SPRABERRY FRACTURE TREATMENT COMPARISON

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ABSTRACT

This study uses actual production data to determine the optimum characteristics of fracture treatments in the Spraberry Trend of West Texas. The details of 116 fracture treatments along with corresponding production decline curves are utilized. The paper uses production data to characterize treatments on the basis of fluid volumes, proppant volumes, fluid type, and injection rate. After isolation of the best fluid type, the treatments are then compared on perforated height, limited entry effects, proppant type and proppant concentration.

In an attempt to explain the results, fluid characteristics and fracture theories are discussed. In conclusion, a generalized treatment recommendation is prepared which utilizes the findings of this study.

INTRODUCTION

The Spraberry Trend of West Texas has long been an area known for large fracture treatments. The large zone thickness (-+1200 feet) offers many challenges to completion engineers who want to optimize production and money spent. These carbonate cemented siltstones are found in the formations known as the Wolfcamp, Dean, Spraberry (Upper, Middle and Lower) and the Jo Mill. Different combinations of these zones are productive throughout the Trend.

Over the course of several decades, many types of fracturing fluids have been pumped at various rates transporting proppant deep into the zones. Different operators have chosen to stay with different fluids for reasons ranging from compatibility to economics to availability. Good wells have been made with virtually every fluid. In light of this fact, many questions have arisen over what are the characteristics of the best treatment. Many studies have been made and most have used initial potentials (IP's) as a measure. This paper uses actual and projected estimated ultimate oil recoveries for 116 wells in Reagan and Upton Counties, Texas.

GENERAL BACKGROUND

Where

In an effort to nullify some effects of changing reservoir characteristics, the study was broken down into five approximately 40 square mile areas. Analysis was then done on the areas to determine local optimum fracture treatment characteristics. Areas I through IV are in the northwest quadrant of Reagan County, Texas and Area V is across the county line in Upton County, Texas (Figure 1). This group of areas are located approximately 80 miles southeast of Midland, Texas and just northwest of Stiles, Texas.

Type

The entire study includes production and treatment information from 116 wells. A breakdown of the number of wells in each area can be seen in Table 1. Areas I - IV include 80 acre infill wells only, whereas, Area V includes 160 acre wells only. The purpose of this study was not only to determine the optimum treatment but to isolate the most productive formations. Table 2 points out that of the 100 Reagan County wells, there are nine different combinations of producing formations. Even though the number of wells in some categories are not statistically valid, some conclusions will be drawn.

Stimulation Breakdown

As stated above, the purpose of this study is to compare different fracture treatments. In the Spraberry Trend, there have been many types of fracture treatments used. This study isolates five of the most common. Table 3 indicates the number of wells representing the different fracturing fluids. These fluid types will be discussed later in the fluid comparison section of this paper. It should be pointed out, however, that polyemulsion with crosslinked water is referring to treatments which use polyemulsion on the Dean formation and crosslinked water on the Spraberry formations. A typical Spraberry completion involves three separate fracture treatments, one each on the Dean, Lower and Upper Spraberry.

A typical chart of treatment parameters is shown in Table 4. The categories used for analysis in individual areas are those of fluid type, fluid amount, proppant amount and injection rate. Later in the study, after the optimum fluid is determined, the study uses fluid volume, proppant amount, injection rate, perforated height, limited entry effect, proppant type and maximum proppant concentration to characterize the best treatments.

Production

A typical Spraberry production decline curve is shown in Figure 2. The study uses only wells which have at least a two year production history. On wells which required extrapolation, common decline methods were used. A wells ultimate cumulative production is determined by summarizing all oil from original completion down to 100 barrels of oil per month (three BOPD). This ultimate cumulative production is used as a measure for all fracture treatment parameters as well as 36 month cumulative production. The purpose of using both time periods was to determine the short and long term effects of different treatment characteristics. Even though IP's were obtained on as many wells as possible, they were not used in the evaluation. It is felt that extended production numbers are a much better measure of fracture treatment results.

AREA ANALYSIS

Area I

Because of the limited number and diverse type of wells in Area I, no valid optimum treatment parameters could be determined. This area, however, is used in the overall Reagan County summary. The total Estimated Ultimate Recovery (EUR) for the average well studied in this area is 25,576 barrels of oil and 13,169 barrels after 36 months.

Area II

Area II is located just north of Stiles, Texas and includes 26 study wells. These wells are of three types with the best wells having fracture treatments on the Dean and Lower and Upper Spraberry formations. There are three wells in this area which include a frac on the Wolfcamp instead of two separate fracs on the Spraberry. The EUR of these three wells is 25% less than the typical three zone completion.

An average treatment on a well studied in this area consists of 162,000 gallons of crosslinked gelled water carrying 419,000 pounds of proppant at a rate of 42.4 BPM. The optimum fracture treatment of the wells studied in Area II consist of pumping 200,000 gallons of crosslinked gelled water transporting 470,000 pounds of 20-40 mesh sand at an injection rate of 42 BPM.

Area III

Area III consists of 31 wells evenly packed within a four mile radius circle. This area is located approximately 18 miles west-northwest of Stiles, Texas. As in Area II, this area consists of three different formation combinations. Most wells have the typical Dean, Lower and Upper Spraberry completions. However, the best wells have an additional fracture treatment on the Jo Mill zone. The average production in the area is 20,570 barrels after 36 months and 46,951 barrels for the life of the well. The wells with an additional frac on the Jo Mill have a 36 month production of 29,636 barrels and an EUR of 65,011 barrels. It should be pointed out that the three zone completions usually include perforations in the Jo Mill zone, however, it does not have a separate fracture treatment.

The average fracture treatment on a well in Area III consists of 169,000 gallons of refined oil carrying 358,000 pounds of proppant at 23.3 BPM. The optimum fracture treatment of the wells studied in Area III consists of pumping at least 255,000 gallons of crosslinked gelled water transporting 500,000 pounds of 20-40 mesh sand and tailing in with 12-20 mesh sand and injected at a rate of 40 BPM.

Area IV

Area IV is another tightly packed area of 28 wells. The maximum distance between any two wells in this area is five miles. The area is located approximately 20 miles due west of Stiles, Texas. This area consists of only two different zone combinations. The typical three zone combination is included in 22 wells with the other six wells having been completed in the Dean only. The Dean appears to be a major production contributor in this area which is evidenced by the fact that the six wells with the Dean only have an average production of 32,711 barrels which is more than 77% of the production of the other 22 three zone wells. The average EUR of the wells in Area IV is 40,164 barrels with 20,521 barrels coming after 36 months.

The average treatment in the three zone wells consists of 167,000 gallons of crosslinked gelled water carrying 392,000 pounds of proppant at a pump rate of 43 BPM. The optimum fracture treatment on the wells in Area IV consist of pumping at least 180,000 gallons crosslinked gelled water transporting only 310,000 pounds of 20-40 mesh sand with a tail-in of 12-20 sand on the Spraberry zones. An average injection rate of 39 BPM is obtained.

Area V

Area V consists of 16 wells in an area 12 miles north of Rankin, Texas in Upton County. The wells in this area are 160 acre wells and are included in an effort to draw some comparisons between 80 and 160 acre wells without the effects of direct offset 80 acre wells. This area is not included in the later treatment comparisons. The average EUR from the wells in this area is 64,961 barrels with 22,723 barrels coming in the first 36 months. All the wells in this area are typical three zone completions. Because of the limited number of wells, it is impossible to draw a conclusion on the optimum treatment characteristics, however, it could be generalized that polyemulsion or gelled water makes the best wells. It should be noted that the crosslinked water was not in common use when this area was developed.

REAGAN COUNTY SUMMARY

Upon review of the four Reagan County areas, it can be seen that there may be some changing reservoir characteristics which cause the dramatic EUR differences. This section groups all 100 wells in Reagan County into one summary and draws conclusions. Nine different combinations of zones were studied and results shown in Table 2. It is difficult to statistically claim any validity for the categories with low sample number, however, some generalities may be made. The average Dean, Lower Spraberry and Upper Spraberry zone completion in Reagan County, regardless of type of fracture treatment, will produce 42,883 barrels with 19,100 barrels coming in the first 36 months. All eight wells which fracture treat the Wolfcamp apparently sacrifice fluid volume in more valuable zones. This, in turn, leads to less fracture length and less production. Again, the Dean and Jo Mill zones appear to be the significant contributors.

The next area of interest is that of fluid type. Chart 1 compares the five different fluids using both 36 month and ultimate cumulative production as a yardstick. Crosslinked gelled water obviously appears to win both short and long term production. Surprisingly, refined oil has made the second best well in the areas studied. It should be noted that this analysis based on fluid type makes no adjustment for other parameters such as fluid amount. Refined oil treatments were typically 33% smaller in volume than crosslinked gelled water treatments. Polyemulsion, polyemulsion with crosslinked gelled water and plain gelled water were third, fourth and fifth, respectively.

It is obvious from Chart 2 that both short and long term production increases proportionally with fluid volume. However, upon observing the proppant volume comparison in Chart 3, the same conclusion cannot be drawn. The optimum proppant volume appears to be from 300,000 pounds to 400,000 pounds. These two observations may indicate that length and total area of a fracture are important but not necessarily the conductivity. Chart 4 compares injection rates and indicates no obvious choice even though 30-40 BPM has produced slightly better results.

It should be noted that the above conclusions were drawn with no regard for actual fluid type. By the nature of a fluid, obvious compensations may be made in the area of fluid volume, proppant volume and injection rate. For example, a refined oil treatment cannot transport high concentrations of proppant and must be pumped at lower rates due to excessive friction and reduced hydrostatic head. The next section attempts to nullify these effects by concentrating only on one fluid type.

CROSSLINKED WATER SUMMARY

Indicated in the last section, crosslinked gelled water is the optimum fluid. This section deals with this fluid exclusively and attempts to narrow down the characteristics of the optimum treatment. Table 5 compares four different zone combinations. Again, the Wolfcamp does not appear to be a significant contributor and the Dean does. The cumulative of the typical three zone completion is 23,049 barrels after 36 months and 57,693 barrels estimated ultimate recovery. A 28% increase in short term production is noticed when the Jo Mill section is fracture treated independently.

As indicated in other comparisons, Table 6 points out the benefits of pumping a greater fluid volume. Even though the large volumes have a 37% increase in short term production over the 180,000 gallon average, a 67% increase is realized in the total life production. This may indicate that the added area of the larger volume is draining reservoir which the smaller volume never exposes. Table 7 indicates the opposite is true with proppant amounts. The lower the amount of proppant, the better the 36 month and ultimate production.

Table 8 compares the different pump rates of crosslinked gelled water. Lower rates appear to be optimum even though there is no consistency with higher rates.

The study then attempts to define more characteristics of the better wells. Table 9 compares the average perforated heights of the Lower Spraberry in three zone wells. It is clearly seen that smaller (<100 feet) perforated intervals produce better wells. Table 10 then compares limited entry in the form of BPM per perforation. The best wells appear in the category with pump rates greater than 2.5 BPM per perforation.

Several different proppant types and concentrations have been used in crosslinked gelled water treatments in Reagan County. Table 11 points out that tail-ins of 12-20 mesh sand are found in the best wells. The best wells also have maximum sand concentrations of no more than three pounds per gallon as shown in Table 12. In fact, oil production declines as higher proppant concentrations are pumped. Attempts are made later in this paper to theorize the reasons behind some of these contradictions.

FLUID COMPARISON

To be able to understand the strange characteristics of the best fracture treatments, one must be familiar with fracturing fluids. This section will attempt to point out the different characteristics of the five fluids discussed earlier in this paper.

Most fluids fall into the two distinct categories of perfect support fluids and banking type fluids. Chart 5 compares these two types in graphic form. Typically, crosslinked gelled water is considered a perfect support fluid which distributes the proppant relatively evenly throughout the height of an interval. The banking fluids, such as polyemulsion, refined oil and gelled water allow proppant to settle as fluid rates within the fracture slow. This settling eventually results in sand backing above boundary zones. The conductivity in a banking situation is good because the proppant settles into the created width instead of the fracture closing on a less concentrated pack as is the case with perfect support fluids.

Many other characteristics of the different fluids are compared in Table 13. In an effort to compare the different results of these fluids, a comparison is made using computer geometry fracture modeling for identical fluid volumes in a typical Lower Spraberry zone. The input parameters are shown in Table 14 and the resulting calculated data is shown in Table 15. The results of the three banking fluids are very similar and it is easily seen that the negative characteristic of these systems is the low proppant bank height. The overall area of reservoir exposure is low even though the proppant conductivity is high and the propped length is good.

The first two columns of Table 15 compare the same basic fluid which has undergone different shear history. The first column displays the characteristics of a solidly crosslinked, high viscosity fluid which has had little, if any, viscosity reduction due to shear. Shear, in this case, may be pipe induced or more likely, perforation induced. This high viscosity system has the largest fracture height, the shortest fracture length and the largest fracture width. This fluid also has the highest net pressure at shutdown. As will be discussed later, these are not desired properties in a Spraberry fracture treatment.

The next column describes the calculated data of a thinner crosslinked fluid which has undergone an extreme shear history which has reduced its viscosity. The results are lower fracture height, deeper proppant penetration, less fracture width and less net pressure at shutdown. This situation of higher shear, which is usually considered undesirable, may be producing the ideal fracture geometry for a Spraberry zone.

THEORY

Prior to this section, all conclusions have dealt primarily with the actual survey results. This section attempts to offer some explanations as to why certain qualities are found in the best fracture treatments. As described previously, the best fracture treatment appears to be a large volume of crosslinked gelled water pumped at an injection rate greater than 2.5 BPM per perforation. This fluid transports a maximum proppant concentration of 3 ppg and tails in with 12-20 mesh sand. The best wells include low perforated height in each zone with the addition of a Jo Mill zone preferable. As described in the previous fluid section, a fluid which has undergone high shear will have a lower viscosity. This can explain why the high limited entry fracs have made better wells. The low viscosity crosslinked fluid will have deeper proppant penetration with less height growth. With greater extension in the zone of interest, more desirable reservoir (net pay) is connected to the wellbore.

Two recent schools of thought for Spraberry reservoir drainage are that production may come from vertical natural fractures or may come through the matrix. Long contained fractures would support both of these theories. Long fractures will cross a greater number of vertical fractures and will also expose a more desirable area of reservoir and therefore, more matrix.

A common drawback to low viscosity crosslinked fluids is their inability to generate enough width to transport large amounts of proppant. This would explain why the best wells have low proppant concentrations, the fluid is not stout enough to carry higher concentrations. If a higher viscosity fluid were pumped in an attempt to carry the large amounts of proppant, larger fracture widths would be obtained, thereby more height growth out of zone and less proppant penetration in zone.

This theory says that Spraberry intervals require deep proppant penetration and not necessarily high proppant concentrations. The stimulation industry has not yet developed the low viscosity fluids required to be logistically allowable on the surface and still be considered perfect support. The above theory claims that shear has achieved this ultimate goal.

CONCLUSIONS

1. The cumulative production of an 80 acre infill well will be approximately one-third less than a 160 acre well.

2. The key producing intervals appear to be the Dean and Jo Mill with little production derived from the Wolfcamp.

3. This study determines that the optimum fracturing fluid is crosslinked gelled water. It also reveals that the greater the volume of fracturing fluid, the higher the ultimate cumulative production.

4. It is evident that large amounts of proppant and high proppant concentrations are not required to produce high cumulative production. The study also points out that tailing-in with 12-20 mesh proppant is effective.

5. The results of this study indicate that limiting height growth in some form produces greater propped fracture lengths and thereby much higher production. This can be accomplished by limiting perforated height, using low viscosity fluids and/or limiting injection rates.

Table 1
Number of Wells in Each Area

POPULATION BREAKDOWN LOCATION	NO. OF WELLS	
REAGAN COUNTY (80 ACRES)		
AREA I	17	
AREA II	26	
AREA III	29	
AREA IV	28	
TOTAL REAGAN COUNTY		100
UPTON COUNTY (160 ACRES)		16
TOTAL WELLS STUDIED		116

Table 2
Breakdown of Reagan County Wells by Formation Combination

ZONES TREATED	NO OF WELLS	AVG. 36 MO. PROD. BOPW	TOTAL CUM. PROD. BOPW
WOLFCAMP, DEAN 2 SPRABERRIES	4	16,190	29,732
WOLFCAMP, DEAN & SPRABERRY	3	12,690	30,675
WOLFCAMP, DEAN & U. SPRABERRY	1	18,289	26,487
DEAN ONLY	6	17,052	32,711
DEAN & L. SPRABERRY	2	15,609	24,866
DEAN & U. SPRABERRY	2	7,295	14,853
DEAN, L. SPRABERRY & U. SPRABERRY	78	19,100	42,883
DEAN, JO MILL, L. & U. SPRABERRY	3	29,636	65,011
L. & U. SPRABERRY	1	15,600	39,190
TOTAL (AVERAGES)	100	18,635	40,922

Table 3
Breakdown of Wells by Fracturing Fluid Type

FLUID (ALL WELLS)	NO. OF WELLS	% OF TOTAL
REFINED OIL (R/O)	40	34.5
POLYEMULSION (P-E)	25	21.5
POLYEMULSION W/X-LINKED WATER	10	8.6
CROSS-LINKED WATER	30	25.9
GELLED WATER	11	9.5
TOTAL FOR STUDY	116	

Table 4
Typical Treatment Parameters

AREA II

Well #	Location Sec. - Survey		Fmtn.	No. Perfs.	Type Fluid	Fluid Vol. 1000 gal.	Sand Vol. 1000# - Size		Max. Con. Sd.	Frac Rate	I.P.	36 Mo. Prod. BBL/Well	Cum. to 100 BPM
35 cont			U Sp		CXW	60	180	20/40	4	55±			
36	5	Blk.G,C&M	Dn		CXW	60	180	20/40	4	55±		18,514	37,439
			L Sp		CXW	60	180	20/40	4	55±			
			U Sp		CXW	60	180	20/40	4	55±			
37	5	Blk.G,C&M	Dn		CXW	60	180	20/40	4	55±		9,418	19,100
			L Sp		CXW	60	180	20/40	4	55±			
			U Sp		CXW	60	180	20/40	4	55±			
38	5	Blk.G,C&M	Dn		CXW	60	180	20/40	4	55±		10,201	20,689
			L Sp		CXW	60	180	20/40	4	55±			
			U Sp		CXW	60	180	20/40	4	55±			
39	6	Blk.G,C&M	Dn		PEX	42	89	20/40	4	23		19,464	40,839
							10	100					
			L Sp		PEX	42	89	20/40	4	35			
							10	100					
			U Sp		PEX	42	75	20/40	4	35			
							10	100					
40	6	Blk.G,C&M	Dn		PEX	42	89	20/40	4	23		19,464	40,839
							10	100					
			L Sp		PEX	42	89	20/40	4	35			
							10	100					
			U Sp		PEX	42	75	20/40	4	35			
							10	100					
41	6	Blk.G,C&M	Dn		PEX	42	89	20/40	4	23		15,758	32,458
							10	100					
			L Sp		PEX	42	89	20/40	4	35			
							10	100					

Table 5
Breakdown of Crosslinked Water Fracs in Reagan County by Formation Combination

ZONES TREATED	NO OF WELLS	AVG. 36 MO. PROD. BOPW	TOTAL CUM. PROD. BOPW
WOLFCAMP, DEAN, U. & L. SPRABERRY	2	16,337	33,997
DEAN ONLY	6	17,052	39,019
DEAN, U. & L. SPRABERRY	18	23,049	57,593
DEAN, L. SPRABERRY JO MILL & U. SPRABERRY	3	29,636	65,011
TOTALS	29	22,027	52,890

Table 6
Crosslinked Water Fluid Volume Comparison

FLUID VOLUME BREAKDOWN (3 ZONE WELLS ONLY)

FLUID VOLUME	AVE. 36 MO. PROD. BOPW	TOTAL CUM. PROD. BOPW
120,000 GALLONS	11,270	18,991
180,000 GALLONS	20,917	48,664
*185,000 - 260,000 GALLONS	28,581	80,900

Table 7
Crosslinked Water Proppant Volume Comparison

PROPPANT AMOUNT BREAKDOWN (3 ZONE WELLS ONLY)

PROPPANT AMOUNT	AVE. 36 MO. PROD BOPW	TOTAL CUM. PROD. BOPW
*315,000 - 403,000 POUNDS	28,801	80,797
488,000 - 540,000 POUNDS	20,917	48,664
555,000 - 625,000 POUNDS	10,610	19,299

* OPTIMUM

Table 8
Crosslinked Water Injection Rate Comparison

AVERAGE INJECTION RATE (3 ZONE WELLS ONLY)

AIR (BPM)	AVE. 36 MO. PROD. BOPW	TOTAL CUM. PROD. BOPW
* 31 - 40	26,783	77,919
41 - 50	14,477	29,058
> 50	20,921	48,606

Table 9
Crosslinked Water Perforated Height Comparison in Lower Spraberry Zones

PERFORATED HEIGHT (3 ZONE WELLS ONLY)

AVG. FEET/ZONE	AVE. 36 MO. PROD BOPW	TOTAL CUM. PROD. BOPW
* < 100 FEET	37,566	117,000
101 - 399 FEET	14,037	29,263
> 400 FEET	20,921	48,606

* OPTIMUM

Table 10
Limited Entry Comparison

BPM PER PERF	AVG. 36 MO. PROD. BOPW	TOTAL CUM. PROD. BOPW
< 1.5	10,460	19,299
1.5 - 2.5	19,309	43,719
* > 2.5	37,566	117,000

Table 11
Crosslinked Water
Comparison of Proppant Type

PROPPANT TYPE (3 ZONE WELLS ONLY)

MESH	AVE. 36 MO. PROD. BOPW	TOTAL CUM. PROD. BOPW
20 - 40	18,057	39,540
* 20 - 40 W/12-20 TAIL-IN	34,231	99,199

Table 12
Crosslinked Water — Comparison of Maximum Proppant Concentration

MAXIMUM PROPPANT CONCENTRATION (3 ZONE WELLS ONLY)

MAX. LB./GAL.	AVE. 36 MO. PROD. BOPW	TOTAL CUM. PROD. BOPW
* 3	37,566	117,000
4	18,057	39,540
5	20,870	49,192

Table 13
Comparison of Typical Spraberry Fracturing Fluids

Generic Name	X-Linked HPG	Borate-HPG	Gelled H_2O	Polyemulsion	Refined Oil
Smith Trade Name	GWX-7	GWX-9	30 ppg WGA-2	WEP-1	Refined Oil
Base Fluid	2%KCl,Lt.Brine	2% KCl, Brine	2% KCl, Brine	67% Oil 33% Water	Refined Oil
Specific Gravity	Base Fluid	Base Fluid	Base Fluid	0.916	± 0.930
Proppant Support	Perfect	Near Perfect	Banking	Banking	Banking
Friction (to H_2O)	56% Reduction	45% Reduction	56% Reduction	158% Increase	250% Increase
Shear Sensitivity	Moderate	Very Low	Low	Low	Low
Fluid Loss	Good	Good	Fair	Good	Fair
Height Growth	Large	Large	Small	Moderate	Moderate
Main Advantages	High Proppant Low Friction Perfect Support	High Proppant Shear Resistant	Low Friction Low Height Growth	Low Fluid Loss Low Cost Good Clean Up	Low Cost
Disadvantages	Shear Sensitive	High pH	Low Proppant Banking Fluid	High Friction Banking Fluid	High Friction Banking Fluid Damaging

Table 14
Typical Lower Spraberry Fracturing Input Parameters

Operator:	Spraberry Oil Company
Formation:	Lower Spraberry
Well Name:	Typical, Reagan County, Texas

Reservoir Properties

Average Depth:	7100 feet
Fracture Height:	200 feet
Fracture Gradient:	0.52 psi/foot
Fracture Pressure:	3640 psi
Porosity:	9.0 percent
Permeability:	0.2 millidarcies
Bottom Hole Pressure:	1500 psi
Bottom Hole Temperature:	130 deg. F.
Reservoir Compressibility:	0.00003/psi
Reservoir Fluid Viscosity:	1.2 centipoise
Poisson's Ratio:	0.25 dimensionless
Young's Modulus:	5,500,000 psi

Table 15
Fracturing Fluid Comparison - Calculated Data

	GWX-7 HIGH VISCOSITY	GWX-7 LOW VISCOSITY	WGA-2 GELLED WATER	WEP-1 POLYEMULSION	REFINED OIL
FRACTURE HEIGHT (FEET)	300	200	150	150	200
PROPPANT BANK HEIGHT (FEET)	300	200	50	56	56
TOTAL FLUID PENETRATION (FEET)	281	615	748	716	589
PROPPANT PENETRATION (FEET)	258	553	575	444	526
AVERAGE FRACTURE WIDTH (INCHES)	0.45	0.3	0.27	0.27	0.27
NET PRESSURE AT SHUTDOWN (PSI)	430	345	328	380	430
AVERAGE PROPPANT CONCENTRATION (LB/FT } 2)	1.2	1.1	2.4	3.3	2.7

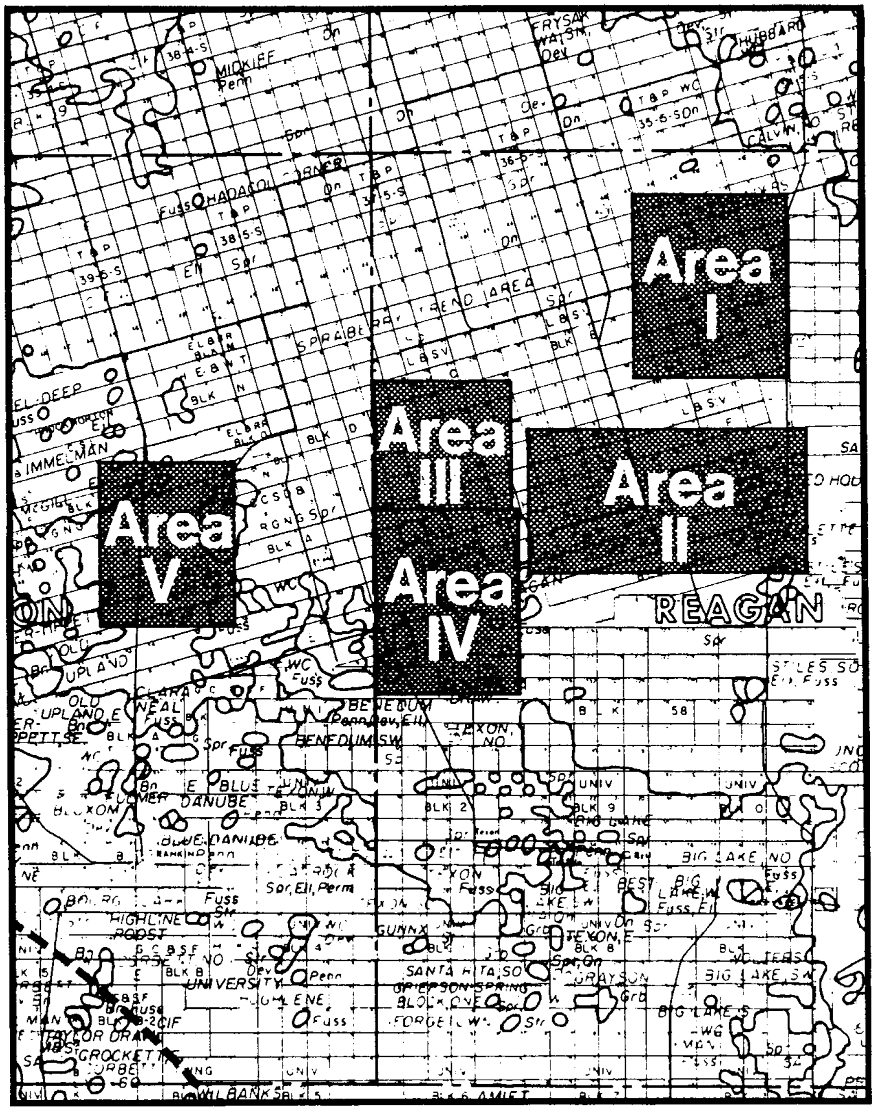


Figure 1 - Map of subject areas in the Spraberry Trend

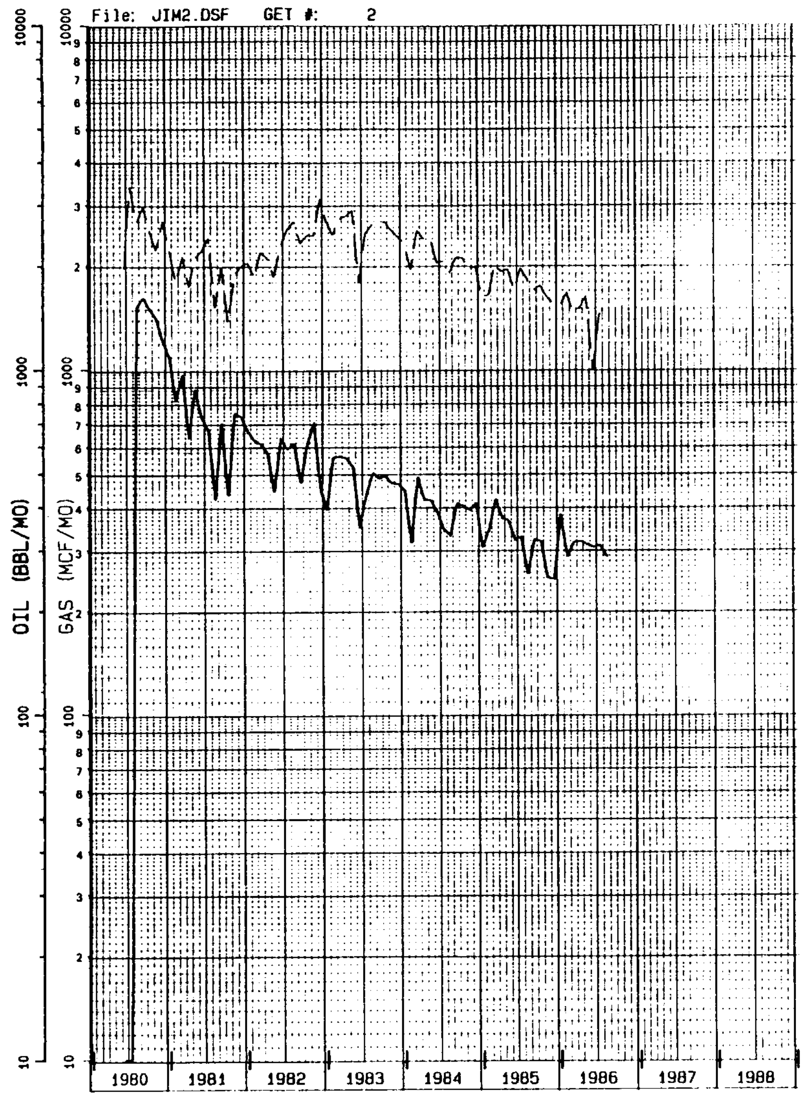


Figure 2 - Typical production decline (Area II - Well No. 34)

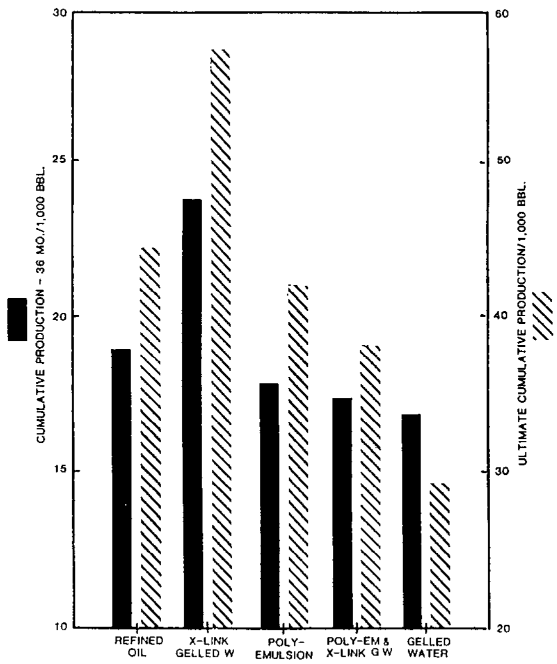


Chart 1
Reagan County Fluid Type
Comparison

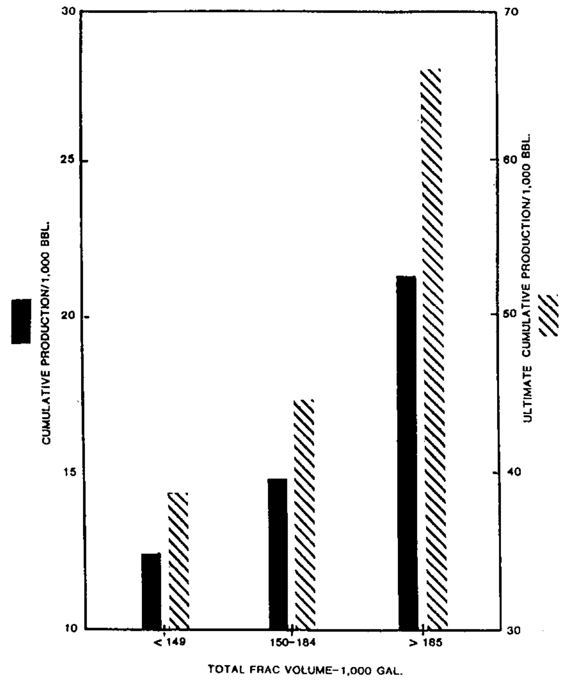


Chart 2
Reagan County Frac Fluid
Volume Comparison

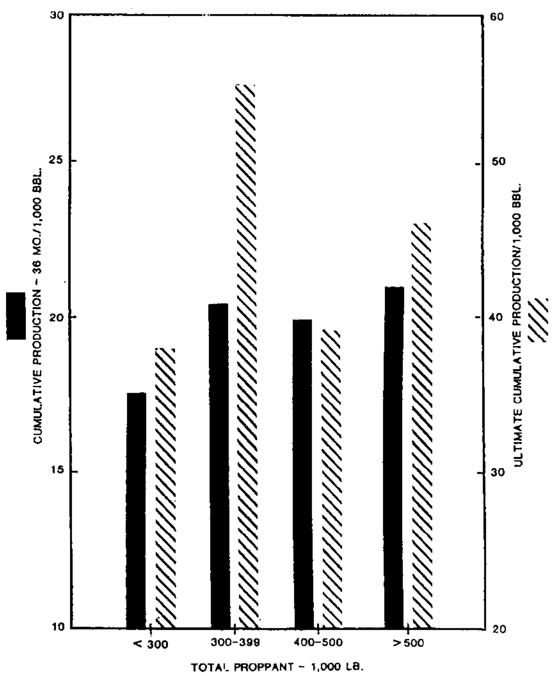


Chart 3
Reagan County Proppant Volume
Comparison

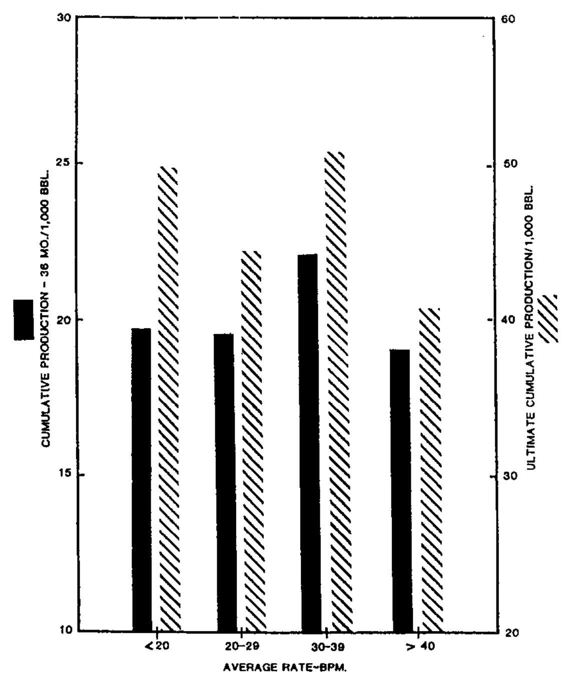
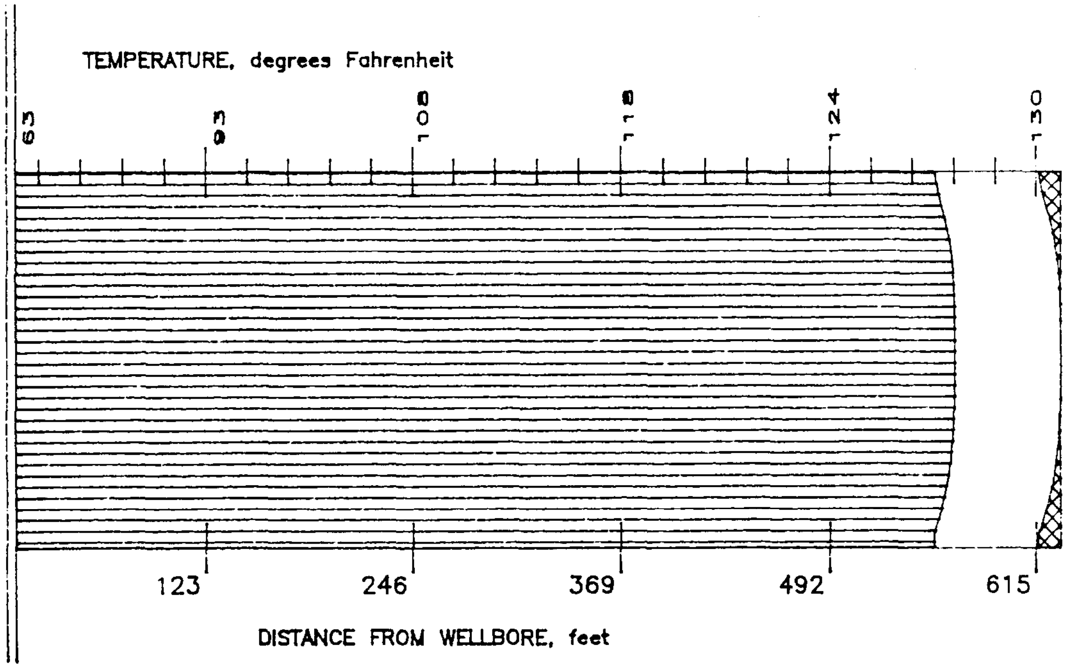
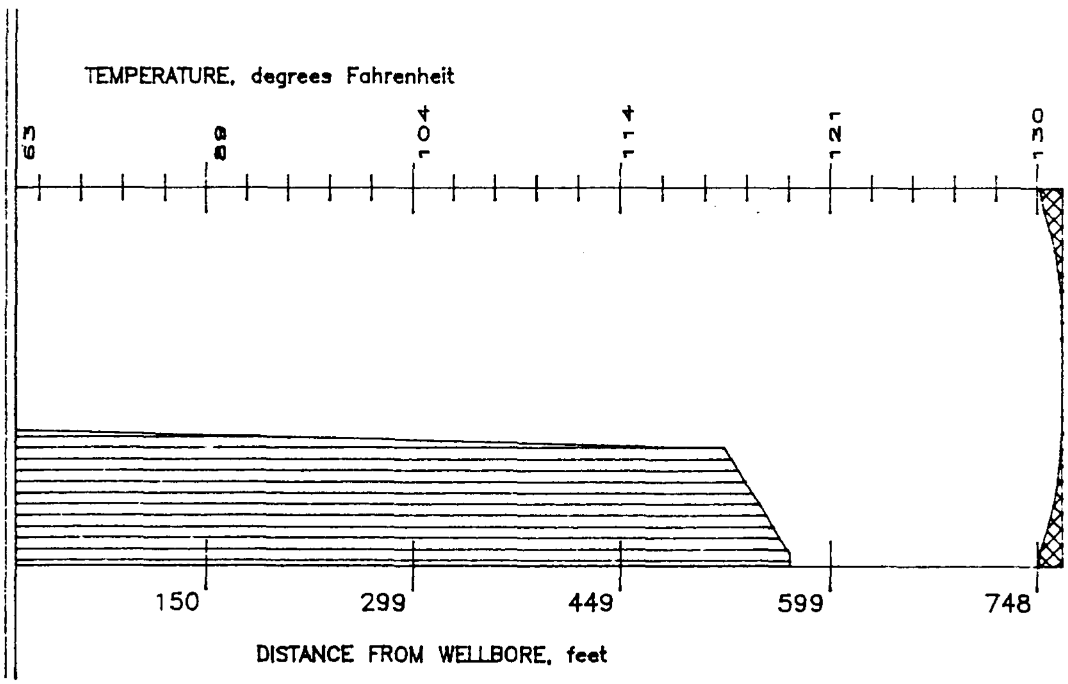


Chart 4
Reagan County Injection Rate
Comparison



Current proppant penetration: 553



SANDBANK HEIGHT=50, PENETRATION=575

Chart 5
Comparison of Perfect Support Fluid (Top) to
Banking Fluid (Bottom)