SPE 102681

Restimulation: Candidate Selection Methodologies and Treatment Optimization

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This paper was prepared for presentation at the 2006 SPE Annual Technical Conference and Exhibition held in San Antonio, Texas, U.S.A., 24–27 September 2006.

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Abstract

Restimulation of existing wells represents a vast underexploited resource. A successful refracturing treatment is one that creates a fracture having higher fracture conductivity and/or penetrating an area of higher pore pressure than the previous fracture. Refracturing requirements are different in highly permeable formations (high fracture conductivity) as compared to low permeable ones (moderate fracture conductivity). Understanding these basic differences is essential to a successful restimulation.

In the past, candidate selection methodology has focused on underperforming wells. This simplistic approach has yielded disappointing results and has led to a common misconception that restimulations "don't work." Production statistics of a well alone may not offer an effective restimulation candidate selection methodology. Other parameters such as high BHP (remaining reservoir energy), recoverable reserves, ϕ-h[1] and favorable response to original fracture jobs (IP) could play an equally important role, if not greater, in determining the success of restimulation. In fact, studies have shown that selecting poor or underperforming wells for restimulation is likely to result in worse outcomes than random selection of workover candidates.

Studies performed to date have concluded that no selection criteria can be universally applied to every situation; rather that the selection methodology for workover candidates must be customized to fit particular situations. This paper explores the common traits shared by fields likely to have underexploited restimulation potential and suggests methodologies that should be applied to various field types. The case histories illustrated in this paper will highlight the various treatment parameters optimized for successful restimulation. The conclusions of this paper are based on our work in selecting restimulation candidates as well as published results of other operators. Application of the correct candidate selection methodology to a particular field type will inevitably lead to a higher success rate of restimulation walkovers and the capture of an underexploited resource.

Introduction

Selection criteria of refracture candidates from a given set of wells in a field will vary depending on the reservoir under question and the prevailing well conditions. To be successful, refracturing treatments must result in longer and/or more conductive propped fractures, or expose more net pay thickness to the wellbore (establishing linear flow into the wellbore) as compared to the well conditions that exist prior to restimulation.

In light of the above, two key important aspects of any restimulation program or attempt are: (i) learn from existing experience in the field or area about restimulation and formulate a reservoir specific selection criteria that will capture the key ingredients for the success of restimulation and (ii) a thorough understanding of the treatment parameters that govern the success of a restimulation job so as to be able to optimize the treatment for maximum rate of return. Advances in the design and evaluation software, improved diagnostic techniques, etc, have played a key role in restimulation success during the past ten years, as have the technological advances in stimulation fluids and proppants. This paper will focus on the common attributes shared by known successful restimulation candidates in the industry. An attempt will be made to highlight the attributes mentioned in this paper through some well-known case histories. Based on the existing knowledge base on the restimulation identification process, a systematic and comprehensive candidate selection methodology will be presented in this paper. Towards the end, a list of factors to look for while evaluating a field or reservoir for restimulation will be highlighted for reference.

Restimulation Activity – Past and Present

The objective of any fracture stimulation treatment either during initial completion or during restimulation is to definitely bypass the near-wellbore damage, penetrate deeper into the reservoir and increase connectivity with the reservoir. Refracturing attempts started soon after the introduction of hydraulic fracturing in about 1947, but early applications required significant effort in problem diagnosis and candidate selection, with mixed results. Until the last decade, restimulation was generally not considered a good option. It was sometimes believed that restimulation treatments could

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not be economically justified or that it might even be preferable to abandon the well, as operators were wary about resorting to restimulation due to bad experiences with refracturing in the past.

Between 1996 and 1998, the Gas Research Institute (GRI), now called the Gas Technology Institute (GTI), conducted a study investigating fracture restimulation as a means of enhancing well productivity and adding recoverable reserves. This preliminary evaluation study resulted in the identification of significant on-shore gas potential in the United States (**Fig. 1**)[2]. High product prices and higher development costs have cultivated a renewed interest in restimulation among operators worldwide. From the restimulation activity so far in United States and other areas, including China, Algeria, Brazil and Russia, it is evident that great refracturing potential exists worldwide, even in mature oil fields[3,4,5,6]. **Fig. 2** represents a map showing the restimulation activity areas in the southern part of the United States. Some of the cases histories presented in the later sections of this paper fall in this area.

Common Traits of Potential Restimulation Areas

The common traits of areas with restimulation potential can be classified as follows:

1. complex reservoirs with problematic initial completions;
2. plays with important technological improvements;
3. older wells that have suffered damage during production;
4. plays with multiple producing horizons that may have been stimulated with limited entry techniques.

These traits will be highlighted in each of the case histories discussed in this paper to emphasize the sub components of each of these traits. Though the above-mentioned set of traits is a broad classification, it can definitely serve as a guideline for candidate selection and key parameters to consider while selecting candidates for restimulation.

Restimulation – Case Histories

Case History #1: Barnett Shale Gas Restimulation Program (Traits #1 and #2)

The Barnett Shale exhibits common traits 1 and 2. It is an extremely complex reservoir that has undergone an evolution in stimulation practices during the history of its development. The Barnett is a Mississippian-age shale formation, which has been deposited in a deep marine environment. Barnett Shale consists of layered mudstone, siltstone and some interbedded limestone with open and calcite-filled natural fractures[2]. Matrix permeability is extremely low about .0001 to .001 mD. With a calculated recovery of 8 to 10% of the gas in place, massive fracturing treatments are required to achieve economic production from this shale formation.

Barnett Shale completions started in the 1980s, when fracturing treatments involved the use of high polymer gel loading, crosslinked-gel fluids, moderate proppant concentrations with minimal external breaker added to the fluid. With time, the stimulation treatments evolved and the polymer concentrations were gradually reduced, nitrogen was used to enhance flowback and the overall fluid and proppant volumes were increased. Further improvements were made in the form of increasing the breaker systems and elimination of solid fluid-loss additives. These improvements in the job treatment design resulted in continuous increases in well productivity. Slick-water treatments became the predominant stimulation method in 1997. Refracturing with large job volumes yielded much better productivities than the initial completions (**Fig. 3**). Much of the success of restimulation in the Barnett has come from slick-water jobs that followed cross-linked jobs.

Analysis of near- and far-stress fields in the Barnett indicate that the new fractures created during restimulation followed the original fracture plane for a short distance before diverging along a new direction[7,8]. As the Barnett shale has minimum anisotropy, fracture reorientation is a definite possibility and so is the development of a complex fracture network that will further enhance well productivity by contacting virgin rock away from the wellbore. Knowledge of these concepts and its potential implications are being studied even today. It has also been noted that fracture reorientation does not always occur on every restimulation performed in Barnett Shale. Increased understanding of fracture reorientation and complex fractures is made possible with the help of micro-seismic hydraulic fracture monitoring techniques. While it is felt that fracture reorientation is an important factor in the success of Barnett restimulations, additional study will be required to predict where it will be a key driver in the candidate selection process.

Case History #2: Vicksburg Basin Restimulation Candidates Selection (Traits #1, #2 and #4)

Like the Barnett, the Vicksburg is a complex reservoir that has undergone a technology evolution since wells were originally stimulated. However, it also has common trait number 4, multiple producing horizons. While it is a safe bet that a field possessing 3 of the 4 common traits associated with restimulation potential will have candidates, the selection of those candidates requires careful screening.

Completions in this basin date back to the 1970's and 1980's. Typically, Vicksburg is a tight gas sand with permeabilities ranging between 0.005md and 0.1md. A Vicksburg basin study identified underperforming wells and explored the use of improved well-completion practices and restimulation techniques. Many wells had multiple zone completions with limited entry techniques being applied on some of these zones. Schlumberger together with Kerr-McGee formulated an integrated workflow to identify refracture opportunities. Key elements are Moving Domain Analysis (MDA) to sort through and organize production statistics and, development of a specific petrophysical model to identify bypassed gas zones. **Fig. 4** gives an example of the various factors that were considered for initial screening before doing a detailed production analysis on a well-by-well basis. The Vicksburg restimulation program had a success rate greater than 80% because key performance drivers were identified and a highly customized selection methodology was

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developed.

Case History #3: Codell DJ Basin Refracture Program (Traits #1 and #2)

The Codell restimulation program involved the successful restimulation of literally thousands of wells. It shares common traits 1 and 2.

Codell Sandstone is Upper Cretaceous[9,10] in age and produces condensate and gas with little water at true vertical depths of 7,000 to 8,000 ft. The permeability in the Codell interval is very low due to the small and tortuous pore network. Though limited entry treatments provided substantial cost savings in completing Codell and Niabrara formations together, the amount of proppant pumped into Codell formation was also lower. Besides using limited entry technique for stimulation, high polymer loading fluids with basic persulfate breakers were used as the fracturing fluid. Thus, wells were not being stimulated effectively resulting in shorter fracture half-lengths and gel damage from the high polymer fracturing fluids. These are the two major reasons for the initiation of the Codell refracture program.

During the course of the refracture program, the high polymer hydroxypropyl guar (HPG) was replaced with a low polymer fluid system Carboxy Methyl Guar (CMG) polymer. This polymer is a single derivative guar and is not propoxylated like Carboxy Methyl HPG. For the CMG to achieve the enhanced chain expansion, clean potable water with extremely low total dissolved solids is required. The success of this refracture program is to be attributed to the evolution of fracture technology and real-time supervision (fracture diagnostics) to keep the fracture in the zone of interest. Fracture reorientation phenomena have also been observed quite commonly in this basin to a point that sometimes the same zone has been restimulated twice after the initial stimulation. **Fig. 5** shows a typical post-refracture treatment response in the Codell.

Case History #4: Weighted Parameter Candidate Selection Methodology applied to a Gas Field in China (Traits #2 and #3)

This field exhibited common traits 2 and 3, i.e., an area where technology improvements created opportunities and older wells that had been damaged during the course of their producing lives.

The SinoPec Xinchang gas reservoir is located in southwest China[11]. It is a tight sandstone formation with natural fissures. As the production rate of individual wells was going through a decline, restimulation was considered as an option to maintain the overall field production. The preliminary candidate selection methodology used to rank the wells involved a weighted parameter approach with parameters like kh, cumulative production, previous treatment etc. (**Fig. 6**) It was determined that drainage area has significant effects on long term production and so it was key to obtain longer fracture half-length and optimize well placement. **Fig. 7** shows the production increase obtained after restimulation in one of the selected wells.

Case History #5: Artificial Neural Networks to identify Restimulation Candidates

In this paper[12], artificial neural network analysis is discussed as a way to identify restimulation candidates in the Red Oak field. Development of an artificial neural network for any application involves preparing the data, determining the relative significance of variables, training the neural network and evaluating its suitability in predicting outcomes. It must be mentioned that several of the key input variables used in this network training have to do with refracture procedure applied during well recompletion such as refracture fluid type, fluid volume, proppant weight and proppant type.

Candidate Selection Methodology – A Comprehensive Approach

An effective selection methodology is essential to a successful restimulation program. There is no one set of selection criteria that can be applied to every situation. However, it is possible to formulate a framework for proceeding with the candidate selection (for a certain field) irrespective of circumstances. The following steps were formulated as a comprehensive approach to candidate selection by Schlumberger Data and Consulting Services.

1. Literature Review

The first step is to review any published information that could shed light on the area in question, particularly published data regarding stimulation techniques. Particularly for areas that have either of common traits 1 or 2, it can be very useful to learn from the published experiences of others. This is a critical first step.

2. Moving Domain Analysis (MDA) or Artificial Neural Network - Phase 1 Scoping Study

Numerous papers have been written describing the utility of MDA in identifying and quantifying infill opportunities. MDA is also quite useful for organizing statistical data and identifying drivers of well performance. An analysis of the field area using data available in the public domain will shed light on the area and may point to superior completion techniques that could lead to restimulation opportunities. Artificial Neural Network software serves a similar function by providing a more automated means to screen a large number of wells. The purpose of both of these techniques is not to select candidates but to eliminate them.

3. Performance Based Screening

It has been demonstrated that in some areas the poorest performers also make the poorest restimulation candidates. In general, this tends to be the case for complex, low permeability, noncompetitive reservoirs. In other, less complex, competitive reservoirs, under-performance can prove to be an effective selection criterion. However, even when restimulation candidates cannot be advanced based on under-performance, it may still be possible to screen candidates based on performance, if only to eliminate from consideration under-performing wells. In other words, performance can nearly always be used as a screening for selection of restimulation candidates. How it will be used is dependent on

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the type of reservoir being studied. Before proceeding to Step 4, if warranted, production type curve matching to provide an indication of reservoir quality and completion efficiency can be performed. In all cases, there must be sufficient remaining reserve potential for a given well to warrant consideration for restimulation.

4. Well Data Review

The primary objective of the preceding three steps was to shed some light on which wells in a field might hold promise as restimulation candidates without actually having to perform a close examination of well file data. The review of public data and production histories should have narrowed the focus of further review considerably, both in terms of numbers of wells to scrutinize and what, in particular, to look for in a restimulation candidate. For example, fracture fluid, proppant type, perforation scheme, or some other completion peculiarity may have been identified as a potential cause of under-performance from the screening phase. A review of well file data will enable an evaluation of the current well condition as well as a complete compilation of the well history. It is likely that additional wells could be eliminated from consideration in this step based on their mechanical condition.

5. Identification of Key Drivers and Indicators

A thorough review of a number of well files from the field of interest should confirm the existence of key drivers of well performance. Based on these drivers, a candidate ranking system can be devised that will serve to further screen wells in the field. Production data analysis can be performed on the wells surviving this additional level of screening so that forecasted production resulting from a refracturing treatment can be derived. The top candidate wells based on this analysis can move on to the next step.

6. Evaluation of Best Candidate Wells (using an Integrated Evaluation Methodology)

An integrated (well, reservoir, completion) evaluation methodology should be performed on every well before the restimulation, at least in the beginning of the study. This integrated evaluation methodology will help to verify that the key drivers identified in step 5 are just that, and that there are not other equally important, though less obvious, indicators that could have been missed, e.g., misidentification of pay in the original completion.

7. Restimulation of Best Candidate Wells

At this stage in the process, the operator should stimulate the wells shown to be the best prospects. The integrated evaluation should have resulted in an optimized treatment that will yield a longer and/or more conductive fracture or contact portions of the reservoir that were untouched in the original treatment.

8. Evaluation of Results and Revision of Selection Criteria

In practice, it is necessary to validate the selection of the candidate wells by pumping the restimulation treatments and comparing actual results with forecasted rates. Ideally, at least three wells should be restimulated because of the likelihood that the results of one or two workovers could be unduly influenced by factors unrelated to the selection process, such as unforeseen mechanical issues arising during the workover. In addition to hitting homeruns with the initial attempts at restimulating wells in a field, one of the primary objectives at this stage in the program is to fine-tune the selection process by verification that the drivers used to identify wells in need of restimulation are effective. Lessons learned from actual results will typically reveal other important selection considerations.

Key Factors Leading To Restimulation Candidate Identification

Given below is a partial list of key factors to consider or compare to be able to identify restimulation candidates:

- Relatively high reservoir pressure (energy) indicating that a significant portion of initial reserves is still in place.
- Low productivity relative to other wells with comparable pay in a homogenous reservoir.
- Damaged wells with a high ratio of remaining reserves to the existing production rate.
- Wells with high k and high skin value
- Old completions with less than optimal treatments.
- Limited entry completions.
- Scale, embedment of proppant, proppant crushing, proppant flowback.
- Possibility of fracture reorientation.
- Previous treatments that had screened out.
- Treatments that had used incompatible fluids.
- Smaller original stimulation treatment in comparison to the deliverability of the reservoir.
- Reservoir complexity leading to completion problems.

Optimizing Fracture Penetration And Fracture Conductivity

Treatment optimization of any restimulation treatment will essentially follow the same guidelines as for a new completion stimulation treatment. According to Pratz[13], the steady-state productivity improvement of fracturing was related to the Dimensionless Fracture Capacity, F_{CD}. This term is described as the ratio of fracture's ability to flow fluids from fracture tip to the wellbore, to the reservoir's ability to flow fluids from the reservoir to the fracture face and is defined as:

$$F_{CD} = (k_f w / k X_f)$$

where $k_f w$ is the fracture conductivity, k is the reservoir permeability, and X_f is the fracture half-length. **Fig. 8** is a log-log plot developed after Prats of the steady-state folds of increase (FOI) versus Relative Conductivity for fracture half-lengths of 100, 500 and 1000 ft. Based on this observation, restimulation treatments in wells in permeable formations should be designed to maximize fracture conductivity. Alternatively, restimulation treatments in low permeability formations should be designed to increase fracture half-length.

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Conclusions

Restimulation is an area, which is fast attracting attention among operators due to the increasing need and confidence in the process. Needless to say, candidate selection remains a key step in any restimulation program to have a high probability of success.

- The areas ripe for restimulation have one or more of the common traits mentioned in this paper.
- The ranking system applied to candidates in the Vicksburg basin study yielded success to the restimulation program whereas the gas field in China followed a weighted average approach for candidate selection.
- When considering a field for restimulation that has more than a few wells, a quick first pass evaluation using moving domain analysis or neural network type techniques using the readily available data could narrow down or prioritize the wells for in-depth analysis.
- Stimulation treatment parameters such as total fluid volume, fluid type, and proppant volume and proppant type are observed to have a major impact on the outcome of any restimulation campaign.
- Candidate selection methodology must be tailored to the field considered for restimulation.
- Though there is not a universal candidate selection methodology that can be applied to every field, the generic steps outlined in this paper takes the user through the evaluation process in a systematic fashion to arrive at a few candidates for restimulation.

References

1. Fleming, M. E.: "Successful Refracturing in the North Westbrook Unit," paper SPE 24011, presented at the SPE Permian Basin Oil and Gas Recovery Conference, Midland, Texas, USA, March 18-20, 1992.

2. Dozier, G., Elbel, J., Fielder, E., Hoover, R., Lemp, S., Reeves, S., Siebrits, E., Wisler, D. and Wolhart, S.: "Refracturing Works," Schlumberger Oilfield Review Article, Autumn 2003.

3. Pospisil, G., Lynch, K. W., Pearson, C. M. and Rugen, J. A.: "Results of a Large-Scale Refracture Stimulation Program, Kuparuk River Unit, Alaska," paper SPE 24857, presented at the 67th SPE Annual Technical Conference and Exhibition, Washington, DC, USA, October 4-7, 1992.

4. Olson, K. E.: "A Case Study of Hydraulically Refractured Wells in the Devonian Formation, Crane County, Texas," paper SPE 22834, presented at the 66th SPE Annual Technical Conference and Exhibition, Dallas, TX, USA, October 6-9, 1991.

5. Wright, C. A., Stewart, D. W., Emanuele, M. A., Wright, W. W.: "Reorientation of Propped Refracture Treatments in the Lost Hills Field," paper SPE 27896, presented at the SPE Western Regional Meeting, Long Beach, California, USA, March 23-25, 1994.

6. Marquardt, M. B., van Batenburg, D. and Belhaouas, R.: "Production Gains from Re-Fracturing Treatments in Hassi Messaoud, Algeria," paper SPE 65186, presented at the SPE European Petroleum Conference, Paris, France, October 24-25, 2000.

7. Siebrits, E., Elbel, J. L., Hoover, R. S., Diyashev, I. R., Griffin, L. G., Wright, C. A., Davidson, B. M., Steinsberger, N. P., Hill, D. G.: "Refracture Reorientation Enhances Gas Production in Barnett Shale Tight Gas Wells," paper SPE 63030, presented at the SPE Annual Technical Conference and Exhibition, Dallas, Texas, USA, October 1-4, 2000.

8. Wright, C. A. and Conant, R. A.: "Reorientation of propped refracture treatments," paper SPE 28078, presented at the Eurock SPE/ISRM Rock Mechanics in Petroleum Engineering Conference, Delft, The Netherlands, August 29-31, 1994.

9. Shaefer, M. T. and Lytle, D. M.: "Fracturing Fluid Evolution Plays a Major Role in Codell Refracturing Success," paper SPE 71044, presented at the SPE Rocky Moutain Petroleum Technology Conference, Keystone, Colorado, USA, May 21-23, 2001.

10. Sencenbaugh, R. N., Lytle, D. M., Birmingham, T. J., Simmons, J. C. and Shaefer, M. T.: "Restimulating Tight Gas Sand: Case Study of the Codell Formation," paper SPE 71045, presented at the SPE Rocky Moutain Petroleum Technology Conference, Keystone, Colorado, USA, May 21-23, 2001.

11. "Best Practice: Comprehensive Candidate Selection Process Leads to the Success of Refracturing Project" – Schlumberger InTouch Best Practice Article shared by Schlumberger, China.

12. Shelley, R. F.: "Artificial Neural Networks Identify Restimulation Candidates in the Red Oak Field," paper SPE 52190, presented at the SPE Mid-Continent Operations Symposium, Oklahoma City, Oklahoma, USA, March 28-31, 1999.

13. Reese, J. L., Britt, L. K. and Jones, J. R.: "Selecting Economic Refracturing Candidates," paper SPE 28490, presented at the 69th SPE Annual Technical Conference and Exhibition, New Orleans, Louisiana, USA, September 25-28, 1994.

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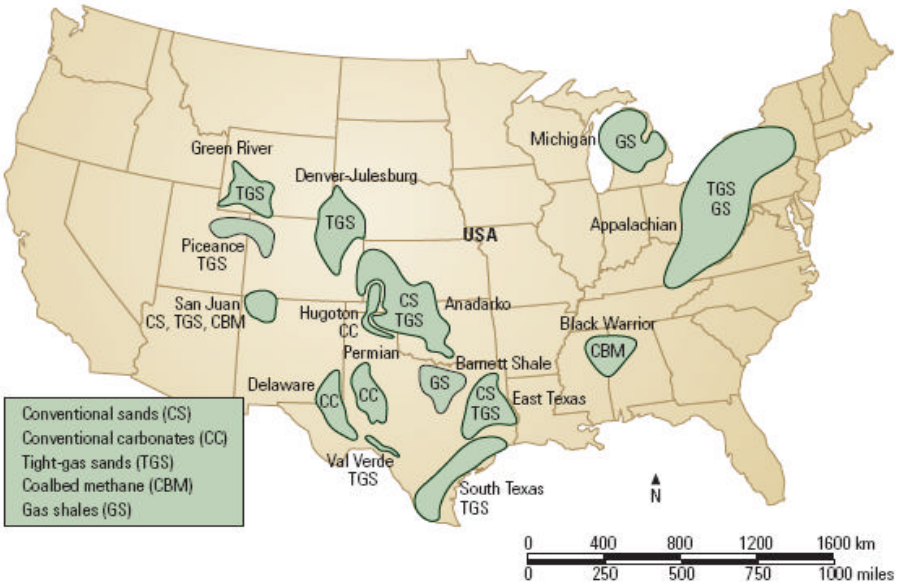

Fig. 1: Areas with restimulation potential in the USA based on the Gas Technology Institute (GTI) study

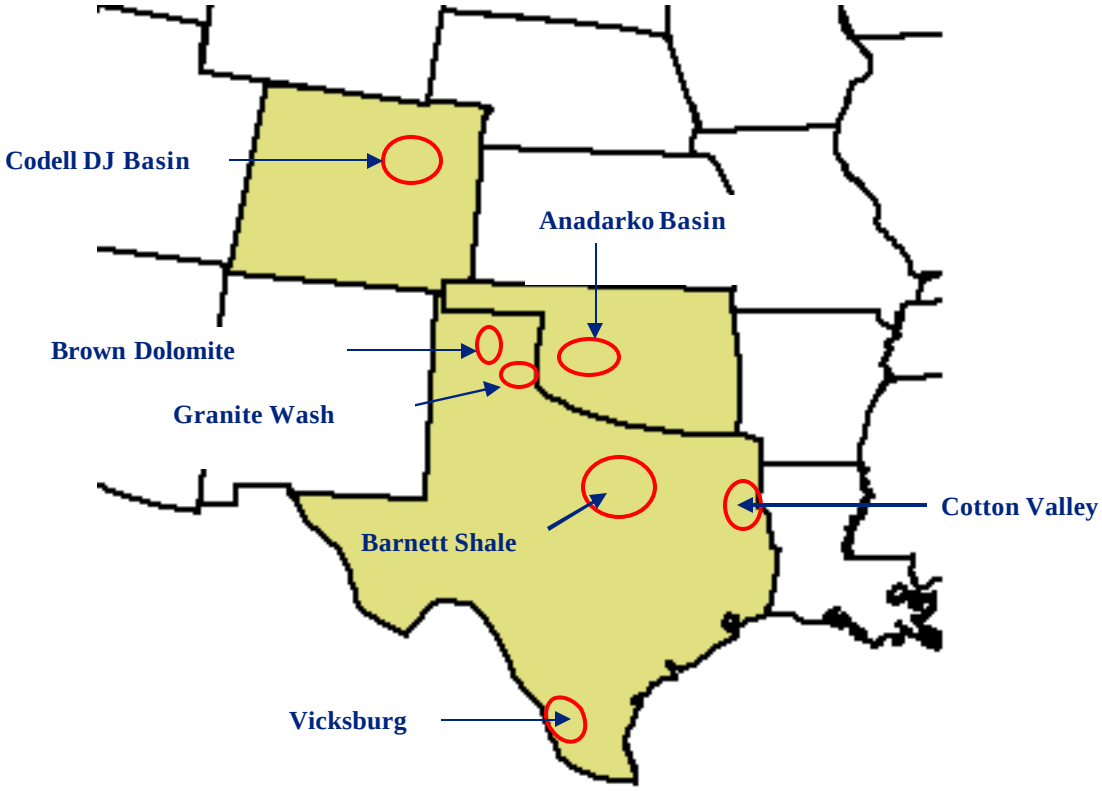

Fig. 2: Restimulation activity areas in the southern part of United States

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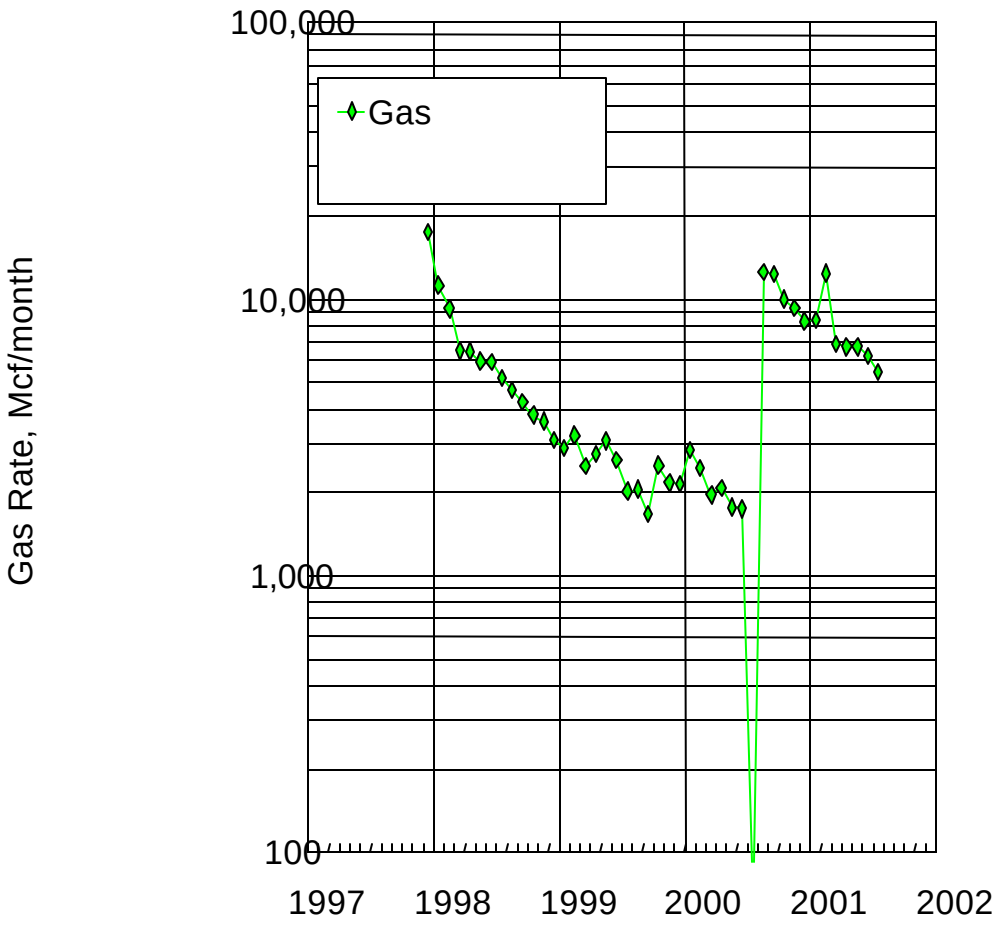

Fig. 3: Typical Restimulation Response for a Barnett Shale Well

Candidate Indicator	Well #1	Well #2	Well #3
Gas Best 12	3	3	5
60 Productive Months Cum	2	1	5
(Ranking for workover review & pre-production trend analysis)	5	4	10
Water prod. vs. Gas prod ratio	4	2	5
Gas Decline Trend	4	3	5
*****Proppant type & amount***	1	1	4
(Ranking for production modelling, economic analysis, pressure survey)	14	10	24

Fig. 4: Sample Screening Criteria used in Vicksburg Basin Study

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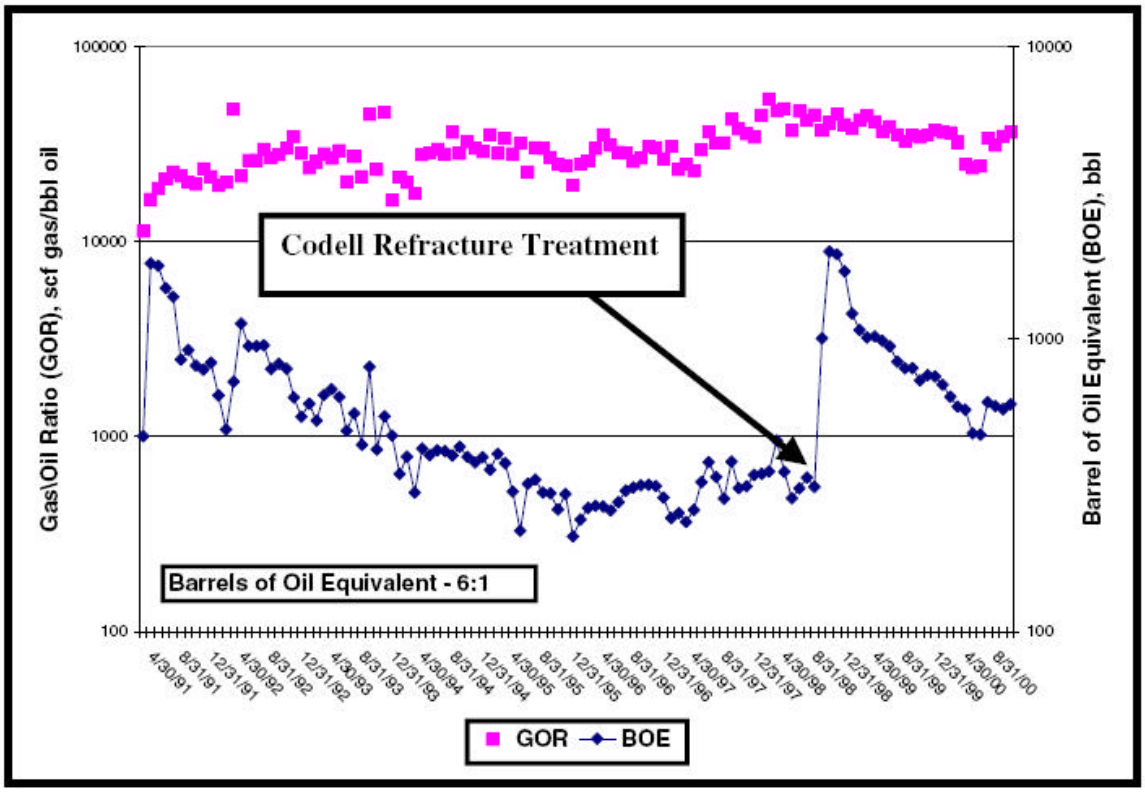

Fig. 5: Typical Response of a Codell Refracture Treatment

- 20% - Kh (validated perm times net pay)
- 20% - Cumulative production
- 20% - Previous treatment (proppant/m net pay)
- 10% - Cumulative production time
- 15% - Gas Saturation
- 10% - Current Performance
- 5% - Recovery Ratio

Fig. 6: Weighted Parameter Approach used for Preliminary Candidate Selection

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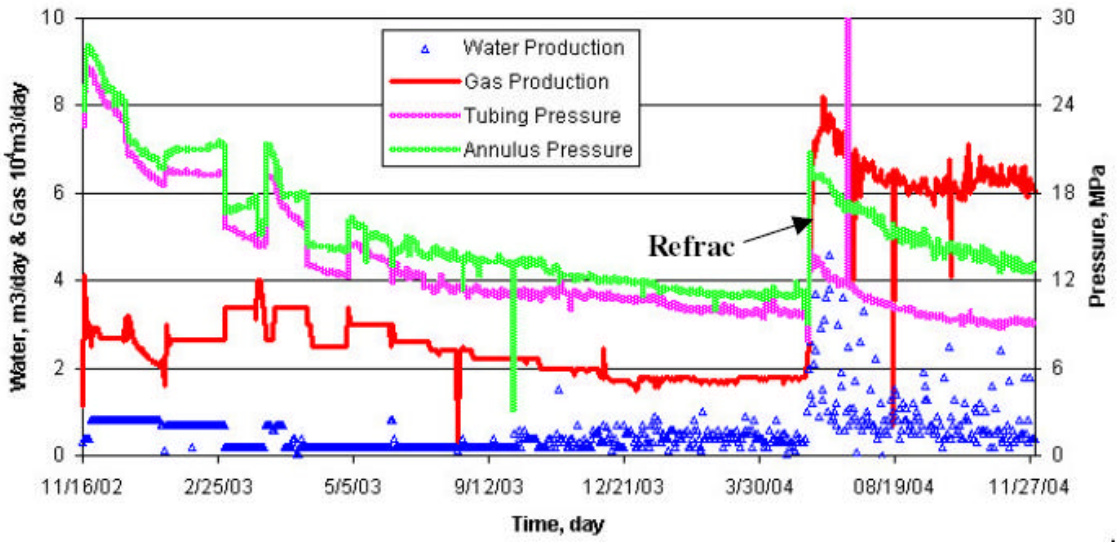

Fig. 7: Production Response from one of the wells selected for restimulation

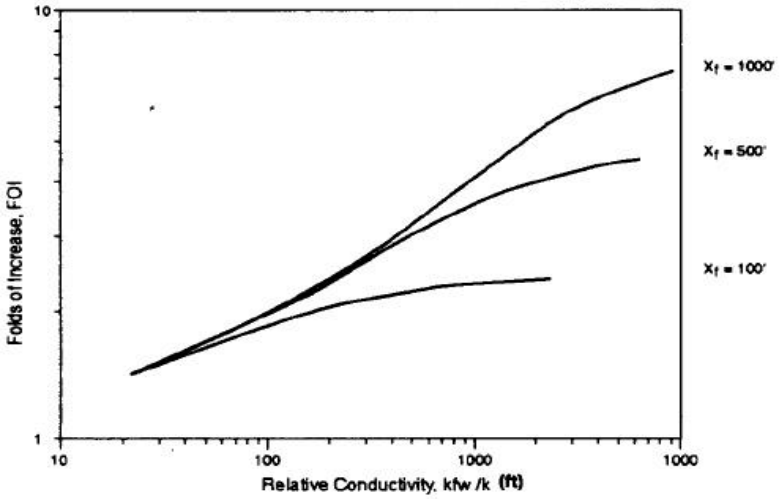

Fig. 8: The Relationship between Fracture Conductivity and Fracture Half-Length (after Prats)

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