Paramount et al Cameron M-73

PARAMOUNT RESOURCES LTD.
CAMERON LAKE SULPHUR POINT
WELL M73 60° 10'N, 117° 15'W
RESERVOIR FLUID STUDY

Prepared for

Paramount Resources Ltd.

Prepared by

Hycal Energy Research Laboratories Ltd.

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591-09

Hycal

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SUMMARY

At the request of Paramount Resources Ltd., Hycal Energy Research Laboratories Ltd. conducted a reservoir fluid study using recombined Sulphur Point reservoir fluid samples from Well M73 (60° 10'N - 117° 15'W) in the Cameron Lake area at the reservoir temperature of 54°C. The saturation pressure of the recombined reservoir fluid had a value of 9540 kPag (1380 psig) at 54°C. Major results of the P.V.T. tests are summarized as follows:

1. Dead oil density at 15.6°C had a value of 857 kg/m^3 giving a stock-tank oil API gravity of 33.61. Dead oil density decreased to 831.0 kg/m^3 at 54°C. Dead oil viscosity at 54°C had a value of 3.88 mPa.s.

2. Live oil solubility measured by a single stage flash had a value of 40.5 m^3/m^3 at standard conditions.

3. Live oil compressibility above the bubblepoint decreased from 3.98×10^{-6} kPa^{-1} in the 9540 to 10 340 kPa region to 2.69×10^{-6} kPa^{-1} in the 31 030 to 34 470 kPa region.

4. Live oil viscosity had a minimum value of 1.65 mPa.s at the bubblepoint pressure of 9540 kPag and increased to 3.24 mPa.s at 34 470 kPag and to 3.88 mPa.s at 0 kPag and 54°C.

5. Liberated gas phase viscosity decreased from 0.0136 mPa.s at 7240 kPag to 0.0114 mPa.s at 0 kPag and 54°C.

6. Liberated gas specific gravity increased from 0.6334 (air = 1.000) for the evolved gas at 7240 kPag to 0.7905 for the evolved gas at 0 kPag. Compositional analysis of the differentially liberated gas indicated an increase in C_2+ content with a reduction in pressure.

7. Gas deviation factor for the evolved gas increased from 0.9056 at 7240 kPa to 0.9980 at ambient pressure and 54°C.

8. Gas formation volume factor increased from 0.0142 m^3/m^3 at 7240 kPa to 1.273 m^3/m^3 at ambient pressure and 54°C.

9. Gas expansion factor decreased from 70.42 m^3/m^3 at 7240 kPa to 0.79 m^3/m^3 at ambient pressure and 54°C.

10. Solution gas-oil ratio under differential liberation had a maximum value of 43.9 m^3/m^3 at 9540 kPag and declined to zero at 0 kPag.

11. Live oil formation volume factor had a maximum value of 1.138 at the saturation pressure of 9540 kPag at 54°C.

12. Live oil density had a minimum value of 806.0 kg/m^3 at the saturation pressure of 9540 kPag at 54°C.

13. Examination of the appearance of the oil and gas phases in the visual cell during the differential liberation test indicated a normal two-phase hydrocarbon equilibrium system, with no evidence of asphaltene precipitation or other problems occurring with a reduction in pressure.

INTRODUCTION

At the request of Susan Rose of Paramount, Hycal Technical Services Ltd. conducted a reservoir fluid study on recombined samples taken from Cameron Lake Well M73. This report describes the experimental equipment and procedures used in the study and presents the results of the experimental work.

DESCRIPTION OF EQUIPMENT

Figure 1 illustrates the PVT equipment used in the Paramount Cameron Lake Sulphur Point Well M73 P.V.T. Study. A visual cell rated to 70,000 kPa is the heart of the apparatus. The capacity of the visual cell is approximately 100 cm^3, and the cell has been calibrated with a cathetometer to determine the internal volume as a function of interface height.

Fluids in the cell are pressurized through the use of mercury, injected into the visual cell to reduce the effective volume. Mercury is used due to emulsification problems occurring with water in lighter oils and to avoid excessive migration of CO_2 or H_2S into solution in the water when CO_2 or H_2S are present in the mixture. To avoid placing mercury directly into the barrel of the Ruska pump which acts as the displacing force for the system, a mercury-water reservoir is used (this also reduces the area to contain mercury spills). The Ruska pump displaces water onto the top of a mercury reservoir which in turn displaces this fluid into the visual cell. A digital gauge equipped with a stainless steel isolator is attached to this portion of the system to monitor the pressure in the visual cell. The isolator reduces the dead volume and prevents oil and mercury from entering the pressure gauges.

The pumps used in all portions of the test are positive displacement type Ruska pumps capable of injecting at rates from 2 - 240 cm^3 per hour at pressures of up to 69,000 kPa. The pumps are accurate to within 0.01 cm^3.

Produced oil and gas volumes after a flash test, are determined in an atmospheric separator. The sample is flashed into a sealed, graduated centrifuge tube which measures the produced liquid volume to the nearest 0.10 cm^3. The gas volume is measured in a Ruska type gasometer connected to the system and is accurate to within 0.10 cm^3. The gas volumes are corrected back to standard conditions of 101.325 kPa and 15.56°C and are used with the measured oil volume to determine the gas-oil ratio. Produced gas samples are subjected to compositional analysis using a Hewlett Packard Series 5880A gas chromatograph. Oil and gas phase condensate samples are subjected to a capillary column analysis using Hycal's Hewlett Packard Series II 5890 chromatograph. This analysis provides a single carbon number liquid mole fraction split from C_1 to C30 plus aromatic and cyclic compounds. This analysis can be used with the gas analysis, measured gas-oil ratio, and a computer recombination program to obtain the initial, single-phase composition at pre-flash conditions.

Viscosity is determined in the apparatus using a calibrated viscosity tube of known physical dimensions. Two Ruska pumps are used in this procedure, injecting and withdrawing samples at exactly the same rate so that the pressure differential across the capillary tube can be monitored. The pressure differential is monitored using a Validyne model DP15 pressure transducer accurate to 0.07 kPa over a 70 kPa pressure range. The transducer measures the direct pressure differential across the tube irrespective of the particular system pressure at the sample point.

The transducer output is directed to a Validyne MC1 20 - channel computer control centre which provides a digital readout of the instantaneous pressure differential in the system. The transducer also outputs to a Hewlett Packard 7132A multi-channel strip chart recorder which provides the operator with a continuous pressure profile during viscosity determination and indicates when steady state has been achieved.

To measure density of a live oil sample, a known volume of oil is displaced into an aluminum pressure cylinder rated for 21,000 kPa. The cylinder volume and weight are measured exactly prior to sampling. The sample cylinder is filled without altering the pressure of the reservoir fluid. The sample cylinder is reweighed on a scale accurate to 0.001 g and the density of the fluid sample determined. The sample is flashed to atmospheric conditions and the gas collected in a gasometer. The volume of the remaining dead oil sample is determined and thus the single stage flash solution gas-oil ratio of the particular sample can be calculated.

The visual cell, capillary tube and density bomb are all mounted within a temperature-controlled oven so that desired thermal test conditions can be attained. Temperature is controlled using a CIC temperature controller accurate to $\pm 0.5°C$. An internally mounted thermometer is present to provide an exact reading of the system temperature. Two circulating fans in the oven ensure a uniform temperature distribution in the system. A cooling coil through which a refrigerant can be circulated is also present, if operation below the ambient lab temperature is required.

The entire oven apparatus is mounted on a rotating swivel and can be rotated through 180° by an attached motor and chain drive. This arrangement allows the oil to be well mixed in the visual cell. The oven can be rotated continuously or on a timed basis. The oven front and back are also equipped with explosion-proof sightglasses to facilitate observation of the visual cell and internal thermometer without opening the oven door and upsetting test thermal conditions.

EXPERIMENTAL PROCEDURE

Paramount supplied Hycal with samples of separator oil and gas from the Sulphur Point zone of Cameron Lake Well M 73. Upon receipt at Hycal the samples were analysed and then physically recombined to yield the target saturation pressure of 9540 kPag at 54°C as specified by Paramount. Additional separator gas was reconstituted by Hycal for use in the recombination due to the small available volume of actual field gas supplied. A single stage G.O.R. measurement was then conducted on this sample.

Once the oil sample had been recombined, a specified volume was transferred into the high-pressure visual cell discussed previously in the "DESCRIPTION OF EQUIPMENT" section and compressibility measurements were performed. A portion of the sample was flashed, the solubility measured and the respective oil and gas phases analysed by gas chromatograph to facilitate calculation of the single-phase recombined composition. Several high-pressure density and viscosity measurements above the bubblepoint pressure were conducted on the remaining sample.

The large visual cell was charged with live oil at above the bubblepoint pressure and at reservoir temperature, and a constant composition flash test was conducted to determine the saturation pressure and total volume as a function of pressure of the recombined oil. Once the pressure-volume test had been completed, the system was repressured to well above the bubblepoint and mixed into single-phase. The viscosity, density, swelling and solubility at the bubblepoint were then measured.

A differential liberation test was performed by reducing the pressure in stages and allowing a gas phase to form. At each pressure stage, the respective gas and oil phase volumes were measured, and the gas phase was removed at constant pressure and subjected to compositional analysis. The viscosity, density, solubility and swelling of the oil phase at the same pressure were then measured. The pressure was reduced to the next pressure level and sufficient time (minimum of 48 hours) was taken to allow an equilibrium gas phase to form and process was repeated.

Dead oil was subjected to viscosity and density tests at 15.5, and 54°C using a Cannon-Fenske type calibrated viscometer and a standard picnometer.

Results and Discussion

Separator samples were obtained from Well M73 as described in the "Experimental Procedure" section and the recombination conducted as outlined.

The reservoir temperature of 54°C was supplied to Hycal by Paramount. The oil was pressurized to single phase at this temperature. Single stage flash G.O.R. on the live oil had a value of 40.5 m^3/m^3 (STP = 15.56°C, 101.325 kPa abs).

Prior to the live oil tests, the density of the dead oil at temperatures of 15.6°C, and 54°C was measured. Results are summarized in Table 1 and have been plotted and appear as Figure 2. Density decreased from 857.0 kg/m^3 to 831.0 kg/m^3 over this temperature range. The stock-tank oil API gravity at a temperature of 15.6°C had a value of 33.61° API. Dead oil viscosity at the reservoir temperature of 54°C and ambient pressure had a value of 3.88 mPa.s. Table 2 provides the composition of the separator gas provide from well M73 (which was subsequently reconstituted for use in the oil recombination).

Table 3 contains the results of the live oil compressibility measurements above the saturation pressure. Compressibility decreased from 3.98×10^{-6} kPa^{-1} (27.4×10^{-6} psi^{-1}) in the 9540 to 10 340 kPa range to 2.69×10^{-6} kPa^{-1} (18.5×10^{-6} psi^{-1}) in the 31 030 - 34 470 kPa range. The compressibility data of Table 3 has been plotted and appears as Figure 3.

Table 4 contains the results of the constant composition expansion test conducted on the initial live oil at 54°C. The data of Table 4 have been plotted on Cartesian coordinates and appear as Figure 4. Saturation pressure for the live oil was determined to have a magnitude of 9540 kPa-gauge. This is a direct determination in a visual cell which allows the exact determination of the first bubble of substantial free gas.

Table 5 contains the recombined oil composition as measured by Hycal using our separator flash recombination routine to C_{30}^{+}.

Table 6 contains the results of the viscosity, formation volume factor and density measurements conducted on the live oil below the bubblepoint. Oil viscosity had a minimum value of 1.65 mPa.s at the bubblepoint and increased as pressure was increased above the bubblepoint to 3.24 mPa.s at 34 470 kPa due to fluid compression effects. Viscosity also increased below the bubblepoint as pressure was reduced due to the evolution of solution gas from the system. Viscosity increased to a maximum value of 3.88 mPa.s at 54°C and ambient pressure. Oil viscosity has been plotted versus pressure and appears as Figure 5. Oil density had a minimum value of 806.0 kg/m^3 at the saturation pressure of 9540 kPa-gauge and 54°C. Oil phase density increased to 873.0 kg/m^3 at 34 470 kPag due to fluid compression effects. Dead oil density also increased below the bubblepoint to a maximum value of 831.0 kg/m^3 at ambient pressure and 54°C. The density data of Table 6 have been plotted and appear as Figure 6.

Live oil formation volume factor had a maximum value of 1.138 at the bubblepoint pressure of 9540 kPa-gauge and decreased to 1.051 at 34 470 kPag and to 1.031 at 0 kPag and 54°C. The formation volume factor data of Table 6 have been plotted and appear as Figure 7.

Table 7 contains a summary of the results of the differential liberation test conducted on the live oil from Paramount Cameron Lake Well M73. As discussed previously, initial live oil density at the bubblepoint at reservoir pressure had a value of 806.0 kg/m^3 giving a recombined oil API gravity of 44.06. Oil formation volume factor and solubility at the bubblepoint had values of 1.138 and 43.9 m^3/m^3 respectively.

The differential liberation test consisted of eight individual pressure stages at 54°C which are as follows:

1) 9540 to 7240 kPag
2) 7240 to 5520 kPag
3) 5520 to 4480 kPag
4) 4480 to 3450 kPag
5) 3450 to 1725 kPag
6) 1725 to 860 kPag
7) 860 to 520 kPag
8) 520 to 0 kPag

The changes in oil phase density, viscosity and formation volume factor under differential liberation have been discussed previously and are summarized for pressures both above and below the bubblepoint in Figures 5 to 7. Gas phase viscosity has been calculated using compositional data and the Lee, Gonzalez, Eakin correlation (Reference 1) is included as a portion of Table 8. Gas phase viscosity decreased from 0.0136 mPa.s at 7240 kPag to

0.0114 mPa.s at 0 kPa-gauge and has been plotted versus pressure and appears as Figure 8. System relative total volume (Table 7) under differential liberation increased from 1.138 to 56.92 (90 kPa-abs reference). This data has been plotted as Figure 9.

Differentially liberated gas-oil ratio decreased from 43.9 m^3/m^3 at the bubblepoint to zero at ambient pressure. Differentially liberated gas-oil ratio has been plotted vs pressure and appears as Figure 10.

Tables 9 to 16 contain the analyses of the solution gas evolved from the oil at each differential liberation step pressure. Examination of the compositional data of Tables 9 to 16 and the specific gravity data of Table 7 indicates that gas gravity increased with a reduction in differential liberation pressure. Tables 9 to 16 also contain calculated gas phase critical properties, both corrected and uncorrected for CO_2 content and calculated gross and net heating values. Gas properties were calculated using methods outlined in References 2 to 5.

Gas deviation factor (Z) is summarized for each of the pressure points as a portion of Table 7. Deviation factor increased from a value of 0.9056 at 7240 kPa to 0.9980 at ambient pressure. Deviation factor has been plotted versus pressure and appears as Figure 11. Gas formation volume factor (Bg - Table 7) increased from 0.0142 m^3/m^3 to 1.2731 m^3/m^3 in the 7240 to ambient pressure range at 54°C. Gas formation volume factor is expressed as the volume of gas at test temperature and pressure over the volume of the same amount of gas at standard conditions of 101.315 kPa and 15.6 °C. Gas formation volume factor has been plotted versus pressure and appears as Figure 12. Gas expansion factor (1/Bg) has also been plotted and appears as Figure 13.

The incremental and cumulative gas gravity data of Table 7 have been plotted and appear as Figures 14 and 15 respectively. The calculated liberated gas phase density at standard and liberation conditions is summarized in Table 8 and has been plotted and appears as Figures 16 and 17 respectively. The oil-gas viscosity ratio data appearing in Table 8 has been plotted and is illustrated as Figure 18.

The system exhibited normal two phase light hydrocarbon behaviour throughout the pressure range tested, with no evidence of the precipitation of asphaltenes with a reduction in pressure.

Data Diskette Summary

A 5¼" floppy data diskette is included at the end of the report which contains all pertinent numerical data from the Paramount Cameron Lake Well M63 PVT study summarized in LOTUS 1-2-3 spreadsheet format. This will facilitate the manipulation and plotting of the data by Paramount personnel, if desired. The contents of the worksheet files are as follows:

Filename	Contents
PARA1. WK 1	Compressibility data [Table 3]
PARA2. WK 1	Pressure-Volume Test data [Table 4]
PARA3. WK 1	Live oil density, viscosity and formation volume factor data [Table 6]
PARA4. WK 1	Differential liberation data [Table 7]
PARA5. WK 1	Gas property data [Table 8]

CONCLUSIONS

At the request of Paramount Resources Ltd., Hycal conducted a reservoir fluid study on reservoir fluid samples from Cameron Lake Well M73 (Sulphur Point Formation). It was concluded that:

1. Dead oil density at 15.6°C had a value of 857 kg/m^3 giving a stock-tank oil API gravity of 33.61. Dead oil density decreased to 831.0 kg/m^3 at 54°C. Dead oil viscosity at 54°C had a value of 3.88 mPa.s.

2. Live oil solubility measured by a single stage flash had a value of 40.5 m^3/m^3 at standard conditions.

3. Live oil compressibility above the bubblepoint decreased from 3.98 x 10^{-6} kPa^{-1} in the 9540 to 10 340 kPa region to 2.69 x 10^{-6} kPa^{-1} in the 31 030 to 34 470 kPa region.

4. Live oil viscosity had a minimum value of 1.65 mPa.s at the bubblepoint pressure of 9540 kPag and increased to 3.24 mPa.s at 34 470 kPag and to 3.88 mPa.s at 0 kPag and 54°C.

5. Liberated gas phase viscosity decreased from 0.0136 mPa.s at 7240 kPag to 0.0114 mPa.s at 0 kPag and 54°C.

6. Liberated gas specific gravity increased from 0.6334 (air = 1.000) for the evolved gas at 7240 kPag to 0.7905 for the evolved gas at 0 kPag. Compositional analysis of the differentially liberated gas indicated an increase in C_2+ content with a reduction in pressure.

7. Gas deviation factor for the evolved gas increased from 0.905 at 7240 kPa to 0.9980 at ambient pressure and 54°C.

8. Gas formation volume factor increased from 0.0142 m^3/m^3 at 7240 kPa to 1.273 m^3/m^3 at ambient pressure and 54°C.

9. Gas expansion factor decreased from 70.42 m^3/m^3 at 7240 kPa to 0.79 m^3/m^3 at ambient pressure and 54°C.

10. Solution gas-oil ratio under differential liberation had a maximum value of 43.9 m^3/m^3 at 9540 kPag and declined to zero at 0 kPag.

11. Live oil formation volume factor had a maximum value of 1.138 at the saturation pressure of 9540 kPag at 54°C.

12. Live oil density had a minimum value of 806.0 kg/m^3 at the saturation pressure of 9540 kPag at 54°C.

13. Examination of the appearance of the oil and gas phases in the visual cell during the differential liberation test indicated a normal two-phase hydrocarbon equilibrium system, with no evidence of asphaltene precipitation or other problems occurring with a reduction in pressure.

REFERENCES

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2. Kay, W.B., "Density of Hydrocarbon Gases and Vapours", *Industrial and Engineering Chemistry, Vol. 28, No. 9,* pp. 1015-1019.

3. Gas Processors Suppliers Association, *Engineering Data Book,* (1972) Ninth Edition, Third Revision, pp. 4-1, 16-1, 16-2, 16-3.

4. Rossini, F.D., et al, Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds (API Research Project 44), 1953, p. 653.

5. Perry, R.H., and Chilton, C.H., *Chemical Engineers' Handbook,* (1973) Fifth Edition, pp. 3-120, 3-121, 31-122.

TABLE 1

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

DEAD OIL PROPERTIES

Temperature		Dead Oil Density (kg/m³)	Dead Oil API Gravity (°API)	Dead Oil Viscosity (mPa.s)
(°C)	(K)			
15.6	288.75	857.0	33.61	--
54.0	327.15	831.0	38.77	3.88

TABLE 2

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF WELL M-73 SEPARATOR GAS

Component	Mole Fraction As Analyzed
N_2	0.0251
CO_2	0.0520
H_2S	0.0068
C_1	0.8885
C_2	0.0154
C_3	0.0068
i-C_4	0.0011
n-C_4	0.0021
i-C_5	0.0007
n-C_5	0.0007
C_6	0.0008
Gas Gravity (air = 1.0)	0.6443
Ppc (kPa abs) Tpc (K) Ppc* (kPa abs) Tpc* (K)	4744.88 200.47 4621.47 195.29
* corrected for H_2S and CO_2	

TABLE 3

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

LIVE OIL COMPRESSIBILITY MEASUREMENTS

Pressure Range		Live Oil Compressibility	
From (kPa)	To (kPa)	kPa^{-1} ($x10^{-6}$)	psi^{-1} ($x10^{-6}$)
9540	10340	3.98	27.4
10340	13790	3.85	26.5
13790	17240	3.56	24.5
17240	20680	3.27	22.5
20680	24130	3.05	21.0
24130	27580	2.91	20.0
27580	31030	2.79	19.2
31030	34470	2.69	18.5

TABLE 4

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

PRESSURE-VOLUME RELATIONSHIPS AT 54°C

Pressure (kPag)	V/Vsat
34470	0.9235
31030	0.9321
27580	0.9411
24130	0.9506
20680	0.9607
17240	0.9716
13790	0.9836
10340	0.9968
9540*	1.0000
8820	1.0400
8250	1.0745
7730	1.1125
4980	1.3530
4450	1.4313
4070	1.4838
3430	1.5780
2960	1.6965
2700	1.7995

* Saturation Pressure

TABLE 5
PARAMOUNT RESOURCES LTD
CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W
COMPOSITIONAL ANALYSIS OF RECOMBINED RESERVOIR FLUID

Component	Mole Fraction
N_2	0.0062
CO_2	0.0150
H2S	0.0017
C_1	0.2918
C_2	0.0083
C_3	0.0100
i-C_4	0.0028
n-C_4	0.0077
i-C_5	0.0053
n-C_5	0.0072
C_6	0.0157
C_7	0.0200
C_8	0.0283
C_9	0.0207
C_{10}	0.0369
C_{11}	0.0418
C_{12}	0.0401
C_{13}	0.0453
C_{14}	0.0384
C_{15}	0.0377
C_{16}	0.0327
C_{17}	0.0271
C_{18}	0.0256
C_{19}	0.0244
C_{20}	0.0203
C_{21}	0.0161
C_{22}	0.0137
C_{23}	0.0107
C_{24}	0.0112
C_{25}	0.0115
C_{26}	0.0082
C_{27}	0.0073
C_{28}	0.0080
C_{29}	0.0060
C_{30}^+	0.0431
CYCLOC_5	0.0023
MCYCLOC_5	0.0034
BENZENE	0.0007
CYCLOC_6	0.0035
MCYCLOC_6	0.0075
TOLUENE	0.0067
o-XYLENE	0.0028
1,2,4-TRIMETHBENZ	0.0072
EB/MP-XYLENE	0.0190
MW Recombined Oil	176.86
MW Separator Oil	254.90
MW Fraction/Density/MW C_6^+	0.6440/0.883835/262.5336

TABLE 6

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

LIVE OIL VISCOSITY FVF AND DENSITY DATA AT 54°C

Pressure (kPa Gauge)	Oil Viscosity (mPa.s)	Oil Density ((kg/m^3)	Oil Formation Volume Factor
34470	3.24	873.0	1.051
31030	3.00	865.0	1.061
27580	2.72	856.0	1.071
24130	2.50	848.0	1.082
20680	2.24	839.0	1.093
17240	2.06	830.0	1.106
13790	1.89	819.0	1.119
10340	1.69	809.0	1.134
9540*	1.65	806.0	1.138
7240	1.97	810.0	1.102
5520	2.16	813.0	1.076
4480	2.30	816.0	1.062
3450	2.47	818.0	1.051
1725	2.73	824.0	1.040
860	2.92	827.0	1.036
520	3.04	829.0	1.033
0	3.88	831.0	1.031

* saturation pressure

TABLE 7
PARAMOUNT RESOURCES LTD.
CAMERON SULPHUR POINT WELL M73-60° 10'N, 117° 15' W
RESULTS OF DIFFERENTIAL VAPORIZATION AT 54 °C

Pressure (kPa)	Density (g/cc)	Viscosity (mPa.s)	Relative Oil Volume (1)	Relative Total Volume (2)	Solution Gas/Oil Ratio (3)	Incr Gas Gravity	Cum Gas Gravity	Deviation Factor (Z)	Gas Formation Factor (4)	Gas Expansion Factor (5)
9540	806.0	1.65	1.138	1.138	43.9	--	--	--	--	--
7240	810.0	1.97	1.102	1.220	35.6	0.6334	0.6334	0.9056	0.0142	70.42
5520	813.0	2.16	1.076	1.373	28.2	0.6200	0.6271	0.9250	0.0189	52.91
4480	816.0	2.30	1.062	1.539	23.6	0.6186	0.6252	0.9363	0.0235	42.55
3450	818.0	2.47	1.051	1.833	18.5	0.6182	0.6238	0.9487	0.0308	32.47
1725	824.0	2.73	1.040	3.162	9.4	0.6389	0.6278	0.9717	0.0615	16.26
860	827.0	2.92	1.036	5.756	4.2	0.6737	0.6338	0.9840	0.1189	8.41
520	829.0	3.04	1.033	8.760	2.4	0.6990	0.6366	0.9891	0.1862	5.37
0*	831.0	3.88	1.031	56.920	0.0	0.7905	0.6450	0.9980	1.2731	0.79

(1)Cubic metres of oil at indicated pressure and temperature per cubic metre of residual oil at 15°C
(2)Cubic metres of oil plus liberated gas at indicated pressure and temperature per cubic metre of residual oil at 15°C
(3)Cubic metres of gas at 101.325 kPa (absolute) and 15°C per cubic metre of residual oil at 15°C
(4)Cubic metres of gas at indicated pressure and temperature per cubic metre at 101.325 kPa (absolute) and 15°C
(5)Cubic metres of gas at 101.325 kPa (absolute) andd 15°C per cubic metre at indicated pressure and temperature
*0 kPa = 90 kPa-abs (Calgary standard)

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TABLE 8

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

LIBERATED GAS PHASE PHYSICAL PROPERTIES AT 54°C

Pressure (kPa Gauge)	Viscosity (mPa.s)	Demsity		Oil-gas Viscosity Ratio
		STP (kg/m^3)	Reservoir kg/m^3	
7240	0.0136	0.775	54.58	144.85
5520	0.0132	0.758	40.02	163.64
4480	0.0129	0.757	31.88	178.29
3450	0.0127	0.756	24.55	194.49
1725	0.0123	0.781	12.70	221.95
860	0.0121	0.824	6.27	241.32
520	0.0119	0.855	3.91	255.46
0	0.0114	0.967	0.758	340.35

TABLE 9

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF DIFFERENTIAL LIBERATION GAS

LIBERATION STEP 9540 TO 7240 kPag

Component	Mole Fraction As Analyzed	Mole Fraction Acid Gas Free
N_2	0.0438	0.0453
CO_2	0.0329	0.0000
H_2S	0.0002	0.0000
C_1	0.8997	0.9305
C_2	0.0085	0.0088
C_3	0.0054	0.0056
i-C_4	0.0006	0.0006
n-C_4	0.0012	0.0012
i-C_5	0.0013	0.0013
n-C_5	0.0012	0.0012
C_6	0.0053	0.0055
Gas Gravity (air = 1.0)		0.6334
Ppc (kPa abs)		4631.09
Tpc (K)		196.24
Ppc* (kPa abs)		4562.16
Tpc* (K)		193.32

* corrected for H_2S and CO_2

TABLE 10

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF DIFFERENTIAL LIBERATION GAS

LIBERATION STEP 7240 TO 5520 kPag

Component	Mole Fraction As Analyzed	Mole Fraction Acid Gas Free
N_2	0.0311	0.0321
CO_2	0.0322	0.0000
H_2S	0.0003	0.0000
C_1	0.9147	0.9457
C_2	0.0103	0.0106
C_3	0.0053	0.0055
i-C_4	0.0007	0.0007
n-C_4	0.0014	0.0014
i-C_5	0.0007	0.0007
C_5	0.0007	0.0007
C_6	0.0025	0.0026
Gas Gravity (air = 1.0)		0.6200
Ppc (kPa abs) Tpc (K) Ppc* (kPa abs) Tpc* (K)		4650.91 196.10 4581.60 193.18
* corrected for H_2S and CO_2		

TABLE 11

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF DIFFERENTIAL LIBERATION GAS

LIBERATION STEP 5520 TO 4480 kPag

Component	Mole Fraction - As Analyzed	Mole Fraction Acid Gas Free
N_2	0.0235	0.0242
CO_2	0.0302	0.0000
H_2S	0.0004	0.0000
C_1	0.9209	0.9501
C_2	0.0118	0.0122
C_3	0.0062	0.0064
i-C_4	0.0008	0.0008
n-C_4	0.0016	0.0016
i-C_5	0.0008	0.0008
n-C_5	0.0008	0.0008
C_6	0.0030	0.0031
Gas Gravity (air = 1.0)		0.6186
Ppc (kPa abs)		4653.96
Tpc (K)		196.98
Ppc* (kPa abs)		4587.64
Tpc* (K)		194.17

* corrected for H_2S and CO_2

TABLE 12

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF DIFFERENTIAL LIBERATION GAS

LIBERATION STEP 4480 TO 3450 kPag

Component	Mole Fraction As Analyzed	Mole Fraction Acid Gas Free
N_2	0.0194	0.0199
CO_2	0.0251	0.0000
H_2S	0.0006	0.0000
C_1	0.9243	0.9489
C_2	0.0134	0.0138
C_3	0.0084	0.0086
i-C_4	0.0010	0.0010
n-C_4	0.0020	0.0021
i-C_5	0.0010	0.0010
n-C_5	0.0010	0.0010
C_6	0.0036	0.0037
Gas Gravity (air = 1.0)		0.6182
Ppc (kPa abs) Tpc (K) Ppc* (kPa abs) Tpc* (K)		4643.04 197.76 4584.74 195.28
* corrected for H_2S and CO_2		

TABLE 13

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF DIFFERENTIAL LIBERATION GAS

LIBERATION STEP 3450 TO 1725 kPag

Component	Mole Fraction As Analyzed	Mole Fraction Acid Gas Free
N_2	0.0100	0.0104
CO_2	0.0413	0.0000
H_2S	0.0008	0.0000
C_1	0.9051	0.9452
C_2	0.0201	0.0210
C_3	0.0125	0.0130
i-C_4	0.0016	0.0016
n-C_4	0.0031	0.0032
i-C_5	0.0012	0.0012
n-C_5	0.0012	0.0012
C_6	0.0031	0.0032
Gas Gravity (air = 1.0)		0.6389
Ppc (kPa abs)		4699.91
Tpc (K)		202.03
Ppc* (kPa abs)		4614.41
Tpc* (K)		198.36
* corrected for H_2S and CO_2		

TABLE 14

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF DIFFERENTIAL LIBERATION GAS

LIBERATION STEP 1725 TO 860 kPag

Component	Mole Fraction As Analyzed	Mole Fraction Acid Gas Free
N_2	0.0080	0.0085
CO_2	0.0598	0.0000
H_2S	0.0015	0.0000
C_1	0.8683	0.9250
C_2	0.0290	0.0309
C_3	0.0199	0.0212
i-C_4	0.0024	0.0026
n-C_4	0.0045	0.0048
i-C_5	0.0016	0.0017
n-C_5	0.0016	0.0017
C_6	0.0034	0.0036
Gas Gravity (air = 1.0)		0.6737
Ppc (kPa abs) Tpc (K) Ppc* (kPa abs) Tpc* (K)		4753.17 207.56 4639.42 202.60
* corrected for H_2S and CO_2		

TABLE 15

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF DIFFERENTIAL LIBERATION GAS

LIBERATION STEP 860 TO 520 kPag

Component	Mole Fraction As Analyzed	Mole Fraction Acid Gas Free
N_2	0.0070	0.0075
CO_2	0.0661	0.0000
H_2S	0.0021	0.0000
C_1	0.8420	0.9035
C_2	0.0383	0.0411
C_3	0.0256	0.0275
i-C_4	0.0037	0.0040
n-C_4	0.0067	0.0072
i-C_5	0.0025	0.0027
n-C_5	0.0022	0.0024
C_6	0.0038	0.0041
Gas Gravity (air = 1.0)		0.6990
Ppc (kPa abs) Tpc (K) Ppc* (kPa abs) Tpc* (K)		4771.88 211.97 4649.58 206.55
* corrected for H_2S and CO_2		

TABLE 16

PARAMOUNT RESOURCES LTD

CAMERON SULPHUR POINT WELL M73-60°10'N, 117° 15'W

COMPOSITIONAL ANALYSIS OF DIFFERENTIAL LIBERATION GAS

LIBERATION STEP 520 TO 0 kPag

Component	Mole Fraction As Analyzed	Mole Fraction Acid Gas Free
N_2	0.0062	0.0068
CO_2	0.0844	0.0000
H_2S	0.0030	0.0000
C_1	0.7409	0.8120
C_2	0.0703	0.0770
C_3	0.0594	0.0651
i-C_4	0.0090	0.0099
n-C_4	0.0155	0.0170
i-C_5	0.0041	0.0045
n-C_5	0.0031	0.0034
C_6	0.0039	0.0043
Gas Gravity (air = 1.0)		0.7905
Ppc (kPa abs) Tpc (K) Ppc* (kPa abs) Tpc* (K)		4806.76 227.87 4668.31 221.32
* corrected for H_2S and CO_2		

FIGURE 1

PVT APPARATUS

PARAMOUNT CAMERON - SULPHUR POINT STUDY

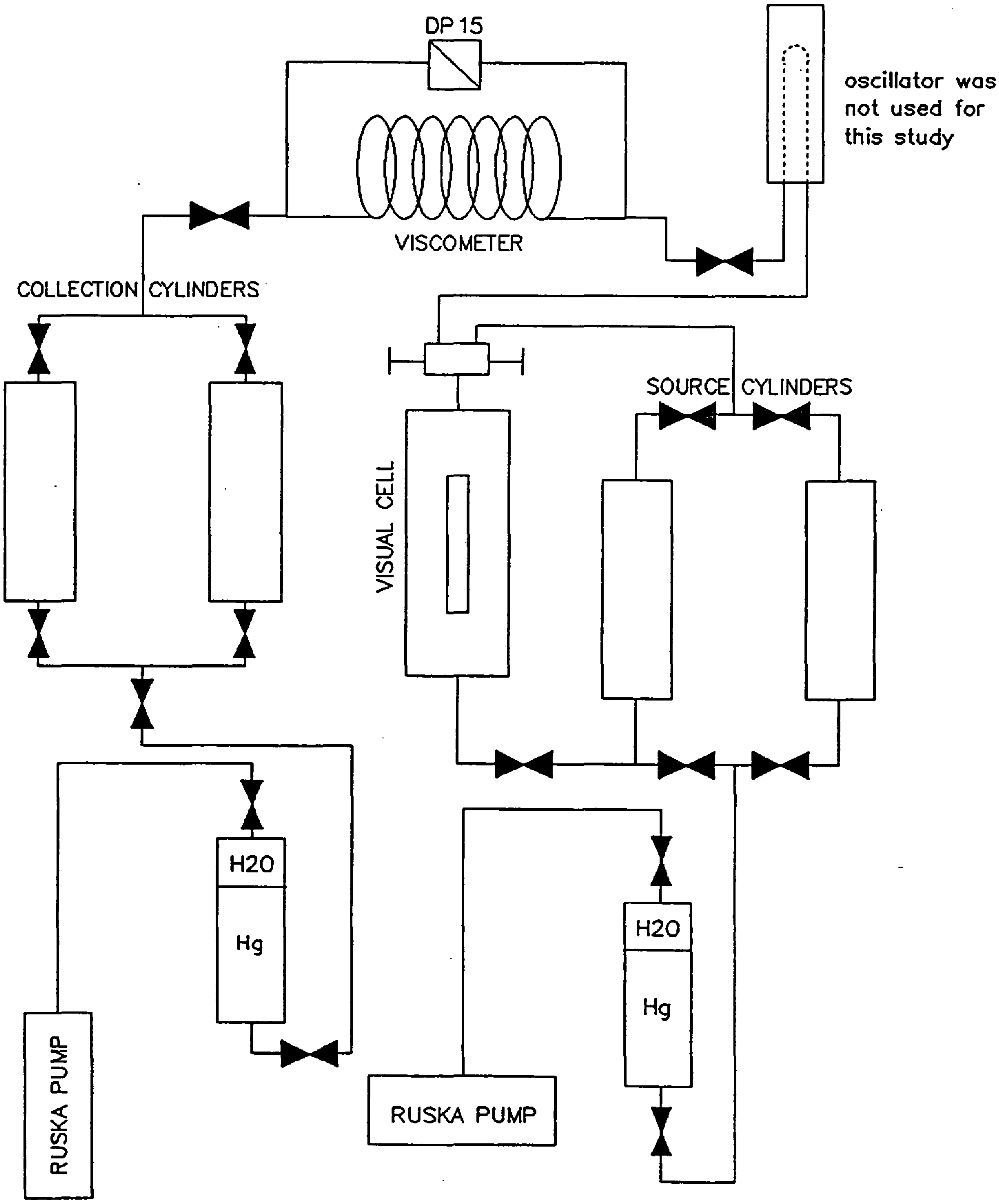


FIGURE 2

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

DEAD OIL DENSITY vs TEMPERATURE

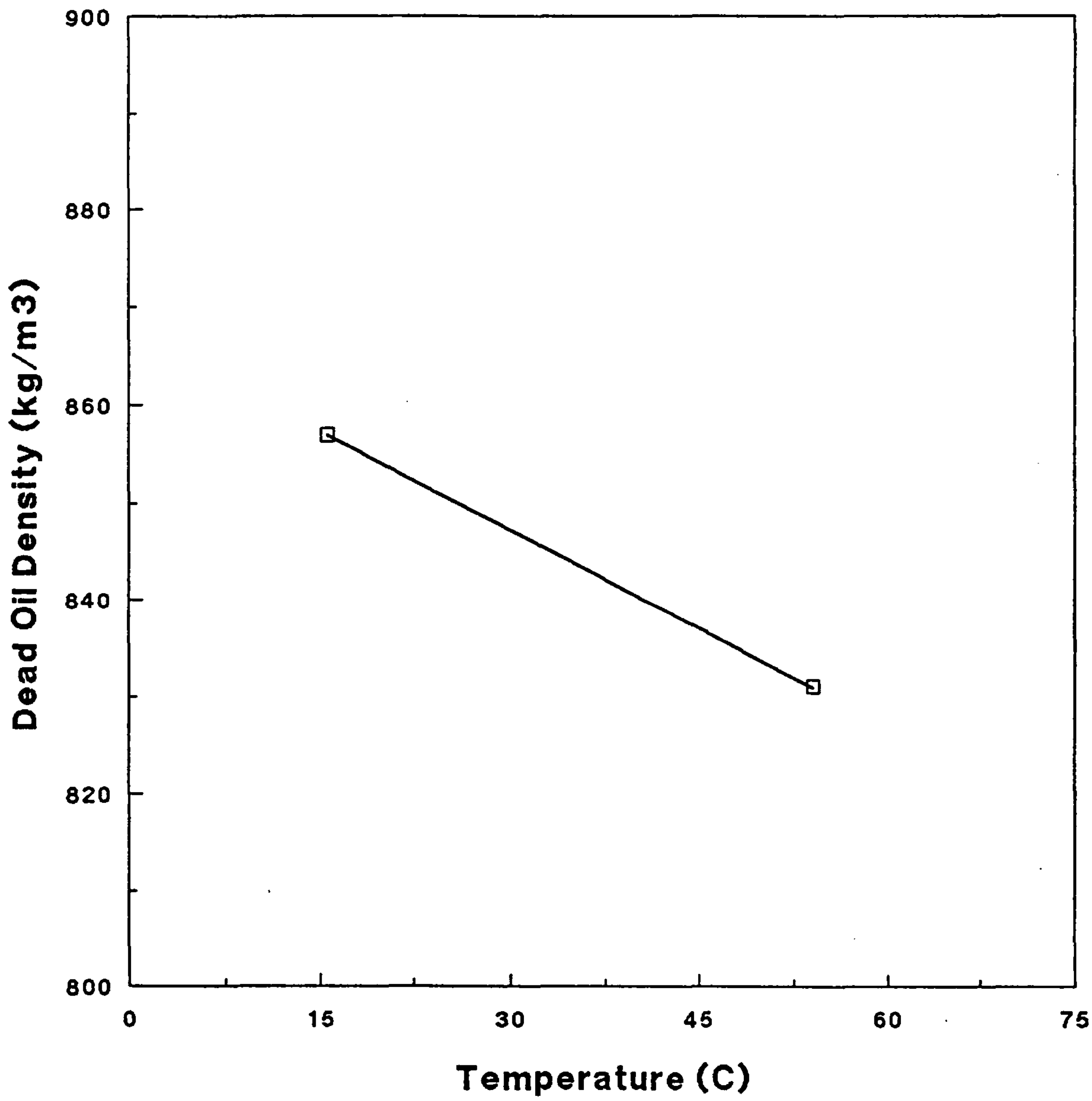


FIGURE 3

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

LIVE OIL COMPRESSIBILITY vs PRESSURE

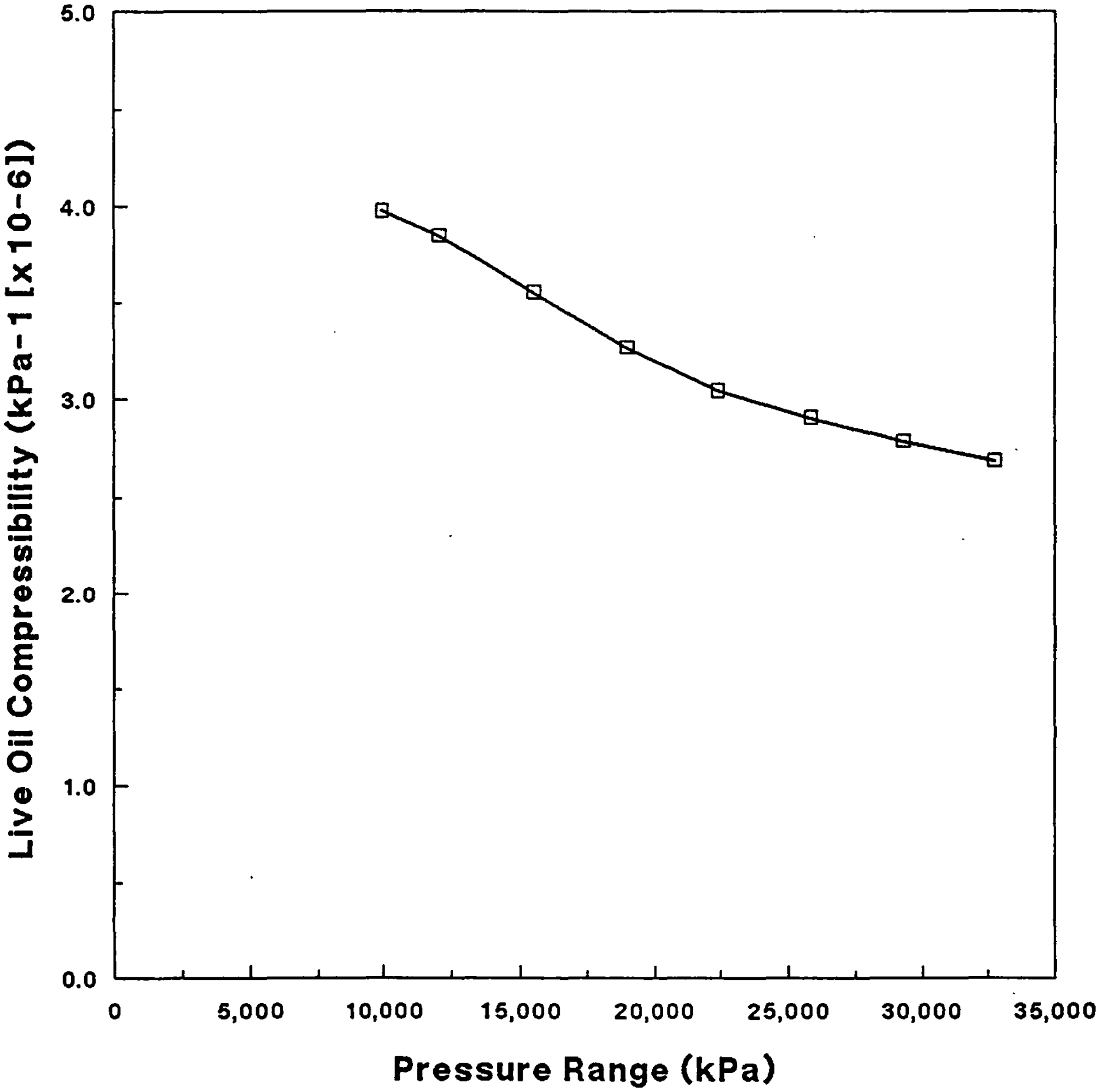


FIGURE 4
PARAMOUNT RESOURCES LTD.
CAMERON SULPHUR POINT
PRESSURE vs V/Vsat

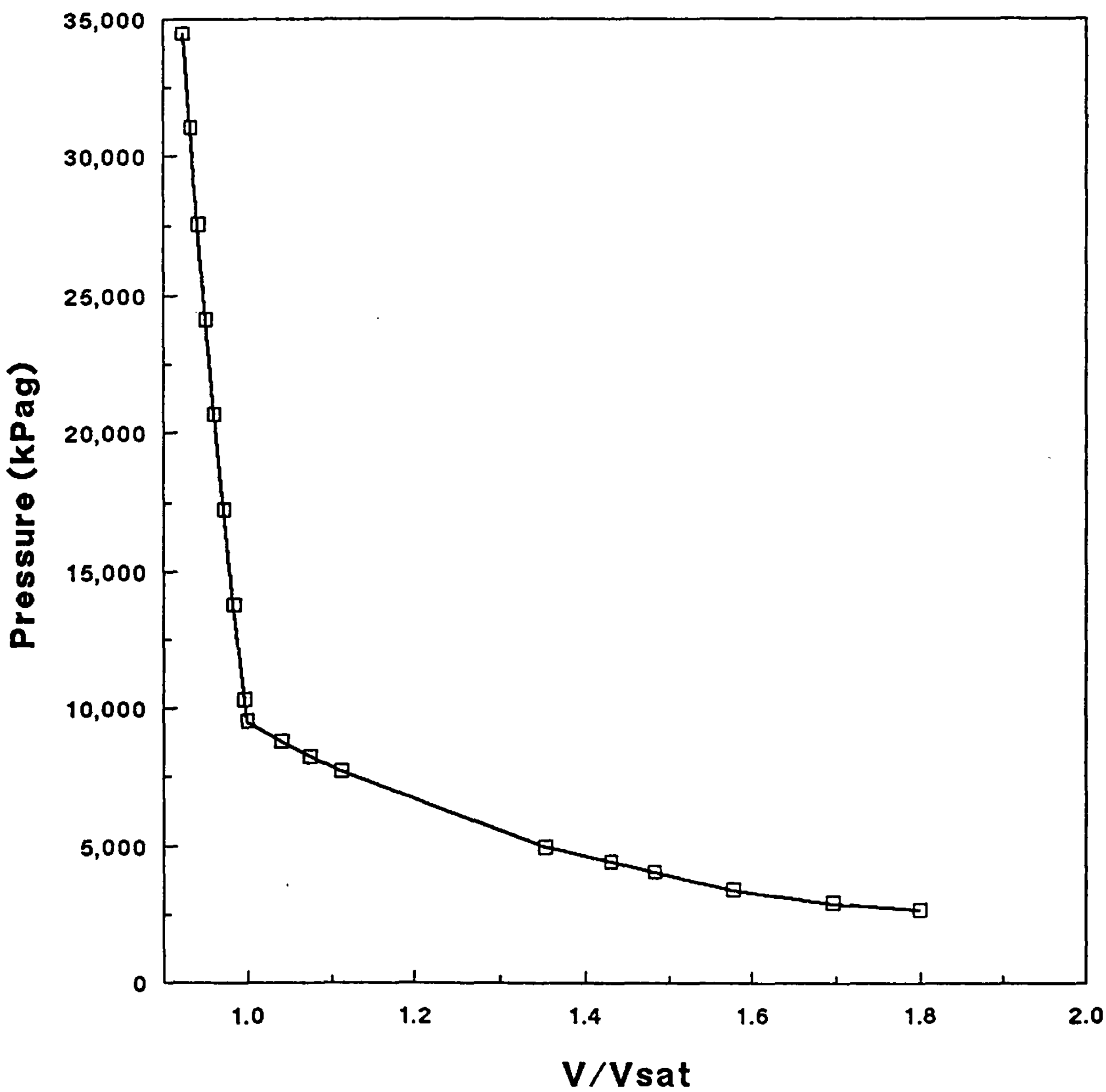


FIGURE 5
PARAMOUNT RESOURCES LTD.
CAMERON SULPHUR POINT
OIL VISCOSITY vs PRESSURE

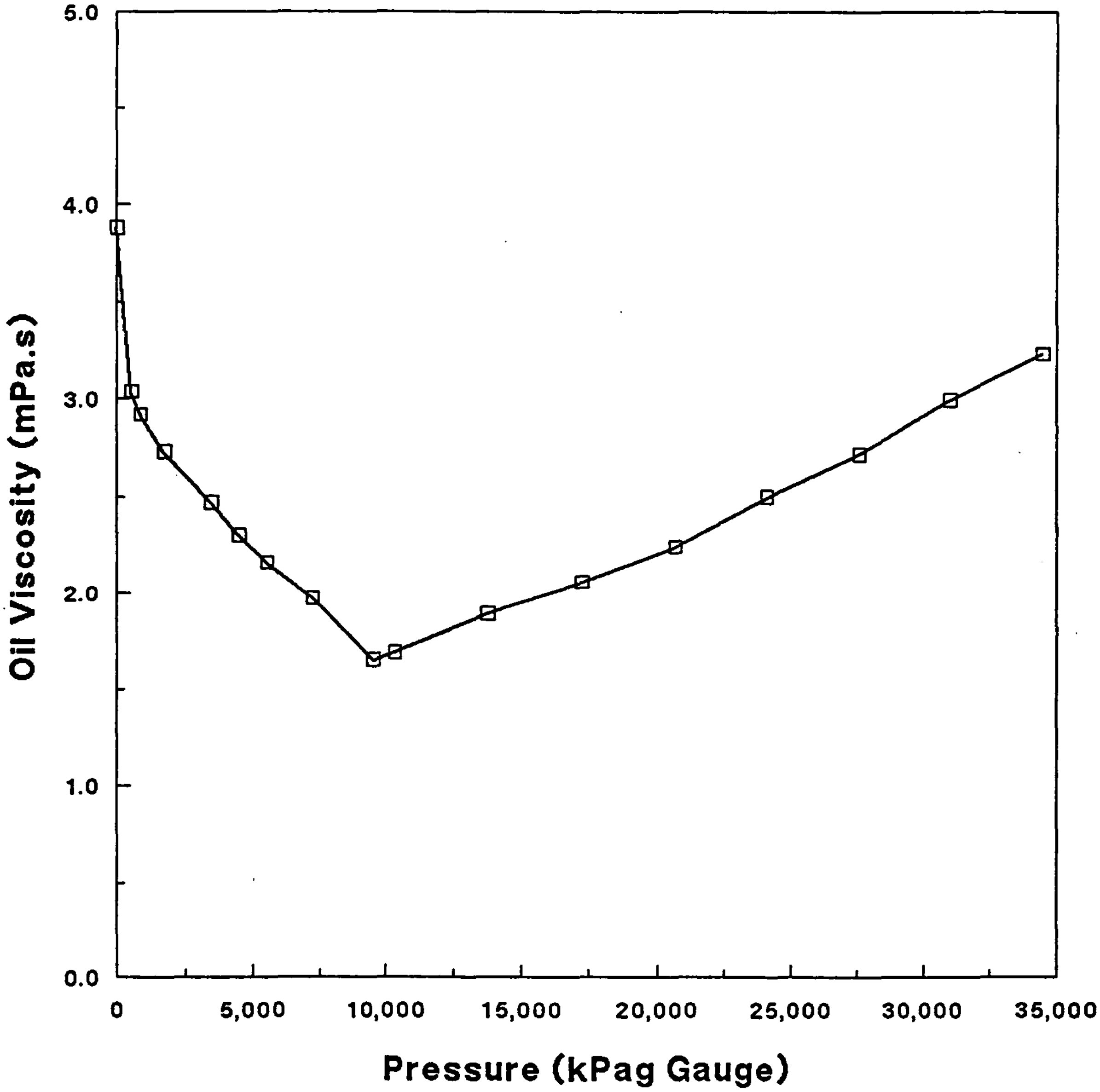


FIGURE 6

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

OIL DENSITY vs PRESSURE

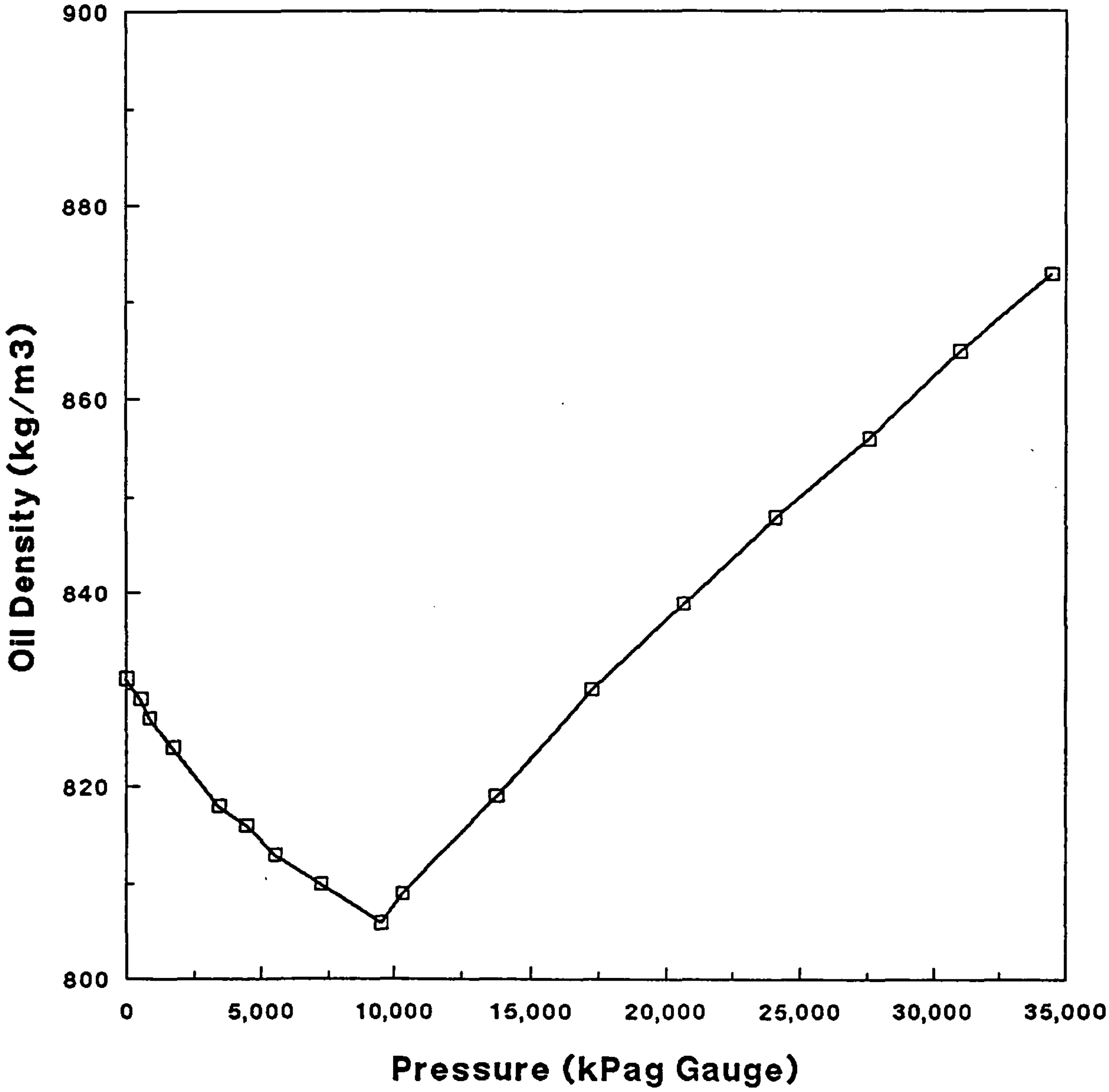


FIGURE 7

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

OIL FORMATION VOLUME FACTOR vs PRESSURE

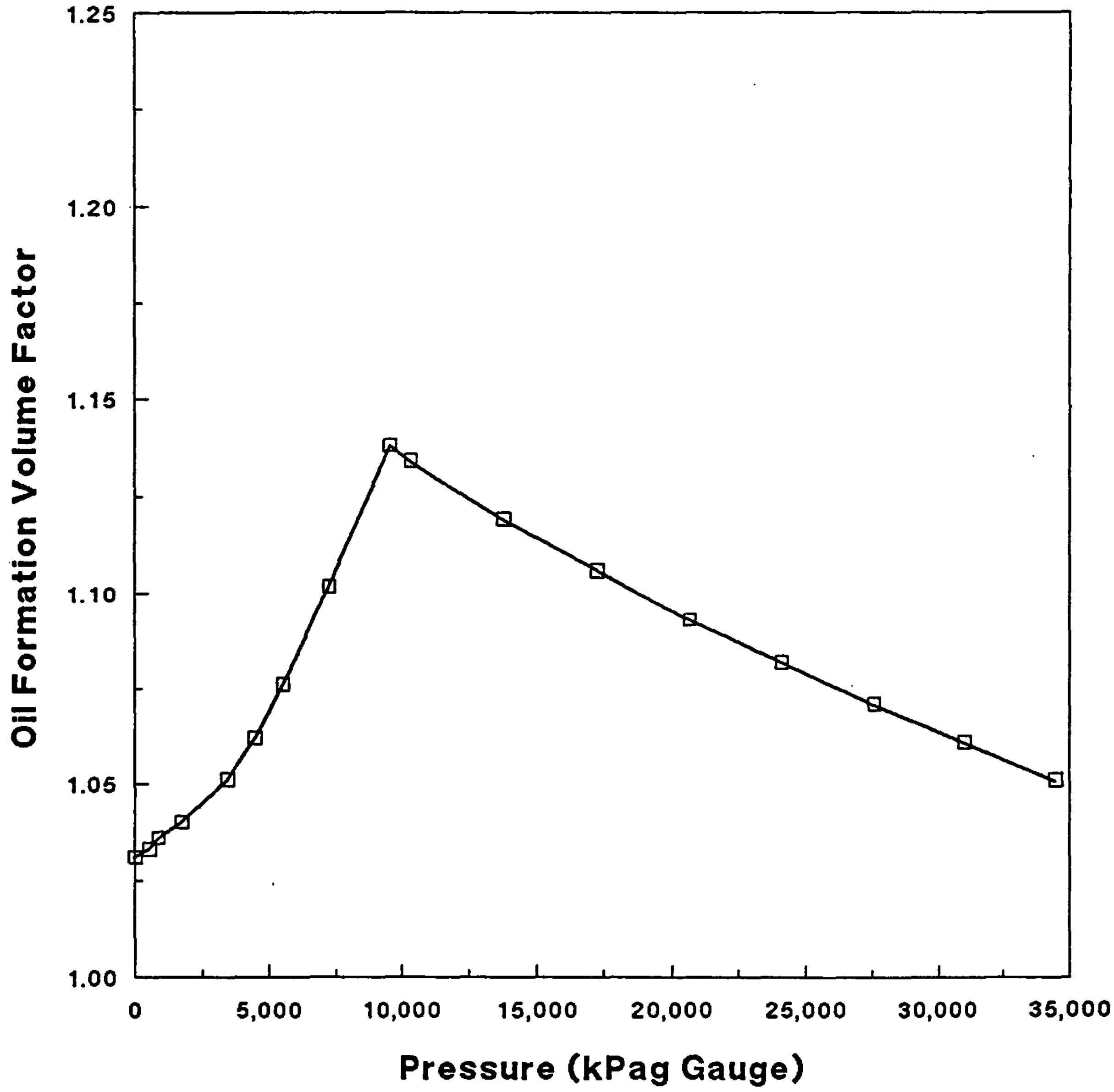


FIGURE 8

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

GAS VISCOSITY vs PRESSURE

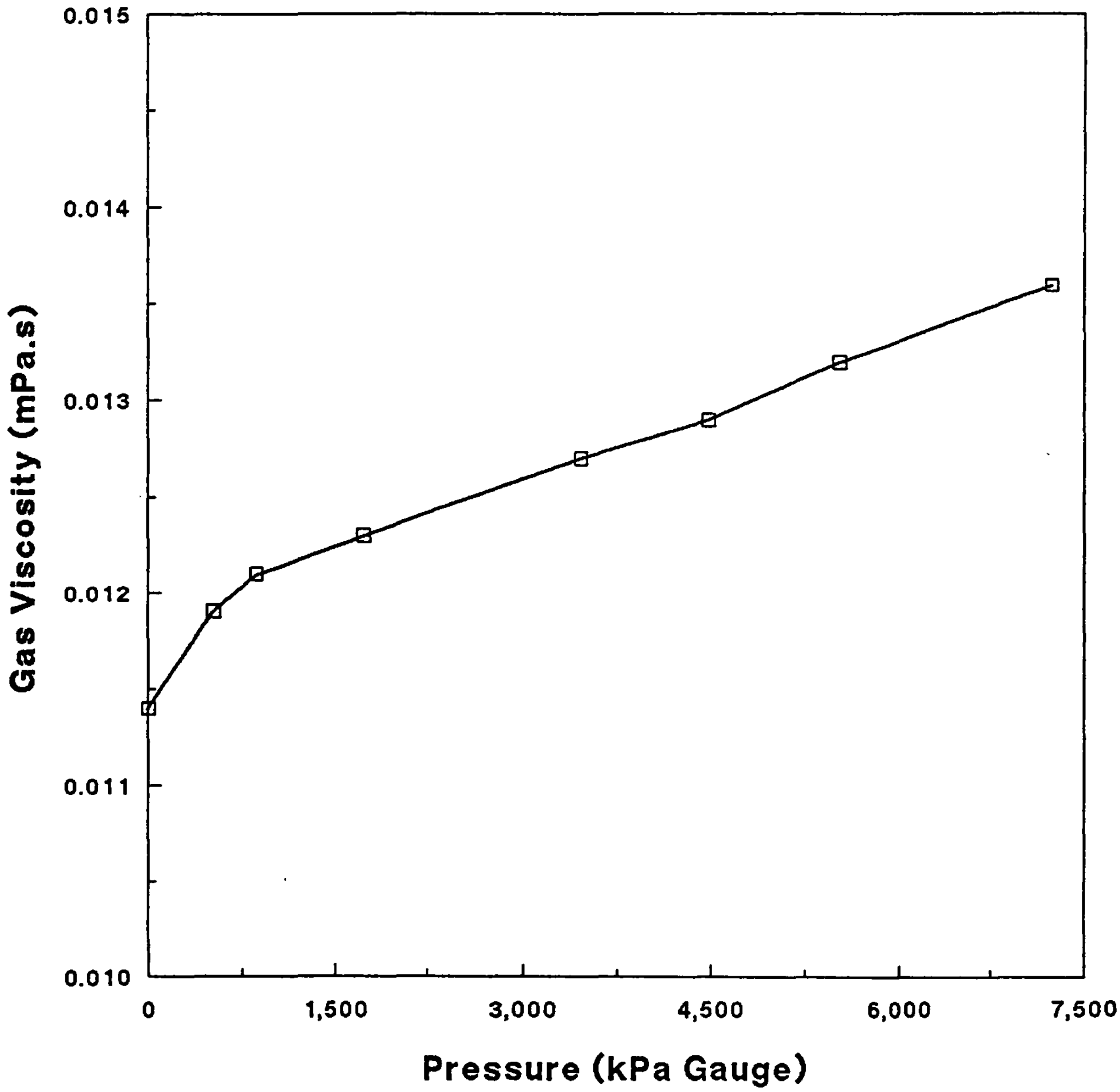


FIGURE 9

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

RELATIVE TOTAL VOLUME vs PRESSURE

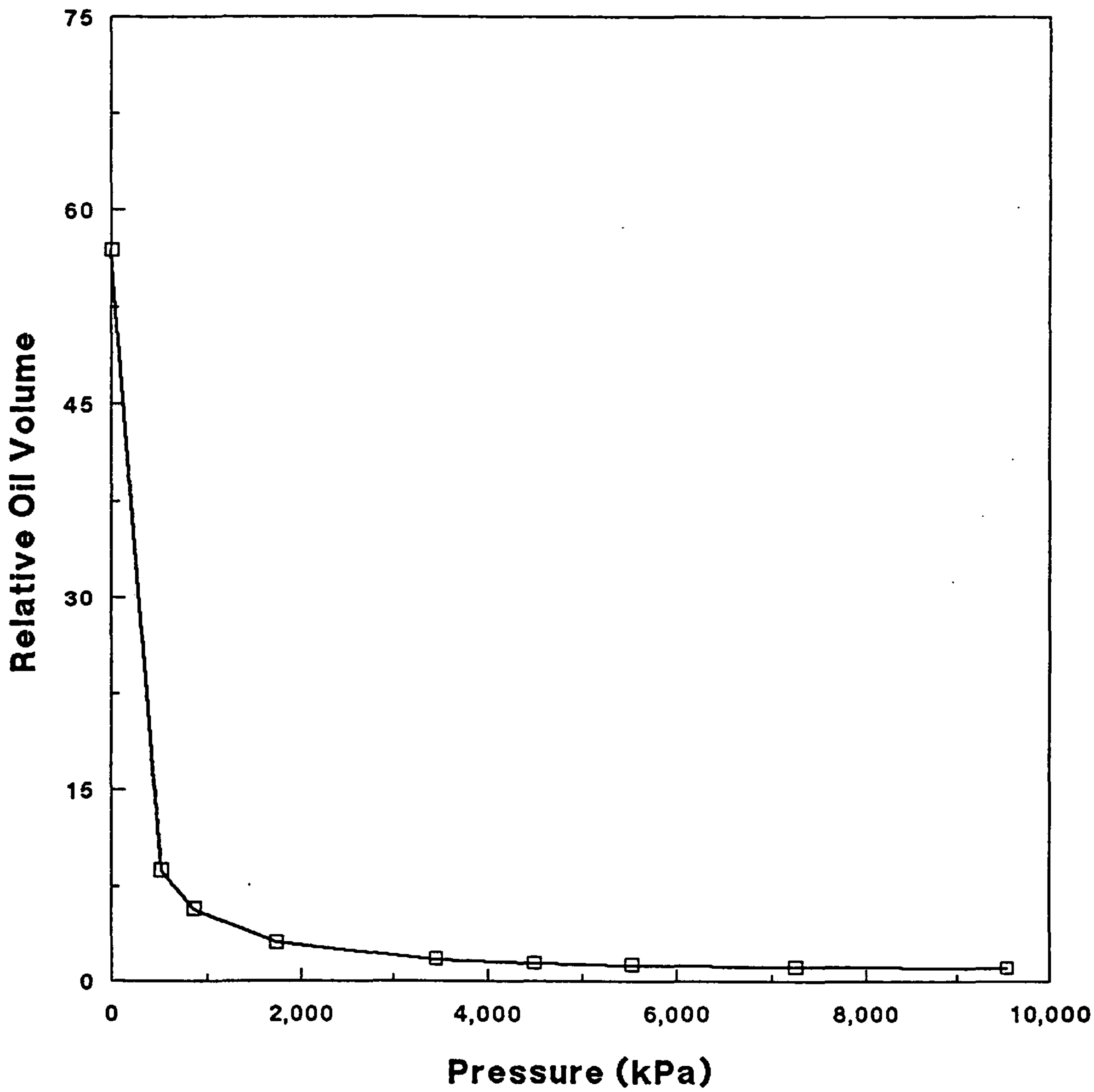


FIGURE 10

PARAMOUNT RESOURCES LTD.
CAMERON SULPHUR POINT
SOLUTION GAS/OIL RATIO vs PRESSURE

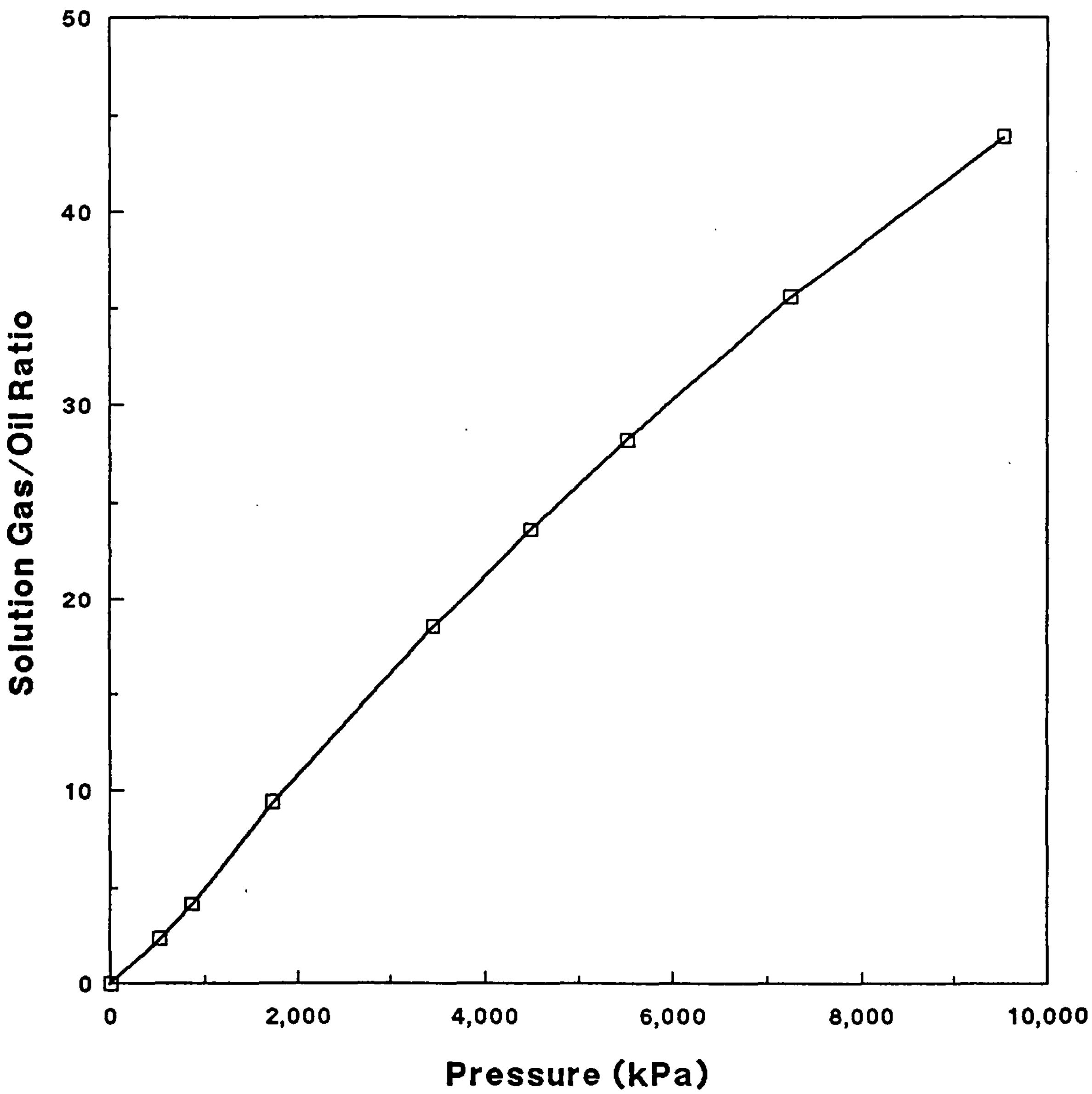


FIGURE 11

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

DEVIATION FACTOR (Z) vs PRESSURE

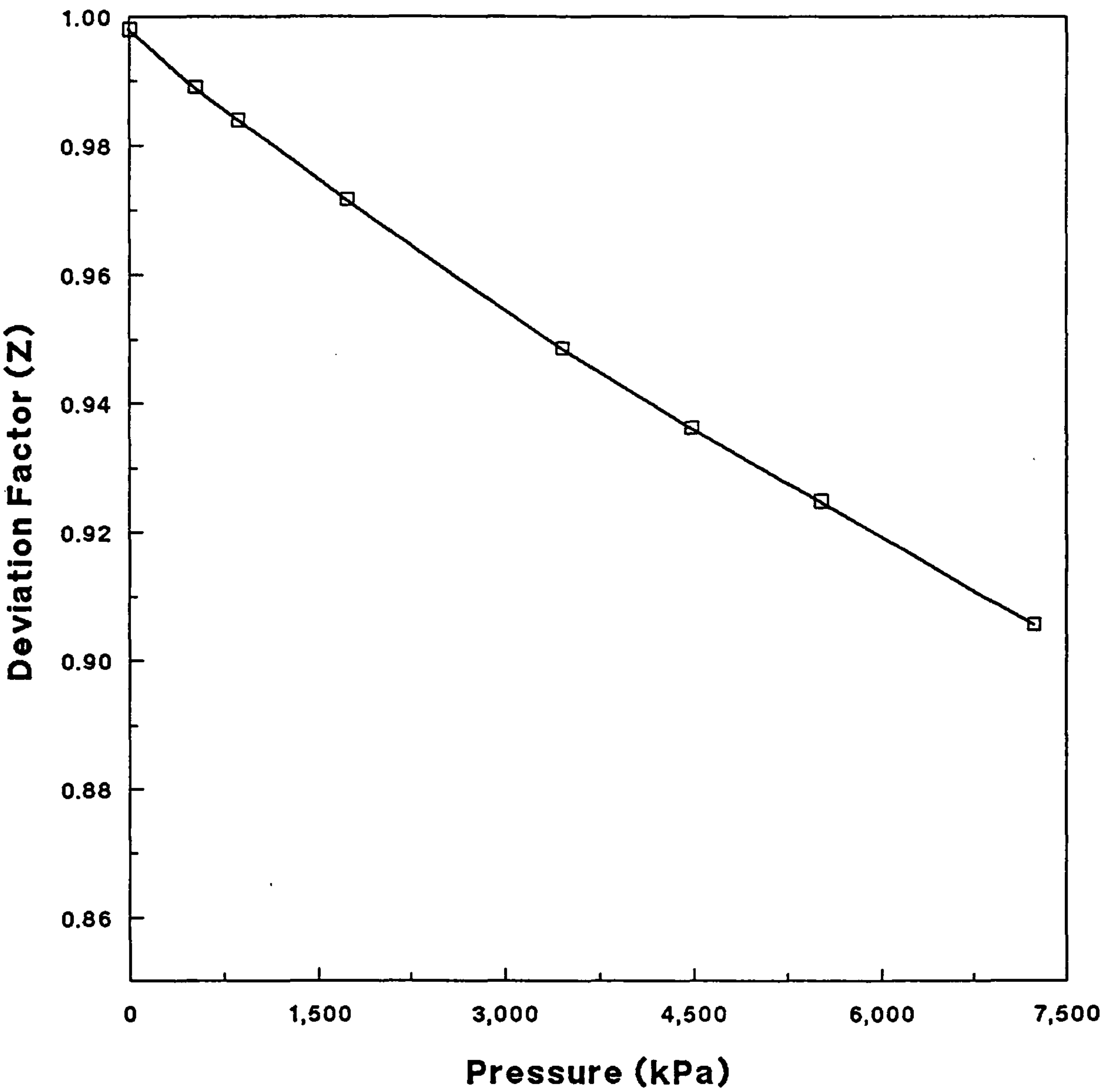


FIGURE 12

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

GAS FORMATION VOLUME FACTOR vs PRESSURE

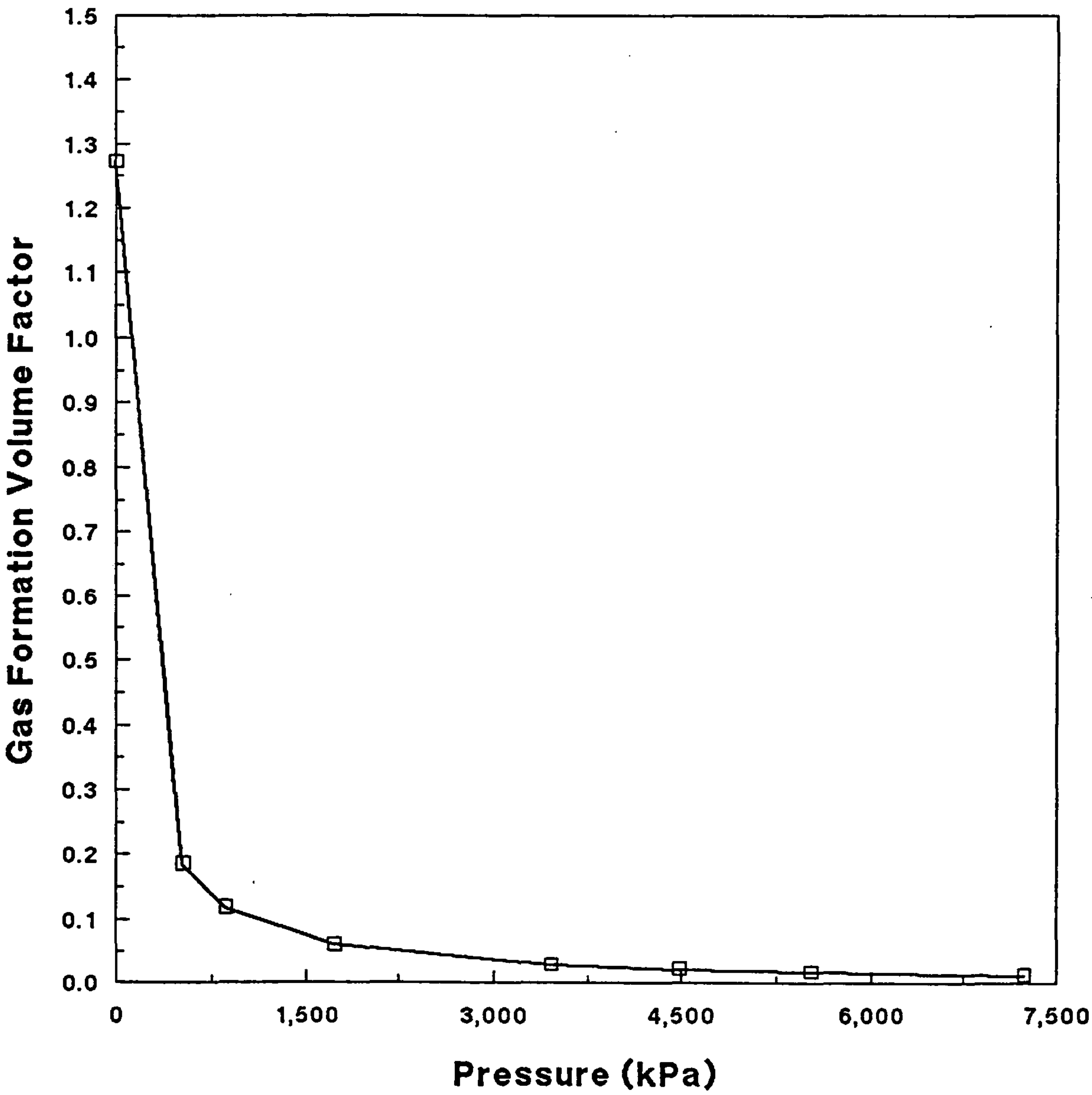


FIGURE 13
PARAMOUNT RESOURCES LTD.
CAMERON SULPHUR POINT
GAS EXPANSION FACTOR vs PRESSURE

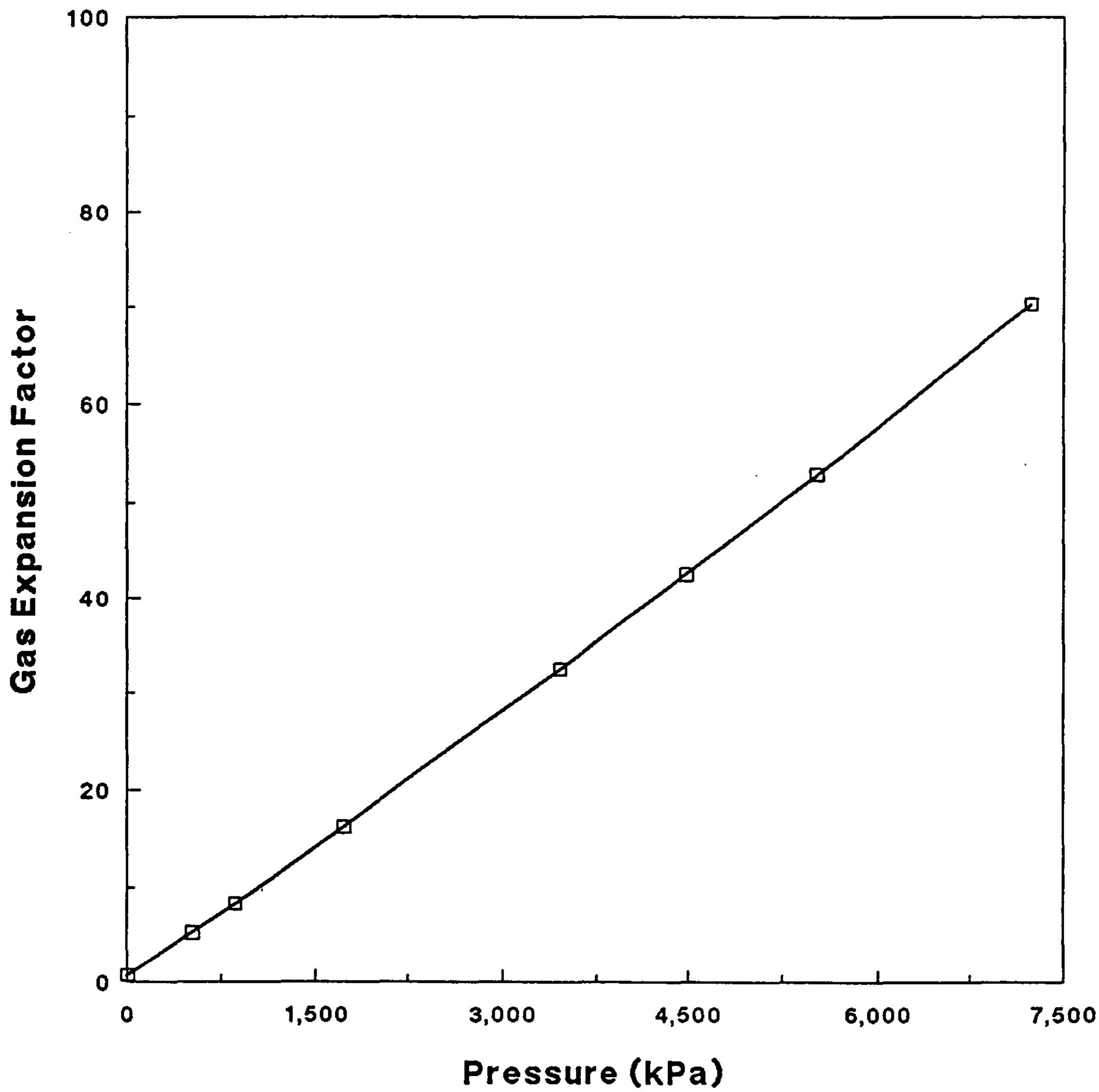


FIGURE 14

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

INCR GAS GRAVITY vs PRESSURE

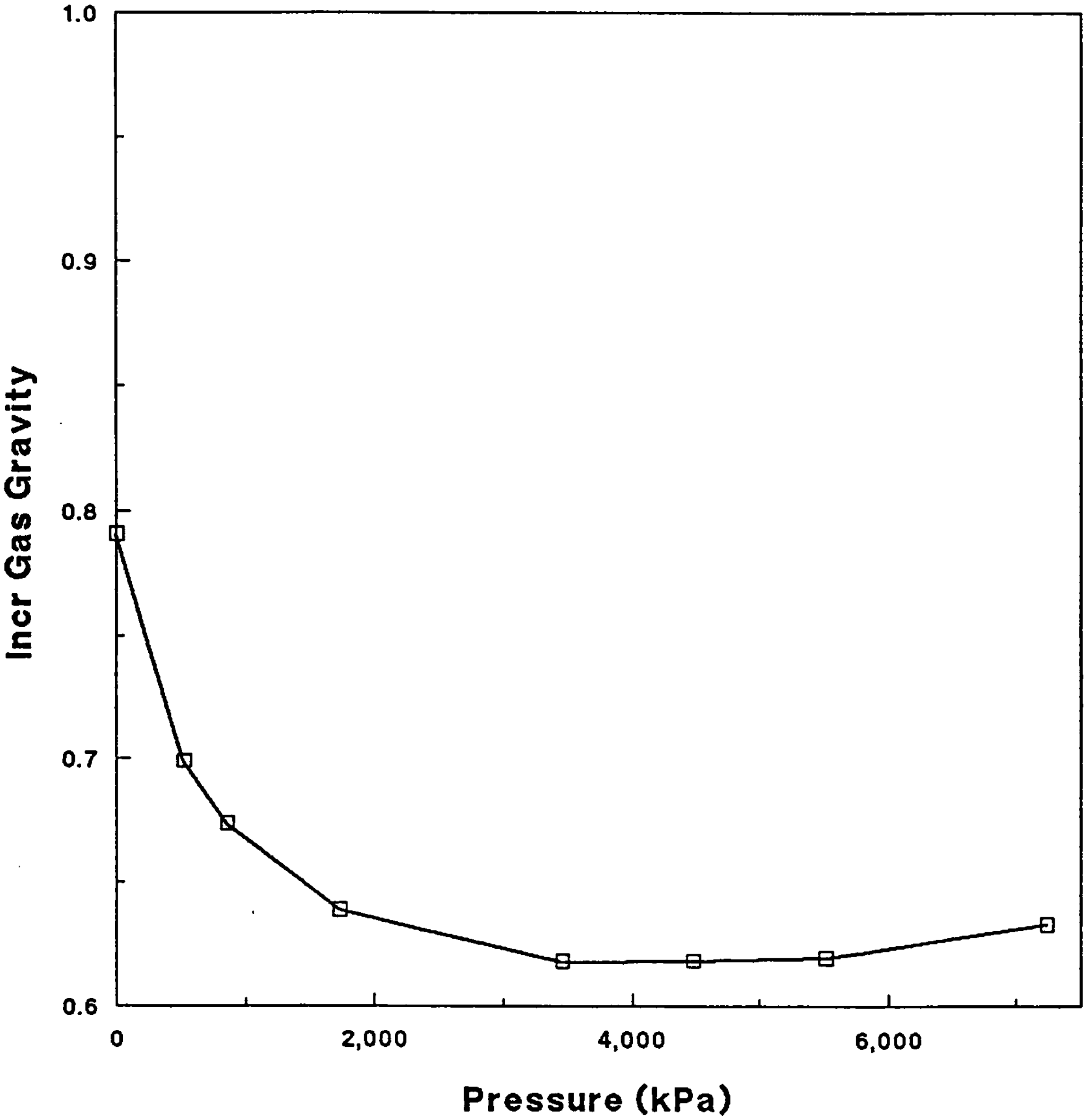


FIGURE 15

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

CUML GAS GRAVITY vs PRESSURE

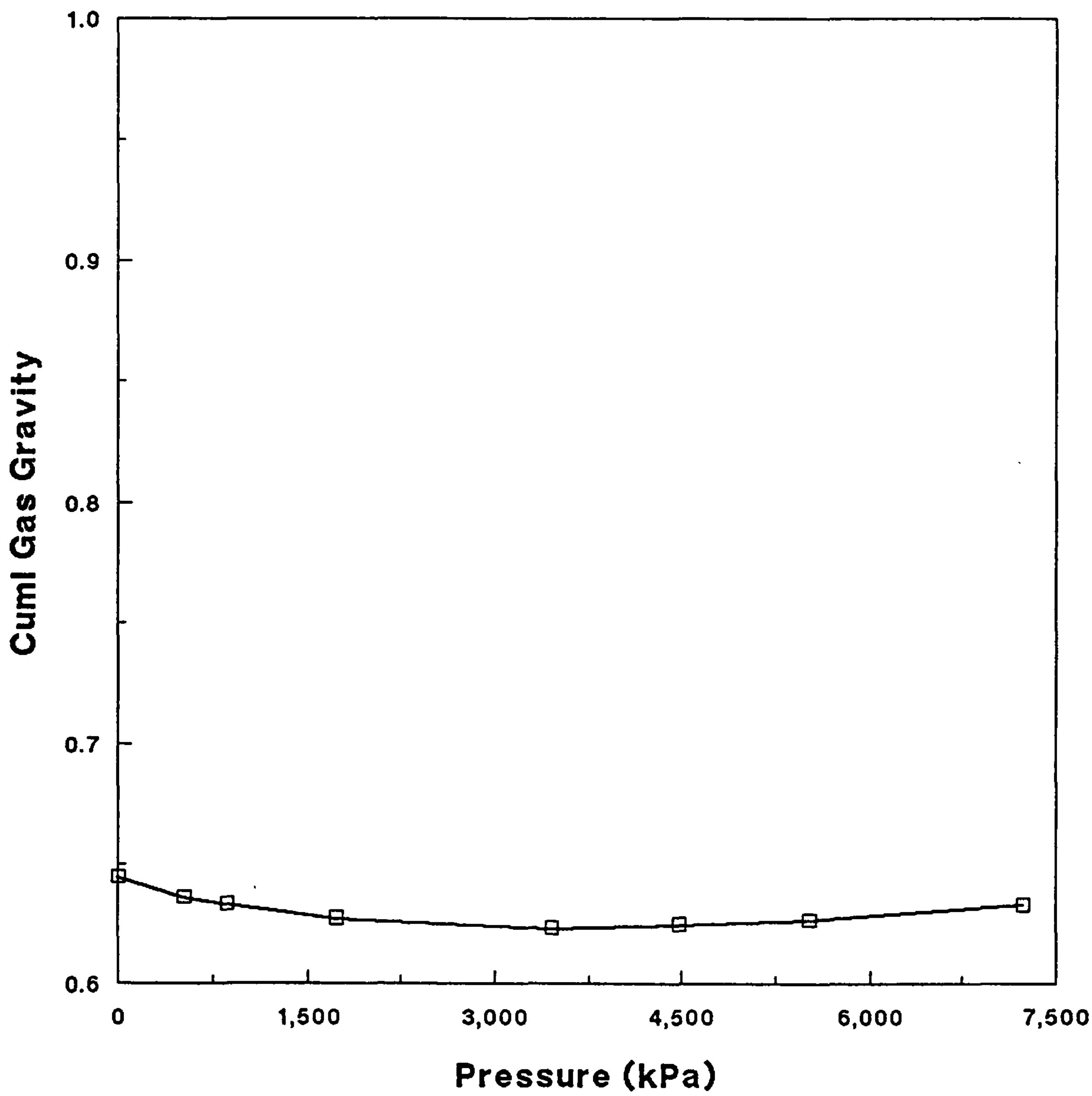


FIGURE 16

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

GAS DENSITY (STP) vs PRESSURE

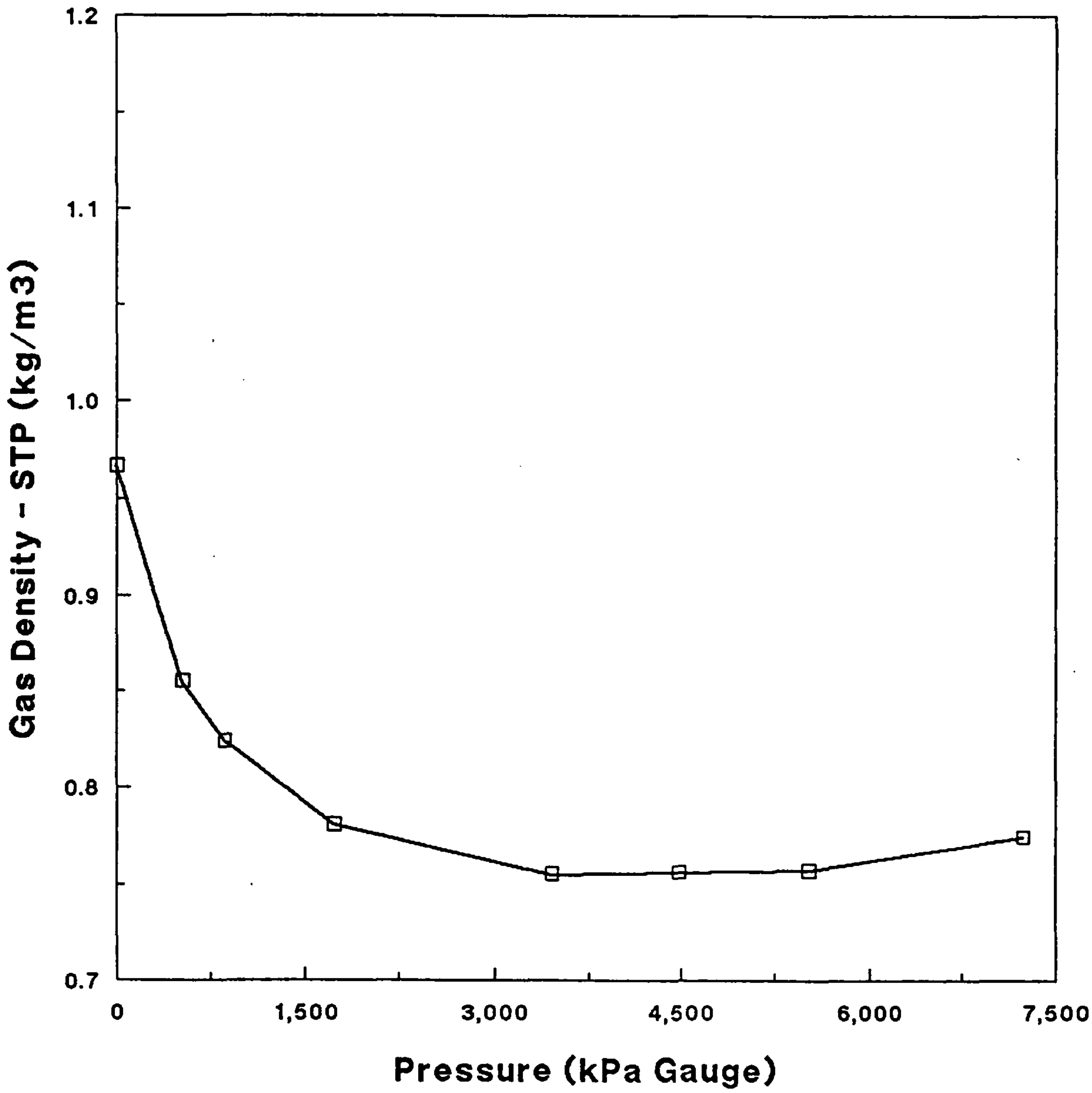


FIGURE 17

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

GAS DENSITY (RESERVOIR) vs PRESSURE

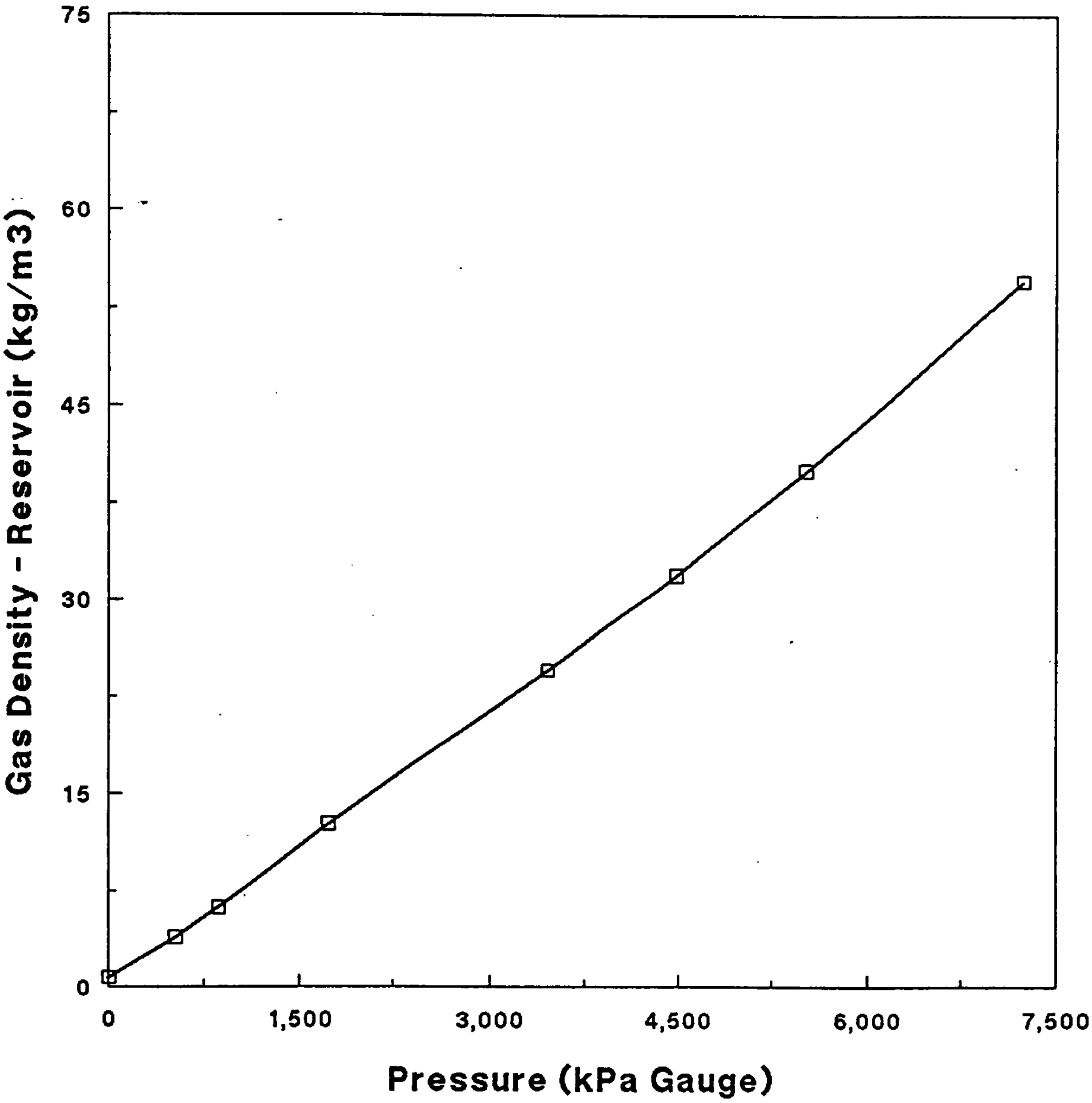
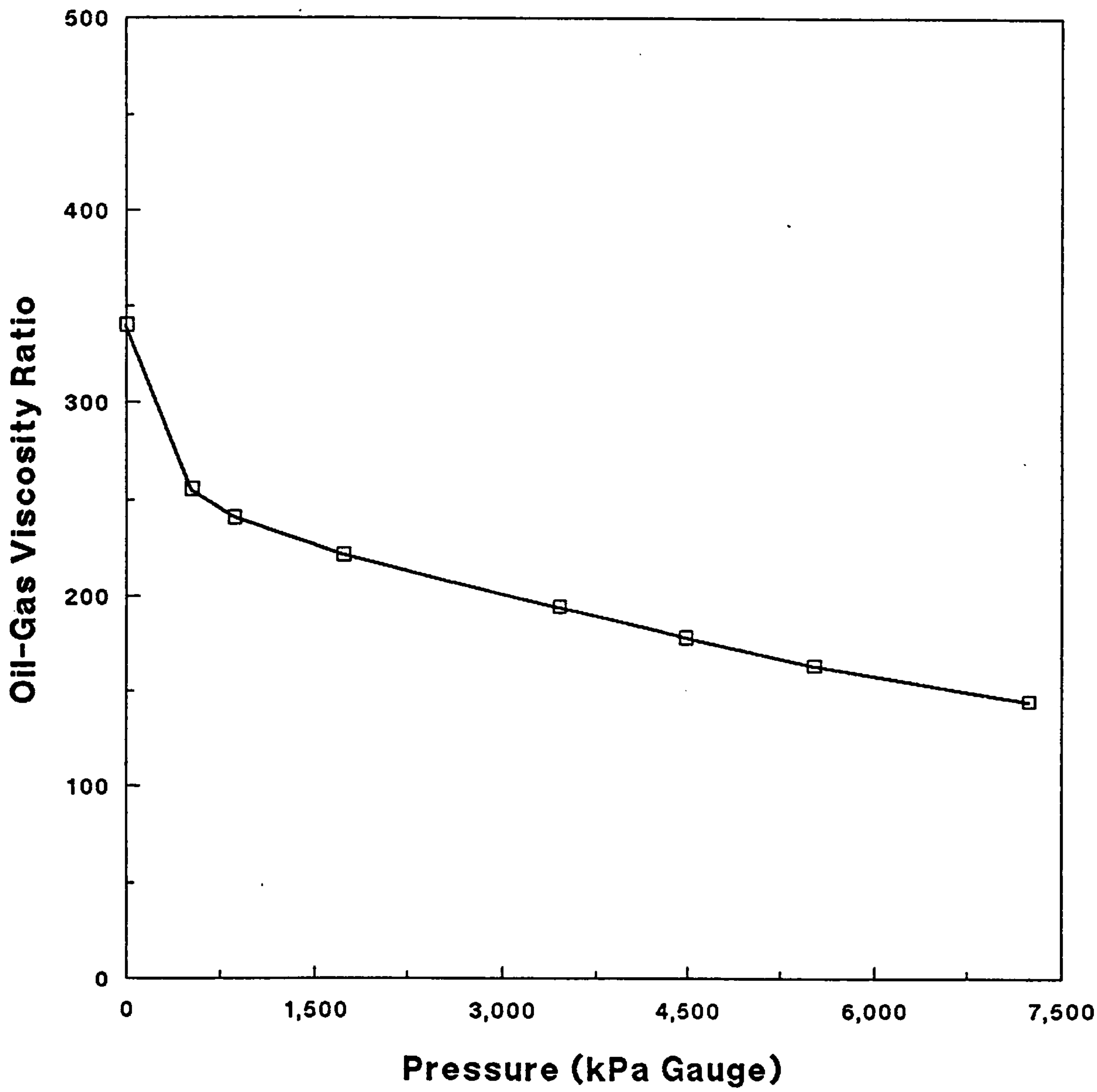


FIGURE 18

PARAMOUNT RESOURCES LTD.

CAMERON SULPHUR POINT

OIL-GAS VISCOSITY RATIO vs PRESSURE



DATA DISKETTE