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RESERVOIR FLUID STUDY

FOR

SHELL WELL 31/2-3

Gro Aksnes

STATOIL
EXPLORATION & PRODUCTION
LABORATORY

APRIL 1981

LAB.81.26

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Classification

Requested by

Shell Exploration and Production Norway.

Subtitle

Reservoir fluid study on adjusted bottom hole sample from 31/2-3 oil zone.

Co-workers

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SUMMARY

This report presents the results from a PVT study performed on a bottom hole sample from well 31/2-3, after adjusting its bubble point to reservoir pressure. This was done by adding gas from a recombined gas sample from 31/2-3.

Summary of key data:

Bubble point	: 157.3 barg (71.1°C) 2281 psig (160°F)
Gas/Oil ratio from single flash (flash cond. 15°C, 1 atm)	: 59.2 SM^3/M^3 332.4 SCF/STB
Gas/Oil ratio from differential flash liberation	: 53.5 SM^3/M^3 300.4 SCF/STB
Formation volume factor from single flash	: 1.171 M^3/M^3
Formation volume factor from differential vaporization	: 1.158 M^3/M^3
Viscosity of reservoir fluid at bubble point	: 2.36 cp
Density of stock tank oil at 15°C from single flash	: 0.9080 g/cm^3
Compressibility of saturated reservoir fluid (pressure range: 157,3-288,8 BAR)	: 9.0×10^{-5} VOL/VOL/BAR (6.2×10^{-6} VOL/VOL/psi)

Composition on page 4.

1. INTRODUCTION

In a telex from Shell 2/12-80 (FORQ21204), we were asked to run a PVT study on bottom hole sample no.2. from well 31/2-3, after adjusting its bubblepoint to reservoir pressure. This was done by adding gas from the recombined gas sample from 31/2-3 used in the condensate study.

2. SAMPLES

This bottom hole sample has been studied before. Data are reported in LAB. 81.13. The adjusting gas has also been studied. Data are reported in LAB 81.12. Sample information can be found in these reports.

3. METHODS AND EQUIPMENTS

The oil was first tranfered to a Ruska visual PVT cell. On the basis of the initial GOR of this oil and a bubble point/GOR correlation (1) the amount of gas required was estimated and added in excess. The sample was then left to equilibrate at reservoir pressure and temperature. The excess gas was then removed under constant pressure.

A constant mass pressure-volume relationship was run at reservoir temperature, and the bubblepoint was visually observed. A single flash was then performed and the oil and gas analysed. (Methods and equipments described in reports LAB 81.12/13).

The viscosity of reservoir fluid are measured using a RUSKA rolling ball viscosimeter. Viscosity at 1 atm and reservoir temperature by capillary viscosimeter.

A new oil mixture was then prepared to run a differential vaporization.

4. RESULTS

The bubble point of the mixtures were determined to be; 157.3 barg (See table 1 and Fig. 1). Results from the single flash are given in table 2.
Extended reservoir fluid analysis from TBP destillation and chromatography in table 3.

Data from the differential vaporization are given in table 4 and Fig. 2.

The viscosity data are given in table 5. It was impossible to make the ball roll when pressure was less then 78.5 barg, therefore the lack of data between this point and 1 atm. (see fig. 3).

In the PVT experiment we experienced that it took very long time to attain gas/oil equilibrium near the bubble point. This difficulty will, because of the apparatus, be even greater in the viscosity experiment. This is the reason why the bubble point pressure in Fig.3 is not well defined. But, because of the equal viscosity values near the bubble point pressure, the viscosity at bubble point is in all probability correct.

5. DISCUSSION

A flash computer program (2) using this composition reproduced the measured GOR, oil density and Bo factor, giving 58.7 (59,2), 0.907 (0,908) and 1.168 (1,171) respectively.

The reservoir fluid density calculated from the gas/oil ratio and formation volume factor from single flash is also in excellent agreement with the one calculated from the differential vaporization; 0.8201 and 0.8206 respectively.

REFERENCES

(1) M. Vazquez, H.D.Beggs, "Correlations for Fluid Physical Property Prediction". JPT (march 80) p. 968.

(2) Standing, "A set of eqn. for computing equilibrium ratios of a crude oil/natural gas system at pressures below 1000 psia". JPT (sept. 1979) p. 1193.

TABLE 1 Constant mass pressure volume analysis of sample at 71.1°C (160°F)

PRESSURE BARg	RELATIVE VOLUME	Y-FACTOR	COMPRESSIBILITY OF SATURATED OIL
288.8	0.9880		Average compressibility above bubblepoint : 9.0×10^{-5} cc/cc/BARg
245.2	0.9921		
215.7	0.9944		
194.7	0.9966		
172.1	0.9989		
159.4	0.9997		
157.3	1.0000		
156.3	1.0012	4.95	
149.5	1.0105	4.94	
144.8	1.0174	4.93	
132.9	1.0400	4.59	
122.6	1.0638	4.44	
108.4	1.1050	4.30	
97.6	1.1477	4.14	
80.4	1.2054	4.00	
71.6	1.3725	3.83	
54.2	1.5327	3.57	
38.9	1.8975	3.39	

$$\text{Y-FACTOR} = \left(\frac{P_B - P}{P}\right) \Big/ \left(\frac{V}{V_B} - 1\right)$$

P_B = bubble point pressure (abs)

V_B = bubble point volume

$P < P_B$

Table 2 Composition of seperator products from single flash and calculated reservoir fluid composition (flash cond. 15°C, 1 atm)

Components	Separator gas mole %	Separator liquid mole %	Reservoir fluid mole %	Molecular weight** g/g mole	Density at 15°C* g/cm^3
Nitrogen	0.43	-	0.18		
Carbondioxid	0.86	-	0.36		
Methane	83.61	-	35.29		
Ethane	8.74	0.10	3.75		
Propane	2.23	0.19	1.05		
iso-Butane	1.77	0.42	0.99		
n-Butane	0.48	0.20	0.32		
iso-Pentane	0.40	0.42	0.41		
n-Pentane	0.14	0.21	0.18		
Hexanes	0.49	1.60	1.13	84	0.7388
Heptanes	0.76	5.39	3.44	96	0.7509
Octanes	0.09	7.05	4.11	107	0.7663
Nonanes	-	5.19	3.00	121	0.7985
Decanes +	-	79.23	45.79	308***	0.9238***
	100.00	100.00	100.00		

Reservoir fluid density (g/cm^3) : 0.8201
Density of oil (g/cm^3) : 0.9080
Molecular weight of oil (g/g mole) : 265
GOR, SM^3/M^3 : 59.2
Bo, M^3/M^3 : 1.171

* TBP destillation reported in LAB.81.20

** From article by D.L.KATZ and A.FIROOZABADI, JPT VOL XX Nov.1978 p.1649

***Calculated; measured values from TBP destillation are 305 and 0,9163 respectively

Table 3 Extended reservoir fluid analysis from TBP destillation* and chromatography

Component	Reservoar fluid mole %	Density at 15°C* (g/cm^3)	Molecular weight** g/g mole
N_2	0.18		
CO_2	0.36		
C_1	35.29		
C_2	3.75		
C_3	1.05		
iC_4	0.99		
nC_4	0.32		
iC_5	0.41		
nC_5	0.18		
C_6	1.13	0.7388	84
C_7	3.44	0.7509	96
C_8	4.11	0.7663	107
C_9	3.00	0.7985	127
C_{10}	3.01	0.8164	134
C_{11}	2.47	0.8296	147
C_{12}	2.77	0.8473	161
C_{13}	3.17	0.8580	175
C_{14}	2.79	0.8642	190
C_{15}	2,99	0.8719	206
C_{16}	2.57	0.8806	222
C_{17}	2.28	0.8829	237
C_{18}	2.05	0.8846	251
C_{19}	2.04	0.8948	263
C_{20}	1.59	0.9065	275
C_{21+}	18.06	0.9499	476***
	100.00		

* TBP destillation reported in LAB.81.20

** From article by D.L.KATZ and A.FIROOZABADI, JPT VOL XXX Nov.1978 p.1649

***Calculated

Table 4 Differential vaporization of sample at 71.1°C (160°F)

PRESSURE BARg	RELATIVE VOLUME (1)	SOLUTION GOR RS (2) (m^3/m^3)	DENSITY SAT.OIL (g/cm^3)	SPESIFIC GRAVITY GAS (air=1)	Z FACTOR GAS
288.8	1.144		0.8306		
245.2	1.149		0.8271		
215.7	1.152		0.8252		
194.7	1.154		0.8234		
172.1	1.157		0.8215		
159.4	1.158		0.8208		
157.3	1.158	53.5	0.8206		
137.8	1.145	47.0	0.8261	0.615	0.893
116.2	1.131	40.0	0.8318	0.610	0.893
96.1	1.117	33.4	0.8371	0.610	0.900
75.0	1.103	26.4	0.8432	0.611	0.927
53.9	1.089	19.4	0.8496	0.616	0.934
30.4	1.072	11.3	0.8569	0.637	0.948
* atm	1.043	0	0.8706	0.764	-
atm 15°C	1.000	0	0.9081	-	-

1) Cubic meter of oil at indicated pressure and temperature per cubic meter of resudial oil at 15°C.

2) m^3 cubic meter of gas at atm. and 15°C per m^3 of residual oil at 15°C.

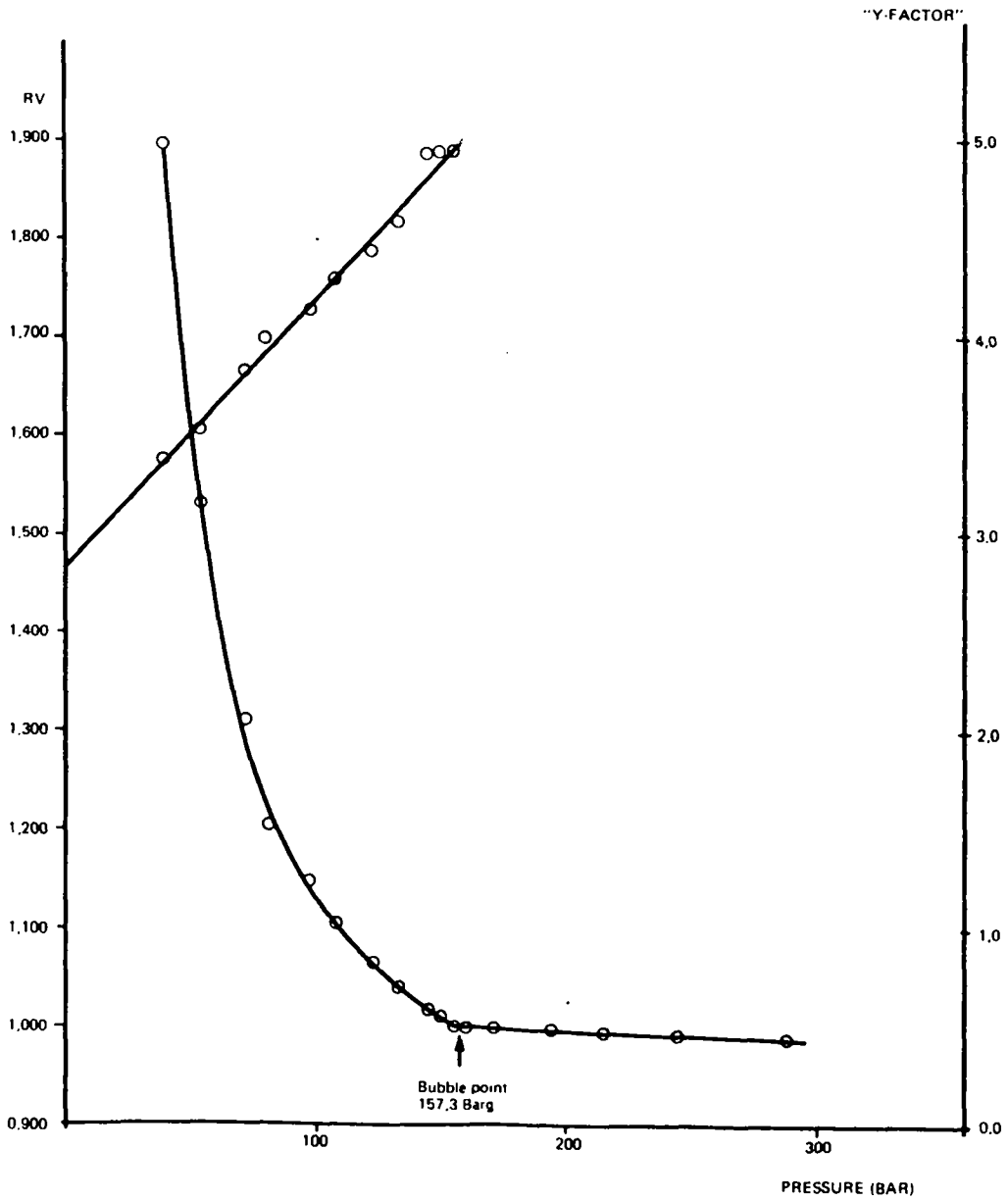
* NB! 1 atm = 1.01325 BAR

Table 5 Viscosity of reservoir fluid vs, pressure at 71.1°C (160°F)

PRESSURE BARg		OIL VISCOSITY CENTIPOISE	CALCULATED* GAS VISCOSITY CENTIPOISE	OIL/GAS VISCOSITY RATIO
294.2	4266	2.77		
248.1	3597	2.64		
191.2	2772	2.44		
176.5	2559	2.40		
166.7	2417	2.37		
158.9	2304	2.36		
150.0	2175	2.36	0.0166	142.2
139.3	2020	2.36	0.0160	147.5
130.4	1891	2.39	0.0155	154.2
119.6	1734	2.49	0.0151	164.9
78.5	1131	3.11	0.0138	225.4
atm		7.15	0.0118	605.9

* Gas viscosities are calculated from Carr, Kobayashi and Burrows Correlations.

Fig. 1: Constant mass pressure relationship



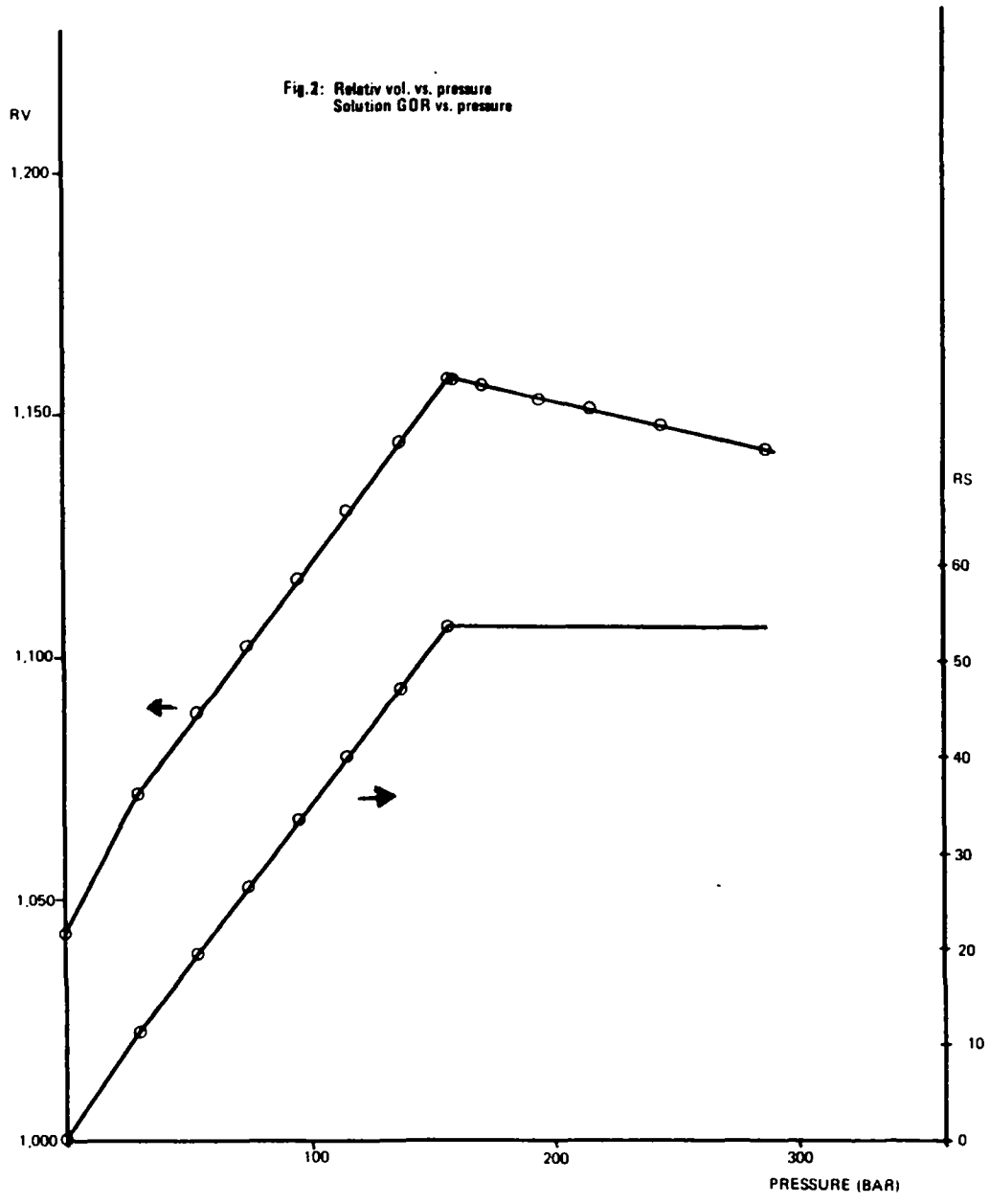


Fig.2: Relativ vol. vs. pressure
Solution GOR vs. pressure

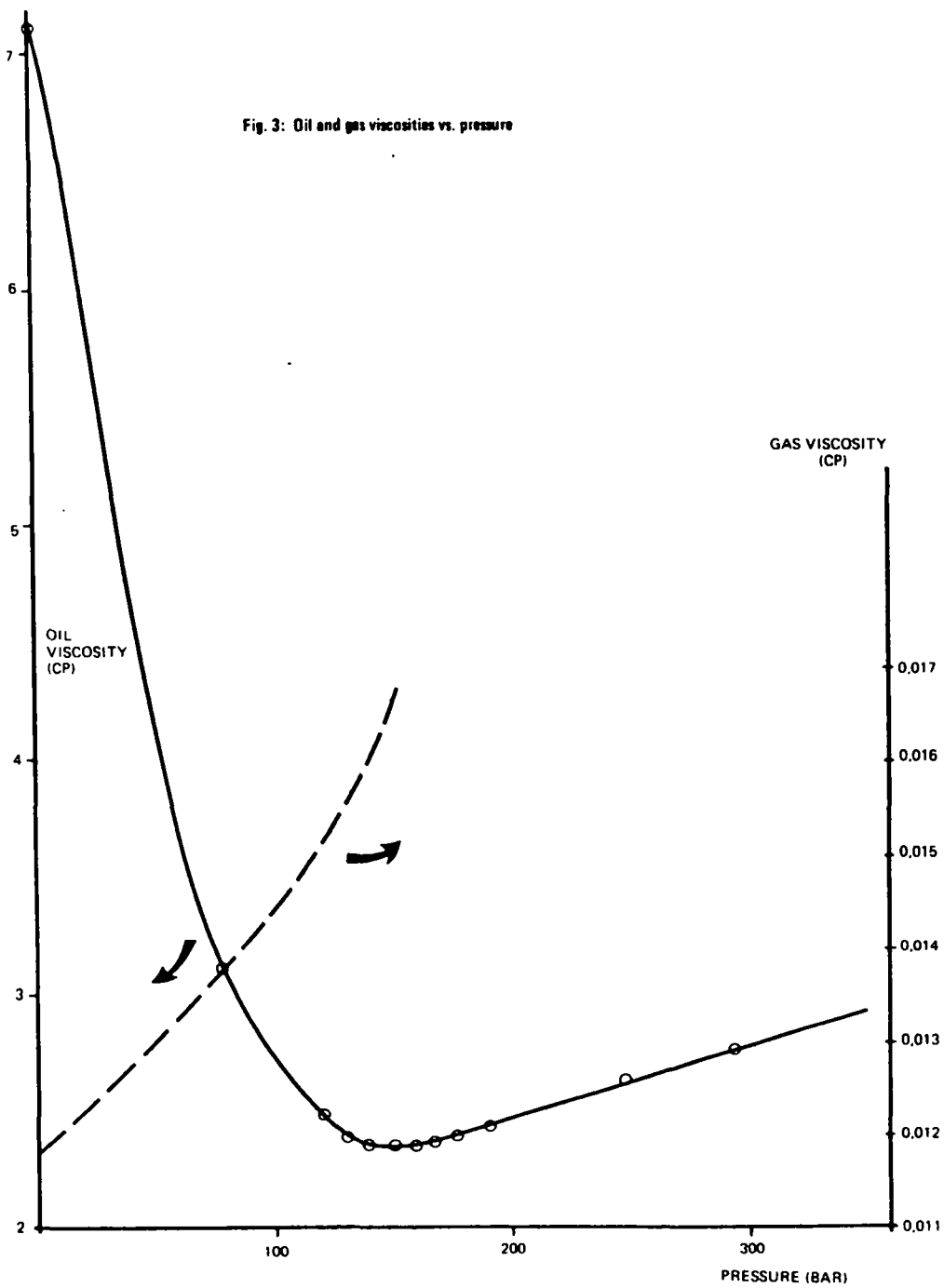


Fig. 3: Oil and gas viscosities vs. pressure