

OILFIELD RESEARCH LABORATORIES

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

April 19, 1966

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. 25, Bourbon County, Kansas, and submitted to our laboratory on April 13, 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. 25

Location NW

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

Name of Sand	Bartlesville
Top of Core	645.0
Bottom of Core	697.0
Top of Sand	645.6
Bottom of Sand	697.0
(Analyzed)	
Total Feet of Permeable Sand	43.2
Total Feet of Floodable Sand	18.5

Distribution of Permeable Sand:
Permeability Range
Millidarcys

	Feet	Cum. Ft.
3 - 10	10.0	10.0
10 - 20	6.4	16.4
20 - 50	14.0	30.4
50 - 100	10.8	41.2
100 & above	2.0	43.2

Average Permeability Millidarcys	40.1
Average Percent Porosity	20.2
Average Percent Oil Saturation	36.1
Average Percent Water Saturation	39.6
Average Oil Content, Bbls./A. Ft.	568.
Total Oil Content, Bbls./Acre	25,147.
Average Percent Oil Recovery by Laboratory Flooding Tests	13.6
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	224.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	4,158.
Total Calculated Oil Recovery, Bbls./Acre	6,860.
(Primary & Secondary)	
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 plastic bags 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:

<u>Depth Interval,</u> <u>Feet</u>	<u>Description</u>
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645.0 - 651.0	Grayish light brown, shaly sandstone.
651.0 - 651.7	Sandy shale.
651.7 - 658.0	Light brown, slightly shaly sandstone.
658.0 - 664.0	Laminated sandstone and shale.
664.0 - 665.0	Brown, slightly shaly sandstone.
665.0 - 665.2	Shale.
665.2 - 666.3	Brown, slightly shaly sandstone.
666.3 - 666.6	Shale.
666.6 - 676.6	Brown, slightly shaly sandstone.
676.6 - 677.6	Light brown, laminated, shaly, carbonaceous sandstone.
677.6 - 681.6	Brown, slightly shaly, slightly carbonaceous sandstone.
681.6 - 697.0	Brown to dark, carbonaceous, slightly shaly sandstone.

Coring was started at a depth of 645.0 feet in sandstone and completed at 697.0 feet also in sandstone. This core shows a total of 44.2 feet of sandstone. For the most part, the pay is made up of brown, slightly shaly sandstone.

PERMEABILITY

For the sake of distribution, the core was divided into three sec-

tions. The weighted average permeability of the upper, middle and lower sections is 57.6, 55.5 and 11.3 millidarcys respectively; the overall average being 40.1 (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 impermeable to a maximum of 177. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a good weighted average percent oil saturation, namely, 36.1. The weighted average percent oil saturation of the upper, middle and lower sections is 14.6, 41.1 and 44.6 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 55.0, 35.0 and 35.6 respectively; the overall average being 39.6 (See Table III). This gives an overall weighted average total fluid saturation of 75.7 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, middle and lower sections is 222, 686 and 659 barrels per acre foot respectively; the overall average being 568. The total oil content, as shown by this core, is 25,147 barrels per acre of which 12,597 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 4,158 barrels of oil per acre was obtained from 18.5 feet of sand. The weighted average percent oil saturation was

reduced from 41.2 to 27.6, or represents an average recovery of 13.6 percent. The weighted average effective permeability of the samples is 3.48 millidarcys, while the average initial fluid production pressure is 24.2 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 43 samples tested, 32 produced water and 18 oil. This indicates that approximately 42 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 6,860 barrels of oil per acre or an average of 371 barrels per acre foot from the 18.5 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	21.4
Oil saturation after flooding, percent	27.6
Performance factor, percent	50.0
Net floodable pay sand, feet	18.5

This core shows a pay sand section (656.6 - 681.6) having a good oil saturation, a moderate water saturation and a wide variation in effective permeability to water.

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Incorporated Lease Woodward Well No. 25

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	646.1	11.1	11	86	97	95	Imp.	1.0	1.0	95	0.00
2	647.1	21.0	11	49	60	179	30.	1.0	2.0	179	30.00
3	648.1	21.0	10	49	59	163	38.	1.0	3.0	163	38.00
4	649.1	19.6	13	60	73	197	61.	1.0	4.0	197	61.00
5	650.1	19.8	16	53	69	246	62.	1.4	5.4	344	86.80
6	652.1	20.8	16	52	68	258	26.	0.9	6.3	232	23.40
7	653.1	20.4	15	50	65	237	60.	1.0	7.3	237	60.00
8	654.1	21.4	17	48	65	282	95.	1.0	8.3	282	95.00
9	655.1	18.1	17	55	72	238	59.	1.0	9.3	238	59.00
10	656.1	20.9	20	48	68	324	83.	1.0	10.3	324	83.00
11	657.1	21.6	32	45	77	535	99.	1.4	11.7	749	138.60
12	664.1	21.0	45	30	75	732	36.	1.0	12.7	732	36.00
13	665.5	19.5	34	38	72	513	48.	1.1	13.8	564	52.80
14	667.1	18.0	38	40	78	531	9.7	1.0	14.8	531	9.70
15	668.1	20.2	47	35	82	736	31.	1.0	15.8	736	31.00
16	669.1	21.8	44	29	73	743	26.	1.0	16.8	743	26.00
17	670.1	20.2	39	39	78	610	24.	1.0	17.8	610	24.00
18	671.1	24.4	32	46	78	606	59.	1.0	18.8	606	59.00
19	672.1	21.8	55	34	89	929	135.	1.0	19.8	929	135.00
20	673.1	21.2	46	34	80	755	177.	1.0	20.8	755	177.00
21	674.1	19.5	35	38	73	529	14.	1.0	21.8	529	14.00
22	675.1	23.5	44	33	77	801	89.	1.0	22.8	801	89.00
23	676.1	23.2	38	28	66	683	47.	1.0	23.8	683	47.00

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company CRA, Incorporated Lease Woodward Well No. 25

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	677.1	24.1	55	28	83	1028	15.	1.0	24.8	1028	15.00
25	678.1	20.7	38	38	76	609	23.	1.0	25.8	609	23.00
26	679.1	21.7	47	32	79	790	55.	1.0	26.8	790	55.00
27	680.1	24.6	33	27	60	629	49.	1.0	27.8	629	49.00
28	681.1	20.2	43	32	75	673	46.	1.0	28.8	673	46.00
29	682.1	20.9	42	29	71	681	33.	1.0	29.8	681	33.00
30	683.1	21.0	45	32	77	733	24.	1.0	30.8	733	24.00
31	684.1	19.7	37	35	72	565	13.	1.0	31.8	565	13.00
32	685.1	17.0	39	41	80	514	7.7	1.0	32.8	514	7.70
33	686.1	19.0	46	29	75	676	4.6	1.0	33.8	676	4.60
34	687.1	20.4	46	31	77	726	15.	1.0	34.8	726	15.00
35	688.1	15.9	35	46	81	431	6.3	1.0	35.8	431	6.30
36	689.1	18.5	37	44	81	530	5.4	1.0	36.8	530	5.40
37	690.1	19.0	46	34	80	678	17.	1.0	37.8	678	17.00
38	691.1	17.2	46	41	87	613	3.2	1.0	38.8	613	3.20
39	692.1	17.3	63	35	98	845	5.0	1.0	39.8	845	5.00
40	693.1	20.5	52	33	85	826	7.7	1.0	40.8	826	7.70
41	694.1	17.0	35	44	79	461	5.2	1.0	41.8	461	5.20
42	695.1	18.9	49	33	82	718	6.0	1.0	42.8	718	6.00
43	696.1	21.9	49	30	79	831	15.	1.4	44.2	<u>1,162</u>	21.00
								Total	-----	25,147	

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company CRA, Incorporated Lease Woodward Well No. 25

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
645.6 - 656.6	9.3	57.6	536.20
656.6 - 681.6	18.5	55.5	1,027.10
681.6 - 697.0	15.4	11.3	174.10
645.6 - 697.0	43.2	40.1	1,737.40

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
645.6 - 656.6	10.3	19.4	14.6	55.0	222	2,291
656.6 - 681.6	18.5	21.4	41.1	35.0	686	12,697
681.6 - 697.0	15.4	19.0	44.6	35.6	659	10,159
645.6 - 697.0	44.2	20.2	36.1	39.6	568	25,147

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Incorporated Lease Woodward Well No. 25

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	646.1	10.9	12	102	0	0	12	87	102	0	Imp.	-
2	647.1	19.9	11	170	0	0	11	79	170	131	4.80	30
3	648.1	21.0	10	163	0	0	10	80	163	222	11.80	20
4	649.1	19.9	14	216	0	0	14	82	216	339	9.60	20
5	650.1	19.9	16	246	0	0	16	83	246	287	11.80	20
6	652.1	20.6	15	239	0	0	15	78	239	143	5.10	20
7	653.1	20.6	15	239	0	0	15	81	239	344	12.80	20
8	654.1	21.4	17	282	0	0	17	78	282	240	13.40	20
9	655.1	18.0	18	251	0	0	18	70	251	70	1.30	20
10	656.1	21.3	20	330	0	0	20	78	330	348	13.60	20
11	657.1	21.1	32	524	6	98	26	67	426	348	13.00	20
12	664.1	20.7	45	722	22	353	23	70	369	70	2.40	20
13	665.5	20.0	34	527	12	186	22	71	341	140	3.70	20
14	667.1	18.1	38	533	9	126	29	70	407	44	1.40	20
15	668.1	20.0	47	729	24	372	23	72	357	67	1.80	20
16	669.1	21.4	44	729	20	331	24	72	398	48	1.50	20
17	670.1	20.7	39	626	16	257	23	72	369	61	1.70	20
18	671.1	24.0	32	596	8	149	24	73	447	340	8.00	20
19	672.1	22.0	55	937	29	494	26	69	443	311	12.00	20
20	673.1	20.8	46	741	18	290	28	68	451	115	3.40	20
21	674.1	19.1	35	517	6	89	29	63	428	20	0.600	35
22	675.1	23.2	44	793	20	360	24	72	433	132	4.10	20
23	676.1	23.0	38	676	12	214	26	72	462	54	1.40	20
24	677.1	23.8	55	1015	14	258	41	47	757	7	0.300	50

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.

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company CRA, Incorporated Lease Woodward Well No. 25

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	678.1	20.2	38	594	6	94	32	52	500	18	0.500	35
26	679.1	21.2	47	773	15	246	32	58	527	48	1.60	20
27	680.1	24.4	33	624	3	57	30	62	567	36	0.900	20
28	681.1	20.4	43	680	8	127	35	58	553	17	0.500	35
29	682.1	20.5	43	683	0	0	43	30	683	0	Imp.	-
30	683.1	20.7	45	722	0	0	45	42	722	3	0.200	50
31	684.1	19.9	38	586	0	0	38	44	586	3	0.200	50
32	685.1	16.6	40	515	0	0	40	49	515	6	0.300	50
33	686.1	19.0	46	677	0	0	46	36	677	7	0.300	45
34	687.1	20.3	46	724	0	0	46	30	724	0	Imp.	-
35	688.1	15.9	37	456	0	0	37	49	456	0	Imp.	-
36	689.1	18.7	36	522	0	0	36	47	522	0	Imp.	-
37	690.1	19.2	47	700	0	0	47	42	700	7	0.400	45
38	691.1	17.0	45	594	0	0	45	43	594	0	Imp.	-
39	692.1	17.3	65	871	0	0	65	33	871	0	Imp.	-
40	693.1	20.7	53	850	0	0	53	36	850	0	Imp.	-
41	694.1	16.9	37	484	0	0	37	46	484	0	Imp.	-
42	695.1	19.0	49	721	0	0	49	35	721	0	Imp.	-
43	696.1	21.6	50	836	0	0	50	30	836	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.

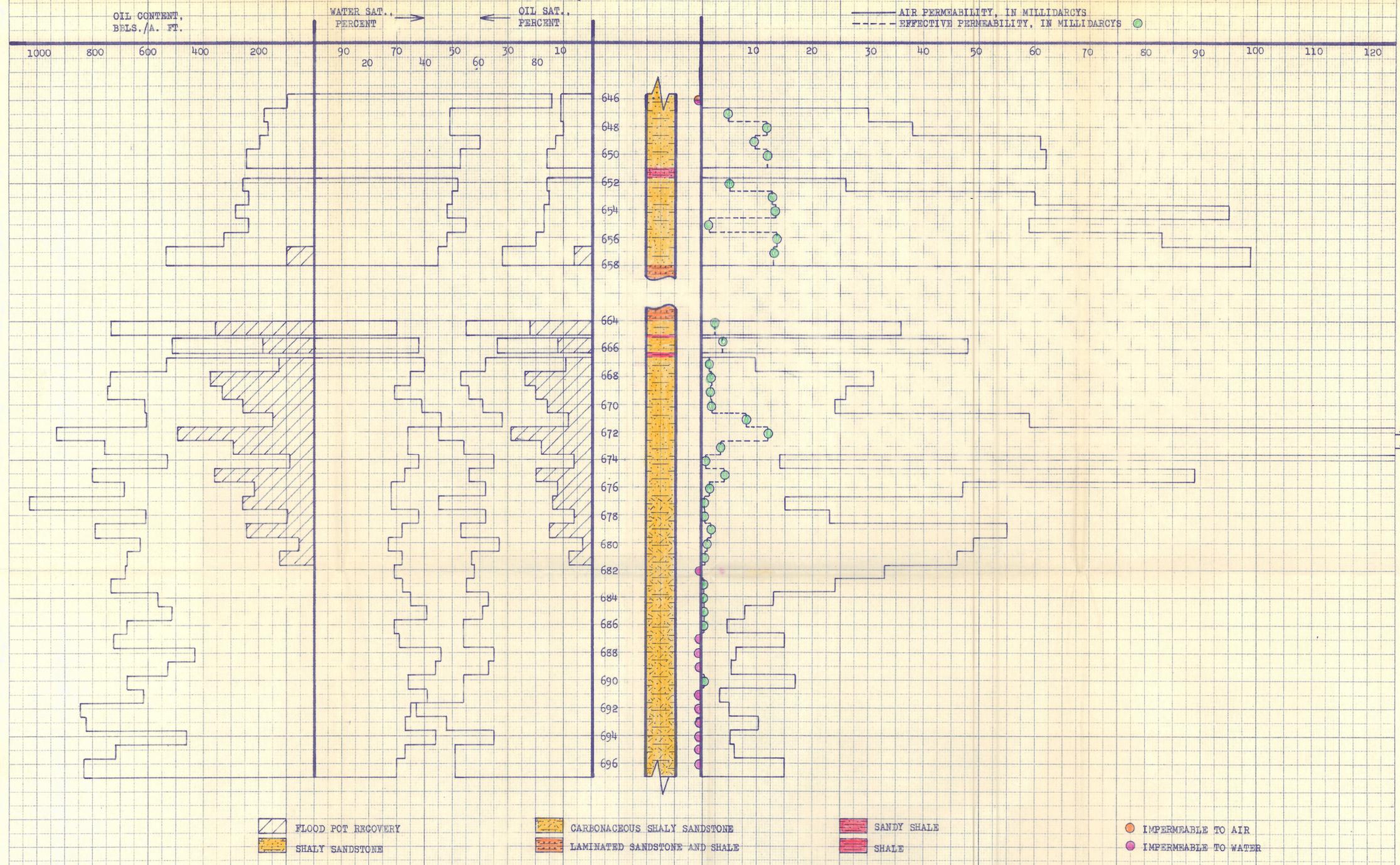
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SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company	CRA, Incorporated	Lease	Woodward	Well No.	25
Depth Interval, Feet	656.6 - 681.6				
Feet of Core Analyzed	18.5				
Average Percent Porosity	21.4				
Average Percent Original Oil Saturation	41.2				
Average Percent Oil Recovery	13.6				
Average Percent Residual Oil Saturation	27.6				
Average Percent Residual Water Saturation	66.1				
Average Percent Total Residual Fluid Saturation	93.7				
Average Original Oil Content, Bbls./A. Ft.	680.				
Average Oil Recovery, Bbls./A. Ft.	224.				
Average Residual Oil Content, Bbls./A. Ft.	456.				
Total Original Oil Content, Bbls./Acre	12,597.				
Total Oil Recovery, Bbls./Acre	4,158.				
Total Residual Oil Content, Bbls./Acre	8,439.				
Average Effective Permeability, Millidarcys	3.48				
Average Initial Fluid Production Pressure, p.s.i.	24.2				

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



KEUFEL & ESSER CO
MADE IN U.S.A.

K&E STANDARD CROSS SECTION
WALSH

CRA, INC.
WOODWARD LEASE WELL NO. 25
BOURBON COUNTY, KANSAS

DEPTH INTERVAL, FEET	FEET OF CORE ANALYZED	AVERAGE POROSITY, PERCENT	AVG. OIL SATURATION PERCENT	AVG. WATER SATURATION PERCENT	AVG. OIL CONTENT BLS./A. FT.	TOTAL OIL CONTENT BLS./ACRE	AVG. AIR PERMEABILITY, MILLIDARCY	CALCULATED OIL RECOVERY, BLS./ACRE
645.6 - 656.6	10.3	19.4	14.6	55.0	222	2,291	57.6	
656.6 - 681.6	18.5	21.4	41.1	35.0	686	12,697	55.5	
681.6 - 697.0	15.4	19.0	44.6	35.6	659	10,159	11.3	
645.6 - 697.0	44.2	20.2	36.1	39.6	568	25,147	40.1	6,860 (Primary & Secondary)