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MASTER

MULTI-PATTERN LOW-TENSION DEMONSTRATION FLOOD,
BIG MUDDY FIELD

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INTRODUCTION

The Big Muddy Low Tension Flood is a commercial-size demonstration project consisting of nine 10-acre injection patterns in the heart of the Big Muddy Oil Field. It is located about 15 miles east of Casper, Wyoming. An attached figure (Exhibit 1) shows the layout of the site.

Project objectives relate to surfactant flooding in the low permeability, high fracture density, fresh water reservoirs, typical of many fields in eastern Colorado and Wyoming. Design technology is based in part on a pilot test conducted previously at an adjacent site.

The work is divided into six steps. The first four are:

1. Conduct preliminary studies to establish pattern orientation and to permit finalizing construction plans.
2. Drill and complete all pattern wells, build the production facilities, complete enough of the injection plant to carry out the preflush step, and to select the formulation and size of the chemical slug.
3. Conduct a preflush to establish the oil production base line and to achieve the desired pattern balance. The injection plant will be completed during this step.
4. Inject the surfactant and polymer slug and taper off the polymer to the water flush.

The final two steps involve performance analysis. The first three steps have been completed and step four began in March, 1981.

SUMMARY

Injection of the chemical slug was completed on August 9, 1982. An estimated total of 888,100 barrels of the slug were injected. Polymer-pusher slug injection began the same day at about the same rate and viscosity as the surfactant phase.

Injectivity continues to be a primary concern. The pressure falloff tests run in three project injectors disproved the plugging theory and pointed toward a thief zone as the cause of the decline. An interference test is planned to study this theory.

Oil production from the DOE project continues to increase. Oil rates for the three months in the third quarter averaged 118, 134, and 146 barrels per day respectively. Sulfonate has appeared in seven of the sixteen producers, but no treating problems have been experienced to date.

A series of sulfonated oil treating tests were performed in July with promising results. It was found that with chemical and heat addition, and residence time, the sulfonated crude can be successfully treated to pipeline water specs and undetectable free sulfonate levels. Based on the results of this test, a full scale treating facility will be designed and installed.

PROGRESS OF FIELD WORK - THIRD QUARTER 1982.

INJECTION.

The injection of the surfactant slug was completed on August 9, 1982 and injection of the polymer-pusher slug began without delay. A total of 888,100 barrels of the chemical slug were injected during the 17 months since the end of the preflush phase. Table 5 shows the distribution of the injected slug compared to the pore volume for each injection well area. This table illustrates that the only areas which received less than their allocated share of the surfactant slug were the patterns around wells 86 and 101.

Injection of the polymer-pusher slug began at the same injection rate and viscosity as the surfactant slug. A small amount (less than 1 wt%) of isobutyl alcohol was blended with the polymer at start-up to aid in phase stability, filterability, and bacterial control. Addition of the alcohol was continued until the existing alcohol supply was depleted. Table 4 shows the injection fluid characteristics for the third quarter of 1982.

INJECTIVITY DECLINE.

Although the injectivity decline seems to have ceased, the low injection rate leads to much pessimism about the project's chances of being an economic success. As was discussed in the previous report, pressure falloff tests were run in three of the nine injection wells. The results of the tests, may be summarized as follows:

1. The reduced injection rates are not caused by plugging in the perforations, sand frac, or in the fracture as was previously believed.
2. Possible causes for the reduced injection rate could be a lower than expected mobility and/or
 - a. The lack of an increase in the effective permeability in the so-called thief zone.
 - b. Reduced vertical coverage possibly from reduced vertical fracture height caused by settling of the proppant. (This appears to be somewhat less likely in view of the results of a recent carbon/oxygen log in Well 74.)

It is presently believed that the lack of an increase in the effective permeability in the thief zone coupled with an increase in the effective permeability in the matrix is the most reasonable explanation for the decreased injection rates.

This theory is supported by the following two observations.

1. Hall plots for all injection wells, with the exception of Nos. 86 and 101, indicate two linear sections which correspond with the preflush and surfactant phases. The slope during the surfactant phase is significantly greater than that from the preflush injection, but no plugging is evident. Instead, the increased slope suggests an increase in resistance to flow.

2. Tracer breakthrough during the preflush phase was very rapid (a matter of hours), but surfactant tracers were not seen at the producers for more than a year and then only in one well. This suggests that some path which was open to flow during the preflush has been essentially shut off.

PRESSURE TRANSIENT TESTING.

It has been recommended to run an interference test to study this theory. Such a test would result in an effective Kh which could be compared with a similar test run on Well 92 during the preflush. It is currently planned to shut-in Well 89 for 2-3 days and observe the pressure response in the four surrounding injectors.

INJECTION WELLS.

Two of the injection wells, Nos. 86 and 101, must be considered as special cases when studying the injectivity problem. Hall plots for the wells show an upswing or continuously increasing slope during the surfactant phase. Each well is presently injecting less than 50 barrels per day and has fluid to the surface.

One possible explanation is that at one time parting pressure was exceeded and the wells reported causing proppant in the fracture to be pushed away from the wellbore. When the pressure decreased, the fracture healed without direct communication between the wellbore and the fracture. A pressure falloff test in Well 101 is planned for late October. This will indicate whether or not communication exists with the fracture.

STRAIN GAUGES.

The new cable used to support the strain gauges in the injection wells was delivered and installed in mid-July. Gauges were set in all injection wells at 1650 feet from the surface.

INJECTION PLANT OPERATION.

The change from surfactant/polymer injection to polymer injection caused no serious problem at the injection plant. Surprisingly, filter operation with the polymer solution is much improved. The 800 square foot filter, which required backwashing daily during the surfactant phase, is now backwashed every third day. The pressure increase across the filter has been 0.1 - 0.2 psi/hr. Filtrate quality is good to excellent.

CARBON/OXYGEN LOG OF WELL 74.

The carbon/oxygen log was run for the third time in R. B. Whiteside No. 74 on August 20, 1982. This well is a designated observation well which is cased, but not perforated. It is located (bottom hole) approximately 155 feet from R. B. Whiteside 57.

Analysis of the recent log showed an increased oil saturation over most of the Second Wall Creek formation with only the top 8 feet showing no change from previous logs. The average oil saturation from this log was 44% compared to 33% in June, 1980, and 35% in February of this year.

Plans are to run the C/O log in No. 74 at least one more time this year in an attempt to determine the maximum oil saturation in the oil bank. A complete logging program for the remainder of the project life is being compiled.

OIL PRODUCTION.

Oil production from the 16 project producers continues to rise. Table 3 shows average oil and water rates, and oil cut for each producer during the third quarter. Table 1 gives project oil and water production rates for the same period.

Figures 4 and 5 show oil production rate and oil rate as a percent of the injection rate respectively. The second curve is plotted to eliminate the affects of the water influx.

SULFONATE AND TRACER ANALYSES.

Analysis of the produced fluids from each well for sulfonate and tracer content is done on a monthly basis. To date, only one well, R. B. Whiteside 88, has shown any evidence of tracer breakthrough. Prior to the August sample, this was also the only well showing the presence of sulfonate, but, with a new technique developed by Conoco's Production Research Division, it now appears that six other wells are also producing small amounts of sulfonate with the oil. The new analytical technique involves the use of thin-film chromatography. One important point to be noted here is that sulfonate breakthrough in the oil and water phases may coincide much closer than was previously believed because of the recently developed ability to detect smaller amounts of sulfonate in the oil phase.

SULFONATED OIL TREATING TESTS.

A field treating test was undertaken in July in an attempt to determine a feasible method for treating sulfonated crude. The test involved doping one of the project producers, R. B. Whiteside No. 89, with varying amounts of Big Muddy surfactant at the wellhead and then attempting to remove the sulfonate from the oil with a three stage treating process. A pilot treating facility was designed and constructed to alleviate the problems associated with a similar test run earlier this year. The results of the recent tests may be summarized as follows:

1. Simulated Big Muddy EOR crude containing five percent or less sulfonate can be treated to pipeline water specifications and undetectable free sulfonate levels with water wash and treating chemical use.
2. The treated oil was comparable to and usually better than the waterflood crude in water up-take test.
3. Treating temperature and residence time are major treating variables. Long residence time can help reduce treating chemical rates.
4. Bottle test results of chemical performance correlate well with pilot test results.

SULFONATED OIL TREATING FACILITY.

Based on the encouraging results of the treating test, a treating system is being designed to incorporate the same ideas as were used in the pilot system. The important parameters include heat and chemical addition, retention time, and water cleanup capability. It is hoped that the facility can be ready for operation by the end of the year.

FIGURE 1

REVISIONS		CONTINENTAL OIL COMPANY	
By	Date	PRODUCTION DEPARTMENT	
		Casper, Wyoming	
		BIG MUDDY	
		SURFACTANT FLOOD	
		County: CONVERSE	State: WYOMING
		Engineer: J.B. Davis	Date: 11-15-74
		Geologist: J.B. Davis	Date: 11-15-74
		Drilling: J.B. Davis	Date: 11-15-74

BIG MUDDY—DOE PROJECT INJECTION PLANT FACILITY LAYOUT

FIGURE 2

FIGURE 3

BIG MUDDY-DOE PROJECT
INJECTION PLANT FLOW SCHEMATIC

FIGURE 4
GDS

FIGURE 5
GDS

DOE OIL PRODUCTION

THIRD QUARTER 1982

<u>Month</u>	<u>BOPD</u>	<u>BWPD</u>	<u>Oil Cut (%)</u>
July	117.9	3044	3.7
August	134.4	3313	3.9
September	146.3	3287	4.3

DOE OIL PRODUCTION SINCE START OF PROJECT		
<u>Month</u>	<u>Corrected Bbls. Oil</u>	<u>Cumulative Bbls.</u>
Feb. 1979	1,264	1,264
Mar. 1979	1,220	2,484
Apr. 1979	655	3,139
May. 1979	605	3,744
Jun. 1979	1,197	4,941
Jul. 1979	1,629	6,570
Aug. 1979	1,045	7,615
Sep. 1979	371	7,986
Oct. 1979	53	8,039
Nov. 1979	0	8,039
Dec. 1979	0	8,039
Jan. 1980	11	8,050
Feb. 1980	885	8,935
Mar. 1980	1,155	10,090
Apr. 1980	1,096	11,186
May 1980	1,169	12,355
Jun. 1980	1,127	13,482
Jul. 1980	982	14,464
Aug. 1980	907	15,371
Sep. 1980	408	15,779
Oct. 1980	1,598	17,377
Nov. 1980	1,294	18,671
Dec. 1980	1,150	19,821
Jan. 1981	740	20,561
Feb. 1981	94	20,655
Mar. 1981	490	21,145
Apr. 1981	1,352	22,497
May 1981	1,054	23,551
Jun. 1981	1,133	24,684
Jul. 1981	1,109	25,793
Aug. 1981	1,245	27,038
Sep. 1981	1,255	28,293
Oct. 1981	1,400	29,693
Nov. 1981	1,990	31,683
Dec. 1981	2,380	34,063
Jan. 1982	2,724	36,787
Feb. 1982	2,376	39,163
Mar. 1982	2,965	42,128
Apr. 1982	2,967	45,095
May 1982	3,289	48,384
Jun. 1982	3,397	51,781
Jul. 1982	3,656	55,437
Aug. 1982	4,446	59,883
Sep. 1982	4,390	64,273

TABLE 2
GDS - 10/20/82

AVERAGE OIL PRODUCTION BY WELL

THIRD QUARTER 1982

<u>WELL NO.</u>	<u>BOPD</u>	<u>BWPD</u>	<u>OIL CUT (%)</u>
54	1.3	143	0.9
57	20.0	148	11.9
58	6.7	107	5.9
68	6.8	52	11.8
81	2.6	369	0.7
82	1.9	268	0.7
83	1.0	249	0.4
87	5.8	245	2.3
88	11.0	185	5.6
89	16.6	248	6.3
90	5.8	176	3.2
91	2.3	381	0.6
94	23.0	276	7.7
95	13.8	165	7.7
96	6.5	169	3.7
100	10.2	194	5.0

INJECTION RATES AND FLUID CHARACTERISTICS

THIRD QUARTER 1982

<u>Month</u>	<u>INJ. RATE</u>	<u>Viscosity (cp)</u>	<u>Weight %</u>	
			<u>Alcohol</u>	<u>Surfactant</u>
July	1455	13.0	5.54	3.19
August	1495	13.0	5.12/1.00	3.03
September	1505	11.9	----	----

TABLE 4
GDS - 10/20/82

SURFACTANT SLUG DISTRIBUTION BY PATTERNS

<u>INJECTION WELL NO.</u>	<u>PORE VOLUME(BBLS)</u>	<u>% OF PORE VOLUME</u>	<u>% OF SURFACTANT SLUG INJECTED</u>
84	970,000	11.35	11.99
85	1,056,000	12.35	12.43
86	971,000	11.35	10.06
101	854,000	9.99	8.55
92	947,000	11.08	11.60
93	1,061,000	12.41	12.74
97	909,000	10.63	11.02
98	898,000	10.50	11.10
99	884,000	10.34	10.51

TABLE 5
GDS - 10/20/82