

Seismic Stacking

GET RESULTS

- Greater accuracy
- Improved imaging
- More applications

The accuracy of microseismic fracture mapping is enhanced by Pinnacle Technologies seismic stacking process, which allows us to record more and smaller events for better microseismic images with more precise event locations. Greater accuracy improves current uses and extends mapping to new, even more challenging regions such as the US Rocky Mountains.

In Utah's Uinta Basin, our patent-pending stacking technology has successfully mapped fractures in areas where poor proximity to offset monitoring wells and small-amplitude microseismic activity had previously been limiting factors.

MAPPING VALUE

Microseismic mapping of hydraulic fractures is a major element in the development of technology plays such as the Barnett shale and tight gas sands. It helps optimize development through measurements of fracture dimensions and growth with respect to areal coverage, height growth, natural-fracture interactions, staging in horizontal and vertical wells, and many other factors. These measurements are used to evaluate well layout and spacing, the number of stages, flow rates and volumes, wellbore design, mechanical problems and many other factors.

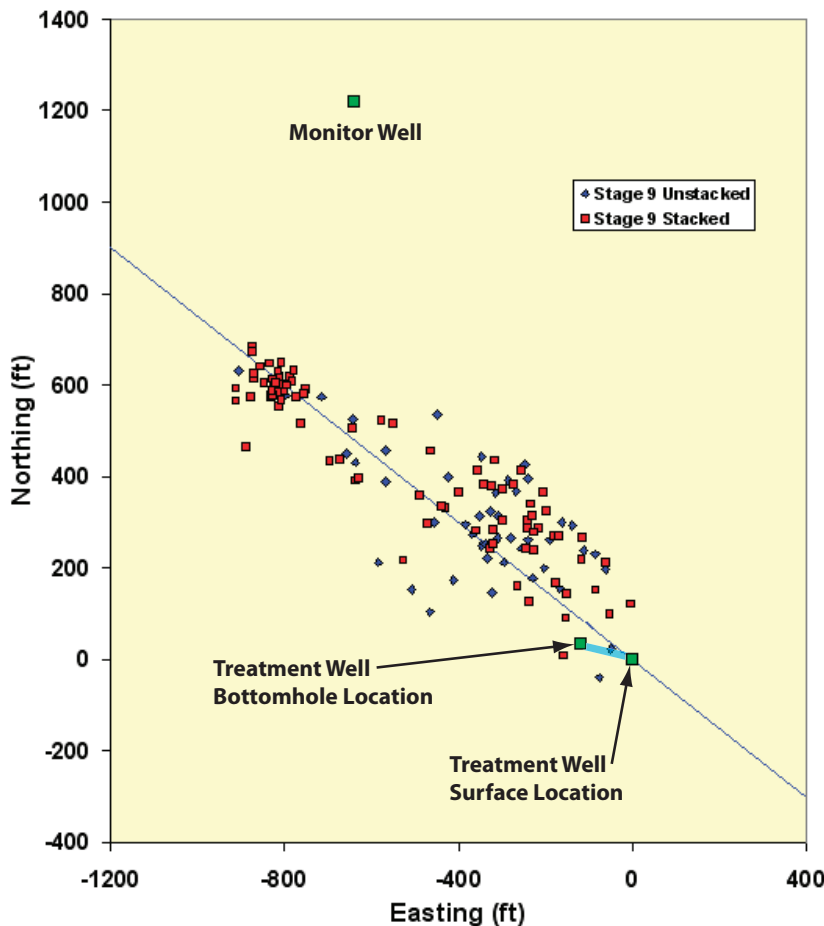
MICROSEISMIC MONITORING

Microseismic monitoring detects and analyzes micro-earthquakes created in large numbers during hydraulic fracturing. Microseisms are intrinsically small events that are difficult to see more than a few thousand feet away, but viewing distances vary considerably from formation to formation. In the Barnett shale, microseisms can often be detected at distances of 4,000 ft or more, whereas the viewing distance in the Rocky Mountains is more typically on the order of 1,500 ft.

These small, slippage events occur along planes of weakness because of many factors, including the stress induced by hydraulically opening a fracture in the earth, changes in pore pressure around the fracture due to leak-off, and the complexities of the fracture itself.

Manifested as wave motion that originates at the source of the slippage, they are detected with downhole receiver arrays.

Figure 1. Plan view comparison of stage 9 stacked (85 events) and unstacked locations (only 45 events) shows small events at fracture tip distinguished by stacking.



The arrays are typically placed in a nearby offset well at a depth relatively close to the interval being fractured. The receiver arrays provide many detection points from which the location of the microseism can be triangulated and directionally determined.

STACKING SOLUTIONS

Because microseisms are high-frequency, low-amplitude events, the receivers are very sensitive and must be sampled at very fast rates to ensure adequate interrogation of the waveform. However, noisy monitoring environments caused by the frac treatment itself, nearby drilling, artificial lift and other issues can often make detection difficult. In addition to noise, microseismic signals are affected by attenuation that reduces signal strength with distance, requiring offset monitoring wells to be relatively close.

To address these signal issues, Pinnacle uses proprietary processing technology to apply commonly-used seismic stacking processes to microseismic applications. By

digitally stacking the signals from a number of receivers in an offset well, the technology improves the signal-to-noise ratio of the produced seismograms. The resulting signal enhancement allows better identification of weak signals and more accurate information on arrival time and the location of the microseism.

The technology places tight clusters of geophones at specific depth intervals in the monitoring well. Microseismic signals are individually recorded from each sensor and digitally stacked to reduce noise.

UTAH PROOF

The effectiveness of the Pinnacle stacking technology was demonstrated in a Uintah basin test in which the monitoring distance was approximately 1,400 ft away from the well being fractured—about the maximum viewing distance throughout many Rocky Mountain basins. In the accompanying images, a side-by-side comparison created using both the stacked and un-stacked

data shows a clear the improvement in the image from the stacked data.

In this CO₂ foam stimulation, digitally stacking signals from multiple receivers improved the signal-to-noise ratio of the resulting seismograms, allowed better identification of weak signals and resulted in more accurate arrival time determination. Hodograms are also improved, resulting in more accurate directional information to help constrain the microseism location.

ECONOMIC IMPACT

Microseismic fracture mapping is a proven advantage for improving stimulations in many formations. In developing unconventional or resource plays, it has proven invaluable.

Now, with improved signal quality, better microseismic images provide more precise locations from smaller and more distant events. The result enhances fracture optimization in traditional applications, and creates new opportunities in regions where fracture mapping has been difficult or impossible.

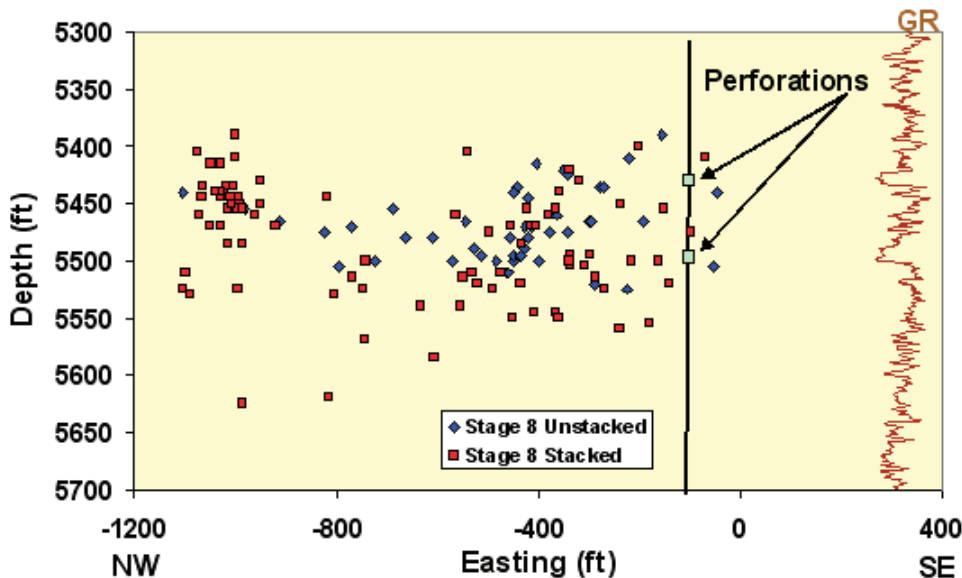


Figure 2. Side view comparison shows additional downward height growth from small events detected with stacked data.

Pinnacle

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