OILFIELD RESEARCH LABORATORIES
536 NORTH HIGHLAND - CHANUTE, KANSAS - PHONE HE1-2650

Chanute, Kansas

CRA, Incorporated
Box 445
Wellington, Kansas

Gentlemen:

Enclosed herewith is the report of the analysis of the Rotary core taken from the Woodward Lease, Well No. 24, Bourbon County, Kansas, and submitted to our laboratory on April 7, 1966.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Benjamin R. Pearman

BRP:rf

3 c. - Wellington, Kansas
1 c. - Muskogee, Oklahoma
1 c. - Independence, Kansas

Oilfield Research Laboratories

GENERAL INFORMATION & SUMMARY

Company CRA, Incorporated Lease Woodward Well No. 24

Location 2260' EWL & 325' NSL, NW

Section 12 Twp. 25S Rge. 21E County Bourbon State Kansas

Name of Sand	Bartlesville
Top of Core	632.0
Bottom of Core	678.0
Top of Sand	640.0
Bottom of Sand (Analyzed)	676.0
Total Feet of Permeable Sand	31.0
Total Feet of Floodable Sand	17.6

Distribution of Permeable Sand:

Permeability Range Millidarcys	Feet	Cum. Ft.
2 - 10	5.8	5.8
10 - 50	11.6	17.4
50 - 100	12.0	29.4
100 & above	1.0	30.4

Average Permeability Millidarcys	42.4
Average Percent Porosity	19.6
Average Percent Oil Saturation	37.4
Average Percent Water Saturation	36.4
Average Oil Content, Bbls./A. Ft.	569.
Total Oil Content, Bbls./Acre	17,612.
Average Percent Oil Recovery by Laboratory Flooding Tests	15.0
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	232.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	4,096.
Total Calculated Oil Recovery, Bbls./Acre (Primary & Secondary)	6,090.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

Fresh water mud was used as the circulating fluid while taking this core. The core was sampled and the samples sealed in cans by a representative of Oilfield Research Laboratories. The well was drilled in virgin territory.

FORMATION CORED

The detailed log of the formation cored is as follows:

Depth Interval, Feet	Description
632.0 - 640.0	Alternate layers of sandstone and shale.
640.0 - 655.0	Light brown, shaly sandstone.
655.0 - 656.5	Sandy shale.
656.5 - 658.0	Laminated sandstone and shale.
658.0 - 660.0	Brown, slightly shaly sandstone.
660.0 - 662.0	Sandy shale.
662.0 - 668.6	Brown, slightly shaly sandstone.
668.6 - 676.0	Brown to dark, carbonaceous, slightly shaly sandstone.
676.0 - 677.0	Dark, carbonaceous, shaly sandstone.
677.0 - 678.0	Shale.

Coring was started at a depth of 632.0 feet in layers of sandstone and shale and completed at 678.0 feet in shale. This core shows a total of 31.0 feet of sandstone. For the most part, the pay is made up of light brown to brown, slightly shaly sandstone.

PERMEABILITY

For the sake of distribution, the core was divided into two sections. The weighted average permeability of the upper and lower

sections is 48.4 and 36.8 millidarcys respectively; the overall average being 42.4 (See Table III). By observing the data given on the coregraph, it is noticeable that the sand has a fairly regular permeability profile. The permeability of the sand varies from 2.7 to a maximum of 101. millidarcys. Several vertical permeability tests were run in the upper section of this core. The results are shown in Tables 1-B, IV and on the coregraph.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a good weighted average percent oil saturation, namely, 37.4. The weighted average percent oil saturation of the upper and lower sections is 33.9 and 40.7 respectively. The weighted average percent water saturation of the upper and lower sections is 39.8 and 33.2 respectively; the overall average being 36.4 (See Table III). This gives an overall weighted average total fluid saturation of 73.8 percent. This low total fluid saturation indicates considerable fluid was lost during coring most of which was probably oil.

The weighted average oil content of the upper and lower sections is 535 and 599 barrels per acre foot respectively; the overall average being 569. The total oil content, as shown by this core, is 17,612 barrels per acre of which 11,758 barrels are in the pay sand section (See Table III).

LABORATORY FLOODING TESTS

The sand in this core responded to laboratory flooding tests, as a total recovery of 4,096 barrels of oil per acre was obtained

from 17.6 feet of sand. The weighted average percent oil saturation was reduced from 43.0 to 28.0, or represents an average recovery of 15.0 percent. The weighted average effective permeability of the samples is 3.76 millidarcys, while the average initial fluid production pressure is 24.4 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 30 samples tested, 22 produced water and 17 oil. This indicates that approximately 57 percent of the sand represented by these samples is floodable pay sand. The tests also show that the sand has a wide variation in effective permeability to water.

CONCLUSION

The results of the laboratory tests indicate that efficient primary and secondary operations in the vicinity of this well should recover approximately 6,090 barrels of oil per acre or an average of 346 barrels per acre foot from the 17.6 feet of floodable pay sand analyzed in this core. These recovery values were calculated using the following data and assumptions:

Original formation volume factor	1.06
Reservoir water saturation, percent	25.0
Average porosity, percent	20.2
Oil saturation after flooding, percent	28.0
Performance factor, percent	50.0
Net floodable pay sand, feet	17.6

This core shows a pay sand section having a good oil saturation, a moderate water saturation, a wide variation in effective permeability

to water and a very slight vertical permeability in the upper section of the core.

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Incorporated Lease Woodward Well No. 24

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water	Total			Ft.	Cum. Ft.		
1	640.1	20.8	22	43	65	354	28.	0.6	0.6	212	16.80
2	641.1	20.0	24	54	78	372	101.	1.0	1.6	372	101.00
3	642.1	21.6	15	54	69	251	75.	1.0	2.6	251	75.00
4	643.1	20.6	33	42	75	527	28.	1.0	3.6	527	28.00
5	644.1	20.2	44	36	80	689	57.	1.0	4.6	689	57.00
6	645.1	19.0	43	36	79	634	21.	1.0	5.6	634	21.00
7	646.1	22.0	36	37	73	614	62.	1.0	6.6	614	62.00
8	647.1	22.0	34	31	65	580	92.	1.0	7.6	580	92.00
9	648.1	20.2	45	35	80	704	72.	1.0	8.6	704	72.00
10	649.1	24.4	39	29	68	738	86.	1.0	9.6	738	86.00
11	650.1	19.5	49	28	77	741	77.	1.0	10.6	741	77.00
12	651.1	17.3	27	50	77	362	3.9	1.0	11.6	362	3.90
13	652.1	19.9	45	34	79	694	25.	1.0	12.6	694	25.00
14	653.1	19.0	31	43	74	456	5.9	1.0	13.6	456	5.90
15	654.5	19.2	22	45	67	327	2.8	1.4	15.0	458	3.92
16	658.4	20.4	42	34	76	664	50.	0.6	15.6	398	30.00
17	659.1	20.3	50	25	75	786	62.	1.4	17.0	1,101	86.80
18	663.1	21.7	44	25	69	740	96.	1.6	18.6	1,185	153.60
19	664.1	19.7	43	29	72	656	57.	1.0	19.6	656	57.00
20	665.1	18.3	38	38	76	539	81.	1.0	20.6	539	81.00
21	666.1	18.3	54	24	78	766	37.	1.0	21.6	766	37.00
22	667.1	19.0	41	34	75	605	44.	1.0	22.6	605	44.00
23	668.1	20.1	45	25	70	701	26.	1.0	23.6	701	26.00

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Incorporated Lease Woodward Well No. 24

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls. / A Ft.	Perm., Mill.	Feet of Sand		Total Oil Content	Perm. Capacity Ft. X md.
			Oil	Water	Total			Ft.	Cum. Ft.		
24	669.1	17.6	48	33	81	655	11.	1.0	24.6	655	11.00
25	670.1	17.5	31	44	75	420	12.	1.0	25.6	420	12.00
26	671.1	18.5	35	37	72	503	15.	1.0	26.6	503	15.00
27	672.1	16.1	28	45	73	350	12.	1.0	27.6	350	12.00
28	673.1	17.5	33	43	76	447	8.3	1.0	28.6	447	8.30
29	674.1	18.5	34	31	65	488	12.	1.0	29.6	488	12.00
30	675.1	17.6	40	37	77	547	2.7	1.4	31.0	766	3.78
								Total-	--------	-17,612	
	-VERTICAL PERMEABILITY-										
1	645.4						13.				
2	647.8						9.4				
3	650.8						Imp.				
4	653.8						Imp.				

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Incorporated Lease Woodward Well No. 24

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
640.0 - 655.0	15.0	48.4	726.52
658.0 - 676.0	16.0	36.8	589.48
640.0 - 676.0	31.0	42.4	1,316.00

Depth Interval, Feet	Feet of Core Analyzed	Average Percent Porosity	Average Percent Oil Saturation	Average Percent Water Saturation	Average Oil Content Bbl./A. Ft.	Total Oil Content Bbls./Acre
640.0 - 655.0	15.0	20.4	33.9	39.8	535	8,032
658.0 - 676.0	16.0	18.3	40.7	33.2	599	9,580
640.0 - 676.0	31.0	19.6	37.4	36.4	569	17,612

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Incorporated Lease Woodward Well No. 24

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation			Volume of Water Recovered cc*	Effective Permeability Millidarcys**	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water	Bbls./A. Ft.			
1	640.1	21.0	23	374	0	0	23	72	374	84	1.40	30
2	641.1	20.0	24	372	0	0	24	74	372	342	12.40	20
3	642.1	21.3	17	281	0	0	17	82	281	256	10.60	20
4	643.1	20.2	33	516	3	47	30	63	469	50	1.00	30
5	644.1	19.9	44	679	18	278	26	71	401	149	3.90	20
6	645.1	18.5	43	616	14	200	29	62	416	23	0.500	35
7	646.1	21.6	36	602	12	201	24	72	401	259	6.80	20
8	647.1	21.5	34	566	10	167	24	74	399	200	4.20	20
9	648.1	20.6	45	719	17	272	28	64	447	124	2.20	30
10	649.1	24.0	39	725	11	204	28	71	521	366	8.60	30
11	650.1	20.0	49	759	24	372	25	74	387	235	6.00	20
12	651.1	17.6	27	368	0	0	27	52	368	0	Imp.	-
13	652.1	19.4	45	676	19	286	26	70	390	24	0.555	20
14	653.1	18.8	32	466	0	0	32	44	466	0	Imp.	-
15	654.5	19.3	22	329	0	0	22	47	329	0	Imp.	-
16	658.4	20.4	42	664	14	222	28	70	442	353	6.60	20
17	659.1	19.8	50	768	24	368	26	71	400	362	8.00	10
18	663.1	21.2	44	723	17	280	27	72	443	363	8.80	10
19	664.1	20.0	43	666	15	232	28	65	434	80	1.50	10
20	665.1	18.8	38	554	10	146	28	59	408	33	0.700	30
21	666.1	18.3	54	766	24	341	30	58	425	9	0.200	30
22	667.1	18.8	41	597	8	116	33	63	481	35	0.800	30
23	668.1	19.7	45	687	9	138	36	54	549	5	0.100	50
24	669.1	17.2	48	639	0	0	48	35	639	0	Imp.	-

Notes: cc—cubic centimeter.

*—Volume of water recovered at the time of maximum oil recovery.

**—Determined by passing water through sample which still contains residual oil.

Oilfield Research Laboratories

RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Incorporated Lease Woodward Well No. 24

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation			Volume of Water Recovered cc*	Effective Permeability Millidarcys**	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water	Bbls./A. Ft.			
25	670.1	17.6	32	436	0	0	32	45	436	0	Imp.	-
26	671.1	18.3	35	496	0	0	35	38	496	0	Imp.	-
27	672.1	16.4	27	343	0	0	27	52	343	5	0.200	50
28	673.1	17.6	34	463	0	0	34	50	463	7	0.200	50
29	674.1	18.4	33	471	0	0	33	33	471	0	Imp.	-
30	675.1	17.9	39	541	0	0	39	40	541	0	Imp.	-
					-VERTICAL EFFECTIVE PERMEABILITY-							
1	645.4									0	Imp.	-
2	647.8									6	0.250	40
3	650.8									0	Imp.	-
4	653.8									0	Imp.	-

Notes: cc—cubic centimeter.

*—Volume of water recovered at the time of maximum oil recovery.

**—Determined by passing water through sample which still contains residual oil.

Oilfield Research Laboratories

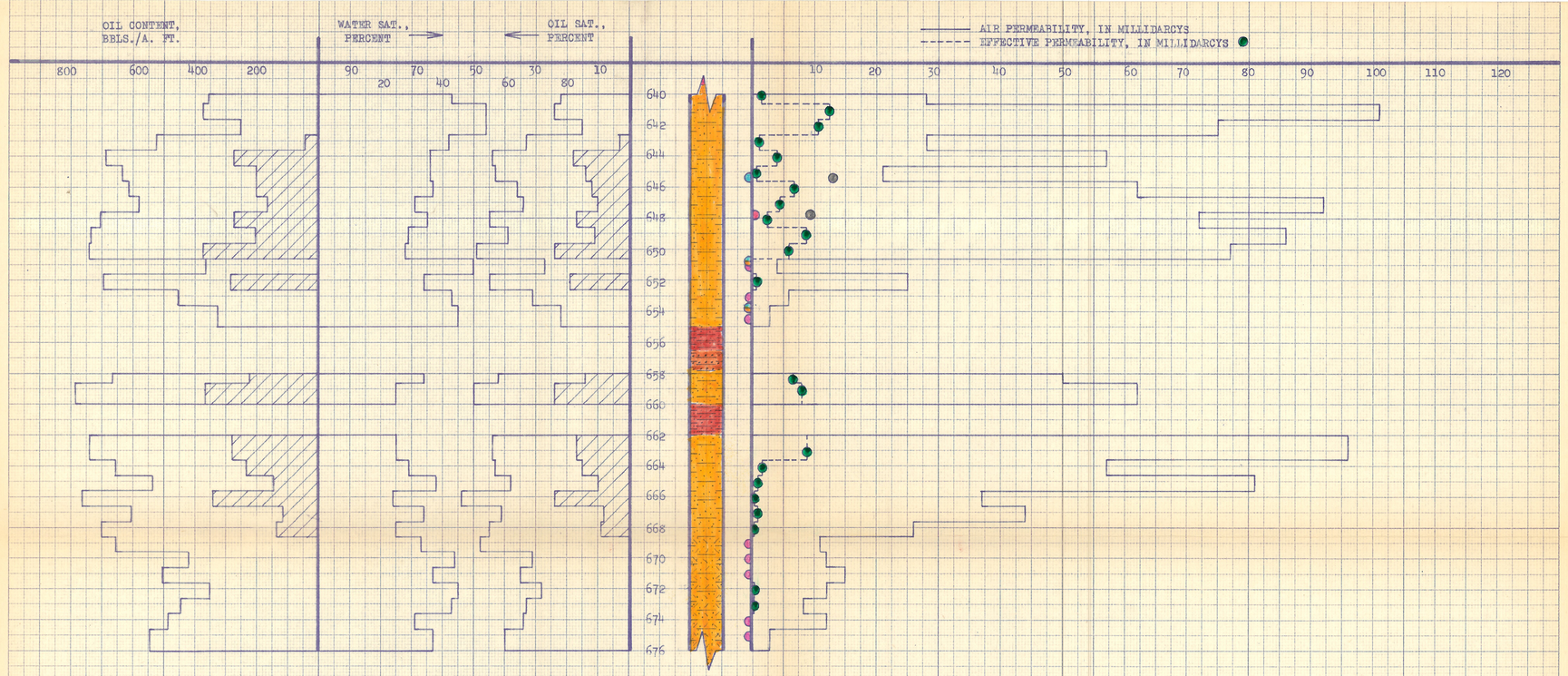
SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company CRA, Incorporated Lease Woodward Well No. 24

Depth Interval, Feet	640.0 - 655.0	658.0 - 676.0	640.0 - 676.0
Feet of Core Analyzed	9.0	8.6	17.6
Average Percent Porosity	20.6	19.7	20.2
Average Percent Original Oil Saturation	40.9	44.9	43.0
Average Percent Oil Recovery	14.2	15.7	15.0
Average Percent Residual Oil Saturation	26.7	29.2	28.0
Average Percent Residual Water Saturation	69.0	64.6	66.9
Average Percent Total Residual Fluid Saturation	95.7	93.8	94.9
Average Original Oil Content, Bbls./A. Ft.	652.	685.	668.
Average Oil Recovery, Bbls./A. Ft.	226.	240.	232.
Average Residual Oil Content, Bbls./A. Ft.	426.	445.	436.
Total Original Oil Content, Bbls./Acre	5,858.	5,900.	11,758.
Total Oil Recovery, Bbls./Acre	2,027.	2,069.	4,096.
Total Residual Oil Content, Bbls./Acre	3,831.	3,831.	7,662.
Average Effective Permeability, Millidarcys	3.74	3.78	3.76
Average Initial Fluid Production Pressure, p.s.i.	25.0	23.8	24.4

NOTE: Only those samples which recovered oil were used in calculating the above averages.



CRA, INC.

WOODWARD LEASE WELL NO. 24
BOURBON COUNTY, KANSAS

DEPTH INTERVAL, FEET	FEET OF CORE ANALYZED	AVERAGE POROSITY, PERCENT	AVG. OIL SATURATION PERCENT	AVG. WATER SATURATION PERCENT	AVG. OIL CONTENT BBLS./A.FT.	TOTAL OIL CONTENT BBLS./ACRE	AVG. AIR PERMEABILITY, MILLIDARCYS	CALCULATED OIL RECOVERY, BBLS./ACRE
640.0 - 655.0	15.0	20.4	33.9	39.8	535	8,032	48.4	
658.0 - 676.0	16.0	18.3	40.7	33.2	599	9,580	36.8	
640.0 - 676.0	31.0	19.6	37.4	36.4	569	17,612	42.4	6,090 (Primary & Secondary)

OILFIELD RESEARCH LABORATORIES
CHANUTE, KANSAS
APRIL, 1966