● CORE ANALYSIS ● WATER REPRESSURING ENGINEERING ● WATER ANALYSIS ● FLOODING WATER TREATMENT ● SURVEYING

OILFIELD RESEARCH LABORATORIES

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October 8, 1959

Sunray Mid-Continent Oil Company
P. O. Box 1878
Wichita, Kansas

Gentlemen:

Enclosed herewith is the report of the analysis of the 3½" Rotary core taken from the Wayham Lease, Well No. W-2, Greenwood County, Kansas, and submitted to our laboratory on October 1, 1959.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Carl L. McElrea

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GENERAL INFORMATION & SUMMARY

Company Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

Location 520' W. of E. Line & 1300' N. of S. Line, NE¼

Section 14 Twp. 24S Rge. 12E County Greenwood State Kansas

Name of Formation	Mississippian
Top of Core	1714.0
Bottom of Core	1763.0
Top of Limestone	1722.0
Bottom of Limestone	1761.0
Total Feet of Permeable Limestone	16.2
Total Feet of Floodable Limestone	8.6

Distribution of Permeable Limestone

Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 5	6.2	6.2
5 - 10	4.8	11.0
10 - 100	3.8	14.8
100 & above	1.4	16.2

Average Permeability Millidarcys	24.7
Average Percent Porosity	17.4
Average Percent Oil Saturation	21.1
Average Percent Water Saturation	67.4
Average Oil Content, Bbls./A. Ft.	285.
Total Oil Content, Bbls./Acre	10,065.
Average Percent Oil Recovery by Laboratory Flooding Tests	6.1
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	105.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	807.
Total Calculated Oil Recovery, Bbls./Acre	1,375.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

A fresh water mud was used as the circulating fluid during the coring of the formation. The core was sampled and the samples were sealed in cans by a representative of Oilfield Research Laboratories.

Depths given in this report are with respect to a point 5 feet above ground level.

FORMATION CORED

The detailed log of the formation cored is as follows:

Depth Interval, Feet	Description
1714.0 - 1715.0	Sandy shaley chert.
1715.0 - 1716.0	Core not received.
1716.0 - 1717.0	Sandy shaley chert.
1717.0 - 1722.0	Core not received.
1722.0 - 1731.1	Cherty shaley limestone.
1731.1 - 1733.0	Hard slightly calcareous shale.
1733.0 - 1733.8	Slightly shaley limestone.
1733.8 - 1734.0	Shaley limestone.
1734.0 - 1736.2	Grayish brown limestone containing an angular fracture.
1736.2 - 1736.7	Chert.
1736.7 - 1741.0	Brown limestone containing a vertical fracture.
1741.0 - 1752.0	Light brown shaley limestone containing two vertical fractures.
1752.0 - 1754.0	Brown limestone containing a vertical fracture.
1754.0 - 1754.3	Chert containing a vertical fracture.
1754.3 - 1756.0	Brown vuggy limestone containing a vertical fracture.
1756.0 - 1757.8	Grayish light brown shaley limestone containing a vertical fracture.
1757.8 - 1758.0	Black calcareous shale containing a vertical fracture.
1758.0 - 1761.0	Brown and gray shaley limestone containing a vertical fracture.
1761.0 - 1763.0	Brown and black calcareous shale containing a vertical fracture.

Coring was started at a depth of 1714.0 feet in sandy shaley chert and completed at 1763.0 feet in brown and black calcareous shale. This core shows a total of 36.1 feet of limestone. For the most part, the pay is made up of shaley limestone.

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 7.8, 6.8 and 53.7 millidarcys respectively; the overall average being 24.7 (See Table III). By observing the data given on the coregraph, it is noticeable that the limestone has a very irregular permeability profile. The permeability of the limestone varies from 0.57 to a maximum of 205 millidarcys.

PERCENT SATURATION & OIL CONTENT

The limestone in this core shows a low weighted average percent oil saturation, namely, 21.1. The weighted average percent oil saturation of the upper, middle and lower sections is 21.0, 20.1 and 23.3 respectively. The weighted average percent water saturation of the upper, middle and lower sections is 61.0, 71.6 and 68.1 respectively; the overall average being 67.4 (See Table III). This gives an overall weighted average total fluid saturation of 88.5 percent.

The weighted average oil content of the upper, middle and lower sections is 242, 292 and 330 barrels per acre foot respectively; the overall average being 285. The total oil content, as shown by this core, is 10,065 barrels per acre (See Table III).

LABORATORY FLOODING TESTS

Part of the limestone in this core responded fairly well to laboratory flooding tests, as a total recovery of 807 barrels of oil per acre

was obtained from 7.7 feet of limestone. The weighted average percent oil saturation was reduced from 30.9 to 24.8, or represents an average recovery of 6.1 percent. The weighted average effective permeability of the samples is 2.53 millidarcys, while the average initial fluid production pressure is 27.2 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 35 samples tested, 11 produced water and 9 oil. This indicates that approximately 31 percent of the limestone represented by these samples is floodable pay. The tests also show that the limestone has a rather wide variation in effective permeability.

CONCLUSION

It is evident from the enclosed data that an efficient water-flood within the vicinity of this well will recover approximately 1,375 barrels of oil per acre. This represents an average recovery of 160 barrels of oil per acre foot from the 8.6 feet of floodable limestone analyzed. The following factors and assumptions were used in calculating this recovery:

Original formation volume factor	1.13
Present formation volume factor	1.03
True water saturation, percent	40.0
Primary oil recovery, percent	10.0
Calculated present oil saturation, percent	44.7
Porosity, percent	21.5
Oil saturation at abandonment, percent	25.0
Performance factor, percent	50.0

The analysis results show 8.6 feet of floodable limestone in the cored section. The floodable pay has fairly good oil and rather high water saturations and a wide variation in effective permeability.

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RESULTS OF PERMEABILITY TESTS

TABLE I

Company Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

Sample No.	Depth Feet	Permeability Millidarcys	Feet of Core		Permeability Capacity Ft. x Md.
			Ft.	Cum. Ft.	
1	1714.5	Imp.	1.0	1.0	0.00
2	1716.5	Imp.	1.0	2.0	0.00
3	1722.5	Imp.	0.7	2.7	0.00
4	1723.0	Imp.	0.5	3.2	0.00
5	1723.5	Imp.	0.6	3.8	0.00
6	1724.1	Imp.	0.6	4.4	0.00
7	1724.6	Imp.	0.5	4.9	0.00
8	1725.2	7.8	0.5	5.4	3.90
9	1725.8	Imp.	0.7	6.1	0.00
10	1726.4	Imp.	0.5	6.6	0.00
11	1728.5	Imp.	0.4	7.0	0.00
12	1729.1	Imp.	0.5	7.5	0.00
13	1729.5	Imp.	0.5	8.0	0.00
14	1729.9	Imp.	0.3	8.3	0.00
15	1730.2	Imp.	0.4	8.7	0.00
16	1730.7	Imp.	0.4	9.1	0.00
17	1731.0	Imp.	0.2	9.3	0.00
18	1733.9	Imp.	0.2	9.5	0.00
19	1734.4	Imp.	0.6	10.1	0.00
20	1734.9	Imp.	0.6	10.7	0.00
21	1735.4	Imp.	0.4	11.1	0.00
22	1735.9	Imp.	0.6	11.7	0.00
23	1736.4	Imp.	0.5	12.2	0.00
24	1736.9	Imp.	0.5	12.7	0.00
25	1737.5	5.9	0.6	13.3	3.54
26	1738.1	5.4	0.6	13.9	3.24
27	1738.7	8.0	0.6	14.5	4.80
28	1739.2	5.4	0.5	15.0	2.70
29	1739.8	2.6	0.6	15.6	1.56
30	1740.4	33.	0.5	16.1	16.50
31	1740.9	11.	0.4	16.5	4.40
32	1741.3	11.	0.6	17.1	6.60
33	1741.8	2.4	0.4	17.5	0.96
34	1742.2	1.3	0.5	18.0	0.65
35	1742.8	9.5	0.6	18.6	5.70
36	1743.4	9.7	0.5	19.1	4.85
37	1743.9	0.70	0.6	19.7	0.42
38	1745.2	1.7	0.6	20.3	1.02
39	1745.8	3.9	0.5	20.8	1.95
40	1746.2	2.7	0.5	21.3	1.35
41	1746.7	11.	0.4	21.7	4.40
42	1747.1	Imp.	0.6	22.3	0.00

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RESULTS OF PERMEABILITY TESTS

TABLE I

Company Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

Sample No.	Depth Feet	Permeability Millidarcys	Feet of Core		Permeability Capacity Ft. x Md.
			Ft.	Cum. Ft.	
43	1747.7	Imp.	0.6	22.9	0.00
44	1748.5	Imp.	0.6	23.5	0.00
45	1748.9	Imp.	0.3	23.8	0.00
46	1749.2	Imp.	0.5	24.3	0.00
47	1749.7	0.57	0.5	24.8	0.28
48	1750.3	Imp.	0.5	25.3	0.00
49	1750.8	Imp.	0.5	25.8	0.00
50	1751.2	Imp.	0.5	26.3	0.00
51	1751.7	Imp.	0.5	26.8	0.00
52	1752.2	17.	0.5	27.3	8.50
53	1752.7	50.	0.5	27.8	25.00
54	1753.2	205.	0.5	28.3	102.50
55	1753.7	55.	0.5	28.8	27.50
56	1754.5	106.	0.4	29.2	42.40
57	1754.9	65.	0.4	29.6	26.00
58	1755.3	177.	0.5	30.1	88.50
59	1755.7	6.3	0.4	30.5	2.52
60	1756.4	Imp.	0.5	31.0	0.00
61	1756.8	Imp.	0.6	31.6	0.00
62	1757.5	Imp.	0.7	32.3	0.00
63	1757.9	Imp.	0.2	32.5	0.00
64	1758.2	Imp.	0.5	33.0	0.00
65	1758.6	4.8	0.5	33.5	2.40
66	1759.3	5.3	0.5	34.0	2.65
67	1759.7	4.8	0.5	34.5	2.40
68	1760.3	4.3	0.5	35.0	2.15
69	1760.7	0.76	0.5	35.5	0.38

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RESULTS OF SATURATION TESTS

TABLE II

Company Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

Sat. No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls./A. Ft.	Feet of Core		Total Oil Content Bbls./Acre
			Oil	Water	Total		Ft.	Cum. Ft.	
1	1714.5	19.6	34	45	79	517	1.0	1.0	517
2	1716.5	18.4	30	39	69	428	1.0	2.0	428
3	1722.7	13.1	18	50	68	183	0.8	2.8	146
F-3	1722.9	21.3	26	-	-	430	0.6	3.4	258
4	1723.9	21.6	23	54	77	385	1.0	4.4	385
5	1724.9	22.3	13	77	90	225	1.0	5.4	225
6	1726.1	15.6	14	81	95	169	1.2	6.6	203
7	1728.9	18.8	6	84	90	88	0.9	7.5	79
8	1729.7	15.4	13	78	91	155	0.8	8.3	124
9	1730.4	14.7	7	75	82	77	1.0	9.3	77
10	1734.1	8.7	21	52	73	142	0.6	9.9	85
11	1735.1	4.8	31	47	78	115	1.0	10.9	115
12	1736.1	6.4	48	36	84	238	0.6	11.5	143
13	1737.3	15.7	39	51	90	475	1.2	12.7	570
14	1738.4	20.9	32	57	89	519	1.1	13.8	571
15	1739.5	23.0	32	59	91	571	1.1	14.9	629
16	1740.7	16.6	31	64	95	400	0.9	15.8	360
17	1741.5	16.8	21	71	92	274	1.0	16.8	274
18	1742.5	23.7	23	70	93	422	1.0	17.8	422
F-19	1743.5	23.1	29	-	-	520	0.6	18.4	312
19	1743.7	16.9	23	72	95	302	0.9	19.3	272
20	1745.5	18.5	11	81	92	158	1.5	20.8	237
21	1746.4	18.7	27	67	94	392	0.9	21.7	353
22	1747.3	17.0	2	90	92	26	1.1	22.8	29
23	1748.7	18.3	7	84	91	99	1.0	23.8	99
24	1749.4	15.9	10	81	91	123	1.0	24.8	123
25	1750.6	16.0	8	76	84	99	1.0	25.8	99

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RESULTS OF SATURATION TESTS

TABLE II

Company Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

Sat. No.	Depth, Feet	Effective Porosity Percent	Percent Saturation			Oil Content Bbls./A. Ft.	Feet of Core		Total Oil Content Bbls./Acre
			Oil	Water	Total		Ft.	Cum. Ft.	
26	1751.4	14.7	11	79	90	126	1.0	26.8	126
27	1752.4	21.6	34	55	89	570	1.0	27.8	570
28	1753.5	21.9	38	46	84	645	1.0	28.8	645
F-29	1754.6	17.2	37	-	-	493	0.4	29.2	197
29	1754.8	13.9	40	53	93	432	0.4	29.6	173
30	1755.5	20.1	27	53	80	421	0.9	30.5	379
31	1756.6	15.3	3	93	96	36	1.1	31.6	40
32	1757.7	16.5	9	89	98	115	0.7	32.3	81
33	1758.4	12.2	26	66	92	246	1.0	33.3	246
34	1759.5	19.7	10	84	94	153	1.0	34.3	153
35	1760.5	16.5	25	67	92	320	1.0	35.3	320
							Total-	- - - - -	10,065

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
1724.9 - 1725.4	0.5	7.8	3.90
1737.2 - 1750.0	9.5	6.8	64.92
1752.0 - 1761.0	6.2	53.7	332.90
1724.9 - 1761.0	16.2	24.7	401.72

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
1714.0 - 1736.2	11.5	15.8	21.0	61.0	242	2,785
1736.7 - 1752.0	15.3	18.3	20.1	71.6	292	4,476
1752.0 - 1761.0	8.5	17.7	23.3	68.1	330	2,804
1714.0 - 1761.0	35.3	17.4	21.1	67.4	285	10,065

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

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	1714.5	19.6	31	472	0	0	31	51	472	0	Imp.	50+
2	1716.5	18.2	27	382	0	0	27	57	382	0	Imp.	50+
3	1722.9	21.3	26	430	5	83	21	67	347	24	0.395	25
4	1723.9	21.0	23	374	1	16	22	64	358	9	0.158	30
5	1724.9	22.6	15	263	0	0	15	77	263	0	Imp.	50+
6	1726.1	15.2	16	189	0	0	16	72	189	0	Imp.	50+
7	1728.9	19.1	9	133	0	0	9	84	133	0	Imp.	50+
8	1729.7	15.3	14	166	0	0	14	76	166	0	Imp.	50+
9	1730.4	14.1	10	110	0	0	10	84	110	0	Imp.	50+
10	1734.1	8.3	24	155	0	0	24	66	155	0	Imp.	50+
11	1735.1	4.6	35	125	0	0	35	36	125	0	Imp.	50+
12	1736.1	6.1	46	218	0	0	46	42	218	0	Imp.	50+
13	1737.3	15.5	37	445	0	0	37	56	445	0	Imp.	50+
14	1738.4	21.0	32	522	5	82	27	69	440	26	0.455	25
15	1739.5	23.6	32	586	11	201	21	77	385	17	0.403	25
16	1740.7	16.2	28	352	0	0	28	66	352	8	0.305	35
17	1741.5	17.6	18	246	0	0	18	81	246	0	Imp.	50+
18	1742.5	23.9	21	389	0	0	21	75	389	0	Imp.	50+
19	1743.5	23.1	29	520	3	54	26	71	466	4	0.080	50
20	1745.5	18.9	14	205	0	0	14	80	205	4	0.100	35
21	1746.4	18.9	28	410	0	0	28	70	410	0	Imp.	50+
22	1747.3	17.3	5	67	0	0	5	88	67	0	Imp.	50+
23	1748.7	18.6	4	58	0	0	4	93	58	0	Imp.	50+
24	1749.4	16.3	12	152	0	0	12	86	152	0	Imp.	50+
25	1750.6	15.6	7	85	0	0	7	92	85	0	Imp.	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 Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

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.			
26	1751.4	14.4	13	145	0	0	13	78	145	0	Imp.	50+
27	1752.4	22.4	34	591	8	139	26	72	452	142	4.34	25
28	1753.5	22.2	38	655	13	224	25	74	431	151	10.22	15
29	1754.6	17.2	37	493	4	53	33	61	440	31	0.687	25
30	1755.5	20.5	27	429	1	16	26	70	413	107	3.62	25
31	1756.6	15.4	4	48	0	0	4	88	48	0	Imp.	50+
32	1757.7	16.9	8	105	0	0	8	86	105	0	Imp.	50+
33	1758.4	12.7	24	236	0	0	24	71	236	0	Imp.	50+
34	1759.5	19.3	10	150	0	0	10	89	150	0	Imp.	50+
35	1760.5	16.5	24	307	0	0	24	70	307	0	Imp.	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.

Oilfield Research Laboratories

SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company Sunray Mid-Continent Oil Co. Lease Wayham Well No. W-2

Depth Interval, Feet	1722.8 - 1724.4	1737.9 - 1743.6	1752.0 - 1756.0	1722.8 - 1756.0
Feet of Core Analyzed	1.6	2.8	3.3	7.7
Average Percent Porosity	21.1	22.5	21.2	21.7
Average Percent Original Oil Saturation	24.1	31.3	33.7	30.9
Average Percent Oil Recovery	2.5	6.9	7.1	6.1
Average Percent Residual Oil Saturation	21.6	24.4	26.6	24.8
Average Percent Residual Water Saturation	65.1	72.5	70.6	70.2
Average Percent Total Residual Fluid Saturation	86.7	96.9	97.2	95.0
Average Original Oil Content, Bbls./A. Ft.	395.	547.	555.	518.
Average Oil Recovery, Bbls./A. Ft.	41.	123.	121.	105.
Average Residual Oil Content, Bbls./A. Ft.	354.	424.	434.	413.
Total Original Oil Content, Bbls./Acre	632.	1,531.	1,829.	3,992.
Total Oil Recovery, Bbls./Acre	66.	343.	398.	807.
Total Residual Oil Content, Bbls./Acre	566.	1,188.	1,431.	3,185.
Average Effective Permeability, Millidarcys	0.247	0.354	5.47	2.53
Average Initial Fluid Production Pressure, p.s.i.	27.5	33.3	22.5	27.2

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