REPORT

PVT-SIMULATION

FLUID DATA FROM 15/9-1 AND 15/6-3

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CONTENTS:

FOREWARD

This report summerized the work done on the fluid-match of gas PVT-samples from 15/9-1. In addition data from 15/6-3 has been included for comparison purposes. The data from the match will be used as input to a one -well compositional study on the 15/9 ALPHA-structure.

1. SUMMARY OF EXISTING DATA

Separator samples were sent to respectively Core Lab. and Exxon Production Research Company (EPR).

Both laboratories measured:
1. Mole % of separator gas and liquid
2. Wellstream composition at reservoir conditions
3. Properties of C_{7+}
4. Dewpoint pressure

The analysis included a full
5. Constant volume depletion study and
6. Constant composition expansion (only EPR)

Core Lab. also reported in their work a calculated gas viscosity from the Carr, Kobayashi and Burrows correlation.

From 15/6-3, EPR has reported the following data:
1. Composition of separator gas and liquid
2. Wellstream composition at reservoir conditions
3. Constant volume depletion which is simulated

We realize that 15/9-1 was samples with 1900 psi drawdown, and that this may have caused som liquid dropout in the reservoir. If some of the heavy ends are lost, the reported dewpoint and liquid dropout measured may be to low. However, most of the drawdown, which are due to the skin, take place close to the wellbore and in the perforations, and there are no room for liquid accumulations.

Gas from 15/6-3, which are sampled with 600 psi drawdown, contain 2,05 mol% C_{7+} compared to 1.89 mol% in 15/9-1, and the maximum liquid dropout fits well data from 15/9-1.

2. LAB. MEASURED DATA AND INPUT TO PVT SIMULATOR

The different wellstream compositions are plotted in fig. 2.1 (The splitt of C_{7+} has been plotted for EPR-data). The plot indicates a fairly semilar composition from all three reports. The liquid dropout curves from constant volume depletion experiment are plotted in fig. 2.2, and there are only slightly differences between the two reports from 15/9-1. EPR's simulated results from 15/6-3 shows a low dewpoint pressure (4133 psig vs. respectively 5700 psig and 5789 psig from the 15/9-1), but nearly the same maximum value of liquid dropout.

The single-well compositional study should answer the problem of retrograde condensation around the wellbore. Due to this reason, the report with the maximum liquid dropout and the highest dewpoint (i.e. Core Lab.'s report) has been used as a input to the fluid-match.
The rest of the input data are specified in table 2.1. In this table C_{7+} has been splitted in C_7, C_8, C_9 and C_{10+} after EPR's data, and weighted with Core Lab.'s fraction of C_{7+} to get 100%.

Component	Mole fraction	Mole weight (gm./gm. mole)
N_2	.0056	28.01
CO_2	.0472	44.01
C_1	.7924	16.04
C_2	.0780	30.07
C_3	.0361	44.09
iC_4	.0047	58.12
nC_4	.0086	58.12
iC_5	.0019	72.15
nC_5	.0036	72.15
C_6	.0030	89.00
C_7	.0052	99.00
C_8	.0040	110.00
C_9	.0025	122.00
C_{10}	.0077	270.00

Mole weight C_{7+}: 172

Table 2.1

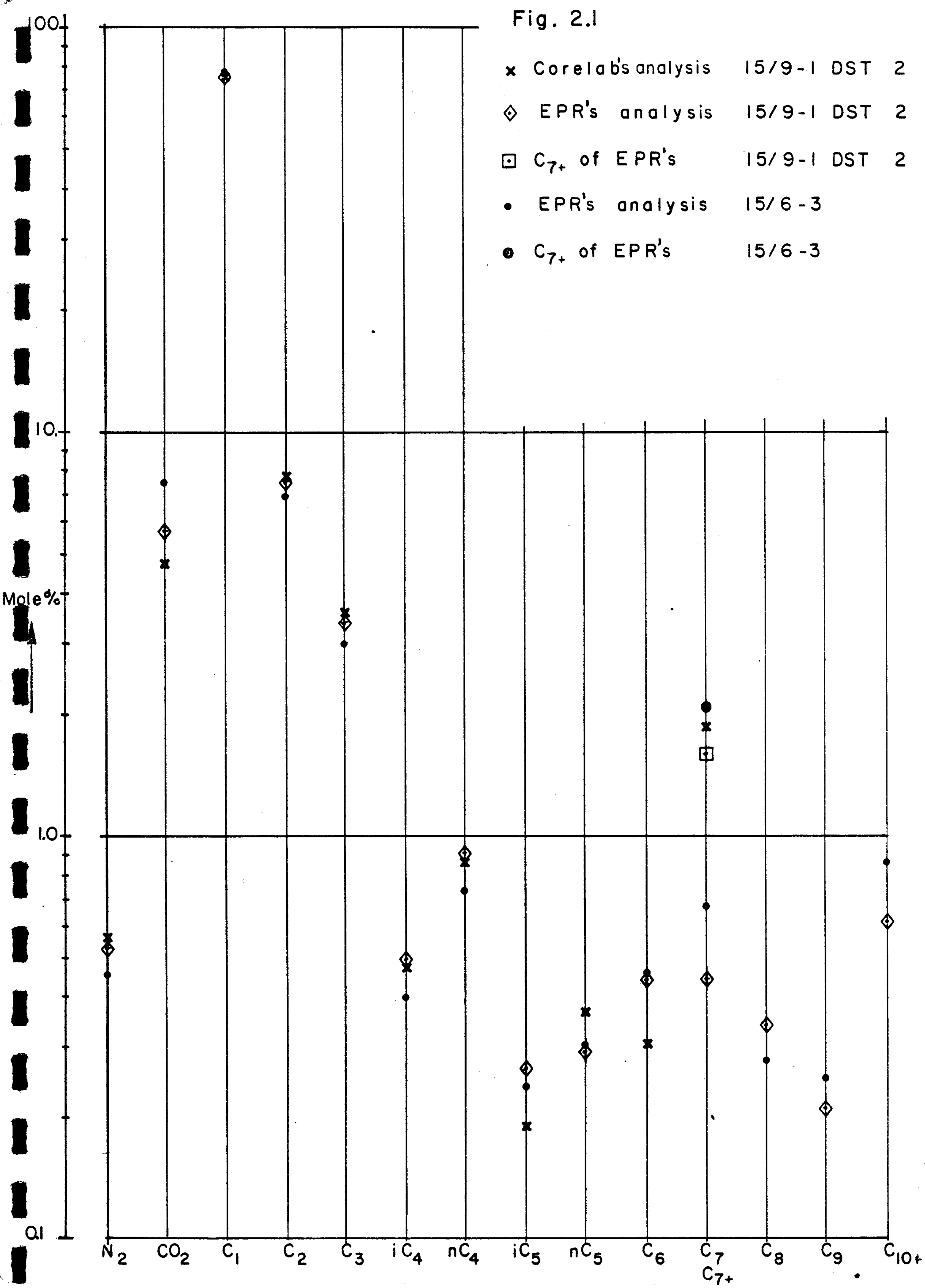
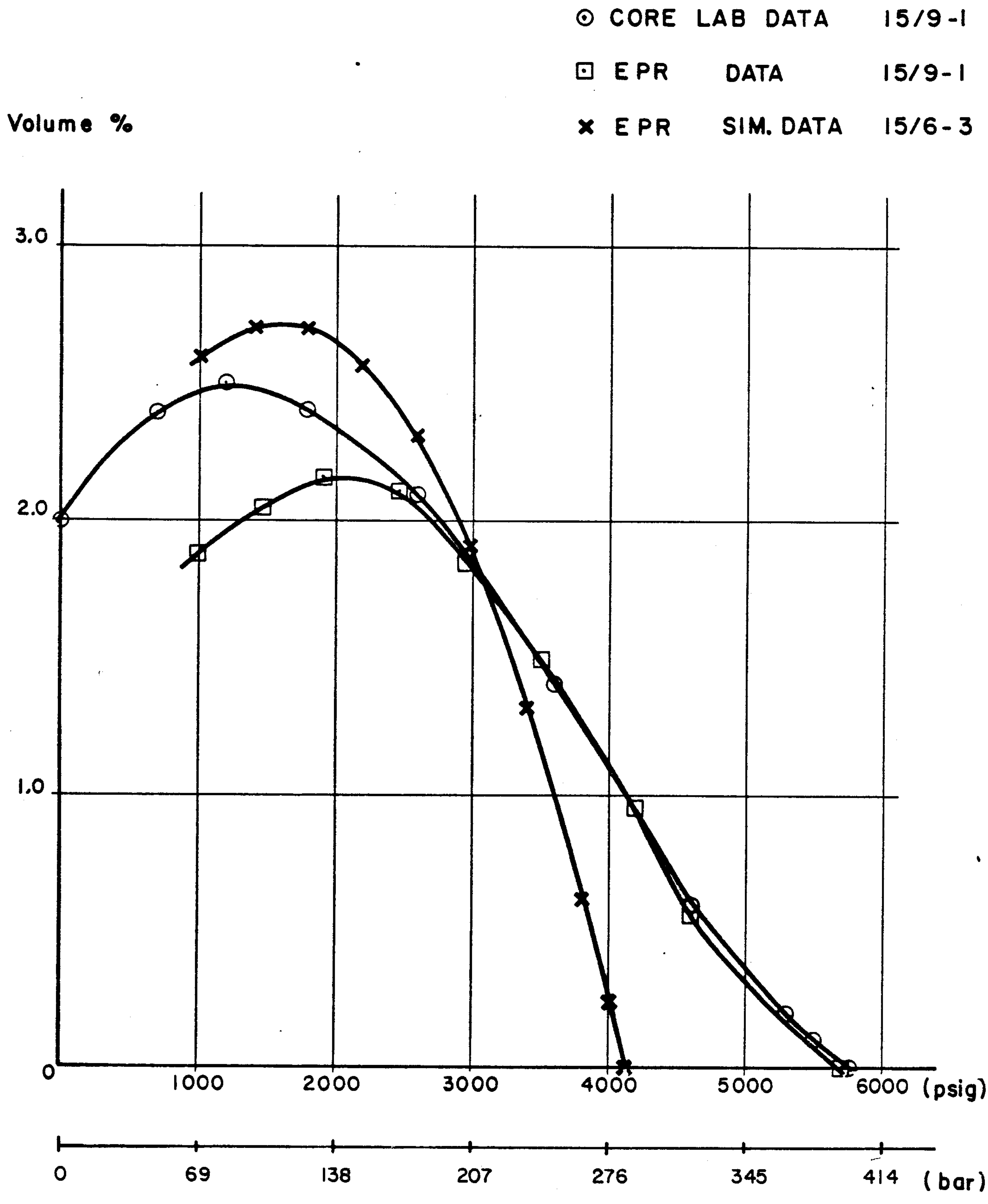


Fig. 2.1
× Corelab's analysis 15/9-1 DST 2
◇ EPR's analysis 15/9-1 DST 2
⊡ C7+ of EPR's 15/9-1 DST 2
• EPR's analysis 15/6-3
⊙ C7+ of EPR's 15/6-3
100.
10.
1.0
0.1
Mole%
N2 CO2 C1 C2 C3 iC4 nC4 iC5 nC5 C6 C7 C8 C9 C10+
C7+

FIG. 2.2

RETROGRADE CONDENSATION DURING DEPLETION

15/9-1 DST 2



3. FLUID PROPERTY MATCH

The principal correlations used in the Fluid Property Package (and in the Compositional Model) are:

a. the Lee-Edminster modification of the Redlich-Kwong equation of state, used to calculate the densities of both the vapour and liquid phases;

b. the Thodo's correlation, used to determine the viscosities of both phases;

c. convergence pressure calculated by the method of Rowe and Silberberg. Component K-values are obtained from the empirical equations of MacDonald which approximate the graphs presented in the NGPSA Engineering Data Book; and

d. the Etter and Kay Correlations, used to calculate critical pressures.

Using the wellstream composition from table 2.1, the first simulated dropout curve (constant volume depletion) gives too much liquid dropout (see fig. 3.1), but a fairly good match of the dewpoint. The moleweight of C_{7+} was then reduced to match Core Lab.'s moleweight of 149 by another split of C_{7+} and the following split gave the lowest liquid dropout:

C_7 : 0.0075

C_8 : 0.0036

C_9 : 0.0027

C_{10} : 0.0051

Moleweight of this C_{7+} equal 150 which is nearly the same as Core Lab.'s report.

In fig. 3.2 the log of K-values are plotted against critical temp.^{2} · 10^{-4} for each component. For a given pressure the points tend to fall on a straight line. * The K-values for C_7, C_8, C_9 and C_{10+} was found not to fit the straight line defined by the lighter components. By adjusting K-values for C_7 to C_{10+}, a better match was obtained, see fig. 3.3, and the liquid dropout curve in fig. 3.1.

If this liquid dropout will results in a serve productivity restrictions in the compositional study, more effort might be put on the match in the high pressure area, where the match gives about 0.8% too much liquid.

The following tables give the results from the match, and fig. 3.4 indicates the match of each component during depletion. Fig. 3.5 gives the gas viscosity compared with Core Lab.'s calculated values.

* SPE papers 7475: Internally consistent correlations for predicting phase compositions for use in reservoir composition simulators by Allen McGhee Rowe.

Pressure (psia)	Relative volume exp.	Relative volume calc.	Liquid sat. (frac.) calc.	Liquid visc. (cp) calc.	Gas visc. (cp) calc.
6415	0.9442	0.9467	0	0.0348	0.0348
5804	1.000	0.9988	0	0.0327	0.0327
4615	1.1546	1.1582	0.0111	0.3366	0.0276
3815	1.3299	1.3375	0.0141	0.3557	0.0241
2615	1.8662	1.8750	0.0138	0.3602	0.0189
1882	2.6124	2.6124	0.0113	0.3700	0.0164
1415	3.5150	3.5286	0.0088	0.3829	0.0151

Table 3.1

RESULTS FROM CONSTANT COMPOSITION EXPANSION.

Pressure (psia)	Liquid saturation exp.	Liquid saturation calc.	Liquid viscosity calc.	Gas viscosity (cp) exp.*	Gas viscosity (cp) calc.
6415	0	0	0.0348	0.0312	0.0348
5804	.001	0	0.0327	0.0293	0.0327
4615	.006	.0129	0.3366	0.0253	0.0276
3615	.0140	.0190	0.3576	0.0219	0.0232
2615	.021	.0229	0.3605	0.0183	0.0189
1815	.024	.0246	0.3702	0.0164	0.0162
1215	.025	.0246	0.3872	0.0148	0.0147
715	.024	.0236	0.4387	0.0137	0.0139
0	.020			0.0134	

* Core Lab. has calculated the gas viscosity from Carr, Kobayashi and Burrows.

Table 3.2

RESULTS FROM CONSTANT VOLUME DEPLETION.

Comp.	Pressure (psia) 6415		5804		4615		3615		2615		1815		1215		710	
	exp.	calc.	exp.	calc.	exp.	calc.	exp.	calc.	exp.	calc.	exp.	calc.	exp.	calc.	exp.	calc.
C_1	.7924	.7924	.7924	.7924	.7953	.7947	.7992	.7962	.8027	.7974	.8050	.7980	.8014	.7976	.7945	.7959
C_2	.0780	.0780	.0780	.0780	.0776	.0779	.0760	.0779	.0760	.0779	.0768	.0782	.0792	.0786	.0817	.0788
C_3	.0361	.0361	.0361	.0361	.0350	.0360	.0344	.0360	.0344	.0359	.0356	.0360	.0370	.0361	.0389	.0365
iC_4	.0047	.0047	.0047	.0047	.0046	.0047	.0044	.0047	.0043	.0047	.0043	.0047	.0046	.0047	.005½	.0048
nC_4	.0086	.0086	.0086	.0086	.0085	.0085	.0084	.0085	.0083	.0085	.0083	.0085	.0086	.0085	.0092	.0087
iC_5	.0019	.0019	.0019	.0019	.0018	.0019	.0017	.0019	.0017	.0019	.0017	.0019	.0018	.0019	.0021	.0019
nC_5	.0036	.0036	.0036	.0036	.0035	.0035	.0034	.0035	.0032	.0035	.0033	.0035	.0036	.0035	.0041	.0036
C_6	.0030	.0030	.0030	.0030	.0026	.0029	.0023	.0029	.0022	.0028	.0022	.0028	.0027	.0028	.0037	.0030
C_{7+}	.0189	.0189	.0189	.0189	.0180	.0169	.0169	.0154	.139	.0141	.0095	0.0134	.0089	.0131	.0075	.0137

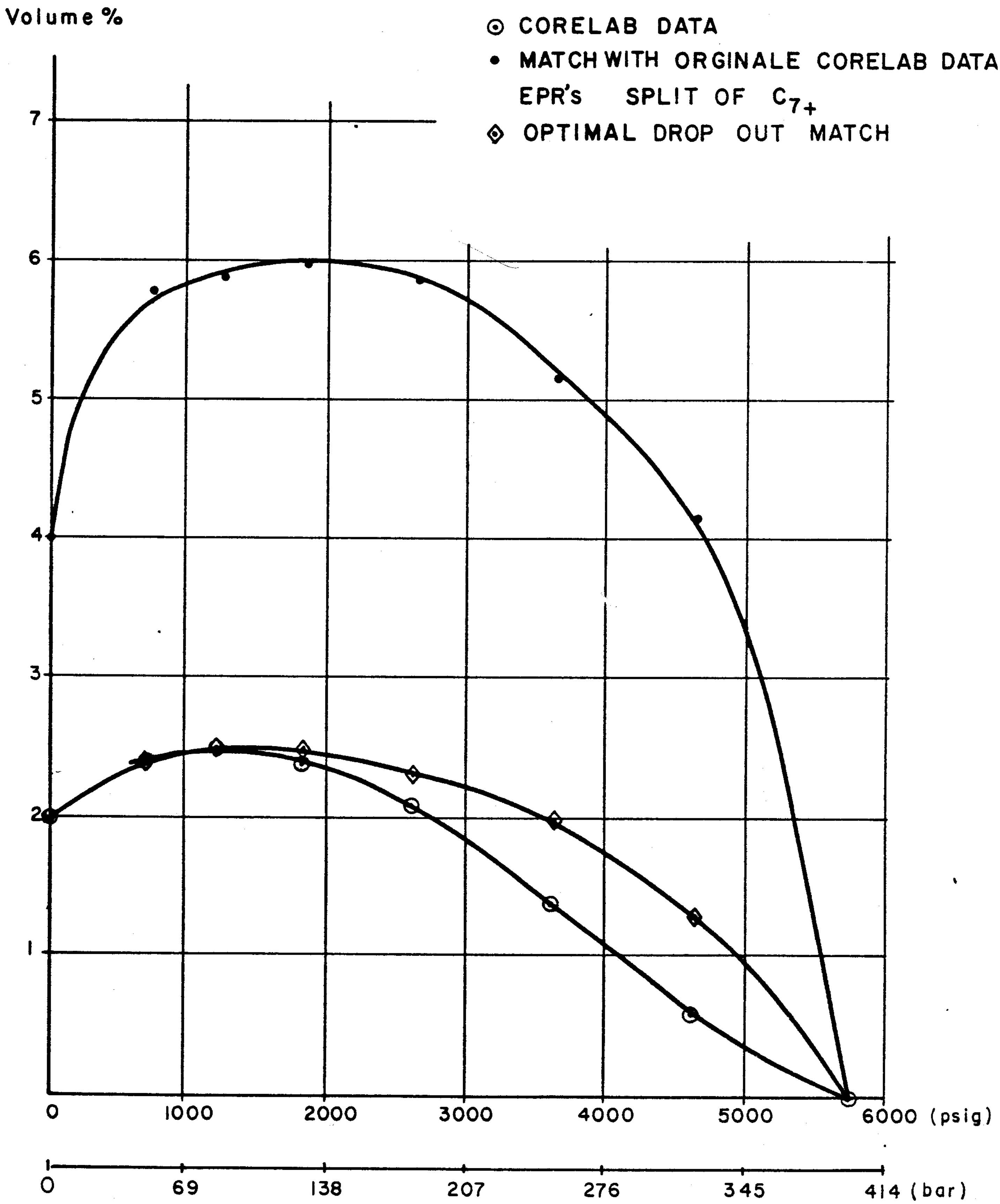
Table 3.3

WELLSTREAM COMPOSITION DURING DEPLETION.

FIG. 3.1

RETROGRADE CONDENSATION DURING DEPLETION

15/9-1 DST 2



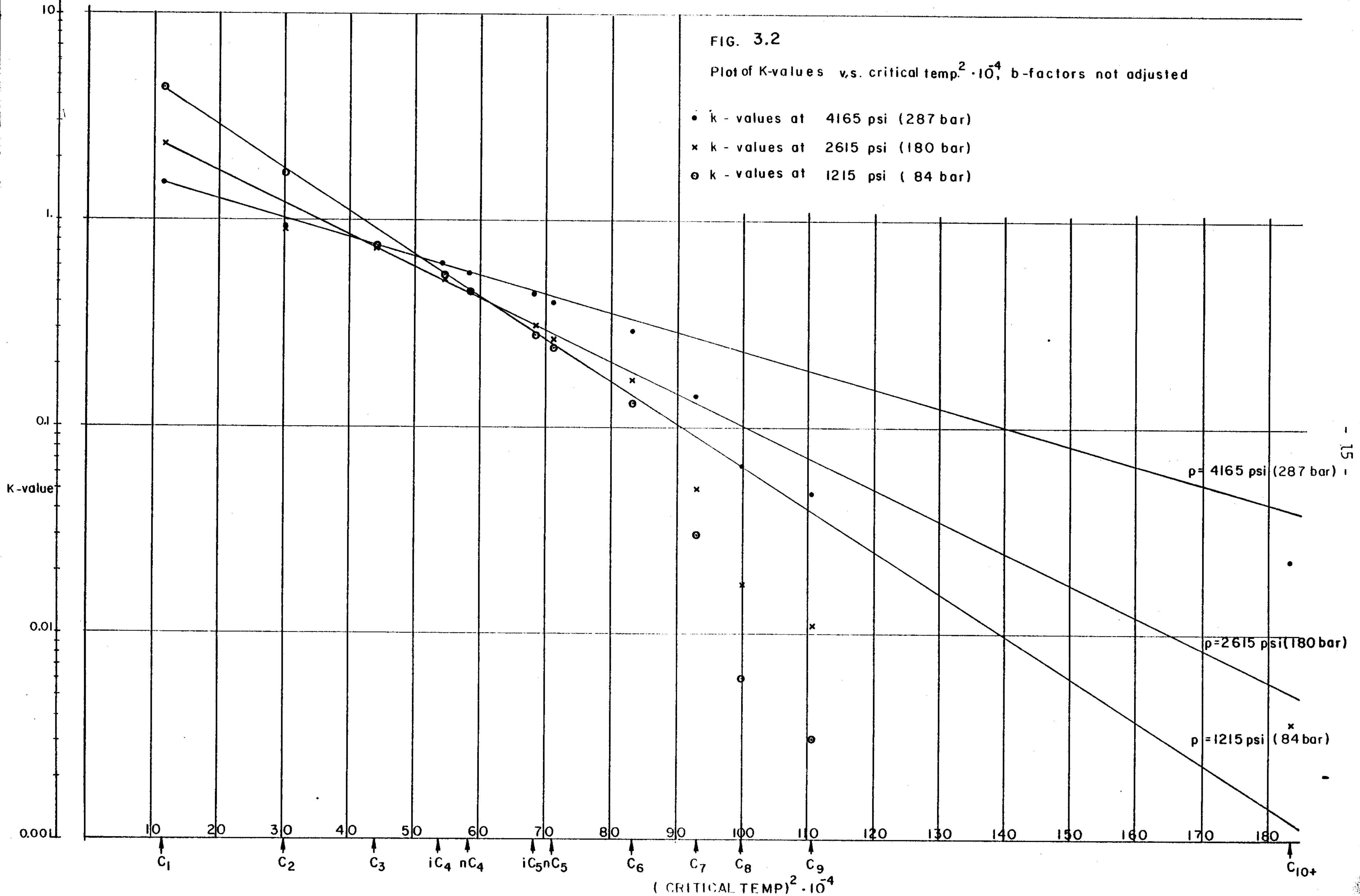


FIG. 3.2
Plot of K-values v.s. critical temp.$^2 \cdot 10^{-4}$, b-factors not adjusted
• k - values at 4165 psi (287 bar)
× k - values at 2615 psi (180 bar)
⊙ k - values at 1215 psi (84 bar)
p= 4165 psi (287 bar)
p=2615 psi(180 bar)
p =1215 psi (84 bar)
K-value
10.
1.
0.1
0.01
0.001
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
C_1 C_2 C_3 iC_4 nC_4 iC_5 nC_5 C_6 C_7 C_8 C_9 C_{10+}
$(\text{CRITICAL TEMP})^2 \cdot 10^{-4}$

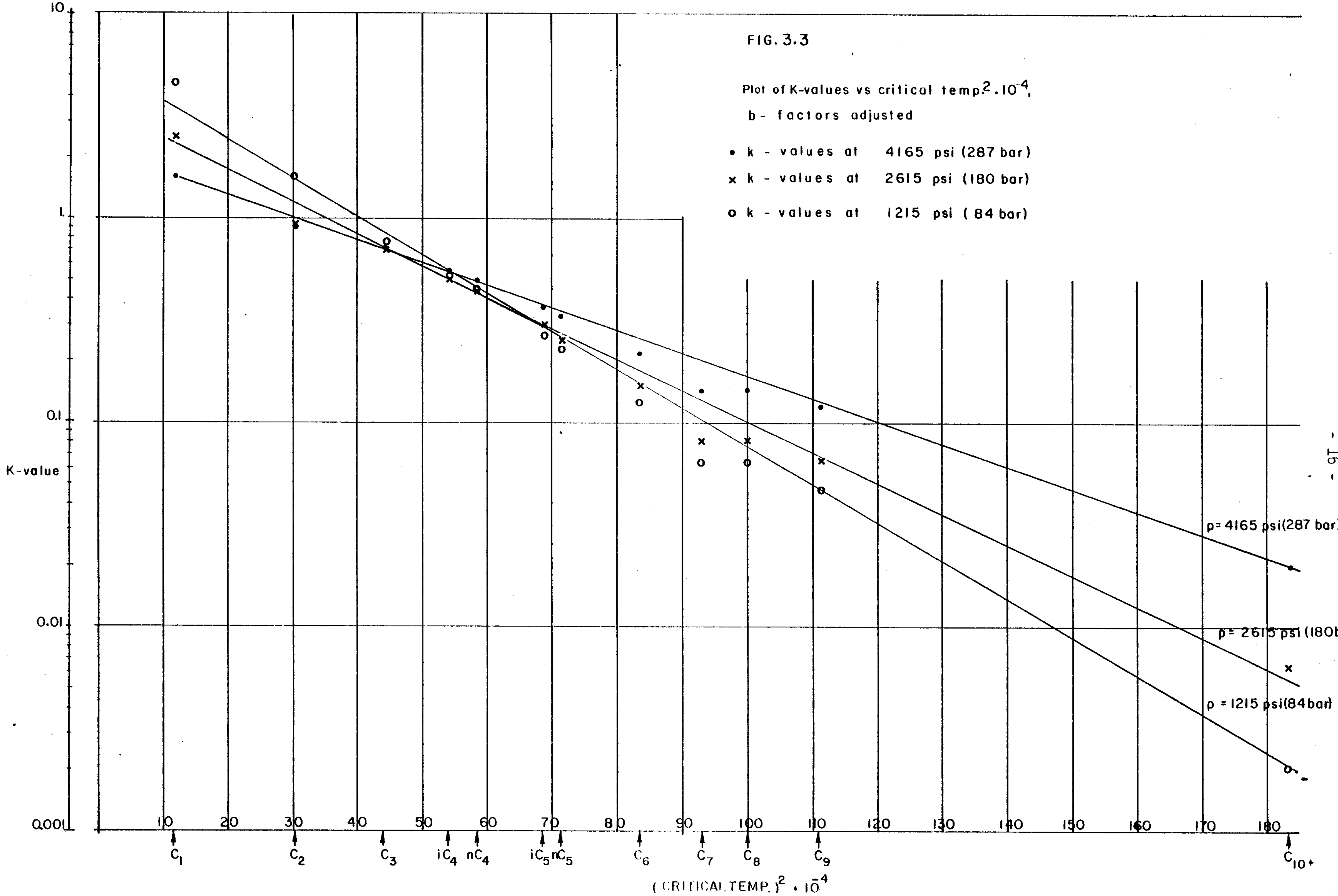


FIG. 3.3

Plot of K-values vs critical temp.$^2 \cdot 10^{-4}$, b - factors adjusted

Fig. 3.4

WELL STREAM COMPOSITION DURING DEPLETION

15/9-1 DST#2

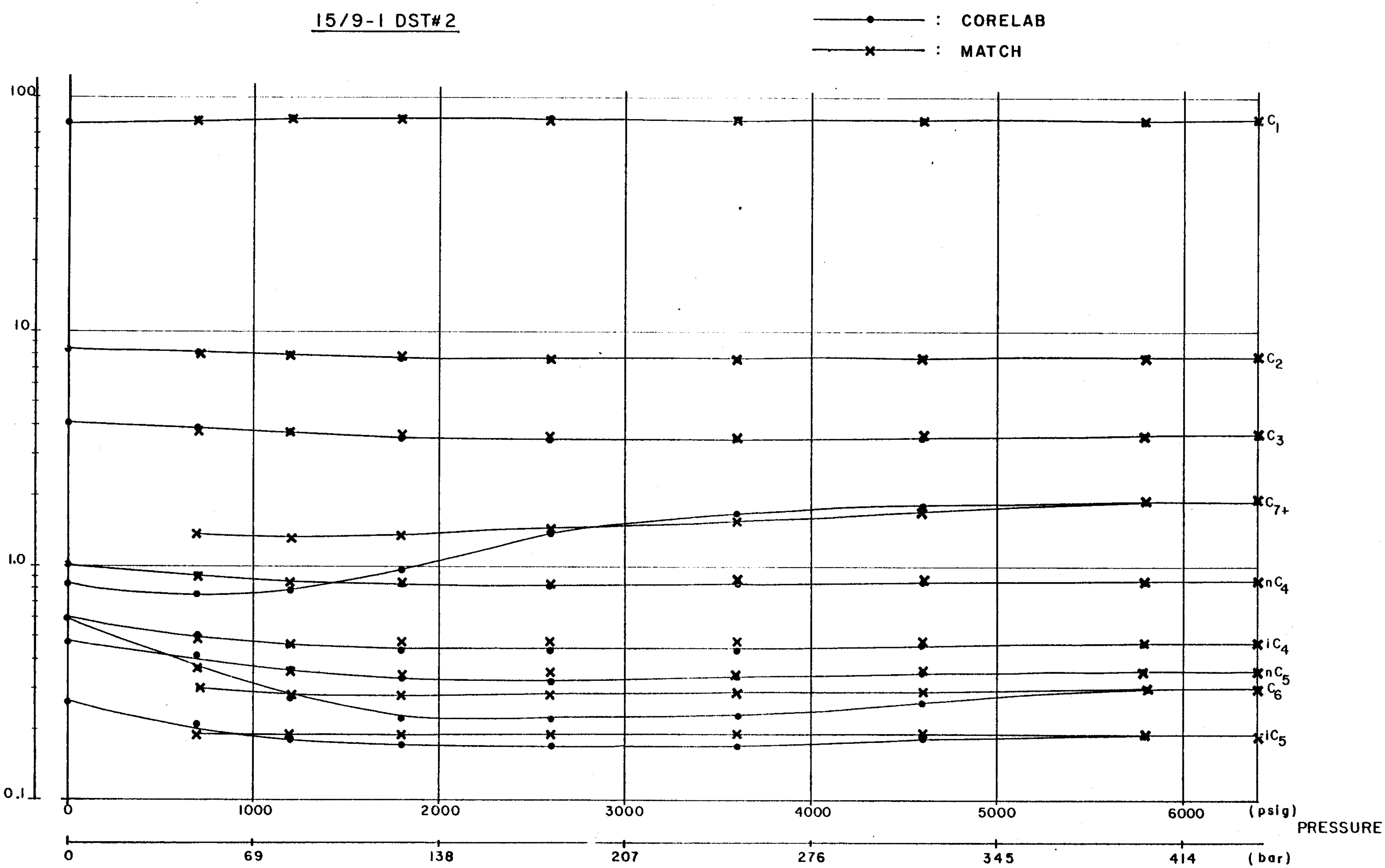


FIG. 3.5

GAS VISCOSITY FROM CONST.VOL.DEPLETION