

FracSeisSM Microseismic Fracture Mapping



GET RESULTS

- Fracture height and length
- Fracture azimuth
- Fracture asymmetry
- Fracture growth vs. time

Pinnacle Technologies offers microseismic fracture mapping, a diagnostic technique that measures created hydraulic fracture dimensions and azimuth. This diagnostic information allows optimization of fracture treatments and well placement/field development strategies. Pinnacle is the world-leader in this technology, performing more than 90% of this type of fracmapping.

HOW IT WORKS

Microseism theory is rooted in earthquake seismology. Like earthquakes, microseisms emit elastic waves—compressional (“p-waves”) and shear (“s-waves”), but they occur at much higher frequencies and generally fall within the acoustic frequency range of 200 Hz to more than 2000 Hz. A hydraulic fracture induces an increase in the formation stress proportional to the net

fracturing pressure as well as an increase in pore pressure due to fracturing fluid leakoff.

Large tensile stresses are formed ahead of the crack tip, which create large amounts of shear stress. Both mechanisms, pore pressure increase and formation stress increase, affect the stability of planes of weakness (such as natural fractures and bedding planes) surrounding the hydraulic fracture and, therefore, causing them to undergo shear slippage. These shear slippages are analogous to small earthquakes along faults, hence the name “microseism” or “micro-earthquake.”

FIELD OPERATION

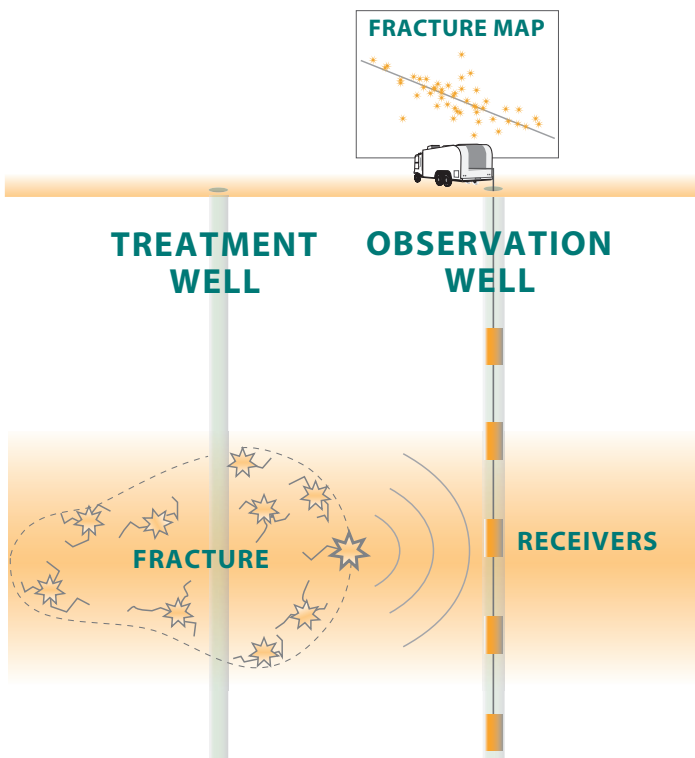
Microseisms are detected with multiple receivers (transducers) deployed on a wireline array in one or more offset wellbores. With the receivers deployed in several wells, the microseism locations can be triangulated as is done in earthquake detection. Triangulation is accomplished by determining the arrival times of the various p- and s-waves, and using the formation velocities to find the best-fit location of the microseisms.

In most cases, though, multiple offset wells are not available. With only a single nearby offset observation well, a multi-level vertical array of receivers is used to locate the microseisms. The figure at left illustrates the procedure of measuring the microseisms with a receiver array, transferring the data to the surface for subsequent processing to yield a map of the hydraulic fracture geometry. Once the microseisms are located, the actual fracture is interpreted to lay within the envelope of microseisms mapped.

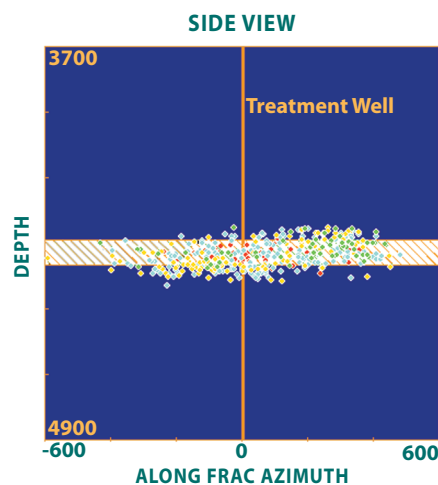
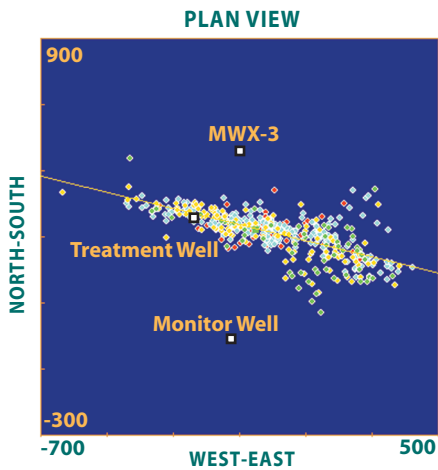
DATA ANALYSIS

Data requirements include formation velocities (obtained from a dipole sonic log or cross-well tomogram), well surface and deviation surveys, and some type of source shot in the treatment well (e.g. perforating

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FRACSEIS: MESA VERDE SAND PICEANCE BASIN



or string shot) to check receiver orientations, formation velocities and test capabilities. Receiver sonde spacing is usually chosen so that the total aperture of the array is about half the distance between the two wells. Ideally, at least one receiver should be in the treatment zone, with another located above and one below this zone, but successful mapping has been performed with no receivers in the fractured interval. For reasonable results, maximum observation distances for microseisms should be within about 2500 ft of the treatment well. This distance is dependant upon formation properties and background noise level. The observation well must be quiet—either a new, unperforated well or an older well with production isolated.

EXAMPLE

This example is divided into four elapsed time slices—early time (red), middle part of job (blue, yellow) and shut-in (green) to show how the fracture growth progresses during the treatment. Early, during the red stage, the fracture grew asymmetrically, with much more growth to the east than to the west, but was vertically contained within

the injection interval. During the middle (blue and yellow) stages, it grew in both directions, but still exhibits significant asymmetry. You can also see some horizontal fracture growth on the east side of the frac in the blue and green stages. Frac length was almost 500' long on the east wing, and about 400' on the west wing.

ECONOMIC IMPACT

Knowing your fracture geometry can improve production economics by increasing reservoir productivity and/or reducing completion costs. This includes optimizing individual fracture treatments, optimizing fracture length, verifying effective payzone coverage, or optimizing the entire field development in terms of well spacing and well layout. Please contact us to learn how Pinnacle's award-winning technologies can help you.

FracSeis is a registered service mark of GTI.

The real-time display pictured above in the top pane shows a map view of the treatment well from which fracture azimuth can be seen. The middle pane is from a different perspective – now looking perpendicularly into the frac plane. The pane at the bottom displays fracture treating pressure coincident with the microseismic event flags.

Pinnacle

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