

OILFIELD RESEARCH LABORATORIES

- REGISTERED ENGINEERS -

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June 7, 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. 3, Crawford County, Kansas, and submitted to our laboratory on June 1, 1962.

Your business is greatly appreciated.

Very truly yours,

OILFIELD RESEARCH LABORATORIES



Carl L. Pate

CLP:rf

1 c. - Jess Miller
1 c. - Jim Guinotte
1 c. - Bud Alcock

Oilfield Research Laboratories

GENERAL INFORMATION & SUMMARY

Company E.J. Dunigan, Jr. Lease Frank Armstrong Well No. 3

Location NE SW NW

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

Name of Sand	Peru
Top of Core	185.0
Bottom of Core	201.2
Top of Sand (Cored)	185.0
Bottom of Sand (Cored)	201.2
Total Feet of Permeable Sand	13.3
Total Feet of Floodable Sand	8.4

Distribution of Permeable Sand:
Permeability Range
Millidarcys

Feet

Cum. Ft.

0 - 5	2.2	2 2
5 - 10	0.9	3 1
10 - 20	1.8	4.9
20 - 30	5.8	10.7
30 & above	2.6	13.3

Average Permeability Millidarcys	20.7
Average Percent Porosity	18.1
Average Percent Oil Saturation	29.7
Average Percent Water Saturation	54.6
Average Oil Content, Bbls./A. Ft.	424.
Total Oil Content, Bbls./Acre	5,633.
Average Percent Oil Recovery by Laboratory Flooding Tests	5.5
Average Oil Recovery by Laboratory Flooding Tests, Bbls./A. Ft.	80.
Total Oil Recovery by Laboratory Flooding Tests, Bbls./Acre	673.
Total Calculated Oil Recovery, Bbls./Acre (Primary & Secondary)	1,940.
Packer Setting, Feet	
Viscosity, Centipoises @	
A. P. I. Gravity, degrees @ 60 °F	
Elevation, Feet	

The sand was cored in water. The core was sampled by a representative of Oilfield Research Laboratories. This well was drilled in a virgin area.

FORMATION CORED

The detailed log of the formation cored is as follows:

Depth Interval, Feet	Description
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185.0 - 187.2	- Brown fine grained sandstone.
187.2 - 187.4	- Brown shaly sandstone.
187.4 - 188.1	- Laminated sandy shale.
188.1 - 188.3	- Light brown shaly sandstone.
188.3 - 188.8	- Gray shale.
188.8 - 189.2	- Laminated sandstone and shale.
189.2 - 189.7	- Brown fine grained sandstone.
189.7 - 190.0	- Gray shale.
190.0 - 190.2	- Light brown shaly sandstone.
190.2 - 190.6	- Gray shale.
190.6 - 191.0	- Alternate layers of sandstone and shale.
191.0 - 192.5	- Brown fine grained sandstone.
192.5 - 194.0	- Brown finely laminated shaly sandstone.
194.0 - 197.6	- Brown fine grained laminated micaceous sandstone.
197.6 - 198.7	- Dark brown fine grained sandstone.
198.7 - 201.2	- Brown medium grained sandstone.

Coring was started at a depth of 185.0 feet in brown, fine grained sandstone and completed at 201.2 feet in brown, medium grained sandstone. This core shows a total of 13.5 feet of sandstone. For the most part, the pay is made up of brown, fine to medium grained 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 15.9 and 24.8 millidarcys respectively; the overall average being 20.7

(See Table III). By observing the data given on the coregraph, it is noticeable that the sand has a very irregular permeability profile. The permeability of the sand varies from 2.7 to a maximum of 39. millidarcys.

PERCENT SATURATION & OIL CONTENT

The sand in this core shows a fair weighted average percent oil saturation, namely, 29.7. The weighted average percent oil saturation of the upper and lower sections is 25.9 and 33.0 respectively. The weighted average percent water saturation of the upper and lower sections is 58.0 and 51.8 respectively; the overall average being 54.6 (See Table III). This gives an overall weighted average total fluid saturation of 84.3 percent.

The weighted average oil content of the upper and lower sections is 366 and 472 barrels per acre foot respectively; the overall average being 424. The total oil content, as shown by this core, is 5,633 barrels per acre (See Table III).

LABORATORY FLOODING TESTS

When taking into consideration that the sand in the core has only a fair oil saturation, part of the sand in this core responded rather well to laboratory flooding tests, as a total recovery of 673 barrels of oil per acre was obtained from 8.4 feet of sand. The weighted average percent oil saturation was reduced from 32.4 to 26.9, or represents an average recovery of 5.5 percent. The weighted average effective permeability of the samples is 0.424 millidarcys, while the average initial fluid production pressure is 39.5 pounds per square inch (See Table V).

By observing the data given in Table IV, you will note that of the 14 samples tested, 12 produced water and 9 oil. This indicates that approximately 64 percent of the sand represented by these samples is floodable pay sand.

CONCLUSION

From a study of the above data, it is estimated that approximately

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604 barrels of oil per acre can be recovered, from the area represented by this core, by efficient primary production methods. An additional recovery of approximately 1,336 barrels can be expected by efficient water-flooding provided the sand will take an adequate volume of water at a reasonable pressure throughout the life of the flood. The following data and assumptions were used in calculating the above oil recovery values:

Present formation volume factor	1.02
Irreducible water saturation, percent	45.0
Primary recovery, estimated, percent	None.
Present oil saturation, percent	53.9
Average porosity, percent	18.6
Oil saturation after flooding, percent	26.9
Performance factor, percent	0.50
Net floodable pay sand, feet	8.4
Reported A.P.I. gravity of oil, degrees	31.0

This core shows a fairly clean sand section having a fair oil saturation, a high water saturation and a low permeability for its depth. The water intake capacity of this sand should be thoroughly tested before any large water-flood development is initiated.

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RESULTS OF SATURATION & PERMEABILITY TESTS

TABLE 1-B

Company E.J. Dunigan, Jr. Lease Frank Armstrong Well No. 3

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	185.5	18.9	31	49	80	455	27.	1.0	1.0	455	27.00
2	186.5	18.4	27	49	76	386	29.	1.2	2.2	463	34.80
3	188.2	17.8	28	60	88	387	3.0	0.2	2.4	77	0.60
4	189.3	17.9	28	58	86	389	4.8	0.5	2.9	194	2.40
5	190.1	19.2	25	55	80	372	6.1	0.2	3.1	74	1.22
6	191.3	18.0	29	55	84	405	15.	0.8	3.9	324	12.00
7	192.4	18.6	28	60	88	404	21.	0.7	4.6	283	14.70
8	193.2	17.3	18	72	90	242	2.7	1.5	6.1	363	4.05
9	194.2	18.1	37	55	90	520	11.	0.7	6.8	364	7.70
10	195.2	18.2	28	61	89	395	14.	1.0	7.8	395	14.00
11	196.2	19.4	29	56	85	436	32.	1.0	8.8	436	32.00
12	197.1	18.2	38	46	84	536	25.	0.9	9.7	483	22.50
13	198.1	18.9	41	45	86	600	22.	1.1	10.8	660	24.20
14	199.1	17.9	30	51	81	417	22.	0.9	11.7	375	19.80
15	200.1	19.1	30	49	79	444	39.	1.0	12.7	444	39.00
16	201.0	17.4	30	53	83	405	33.	0.6	13.3	243	19.80
Total									-----	-5,633	

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SUMMARY OF PERMEABILITY & SATURATION TESTS

TABLE III

Company		Lease		Well No.	
E. J. Dunigan, Jr.		Frank Armstrong		3	
Depth Interval, Feet	Feet of Core Analyzed	Average Permeability, Millidarcys	Permeability Capacity Ft. x Md.		
185.0 - 194.0	6.1	15.9	96.77		
194.0 - 201.2	7.2	24.8	179.00		
185.0 - 201.2	13.3	20.7	275.77		

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
185.0 - 194.0	6.1	17.7	25.9	58.0	366	2,233
194.0 - 201.2	7.2	18.5	33.0	51.8	472	3,400
185.0 - 201.2	13.3	18.1	29.7	54.6	424	5,633

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RESULTS OF LABORATORY FLOODING TESTS

TABLE IV

Company E.J. Dunigan, Jr. Lease Frank Armstrong Well No. 3

Sample No.	Depth, Feet	Effective Porosity Percent	Original Oil Saturation		Oil Recovery		Residual Saturation			Volume of Water Recovered cc ^a	Effective Permeability mDarcy ^{oo}	Initial Fluid Production Pressure Lbs./Sq./In.
			%	Bbls./A. Ft.	%	Bbls./A. Ft.	% Oil	% Water	Bbls./A. Ft.			
1	185.5	18.9	31	455	6	88	25	66	367	17	0.400	40
2	186.5	18.6	27	389	1	14	26	65	375	9	0.186	30
3	188.2	17.2	30	400	0	0	30	62	400	0	Imp.	-
4	189.3	17.5	27	367	0	0	27	67	367	5	0.160	50
5	190.1	18.7	27	392	0	0	27	64	392	0	Imp.	-
6	191.3	18.3	26	369	0	0	26	64	369	6	0.167	50
9	194.2	18.6	37	534	7	101	30	60	433	2	0.124	50
10	195.2	18.4	27	386	0	0	27	68	386	2	0.138	50
11	196.2	19.8	29	445	3	46	26	65	399	6	0.249	50
12	197.1	18.0	38	531	11	154	27	63	377	3	0.169	50
13	198.1	19.2	41	611	13	194	28	65	417	41	0.680	30
14	199.1	17.9	30	417	2	28	28	65	389	5	0.310	50
15	200.1	18.8	30	437	4	58	26	68	379	63	0.818	30
16	201.0	17.2	30	401	2	27	28	66	374	44	1.00	30

Notes: cc—cubic centimeter.

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

^{oo}—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. 3

Depth Interval, Feet	185.0 - 187.2 194.0 - 201.2 185.0 - 201.2		
Feet of Core Analyzed	2.2	6.2	8.4
Average Percent Porosity	18.7	18.6	18.6
Average Percent Original Oil Saturation	28.9	33.7	32.4
Average Percent Oil Recovery	3.3	6.3	5.5
Average Percent Residual Oil Saturation	25.6	27.4	26.9
Average Percent Residual Water Saturation	65.4	64.6	64.9
Average Percent Total Residual Fluid Saturation	91.0	92.0	91.8
Average Original Oil Content, Bbls./A. Ft.	419.	488.	469.
Average Oil Recovery, Bbls./A. Ft.	48.	92.	80.
Average Residual Oil Content, Bbls./A. Ft.	371.	396.	389.
Total Original Oil Content, Bbls./Acre	922.	3,021.	3,943.
Total Oil Recovery, Bbls./Acre	105.	568.	673.
Total Residual Oil Content, Bbls./Acre	817.	2,453.	3,270.
Average Effective Permeability, Millidarcys	0.283	0.473	0.424
Average Initial Fluid Production Pressure, p.s.i.	34.5	41.3	39.5

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