# FLOW/BUILDUP TEST REPORT #1345

## HOME PIERSON 03-08-02-29W1 COPY 2 of 2
## SPEARFISH (1030 - 1036 mKB)
## TEST DATE: DECEMBER 21 - JANUARY 5, 2000

Prepared for:

**ANDERSON EXPLORATION LTD.**

Prepared by:

**PETRO MANAGEMENT GROUP LTD.**

January 2000

P M G

**Petro Management Group Ltd.**

January 20, 2000

**ANDERSON EXPLORATION LTD.**
1600, 324 - 8th Ave. S.W.
Calgary, Alta., T2P 2Z5

**Attn.: Mr. Larry Sopko**

**HOME PIERSON 03-08-02-29W1**
**SPEARFISH (1030 - 1036 mKB)**
**FLOW/BUILDUP TEST**
**TEST DATE: DECEMBER 21 - JANUARY 5, 2000**

As requested, a flow/buildup test analysis was performed on the subject well. A summary of the test data and the analysis results is attached. The report marked ORIGINAL contains the test data on a diskette. Three copies of the report are attached.

Should you have any questions, please feel free to contact me at (403) 216-5101.

Yours truly,
**Petro Management Group Ltd.**

COPY (Original Signed) S. IBRAHIM

Saad Ibrahim, P. Eng.
Principal Engineer

#401, 100 - 4th Avenue S.W.
Calgary, Alberta, Canada T2P 3N2
Email: pmg@petromgt.com
Bus: (403) 216-5100
Fax: (403) 216-5109

# Summary of Test Data & Results

Case Name : Finite Conductivity Fracture #1

Horne Pierson 03-08-02-29W1

Spearfish (1030 - 1036 mKB)

Flow/Buildup

Test Date: Dec. 21 - Jan. 5, 2000

## Model Parameters

| | | | |
|---|---|---|---|
| Oil Permeability ($k_o$) | 5.146 mD | Fracture Half Length ($x_f$) | 10.29 m |
| Gas Permeability ($k_g$) | 0.026 mD | Fracture Flow Capacity ($k_fw$) | 46820.875 mD.m |
| Water Permeability ($k_w$) | 0.033 mD | Fracture Face Skin (sf) | 0.620 |
| Total Mobility ($[k/\mu]_t$) | 3.80 mD/mPa.s | Skin Equivalent to Xf | -4.030 |
| Total Transmisivity ($[kh/\mu]_t$) | 9.51 mDm/mPa.s | Exterior Radius ($r_e$) | 450.00 m |
| Wellbore Storage Constant Dim. ($C_D$) | 22.84 | | |

## Formation Parameters

| | |
|---|---|
| Net Pay (h) | 2.50 m |
| Total Porosity ($\phi_t$) | 16.50 % |
| Oil Saturation ($S_o$) | 60.00 % |
| Gas Saturation ($S_g$) | 0.00 % |
| Water Saturation ($S_w$) | 40.00 % |
| Wellbore Radius ($r_w$) | 0.091 m |
| Formation Temperature (T) | 42.0 °C |
| Formation Compressibility ($c_f$) | 5.729e-7 $kPa^{-1}$ |
| Total Compressibility ($c_t$) | 1.290e-4 $kPa^{-1}$ |

## Production and Pressure

| | |
|---|---|
| $Q_tB_t$ | 3.592 $m^3/d$ |
| Final Oil Rate | 1.300 $m^3/d$ |
| Final Gas Rate | 0.060 $10^3m^3/d$ |
| Final Water Rate | 0.050 $m^3/d$ |
| Final Flowing Pressure ($p_{wfo}$) | 462.00 kPa |
| Final Measured Pressure | 2181.65 kPa |
| Initial Pressure ($p_i$) | 2292.67 kPa |

## Fluid Properties

| | |
|---|---|
| Oil Compressibility ($c_o$) | 2.13743e-4 $kPa^{-1}$ |
| Gas Compressibility ($c_g$) | 4.58427e-4 $kPa^{-1}$ |
| Water Compressibility ($c_w$) | 4.56436e-7 $kPa^{-1}$ |
| Oil Formation Volume Factor ($B_o$) | 1.057 |
| Gas Formation Volume Factor ($B_g$) | 0.046156 $m^3/m^3$ |
| Water Formation Volume Factor ($B_w$) | 1.006 |
| Oil Viscosity ($\mu_o$) | 3.536 mPa.s |
| Gas Viscosity ($\mu_g$) | 11.383 µPa.s |
| Water Viscosity ($\mu_w$) | 0.627 mPa.s |
| Solution Gas Ratio ($R_s$) | 10 $m^3/m^3$ |
| Oil Gravity ($\gamma_o$) | 0.835 |
| Gas Gravity (G) | 0.650 |
| PVT Reference Pressure ($p_{PVT}$) | 2292.67 kPa |
| Bubble Point Pressure ($P_{bp}$) | 2292.67 kPa |

## Synthesis Results

| | |
|---|---|
| Average Error | 0.41 % |
| Synthetic Initial Pressure ($p_i$) | 3205.62 kPa |
| Extrapolated Pressure at Specified Time | 2982.48 kPa |
| Pressure Drop Due To Skin ($\Delta p_s$) | 673.02 kPa |
| Flow Efficiency (FE) | 0.774 |
| Damage Ratio (DR) | 1.293 |

## Forecasts

| | |
|---|---|
| Specified Flowing Pressure ($p_{wfs}$) | 462.00 kPa |
| 3 - Month Constant Rate | 1.421 $m^3/d$ |
| 6 - Month Constant Rate | 1.290 $m^3/d$ |
| Specified Forecast Time | 12.00 month |
| Forecast Constant Rate @ Current Skin | 1.181 $m^3/d$ |
| PI / II (Total Liquids - Actual) | 5.32e-4 $m^3/d/kPa$ |
| Forecast Constant Rate @ Skin=0 | 1.558 $m^3/d$ |
| PI / II (Total Liquids - Ideal) | 7.24e-4 $m^3/d/kPa$ |

## TABLE OF CONTENTS




#401, 100 - 4th Avenue S.W.
Calgary, Alberta, Canada T2P 3N2

Email: pmg@petromgt.com

Bus: (403) 216-5100
Fax: (403) 216-5109

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# SUMMARY OF RESULTS

## SUMMARY OF RESULTS

1. The average reservoir pressure ($P_R$) is 2 982 kPa.

2. The effective permeability to oil of the Spearfish formation is 5.1 mD.

3. The apparent skin factor of -4.0 and the fracture half length of 10.3 confirm that the well was stimulated.

4. The IPR plot indicates a maximum theoretical stabilized oil rate (AOF) of 1.4 $m^3/d$.

5. The radius of investigation is 30.2 m.

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Calgary, Alberta, Canada T2P 3N2
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Bus: (403) 216-5100
Fax: (403) 216-5109
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TEST ANALYSIS

## DISCUSSION

### 1. Test Overview:

The well Home Pierson 03-08-02-29W1 is completed in the Spearfish formation at 1030 - 1036 mKB and is equipped with a 60.3 mm tubing.

The well produced at an oil rate of 1.3 $m^3/d$. Subsequently, the well ws shutin for a 355 hour buildup period. The producing GOR was reported at 46.2 $m^3/m^3$. The oil API gravity is 36 degrees. Oil physical properties were calculated using various standard correlations.

### 2. Data Validation:

During the flow/buildup test, tandem electronic pressure recorders were set at 1033.5 mCF & 1034.5 mCF. The pressure and temperature profiles of the two recorders tracked closely through out the test, as shown in the Raw Data plot (Figure 1), in the Section "Test Data Quality". The difference in pressures, measured by the two recorders, was fairly constant during the buildup period (Figure 2), indicating good quality of recorders and that either would produce the same results. The decline in the early pressure data, during the buildup period, is due to falling liquid level. Due to problems in running the pressure recorders, the first few hours of buildup could not be measured. The last FBHP of 462 kPa was obtained from liquid level measurement prior to the test.

The primary pressure derivative (PPD) plot was constructed for the bottom pressure (Figure 3). The PPD showed major pressure anomalies and only data after 59 hours of shutin is considered valid. The PPD plot should be monotonically decreasing with time for valid buildup data.

Pressure data was reported in absolute. Depth correction was made to adjust the recorded pressures from the recorder run depth to the MPP using a liquid gradient of 10.3 kPa/m, as reported in the final static gradient survey.

#401, 100 - 4th Avenue S.W.
Calgary, Alberta, Canada T2P 3N2
Email: pmg@petromgt.com
Bus: (403) 216-5100
Fax: (403) 216-5109
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## TEST INTERPRETATION

### 1. Pressure Buildup Analysis:

Pressure buildup analysis was performed on the shut-in period. The reservoir parameters were provided by Anderson Exploration Ltd., as shown in the attached form of the test data and results summary. The final oil rate prior to shutting in the well was 1.3 $m^3/d$ at a flowing sandface pressure of 462 kPa, as shown in Stip Chart Figure 4, in the section "Pressure Transient Analysis".

Both the Horner Plot and Derivative Analysis were used, as discussed below, and results were later fine tuned using the pressure history match techniques of the test pressure data.

Wellbore storage regime could not be identified since the early pressure data were not measured, as shown in the Diagnostic/Derivative plot (Figure 5), in the section "Pressure Transient Analysis". Radial flow regime, was identified by the flattening of the pressure derivative.

Radial flow analysis was performed to determine the reservoir parameters using the semi-log straight line, as shown in the Horner plot (Figure 6). The extrapolation of the last data points yielded a $P^*$ of 3 241 kPa. The ($P^*$) was corrected for the shape, areal extent of the reservoir and the location of the well to determine the average reservoir pressure of 3 228 kPa. The results of the Horner plot and the pressure derivative analysis are summarized below:

| | Horner | Derivative |
|---|---|---|
| Effective Permeability, mD | 5.3 | 5.5 |
| Ave. Reservoir Pressure, kPa | 3 228 | n/a |
| Apparent Skin Factor | -2.9 | -2.8 |

## 2. Pressure History Match:

The preliminary results from the Horner plot and pressure derivative analysis were used as starting parameters for the pressure history match of the test data. The best match of the test data was obtained, using the Finite Conductivity Model. The overlay of simulated analysis results on the real test data is presented in the cartesian graph of the raw data, the semi-log graph of the Horner plot, and the log-log graph of the pressure derivative (Figures 7, 8 and 9), in the section "Pressure History Match". The parameters used to achieve the history match are as follows:

| | History Match | |
|---|---|---|
| Ave. Reservoir Pressure, $P_r$ | 2 982 | kPa |
| Effective Permeability, k | 5.1 | mD |
| Skin Factor, S | -4.0 | |
| Fracture Half-Length, Xf | 10.3 | m |
| Fracture Flow Capacity, $K_fw$ | 46820 | mD.m |

## 3. Inflow Performance Relationship (I.P.R)

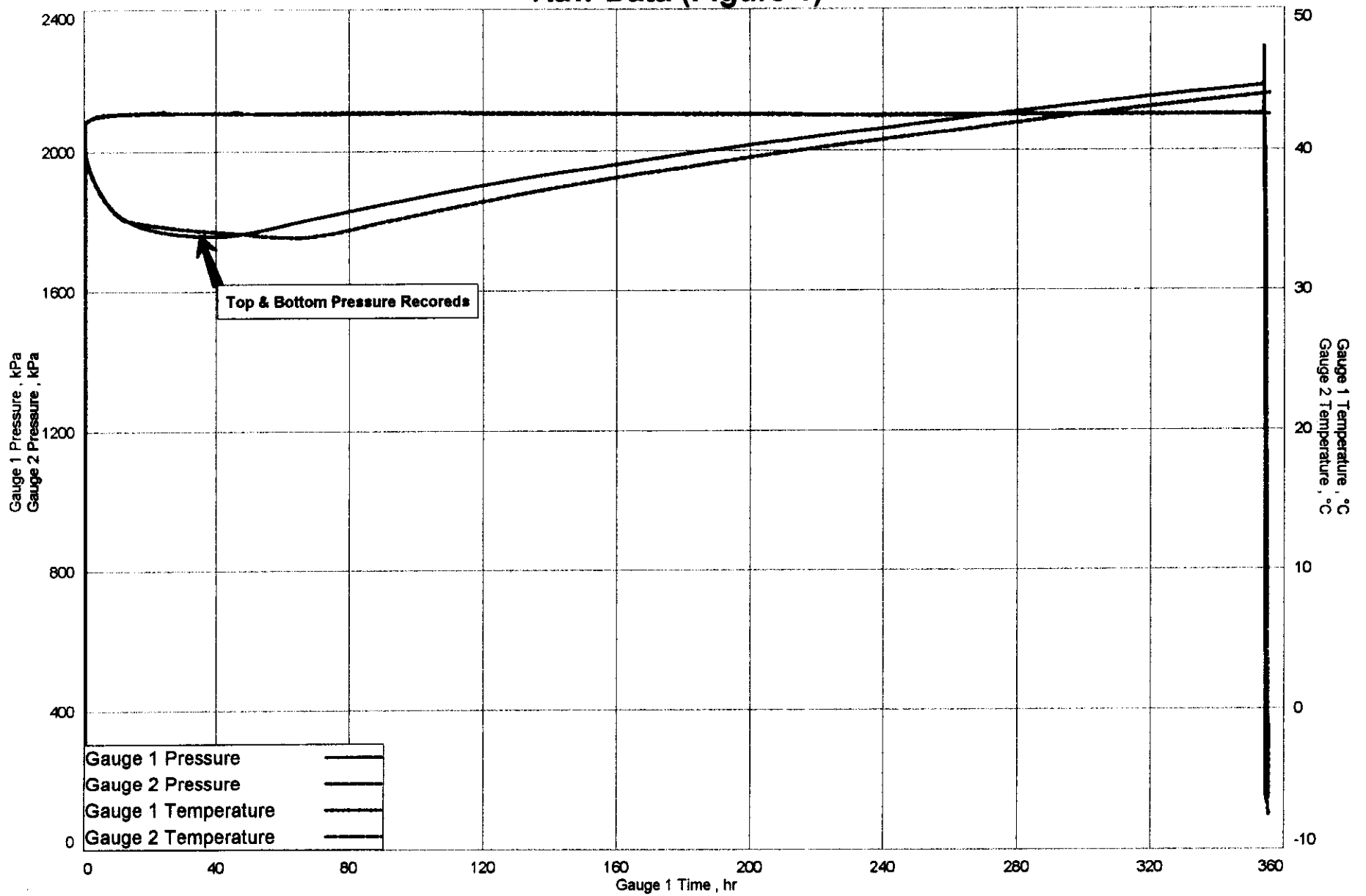
The Inflow Performance Relationship (I.P.R) was constructed using the Vogel equation, as shown in Figure 8, in the Section "I.P.R". The average reservoir pressure of 2 982 kPa and the test data were used to generate the I.P.R plot, at the current skin factor of -4.0 The well maximum theoretical oil rate is 1.4 $m^3/d$.

TEST DATA
QUALITY

100/03-08-002-29W1/0

Home Pierson
Formation: Spearfish

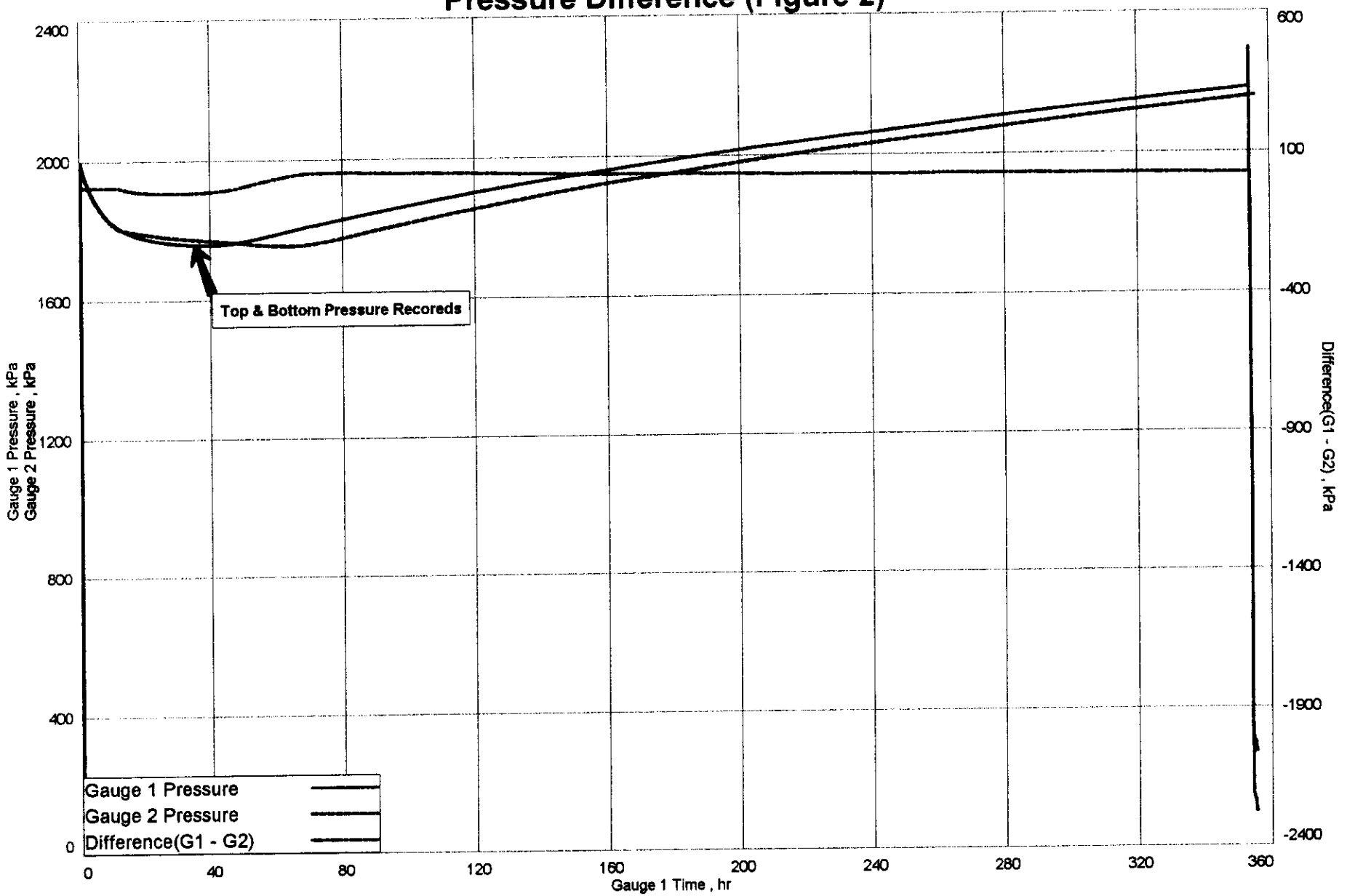
# Raw Data (Figure 1)



100/03-08-002-29W1/0

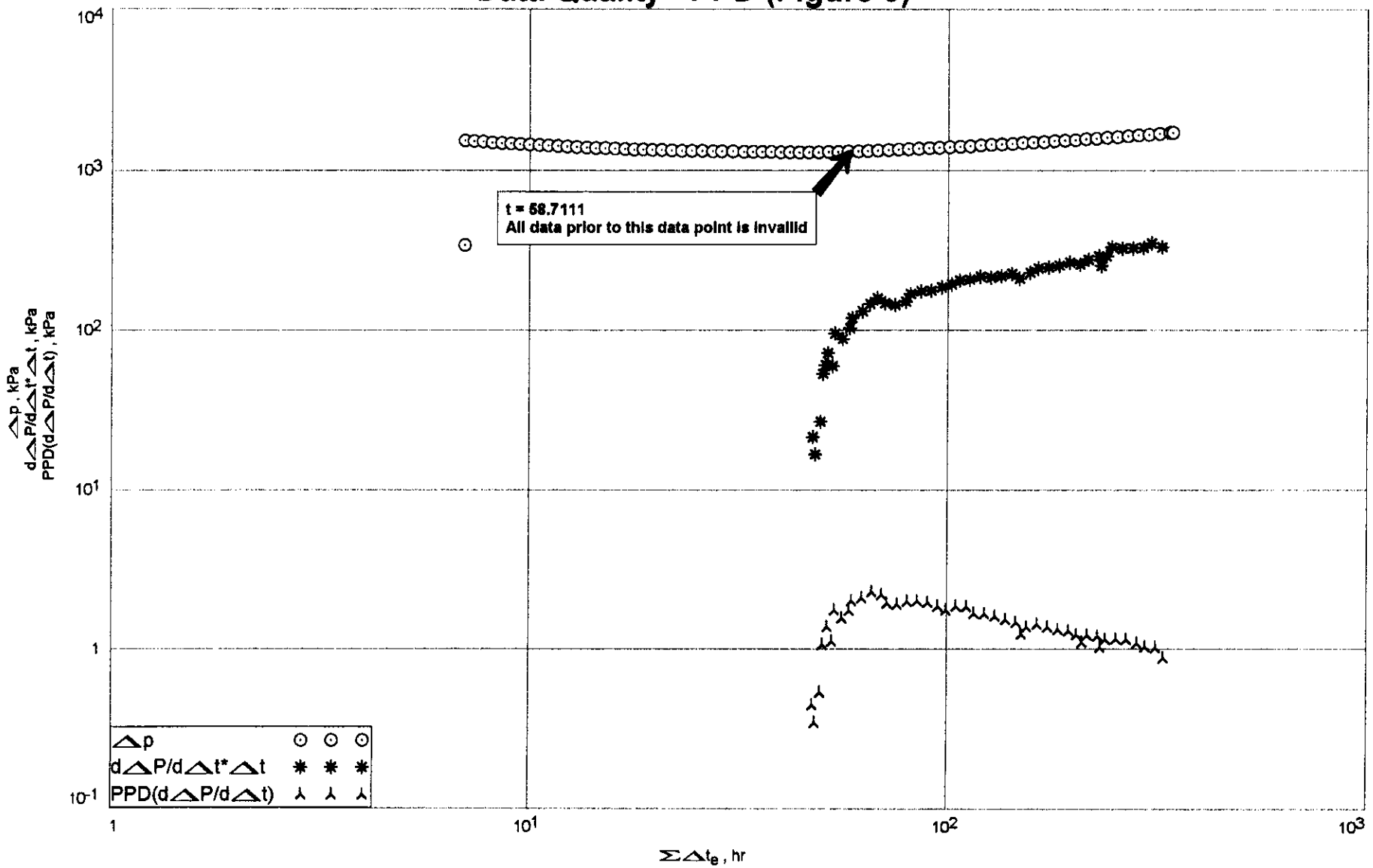
Home Pierson
Formation: Spearfish

# Pressure Difference (Figure 2)



Home Pierson 03-08-02-29W1
Spearfish (1030 - 1036 mKB)
Flow/Buildup
Test Date: Dec. 21 - Jan. 5, 2000

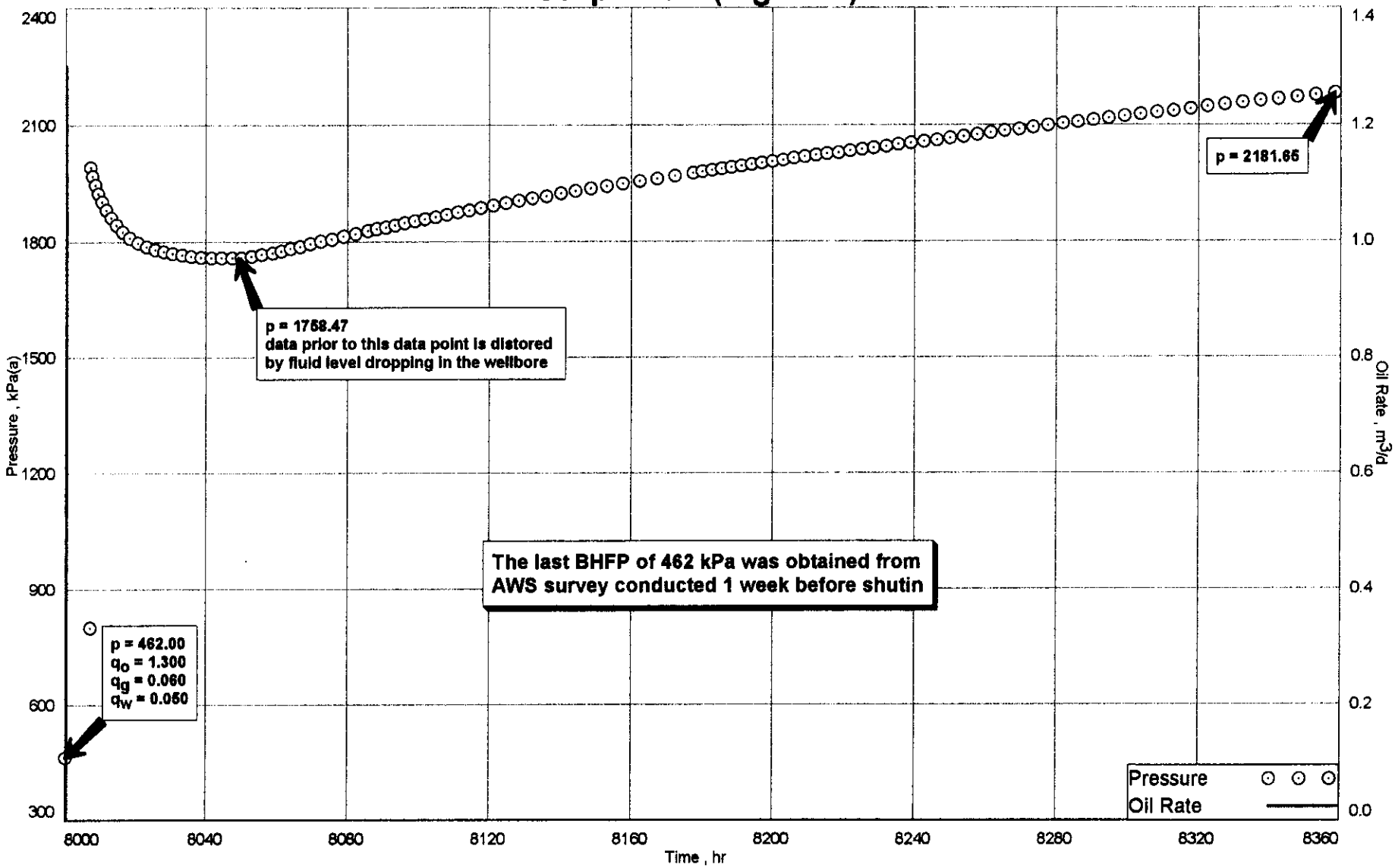
# Data Quality - PPD (Figure 3)



PRESSURE
TRANSIENT
ANALYSIS

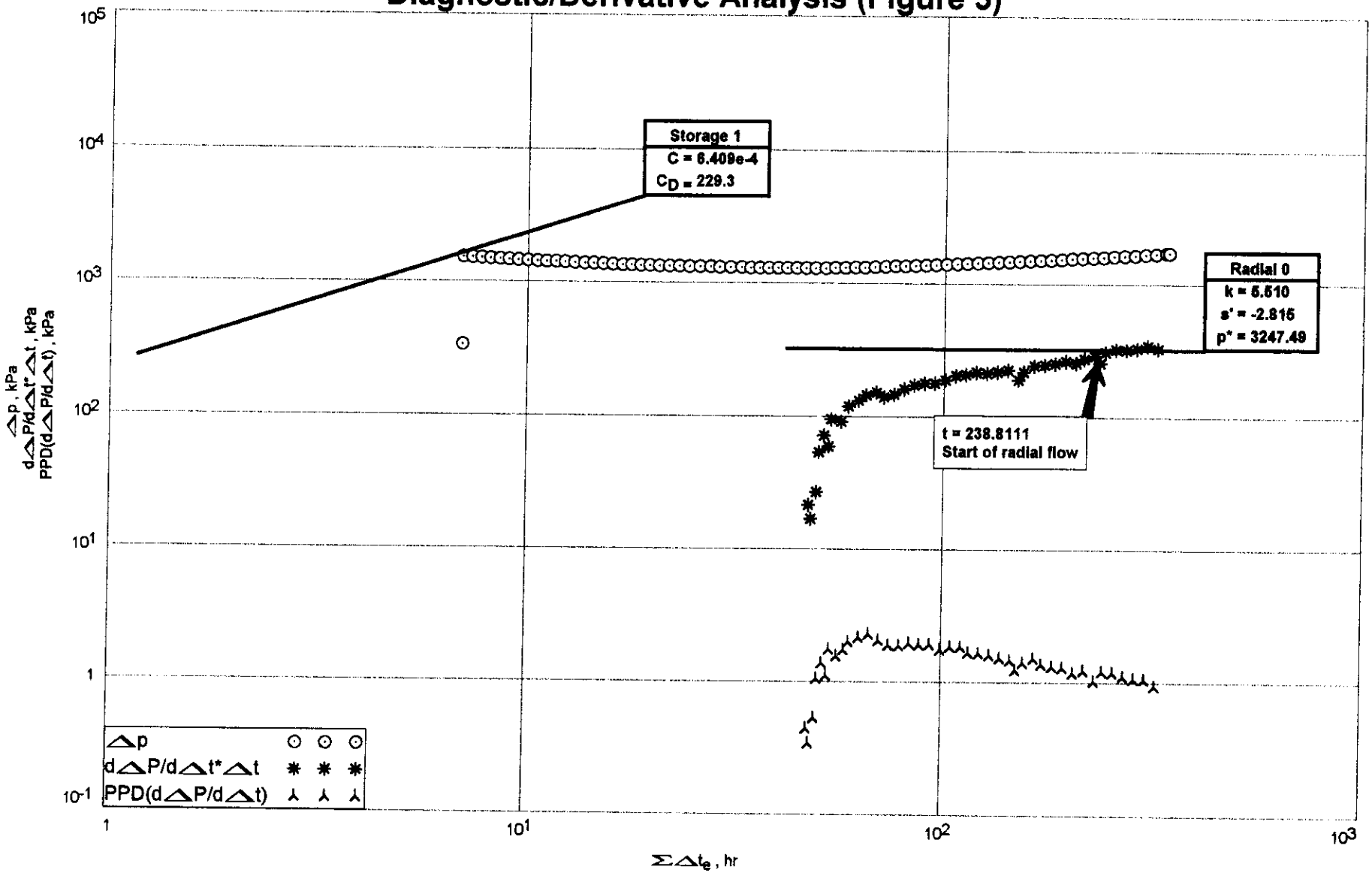
Home Pierson 03-08-02-29W1
Spearfish (1030 - 1036 mKB)
Flow/Buildup
Test Date: Dec. 21 - Jan. 5, 2000

# Strip Chart (Figure 4)



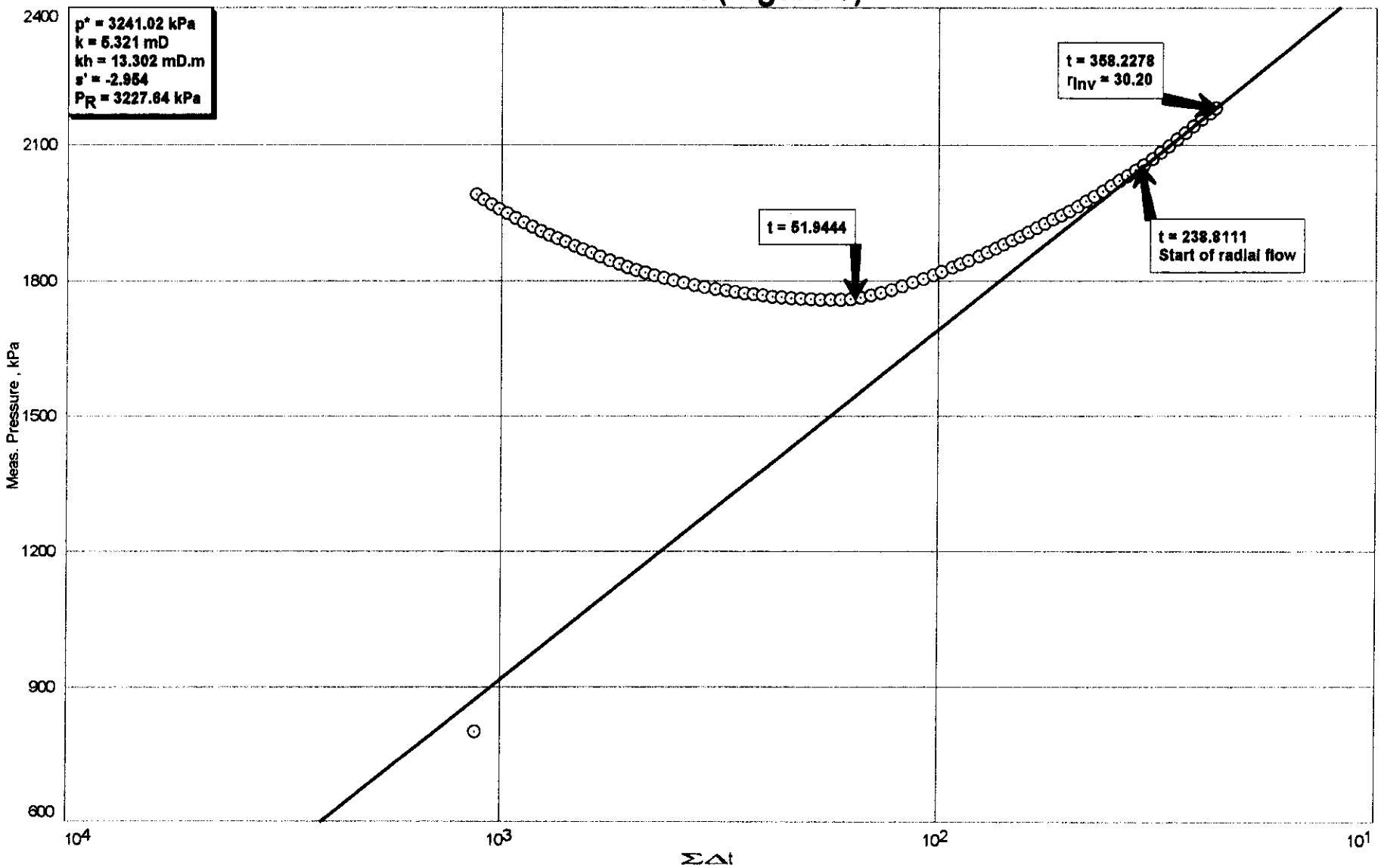
Home Pierson 03-08-02-29W1
Spearfish (1030 - 1036 mKB)
Flow/Buildup
Test Date: Dec. 21 - Jan. 5, 2000

# Diagnostic/Derivative Analysis (Figure 5)



Horne Pierson 03-08-02-29W1
Spearfish (1030 - 1036 mKB)
Flow/Buildup
Test Date: Dec. 21 - Jan. 5, 2000

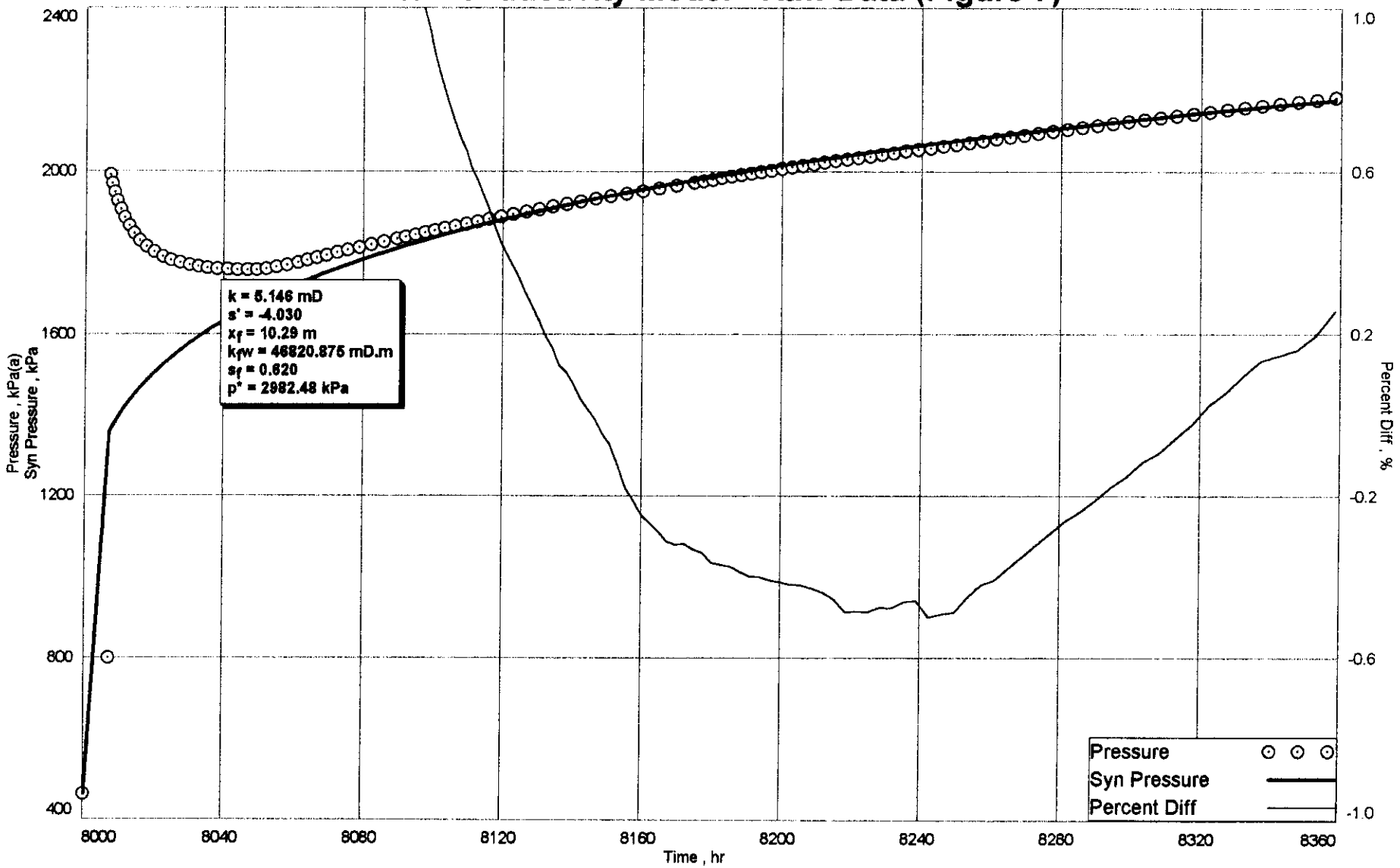
# Horner Plot (Figure 6)



PRESSURE
HISTORY
MATCHING

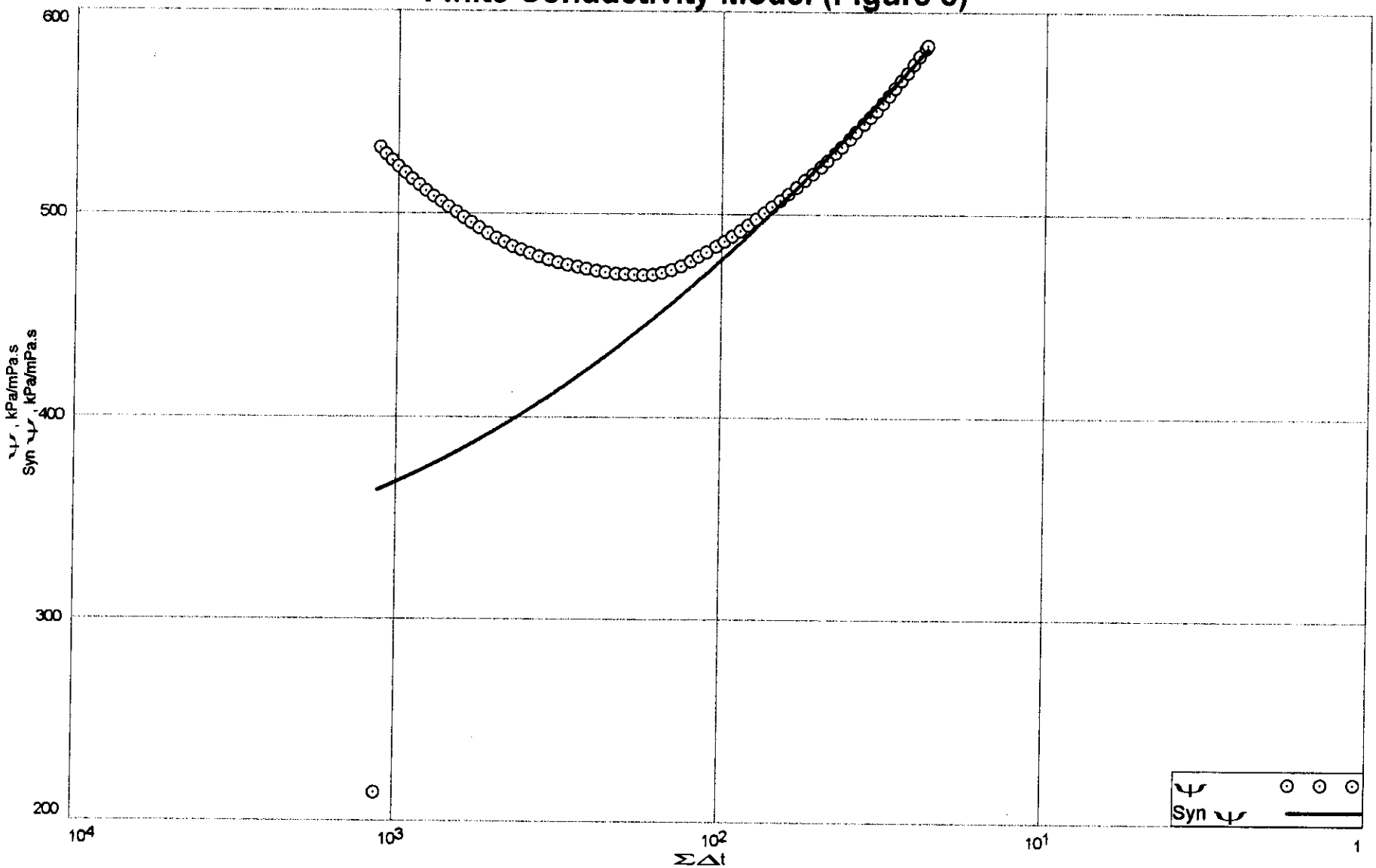
Home Pierson 03-08-02-29W1
Spearfish (1030 - 1036 mKB)
Flow/Buildup
Test Date: Dec. 21 - Jan. 5, 2000

# Finite Conductivity Model - Raw Data (Figure 7)



Home Pierson 03-08-02-29W1
Spearfish (1030 - 1036 mKB)
Flow/Buildup
Test Date: Dec. 21 - Jan. 5, 2000

# Finite Conductivity Model (Figure 8)



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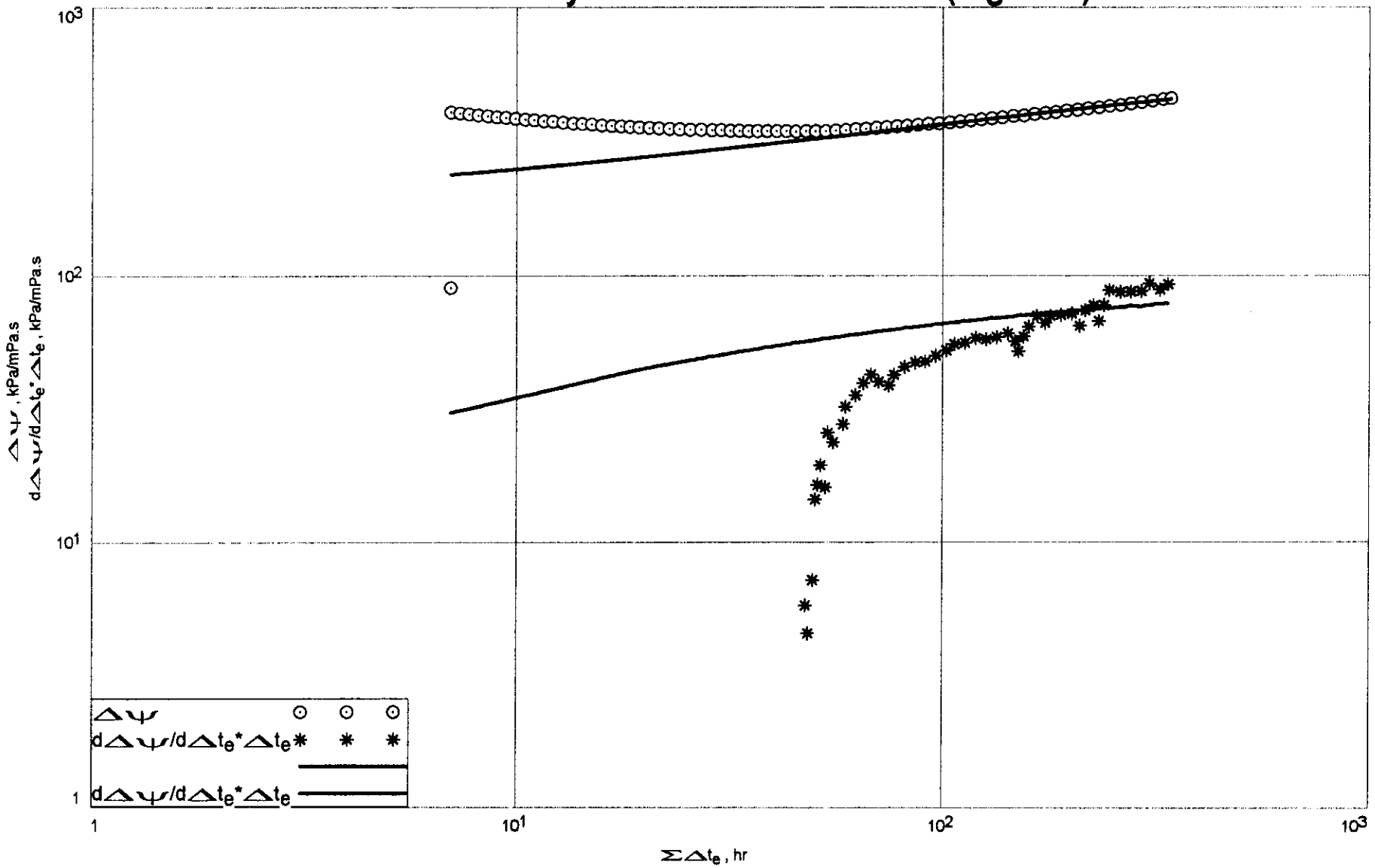
Home Pierson 03-08-02-29W1
Spearfish (1030 - 1036 mKB)
Flow/Buildup
Test Date: Dec. 21 - Jan. 5, 2000

# Finite Conductivity Model - Derivative Plot (Figure 9)



I.P.R.

# Inflow Performance Relationship
# (I.P.R.)

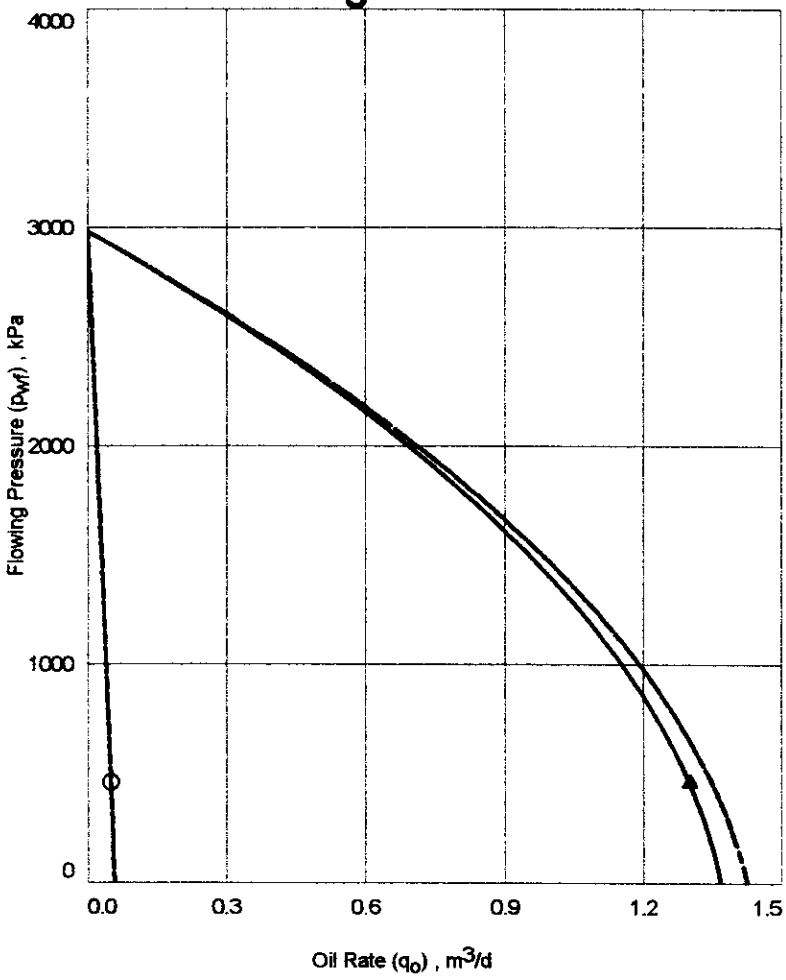
Home Pierson 03-08-02-29W1
Spearfish (1030 - 1036 mKB)

Flow/Buildup
Test Date: Dec. 21 - Jan. 5, 2000

| Test Data | | |
|---|---|---|
| Reservoir Pressure ($p_R$) | 2982.50 | kPa |
| Bubble Point Pressure ($p_{bp}$) | | kPa |
| Test Pressure ($p_{wf}$) | 462.00 | kPa |
| Oil Test Rate ($q_o$) | 1.300 | $m^3/d$ |
| Water Test Rate ($q_w$) | 0.050 | $m^3/d$ |

| Results | | |
|---|---|---|
| Maximum Oil Rate | 1.369 | $m^3/d$ |
| Maximum Water Rate | 0.059 | $m^3/d$ |
| Maximum Total Rate | 1.428 | $m^3/d$ |

## Figure 10




| Flowing Pressure | Oil Rate | Water Rate | Total Rate |
|---|---|---|---|
| kPa | $m^3/d$ | $m^3/d$ | $m^3/d$ |
| 0.00 | 1.369 | 0.059 | 1.428 |
| 200.00 | 1.345 | 0.055 | 1.401 |
| 400.00 | 1.312 | 0.051 | 1.363 |
| 462.00* | 1.300 | 0.050 | 1.350 |
| 600.00 | 1.269 | 0.047 | 1.317 |
| 800.00 | 1.216 | 0.043 | 1.260 |
| 1000.00 | 1.154 | 0.039 | 1.193 |
| 1200.00 | 1.081 | 0.035 | 1.117 |
| 1400.00 | 0.999 | 0.031 | 1.030 |
| 1600.00 | 0.907 | 0.027 | 0.934 |
| 1800.00 | 0.805 | 0.023 | 0.828 |
| 2000.00 | 0.693 | 0.019 | 0.712 |
| 2200.00 | 0.571 | 0.016 | 0.587 |
| 2400.00 | 0.439 | 0.012 | 0.451 |
| 2600.00 | 0.298 | 0.008 | 0.306 |
| 2800.00 | 0.147 | 0.004 | 0.150 |
| 2982.50 | 0.000 | 0.000 | 0.000 |

Note : * Test Point
** Bubble Point
Oil IPR based on Vogel's Equation.
(Quadratic Curve Factor=0.2)

SUBSURFACE
PRESSURES

Well Provers Corp.

*A Division of Select Energy Systems Inc.*

# TRANSMITTAL

| | | | |
|---|---|---|---|
| Customer | **Anderson Exploration Ltd.** | Date: | **January 6, 2000** |
| Address: | **#1600, 324 – 8 Avenue, SW<br>Calgary, Alberta T2P 2Z5** | Job No.: | **99-0183** |
| Attention: | **Mr. Gord Peters** | | |
| Subject: | **Home S Pierson Unit #1 100/03-08-002-29-W1/00** | | |
| Shipped Via: | ☐ Mail ☑ Hand Delivered ☐ Courier ☐ Fax: | | |

| Quantity | Description |
|---|---|
| **One (1)** | **Flow & Build Up Report** |
| **One (1)** | **Static Gradient Report** |
| **One (1)** | **Site Report** |
| **One (1)** | **Diskette (ASCII format only)** |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

**Notes:** .PAS FILES NOT REQUIRED AS TEST PERFORMED IN MANITOBA.

INVOICE TO FOLLOW VIA MAIL.

*Should you have any question or require further information, please contact me at the telephone number below.*

K Sands.

Kellie D. Sands
Accounts Executive

Copies To:

402 – 53rd Avenue, SE • Calgary, Alberta • T2H 0N4
Telephone: (403) 243-7542 • Fax: (403) 287-1424

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# SITE REPORT

| | | | |
|---|---|---|---|
| Customer: | Anderson Exploration | Date: | Jan. 4/00 |
| Location: | 03-08-002-29W1 | Job No.: | 99-0183 |
| Site/Office Contact: | Scott Dalziel<br>Brad Smith | Tel. No.: | 485-7711<br>485-7712 |
| Formation: | **Spearfish** | Technician: | T. Bondarev<br>F. Tadgell |
| Program: | Flow, Build Up & Static Gradient | | |

| | Serial No. | Start Date | Start Time | End Date | End Time |
|---|---|---|---|---|---|
| Top Gauge | 5019 | Dec. 21/99 | 1505 | Jan. 5/00 | 1033 |
| Bottom Gauge | 5020 | Dec. 21/99 | 1505 | Jan. 5/00 | 1033 |

| | | | |
|---|---|---|---|
| **Tubing Pressure (kPa):** | **waxed** | **Casing Pressure (kPa):** | **965.3** |
| **MPP in mKB =** | **1033.0** | **Time Pressured Up:** | |
| **KB =** | **478.34** | **Time On Bottom:** | **7:51** |
| **Ground =** | **474.14** | **Time Off Bottom:** | **7:56** |
| **Difference (KB-Gl) =** | **4.2** | **Time at Surface:** | **8:53** |
| **Tubing or Casing Flowing:** | | | |
| **Well Shut in Date & Time:** | **Dec 21/99 15-10** | | |

| Time (hours): | Summary |
|---|---|
| December 21, 1999 | |
| 1450 | Arrived on location. |
| 1505 | Gauges turned on. |
| 1510 | Run in hole. |
| 1525 | Landed at 1033.5 mKB MPP ← |
| 1550 | Off location. |
| January 5, 2000 | |
| 0715 | Arriving on the location. |
| 0740 | Rig up. |
| 0751 | Stop 1 - 1043 mKB, (-9.5m) |
| 0800 | Stop 2 - 003 mKB, (30m) |
| 0806 | Stop 3 - 973 mKB, (60m) |
| 0813 | Stop 4 - 943 mKB, (90m), 897m. tension on the line more than 300. Stop |
| 0824 | Stop 5 - 693 mKB, (340m) |
| 0834 | Stop 6 - 443 mKB, (590m) |
| 0844 | Stop 7 - 193 mKB, (840m) |
| 0853 | At Surface. 33m to surface line had dead oil |
| 0925 | Rig down |
| | Top-48415 |
| | Bottom-45547 |
| 0942 | Off the location. |
| | |

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Well Provers Corp.

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# Anderson Exploration Ltd.

## Home S Pierson Unit #1
## 100/03-08-002-29-W1/00

## Static Gradient

## January 5, 2000

Release Date: January 6, 2000

402 – 53rd Avenue, SE • Calgary, Alberta • T2H 0N4
Telephone: (403) 243-7542 • Fax: (403) 287-1424
Email: wpc@telusplanet.net

# GENERAL INFORMATION

**Client Information:**

Company: Anderson Exploration Ltd.

Contact: Gord Peters

Phone: (403) 232-5027 Fax: (403) 232-7102 e-mail: petersg@axl.ca

**Site Information:**

Contact: Scott Dalziel / Brad Smith

Phone: (306) 485-7711 Fax: e-mail:

**Well Information:**

Name: Home S Pierson Unit #1

Operator: Anderson Exploration Ltd.

Location-Downhole: 100/03-08-002-29W1/0

Location-Surface: 3-8-2-29-W1

**Test Information:**

| | | | |
|---|---|---|---|
| Company: | Well Provers Corp. | | |
| Representative: | Sherman Reeder | | |
| Supervisor: | A. Bondarev / F. Tadgell | | |
| Test Type: | Static Gradient | Job Number: | 99-0183 |
| Test Unit: | WP-03 | | |
| Start Date: | 2000/01/05 | Start Time: | 07:51:00 |
| End Date: | 2000/01/05 | End Time: | 09:25:00 |
| Report Date: | 2000/01/06 | Prepared By: | Kellie Sands |
| **Remarks:** | | Qualified By: | Sherman Reeder |

# CLIENT INFORMATION

Company: Anderson Exploration Ltd.
Contact: Gord Peters

Street 1: Suite #1600
Street 2: 324 - 8 Avenue, SW
City: Calgary Prov./State: Alberta
Country: Canada Postal Code: T2P 2Z5

Phone: (403) 232-5027 Fax: (403) 232-7102
e-mail: petersg@axl.ca

## SITE INFORMATION

Contact: Scott Dalziel / Brad Smith
Phone: (306) 485-7711 Fax:
e-mail:

## Remarks

# WELL INFORMATION

**Well Name : Home S Pierson Unit #1**

**Well Operator : Anderson Exploration Ltd.**

**Well Location : 100/03-08-002-29W1/0**

**Location-Surface : 3-8-2-29-W1**

**Field : Pierson** **Well Type : Vertical**

**Pool :**

**Formation : Spearfish**

| | | | | | |
|---|---|---|---|---|---|
| Perforation Type : | | | Producing Through : Tubing | Size | 73.00 mm |
| Pool Datum | m | CF | Elevation Referenced Fro | 478.34 m | KB |
| Datum Depth | m | CF | Elevation Referenced To | 474.14 m | GL |
| | | | Offset | 4.20 m | |

## Production Intervals

Production Interval & MPP Reference To : KB MPP Pressure Reference : None

| | From - m | To - m | Depth - m | Pressure - kPa |
|---|---|---|---|---|
| 1. | 1030.50 | 1036.50 | 1. | |
| 2. | | | 2. | |
| 3. | | | 3. | |
| 4. | | | 4. | |
| 5. | | | 5. | |
| 6. | | | 6. | |
| 7. | | | 7. | |
| 8. | | | 8. | |
| 9. | | | 9. | |
| 10. | | | 10. | |
| 11. | | | 11. | |
| 12. | | | 12. | |

Remarks :



Fast

Anderson Exploration Ltd.
100/03-08-002-29W1/0
Start Test Date: 2000/01/05
Final Test Date: 2000/01/05

Home S Pierson Unit #1
Formation: Spearfish

Job Number: 99-0183

| | Depth | Time | Duration | Pressure | Gradient | Spec. Grad. | LL Depth | LL Pres. | Temp. | Gradient |
|---|---|---|---|---|---|---|---|---|---|---|
| | m | hh:mm:ss | min | kPa(a) | kPa/m | kPa/m | m | kPa(a) | °C | °C/m |
| 1 | 1033.00 | 08:53:30 | | 2183.76 | | | | | 42.58 | |
| 2 | 1003.00 | 09:08:30 | 15.00 | 1872.86 | 10.363 | | | | 42.29 | 0.010 |
| 3 | 973.00 | 09:14:30 | 6.00 | 1559.19 | 10.456 | | | | 41.72 | 0.019 |
| 4 | 943.00 | 09:22:00 | 7.50 | 1241.20 | 10.599 | 10.599 | 840.57 | 155.55 | 41.15 | 0.019 |
| 5 | 693.00 | 09:32:30 | 10.50 | 152.03 | 4.357 | | | | 36.17 | 0.020 |
| 6 | 443.00 | 09:36:30 | 4.00 | 146.40 | 0.023 | 0.023 | | | 33.58 | 0.010 |
| 7 | 193.00 | 09:46:00 | 9.50 | 139.59 | 0.027 | | | | 24.70 | 0.036 |
| 8 | 0.00 | 10:05:30 | 19.50 | 130.88 | 0.045 | | | | 5.17 | 0.101 |

Bottom Gauge Serial Number: Start Date: 2000/01/05 07:51:00 Run Depth:

Print Filter Off





Fast

Well
Provers Corp.

*A Division of Select Energy Systems Inc.*

# Anderson Exploration Ltd.

## Home S Pierson Unit #1
## 100/03-08-002-29-W1/00

## Flow & Build Up

## Dec. 21, 1999 - January 5, 2000

Release Date: January 6, 2000

402 – 53rd Avenue, SE • Calgary, Alberta • T2H 0N4
Telephone: (403) 243-7542 • Fax: (403) 287-1424
Email: wpc@telusplanet.net

# GENERAL INFORMATION

**Client Information:**

Company: Anderson Exploration Ltd.

Contact: Gord Peters

Phone: (403) 232-5027 Fax: (403) 232-7102 e-mail: petersg@axl.ca

**Site Information:**

Contact: Scott Dalziel / Brad Smith

Phone: (306) 485-7711 Fax: e-mail:

**Well Information:**

Name: Home S Pierson Unit #1

Operator: Anderson Exploration Ltd.

Location-Downhole: 100/03-08-002-29W1/0

Location-Surface: 3-8-2-29-W1

**Test Information:**

| | | | |
|---|---|---|---|
| Company: | Well Provers Corp. | | |
| Representative: | Sherman Reeder | | |
| Supervisor: | A. Bondarev / F. Tadgell | | |
| Test Type: | Flow & Build Up | Job Number: | 99-0183 |
| Test Unit: | WP-02 | | |
| Start Date: | 1999/12/21 | Start Time: | 15:05:00 |
| End Date: | 2000/01/05 | End Time: | 10:33:00 |
| Report Date: | 2000/01/06 | Prepared By: | Kellie Sands |
| **Remarks:** | | Qualified By: | Sherman Reeder |

# CLIENT INFORMATION

Company: Anderson Exploration Ltd.
Contact: Gord Peters

Street 1: Suite #1600
Street 2: 324 - 8 Avenue, SW
City: Calgary Prov./State: Alberta
Country: Canada Postal Code: T2P 2Z5

Phone: (403) 232-5027 Fax: (403) 232-7102
e-mail: petersg@axl.ca

## SITE INFORMATION

Contact: Scott Dalziel / Brad Smith
Phone: (306) 485-7711 Fax:
e-mail:

## Remarks



Fast

# WELL INFORMATION

**Well Name : Home S Pierson Unit #1**

**Well Operator : Anderson Exploration Ltd.**

**Well Location : 100/03-08-002-29W1/0**

**Location-Surface : 3-8-2-29-W1**

**Field : Pierson** **Well Type : Vertical**

**Pool :**

**Formation : Spearfish**

| | | | | | |
|---|---|---|---|---|---|
| Perforation Type : | | | Producing Through : Tubing | Size | 73.00 mm |
| Pool Datum | m | CF | Elevation Referenced Fro | 478.34 m | KB |
| Datum Depth | m | CF | Elevation Referenced To | 474.14 m | GL |
| | | | Offset | 4.20 m | |

## Production Intervals

Production Interval & MPP Reference To : KB MPP Pressure Reference : None

| | From - m | To - m | Depth - m | Pressure - kPa |
|---|---|---|---|---|
| 1. | 1030.50 | 1036.50 | 1. | |
| 2. | | | 2. | |
| 3. | | | 3. | |
| 4. | | | 4. | |
| 5. | | | 5. | |
| 6. | | | 6. | |
| 7. | | | 7. | |
| 8. | | | 8. | |
| 9. | | | 9. | |
| 10. | | | 10. | |
| 11. | | | 11. | |
| 12. | | | 12. | |

Remarks :

Anderson Exploration Ltd.
100/03-08-002-29W1/0
Start Test Date: 1999/12/21
Final Test Date: 2000/01/05

Home S Pierson Unit #1
Formation: Spearfish

Job Number: 99-0183

| | Date | Clock Time | Time | Bottom Gauge Pres. | Bottom Gauge Temp. | Top Gauge Pres. | Top Gauge Temp. |
|---|---|---|---|---|---|---|---|
| | yyyy/mm/dd | hh:mm:ss | hr | kPa(a) | °C | kPa(a) | °C |
| 1 | 1999/12/21 | 15:05:00 | 0.0000 | 97.51 | 0.35 | 104.74 | 3.41 |
| 2 | 1999/12/21 | 16:05:10 | 1.0028 | 1970.95 | 42.22 | 1965.91 | 42.18 |
| 3 | 1999/12/21 | 17:05:20 | 2.0056 | 1940.91 | 42.37 | 1936.50 | 42.31 |
| 4 | 1999/12/21 | 18:05:29 | 3.0083 | 1916.55 | 42.46 | 1912.71 | 42.38 |
| 5 | 1999/12/21 | 19:05:39 | 4.0111 | 1897.02 | 42.55 | 1893.28 | 42.43 |
| 6 | 1999/12/21 | 20:05:50 | 5.0139 | 1880.30 | 42.58 | 1876.81 | 42.47 |
| 7 | 1999/12/21 | 21:06:00 | 6.0167 | 1865.42 | 42.63 | 1861.82 | 42.51 |
| 8 | 1999/12/21 | 22:06:09 | 7.0194 | 1852.13 | 42.62 | 1848.45 | 42.54 |
| 9 | 1999/12/21 | 23:06:19 | 8.0222 | 1840.32 | 42.66 | 1836.66 | 42.58 |
| 10 | 1999/12/22 | 00:06:30 | 9.0250 | 1829.58 | 42.65 | 1826.10 | 42.59 |
| 11 | 1999/12/22 | 01:06:40 | 10.0278 | 1821.35 | 42.67 | 1817.81 | 42.59 |
| 12 | 1999/12/22 | 02:06:50 | 11.0306 | 1813.70 | 42.69 | 1810.13 | 42.61 |
| 13 | 1999/12/22 | 03:11:00 | 12.1000 | 1807.03 | 42.70 | 1803.81 | 42.63 |
| 14 | 1999/12/22 | 06:11:29 | 15.1083 | 1792.24 | 42.72 | 1798.25 | 42.65 |
| 15 | 1999/12/22 | 09:12:00 | 18.1167 | 1781.85 | 42.76 | 1793.19 | 42.64 |
| 16 | 1999/12/22 | 12:12:30 | 21.1250 | 1774.59 | 42.76 | 1788.75 | 42.66 |
| 17 | 1999/12/22 | 15:12:59 | 24.1333 | 1769.07 | 42.80 | 1784.75 | 42.66 |
| 18 | 1999/12/22 | 18:13:30 | 27.1417 | 1764.55 | 42.71 | 1781.02 | 42.68 |
| 19 | 1999/12/22 | 21:14:00 | 30.1500 | 1761.47 | 42.69 | 1777.97 | 42.68 |
| 20 | 1999/12/23 | 00:14:29 | 33.1583 | 1759.59 | 42.70 | 1775.52 | 42.70 |
| 21 | 1999/12/23 | 03:15:00 | 36.1667 | 1758.42 | 42.67 | 1773.11 | 42.70 |
| 22 | 1999/12/23 | 06:15:29 | 39.1750 | 1757.85 | 42.70 | 1770.84 | 42.71 |
| 23 | 1999/12/23 | 09:15:59 | 42.1833 | 1758.34 | 42.68 | 1768.90 | 42.71 |
| 24 | 1999/12/23 | 12:16:30 | 45.1917 | 1760.68 | 42.67 | 1766.67 | 42.76 |
| 25 | 1999/12/23 | 15:17:00 | 48.2000 | 1764.98 | 42.66 | 1765.14 | 42.71 |
| 26 | 1999/12/23 | 18:17:29 | 51.2083 | 1769.93 | 42.66 | 1760.96 | 42.65 |
| 27 | 1999/12/23 | 21:18:00 | 54.2167 | 1775.39 | 42.68 | 1757.74 | 42.63 |
| 28 | 1999/12/24 | 00:18:30 | 57.2250 | 1781.60 | 42.69 | 1756.00 | 42.64 |
| 29 | 1999/12/24 | 03:18:59 | 60.2333 | 1788.15 | 42.70 | 1754.80 | 42.63 |
| 30 | 1999/12/24 | 06:19:30 | 63.2417 | 1795.00 | 42.68 | 1754.18 | 42.63 |
| 31 | 1999/12/24 | 09:20:00 | 66.2500 | 1801.34 | 42.71 | 1754.60 | 42.61 |
| 32 | 1999/12/24 | 12:20:29 | 69.2583 | 1807.24 | 42.72 | 1757.42 | 42.62 |
| 33 | 1999/12/24 | 15:21:00 | 72.2667 | 1813.10 | 42.74 | 1761.53 | 42.61 |
| 34 | 1999/12/24 | 18:21:30 | 75.2750 | 1818.77 | 42.73 | 1766.23 | 42.60 |
| 35 | 1999/12/24 | 21:21:59 | 78.2833 | 1824.90 | 42.73 | 1771.90 | 42.63 |
| 36 | 1999/12/25 | 00:22:30 | 81.2917 | 1830.86 | 42.76 | 1778.31 | 42.62 |
| 37 | 1999/12/25 | 03:23:00 | 84.3000 | 1836.68 | 42.75 | 1784.90 | 42.63 |

Bottom Gauge Serial Number: Start Date: 1999/12/21 15:05:00 Run Depth:
Top Gauge Serial Number: Start Date: 1999/12/21 15:05:00 Run Depth:
Print Filter Used: Nth Line = 361.000

| | Date | Clock Time | Time | Bottom Gauge Pres. | Bottom Gauge Temp. | Top Gauge Pres. | Top Gauge Temp. |
|---|---|---|---|---|---|---|---|
| | yyyy/mm/dd | hh:mm:ss | hr | kPa(a) | °C | kPa(a) | °C |
| 38 | 1999/12/25 | 06:23:29 | 87.3083 | 1842.50 | 42.76 | 1791.53 | 42.65 |
| 39 | 1999/12/25 | 09:24:00 | 90.3167 | 1848.23 | 42.77 | 1797.82 | 42.66 |
| 40 | 1999/12/25 | 12:24:29 | 93.3250 | 1853.68 | 42.77 | 1803.73 | 42.66 |
| 41 | 1999/12/25 | 15:24:59 | 96.3333 | 1859.12 | 42.75 | 1809.68 | 42.68 |
| 42 | 1999/12/25 | 18:25:30 | 99.3417 | 1864.70 | 42.74 | 1815.50 | 42.68 |
| 43 | 1999/12/25 | 21:26:00 | 102.3500 | 1870.41 | 42.72 | 1821.54 | 42.69 |
| 44 | 1999/12/26 | 00:26:29 | 105.3583 | 1875.90 | 42.75 | 1827.48 | 42.70 |
| 45 | 1999/12/26 | 03:27:00 | 108.3667 | 1881.46 | 42.74 | 1833.27 | 42.69 |
| 46 | 1999/12/26 | 06:27:29 | 111.3750 | 1886.60 | 42.71 | 1839.03 | 42.70 |
| 47 | 1999/12/26 | 09:27:59 | 114.3833 | 1891.69 | 42.74 | 1844.79 | 42.67 |
| 48 | 1999/12/26 | 12:28:30 | 117.3917 | 1897.19 | 42.72 | 1850.29 | 42.64 |
| 49 | 1999/12/26 | 15:29:00 | 120.4000 | 1902.13 | 42.70 | 1855.83 | 42.62 |
| 50 | 1999/12/26 | 18:29:29 | 123.4083 | 1907.08 | 42.68 | 1861.33 | 42.60 |
| 51 | 1999/12/26 | 21:30:00 | 126.4167 | 1911.89 | 42.70 | 1866.96 | 42.62 |
| 52 | 1999/12/27 | 00:30:30 | 129.4250 | 1916.38 | 42.69 | 1872.51 | 42.59 |
| 53 | 1999/12/27 | 03:30:59 | 132.4333 | 1921.35 | 42.69 | 1878.13 | 42.58 |
| 54 | 1999/12/27 | 06:31:30 | 135.4417 | 1925.94 | 42.71 | 1883.18 | 42.59 |
| 55 | 1999/12/27 | 09:32:00 | 138.4500 | 1930.55 | 42.68 | 1888.27 | 42.60 |
| 56 | 1999/12/27 | 12:32:29 | 141.4583 | 1934.95 | 42.69 | 1893.80 | 42.59 |
| 57 | 1999/12/27 | 15:33:00 | 144.4667 | 1939.41 | 42.69 | 1898.71 | 42.59 |
| 58 | 1999/12/27 | 18:33:30 | 147.4750 | 1943.30 | 42.69 | 1903.65 | 42.60 |
| 59 | 1999/12/27 | 21:33:59 | 150.4833 | 1947.10 | 42.69 | 1908.40 | 42.61 |
| 60 | 1999/12/28 | 00:34:30 | 153.4917 | 1951.31 | 42.66 | 1913.01 | 42.60 |
| 61 | 1999/12/28 | 03:35:00 | 156.5000 | 1955.50 | 42.66 | 1918.13 | 42.60 |
| 62 | 1999/12/28 | 06:35:29 | 159.5083 | 1959.96 | 42.64 | 1922.62 | 42.58 |
| 63 | 1999/12/28 | 09:36:00 | 162.5167 | 1964.34 | 42.65 | 1927.17 | 42.59 |
| 64 | 1999/12/28 | 12:36:30 | 165.5250 | 1968.83 | 42.64 | 1931.70 | 42.58 |
| 65 | 1999/12/28 | 15:36:59 | 168.5333 | 1973.19 | 42.63 | 1936.06 | 42.58 |
| 66 | 1999/12/28 | 18:37:30 | 171.5417 | 1977.51 | 42.64 | 1939.75 | 42.58 |
| 67 | 1999/12/28 | 21:38:00 | 174.5500 | 1981.32 | 42.63 | 1943.71 | 42.57 |
| 68 | 1999/12/29 | 00:38:29 | 177.5583 | 1985.85 | 42.63 | 1947.97 | 42.57 |
| 69 | 1999/12/29 | 03:39:00 | 180.5667 | 1989.79 | 42.62 | 1952.05 | 42.55 |
| 70 | 1999/12/29 | 06:39:29 | 183.5750 | 1993.82 | 42.63 | 1956.60 | 42.54 |
| 71 | 1999/12/29 | 09:39:59 | 186.5833 | 1997.92 | 42.63 | 1960.93 | 42.55 |
| 72 | 1999/12/29 | 12:40:30 | 189.5917 | 2001.79 | 42.62 | 1965.56 | 42.54 |
| 73 | 1999/12/29 | 15:41:00 | 192.6000 | 2005.92 | 42.62 | 1969.90 | 42.52 |
| 74 | 1999/12/29 | 18:41:29 | 195.6083 | 2009.72 | 42.61 | 1974.00 | 42.53 |

Bottom Gauge Serial Number: Start Date: 1999/12/21 15:05:00 Run Depth:
Top Gauge Serial Number: Start Date: 1999/12/21 15:05:00 Run Depth:
Print Filter Used: Nth Line = 361.000

| | Date | Clock Time | Time | Bottom Gauge Pres. | Bottom Gauge Temp. | Top Gauge Pres. | Top Gauge Temp. |
|---|---|---|---|---|---|---|---|
| | yyyy/mm/dd | hh:mm:ss | hr | kPa(a) | °C | kPa(a) | °C |
| 75 | 1999/12/29 | 21:42:00 | 198.6167 | 2013.62 | 42.63 | 1978.02 | 42.52 |
| 76 | 1999/12/30 | 00:42:30 | 201.6250 | 2017.46 | 42.62 | 1982.44 | 42.52 |
| 77 | 1999/12/30 | 03:42:59 | 204.6333 | 2021.20 | 42.62 | 1986.32 | 42.53 |
| 78 | 1999/12/30 | 06:43:30 | 207.6417 | 2024.75 | 42.60 | 1990.45 | 42.51 |
| 79 | 1999/12/30 | 09:44:00 | 210.6500 | 2027.50 | 42.60 | 1994.42 | 42.53 |
| 80 | 1999/12/30 | 12:44:29 | 213.6583 | 2031.16 | 42.58 | 1998.45 | 42.53 |
| 81 | 1999/12/30 | 15:45:00 | 216.6667 | 2035.03 | 42.56 | 2002.35 | 42.52 |
| 82 | 1999/12/30 | 18:45:30 | 219.6750 | 2038.77 | 42.52 | 2006.43 | 42.52 |
| 83 | 1999/12/30 | 21:45:59 | 222.6833 | 2042.51 | 42.51 | 2010.21 | 42.50 |
| 84 | 1999/12/31 | 00:46:30 | 225.6917 | 2046.14 | 42.50 | 2014.10 | 42.51 |
| 85 | 1999/12/31 | 03:47:00 | 228.7000 | 2049.68 | 42.50 | 2017.76 | 42.49 |
| 86 | 1999/12/31 | 06:47:29 | 231.7083 | 2053.24 | 42.50 | 2021.43 | 42.49 |
| 87 | 1999/12/31 | 09:48:00 | 234.7167 | 2056.19 | 42.51 | 2024.16 | 42.45 |
| 88 | 1999/12/31 | 12:48:30 | 237.7250 | 2059.11 | 42.52 | 2027.87 | 42.44 |
| 89 | 1999/12/31 | 15:48:59 | 240.7333 | 2062.68 | 42.53 | 2031.70 | 42.44 |
| 90 | 1999/12/31 | 18:49:30 | 243.7417 | 2066.10 | 42.53 | 2035.44 | 42.45 |
| 91 | 1999/12/31 | 21:50:00 | 246.7500 | 2070.01 | 42.53 | 2039.13 | 42.45 |
| 92 | 2000/01/01 | 00:50:29 | 249.7583 | 2073.86 | 42.55 | 2042.75 | 42.45 |
| 93 | 2000/01/01 | 03:51:00 | 252.7667 | 2077.23 | 42.55 | 2046.42 | 42.46 |
| 94 | 2000/01/01 | 06:51:30 | 255.7750 | 2080.61 | 42.55 | 2049.93 | 42.46 |
| 95 | 2000/01/01 | 09:51:59 | 258.7833 | 2084.31 | 42.54 | 2052.76 | 42.46 |
| 96 | 2000/01/01 | 12:52:30 | 261.7917 | 2088.00 | 42.54 | 2055.78 | 42.47 |
| 97 | 2000/01/01 | 15:53:00 | 264.8000 | 2091.44 | 42.54 | 2059.40 | 42.47 |
| 98 | 2000/01/01 | 18:53:29 | 267.8083 | 2094.87 | 42.54 | 2062.74 | 42.47 |
| 99 | 2000/01/01 | 21:54:00 | 270.8167 | 2098.37 | 42.53 | 2066.72 | 42.47 |
| 100 | 2000/01/02 | 00:54:29 | 273.8250 | 2101.60 | 42.54 | 2070.52 | 42.49 |
| 101 | 2000/01/02 | 03:54:59 | 276.8333 | 2105.36 | 42.55 | 2073.98 | 42.50 |
| 102 | 2000/01/02 | 06:55:30 | 279.8417 | 2108.48 | 42.55 | 2077.23 | 42.50 |
| 103 | 2000/01/02 | 09:56:00 | 282.8500 | 2111.87 | 42.54 | 2081.12 | 42.48 |
| 104 | 2000/01/02 | 12:56:29 | 285.8583 | 2115.07 | 42.54 | 2084.63 | 42.49 |
| 105 | 2000/01/02 | 15:57:00 | 288.8667 | 2118.41 | 42.55 | 2088.20 | 42.48 |
| 106 | 2000/01/02 | 18:57:29 | 291.8750 | 2121.62 | 42.54 | 2091.61 | 42.49 |
| 107 | 2000/01/02 | 21:57:59 | 294.8833 | 2124.75 | 42.55 | 2095.09 | 42.47 |
| 108 | 2000/01/03 | 00:58:30 | 297.8917 | 2127.85 | 42.55 | 2098.36 | 42.48 |
| 109 | 2000/01/03 | 03:59:00 | 300.9000 | 2130.98 | 42.55 | 2101.94 | 42.48 |
| 110 | 2000/01/03 | 06:59:29 | 303.9083 | 2134.17 | 42.56 | 2105.29 | 42.49 |
| 111 | 2000/01/03 | 10:00:00 | 306.9167 | 2137.33 | 42.56 | 2108.57 | 42.49 |

Bottom Gauge Serial Number: Start Date: 1999/12/21 15:05:00 Run Depth:
Top Gauge Serial Number: Start Date: 1999/12/21 15:05:00 Run Depth:
Print Filter Used: Nth Line = 361.000

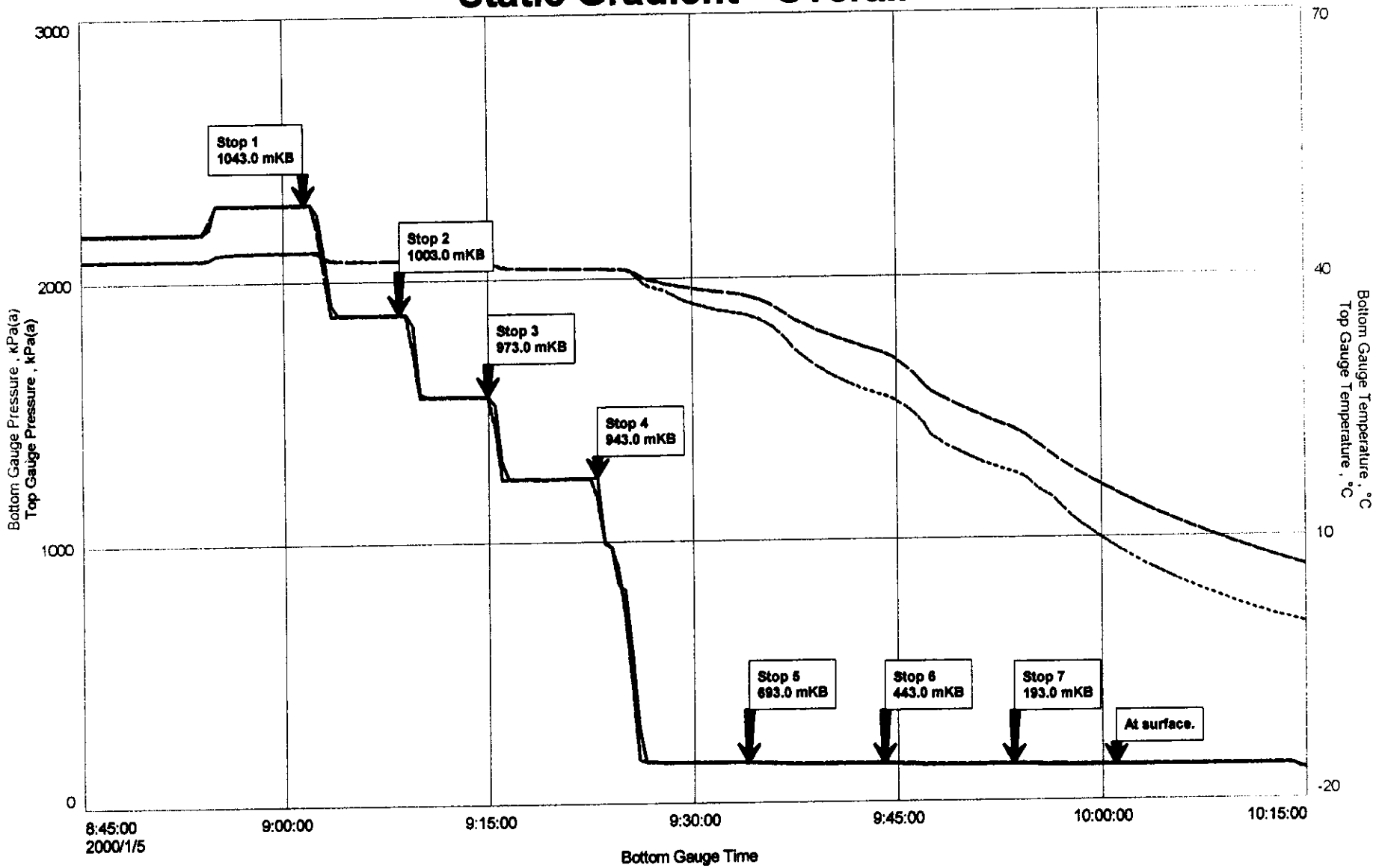
| | Date | Clock Time | Time | Bottom Gauge Pres. | Bottom Gauge Temp. | Top Gauge Pres. | Top Gauge Temp. |
|---|---|---|---|---|---|---|---|
| | yyyy/mm/dd | hh:mm:ss | hr | kPa(a) | °C | kPa(a) | °C |
| 112 | 2000/01/03 | 13:00:29 | 309.9250 | 2140.53 | 42.56 | 2111.83 | 42.48 |
| 113 | 2000/01/03 | 16:00:59 | 312.9333 | 2143.66 | 42.56 | 2115.09 | 42.48 |
| 114 | 2000/01/03 | 19:01:30 | 315.9417 | 2146.96 | 42.57 | 2118.35 | 42.49 |
| 115 | 2000/01/03 | 22:02:00 | 318.9500 | 2149.97 | 42.57 | 2121.45 | 42.49 |
| 116 | 2000/01/04 | 01:02:29 | 321.9583 | 2153.03 | 42.56 | 2124.69 | 42.49 |
| 117 | 2000/01/04 | 04:03:00 | 324.9667 | 2156.11 | 42.56 | 2127.65 | 42.49 |
| 118 | 2000/01/04 | 07:03:30 | 327.9750 | 2159.15 | 42.55 | 2130.95 | 42.49 |
| 119 | 2000/01/04 | 10:03:59 | 330.9833 | 2162.27 | 42.54 | 2134.04 | 42.50 |
| 120 | 2000/01/04 | 13:04:30 | 333.9917 | 2164.81 | 42.55 | 2137.20 | 42.50 |
| 121 | 2000/01/04 | 16:05:00 | 337.0000 | 2167.62 | 42.57 | 2140.41 | 42.50 |
| 122 | 2000/01/04 | 19:05:29 | 340.0083 | 2170.11 | 42.58 | 2143.66 | 42.51 |
| 123 | 2000/01/04 | 22:06:00 | 343.0167 | 2172.90 | 42.57 | 2146.75 | 42.51 |
| 124 | 2000/01/05 | 01:06:29 | 346.0250 | 2175.79 | 42.58 | 2149.78 | 42.50 |
| 125 | 2000/01/05 | 04:06:59 | 349.0333 | 2178.77 | 42.57 | 2152.90 | 42.51 |
| 126 | 2000/01/05 | 07:07:30 | 352.0417 | 2181.86 | 42.56 | 2155.87 | 42.51 |
| 127 | 2000/01/05 | 10:08:00 | 355.0500 | 131.37 | 3.25 | 2158.99 | 42.50 |
| 128 | | | | | | 2161.39 | 42.49 |
| 129 | | | | | | 2164.25 | 42.51 |
| 130 | | | | | | 2166.88 | 42.51 |
| 131 | | | | | | 2169.66 | 42.51 |
| 132 | | | | | | 2172.62 | 42.51 |
| 133 | | | | | | 2175.59 | 42.52 |
| 134 | | | | | | 2178.66 | 42.52 |
| 135 | | | | | | 135.06 | 7.79 |
| 136 | | | | | | 105.93 | -1.51 |

Bottom Gauge Serial Number: Start Date: 1999/12/21 15:05:00 Run Depth:
Top Gauge Serial Number: Start Date: 1999/12/21 15:05:00 Run Depth:
Print Filter Used: Nth Line = 361.000

Anderson Exploration Ltd.
100/03-08-002-29W1/0
Start Test Date: 2000/01/05
Final Test Date: 2000/01/05

Home S Pierson Unit #1
Formation: Spearfish
Job Number: 99-0183

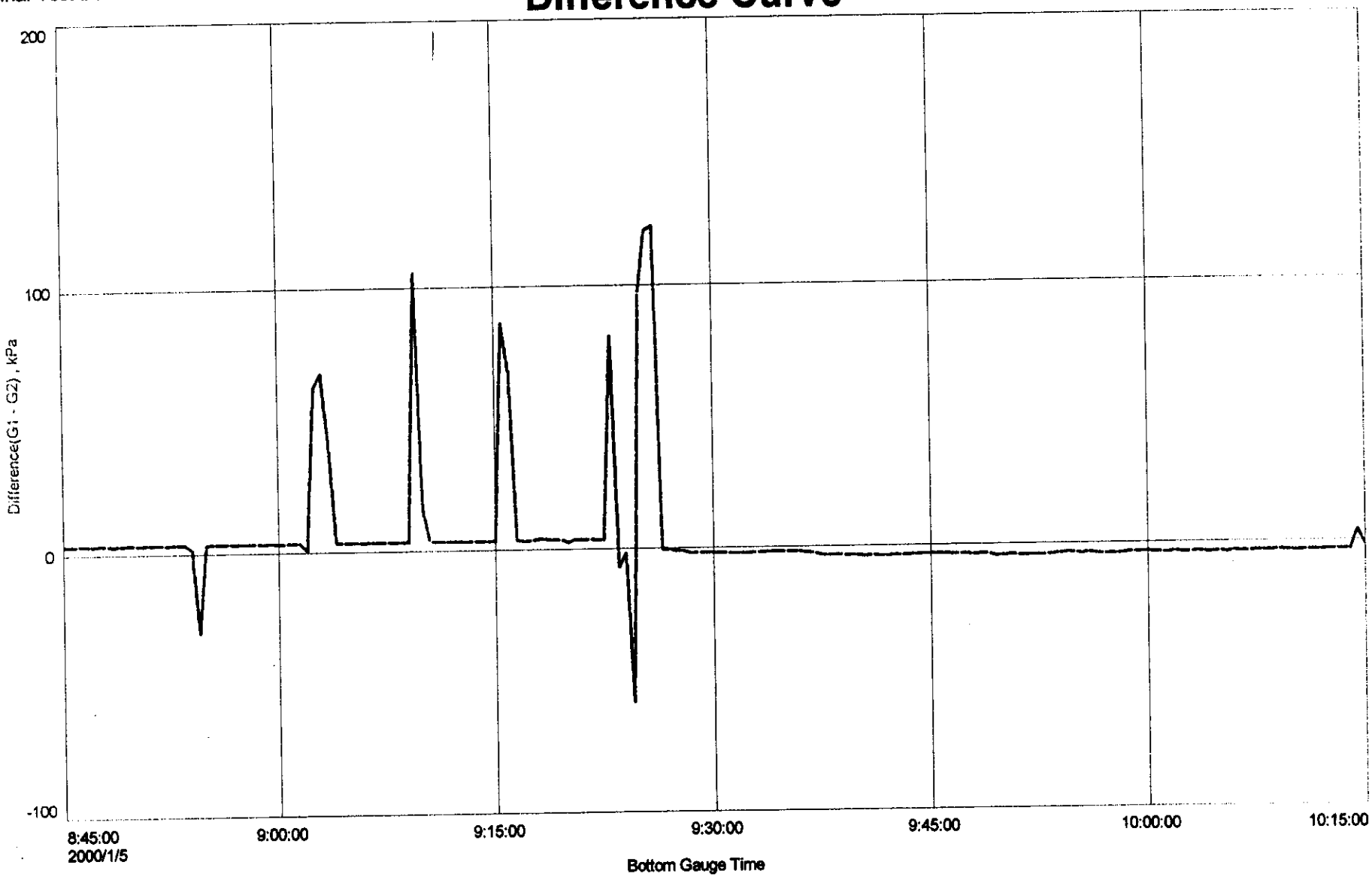
# Static Gradient - Overall



Anderson Exploration Ltd.
100/03-08-002-29W1/0
Start Test Date: 2000/01/05
Final Test Date: 2000/01/05

Home S Pierson Unit #1
Formation: Spearfish
Job Number: 99-0183

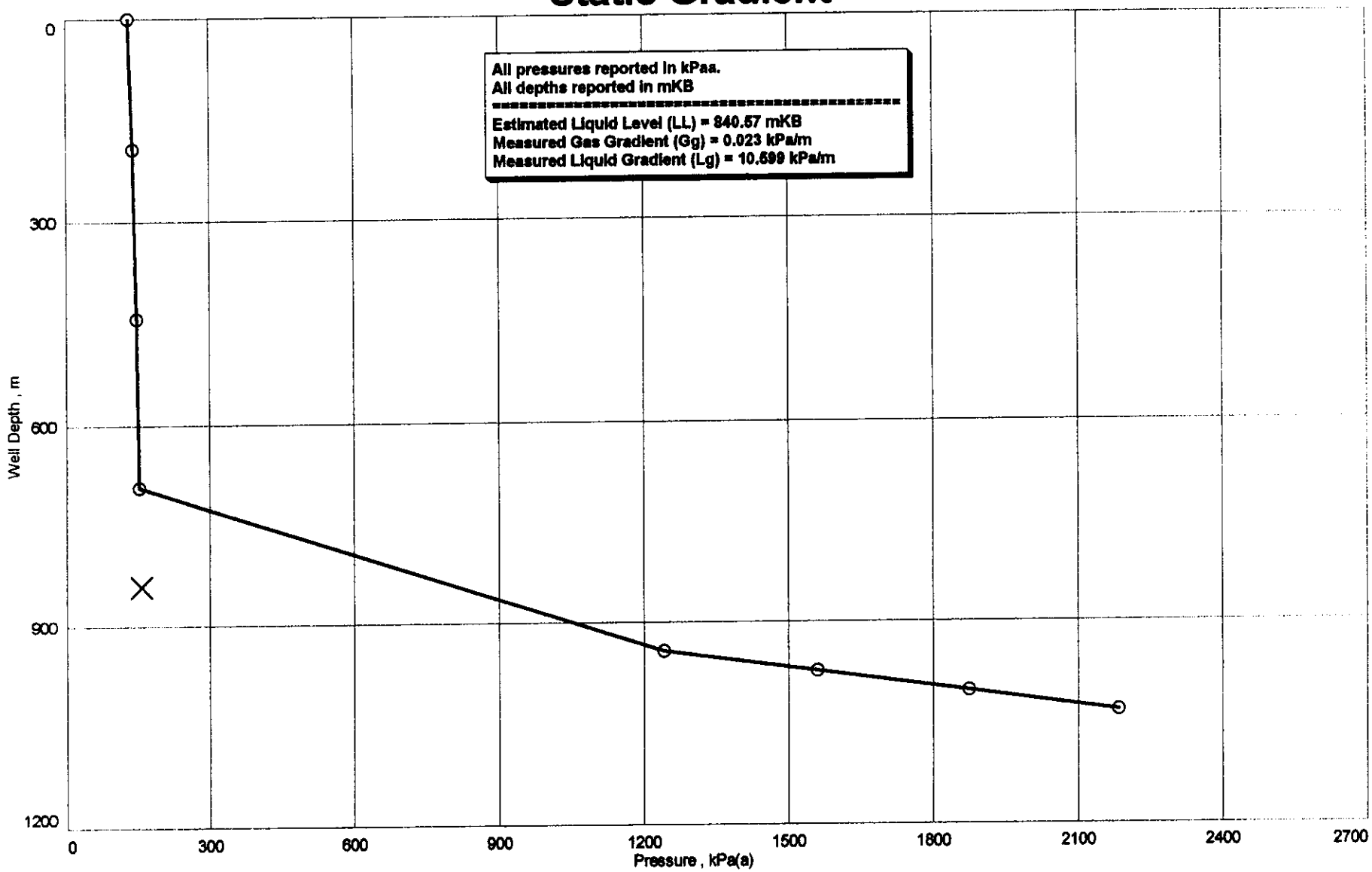
# Difference Curve



Anderson Exploration Ltd.
100/03-08-002-29W1/0
Start Test Date: 2000/01/05
Final Test Date: 2000/01/05

Home S Pierson Unit #1
Formation: Spearfish
Job Number: 99-0183

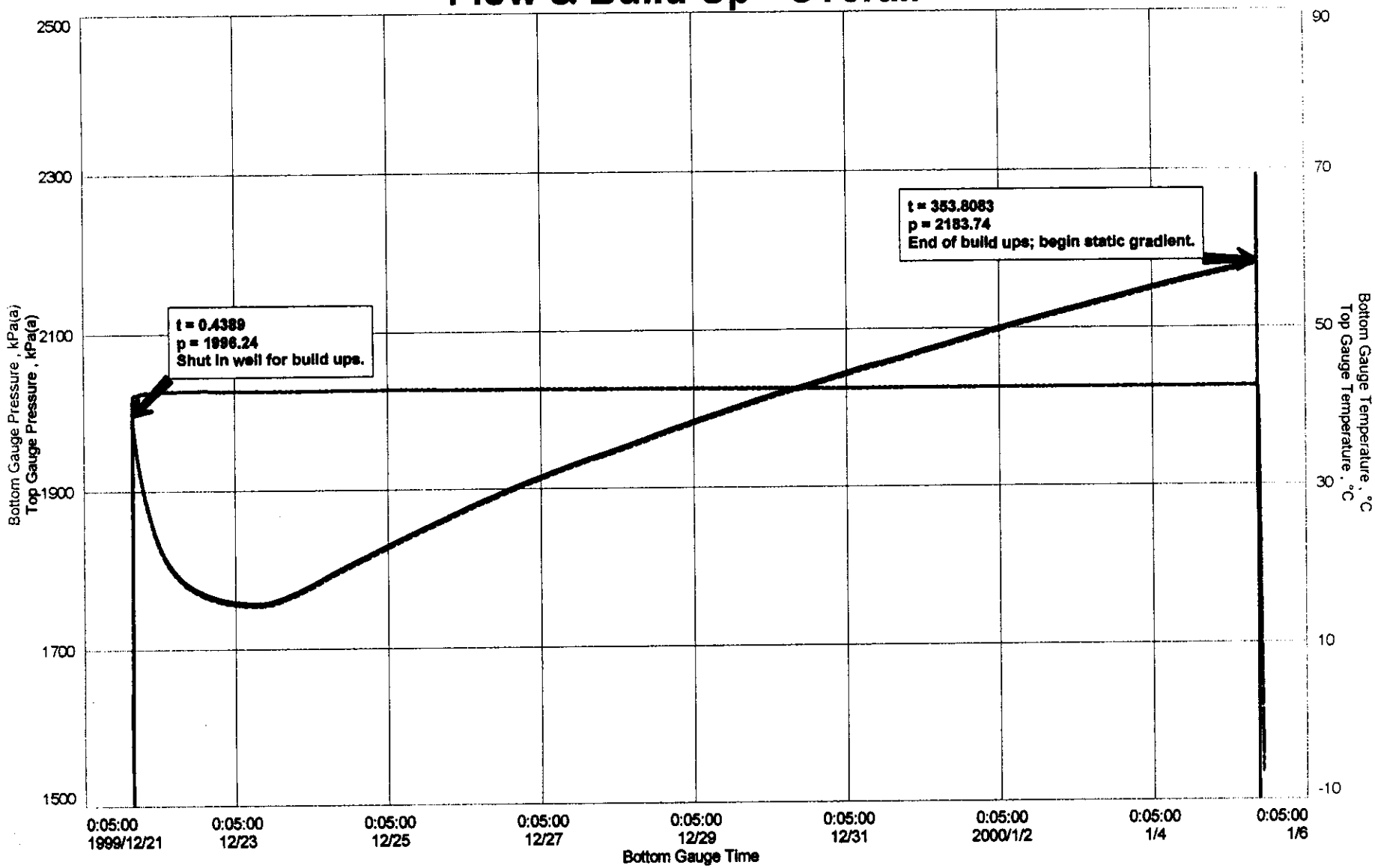
# Static Gradient



Anderson Exploration Ltd.
100/03-08-002-29W1/0
Start Test Date: 1999/12/21
Final Test Date: 2000/01/05

Home S Pierson Unit #1
Formation: Spearfish
Job Number: 99-0183

# Flow & Build Up - Overall



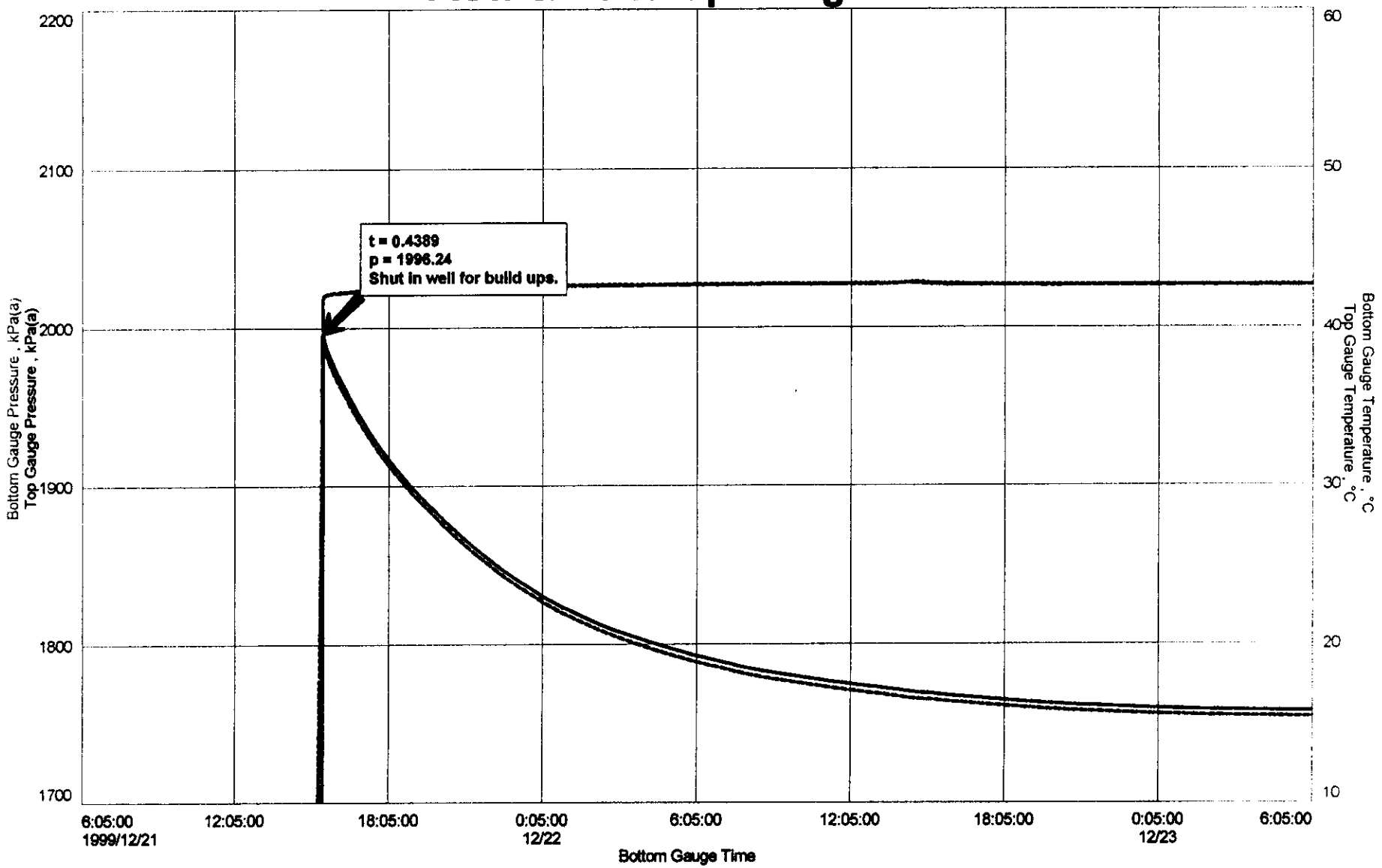



Fast

Anderson Exploration Ltd.
100/03-08-002-29W1/0
Start Test Date: 1999/12/21
Final Test Date: 2000/01/05

Home S Pierson Unit #1
Formation: Spearfish
Job Number: 99-0183

# Flow & Build Up - Magnified






Fast

# EQUATIONS

and

# NOMENCLATURE

(METRIC UNITS)

## BASIC TIME FUNCTIONS

Flow Time $t$

Shut-In Time $\Delta t$

Horner Time $\frac{t + \Delta t}{\Delta t}$

Superposition Time $t_n = \sum_{j=1}^{n} \frac{q_j - q_{j-1}}{q_n} \log(t - t_{j-1})$

$$\Delta t_n = \sum_{j=1}^{n} \frac{q_j}{q_n} \log \frac{t_n + \Delta t - t_{j-1}}{t_n + \Delta t - t_j}$$

Equivalent Time $\Delta t_e = \frac{t \cdot \Delta t}{t + \Delta t}$

Root Time $\sqrt{t}$

$\sqrt{\Delta t}$

Tandem Root Time $\sqrt{t+\Delta t} - \sqrt{\Delta t}$

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## BASIC TIME FUNCTIONS (cont'd)

Quad Root Time $\sqrt[4]{t}$

$\sqrt[4]{\Delta t}$

Tandem Quad Root Time $\sqrt[4]{t+\Delta t} - \sqrt[4]{\Delta t}$

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## TYPECURVES - DIMENSIONLESS VARIABLES

$$\Delta p_D = \frac{(kh/\mu)_t \, \Delta p}{141.2 \, q_t \, B_t}$$

$$t_D = \frac{2.637E-4(k/\mu)_t \, t}{\phi c r_w^2}$$

$$\frac{t_D}{C_D} = 0.000295 \, (\frac{kh}{\mu})_t \frac{t}{C}$$

$$C_D e^{2s} = \frac{0.8936 \, C \, e^{2s}}{\phi c h r_w^2}$$

$$t_{DA} = \frac{2.637E-4 \, (k/\mu)_t \, t}{\phi c A}$$

$$t_{Dxf} = \frac{2.637E-4 \, (k/\mu)_t \, t}{\phi c x_f^2}$$

$$(k_f w)_D = \frac{k_f w}{k x_f}$$

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## McKINLEY ANALYSIS

Wellbore Capacity

$$F = \left(\frac{\Delta p\ F}{qB}\right)\left(\frac{qB}{\Delta p}\right)$$

Alpha

$$\alpha = \frac{F}{5.615}$$

**Note:** Alpha is the same as C

Wellbore Storage Constant
Compressible Fluid

$$C = c_{ws} V_{ws}$$

Wellbore Storage Constant
Changing Liquid Level

$$C = \frac{cross\text{-}sectional\ area}{5.615\ liquid\ gradient}$$

Transmissivity

$$\frac{kh}{\mu} = \left(\frac{T}{F}\right) F$$

Pressure Drop Skin

$$\Delta p_s = \left[1 - \frac{kh_{(wellbore)}}{kh_{(formation)}}\right] \Delta p_{(departure)}$$

Flow Efficiency

$$FE = \frac{p^* - p_{wf} - \Delta p_s}{p^* - p_{wf}}$$

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## SEMILOG ANALYSIS

Transmissivity

$$\left(\frac{kh}{\mu}\right)_t = \frac{162.6\ q_t\ B_t}{m}$$

Permeability

$$k = \frac{162.6\ q_o\ B_o\ \mu_o}{mh}$$

Skin Factor

$$s' = 1.151\left[\frac{p_{ws} - p_{wfo}}{m} - \log\frac{t\Delta t}{t+\Delta t} - \log\left(\frac{(k/\mu)_t}{\phi_t c_t r_w^2}\right) + 3.23\right]$$

Pressure Drop due to Skin

$$\Delta p_s = 0.869\ ms'$$

Flow Efficiency

$$FE = \frac{\bar{p}_R - p_{wfo} - 0.869\ ms'}{\bar{p}_R - p_{wfo}}$$

Damage Ratio

$$DR = \frac{1}{FE}$$

Radius of Investigation

$$r_{inv} = \sqrt{\frac{(k/\mu_t)\ t}{948\phi_t c_t}}$$

Time to Stabilization

$$t_s = \frac{\phi\ c\ A}{2.637E{-}4\ (k/\mu)_t}(t_{DA})_{pss}$$

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## SEMILOG ANALYSIS (cont"d)

Stabilized Rate

$$q_s = \frac{p_i - p_{wfo}}{\frac{162.6\ B_o}{(k/\mu)_o\ h}\left(\log\left(\frac{4A}{1.781\ r_w^2 C_A}\right) + \frac{4\pi(t_{DA})_{pss}}{2.303} + \frac{2s'}{2.303}\right)}$$

Productivity Index

$$P\ I = \frac{q}{\bar{p}_R - p_{wfo}}$$

MBH Average Pressure

$$\bar{p}_R = p^* - \frac{m}{2.303}\ (MBH\ function)$$

DIETZ Average Pressure

$$(\Delta t)_{\bar{p}_R} = \frac{\phi\ c_t\ A}{2.637E{-}4\ C_A (k/\mu)_t}$$

## LINEAR ANALYSIS

Fracture half-length

$$x_f = \frac{4.064\ q_t\ B_t}{mh(\phi c k/\mu)_t^{1/2}}$$

Channel width

$$W = \frac{8.128\ q_t\ B_t}{mh(\phi c k/\mu)_t^{1/2}}$$

Skin Factor

$$s = \ln \frac{2\ r_w}{x_f}$$

## BI-LINEAR ANALYSIS

Fracture Conductivity

$$k_f w = \left[\frac{44.1\ qB\mu}{mh(\phi\mu c k)^{1/4}}\right]^2$$

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## NOMENCLATURE

| Symbol | Description | Metric (SI) | Field |
|---|---|---|---|
| a | LIT flow equation coefficient | - | - |
| A | drainage area | $m^2$ | $ft^2$ |
| AOF | absolute open flow potential (gas) | $10^3m^3/d$ | MMcfd |
| b | LIT flow equation coefficient | - | - |
| B | formation volume factor | - | - |
| c | compressibility | $kpa^{-1}$ | $psi^{-1}$ |
| $c_{ws}$ | compressibility of wellbore fluids | $kpa^{-1}$ | $psi^{-1}$ |
| C | wellbore storage/unloading constant | $m^3/kPa$ | bbl/psi |
| C | simplified flow equation coefficient | - | - |
| $C_A$ | shape factor | - | - |
| $C_{aD}$ | apparent wellbore storage constant | - | - |
| $C_D$ | dimensionless wellbore storage constant | - | - |
| $C_{pD}$ | storage pressure parameter | - | - |
| DR | damage ratio | - | - |
| F | wellbore capacity (McKinley) | $m^3/kPa$ | $ft^3/psi$ |
| FE | flow efficiency | - | - |
| G | relative density (gas) | - | - |
| GOR | gas-oil ratio | $m^3/m^3$ | $ft^3/bbl$ |
| h | net pay | m | ft |
| k | permeability | mD | md |
| $k_{(x,y,z)}$ | permeability in the x,y,z direction | mD | md |
| $k_f$ | fracture permeability | mD | md |
| $k_fw$ | fracture conductivity | mD.m | md.ft |
| kh | flow capacity | mD.m | md.ft |
| $k/\mu$ | mobility | - | - |
| $kh/\mu$ | transmissivity | - | - |

| Symbol | Description | Metric (SI) | Field |
|---|---|---|---|
| $L$ | length of horizontal well | m | ft |
| $L_e$ | effective length of horizontal well | m | ft |
| $m$ | slope of transient plots | - | - |
| $n$ | simplified flow equation coefficient | - | - |
| $p$ | pressure | kPa | psia |
| $p_{bp}$ | bubble point pressure | kPa | psia |
| $p_c$ | gas pseudo-critical pressure | kPa | psia |
| $p_i$ | initial pressure | kPa | psia |
| $p_R$ | average reservoir pressure | kPa | psia |
| $p_{tf}$ | flowing wellhead pressure | kPa | psia |
| $p_{ts}$ | shut-in wellhead pressure | kPa | psia |
| $p_{wf}$ | flowing sandface pressure | kPa | psia |
| $P_{wfo}$ | final flowing pressure | kPa | psia |
| $p_{ws}$ | shut-in sandface pressure | kPa | psia |
| $p^*$ | extrapolated pressure | kPa | psia |
| $\Delta p_D$ | dimensionless pressure | - | - |
| $\Delta p$ | pressure drop | kPa | psi |
| PI | productivity index | $m^3/d/kPa$ | bbl/d/psi |
| $q$ | flow rate - gas<br>- liquid | $10^3m^3/d$<br>$m^3/d$ | MMcf/d<br>bbl/d |
| $q_j$ | $j^{th}$ flow rate | $m^3/d$ | bbl/d |
| $q_n$ | $n^{th}$ flow rate | $m^3/d$ | bbl/d |
| $q_s$ | stabilized rate - gas<br>- liquid | $10^3m^3/d$<br>$m^3/d$ | MMcf/d<br>bbl/d |
| $r_e$ | external radius | m | ft |
| $r_{inv}$ | radius of investigation | m | ft |
| $r_w$ | wellbore radius | m | ft |
| $R_s$ | solution gas ratio | $m^3/m^3$ | $ft^3/bbl$ |

| Symbol | Description | Metric (SI) | Field |
|---|---|---|---|
| $s$ | skin factor | - | - |
| $s'$ | apparent skin factor | - | - |
| $S$ | saturation (oil, gas, water) | - | - |
| $t$ | time | hr | hr |
| $t_D$ | dimensionless time | hr | hr |
| $t_a$ | pseudo-time | hr | hr |
| $t_{DA}$ | dimensionless time (based on drainage area) | hr | hr |
| $t_{Dxf}$ | dimensionless time (based on fracture 1/2 length) | hr | hr |
| $t_n$ | $n^{th}$ flow period, or superposition time | - | - |
| $\Delta t$ | shut-in time | hr | hr |
| $\Delta t_a$ | shut-in pseudo-time | hr | hr |
| $\Delta t_e$ | equivalent time | hr | hr |
| $(t_{DA})_{pss}$ | dimensionless time at pseudo-steady state | - | - |
| $t_s$ | time to stabilization | hr | hr |
| $T$ | temperature | K | °R |
| $T_c$ | gas pseudo-critical temperature | K | °R |
| $V_{ws}$ | wellbore volume - gas<br>- liquid | $m^3$<br>$m^3$ | $ft^3$<br>bbl |
| $W$ | channel width | m | ft |
| $w$ | fracture width | m | ft |
| $x_e$ | length of reservoir | m | ft |
| $x_f$ | fracture half-length | m | ft |
| $x_o$ | x -location of observation well | m | ft |
| $x_w$ | x- location of centre of active well | m | ft |
| $y_e$ | width of reservoir | m | ft |
| $y_o$ | y- location of observation well | m | ft |
| $y_w$ | y- location of centre of active well | m | ft |
| $Z$ | gas compressibility factor | - | - |
| $z_w$ | z-location of centre of active well | m | ft |

| Symbol | Description | Metric (SI) | Field |
|---|---|---|---|
| $\alpha$ | wellbore storage/unloading constant | $m^3/kPa$ | bbl/psi |
| $\mu$ | viscosity - gas | $\mu$Pa.s | cp |
| | - liquid | mPa.s | cp |
| $\lambda$ | inter-porosity flow coefficient | - | - |
| T | transmissivity (McKinley) | mD.m/mPa.s | md.ft/cp |
| $\phi$ | porosity | - | - |
| $\psi$ | pseudo-pressure | $kPa^2/\mu Pa.s$ | $psia^2/cp$ |
| $\omega$ | storativity ratio | - | - |

**Subscripts**

| | |
|---|---|
| D | dimensionless |
| DA | dimensionless based on area |
| Dxf | dimensionless based on fracture half -length |
| f | formation or flowing |
| g | gas |
| i | initial |
| o | oil |
| R | reservoir |
| s | shut-in, skin, stabilized or storage |
| t | total, transient, or wellhead (tubing head) |
| w | water or wellbore (sandface) |
| ref | evaluated at reference pressure |

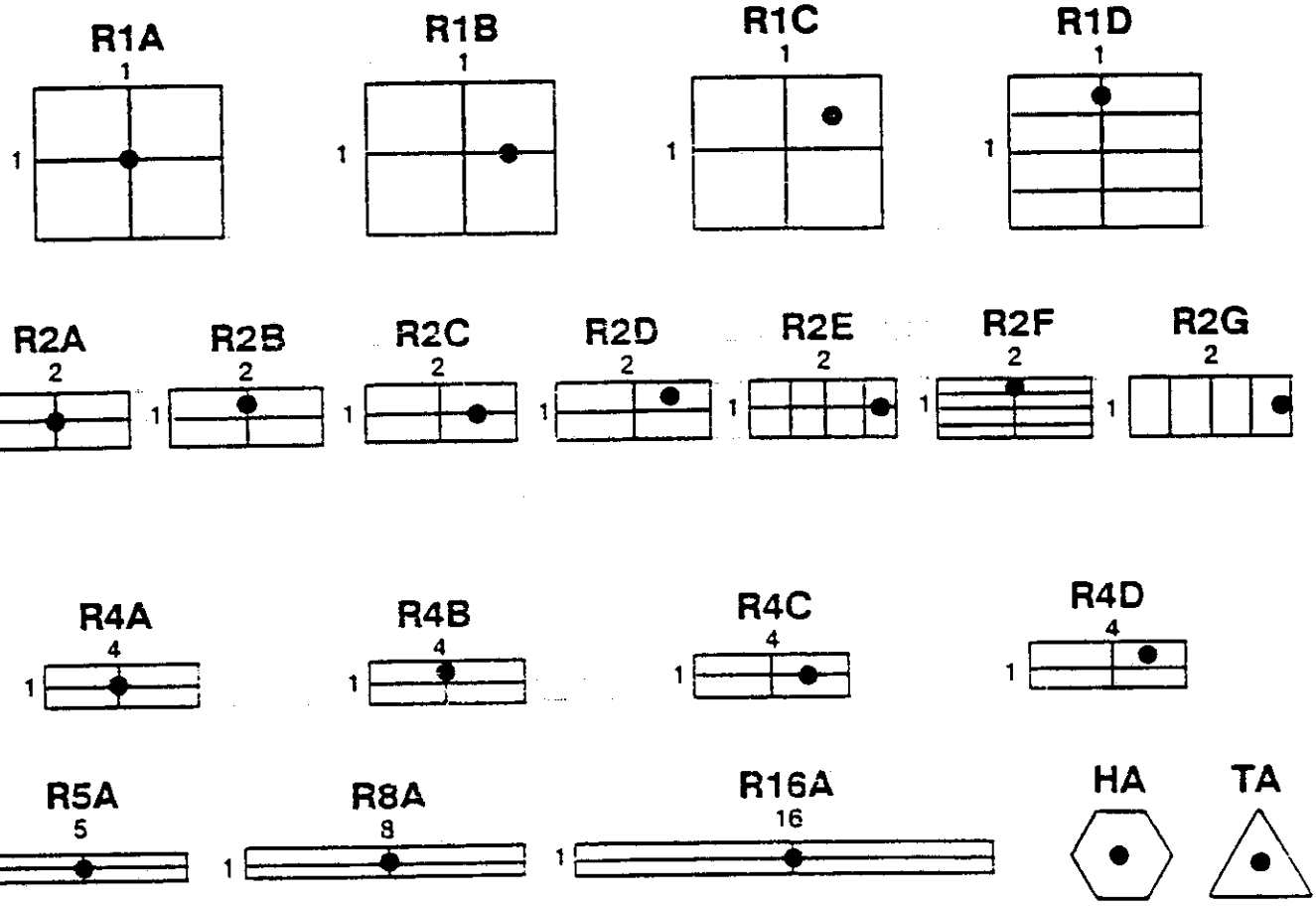
**Superscripts**

| | |
|---|---|
| - | average |

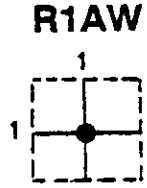
# DIETZ SHAPE CODES

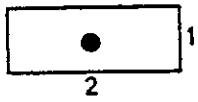
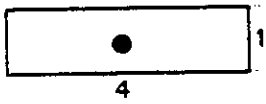
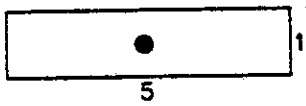
## AVERAGE RESERVOIR PRESSURE - MBH CORRECTIONS

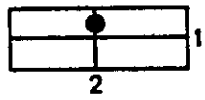
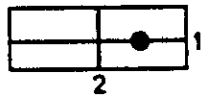
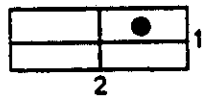
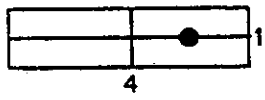
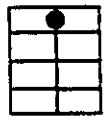
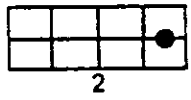
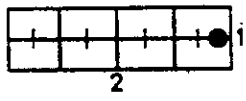
### NO FLOW OUTER BOUNDARY




### CONSTANT PRESSURE OUTER BOUNDARY



| | $\ln C_A$ | $C_A$ | STABILIZED CONDITIONS FOR $t_{DA}$ > |
|---|---|---|---|
| IN BOUNDED RESERVOIRS | | | |
|  | 3.45 | 31.6 | 0.1 |
|  | 3.43 | 30.9 | 0.1 |
|  | 3.45 | 31.6 | 0.1 |
|  | 3.32 | 27.6 | 0.2 |
|   | 3.30 | 27.1 | 0.2 |
|   | 3.09 | 21.9 | 0.4 |
|   | 3.12 | 22.6 | 0.2 |
|   | 1.68 | 5.38 | 0.7 |
|   | 0.86 | 2.36 | 0.7 |
|  | 2.56 | 12.9 | 0.6 |
|  | 1.52 | 4.57 | 0.5 |

| | $\ln C_A$ | $C_A$ | STABILIZED CONDITIONS FOR $t_{DA}$ > |
|---|---|---|---|
|   | 2.38 | 10.8 | 0.3 |
|   | 1.58 | 4.86 | 1.0 |
|   | 0.73 | 2.07 | 0.8 |
|   | 1.00 | 2.72 | 0.8 |
|   | -1.46 | 0.232 | 2.5 |
|   | -2.16 | 0.115 | 3.0 |
|  | 1.22 | 3.39 | 0.6 |
|   | 1.14 | 3.13 | 0.3 |
|   | -0.50 | 0.607 | 1.0 |
|   | -2.20 | 0.111 | 1.2 |
|   | -2.32 | 0.098 | 0.9 |
| IN WATER DRIVE RESERVOIRS | | | |
|  | 2.95 | 19.1 | 0.1 |
| IN RESERVOIRS OF UNKNOWN PRODUCTION CHARACTER | | | |
|  | 3.22 | 25 | 0.1 |

## PSEUDO-STEADY STATE SHAPE FACTORS FOR VARIOUS RESERVOIRS

FROM DIETZ (1965)

## UNITS CONVERSION AND PREFIXES

| METRIC (SI) UNIT | FIELD UNIT | DIVIDED BY |
|---|---|---|
| $10^3m^3/d$ | MMcfd | 2.817 399 E+01 |
| kPa | psia | 6.894 757 E+00 |
| mD | md | 9.869 233 E-01 |
| mD.m | md.ft | 3.008 142 E-01 |
| m | ft | 3.048 E-01 |
| $m^3$ | bbl (35 Imp gal)<br>(42 US gal) | 1.589 873 E-01 |
| Pa.s | cp | 1.0 E+03 |
| °C | °F | (°F-32)5/9 E+00 |
| K | °R | 5/9 E+00 |
| $m^2$ | section (640 acres) | 2.589 988 E+06 |
| ha | section (640 acres) | 2.589 988 E+02 |
| $m^3$ | gallon (Imp) | 4.546 09 E-03 |
| $m^3$ | gallon (US) | 3.785 412 E-03 |
| $m^3/10^3m^3$ | bbl/MMcf | 5.643 052 E-03 |

Standard conditions: Metric (SI) 15°C, 101.325 kPa
Field 60°F, 14.65 psia

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