Fiber Optic Solutions

Distributed Acoustic and Distributed Temperature Sensing (DAS & DTS)

BROCHURE

OVERVIEW

Fiber optics sensing technology has revolutionized the way we monitor hydraulic fracturing of unconventional reservoirs and enhanced geothermal systems. ESG's Fusion Array™ service acquires fiber and geophone data in the same well, which allows operators to maximize subsurface diagnostic data in the same well footprint. Optical fiber is used to acquire distributed acoustic sensing (DAS) and distributed temperature sensing (DTS). DAS data is primarily used for cross-well strain and microseismic monitoring during hydraulic fracturing, while DTS data is used for temperature monitoring.

This technology requires an optical fiber installed permanently behind the casing, or temporarily in the offset well and an interrogator on the surface. Fiber optic data can be acquired on dedicated or in wireline conveyed fibers. The entire length of fiber acts as a continuous one component sensor.

DAS CROSS-WELL STRAIN IMPACT

Cross-well strain data (component of low frequency DAS data) can be used to watch and mitigate frac-hits in **real time**. Impacts to business include evaluation of

- Well spacing
- Limited entry
- Stress shadowing, and
- Diverted effectiveness from far field data.

Crosswell-strain and microseismic results can be integrated into seismic volumes.

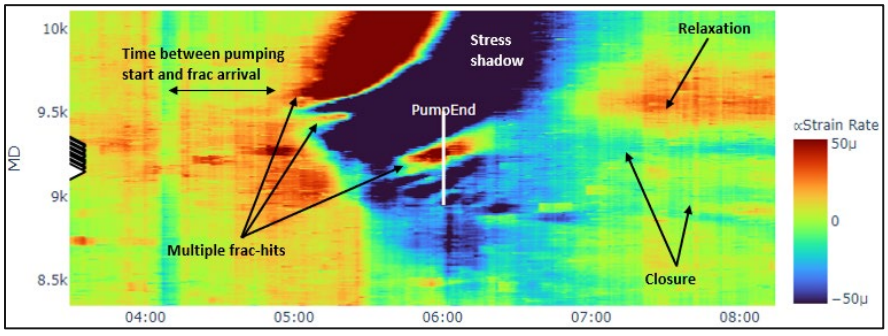

Figure 1. Cross-well strain data for a single stage showing stress shadow and relaxation zones with multiple frac-hits.

KEY ELEMENTS

- Optical fiber is used to measure DAS and/or DTS data. DAS data can be used for cross well strain or microseismic validation
- ESG Fiber Optic Services includes temporary fiber deployments, interrogation of existing fibers for DAS or DTS data, processing of cross-well strain, DAS microseismic, In-well strain and production/flowback monitoring
- DAS and DTS data can be integrated with geophone microseismic data to fully gain a comprehensive view of subsurface activities
- Cross-well strain provides a direct, physical measurement of rock deformation over time
- ESG's FusionArray™ service acquires both DAS and geophone microseismic data in the same well footprint
- ESG's DAS microseismic uses the same geophone processing techniques developed over the last 3 decades
- Waterfall plots in real time
- Integration with geophone, surface EM and other available data sets

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MONITOR COMPLETIONS WITH IN-WELL FIBER

Fiber in the treatment well can be used to understand cluster efficiency. Using DAS FBE (Frequency Band Extracted) data, we can compute several attributes, such as acoustic energy, to monitor.

- Which clusters are active, and which are not?
- Plug failures to get cross-stage communication
- Flow distribution to each perforation cluster and rate with time during pumping
- Production and flowback from individual stages/clusters

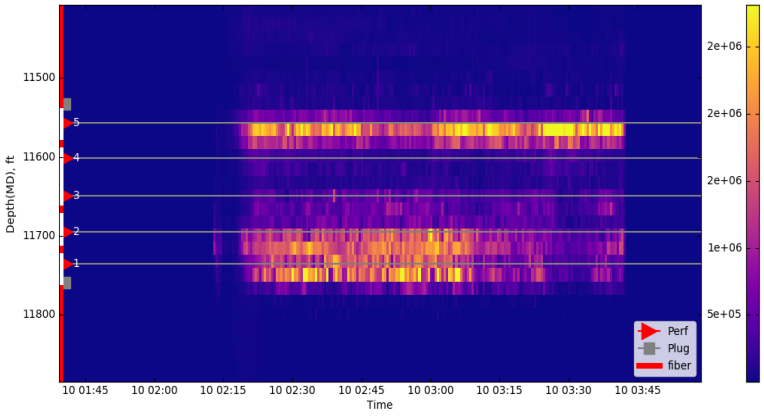

Figure 2. Acoustic energy computed from DAS data acquired with a fiber installed behind casing of a treatment well. White vertical bars represent the portion of fiber (red line) used to measure the average cumulative energy for each perf cluster (red triangle). I.e. Completion efficiency

DAS MICROSEISMIC

DAS microseismic monitoring enables acquiring strain or strain rate field sampled with high spatial resolution. DAS microseismic detects stress induced fractures. Measured induced fracture volume can be used to quanitfy a productive reservoir volume, evaluate communication between stacked reservoirs, determine proper well spacing, and improve reservoir -to production models.

DISTRIBUTED TEMPERATURE SENSING (DTS)

Distributed temperature sensing (DTS) data is recorded with a separate interrogator and fiber (usually multimode fiber) deployed in either treatment or offset wells with any deployment method.

DTS data recorded with a fiber in the treatment well can be used to determine

- Isolation effectiveness between perforation clusters
- Relative amount of fluid each perforation cluster takes
- Fracture initiation points
- Effectiveness of fluid diversion

DTS data recorded with a fiber in the offset well can be used to monitor

- Temperature changes when a fracture hits the monitor well
- Closure of pre-existing temperature corridor
- To confirm fracture arrival to the fiber well and integrate with DAS and other data sets

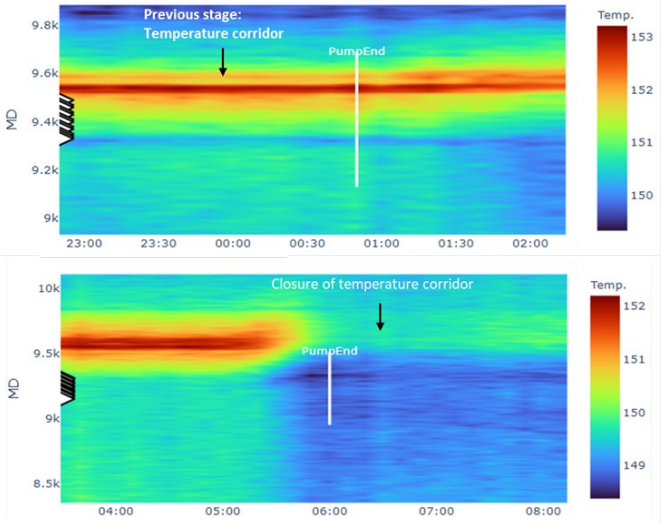

Figure 3. Distributed temperature sensing (DTS) acquired with an offset fiber used to monitor frac-hits and temperature changes due to fluid driven interactions.

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