Welcome to our first issue

seismic profile

SHALE GAS Seismic solutions for stimulation and permanent reservoir monitoring

EM Jeremy Cresswell on the latest developments

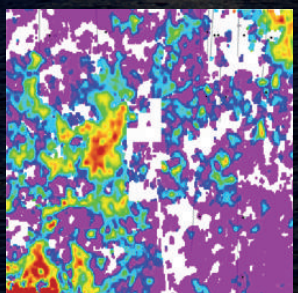
ON STREAM WITH PGS Exorcising the ghost. Keith Forward on the new streamer technology.

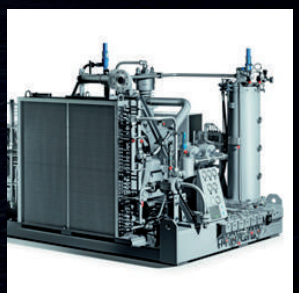
DATA INTERPRETATION Pre-stack and post-stack along with 'Big Data'. Bill Shea analyses the analysis

NEW VESSELS Jeremy Cresswell runs his pen over the fleet of new-builds.

SUMMER 2012
ISSUE 1

ISSUE ONE SUMMER 12 EM MARINE SEISMIC SHALLOW WATER DATA INTERPRETATION





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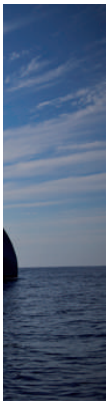

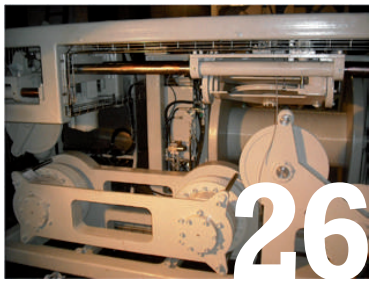

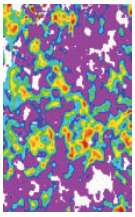

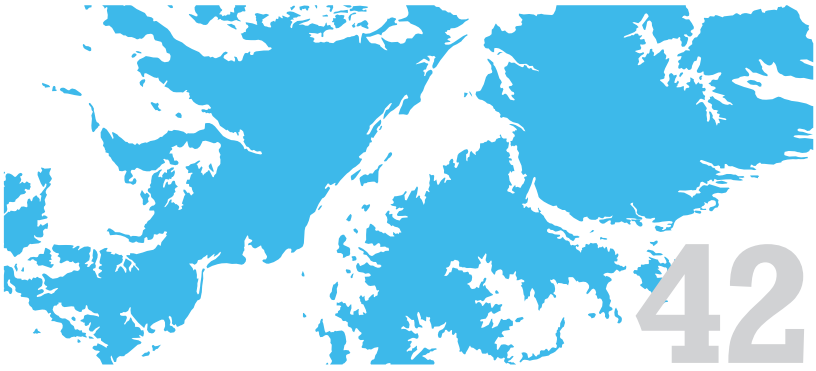

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Data interpretation

Pre-stack seismic is essential input for quantitative amplitude interpretation. Pre-stack gathers are needed to QC data quality after contractor processing, and to track 3D changes in amplitude-versus-offset (AVO) for detailed reservoir characterization. AVO response on reservoir reflections is routinely used to risk prospects, predict reservoir lithology and fluid type, evaluate porosity, and calculate pay. AVO response is also a key input to seismic inversion, which attempts to predict elastic rock properties from seismic amplitude response and limited well calibration.

Unfortunately, today's pre-stack datasets are massive, and best-practice workflows normally require multiple software packages and months of work time for processing QC, data conditioning, and detailed amplitude interpretation. Projects are commonly delayed by months to fix processing errors, pass data between applications, and integrate rock physics and seismic results. During periods of active exploration and field development, specialists often fail to deliver results in time for key drill decisions.

"Big Data" technologies are fully capable of crunching through multi-terabyte pre-stack datasets. However, most interpretation software is built on less powerful workstation platforms. Pre-Stack Pro is a new breed of software, which leverages high-performance computing (HPC) technologies to overcome performance bottlenecks and deliver real-time quantitative interpretation directly from full-survey pre-stack datasets. Pre-Stack Pro combines fast processing and advanced data visualization in one tool, giving asset teams the power to QC contractor data, fix data quality problems, and quickly generate angle stacks, attribute volumes, and rich attribute maps in a single interpretation canvas. Today, even inexpensive

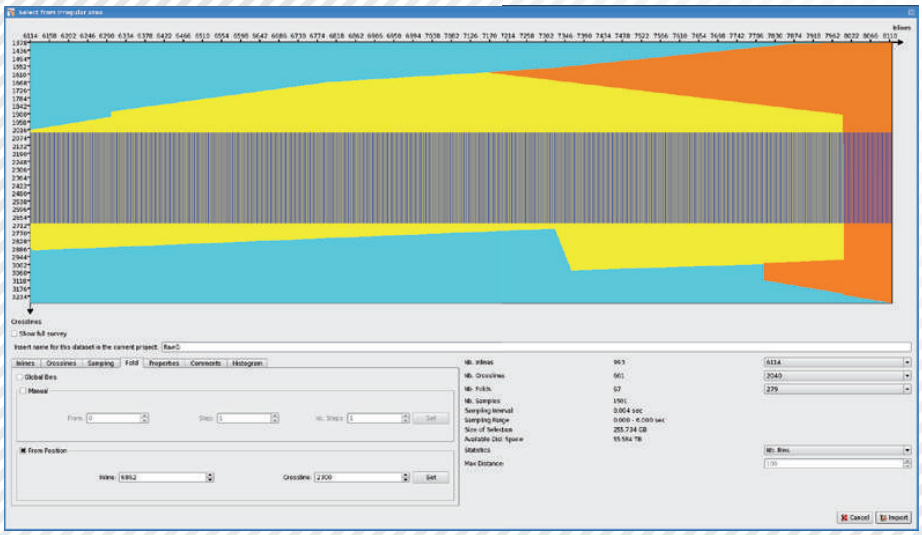


Figure 1. *Fold Map extracted from SEGY trace headers from a merged 3D survey. Yellow and Orange areas contain gathers with different slightly fold. Data selection (255 GB) to be loaded to Pre-Stack Pro are shown in gray. Data are loaded to parallel storage to accelerate I/O within the application and deliver data quickly to global shared memory.*

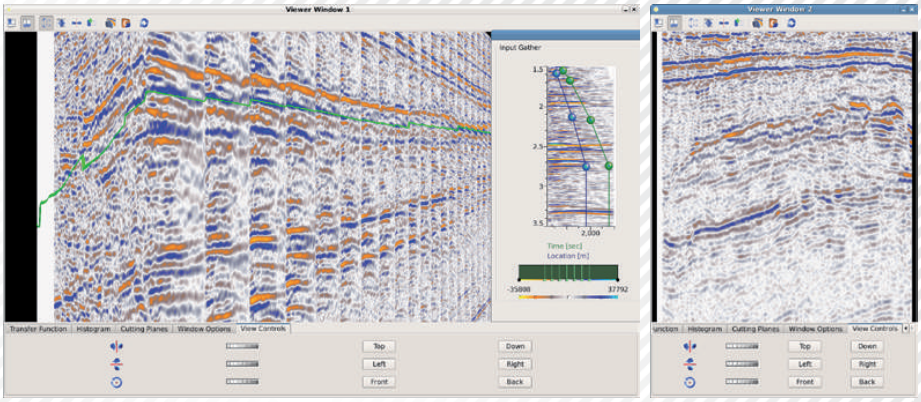


Figure 2. *Pre-stack (A) and stacked (B) seismic displayed in linked Pre-Stack Pro viewers. The pre-stack viewer contains more than 105 gathers, which may be viewed as common offset planes or gather panels. Data are stacked in memory using inner and outer offset mutes (shown), and changes to the mute are updated instantly on the entire stacked subvolume. With sufficient shared memory (100s-1000s GB), stacking of entire pre-stack datasets is possible.*

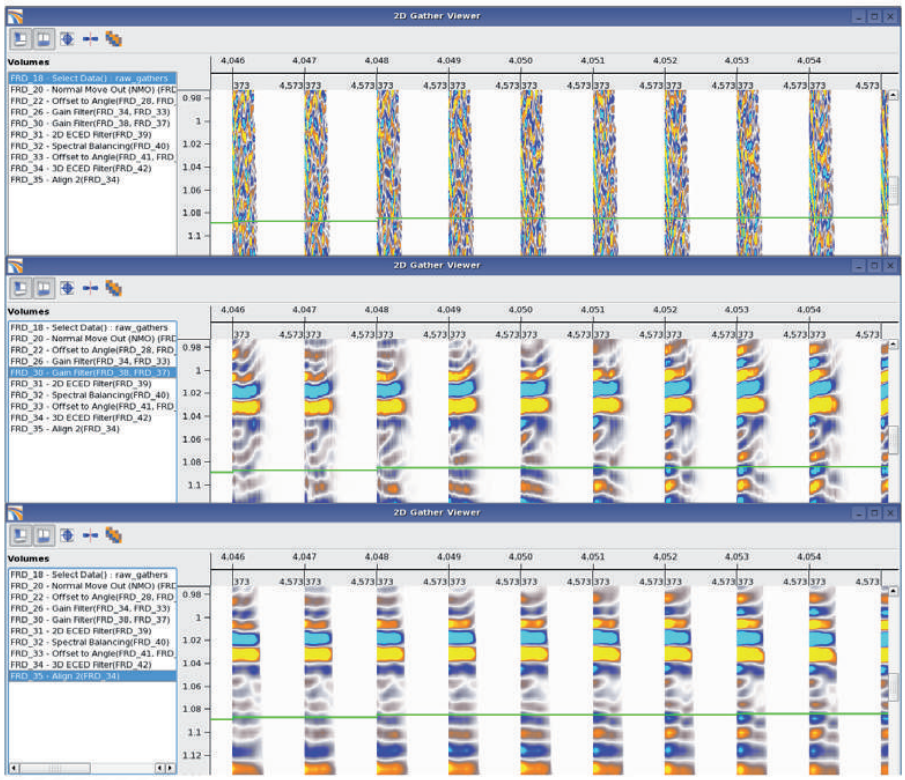
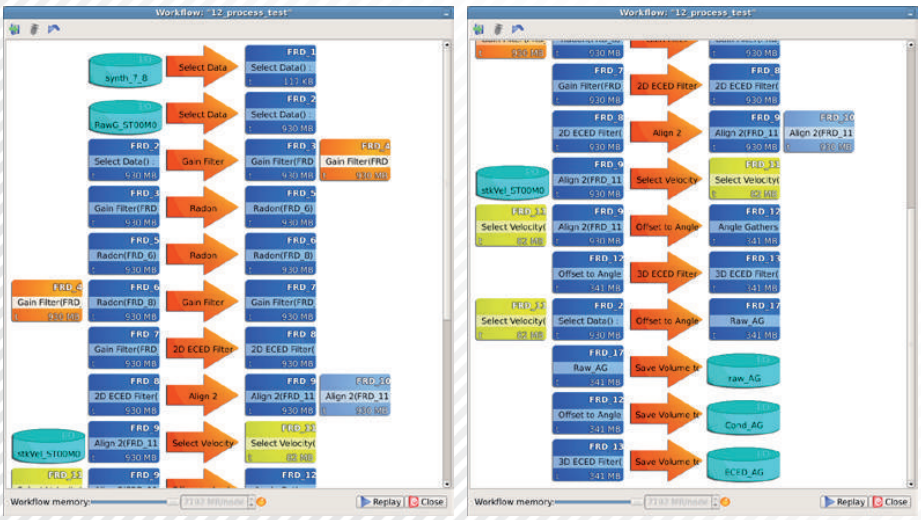


Figure 3 (right). *Pre-stack processing sequence visualized in 2D gather viewer. All intermediate volumes are stored in memory on backend server, and graphics are rendered on CPUs and sent to client as video streams. Sequence shows input gathers (A), gathers after parabolic and linear tau-p Radon (B) , and final gathers after 3D random noise cancellation and flattening (C). Top of targeted reservoir sequence is shown by green horizon.*

Figure 4 (below). *Pre-Stack Pro processing workflow, which loads data, removes noise, flattens events, and generates 6-fold angle gathers as input to pre-stack inversion. The workflow can be run interactively (in memory) on small test volumes, and re-run in batch mode on the full survey.*

server systems have sufficient throughput to process and analyze prospect-sized areas in days. By analyzing data in more detail, geophysicists improve their overall understanding of risk and uncertainty associated with specific amplitude prospects.

Development of today's commercial product began in 2006, when researchers from Germany's Fraunhofer ITWM and Stavanger-based EnVision teamed up to discuss ways to apply cluster computing technology to seismic analysis. At the time, clusters were widely used for seismic imaging, but not to analyze results after migration. The research team believed that a highly-parallel application built on a coming generation of multi-core CPUs and distributed computing frameworks could dramatically increase data throughput, and allow real-time processing of millions of gathers. Statoil's R&D centre in Norway funded early prototypes built on an existing Fraunhofer graphic server engine, and Houston's Rock Solid Images contributed money and working code to the effort. Envision and Fraunhofer spun off Sharp Reflections in 2010, to commercialize the first commercial product. Since launch, customers have contributed nearly $1 million to enhance functionality, improve algorithms, and develop new interpretation tools that extend Pre-Stack Pro's capabilities.



On multi-server systems, Pre-Stack Pro stores and accesses complete pre-stack datasets on parallel storage servers, giving each compute node access to the entire dataset. The application uses Fraunhofer's GPI to create an aggregated memory architecture, which allows large gather subsets to be loaded to memory, visualized, or used as input for all processing modules. Data in memory can be converted from offset to angle, stacked, opacity rendered, or stacked in seconds. Tens of thousands of gathers can be scanned quickly in the applications' 3D viewers, which

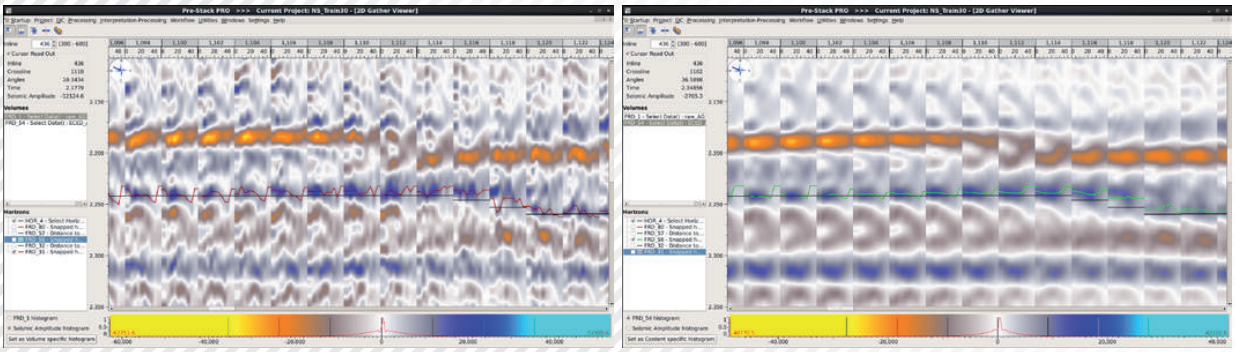


Figure 5. *Angle gathers from reservoir zone between 2.1 and 2.3 seconds TWT, before (A) and after (B) conditioning. Solid black line in (A) indicates the position of an imported base reservoir horizon interpreted on a full-offset stack, and red pick is snapped to the pre-stack reflection. Green pick on conditioned gathers is more stable, and provides a high-resolution picture of AVO response at the base of a thick porous sand.*

render images directly on the CPU and send high frame rate streams to the client graphics card. Simple animation often reveals spatial variation in multiples and other coherent noise, that can be removed by additional, targeted processing.

On-the-fly data conditioning is a cornerstone of the application, and essential to its "view and do" philosophy. Parallelization across cores reduces run-times dramatically on compute intensive noise attenuation and gather flattening processes. Most post-migration filtering routines applied to gathers are well-suited to parallelization. When Pre-Stack Pro is deployed in a scalable, multi-node system, full data conditioning workflows can be executed on 105-106 gathers in a matter of hours. Users can combine all filter operations into a single master workflow, and QC results and differences for each operation in a new, multi-volume 2D gather viewer. Most algorithms make extensive use of stencil codes, which efficiently distribute "bricks" of gathers to each core, to permit spatial averaging within calculations. For example, spatial filtering of residual velocities calculated by Pre-Stack Pro's RNMO routine yields more stable results than corrections computed gather-by-gather without filtering.

Ultimately, pre-stack noise filtering and flattening are applied to improve the spatial consistency of AVO results, and to reveal updip/

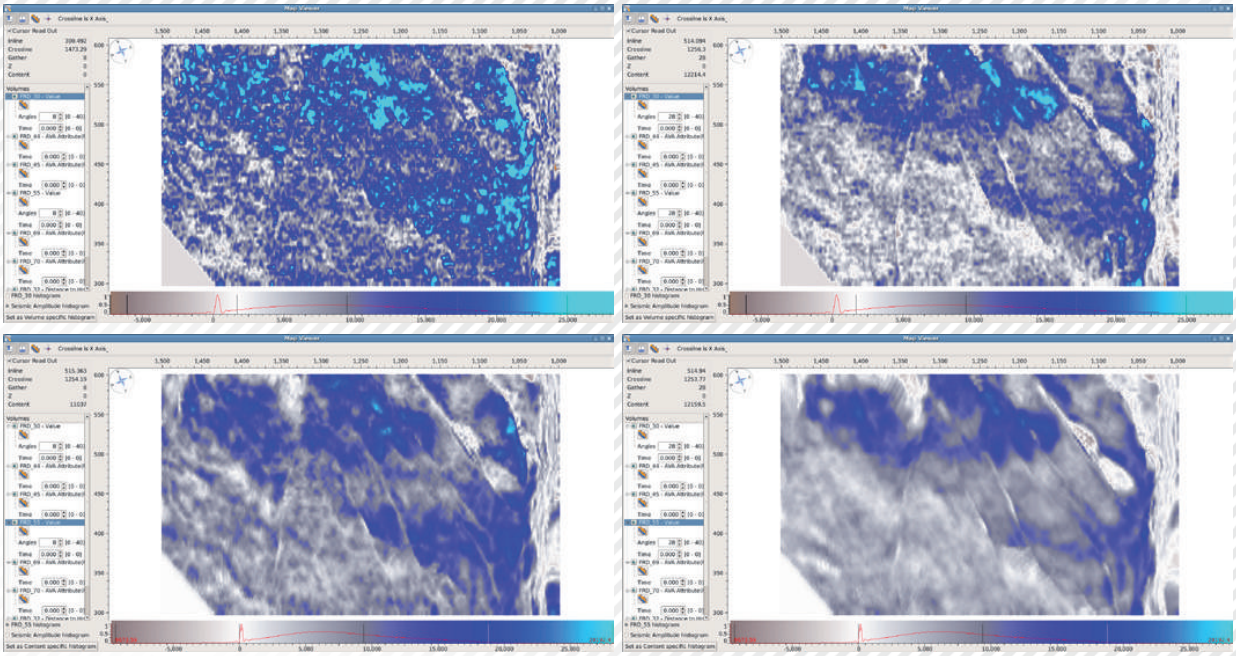


Figure 6. *Horizon attribute extractions generated directly from angle gathers, before (A-B) and after data conditioning (C-D). Conditioning and map generation are executed in a single interactive flow, so the effect of data quality enhancement can be assessed in real time. Maps represent maximum peak amplitude calculated at base reservoir, as extracted from raw near from 8-12 degrees (A), raw far from 28-32 degrees (B), conditioned near from 8-12 degrees (C), and conditioned far (D) from 28-32 degrees. Improvement after conditioning is especially dramatic on the near stack, and AVO relationship (dimming with increasing offset) is easily seen on the conditioned maps.*

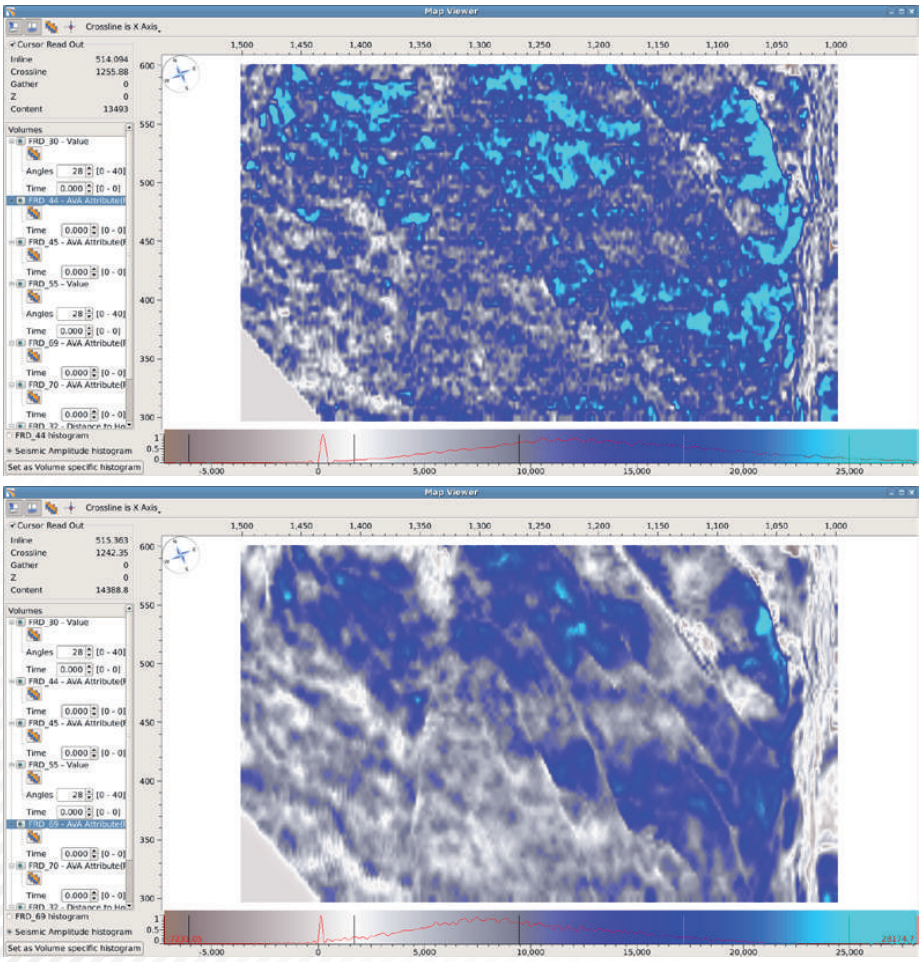
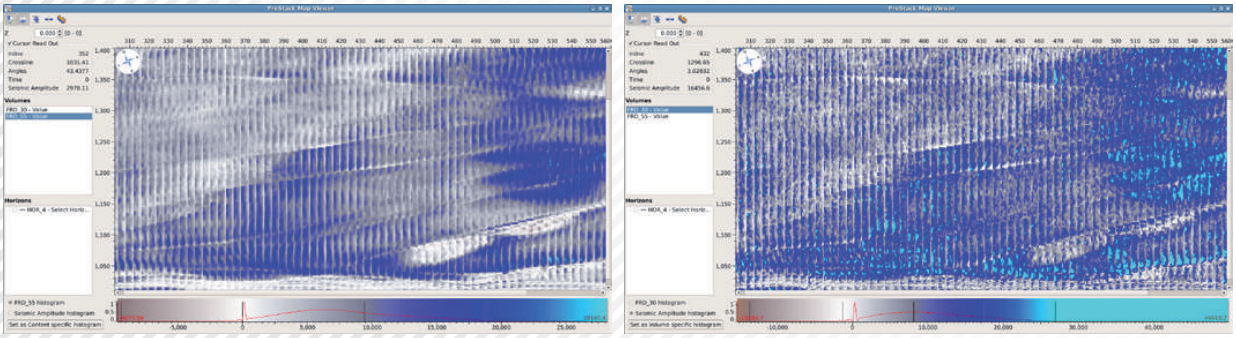


Figure 7. *Intercept calculations from the base sand horizon shown in Figure 4, as calculated from raw gathers (A) and after pre-stack conditioning (B). Noise is significantly reduced, and hydrocarbon and tuning effects are more clearly visible on the conditioned maps.*

Figure 8. *Pre-stack gather maps extracted from raw (A) and conditioned (B) angle gathers on the base reservoir horizon. Amplitudes are displayed for ALL angles and offsets across the same area as shown in Figures 6 and 7. AVA effects for the single pre-stack reflection can be seen clearly on all inlines and crosslines. These gather maps can be used to confirm fluid-related amplitude effects, or for detailed well targeting in conjunction with synthetic pre-stack seismic models.*



downdip amplitude changes that distinguish hydrocarbon and brine-filled reservoirs. For EAGE 2012, Sharp Reflections will release a new amplitude mapping module with Pre-Stack Pro 3.0, which extracts pre-stack and post-stack attributes directly from gathers in memory. Imported horizons are snapped to offset or angle traces to create pre-stack picks. Instantaneous or windowed amplitude statistics are displayed as multi-volume map animations (e.g. one map for each offset), or as pre-stack maps showing amplitudes for every pre-stack trace. With these new tools, interpreters can quickly identify and investigate amplitude anomalies without moving the data to their interpretation systems. Teams can immediately see the impact of data conditioning on partial stacks and AVA attributes, and update pre-drill risk assessments in near-real time.

"Big Data" computing has the potential to dramatically reshape the way geophysicists carry out seismic reservoir characterization. Teams can seamlessly integrate data processing and amplitude interpretation in a single analysis flow, starting directly from migrated gathers. Faster software workflows will cut cycle times for reprocessing and improve the reliability of amplitude data for quantitative interpretation. Interpreters who embrace pre-stack methods will gain a greater understanding of their data, and generate more high-quality prospects in less time.

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