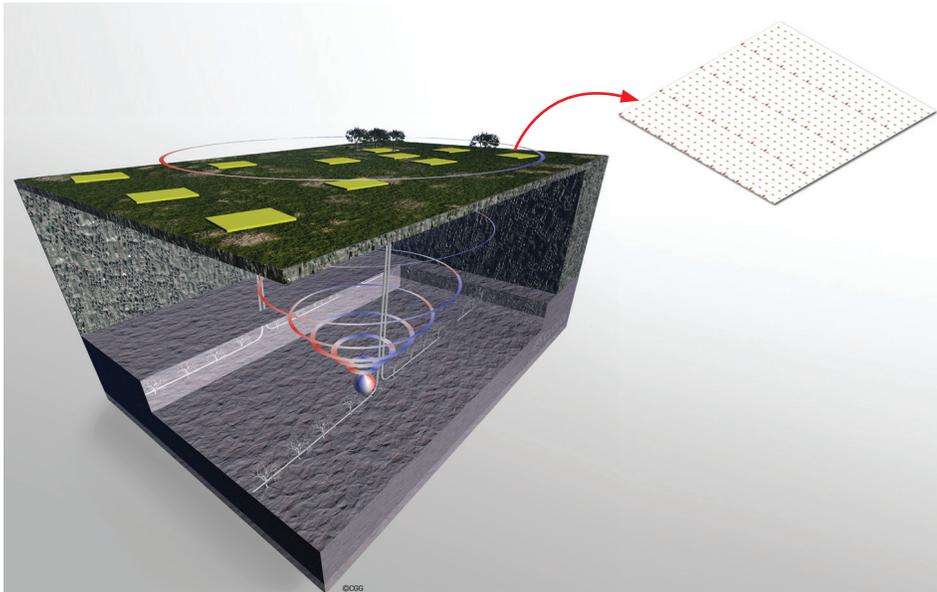


# Surface Array Microseismic Monitoring

Optimizing reservoir stimulation and production



*Proprietary patch design captures valuable real-time data and accurately maps the complex geometric behaviors.*

Microseismic monitoring provides vital information about how the fracture treatment is stimulating the reservoir. This insight allows you to evaluate and control fracture dimensions during the stimulation process, as well as refine and optimize future treatments on nearby wells.

CGG has been at the forefront of advanced seismic processing, and now through Magnitude, the joint venture with Baker Hughes, we've integrated this expertise with hydraulic fracture monitoring.

Magnitude's surface array microseismic monitoring is an effective, industry-accepted application for understanding hydraulic stimulation effects on a reservoir. The wide surface coverage of surface array designs

provides the aperture required for accurate event location and geomechanical analyses (moment tensors, stress ratio analysis), eliminating the constraints, costs, and risks associated with the use of observation or production wells for borehole monitoring purposes.

Utilizing field-proven patch array design for avoiding and attenuating noise, surface monitoring captures valuable real-time data and accurately maps the complex geometric behavior of unconventional plays during the hydraulic stimulation process. Having this knowledge at hand allows completions engineers to confidently analyze the effectiveness of stimulation parameters such as pumping pressures, fluid type, and proppant type as the fracturing unfolds; thus,

## Applications:

- Onshore operations
- Unconventional/conventional reservoirs

## Benefits:

- Assess recovery potential
  - Flexible and reliable array design through the advantages of UNITE cableless recording technology
  - More reliable locations with superior signal-to-noise ratio
- Update the field development plan
  - Reliable detections of small magnitude events from highly sensitive monitoring networks
  - Moment tensor solutions for every microseismic event through Magnitude's industry-proven full waveform inversion processing
- Interpret results to forecast production
  - Results free of false events (noise identified as an event) through event characterization and strict QC of each detection

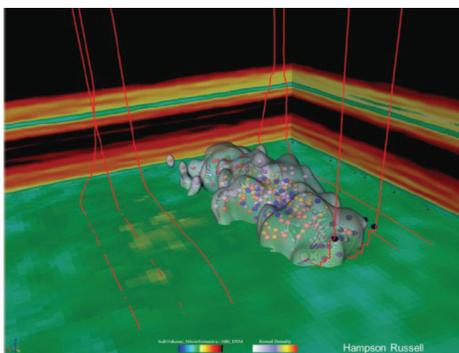
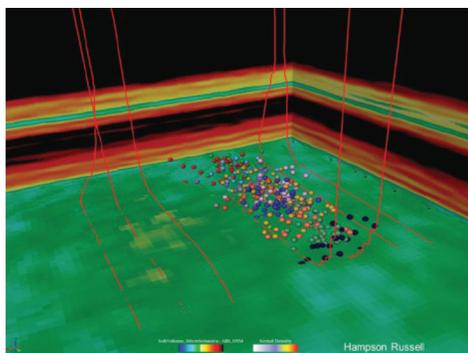
allowing critical changes to be made to optimize the hydraulic stimulation in real time.

Our final post processing and geomechanical deliverables close the loop with our clients, supporting long-term optimization of field development by improving metrics such as wellbore azimuths, and stage and well spacing to maximize reservoir drainage.

The key to all successful microseismic monitoring is safeguarding the signal and attenuating the noise. Magnitude has designed an array network that effectively accomplishes both. Our proprietary design is a series of densely populated arrays which are easily deployed and highly adaptable to the environment, allowing optimization in permitting, line clearing, and the avoidance of noise-prone areas. The short distance between geophone strings allows advanced summation in both in-line and cross-line

directions resulting in a much higher signal-to noise ratio. Field tests have shown that noise reduction up to 27 db is consistently achieved in comparison to radial designs addressing only inline noise.

By leveraging the strategic Shale Science Alliance between Baker Hughes and CGG--Magnitude microseismic monitoring leverages an industry-recognized technology portfolio of seismic and reservoir characterization, to offer an unsurpassed microseismic solution which includes the following: feasibility/seismicity studies, survey design, acquisition, waveform processing (real time and post-acquisition), geomechanical analysis, and advanced reservoir modeling. Pressure pumping technology and services can also be offered as part of a fully integrated fracture optimization solution.



*Hampson-Russell microseismic module*