



Microseismic Hydraulic Fracture Mapping Service

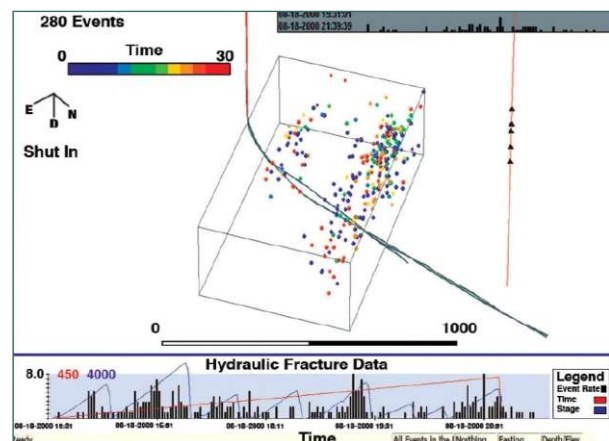
Weatherford's microseismic hydraulic fracture mapping service brings together world-class seismologists, field operators, and state-of-the-art seismic tools to record, process, and interpret microseismicity from single- or multi-staged hydraulic fracture stimulations in both convention and unconventional completions. This service provides three-dimensional rendering and animation of fracture network initiation, growth, and in-filling.

Weatherford offers at-the-wellsite and off-the-wellsite fracture mapping. When performed at the wellsite, the microseismicity is processed and mapped during the stimulation. These results are streamed to the frac engineer who evaluates fracture development in real time—its isolation or breakouts, as well as the success of the treatment.

Off-the-wellsite services include post-treatment processing in which the data are also analyzed, interpreted, evaluated, and mapped. Mapping includes a time-lapse animation

of microseismicity. These data create a picture of the stimulation which helps determine efficient well-spacing rules, revealing anomalous drainage patterns and subsurface well interference, and mapping of inefficient completion designs. Microseismic mapping and evaluation of hydraulic stimulations are proven technologies.

At the treatment site, Weatherford has the capability to deploy its multi-level seismic arrays in two ways: in a neighboring well (or wells) and in the treatment well. For neighboring well deployments, Weatherford offers its Sercel SlimWave array or arrays, and its Avalon Geochain array. In the treatment well, Weatherford offers the TABS system, technology licensed from ExxonMobil Upstream Research Company (URC). Weatherford's processing, evaluating, mapping, and animation algorithms are unrivaled in fracture mapping services. We offer the slimmest options, highest data sampling arrays (one-quarter and one-fifth millisecond sampling) and highest temperature ratings.



Horizontal well stimulation in oblique view.

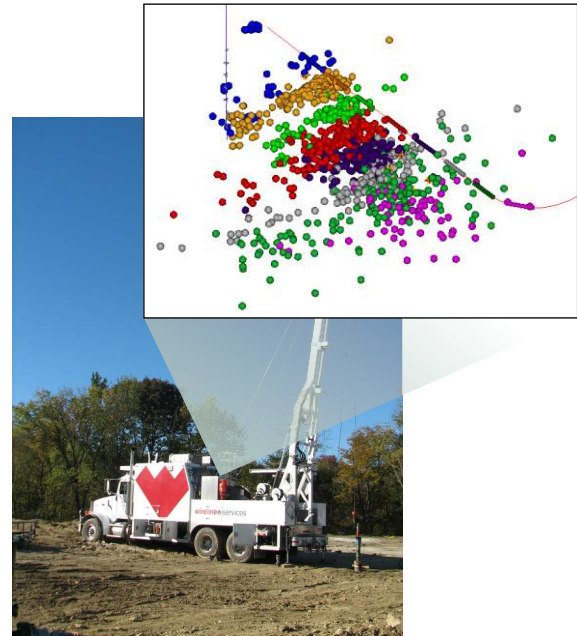
Weatherford's hydraulic fracture mapping service maps the drainage area about the wellbore and the lack of effective stimulation in the farthest half of the lateral. Individual event locations, colored by pump time, indicate that, over time, fracture complexity increases while fracture extent does not change.



Hydraulic Fracture Mapping Service

Applications

- Monitoring stimulated geometry to avoid fracture growth into water-bearing zones
- Mapping reservoir fluid mechanics and drainage, improve reservoir management, decrease bypassed pay, and reduce the number of unnecessary wells
- Mapping anomalous drainage patterns due to natural fractures and faulting.
- Evaluating stimulation program effectiveness
- Improving stimulation placement and efficiency
- Identifying proppant bridging
- Defining efficient well placement for infill development



Features, Advantages and Benefits

- Weatherford arrays can deploy on all varieties of conventional wirelines, saving time and money since specialty wirelines are not needed, and conventional wirelines are more available.
- Weatherford's microseismic hydraulic fracture mapping service has been used in tight-gas completions, fault mapping, reservoir imaging, waterflood conformance, and drilling-waste disposal and injection, offering the assurance that only a proven, mature technology can give.
- Weatherford can combine its mapping and hydraulic fracturing capabilities, providing one-stop, full-service hydraulic fracture stimulation and monitoring services.
- Weatherford's masted wireline truck removes the need for an external hoist truck, cherry picker, or crane, eliminating the need to contract a third-party apparatus.
- Weatherford can deploy multiple, time-synchronized arrays, translating improved data analysis into improved results, as well as serving as the basis for new data product enhancements, such as Seismic Moment Tensor (SMT) inversion.



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Specifications

SlimWave Array

- 8-12 geophone levels at 100-ft (flexible-cable) spacing
- Sustained operation at 135°C (275°F)
- 1 11/16-in. diameter
- 14.5 kpsi rated
- 30-Hz geophones
- 0.25 ms sampling (0 to 1660 Hz bandwidth)
- Fits through tubulars



Geochain Array

- 8 geophone levels at 100-ft (flexible-cable) spacing
- Sustained operation at 180°C (355°F)
- 3 5/8-in. diameter
- 20 kpsi rated
- 15-Hz geophones
- 0.375-0.25 ms samplings (0 to 1066 Hz to 0 to 1660 Hz bandwidths)
- Deployable in horizontal sections
- Deployable by tractor

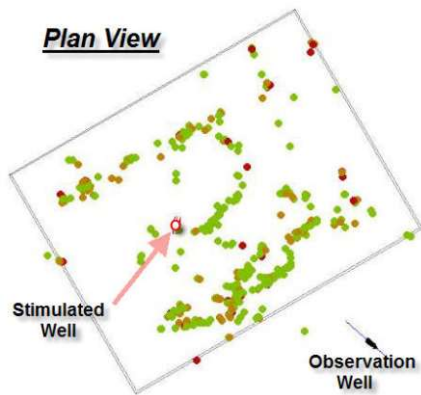
TABS System

- 3 geophone levels, 32-ft spacing, 72-ft rigid tool body
- Sustained operation at 165°C (330°F)
- Tool body contains surface-telemetered gyroscope, collar-locator, DH temperature, and pressure gauges
- 2.6-in. diameter
- 20 kpsi rated
- 30-Hz geophones
- 0.20 ms sampling (0 to 1660 Hz bandwidth)
- Deployable on coiled tubing

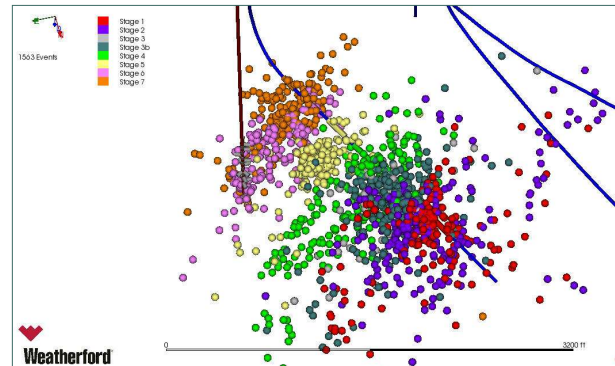




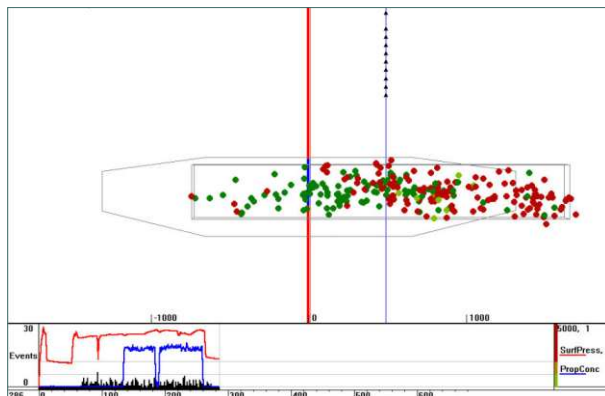
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Vertical well stimulation in plan view.
Complex fracture system shown by microseismicity indicates a widening fracture pattern over time.



Horizontal well stimulation in plan view.
Horizontal well, multi-stage stimulation in shale indicates interaction and overlap between stimulation stages.



Vertical well in vertical plane.
Monitored from an offset well array (triangles), microseismic data show asymmetric wing growth. Box enhances rendering asymmetry of stimulation. Rectangle with corners clipped is model developed from injection parameters. Model shows stimulation as symmetric and having grown up and down, out of formation; microseismic data show contained stimulation, staying in zone.