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BARR

March 31, 2021

Mr. Race Rolland
Xcel Energy
414 Nicollet MP 700
Minneapolis, MN 55401

Re: Cyclic Degradation Geotechnical Evaluation [DRAFT]
Nobles Wind Repower Project - Nobles County, Minnesota

Dear Mr. Rolland:

Barr Engineering Co. (Barr), under authorization and contract with Xcel Energy (Xcel), has completed the cyclic degradation geotechnical evaluation at the Nobles Wind Repower Project located in Nobles County, Minnesota. This evaluation included assessment of soil behavior subjected to cyclic loading at three proposed repower wind turbine locations. In this report, including all attachments, the proposed repower wind turbine locations are referenced using the May 1, 2020, layout provided by Xcel[1] and summarized in Table 1.

This letter report serves to evaluate the geotechnical conditions observed at select proposed wind turbine locations with respect to potential cyclic degradation. The original geotechnical site investigation is discussed in the Geotechnical Engineering Report Nobles Wind Project, dated September 2009[2].

Field Work

A total of three soil borings with sampling were completed during this geotechnical investigation. The field work was performed in December 2020. Soil borings were offset approximately 60 feet from the center of the existing wind turbines. Figure 1 indicates the locations where the soil borings were performed. Under subcontract to Barr, Interstate Drilling Services LLP of Grand Forks, North Dakota, performed the soil borings using hollow-stem auger drilling techniques. The soil borings at the select wind turbine locations were completed to depths of approximately 14 feet. Soil sampling and classification was performed at 2.5-foot intervals to 7.5 feet then continuously to the termination depth of the borings. All split-spoon sampling and standard penetration testing was performed in accordance with ASTM D1586. Three-inch-diameter Shelby tube samples were collected at selected depths in accordance with ASTM D1587. Groundwater levels were observed during drilling or immediately after the completion of the soil borings (Table 2).

All samples were sealed in the field to preserve the in-situ moisture content. Samples were delivered to Soil Engineering Testing Inc. (SET) in Bloomington, Minnesota, for laboratory testing. Soil boring logs are included in Attachment A while laboratory test results are included in Attachment B.

[1] Sulzer, Roland. Communication to Eric Brandner. Electronic correspondence on May 1, 2020.
[2] Barr Engineering Co., Geotechnical Engineering Report, Nobles Wind Project, Nobles County, Minnesota, September 2009.

Standpipe piezometers were installed at each investigation site in an adjacent boring to the geotechnical sample soil boring. Piezometers were constructed having a bottom depth of approximately 12 feet below the existing ground surface. Two piezometer readings were collected one and two months after installation. Piezometer readings are provided in Table 2.

Laboratory Testing

The laboratory testing program for the project included index, strength, and cyclic testing. Testing was performed in February 2020. Testing completed focused on undisturbed thin-wall samples collected at a depth roughly corresponding to the base of the turbine foundation. The tests described in the following sections were conducted on the thin-wall tube soil samples used for cyclic testing.

Index Testing

Moisture Content

A total of three moisture content tests were conducted. The soils tested were classified as sandy lean clay (CL) and sandy lean clay with a trace of gravel (CL). The clays exhibited moisture contents ranging from 18 to 22 percent, with an average of approximately 20 percent, indicating the clayey soils were generally in a moist condition.

Moisture content test results generally concur with laboratory testing previously completed for the project[2] and are summarized in Table 3.

Unit Weight Testing

Three in-situ dry unit weight tests were performed. The results ranged from 104 to 110 pounds per cubic foot (pcf) with an average of 107 pcf. An average moist unit weight was calculated to be 129 pcf.

In-situ unit weight test results generally concur with laboratory testing previously completed for the project[2] and are summarized in Table 3.

Atterberg Limits

Three Atterberg limits tests were conducted. The results indicate liquid limits ranging from 31 to 34 percent and plastic limits ranging from 13 to 16 percent, with resulting plasticity indices varying between 18 and 22 percent.

Atterberg limits test results generally concur with laboratory testing previously completed for the project[2] and are summarized in Table 3.

Grain Size Distribution

Three grain size distribution tests, including mechanical sieve and hydrometer, were conducted. The results indicate:

- gravel contents ranging from 1 to 3 percent,
- sand contents ranging from 37 to 43 percent,
- silt contents ranging from 39 to 40 percent, and
- clay-size fractions ranging from 18 to 22 percent.

Grain size distribution test results generally concur with laboratory testing previously completed for the project[2] and are summarized in Table 3.

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Cyclic Testing

Cyclic testing was performed to simulate the loading induced on the subgrade soils under the portion of the foundation experience gapping conditions (foundation heel, or upwind side of the foundation).

Equivalent Loading Conditions

The cyclic loading for the geotechnical samples considered 11 years of cycles/time for the GE 1.5sle turbine in addition to 20 years of cycles/time for the repowered GE 1.6-97 turbine. The equivalent load cycle method was utilized to reduce the total fatigue loading with varying mean loads into a single dataset of 250 cycles with a single mean load, based on an S-N material slope of 15. This equivalent loading was relevant to the bottom of the tower and the top of the foundation. It was then further translated into applied bearing stresses on the bottom of the foundation via Barr's foundation calculation software.

Principal Stress Determination

Principal stresses occurring in the foundation subgrade soils were calculated based on the equivalent load distribution using FLAC (Fast Lagrangian Analysis of Continua) software. FLAC allows for the computation of stresses induced in the soils under the foundation as a result of changing structural loads at the surface. These structural loads were simulated as trapezoidal and/or triangular stresses applied at the foundation embedment depth.

Using FLAC, the cyclic behavior of the major and minor principal stresses and corresponding shear stress were determined. Based on FLAC modeling, significant cyclic variations were found in the major and minor principal stresses relative to a rather small corresponding variation in shear stress. Variations in stresses are provided in Table 4.

Testing Method

Due to the very small variation in shear stress and the large variation in normal stress (as demonstrated in FLAC), cyclic direct simple shear (CDSS) testing (ASTM D8296) was not possible. Additionally, the ASTM standard for cyclic triaxial testing (ASTM D3999) was not considered because confining chamber pressure is held constant through the testing process according to the ASTM. The actual field conditions anticipated for the proposed wind turbine would create a significant variation in both the major and minor principal stress in the soil subgrade near the turbine foundation. Using a triaxial stress path approach was considered the most appropriate method to analysis the actual anticipated field conditions.

Cyclic testing was completed using stress path sequencing in a triaxial chamber, in which the major and minor principal stresses underwent 250 full cycles. The major and minor principal stresses were computed from the FLAC model described above.

The test procedure included back-pressure saturating and consolidating the specimens to the average of the major and minor principal stress. The cyclic portion of the testing was completed in an undrained manner, in which major and minor principal stresses were controlled and axial strain was measured. Following the stress application of each half cycle, the specimen was allowed to rest for approximately 54 seconds during which excess pore-water pressure dissipation was monitored.

Results

Results of cyclic testing indicate the applied cyclic loading increased pore-water pressure and accumulated axial strain during testing. The undrained Young's modulus was found to increase for B12 and B129 during testing, while at B96 a constant undrained Young's modulus was observed.

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Strength Testing

Consolidated-Undrained (CU) Triaxial Testing

The undrained shear strength of the soil was measured using consolidated-undrained (CU) triaxial tests on thin-wall samples collected at each of the three turbine locations. This testing was completed on control specimens (called "control") not subjected to cyclic loading, as well as specimens having undergone cyclic loading (called "cycled"). The control and cycled specimens were trimmed side by side from the same thin-wall sample to minimize differences in material properties.

The CU triaxial test results for control specimens indicate deviator stresses at failure ranging from 1.40 to 2.27 tons per square foot (tsf) with an average of 1.71 tsf considering the maximum deviator stress failure criteria. Cycled deviator stresses at failure ranged from 1.62 to 1.87 tsf with an average of 1.76 tsf. At B12 and B129, measured undrained shear strengths were observed to increase following cyclic loading. At B96, deviator stresses decreased from the control to the cycled specimen from 2.27 to 1.87 tsf. The minimum undrained shear strength for the control and cycled specimens were 1,400 and 1,620 psf, respectively. Laboratory strength test results are provided in Attachment B and are summarized in Table 3.

The test results generally concur with laboratory testing previously completed for non-cycled specimens for the project[2].

Evaluation of Results

The results of the geotechnical field and laboratory investigation indicate the soil conditions are consistent with the typical conditions found across the site as discussed in the original Nobles Wind Project Geotechnical Engineering Report[2]. Sandy lean clay was identified as the foundation subgrade soil at the three investigated sites. Groundwater identified in the piezometers at the site ranged from a depth of 7 to 11 feet below the ground surface. Laboratory index testing revealed material consistent with glacial till found across the site[2].

As stated previously, undrained shear strength testing was performed on a control and a cycled soil specimen from each location. Strength increases from the control to the cycled specimens were identified at B12 and B129 while a decrease in strength was observed at B96. All strength testing results, including those after cycling, indicate undrained shear strengths greater than the minimum value of 1,300 psf required in the design.

Analysis of the cyclic testing data indicates an increase in excess pore-water pressure and axial strain for all specimens during testing. Undrained Young's modulus values were approximated for each specimen. An increase in Young's modulus, or strain hardening, was identified at B12 and B129, while a constant undrained Young's Modulus was observed at B96.

For a number of loading cycles calculated to be equivalent to 31 years of turbine operation (11 years baseline turbine plus 20 years of repower turbine), the soil samples were found to not be susceptible to degradation, based on the following criteria:

- Settlement: Differential settlement induced by cyclic loading is anticipated to be minimal based on measured cumulative axial strain.
- Stiffness: Constant or increasing Young's modulus results indicated either neutral conditions or an improvement of the foundation subgrade soil stiffness.
- Strength: The undrained shear strength of soils for cycled specimen strength testing was found to exceed the design requirement.

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General

The analysis and conclusions provided are based on the results of fieldwork from recent investigations. Using engineering methods and practices applicable to realistic field conditions, the investigations performed have made every reasonable effort to characterize the site. However, the likelihood that conditions may vary from any specific location tested both in space and time is still possible, and careful attention should be undertaken to observe foundation and geotechnical condition in the near vicinity of the structure during the operational lifetime of the wind turbine by qualified personnel.

Closing

Thank you for the opportunity to provide this service. If you have any questions, feel free to contact Eric Brandner 952-832-2887.

Sincerely,

BARR ENGINEERING CO.

Attachments

Table 1 Summary of Supplemental Geotechnical Investigation
Table 2 Summary of Groundwater Measurements
Table 3 Summary of Laboratory Test Results
Table 4 Summary of Stresses under Foundation Heel
Figure 1 Soil Boring Locations
Attachment A Geotechnical Boring Logs
Attachment B Laboratory Test Results

DRAFT

Certification

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly licensed Professional Engineer under the laws of the Minnesota.

DRAFT

Eric J Brandner P.E.

PE #:

Date

DRAFT

Table 1
Summary of Supplemental Geotechnical Investigation

Structure Type	Structure ID*	Geographic NAD83		Soil Boring	Piezometer
		Latitude	Longitude		
Turbine	B12	43.715479	-95.861945	X	X
Turbine	B96	43.673433	-95.737727	X	X
Turbine	B129	43.705276	-95.754668	X	X

*All wind turbine locations are referenced based on information provided to Barr on May 1, 2020

Table 2
Summary of Groundwater Measurements

Structure / Location Type	Soil Boring ID	Depth to Groundwater [ft]*			
		During Drilling*	After Drilling*	Piezometer	
				1/4/2021	1/27/2021
Turbine	B12	NE	NE	7.1	7.3
Turbine	B96	NE	NE	11.3	11.1
Turbine	B129	NE	NE	9.1	9.6

NE = Readings in which water was not encountered.

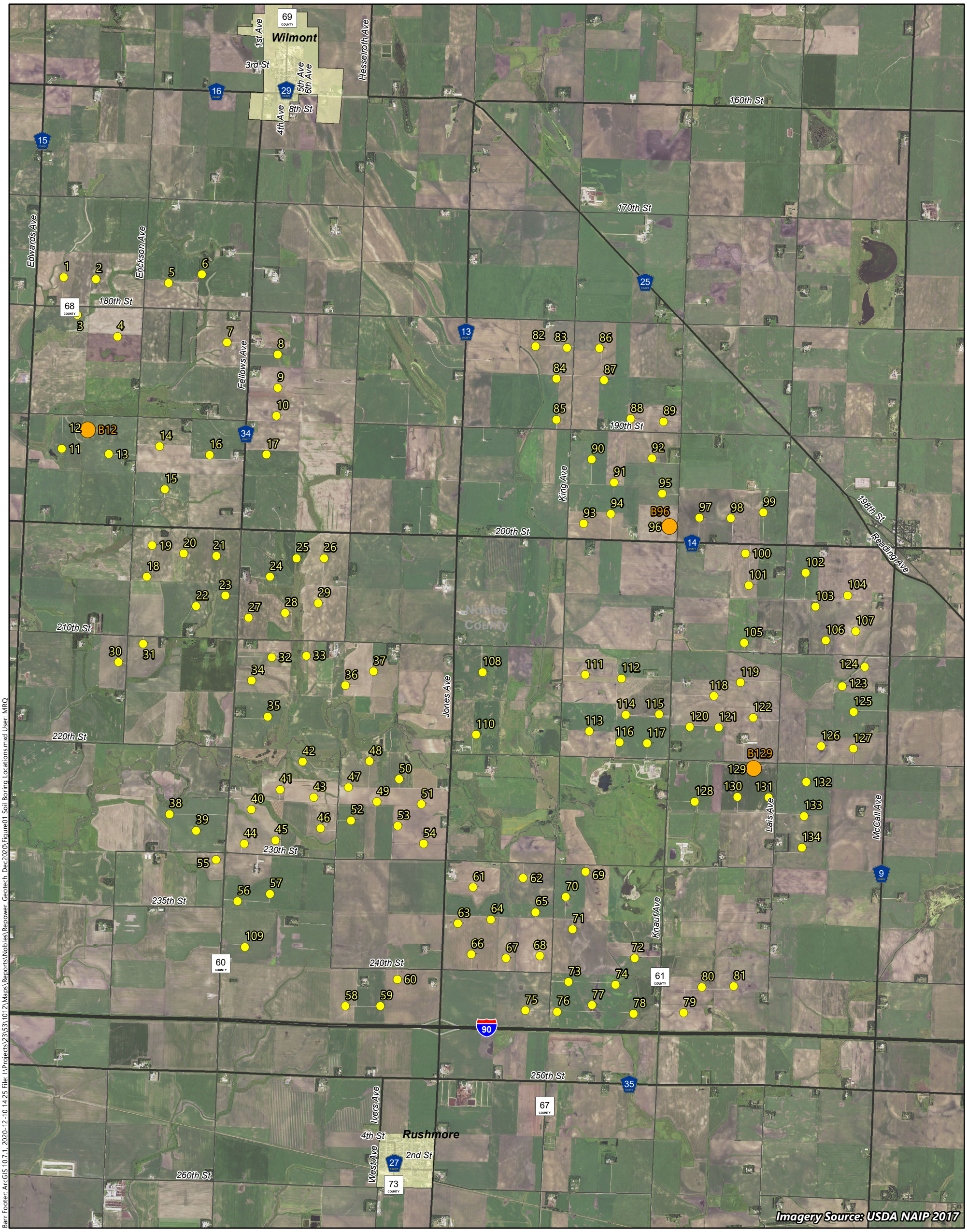
*Due to the presence of clay, groundwater observations in the soil boreholes may not provide a reliable estimate of the groundwater table.

Table 3
Summary of General Laboratory Test Results

Geotechnical ID	Depth [ft]	USCS Classification	Moisture Content [%]	Dry Unit Weight [pcf]	Liquid Limit [%]	Plastic Limit [%]	Plasticity Index [%]	Percent Gravel [%]	Percent Sand [%]	Percent Silt [%]	Percent Clay [%]	Control CU Triaxial Deviator Stress at Failure [tsf]	Cycled CU Triaxial Deviator Stress at Failure [tsf]
B12	10.5	CL	21.4	106.5	34	15	19	2.5	36.8	39.6	21.2	1.40	1.62
B96	8.5	CL	17.8	110.0	38	16	22	2.4	36.5	39.3	21.8	2.27	1.87
B129	8.5	CL	21.9	103.8	31	13	18	0.6	42.6	39.0	17.9	1.46	1.78
		Number	3	3	3	3	3	3	3	3	3	3	3
		Mean	20.4	106.8	34	15	20	2	39	39	20	1.71	1.76
		Standard Deviation	2.2	3.1	4	2	2	1	3	0	2	0.5	0.1
		Minimum	17.8	103.8	31	13	18	1	37	39	18	1.40	1.62
		Maximum	21.9	110.0	38	16	22	3	43	40	22	2.27	1.87

Table 4
Summary of Stresses under Foundation Heel

Stress	Load Concentration Location	
	Toe (Downwind)	Heel (Upwind)
Major Principal σ_1 (psf)	820	2,093
Minor Principal σ_3 (psf)	228	1,261
Shear Stress τ (psf)	296	309



Barr Footer: ArcGIS 10.7.1, 2020-12-10 14:25 File: I:\Projects\23\53\1012\Maps\Reports\Nobles\Repower_Geotech_Dec2020\Figure01 Soil Boring Locations.mxd User: MRQ

- Turbine Location
- Soil Boring Location
- Municipal Boundary

Feet
4,500 0 4,500

Meters
1,500 0 1,500

Figure 1

SOIL BORING LOCATIONS
Nobles Repower Wind Project
Xcel Energy
Nobles County, Minnesota

Attachment A

Geotechnical Boring Logs

DRAFT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

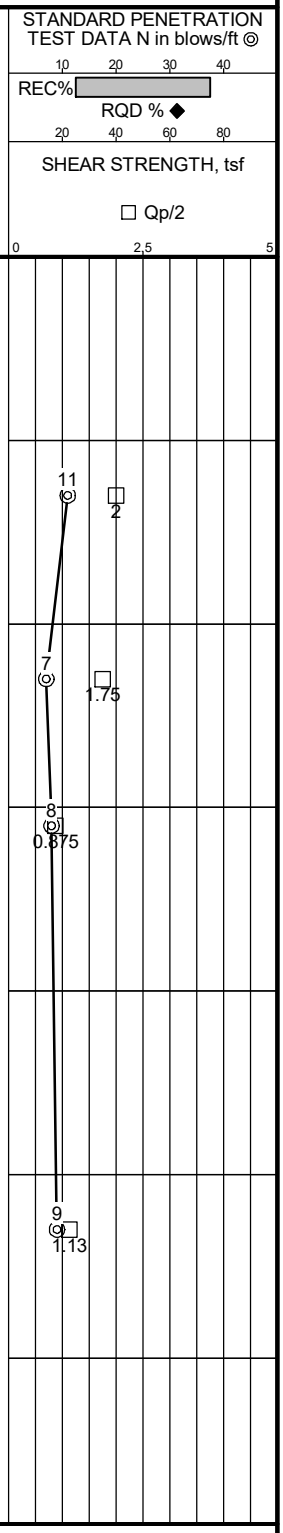
LOG OF BORING B12

Project:	Nobles Wind Repower Project	Surface Elevation:	Not Provided
Job No.:	23/53-1012	Drilling Method:	HSA
Location:	Nobles County, Minnesota	Sampling Method:	SS and TWT
Coordinates:	Lat: 43.71548° Long: -95.86195°	Completion Depth:	14.0 ft
Datum:	NAD83 Lat/Long		

Surface Elev.: Not Provided

Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
0.0	TOPSOIL (CL): dark brown; moist; trace organics (fine root hairs); trace sand; trace gravel.			
2.0	LEAN CLAY WITH SAND (CL): tan w/ orange/gray mottles; moist; trace gravel.	1	83	11
5.0		2	17	7
7.5	7': increased moisture content; pushed rock with spoon.	3	67	8
8.5	8.5': color change to brown.	TWT 1	100	
10.0		TWT 2	88	
12.5		4	100	9
14.0	Bottom of Boring at 14.0 feet			

STANDARD PENETRATION TEST DATA N in blows/ft ◎
REC% RQD % ◆
SHEAR STRENGTH, tsf □ Qp/2



Date Boring Started:	12/1/20 9:42 am	Water Levels (ft)	Remarks:
Date Boring Completed:	12/1/20 10:12 am	▽ After Drilling Dry	
Logged By:	JMP2	▼ At Time of Drilling Dry	
Drilling Contractor:	Interstate Drilling		
Drill Rig:	Diedrich D-50		Weather: 32F, clear

M:\GINT\PROJECTS\23531012 NOBLES REPOWER PROJECT.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING B129

Project:	Nobles Wind Repower Project	Surface Elevation:	Not Provided
Job No.:	23/53-1012	Drilling Method:	HSA
Location:	Nobles County, Minnesota	Sampling Method:	SS and TWT
Coordinates:	Lat: 43.67343° Long: -95.73772°	Completion Depth:	14.0 ft
Datum:	NAD83 Lat/Long		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Not Provided					
		TOPSOIL (CL): dark brown; moist; trace organics (fine root hairs).					
	2.5	LEAN CLAY (CL): fine grained; tan; moist; trace sand. 2.0ft			1	61	10
	5.0	5': moist; w/ sand; color change to tan/orange; trace gravel.			2	83	6
	7.5				3	67	8
					TWT 1	96	
	10.0				TWT 2	109	
	12.5	12.5': color change to dark green/brown.			4	100	7
		Bottom of Boring at 14.0 feet 14.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

Date Boring Started:	11/30/20 3:45 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/30/20 4:20 pm	▼ End of Drilling Dry	
Logged By:	JMP2	▼ At Time of Drilling Dry	
Drilling Contractor:	Interstate Drilling		
Drill Rig:	Diedrich D-50		Weather: 34F, clear

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Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING B96

Project:	Nobles Wind Repower Project	Surface Elevation:	Not Provided
Job No.:	23/53-1012	Drilling Method:	HSA
Location:	Nobles County, Minnesota	Sampling Method:	SS and TWT
Coordinates:	Lat: 43.70528° Long: -95.75467°	Completion Depth:	14.0 ft
Datum:	NAD83 Lat/Long		

Surface Elev.: Not Provided

Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
0.0	TOPSOIL (CL): dark brown; moist; trace organics (fine root hairs); trace sand; trace gravel.			
	SANDY LEAN CLAY (CL-SC): fine to coarse grained; tan; moist; iron staining; trace gravel. 1.8ft	1	67	9
2.5				
5.0	5': increased moisture content.	2	83	7
7.5	LEAN CLAY (CL): tan/brown; moist; trace gravel; trace sand; trace silt. 7.0ft	3	100	11
	7': pushed rock, ribbony sample.	TWT 1	96	
10.0		TWT 2	75	
12.5		4	100	12
	Bottom of Boring at 14.0 feet 14.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
☐ Qp/2
0 2.5 5

9 ◎ ☐ 2
7 ◎ ☐ 1.25
11 ◎ 1.13
12 ◎ ☐ 1.5

Date Boring Started:	12/1/20 12:05 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	12/1/20 12:35 pm	▽ After Drilling Dry	
Logged By:	JMP2	▼ At Time of Drilling Dry	
Drilling Contractor:	Interstate Drilling		
Drill Rig:	Diedrich D-50		Weather: 40F, clear

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Attachment B

Laboratory Test Results

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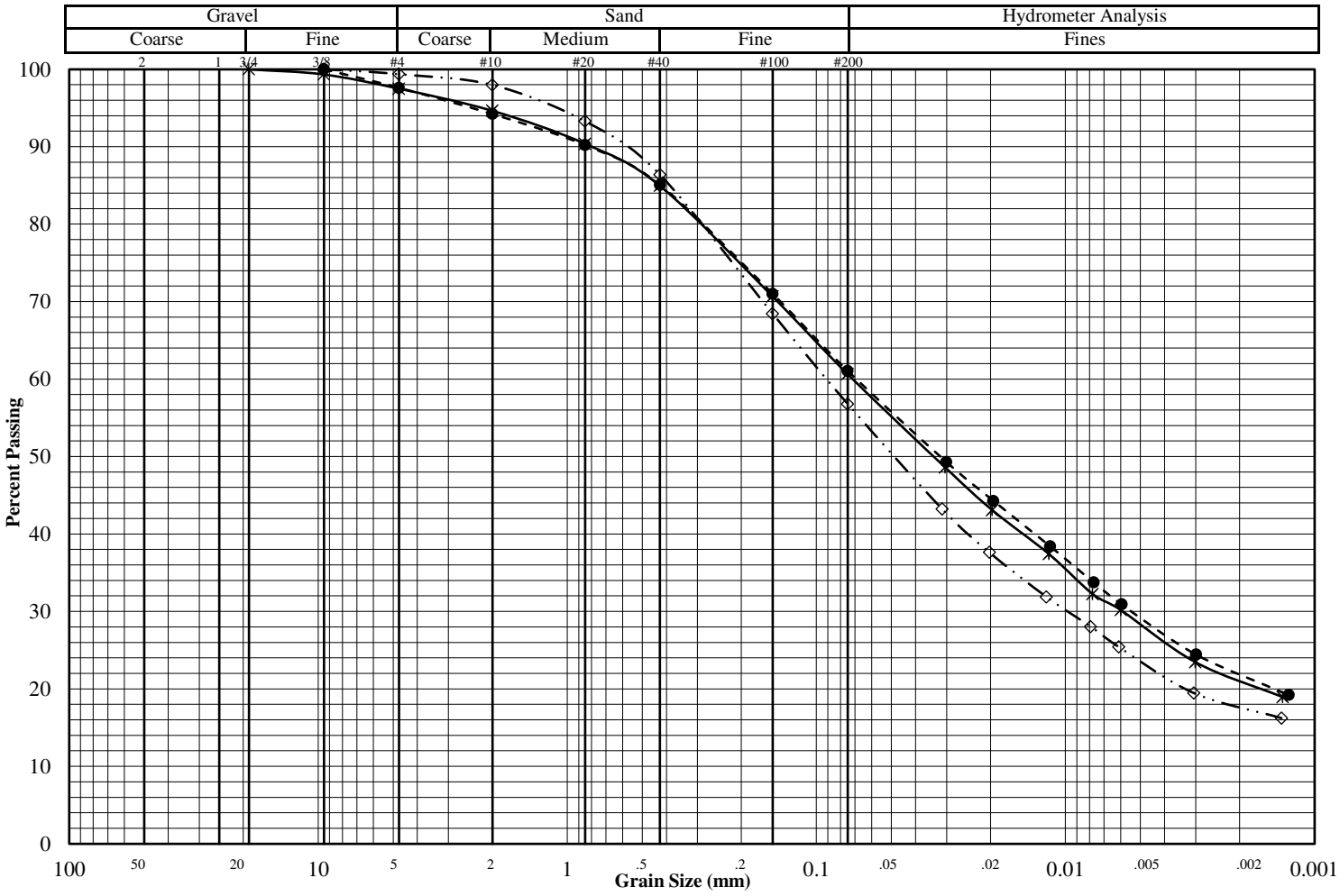
Grain Size Distribution ASTM D422-16

Job No. : **12987**

Project:	Nobles	Test Date:	2/19/21
Reported To:	Barr Engineering Company	Report Date:	2/23/21

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
*	B12	TWT2	10.5-12.5	TWT	Sandy Lean Clay w/a trace of gravel (CL)
●	B96	TWT3	8.5-10.5	TWT	Sandy Lean Clay w/a trace of gravel (CL)
◇	B129	TWT3	8.5-10.5	TWT	Sandy Lean Clay (CL)



Additional Results	*	●	◇
Liquid Limit	34	38	31
Plastic Limit	15	16	13
Plasticity Index ASTM:D4316	19	22	18
Water Content ASTM:D2216			
Dry Density (pcf) ASTM:D7263			
Specific Gravity ASTM:D854	2.69*	2.69*	2.69*
Porosity			
Organic Content ASTM:D2974			
pH ASTM:D4972 Method B			

(* = assumed)

Percent Passing

	*	●	◇
Mass (g)	239.5	220.8	276.3
2"			
1.5"			
1"			
3/4"	100.0		
3/8"	99.3	100.0	100.0
#4	97.5	97.6	99.4
#10	94.7	94.2	98.0
#20	90.4	90.2	93.3
#40	85.0	85.1	86.4
#100	70.7	71.0	68.4
#200	60.7	61.1	56.8

	*	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

Grain Size Distribution ASTM D422-16

Job No. : **12987**

Project:	Nobles	Test Date:	2/19/21
Reported To:	Barr Engineering Company	Report Date:	2/23/21

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
Spec 1	B12	TWT2	10.5-12.5	TWT	Sandy Lean Clay w/a trace of gravel (CL)
Spec 2	B96	TWT3	8.5-10.5	TWT	Sandy Lean Clay w/a trace of gravel (CL)
Spec 3	B129	TWT3	8.5-10.5	TWT	Sandy Lean Clay (CL)

Sieve Data

Specimen 1		Specimen 2		Specimen 3	
Sieve	% Passing	Sieve	% Passing	Sieve	% Passing
2"		2"		2"	
1.5"		1.5"		1.5"	
1"		1"		1"	
3/4"	100.0	3/4"		3/4"	
3/8"	99.3	3/8"	100.0	3/8"	100.0
#4	97.5	#4	97.6	#4	99.4
#10	94.7	#10	94.2	#10	98.0
#20	90.4	#20	90.2	#20	93.3
#40	85.0	#40	85.1	#40	86.4
#100	70.7	#100	71.0	#100	68.4
#200	60.7	#200	61.1	#200	56.8

Hydrometer Data

Specimen 1		Specimen 2		Specimen 3	
Diameter (mm)	% Passing	Diameter	% Passing	Diameter	% Passing
0.030	48.6	0.030	49.3	0.031	43.2
0.020	43.1	0.019	44.3	0.020	37.6
0.012	37.4	0.012	38.4	0.012	31.9
0.008	32.2	0.008	33.8	0.008	28.0
0.006	30.2	0.006	30.9	0.006	25.4
0.003	23.4	0.003	24.4	0.003	19.5
0.001	18.9	0.001	19.2	0.001	16.2

Remarks

Specimen 1	Specimen 2	Specimen 3

9530 James Ave South

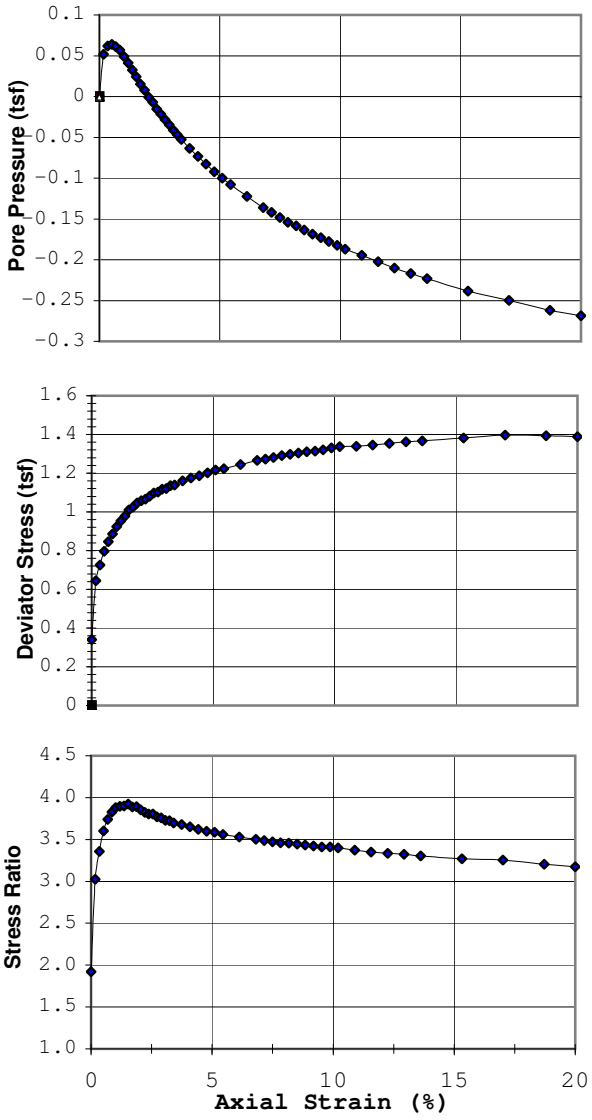
SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B12** Sample #: **Control** Type: **3T** Depth (ft): **10.5-12.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**

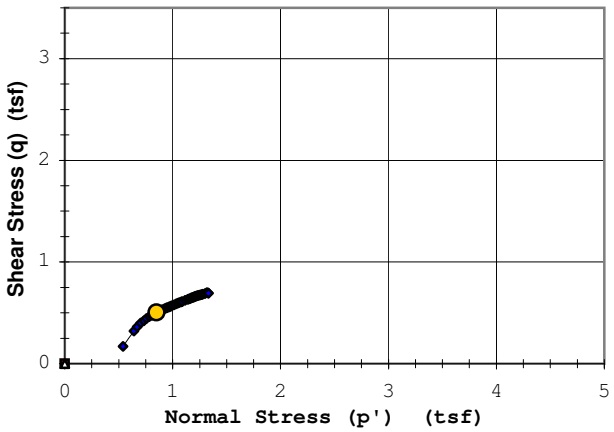


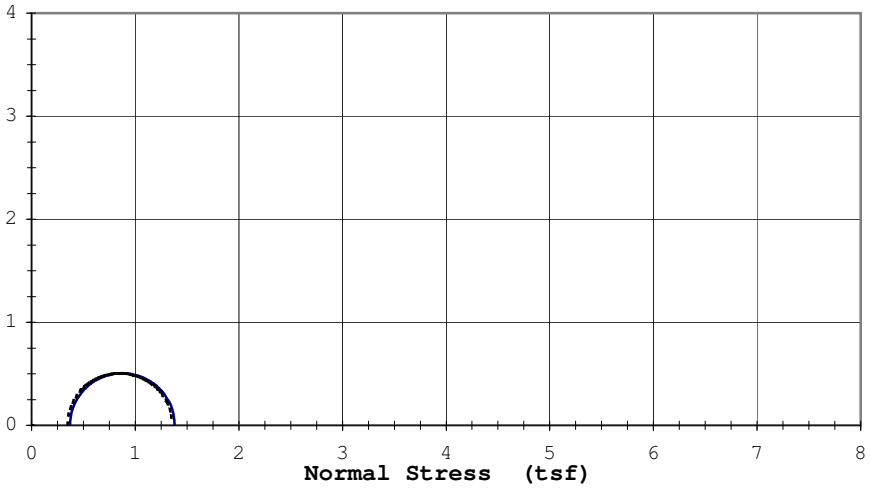
Failure Criterion:	**Max. Stress Ratio**
Angle of internal friction, **ϕ' =**	°
Apparent Cohesion, **c' =**	(tsf)
Test Date: 2/10/21	Liquid Limit: 34
Test Type: CU w/pp	Plastic Limit: 15
Strain Rate (in/min): 0.000735	Plasticity Index: 19
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	19.4				
Dry Density (pcf)	104.9				
Void Ratio	0.60				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	21.4				
Dry Density (pcf)	106.5				
Void Ratio	0.58				
Back Pressure (tsf)	9.1				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.40				
Ultimate Deviator Stress (tsf)	1.39				
Deviator Stress at Failure (tsf)	1.01				
Max. Pore Pressure Buildup (tsf)	0.06				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	1.5				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

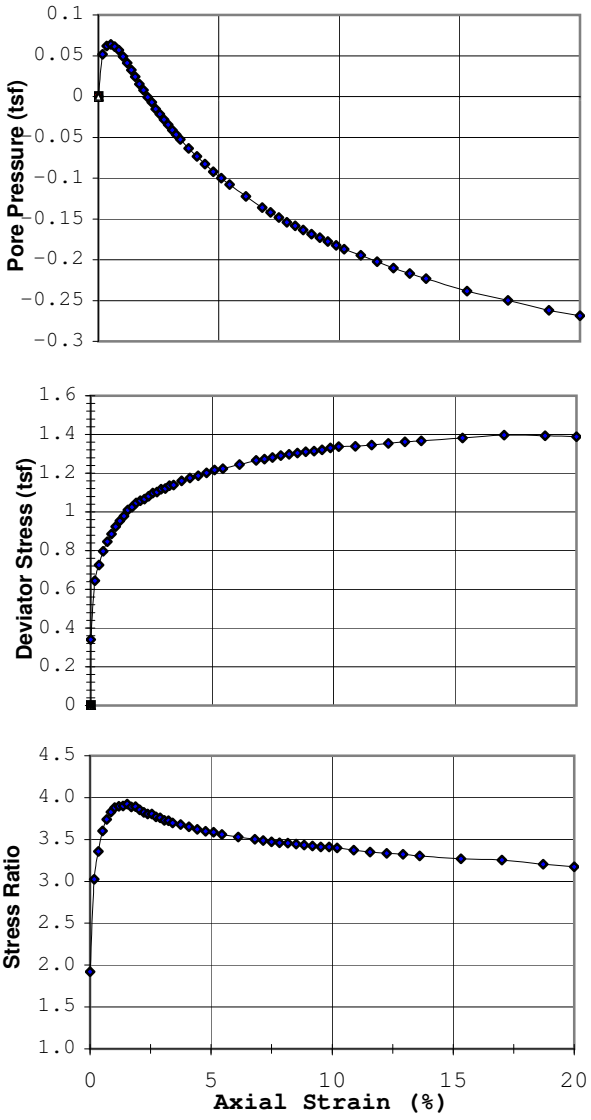
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

9530 James Avenue South
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B12** Sample #: **Control** Type: **3T** Depth (ft): **10.5-12.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**

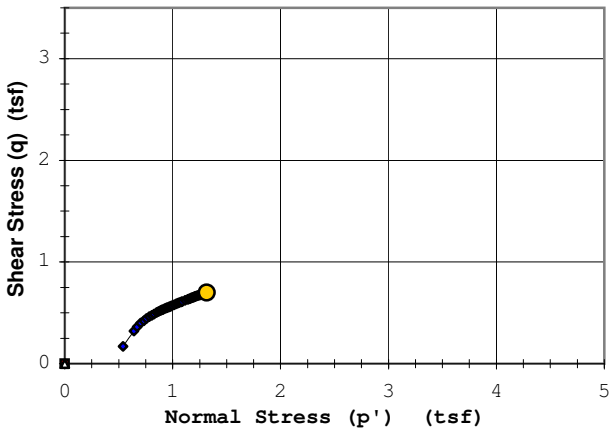


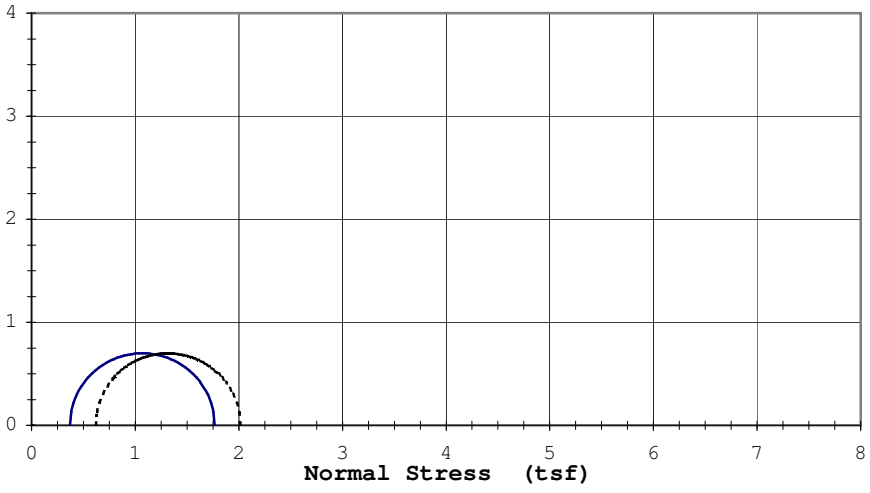
Failure Criterion:	**Max. Deviator Stress**
Angle of internal friction, **ϕ' =**	°
Apparent Cohesion, **c' =**	(tsf)
Test Date: 2/10/21	Liquid Limit: 34
Test Type: CU w/pp	Plastic Limit: 15
Strain Rate (in/min): 0.000735	Plasticity Index: 19
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	19.4				
Dry Density (pcf)	104.9				
Void Ratio	0.60				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	21.4				
Dry Density (pcf)	106.5				
Void Ratio	0.58				
Back Pressure (tsf)	9.1				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.40				
Ultimate Deviator Stress (tsf)	1.39				
Deviator Stress at Failure (tsf)	1.40				
Max. Pore Pressure Buildup (tsf)	0.06				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	17.0				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

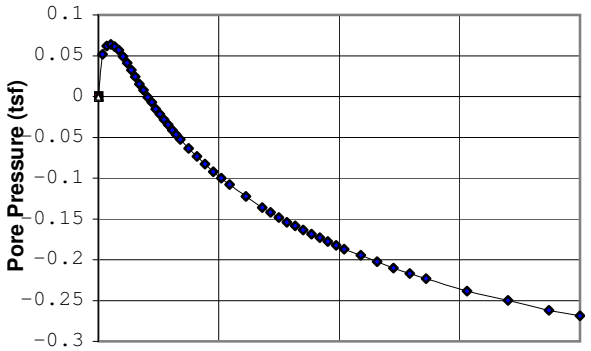
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

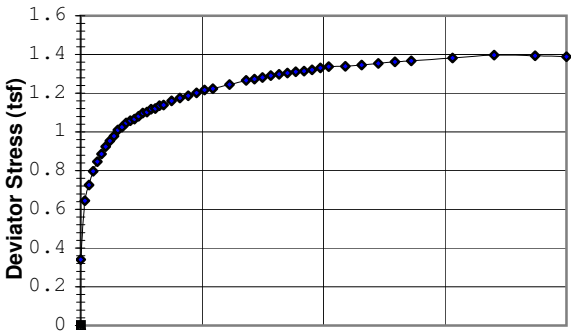
9530 James Avenue South — OIL ENGINEERING TESTING, INC. — Bloomington, Minnesota 55431

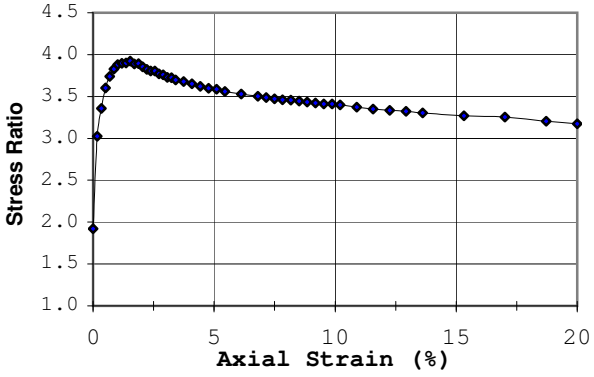
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B12** Sample #: **Control** Type: **3T** Depth (ft): **10.5-12.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**





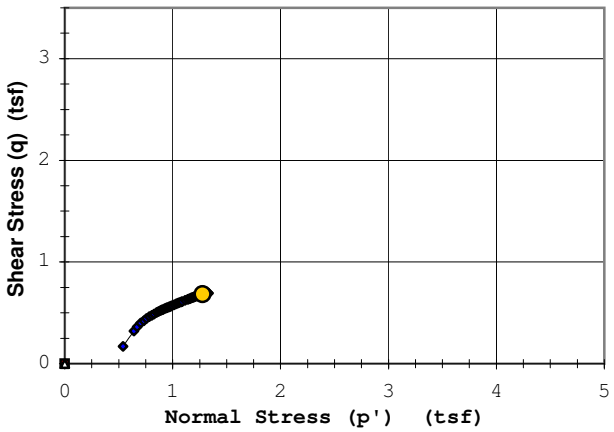


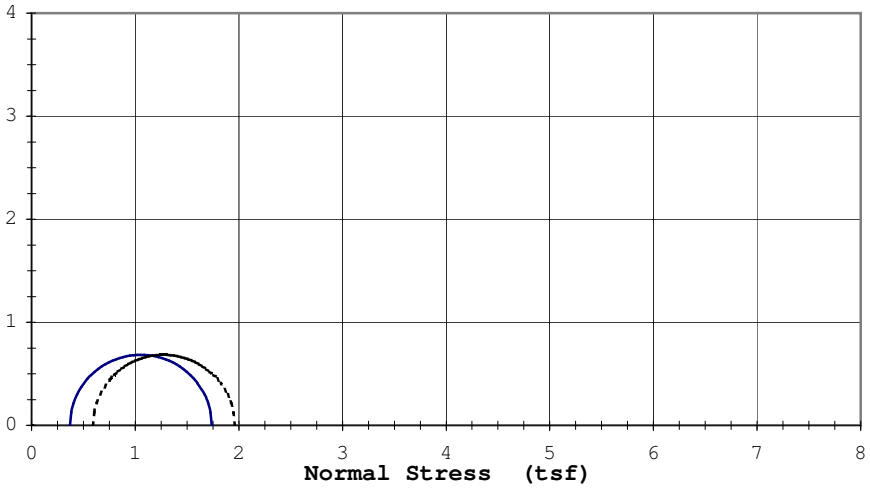
Failure Criterion:	**Given Strain of: 15%**
Angle of internal friction, **ϕ' =**	°
Apparent Cohesion, **c' =**	(tsf)
Test Date: 2/10/21	Liquid Limit: 34
Test Type: CU w/pp	Plastic Limit: 15
Strain Rate (in/min): 0.000735	Plasticity Index: 19
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	19.4				
Dry Density (pcf)	104.9				
Void Ratio	0.60				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	21.4				
Dry Density (pcf)	106.5				
Void Ratio	0.58				
Back Pressure (tsf)	9.1				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.40				
Ultimate Deviator Stress (tsf)	1.39				
Deviator Stress at Failure (tsf)	1.37				
Max. Pore Pressure Buildup (tsf)	0.06				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	15.0				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

9530 James Avenue South
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

Triaxial Data

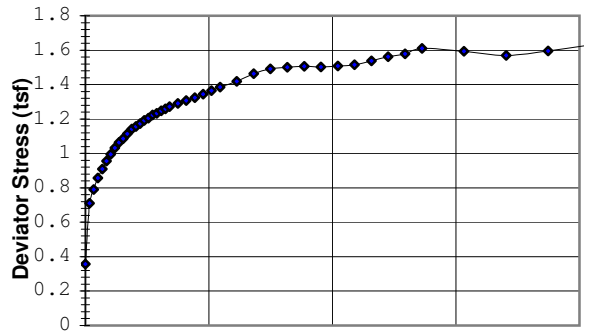
Boring: B12 Sample: Control Depth: 10.5-12.5 Job: 12987 Date: 2/23/21

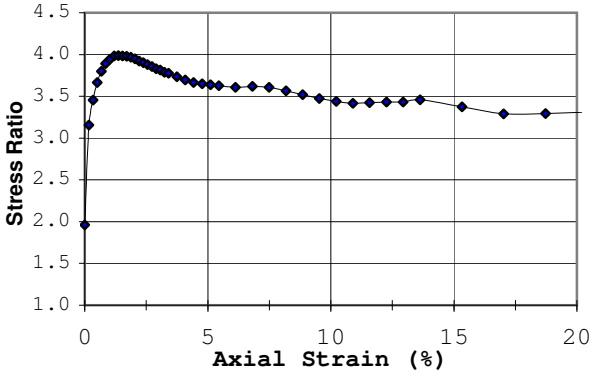
Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.34	0.00												
0.17	0.64	0.05												
0.34	0.73	0.06												
0.51	0.80	0.06												
0.68	0.85	0.06												
0.85	0.89	0.06												
1.02	0.92	0.05												
1.19	0.95	0.04												
1.36	0.98	0.03												
1.53	1.01	0.02												
1.70	1.03	0.02												
1.87	1.05	0.01												
2.04	1.06	0.00												
2.22	1.07	-0.01												
2.39	1.08	-0.02												
2.56	1.10	-0.02												
2.73	1.10	-0.03												
2.90	1.12	-0.03												
3.07	1.12	-0.04												
3.24	1.14	-0.05												
3.41	1.14	-0.05												
3.75	1.16	-0.06												
4.09	1.18	-0.07												
4.43	1.19	-0.08												
4.77	1.20	-0.09												
5.10	1.22	-0.10												
5.44	1.22	-0.11												
6.12	1.25	-0.12												
6.81	1.27	-0.14												
7.15	1.27	-0.14												
7.49	1.28	-0.15												
7.83	1.29	-0.15												
8.17	1.30	-0.16												
8.51	1.30	-0.16												
8.85	1.31	-0.17												
9.19	1.31	-0.17												
9.53	1.32	-0.18												
9.87	1.33	-0.18												
10.21	1.34	-0.19												
10.89	1.34	-0.19												
11.57	1.35	-0.20												
12.25	1.35	-0.21												
12.93	1.36	-0.22												
13.61	1.37	-0.22												
15.31	1.38	-0.24												
17.02	1.40	-0.25												
18.71	1.39	-0.26												
20.00	1.39	-0.27												

TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B12** Sample #: **Cycled** Type: **3T** Depth (ft): **10.5-12.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**





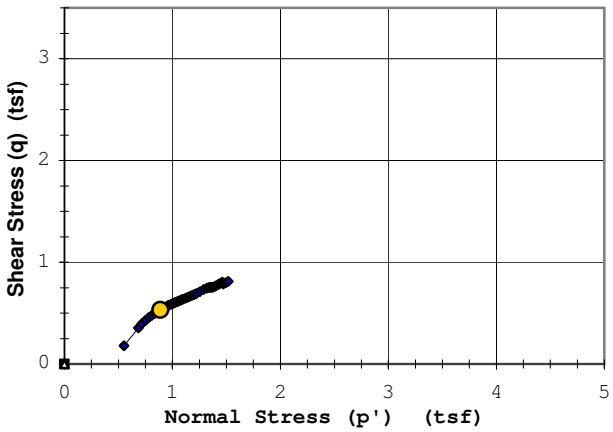
Failure Criterion:	**Max. Stress Ratio**
Angle of internal friction, **ϕ' =**	°
Apparent Cohesion, **c' =**	(tsf)

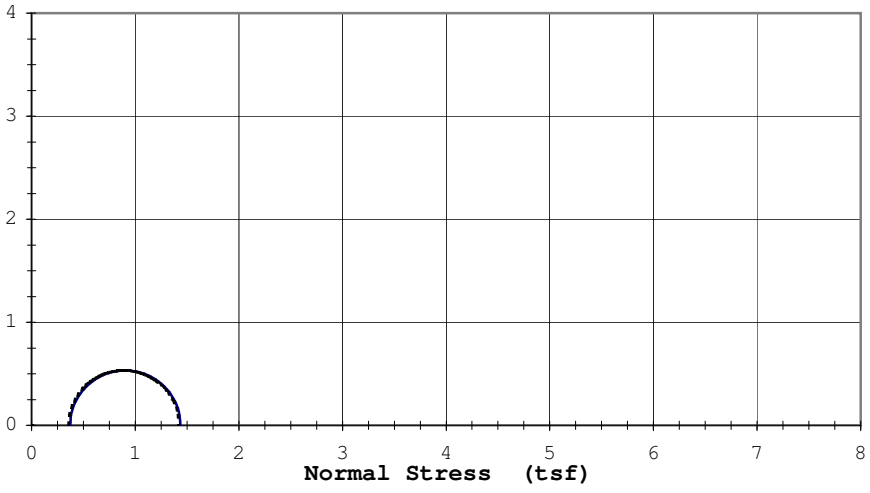
Test Date:	2/10/21			Liquid Limit:		34
Test Type:	CU w/pp			Plastic Limit:		15
Strain Rate (in/min):	0.000735			Plasticity Index:		19
Strain Rate (%/min):	0.025			Spec. Gravity (Assumed):		2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	20.0				
Dry Density (pcf)	105.6				
Void Ratio	0.59				
After Consolidation					
Diameter (in)	1.44				
Height (in)	2.94				
Water Content (%)	21.3				
Dry Density (pcf)	106.8				
Void Ratio	0.57				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.62				
Ultimate Deviator Stress (tsf)	1.62				
Deviator Stress at Failure (tsf)	1.06				
Max. Pore Pressure Buildup (tsf)	0.05				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	1.4				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

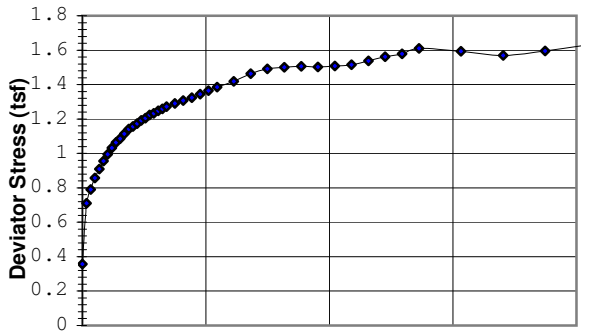
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

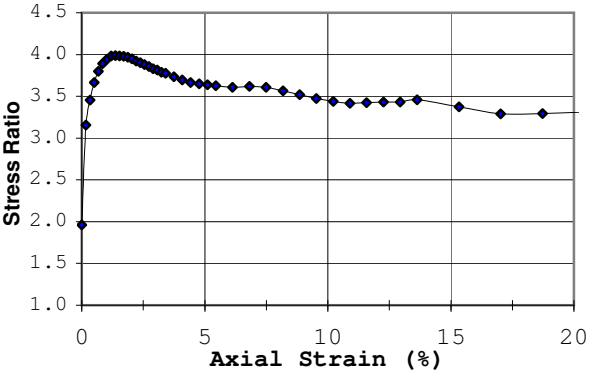
9530 James Avenue South
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B12** Sample #: **Cycled** Type: **3T** Depth (ft): **10.5-12.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**





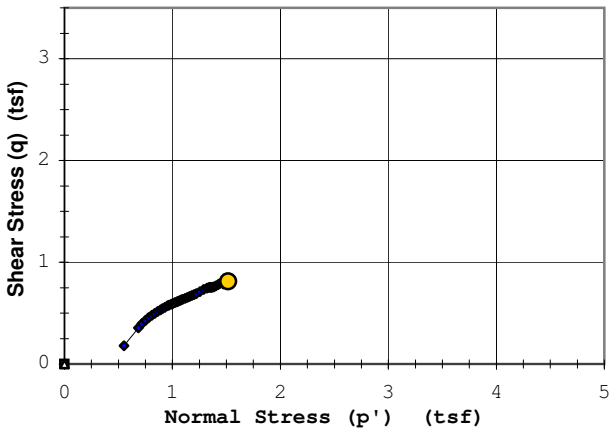
Failure Criterion: **Max. Deviator Stress**
Angle of internal friction, **ϕ' =** °
Apparent Cohesion, **c' =** (tsf)

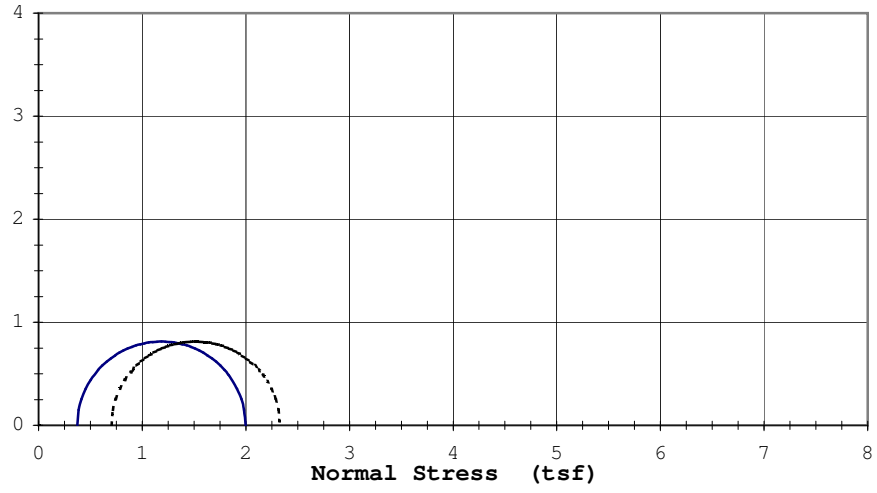
Test Date:	2/10/21		Liquid Limit:		34
Test Type:	CU w/pp		Plastic Limit:		15
Strain Rate (in/min):	0.000735		Plasticity Index:		19
Strain Rate (%/min):	0.025		Spec. Gravity (Assumed):		2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	20.0				
Dry Density (pcf)	105.6				
Void Ratio	0.59				
After Consolidation					
Diameter (in)	1.44				
Height (in)	2.94				
Water Content (%)	21.3				
Dry Density (pcf)	106.8				
Void Ratio	0.57				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.62				
Ultimate Deviator Stress (tsf)	1.62				
Deviator Stress at Failure (tsf)	1.62				
Max. Pore Pressure Buildup (tsf)	0.05				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	20.2				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure
α = ° a = (tsf)

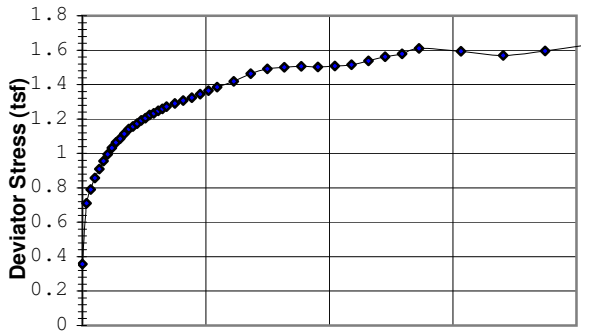
---------- Effective ϕ': ° c'= (tsf)
_____ Total ϕ: ° c= (tsf)

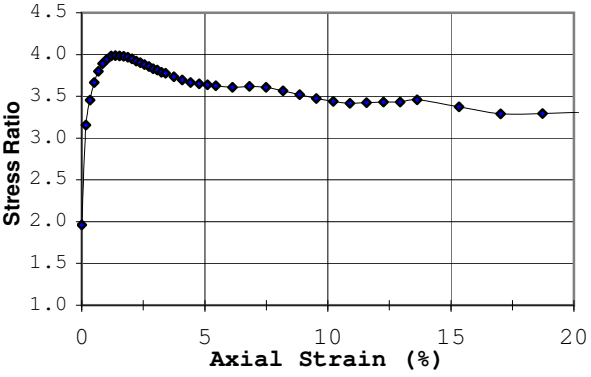
9530 James Avenue South
OIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B12** Sample #: **Cycled** Type: **3T** Depth (ft): **10.5-12.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**





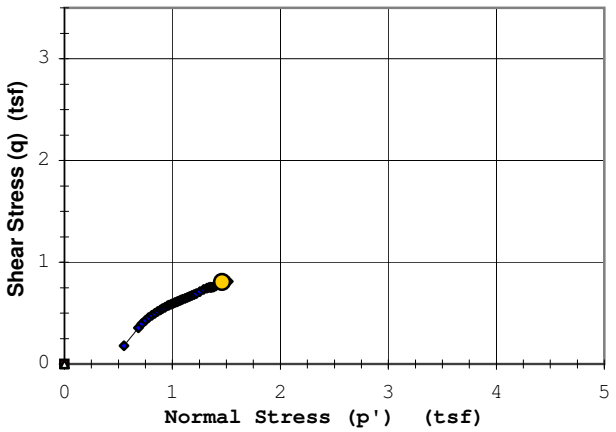
Failure Criterion: **Given Strain of: 15%**
Angle of internal friction, **ϕ' =** °
Apparent Cohesion, **c' =** (tsf)

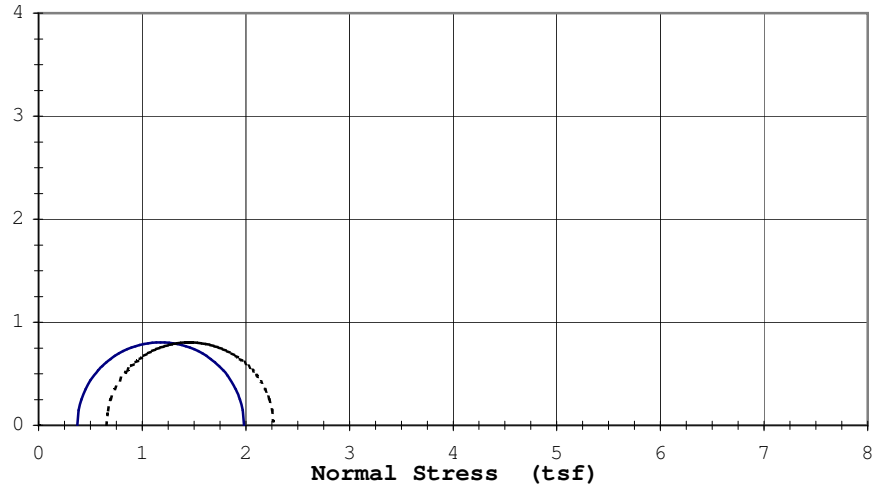
Test Date:	2/10/21		Liquid Limit:		34
Test Type:	CU w/pp		Plastic Limit:		15
Strain Rate (in/min):	0.000735		Plasticity Index:		19
Strain Rate (%/min):	0.025		Spec. Gravity (Assumed):		2.69

	A	B	C	D	E
Before Consolidation					
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	20.0				
Dry Density (pcf)	105.6				
Void Ratio	0.59				
After Consolidation					
Diameter (in)	1.44				
Height (in)	2.94				
Water Content (%)	21.3				
Dry Density (pcf)	106.8				
Void Ratio	0.57				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.62				
Ultimate Deviator Stress (tsf)	1.62				
Deviator Stress at Failure (tsf)	1.61				
Max. Pore Pressure Buildup (tsf)	0.05				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	15.0				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

9530 James Avenue South
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

Triaxial Data

Job: **12987**

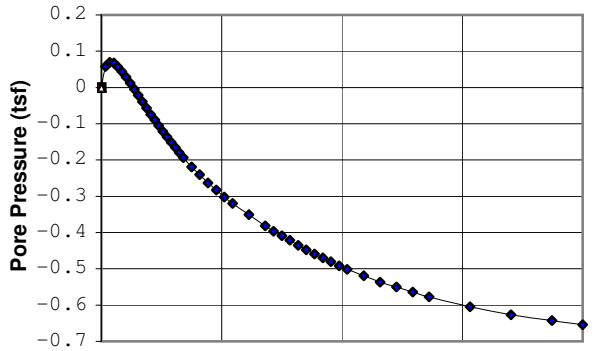
Boring: B12 Sample: Cycled Depth: 10.5-12.5 Date: 2/23/21

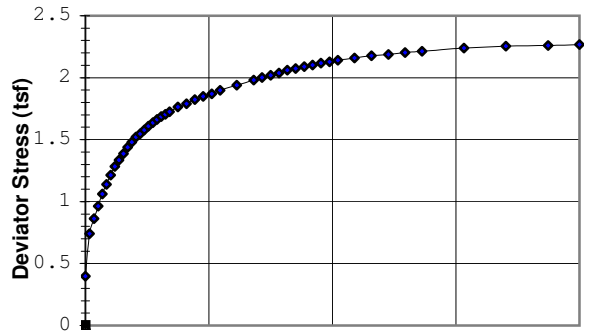
Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.36	0.00												
0.17	0.71	0.04												
0.34	0.79	0.05												
0.51	0.86	0.05												
0.68	0.91	0.05												
0.85	0.96	0.04												
1.02	0.99	0.03												
1.19	1.03	0.03												
1.36	1.06	0.02												
1.53	1.09	0.01												
1.70	1.11	0.00												
1.88	1.14	-0.01												
2.04	1.16	-0.02												
2.21	1.17	-0.03												
2.38	1.19	-0.04												
2.55	1.21	-0.05												
2.72	1.22	-0.06												
2.89	1.23	-0.06												
3.07	1.25	-0.07												
3.24	1.26	-0.08												
3.41	1.27	-0.09												
3.75	1.29	-0.10												
4.09	1.31	-0.11												
4.43	1.32	-0.12												
4.77	1.35	-0.14												
5.11	1.37	-0.15												
5.45	1.39	-0.16												
6.13	1.42	-0.17												
6.81	1.46	-0.19												
7.49	1.49	-0.20												
8.17	1.50	-0.21												
8.85	1.51	-0.23												
9.54	1.50	-0.24												
10.22	1.51	-0.25												
10.90	1.51	-0.25												
11.58	1.54	-0.26												
12.26	1.56	-0.27												
12.94	1.58	-0.28												
13.62	1.61	-0.28												
15.33	1.59	-0.30												
17.03	1.57	-0.31												
18.73	1.60	-0.32												
20.20	1.62	-0.33												

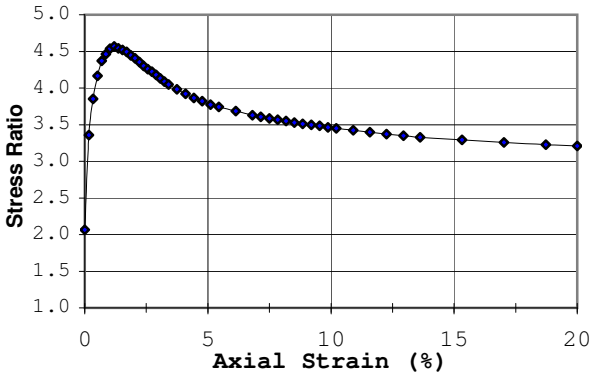
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B96** Sample #: **Control** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sady Lean Clay w/a trace of gravel (CL)**



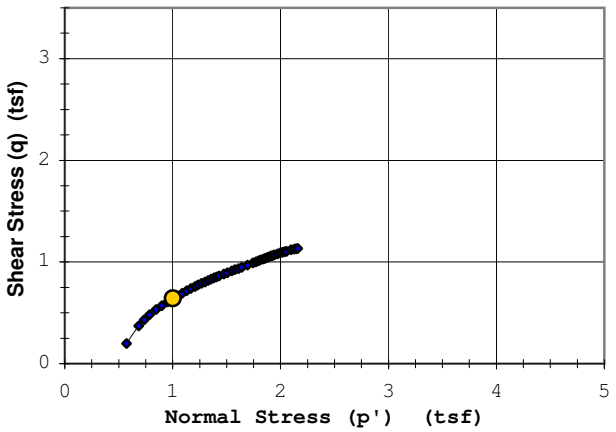


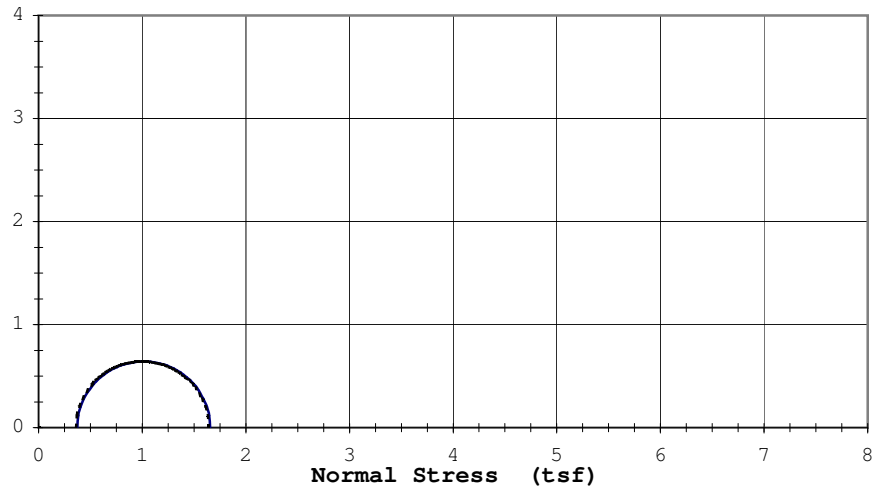


Failure Criterion:	Max. Stress Ratio				
Angle of internal friction, **ϕ' =**	°				
Apparent Cohesion, **c' =**	(tsf)				
Test Date: 2/16/21	Liquid Limit: 38				
Test Type: CU w/pp	Plastic Limit: 16				
Strain Rate (in/min): 0.000735	Plasticity Index: 22				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	17.8				
Dry Density (pcf)	110.0				
Void Ratio	0.53				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	18.9				
Dry Density (pcf)	111.3				
Void Ratio	0.51				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	2.27				
Ultimate Deviator Stress (tsf)	2.27				
Deviator Stress at Failure (tsf)	1.28				
Max. Pore Pressure Buildup (tsf)	0.07				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	1.2				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

9530 James Avenue South

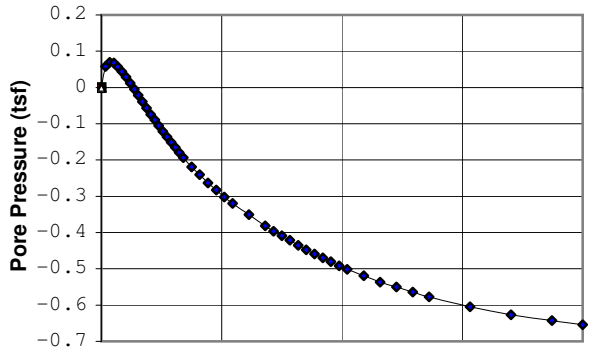
OIL ENGINEERING TESTING, INC.

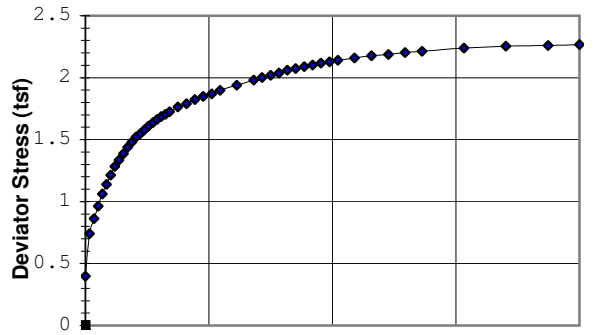
Bloomington, Minnesota 55431

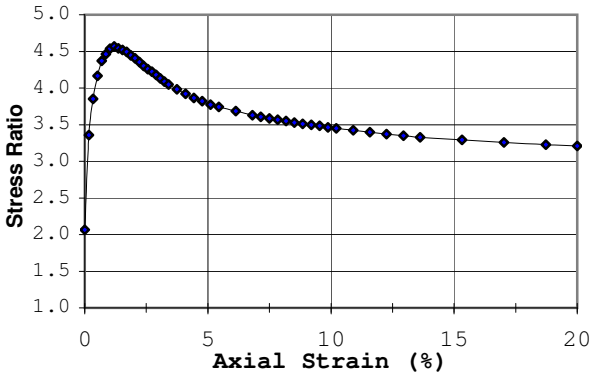
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B96** Sample #: **Control** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sady Lean Clay w/a trace of gravel (CL)**



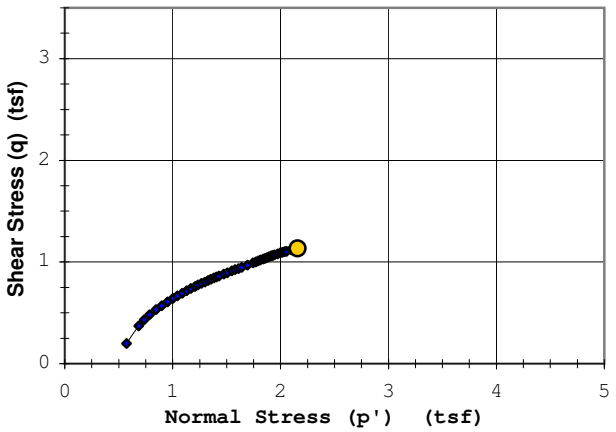


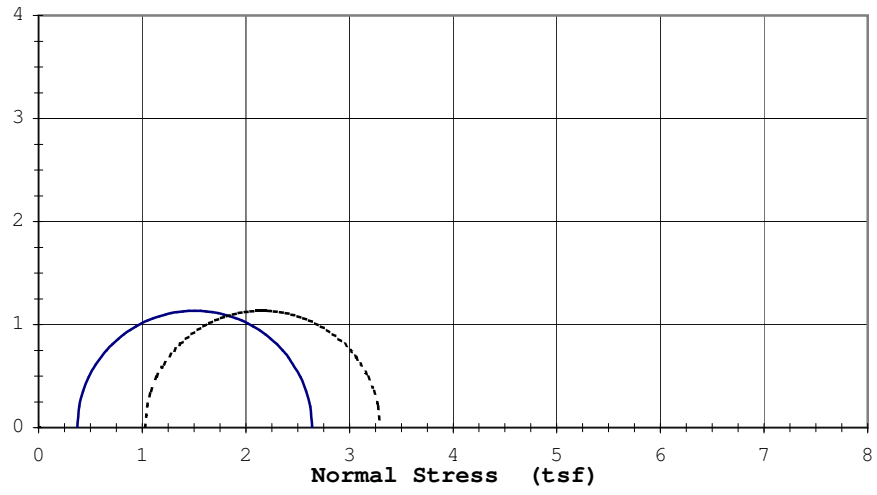


Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21		Liquid Limit:	38		
Test Type: CU w/pp		Plastic Limit:	16		
Strain Rate (in/min): 0.000735		Plasticity Index:	22		
Strain Rate (%/min): 0.025		Spec. Gravity (Assumed):	2.69		
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	17.8				
Dry Density (pcf)	110.0				
Void Ratio	0.53				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	18.9				
Dry Density (pcf)	111.3				
Void Ratio	0.51				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	2.27				
Ultimate Deviator Stress (tsf)	2.27				
Deviator Stress at Failure (tsf)	2.27				
Max. Pore Pressure Buildup (tsf)	0.07				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	20.0				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

9530 James Avenue South

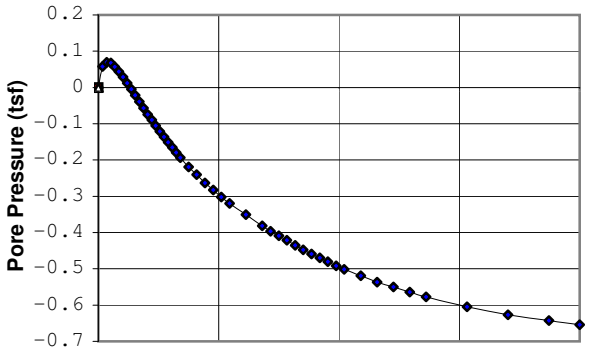
OIL ENGINEERING TESTING, INC.

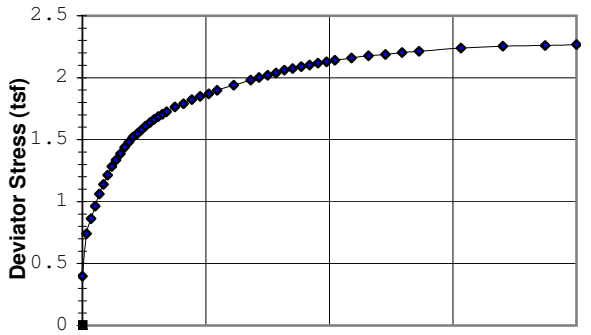
Bloomington, Minnesota 55431

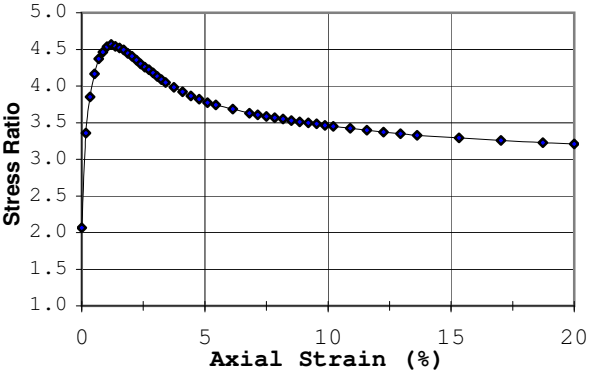
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B96** Sample #: **Control** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sady Lean Clay w/a trace of gravel (CL)**





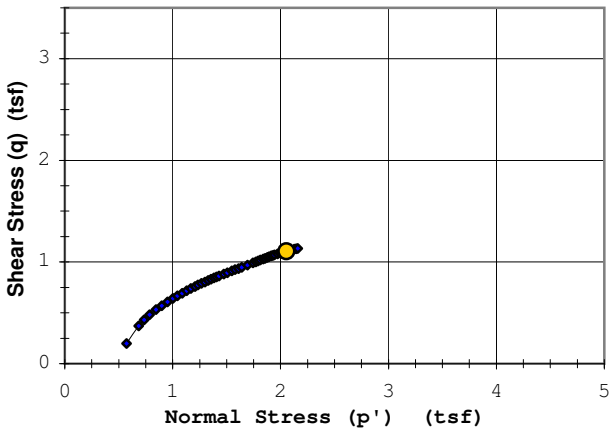


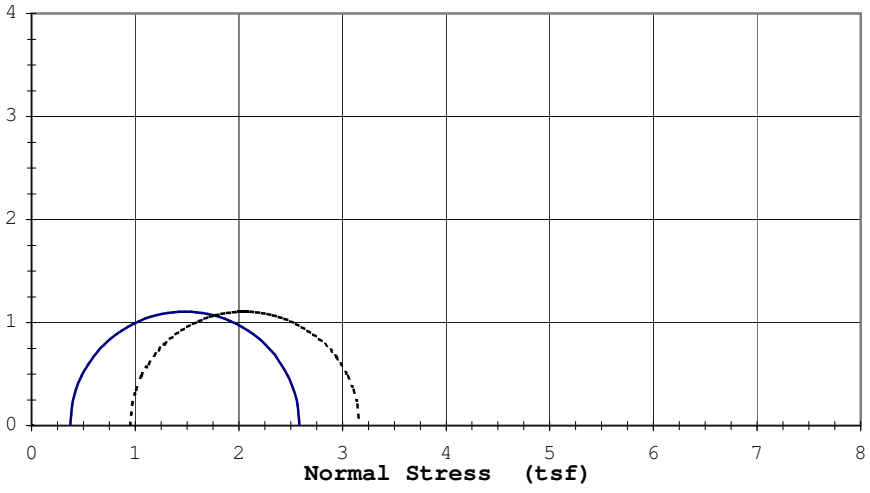
Failure Criterion:	Given Strain of: 15%				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21	Liquid Limit: 38				
Test Type: CU w/pp	Plastic Limit: 16				
Strain Rate (in/min): 0.000735	Plasticity Index: 22				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	17.8				
Dry Density (pcf)	110.0				
Void Ratio	0.53				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	18.9				
Dry Density (pcf)	111.3				
Void Ratio	0.51				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	2.27				
Ultimate Deviator Stress (tsf)	2.27				
Deviator Stress at Failure (tsf)	2.21				
Max. Pore Pressure Buildup (tsf)	0.07				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	15.0				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

9530 James Avenue South
OIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

Triaxial Data

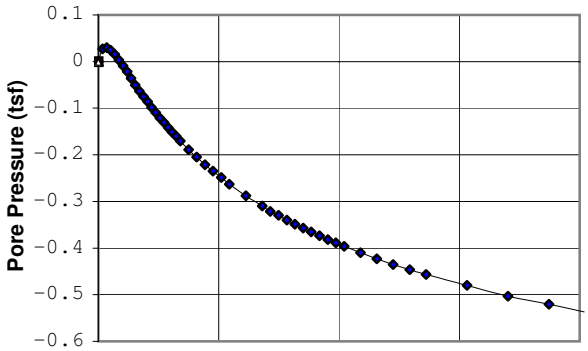
Boring: B96 Sample: Control Depth: 8.5-10.5 Job: 12987 Date: 2/23/21

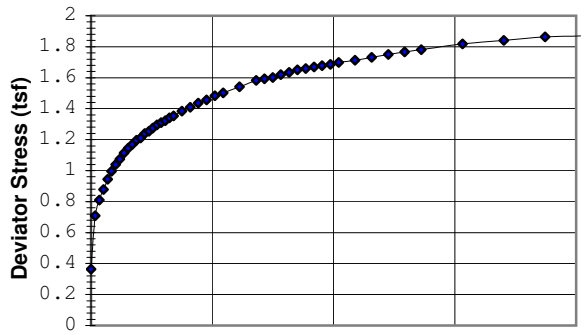
Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.40	0.00												
0.17	0.74	0.06												
0.34	0.86	0.07												
0.51	0.96	0.07												
0.68	1.06	0.06												
0.85	1.14	0.04												
1.02	1.21	0.03												
1.20	1.28	0.01												
1.37	1.34	0.00												
1.54	1.39	-0.02												
1.71	1.44	-0.04												
1.88	1.48	-0.06												
2.05	1.52	-0.07												
2.22	1.55	-0.09												
2.39	1.58	-0.11												
2.56	1.61	-0.12												
2.73	1.64	-0.14												
2.90	1.66	-0.15												
3.07	1.69	-0.17												
3.24	1.71	-0.18												
3.41	1.73	-0.19												
3.75	1.76	-0.22												
4.09	1.79	-0.24												
4.43	1.82	-0.26												
4.77	1.85	-0.28												
5.11	1.87	-0.30												
5.45	1.90	-0.32												
6.13	1.94	-0.35												
6.81	1.98	-0.38												
7.15	2.00	-0.40												
7.49	2.02	-0.41												
7.83	2.04	-0.42												
8.17	2.06	-0.44												
8.52	2.07	-0.45												
8.86	2.09	-0.46												
9.20	2.10	-0.47												
9.54	2.12	-0.48												
9.88	2.13	-0.49												
10.22	2.14	-0.50												
10.90	2.16	-0.52												
11.58	2.18	-0.54												
12.26	2.19	-0.55												
12.94	2.20	-0.56												
13.62	2.21	-0.58												
15.32	2.24	-0.60												
17.03	2.25	-0.63												
18.73	2.26	-0.64												
20.00	2.27	-0.65												

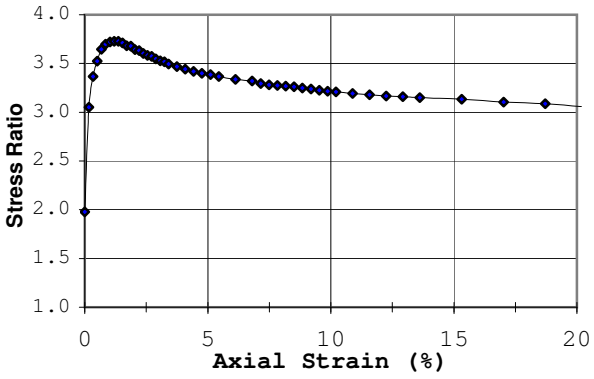
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/21/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B96** Sample #: **Cycled** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**





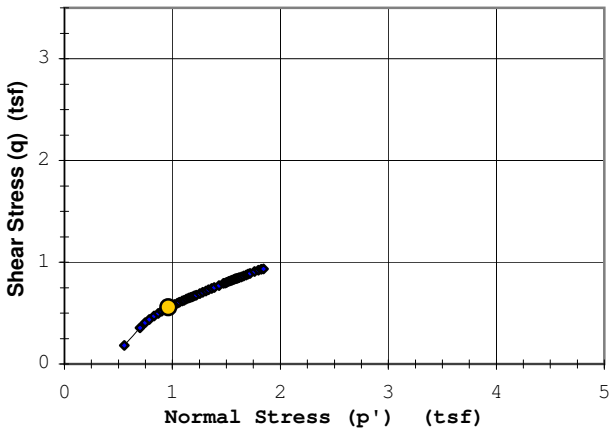


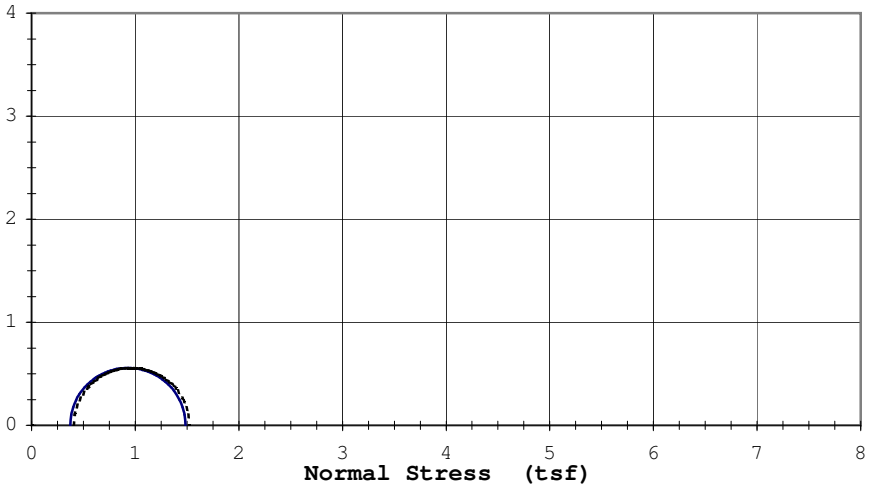
◆ ■ △ + X

Failure Criterion:	Max. Stress Ratio				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21	Liquid Limit: 38				
Test Type: CU w/pp	Plastic Limit: 16				
Strain Rate (in/min): 0.000736	Plasticity Index: 22				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	17.8				
Dry Density (pcf)	110.4				
Void Ratio	0.52				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	18.6				
Dry Density (pcf)	112.0				
Void Ratio	0.50				
Back Pressure (tsf)	4.8				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.87				
Ultimate Deviator Stress (tsf)	1.87				
Deviator Stress at Failure (tsf)	1.11				
Max. Pore Pressure Buildup (tsf)	0.03				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	1.4				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

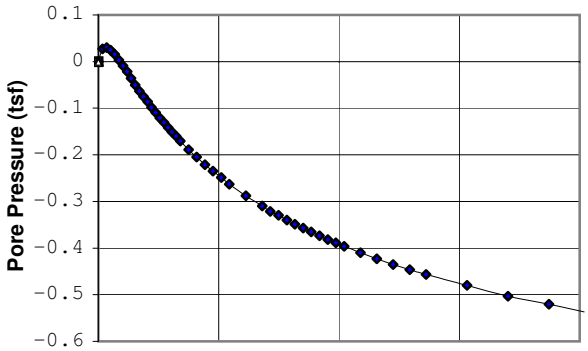
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

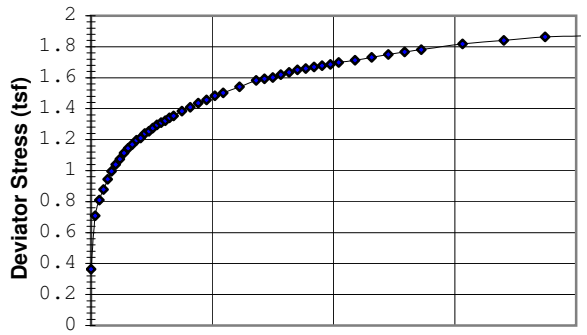
9530 James Avenue South — Bloomington, Minnesota 55431
SOIL ENGINEERING TESTING, INC.

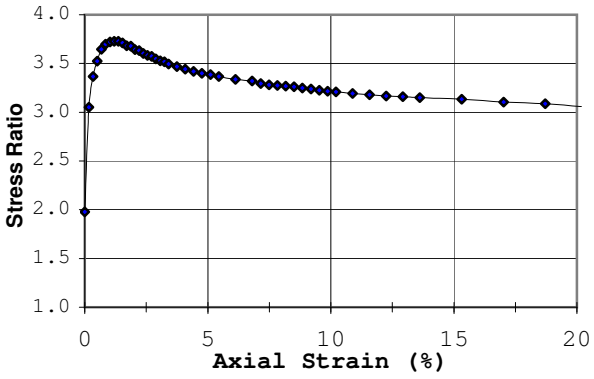
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/21/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B96** Sample #: **Cycled** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**



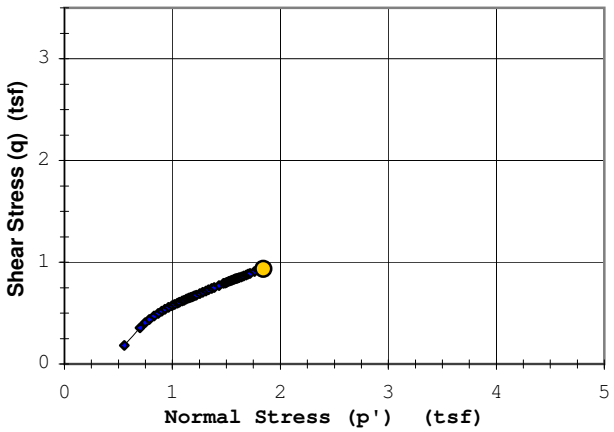


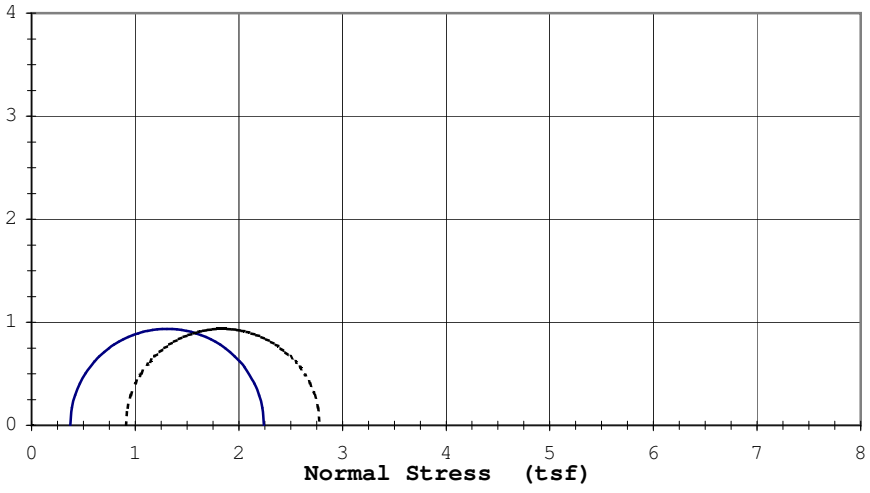


Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21	Liquid Limit: 38				
Test Type: CU w/pp	Plastic Limit: 16				
Strain Rate (in/min): 0.000736	Plasticity Index: 22				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	17.8				
Dry Density (pcf)	110.4				
Void Ratio	0.52				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	18.6				
Dry Density (pcf)	112.0				
Void Ratio	0.50				
Back Pressure (tsf)	4.8				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.87				
Ultimate Deviator Stress (tsf)	1.87				
Deviator Stress at Failure (tsf)	1.87				
Max. Pore Pressure Buildup (tsf)	0.03				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	20.2				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

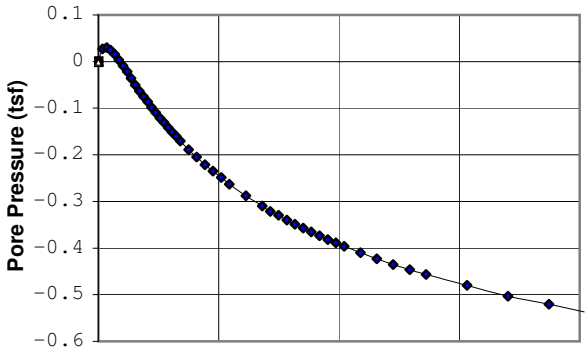
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

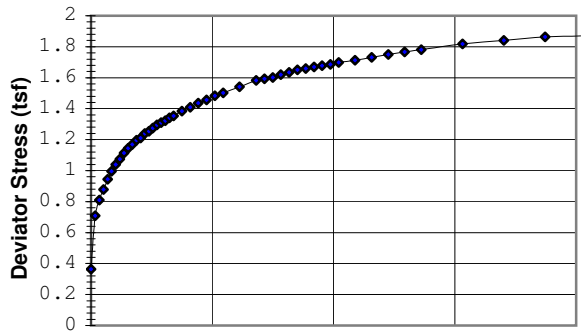
9530 James Avenue South — Bloomington, Minnesota 55431

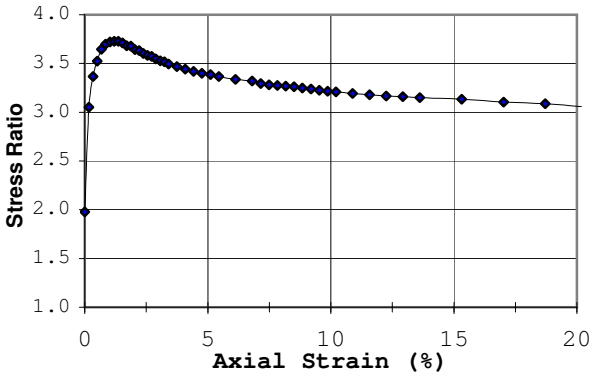
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/21/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B96** Sample #: **Cycled** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay w/a trace of gravel (CL)**



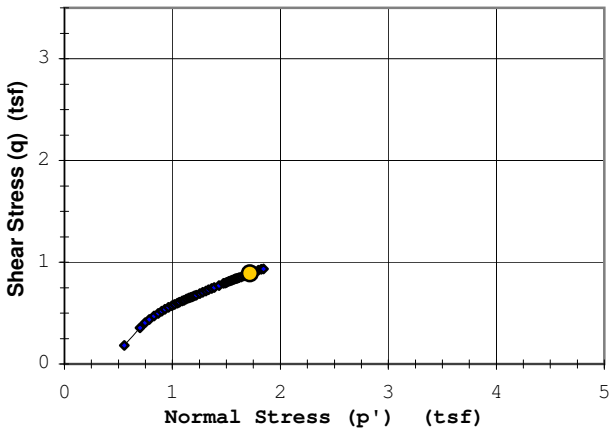


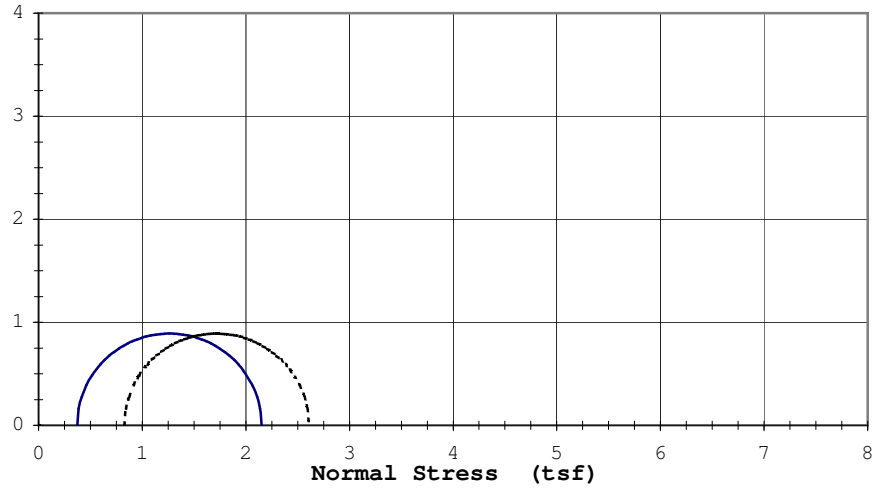


Failure Criterion:	Given Strain of: 15%				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21	Liquid Limit: 38				
Test Type: CU w/pp	Plastic Limit: 16				
Strain Rate (in/min): 0.000736	Plasticity Index: 22				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	17.8				
Dry Density (pcf)	110.4				
Void Ratio	0.52				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	18.6				
Dry Density (pcf)	112.0				
Void Ratio	0.50				
Back Pressure (tsf)	4.8				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.87				
Ultimate Deviator Stress (tsf)	1.87				
Deviator Stress at Failure (tsf)	1.78				
Max. Pore Pressure Buildup (tsf)	0.03				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	15.0				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

9530 James Avenue South
OIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

Triaxial Data

Job: **12987**

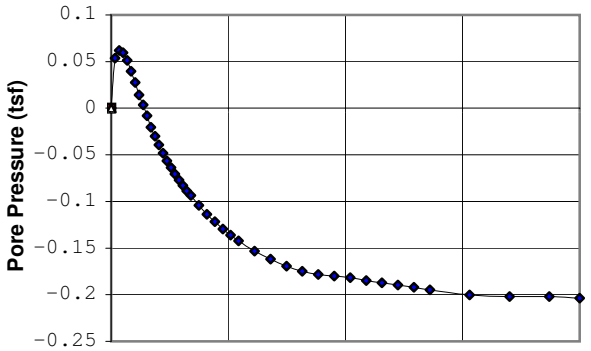
Boring: B96 Sample: Cycled Depth: 8.5-10.5 Date: 2/21/21

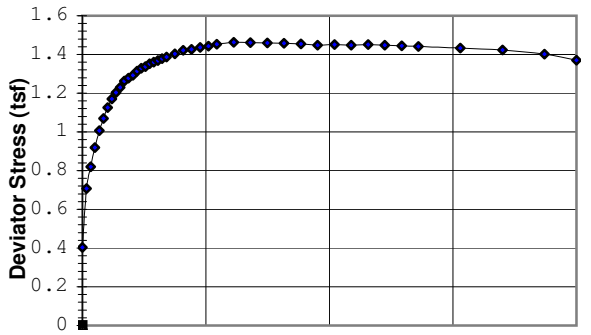
Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.36	0.00												
0.17	0.71	0.03												
0.34	0.81	0.03												
0.51	0.88	0.02												
0.68	0.94	0.02												
0.85	1.00	0.00												
1.02	1.04	-0.01												
1.19	1.07	-0.02												
1.36	1.11	-0.04												
1.53	1.14	-0.05												
1.70	1.17	-0.06												
1.87	1.20	-0.07												
2.04	1.21	-0.09												
2.21	1.24	-0.10												
2.38	1.25	-0.11												
2.55	1.27	-0.12												
2.72	1.30	-0.13												
2.89	1.31	-0.14												
3.06	1.32	-0.15												
3.23	1.34	-0.16												
3.40	1.35	-0.17												
3.74	1.39	-0.19												
4.08	1.41	-0.20												
4.42	1.44	-0.22												
4.76	1.46	-0.23												
5.10	1.48	-0.25												
5.45	1.50	-0.26												
6.13	1.54	-0.29												
6.81	1.58	-0.31												
7.15	1.59	-0.32												
7.49	1.60	-0.33												
7.83	1.62	-0.34												
8.17	1.63	-0.35												
8.51	1.65	-0.36												
8.85	1.66	-0.37												
9.19	1.67	-0.37												
9.53	1.68	-0.38												
9.87	1.69	-0.39												
10.21	1.70	-0.40												
10.89	1.71	-0.41												
11.57	1.73	-0.42												
12.25	1.75	-0.44												
12.93	1.77	-0.45												
13.61	1.78	-0.46												
15.31	1.82	-0.48												
17.02	1.84	-0.50												
18.72	1.86	-0.52												
20.19	1.87	-0.54												

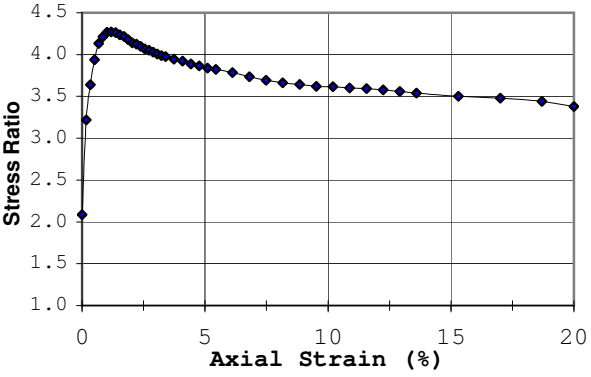
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B129** Sample #: **Control** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay (CL)**



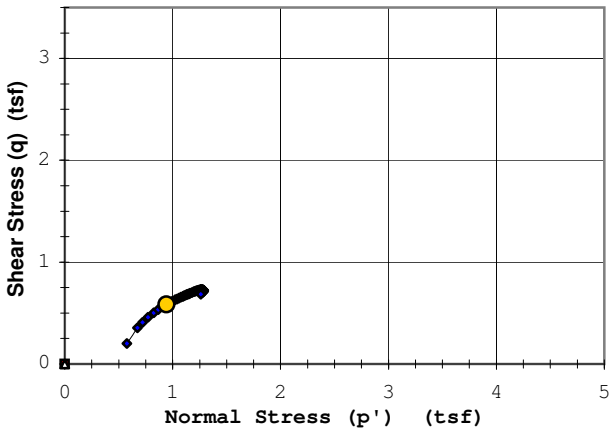


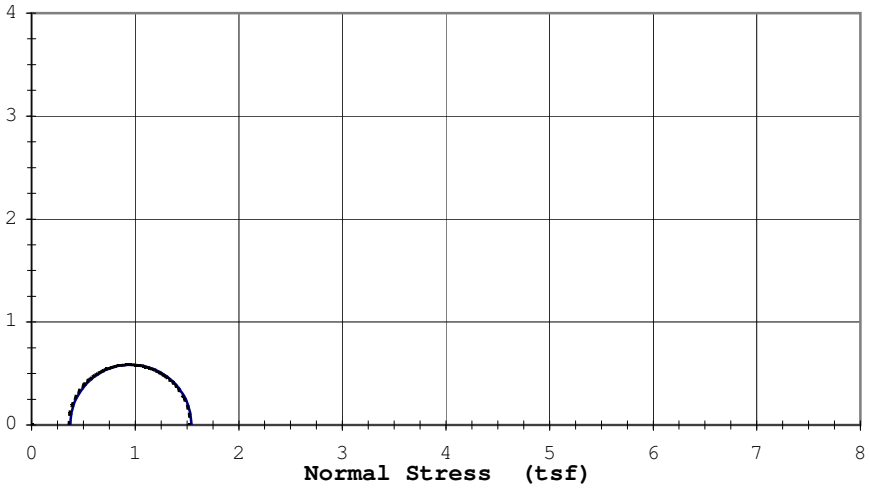


Failure Criterion:	Max. Stress Ratio				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21	Liquid Limit: 31				
Test Type: CU w/pp	Plastic Limit: 13				
Strain Rate (in/min): 0.000735	Plasticity Index: 18				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	21.9				
Dry Density (pcf)	103.8				
Void Ratio	0.62				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	22.2				
Dry Density (pcf)	105.1				
Void Ratio	0.60				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.46				
Ultimate Deviator Stress (tsf)	1.37				
Deviator Stress at Failure (tsf)	1.17				
Max. Pore Pressure Buildup (tsf)	0.06				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	1.2				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

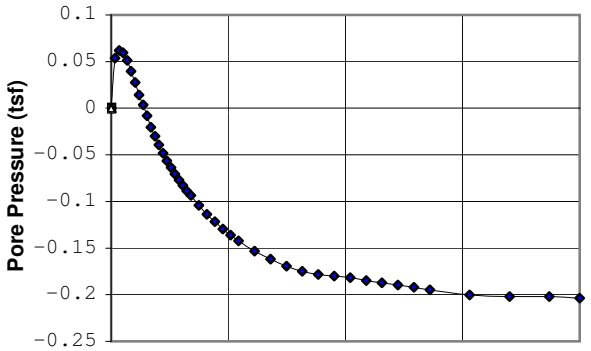
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

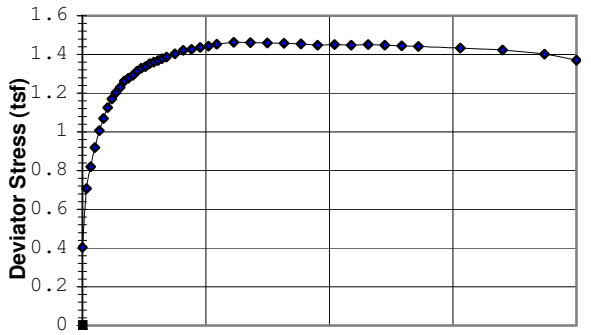
9530 James Avenue South — Soil Engineering Testing, Inc. — Bloomington, Minnesota 55431

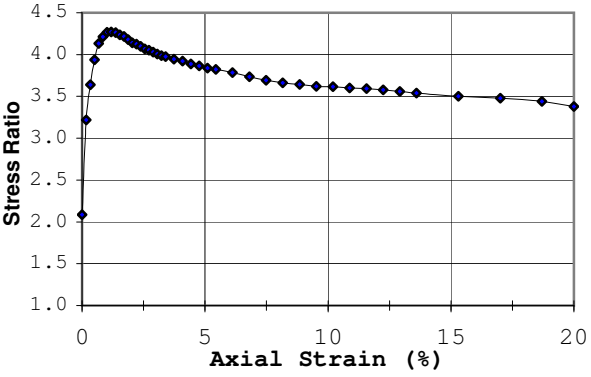
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B129** Sample #: **Control** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay (CL)**



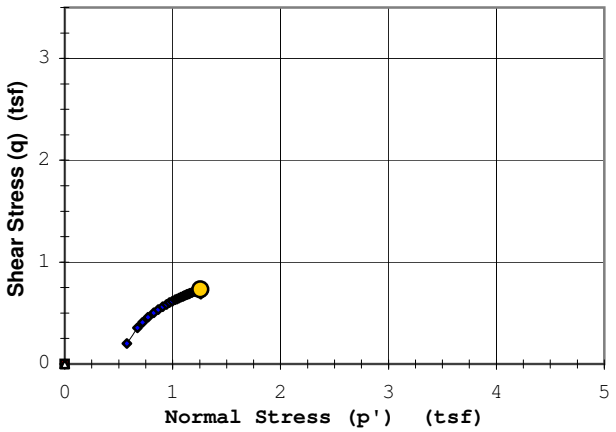


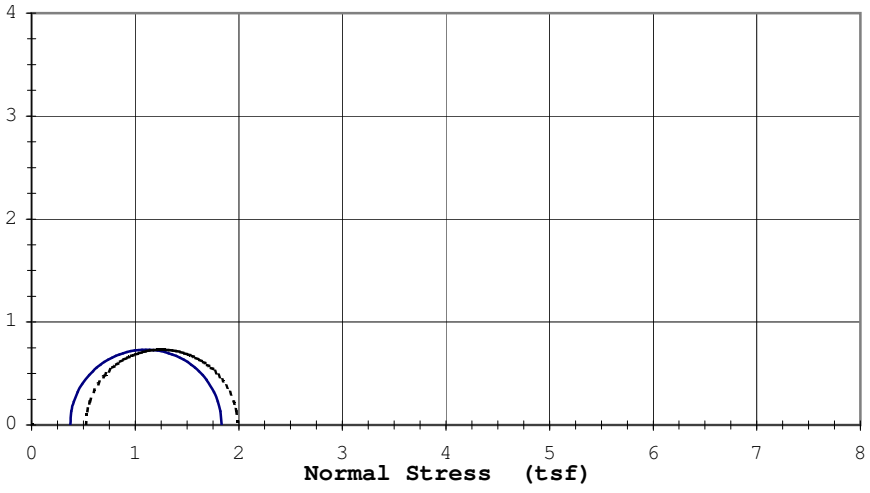


Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21	Liquid Limit: 31				
Test Type: CU w/pp	Plastic Limit: 13				
Strain Rate (in/min): 0.000735	Plasticity Index: 18				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	21.9				
Dry Density (pcf)	103.8				
Void Ratio	0.62				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	22.2				
Dry Density (pcf)	105.1				
Void Ratio	0.60				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.46				
Ultimate Deviator Stress (tsf)	1.37				
Deviator Stress at Failure (tsf)	1.46				
Max. Pore Pressure Buildup (tsf)	0.06				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	6.1				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

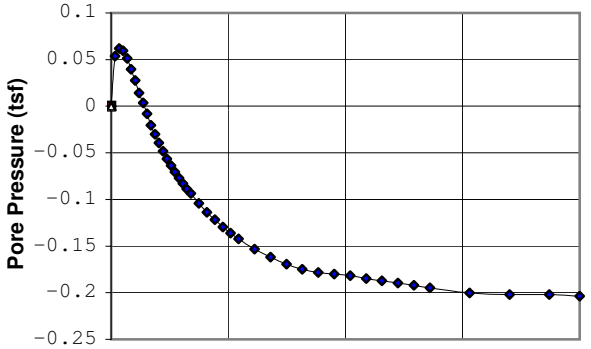
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

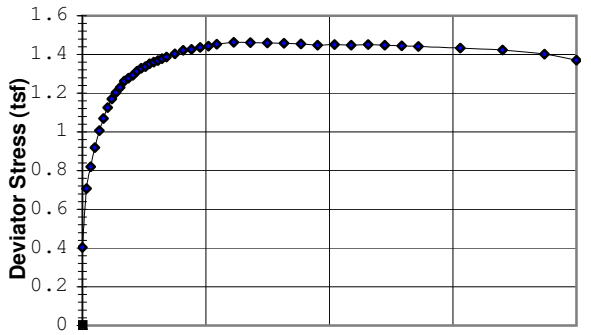
9530 James Avenue South
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

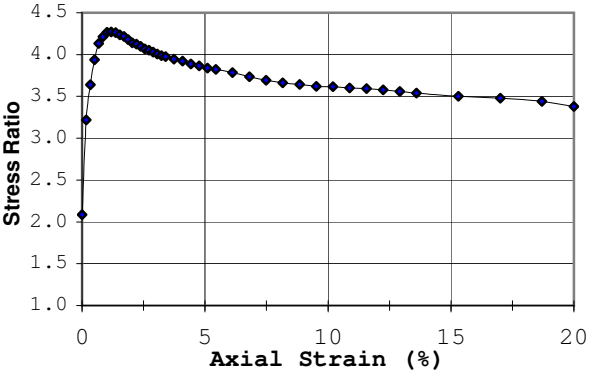
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B129** Sample #: **Control** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay (CL)**



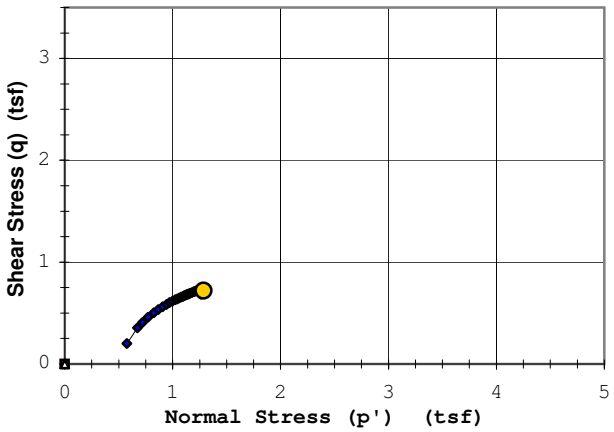


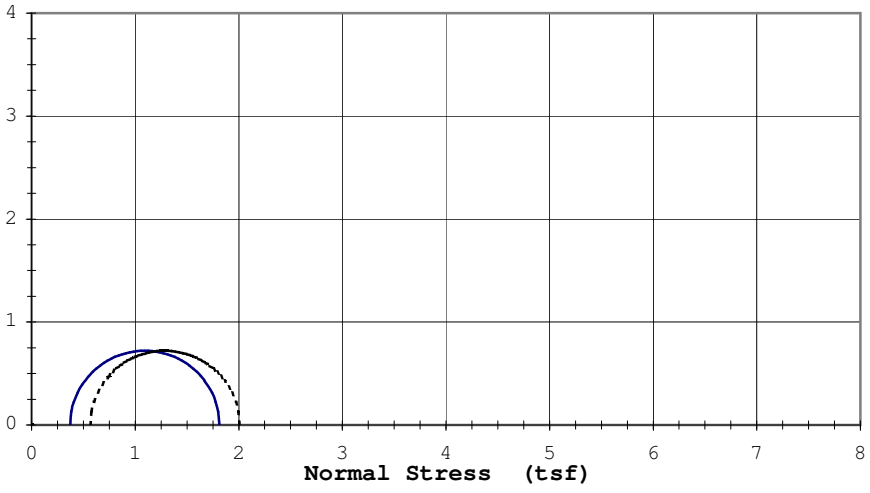


Failure Criterion:	Given Strain of: 15%				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21	Liquid Limit: 31				
Test Type: CU w/pp	Plastic Limit: 13				
Strain Rate (in/min): 0.000735	Plasticity Index: 18				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.96				
Water Content (%)	21.9				
Dry Density (pcf)	103.8				
Void Ratio	0.62				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.94				
Water Content (%)	22.2				
Dry Density (pcf)	105.1				
Void Ratio	0.60				
Back Pressure (tsf)	4.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.46				
Ultimate Deviator Stress (tsf)	1.37				
Deviator Stress at Failure (tsf)	1.44				
Max. Pore Pressure Buildup (tsf)	0.06				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	15.0				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

9530 James Avenue South
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

Triaxial Data

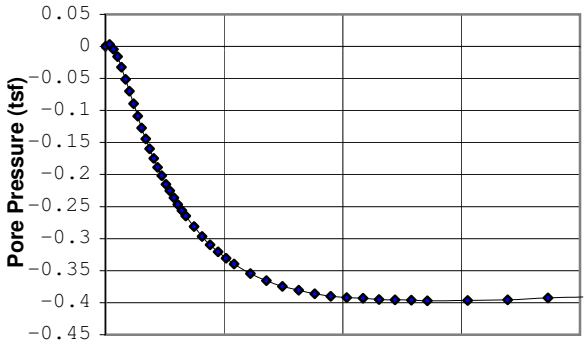
Boring: B129 Sample: Control Depth: 8.5-10.5 Job: 12987 Date: 2/23/21

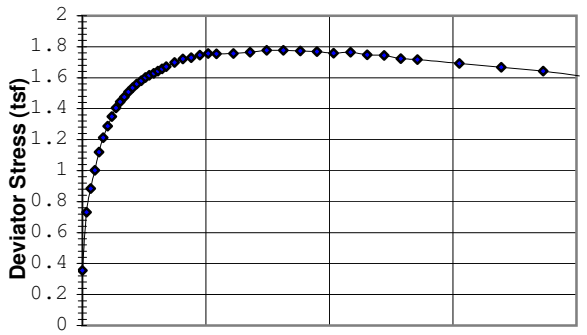
Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.40	0.00												
0.17	0.71	0.05												
0.34	0.82	0.06												
0.51	0.92	0.06												
0.68	1.01	0.05												
0.85	1.07	0.04												
1.02	1.13	0.03												
1.19	1.17	0.01												
1.36	1.20	0.00												
1.53	1.23	-0.01												
1.70	1.26	-0.02												
1.87	1.28	-0.03												
2.04	1.29	-0.04												
2.21	1.31	-0.05												
2.38	1.33	-0.06												
2.55	1.34	-0.06												
2.72	1.35	-0.07												
2.89	1.36	-0.08												
3.06	1.37	-0.08												
3.23	1.38	-0.09												
3.40	1.39	-0.09												
3.74	1.40	-0.10												
4.08	1.42	-0.11												
4.42	1.43	-0.12												
4.76	1.44	-0.13												
5.10	1.44	-0.14												
5.44	1.45	-0.14												
6.12	1.46	-0.15												
6.80	1.46	-0.16												
7.48	1.46	-0.17												
8.16	1.46	-0.17												
8.84	1.46	-0.18												
9.52	1.45	-0.18												
10.20	1.45	-0.18												
10.88	1.45	-0.18												
11.56	1.45	-0.19												
12.24	1.45	-0.19												
12.92	1.44	-0.19												
13.60	1.44	-0.19												
15.30	1.43	-0.20												
17.00	1.42	-0.20												
18.70	1.40	-0.20												
20.00	1.37	-0.20												

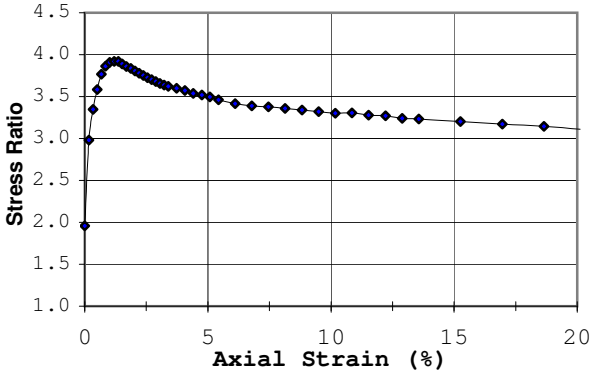
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B129** Sample #: **Cycled** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay (CL)**





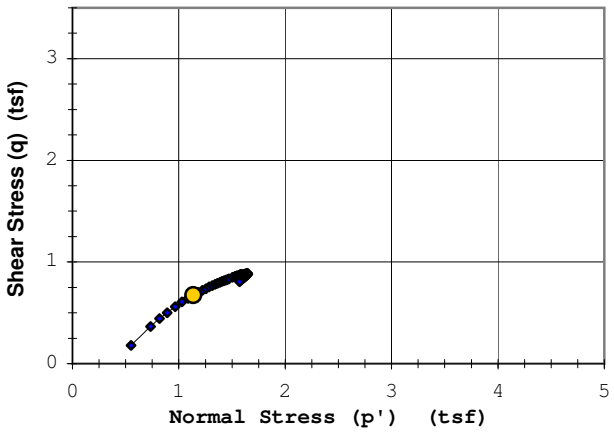


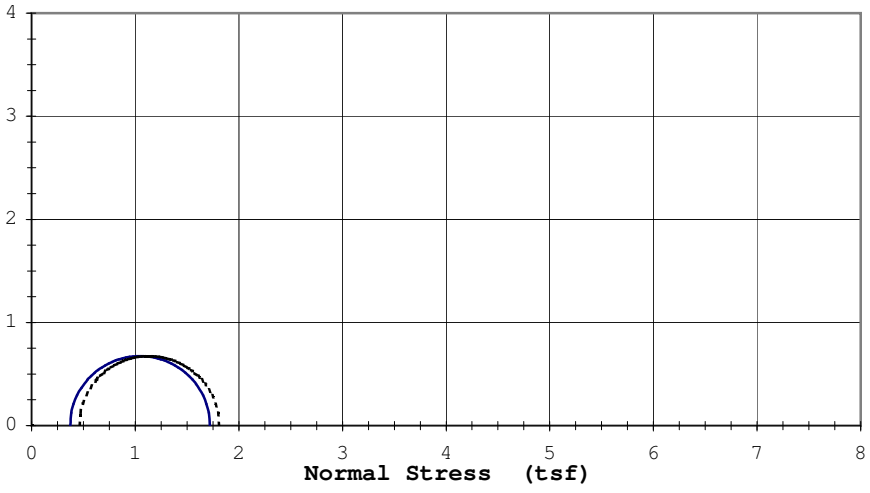
Failure Criterion:	**Max. Stress Ratio**
Angle of internal friction, **ϕ' =**	°
Apparent Cohesion, **c' =**	(tsf)
Test Date: 2/16/21	Liquid Limit: 31
Test Type: CU w/pp	Plastic Limit: 13
Strain Rate (in/min): 0.000738	Plasticity Index: 18
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	18.9				
Dry Density (pcf)	107.8				
Void Ratio	0.56				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.95				
Water Content (%)	20.1				
Dry Density (pcf)	109.0				
Void Ratio	0.54				
Back Pressure (tsf)	5.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.78				
Ultimate Deviator Stress (tsf)	1.61				
Deviator Stress at Failure (tsf)	1.35				
Max. Pore Pressure Buildup (tsf)	0.00				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	1.2				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

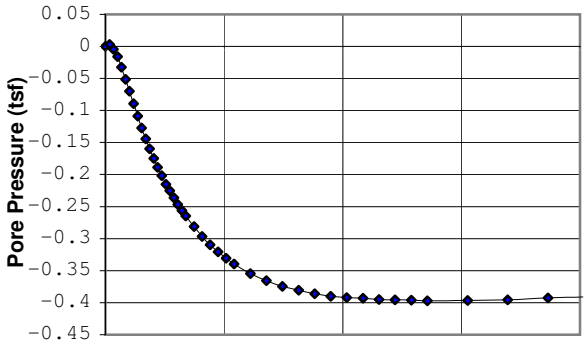
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

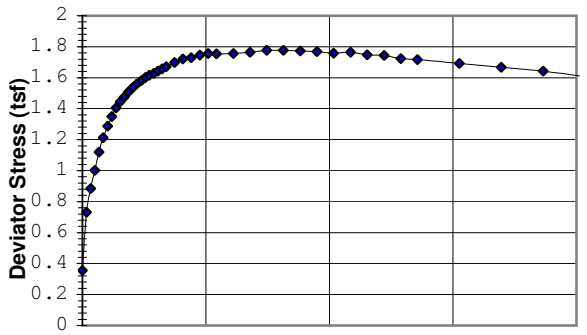
9530 James Avenue South
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

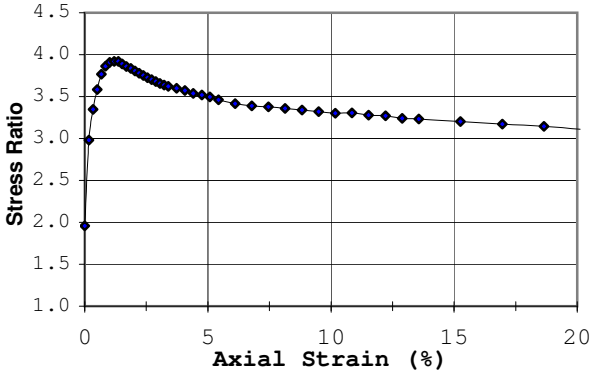
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B129** Sample #: **Cycled** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay (CL)**



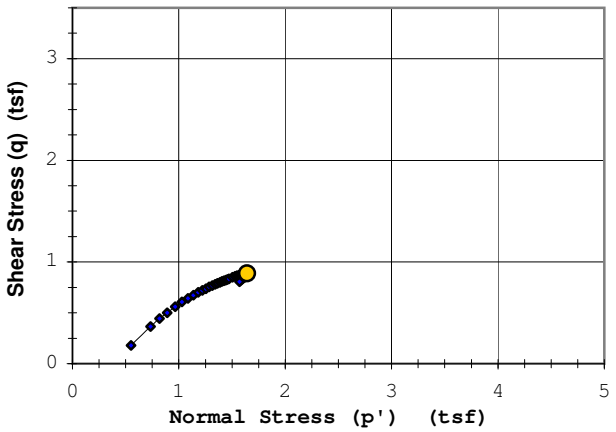


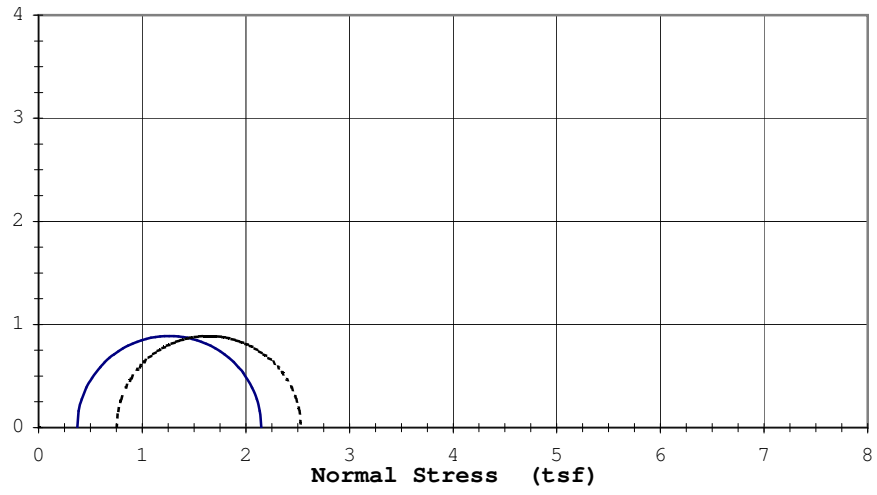


Failure Criterion:	Max. Deviator Stress				
Angle of internal friction, ϕ' =	°				
Apparent Cohesion, c' =	(tsf)				
Test Date: 2/16/21	Liquid Limit: 31				
Test Type: CU w/pp	Plastic Limit: 13				
Strain Rate (in/min): 0.000738	Plasticity Index: 18				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	18.9				
Dry Density (pcf)	107.8				
Void Ratio	0.56				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.95				
Water Content (%)	20.1				
Dry Density (pcf)	109.0				
Void Ratio	0.54				
Back Pressure (tsf)	5.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.78				
Ultimate Deviator Stress (tsf)	1.61				
Deviator Stress at Failure (tsf)	1.78				
Max. Pore Pressure Buildup (tsf)	0.00				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	8.1				

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure			
α =	°	a =	(tsf)

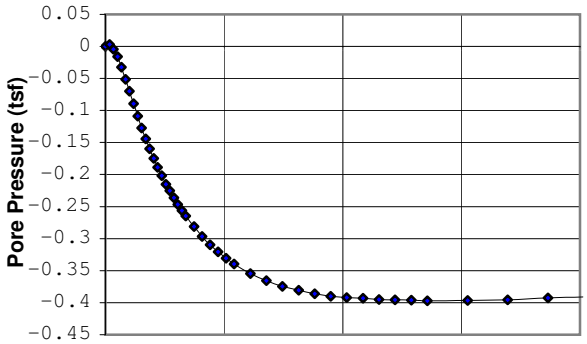
----------	Effective ϕ':	°	c'=	(tsf)
_____	Total ϕ:	°	c=	(tsf)

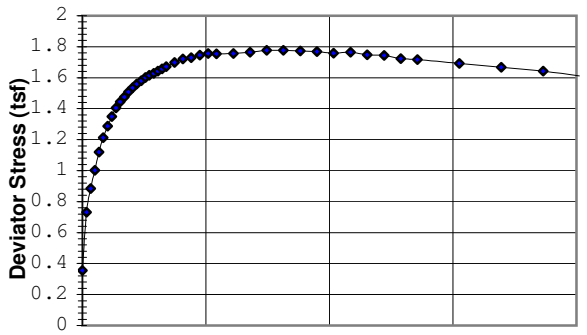
9530 James Avenue South
SOIL ENGINEERING TESTING, INC.
Bloomington, Minnesota 55431

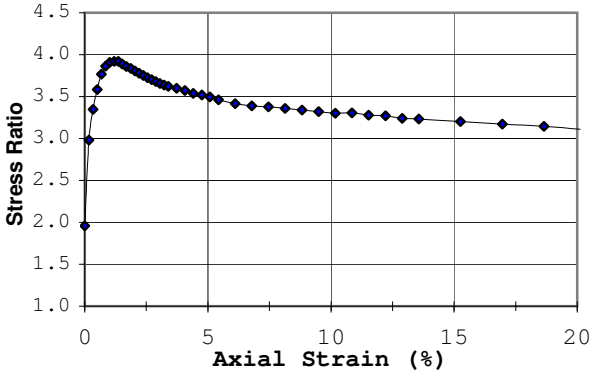
TRIAXIAL TEST ASTM: D 4767

Job No. **12987**
Date: **2/23/21**

Project: **Nobles / Barr Engineering Company**
Boring #: **B129** Sample #: **Cycled** Type: **3T** Depth (ft): **8.5-10.5**
Soil Type: **Sandy Lean Clay (CL)**







◆ Failure Criterion: **Given Strain of: 15%**

Angle of internal friction, **ϕ' =** °

Apparent Cohesion, **c' =** (tsf)

Test Date:	2/16/21		Liquid Limit:		31
Test Type:	CU w/pp		Plastic Limit:		13
Strain Rate (in/min):	0.000738		Plasticity Index:		18
Strain Rate (%/min):	0.025		Spec. Gravity (Assumed):		2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44				
Height (in)	2.97				
Water Content (%)	18.9				
Dry Density (pcf)	107.8				
Void Ratio	0.56				
After Consolidation					
Diameter (in)	1.43				
Height (in)	2.95				
Water Content (%)	20.1				
Dry Density (pcf)	109.0				
Void Ratio	0.54				
Back Pressure (tsf)	5.0				
Minor Principal Stress (tsf)	0.37				
Max. Deviator Stress (tsf)	1.78				
Ultimate Deviator Stress (tsf)	1.61				
Deviator Stress at Failure (tsf)	1.72				
Max. Pore Pressure Buildup (tsf)	0.00				
Pore Pressure Parameter "B"	0.95				
Pct. Axial Strain at Failure	15.0				

■

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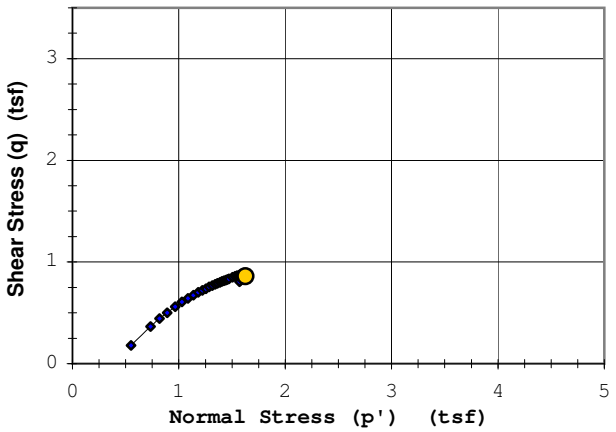
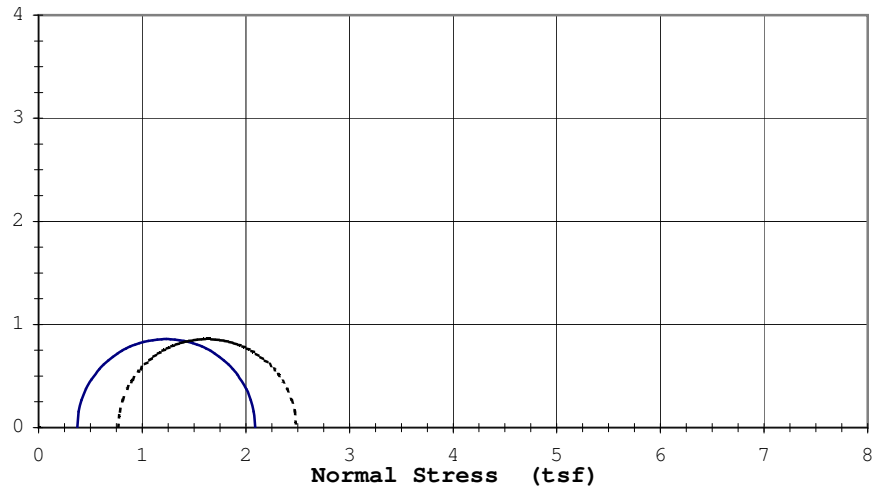
X

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.
A correction for membrane stiffness was applied to the deviator stress.





Rupture Envelope at Failure
α = ° a = (tsf)

---------- Effective ϕ': ° c'= (tsf)
_____ Total ϕ: ° c= (tsf)

9530 James Avenue South

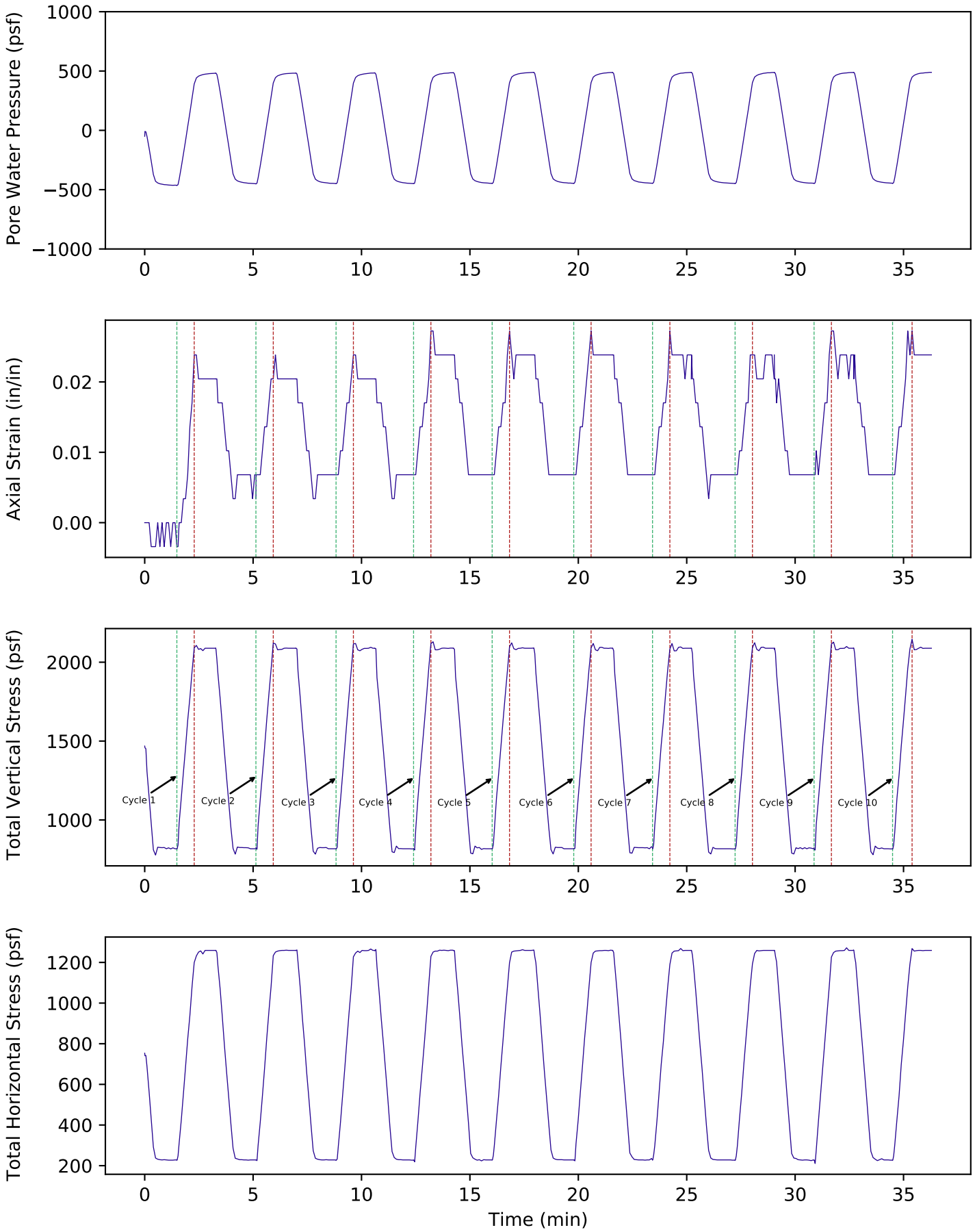
OIL ENGINEERING TESTING, INC.

Bloomington, Minnesota 55431

Triaxial Data

Boring: B129 Sample: Cycled Depth: 8.5-10.5 Job: 12987 Date: 2/23/21

Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.36	0.00												
0.17	0.73	0.00												
0.34	0.89	0.00												
0.51	1.00	-0.02												
0.68	1.12	-0.03												
0.85	1.21	-0.05												
1.02	1.29	-0.07												
1.19	1.35	-0.09												
1.36	1.40	-0.11												
1.53	1.44	-0.13												
1.70	1.48	-0.14												
1.87	1.51	-0.16												
2.03	1.53	-0.17												
2.20	1.56	-0.19												
2.38	1.58	-0.20												
2.55	1.60	-0.22												
2.71	1.61	-0.23												
2.88	1.63	-0.24												
3.05	1.64	-0.25												
3.22	1.66	-0.26												
3.39	1.67	-0.26												
3.73	1.70	-0.28												
4.07	1.72	-0.30												
4.41	1.73	-0.31												
4.75	1.75	-0.32												
5.09	1.76	-0.33												
5.43	1.75	-0.34												
6.11	1.76	-0.35												
6.78	1.76	-0.37												
7.46	1.78	-0.37												
8.14	1.78	-0.38												
8.82	1.77	-0.39												
9.50	1.77	-0.39												
10.17	1.76	-0.39												
10.85	1.76	-0.39												
11.53	1.75	-0.39												
12.21	1.74	-0.40												
12.89	1.72	-0.40												
13.57	1.72	-0.40												
15.26	1.69	-0.40												
16.96	1.67	-0.40												
18.65	1.64	-0.39												
20.12	1.61	-0.39												



Barr Engineering Co
Nobles Wind Farm
23531012

Variables vs Time
March 2021
B12
Stress Path Data

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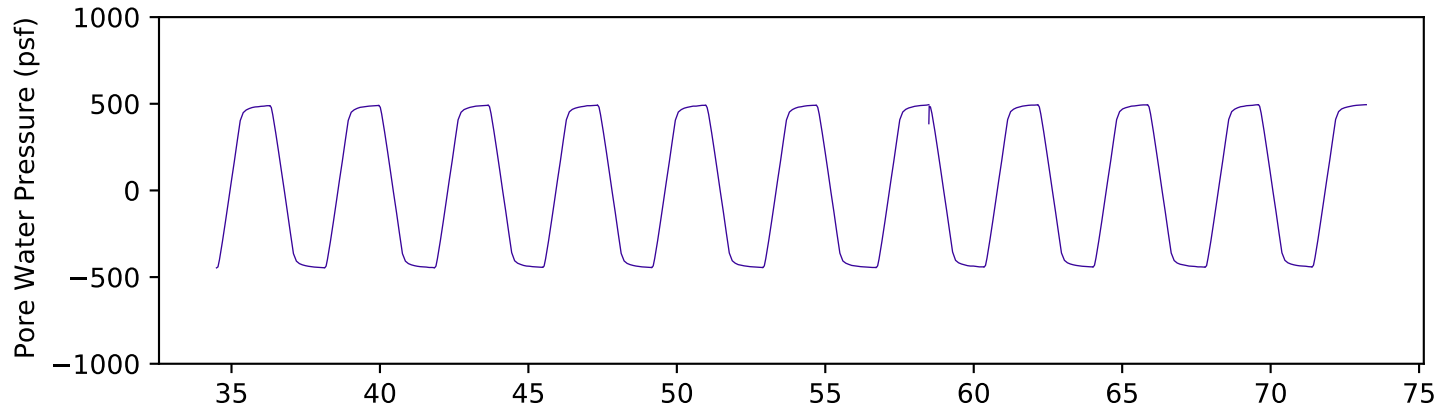

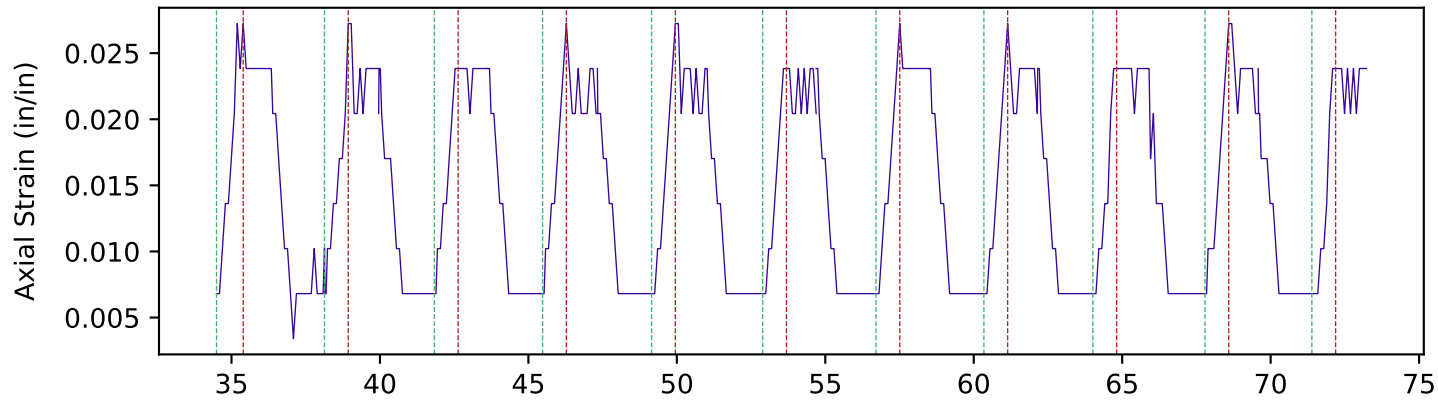

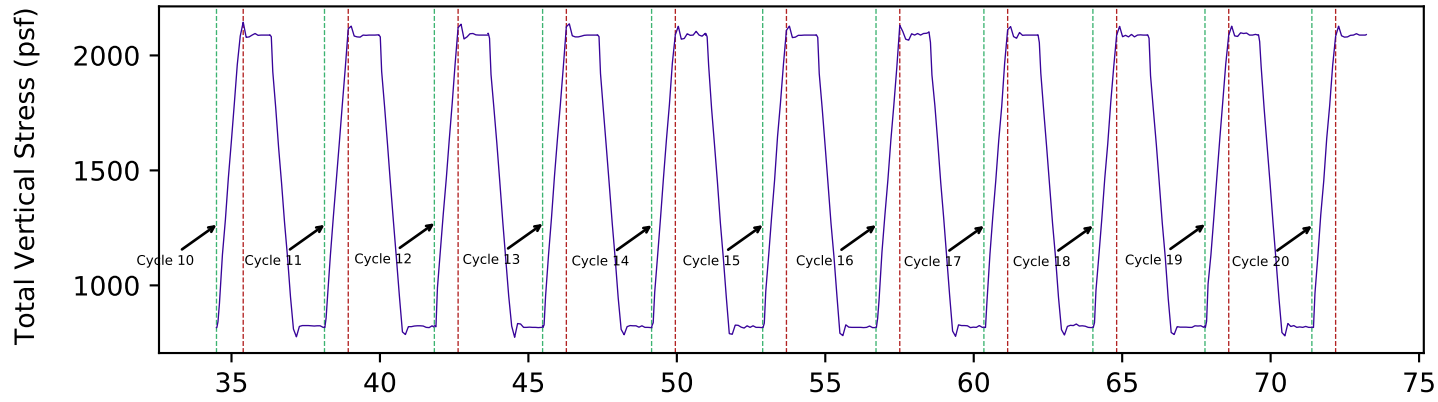

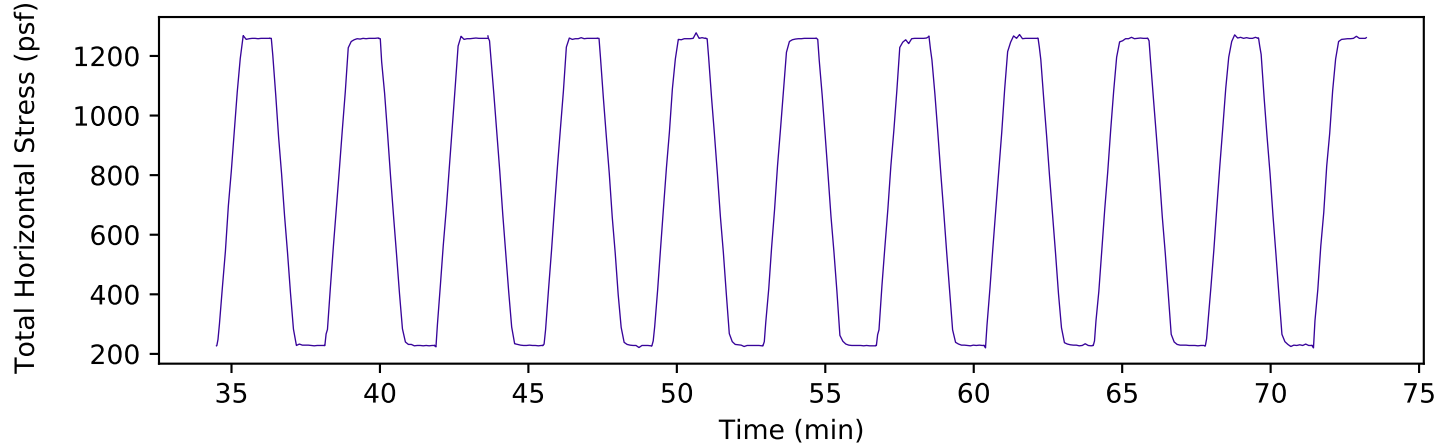

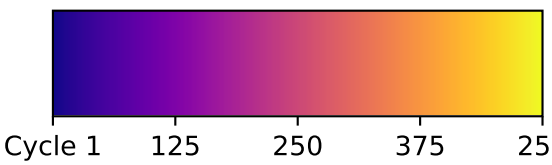

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Variables vs Time
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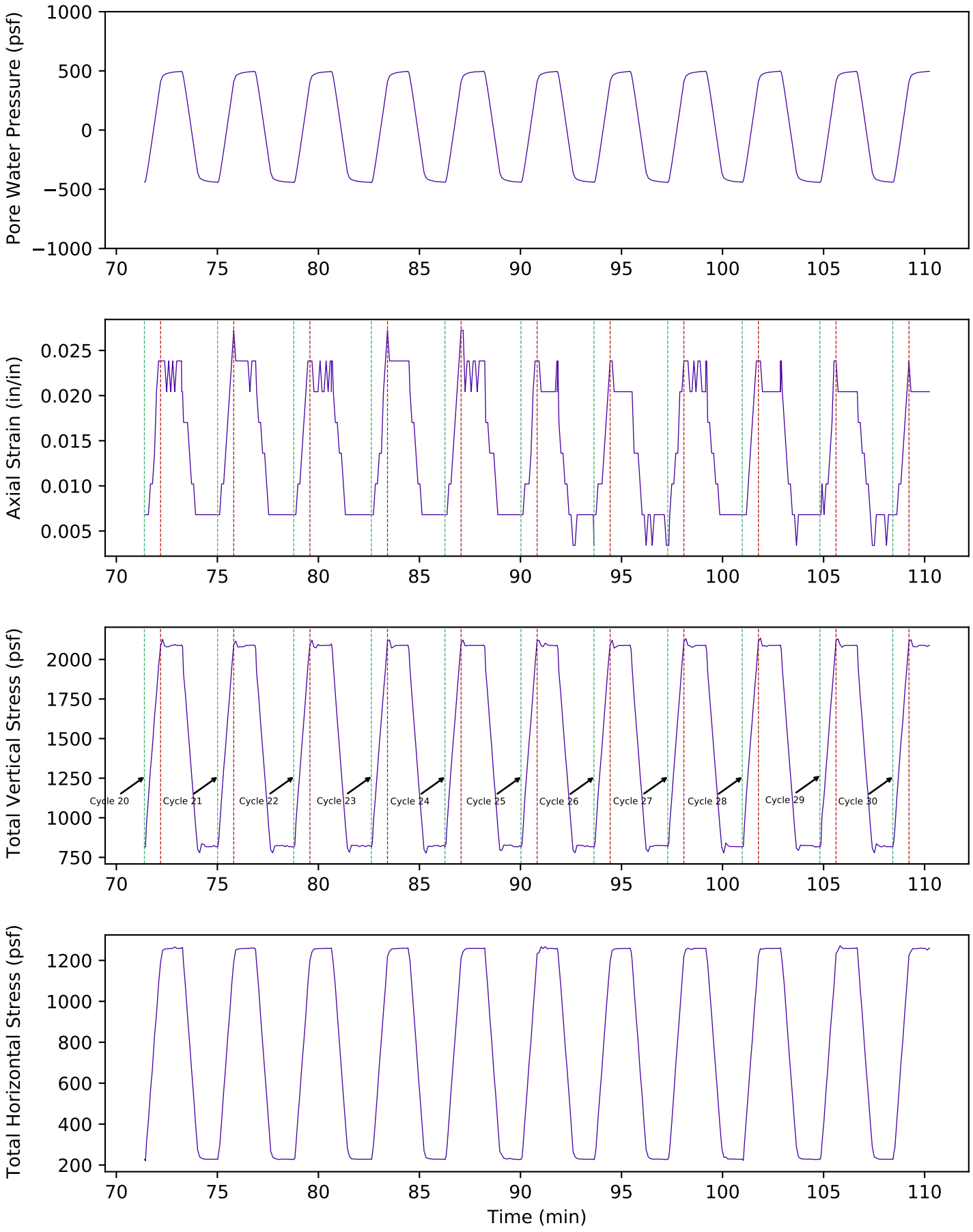

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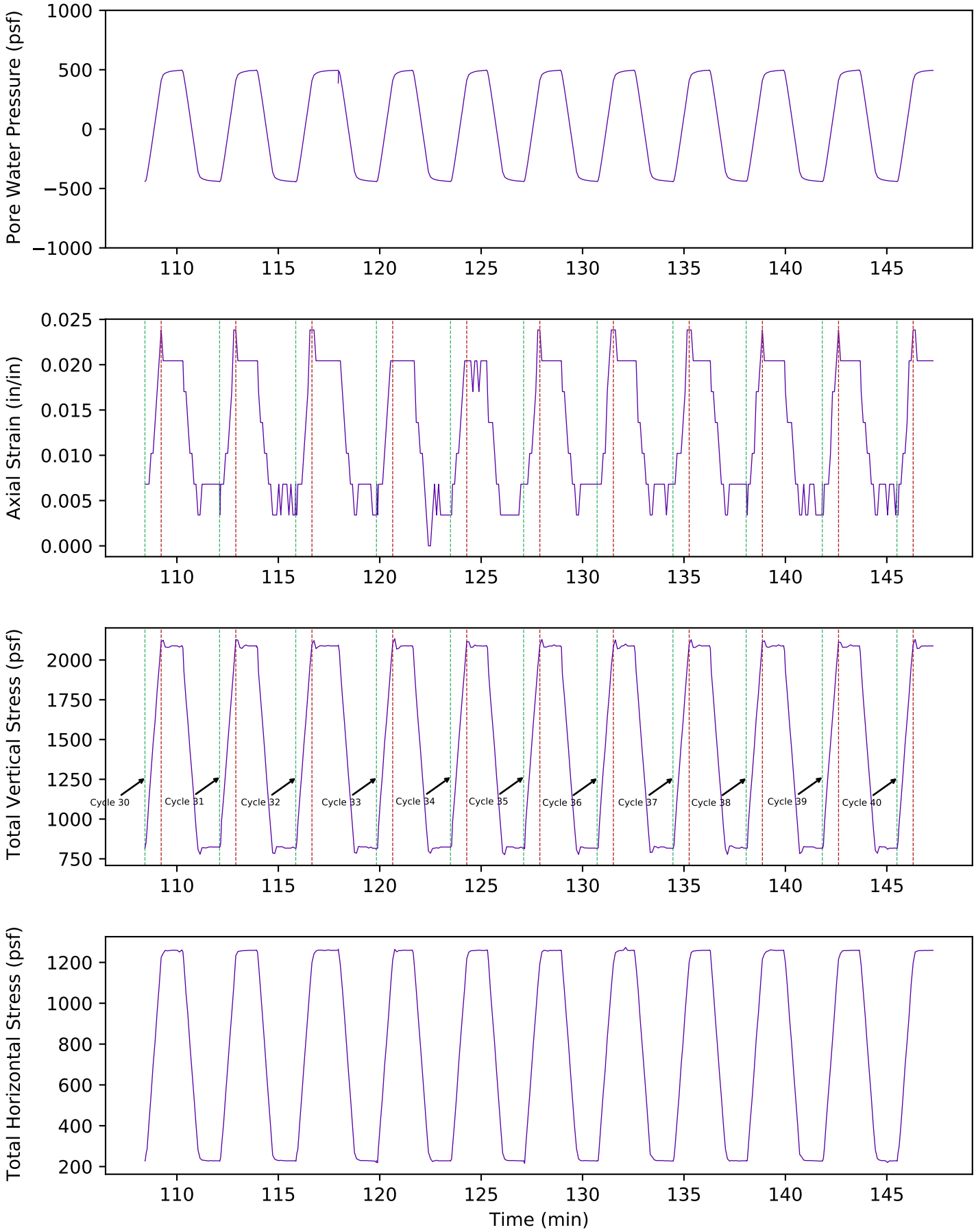

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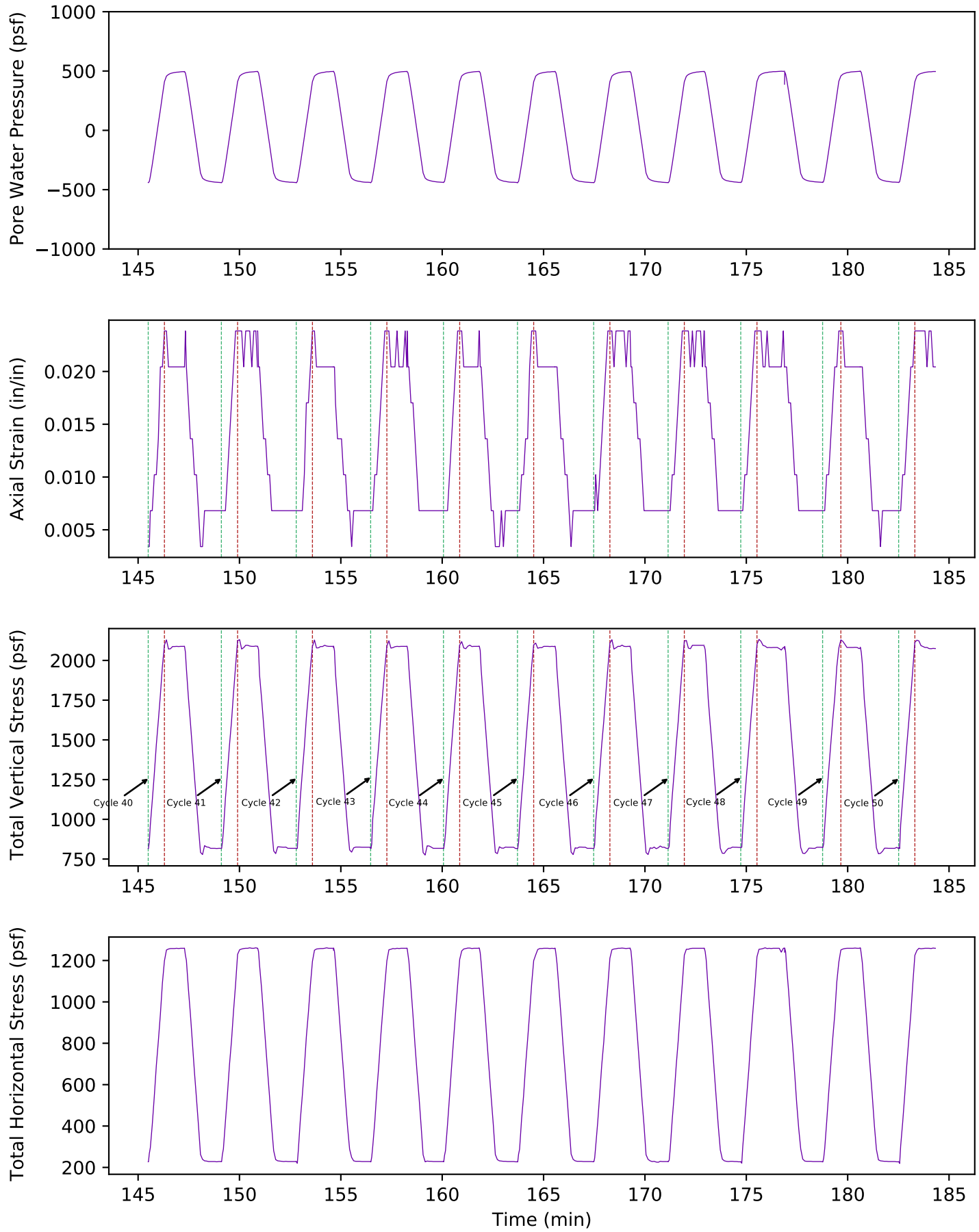

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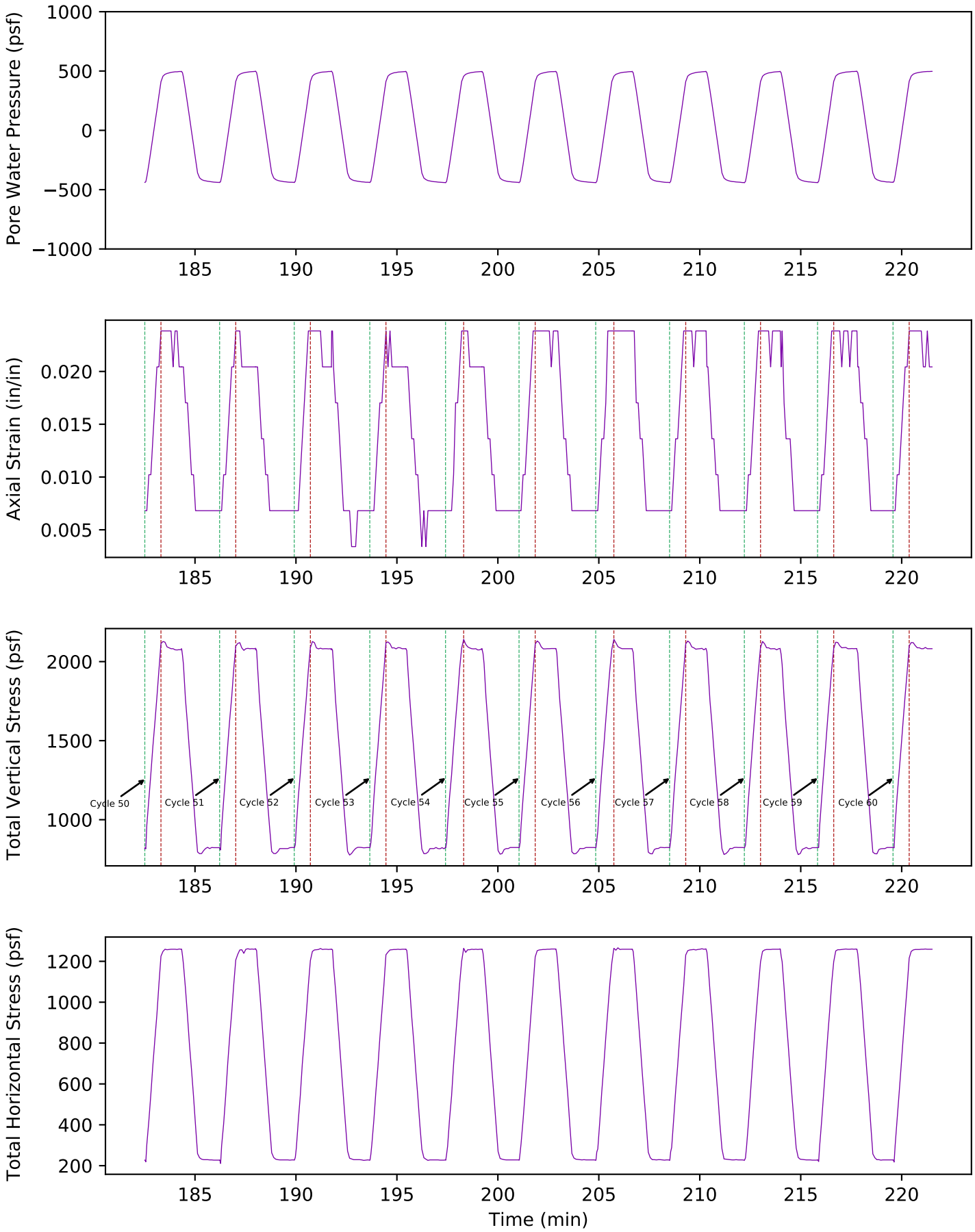

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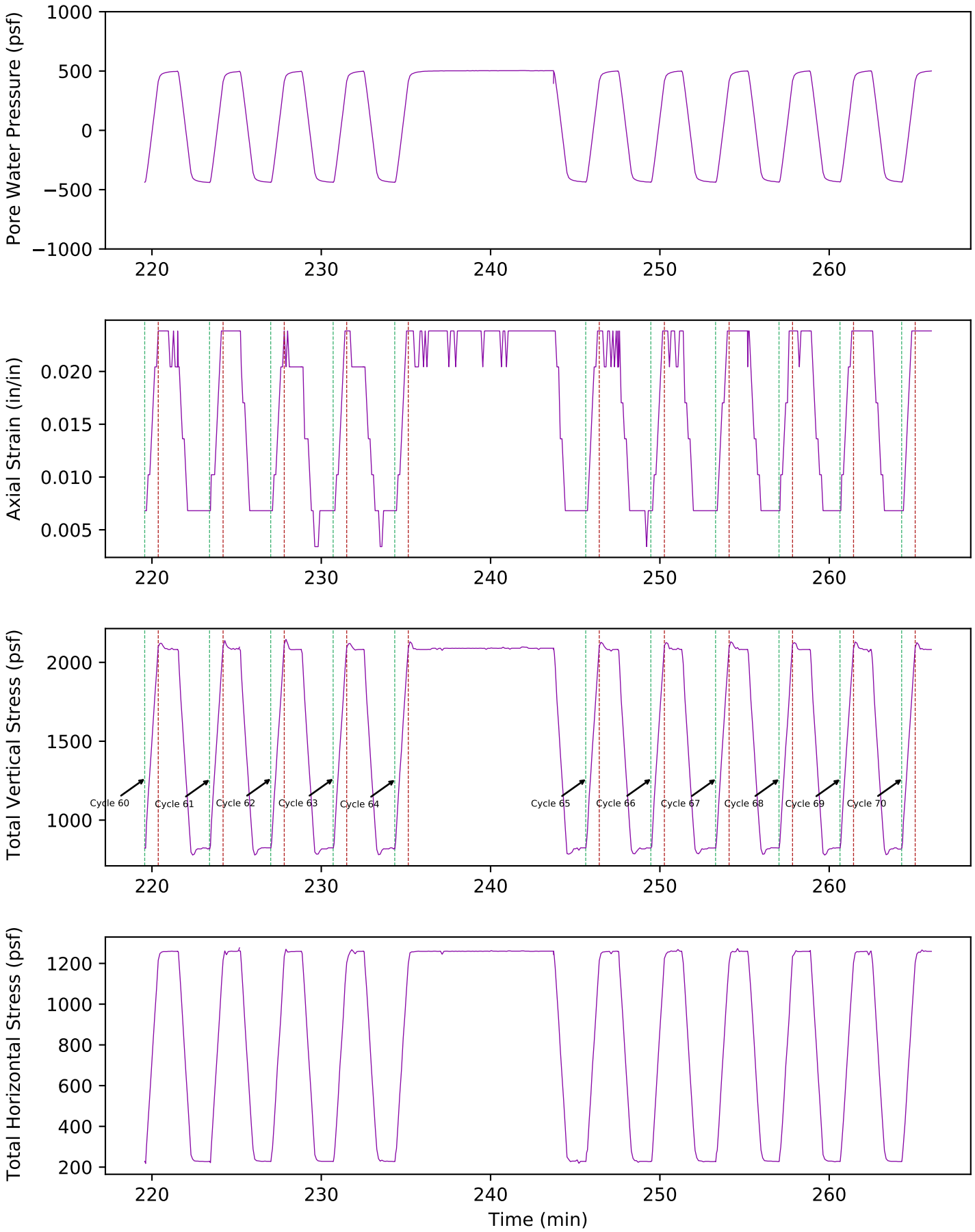

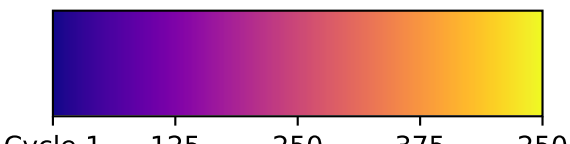

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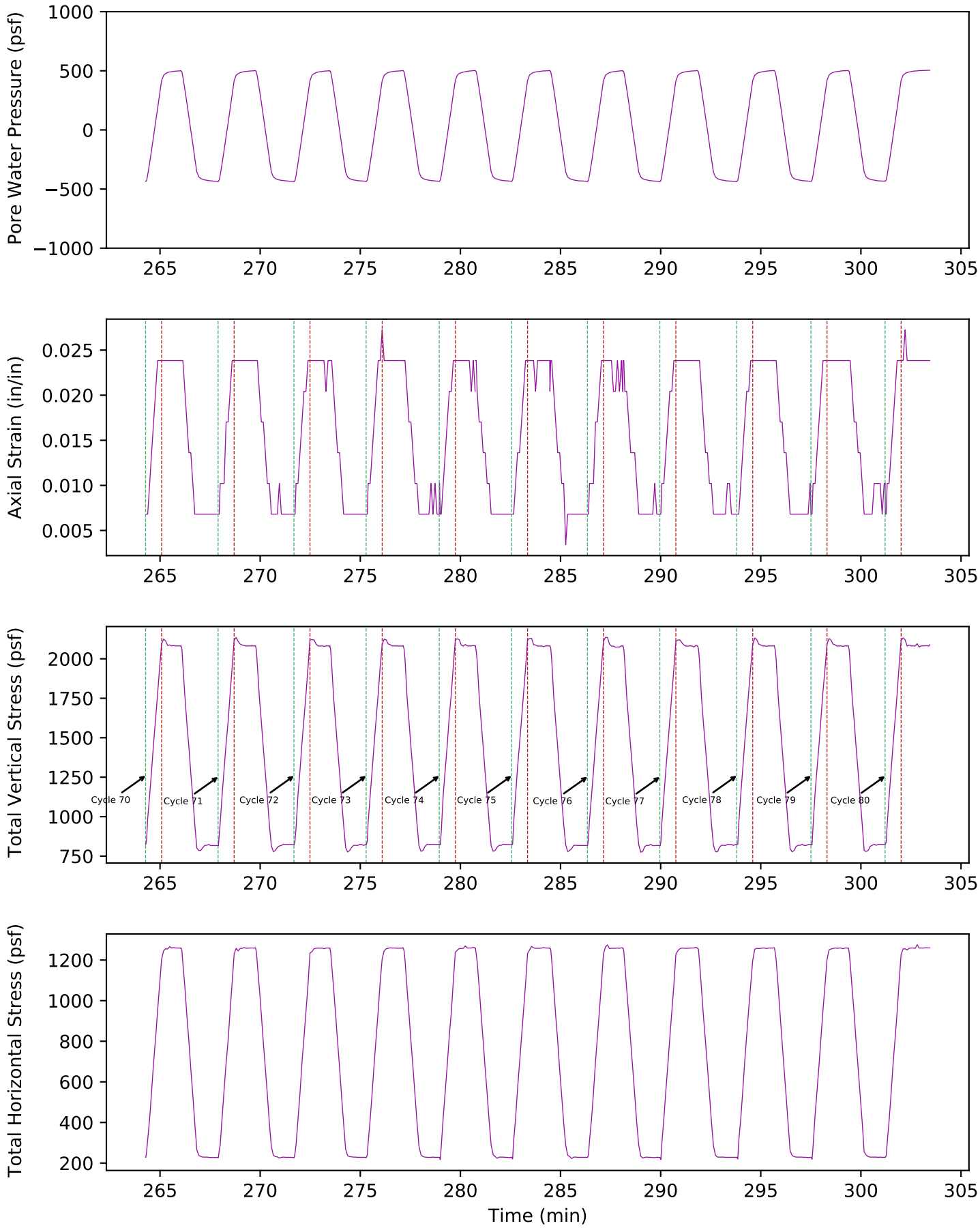

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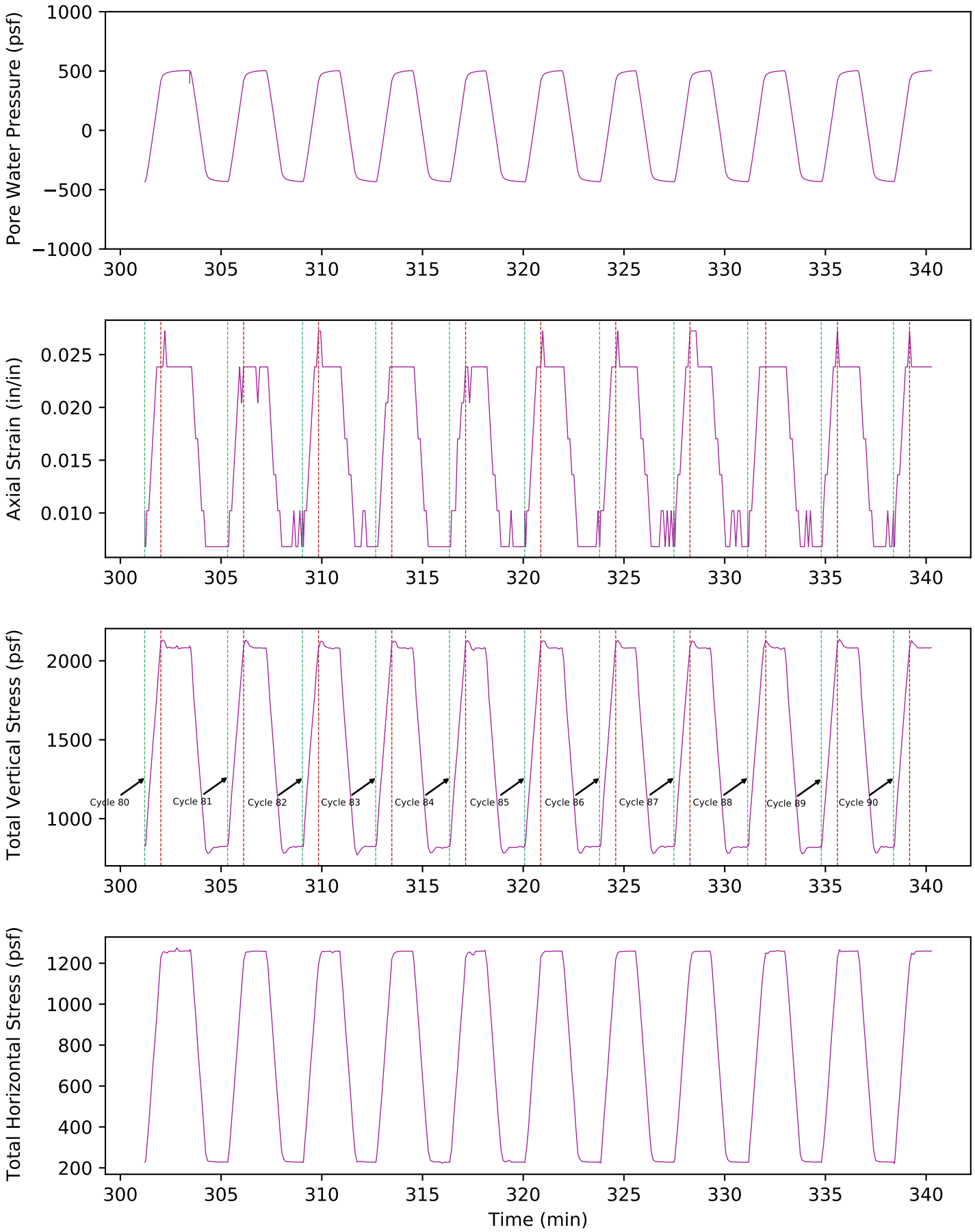

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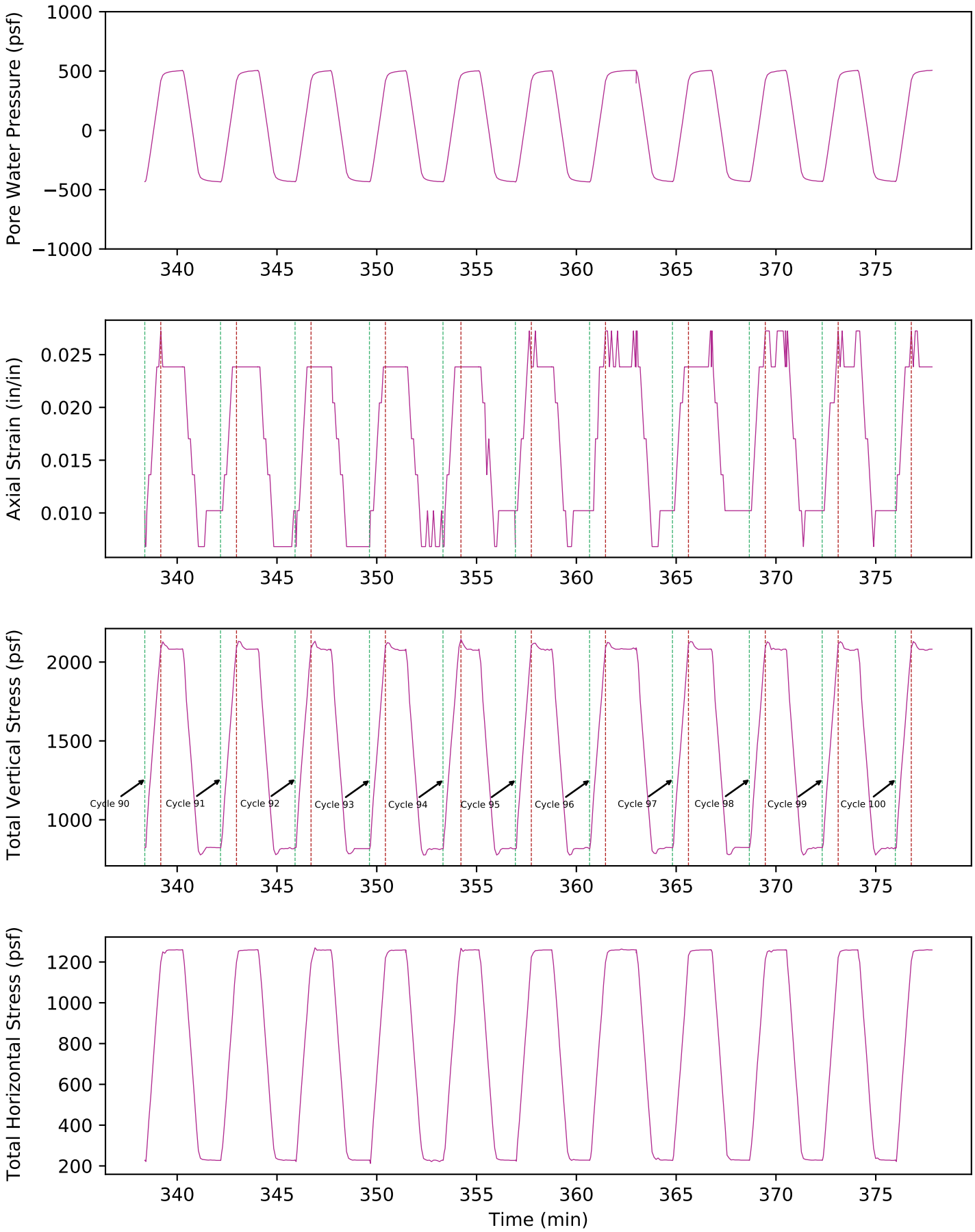

Cycle 1 125 250 375 250

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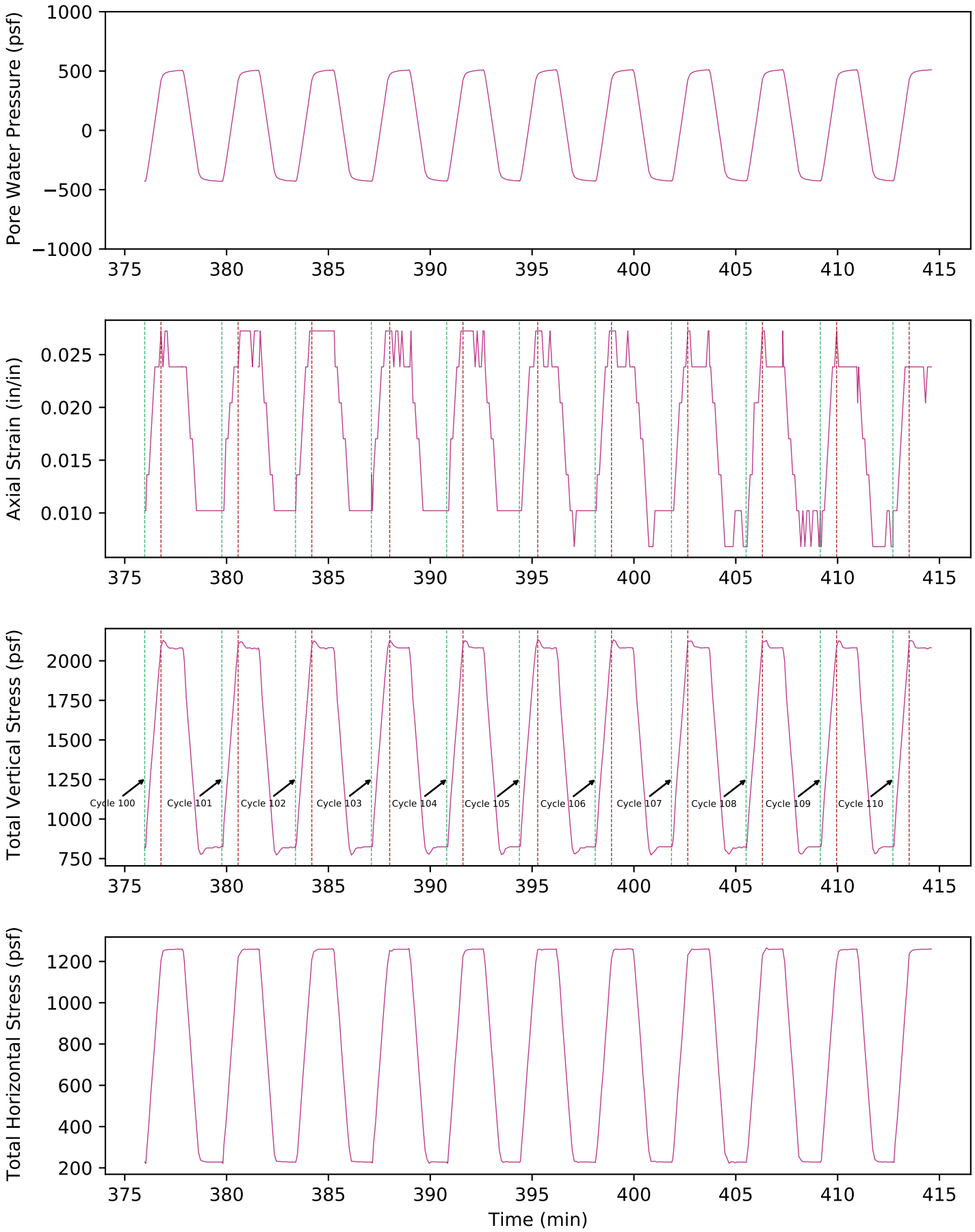

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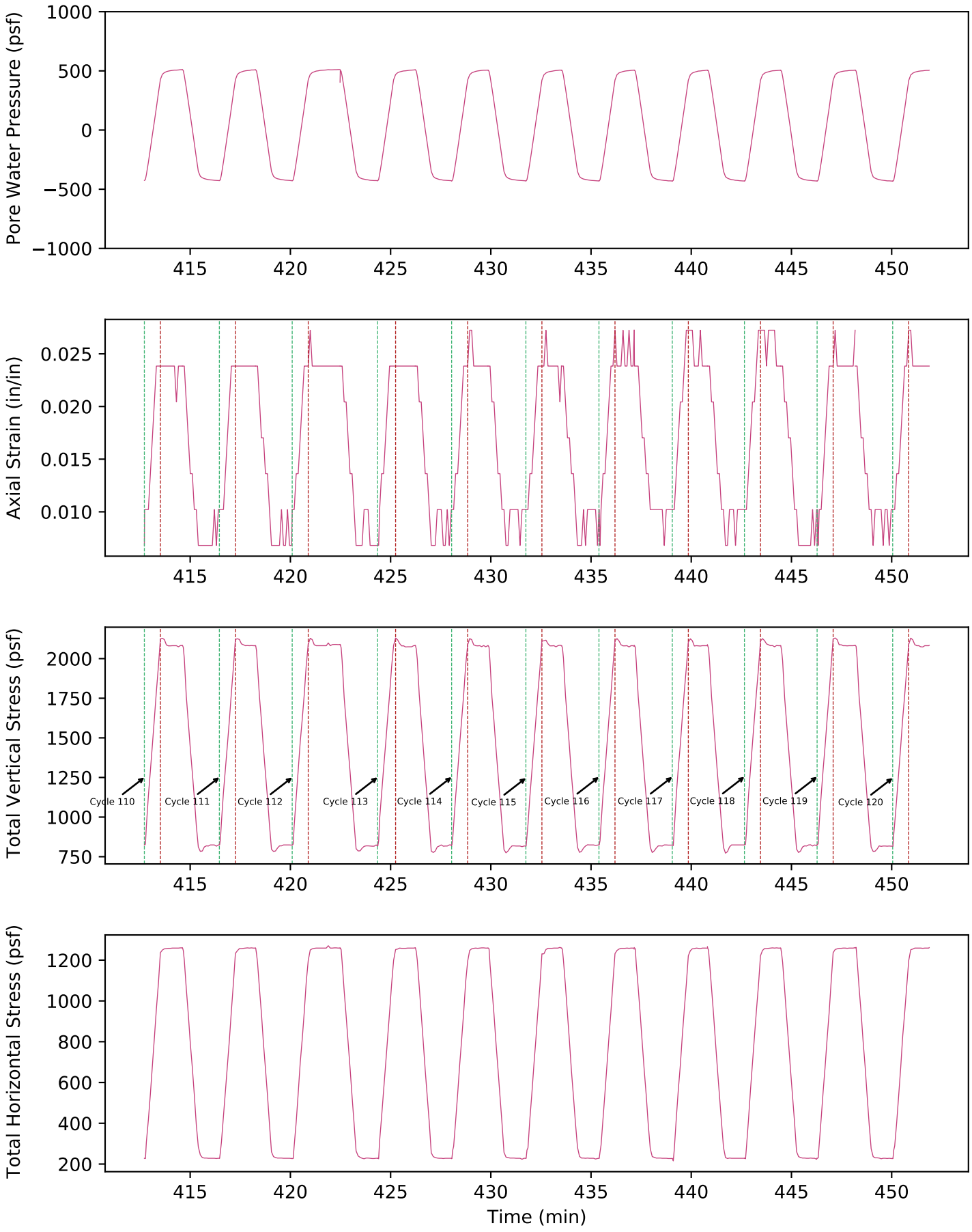

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Variables vs Time
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Stress Path Data

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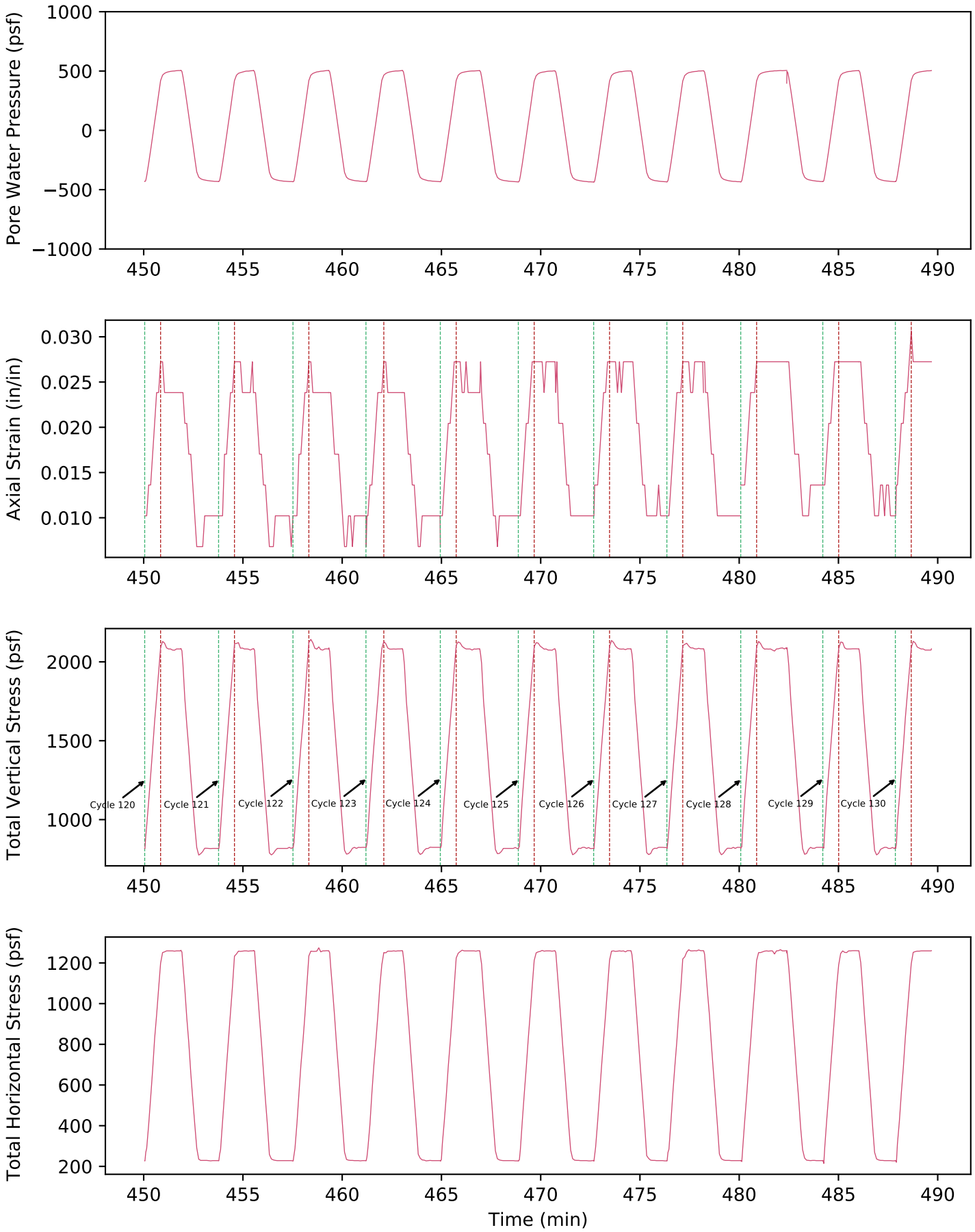

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Variables vs Time
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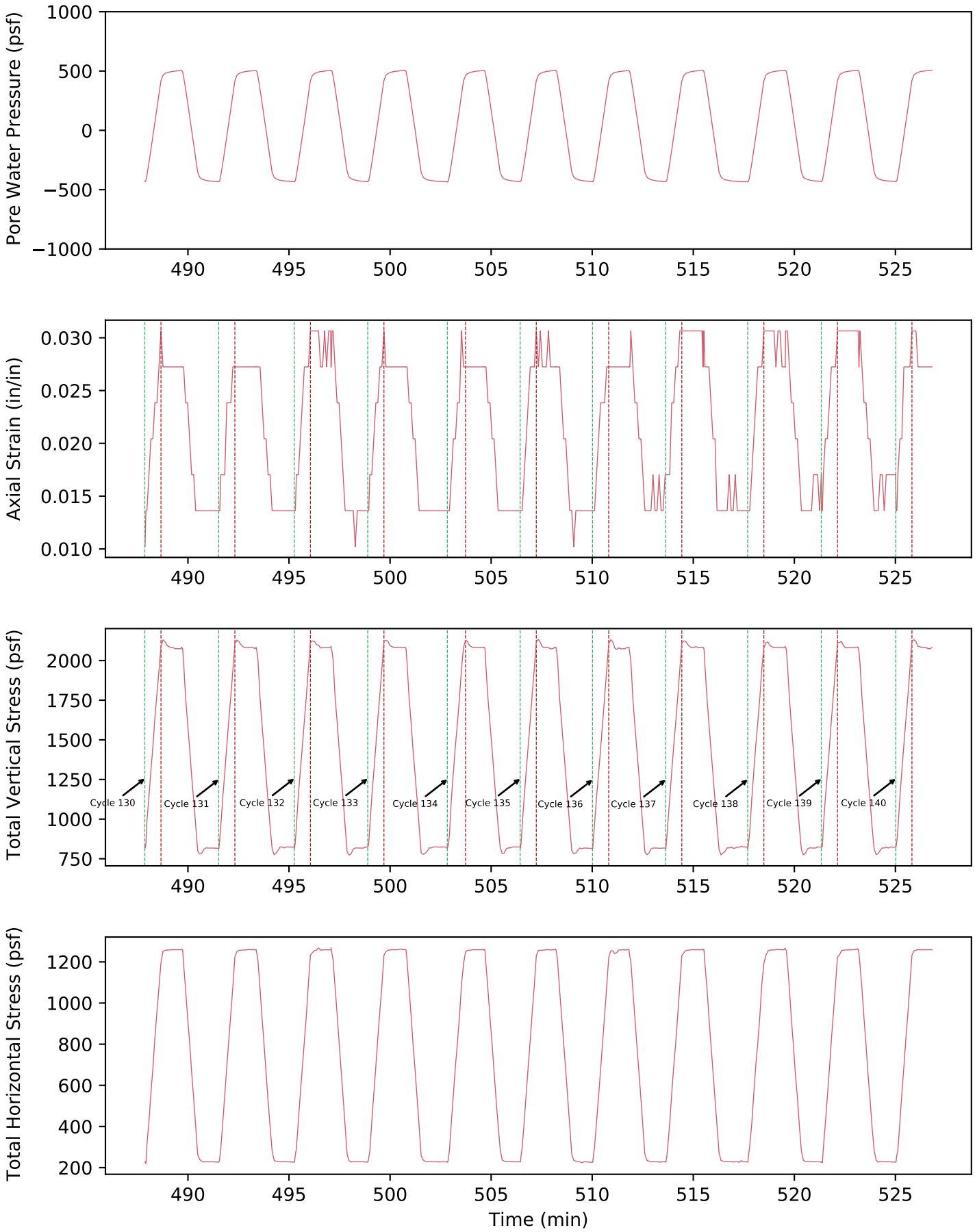

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Variables vs Time
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B12
Stress Path Data

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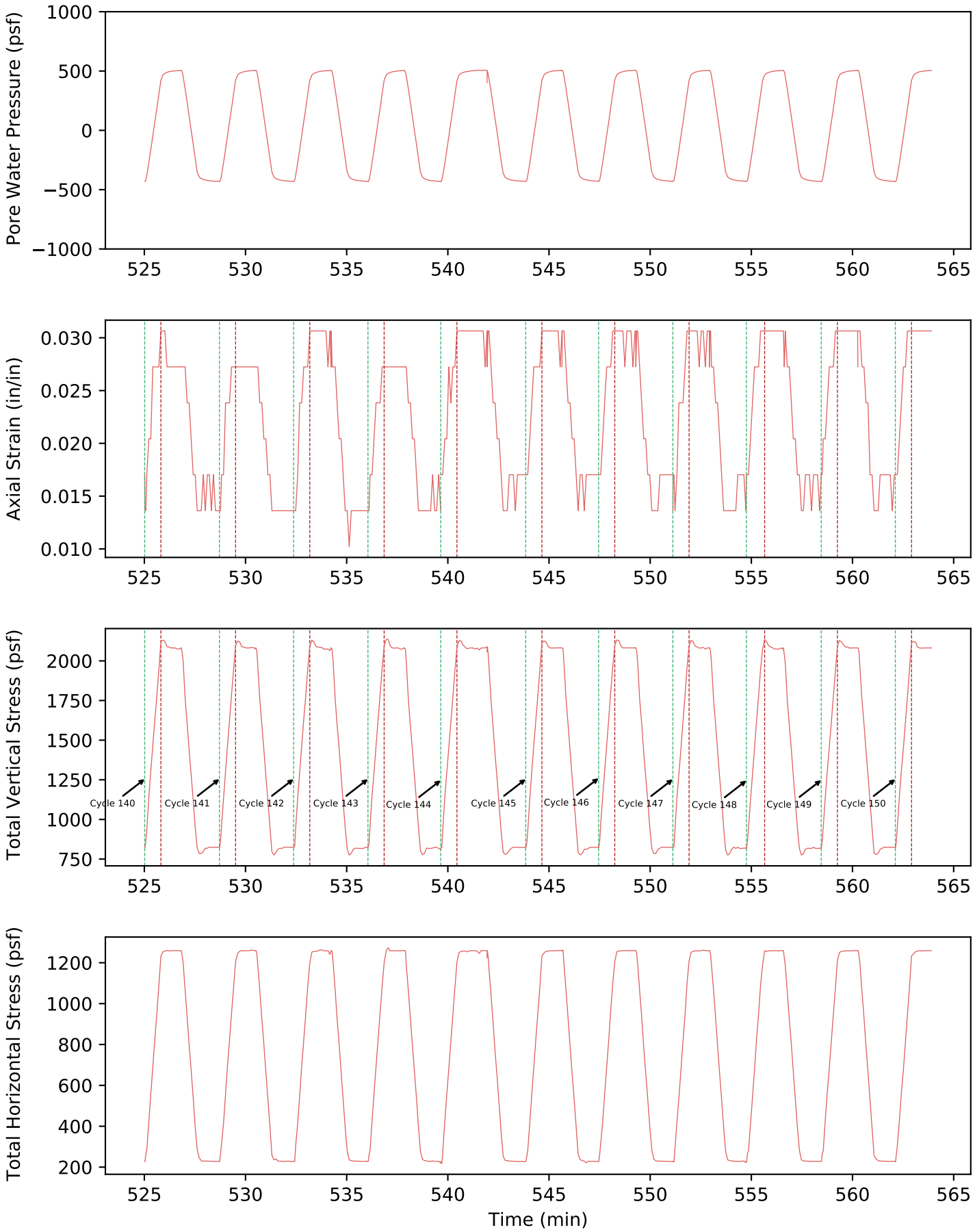

Barr Engineering Co
Nobles Wind Farm
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Variables vs Time
March 2021
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Stress Path Data

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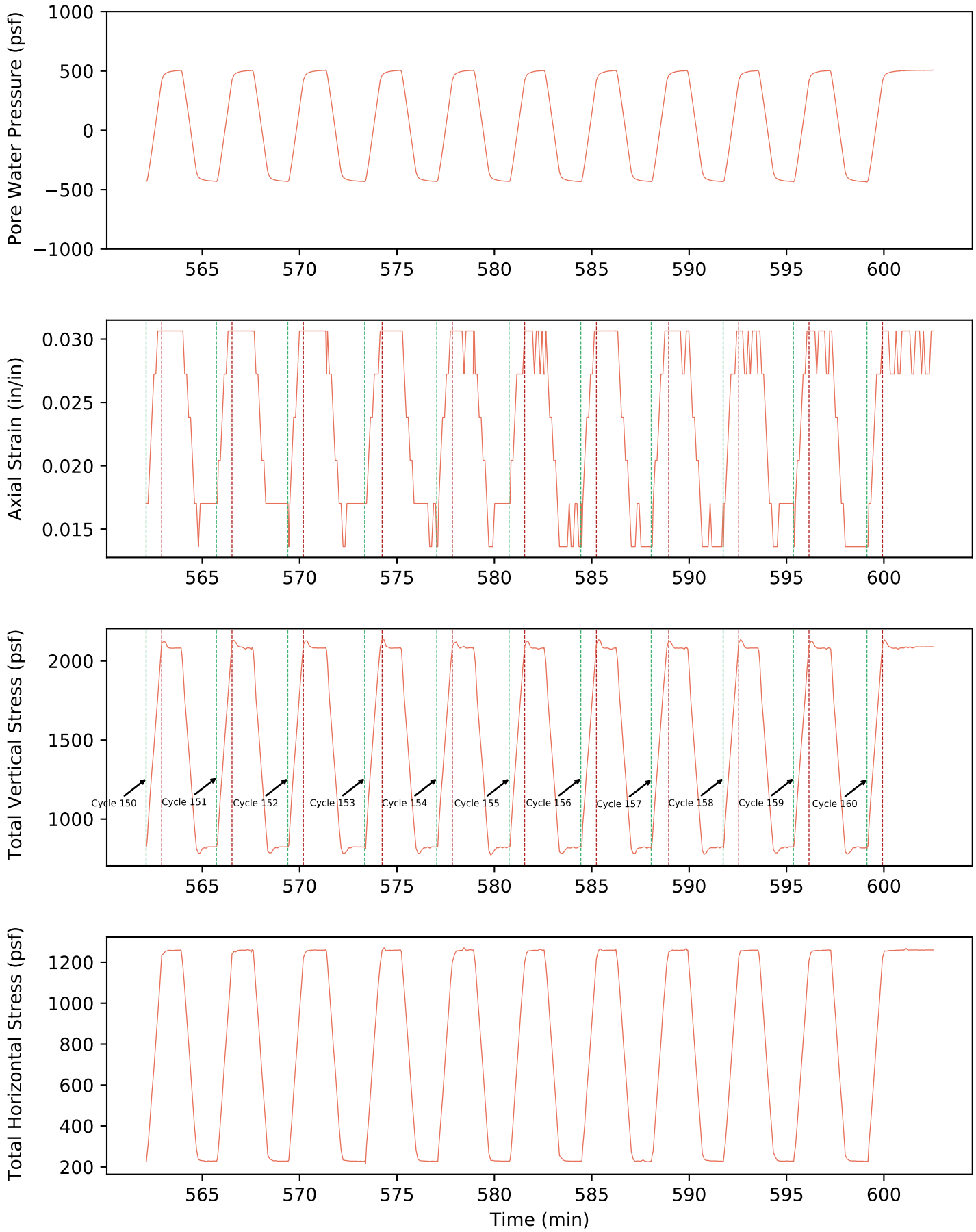

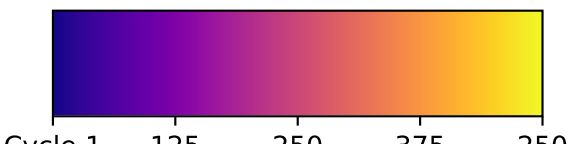

Barr Engineering Co
Nobles Wind Farm
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Variables vs Time
March 2021
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Stress Path Data

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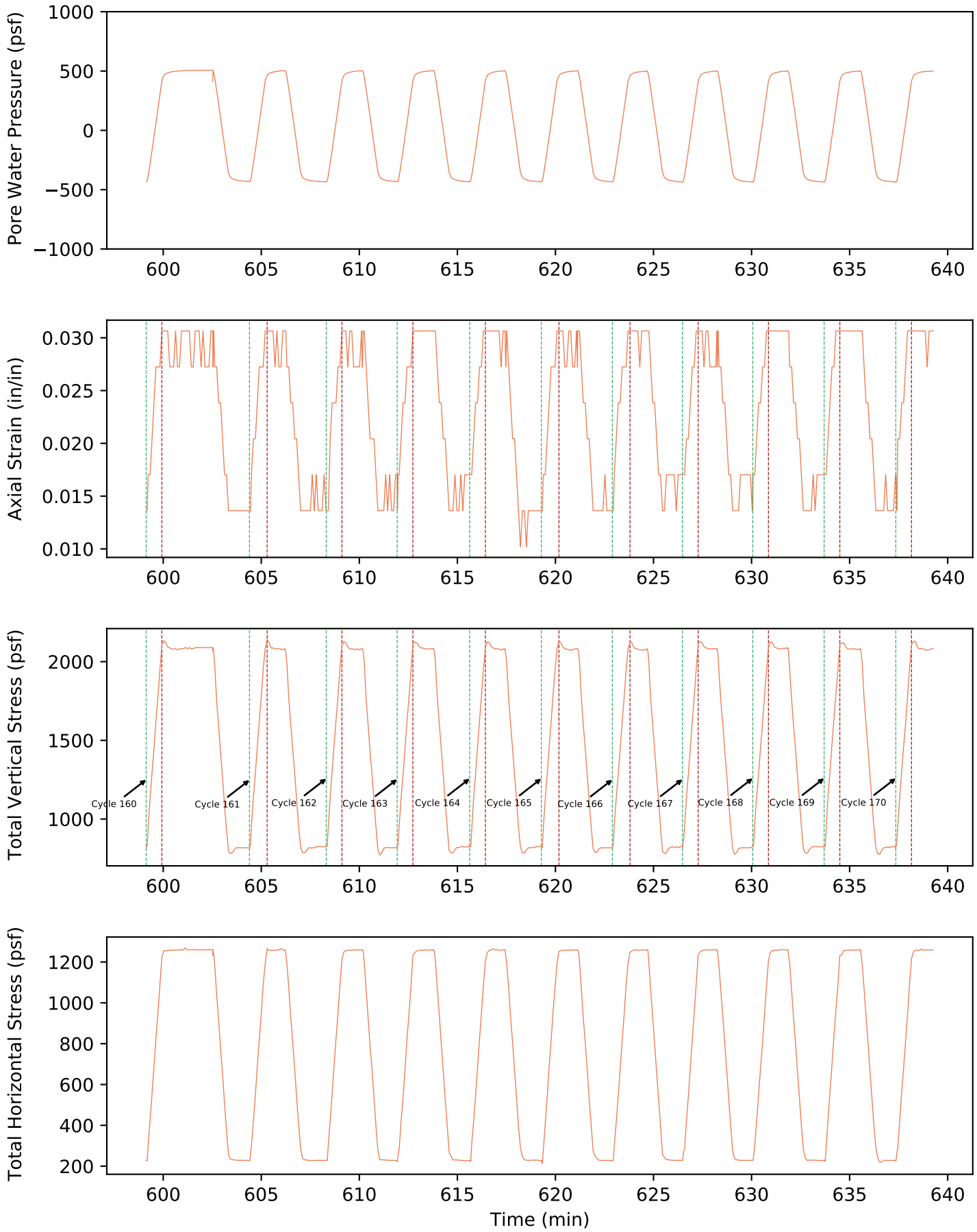

Barr Engineering Co
Nobles Wind Farm
23531012

Variables vs Time
March 2021
B12
Stress Path Data

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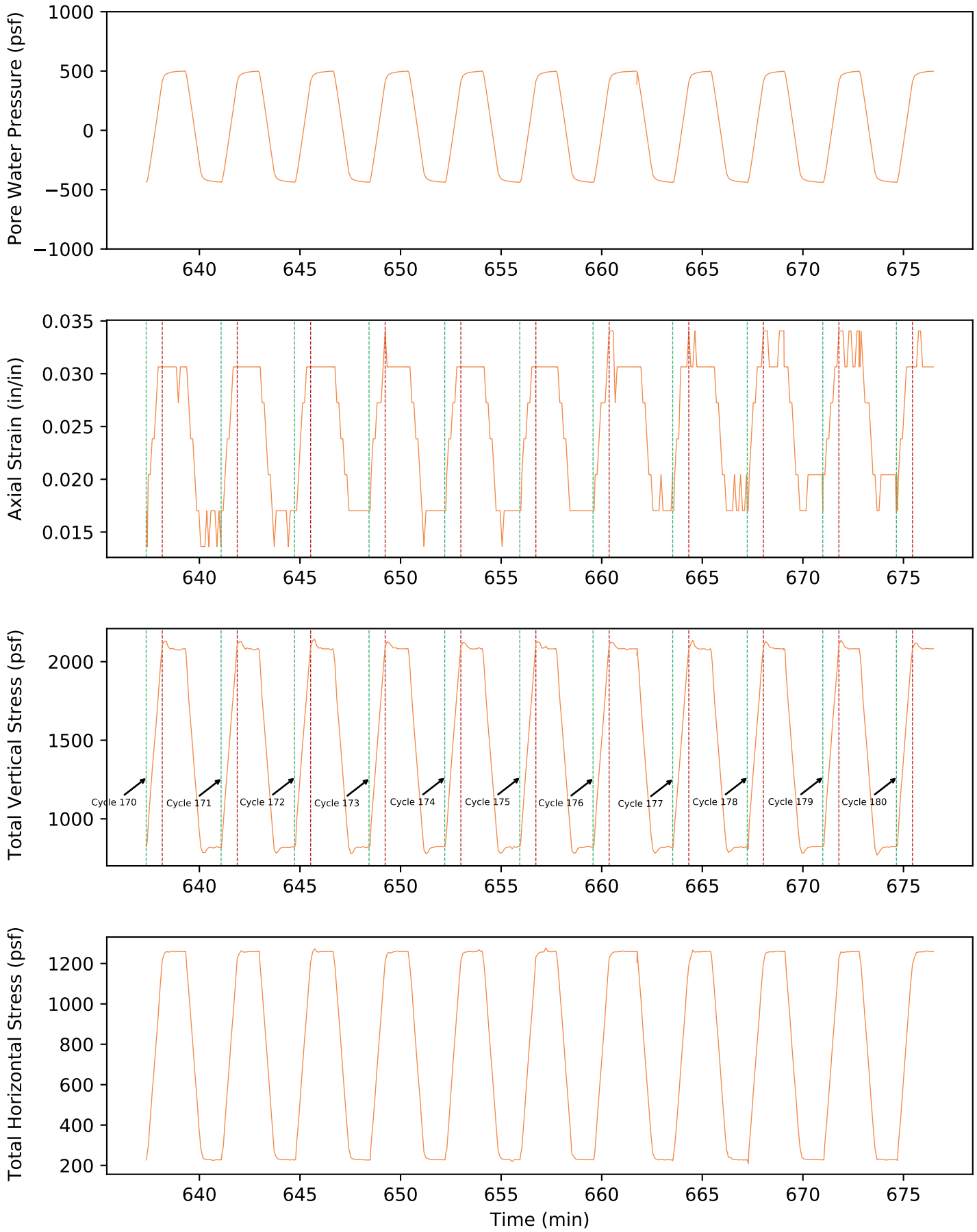

Barr Engineering Co
Nobles Wind Farm
23531012

Variables vs Time
March 2021
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Stress Path Data

BARR

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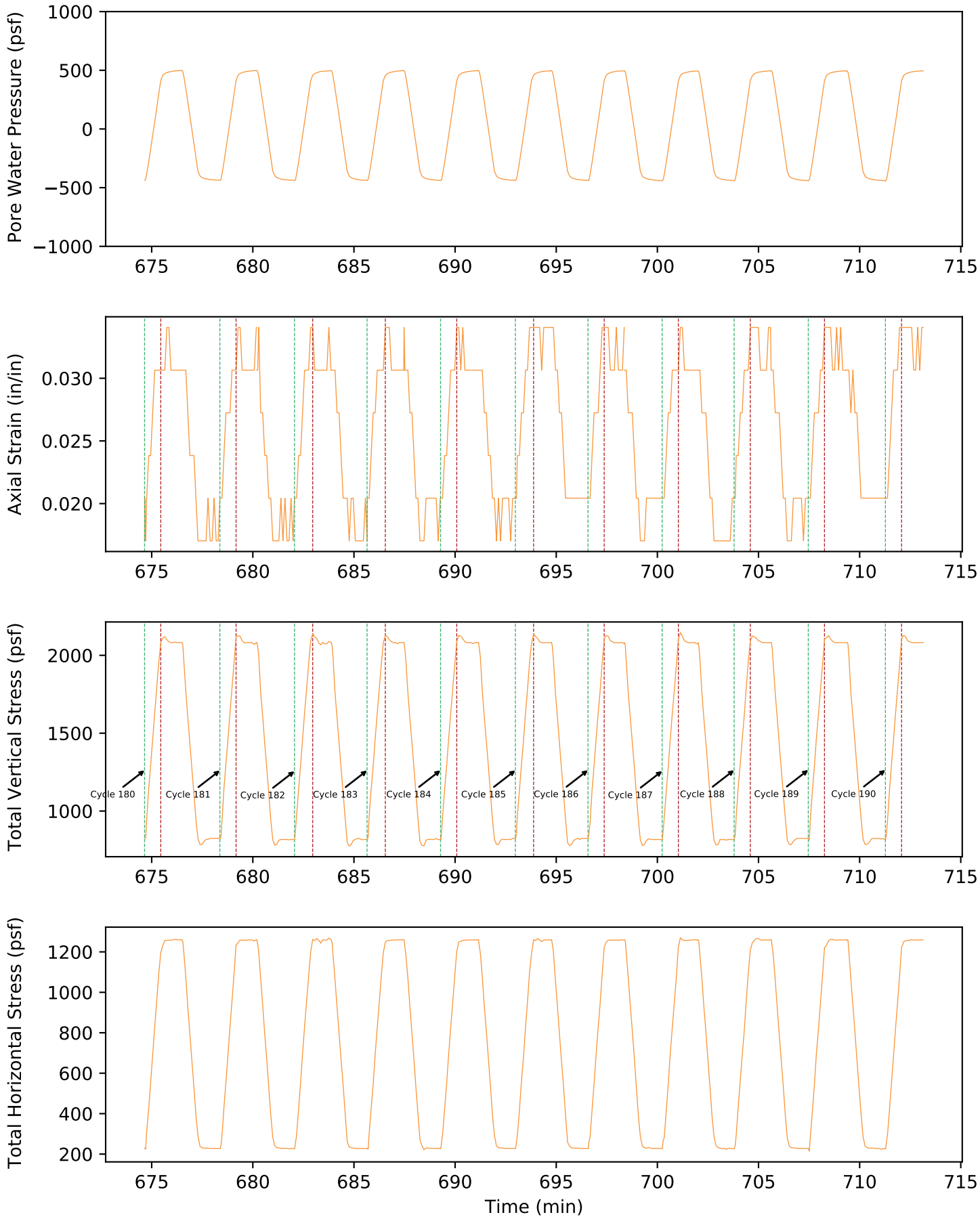

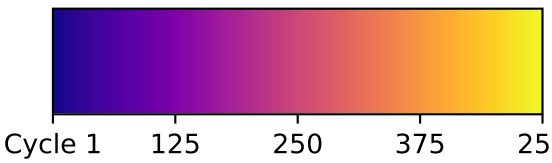

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Variables vs Time
March 2021
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Stress Path Data

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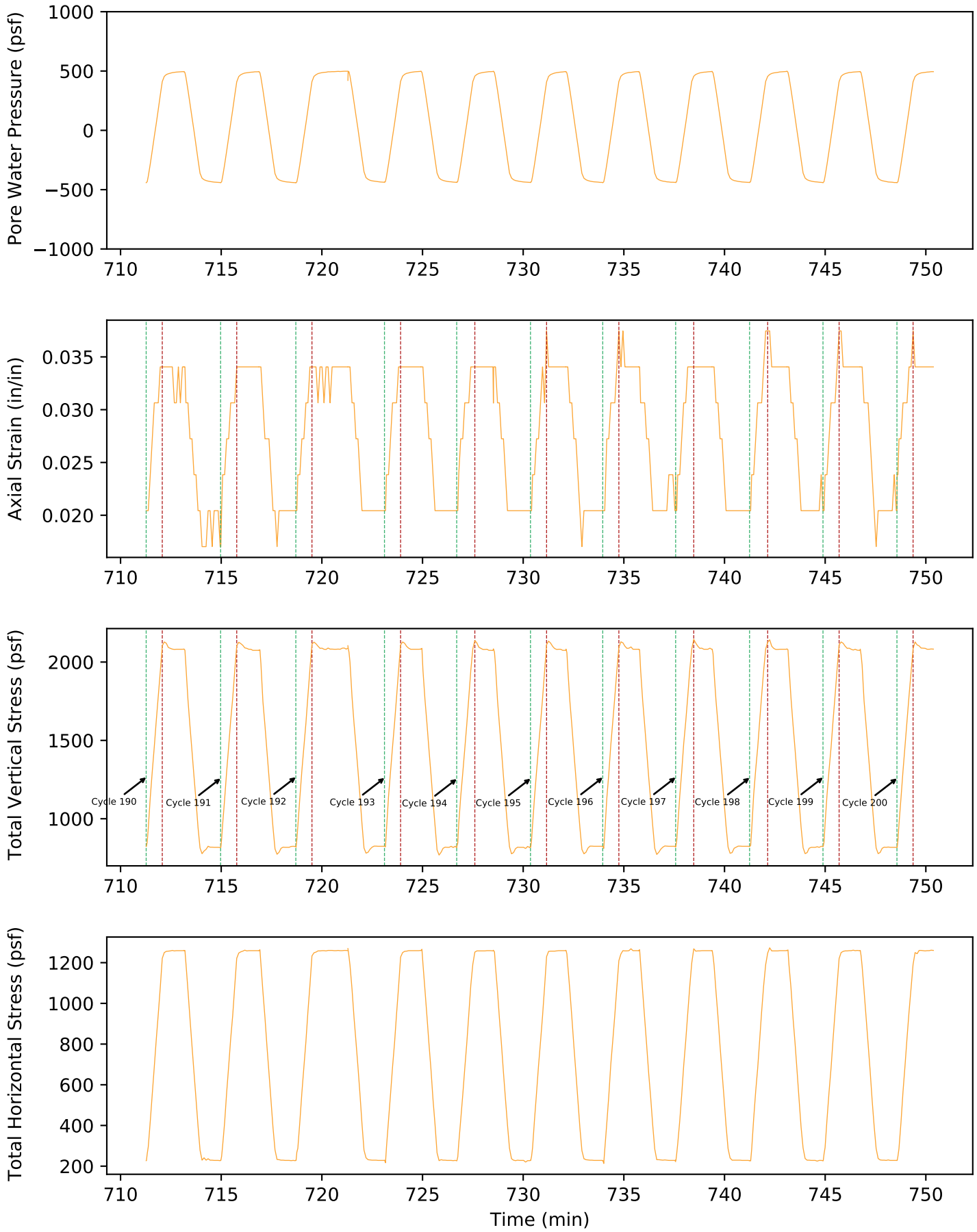

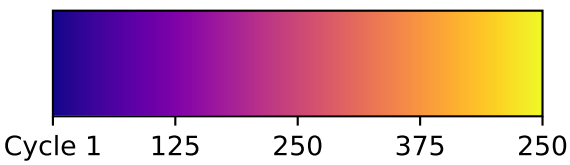

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Variables vs Time
March 2021
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Stress Path Data

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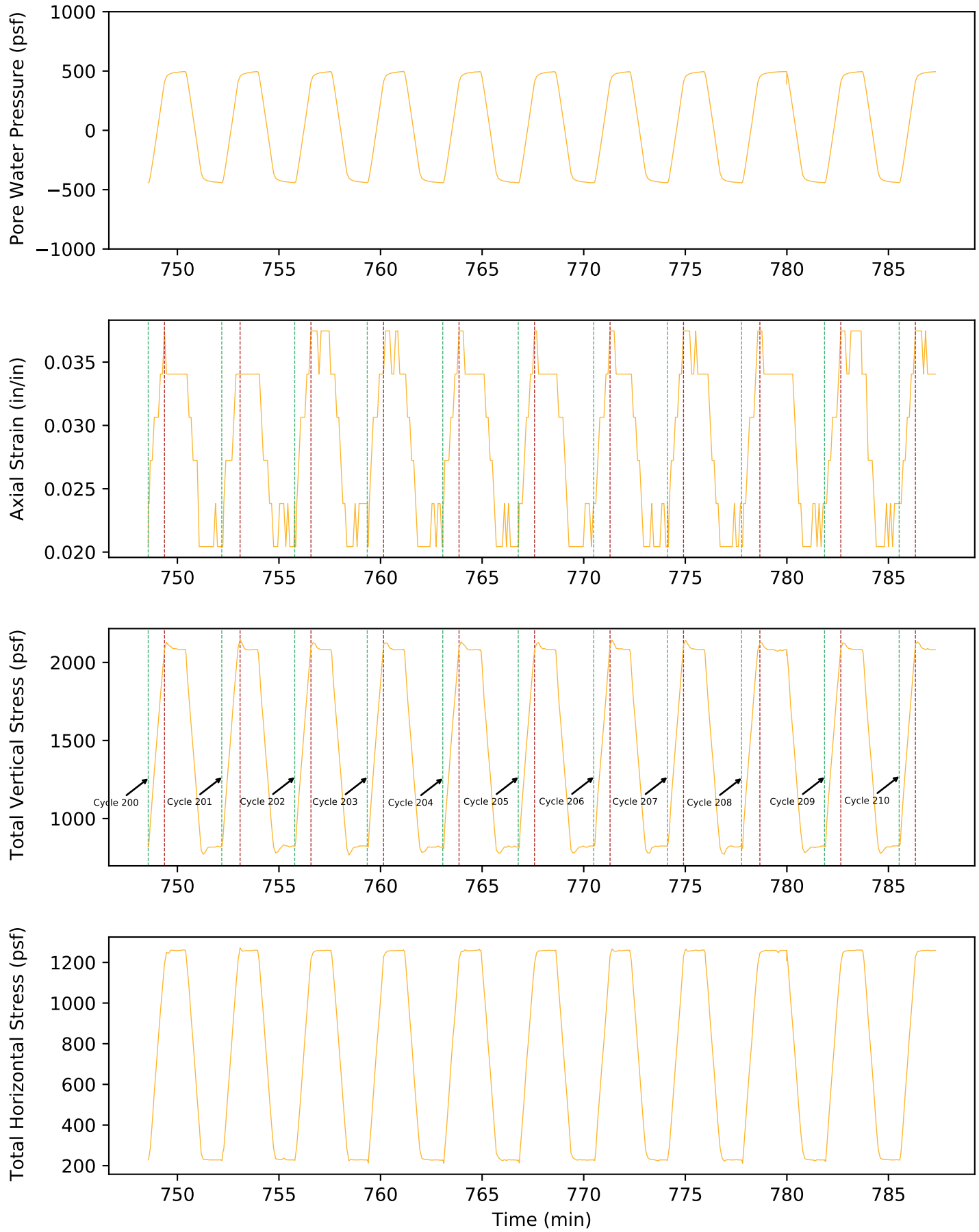

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Variables vs Time
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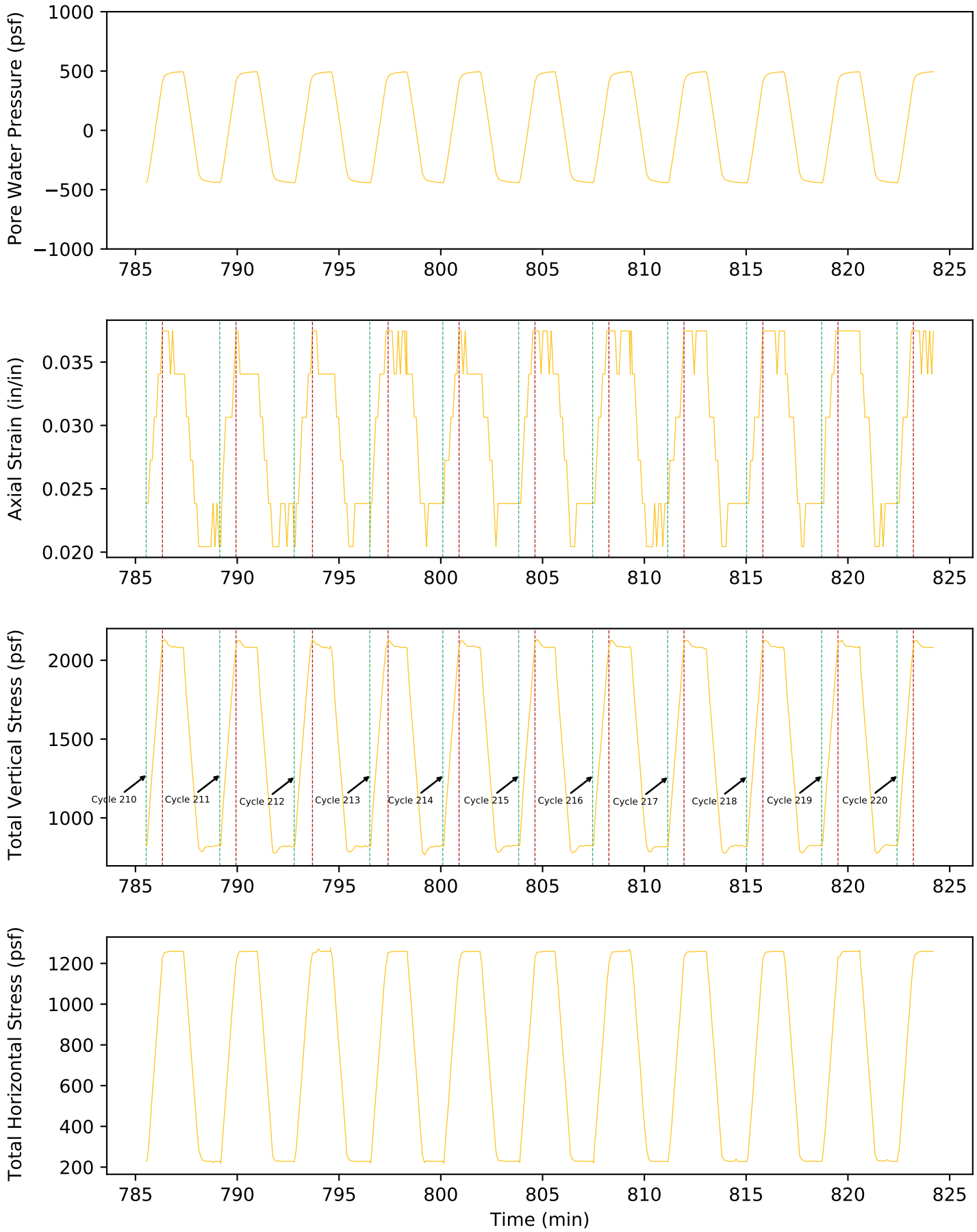

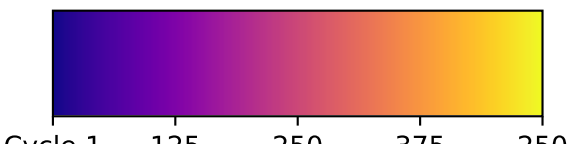

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Variables vs Time
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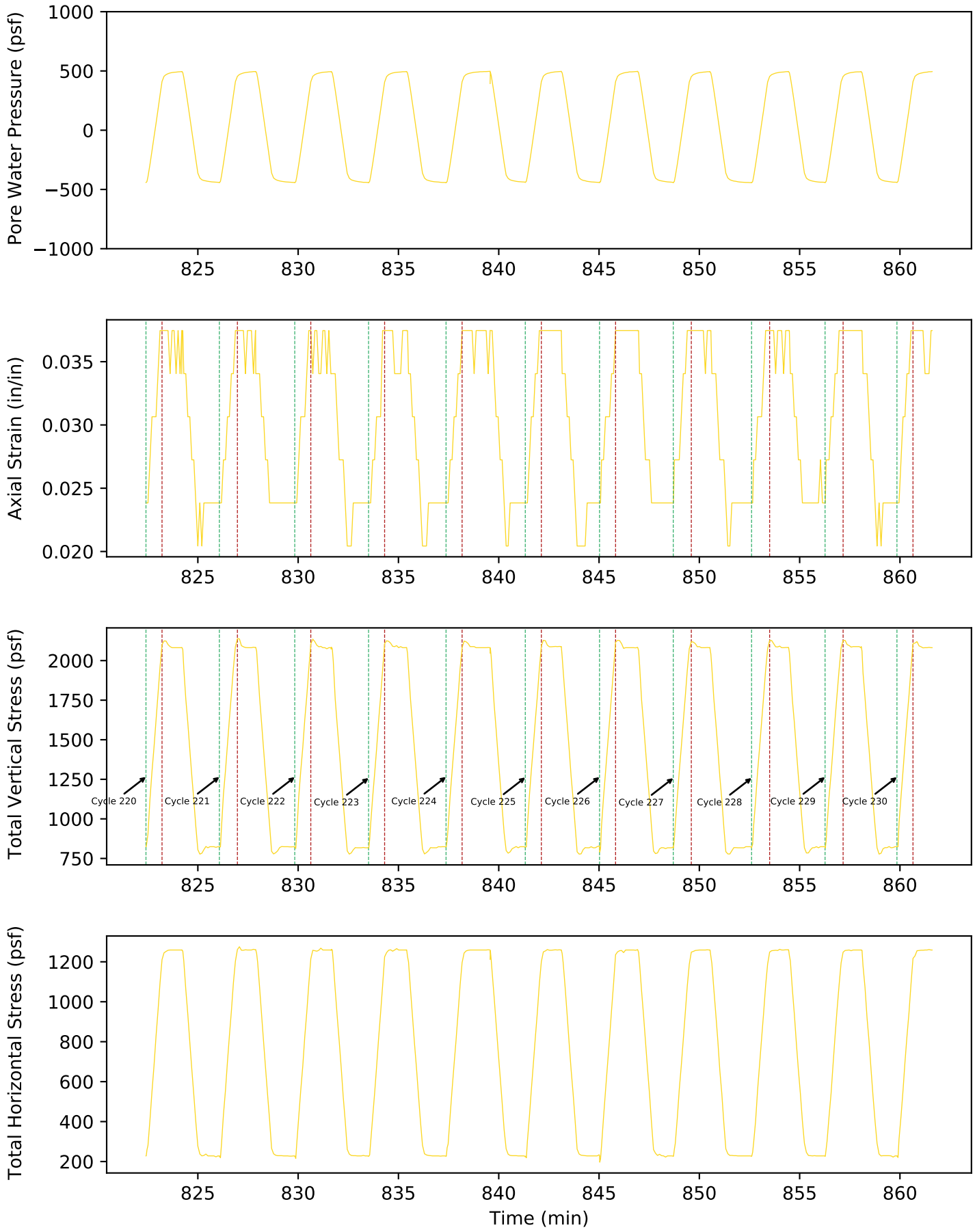

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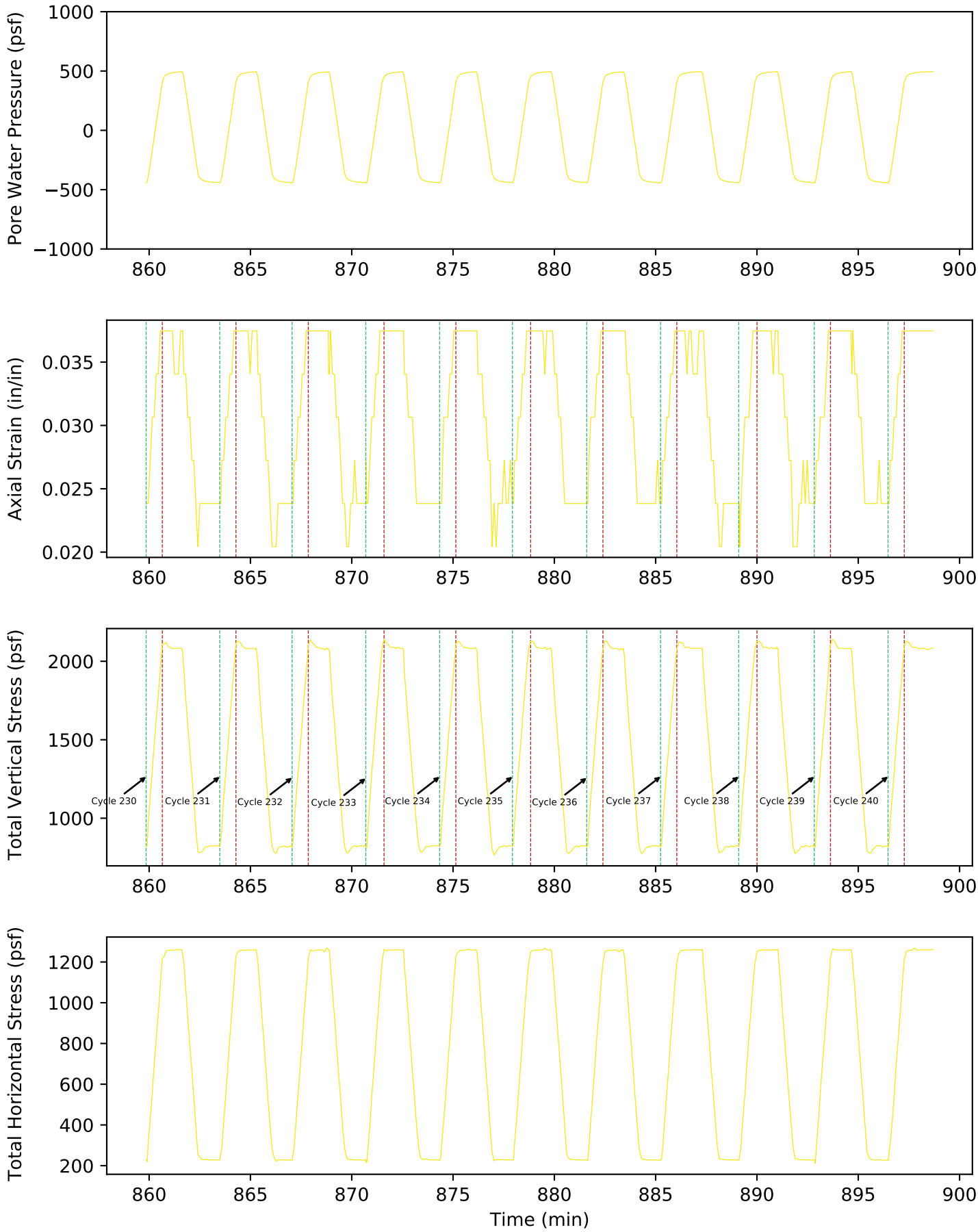

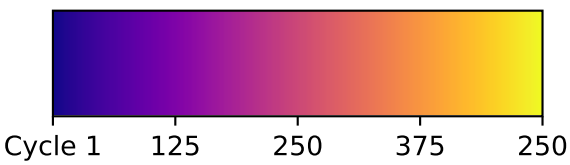

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Variables vs Time
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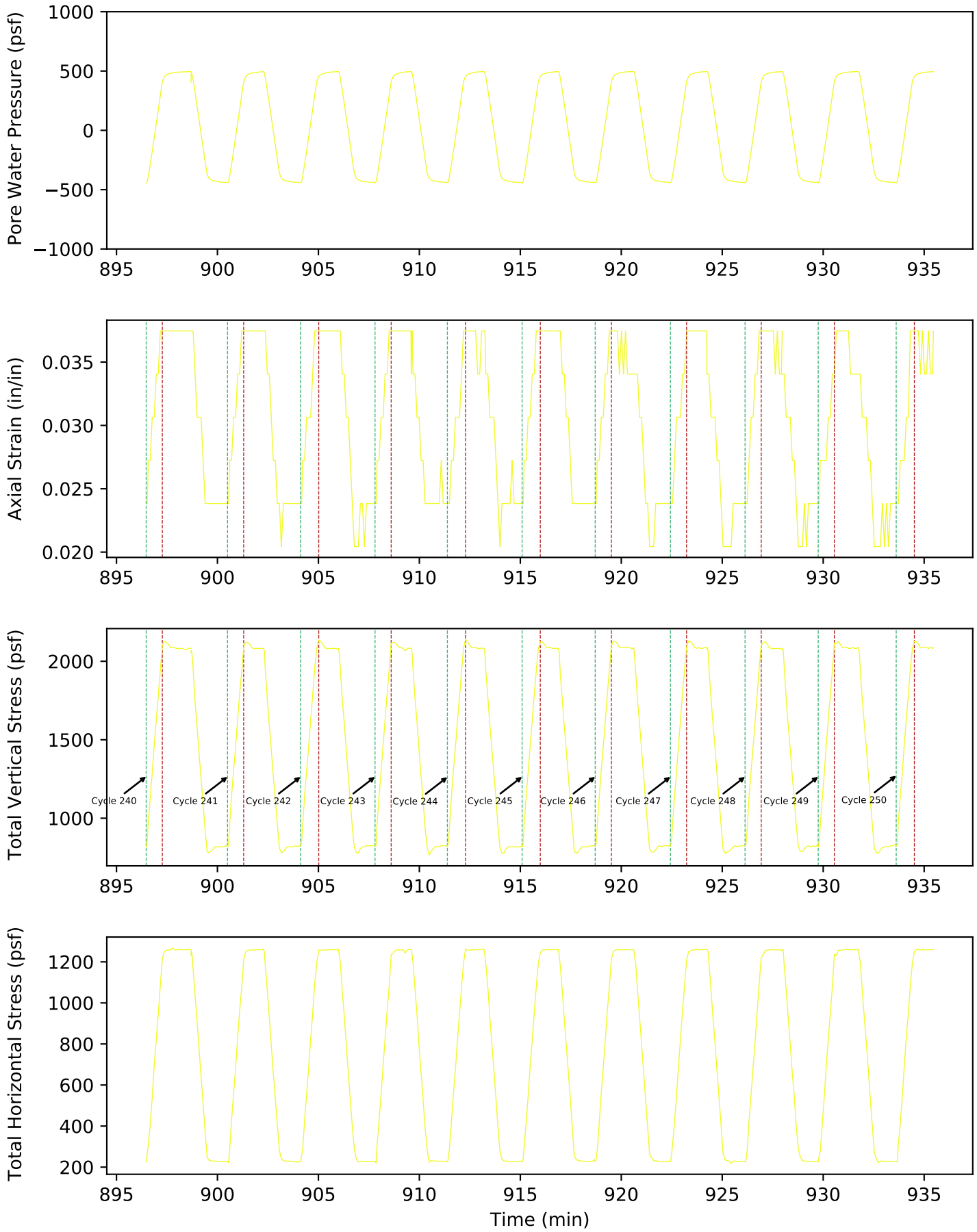

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Variables vs Time
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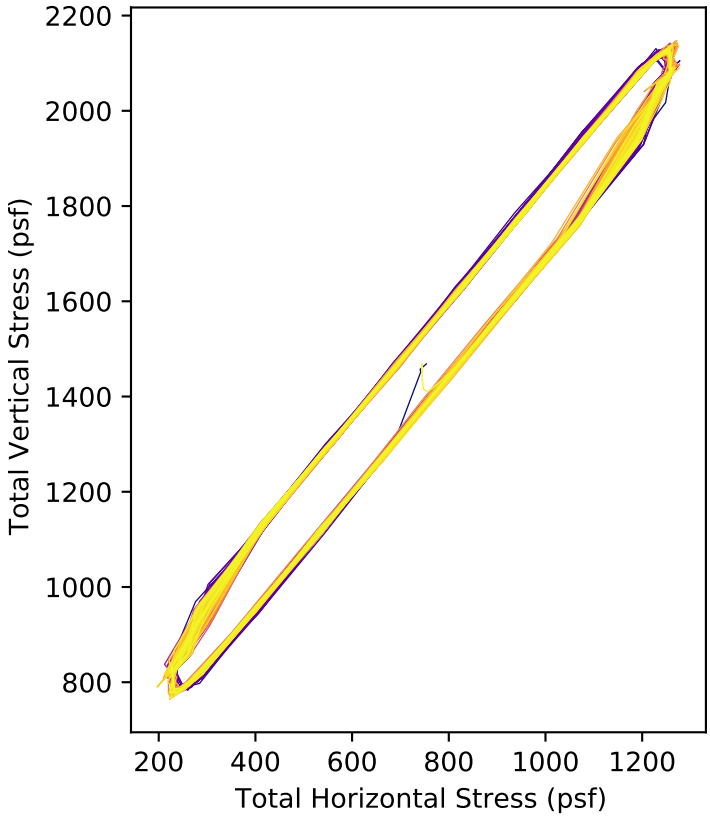

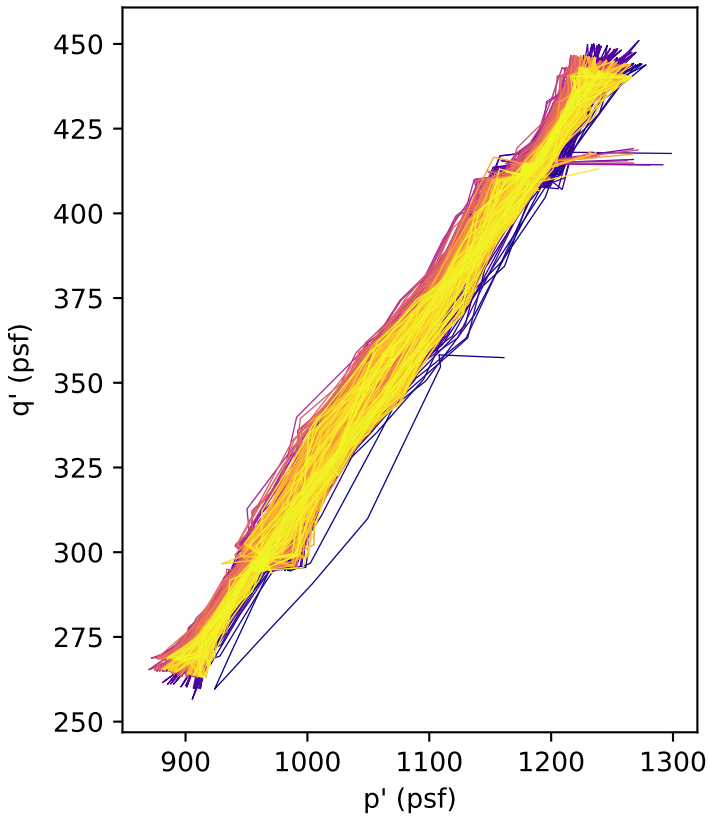

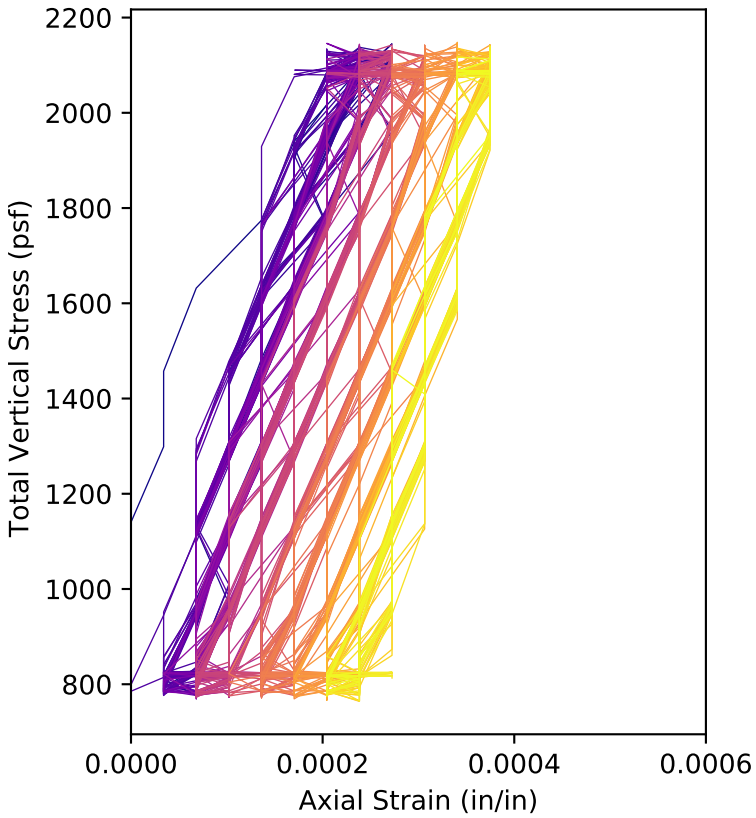

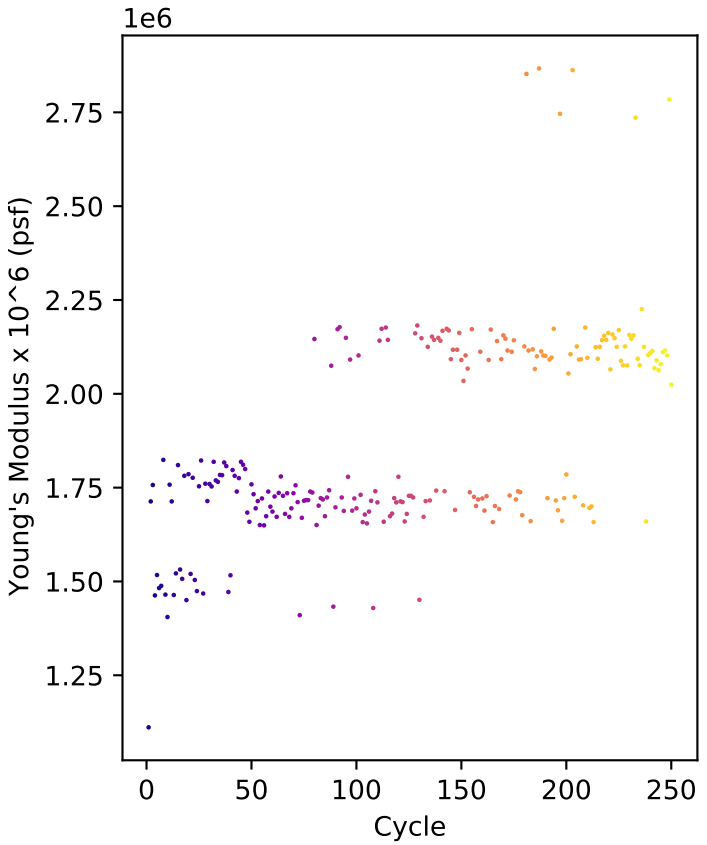

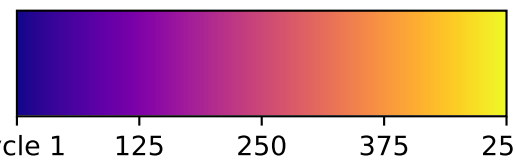

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Hysteresis Graphs
March 2021
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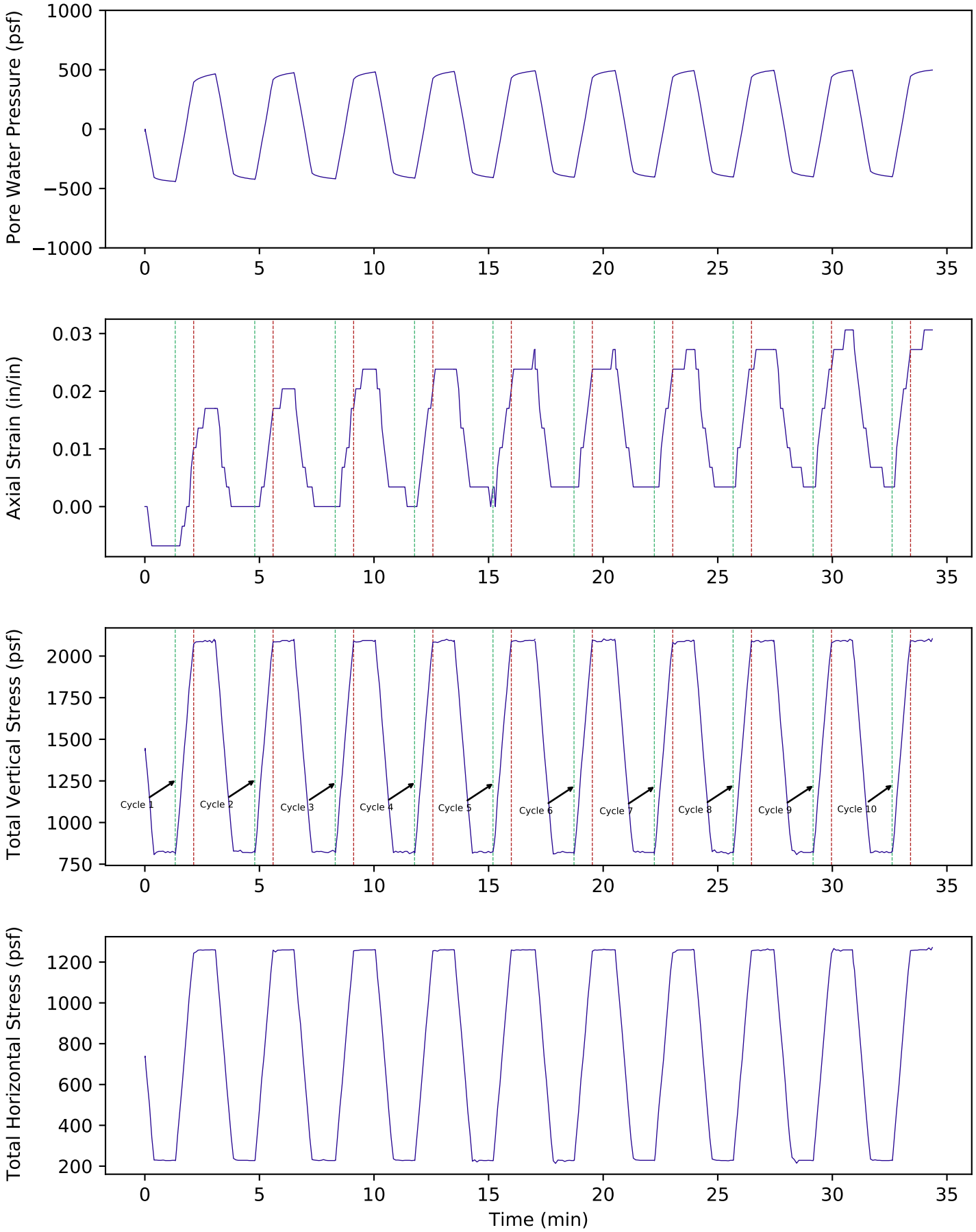

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Variables vs Time
March 2021
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Stress Path Data

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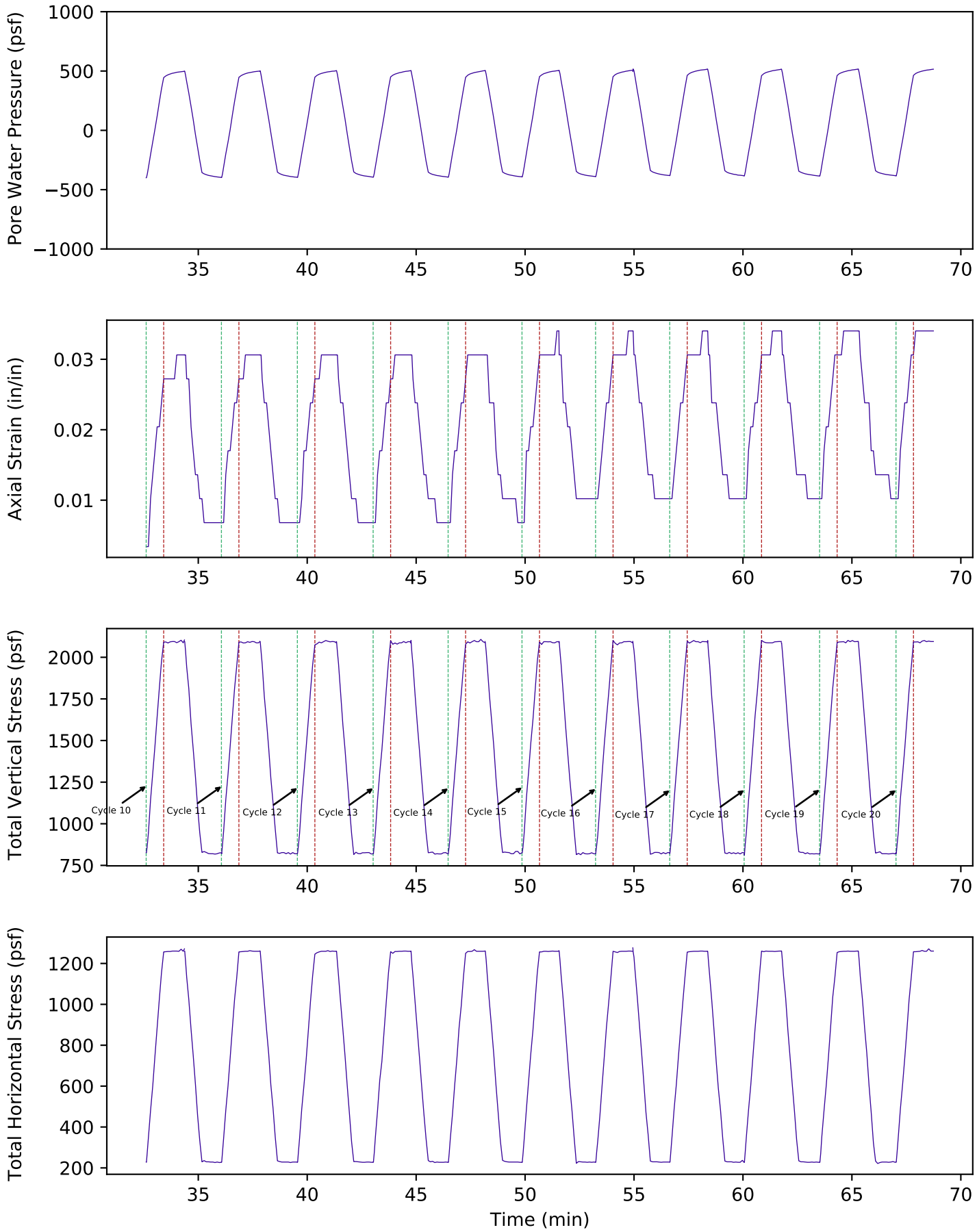

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Variables vs Time
March 2021
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Stress Path Data

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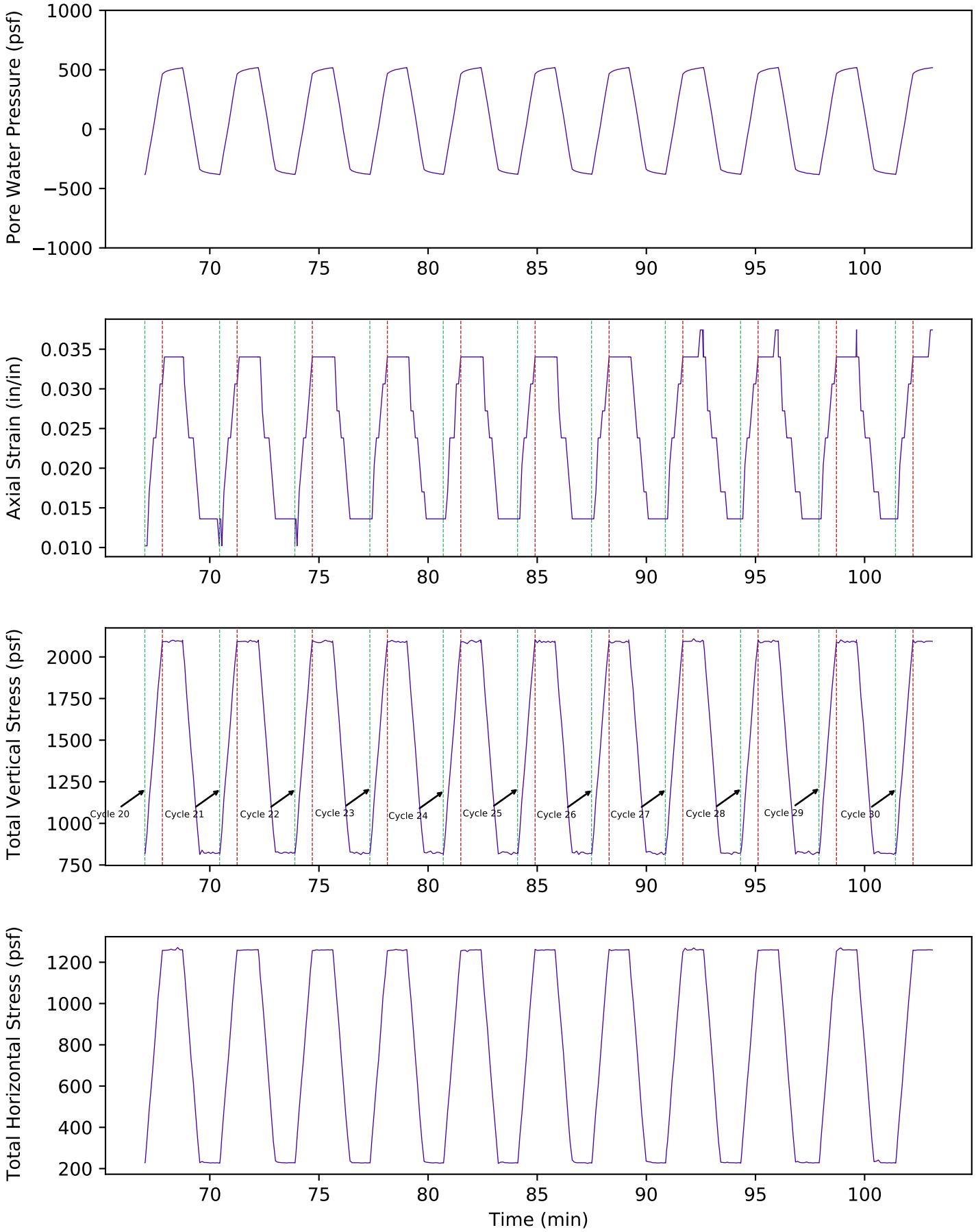

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Variables vs Time
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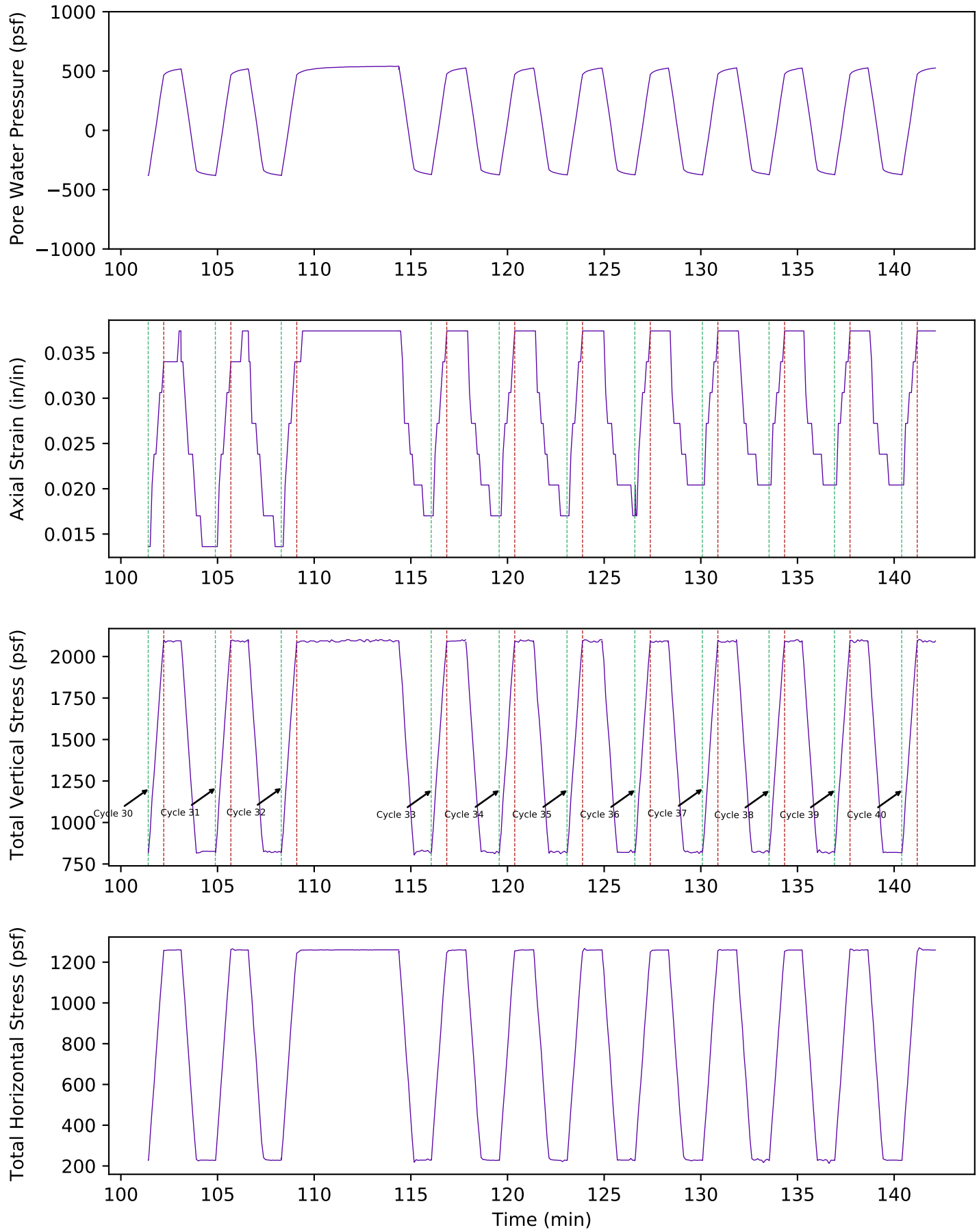

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Variables vs Time
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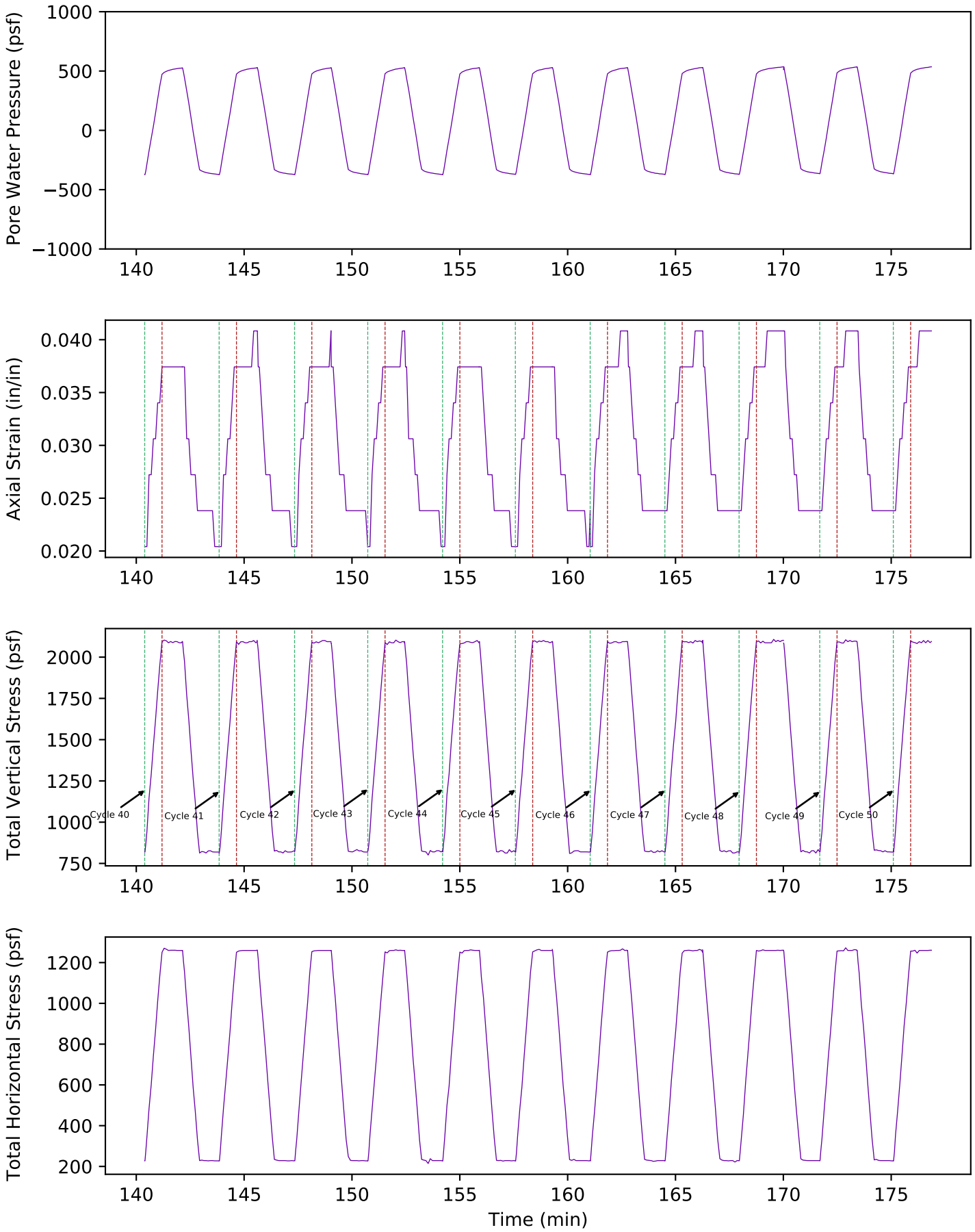

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Variables vs Time
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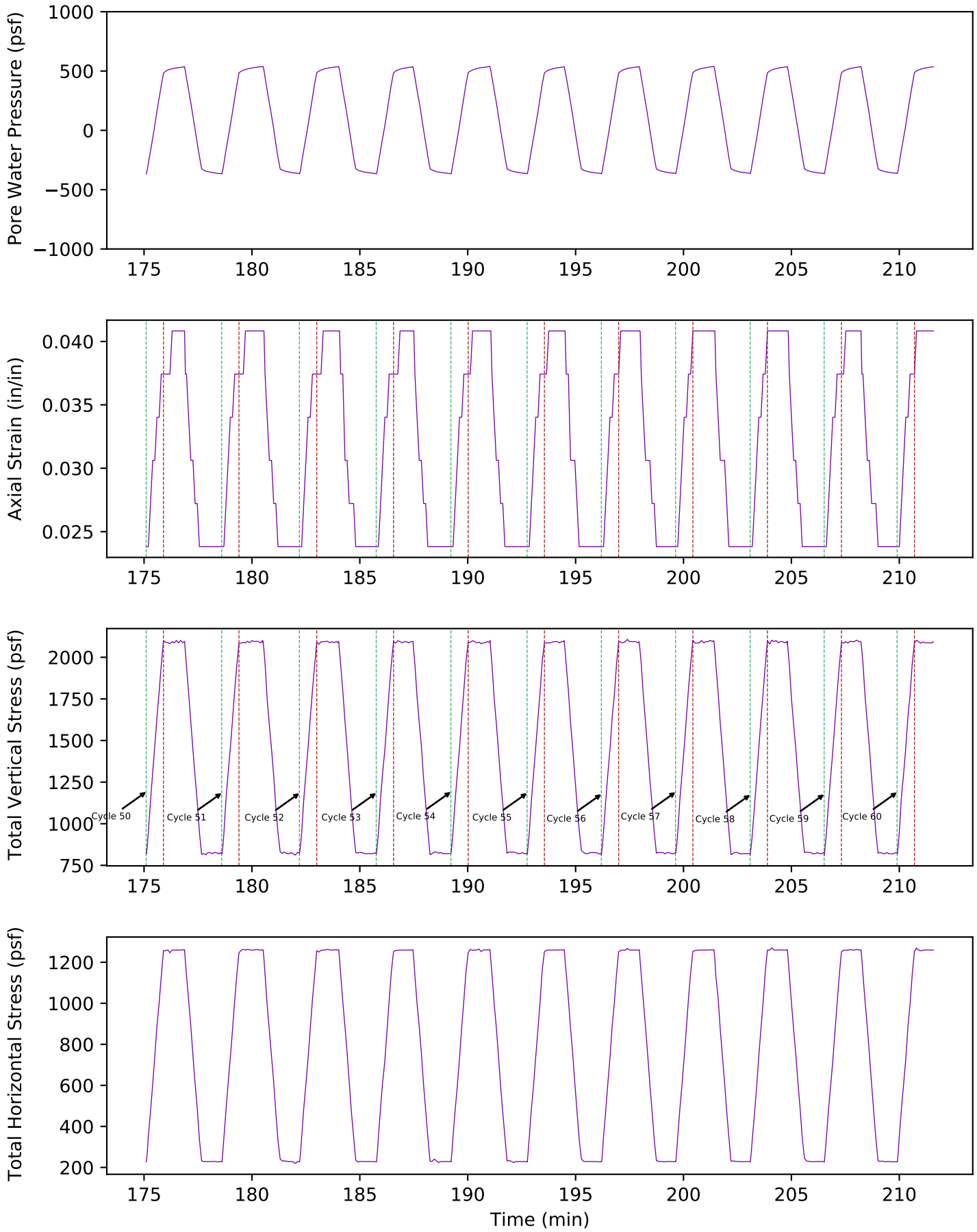

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Variables vs Time
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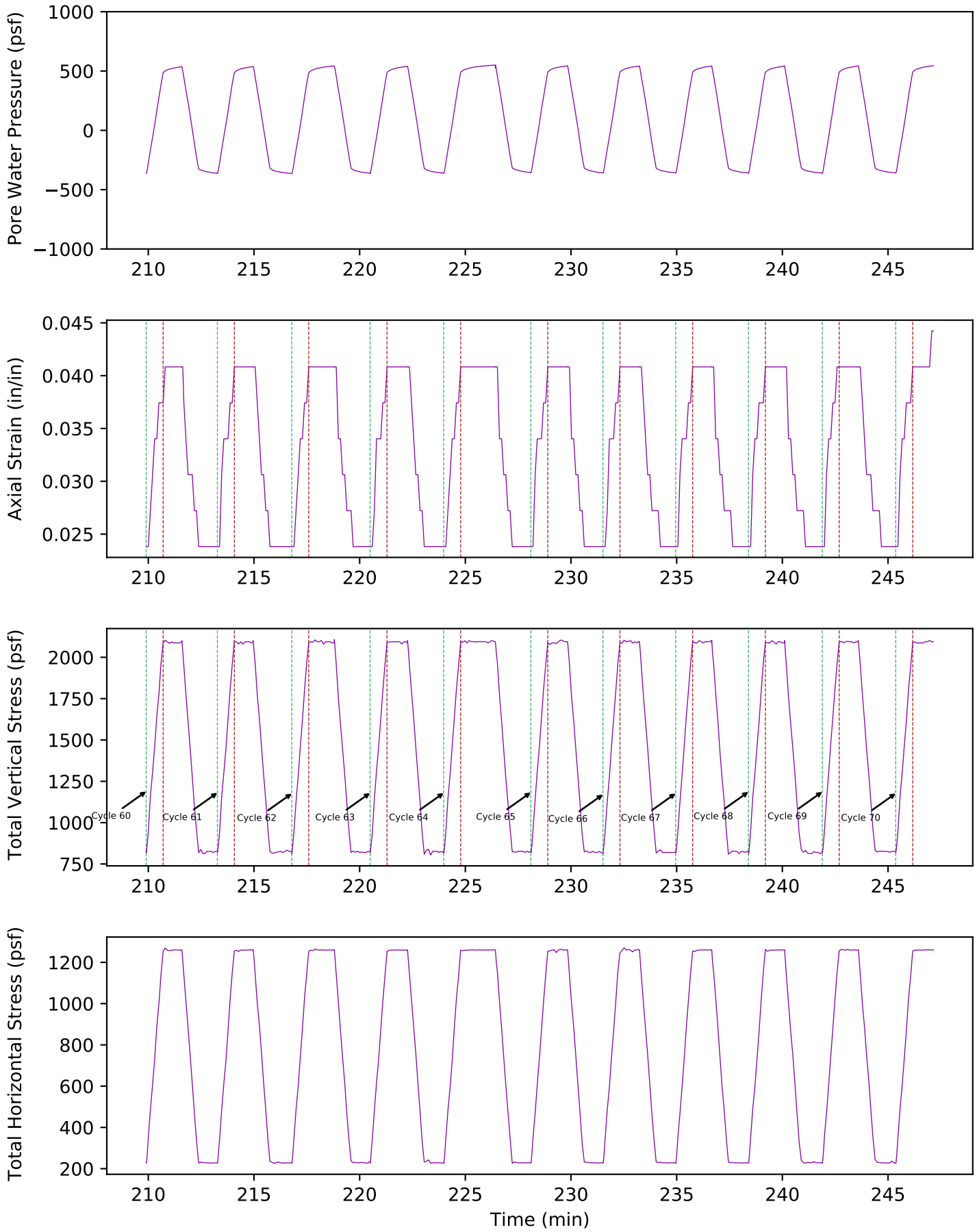

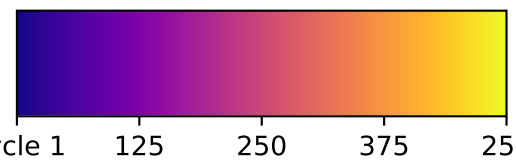

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Variables vs Time
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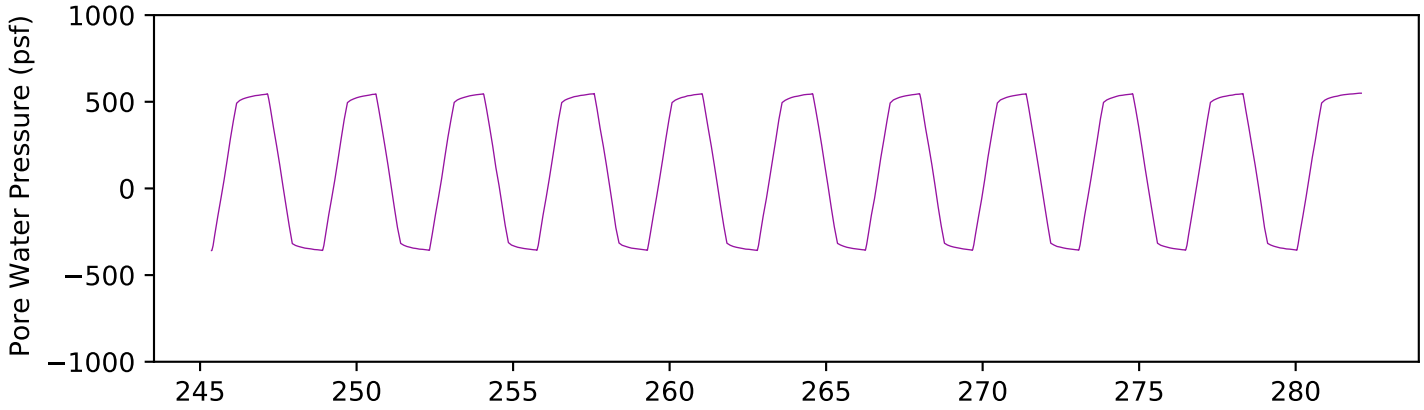

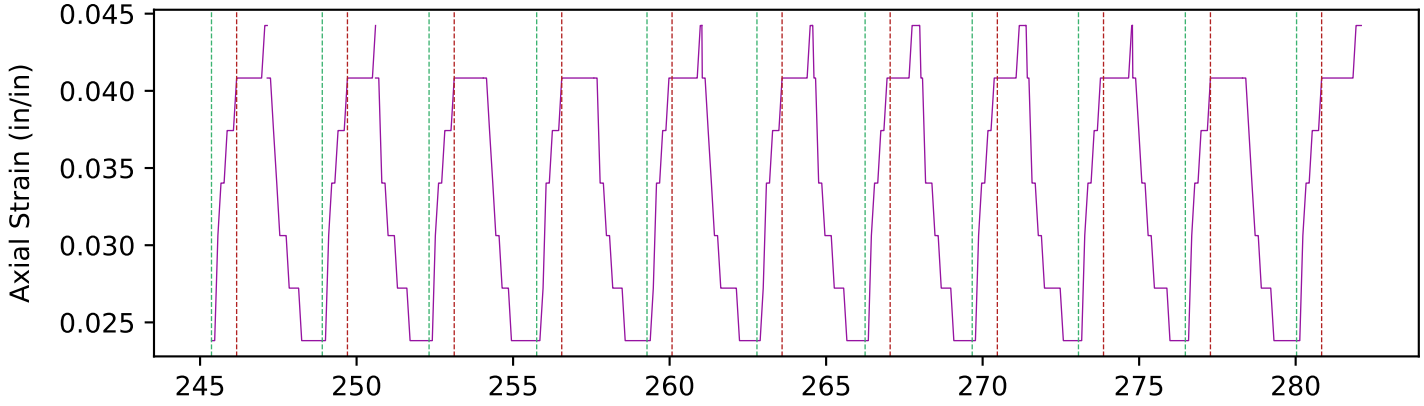

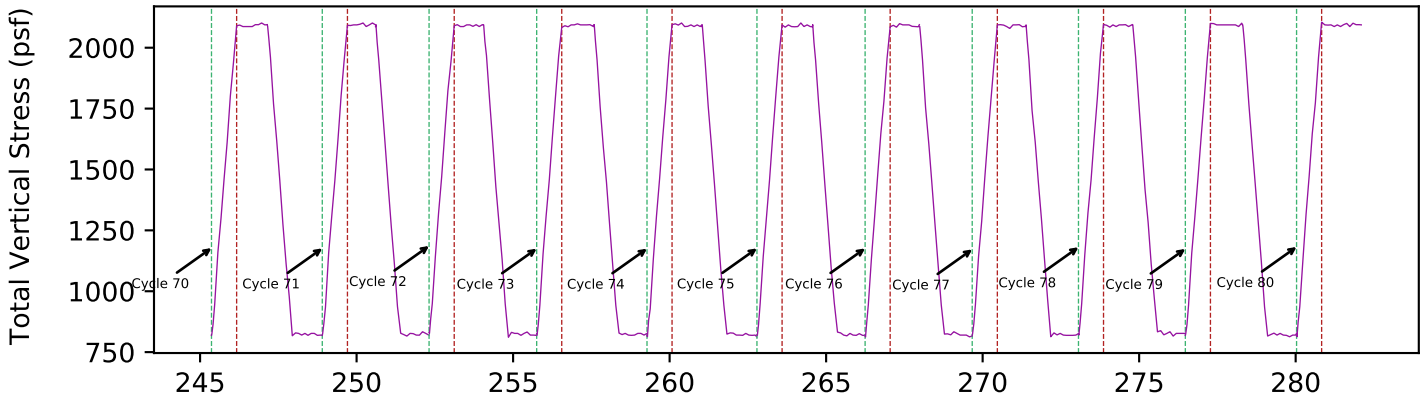

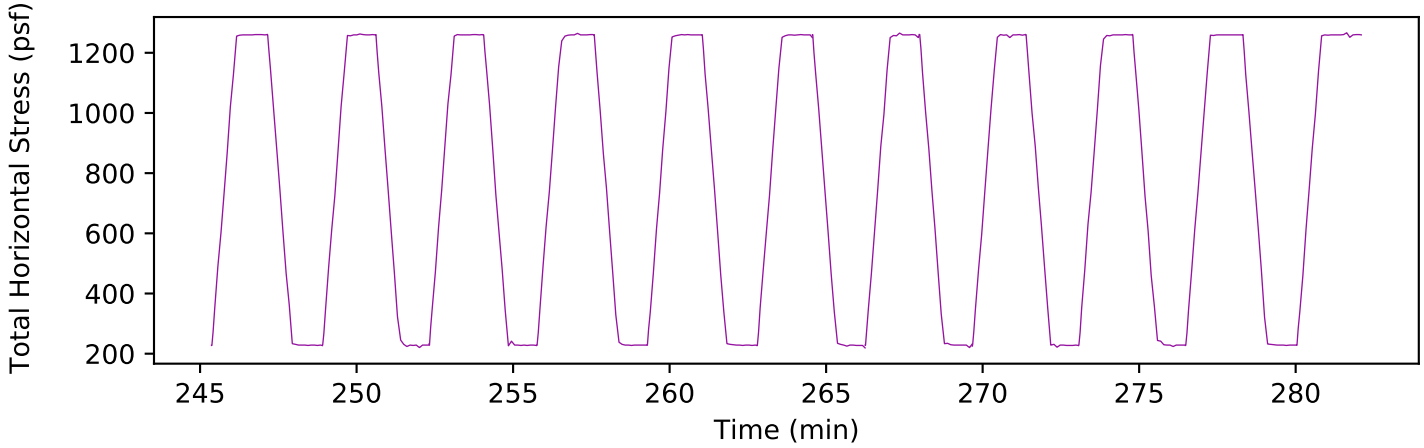

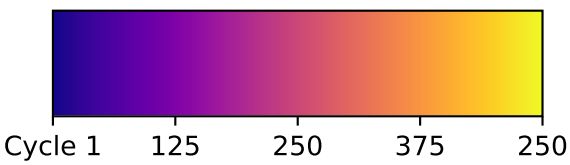

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Variables vs Time
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Stress Path Data

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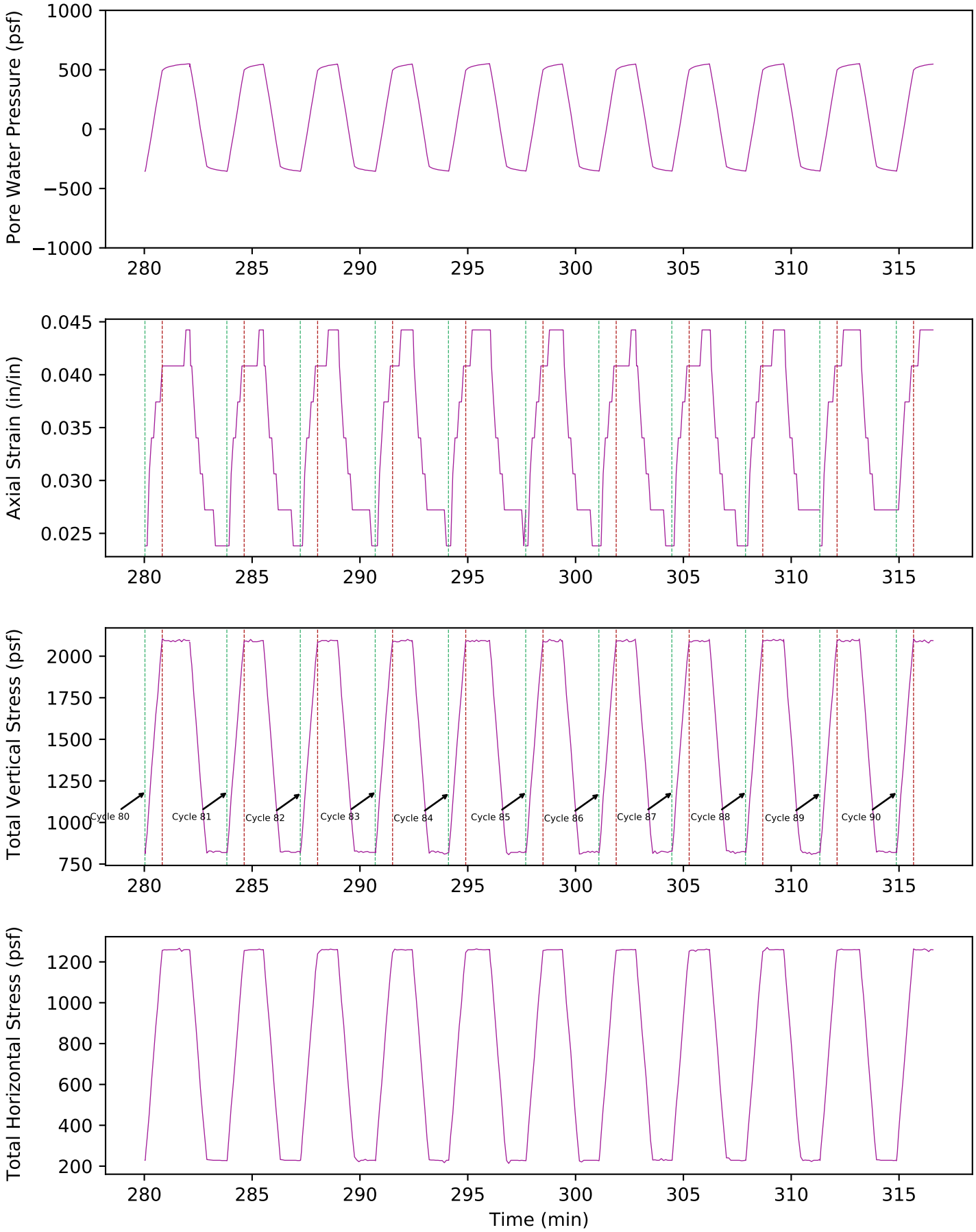

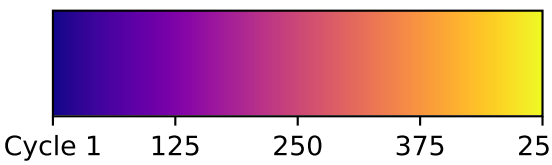

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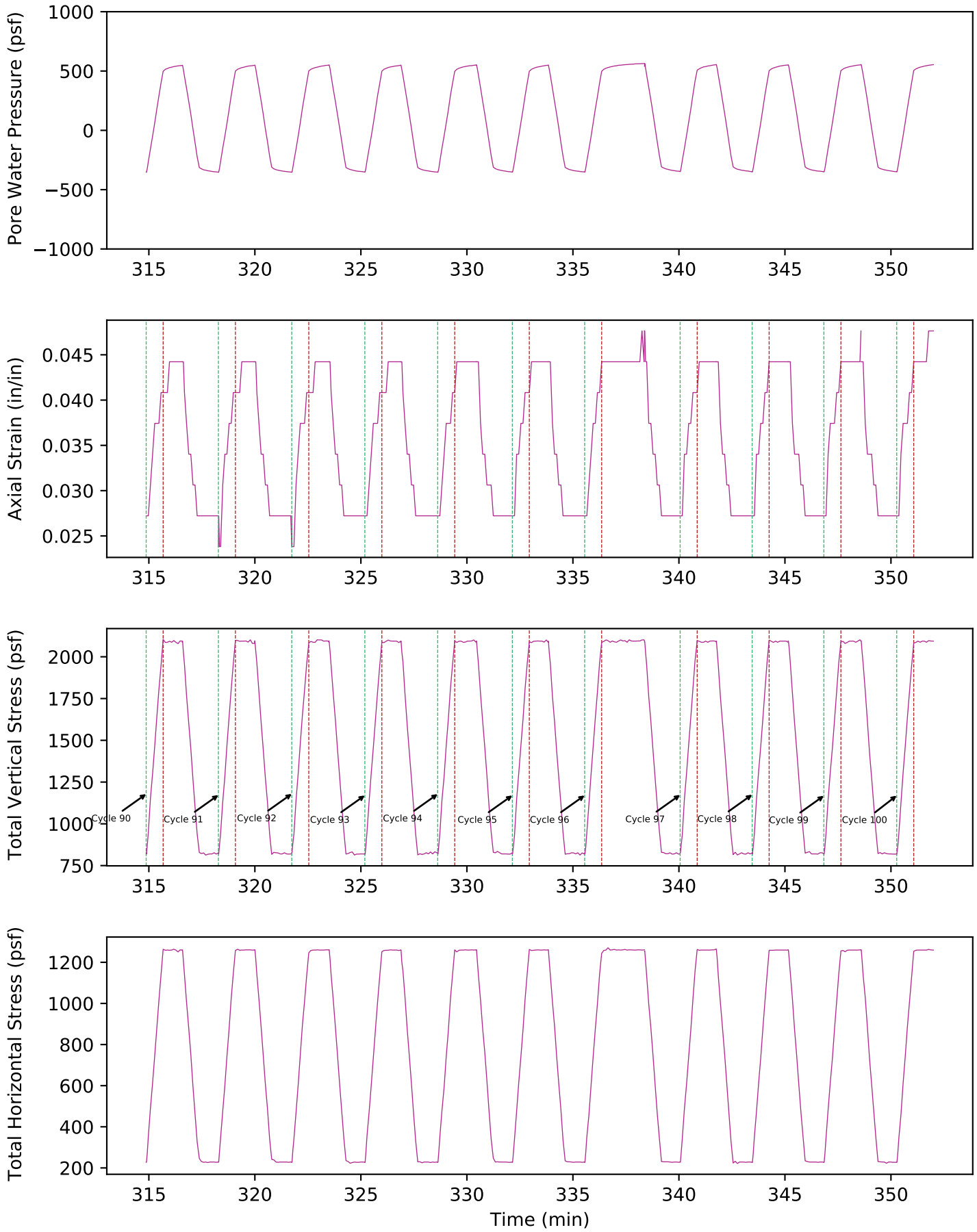

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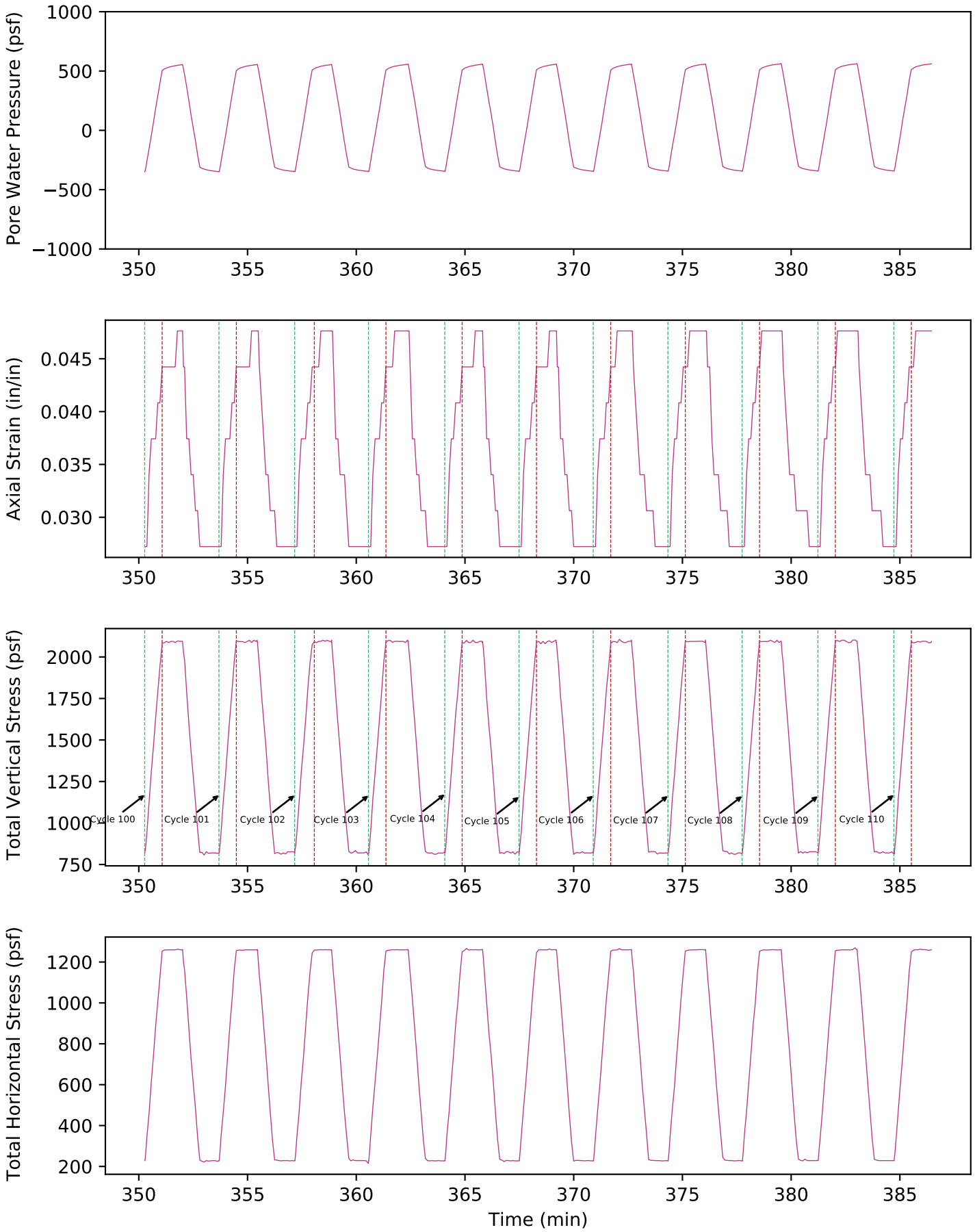

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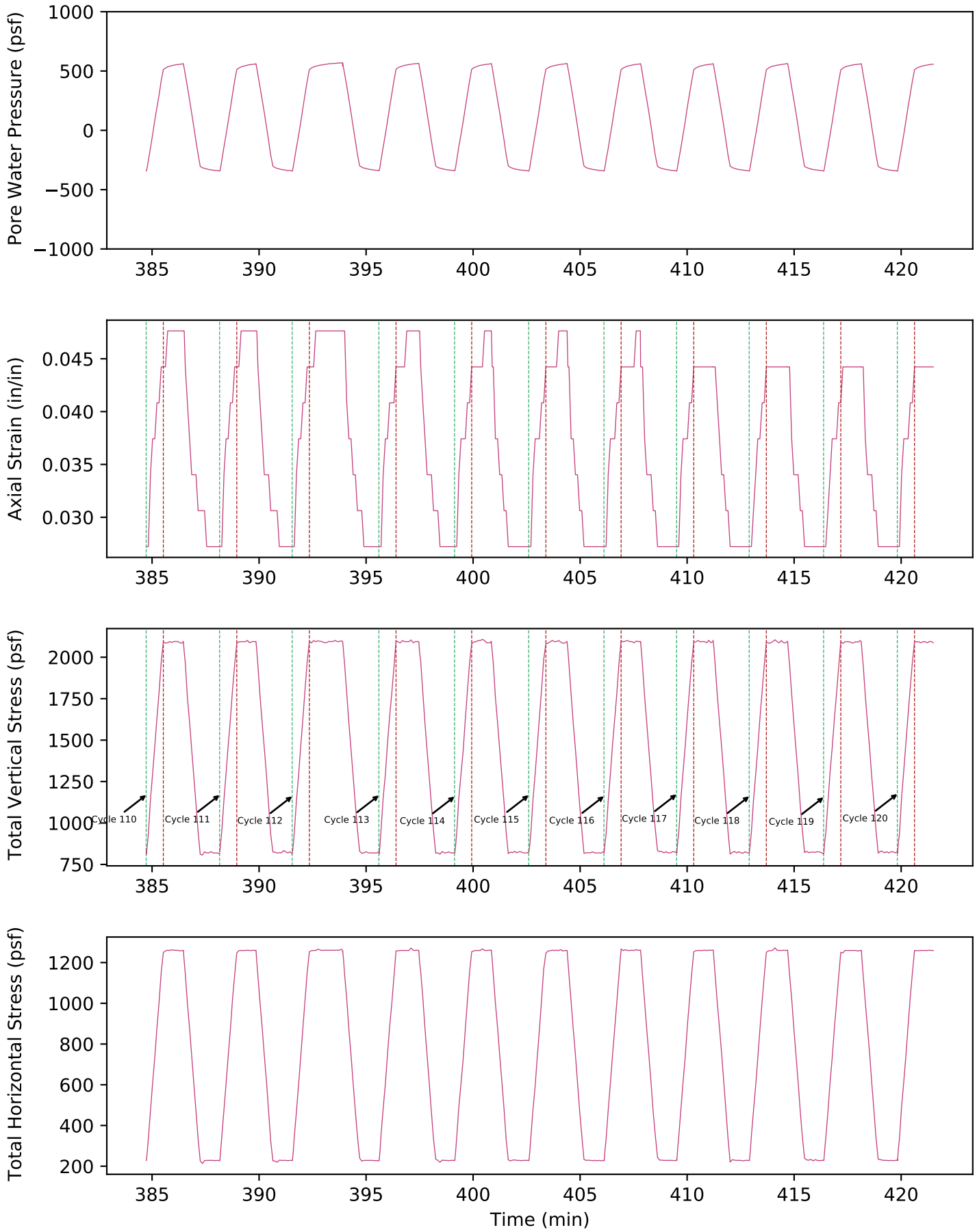

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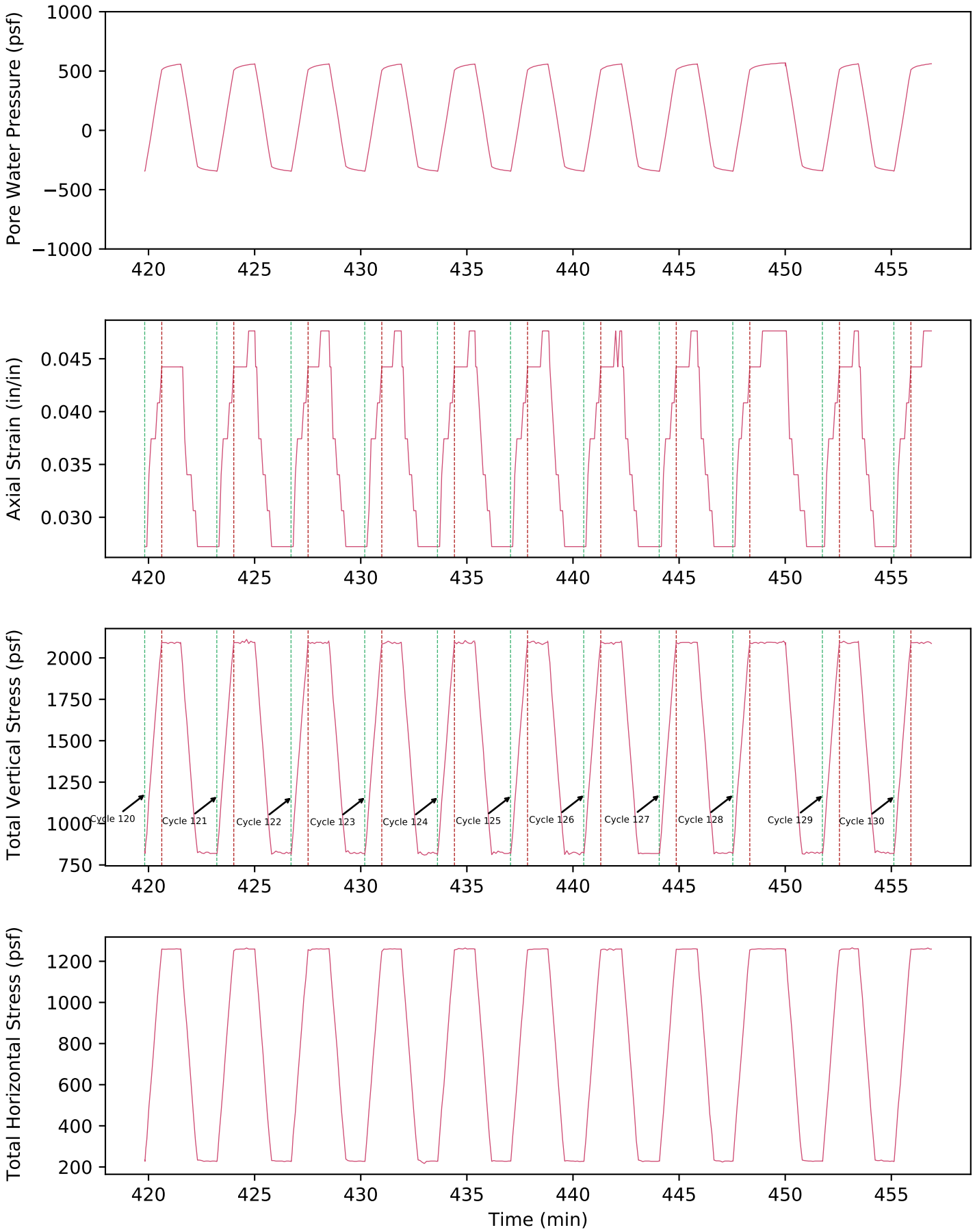

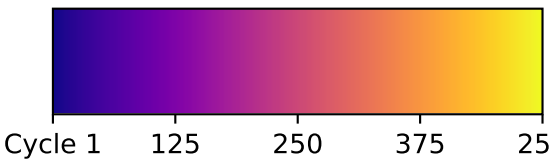

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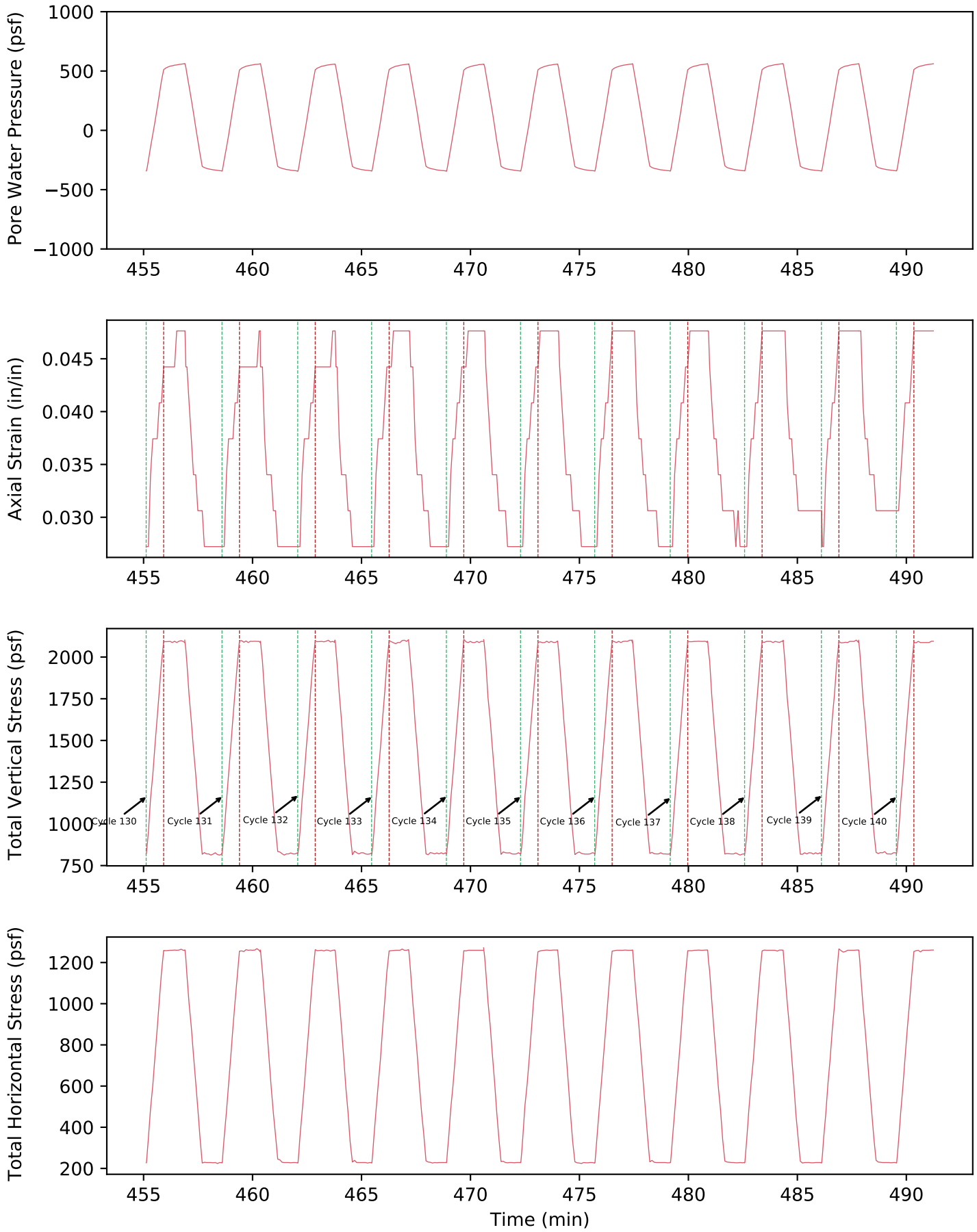

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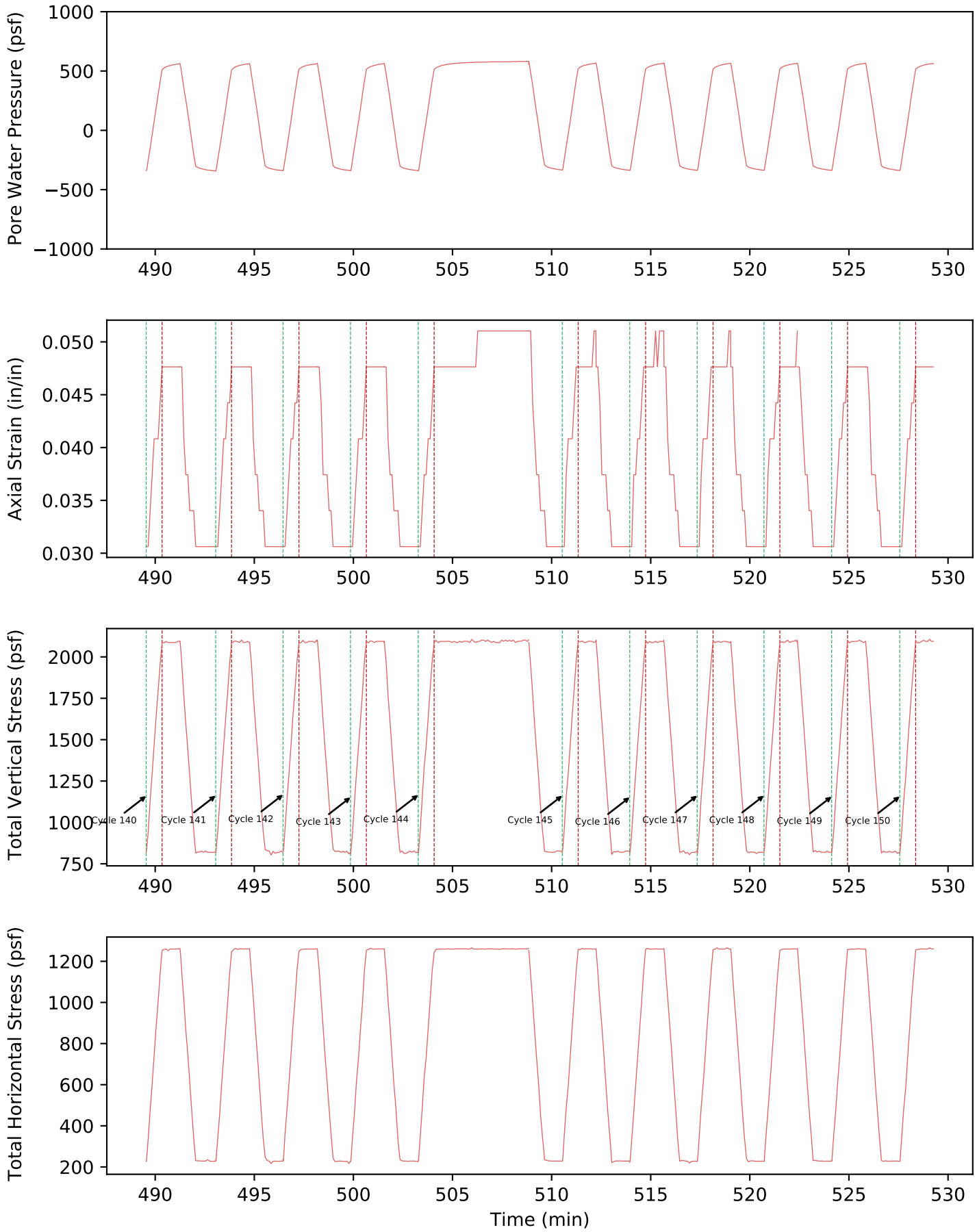

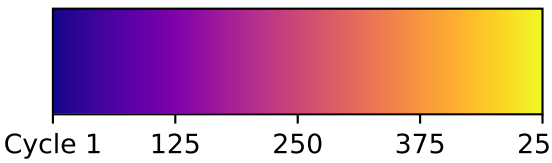

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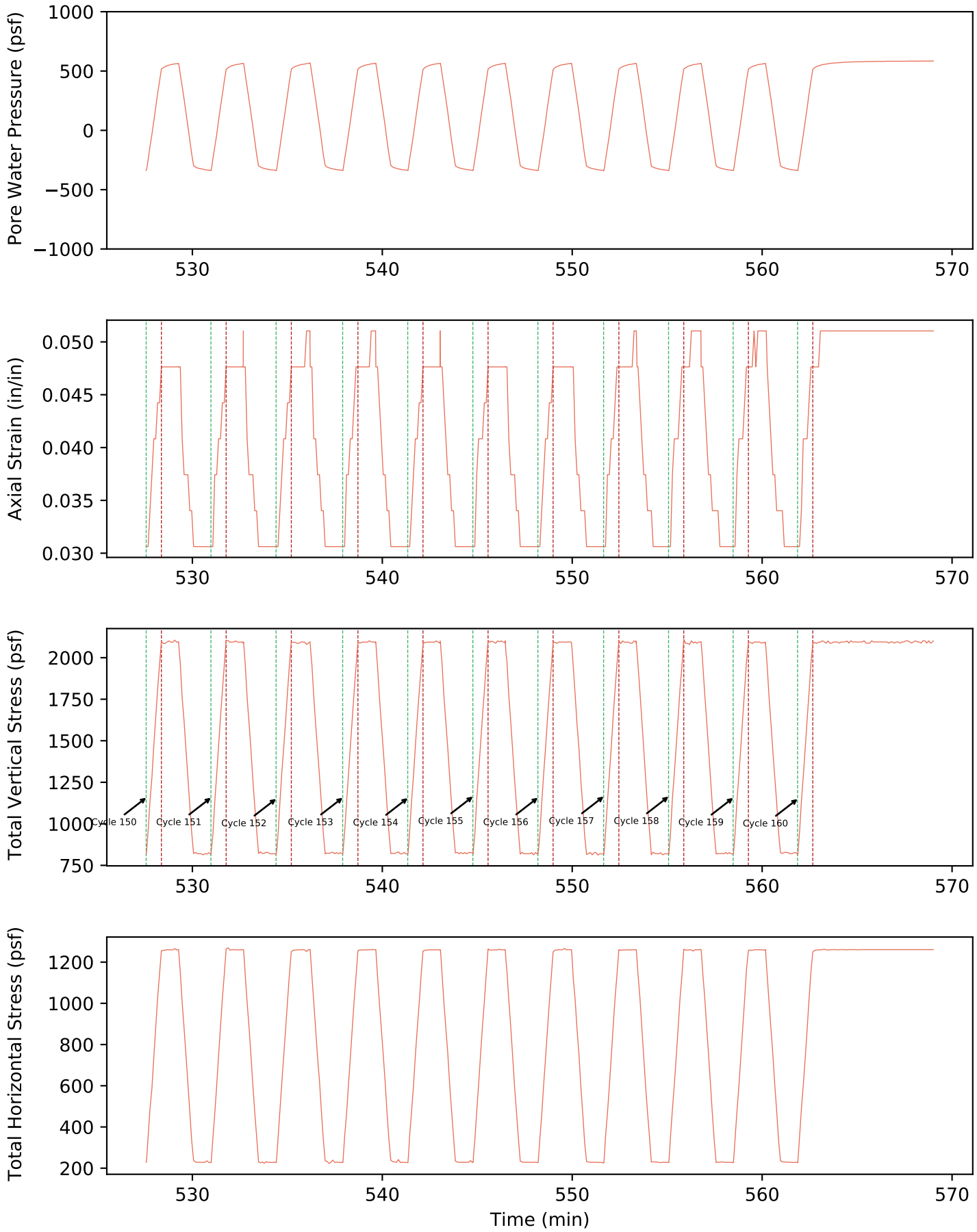

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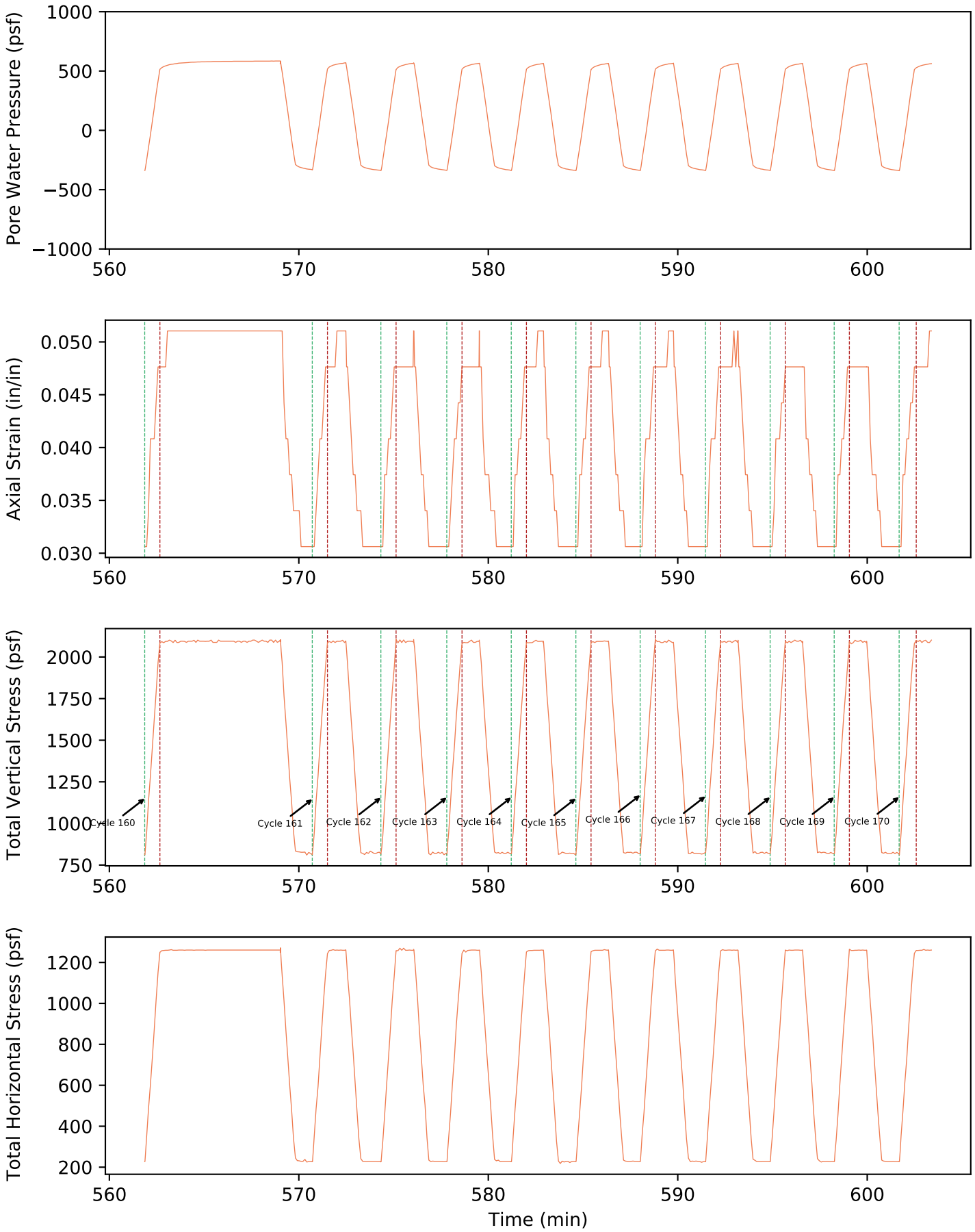

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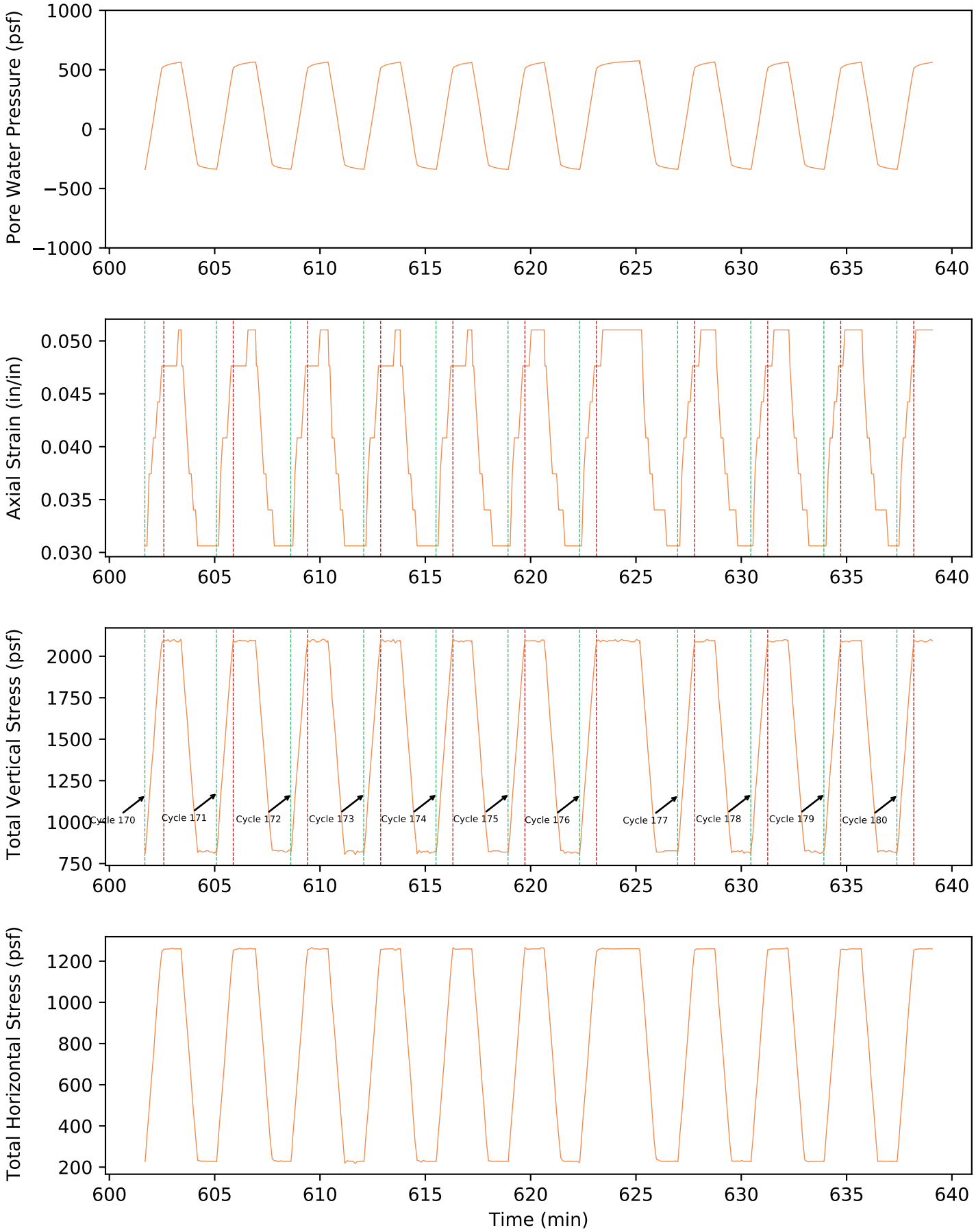

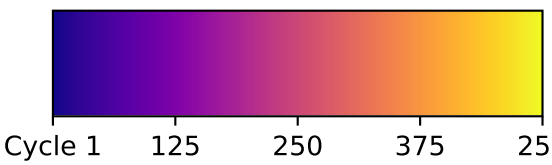

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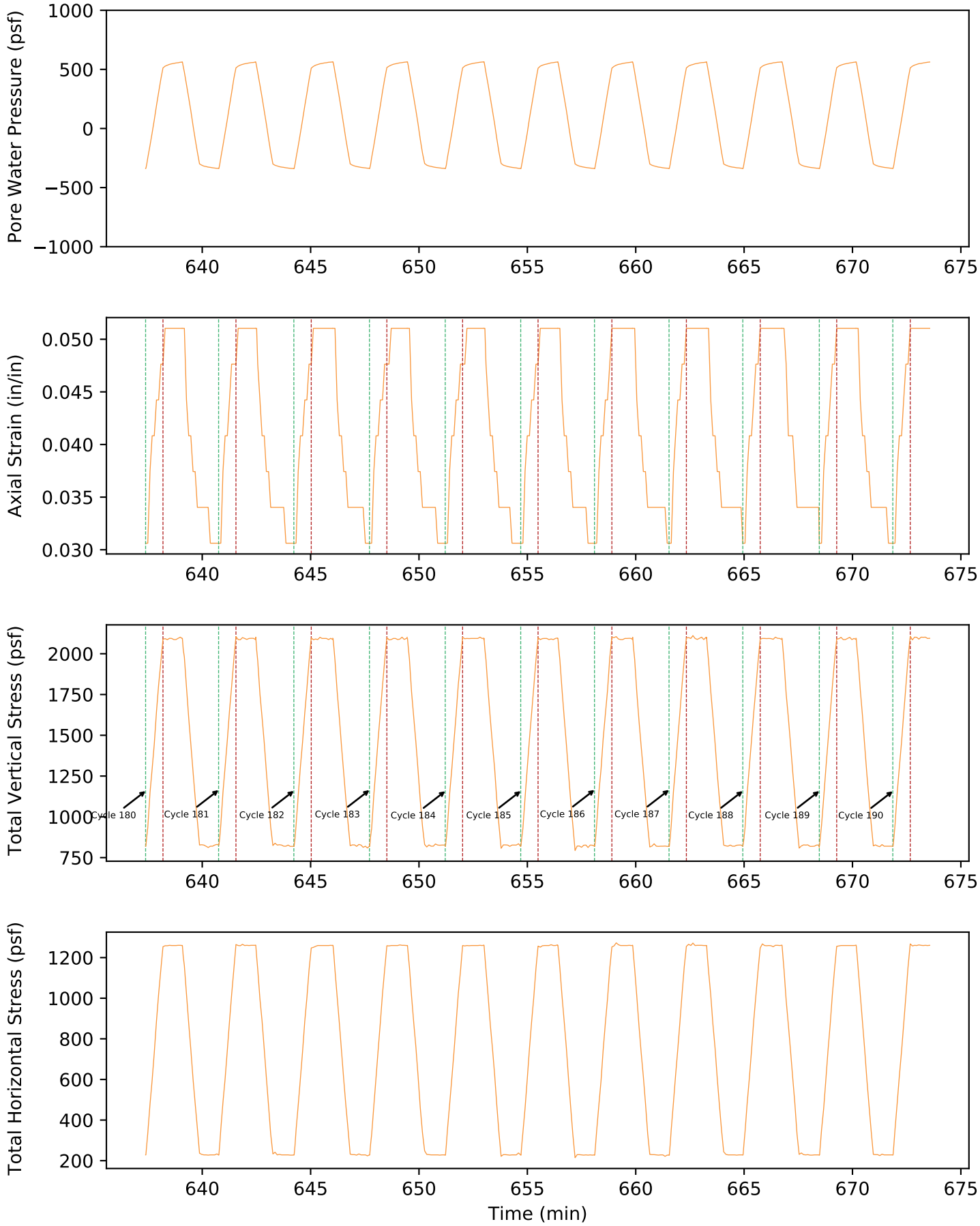

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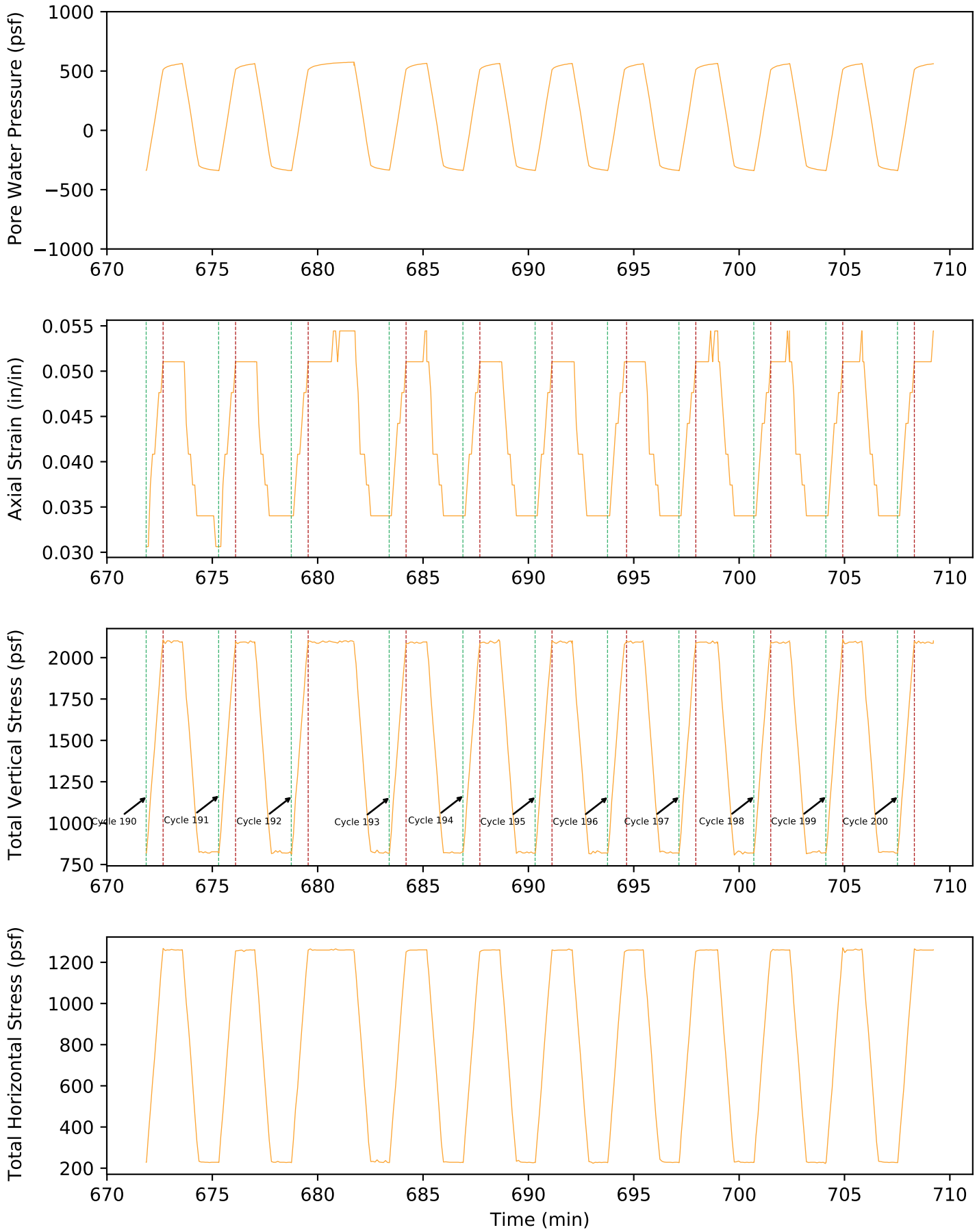

Cycle 1 125 250 375 250

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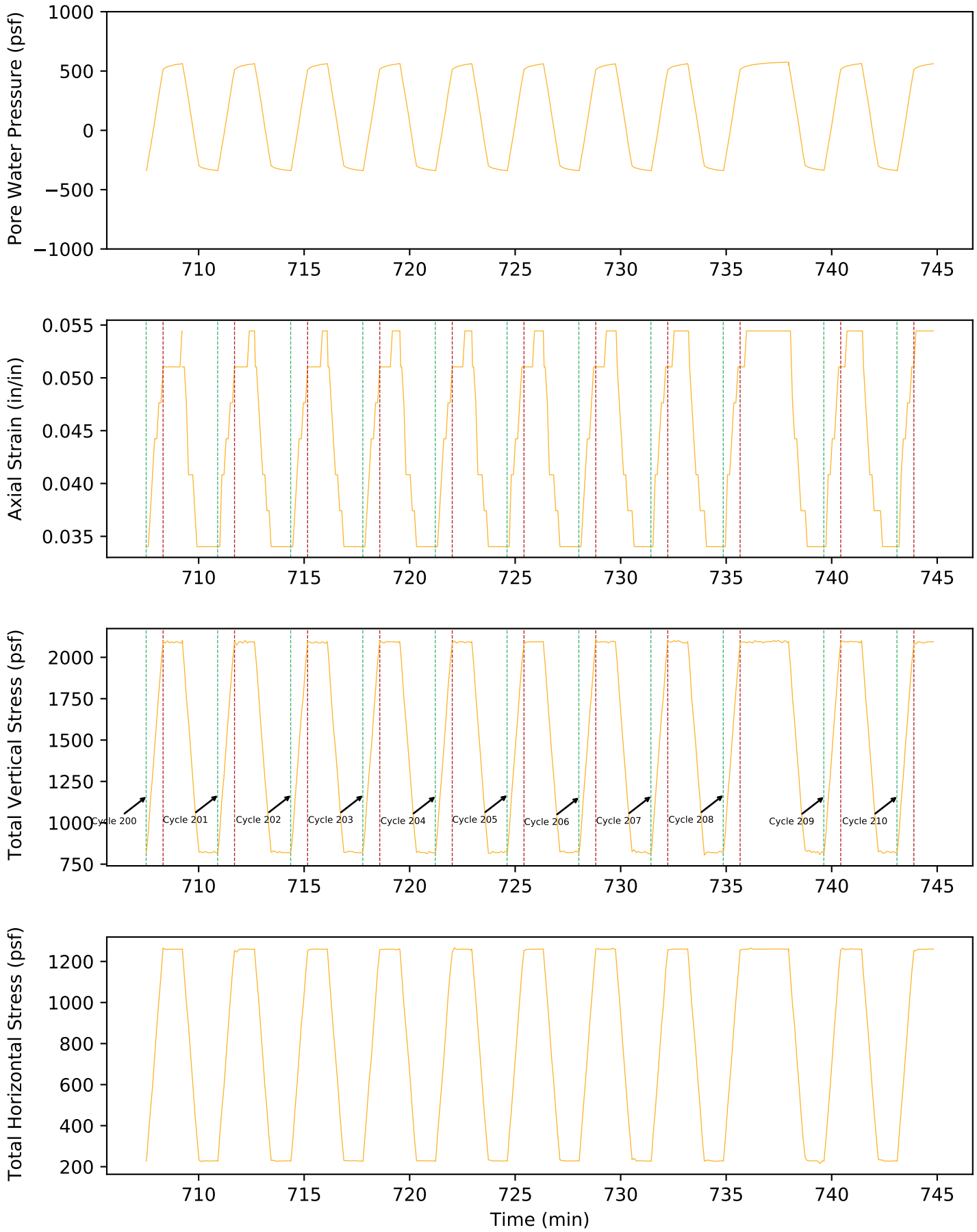

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Variables vs Time
March 2021
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Stress Path Data

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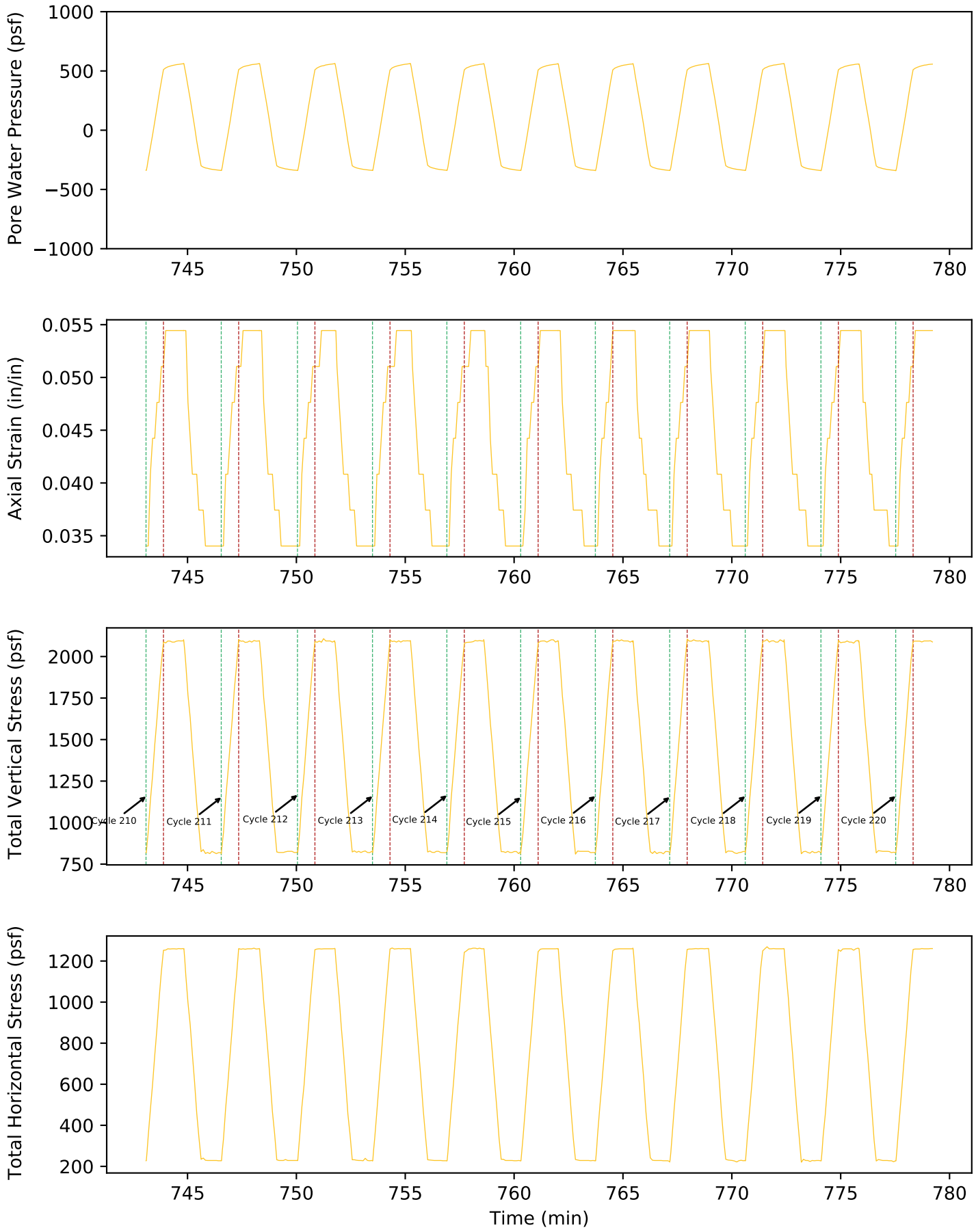

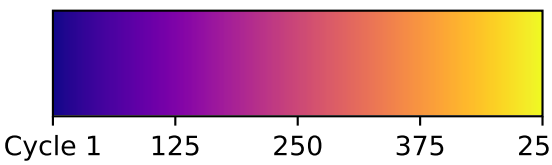

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Variables vs Time
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Stress Path Data

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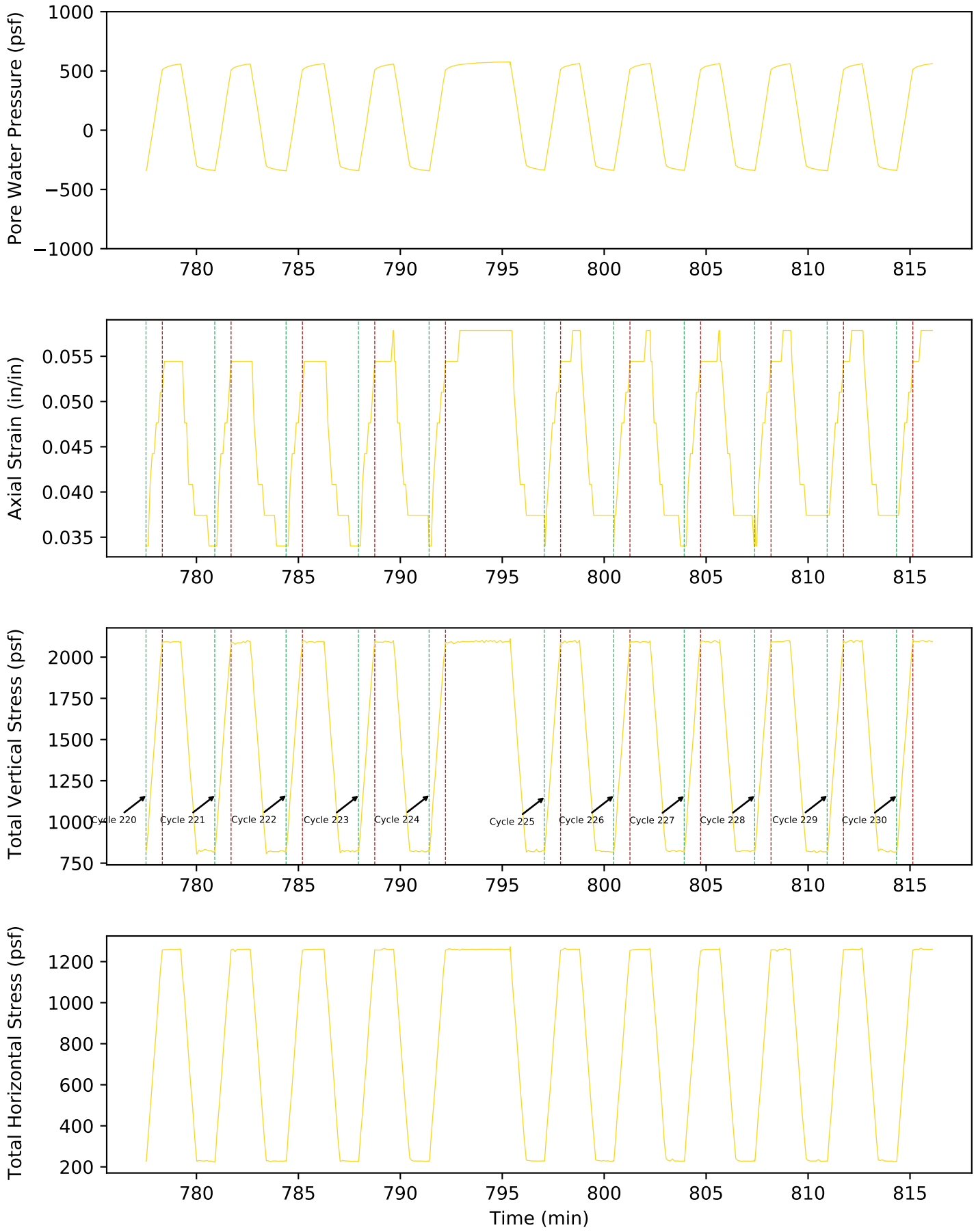

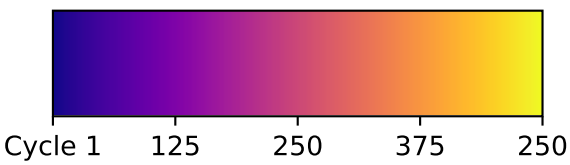

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Variables vs Time
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Stress Path Data

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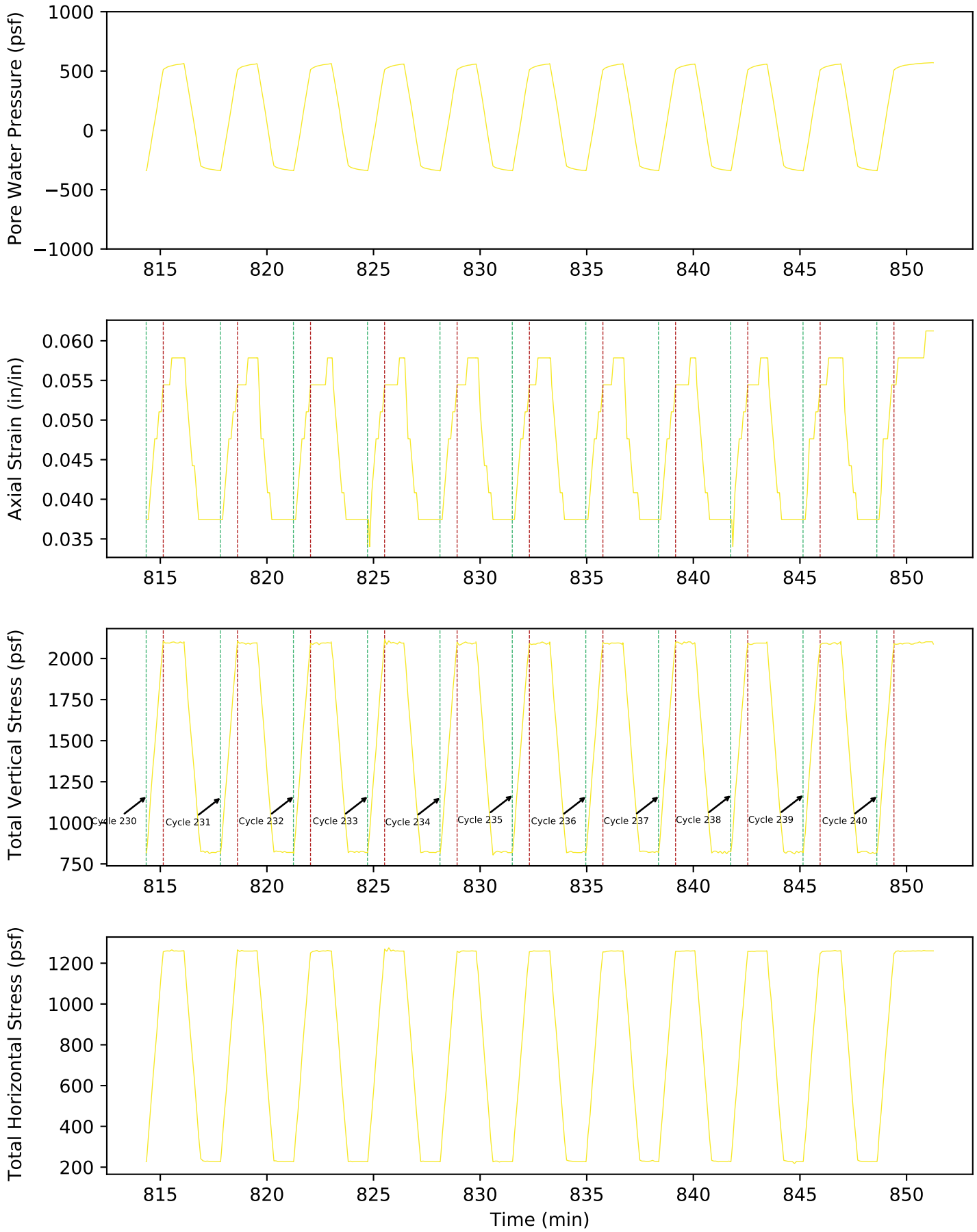

Cycle 1 125 250 375 250

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Variables vs Time
March 2021
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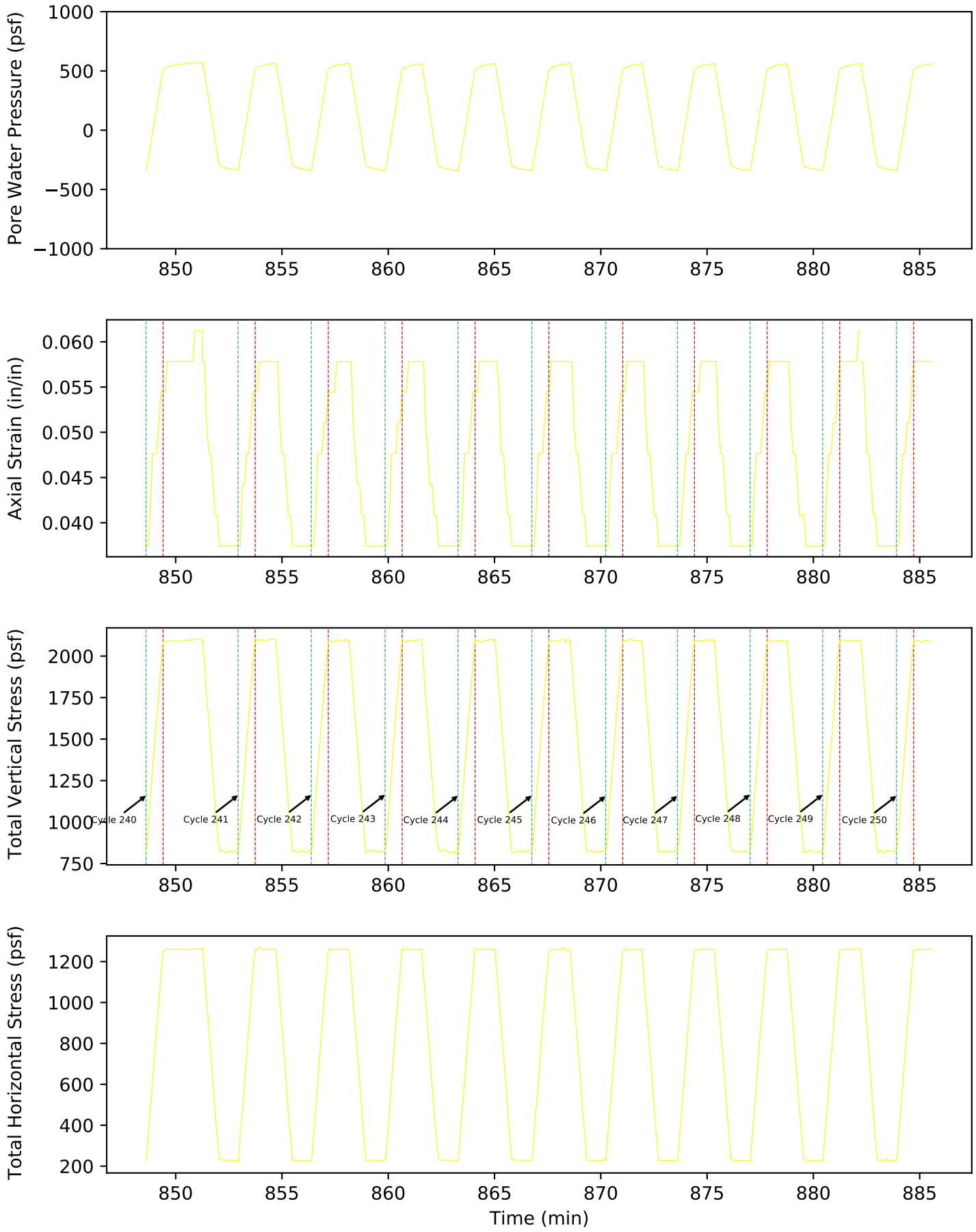

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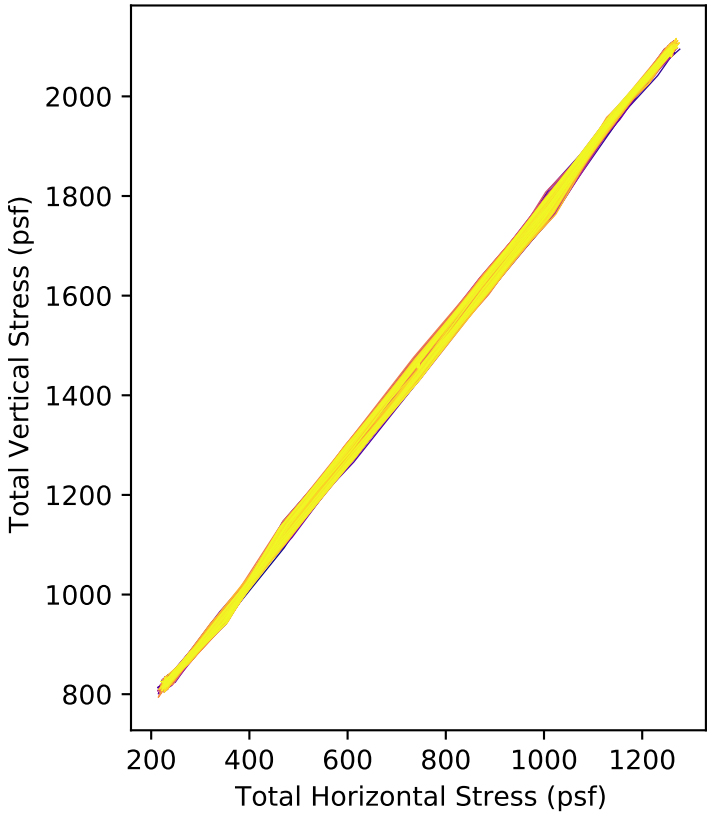

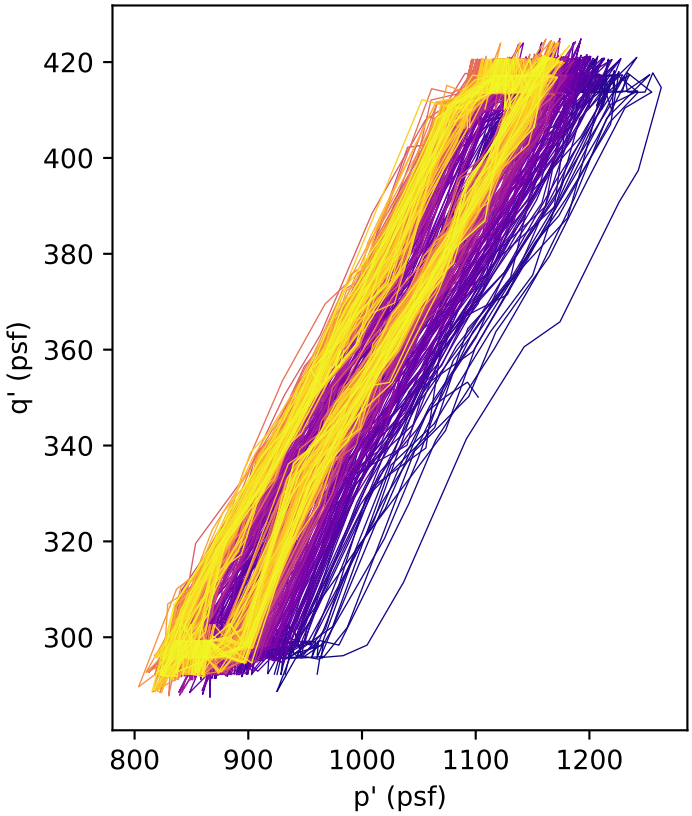

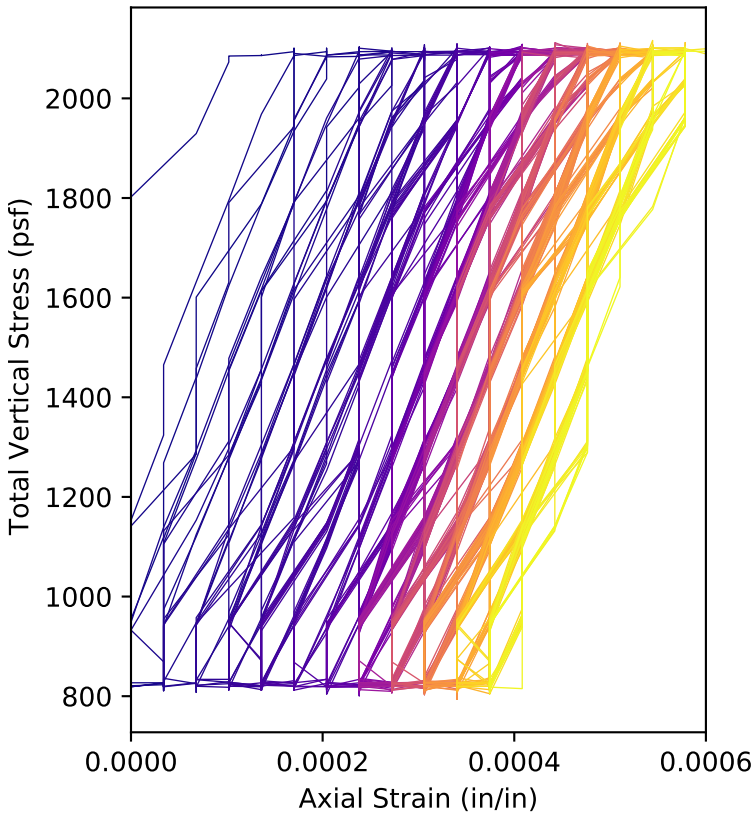

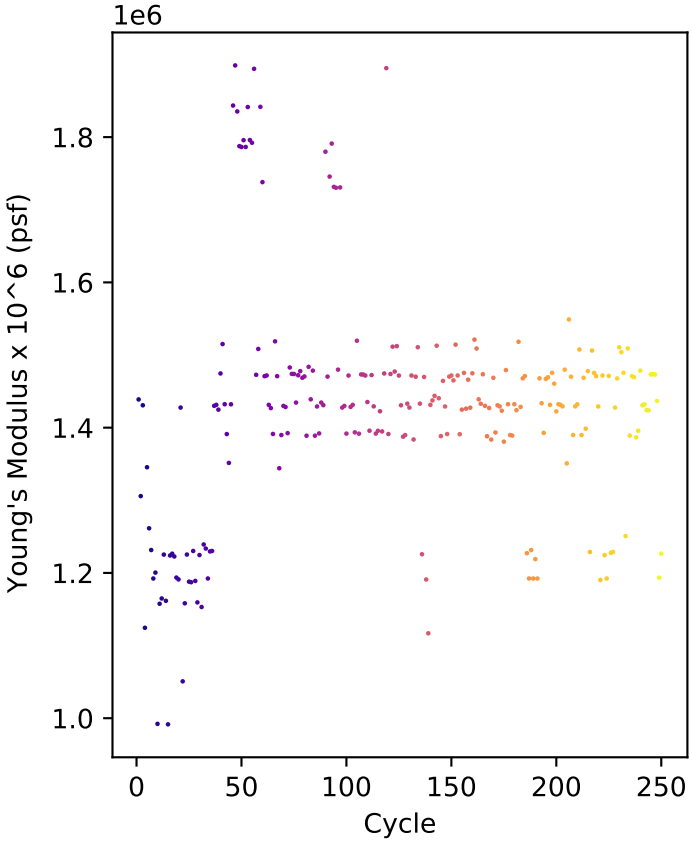

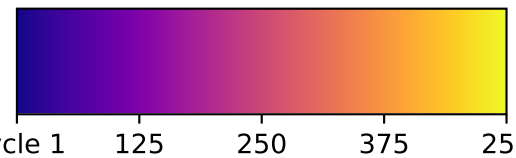

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Hysteresis Graphs
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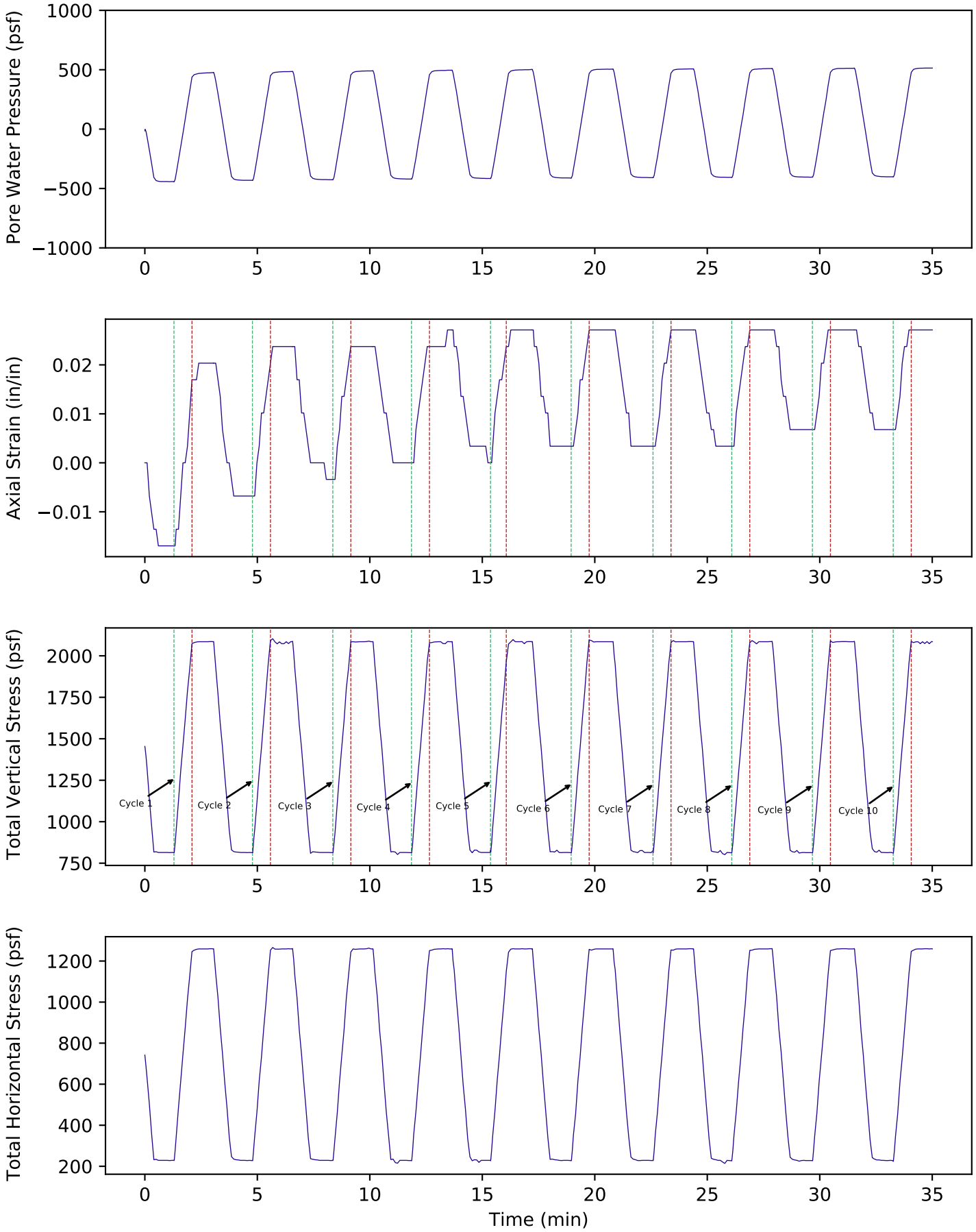

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Variables vs Time
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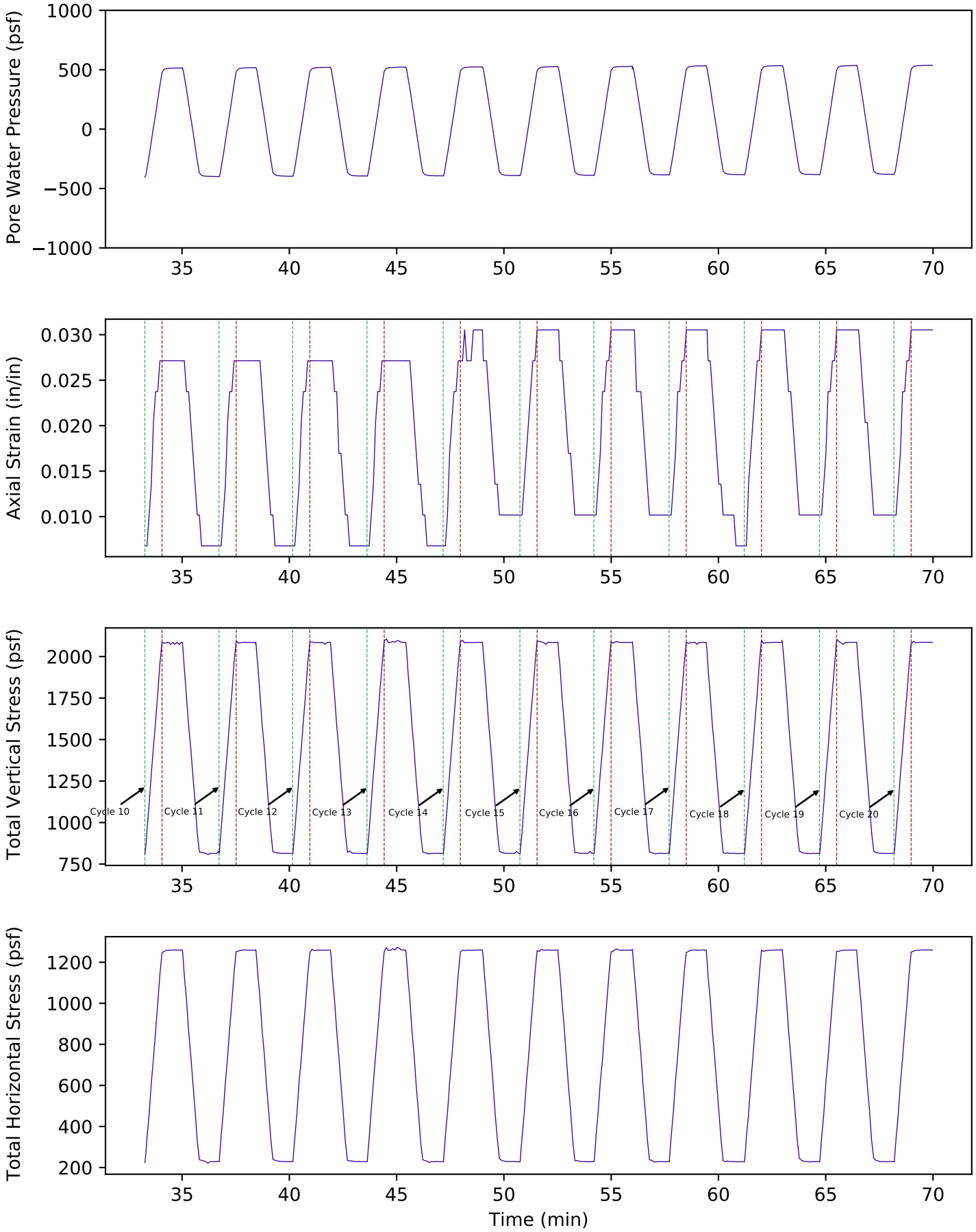

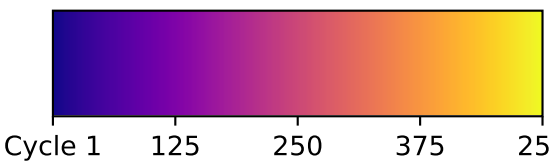

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Variables vs Time
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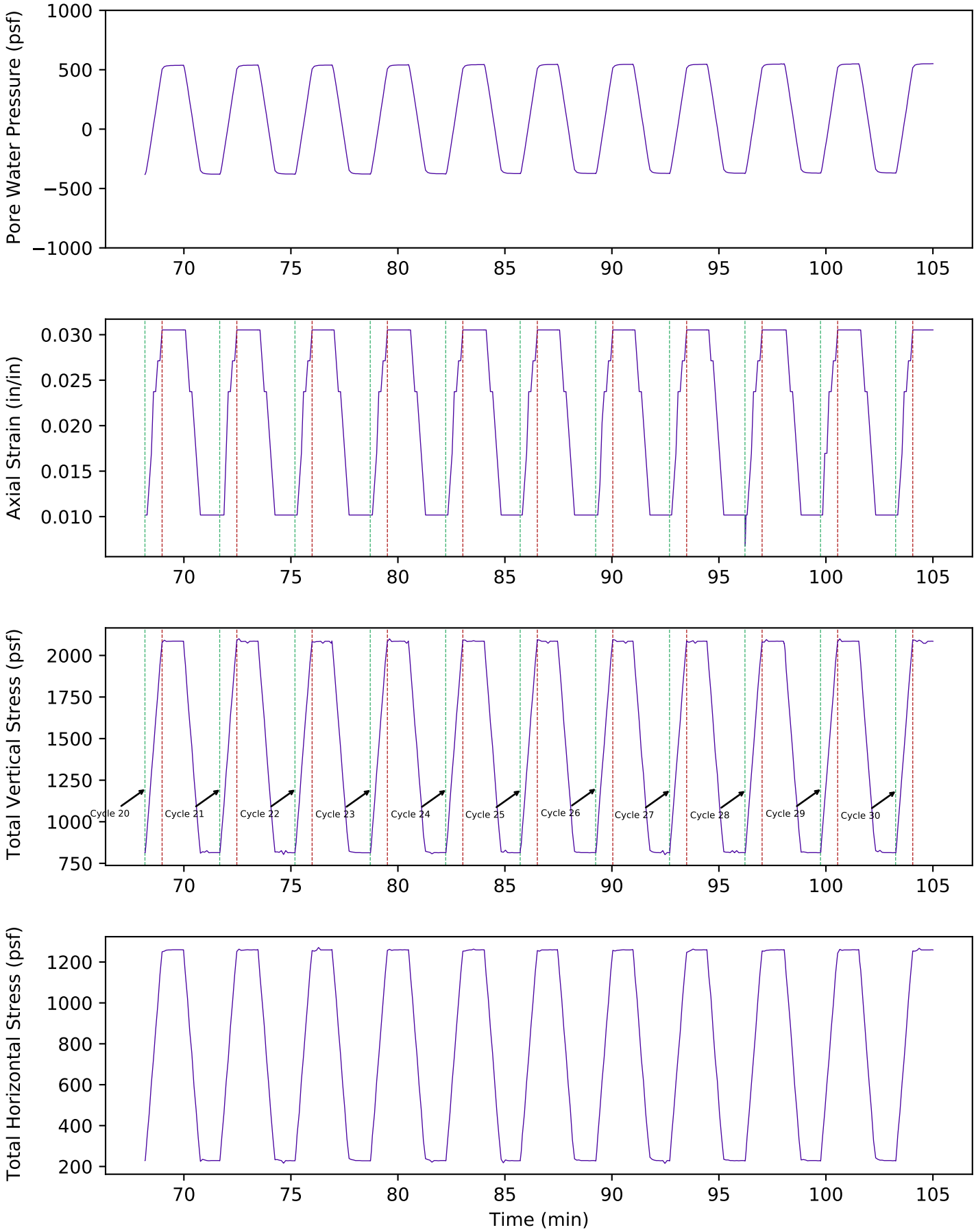

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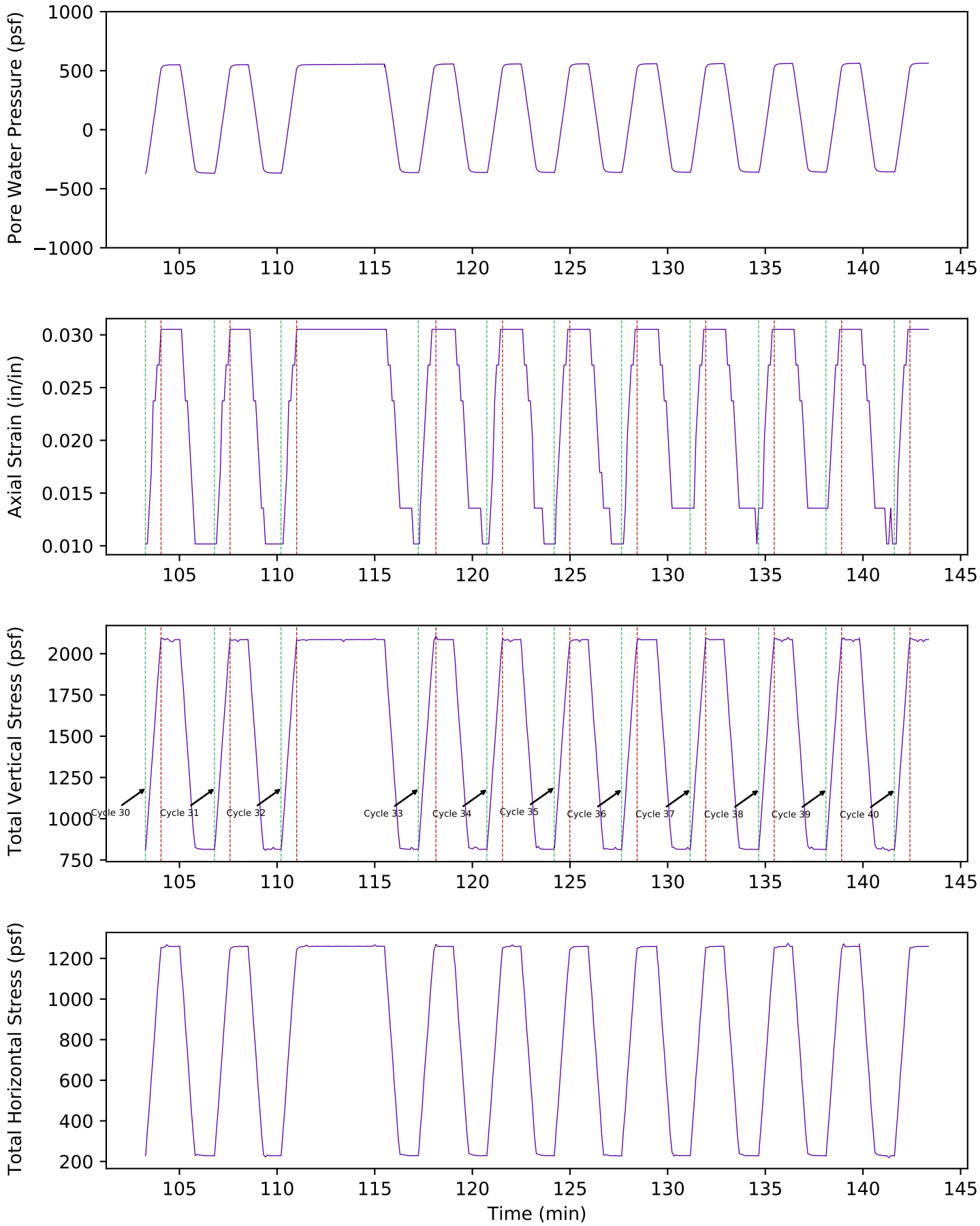

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Variables vs Time
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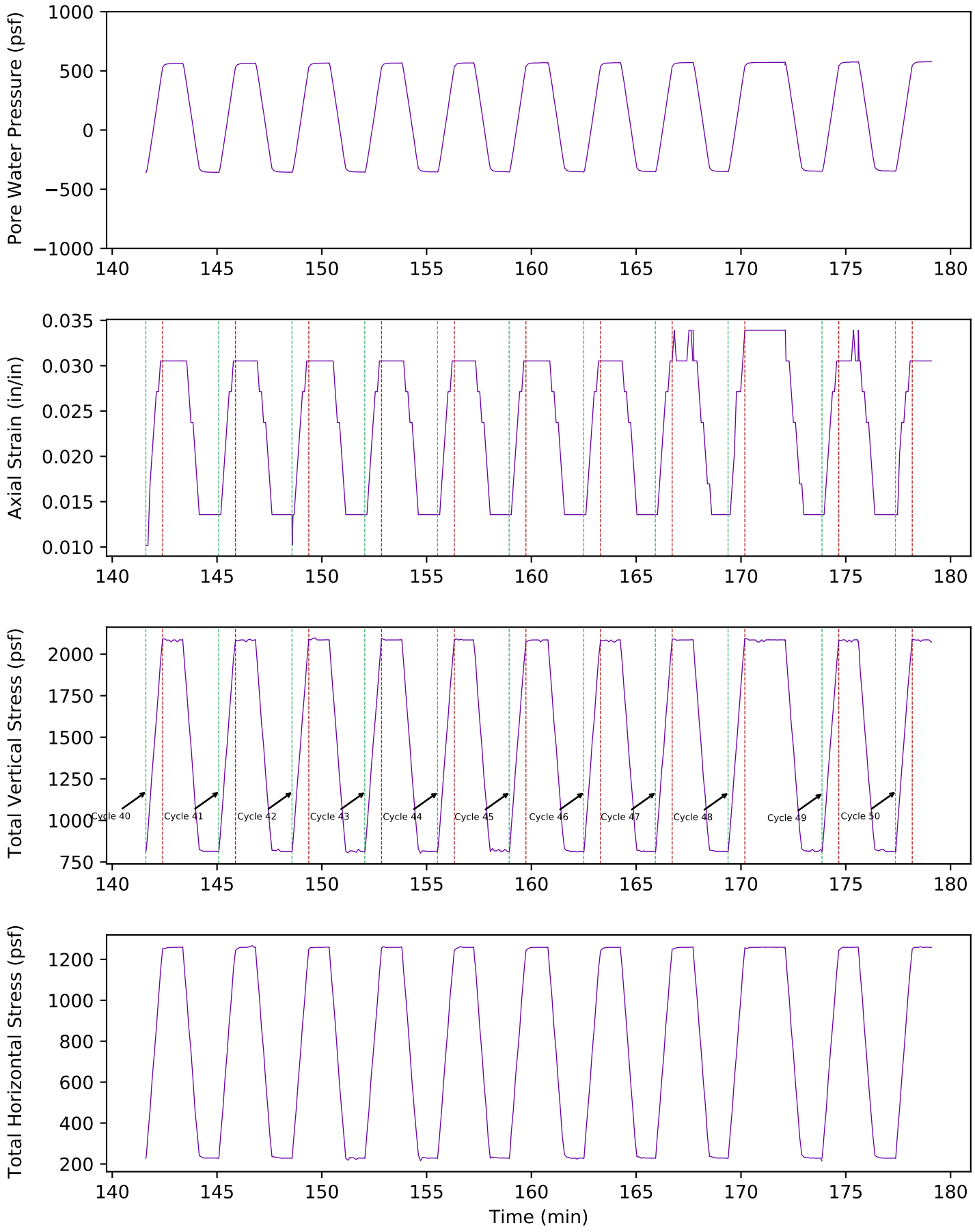

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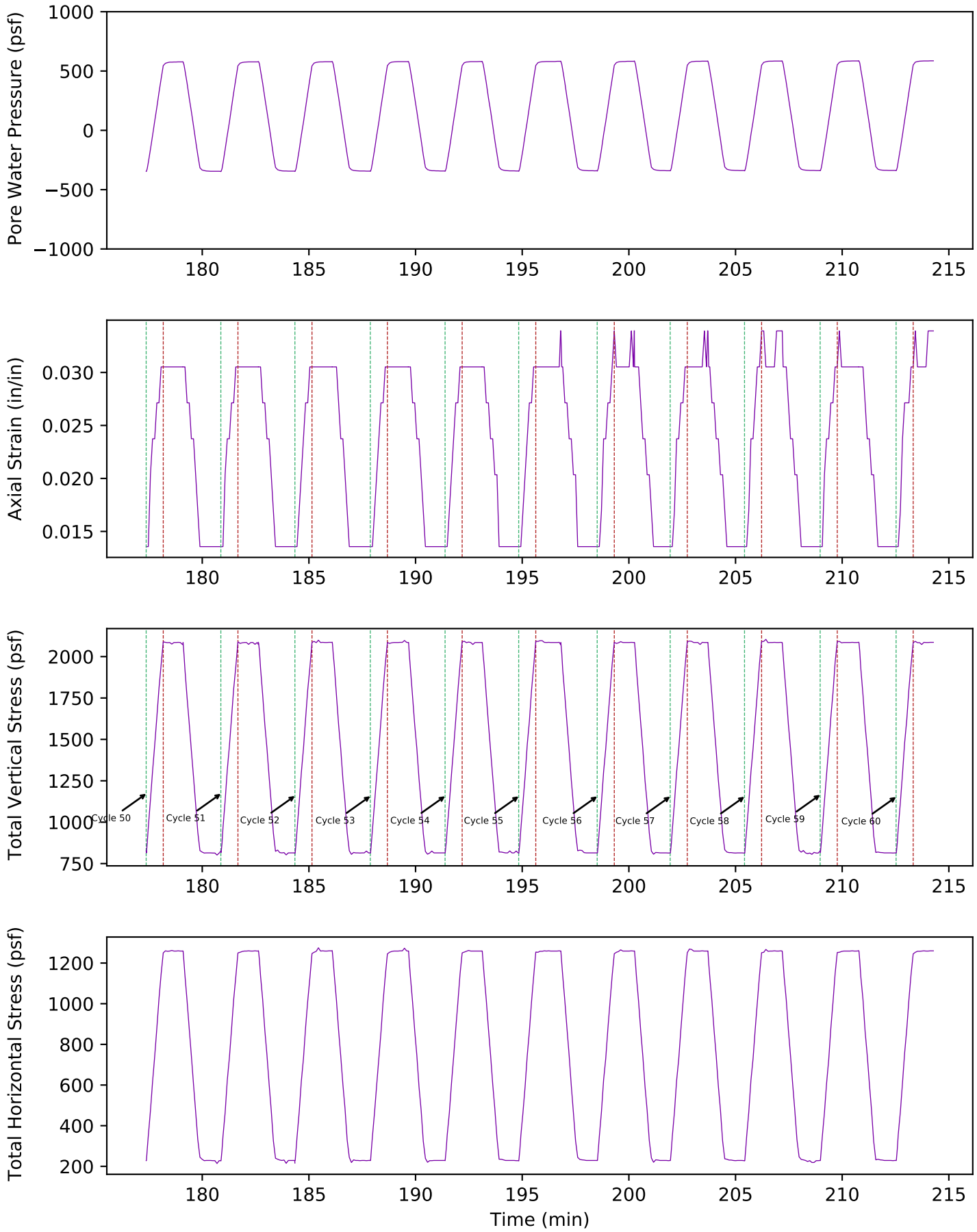

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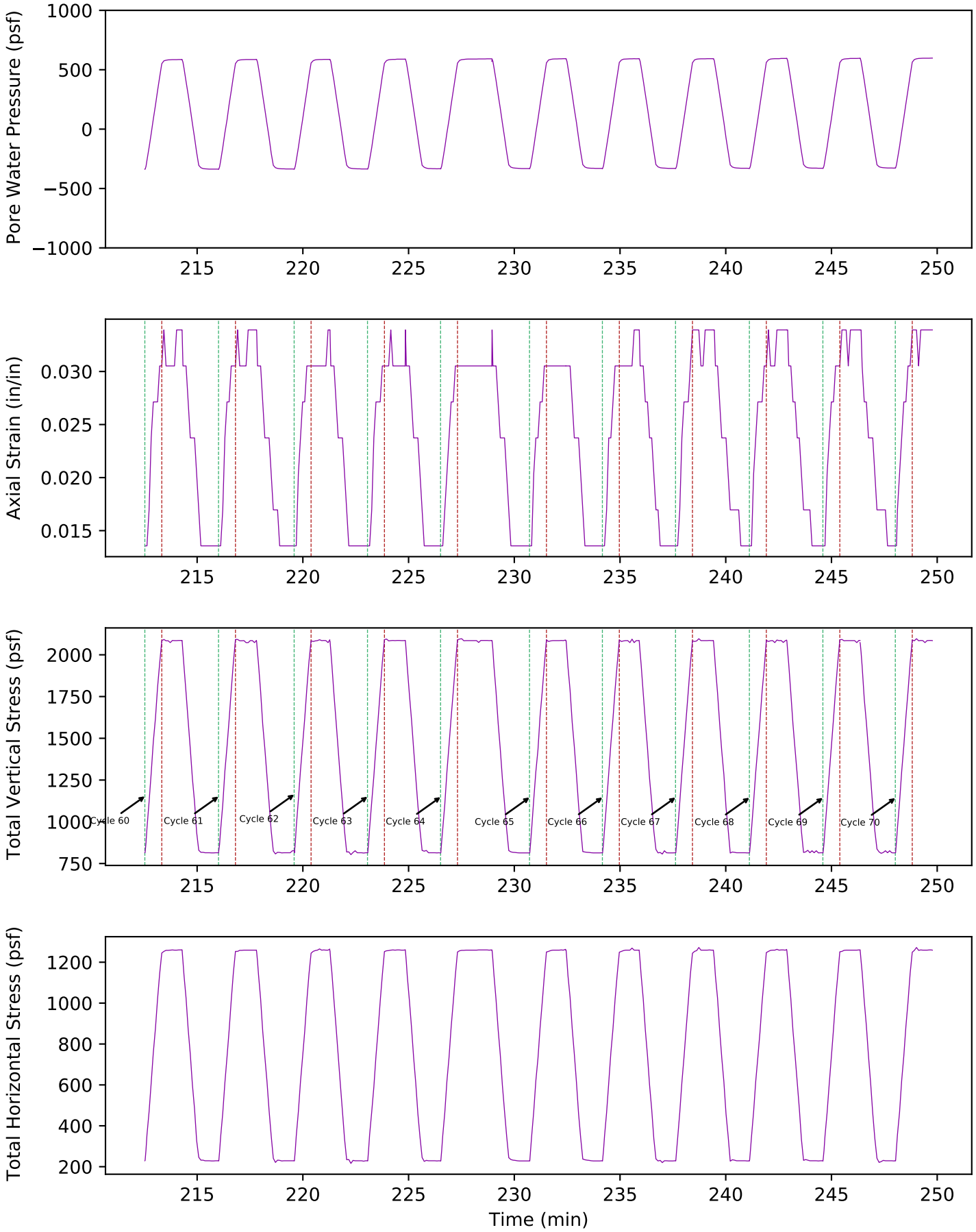

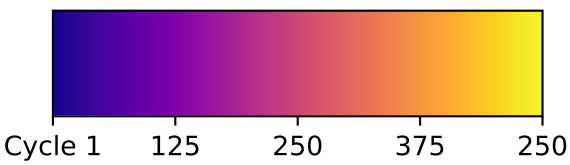

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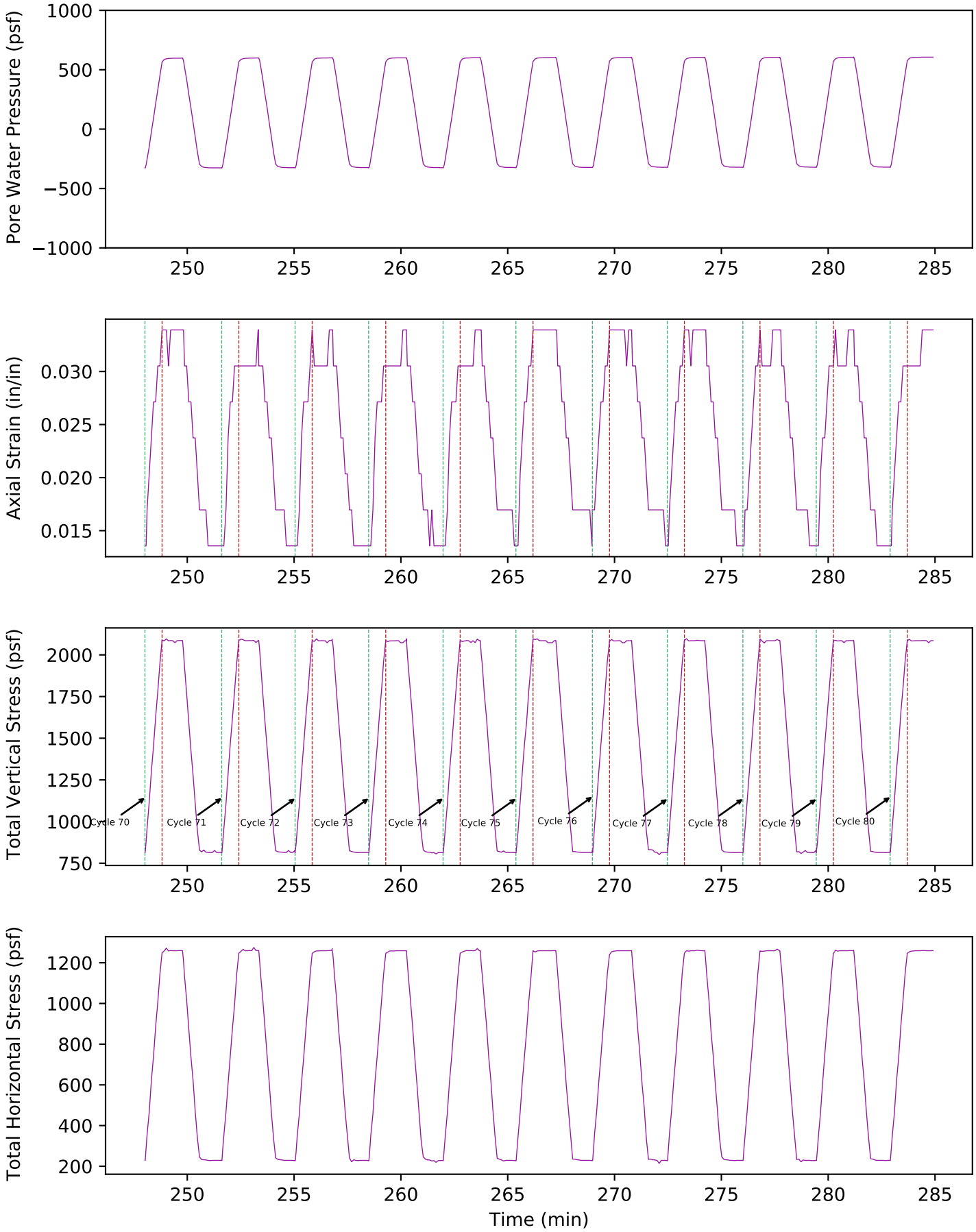

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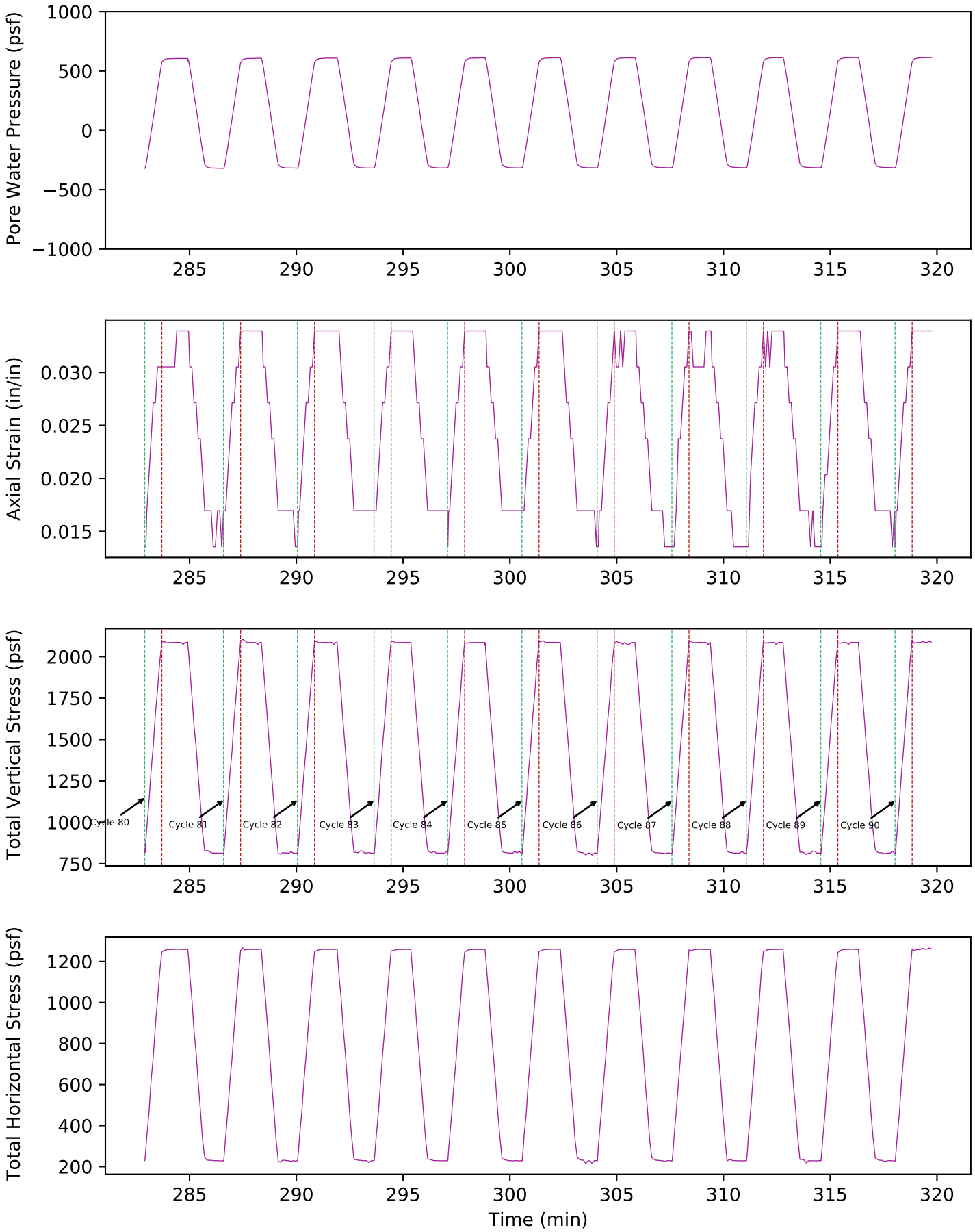

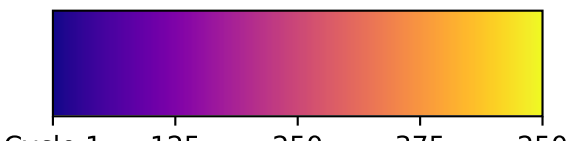

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Variables vs Time
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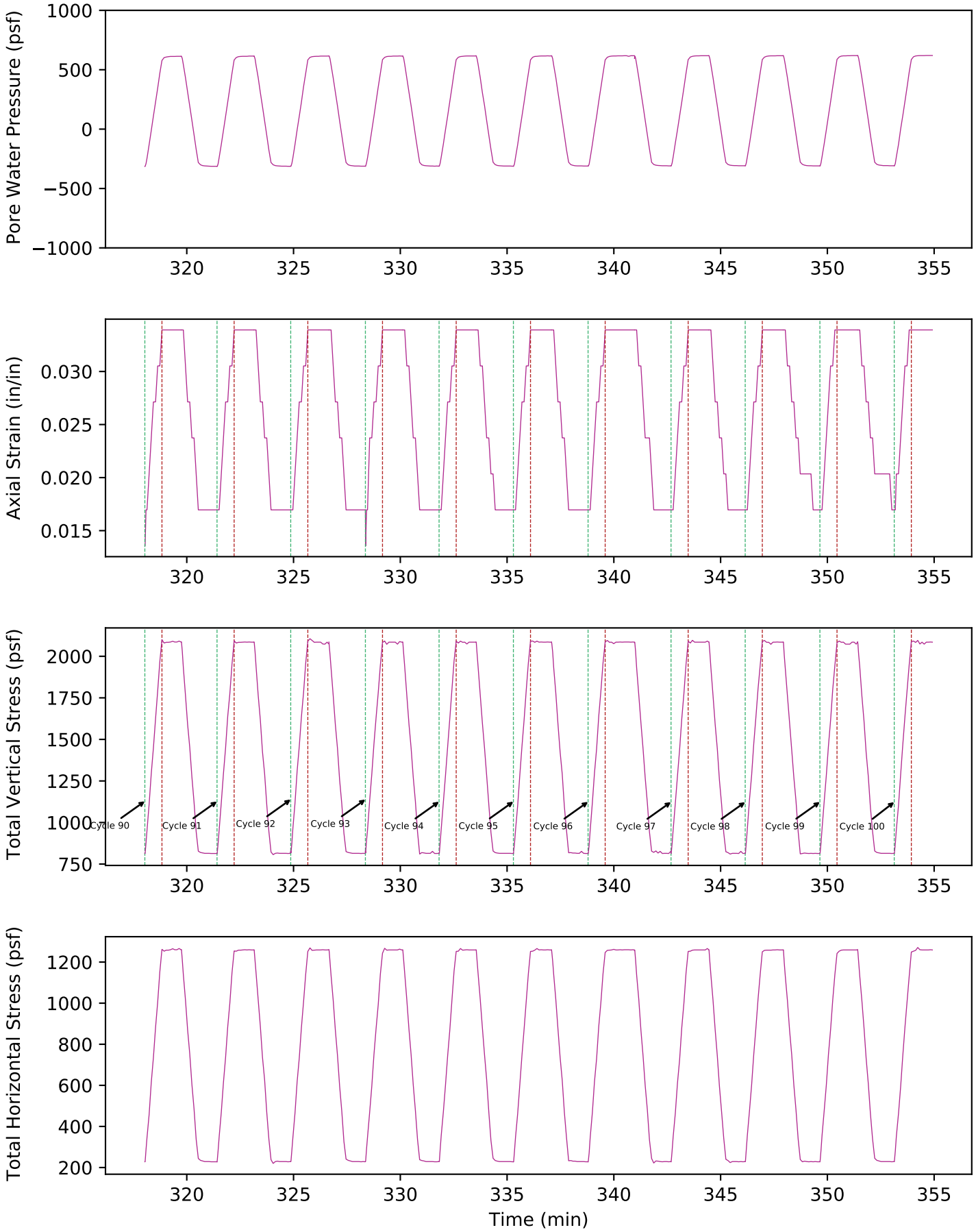

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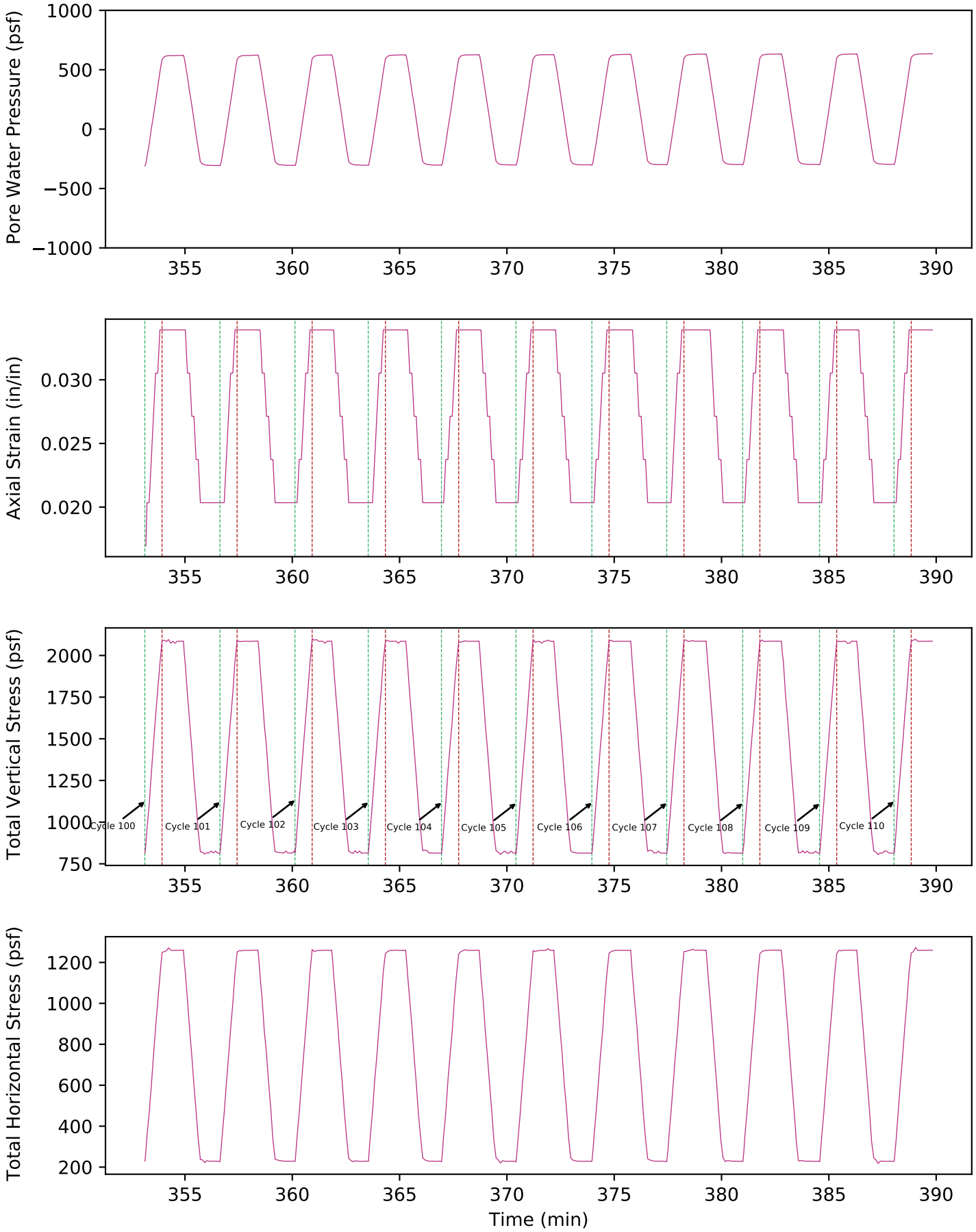

Cycle 1 125 250 375 250

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Variables vs Time
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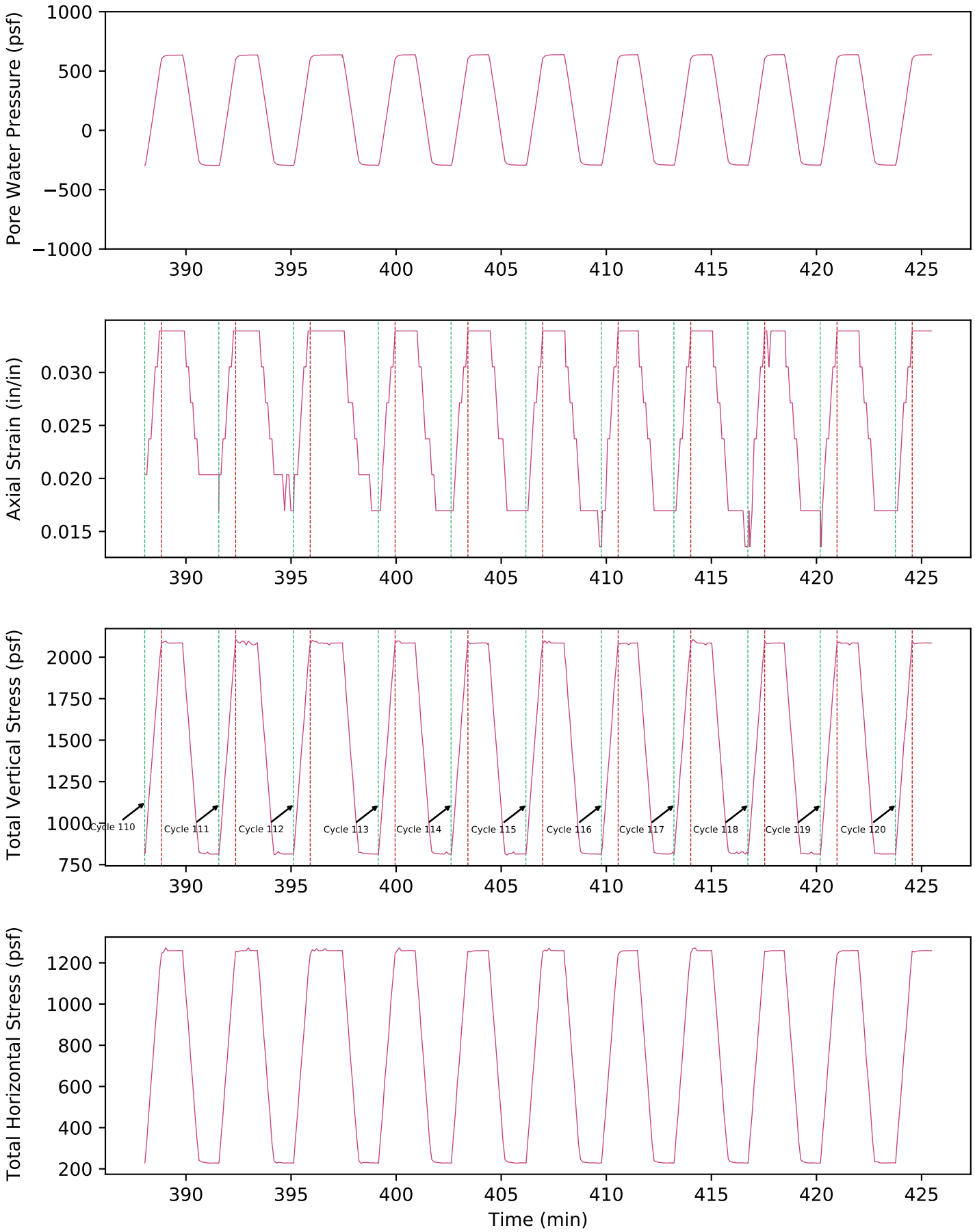

Cycle 1 125 250 375 250

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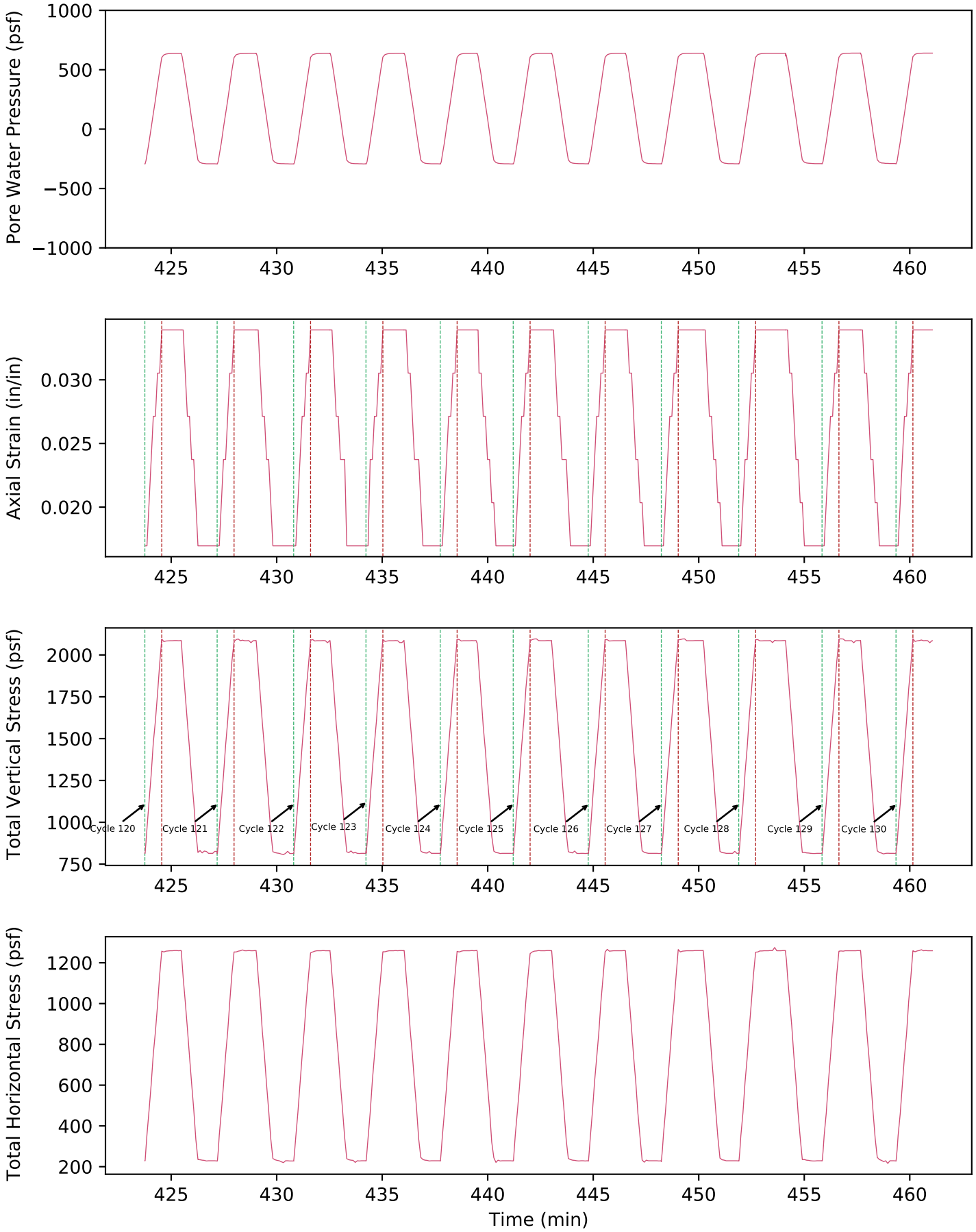

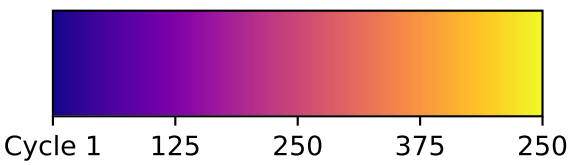

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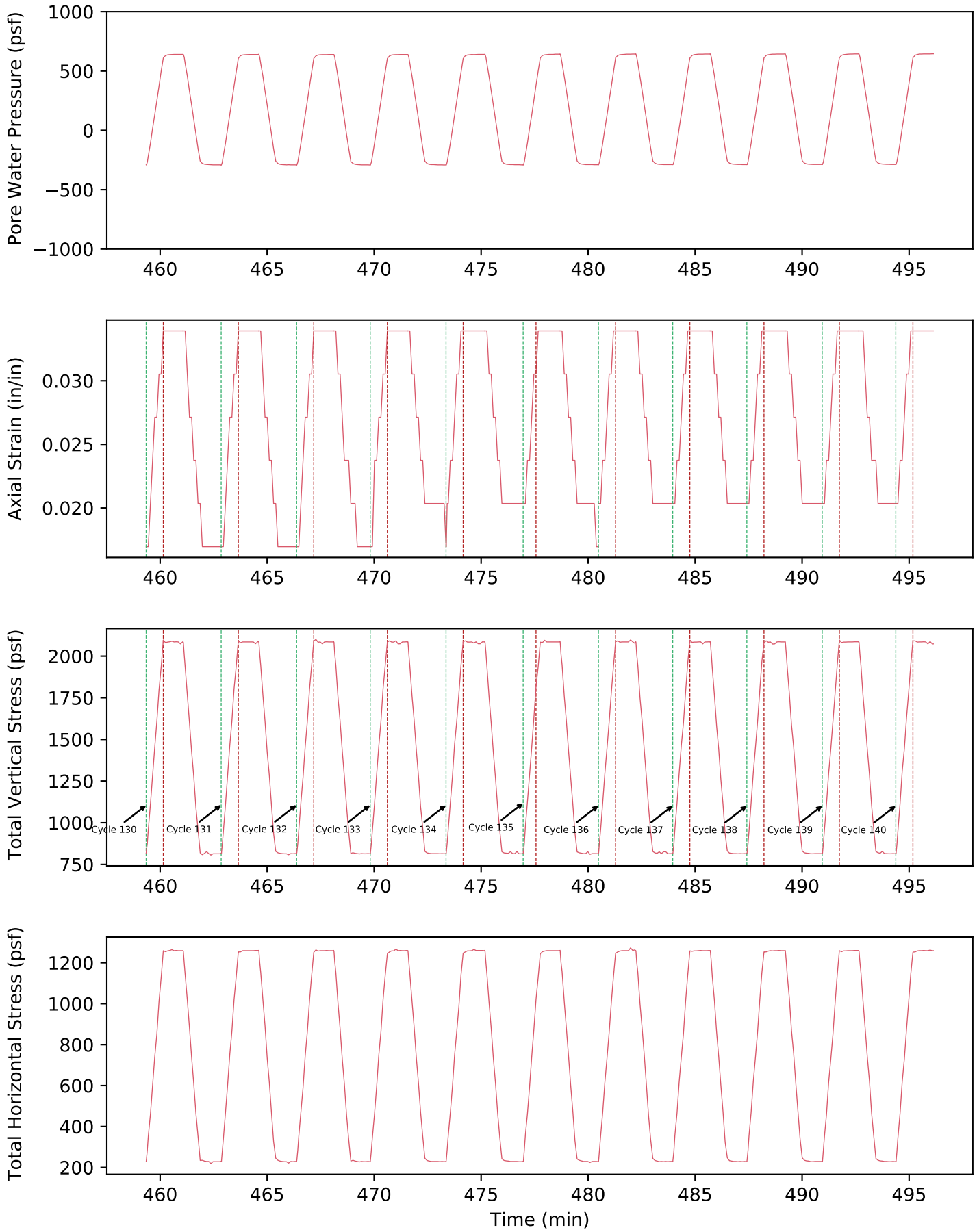

Cycle 1 125 250 375 250

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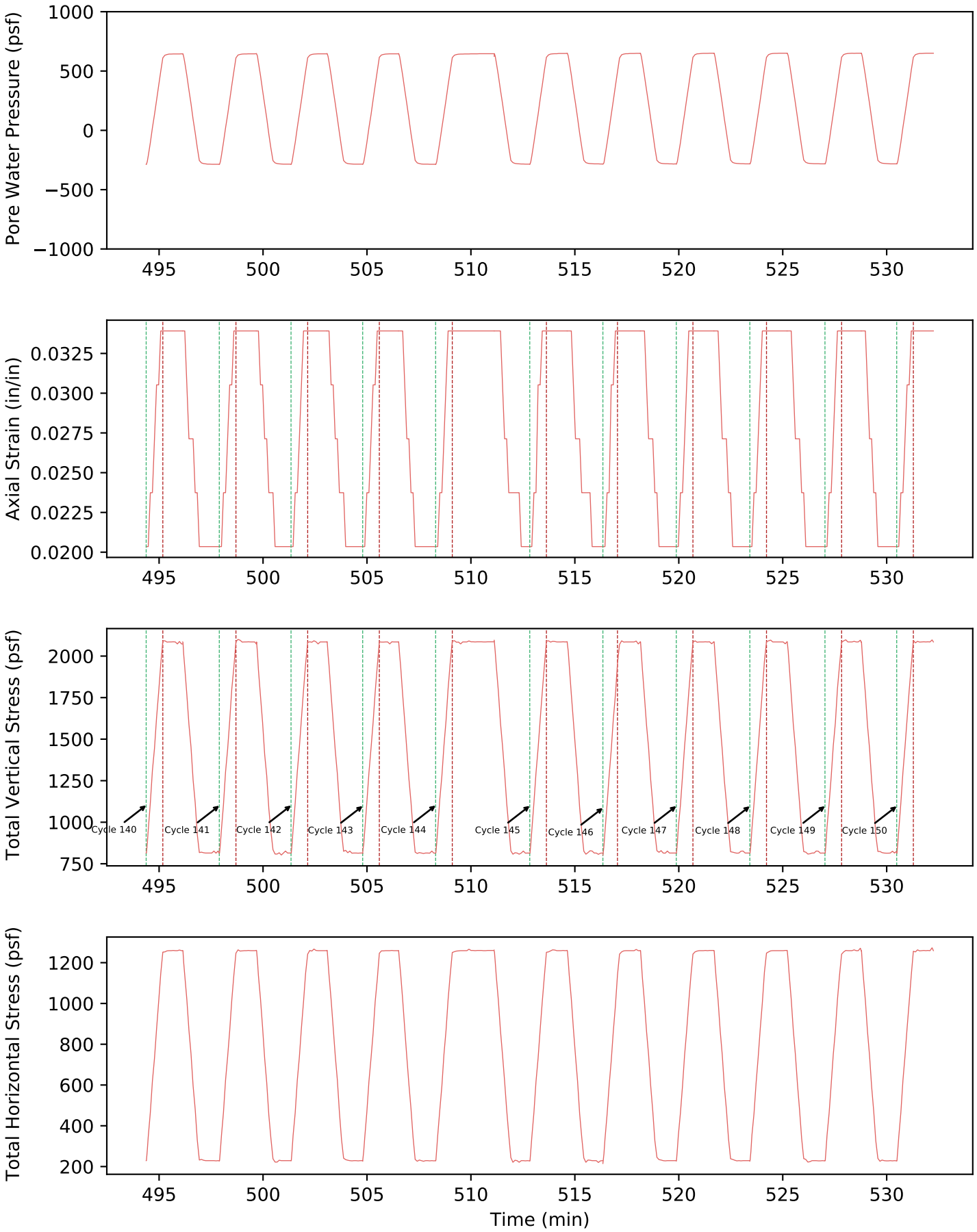

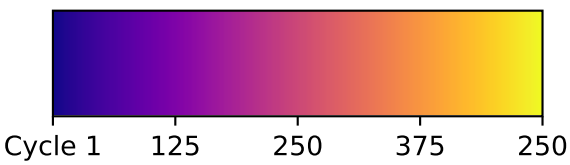

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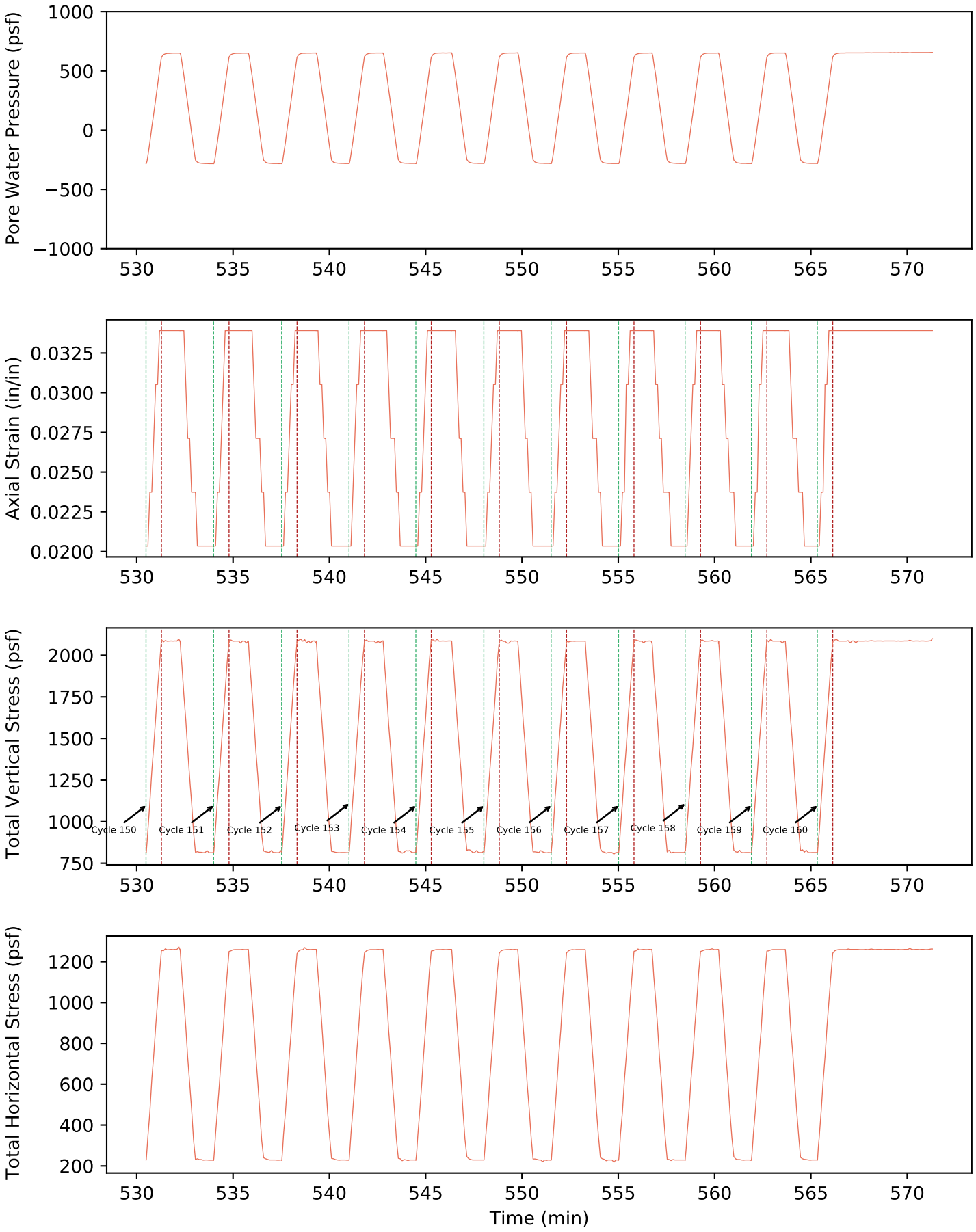

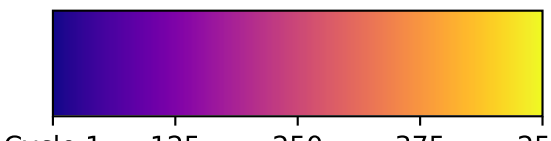

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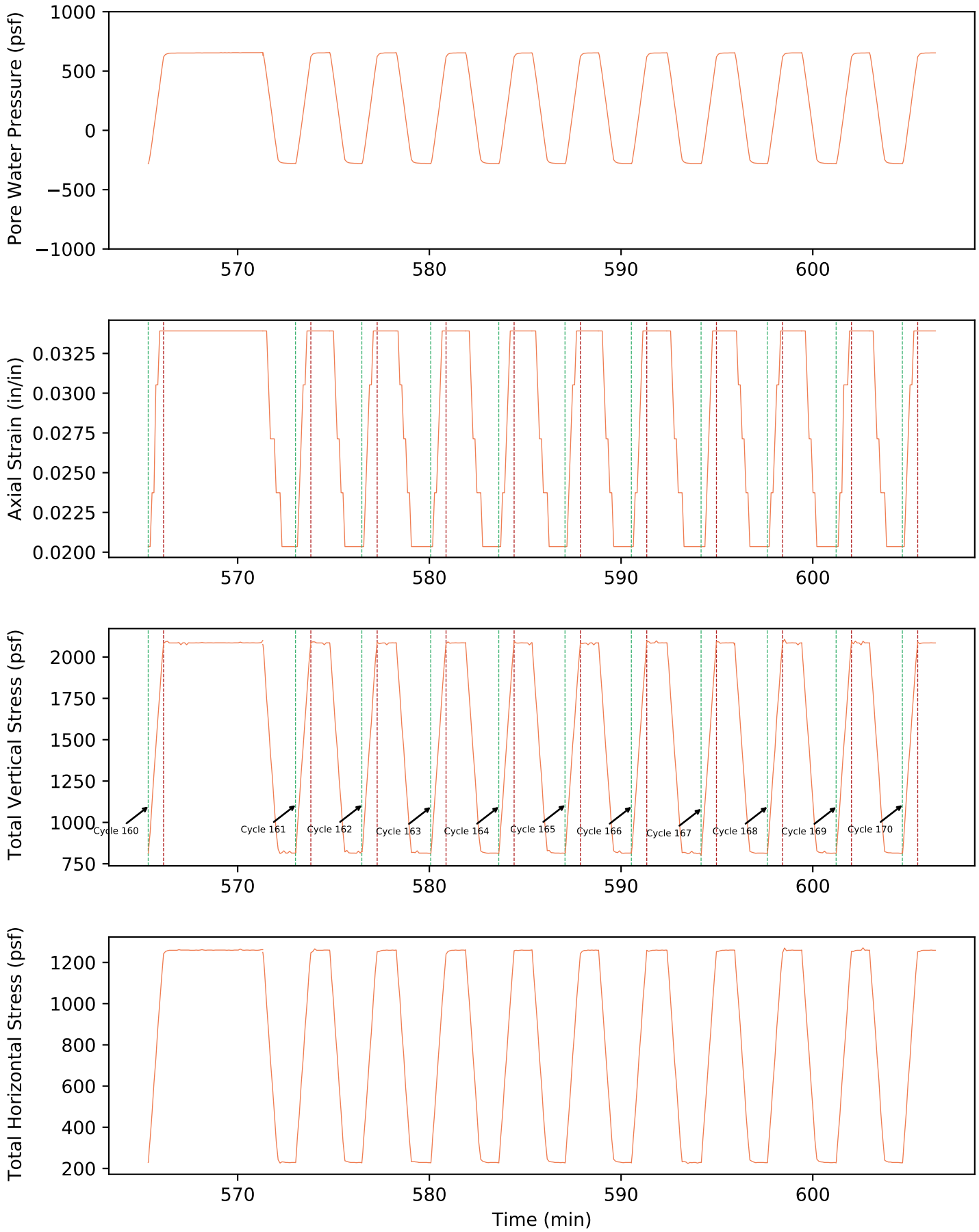

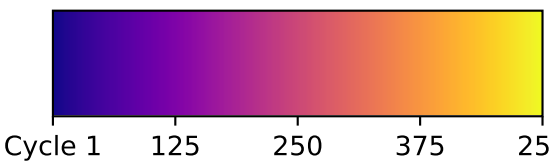

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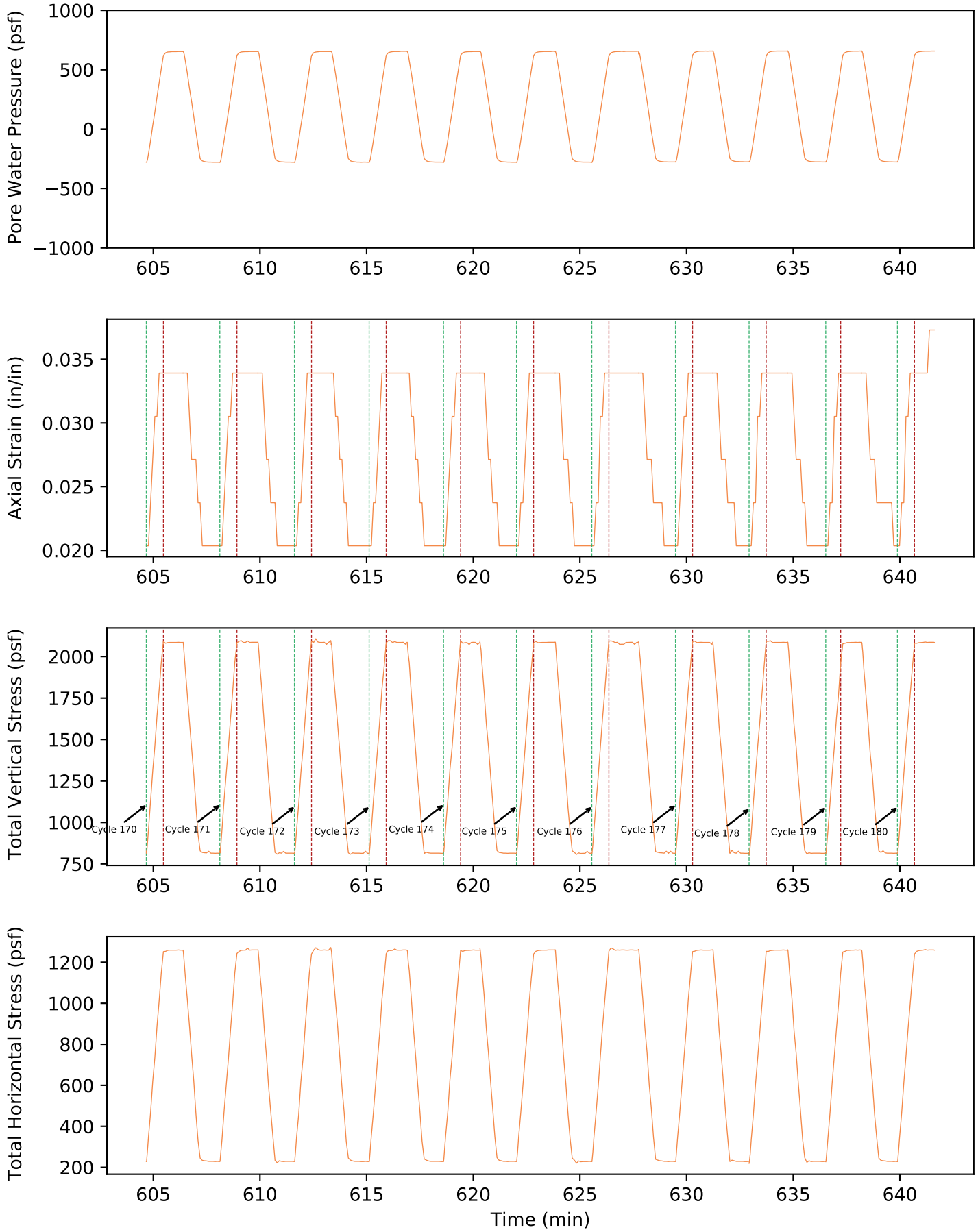

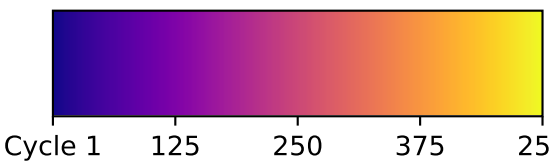

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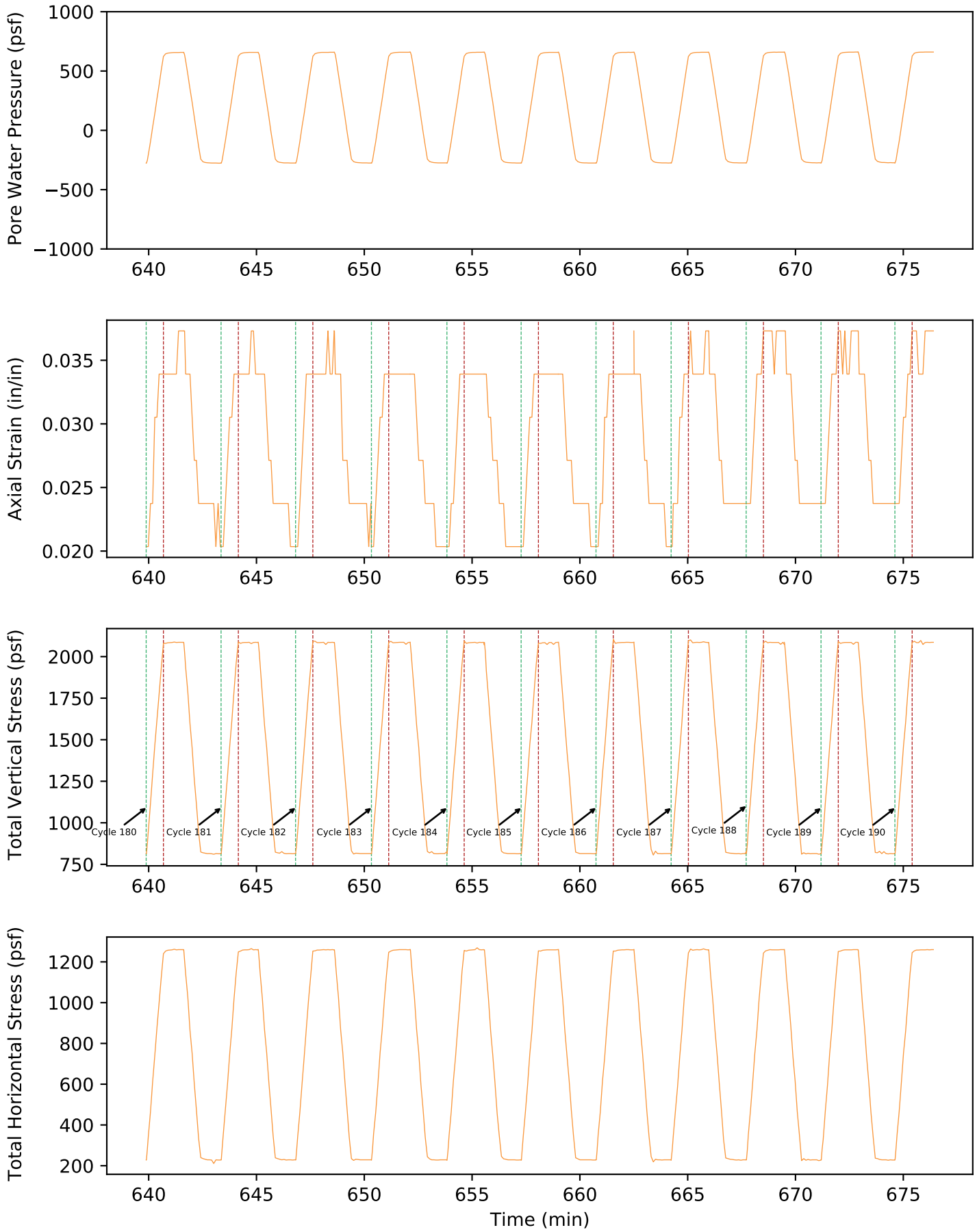

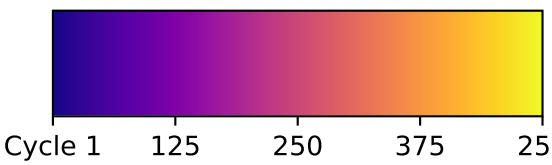

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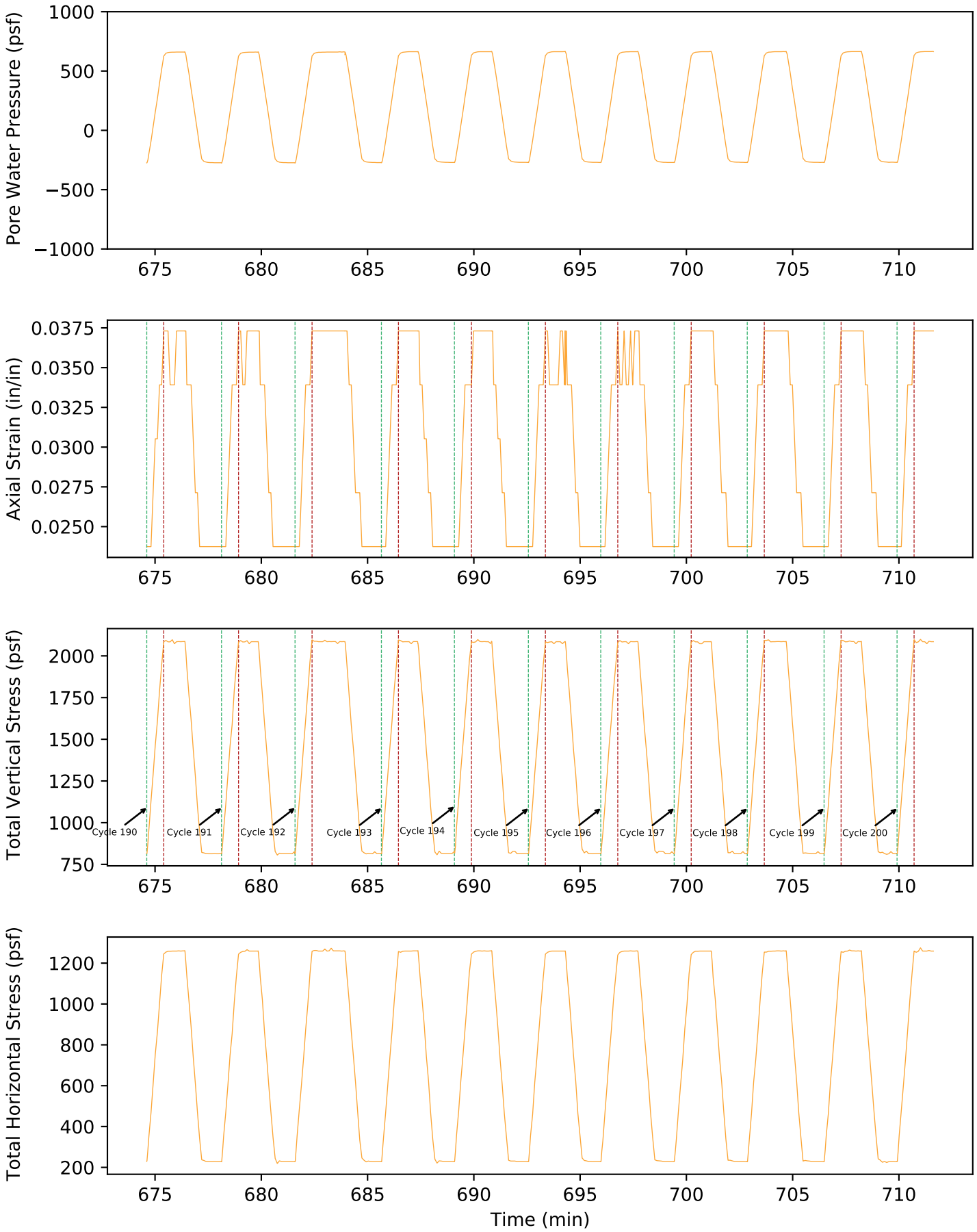

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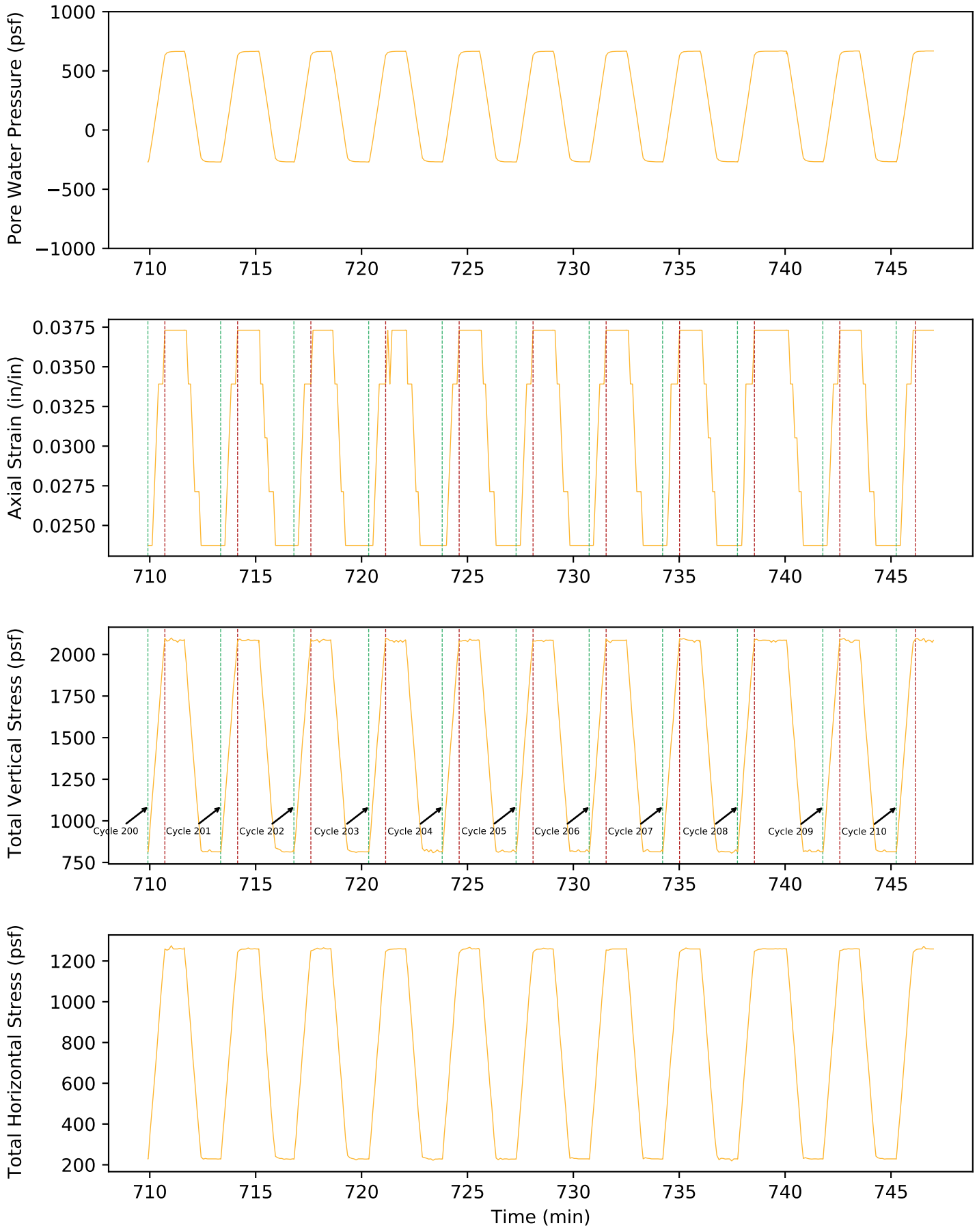

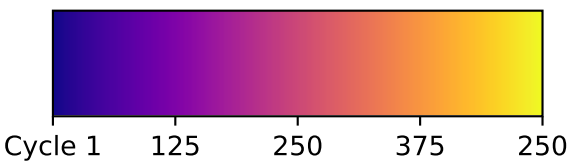

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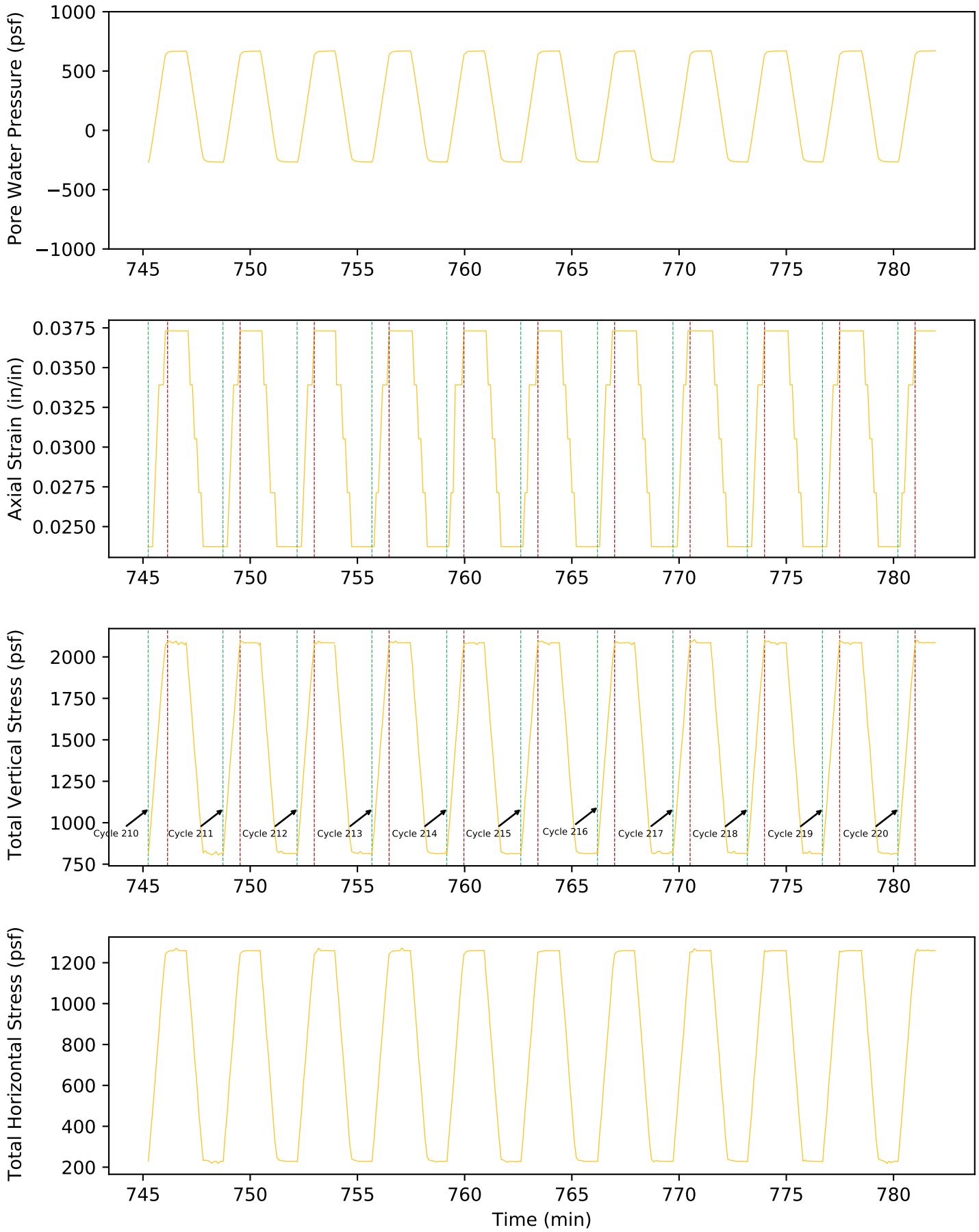

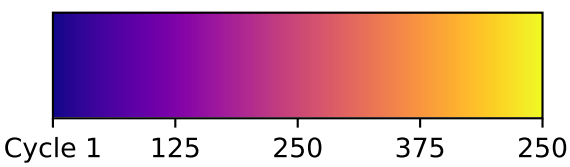

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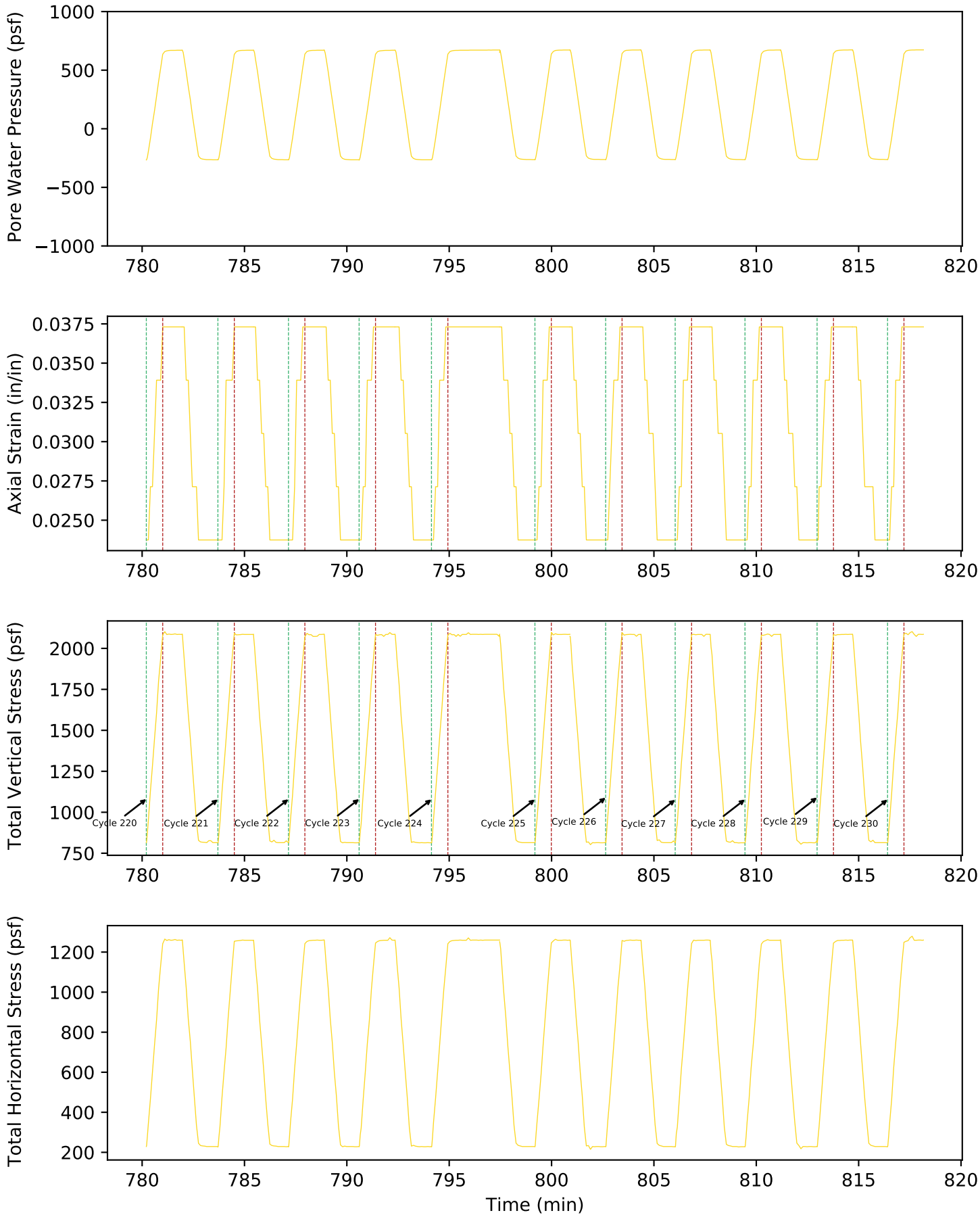

Cycle 1 125 250 375 250

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Variables vs Time
March 2021
B129
Stress Path Data

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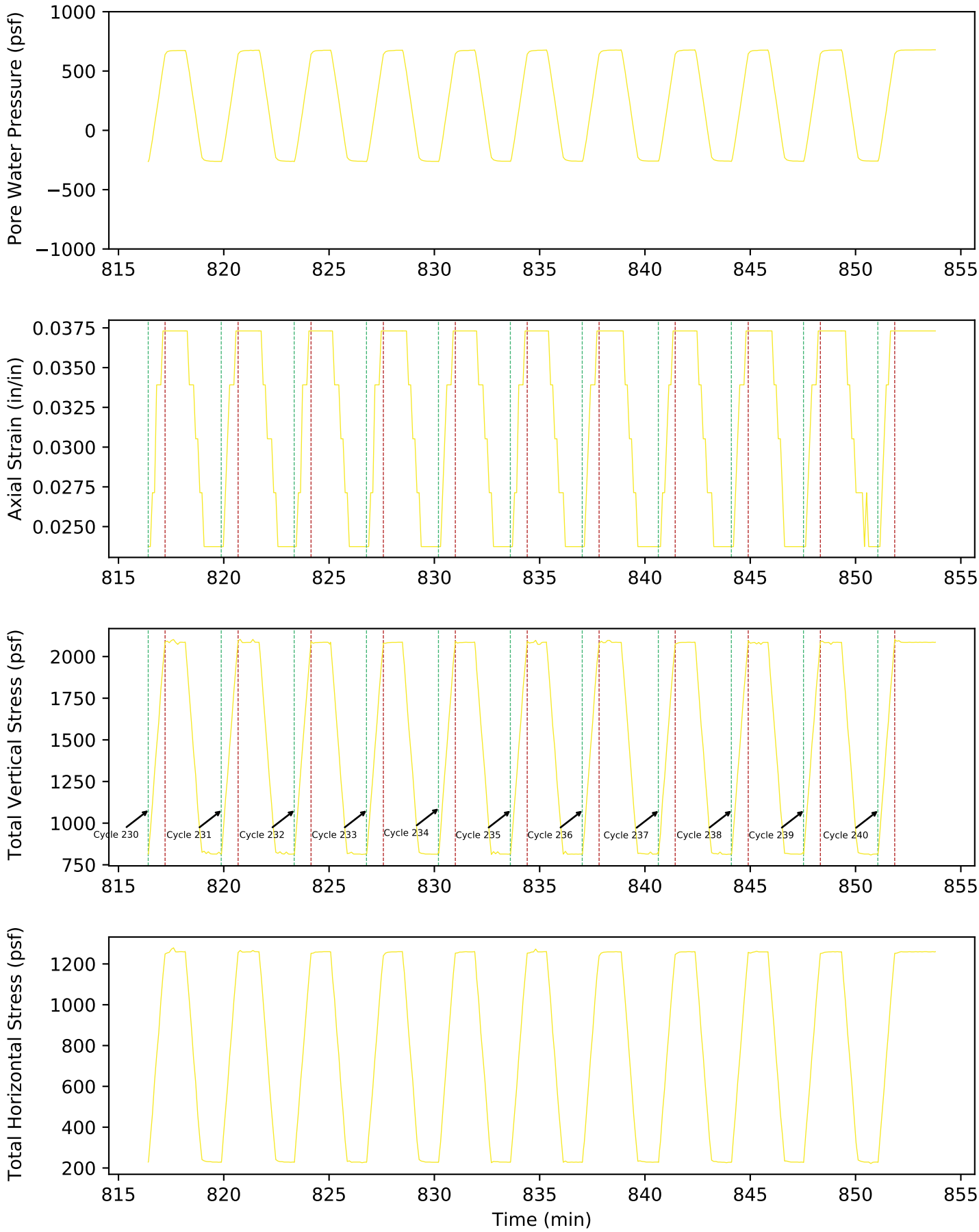

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Variables vs Time
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Stress Path Data

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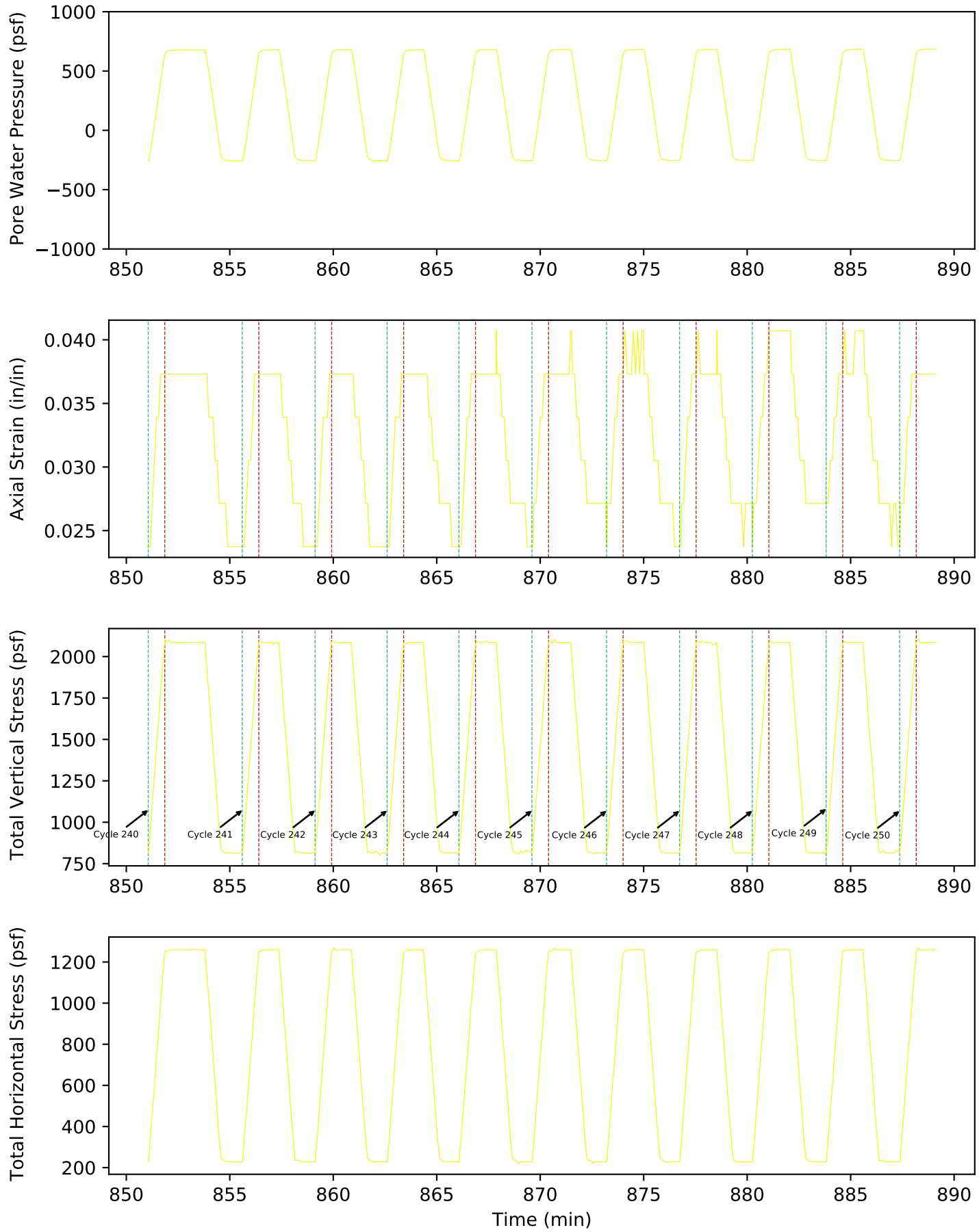

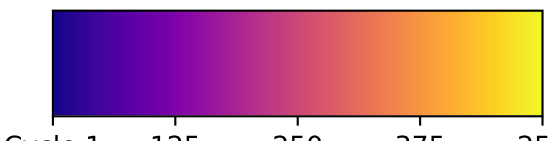

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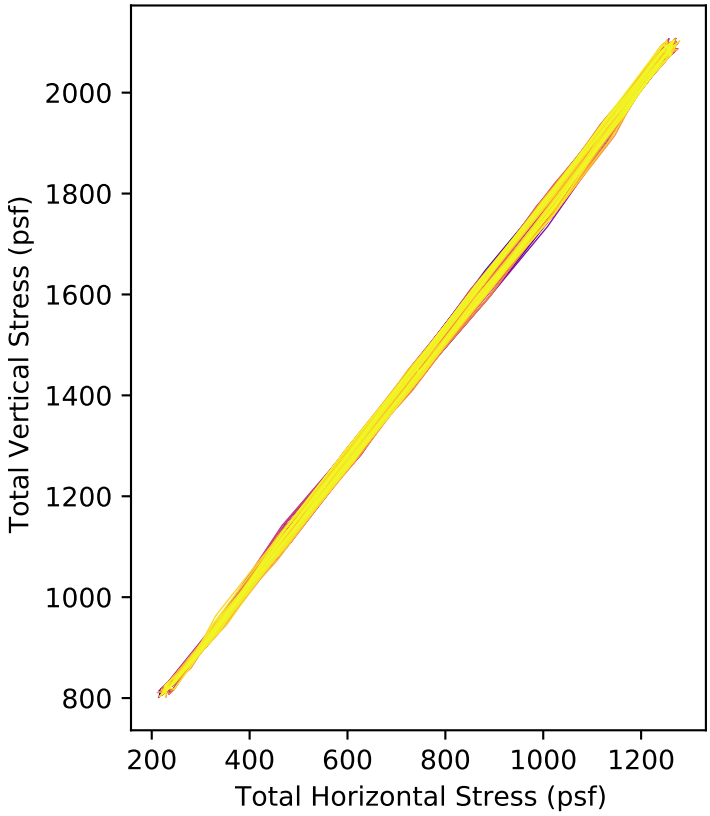

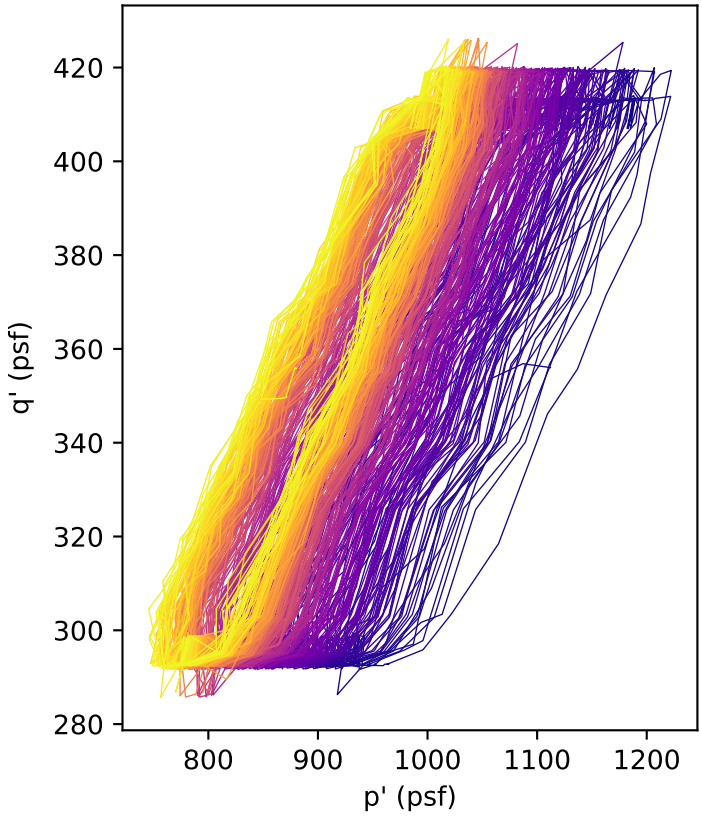

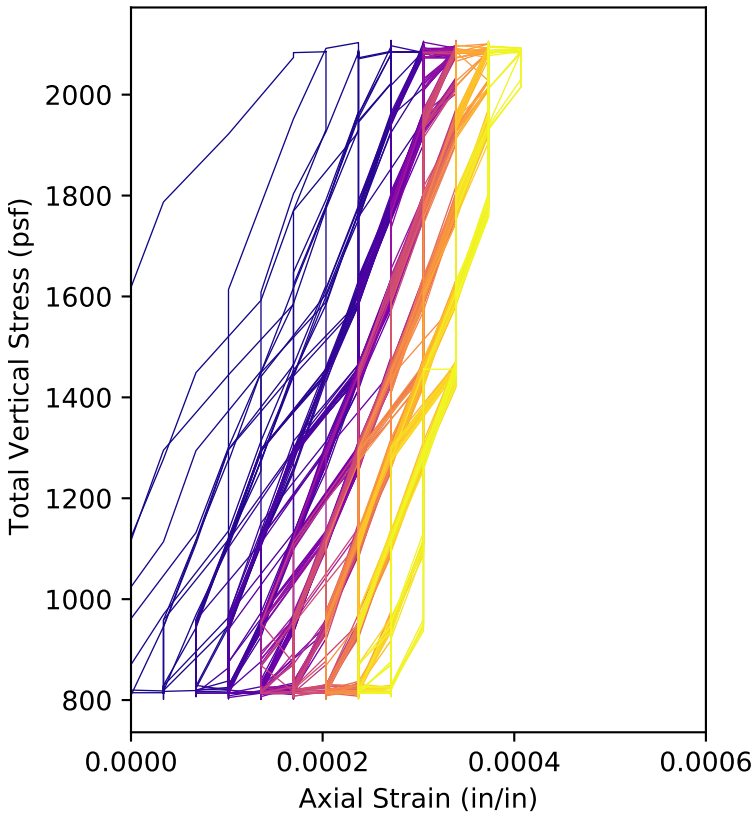

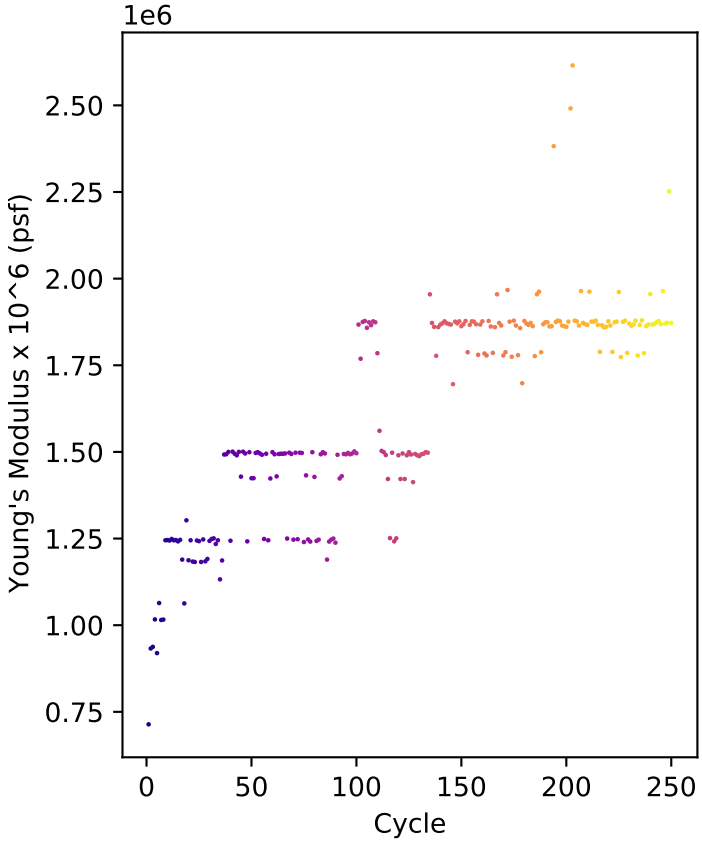

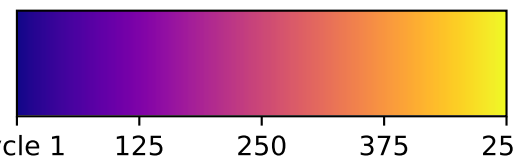

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Hysteresis Graphs
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