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

OILFIELD RESEARCH LABORATORIES

- REGISTERED ENGINEERS -

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September 4, 1959

Mr. H. G. Forbes
Eureka, Kansas

Dear Sir:

Enclosed herewith is the report of the analysis of the 3½" Rotary core taken from the Freeburg Lease, Well No. 5-A, Greenwood County, Kansas, and submitted to our laboratory on August 28, 1959.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Carl L. McElrea

Carl L. McElrea

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GENERAL INFORMATION & SUMMARY

Company H. G. Forbes Lease Freeburg Well No. 5-A

Location SE¼, NE¼, SE¼

Section 22 Twp. 22S Rge. 11E County Greenwood State Kansas

Name of Sand	Bartlesville
Top of Core	1891.0
Bottom of Core	1935.0
Pay Top of Sand	1914.6
Pay Bottom of Sand	1933.4
Total Feet of Permeable Sand (Analyzed)	17.0
Total Feet of Floodable Sand (Analyzed)	13.7

Distribution of Permeable Sand:

Permeability Range Millidarcys	Feet	Cum. Ft.
0 - 5	3.0	3.0
5 - 10	2.3	5.3
10 - 20	5.5	10.8
20 - 30	3.0	13.8
30 & over	3.2	17.0

Average Permeability Millidarcys	17.8
Average Percent Porosity	17.9
Average Percent Oil Saturation	20.0
Average Percent Water Saturation	53.0
Average Oil Content, Bbls./A. Ft.	283.
Total Oil Content, Bbls./Acre	5,124.
Average Percent Oil Recovery by Laboratory Flooding Tests	3.6
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	52.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	714.
Total Calculated Oil Recovery, Bbls./Acre	2,280.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

Magcogel mud was used as the circulating fluid during the coring of the sand.

Samples were taken from the core and sealed in cans by a representative of Oilfield Research Laboratories.

FORMATION CORED

The detailed log of the formation cored is as follows:

Depth Interval, Feet	Description
1891.0 - 1911.0	Shale (Discarded at well).
1911.0 - 1912.0	Shale.
1912.0 - 1913.6	Gray shaley sandstone.
1913.6 - 1914.0	Brown fine grained micaceous shaley sandstone.
1914.0 - 1916.5	Light brown fine grained micaceous slightly shaley sandstone.
1916.5 - 1917.0	Gray shaley sandstone.
1917.0 - 1917.7	Light brown fine grained slightly shaley sandstone.
1917.7 - 1919.8	Gray sandy limestone.
1919.8 - 1921.3	Light brown fine grained micaceous slightly shaley sandstone.
1921.3 - 1921.5	Laminated sandy shale.
1921.5 - 1933.4	Light brown fine grained micaceous sandstone.
1933.4 - 1935.0	Loss.

Coring was started at a depth of 1891.0 feet in shale and completed at 1935.0 feet. The core of the interval extending from 1933.4 to 1935.0 feet was not recovered. This core shows a total of 19.1 feet of sandstone. For the most part, the pay is made up of light brown fine grained micaceous 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 4.7 and 23.5 millidarcys respectively; the overall average being 17.8 (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 1.9 to a maximum of 70 millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a low weighted average percent oil saturation, namely, 20.0. The weighted average percent oil saturation of the upper and lower sections is 18.2 and 21.0 respectively. The weighted average percent water saturation of the upper and lower sections is 59.6 and 49.6 respectively; the overall average being 53.0 (See Table III). This gives an overall weighted average total fluid saturation of 73.0 percent. This low total fluid saturation indicates considerable fluid was lost during coring which probably was oil.

The weighted average oil content of the upper and lower sections is 245 and 301 barrels per acre foot respectively; the overall average being 283. The total oil content, as shown by this core, is 5,124 barrels per acre (See Table III).

LABORATORY FLOODING TESTS

Part of the sand in this core responded fairly well to laboratory flooding tests, as a total recovery of 714 barrels of oil per acre was obtained from 13.7 feet of sand. The weighted average percent oil saturation was reduced from 21.2 to 17.6, or represents an average recovery of 3.6 percent. The weighted average effective permeability of the samples is 1.72 millidarcys, while the average initial fluid production pressure is 32.8 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 20 samples tested, 15 produced water and 14 oil. This indicates that approximately 70 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.

CONCLUSION

It is evident from the enclosed data that an efficient water-flood will recover approximately 2,280 barrels per acre from the area of which this core is representative. This represents an average recovery of 166 barrels of oil per acre foot from the 13.7 feet of floodable sand in the cored section. The following factors and assumptions were used in calculating this recovery:

Original formation volume factor	1.14
Present formation volume factor	1.03
True water saturation, percent	40.0
Primary oil recovery, percent	10.0
Calculated present oil saturation, percent	43.6
Porosity, percent	18.6
Oil saturation at abandonment, percent	22.0
Performance factor	0.55

The analysis results show 13.7 feet of floodable sand in the cored section. The floodable sand has low oil and rather high water saturations and a wide variation in permeability. It is evident that the oil saturations were reduced to near residual values during coring.

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RESULTS OF PERMEABILITY TESTS

TABLE I

Company H. G. Forbes Lease Freeburg Well No. 5-A

Sample No.	Depth Feet	Permeability Millidarcys	Feet of Core		Permeability Capacity Ft. x Md.
			Ft.	Cum. Ft.	
1	1911.9	Imp.	0.5	0.5	0.00
2	1912.4	Imp.	0.7	1.2	0.00
3	1912.9	Imp.	0.5	1.7	0.00
4	1913.4	Imp.	0.4	2.1	0.00
5	1913.9	1.9	0.4	2.5	0.76
6	1914.4	5.1	0.7	3.2	3.57
7	1914.9	10.	0.5	3.7	5.00
8	1915.4	4.8	0.5	4.2	2.40
9	1915.9	2.4	0.5	4.7	1.20
10	1916.4	4.2	0.3	5.0	1.26
11	1916.9	Imp.	0.5	5.5	0.00
12	1917.4	2.4	0.7	6.2	1.68
13	1919.9	8.2	0.4	6.6	3.28
14	1920.4	5.1	0.5	7.1	2.55
15	1920.9	4.2	0.6	7.7	2.52
16	1921.4	Imp.	0.2	7.9	0.00
17	1921.9	7.4	0.7	8.6	5.18
18	1922.4	12.	0.5	9.1	6.00
19	1922.9	11.	0.5	9.6	5.50
20	1923.4	13.	0.5	10.1	6.50
21	1923.9	15.	0.5	10.6	7.50
22	1924.4	12.	0.5	11.1	6.00
23	1924.9	11.	0.5	11.6	5.50
24	1925.4	16.	0.5	12.1	8.00
25	1925.9	30.	0.5	12.6	15.00
26	1926.4	19.	0.5	13.1	9.50
27	1926.9	20.	0.5	13.6	10.00
28	1927.4	21.	0.5	14.1	10.50
29	1927.9	13.	0.5	14.6	6.50
30	1928.4	27.	0.5	15.1	13.50
31	1928.9	37.	0.5	15.6	18.50
32	1929.4	29.	0.5	16.1	14.50
33	1929.9	25.	0.5	16.6	12.50
34	1930.4	25.	0.5	17.1	12.50
35	1930.9	35.	0.5	17.6	17.50
36	1931.4	15.	0.5	18.1	7.50
37	1931.9	31.	0.5	18.6	15.50
38	1932.4	33.	0.5	19.1	16.50
39	1932.9	70.	0.7	19.8	49.00

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RESULTS OF SATURATION TESTS

TABLE II

Company H. G. Forbes **Lease** Freeburg **Well No.** 5-A

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	1912.1	15.9	14	79	93	172	0.6	0.6	103
2	1913.1	13.3	12	81	93	124	1.0	1.6	124
3	1914.1	18.7	17	57	74	246	0.6	2.2	148
4	1915.1	19.1	23	47	70	342	1.0	3.2	342
5	1916.1	17.5	22	52	74	299	0.9	4.1	269
6	1917.1	17.1	19	54	73	252	0.7	4.8	176
7	1920.1	18.2	22	51	73	311	0.8	5.6	249
8	1921.1	16.3	15	58	73	190	0.7	6.3	133
9	1922.1	17.9	17	52	69	236	1.1	7.4	260
10	1923.1	18.0	23	51	74	321	1.0	8.4	321
11	1924.1	18.2	19	51	70	268	1.0	9.4	268
12	1925.1	18.1	22	49	71	309	1.0	10.4	309
13	1926.1	19.0	22	45	67	324	1.0	11.4	324
14	1927.1	17.5	22	49	71	299	1.0	12.4	299
15	1928.1	17.9	22	50	72	306	1.0	13.4	306
16	1929.1	18.5	19	49	68	273	1.0	14.4	273
17	1930.1	19.6	21	47	68	319	1.0	15.4	319
18	1931.1	19.4	18	54	72	271	1.0	16.4	271
19	1932.1	16.7	22	55	77	286	1.0	17.4	286
20	1933.1	21.3	26	41	67	430	0.8	18.2	344
							Total- - - - - -		5,124

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company H. G. Forbes Lease Freeburg Well No. 5-A

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.
1913.6 - 1921.3	5.1	4.7	24.22
1921.5 - 1933.4	11.9	23.5	279.18
1913.6 - 1933.4	17.0	17.8	303.40

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
1912.0 - 1921.3	6.3	17.0	18.2	59.6	245	1,544
1921.5 - 1933.4	11.9	18.5	21.0	49.6	301	3,580
1912.0 - 1933.4	18.2	17.9	20.0	53.0	283	5,124

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company H. G. Forbes Lease Freeburg Well No. 5-A

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	1912.1	16.2	12	151	0	0	12	77	151	0	Imp.	50+
2	1913.1	13.5	11	115	0	0	11	78	115	0	Imp.	50+
3	1914.1	19.3	16	240	0	0	16	68	240	0	Imp.	50+
4	1915.1	19.2	23	342	6	89	17	67	253	6	0.203	45
5	1916.1	17.0	20	264	0	0	20	68	264	0	Imp.	50+
6	1917.1	16.4	19	242	0	0	19	70	242	0	Imp.	50+
7	1920.1	18.2	22	311	3	42	19	75	269	18	0.585	40
8	1921.1	16.8	13	169	0	0	13	75	169	7	0.302	50
9	1922.1	18.0	17	238	1	14	16	73	224	16	0.416	40
10	1923.1	18.0	23	321	3	42	20	74	279	20	0.504	30
11	1924.1	17.8	19	263	2	28	17	76	235	28	0.711	30
12	1925.1	17.8	22	304	2	28	20	77	276	34	1.02	30
13	1926.1	18.5	22	316	6	86	16	79	230	34	0.800	30
14	1927.1	17.8	22	304	8	111	14	81	193	40	1.13	30
15	1928.1	18.4	22	315	3	43	19	79	272	53	1.70	30
16	1929.1	18.6	19	274	4	58	15	82	216	64	2.41	30
17	1930.1	19.9	21	324	3	46	18	77	278	102	3.24	30
18	1931.1	20.0	18	280	1	16	17	75	264	108	4.06	30
19	1932.1	16.9	22	288	2	26	20	73	262	34	0.414	35
20	1933.1	21.2	26	427	7	115	19	74	312	168	8.10	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.

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SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company H. G. Forbes Lease Freeburg Well No. 5-A

Depth Interval, Feet	1914.6 - 1920.6	1921.5 - 1933.4	1914.6 - 1933.4
Feet of Core Analyzed	1.8	11.9	13.7
Average Percent Porosity	18.8	18.5	18.6
Average Percent Original Oil Saturation	22.6	20.9	21.2
Average Percent Oil Recovery	4.7	3.4	3.6
Average Percent Residual Oil Saturation	17.9	17.5	17.6
Average Percent Residual Water Saturation	70.5	76.7	75.8
Average Percent Total Residual Fluid Saturation	88.4	94.2	93.4
Average Original Oil Content, Bbls./A. Ft.	328.	302.	305.
Average Oil Recovery, Bbls./A. Ft.	68.	50.	52.
Average Residual Oil Content, Bbls./A. Ft.	260.	252.	253.
Total Original Oil Content, Bbls./Acre	591.	3,592.	4,183.
Total Oil Recovery, Bbls./Acre	123.	591.	714.
Total Residual Oil Content, Bbls./Acre	468.	3,001.	3,469.
Average Effective Permeability, Millidarcys	0.373	1.93	1.72
Average Initial Fluid Production Pressure, p.s.i.	42.5	30.4	32.8

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