

OILFIELD RESEARCH LABORATORIES

- REGISTERED ENGINEERS -

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June 23, 1962

E.J. Dunigan, Jr.
Box 261
Pampa, Texas

Dear Sir:

Enclosed herewith is the report of the analysis of the Cable Tool core taken from the Frank Armstrong Lease, Well No. 4, Crawford County, Kansas, and submitted to our laboratory on June 18, 1962.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES

Benjamin R. Pearman
Benjamin R. Pearman

BRP:rf

4 c. - E.J. Dunigan, Jr.
1 c. - Jess Miller
1 c. - Jim Guinotte
1 c. - Bud Alcock

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GENERAL INFORMATION & SUMMARY

Company E.J. Dunigan, Jr. Lease Frank Armstrong Well No. 4

Location SE NW

Section 3 Twp. 28S Rge. 23E County Crawford State Kansas

Name of Sand	Peru
Top of Core	180.0
Bottom of Core	195.6
Top of Sand (Reported)	177.0
Bottom of Sand (Analyzed)	195.6
Total Feet of Permeable Sand	15.6
Total Feet of Floodable Sand	9.0

Distribution of Permeable Sand:
Permeability Range
Millidarcys

Feet

Cum. Ft.

0 - 10	1.0	1.0
10 - 20	4.3	5.3
20 - 50	9.7	15.0
50 & above	0.6	15.6

Average Permeability Millidarcys	25.4
Average Percent Porosity	18.5
Average Percent Oil Saturation	29.4
Average Percent Water Saturation	61.5
Average Oil Content, Bbls./A. Ft.	419.
Total Oil Content, Bbls./Acre	6,536.
Average Percent Oil Recovery by Laboratory Flooding Tests	2.8
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	41.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	369.
Total Calculated Oil Recovery, Bbls./Acre (Primary & Secondary)	1,890.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

Water was used as the coring fluid while taking this core. The core was sampled and the samples sealed in cans by a representative of the laboratory. The well was drilled in virgin territory.

FORMATION CORED

The detailed log of the formation cored is as follows:

<u>Depth Interval, Description</u> <u>Feet</u>

180.0 - 184.0 - Brown, slightly shaly sandstone.
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184.0 - 184.7 - Brown conglomeratic sandstone.
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184.7 - 189.0 - Brown slightly shaly sandstone.

189.0 - 193.7 - Grayish brown, shaly sandstone.

193.7 - 195.6 - Gray to dark, slightly calcareous, slightly carbonaceous sandstone.

Coring was started at a depth of 180.0 feet in slightly shaly sandstone and completed at 195.6 feet in carbonaceous sandstone. This core shows a total of 15.6 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 two sections. The weighted average permeability of the upper and lower sections is 24.2 and 27.2 millidarcys respectively; the overall average being 25.4 (See Table III). By observing the data given on the coregraph, it is noticeable that the sand has a rather uniform permeability profile. The permeability of the sand varies from 5.6 to a maximum of 55. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a fair weighted average percent oil saturation, namely, 29.4. The weighted average percent oil saturation of the upper and lower sections is 29.0 and 30.1 respectively. The weighted

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average percent water saturation of the upper and lower sections is 61.4 and 62.0 respectively; the overall average being 61.5 (See Table III). This gives an overall weighted average total fluid saturation of 90.9 percent.

The weighted average oil content of the upper and lower sections is 424 and 414 barrels per acre foot respectively; the overall average being 419. The total oil content, as shown by this core, is 6,536 barrels per acre (See Table III).

LABORATORY FLOODING TESTS

The sand in this core responded to laboratory flooding tests, as a total recovery of 369 barrels of oil per acre was obtained from 9.0 feet of sand. The weighted average percent oil saturation was reduced from 29.6 to 26.8, or represents an average recovery of 2.8 percent. The weighted average effective permeability of the samples is 1.00 millidarcys, while the average initial fluid production pressure is 28.9 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 14 samples tested, all produced water and 9 oil. This indicates that approximately 64 percent of the sand represented by these samples is floodable pay sand. The tests also show that the sand has a rather uniform effective permeability to water.

CONCLUSION

A study of the laboratory data indicates that efficient primary and secondary operations in the vicinity of this well should recover approximately 670 and 1,220 barrels of oil per acre respectively.

The following data and assumptions were used in calculating the above recovery values:

Original formation volume factor	1.02
Reservoir water saturation, percent	53.0

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Primary recovery, estimated, percent	3.0
Average porosity, percent	19.1
Oil saturation after flooding, percent	26.8
Performance factor, percent	55.0
Net floodable pay sand, feet	9.0

This core shows a slightly shaly pay sand section having a fair oil saturation, a somewhat high water saturation and uniform effective permeability to water.

The above recovery values were calculated assuming that satisfactory injection rates can be maintained throughout the flood life of the property.

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company E. J. Dunigan, Jr. Lease Frank Armstrong Well No. 4

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			Ft.	Cum. Ft.		
1	180.1	18.9	27	53	396	55.	0.6	0.6	238	33.00
2	181.1	16.9	30	68	393	22.	1.0	1.6	393	22.00
3	182.1	18.9	28	62	410	17.	1.0	2.6	410	17.00
4	183.1	19.7	27	57	412	14.	1.4	4.0	576	19.60
5	184.1	18.9	28	67	410	26.	0.7	4.7	287	18.20
6	185.1	19.4	29	64	436	20.	0.9	5.6	392	18.00
7	186.1	19.4	29	58	436	21.	1.0	6.6	436	21.00
8	187.1	19.4	33	61	497	34.	1.0	7.6	497	34.00
9	188.1	18.4	29	62	414	25.	1.4	9.0	579	35.00
10	189.1	18.7	26	63	377	49.	0.6	9.6	226	29.40
11	190.1	20.2	25	61	392	31.	1.0	10.6	392	31.00
12	191.1	19.2	32	62	476	16.	1.0	11.6	476	16.00
13	192.1	20.3	28	68	441	32.	1.0	12.6	441	32.00
14	193.1	17.5	26	63	353	22.	1.1	13.7	388	24.20
15	194.1	17.7	34	61	467	46.	0.9	14.6	421	41.40
16	195.1	12.7	39	56	384	5.6	1.0	15.6	384	5.60
Total								-----	6,536	

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company E.J. Dunigan, Jr. Lease Frank Armstrong Well No. 4

Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, mDarcy	Permeability Capacity Fl. x Md.
180.0 - 189.0	9.0	24.2	217.80
189.0 - 195.6	6.6	27.2	179.60
180.0 - 195.6	15.6	25.4	397.40

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 Bbl./Acre
180.0 - 189.0	9.0	18.9	29.0	61.4	424	3,808
189.0 - 195.6	6.6	18.0	30.1	62.0	414	2,728
180.0 - 195.6	15.6	18.5	29.4	61.5	419	6,536

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company		E. J. Dunigan, Jr.		Lease		Frank Armstrong		Well No.		4	
Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation		Volume of Water Recovered cc ^a	Effective Permeability Millidarcys ^b	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water			
1	180.1	18.9	28	410	0	0	28	68	10	0.473	40
2	181.1	17.6	30	409	41	41	27	69	18	0.575	40
3	182.1	19.2	28	416	30	30	26	64	31	0.581	40
5	184.1	18.7	28	406	29	29	26	72	24	0.387	30
6	185.1	19.2	29	431	30	30	27	67	45	0.912	20
7	186.1	19.0	29	427	59	59	25	62	66	1.08	20
8	187.1	19.7	33	504	76	76	28	69	67	1.32	30
9	188.1	18.2	29	409	28	28	27	71	28	0.664	30
10	189.1	19.0	27	398	0	0	27	64	26	0.870	30
11	190.1	20.0	24	372	0	0	24	68	22	0.636	30
12	191.1	19.5	32	484	45	45	29	63	22	0.636	30
13	192.1	20.4	28	443	32	32	26	71	104	2.81	20
14	193.1	17.2	25	333	0	0	25	70	23	0.678	40
16	195.1	12.3	40	381	0	0	40	57	4	0.102	50

Notes: cc—cubic centimeter.

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

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

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SUMMARY OF LABORATORY FLOODING TESTS

TABLE V

Company	E.J. Dunigan, Jr.	Lease	Frank Armstrong	Well No.	6
Depth Interval, Feet	180.0 - 189.0	189.0 - 195.6	180.0 - 195.6		
Feet of Core Analyzed	7.0	2.0	9.0		
Average Percent Porosity	18.8	20.0	19.1		
Average Percent Original Oil Saturation	29.5	30.0	29.6		
Average Percent Oil Recovery	2.9	2.5	2.8		
Average Percent Residual Oil Saturation	26.6	27.5	26.8		
Average Percent Residual Water Saturation	67.6	67.0	67.5		
Average Percent Total Residual Fluid Saturation	94.2	94.5	94.3		
Average Original Oil Content, Bbls./A. Ft.	429.	464.	436.		
Average Oil Recovery, Bbls./A. Ft.	42.	39.	41.		
Average Residual Oil Content, Bbls./A. Ft.	387.	425.	395.		
Total Original Oil Content, Bbls./Acre	3,001.	927.	3,928.		
Total Oil Recovery, Bbls./Acre	292.	77.	369.		
Total Residual Oil Content, Bbls./Acre	2,709.	850.	3,559.		
Average Effective Permeability, Millidarcys	0.796	1.72	1.00		
Average Initial Fluid Production Pressure, p.s.i.	30.0	25.0	28.9		

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