Building Better, More Accurate Earth Reconstructions

Seismic inversion algorithm can be applied to post-stack and prestack data to recover rock properties.

By Dave McCann, ION Geophysical

When ION Geophysical embarked on the task of building a new inversion algorithm that would more accurately reconstruct the Earth, the company went back to first principles. This meant looking at the various depositional environments and the distributions of impedance contrasts. What was determined was that commercially available inversion algorithms assume a Gaussian distribution that does not adequately represent the broad range of impedance contrasts observed in geology. A different approach was needed. Based on that realization, the company developed its new inversion algorithm, PrecisION.

In every geologic province, obtaining an understanding of the rock properties is essential for successful operations. Unfortunately, there is a significant difference between what can be predicted from seismic data and what can be seen in a well. Built with insights derived from actual earth and physics data, PrecisION is a novel seismic inversion technique that can be applied to post-stack and prestack seismic data to recover rock properties.

When compared to commercial software, the new algorithm can provide superior earth reconstructions with greater accuracy and resolution. This is very helpful in clearly identifying layer boundaries necessary for prospect evaluation, drill planning and reservoir modeling. The inversion algorithm performs its analysis in the Eigen domain, a province in which usable information is easily separated from noise to produce very stable inversion results.

Within the Eigen domain, independent signals are naturally segmented into various Eigen vectors. Due to algorithmic parameterization, the Eigen vectors are inverted are for Vp, Vs and density. This approach is advantageous because the algorithm determines whether or not the offsets and signal-to-noise ratio will allow for the successful inversion of Vs and density. It also yields an uncertainty volume associated with each of the parameters that can be inverted. This uncertainty volume also can be used to quality-check the processing and ensure the highest possible quality. These advantages can be used to aid in the evaluation of prospect risk and decision-making.

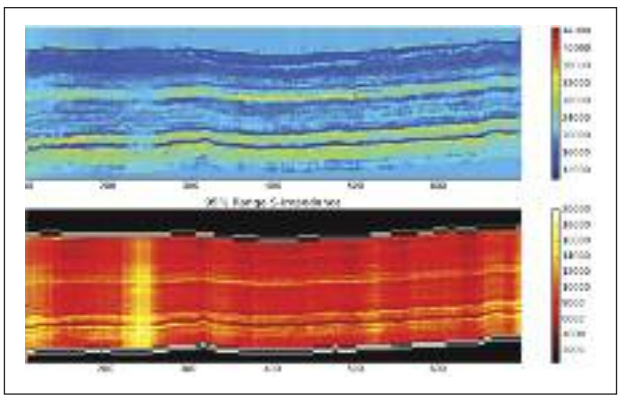

Figure 1. Inverted shear impedance (top) and its 95% confidence range (bottom) are shown. (Image courtesy of ION Geophysical)

Figure 1 shows the inverted shear impedance from one of ION's studies. The impedance values range from a low of 12,000 to a high of 44,000. Below the shear impedance image, a related image can be seen that identifies the uncertainty of the inversion. For

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Gathering Seismic Data Using Hybrid Radio Telemetry

A seismic recording system can deliver uninterrupted seismic crew productivity and effective data storage.

Contributed by Wireless Seismic Inc.

Modern seismic recording instruments fall into two camps: cabled and cablefree. Cabled systems have long been the default system of choice, recording data in real time and allowing operators to continuously gauge and control the condition of the spread.

A screenshot of the RT System 2 Central shows WRUs in green collecting data in real time. The blue WRUs designate lost radio connectivity while continuing to record and store data to flash memory. Production continues with no data loss. (Image courtesy of Wireless Seismic Inc.)

This choice comes at a price. The cables that enable instant data transmission are cumbersome to move around and need to be in perfect condition to function. The difficulties in transmitting high-bandwidth data through miles of cables and thousands of connectors can result in significant downtime while troubleshooters check the spread for problems and make repairs. This downtime reduces the working day and crew productivity.

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2014 SEG SHPCPHPC Focus Theater Schedule

Day	Time Slot	Presenting Company	Presentation Title	Presenter	Presenter Job Title
Monday	9:00AM	Christie Digital/Landmark	Taking Exploration Geophysics to a Next Level with Big Data	Dr. Satyam	Landmark Chief Data Scientist
10/27/2014	9:30AM	Intel	Methodology for Application Characterization and Modernization Applied to Seismic Imaging	Gregg Skinner	Senior Application Engineer
	10:00AM	Altair & Cray	Leveraging HPC for Deep-Sea Component Engineering	Altair: Rick Watkins & Cray: Geert Wenes	Altair: Business Development Manager-Oil and Gas & Cray: Senior Practice Leaderin Custom Engineering
	10:30AM	Nimbix	Why the Time is Right for High Performance Computing in the Public Cloud?	Leo Reiter	Chief Technology Officer
	11:00AM	Kitware	Enterprise HPC Analysis and Visualization with ParaViewWeb	Patrick O'Leary	Assistant Director of Scientific Computing
	11:30AM	Cray	Full Range RTM in Support of FWI using Dense GPU and HPC System	Bert Beals	Global Lead, Energy Industry
	Noon		Lunch		
	1:00PM	HGST	Accelerate Exploration Data Access with HGST Flash Storage	Brian Morris	Oil and Gas Enterprise Account Manager
	1:30PM	Avere System	How to Leverage a Hybrid Cloud Solution to Optimize Upstream Workflow: Increase Agility while Accelating Performance	Tom Ledoux	Senior Systems Engineer
	2:00PM	SimpliVity Corporation	The Best of Both Worlds for Oil & Gas IT Environments: x86 Cloud Economics with Enterprise Capabilities	Marty Sanders	VP of Sales
	2:30PM	Adaptive Computing	Accelerate Insights – Speed Hydrocarbon Exploration	Paul Anderson	Director of Professional Services
	3:00PM	Altair	Simplifying the Management of HPC Application Environments	Victor Wright	Enterprise Computing Solutions Specialist
	3:30PM	Acceleware	Computational Trade-Offs of Higher Order in Time RTM	Scott Quiring	Team Lead Software Developer
	4:00PM	PCPC Direct	High Performance Computing technology trends and directions	Eric Collins	Chief Architect
	4:30PM	NetApp	High Performance Storage Solution for Landmark SeisSpace	Ajay Kale	
	5:00PM	Rescale	Introduction to Rescale: Cloud Simulation Platform	Joris Poort	CEO
	5:30PM	Hitachi Data Systems	Check Electronic Monitor for updates	Larry Rice	Director of Energy Vertical

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Standardization will allow companies to manage data for the long term, providing an audit trail of data loading, identification of data sources, management of access/entitlements and tagging data quality.

The MetaStore 2.0 beta version includes basic data management, analytical and visualization capabilities on the PPDM database (supporting both Oracle and MS SQL Server).

The future is open

The Metastore has been designed as a fully flexible, open system with an open door policy to allow vendors to either write data access routines or provide an API such that any vendor's data or proprietary rock property data may be stored, queried and accessed in the system.

Giving companies the ability to create comprehensive and accessible repositories of their data assets using open technology shifts the emphasis away from data management as a passive task and encourages active engagement with end users.

Demos of the Ikon MetaStore will run daily at booth 1208. ■

Exhibition Hours

Sunday, Oct. 26 (Icebreaker).....6 p.m. to 8 p.m.
Monday, Oct. 27 .....9 a.m. to 6 p.m.
Tuesday, Oct. 28.....9 a.m. to 6 p.m.
Wednesday, Oct. 29.....9 a.m. to 4 p.m.

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this study, the company displayed uncertainty to three standard deviations or a 95% uncertainty range. In this display, the lower values, or red color, indicate a more reliable value of the inversion. The yellow color indicates a larger uncertainty, i.e. less reliable inversion.

A vertical yellow bar to the left of the display also can be observed—this is an area of limited seismic coverage, with an associated lower confidence in the inversion. In addition, for this pass of the processing, a small degree of residual moveout was left on the gathers. This can be seen per the uncertainty volume as yellow spectrum colors that correspond to major events along the seismic line. This clearly indicates a need to review the preprocessing of the data.

The key risk in any inversion lies with the quality of the preprocessing. It's a simple formula: The greater the quality, the lower the risk. ION optimizes data quality by embedding a reservoir characterization specialist within the processing team. At each stage of processing, the parameters selected are checked to confirm that the resultant data still meet the stringent criteria necessary for elastic inversion. By following this rigorous workflow, the company can reduce the possibility that preprocessing will yield data inadequate for reservoir prediction. This would prove a significant risk were the preprocessing done elsewhere.

Through careful preprocessing and the analysis of uncertainty offered through the PrecisION workflow, ION seeks to improve the reliability of the data used to predict reservoir properties and related prospect and/or field economics. ■

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truncation against the complex salt overhang are very important to increase confidence while prospect mapping. Analysis of the legacy vertical transverse isotropic (VTI) dataset showed mis-ties at key well locations along dipping salt flanks, which established the need for a tilted transverse isotropic (TTI) approach during model building. Major steps in the depth-modeling workflow included calibration of the existing model with checkshot information, estimation of epsilon and delta parameters using an automated focusing analysis and multiple iterations of grid-based tomography for sediment definition to solve for both the short and long wavelength features of velocity anomalies in the model. Both Kirchhoff migration and reverse time migration (RTM) were used for salt body interpretation and modeling. Broadband processing helped improve the low-frequency signal in the subsalt, which generated good-quality picks on the migrated gathers. For subsalt velocity and model updating, both conventional tomography and RTM-based delayed image time (DIT) scans also were used.

Image comparisons

The reprocessed data showed better overall resolution due to the Clari-Fi processing that had been applied. In particular, the major and subtle fault features are more interpretable as visible on the depth slice. In addition to better ties at the well locations along the steep flanks due to well calibration and TTI modeling, the signal below salt and subsalt truncations are now better focused due to usage of RTM and DIT.

Visit TGS at booth 825 for more information. ■

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The advent and adoption of autonomous cable-free systems in recent years has circumvented many of the cable systems' problems. These autonomous nodal systems tend to be lower in weight and volume than cable systems. Operators simply deploy them in the field and leave them to acquire data, trusting that data are being recorded and that the spread remains within specification (e.g., noise levels, quality of geophone coupling, etc.). As the electronics of these systems are reliable, this choice is often a safe bet. Contractors don't have to wait on the recording system status to start shooting, so productivity is limited by the energy source, not by the recording system.

Since autonomous nodes are blind, the user has no idea if they are recording or are still in place. They have no real-time quality control, making it impossible to monitor the state of the spread. Data have to be harvested from the nodes by bringing them back to the camp or by harvesting the data *in situ* using complex field terminals. The contractor has to invest in and mobilize large transcription trailers to house the expensive computers needed to carry out this work. The user has to wait for days or weeks to see the data produced by skilled technicians in the field, which often leads to delays in making informed decisions on the ongoing survey parameters.

Up to 20% extra units are needed in the field with some nodal systems since they need to be taken off the line for harvesting and battery recharging. At the end of the survey, all of the nodes are brought back to camp, resulting in a huge backlog as they wait to be harvested.

Wireless Seismic's RT System 2 is an alternative system that seeks to offer the best of both worlds. The system architecture is best imagined as a cable system, where the cables are replaced by high-bandwidth radios that transmit data wirelessly in real time between wireless remote units (WRUs). The system works by digitizing the analog input data from the geophones and storing them in the WRU's memory. The data are then streamed through the telemetry system to the central recording system. As the transmission distance between WRUs is small, the system is not subject to the limitations of other radio architectures. RT System 2 is free from the drawbacks of cabled systems and offers the benefits of autonomous nodes.

The system features a hybrid radio telemetry system so that if a WRU loses radio connectivity, its internal GPS turns on and continues to record seamlessly, storing data into its large flash memory. When radio connectivity is restored, the buffered data are transmitted wirelessly to the central recorder, as telemetry bandwidth permits, and the internal GPS switches off to extend battery life.

Visit Wireless Seismic at booth 908 for more information. ■