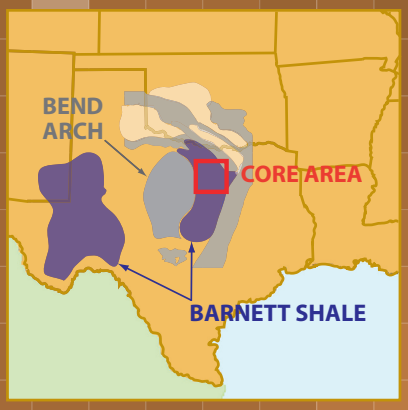
To Cement or Not to Cement, that is the Question

Optimizing Horizontal Completions in the Barnett Shale using FracSeis.®



THE SETTING

- Fort Worth Basin of North Texas
- 0.00007 mD Barnett Shale
- Naturally Fractured
- Horizontal Wellbores

Pinnacle

THE BACKGROUND

The ultra-low permeability Barnett Shale is a relatively new play (75% of the producing wells in the Barnett have been drilled since 2000). By 2002, the Newark East Field was the largest gas producer in Texas and the 7th largest gas producer in the United States!

Horizontal drilling is now commonly utilized to optimize gas production. Issues such as nearby water bearing intervals, inadequate surface locations, improved gas production rates and cost per scf can be addressed by the use of horizontal wellbores. The goal is to maximize fracture network surface area in the targeted pay intervals, and in some areas, reduce the probability of excessive fracture height growth.

Devon Energy's first 23 horizontal wells in the "Core" area were studied and half were mapped with the FracSeis microseismic mapping technique to optimize completion and stimulation techniques.

PINNACLE PERFORMS

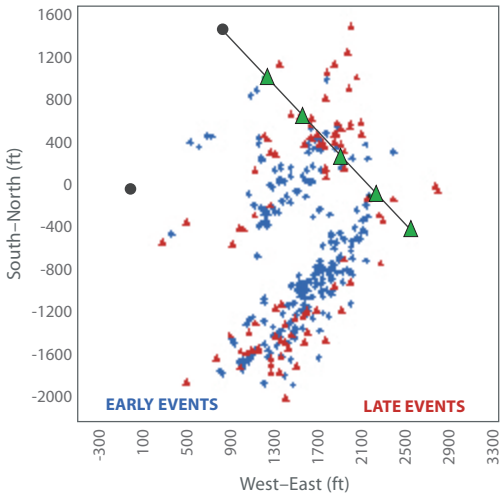
All Barnett horizontal pilots were cased for borehole stability and by number, were about equally cemented and uncemented. The laterals were 1000–4000 ft in length.

Current Barnett waterfracs or "light sand" treatments can employ a million pounds or more of proppant! With longer horizontal sections, multiple stages are required for effective coverage.

Multiple stages are designed similarly to the single stage treatments with the wellbore generally separated into equal sections. The previously stimulated sections of the reservoir are somewhat isolated from the subsequent stages by bridge plugs and a stress diversion effect. The stress diversion effect is present when the reservoir has been "supercharged" by the previous fracture treatment. These two isolation means (one mechanical and one due to increased stress) influence the subsequent stage to stimulate reservoir areas that were not treated in the previous stage.

While cemented horizontal wells allow for more control of fracture initiation locations, problems are often encountered in achieving fracture initiation. Excessive near wellbore pressure losses with accompanying low injection rates and high treating pressures are often observed in cemented wells. Procedures to alleviate the problem including re-perforating, jet cutting holes, acidizing, and pumping gel and sand slugs are not 100% successful. These steps add time and cost compared with a problem-free treatment.

A "stress shadow" effect is clearly seen in the mapping results. When a hydraulic fracture is opened, the compressive stress normal to the fracture faces is increased above the



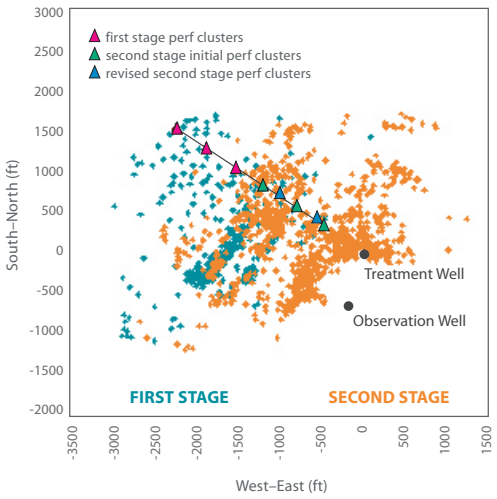


Figure 3. Fracture geometry from a single-stage uncemented completion. Early events (diamonds) were seen mostly around perforation clusters near the middle and toe of the lateral so a series of sand slugs were pumped in an effort to divert fracturing more toward the heel. About half of events (triangles) after the proppant slugs were seen near the middle of the lateral indicating at least partial diversion due to the slugs.

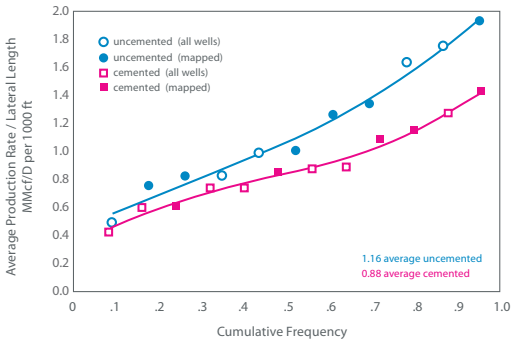


Figure 4. Cumulative Frequency distribution of average daily production rate for best six months of Pilot's 23 horizontal wells and 7 nearby vertical wells.

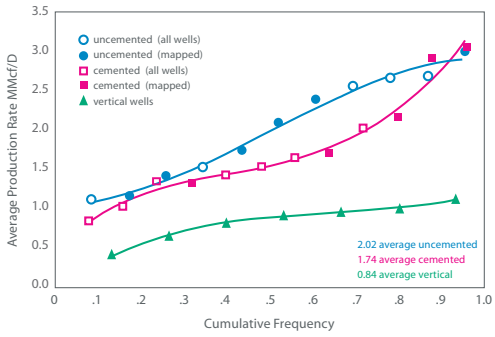


Figure 5. Cumulative Frequency distribution, average production rate normalized by length of horizontal section.

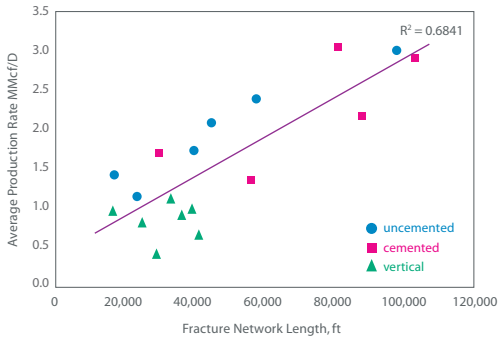


Figure 6. Cumulative length of individual fracture segments correlates to improved well productivity.

initial in-situ stress (Smin) by an amount equal to the net fracturing pressure (Pnet). The rate at which this stress perturbation declines as you move away from the fracture face is controlled by the smallest fracture dimension (height or length). The Barnett's stress shadow radiates out to an offset distance equal to about 1.5 times the fracture height.

RESULTS

As can be seen in Figure 4, horizontal wells outperform their vertical neighbors by 2 to 3 fold. A significant group of the uncemented wells outperformed the cemented wells in the Core area.

To eliminate potential bias of production results, we looked at daily production rate normalized for lateral length and also normalized for various treatment parameters. In Figure 5 you can see that the uncemented wells in the total population outperformed their cemented neighbors.

Figure 6 shows the correlation of average daily production for the best 6 months of all mapped horizontal treatments and 7 neighboring vertical well treatments versus fracture network length. The cumulative fracture network length derived for all of the above treatments is described in SPE 90051 where more detail can be found. As can be seen a good correlation exists between total fracture network size and well productivity.

CONCLUSIONS

1) Within any fracture treatment stage, 1 or 2 perforation clusters is preferred to 3 or more due to stress shadowing effects.

2) Fractures were largely contained within the Barnett intervals.

3) Real-time usage of fracture mapping led to on-the-fly changes on several frac treatments.

4) Horizontal well production was about 2-3 times higher than vertical wells for the first 180 days.

5) Cemented completions are more problematic than uncemented completions.

6) Uncemented completions appear to have a statistical production advantage over cemented completions in the pilot area.

7) Frac coverage along uncemented wells was generally as good as that on cemented wells

So for this pilot study of "Core" area of the Barnett, uncemented wellbores appear "to be, or ought to be, the answer".