EXXON PRODUCTION RESEARCH COMPANY

CORE ANALYSIS REPORT
SEAHORSE WELL 1

A. T. Clothier
K. A. Coleman
L. E. Reese
J. M. Wooten

Reservoir Division

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EPR.129PS.79

EXXON PRODUCTION RESEARCH COMPANY
POST OFFICE BOX 2189 · HOUSTON, TEXAS 77001

RESERVOIR DIVISION

C. C. MATTAX
MANAGER

October 4, 1979

Mr. J. F. Kirk
Esso Australia Ltd.
G. P. O. Box 4047
Sydney, N.S.W., 2001
Australia

ATTN: Mr. C. A. Langner

Dear Sir:

EPR.129PS.79 - Core Analysis Report
Seahorse Well No. 1

The attached report includes results of all core analysis tests on Seahorse Well Number 1. The program included a waterflood of composite cores, centrifuge tests for water-oil imbibition capillary pressure as well as horizontal and vertical permeabilities and porosities. Results of the special core analysis tests are quite consistent and are expected to be representative of the reservoir material found in this well.

Very truly yours,

C. C. MATTAX

By Clay Gruesbeck
C. Gruesbeck

CG:eeg

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INTRODUCTION

This report includes results of all tests performed on cores from Seahorse Well 1. The work was authorized in a telex of January 5, 1979 from D. A. Collins of Esso Australia to Mattax/Rossen of EPRCo.

The following table shows the tests performed:

Test	Planned	Performed
1. Horizontal permeability, porosity grain density	12	12
2. Vertical permeability, porosity, grain density	5	5
3. Waterflood of composite core @ 160°F and NOBP (Samples from 1425.3-1433.3M)	1	1
4. Water-oil imbibition capillary pressure (Samples from 1425.3-1433.3 M)	4	3

DISCUSSION

Conventional Core Data

All of the core pieces received from Esso Australia are listed in Table I. All of the plugs that were cut from the available core material are listed in Table II. The permeability, porosity, grain density, and tests performed are also listed in Table II. All tests were performed at 3500 psi overburden pressure.

Most horizontal and vertical permeability measurements were made using nitrogen and porosity measurements were made using the Boyle's Law Procedure.

Permeabilities and porosities for samples used in special core analysis tests were obtained during the tests and the permeability is reported as $K_{o\ (cw)}$.

Water-Oil Relative Permeability

The waterflood test was performed at reservoir conditions of 160°F and 2000 psi back pressure. The oil phase used in this test was a bottom hole sample of Seahorse crude with a saturation pressure of 1572 psi at 160°F. The brine phase used was a Laboratory synthetic brine containing 80,000 ppm NaCl and 20,000 KCl.

Results of the waterflood tests are shown in Figures 1-3 and computer output sheets for calculation of relative permeability data [1*] are attached at the end of the report.

Water-Oil Imbibition Capillary Pressure

Water-Oil imbibition capillary pressure tests were performed in the centrifuge using three samples from the interval 1425.3 - 1433.3 M. A fourth test failed in the centrifuge and only permeability and porosity data were obtained.

Centrifuge data showing average water saturations at equilibrium for each of the applied capillary pressures are shown in Table III. Calculated face saturations [2,3*] are plotted versus capillary pressure in Figures 4-6.

These tests are normally performed in two parts. The core was initially saturated with dead Seahorse crude oil with connate water in place and contacted with brine at a temperature of 160°F so that oil production resulting from spontaneous imbibition of brine can be measured. After approximately a week, the samples are transferred to the centrifuge to obtain data that describes the forced portion of the capillary pressure test.

* References are shown at the end of the text.

REFERENCES

[1]Johnson, E.F.: Bossler, D.P.; and Naumann, V.O.: "Calculation of Relative Permeability from Displacement Experiments, "Trans. AIME (1959), 216,370.

[2]Hassler, G.L.; and Brunner, E.: "Measurement of Capillary Pressure in Small Core Samples, "Trans. AIME (1945), 160, 114-123.

[3]Slobod, R.L.; Chambers, A.; Phren, W.L. Jr.: "Use of Centrifuge for Determining Connate Water, Residual Oil, and Capillary Pressure Curves for Small Core Samples, "Trans. AIME (1951), 192, 127-134.

Table I

Cores Received

Seahorse 1

Cores Received

1413.34-.47
1425.3-.4
1430.1-.2
1430.75-.85
1433.2-.3
1435.0-.1
1435.42-.55
1435.8-.9
1459.0-.1
1459.1-.2
1459.4-.55
1465.6-.84

Also 1 core 3, loose sand
1 core 5, loose sand
} Not Cut

TABLE II
Core Properties
Seahorse 1

Depth, m	Porosity % PV	Permeability, md $k_{o(cw)}$	Permeability, md k_a	Grain Density gm/cc	Test
1413.36	17.8		72	2.67	P + P*
1413.40V	17.4		63	2.65	P + P
1425.34	26.8	673			
1425.37V	.55		.94	2.58	P + P
1430.13	25.8	638			W-O Imbibition
1430.15					Composite
1430.17					Composite
1430.19					Composite
1430.77					
1430.80					Composite
1430.83					Composite
1433.23					
1433.28	20.6	68.8			W-O Imbibition
1435.03	19.5	1890			W-O Imbibition
1435.07	25.0		870	2.59	P + P
1435.47	17.8		100	2.55	P + P
1435.52V	24.7		37	2.62	P + P
1435.84					
1435.89	27.4		3500	2.66	P + P
1459.03	25.2		287	2.62	P + P
1459.07V	26.4		233	2.40	P + P
1459.13	26.4		340	2.64	P + P
1459.17					
1459.46					
1459.50	25.3		285	2.63	P + P
1465.64					
1465.70	24.4		650	2.64	P + P
1465.78V	23.9		350	2.64	P + P

* Permeability and Porosity

Composite Inlet 1430.15, 1430.17, 1430.19, 1430.80, 1430.83 Outlet

TABLE III

WATER-OIL IMBIBITION CAPILLARY PRESSURE DATA

IN CENTRIFUGE AT 160°F

SEAHORSE WELL

CORE NAME	1430.13	1433.28	1435.03
CORE DEPTH, FEET	1430.13	1433.28	1435.03
PERMEABILITY, KO(CW), MD	638	68.8	1890
POROSITY, PCT. BULK VOLUME	25.8	20.6	19.5
PORE VOLUME, PV, CC	14.7	11.5	11.1
CONNATE WATER, PCT. PV	18.2	7.3	13.4
LENGTH, CM	5.09	5.02	5.09

CAP. PRESSURE (PO-PW), PSI	AVERAGE BRINE SAT., PCT. PV	CAP. PRESSURE (PO-PW), PSI	AVERAGE BRINE SAT., PCT. PV	CAP. PRESSURE (PO-PW), PSI	AVERAGE BRINE SAT., PCT. PV
0	30.1	0	21.0	0	35.4
-0.54	68.6	-0.53	59.7	-0.54	73.9
-1.21	76.8	-1.19	70.2	-1.21	86.5
-2.15	80.9	-2.11	71.9	-2.15	90.2
-4.83	85.6	-4.75	80.6	-4.83	95.6
-10.9	87.7	-10.7	85.0	-10.9	99.2
-19.3	88.4	-19.0	86.7	-19.3	99.2

FIGURE 1

WATERFLOOD PRODUCTION DATA

Field Seahorse Reservoir _____

Well 1 _____

Test Condition 160°F 2000 psi

Core No., Depth, m.	Length cm	S_{cw} % P.V.	k_o (cw) md	μ_o/μ_w
Composite 1430	33.83	27.8	141	0.419

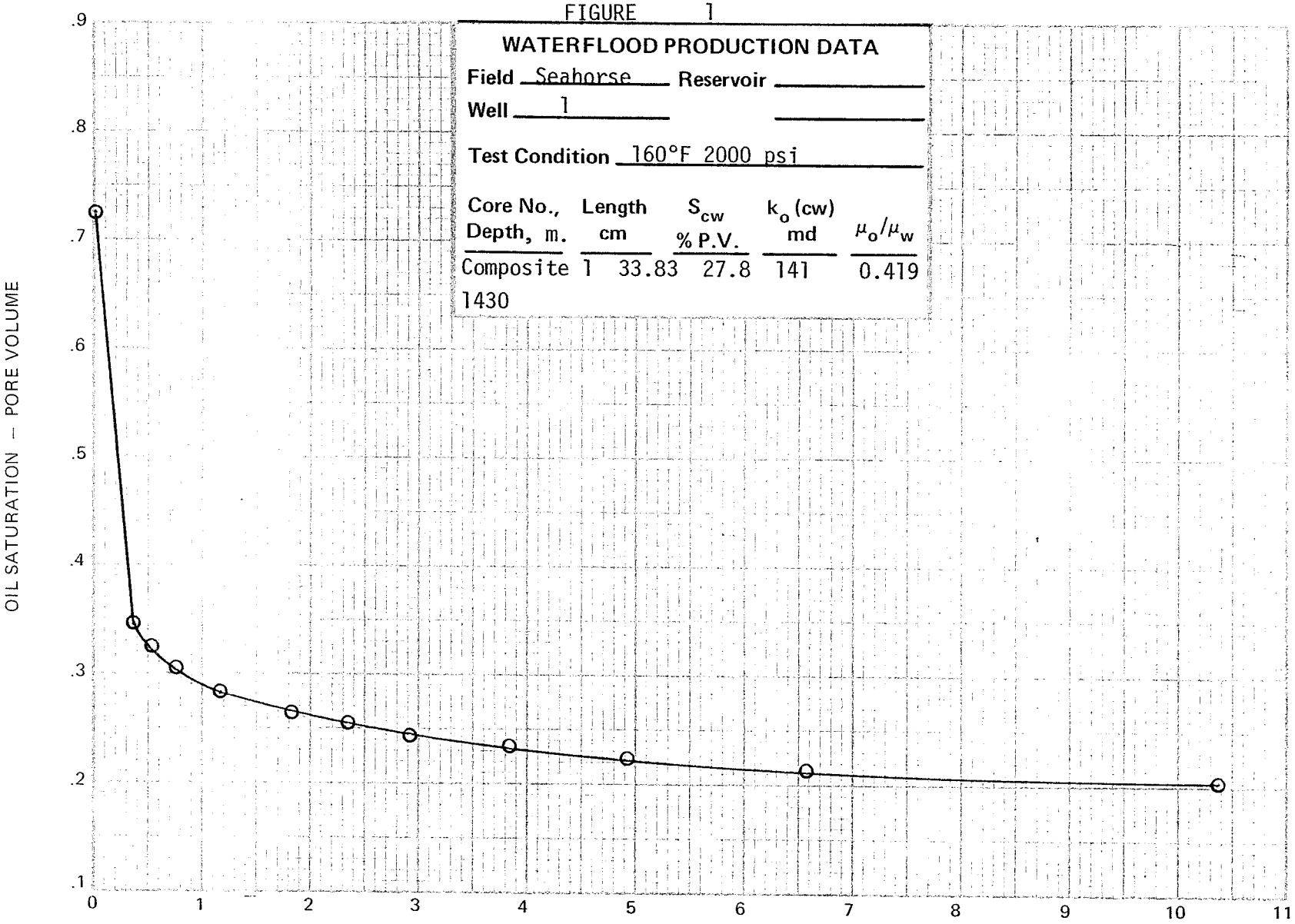


FIGURE 2

OIL-WATER RELATIVE PERMEABILITY BY WATERFLOOD

Field Seahorse Reservoir

Well 1

Core	Composite 1	Porosity, % B.V.	24.2
Depth, m.	1430	Oil Viscosity, cp	0.197
Permeability, k_o (cw), md	141	Brine Viscosity, cp	0.470
Connate Water, % P.V.	27.8		

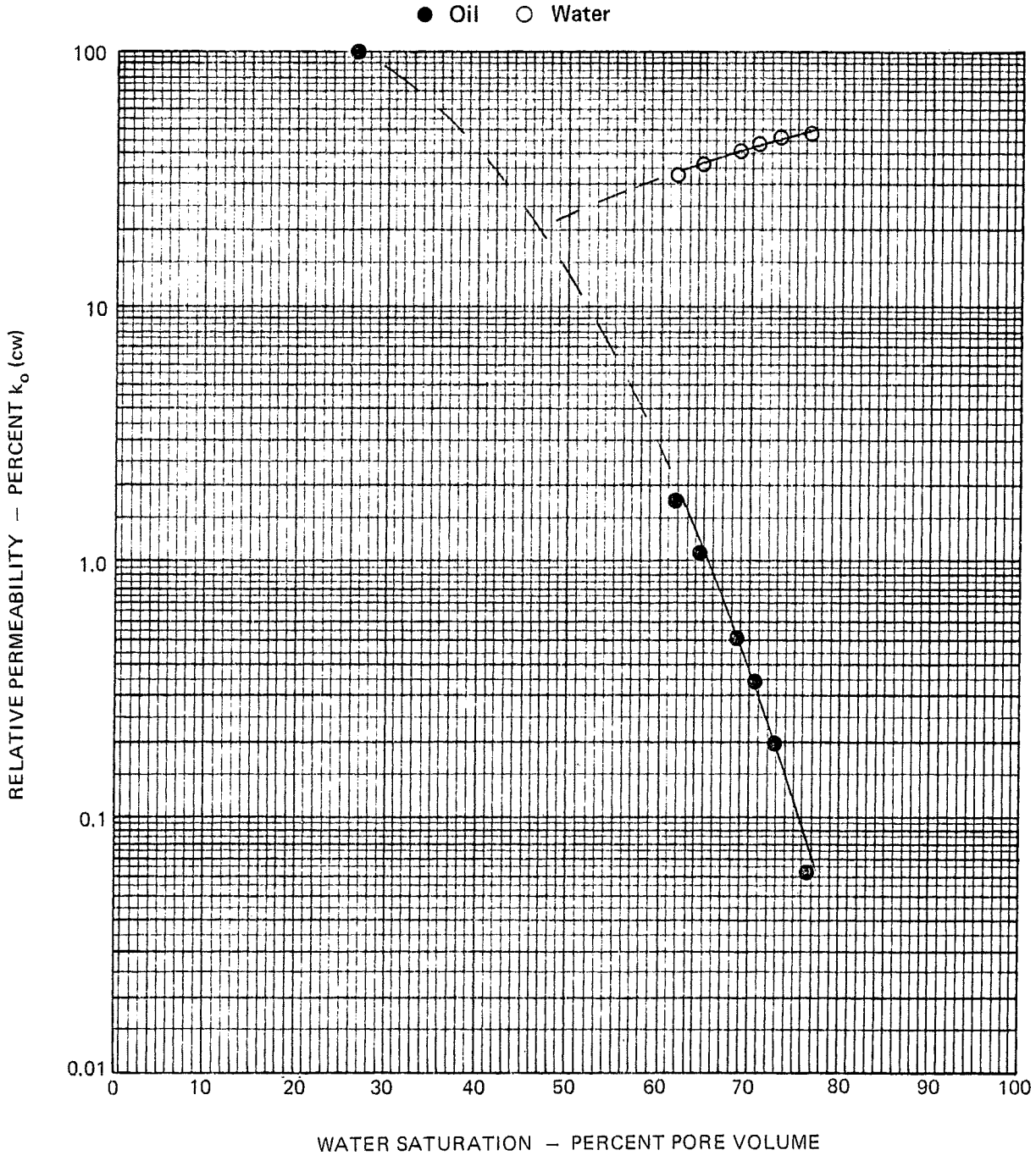


FIGURE 3

OIL-WATER RELATIVE PERMEABILITY RATIO

Field Seahorse Reservoir

Well 1

Core No.,	Depth, m.	Permeability k_o (cw), md	Connate Water % P.V.
Composite 1	1430	141	27.8

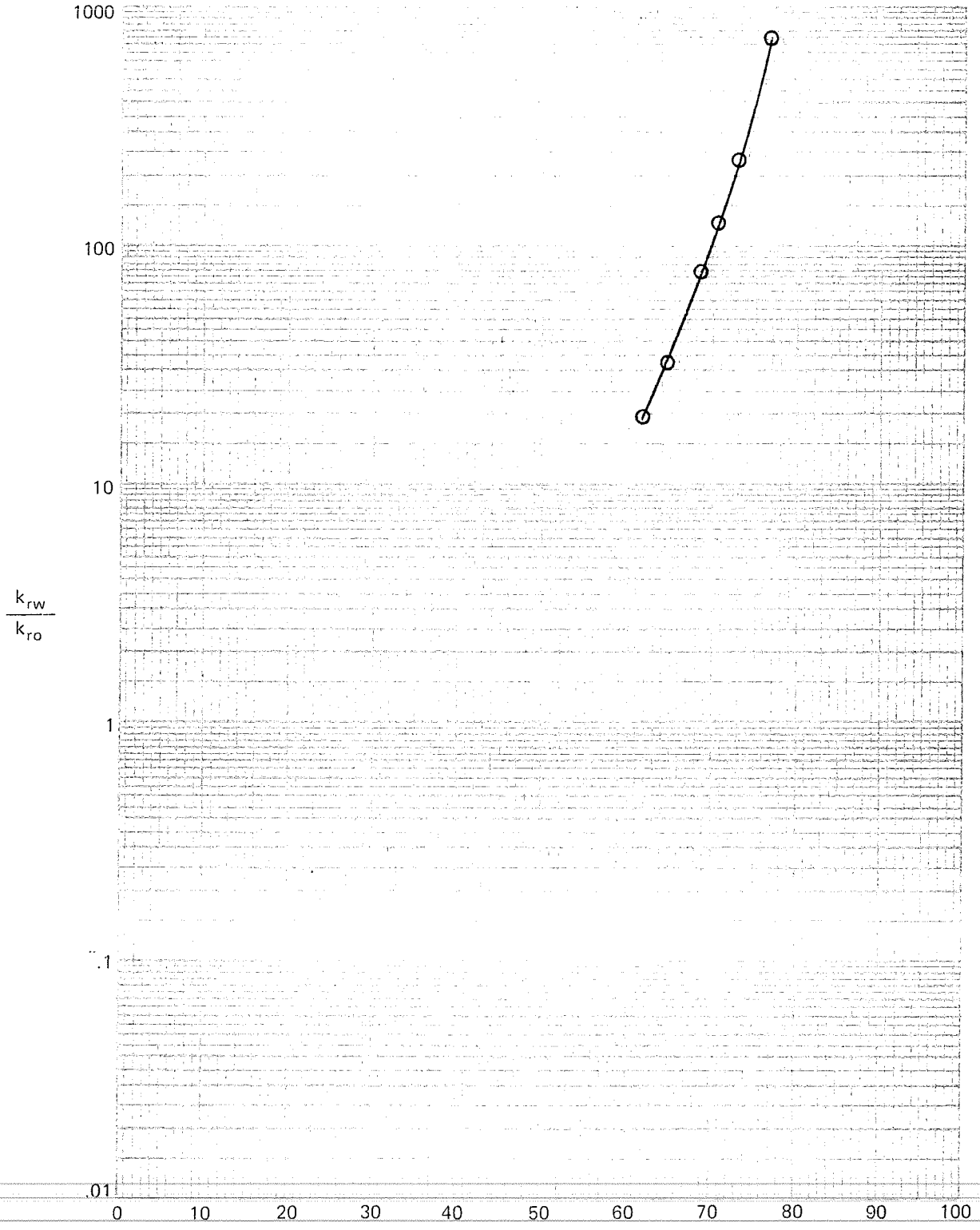


FIGURE 4

WATER-OIL IMBIBITION CAPILLARY PRESSURE BY CENTRIFUGE

Field Seahorse Reservoir _____

Well _____

Core No., Depth, m.	Permeability, k_o(cw), md	Porosity, % B.V.	Connate Water, % P.V.
1430.13	638.	25.8	18.2

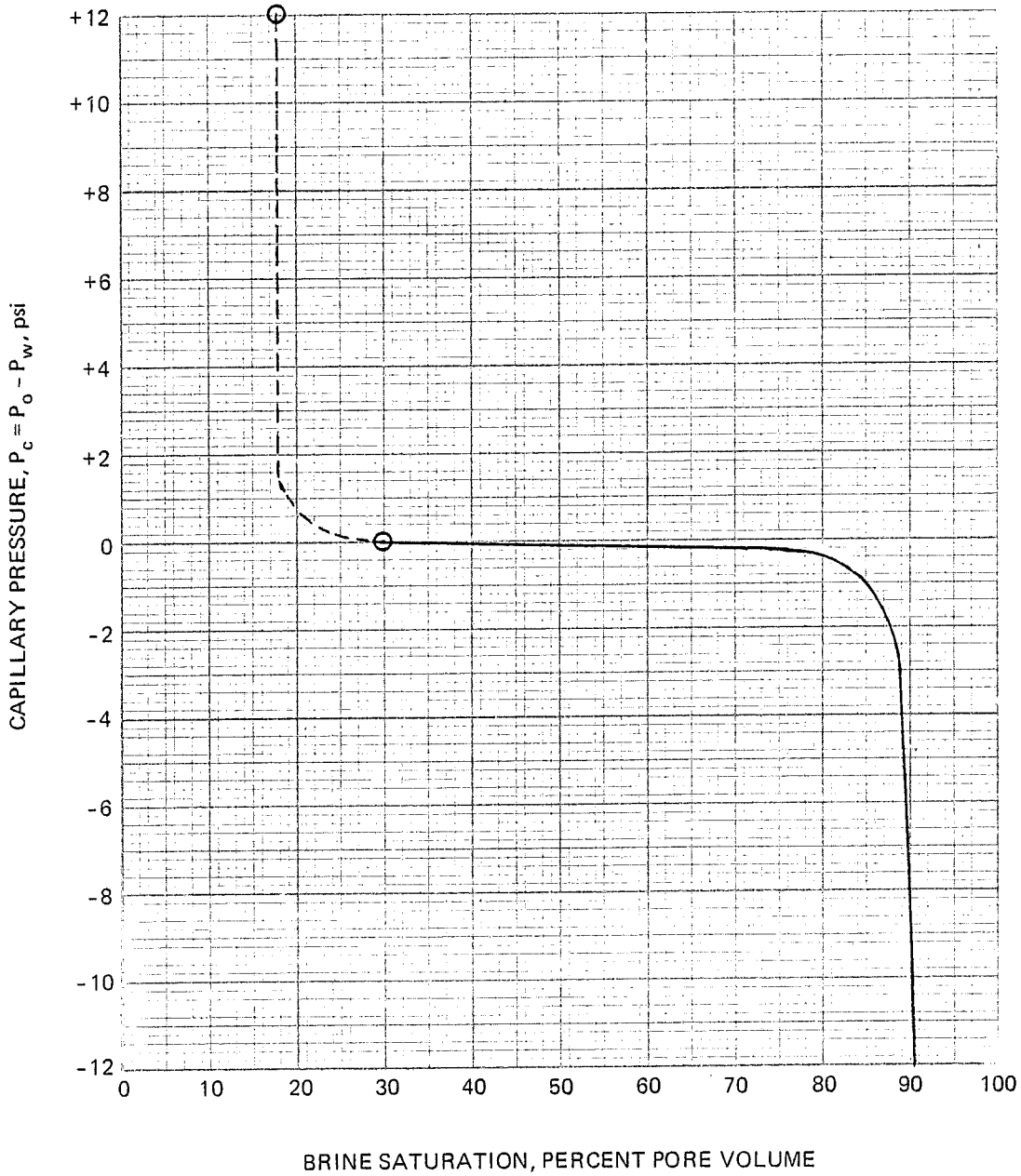


FIGURE 5

WATER-OIL IMBIBITION CAPILLARY PRESSURE BY CENTRIFUGE

Field Seahorse Reservoir _____

Well _____

Core No., Depth, m.	Permeability, k_o(cw), md	Porosity, % B.V.	Connate Water, % P.V.
1433.28	68.8	20.6	7.3

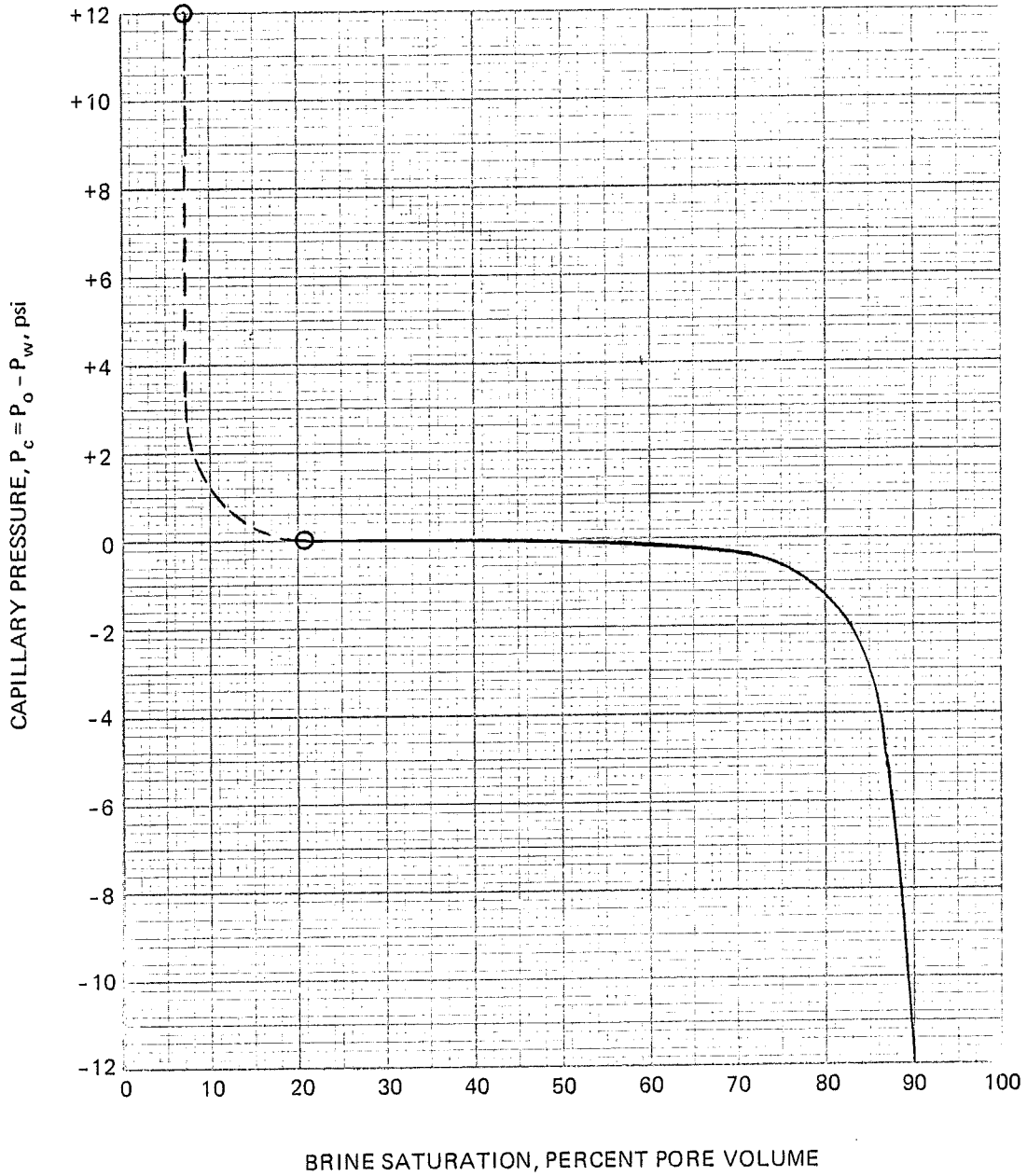


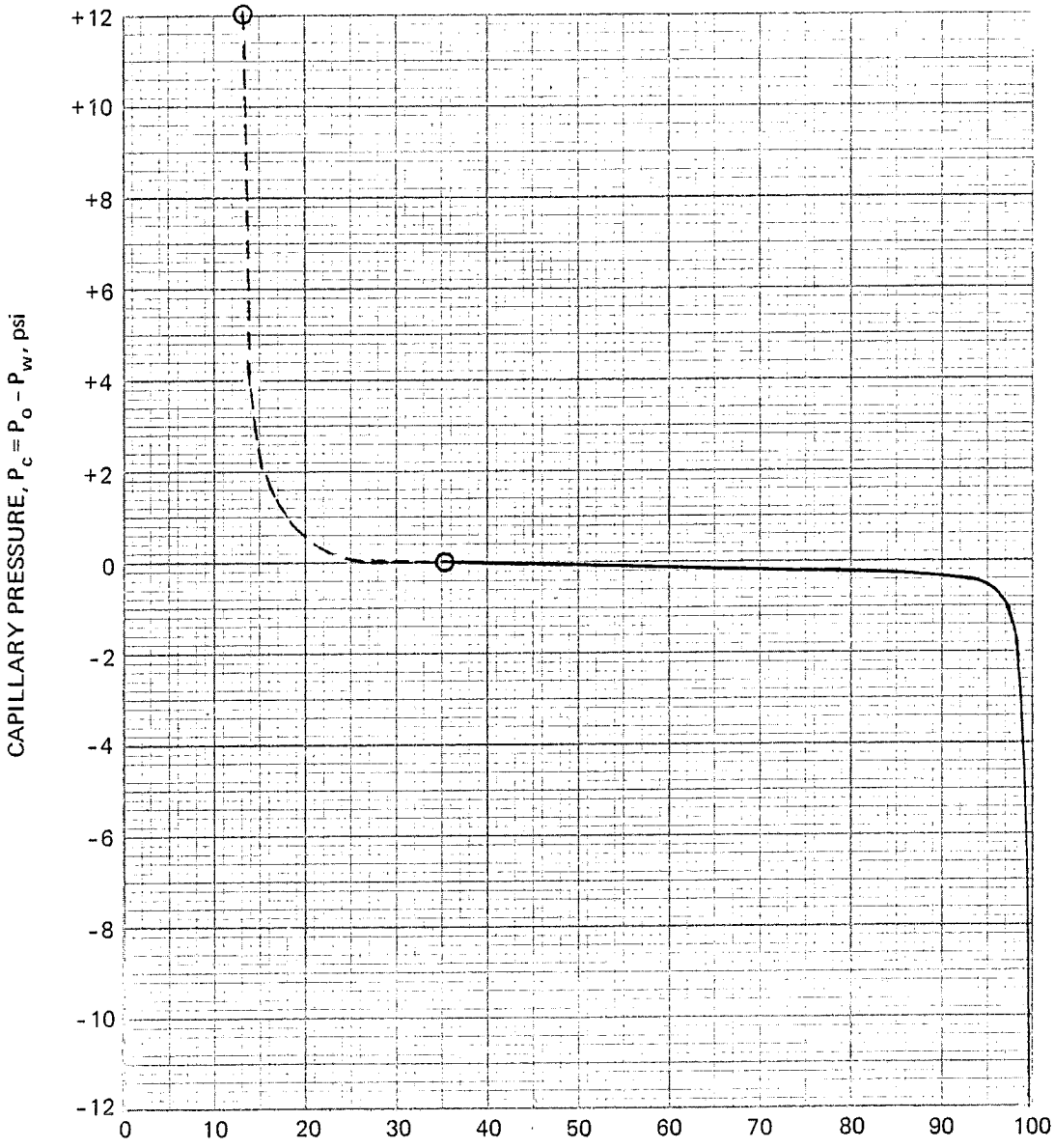
FIGURE 6

WATER-OIL IMBIBITION CAPILLARY PRESSURE BY CENTRIFUGE

Field Seahorse Reservoir _____

Well _____

Core No., Depth, m.	Permeability, k_o(cw), md	Porosity, % B.V.	Connate Water, % P.V.
1435.03	1890	19.5	13.4



EPRCO WATERFLOOD CALCULATION, SAMPLE COMP.1 CONDITION - PRESERVED DATE 5-29-79

COMPANY	RESERVOIR	WELL NO.	DEPTH FT.	SAMPLE NO.	WATERFLOOD NUMBER	TOT. TIME INCREMENTS IN FLOOD
ESSO AUSTRALIA	SEAHORSE	WELL 1	4691.000	COMP.1	1	18

CORE LENGTH, CM	33.830
CROSS-SECTIONAL AREA OF CORE, SQ CM	11.340
BULK VOLUME, CC	383.632
PORE VOLUME OF CORE, CC	93.000
HYDROCARBON VOLUME, CC	67.100
OIL VISCOSITY IN TEST, CP	0.197
FLOODING BRINE VISCOSITY IN TEST, CP	0.470
VISCOSITY RATIO	0.419
POROSITY, PCT. BULK VOLUME	24.242
SCALING FACTOR, LVMUB	5.732
KOCW, PREDETERMINED PERMEABILITY TO OIL IN PRESENCE OF CONNATE WATER, MD	141.000
KBRO, BRINE PERMEABILITY AT RESIDUAL OIL SATURATION	77.319
FLOW VELOCITY IN CORE, INCHES/DAY	845.536
TIME CONVERSION FACTOR, UNITS/MINUTE	0.500
TIME UNITS AT FLOOD START	0.140
PRESSURE CONVERSION FACTOR, UNITS/PSI	4.000
PRESSURE UNITS AT ZERO PRESSURE	0.0
TEMPERATURE OF CORE DURING FLOOD, DEG F	160.000
CORE OUTFLOW FACE PRESSURE, PSIG	2000.000
INITIAL OIL IN PLACE, PCT. PV	72.150
CONNATE WATER, INITIAL WATER IN PLACE, PCT. PV	27.849
OIL DISPLACED DURING FLOOD, PCT. PV	52.051

RELATIVE PERMEABILITY CALCULATION METHOD - SMOOTHED (5 POINT, LEAST SQUARES, BOSSLER)

COMMENTS

BREAK THRU AT STEP 3 - LIVE SEAHORSE CRUDE SAT.PRESS. 1572 AT 160 F

INLET 1430.15,1430.17,1430.19,1430.80,1430.83 OUTLET-LAB SYNTHETIC BRINE

EPRCO WATERFLOOD CALCULATION, SAMPLE COMP.1 CONDITION - PRESERVED DATE 5-29-79

CONTINUOUS CHART TYPE FLOOD
DISPLACED OIL RECORDED FROM SEPARATOR TRANSDUCER OUTPUT

INPUT DATA

READING OF OIL RECOVERY SYSTEM AT FLOOD START, UNITS	10.0000
OIL RECOVERY VOLUME FACTOR, CC/UNIT	0.9380
BRINE HOLDUP, CC. (VOLUME OF SYSTEM BETWEEN CORE OUTLET AND OIL COLLECTOR)	0.0
OIL HOLDUP, CC. (VOLUME OF OIL IN INLET AND OUTLET LINES OF CORE HOLDER, NOT PART OF HV)	1.4000
BRINE INJECTION RATE, CC/MIN	4.1000
COMPUTED TIME TO PRODUCE OIL PLUS WATER HOLDUP, MIN	0.3415

STEP NO.	CUMULATED TIME FROM START OF FLOOD TIME UNITS	PRESSURE DROP ACROSS CORE PRESSURE UNITS	PRODUCED OIL READING CHART UNITS
1	3.0000	65.2000	34.8000
2	4.0000	84.6000	43.7000
3	4.5800	98.0000	48.8000
4	5.0400	98.0000	49.5000
5	5.5000	98.0000	50.0000
6	6.3300	96.0000	51.0000
7	7.6400	94.0000	52.0000
8	9.0000	92.0000	53.0000
9	10.8000	89.9000	54.0000
10	13.5000	87.5000	55.0000
11	17.3000	85.0000	56.0000
12	21.0000	83.2000	57.0000
13	27.0000	81.5000	58.0000
14	33.5000	80.4000	59.0000
15	44.0000	78.5000	60.0000
16	56.0000	76.9000	61.0000
17	75.0000	74.2000	62.0000
18	118.0000	71.1000	63.1000

EPRCO WATERFLOOD CALCULATION, SAMPLE COMP.1 CONDITION - PRESERVED DATE 5-29-79

STEP NO.	AVG. OIL SAT. PERCENT PV	OIL DISPLACED PERCENT PV	OIL DISPLACED PERCENT HV	VOLUME BRINE INJECTED, PV	VOLUME OIL PRODUCED, CC	TOTAL FLUID PRODUCED, CC
1	48.6426	23.5079	32.5818	0.2371	21.8624	22.0520
2	39.6660	32.4845	45.0232	0.3253	30.2106	30.2520
3	34.5221	37.6283	52.1525	0.3764	34.9944	35.0080
4	33.8161	38.3344	53.1311	0.4170	35.6510	38.7800
5	33.3118	38.8387	53.8300	0.4575	36.1200	42.5520
6	32.3032	39.8473	55.2280	0.5307	37.0580	49.3580
7	31.2946	40.8559	56.6259	0.6462	37.9960	60.1000
8	30.2860	41.8645	58.0238	0.7661	38.9340	71.2519
9	29.2774	42.8731	59.4217	0.9249	39.8720	86.0119
10	28.2688	43.8817	60.8196	1.1629	40.8100	106.1519
11	27.2602	44.8903	62.2175	1.4980	41.7480	139.3118
12	26.2516	45.8989	63.6154	1.8242	42.6860	169.6519
13	25.2430	46.9075	65.0134	2.3532	43.6240	218.8519
14	24.2344	47.9161	66.4113	2.9264	44.5620	272.1519
15	23.2258	48.9247	67.8092	3.8522	45.5000	358.2517
16	22.2172	49.9333	69.2071	4.9102	46.4380	456.6519
17	21.2086	50.9419	70.6050	6.5855	47.3760	612.4517
18	20.0991	52.0514	72.1427	10.3769	48.4078	965.0518

EPRCU WATERFLOOD CALCULATION, SAMPLE COMP.1 CONDITION - PRESERVED DATE 5-29-79

RELATIVE PERMEABILITIES

STEP NO.	CALC. OIL SAT. AT OUTLET CORE FACE PCT. HV	CALC. OIL SAT. AT OUTLET CORE FACE PCT. PV	CALC. WATER SAT. AT OUTLET CORE FACE PCT. PV	RELATIVE PERMEABILITY TO BRINE PCT.	RELATIVE PERMEABILITY TO OIL PCT.	RELATIVE PERMEABILITY RATIO
1	*******	73.2766	26.7234	-4.3479	48.6734	-0.08933
2	89.1192	64.3000	35.7000	27.1288	35.4799	0.76462
3	81.9899	59.1562	40.8438	38.6288	30.6597	1.25992
4	66.0476	47.6537	52.3463	33.5780	6.9900	4.80370
5	54.4760	39.3047	60.6953	33.3417	2.1063	15.82938
6	52.8116	38.1039	61.8961	33.6299	1.7297	19.44318
7	51.2391	36.9693	63.0307	34.4345	1.3894	24.78389
8	49.2121	35.5068	64.4932	36.0378	1.1046	32.62602
9	47.1942	34.0509	65.9491	37.5587	0.8567	43.83905
10	45.4711	32.8077	67.1923	39.0104	0.6641	58.74225
11	43.8069	31.6069	68.3931	40.5880	0.5084	79.83391
12	42.4625	30.6369	69.3631	42.2384	0.4361	96.85884
13	40.8907	29.5029	70.4971	44.0669	0.3405	129.41045
14	39.2363	28.3092	71.6908	45.3338	0.2683	168.95398
15	37.6069	27.1336	72.8664	46.2011	0.1985	232.79691
16	35.3755	25.5237	74.4763	47.1045	0.1339	351.91724
17	33.9776	24.5151	75.4849	47.1857	0.0998	472.79858
18	32.4399	23.4056	76.5944	47.2727	0.0633	746.37061

EPRCO WATERFLOOD CALCULATION, SAMPLE COMP.1 CONDITION - PRESERVED DATE 5-29-79

RELATIVE INJECTIVITY

STEP NO.	BRINE INJECTED, PV	RELATIVE INJECTIVITY
1	0.2371	0.2569
2	0.3253	0.1980
3	0.3764	0.1709
4	0.4170	0.1709
5	0.4575	0.1709
6	0.5307	0.1745
7	0.6462	0.1782
8	0.7661	0.1820
9	0.9249	0.1863
10	1.1629	0.1914
11	1.4980	0.1970
12	1.8242	0.2013
13	2.3532	0.2055
14	2.9264	0.2083
15	3.8522	0.2133
16	4.9102	0.2178
17	6.5855	0.2257
18	10.3769	0.2355