



# Applied Seismology

## APPLYING SEISMOLOGY TO THE ENGINEERED ENVIRONMENT

Applied Seismology Consulting provides cutting-edge research, consultancy and tailor-made technological solutions for local and regional geosphere characterisation, remote monitoring of critical rock excavations and engineered structures

## CUSTOM SOLUTIONS

Supplying an integrated work package along the full data path through sensor array design, data acquisition, processing and interpretation. Our toolbox of processing, visualisation and network functions are under continual development. Customised developments can be commissioned.

## QUALITY ASSURANCE

Our seismic software has been available as a commercial product for over 20 years. Documented algorithms. Benchmarked and tested against synthetic seismicity.

For more information on any of our products or services, please visit our website at:

[appliedseismology.co.uk](http://appliedseismology.co.uk)

Applied Seismology Consulting (ASC) has over 20 years of experience in applying the methods and analyses of seismology to a wide range of engineering applications at all scales from regional earthquake site characterization to microseismic and acoustic emission studies. Services are targeted at supplying an integrated work package along the full data path through sensor array design, data acquisition, processing and interpretation. These services include reviewing natural and induced seismicity, ground motion prediction and monitoring, working within regulatory systems and designing, operating and reporting on microseismic monitoring. Itasca is a world leader in geomechanics, hydrogeological, seismic and microseismics applications combining seismic excellence with state-of-the-art geomechanical simulations to offer a new standard in understanding the impact of engineering operations.

We offer custom solutions to maximise the output from seismic monitoring:

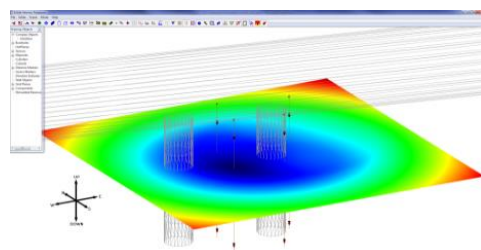
- Assessment of local and regional baseline seismicity conditions in the preparation for engineering projects
- Evaluation of information on existing natural and induced seismicity in target areas including historical information and monitoring carried out in the local area pre-development
- Analysis of induced seismicity and interpretation of induced and mobilized fracture networks after engineering operations.
- Integration of seismic observations with geomechanical models for the simulation of potential risk scenarios associated with engineering operations



## Seismology Applied to the Engineered Environment

Applied Seismology Consulting can assist in all stages of seismic and microseismic analysis:

- Seismic Network Array design
- Installation, commissioning and maintenance of monitoring equipment
- Data processing, analysis and interpretation
- Project Management
- Seismic and Geomechanical modelling
- QC of seismic data sets



## Environmental



### EXAMPLE AREAS OF APPLICATION

- Risk assessment in planning stages of large civil infrastructure.
- Monitoring of structure health and integrity
- Hydraulic fracturing operations: Geothermal, Oil and Gas
- Stability and risks on geological storage infrastructure
- Imaging of impact of mining operations on structures and surface
- Validation and input into predictive geomechanical models

Understanding the local seismic behaviour enables the seismic hazard in a region to be determined at the different stages of development and planning. Seismic monitoring and analysis can quantify the impact on background vibration of new or planned infrastructure developments such as for example transport networks and wind farms. Continuous monitoring and analysis of patterns in seismicity can be used in early warning and prediction of geohazards such as landslides or subsidence.

- Local and regional seismic hazard assessment
- Seismic and environmental vibration analysis
- Induced seismicity evaluation
- Monitoring and analysis of geohazards
- Monitoring and analysis of baseline seismicity
- Monitoring of impact of engineering operations

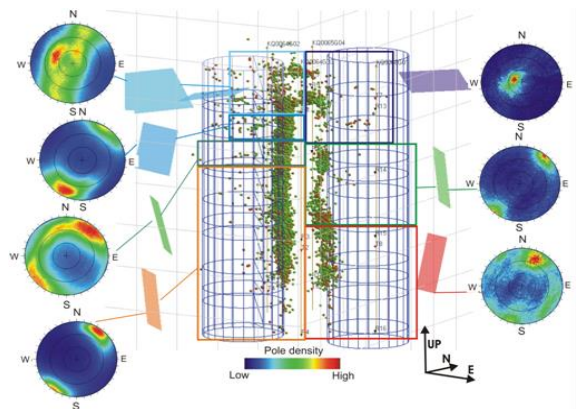
## Engineering



Passive and active seismic monitoring are non-intrusive, non-destructive techniques to characterise the health state and integrity of rock and engineered structures, providing a means of imaging and quantifying crack development, damage and disturbance accumulation. Seismic observations can be used to update predictive structural models.

- Seismic risk assessment
- Structure integrity monitoring and modelling
- Safety and containment monitoring of underground geological storage
- Characterisation of Excavated Damage Zones and crack density evolution.
- Seismic alarm systems
- Acoustic Emission and microseismic monitoring to detect fractures around engineered structures and delineate potential fluid pathways.
- Evaluation of induced seismicity
- Blast vibration monitoring

- Validation and development of numerical models for predictive modelling of structural health and response.



## Energy



Seismic and microseismic monitoring are unique technologies to image and quantify the impact and effectiveness of reservoir stimulation. Seismic parameters allow the characterisation and imaging of induced and mobilised fracture networks. Seismic analysis combined with geomechanical models provide a better understanding of the fracturing processes in the reservoir and the environment allowing the adoption of control and optimisation measures

- Imaging and modelling of reservoir stimulation
- Real-time microseismic monitoring
- Implementation of seismic traffic light system
- Analysis of in-situ and induced fracture
- Evaluation of induced seismicity
- Infrastructure integrity monitoring
- Monitoring and analysis of vibration

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## InSite™ SEISMIC PROCESSOR

InSite™ is ASC's integrated data acquisition, management, processing, visualisation and interpretation software developed over the past two decades for seismological studies.

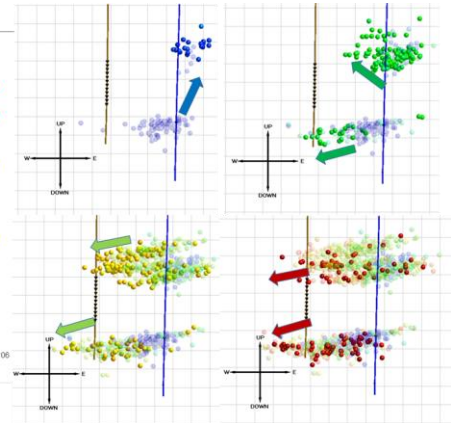
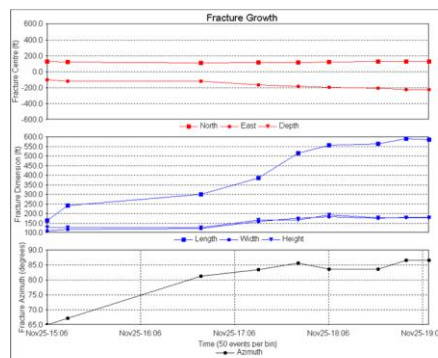
Provides a solution for all seismology applications, ranging in scale from acoustic emissions in the laboratory, through microseismics around mining and petroleum fields, up to regional-scale earthquakes.

Manage your data with comprehensive import and export of raw and processed event data. Locate events through simple and complex velocity models.

Carry out manual and automated waveform processing. Visualize seismic events, field objects, geological structures and analysis objects.

Applied Seismology Consulting can assist in all stages of seismic and microseismic analysis:

- Perform ground motion review including PGV, PPV, and PGA.
- Follow the protocols developed by relevant national regulators.
- Compare different seismic scales including intensity scales.
- Provide mitigation advice by combining historical natural and induced seismicity catalogue, the response of local traffic light system, and engineering data.
- Review available information on observed seismicity.
- Integrate the seismic activity with geology, structure (including faults) and in-situ stresses in the target area to avoid potential interference with existing critically stressed faults.
- Monitor the nature, geometry, growth pattern and extent of the mobilized or induced fracture network growth during engineering operations.
- Implement the Traffic Light System in compliance with local regulations. Advise on operations in the case of Amber or Red seismic events between hydraulic fracturing stages in accordance with the Traffic Light System.
- Construct predictive models of damage and fracture evolution based on local geomechanical properties and different engineering scenarios
- Characterise the effects on a variety of civil structures from induced seismic events. This includes:
  - a) Physical damage or integrity degradation to rocks or reservoirs;
  - b) Physical damage to civil infrastructure, such as buildings, dams, slopes, underground laboratories.
  - c) Human activity interference.



Applied Seismology Consulting can assist in all stages of seismic and microseismic analysis:

- Array design: Cost/Benefit analysis of different acquisition geometry.
- Pre-processing: Ensure data quality by performing spectral analysis and array validation.
- Locating events: High quality picks and locations of seismic and microseismic events.
- Post processing: Quality control and data validation.
- Advanced Analysis: moment tensors, discrete fracture networks, clustering and custom visualisation techniques.
- Interpretation: Adding value to the microseismic data to solve your problem including risk analysis of economic benefits and/or safety monitoring.

For more information on any of our products or services, please visit our website at:

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## Seismic Monitoring

Applied Seismology Consulting works in partnership with leading vendors of surface and downhole seismic monitoring equipment to provide a full solution tailored to the monitoring objectives:

### PROFESSIONAL DEVELOPMENT

Provide non-specialist staff with an overview and general understanding of the application of seismic monitoring and analysis to their area of expertise.

### ADD VALUE

Maximise the return on your monitoring investment.

### APPLY

Use advanced commercial software through hands-on training using real-world examples and case studies from a range of microseismic monitoring applications.

### WORKFLOWS

Manage your workflows more effectively and reach higher levels of productivity.

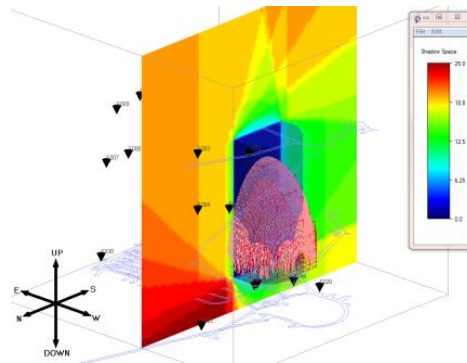
### EXPERT-LED

Courses taught by ASC geophysicists with many years' experience processing and interpreting seismic data at all scales.

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- Design and optimise the acquisition geometry of surface and buried arrays. Evaluate the effects of existing configurations on the monitoring and interpretation of seismic datasets
- Analysis of existing monitoring arrays and design of new or complementary arrays to meet the project target sensitivity and resolution.
- Provide real-time natural and induced seismic monitoring service and real-time or post-operation assessment on operational effects.
- Provision of active seismic surveys for the analysis of induced damage and fracturing at different scales



## Training

Applied Seismology Consulting offers a wide range of training courses and custom courses delivered in-house at our UK office or at your company's office or remotely online. Our training courses include

- Introduction to seismology and seismic monitoring
- Induced seismicity
- Seismic, microseismic and Acoustic Emission (AE) data acquisition and analysis
- Advanced seismic/microseismic techniques and interpretation
- Basic, intermediate and advanced InSite software user training
- Customised and bespoke training to meet your requirements and needs.

Please contact us to discuss the above training courses or for any bespoke training