BRINE EXTERNAL POLYMULSION ACID FRACTURING IN PERMIAN BASIN CARBONATE RESERVOIRS

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ABSTRACT

The brine external polymulsion acid fracturing technique has been successfully utilized by Exxon to stimulate the low-permeability carbonate reservoirs of the Permian Basin. Compared to the traditional proppant fracturing methods, this approach offers the advantages of lower cost, reduced mechanical risk, and greater adaptability to difficult well situations.

Polymulsion is an external aqueous-phase oil-water emulsion. The non-Newtonian properties of this emulsion create an efficient fracturing fluid which exhibits excellent pumping characteristics.

The brine external polymulsion acid fracturing technique involves pumping a pad of polymulsion fluid followed by an approximately equal volume of high viscosity acid containing a fluid loss control additive. Results obtained from the application of this technique in the Drinkard formation of the B-D-T field in Eastern New Mexico and in the Clearfork-Glorieta formations of the Robertson Clearfork Unit in West Texas will be presented.

INTRODUCTION

Brine external polymulsion acid fracturing offers several distinct advantages over conventional proppant fracturing in Permain Basin carbonate reservoirs. Major advantages are higher productivity, greater adaptability to multi-stage stimulations, and reduced mechanical risk. This fracturing system employs acid to etch the fracture created by the brine external polymulsion pad. Polymulsion is an external aqueous-phase oil-water emulsion. The non-Newtonian properties of this emulsion create an efficient fracturing fluid which exhibits excellent pumping and fluid-loss characteristics. The acid creates a flow path to the wellbore that is several times more permeable than conventional proppant fracturing systems.

This paper will primarily describe acid fracturing techniques and results obtained in two fields within the Permian Basin. Figure No. 1 is an area plat showing these fields. The Robertson Clearfork field is located approximately 10 miles southwest of Seminole, Texas, and the Drinkard field is near Eunice, New Mexico.

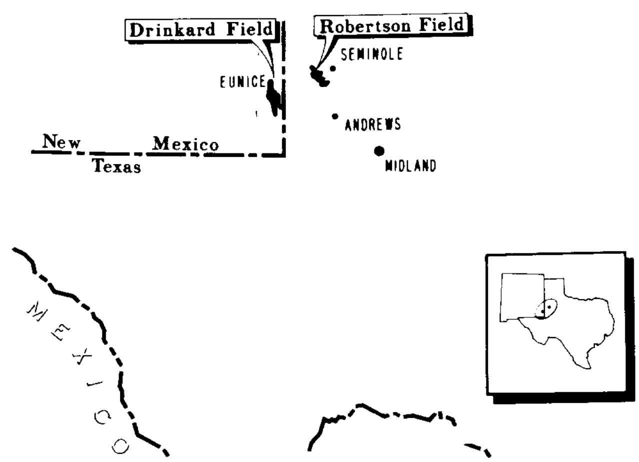

FIGURE 1—INDEX MAP

FIELD RESULTS IN THE ROBERTSON CLEARFORK FIELD

The area of interest in the Robertson Clearfork field is a 4800-acre waterflood project operated by Exxon. Initial development of this dissolved gas drive reservoir began in 1942 with waterflood operations beginning in 1970.

The pay consists of the Glorieta, Upper Clearfork, and Lower Clearfork reservoirs. It is a massive, tight, highly stringerized dolomite structure. There are 60 correlatable porosity stringers in 1200 ft of gross section. Figure No. 2 is a two-well cross section showing how the 250 ft of net pay is distributed. The average porosity of 6% and the average permeability is 0.2 md.

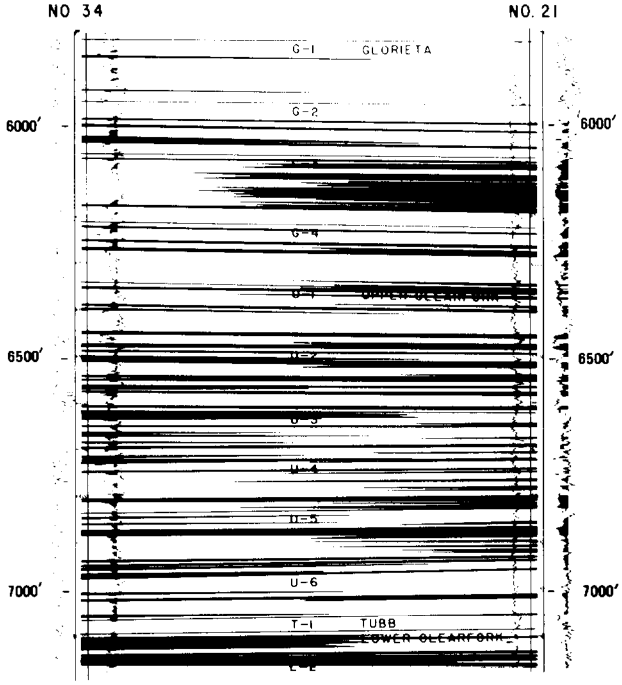

FIGURE 2—ROBERTSON FIELD: CROSS SECTION

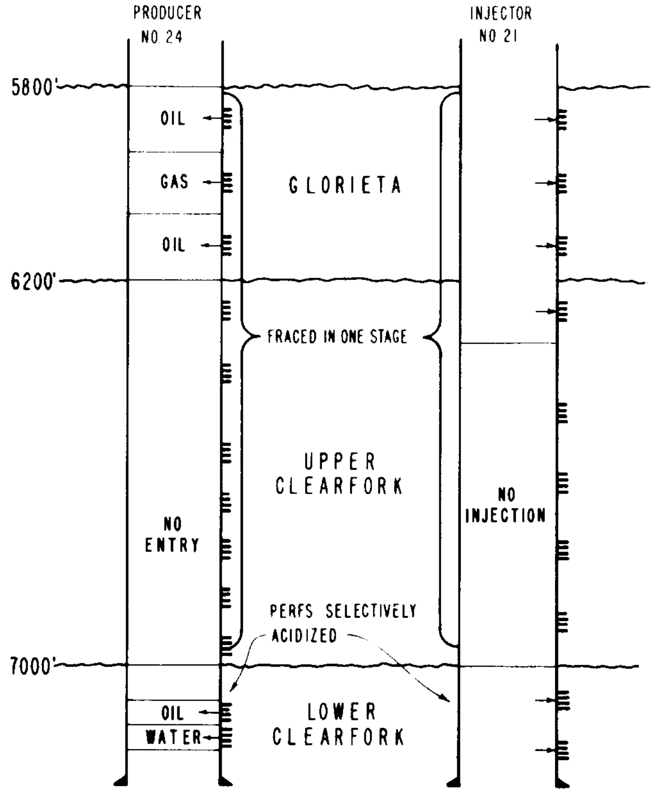

FIGURE 3—TYPICAL PROFILES: ROBERTSON FIELD

Conventional proppant fracture stimulations used during field development averaged 20,000 gal of fracturing fluid and 40,000 lb of sand. These stimulations were high-rate, single-stage jobs that frequently employed the concept of limited entry. Average initial potential was 141 BOPD. To quantitatively define the actual percentage of pay effectively completed using this stimulation method, producing and injection profiles were run on several wells in the field. Figure No. 3 shows typical profiles that were encountered. Fracture of this 1200-ft gross vertical section in one stage effectively stimulated only 30% to 40% of the pay as indicated by the respective producing and injection profiles. A recent reservoir study indicated that poor pay continuity and low percentage of pay effectively completed would result in an anomalously low recovery. Infill drilling and workovers on existing wells were undertaken in an effort to increase ultimate recovery.

Figure No. 4 shows the acid fracturing technique being used on the infill wells. The lowest zone (a potential high-pressure zone) is completed as an

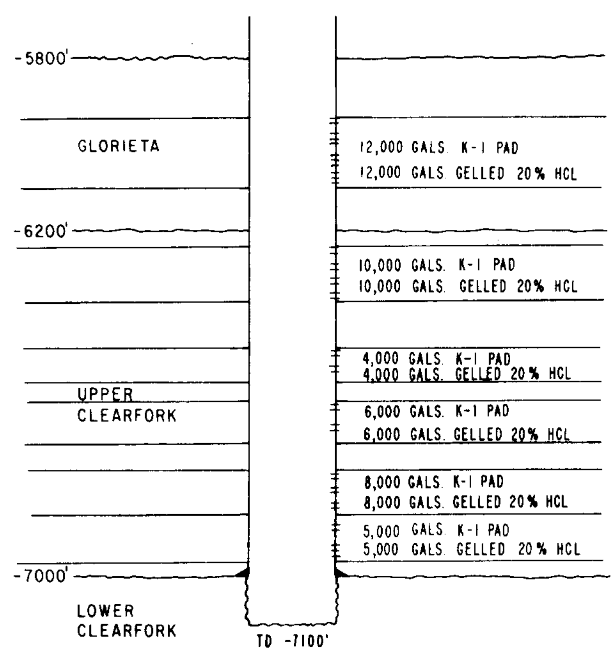

FIGURE 4—TYPICAL INFILL WELL COMPLETION

open hole to reduce the risk of contaminating the primary cement job. This greatly improves the ability to selectively acid fracture stimulate individual zones in the Upper Clearfork and Glorieta. These intervals are perforated after evaluation of the open hole.

The cased hole is stimulated in several stages. Starting with the lowest stage interval, individual zones are mechanically isolated by means of the bridge plug and packer and are selectively acid fracture stimulated. Typical stage volumes are shown on the right-hand side of Figure No. 4. The effectiveness of this technique is evaluated by placing radioactive sand in the flush of each individual stage. The results of follow-up surveys to indicate sand placement and fluid entry are shown in Figure No. 5. Both the radioactive sand placement survey and the fluid entry profile indicate an increase in percentage of pay effectively completed. The no-entry zones result from lack of stimulation or lack of offset injection support. This same technique has been used on the workovers with similar results. Several wells have been surveyed, and all of the wells indicate a significant improvement over previous stimulation techniques in percentage of pay effectively completed.

These multi-stage fracture stimulations at Robertson Clearfork field require special tools and techniques due to the high pressures and flow rates encountered after each stage stimulation. After-frac blowdown rates of 600 to 800 BPD at surface pressures ranging from 800 to 1200 psi are typical for individual stages. Stimulation work under these conditions would require several days if each individual zone were allowed to bleed down. This would run the job cost up significantly. To lower these costs, stripping operations are performed during the frac job. Figure No. 6 shows the individual zone isolation using the bridge plug and packer and the movement down the tubing of the fracturing fluids. The top 1500 ft of the workstring is Hydril flush-joint tubing to allow easier movement of the string through the tubing stripper. The flapper valve as positioned will allow flow down the tubing only. The remaining tubing is standard 8-rd upset. Figure No. 7 shows movement of the bridge plug and packer to another stage. Flow out of the tubing-casing annulus is prevented by the tubing stripper while the flapper valve prevents flow up the tubing. Typical surface pressures observed during this phase

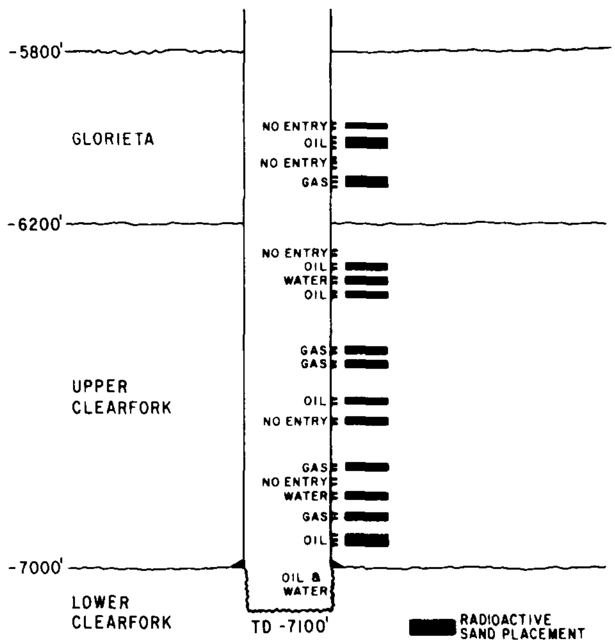

FIGURE 5—TYPICAL INFILL WELL COMPLETION: FOLLOW-UP SURVEYS

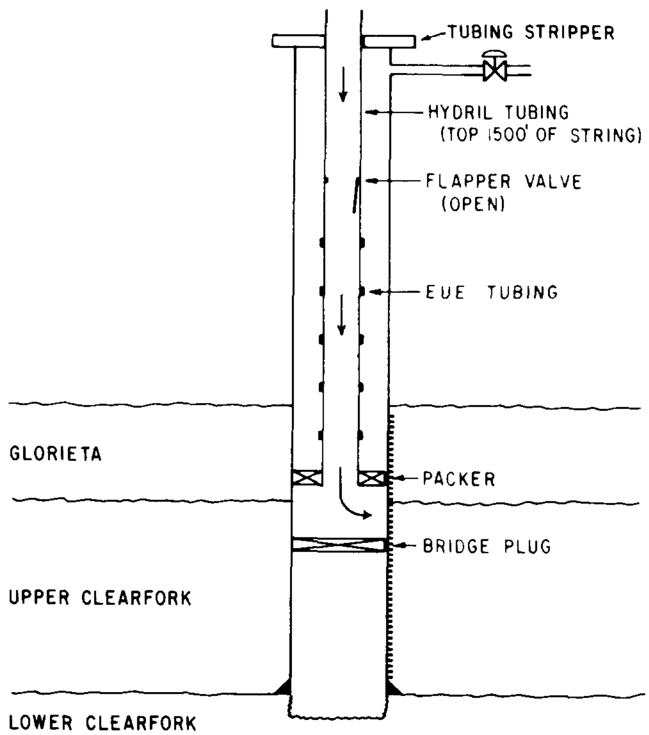

FIGURE 6—STRIPPING OPERATIONS DURING FRAC JOB, PHASE ONE

are 1500 to 1700 psi. Figure No. 8 shows the wellbore after the stimulation of all zones. The bridge plug and packer are pulled above all perfs, the flapper valve is mechanically sheared open, and the well is allowed to flow down until such time as the bridge plug and packer can be removed and the production string run. Moving the bridge plug and packer under pressure has allowed performing as many as 10 stages in one day as compared to the previous average of one stage per day when allowing each stage to bleed down before moving the bridge plug and packer. Estimated cost savings in rig and hydraulic horsepower time due to stripping is $7000 to $10,000 per job.

Selective stimulation of this stringerized reservoir using conventional proppant fracture systems would be extremely expensive, since the stripping techniques described above could not be employed. Computer modeling of the two fracture stimulation techniques shows a stimulation ratio of 3 for the conventional proppant fracture system and a stimulation ratio of 3.8 for the brine external polymulsion acid fracture system. The average initial potential of the 24 infill wells drilled to date is 258 BOPD and 195 BWPD. Figure No. 9 shows the comparison between the initial potentials of development wells and the infill wells. After 20 years of field development and depletion, the initial potentials of the infill wells are twice as large as the initial potentials of development wells. This results from a much larger percentage of the pay effectively completed and a more productive fracture in a given well.

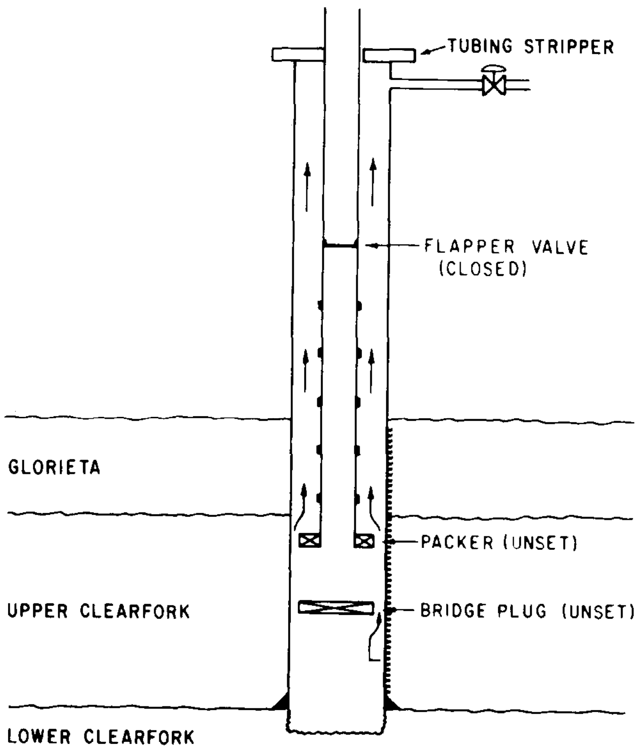

FIGURE 7—STRIPPING OPERATIONS DURING FRAC JOB, PHASE TWO

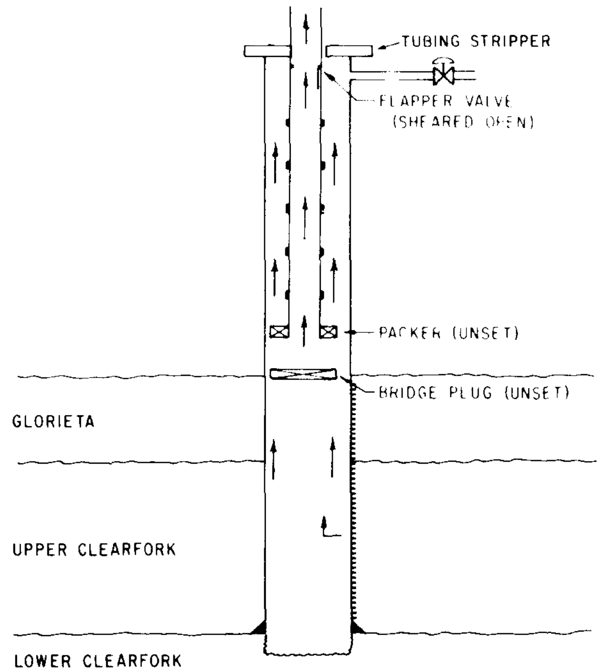

FIGURE 8—STRIPPING OPERATIONS DURING FRAC JOB, PHASE THREE

1942 DEVELOPMENT WELLS

FRACTURE STIMULATION	INITIAL POTENTIAL
20,000 GALS. FRAC. FLUID, 40,000 POUNDS SANDS.	141 BOPD

1977 INFILL WELLS

45,000 GALS. POLYMULSION PAD, 45,000 GALS. GELLED 20% HCL	258 BOPD 195 BWPD

FIGURE 9—ROBERTSON FIELD STIMULATION RESULTS

DRINKARD FIELD RESULTS

Figure No. 10 shows the workover and drilling activity in the Blinebry-Drinkard-Tubb area. The primary workover activity is concentrated in the Drinkard field. The outlined areas are Exxon leases. The Drinkard pay is very similar to the Robertson Clearfork field pay, only much smaller in gross interval (300 ft). The primary objective of the workovers is recompletion in the gas section of this depleted oil reservoir. The average buildup of 118 Drinkard workovers is 700 MCF per day. A majority of these workovers employed conventional proppant fracture stimulation methods that averaged 36,000 gal of fracturing fluid and 50,000 lb of sand. Fifteen of these workovers employed the brine external polymulsion acid fracture system. These workovers averaged 20,000 gal of brine external polymulsion pad followed by 20,000 gal of gelled 20% HCl and were usually done in two stages. Average buildup per workover is 2230 MCF per day. Figure No. 11 shows the clear superiority of acid fracture stimulation in this stringerized carbonate reservoir.

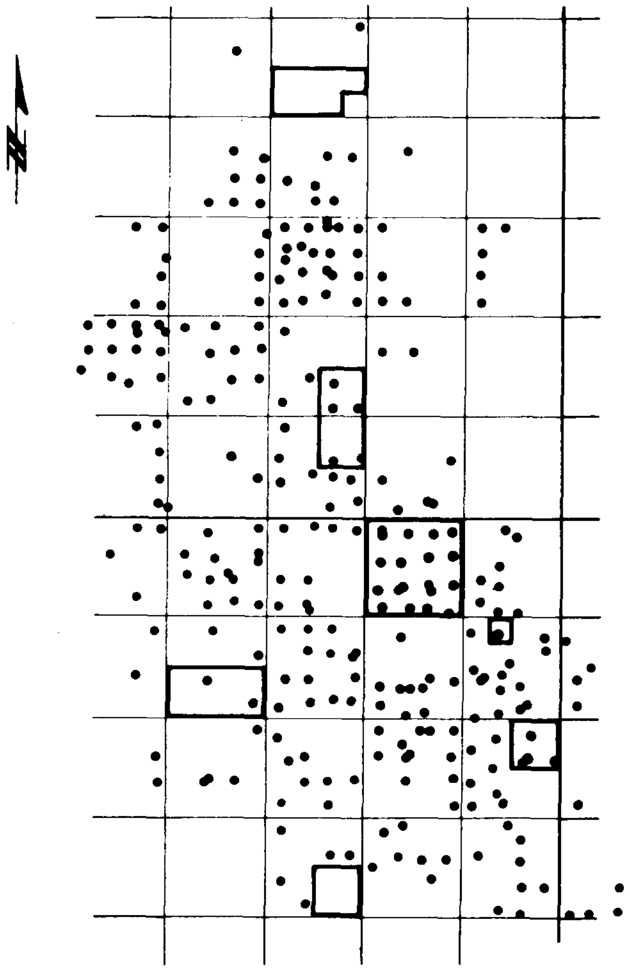

FIGURE 10—B-D-T DEVELOPMENT, WORKOVERS, NEW WELLS: B-D-T AREA, LEA COUNTY, NEW MEXICO

	AVERAGE SIZE OF STIMULATION	AVERAGE BUILDUP MCF/DAY
PROPPANT FRACTURE STIMULATIONS	36,000 GALS. FRAC. FLUID, 50,000 POUNDS SAND	700
ACID FRACTURE STIMULATIONS	20,000 GALS. POLY-MULSION PAD, 20,000 GALS. GELLED 20% HCL	1,230

FIGURE 11—DRINKARD WORKOVER RESULTS

CONCLUSIONS

Experience with the Robertson Clearfork and Drinkard fields indicates:

1. Brine external polymulsion acid fracturing exhibits greater adaptability to difficult well situations such as stimulation of the Robertson Clearfork field pay.
2. Acid fracturing allows the use of cost-saving techniques that are not possible with conventional proppant fracturing.
3. Field results in the Robertson Clearfork field and the Drinkard field indicate higher productivity for acid fracturing for the following reasons: (a) increase in percentage of pay effectively stimulated, and (b) a more conductive fracture.
4. Acid fracturing has less mechanical risk than proppant fracturing.