

# Refrac Reorientation

## Taking Fracturing in a New Direction



**THE SETTING**

- Barnett Shale
- Naturally Fractured
- Tight Gas
- 7000' - 8000'
- Ft. Worth Basin, North Texas



### THE BACKGROUND

Hydraulic fracturing is necessary for commercial production in the extremely low-permeability Barnett Shale formation of North Texas and hydraulic fracturing techniques in this area have evolved to a light sand or “waterfrac” stimulation as the treatment of choice. Because fracturing has been performed for many years, the opportunity exists to identify candidates where successful refracturing treatments could have a substantial economic impact.

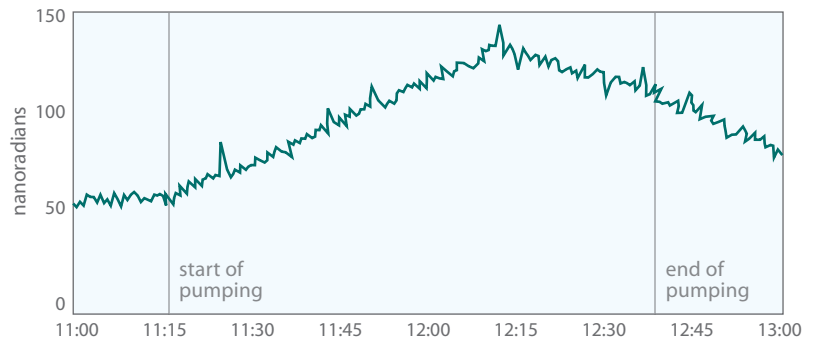
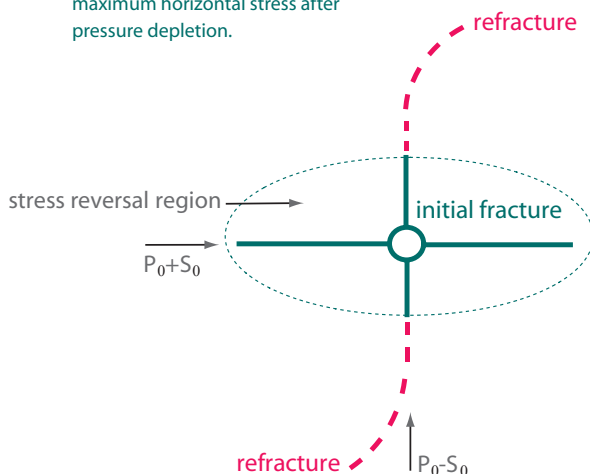
Historically, refracs have been used primarily to increase production in poorly fractured wells. A less common use of this technology is refracturing wells that have exhibited good production from properly designed and executed original treatments. In late 1999/early 2000, Pinnacle Technologies performed a pilot refrac study for Mitchell Energy Corporation, now Devon Corporation, in the Barnett Shale which helps explain why refracs work well in some areas and poorly in others.

### PINNACLE PERFORMS

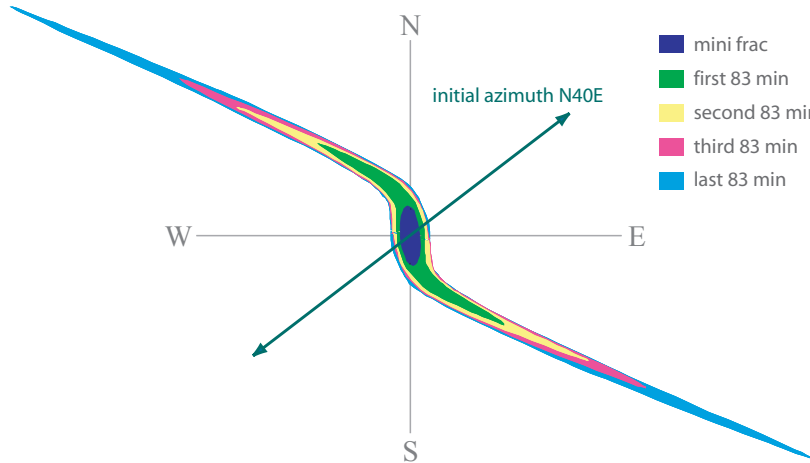
Refracture orientation had been previously observed in soft, shallow reservoirs and considerable theoretical work shows that refracs may reorient at 90 degrees from the direction of the original fracture under certain conditions. Production will cause a local redistribution of pore pressure in an expanding elliptical pattern around the initial fracture. Depletion reduces the maximum horizontal stress component (in the direction of the fracture) more quickly than the minimum (orthogonal) stress. If the induced stress changes are large enough to overcome the effect of the horizontal deviatoric stress, then the original direction of minimum horizontal stress becomes the new maximum stress within an elliptical region surrounding the fracture. Under these conditions, refracs will propagate at 90 degrees to the original frac azimuth until they reach the limit of the stress reversal region.

In these cases, a refrac could penetrate untapped sections of the reservoir, significantly increasing production rate and reserves. Additionally, the original direction of maximum stress is typically the direction of maximum permeability, which means that if a refrac reorients itself by 90 degrees, it is now situated favorably so that the maximum direction of permeability is feeding directly into the fracture along its length.

Stress reversal region shown above indicates elliptical area where original minimum horizontal stress becomes new maximum horizontal stress after pressure depletion.



Raw tiltmeter signal shows early abrupt reorientation and later gradual reorientation during fracture treatment.



Plan view of efracure azimuth changing with time.

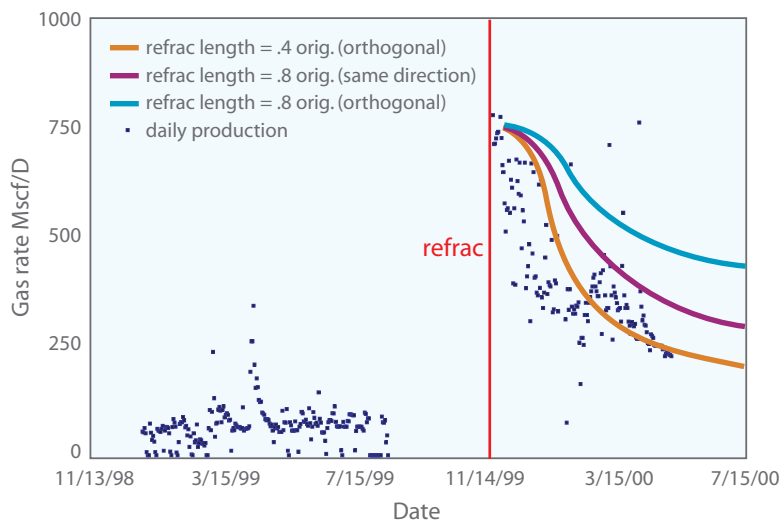
Pinnacle’s surface tiltmeters were deployed on three waterfracs to measure the azimuth of hydraulic fractures created during these refrac treatments. The tiltmeter signal is seen to change (fracture is slowly reorienting) throughout the refrac treatment. In plan view, the fracture originally propagates almost North-South (N5W) during the early portion of the treatment and then slowly rotates to a more NW-SE azimuth (N66W) by the end of the refrac. The original orientation (from other fracs in this area is NE-SW or N40E), so the refrac left the near wellbore at about 45 degrees oblique to the original, then gradually reoriented itself to just over 90 degrees (orthogonal) to the original fracture. For more details, see SPE 63030.

highest directional permeability to feed the fracture, production increased eight-fold, from 100Mscf/d to 800Mscf/d and gas production after six months was still at 300Mscf/d (three-fold increase at higher line pressure), quickly paying out the refracture stimulation costs and increasing production and reserves. As a result, Mitchell has since embarked on an aggressive refracturing program in the Barnett Shale.

Production history was matched for the refrac treatment assuming either new parallel fractures or orthogonal fractures and evaluating two different orthogonal re-fracture lengths (80% and 40% of original frac length). The best match determined that the fracture was orthogonal and that it was about 40% the length of the original fracture.

**THE RESULTS**

Because the new orientation was in a less-drained area and in a direction allowing the



Production history match for refrac treatment showing best match is for an orthogonal fracture about 40% of the length of the original.

Houston	281-876-2323
Denver	720-344-3464
Calgary	403-516-2260
Bakersfield	661-335-7711
San Francisco	415-861-1097
Dallas	972-401-0090
Delft	31-15-219-0062
Moscow	7-495-781-4820
Beijing	86-13838562150
Oklahoma City	405-604-5634
Midland	432-386-6791
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