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THE APPLICATION OF UNION PACIFIC RESOURCES CORPORATION FOR AUTHORITY PURSUANT TO STATEWIDE RULE 50 FOR THE FRANK DRGAC LEASE WELL NO. 2 AND THE R. LEOHR "A" UNIT WELL NO. 1, GIDDINGS (AUSTIN CHALK-3) FIELD, BURLESON COUNTY, TEXAS

APPEARANCES:	REPRESENTING:
Mr. Glenn E. Johnson, Attorney Dr. Steven W. Poston, Professor of Petroleum Engineering Texas A&M University Dr. D. Nathan Meehan, Manager of Technical Services Mr. J. R. Carter, Jr., Regulatory Manager	Union Pacific Resources Corp.
Mr. David Jackson, Attorney Mr. Robert Dreyling, Technical Advisor Mr. Thomas L. Gardner, Reservoir Engineer	Exxon Company U.S.A.
Mr. Richard Zuniga, Graduate Engineer	Clayton Williams, Inc.

PROCEDURAL HISTORY

Application Filed:	February 21, 1991
Administratively Rejected:	February 22, 1991
Notice of Hearing:	February 29, 1991
Hearing Held:	April 2, 1991
PFD Circulated:	
Heard By:	Doug O. Johnson, P. E. Technical Hearings Examiner Ronald C. Schultz, Jr., Hearings Examiner,

EXAMINERS' REPORT AND PROPOSAL FOR DECISION

STATEMENT OF THE CASE

Union Pacific Resources Corporation (UPRC) asks that the Commission approve of its proposed enhanced oil recovery projects on the Frank Drgac Lease, Well No. 2 and R. Leohr "A" Unit, Well No. 1 as eligible for the recovered oil tax rate assessed pursuant to the provisions of Statewide Rule 50.

Clayton Williams and Exxon were represented at the hearing as interested parties.

The Commission has not previously considered whether the proposed enhanced recovery method is eligible for the recovered oil tax rate. UPRC refers to the proposed method as "cyclic imbibition water soaks". In the oil field vernacular it is referred to as waterfrac'ing. Imbibition is the phenomenon whereby capillary forces will cause water to soak into a low permeability formation like the Austin Chalk and displace some of the oil which may be trapped there. Although there are numerous studies published in the technical literature which cite the potential to exploit the imbibition phenomenon as a method of enhanced oil recovery in naturally fractured reservoirs, it appears that UPRC's proposed method may be the first large scale application of this technology.

The examiners recommend that the application be approved because the evidence shows that the proposed project meets the requirements of a new enhanced oil recovery project. It is anticipated to result in the production of 24,000 barrels of oil from each of the two subject wells that could not otherwise be recovered. In addition to these two wells there may be as many as 2,000 other wells in the Giddings (Austin Chalk-3) Field which are candidates for this EOR process.

Besides describing the proposed EOR process, two issues discussed in this report are as follows:

1. Instead of using a pattern of injection and producing wells, UPRC proposes to inject a single slug of from 20,000 to 30,000 barrels of fresh water (with certain additives) at high rates and pressures into each of the two subject wells. The wells will then be left shut-in for several weeks to allow the water to soak into the formation. Does this process require an injection permit under Rule 46? No, the injection stage of this procedure is similar to many artificial stimulation techniques that do not require a permit under Rule 46 and it is also similar to other steam and carbon dioxide "huff-n-puff" style tertiary EOR techniques that also do not require injection permits.

2. Rule 50(j) states that "the operator must notify the Commission and comptroller in writing within 30 days after the last day of active operations." Since *active operations* is defined by Rule 50(c)(1) as the "commencement and continuation of fluid injection...," and since *fluid injection* is defined by Rule 50(c)(6) as "injection through an injection well..." the "termination date" should be defined in advance.

DISCUSSION OF THE EVIDENCE

Both the Leohr A-1 and Drgac No. 2 are conventional vertical completions in the Giddings (Austin Chalk-3) Field. The Leohr A-1 was initially completed in 1985, the Drgac No. 2 was completed in 1984. Both wells were artificially stimulated with large, conventional proppant-laden gelled fluids. Both wells are near their economic limit of production. The Leohr A-1 has produced approximately 52,000 barrels of oil, and is currently producing approximately 10 BOPD. The Drgac No. 2 has produced approximately 95,000 barrels of oil, and is currently producing approximately 15 BOPD.

The proposed enhanced recovery method involves injecting 20,000 to 30,000 barrels of fresh water at a rate of 60 to 80 barrels per minute. Certain materials are added to the water in an attempt to spread it out and invade as many different natural fractures as possible so as to augment the imbibition phenomenon. These additives, the typical amount, and purpose for each are as follows:

Additives	Purposes
200 BBLS 15% HCL	-Wellbore & formation clean-up
50 GAL Acid Retarder	-Allow greater penetration before acid spent
5000 LBS Wax Beads	-Diverter for maximum creative coverage
210 GAL Friction Reducer	-Maintain high injection rates
210 GAL Surfactant	-Enhance imbibition
420 LBS Bactericide	-Prevent bacteria forming
17 GAL Corrosion Inhibitor	-Protect from corrosion
17 GAL Iron Sequestrant	-Keeps any iron precipitant in solution to prevent formation plugging

After the water is injected, each well will be left shut-in for two to three weeks to allow the water enough time to soak into the matrix rock. The shut-in period is critical because imbibition is a time-dependent phenomenon, it cannot be "hurried up" by injecting more water at higher pressures. Some of the variables which influence the imbibition rate include rock porosity, permeability, fluid densities and viscosities, interfacial tension between water and oil, rock/fluid wettability conditions, the pressure and temperature in the formation and the related thermodynamic properties of the oil and water. A key factor controlling the practical effectiveness of the imbibition process to enhance oil recovery is the matrix block size; the greater the incidence of natural fractures, the smaller the block size the greater the surface area (fractures) that can be invaded by the injected water.

This characteristic of the Austin Chalk (low permeability rock combined with high permeability fractures) simultaneously makes it an eligible candidate for exploitation of the imbibition process while making it ineligible for other, more conventional, enhanced recovery techniques. Many naturally fractures reservoirs can be described as having a low permeability matrix that constitutes most of the reservoir storage capacity and high permeability fracture systems that make up only a small fraction of the entire reservoir storage capacity. With water-wet or mixed wettability microfractures and matrix rock, water exposed to the rock will imbibe

into the rock and displace the non-wetting oil phase by countercurrent flow. The extent of imbibition will be a function of capillary pressure phenomena. While this phenomena is present to some extent in conventional waterfloods, it is only in low permeability, naturally fractured reservoirs that it becomes important. High and even moderate permeability rocks allow a significant degree of fluid flow into the matrix simply due to the force of the injection pumps and gravity such that capillary forces are comparatively negligible. Low permeability reservoirs without extensive natural fractures make it almost impossible to inject significant volumes of water and contact large surface areas of the rock. Large surface areas (which result directly from small fracture spacing and sufficiently high injection rates and pressures to maximize contact area) are the key to successful imbibition projects. Similar efforts conducted in the Spraberry (Trend Area) Field and the Pearsall (Austin Chalk) Field have not been as successful as early results in the Giddings (Austin Chalk-3) Field because the fracture density is too sparse.

The Department of Energy and State of Texas are currently providing matching funds for a three year, $3 million study of the Austin Chalk to identify potential mechanisms for enhanced recovery from fractured, low permeability reservoirs. This study has identified the imbibition process as the only practical method to economically enhance recovery. The purpose of the study is to determine whether the use of carbonated water will improve the moderate success rate seen in the projects conducted so far.

To date, UPRC has performed about two hundred imbibition treatments in the Giddings (Austin Chalk-3) Field. The process is repeatable and has been performed several times on some wells. Results from two of the more responsive wells were presented at the hearing. In each case, the wells were producing less than 10 BOPD before water injection. In each case, a significant improvement in oil recovery resulted after each of two injection cycles. In one case the total incremental production amounted to 97% of the ultimate primary recovery and in the other case it amounted to 227% of primary.

There is a large amount of potentially recoverable secondary oil if the imbibition process can be successfully applied throughout the Giddings (Austin Chalk-3) Field. Total production from the field as of January 1, 1990 had been 187.3 million barrels of oil. UPRC estimated that the ultimate primary recovery could amount to approximately 255 million barrels. Although the pore volume recovery efficiency from the Austin Chalk is notoriously very low (estimated at less than 10% of the original oil in place), incremental secondary reserves conservatively estimated at 50% of primary could amount to 127.5 million barrels. There are currently about 2000 wells in the field that are potential candidates for the cyclic imbibition water injection process. Assuming an average incremental oil recovery of 20,000 barrels per injection cycle and two cycles per well, the total incremental oil recovery would be 80 million barrels. It costs about $75,000 to perform each imbibition treatment. Again, assuming two injection cycles for each of 2000 wells, the total expense will be $300 million.

EXAMINERS' OPINION

The examiners recommend that the Commission approved UPRC's proposed project for qualification under Rule 50. Rule 50 applies to "enhanced oil recovery projects," which are projects that use any process other than primary recovery to displace oil from the reservoir Rule 50(b)(1)(A), (c)(4). UPRC's proposed project meets this criteria. The primary drive mechanism

in the Giddings (Austin Chalk-3) Field is solution gas drive augmented by gravity drainage. The "cyclic imbibition water soaks" method displaces oil differently than the primary drive mechanism. Water imbibed into the pore spaces of the rock (due to capillary attraction) displaces oil into the fracture systems where it then can be produced by the well.

The examiners also recommend that the order approving the project contain a provision clearly defining when these projects terminate. Rule 50 contemplates projects that continuously inject because termination occurs when fluid injection program stops or is discontinued. Rule 50(j),(c)(14). Obviously, injection must stop for some period of time to allow the injected fluids to soak and to produce the well. To avoid confusion regarding the termination of these projects, the examiners recommend that the order contain the following provision:

> TERMINATION - For the purposes of this project, termination occurs 90 days after the production rate falls and remains below the rate of production achieved prior to the first cyclic injection.
>
> If no further cyclic injections are contemplated, UPRC must notify the Commission and the Comptroller in writing within 30 days after the production rate falls below the rate of production achieved prior to the first cyclic injection.

FINDINGS OF FACT

1. Notice was issued to the applicant at least ten (10) days prior to the date of the hearing.

2. The Giddings (Austin Chalk-3) Field is a naturally fractured limestone formation with very low permeability matrix rock broken up by relatively high permeability fracture systems.

3. The primary drive mechanism in the Giddings (Austin Chalk-3) Field is solution gas drive augmented by gravity drainage. The primary recovery efficiency from the Austin Chalk formation is very low, less than 10%.

4. UPRC proposes to use the cyclic imbibition water soak process on its Frank Drgac Lease, Well No. 2 and R. Leohr "A" Unit, Well No. 1 to recover additional oil.

5. The cyclic imbibition water soak process successfully exploits the imbibition phenomenon to improve oil recovery from the Austin Chalk.

6. The cyclic imbibition water soak process uses a displacement process that is different than the primary recovery process.

7. Implemented on a field-wide basis, the procedure could result in the recovery of between 80 and 127.5 million barrels of oil at a total cost of $300 million.

CONCLUSIONS OF LAW

1. Proper notice was timely issued to all persons legally entitled to notice.

2. All things have been done to give the Commission jurisdiction in this matter.

3. The Commission has jurisdiction to qualify new enhanced recovery projects for the recovered oil tax rate pursuant to §202.054 Tax Code.

4. The cyclic imbibition water soak process is a new enhanced recovery project eligible for the recovered oil tax rate.

EXAMINERS' RECOMMENDATION

Based on the foregoing, the examiners recommend that the application be approved.

Respectfully submitted,

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DJ/RCS:amw

Date of Commission Action: December 10, 1991.