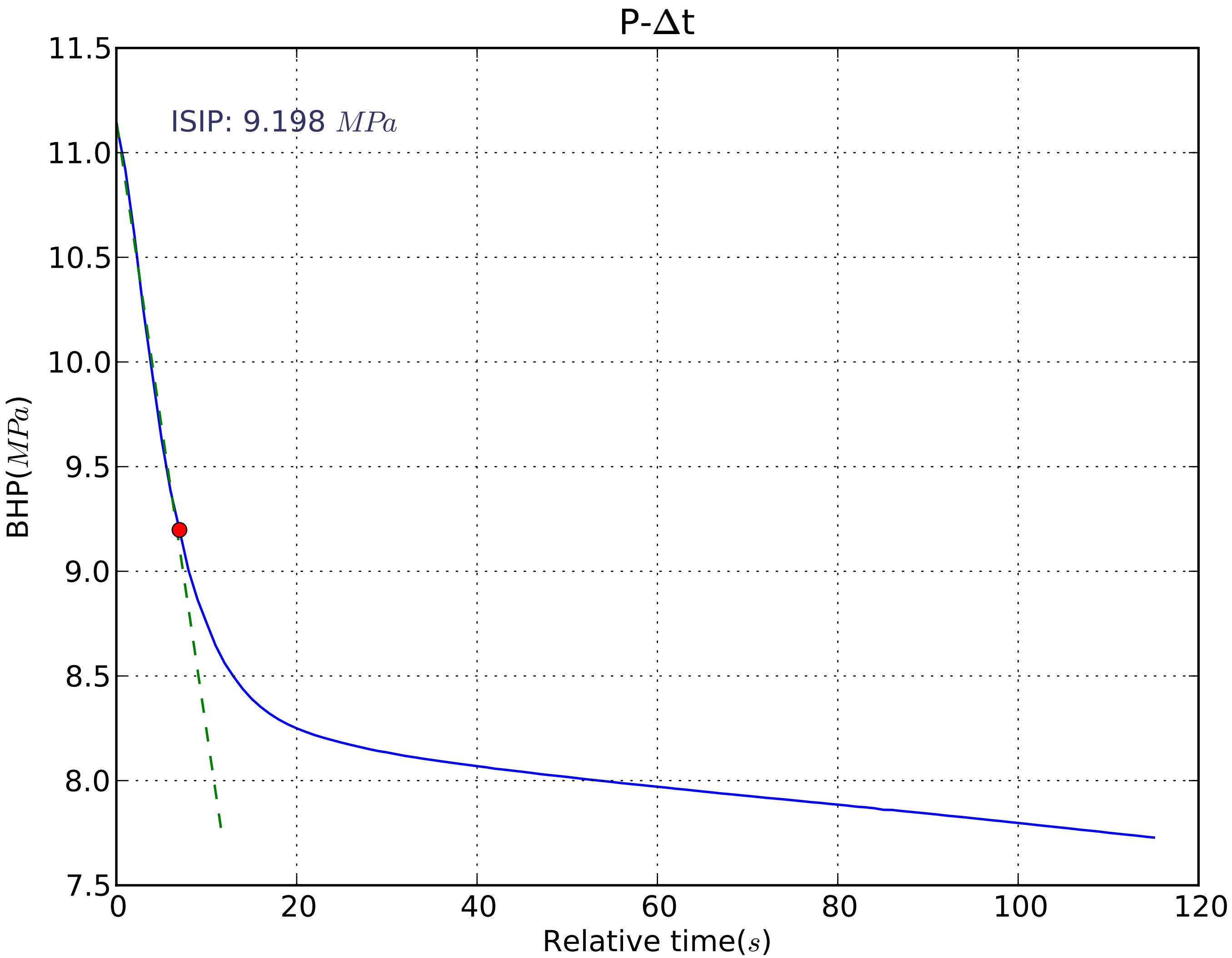
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 01

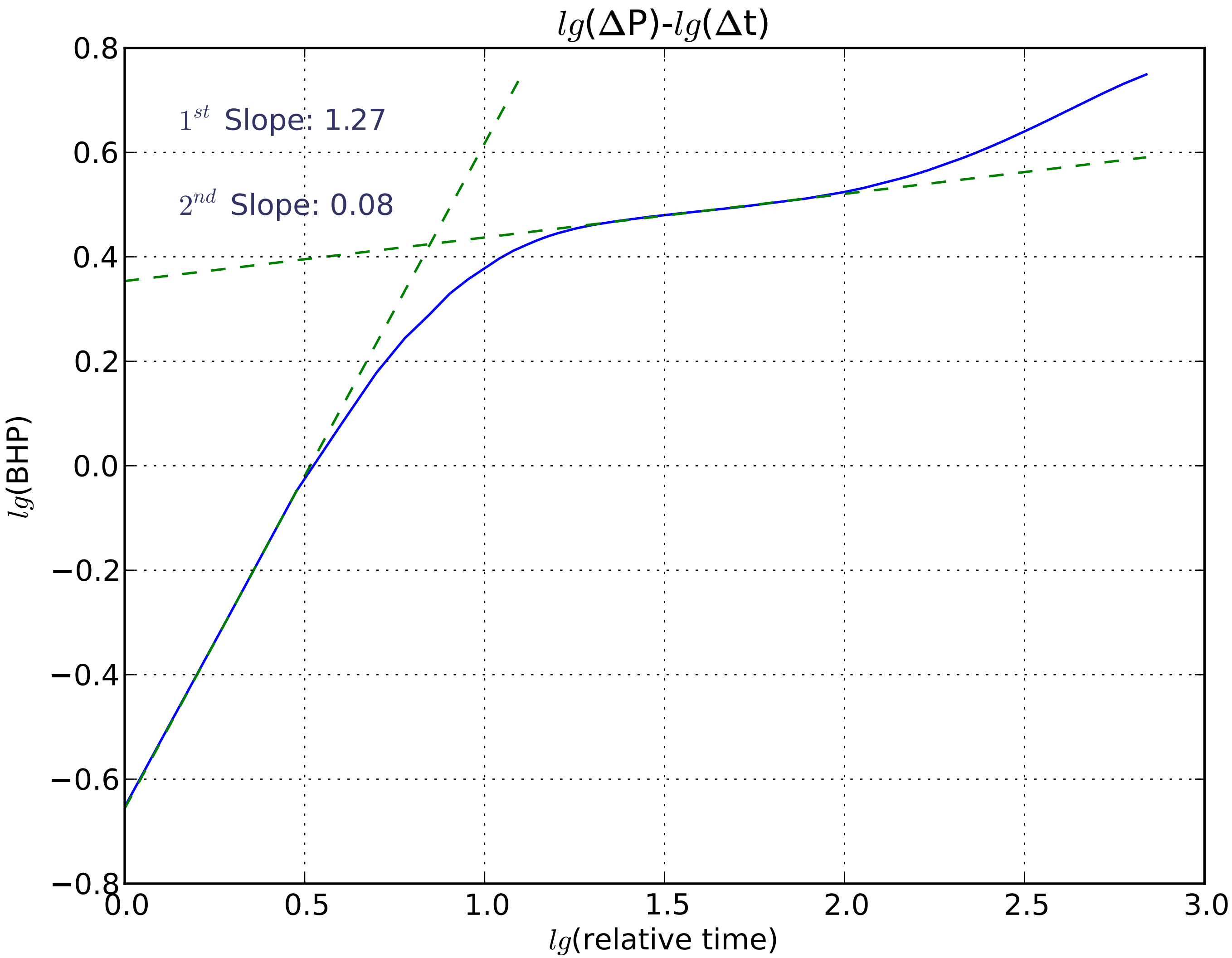
BitCan
Geosciences & Engineering Inc.




P-Δt
ISIP: 9.198 MPa
BHP(MPa)
Relative time(s)
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
0
20
40
60
80
100
120

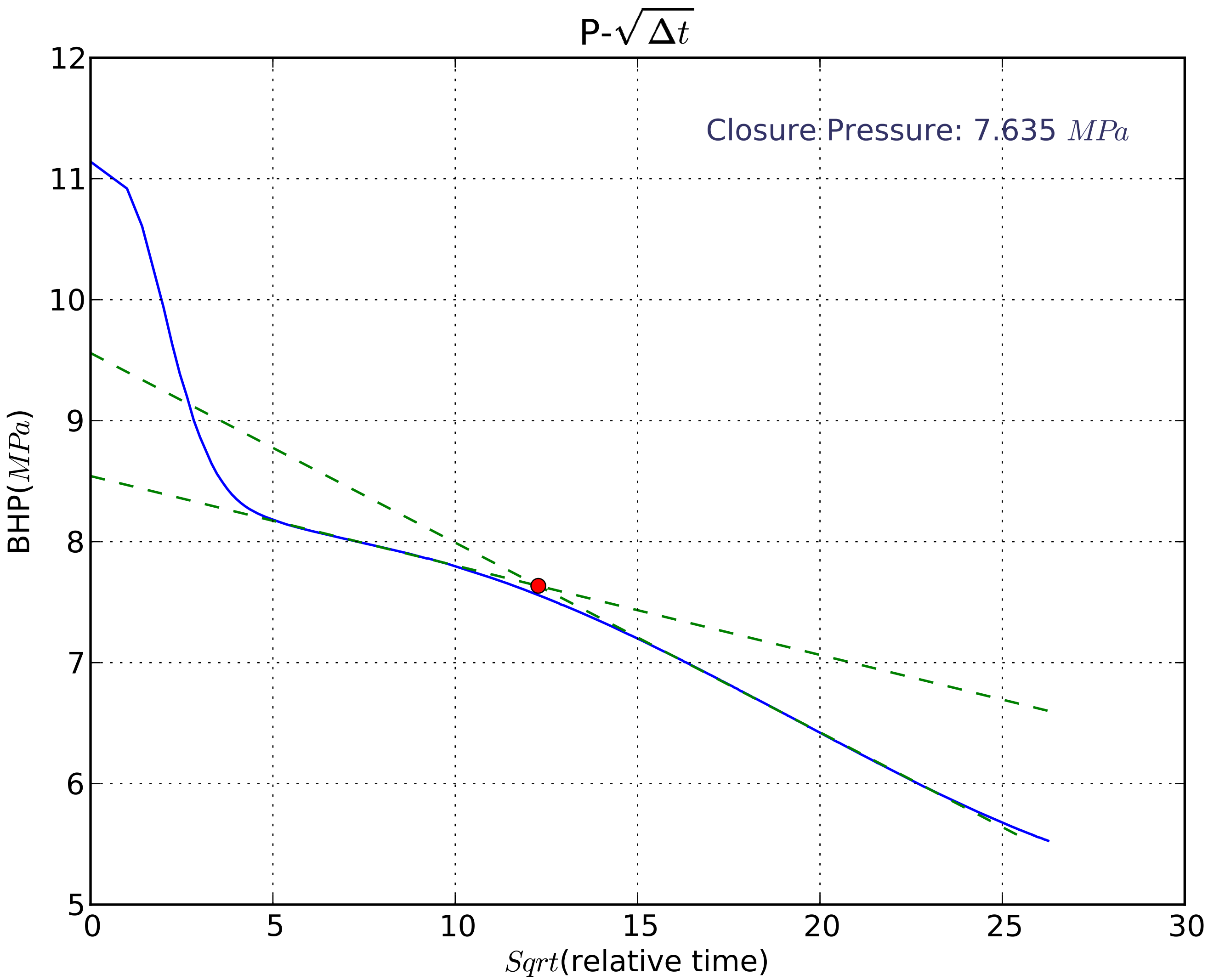
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 01

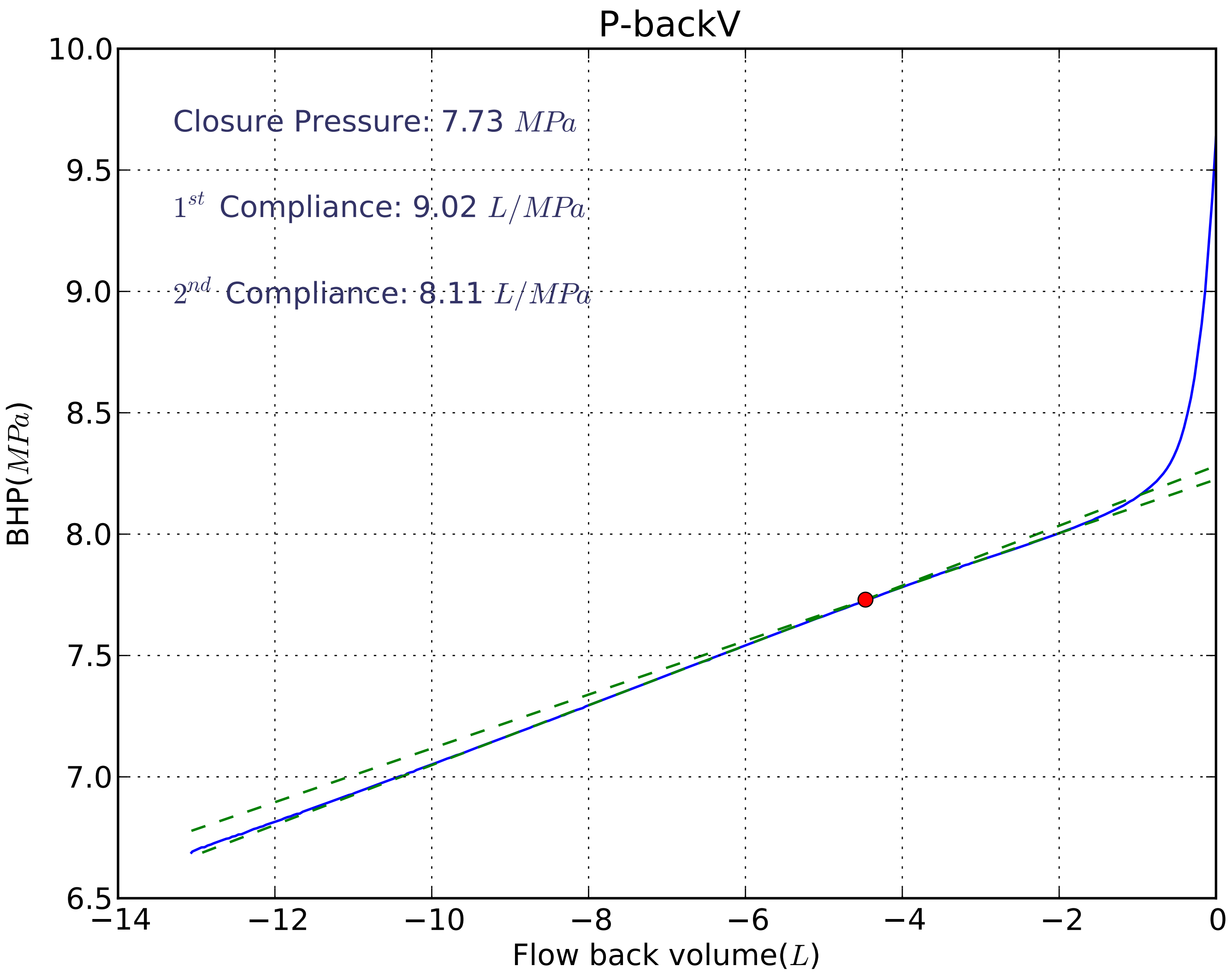
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 01

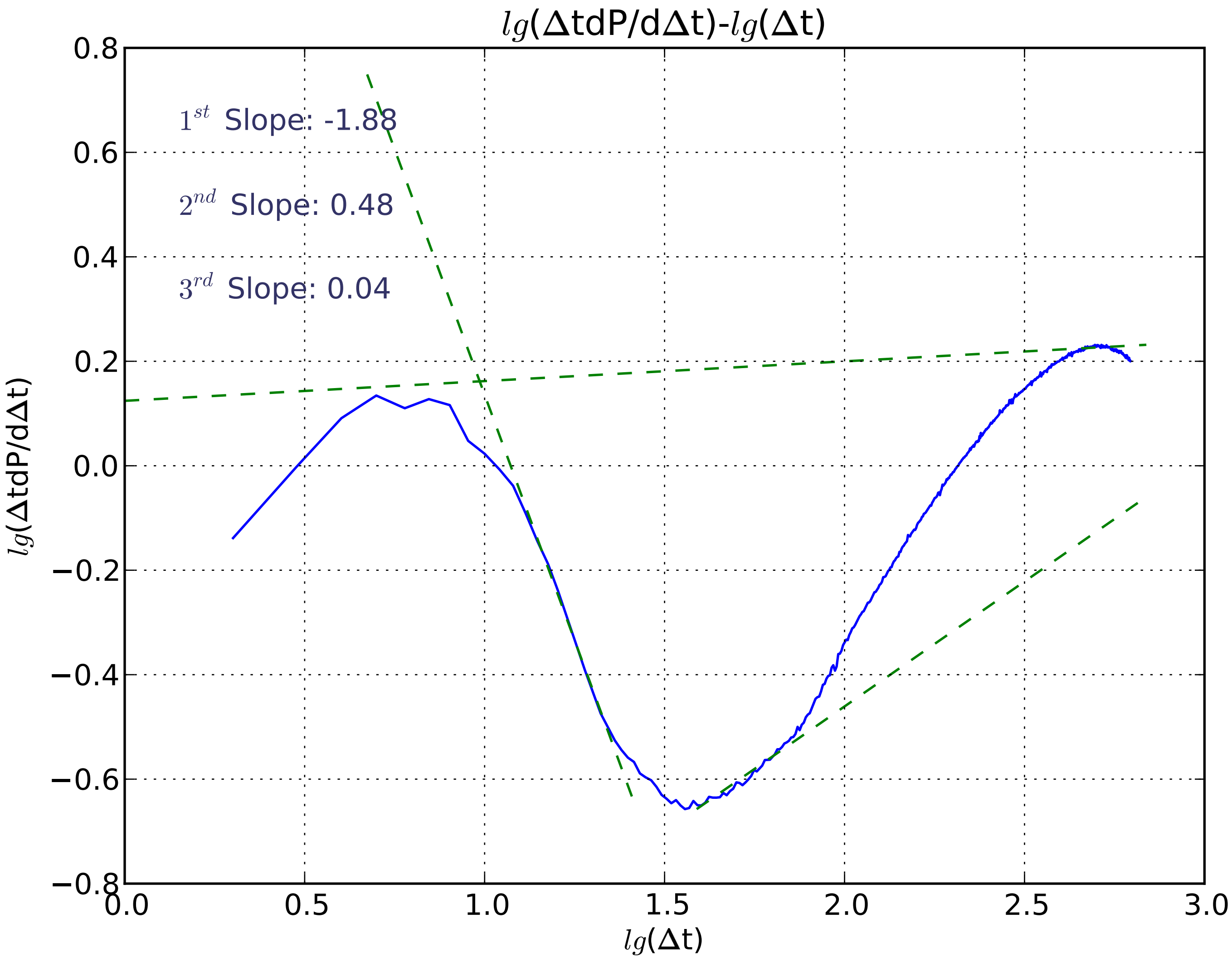
BitCan
Geosciences & Engineering Inc.




P-backV
Closure Pressure: 7.73 MPa
1^{st} Compliance: 9.02 L/MPa
2^{nd} Compliance: 8.11 L/MPa
BHP(MPa)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
−14
−12
−10
−8
−6
−4
−2
0
Flow back volume(L)

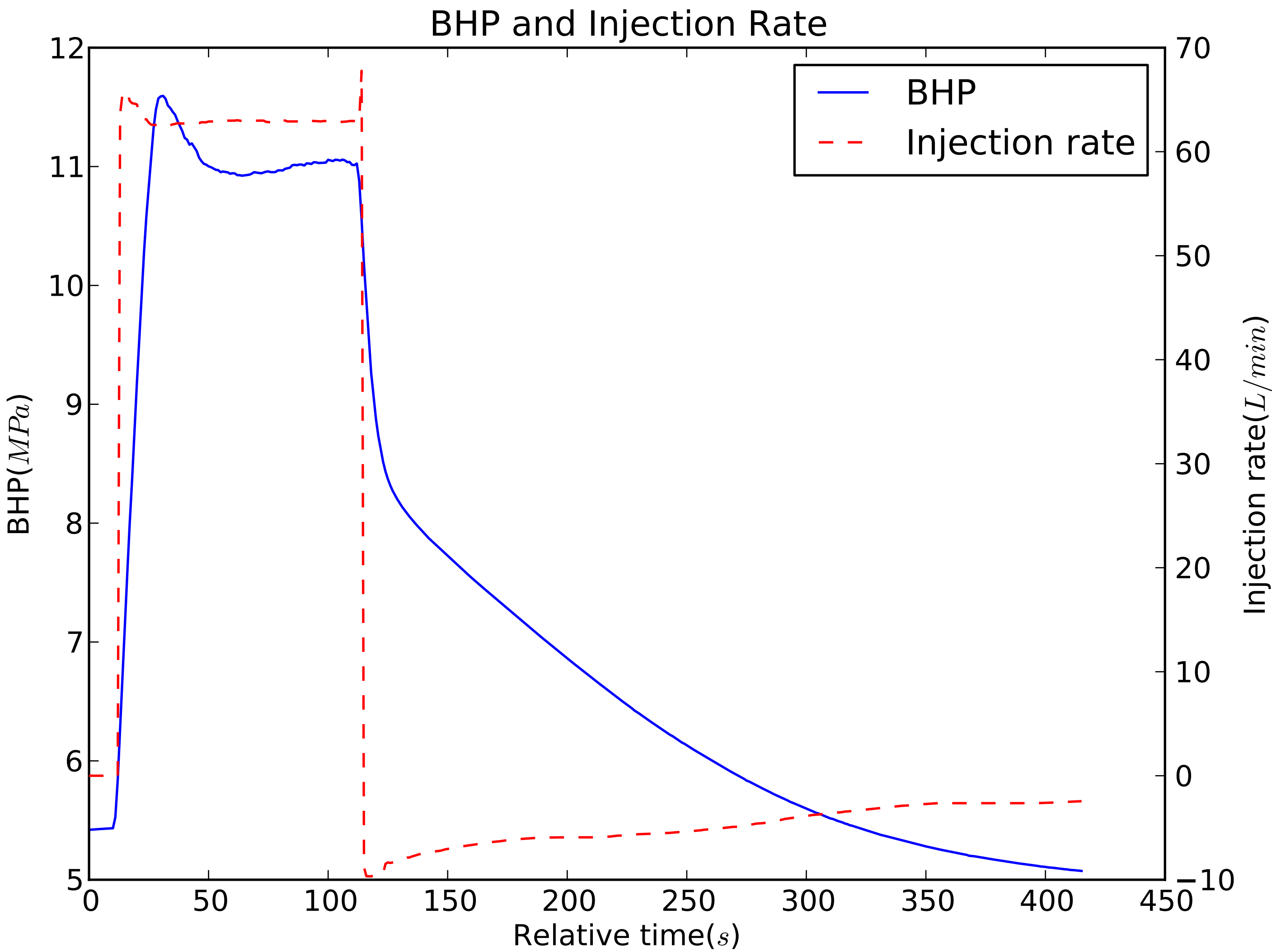
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 01

BitCan
Geosciences & Engineering Inc.



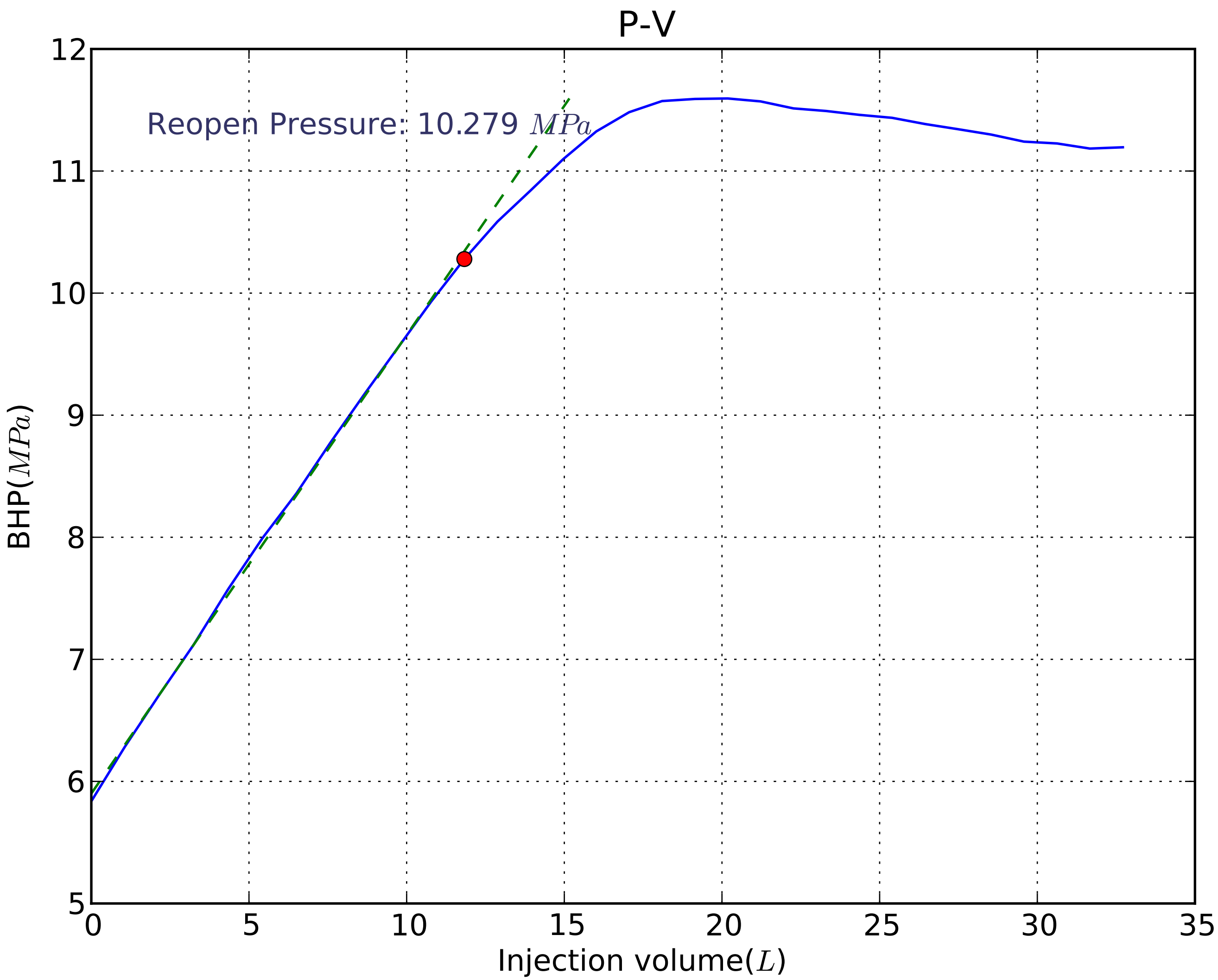
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 02

BitCan
Geosciences & Engineering Inc.



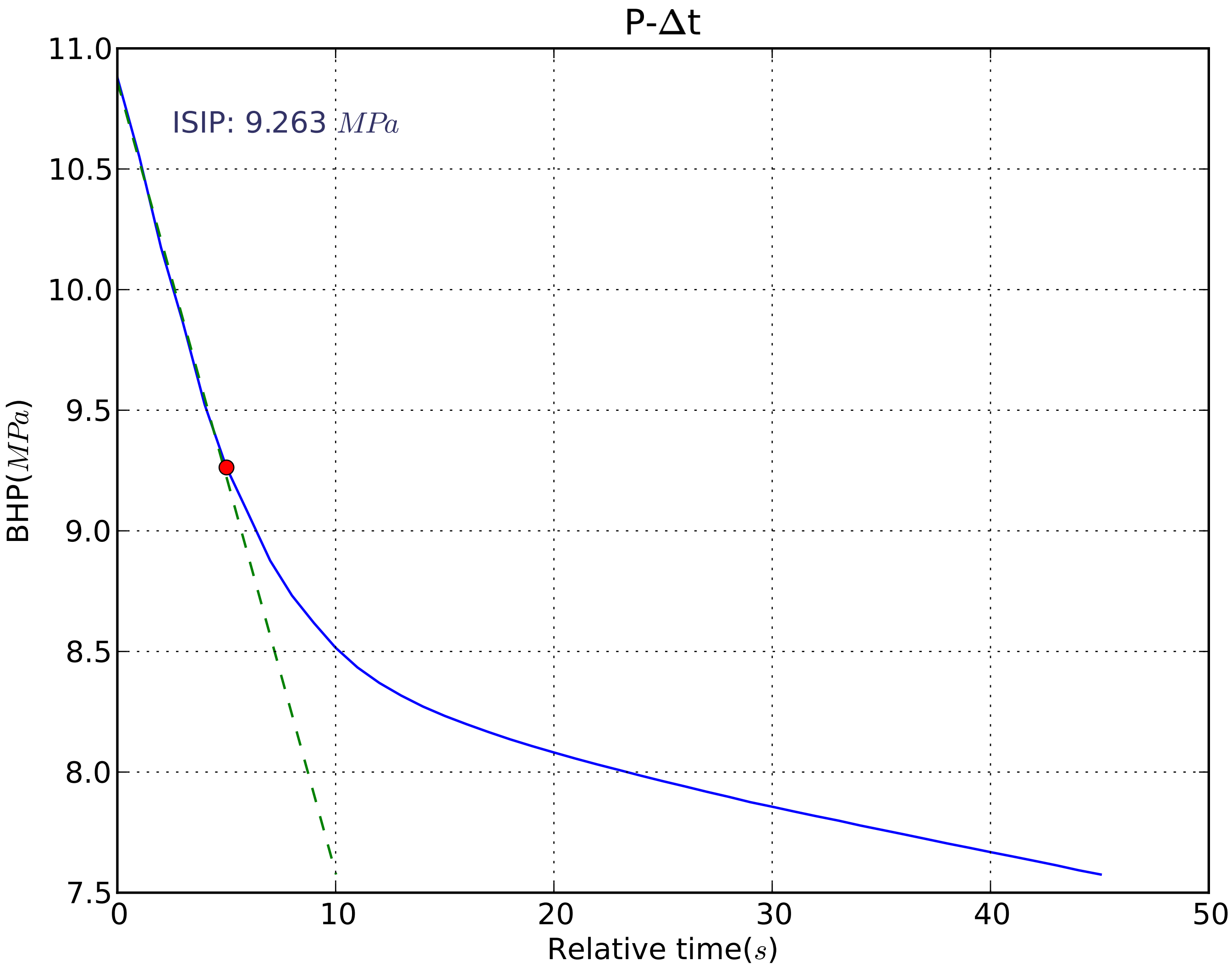
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 02

BitCan
Geosciences & Engineering Inc.



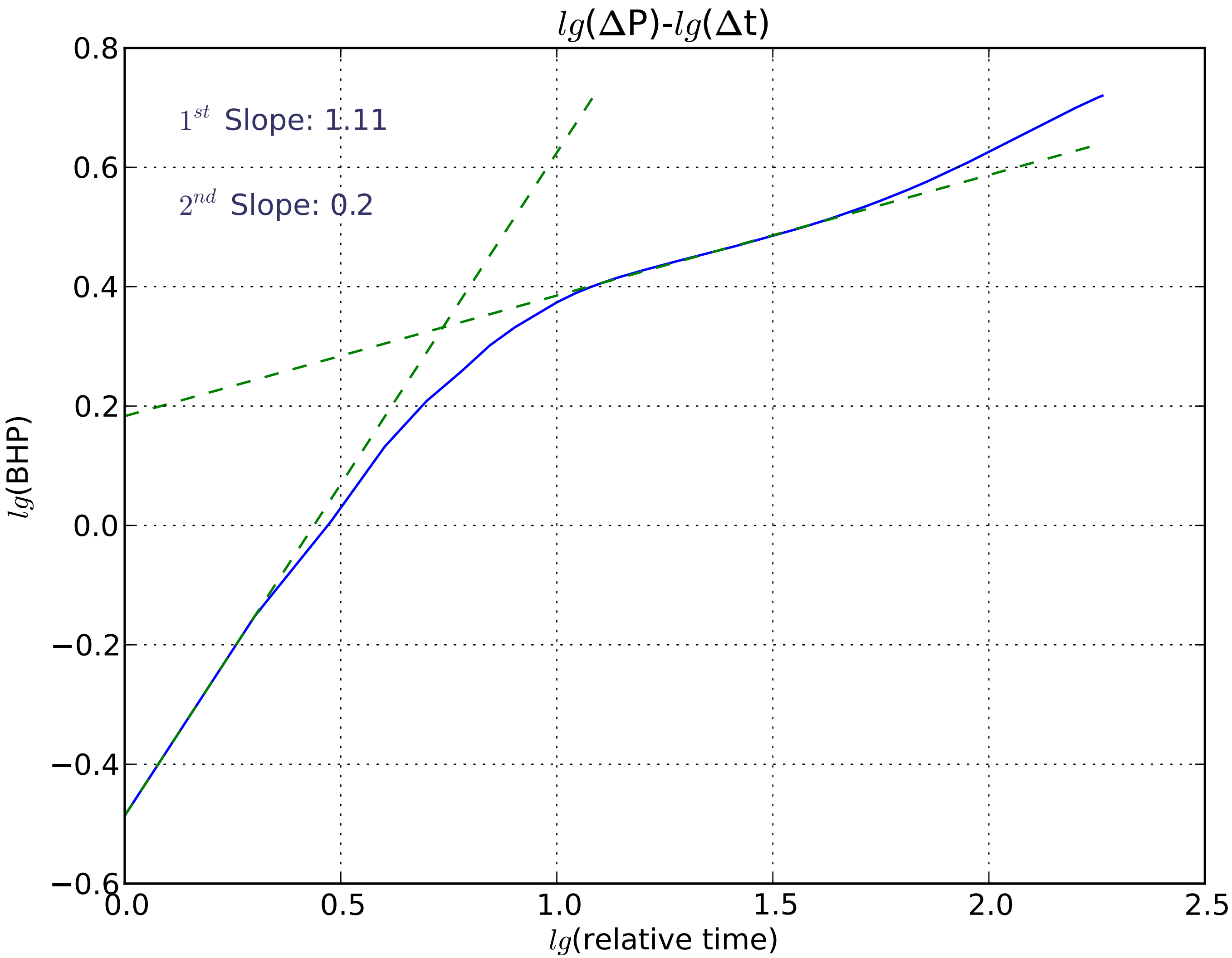
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 02

BitCan Geosciences & Engineering Inc.



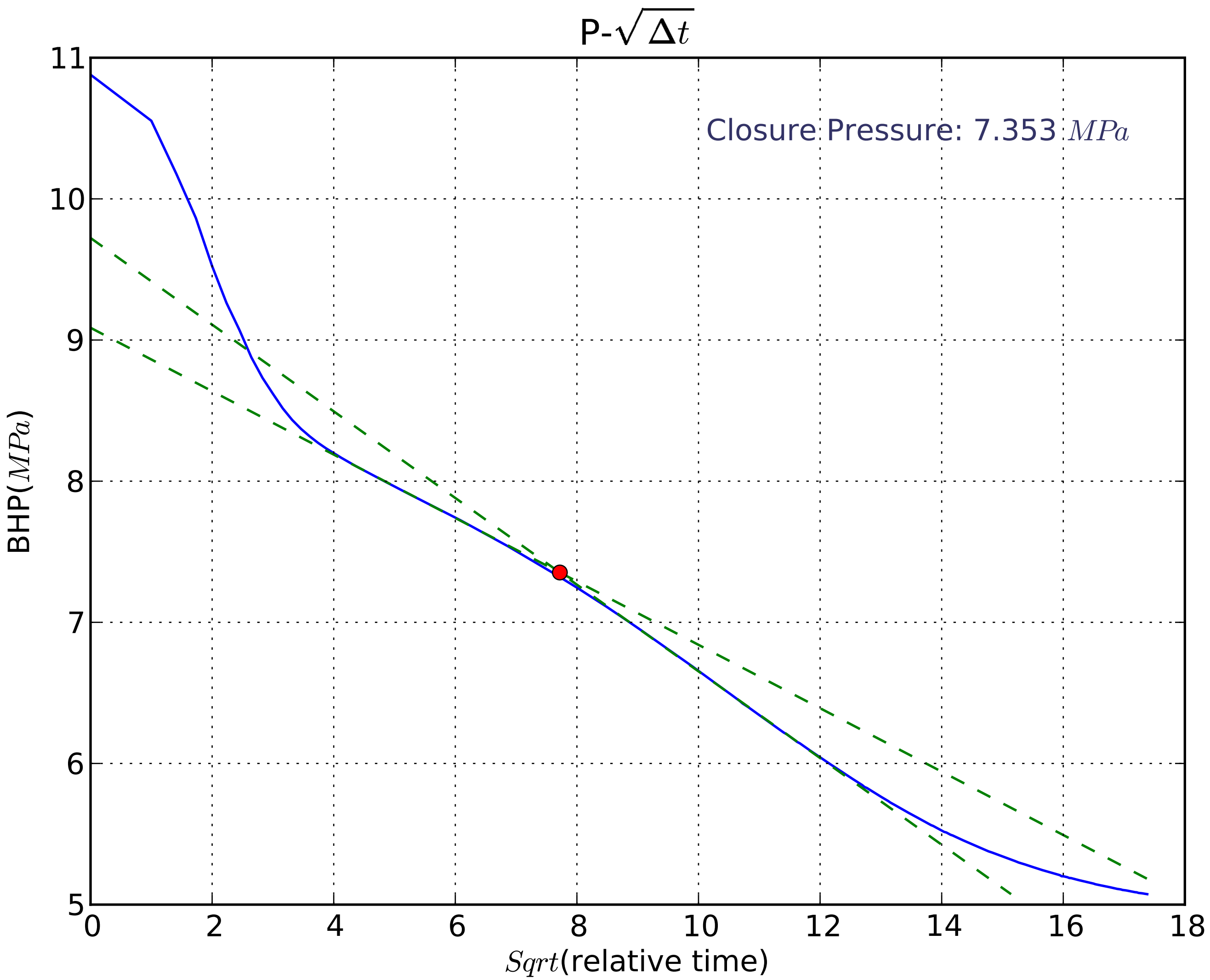
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 02

BitCan
Geosciences & Engineering Inc.



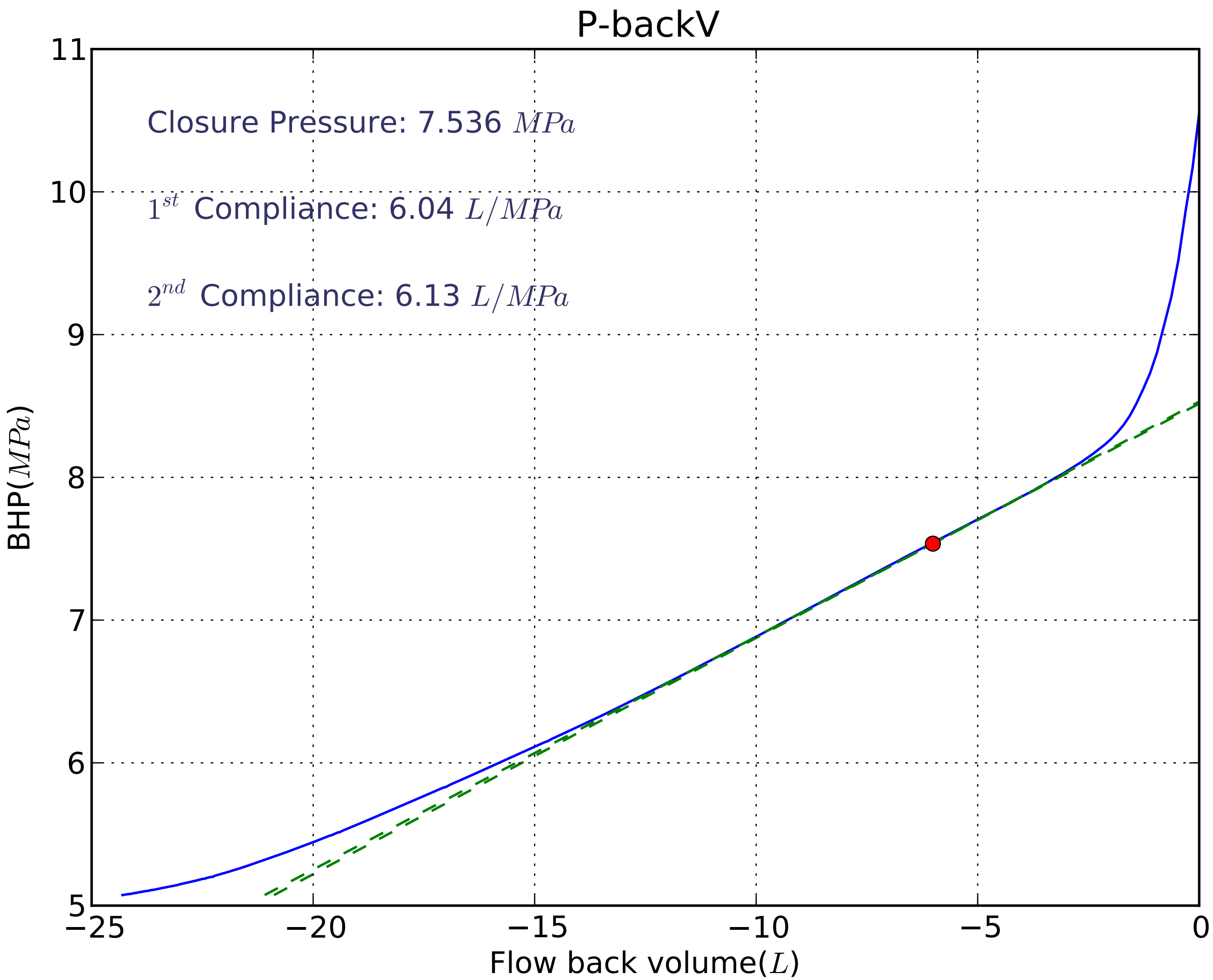
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 02

BitCan
Geosciences & Engineering Inc.



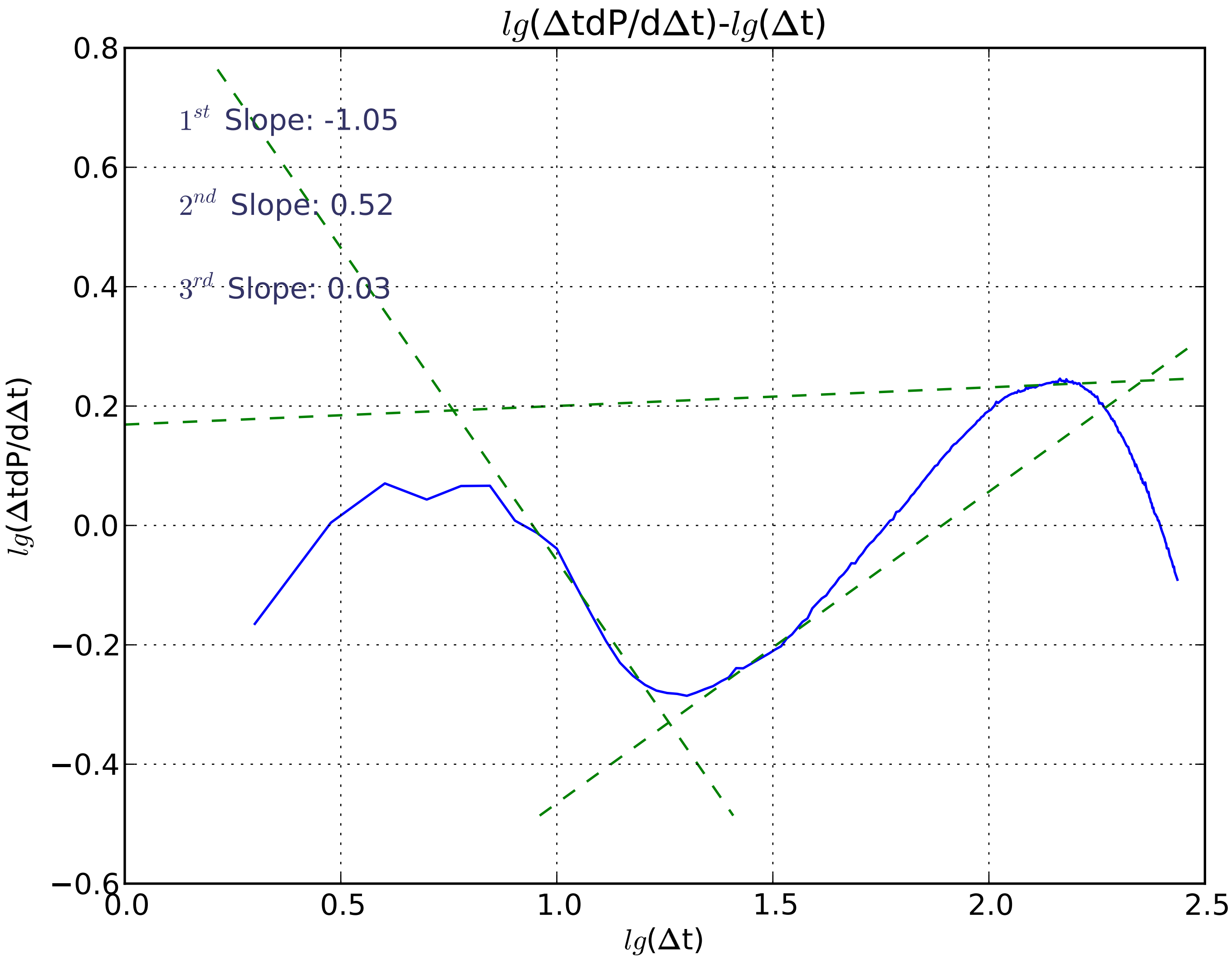
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 02

BitCan
Geosciences & Engineering Inc.



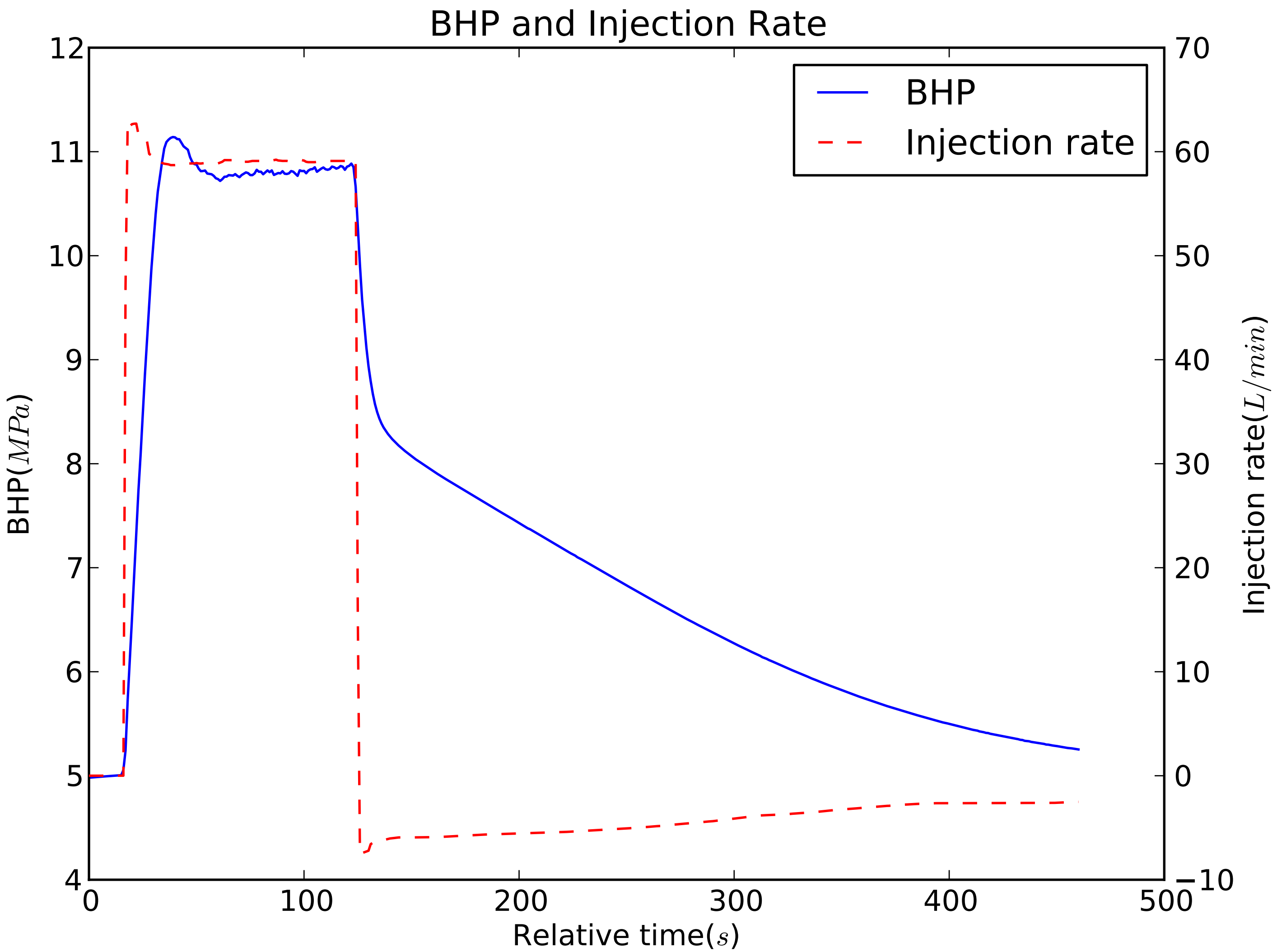
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 02

BitCan Geosciences & Engineering Inc.



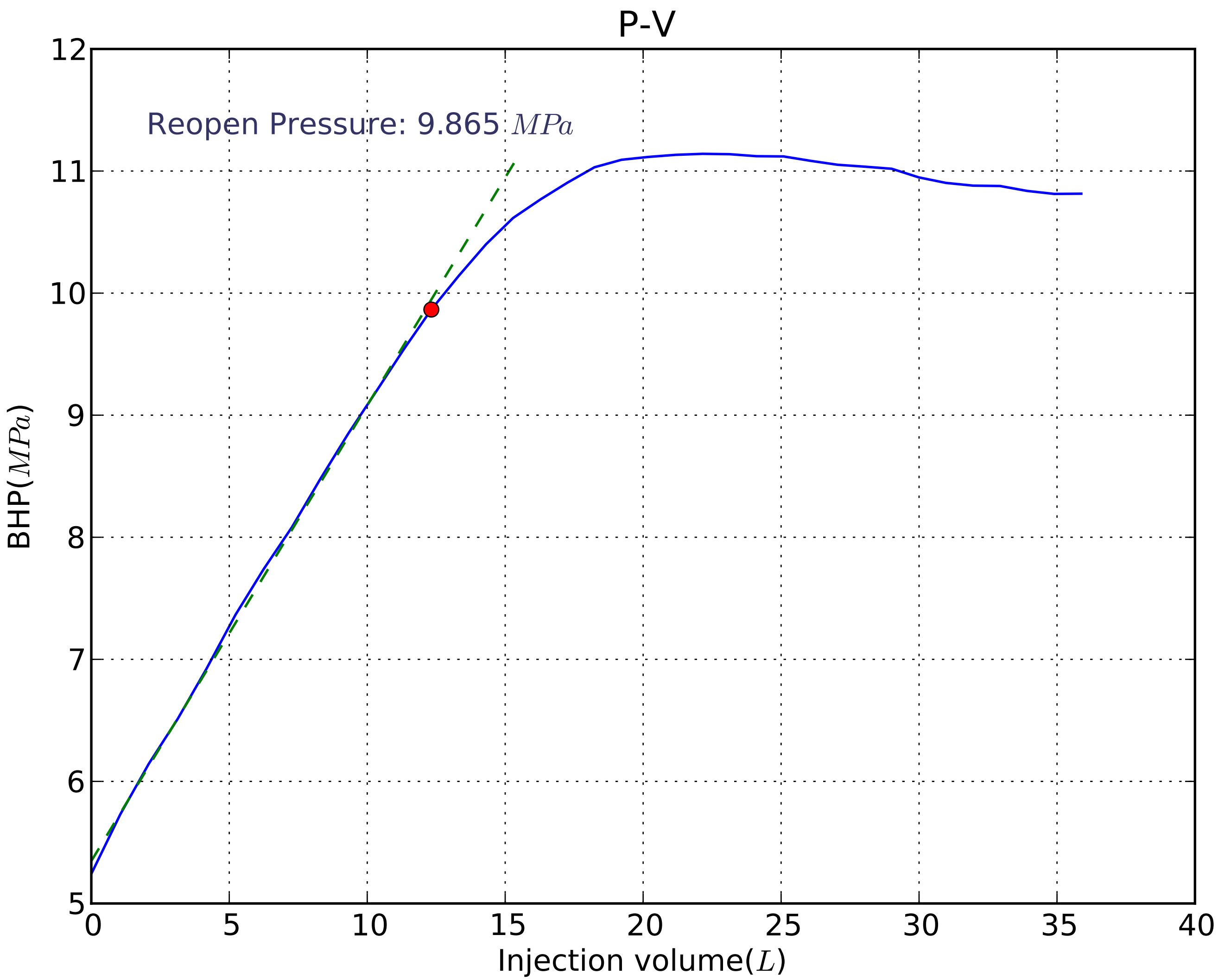
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 03

BitCan
Geosciences & Engineering Inc.



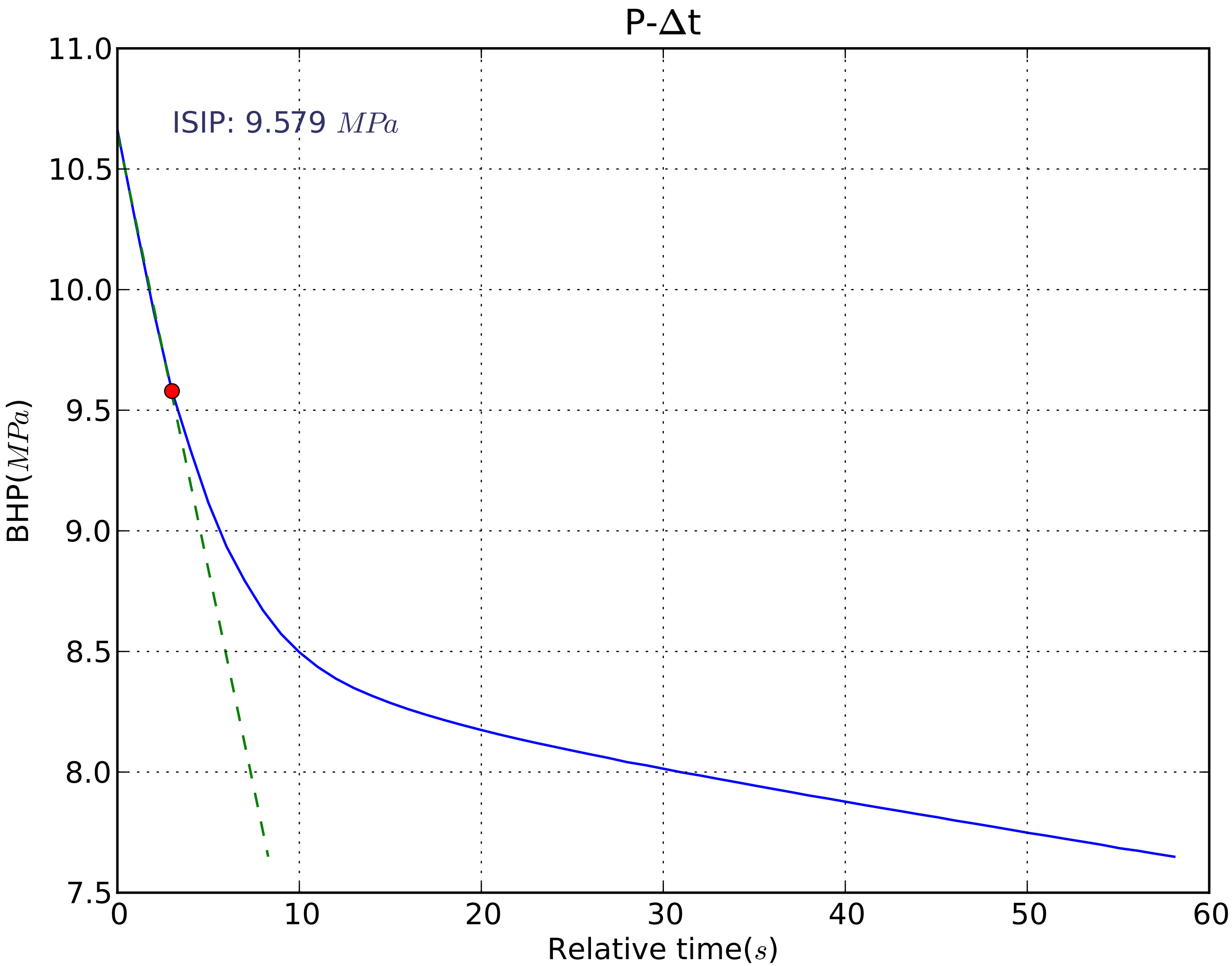
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 03

BitCan
Geosciences & Engineering Inc.



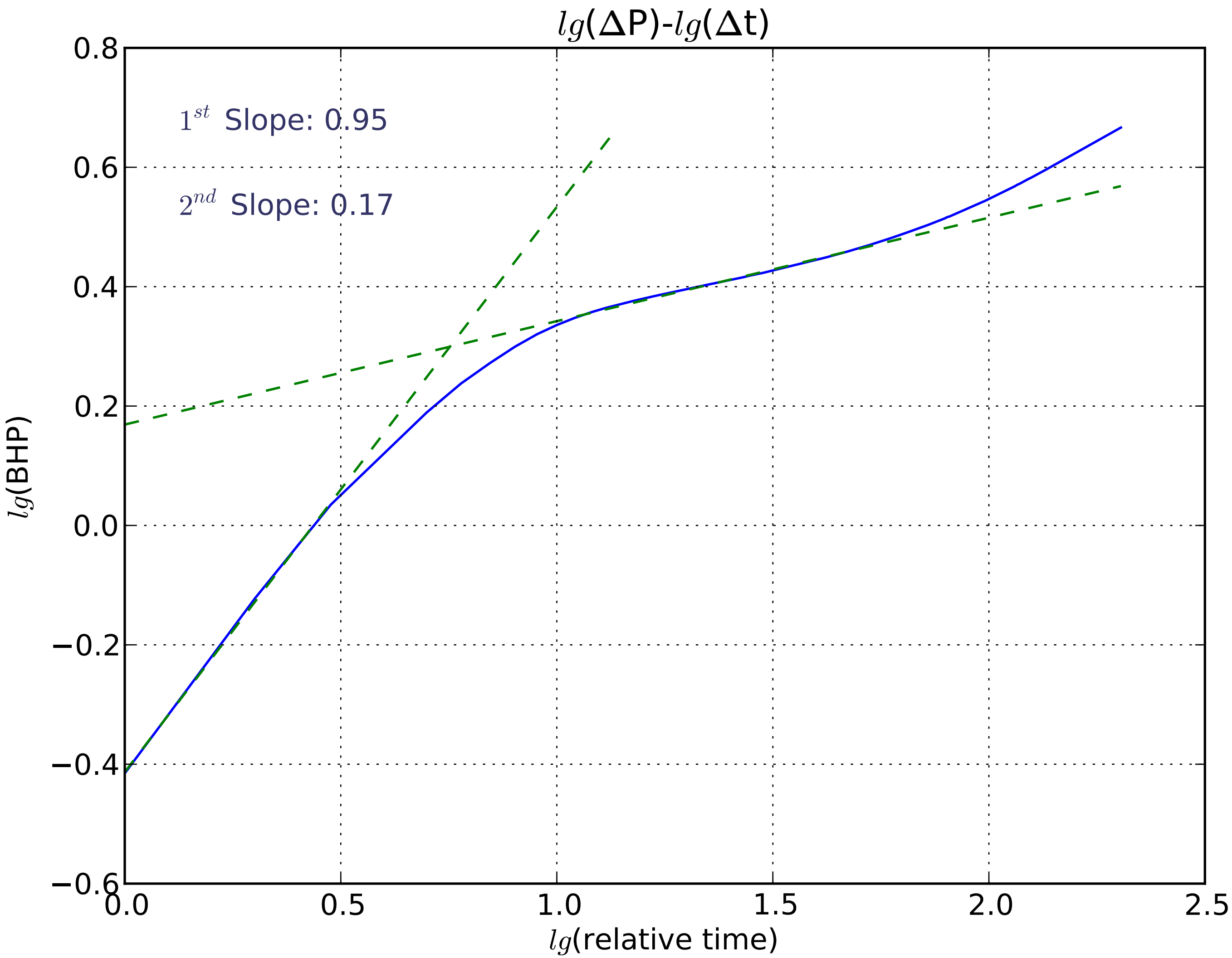
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 03

BitCan
Geosciences & Engineering Inc.

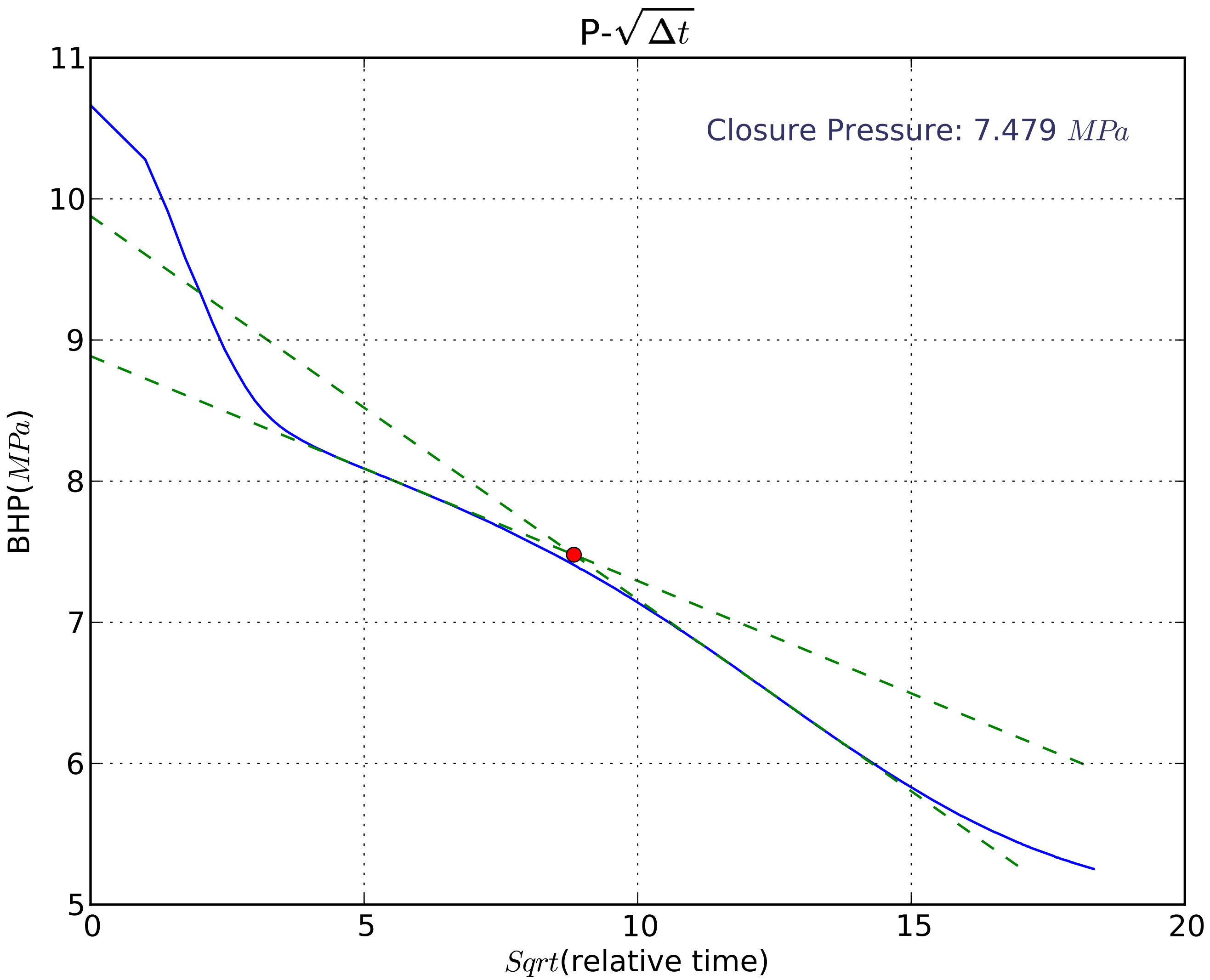


Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 03

BitCan
Geosciences & Engineering Inc.

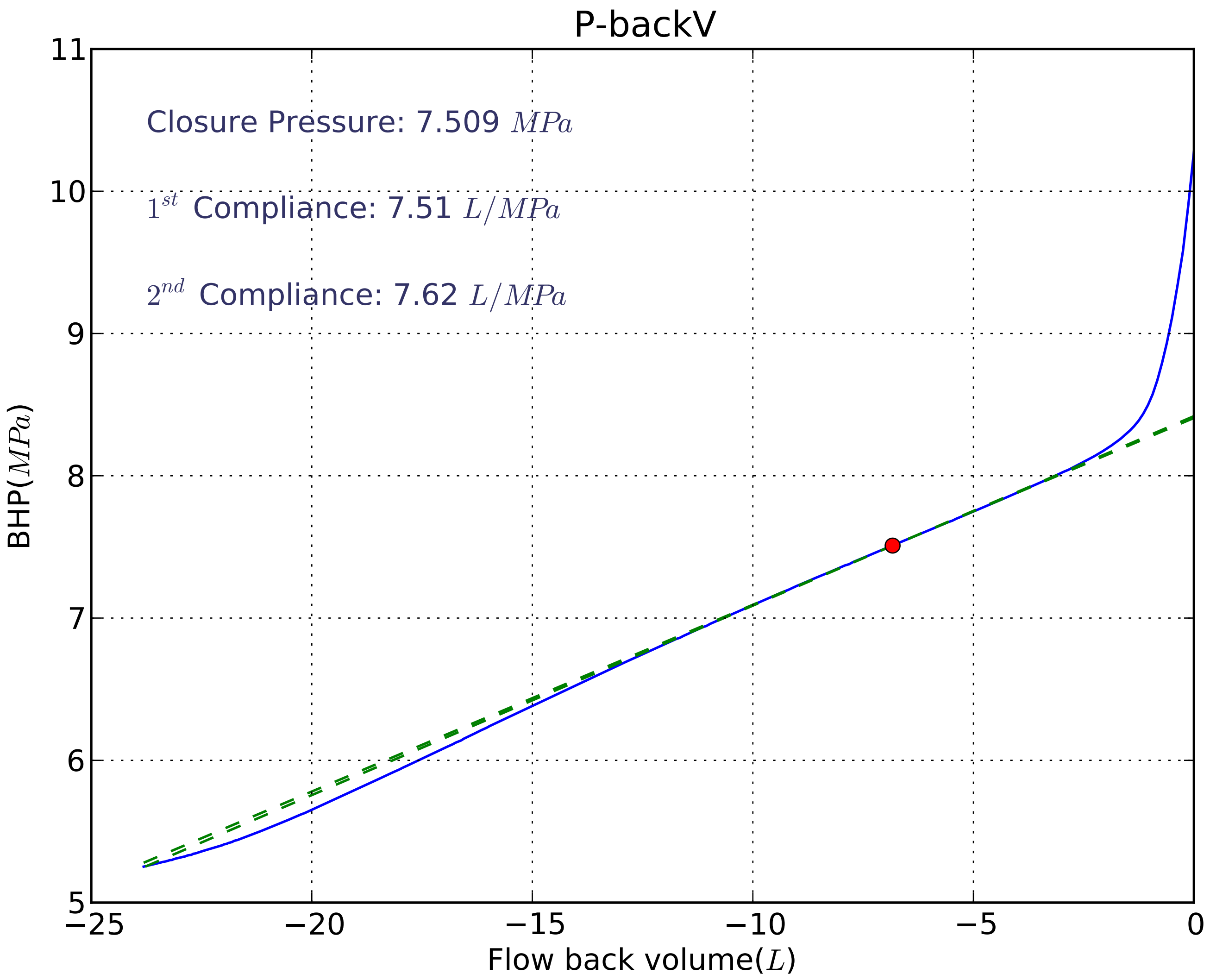


Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 03



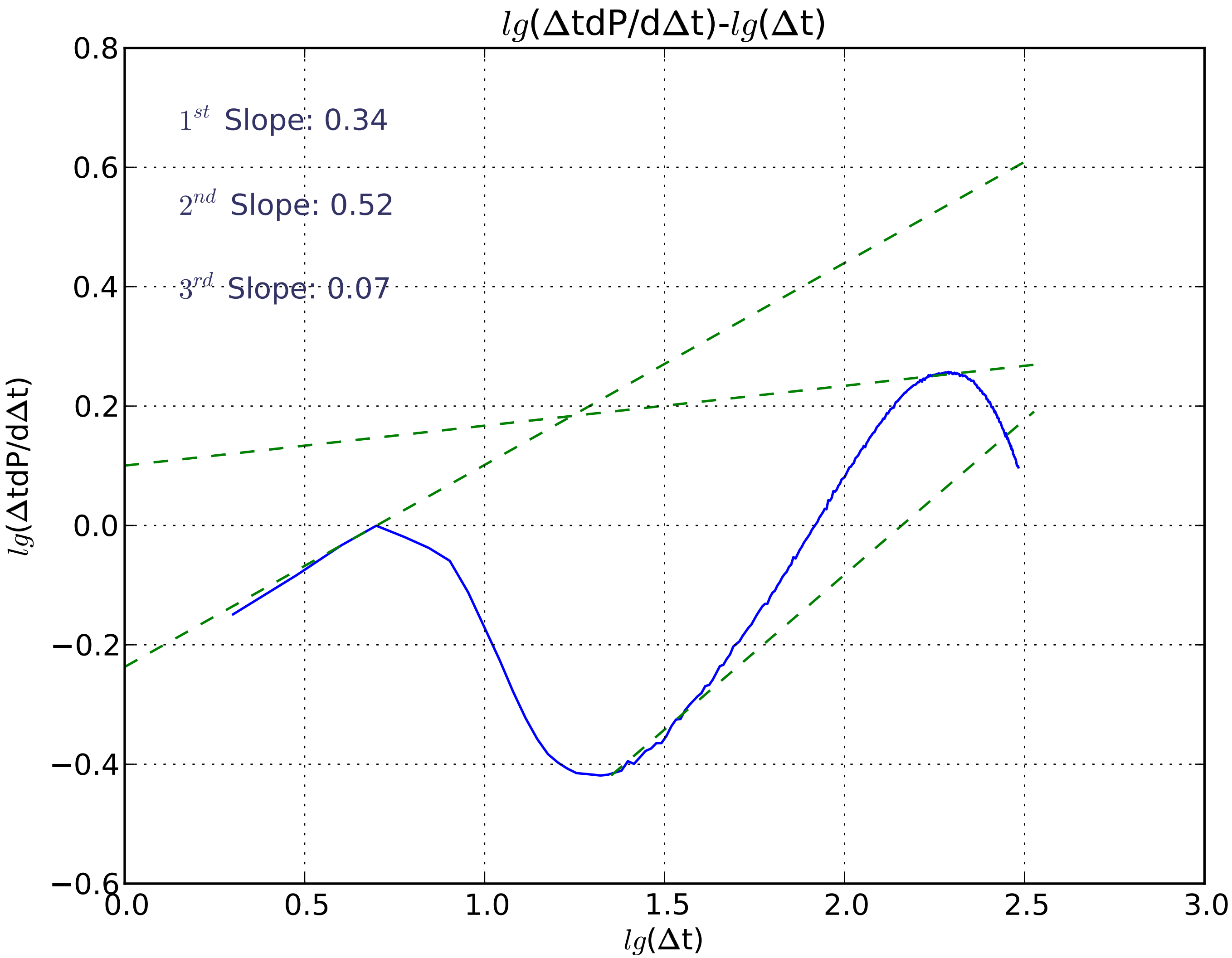
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 03

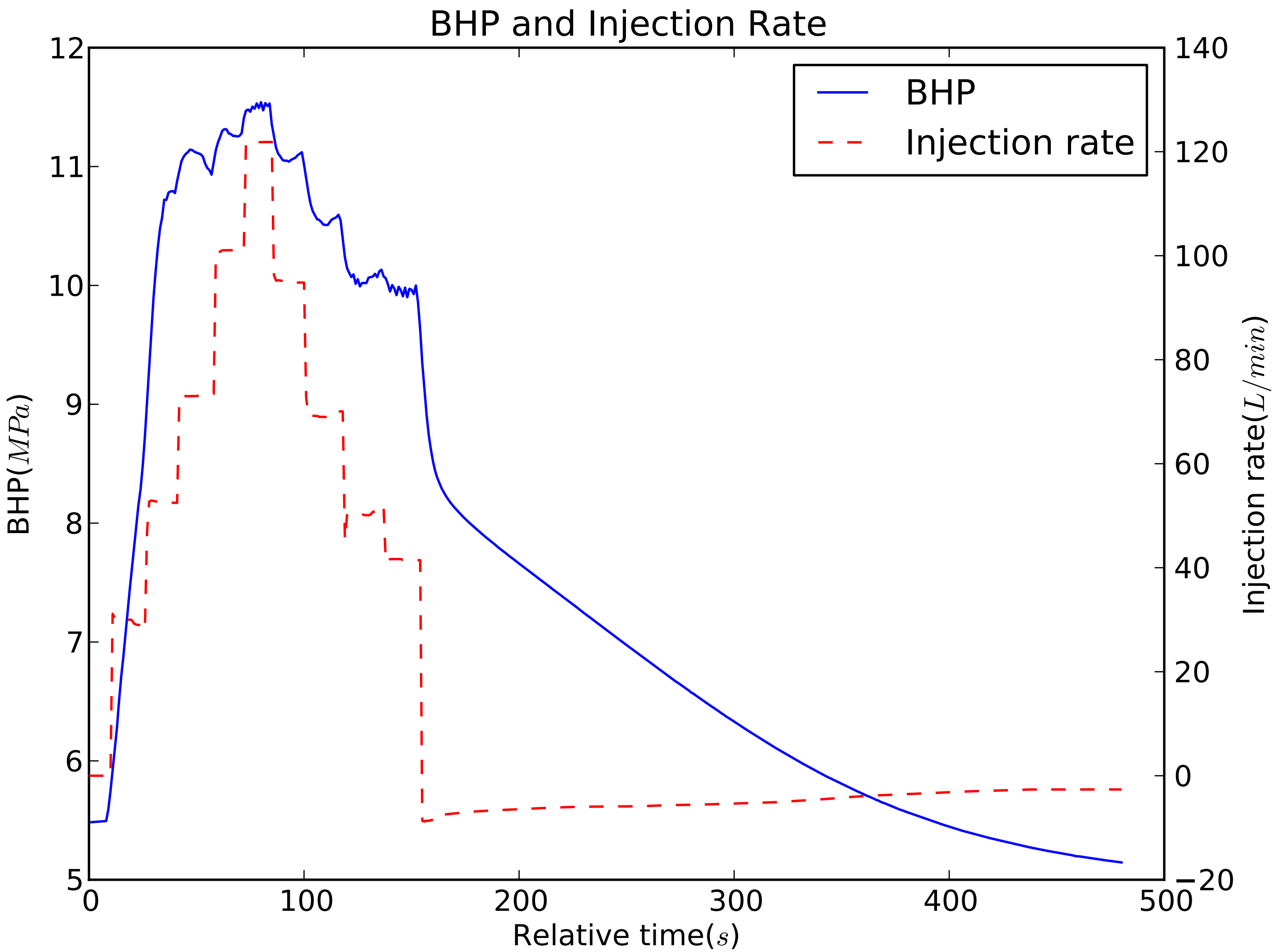
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 03

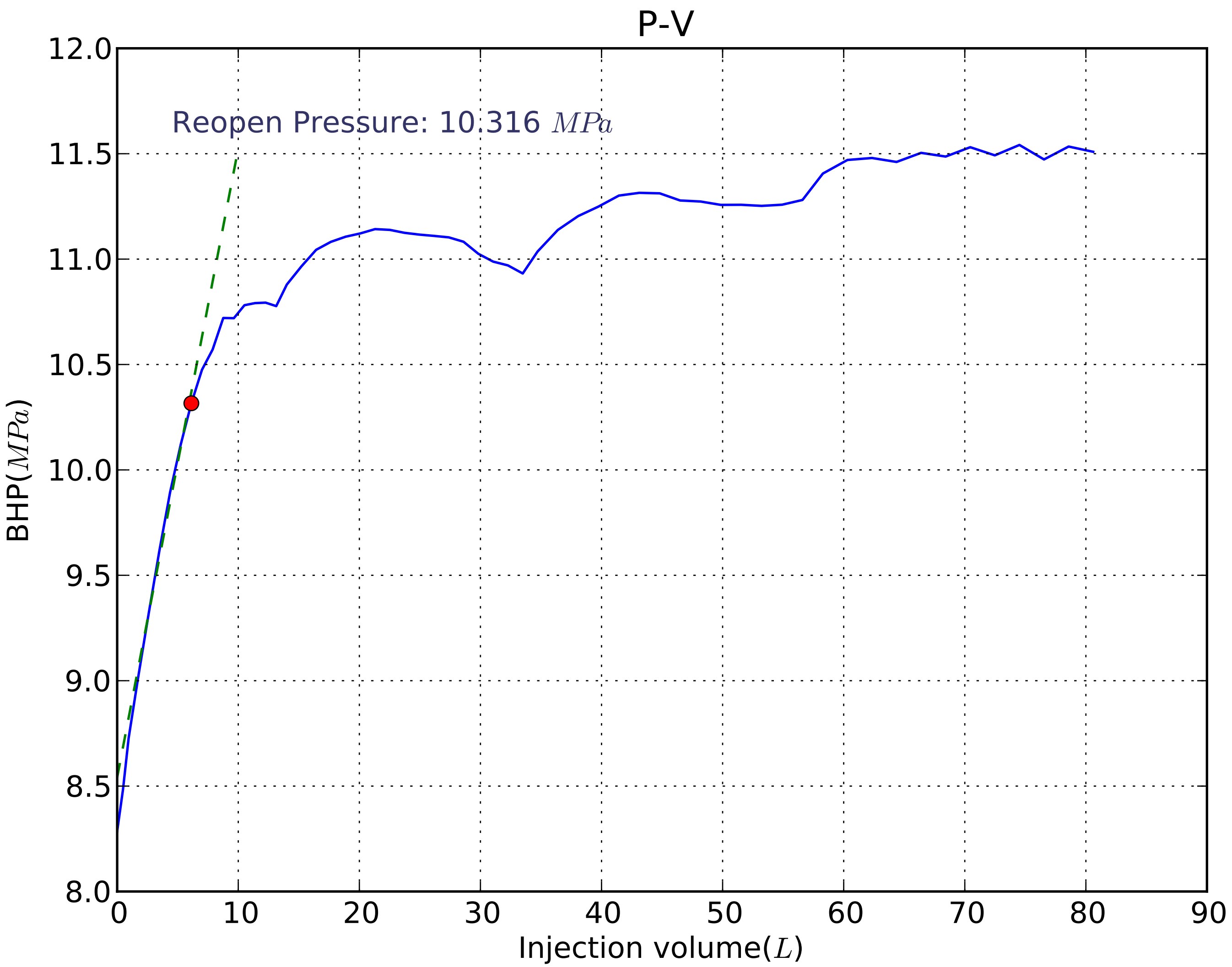
BitCan
Geosciences & Engineering Inc.




BHP and Injection Rate
BHP
Injection rate
BHP(MPa)
Injection rate(L/min)
Relative time(s)
12
11
10
9
8
7
6
5
140
120
100
80
60
40
20
0
−20
0
100
200
300
400
500

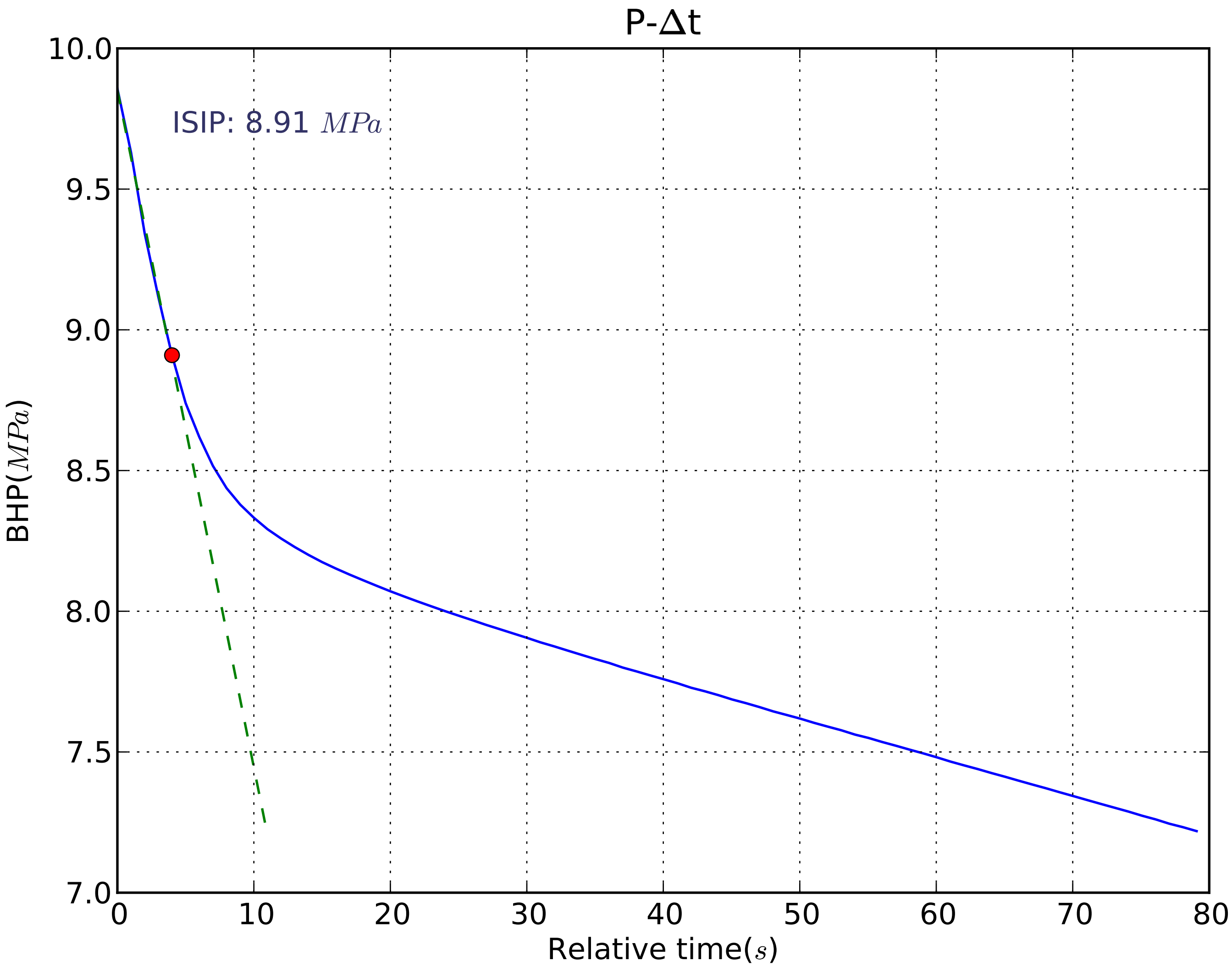
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 04

BitCan
Geosciences & Engineering Inc.

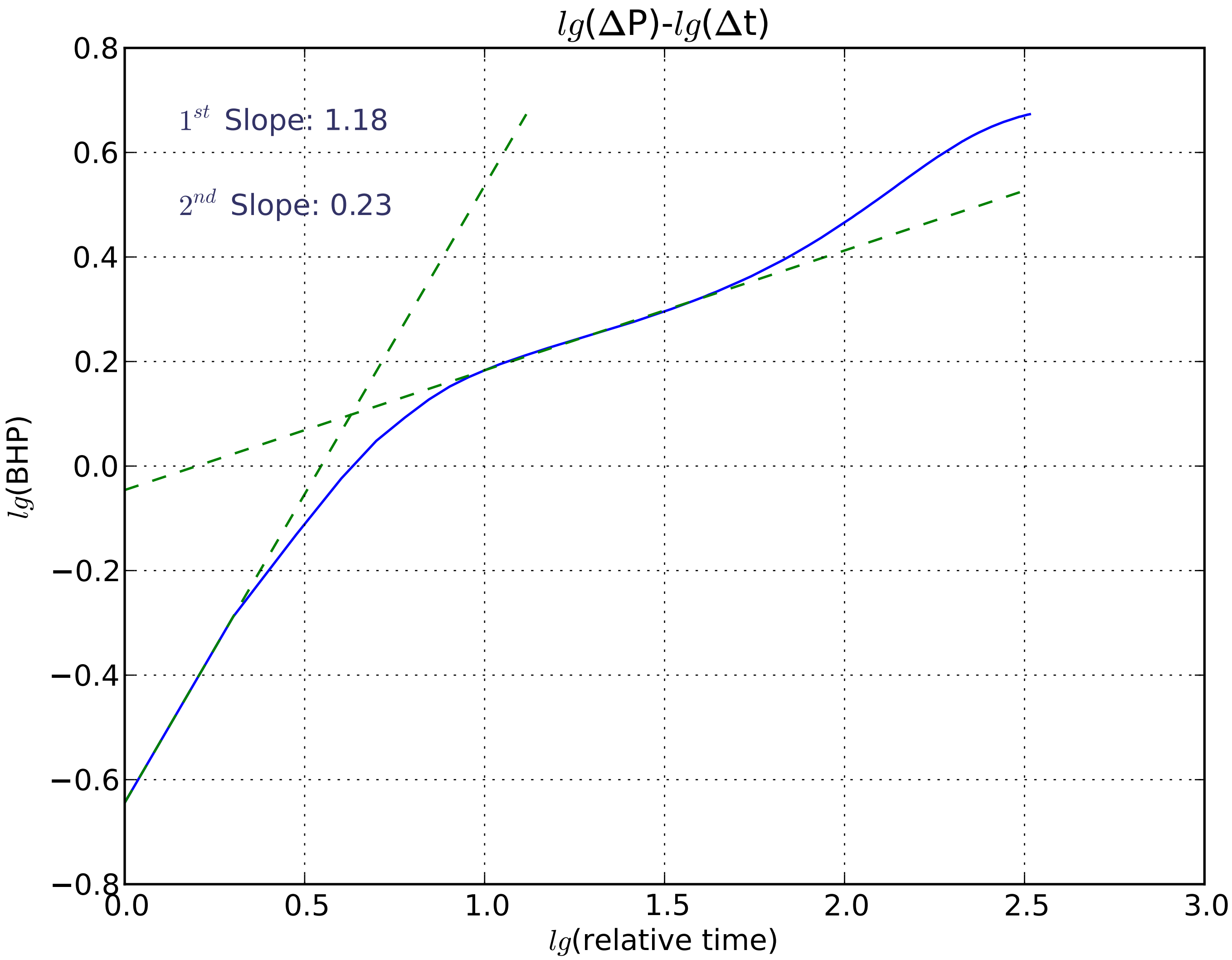


Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 04

BitCan
Geosciences & Engineering Inc.

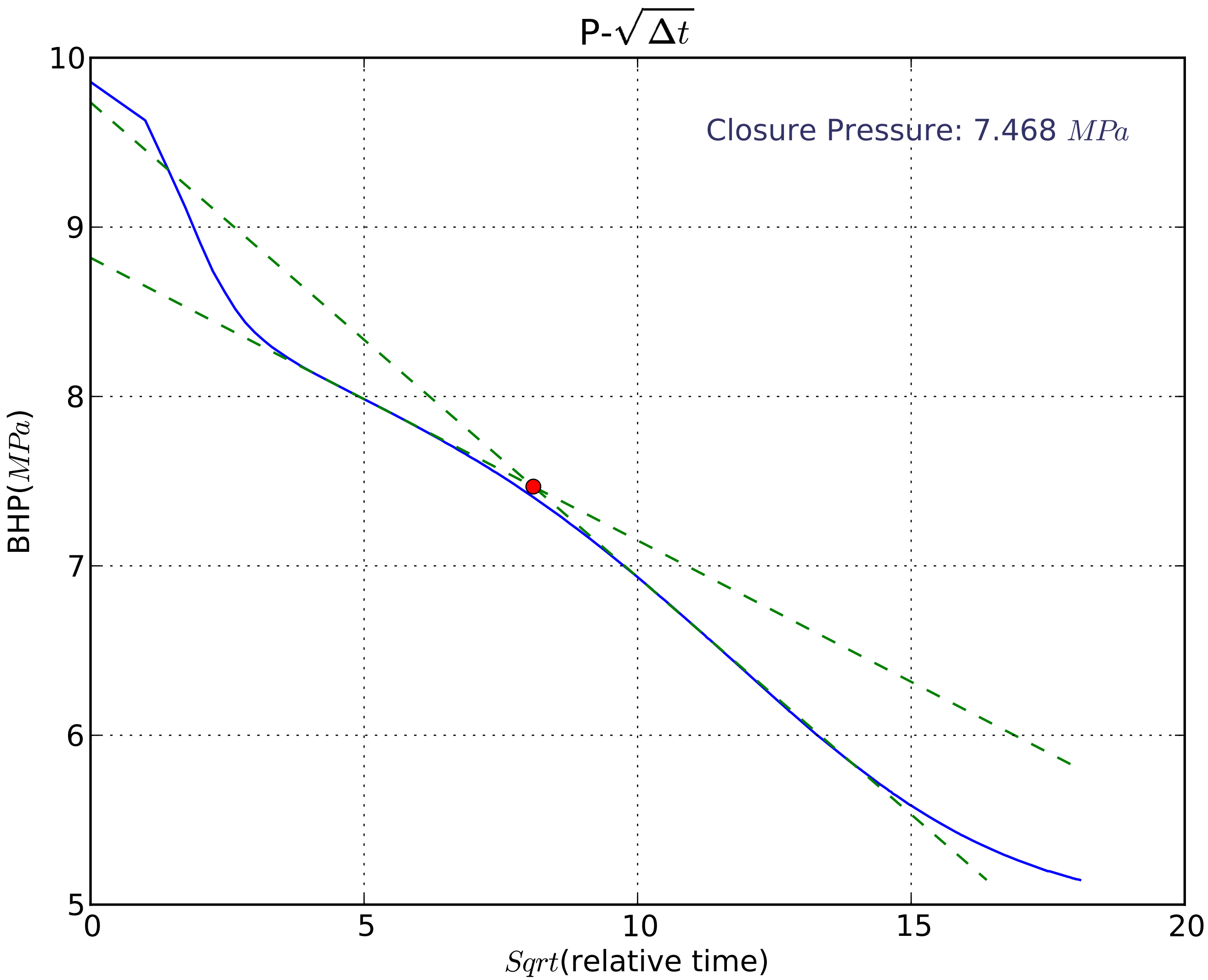


Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 04



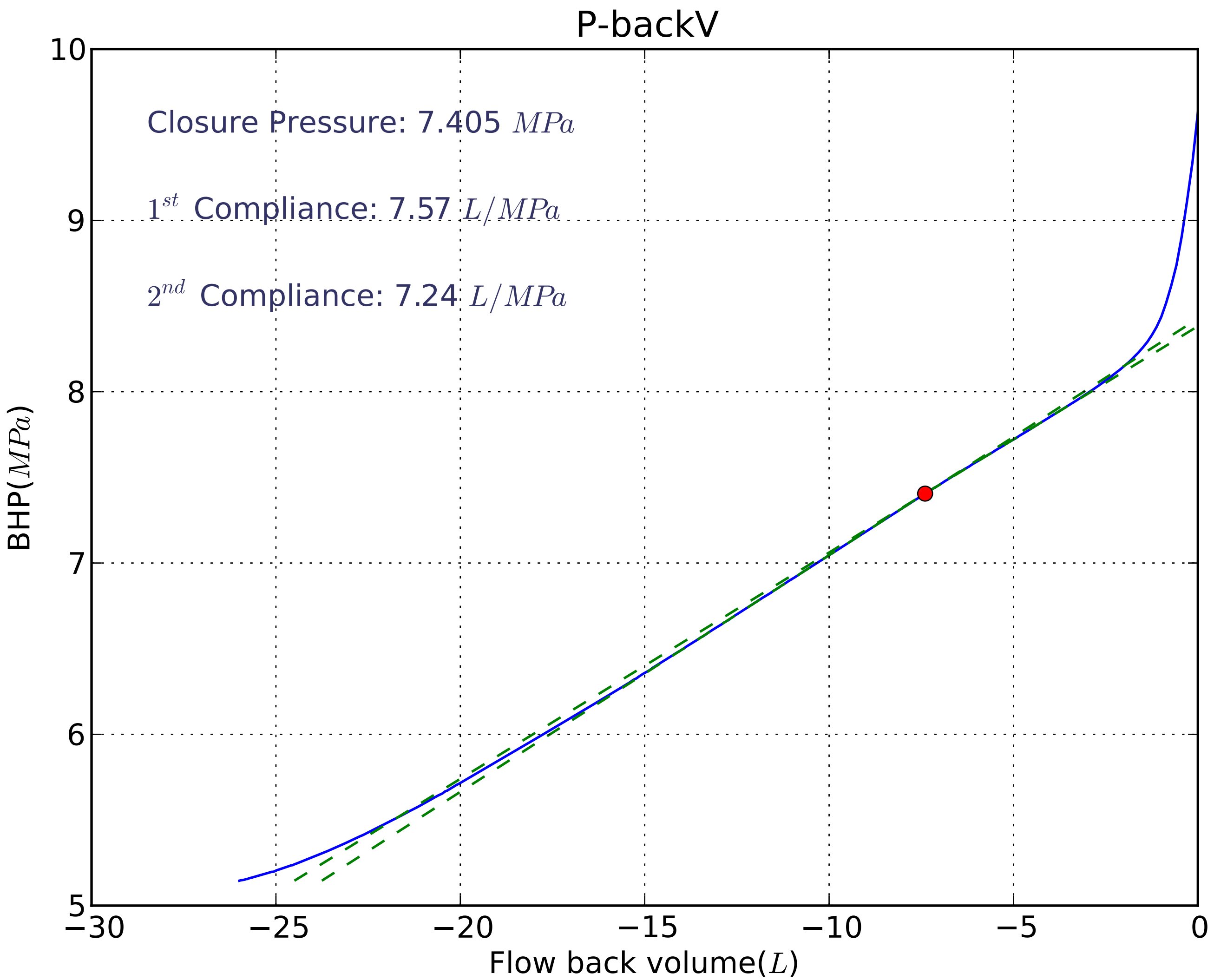
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 04

BitCan
Geosciences & Engineering Inc.



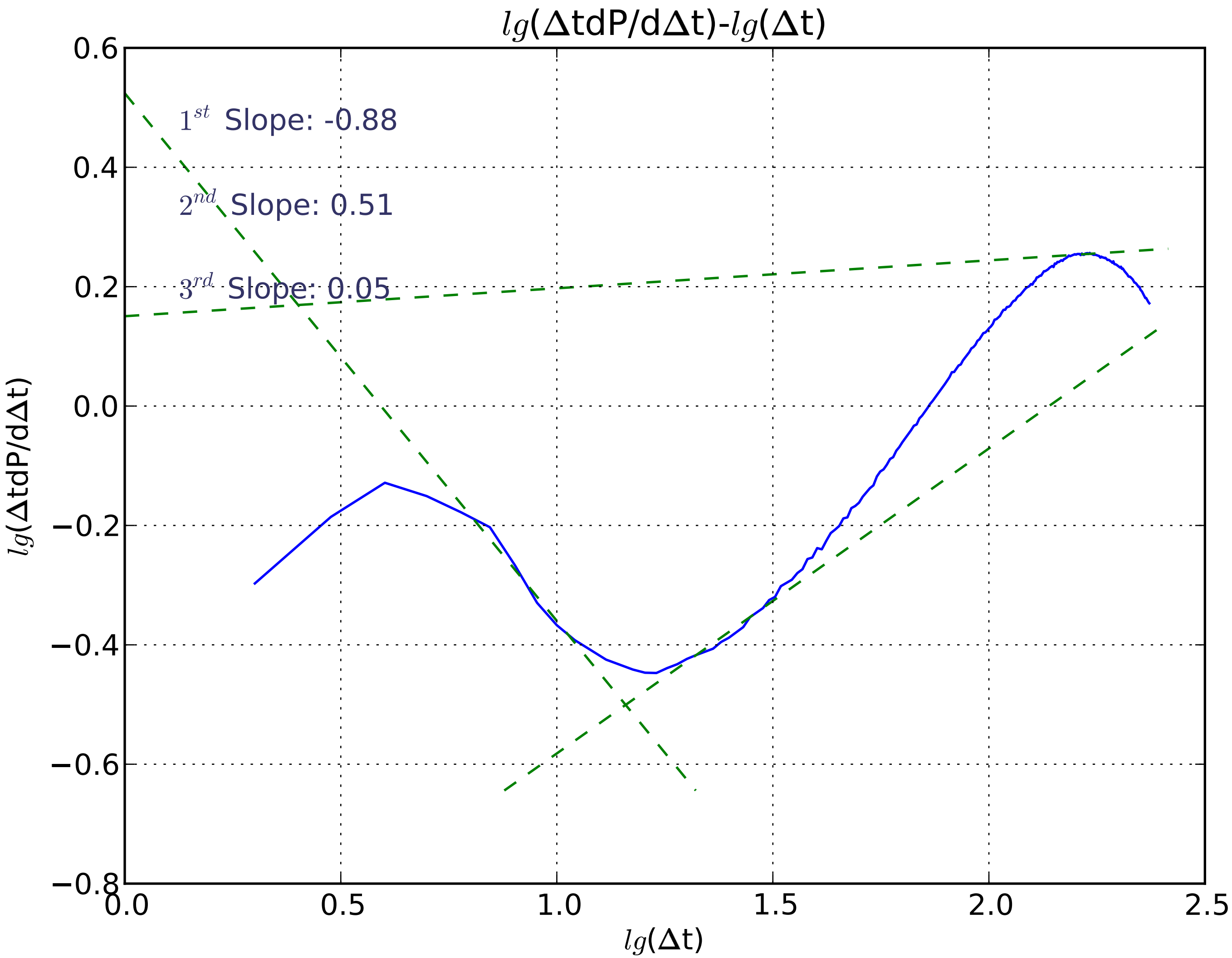
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 04

BitCan
Geosciences & Engineering Inc.



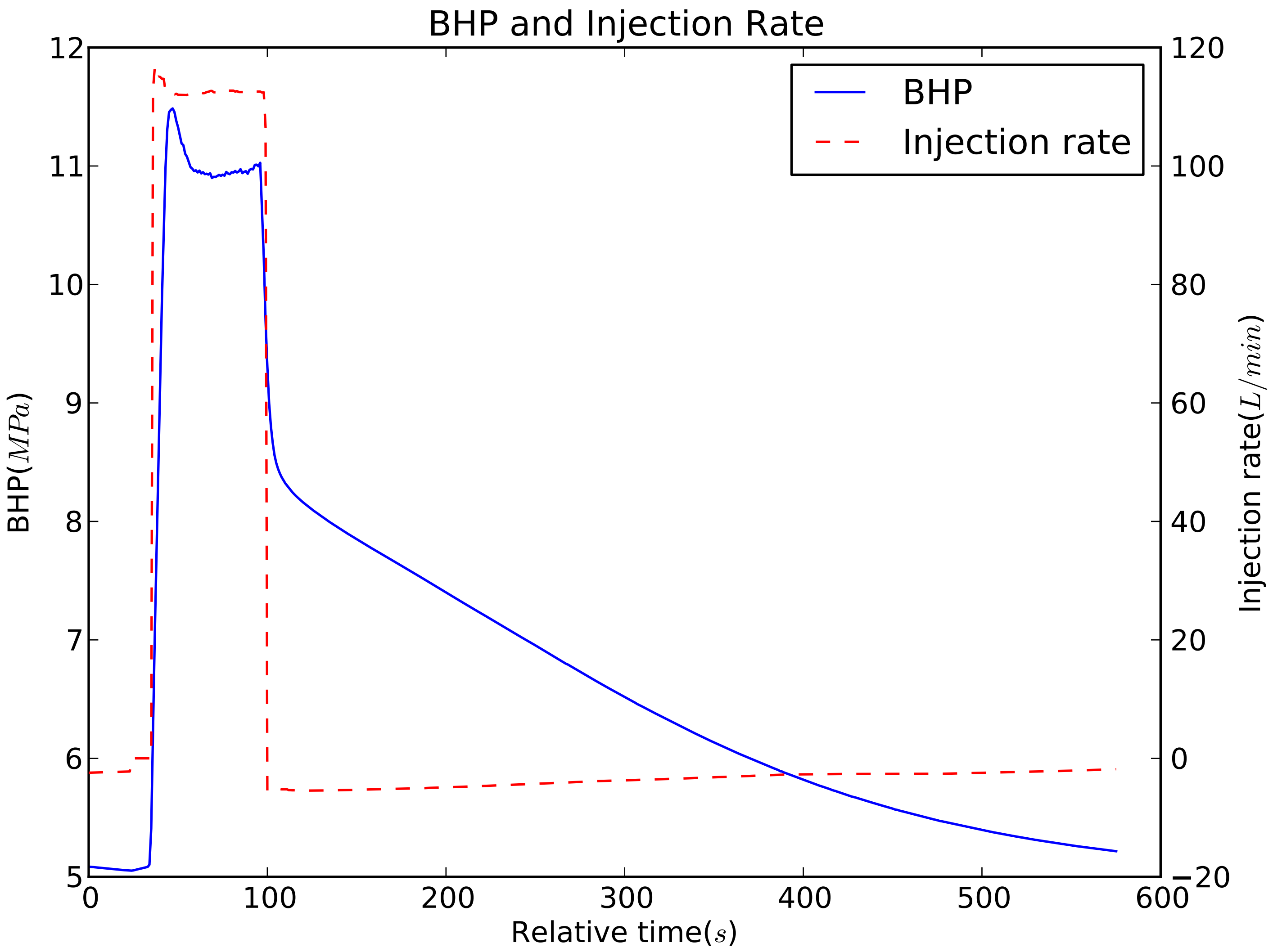
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 04

BitCan
Geosciences & Engineering Inc.



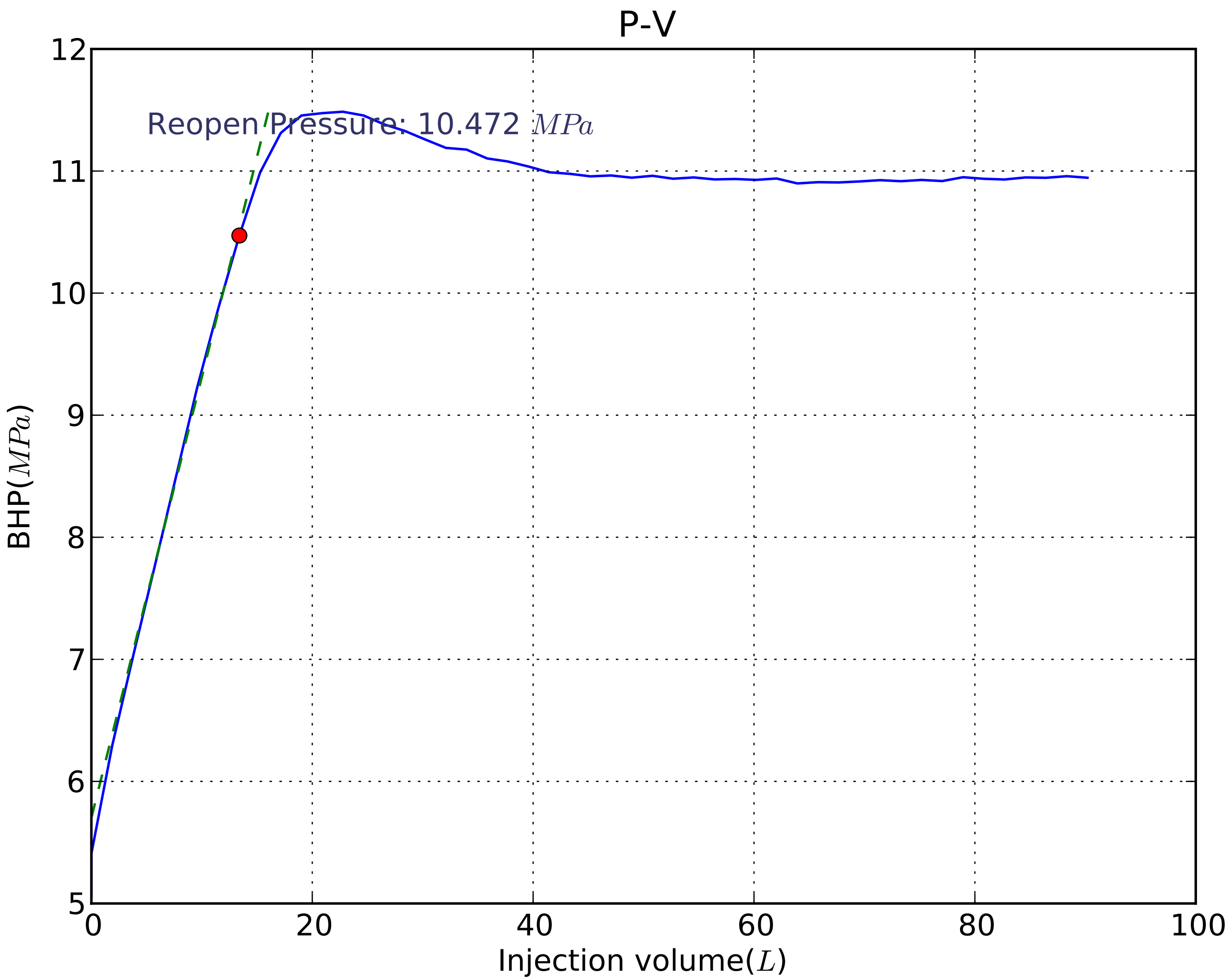
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.



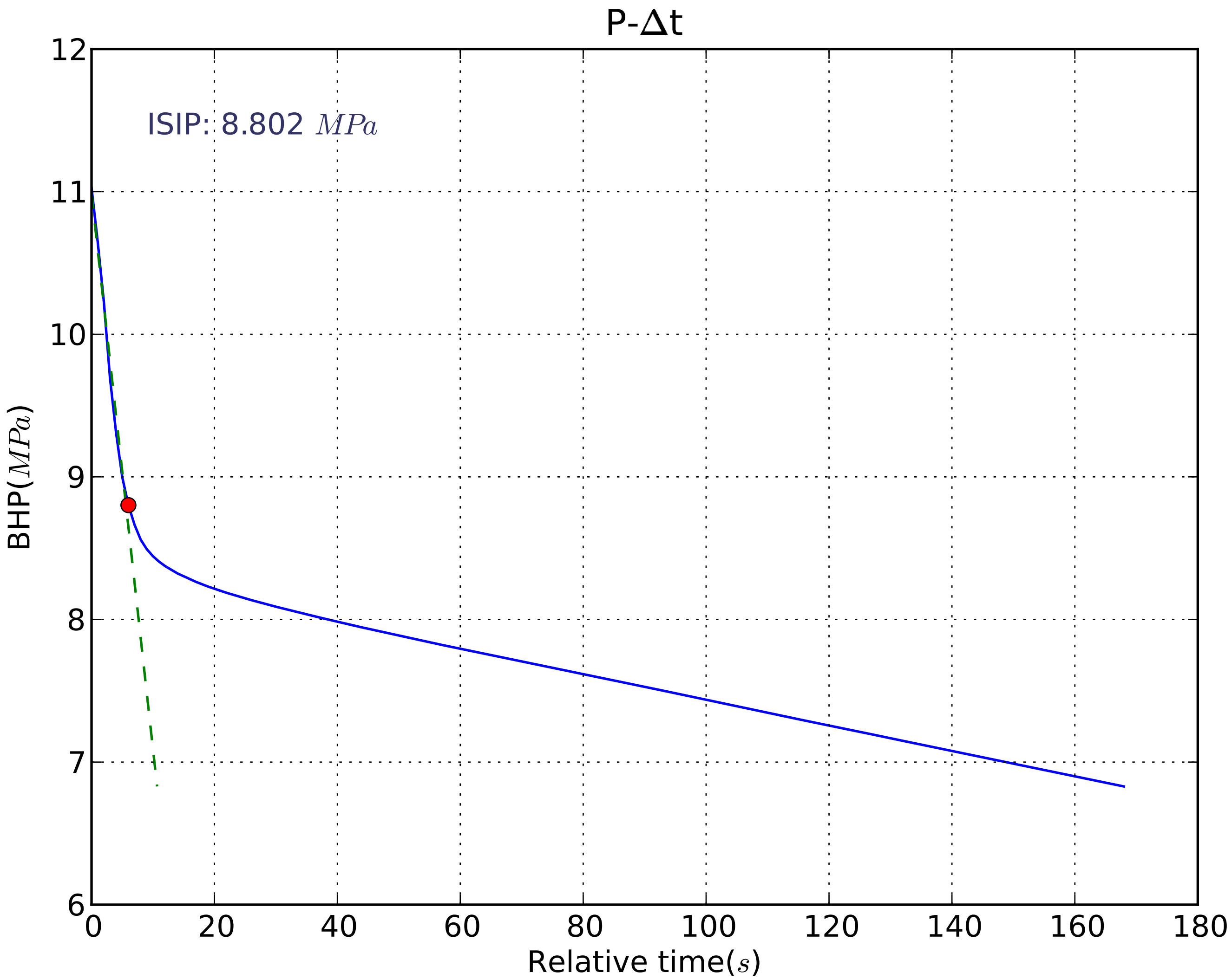
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.



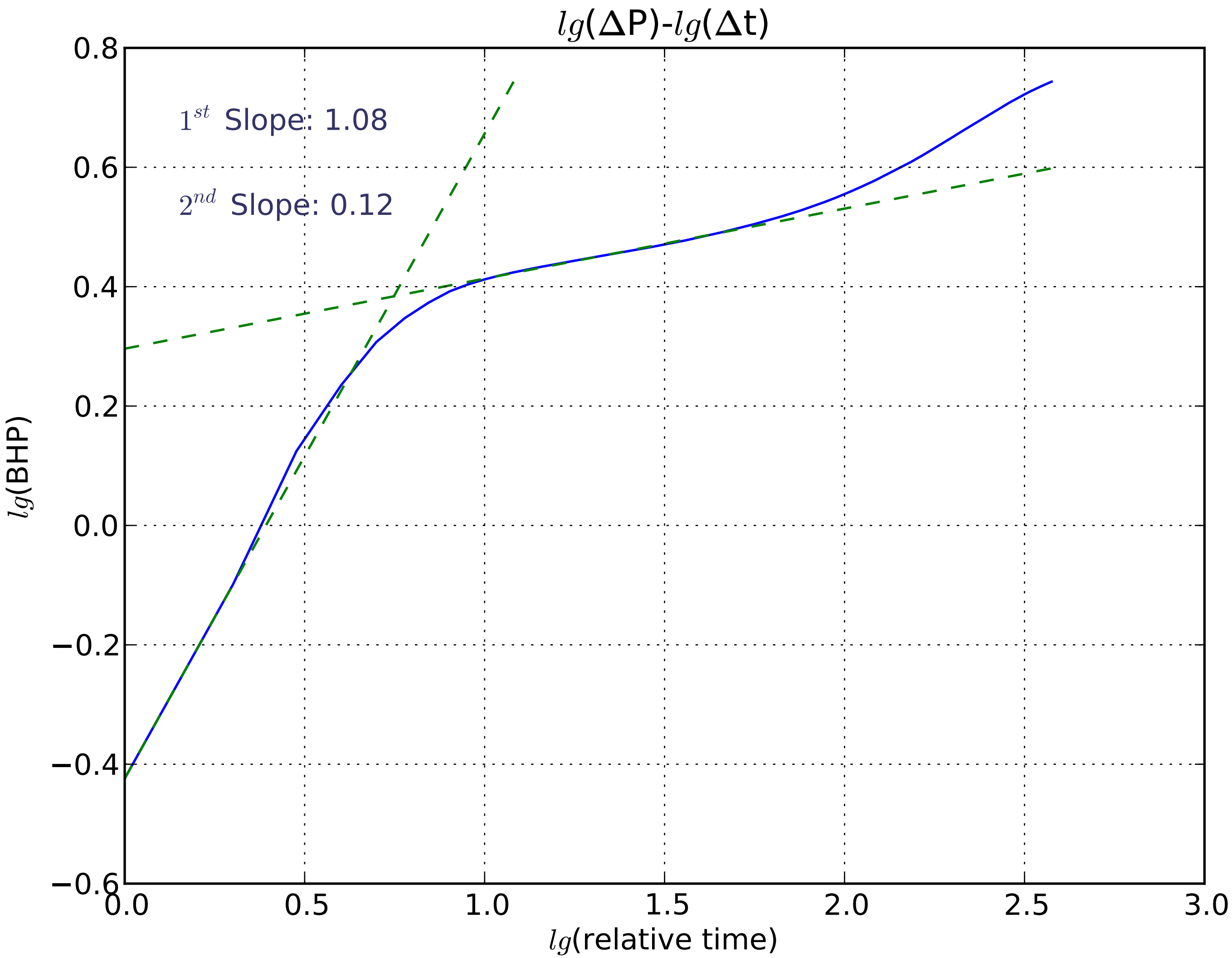
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.



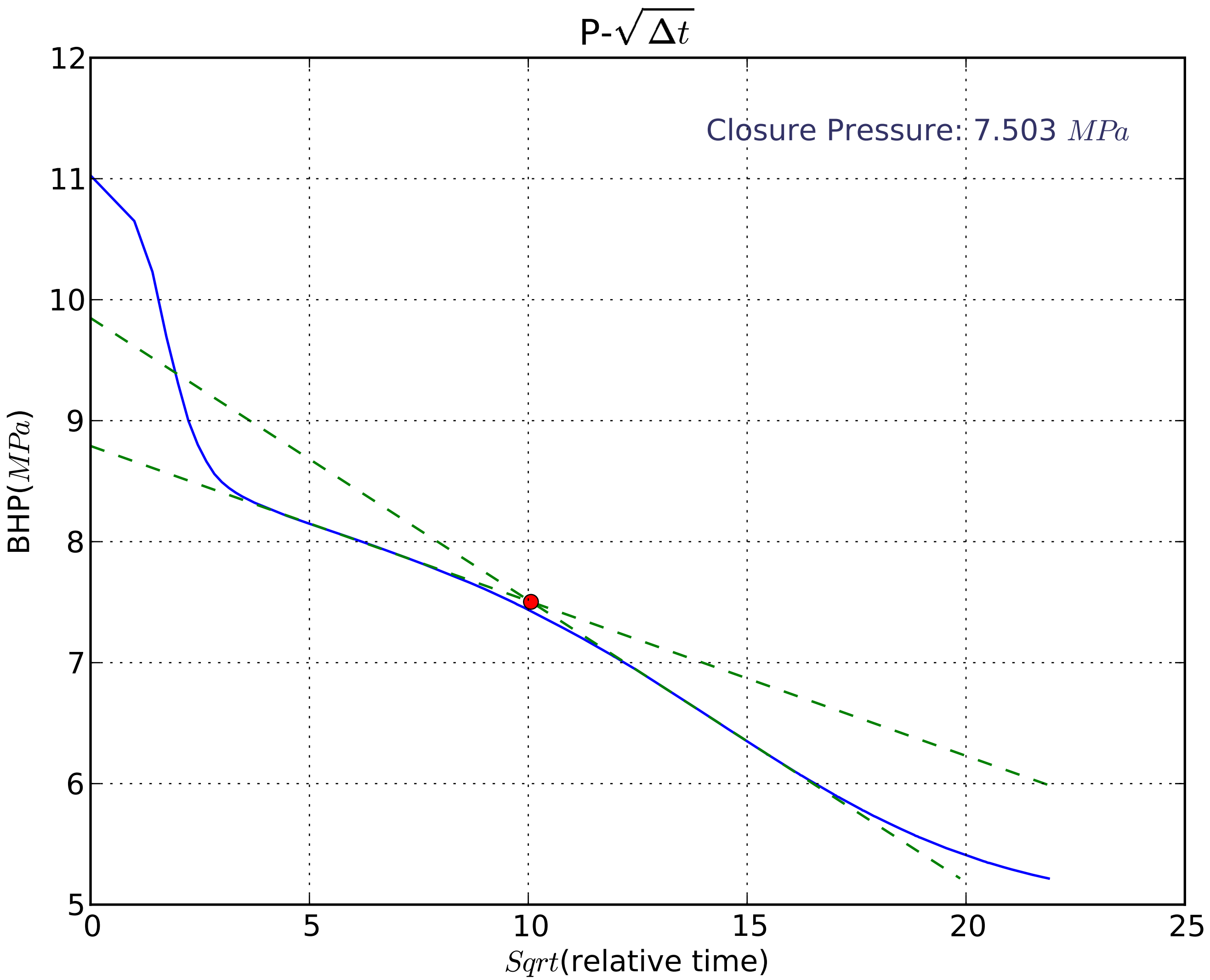
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.



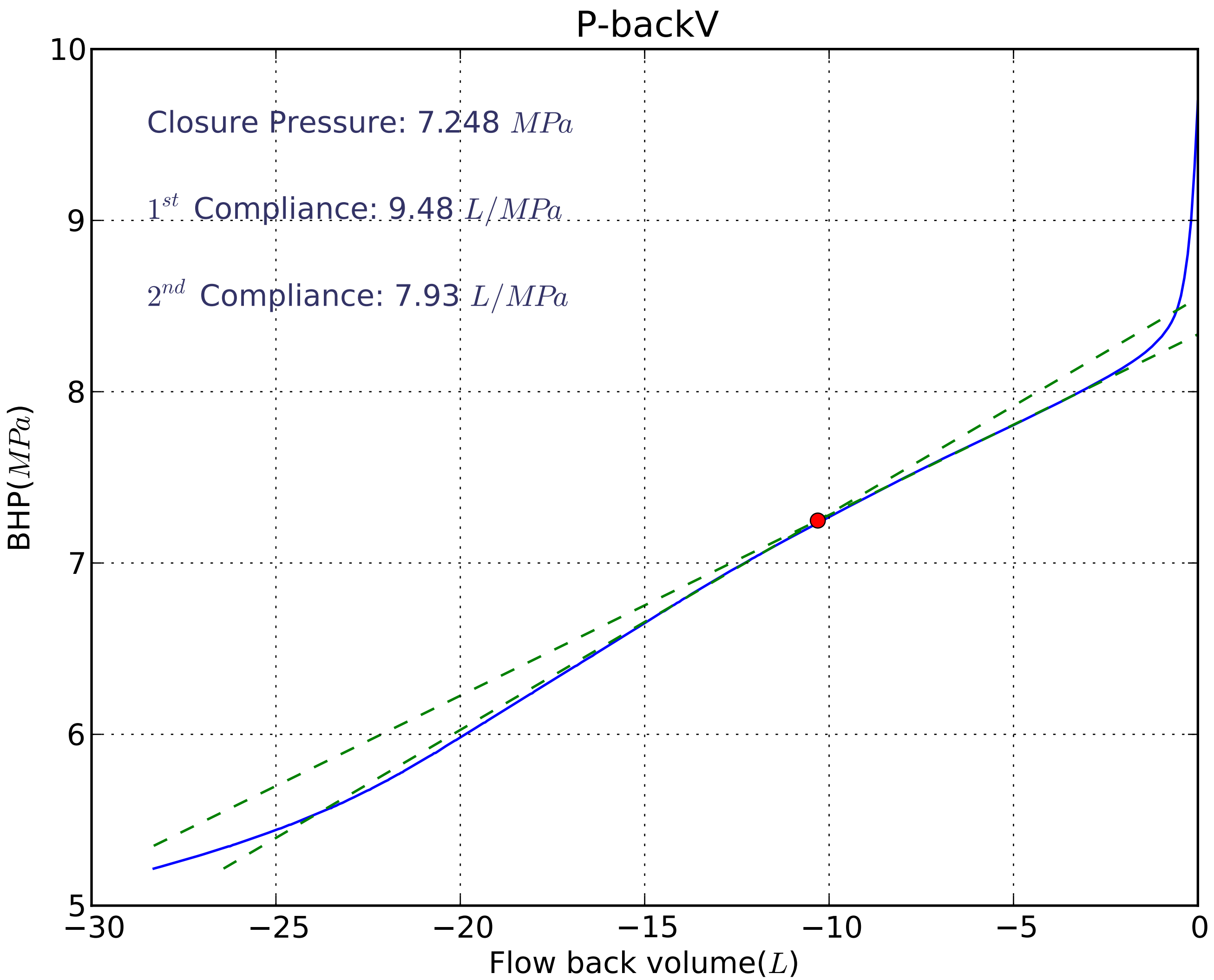
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.



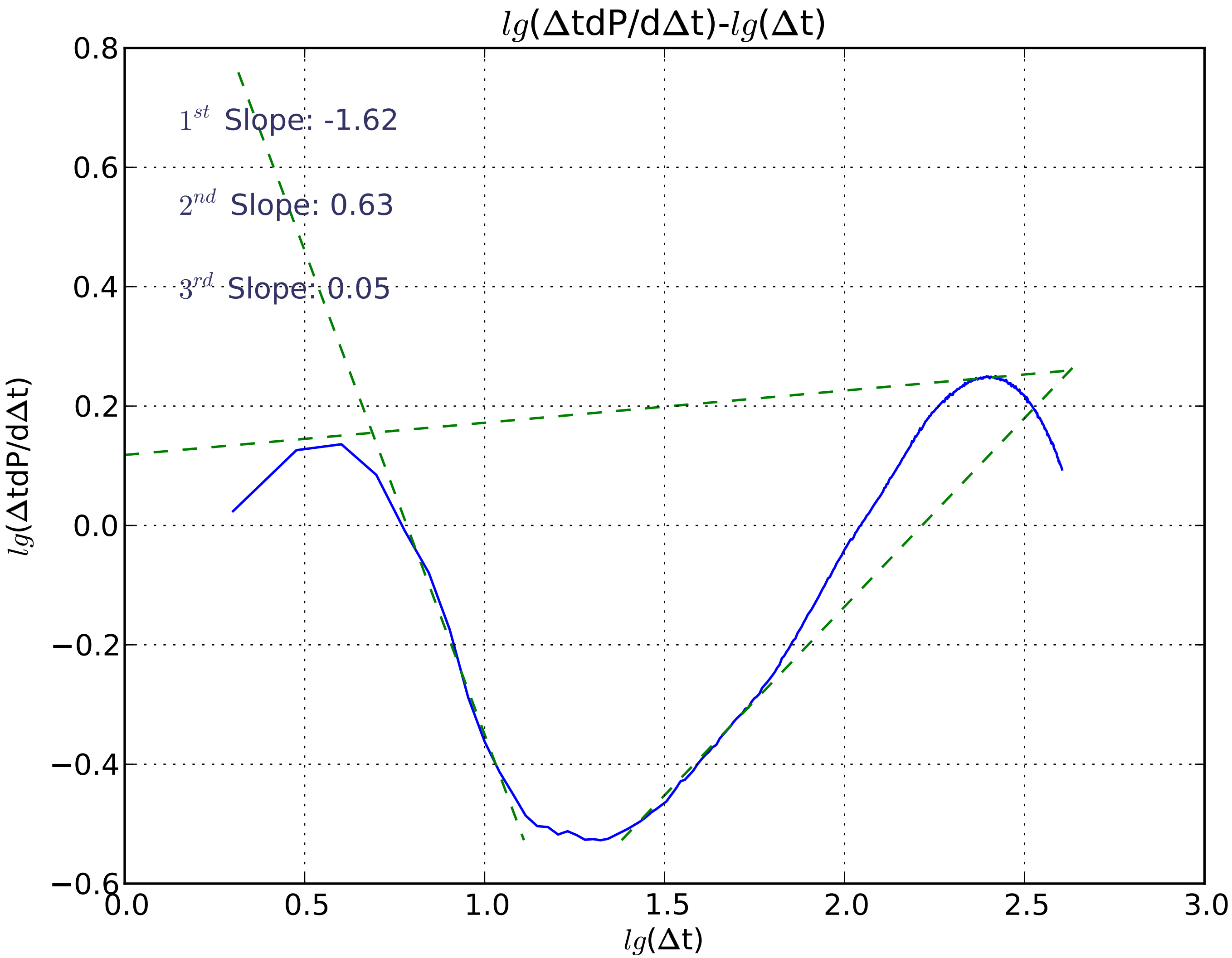
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.



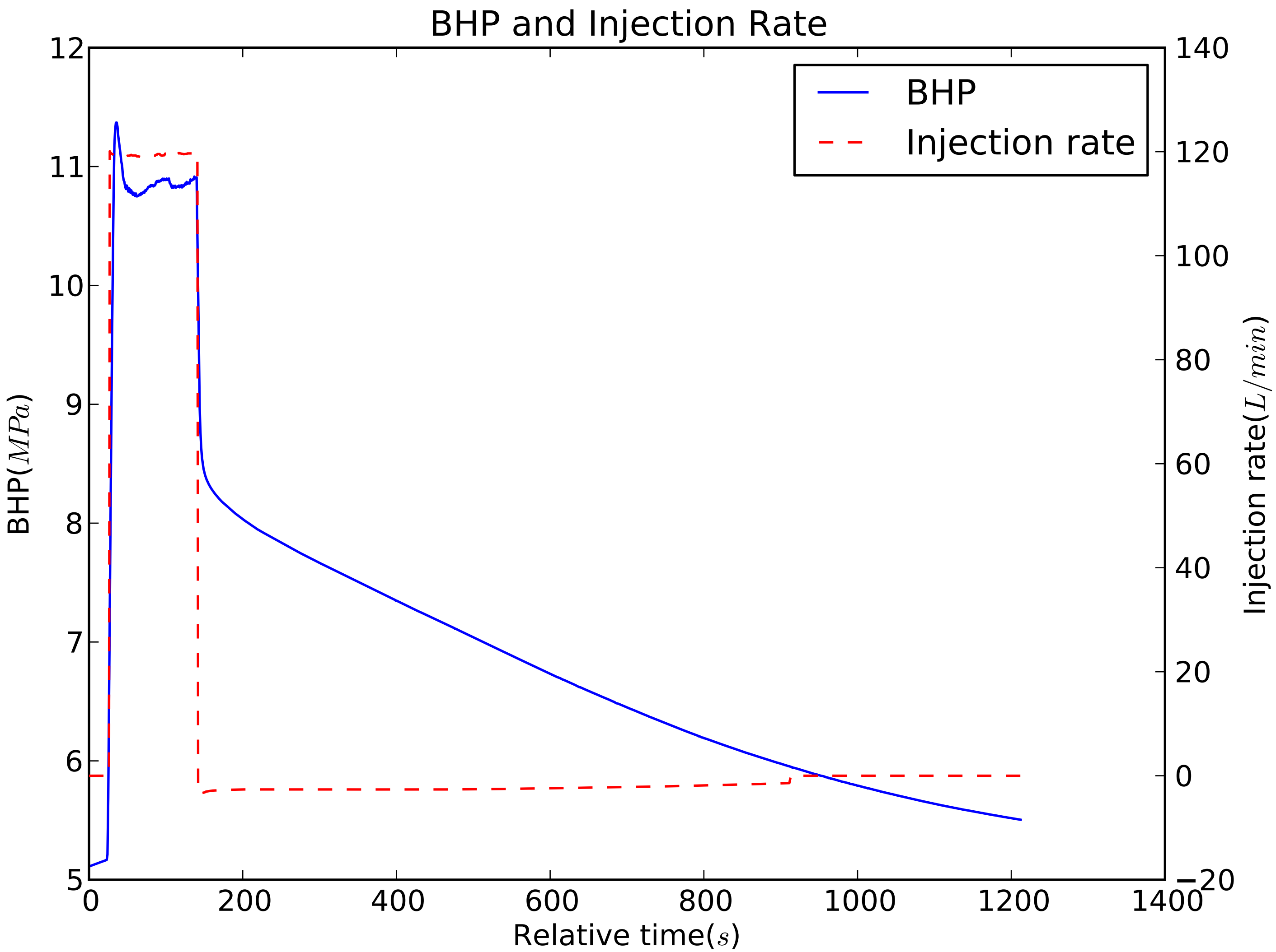
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.



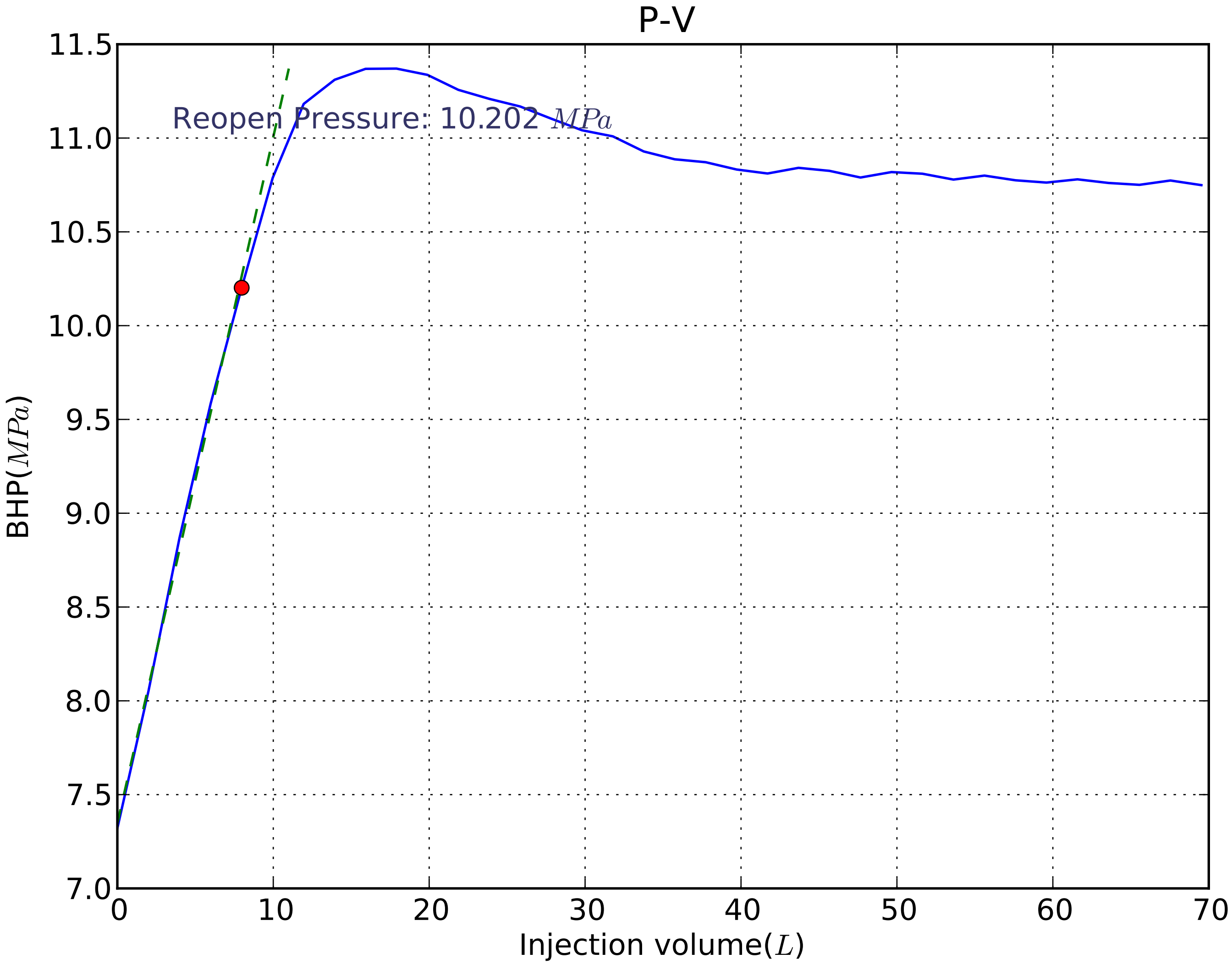
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 06

BitCan Geosciences & Engineering Inc.



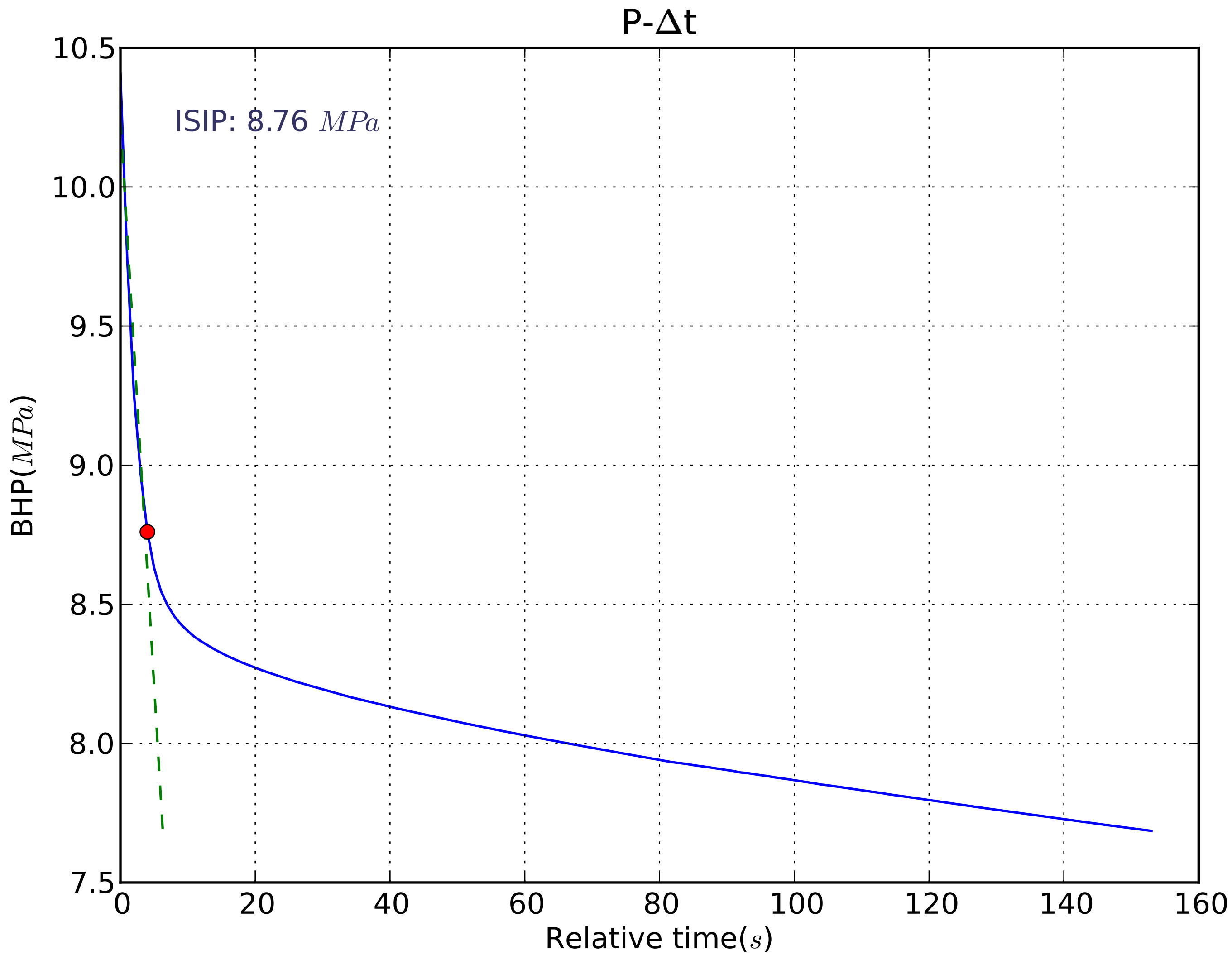
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 06

BitCan
Geosciences & Engineering Inc.



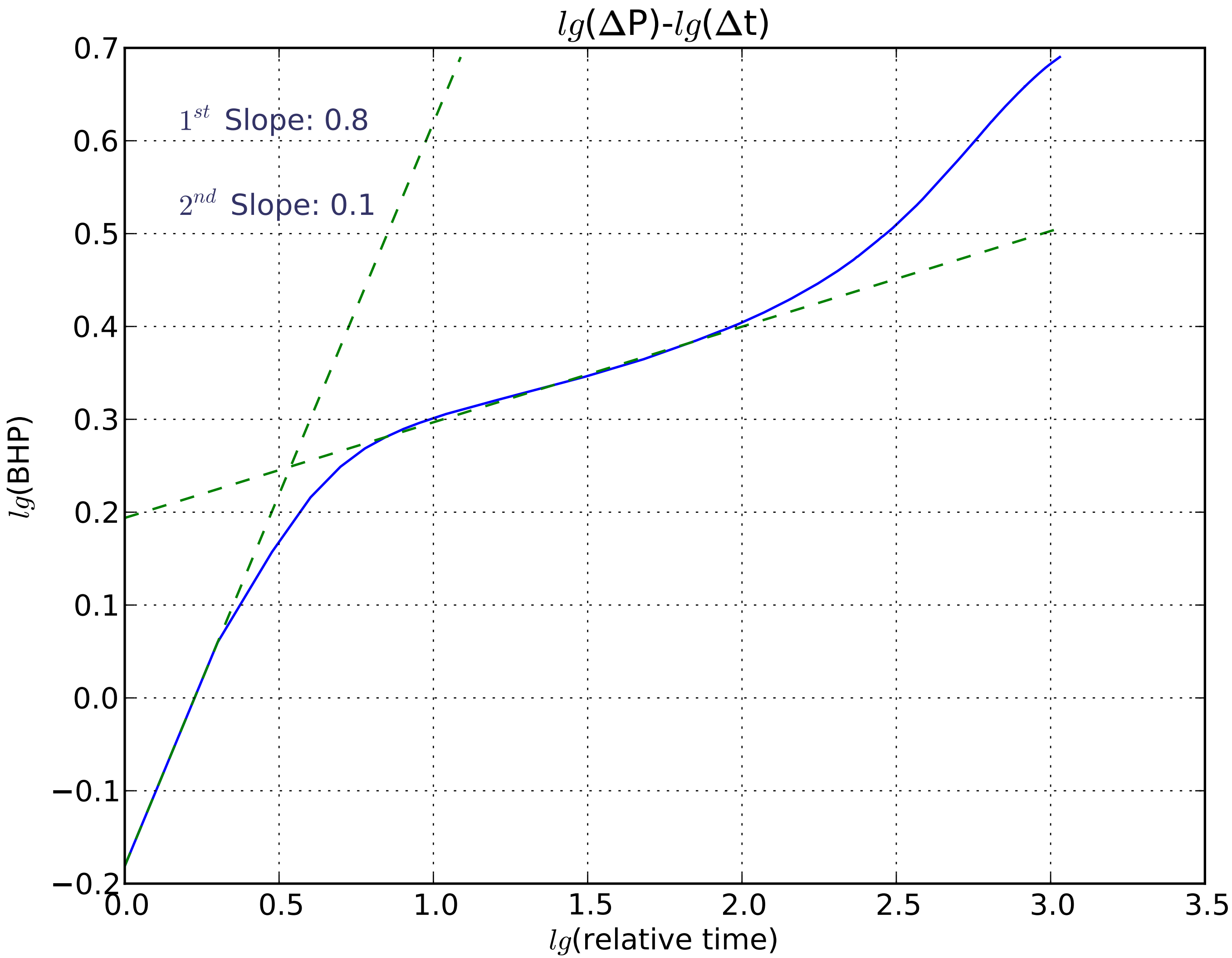
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 06

BitCan
Geosciences & Engineering Inc.

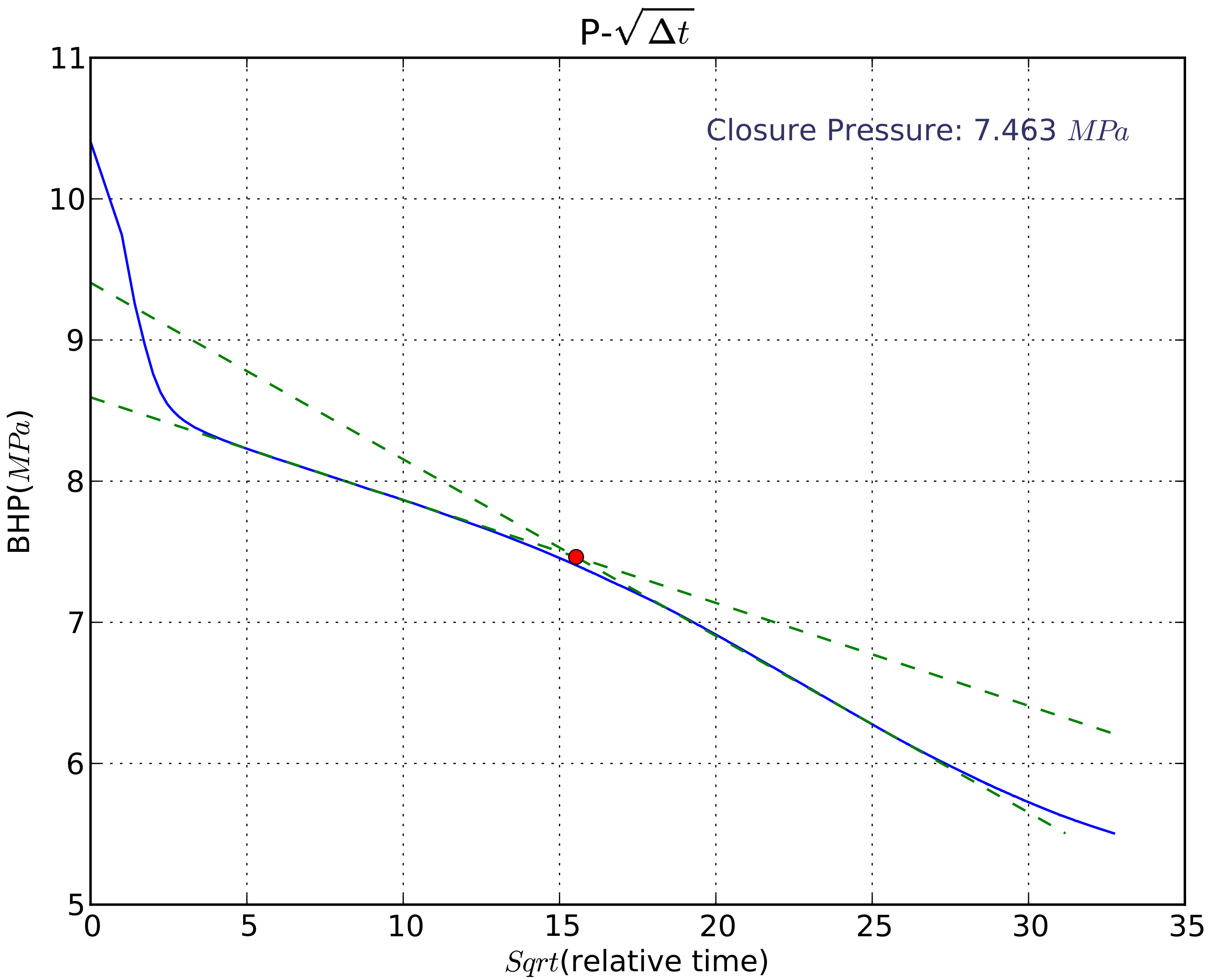


Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 06

BitCan
Geosciences & Engineering Inc.

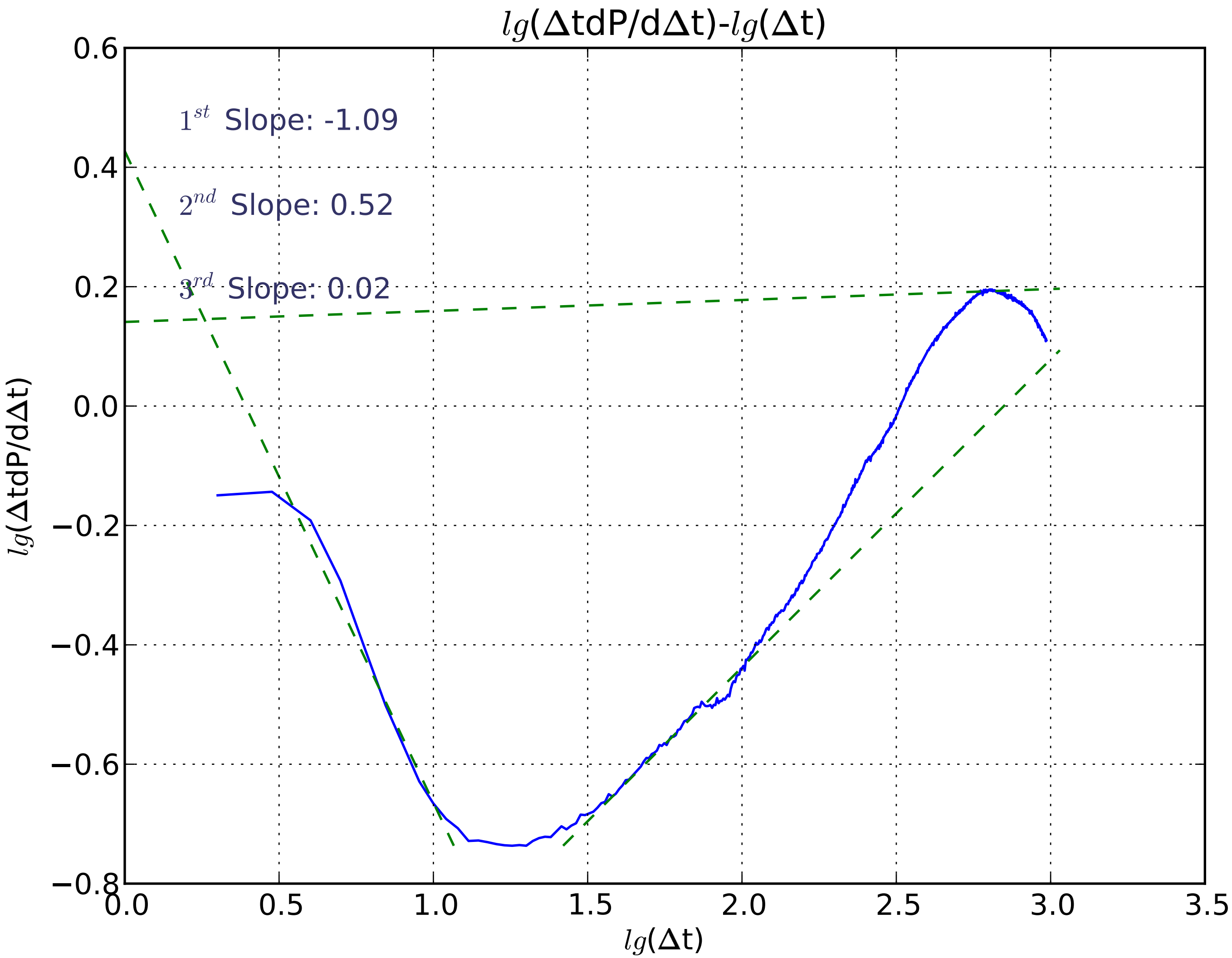


Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 06



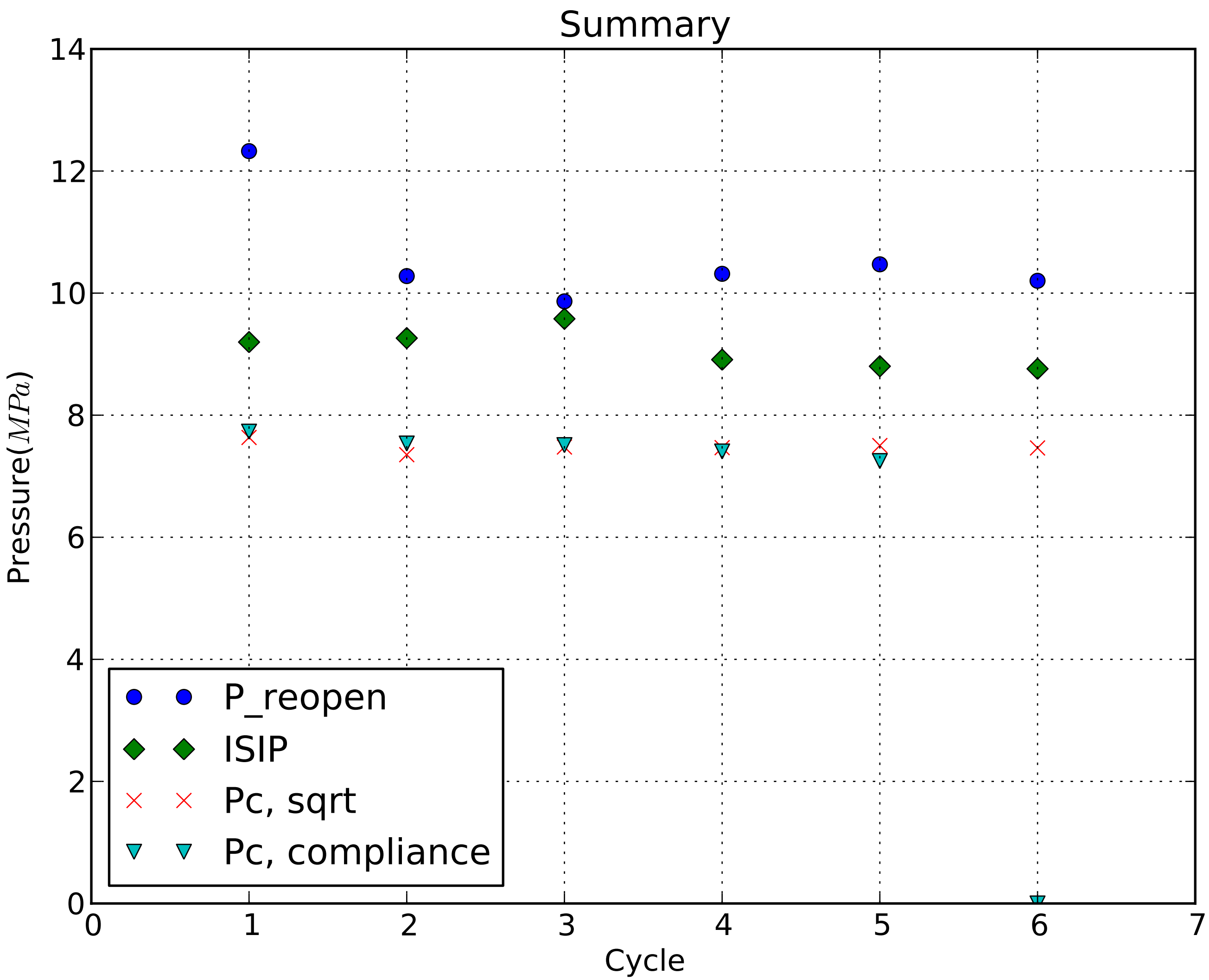
Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 06

BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 493.0m
Formation: GP
Cycle: 1 to 6

BitCan
Geosciences & Engineering Inc.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	12.326	9.198	7.635	7.730	2.54	9.02	8.11
2	10.279	9.263	7.353	7.536	2.66	6.04	6.13
3	9.865	9.579	7.479	7.509	2.68	7.51	7.62
4	10.316	8.910	7.468	7.405	3.35	7.57	7.24
5	10.472	8.802	7.503	7.248	2.77	9.48	7.93
6	10.202	8.760	7.463	0.000	2.73	0.00	0.00

ANALYSIS PLOTS

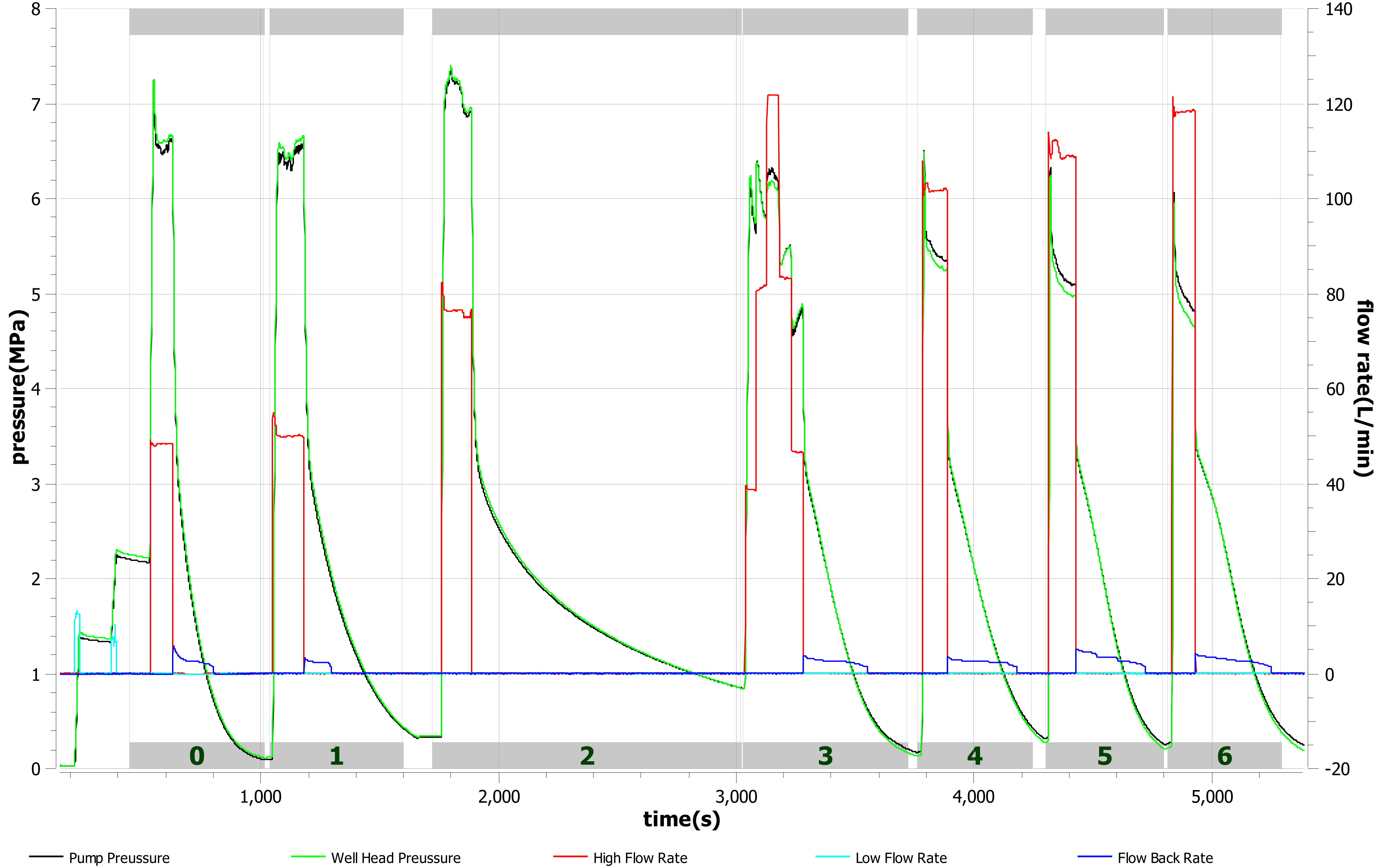
WELL: PENGROWTH LNDBRGH WELL 13-13-58-5W4

Test 3: GP Zone #2 at 484 m

BitCan
Geosciences & Engineering Inc.
www.bitcange.com

Client: Pengrowth Energy Corp.
Well: 13-13-58-5W4
Depth: 484
Formation: GP
Start @: Thu Mar 3 16:49:34 2011

Mini-Frac Test



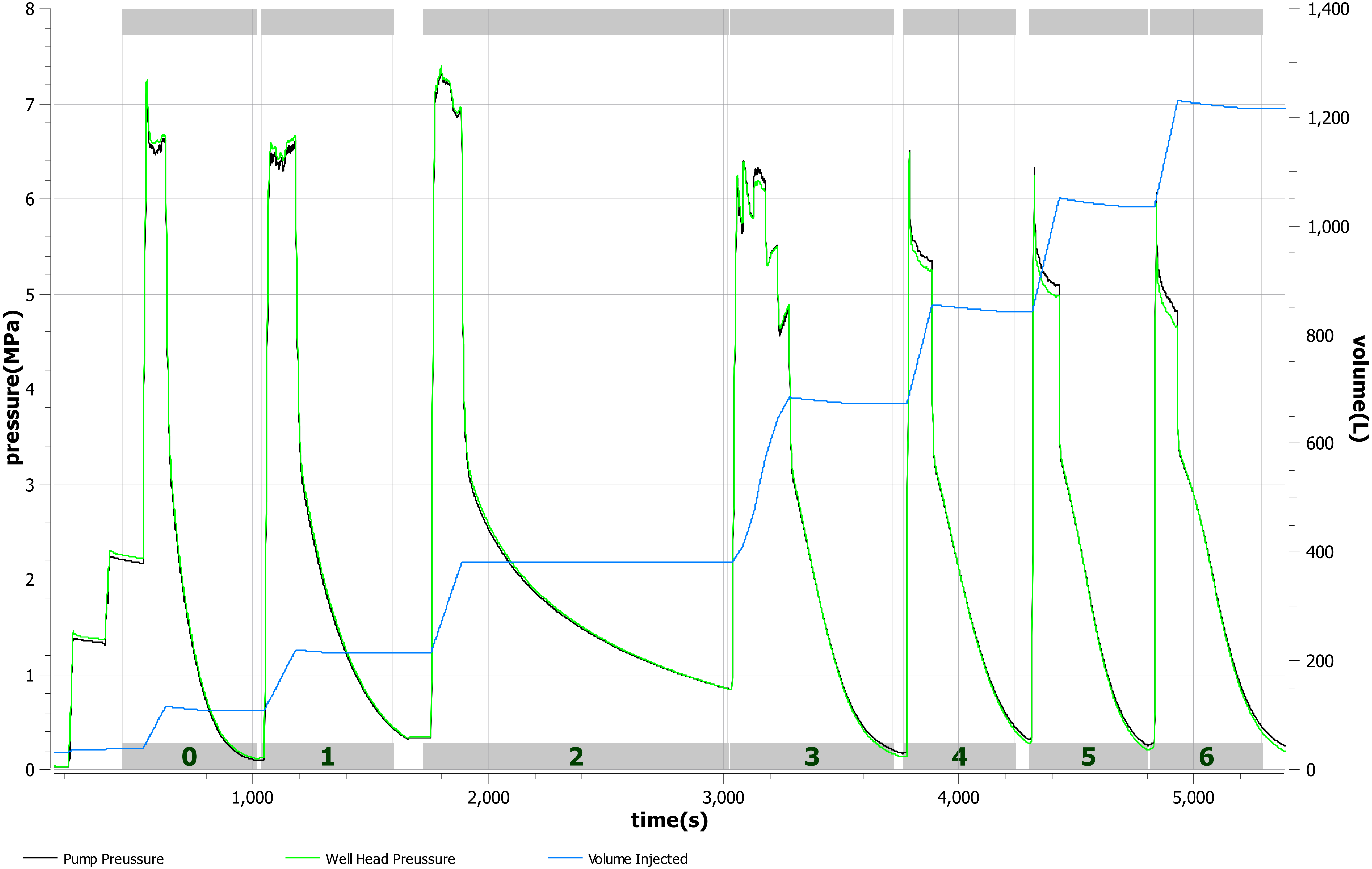
Generated by MiniMonitor

BitCan Geosciences & Engineering Inc.

www.bitcange.com

Client: Pengrowth Energy Corp.
Well: 13-13-58-5W4
Depth: 484
Formation: GP
Start @: Thu Mar 3 16:49:34 2011

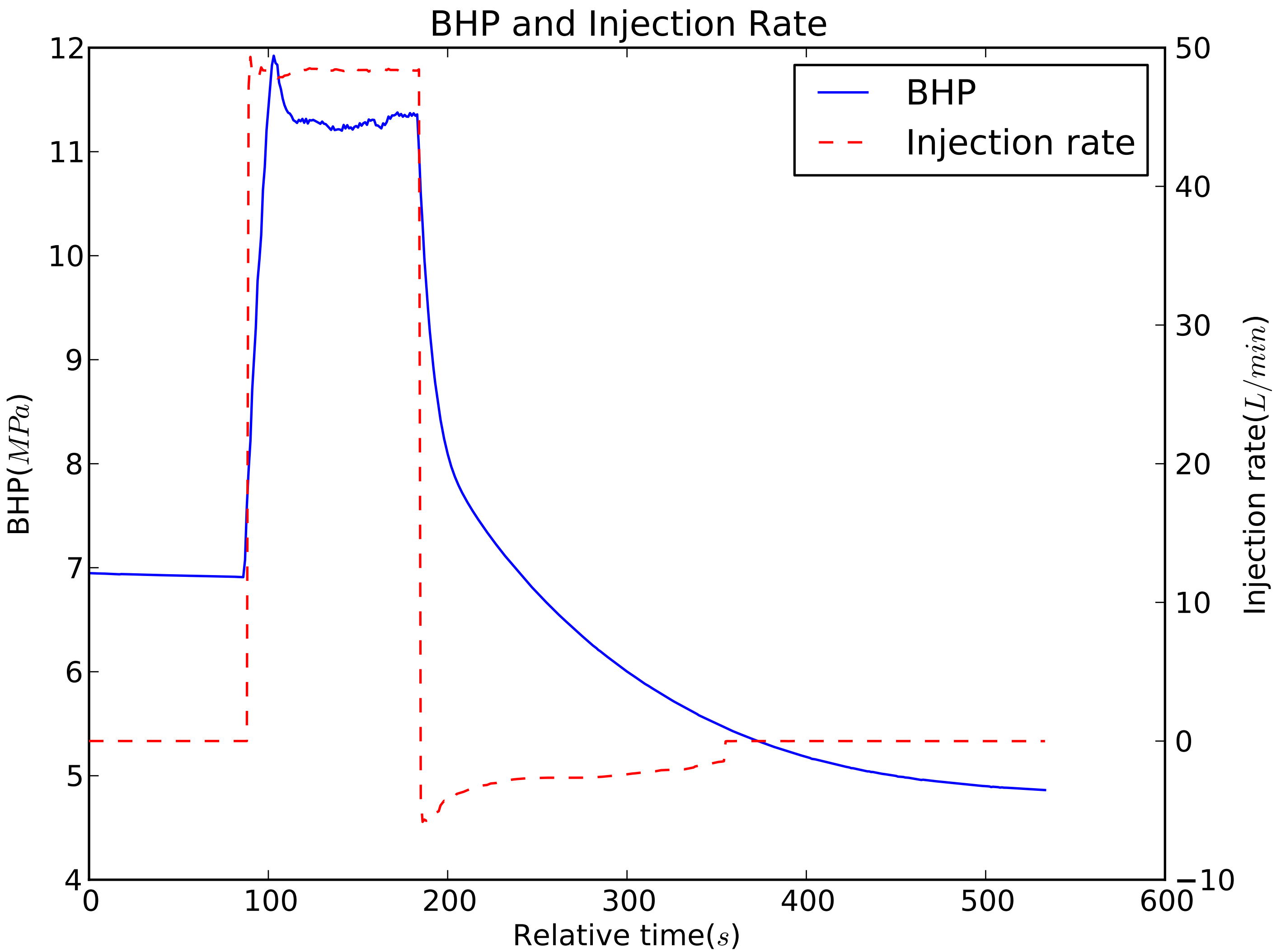
Mini-Frac Test



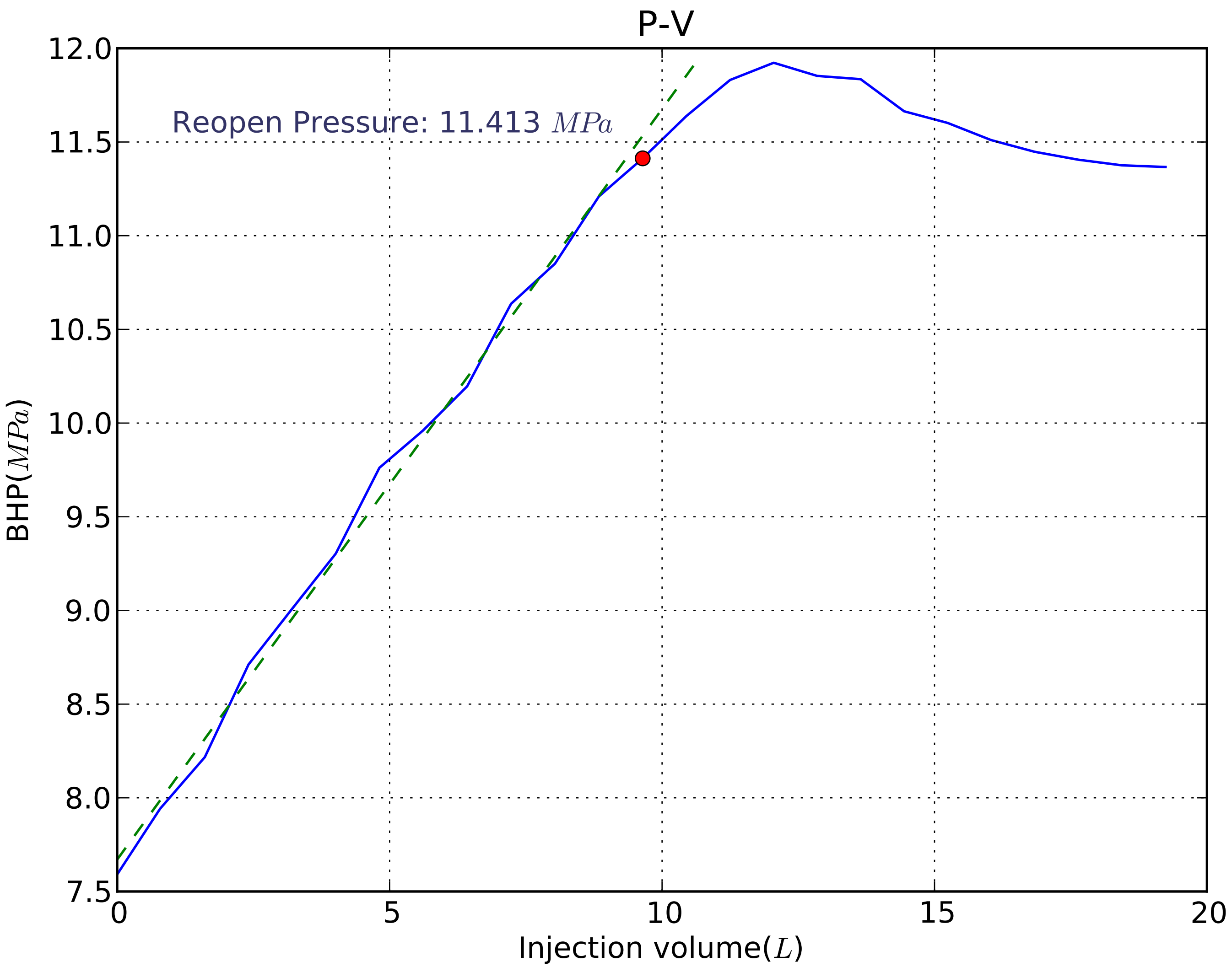
Generated by MiniMonitor

Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 01

BitCan
Geosciences & Engineering Inc.

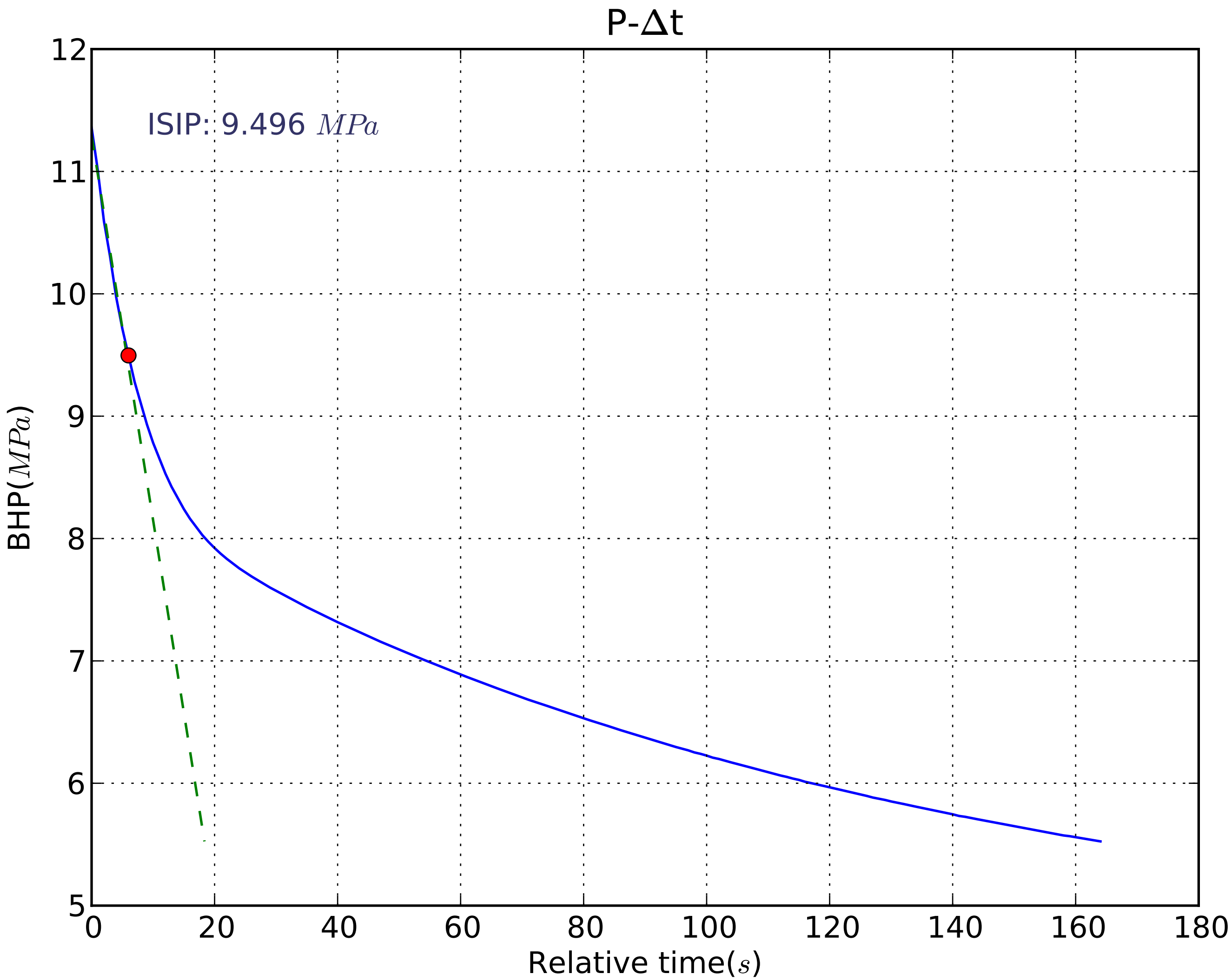


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 01



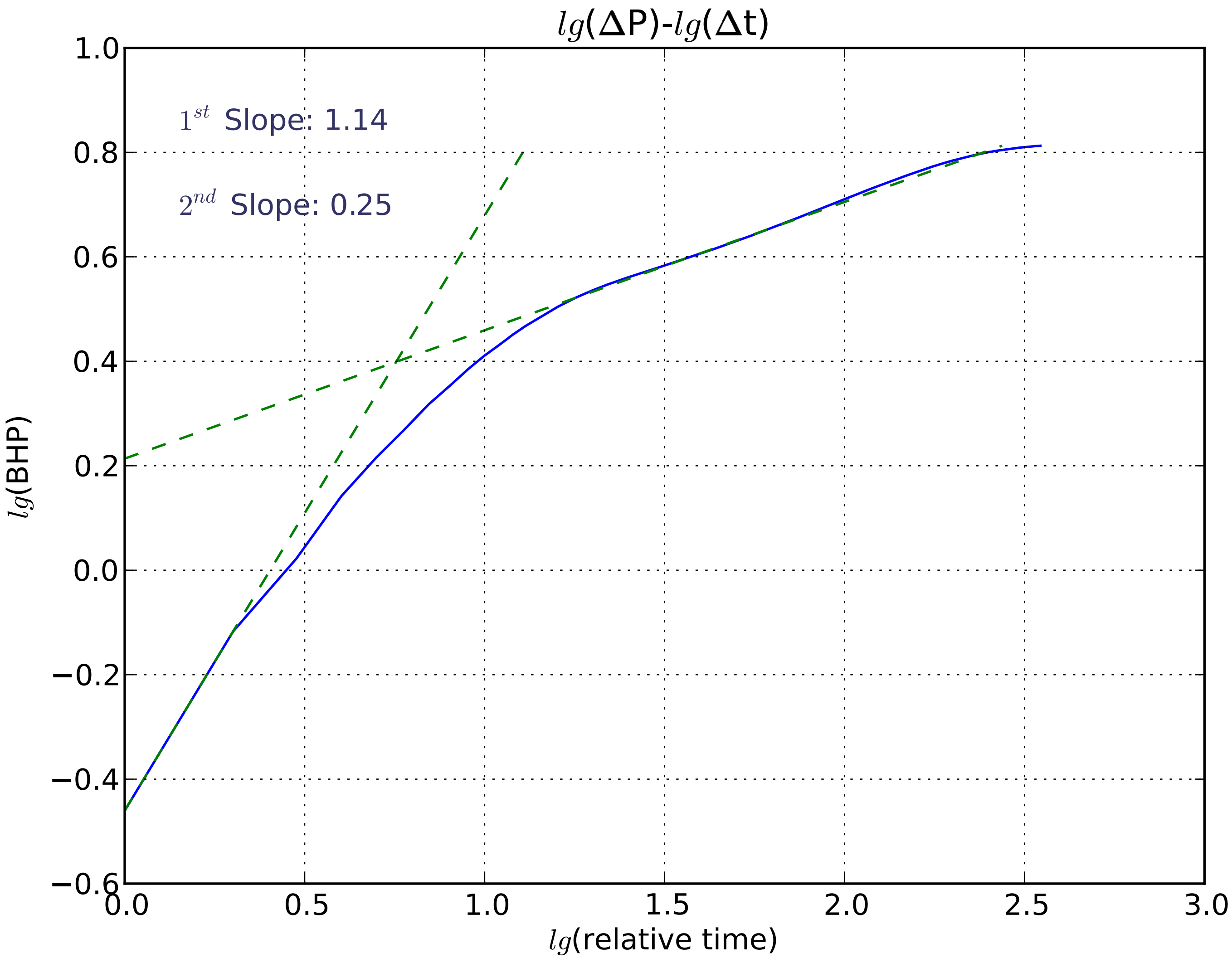
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 01

BitCan
Geosciences & Engineering Inc.

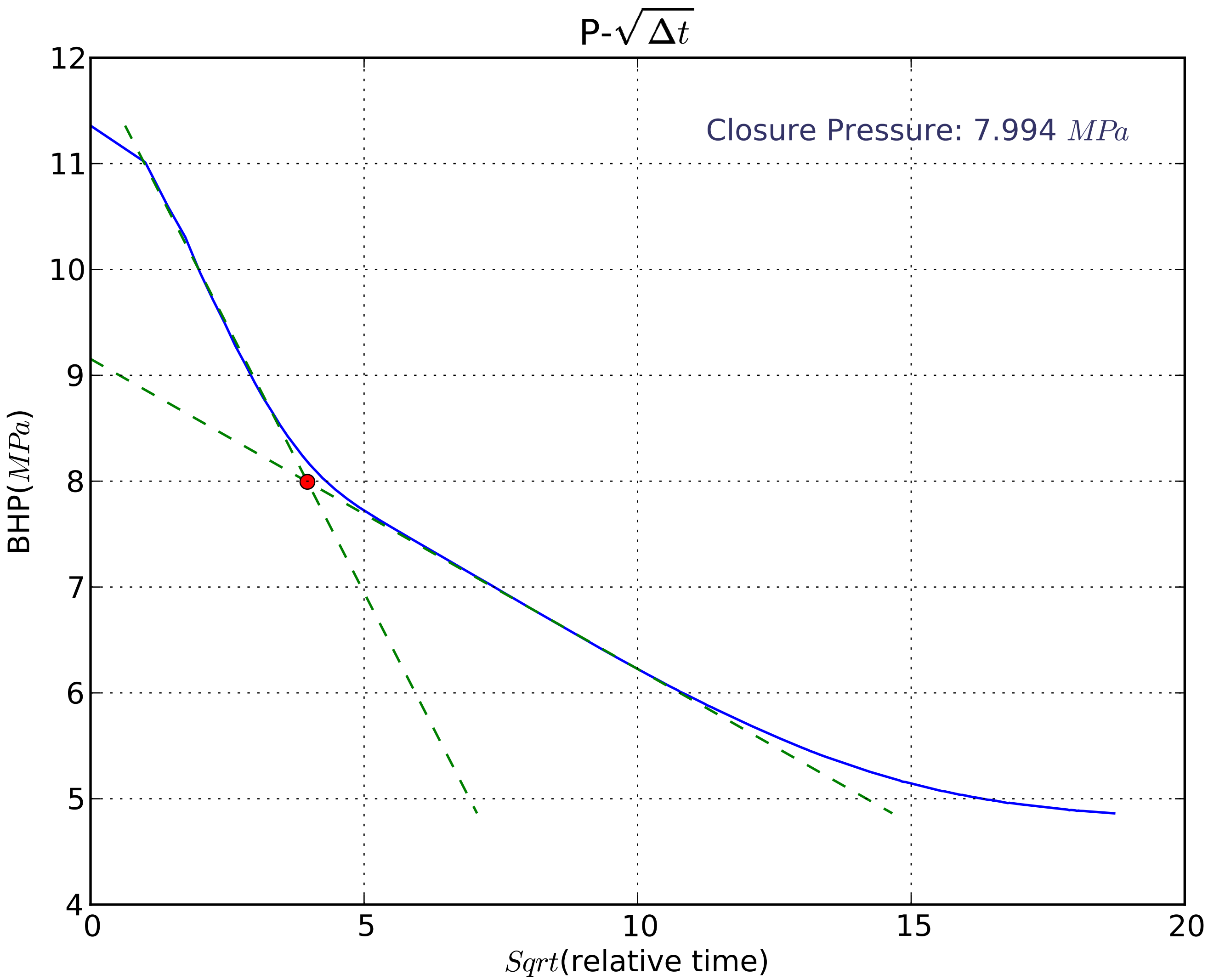


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 01

BitCan
Geosciences & Engineering Inc.

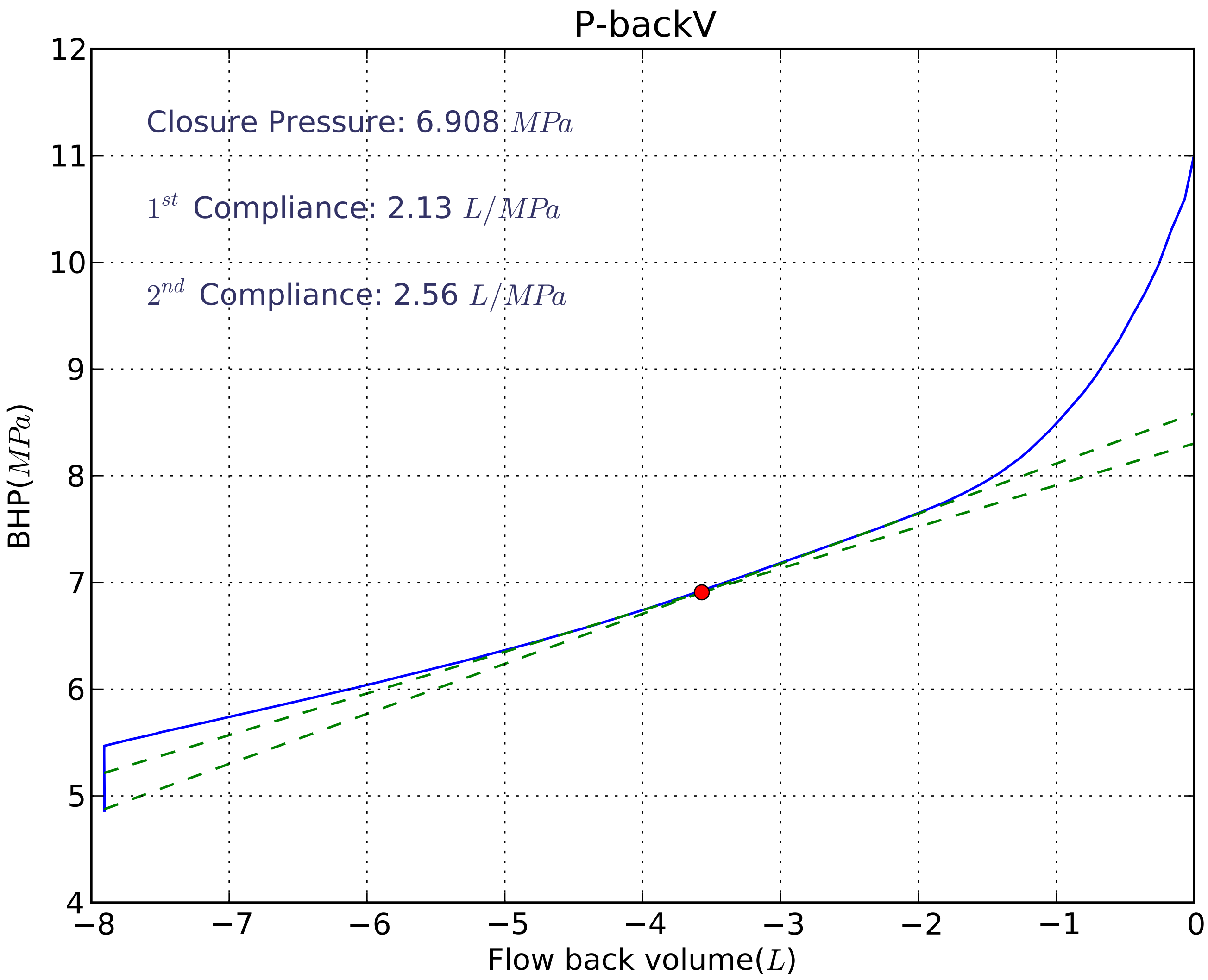


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 01



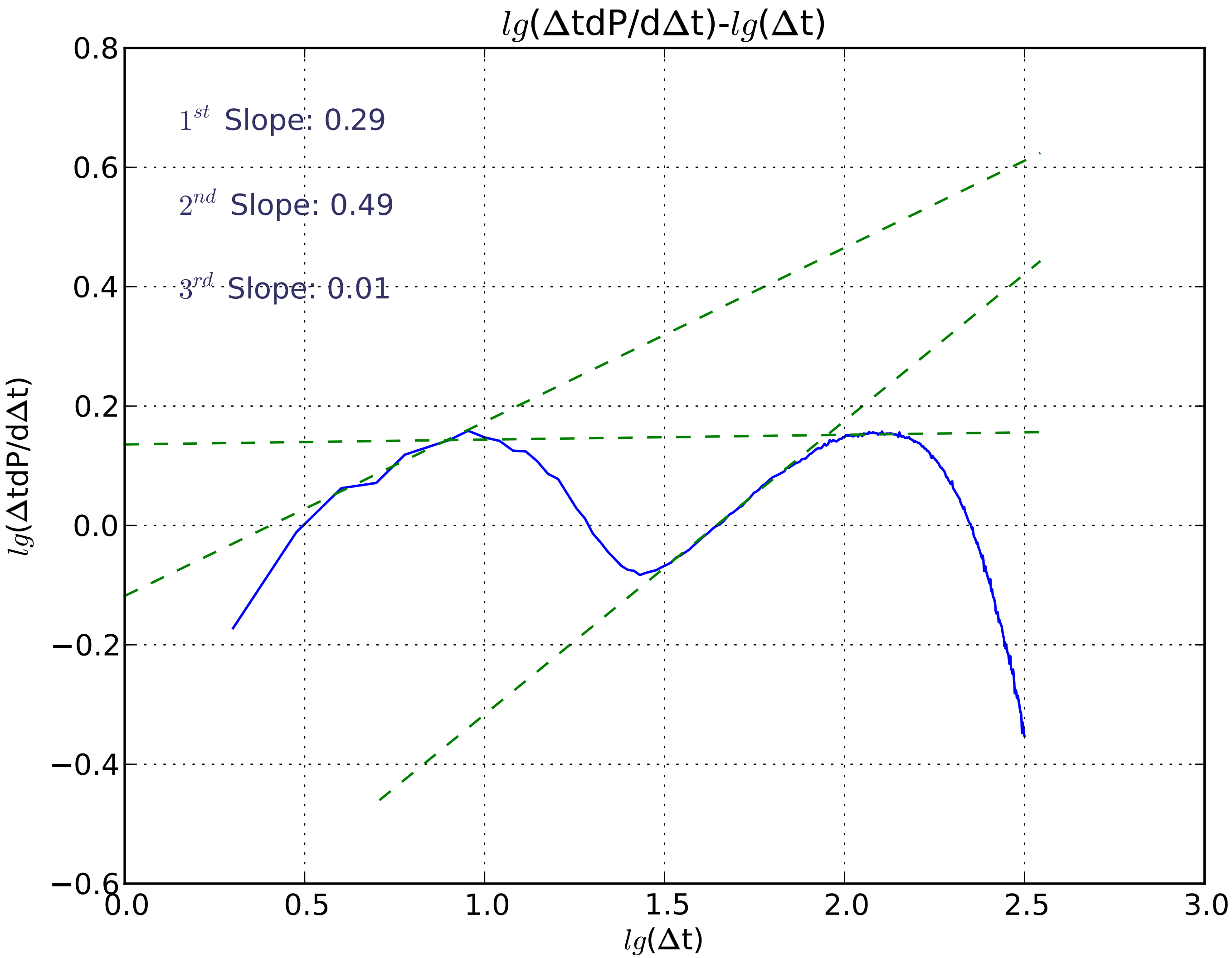
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 01

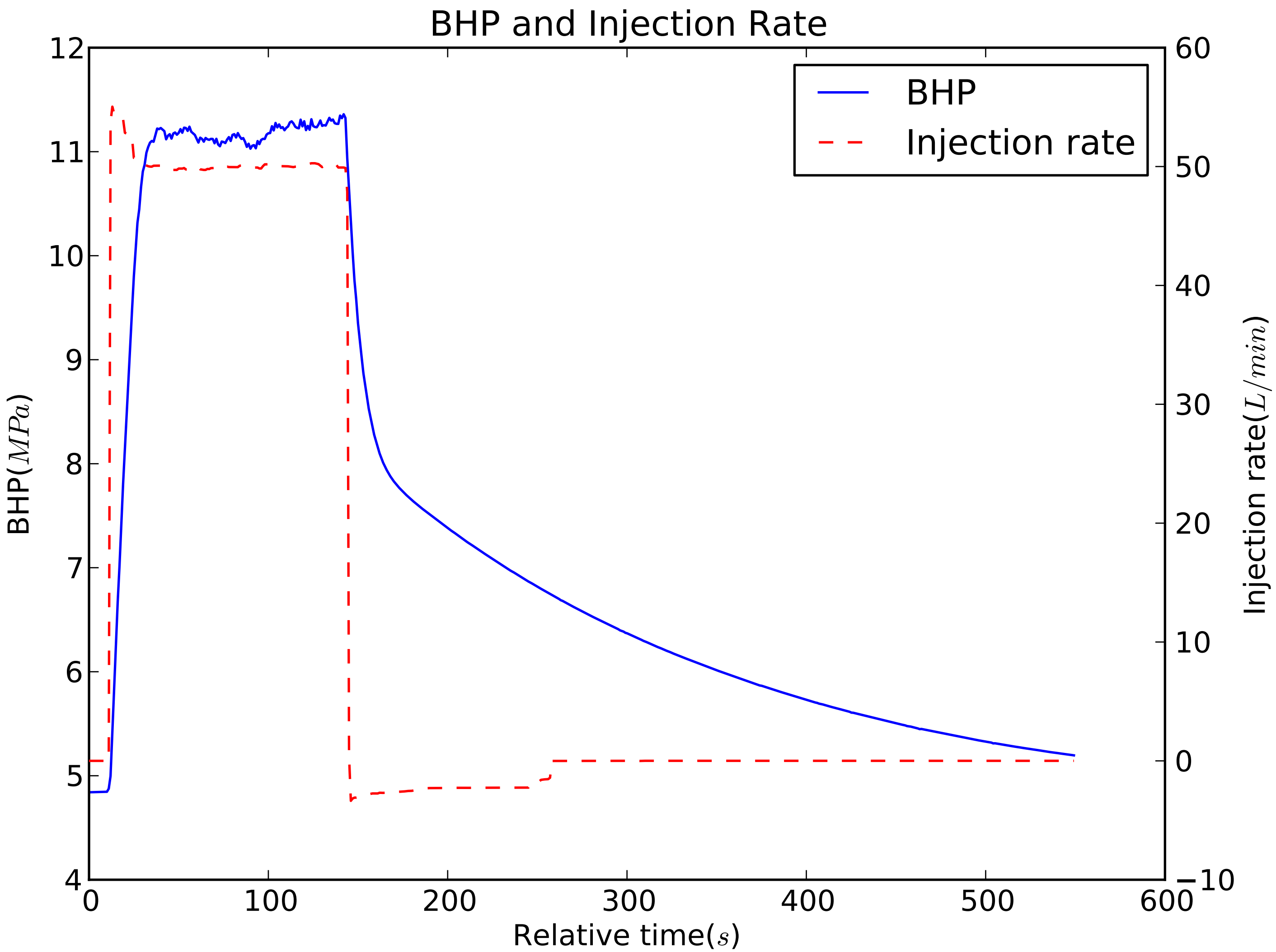
BitCan
Geosciences & Engineering Inc.

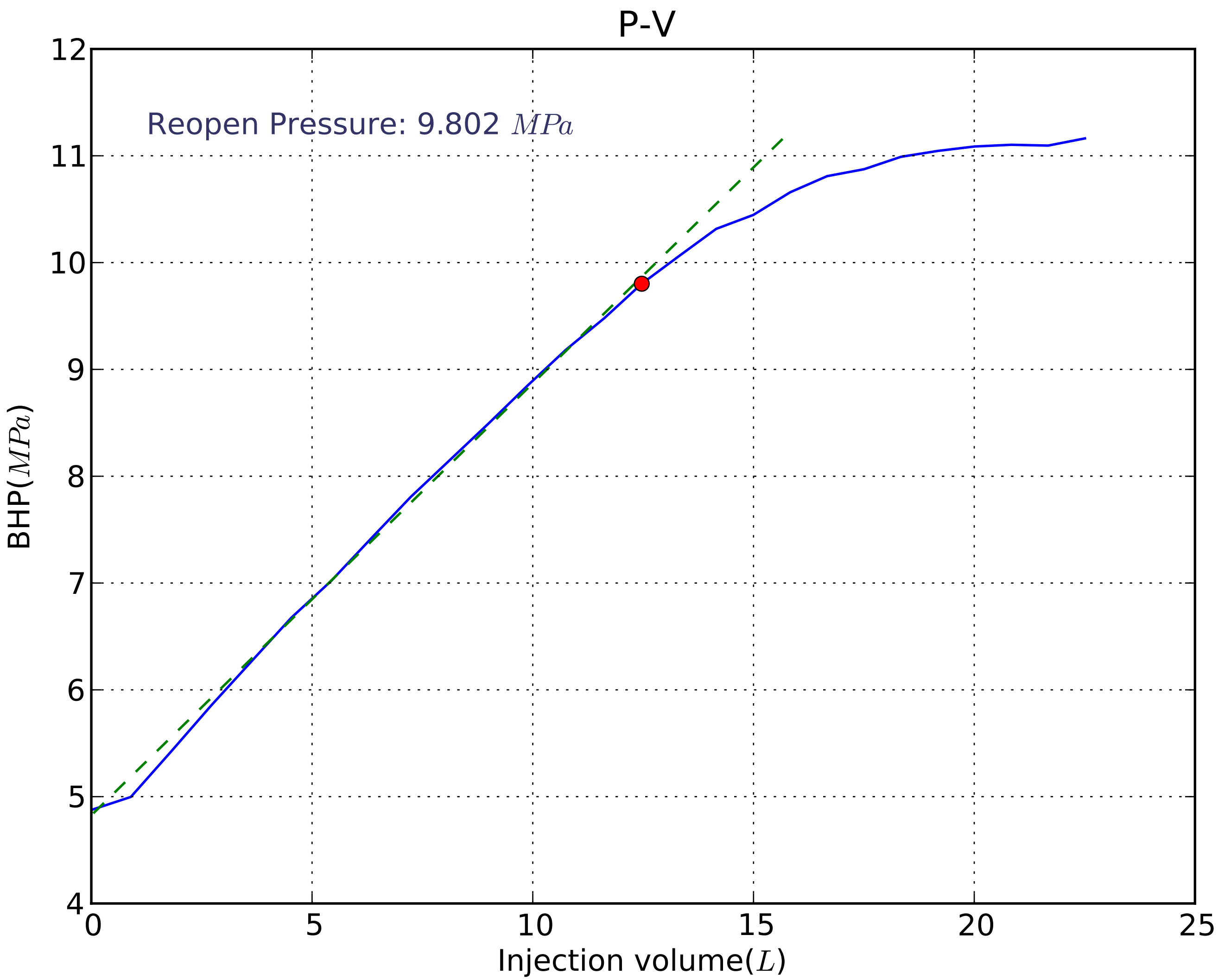


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 01

BitCan
Geosciences & Engineering Inc.

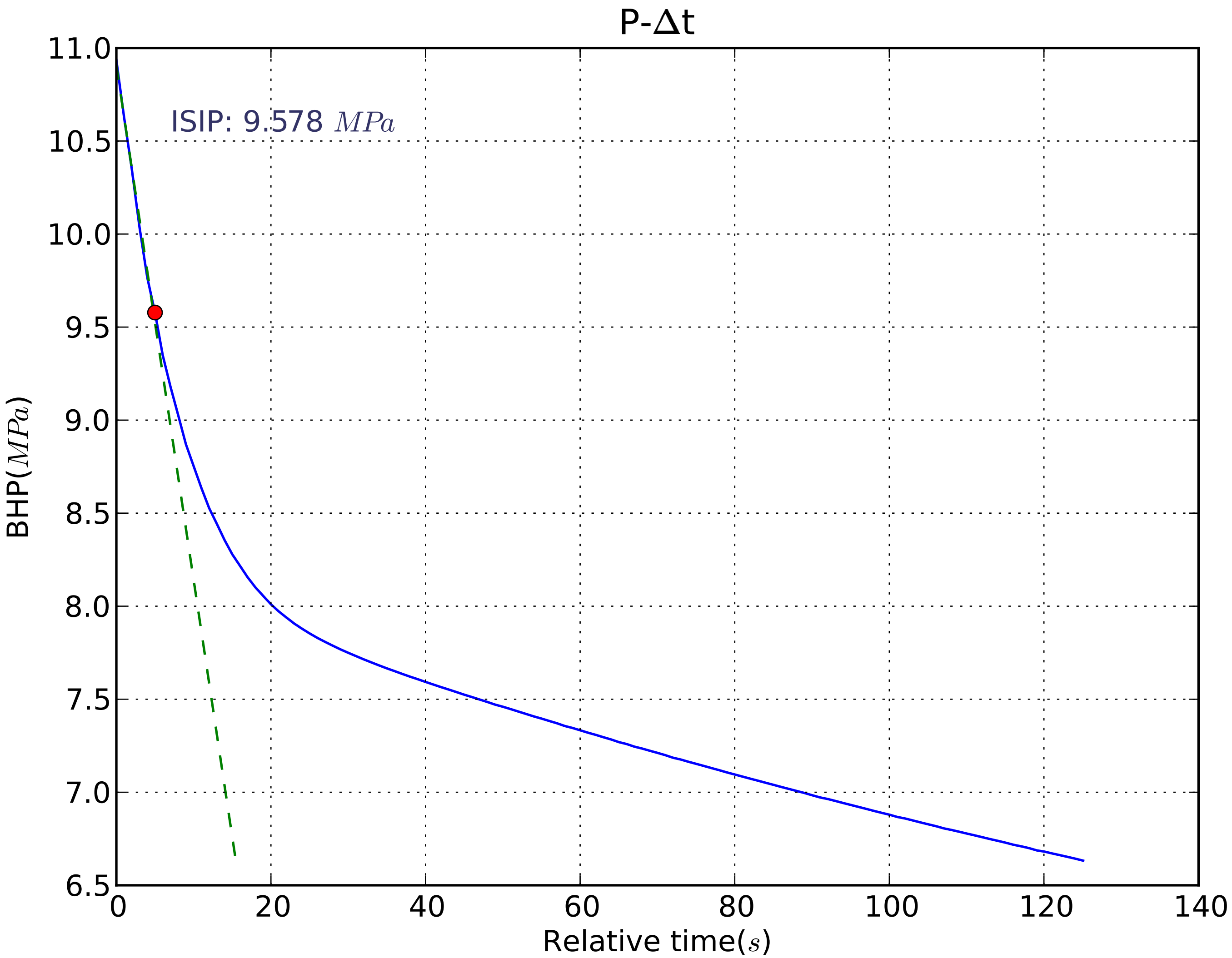



BHP and Injection Rate
BHP
Injection rate
BHP(MPa)
Injection rate(L/min)
Relative time(s)
12
11
10
9
8
7
6
5
4
60
50
40
30
20
10
0
−10
0
100
200
300
400
500
600

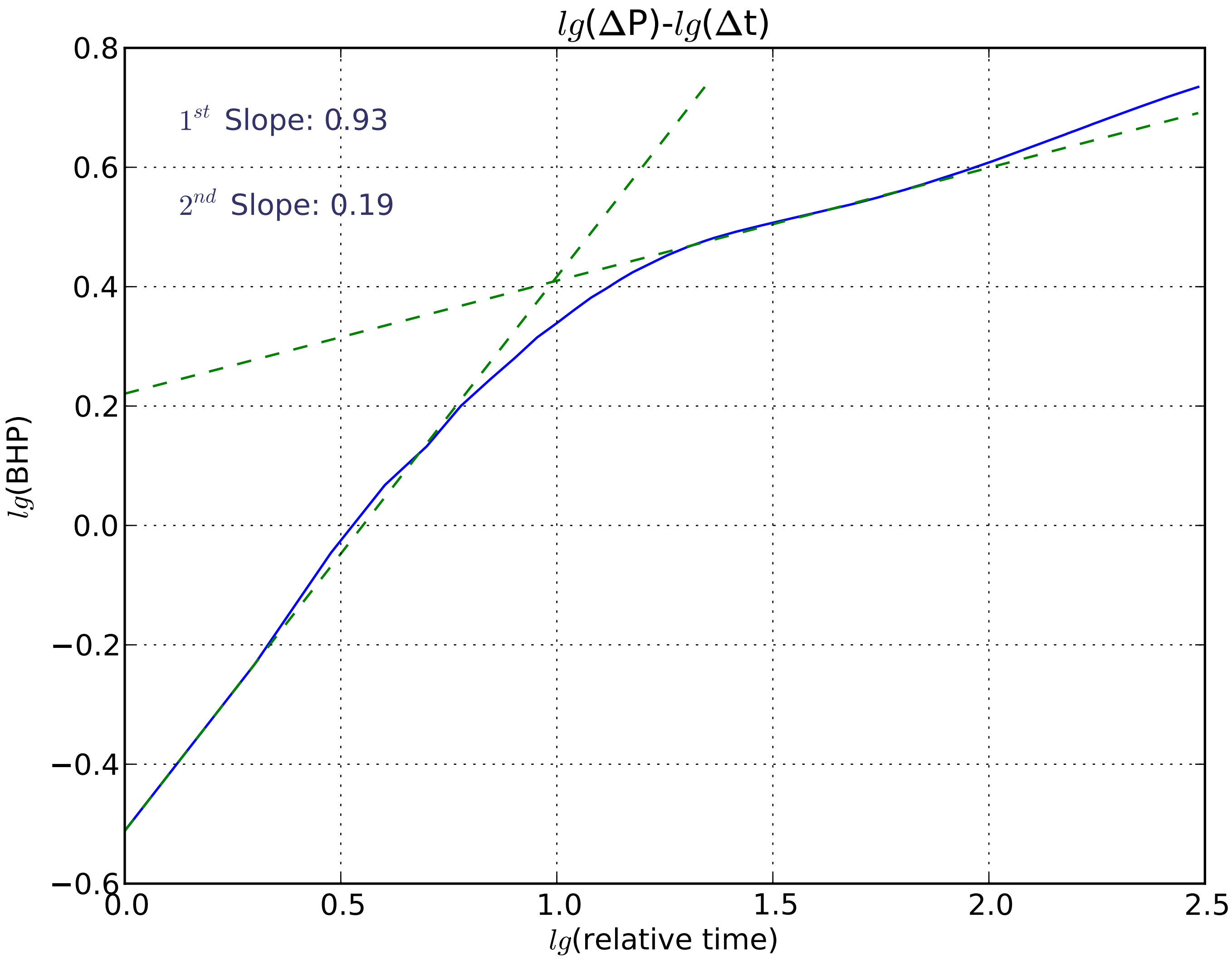

P-V
Reopen Pressure: 9.802 MPa
BHP(MPa)
Injection volume(L)
12
11
10
9
8
7
6
5
4
0
5
10
15
20
25

Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 02

BitCan Geosciences & Engineering Inc.

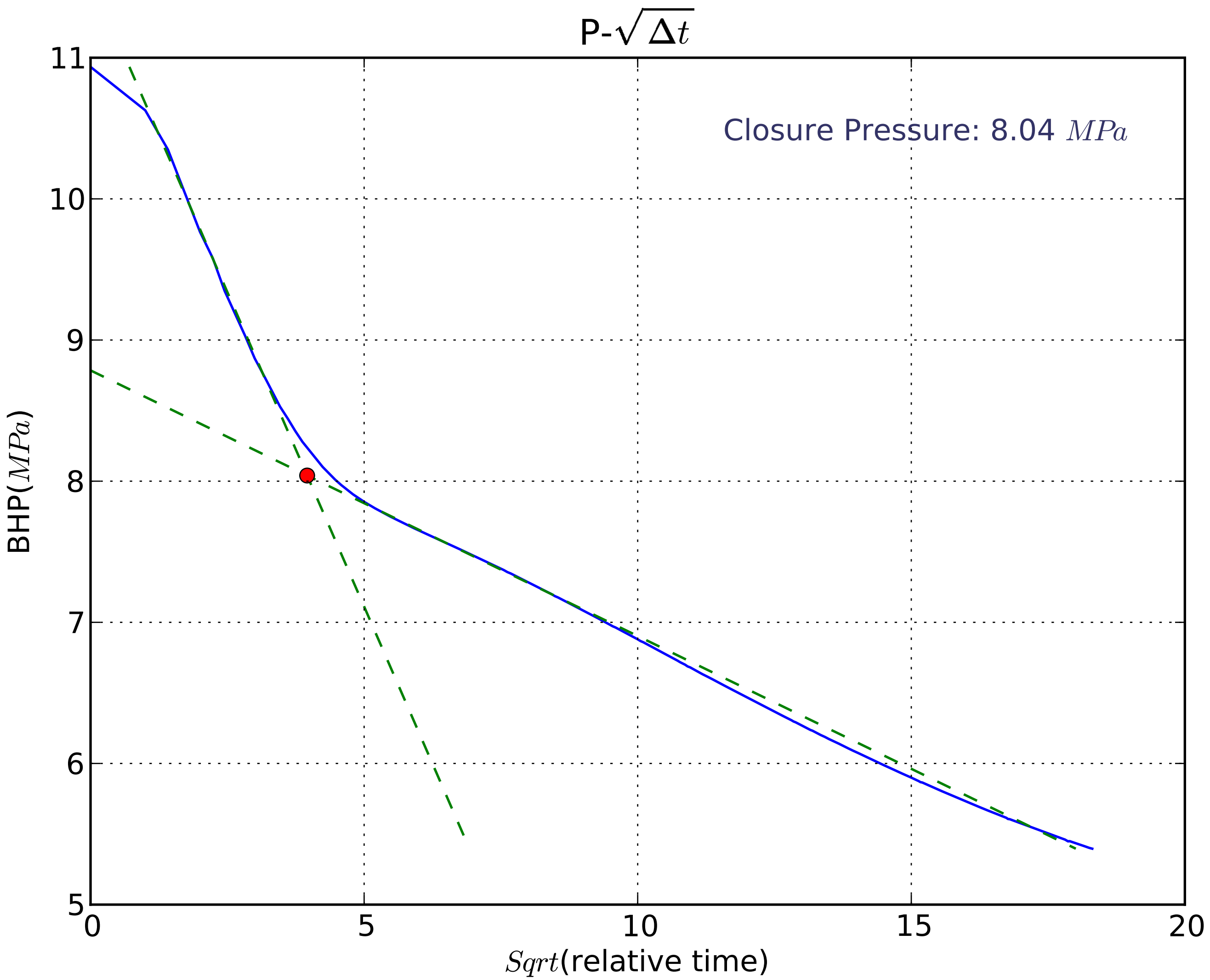


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 02



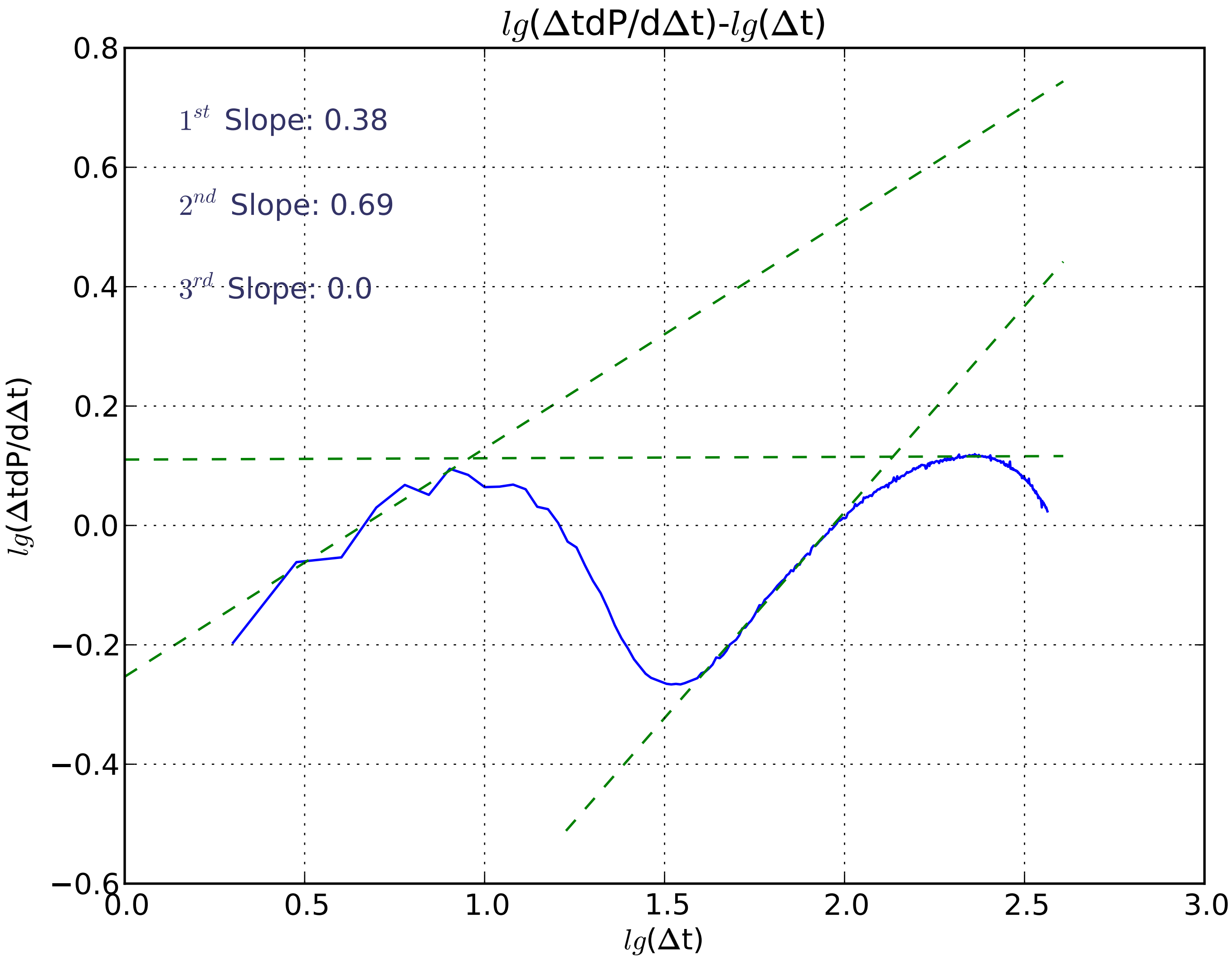
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 02

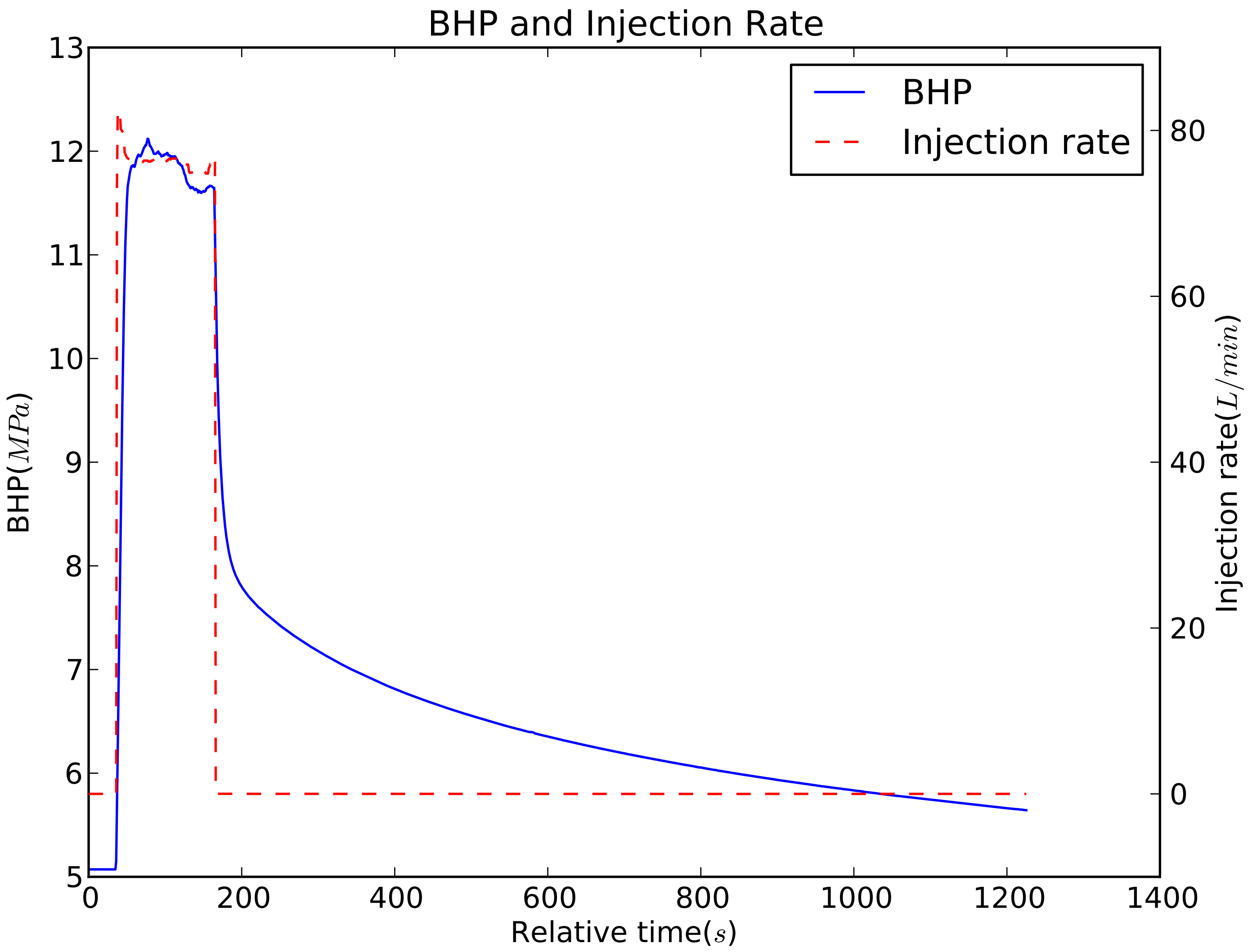
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 02

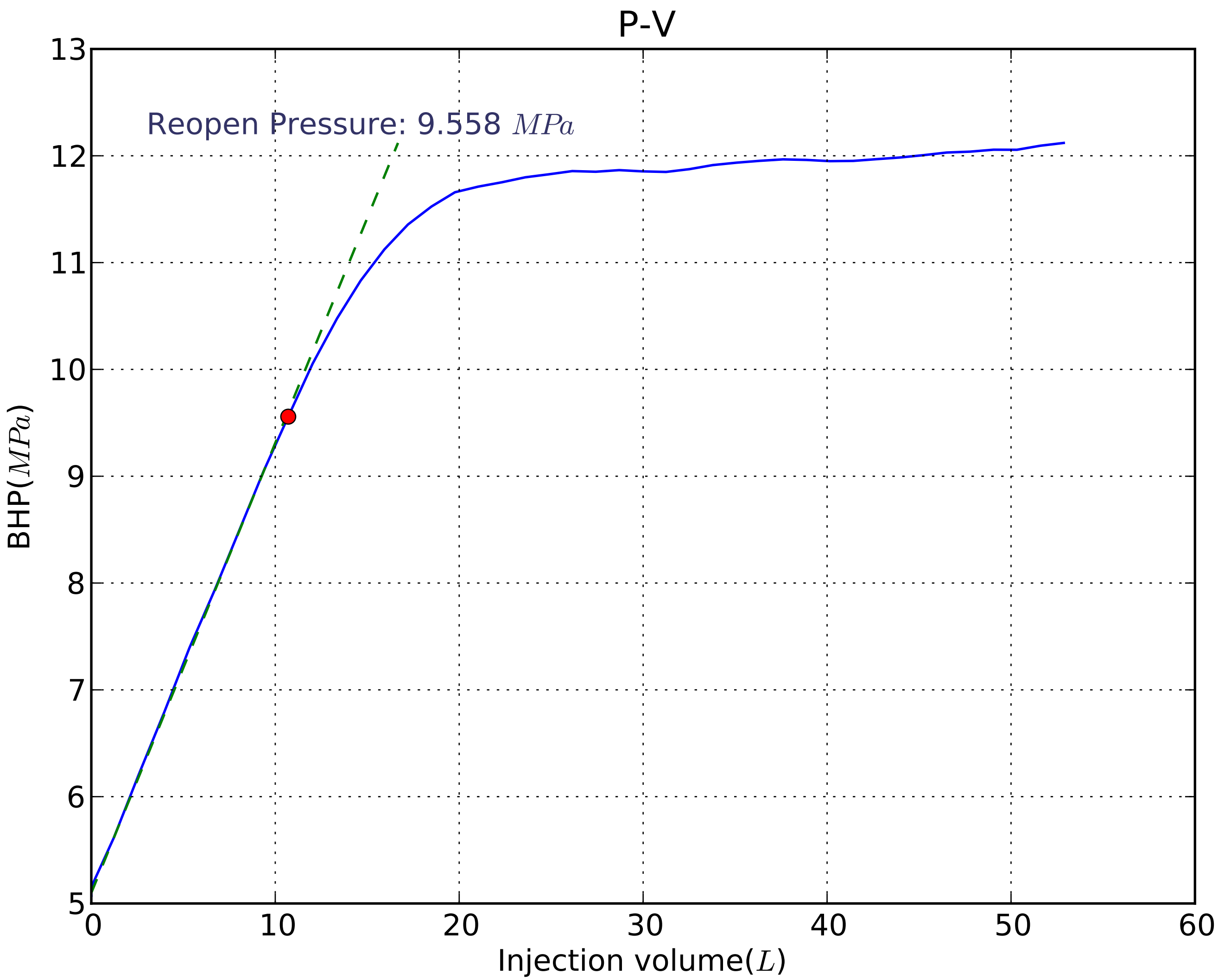
BitCan
Geosciences & Engineering Inc.



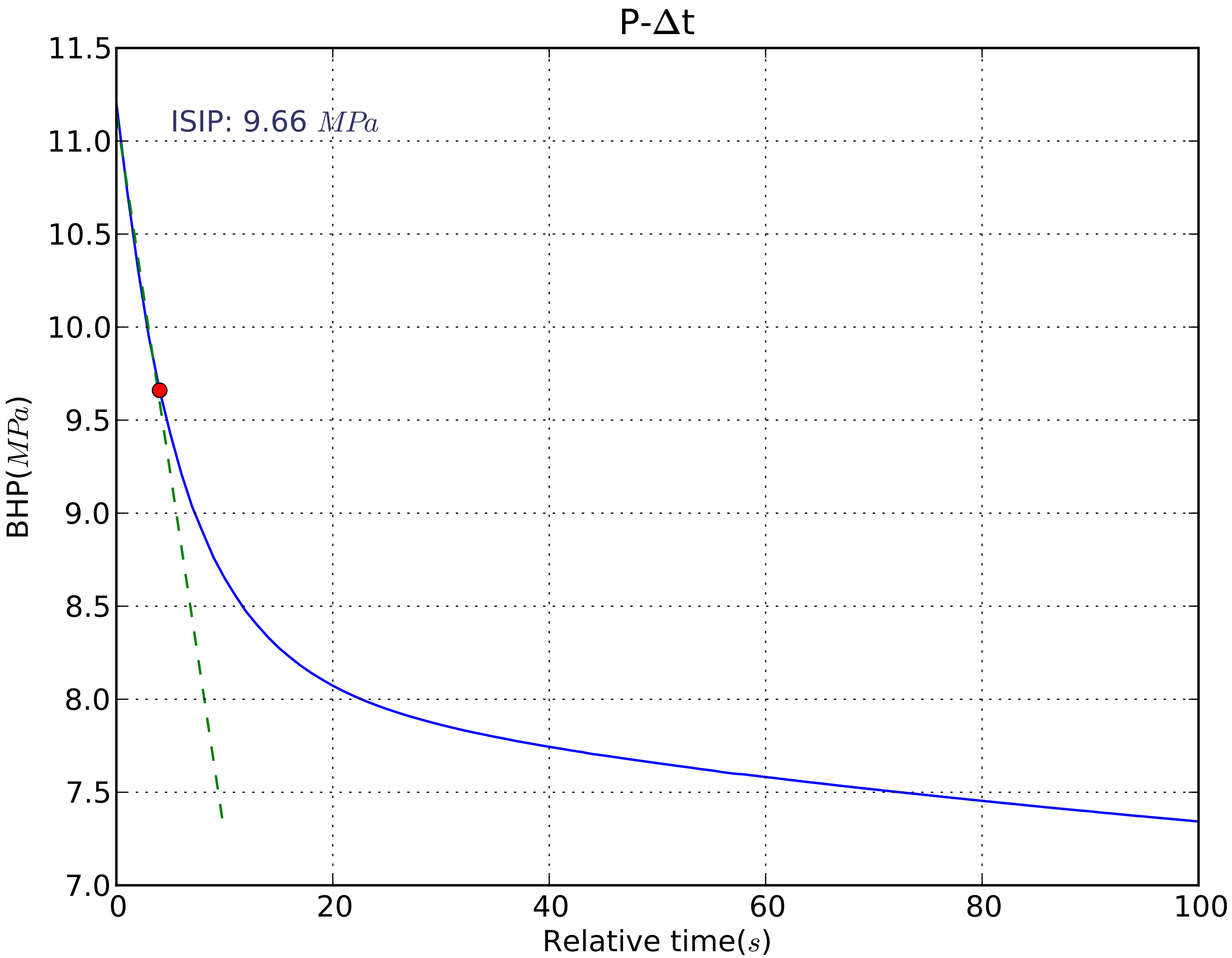

BHP and Injection Rate
BHP
Injection rate
BHP(MPa)
Injection rate(L/min)
Relative time(s)
13
12
11
10
9
8
7
6
5
80
60
40
20
0
0
200
400
600
800
1000
1200
1400

Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 03

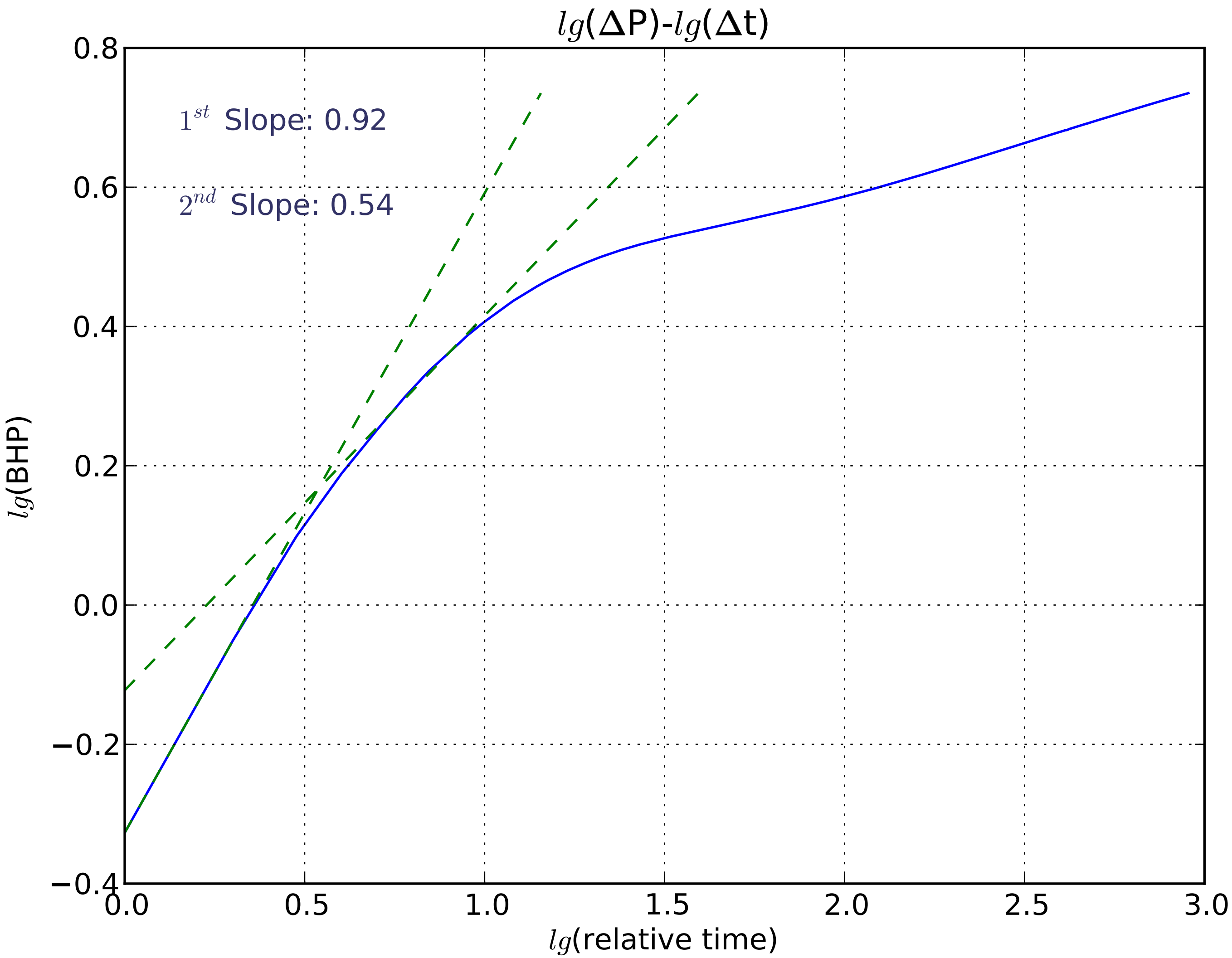
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 03

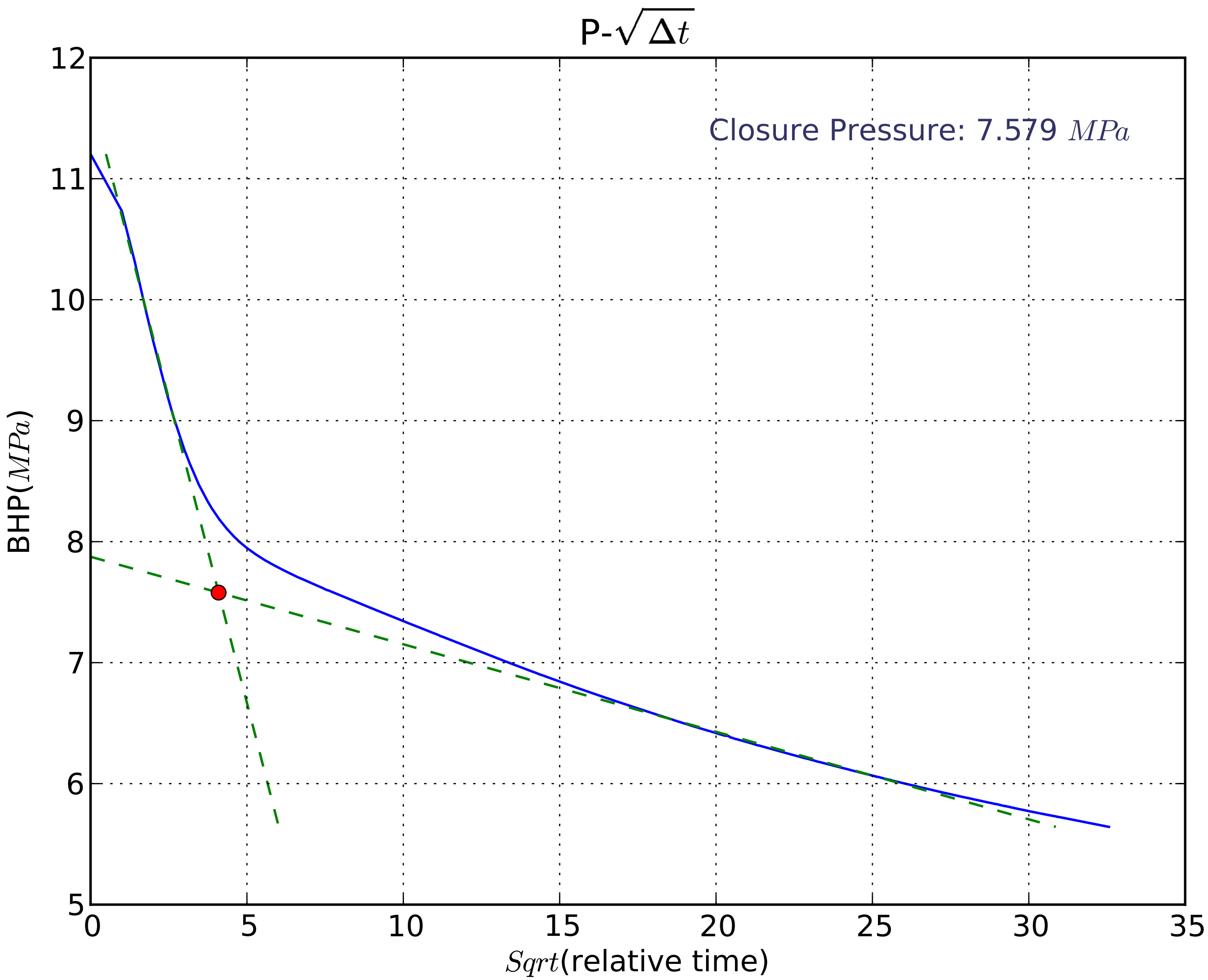


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 03



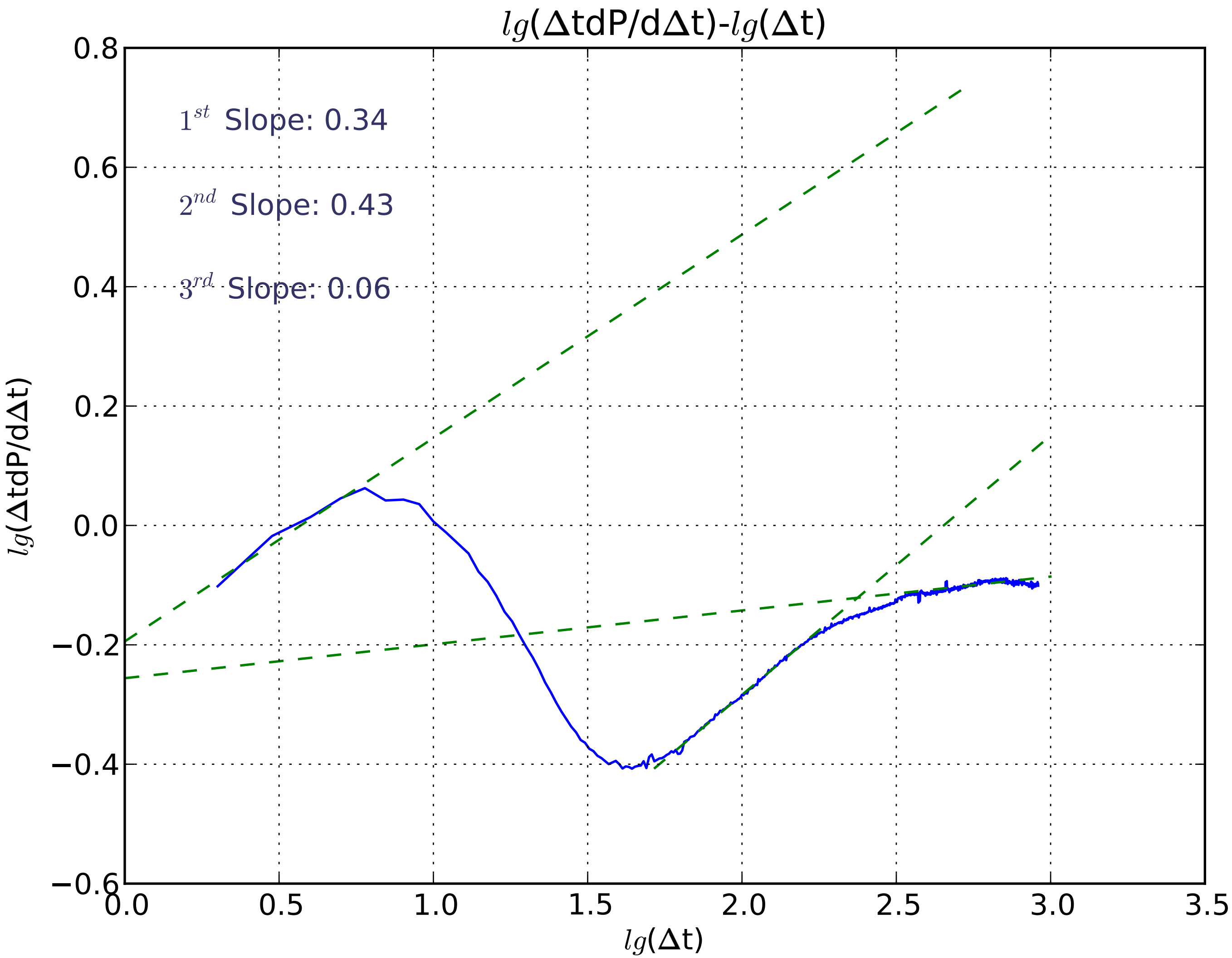
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 03

BitCan
Geosciences & Engineering Inc.



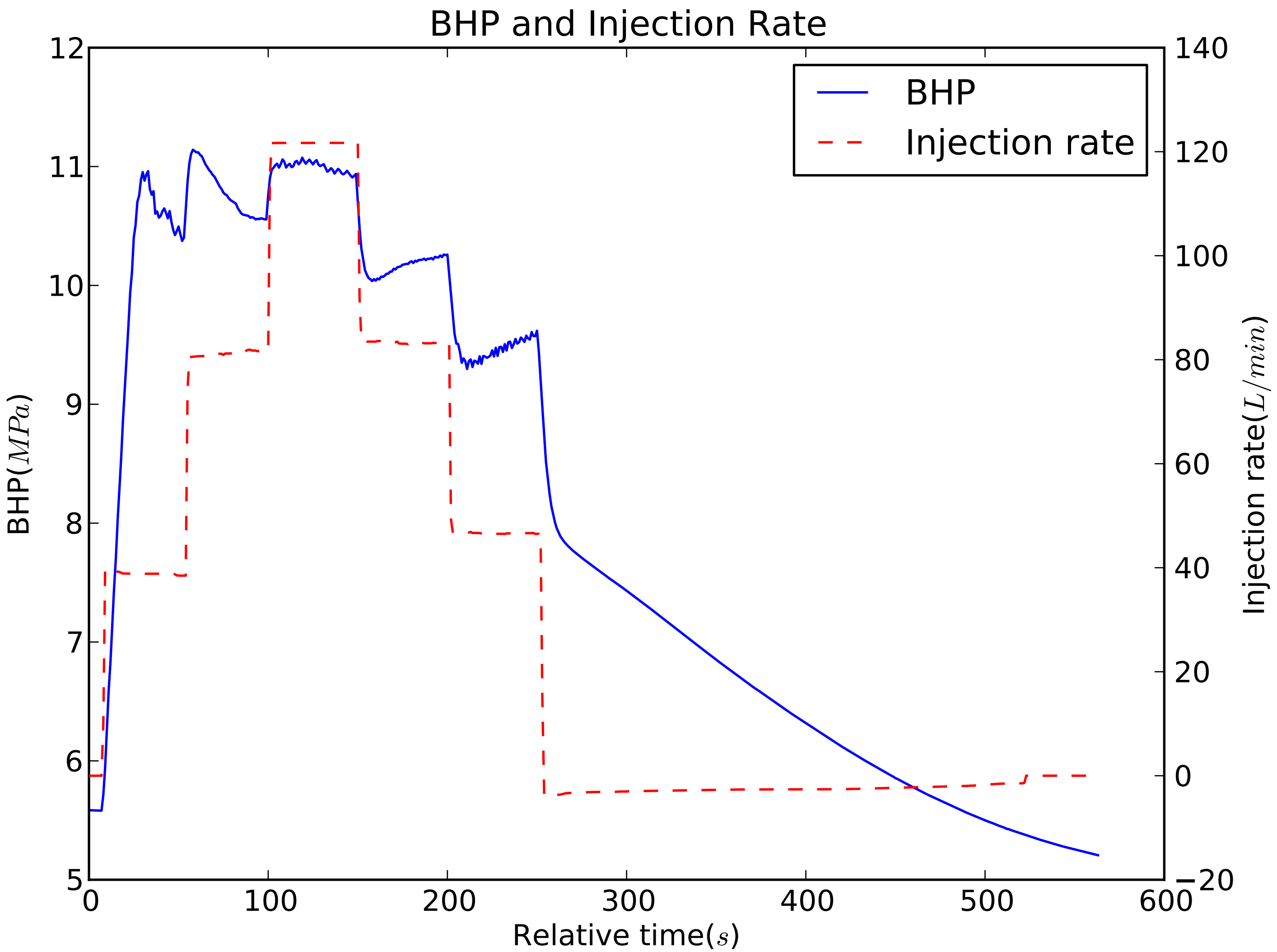
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 03

BitCan
Geosciences & Engineering Inc.



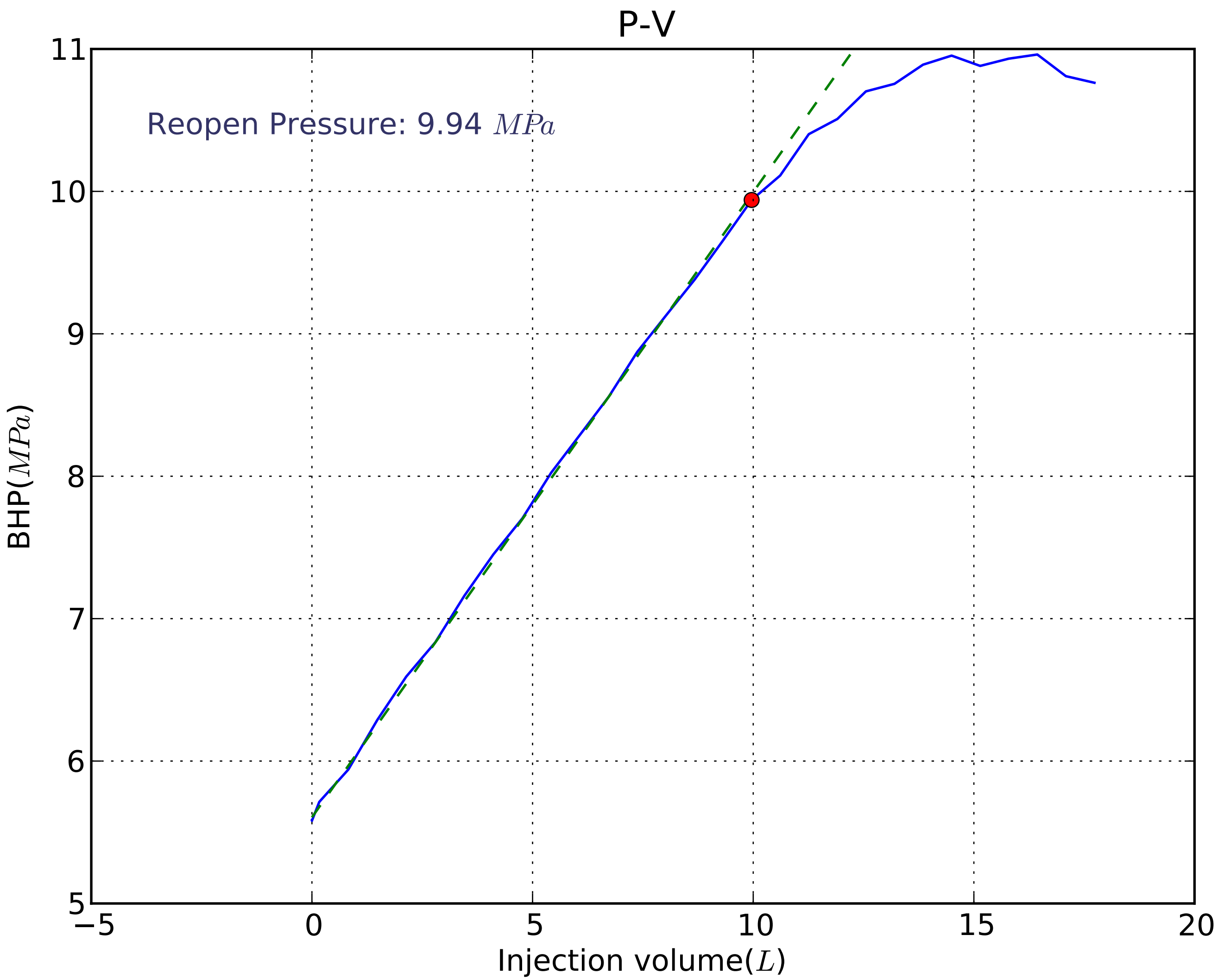
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 04

BitCan
Geosciences & Engineering Inc.

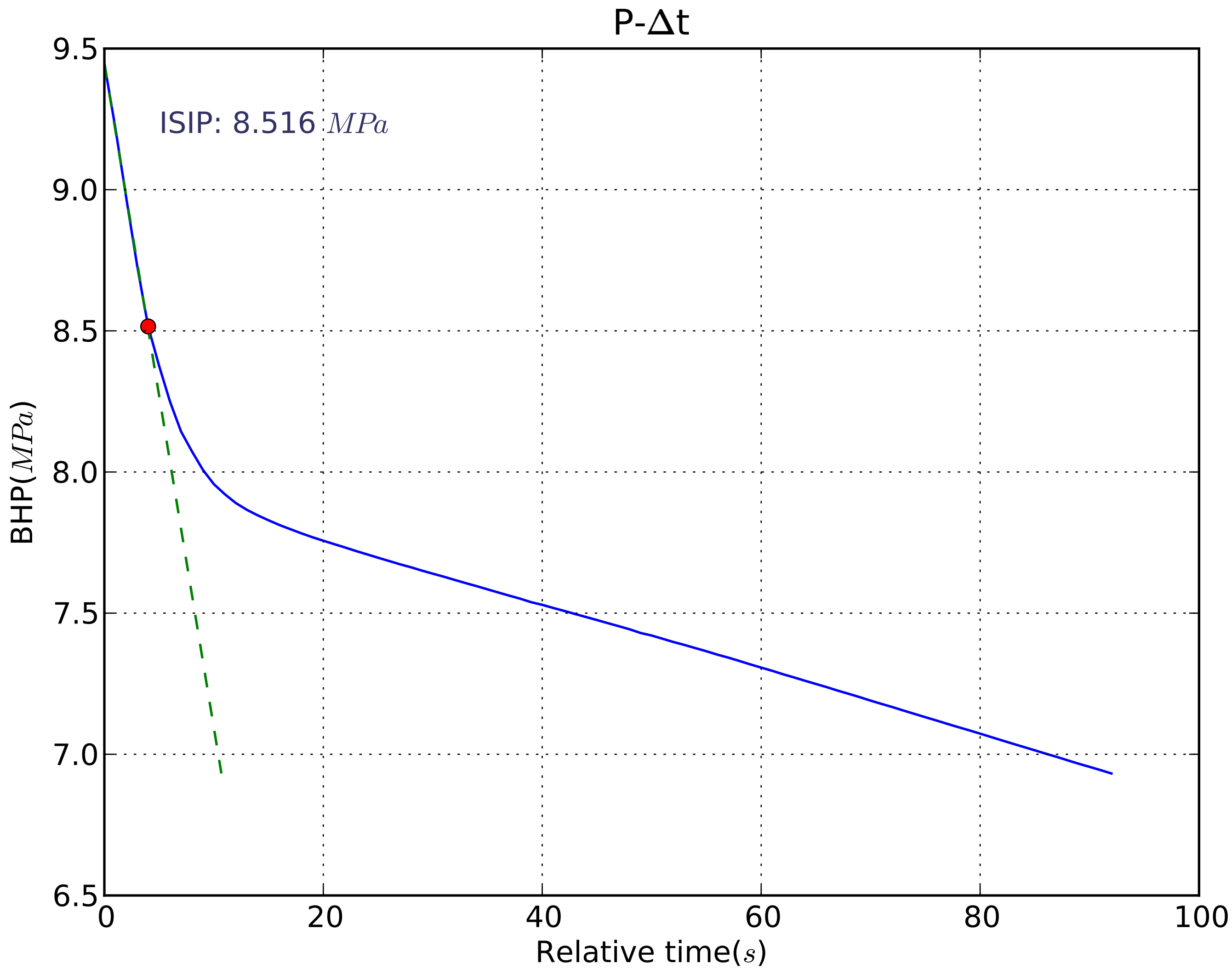


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 04

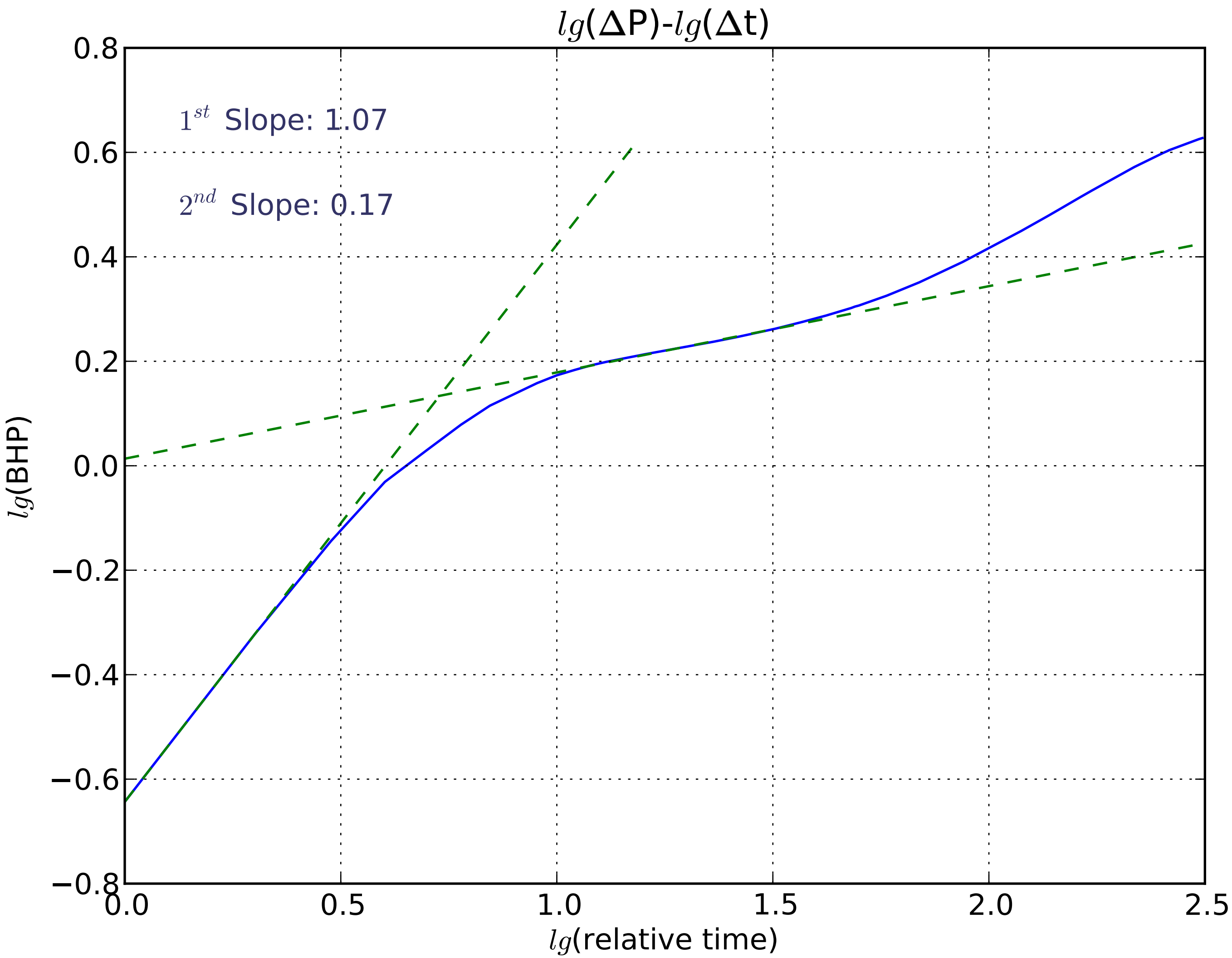
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 04

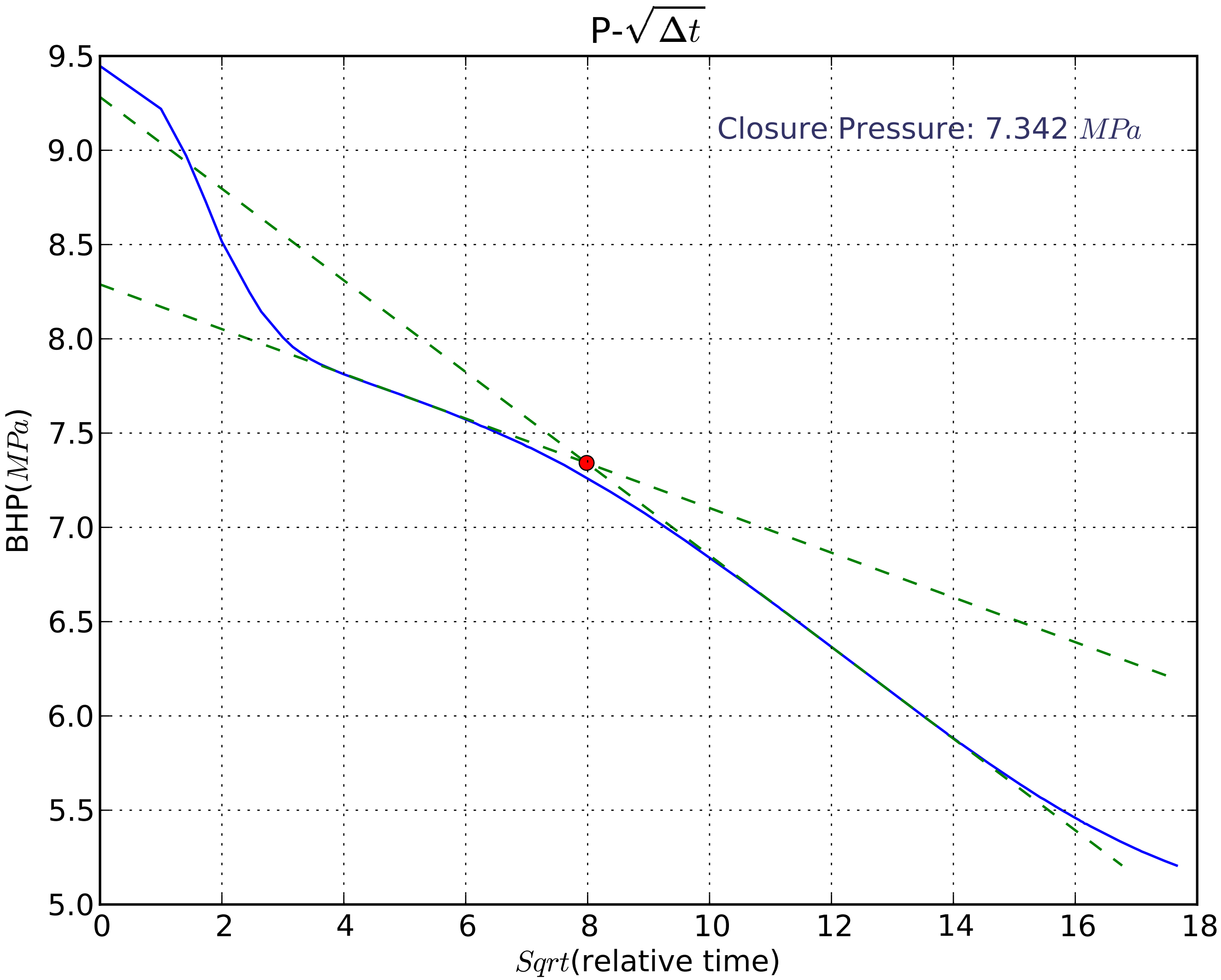


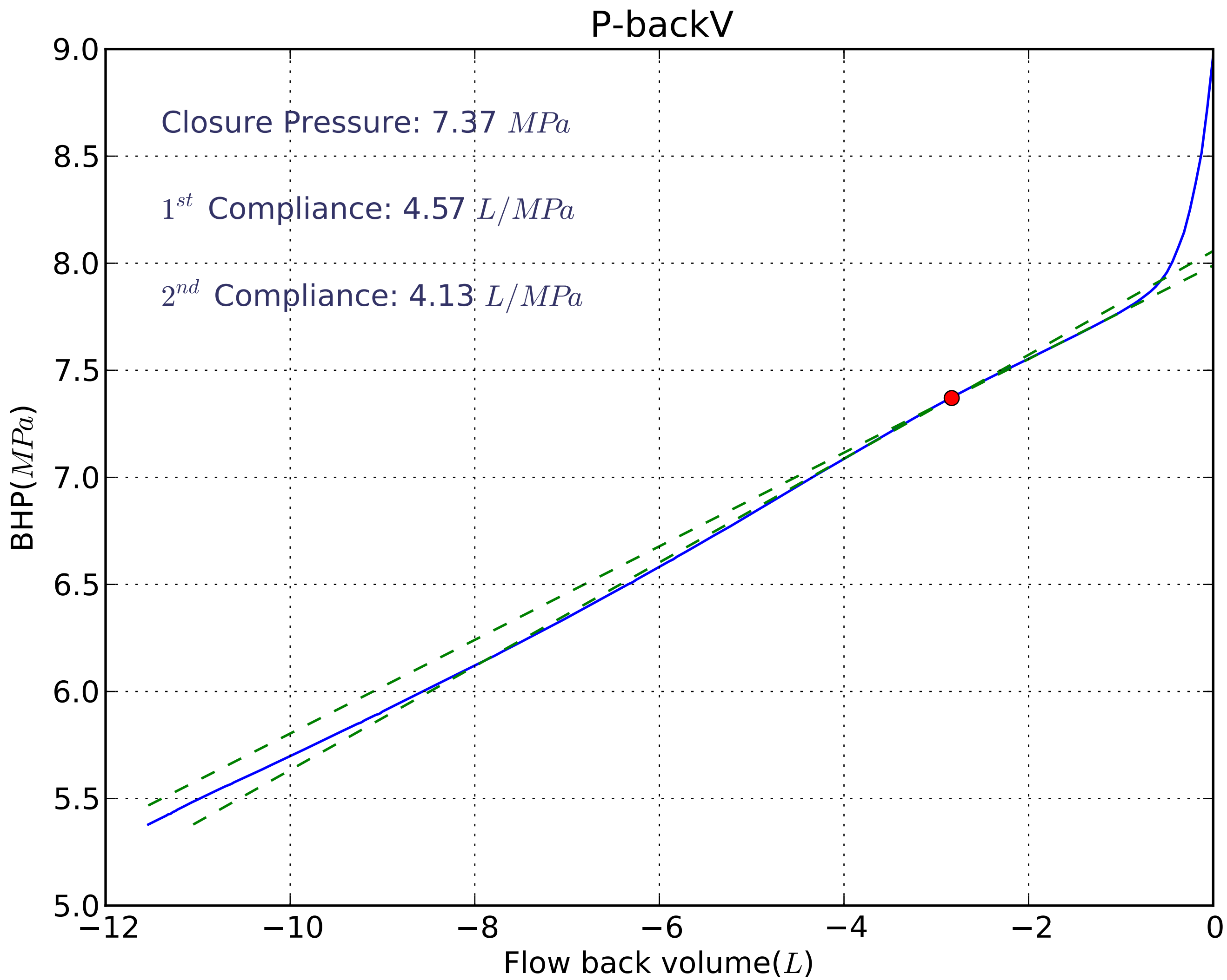
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 04



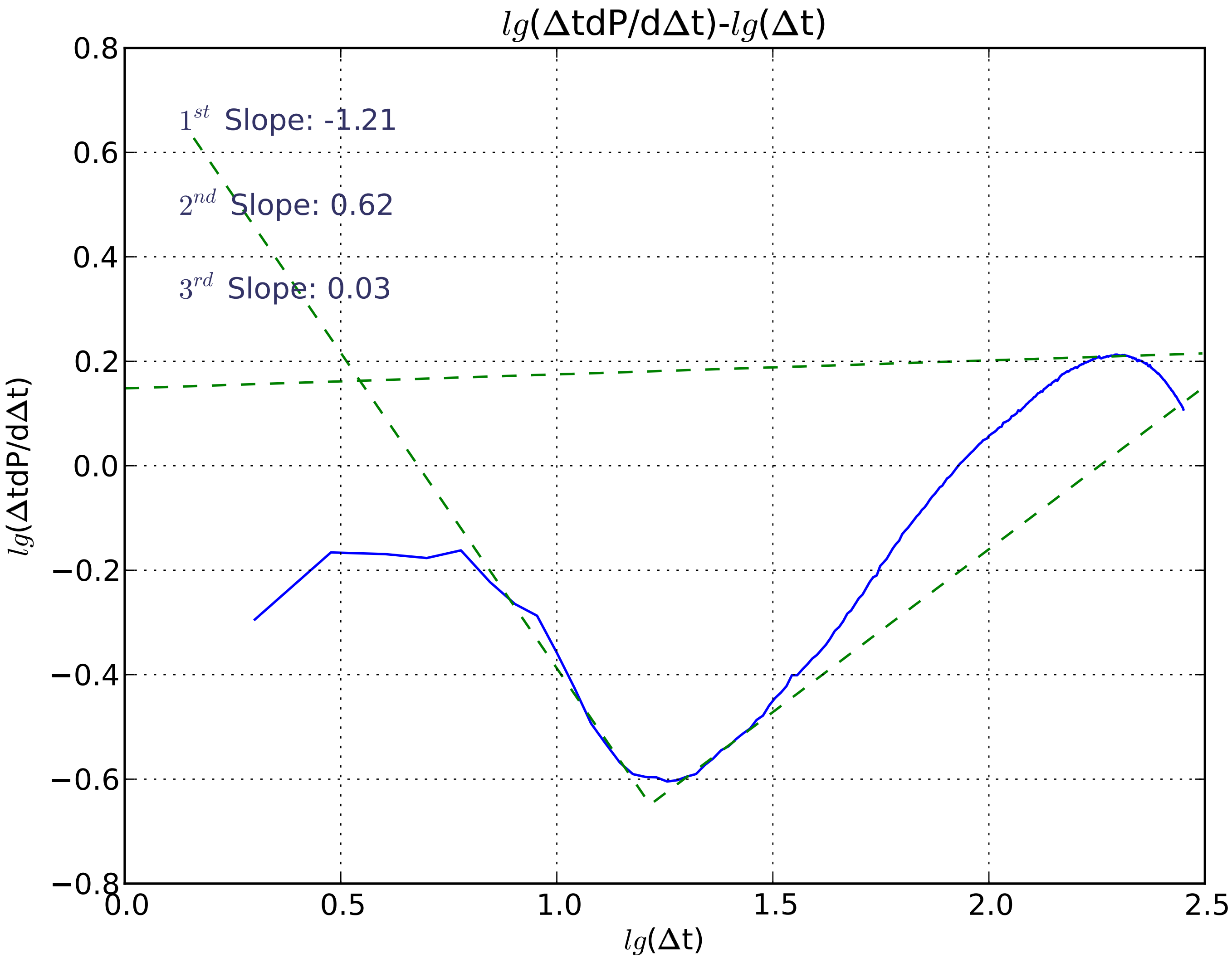
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 04

BitCan
Geosciences & Engineering Inc.

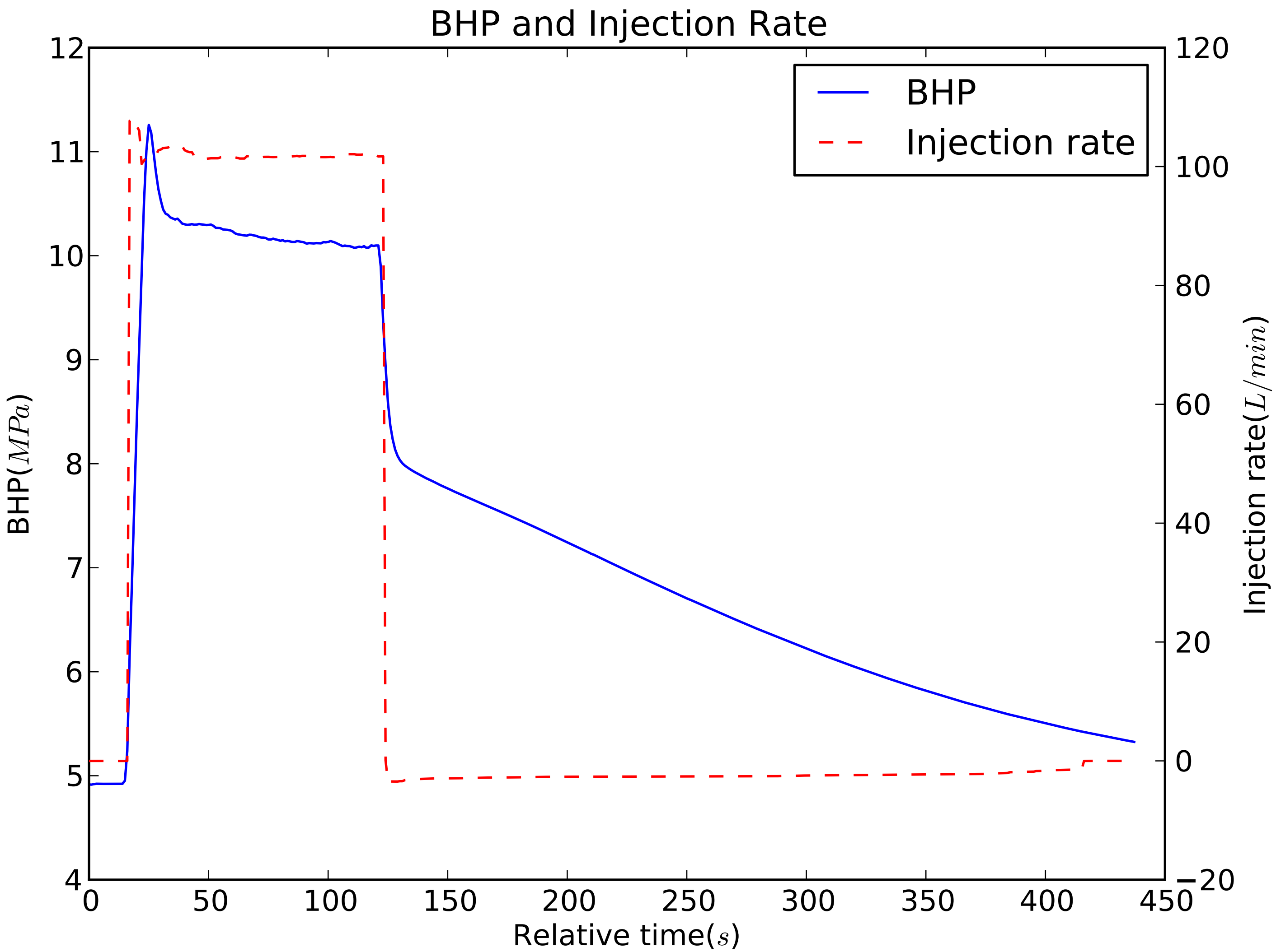



P-backV
Closure Pressure: 7.37 MPa
1^{st} Compliance: 4.57 L/MPa
2^{nd} Compliance: 4.13 L/MPa
BHP(MPa)
Flow back volume(L)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
−12
−10
−8
−6
−4
−2
0

Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 04

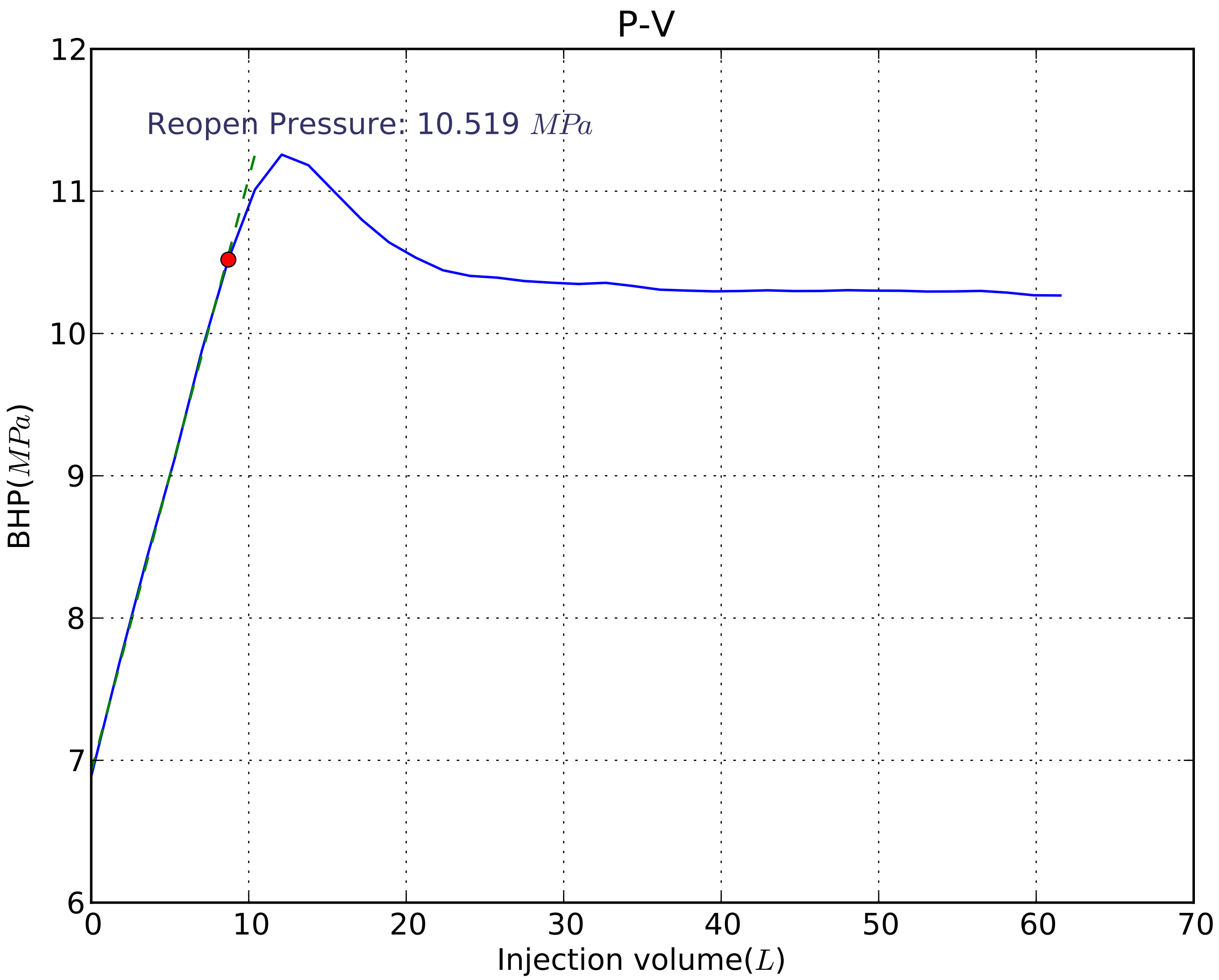


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 05



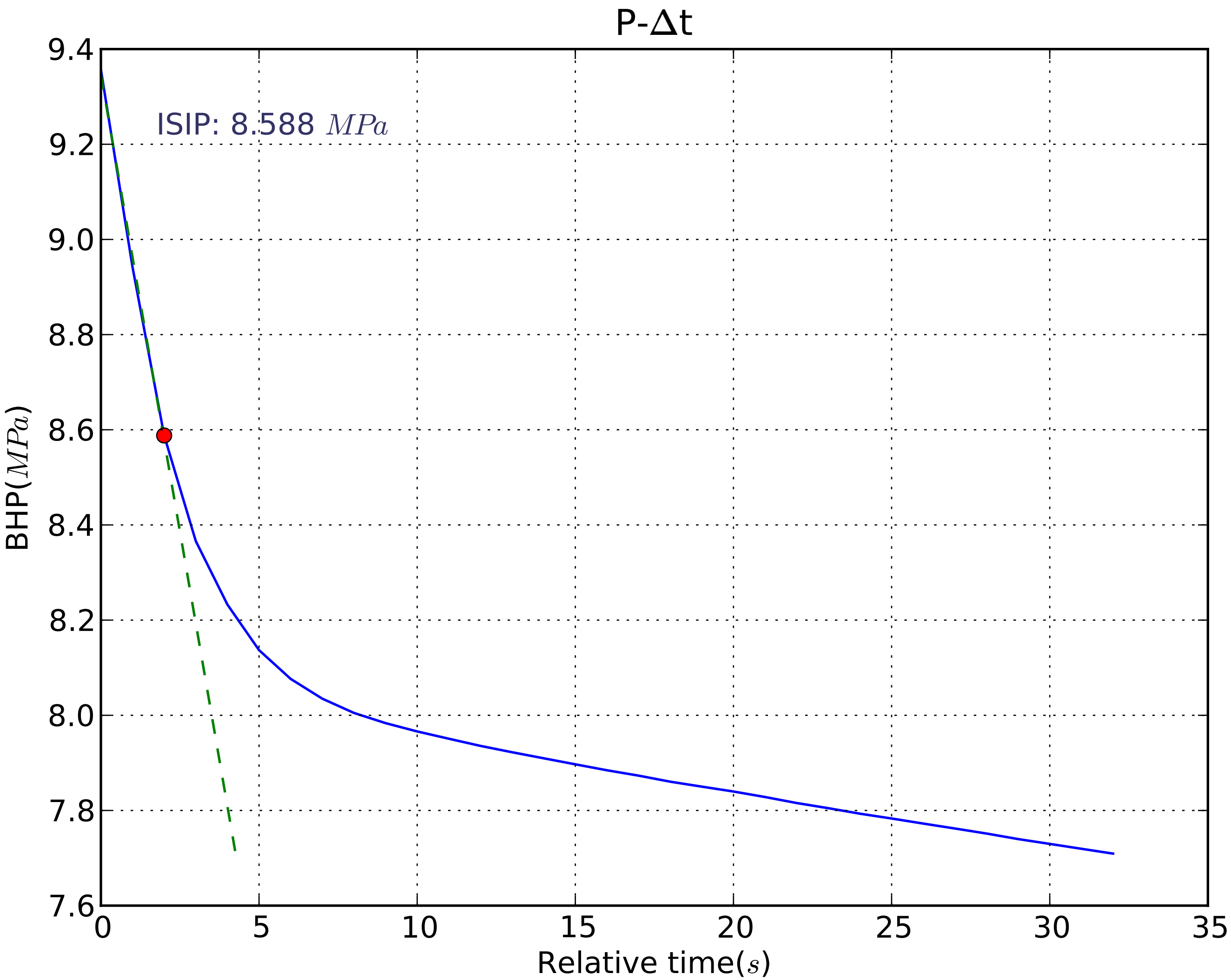
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 05

BitCan Geosciences & Engineering Inc.



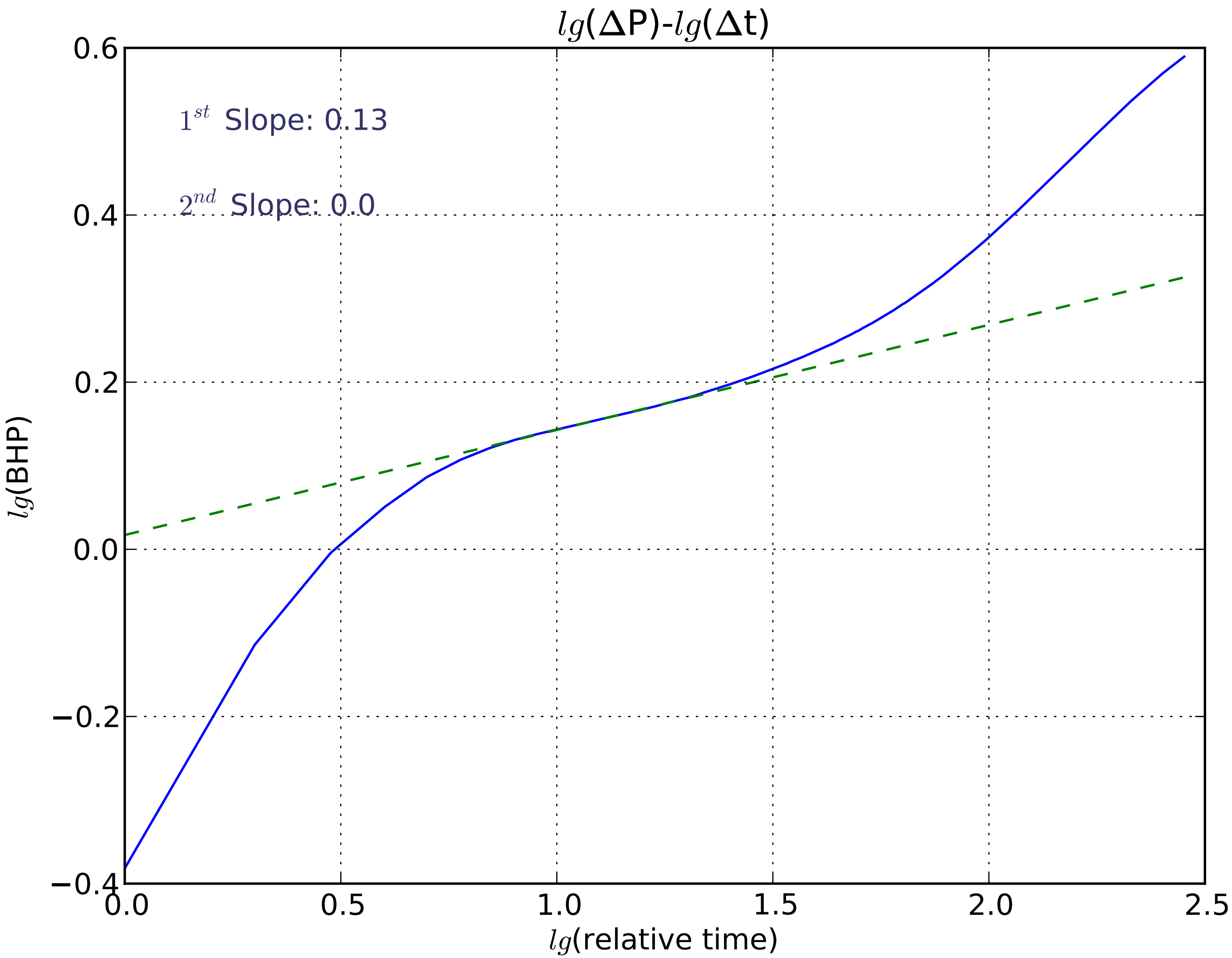
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.

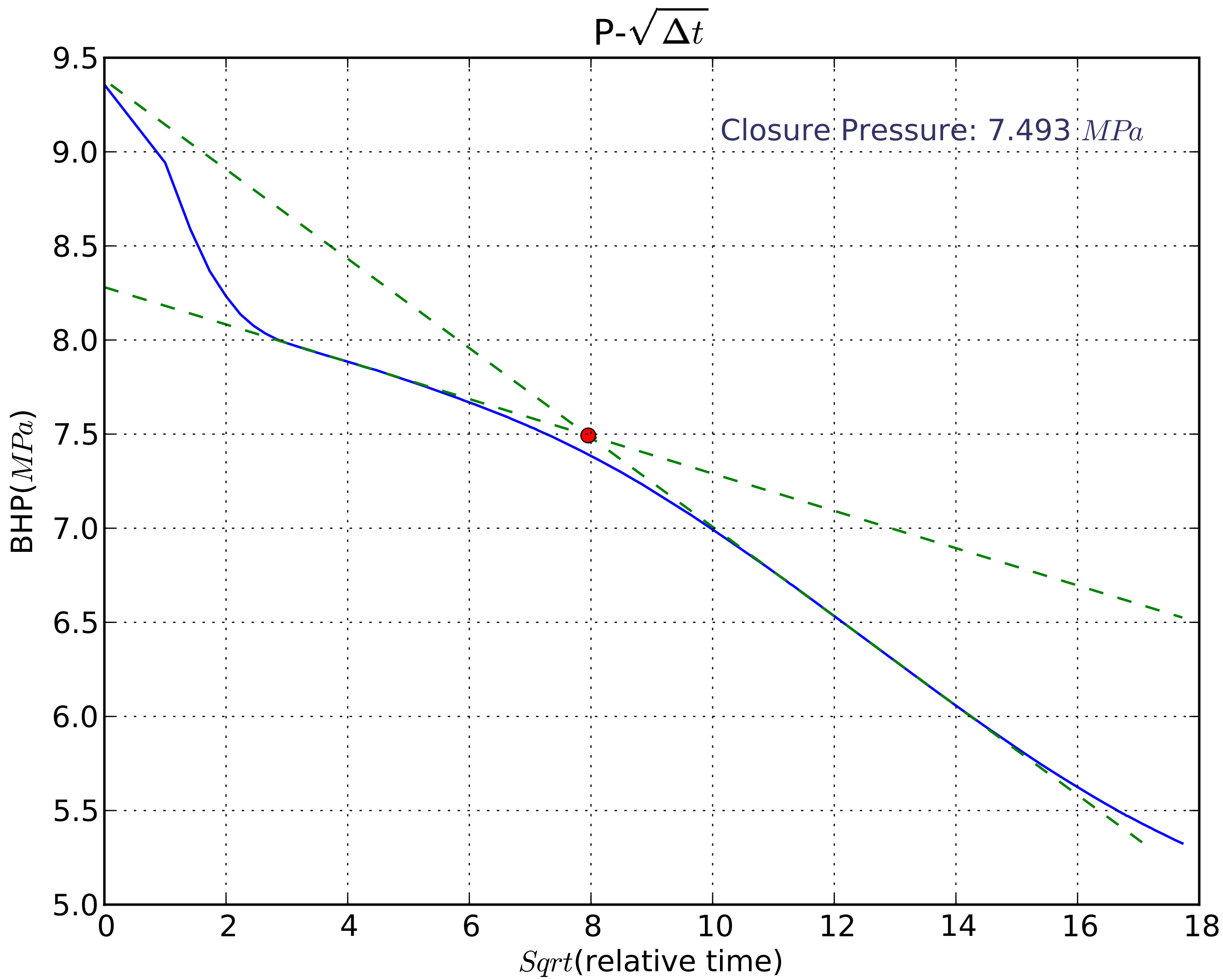


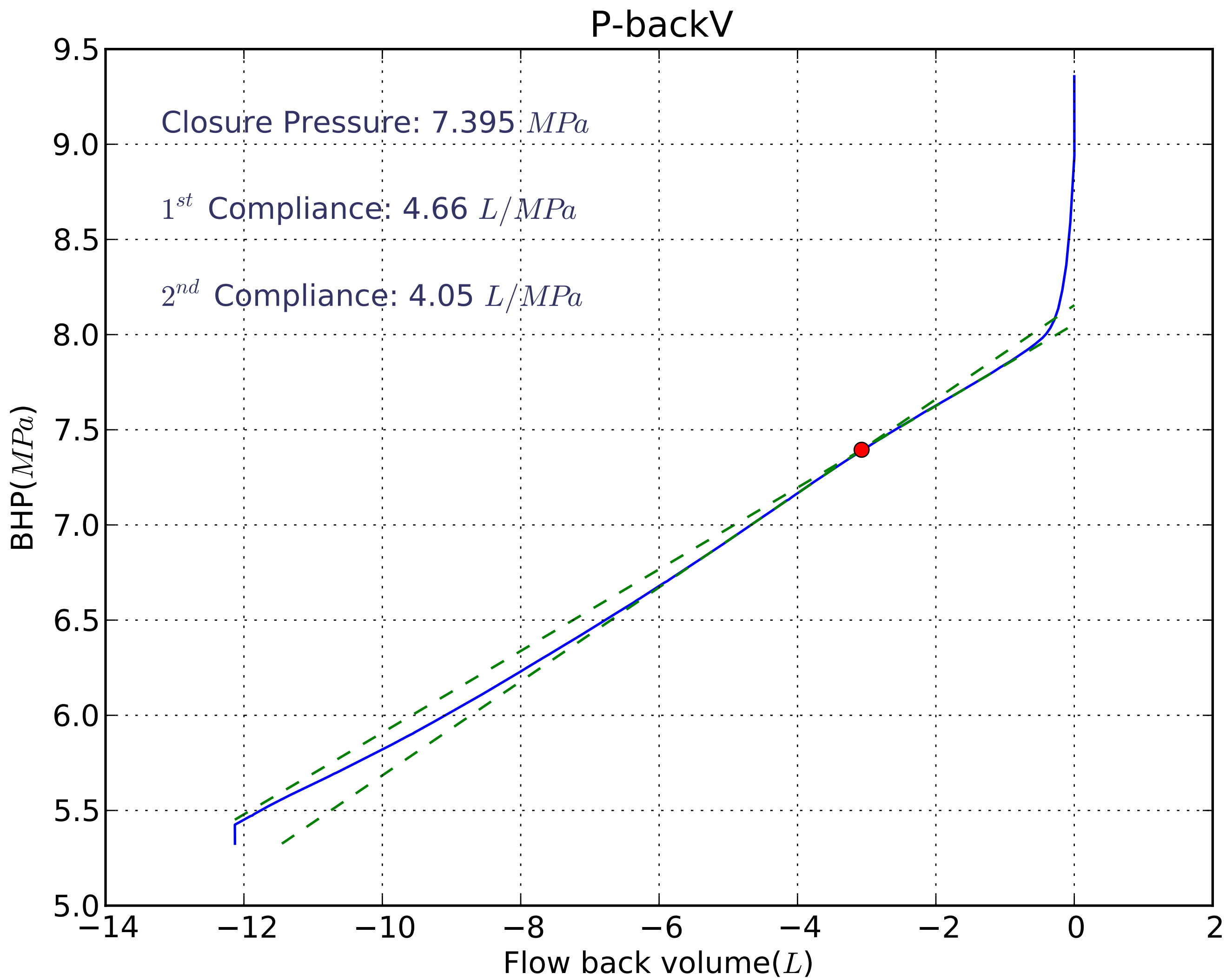
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 05

BitCan
Geosciences & Engineering Inc.



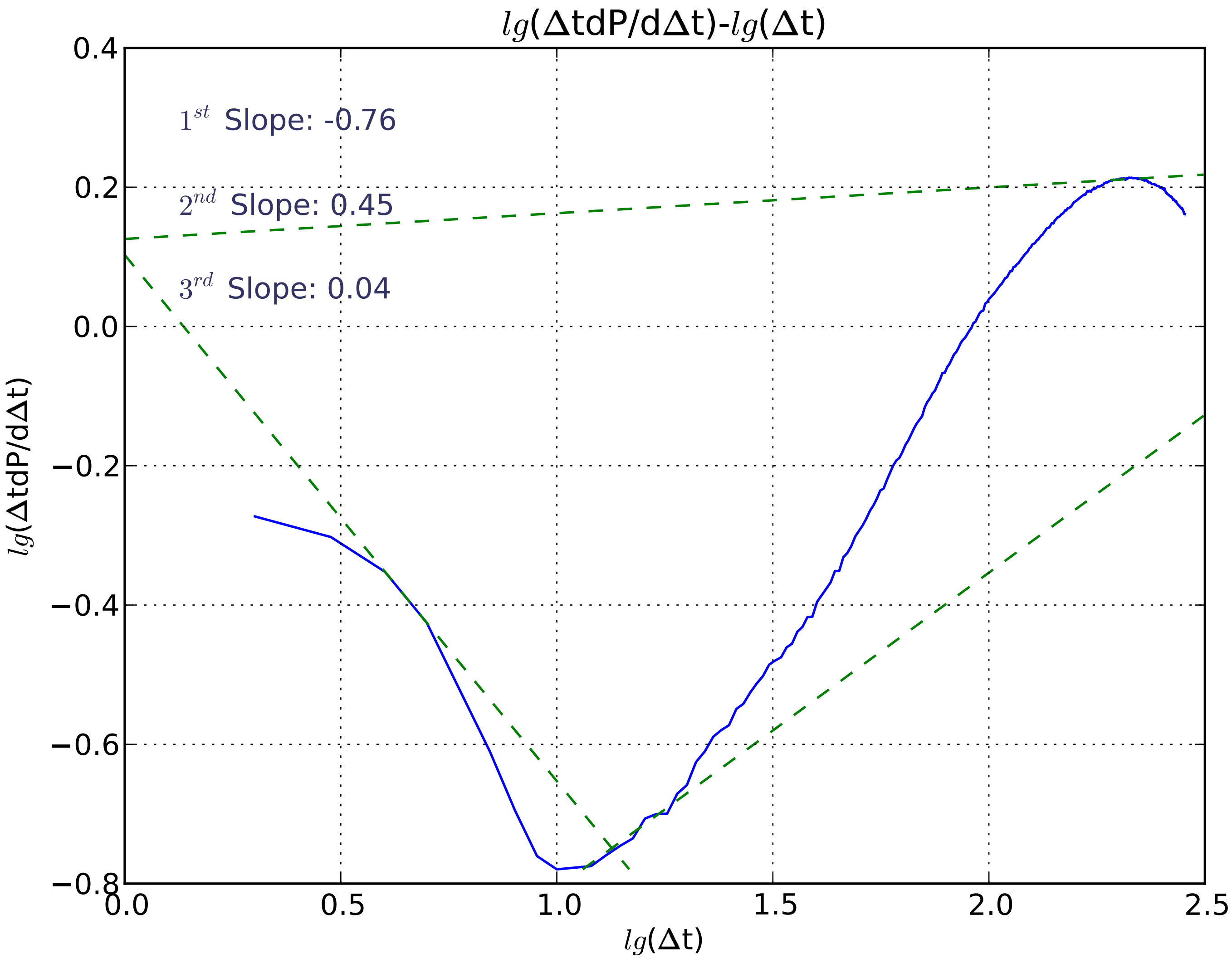
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 05

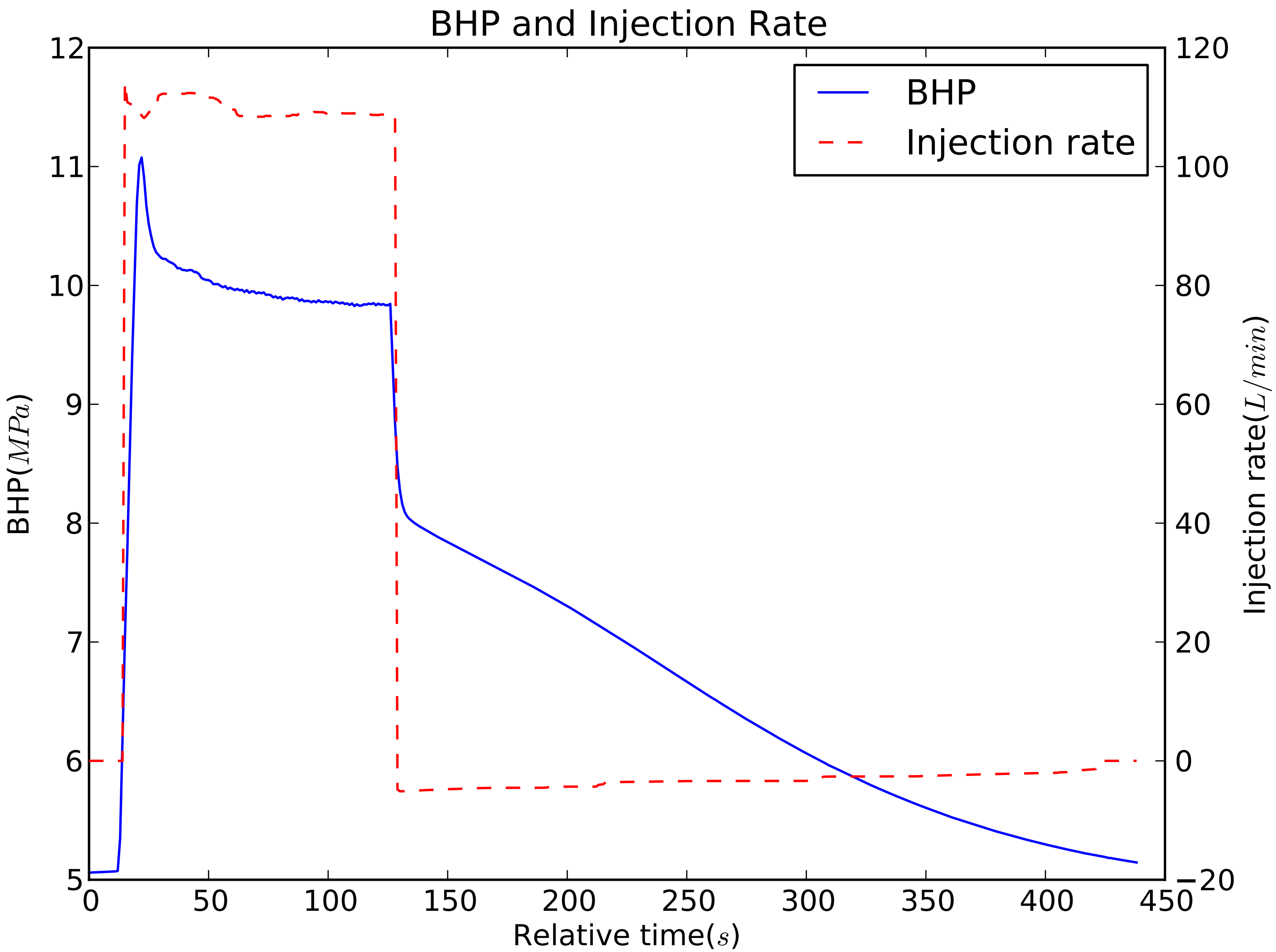



P-backV
Closure Pressure: 7.395 MPa
1^{st} Compliance: 4.66 L/MPa
2^{nd} Compliance: 4.05 L/MPa
BHP(MPa)
Flow back volume(L)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
−14
−12
−10
−8
−6
−4
−2
0
2

Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 05

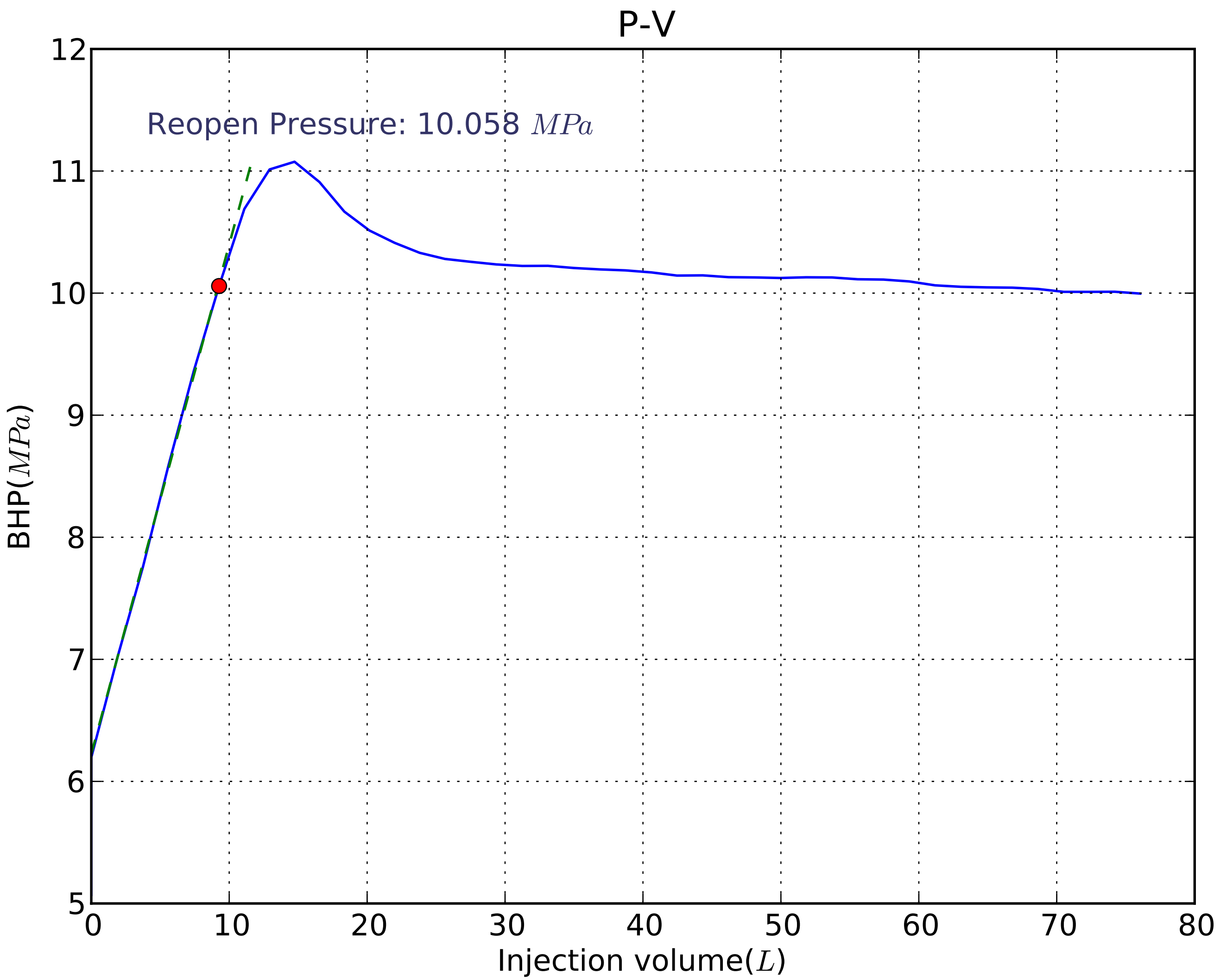
BitCan
Geosciences & Engineering Inc.




BHP and Injection Rate
BHP
Injection rate
BHP(MPa)
Injection rate(L/min)
Relative time(s)
12
11
10
9
8
7
6
5
120
100
80
60
40
20
0
−20
0
50
100
150
200
250
300
350
400
450

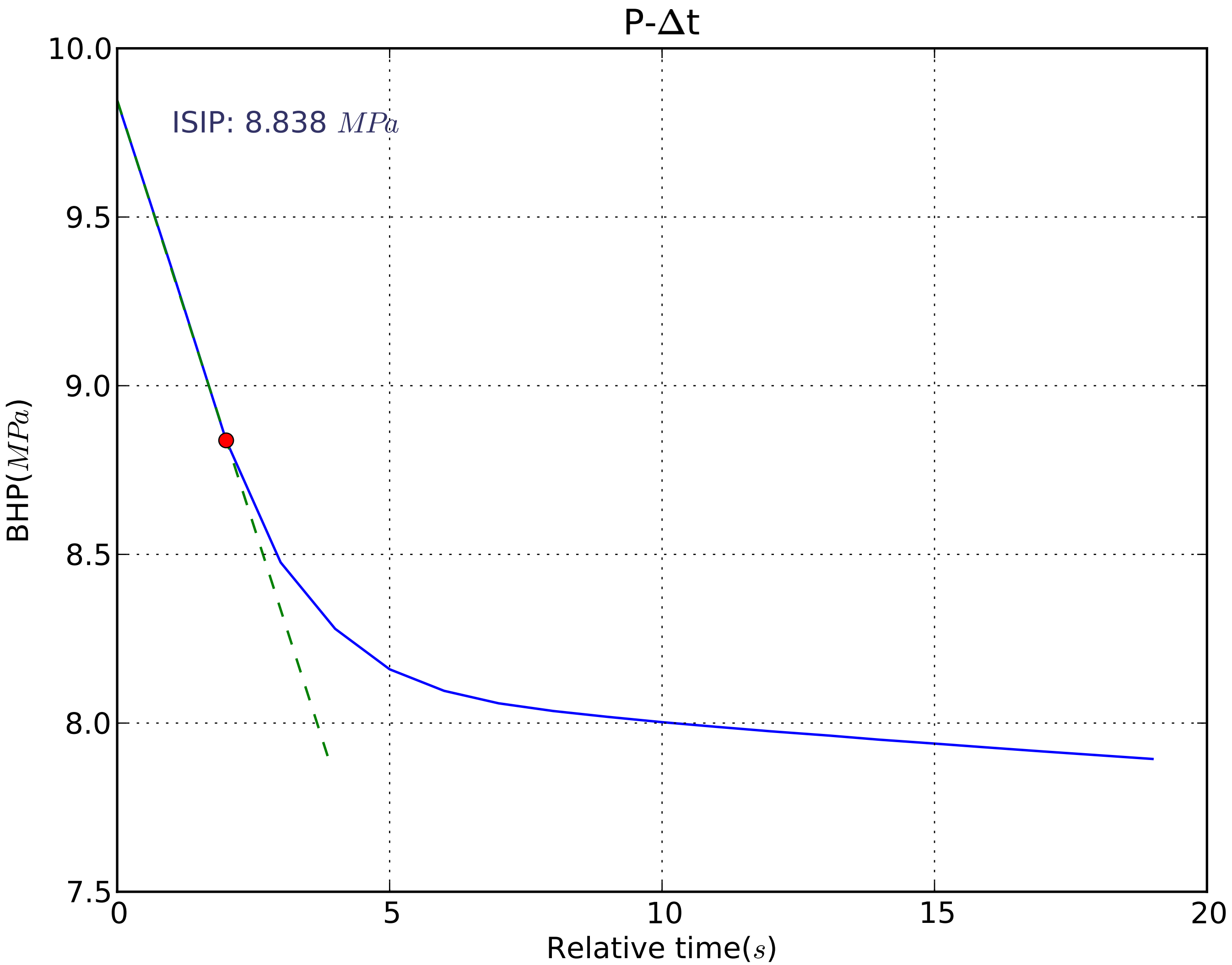
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 06

BitCan
Geosciences & Engineering Inc.

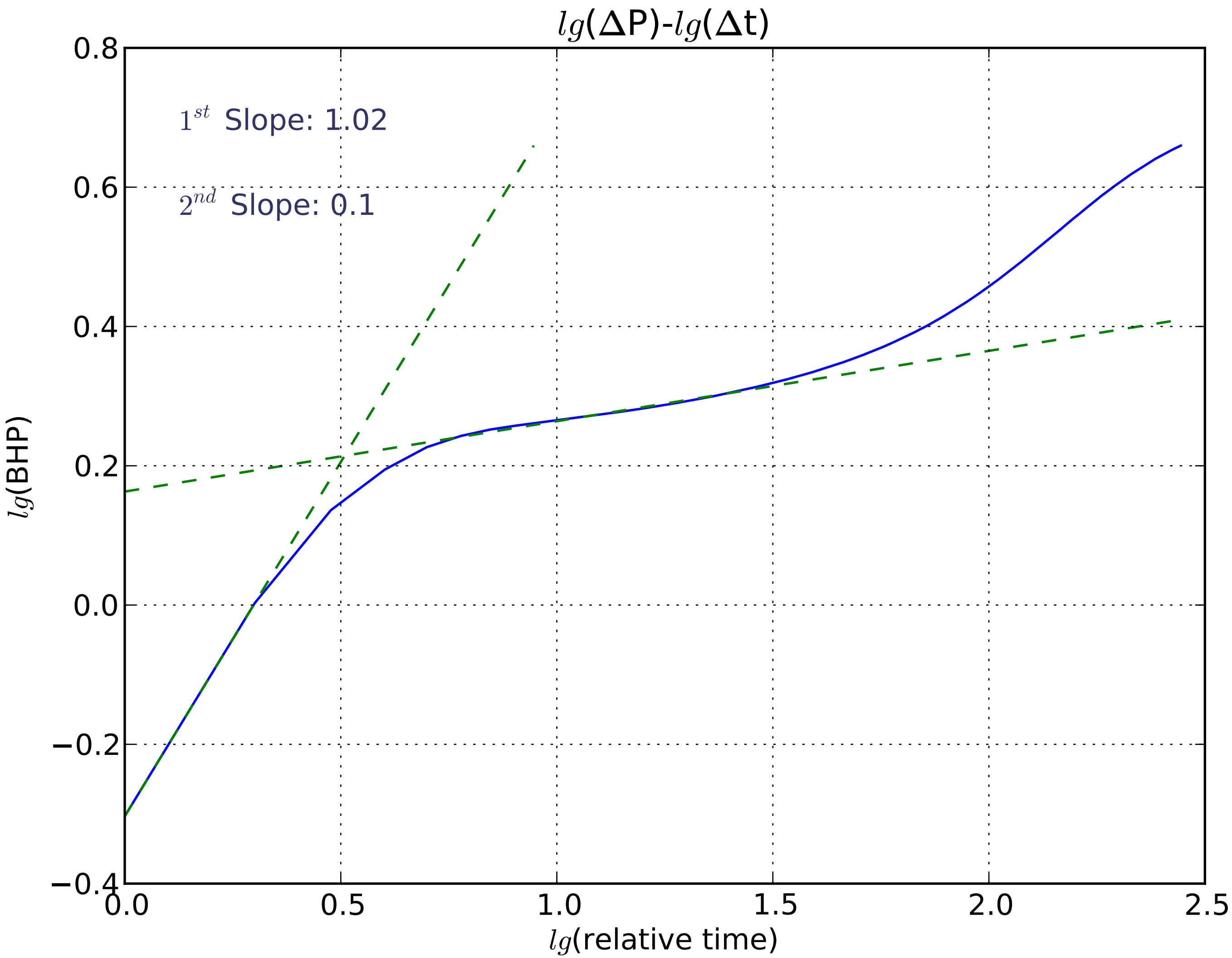


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 06

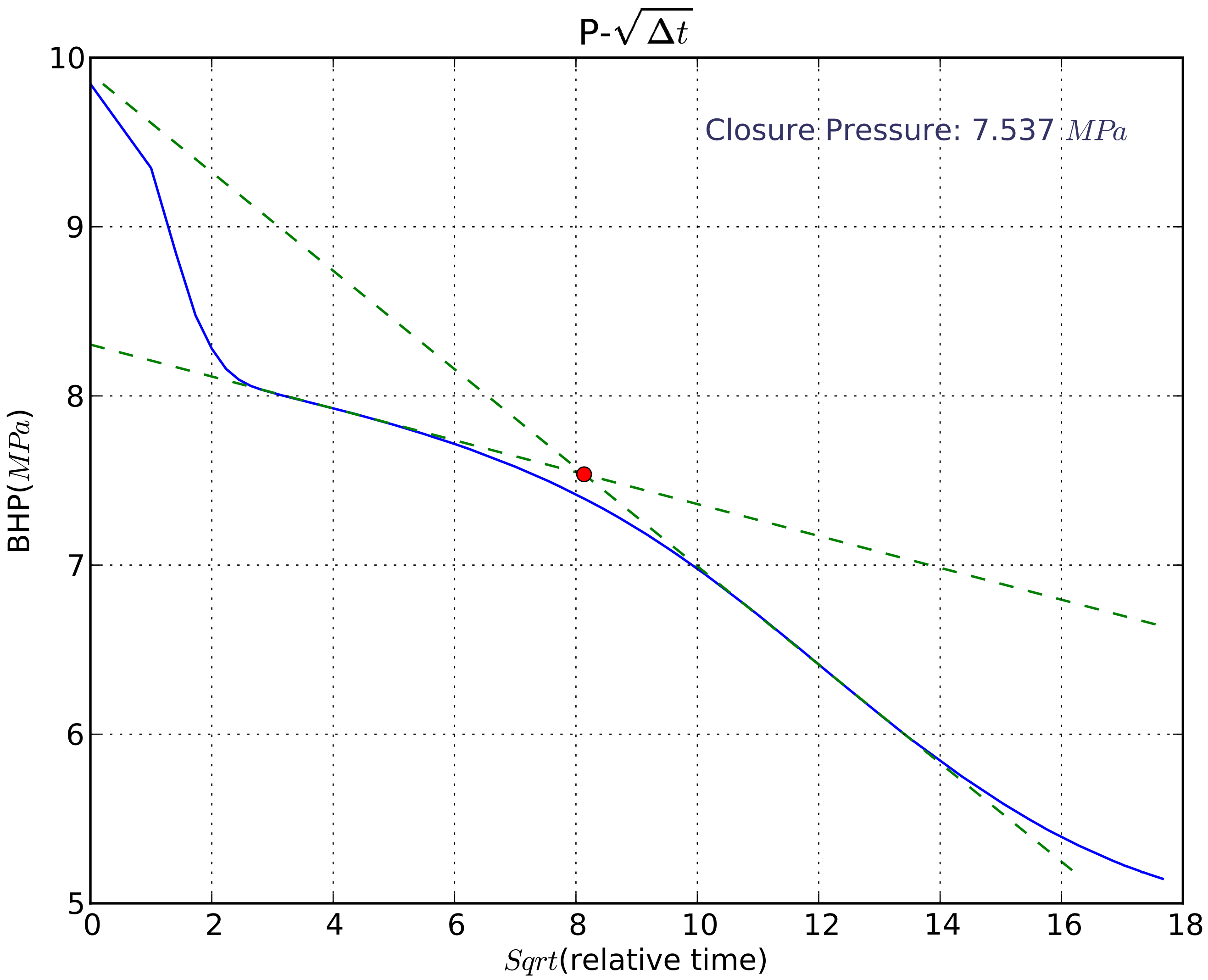
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 06

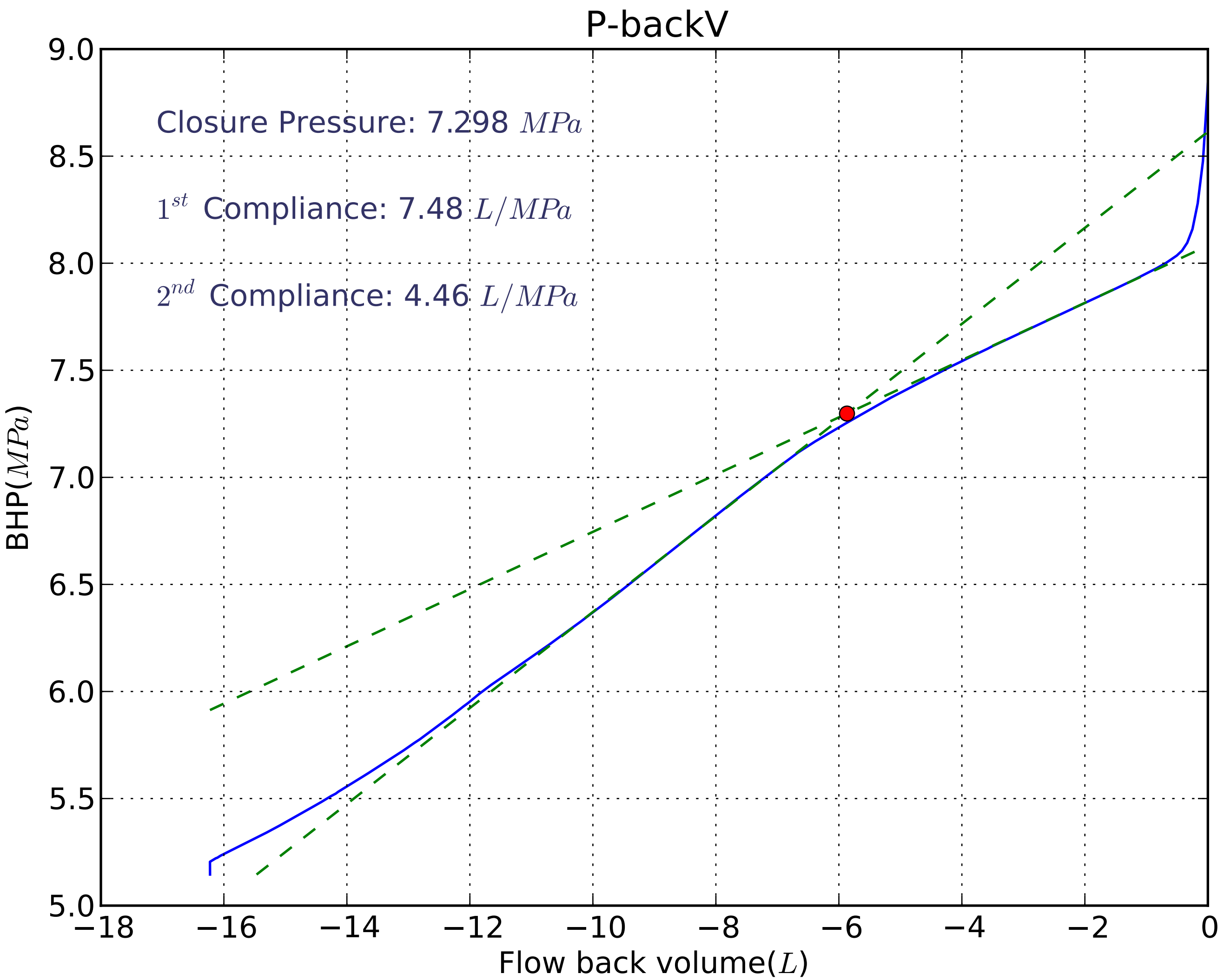


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 06



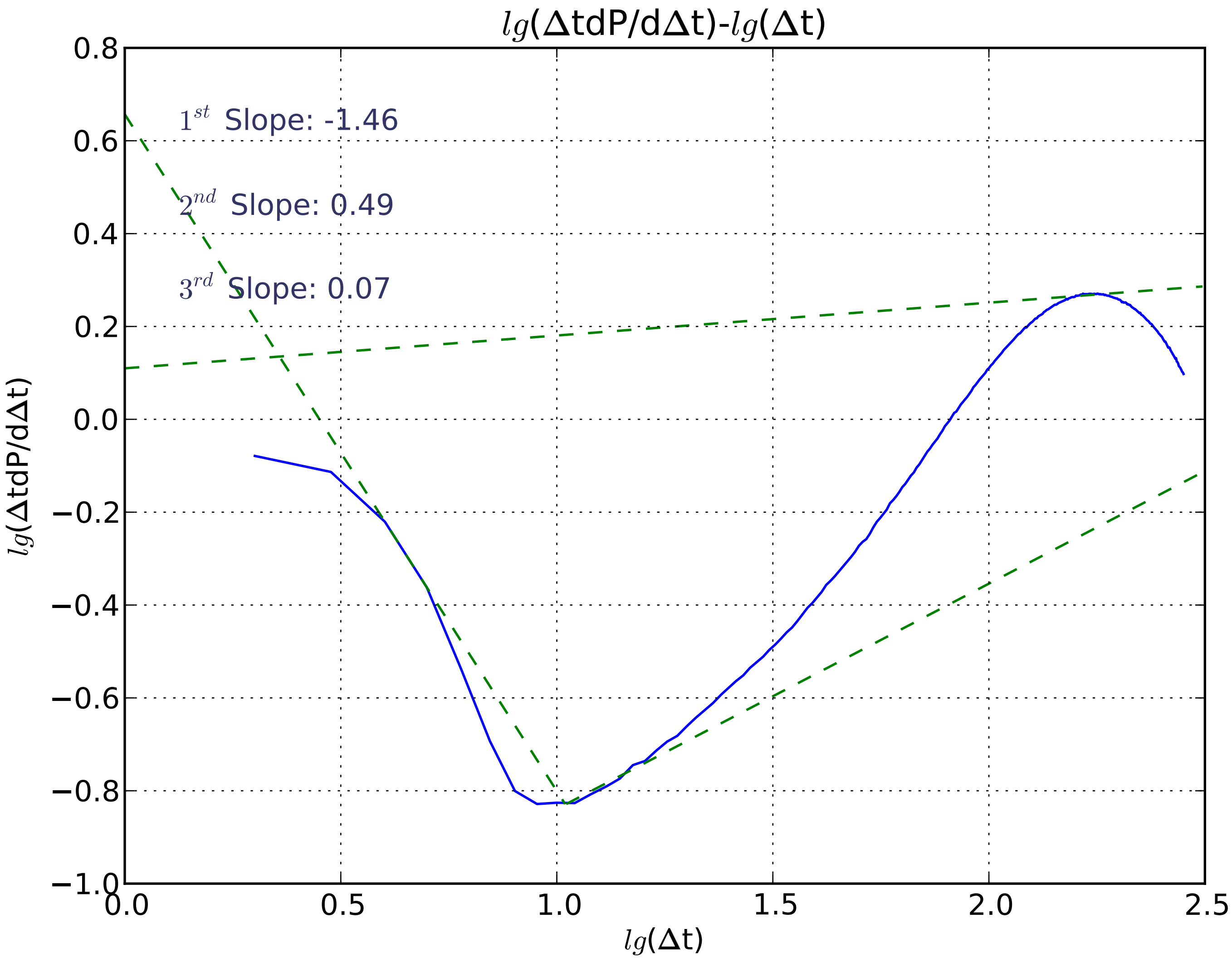
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 06

BitCan
Geosciences & Engineering Inc.

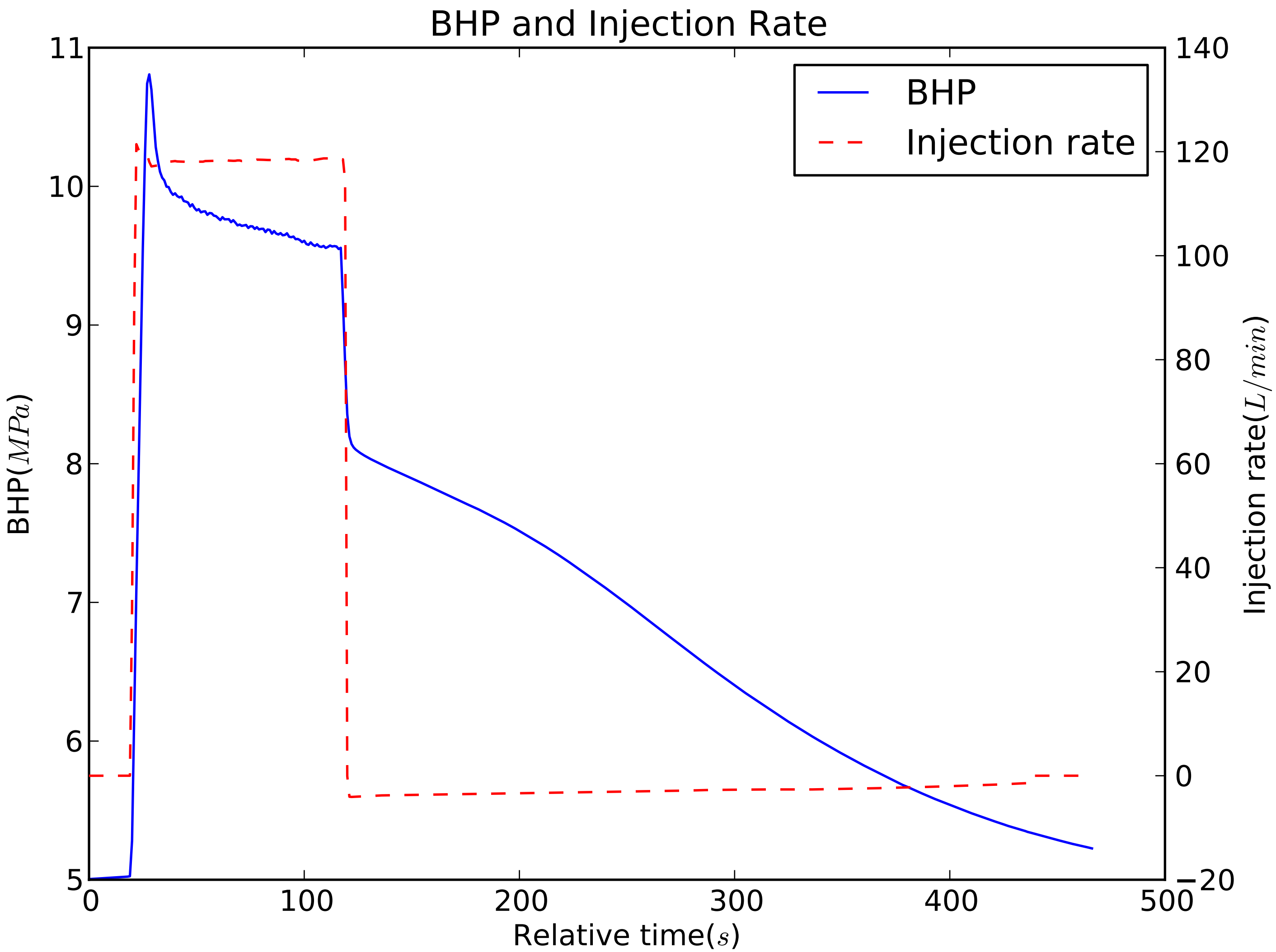


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 06

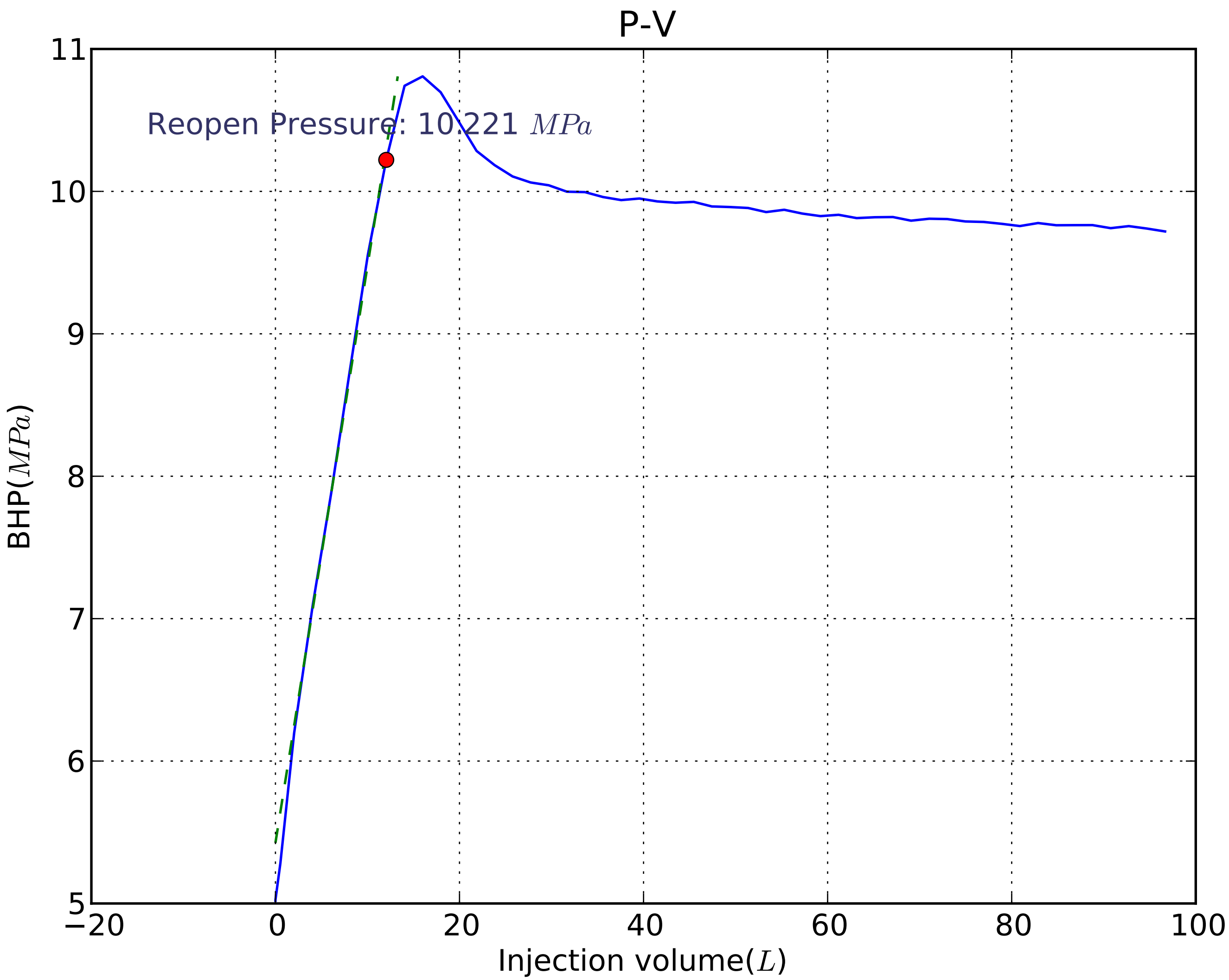
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 07

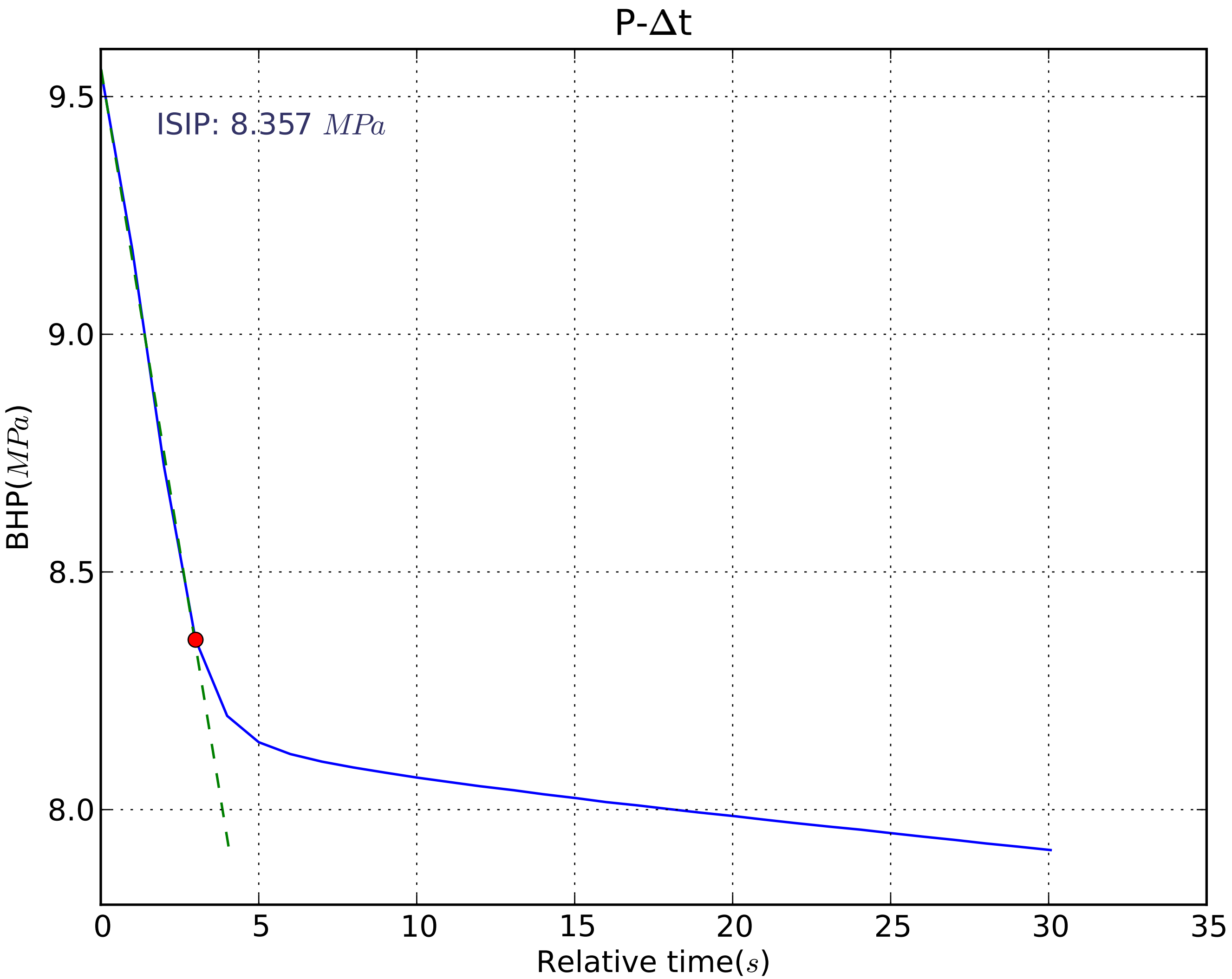


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 07

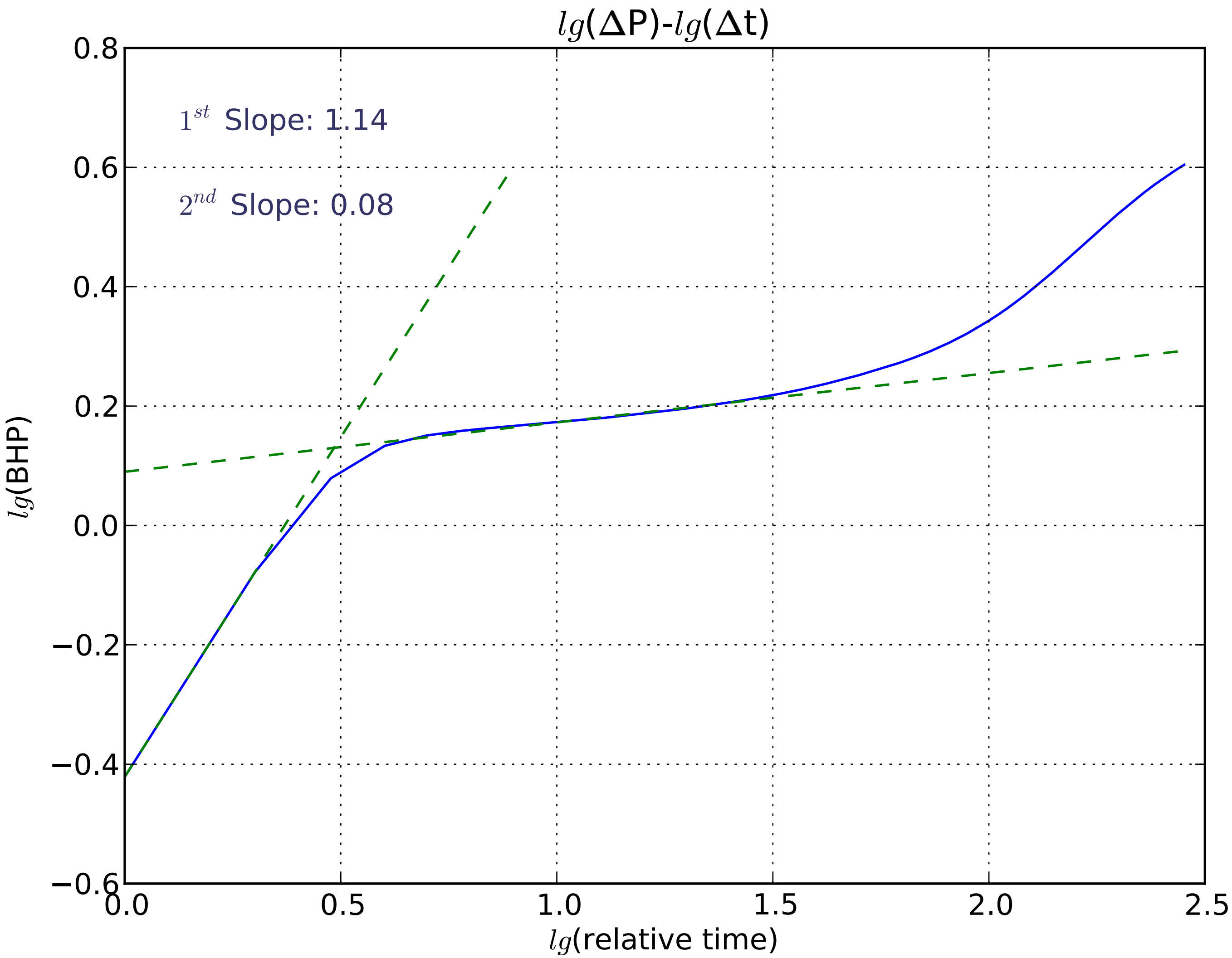


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 07

BitCan
Geosciences & Engineering Inc.

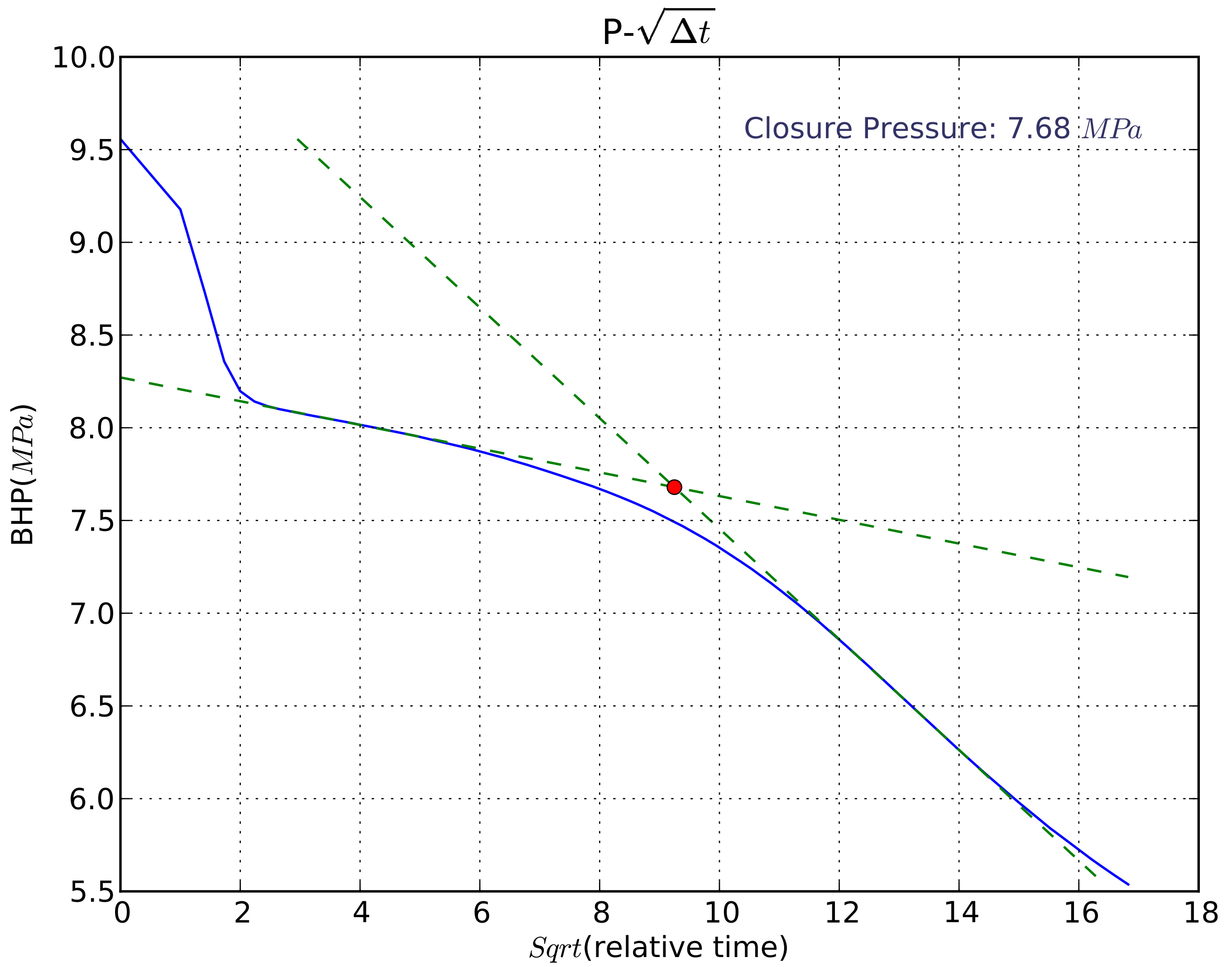


Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 07



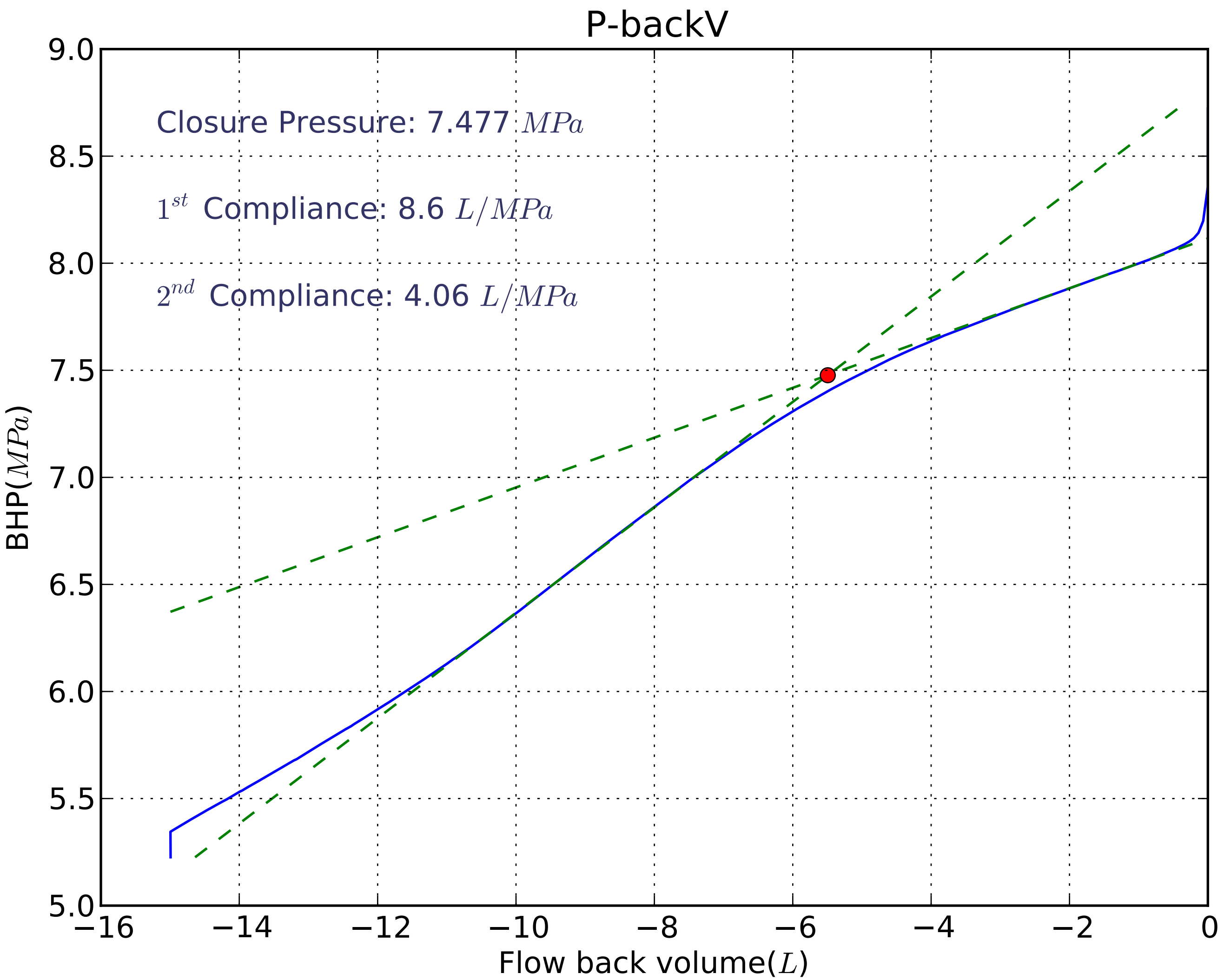
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 07

BitCan Geosciences & Engineering Inc.



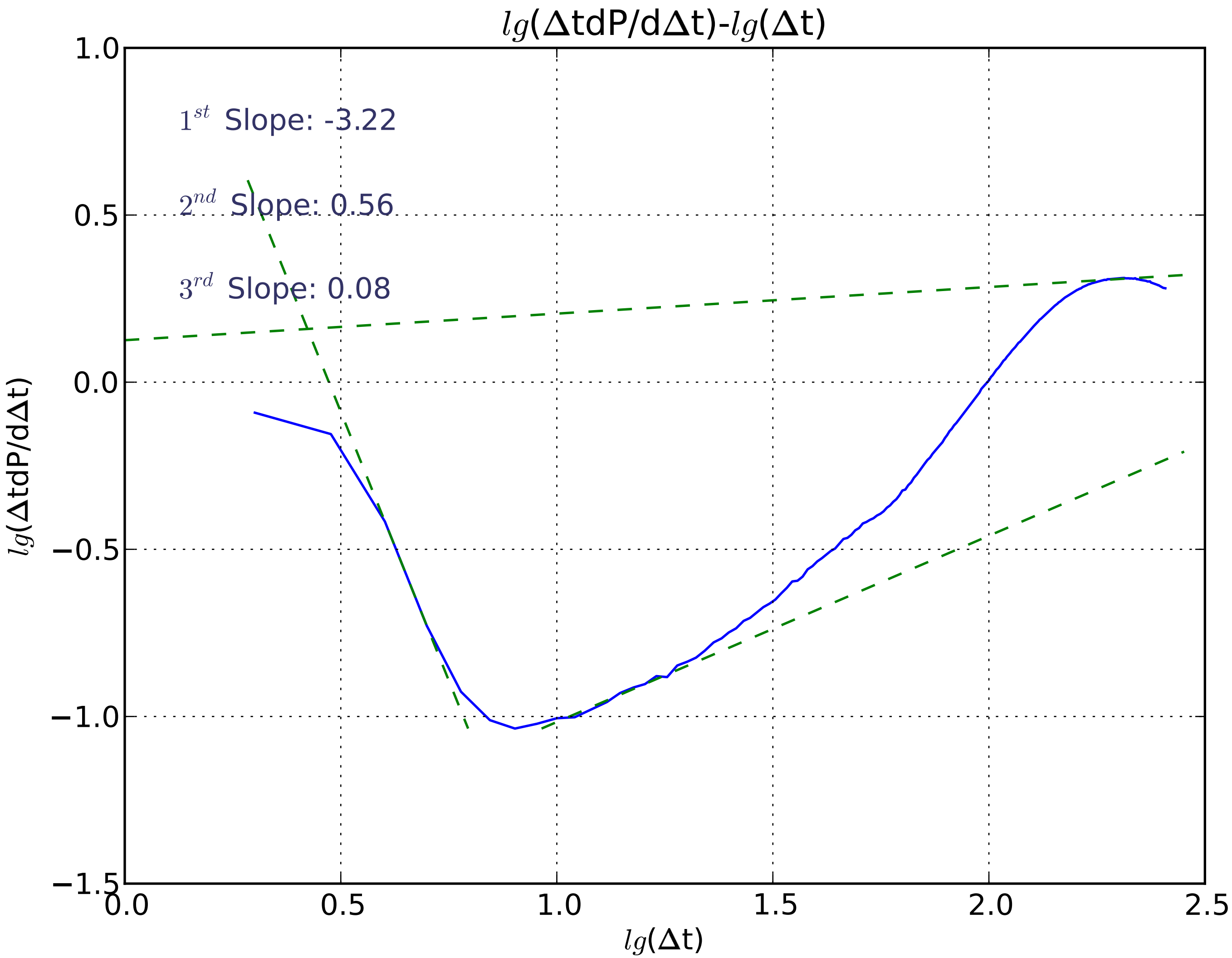
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 07

BitCan
Geosciences & Engineering Inc.



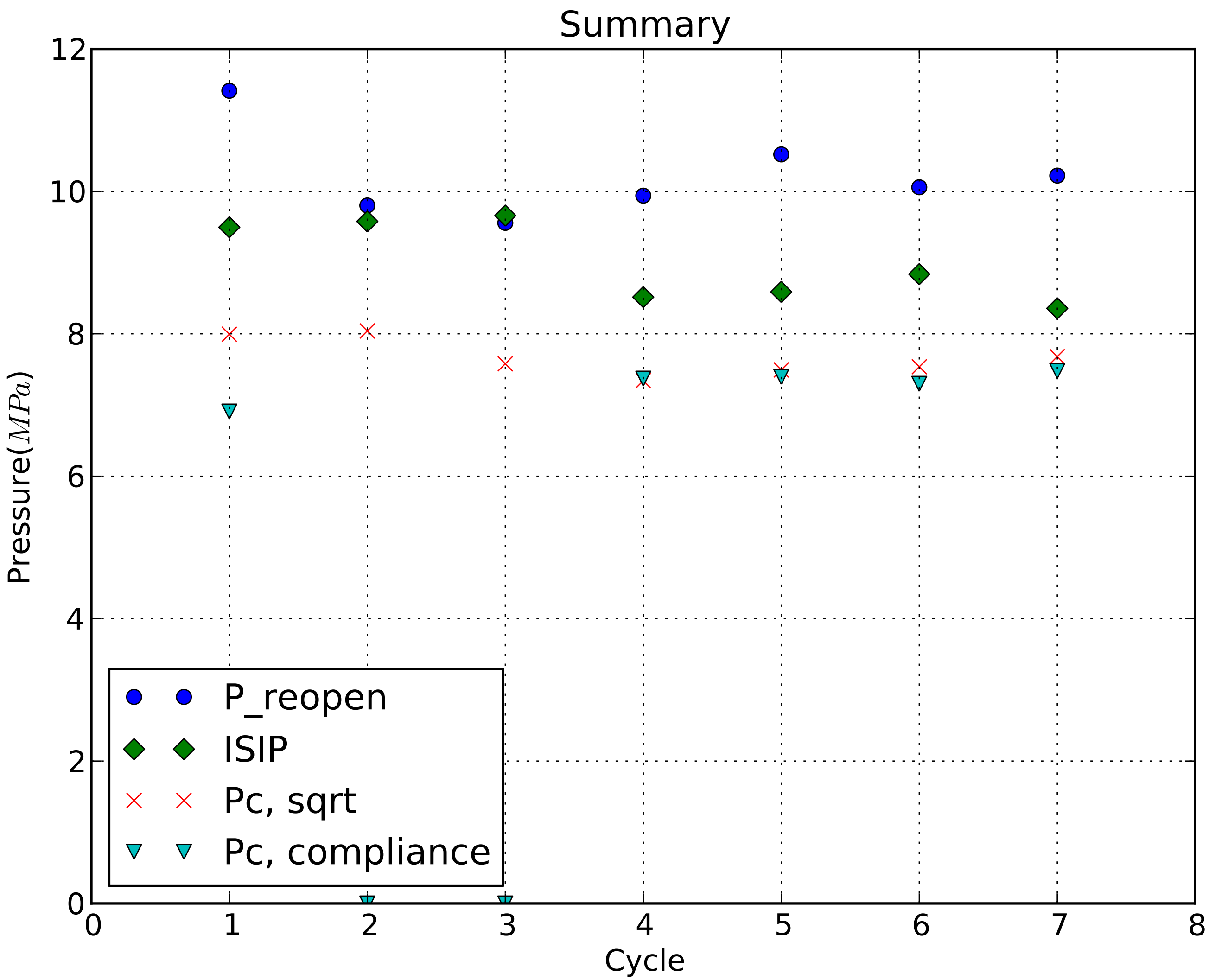
Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 07

BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 484.0m
Formation: GP
Cycle: 1 to 7

BitCan
Geosciences & Engineering Inc.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	11.413	9.496	7.994	6.908	2.50	2.13	2.56
2	9.802	9.578	8.040	0.000	2.47	0.00	0.00
3	9.558	9.660	7.579	0.000	2.37	0.00	0.00
4	9.940	8.516	7.342	7.370	2.28	4.57	4.13
5	10.519	8.588	7.493	7.395	2.40	4.66	4.05
6	10.058	8.838	7.537	7.298	2.40	7.48	4.46
7	10.221	8.357	7.680	7.477	2.47	8.60	4.06

ANALYSIS PLOTS

WELL: PENGROWTH LNDBRGH WELL 13-13-58-5W4

Test 4: GP Zone #3 at 476 m

Previous View Main Menu Search

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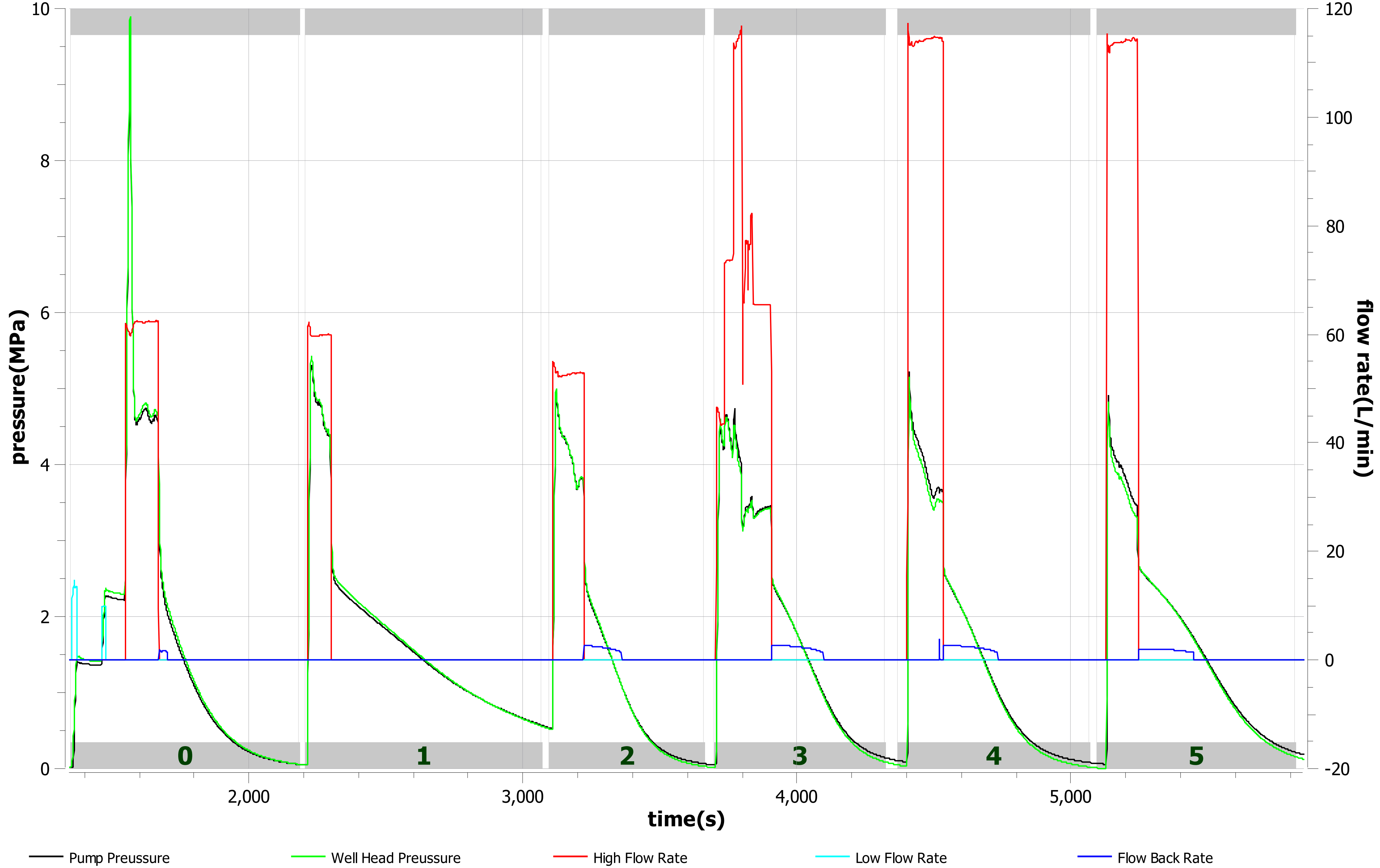
www.bitcange.com

Client: Pengrowth Energy Corp
Well: 13-13-58-5W4
Depth: 476

Formation: unknown shale
Start @: Fri Mar 4 07:30:08 2011

Mini-Frac Test

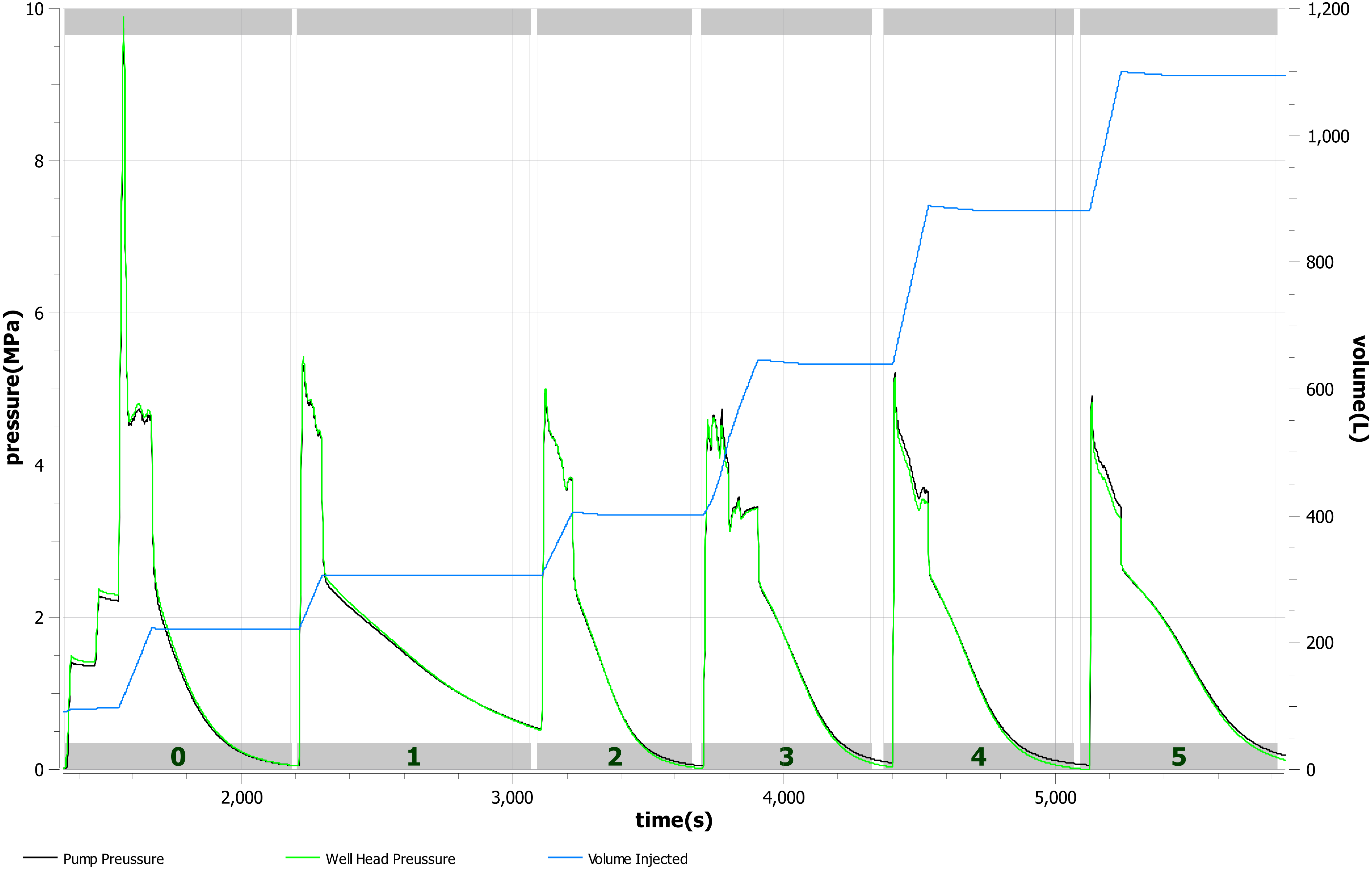


Generated by MiniMonitor

BitCan
Geosciences & Engineering Inc.
www.bitcange.com

Client: Pengrowth Energy Corp
Well: 13-13-58-5W4
Depth: 476
Formation: unknown shale
Start @: Fri Mar 4 07:30:08 2011

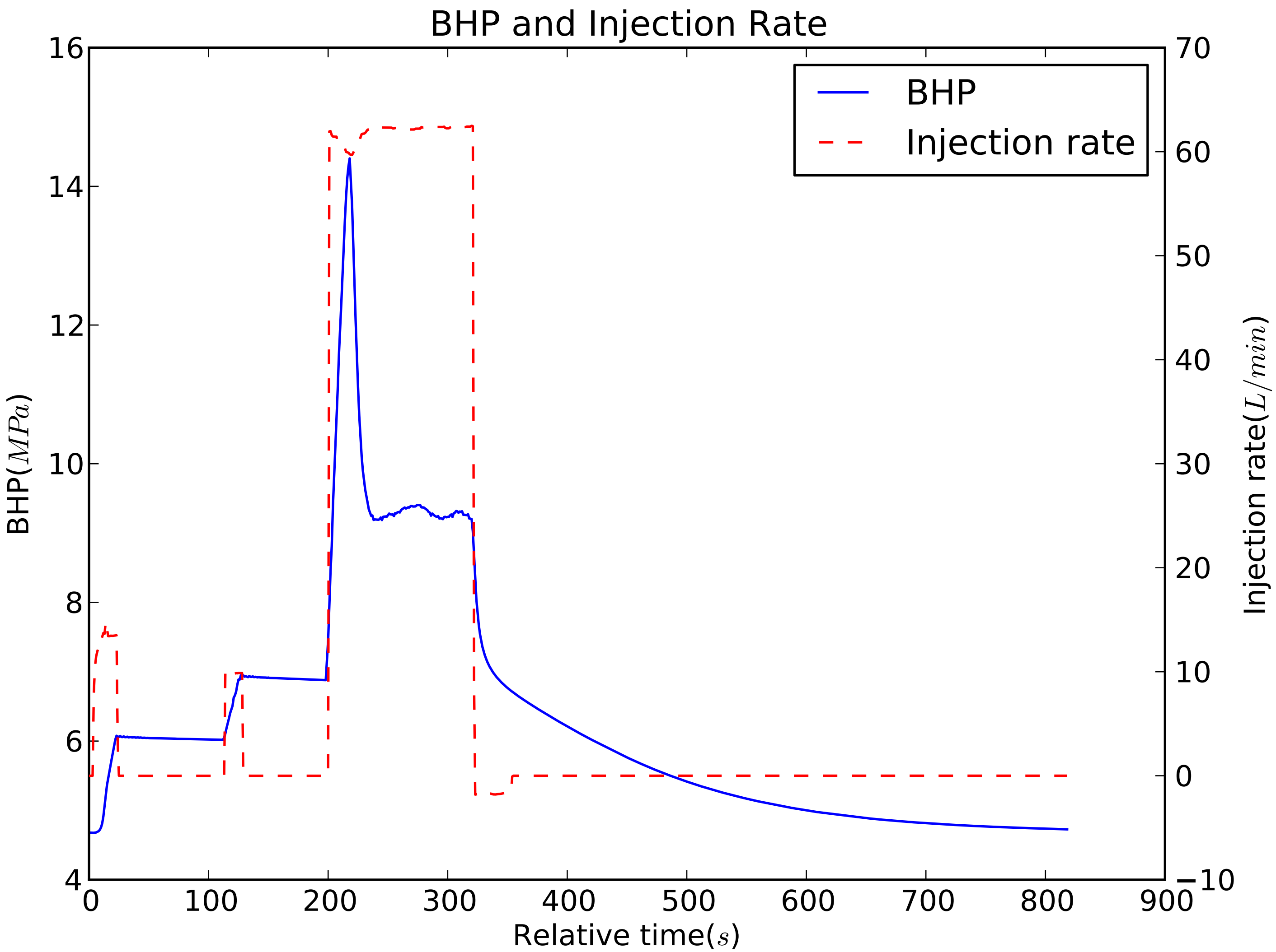
Mini-Frac Test



Generated by MiniMonitor

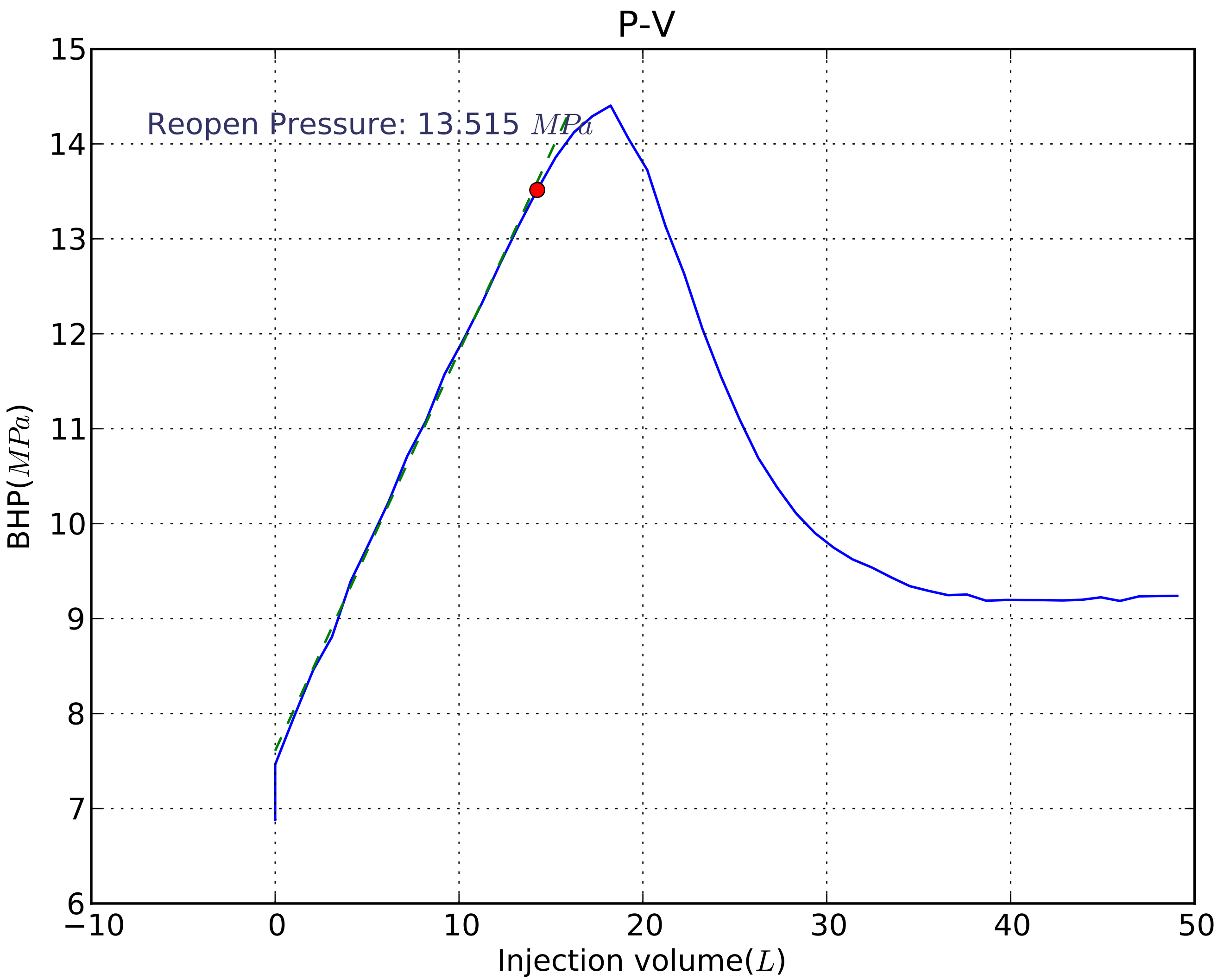
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 01

BitCan
Geosciences & Engineering Inc.



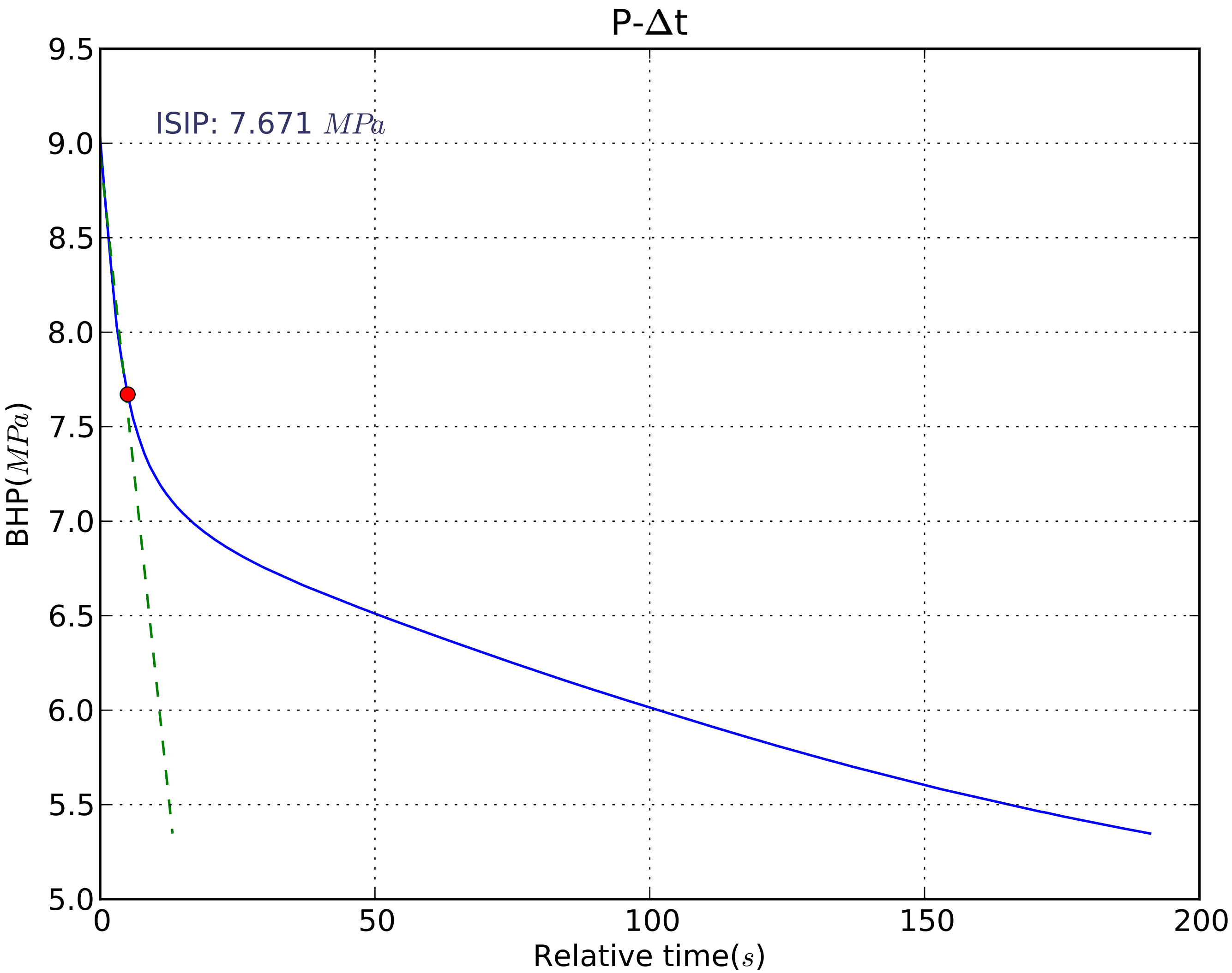
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 01

BitCan
Geosciences & Engineering Inc.



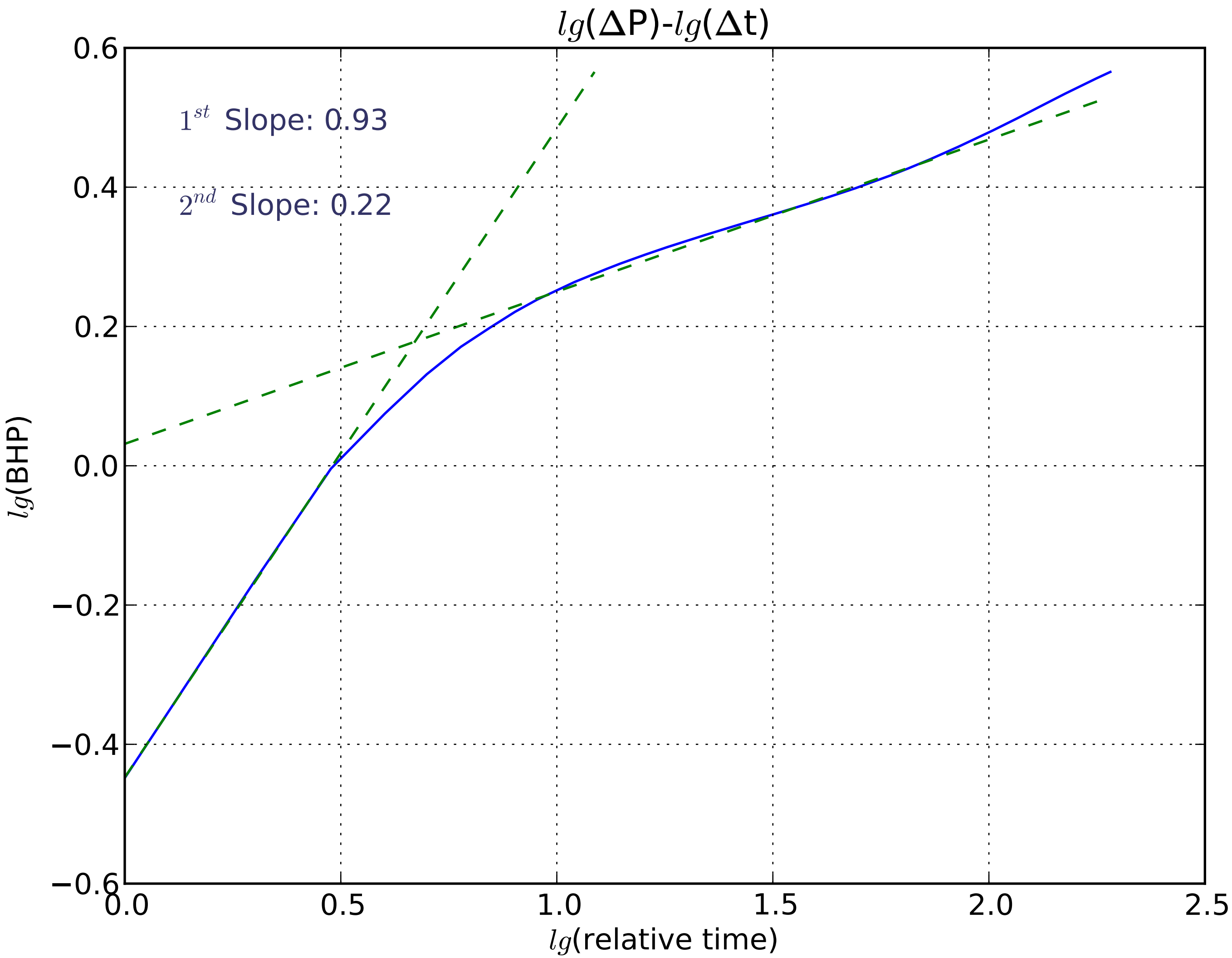
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 01

BitCan
Geosciences & Engineering Inc.

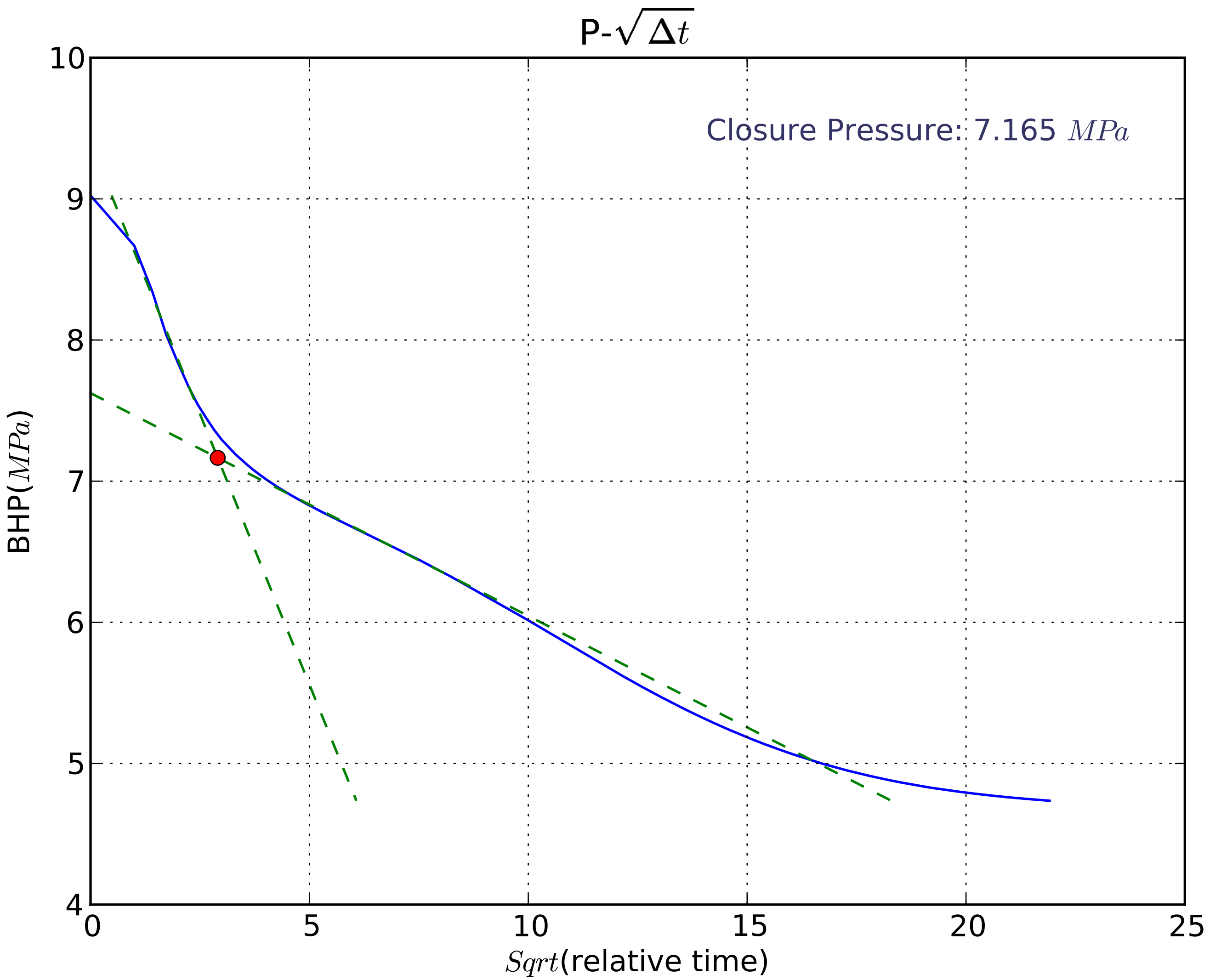


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 01

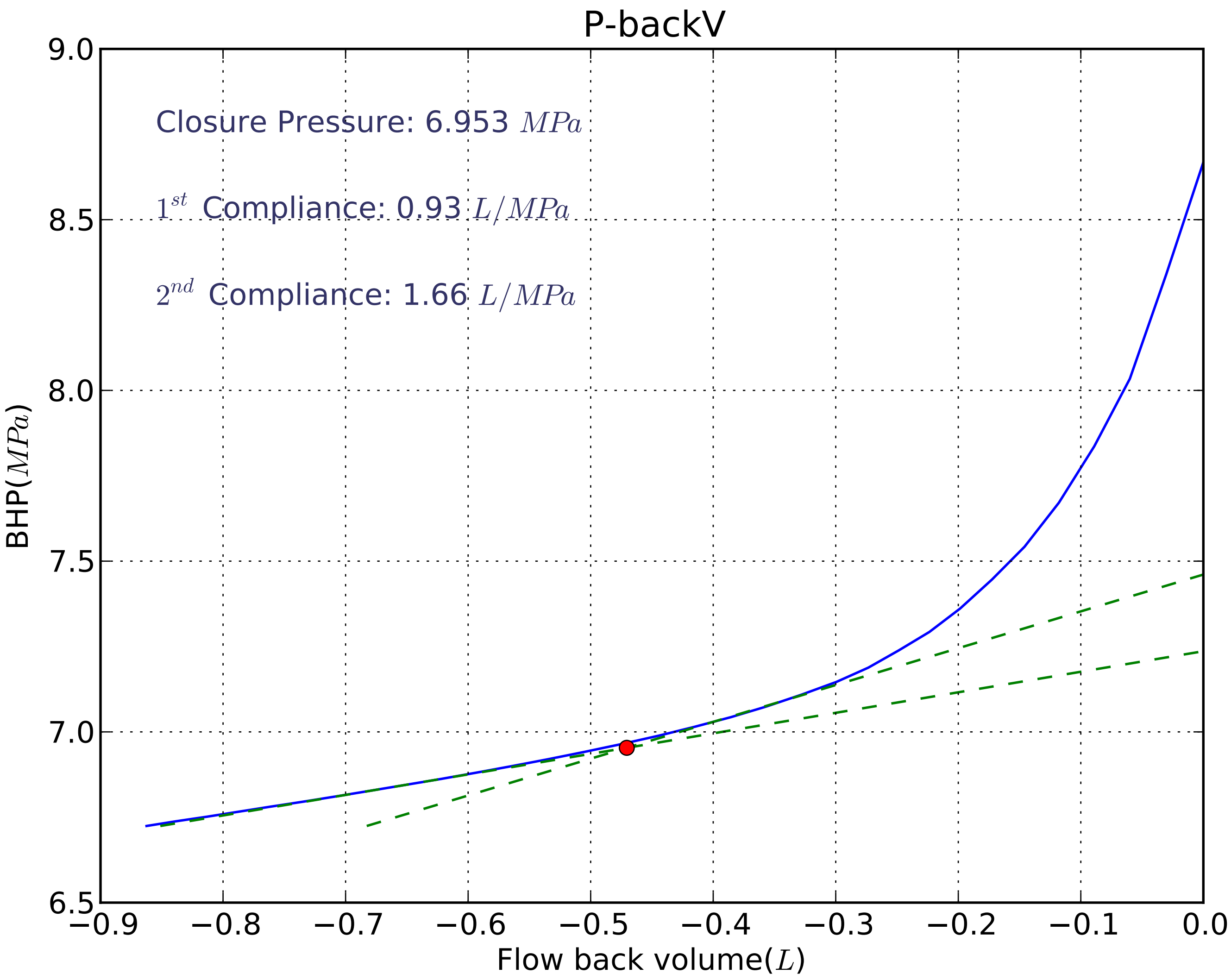
BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 01

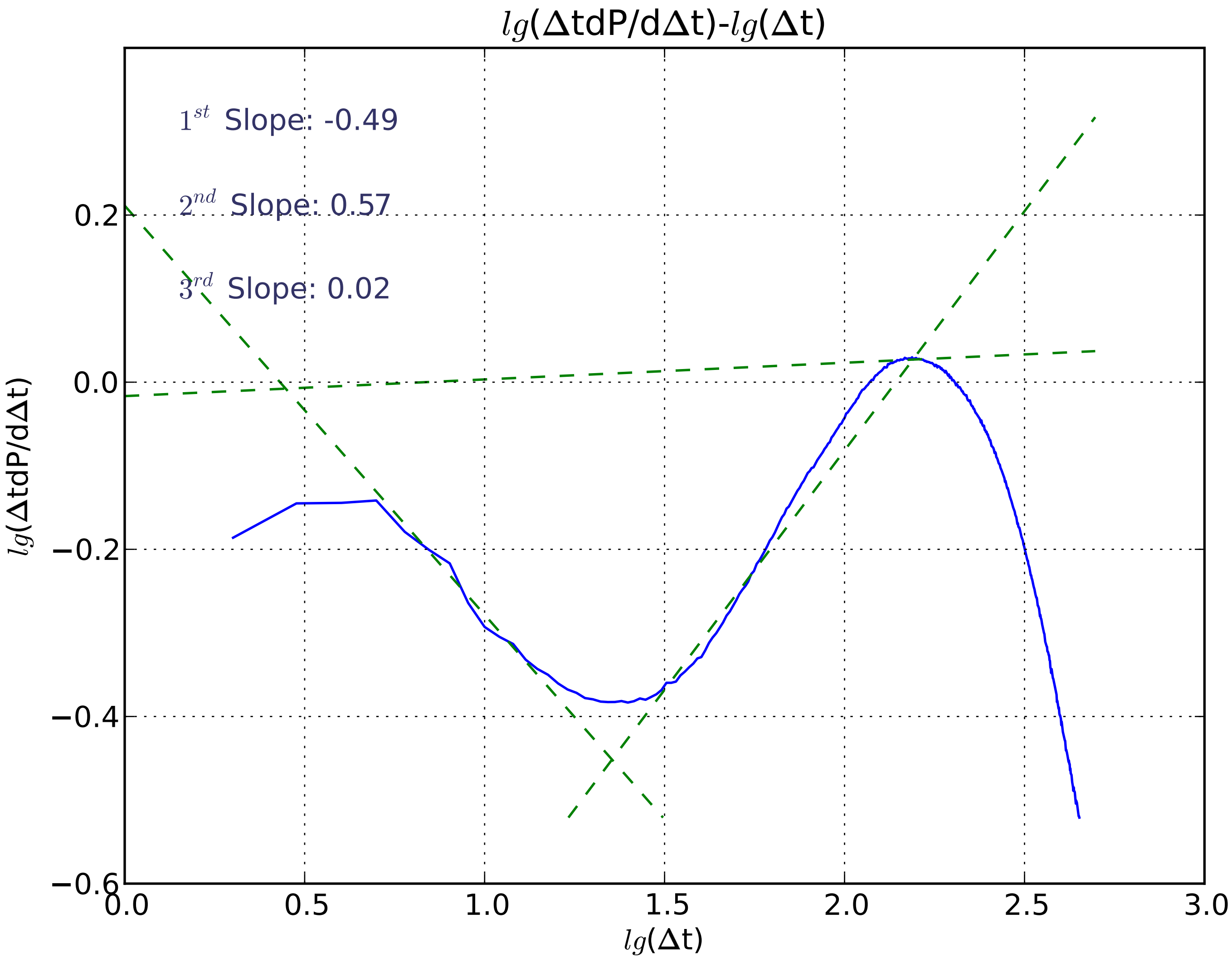


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 01

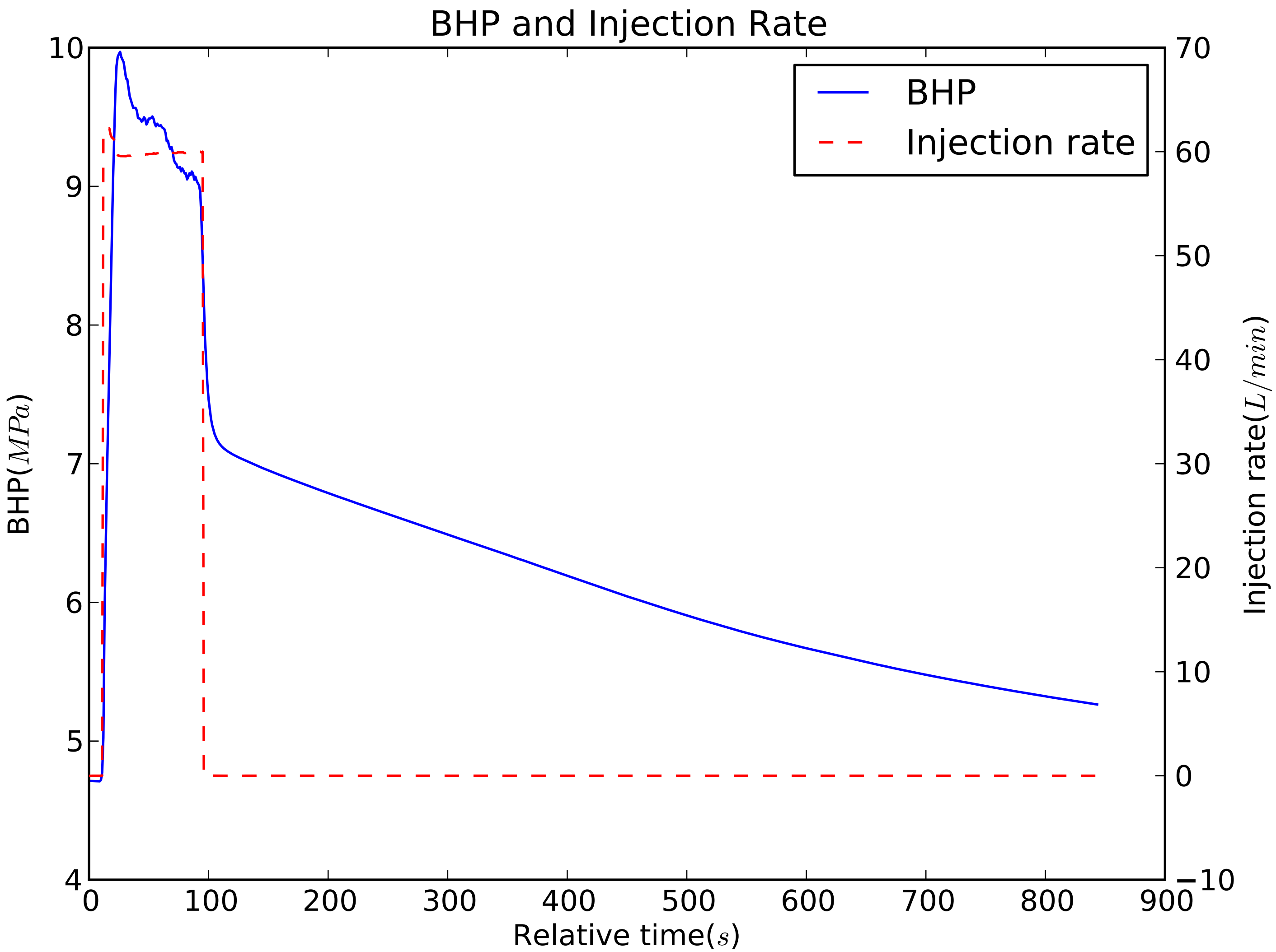


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 01

BitCan
Geosciences & Engineering Inc.

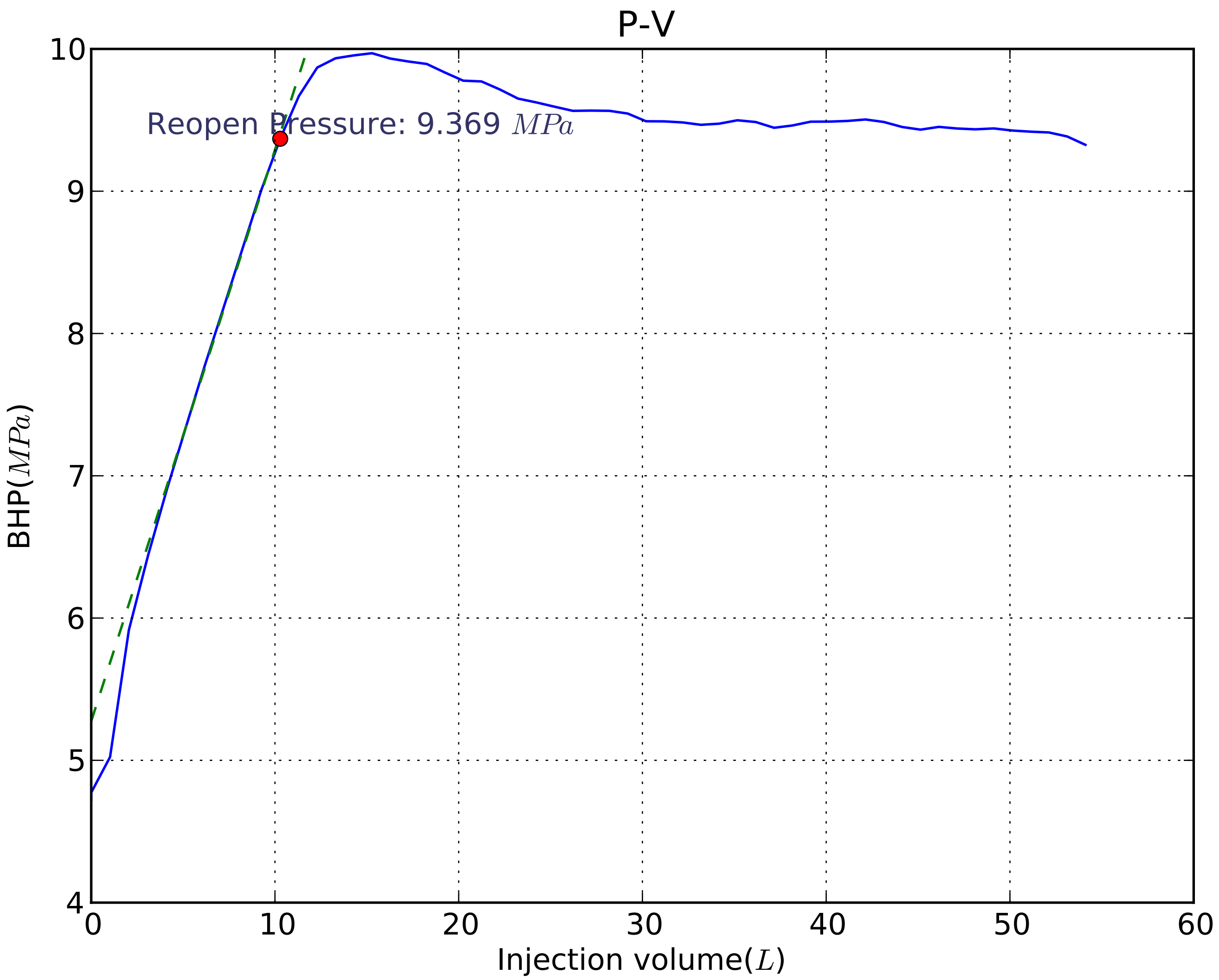


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 02



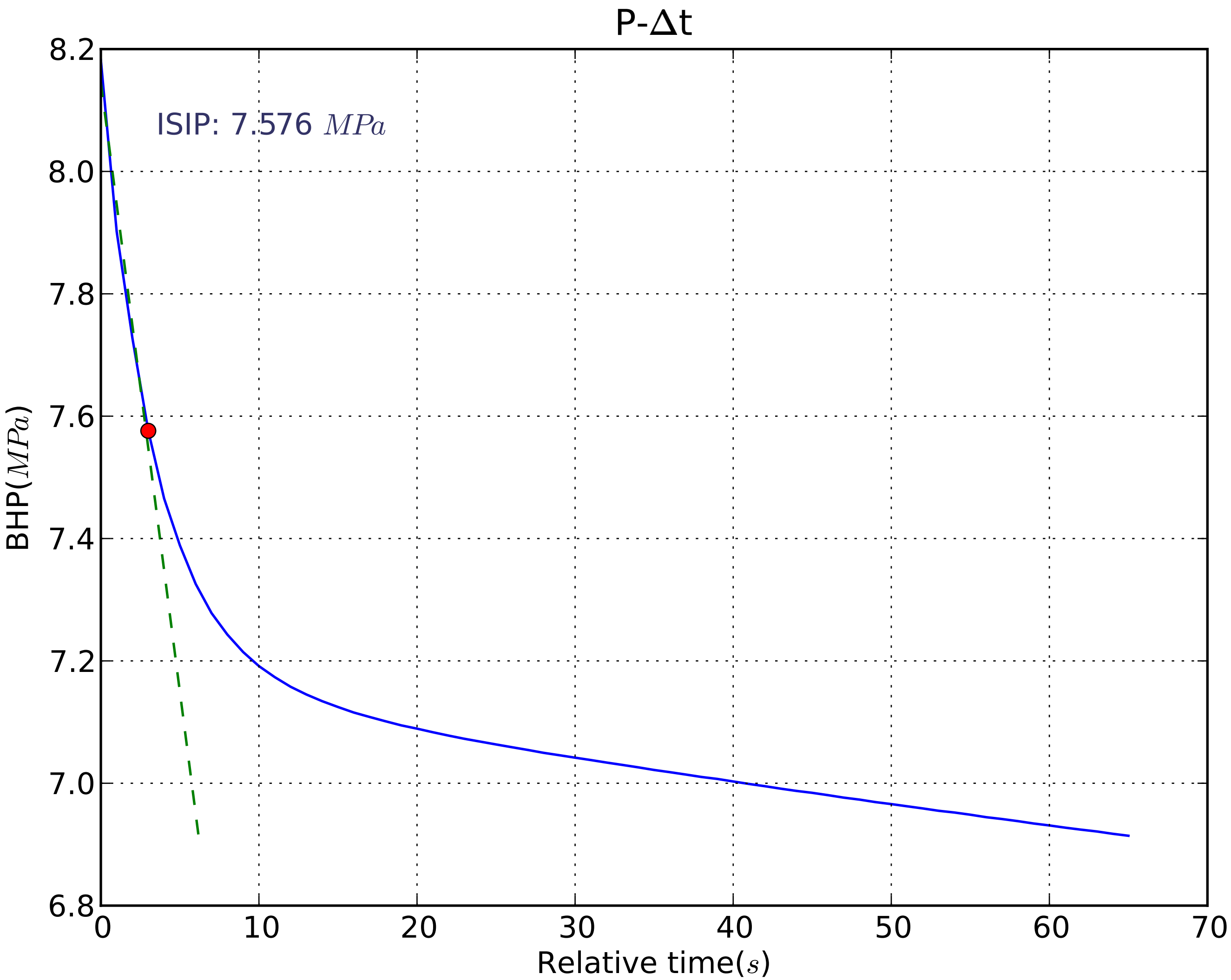
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 02

BitCan
Geosciences & Engineering Inc.



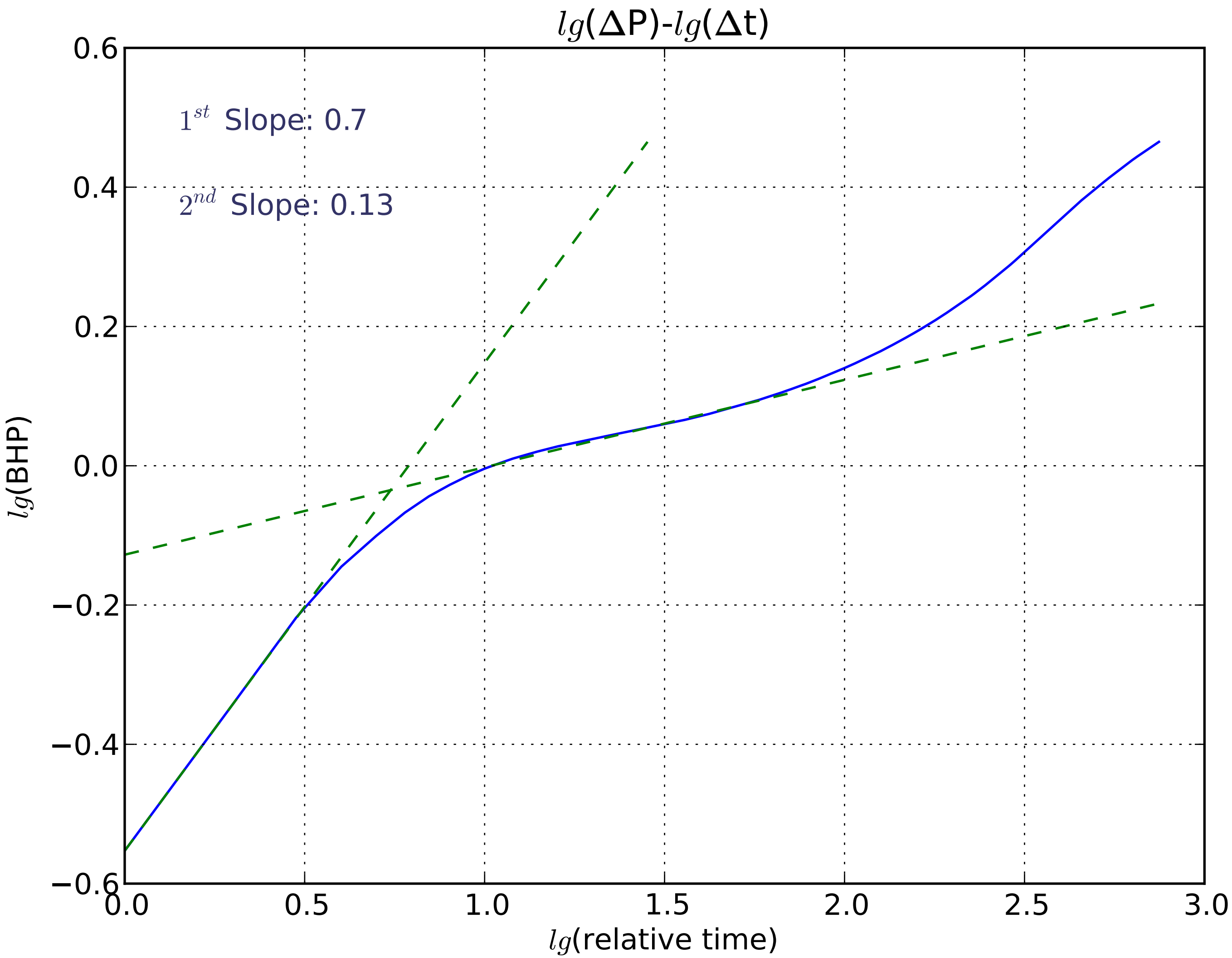
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 02

BitCan Geosciences & Engineering Inc.

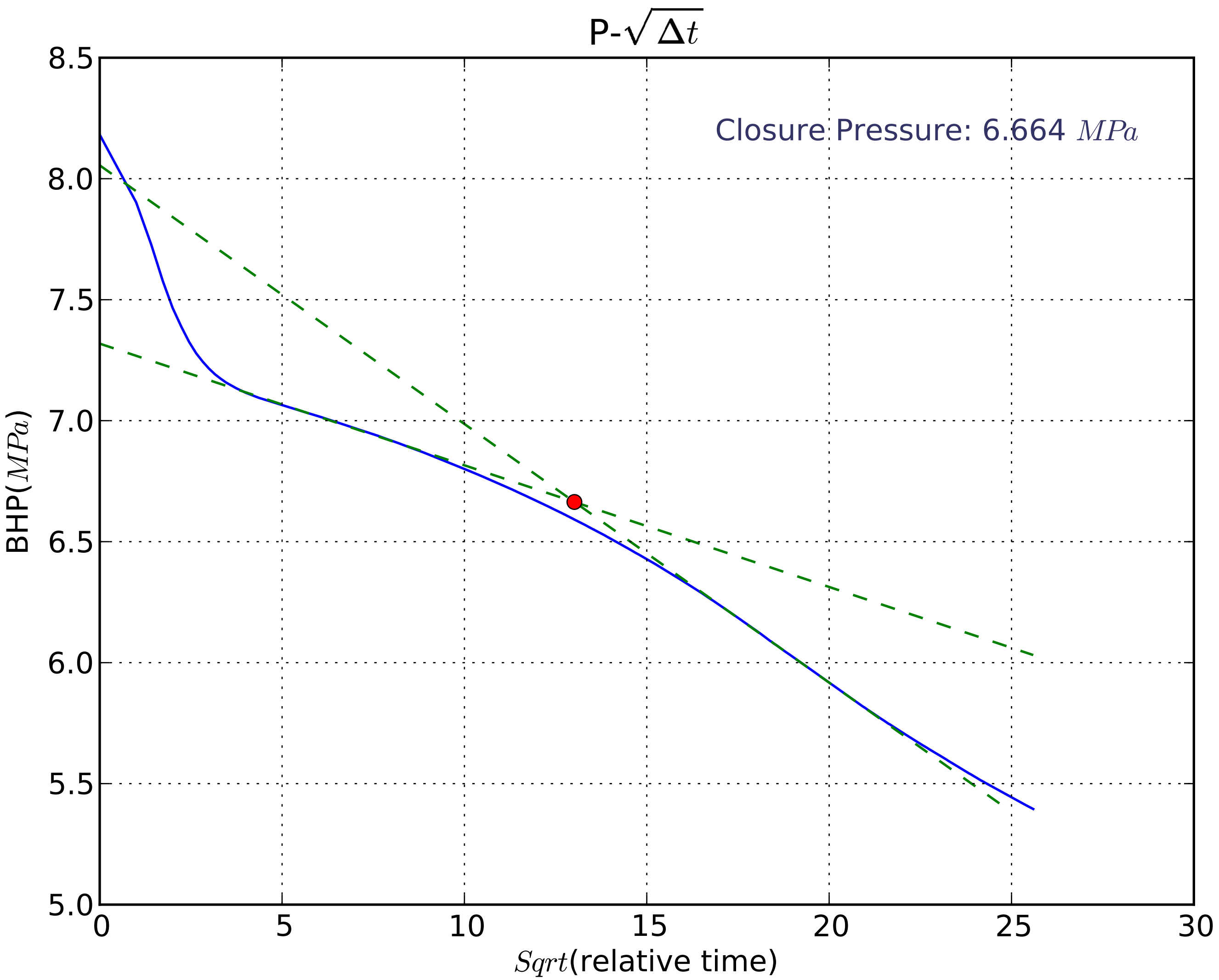


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 02

BitCan
Geosciences & Engineering Inc.

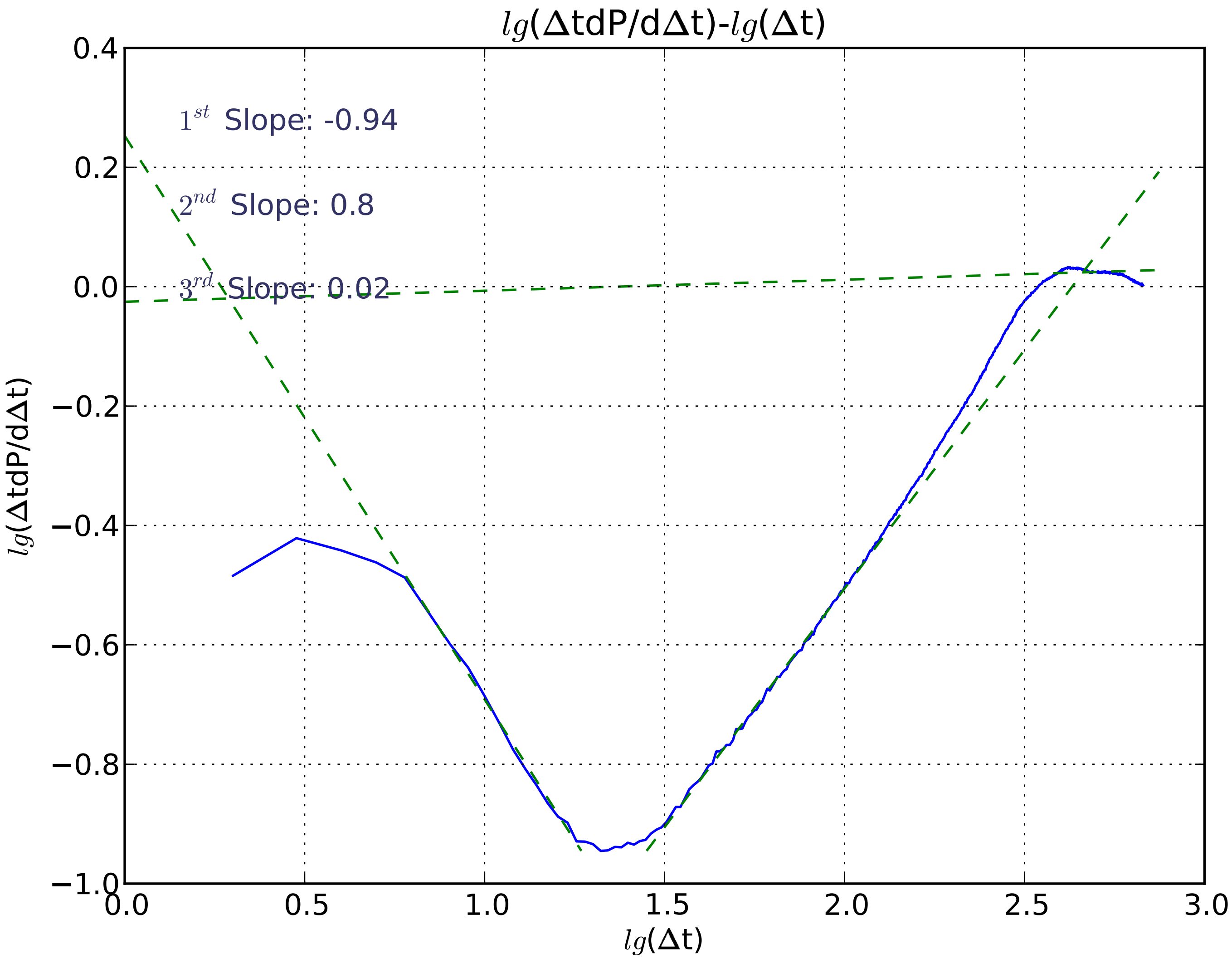


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 02



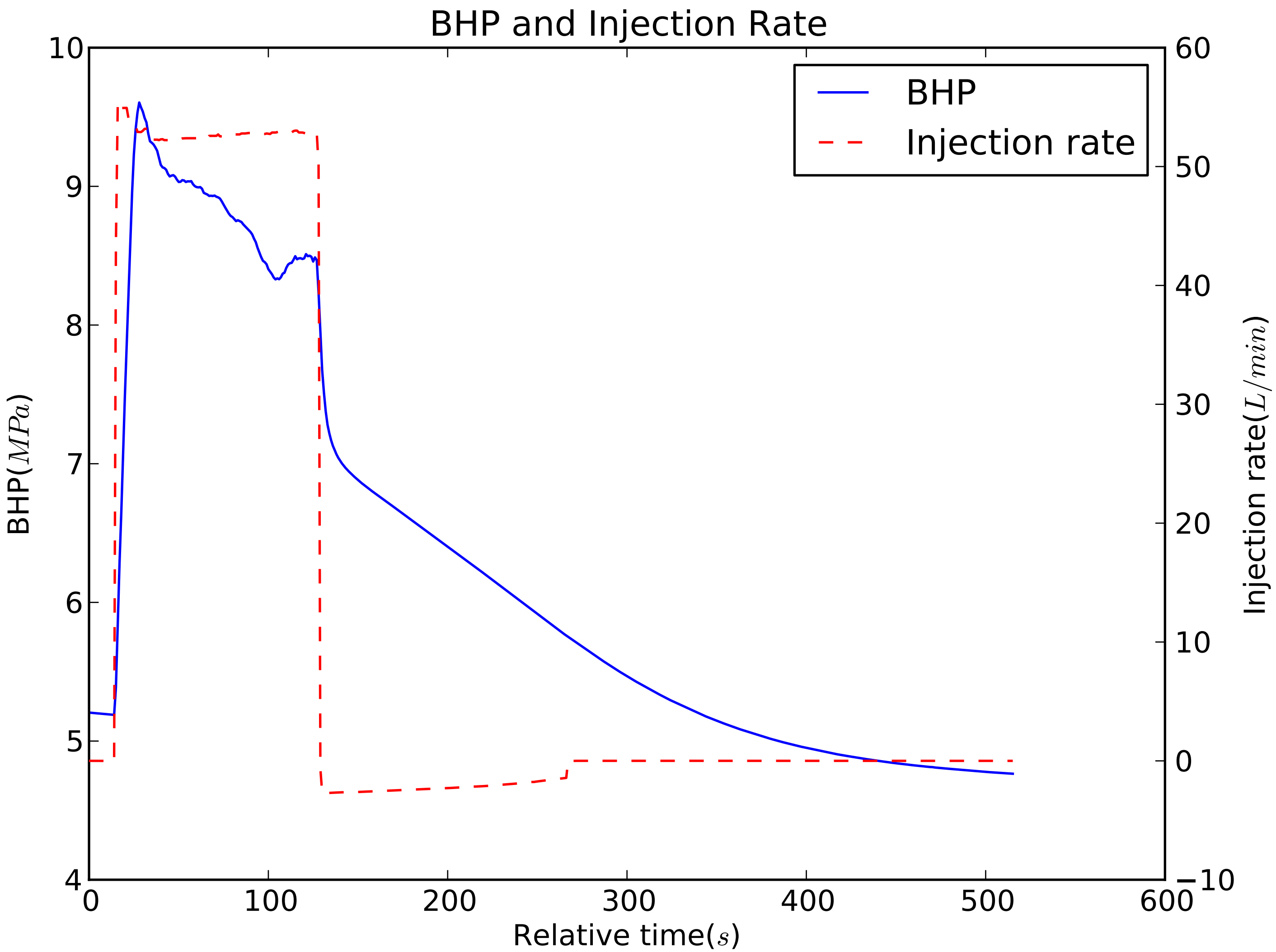
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 02

BitCan Geosciences & Engineering Inc.

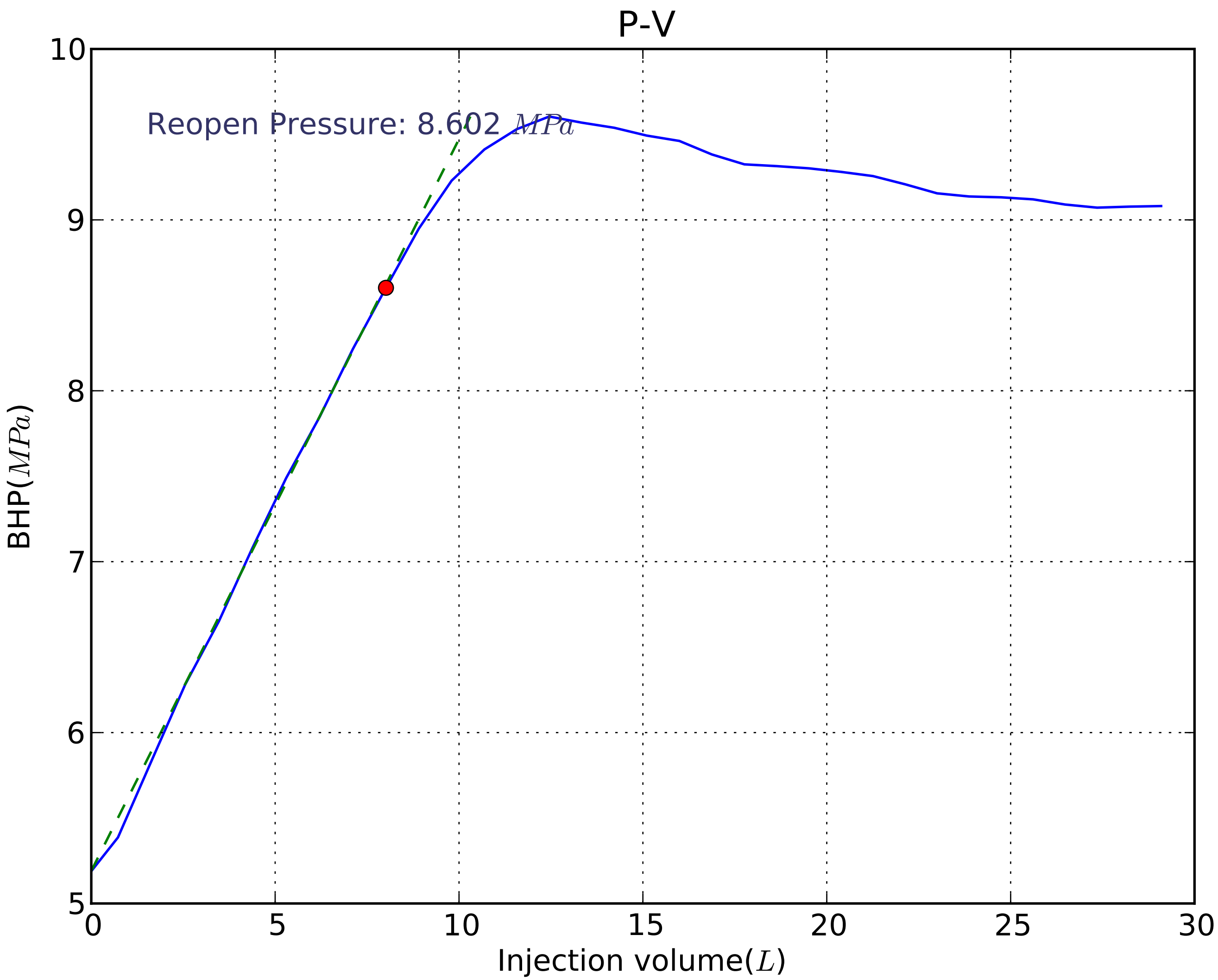


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 03

BitCan
Geosciences & Engineering Inc.

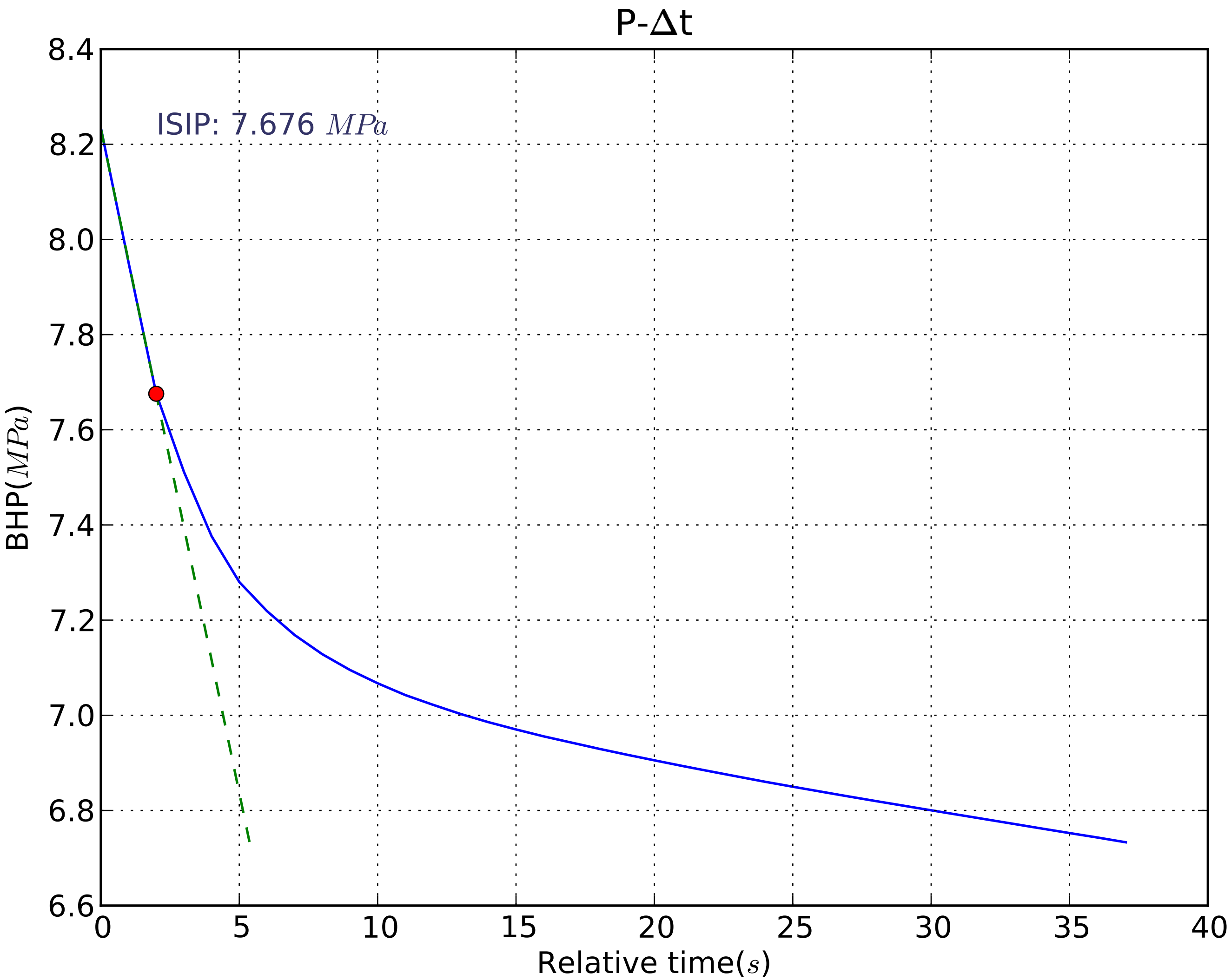


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 03



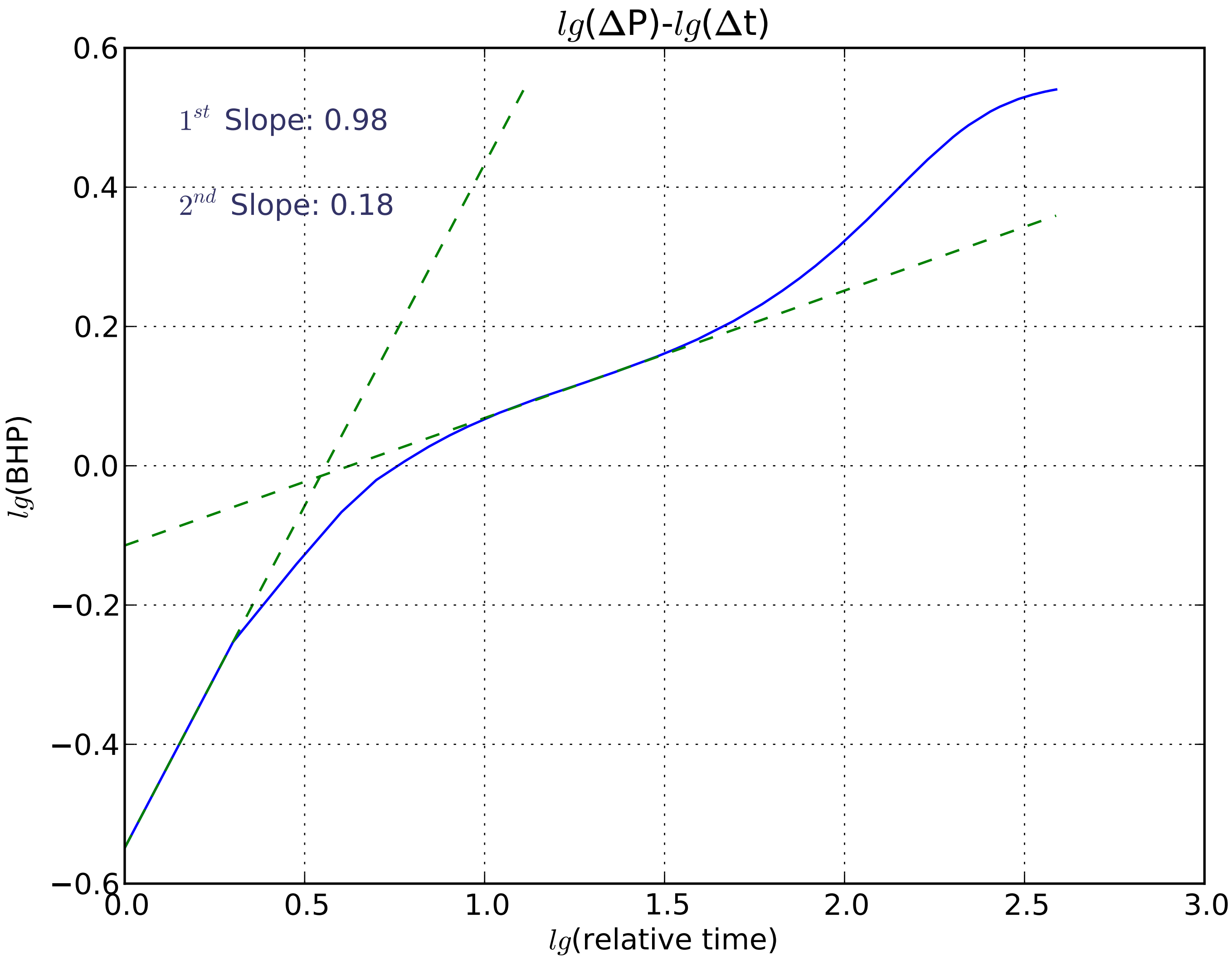
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 03

BitCan
Geosciences & Engineering Inc.

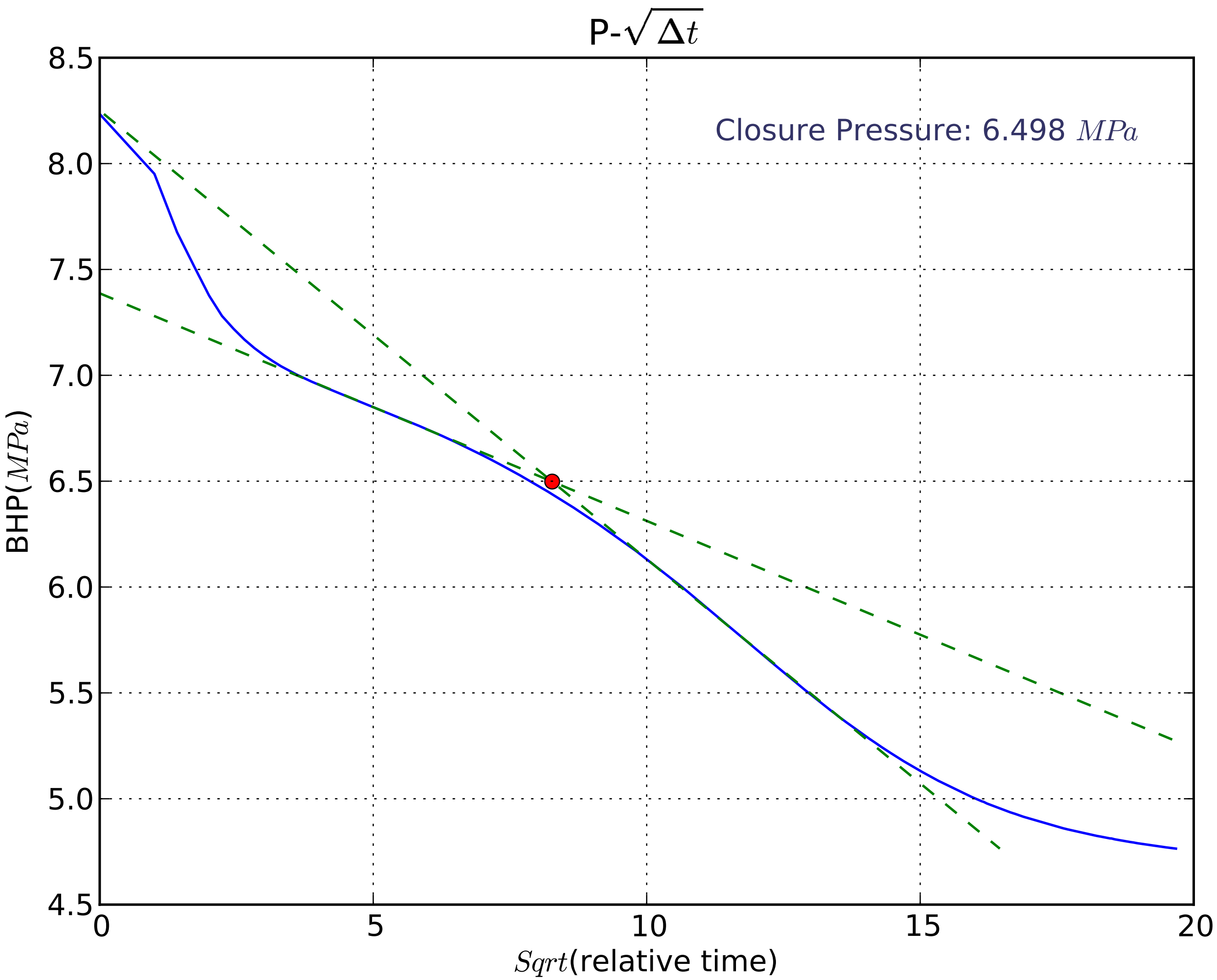


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 03

BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 03



Well: 13-13
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Formation: Unknown Shale
Cycle: 03

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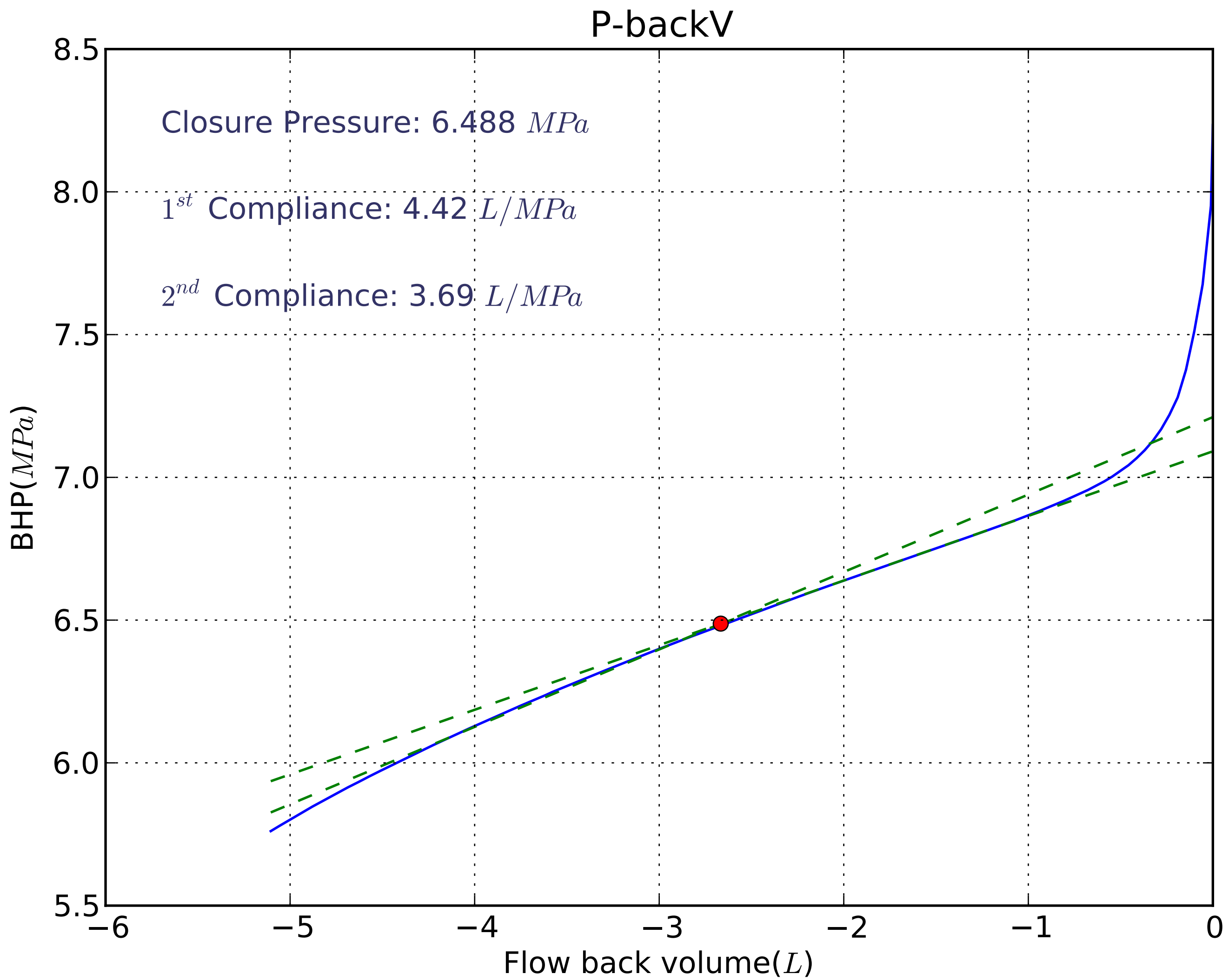

Well: 13-13
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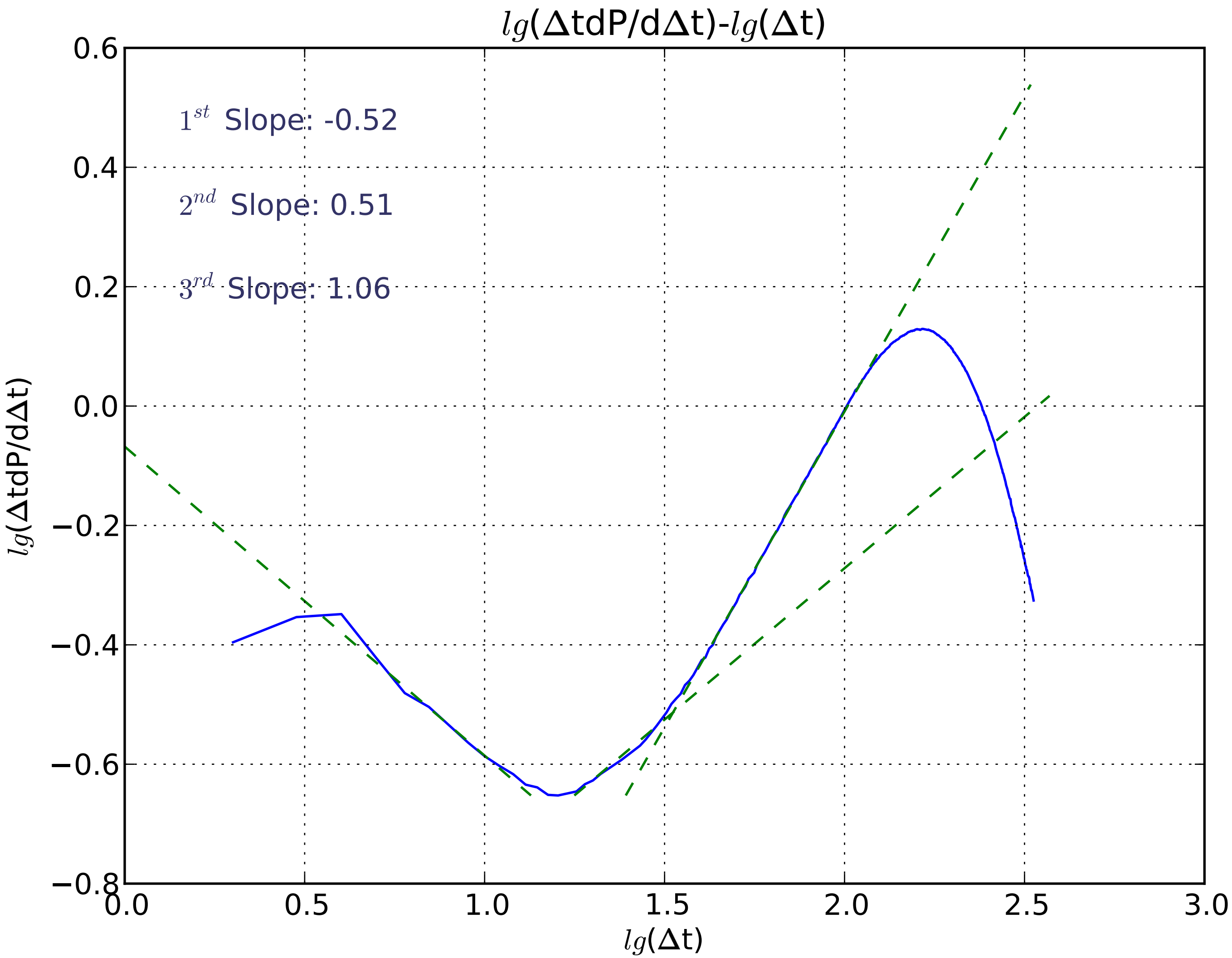
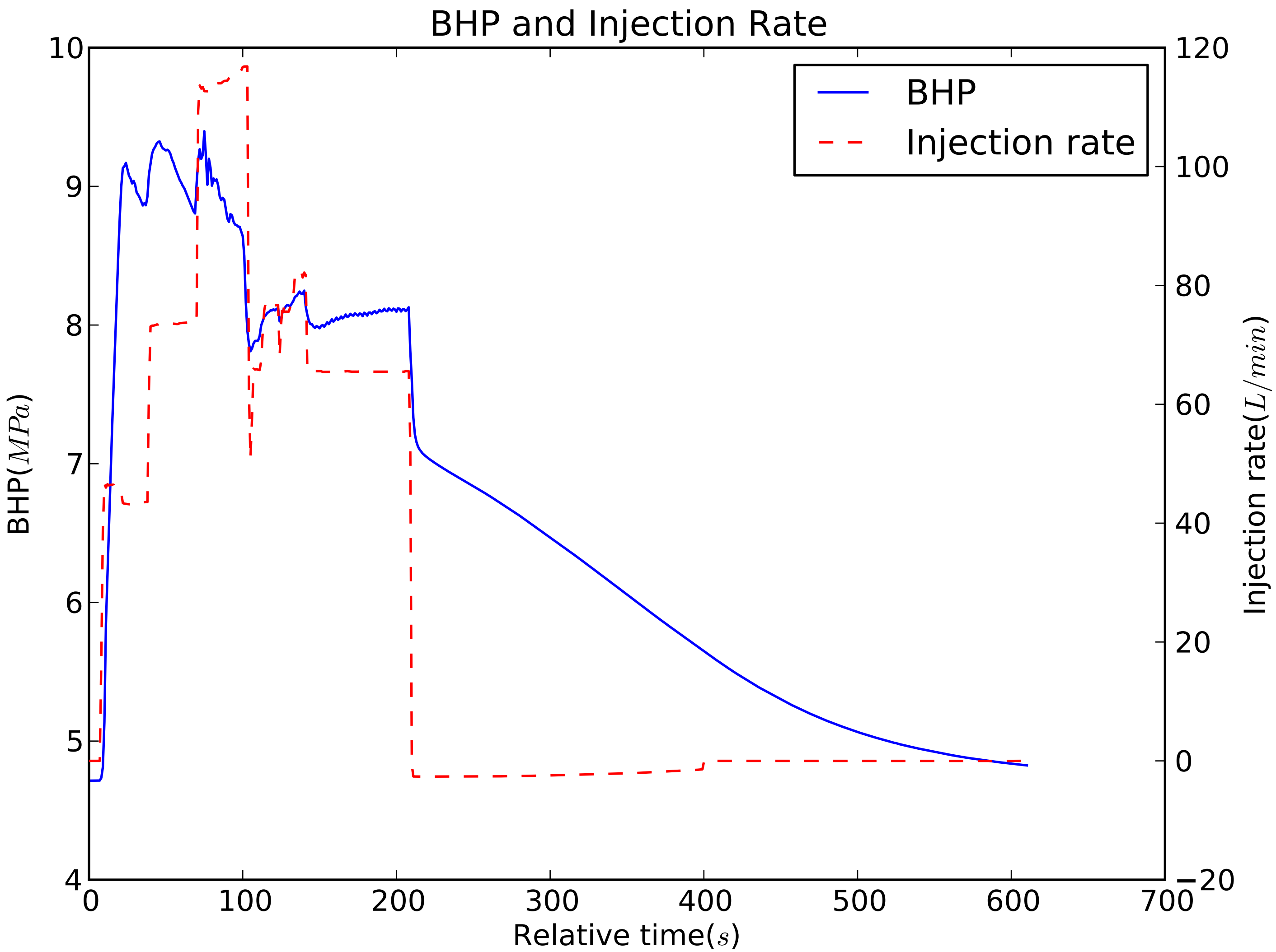
Formation: Unknown Shale
Cycle: 03

BitCan
Geosciences & Engineering Inc.



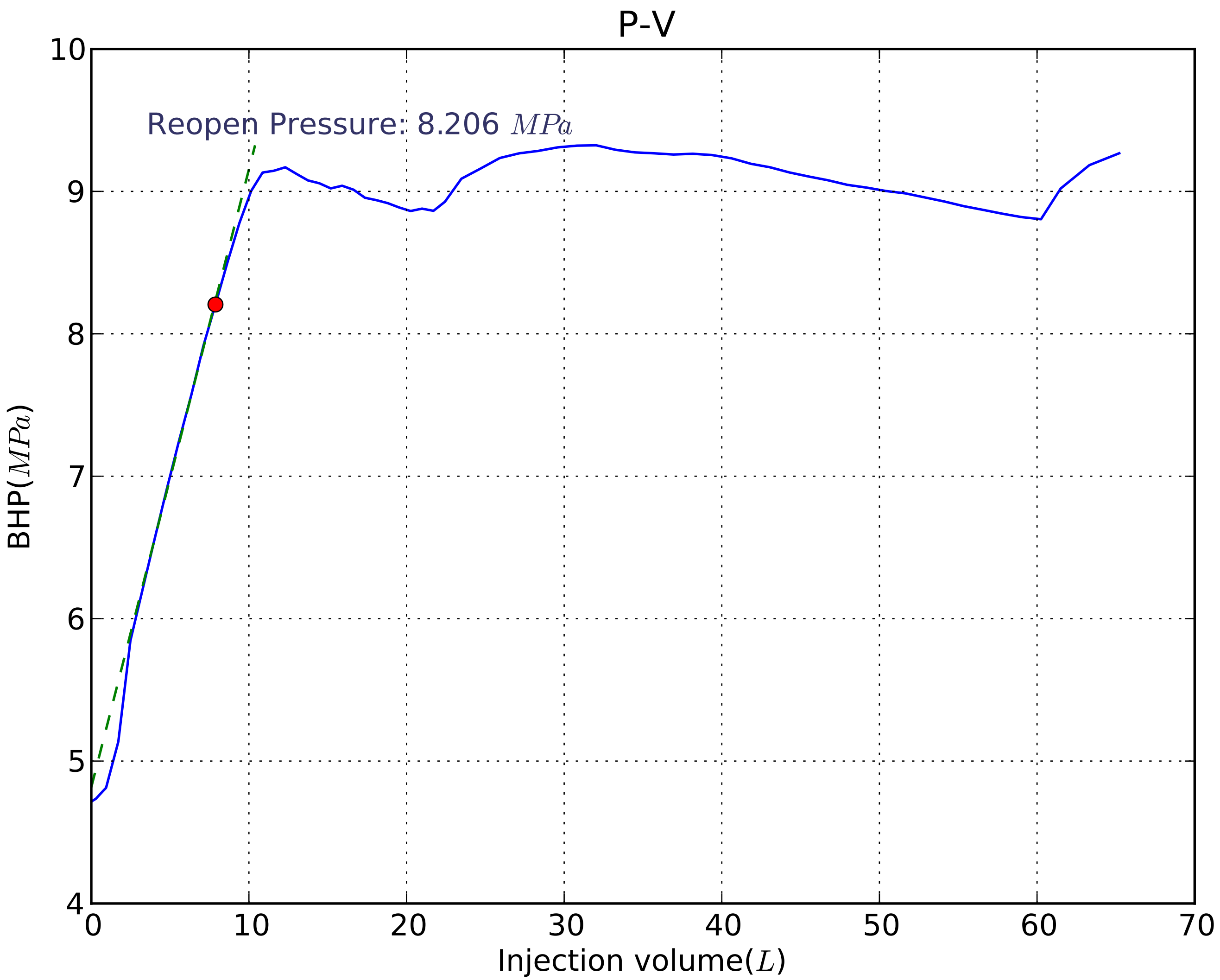
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 04

BitCan Geosciences & Engineering Inc.



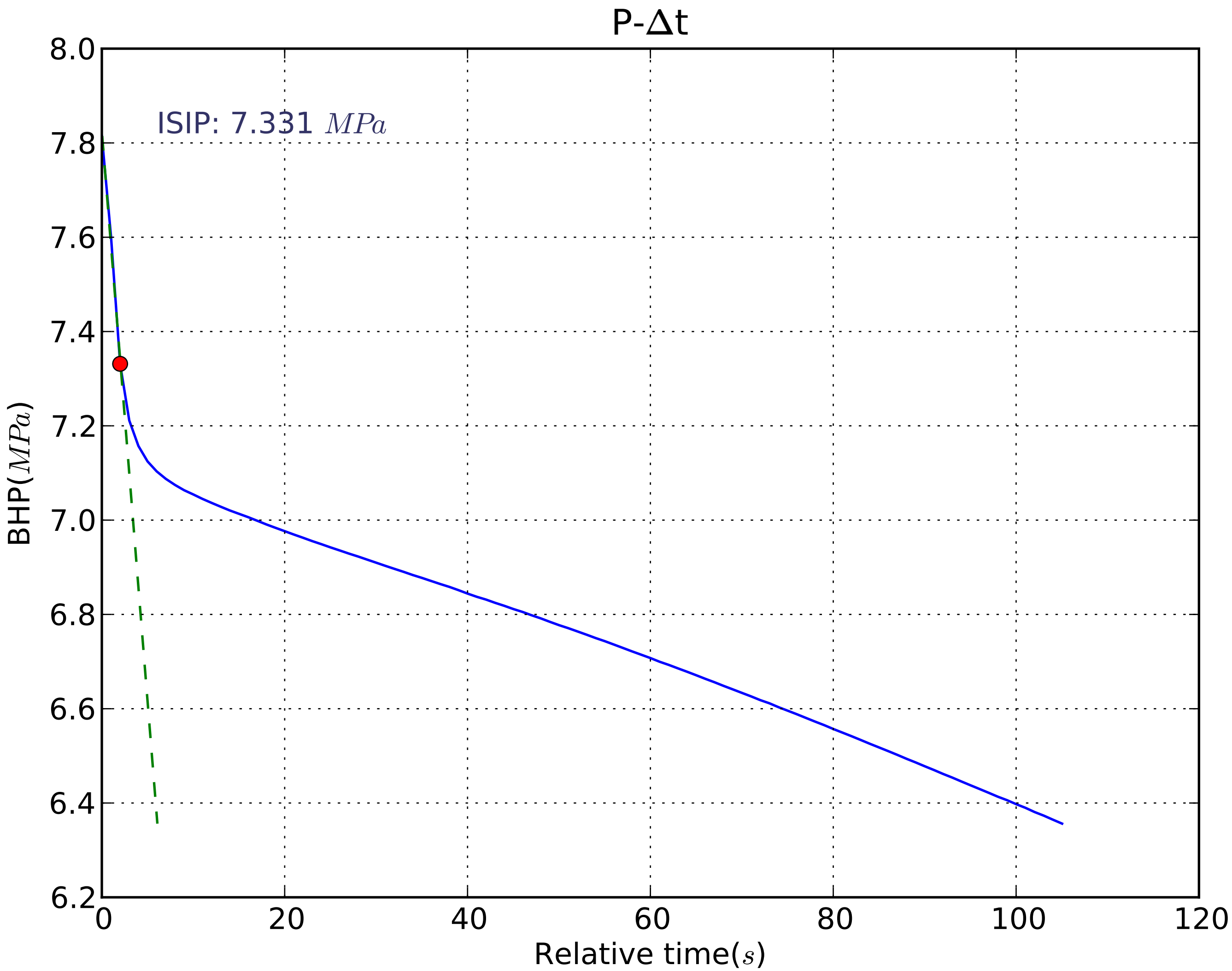
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 04

BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 04

BitCan
Geosciences & Engineering Inc.



Well: 13-13
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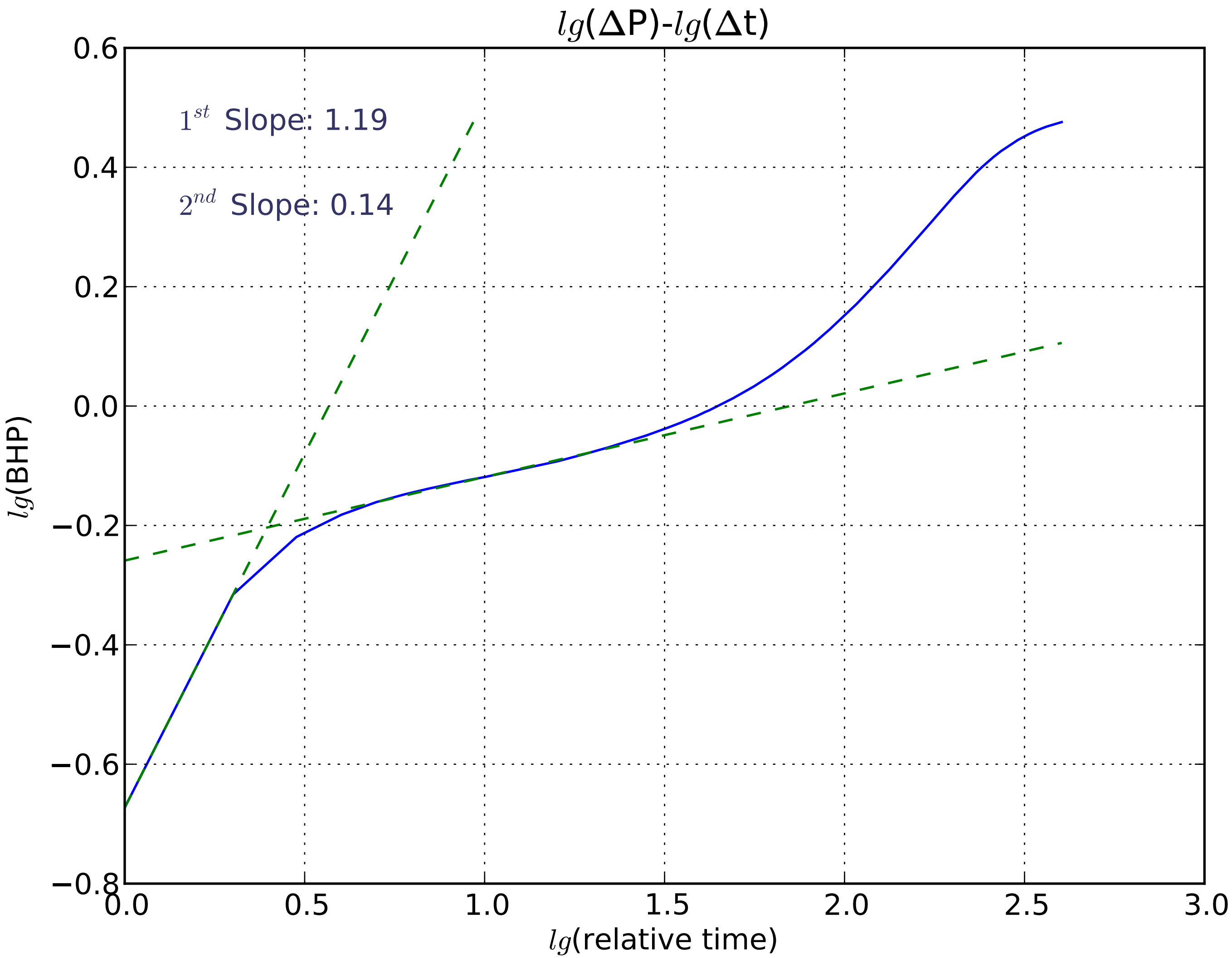
Formation: Unknown Shale
Cycle: 04

BitCan
Geosciences & Engineering Inc.



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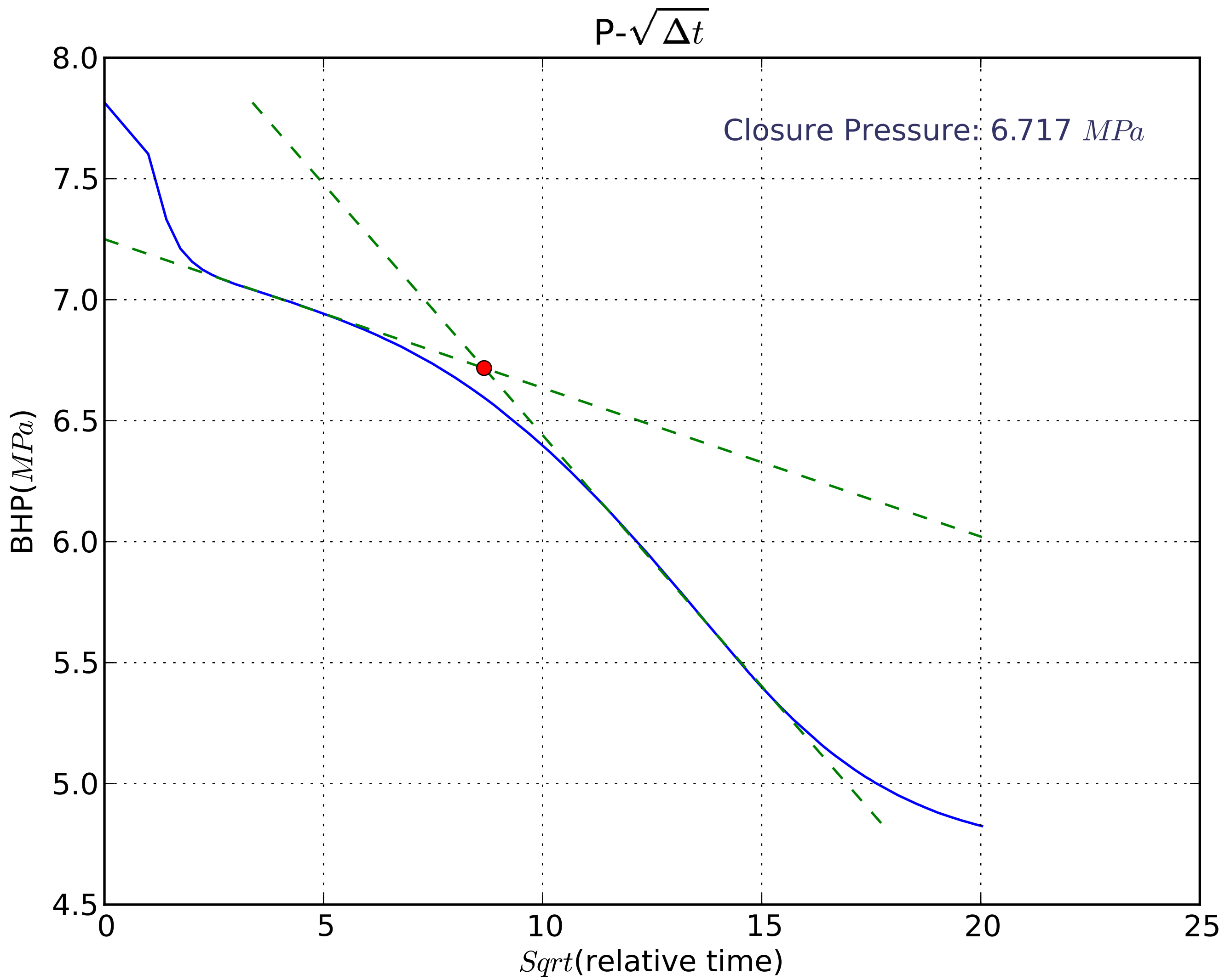
Cycle: 04

Geosciences & Engineering Inc.



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Formation: Unknown Shale
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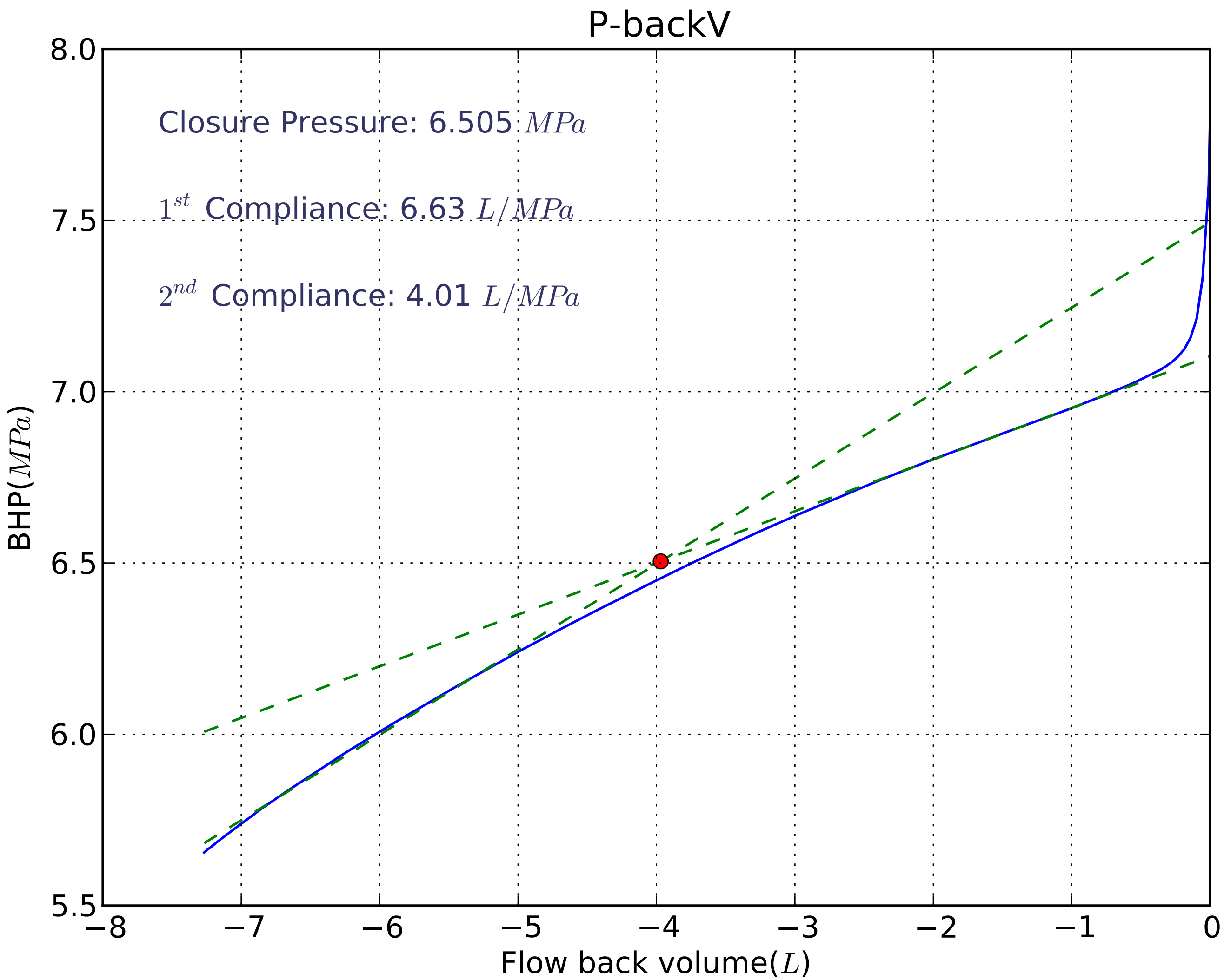
BitCan Geosciences & Engineering Inc.



Well: 13-13
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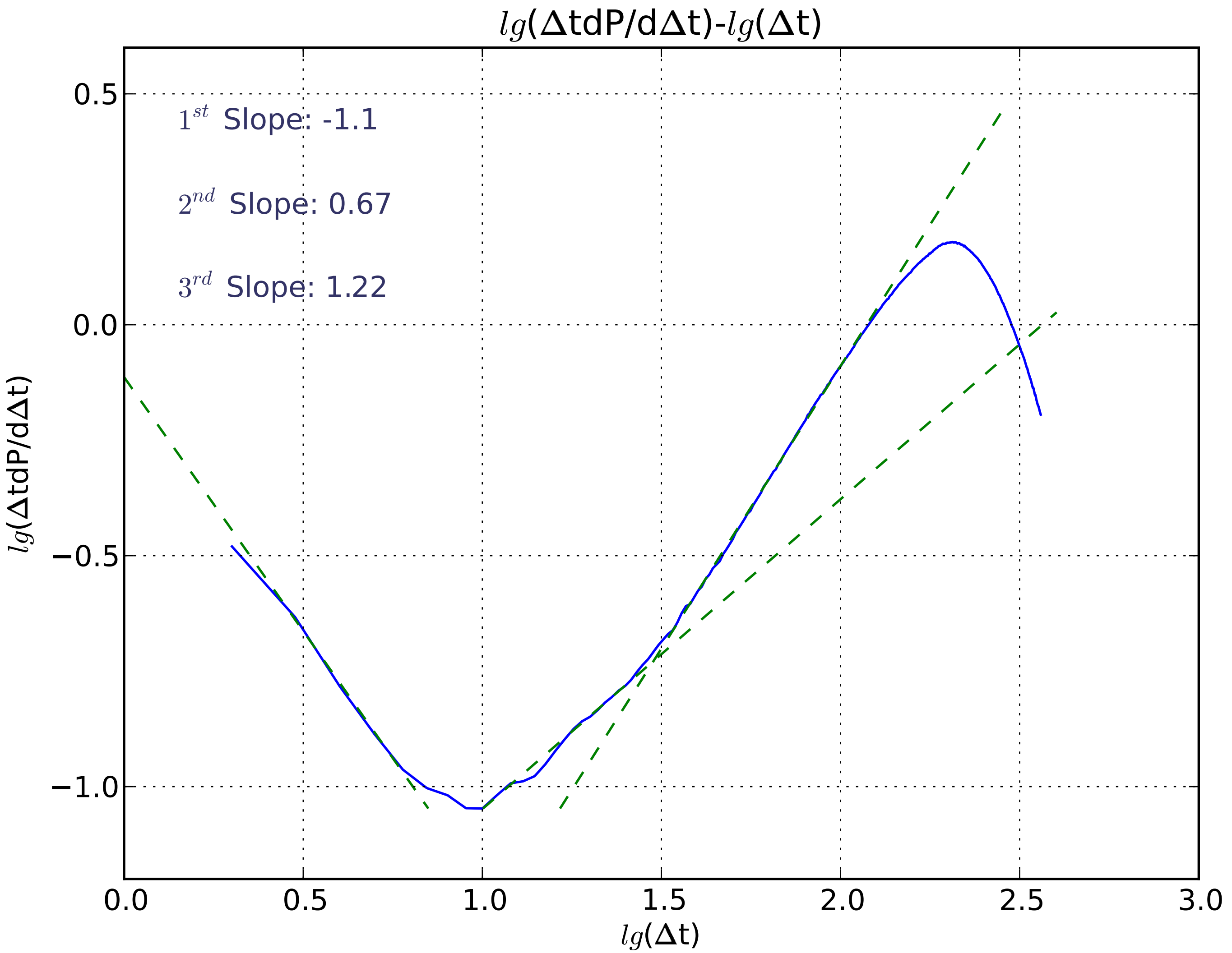
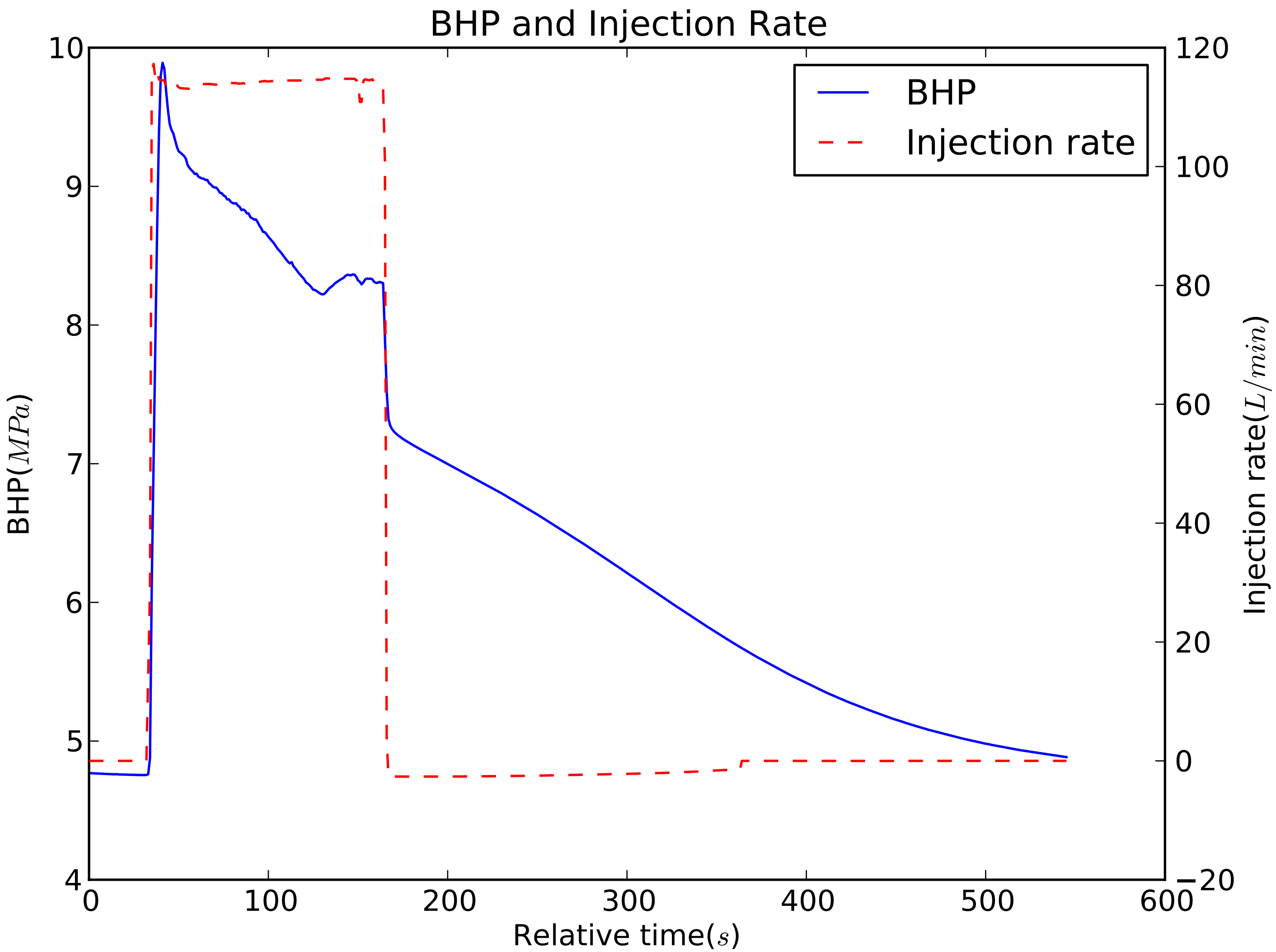
BitCan
Geosciences & Engineering Inc.

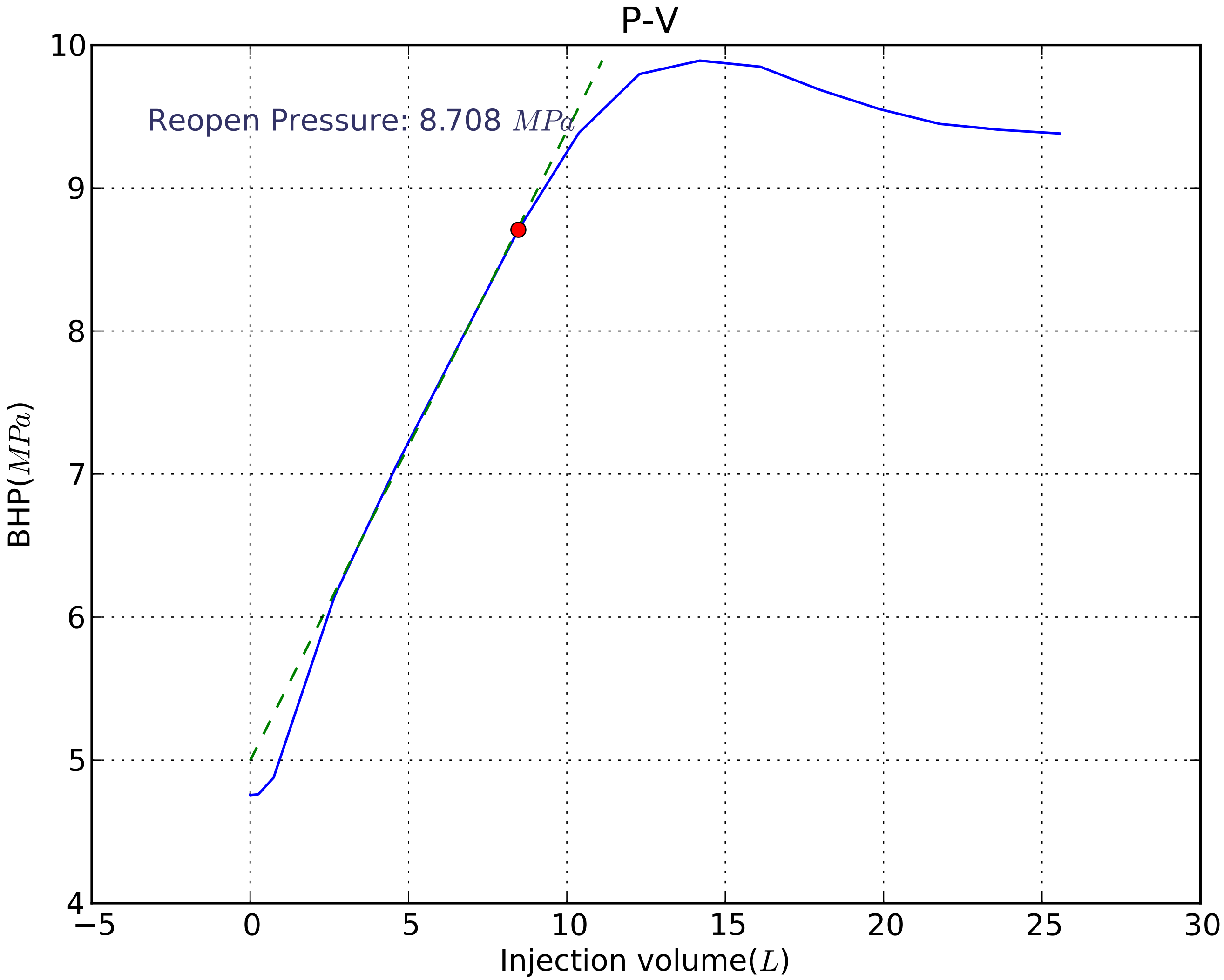


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 05

BitCan
Geosciences & Engineering Inc.

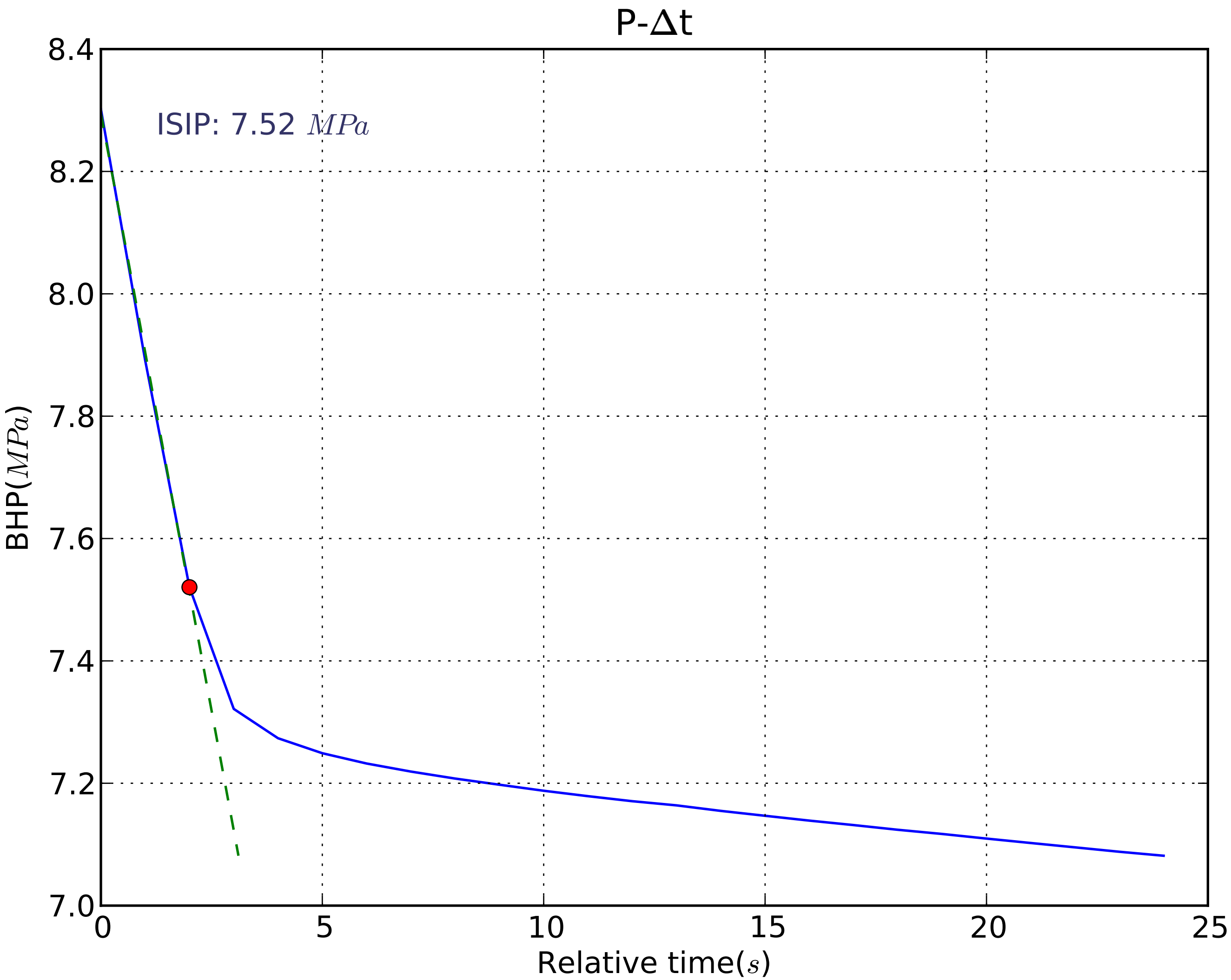


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 05



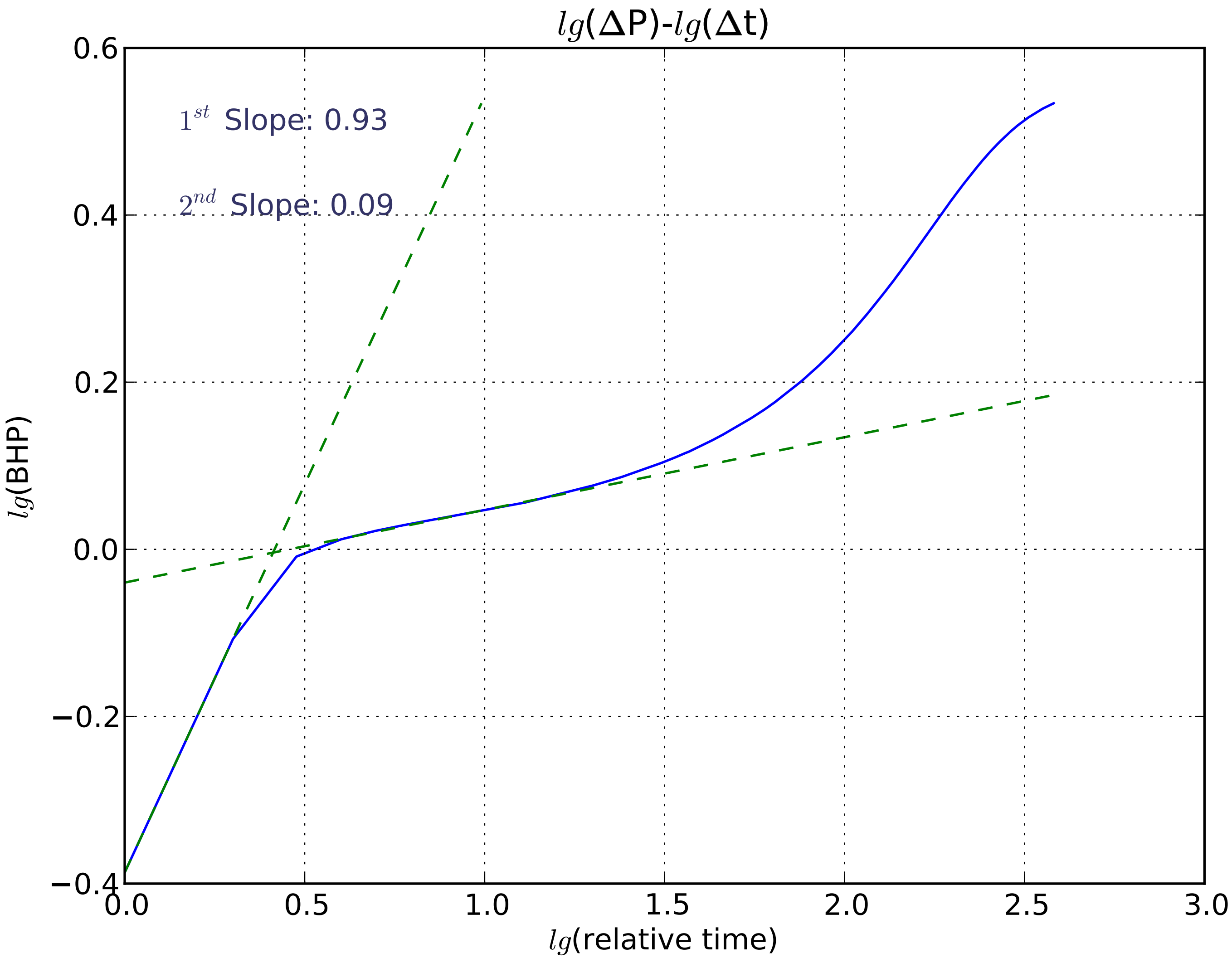
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 05

BitCan
Geosciences & Engineering Inc.



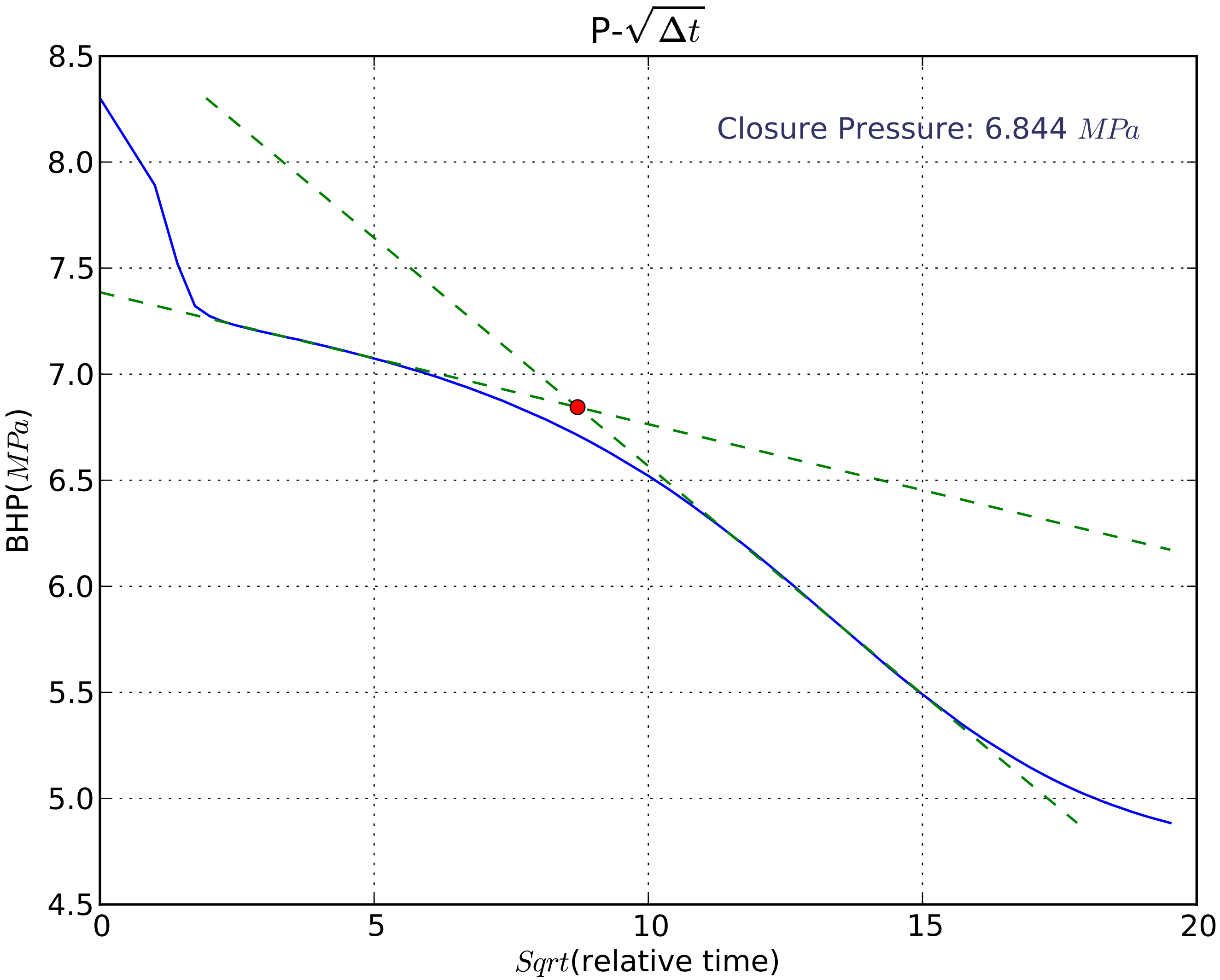
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 05

BitCan Geosciences & Engineering Inc.



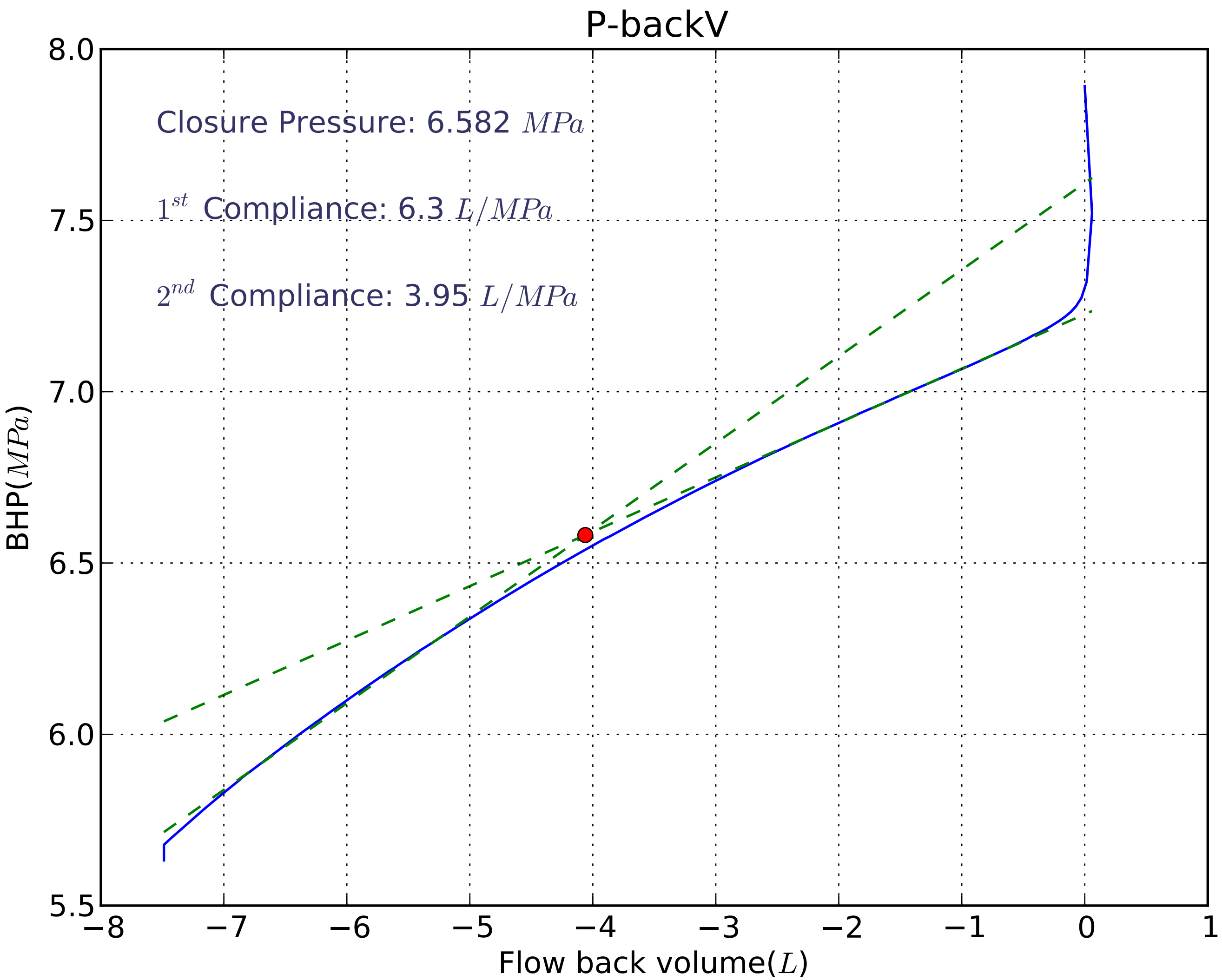
Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 05

BitCan Geosciences & Engineering Inc.



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 05

BitCan
Geosciences & Engineering Inc.



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 05

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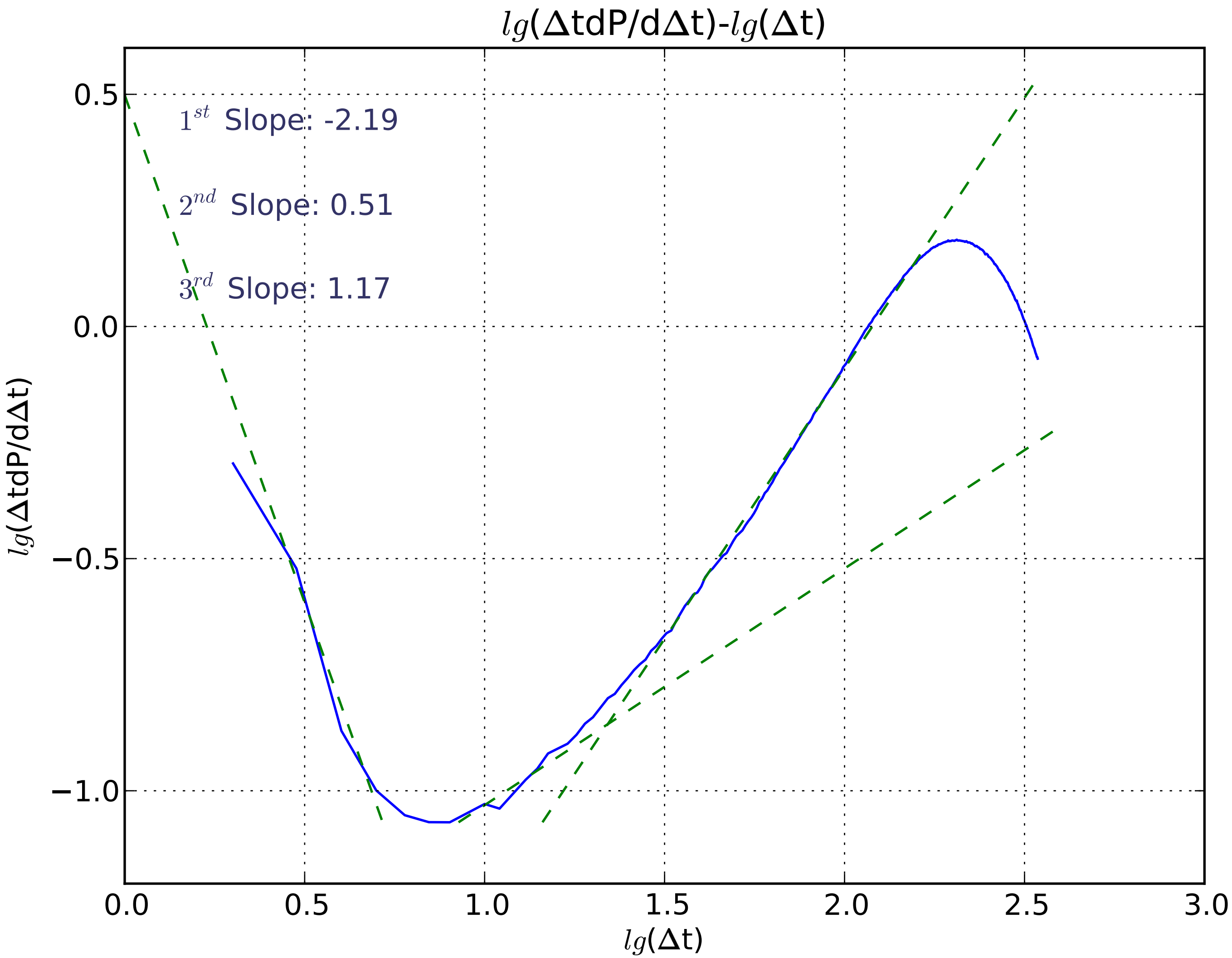

Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 06

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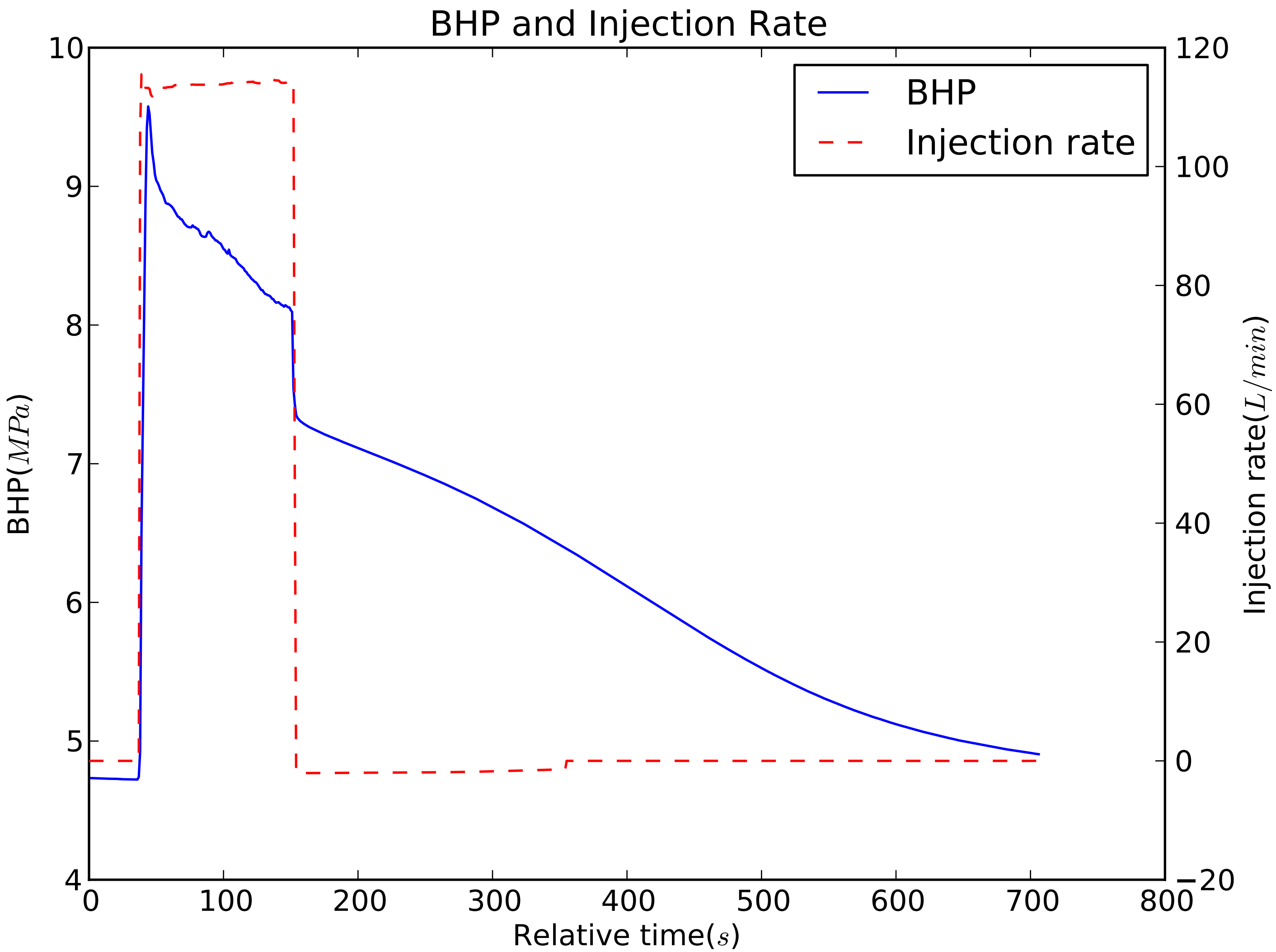

Well: 13-13
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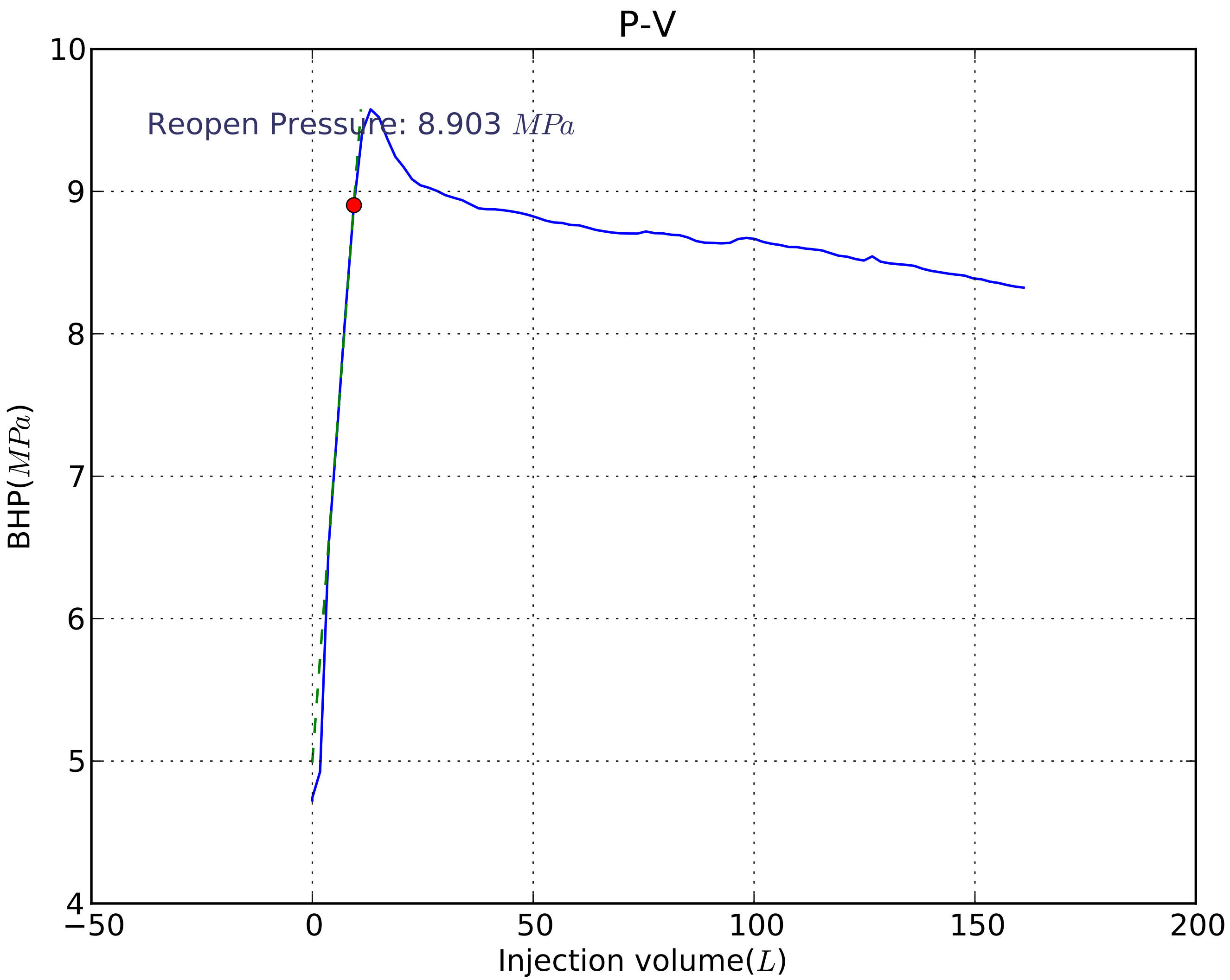
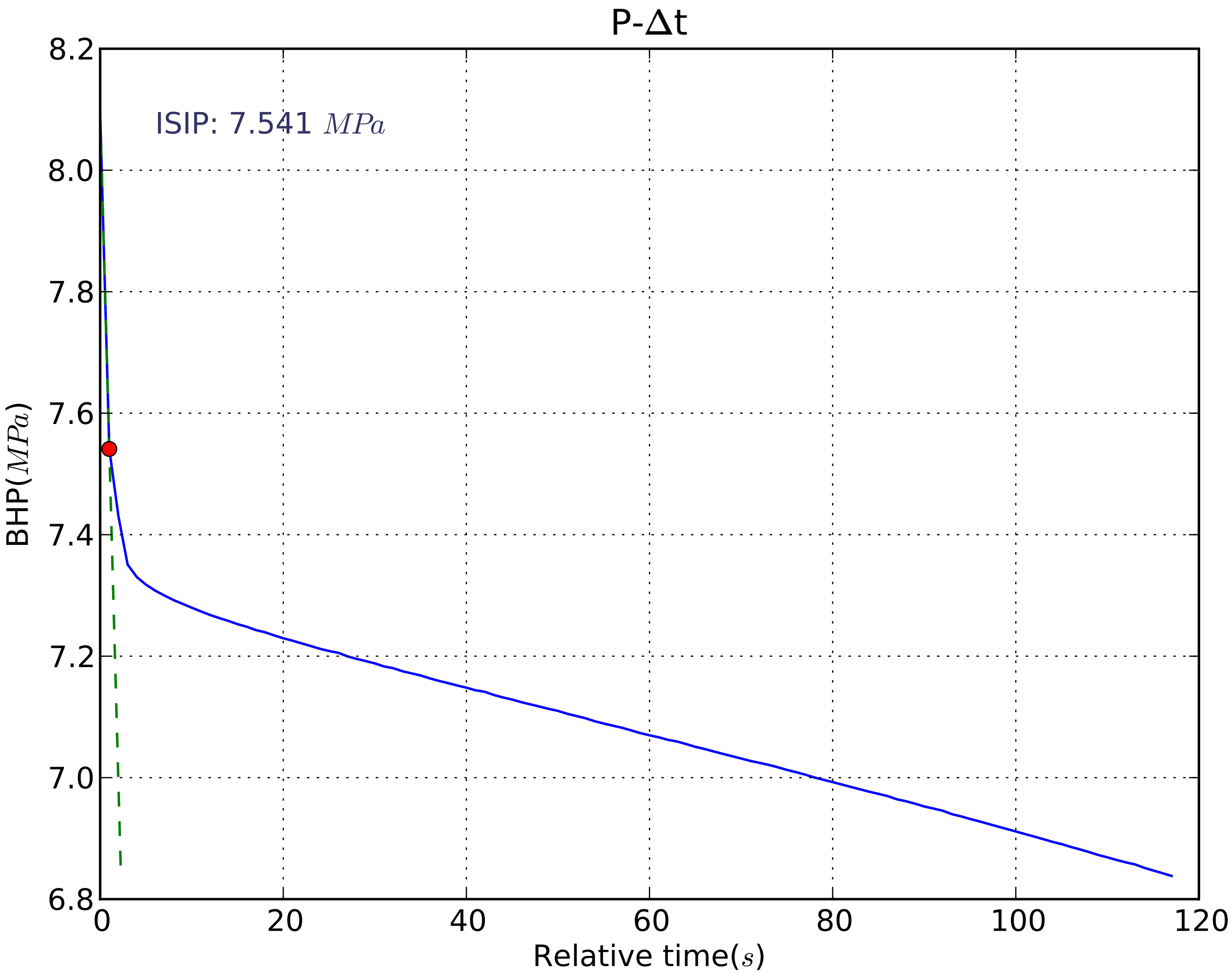
Cycle: 06



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 06



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 06

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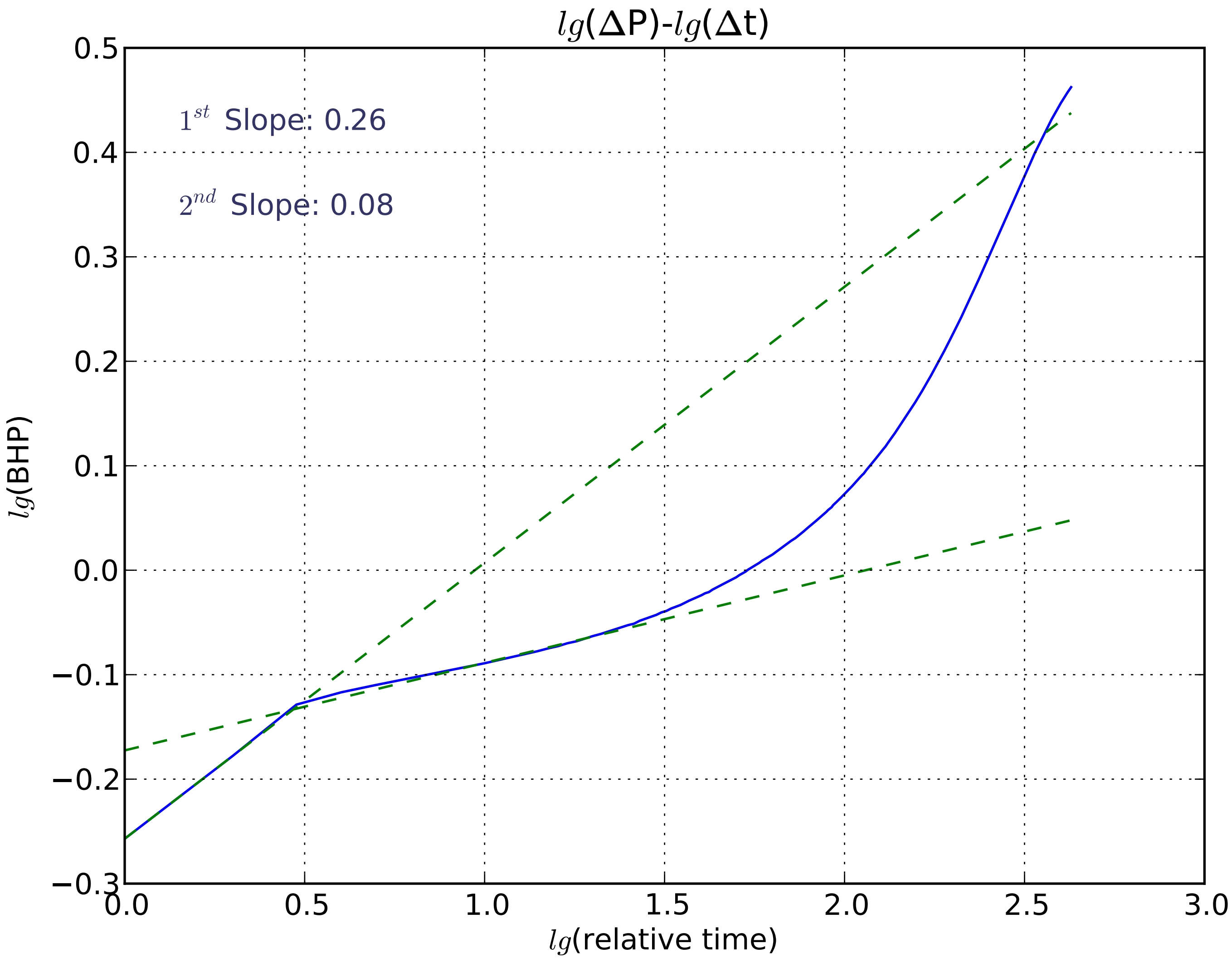

Well: 13-13
Depth: 476.0m
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Cycle: 06

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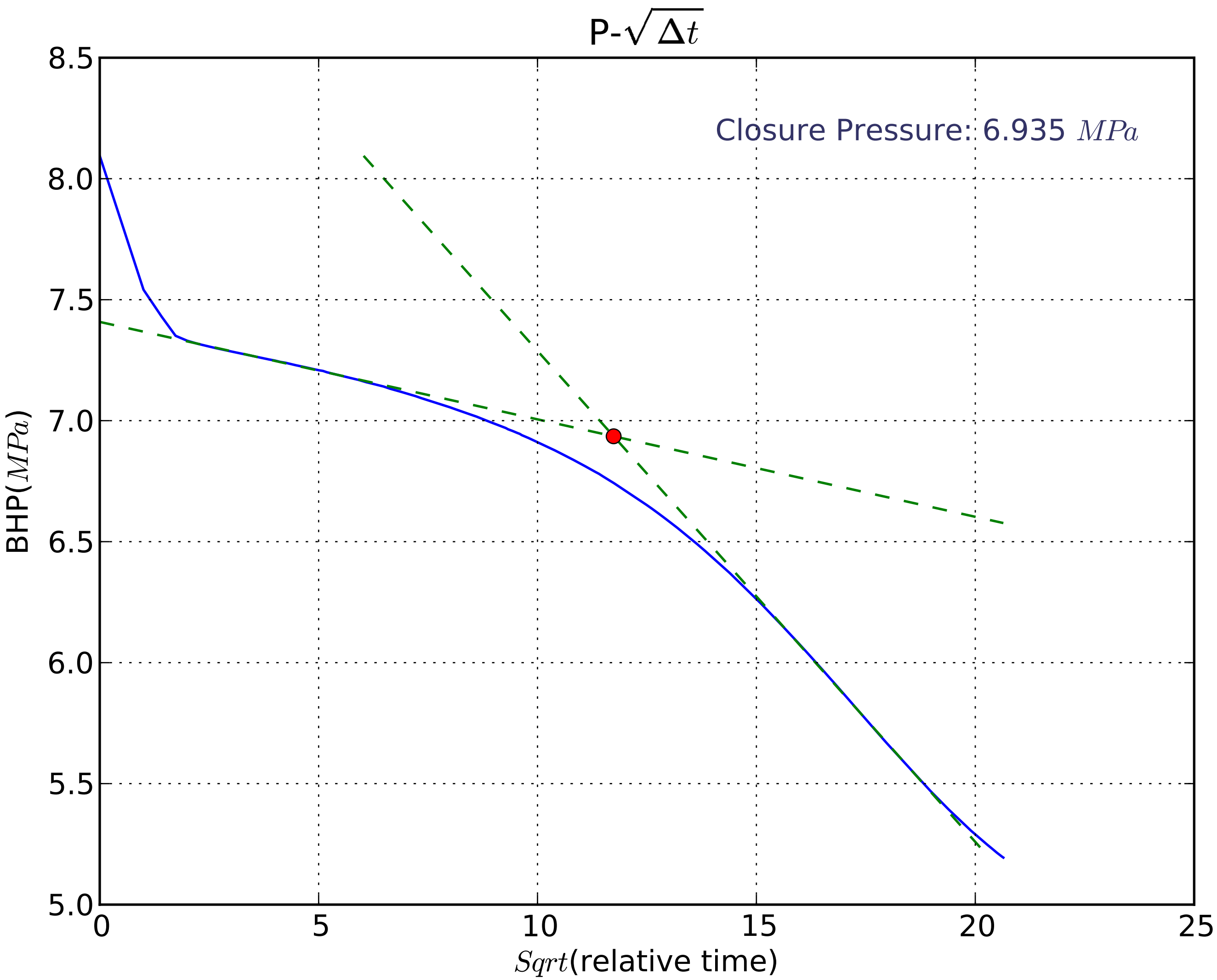
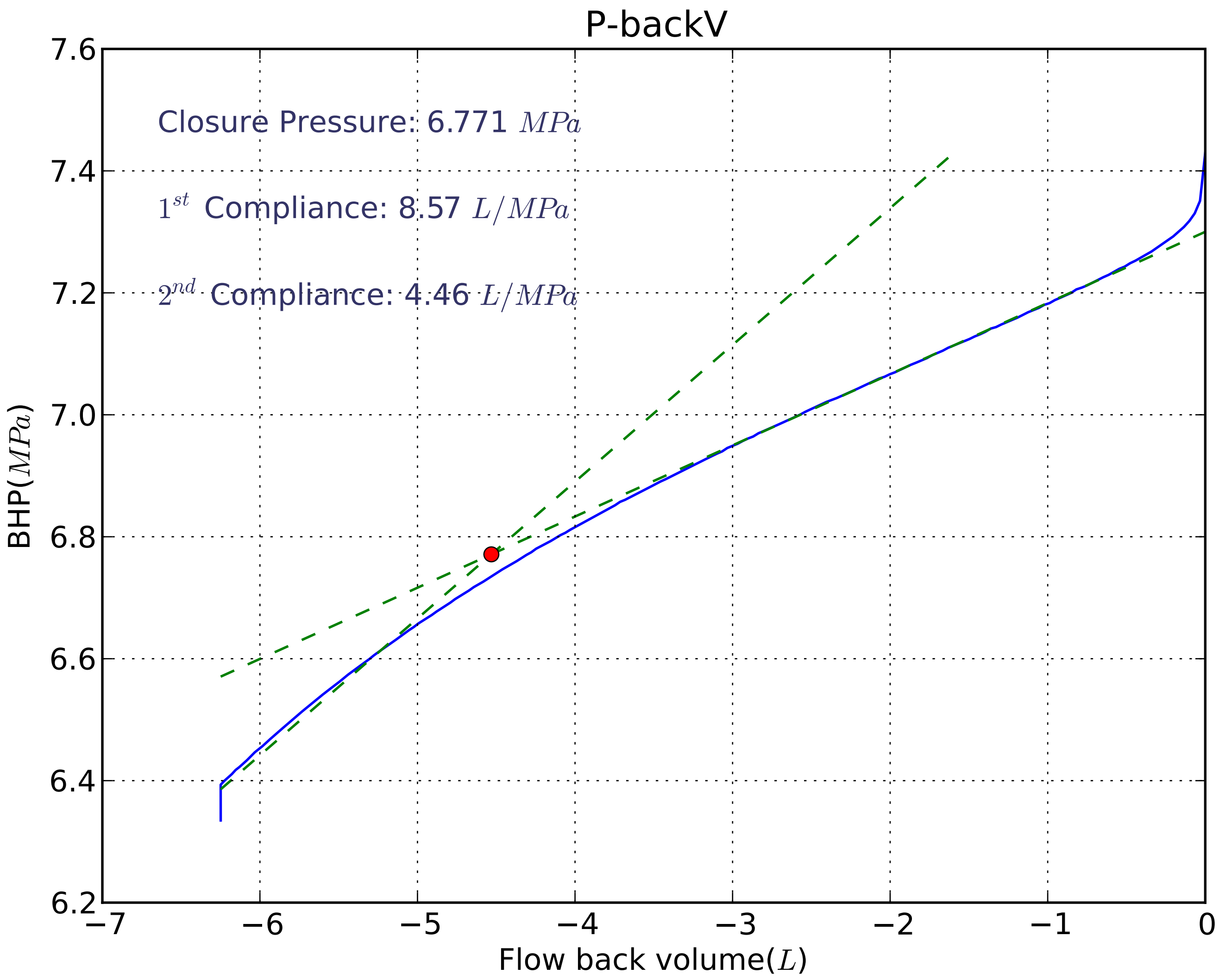


Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 06



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 06

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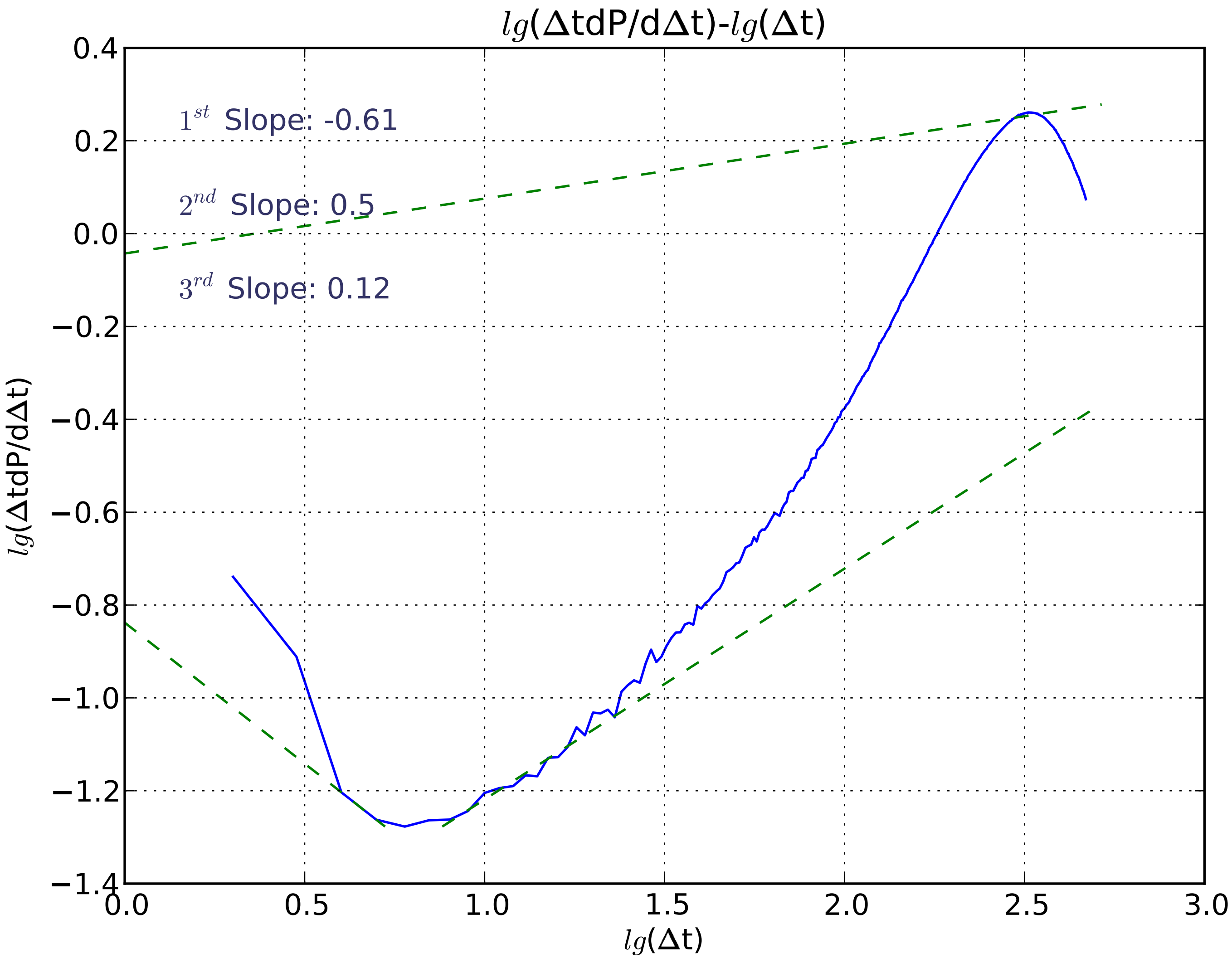
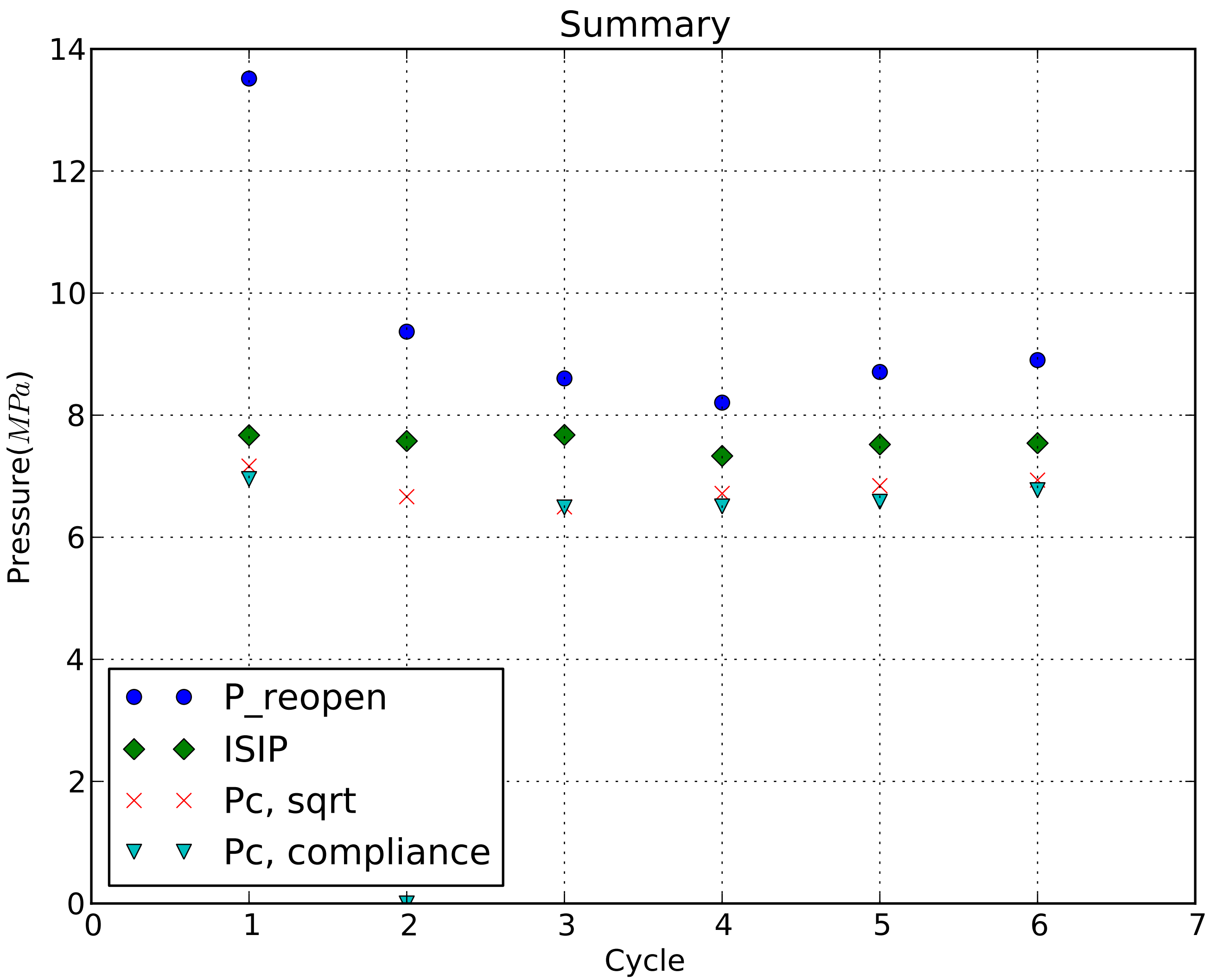
Geosciences & Engineering Inc.



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 1 to 6



Well: 13-13
Depth: 476.0m
Formation: Unknown Shale
Cycle: 1 to 6

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Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	13.515	7.671	7.165	6.953	2.38	0.93	1.66
2	9.369	7.576	6.664	0.000	2.49	0.00	0.00
3	8.602	7.676	6.498	6.488	2.34	4.42	3.69
4	8.206	7.331	6.717	6.505	2.31	6.63	4.01
5	8.708	7.520	6.844	6.582	2.27	6.30	3.95
6	8.903	7.541	6.935	6.771	2.40	8.57	4.46

MINI-FRAC TESTS AT PENGROWTH WELL: LNDBRGH 13-24-58-5W4[1]
--- Summary of the tests and analysis results ---

Bin Xu and Y. Yuan[2]

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APEGGA Permit of Practice #07814

March 23, 2012

On behalf of Pengrowth, BitCan has conducted 3 mini-frac tests on Well: LNDBRGH 13-24-58-5W4:

1) General Petroleum (GP) caprock at 504 m TVD,
2) GP caprock at 514 m,
3) Lloydminster payzone at 530 m.

The test locations are denoted on the well log as shown in Figure 1. Objectives of the tests were to assess the in-situ stress conditions. This report will illustrate how the in-situ minimum stress was estimated as well as include a summary of the results.

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[2] Responsible member under APEGGA rules.

1. General test procedure

The current mini-/micro-hydraulic fracturing tests are regarded as the most reliable method to assess the in-situ minimum stress. Via controlled well injection, it creates a fracture and propagates it to a sufficient distance from the injection well and into the formation. This ensures the fracture senses the far-field stress condition. Multiple cycles are run to verify the data consistency. The pressure data is analyzed to estimate the fracture closure pressure. The fracture closure pressure can then be equated to the in-situ minimum stress acting perpendicular to the fracture. Figures 2 - 4 plot the recorded pressure and rate history during each of the tests.

Our tests employ new advancements and improvements to the mini-/micro-hydraulic fracturing stress test protocol currently used in the petroleum industry. Our testing procedure contains modifications tailored specifically for use in the oil sands and heavy oil development. Before commencing testing, the target interval was perforated. Water was then injected directly down into the casing. Testing began at the lowest depth and a packer was set between two adjacent perforation intervals. Multiple injection and shut-in cycles were used during each test. The injection pressures were monitored on-site via two surface pressure sensors: one close to the pumps and the other at the wellhead.

A flow-back procedure was also used during each test. For the flow-back, a certain volume of water is manually withdrawn from the injection system (wellbore plus the fracture) during the shut-in period. The fracture closure is thus managed by the manually reduced pressure drop. A plot of BHP vs. cumulative injected volume (called compliance plot), can be used to detect the fracture closure. It is generally agreed that a properly executed and accurately metered flow-back yields better constrained data on the minimum stress. BitCan’s mini-frac test system can accurately control and meter the flown-back volume and rate. Figure 5 illustrates an example compliance plot and its interpreted fracture closure pressure.

2. Depth profile of the in-situ minimum stress

The interpreted in-situ minimum stresses (Smin) at the tested depths of Well 13-24 are shown in Figure 1. Their specific values are summarized in the following table:

Pengrowth LNDBRGH 13-24-58-5W4						
	TVD, m	Min. stress		Vert. stress		Stress regime
		MPag	kPag/m	MPa	kPa/m	
Lloydminster	530.0	6.164 to 7.228	11.63 to 13.64	11.342	21.40	V. frac
GP #1	514.0	8.144	15.84	11.011	21.42	V. frac
GP #2	504.0	7.057	14.00	10.796	21.42	V. frac

The range of Smin values for the Lloydminster test represents the lower and upper bounds. All the tests showed a vertical fracture stress regime ("V. frac") where the measured Smin is smaller than the vertical overburden stress and a vertical fracture is expected at these depths. However, the stress barrier effect still exists in which, the caprock has a larger Smin than the underlying reservoir. This is favorable to the caprock integrity. A vertical fracture, if it is formed in the reservoir, requires a higher pressure to propagate upwards into the caprock. The hydraulic fracturing stimulation in the hard rock formations relies on such a stress contrast to contain the created fracture from propagating out of the target zone.

3. Analysis of field data

It is BitCan's practices to place great deal of emphasis on acquiring high quality data during testing. As shown in Figures 2 to 4, multiple injection/shut-in cycles were used in each test. In all the tests, obvious formation breakdown occurred in the first injection cycle, i.e., a fracture was formed. In the subsequent injection cycles during each test, the pressure declined or stayed relatively flat, signalling the continuous fracture propagation.

For each injection/shut-in cycle, the fracture closure pressure was interpreted by a linear flow (or sqrt(t)) plot. A system compliance plot was also used for the interpretations if the flow-back procedure was used. A good compliance plot, such as the one shown in Figure 5, should have two different slopes. Intersection of these two slopes denotes the fracture closure pressure. The initial slope, corresponding to before the fracture closes, is steeper while the second slope, reflecting the post-closure system compliance, is less inclined.

The fracture closure pressures, interpreted as described above, are reconciled in Figures 6 to 8 between the different cycles in each test. In general, a consistent closure pressure is seen in each test among the different cycles. Moreover, different interpretation methods, sqrt(t) or compliance plots, all give a similar closure pressure. Combining these methods serves to enhance the interpretation accuracy.

The pressure declined very fast during the shut-in period in the Lloydminster reservoir test at 530 mTVD (Figure 4). The lower bound fracture closure pressure is interpreted from the sqrt(t) plot while the Instantaneous Shut-in Pressure (ISIP) or fracture re-opening pressure (P_reopen) yields the upper bound (Figure 8).

The GP caprock test at 504 m shows multiple linear slope intervals. The Smin value given in this report at this depth was taken as the average of the lower interpreted fracture closure pressures as shown in Figure 6. This is reasonable for the following two reasons: One is based on the conventional conservative engineering design principal. A Maximum Operating Pressure (MOP) based on a lower Smin value is inherently smaller or safer than MOP based on a higher Smin. Moreover, those shut-in cycles showing a lower closure pressure tend to have a better-defined fracture closure moment.

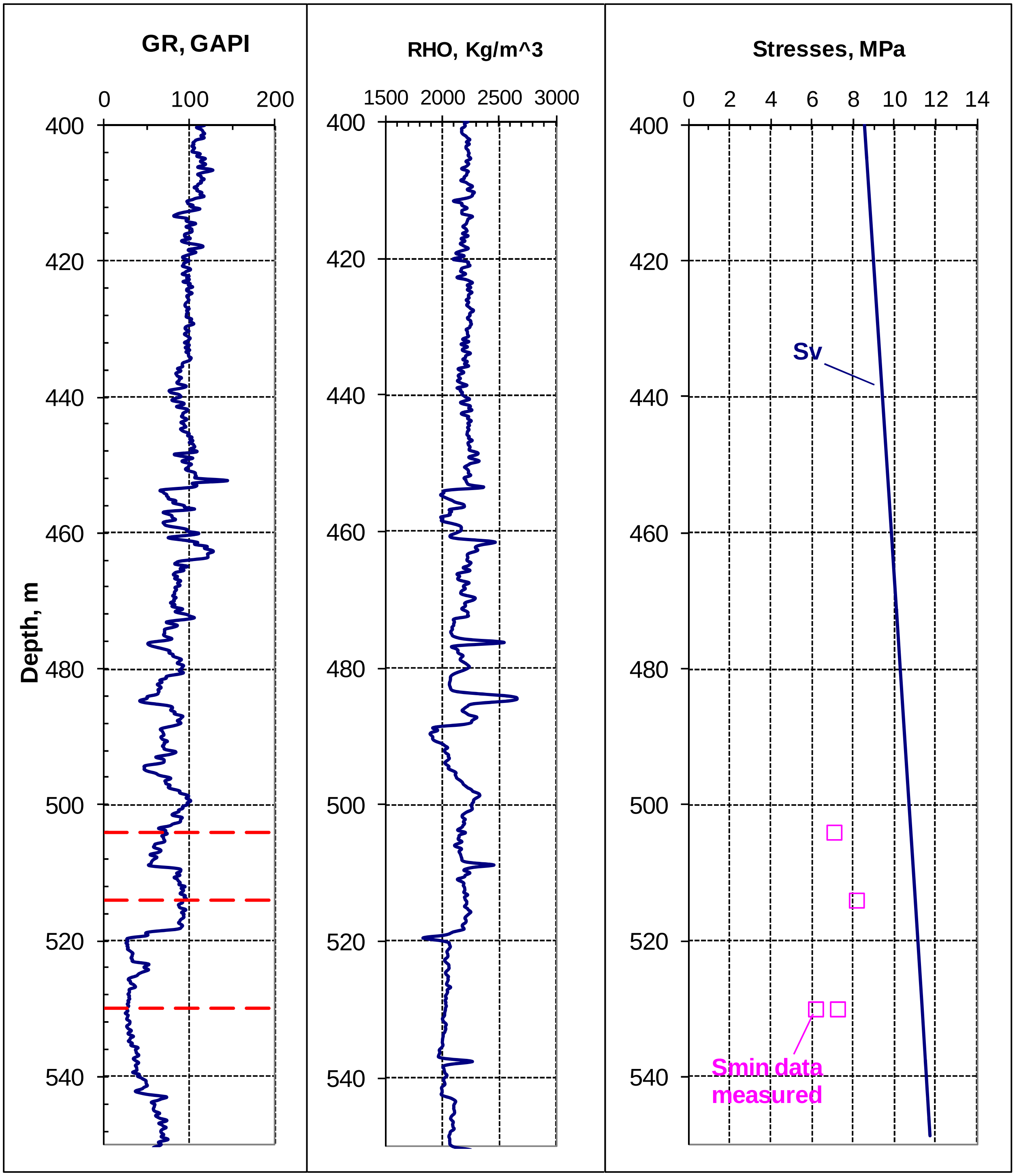


Figure 1: Summary of the in-situ minimum stresses measured from Well 13-24. Red dotted lines on the gamma log denote the mini-frac test intervals. "Sv" denotes the vertical overburden stress calculated from the density log. "Smin" in squares is the interpreted minimum stress from the mini-frac tests.

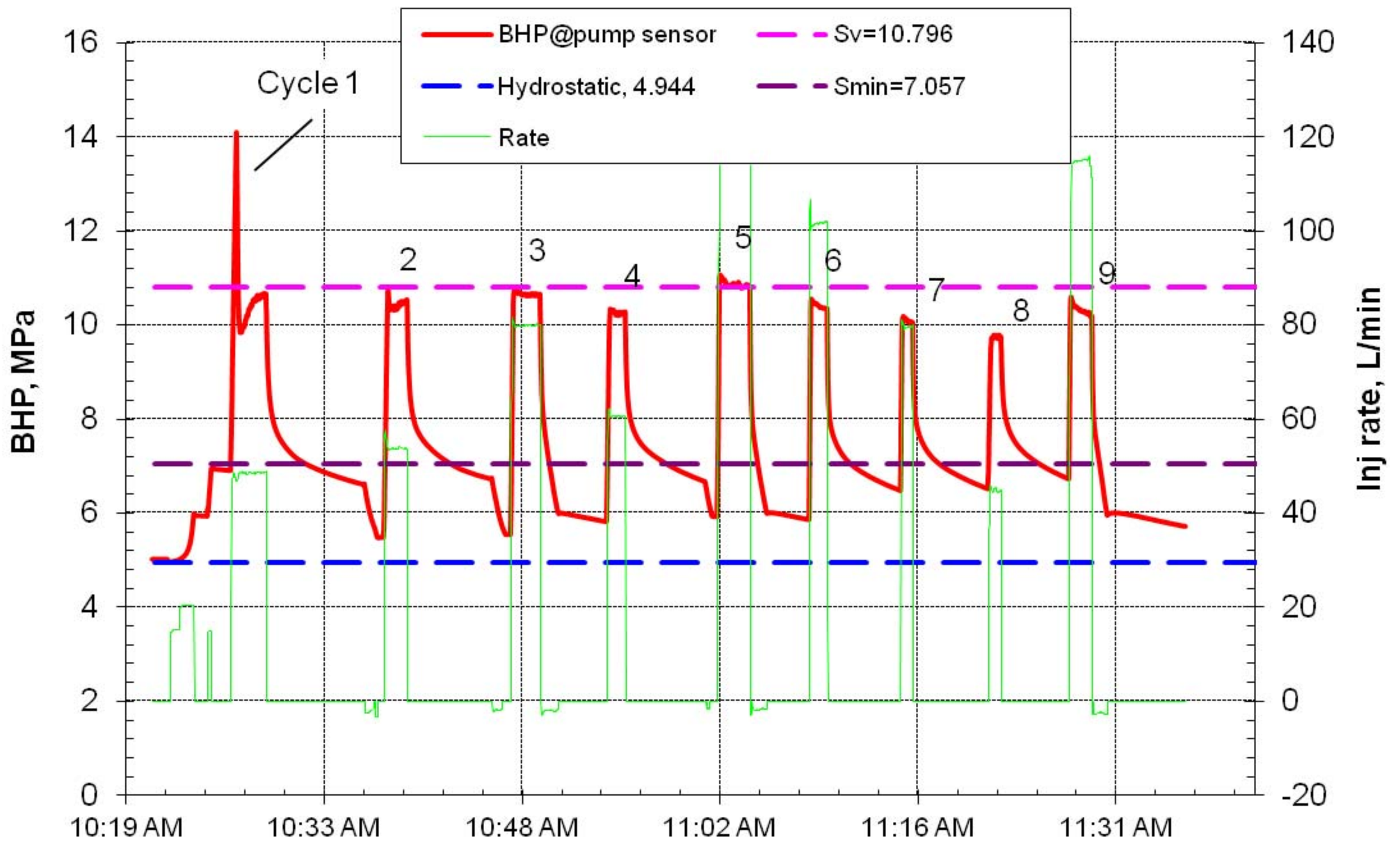


Figure 2: Recorded pressure history during the injection test in Pengrowth Well 13-24 at 504 m TVD. The bottomhole pressures ("BHP") were calculated from a surface pressure sensor at the pump plus the hydraulic head ("Hydrostatic") from the water column weight. The overburden weight ("Sv") was calculated from the density log. "SHmin" was the in-situ minimum horizontal stress or fracture closure pressure interpreted from the pressure data. Similar conventions are used below unless otherwise specified.

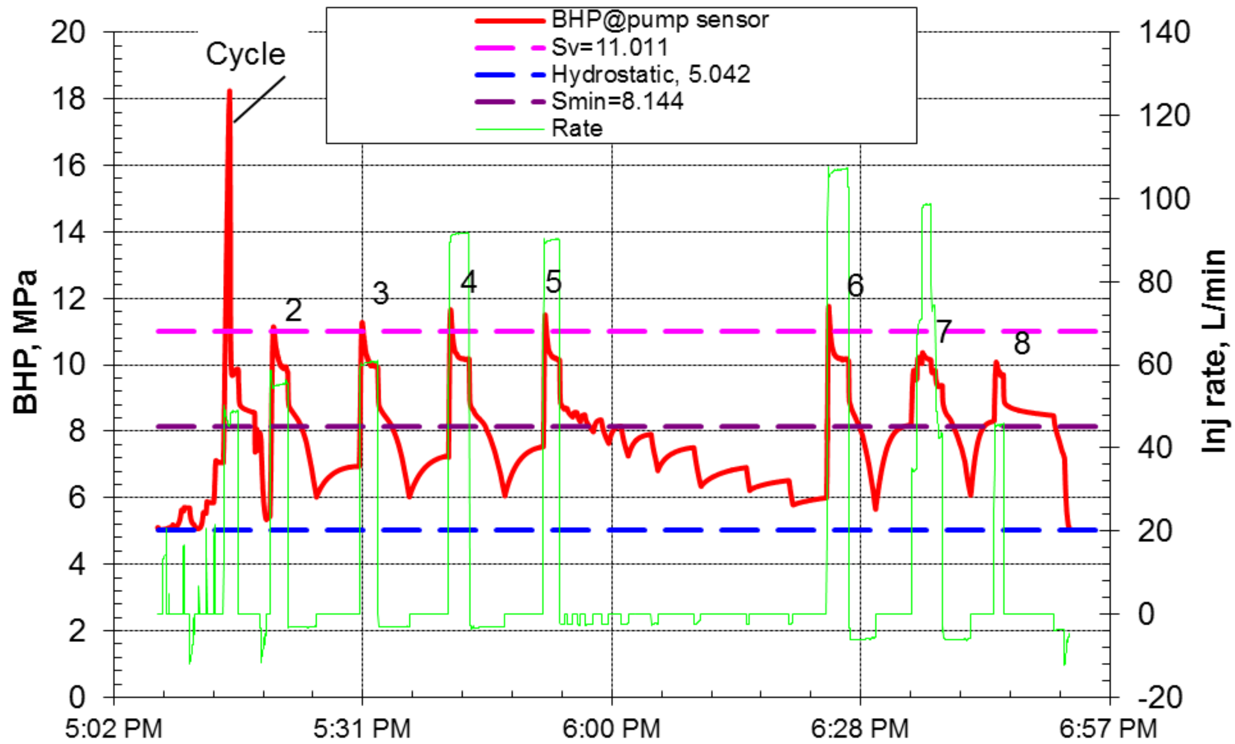


Figure 3: Pressure history during the injection test in Pengrowth Well 13-24 at 514 m TVD.

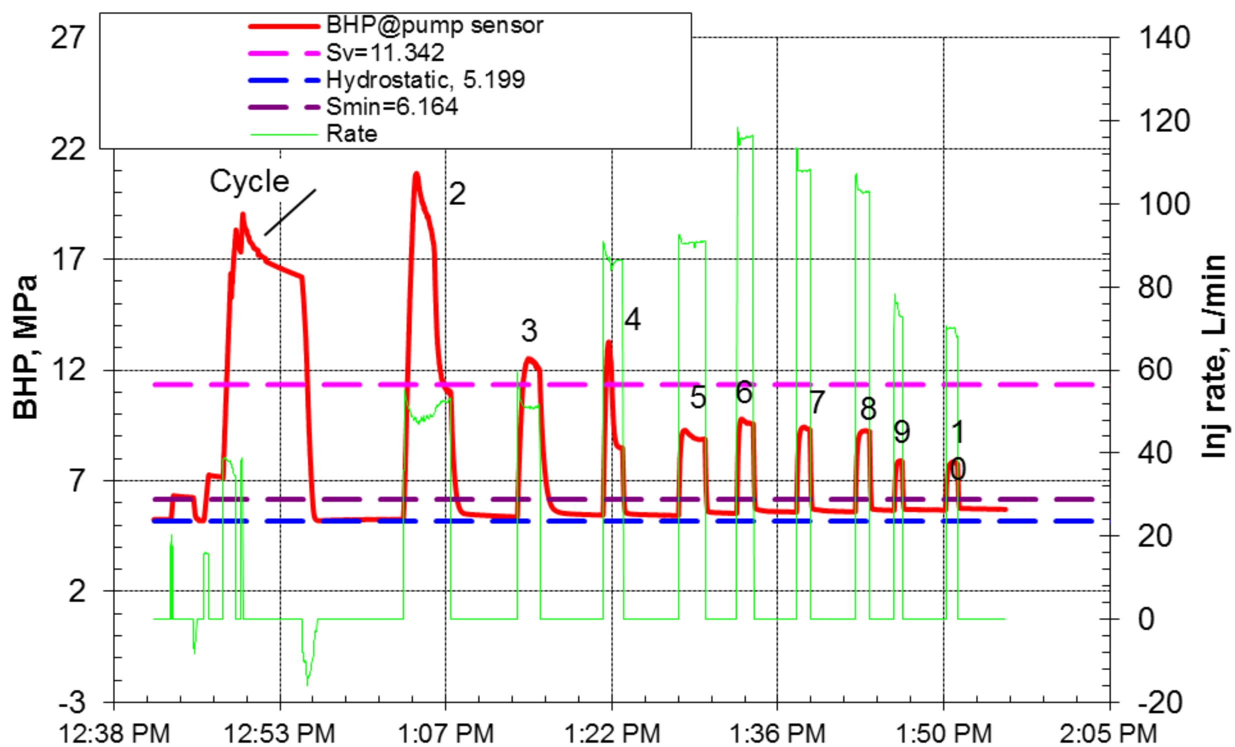


Figure 4: Pressure history during the injection test in Pengrowth Well 13-24 at 530 m TVD.

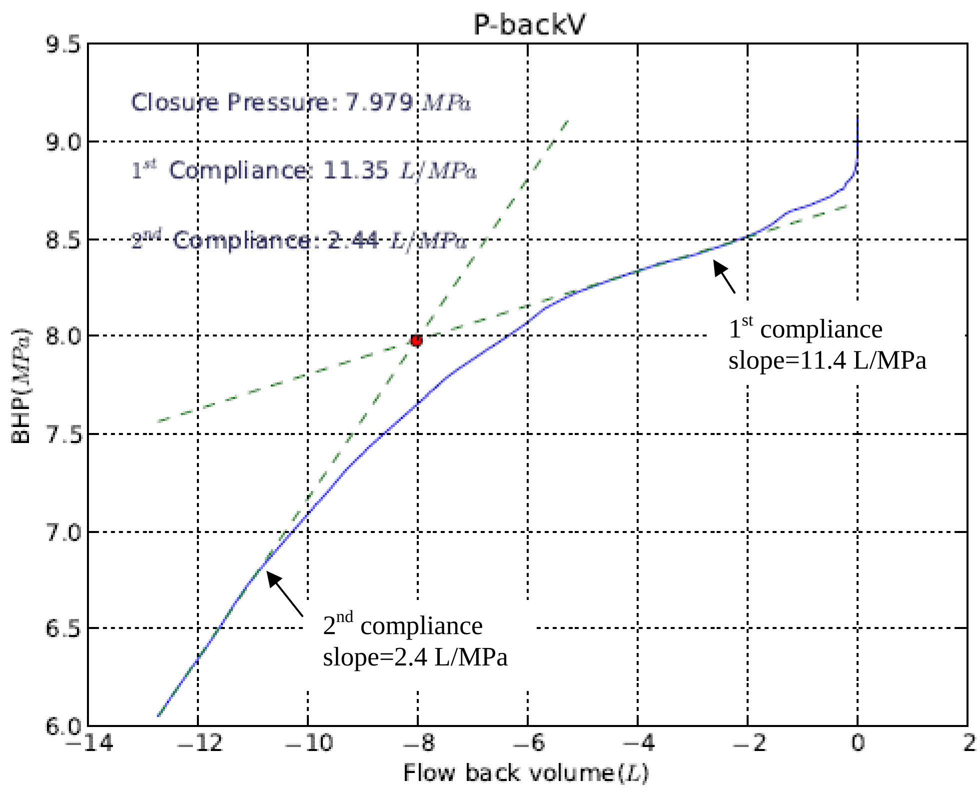
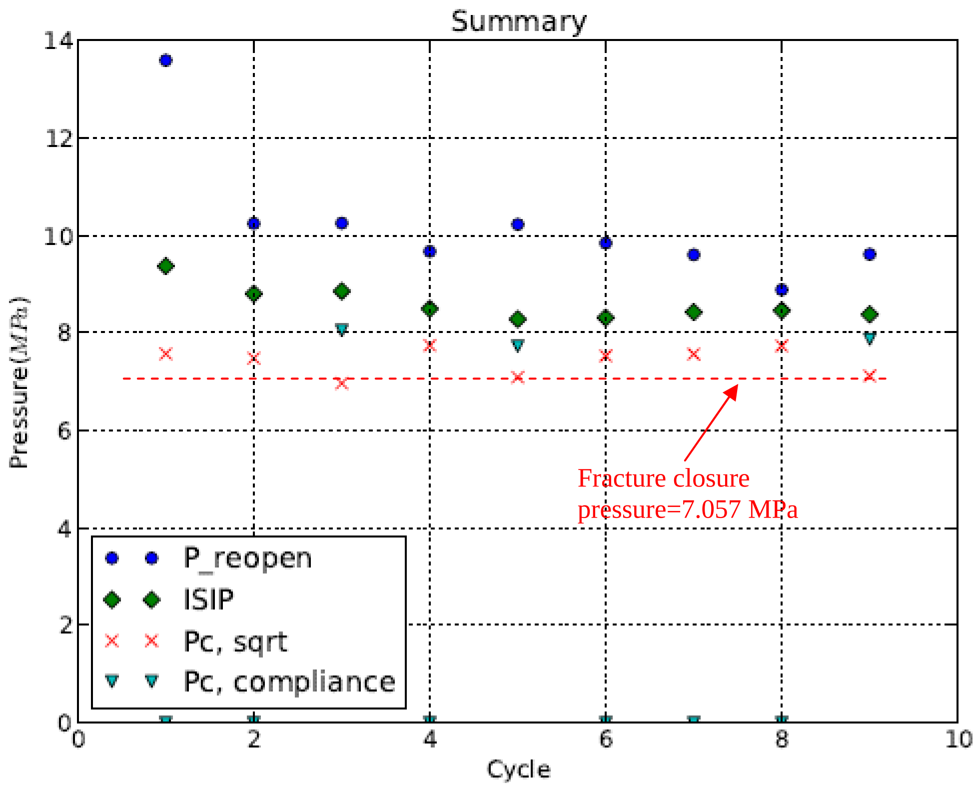


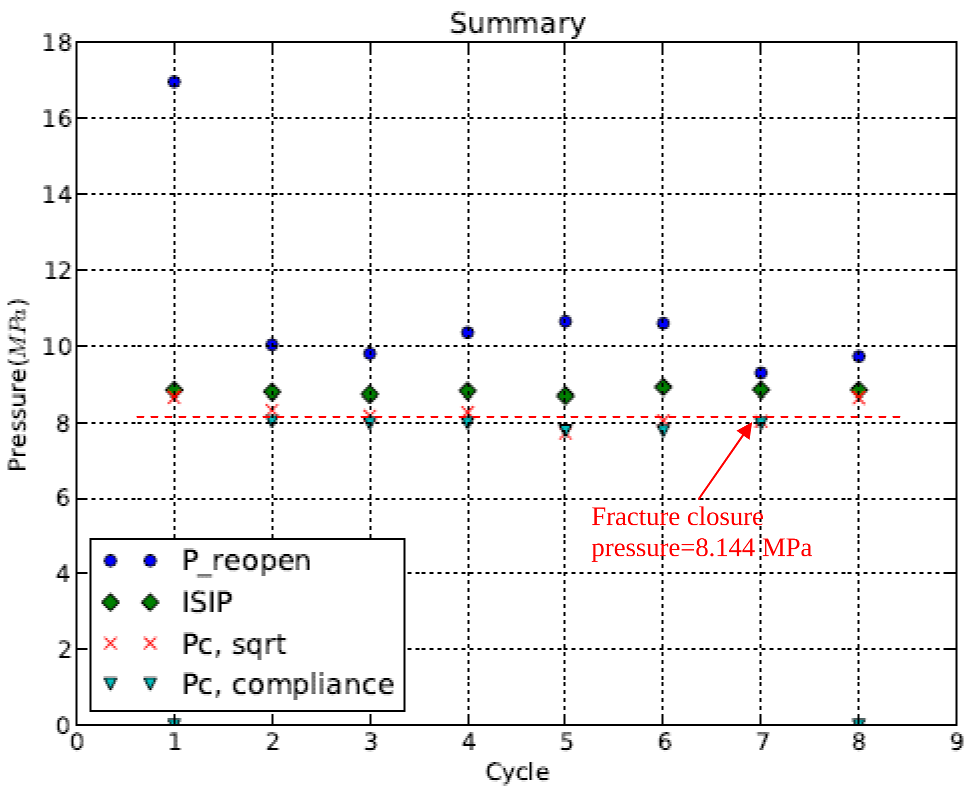
Figure 5: Fracture closure pressure interpreted from the compliance plot for Cycle #4 in the GP #1 test at 514 mTVD. The negative volume on the x-axis denotes the flown-back volume.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	13.598	9.373	7.571	0.000	2.73	0.00	0.00
2	10.247	8.805	7.479	0.000	2.89	0.00	0.00
3	10.254	8.857	6.965	8.048	2.79	0.23	1.07
4	9.673	8.493	7.743	0.000	2.82	0.00	0.00
5	10.227	8.282	7.088	7.725	2.59	0.28	0.98
6	9.844	8.312	7.527	0.000	2.74	0.00	0.00
7	9.604	8.427	7.564	0.000	2.59	0.00	0.00
8	8.886	8.460	7.734	0.000	2.46	0.00	0.00
9	9.614	8.380	7.118	7.869	2.48	0.19	1.24

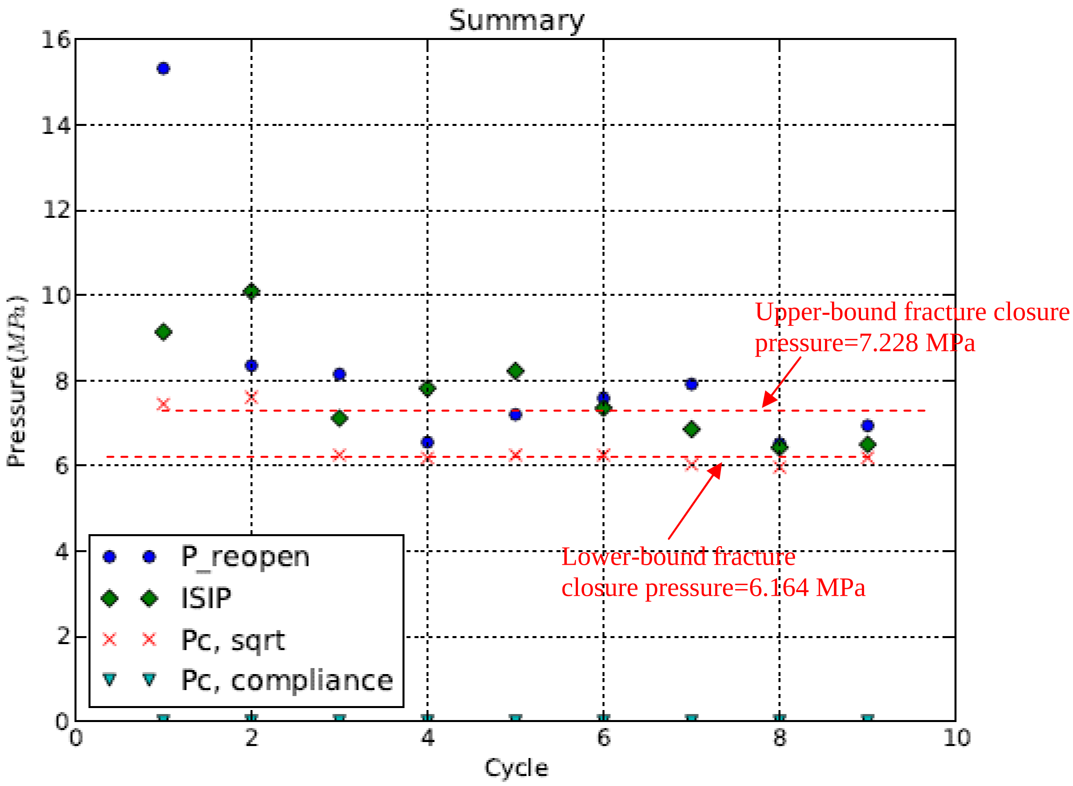
Figure 6: Various characteristic pressures interpreted from the test at 504 m, Well 13-24. “P_reopen” denotes the fracture reopening pressure where the fracture starts to re-open during the subsequent injection. “ISIP” is the Instantaneous Shut-In Pressure. “Pc, sqrt” refers to the fracture closure pressure extracted by the sqrt(dt)-plot. “Pc, compliance” is the fracture closure pressure extracted by the compliance plot from the flow-back tests. “Cb, inj (Cf, back or Cb, back)” refers to the initial system compliance during the injection (the system compliance before or after the fracture closure during the flowback). Similar convention for the legends holds in this report unless otherwise specified.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	16.970	8.833	8.650	0.000	2.65	0.00	0.00
2	10.024	8.789	8.323	8.019	2.95	8.04	2.05
3	9.791	8.727	8.175	7.969	2.55	8.62	2.33
4	10.347	8.811	8.265	7.979	2.64	11.35	2.44
5	10.642	8.689	7.715	7.774	2.83	11.43	2.51
6	10.591	8.906	8.045	7.768	2.51	10.78	3.43
7	9.281	8.842	8.027	7.970	3.44	17.25	3.96
8	9.719	8.830	8.635	0.000	3.17	0.00	0.00

Figure 7: Various characteristic pressures interpreted from the test at 514 m.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	15.327	9.136	7.456	0.000	2.66	0.00	0.00
2	8.346	10.090	7.610	0.000	3.47	0.00	0.00
3	8.145	7.120	6.256	0.000	2.96	0.00	0.00
4	6.556	7.814	6.187	0.000	3.53	0.00	0.00
5	7.207	8.219	6.255	0.000	3.99	0.00	0.00
6	7.589	7.358	6.256	0.000	4.78	0.00	0.00
7	7.910	6.862	6.031	0.000	6.74	0.00	0.00
8	6.527	6.433	5.971	0.000	4.08	0.00	0.00
9	6.946	6.504	6.194	0.000	7.44	0.00	0.00

Figure 8: Various characteristic pressures interpreted from the test at 530 m.

MINI-FRAC TESTS AT PENGROWTH WELL: LNDBRGH 13-24-58-5W4[1]
--- Discussions on the tests, interpretation and results ---

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March 23, 2012

3 mini-frac tests were completed on Well: LNDBRGH 13-24-58-5W4. An earlier report summarizes the general test procedure and presents the pressure/rate history and a summary of the interpreted fracture closure pressures from each test[3]. Another report compiles all the relevant analysis plots for each cycle in all of the tests[4]. The present report offers a further discussion on the tests and their interpretations. It will begin by describing an attempt to assess the relative error in the tests and their interpretations. It will then describe how to fully utilize the mini-frac test results for designing the field operation. In essence, the mini-frac tests are not merely to satisfy ERCB's requirements. It can be designed, executed and used as a cost-effective geomechanical field test, proactively guiding the field operation.

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[2] Responsible member under APEGGA rules.

[3] Mini-frac tests at Pengrowth Well: LNDBRGH 13-24-58-5W4 --- Summary of the tests and analysis results --- BitCan report 01-121. 10 p.

[4] Mini-frac tests at Pengrowth Well: LNDBRGH 13-24-58-5W4 --- Compilation of analysis plots. BitCan report 01-121 (3). 182 p.

1. Consistency check as an error analysis measure

As one of its quality control measures, BitCan uses multiple test cycles in each mini-frac test. In general, these cycles vary in the operating condition, being it with or without flow-back, different flow-back rates, or the flow-back rate being managed constant or variable as an outcome of the decreasing pressure difference. If a consistent fracture closure pressure can be derived despite these different operating conditions, it is normally a good indication of good quality tests and interpretations[5]. Therefore, a statistical analysis on the variation between the different cycles can offer a quantitative error analysis.

Take the test at 530 m for example. The following table summarizes the fracture closure pressures interpreted from each cycle of the test using the sqrt(t) plot. The corresponding mean and standard deviation ("std dev") are calculated as shown below. The mean pressure is reported as the in-situ minimum stress in all of our communications and reports. For all the tests for all of BitCan's clients, the first two cycles are taken out of the analysis. The initial cycles may have not propagated the fracture far away enough from the injection well and thus, the near-wellbore complexities obscure the interpretations.

Cycle	Pc_sqrt (MPa)
1	7.456
2	7.61
3	6.256
4	6.187
5	6.255
6	6.256
7	6.031
8	5.971
9	6.194
mean	6.164286
std dev	0.116601
rel. error	1.89%

The relative error, "rel. error", in the above table is calculated by dividing "mean" by "std dev". A small percentage of relative error certainly supports the consistency in the interpreted closure pressures and thus, a good measure of the interpretation accuracy in general.

[5] Some exceptions do occur. These will be discussed on the individual basis.

2. Comparison with the density-derived vertical stress

Another effort to assess the interpretation accuracy is to compare the fracture closure pressure interpreted from the mini-frac tests with the vertical overburden stress, Sv that can be calculated independently from the density log. Assuming that such calculated vertical stress is indeed the in-situ minimum stress and thus should be measured by the mini-frac tests, one can obtain another measure on the relative error in the mini-frac tests. It is generally recognized that in the caprock shales at shallow depths, the above assumption holds true. Our experience has certainly supported this assumption.

For the other tests, the above-stated assumption may not hold, i.e., Sv is inherently not the in-situ minimum stress and thus, should not be measured by the mini-frac tests. This normally happens in the oilsands payzone or tests at deep depths such as all the tests on the current Well 13-24. In this case, the comparison with the density-derived Sv can tell about the stress regime When the fracture closure pressure which is often equated to the in-situ minimum stress, Smin, is smaller than Sv, it means a vertical fracture is formed and the closure pressure represents the in-situ minimum horizontal stress, SHmin. In this case, the vertical fracture stress regime, "V. frac", is present.

In BitCan's terminologies, if Smin is smaller than Sv by more than 10%, the "V. frac" stress regime is assigned. If Smin is smaller than Sv by 5 to 10%, a near vertical fracture stress regime, "~V. frac", is assigned. If Smin differs from Sv by less than 5%, a horizontal fracture stress regime, "H. frac", is assigned. In the latter, the measured fracture closure pressure is close to Sv, i.e., a horizontal fracture is formed. Note that it is possible that the in-situ minimum horizontal stress is close to Sv. In this case, the preferred fracture direction is not certain between vertical and horizontal directions.

3. Summary on the error analysis

The above-described approach is extended for all the tests and their relevant details are summarized below:

Pengrowth LNDBRGH 13-24-58-5W4							Std dev --- Standard deviation.			
	TVD, m	Min. stress		Vert. stress		Stress regime	Statistics measures		Relative error	
		MPag	kPag/m	MPa	kPa/m		Mean, MPa	Std dev, MPa	Sv	std/mean
Lloydminster	530.0	6.164	11.63	11.342	21.40	V. frac	6.164	0.117	-45.7%	1.9%
GP #1	514.0	8.144	15.84	11.011	21.42	V. frac	8.144	0.305	-26.0%	3.7%
GP #2	504.0	7.057	14.00	10.796	21.42	V. frac	7.057	0.081	-34.6%	1.1%

Therefore, the relative error is smaller than 5% for all the tests if estimated by standard deviation vs. mean. This is a satisfactory evidence to support the accuracy of our mini-frac tests and interpretations. Moreover, Smin measured from each mini-frac test is all smaller than Sv by a margin of 26 to 46%. Thus, a vertical fracture stress regime, "V. frac", is present at all the test intervals. This is expected given their relative deep depths.

4. Uncertainty in the interpretations for the reservoir test

The low fracture pressure gradient near 11.6 kPa/m interpreted from the reservoir test should be regarded with caution. It is too low close to the hydrostatic gradient. The in-situ reservoir mobility is significant as shown by the fast pressure decline during the shut-in. As a result, the fracture closed rapidly, perhaps in seconds, after the shut-in. The fracture closure pressure was interpreted using the linear flow or sqrt(t) plot. This linear flow regime may be mixed with the wellbore storage effect and/or disappearing near-wellbore friction, which makes it difficult to detect the true fracture closure.

Obvious breakdown was seen in the first cycle as shown by the large pressure drop during the injection (Figure 1). In the subsequent injection, the pressure decreased somewhat or remained flat, all of which point out the fracture propagation behaviour. A secondary breakdown event was seen in Cycle #3 (Figure 1). Correspondingly, the fracture closure pressure dropped in Cycle #3 and remained low since then (Figure 2).

The fracture re-opening pressure, P_reopen, or Instantaneous Shut-in Pressure, ISIP, can provide the upper bound to the fracture closure pressure. Their corresponding statistical mean and deviation are calculated below:

Cycle	P-reopen (MPa)	ISIP (MPa)	Pc_sqrt (MPa)
1	15.327	9.136	7.456
2	8.346	10.09	7.61
3	8.145	7.12	6.256
4	6.556	7.814	6.187
5	7.207	8.219	6.255
6	7.589	7.358	6.256
7	7.91	6.862	6.031
8	6.527	6.433	5.971
9	6.946	6.504	6.194
mean	7.268571	7.187143	6.164286
std dev	0.638718	0.662384	0.116601
rel. error	8.79%	9.22%	1.89%

Therefore, an upper bound to the fracture closure pressure in the Lloydminster reservoir sands at 530 mTVD is 7.187 to 7.268 MPa (average at 7.228 MPa) or 13.6 to 13.7 kPa/m in gradient.

5. Applications of the test results to the field operation

The interpreted in-situ minimum stresses (Smin) are summarized in the following table:

Pengrowth LNDBRGH 13-24-58-5W4						
	TVD, m	Min. stress		Vert. stress		Stress regime
		MPag	kPag/m	MPa	kPa/m	
Lloydminster	530.0	6.164 to 7.228	11.63 to 13.64	11.342	21.40	V. frac
GP #1	514.0	8.144	15.84	11.011	21.42	V. frac
GP #2	504.0	7.057	14.00	10.796	21.42	V. frac

The stress barrier between the Lloydminster reservoir and GP (General Petroleum) caprock is obvious in the above measurements. The reservoir has a fracture pressure gradient at 11.63 to 13.64 kPa/m while the gradient in its immediate caprock is 15.84 kPa/m. As the first-order engineering design, this contrast can be used to guide the field operation designs as follows.

4.1. Operating pressures

The immediate GP caprock has a Smin=15.84 kPa/m. Based on this measurement, the margin of safety for various operating pressures in the underlying Lloydminster reservoir is listed below:

Smin@cap	15.84	kPa/m	
MOP, kPa/m	MOP at 518 m, MPa	Margin of Safety	% of Smin@cap
7.92	4.10	100%	50%
9.50	4.92	67%	60%
11.09	5.74	43%	70%
12.67	6.56	25%	80%
14.26	7.38	11%	90%

The Margin of Safety (M.S.) for a Maximum Operating Pressure (MOP) is defined as follows:

M.S. = Smin@cap/MOP - 1

where Smin@cap represents the in-situ minimum stress in the GP #1, i.e., equal to 8.144 MPa or 15.84 kPa/m. It is assumed here that it is unsafe to allow MOP to reach Smin in the caprock. This is reasonable to design the operation against the hydraulically-driven fracture propagation from the reservoir into the caprock. Therefore, a M.S. at zero means failure and larger than zero means no failure. The greater the M.S. the safer the caprock is from failure.

Sometimes, a simple percentage of the Smin in the caprock is used to guide the operation pressure design. At 80%, MOP can be 6.56 MPa and its associated M.S. is 25%. At 90%, MOP can be 7.38 MPa and its M.S. is 11%.

4.2. Dilation pressures for the Lloydminster reservoir

To promote the geomechanical dilation effect, the reservoir recovery processes should operate at pressures as high as possible. The in-situ minimum stress in the reservoir plays an important role in the dilation. The reservoir has a upper bound Smin=13.64 kPa/m. If this is true, the first-order engineering analysis normally suggests that significant dilation should occur if the reservoir operating pressure is close to this Smin. At this operating pressure, the Margin of Safety for the caprock integrity is 16% --- a significant margin favorable for the caprock integrity. Therefore, on the tested well, optimization can be sought in the MOP so that it is safe for the caprock integrity and meanwhile, promotes dilation in the reservoir.

4.3. A word of caution

It should be noted that caprock integrity is a very complex issue. Many factors contribute and therefore, many mechanisms can potentially compromise the caprock integrity (Yuan, 2008[6]). The above observations in 4.1 and 4.2 refer to a situation involving hydraulically-driven fracture propagation controlled by high fluid pressure inside the fracture and acting against the original in-situ stresses. It does not consider the mode of shear failure which can potentially compromise the caprock integrity. It does not address impact of reservoir deformation on the caprock. It does not consider thermal stresses. The thermal stresses and reservoir deformation may be significant during the thermal stimulations and should be considered. The ongoing geomechanical laboratory tests and simulations will investigate these issues.

Furthermore, the above discussions in 4.1 and 4.2 assume that the measured stress condition holds across the region. It may not be true if complex geology is present. Examples include post-depositional collapse structures and large faults. These and other factors should be considered in dedicated efforts.

[6] Yuan, Y., 2008, Overburden/casing integrity in SAGD without high operating pressures. Presented at Canadian International Petroleum Conference in June, 2008 in Calgary. Paper # CIPC-2008-206.

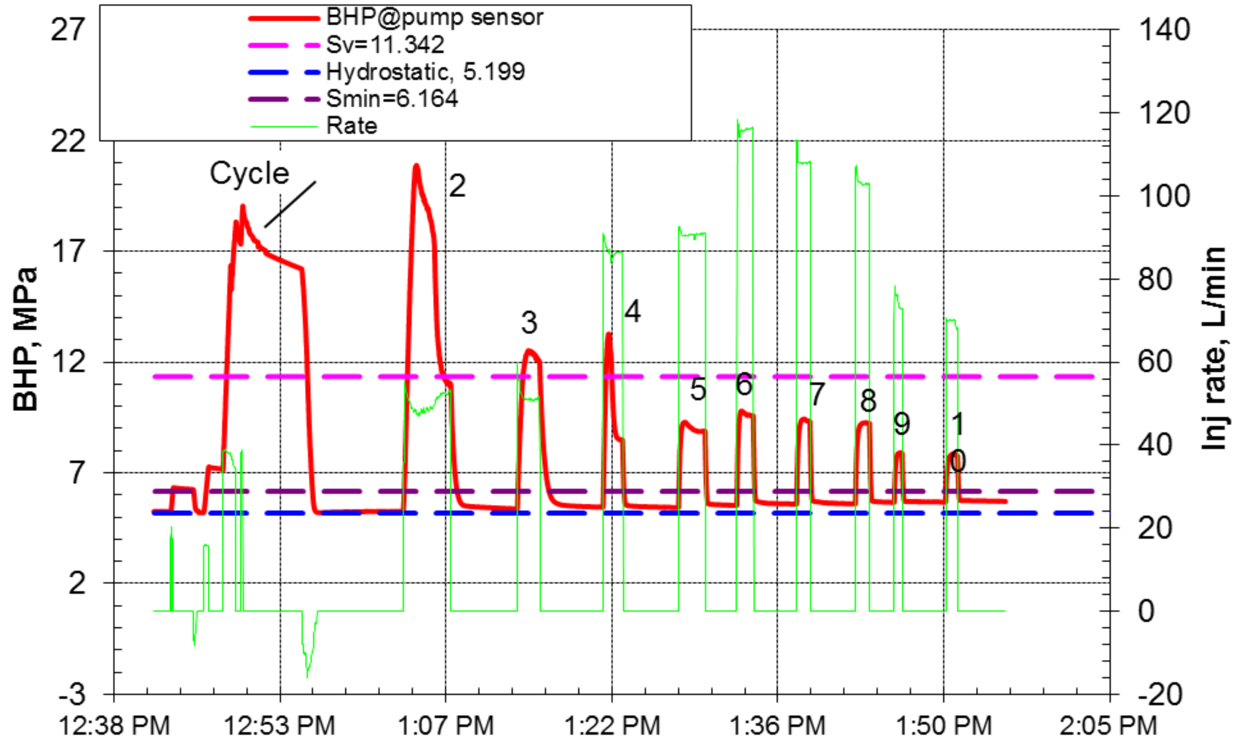
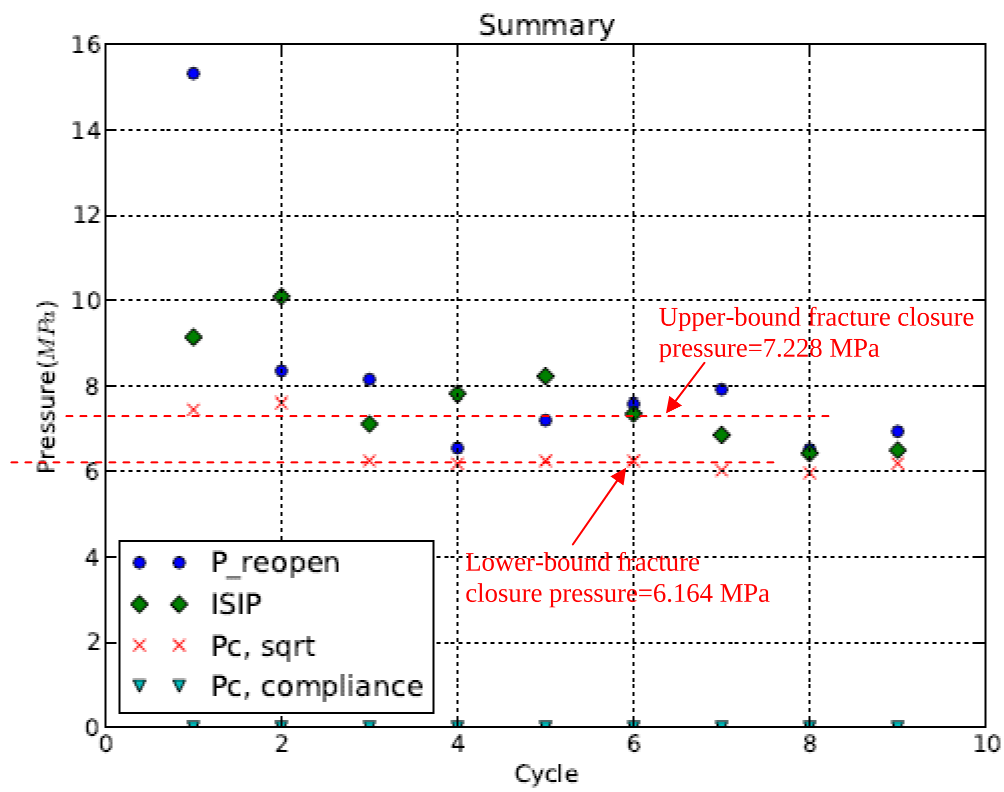


Figure 1: Recorded pressure history during the injection test in the reservoir sands at 530 m TVD, Pengrowth Well 13-24. The bottomhole pressures ("BHP") were calculated from a surface pressure sensor at the pump plus the hydraulic head ("Hydrostatic") from the water column weight. The overburden weight ("Sv") was calculated from the density log. "SHmin" was the in-situ minimum horizontal stress or fracture closure pressure interpreted from the pressure data. Similar conventions are used below unless otherwise specified.



Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	15.327	9.136	7.456	0.000	2.66	0.00	0.00
2	8.346	10.090	7.610	0.000	3.47	0.00	0.00
3	8.145	7.120	6.256	0.000	2.96	0.00	0.00
4	6.556	7.814	6.187	0.000	3.53	0.00	0.00
5	7.207	8.219	6.255	0.000	3.99	0.00	0.00
6	7.589	7.358	6.256	0.000	4.78	0.00	0.00
7	7.910	6.862	6.031	0.000	6.74	0.00	0.00
8	6.527	6.433	5.971	0.000	4.08	0.00	0.00
9	6.946	6.504	6.194	0.000	7.44	0.00	0.00

Figure 2: Various characteristic pressures interpreted from the test at 530 m. “P_reopen” denotes the fracture reopening pressure where the fracture starts to re-open during the subsequent injection. “ISIP” is the Instantaneous Shut-In Pressure. “Pc, sqrt” refers to the fracture closure pressure extracted by the sqrt(dt)-plot. “Pc, compliance” is the fracture closure pressure extracted by the compliance plot from the flow-back tests. “Cb, inj (Cf, back or Cb, back)” refers to the initial system compliance during the injection (the system compliance before or after the fracture closure during the flowback).

MINI-FRAC TESTS AT PENGROWTH WELL: LNDBRGH 13-24-58-5W4[1]

--- Compilation of analysis plots ---

Y. Yuan[2] and Bin Xu

BitCan Geosciences & Engineering Inc.
Bay 8, 3200 – 14 Ave, N.E., Calgary, Alberta T2A 6J4
APEGGA Permit of Practice #07814

March 23, 2012

In various appendices, this report compiles all the analysis plots for the tests. Each plot occupies a page. They are first organized according to the test intervals. Plots are then grouped according to the test cycles sequentially from the first to the last. For each cycle, the following sequence of plots is arranged:

(1). "BHP and Injection Rate" plots the pressure/rate history, "Relative time" on the x-axis is calculated from the start of the cycle.
(2). "P-V" plot for the pressure vs. injection volume plot to identify "P_reopen".
(3). "P-Δt" plots the pressure decline during the shut-in. "Relative time" on the x-axis is calculated with respect to the start of the shut-in period. This plot determines ISIP.
(4). "lg(ΔP)-lg(Δt)" plots the pressure drop during the shut-in (ongoing pressure minus the pressure at the start of the shut-in) against the shut-in time on the log-log plot. It is used to identify two slopes whose magnitudes are denoted. The 1st or 2nd slopes are counted from the origin to the right.
(5). "P-√Δt" for the p-sqrt(t) plot to identify "Pc, sqrt".

[2] Responsible member under APEGGA rules.

(6). "P-backV" is made only if the flow-back is executed during the test. It plots the pressure vs. fluid volume being flown back. 2 slopes are identified and their intersection is the fracture closure pressure, "Pc, compliance". The slopes are denoted on the plot. The 1^{st} and 2^{nd} slopes are counted from the "0" point on the axis, i.e. the right-hand side end, to the left.

(7). "lg(Δt*dP/dΔt)-lg(Δt)" means the semi-log pressure derivative plot on the log-log scale. The y-axis lg(Δt*dP/dΔt) is actually the derivative with respect to the natural log of the incremental time after the shut-in starts, i.e. dP/d(ln(Δt)). 3 slopes are identified to show the flow regimes. They are identified in the legend by "1^{st}" to "3^{rd}" corresponding respectively to fitted lines from the left-most to the right-most. The linear flow period should have a slope of close to 0.5.

There are two summary pages after all the cycles are presented: the first plots the characteristic pressures according to the cycle sequences and the second lists their numeric values in a table. The compliance values are also listed: "Cb, inj" refers to the initial system compliance during the injection. "Cf, back or Cb, back" is the system compliance before or after the fracture closure during the flowback.

ANALYSIS PLOTS

WELL: LNDBRGH 13-24-58-5W4

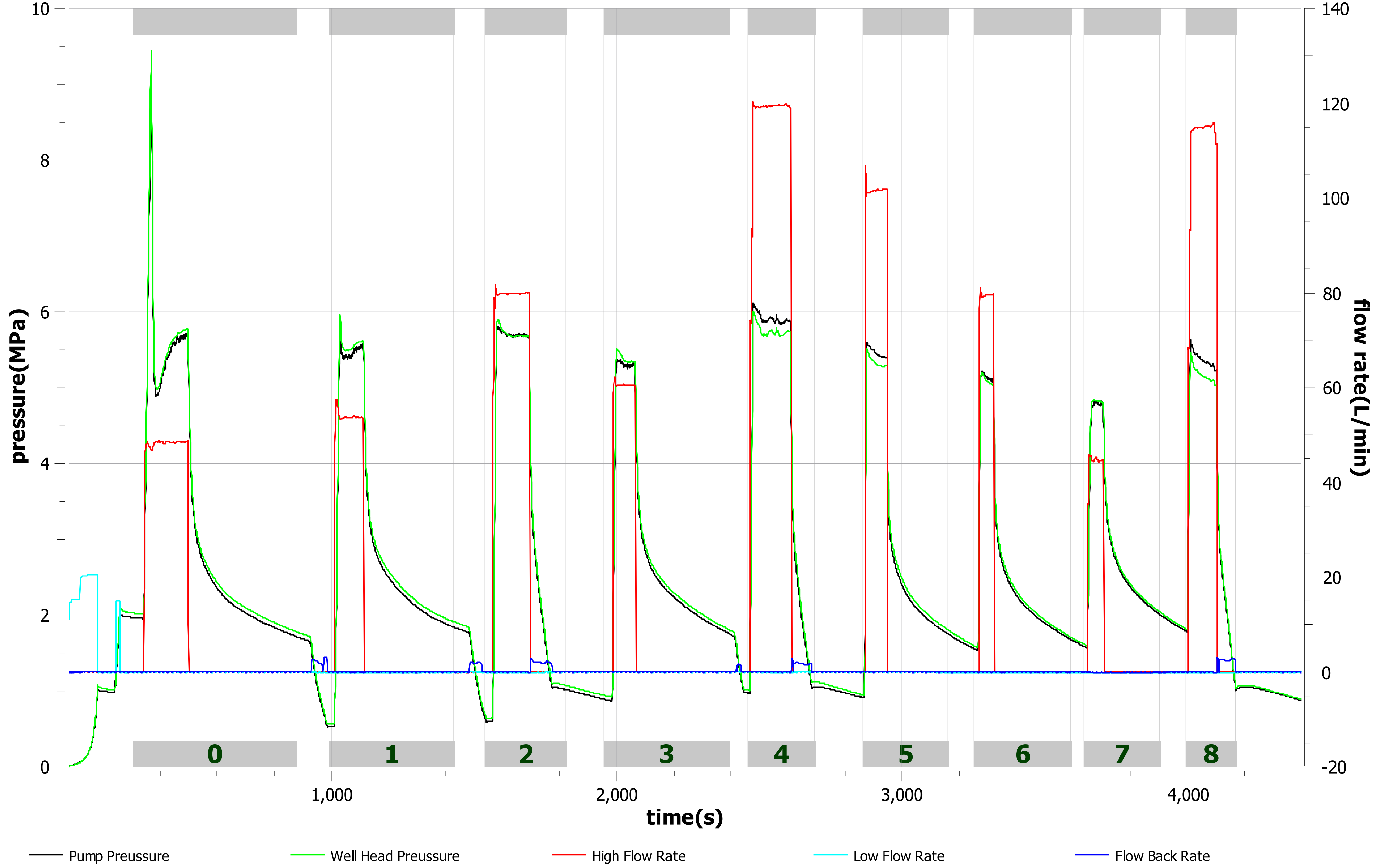
Test 1: General Petroleum (GP) caprock
at 504 m TVD

BitCan
Geosciences & Engineering Inc.
www.bitcange.com

Client: PenGrowth
Well:
Depth: 504

Formation: CapRock
Start @: Tue Jan 3 10:21:02 2012

Mini-Frac Test



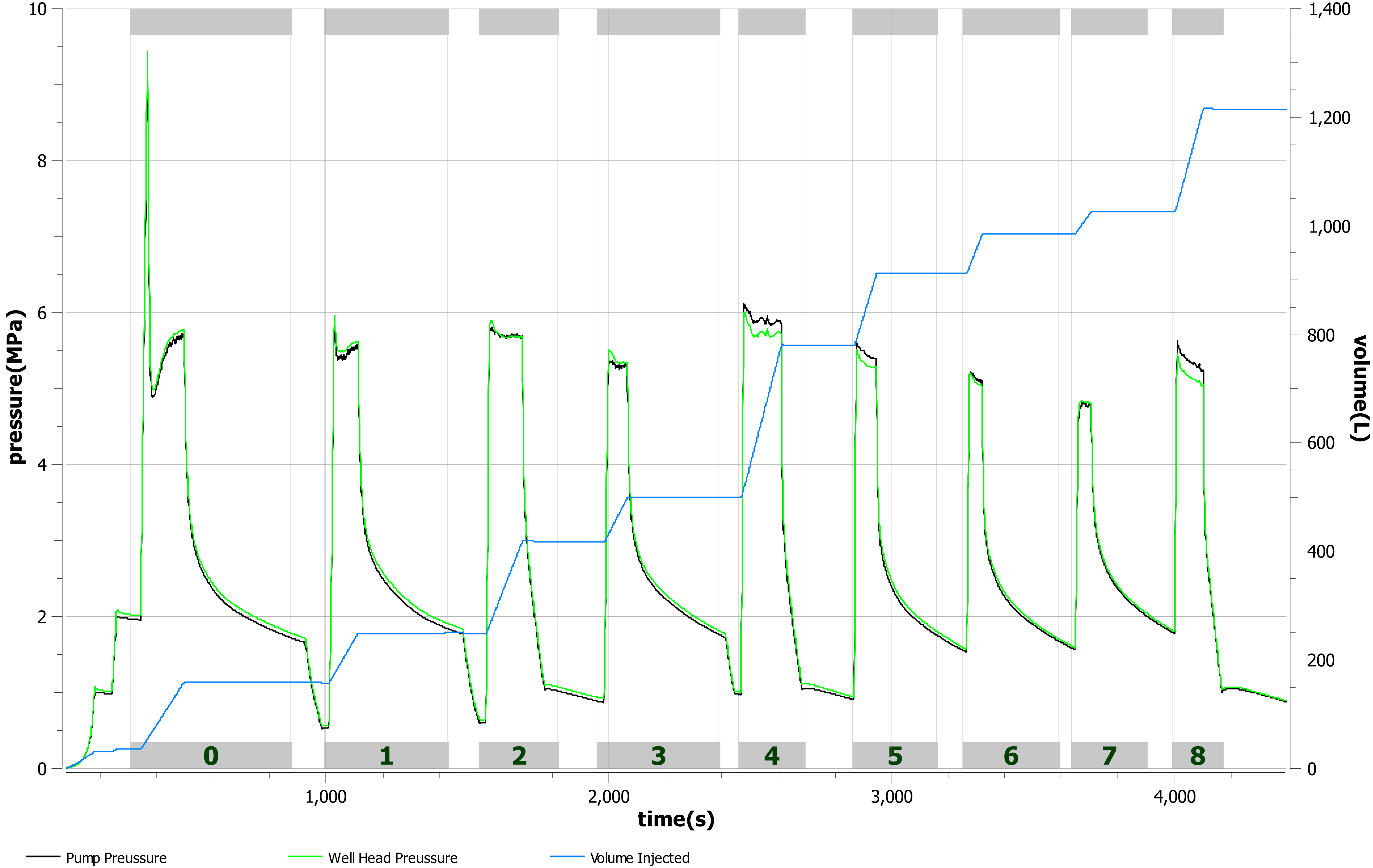
BitCan
Geosciences & Engineering Inc.

www.bitcange.com

Client: PenGrowth
Well:
Depth: 504

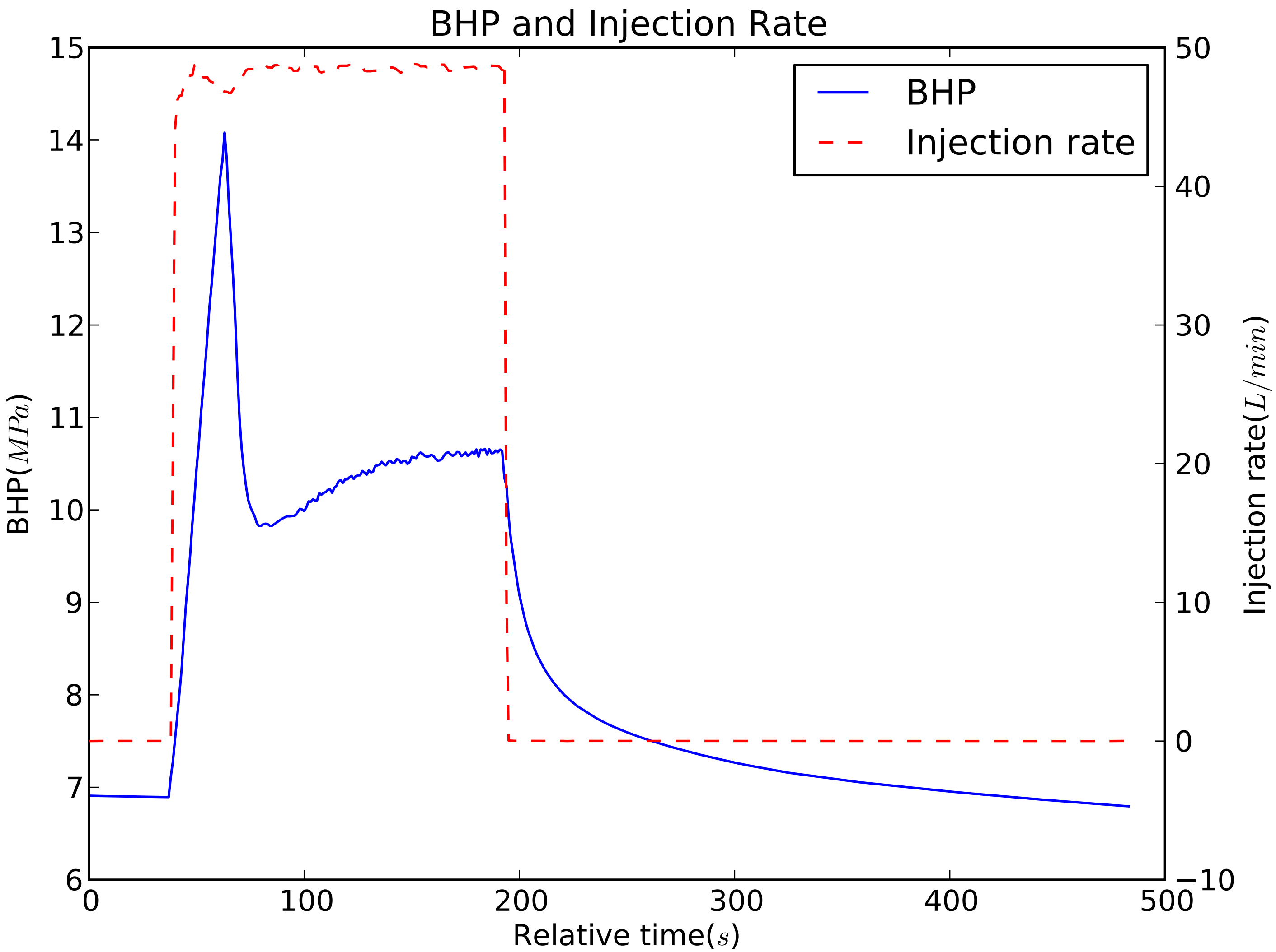
Formation: CapRock
Start @: Tue Jan 3 10:21:02 2012

Mini-Frac Test



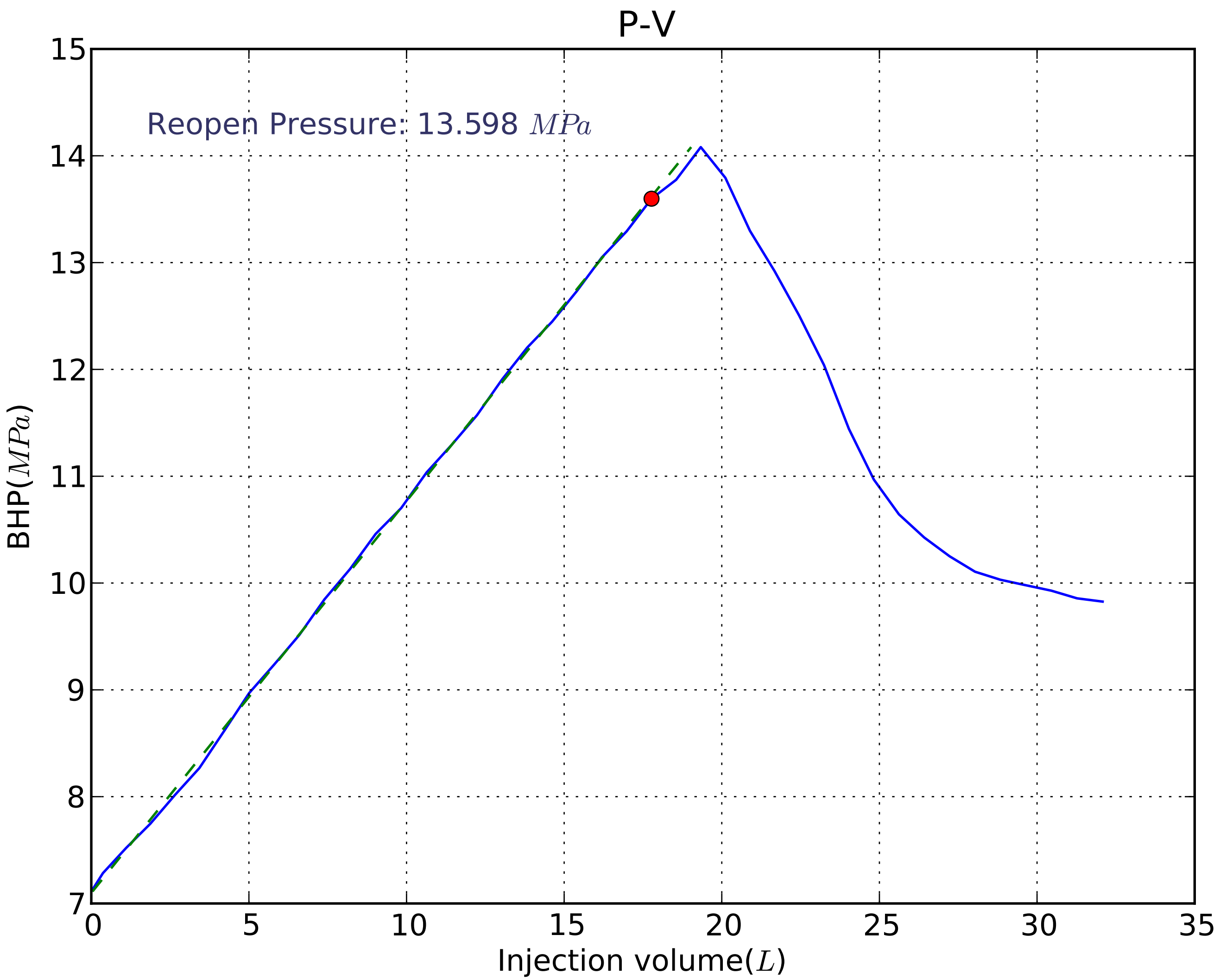
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 01

BitCan
Geosciences & Engineering Inc.



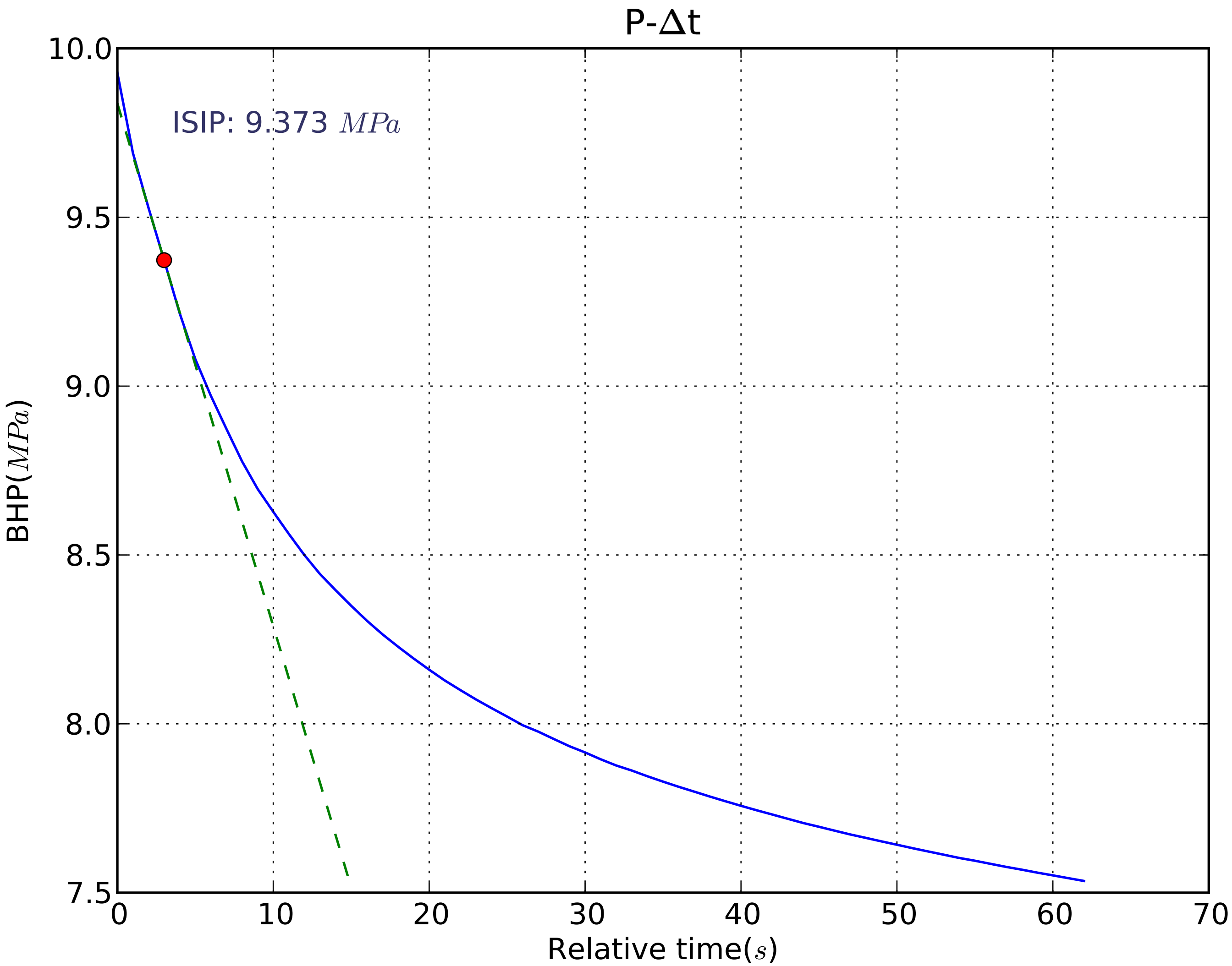
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 01

BitCan
Geosciences & Engineering Inc.

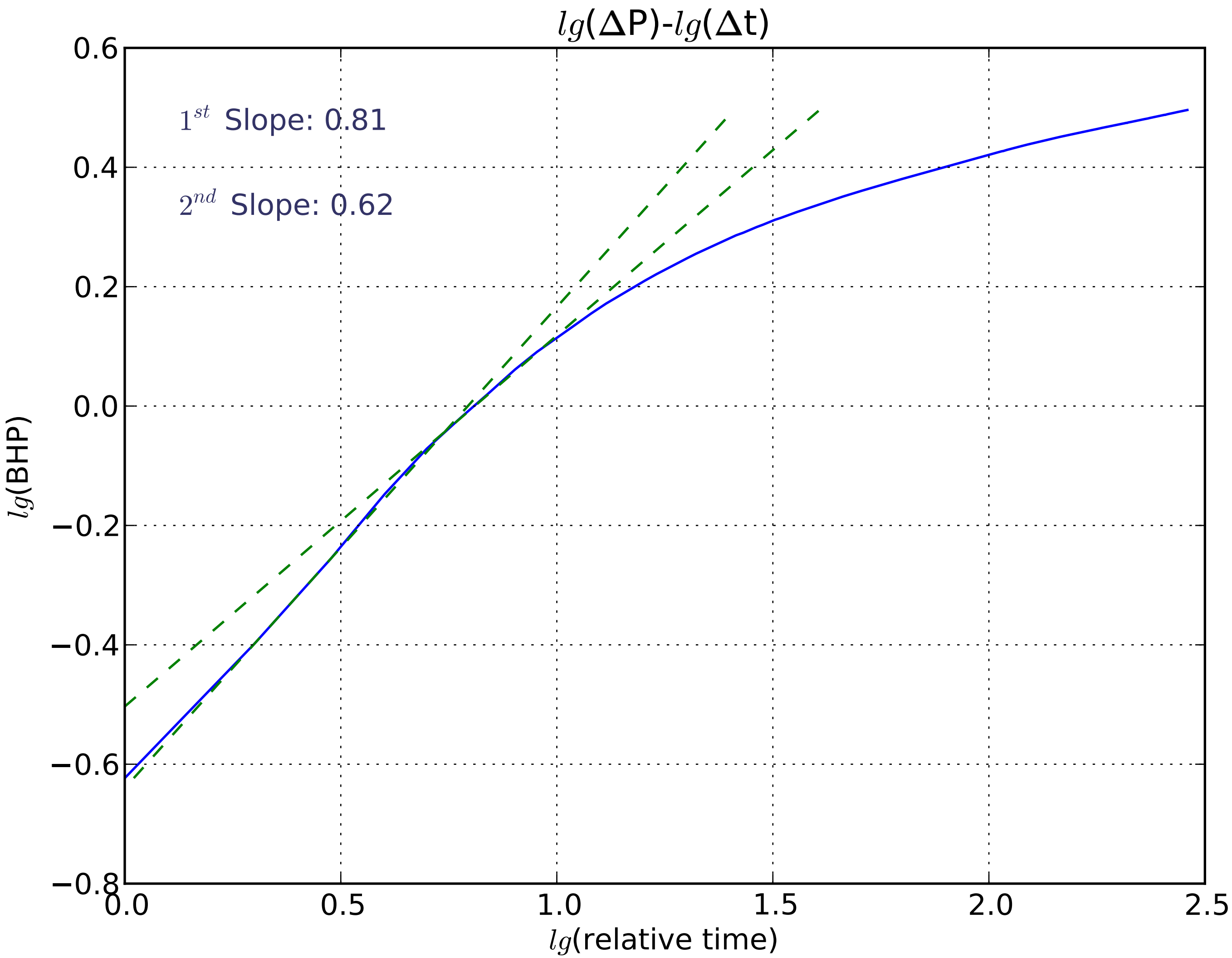


Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 01

BitCan
Geosciences & Engineering Inc.

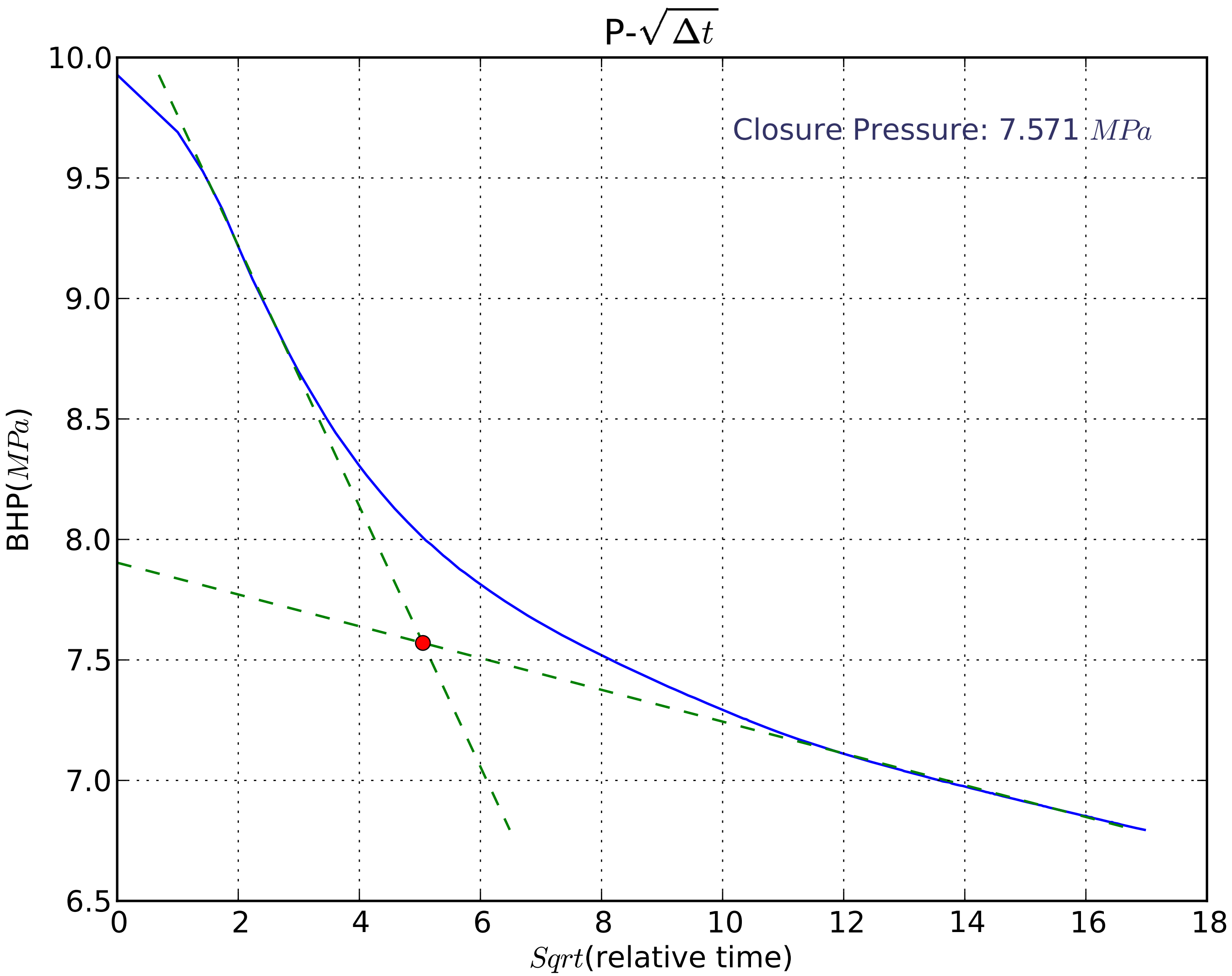


Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 01



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 01

BitCan
Geosciences & Engineering Inc.



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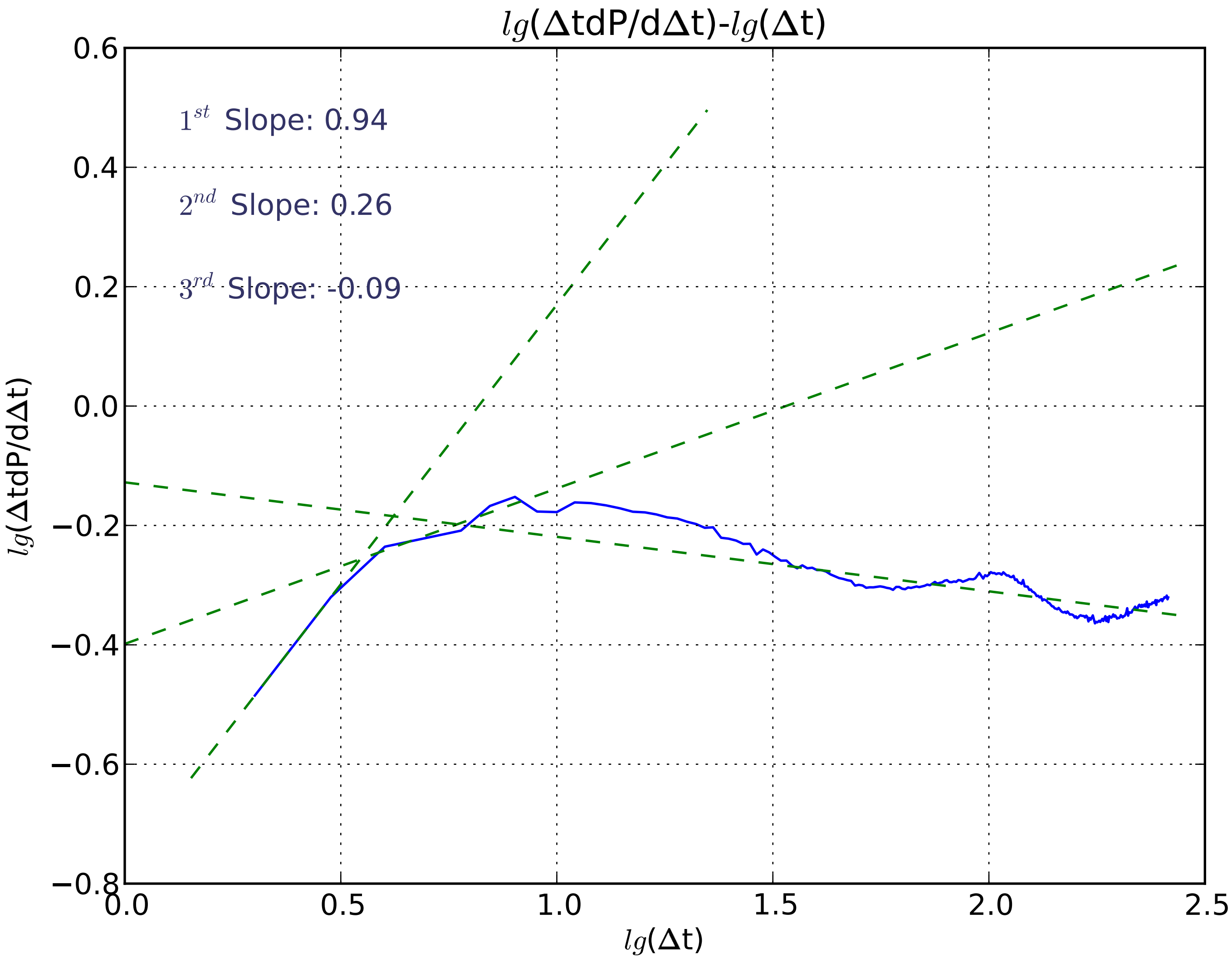
Geosciences & Engineering Inc.



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 02

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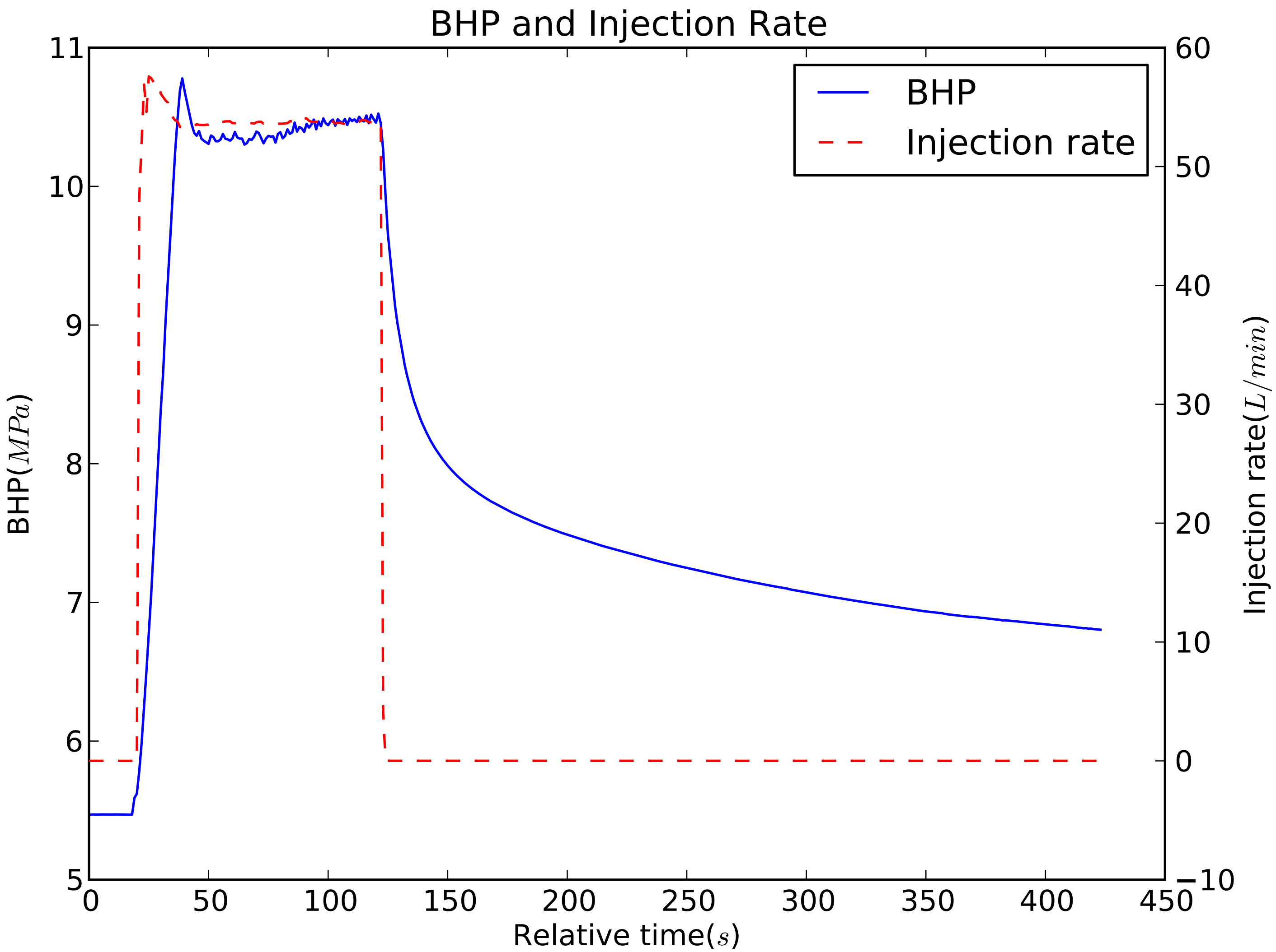
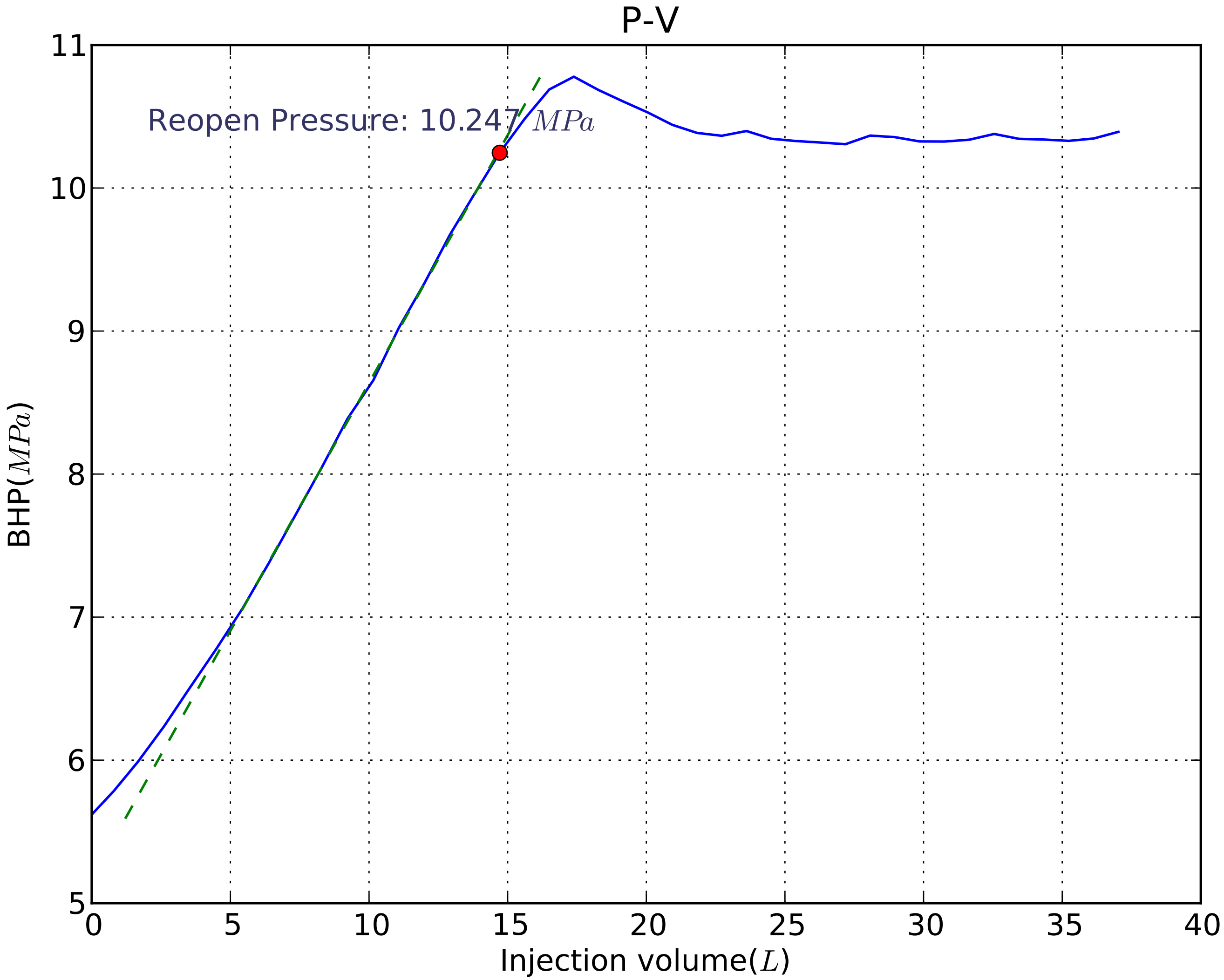
Geosciences & Engineering Inc.



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 02



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 02

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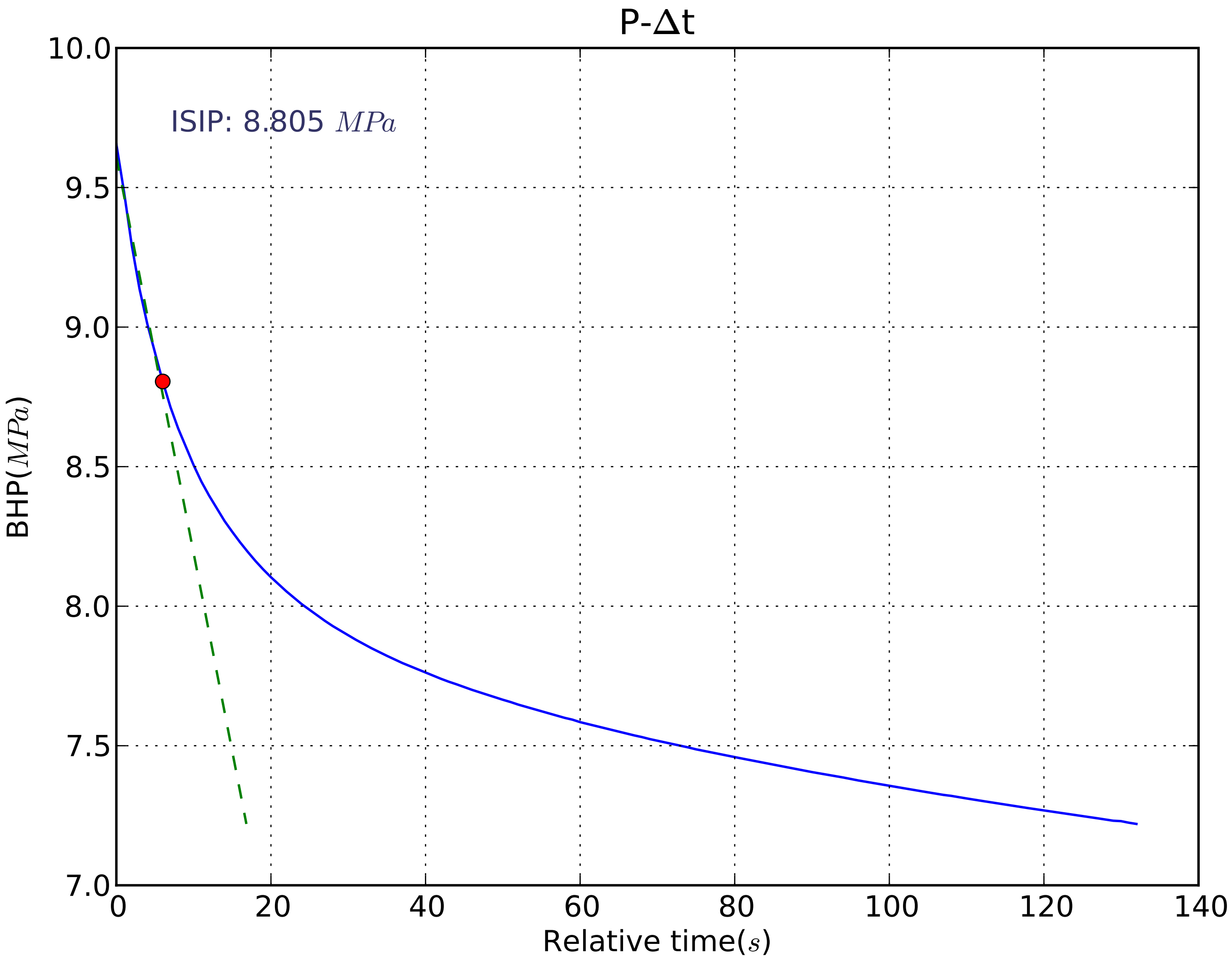
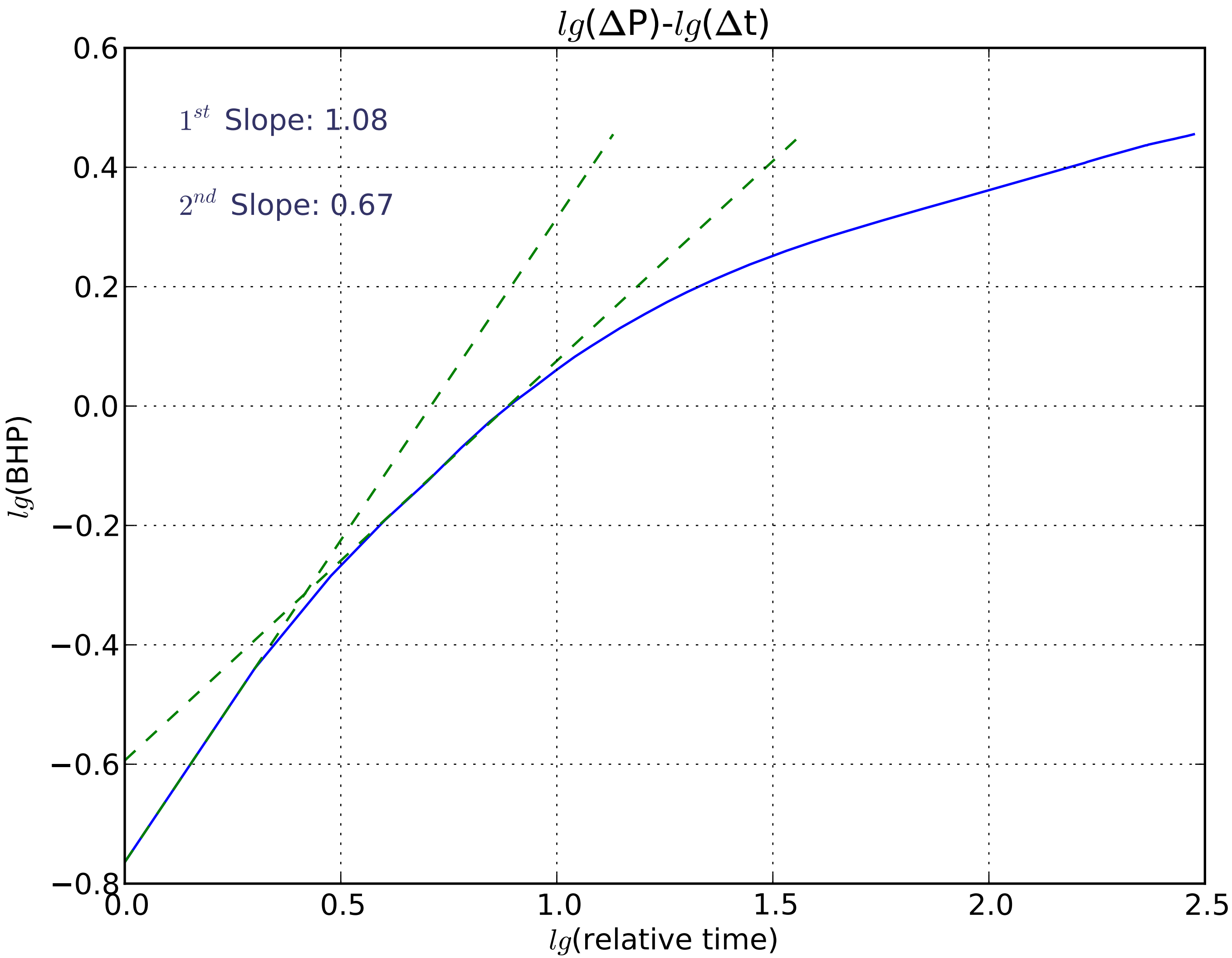
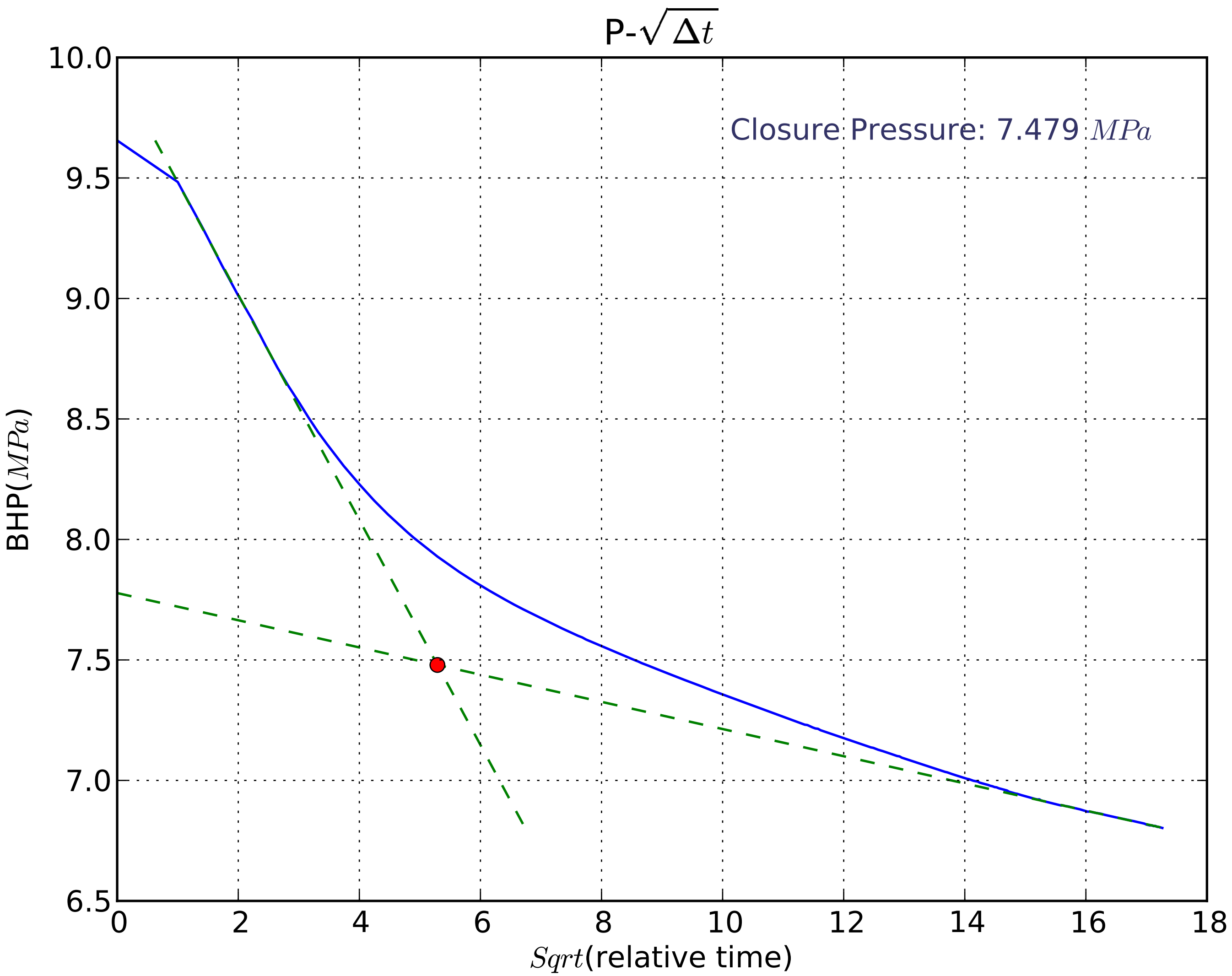




$lg(\Delta P)$-$lg(\Delta t)$
1^{st} Slope: 1.08
2^{nd} Slope: 0.67
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
lg(BHP)
0.0
0.5
1.0
1.5
2.0
2.5
lg(relative time)

Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 02



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 02

BitCan
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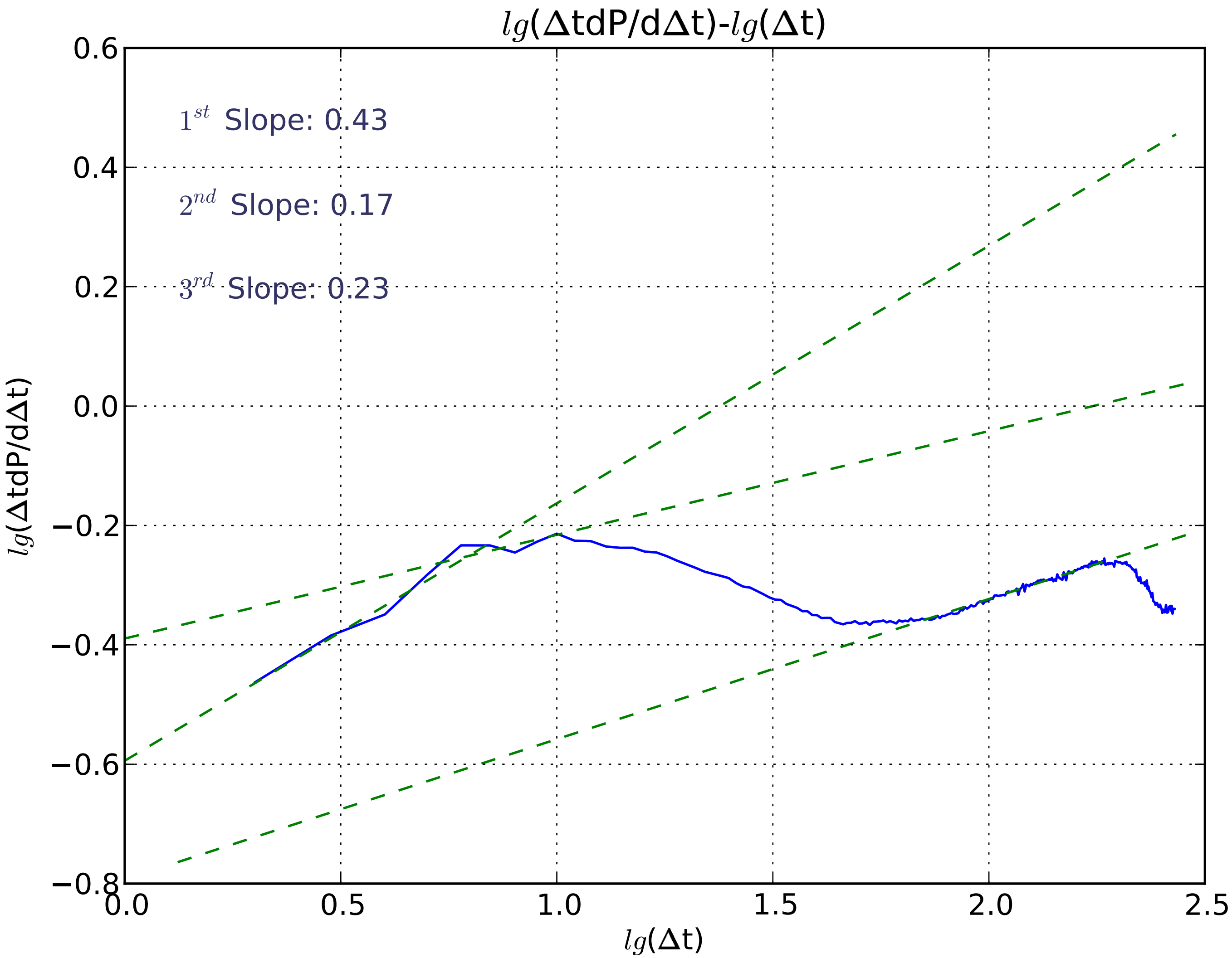
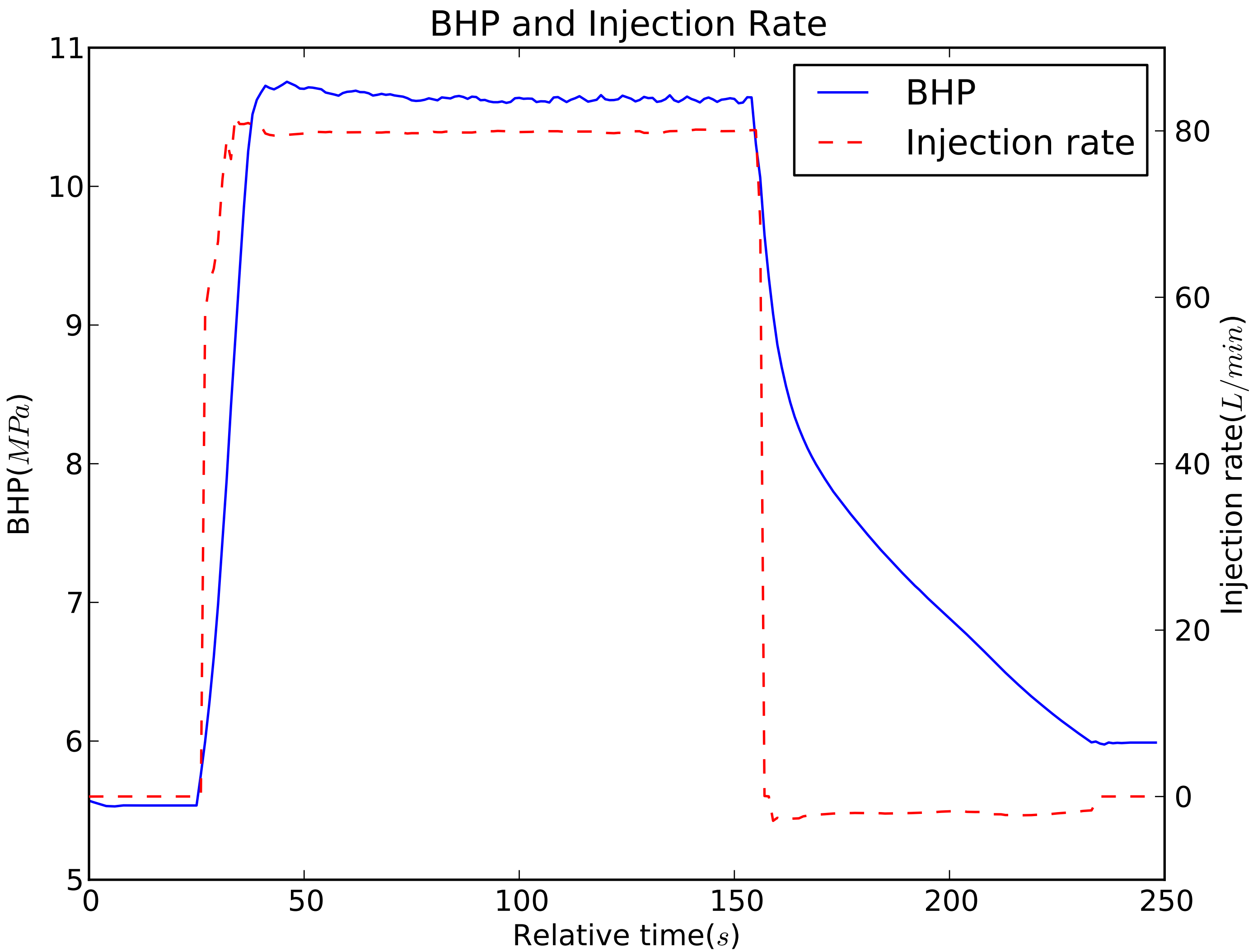


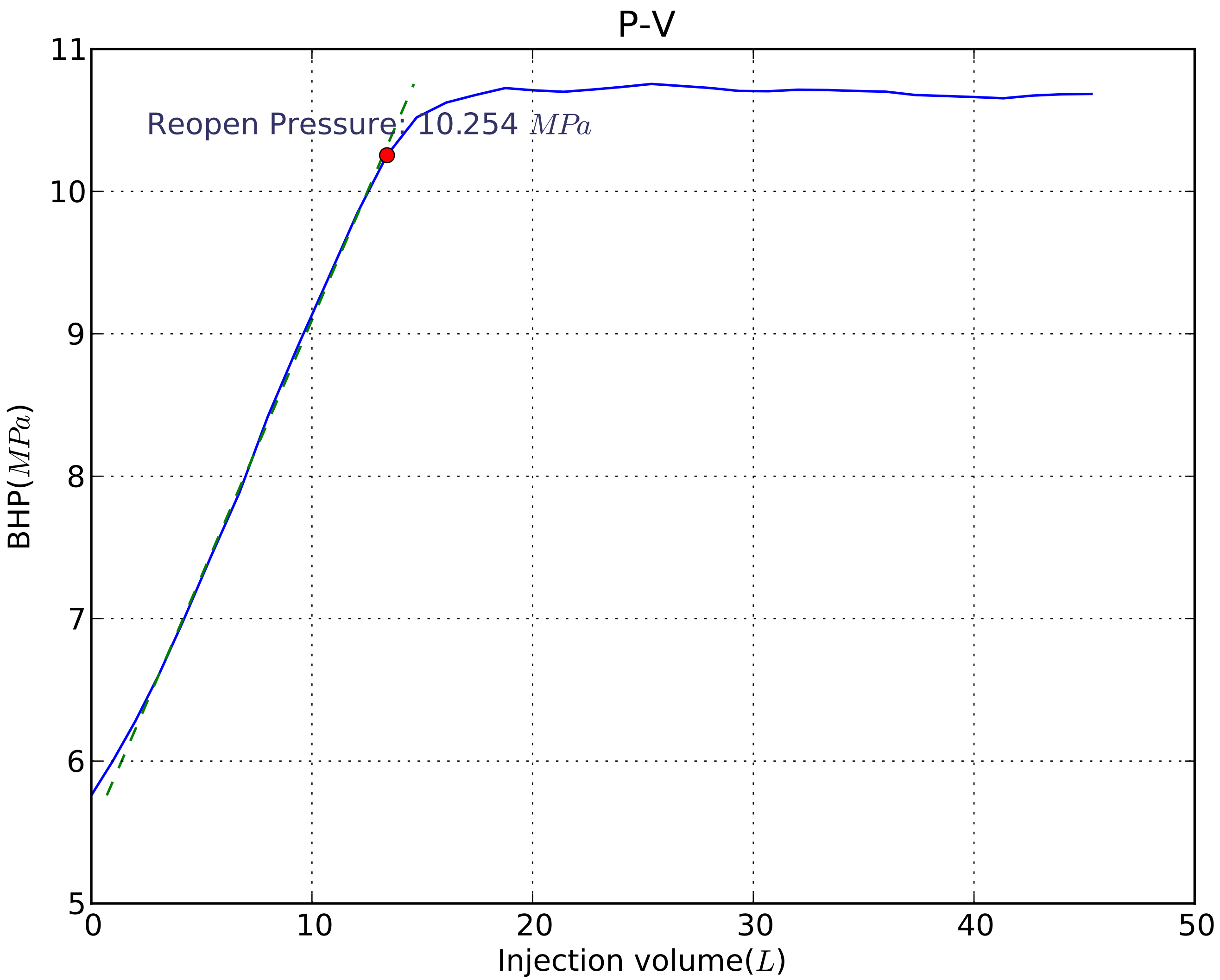
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 03

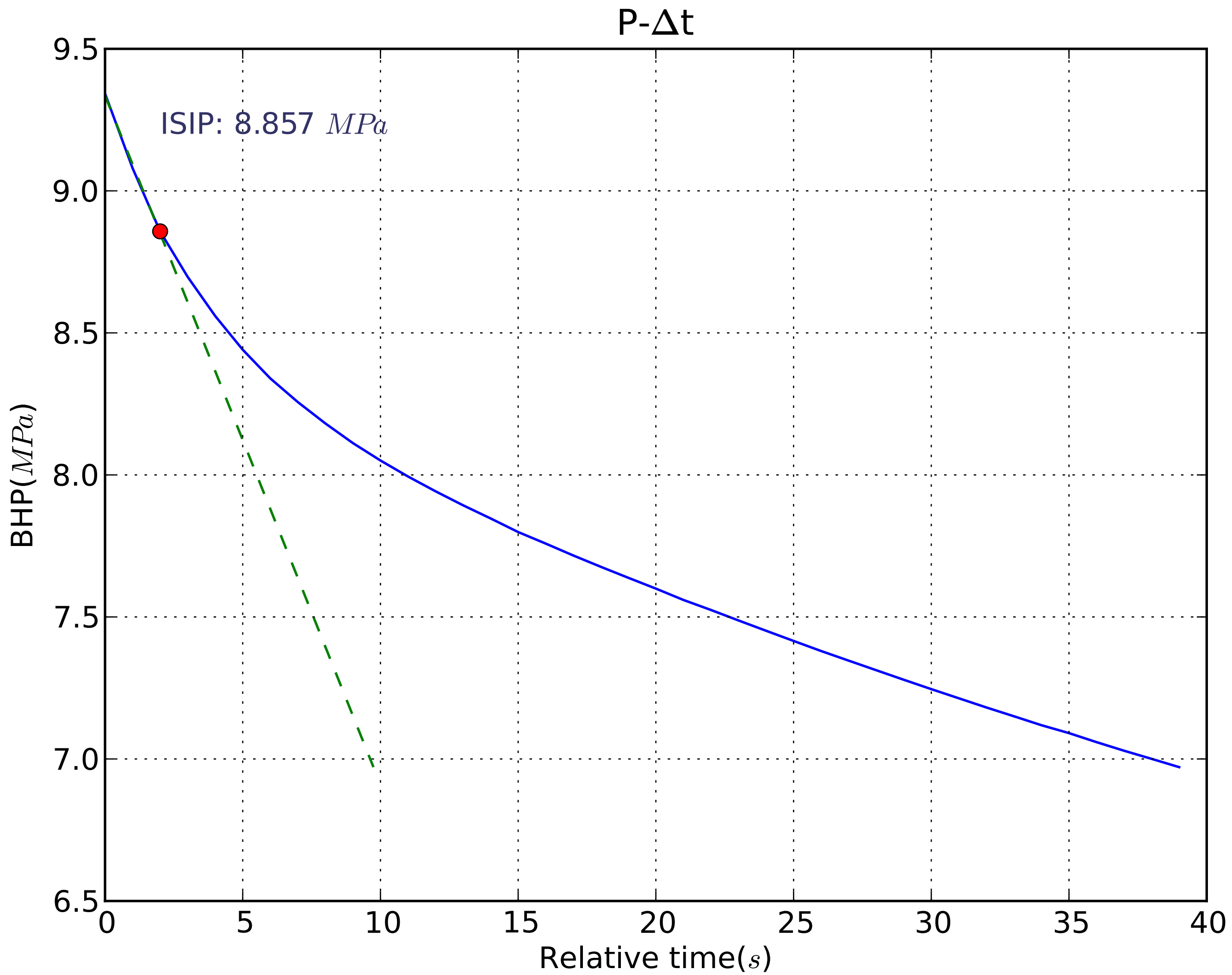
BitCan
Geosciences & Engineering Inc.



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 03

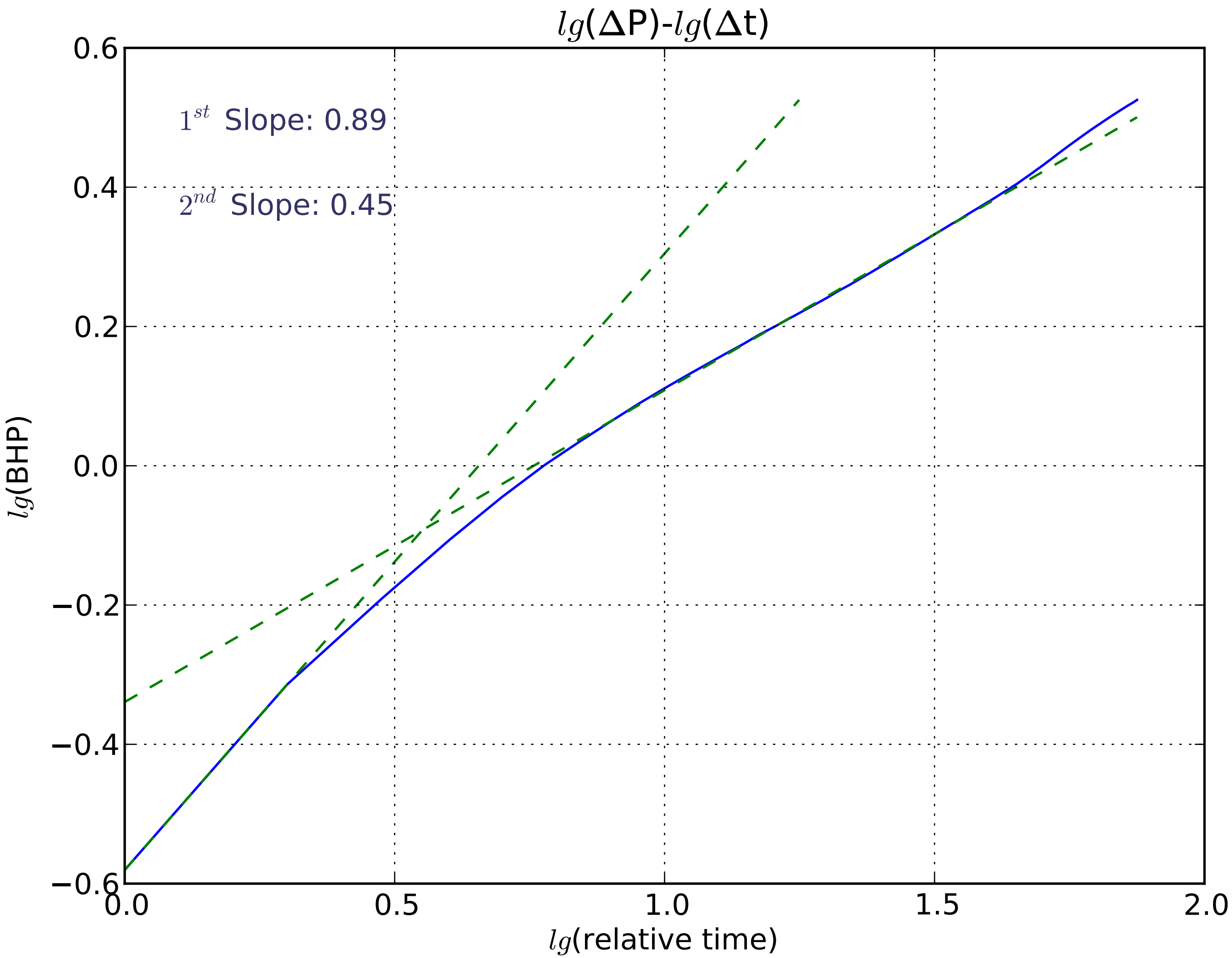
BitCan
Geosciences & Engineering Inc.




P-Δt
ISIP: 8.857 MPa
BHP(MPa)
Relative time(s)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
0
5
10
15
20
25
30
35
40

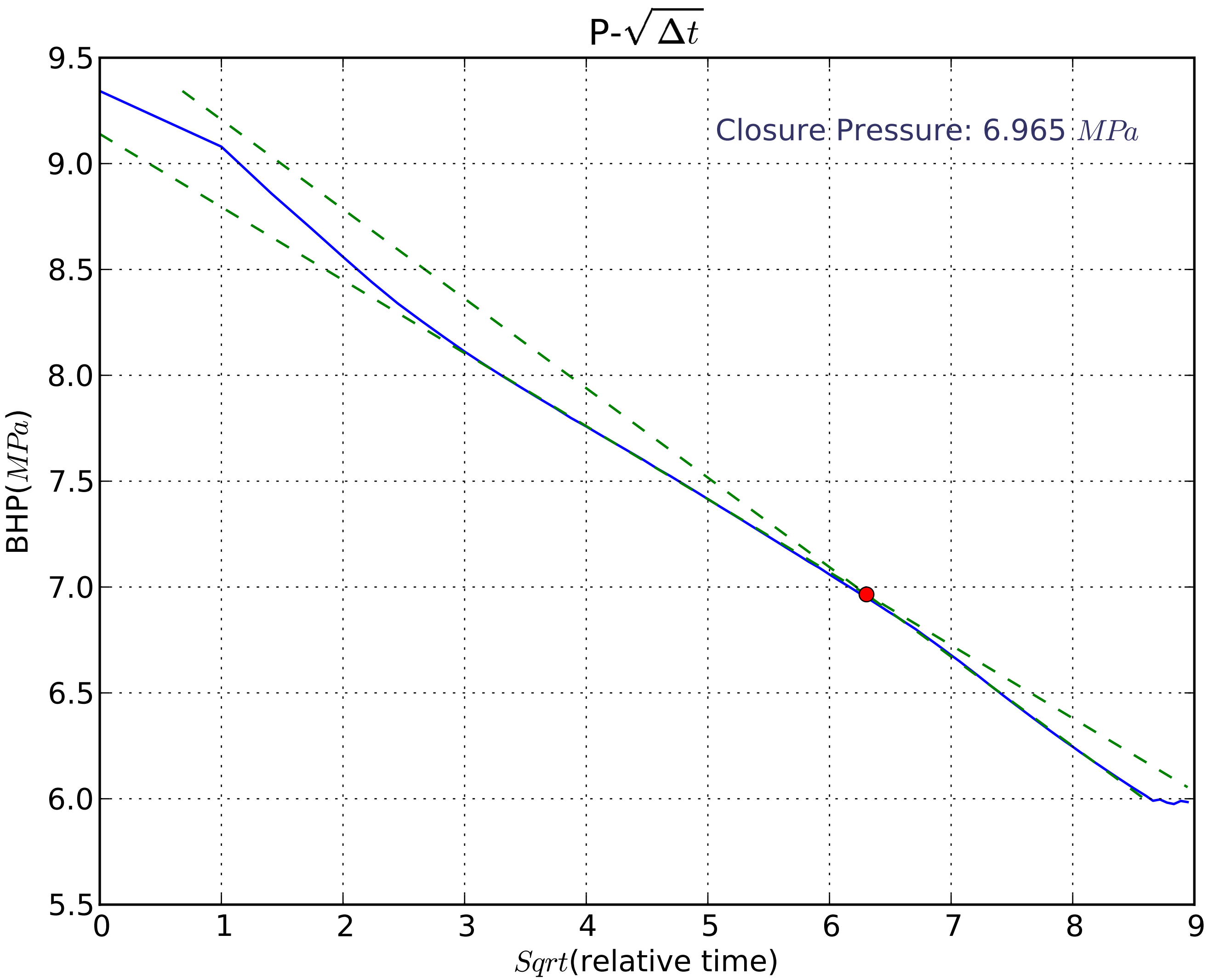
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 03

BitCan
Geosciences & Engineering Inc.



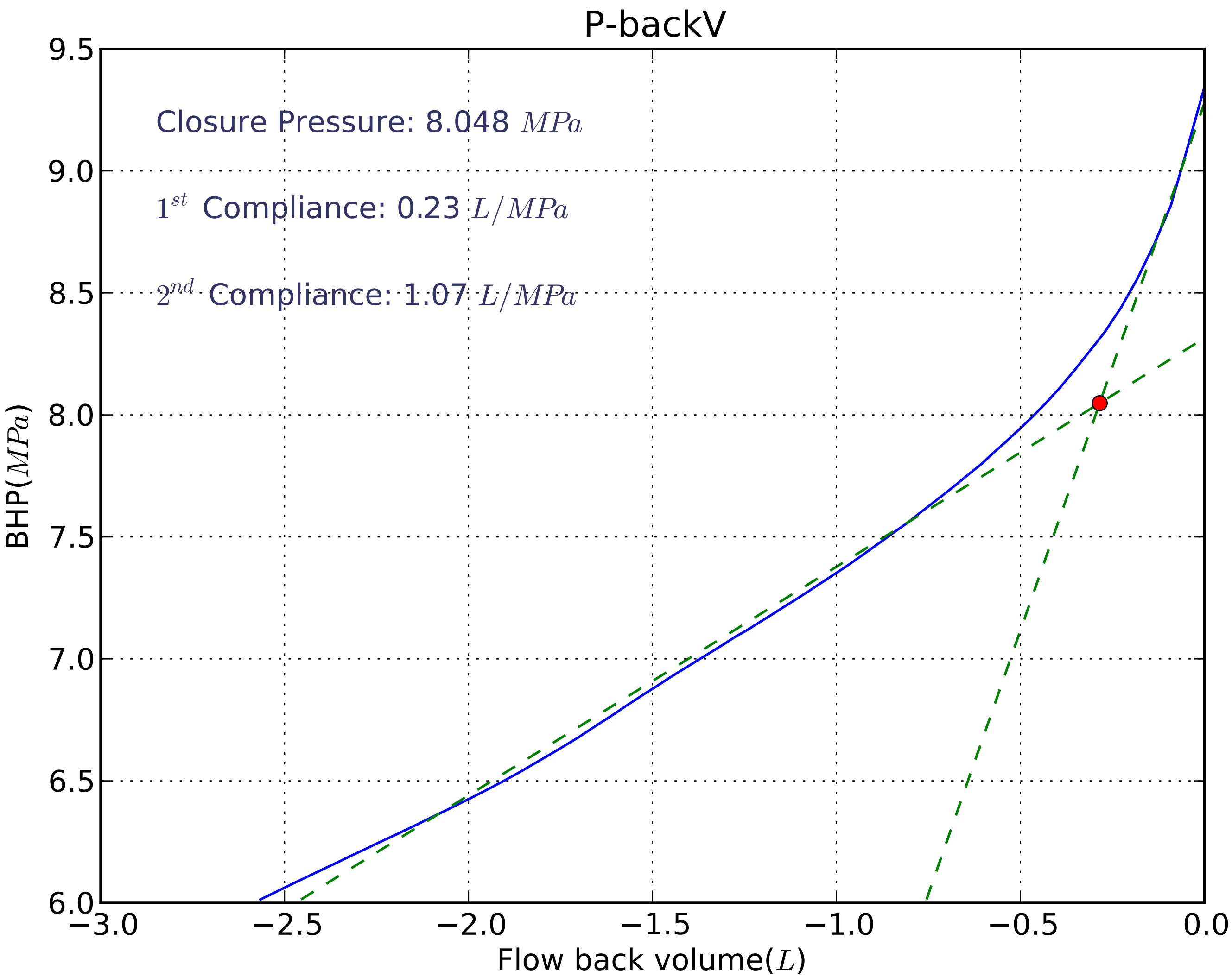
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 03

BitCan
Geosciences & Engineering Inc.



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 03

BitCan
Geosciences & Engineering Inc.



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 03

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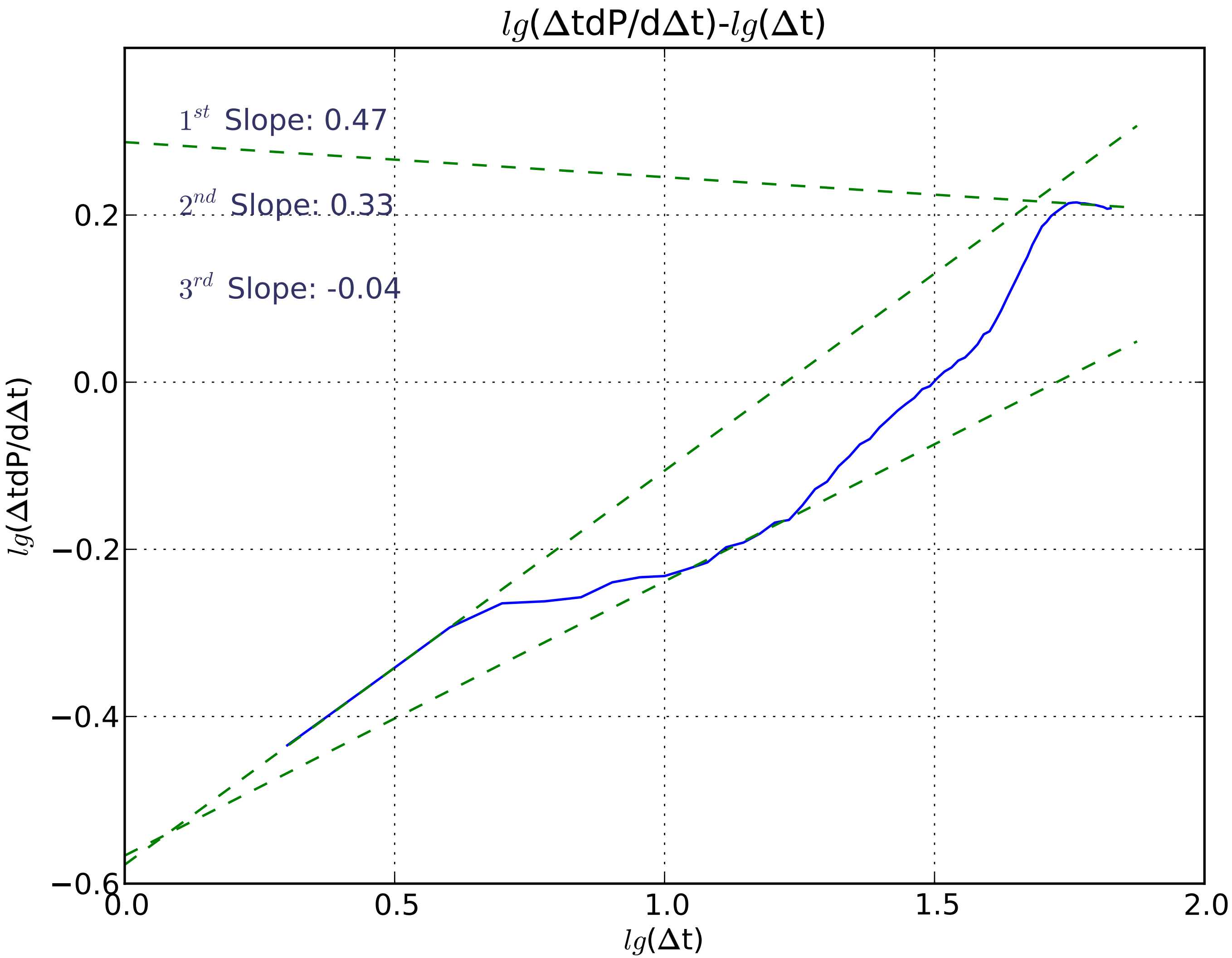
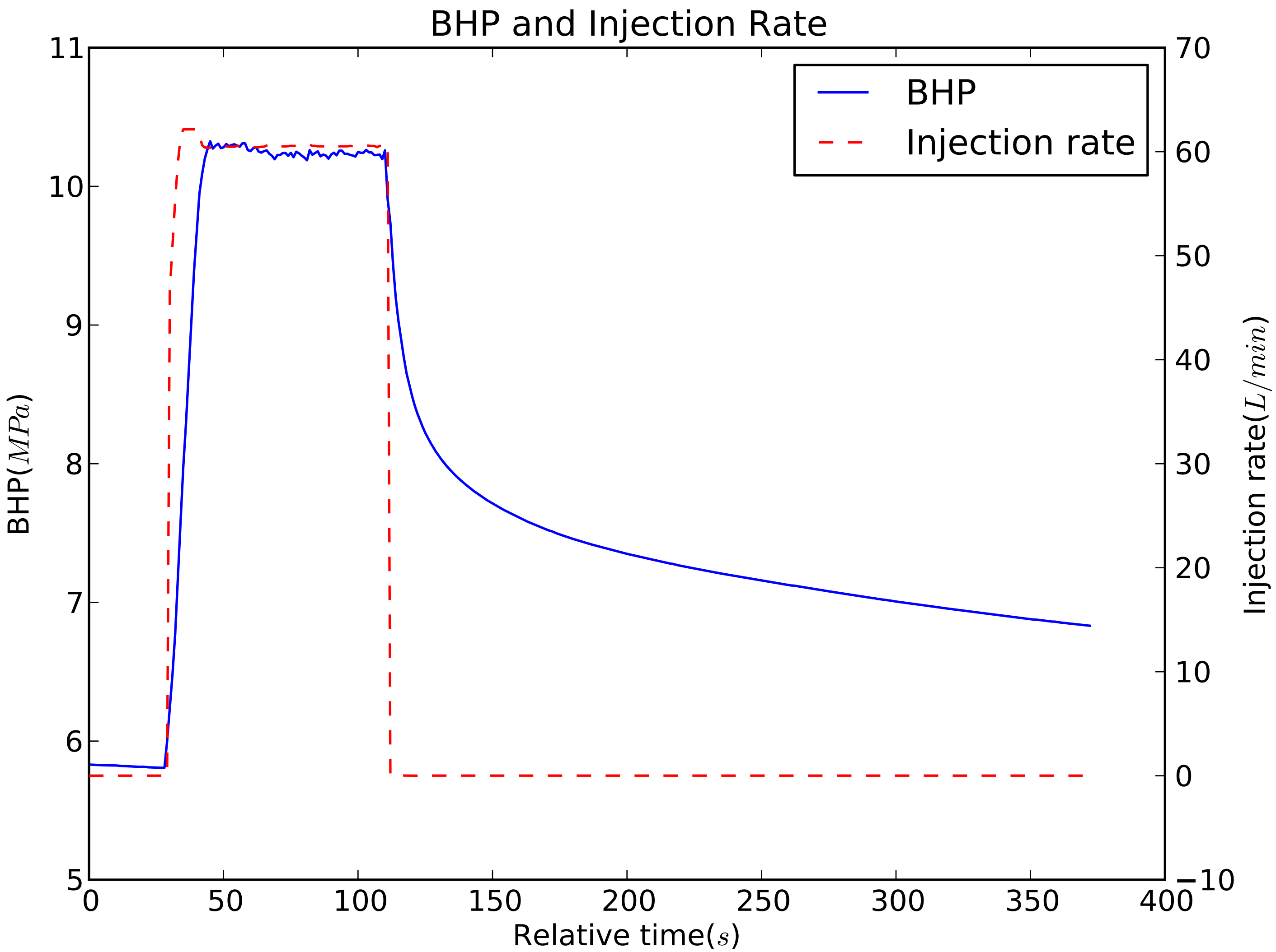
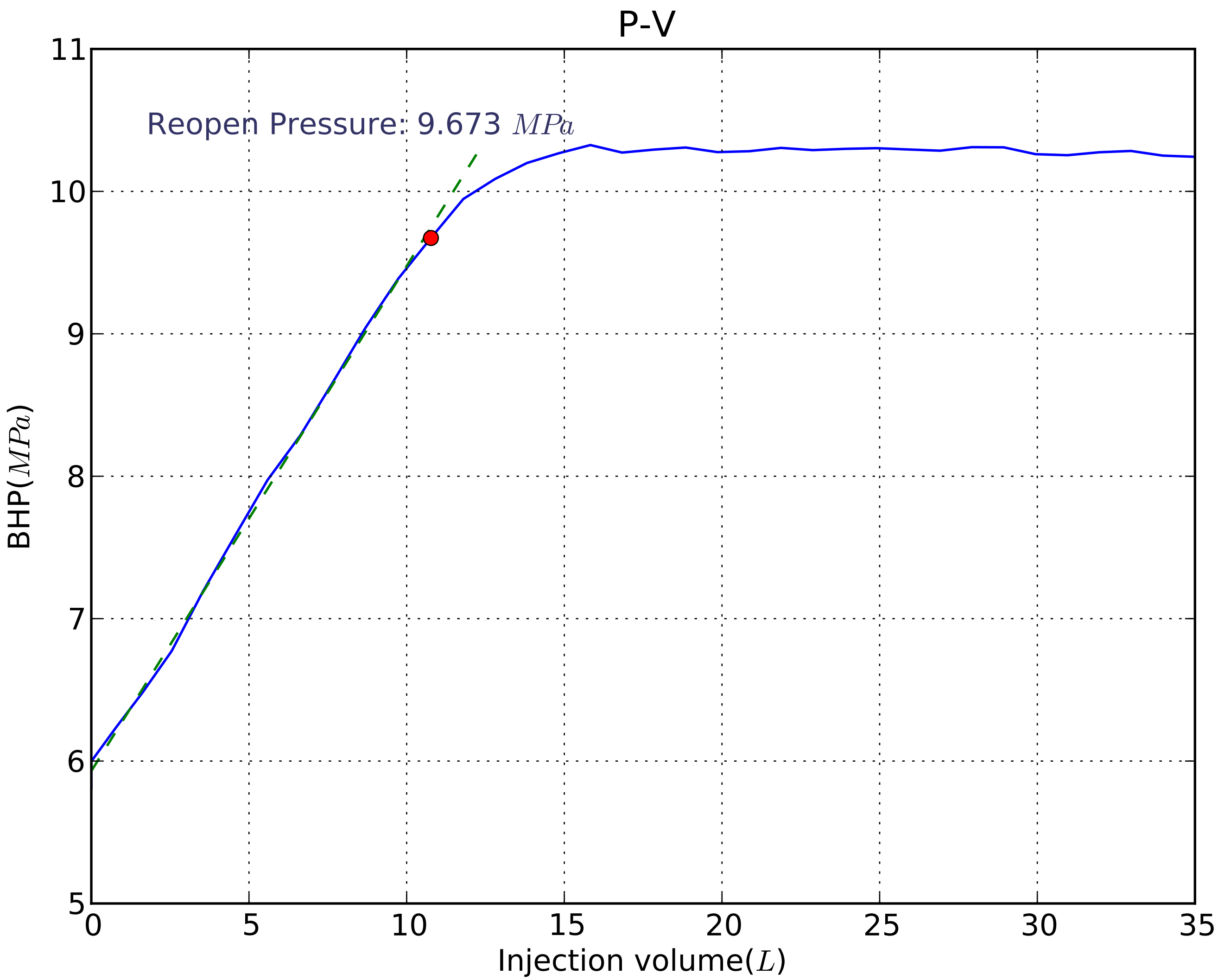


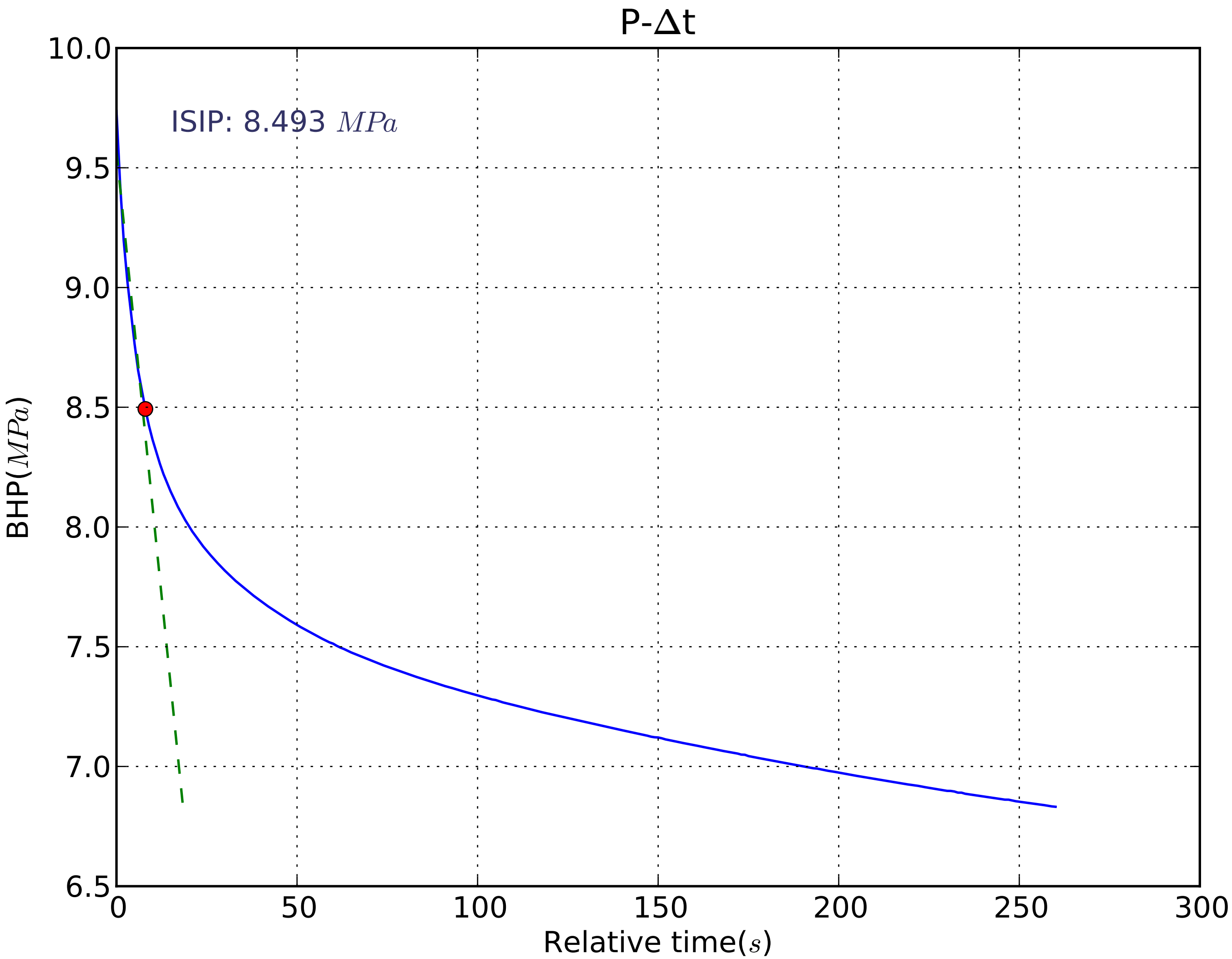

BHP and Injection Rate
BHP
Injection rate
BHP(MPa)
Injection rate(L/min)
Relative time(s)
11
10
9
8
7
6
5
70
60
50
40
30
20
10
0
−10
0
50
100
150
200
250
300
350
400

Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 04



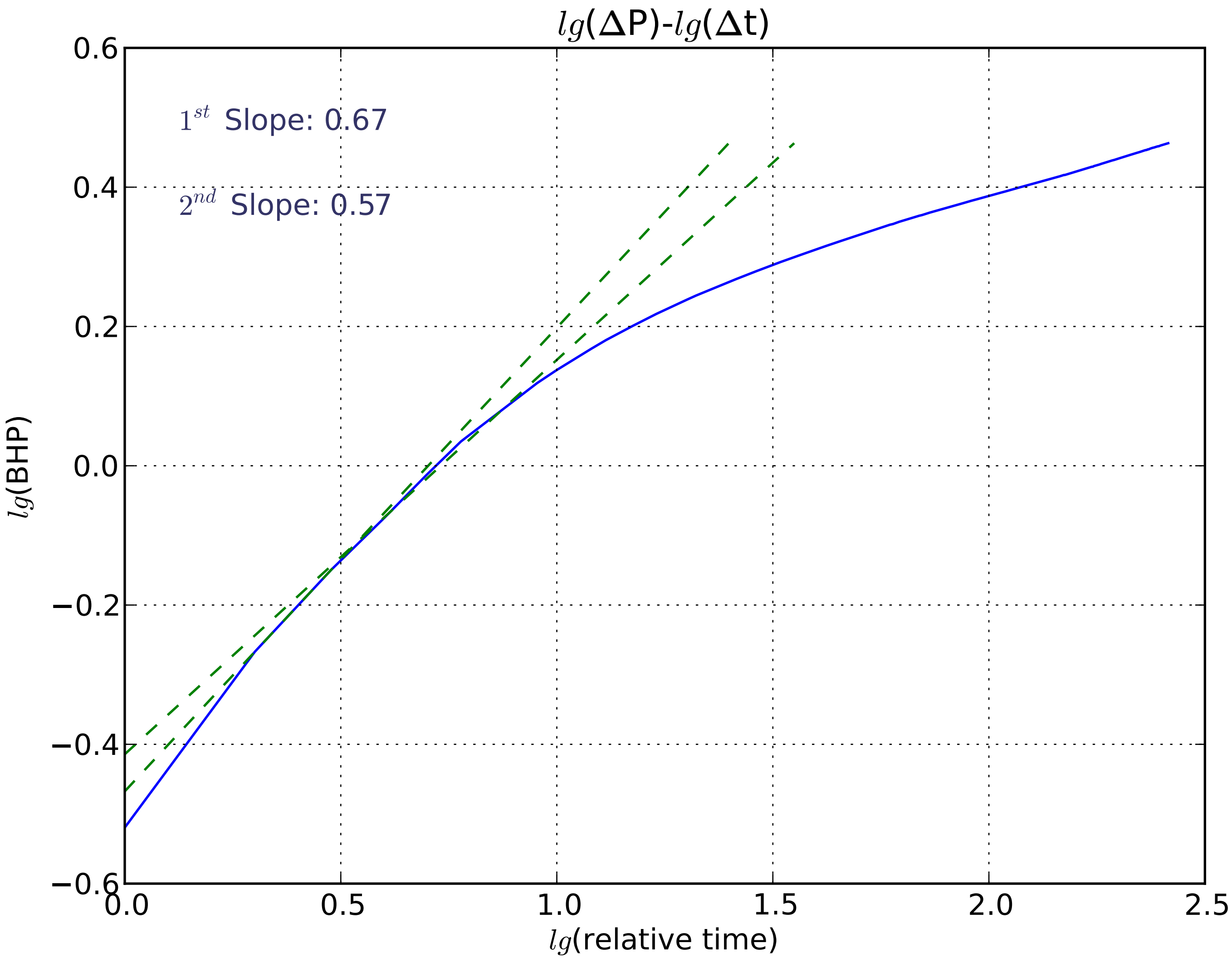
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.

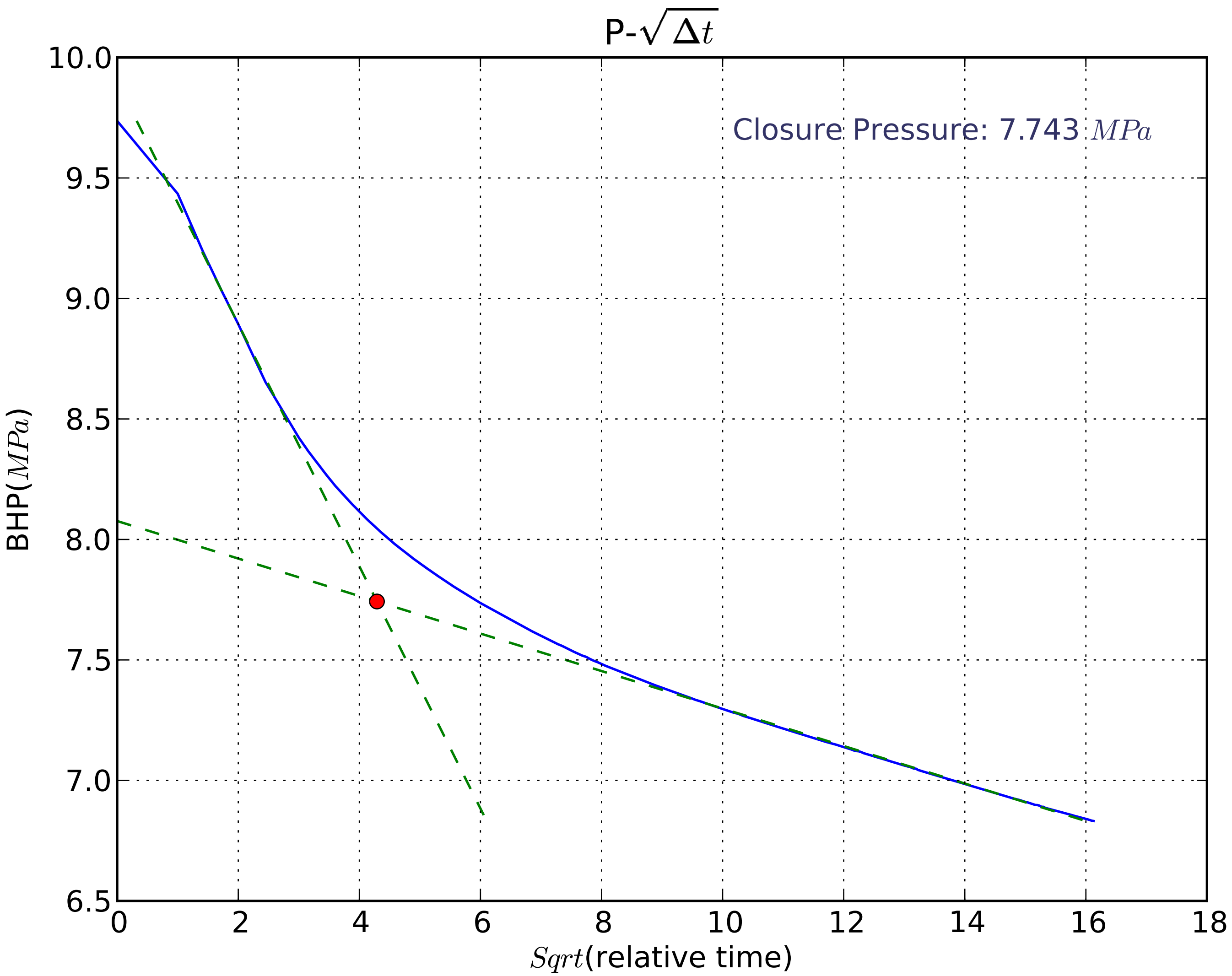


Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.

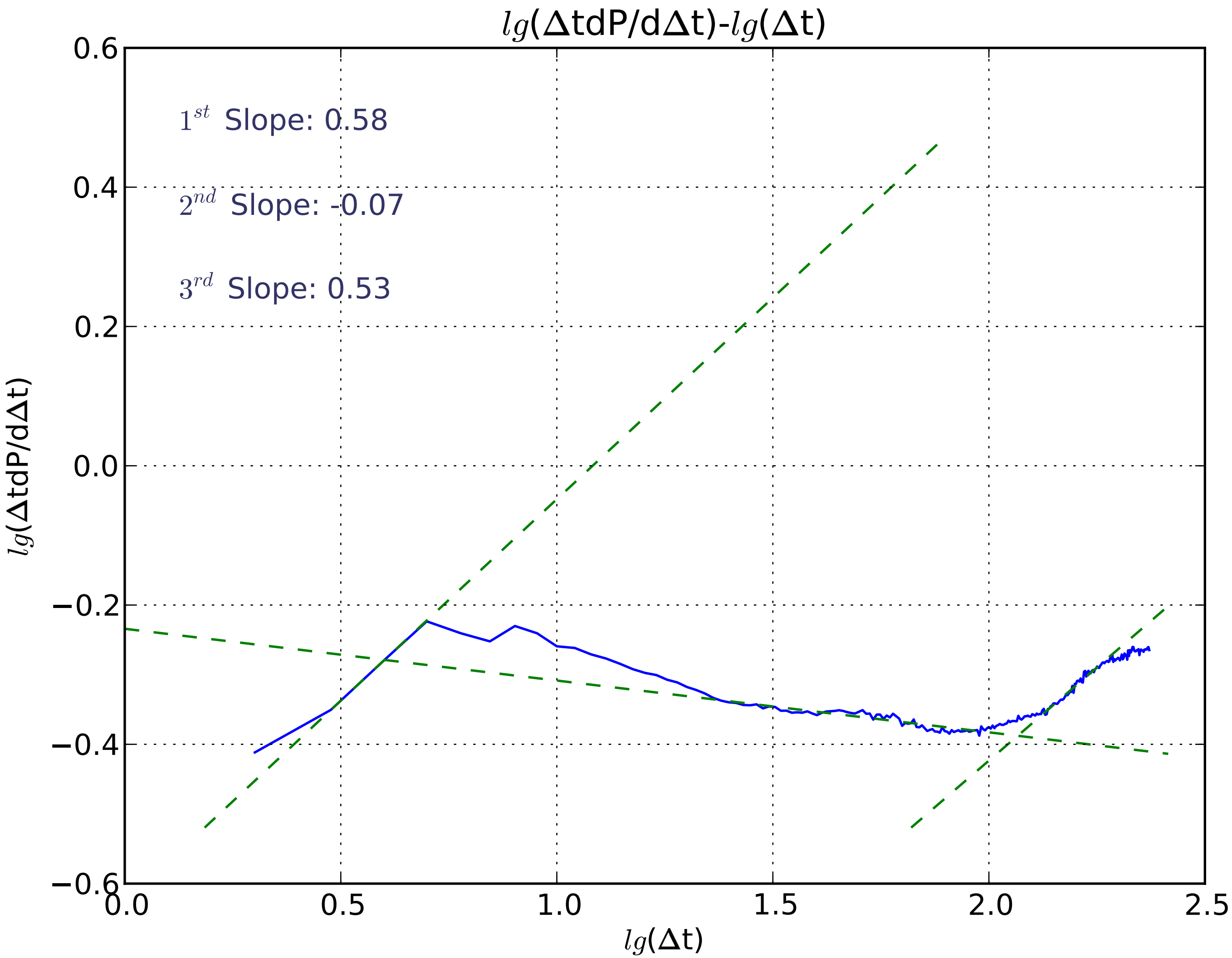


BitCan Geosciences & Engineering Inc.



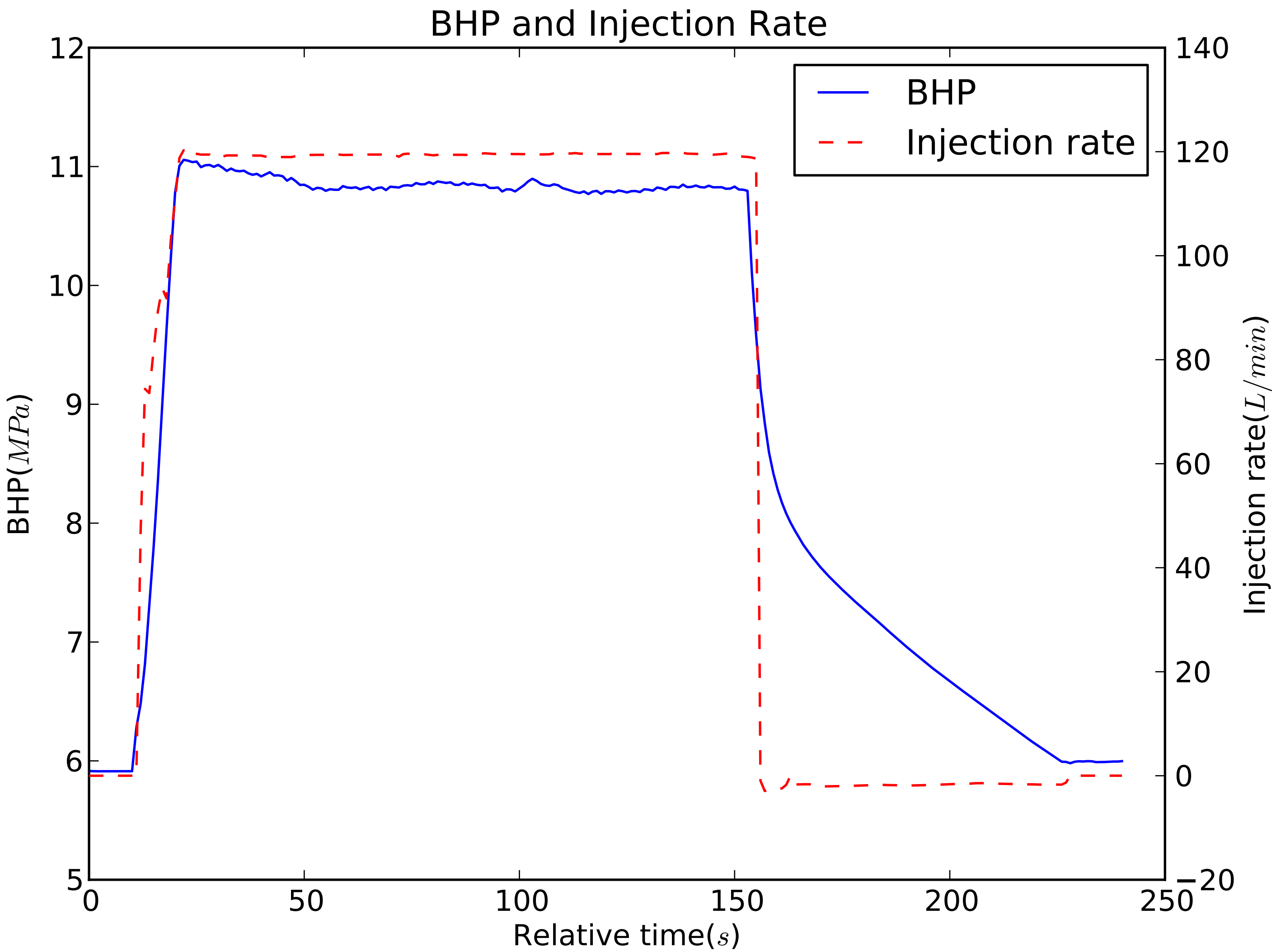
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.



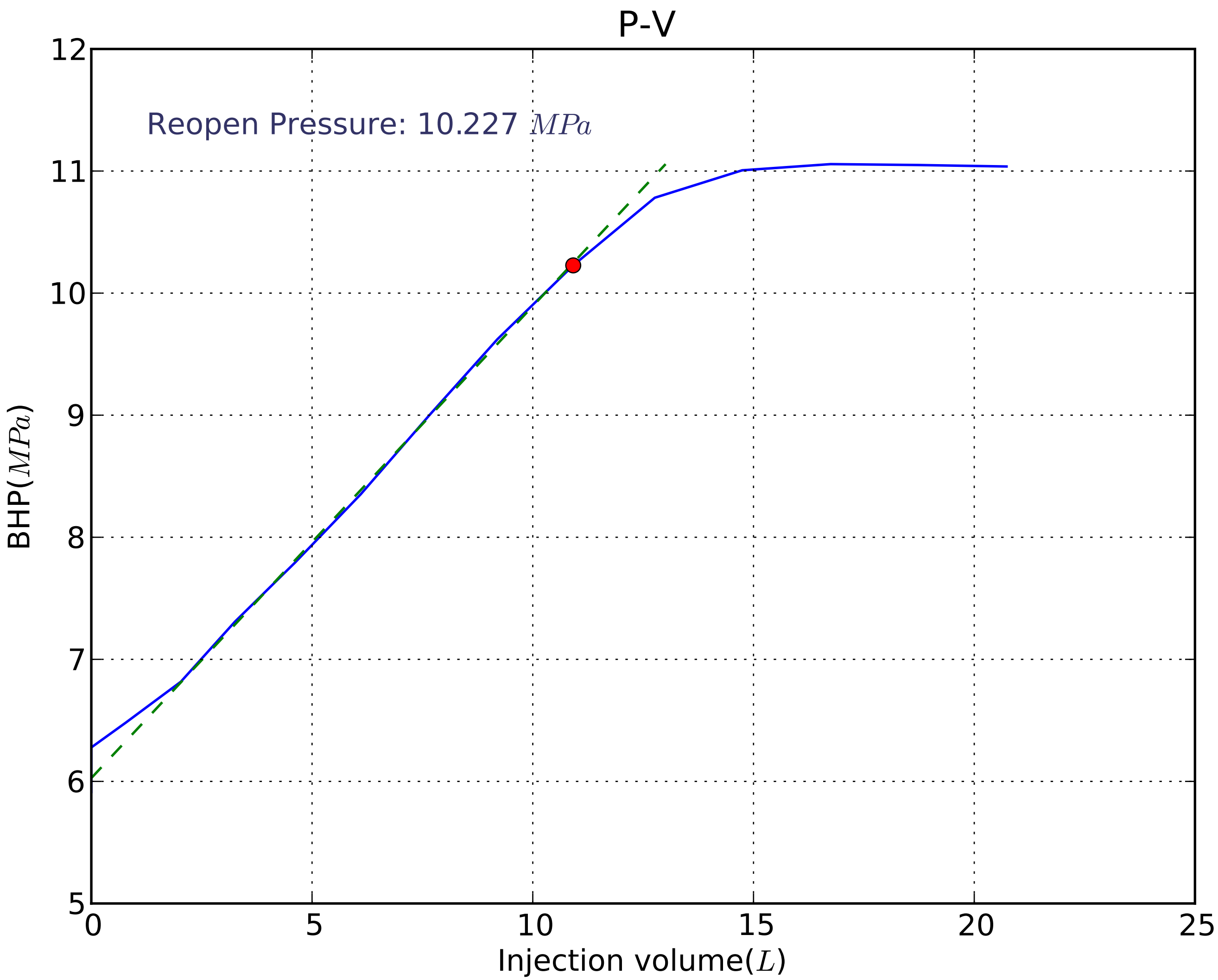
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 05

BitCan
Geosciences & Engineering Inc.



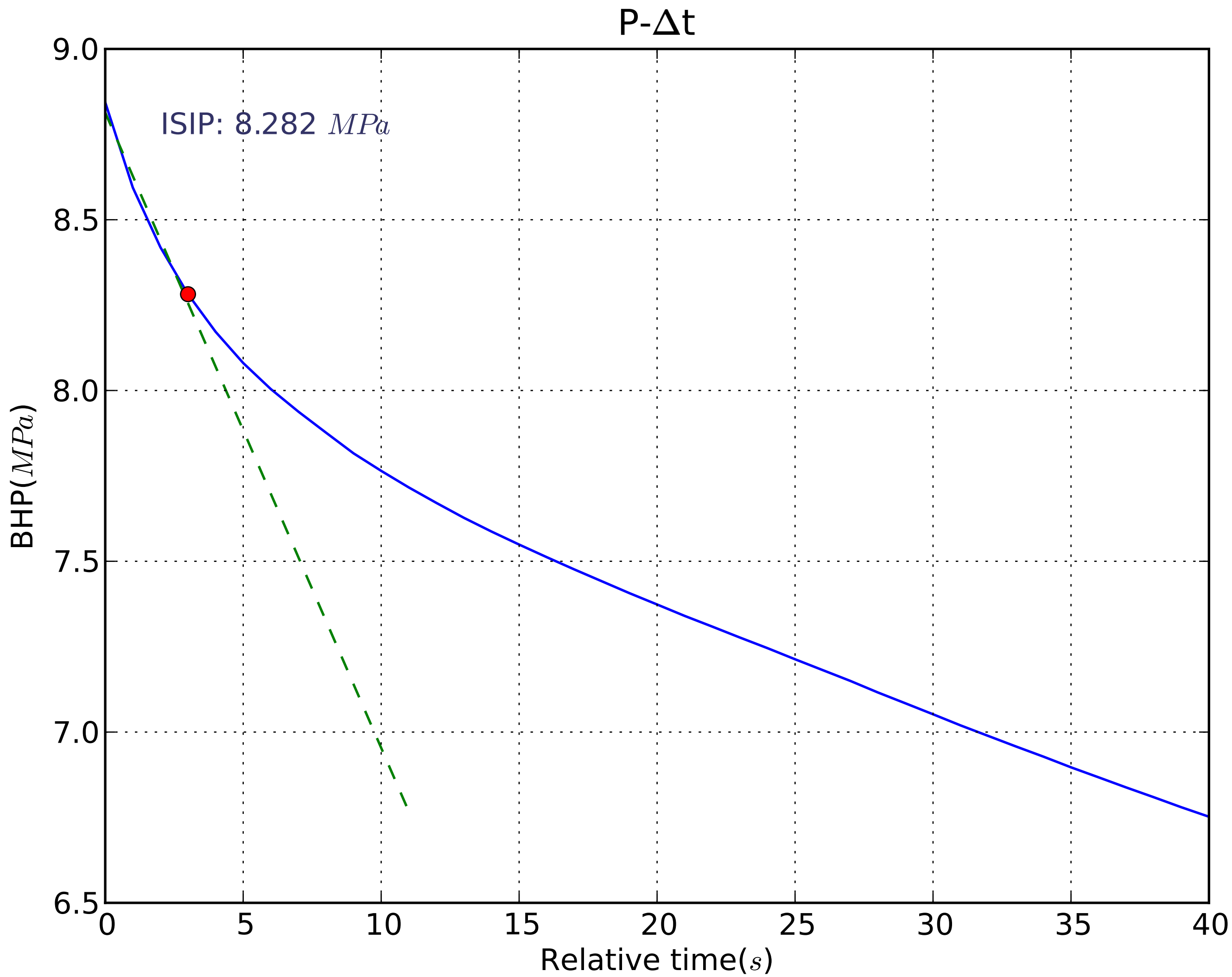
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 05

BitCan
Geosciences & Engineering Inc.

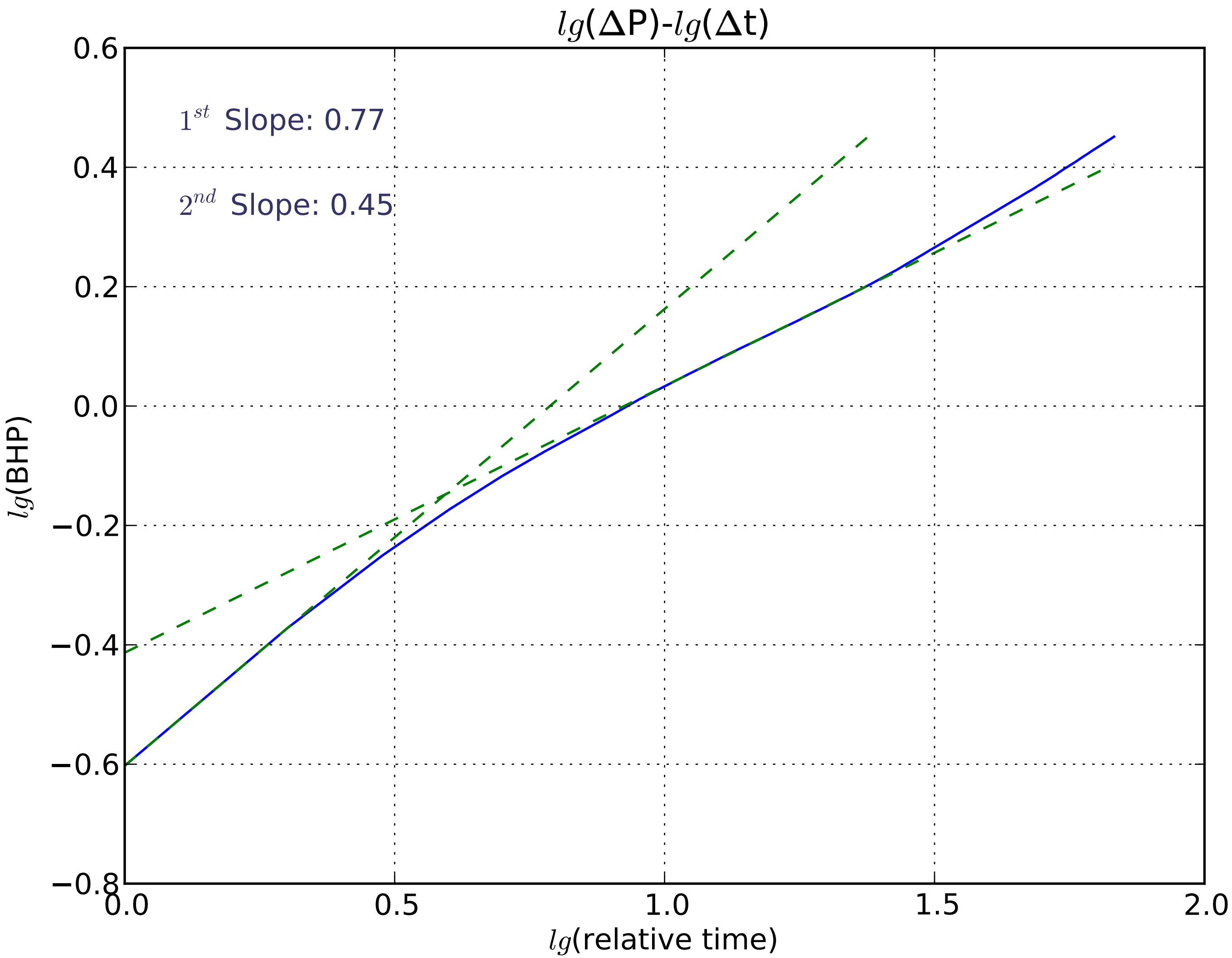


Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 05

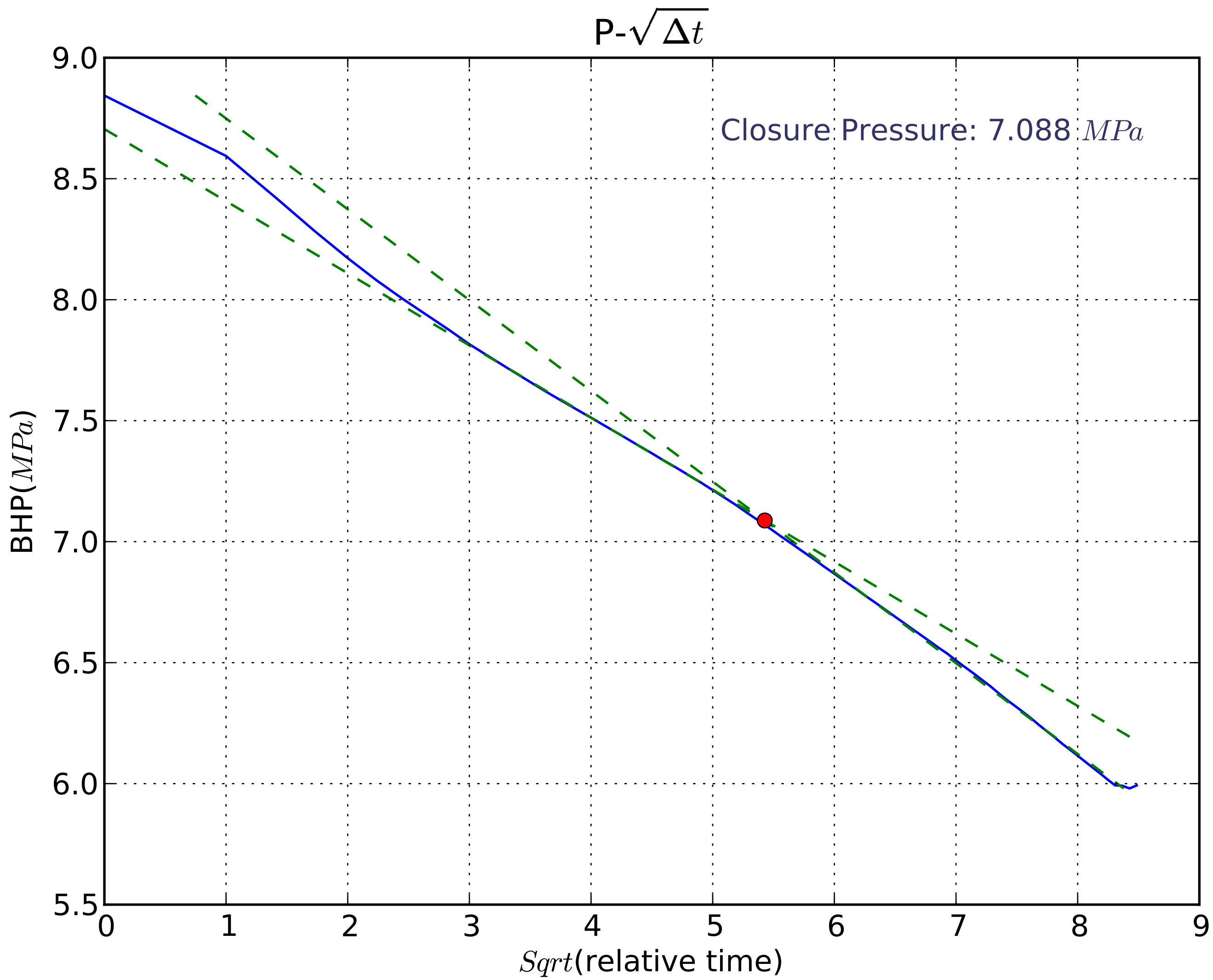
BitCan
Geosciences & Engineering Inc.



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 05

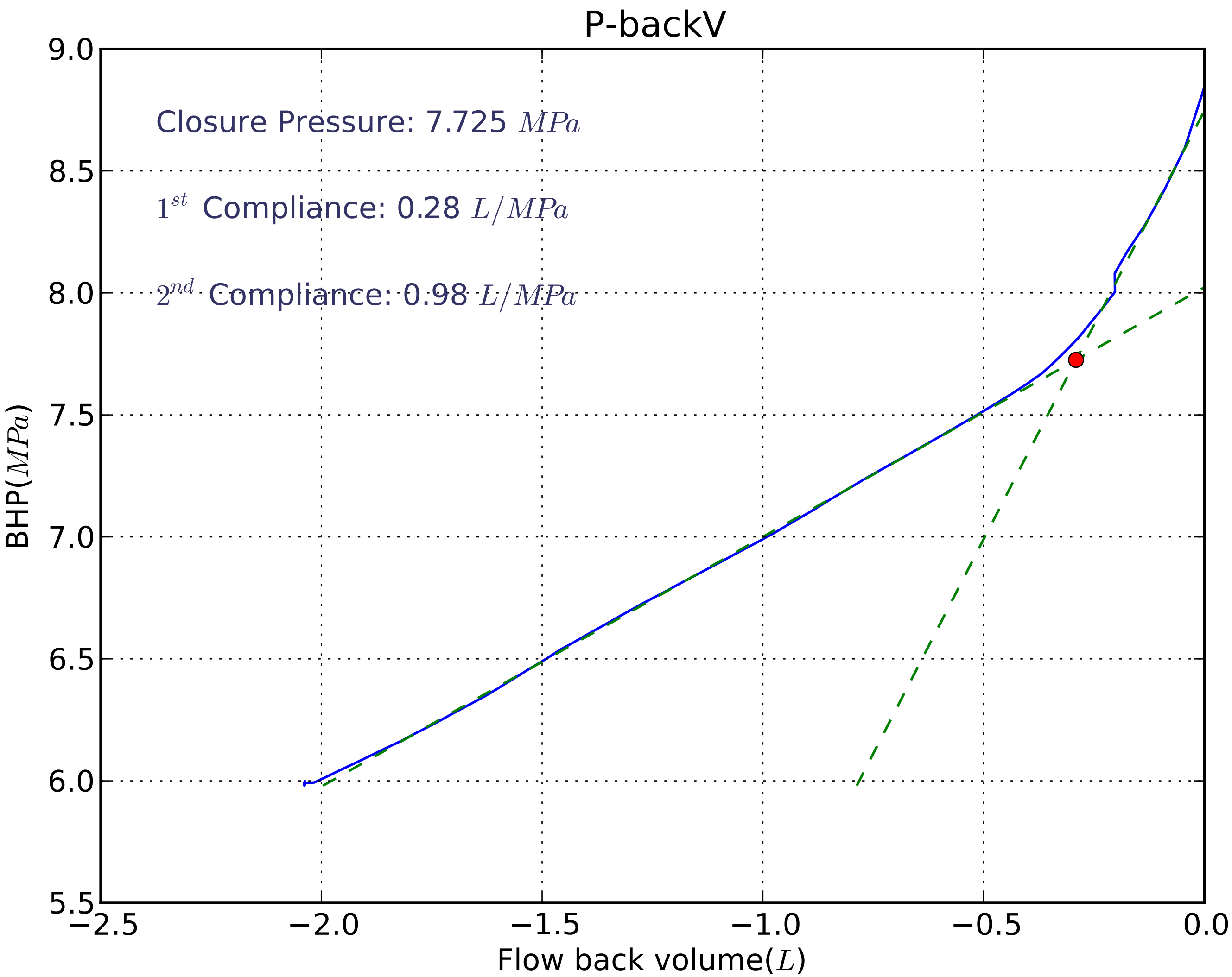


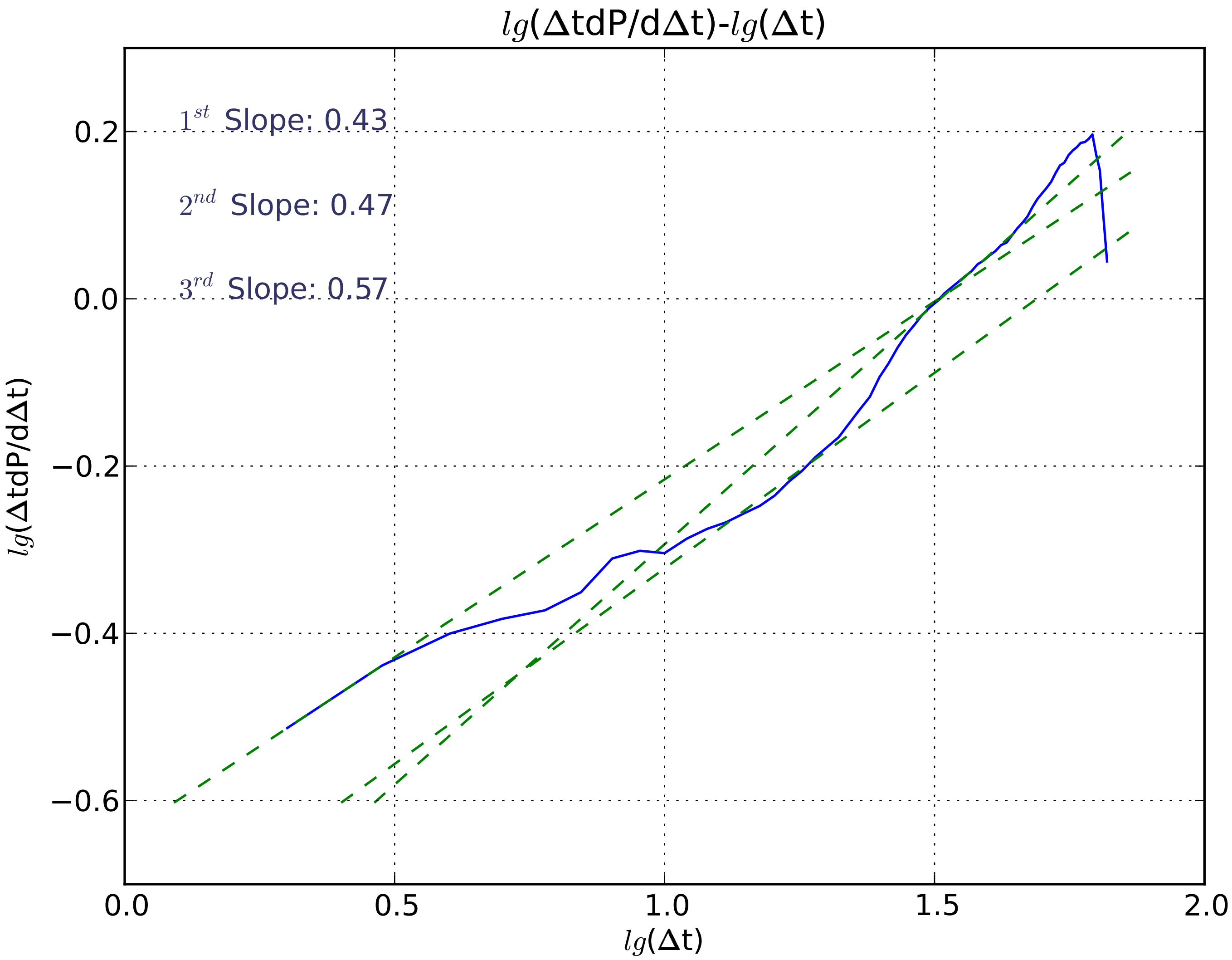
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 05



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 05

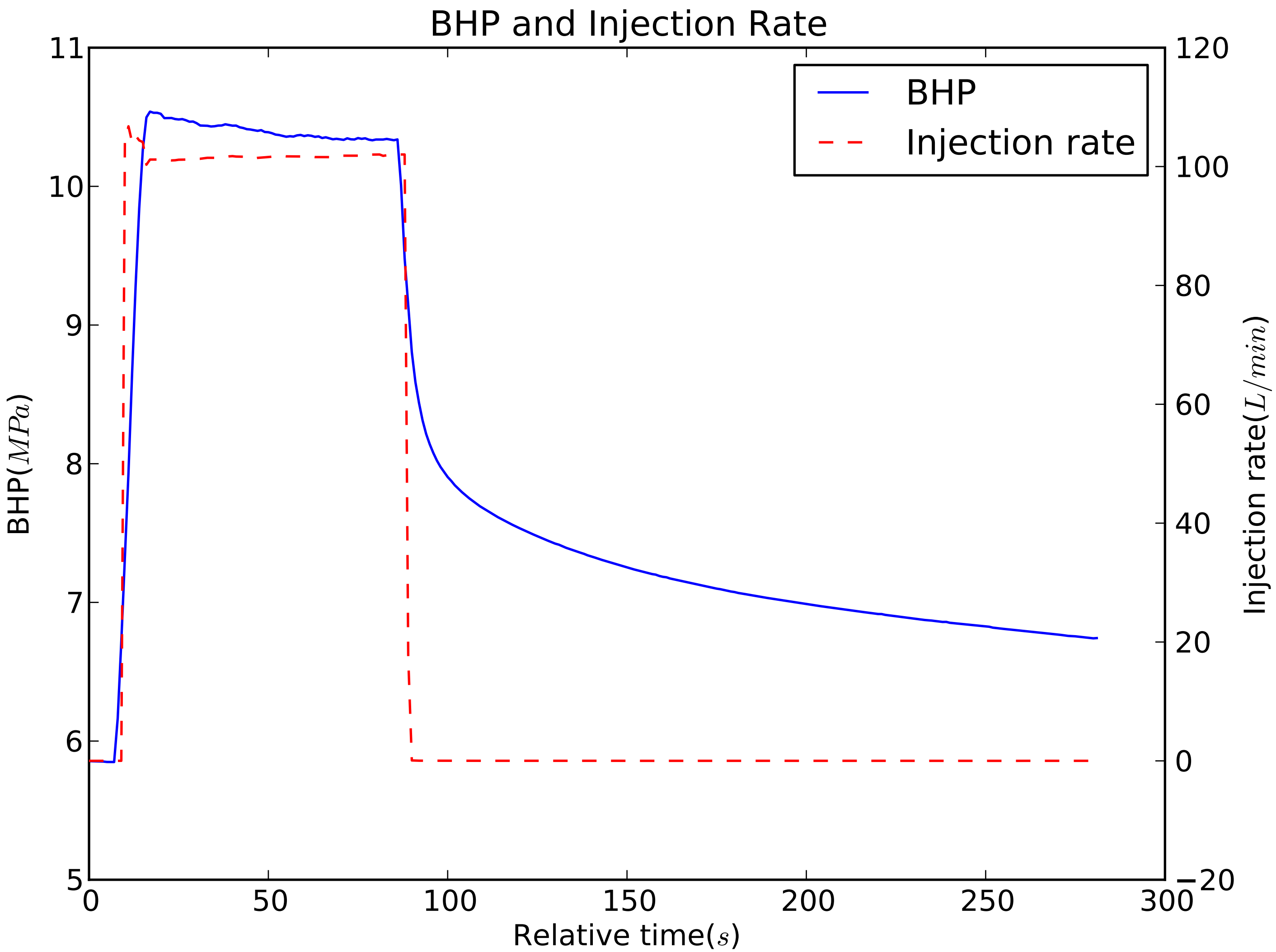
BitCan
Geosciences & Engineering Inc.




$lg(\Delta tdP/d\Delta t)$-$lg(\Delta t)$
1^{st} Slope: 0.43
2^{nd} Slope: 0.47
3^{rd} Slope: 0.57
0.2
0.0
−0.2
−0.4
−0.6
0.0
0.5
1.0
1.5
2.0
$lg(\Delta tdP/d\Delta t)$
$lg(\Delta t)$

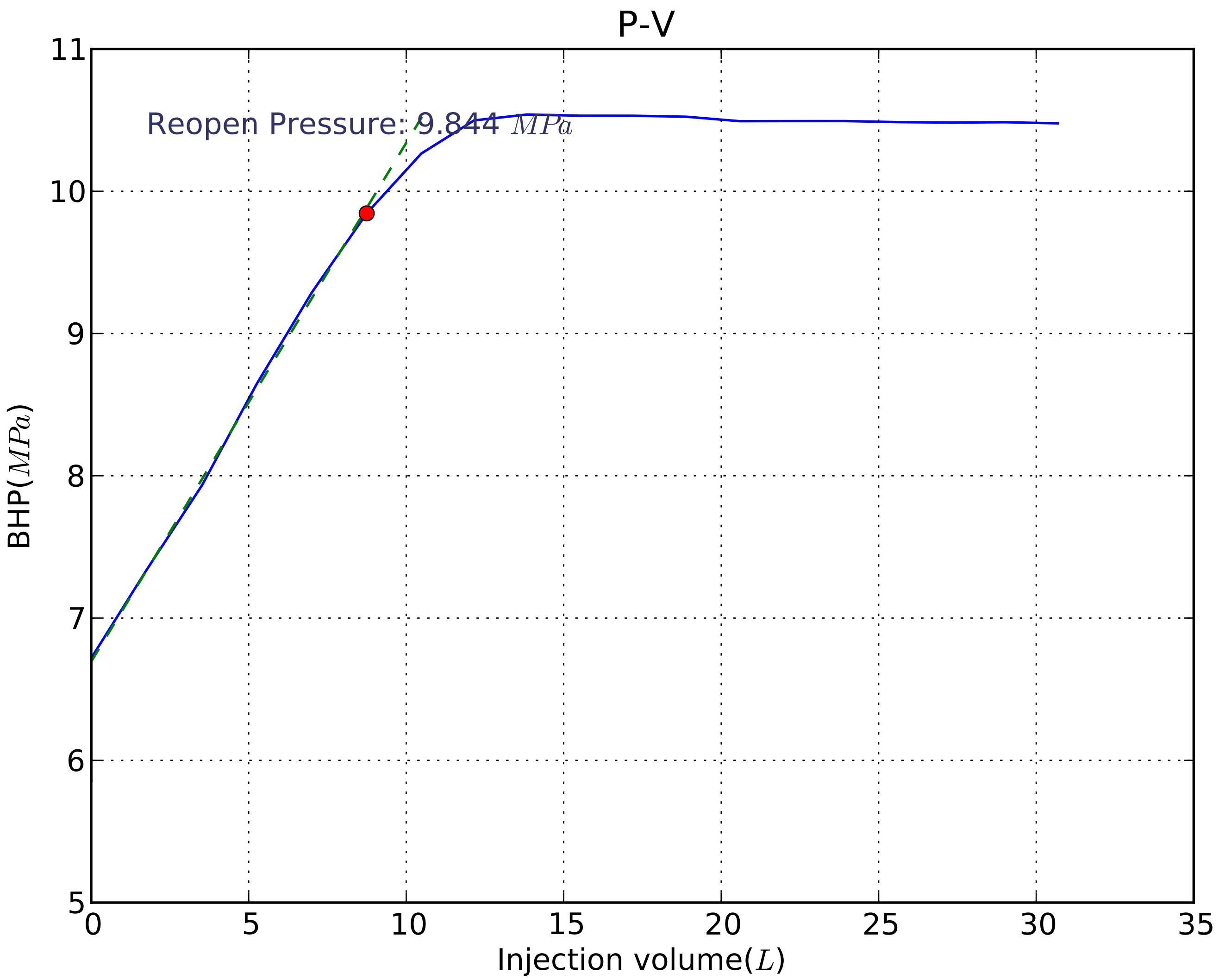
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 06

BitCan
Geosciences & Engineering Inc.

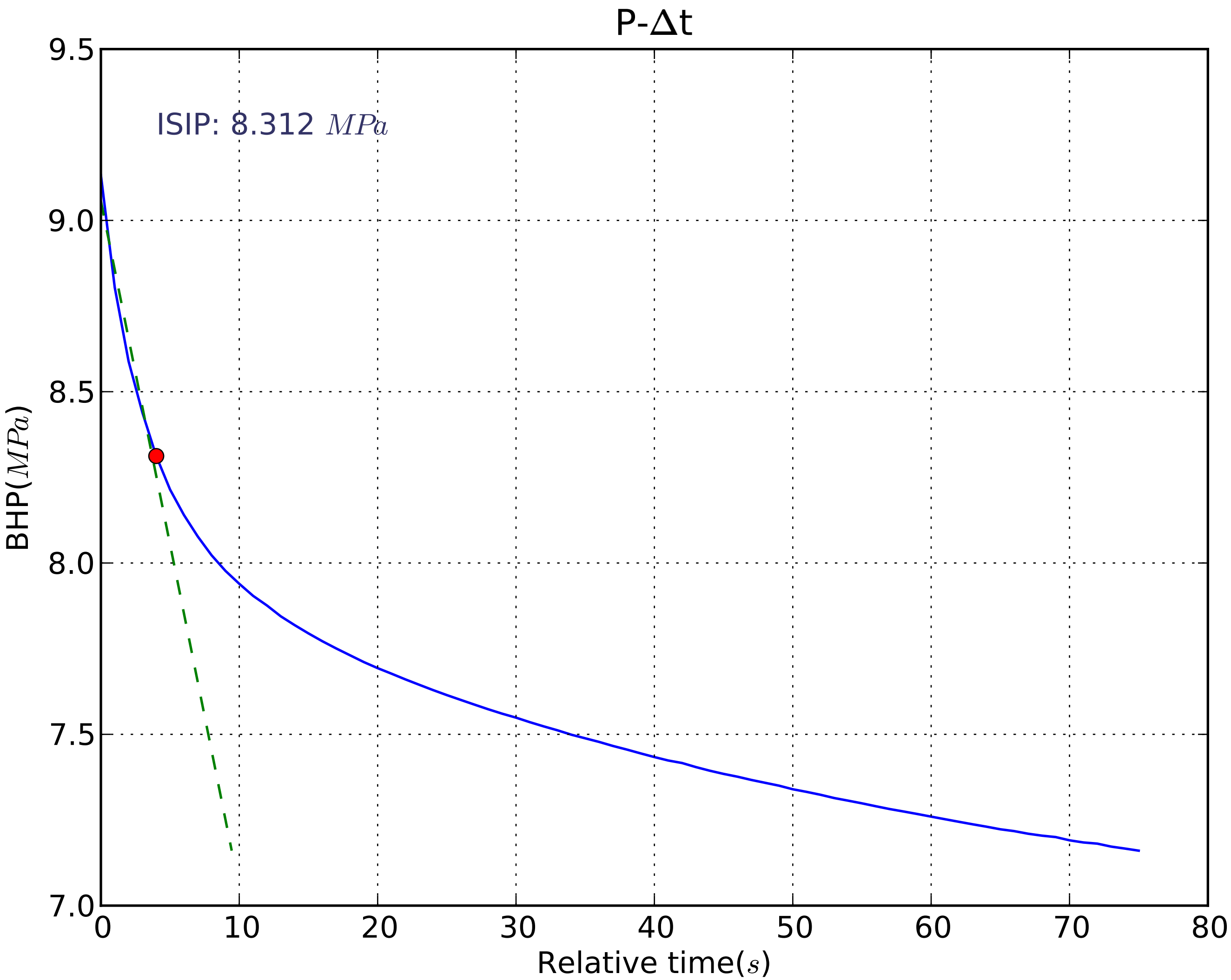


Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 06

BitCan
Geosciences & Engineering Inc.

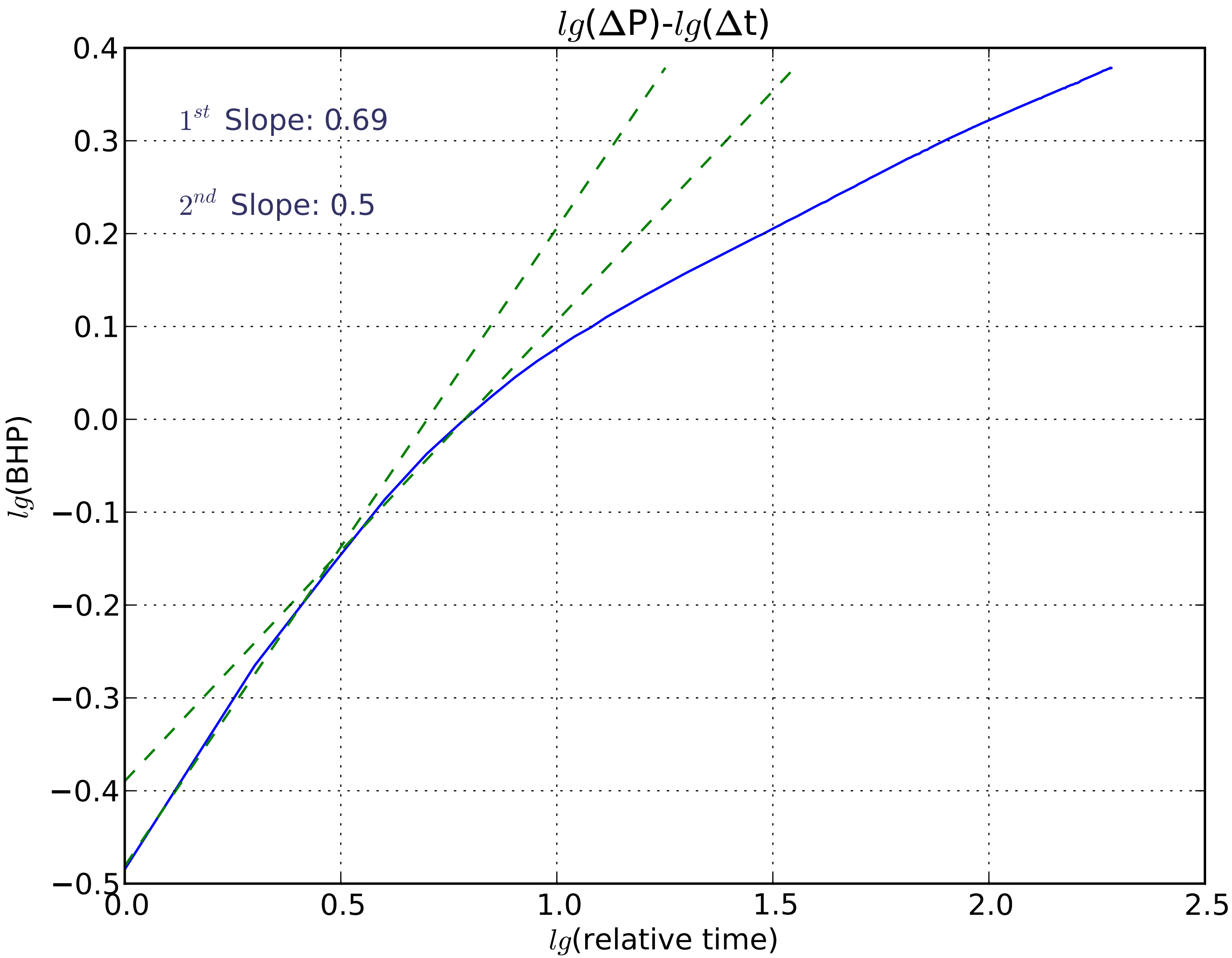


BitCan
Geosciences & Engineering Inc.



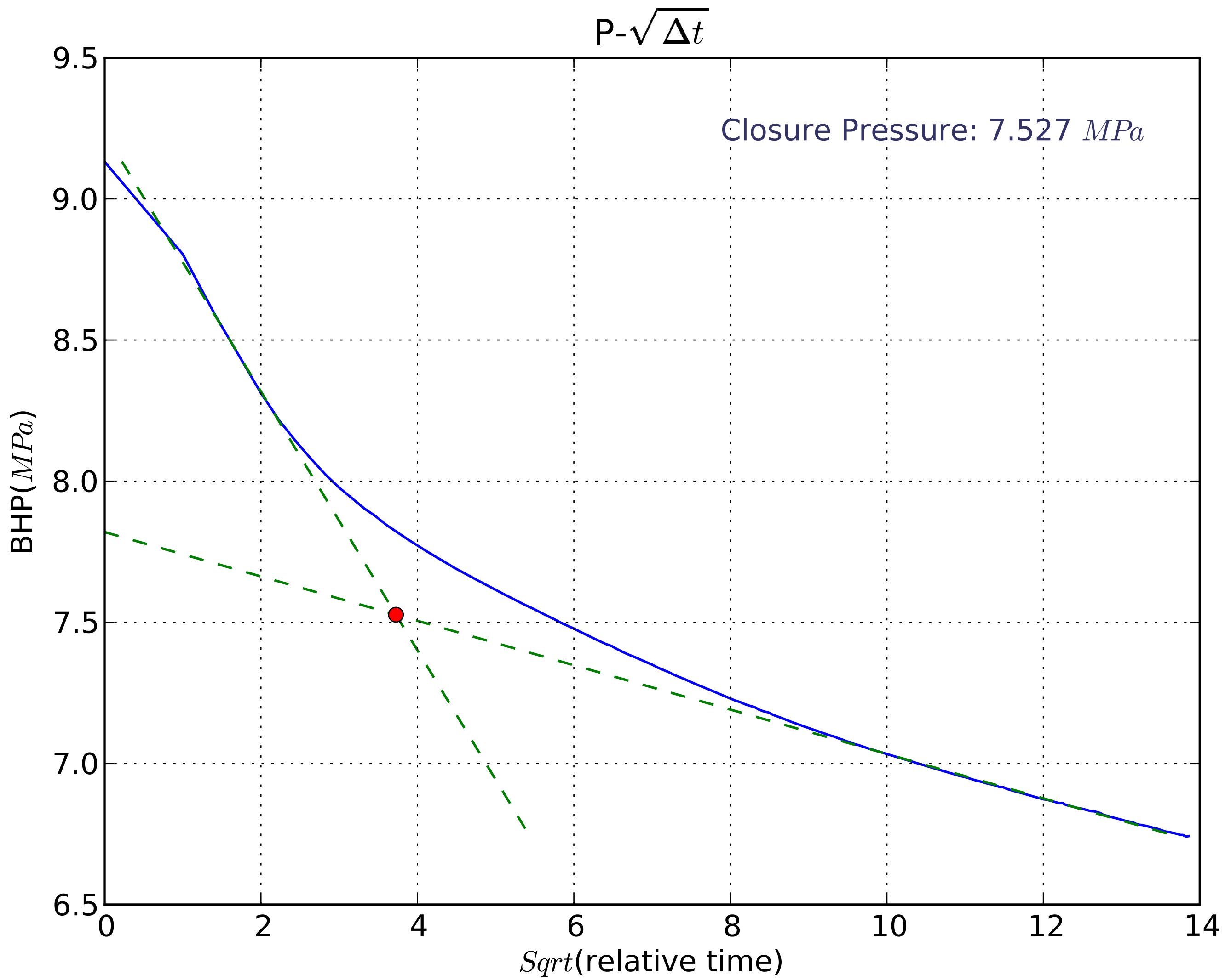
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 06

BitCan
Geosciences & Engineering Inc.



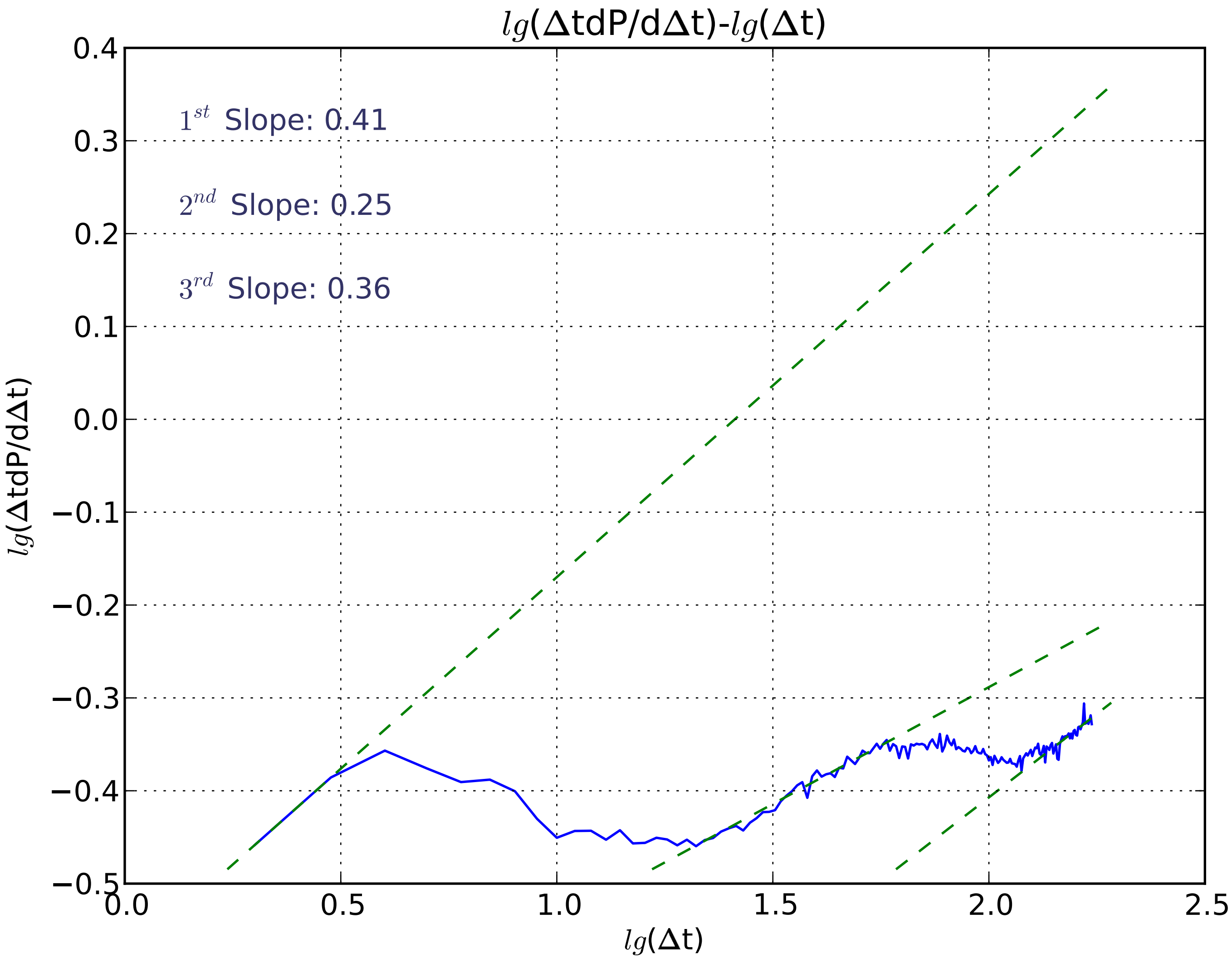
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 06

BitCan
Geosciences & Engineering Inc.



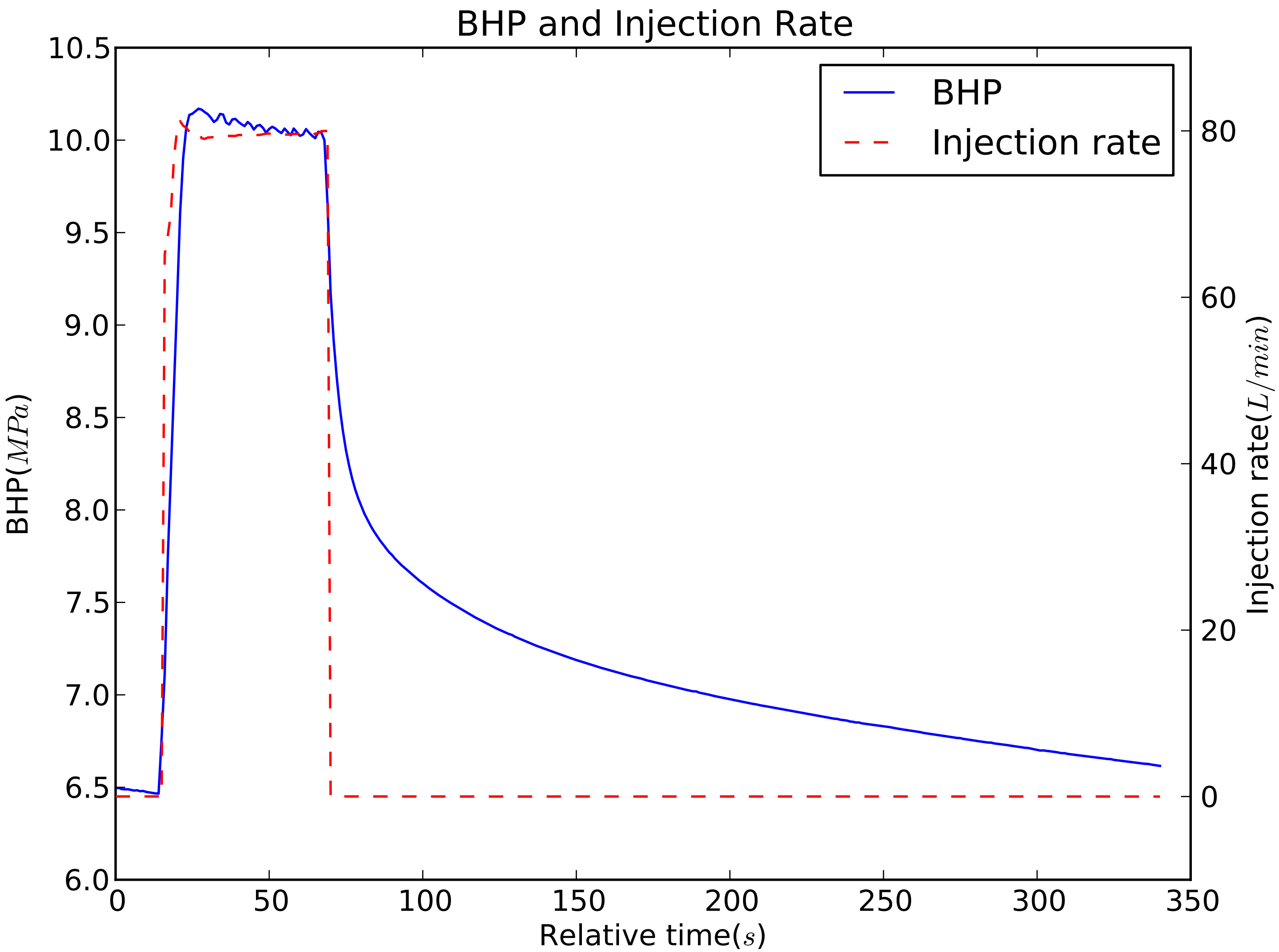
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 06

BitCan
Geosciences & Engineering Inc.



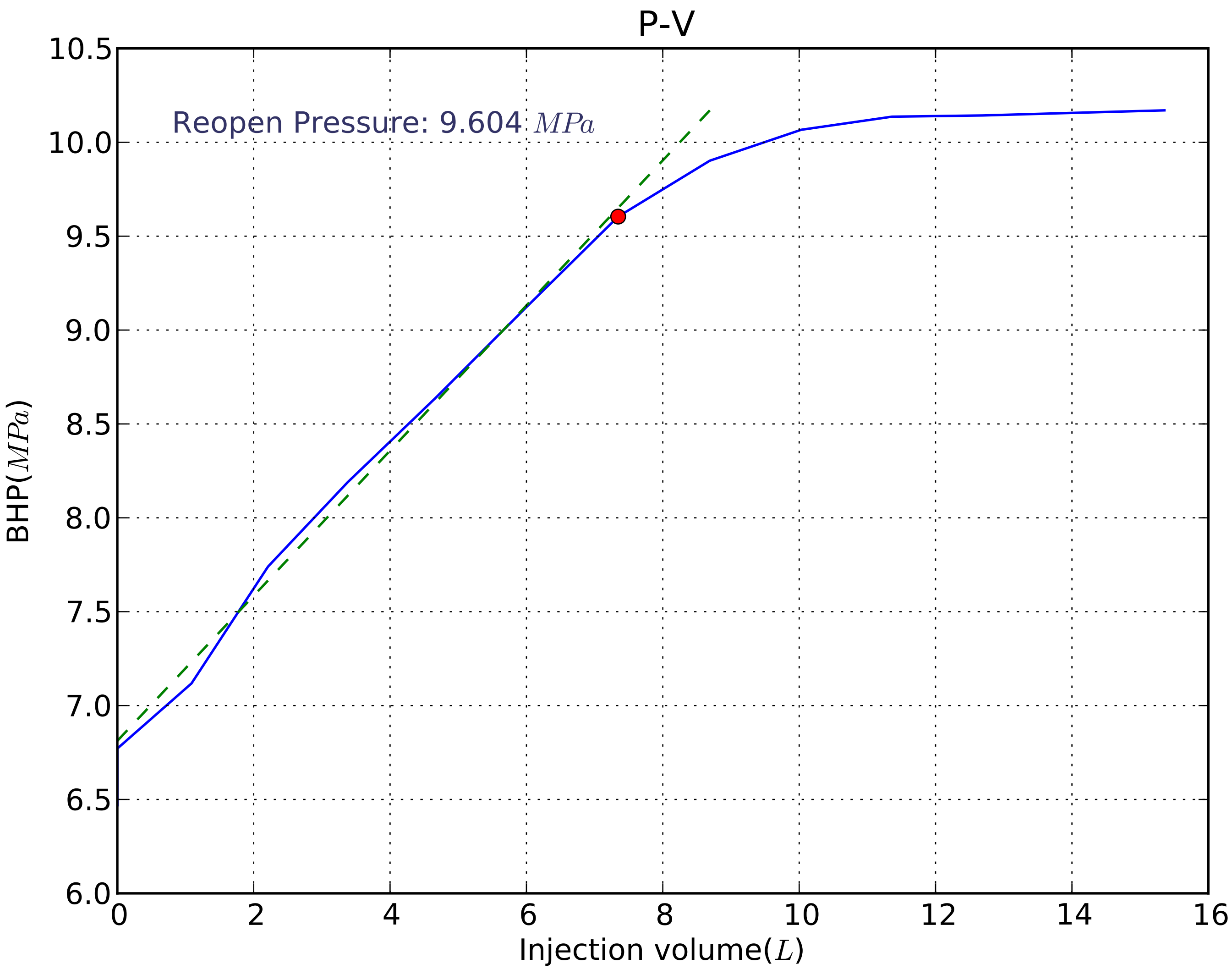
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 07

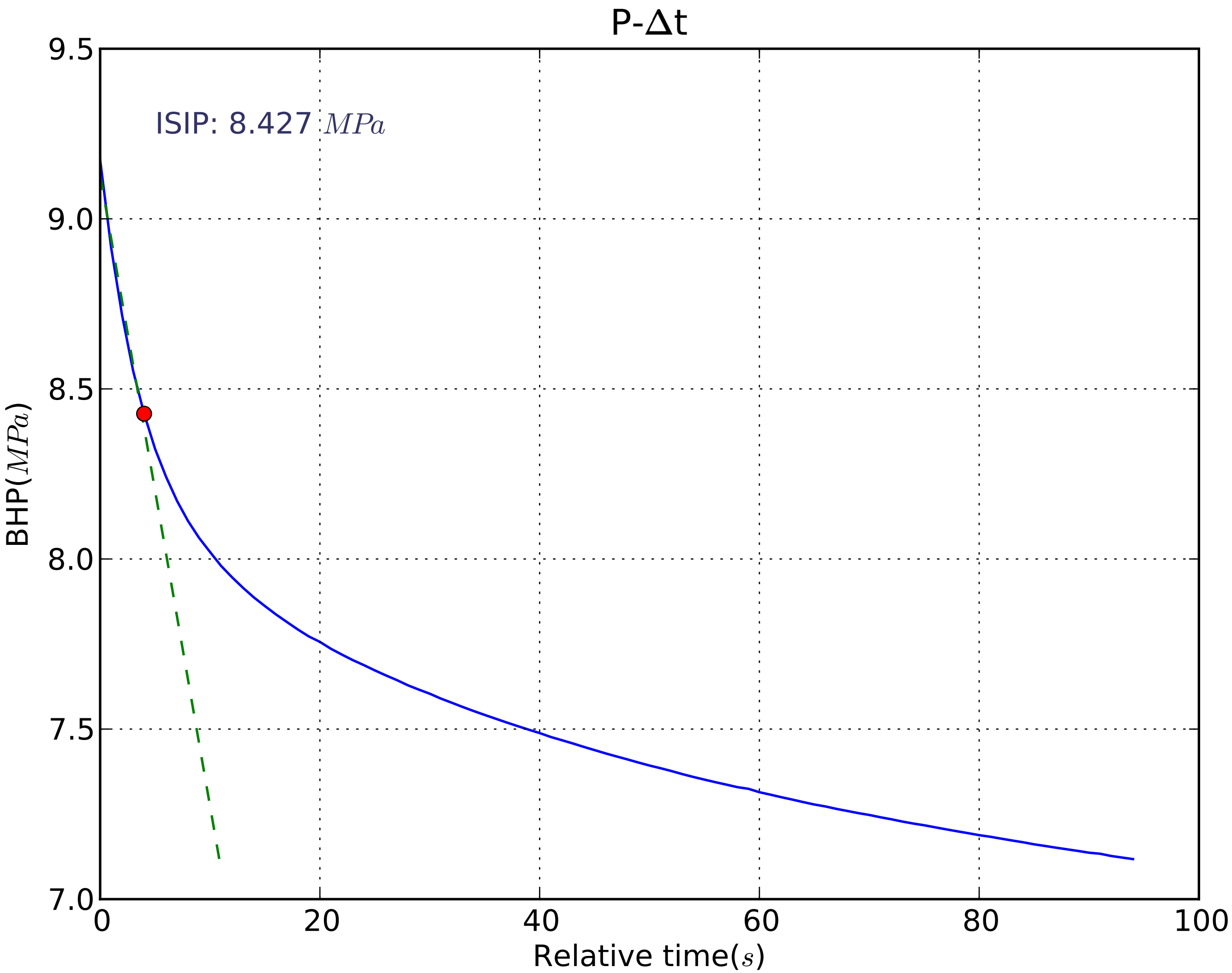
BitCan Geosciences & Engineering Inc.



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 07

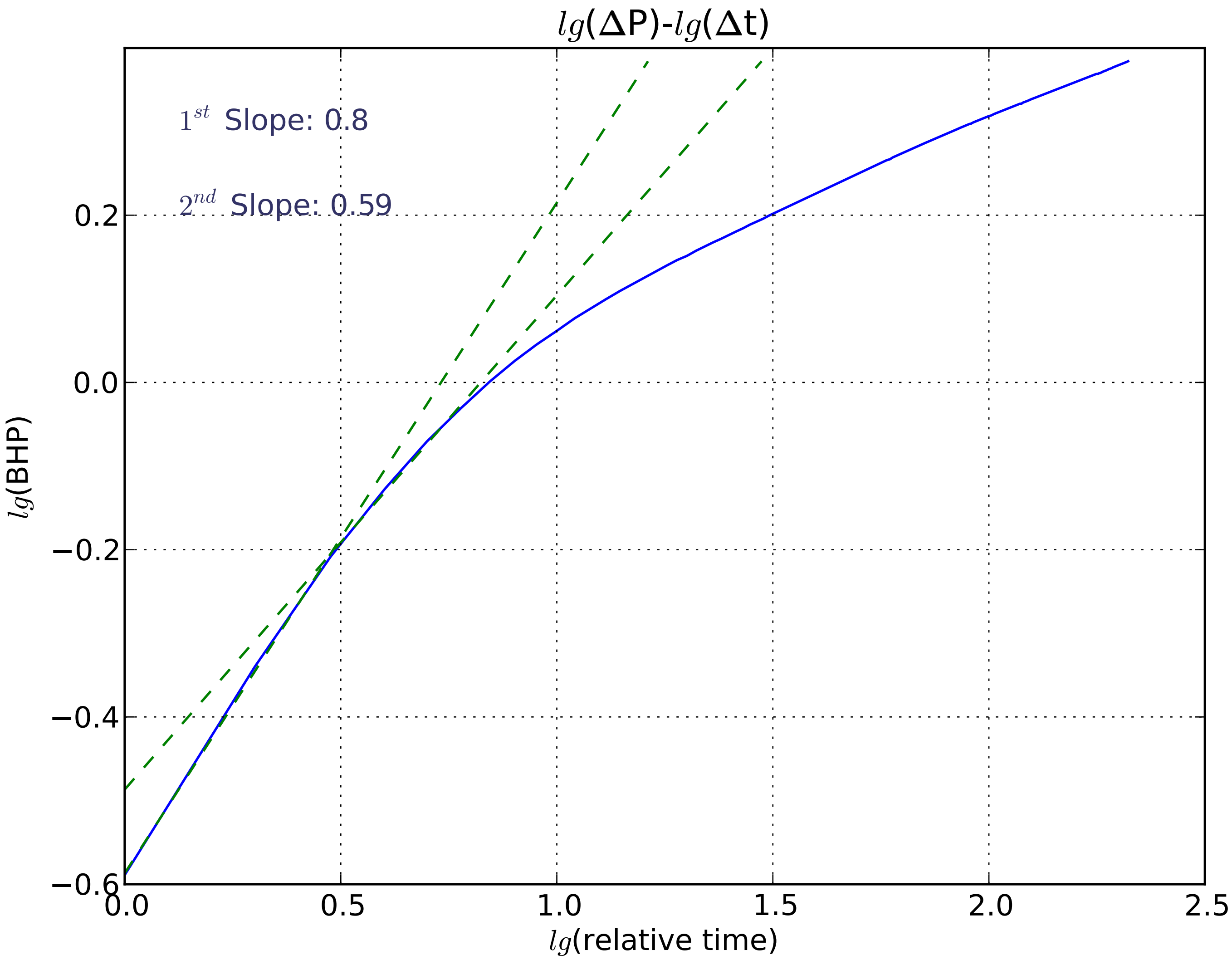
BitCan
Geosciences & Engineering Inc.




P-Δt
ISIP: 8.427 MPa
BHP(MPa)
Relative time(s)
9.5
9.0
8.5
8.0
7.5
7.0
0
20
40
60
80
100

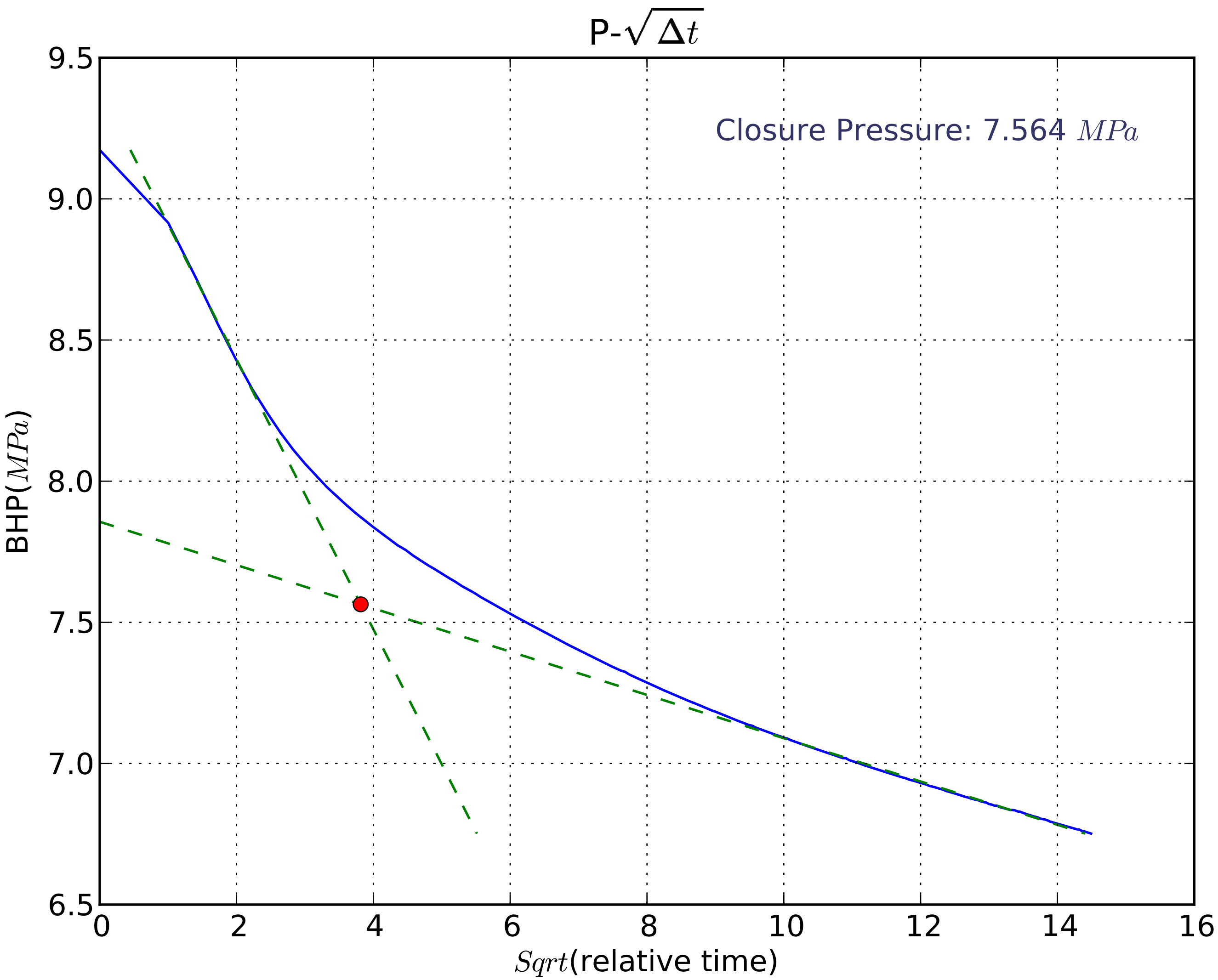
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 07

BitCan
Geosciences & Engineering Inc.



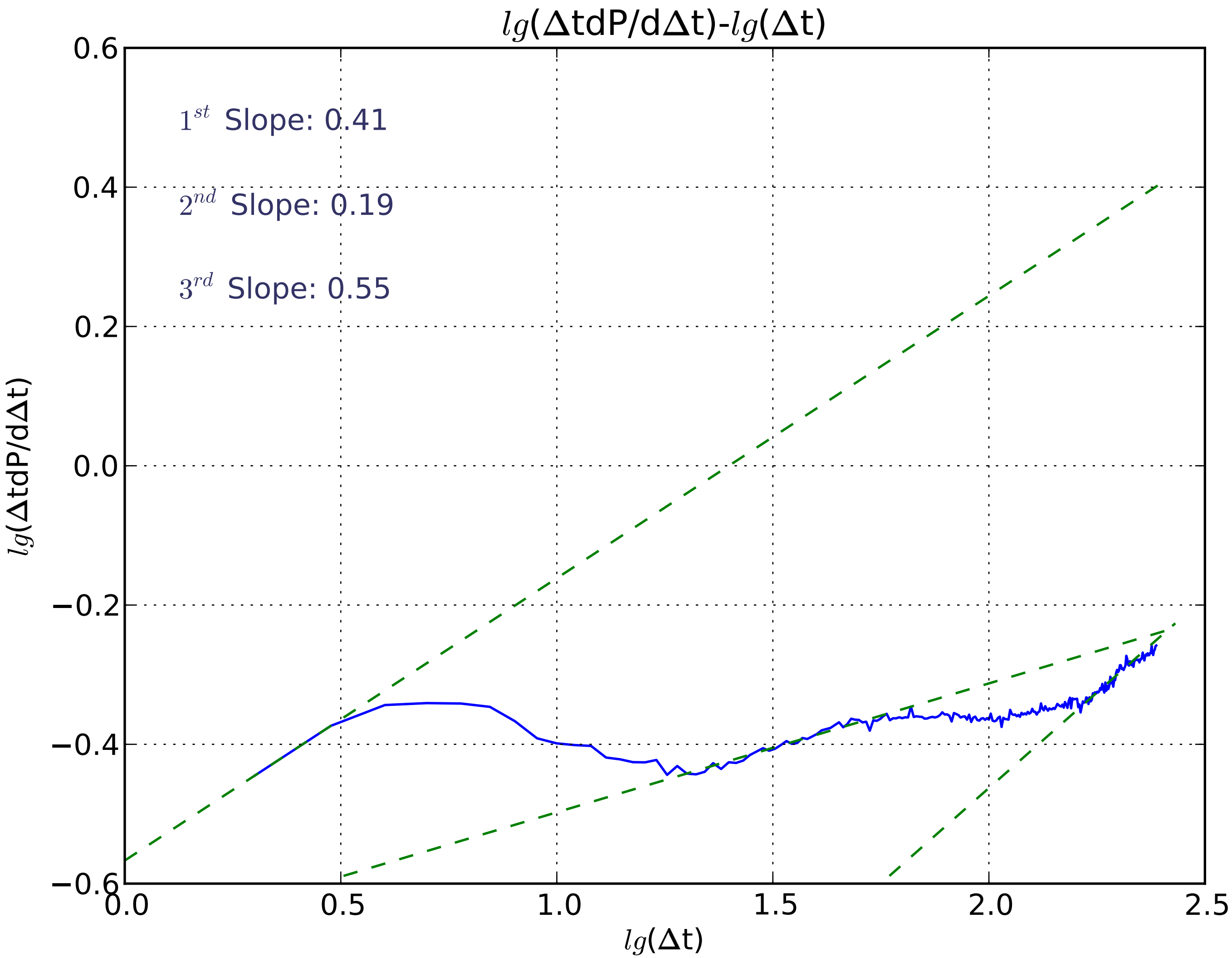
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 07

BitCan
Geosciences & Engineering Inc.



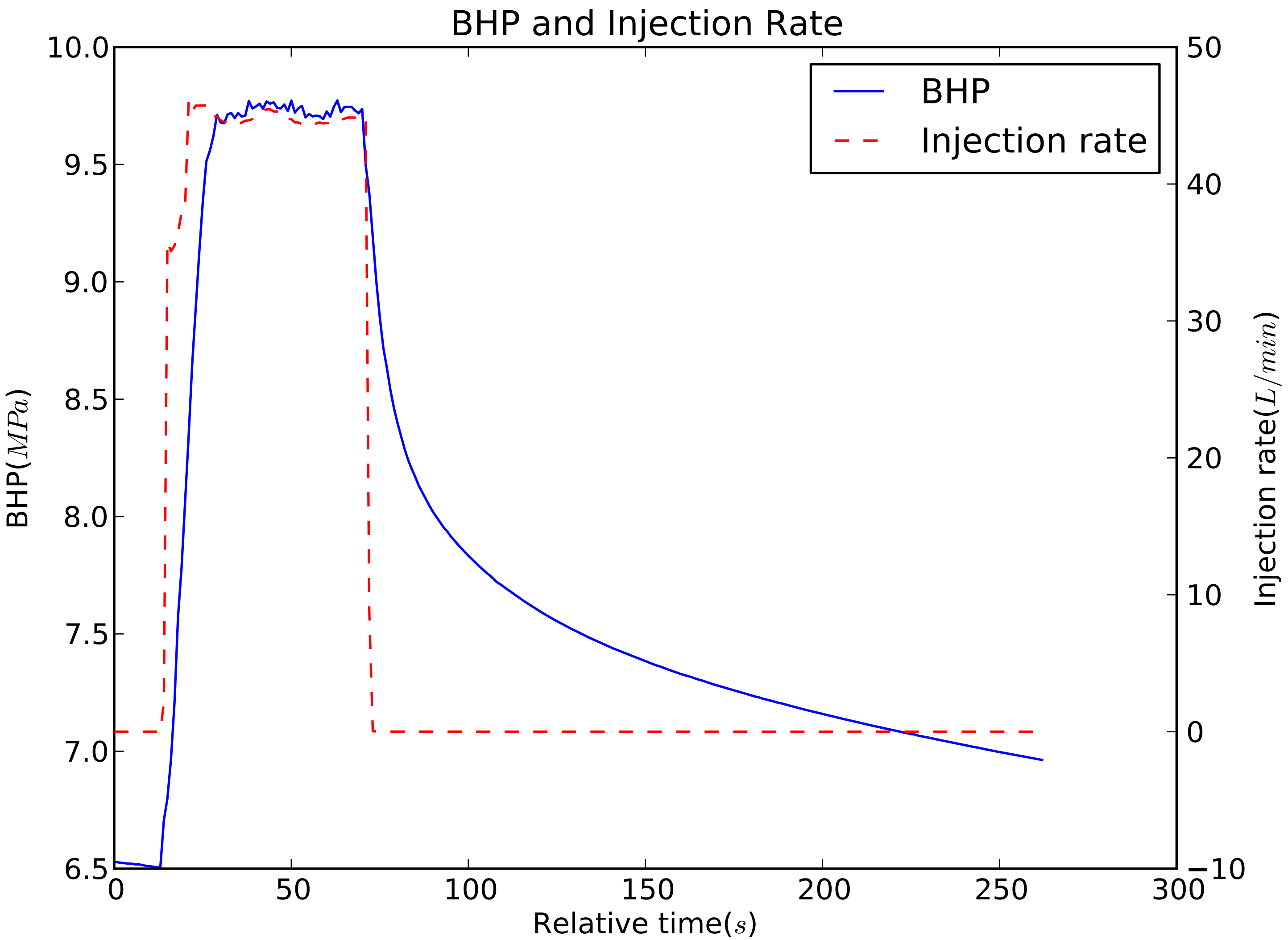
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 07

BitCan
Geosciences & Engineering Inc.



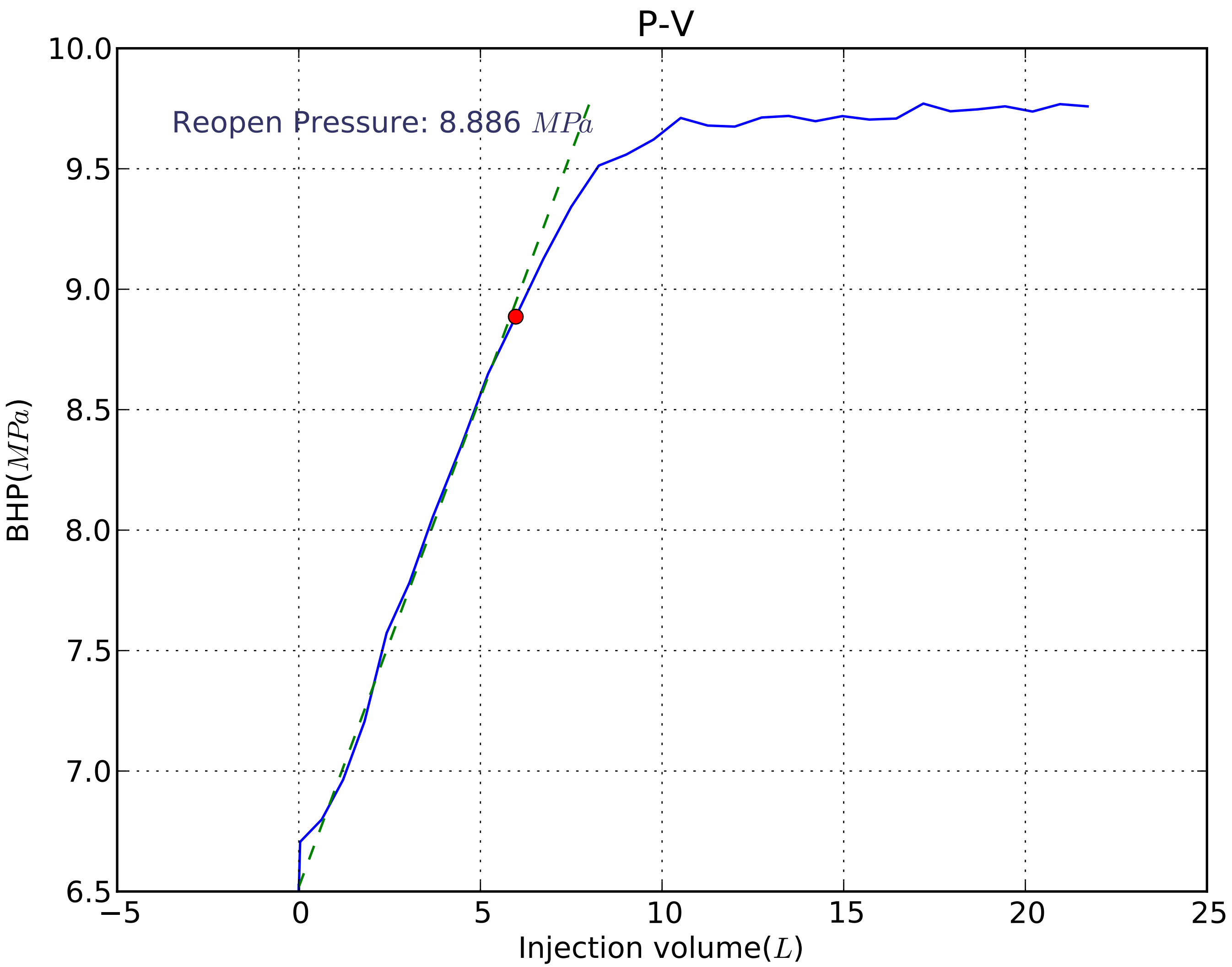
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 08

BitCan
Geosciences & Engineering Inc.



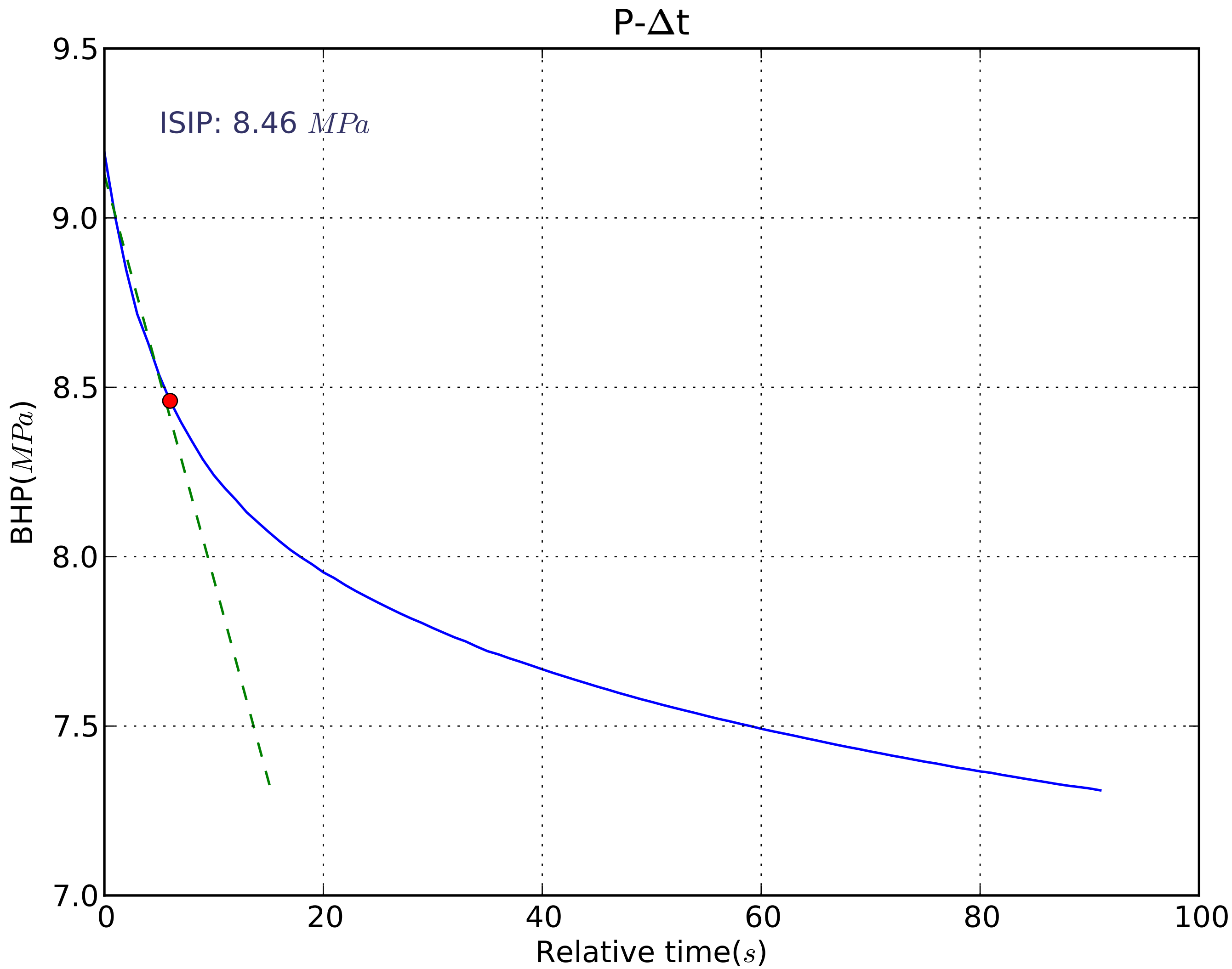
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 08

BitCan
Geosciences & Engineering Inc.

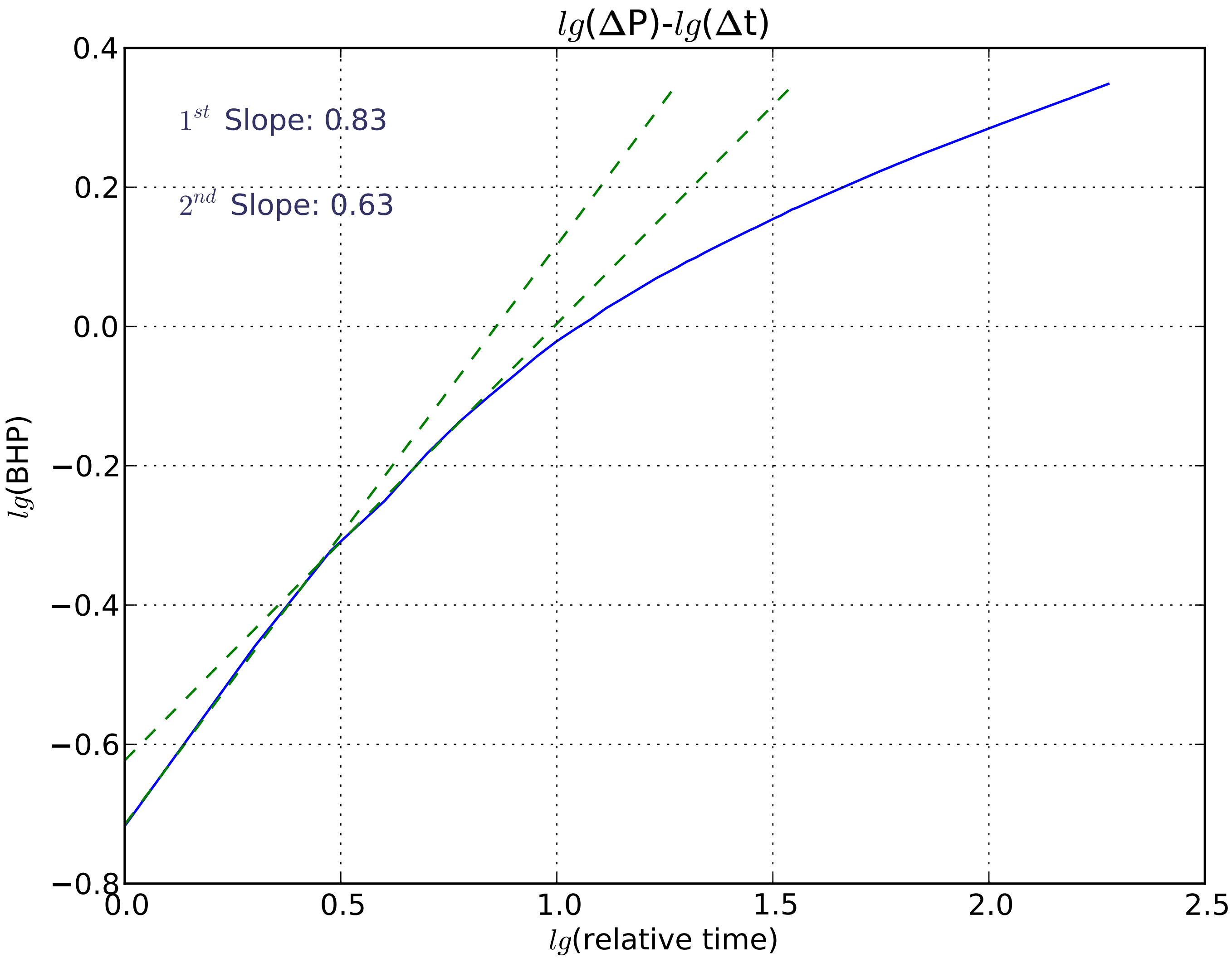


Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 08

BitCan
Geosciences & Engineering Inc.

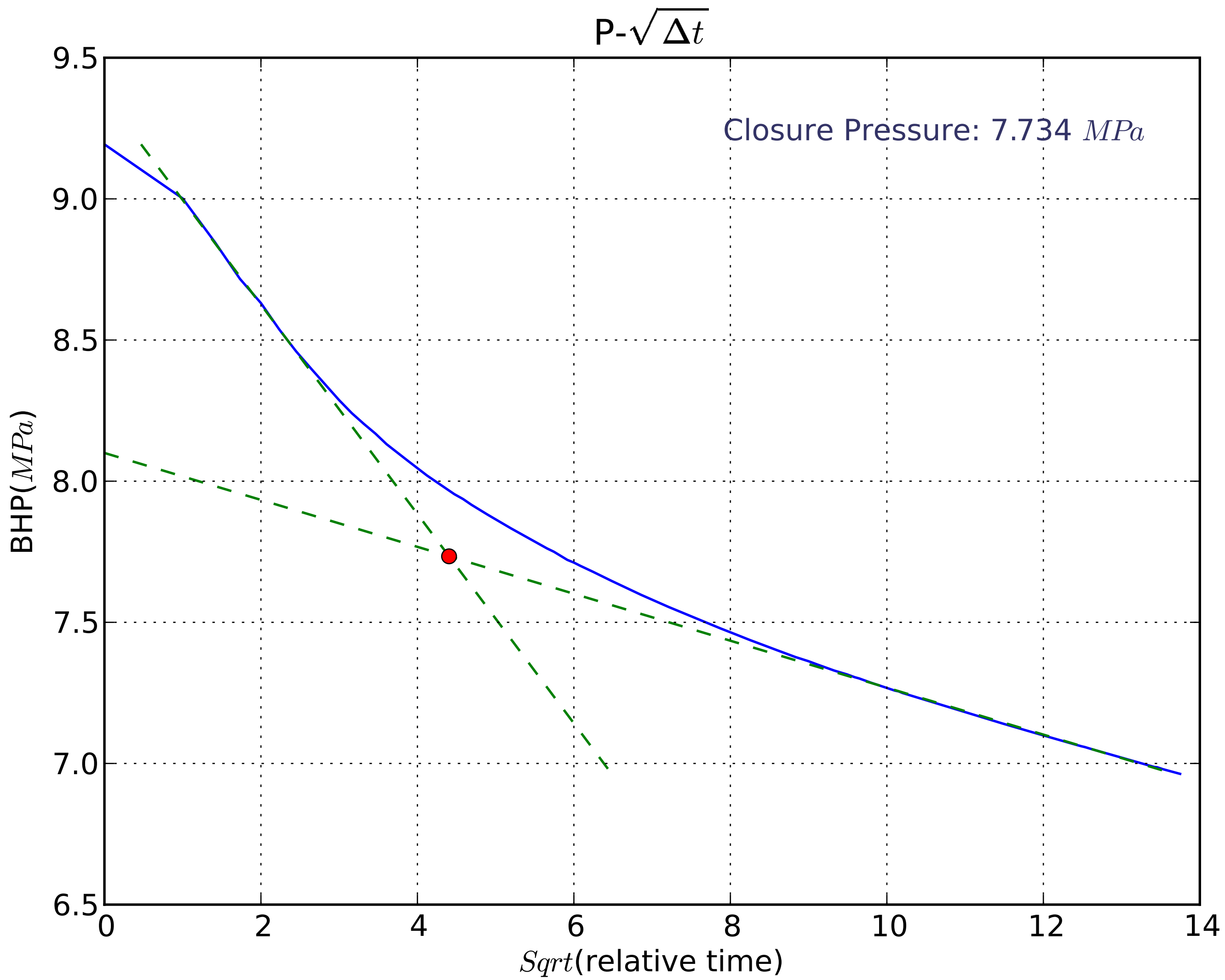


Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 08



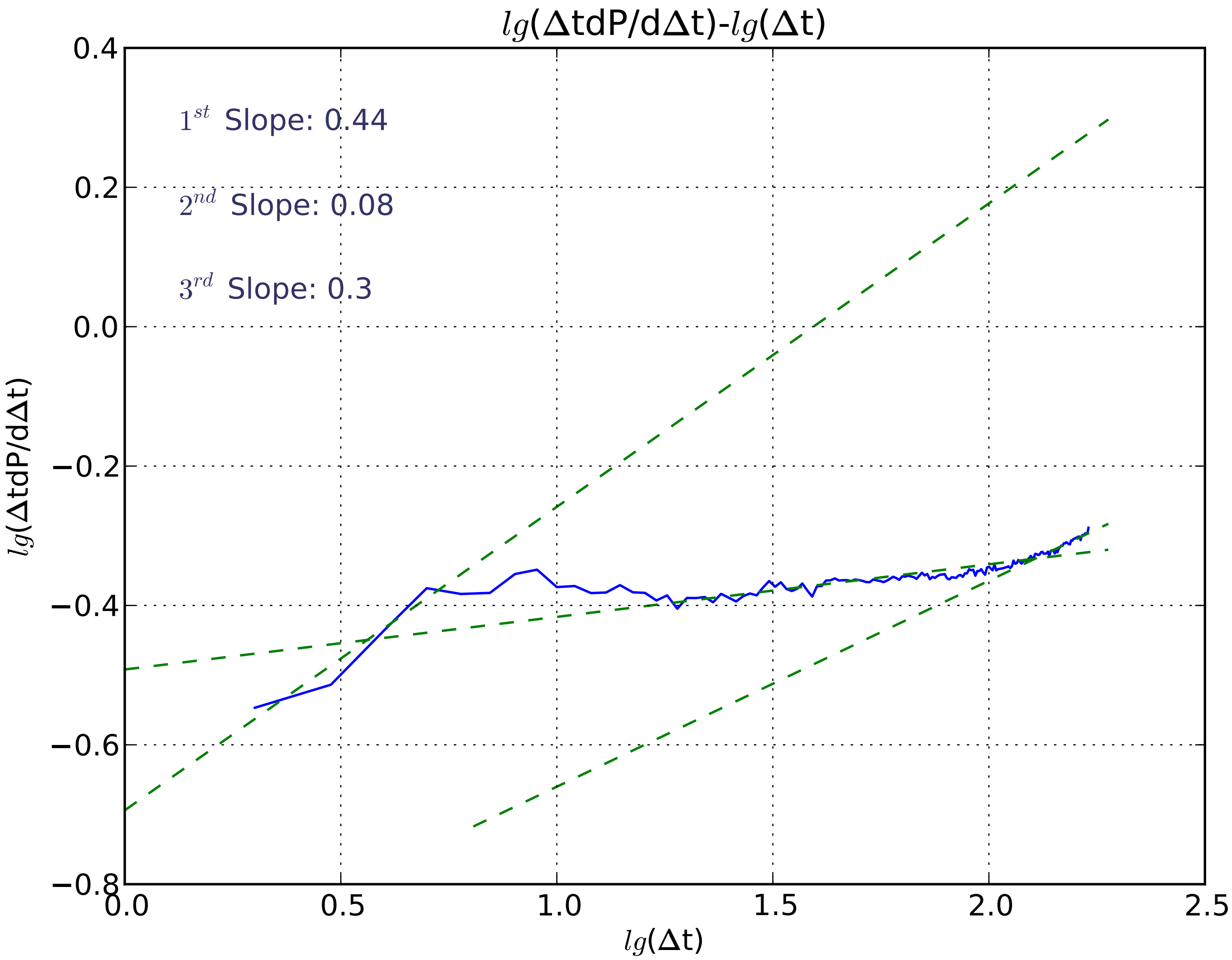
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 08

BitCan
Geosciences & Engineering Inc.



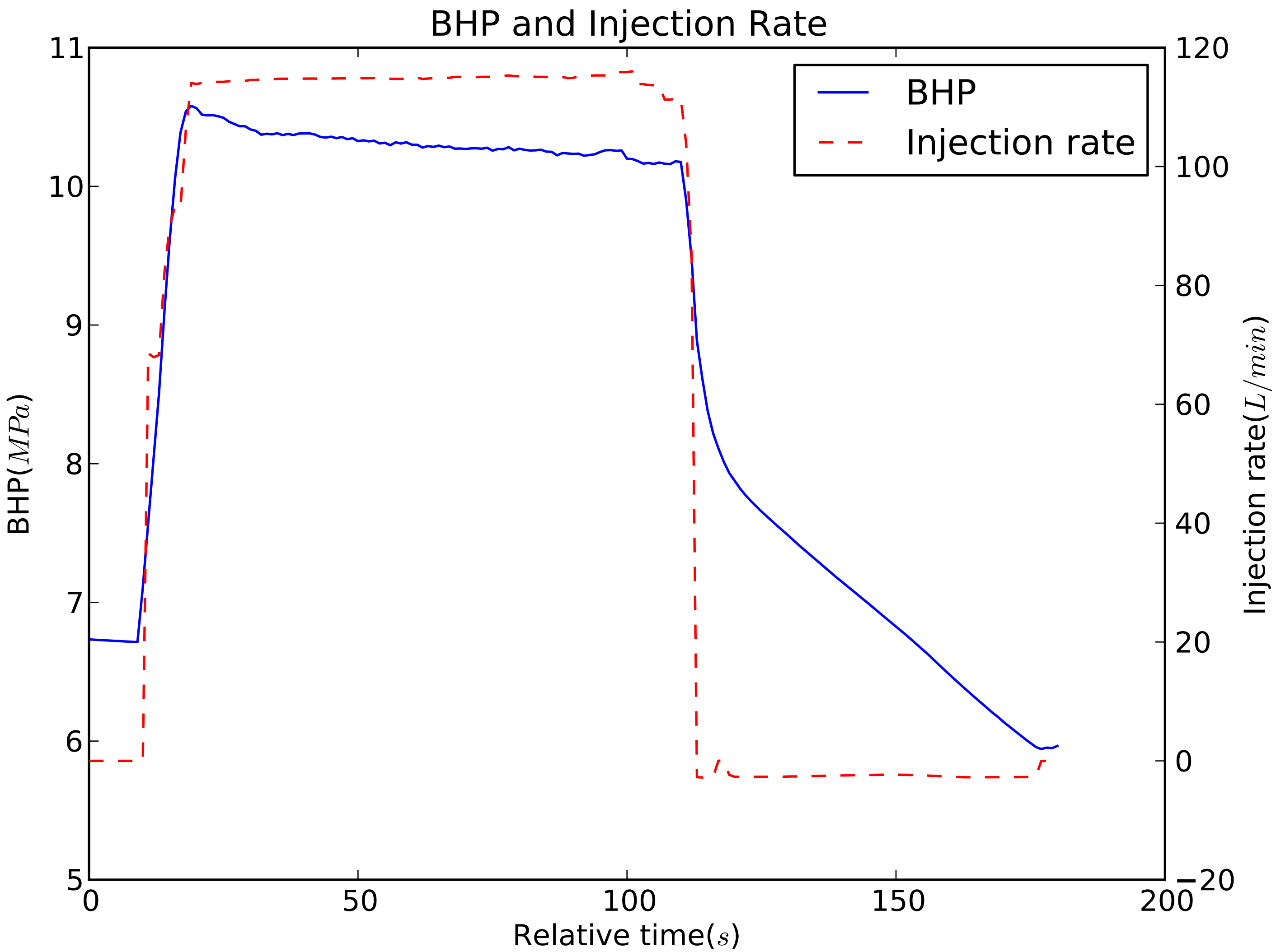
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 08

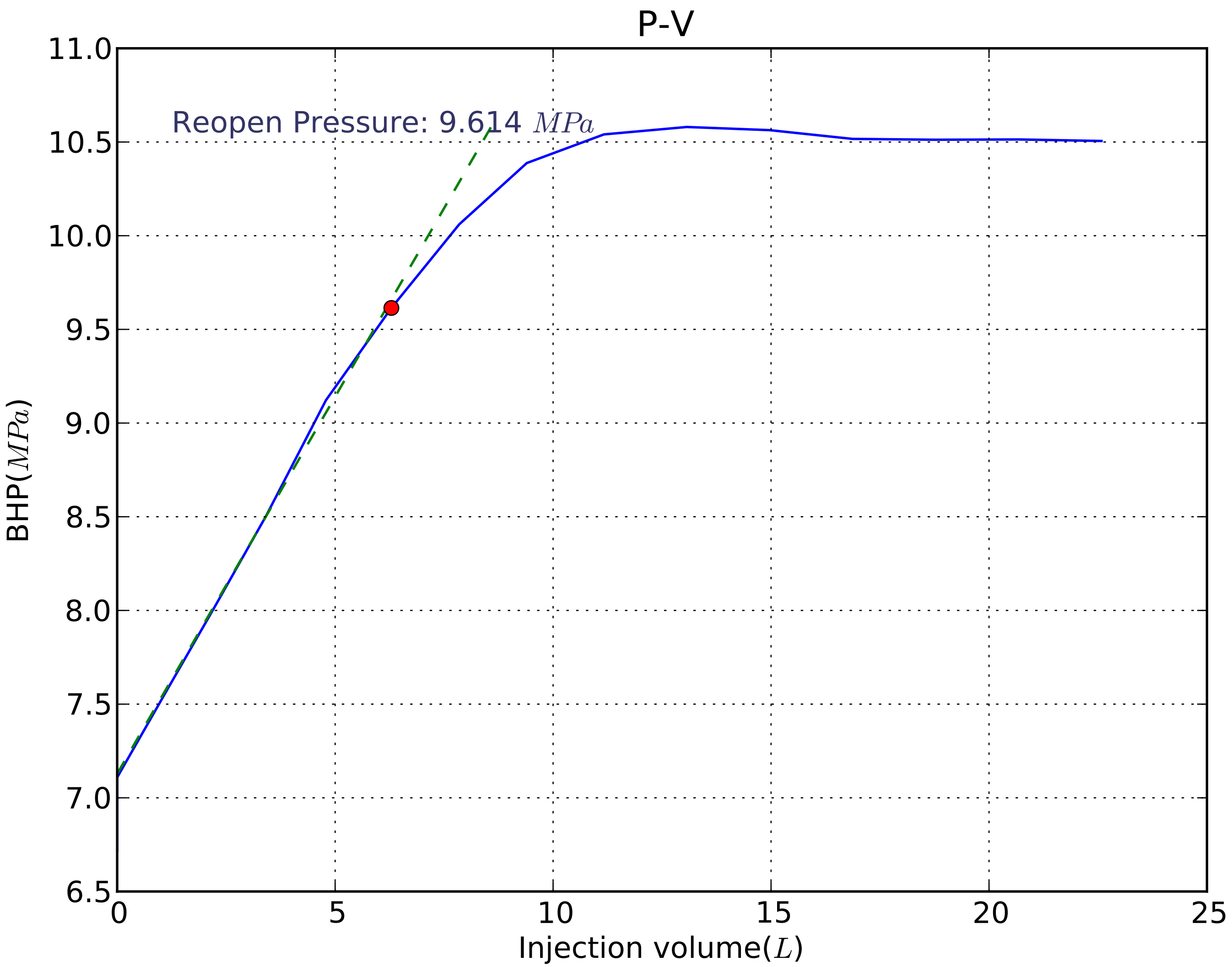
BitCan
Geosciences & Engineering Inc.



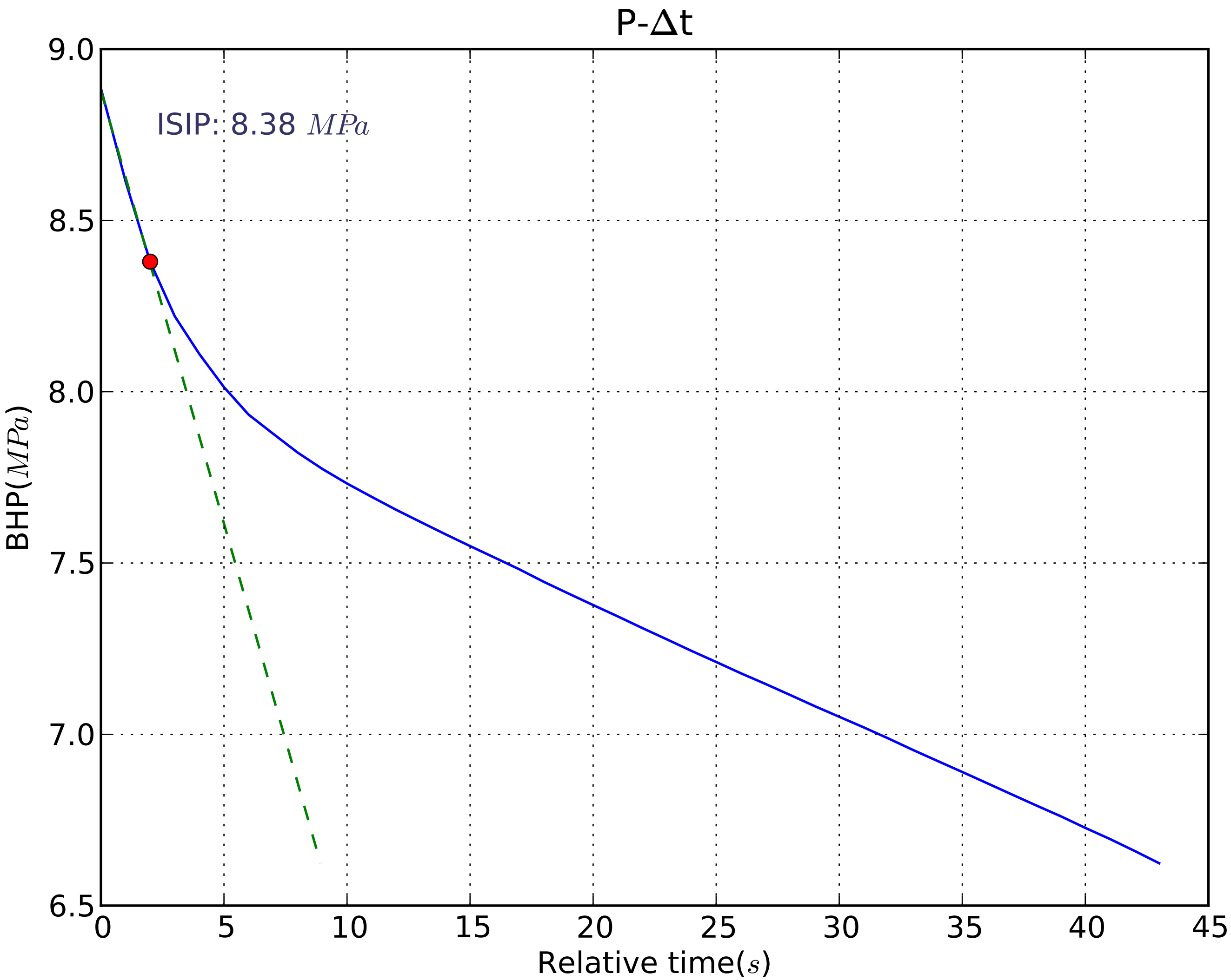
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 09

BitCan Geosciences & Engineering Inc.



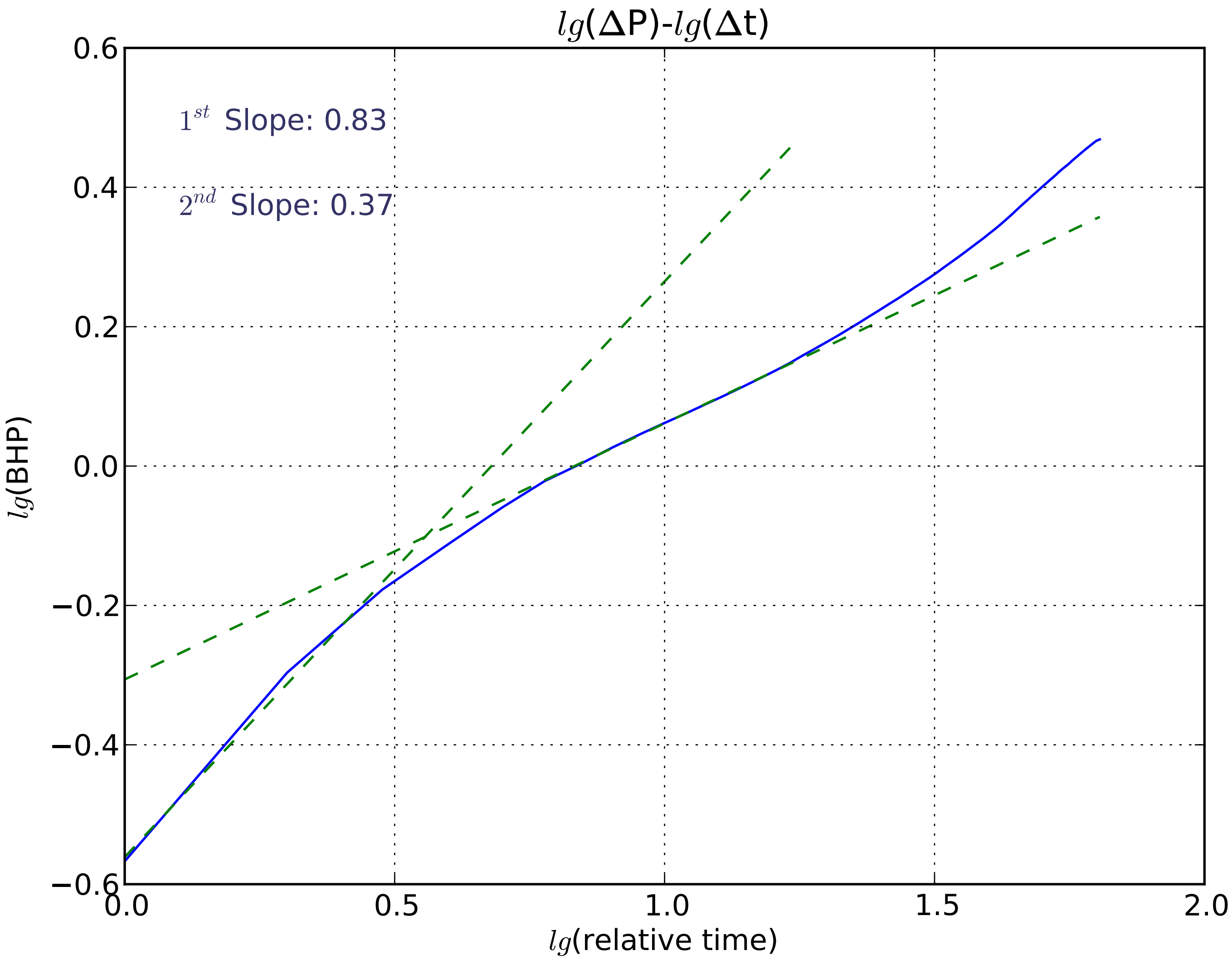

P-V
Reopen Pressure: 9.614 MPa
BHP(MPa)
Injection volume(L)
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
0
5
10
15
20
25

Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 09



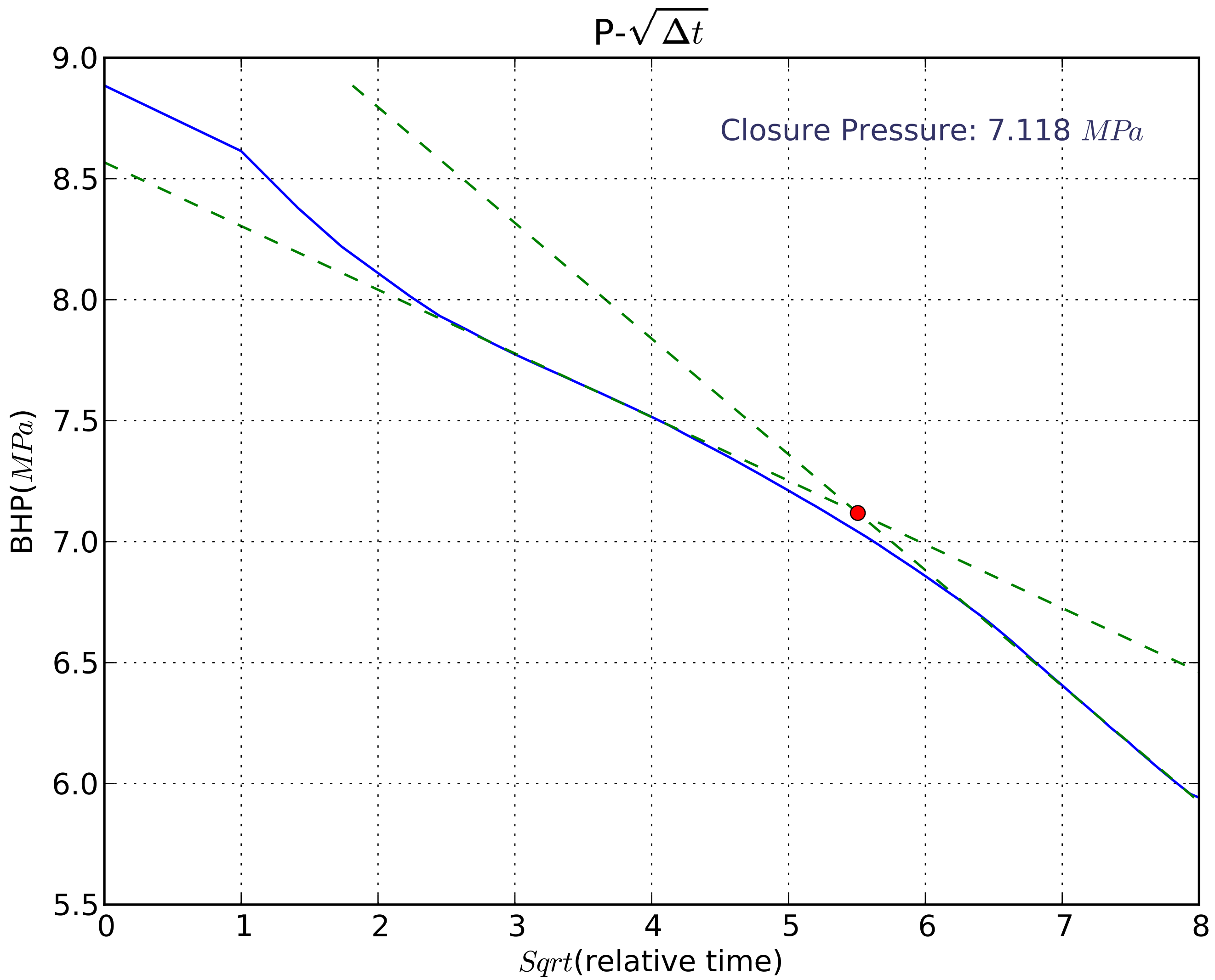
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 09

BitCan
Geosciences & Engineering Inc.



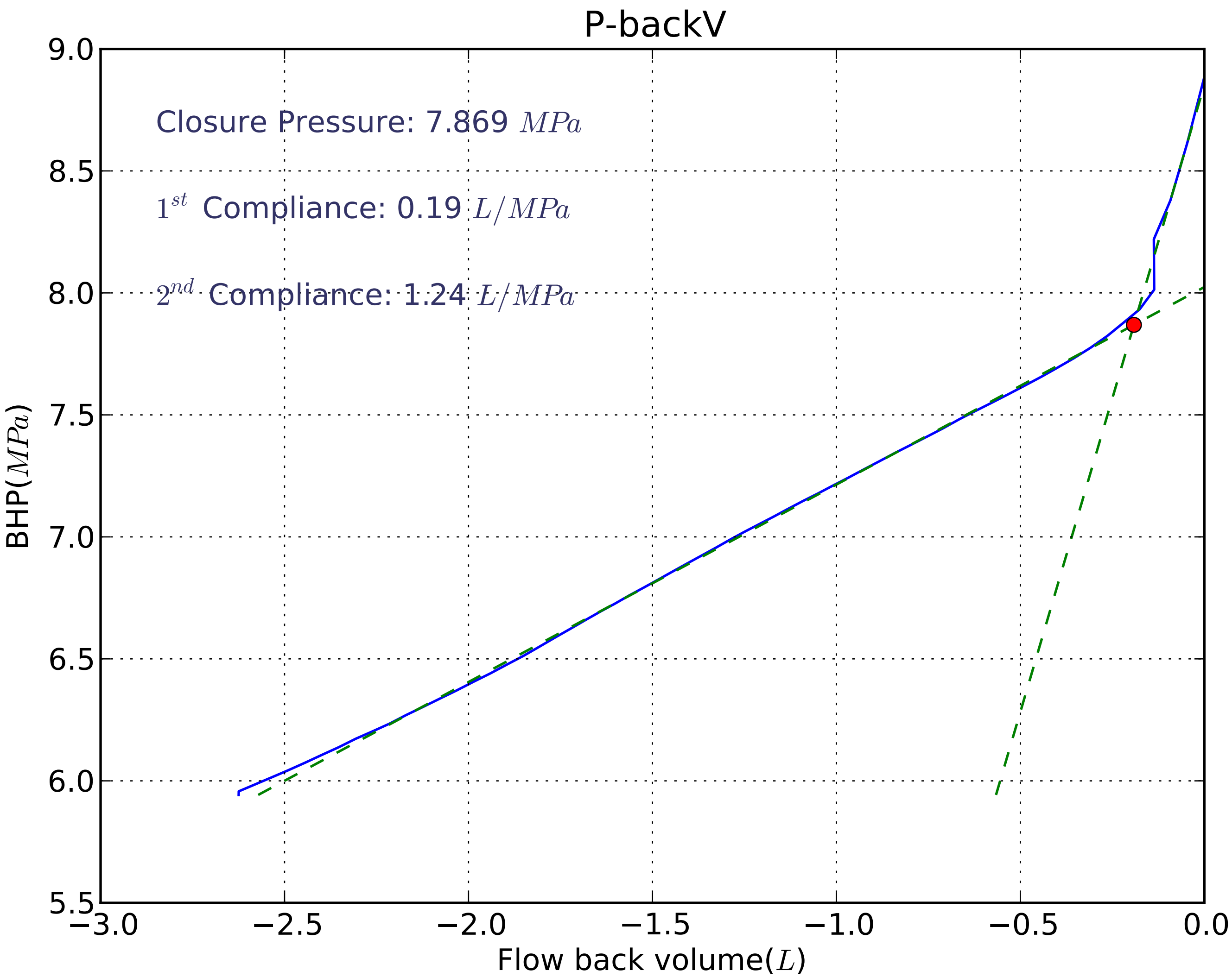
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 09

BitCan
Geosciences & Engineering Inc.



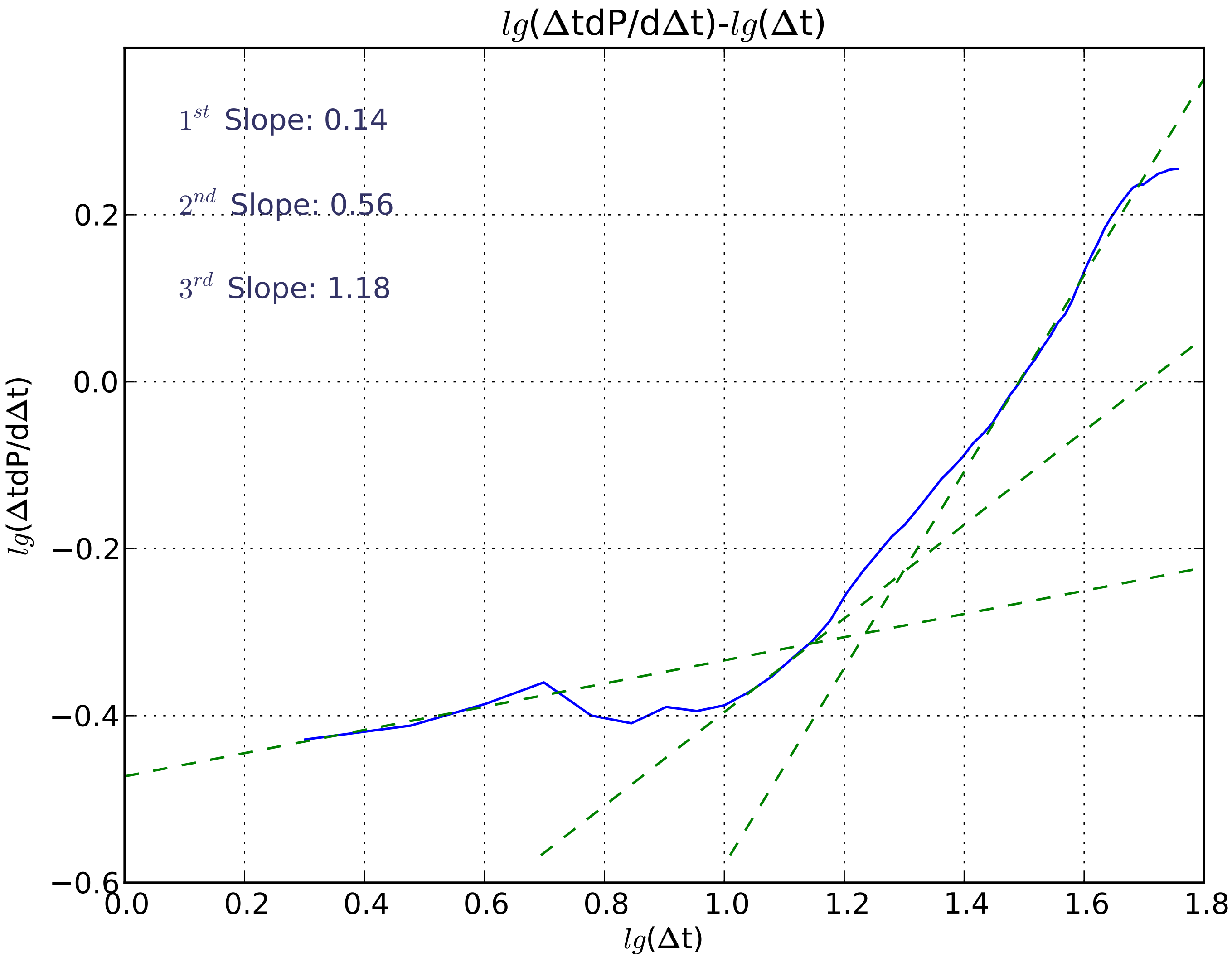
Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 09

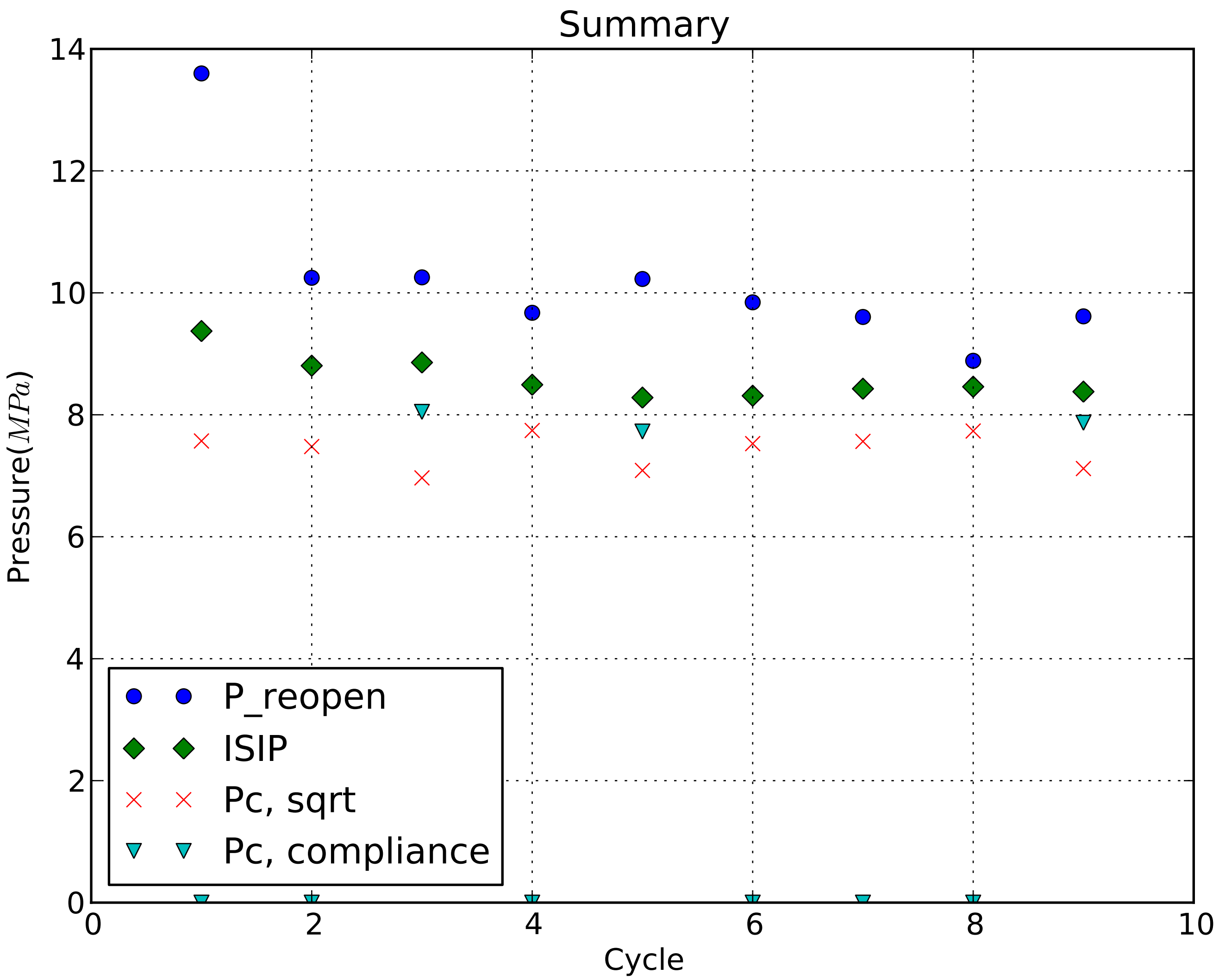
BitCan
Geosciences & Engineering Inc.



Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 09

BitCan
Geosciences & Engineering Inc.




Summary
14
12
10
8
6
4
2
0
0
2
4
6
8
10
Pressure(MPa)
Cycle
P_reopen
ISIP
Pc, sqrt
Pc, compliance

Well: Pengrowth LNDBRGH 13-24-58-5W4
Depth: 504.0m
Formation: General Petroleum
Cycle: 1 to 9

BitCan Geosciences & Engineering Inc.

Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	13.598	9.373	7.571	0.000	2.73	0.00	0.00
2	10.247	8.805	7.479	0.000	2.89	0.00	0.00
3	10.254	8.857	6.965	8.048	2.79	0.23	1.07
4	9.673	8.493	7.743	0.000	2.82	0.00	0.00
5	10.227	8.282	7.088	7.725	2.59	0.28	0.98
6	9.844	8.312	7.527	0.000	2.74	0.00	0.00
7	9.604	8.427	7.564	0.000	2.59	0.00	0.00
8	8.886	8.460	7.734	0.000	2.46	0.00	0.00
9	9.614	8.380	7.118	7.869	2.48	0.19	1.24

Previous View

ANALYSIS PLOTS

WELL: LNDBRGH 13-24-58-5W4

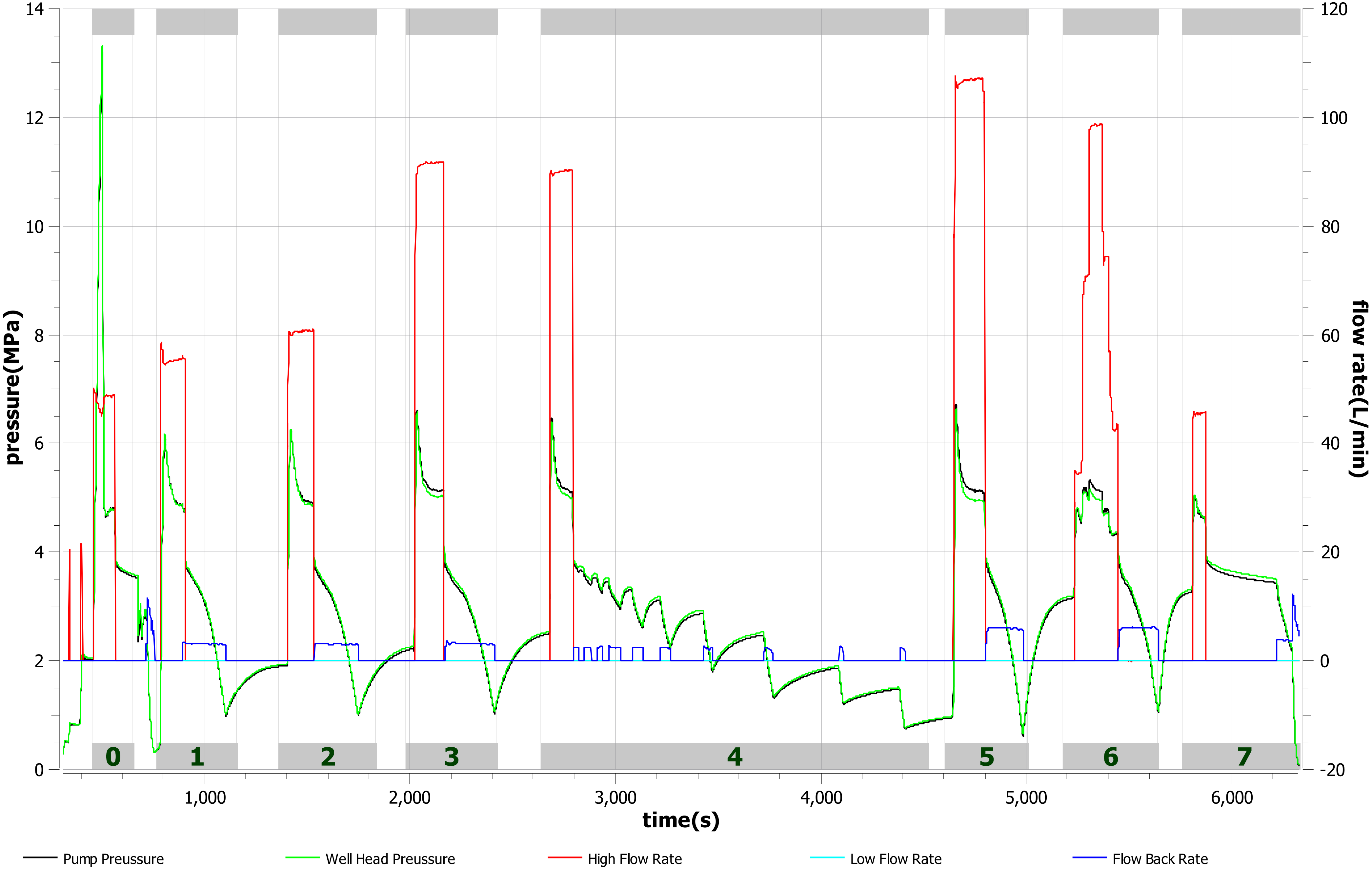
Test 2: General Petroleum (GP) caprock at 514 m TVD

BitCan
Geosciences & Engineering Inc.
www.bitcange.com

Client: Pengrowtg
Well:
Depth: 514

Formation: Caprock
Start @: Mon Jan 2 17:07:22 2012

Mini-Frac Test



Generated by MiniMonitor

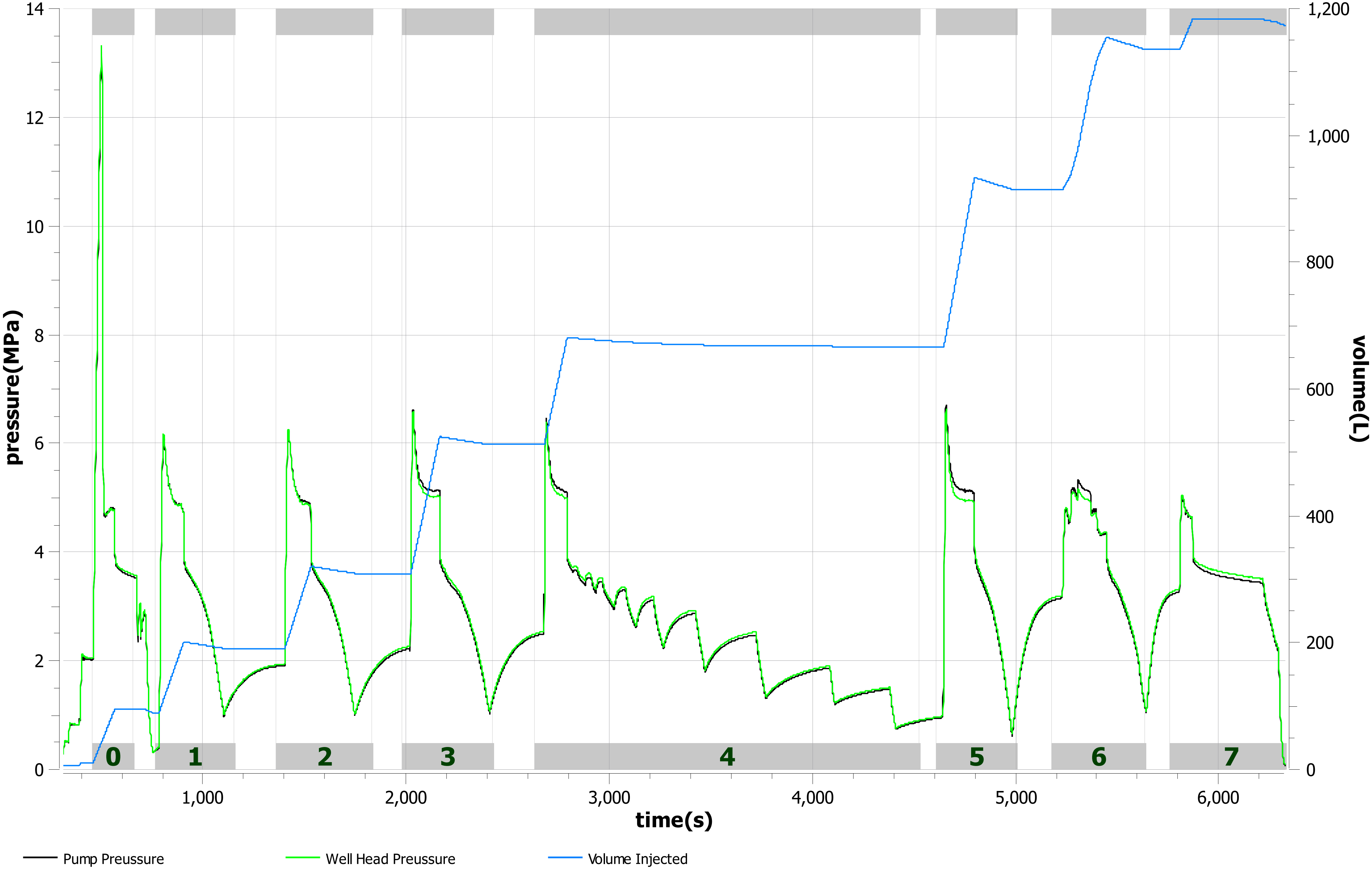
BitCan
Geosciences & Engineering Inc.

www.bitcange.com

Client: Pengrowtg
Well:
Depth: 514

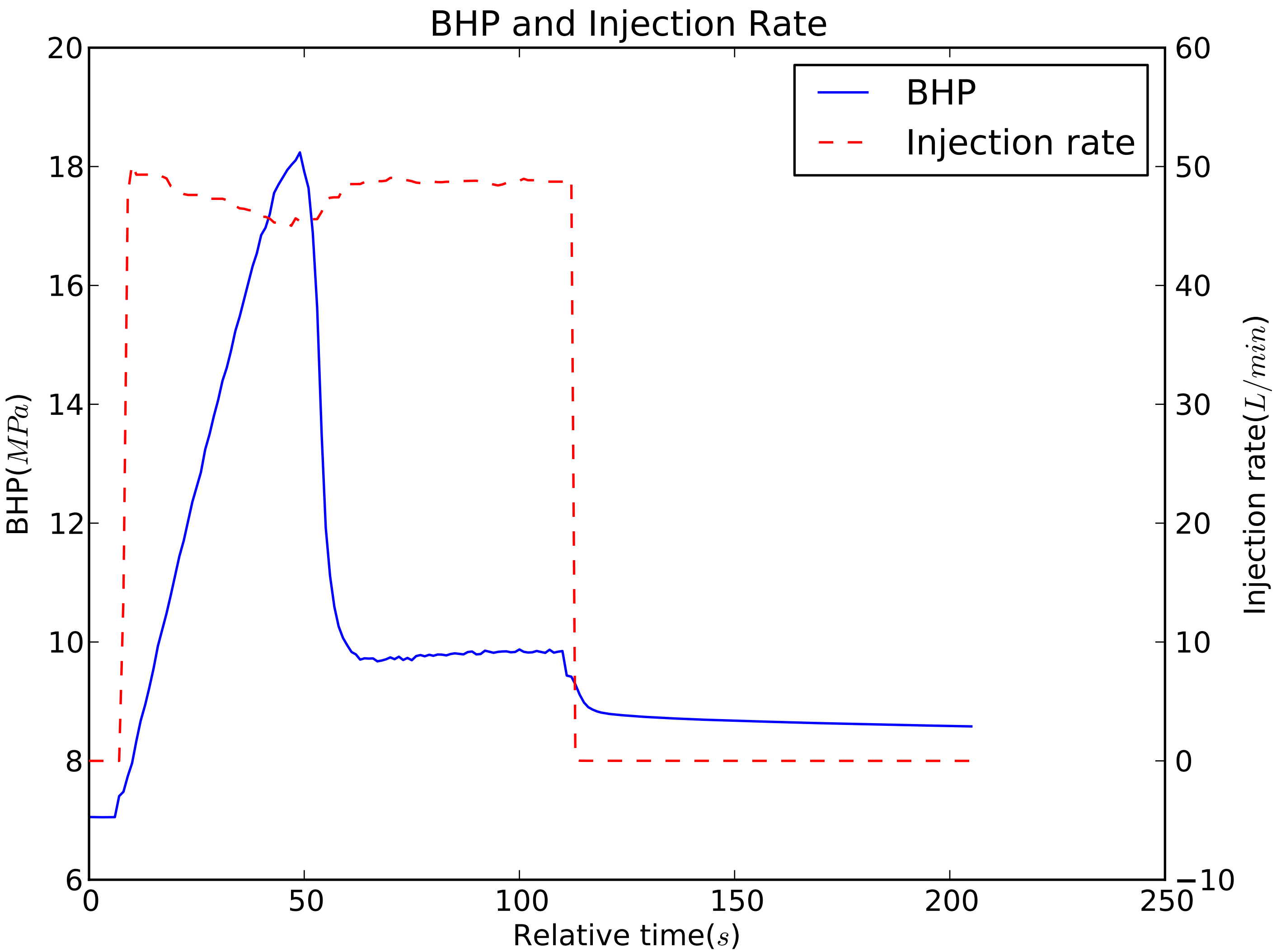
Formation: Caprock
Start @: Mon Jan 2 17:07:22 2012

Mini-Frac Test

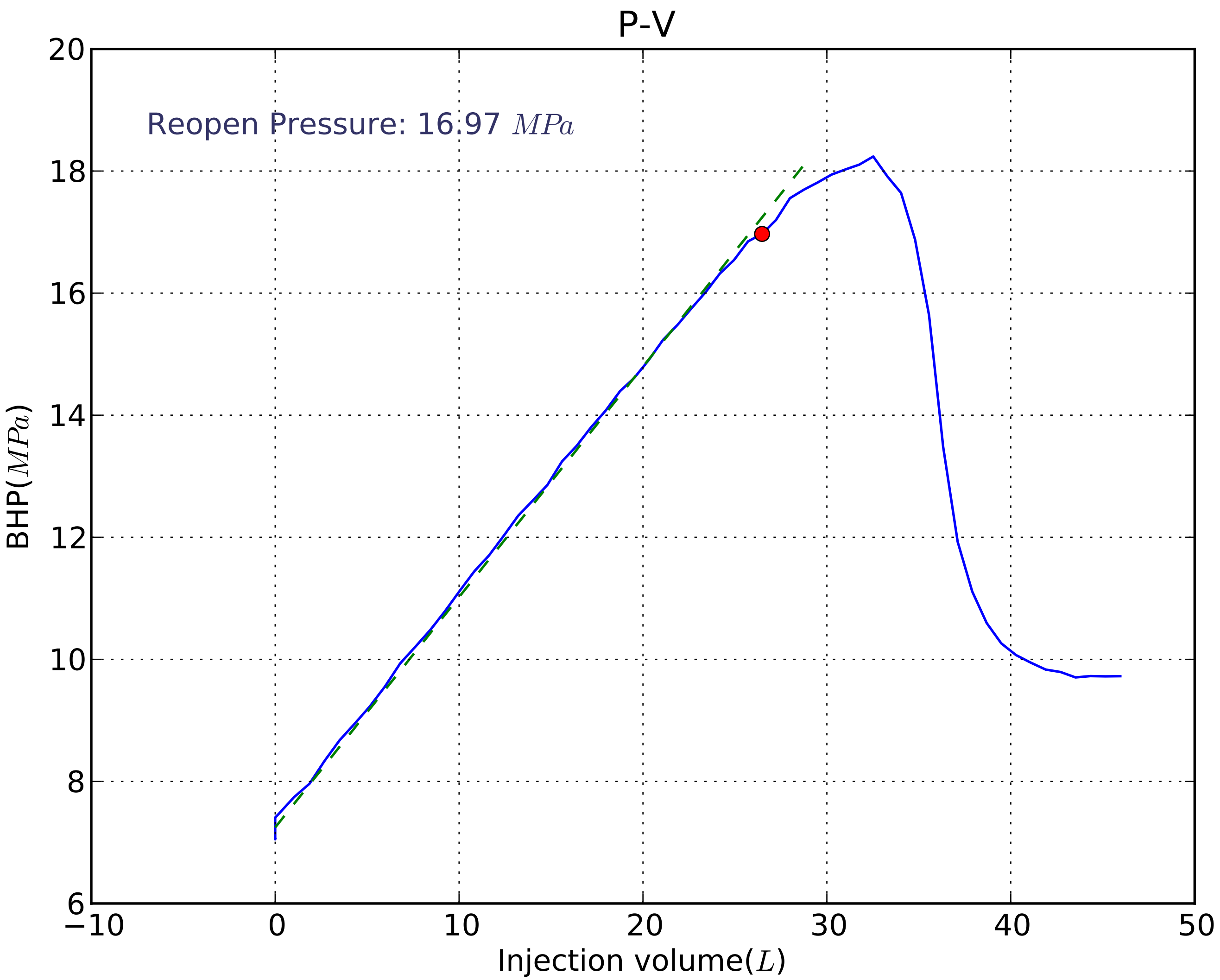


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 01

BitCan
Geosciences & Engineering Inc.

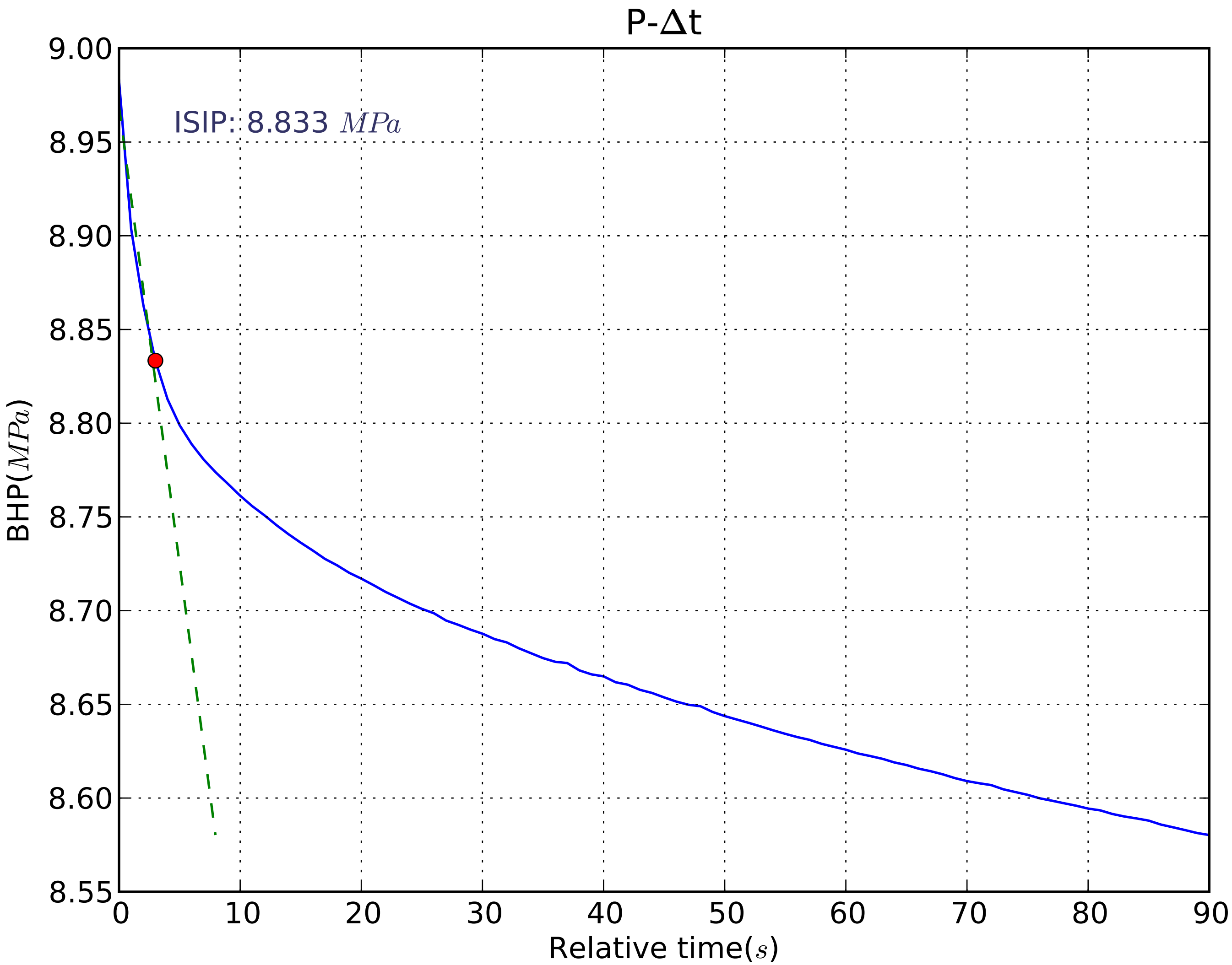


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 01

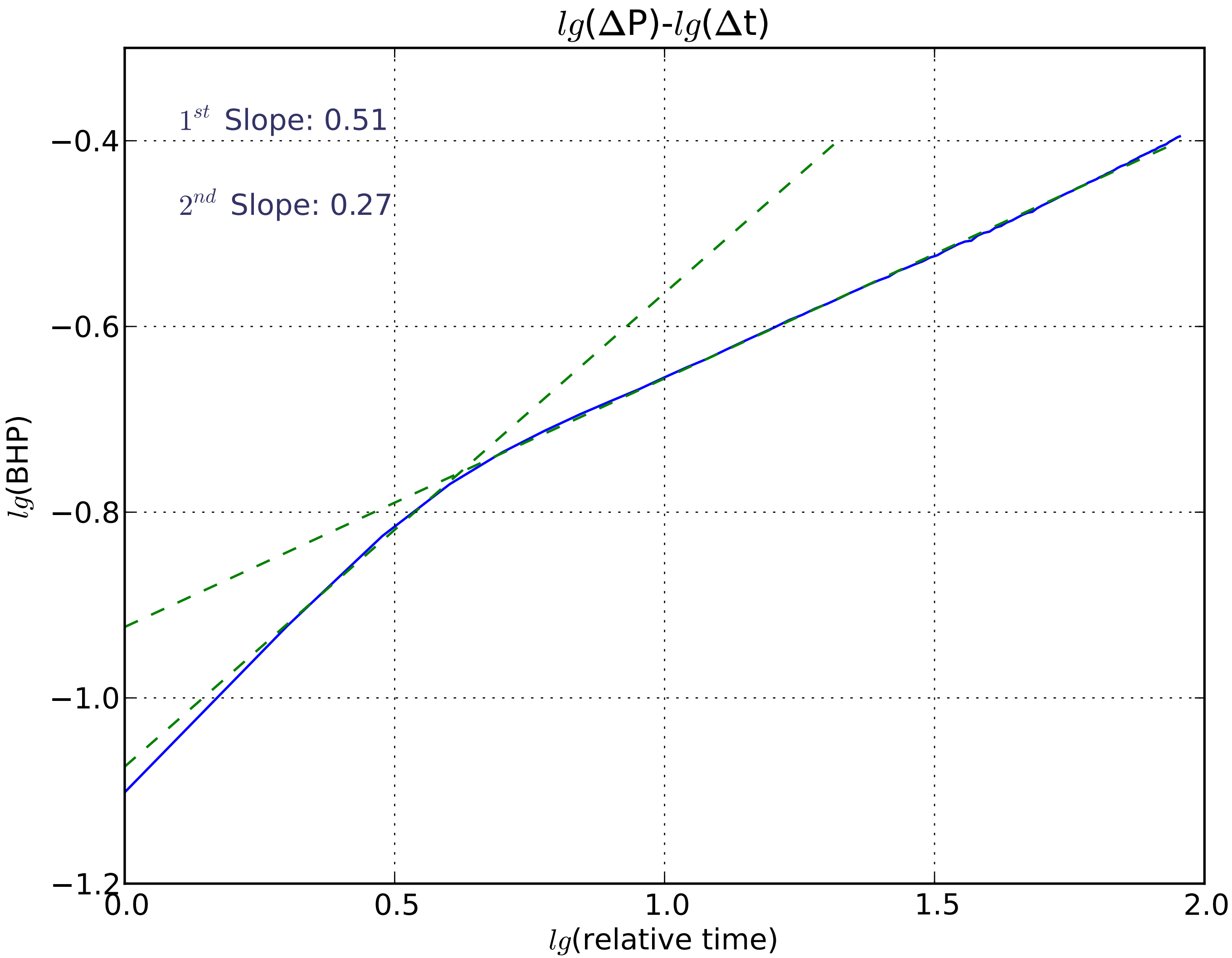


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 01

BitCan
Geosciences & Engineering Inc.

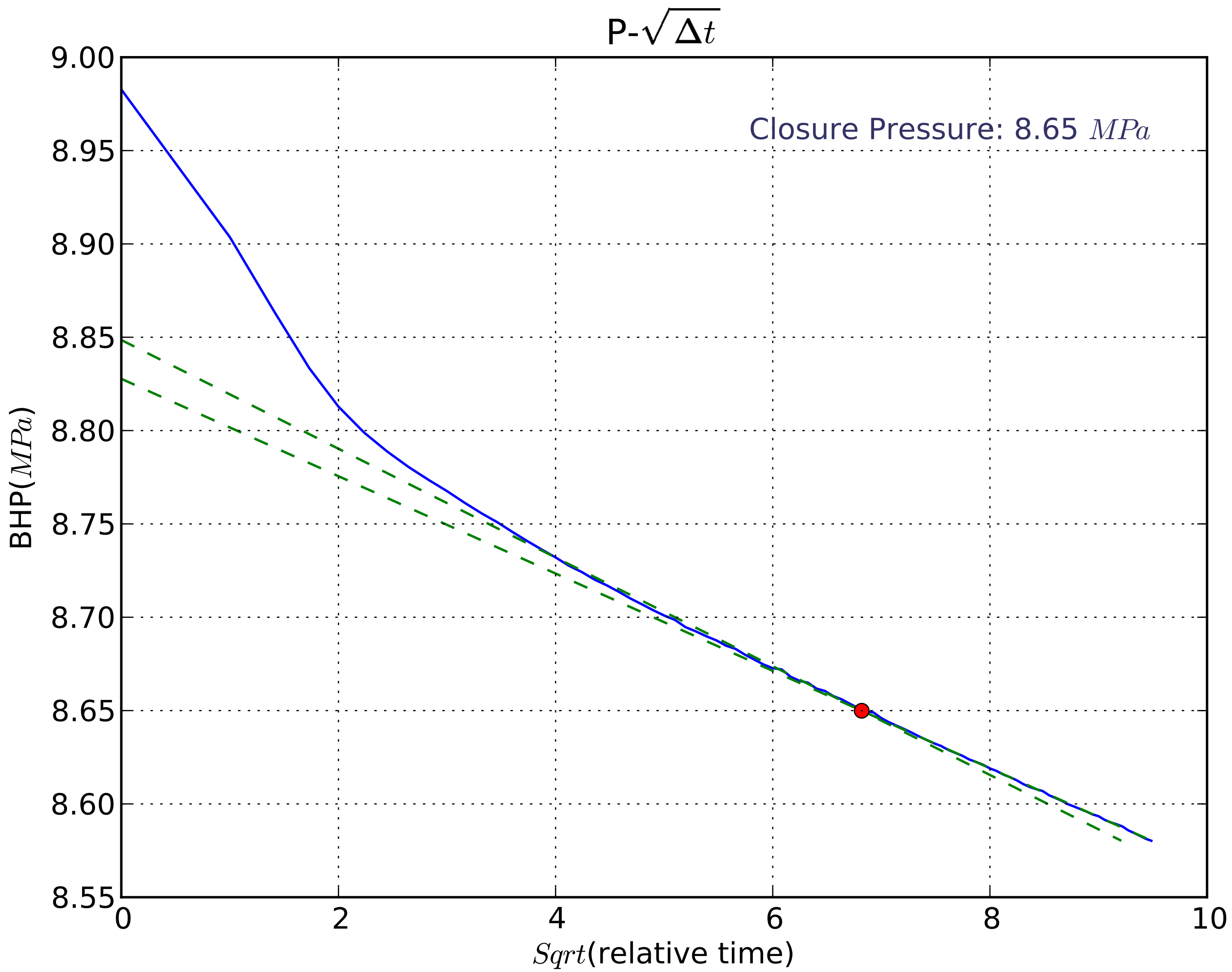


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 01

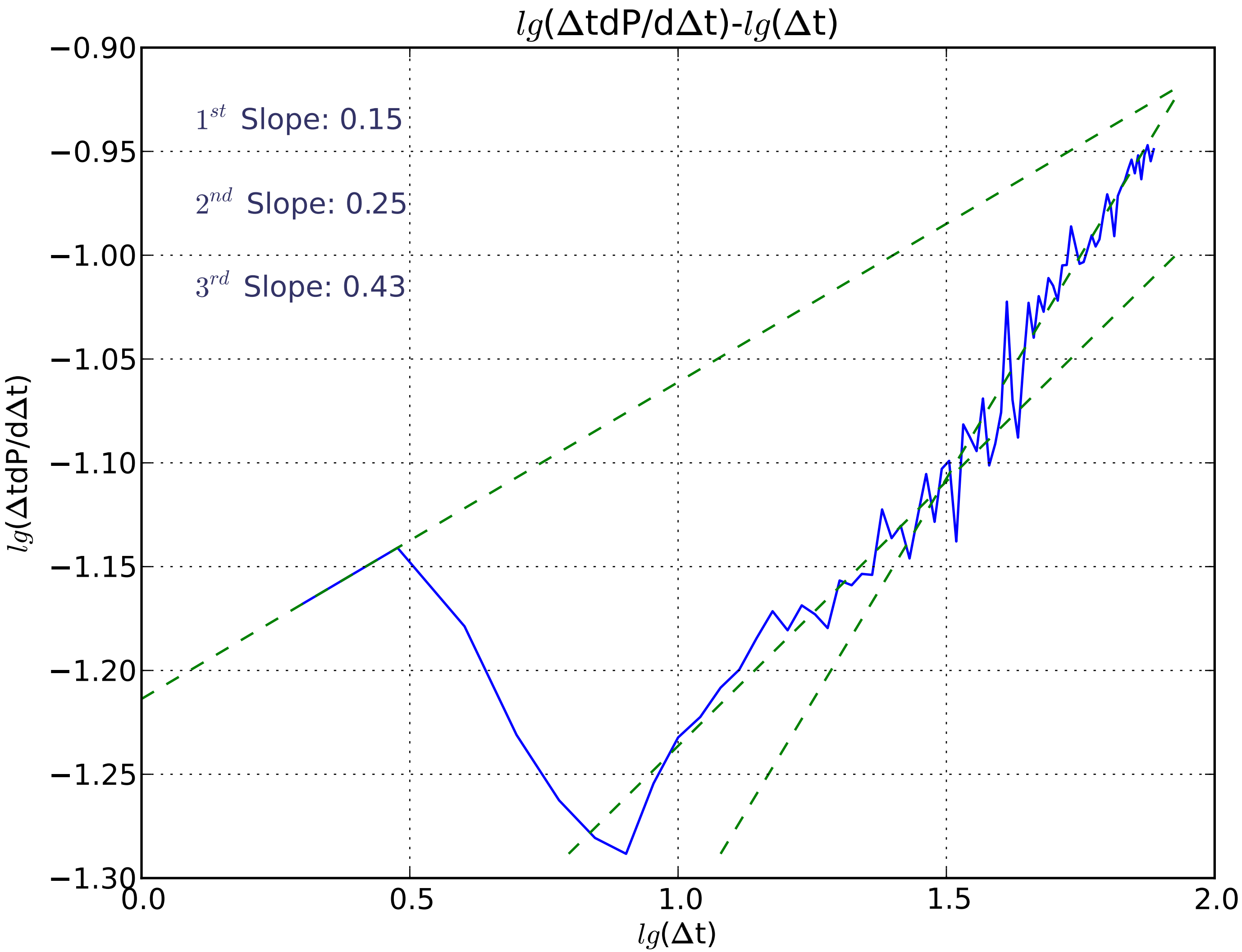


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 01

BitCan
Geosciences & Engineering Inc.

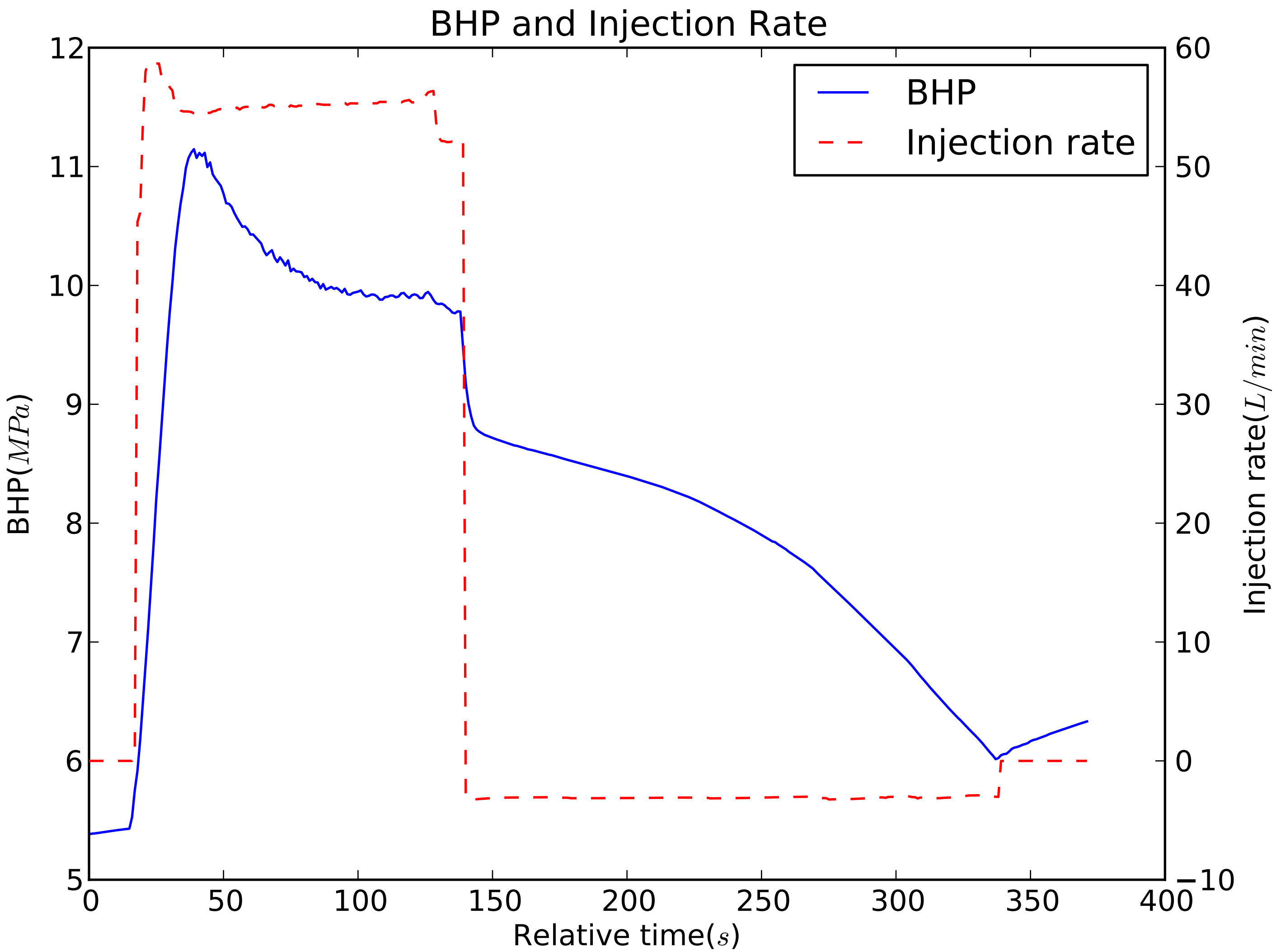


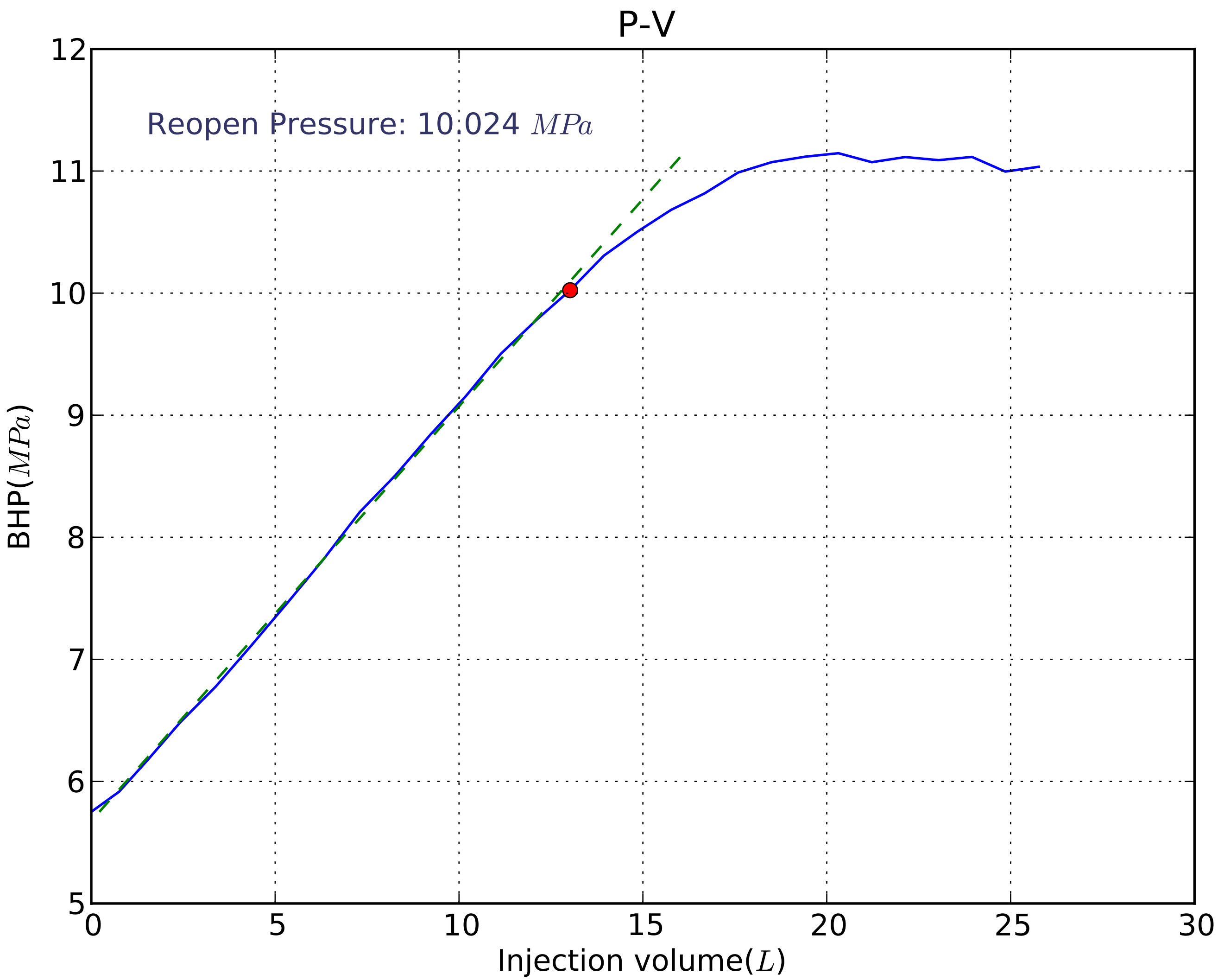
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 01



Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 02

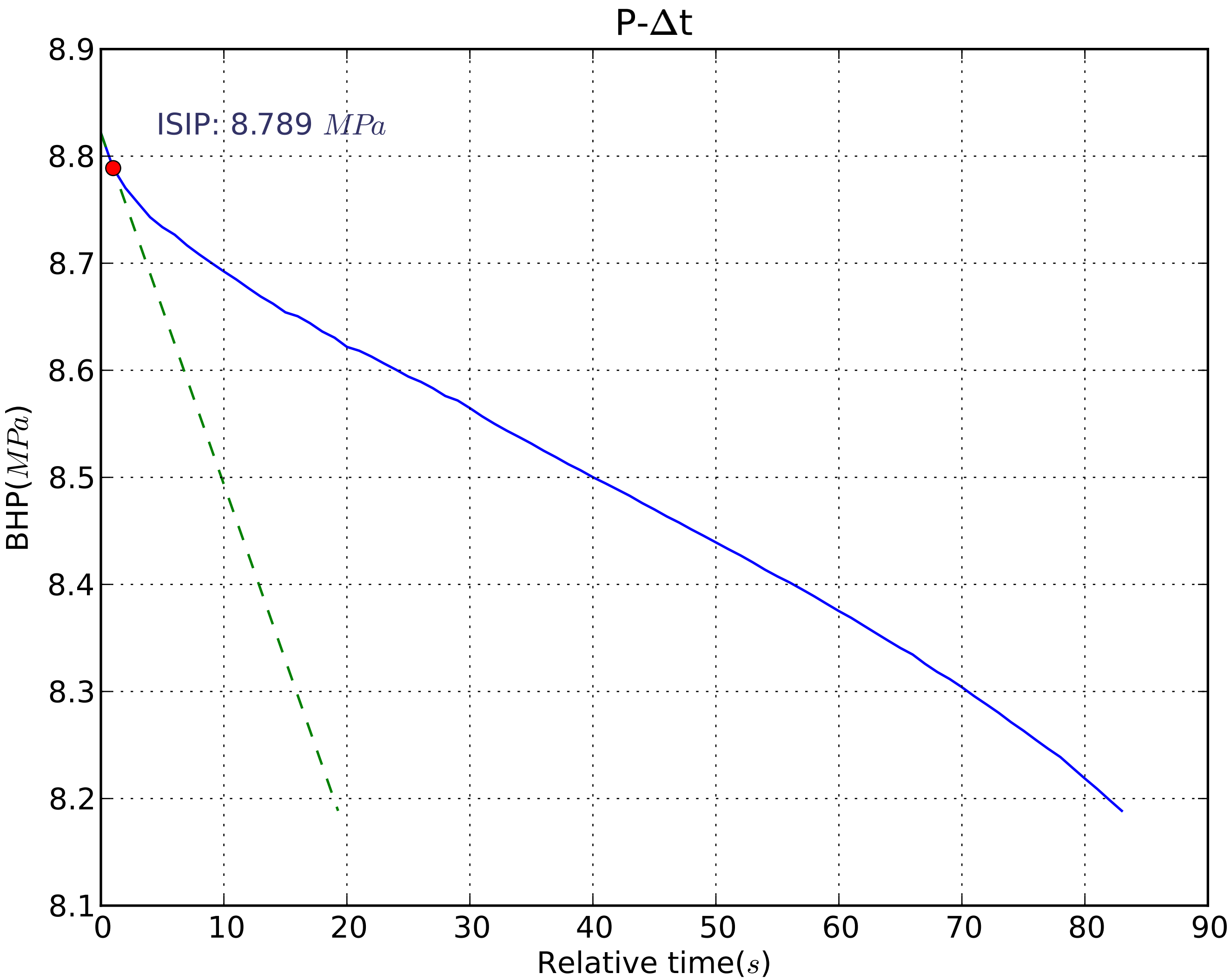
BitCan
Geosciences & Engineering Inc.




P-V
Reopen Pressure: 10.024 MPa
BHP(MPa)
Injection volume(L)
12
11
10
9
8
7
6
5
0
5
10
15
20
25
30

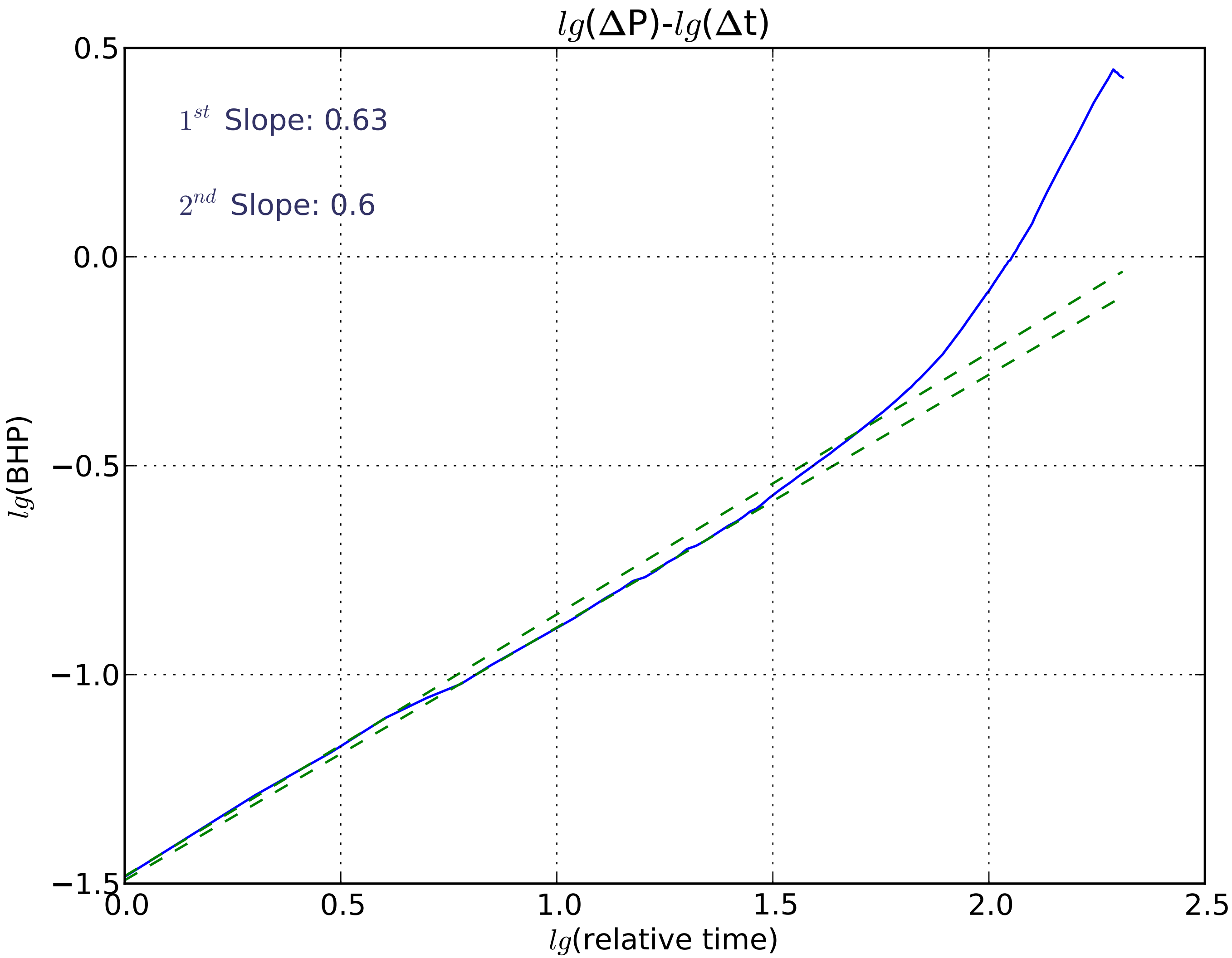
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 02

BitCan
Geosciences & Engineering Inc.

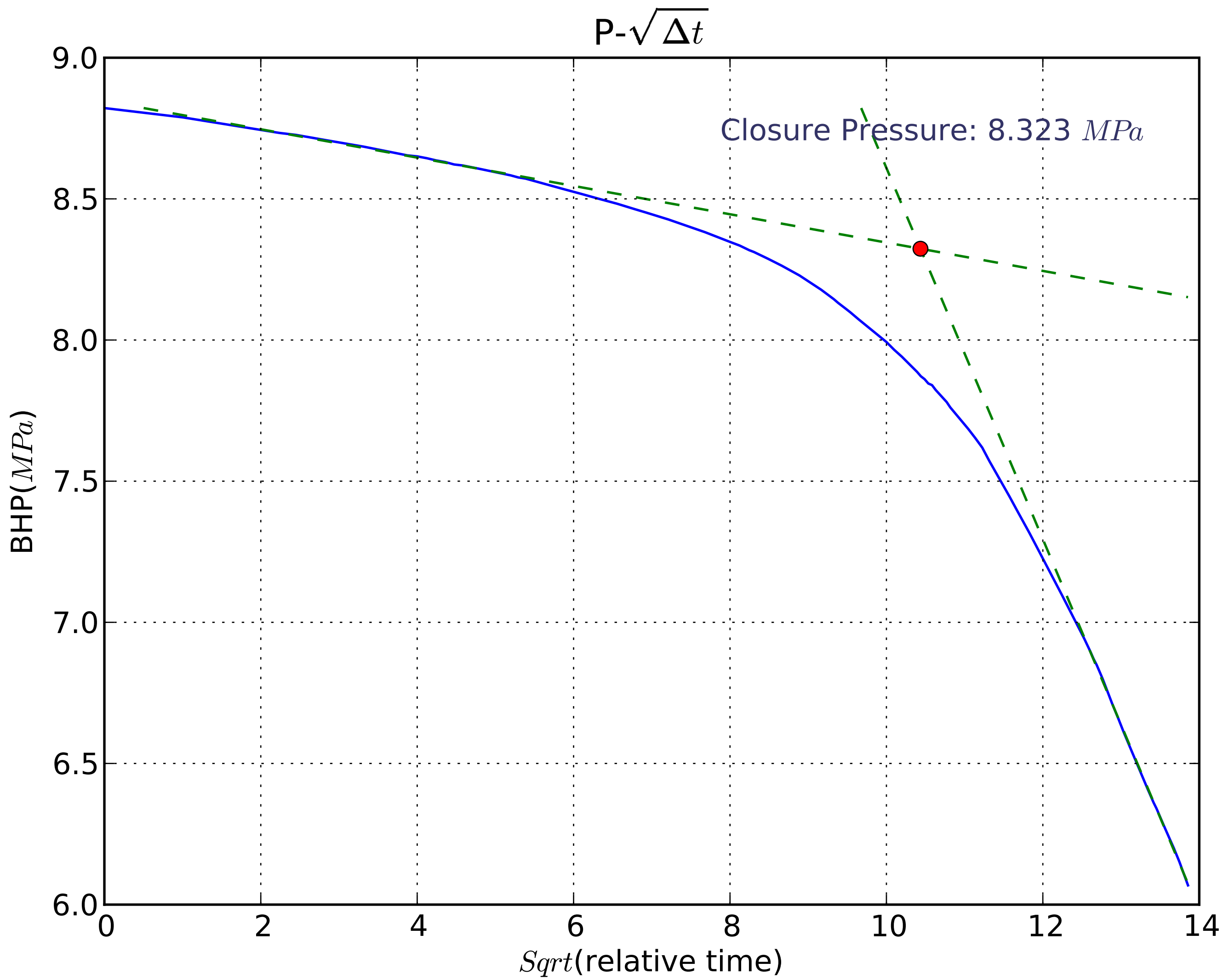


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 02

BitCan
Geosciences & Engineering Inc.

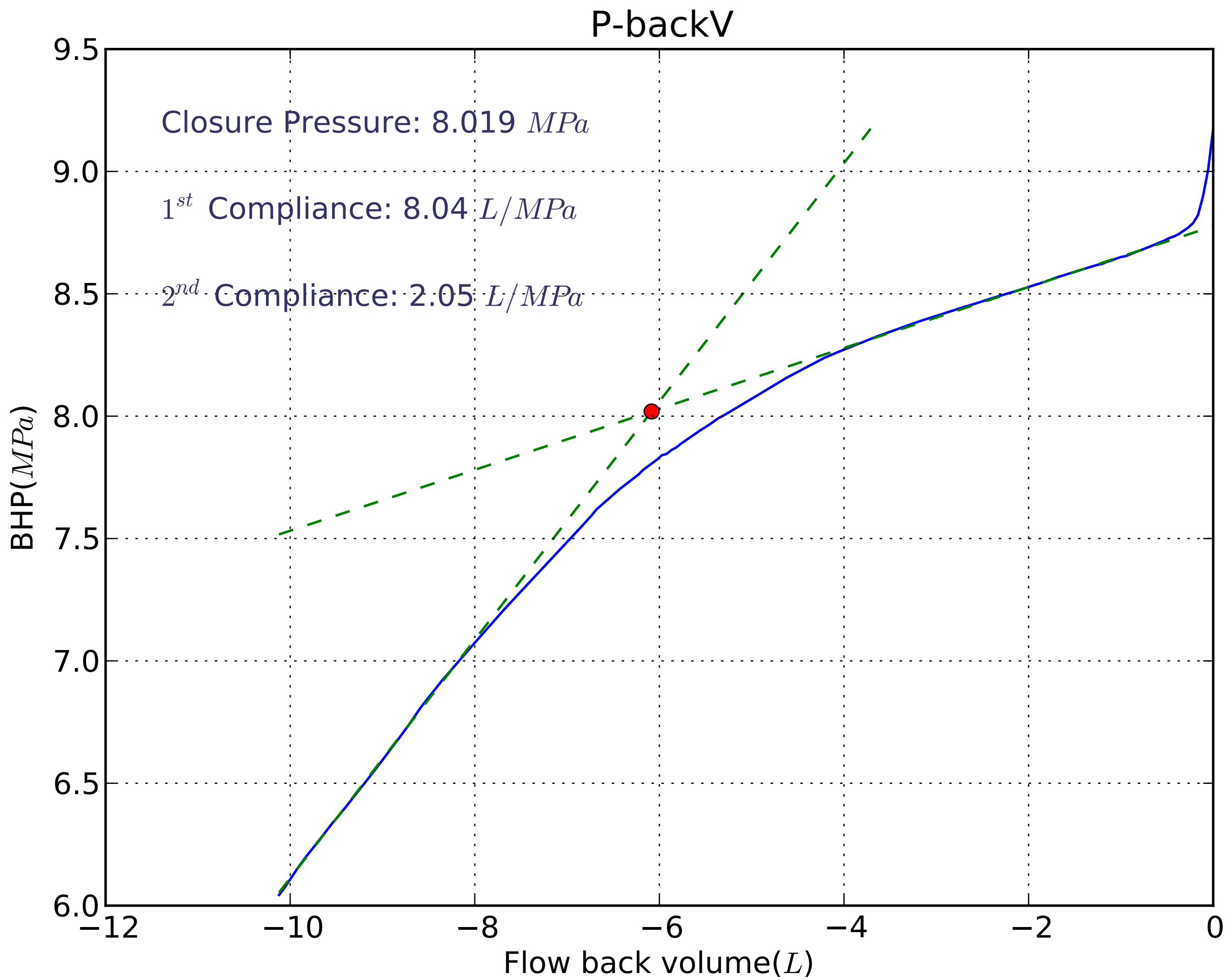


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 02



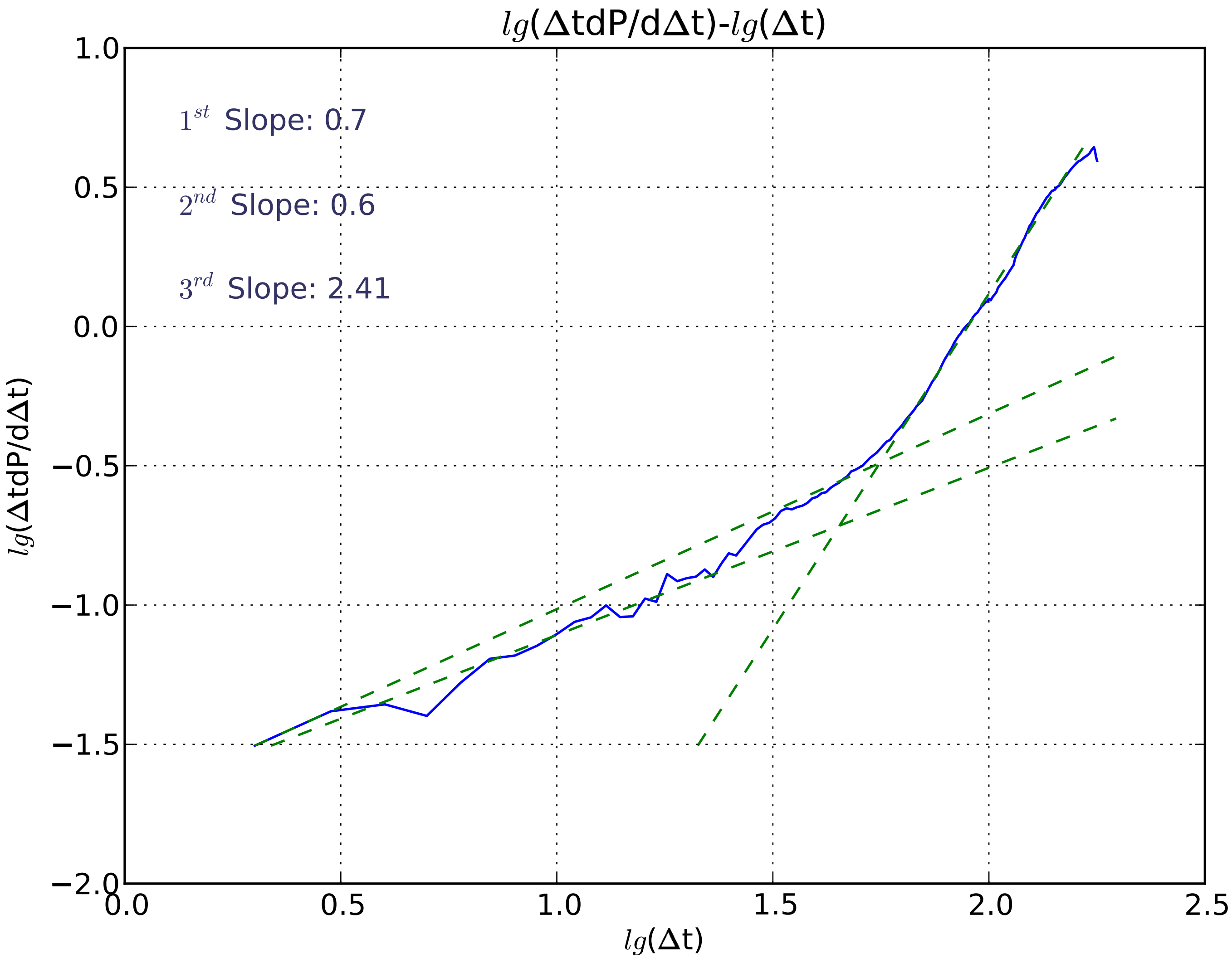
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 02

Geosciences & Engineering Inc.



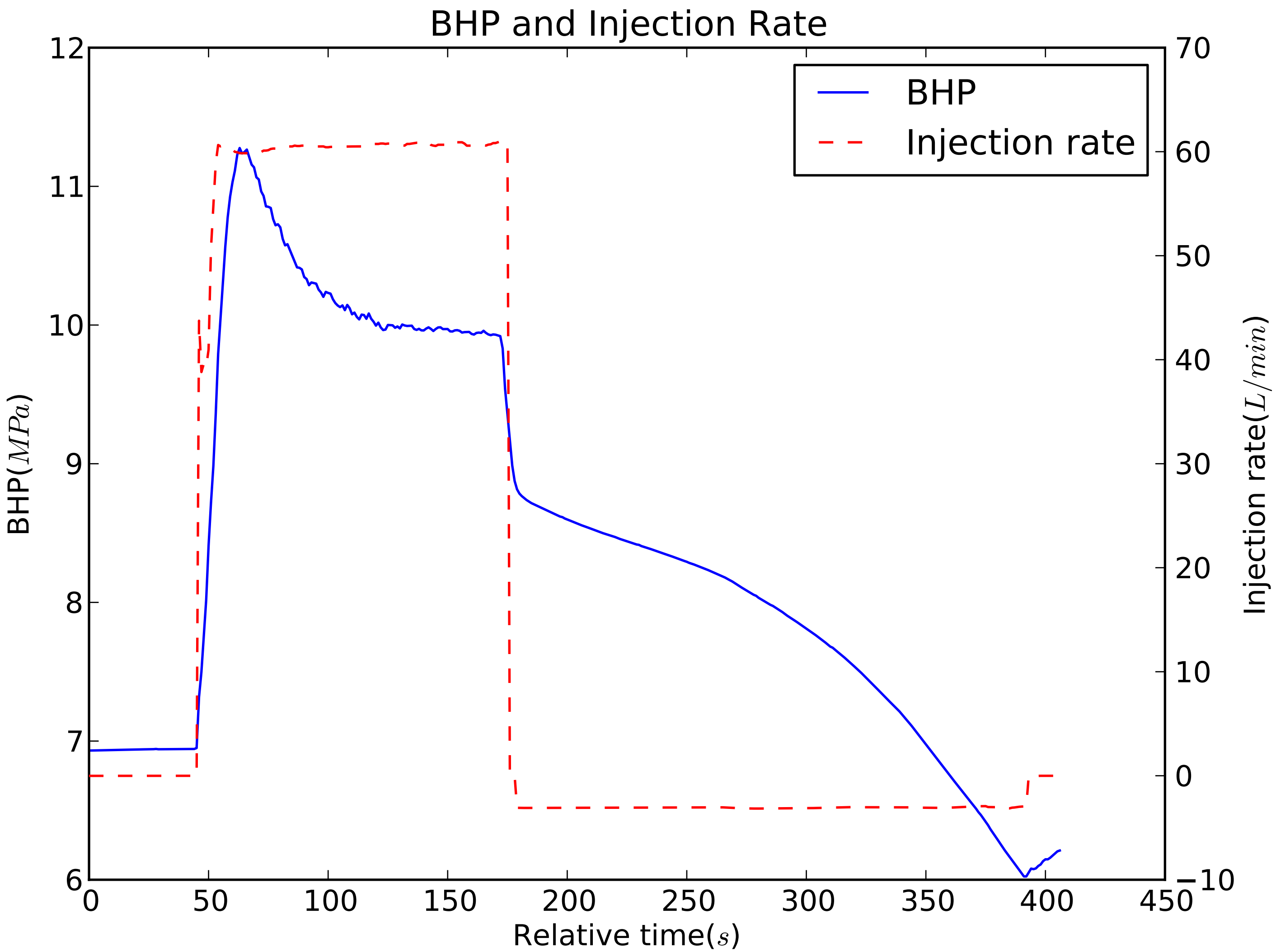
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 02

BitCan Geosciences & Engineering Inc.

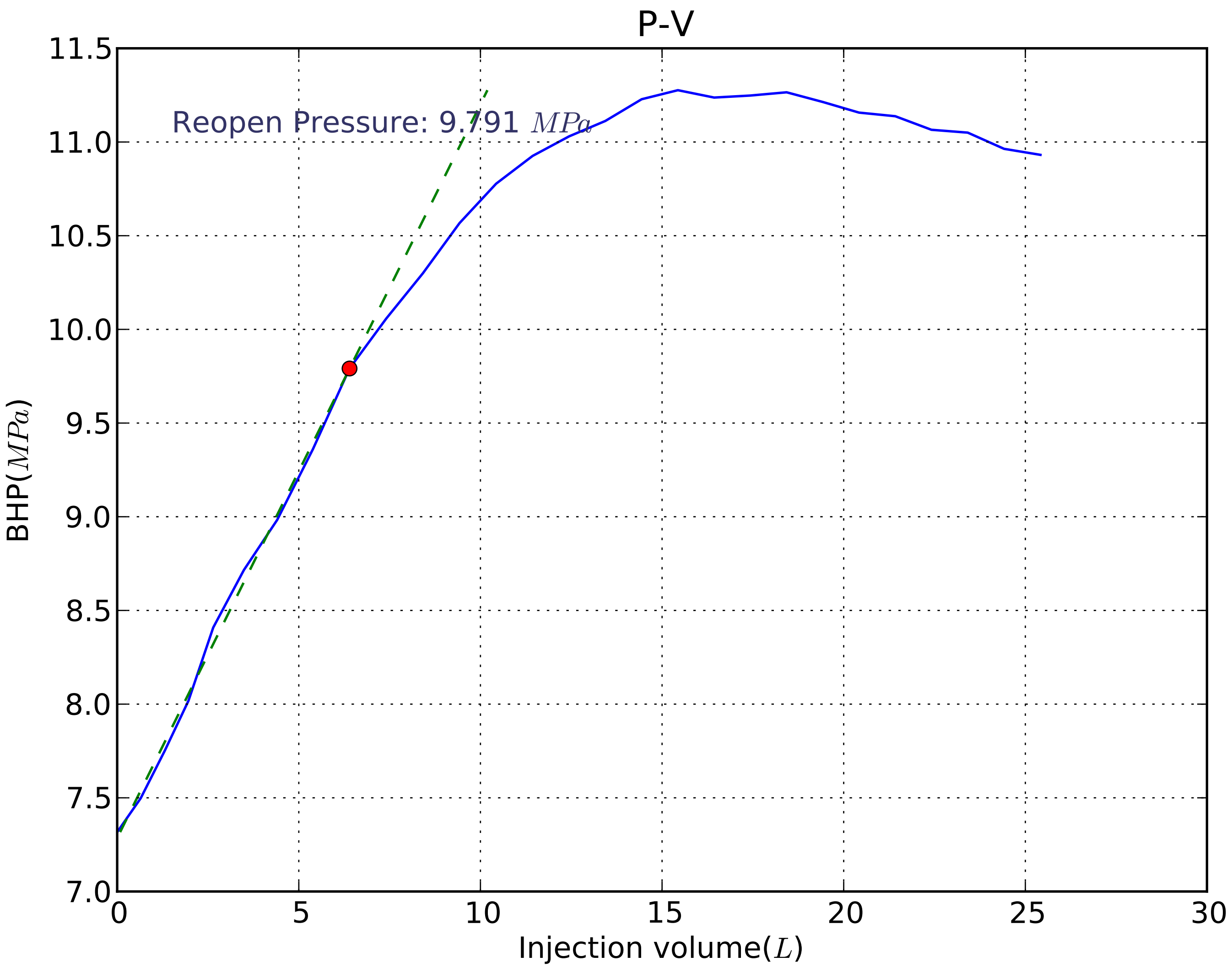


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 03

BitCan
Geosciences & Engineering Inc.

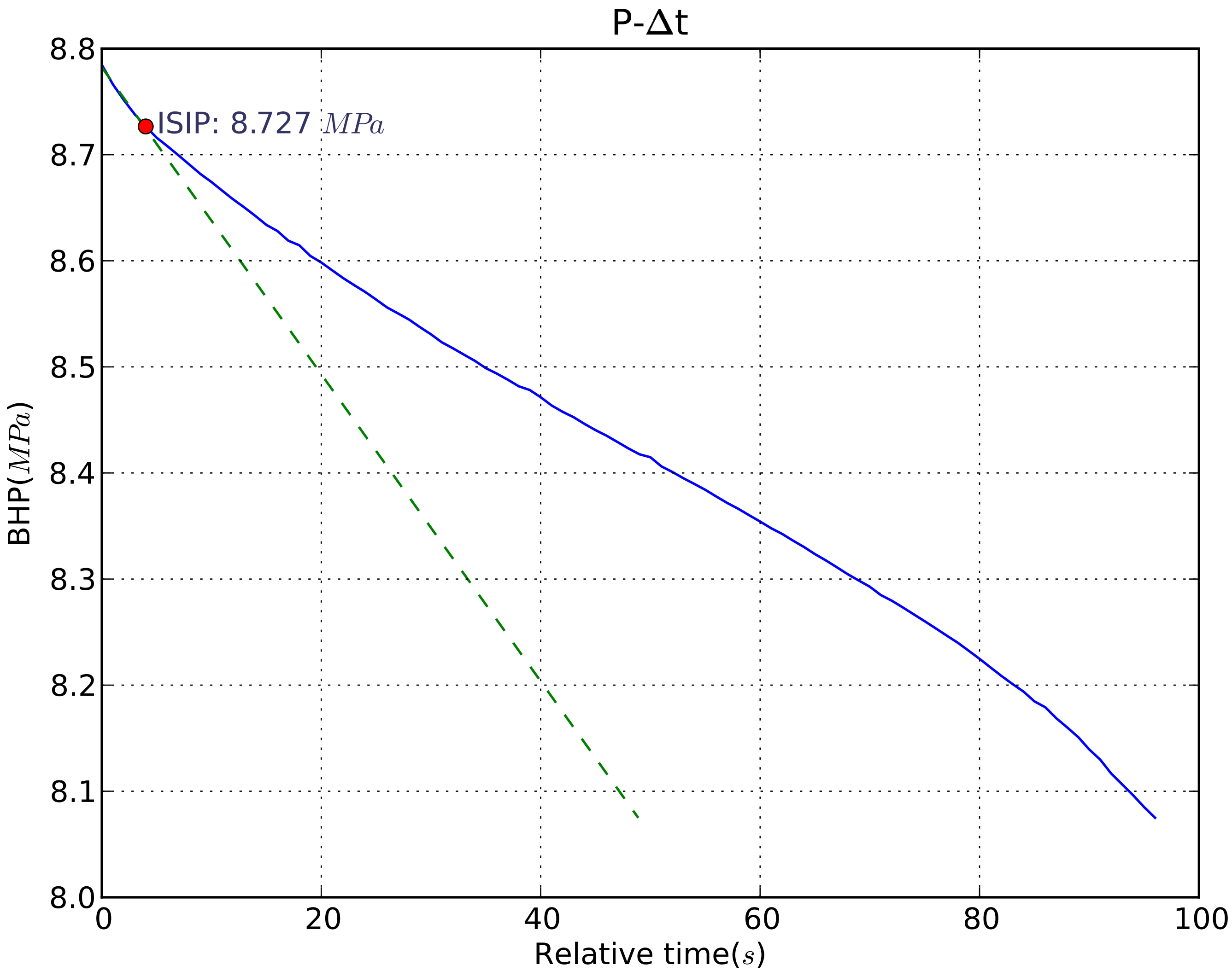


BitCan
Geosciences & Engineering Inc.

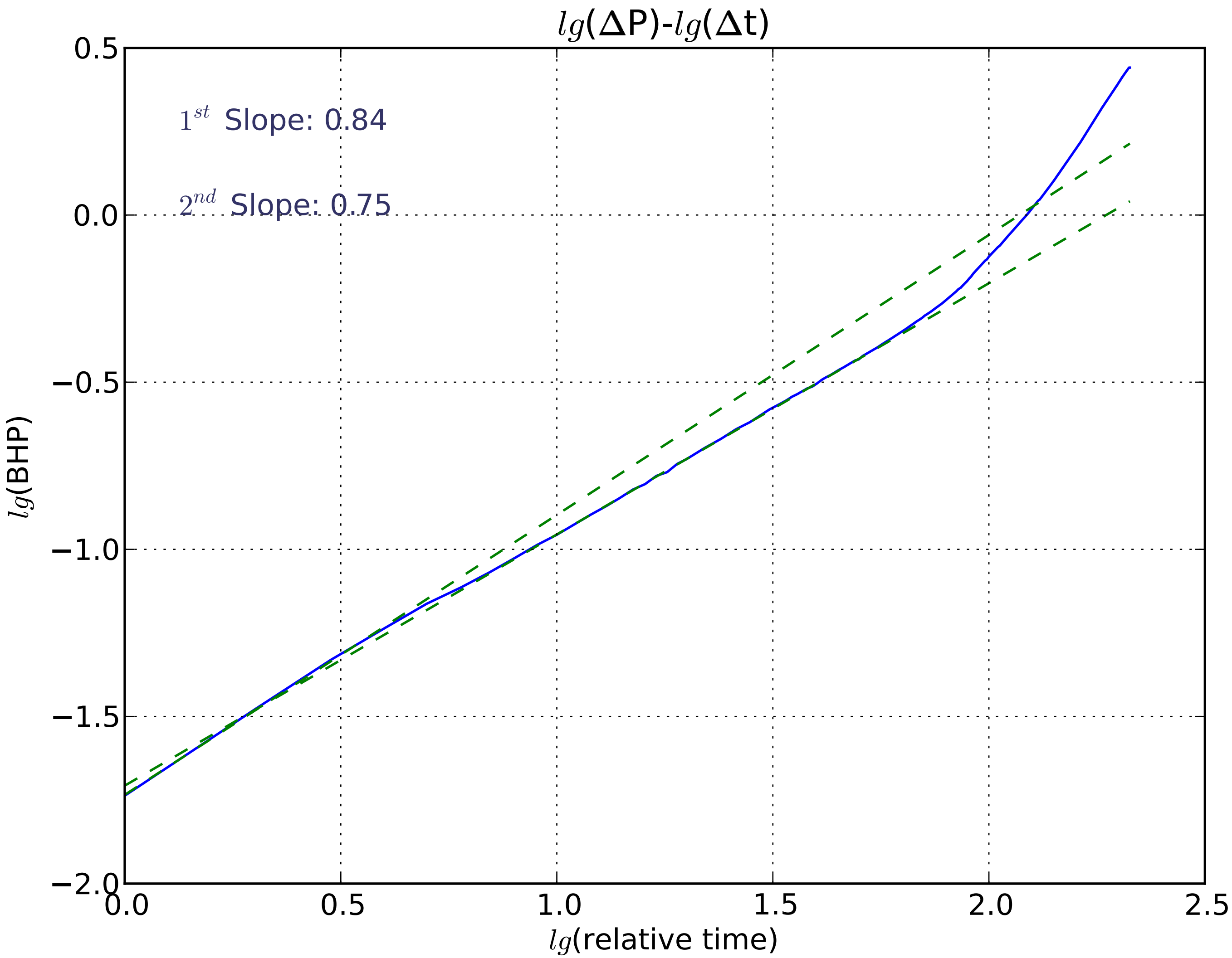


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 03

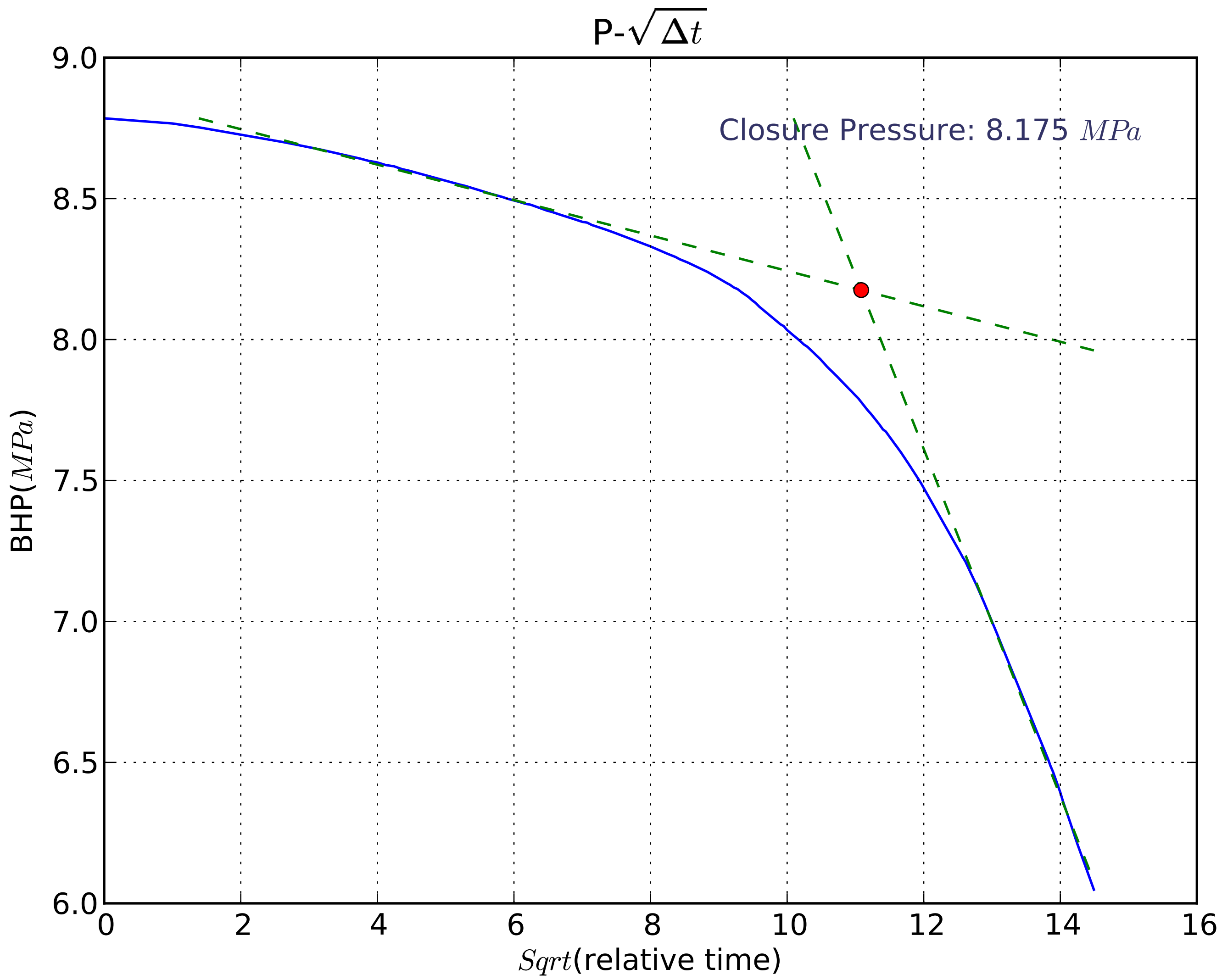
BitCan
Geosciences & Engineering Inc.



BitCan
Geosciences & Engineering Inc.

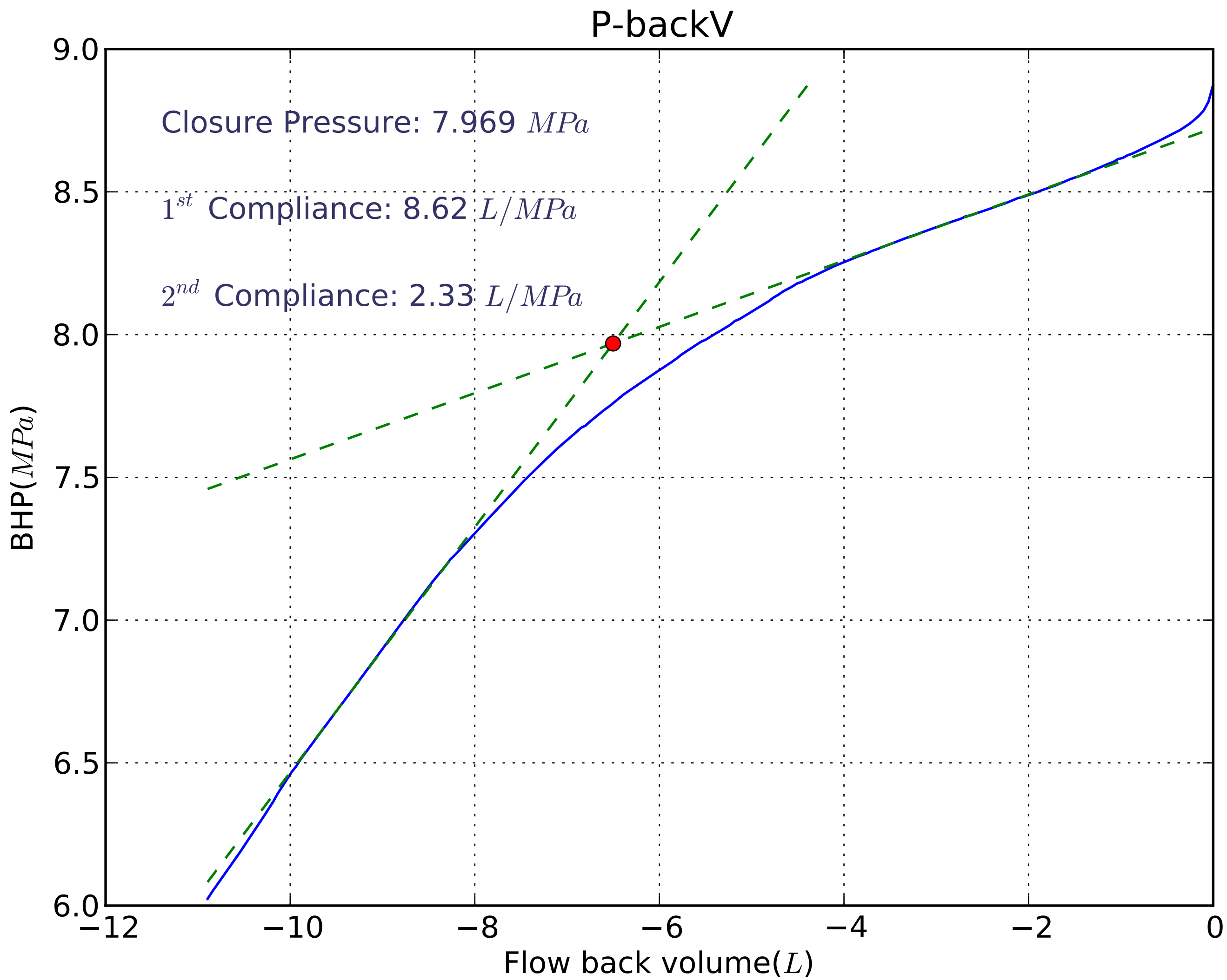


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 03

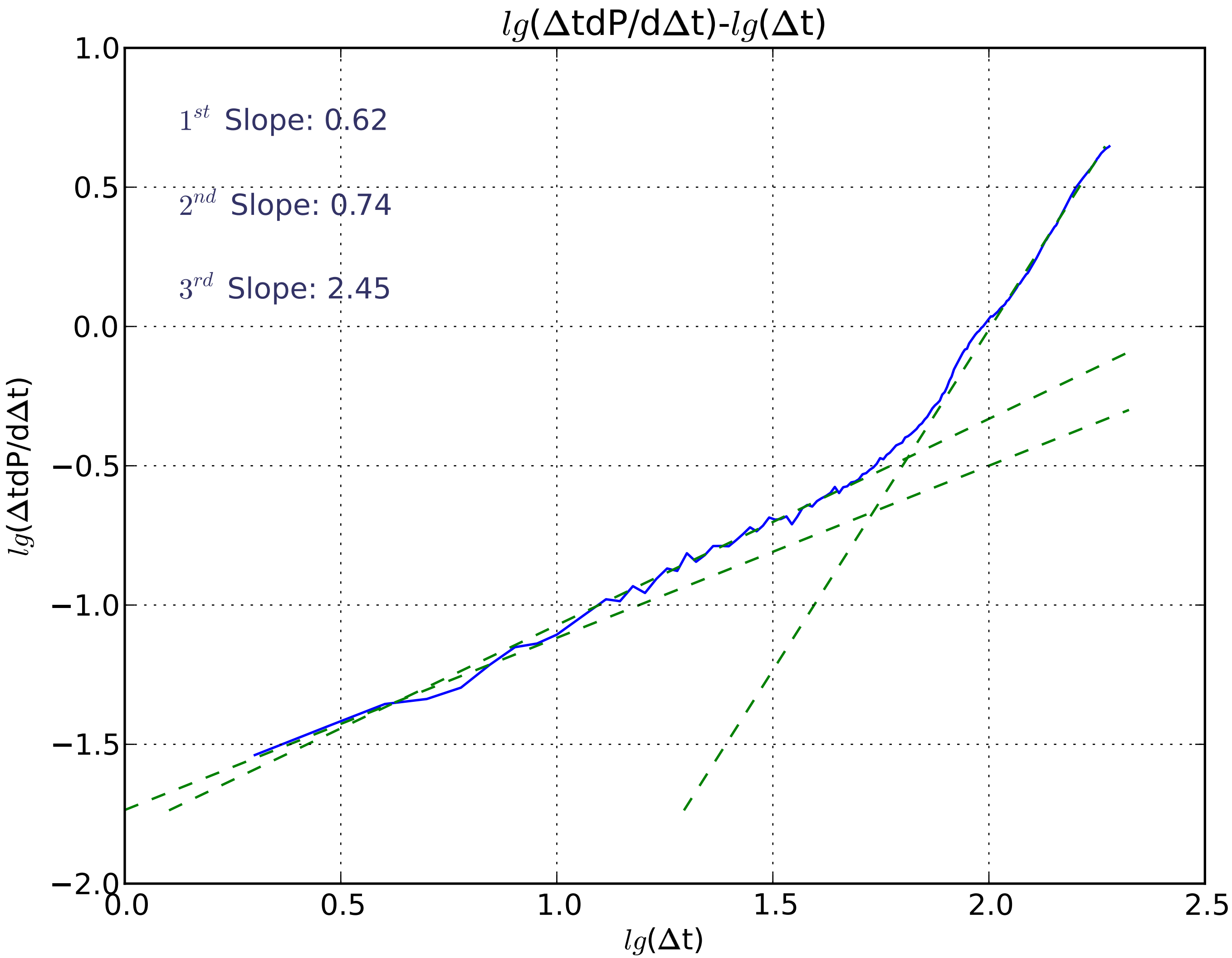


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 03

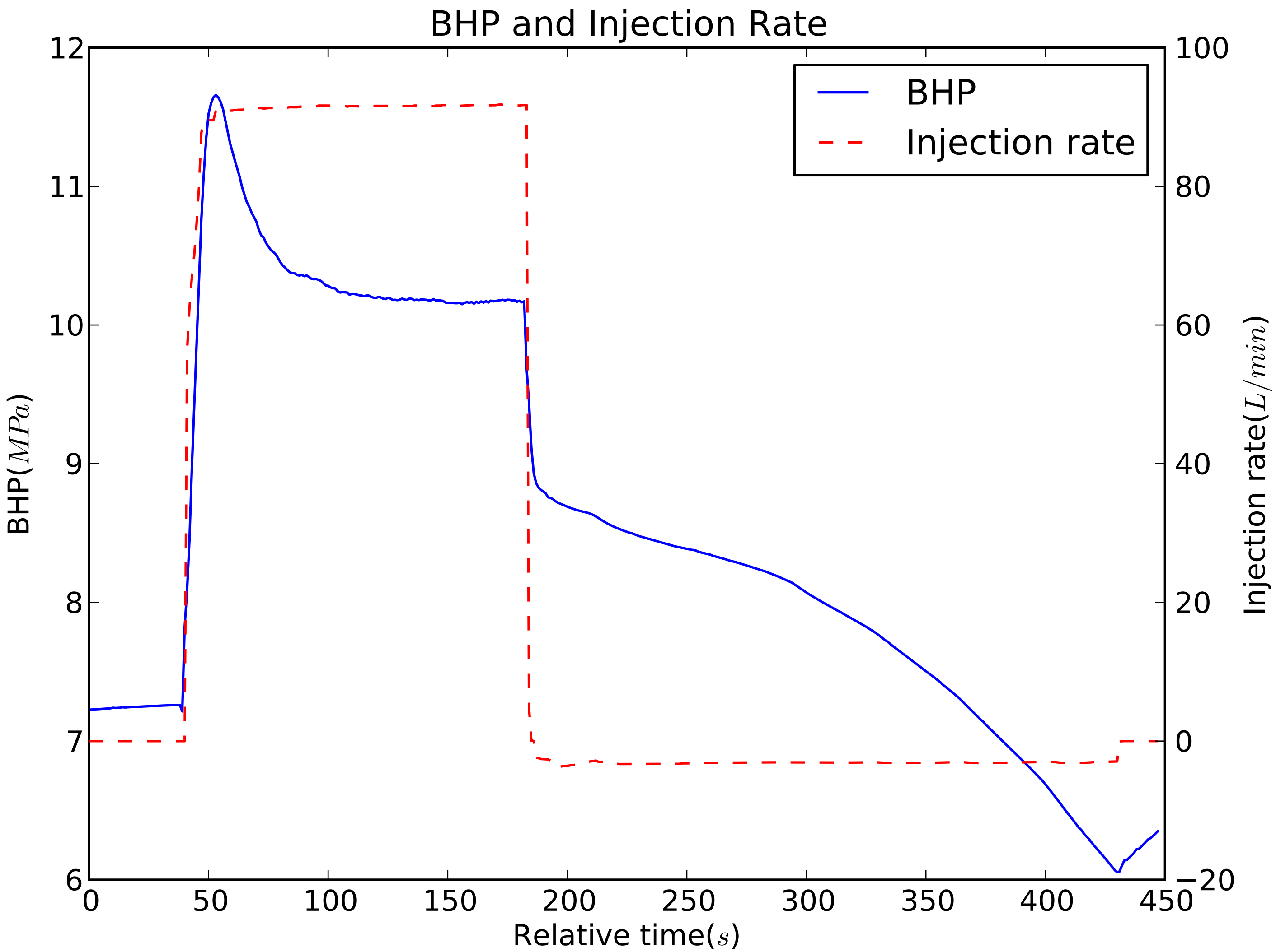
BitCan
Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 03

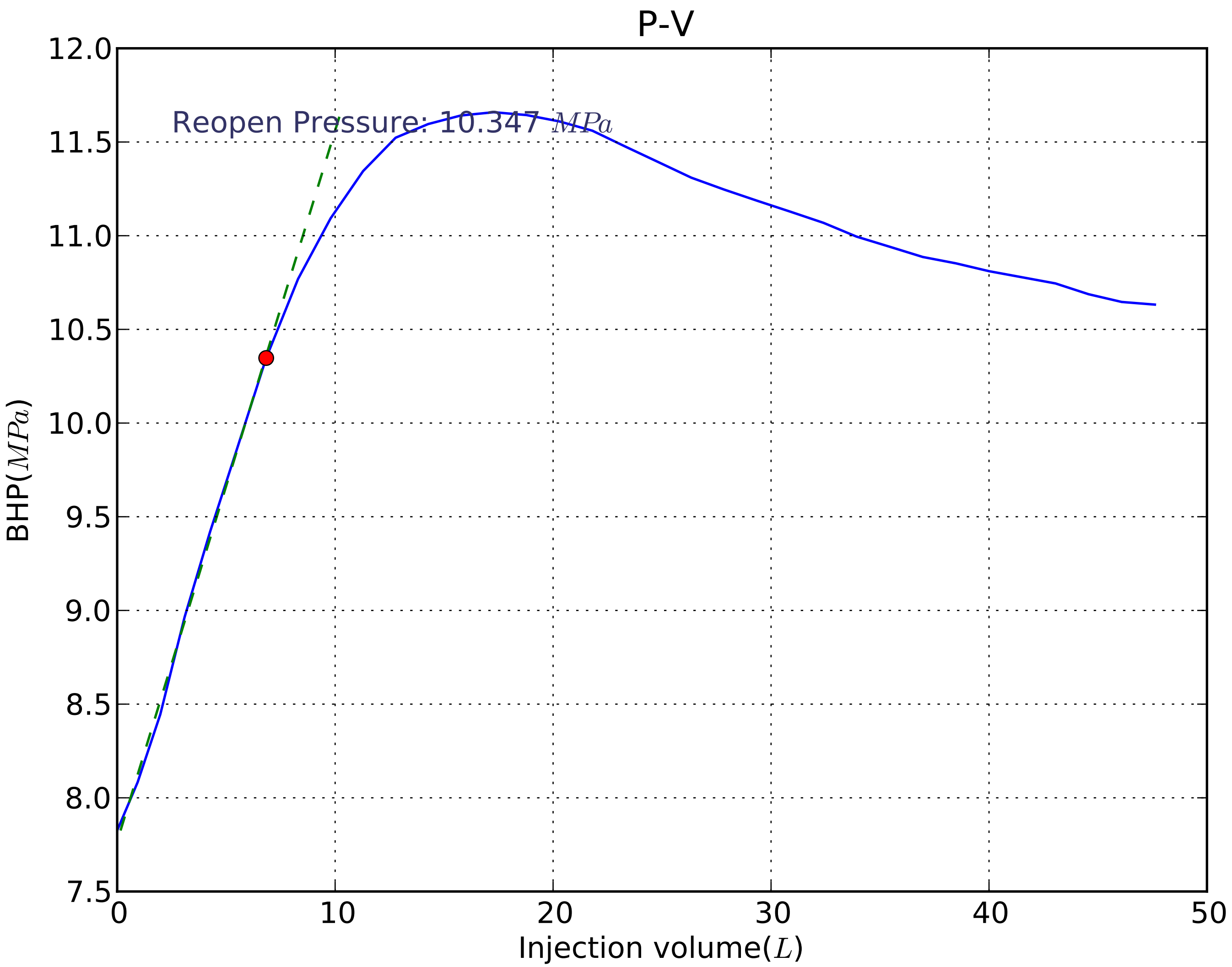


BitCan
Geosciences & Engineering Inc.



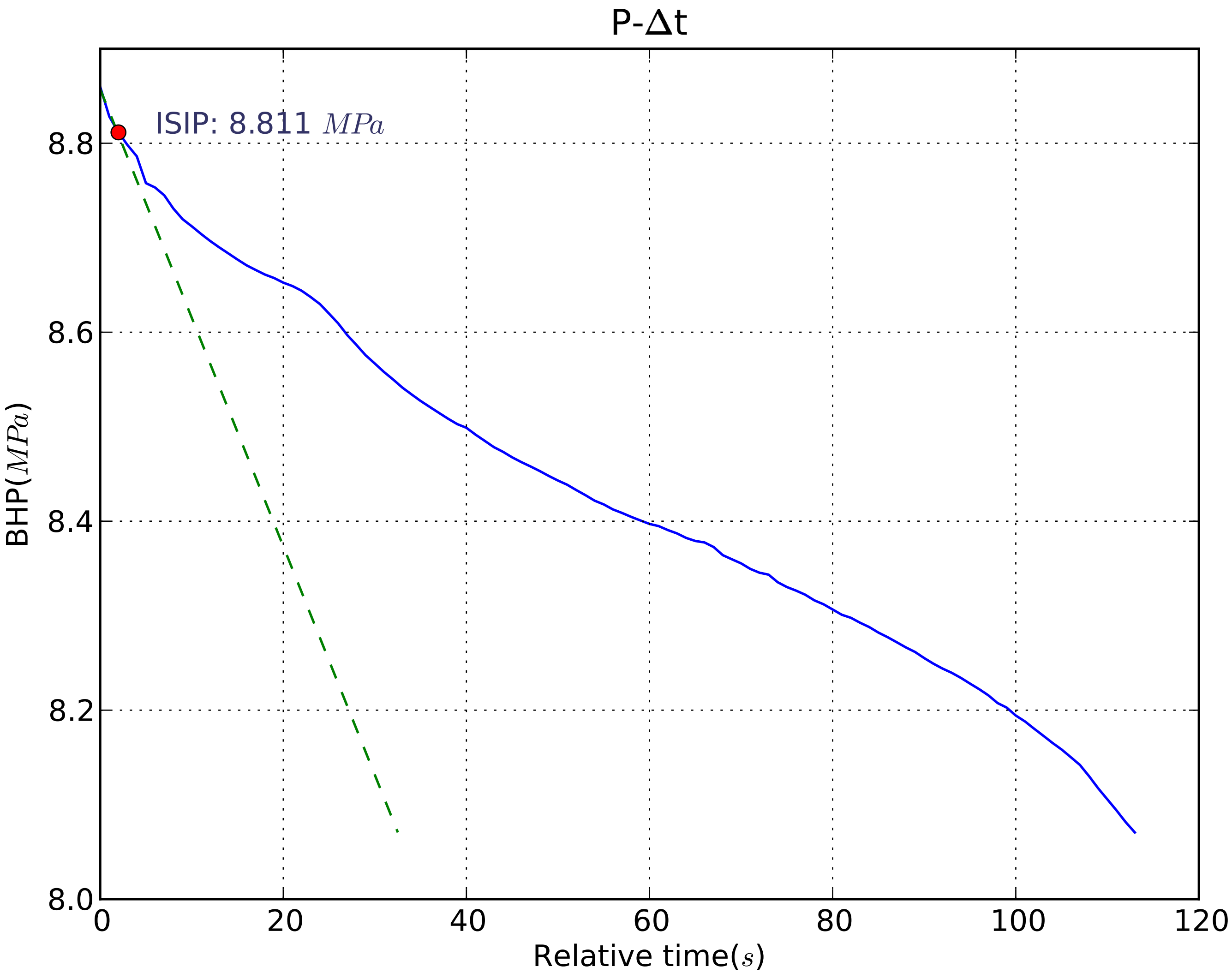
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.



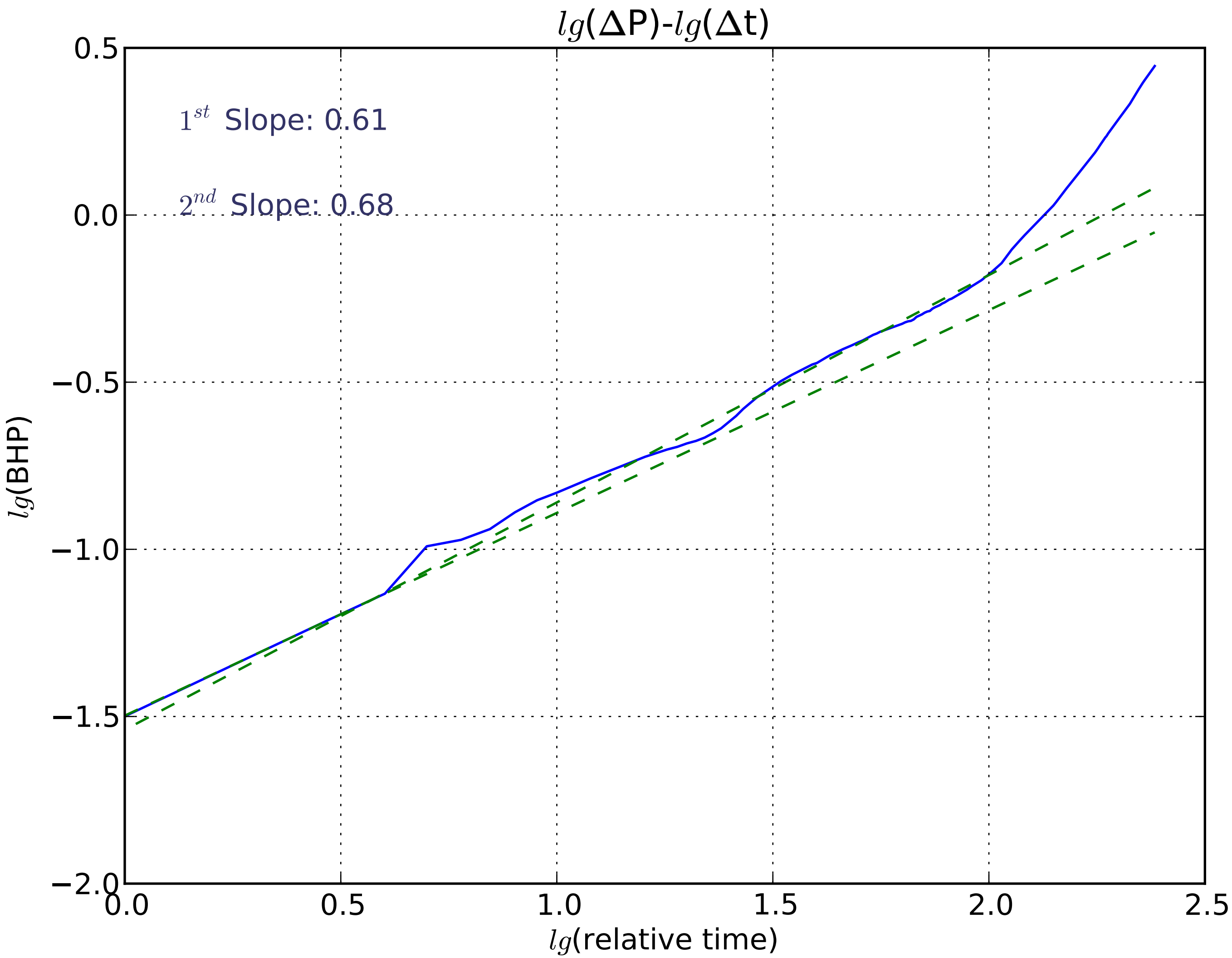
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.



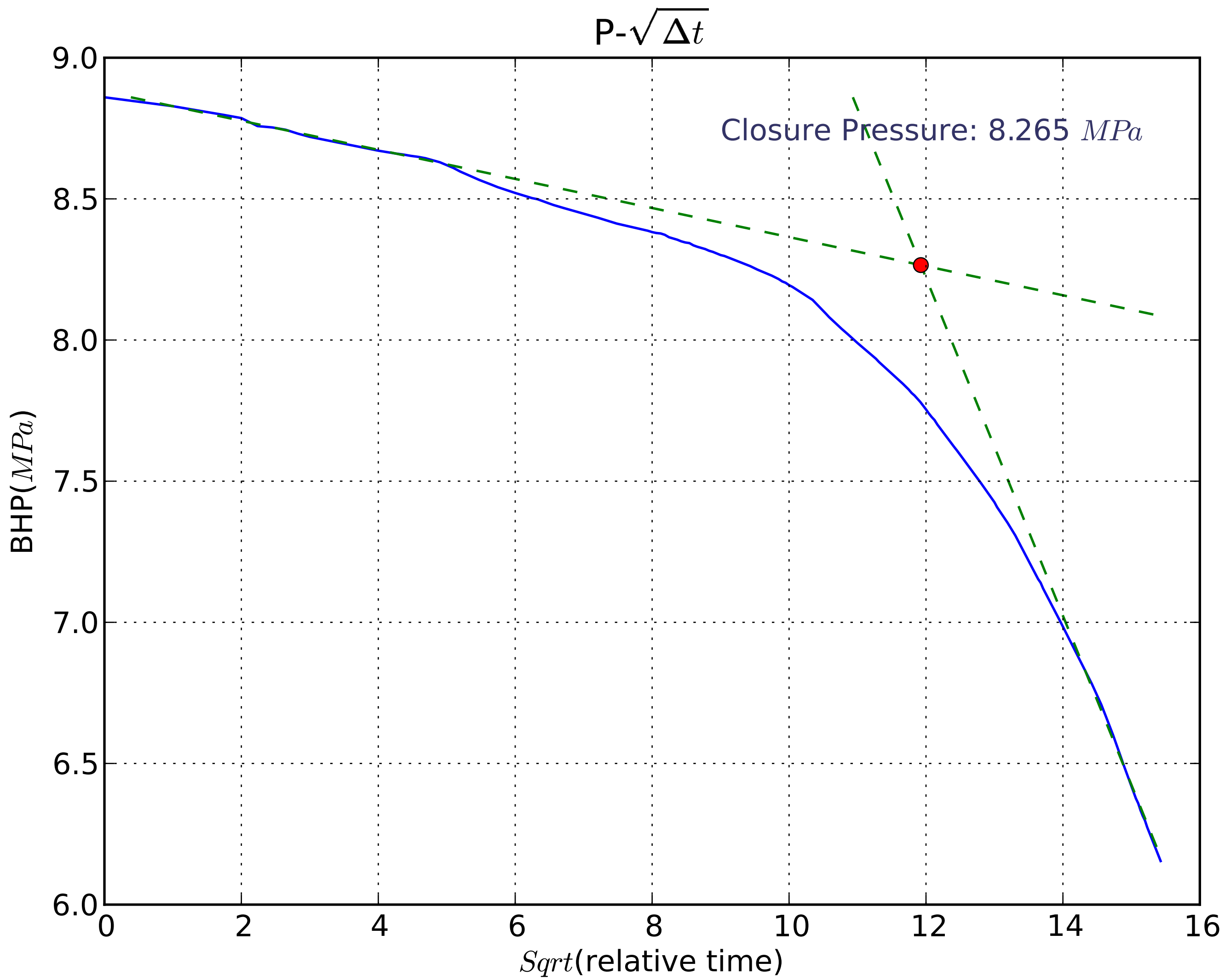
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.



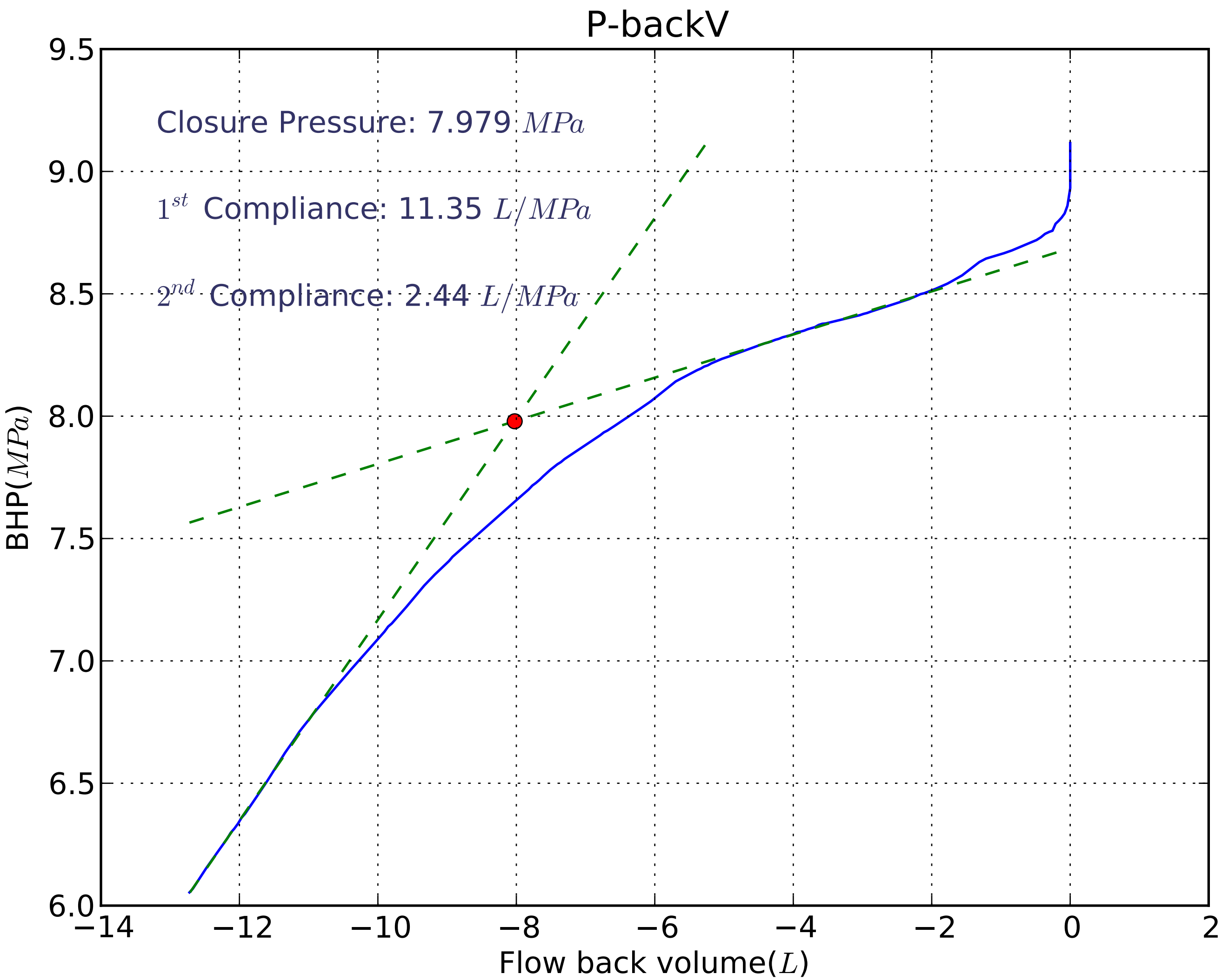
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.



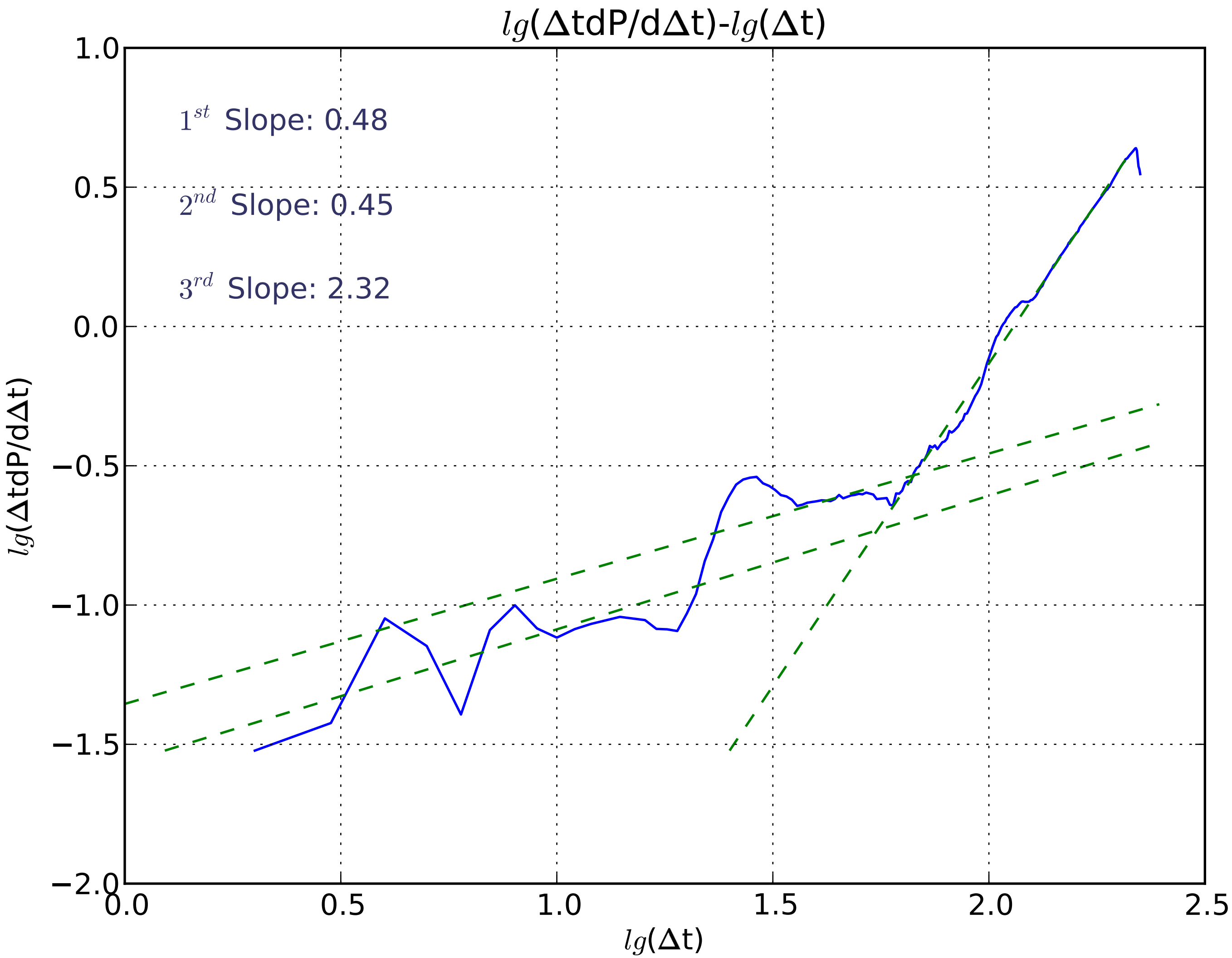
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.

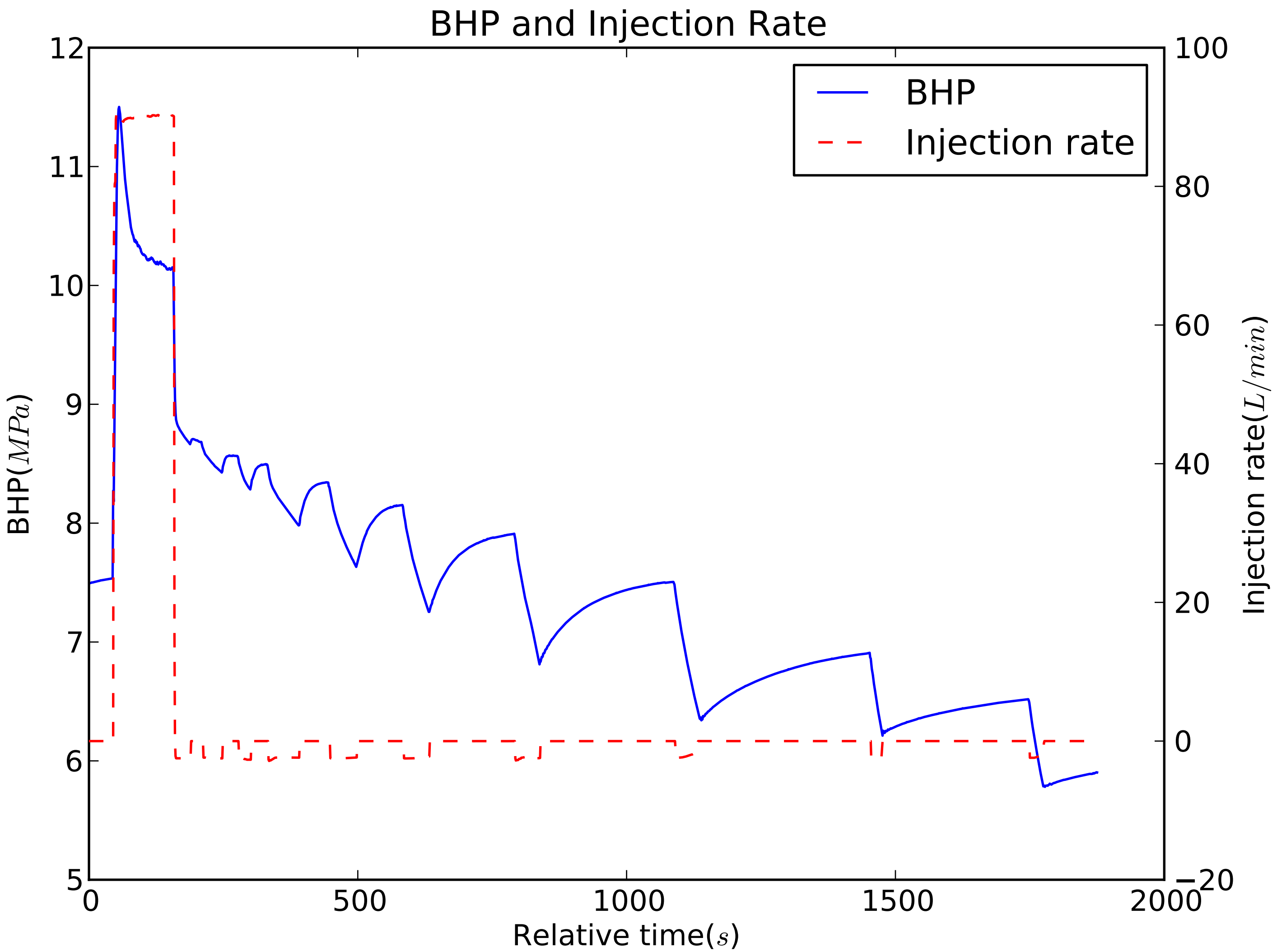


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 04

BitCan
Geosciences & Engineering Inc.

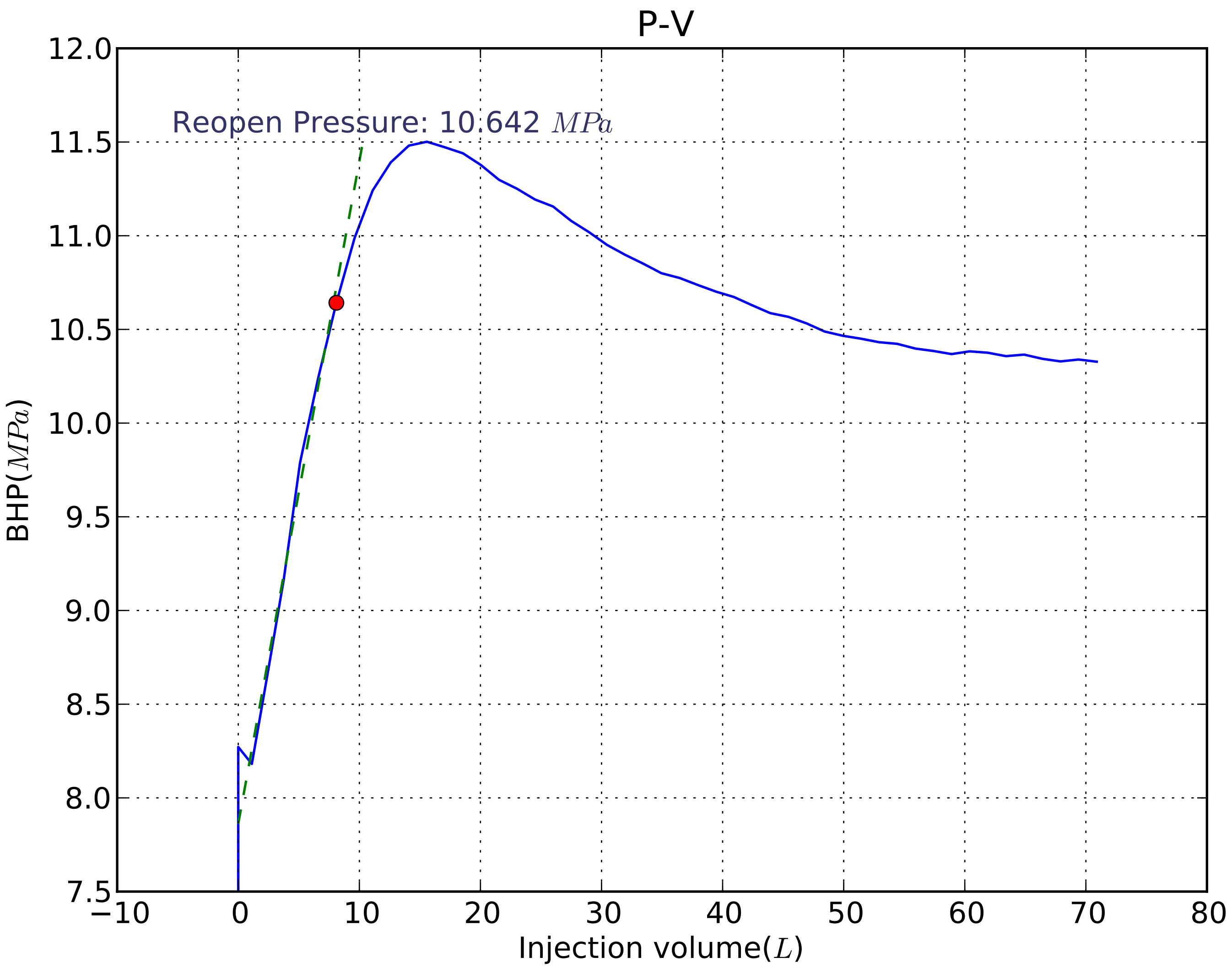


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 05



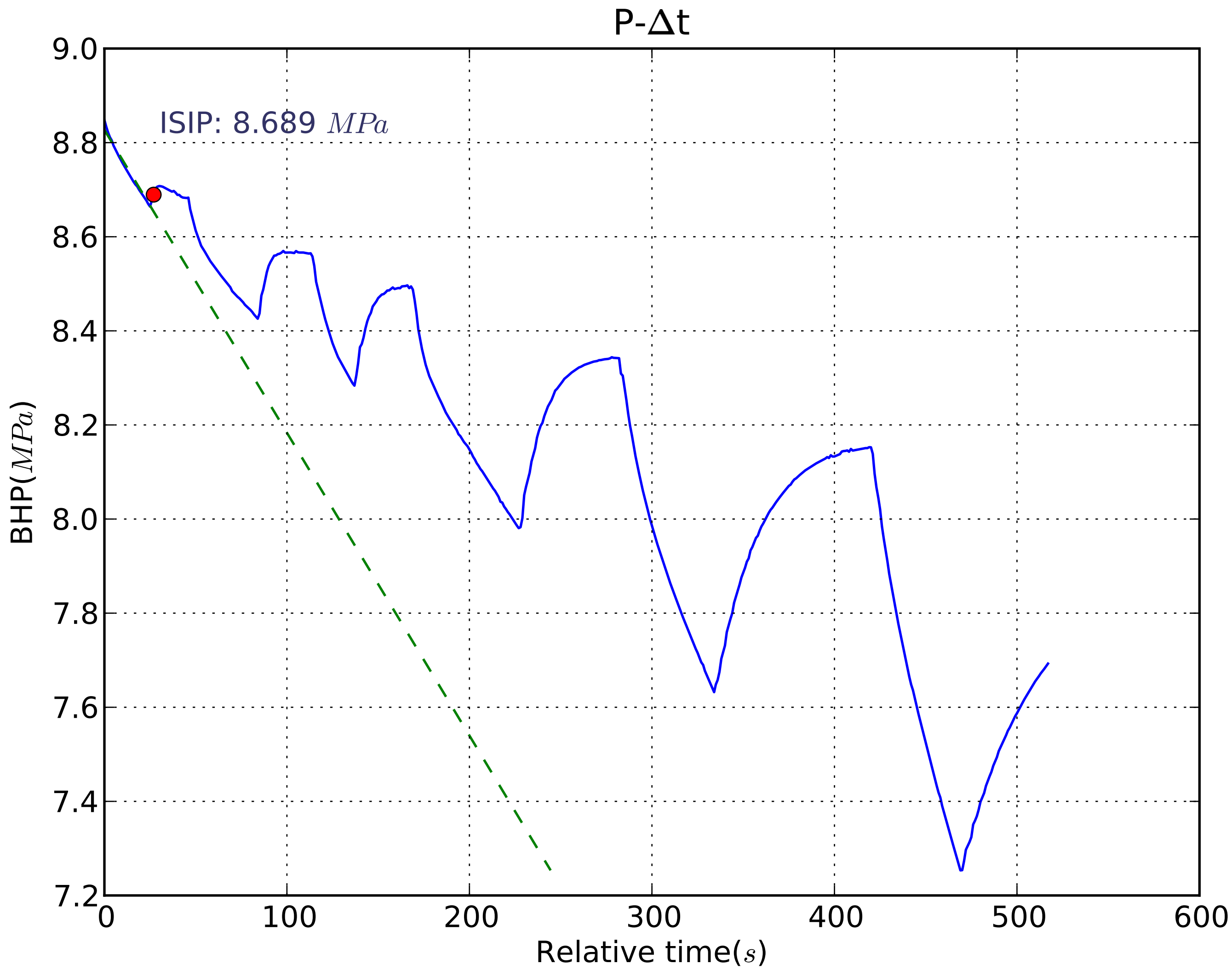
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 05

BitCan
Geosciences & Engineering Inc.

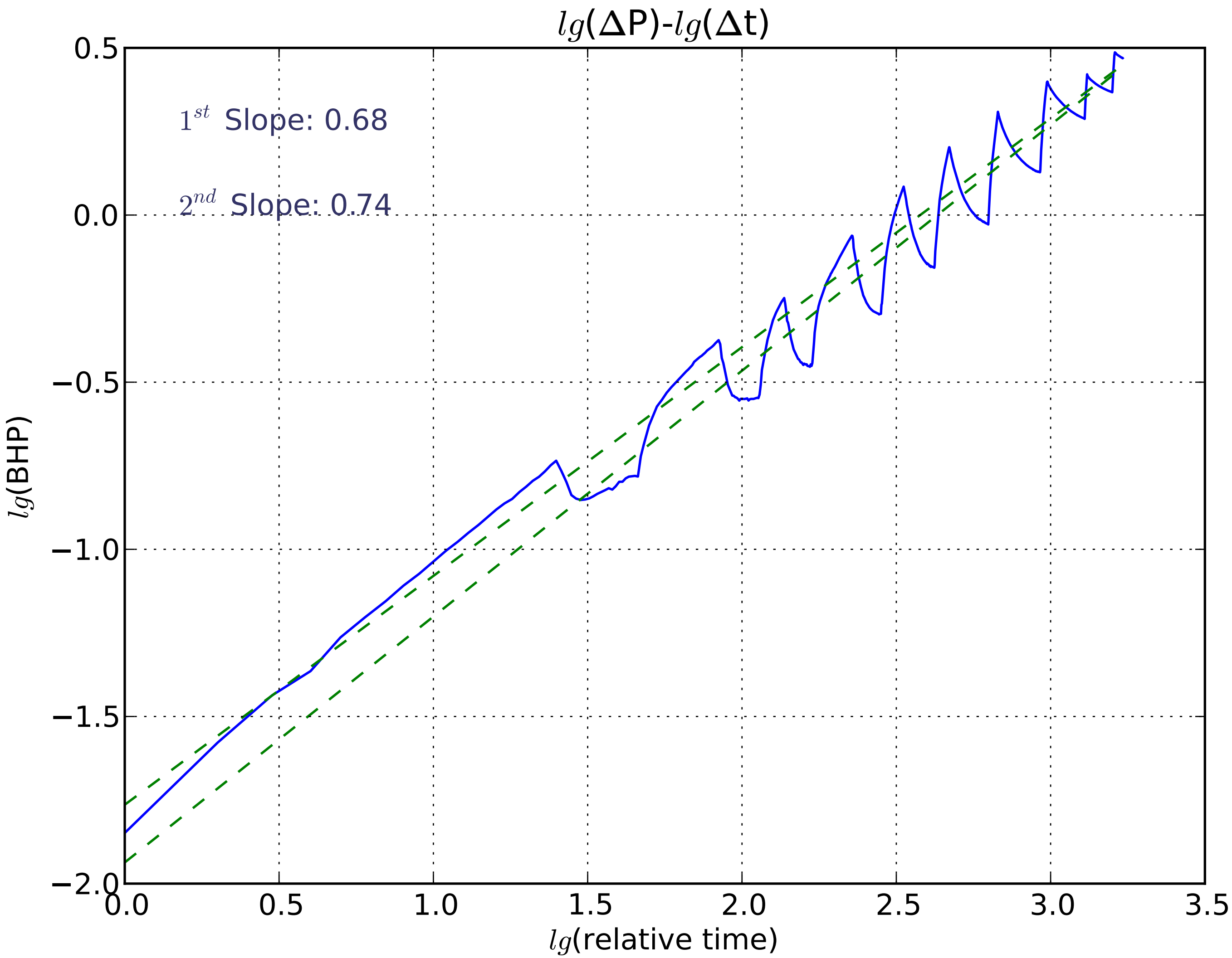


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 05

BitCan
Geosciences & Engineering Inc.

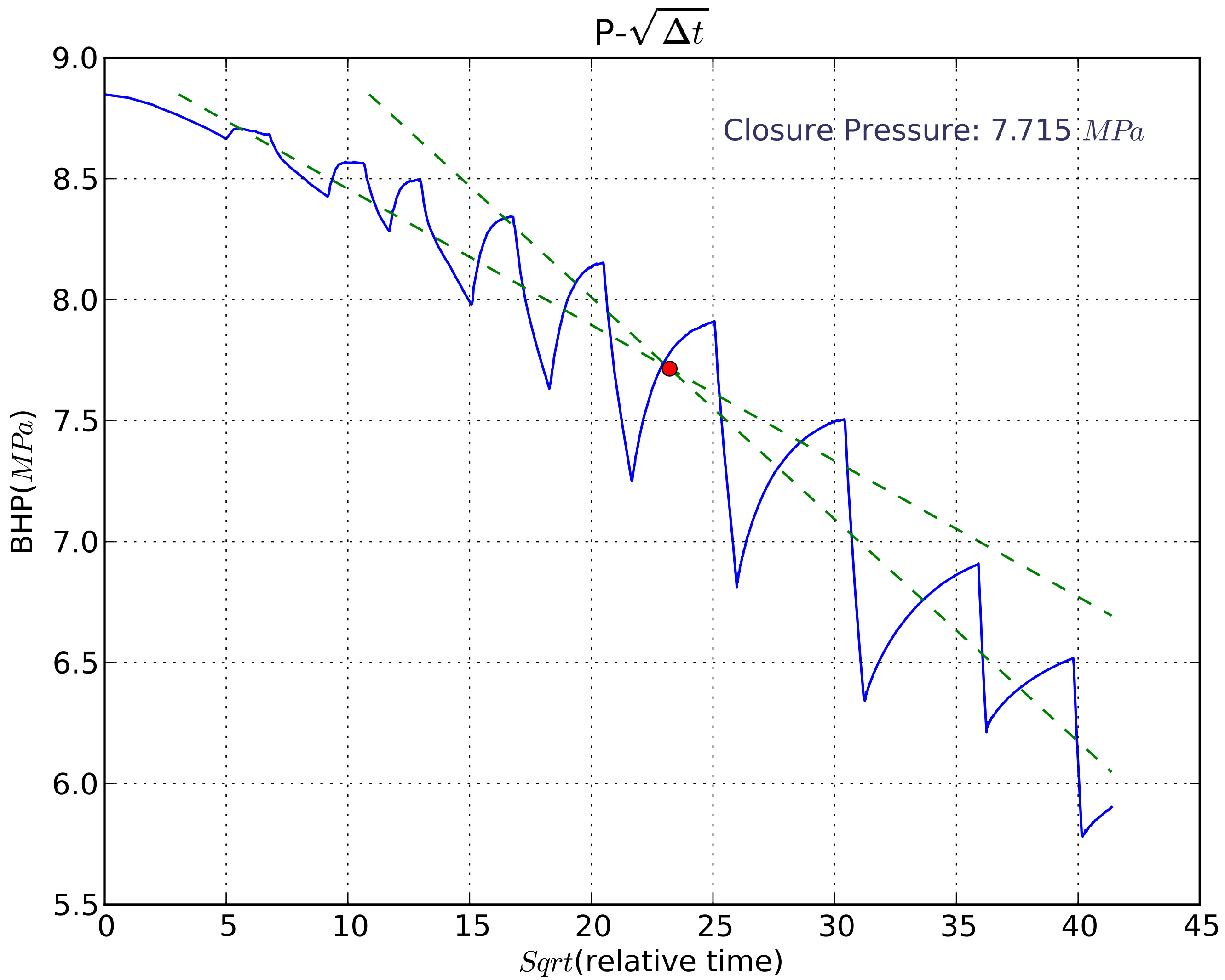


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 05



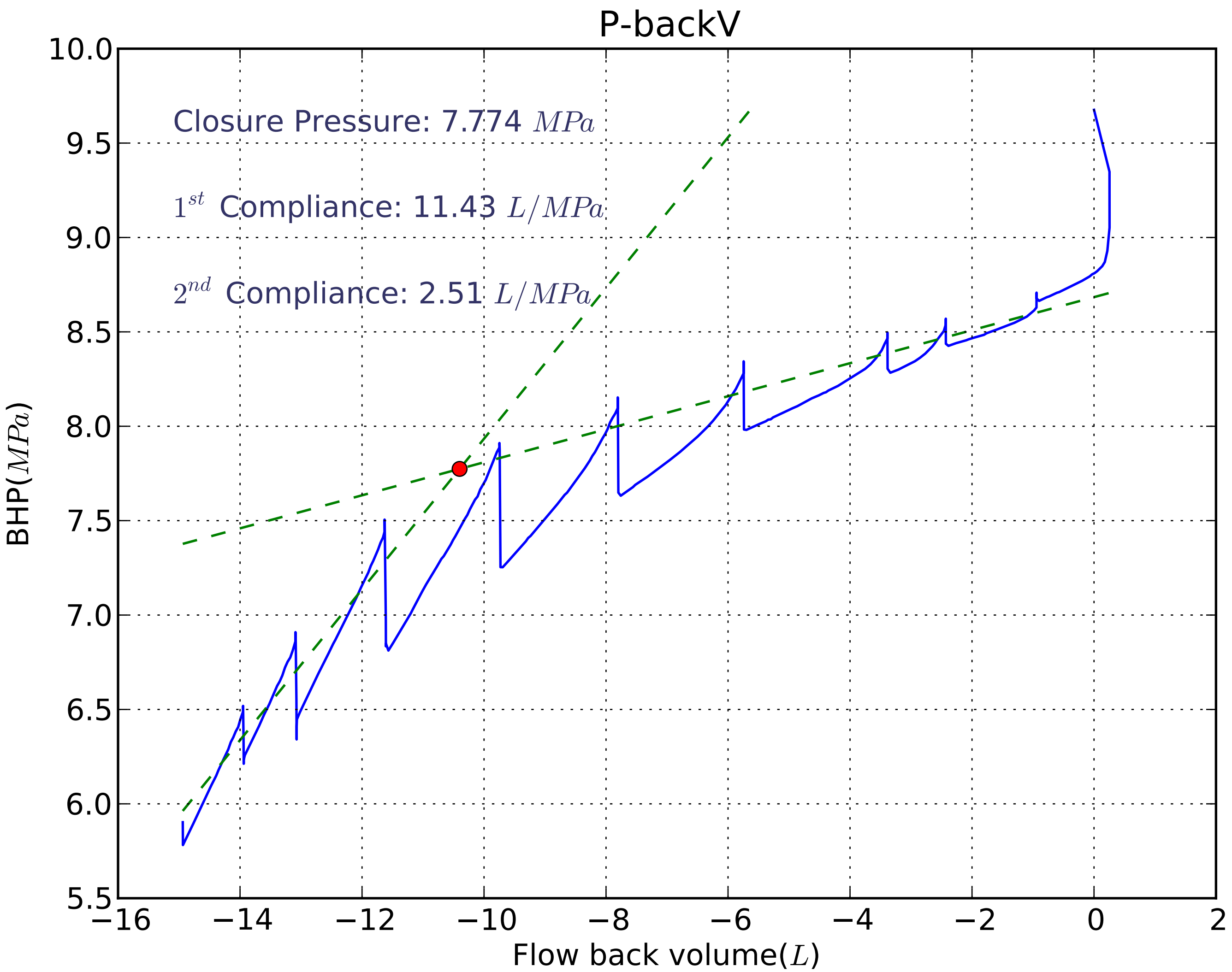
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 05

BitCan
Geosciences & Engineering Inc.



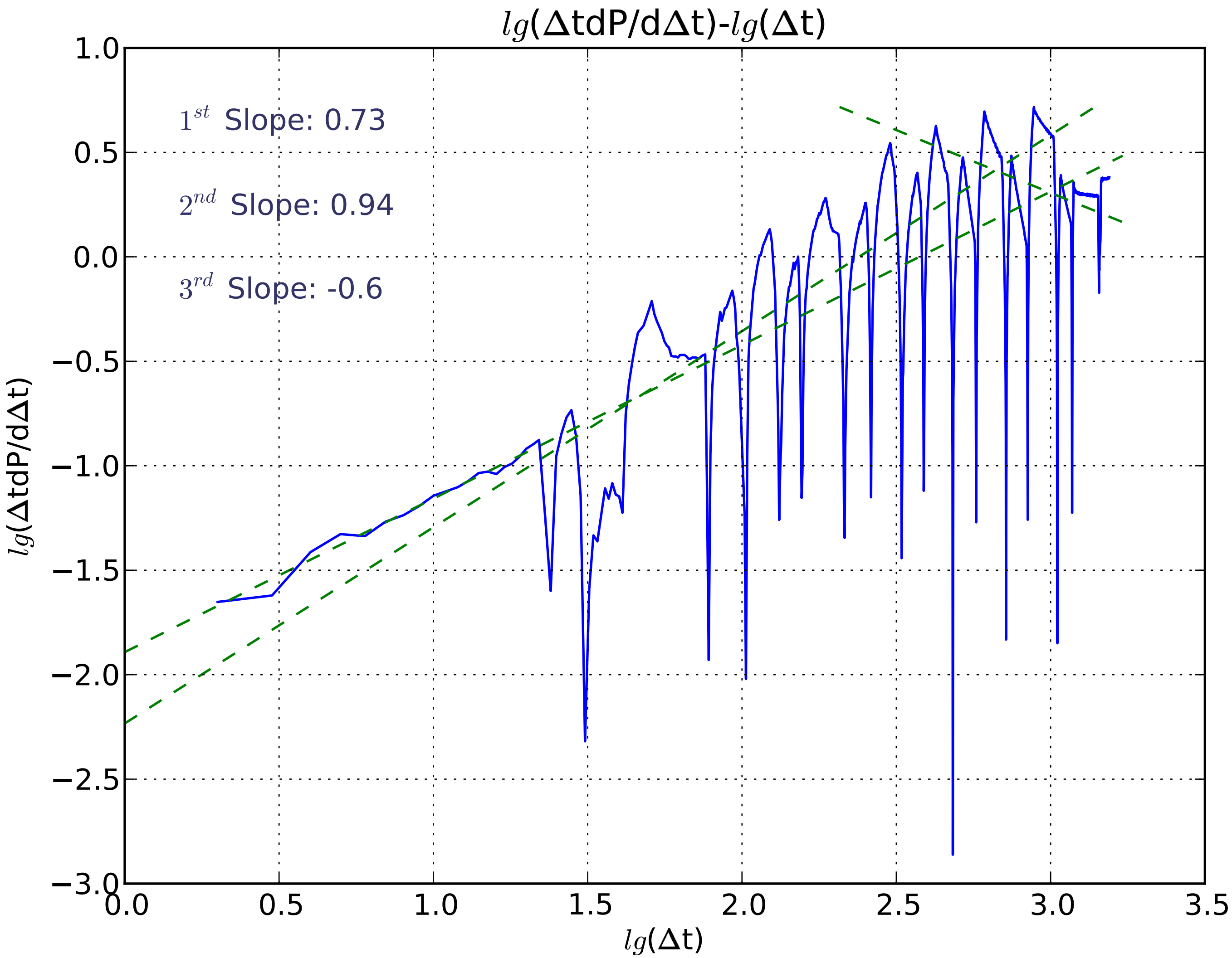
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 05

BitCan
Geosciences & Engineering Inc.



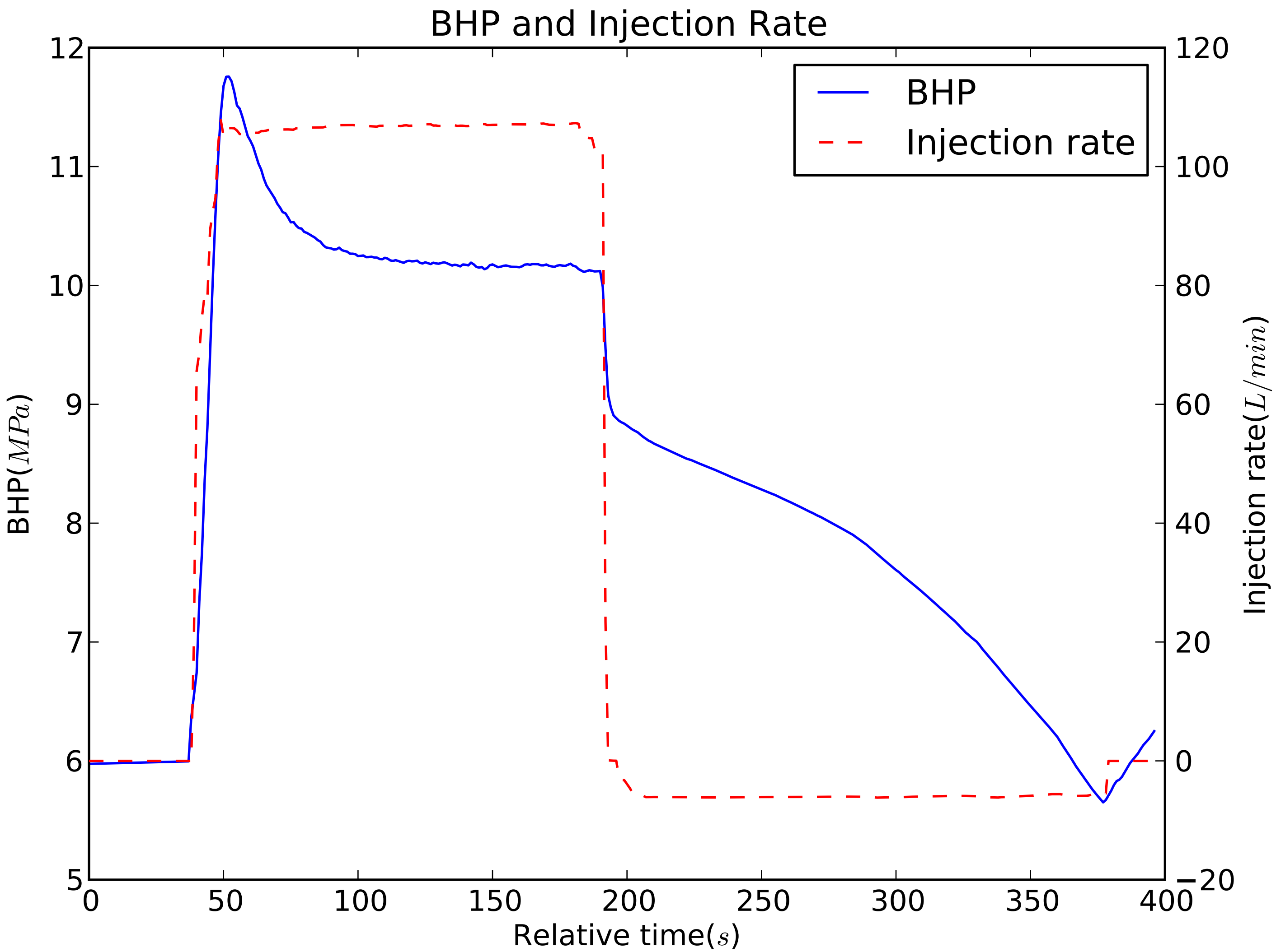
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 05

BitCan
Geosciences & Engineering Inc.



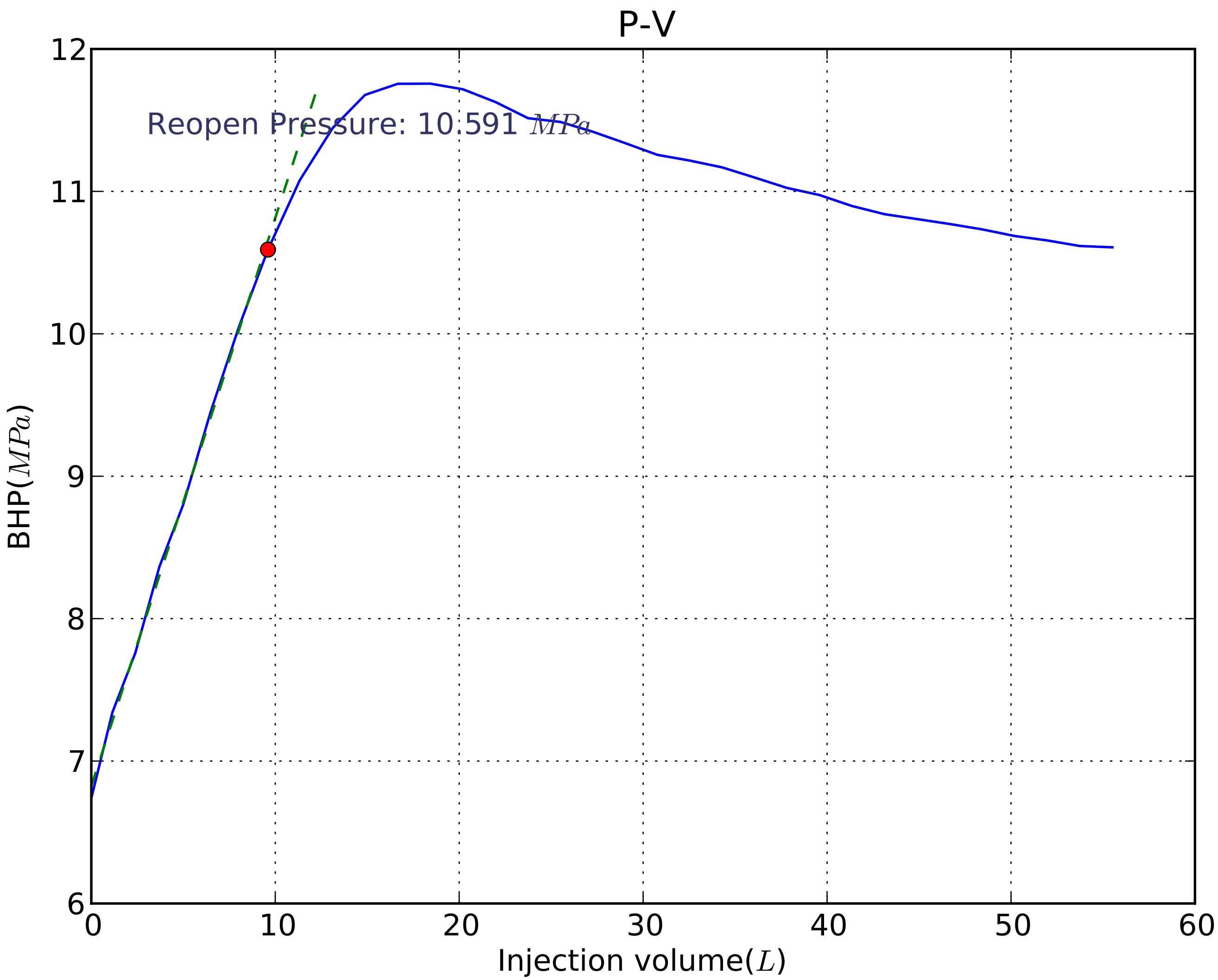
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 06

BitCan
Geosciences & Engineering Inc.



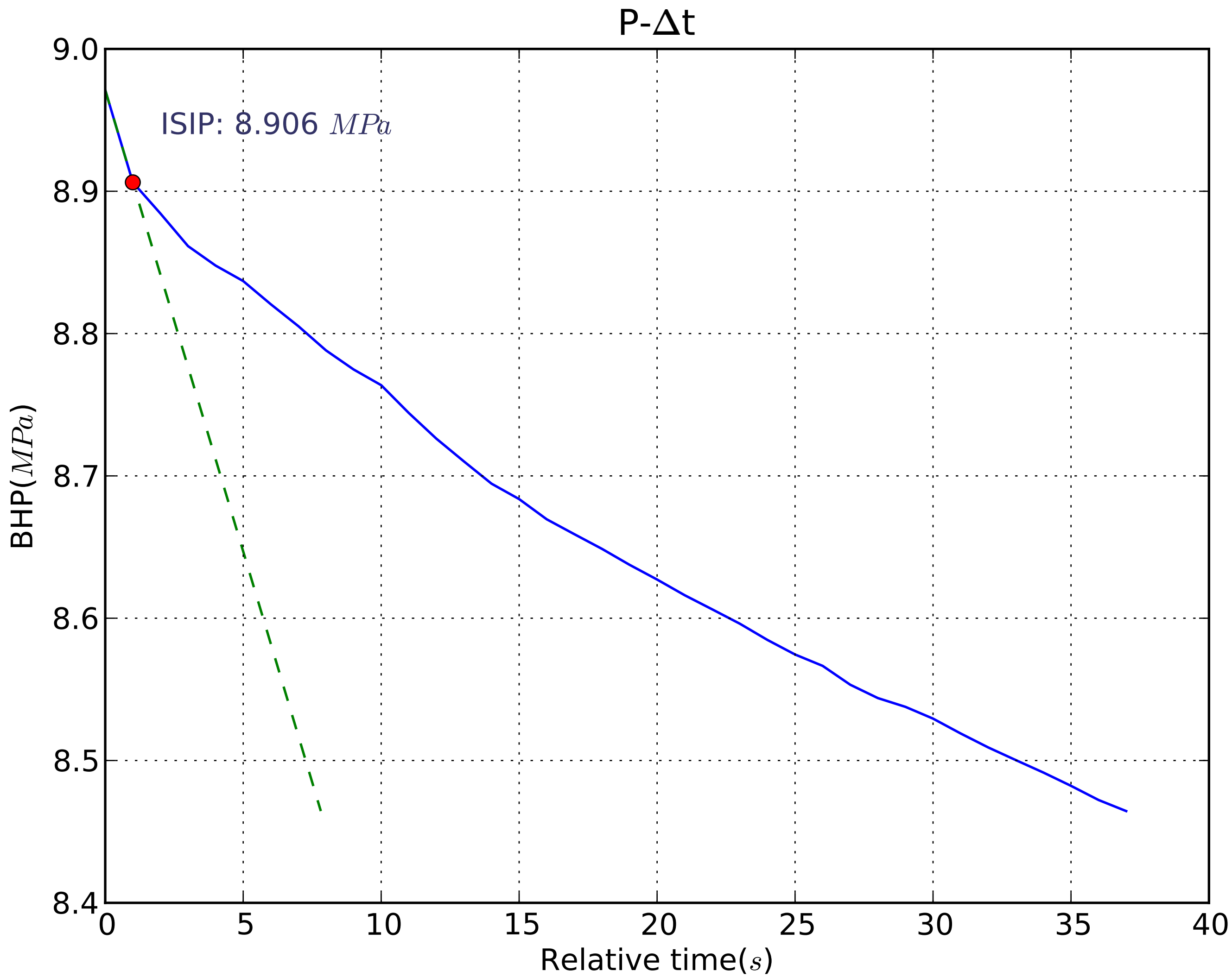
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 06

BitCan
Geosciences & Engineering Inc.

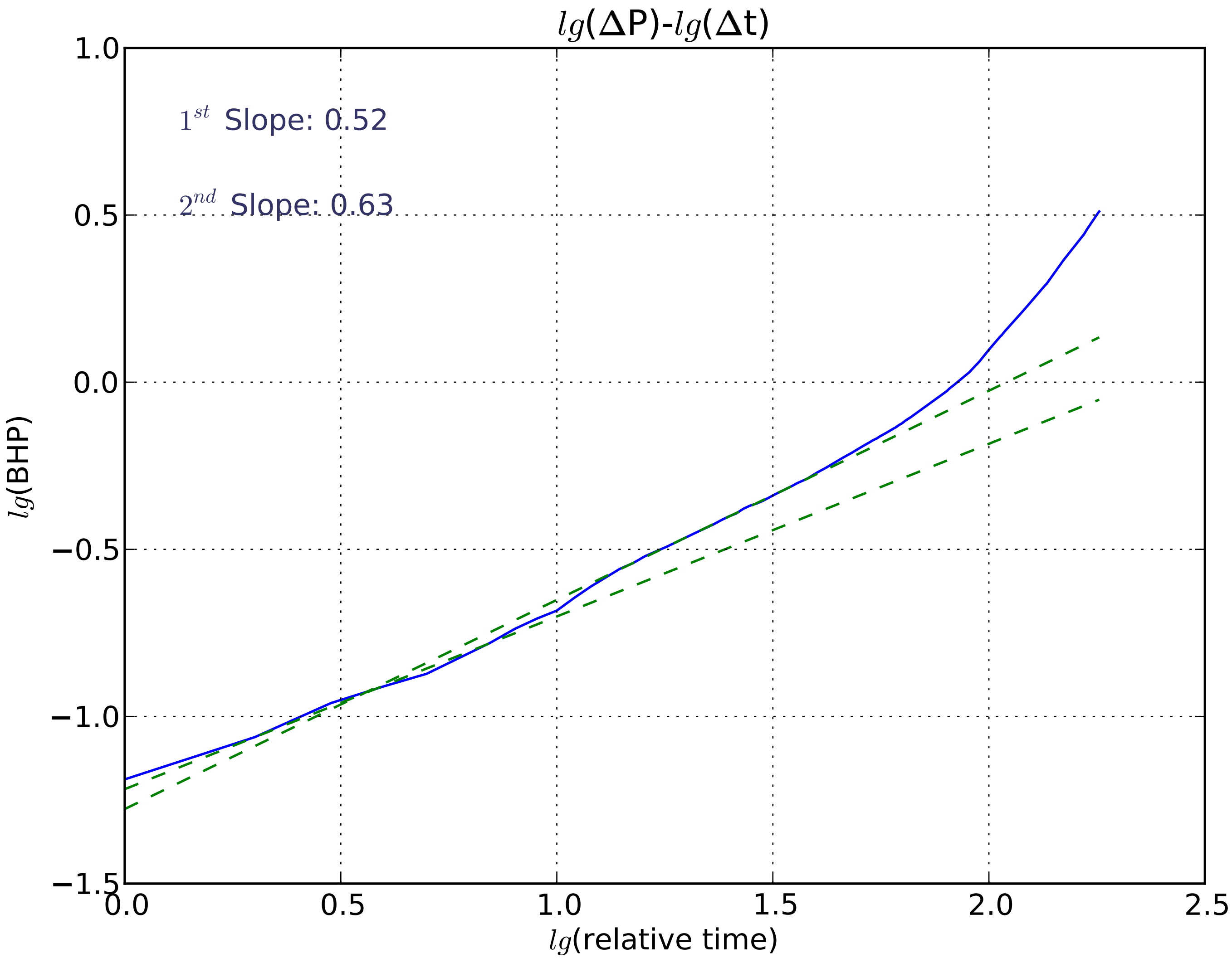


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 06

BitCan Geosciences & Engineering Inc.

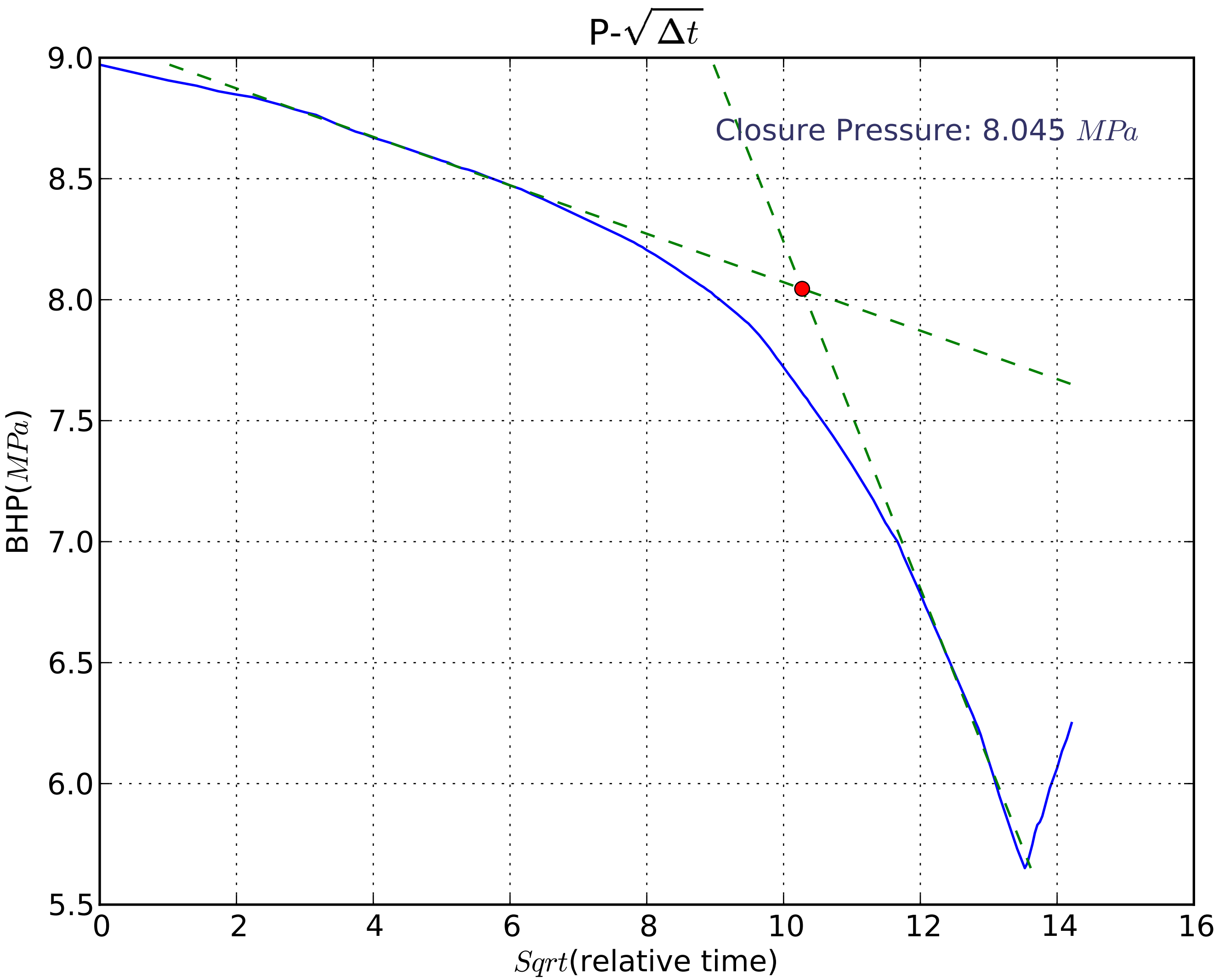


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 06

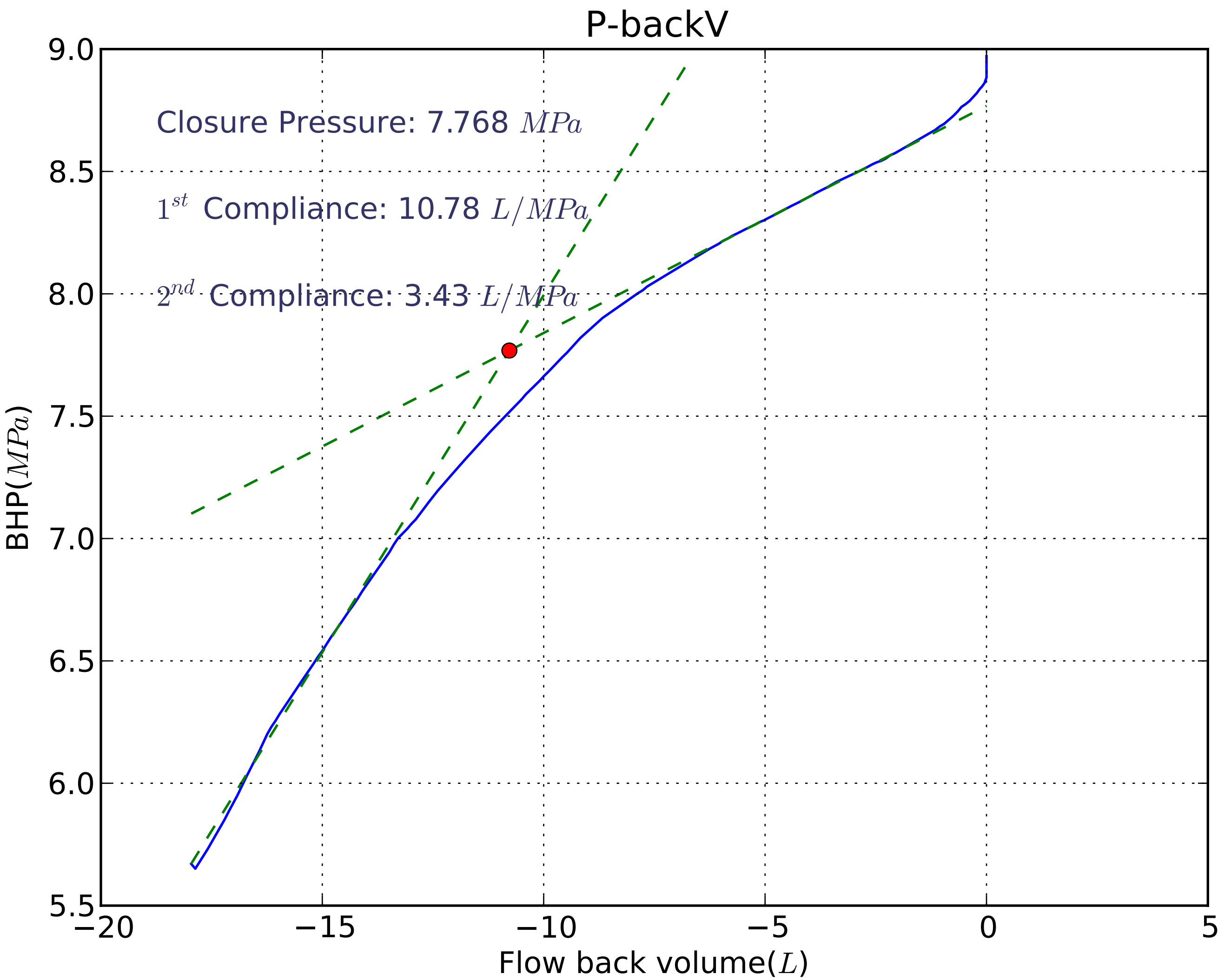


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 06

BitCan Geosciences & Engineering Inc.

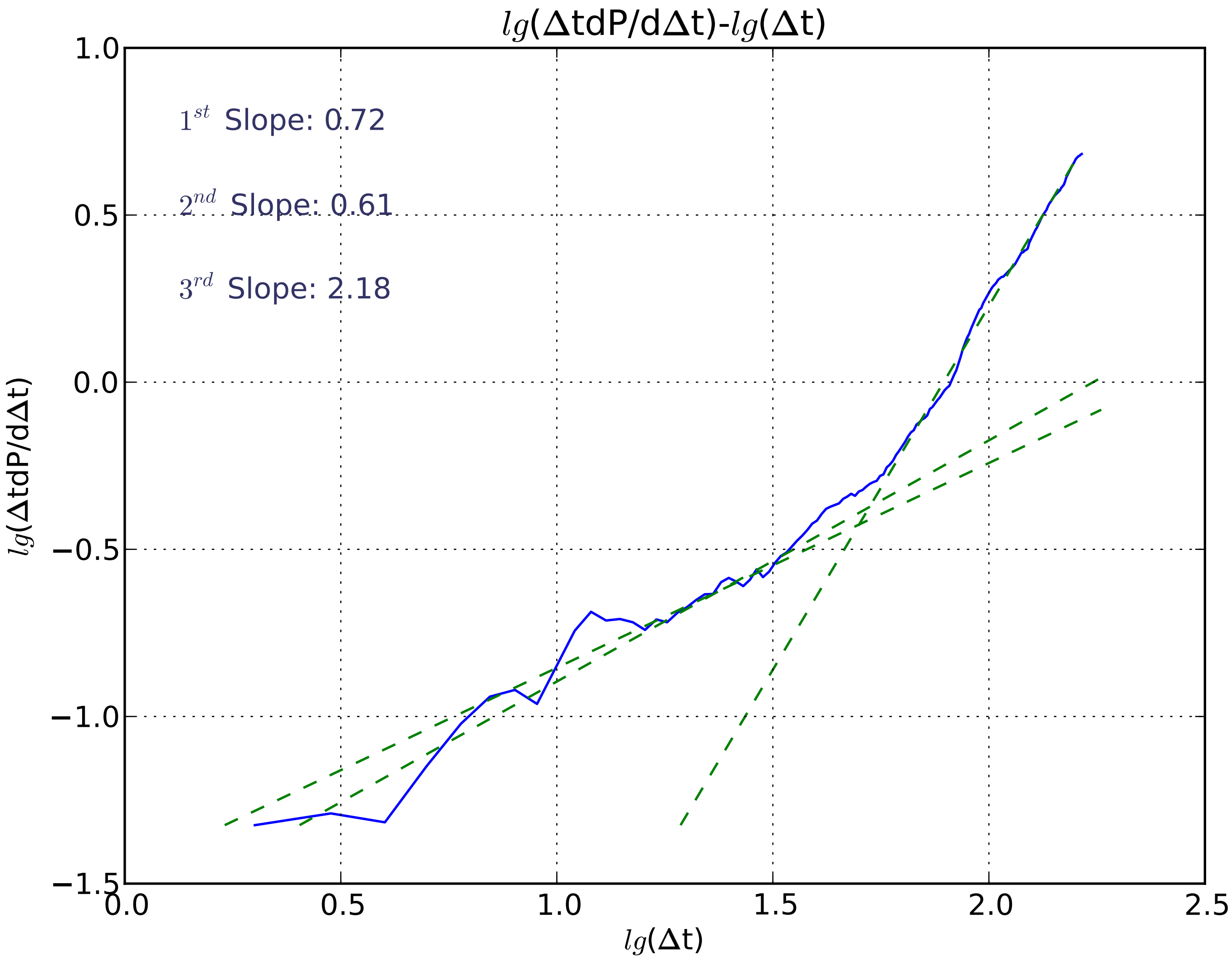


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 06



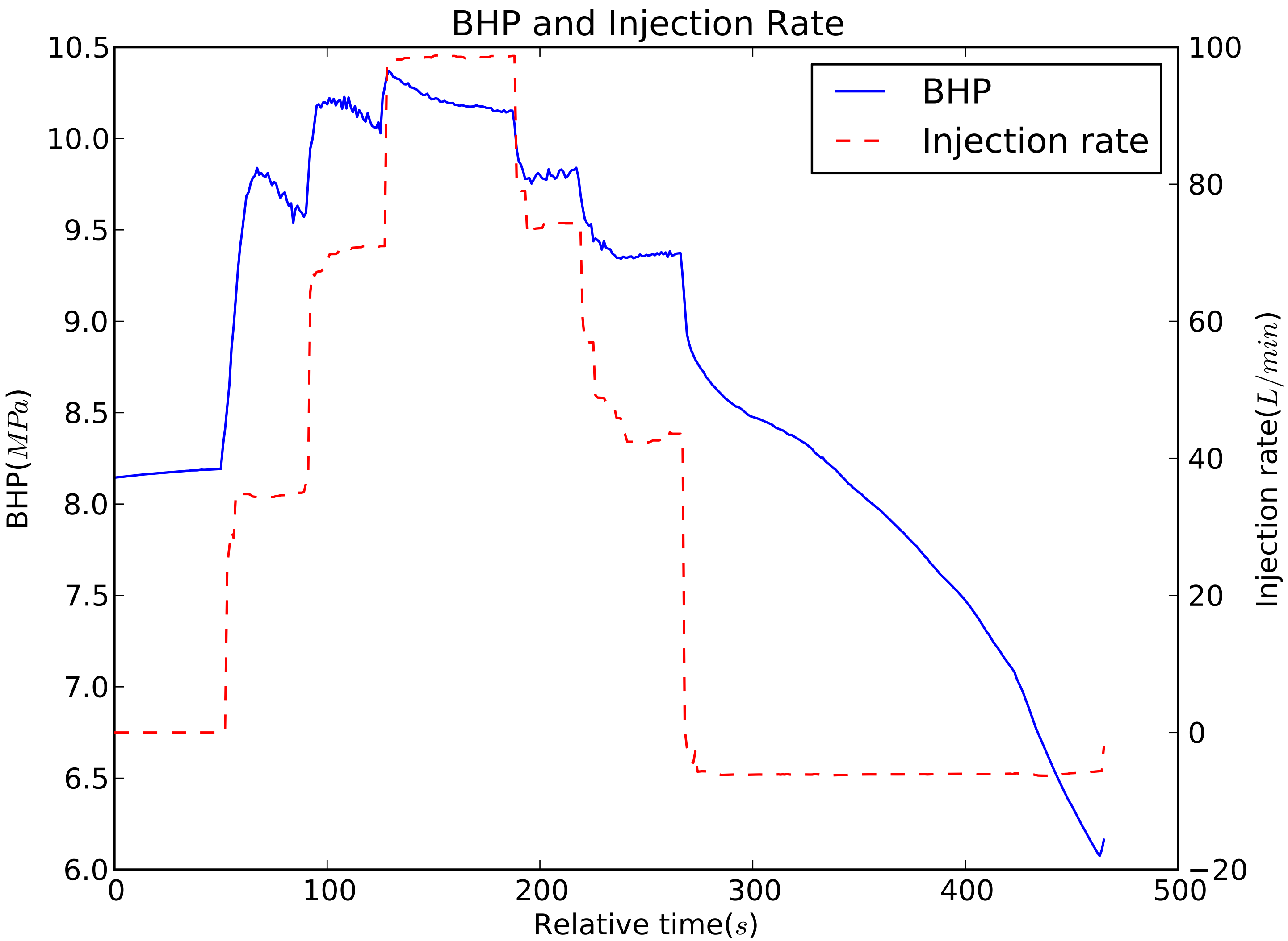
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 06

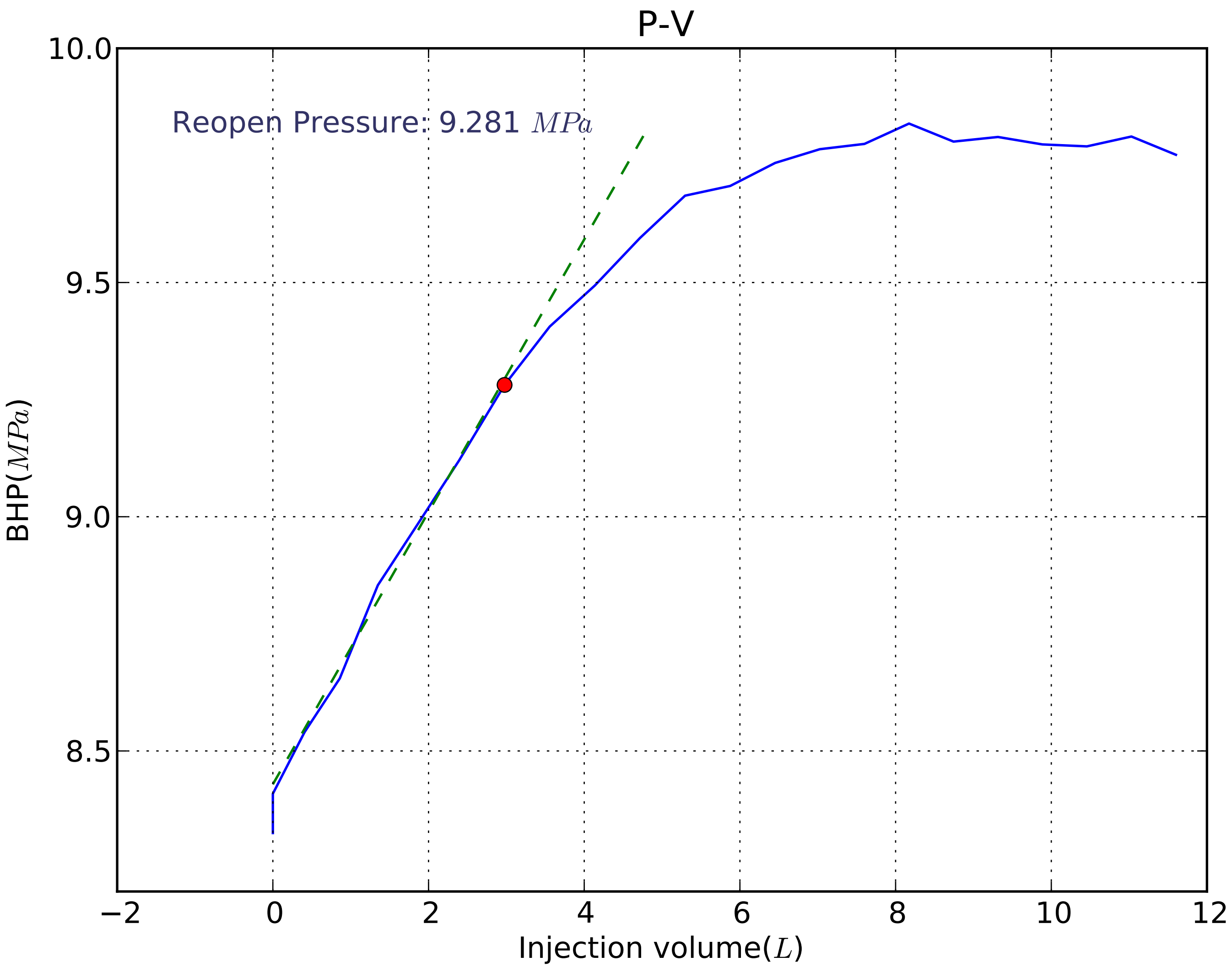
BitCan Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 07

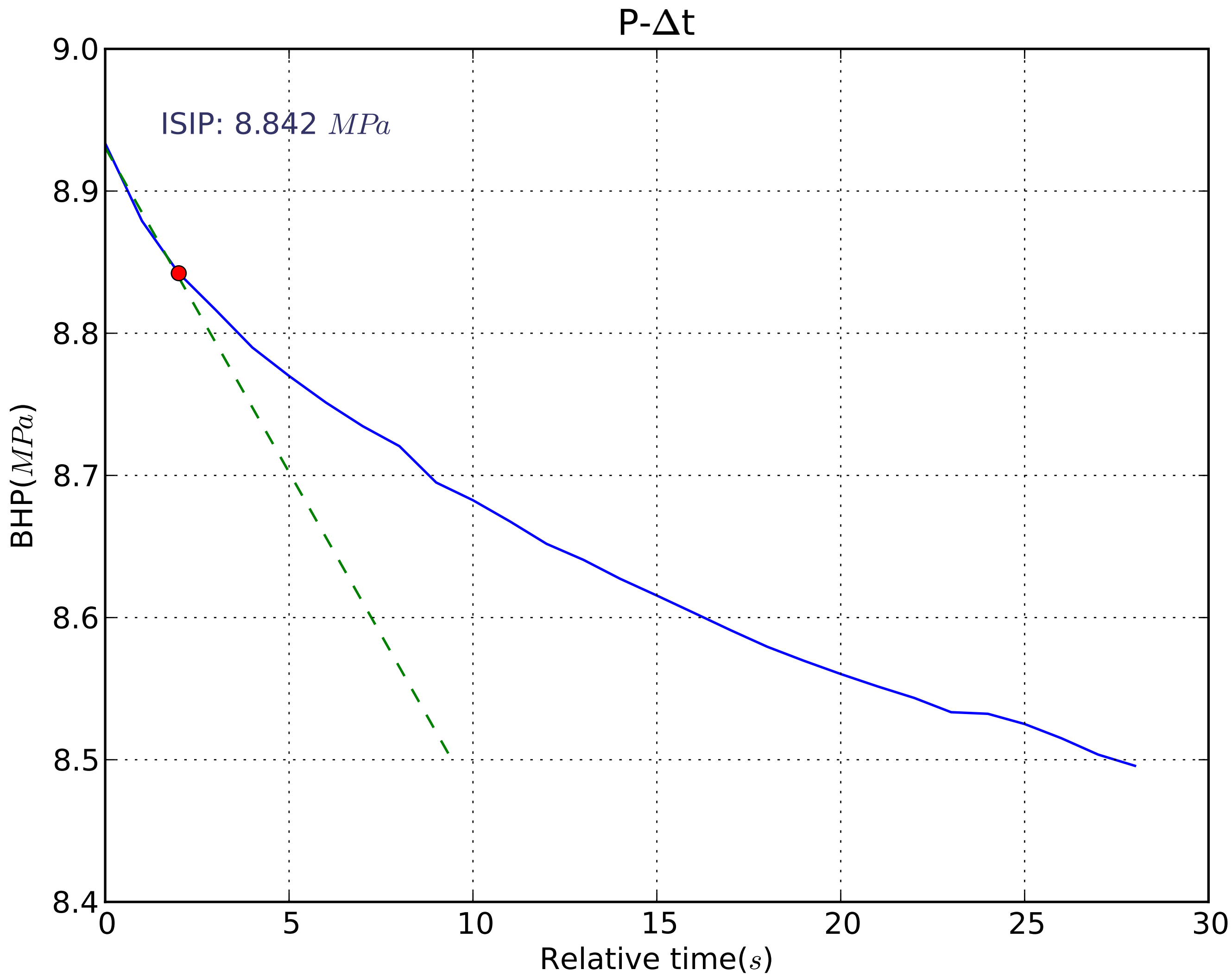
BitCan Geosciences & Engineering Inc.



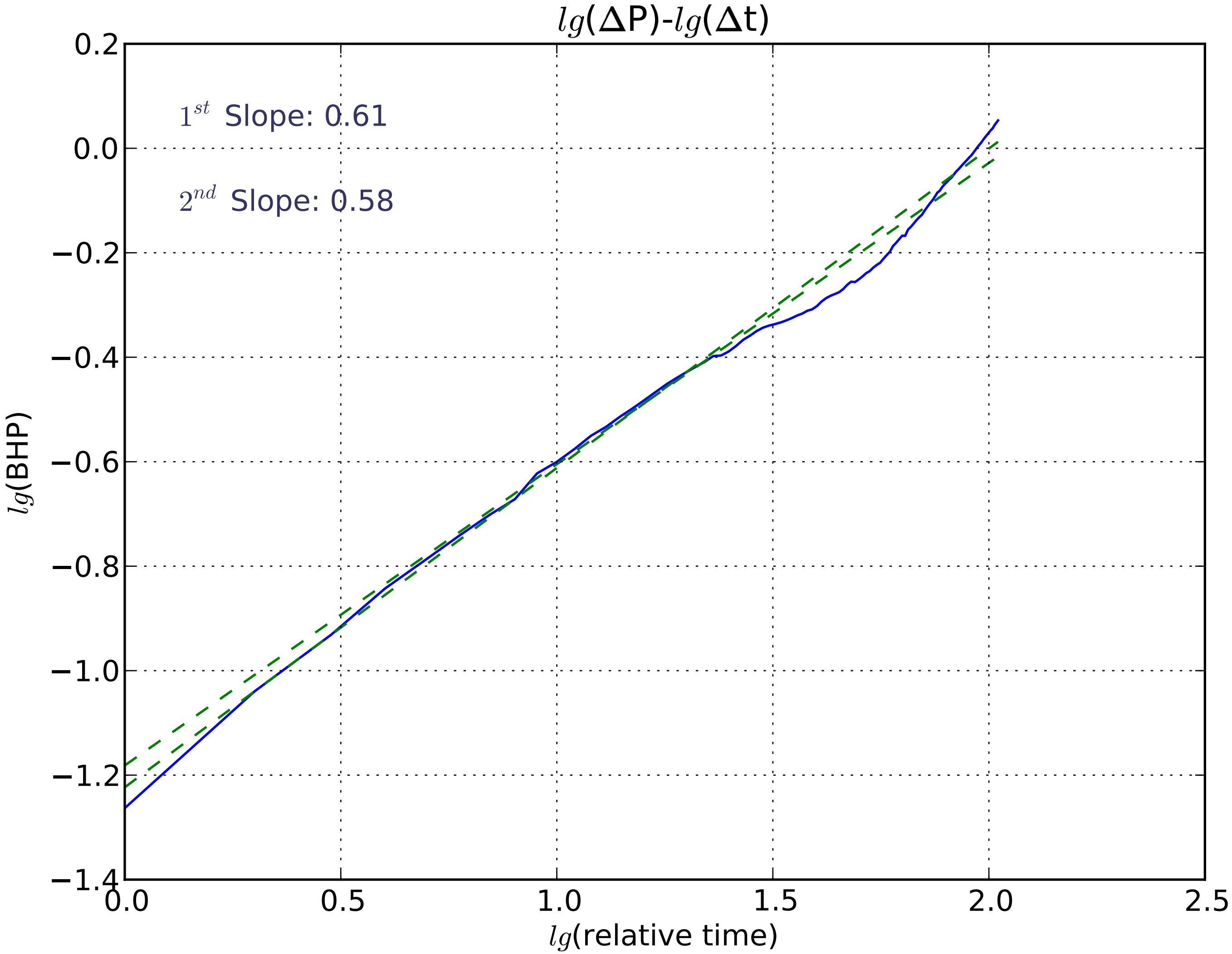

P-V
Reopen Pressure: 9.281 MPa
BHP(MPa)
10.0
9.5
9.0
8.5
−2
0
2
4
6
8
10
12
Injection volume(L)

Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 07

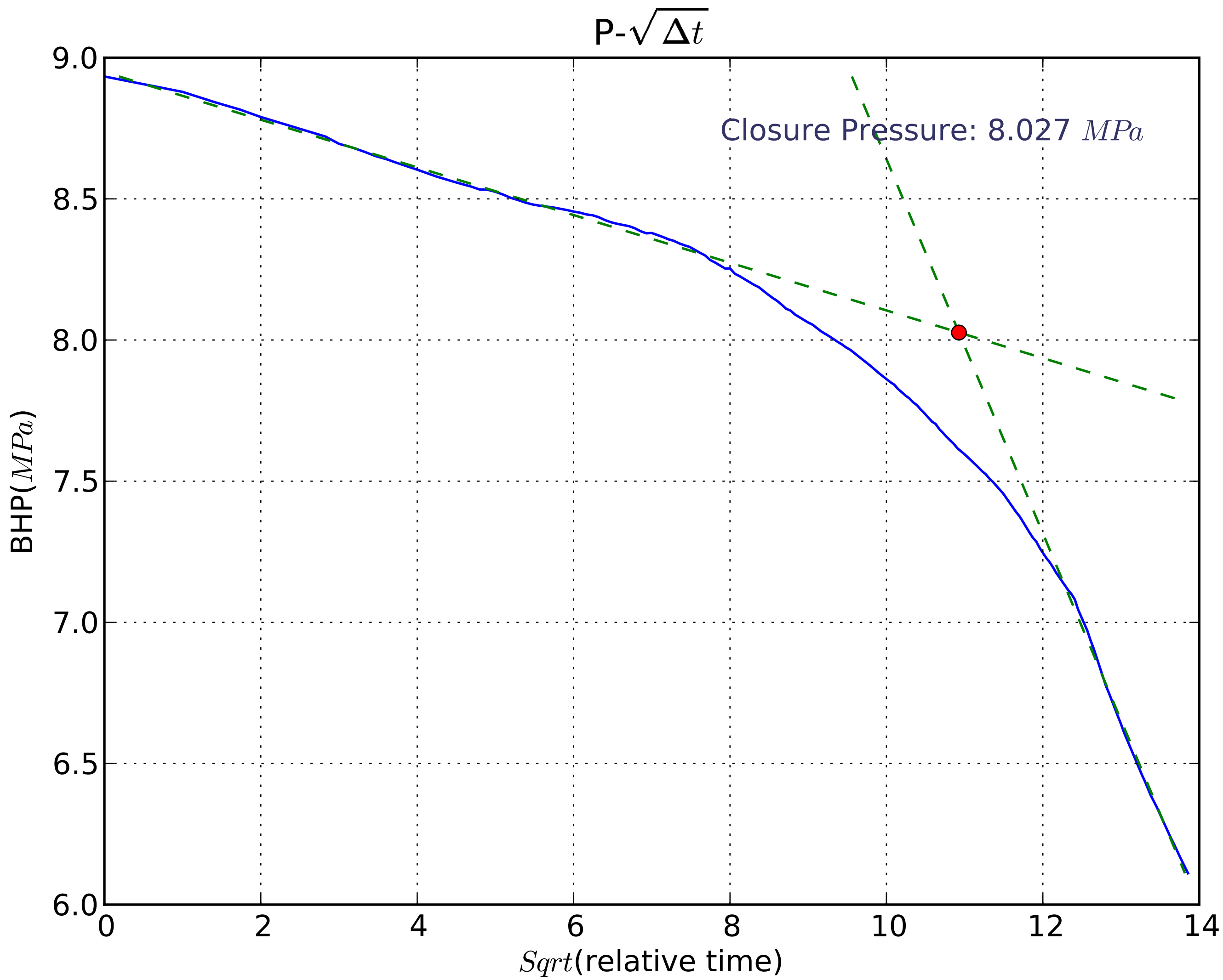
BitCan Geosciences & Engineering Inc.



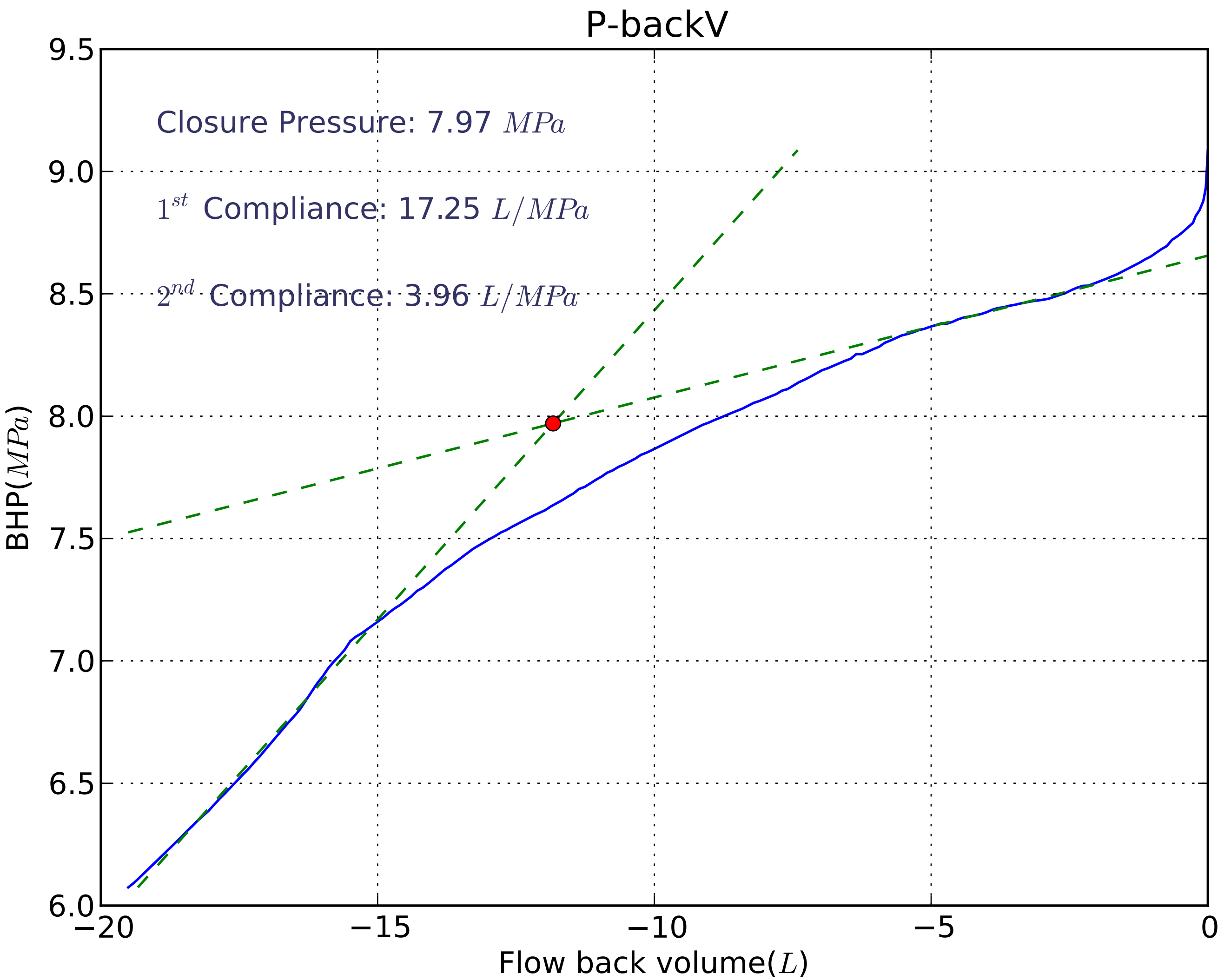
BitCan
Geosciences & Engineering Inc.



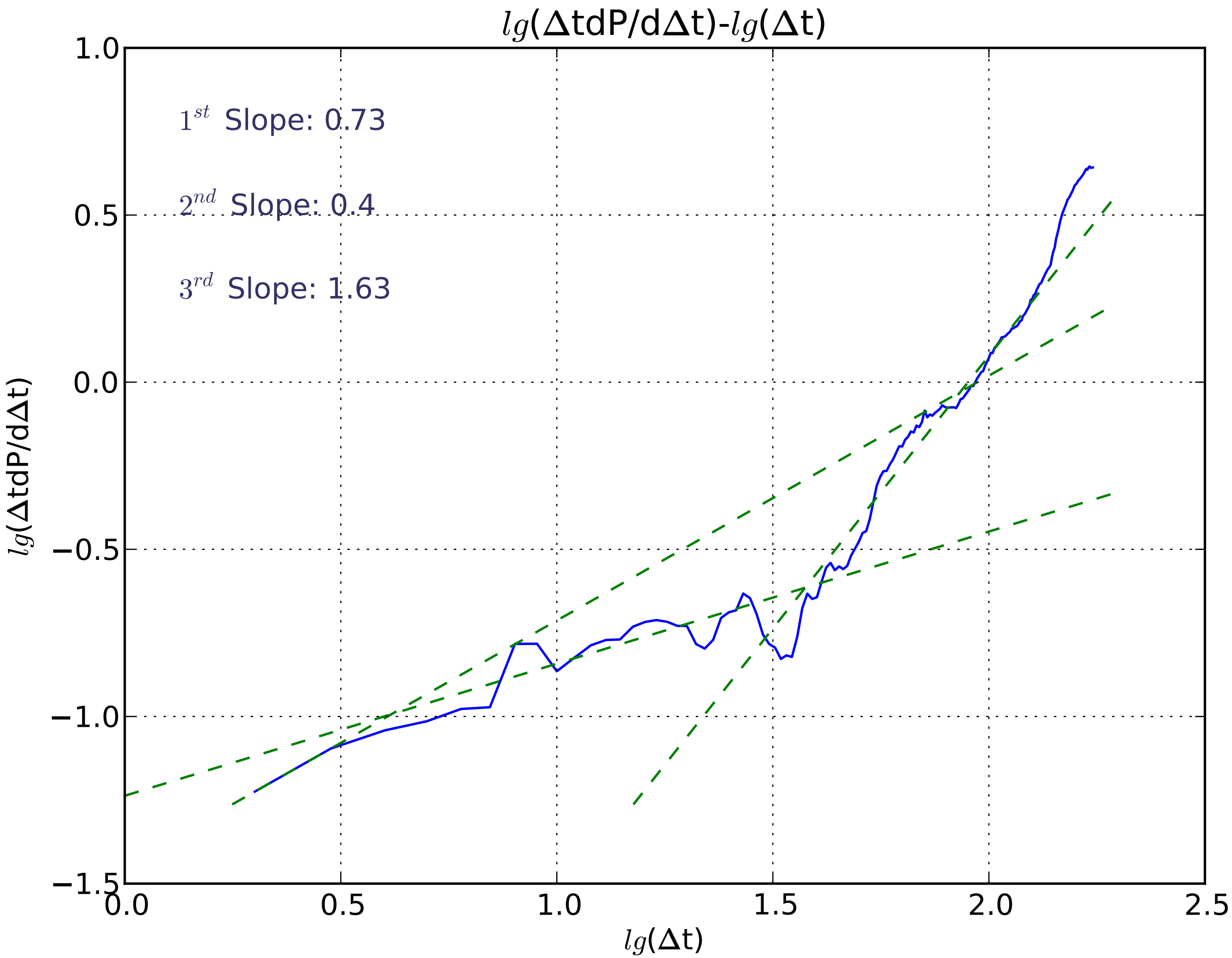
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 07



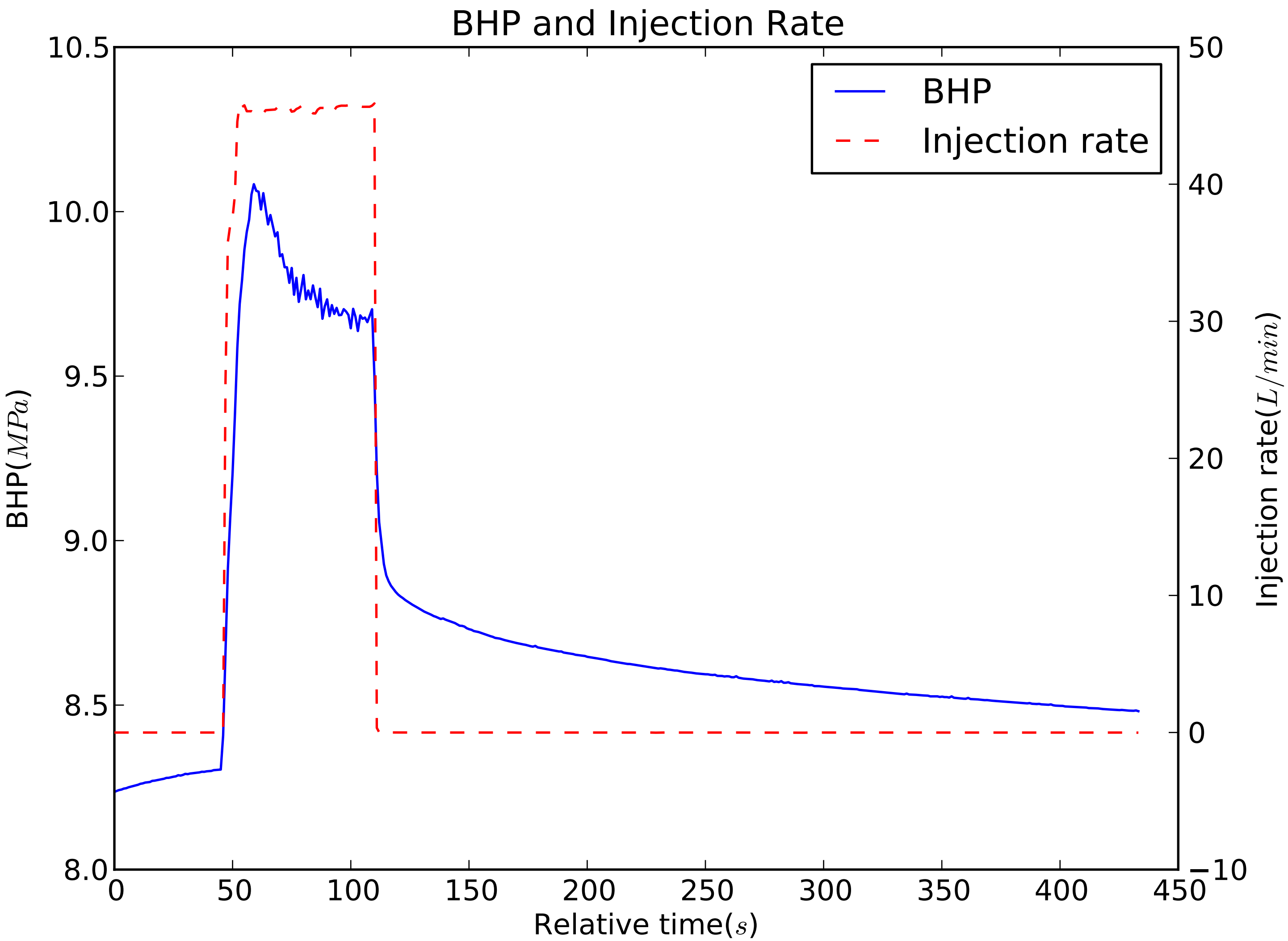
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 07



BitCan
Geosciences & Engineering Inc.

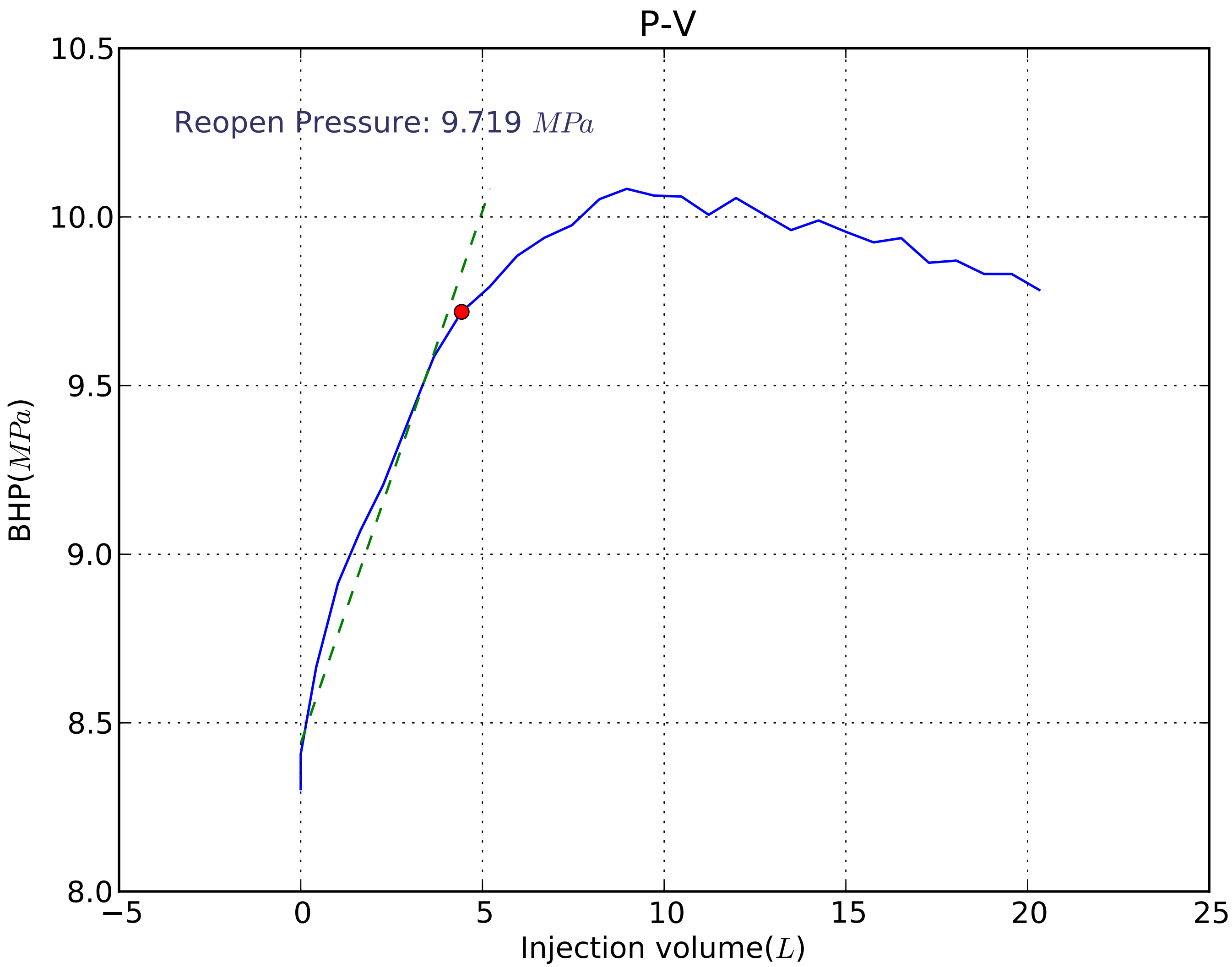


Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 08



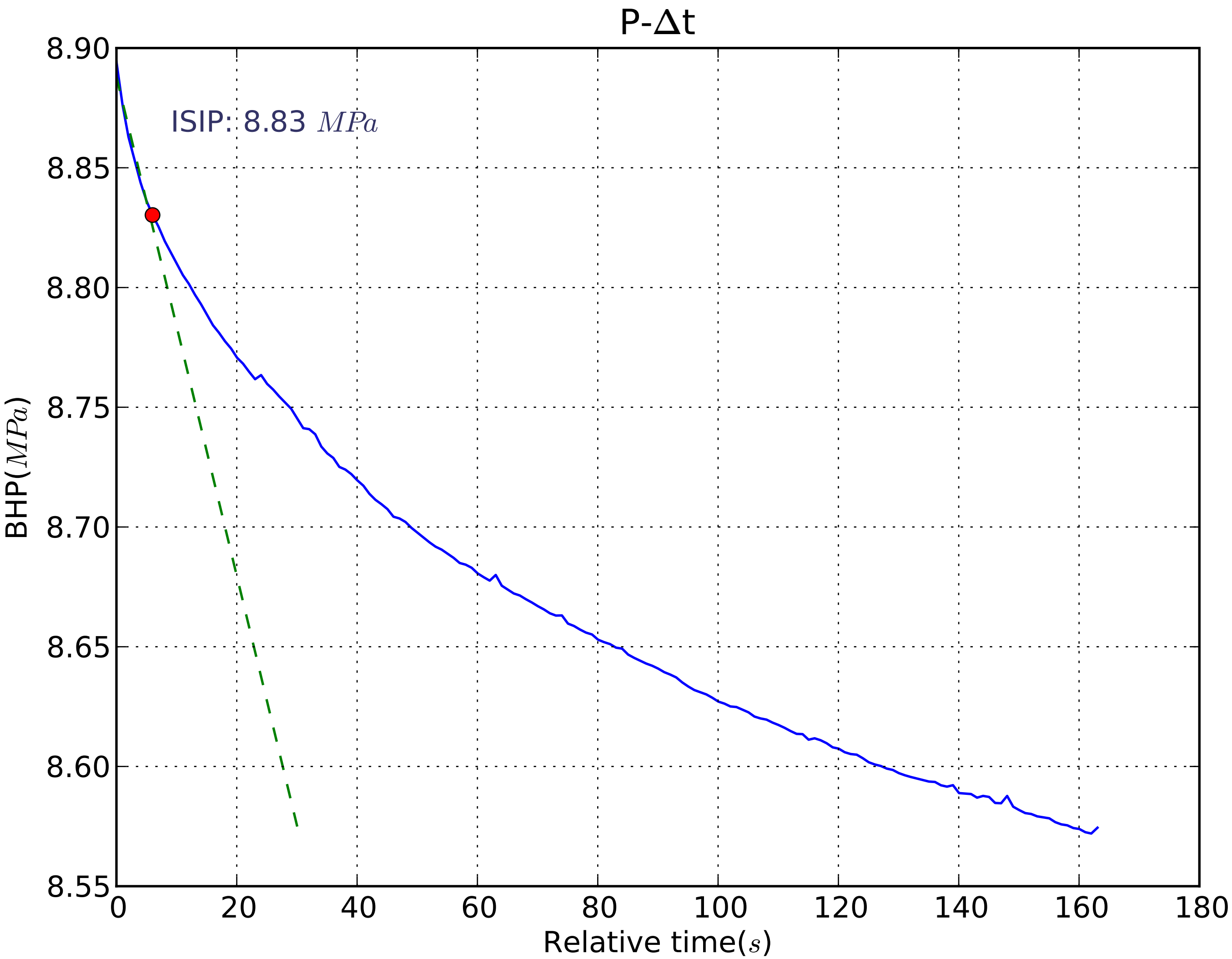
Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 08

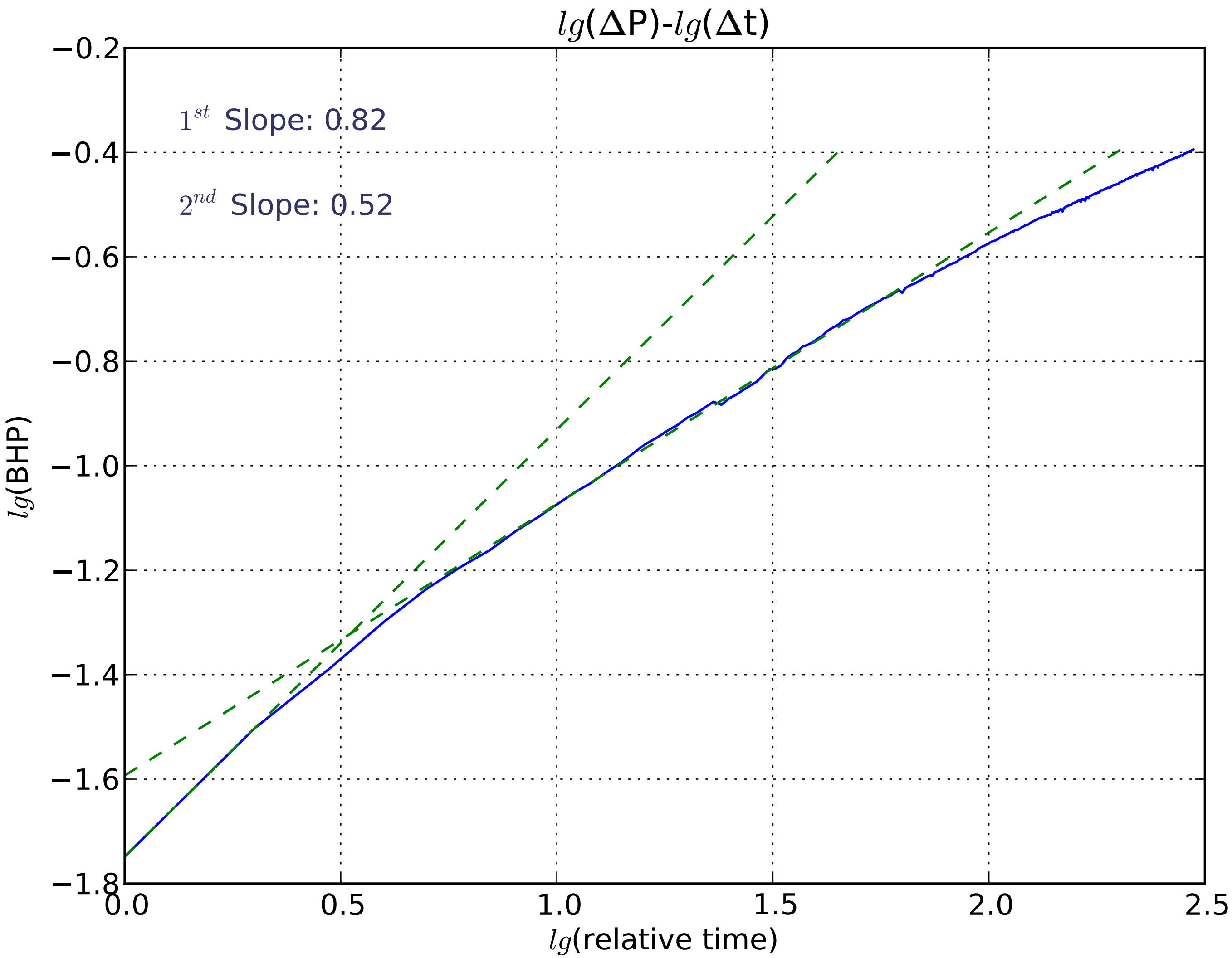
BitCan Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 08

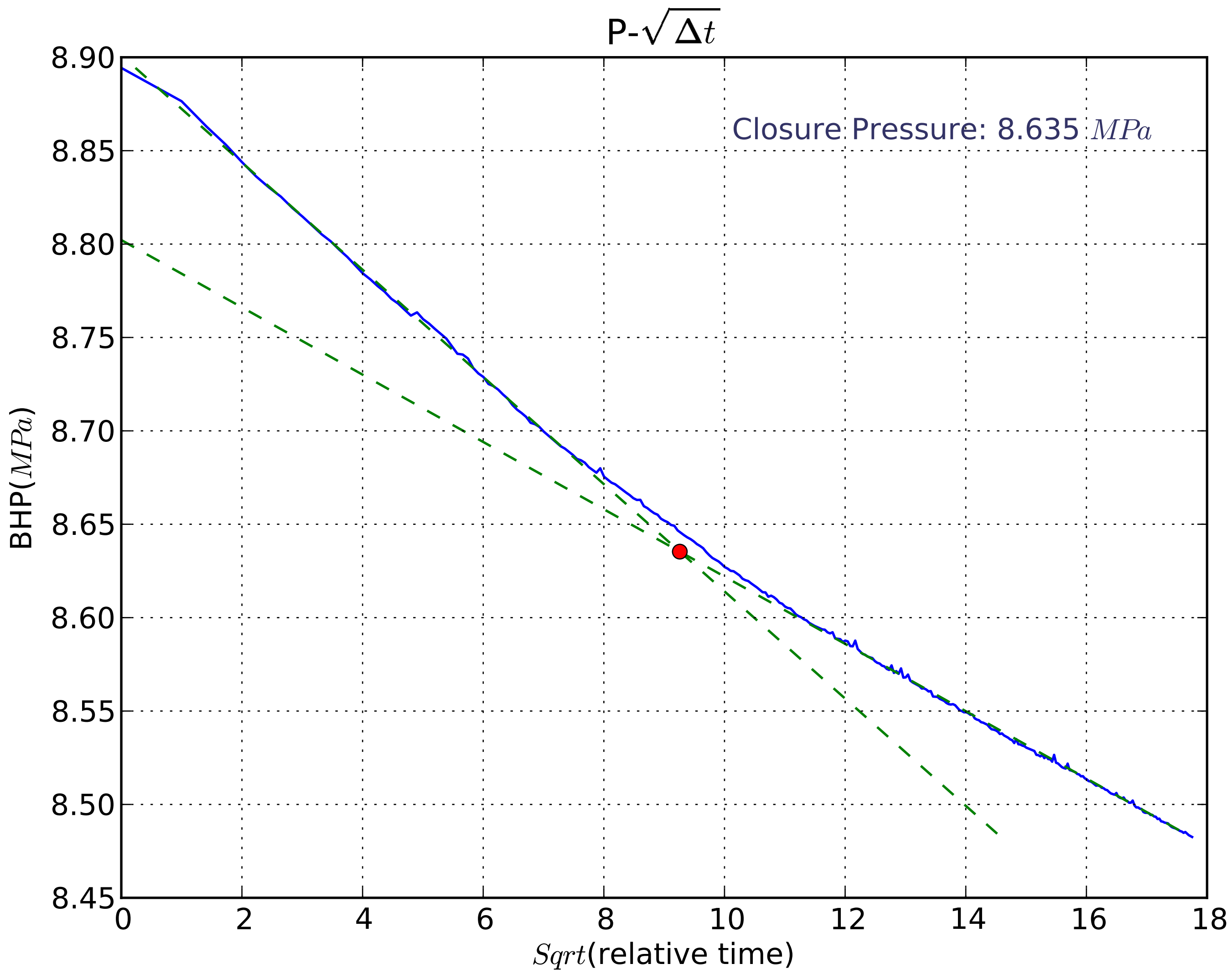
BitCan
Geosciences & Engineering Inc.

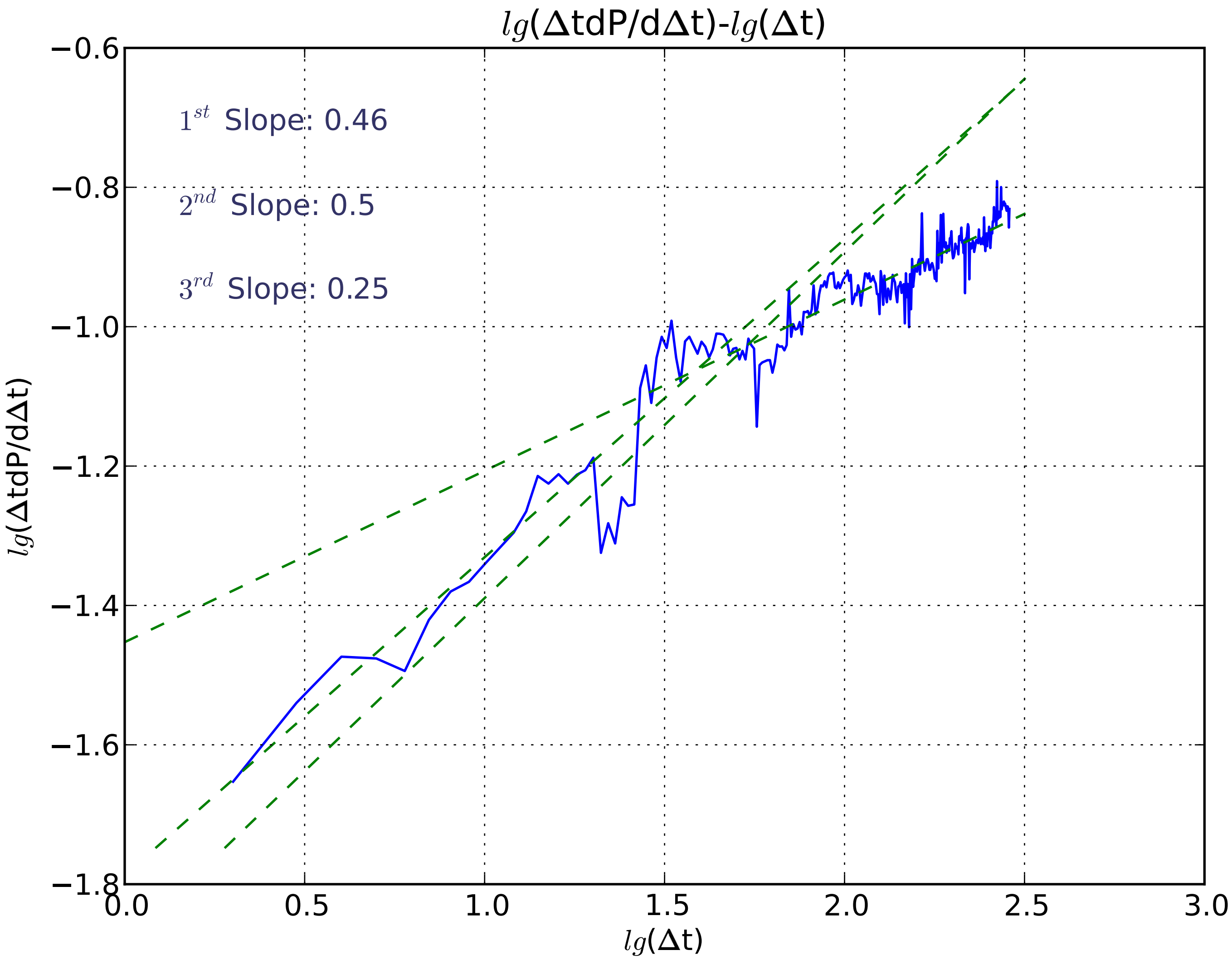


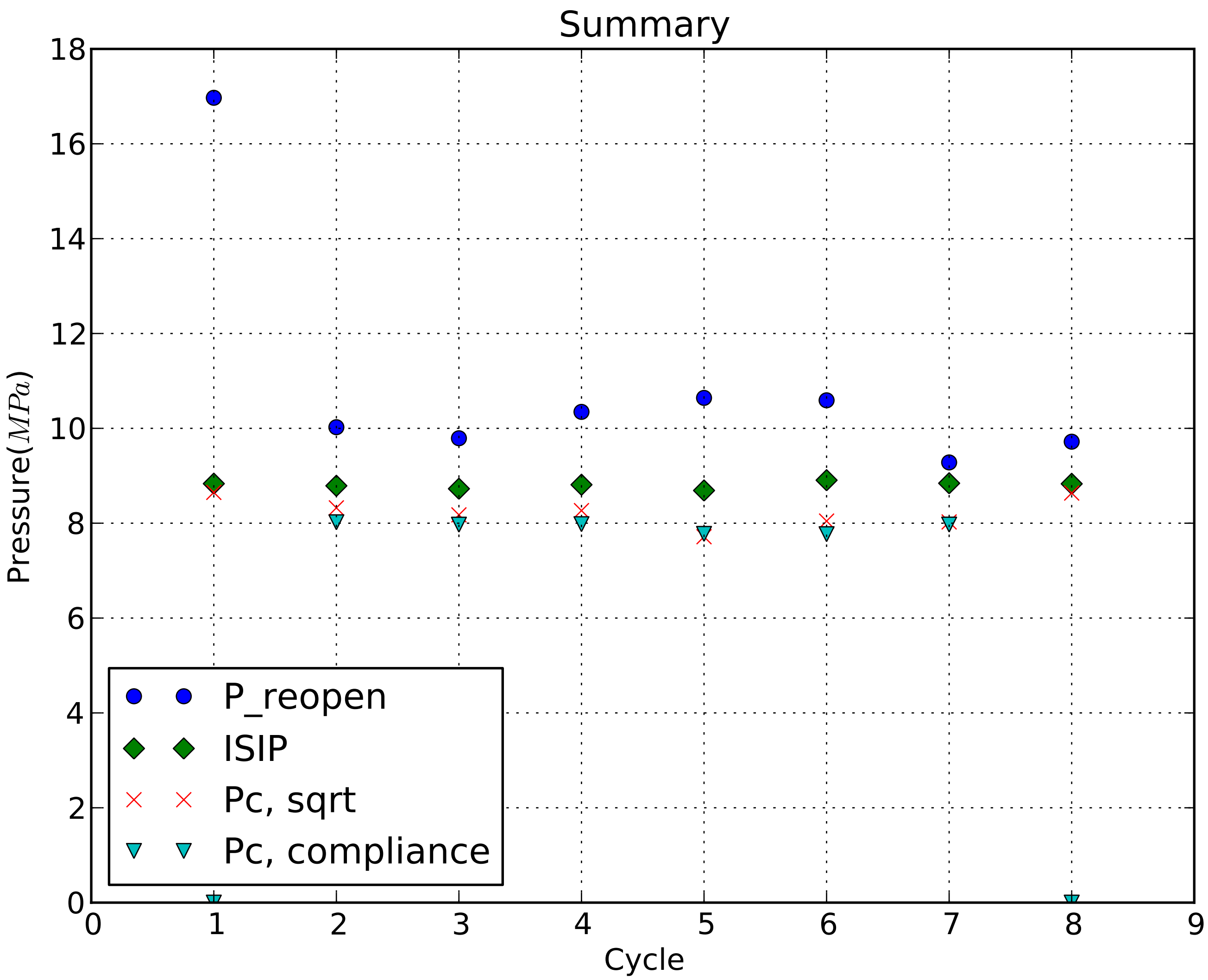

$lg(\Delta P)$-$lg(\Delta t)$
1^{st} Slope: 0.82
2^{nd} Slope: 0.52
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4
−1.6
−1.8
0.0
0.5
1.0
1.5
2.0
2.5
lg(BHP)
lg(relative time)

Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 08

BitCan
Geosciences & Engineering Inc.




$lg(\Delta tdP/d\Delta t)$-$lg(\Delta t)$
1^{st} Slope: 0.46
2^{nd} Slope: 0.5
3^{rd} Slope: 0.25
−0.6
−0.8
−1.0
−1.2
−1.4
−1.6
−1.8
0.0
0.5
1.0
1.5
2.0
2.5
3.0
$lg(\Delta t)$
$lg(\Delta tdP/d\Delta t)$


Summary
Pressure(MPa)
Cycle
18
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
P_reopen
ISIP
Pc, sqrt
Pc, compliance

Well: Pengrowth 13-24-58-5W4
Depth: 514.0m
Formation: General Petroleum
Cycle: 1 to 8

BitCan Geosciences & Engineering Inc.

Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	16.970	8.833	8.650	0.000	2.65	0.00	0.00
2	10.024	8.789	8.323	8.019	2.95	8.04	2.05
3	9.791	8.727	8.175	7.969	2.55	8.62	2.33
4	10.347	8.811	8.265	7.979	2.64	11.35	2.44
5	10.642	8.689	7.715	7.774	2.83	11.43	2.51
6	10.591	8.906	8.045	7.768	2.51	10.78	3.43
7	9.281	8.842	8.027	7.970	3.44	17.25	3.96
8	9.719	8.830	8.635	0.000	3.17	0.00	0.00

Previous View

ANALYSIS PLOTS

WELL: LNDBRGH 13-24-58-5W4

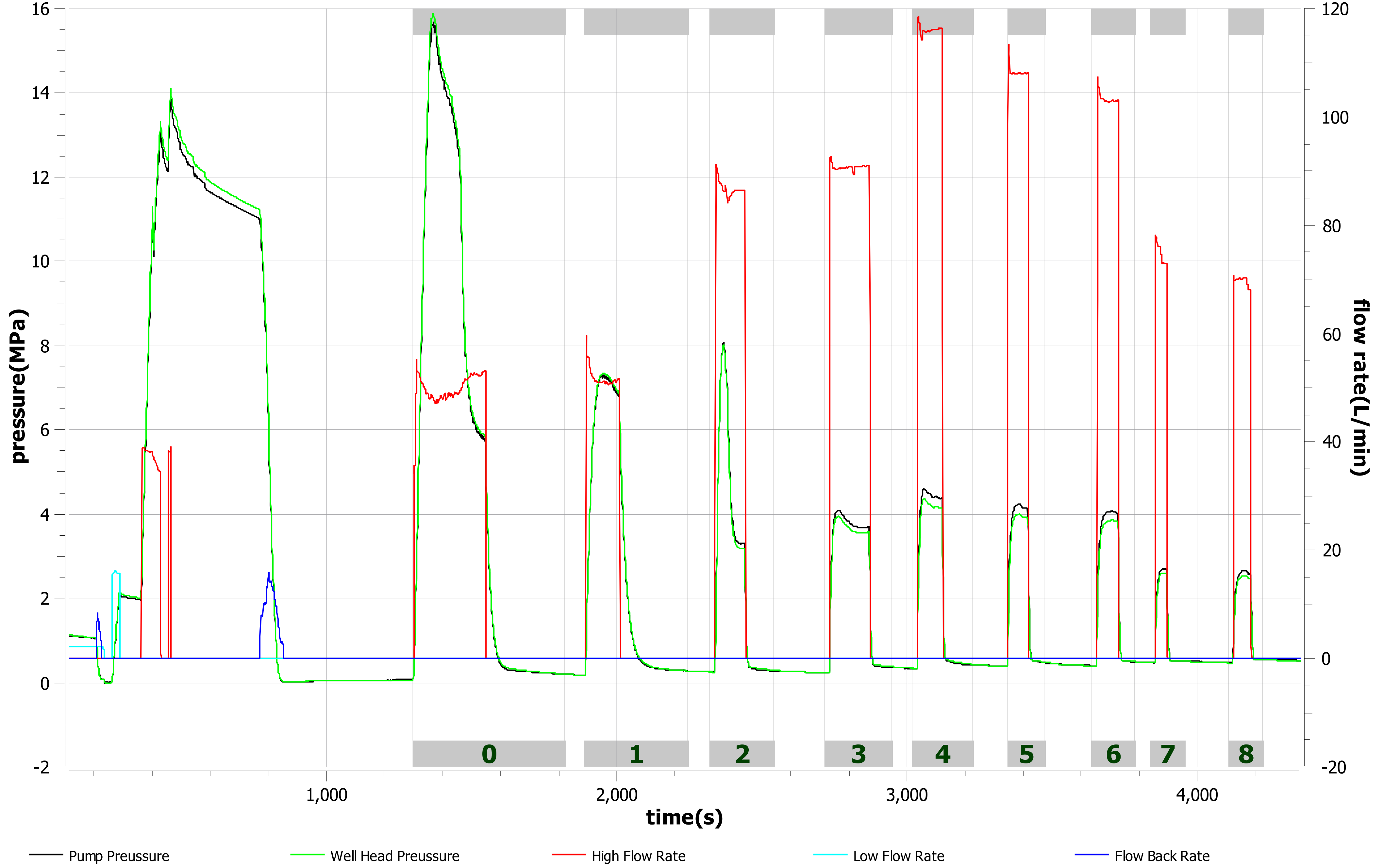
Test 3: Lloydminster payzone at 530 m

BitCan
Geosciences & Engineering Inc.
www.bitcange.com

Client: PenGrowth
Well: 5-17
Depth: 530

Formation: Oilsands
Start @: Mon Jan 2 12:42:15 2012

Mini-Frac Test



Previous View

Main Menu Search

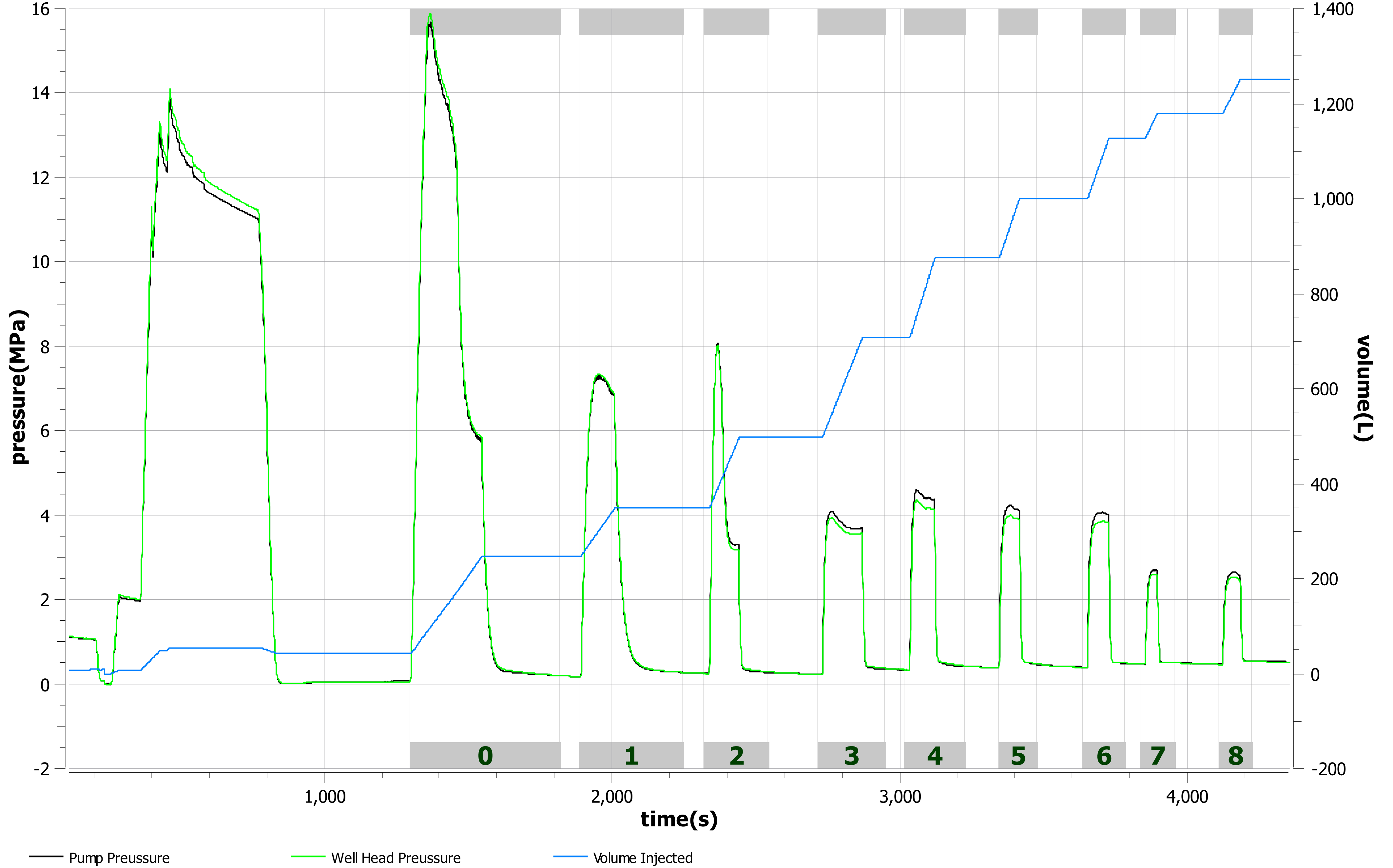
BitCan
Geosciences & Engineering Inc.

www.bitcange.com

Client: PenGrowth
Well: 5-17
Depth: 530

Formation: Oilsands
Start @: Mon Jan 2 12:42:15 2012

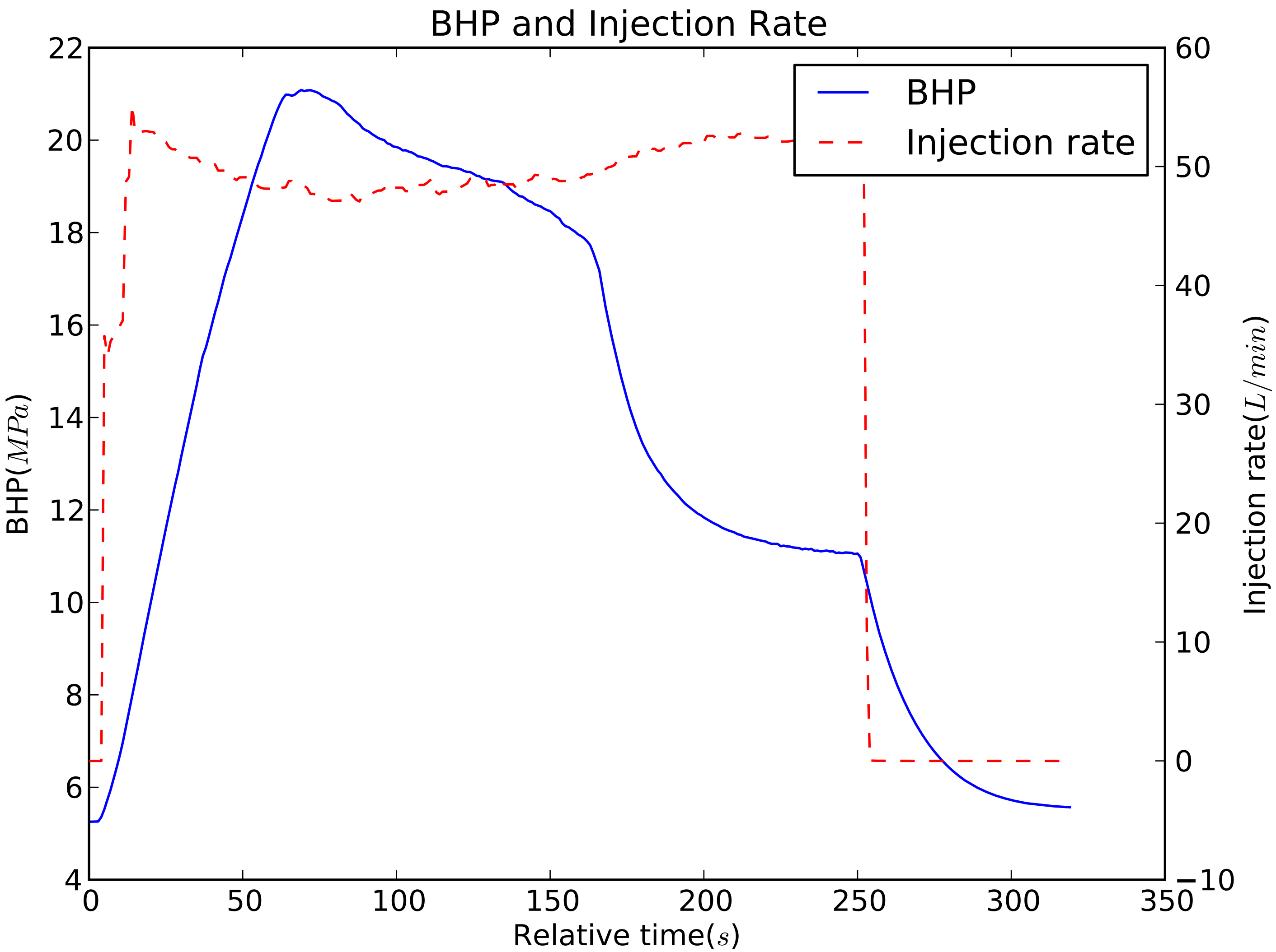
Mini-Frac Test



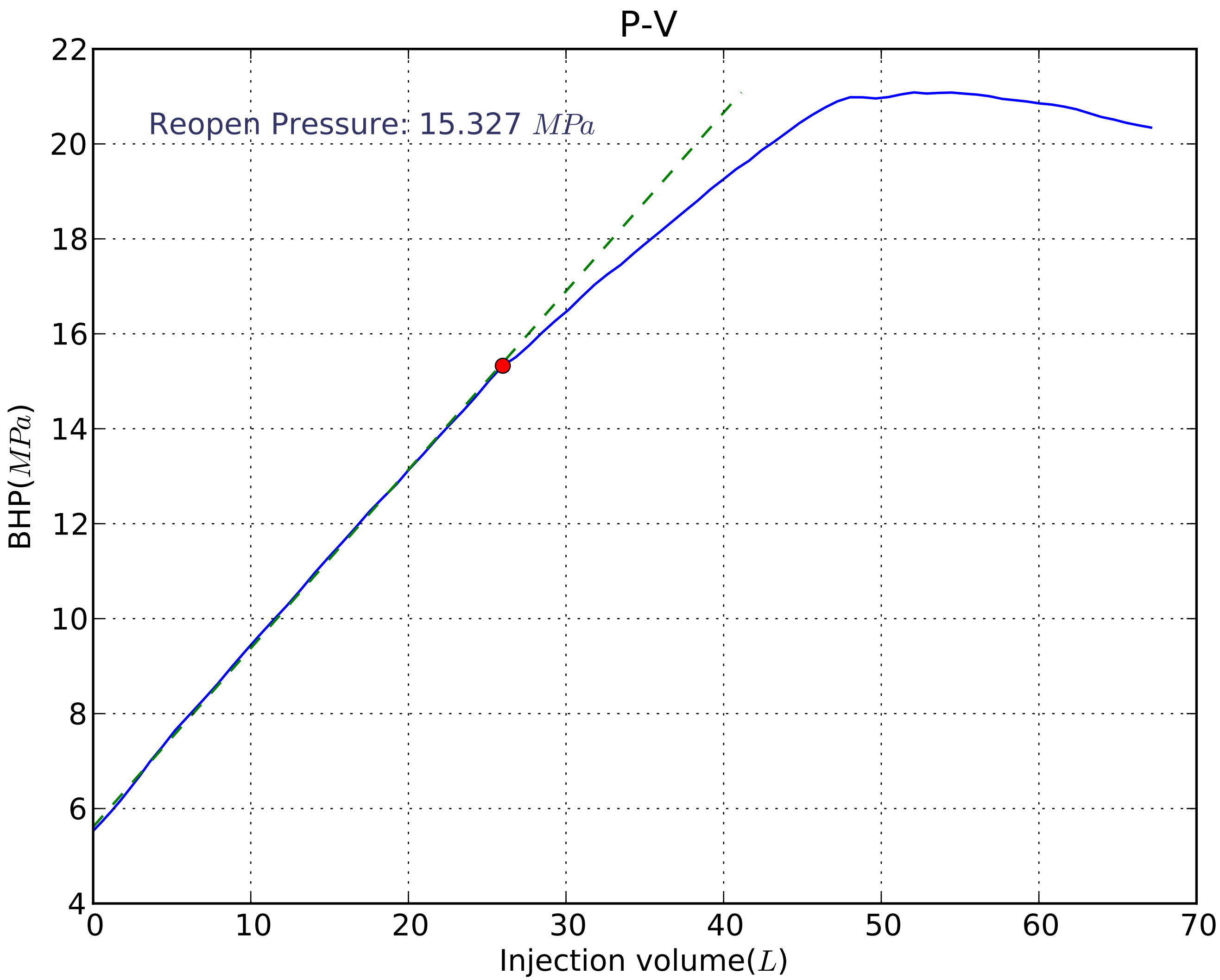
Generated by MiniMonitor

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 01

BitCan
Geosciences & Engineering Inc.

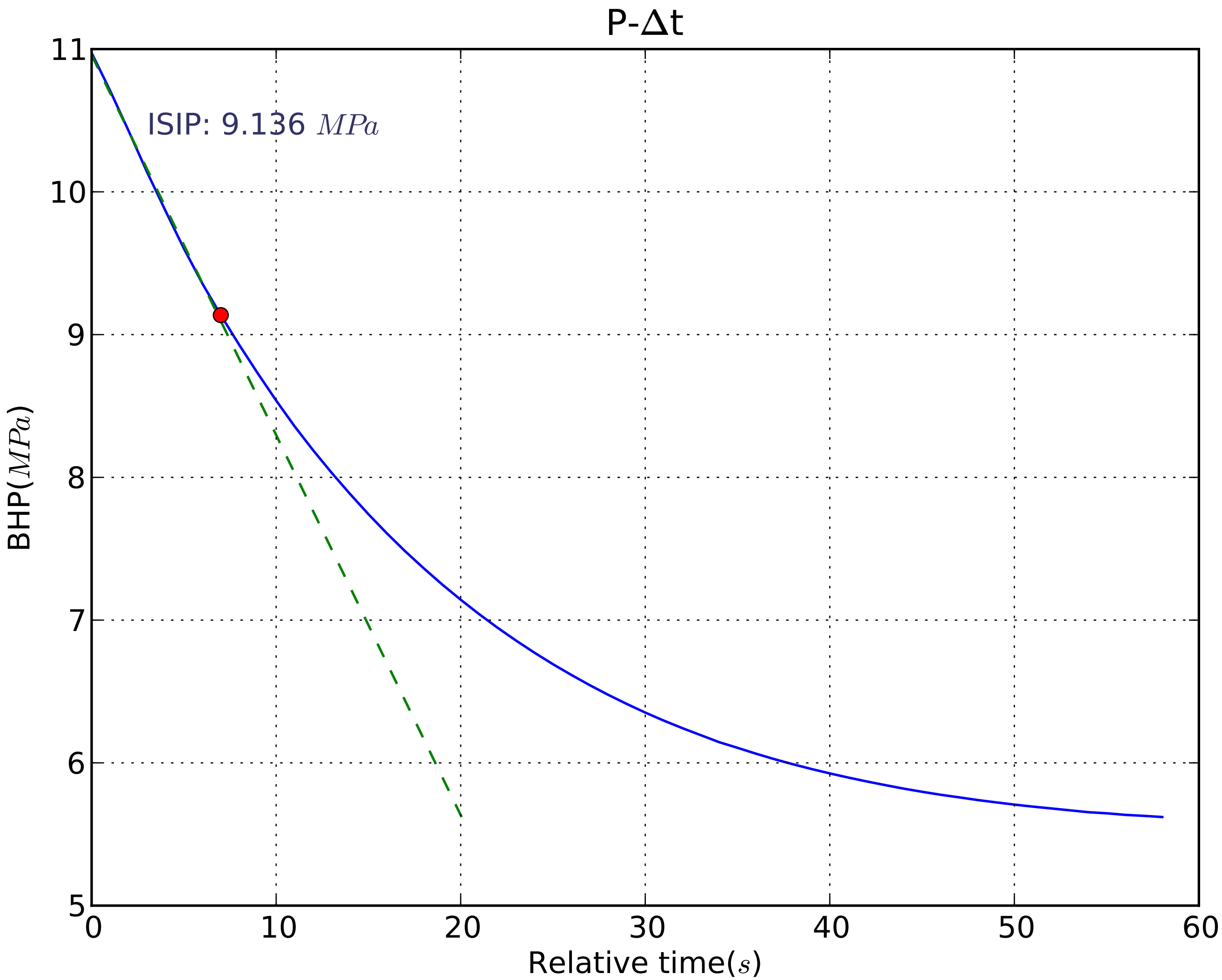


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 01

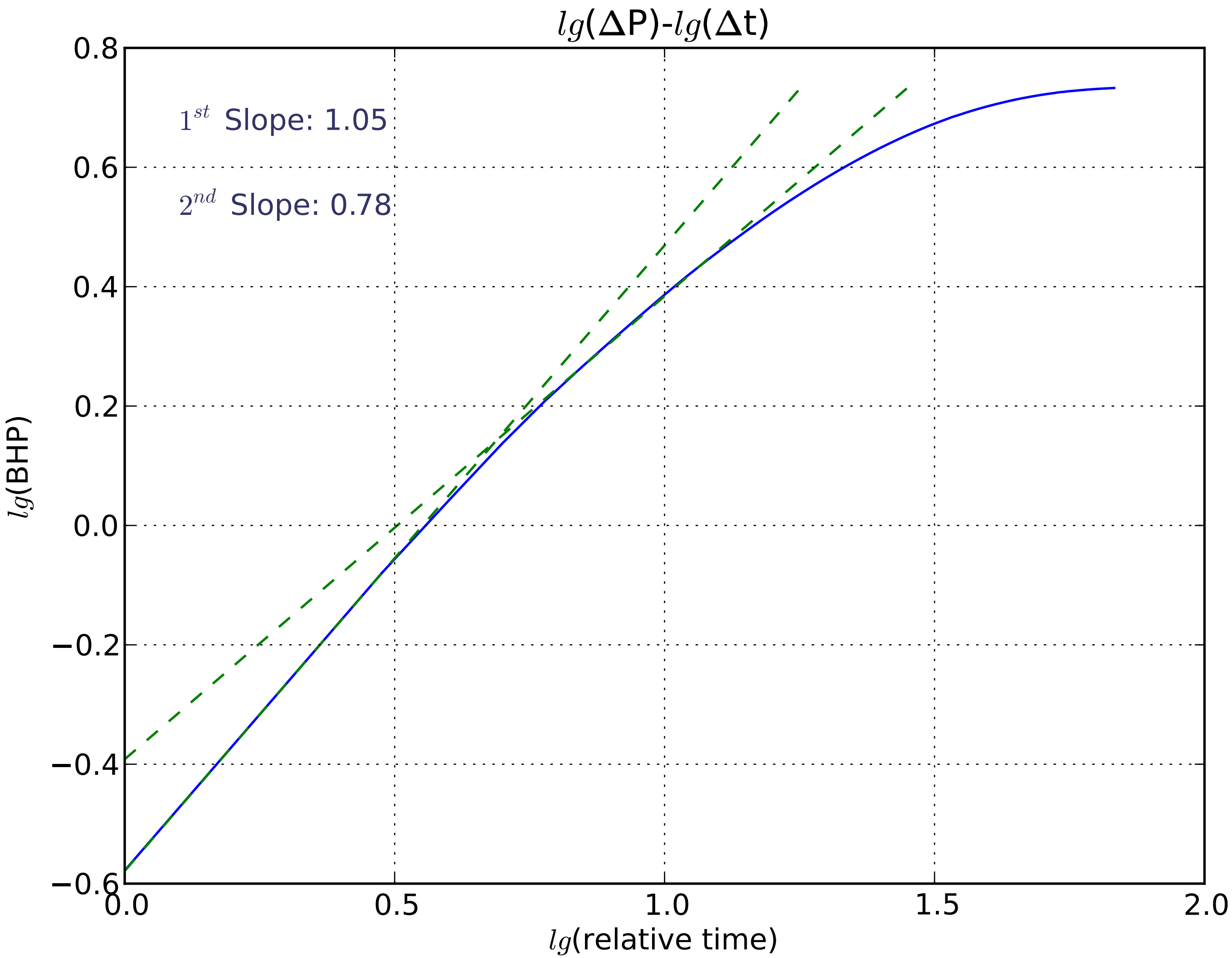


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 01

BitCan
Geosciences & Engineering Inc.

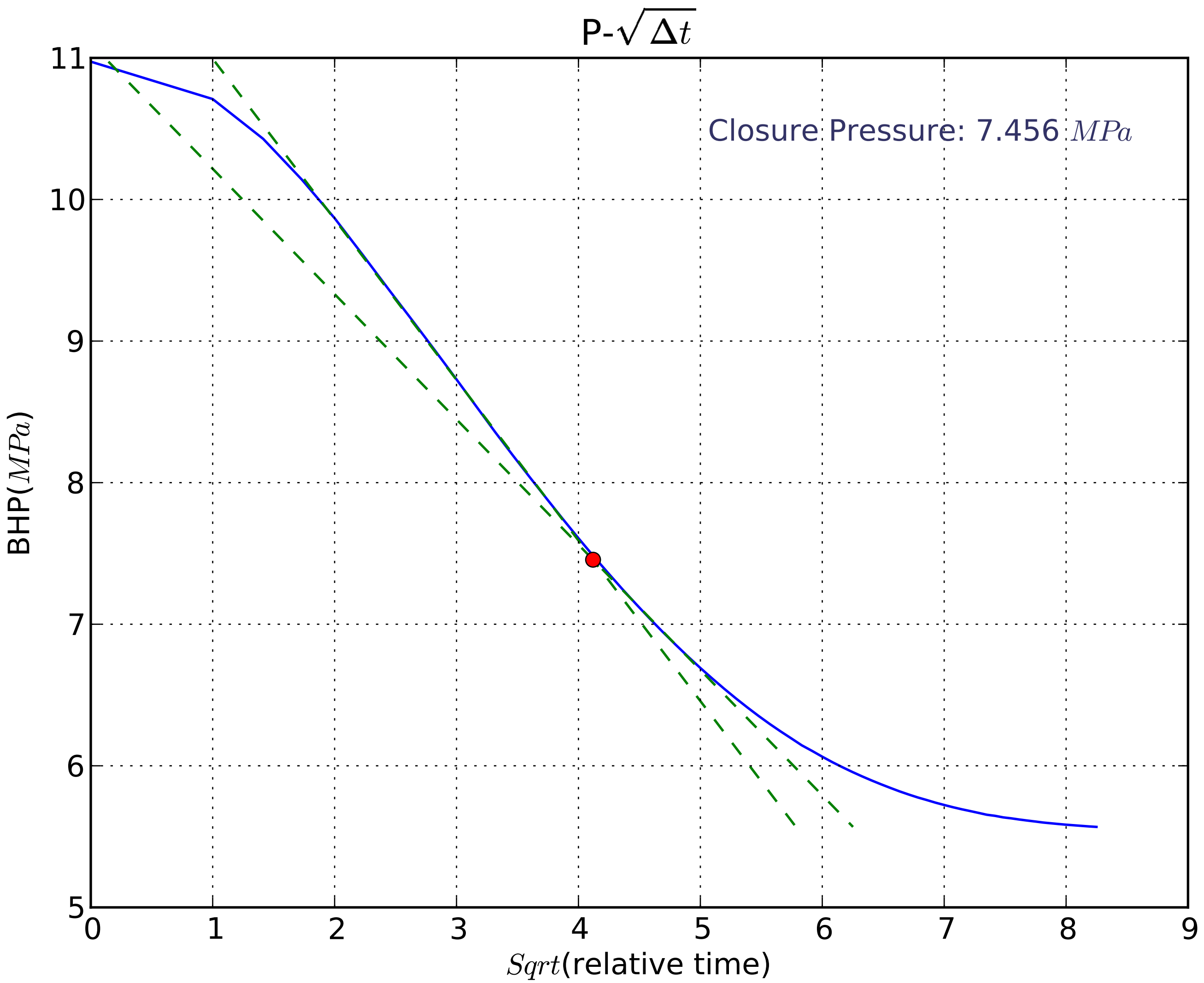


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 01



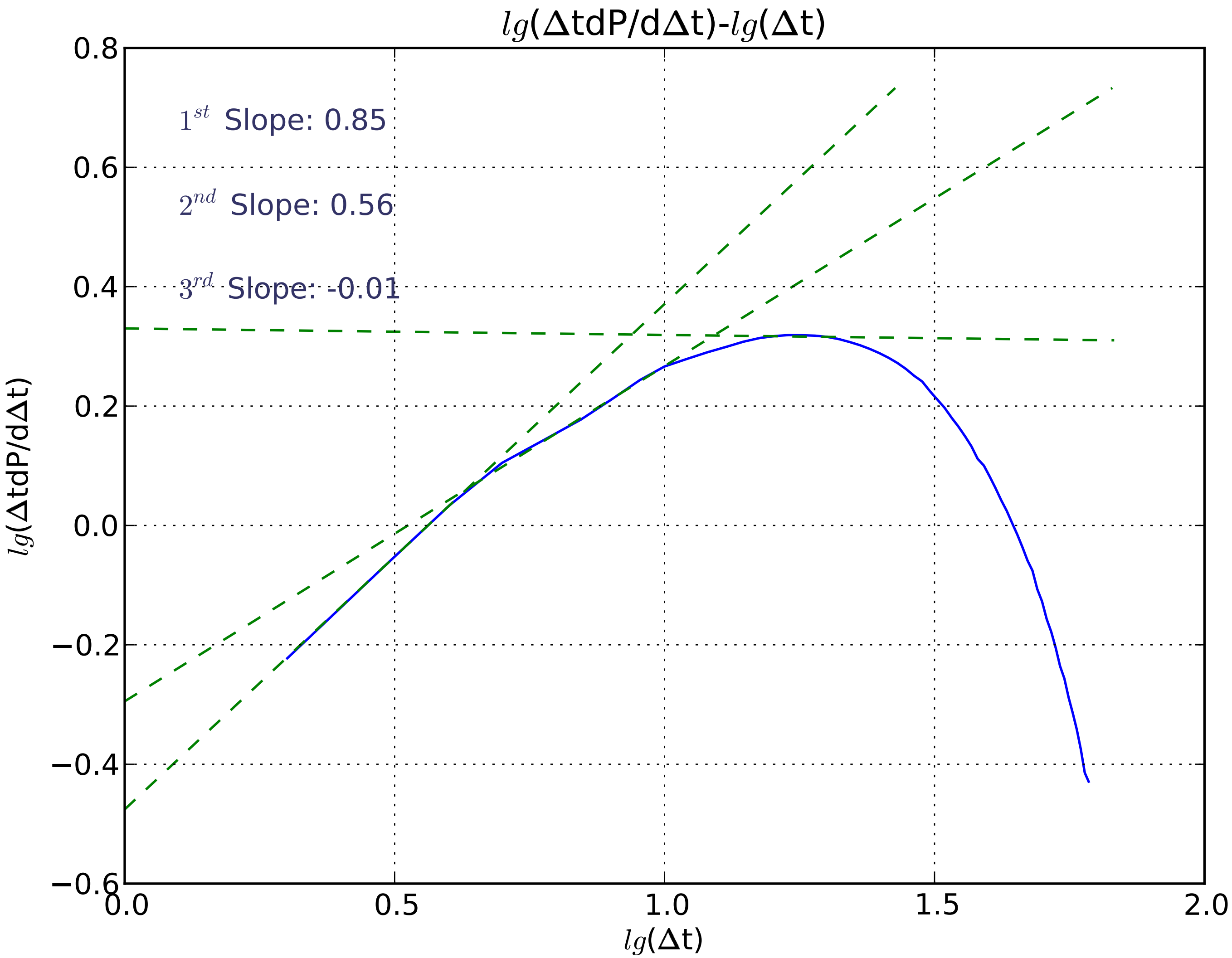
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 01

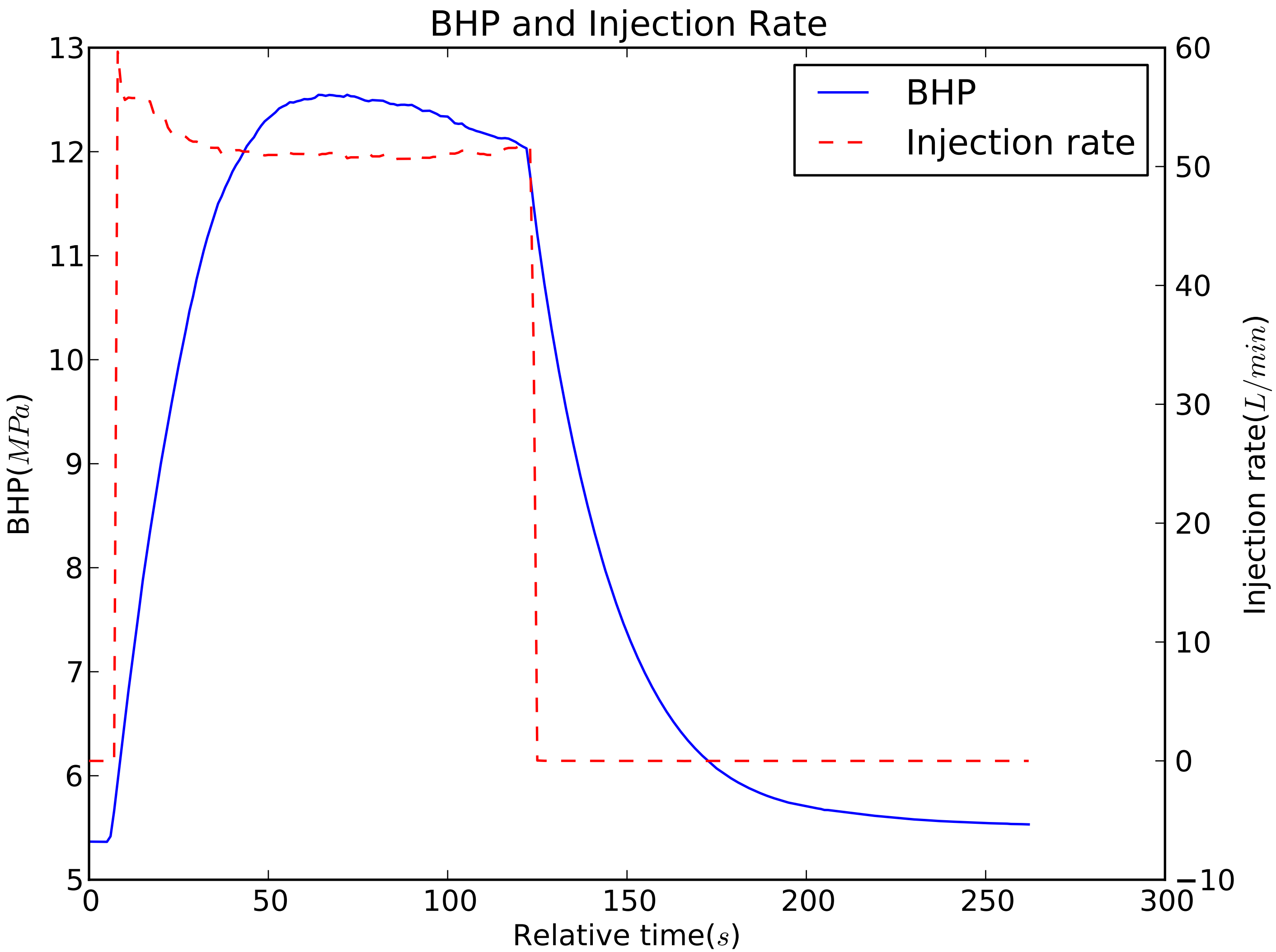
BitCan
Geosciences & Engineering Inc.



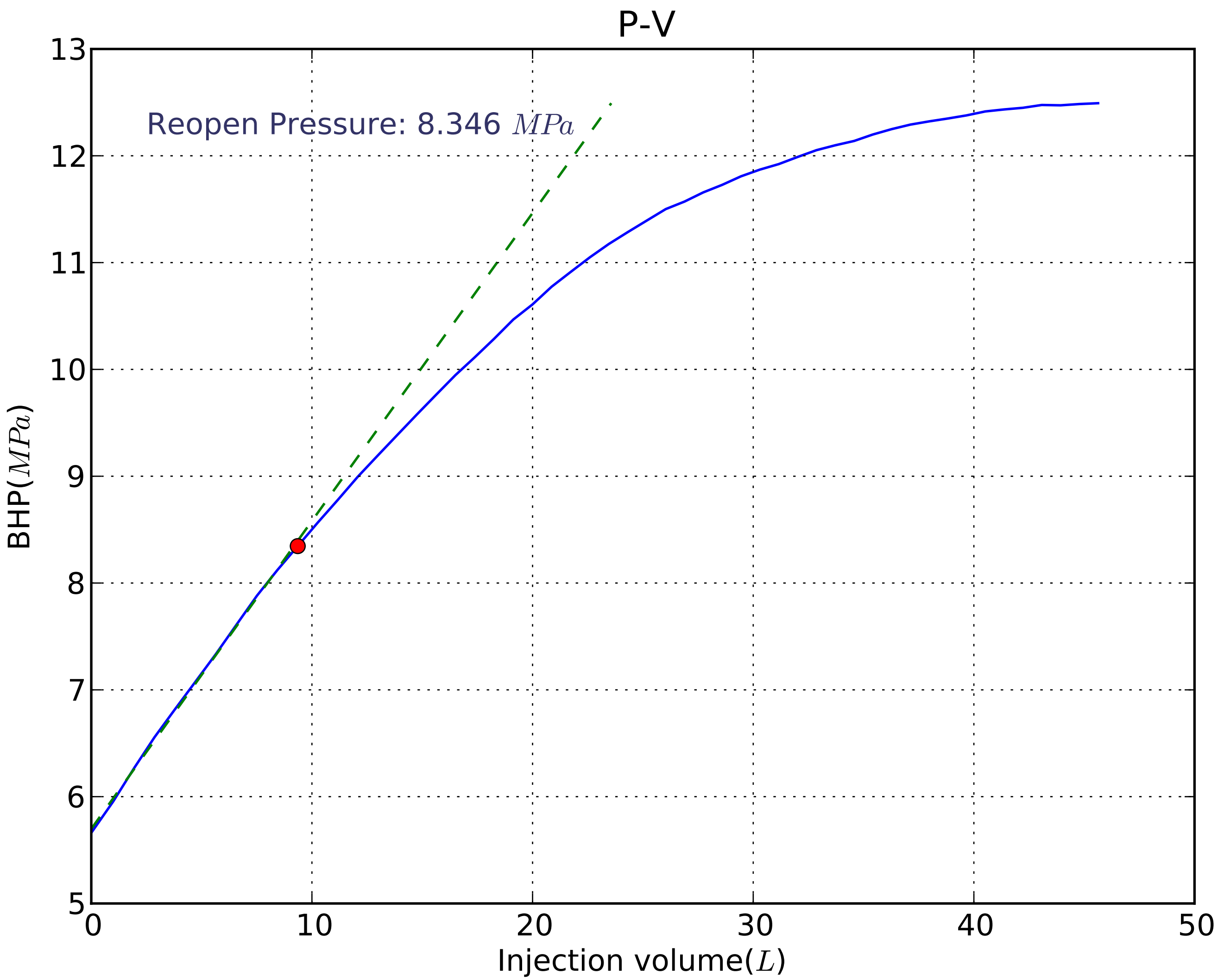
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 01

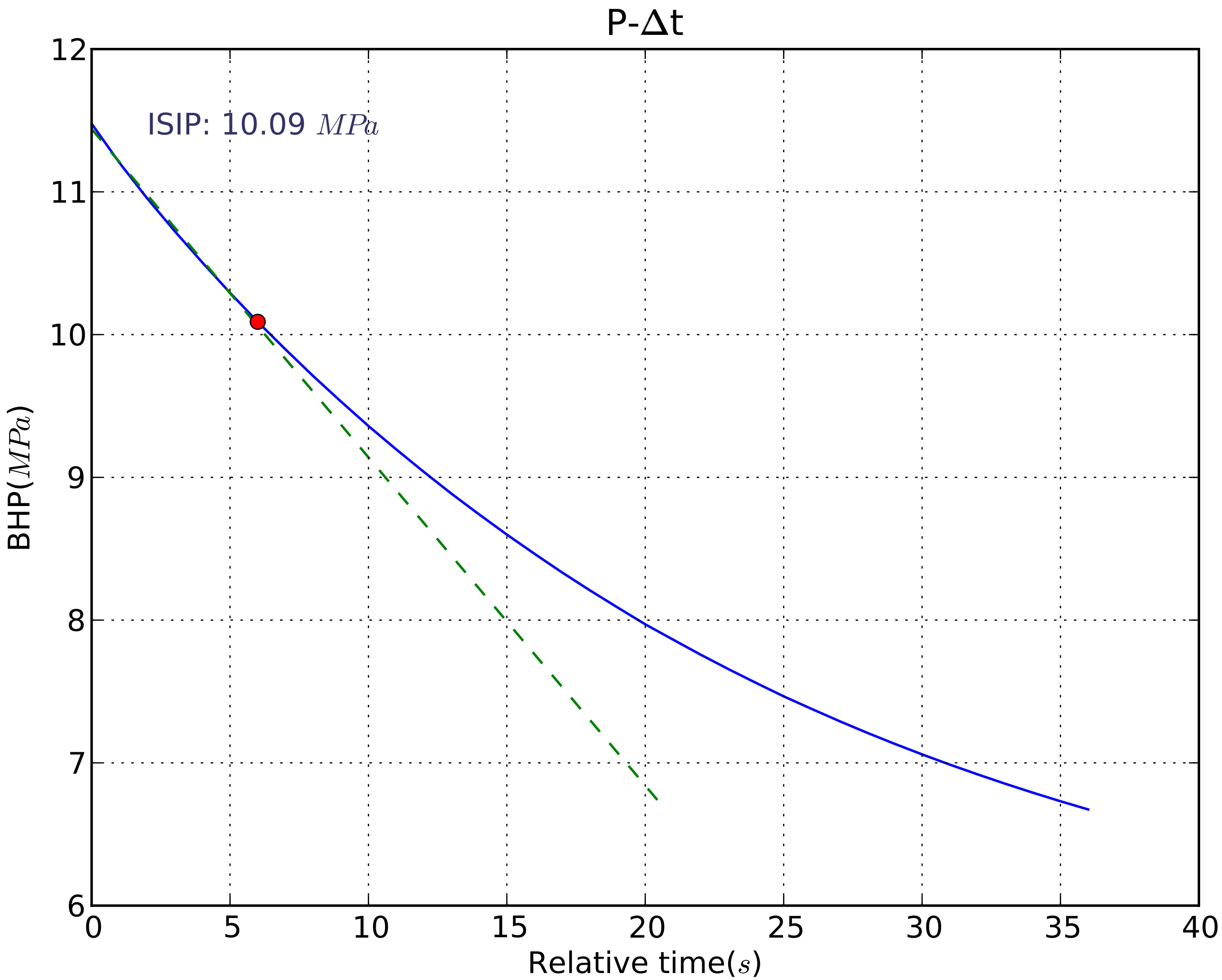
BitCan
Geosciences & Engineering Inc.




BHP and Injection Rate
BHP
Injection rate
BHP(MPa)
Injection rate(L/min)
Relative time(s)
13
12
11
10
9
8
7
6
5
60
50
40
30
20
10
0
−10
0
50
100
150
200
250
300

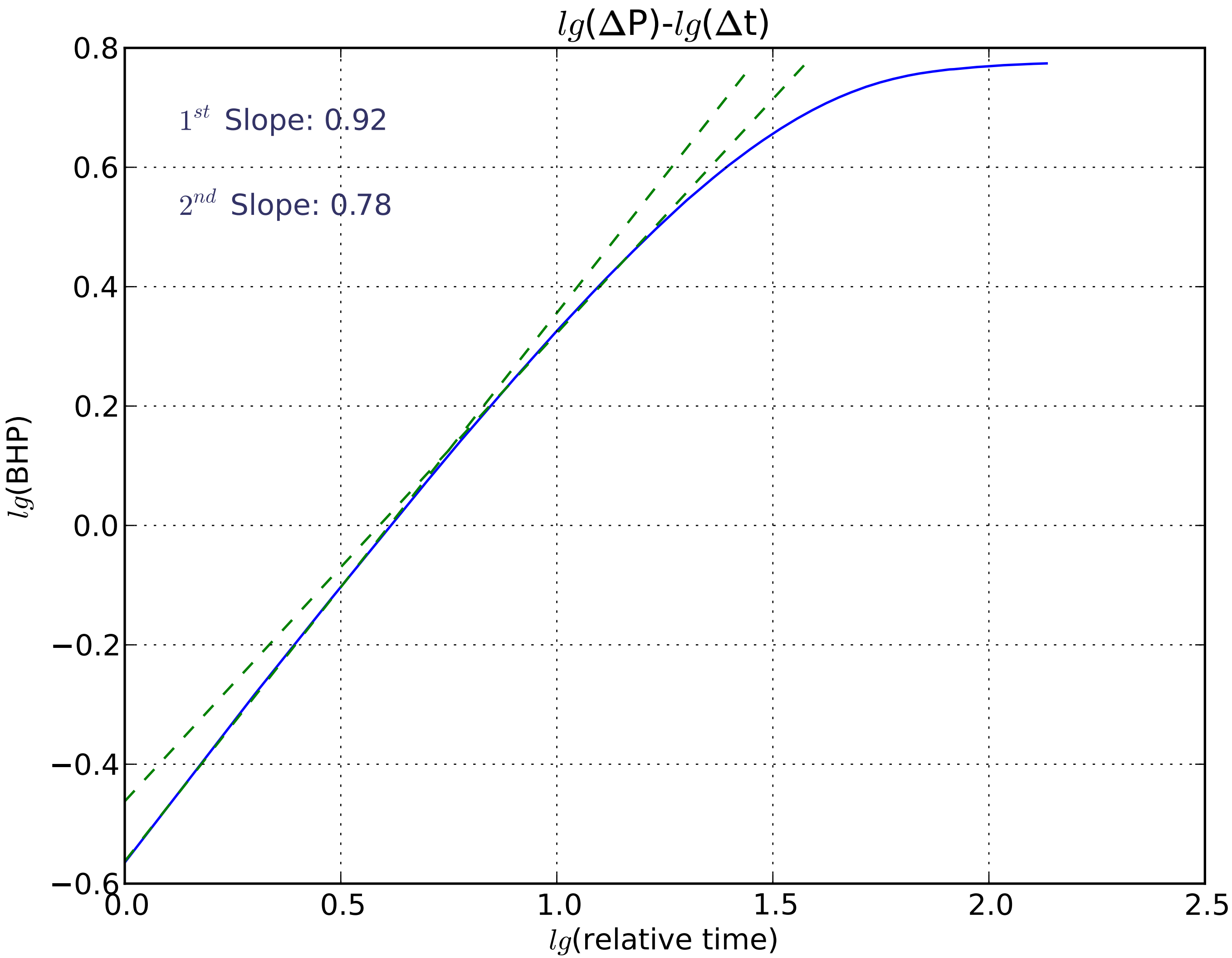
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 02




P-Δt
ISIP: 10.09 MPa
BHP(MPa)
Relative time(s)
12
11
10
9
8
7
6
0
5
10
15
20
25
30
35
40

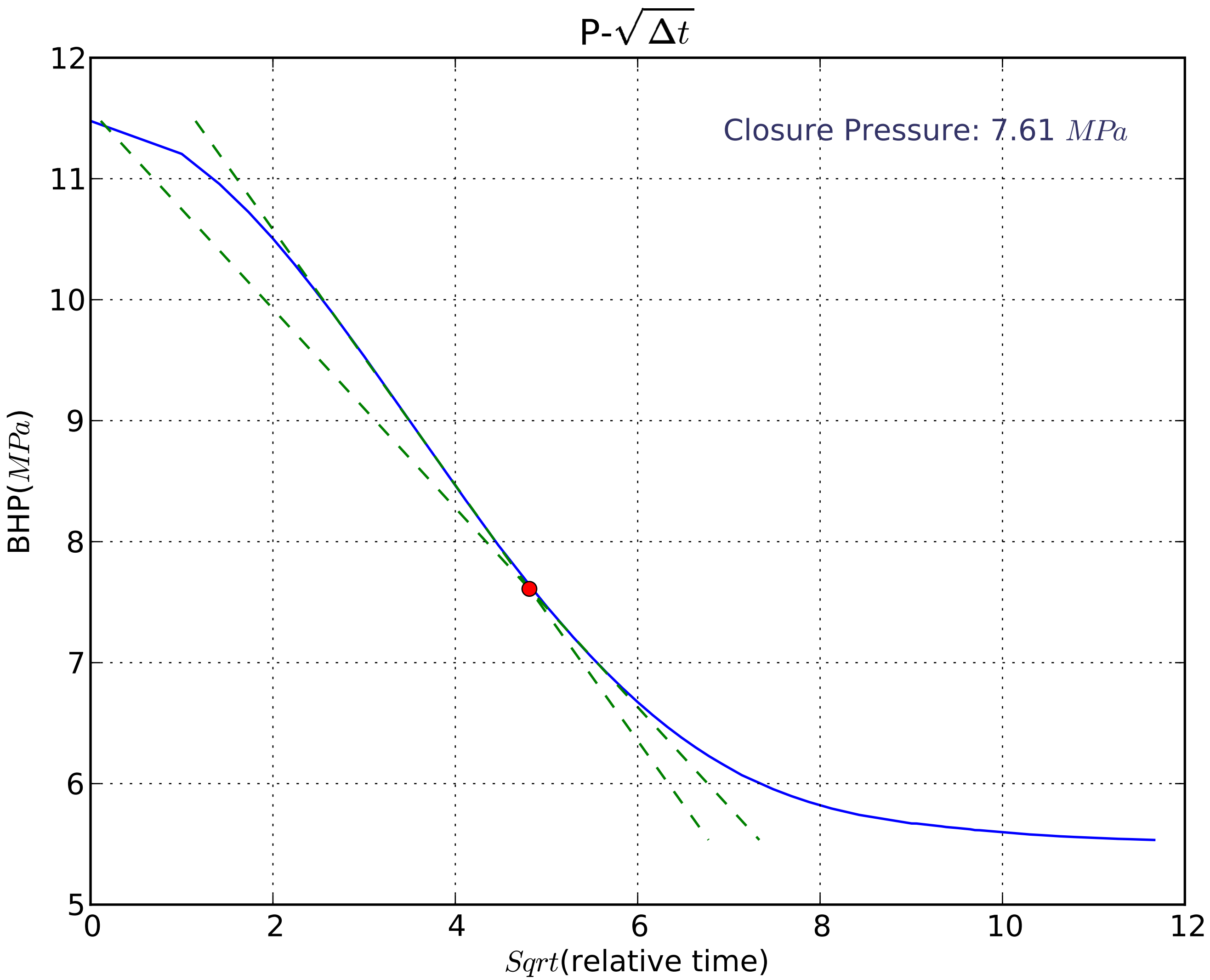
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 02

BitCan
Geosciences & Engineering Inc.



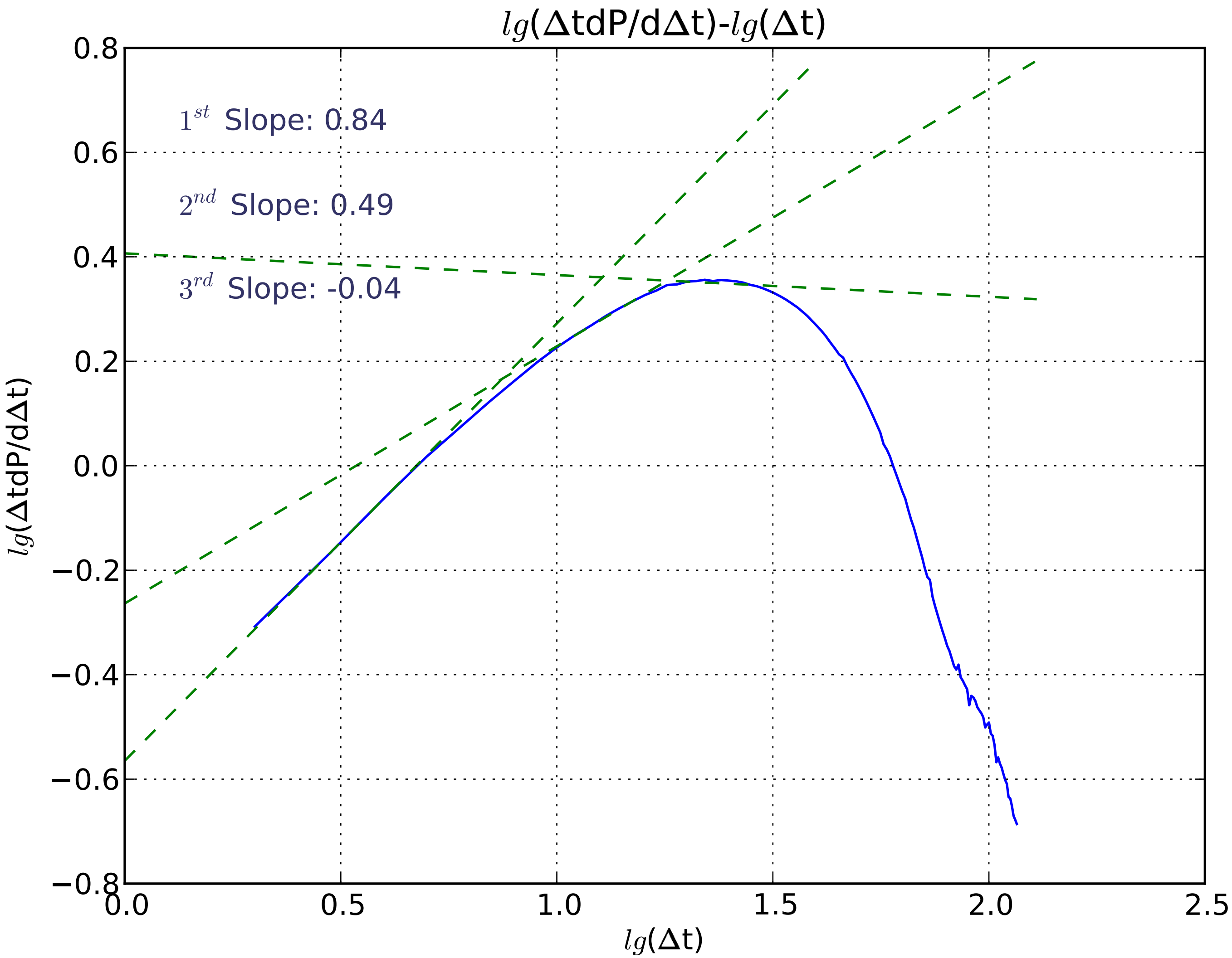
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 02

BitCan
Geosciences & Engineering Inc.



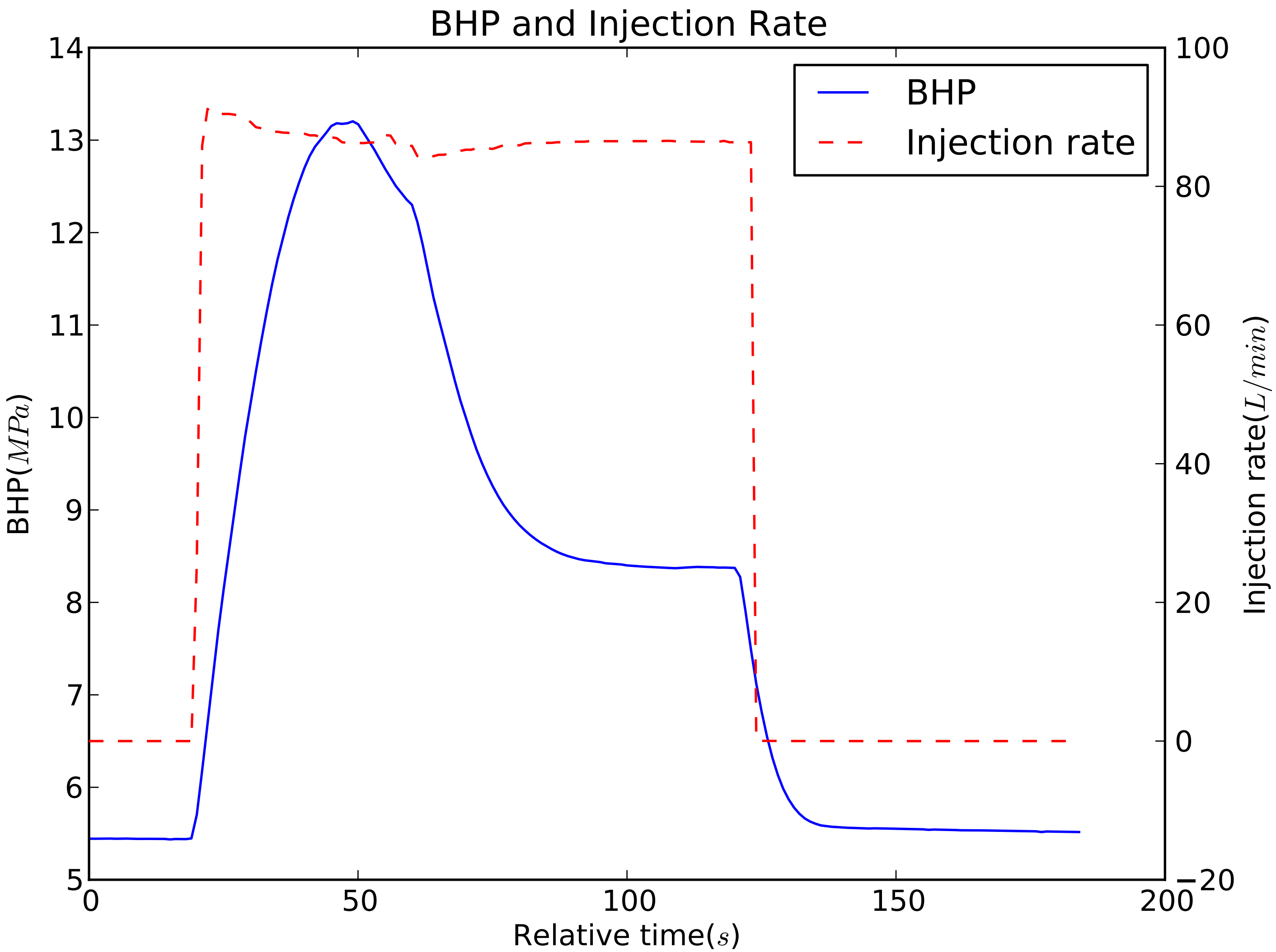
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 02

BitCan
Geosciences & Engineering Inc.

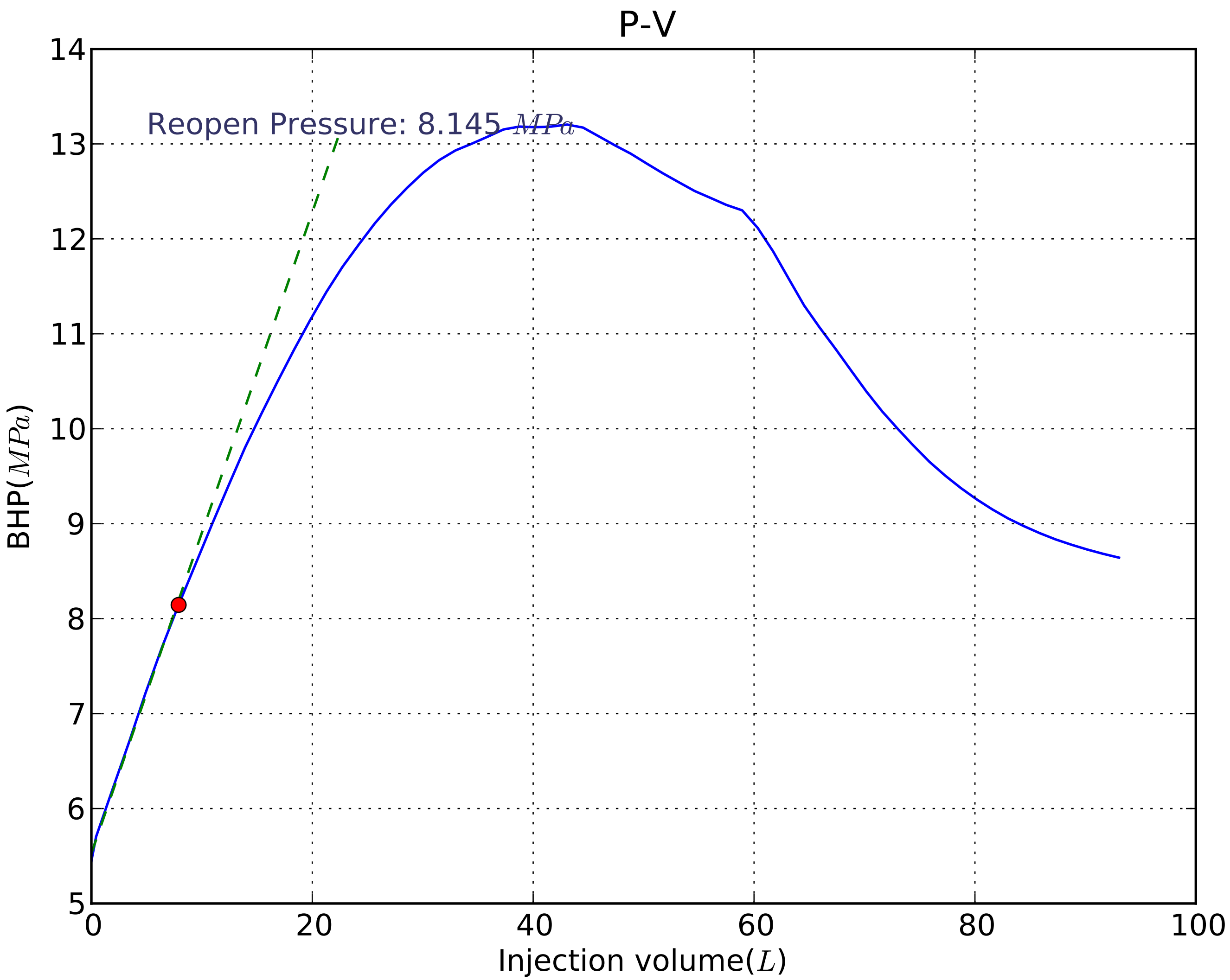


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 03

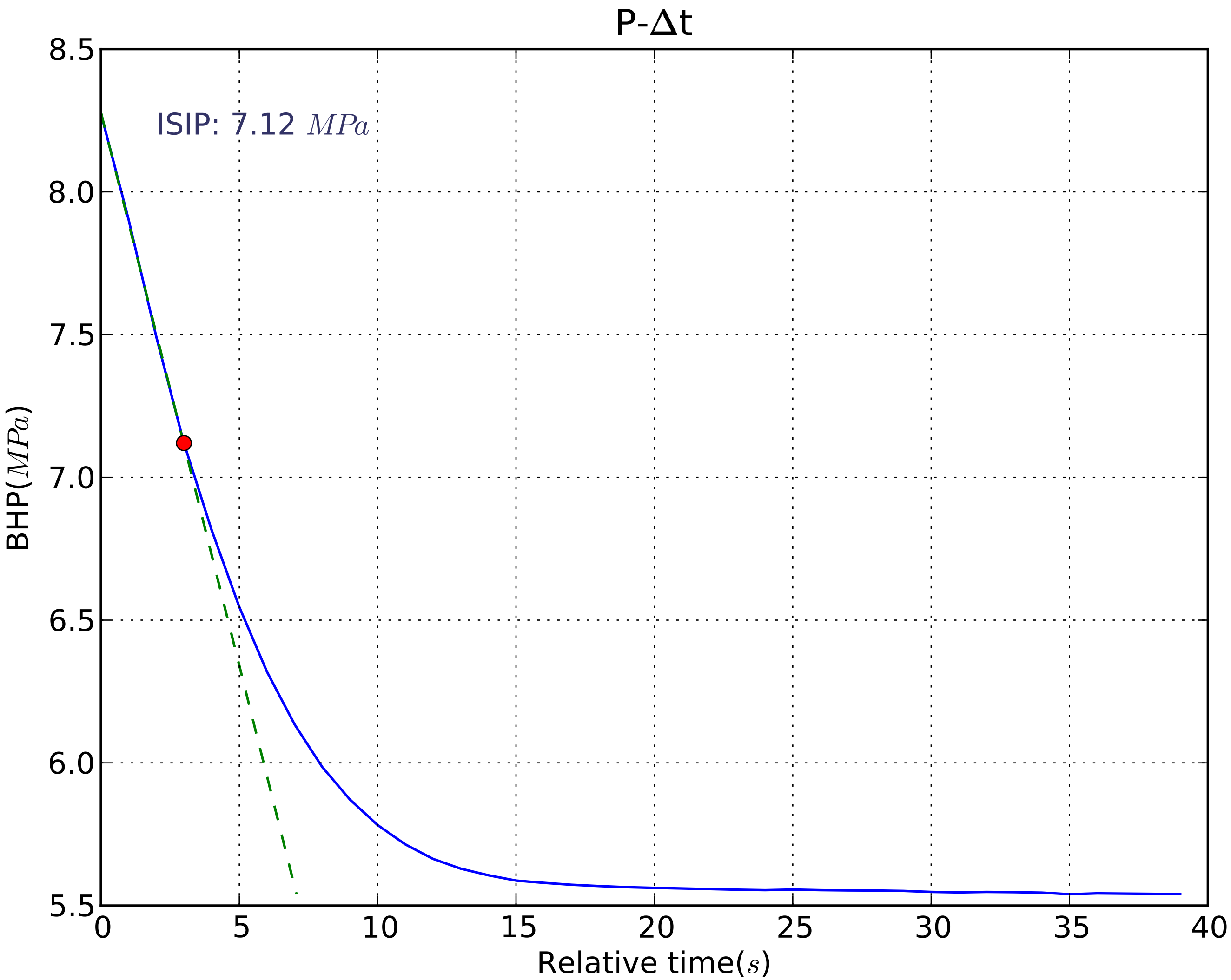
BitCan
Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 03

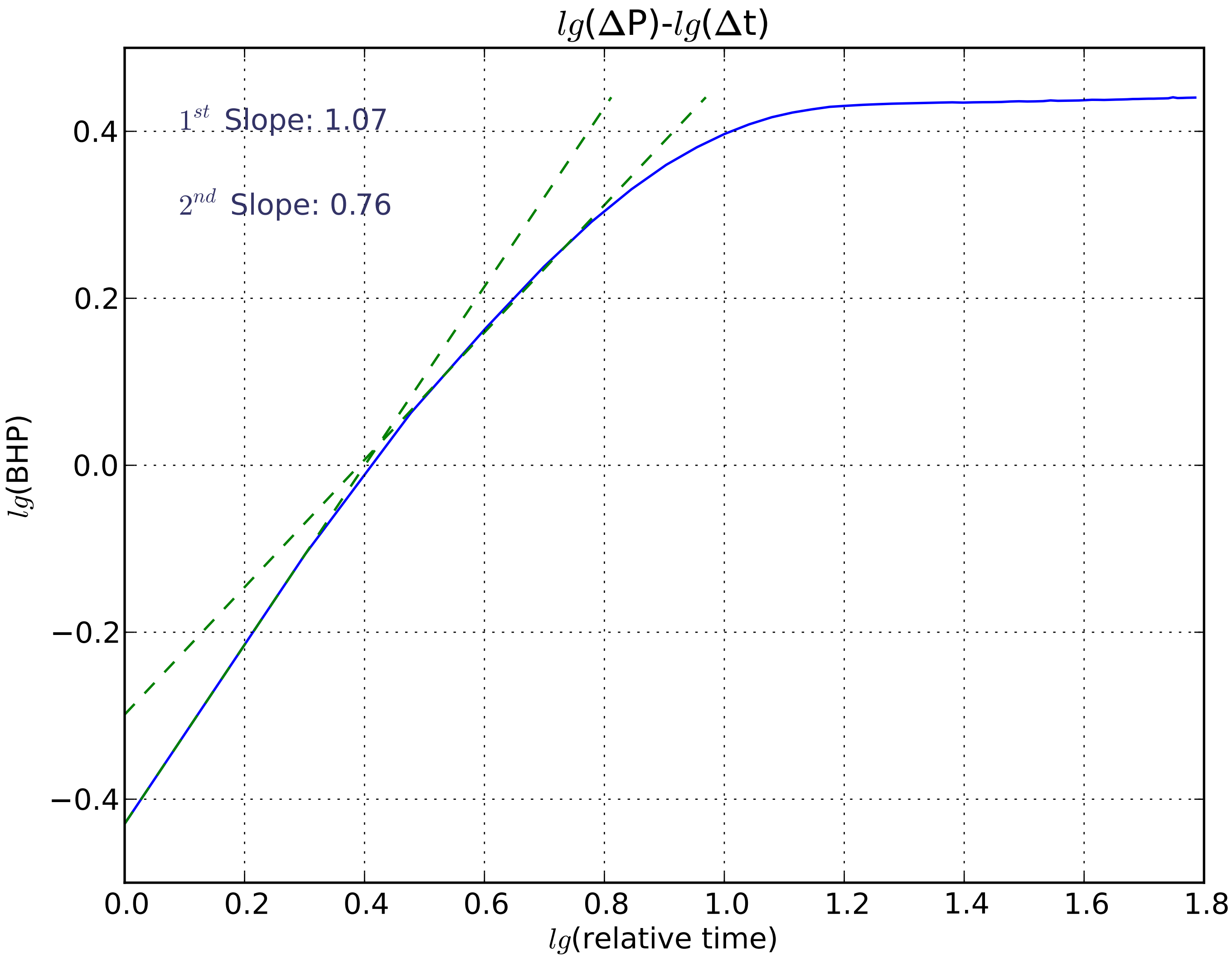


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 03



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 03

BitCan
Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 03

BitCan
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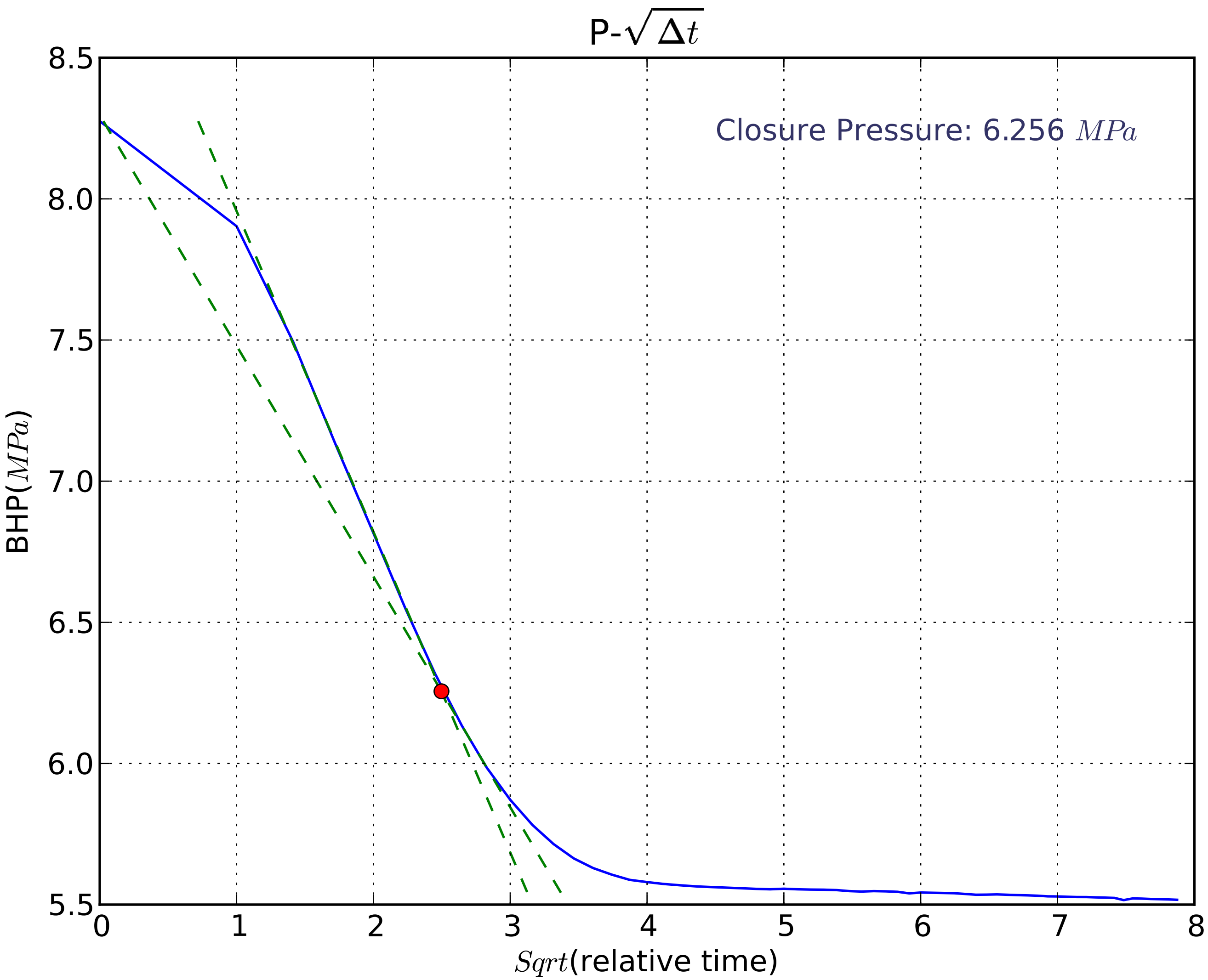

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 03

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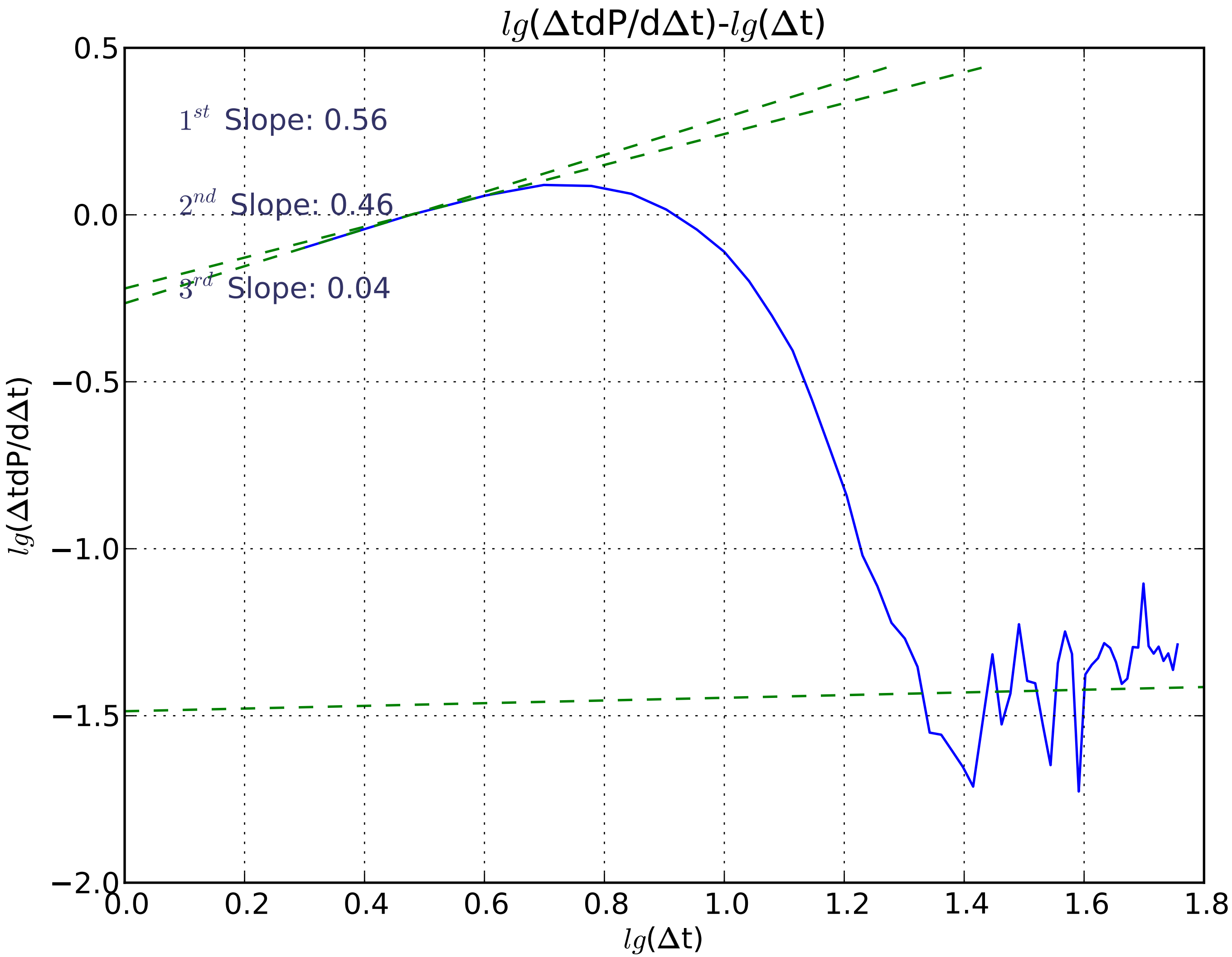

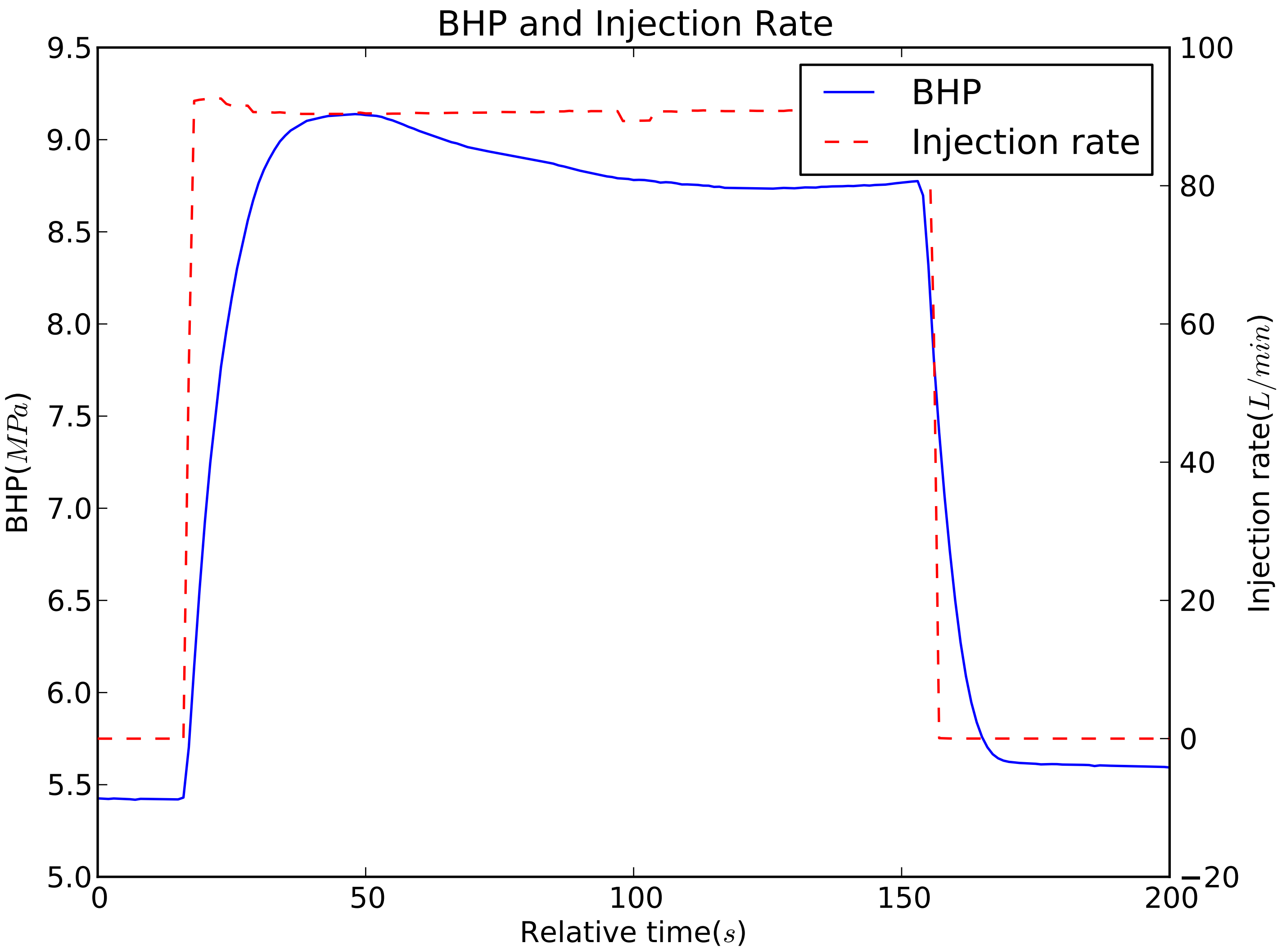
BHP and Injection Rate
BHP
Injection rate
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
BHP(MPa)
100
80
60
40
20
0
−20
Injection rate(L/min)
0
50
100
150
200
Relative time(s)

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 04

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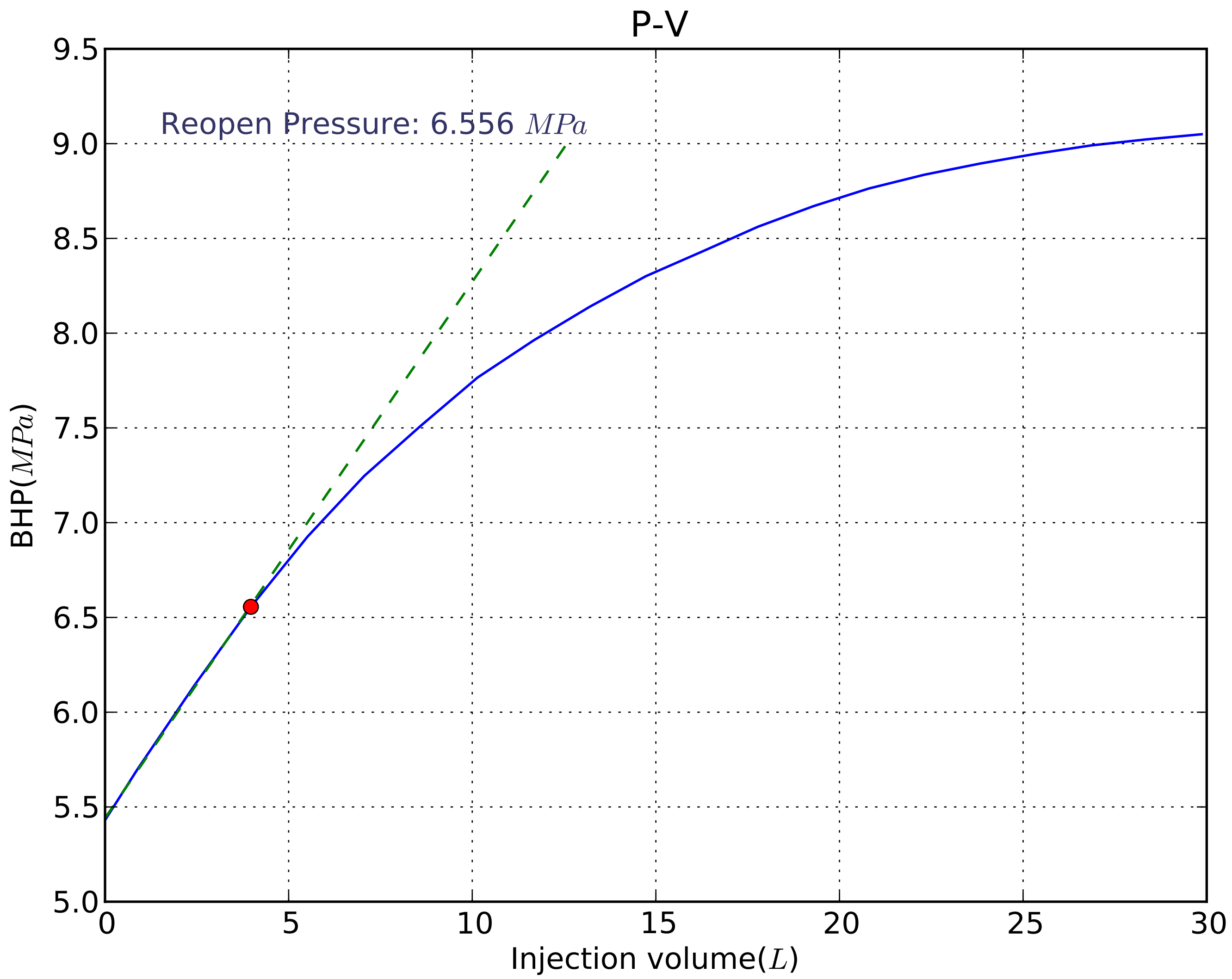
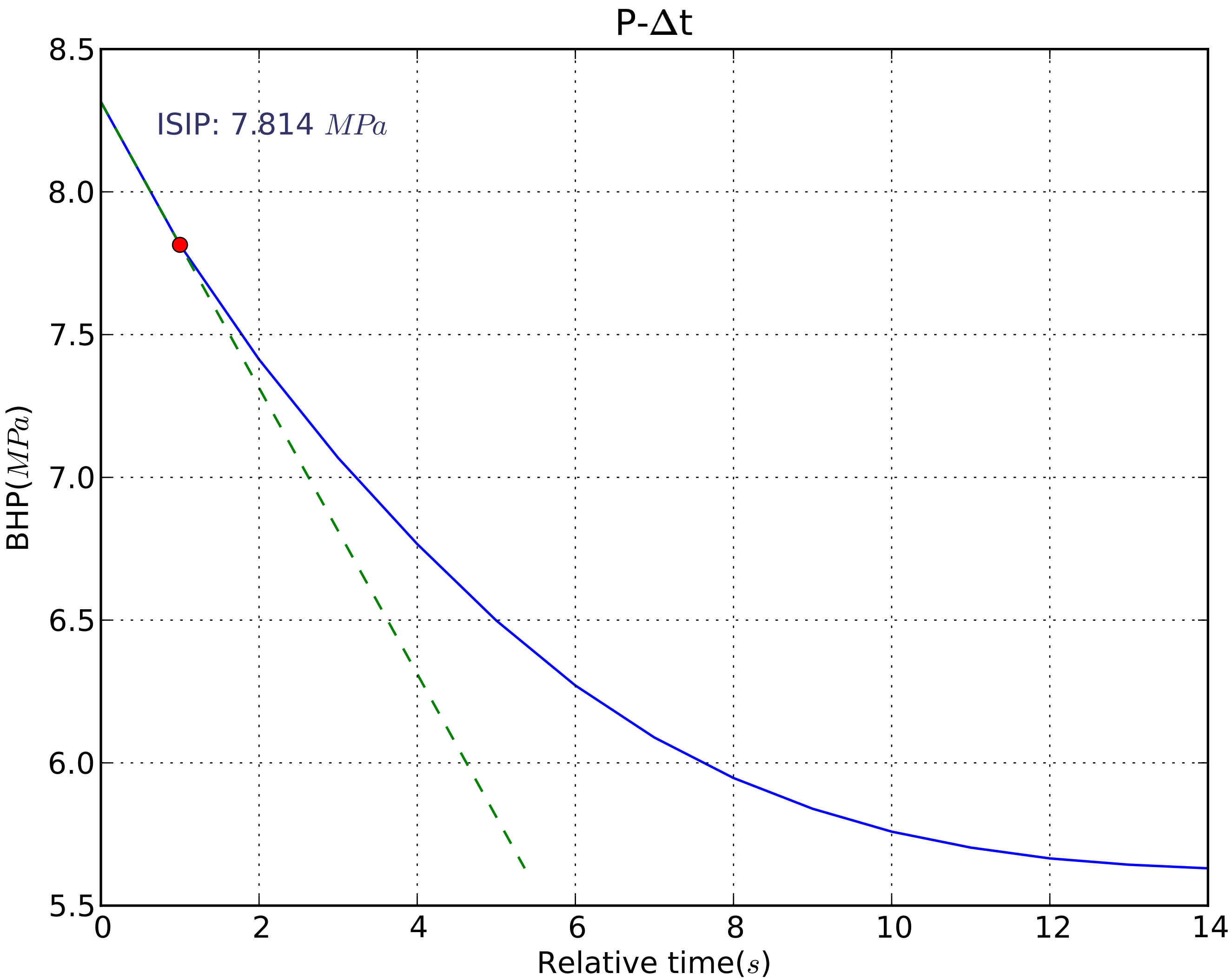
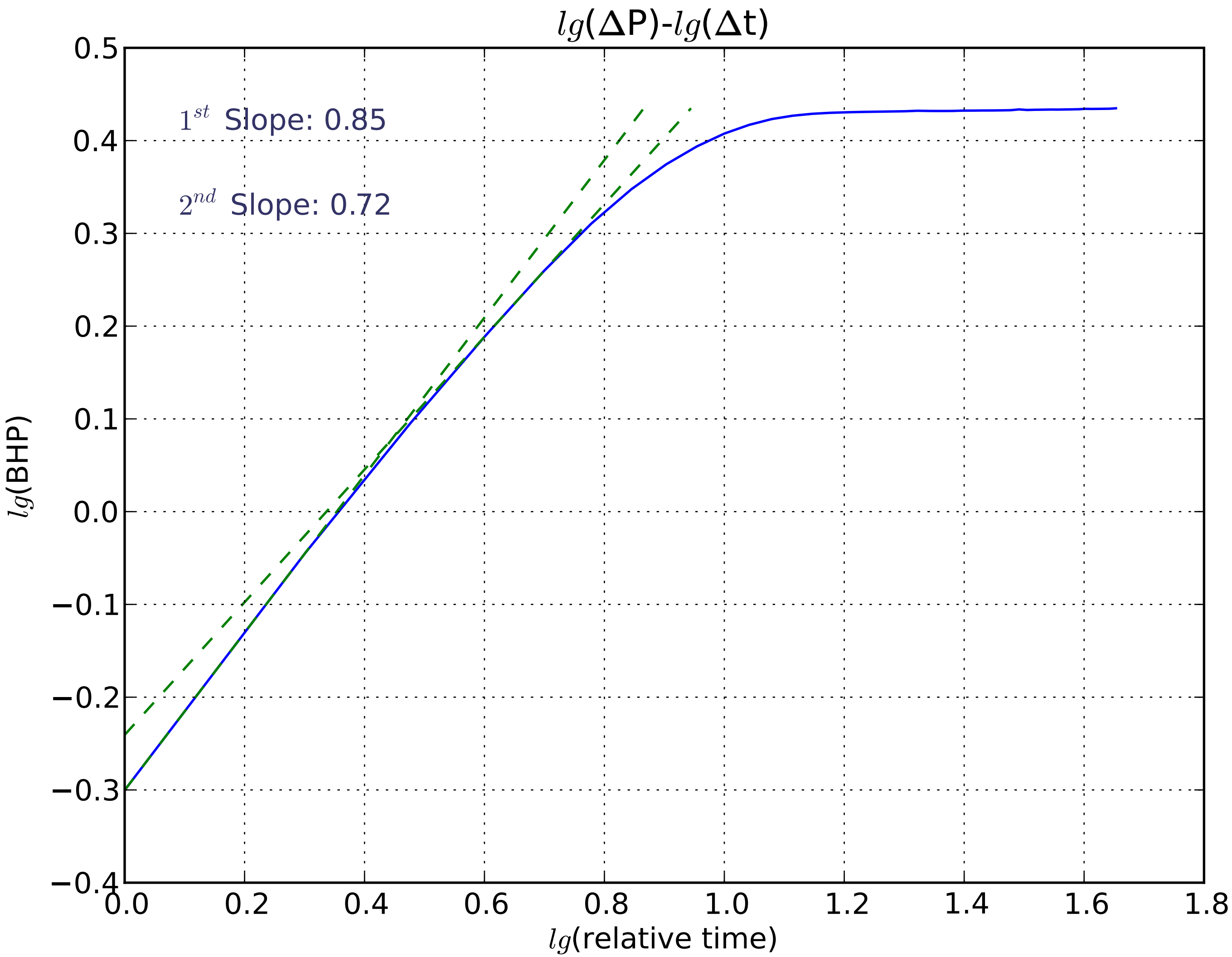


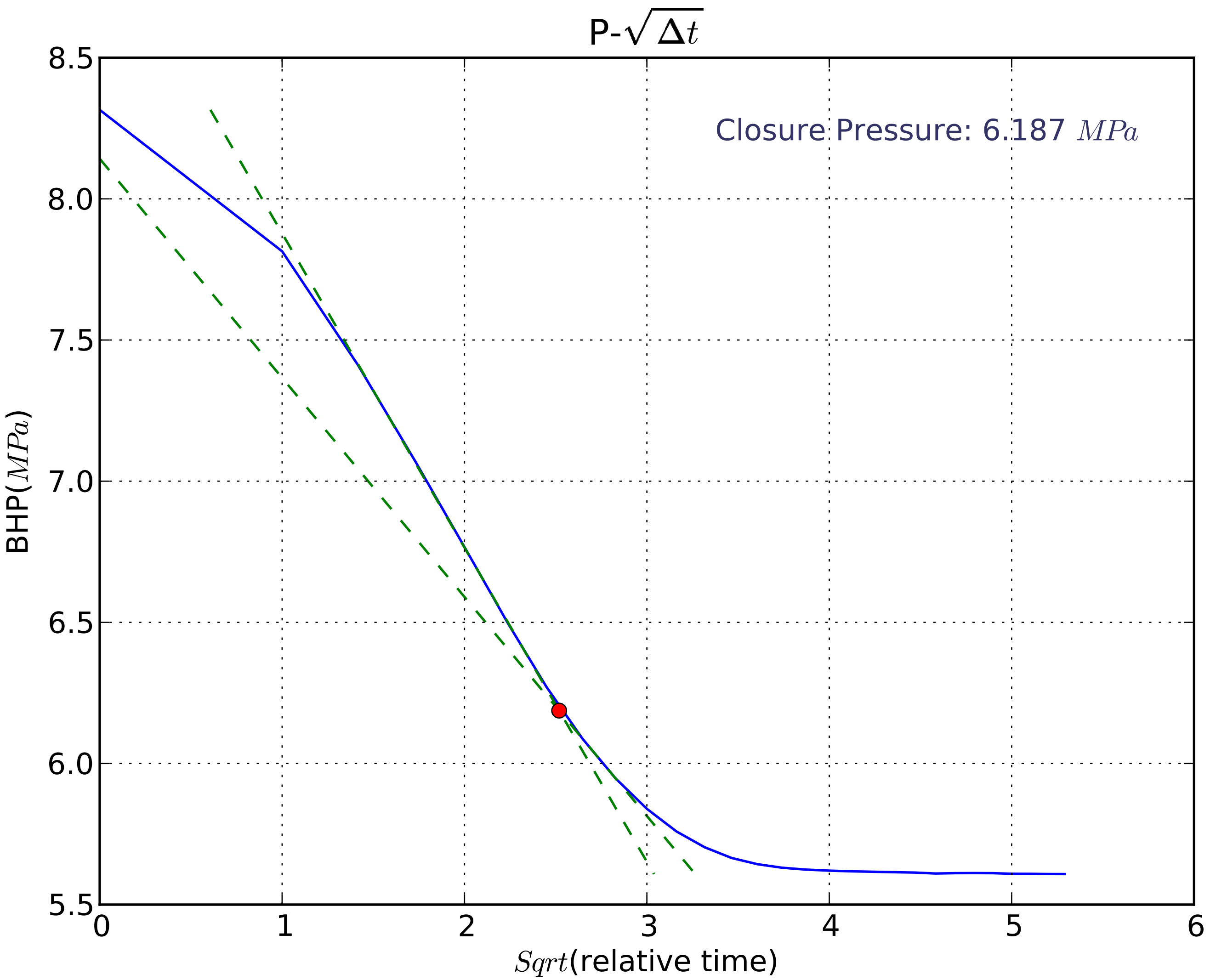

P-Δt
ISIP: 7.814 MPa
BHP(MPa)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
0
2
4
6
8
10
12
14
Relative time(s)

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 04

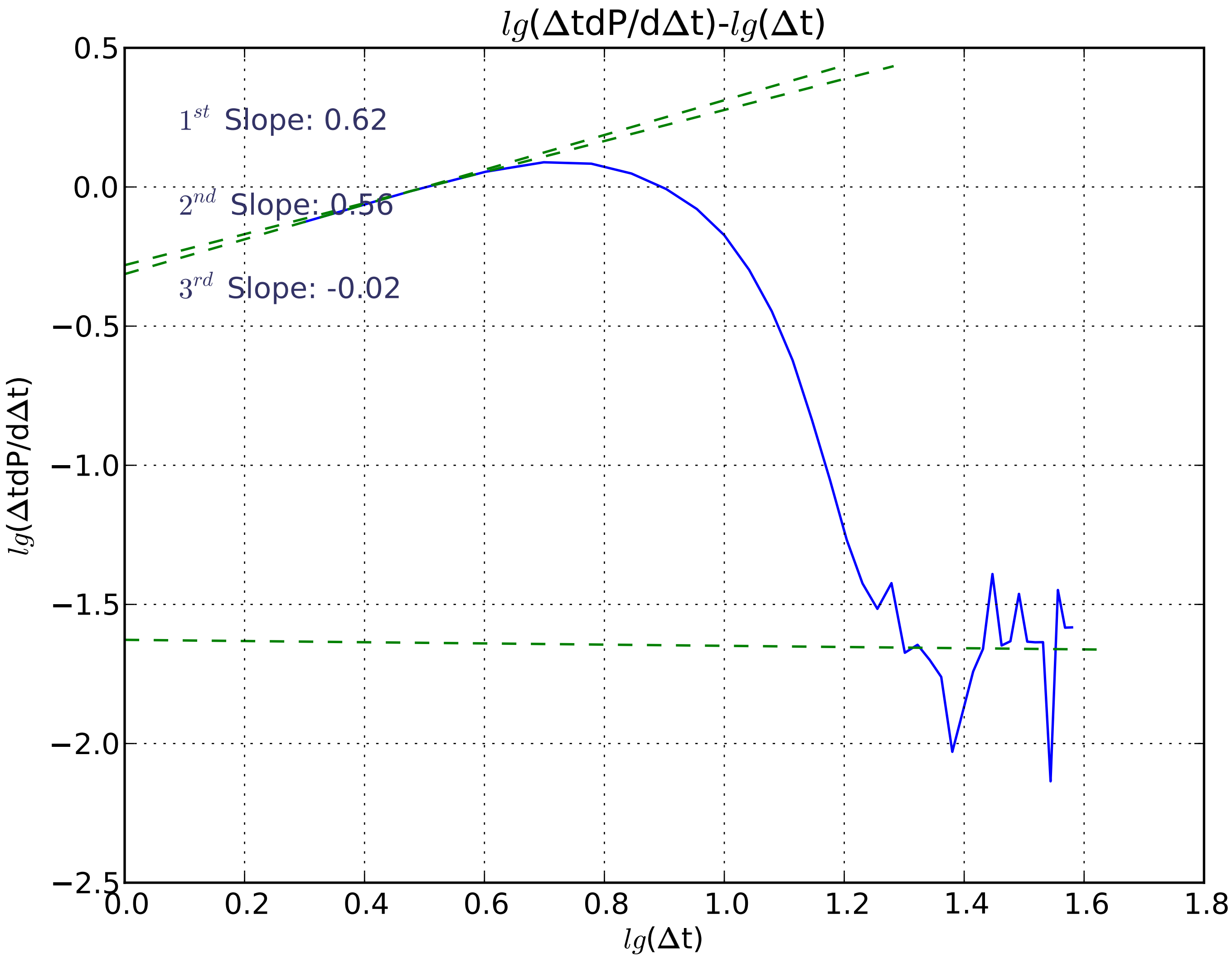


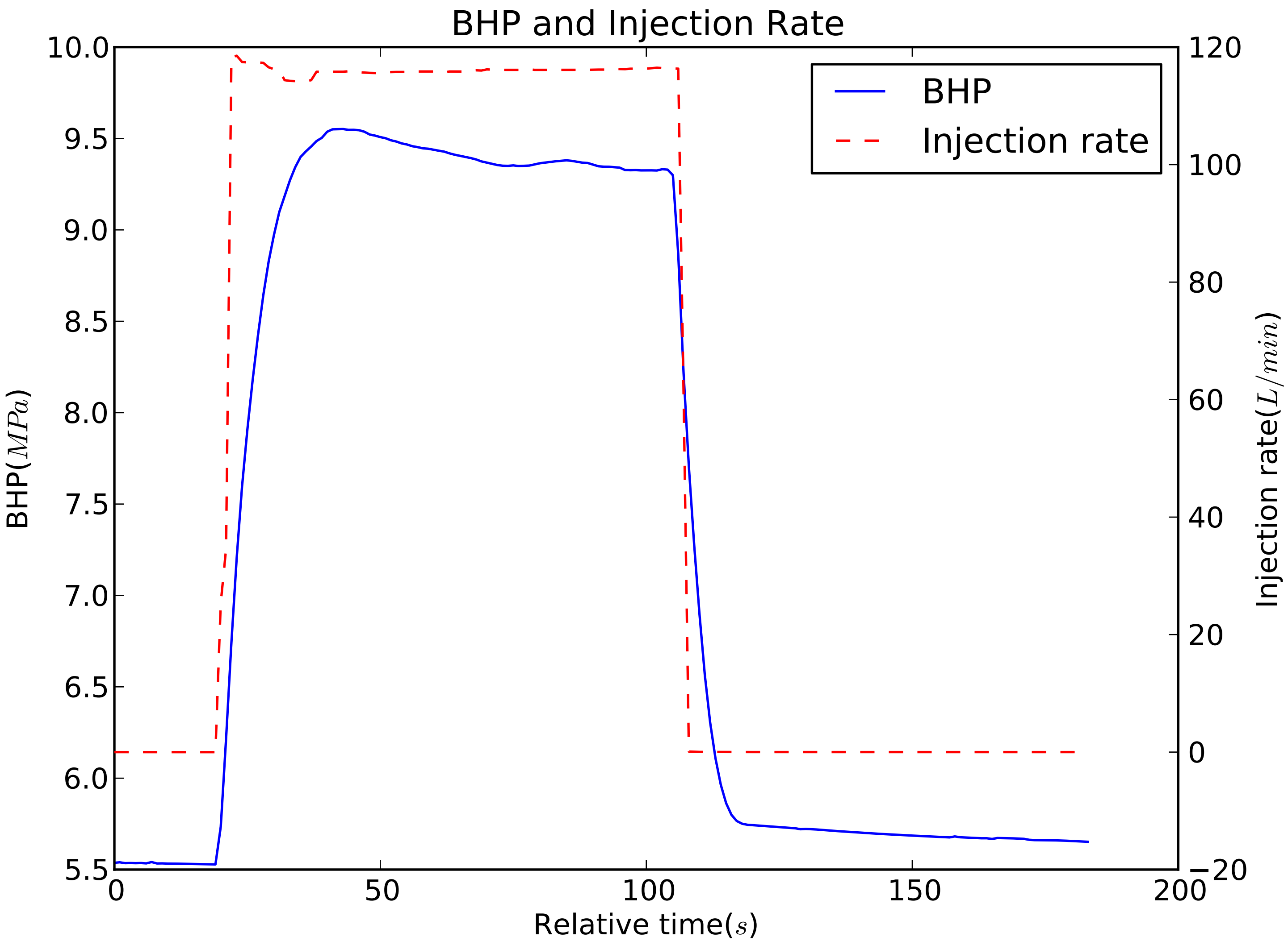
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 04

BitCan
Geosciences & Engineering Inc.



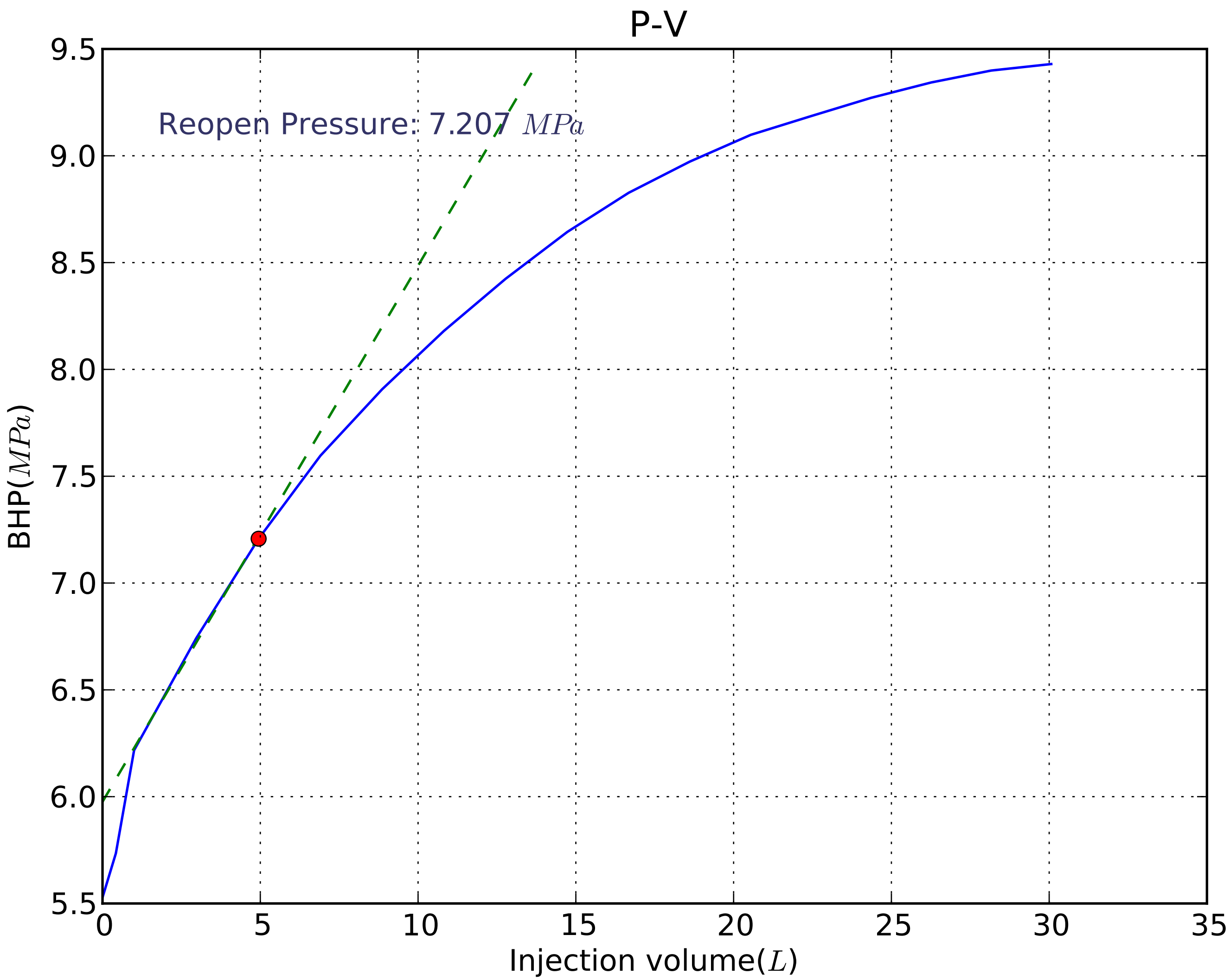
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 04



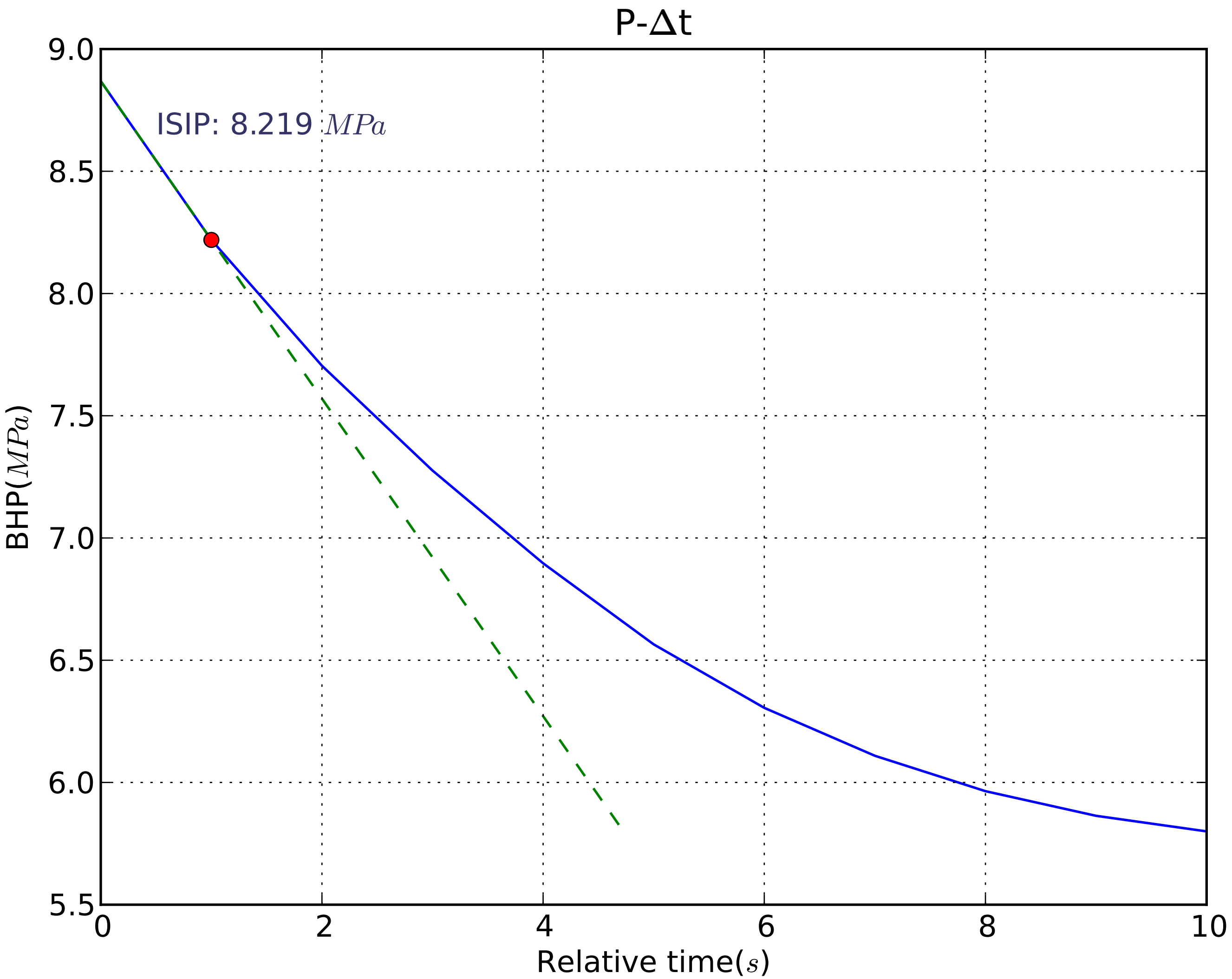

BHP and Injection Rate
BHP
Injection rate
BHP(MPa)
Injection rate(L/min)
Relative time(s)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
120
100
80
60
40
20
0
−20
0
50
100
150
200

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 05

BitCan
Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 05



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 05

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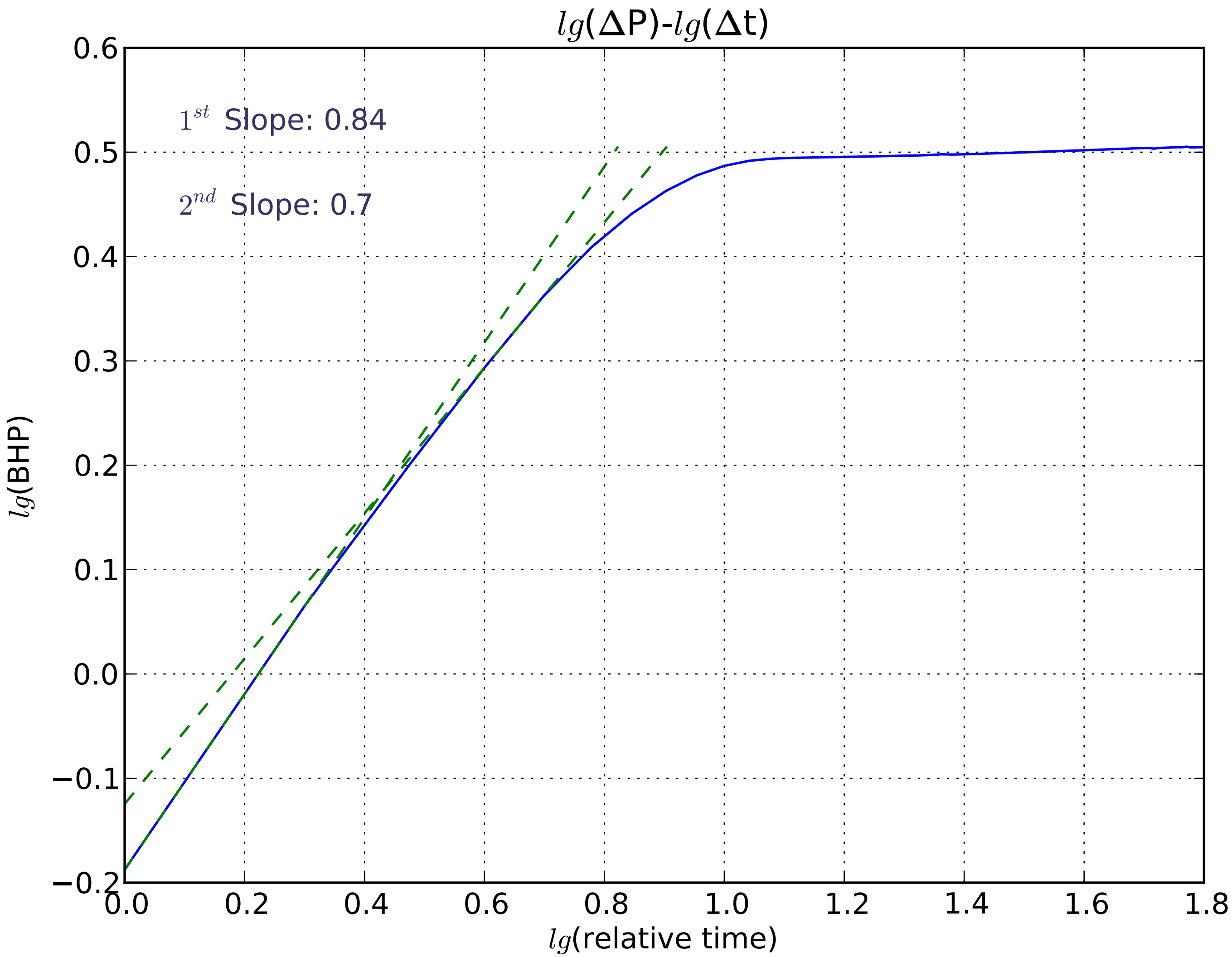
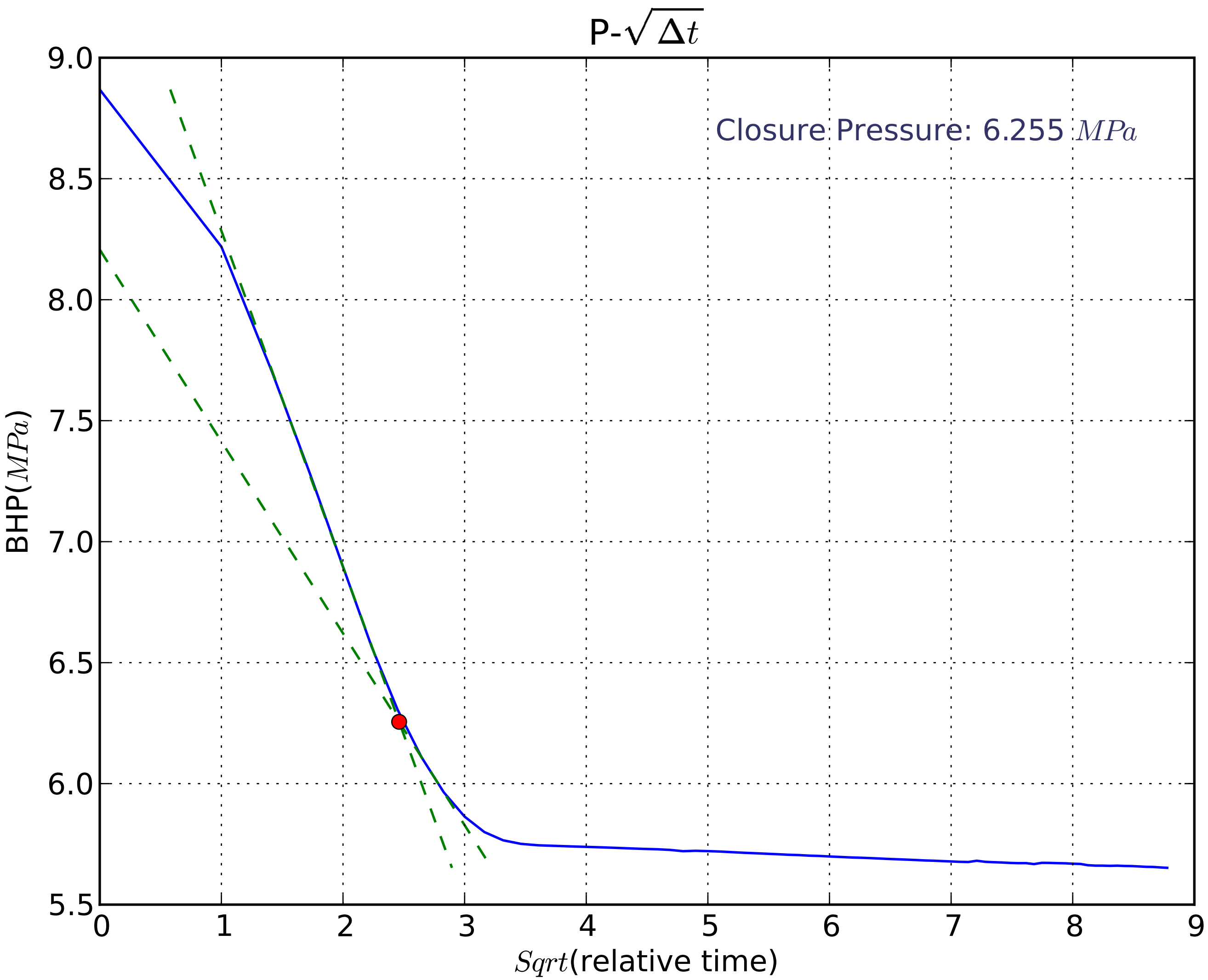


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 05



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 05

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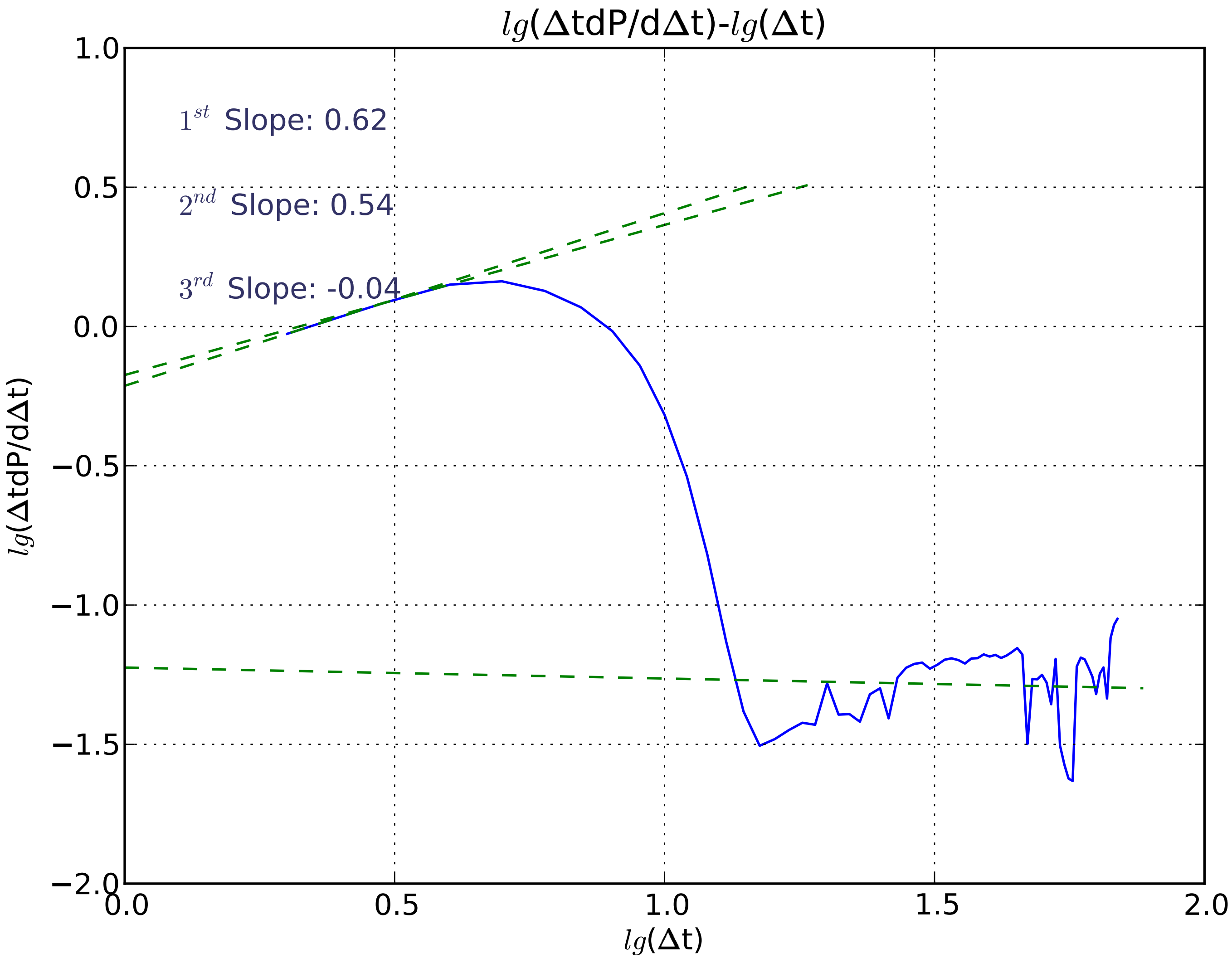
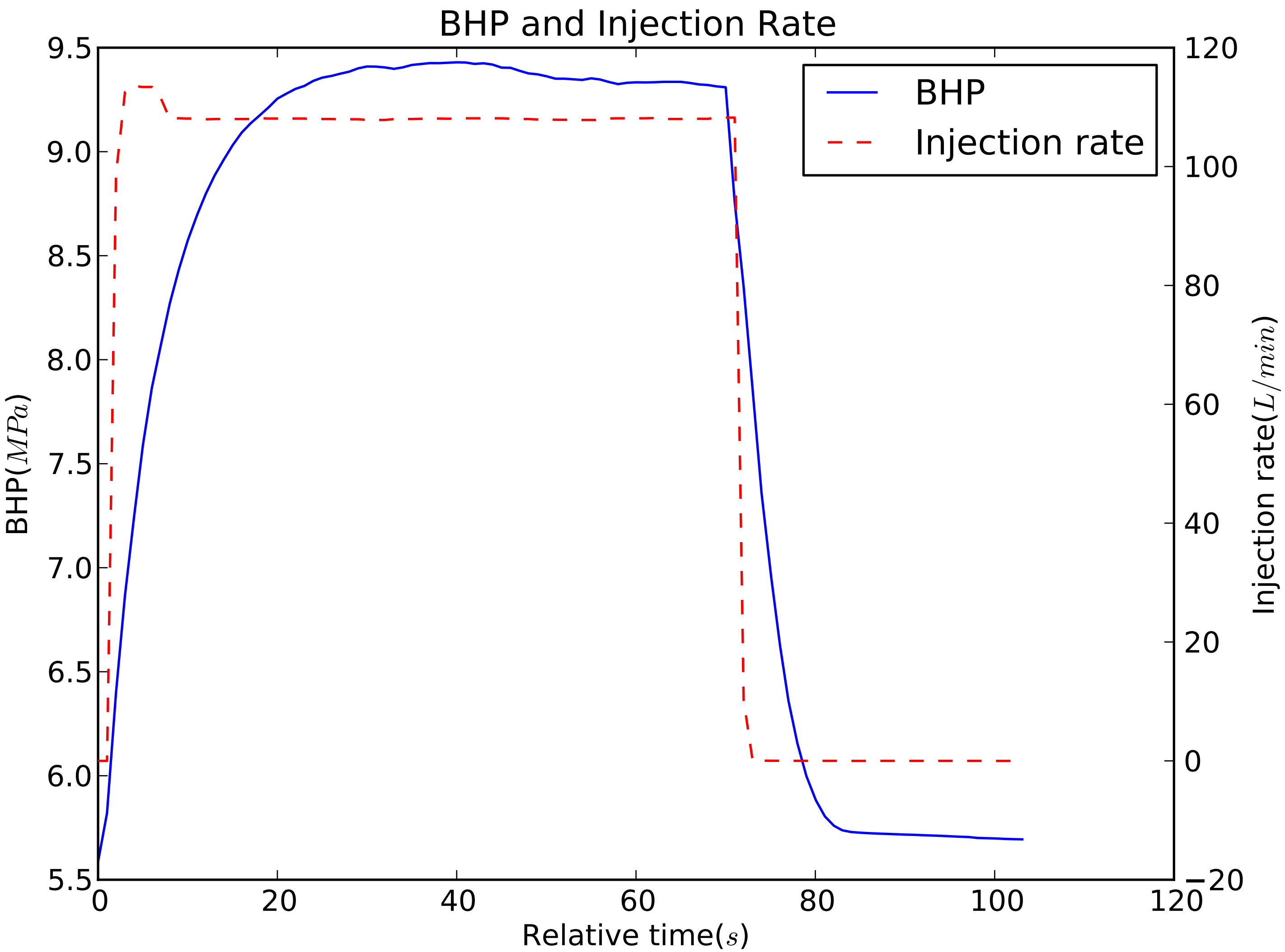


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 06



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 06

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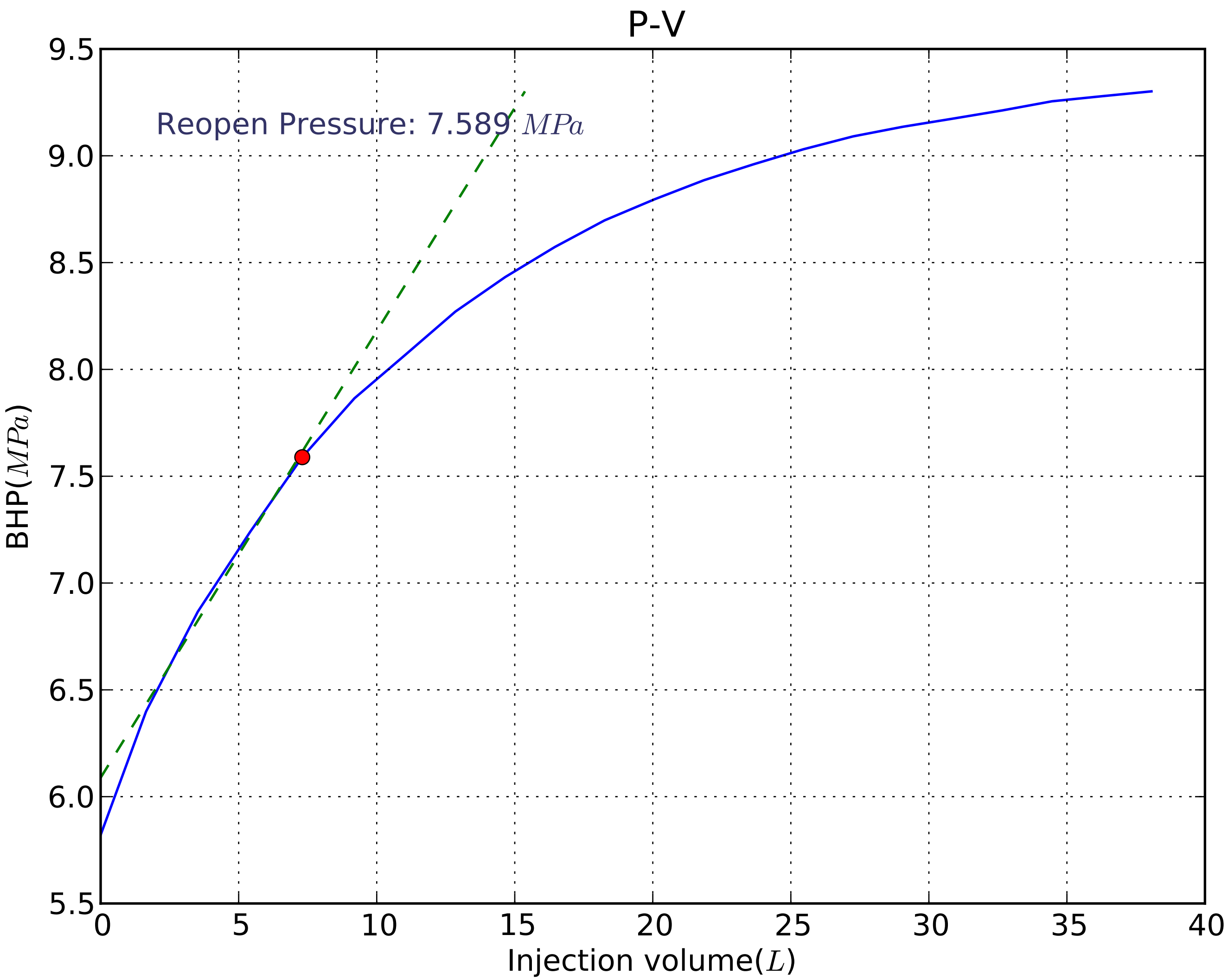
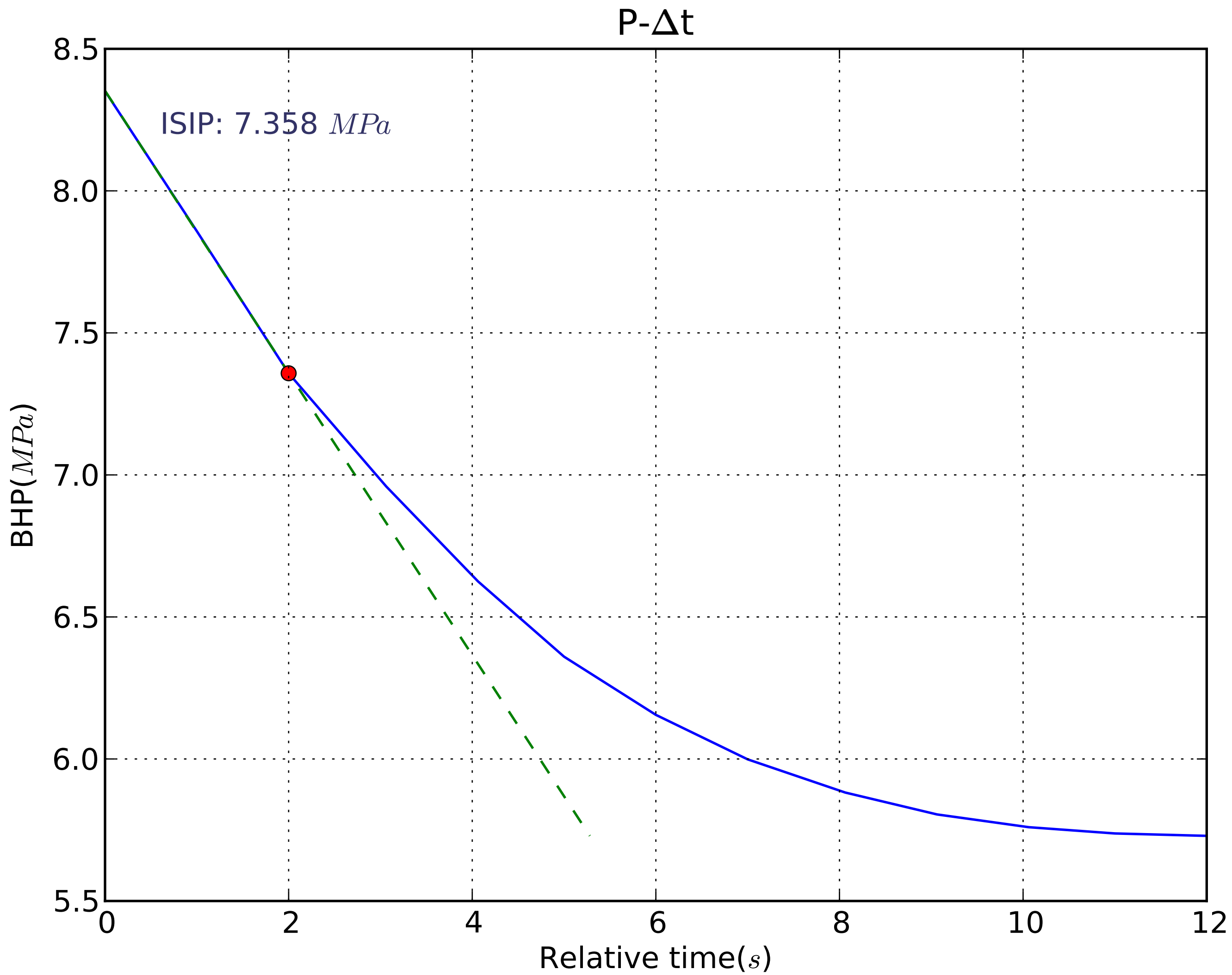
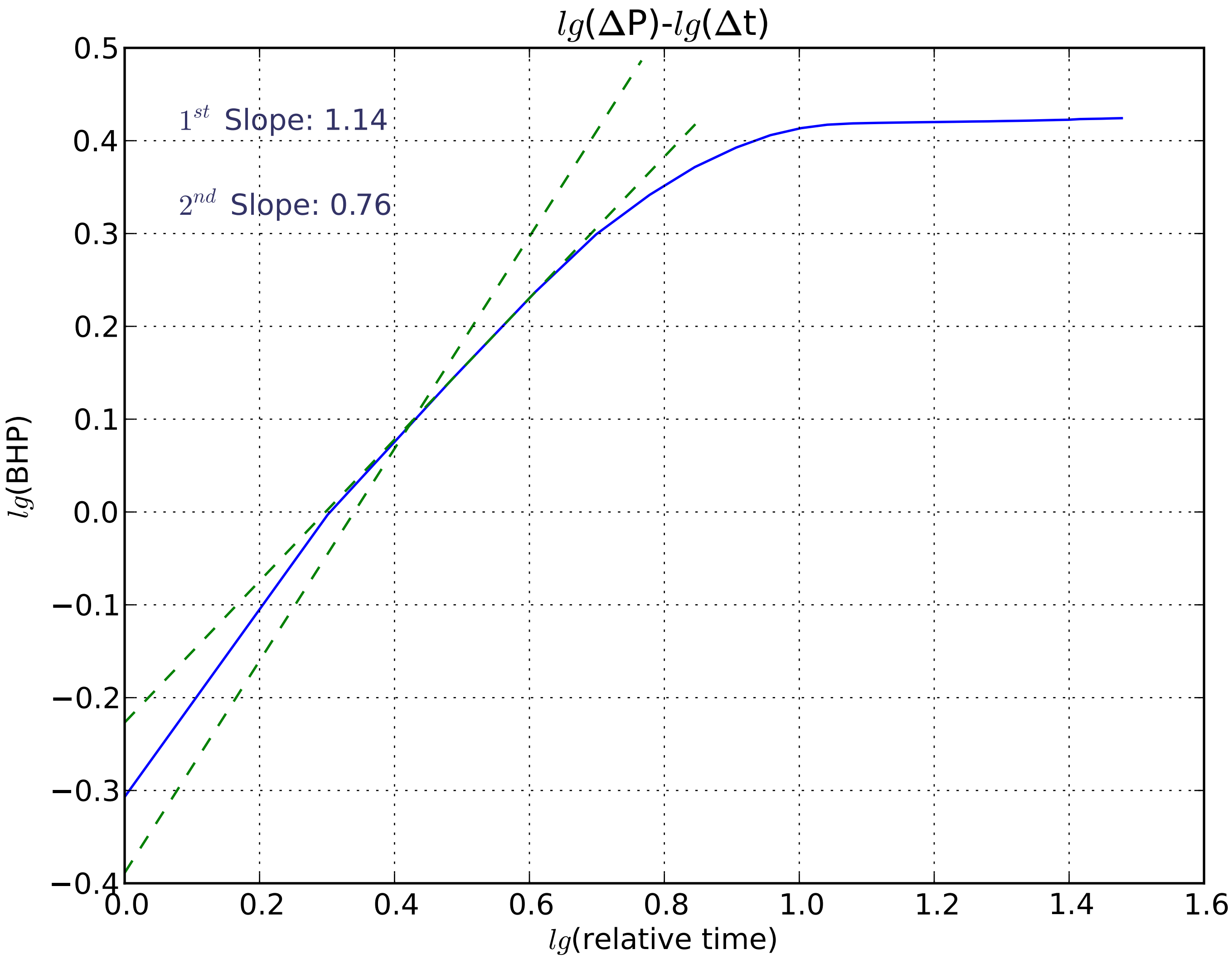


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 06

BitCan
Geosciences & Engineering Inc.

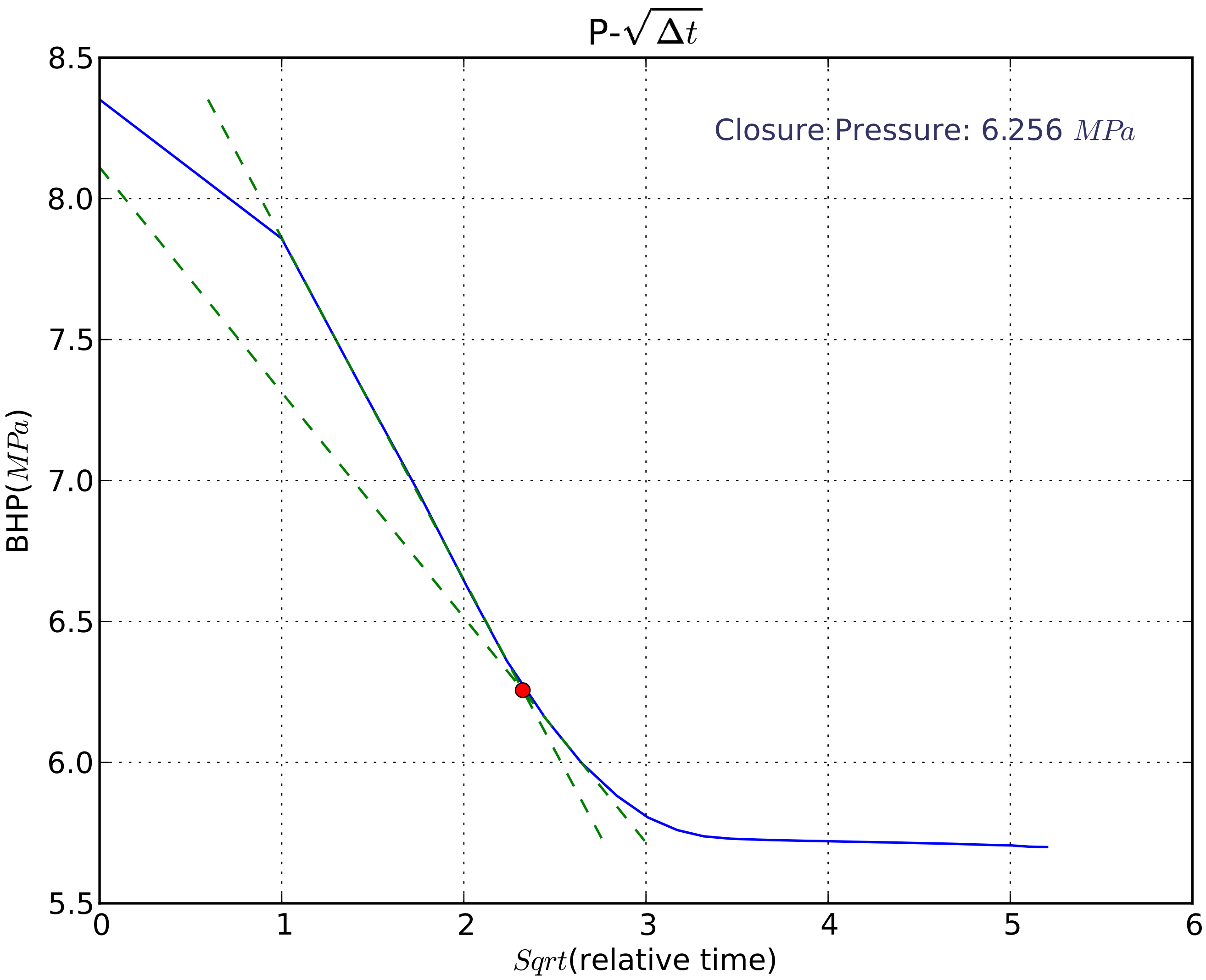


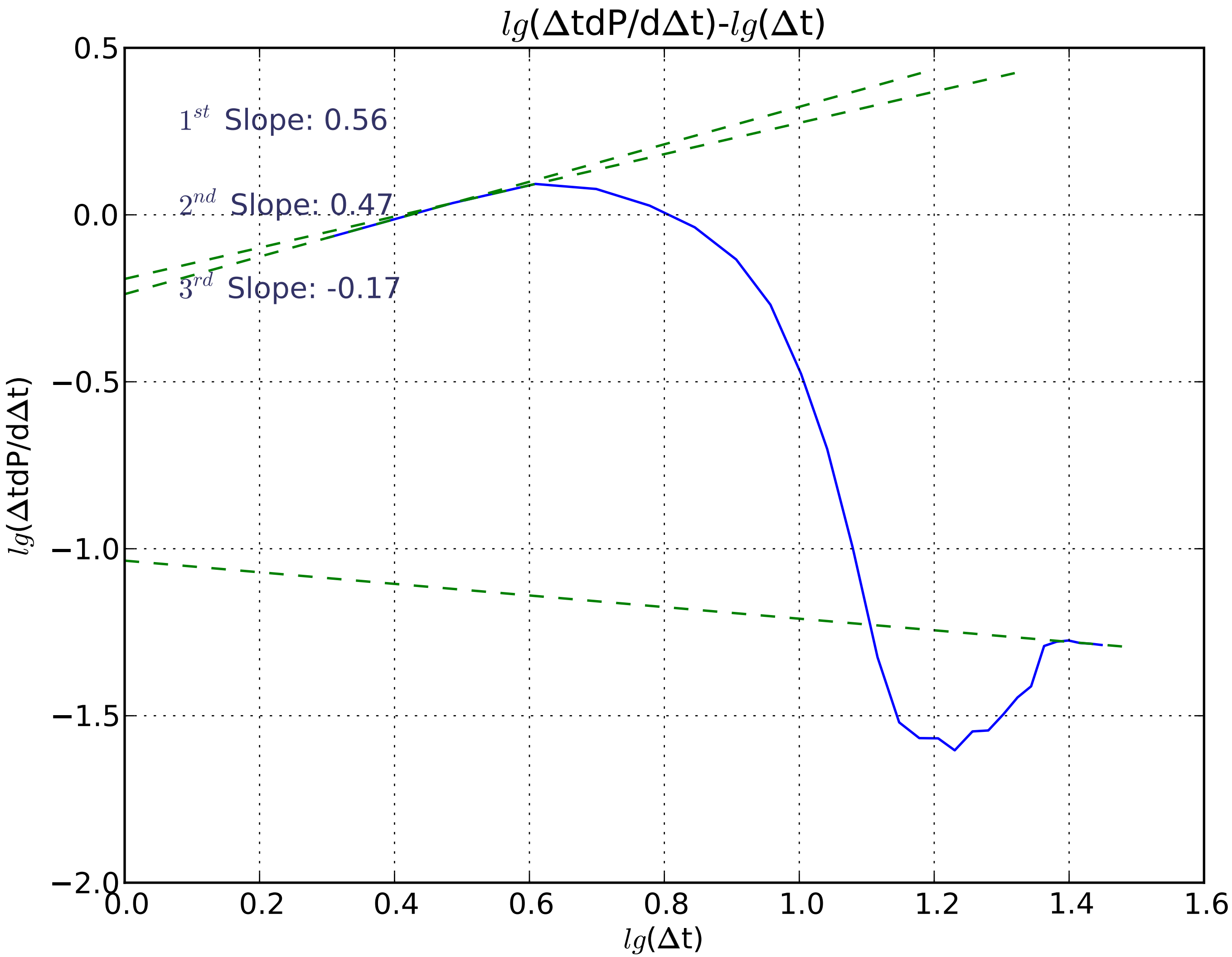
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 06



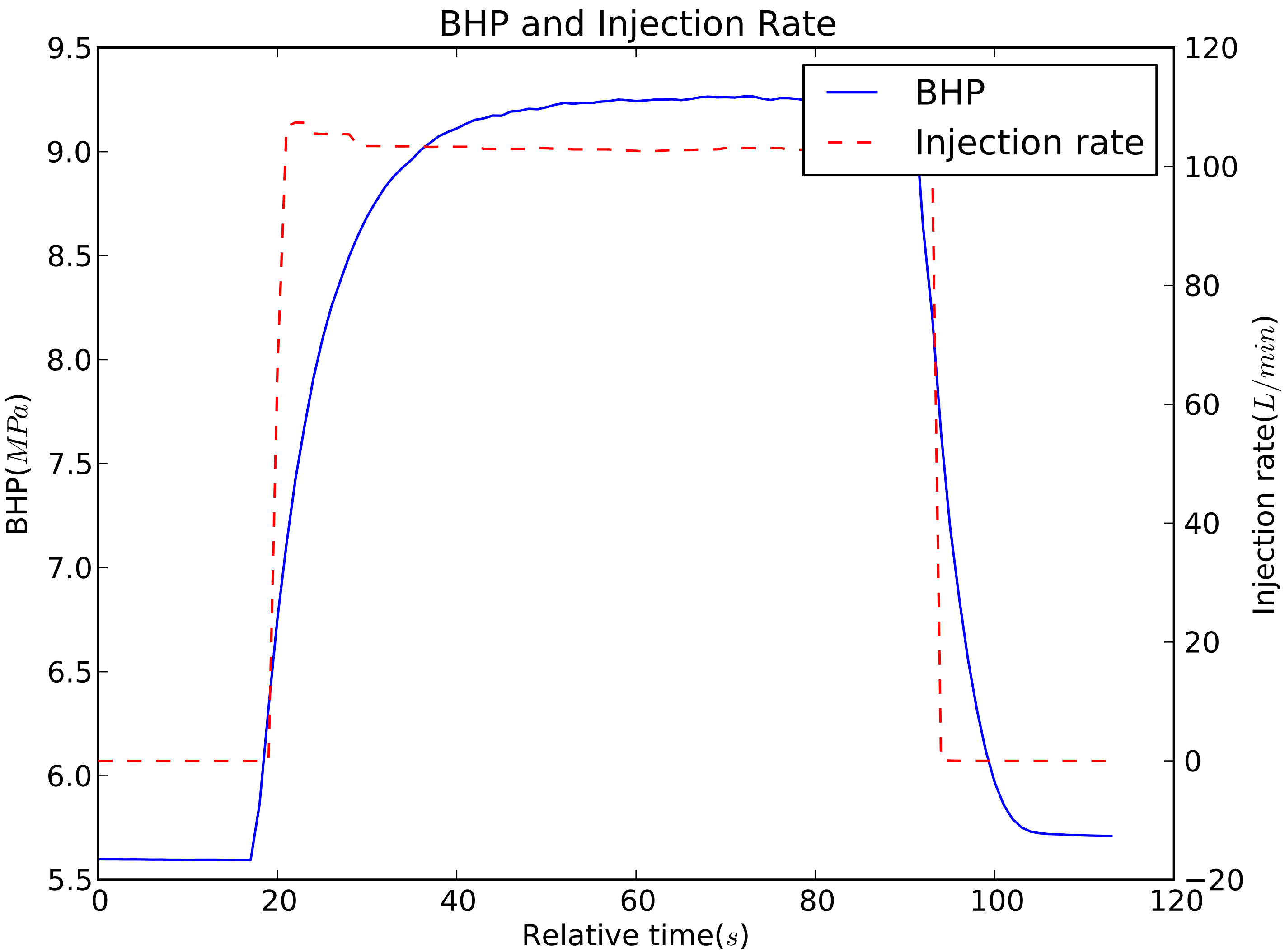
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 06

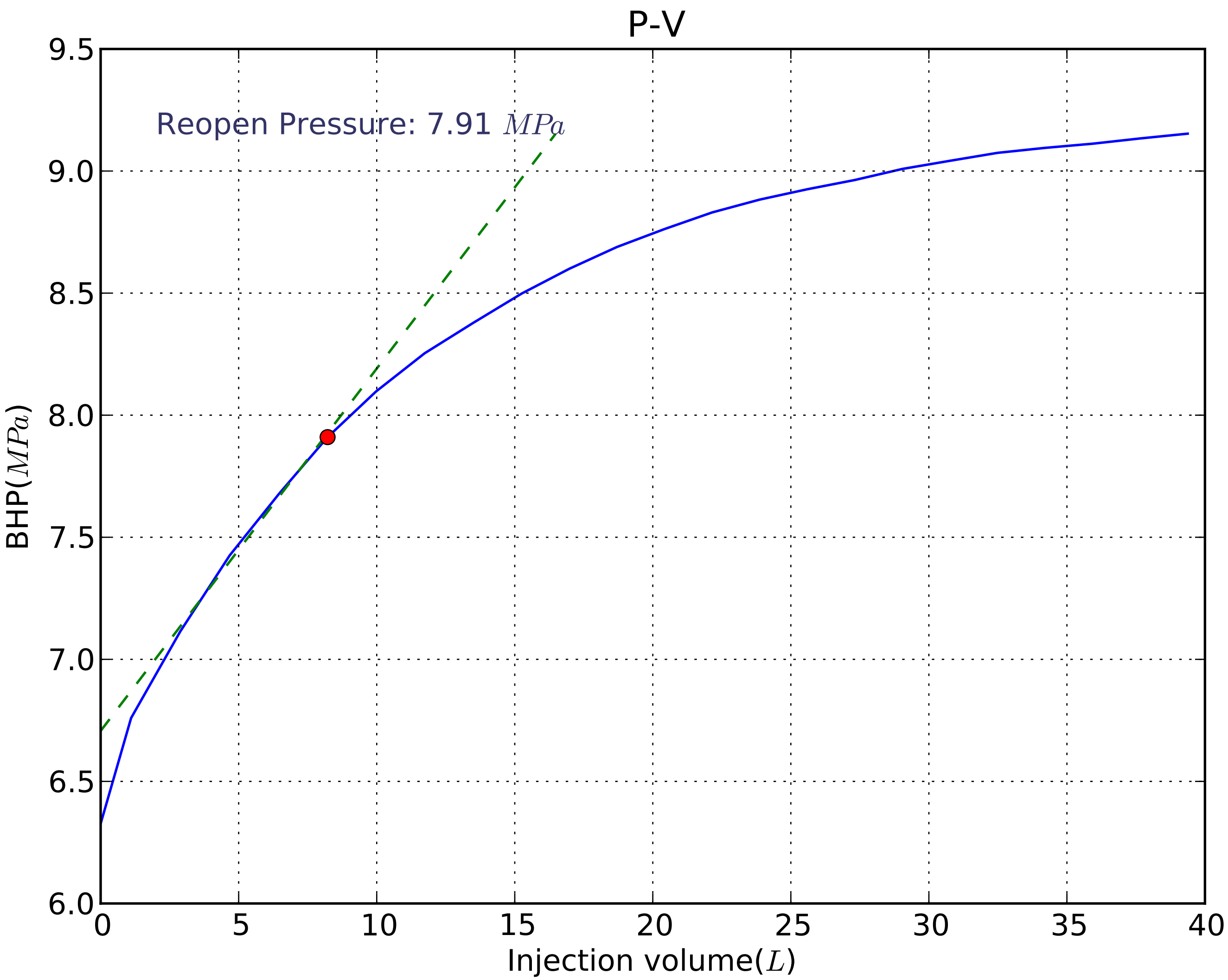
BitCan
Geosciences & Engineering Inc.




lg(ΔtdP/dΔt)-lg(Δt)
1^{st} Slope: 0.56
2^{nd} Slope: 0.47
3^{rd} Slope: -0.17
0.5
0.0
−0.5
−1.0
−1.5
−2.0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
lg(ΔtdP/dΔt)
lg(Δt)

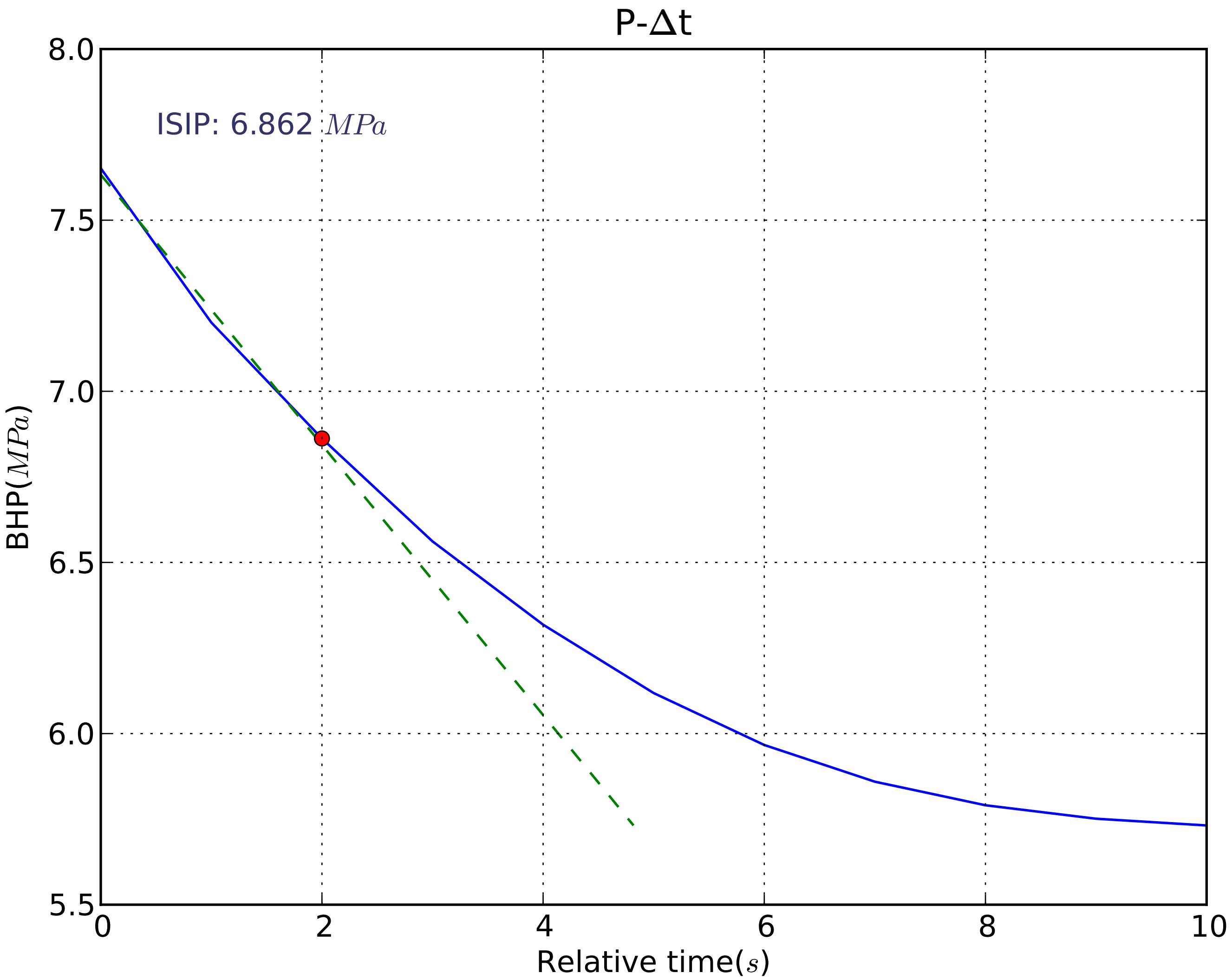
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 07




P-V
Reopen Pressure: 7.91 MPa
BHP(MPa)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
0
5
10
15
20
25
30
35
40
Injection volume(L)

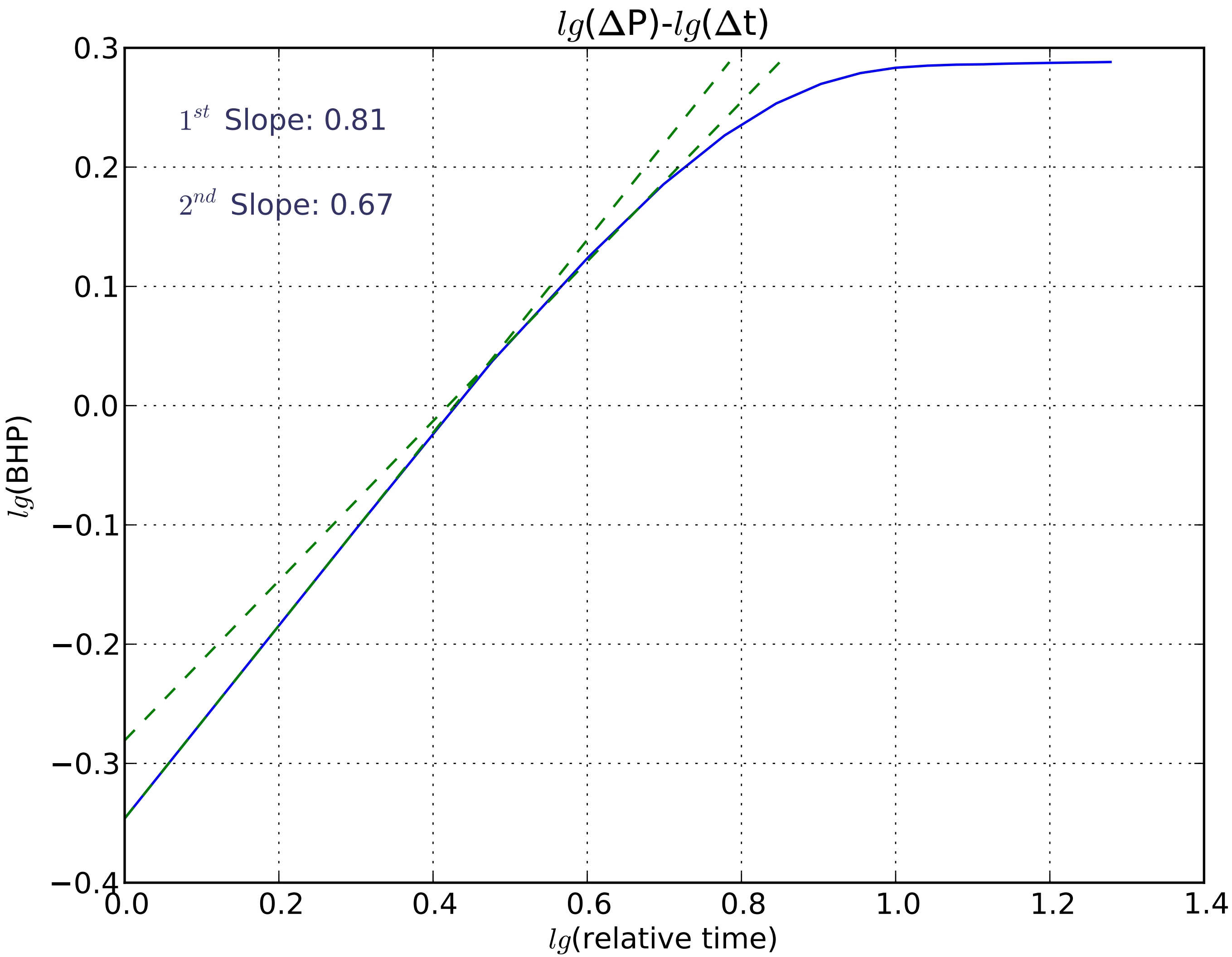
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 07

BitCan
Geosciences & Engineering Inc.



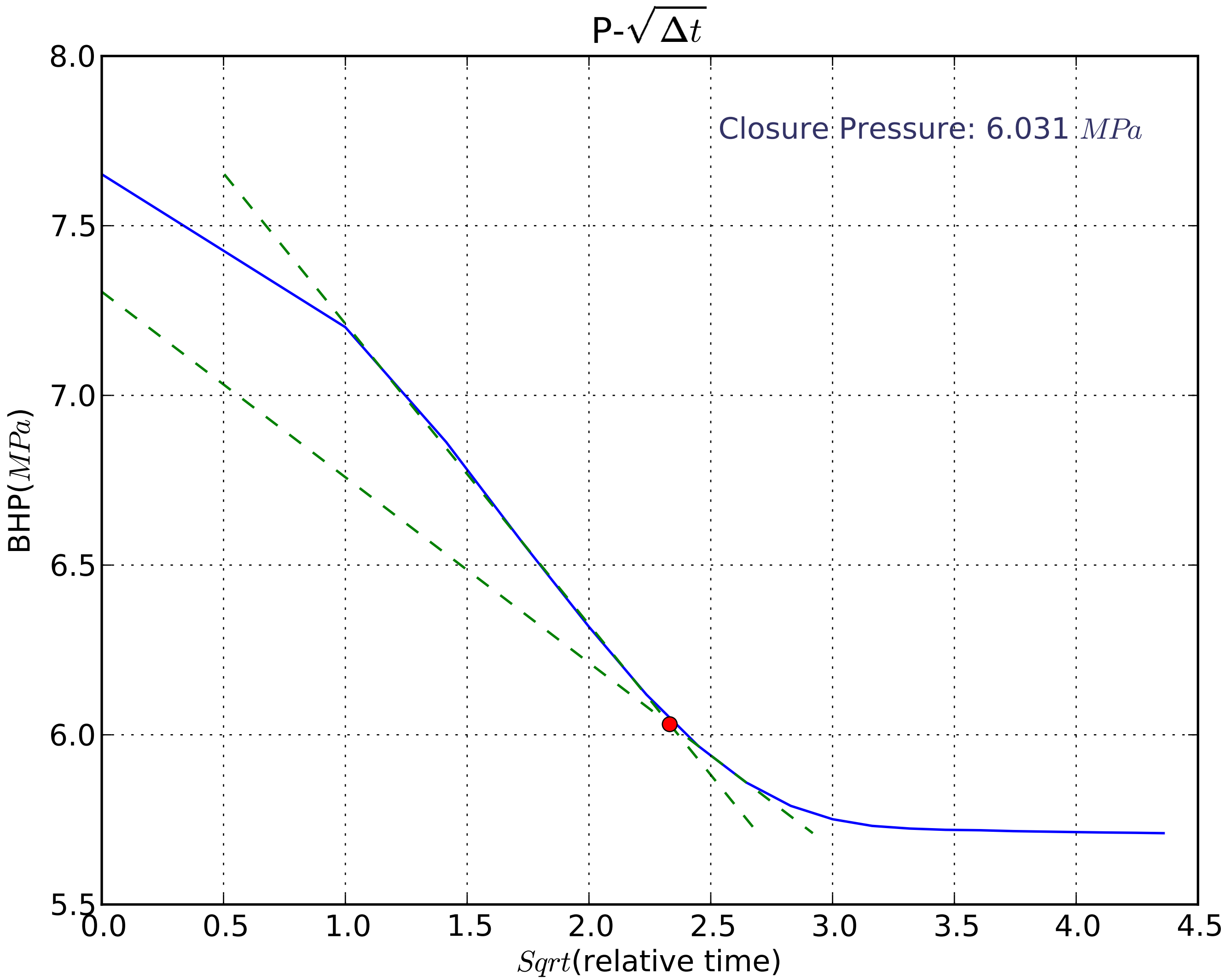
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 07

BitCan
Geosciences & Engineering Inc.



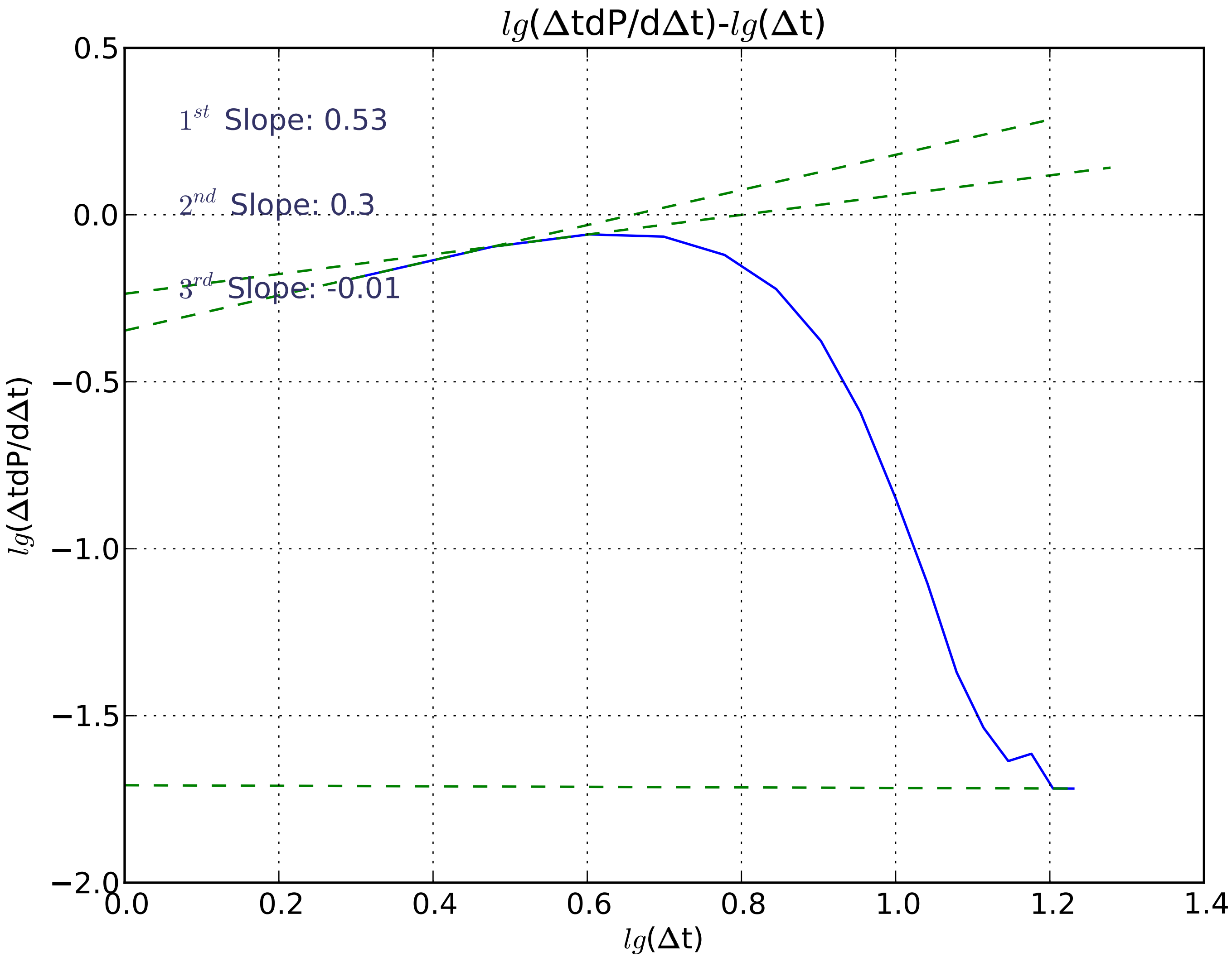
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 07

BitCan
Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 07

BitCan Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 08

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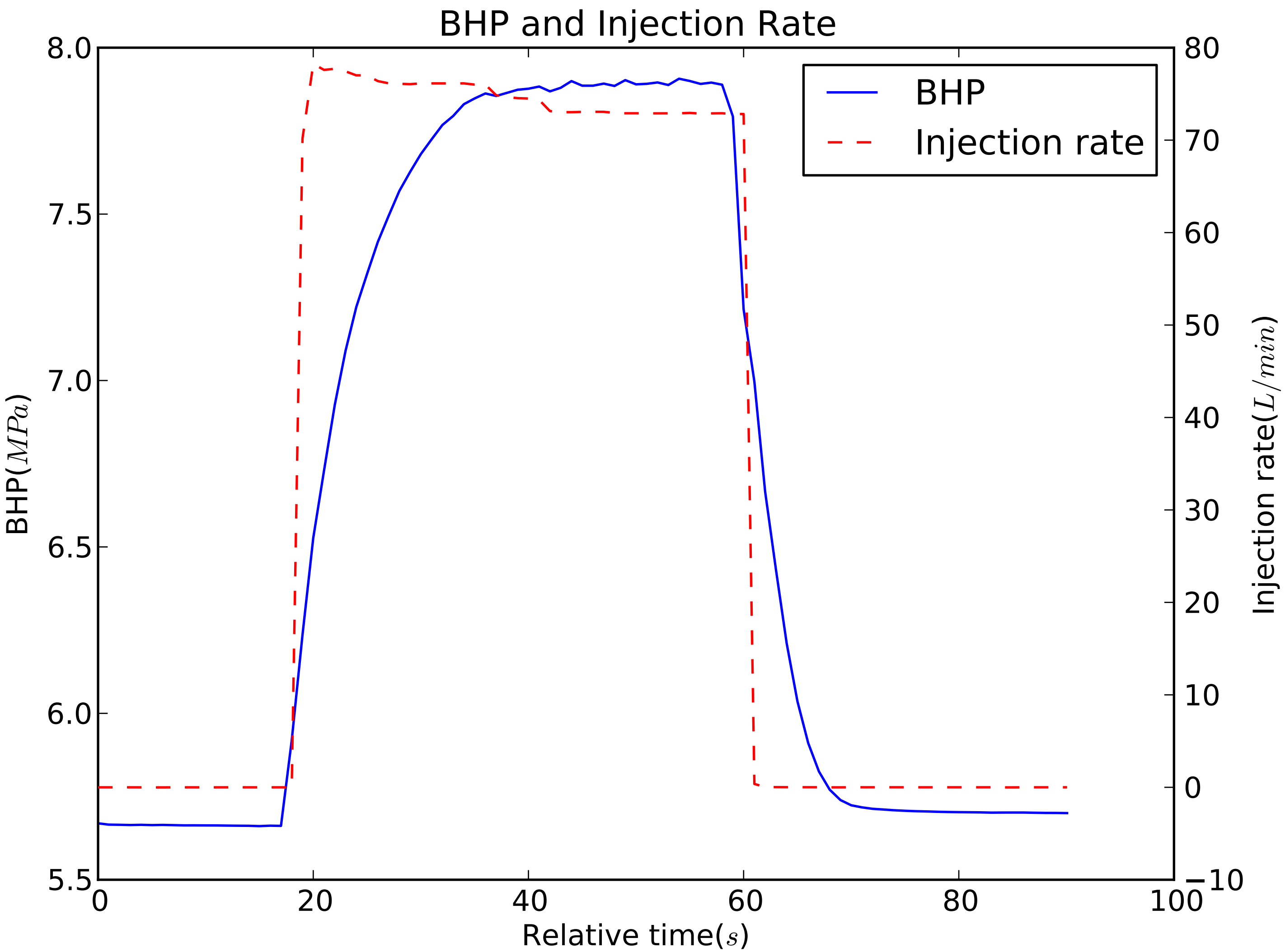
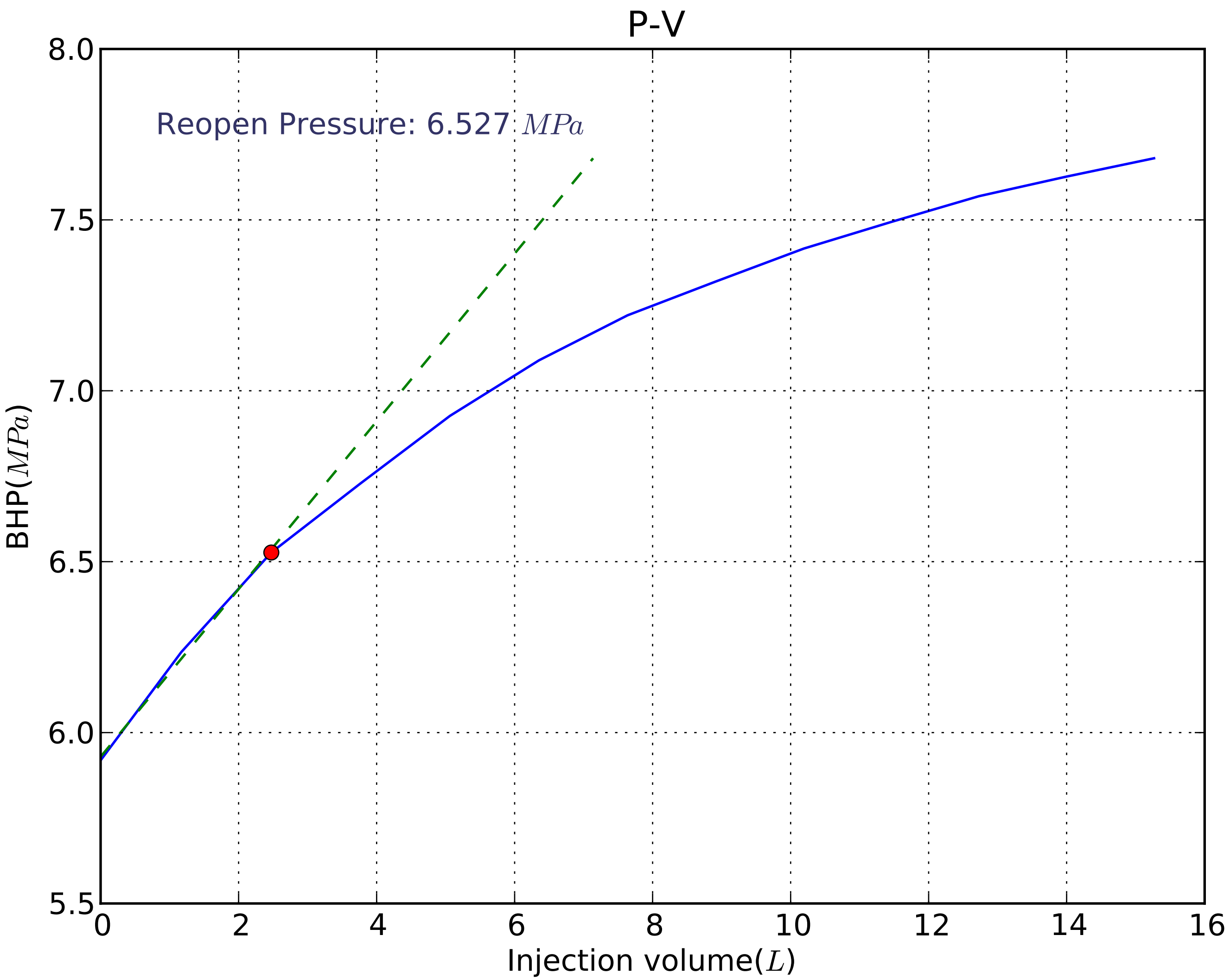
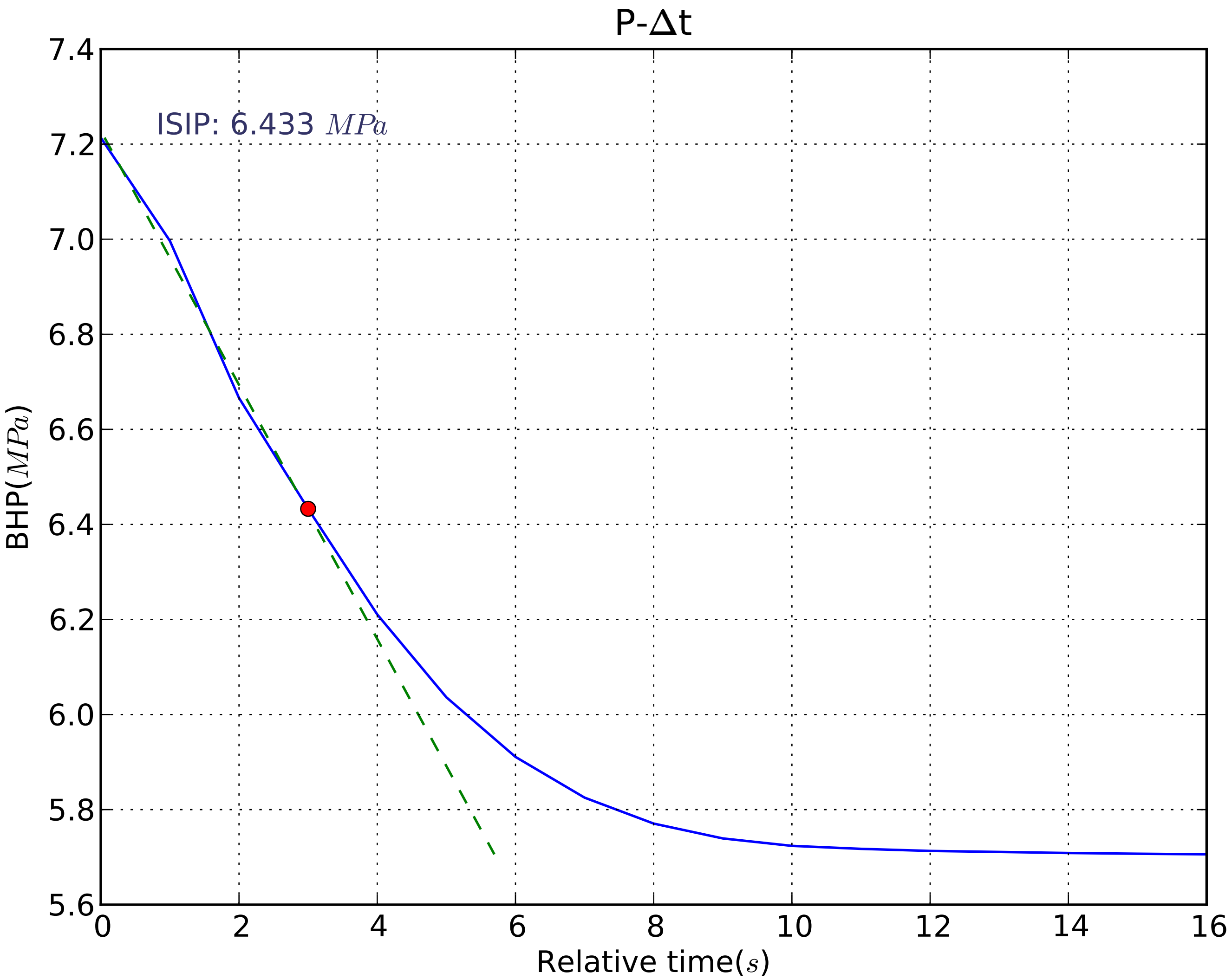


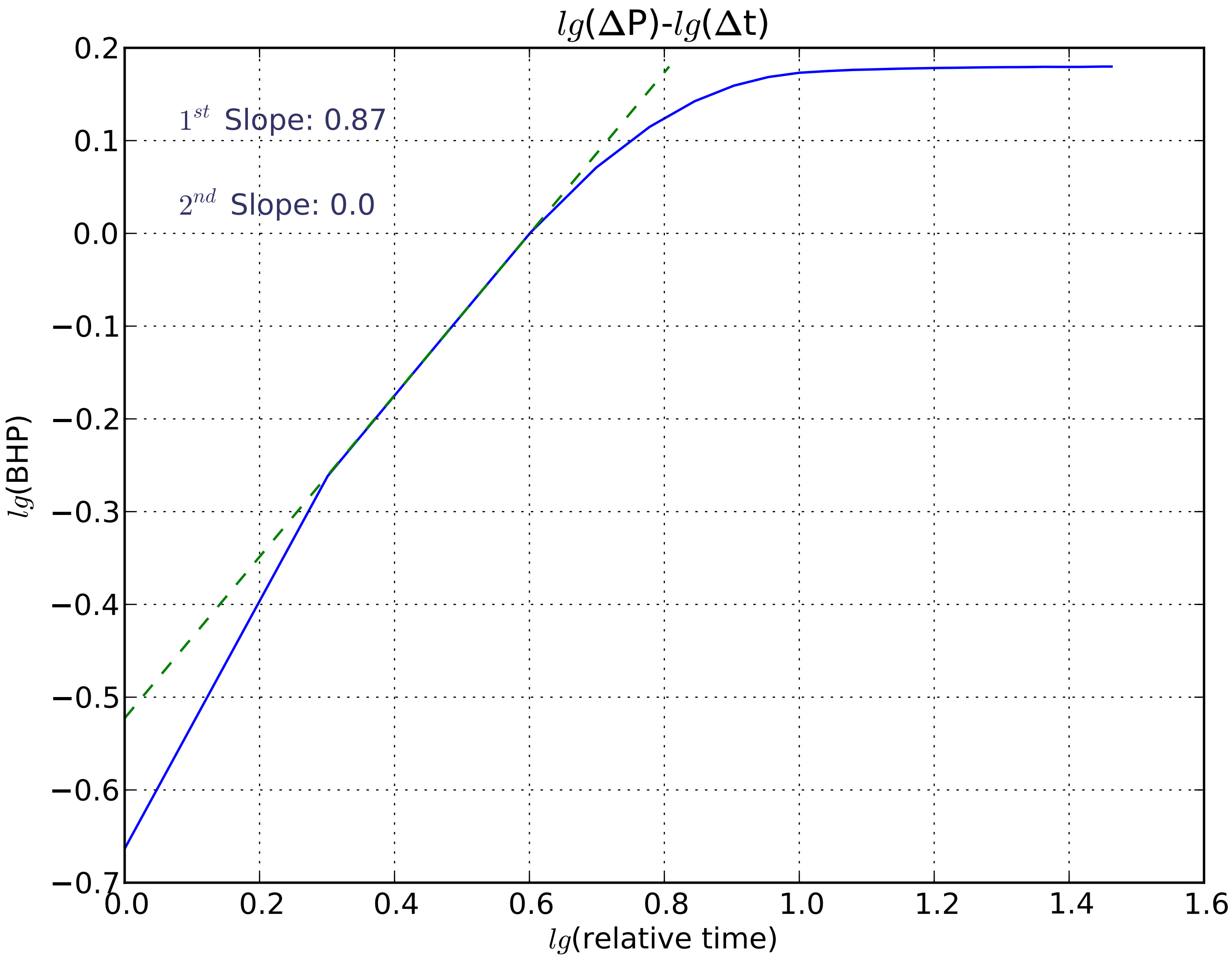
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 08




P-Δt
ISIP: 6.433 MPa
BHP(MPa)
Relative time(s)
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6
0
2
4
6
8
10
12
14
16

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 08

BitCan
Geosciences & Engineering Inc.



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 08

BitCan
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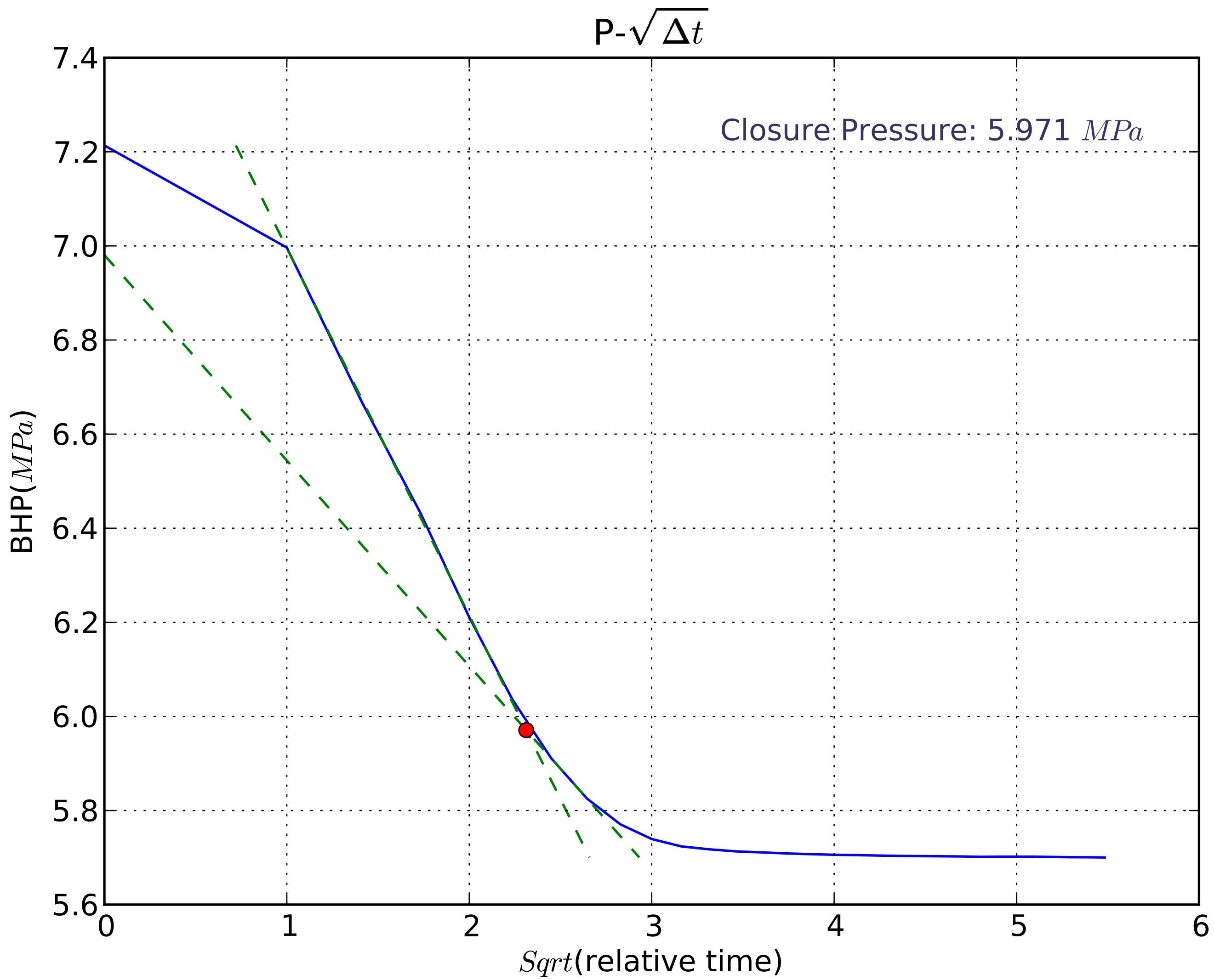
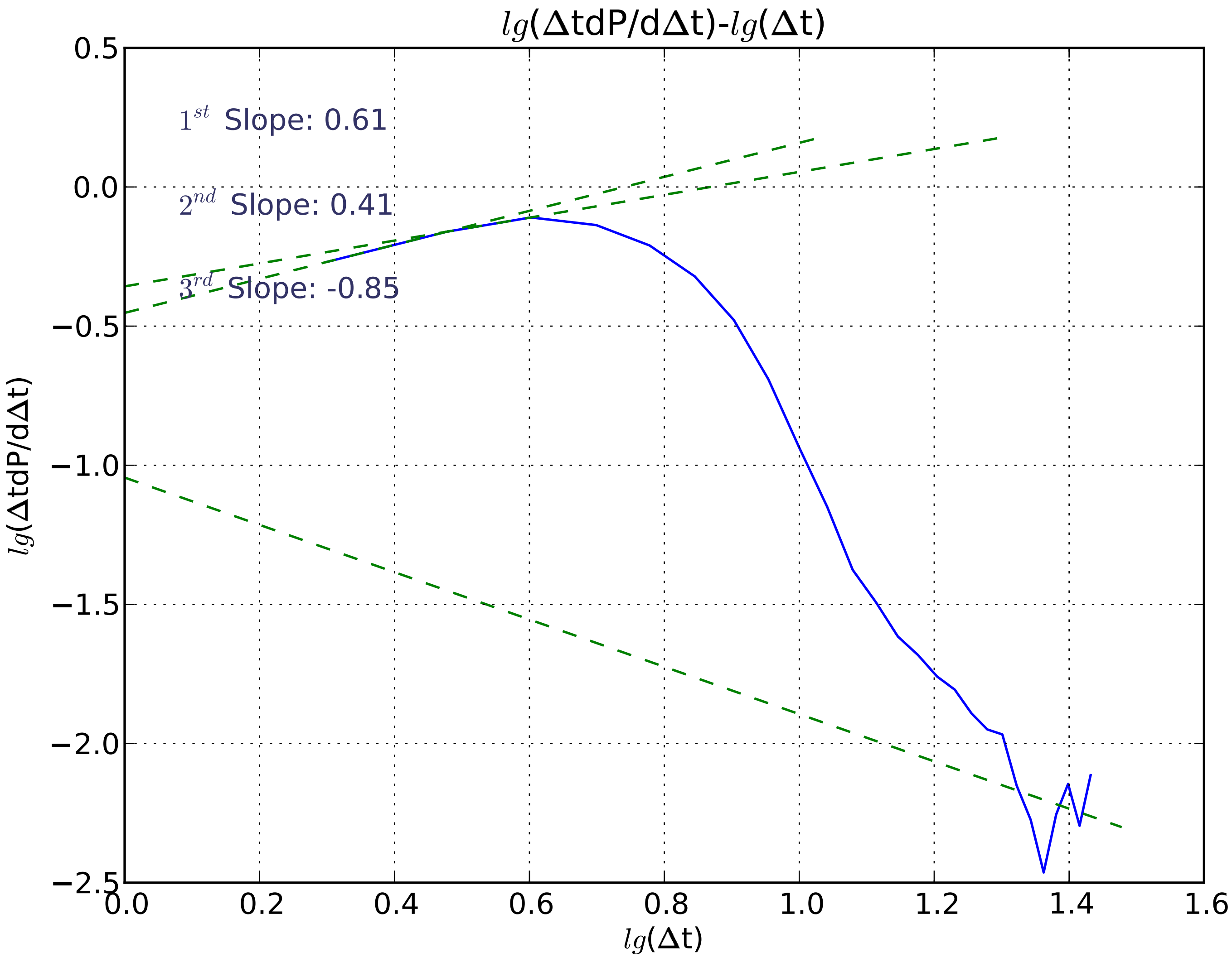
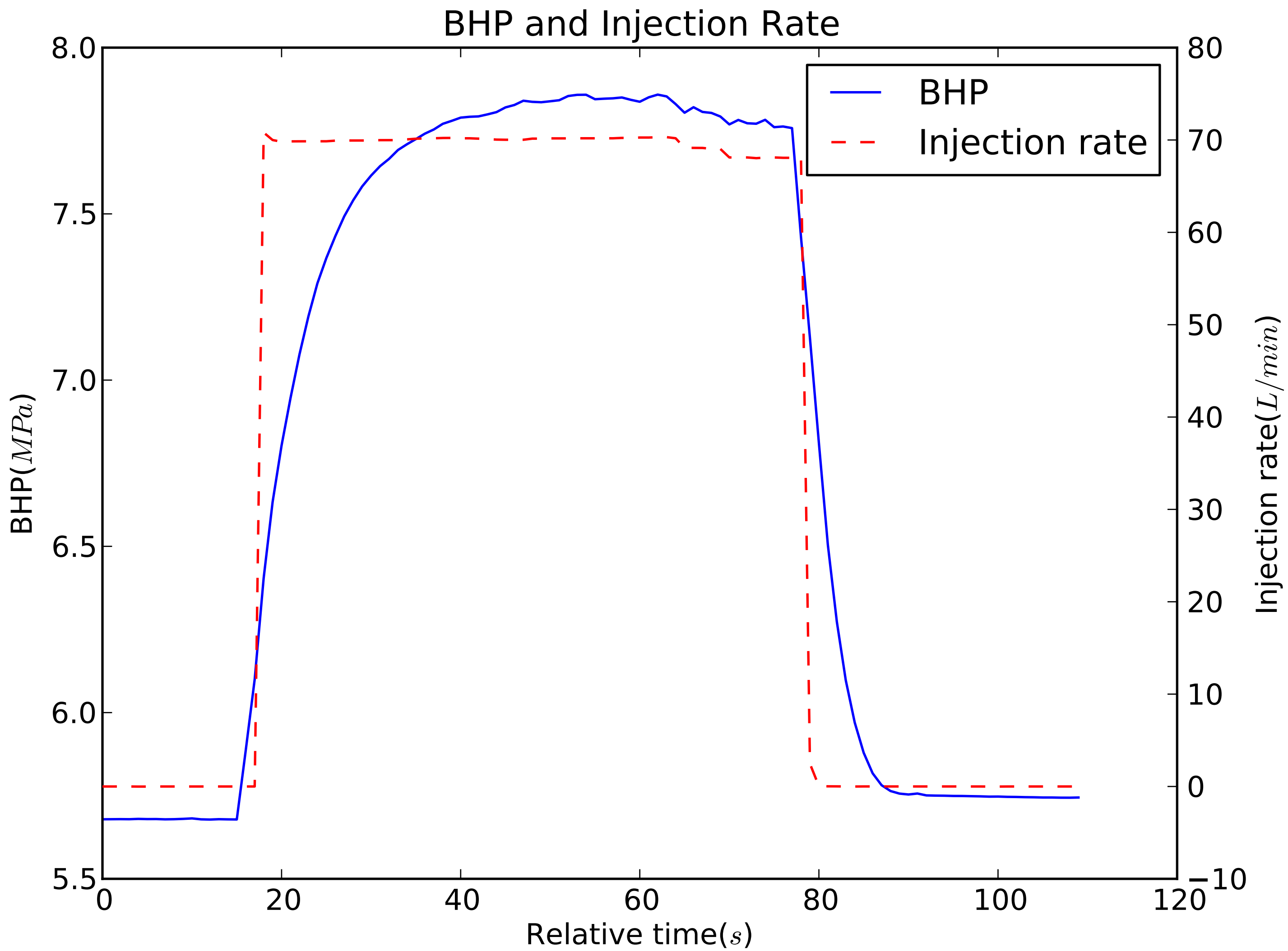
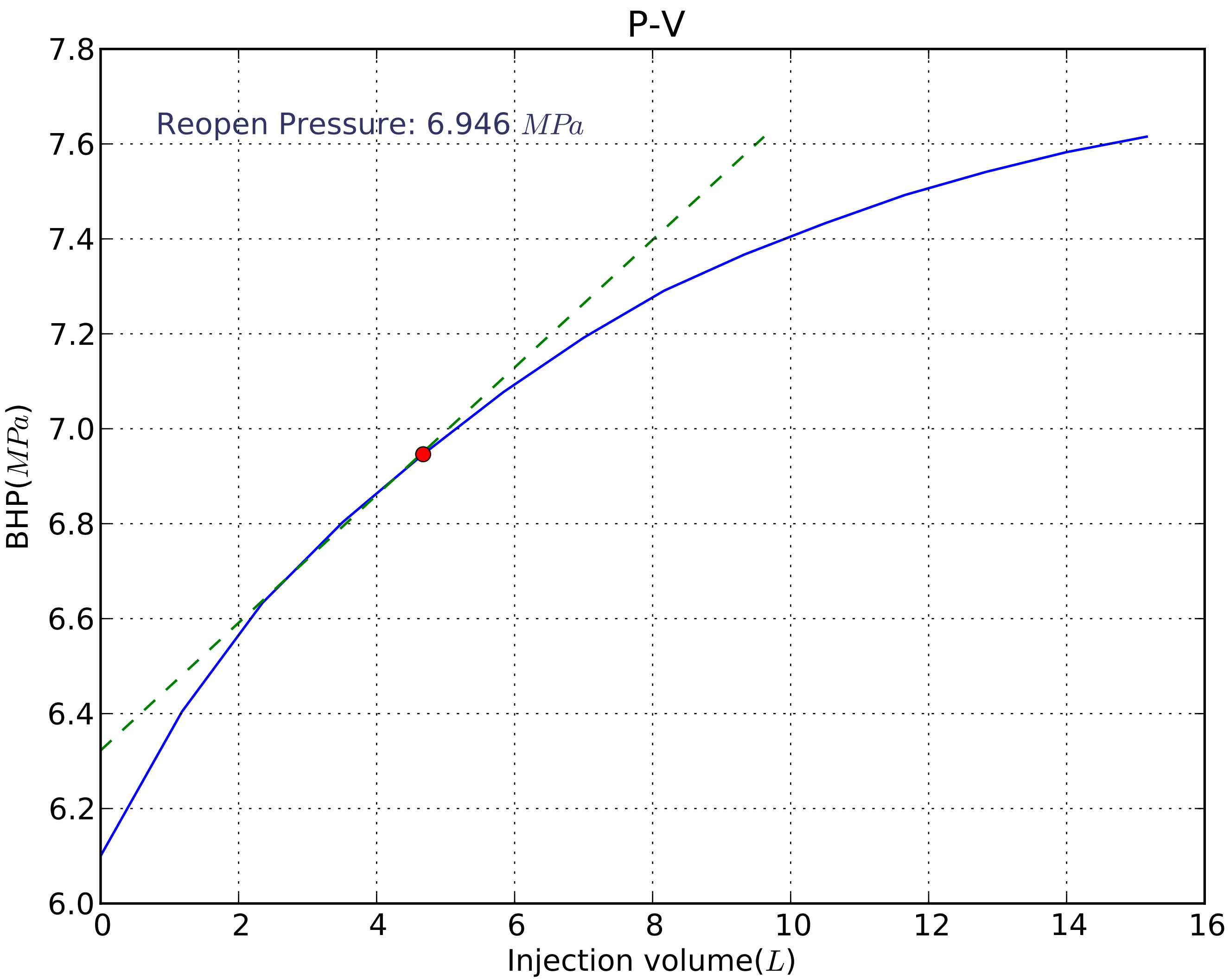


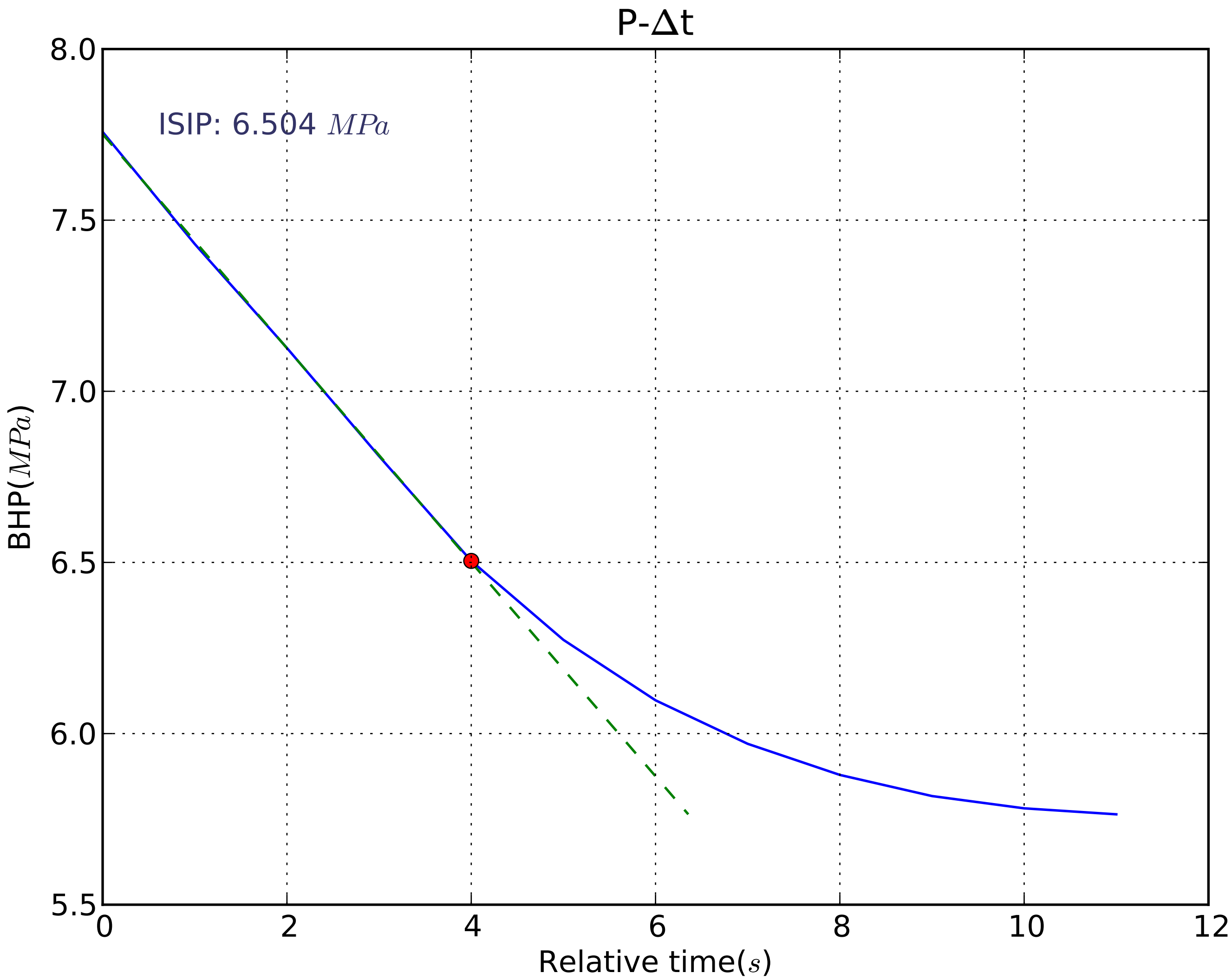
Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 08



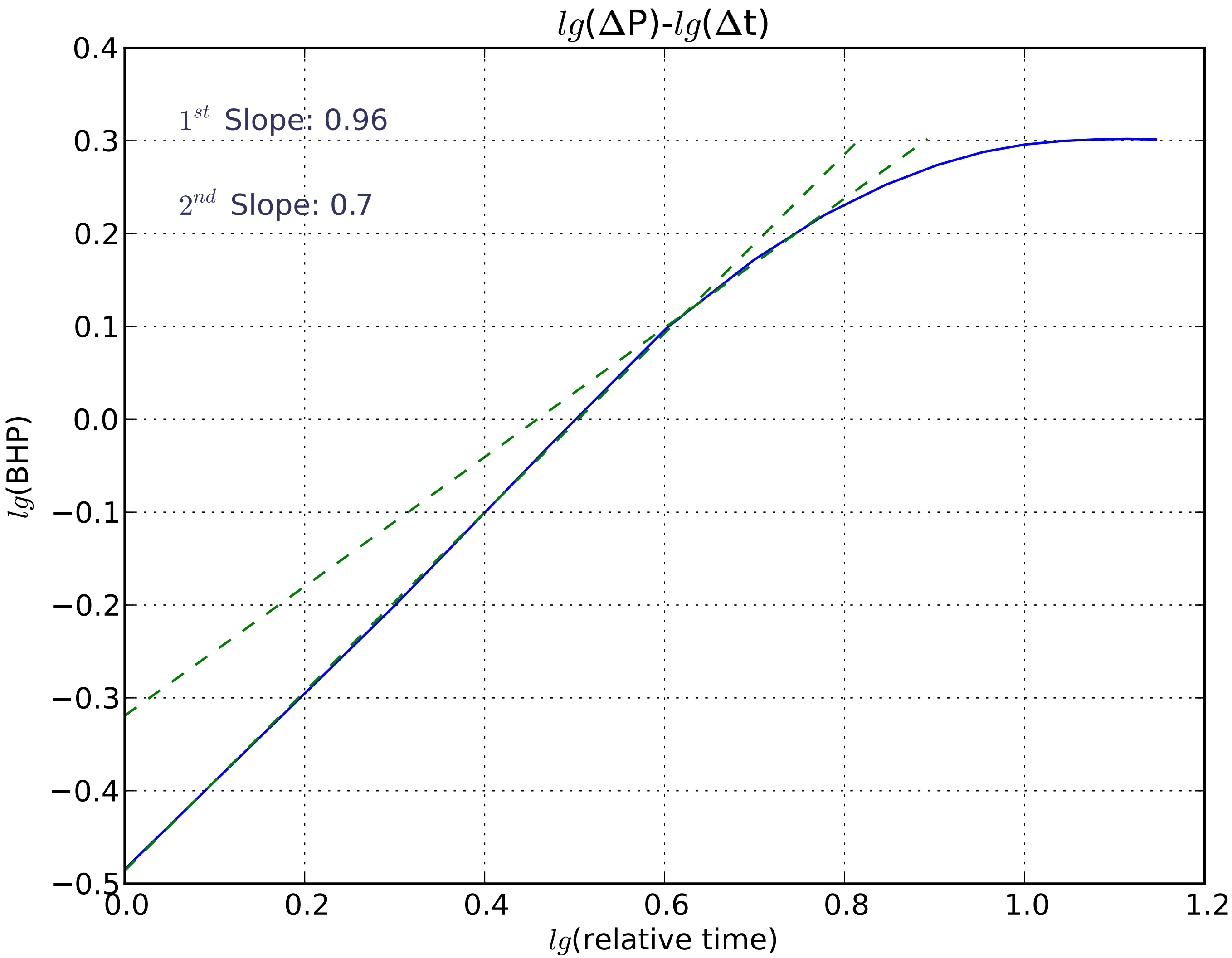

BHP and Injection Rate
BHP
Injection rate
BHP(MPa)
Injection rate(L/min)
Relative time(s)
8.0
7.5
7.0
6.5
6.0
5.5
0
20
40
60
80
100
120
80
70
60
50
40
30
20
10
0
−10

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 09




P-Δt
ISIP: 6.504 MPa
BHP(MPa)
8.0
7.5
7.0
6.5
6.0
5.5
0
2
4
6
8
10
12
Relative time(s)

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 09



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 09

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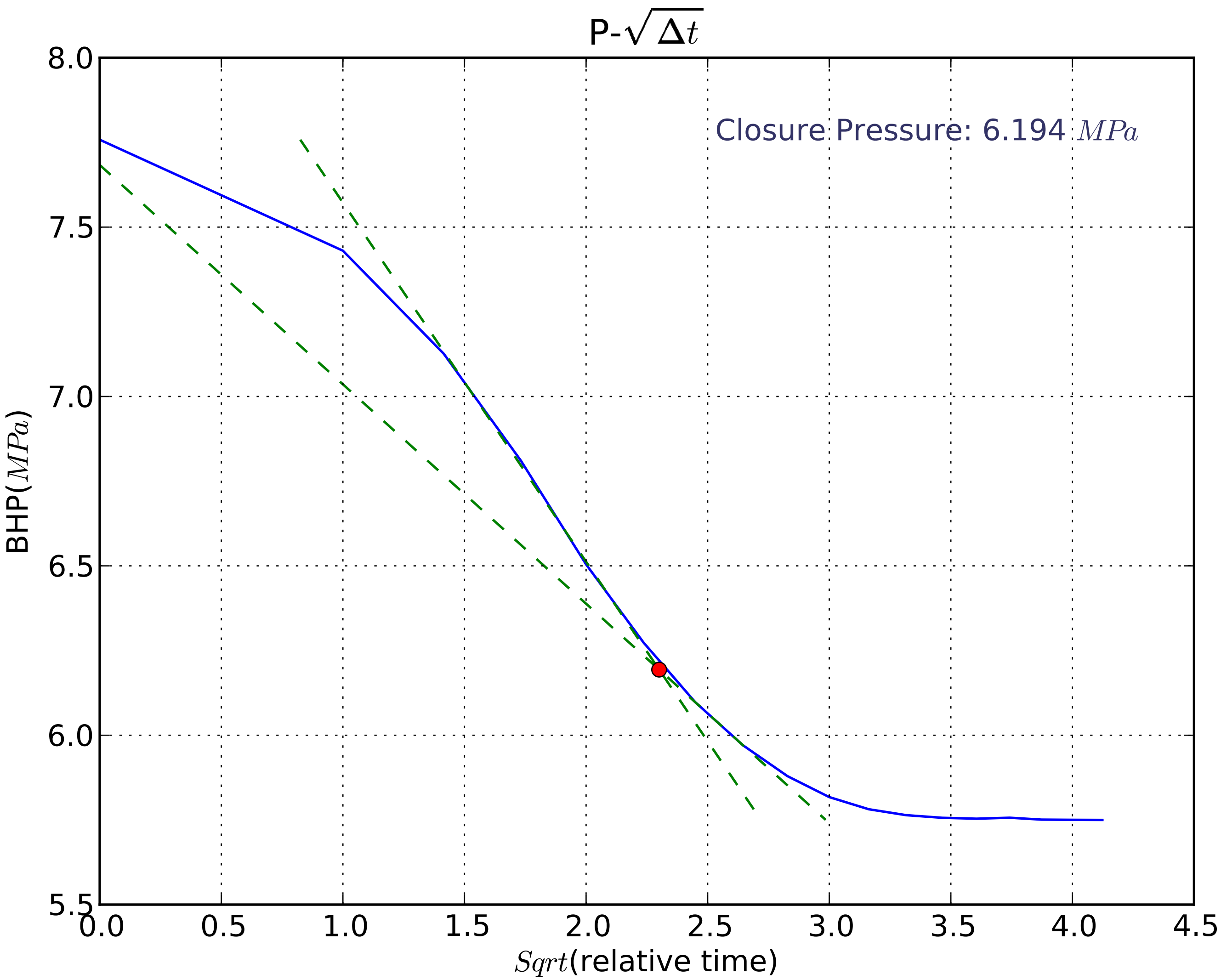
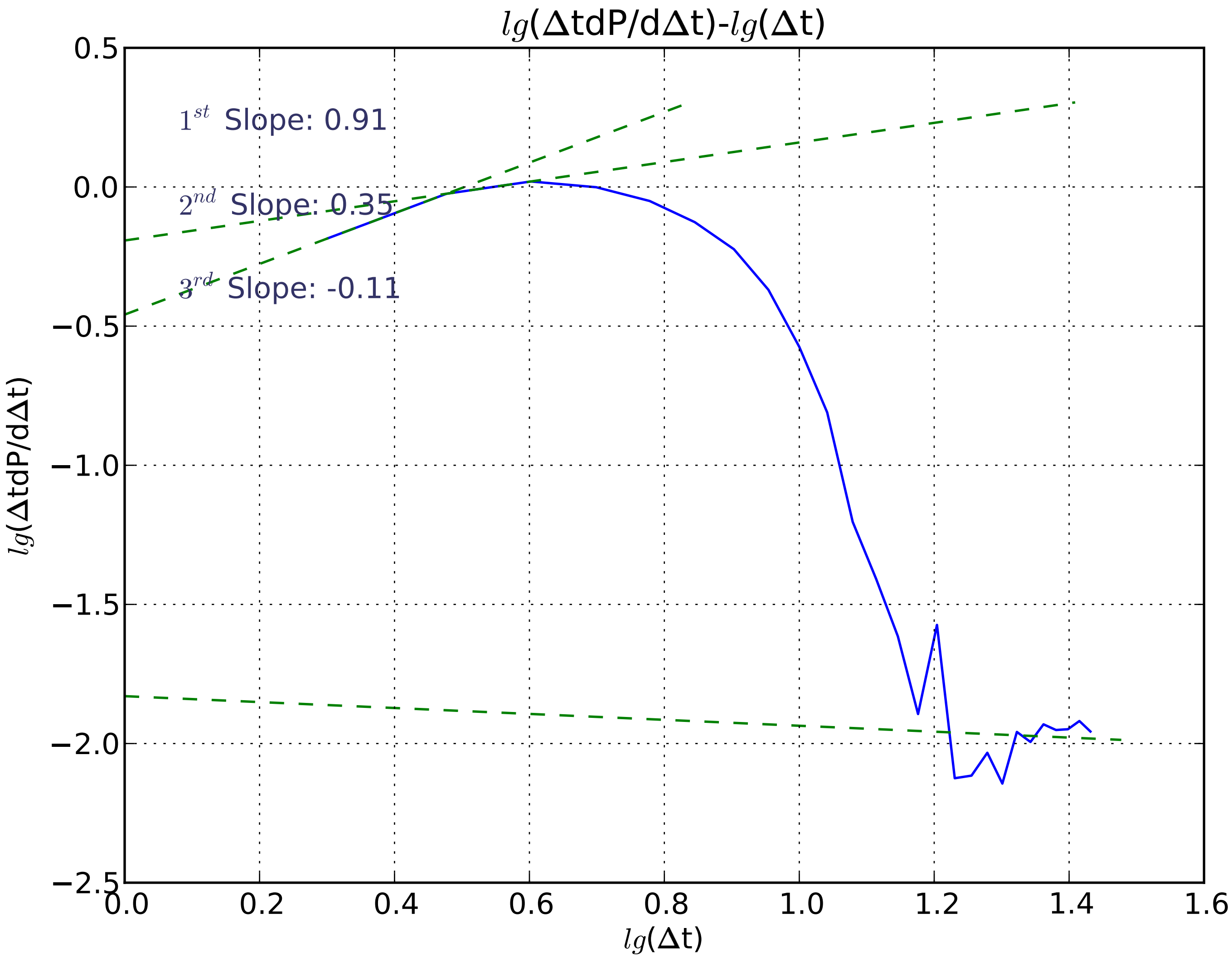


Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 09



Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 1 to 9

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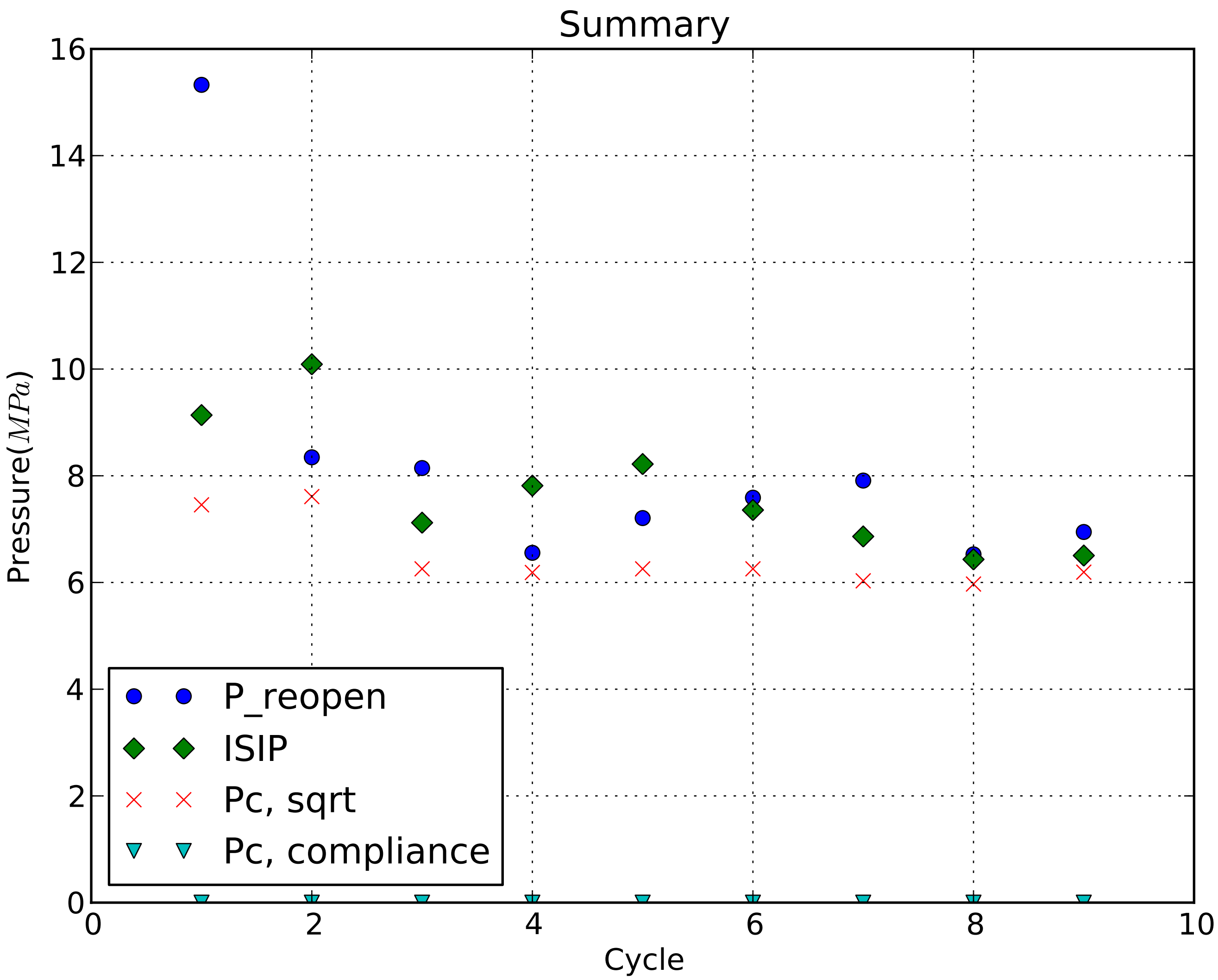

Well: Pengrowth 13-24-58-5W4
Depth: 530.0m
Formation: Lloydminster
Cycle: 1 to 9

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Characteristic Pressures and Compliances

Cycle #	P_reopen (MPa)	ISIP (MPa)	Pc, sqrt (MPa)	Pc, compliance (MPa)	Cb, inj (L/MPa)	Cf, back (L/MPa)	Cb, back (L/MPa)
1	15.327	9.136	7.456	0.000	2.66	0.00	0.00
2	8.346	10.090	7.610	0.000	3.47	0.00	0.00
3	8.145	7.120	6.256	0.000	2.96	0.00	0.00
4	6.556	7.814	6.187	0.000	3.53	0.00	0.00
5	7.207	8.219	6.255	0.000	3.99	0.00	0.00
6	7.589	7.358	6.256	0.000	4.78	0.00	0.00
7	7.910	6.862	6.031	0.000	6.74	0.00	0.00
8	6.527	6.433	5.971	0.000	4.08	0.00	0.00
9	6.946	6.504	6.194	0.000	7.44	0.00	0.00