

OILFIELD RESEARCH LABORATORIES

536 NORTH HIGHLAND - CHANUTE, KANSAS - PHONE HE1-2650

July 9, 1966

CRA, Incorporated
Box 445
Wellington, Kansas

Gentlemen:

Enclosed herewith is a report of the analysis of the Rotary core taken from the Woodward Lease, Well No. 29-I, Bourbon County, Kansas, and submitted to our laboratory on July 5, 1966.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Benjamin R. Pearman
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, Inc. Lease Woodward Well No. 29-I

Location 2065' EWL & 480' NSL, SW $\frac{1}{4}$

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

Name of Sand - - - - - Bartlesville

Top of Core - - - - - 638.0

Bottom of Core - - - - - 683.0

Top of Sand - - - (Analyzed) - - - 638.6

Bottom of Sand - - - (Analyzed) - - - 674.6

Total Feet of Permeable Sand - - - - - 31.8

Total Feet of Floodable Sand - - - - - 14.4

Distribution of Permeable Sand: Permeability Range Millidarcys

	Feet	Cum. Ft.
2 - 10	10.8	10.8
10 - 20	4.8	15.6
20 - 50	5.2	20.8
50 - 100	7.0	27.8
100 & above	4.0	31.8

Average Permeability Millidarcys - - - - - 47.1

Average Percent Porosity - - - - - 18.3

Average Percent Oil Saturation - - - - - 32.5

Average Percent Water Saturation - - - - - 41.9

Average Oil Content, Bbls./A. Ft. - - - - - 470.

Total Oil Content, Bbls./Acre - - - - - 14,984.

Average Percent Oil Recovery by Laboratory Flooding Tests - - - - - 11.4

Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft. - - - - - 177.

Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre - - - - - 2,557.

Total Calculated Oil Recovery, Bbls./Acre - (Primary & Secondary) - - - - - 5,220.

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, <u>Feet</u>	<u>Description</u>
--------------------------------	--------------------

638.0 - 640.0	- Light brown, laminated, shaly sandstone.
---------------	--

640.0 - 640.8	- Sandy shale.
---------------	----------------

640.8 - 644.4	- Light brown, laminated, shaly sandstone.
---------------	--

644.4 - 647.0	- Laminated sandstone and shale.
---------------	----------------------------------

647.0 - 653.8	- Light brown, laminated, shaly sandstone.
---------------	--

653.8 - 654.2	- Sandy shale.
---------------	----------------

654.2 - 666.6	- Brown, laminated, slightly shaly sandstone.
---------------	---

666.6 - 675.8	- Brown to dark, laminated, slightly shaly, slightly carbonaceous sandstone.
---------------	--

675.8 - 682.0	- Gray sandy shale.
---------------	---------------------

682.0 - 683.0	- Dark sandy shale.
---------------	---------------------

Coring was started at a depth of 638.0 feet in shaly sandstone and completed at 683.0 feet in sandy shale. For the most part, the pay is made up of brown, laminated, slightly shaly sandstone.

PERMEABILITY

For the sake of distribution, the core was divided into three sections. The weighted average permeability of the upper, middle and lower sections is 13.6, 95.9 and 19.3 millidarcys respectively;

the overall average being 47.1 (See Table III). By observing the data given on the coregraph, it is noticeable that the sand has an irregular permeability profile. The permeability of the sand varies from 2.6 to a maximum of 273. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a good weighted average percent oil saturation, namely, 32.5. The weighted average percent oil saturation of the upper, middle and lower sections is 19.9, 42.5 and 35.2 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 53.6, 29.2 and 45.4 respectively; the overall average being 41.9 (See Table III). This gives an overall weighted average total fluid saturation of 74.4 percent. This low total fluid saturation indicates considerable fluid was lost during coring most of which probably was oil.

The weighted average oil content of the upper, middle and lower sections is 256, 656 and 489 barrels per acre foot respectively; the overall average being 470. The total oil content, as shown by this core, is 14,984 barrels per acre of which 9,260 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 2,557 barrels of oil per acre was obtained from 14.4 feet of sand. The weighted average percent oil saturation was reduced from 41.4 to 30.0, or represents an average recovery of 11.4 percent. The weighted average effective permeability of the

samples is 7.05 millidarcys, while the average initial fluid production pressure is 22.0 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 33 samples tested, 27 produced water and 15 oil. This indicates that approximately 45 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

Based on the results of the laboratory tests it appears that efficient primary and secondary operations in the vicinity of this well should recover approximately 5,220 barrels of oil per acre or an average of 363 barrels per acre foot from the 14.4 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	20.0
Average porosity, percent	19.9
Oil saturation after flooding, percent	30.0
Performance factor, percent	50.0
Net floodable pay sand, feet	14.4

This core shows a pay sand section (654.2 - 666.6) having a good oil saturation, a moderate water saturation and a wide variation in effective permeability to water.

Oilfield Research Laboratories

RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Incorporated Lease Woodward Well No. 29-I

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	639.1	17.0	10	60	70	132	32.	1.0	1.0	132	32.00
2	641.1	19.8	14	57	71	215	14.	0.8	1.8	172	11.20
3	642.1	17.1	11	56	67	146	6.5	1.0	2.8	146	6.50
4	643.1	16.3	9	62	71	114	9.6	1.0	3.8	114	9.60
5	644.1	16.6	12	60	72	154	37.	0.8	4.6	123	29.60
6	647.1	16.6	23	55	78	296	4.3	0.6	5.2	178	2.58
7	648.1	20.2	15	49	64	235	18.	1.0	6.2	235	18.00
8	649.1	15.8	34	58	92	416	19.	1.0	7.2	416	19.00
9	650.1	14.9	28	49	77	323	5.8	1.0	8.2	323	5.80
10	651.1	17.8	24	48	72	332	15.	1.0	9.2	332	15.00
11	652.1	16.0	24	50	74	298	2.6	1.0	10.2	298	2.60
12	653.1	15.7	31	44	75	377	3.1	1.2	11.4	452	3.72
13	654.3	18.8	35	37	72	510	37.	0.4	11.8	204	14.80
14	655.1	18.1	32	34	66	449	8.8	1.0	12.8	449	8.80
15	656.1	17.9	43	34	77	597	66.	1.0	13.8	597	66.00
16	657.1	16.8	43	32	75	559	55.	1.0	14.8	559	55.00
17	658.1	22.8	42	24	66	742	135.	1.0	15.8	742	135.00
18	659.1	18.7	45	35	80	653	73.	1.0	16.8	653	73.00
19	660.1	19.5	35	30	65	529	97.	1.0	17.8	529	97.00
20	661.1	23.2	44	20	64	791	169.	1.0	18.8	791	169.00
21	662.1	20.8	52	19	71	837	51.	1.0	19.8	837	51.00
22	663.1	20.7	46	24	70	738	273.	1.0	20.8	738	273.00
23	664.1	19.8	52	26	78	796	39.	1.0	21.8	796	39.00
24	665.1	21.0	40	38	78	651	125.	1.0	22.8	651	125.00

Oilfield Research Laboratories

RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Incorporated Lease Woodward Well No. 29-I

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.		
25	666.1	20.5	38	31	69	604	83.	1.0	23.8	604	83.00
26	667.1	15.7	23	55	78	280	6.8	1.0	24.8	280	6.80
27	668.1	17.2	41	45	86	546	3.8	1.0	25.8	546	3.80
28	669.1	17.1	34	49	83	451	27.	1.0	26.8	451	27.00
29	670.1	15.6	29	53	82	350	28.	1.0	27.8	350	28.00
30	671.1	19.2	33	42	75	491	7.3	1.0	28.8	491	7.30
31	672.1	18.9	46	42	88	674	19.	1.0	29.8	674	19.00
32	673.1	20.4	38	35	73	600	60.	1.0	30.8	600	60.00
33	674.1	18.2	37	42	79	521	2.6	1.0	31.8	521	2.60
								Total-----		14,984	

Oilfield Research Laboratories

SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Incorporated Lease Woodward Well No. 29-I

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
638.6 - 653.8	11.4	13.6	155.60
654.2 - 666.6	12.4	95.9	1,189.60
666.6 - 674.6	8.0	19.3	154.50
638.6 - 674.6	31.8	47.1	1,499.70

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
638.6 - 653.8	11.4	16.9	19.9	53.6	256	2,921
654.2 - 666.6	12.4	19.9	42.5	29.2	656	8,150
666.6 - 674.6	8.0	17.8	35.2	45.4	489	3,913
638.6 - 674.6	31.8	18.3	32.5	41.9	470	14,984

Oilfield Research Laboratories
RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Incorporated Lease Woodward Well No. 29-I

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	639.1	17.3	12	161	0	0	12	67	161	124	2.50	10
2	641.1	19.4	13	195	0	0	13	79	195	118	3.80	20
3	642.1	16.8	9	117	0	0	9	85	117	24	0.700	40
4	643.1	16.8	9	117	0	0	9	83	117	40	0.900	30
5	644.1	16.7	14	181	0	0	14	74	181	18	0.445	40
6	647.1	16.6	24	309	0	0	24	56	309	0	Imp.	-
7	648.1	20.0	15	232	0	0	15	76	232	215	4.90	10
8	649.1	16.2	34	426	0	0	34	63	426	128	2.00	20
9	650.1	15.1	27	316	0	0	27	54	316	4	0.200	50
10	651.1	17.5	24	326	0	0	24	73	326	26	0.600	40
11	652.1	16.1	25	312	0	0	25	74	312	2	0.100	50
12	653.1	16.0	31	384	0	0	31	67	384	6	0.500	50
13	654.3	19.1	35	519	8	119	27	71	400	120	3.30	20
14	655.1	18.3	32	454	3	43	29	65	411	47	1.30	30
15	656.1	18.4	43	613	14	200	29	70	413	97	2.40	30
16	657.1	17.3	43	576	16	214	27	72	362	213	14.20	10
17	658.1	22.4	42	730	15	260	27	70	470	324	19.20	20
18	659.1	19.1	45	666	17	252	28	67	414	130	6.40	20
19	660.1	19.5	35	530	9	136	26	72	394	149	8.30	20
20	661.1	23.0	44	784	13	232	31	66	552	333	12.00	20
21	662.1	21.2	52	855	18	296	34	61	559	351	9.00	10
22	663.1	20.4	46	728	17	269	29	70	459	330	11.00	10
23	664.1	19.5	52	786	20	302	32	66	484	41	1.00	20
24	665.1	21.4	40	664	8	133	32	66	531	254	12.00	20

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. 29-I

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	666.1	21.0	38	619	7	114	31	67	505	46	2.60	30
26	667.1	15.9	25	308	0	0	25	71	308	12	0.400	40
27	668.1	17.0	41	541	0	0	41	47	541	0	Imp.	-
28	669.1	17.4	34	458	2	27	32	63	431	14	0.400	40
29	670.1	15.7	30	365	0	0	30	54	365	0	Imp.	-
30	671.1	19.1	34	503	0	0	34	41	503	0	Imp.	-
31	672.1	19.1	46	681	0	0	46	44	681	0	Imp.	-
32	673.1	20.0	38	589	2	31	36	53	558	17	0.445	30
33	674.1	18.0	38	529	0	0	38	44	529	0	Imp.	-

Notes: cc—cubic centimeter.

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

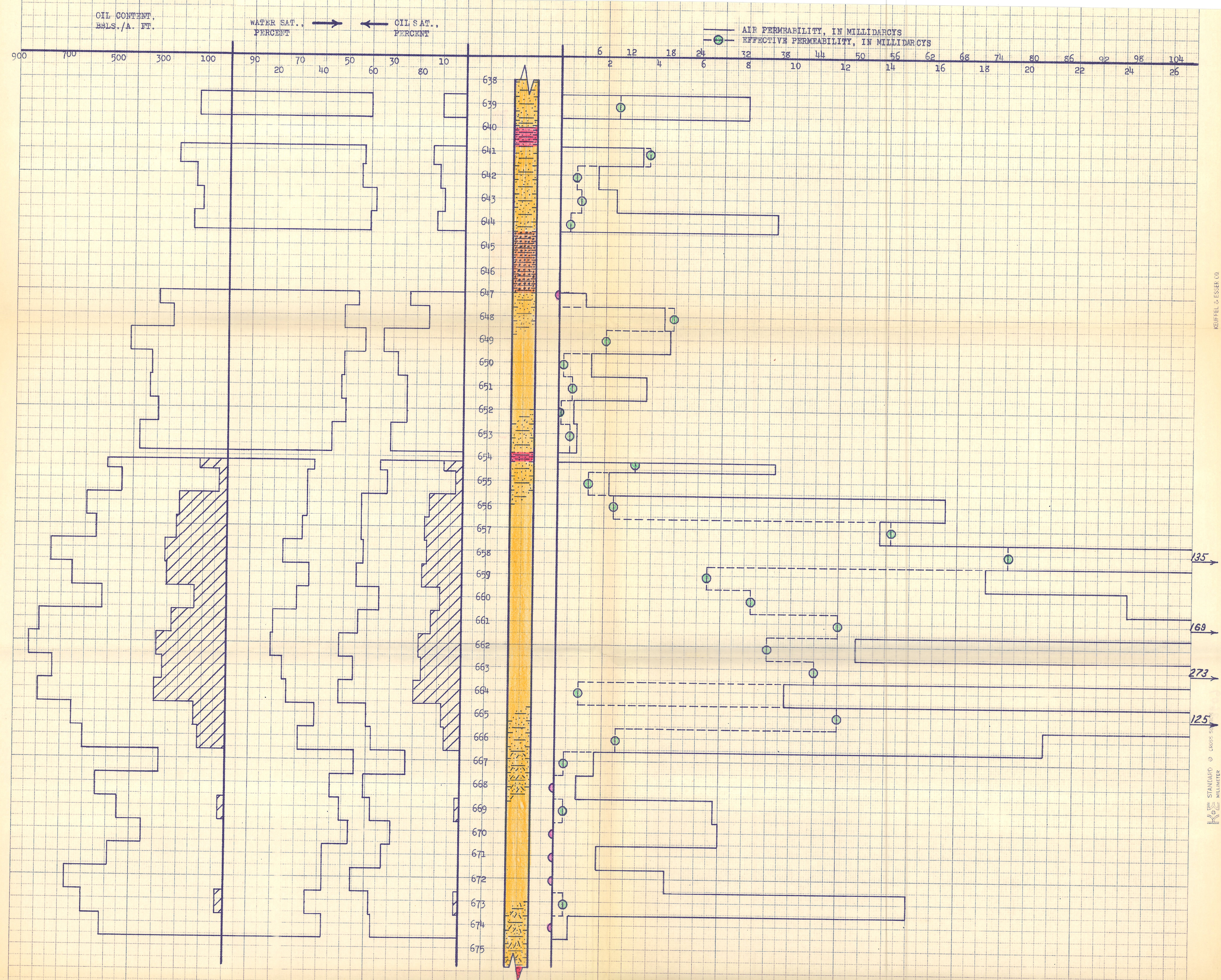
**—Determined by passing water through sample which still contains residual oil.

Oilfield Research Laboratories
SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company	CRA, Incorporated	Lease	Woodward	Well No.	29-I
Depth Interval, Feet	654.2 - 666.6	666.6 - 674.6	654.2 - 674.6		
Feet of Core Analyzed	12.4	2.0	14.4		
Average Percent Porosity	20.1	18.7	19.9		
Average Percent Original Oil Saturation	42.3	36.0	41.4		
Average Percent Oil Recovery	12.9	2.0	11.4		
Average Percent Residual Oil Saturation	29.4	34.0	30.0		
Average Percent Residual Water Saturation	67.8	58.0	66.4		
Average Percent Total Residual Fluid Saturation	97.2	92.0	96.4		
Average Original Oil Content, Bbls./A. Ft.	662.	524.	642.		
Average Oil Recovery, Bbls./A. Ft.	201.	29.	177.		
Average Residual Oil Content, Bbls./A. Ft.	461.	495.	465.		
Total Original Oil Content, Bbls./Acre	8,213.	1,047.	9,260.		
Total Oil Recovery, Bbls./Acre	2,499.	58.	2,557.		
Total Residual Oil Content, Bbls./Acre	5,714.	989.	6,703.		
Average Effective Permeability, Millidarcys	8.12	0.422	7.05		
Average Initial Fluid Production Pressure, p.s.i.	20.0	35.0	22.0		

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



C. R. A. INC.
WOODWARD LEASE WELL NO. 29-1
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
638.6 - 653.8	11.4	16.9	19.9	53.6	256	2,921	13.6	
654.2 - 666.6	12.4	19.9	42.5	29.2	656	8,150	95.9	
666.6 - 674.6	8.0	17.8	35.2	45.4	489	3,913	19.3	
638.6 - 674.6	31.8	18.3	32.5	41.9	470	14,984	47.1	5,220 (Primary & Secondary)

OILFIELD RESEARCH LABORATORIES
CHANUTE, KANSAS
JULY, 1966

KEPPEL & ESSEH CO.
MADE IN U.S.A.

STANDARD 1/2 INCHES
KEPPEL & ESSEH CO.
MADE IN U.S.A.