Which do you want? Conventional fracs? Water fracs? Both!

THE SETTING

- **Bossier Sand**
- **Low Permeability ~0.1 mD**
- **Desire Longer Effective Fracs**
- **Need More Fracture Conductivity**

Pinnacle

Going Hybrid in the Bossier

With much of our industry focusing on waterfracs, Anadarko Petroleum Corporation (APC), an early pioneer of these fracture treatments, decided it was time to move on in the Bossier sand. With its relatively low average permeability of about 0.1 mD, the Bossier first appeared to be a reasonable candidate for waterfracs, as they provided better production response at a lower cost compared to conventional fracture treatments. A closer look at fracture treatment and production performance, assisted by Pinnacle Technologies and our FracSeis direct fracture diagnostic technique along with the development of a calibrated fracture model using the FracproPT system, showed that using a "hybrid" strategy consisting of partial waterfrac and partial conventional treatment characteristics yielded the best results.

This mapping project was performed in the East Texas Basin and targeted intervals within the Bossier sand in newly drilled wells. The Bossier interval, which lies immediately beneath the Cotton Valley Sandstones, is a thick, lithologically complex system containing black to gray-black shales interbedded with fine-grained to very fine-grained argillaceous sandstones.

In the mid-1990s, Anadarko started development of the Bossier using conventional propped fracture treatments, with details of the fracture treatment size and production results provided in the table below. In the late 1990s, APC started experimenting with waterfracs, following success Pinnacle engineers pioneered with waterfracs in the overlying Cotton Valley formation (see SPE 38611). Initial production for wells improved with waterfracs, and this was believed to be due to a dramatic reduction in gel damage and also due to the fact that fractures would be more confined to the target pay, as net fracturing pressures are typically lower during waterfracs. Proppant concentrations in these waterfracs were then gradually stepped up. As proppant loading slowly increased, so did initial production response. This indicated that conductivity and effective fracture length were very important in the Bossier, and that neither of these parameters had been optimized in the way that they had for Cotton Valley water fracs. Therefore, APC saw more room for improving propped fracture length and proppant conductivity. This was achieved by using a fracturing fluid with damage characteristics close to slickwater and the transport capabilities of a gel—thus the "hybrid" fracture treatment was born, using a slickwater pad and a low-loading gel for slurry. At the same time, conductivity was enhanced by switching to ceramic proppant.

To summarize, the objectives of the "hybrid fracture" design were to:

- Create the contained fracture height growth observed in Bossier waterfracs;
- Obtain proppant transport similar to conventional crosslink gels;
- Improve treatment success by reducing screen-outs;
- Decreasing gel damage compared to conventional crosslinked gel treatments;
- Lower gel and fluid cost compared to conventional crosslinked gel treatments;
- Increase effective fracture half-length

PARAMETER	CONVENTIONAL	WATERFRACS	HYBRID FRACS
Conducted During	Mid 1990s	Late 1990s	Since 2000
Fluid Type	40-50# HPG	Slickwater	Slickwater pad/30# Borate during prop
Proppant Type	20/40 sand	20/40 sand	40/70 RC ceramic
Avg. Fluid Vol.(bbl)	5,000	10,000	8,000
Avg. Proppant Vol.(klbs)	200,000	20,000-200,000	200,000
Geometry	Out-of-zone growth	Confined; Smaller effective length due to poor transport	Confined; Improved effective length
Conductivity	Poor due to gel damage	Improved with less damage	Improved with less damage
First Month Prod. Rate per Net Pay (MMscf/ft)	20	25-40	45
Avg. Treatment Cost	**$200-350k**	**$50-150k**	**$175-225k**

Figure 1. Fracture Treatment Parameters for conventional, waterfrac and hybrid fracs.

Figure 2 illustrates the sequential improvements seen in frac strategy.

Pinnacle Technologies' microseismic mapping services were utilized to investigate the merits of this new hybrid strategy. Figure 3 shows the difference between an uncalibrated and a calibrated FracproPT model run for the Bossier. As shown by the microseismic events, a higher shale content in the lower York is enough to prevent fracture growth through the full York interval. The uncalibrated model run does not appropriately capture the observed fracture growth behavior. The calibrated model, which relies on some level of composite layering for height growth through laminated layers, does capture the actual growth behavior quite well, while also matching the observed net pressure response during the treatment.

APC uses FracproXACT, the FracproPT Design System that incorporates formation and area dependent model settings, as a reliable and predictive tool to design future fracture treatments in the Bossier. So you see, in the never-ending quest to improve effective fracture length and fracture conductivity, sometimes you are able to have it all.

Additional information is available in SPE 84488, 84489 and SPE 89876.

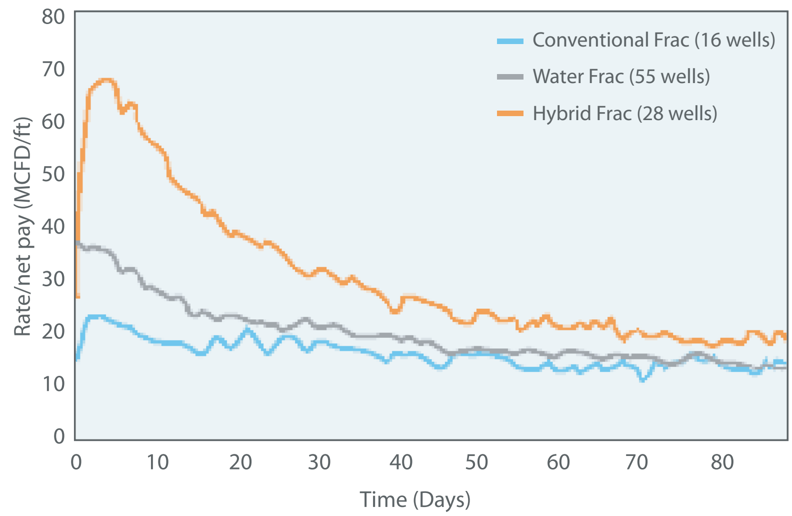

Figure 2. Initial production response averages for three different types of fracture treatments pumped in the Bossier.

FracproXACT

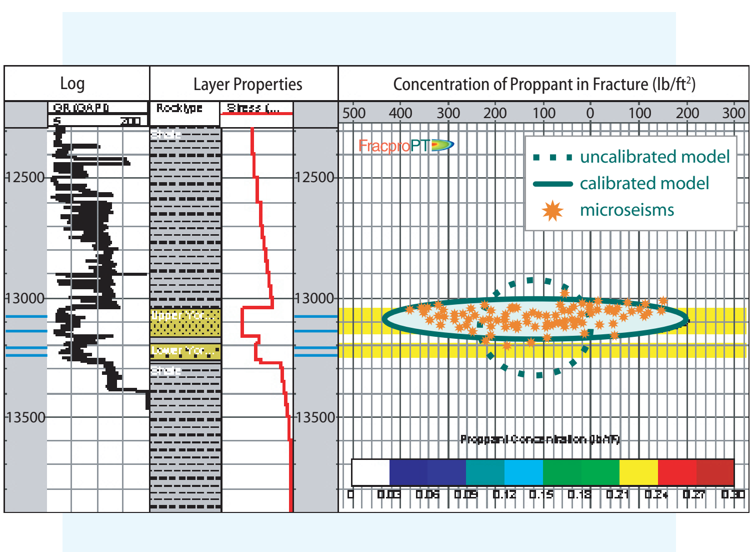

Figure 3. Fracture geometry for calibrated and uncalibrated model compared with FracSeis mapping data.

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