Advance it Down the Fairway

THE SETTING

- **Barnett Shale**
- **Ft. Worth Basin, North Texas**
- **Low Permeability**
- **Naturally-Fractured**
- **Large Waterfracs**

Pinnacle

THE BACKGROUND

Mitchell Energy (now Devon Energy) is successfully developing the Barnett Shale in North Texas. The Barnett is a very low permeability naturally fractured reservoir that cannot be produced economically unless hydraulically fractured. The use of "light sand" or waterfrac treatments has considerably improved both the production performance and the economics in this reservoir. Because of its extremely low permeability, the drainage distance from a fracture face is very small. Fortunately, a fracture treatment in the Barnett is more likely to be very complex rather than simple—this allows a fracture "fairway" to be created during a treatment with many fractures at different orientations potentially contributing to production. Devon and Pinnacle have mapped numerous treatments in the Barnett and are gaining a better understanding about how these fractures grow and of the area contacted by the fracture fairways.

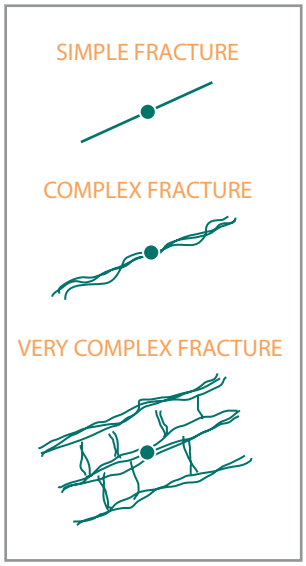
PINNACLE PERFORMS

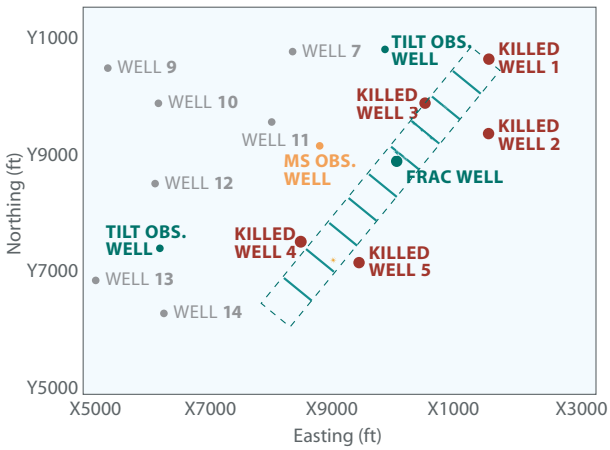
Fracture mapping with surface tiltmeters and FracSeis Microseismic Mapping on 16 frac treatments in two fields determined that the primary (hydraulic) fracture orientation is NE to SW in this area. Additionally, the natural fractures in this area are oriented orthogonal to the primary fracturing (NW to SE) and these natural fractures may be activated (opened) during a hydraulic fracture treatment. The length and width of the resulting fracture "fairway" is important in determining the extent of area contacted by the fracture so that subsequent well locations and spacings can be optimized. Because of the small drainage distance from a fracture, the density of fractures within this fairway is also important—there are opportunities for additional wells to be drilled in less densely fractured areas within a fracture fairway or for refracs to be performed that may extend the fairway or more densely populate it with new fractures.

An example data set illustrates the complexity of fracture growth in the Barnett Shale. Surface Tiltmapping was used to determine the primary and secondary fracture orientation and the volume of fracturing slurry placed in each orientation. The wide green rectangle is the primary fracture length (downhole tiltmapping) and orientation (surface tiltmapping) while the "crossties" indicate the volume of fluid placed into the secondary (natural) fracture orientation with each crosstie representing 5% of total slurry volume (45% in the NW direction on this frac). The orange points represent microseismic events. The width of this fracture fairway is very wide, about 900' across.

THE RESULTS

This fracture treatment is mostly confined within the Lower Barnett and the fracture fairway half-length is very long, of order 3000'. This fracture treatment covered the entire targeted pay and created a wide and complex fairway with fractures growing in multiple orientations. The green ovals show frac geometry measured by downhole tiltmeters at the ends of the fairway while

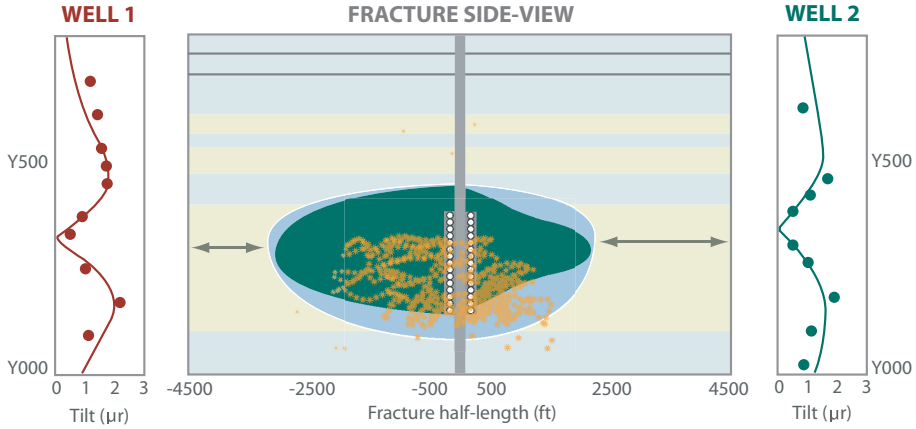




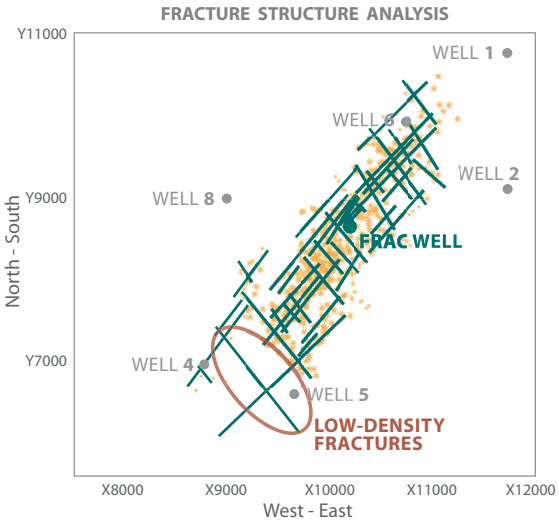
Map view showing long fracture fairway and fracture complexity (fairway width).

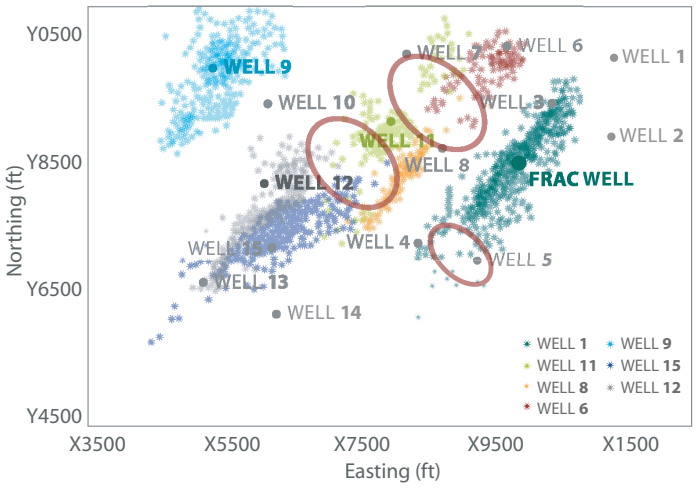
the orange data points are microseismic events measured by an array perpendicular to the center of the fracture fairway. The translucent blue area is the integrated fracture geometry from combining the highest confidence measurement for each fracture parameter – this geometry was used to create a calibrated 3-D FracproPT model for this area. For more details, see SPE 77441.

A new technique was developed to look at fracture growth with time. Small increments (in this case 40 events) of data are fit into a linear regression model to determine the length and orientation of the many fracture structures as they are being created. The map view at bottom shows the microseismic results from 7 mapped fracture treatments in the Lower Barnett. Several "holes" in the fracture fairway are visible even accounting for observation well bias. These holes (or fairway "bunkers") may be due to aseismic lithologies , or more likely, due to a lack of fracture network in these areas and thus be targets for refrac treatments or even new drilling locations in order to more completely drain this field. Combining fracture diagnostic technologies from different location perspectives is useful in ensuring that we "use all of the fairway" in the game of maximizing NPV.



Side view of fracture treatment showing tilt and microseismic data integrated to provide a composite geometry used to callibrate 3-D frac model.





Several "holes" in the fracture fairway are apparent in the above data,leading to potential new drill or refrac candidates.

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