THE RULISON FIELD MASSIVE HYDRAULIC
FRACTURING EXPERIMENT

FINAL REPORT

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July 1977

PREPARED FOR THE
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
NEVADA OPERATIONS OFFICE

and

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MASSIVE HYDRAULIC FRACTURING EXPERIMENT

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ABSTRACT

The Rulison Field, Garfield County, Colorado, has seven producing gas wells completed in the Mesaverde formation. One of these wells, the Federal #3-94, was selected for a massive hydraulic fracturing experiment. The Federal #3-94 has a producing history of more than ten years.

The experimental fracture treatment was applied in two stages treating separately the gross perforated intervals from 6198' to 6363' (Stage 1) and 5170' to 5630' (Stage 2). Approximately 485,000 gallons of gelled water, 1,070,000 pounds of sand and 500 standard cubic feet of nitrogen per barrel were used. A brief cleanup flow period was allowed between stages. The fracture treatments were performed in August 1976.

The treatment was designed to extend a fracture approximately 1400' from the wellbore with a propped fracture width of 0.176 inches. The production increase was expected to range from 5.5 to 6.2 times the pre-treatment rate of 35 thousand standard cubic feet per day.

The results of the massive hydraulic fracturing treatment were poor. Production of gas was enhanced by a factor of less than 2. The average flow rate during early 1977 was about 50 thousand cubic feet per day. The lack of success is attributed to both low reservoir permeability and a restricted reservoir due to sand lenticularity.

Prepared for the Energy Research and Development Administration
Under Contract No. EY-76-C-08-0679.

I. History of Rulison Field

The Rulison Field (Figure 1) discovery well, Juhan #1, Garfield County, Colorado, was completed in the gas bearing Mesaverde formation in 1952. Subsequent drilling through 1956 resulted in six (6) additional Mesaverde well completions.

Two additional Mesaverde wells were completed by Austral Oil Company in 1966 to gather data for the Project Rulison feasibility study. Project Rulison was a joint industry-government experiment to assess the feasibility of stimulating the flow and recovery of natural gas from the Mesaverde formation by fracturing with a contained nuclear explosive. The project was completed in 1971. (See References)

One o

One of the wells which was completed in 1966, the Federal #3-94, was selected for the massive hydraulic fracturing experiment described herein.

II. Federal #3-94; Completion and Production History

The Federal #3-94 was completed in the Mesaverde formation with a 7" casing liner fully cemented from 4432' to 6505'. Perforations in the 7" casing span the interval from 5170' to 6353' and are grouped as follows:

1. 5170-5434'; 20 holes (selective perforations)
2. 5484-5630'; 20 holes (selective perforations)
3. 6198-6205'; 14 holes (2 holes/foot)
4. 6333-6353'; 20 holes (1 hole/foot)

Each group of perforations was initially (original completion) treated with the following volumes of fluid (water inhibited with 2% potassium chloride) and propping agent:

<u>Perforation Group</u>	<u>Gallons Fluid</u>	<u>Pounds 20-40 Mesh Sand</u>
1	50,568	46,200
2	81,900	83,538
3	42,000	42,000
4	53,300	60,000

This treatment resulted in an initial producing potential of 595 thousand standard cubic feet of gas per day. Upon subsequent connection to a pipeline, the well exhibited a behavior typical of the wells in this field (Figure 2). A steady decline in both flow rate and pressure were observed through 1970. Thereafter the flow rate was governed by the fluctuations in pipeline pressure. As of July 30, 1976, and prior to MHF treatment, cumulative production from the well was 181.228 million standard cubic feet.

The selection of this well for a massive hydraulic fracturing experiment was on the basis of (1) being in mechanically sound condition, (2) having several years of production history, and (3) being located in a part of the field where considerable information is known about the characteristics of the gas reservoir, i.e., porosity, permeability, thickness, water saturation.

III. Massive Hydraulic Fracture Treatment Design

Basic reservoir and well data (Figure 3) were submitted to the two major oil field service companies in order to develop the basic fracturing treatment proposal. The final accepted design employed a two-stage treatment separating perforations in Group 1 and 2 from Group 3 and 4 (see list above).

The lower perforations (Group 1 and 2) were isolated by means of tubing (2-7/8" OD) and packer and were treated with approximately 205,000 gallons of fluid containing 420,000 pounds of sand (140,000 pounds 20/20 mesh, 280,000 pounds 10/20 mesh) and 500 standard cubic feet per barrel of nitrogen. After a brief cleanup flow period, the lower perforations were isolated with a retrievable plug and the upper perforations (Group 3 and 4) were treated with approximately 280,000 gallons of the same fluid containing approximately 650,000 pounds of sand (350,000 pounds 20/40 mesh, 300,000 pounds 10/20 mesh) and 500 standard cubic feet of nitrogen. The frac fluid used was Dowell's water base controlled gel (trade name YF4G). Sand concentrations as high as 4 pounds per barrel fluid were achieved.

The fracture treatment was designed to extend propped fracture length approximately 1400' from the wellbore. The propped fracture width was calculated to be 0.176 to 0.179 inches.

Production increase was expected to range from 5.5 to 6.2 times greater than the pre-treatment rate of approximately 35 thousand standard cubic feet of gas per day.

IV. Post-Treatment Results

Following the execution of the fracturing treatments, the well was recompleted with a string of 2-3/8" OD production tubing suspended without a packer to a depth just above the perforations. The well was flowed to a pit for a period of several days prior to reconnection to the pipeline. A considerable amount of swabbing was required to remove large quantities of frac fluid and enable the well to flow. After recovery of approximately 50%-60% of the frac fluid, the well was able to flow intermittently into the pipeline. Additional swabbing was required on occasion. The post-treatment results are shown in Figure 4.

V. Analysis of Fracture Treatment Results

The results of this massive hydraulic fracturing treatment have not been encouraging. The relatively low natural reservoir energy coupled with continued influx of fracturing fluids into the wellbore have prevented the well from flowing on a sustained basis. Installation of a production packer above all perforations and later between perforation Groups 2 and 3 did not result in improved well performance.

From the post-treatment data it would appear that production of gas has been enhanced by a factor of less than 2.

VI. Cost of Program

The direct costs incurred for this experiment are as follows:

1. Fracturing services	\$ 251,000*
2. Rig	34,000*
3. Equipment, tool rentals	17,000
4. Water, hauling	9,000
5. Other trucking costs	7,000
6. Completion services	4,000
7. Location preparation	2,000*
8. Other miscellaneous costs	1,000
9. Project management costs	<u>12,000</u>

TOTAL ..... \$ 337,000

* Reimbursed by ERDA

VII. Conclusions

It is concluded that the application of massive hydraulic fracturing techniques in the Federal #3-94 Well has not been successful in stimulating the flow and recovery of natural gas from the Mesaverde formation. The lack of success is attributed primarily to both low reservoir permeability and a restricted reservoir due to sand lenticularity. Only a slight increase in flow rate was achieved, but is overwhelmed by the cost to achieve this increase.

References

The Project Rulison Open File System contains feasibility studies, project data and safety contractor reports. Such files have been established by E.R.D.A. in Las Vegas, Nevada; Denver, Colorado; and Bartlesville, Oklahoma. Copies of all material can also be obtained from E.R.D.A., Division of Technical Information, Oak Ridge, Tennessee.

Map Showing Location of Rulison Field

FIGURE 2

Frac Interval 5170-5434'

<u>Gross Zone</u>	<u>Perforated Zone</u>	<u>BHTP PSI</u>	<u>BHP* PSI</u>	<u>Ø %</u>	<u>k md</u>	<u>Gross Sand</u>	<u>Net Sand</u>	<u>No. Perfs.</u>
5156 - 5185	5170-5186.5'	3937	1500	12	.01*	29'	21'	5
5284 - 5327	5304-5330'	3937	1500	8	.01*	43'	19' 10'	8
5337 - 5368'	5359-5368.5'	3937	1500	5	.01*	31'	5' 13'	2
5404 - 5434'	5416-5434'	3937	1500	11	.01*	30'	30'	6

Frac Interval 5484 - 5630'

5455 - 5517'	5484.5-5586' 5498-5517'	4077	1500	13 13.5	.01* .01*	62'	13' 29'	2 5
5528 - 5564'	5539-5542' 5554-5564'	4077	1500	11	.01*	36'	34'	2 3
5580 - 5586'	5588'	4077	1500	9*	.01*	6'	6'	1
5594 - 5640'	5606-5630'	4077	1500	11	.01*	46'	46'	7

Frac Interval 6198-6205'

5176 - 5194'	6198-6205'	5430	1500	9*	.01*	18'	14'	14
6212 - 6222'						10'	10'	

Frac Interval 6333-6353'

6309 - 6360'	6333-6353'	5259	1500	13.5	.01*	51'	37'	20

*Average

Figure 3

FIGURE 4