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Imaging breakthrough promises more reliable SRV calculations

By Dr. Brad Artman

Spectraseis researchers have announced a breakthrough in imaging for microseismic events that will drastically improve frac engineers' confidence in stimulated reservoir volume (SRV)

SRV is a critical factor in resource plays, used by engineers to assess the effectiveness of a frac treatment, establish parameters for future frac stages and to compute decline curves for quantifying bookable reserves.

Yet estimates derived from the ray-based imaging approaches widely used by microseismic processors are rife with uncertainties.

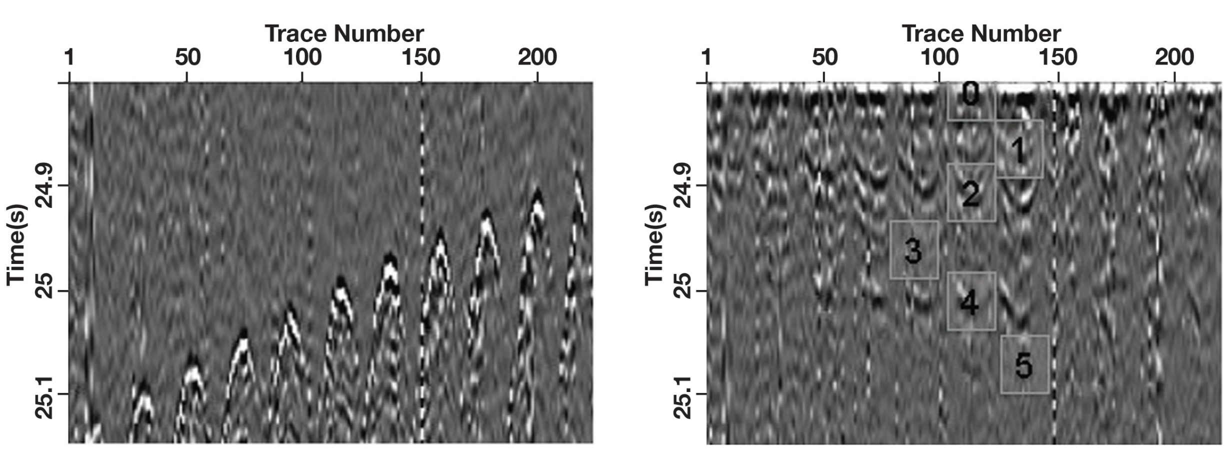
"Current location techniques are likely causing operators to significantly overestimate the extent and structure of their frac networks" says Dr. Brad Artman, a research scientist at Spectraseis.

"Any processing method that assumes a fracture event produces a single arrival will routinely produce false events, which can lead to major errors in calculating the volume of interest," continues Dr. Artman.

In Figure 1, a single microseismic event generates as many as five arrivals due to multi-pathing. Projecting these arrivals to a subsurface location results in a 'comet tail' of false events extending away from the one true event. The other four events imaged in the results are artifacts of the processing.

> Elastic wave-equation imaging is proven new technology that will greatly increase the value of microseismic data to frac engineers

Figure 1: The multiples problem — a single perforation shot from a surface array, raw (left) and flattened on the first arrival (right). Intrabed multiples labeled 1-5 have high S/N and faster apparent velocity, generating four false events in the volume. Elastic wave equation imaging eliminates this problem.



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In a recent example from Canada, Spectraseis believes the operator could be at risk of overestimating their SRV by as much as 25%.

Exacerbating the multiples problem is many processors' reliance on acoustic processing with single component data. This can introduce a spurious location for every real event.

"Engineers interpreting frac event images derived from P-wave-only processing need to keep in mind that events they are seeing nearer the array can be mishandled S arrivals" says Dr. Artman.

Incorrectly locating S-wave arrivals could also lead to costly operating decisions. A frac engineer seeing falsely positioned events developing in the overburden could curtail a treatment to avoid a breach, when in reality the frac has stayed well inside the target zone. This could reduce the productivity of the stage or the entire stimulation program.

"The better approach", says Artman, "is full elastic wave equation imaging of microseisimic data, combined with high-sensitivity, broadband equipment to sample the whole wavefield from both surface and borehole locations."

Spectraseis' solution combines a number of elements which work together to deliver engineers and their management richer and more accurate SRV estimates and more reliable data for reservoir modeling.

Firstly, high sensitivity 3C broadband surface and borehole receivers are used, with instrument self-noise below the minimum of the ambient Earth noise. The company's Ultra Sense™ arrays draw on a range of tools, including a one-of-a-kind borehole instrument with strong low frequency response and the industry's lowest detection threshold for frac events.

A recent Ultra Sense™ deployment, in conjunction with Canada's mu-SIC microseismic consortium, delivered a unique broadband dataset showing a clear improvement in event detection compared to conventional tools.

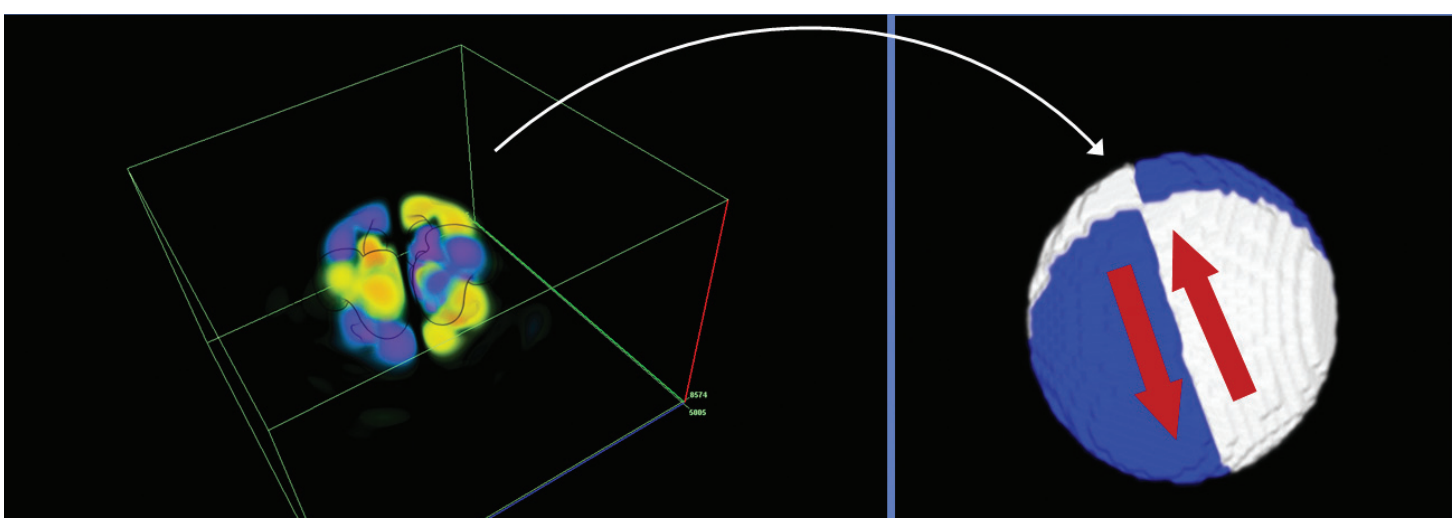
The advantage to the operator is a flexible acquisition strategy combining the most advanced instruments, integrating real-time data as needed.

> Today, high-sensitivity broadband instruments are capable of sampling the whole wavefield from both surface and borehole locations

Spectraseis uses forward modeling to design the optimal acquisition geometry prior to field work to incorporate the objectives of the program into the local setting. Solutions include arrays with any combination of surface, near-surface, and borehole deployments.

"Our main goal in developing the survey geometry is to get the operator the best possible dataset within their budgetary parameters and ensure that the program goals will be met. We can then deploy whatever tools are needed to optimize the results."

Figure 2: Positive and negative radiation of P and S energy from a fracture is imaged on the left. The fracture plane and radiation direction need only minor interpretation to arrive at the seismic moment tensor diagram depicted on the right.



But the breakthrough poised to get the most attention from the industry is Spectraseis' implementation of the first elastic wave equation imaging algorithm for frac events. The company's Time Reverse Imaging (TRI) method, the subject of eight issued and pending U.S. patents, naturally addresses the pitfalls mentioned above by eliminating the assumptions and simplifications of ray-based techniques.

TRI also removes the need for intensive operator input, reducing processor bias and improving efficiency. "Elastic processing is the natural domain to handle multi-mode data generated by fracturing rocks," says Dr. Artman. "It is a natural evolution for microseismic to capitalize on the power of migration methods."

In another new development, image analysis techniques to be presented at SEG 2011 provide a robust confidence estimate for every imaged event.

The result is a step-change in the potential value of microseismic fracture data to the working engineer. By delivering richer, more accurate, and more robust imaging Spectraseis adds confidence to SRV calculations and reliable frac characterization results for integration with reservoir models (Figure 2).

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