Geomechanics Characterization

PetroFrontier Australia Pty Ltd
- Well(s) McIntyre-1 & Baldwin-1-

Prepared for:

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Attention:

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TR11-401072_KL
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1 EXECUTIVE SUMMARY

TerraTek Kuala Lumpur has been requested by PetroFrontier Australia Pty Ltd to conduct a rock mechanics study on well McIntyre-1 and Baldwin-1 downhole cores. The objective of the study is to conduct rock mechanical testing to evaluate the elastic and compressive strength properties for shale cores. These rock mechanical properties are required for predictions of wellbore stability.

A rock mechanics study was conducted on McIntyre-1 and Baldwin-1 core samples, consisting of single stage triaxial tests on shale. Compressive strength and elastic parameters, such as Young's modulus and Poisson's ratio, were determined for the shale samples based on the experimental results.

2 BACKGROUND

Mechanical analyses were conducted on supplied reservoir sandstone and preserved shale core material from the Well McIntyre-1 and Baldwin-1, for the PetroFrontier Australia Pty. Ltd. The testing program consisted of:

Single stage triaxial compression tests on shale samples at room temperature.

For this test program, PetroFrontier Australia Pty. Ltd. provided sections of shale core taken from zones of interest from both wells. All stress levels (confining, pore, etc.) for STXC tests, including ramp/depletion rates, were specified by the client. All depths indicated within this summary and represents measured depths taken directly from the received material. The purpose of the testing was as follows:

- ➢ To provide strength information for the material. With such information, predictions of borehole stability can be performed;
- ➢ To provide parameters for drilling, completions and stimulation design;

Table R1 lists the supplied core material for this test program. The sample prepared list and testing matrix for this program is provided in Table R2 and Table R3 respectively. All laboratory data, including procedures, tabulated results, stress-strain plots and post-test sample images will be provided in electronic form.

Table R1. Material Received

Well	Lithology Type	Core Depth (m)	Length (cm)	Diameter (cm)	Received Conditions / Comments
McIntyre-1	Shale	787.05 – 787.10	21.0	6.5	No preservation
Baldwin-1	Shale	870.12 – 870.20	24.0	6.5	

Table R2. Samples Prepared

Well	Sample ID	Depth (m)	Orientation	Test Performed[1]
McIntyre-1	MCI-1	787.08	Vertical	TXC
Baldwin-1	BDW-1	870.16	Vertical	TXC

Table R3. Testing Matrix

Well	Depth (m)	STXC
McIntyre-1	787.08	MCI-1
Baldwin-1	870.16	BDW-1
Totals:		**2**

[1] TXC = Single-Stage Triaxial Compression Test.

3 ROCK FAILURE PROPERTIES

3.1 Compression Testing

Single stage and multi-stage triaxial compression tests were performed on vertical plugs obtained from shale samples at specified confining pressures. The shales were tested under a slow strain rate (loading rate) of approximately $1x10^{-7}$ (strain/sec) with a fine steel mesh screen wrapped around the sample for proper pore fluid drainage with the pore line vented to atmosphere. All compression tests were conducted under room temperature. All the single stage triaxial tests on shale samples were tested under 'as received' conditions

Single stage triaxial compression test results on shale samples, including quasi-static mechanical properties, are summarized in Table R4 and R5. Corresponding stress-strain plots are presented in Figure R1 through Figure R16. The effective residual strength for most of the shale samples were not achieved due to the nature of the loading mode and difficulty in estimating the exact time when the samples reached their peak stress points.

Table R4. Summary of Single Stage Triaxial Compression Tests – Shale (First Scenario[2])

Well	Sample ID	Depth (m)	Saturation[3]	As-Received Bulk Density (g/cm^3)	Effective Confining Pressure[4] (MPa)	Effective Compressive Strength (MPa)	Effective Residual Compressive Strength (MPa)	Quasi-Static Young's Modulus (MPa)	Quasi-Static Poisson's Ratio
McIntyre-1	MCI-1	787.08	As-Received	2.554	13	189.70	--	29,050	0.21
Baldwin-1	BDW-1	870.16	As-Received	2.759	15	249.50	--	36,190	0.28

Table R5. Summary of Single-Stage Triaxial Compression Tests – Shale (Second Scenario[5])

Well	Sample ID	Depth (m)	Saturation[6]	As-Received Bulk Density (g/cm^3)	Effective Confining Pressure[7] (MPa)	Effective Compressive Strength (MPa)	Effective Residual Compressive Strength (MPa)	Quasi-Static Young's Modulus (MPa)	Quasi-Static Poisson's Ratio
McIntyre-1	MCI-1	787.08	As-Received	2.554	13	189.70	--	30,470	0.18
Baldwin-1	BDW-1	870.16	As-Received	2.759	15	249.50	--	40,060	0.15

[2] First scenario refers to Young's modulus and Poisson's ratio was calculated at 30 – 50% of the peak of axial stress difference which is a standard by TerraTek.
[3] All samples were tested 'as received' conditions without saturating with fluids or oven-drying.
[4] All samples were tested with Pp = 0 psi, using an axial loading rate of $1x10^{-7}$ strain/sec.
[5] Second scenario refers to Young's modulus and Poisson's ratio was calculated at 5 – 25% of the peak axial stress difference as requested by DCS APG.
[6] All samples were tested 'as received' conditions without saturating with fluids or oven-drying.
[7] All samples were tested with Pp = 0 psi, using an axial loading rate of $1x10^{-7}$ strain/sec.

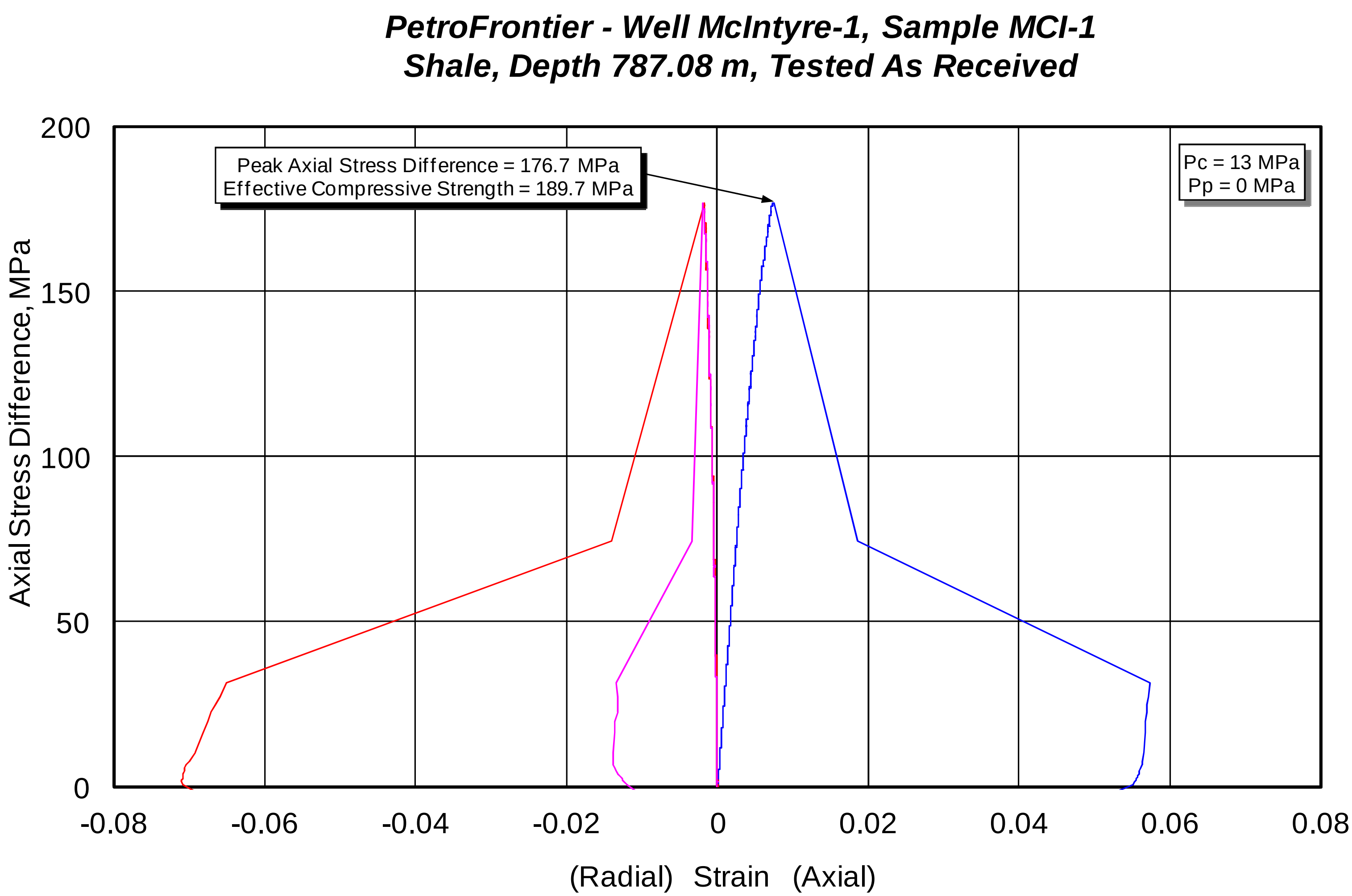

Figure R1. **Summary plot of the stress-strain response for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. The effective compressive strength for each test is indicated in the figure.**

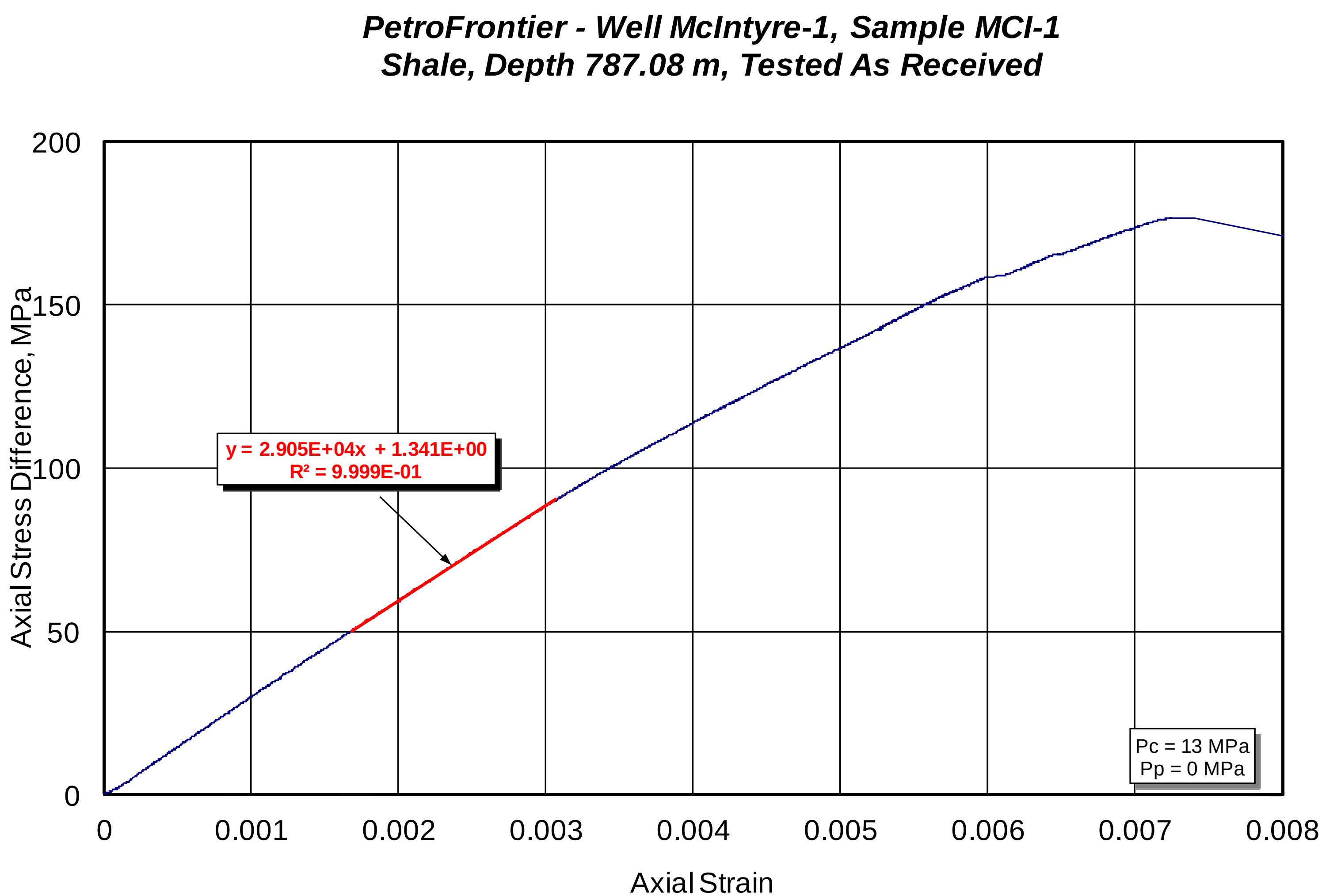

Figure R2. A detailed view of the axial stress difference versus axial strain for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. Young's modulus was calculated from the highlighted area shown (first scenario at 30% – 50 % of the peak axial stress difference).

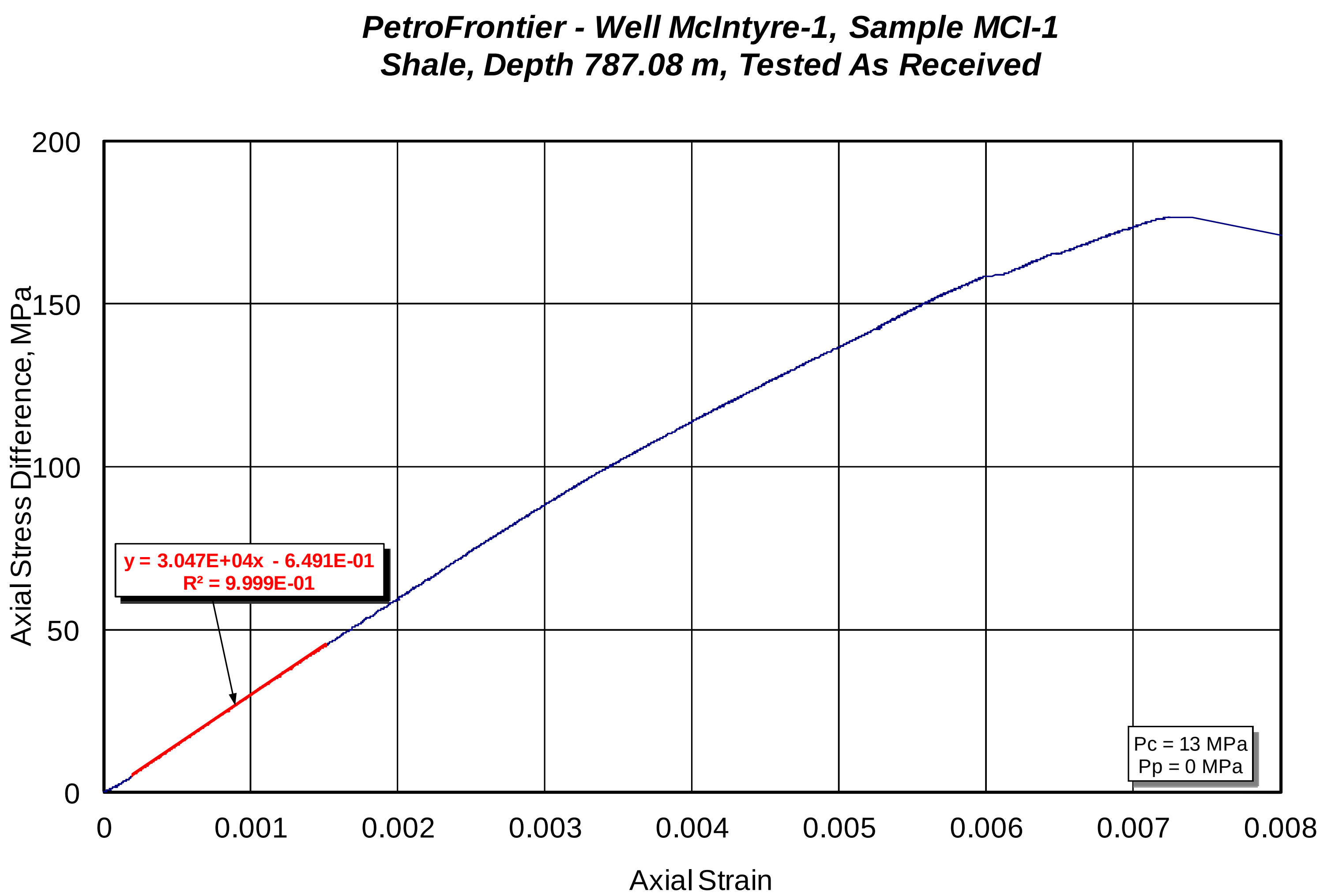

Figure R3. **A detailed view of the axial stress difference versus axial strain for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. Young's modulus was calculated from the highlighted area shown (second scenario at 5% – 25 % of the peak axial stress difference).**

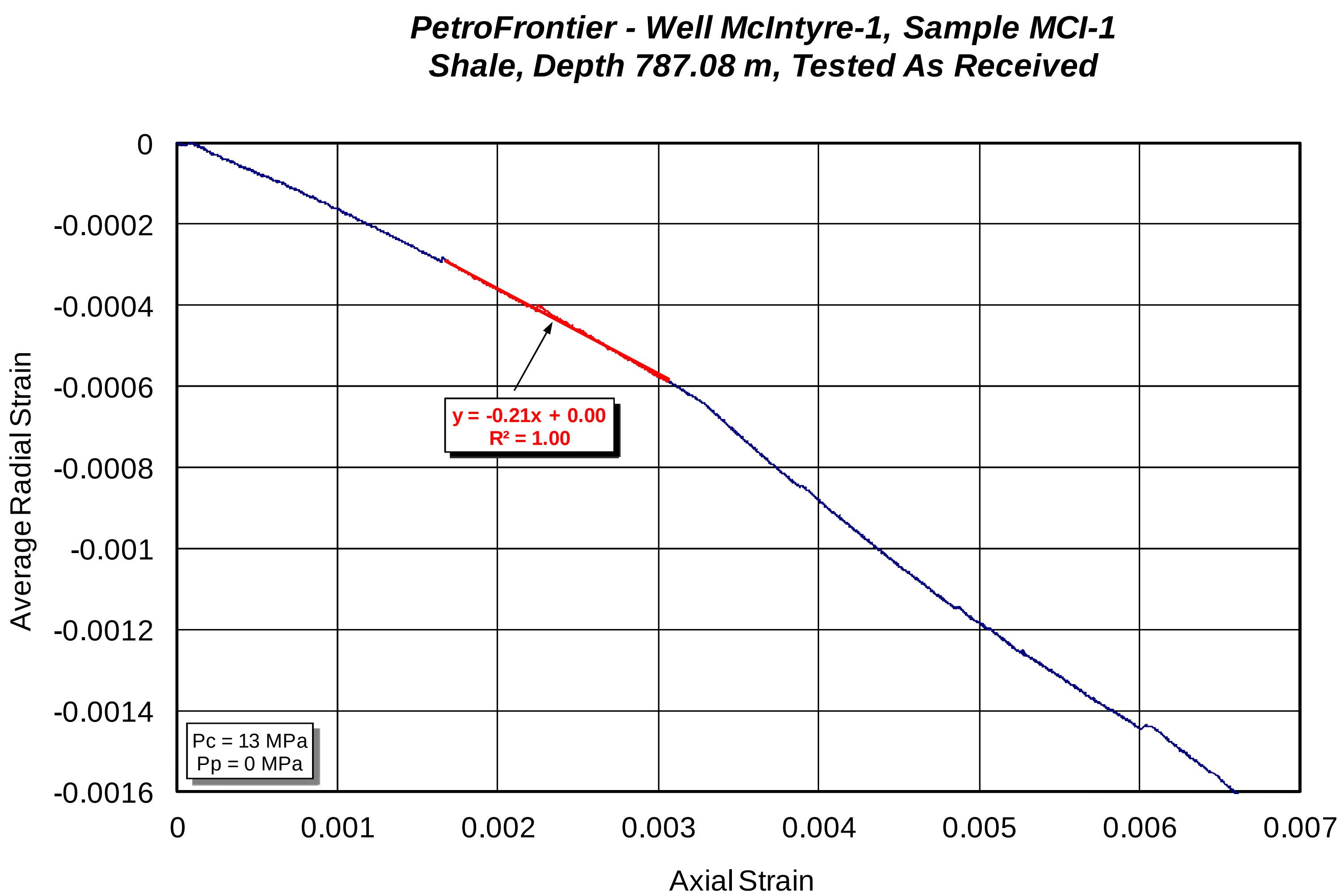

Figure R4. **A detailed view of the averaged radial strain versus the axial strain for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. Poisson's ratio was calculated from the highlighted area shown (first scenario at 30% – 50% of the peak axial stress difference) .**

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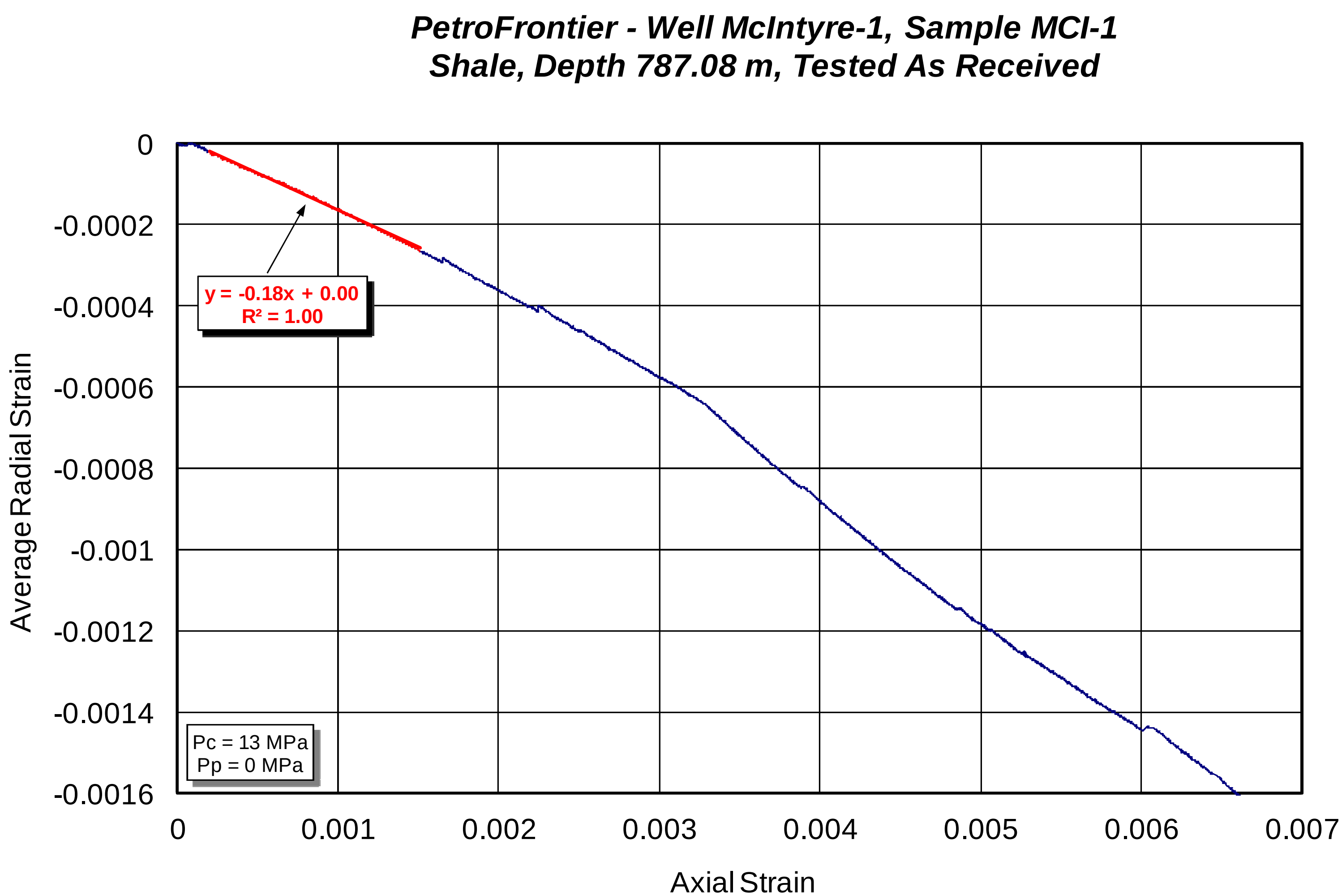

Figure R5. A detailed view of the averaged radial strain versus the axial strain for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. Poisson's ratio was calculated from the highlighted area shown (second scenario at 5% – 25 % of the peak axial stress difference) .

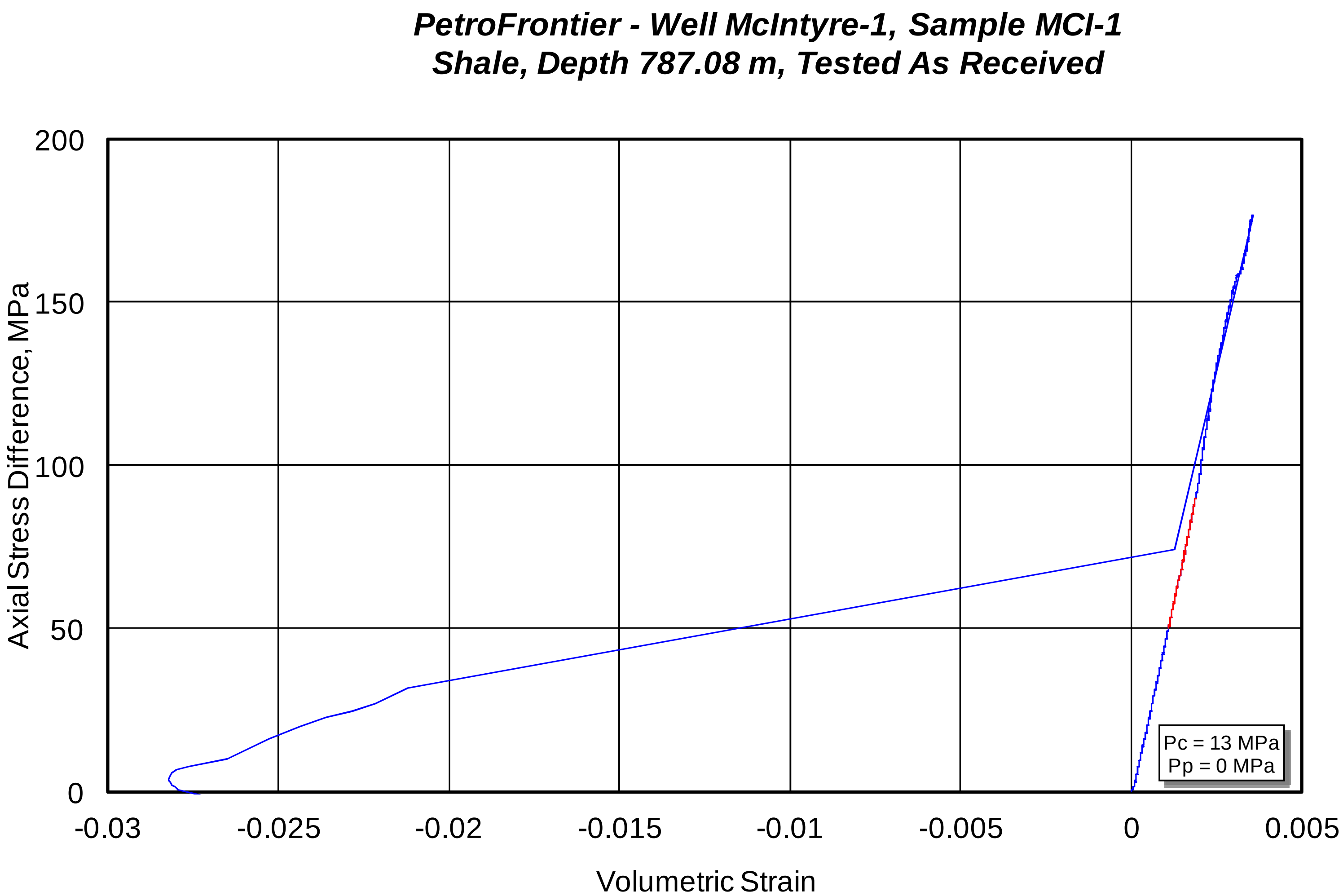

Figure R6. A detailed view of the averaged axial strain difference versus the volumetric strain for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. The Young's modulus and Poisson's ratio are calculated from the highlighted area shown (first scenario at 30 – 50 % of the peak axial stress difference).

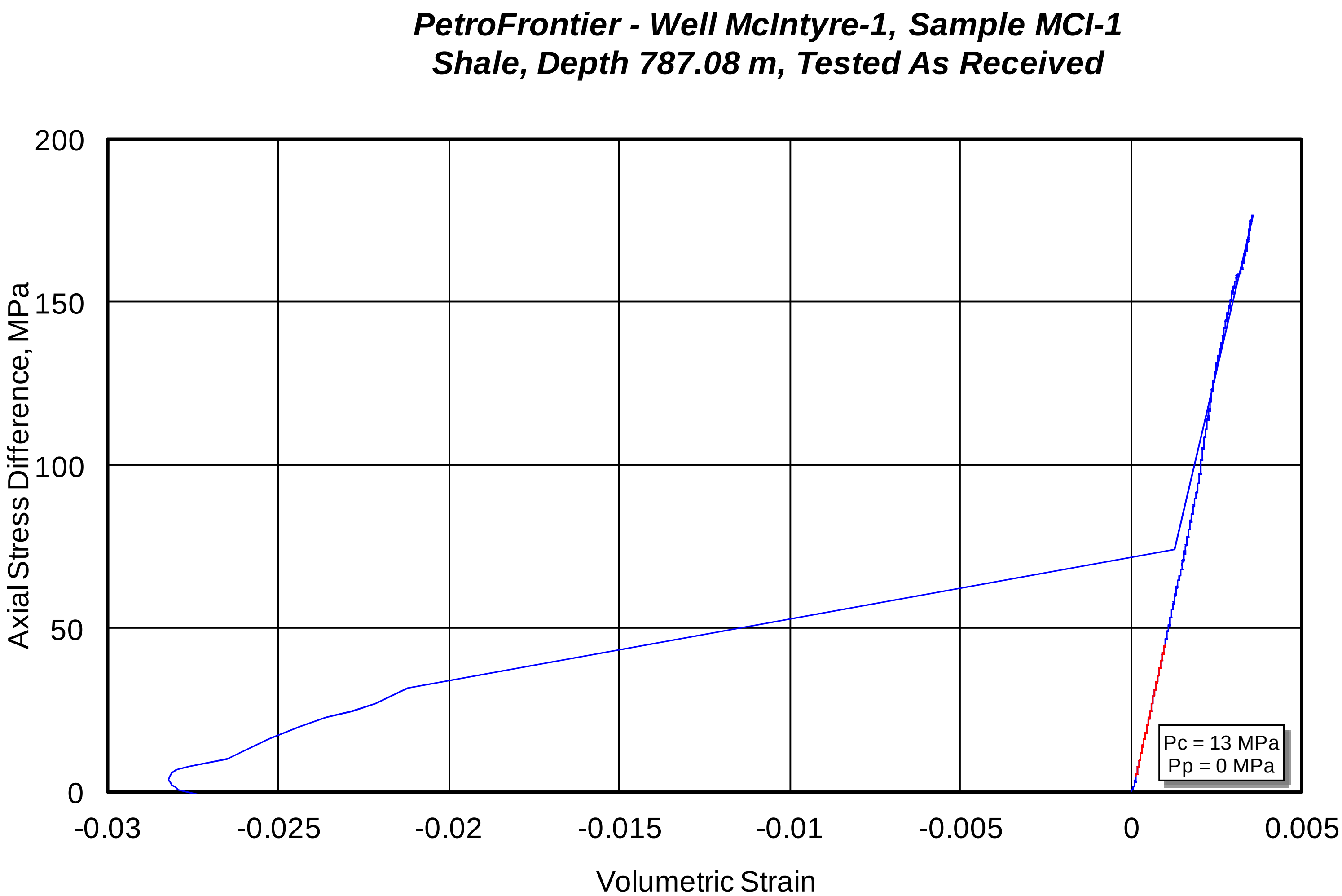

Figure R7. **A detailed view of the averaged axial strain difference versus the volumetric strain for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. The Young's modulus and Poisson's ratio are calculated at the highlighted area shown (second scenario at 5 – 25 % of the peak axial stress difference).**

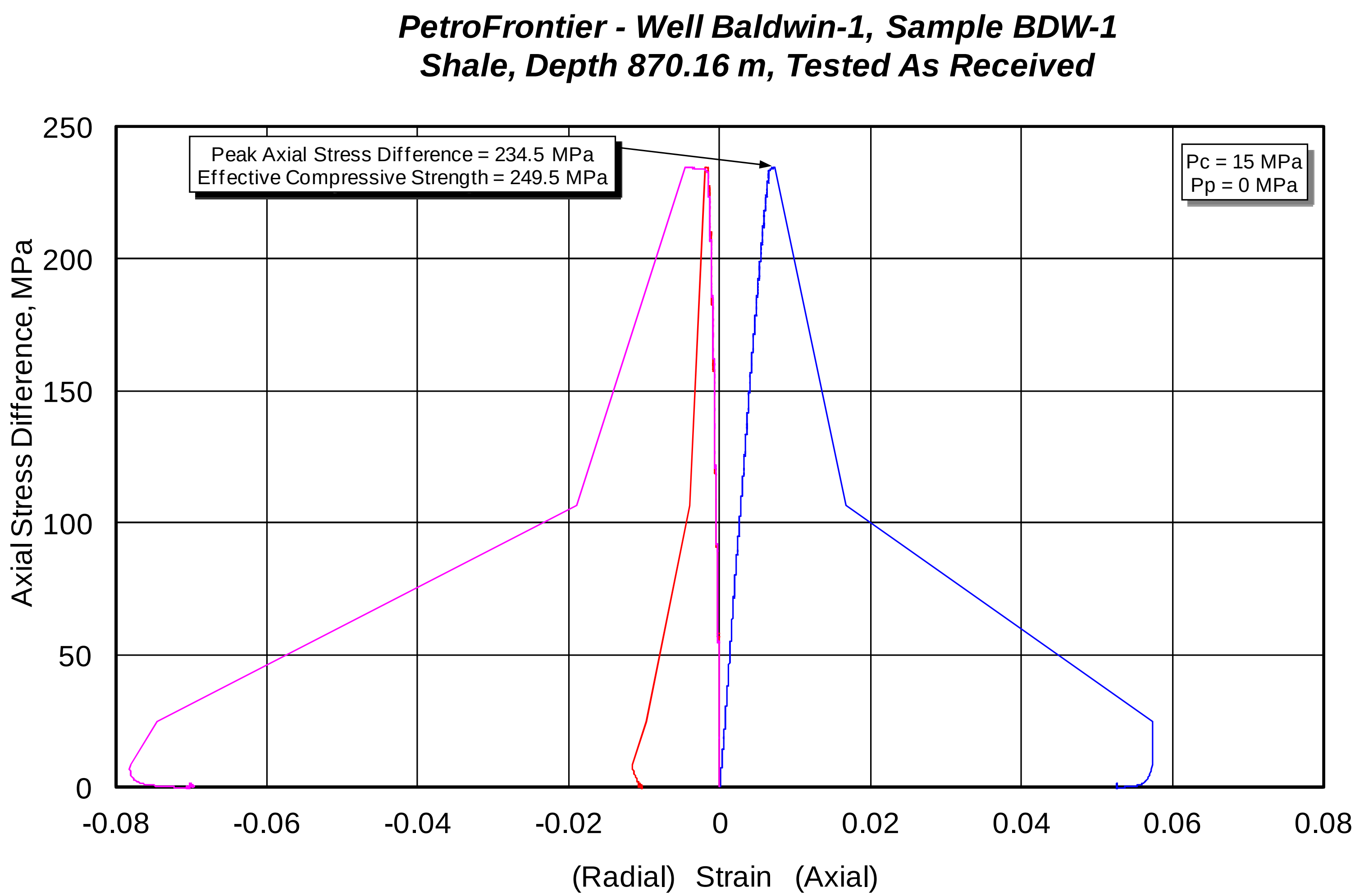

Figure R8. **Summary plot of the stress-strain response for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. The effective compressive strength for each test is indicated in the figure.**

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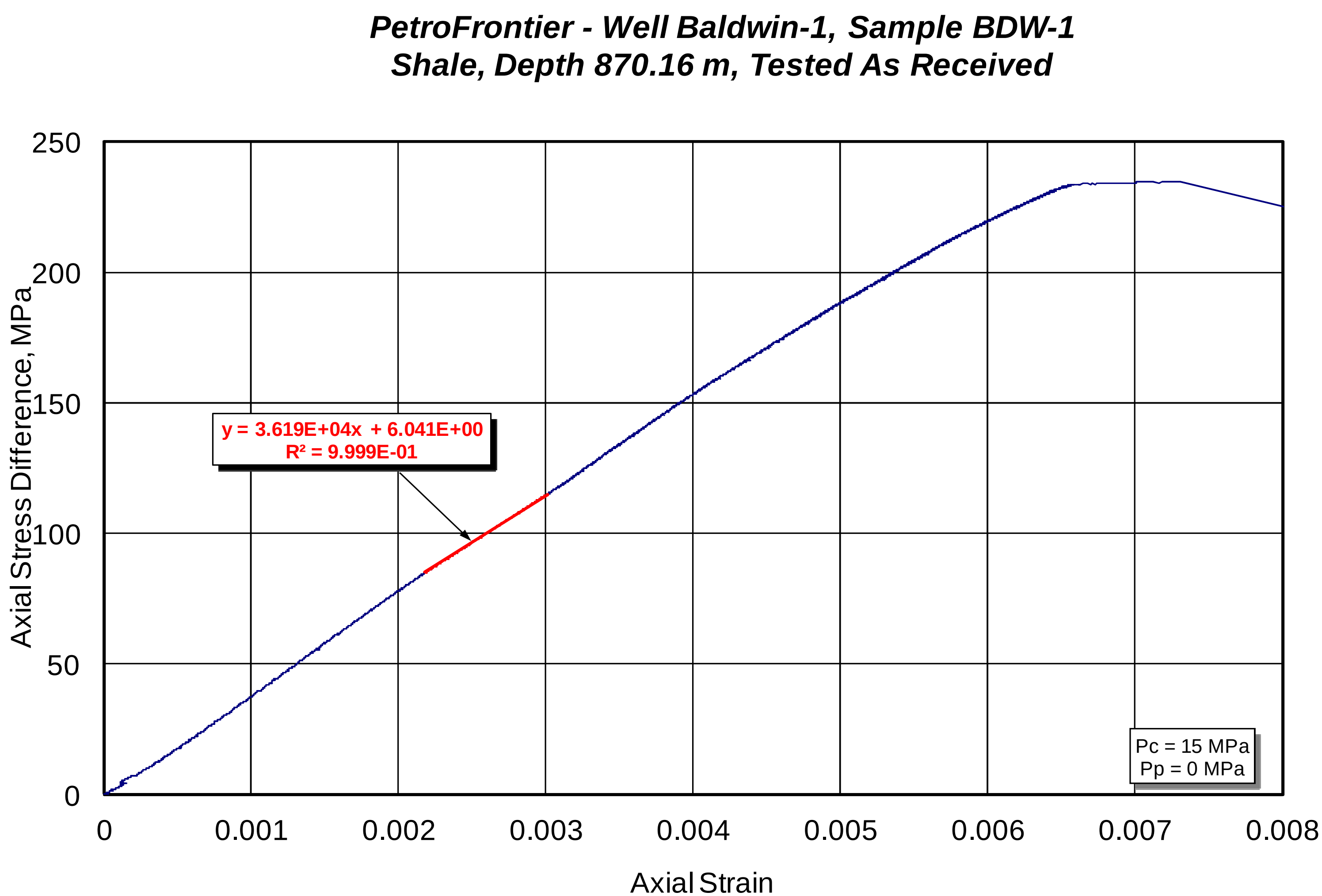

Figure R9. **A detailed view of the axial stress difference versus axial strain for sample BDW-1 from a shale core section, Well Baldwin-1, depth 870.16 m. Young's modulus was calculated from the highlighted area shown (first scenario at 30% – 50 % of the peak axial stress difference).**

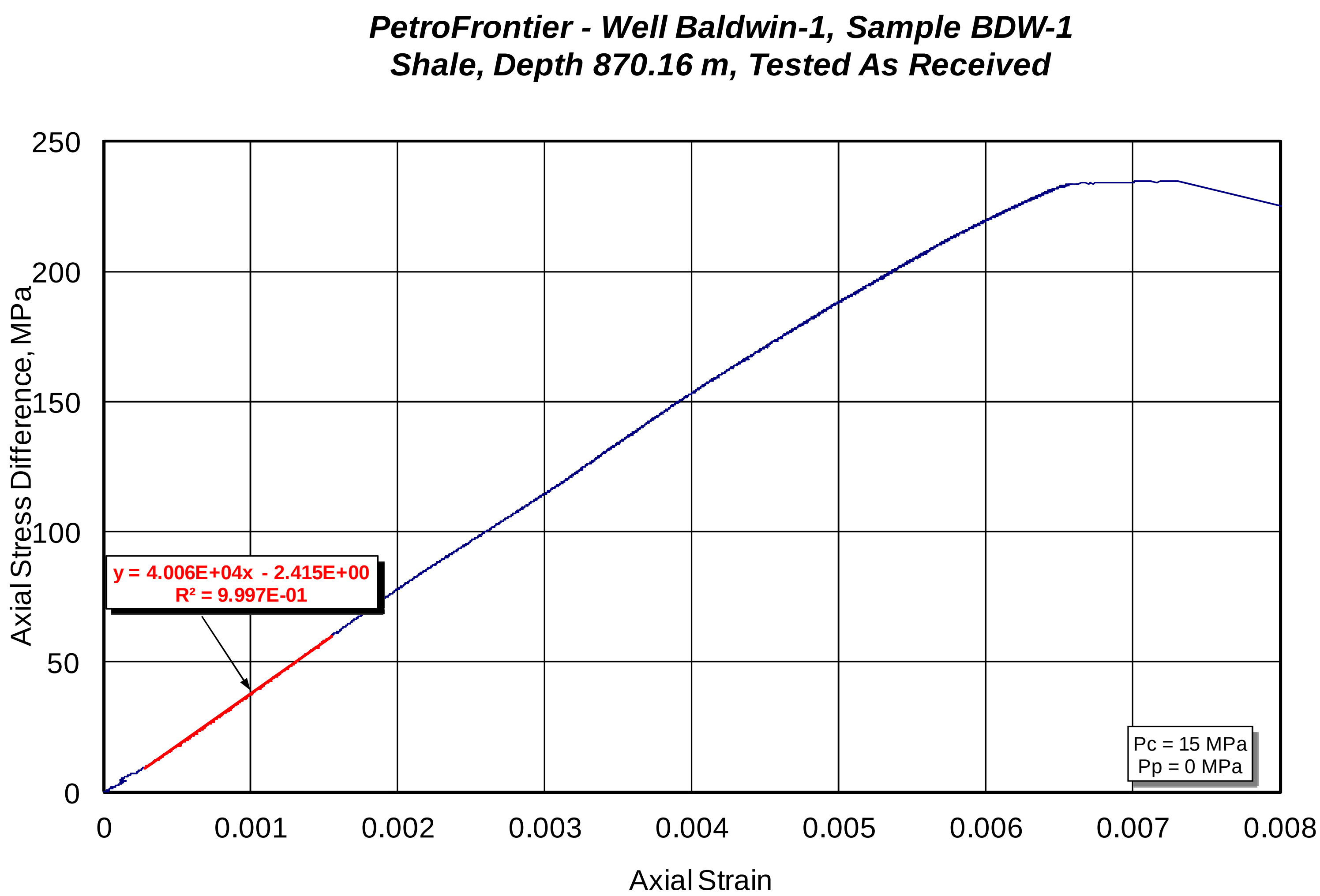

Figure R10. **A detailed view of the axial stress difference versus axial strain for sample BDW-1 from a shale core section, Well Baldwin-1, depth 870.16 m. Young's modulus was calculated from the highlighted area shown (second scenario at 5% – 25 % of the peak axial stress difference) .**

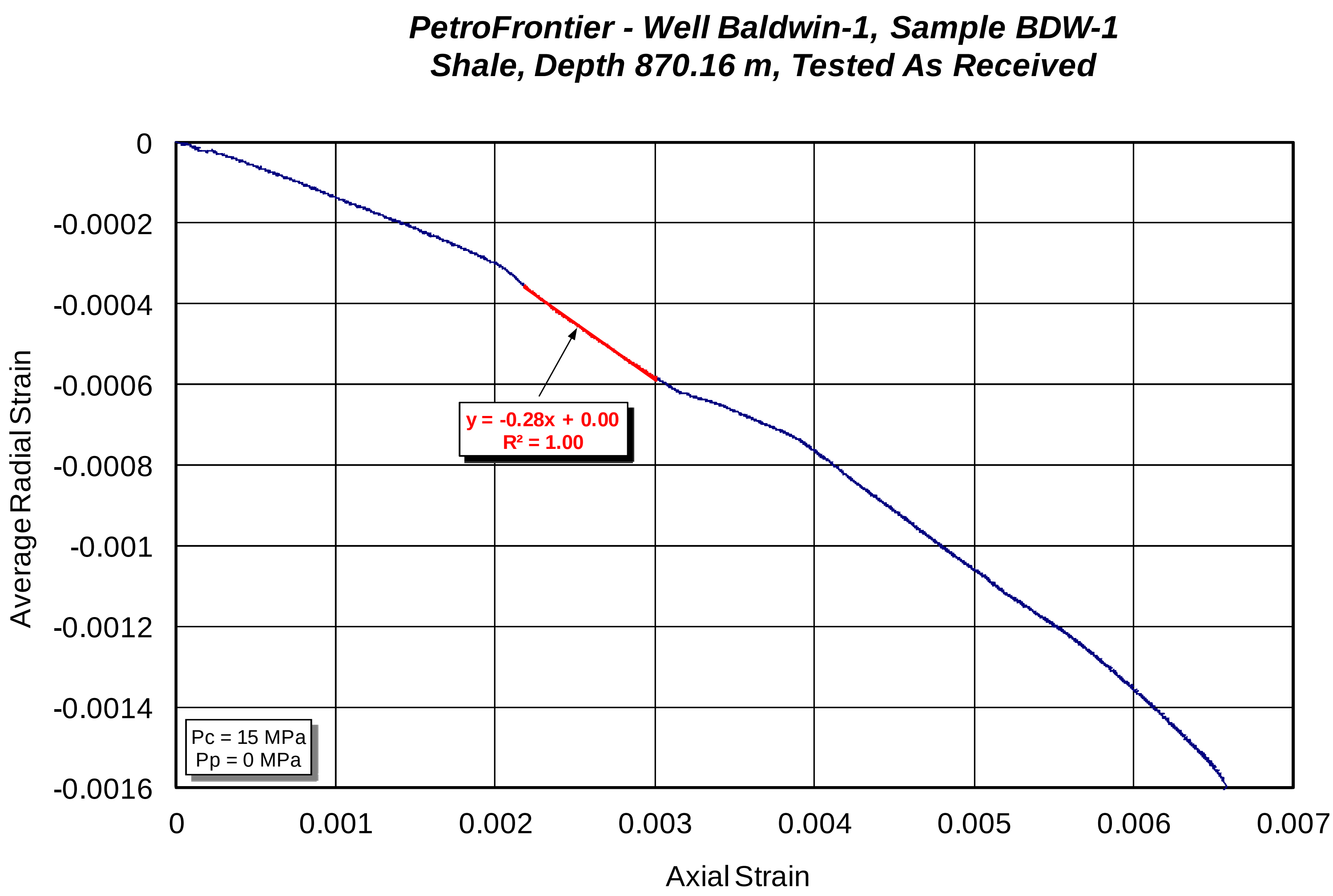

Figure R11. **A detailed view of the averaged radial strain versus the axial strain for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. Poisson's ratio was calculated from the highlighted area shown (first scenario at 30 – 50% of the peak axial stress difference).**

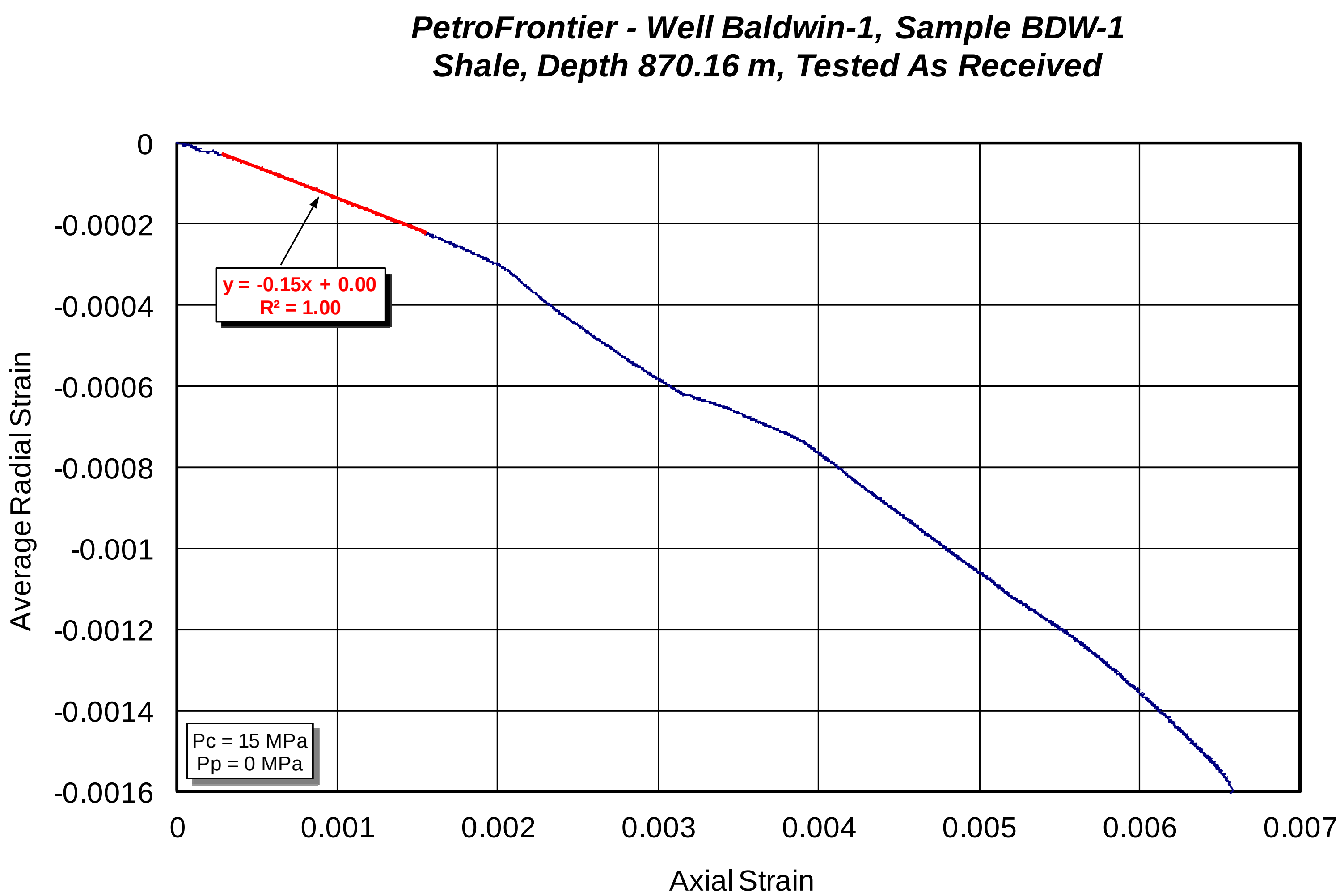

Figure R12. **A detailed view of the averaged radial strain versus the axial strain for sample BDW-1 from a shale core section, Well Baldwin-1, depth 787.08 m. Poisson's ratio was calculated from the highlighted area shown (second scenario at 5% – 25% of the peak axial stress difference).**

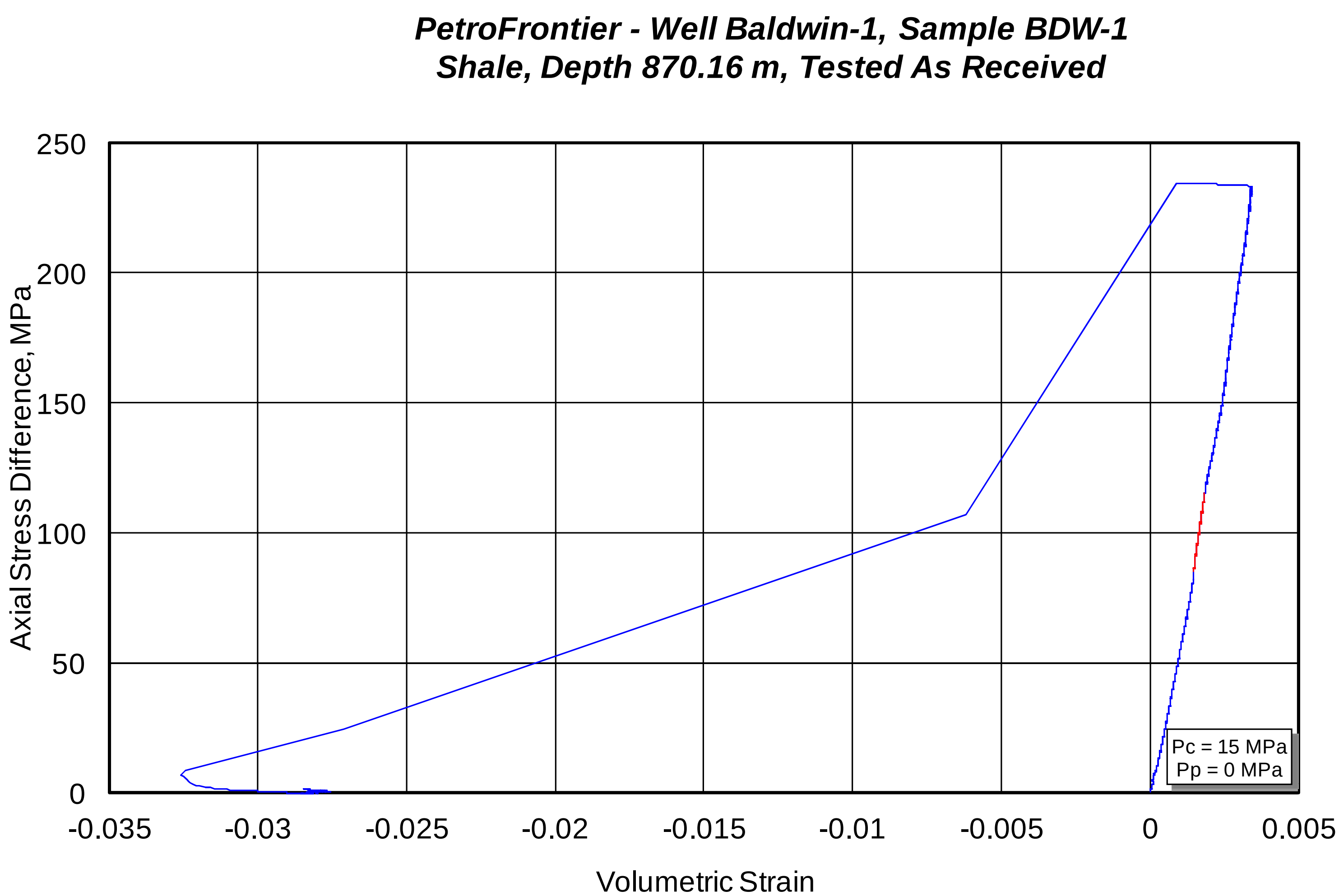

Figure R13. **A detailed view of the averaged axial strain difference versus the volumetric strain for sample MCI-1 from a shale core section, Well McIntyre-1, depth 787.08 m. The Young's modulus and Poisson's ratio are calculated from the highlighted area shown (first scenario at 30% – 50 % of the peak axial stress difference).**

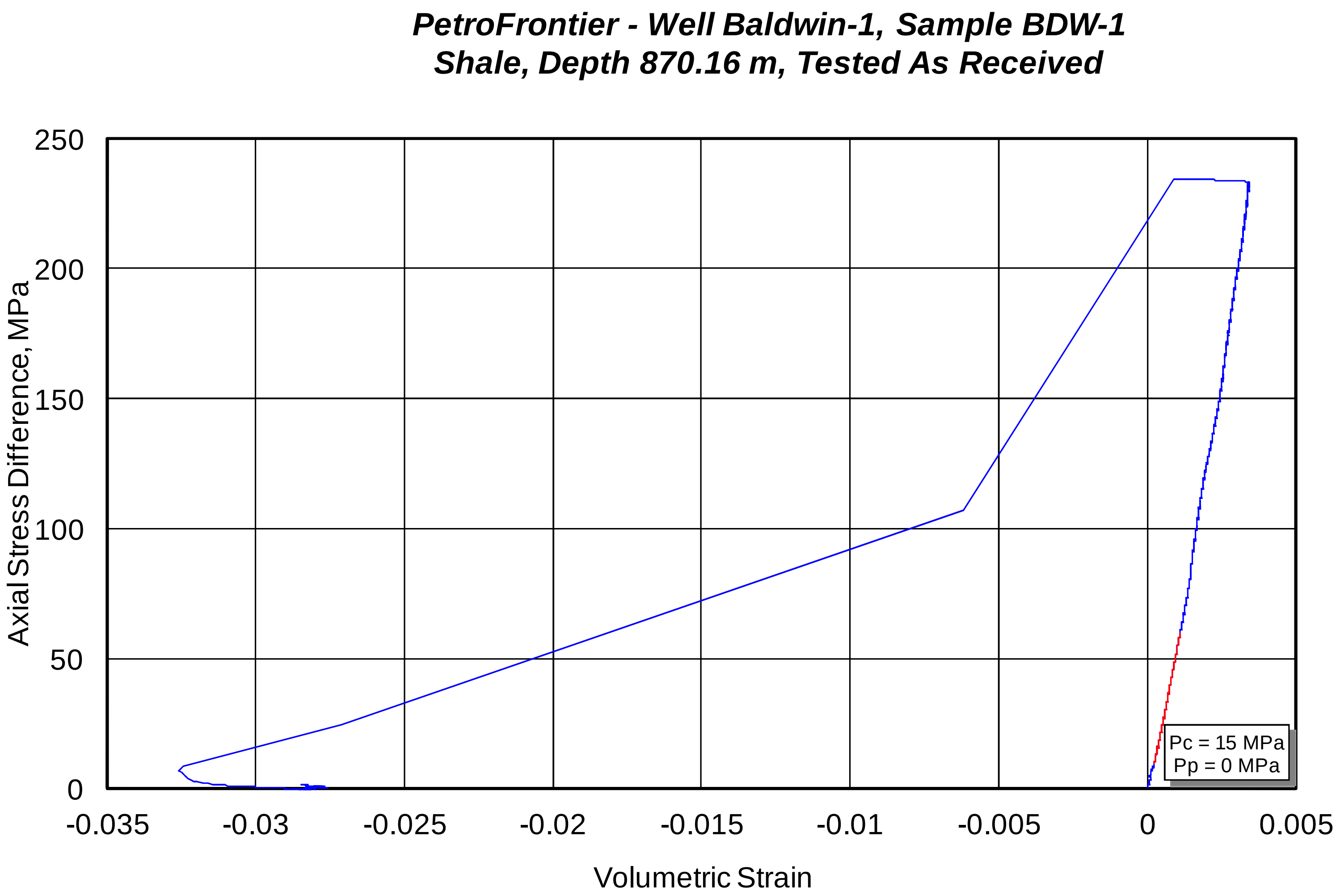

Figure R14. **A detailed view of the averaged axial strain difference versus the volumetric strain for sample BDW-1 from a shale core section, Well Baldwin-1, depth 870.16 m. The Young's modulus and Poisson's ratio are calculated from the highlighted area shown (first scenario at 5% – 25 % of the peak axial stress difference).**

4 SUMMARY

4.1 Failure Characterization

Well McIntyre-1

- The effective compressive strength obtained from single-stage triaxial test conducted on vertical shale sample was 189.7 MPa, while the loading quasi-static Young's modulus and Poisson's ratio at the first scenario which corresponded to the 30 – 50% of the peak axial stress difference were 29,050 MPa and 0.21 respectively. The loading quasi-static Young's modulus and Poisson's ratio at the second scenario which corresponded to the 5 – 25% of the peak axial stress difference were 30,470 MPa and 0.18 respectively.

Well Baldwin-1

- The effective compressive strength obtained from single-stage triaxial test conducted on vertical shale sample was 249.5 MPa, while the loading quasi-static Young's modulus and Poisson's ratio at the first scenario which corresponded to the 30 – 50% of the peak axial stress difference were 36,190 MPa and 0.28 respectively. The loading quasi-static Young's modulus and Poisson's ratio at the second scenario which corresponded to the 5 – 25% of the peak axial stress difference were 40,060 MPa and 0.15 respectively.

5 AVERAGE PROPERTIES

Averaged properties for the McIntyre-1 and Baldwin-1 geomechanics testing program are presented in Table R6.

Table R6. Principal Results of this Study – Averaged Properties

Property	McIntyre-1	Baldwin-1
Core Depth Range (m)	787.05 – 787.10	870.12 – 870.20
Lithotype	Shale	Shale
Orientation	Vertical	Vertical
Effective Compressive Strength (MPa)	189.7	249.5
Quasi-Static Young's Modulus at 30% – 50% of the peak of axial stress difference (MPa)	29,050	36,190
Quasi-Static Young's Modulus at 5% – 25% of the peak of axial stress difference (MPa)	30,470	40,060
Quasi-Static Poisson's Ratio at 30% – 50% of the peak of axial stress difference	0.21	0.28
Quasi-Static Poisson's Ratio at 5% – 25% of the peak of axial stress difference	0.18	0.15

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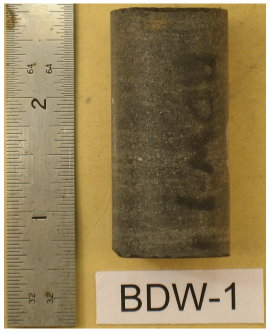
6 PHOTOS

6.1 Pre-Test Photos



6.2 Post-Test Photos