

OIL CONSERVATION DIVISION

MR. KELLY

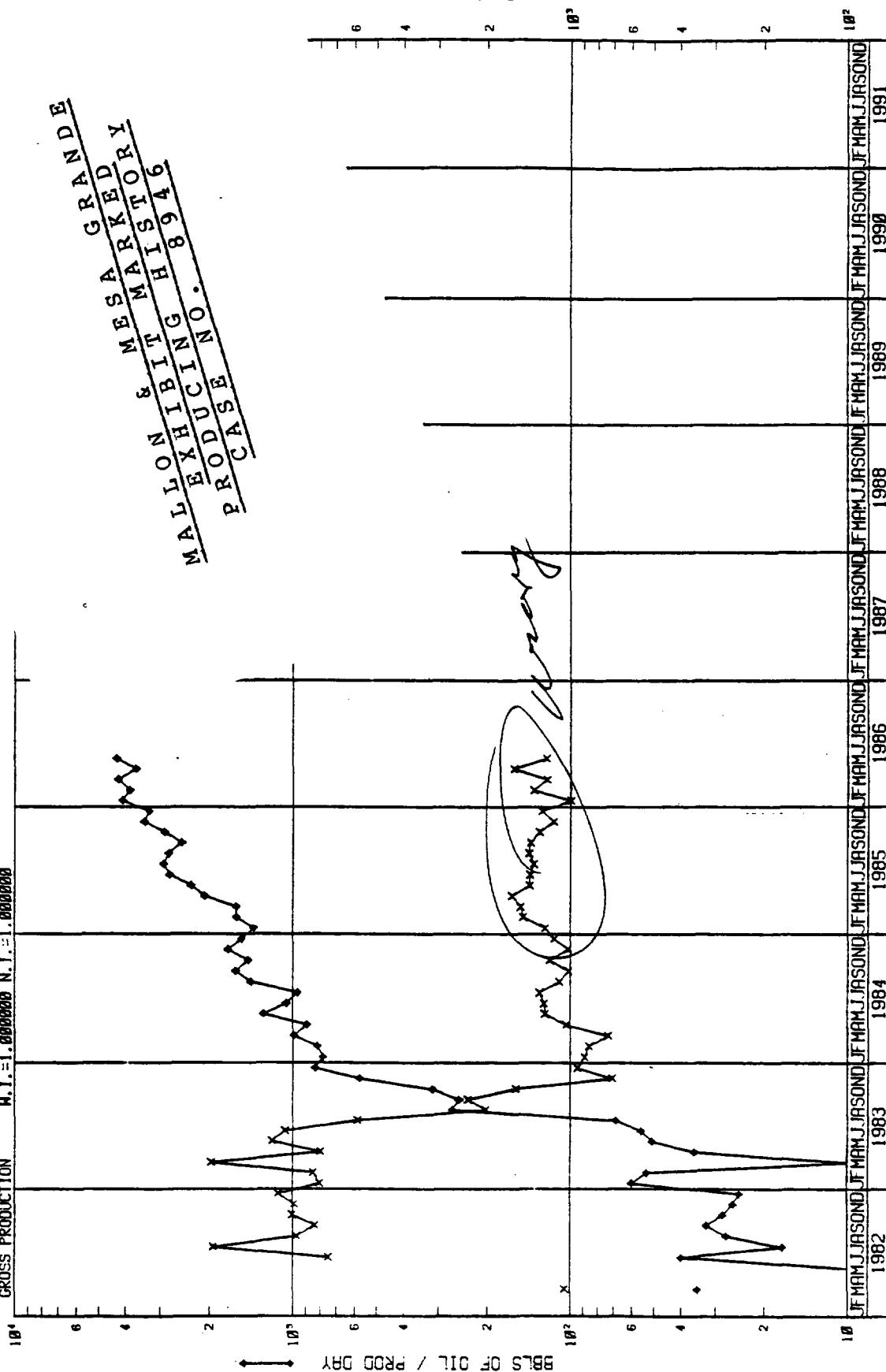
BENSON-MONTIN-GREER DRILLING CORP.
EXHIBITS IN CASE NOS. 8946 & 8950
BEFORE THE OIL CONSERVATION DIVISION OF THE
NEW MEXICO DEPARTMENT OF ENERGY AND MINERALS

AUGUST 7, 1986

NMOC/NMOCD Case No.	<u>8950</u>
Hearing Date	<u>8/21/86</u>
<u>Benson-Montin-Greer</u>	
Exhibit No.	<u>6</u>

W.I.=1.00000 N.I.=1.00000

GAS-OIL RATIO (SCF/BBL)



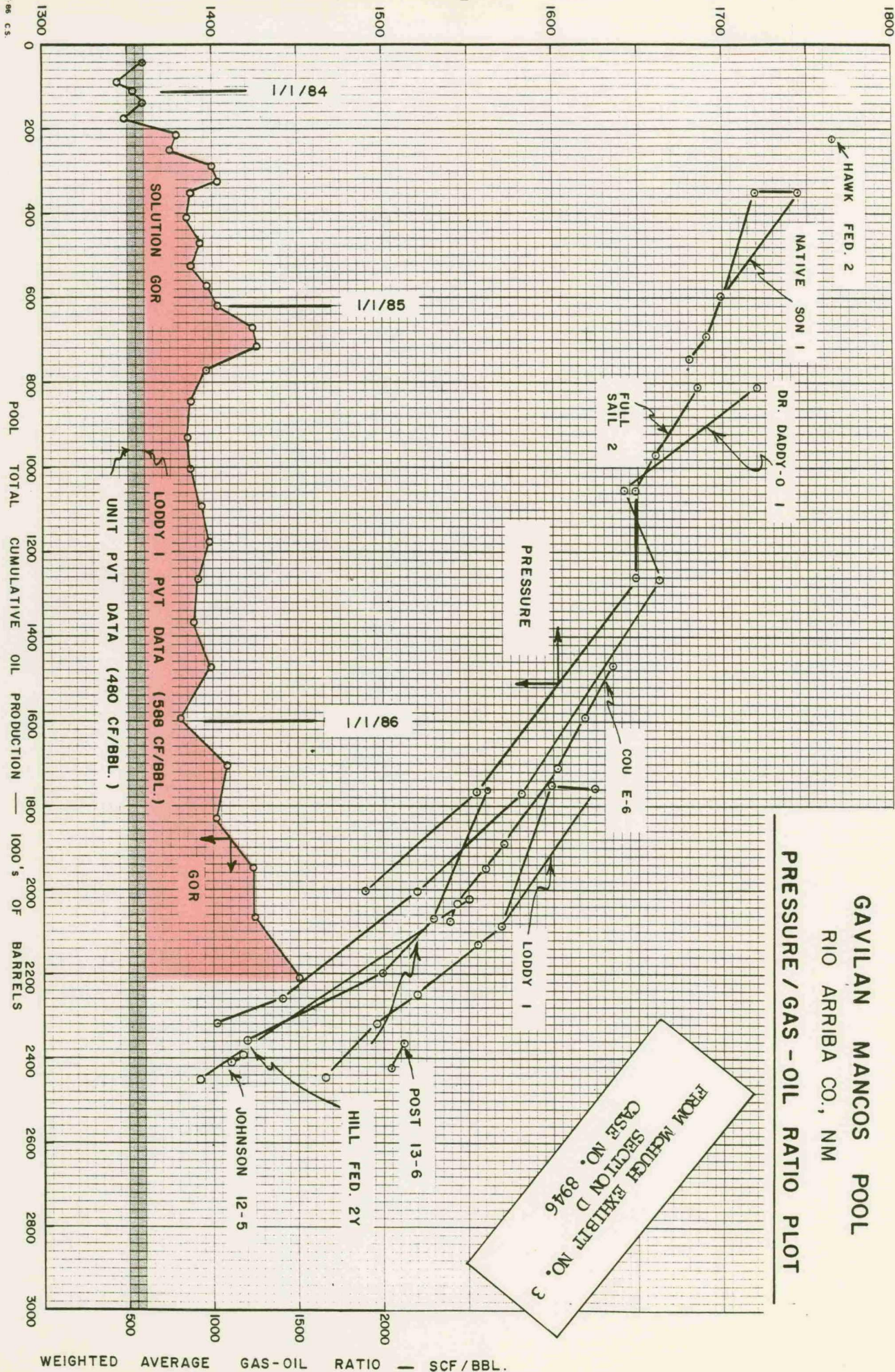
	POOL TOTAL		SUM OF #1 GAV 2 GAV-HDW		POOL TOTAL LOSS #1 GAV 2 GAV-HDW		
	OIL	GAS	OIL	GAS	OIL	GAS	WTRD AUG
1983							
AUG	6924	18,643	3030	15,119	3894	3524	905
SEPT	8205	17,956	3254	11,560	4951	6396	1292
OCT	10,112	15,568	497	3,888	9,665	11,680	1209
NOV	21,375	12,761	171	1329	21,204	11,932	539
DEC	31,627	25,247	2477	10,970	29,150	18,277	490
1984							
JAN	29,448	22,379	2707	8640	26,741	13,734	514
F	29,380	20,990	2613	6452	26,767	14,538	543
M	35,279	23,521	2829	7526	32,430	15,995	493
A	30826	29,178	2886	7006	27,940	22,172	794
M	48,126	52,385	4728	19,879	43,328	32,506	750
J	37,533	43,143	2837	8,212	34,696	34,931	1007
JUL	35,510	40,491	2648	6,519	32,862	33,972	1034
AUG	48,575	50,402	2533	10,243	46,042	40,159	872
SEP	53,177	55,346	2,223	11,991	50,954	43,355	851
OCT	49,721	56,561	2,263	11,742	47,458	44,819	944
NOV	53,276	56,226	2,385	11,354	50,891	44,872	882
DEC	50,573	57,046	2,489	10,298	48,084	46,748	972

1985

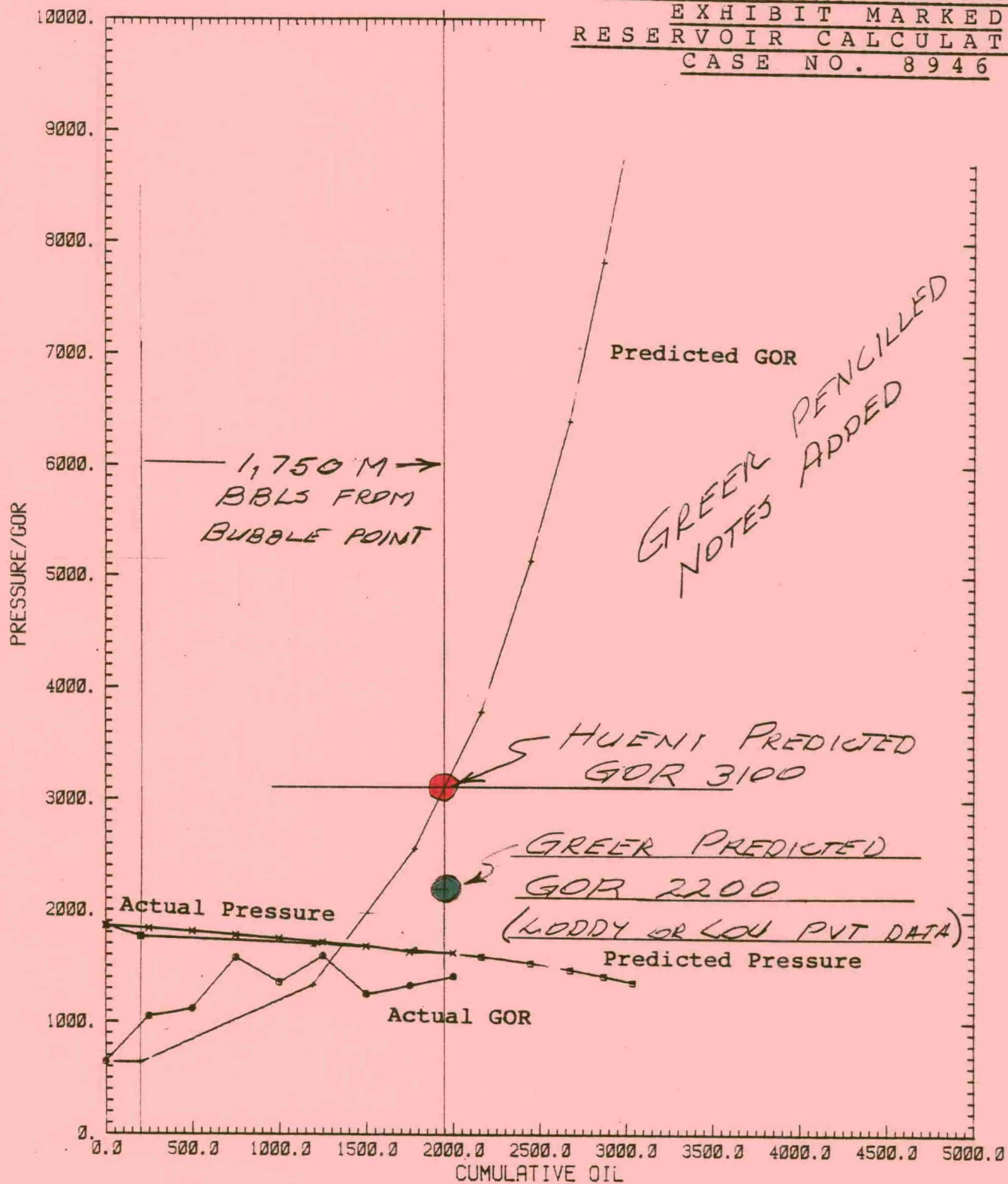
	POOL TOTAL		SUM OF GRV #1 & 16AV. NOW		POOL TOTAL LESS RI GRV. & 16AV. NOW		
	oil	gas	oil	gas	oil	gas	GOR
JAN	44,587	54,837	1260	9,593	43,319	45,244	1094
FEB	46,407	68,213	1551	11,506	44,856	56,707	1264
MAR	51,713	77,356	1894	13,183	49,819	64,173	1289
APR	66,736	103,132	5321	43,219	61,415	59,913	976
MAY	73,684	102,362	7922	43,770	65,762	58,592	891
JUN	85,109	123,428	8,547	57,843	76,562	65,585	857
JULY	86,256	118,877	8260	51,920	77,996	66,957	859
AUG	88,588	124,740	7273	49,058	81,315	75,682	931
SEPT	77,586	107,418	6190	37,131	71,396	70,287	985
OCT	92,791	120,078	6749	41,308	86,042	78,770	916
NOV	103,754	120,043	5545	31,768	78,209	88,075	897
DEC	105,578	131,884	6837	34,169	98,741	97,715	990

1986

JAN	131,058	185,508	7193	35,840	123,865	99,668	805
FEB	111,329	149,845	5802	34,799	105,527	115,046	1070
MARCH	127,446	160,868	6319	38,384	121,627	122,484	1007
APR	109,478	174,136	3842	38,252	105,636	135,884	1286
MAY	126,731	165,278	2644	10,841	124,087	154,437	1245
JUN	163,093	258,723	4775	20,105	158,318	238,418	1507



MALLON & MESA GRANDE
EXHIBIT MARKED
RESERVOIR CALCULATIONS
CASE NO. 8946



- x ACTUAL PRESSURE
- ACTUAL GOR
- ▣ PREDICTED PRESSURE
- + PREDICTED GOR

MALLON/MGR

GAVILON MANCOS POOL

ACTUAL VS SOLUTION GAS DRIVE RECOVERY

SCALE: NTS

DATE: 35-AUG-86

SOURCE:

DRAWING NO.

Jerry R. Bergeson & Associates Inc.

RESERVOIR FLUID STUDY

for

Jerome P. McHugh and Associates

Lottie No. 1 Well
Lindrith Unit Field
Sandoval County, New Mexico
File Number: ARFL-860042

CORE LABORATORIES, INC.

Reservoir Fluid Analysis

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Company Jerome P. McHugh and Associates Date Sampled February 26, 1986
 Well Lottie No. 1 County Sandoval
 Field Lindrith Unit State New Mexico

FORMATION CHARACTERISTICS

Formation Name Gallup Mancos
 Date First Well Completed _____
 Original Reservoir Pressure _____ PSIG @ _____ Ft.
 Original Produced Gas/Oil Ratio _____ SCF/Bbl
 Production Rate _____ Bbl/Day
 Separator Pressure and Temperature _____ PSIG _____ °F.
 Oil Gravity at 60°F. _____ °API
 Datum _____ Ft. Subsea
 Original Gas Cap _____

WELL CHARACTERISTICS

Elevation 7155 GL _____ Ft.
 Total Depth PD 8130 TD 8175 _____ Ft.
 Producing Interval 6822-7122 _____ Ft.
 Tubing Size and Depth 2 7/8 In. to 7148 _____ Ft.
 Productivity Index _____ Bbl/D/PSI @ _____ Bbl/Day
 Last Reservoir Pressure 1648 PSIG @ 6994 _____ Ft.
 Date February 26, 1986
 Reservoir Temperature 170 °F. @ 6994 _____ Ft.
 Status of Well Shut in since September 10, 1985
 Pressure Gauge Amerada
 Normal Production Rate _____ Bbl/Day
 Gas/Oil Ratio _____ SCF/Bbl
 Separator Pressure and Temperature _____ PSIG, _____ °F.
 Base Pressure _____ PSIA
 Well Making Water _____ % Cut

SAMPLING CONDITIONS

Sampled at 6994 _____ Ft.
 Status of Well Shut in
 Gas/Oil Ratio _____ SCF/Bbl
 Separator Pressure and Temperature _____ PSIG, _____ °F.
 Tubing Pressure 354 _____ PSIG
 Casing Pressure 1312 _____ PSIG
 Sampled by Tefteller, Inc.
 Type Sampler Wofford

REMARKS:

CORE LABORATORIES, INC.

Reservoir Fluid Analysis

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Well Lottie No. 1

SUMMARY OF SAMPLES RECEIVED IN LABORATORY

Subsurface Fluid Samples

Laboratory Bubble Point Pressure

<u>Cylinder Number</u>	<u>Pressure, PSIG</u>	<u>Temperature, °F.</u>
SS-2049*	1135	72
SS-708	1132	72

* Selected for use in reservoir fluid study.

CORE LABORATORIES, INC.

Reservoir Fluid Analysis

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Well Lottie No. 1

HYDROCARBON ANALYSIS OF RESERVOIR FLUID SAMPLE

<u>Component</u>	<u>Mol Percent</u>	<u>Weight Percent</u>	<u>Density, Gm/Cc @ 60°F.</u>	<u>°API @ 60°F.</u>	<u>Molecular Weight</u>
Hydrogen Sulfide	0.00	0.00			
Carbon Dioxide	0.00	0.00			
Nitrogen	0.08	0.02			
Methane	24.58	3.64			
Ethane	8.79	2.44			
Propane	7.77	3.17			
iso-Butane	1.42	0.77			
n-Butane	4.66	2.50			
iso-Pentane	2.05	1.37			
n-Pentane	2.61	1.74			
Hexanes	3.72	2.88			
Heptanes plus	<u>44.32</u>	<u>81.47</u>	0.8335	38.1	199
	100.00	100.00			

CORE LABORATORIES, INC.
Reservoir Fluid Analysis

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Well Lottie No. 1

VOLUMETRIC DATA OF RESERVOIR FLUID SAMPLE

Saturation pressure (bubble point pressure) = 1482 PSIG @ 170°F.

Specific volume at saturation pressure = 0.02291 ft³/lb @ 170°F. *

Thermal expansion @ 5000 PSIG = 1.05109 V @ 170°F./V @ 75°F.

Compressibility @ 170°F.:

From 5000 PSIG to 4000 PSIG = 8.82×10^{-6} V/V/PSI

From 4000 PSIG to 3000 PSIG = 9.92×10^{-6} V/V/PSI

From 3000 PSIG to 2000 PSIG = 11.09×10^{-6} V/V/PSI

From 2000 PSIG to 1482 PSIG = 12.41×10^{-6} V/V/PSI

CO₂

* DENSITY FOR ADJUSTING PRESSURES
TO DATUM:

$$.02291 \text{ ft}^3/\text{lb} \rightarrow 43.649 \text{ lb/ft}^3$$

$$\frac{43.649 \text{ lb/ft}^3}{144 \text{ in}^2/\text{ft}^2} = .303 \text{ lb/in}^2 \text{ per ft}$$

CORE LABORATORIES, INC.

Reservoir Fluid Analysis

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 Well Lottie No. 1

PRESSURE-VOLUME RELATIONS AT 170°F.
(Constant Composition Expansion)

<u>Pressure,</u> <u>PSIG</u>	<u>Relative</u> <u>Volume(1)</u>	<u>Y</u> <u>Function(2)</u>
5000	0.9642	
4500	0.9683	
4000	0.9728	
3500	0.9776	
3000	0.9826	
2500	0.9878	
2000	0.9936	
1800	0.9960	
1700	0.9973	
1648(3)	0.9979	
1600	0.9985	
1500	0.9998	
1482(4)	1.0000	
1462	1.0058	
1444	1.0112	
1430	1.0157	
1395	1.0269	
1340	1.0465	2.255
1242	1.0882	2.166
1096	1.1671	2.079
936	1.2932	1.958
793	1.4575	1.864
673	1.6631	1.773
522	2.0745	1.664
396	2.6922	1.561
288	3.6447	1.490

- (1) Relative Volume: V/V_{sat} is barrels at indicated pressure per barrel at saturation pressure.
- (2) Y Function = $\frac{(P_{sat}-P)}{(P_{abs})(V/V_{sat}-1)}$
- (3) Reservoir Pressure
- (4) Bubble Point Pressure

*Reservoir Fluid Analysis*DIFFERENTIAL VAPORIZATION AT 170°F.

Pressure, PSIG	Solution Gas/Oil Ratio(1)	Relative Oil Volume(2)	Relative Total Volume(3)	Oil Density, Gm/Cc	Deviation Factor, Z	Gas Formation Volume Factor(4)	Incremental Gas Gravity
1482	588	1.380	1.380	0.6991			
1300	537	1.358	1.465	0.7045	0.852	0.01179	0.711
1100	480	1.333	1.605	0.7113	0.865	0.01412	0.721
900	423	1.307	1.824	0.7160	0.878	0.01747	0.731
700	365	1.281	2.184	0.7252	0.896	0.02281	0.757
500	305	1.253	2.881	0.7327	0.914	0.03231	0.794
300	241	1.222	4.576	0.7411	0.939	0.05426	0.888
153	184	1.192	8.692	0.7489	0.962	0.10424	1.032
90	142	1.166	14.566	0.7558	0.973	0.16868	1.231
0	0	1.055		0.7769			1.921
		at 60°F. = 1.000					

Gravity of Residual Oil = 40.9°API @ 60°F.

- (1) Cubic feet of gas at 15.025 psia and 60°F. per barrel of residual oil at 60°F.
- (2) Barrels of oil at indicated pressure and temperature per barrel of residual oil at 60°F.
- (3) Barrels of oil plus liberated gas at indicated pressure and temperature per barrel of residual oil at 60°F.
- (4) Cubic feet of gas at indicated pressure and temperature per cubic foot at 15.025 psia and 60°F.

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitability of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.

Reservoir Fluid Analysis

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 Well Lottie No. 1

VISCOSITY DATA AT 170°F.

<u>Pressure, PSIG</u>	<u>Oil Viscosity, Centipoise</u>	<u>Calculated Gas Viscosity, Centipoise</u>	<u>Oil/Gas Viscosity Ratio</u>
5000	0.69		
4000	0.64		
3000	0.59		
2000	0.55		
1648 (1)	0.53		
1482 (2)	0.52		
1300	0.54	0.0150	36.0
1100	0.59	0.0144	41.0
900	0.65	0.0139	46.8
700	0.77	0.0133	57.9
500	0.92	0.0128	71.9
300	1.08	0.0120	90.0
153	1.21	0.0112	108.0
90	1.27	0.0105	120.9
0	1.33		

- (1) Reservoir Pressure
- (2) Bubble Point Pressure

CORE LABORATORIES, INC.

Reservoir Fluid Analysis

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SEPARATOR TESTS OF RESERVOIR FLUID SAMPLE

Separator Pressure, PSIG	Temp., °F.	Gas/Oil Ratio (1)	Gas/Oil Ratio (2)	Tank Oil Gravity, °API @ 60°F.	Formation Volume Factor(3)	Separator Volume Factor(4)	Gas Gravity
50 to 0	100 70	427 51	447 <u>51</u> 498	 42.7	 1.305	1.046 1.004	0.881* 1.275
100 to 0	100 70	366 94	393 <u>95</u> 488	 42.9	 1.298	1.074 1.006	0.829* 1.326
125 to 0	100 70	344 115	374 <u>116</u> 490	 42.9	 1.299	1.087 1.005	0.812* 1.330
150 to 0	100 70	325 133	357 <u>134</u> 491	 42.9	 1.300	1.099 1.005	0.794* 1.330

- (1) Gas/Oil Ratio in cubic feet of gas at 15.025 psia and 60°F. per barrel of oil at indicated pressure and temperature.
- (2) Gas/Oil Ratio in cubic feet of gas at 15.025 psia and 60°F. per barrel of stock tank oil at 60°F.
- (3) Formation Volume Factor is barrels of saturated oil at 1482 psig and 170°F. per barrel of stock tank oil at 60°F.
- (4) Separator Volume Factor is barrels of oil at indicated pressure and temperature per barrel of stock tank oil at 60°F.

HYDROCARBON ANALYSES OF SEPARATOR GAS SAMPLES

Component	50 PSIG, 100°F.		100 PSIG, 100°F.		125 PSIG, 100°F.		150 PSIG, 100°F.		
	Mol	Percent	GPM	Mol	Percent	GPM	Mol	Percent	GPM
Hydrogen Sulfide	0.00			0.00			0.00		
Carbon Dioxide	0.00			0.00			0.00		
Nitrogen	0.20			0.22			0.23		
Methane	62.33			66.63			68.39		
Ethane	18.57		5.065	17.97		4.902	17.58		4.795
Propane	11.60		3.260	9.81		2.757	9.04		2.541
iso-Butane	1.38		0.461	1.09		0.364	0.95		0.317
n-Butane	3.45		1.110	2.57		0.827	2.30		0.740
iso-Pentane	0.75		0.280	0.54		0.202	0.48		0.179
n-Pentane	0.71		0.262	0.50		0.185	0.45		0.166
Hexanes	0.46		0.182	0.33		0.131	0.30		0.119
Heptanes plus	0.55		0.236	0.34		0.147	0.28		0.121
	100.00		10.856	100.00		9.515	100.00		8.978

Gas gravity (Air = 1.000): 0.881

0.829

0.794

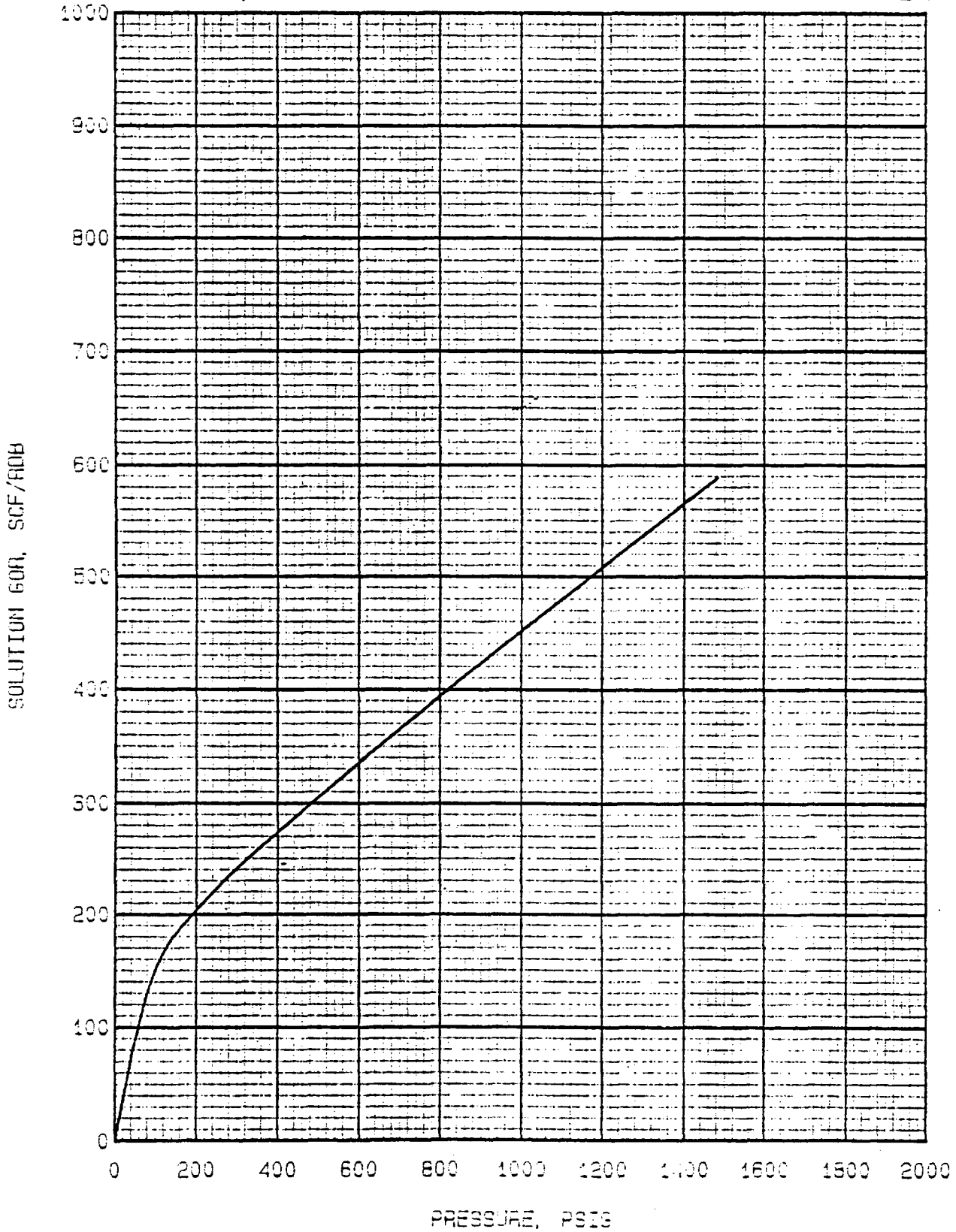
Gross heating value (BTU
per cubic foot of dry gas
at 15.025 psia and 60°F.): 1549

1465

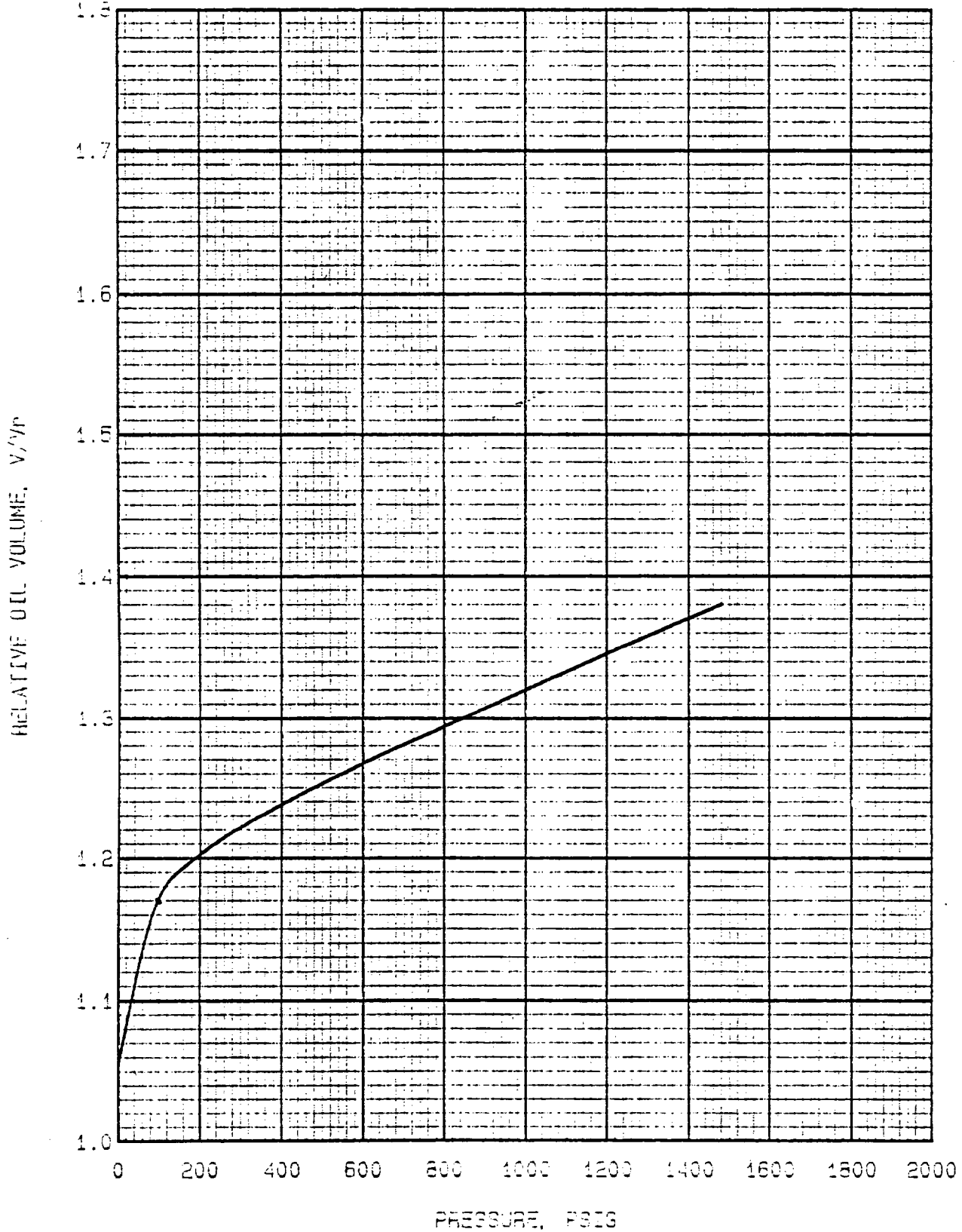
1438

1410

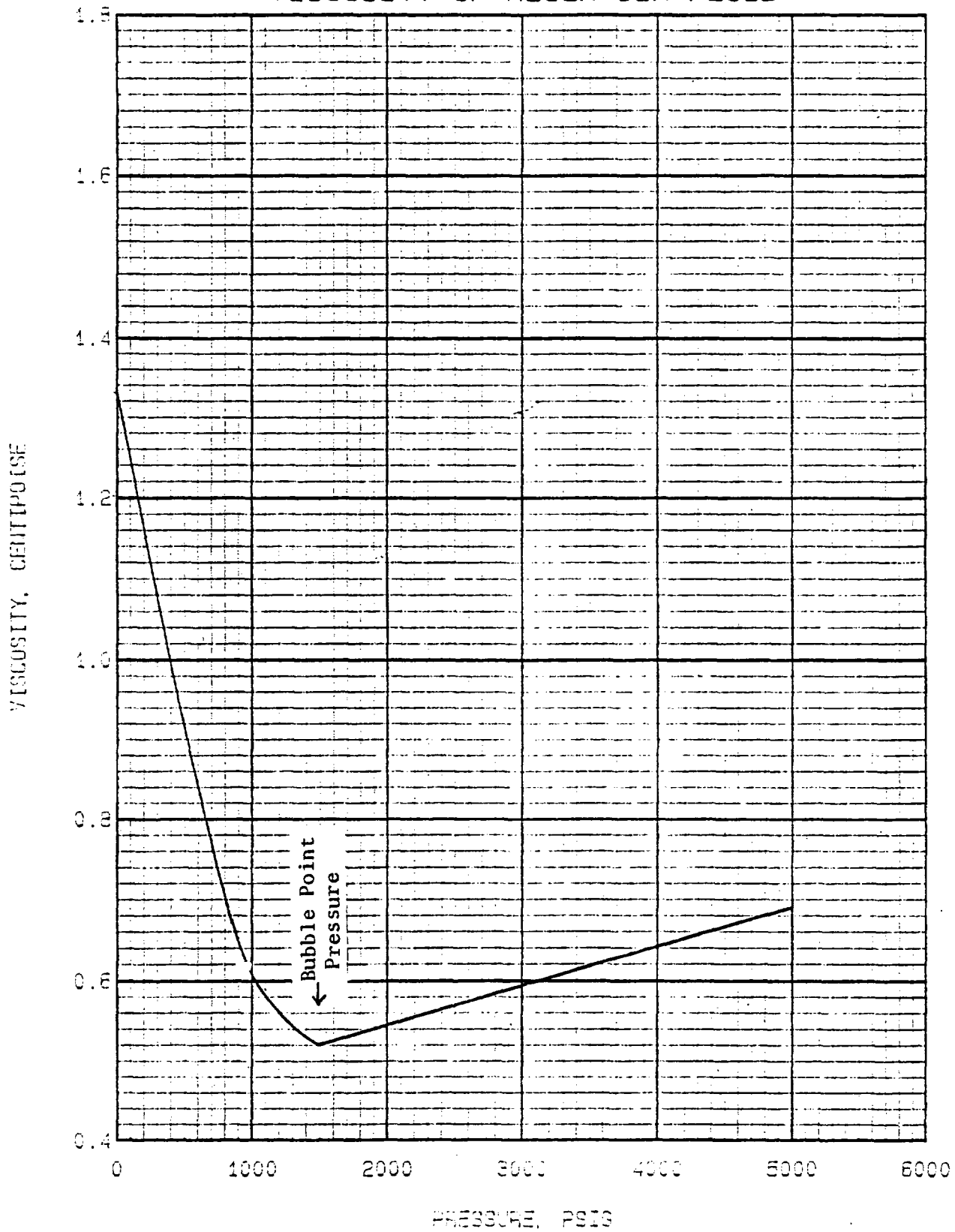
SOLUTION GAS/OIL RATIO DURING DIFFERENTIAL VAPORIZATION

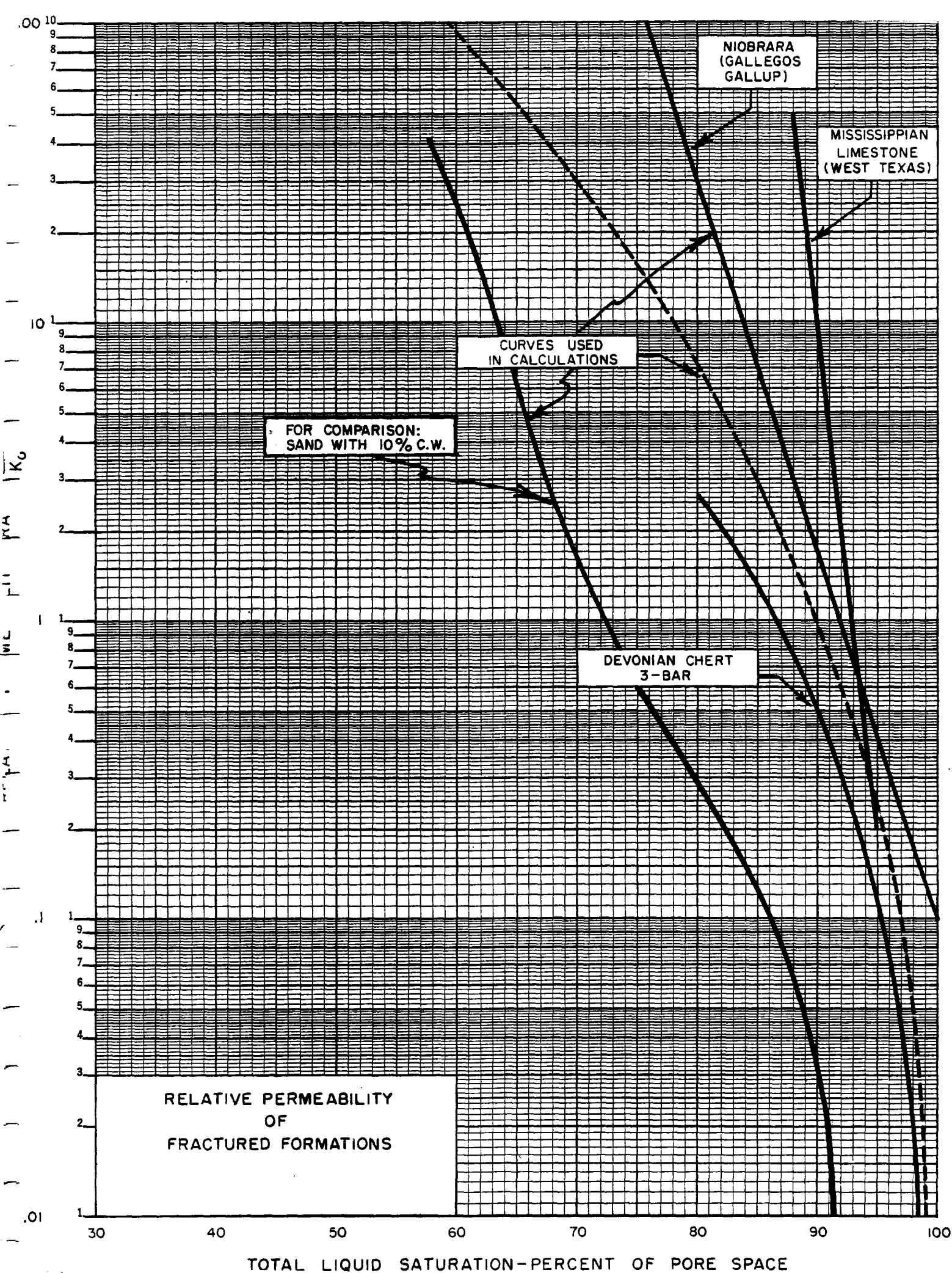


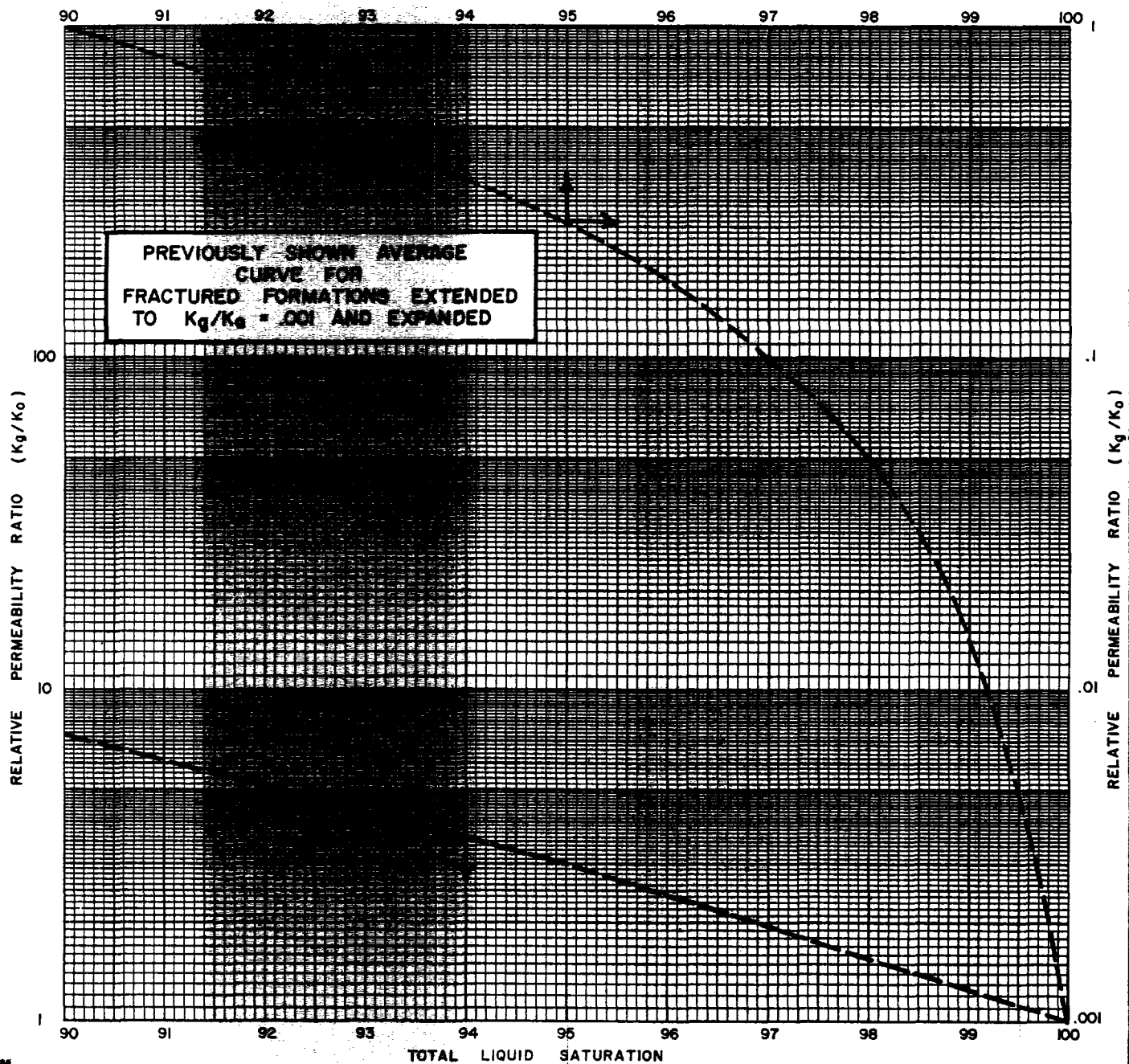
RELATIVE OIL VOLUME DURING DIFFERENTIAL VAPORIZATION



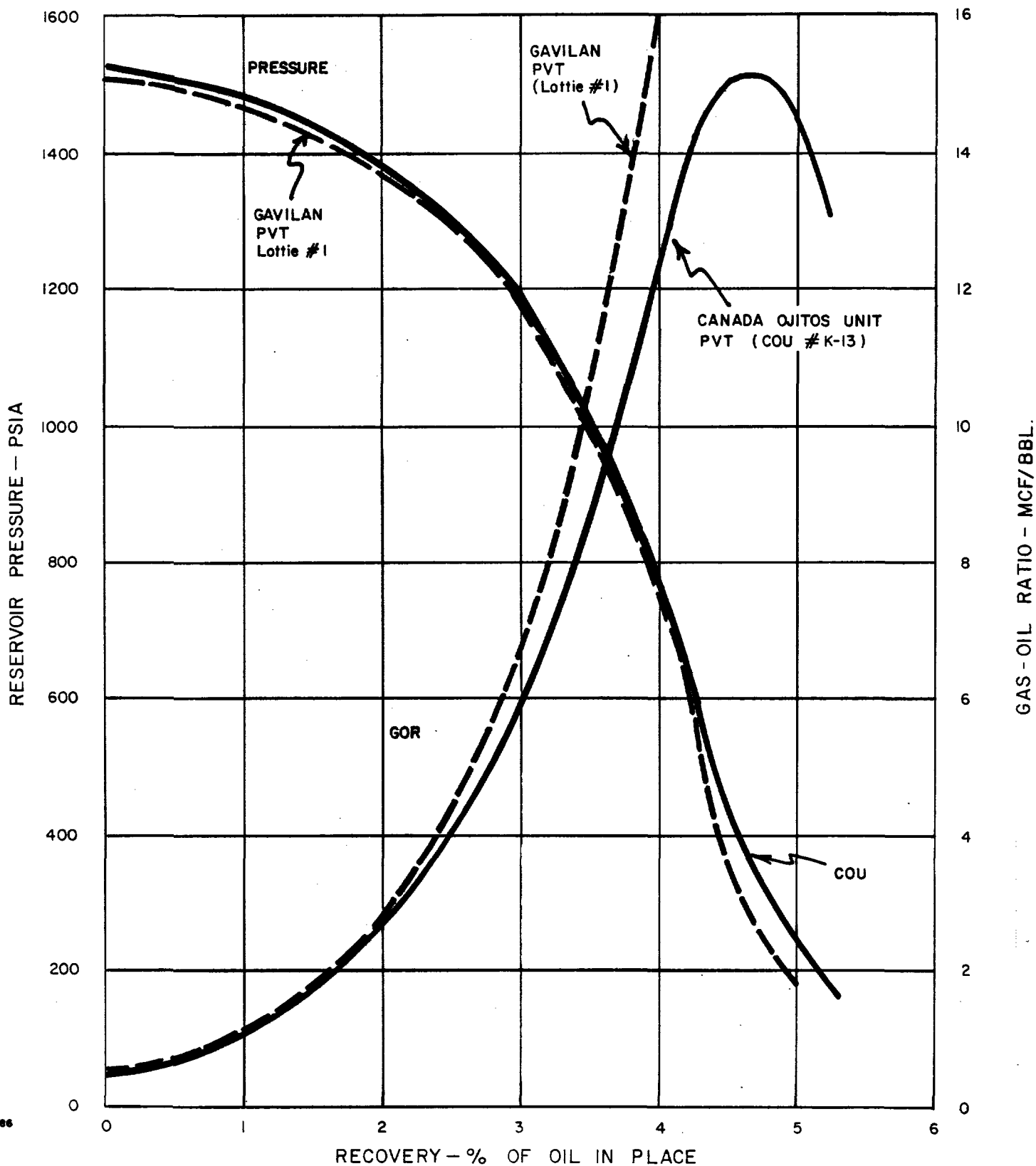
VISCOSITY OF RESERVOIR FLUID







CALCULATED SOLUTION GAS DRIVE
PRODUCTION HISTORIES
For
FRACTURED FORMATIONS (CURVE "A")
AND
PVT DATA FOR WEST PUERTO CHIQUITO (COU K-13)
AND GAVILAN (LOTTIE #1)



CORE LABORATORIES, INC.

Reservoir Fluid Analysis

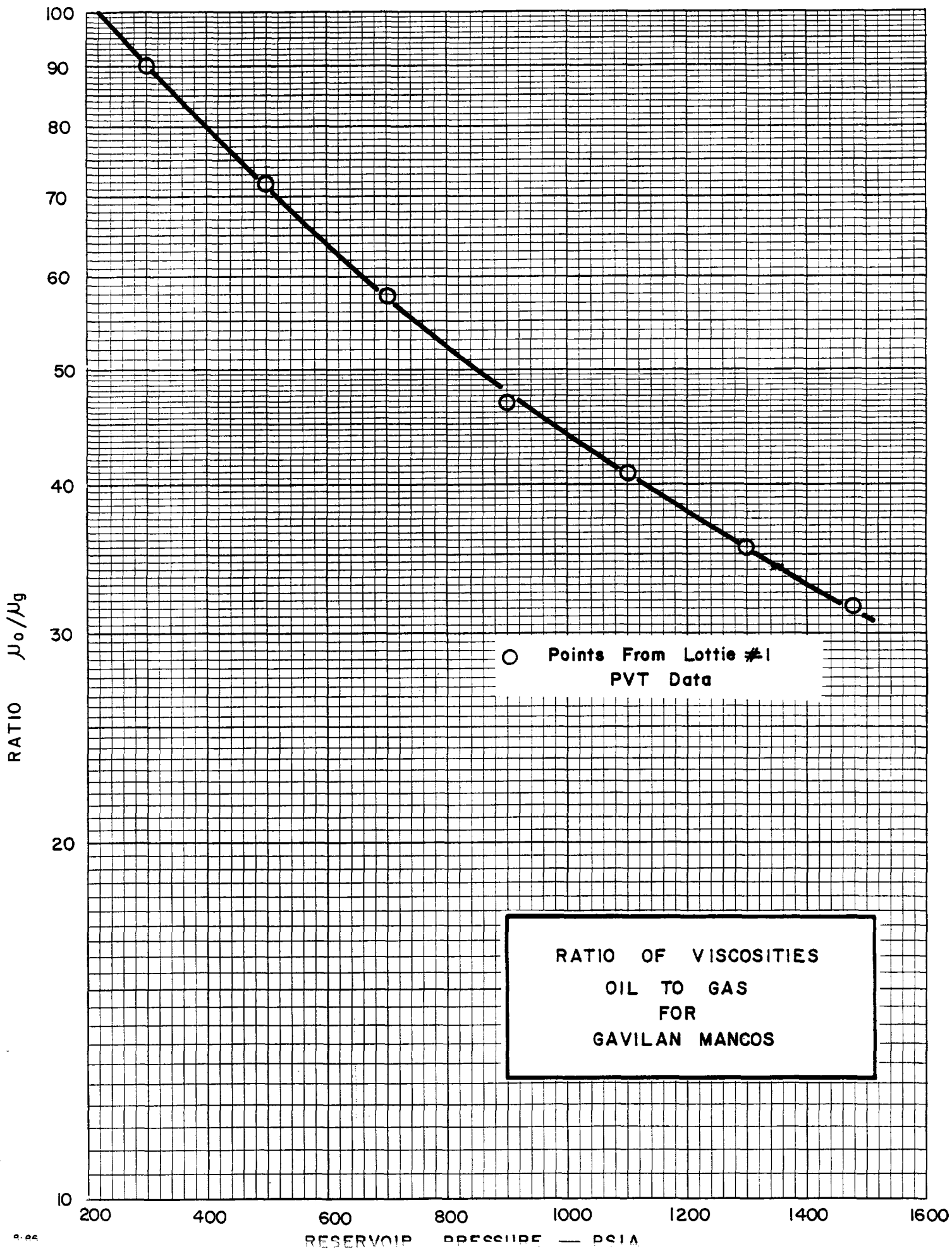
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 Well Lottie No. 1

VISCOSITY DATA AT 170°F.

<u>Pressure,</u> <u>PSIG</u>	<u>Oil Viscosity,</u> <u>Centipoise</u>	<u>Calculated</u> <u>Gas Viscosity,</u> <u>Centipoise</u>	<u>Oil/Gas</u> <u>Viscosity</u> <u>Ratio</u>
5000	0.69		
4000	0.64		
3000	0.59		
2000	0.55		
1648 (1)	0.53		
1482 (2)	0.52		
1300	0.54	0.0156	33.3
1100	0.59	0.0150	36.0
900	0.65	0.0144	41.0
700	0.77	0.0139	46.8
500	0.92	0.0133	57.9
300	1.08	0.0128	71.9
153	1.21	0.0120	90.0
90	1.27	0.0112	108.0
0	1.33	0.0105	120.9

est

- (1) Reservoir Pressure
 (2) Bubble Point Pressure



TOTAL LIQUID SATURATION
VERSUS PRESSURE
GAVILAN PVT DATA

TOTAL LIQUID SATURATION — PERCENT

96

97

98

99

100

96

97

98

99

100

IF B.P. IS 1500# → 1500

1400

1300

HORIZONTAL SCALE

IF B.P. IS 1550# → 1550

1450

1350

IF B.P. IS 1600# → 1600

1500

1400

RELATIVE PERMEABILITY RATIOS
ESTIMATED FROM FIELD DATA

McHUGH NATIVE SON #2

Top A Zone +485

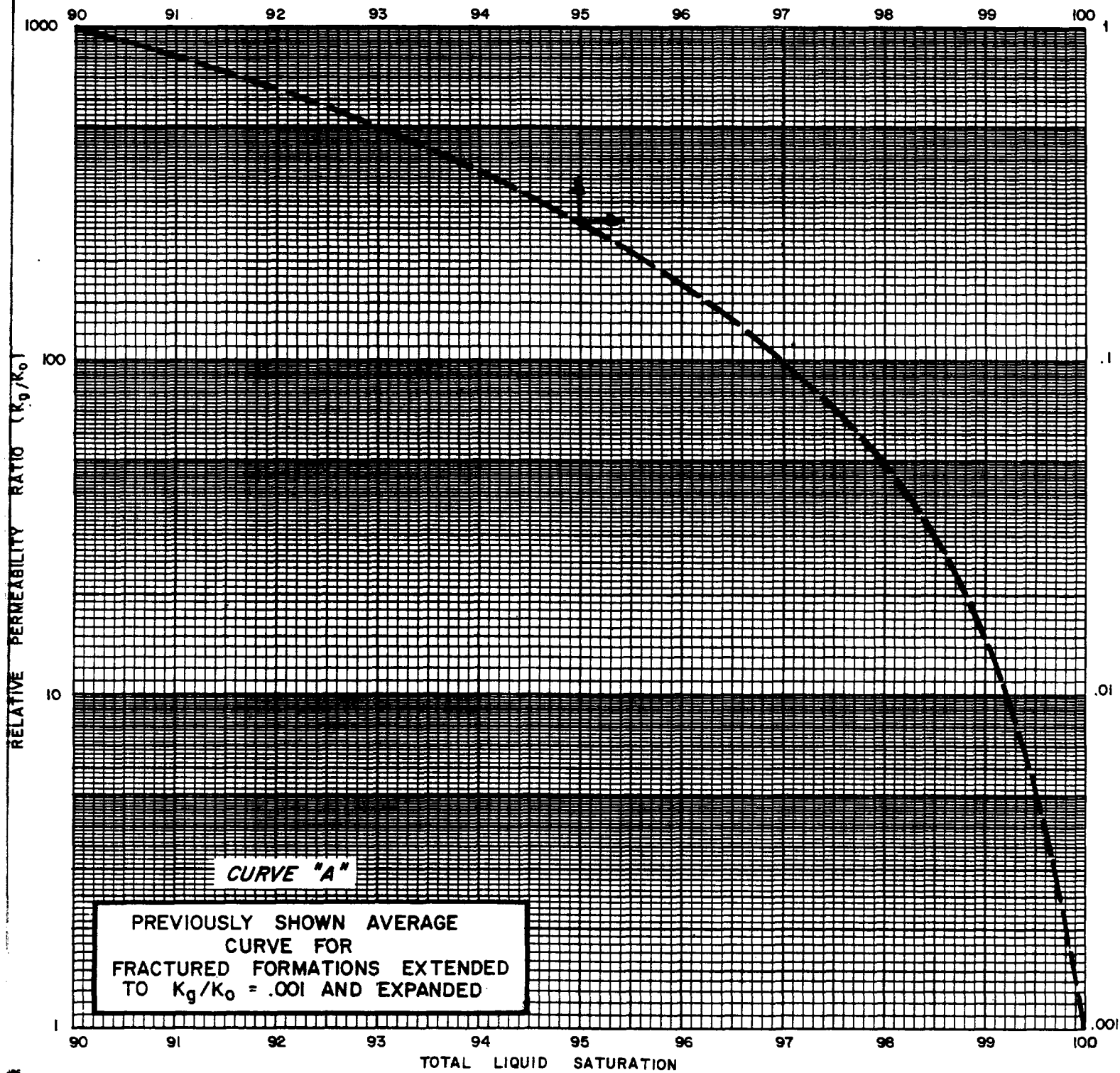
(Top A Zone Δ P
from +370) -65#

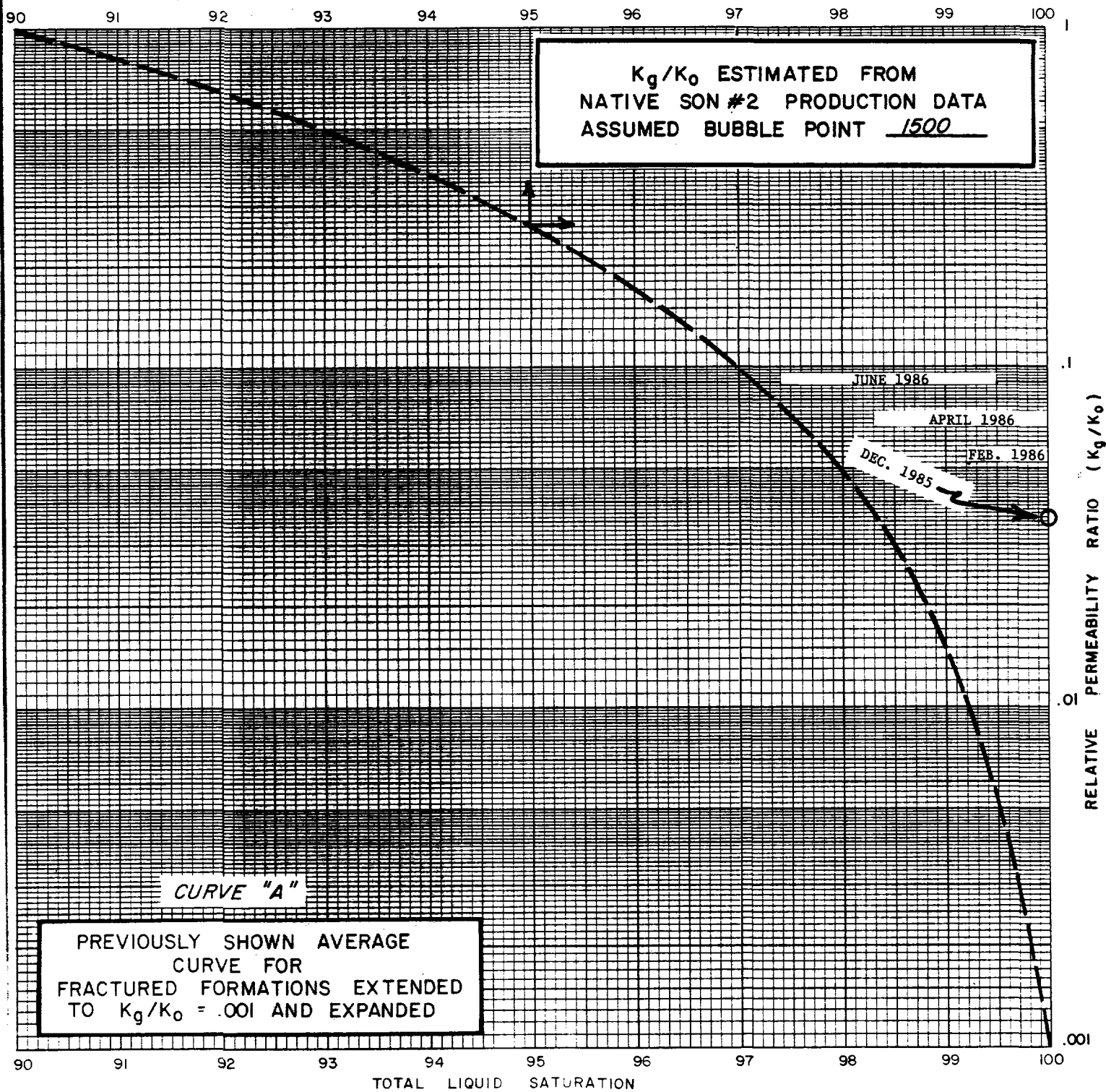
(Base C Zone
from +370) +35#

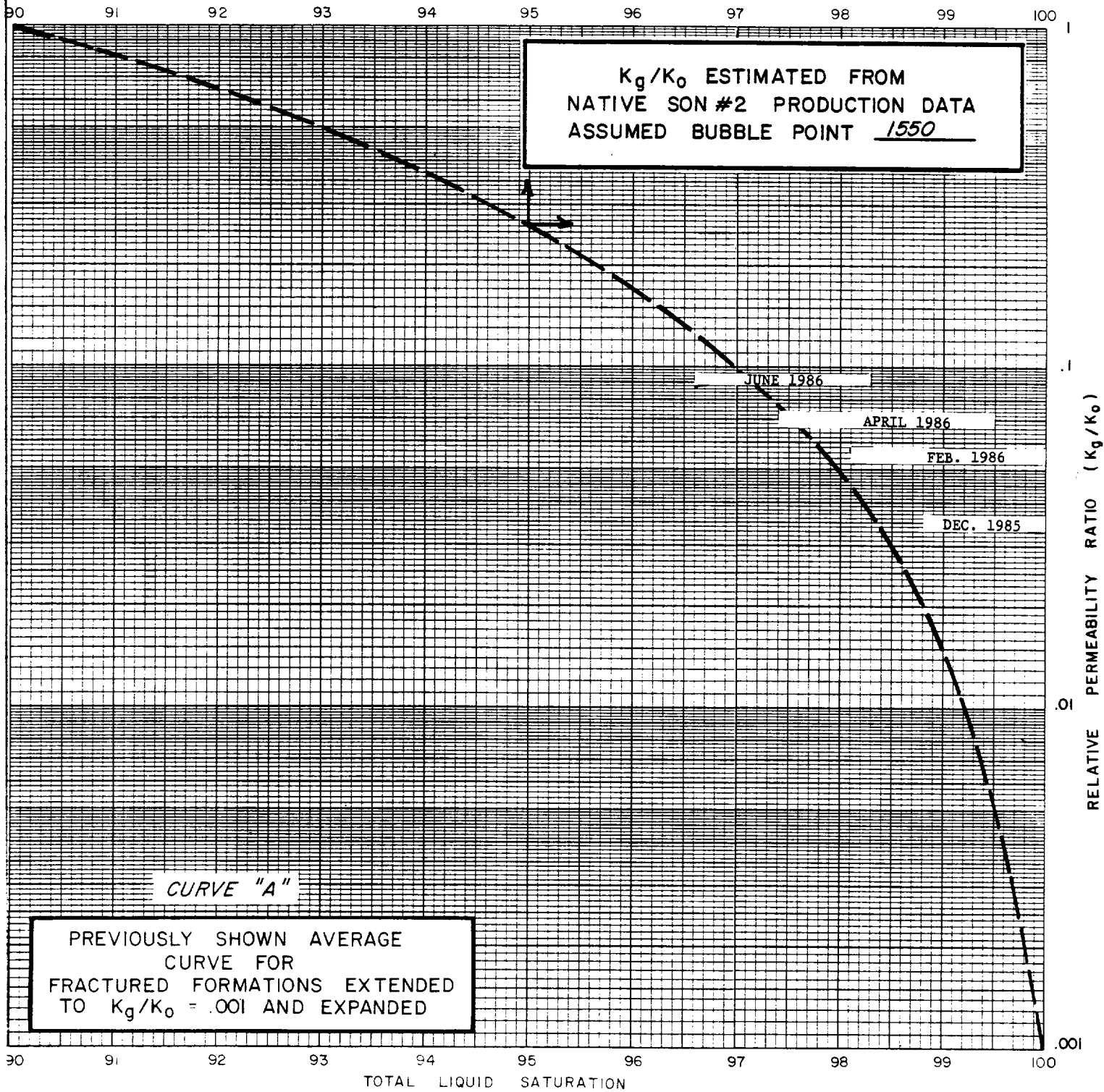
Month	<u>Dec. 1985</u>	<u>Feb. 1986</u>	<u>April 1986</u>	<u>June 1986</u>
Pressures:				
Est. Datum	1575	1540	1500	1450
Est. Top A Zone	1510	1475	1435	1385
Est. Bottom C Zone	1610	1575	1535	1485
Average P	1560	1525	1485	1435
GOR	1447	1934	2259	2835
Rs	580	580	570	560
μ_o/μ_g	30	31	32	33
Bg (SCF/bbl)	584	571	556	537
Bo	1.38	1.38	1.38	1.38
Kg/Ko*	.036	.055	.069	.093
Total liquid saturation for				
B.P. = 1500#	100	99.2-100	98.3-100	97.4-99.5
Total liquid saturation for				
B.P. = 1550#	98.8-100	98.1-100	97.4-99.5	96.6-98.3
Total liquid saturation for				
B.P. = 1600#	97.8-100	97.2-99.2	96.6-98.1	95.9-97.4

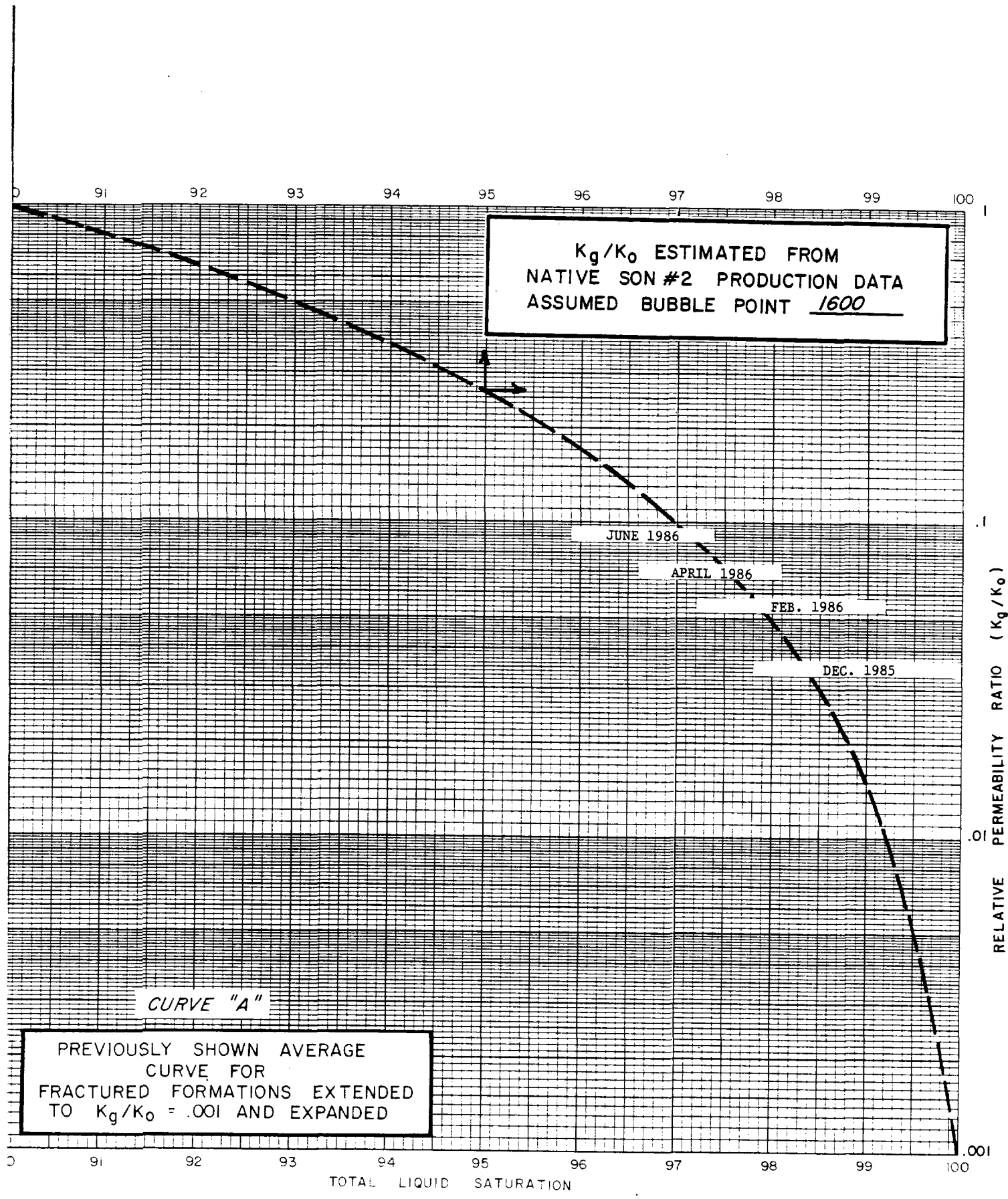
$$* \text{ Kg/Ko} = \left(\frac{R - R_s}{B_o B_g} \right) \left(\frac{\mu_g}{\mu_o} \right)$$

R = Produced GOR, cf/bbl
Rs = Gas in Solution, cf/bbl
Bo = Oil FVF, reservoir bbl/stock tank bbl
Bg = Gas FVF, SCF/bbl
 μ_g/μ_o = Ratio of Gas to Oil Viscosities









Fluid Properties

Fluid property information was available for three wells:

1. McHugh, Loddy #1
2. McHugh, Native Son #3
3. BMG, Canado Ojitos Unit #12-11

After correcting the fluid property information to a common set of separator conditions, the Loddy #1 and COU #12-11 samples agreed quite closely both with respect to bubble point pressure (1482 psig and 1519 psig respectively) and trend in oil formation volume factor. It was concluded that the Native Son #3 sample was therefore not representative. The remaining samples were both taken after significant production from their respective pools and it could not be determined if the lab reported bubble point pressure reflected true reservoir conditions or if some gas evolution had occurred prior to sampling. Evidence that a higher bubble point existed initially in the reservoir is found in the absence of initial solution gas-oil ratios early in the life of the pool indicating an early pressure decline below the original bubble point pressure. Consequently, the lab reported data was corrected to an assumed bubble point pressure of 1770 psia which is the original pressure at the top of the Niobrara "A" section of the Gavilan Howard #1 which was found to be oil bearing. The fluid properties contained in the attached tables and plots reflect this extrapolation to the higher bubble point pressure. It should be noted that the adjusted initial dissolved gas-oil ratio for the Loddy #1 (which was the final sample selected) amounted to 646 cubic feet per barrel and agreed quite closely with the initial producing gas-oil ratio of the Rucker Lake #2 which was approximately 650 cubic feet per barrel for several months.

Case Memoranda #1

Case #1 1770