

Event-IQ

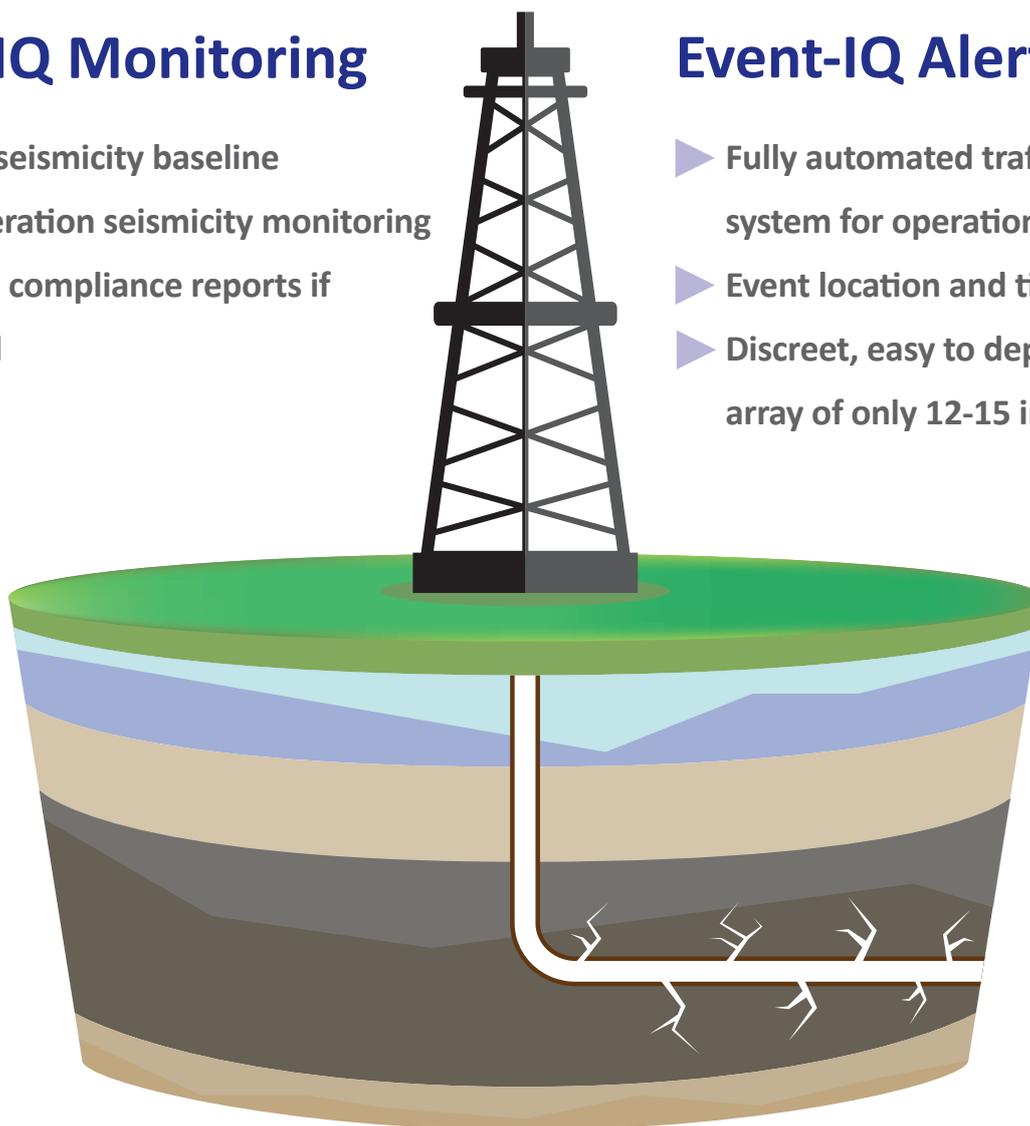
Hydraulic fracturing - seismicity monitoring for the life of the well

Event-IQ Monitoring

- ▶ Natural seismicity baseline
- ▶ Post operation seismicity monitoring
- ▶ Detailed compliance reports if required

Event-IQ Alert

- ▶ Fully automated traffic light system for operational wells
- ▶ Event location and time
- ▶ Discreet, easy to deploy surface array of only 12-15 instruments



For well locations where hydraulic fracturing compliance monitoring is a requirement, Event-IQ is a fully integrated solution that incorporates baseline, operational and post operation seismic monitoring.

Choose your preferred level of service from instruments only to a fully managed seismic monitoring solution over the life of the well, including detailed reporting.

PASSIVE MODE:

Event-IQ Monitoring for baseline and post-operation

Full service Solution

Prior to well operation we establish baseline seismicity characteristics using a surface array of Güralp broadband instruments in the area of the well. The same instruments are left in-situ to record present and post-operation seismicity.

Based on your requirements and the well location, we define the area for survey and the array design in order to meet the required seismicity detection capability. We plan the installation, supply the seismic instrumentation and manage the deployment of the sensors, data collection and processing.

On completion of the pre- and post-operation monitoring we provide you with detailed reports to meet the local legislative requirements.



Güralp broadband instrumentation is buried near the surface with only the GPS module visible (inset)

REAL-TIME MODE:

Event-IQ Alert for operational wells

Detecting Low Magnitude Events

Local noise can prevent small microseismic events of less than 0.0 magnitude from being detected. Techniques to overcome this have either required shallow borehole arrays or very large (2000 or more) geophone arrays.

A Small Surface Array

The Güralp Event-IQ Alert system uses advanced processing techniques to improve signal-to-noise ratios for low magnitude events using a small array of 12 to 15 surface seismometers. This eliminates shallow borehole drilling costs and minimises disruption in the locality of the well.

Novel data processing approaches using beamforming-and-stacking enables Güralp to detect events that are below the noise thresholds on individual sensors.

Beamforming and Migration to Detect Small-Magnitude Events

Waveforms from individual stations are time-shifted according to expected arrival times, and stacked together, reducing noise levels, while boosting coherent signals, allowing an event to be detected.

By beamforming and stacking these waveforms, this energy is migrated back to its origin time and position, revealing a clear and well-constrained source such as a seismic event induced by the hydraulic stimulation.

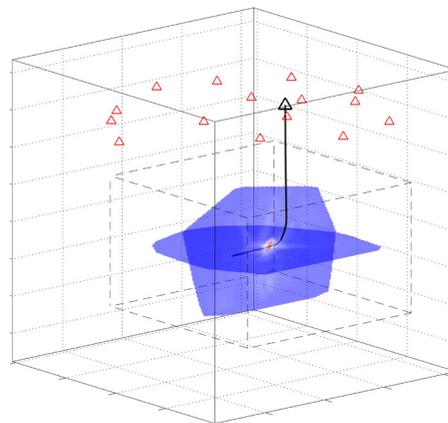


Diagram 1
An example of the Güralp beamforming-and-stacking event detection algorithm. The stack shows a clear and well defined peak marking an event location.

More commonly applied to large arrays used for microseismic monitoring, Güralp's Event-IQ processing technology is modified to produce optimal results using smaller arrays of surface broadband seismometers ensuring that traffic light scheme obligations are met.

Automated Monitoring

Beamforming-and-stacking methods allow for fully automated processing workflows, so ambiguity from manual picking and location of events is reduced.

The array will operate in real-time, providing the operator with immediate warnings if events above or close to traffic light scheme thresholds are detected during hydraulic stimulation. Full reporting to meet the local legislative standards will also be provided.

THE IMPORTANCE OF BROADBAND

Güralp instruments are true broadband seismometers. True broadband capability is vital to the effective implementation of a traffic light scheme where earthquake magnitudes must be accurately quantified.

Earthquake magnitudes are measured from displacement spectra, as shown in the figure to the right. Only broadband instruments are capable of capturing the full range of displacement spectra, producing a robust estimate of earthquake magnitude.

Industry-standard geophones are limited to high frequencies, resulting in systematic underestimation of magnitudes. Viegas et al. (2012)* show that using data from geophones rather than broadband sensors can lead to measurement errors of as much as 0.6 magnitude units.

Güralp seismic sensors are tried and trusted the world over to deliver high quality broadband seismic data - we have sold over 10,000 instruments to date.

*Viegas G., Baig A., Coulter W., and Urbancic T., 2012: Effective monitoring of reservoir-induced seismicity utilizing integrated surface and downhole seismic networks: First Break 30, 77-81

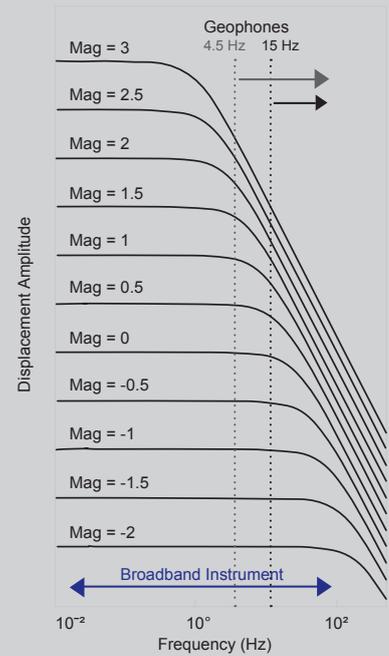


Diagram 2
Comparison showing Güralp broadband instrument and geophone responses

▶▶▶▶ QUICK VIEW:

Event-IQ Monitoring

Baseline and post operation

- ▶ Discreet, easy to deploy surface instruments
- ▶ Full service delivery including planning, design, deployment and monitoring
- ▶ Preparation of locally compliant reports at each stage

Event-IQ Alert

Traffic light system for operational wells

- ▶ Requires a small, environmentally sensitive array of only 12 to 15 surface instruments
- ▶ No drilling required
- ▶ Discreet, easy to deploy surface instruments.
- ▶ Full service delivery including planning, design, deployment and automatic alert programming to meet your requirements
- ▶ Full reporting to meet the local legislative standards will also be provided



MAGNITUDE 0.0
INJECTION PROCEEDS AS
PLANNED



MAGNITUDE 0.0 - 0.5
INJECTION PROCEEDS
WITH CAUTION



MAGNITUDE 0.5
INJECTION IS
SUSPENDED
IMMEDIATELY

Diagram 3
Example traffic light monitoring system alert triggers. Trigger levels are pre-selected by the operator according to local requirements