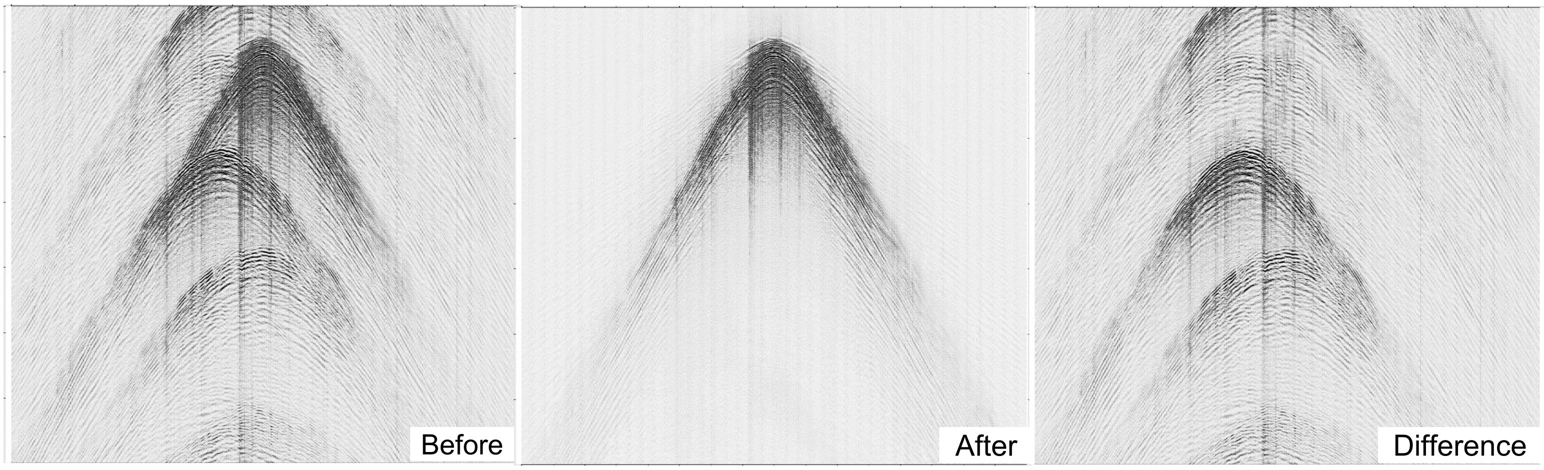
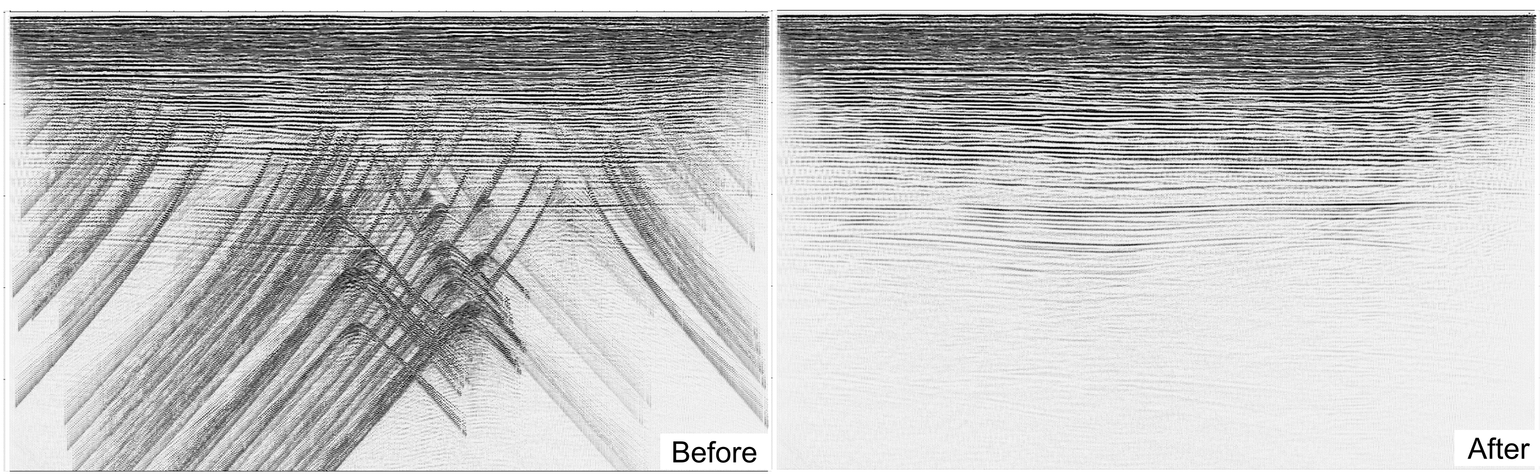
Inversion-based Deblending

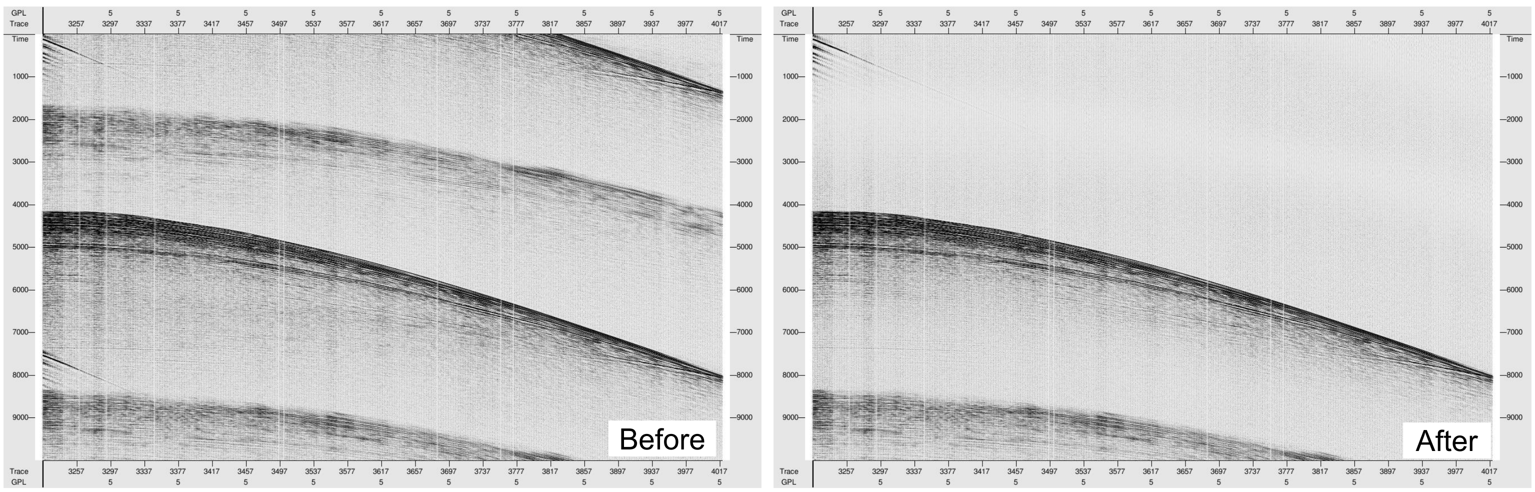
GeoEast provides inversion-based deblending techniques for land vibroseis, marine streamer and OBN data. These techniques are capable of separating highly blended data with high accuracy, and have been updated recently to handle irregular shot sampling and residual source interferences.



Shot gathers of land vibroseis data before and after deblending



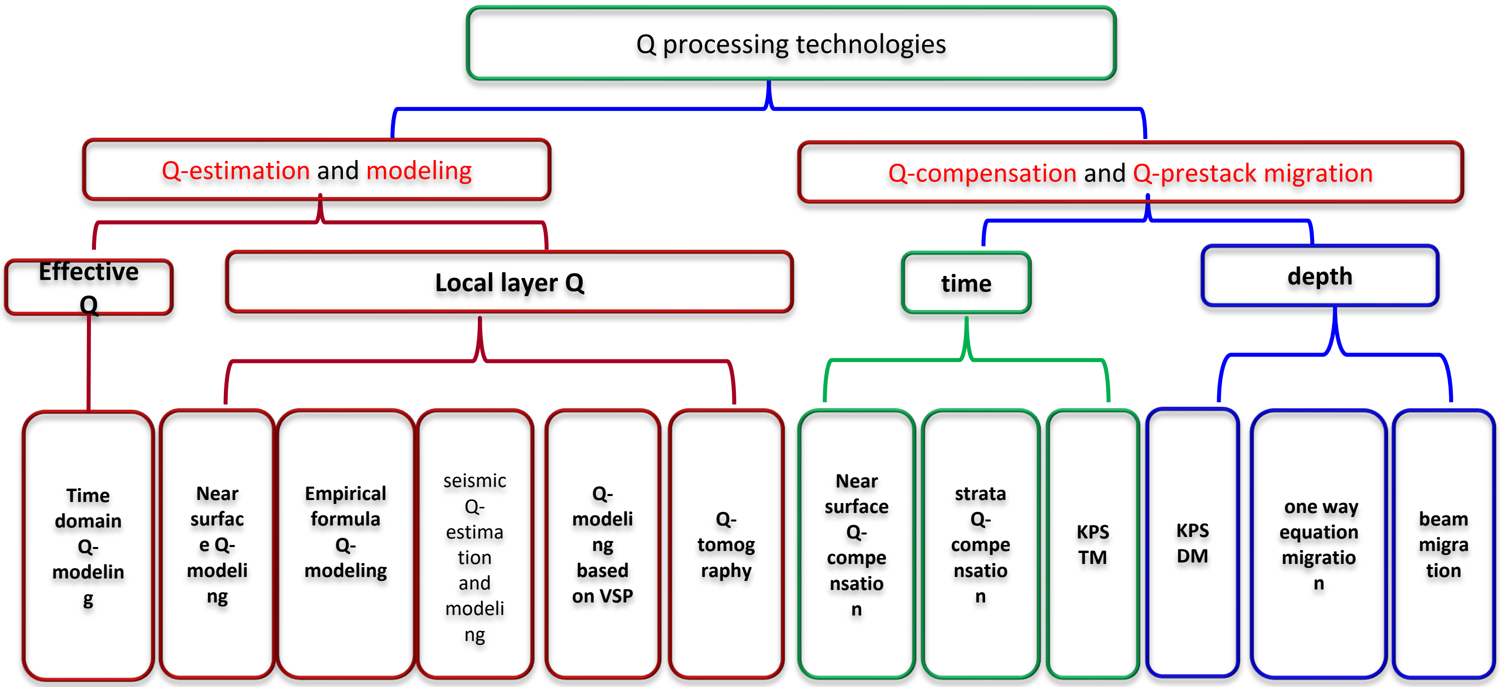
Stack sections of OBN data before and after deblending



Shot gathers of streamer data before and after deblending

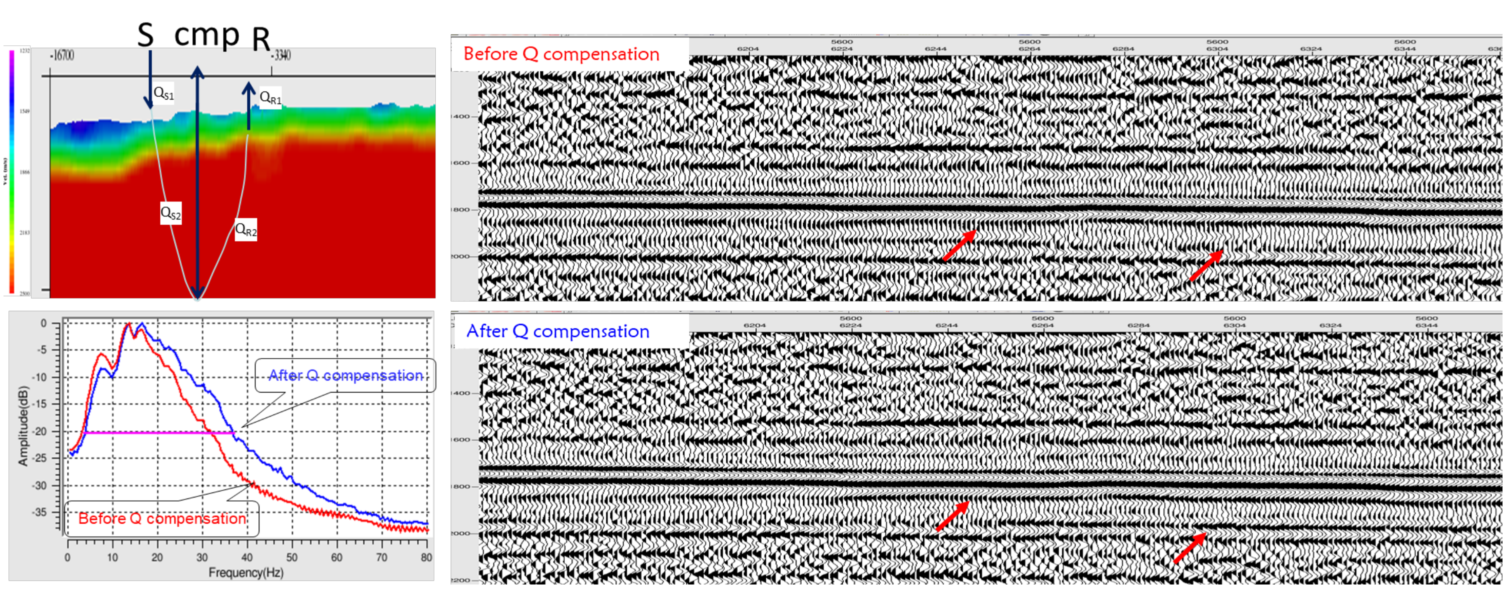
GeoEast-Q processing techniques introduction

GeoEast Q processing techniques include Q estimation and modeling, Q compensation, Q prestack migration technology series, which effectively compensation the influence of loose surface and earth on seismic signal absorption and attenuation.



Near surface Q modeling and compensation

Our near surface Q compensation uses microlog data to estimate the near surface Q value, and combines with the near surface velocity model obtained by tomographic inversion to establish a near surface time domain Q model and perform near surface Q compensation to eliminate the absorption and attenuation of seismic waves by the near surface.

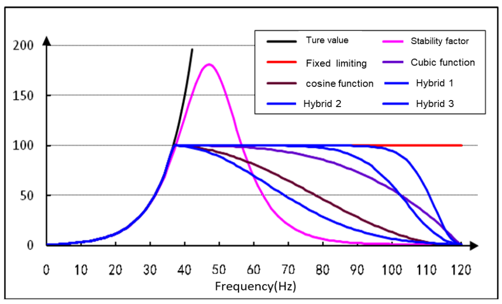


Q modeling and near surface Q compensation on Loess Plateau dataset

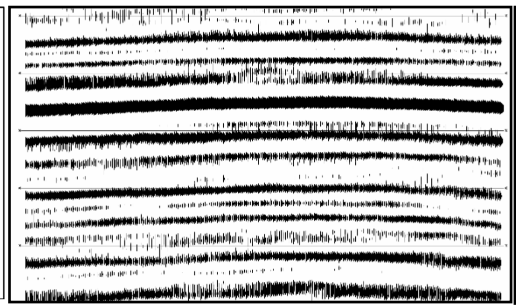
Q estimation and compensation

The VSP data in well has high quality direct transmission wave, which can accurately estimate the Q value of the stratum penetrated, and has high reliability，compared with VSP data, the accuracy of Q value estimated by surface seismic data is poor, but in the overall macro trend, it can better show the spatial distribution of Q value.

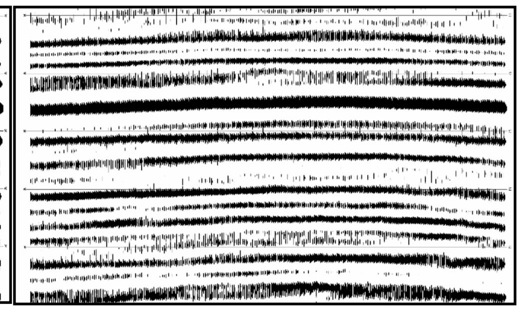
Q-compensation is performed before deconvolution, High frequency stability control is the key to Q compensation. After Q-compensation, the frequency band can be widened and the difference of wavelet in different surface areas can be weakened,and the dominant frequency(df) of seismic data has been significantly improved.



High frequency stability control



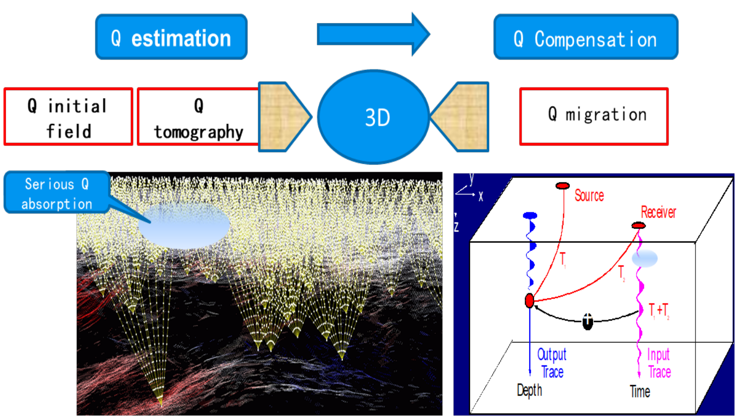
Before Q compensation



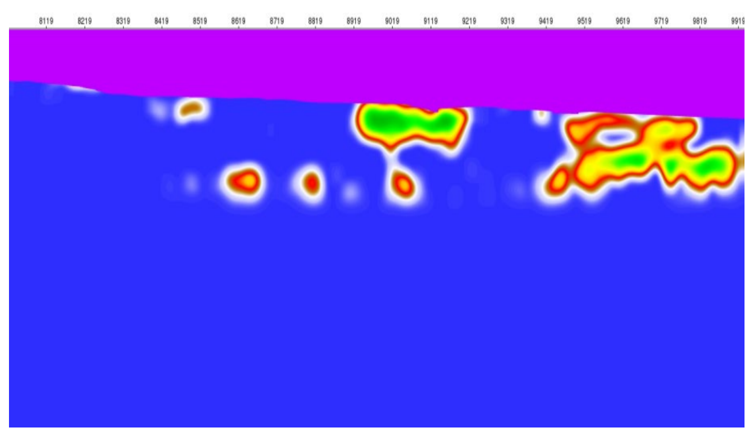
After Q compensation

Q modeling and Q Pre-stack migration

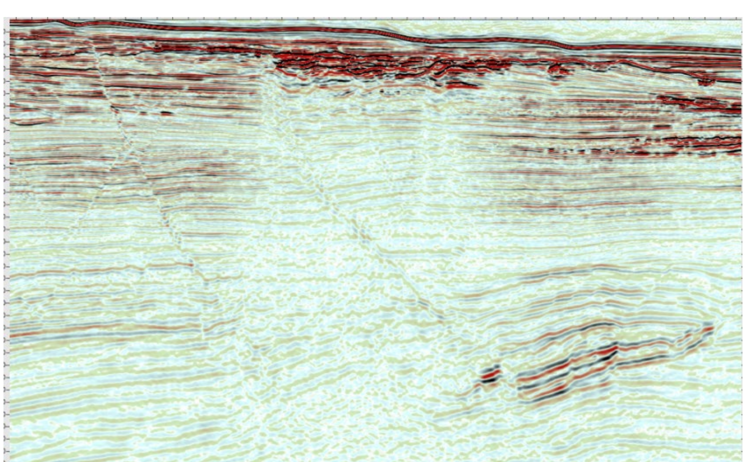
The depth/time domain Q modeling and integration Q migration technology series with complete functions has the same migration effect, and the inversion effect of Q tomography is better and more efficient.



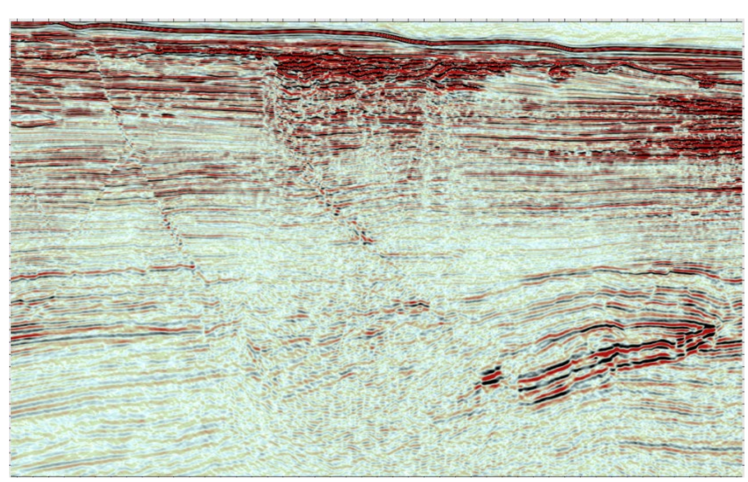
3D Q-migration in 3D space



Q model by Q tomography



Conventional migration results



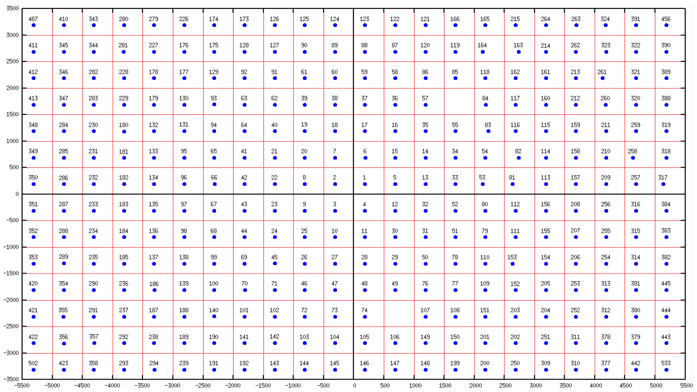
Q migration results

OVT Package

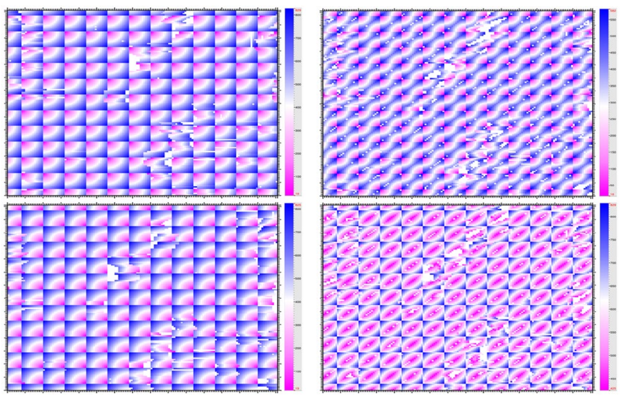
OVT (Offset Vector Tile) technology is the suitable solution for processing wide-azimuth, high-density seismic data and can make full use of the information carried this kind of data to improve processing effect and precision. The OVT package consists of core modules like OVT extraction, OVT domain interpolation and regularization, OVT prestack migration, azimuthal anisotropic velocity inversion and ,residual moveout correction, etc., covering all necessary functions for a complete OVT processing workflow.

OVT binning

using the technique of sequential access of block data and manipulate data header directly to improve efficiency, OVT swapping realizes high-precision OVT binning.



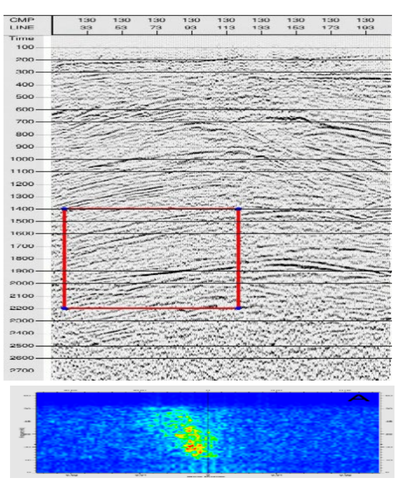
OVT binning numbering method
Abscissa: offset_x， Ordinate: offset_y



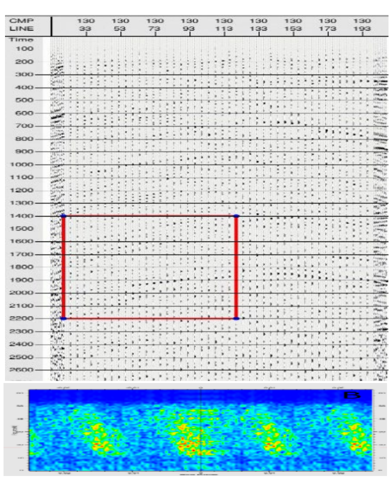
OVT swap can reduce the range of offset in OVT gather

6D interpolation regularization

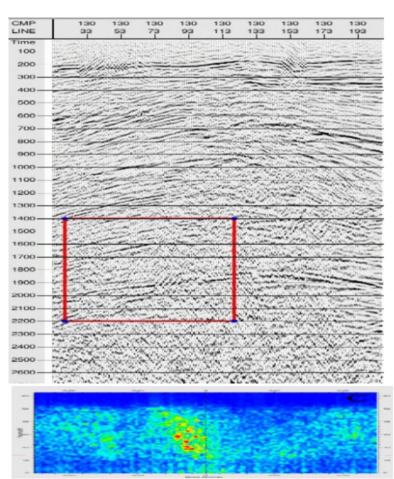
GeoEast provide both 5D and 6D data regularization techniques. The 6D technique, which is the 5D one with angle constraint added, has a higher anti-aliasing capacity for the angle constraint connects the information of different frequencies. .



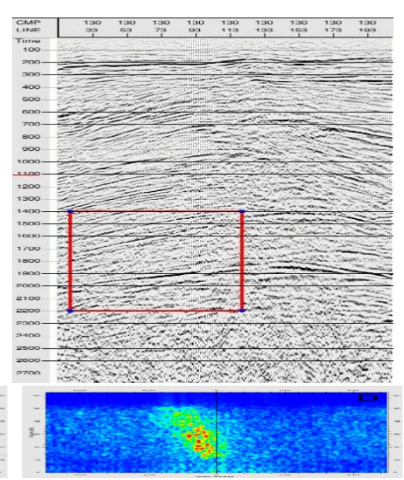
Input stack and its FK spectrum



3 to 1 decimated stack and its FK spectrum



Output of decimated stack and its FK spectrum after 5D data regularization



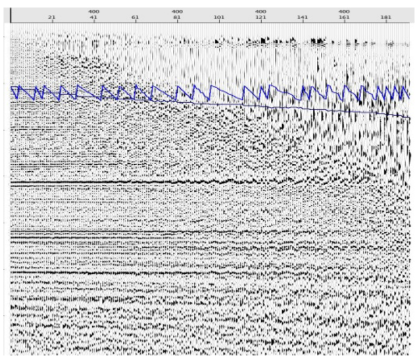
Output of decimated stack and its FK spectrum after 6D data regularization

OVT Package

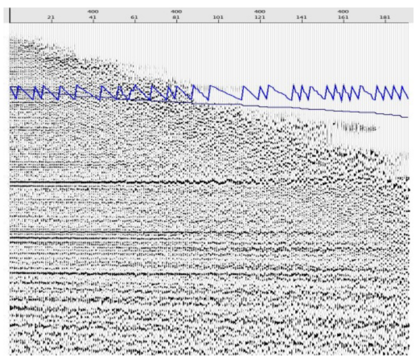
OVT PSTM&PSDM

Migrates OVT data with the fully-automatic workflow, and the efficiency is more than 3 times higher than other softwares.

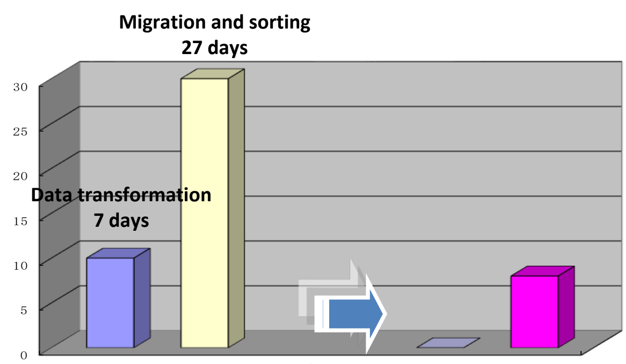
Comparison list	GeoEast	Software 1	Software 2
Data loading	Single job	Sequential loading	Sequential loading
Traveltime computation		Multiple times	Single time
Migration		Single time	Multiple times
Spiral gather sorting		Independent sorting	Independent sorting



Spiral gather of software1

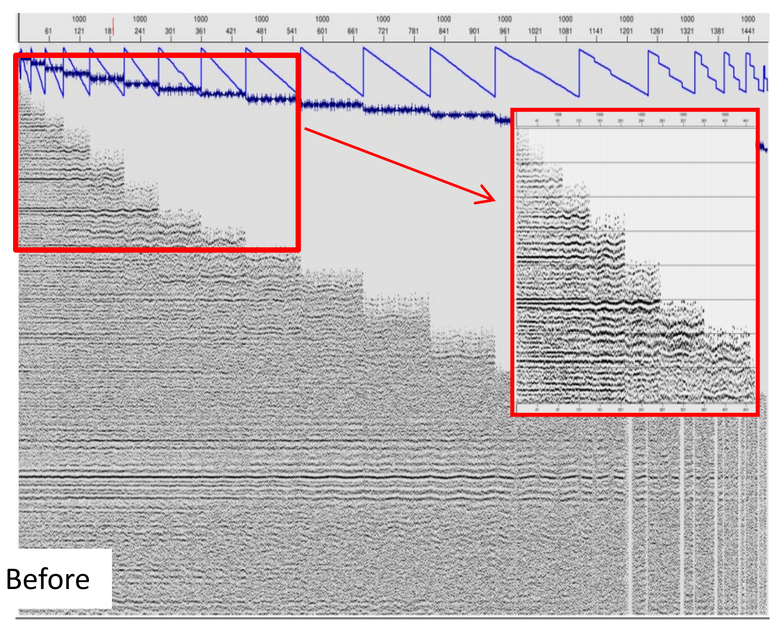


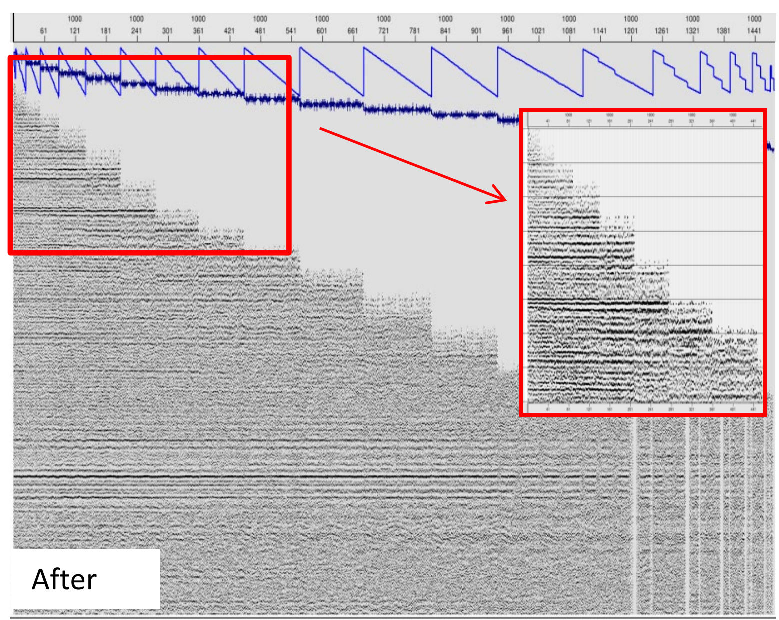
Spiral gather of GeoEast



HTI correction

The azimuthal anisotropy velocities is calculated by automatically picked residual moveouts, and the HTI effect correction is carried out by using the azimuthal anisotropy velocities.





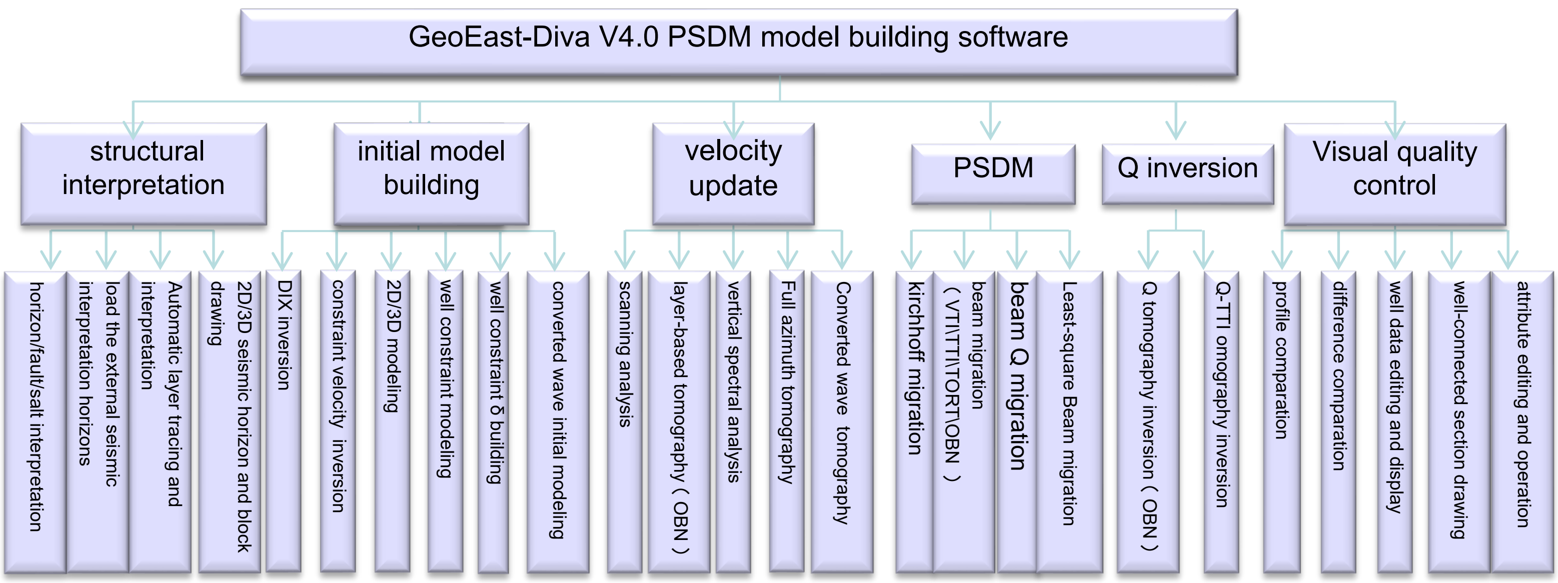
Spiral gather before and after HTI correction

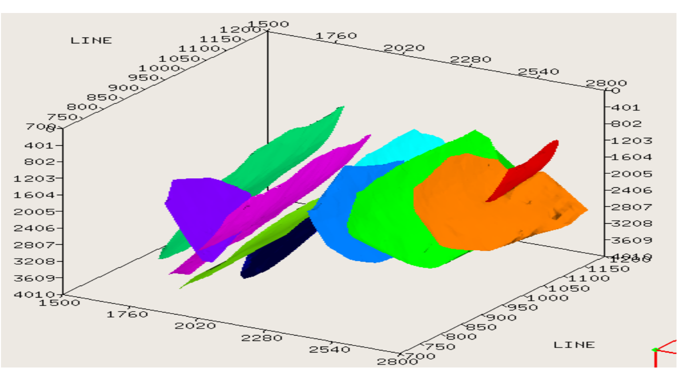
Velocity Model Building for Depth Imaging

GeoEast provides P-wave and PS-wave anisotropic velocity analysis in time domain, blocky velocity model building in depth domain, anisotropic grid tomography velocity updating and full waveform inversion.

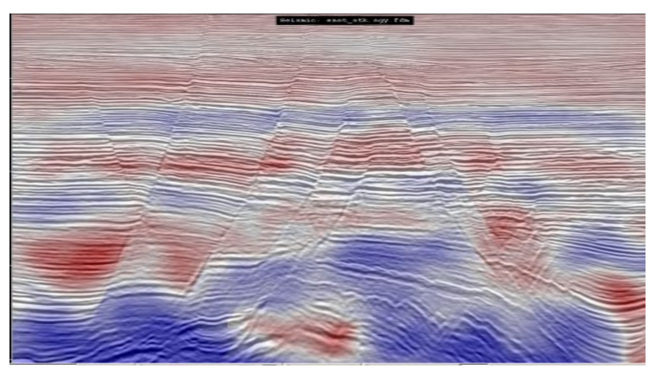
Diva, a depth domain velocity model building package

Diva can handle media of VTI/TTI/TORT and Q, it also can incorporate information and fault constraints. It can be used for building models of offshore with undulating surface, streamer and OBN.

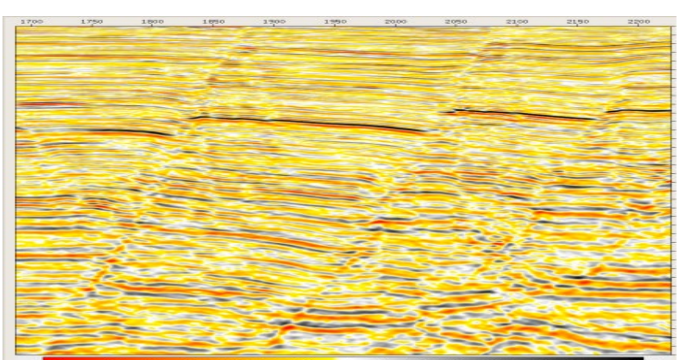




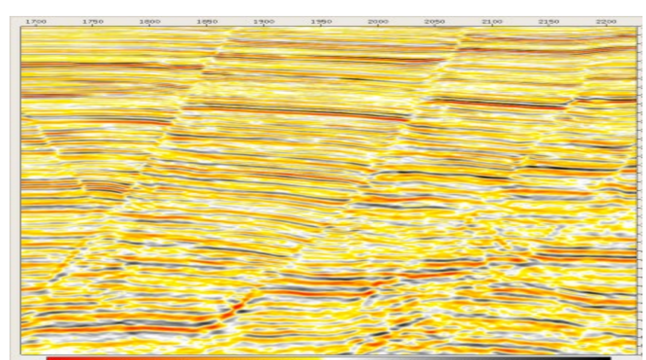
Fault-constrained construction



Velocity Updates of fault-controlled tomography



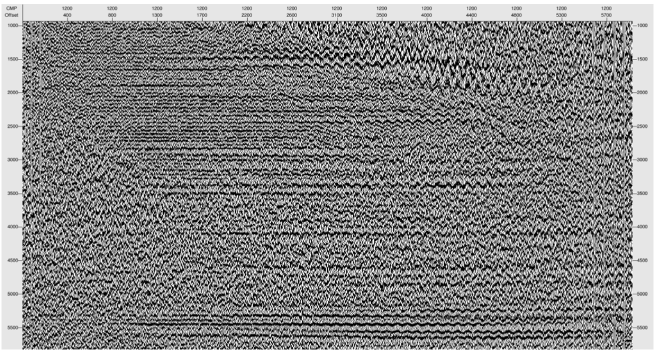
Initial PSDM



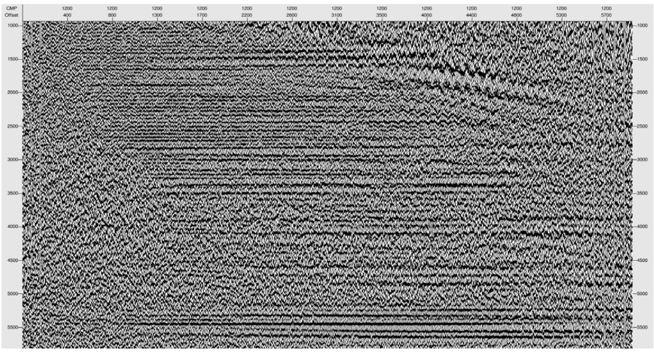
PSDM with Velocity Field From Fault Constrained Tomography

Anisotropic grid tomography velocity updating

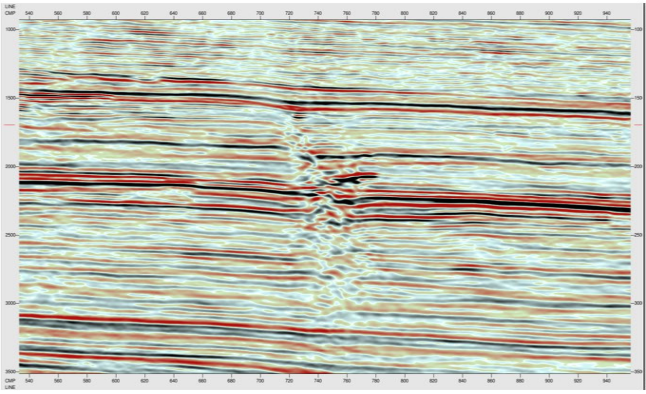
It can meet the requirements of fast seismic modeling of VTI / TTI / TORT in depth domain.



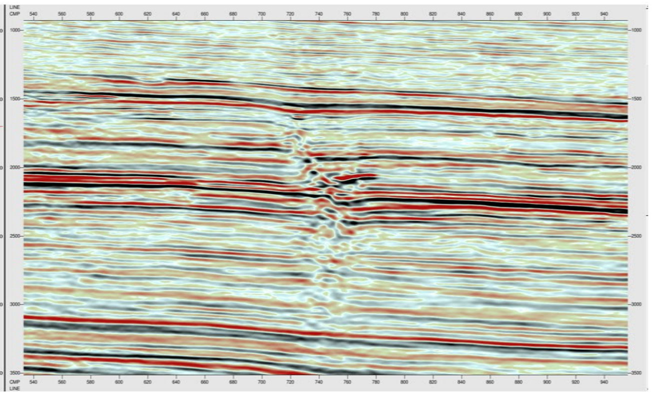
TTI PSDM Gathers



TORT PSDM Gathers



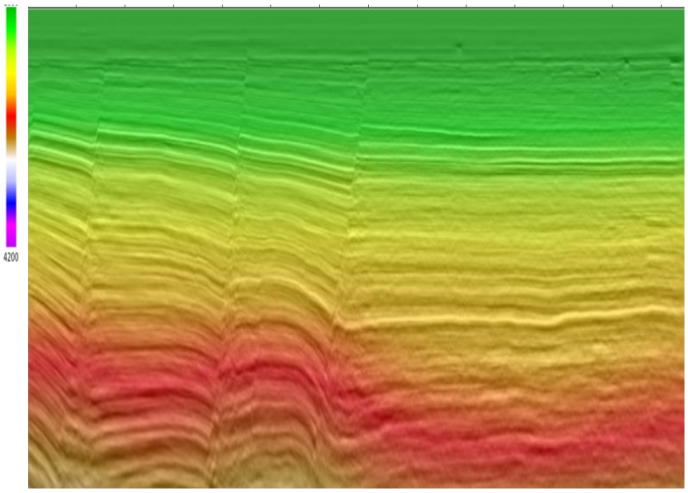
TTI PSDM Section



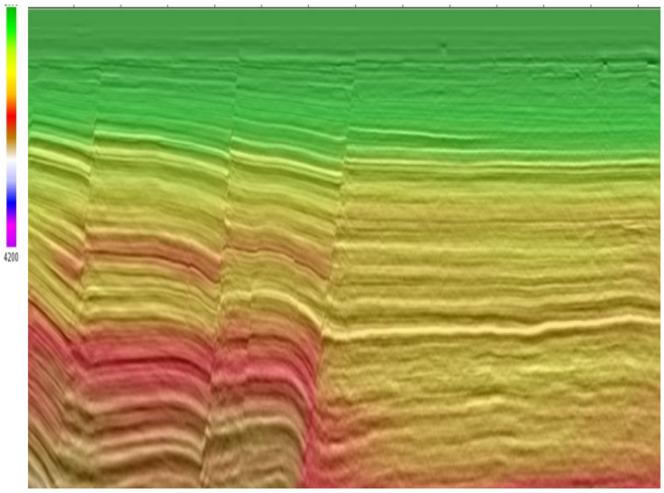
TORT PSDM Section

Full Waveform Inversion (FWI)

High-precision velocity model in depth domain can be built through full waveform inversion in time, frequency and Laplace domains combined with grid tomography.



PSDM with Initial Velocity Model



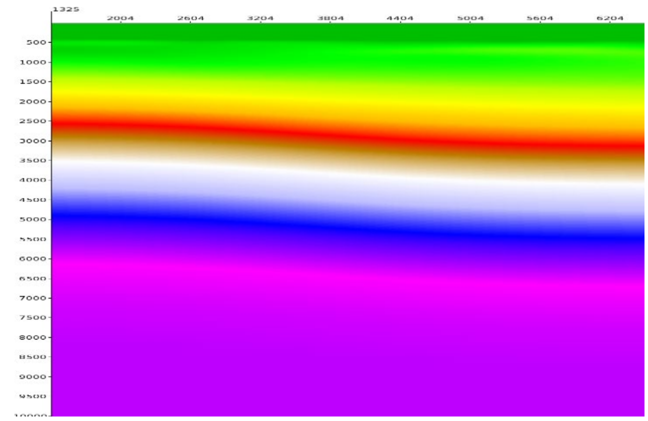
PSDM with Velocity Model Updated by FWI

Full waveform inversion (FWI) introduction

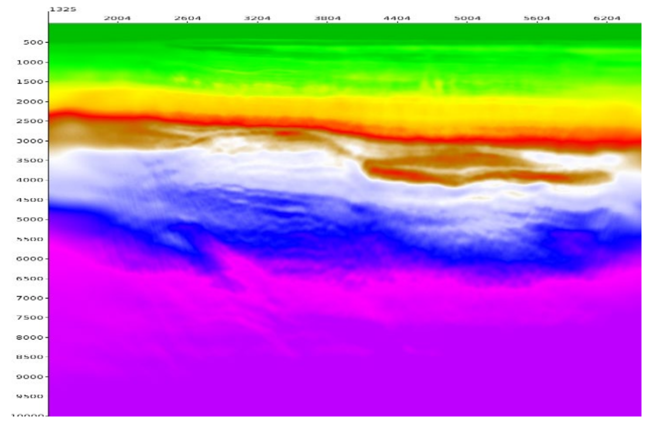
GeoEast Full-waveform inversion method includes refraction inversion and reflection inversion. We also have several ways to handle the cycle-skipping issues in FWI such as time-lag FWI; To deal with land, we also provide first-break FWI.

Conventional refraction FWI

Our conventional refraction FWI follows the standard optimization theory, where we minimize the two-norm errors of synthetic and recorded data, by utilizing optimization solvers like the steepest descent, nonlinear conjugate gradient, or even quasi-Newton method.



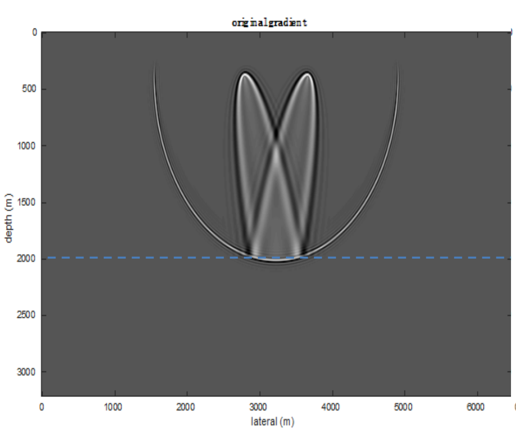
Initial velocity model



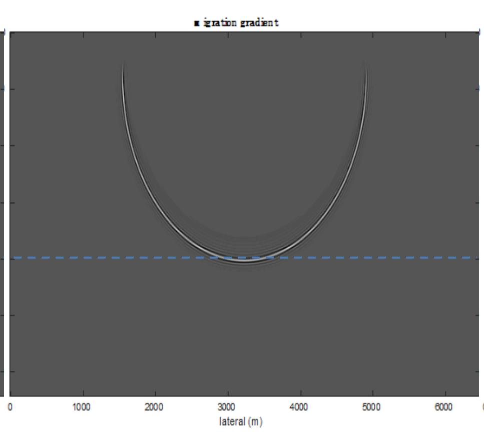
FWI velocity model

Reflection FWI

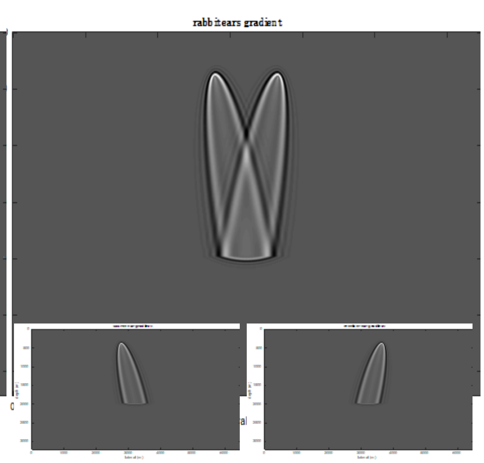
Similar to other providers, our reflection FWI uses gradient separation ideas to split standard FWI gradient into low wavenumber-rabbit ear' like- component and high wavenumber migration eclipse component. The low wavenumber part is used to update velocity, while the high wavenumber part is used to update density. Density update will yield notable reflections for the velocity update.



Standard FWI update



Reflection FWI update for dencity

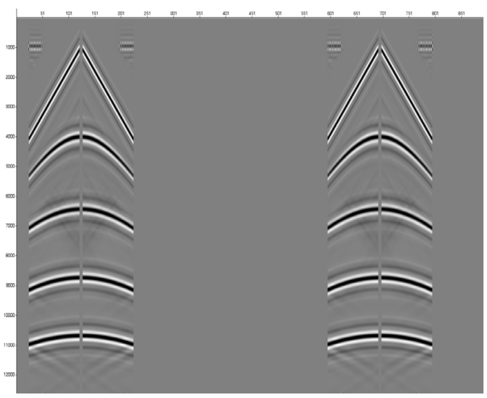


Reflection FWI update for velocity

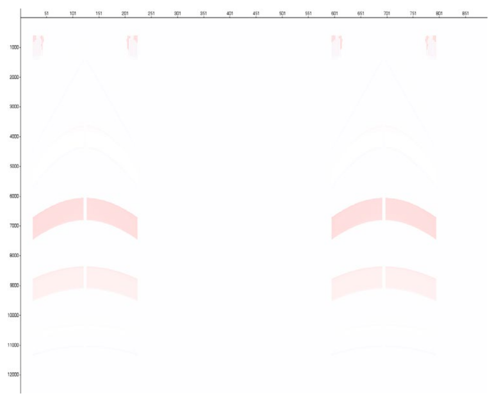
Full waveform inversion (FWI) introduction

Time-lag FWI

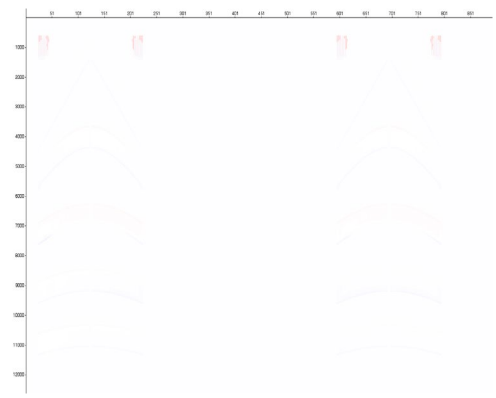
To tackle the cycle-skipping issue, we also developed time-lag FWI, in which we minimize the cross-correlation time lag of modeled and observed data. This approach can allow our inversion scheme to rely on the time error of the events, instead of the phase error which is the main cause of the cycle-skipping issue. We also possess other anti-cycle skipping technologies such as dynamic-time wrapping, adaptive-filter, and so on, prepared for different real data problems.



Modeling shot record



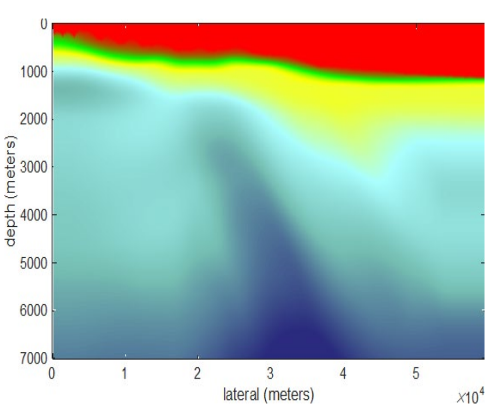
Time-lag of initial model



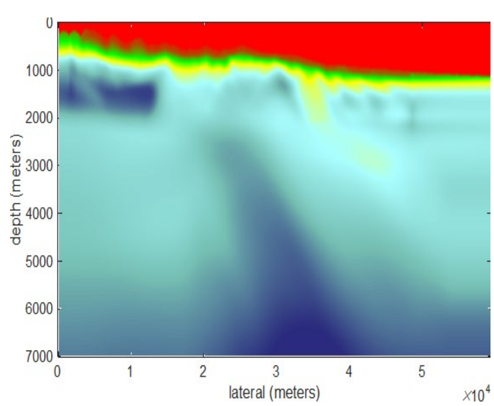
Time-lag after FWI

First-break FWI

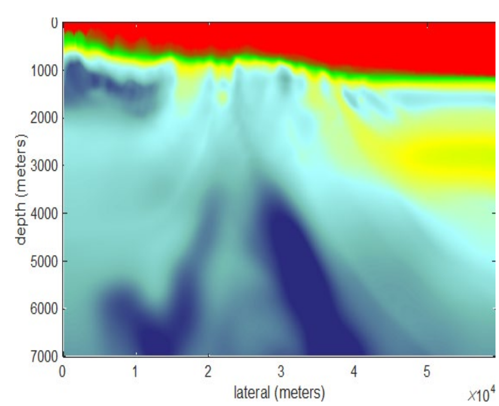
Inverting a land dataset is very challenging, because of the complexity of the data. A land acquired shot record has ground roll and guided wave components that are very hard to simulate accurately with wave equation modeling methods. Guided wave is refraction energy that travels multiple times between ground surface and reflectors. To play safe, one of the most practical approaches to run FWI on land data is to start inversion with first break information, which can be obtained freely from the static correction processing step.



Initial model



First-break FWI



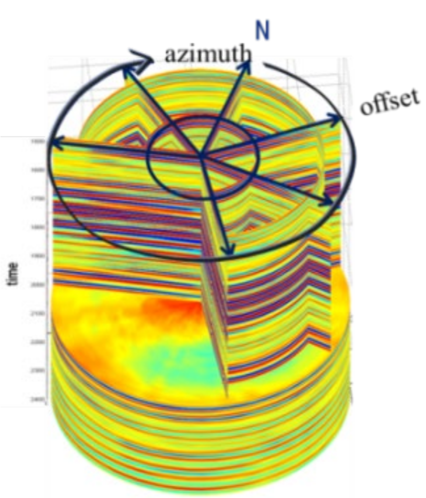
Conventional FWI

Pre-stack 5D Seismic Data Interpretation

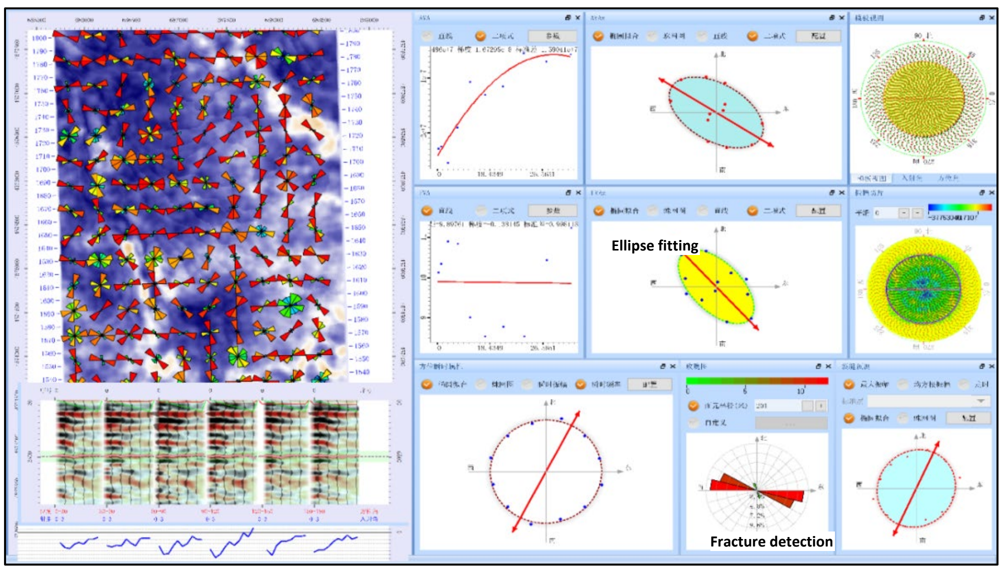
Pre-stack 5D interpretation techniques are developed to fully excavate pre-stack information. Compare to 3D data, the offset and azimuth anisotropy information of the pre-stack data are utilized to finely depict the distribution of fractures and hydrocarbon.

Interactive 5D Seismic Data Analysis

Advanced 5D seismic data interpretation involves 5D gather optimization and analysis, template-based partial azimuth/offset stacking and pre-stack fracture detection by ellipse fitting method, and azimuth-based hydrocarbon detection.



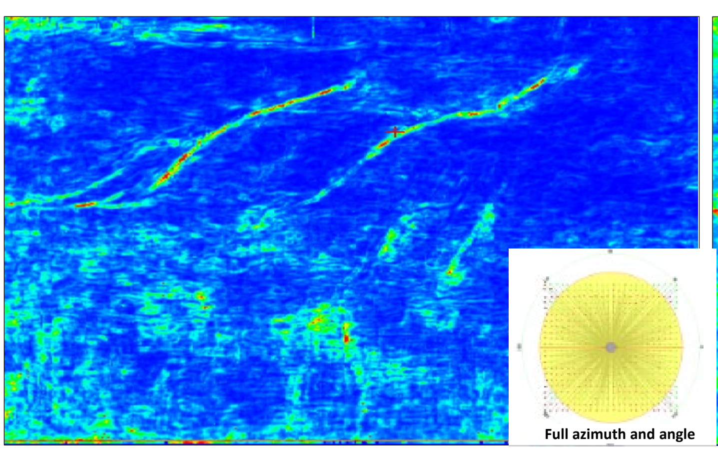
Prestack 5D gather



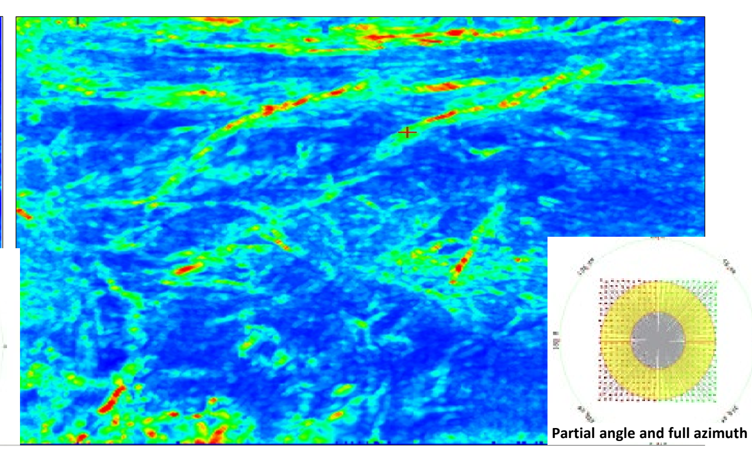
Interactive 5D seismic data analysis

Geological objective-guided interactive template optimization

GeoEast provides interactive 5D gather optimization template definition function, the user can define partial stacking parameter considering geological factors such as burial depth, fault strike and structure attitude. This functionality leads to the improvement of the image quality and accuracy of fracture detection and hydrocarbon detection.



Full azimuth and angle stacking
suppress geological detail

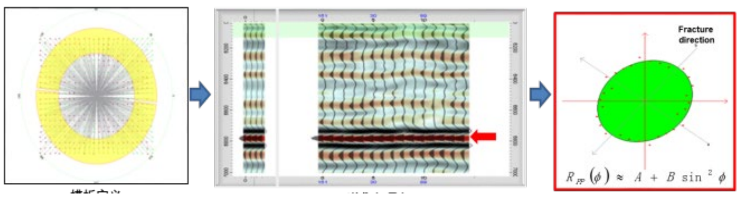


Partial azimuth and angle stacking
reveal more information

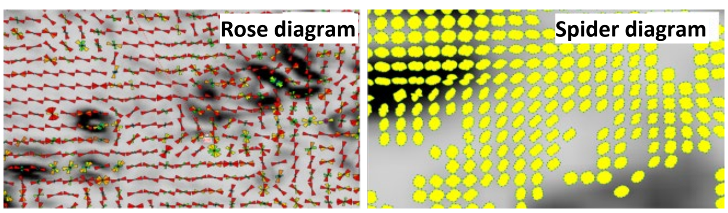
Pre-stack 5D Seismic Data Interpretation

Pre-stack fracture prediction based on 5D seismic data

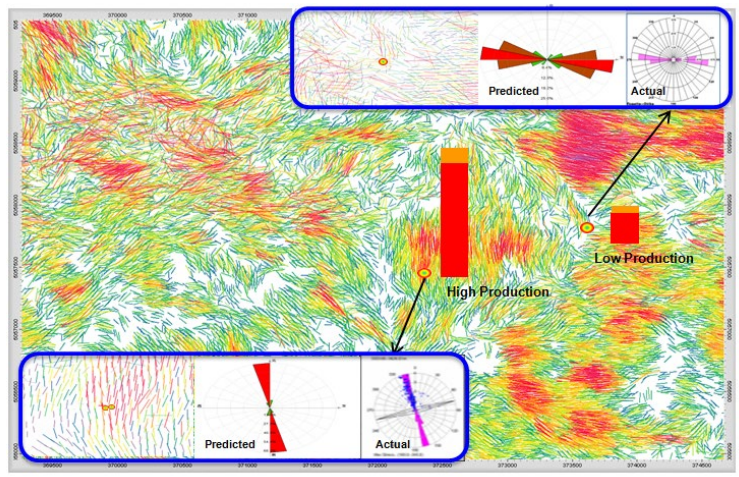
Based on HTI theory, fracture azimuth, density and degree of confidence are detected with the optimized 5D gather, where elliptical fitting or statistics are employed to analyze seismic attributes such as amplitude and travel time.



Anisotropy analysis based on optimal template



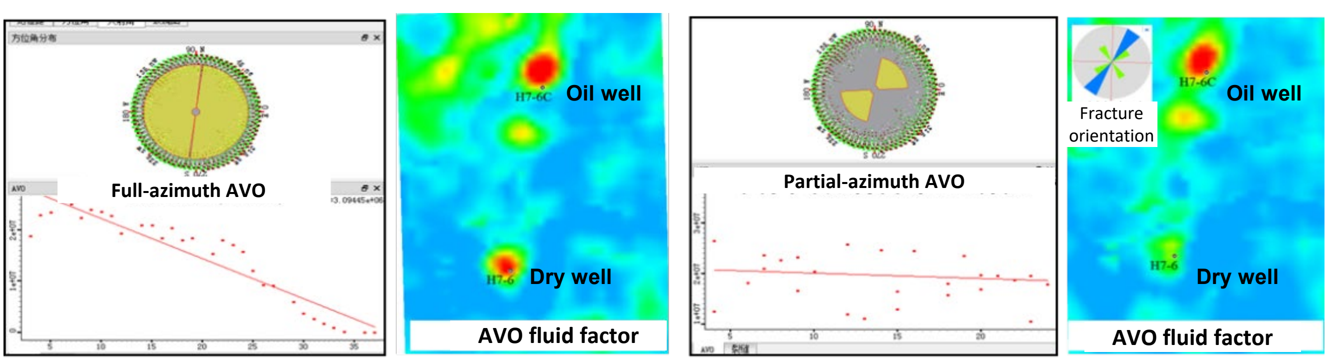
Various displays of fracture detection results



Comparison of detected fracture based on 5D seismic data and measured fracture in a block in West China

AVOAz

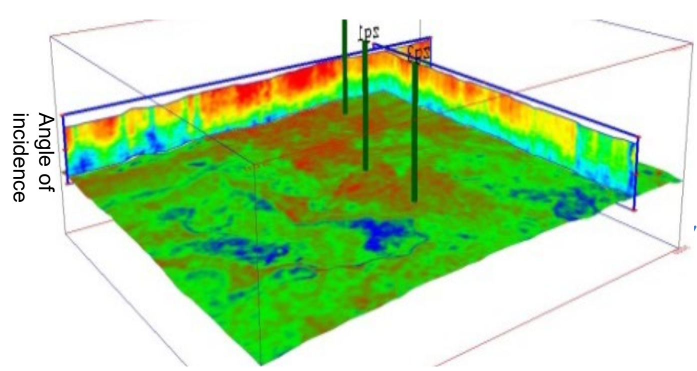
Azimuthal AVO analysis based on 5D gather data can effectively mitigate the pitfalls of anisotropy impact on AVO, and thus improve hydrocarbon detection accuracy.



The application of AVOAz to detect hydrocarbon can effectively reduce the impact of fracture anisotropy

FVOAz

FVO is used to investigate the frequency gradient and intercept of the formation of interest. FVO analysis can be performed along the fracture orientation to increase the accuracy of hydrocarbon detection.



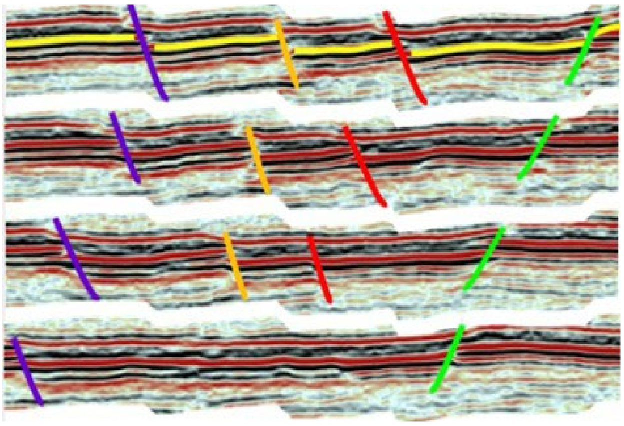
FVO gradient (plane) and frequency (section) along horizon

Fine Efficient Structure Interpretation and Modeling

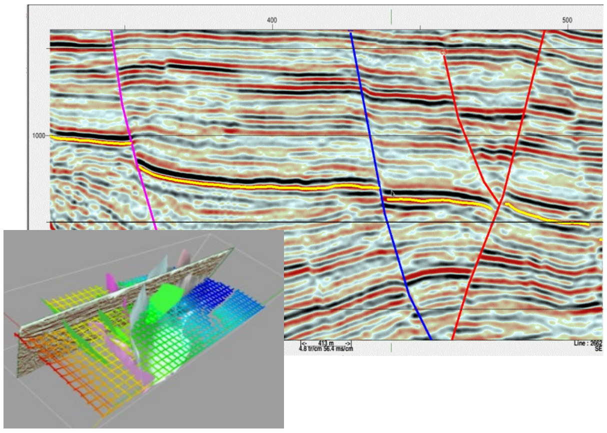
GeoEast structure interpretation supports basin level multi-survey joint 2D/3D interpretation in time and depth domains, with specific techniques in multi-line section interpretation, horizon auto-tracking, fault auto-tracking and fault polygon auto-interpretation, trap auto-generation and trap elements auto-statistics, etc.

Efficient horizon interpretation

Based on high-precision well-seismic calibration and multi-well correlation, four horizon auto-tracking methods have been developed to fit for seismic data of different qualities. Combined with 3DV , the precision and efficiency of horizon interpretation are further improved.



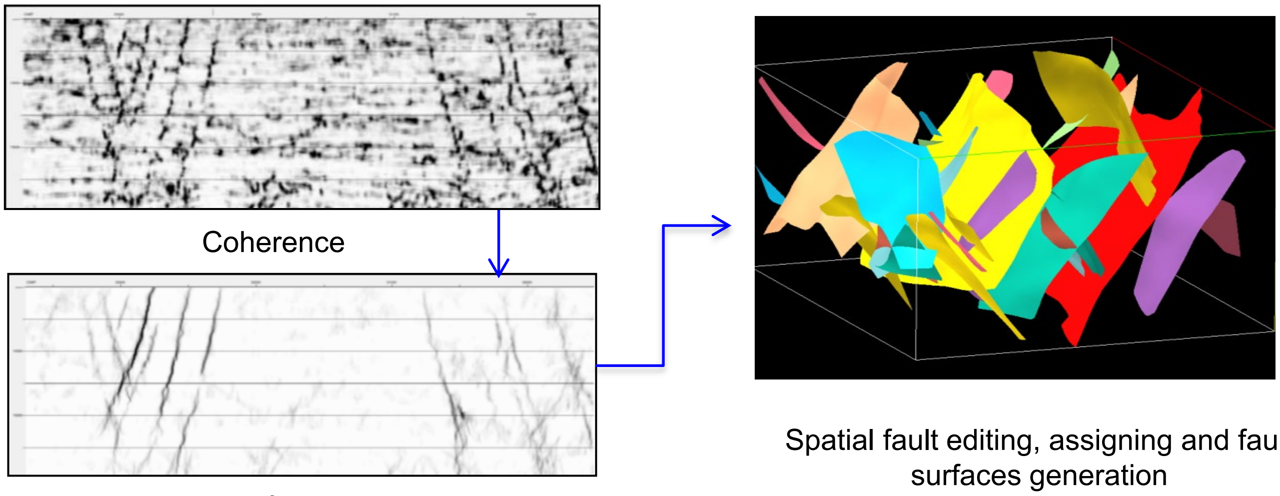
Multi-line section interpretation



Horizon auto-tracking in 2D and 3D scene

High-precision fault interpretation

Functions provided include section/slice fault interpretation, real-time fault surface generation, footwall/hanging wall auto-identification, fault auto-tracking. Multi-line section technique is available to compare subtle fault changes among adjacent sections to ensure the interpretation accuracy. Combined structural attributes with 3DV, fault auto-tracking are performed with improved efficiency.



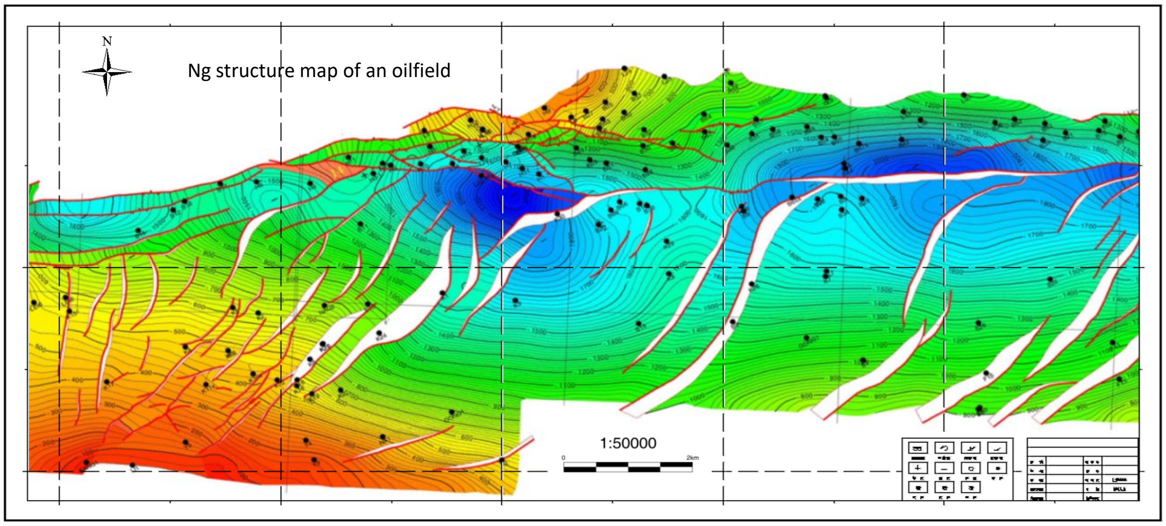
Coherence

Ant

Spatial fault editing, assigning and fault surfaces generation

Structure mapping

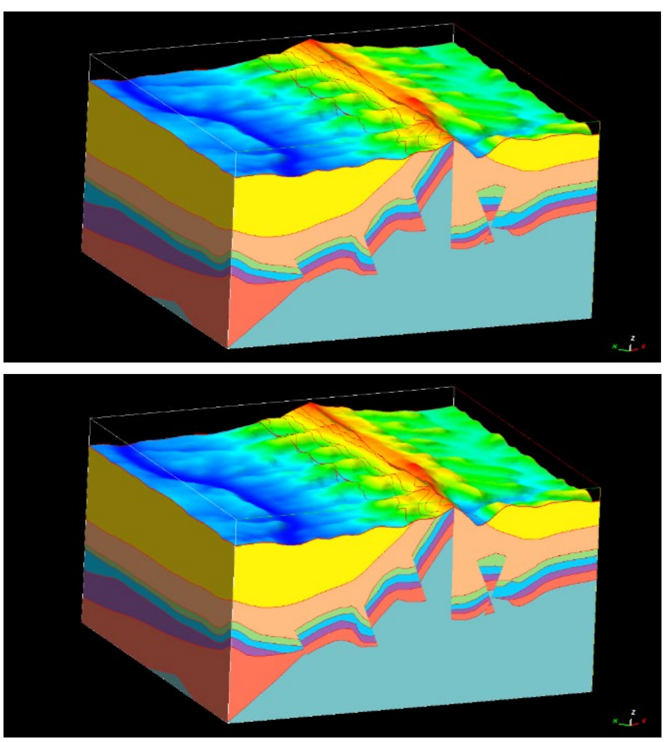
GeoEast is capable of mapping joint 2D/3D multi-surveys with massive data, with flexibility in simultaneous multi-geobody mapping, interactive contour editing, trap auto-tracking and elements auto-statistics. It supports duty tables, legends and labels, titles and other user-defined notes, and it also supports various file formats export such as CGM and DXF.



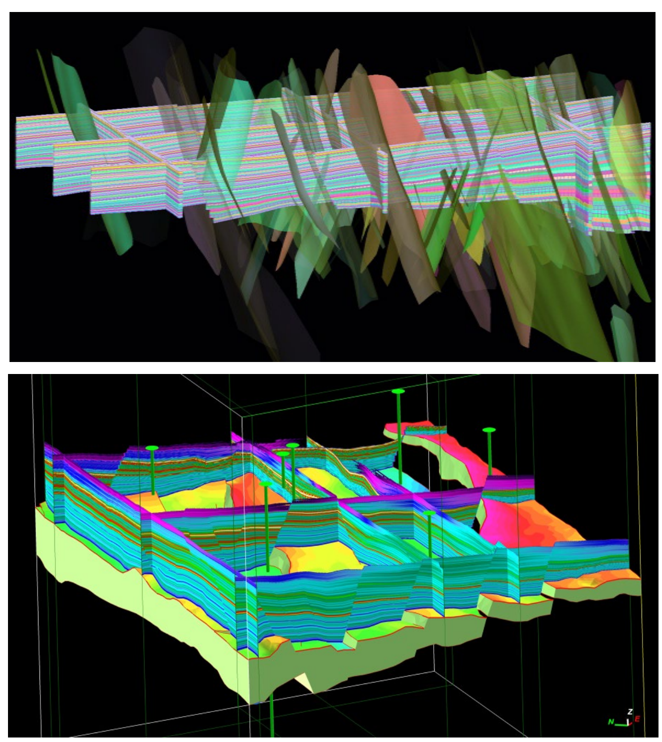
Flexible and convenient industrial mapping

Complex 3D Structure Modeling

GeoEast provides integrated interpretation and complex 3D modeling functions. The dynamic modeling technique supports complicated structure modeling for normal/reverse faults, unconformities, salt domes, and property modeling with structure constraint..



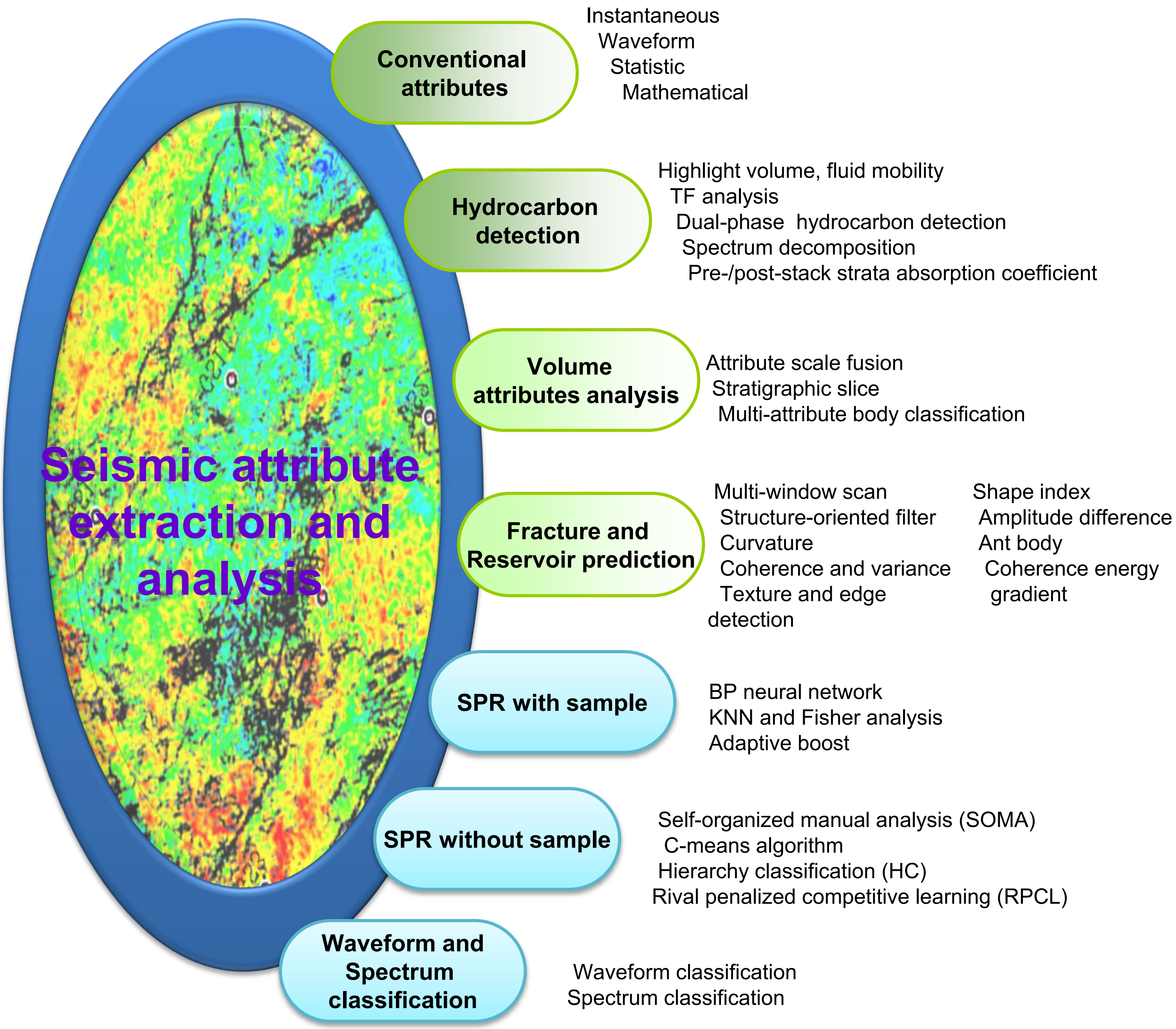
Reverse fault modeling



Property modeling

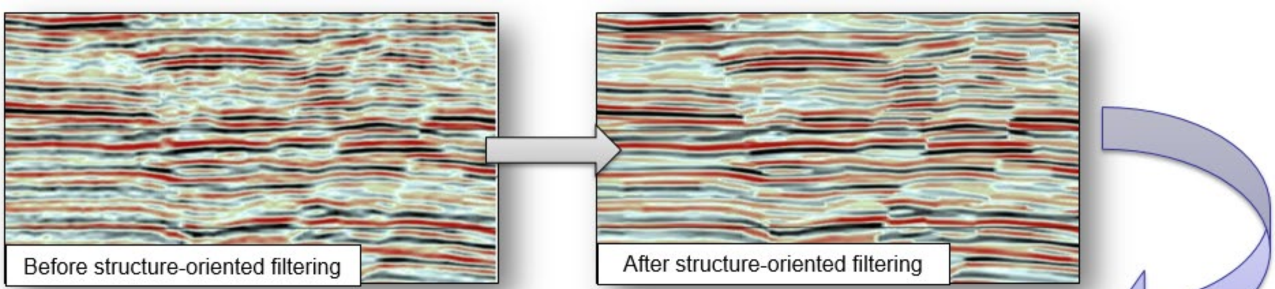
Modern Seismic Attribute Extraction and Analysis

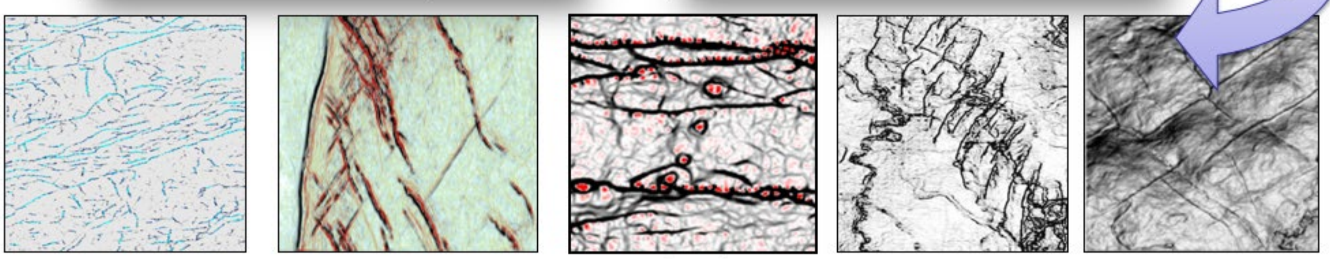
Over 100 volume attributes, 60 surface attributes, and 9 attribute classification techniques are provided, which, combined with drilling data, are widely used in reservoir prediction, hydrocarbon detection, seismic and sedimentary facies analysis for complicated geobodies such as sandbody, channel, carbonate reservoir, reef and volcanoes.



Fault Identification

On the basis of structure-oriented filtering, multi-scale volume curvature, coherence, variance, edge detection, dip, ant volume, fault index, attribute fusion and other technologies are used to finely depict small scale faults.



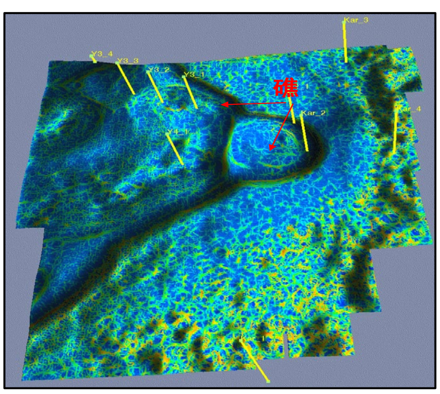


Ant | Fault index | Curvature | Coherence | Dip

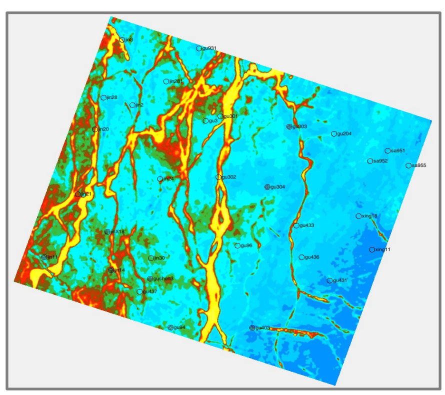
Attribute assist fault identification

Various type of Reservoir Prediction

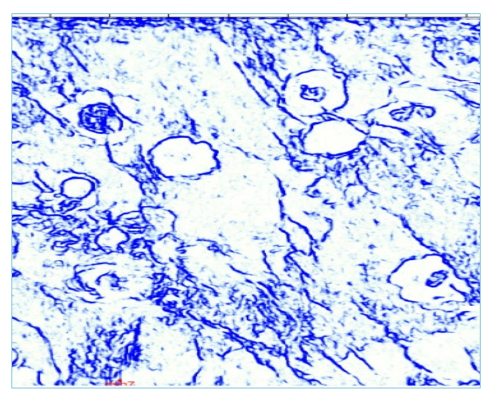
GeoEast provides a complete technique suite for diversified reservoir prediction. The modern seismic attribute and AI based attribute analysis functions are used for various type of reservoir characterization such as subtle fault or fracture, karst caves, channel, reef, volcano, and so on.



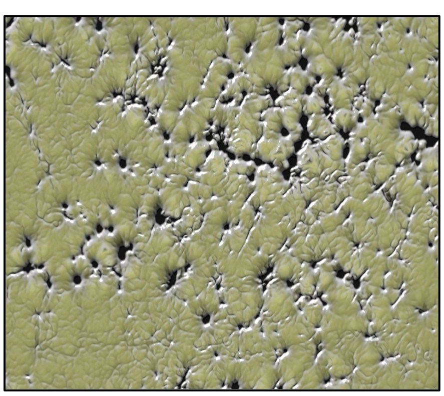
Reef



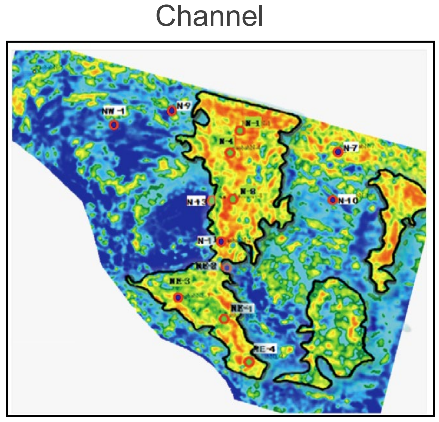
Channel



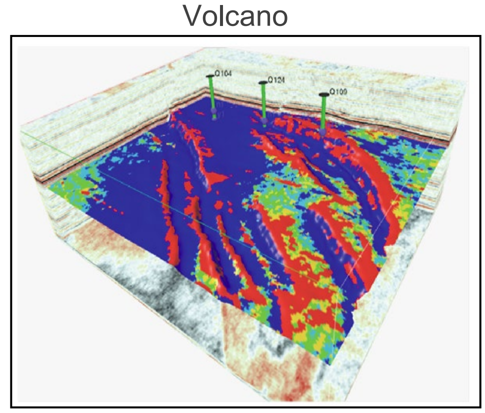
Volcano



Karst Cave



Hydrocarbon detection

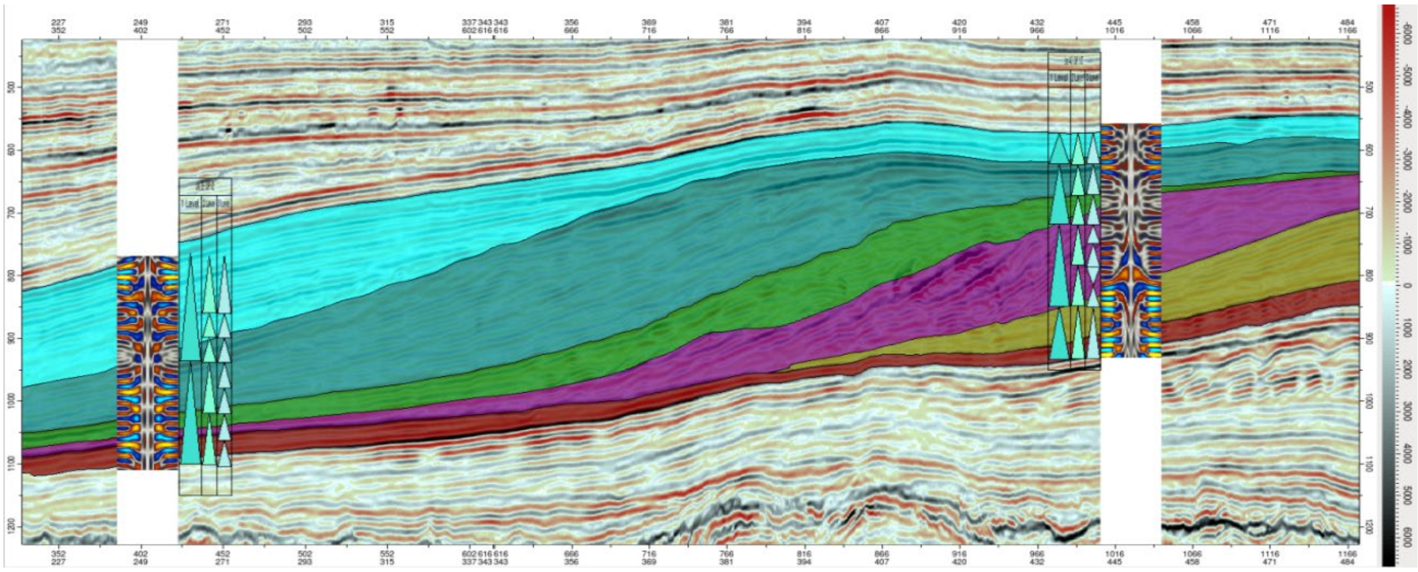


Sedimentary facies analysis

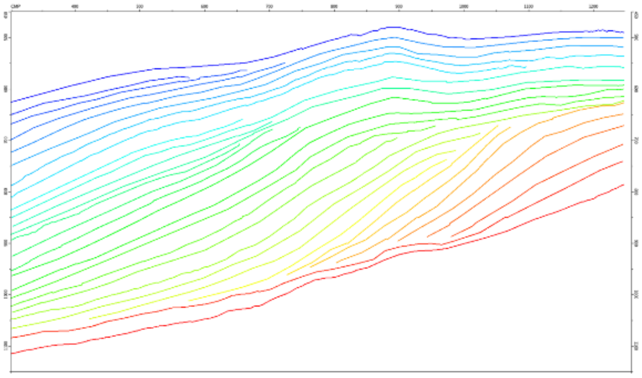
Sequence Stratigraphy Interpretation and Geologic Analysis

Sequence Stratigraphy Interpretation

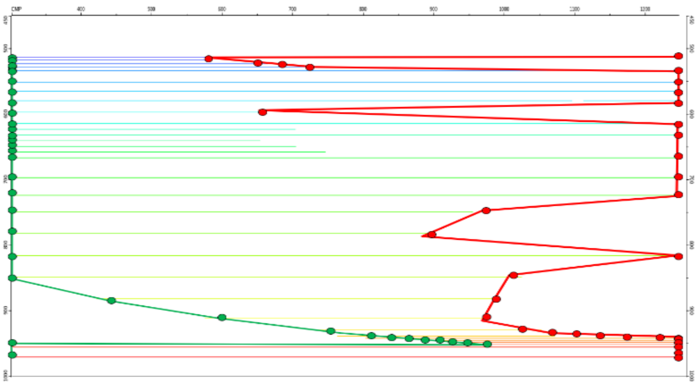
GeoEast provides efficient seismic stratigraphic interpretation functions. Several sequence analysis tools are available including single well sequence analysis, seismic stratigraphic cube analysis, Wheeler domain transform and depositional cycle division based on the sequence stratigraphy theory, assisting in identifying lithologic traps and subtle reservoirs.



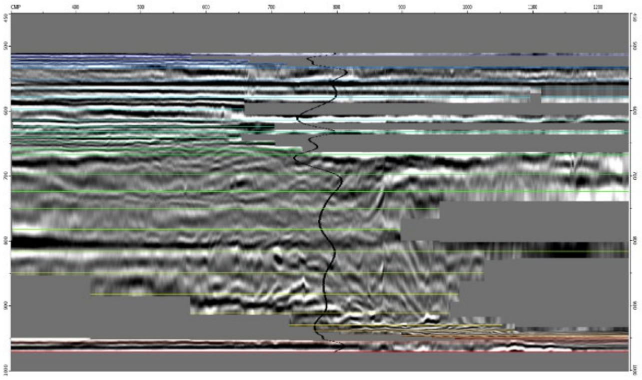
Time-frequency-based sequence stratigraphic interpretation



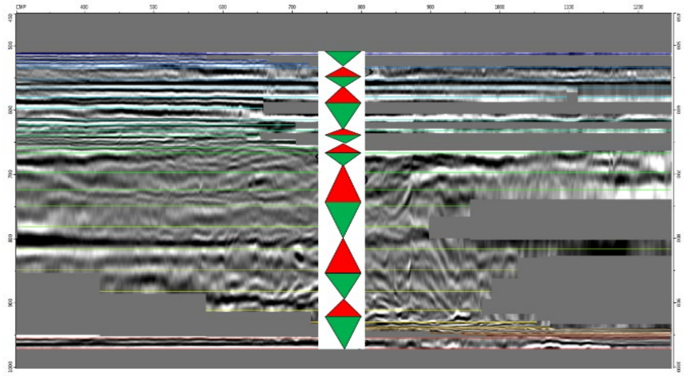
Sequence stratigraphic analysis



Strata denudation line auto-track



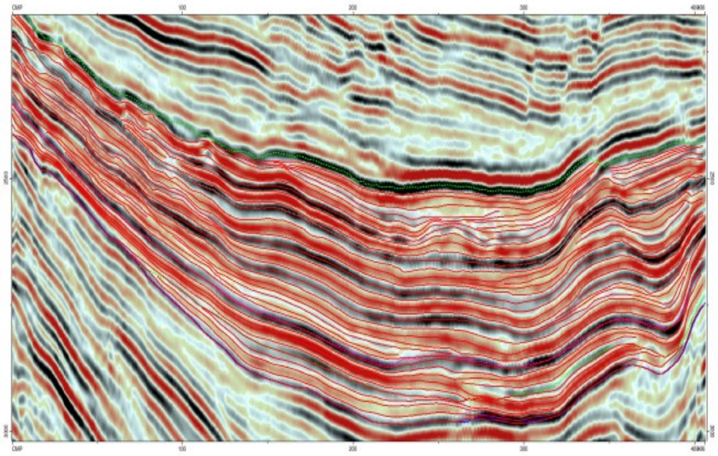
Strata cycle auto calculation



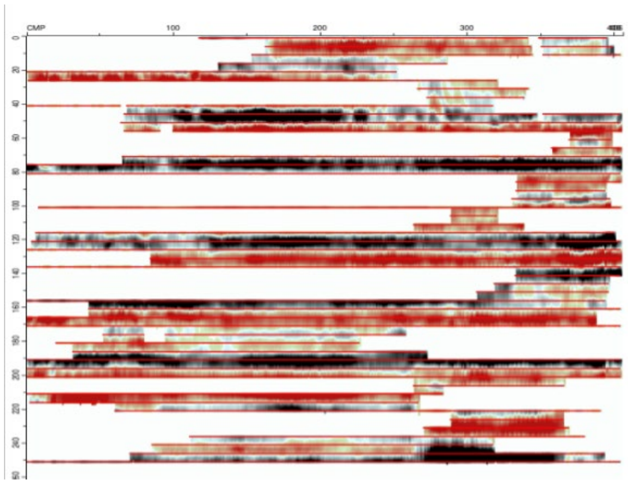
Sedimentary cycle analysis

Sequence Stratigraphy Interpretation and Geologic Analysis

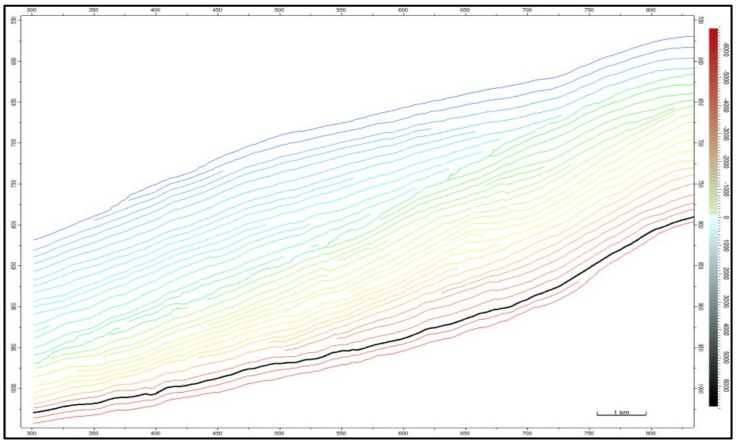
Sequence Stratigraphy Interpretation



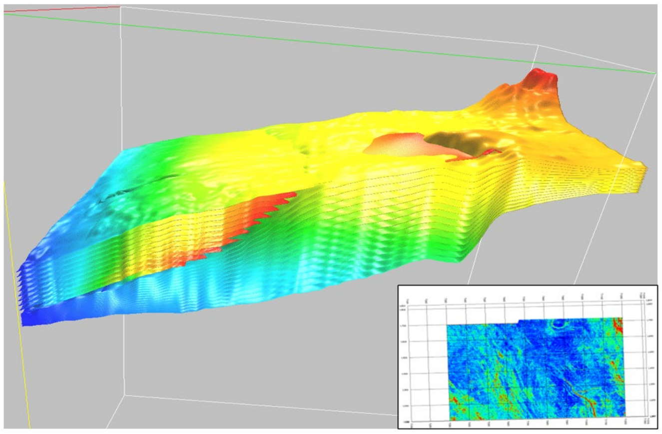
Seismic stratigraphy analysis



Wheeler-domain transform



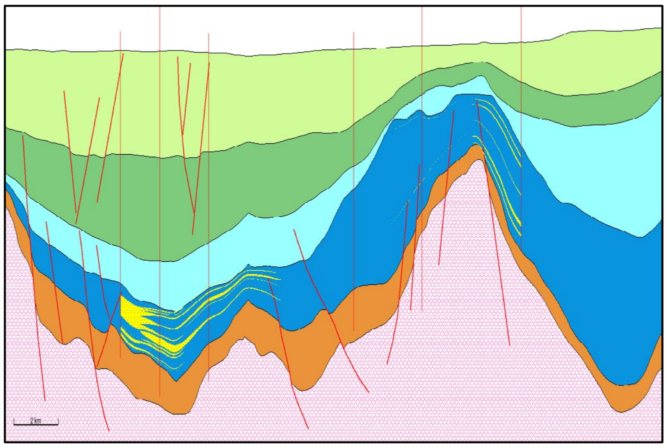
Seismic stratigraphy cube



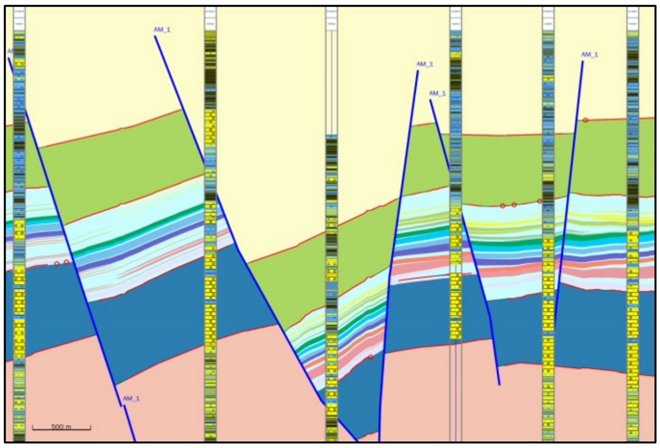
Stratigraphic surface attribute

Geological Analysis

GeoEast provides 2D geological and reservoir profile auto-generation function based on seismic interpretation results, and the well correlation constrained by seismic attributes. These tools give large improvement in efficiency and accuracy geological analysis.



Reservoir profile auto-generation



Seismic constraint well correlation

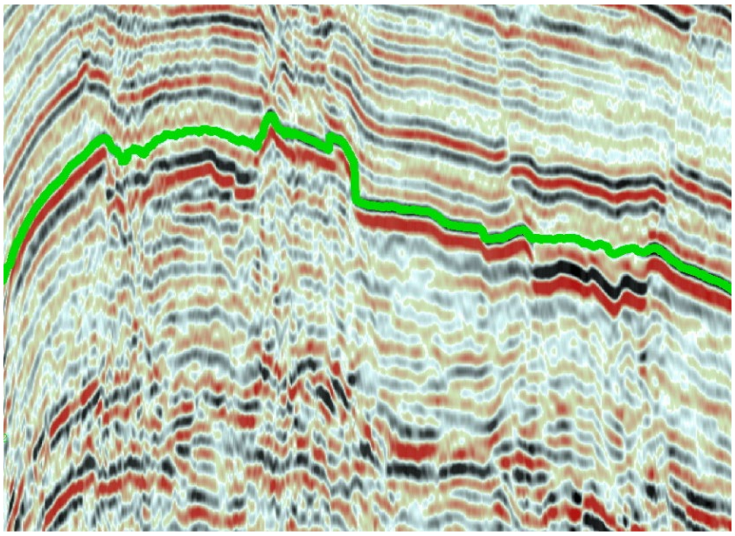
Deep Learning-based Horizon and Fault Interpretation

AI-based Seismic Data Interpretation

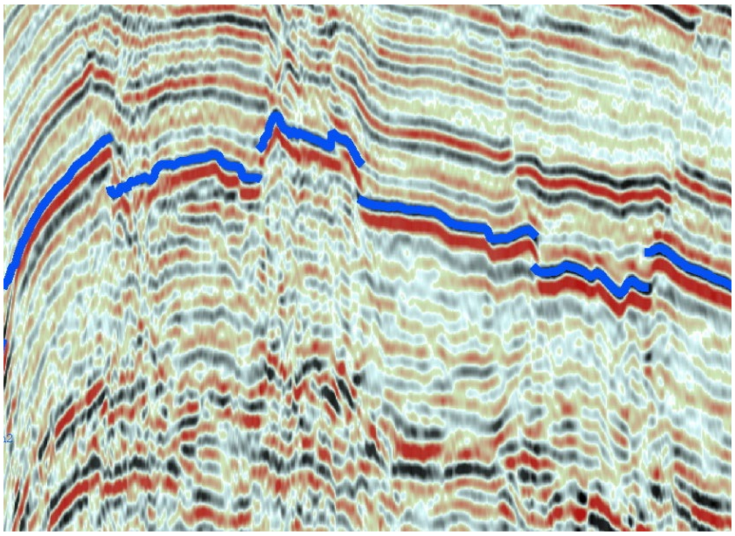
In oil & gas exploration field, artificial intelligence technique have been paid increasing attention. BGP attaches great importance to the research and development of AI technique.

Deep Learning-based Horizon Interpretation

The traditional horizon auto tracking technique is often based on waveform similarity or spatial density, which is not reliable when the seismic event encounter fault. However, even without fault constraint, deep learning based horizon auto tracking technique is able to obtain decent result in fault zone.

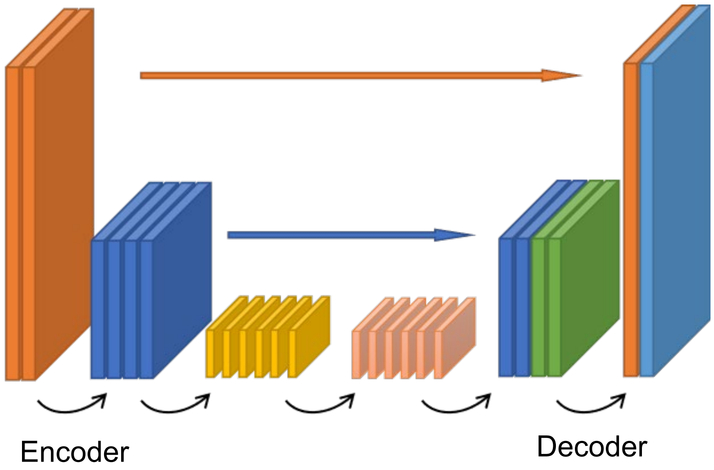


Traditional horizon auto tracking

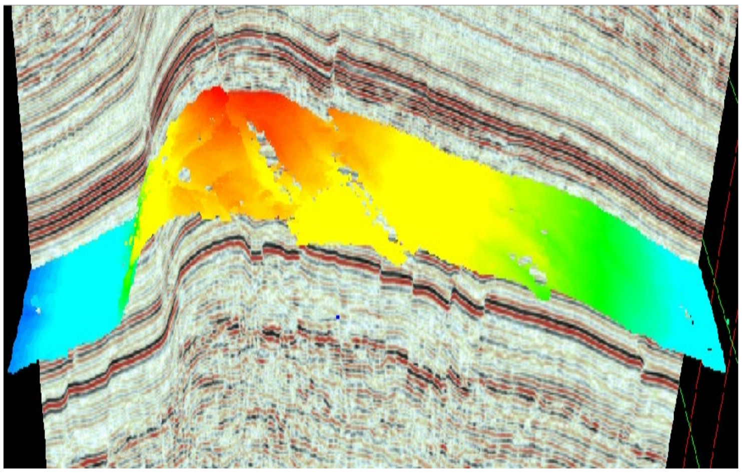


Deep learning based horizon interpretation

The Encoder-Decoder network based horizon auto tracking technique utilizes Encoder to extract multi-scale feature and Decoder to identify multi-scale horizon, so as to minimize the error.



Encoder-Decoder network architecture



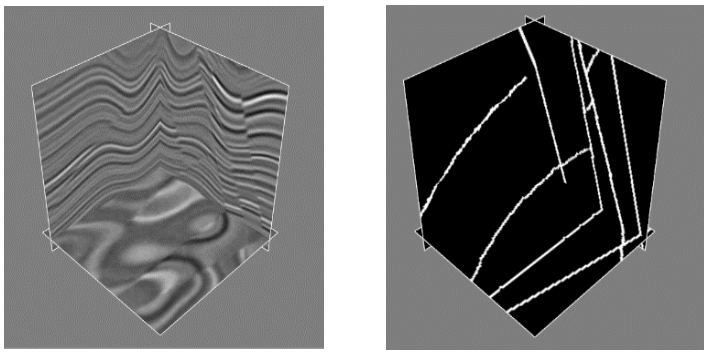
GeoEast AI horizon interpretation in 3D scene

The accuracy and efficiency of Deep learning-based horizon interpretation is promising. The accuracy of AI interpretation of single horizon in the faulted dataset is up to 97%, and the efficiency is greatly improved compare to traditional auto tracking and manual modification.

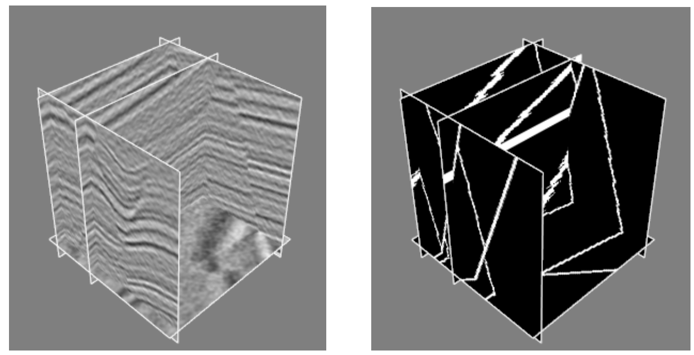
Deep Learning-based Horizon and Fault Interpretation

Deep Learning-based Fault Interpretation

GeoEast integrates synthetic label with field data label to create a complete tag library that covers most of the fault types. It innovatively adopts the theoretical model plus field data driven deep learning algorithm to realize automatic fault identification.

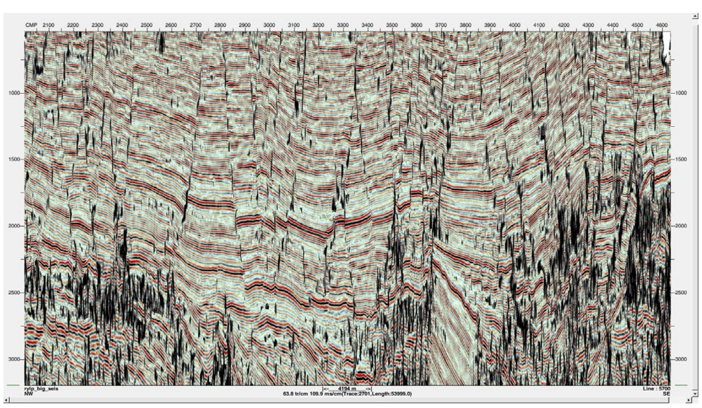


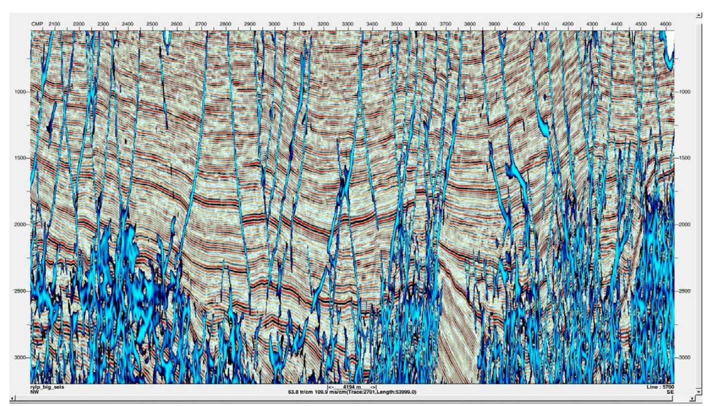
Synthetic data label

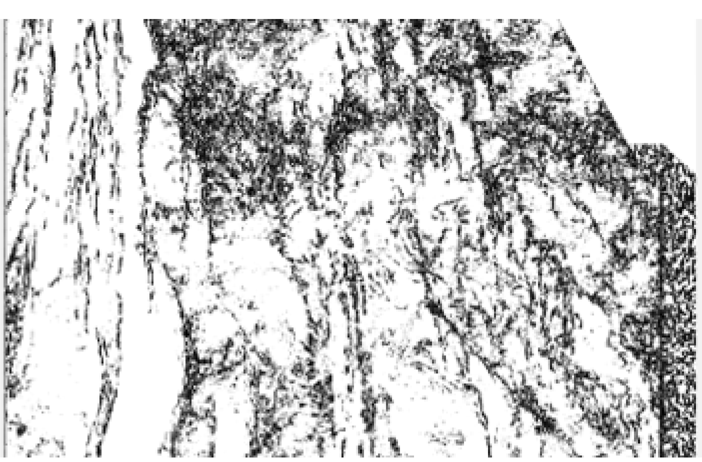


Field data label

In deep learning-based fault interpretation, we apply U-net model and introduce attention mechanism to focus on fault skeleton. So that the fault imaging result is much more clean and continuous than tradition fault attribute such as coherence.







Coherence

Deep learning

Comparison of coherence attribute and deep learning based fault interpretation