BGP – Beyond Geophysical Prospecting

BGP

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BGP

BGP

Company Profile

BGP, an integrated geo-solution provider, strives in its policies to be human-oriented,attach primary importance to health and safety and devote itself to worldwide environmentalprotection and to play its part in the transition to renewable Energy sources and sobecoming a more responsible and sustainable company.

Business Scope

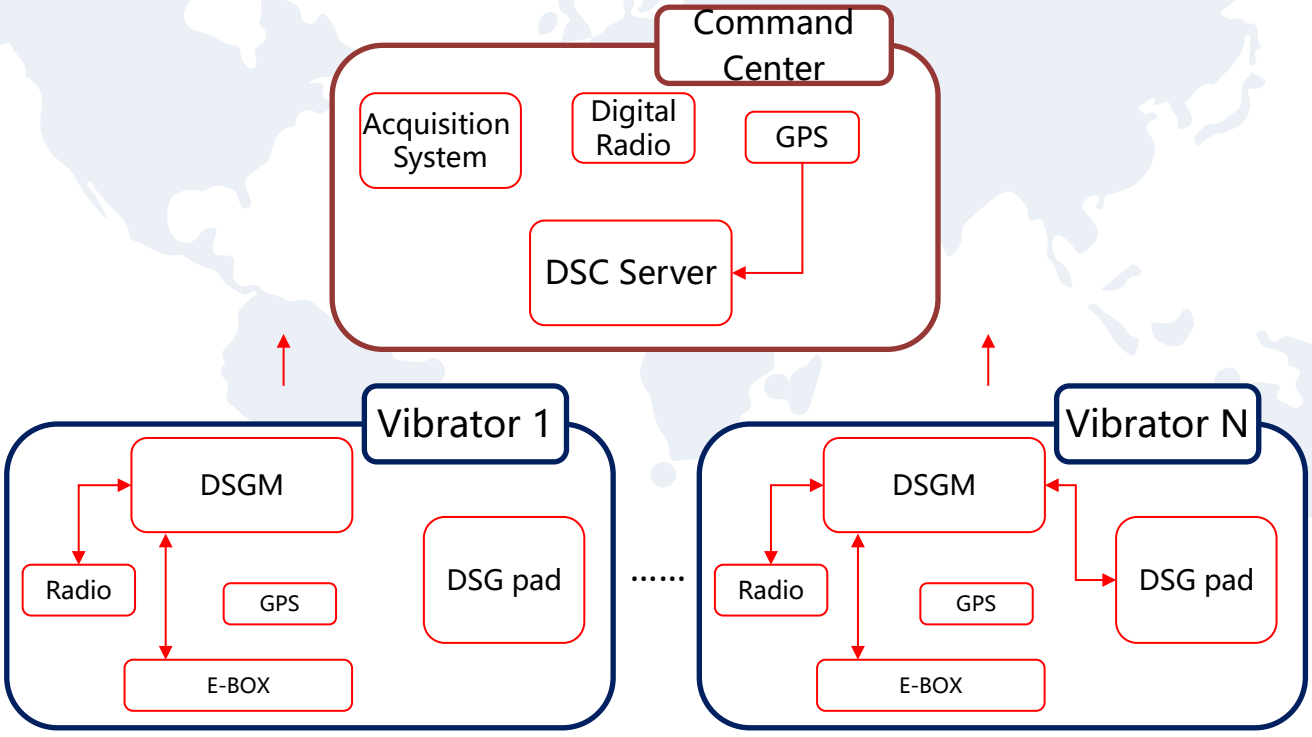
- Onshore Seismic Acquisition
- Offshore Seismic Acquisition
- Seismic Data Processing
- Seismic Data Interpretation & Reservoir Geophysics
- Geophysical R & D
- Optical Fiber Intelligence Reservoir Geophysics (OFIRG)
- Non-Seismic Surveys
- Geophysical Software Systems
- Equipment Manufacturing
- Multi-Client Business
- New Energy Business

Digital Seismic System

Digital seismic system, referred to DSS, is a seismic production management and acquisition control system that uses intelligent information technology to realize convenient and effective exploration. Over the years, DSS has simplified the process of field operations, production management and command coordination by virtue of its low consumption, high efficiency and reliable technical characteristics, greatly optimizing the production efficiency. DSS is suitable for a variety of production modes, becoming a powerful instrument for BGP overseas markets.

Architecture

DSS consists of DSC(Digital Seismic Commander) and DSG(Digital Seismic Guidance)



DSS Architecture

Features

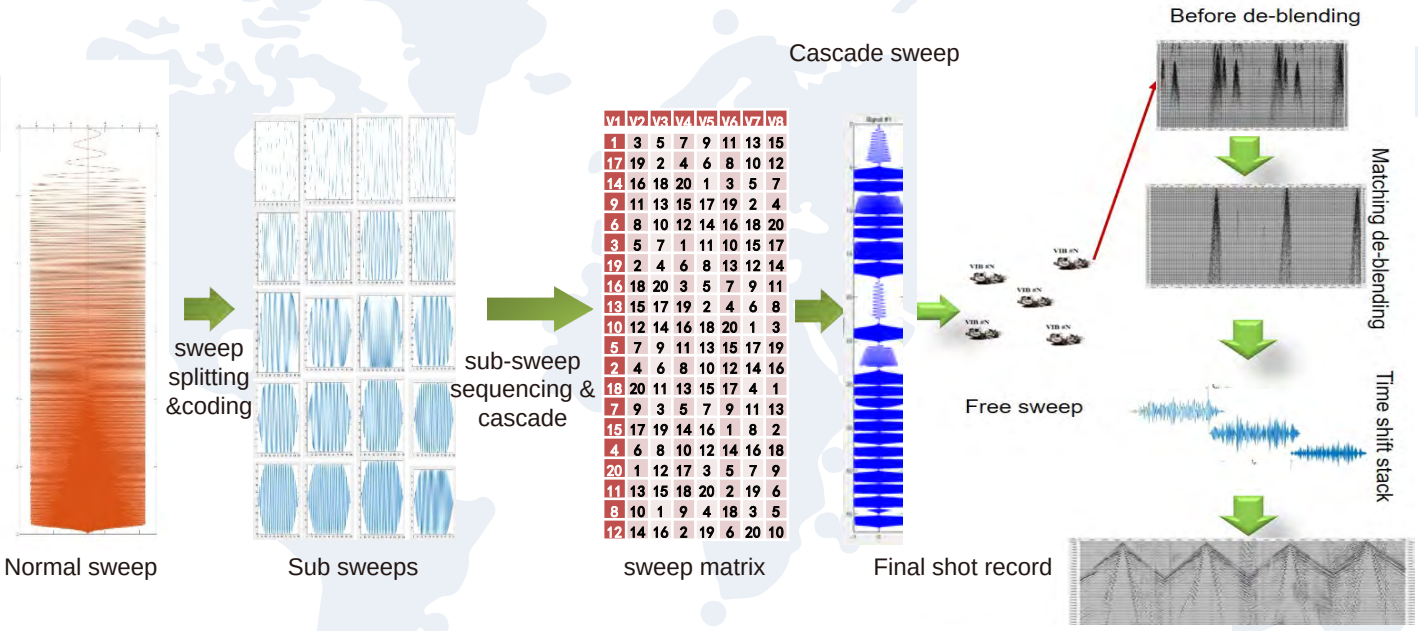
- Stake-less Navigation: DSG only, Suitable for vibrator operation, bulldozer construction and other engineering vehicle navigation.
- Production Monitoring: (DSC and DSG) Suitable for observer to monitor production and not control the vibrator. Observer distributes tasks for vibrator groups and vibrators feedback production and quality control information.
- Real-time Shooting Control: (DSC and DSG) Suitable for joint operation of observer and vibrator. Observer controls the vibrator shooting and gets QC information from the vibrators.

Frequency Separated Simultaneous Sweep (FSSS)

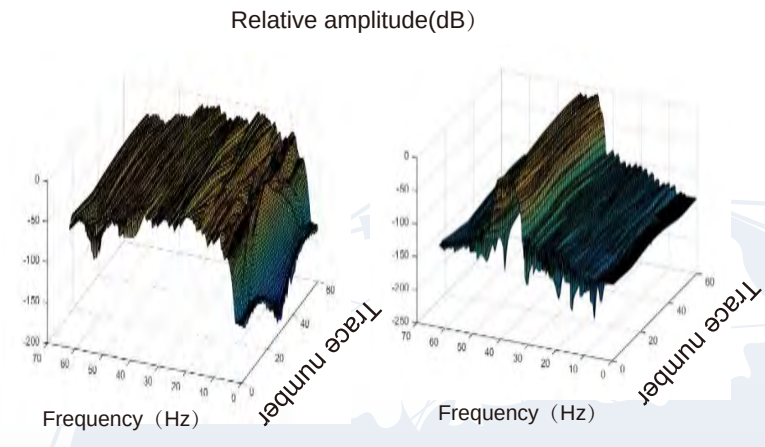
A High fidelity and productivity vibroseis acquisition method

Based on time-frequency domain orthogonality between different sweeps, Frequency Separated Simultaneous Sweep (FSSS) will eliminate the blended noise and maintain high fidelity with high productivity.

FSSS Functional Diagram

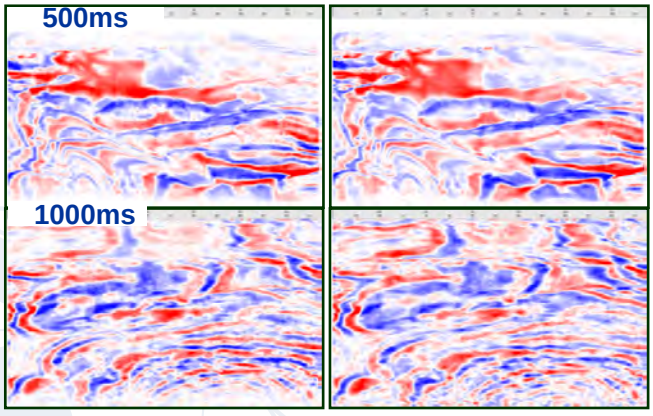


FSSS results



Before de-blending　　After de-blending

Comparison of 2D FFT spectrum



Flip-flop　　FSSS

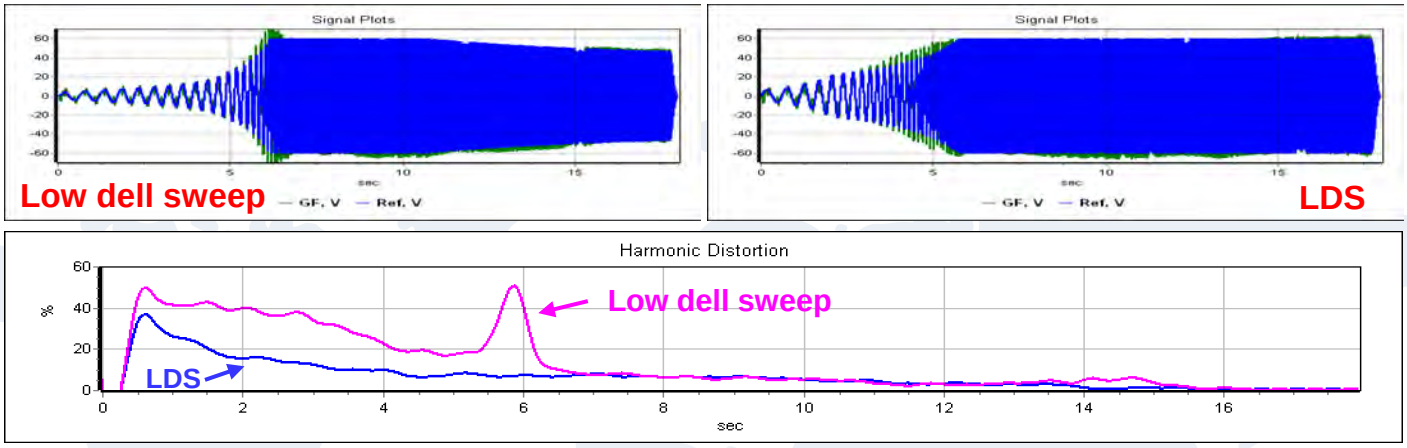
Time slices comparison

With same geometry, the daily productivity of FSSS is 6 times that of flip-flop

Low Distortion Sweep (LDS)

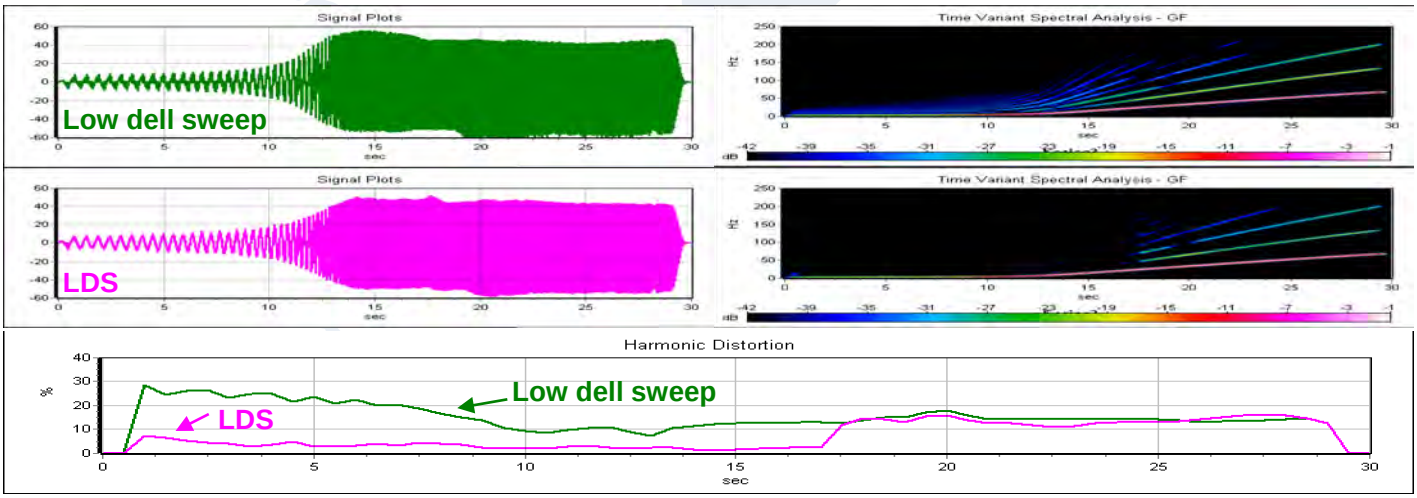
The Low Distortion Sweep (LDS) technique, especially developed by BGP for broadband surveys using conventional vibrators, mainly solves two low frequency sweep problems and can obtain better broadband seismic data.

1. Reduction of the sudden surge of harmonic distortion in signal transition zone

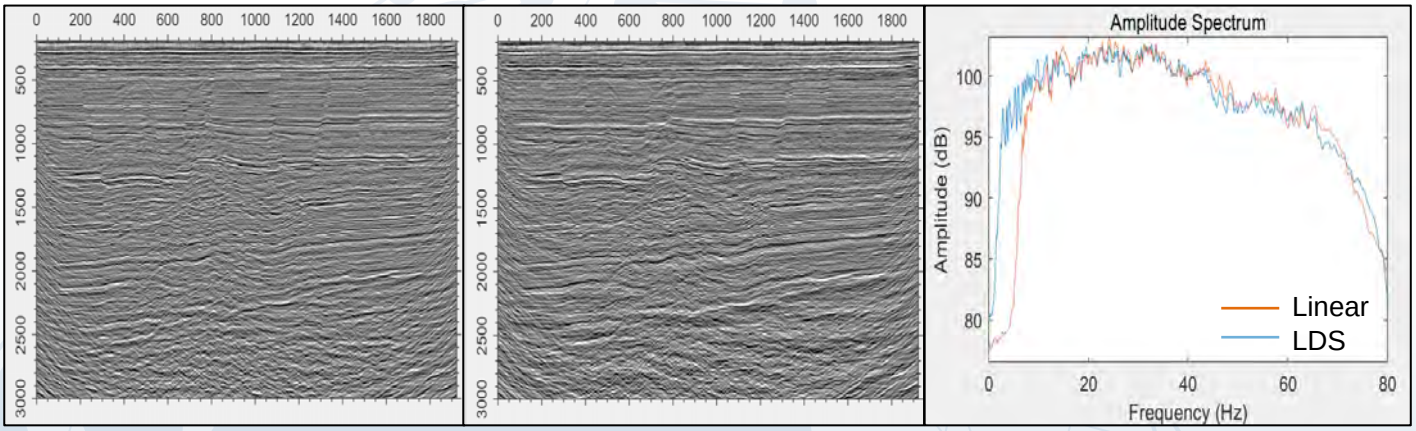


Using the LDS technique, the distortion is reduced by more than 20% on average and more than 40% in the transition zone of the sweep signal.

2. Suppression of the serious harmonics at low frequency



3. Acquisition of better broadband seismic data



Linear sweep (6-84Hz) LDS (1.5-84Hz)

Multi-Client Seismic Solutions

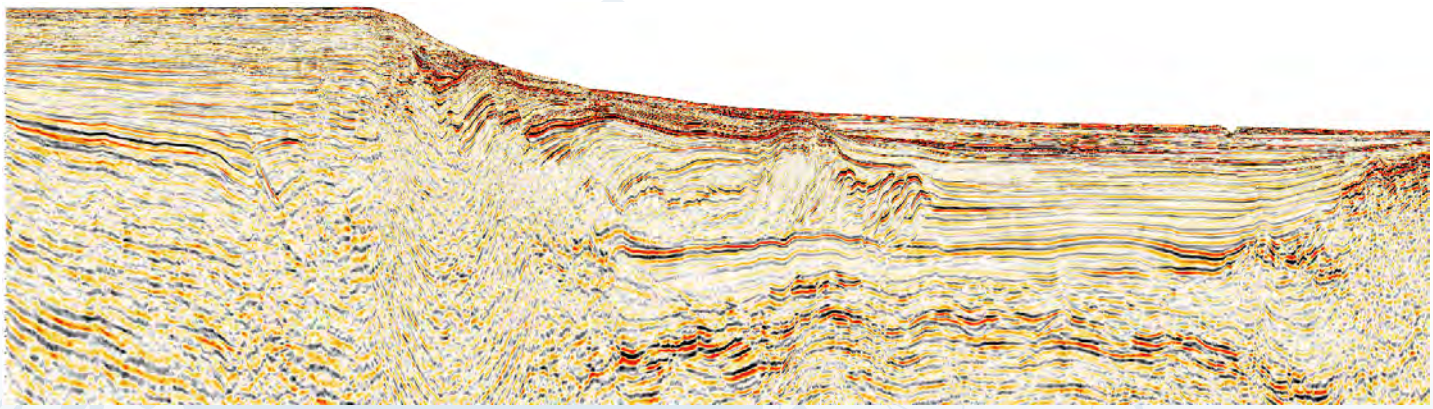
BGP Multi-Client provides the highest quality Multi-Client geophysical and geological data & services to the global oil and gas industry to assist with licensing rounds and the preparation of regional data programs. BGP has acquired a vast of multi-client seismic data in onshore and offshore basins in South America, Europe, Africa, Middle East and Asia Pacific. The database of gravity and magnetics is also available.

Features

- Focusing on client demands
- Providing flexible MC services or a combination of Multi-client and Contract services
- Utilizing continued technological development to improve subsurface understanding
- Satisfying all the seismic requirements of clients by offering 2D, 3D, 4D seismic survey design, acquisition, processing, interpretation, and reprocessing.

MC activity map

Benefits



Reprocessed 2D Seismic Section in Brazil Equatorial Margin

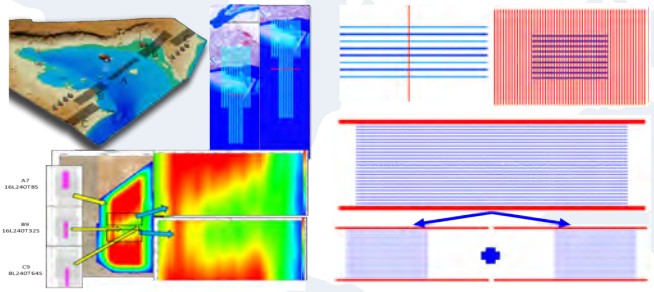
OBN Seismic Exploration Solutions

BGP OBN Briefing

Ocean bottom node (OBN) seismic exploration service, supported by software and equipment owned by BGP, has become a focus area for BGP in recent years, with regards to both technology and business development. This acquisition methodology requires extensive planning and integrated navigation of the seismic flotilla to achieve optimal operational efficiency for node deployment and retrieval, comprises massive data QC and on-site processing and yields superior 4-component seismic data with full azimuth, high fold, long offset and high S/N.

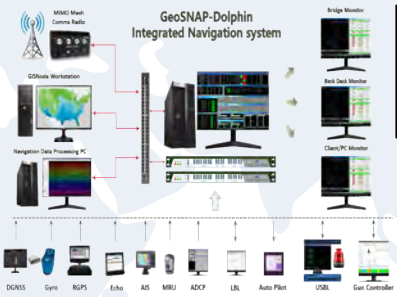
BGP OBN Key Techniques

1. OBN Geometry Design



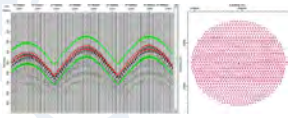
Geometry Design for Various Terrains

2. Integrated Navigation & Positioning



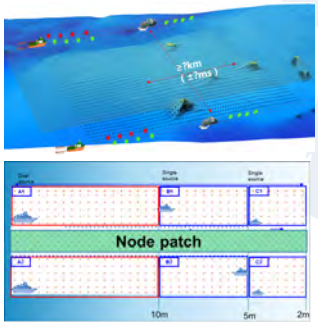
Dolphin Integrated Navigation System

BPS Acoustic Positioning

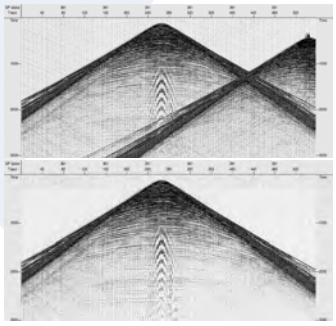


BGP FBP Solution

3. Marine Seismic High-efficiency Acquisition



Multiple Sources Blended Shooting

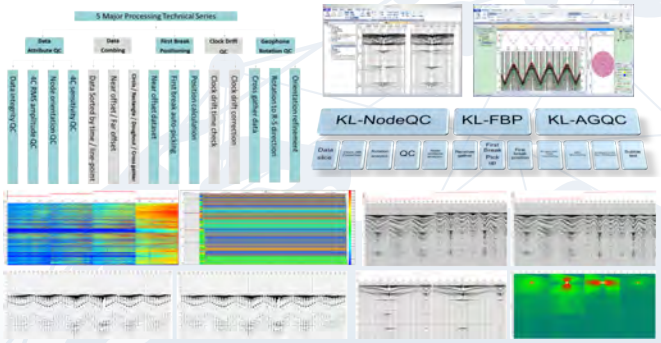


Data De-blending

4. OBN Automatic Deployment & Retrieval System

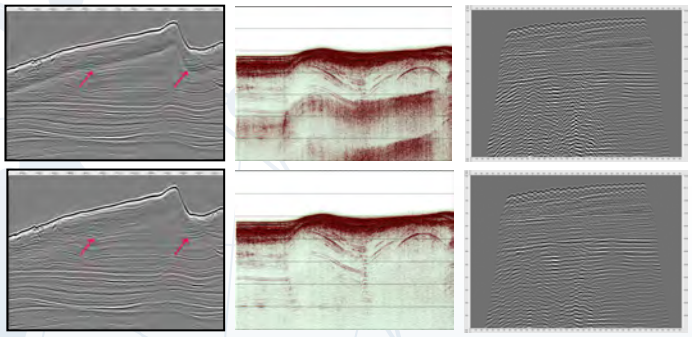
Module, Conveyor and Deployment & Retrieval System

5. OBN Data Quality Control System



KL-NodeQC Software

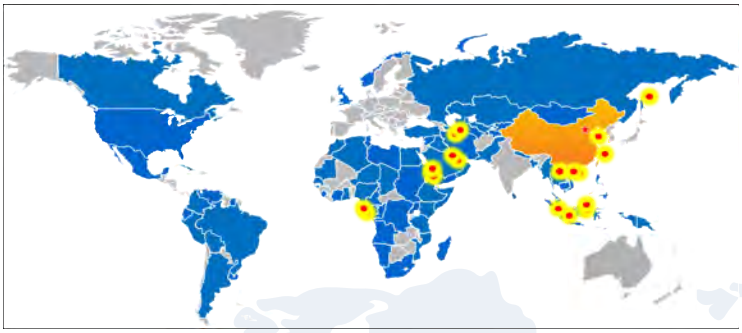
6. OBN Data Processing



Broadband Processing / Multiple Removal / Vz Noise Suppression

OBN Seismic Exploration Solutions

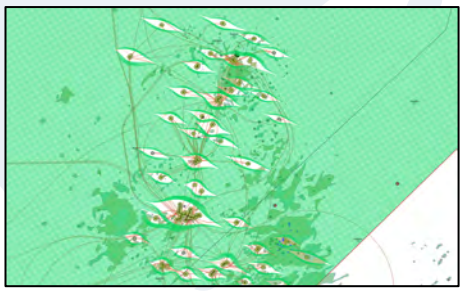
BGP OBN Experience

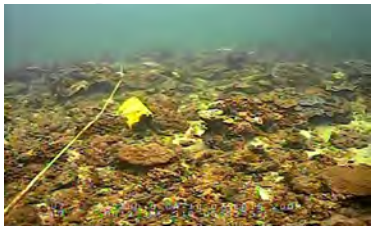


Since entering the OBN market in 2015, BGP Offshore has established itself as the major OBN service provider globally, with more than ten large scale projects to date, and with the surveys in Indonesia, Abu Dhabi, Brunei and Saudi Arabia being the largest OBN projects in 2017, 2018, 2019 and 2023, respectively.

Brunei 3D/4D OBN Survey

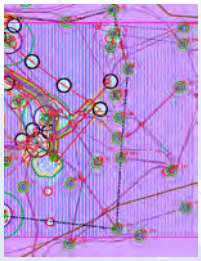
- 140+ platforms
- 7500+ close passes
- High 4D repeatability
- Sensitive coral areas
- ROV operation (node layout close to obstruction / coral protection)
  No time lost to SIMOPs
- 4 PB acquired seismic data
- High data quality and
- improved structural imaging





Middle East OBN Survey

- Largest survey area in the world: >30000 km2
- ~200 platforms in the oil field
- Nominal fold up to 9600
- Aspect ratio: 1
- High efficiency blended shooting: max 74113 shots/day with 6 source vessel and 10 sources
- More than 80 million shots
- 2.2 million node locations
- 34,192 close passes in 500m safe distance
- More than 70 vessels, >1450 staff



Towed Streamer Seismic Briefing

BGP Offshore towed streamer seismic services cover 2D, 3D and 4D acquisition and processing. Operation fleets deliver high quality seismic data and comply with the highest QHSSE standards. During the past two decades, BGP's towed streamer seismic services have been provided to more than 70 clients in over 60 countries.

BGP Offshore uses the most advanced techniques in the world for exploration, reservoir delineation, characterization, and monitoring. BGP Offshore commitment to towed streamer development focuses on improving productivity and data quality, reducing cost and improving turn-around time.

BGP Prospector
Seal 428 recording system
12 × 8km Solid streamer
Steerable source
Advanced INS

DONG FANG KAN TAN NO1
Seal 428 recording system
1 x 12km Solid streamer
Advanced INS

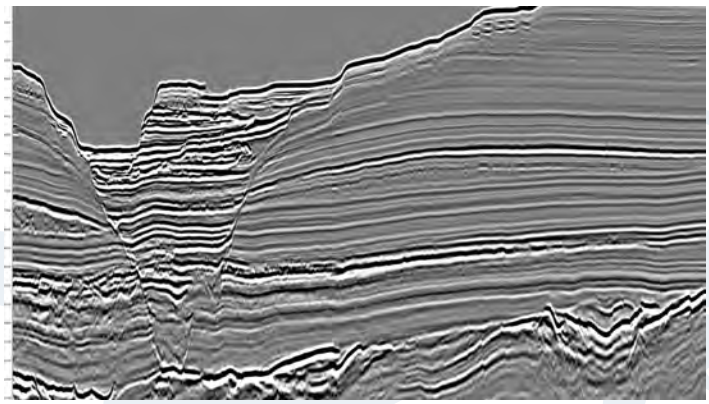
BGP Explorer
Seal 428 recording system
4 x 4.5km Solid streamer
Advanced INS

BGP Challenger
Seal 428 recording system
2 x 6 km Solid streamer
Advanced INS

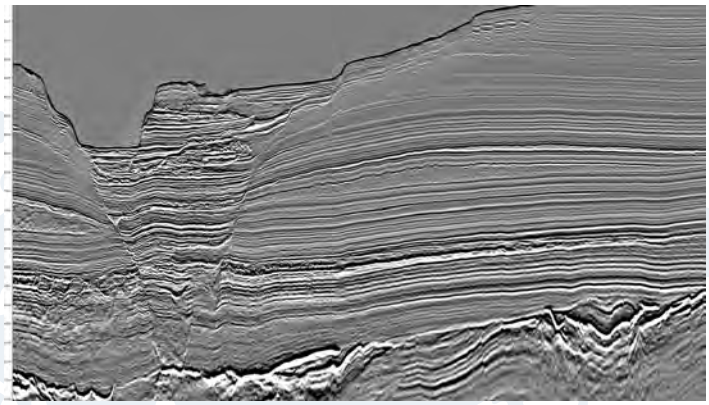
Towed Streamer Seismic Solutions

Broadband solution

BGP Offshore proposes a broadband acquisition technical solution with deeper towing streamer, variable-depth streamer, multi-level air gun array, and post enhanced broadband processing to get high resolution images of the subsurface structure.



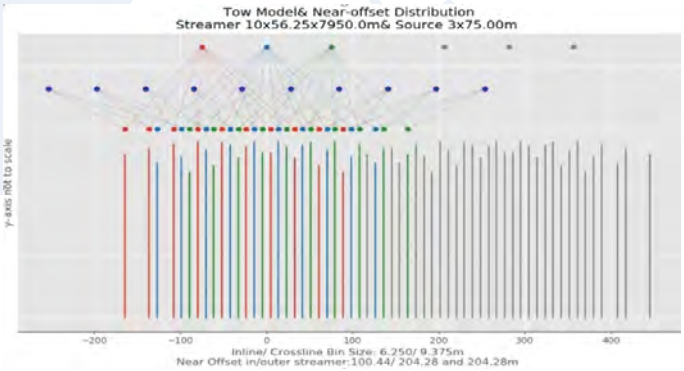
Before broadband processing



After broadband processing

High-efficiency Acquisition

BGP Offshore provides high-efficiency acquisition solutions including wide towing streamers, undershooting operation, triple source, continuous recording and fan mode towing streamers for improving operation efficiency and seismic data quality, reducing the operation cost.



Wide-towing triple sources streamer acquisition

4D Acquisition

BGP Offshore supplies conventional 4D and/or hybrid 4D acquisition with towed streamer and OBN solutions for 4D seismic monitoring. These solutions provide high source repeatability and good feather match.

- Shot-by-shot estimation of the source signature.
- Low noise, solid streamers.
- A dense acoustic positioning system.
- Steerable streamers and sources.

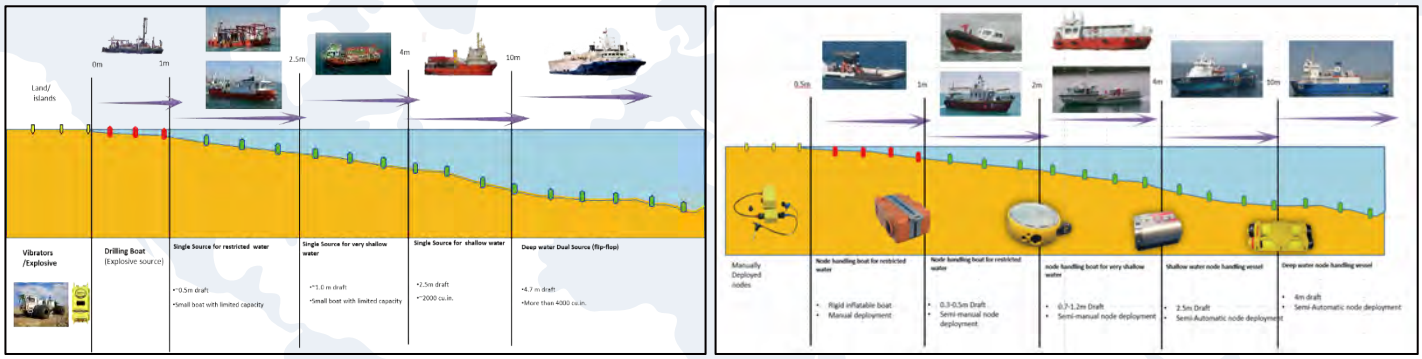
Undershooting in complex area

Transition Zone (TZ) Seismic Solutions

Broadband solution

BGP has over 20 years of global experience in the complex transitional zone operations, forming the most professional transitional zone seismic operation capability and possessing a large number of all-terrain seismic operation equipment.

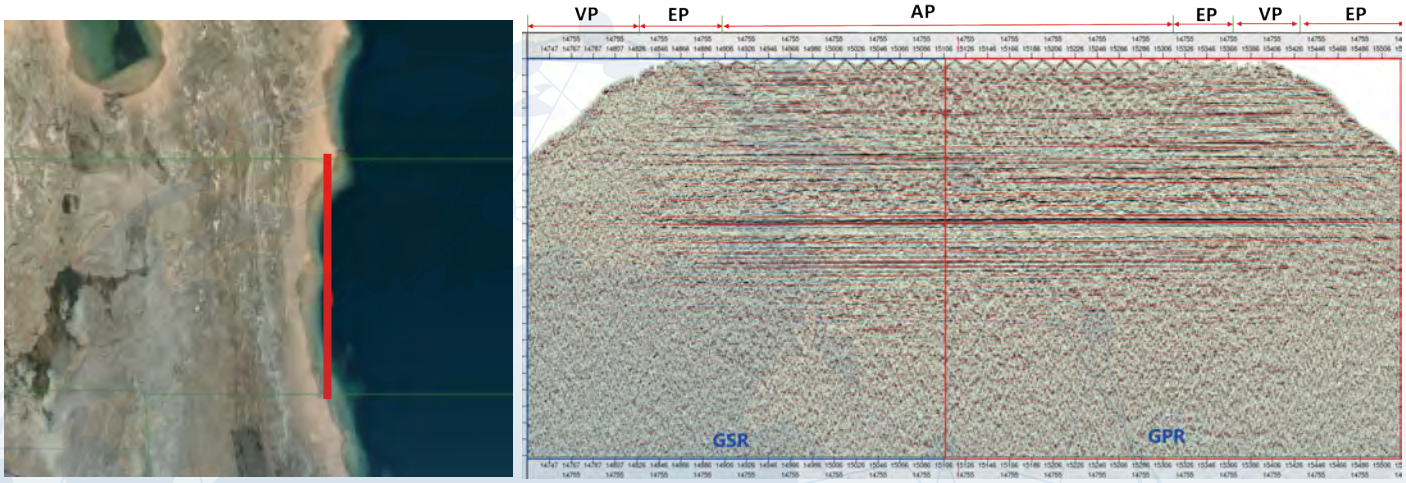
BGP has undertaken more than 20 transition zone projects, including those extra-large projects in Kuwait, Saudi Arabia and the United Arab Emirates, and provided high-quality seamless seismic data in TZ area involved in the urban area, Desert Gobi, rainy forest, beach, extremely shallow water, shallow water, offshore oil field operational zones and other complex terrain.



Full-terrain Integrated Source (left) and Receiver (right) Facilities for Seamless Acquisition

System setup & debugging → Node test and charging → Node maintenance → Node transfer → Node deployment & retrieval → Seismic data → Node analysis

Node Operation for TZ Seismic Acquisition



Integrated Data after Consistency Processing

Deblending

BGP's inversion based deblending algorithm dramatically improves productivity and efficiency in data acquisition and can handle any environment such as land, marine, towed streamer or OBN.
Applied on 3D common-receiver gathers, this method separates signal and noise iteratively in the frequency-wavenumber-wavenumber (f-k-k) domain.

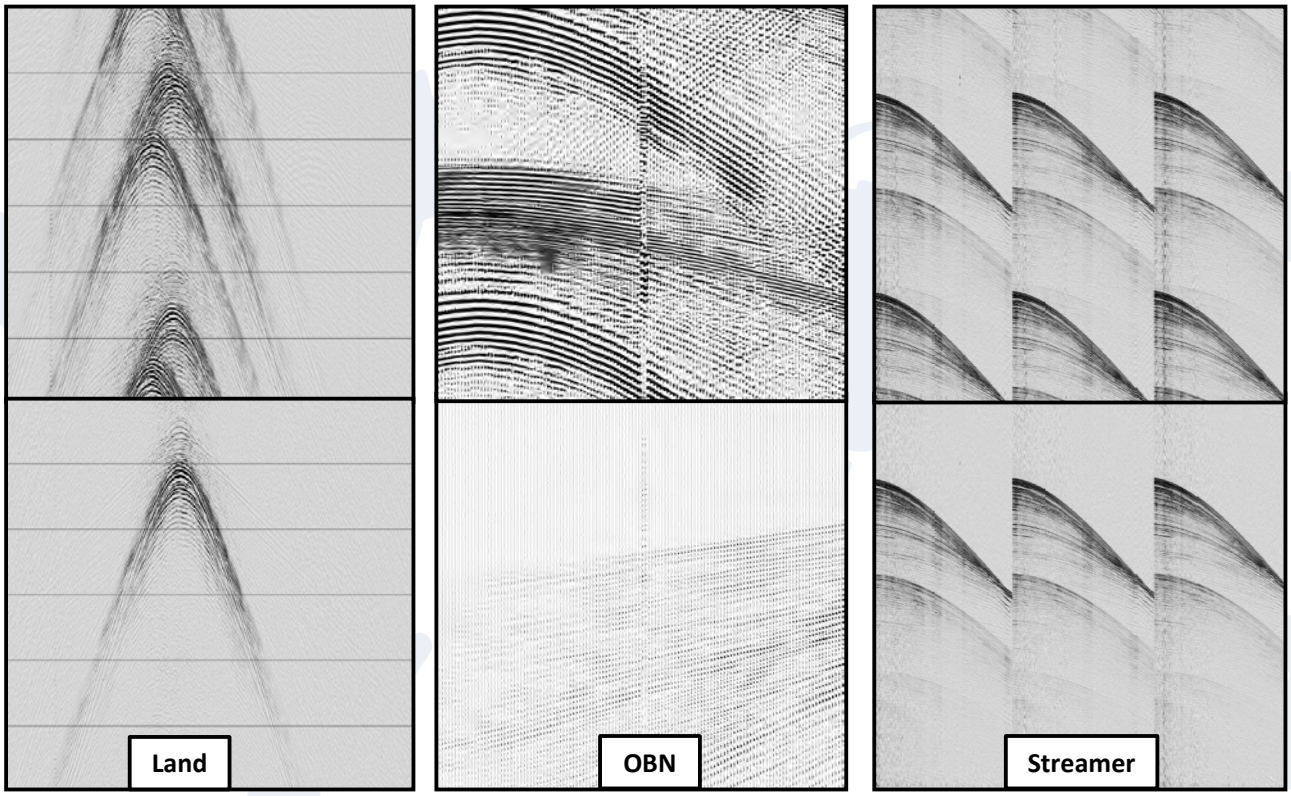


Figure 1: Common shot gathers before deblending (top) and after deblending (bottom)

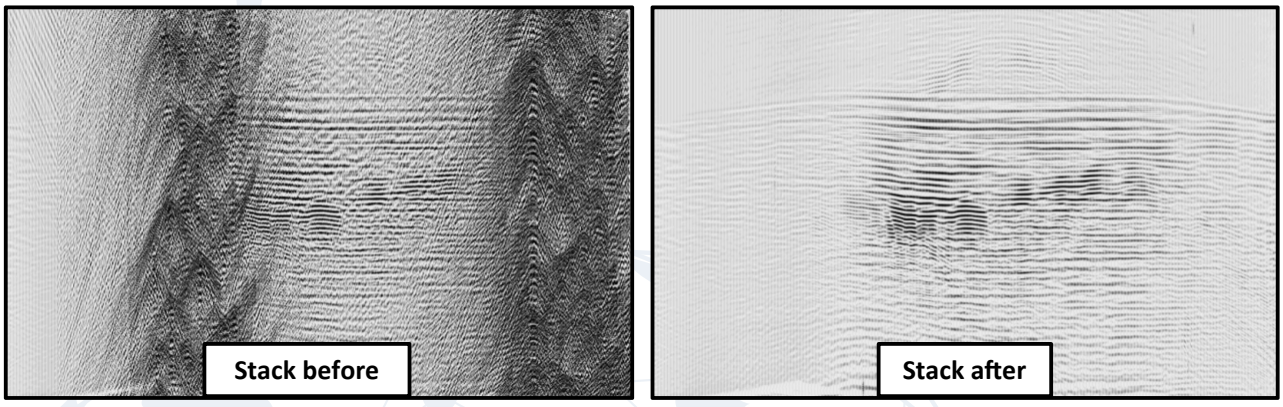


Figure 2: Stack section before deblending (left) and after deblending (right)

Features

- Ultra-high recording efficiency in the field
- Cost effective
- High accuracy and fidelity in deblending
- Land & marine data (streamer, OBN)

Joint Deblending and Compressive Sensing Reconstruction

BGP has taken seismic deblending and compressive sensing one step further with the recent development of its industry leading joint deblending and compressive sensing algorithm. Conventional cascaded deblending and compressive sensing (CS) reconstruction cannot accurately solve the problem as the two processes influence each other. Preforming deblending and CS reconstruction as a simultaneous process improves both data quality and efficiency.

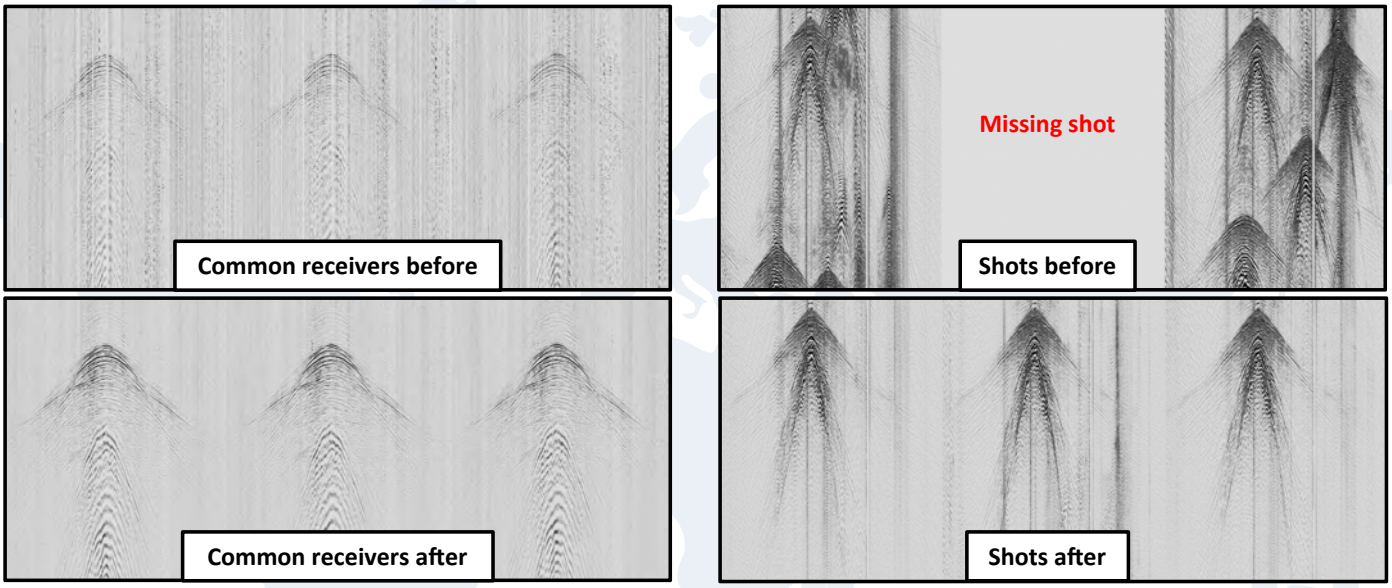


Figure 3: Shots and receivers before (top) and after (bottom) simultaneous deblending and compressive sensing

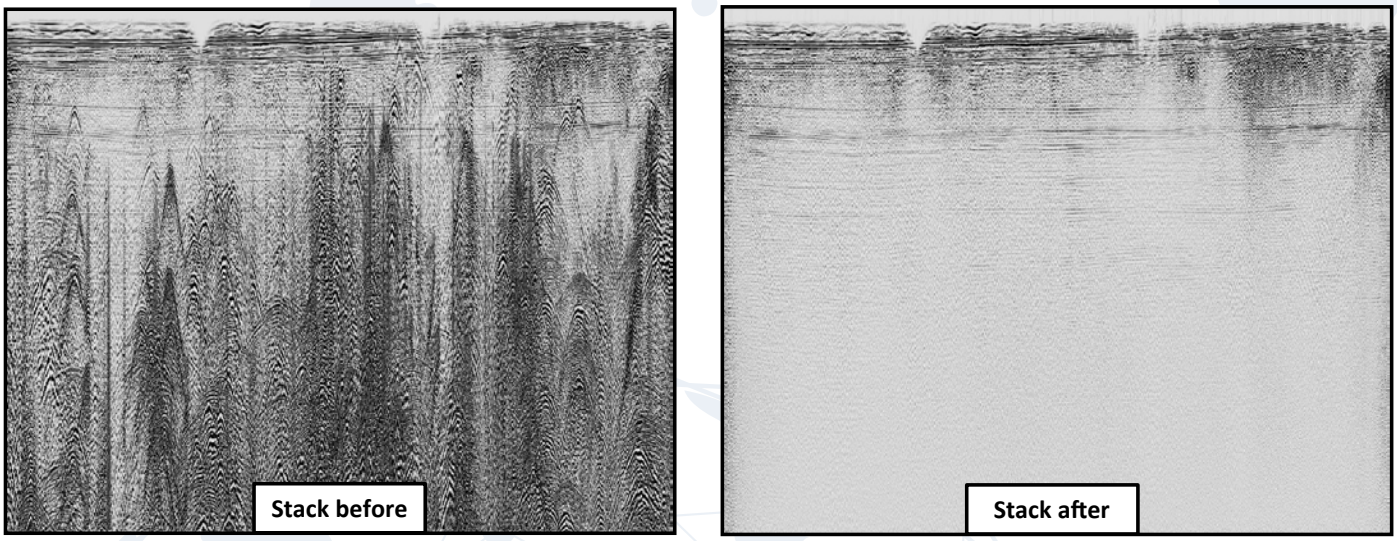


Figure 4: stack section QCs

BGP's cutting-edge joint deblending and compressive sensing data reconstruction provides an efficient and high-quality processing technique which strongly supports CS based simultaneous shooting acquisition.

OBS Data Processing

BGP’ s advanced Ocean Bottom Seismic processing and imaging technologies are systematically aiding our client’ s understanding of the subsurface. Industry leading pre-processing workflows as well as state-of-the-art Full Waveform Inversion and Impedance inversion algorithms make full use of OBS low-frequency, full-azimuth, ultra-long offset information.

Optimized pre-processing workflows:

With advanced and tailored pre-processing workflows, BGP can address all different types of challenges from shallow to deep water environments.

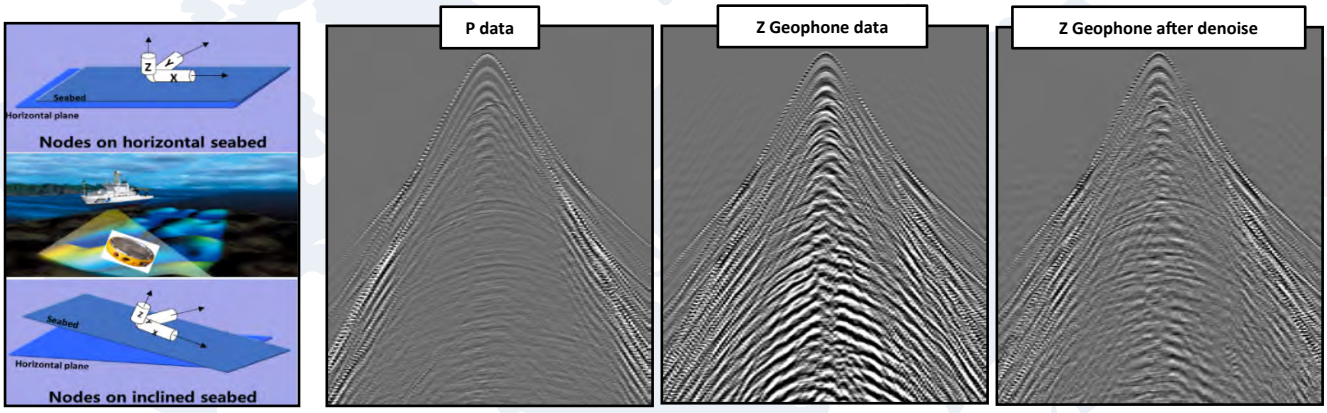


Figure 1:OBN denoise of vertical geophone

Up Down Deconvolution (UDD) technology attenuates all free-surface multiples and removes the effects of the source ghost and signature producing enhanced resolution and better imaging.

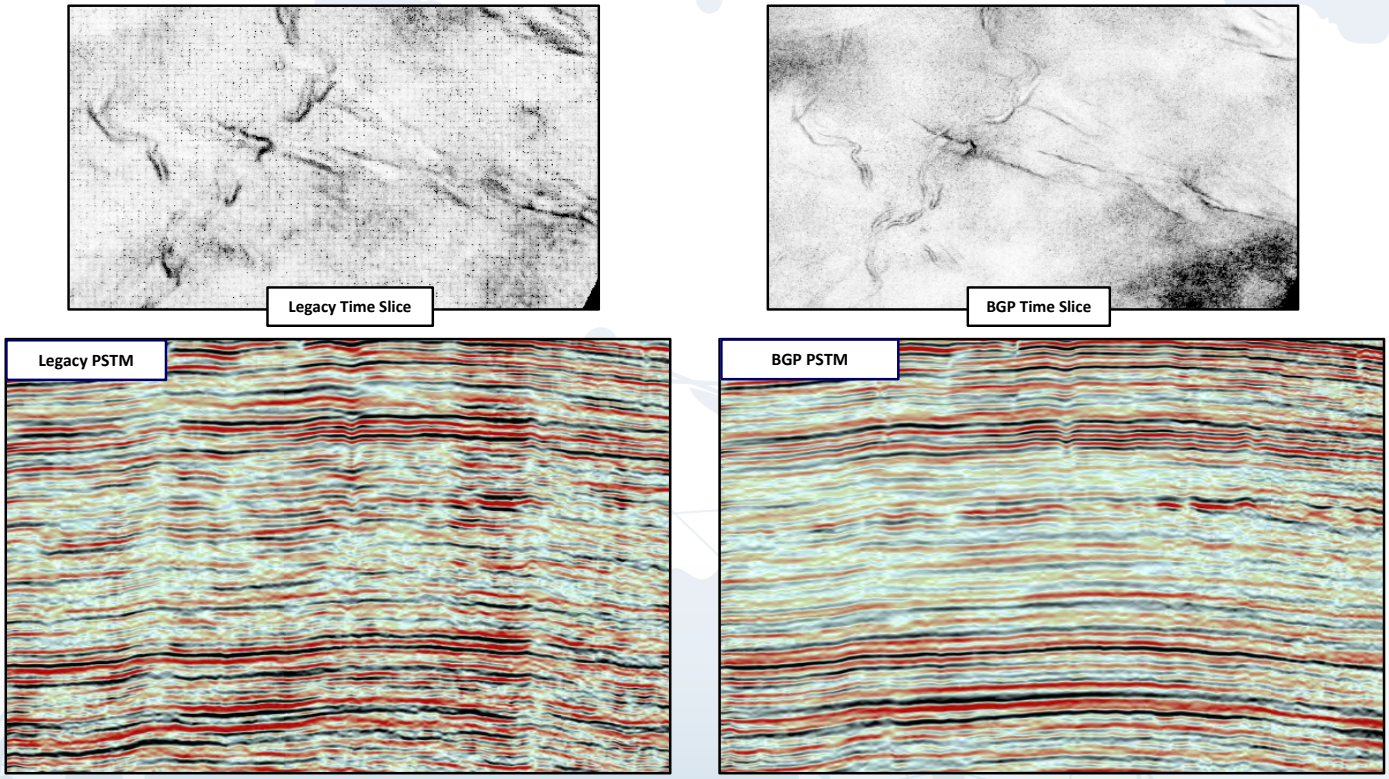


Figure 2: comparison of legacy vs BGP PSTM stack sections and time slices

Full Waveform Inversion FWI:

BGP's FWI framework overcomes even the most challenging environments. This technology leverages anti-cycle skipping technology by solving a least-squares objective function and by minimizing the travel time misfit in both data and image domains.

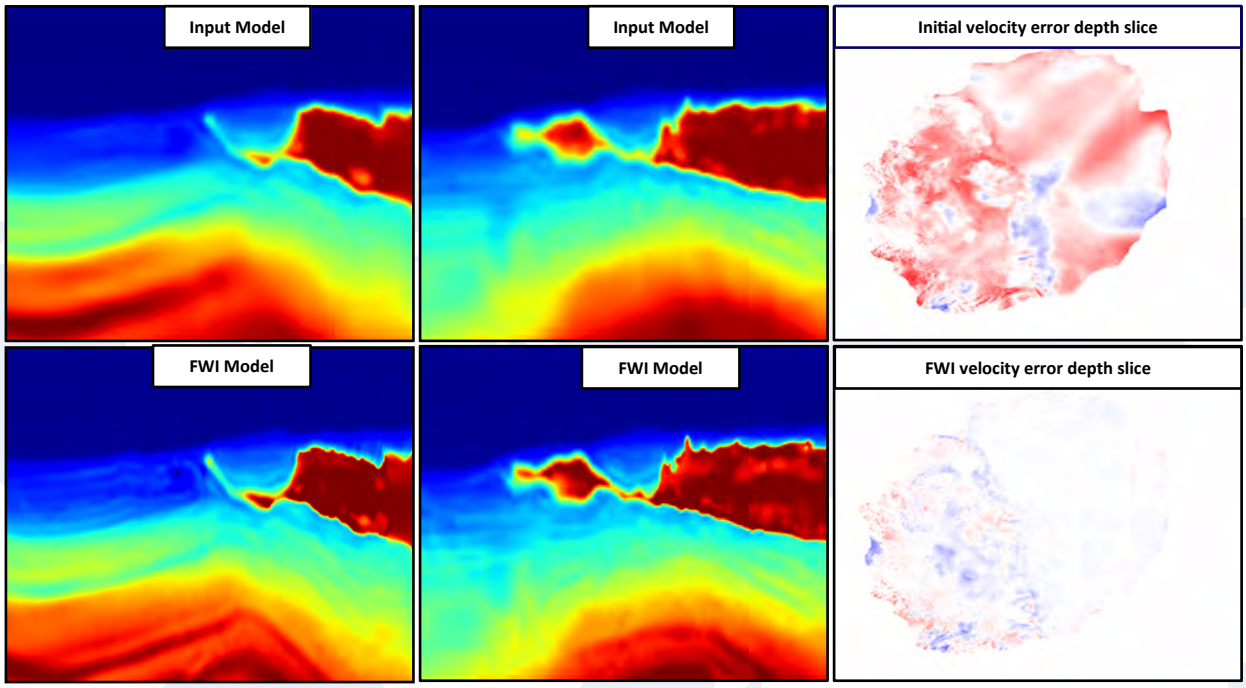


Figure 3: Deep water Gulf of Mexico OBN FWI

Full Waveform Impedance Inversion FWII:

The state-of-the-art full waveform impedance inversion workflow based on true amplitude migration inverts both velocity and impedance simultaneously. From raw data, higher resolution images are generated earlier in the workflow providing our customers with real subsurface insight.

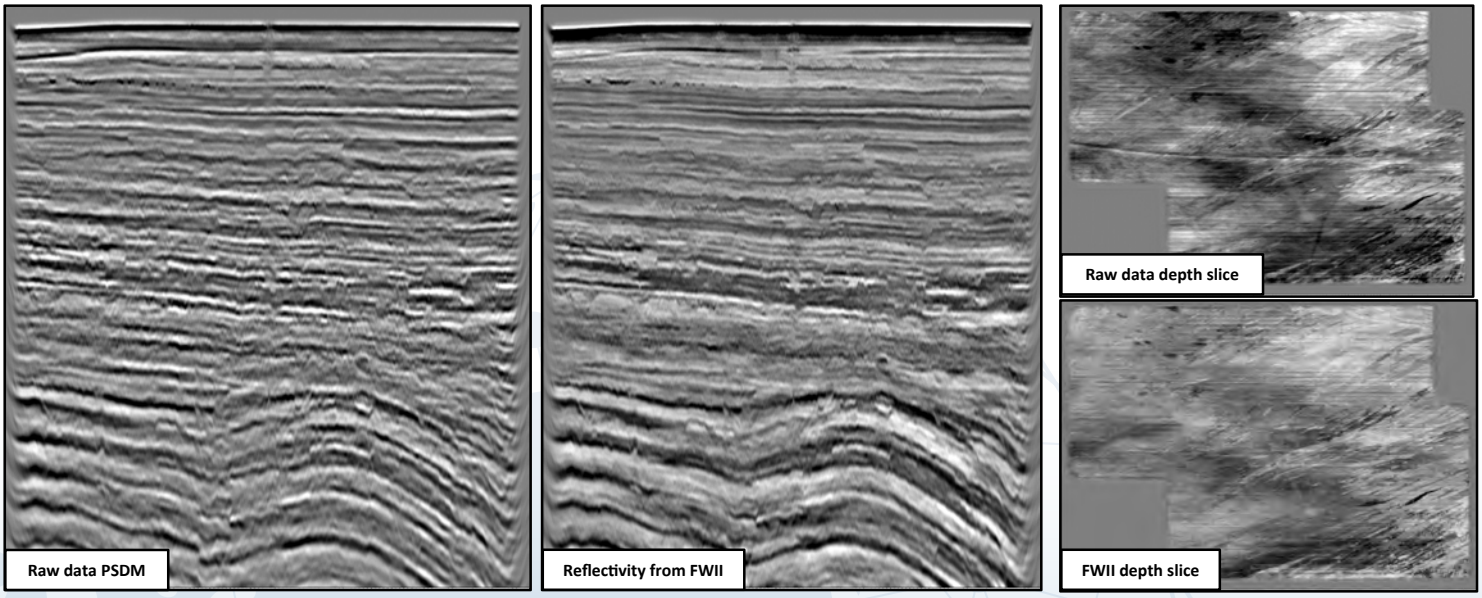


Figure 4: Full Waveform Impedance Inversion (comparison of FWII from raw data vs raw PSDM data)

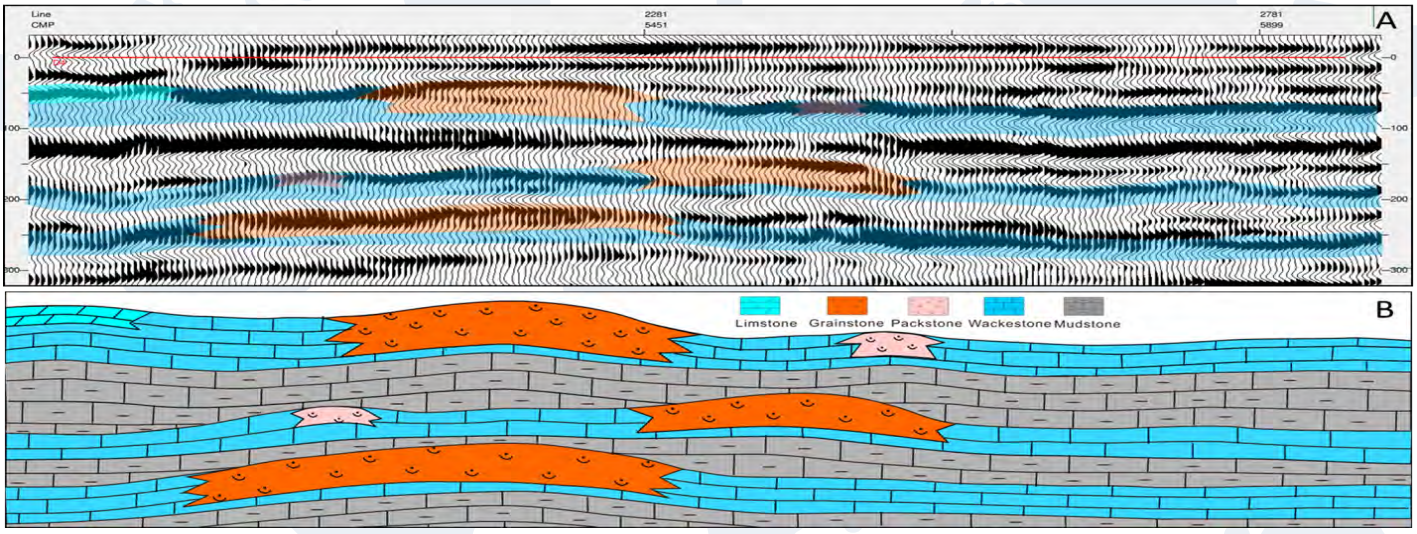
The Integration of Seismic, Geology and Engineering

Pilot Horizontal Well Design

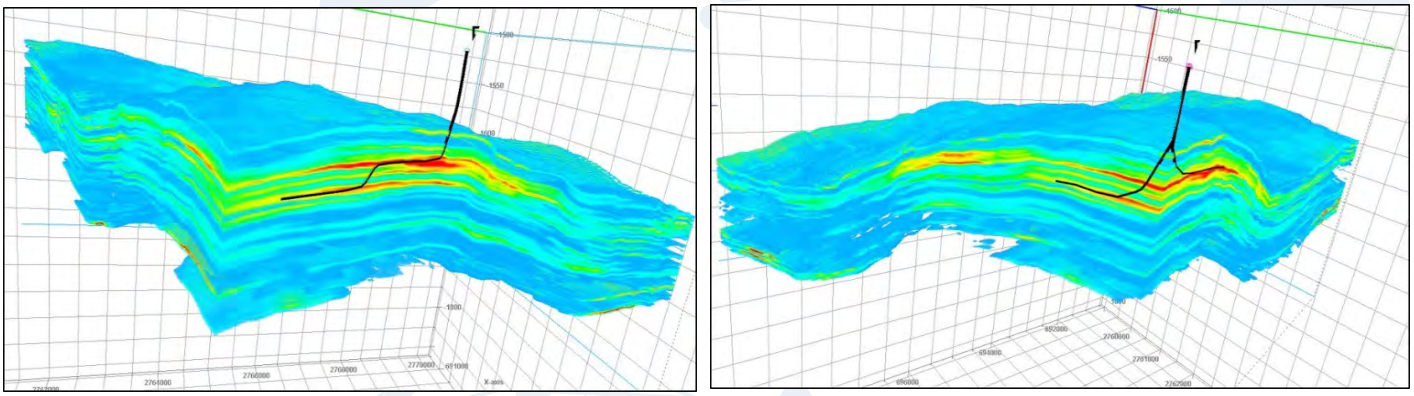
Sweet spot characterization is based on facies analysis, seismic attribute analysis, seismic inversion and geological modeling, which can be used for different well types and well trajectories design. It can be integrated with reservoir simulation to optimize the design parameters for horizontal wells.

Advantages :

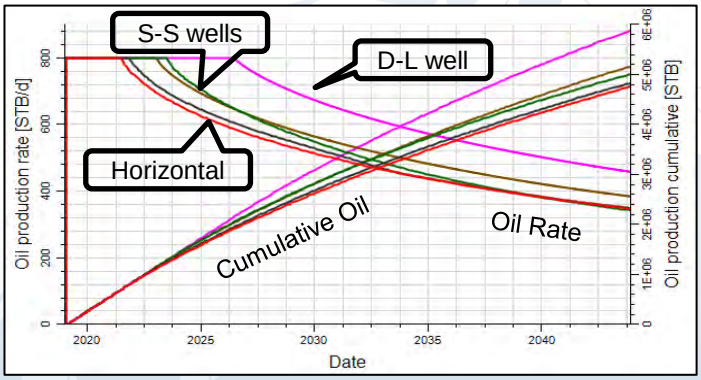
- Characterize sweet spot of tight reservoir and apply favorable area for well in placement.
- Improved reservoir penetration with a higher production rate.



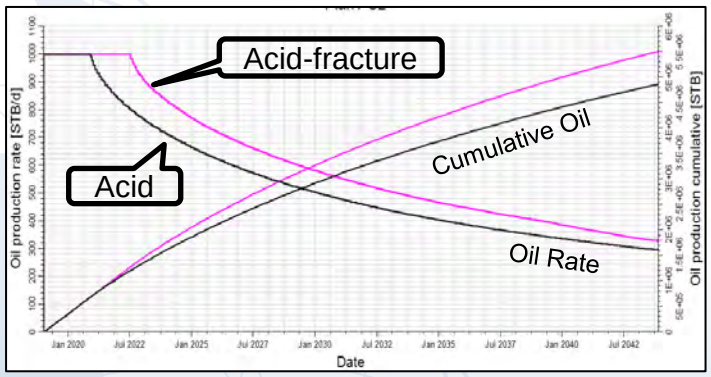
Seismic section and sedimentary facies analysis for sweet spots



Horizontal well trajectory design



Well type optimization (simulation)



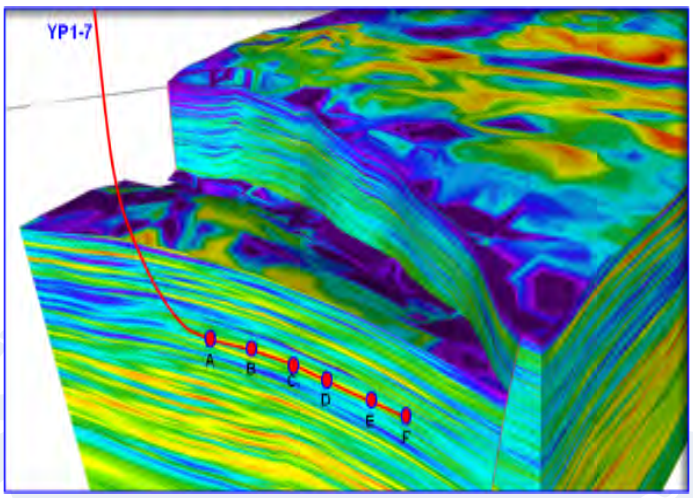
Production optimization (simulation)

Seismic and Geology Guided Drilling

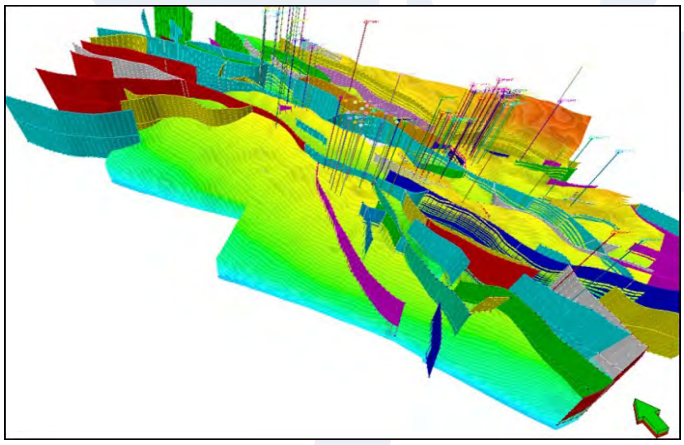
BGP's unique seismic and geology guided drilling (SGGD) tool maps target intervals and adjusts well trajectory to guide drill bit steering in real time based on LWD information and seismic inversion.

Advantages :

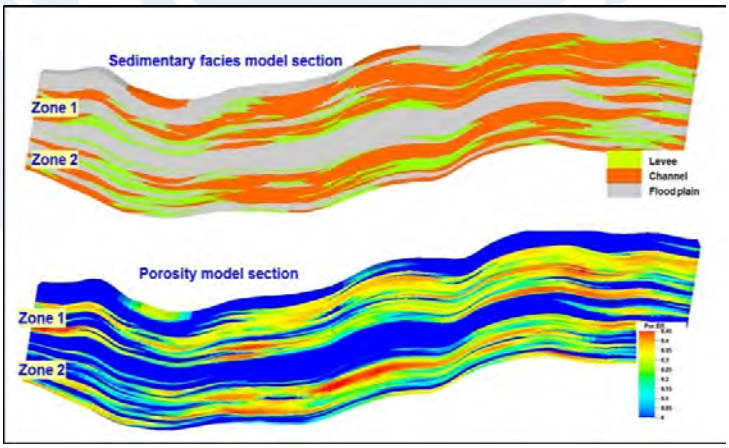
- Optimal horizontal well design
- Enhanced target-entering accuracy and precision
- Improved rate of well placement and reservoir penetration



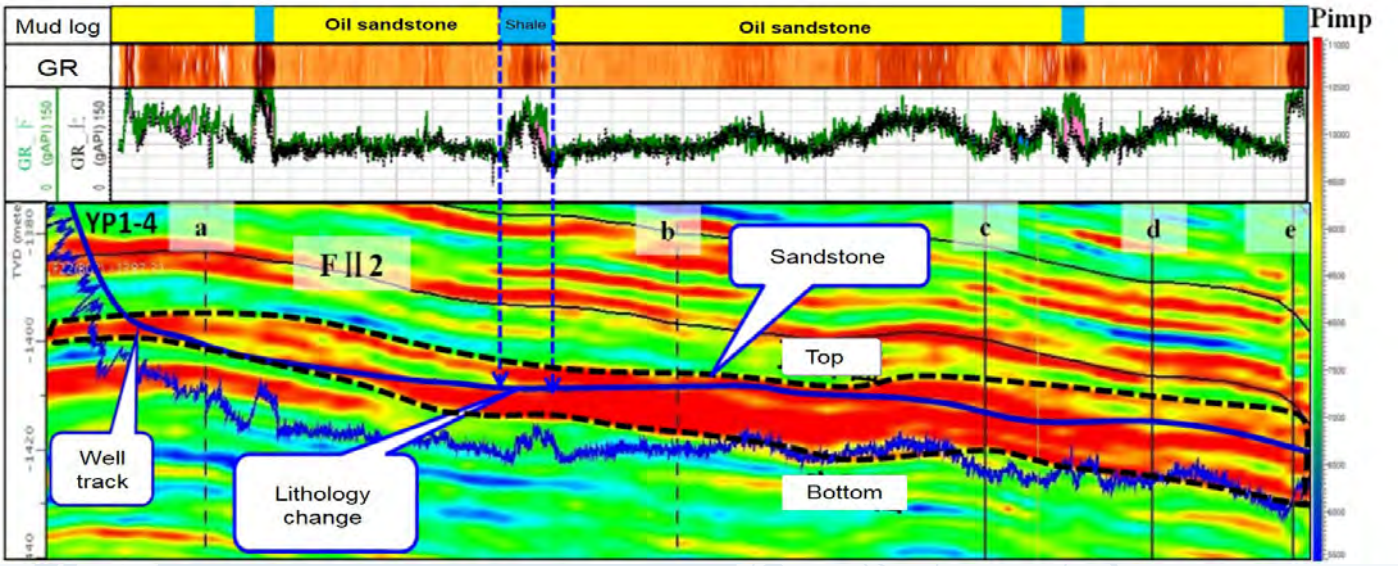
Horizontal well trajectory design



Fault and structure model



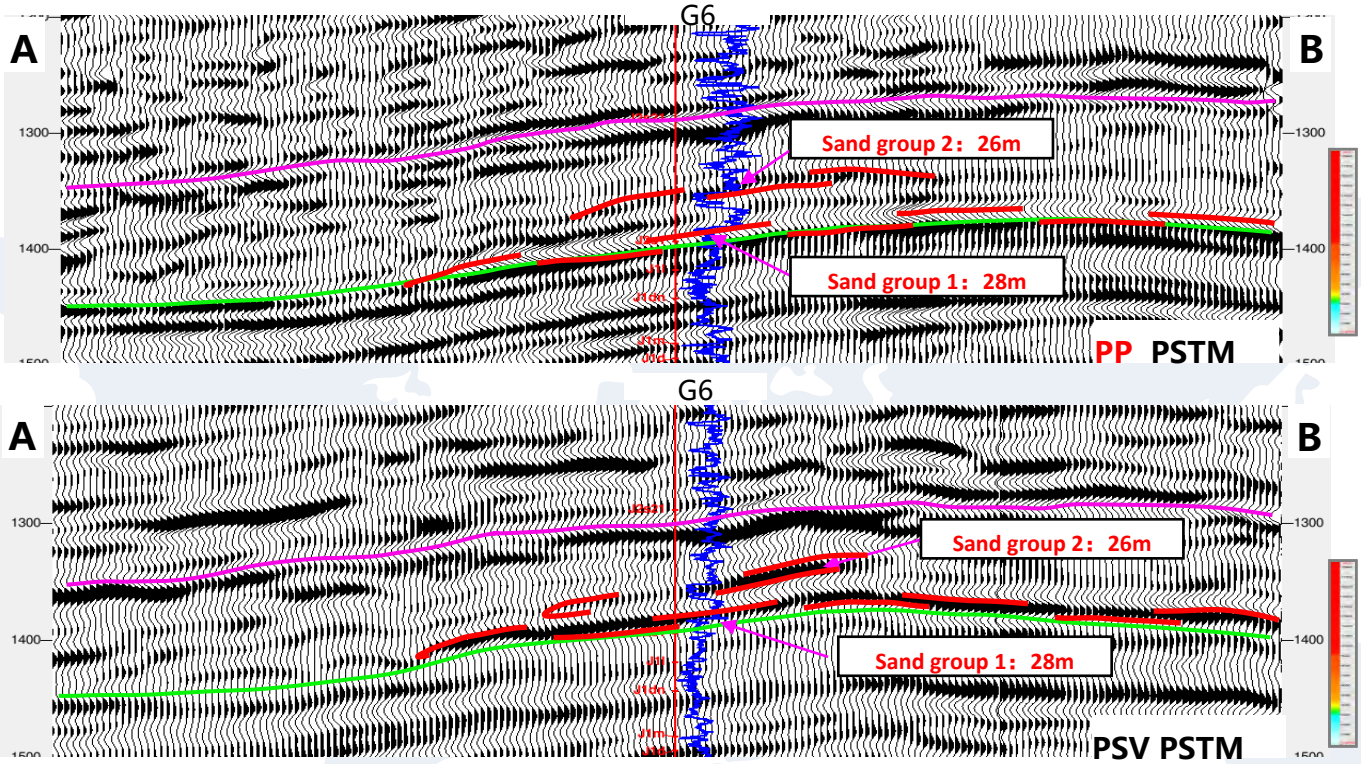
Reservoir petrophysical modeling



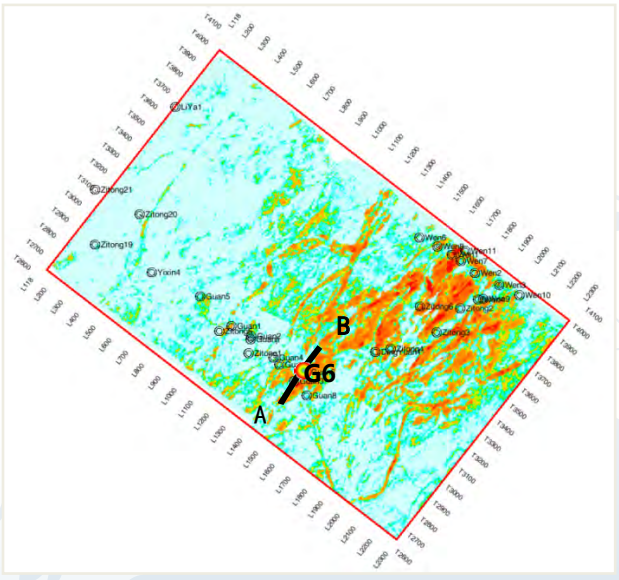
Case: sudden lithologic change warning, confirmation and trajectory adjustment for horizontal well Segment

P-SV Wave Exploration

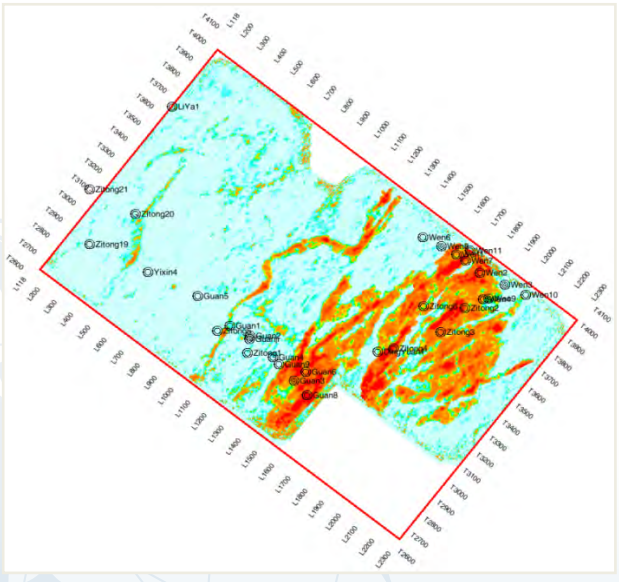
BGP has advanced processing and interpretation technologies for P-SV seismic data, committing to obtain the proper earth structure characters such as gas cloud conditions and detailed description of complex reservoirs.



The P-SV wa ve can better characterize the "hidden" sand body, and the seismic response characteristics of th e sand group are more obvious in the P-SV wave than in the P-wave



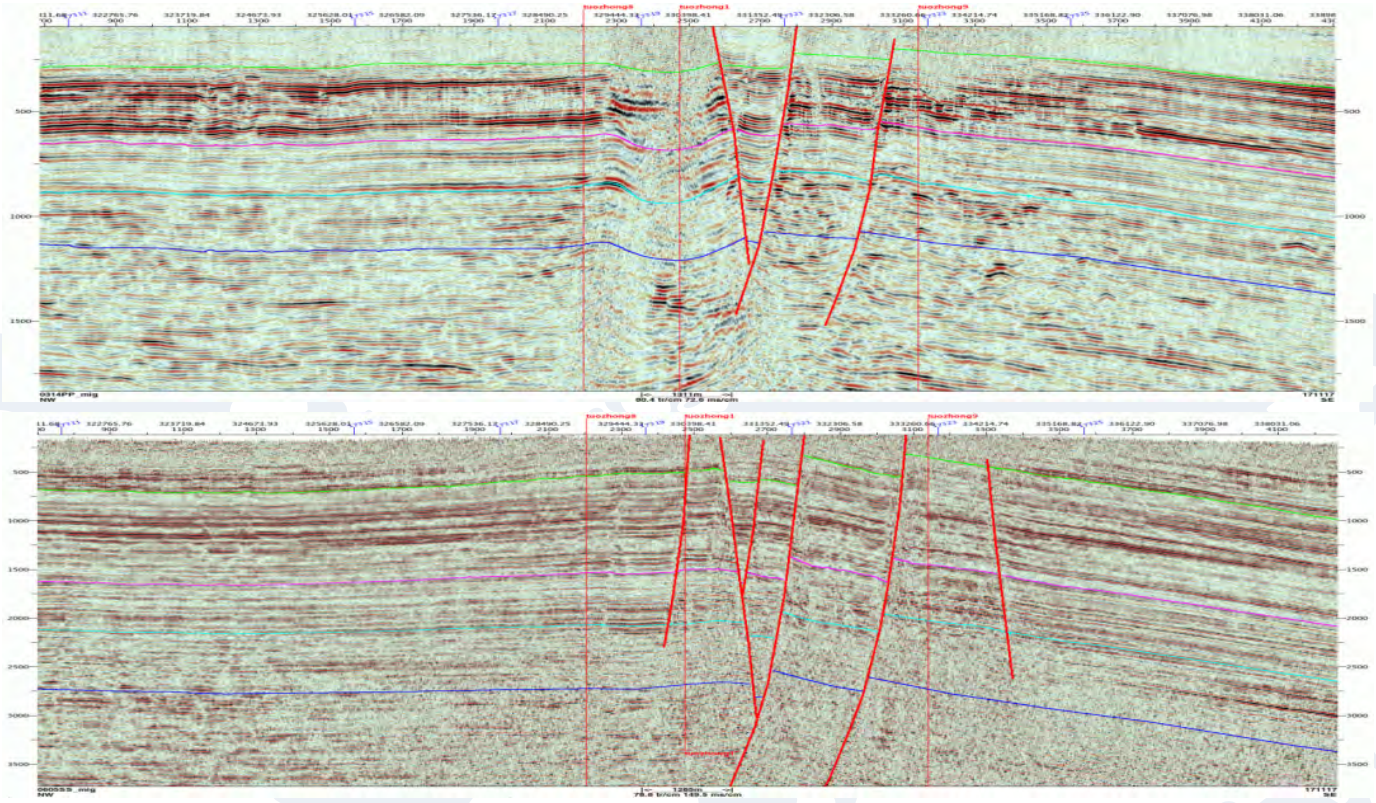
P wave Average peak amplitude of sand group 1



P-SV wave Average peak amplitude of sand group 1

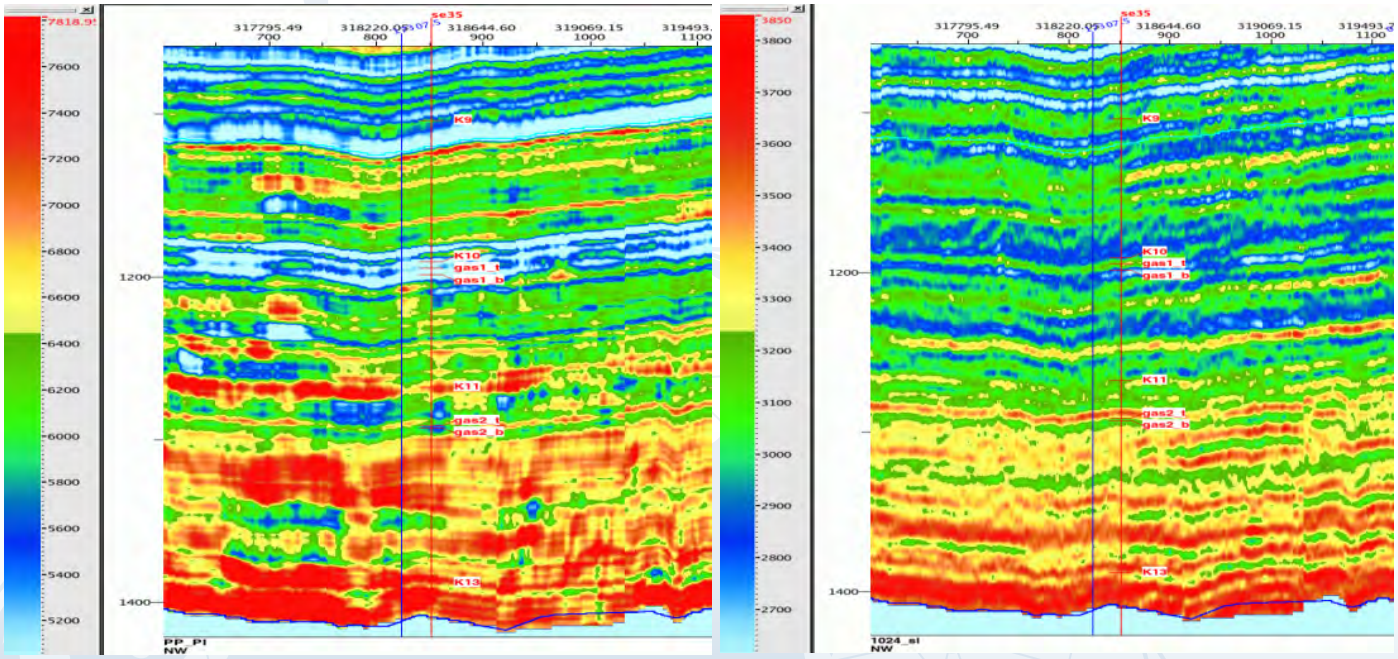
Shear Wave Exploration

BGP has made continuous efforts in R&D to find out solutions to shear wave data acquisition, processing and interpretation, especially for gas cloud, complex reservoir environments, finally obtaining optimized results.



Comparison of seismic sections of PP and SS (SH-SH) at the same location

The PP section shows a blurred image and pull-downs due to the presence of a gas cloud with the SS section virtually eliminating the impact of the gas cloud and the image is clear and the structure is resolved, better than PP.



Comparison of impedance inverted by PP and SS (SH-SH)

Time Lapse (4D) Seismic Monitoring

Integrated Reservoir Monitoring

To meet the needs of the energy industry in both oil and gas exploration and carbon capture storage, BGP offers a fully integrated 4D seismic workflow including repeatability analysis, acquisition designing, 4D processing, structural interpretation and reservoir characterization.

4D Multicomponent Processing Workflow

4D multicomponent time lapse PP and PS wave processing achieves accurate reservoir characterization for seismic monitoring purposes. Our integrated 4D noise attenuation and fold normalization workflow reduces the impact of different acquisition setups and vintages to enhance the 4D reservoir signature.

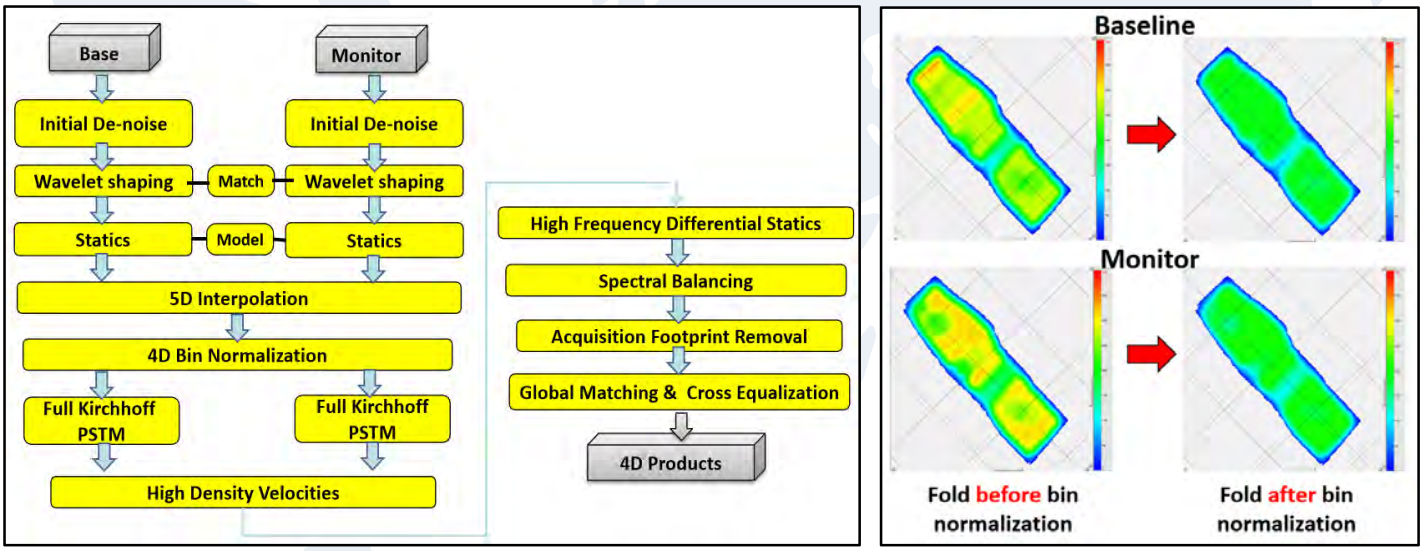


Figure 1: 4D processing workflow (left); fold plots before and after bin normalization (right)

4D seismic technology is an essential tool for reservoir development and field recovery optimization. The objective is to ensure repeatability between the baseline and the monitor survey to enhance the 4D response and gain insight into the reservoir conditions.

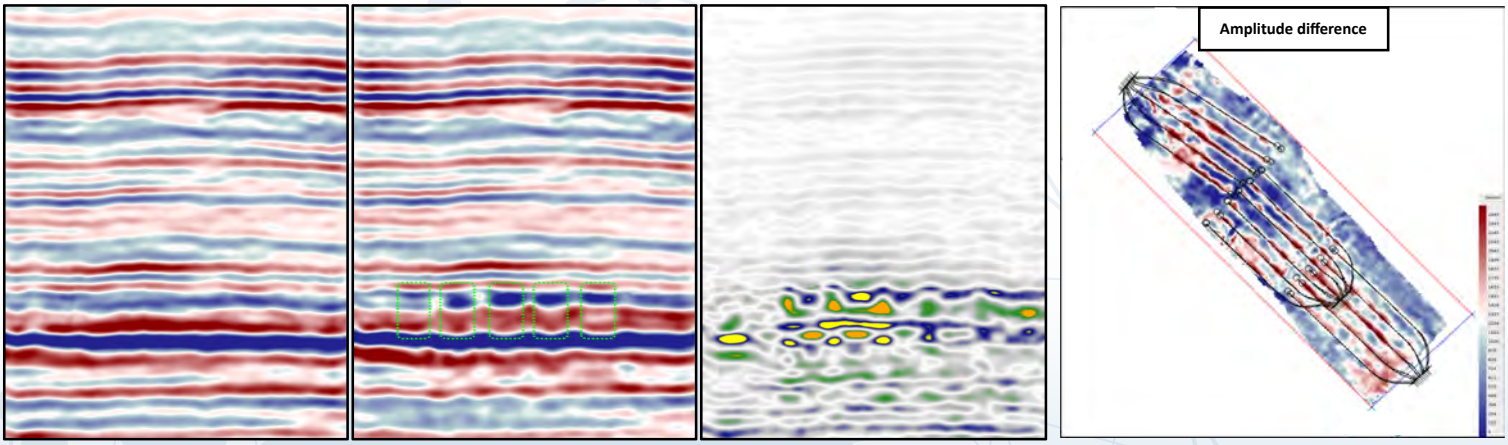


Figure 2: PP Baseline Stack section (left) ; PP Monitor Stack section (middle) ; difference stack and slice (right)

Time Lapse (4D) Seismic Monitoring

4D Rock Physics Analysi

Rock physics analysis is an integral part of BGP's 4D qualitative and quantitative 4D seismic interpretation. Based on the improved Gassmann theory, time-lapse simulation of elastic parameters is conducted to gain insight into changes in seismic properties associated with the production of the field for oil and gas development or with C02 injection for CCS.

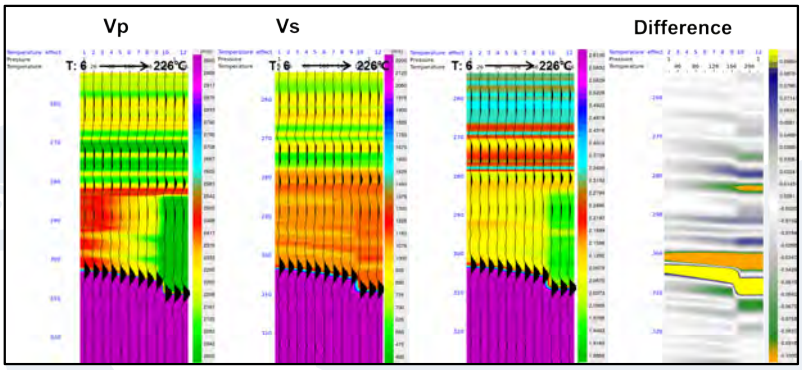


Figure 3: Forward modelling

4D Seismic Inversion

BGP's advanced pre-stack PP-PS inversion workflows and dynamic reservoir modeling technology provide rapid and reliable 4D attributes for reservoir monitoring and simulation.

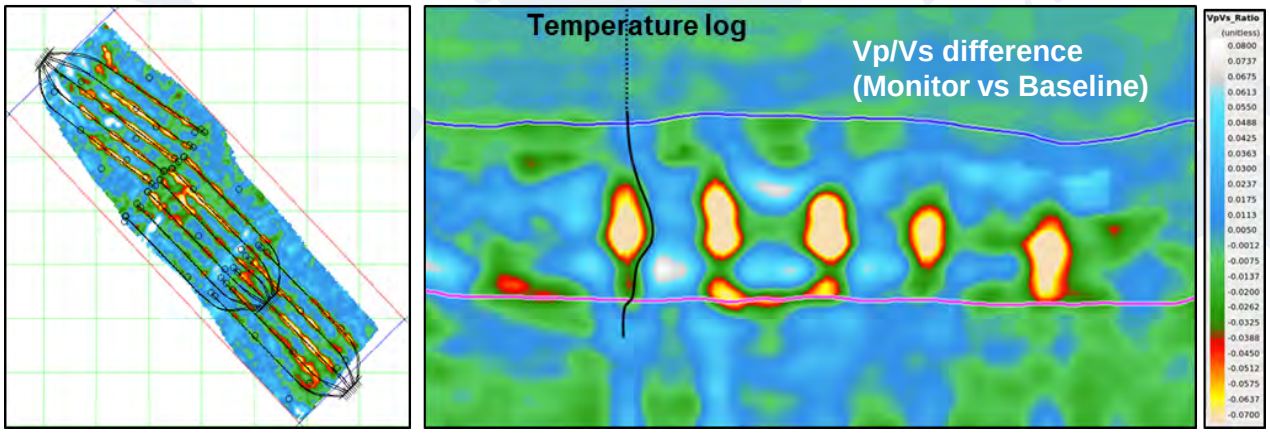


Figure 4: Comparison between predicted Vp/Vs ratio vs temperature well log

In this example below, the predicted temperature, steam chambers and remaining oil models were crucial for optimizing development of the field for enhanced recovery.

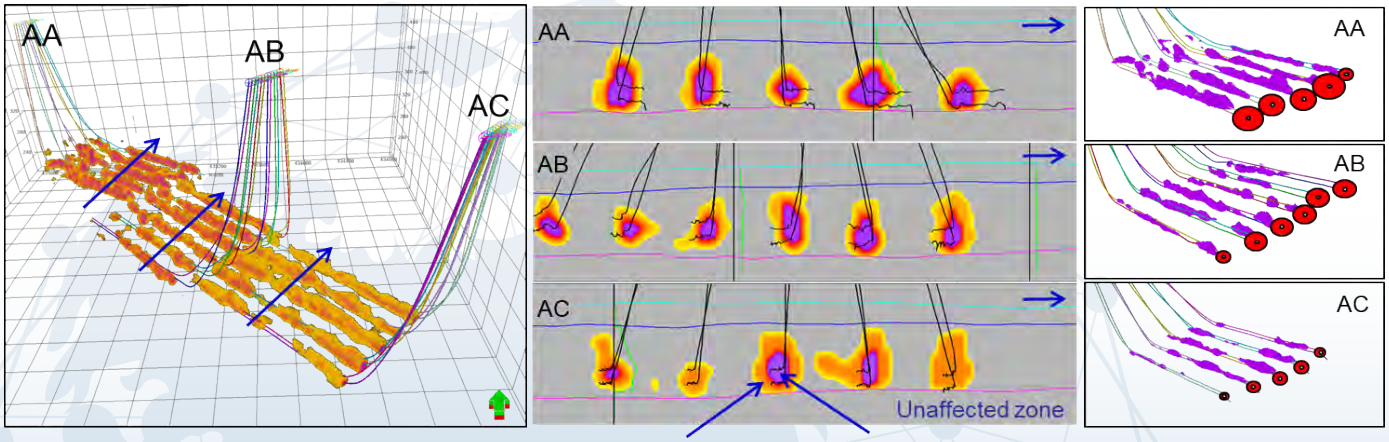


Figure 5: Comparison between cumulative production and predicted steam chamber

Integrated Seismic Data Processing and Interpretation

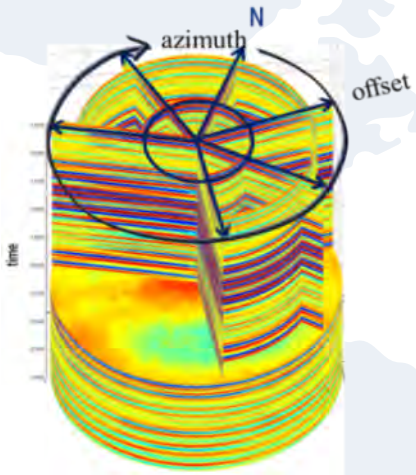
5D Seismic Interpretation

Pre-stack 5D Seismic Data Interpretation

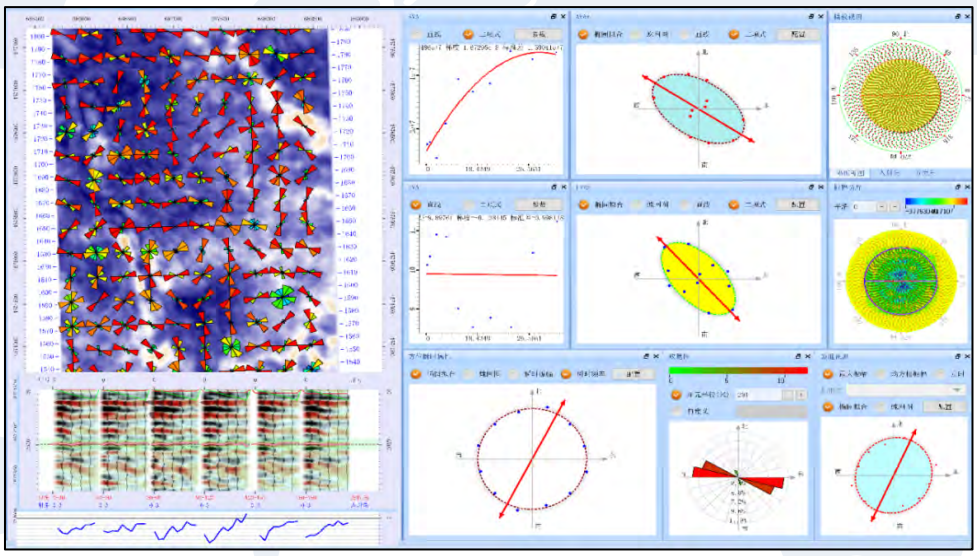
Pre-stack 5D interpretation techniques have been developed to fully extract pre-stack information. Compared to 3D interpretation, information in offset and azimuth dimensions is utilized to finely depict the distribution of fractures and hydrocarbons.

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 and azimuth-based hydrocarbon detection.



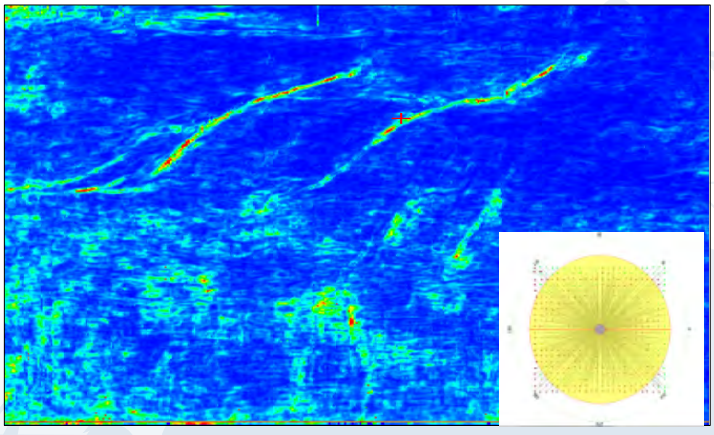
Prestack 5D gather



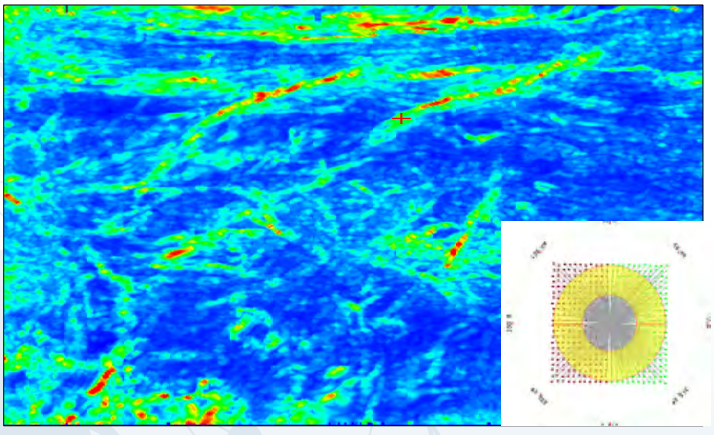
Interactive 5D seismic data analysis

Geological objective-guided interactive template optimization

GeoEast provides an interactive 5D gather optimization template definition function and the user can define partial stacking parameters 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

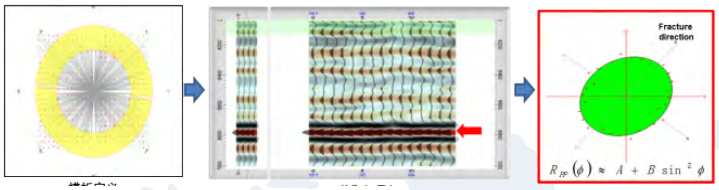


Partial azimuth and angle stacking reveal more information

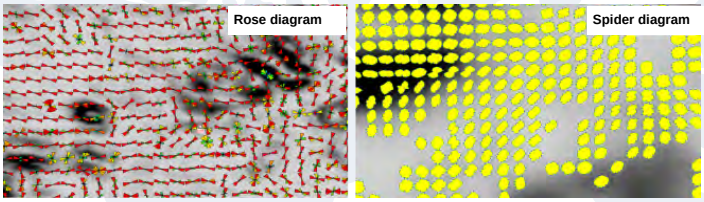
Integrated Seismic Data Processing and Interpretation

Pre-stack fracture prediction based on 5D seismic data

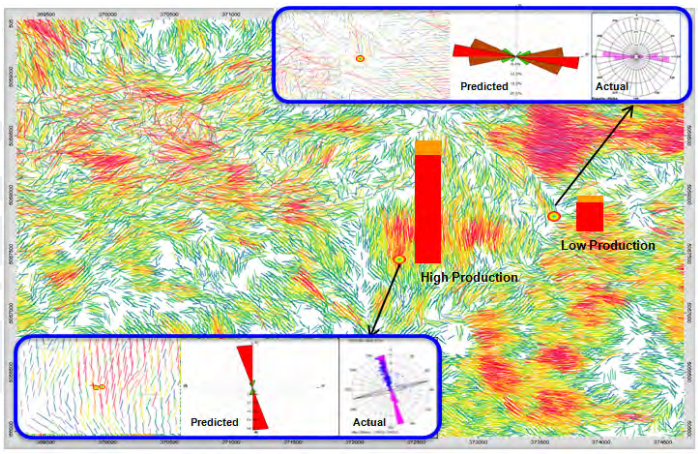
Based on the HTI theory, fracture azimuth, density and confidence interval are detected with the optimized 5D gather, where elliptical fitting or statistics is employed to analyze seismic attributes such as amplitude and travel times.



Anisotropy analysis based on optimal template



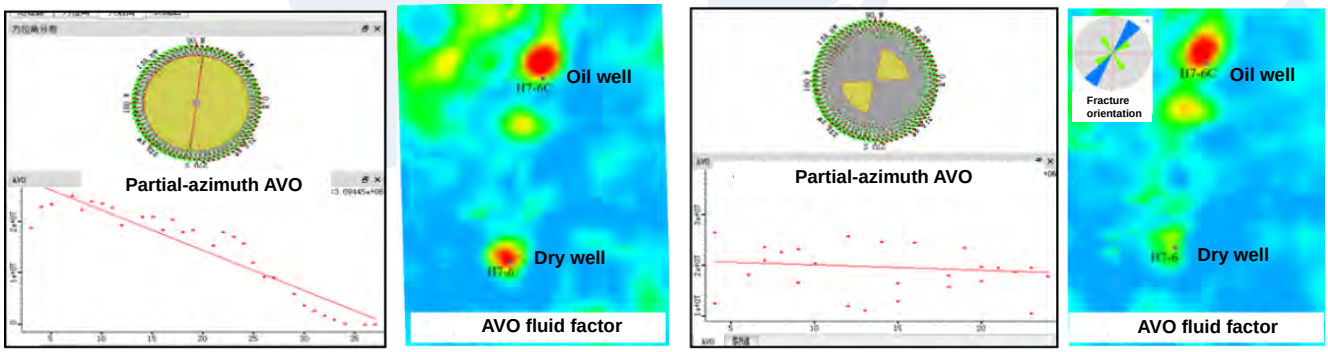
Various displays of fracture detection results



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

AVOAz

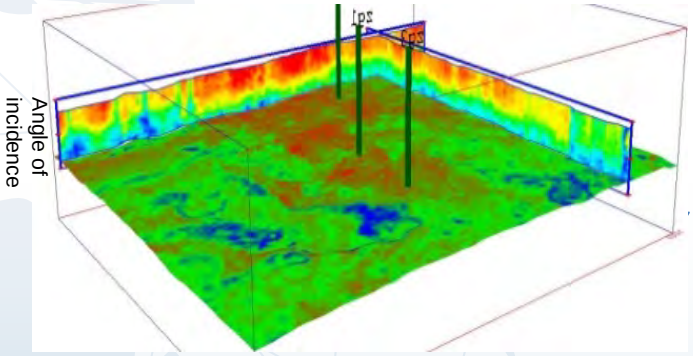
Azimuthal AVO analysis based on 5D gather data can effectively mitigate anisotropy impact on AVO response and thus improve hydrocarbon detection accuracy.



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 fracture orientation to increase the accuracy of hydrocarbon detection.

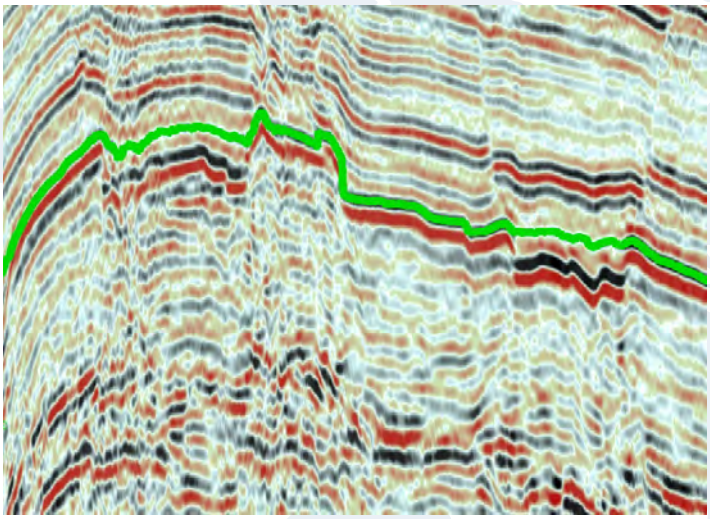


FVO gradient (plane) and frequency (section) along horizon

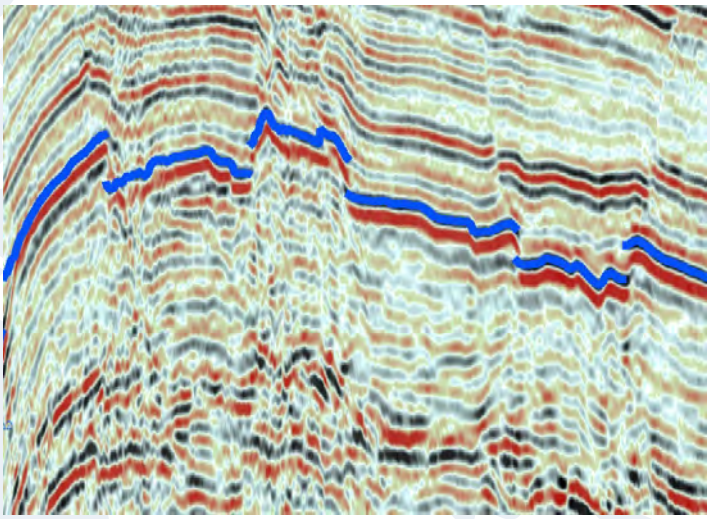
AI Interpretation

Deep Learning-based Horizon Interpretation

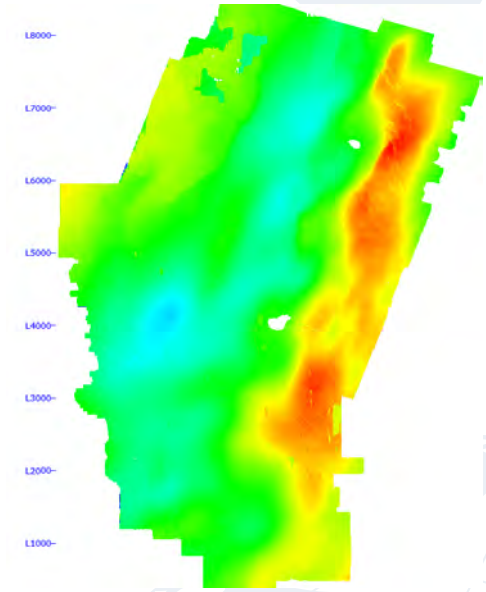
The traditional horizon auto tracking technique is usually based on waveform similarity or spatial density, which is not reliable when the seismic event crosses faults. However, even without fault constraints, the deep learning based horizon auto tracking technique is able to obtain decent results in the fault zone.



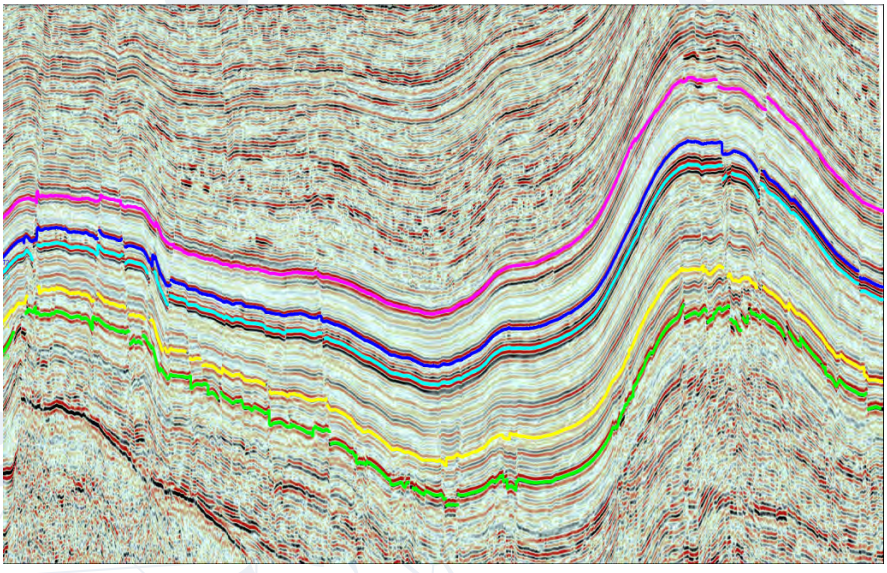
Traditional horizon auto tracking



Deep learning based horizon interpretation



AI horizon tracking

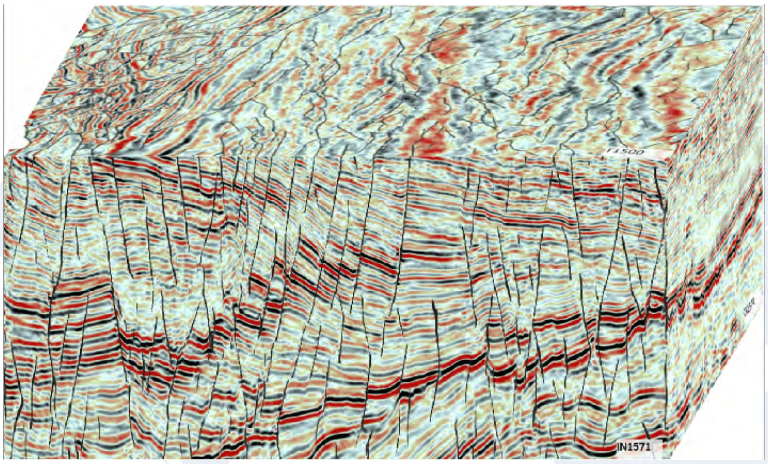


AI Multi-horizon tracking

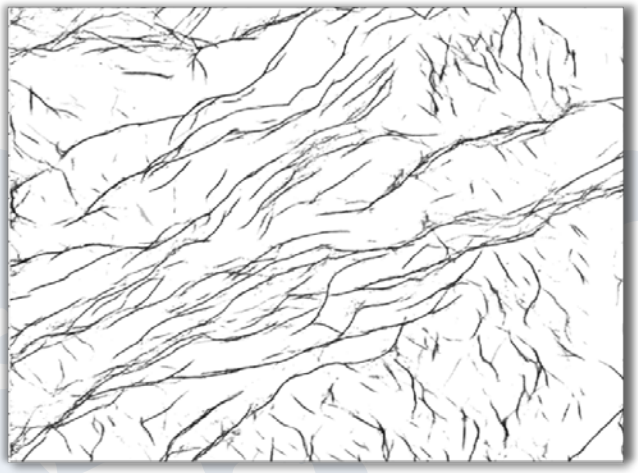
The accuracy and efficiency of Deep learning-based horizon interpretation is promising. The accuracy of AI interpretation of single horizons of a highly faulted data is up to 97%, and the efficiency is greatly improved compared to traditional auto tracking and manual modifications.

Deep Learning-based Fault Interpretation

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.



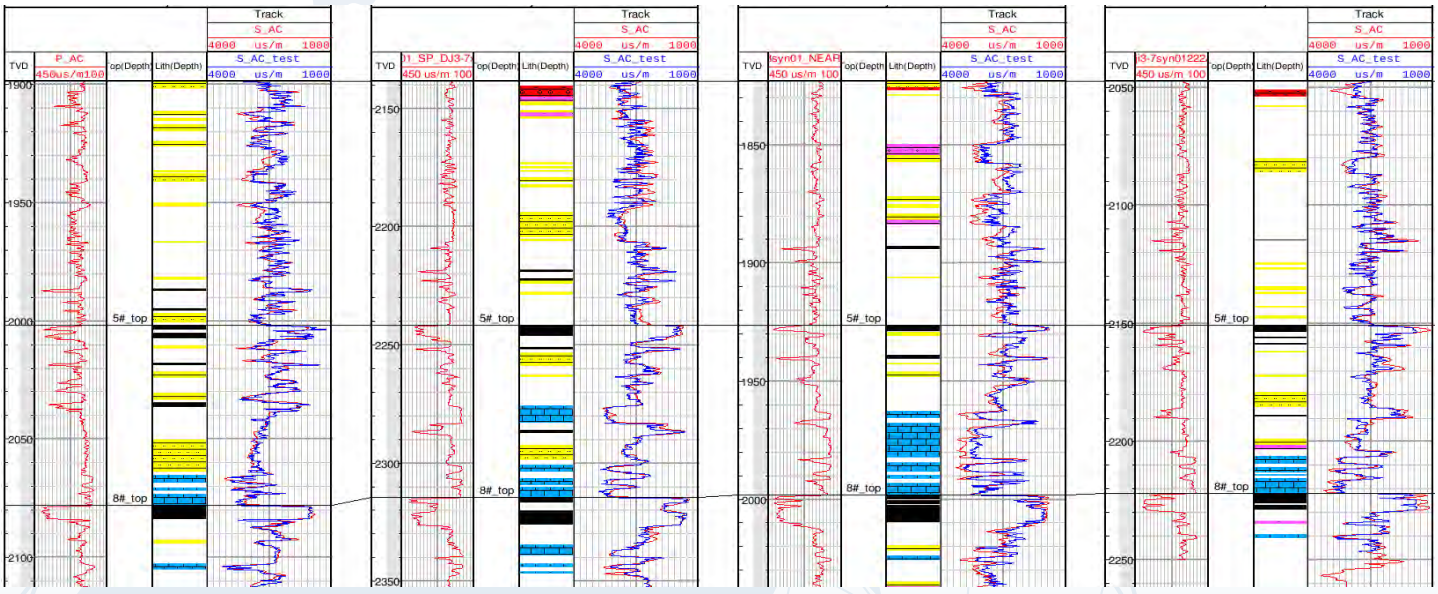
AI fault prediction cube



Slice of AI fault prediction

AI Logging Interpretation

GeoEast provides AI logging interpretation functions such as AI lithology prediction and AI logging curve prediction. The accuracy of AI prediction is higher than conventional rock physics modeling or empirical fitting.

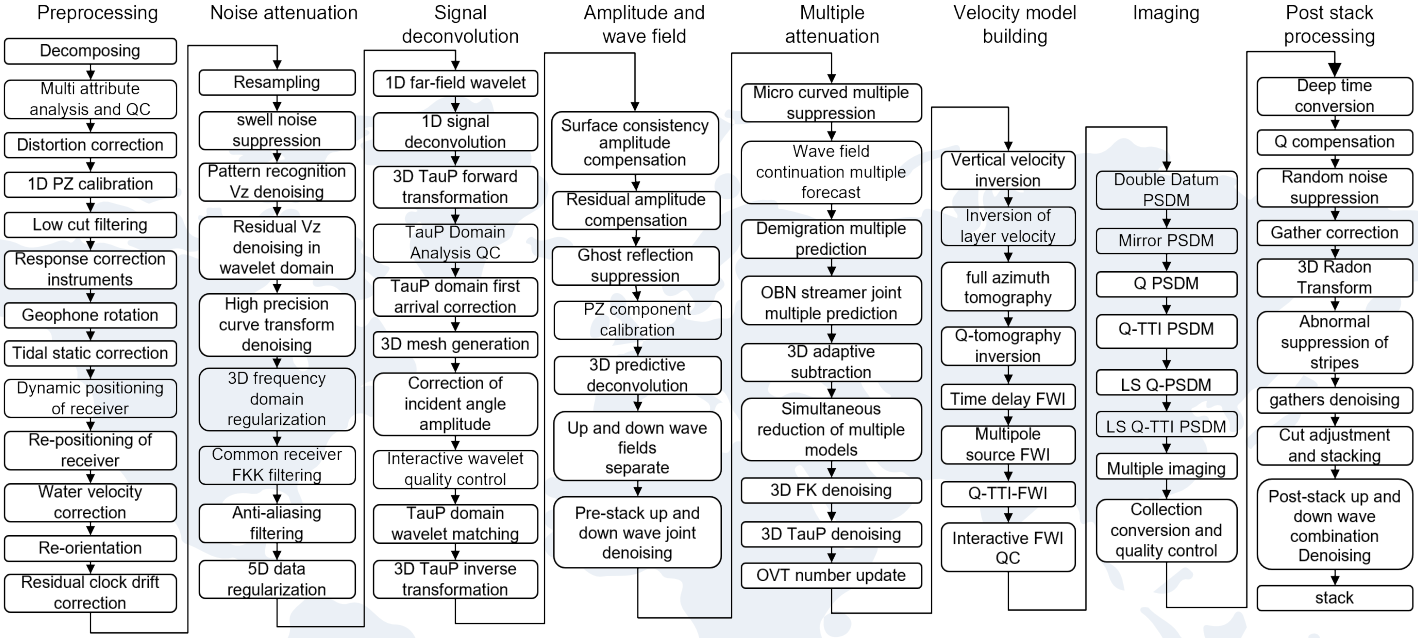


Red: Original curve
Blue: AI predicted curve

Integrated Seismic Data Processing and Interpretation

Marine Data Processing

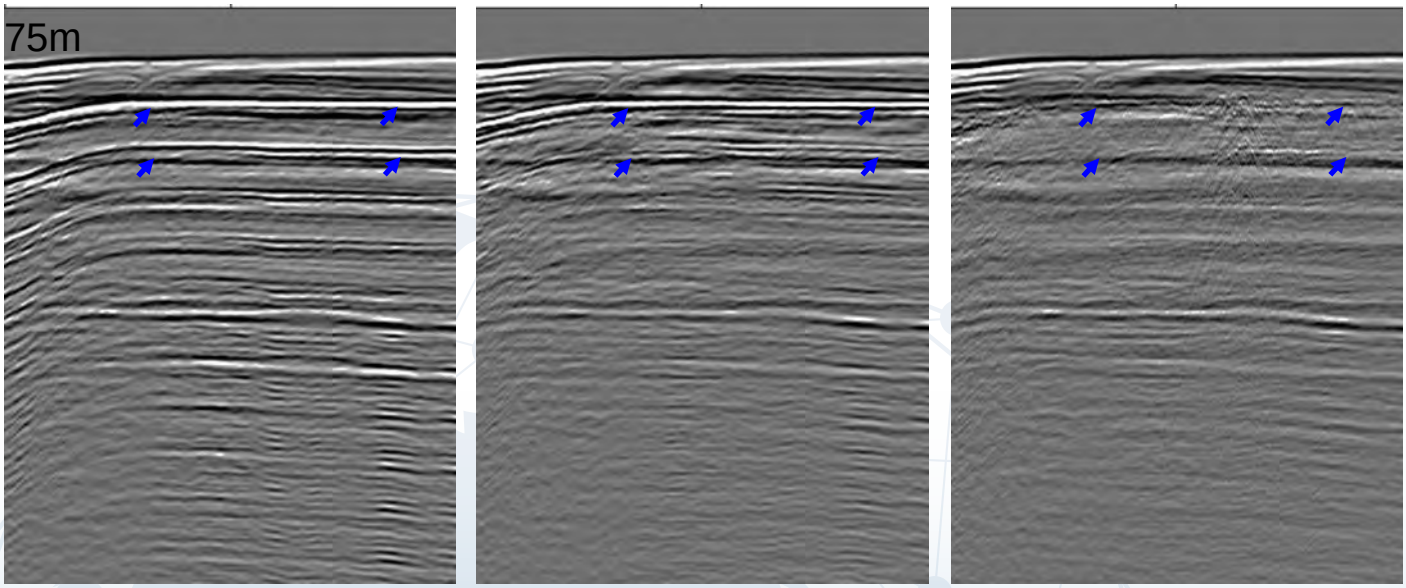
Various functions of GeoEast are available for different kinds of marine data such as streamer, OBC and OBN. They cover different purposes including on-site acquisition QC, noise attenuation, broadband processing, multiples attenuation and mirrored migration.



GeoEast full OBN processing flow

EPSI

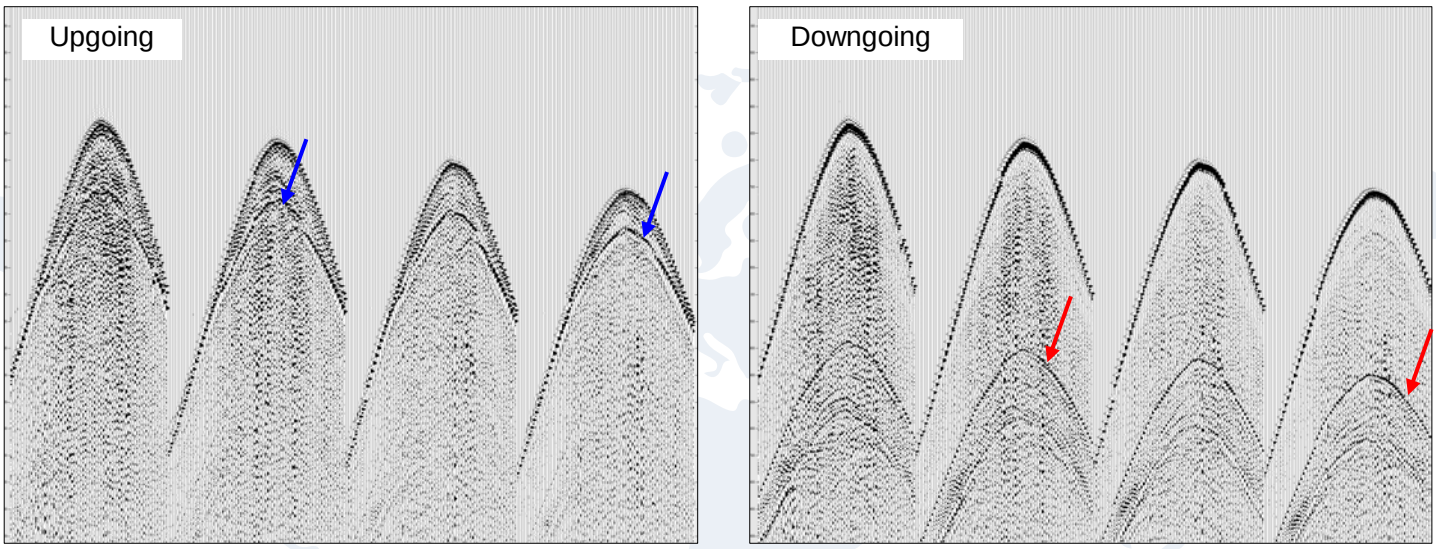
Estimation of primaries by sparse inversion (EPSI) estimates and separates primaries and surface multiples by inversion. It copes well with the problems faced by SRME for shallow water streamer data, such as lack of near-offset data and strong interference of primaries and multiples.



Stack of data | Stack of data after SRME | Stack of data after EPSI

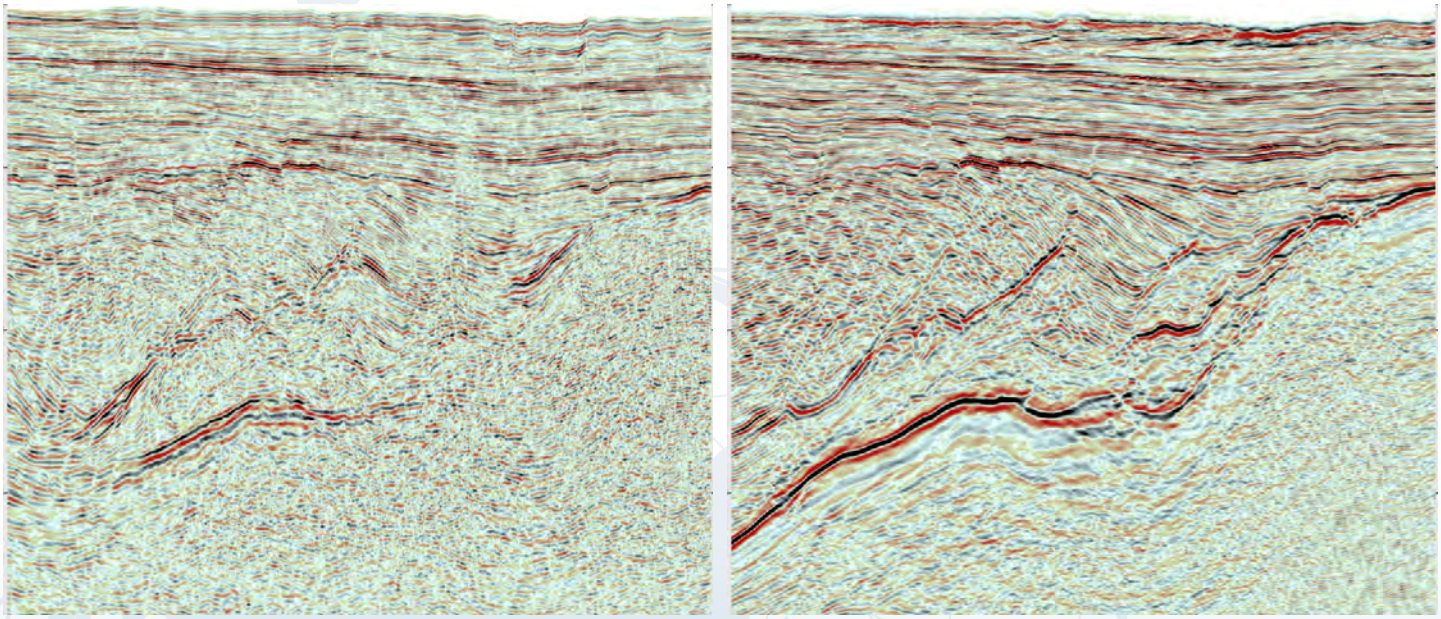
Ocean Bottom Node(OBN) data Processing

GeoEast provides a complete set of OBN data processing techniques for the entire OBN processing flow. Featured techniques include Vz denoise, time-varying CRP binning and dual-datum migration.



The receiver gathers before and after wavefield separation

The Wavefield separation technique, which is based on a spatial calibration filter and PZ summation, is able to separate the up-going and down-going wavefields.



Streamer vintage

OBN fast track

Cloud Computing Management System

The Cloud Computing Management System realizes a couple of functions including resources sharing, data centralization and application integration. It enables transformation of the processing and interpretation business from traditional mode to cloud computing mode (SaaS).

Resource Management And Monitoring

Support above 2000 nodes (support heterogeneity)
Automatic resource discovery
Batch configuration management
One-click deployment, automatic operation and maintenance
Second-level monitoring, storage management and fault alarm

Software Management

Software registration
Software distribution

User Management

Automatically discover users
Department management
User group management
Role management

Remote Visualization

Automatic load balancing
Session saving
Perfectly support 3D applications
Support Linux, Windows, custom monitors
Low broadband
Multi-user collaboration

Job Scheduling

Quota management
Flexible scheduling
IO overload protection
Application programming interface
Support multi-application resources sharing

Statistical Analysis

Server statistics
Cluster statistics
Storage statistics
Connected user, device and application statistics

Data Management

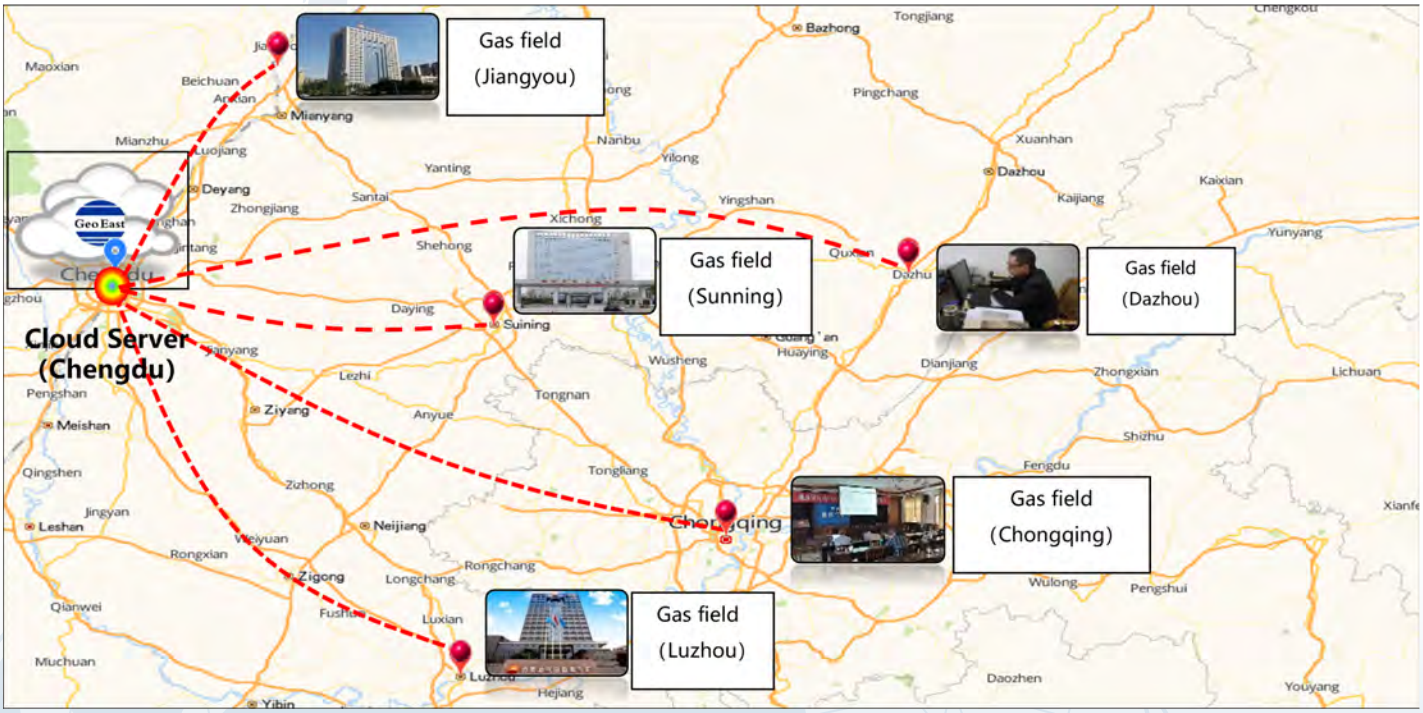
Private data upload and download management
Public data upload and download management

Extensively combined with Public Clouds

It is widely combined with public clouds such as Petro-China Cloud, Tianhe Cloud, Alibaba Cloud and CSTCloud.

Main Values

- Centralized resource management to effectively reduce business costs
- Working environment supporting entire business process to improve efficiency
- Mobile office anytime anyplace to make computing efficient
- Professional management to provide better service quality



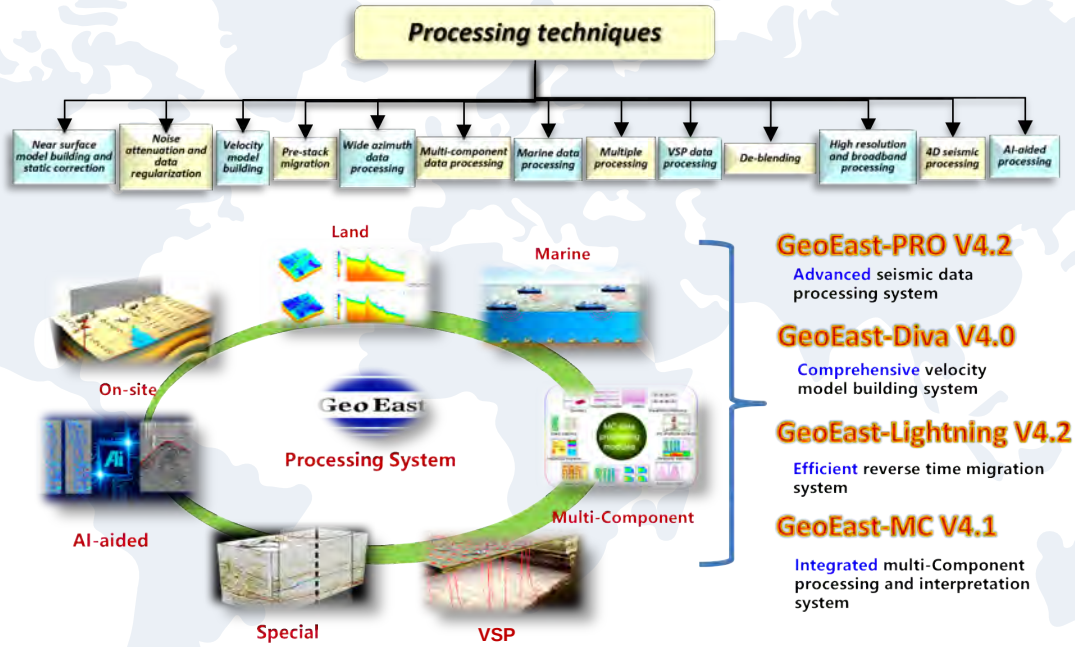
Application Example

GeoEast - An Integrated Seismic Data Processing and Interpretation Software System

GeoEast is a comprehensive, large-scale geophysical data processing and interpretation software system. It can fully meet the demands of time domain and depth domain processing and interpretation of geophysical data acquired from complex geological and geophysical conditions of both land and marine. It also provides end-to-end solutions for VSP, shear wave, and unconventional data processing.

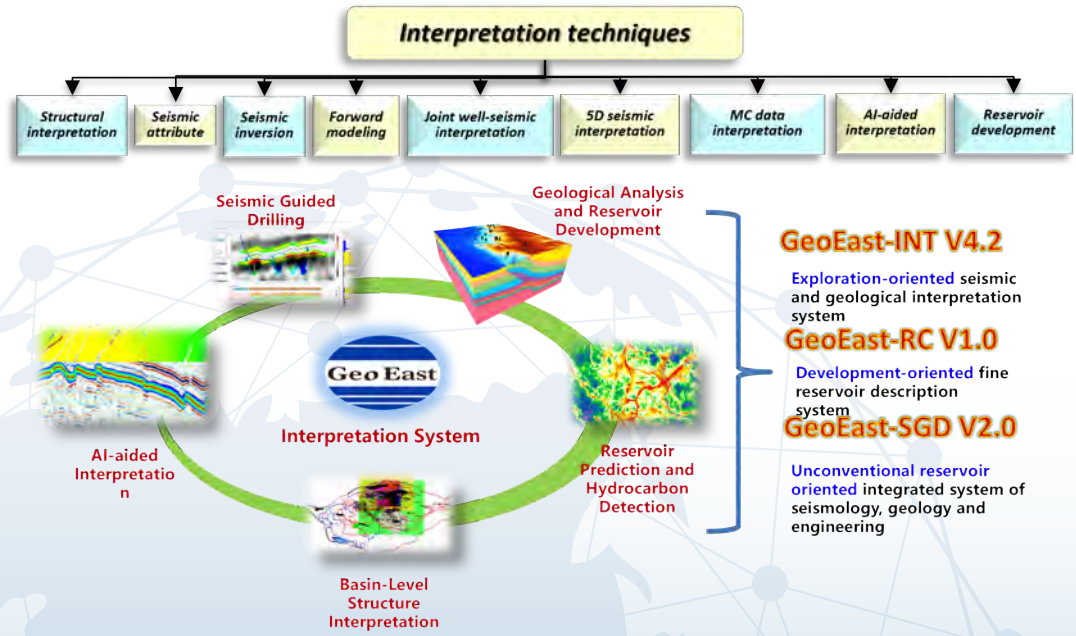
Processing Software

■ 7 packages ■ 24 technology series ■ 400+ modules



Interpretation Software

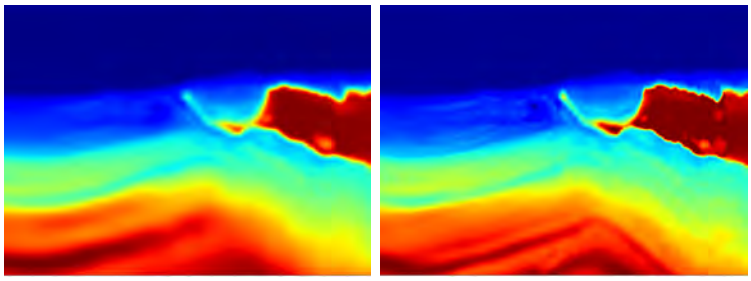
■ 7 packages ■ 24 technology series ■ 400+ modules



GeoEast - An Integrated Seismic Data Processing and Interpretation Software System

FWI

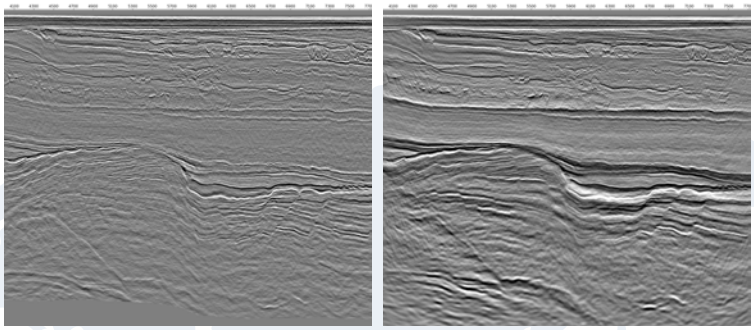
Equipped with full waveform inversion technology in time domain, frequency domain, and Laplace domain, it can be used in conjunction with tomography to establish a high-precision velocity model.



Legacy velocity model | JDFWI inverted velocity model

FWI Imaging

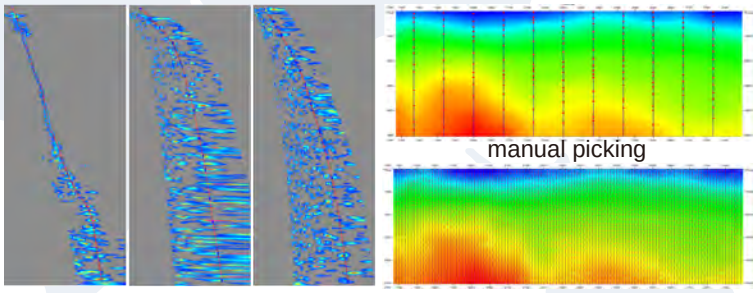
Expanding low frequencies: Non-linear inversion can generate low frequencies that seismic waves do not possess.
Expanding illumination: Non-reflective waves can cover illumination structures that reflective waves cannot.



PSDM | PSDM + FWI

AI Processing

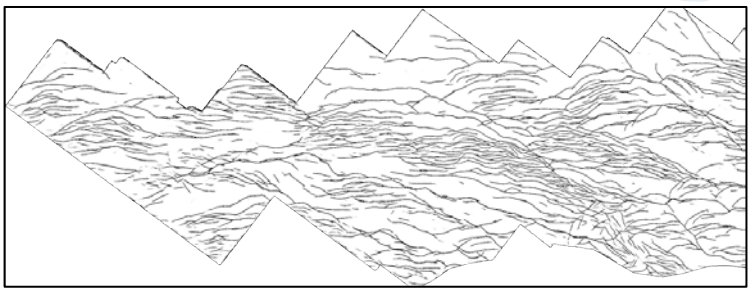
GeoEast has developed intelligent processing modules for time-consuming and labor-intensive processes such as first break picking, velocity picking, and noise attenuation. The accuracy and efficiency improved dramatically.



Different S/N data | DL picking

AI Interpretation

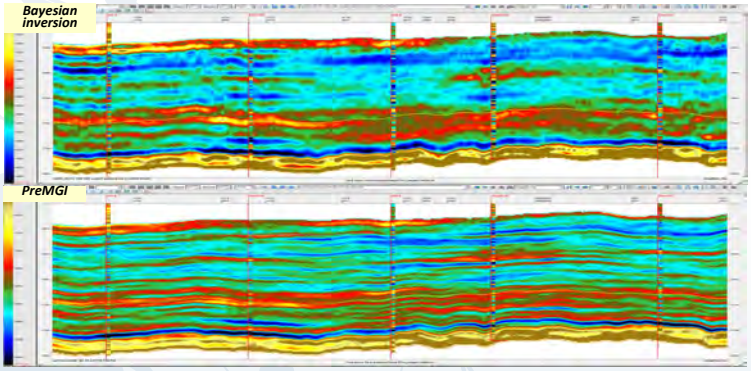
A deep learning-based artificial intelligence neural network has been developed, equipped with a series of intelligent interpretation technologies including horizon interpretation, fault identification, well log curve prediction, well log lithology prediction, and geological body identification.



AI-aid fault prediction

Seismic Inversion

GeoEast provides rich pre-stack and post-stack seismic inversion methods and complete workflow, which can meet the needs of reservoir prediction in different stages of exploration and development.



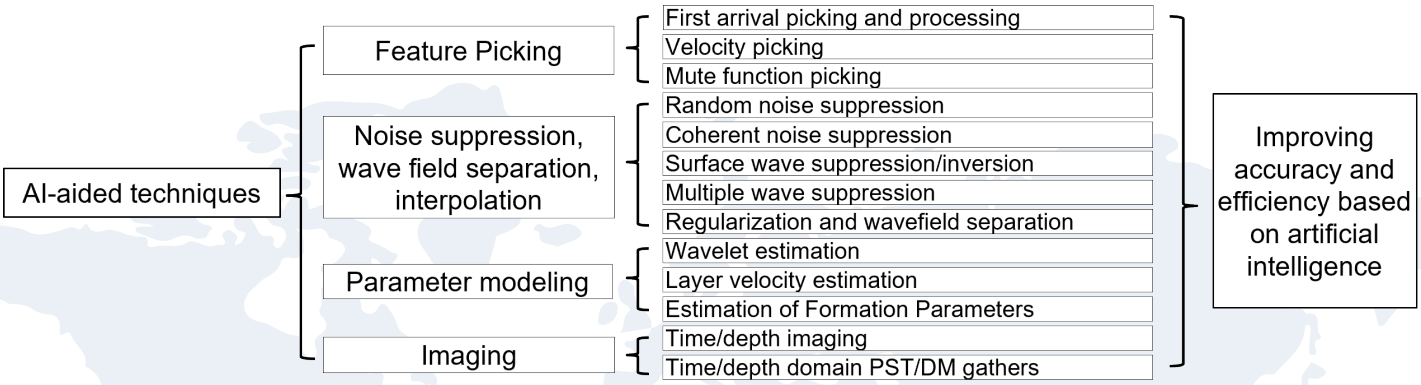
Inverted shear wave impedance

Integrated Seismic Data Processing and Interpretation

AI Processing

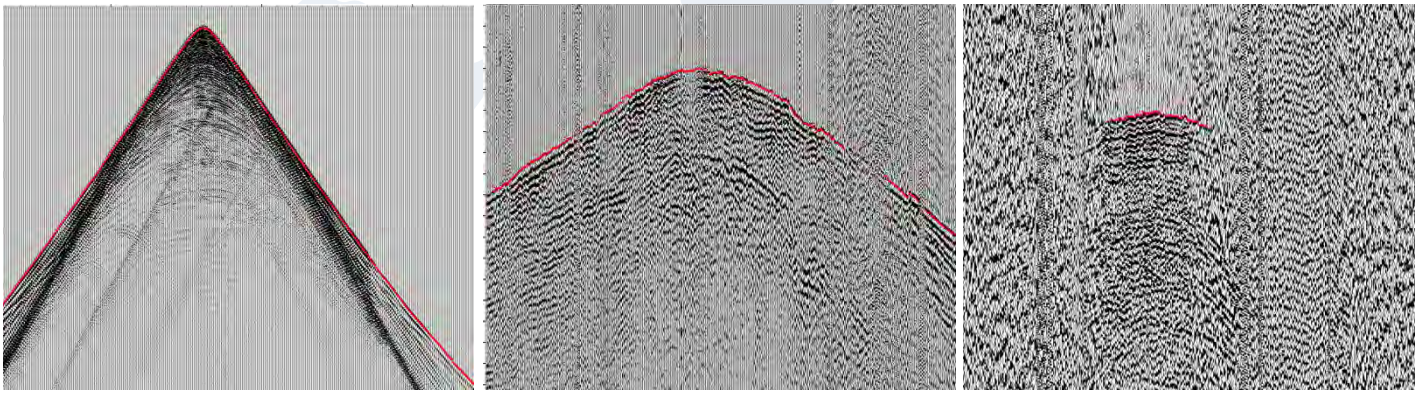
AI-aided Seismic Data Processing

In the oil & gas exploration field, artificial intelligence techniques have been paid increasingly more attention. BGP attaches great importance to the research and development of AI-aided processing technique.



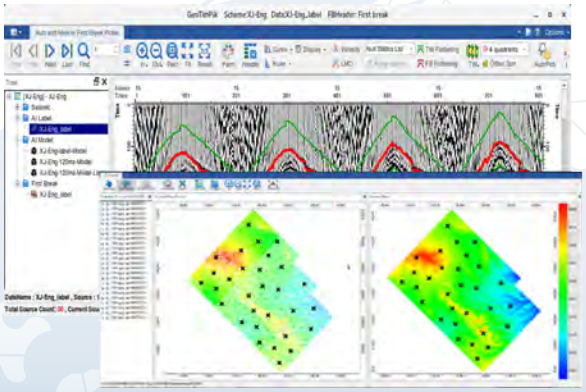
Deep Learning-based First-Break Picking

GeoEast provides a deep learning-aided first-break picking technique which can efficiently pick data of different S/N levels with very high accuracy. The technique has been applied on lot of processing projects with different S/N levels.

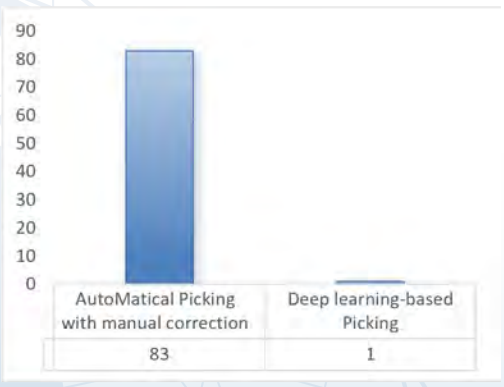


High S/N data | Middle S/N data | Low S/N data

An interactive software package with all the related functions such as label making, model training and first arrival predicting is provided. The package supports CPU/GPU/DCU HPC devices and computational efficiency is more than 80 times higher than that of conventional methods.



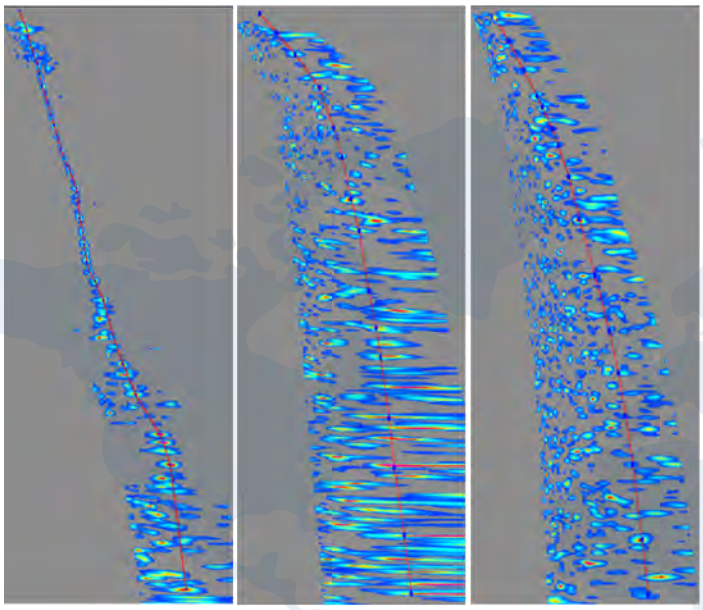
Interactive software with full functionality



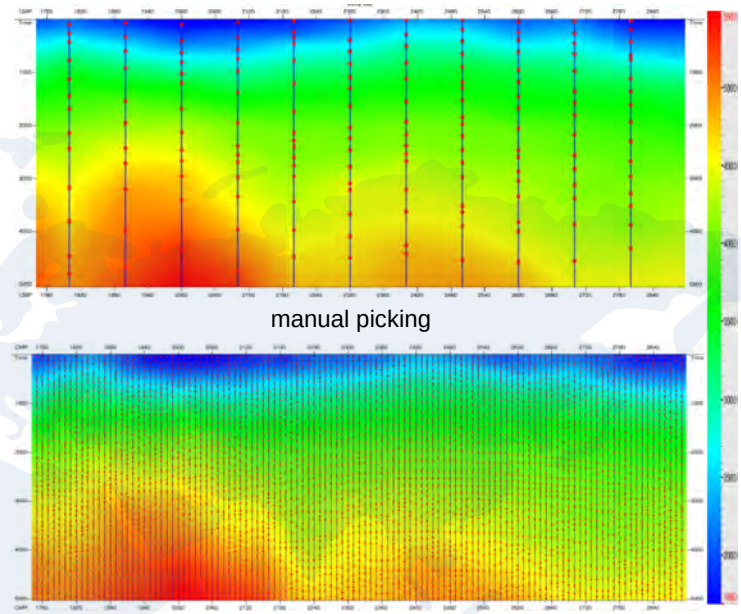
Computational Efficiency Comparison

Deep Learning-aided Velocity Picking

GeoEast provides a deep learning-aided velocity picking technique which can properly handel velocity spectra of different quality and give quality picking results.

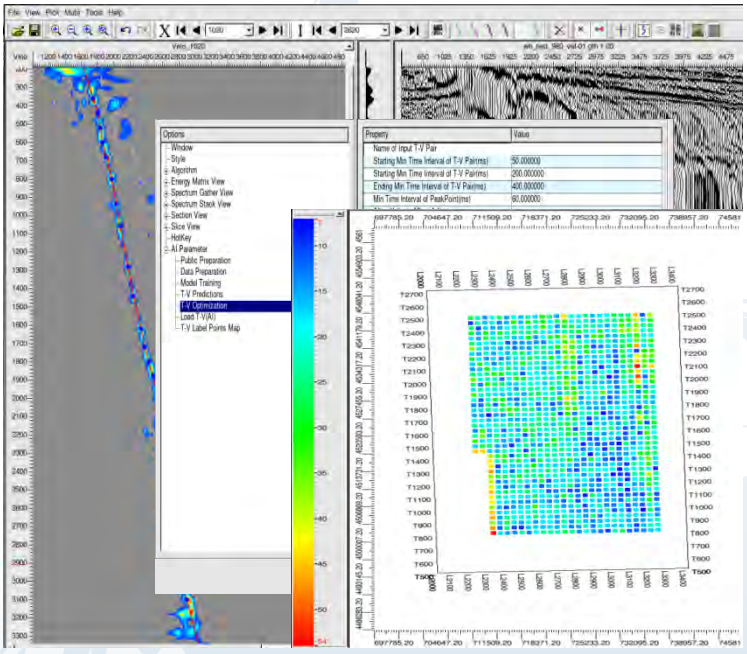


different S/N data

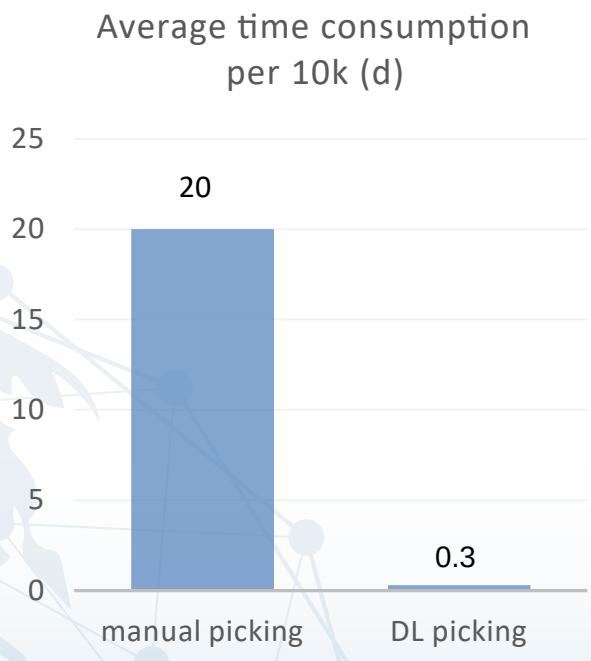


DL picking

Interactive software with full functionality is also developed for label selection, model training, picking prediction, optimization, and quality control. And supports multiple HPC hardware devices, with overall efficiency dozens of times higher than traditional methods.



Interactive software with full functionality



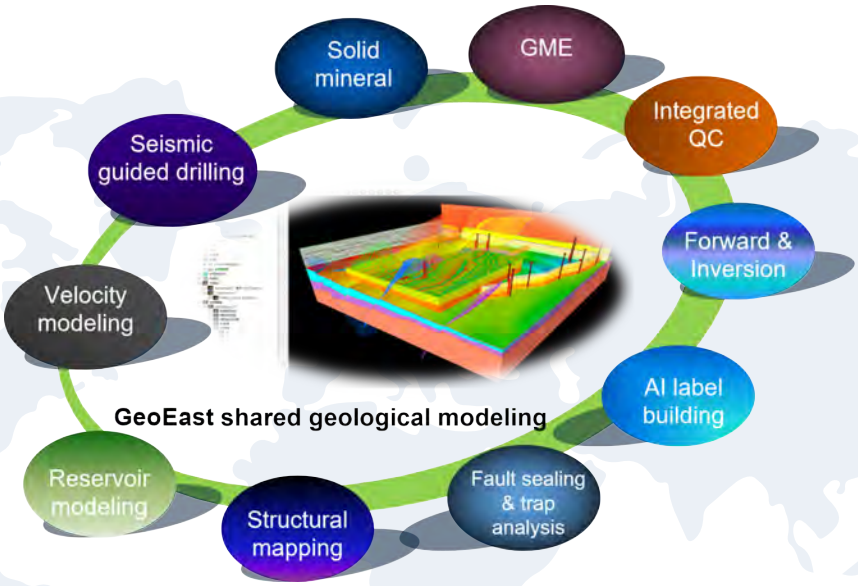
Computational Efficiency Comparison

Integrated Seismic Data Processing and Interpretation

Geological Modeling

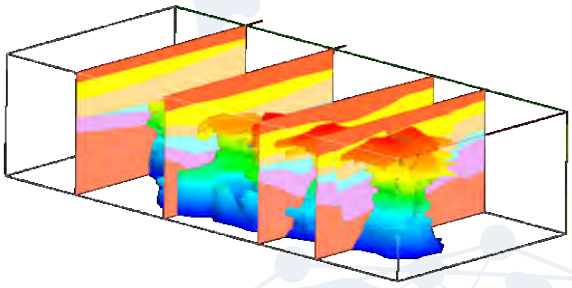
Reverse Time Migration

GeoEast provides an integrated complex 3D geological model building platform, with key techniques for reservoir grid modeling and complex structure modeling, it is suitable for various types of geological conditions.

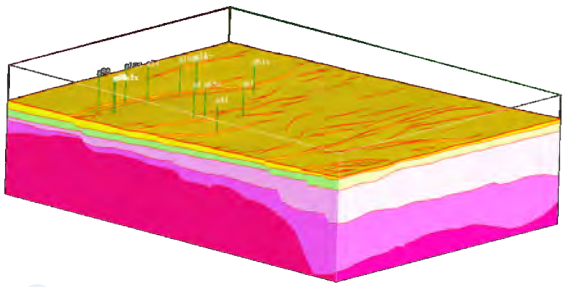


Sample application scenarios

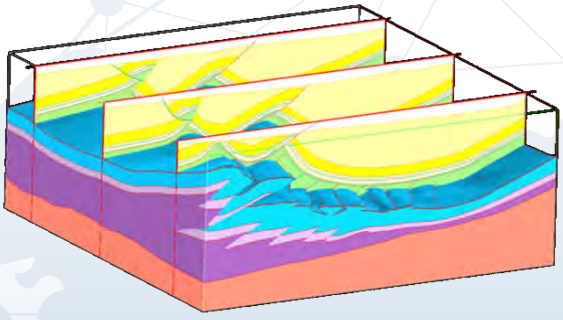
The shared modeling platform can applied in seismic, from data acquisition through interpretation, GME, solid mineral and reservoir development. It has been widely applied in seismic inversion initial model building, property modeling, forward modeling, geological anomalous body modeling, and geological profile generation, etc.



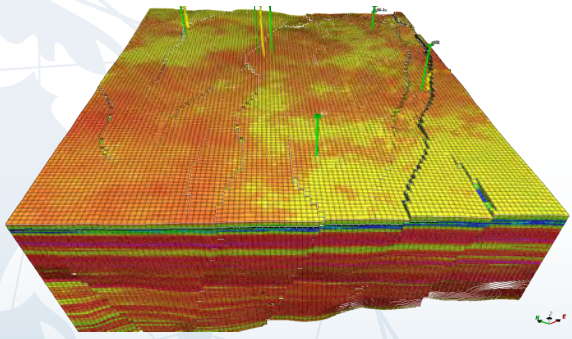
Solid mineral



Complex fault blocks



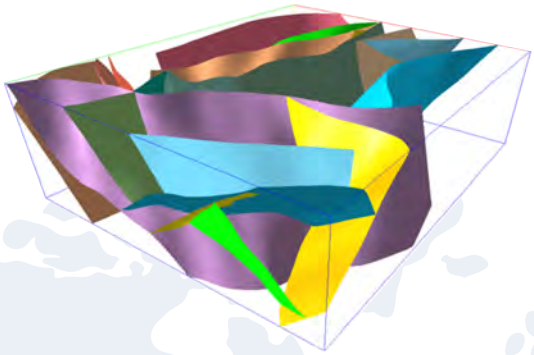
Overthrust structure



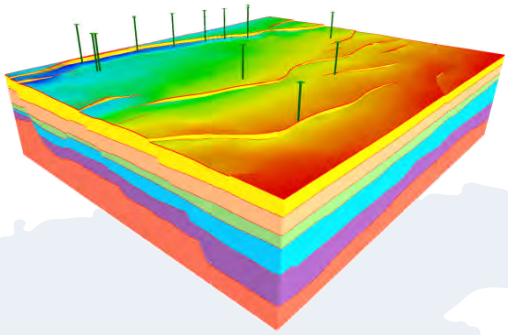
Porosity modeling

Structure Model building

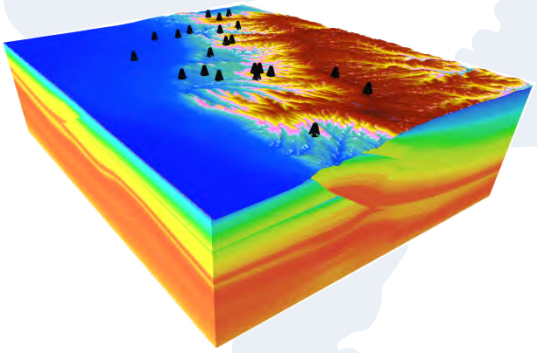
GeoEast provide an integrated interpretation and modeling functions. It offers a user-friendly approach in modeling complex structures such as normal and reverse faults, unconformities, etc.



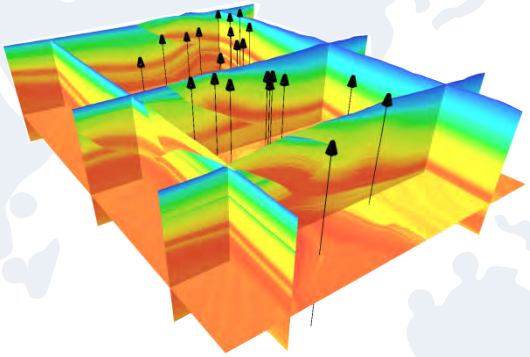
Fault surface model



Structure model



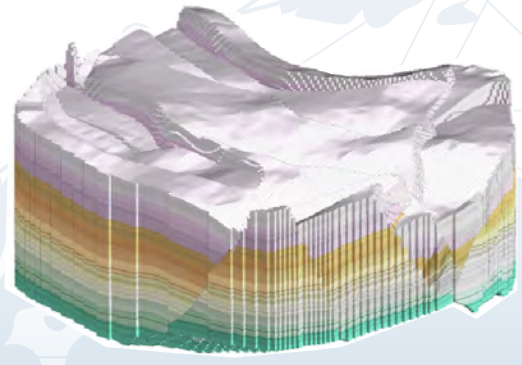
Velocity model



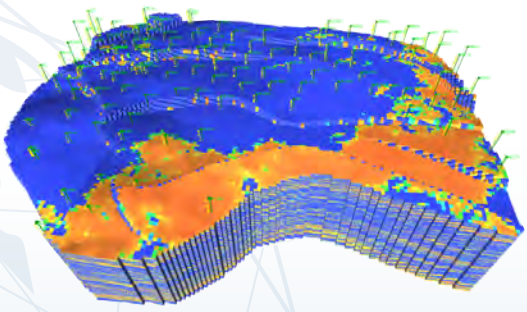
Model QC

Reservoir Modeling

A suite of key techniques for reservoir grid modeling are provided, including fine reservoir structure modeling of complex fault blocks, reservoir grid modeling (stair-stepped grid, corner grid), facies controlled property modeling (sedimentary facies sequence indicator simulation, co-simulation), etc.



Reservoir grid model



Reservoir property model

Integrated Seismic Data Processing and Interpretation

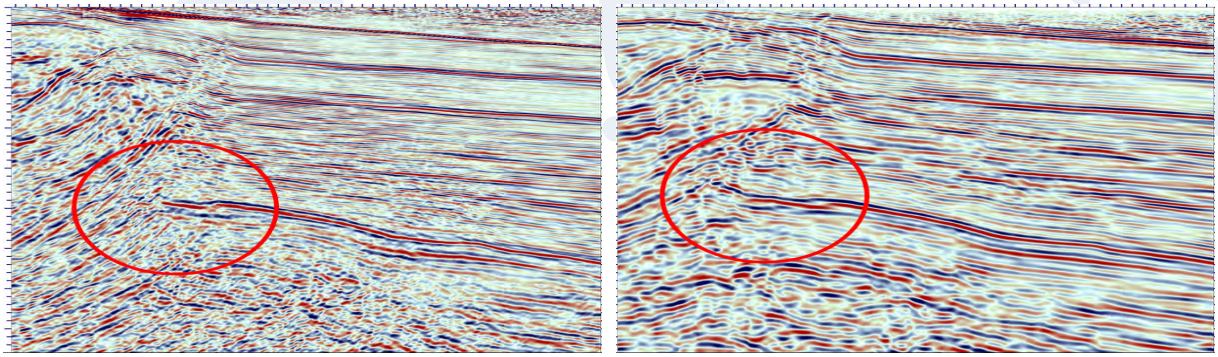
High-accuracy Pre-stack Imaging

GeoEast provides imaging techniques using Kirchhoff, Gaussian Beam, One-way Wave Equation and Two-way Wave equation engines. These methods can process seismic data with various acquisition types, such as undulate surface, OVT, OBS (OBN + OBC). They can be used to image complex geological structures such as faults, overthrusts, buried hills, karst caves, salt domes, gas chimneys, volcanoes and carbonate reservoirs. With advanced CPU/GPU parallel computation, these imaging methods have very high computational efficiency.

Migration Algorithm	Gather output	GPU	Media	Inverse Q	Least-squares migration
RTM	ODCIG, ADCIG	✓	TTI, TORT	✓	✓
Kirchhoff	OVT, ODCIG ADCIG	✓	TTI, TORT	✓	✓
Gaussian Beam	OVT, ODCIG ADCIG		TTI, TORT	✓	✓
One-way Wave Equation	OVT, ODCIG ADCIG		TTI	✓	✓

Reverse Time Migration

RTM is capable of migrating data of rugged surfaces and with OBS setting etc.. It can also accommodate VTI/TTI anisotropy and output multi-azimuth ADCIGs. With the enhanced CPU-GPU heterogeneous computation, RTM has an industry leading computational efficiency.

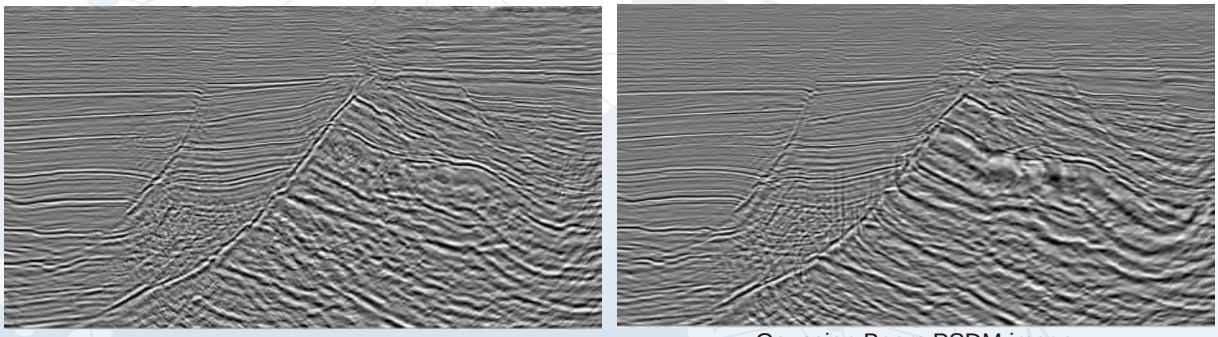


Kirchhoff PSDM image

RTM PSDM image

Gaussian Beam Pre-stack Depth Migration

Beam migration is available for undulating surfaces and VTI/TTI anisotropy medium. It can quickly generate azimuth ADCIGs and efficiently verify migration results with various velocity models.

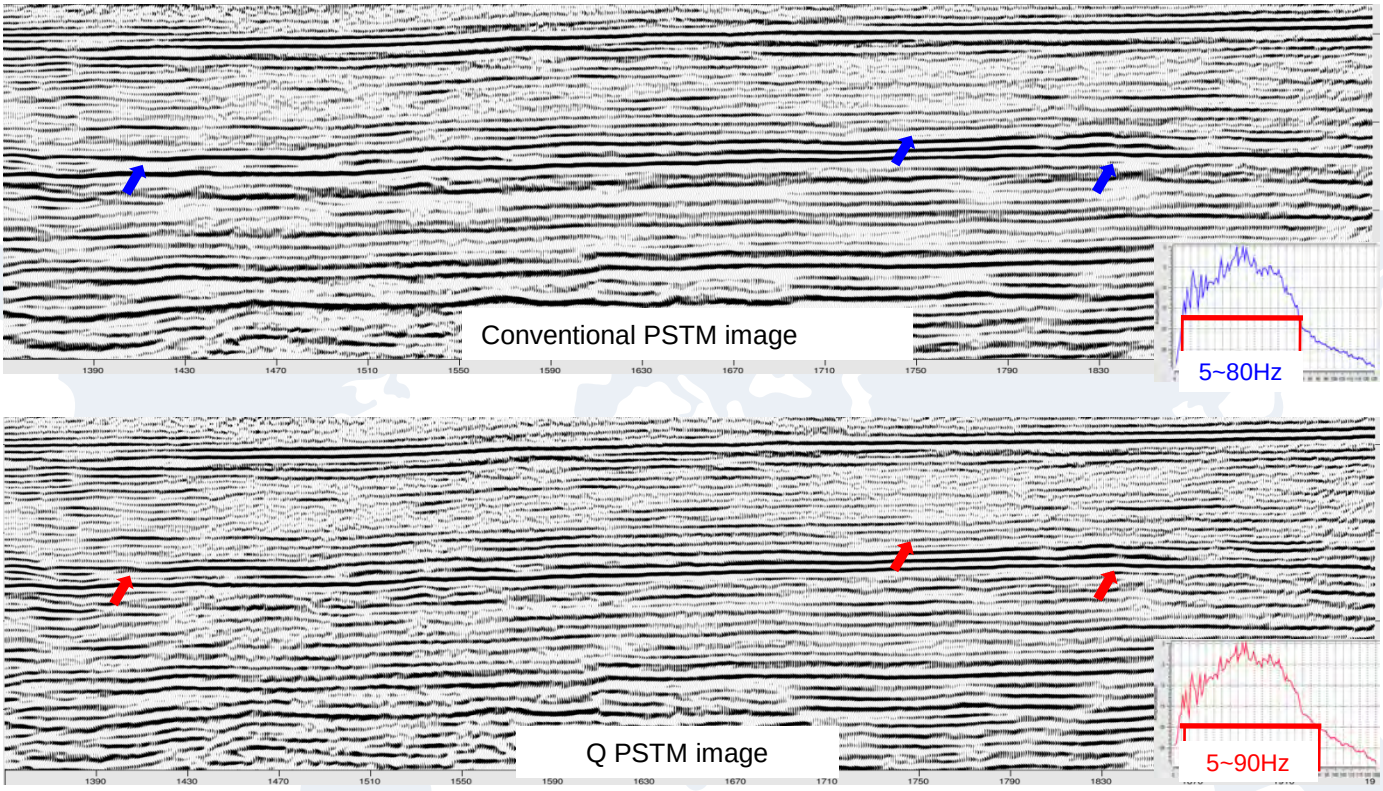


Gaussian Beam PSDM image

Gaussian Beam PSDM image from another software

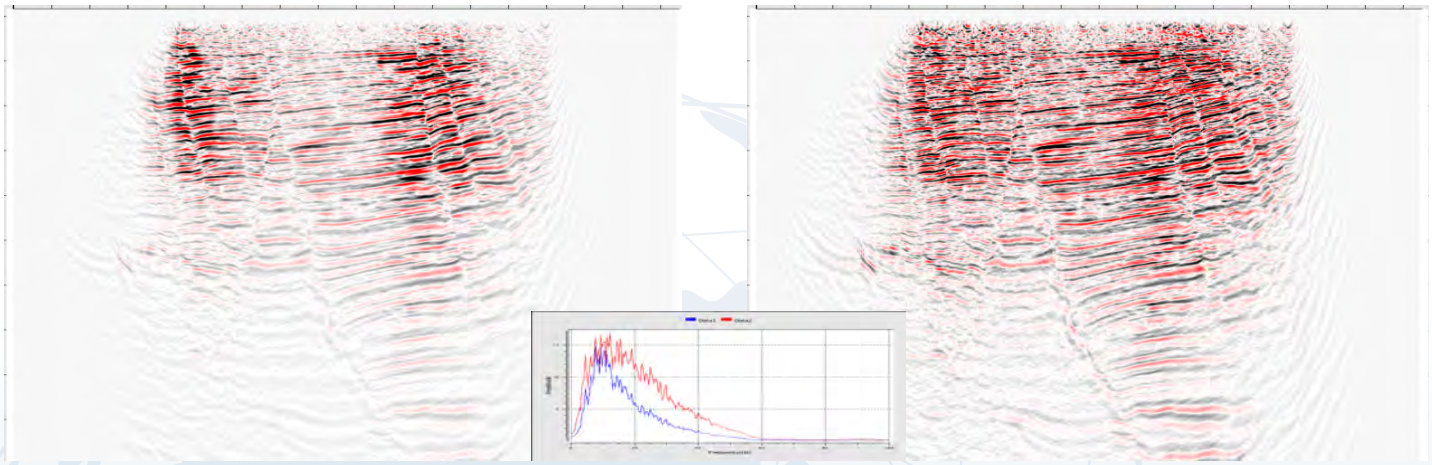
Q Pre-stack Depth Migration

GeoEast has a series of Q migration techniques including Kirchhoff, Gaussian Beam, One-way wave Equation and Reverse Time Migration. Q migration can improve imaging resolution in various cases, especially for areas with gas clouds.



Least-squares Migration

GeoEast provides least-squares migration (LSM) techniques of Kirchhoff, one-way and two-way wave equation algorisms. With these LSM techniques, seismic images can be effectively improved in terms of not only in resolution but also in illumination.

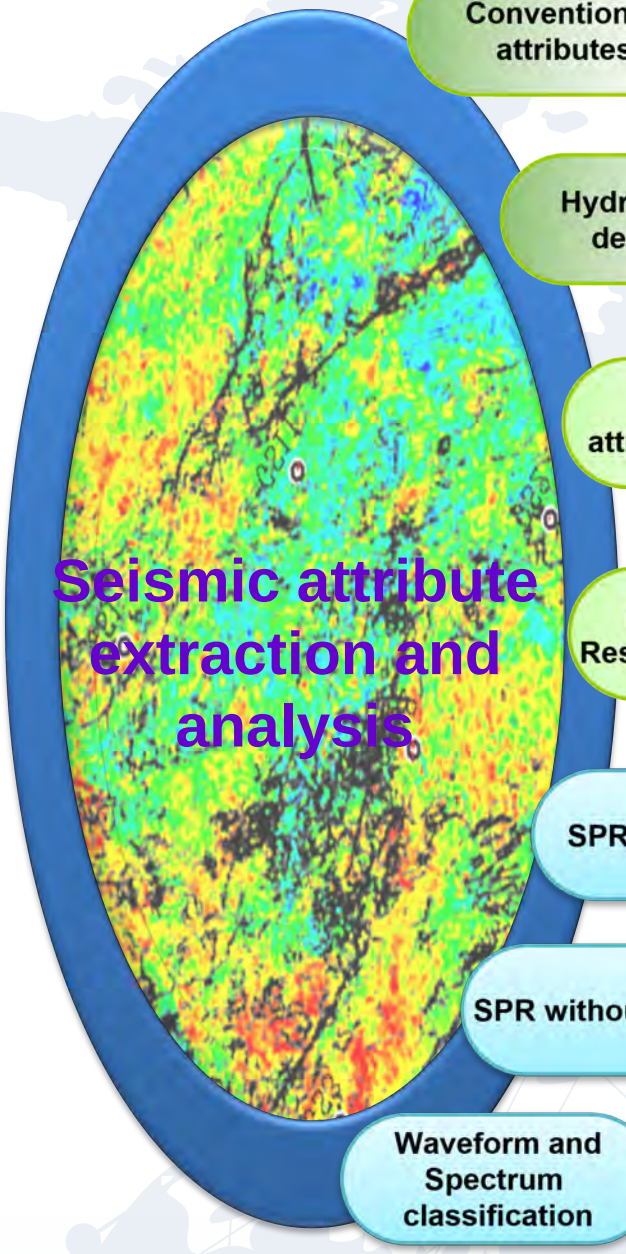


One-way wave equation migration

Least-Squares Migration

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.



Conventional attributes
Instantaneous
Waveform
Statistic
Mathematical

Hydrocarbon detection
Highlighted volume, fluid mobility
TF analysis
Dual-phase hydrocarbon detection
Spectrum decomposition
Pre-/post-stack strata absorption coefficient

Volume attributes analysis
Attribute fusion
Stratigraphic slice
Multi-attribute body classification

Fracture and Reservoir prediction
Multi-window scan
Structure-steered filtering
Curvature
Coherence and variance
Texture and edge detection
Shape index
Amplitude difference
Ant body
Coherence energy
gradient

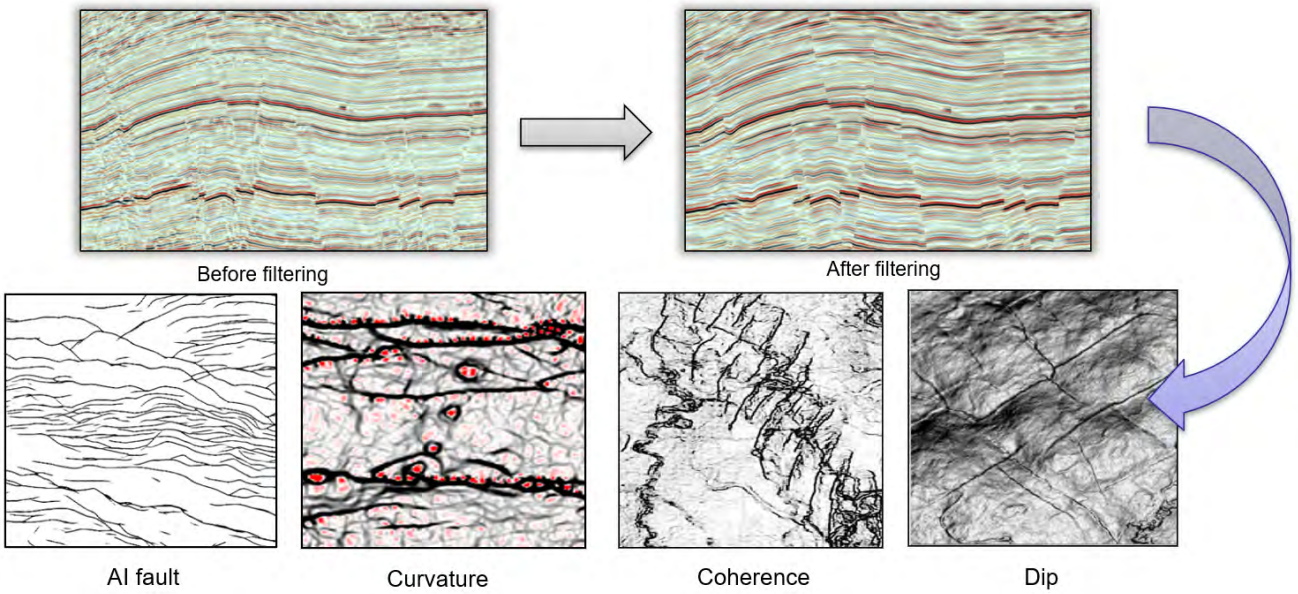
SPR with sample
BP neural network
KNN and Fisher analysis
Adaptive boost

SPR without sample
Self-organized manual analysis (SOMA)
C-means algorithm
Hierarchy classification (HC)
Rival penalized competitive learning (RPCL)

Waveform and Spectrum classification
Waveform classification
Spectrum classification

Fault Identification

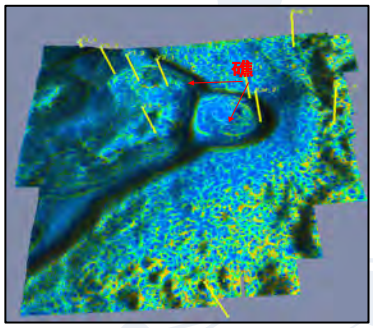
GeoEast provides functions such as 4C rotation of sources and receivers, 4C shear wave splitting analysis, separation of fast and slow shear waves etc. with high quality S-wave images being obtained and the structural characteristics are correctly delineated in gas cloud areas.



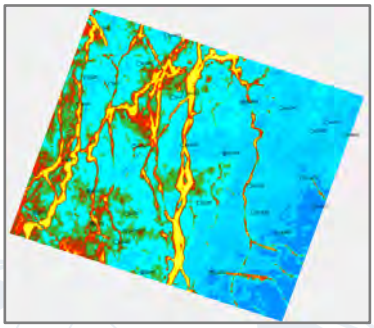
Attribute assist fault identification

Various types of Reservoir Prediction

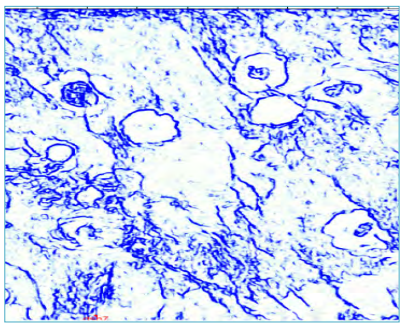
GeoEast provides a complete technique suite for diversified reservoir prediction. The modern seismic attribute and AI based attribute analysis functions are used for various type of reservoir characterization such as subtle fault or fracture, karst caves, channel, reef, volcano, and so on.



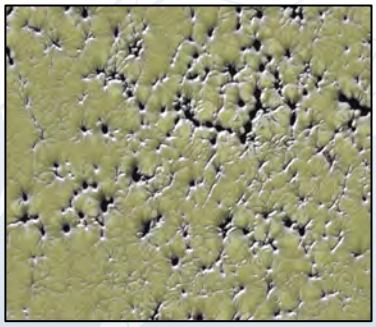
Reef



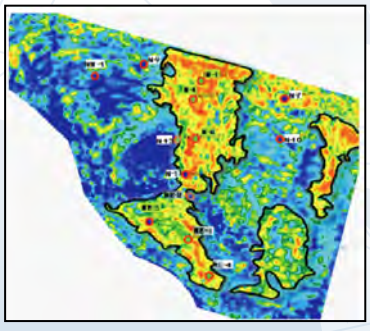
Channel



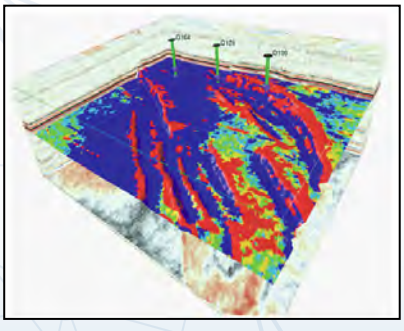
Volcano



Karst Cave



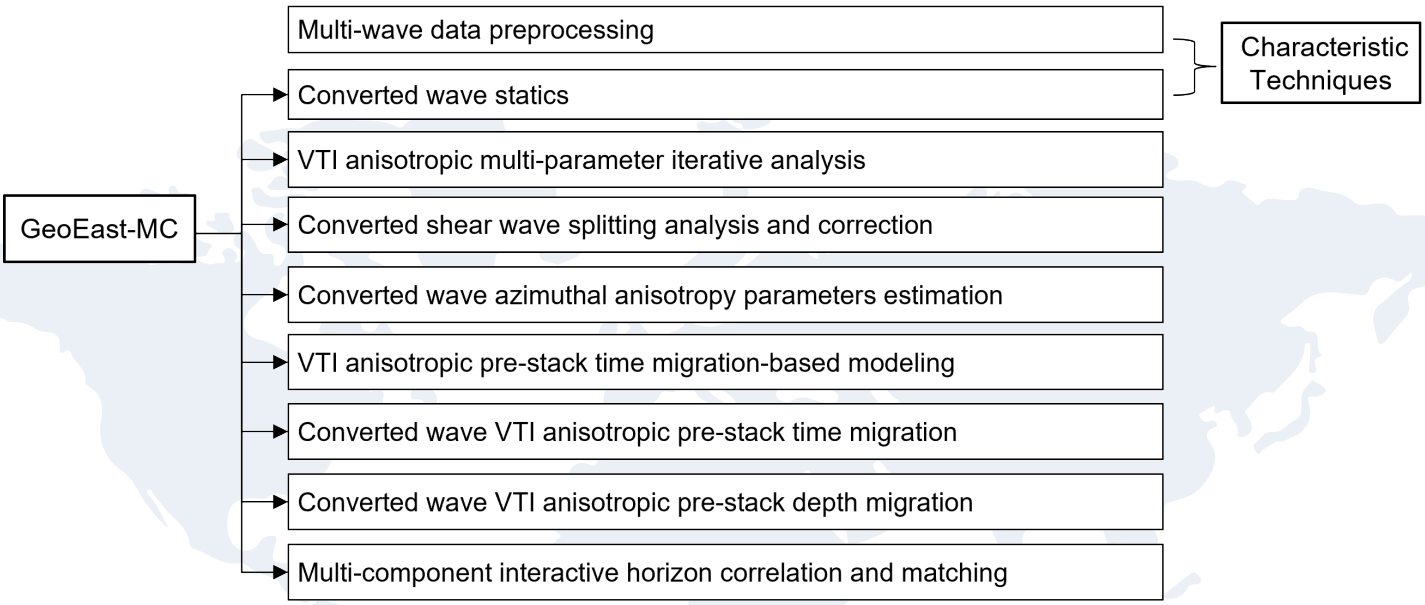
Hydrocarbon detection



Sedimentary facies analysis

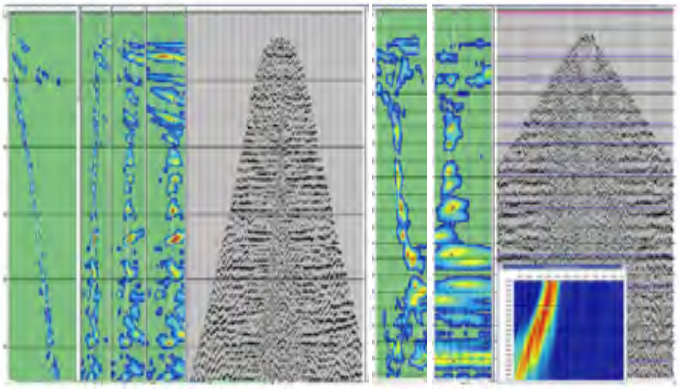
Multi-component Processing

A comprehensive suite of functions for multi-component data processing and interpretation are available, including preprocessing, converted wave statics, VTI multi-parameter analysis and imaging, multi-component matching and inversion etc.

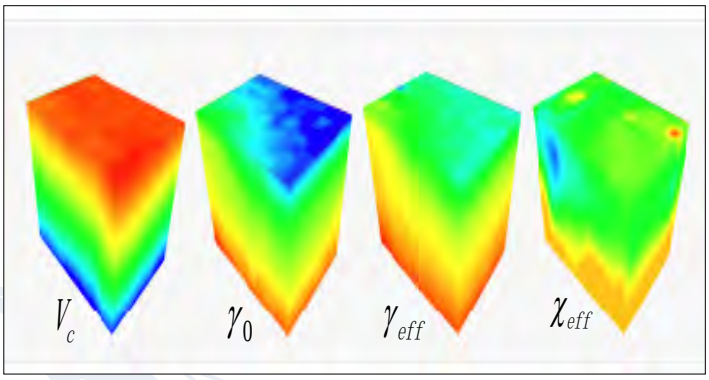


VTI anisotropic multi-parameter iterative analysis

GeoEast provides functions such as VTI dual-parameter spectrum, four-parameter, and multi-azimuth and multi-parameter analysis for interactive iterative analysis, interpolation and field building for PS-wave stacking and PSTM parameters.



VTI anisotropic 4-parameter (left) and 2-parameter dual-spectrum analysis(right)

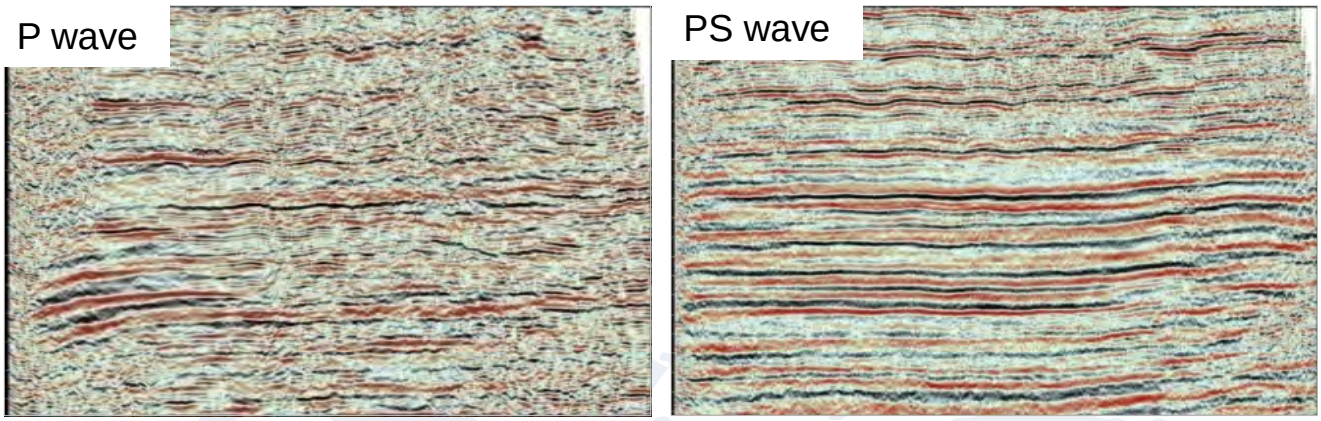


PSTM parameter field

VTI anisotropic pre-stack time/depth migration

VTI anisotropy, bending rays and large-scale parallel computation techniques are provided. Amplitude-weighting factor, anti-aliasing factor and migration aperture fitting PS-wave imaging are designed to improve imaging quality.

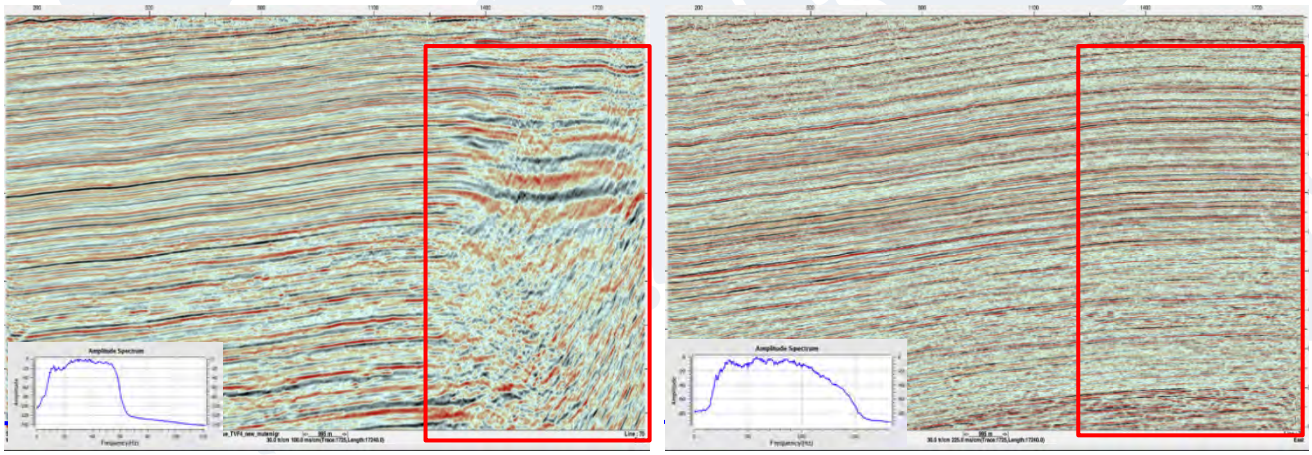
Integrated Seismic Data Processing and Interpretation



VTI anisotropic PSTM

Shear wave data processing

GeoEast provides functions such as 4C rotation of sources and receivers, 4C shear wave splitting analysis, separation of fast and slow shear waves etc. with high quality S-wave images being obtained and the structural characteristics are correctly delineated in gas cloud areas.

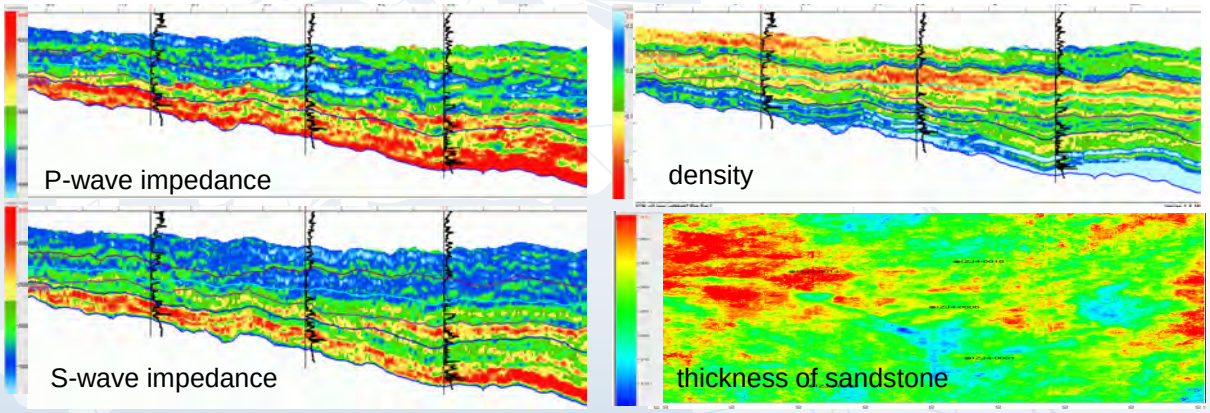


PSTM of P wave

PSTM of S wave

Multi-component inversion: from qualitative to quantitative

A series of multi-component inversion techniques have been formed from qualitative to quantitative.

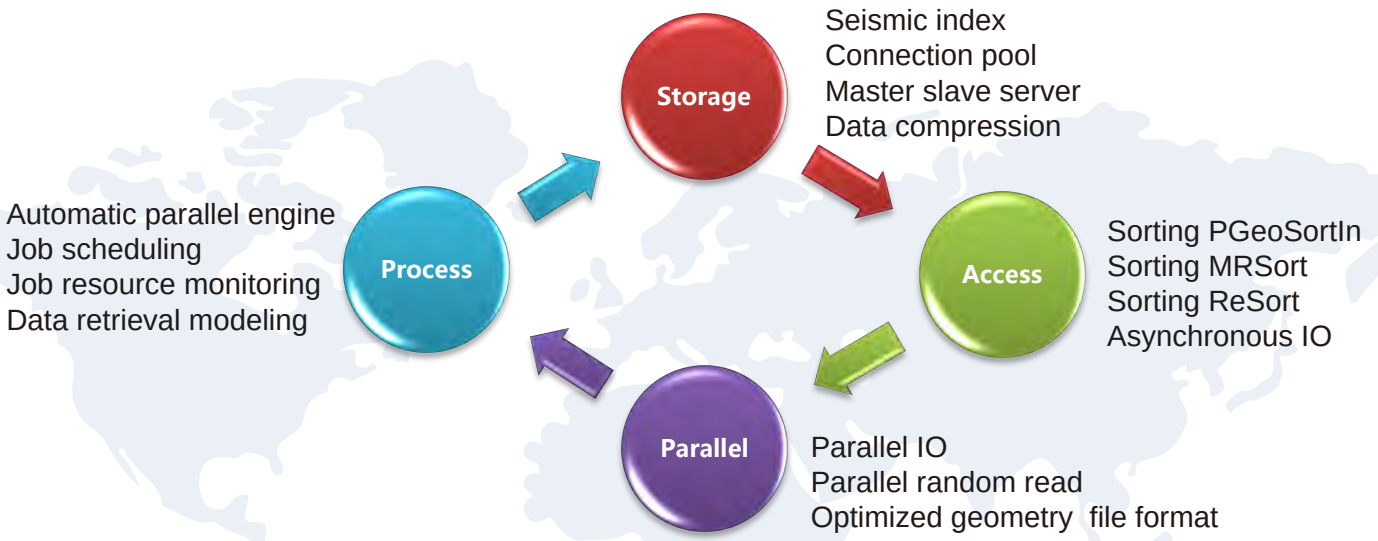


Pre-stack joint inversion and interpretation results of field multi-component data

Integrated Seismic Data Processing and Interpretation

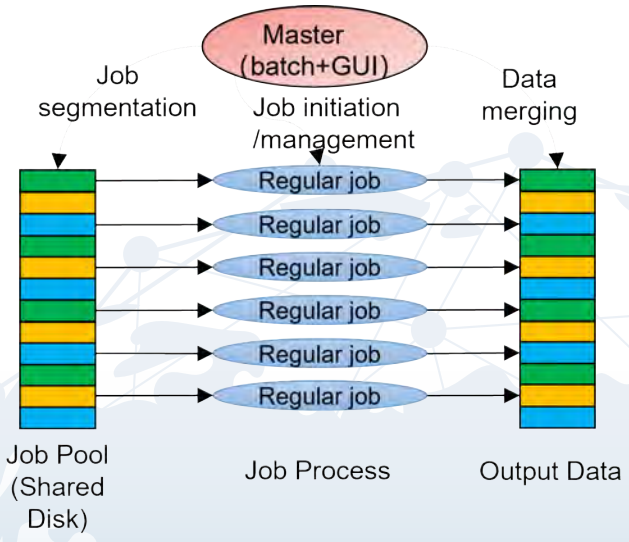
PB-scale Massive Data Management

A systematic solution ranging from data compression, through trace sorting & parallel IO, to automatic parallelization, to help customers effectively solve the problem of PB-scale massive data management.

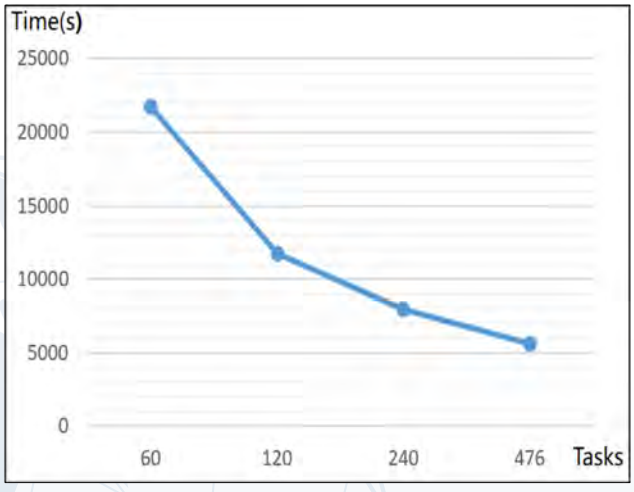


Automatic Parallel Engine（GeoNpe）

- Automatically run seismic jobs in parallel across multiple-nodes
- Significantly shorten the time of seismic data processing
- High efficiency, wide applicability , high reliability and fully automatic



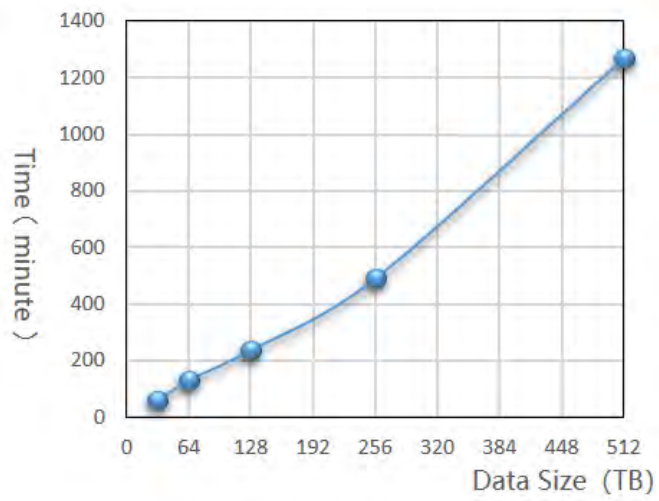
Conventional processing architecture based on independent processes



PB level data performance efficiency improvement

Parallel Trace Sorting & Seismic Indexing

- Improve the efficiency of seismic data input
- Support task migration for faulty nodes



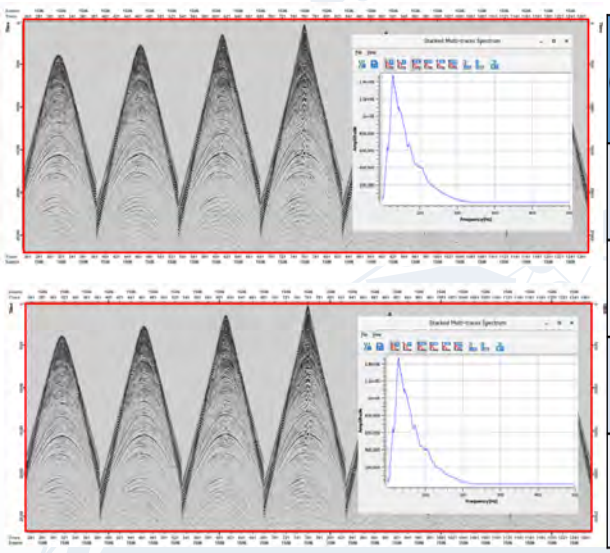
Support task migration for faulty nodes

Parallel Indexing （50TB）		Time(m)	Throughput (10000 traces/m)
GeoEast V3.X Platform		144	1254
iEco Platform	8 nodes	37	4880
	16 nodes	23	7850
	32 nodes	17	10621

Performance comparison of parallel indexing

High Fidelity Seismic Data Compression Technology

- A high fidelity algorithm is used to compress/uncrompress seismic datasets
- Reduce storage requirements and improve disk utilization



Data compression rate reaches over 30%, effectively reducing storage space usage

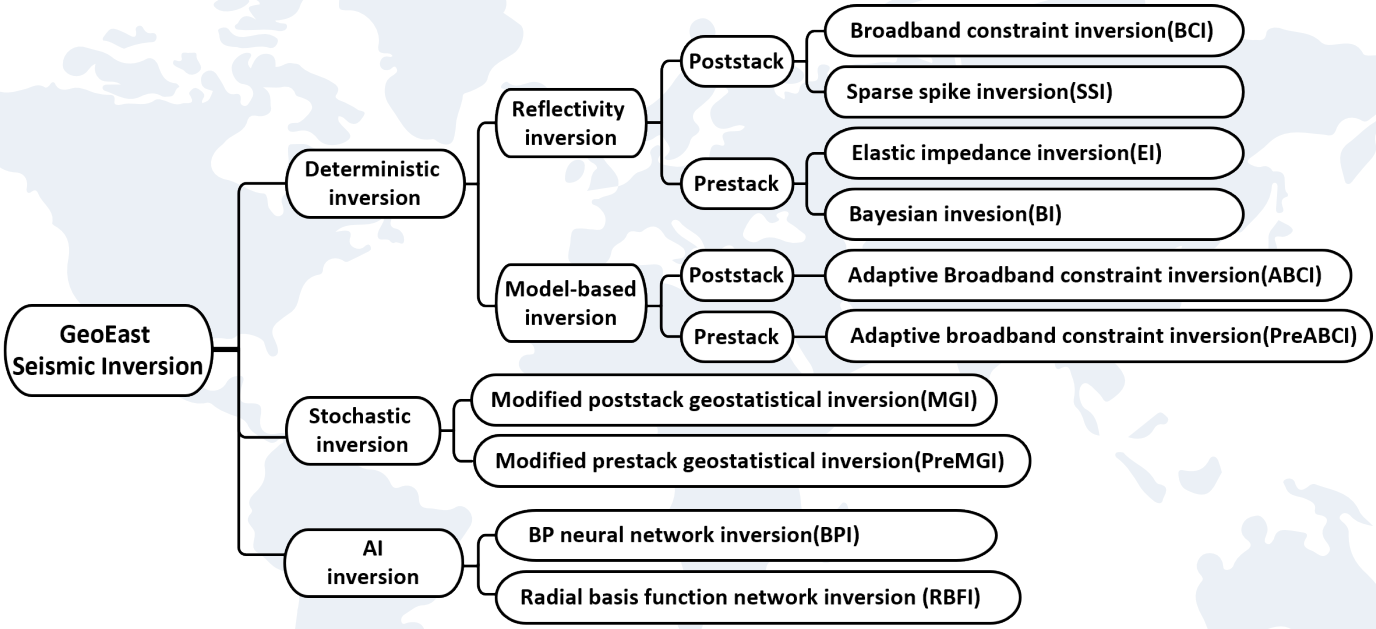
N of concurrent task	Type	Time (Original)	Time (Compression/ Decompression)	Original IO (MB/s)	Time variation
100	Read data	0:59:31	0:50:55	177	Reduce14.45%
100	R&W data	1:27:31	1:13:24	120	Reduce16.13%
50	R&W data	1:08:13	1:02:56	154	Reduce7.79%
1	R&W +Calculate	67:54:18	68:03:57	2.58	Increase0.24%, Basically unchanged

Effectively alleviate cluster storage IO load and improve performance

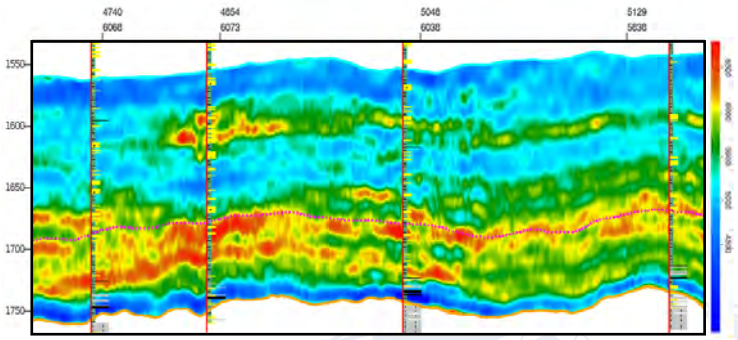
Seismic Inversion

Family of seismic inversion techniques

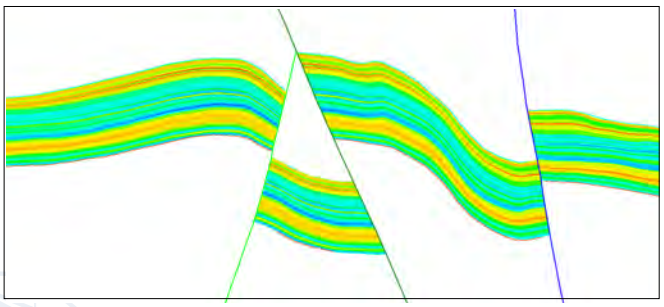
GeoEast provides a series of seismic inversion techniques, ranging from post-stack to pre-stack, from deterministic to stochastic, and from conventional to AI-aided, which meet the needs of reservoir prediction including thin clastic rocks, heterogeneous reservoirs, and complex structural reservoirs, etc. It has achieved good application results in the exploration and development of major oil and gas fields around the world.



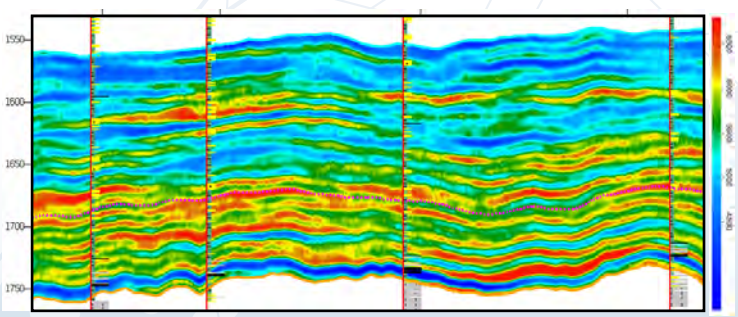
GeoEast seismic technical series



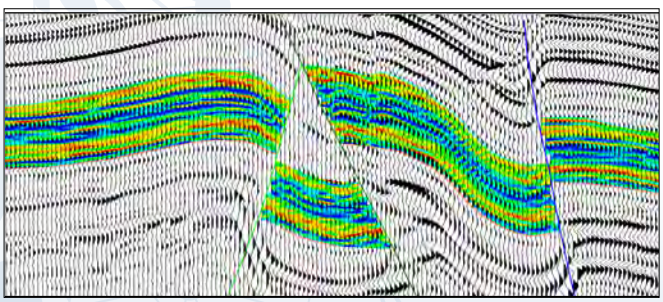
Conventional prestack inversion of S-impedance(BI)



Complex structure initial modeling



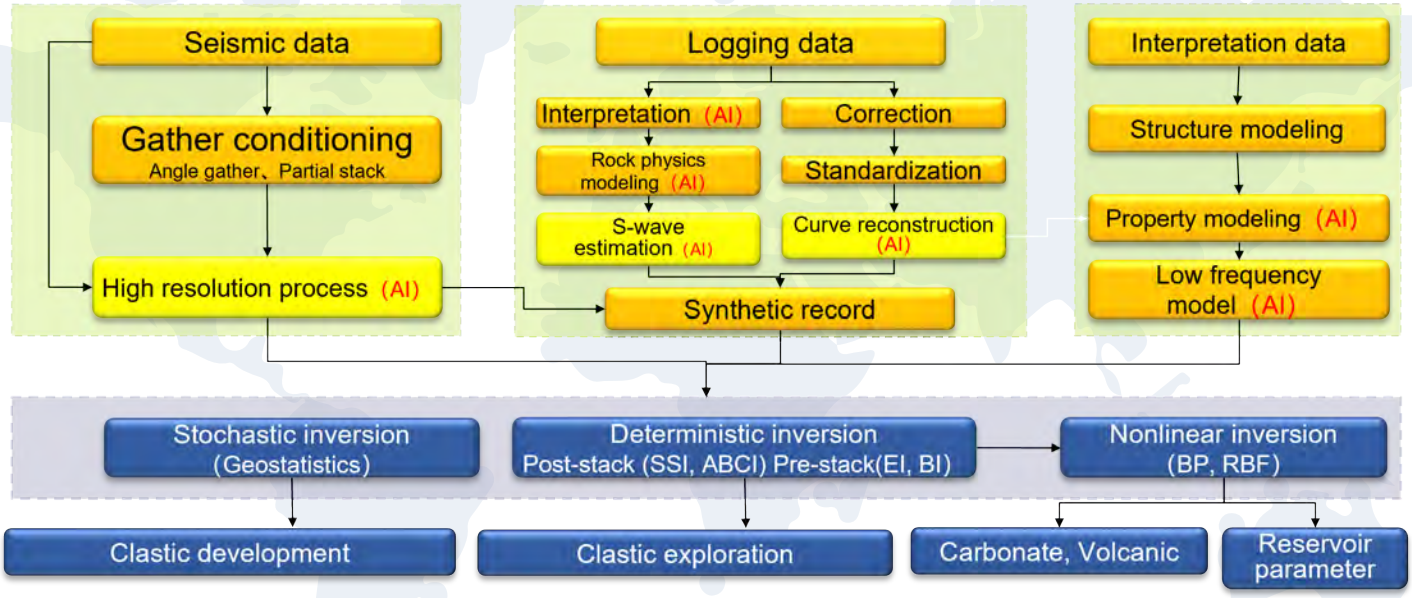
High resolution inversion of S-impedance(PreMGI)



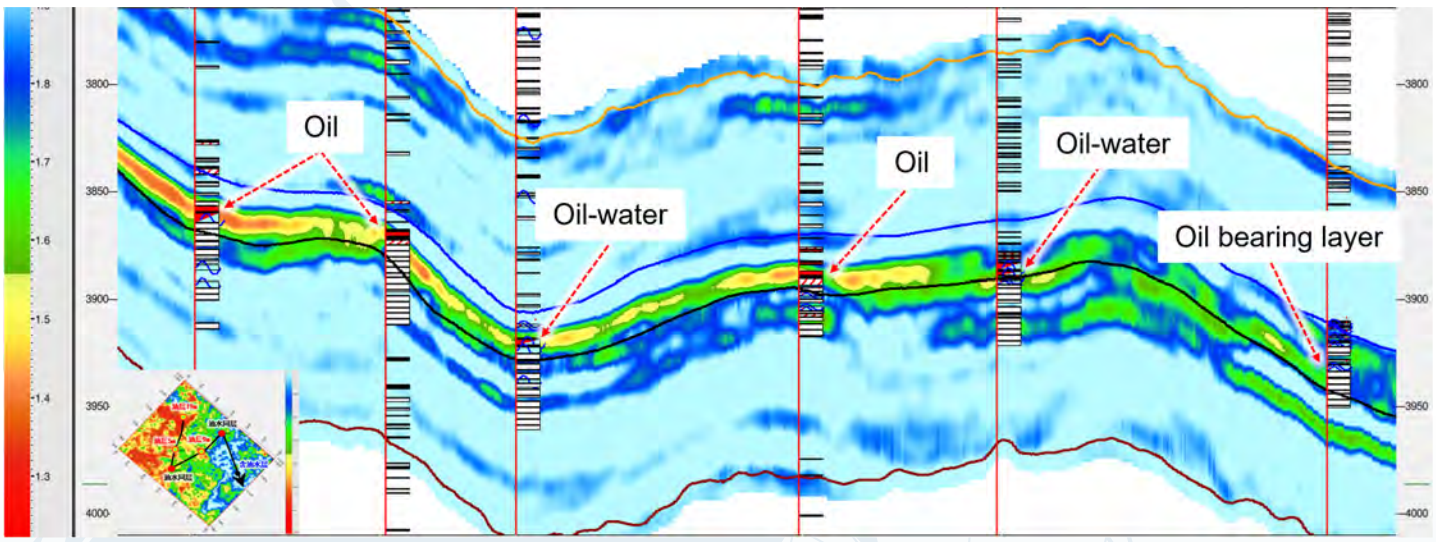
Complex structure constrained inversion

Refined seismic inversion workflow

Based on the various techniques available, such as well data conditioning, well-seismic calibration, wavelet extraction, crossplot and histogram analysis, initial model building, sandbody extraction, etc., comprehensive pre-stack/post-stack seismic inversion workflows and complementary technical series can be built for different purposes.



GeoEast Seismic inversion workflow



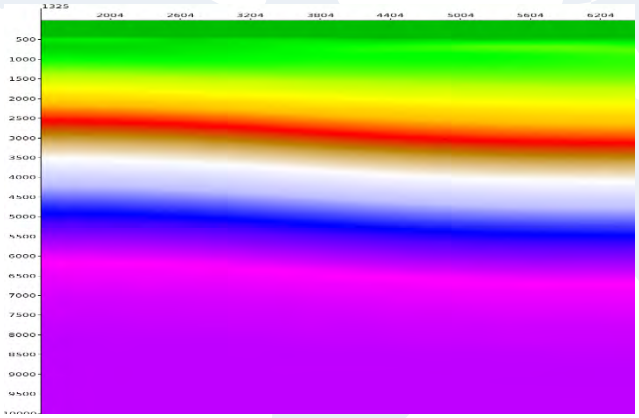
Vp-Vs ratio of pre-stack Bayesian inversion

GeoEast-full waveform inversion (FWI)

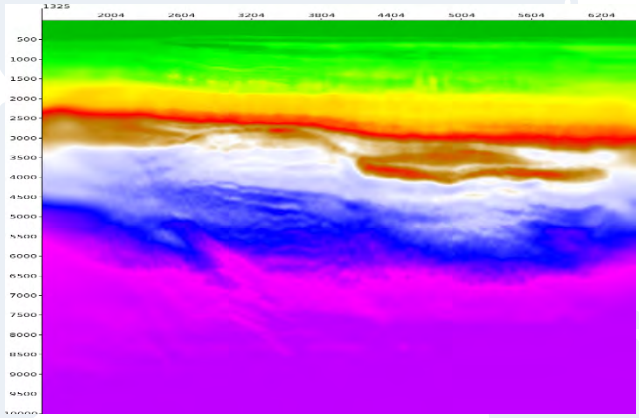
GeoEast Full-waveform inversion includes refraction inversion and reflection inversion. Several techniques for handling practical issues are provided, such as adaptive time FWI for handling cycle-skipping, and first-break FWI for complex and low SNR land data. The FWI inversions also consider earth Q absorption, and it can invert velocity, density, Q and epsilon, the so called Multi Parameter Inversion.

Conventional refraction FWI

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



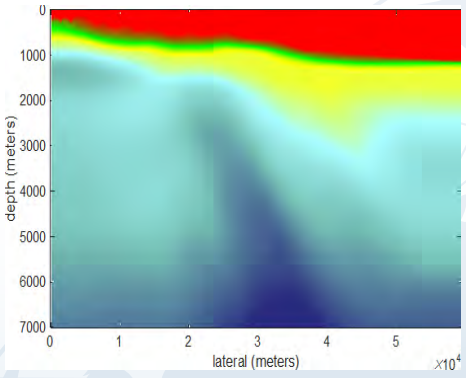
Initial velocity model



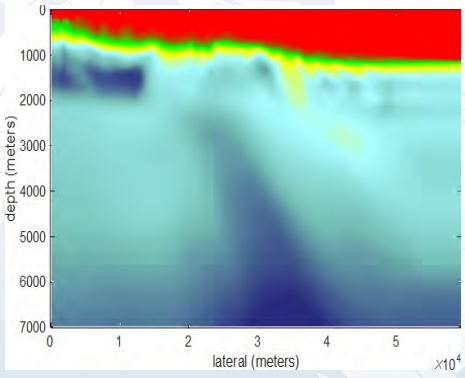
FWI velocity model

First-break FWI

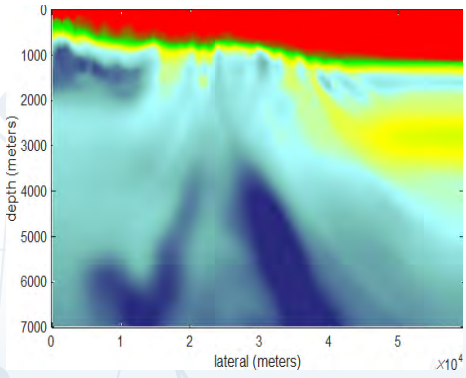
Inverting a land dataset is very challenging, because of the complexity of the data. Ground rolls and guided waves in land data are very hard to simulate accurately with wave equation modeling methods. Guided wave is a kind of refraction energy that bounces multiple times between surface and reflectors. 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



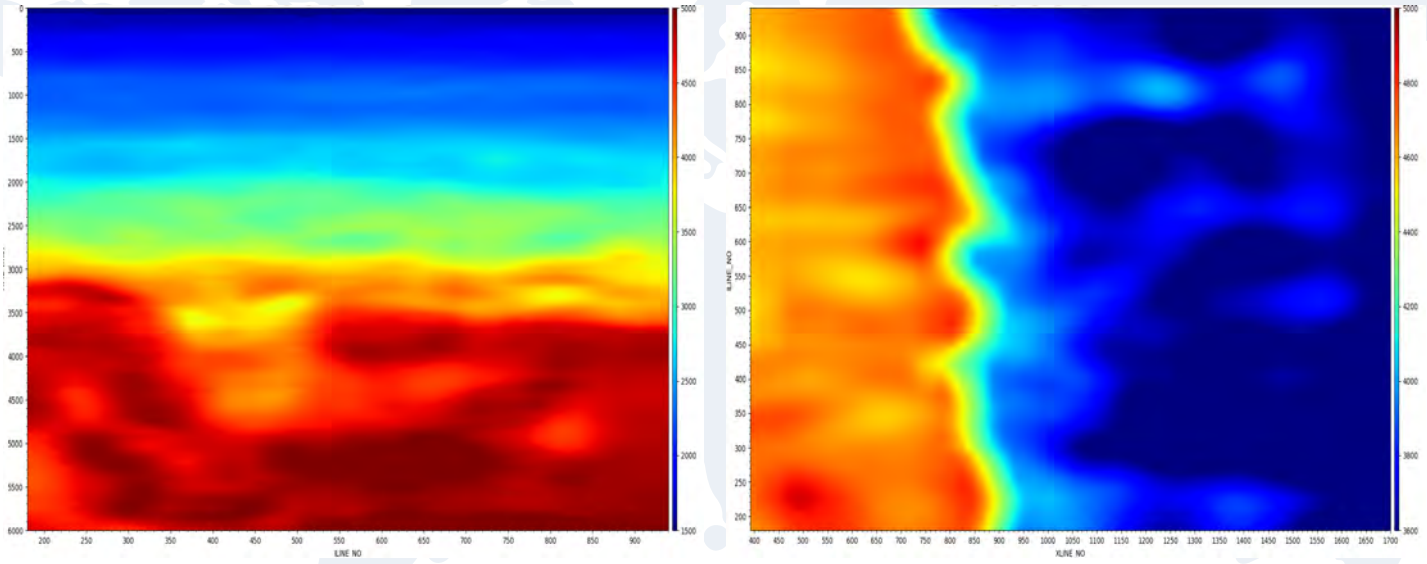
First-break FWI



Conventional FWI

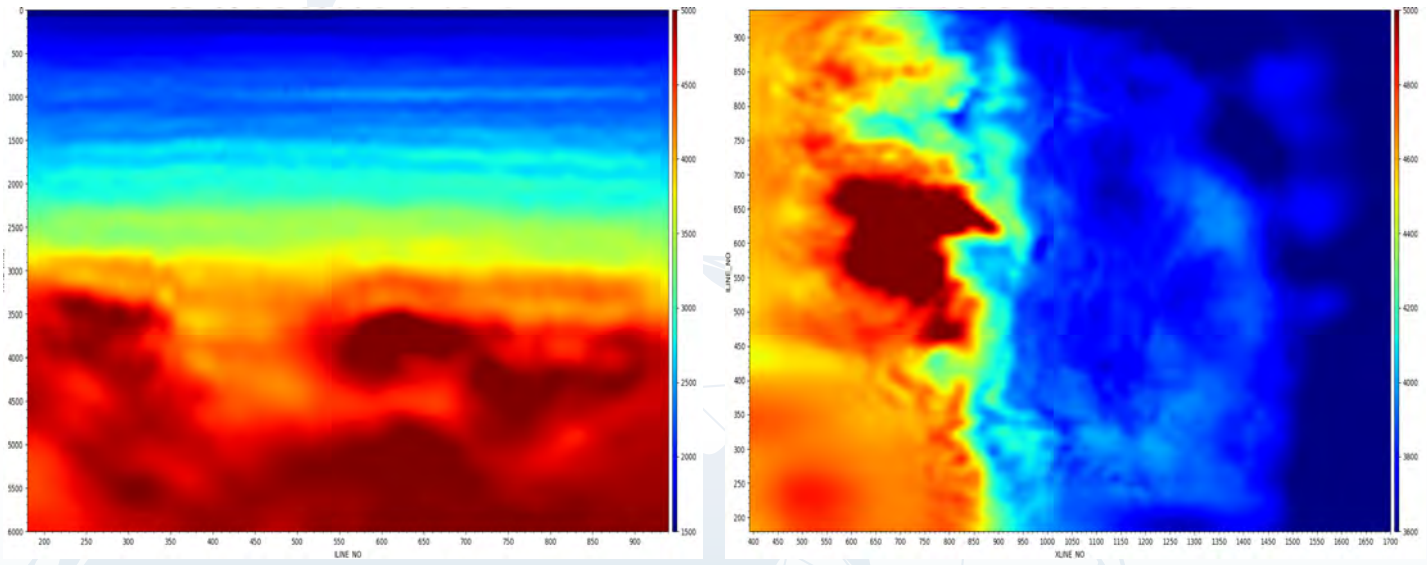
Time-Adaptive FWI

To tackle the cycle-skipping issue, we also developed time-adaptive 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 techniques such as dynamic-time wrapping, adaptive-filter, and so on, prepared for different real data problems.



Inline slice

Initial velocity model

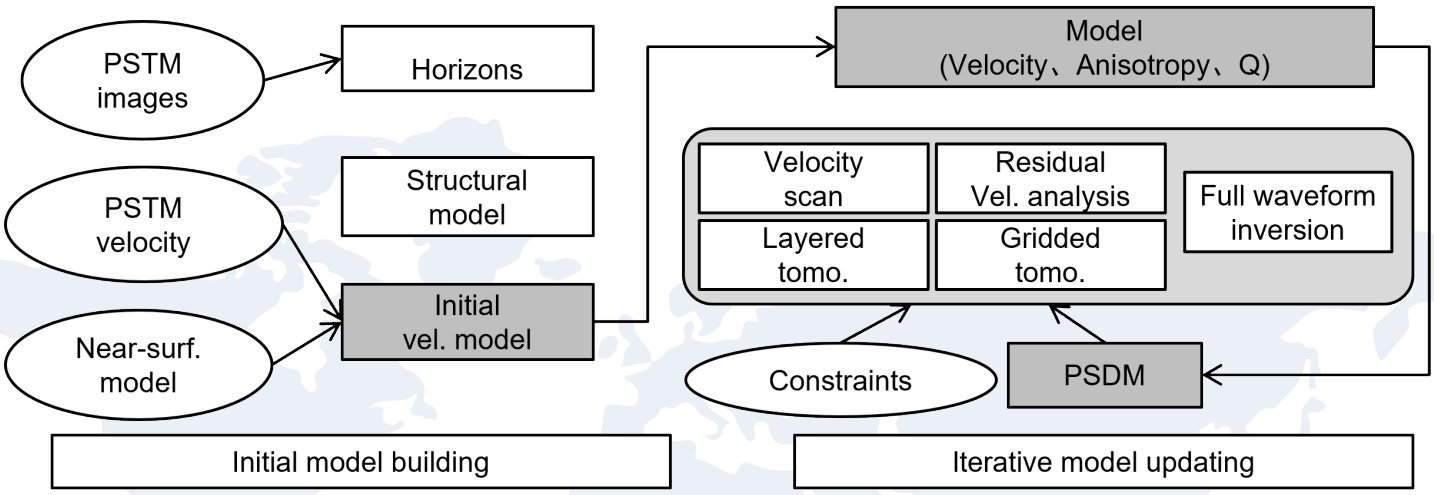


Inline slice

Updated velocity model through FWI

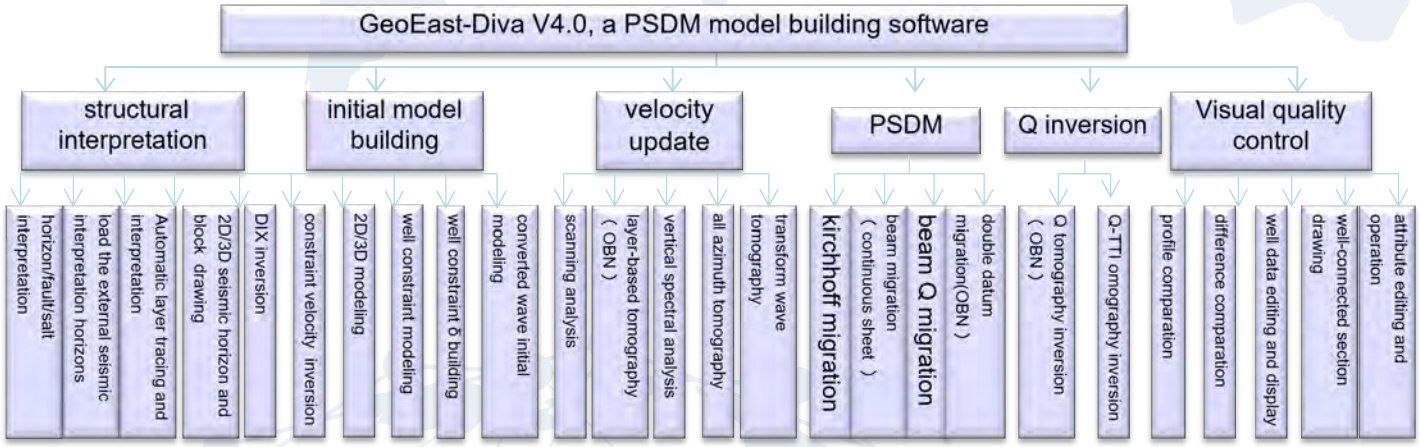
Velocity Model Building for Depth Imaging

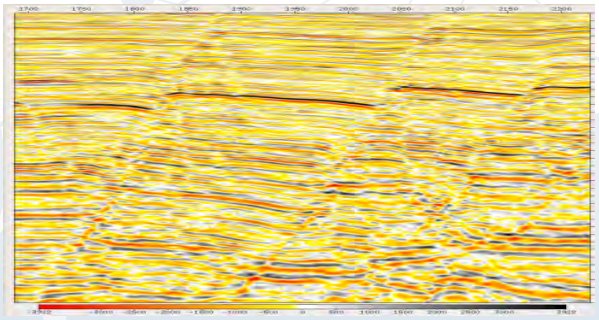
GeoEast provides techniques for time domain P-wave and PS-wave anisotropic velocity analysis, depth domain blocky velocity model building, anisotropic gridded tomography velocity updating and full waveform inversion.



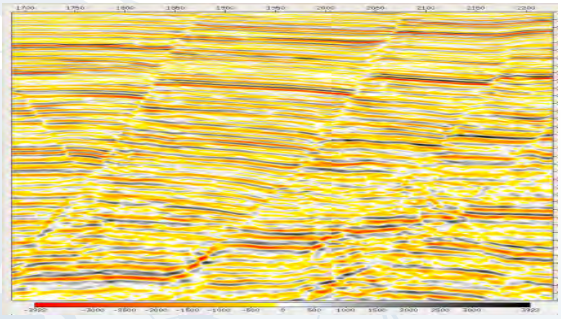
Diva - a depth domain velocity model building package

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





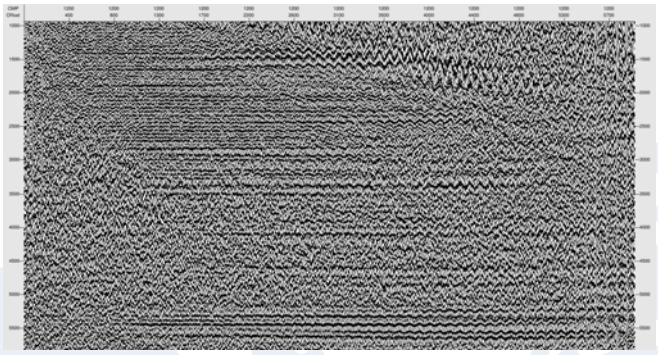
Initial PSDM



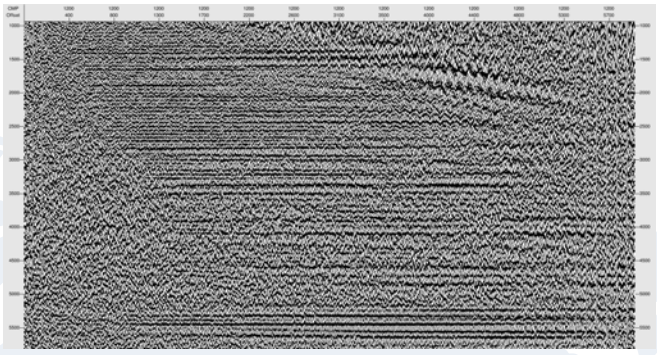
PSDM with Velocity Field From Fault Constraine Tomography

Anisotropic grid tomography velocity updating

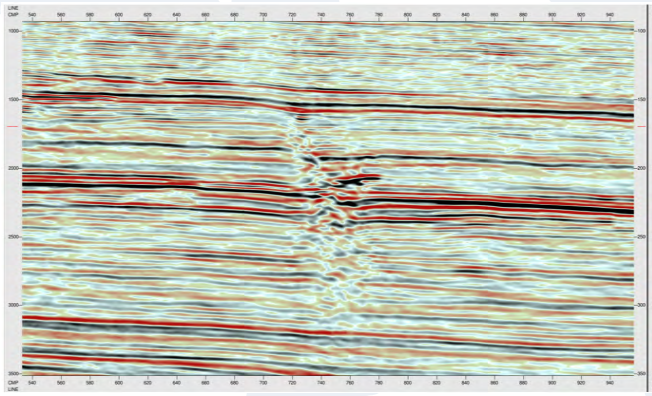
It can meet the requirements of fast seismic modeling of VTI / TTI / TORT in depth domain.



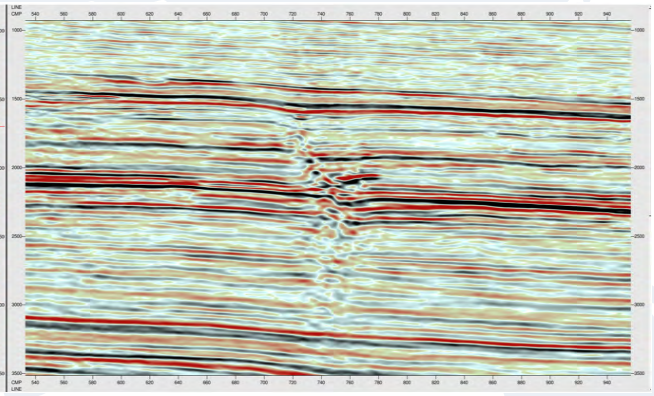
TTI PSDM Gathers



TORT PSDM Gathers



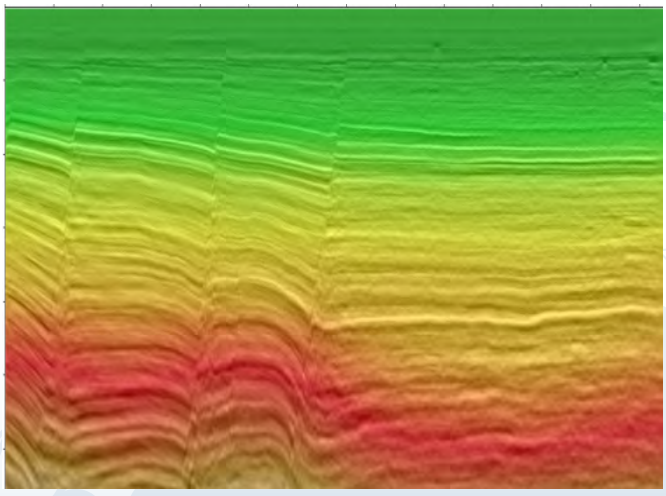
TTI PSDM Section



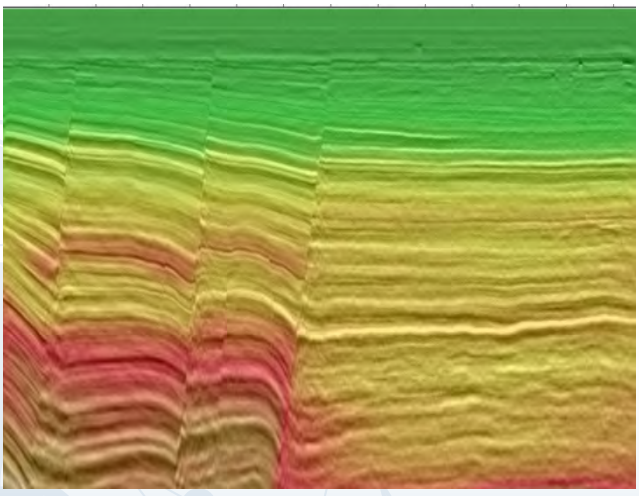
TORT PSDM Section

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 gridded tomography.



PSDM with Initial Velocity Model



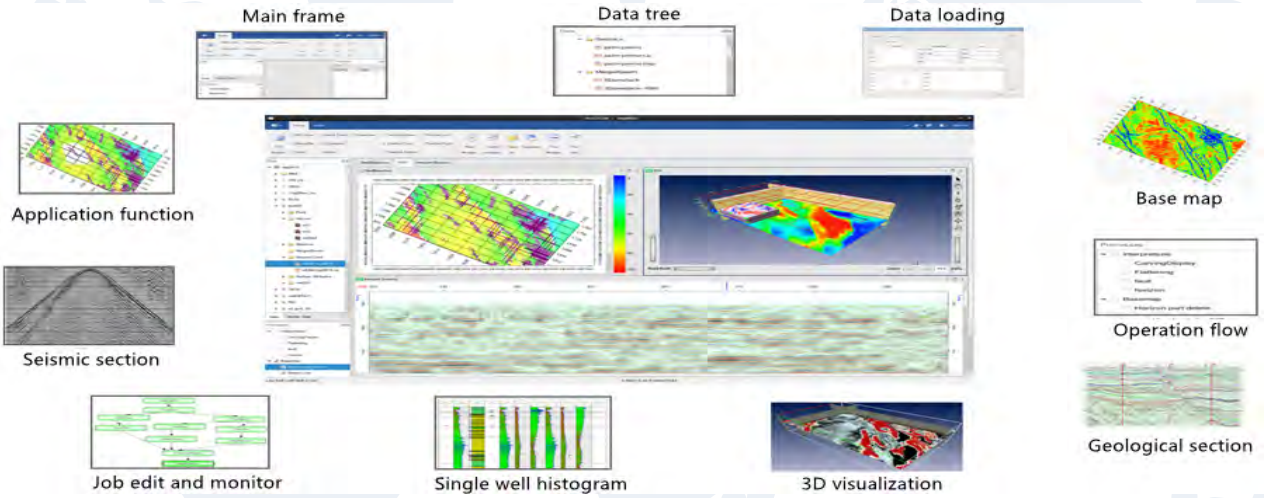
PSDM with Velocity Model Updated by FWI

Integrated Seismic Data Processing and Interpretation

Open Software Development Framework

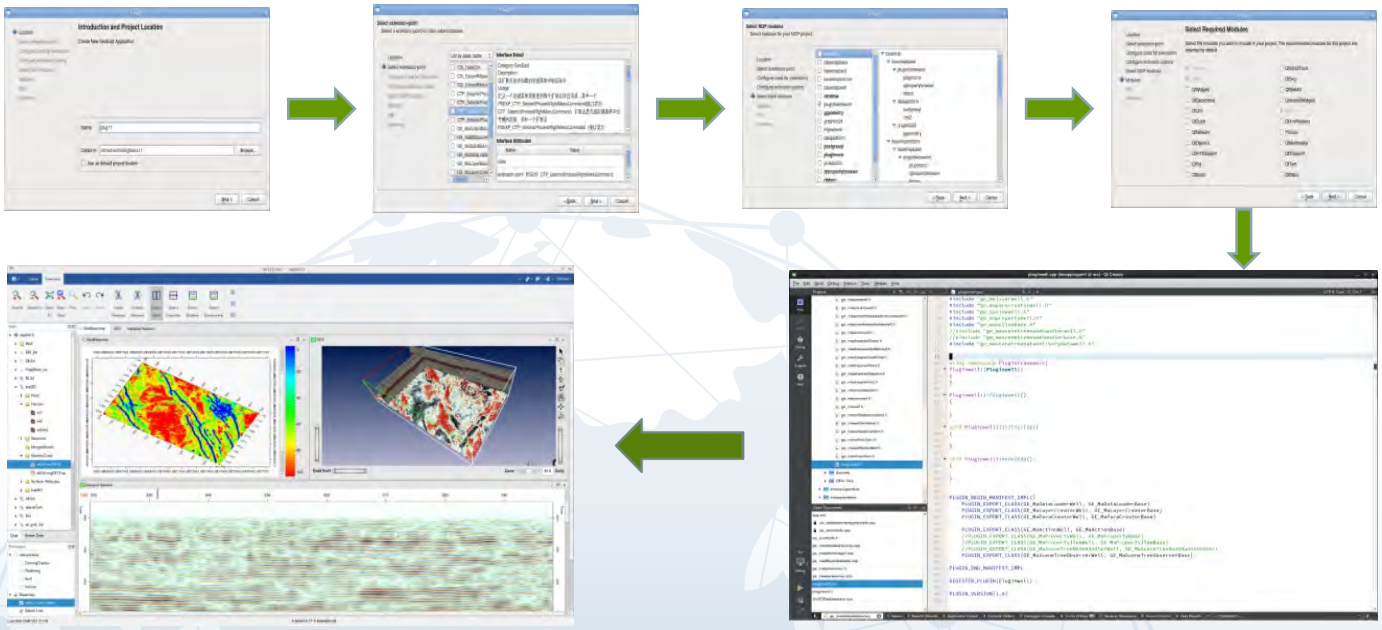
Interactive Development Framework Technology Based on Typical Scenarios

It realizes the plugin interactive application development framework and typical business operation scenarios through a microkernel design. The “Scene plus plugins” mode fundamentally improves the scalability and openness of the system.



Application Integration & Development Technology Based on IDE

An IDE tool is available to develop plugins and functions, which improves the programming efficiency and quality significantly.

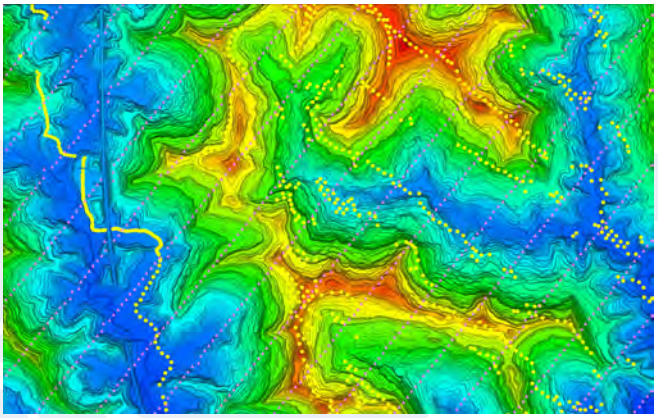


Seismic Acquisition Design

KLSeis seismic survey acquisition design software includes KL-LandDesign, KL-Streamer and KL-DataDriven and delivers optimized designs for land, marine and transitional zone seismic surveys.

KL-LandDesign

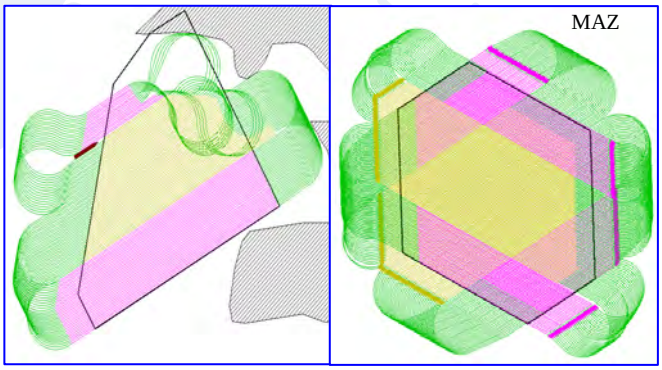
- Optimize acquisition parameters including source, receiver and source-receiver array, etc.
- Design and edit source/receiver points up to the level of 10 million
- Automatic terrain-avoidance of source/receiver points
- Bin attributes analysis and pre-stack attribute analysis



Automatic terrain-avoidance

KL-Streamer

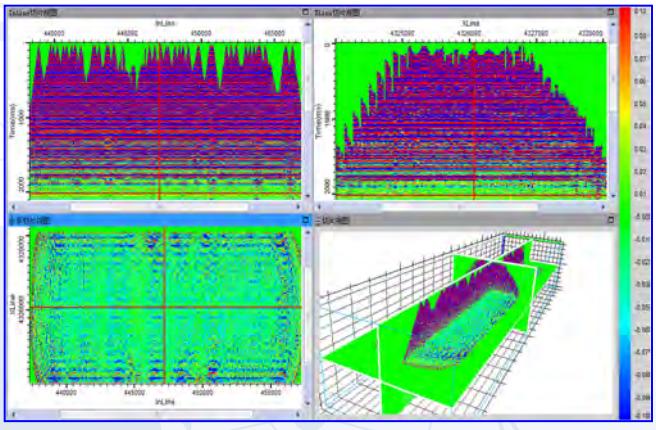
- Template design and preplot
- Sail line optimization and bin attribute analysis
- 4D seismic acquisition design and QC



Streamer acquisition design

KL-DataDriven

- Optimize acquisition parameters based on legacy data
- Imaging analysis with different geometries for stack data volume
- Source or receiver array analysis



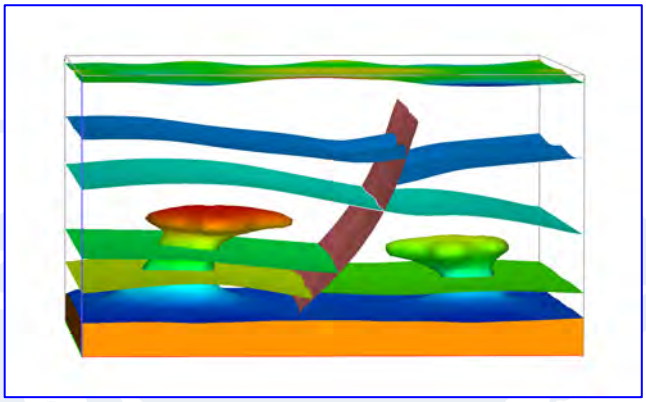
Imaging analysis for stack data volume

Modeling and Illumination

KLSeis modeling and illumination software includes KL-2DModeling, KL-3DGeoModeler and KL-3DModeling. The software builds 2D or 3D complex models, performs seismic forward modeling and compares illumination of different geometries.

KL-2DModeling

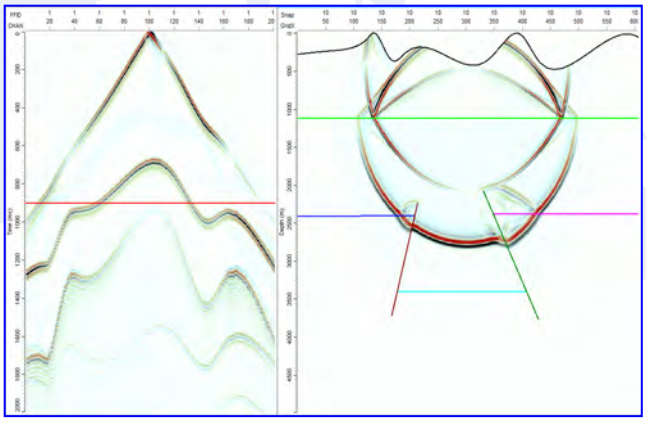
- Build 2D complex geological models
- Forward modeling includes ray tracing, Gauss beam, acoustic, elastic and viscous elastic
- Wave equation illumination



Mushroom-like intrusive body

KL-3DGeoModeler

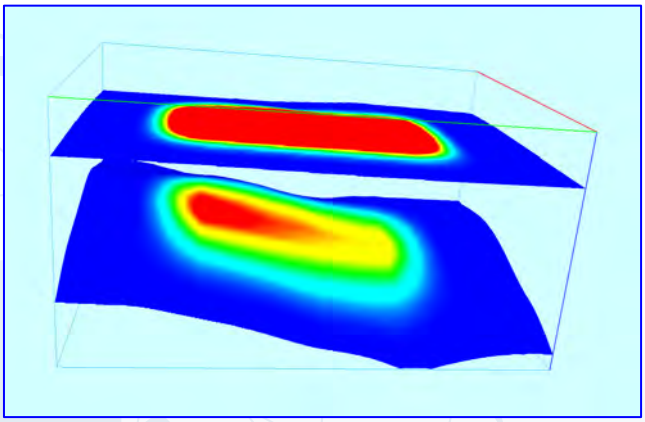
- Create 3D geological models using the seismic interpretation data
- Build overthrust, pinchout, overlap, sand body, lenticular body and mushroom-like intrusive bodies, etc.
- Interactively edit complex layers and faults of 3D models



Acoustic finite difference modeling and snapshot

KL-3DModeling

- Input multiple formats of geological models
- Acoustic finite difference modeling based on CPU+GPU
- Output snapshots
- Fast layer illumination based on wave equation



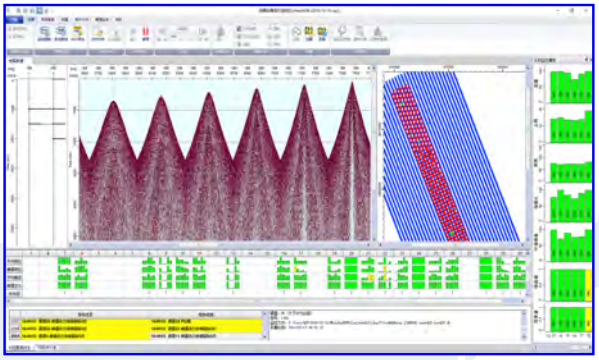
Wave equation layer illumination

Seismic Data QC

KLSeis seismic data QC software includes KL-RtQC, KL-DataAE and KL-SeisPro and meets the QC requirements for equipment, seismic data and acquisition parameters.

KL-RtQC

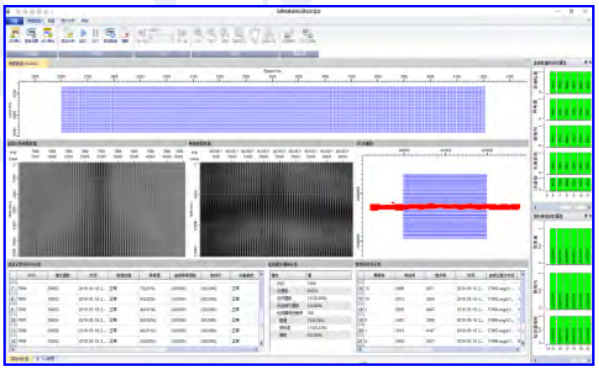
- Real-time monitor seismic data, such as energy, ambient noise, acquisition parameters, auxiliary traces, etc.
- Monitor the performance of vibrators and receivers
- Real-time monitor continuous records based on micro-seismic mode for UHP seismic acquisition



Real-time monitor seismic data and the performance of vibrators

KL-DataAE

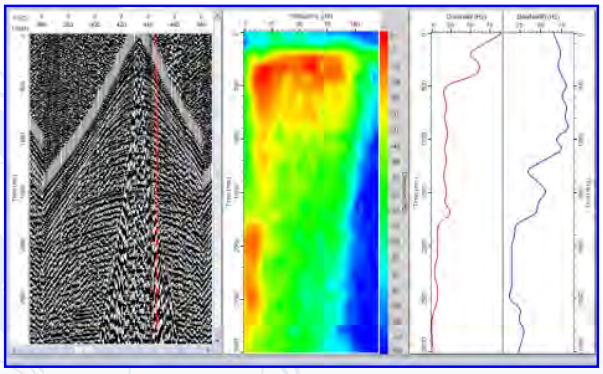
- Seismic data interactive analysis such as frequency spectrum,time-frequency,F-K, energy, time-varying energy, S/N etc.
- Seismic data preprocessing such as zone filtering, frequency scanning, gain balance, mute and LMO etc.
- Comparison of spectrum, energy and signal-to-noise of different shots



Real-time monitor continuous records based on micro-seismic mode

KL-SeisPro

- Seismic data dump, simultaneously output to disks and tapes
- Header block information and seismic data QC
- Convert seismic data format between SEG-D and SEG-Y



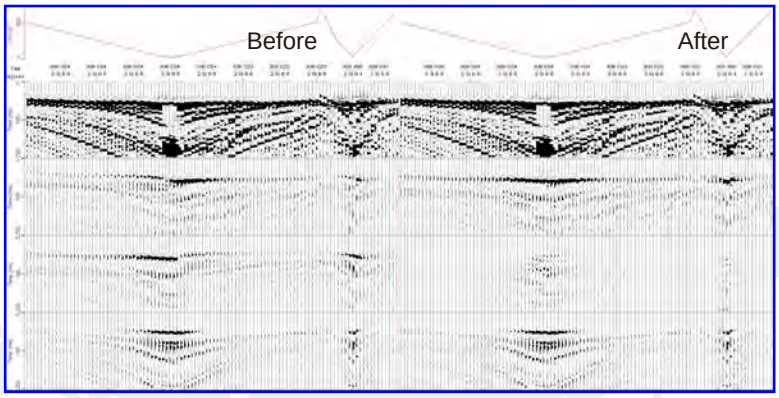
Interactive analysis to seismic data

Offshore Acquisition QC

KLSeis offshore acquisition QC software includes KL-NodeQC, KL-AGQC and KL-FBP and meets the requirements of segmentation of OBN data, QC of seismic data and airgun performance and positioning of nodes.

KL-NodeQC

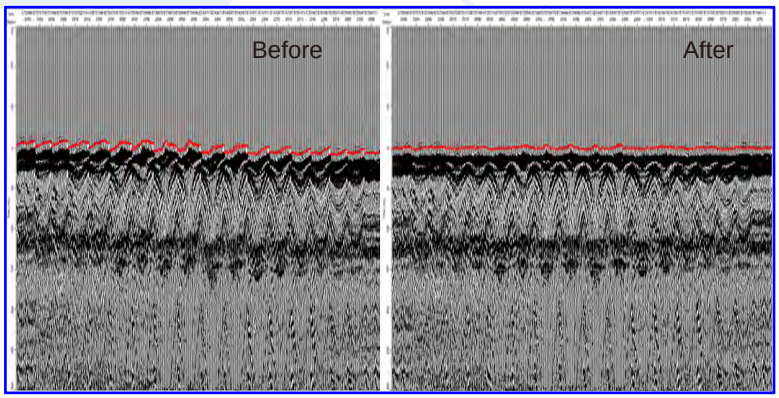
- OBN data segmentation, daily
- segmentation capability over
- 10TB
  Clock drift correction
- Multi-component rotation
  OBN attribute analysis



multi-component rotation

KL-FBP

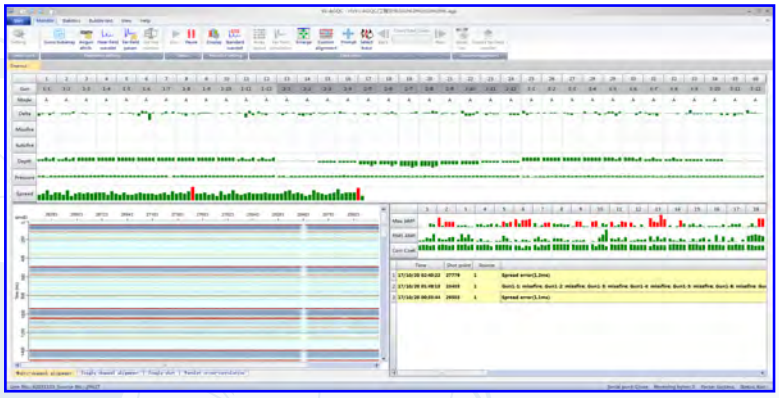
- First break high-precision picking
- Interactive positioning to OBN
- Automatic positioning
- Positioning precision analysis and evaluation, the positioning precision is less than 3 meters



first break positioning

KL-AGQC

- Real-time QC of airgun
- Real-time QC to near field wavelet
- Bubble test
- Far field wavelet simulation
- Attribute statistics and analysis



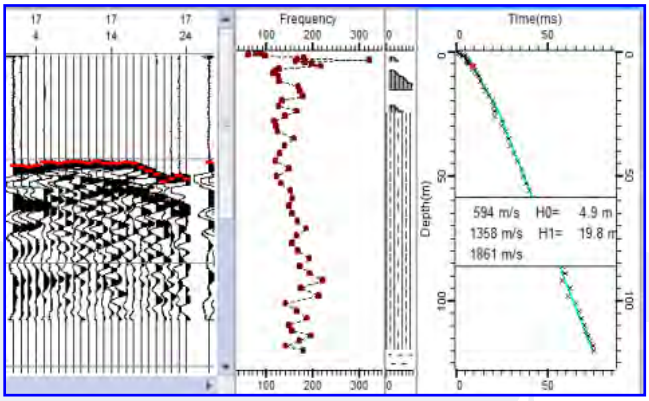
Real-time monitor of airgun performance

Near Surface Investigation and Statics

KLSeis near surface investigation and statics software includes KL-LVL, KL-FBPicker, KL-RefraStatics and KL-TomoStatics and provides static and near surface model for seismic data processing.

KL-LVL

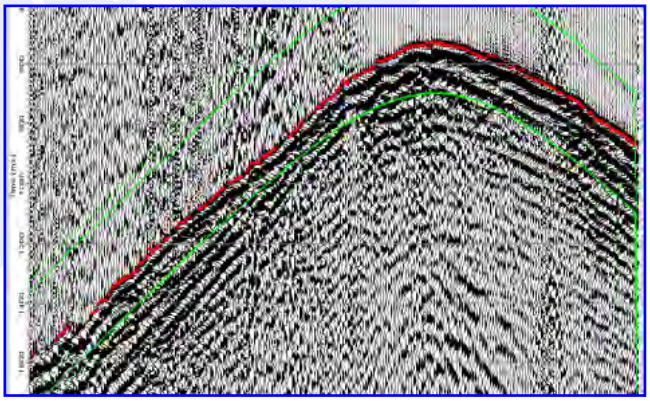
- Interpretation of shallow refraction
- Interpretation of uphole data
- Kinetic curve analysis
- Q estimation of near surface



Uphole interpretation

KL-RefraStatics

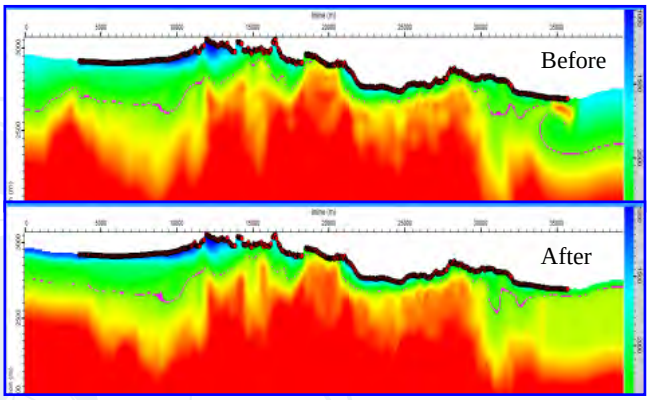
- First breaks automatic picking and QC
- Flexibly interactively branch refraction layers
- Refraction velocity and delay time calculation
- Model building constrained by near surface investigation data



First break picking

KL-TomoStatics

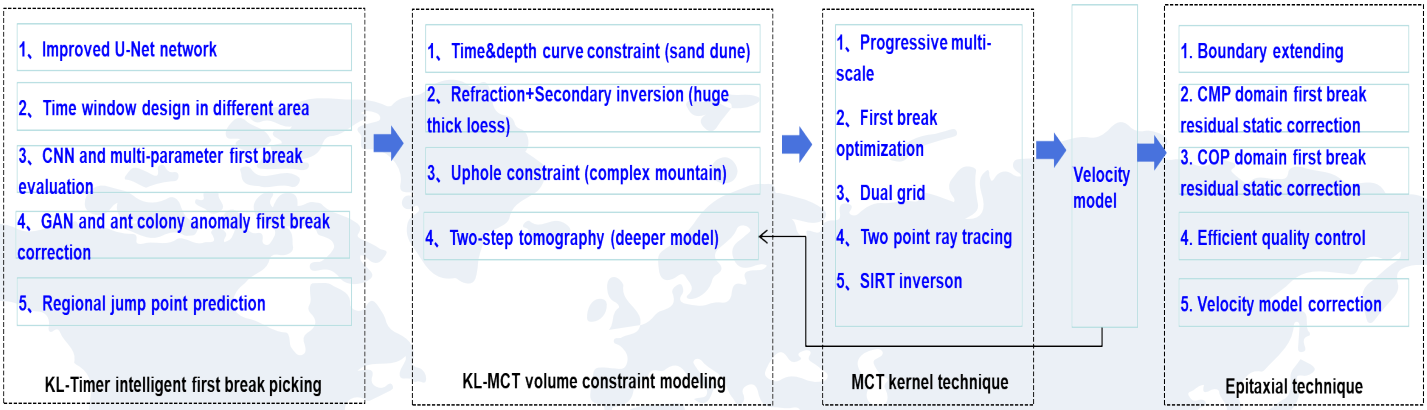
- Tomography inversion and QC
- Tomography model interpretation
- Datum statics calculation
- FB-based residual statics calculation



Boundary optimization of tomography model

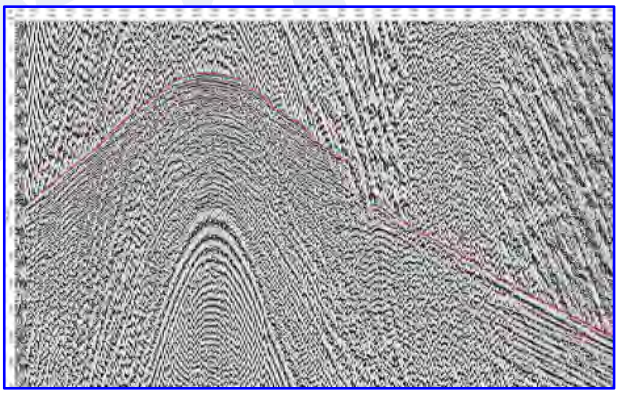
Near Surface Investigation and Statics

KLSeis near surface modeling software, using AI technology to extract and train the first break features, and realize the intelligent first break picking of low S/N data; Based on the data of near-surface investigation results, dune curve and VSP, a volume constraint model is built. Multi-scale tomography inversion technique is used to provide a high-precision near-surface velocity model for "true" surface migration.



KL-Timer

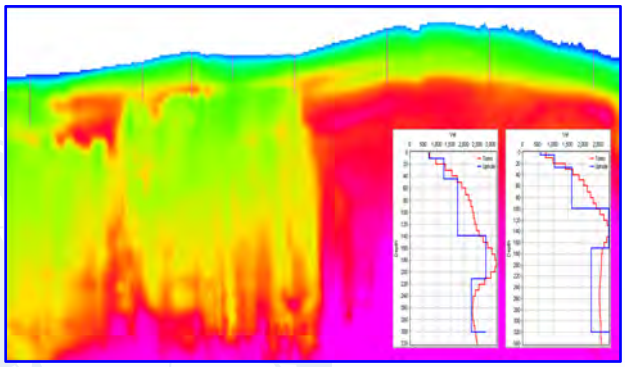
- Time window design in multi- domains
- Intelligent first break picking and QC
- Comprehensively abnormal first break identification
- High quality abnormal first break correction



First break picking

KL-MCT

- Progressive multi-scale constrained tomography inversion
- Dune curve constrained tomography inversion
- Quadratic inversion technique of residual time difference
- Uphole constrained tomography inversion



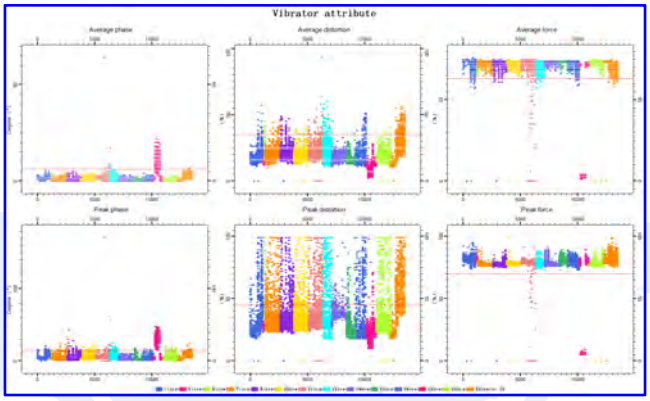
Velocity reversing model of uphole constrained tomography inversion

Vibroseis

KLSeis vibroseis software includes KL-VibEQA, KL-VibParam, KL-VibSig and KL-VibPlan and has the functions of vibrator performance QC, sweep signal design, operation parameters analysis and operation plan optimization.

KL-VibEQA

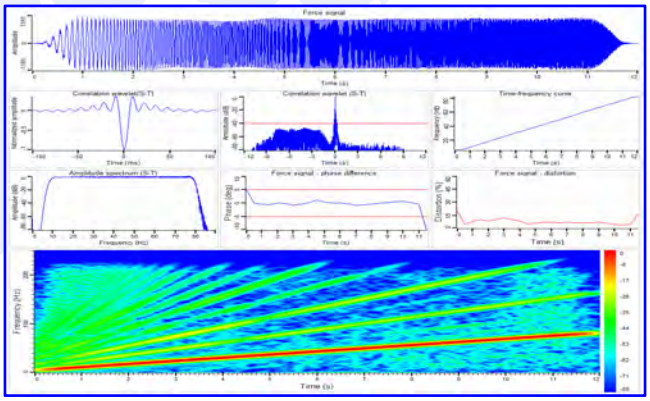
- Vibrator performance, COG, similarity test and extended QC data analysis
- FDU/BOX and geophone test QC Ground force analysis



Vibrator performance QC

KL-VibParam

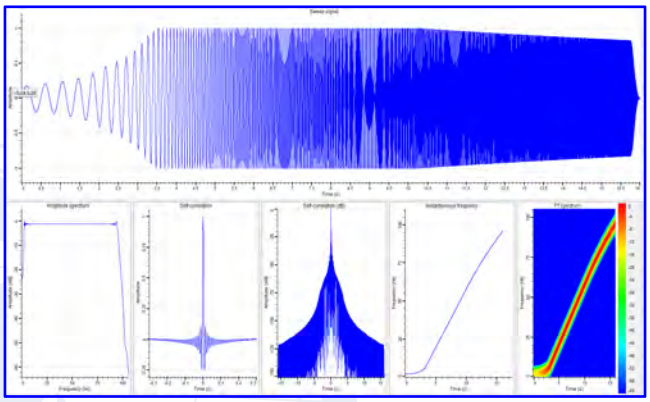
- Optimizing parameters of conventional vibroseis operation mode
- Design slip time for slip sweep
- Design simultaneous sweeping distance for DSSS
- Optimizing parameters for ISS



Vibrator similarity analysis

KL-VibSig

- Design linear and nonlinear conventional sweeps
- Design customized sweeps， such as low-dwell, shaped and segments, etc.



Low-dwell sweep Design

KL-VibPlan

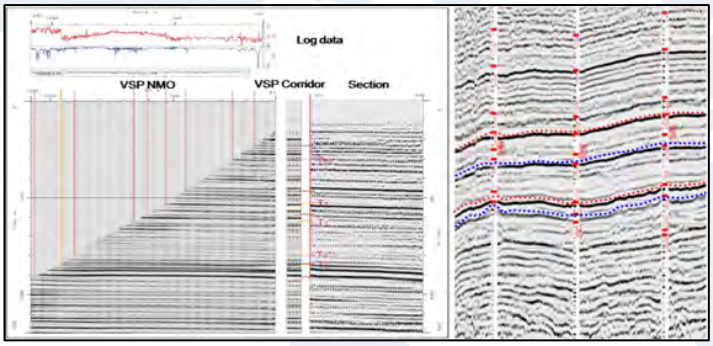
- Productivity estimation for different vibroseis operation plan
- Optimization equipment deployment plan
- Zipper operation plan analysis

VSP

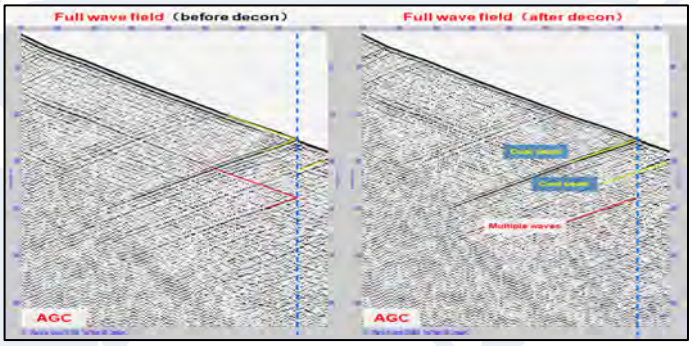
The Vertical seismic profile (VSP) adopts the observation method of surface excitation and well reception, which can establish accurate time depth relationships and obtain accurate velocity data such as average velocity and layer velocity, so as to accurately calibrate seismic and geological reflection layers and predict the burial depth of target layers underground, etc.

Zero offset VSP

With the accurate time-depth relationship and VSP NMO result, well information and the surface seismic section can be tied in the time and depth domain. Multiple waves can be identified by the wavefield before and after deconvolution.



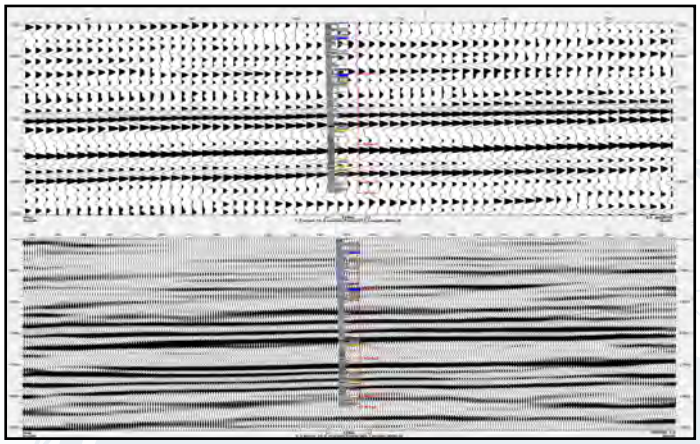
Calibration Seismic Data with VSP and Logging



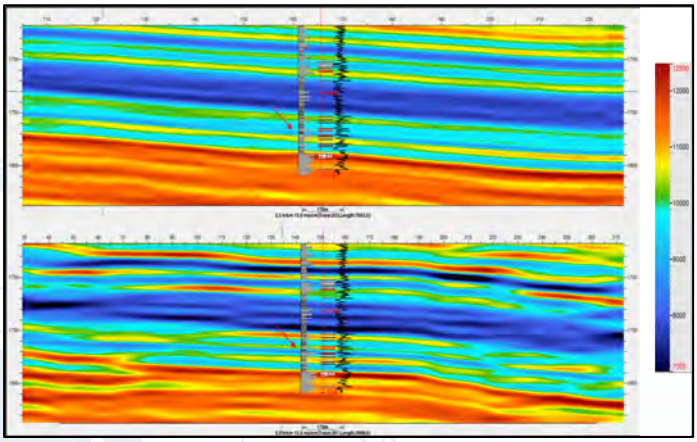
Analysis of Multiple Waves

Walkaway VSP

Compared with surface seismic, the Walkaway VSP has the advantages of high resolution and accurate depth position. It has been widely used for borehole vicinity structure imaging, high-precision reservoir prediction and time-lapse reservoir monitoring.



Comparison of Imaging Between Walkaway VSP (below) and Surface Seismic (above)



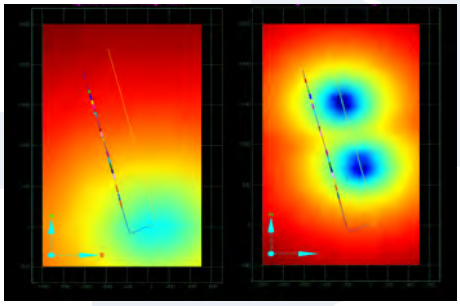
Comparison of Inversion Between Walkaway VSP (below) and Surface Seismic (above)

Microseismic Monitoring for Hydraulic Fracturing

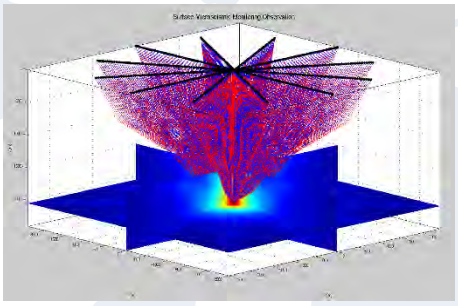
The microseismic monitoring technique records seismic waves generated by hydraulic fracturing, maps rock rupturing locations, evaluates fracturing results and guides optimizations of treatment parameters in real time.

Microseismic monitoring acquisition

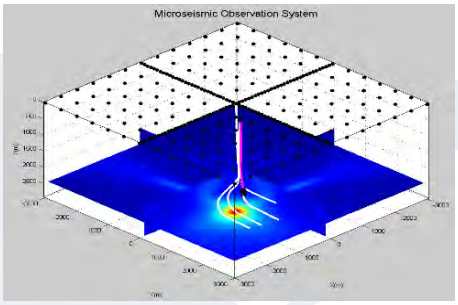
- Microseismic feasibility analysis
- Acquisition parameters demonstration
- Microseismic event location error prediction



Vertical and horizontal array monitoring



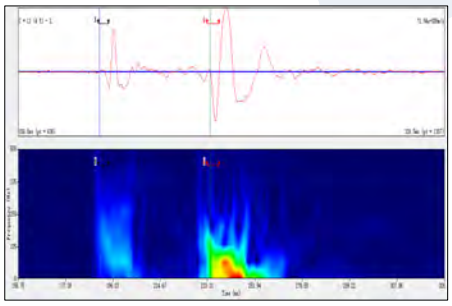
Surface array monitoring



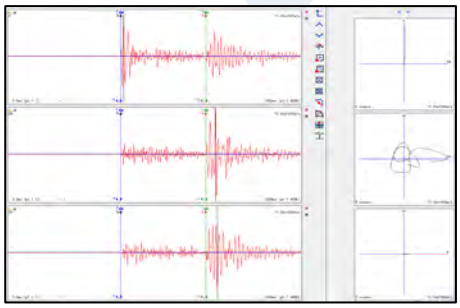
Borehole and surface long term monitoring

Microseismic monitoring real-time processing

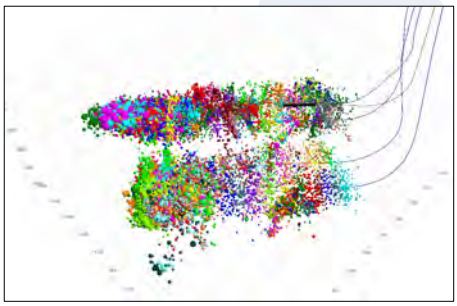
- Microseismic events identification
- First-break picking of P or S waves
- Polarization analysis
- Mapping microseismic events locations



First-break automatic picking



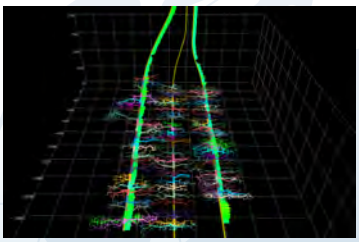
Polarization analysis



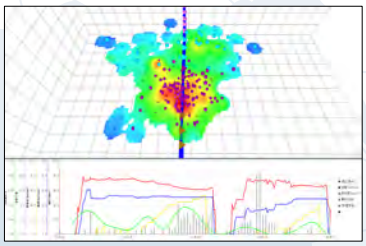
Events location

Microseismic monitoring interpretation

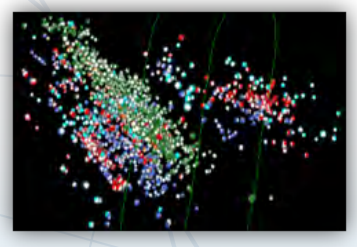
- Describing dimensions of artificial fractures
- Comprehensive analysis of the fracturing curve
- Reckoning volumes of fractured rocks
- Inverting focal mechanisms



Continuous fracture network



Matching fracturing curve



Focal mechanism inversion

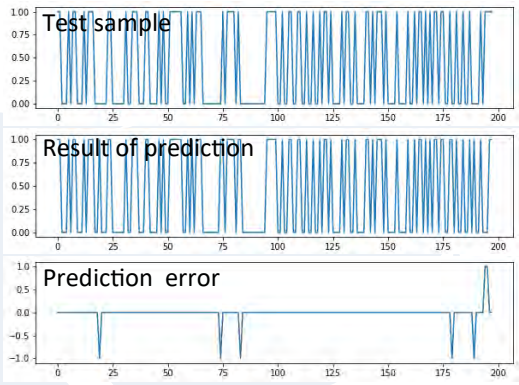
Geo-engineering Integration Based on Microseismic

Geo-engineering integration combines geophysical, geological and engineering data with microseismic data to predict sweet spots, guide placements of well locations, optimize horizontal well trajectory and reduces engineering risk in advance.

Prediction hydraulic fracturing in advance

Natural fractures are studied by using geophysical, geological, engineering parameters and microseismic data to improve drilling efficiency and optimize wellbore trajectory.

- Seismic attributes enhancement
- Natural fracture prediction
- Casing deformation prediction

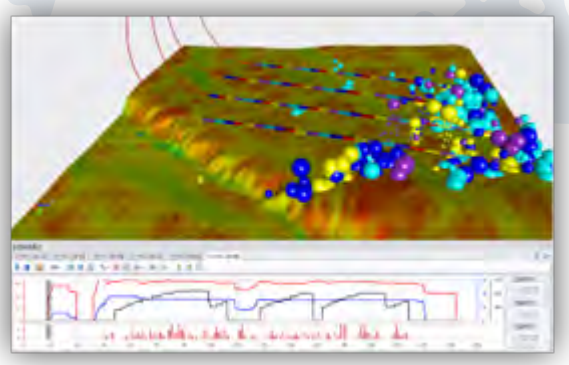


Casing deformation prediction by using random forest

Real-time forecast and adjustment

With the integration analysis of micro-seismic events with geophysical characteristics and fracturing parameters, an engineering risk mechanism can be established to help optimize treatment parameters in the field.

- Microseismic energy analysis
- Microseismic b-value analysis
- Comprehensive analysis of fracturing parameters and microseismic events

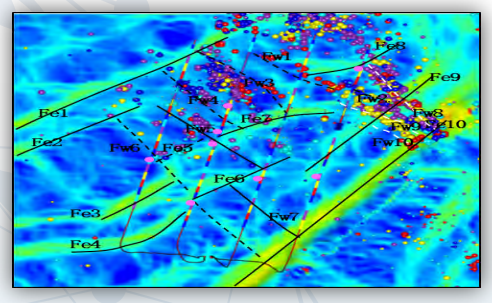


Overlap display of Microseismic events , of fracturing parameters and curvature attribute

Post-hydraulic fracture evaluation

Combined with the production information, the sweet spot distributions can be optimized, well trajectories can be adjusted and well spacing for upcoming development reservoir in the vicinity can be determined.

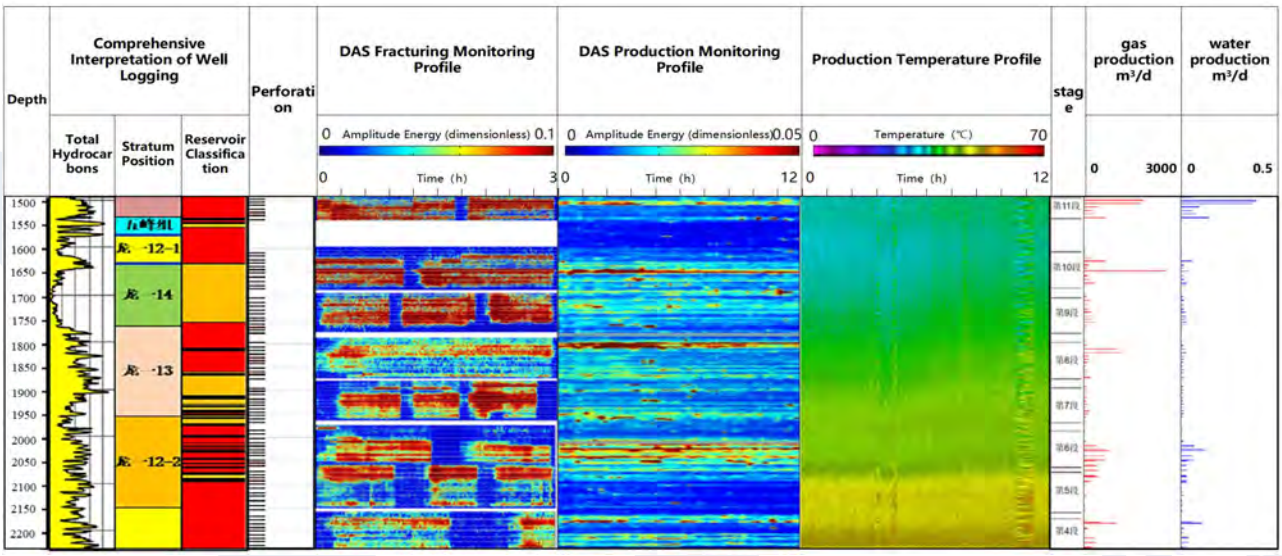
- Artificial fractures comprehensive interpretation
- Geomechanics prediction
- Well trajectory optimization



Overlap display of microseismic events with nature fracture

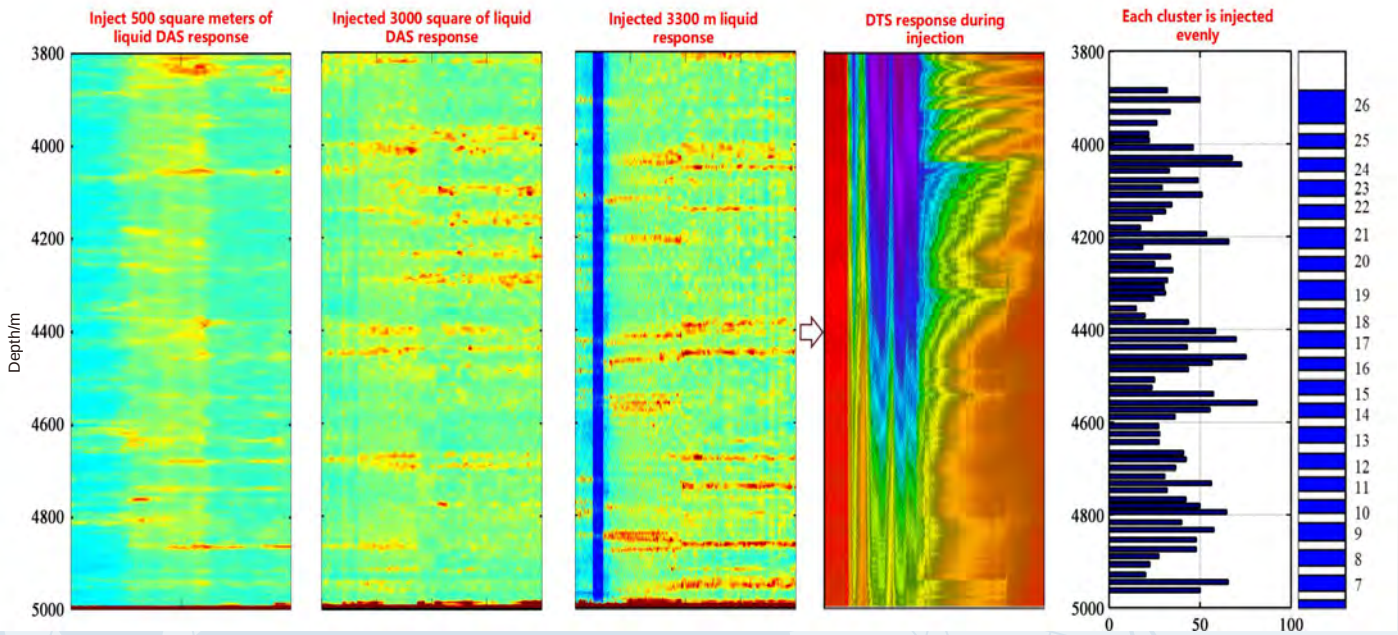
Reservoir Stimulation and Production Dynamics Monitoring Technology

Distributed optical fiber sensing technology (DTS/DAS/DSS) is capable of being applied in hydraulic fracturing monitoring and continuous real-time production dynamic monitoring. It provides a reliable basis for the evaluation of hydraulic fracturing operations, reservoir formation dynamic quality (oil/gas production profile), fluid control and blockage, production plan adjustment, and enhanced oil/gas recovery (EOR). It provides a potential area direction for finding residual oil as well as improving the oil recovery rate. It is a vital substitute for production logging and tracer logging.



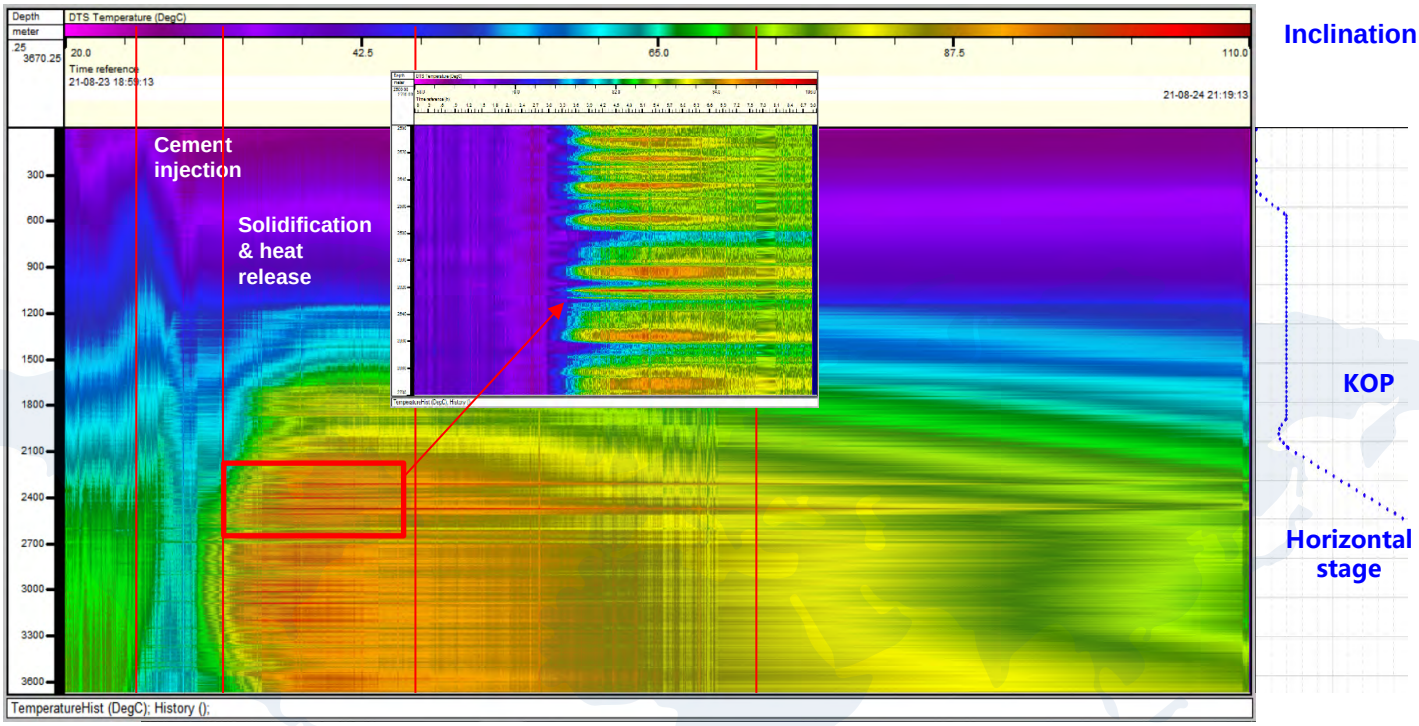
Fracturing & Production Dual Visualization

Fiber-optic injection profile monitoring technology guides the optimization of shale oil injection systems in the Dagang fault basin in real time. By gradually increasing the injection rate and injection liquid quantity, the uniform injection of liquid in each section is realized. Subsequently, the daily production of the well is increased by 50%, and the system optimization effect is remarkable.



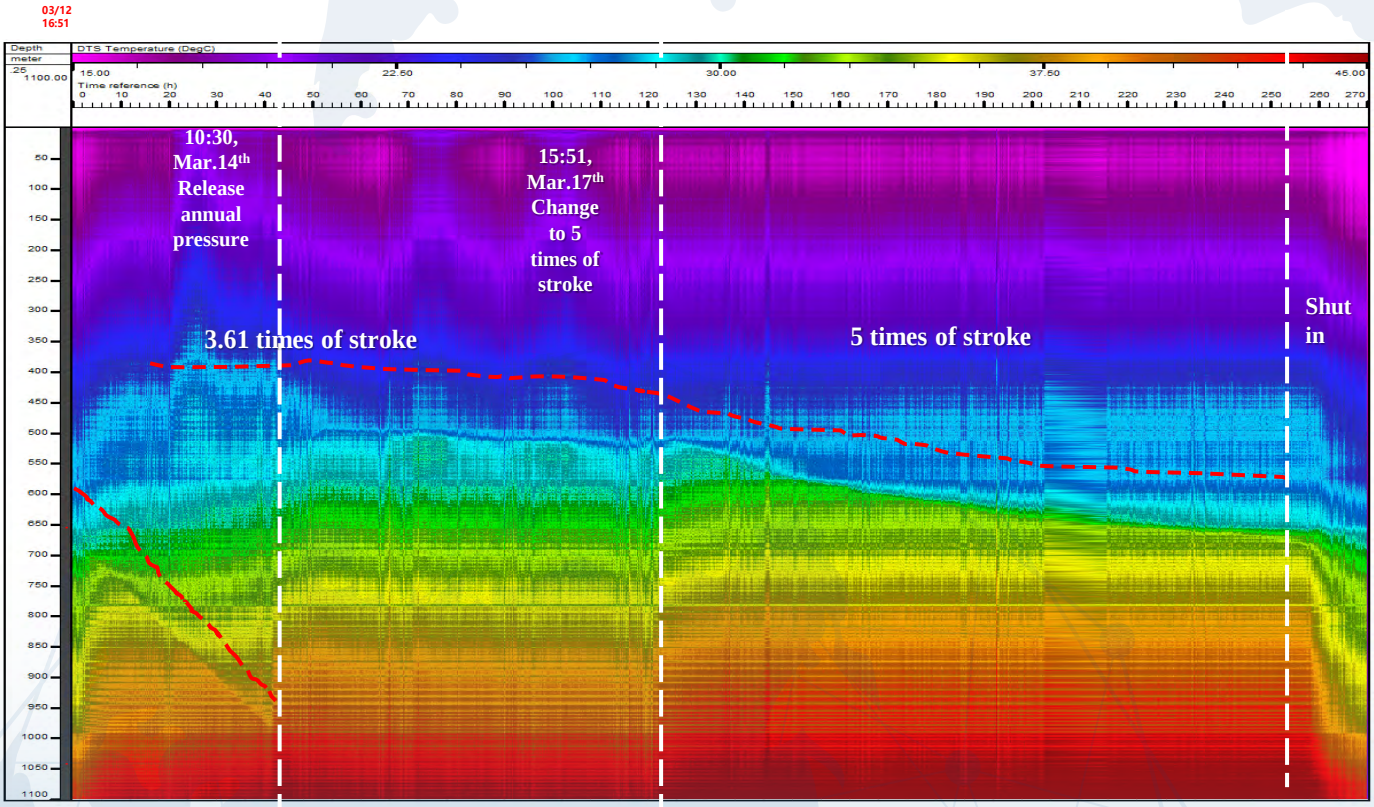
Injection Profile for Different Injection Rates

Heat will be released during the cementing process, which leads to a temperature increment at different depths; differences in temperature changes can be monitored by DTS, which can be applied to evaluate the quality of cementing.



Cementing Process Monitoring and Quality Evaluation

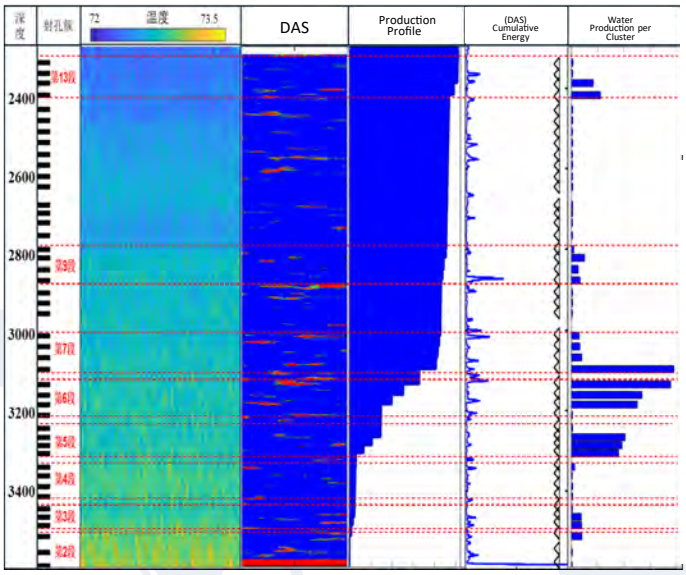
Furthermore, differences in specific heat capacities for liquid and gas result in a different temperature change rate of fiber cable submerged in liquid and gas. Thus, the G/W interface can be identified by DTS, dynamic liquid level can be monitored in oil well during the oil extraction.



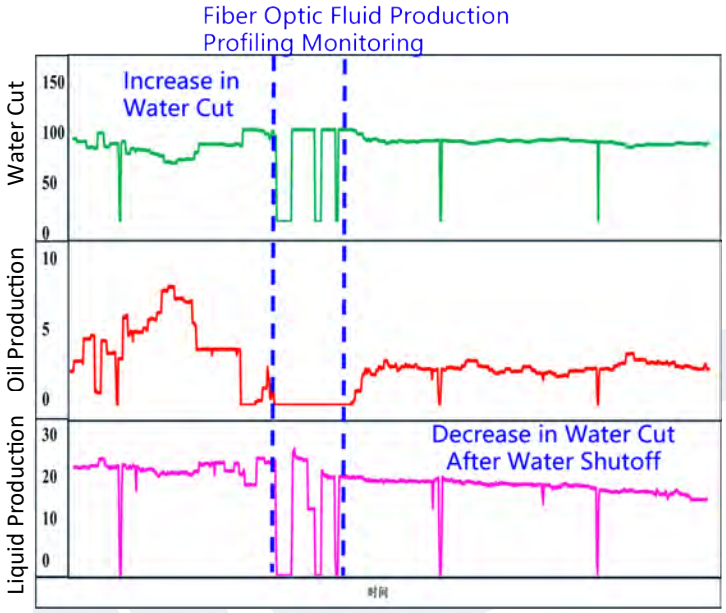
Injection Profile for Different Injection Rates

Reservoir Stimulation and Production Dynamics Monitoring Technology

High water content in horizontal wells is a big problem for oil fields. In response to the difficulty of managing water breakthrough, an innovative fiber optic water identifying and plugging technology has been developed, providing a quick solution for horizontal well management.

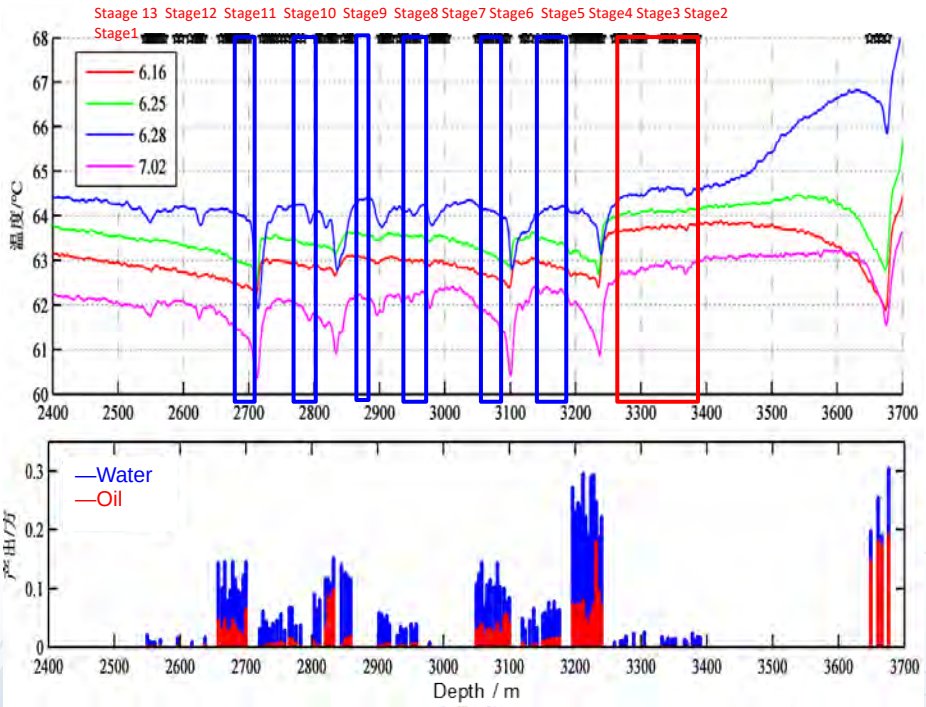


Fiber Optic Monitoring Fluid Production Profile



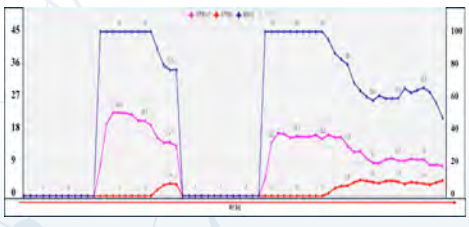
Production Dynamic Curve After Water Shutoff

In response to the problem of poor production capacity in old oil wells, through rapid interpretation of the production profile inversed by DAS&DTS, the utilization rate of each production layer and the sections that have not been fully stimulated are determined, optimizing the re-acidizing scheme. This guides the implementation of secondary development by acidizing stimulation.



Fiber Optic Monitoring of Cluster Production

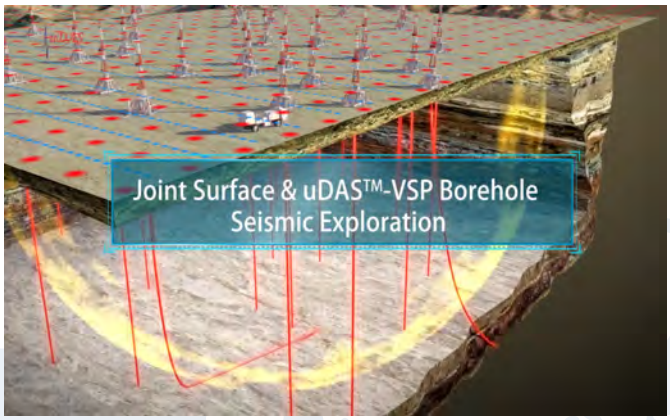
Stage	Perforation Depth	Old Acid Volume		New Acid Volume		Production Volume
层位	改造段数	射孔井段	原设计酸量 (m³)	原酸化设计	优化后酸量 (m³)	优化后酸化设计	排量 (m³/min)
长7	1	3649-3677	45	1	20	1	0.7-1.0
	2	3332-3386					
	3	3260-3305					
	4	3196-3240			10	2	
	5	3120-3176					
	6	3050-3096	35	2	20	3	
	7	2979-3026					
	8	2902-2959					
	9	2804-2859			10	4	
	10	2721-2783	35	3	20	5	
	11	2658-2700					
	12	2590-2638					
	13	2542-2570					
合计			115		80		



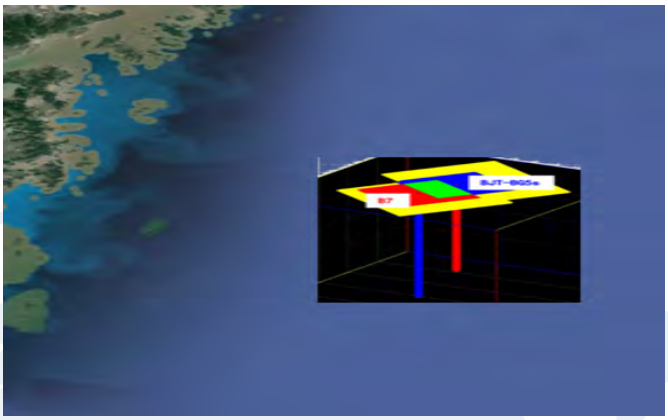
Fine Acidizing

Joint Borehole-Ocean/Borehole-Surface Exploration Technology and Application Effect

The joint borehole-ocean/borehole-surface exploration technology is based on the surface seismic acquisition, implementing optical fiber data acquisition simultaneously in the well, which has the advantage of full well interval, high density, high coverage reception.

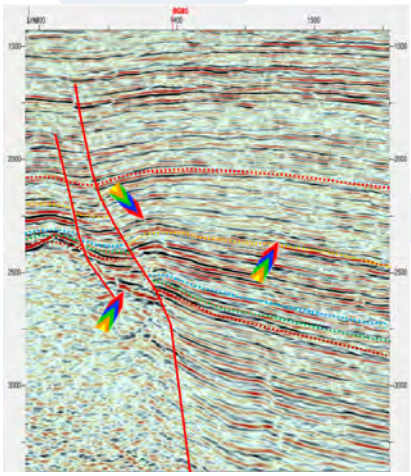


Borehole-surface Joint Exploration Stereoscopic Diagram

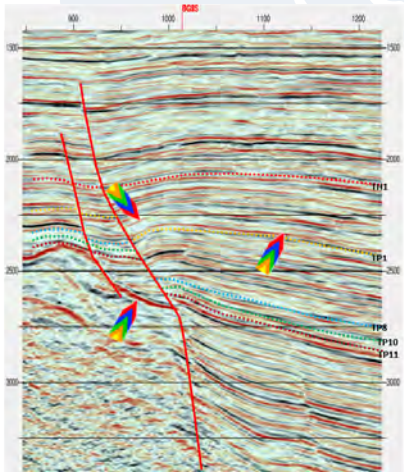


Schematic Diagram of Borehole-ocean Acquisition Coverage

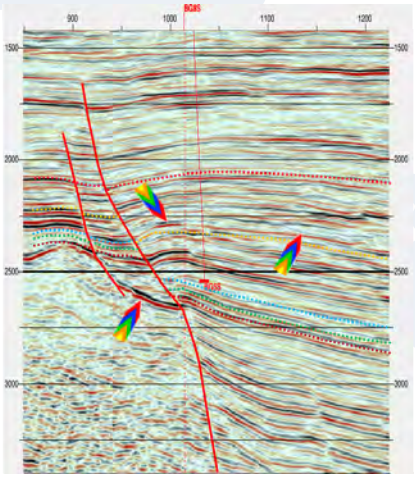
An application case of DAS joint exploration in Pinghu oil and gas field, East China Sea



Data on Towing Cables

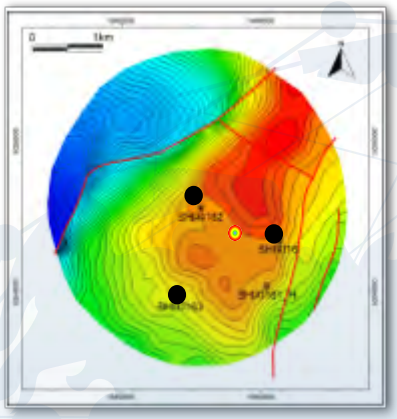


OBN Imaging

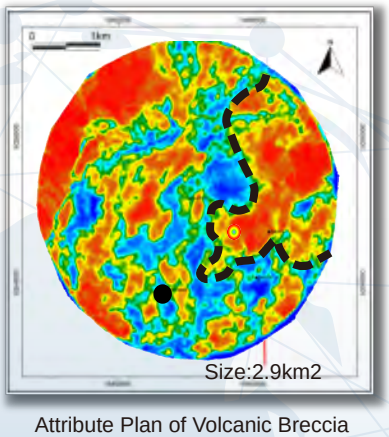


3D VSP Imaging

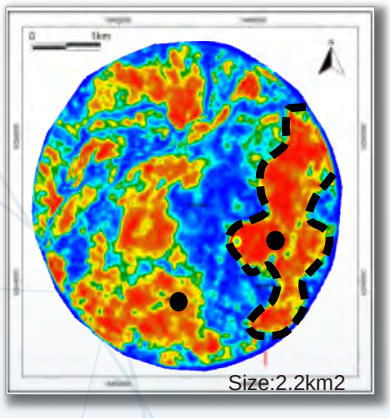
Seismic characterization technology of igneous rock masses using 3D VSP joint Borehole-surface exploration data in Shixi



Structure of the Top Boundary of Carboniferous System



Attribute Plan of Volcanic Breccia Section



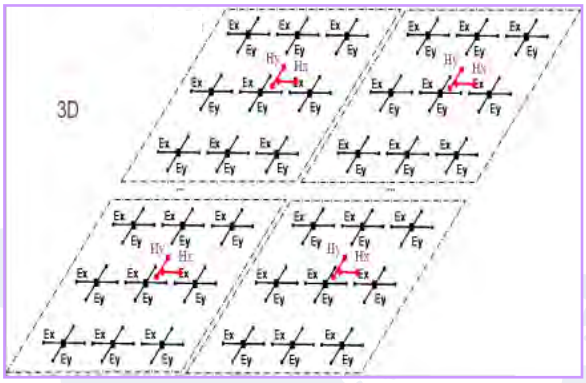
Attribute Plan of Carboniferous Weathering Crust

3D GME Survey

BGP provides an integrated solution with 3D GME (Gravity, Magnetic, Electromagnetic) & Seismic to identify subsurface structures in complex exploration areas.

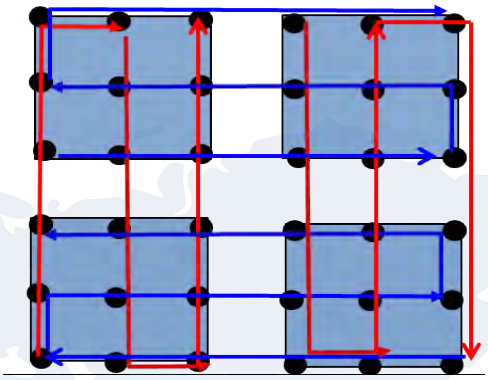
Acquisition

3D small-bin MT/AMT acquisition



A 3D small-bin includes one 4-channel and eight 2-channel receiver systems, which is synchronized by GNSS satellites.

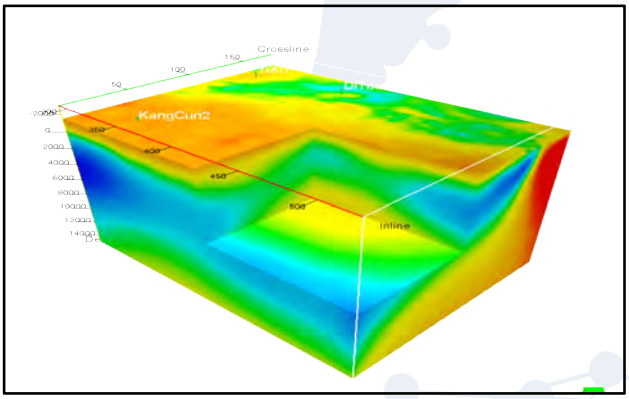
High accuracy 3D gravity & magnetic acquisition



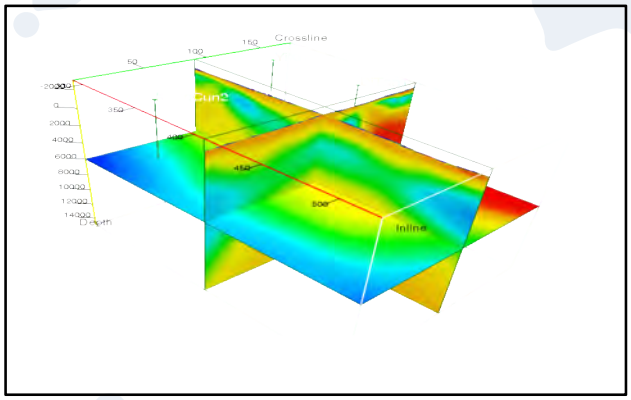
Two independent observation loops make gravity and magnetic observation accuracy 100% increasing.

Processing & Interpretation

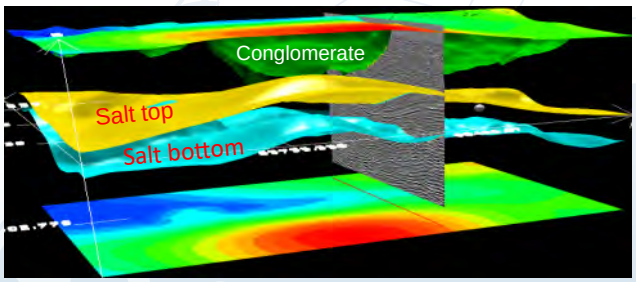
3D MT apparent resistivity image



3D density image



3D MT and gravity joint interpretation

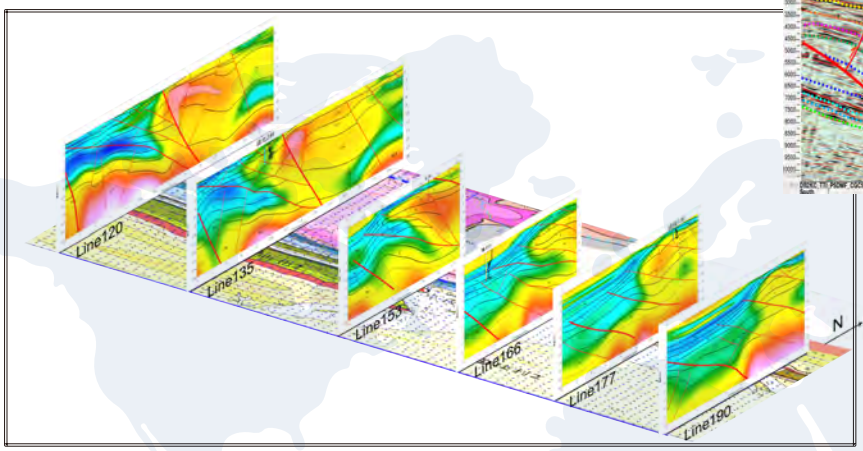


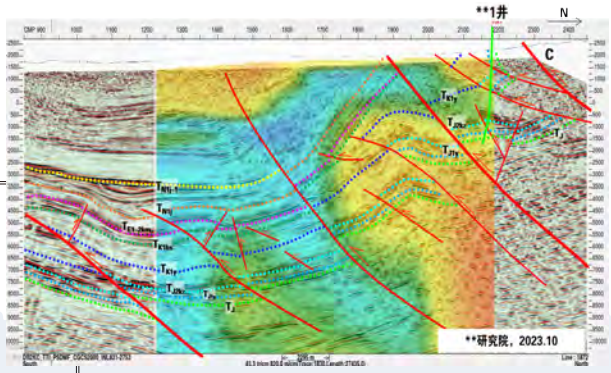
Gravity, Magnetic, EM, Seismic and logging data can be processed and interpreted on BGP-developed Geo-East comprehensive processing and interpretation software system.

Applications of 3D GME

Integrated 3D GME with seismic, logging and geological data can map the distribution of lithology, layer and analyze the pattern of sedimentary deposits.

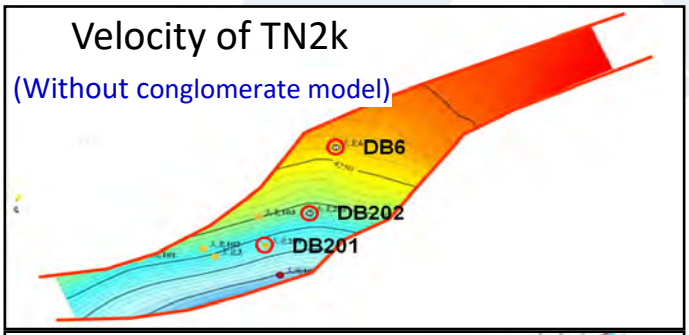
Joint interpretation sections with
3D gravity, magnetic and MT data

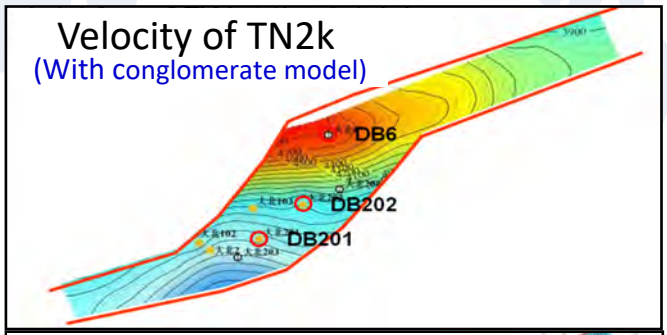


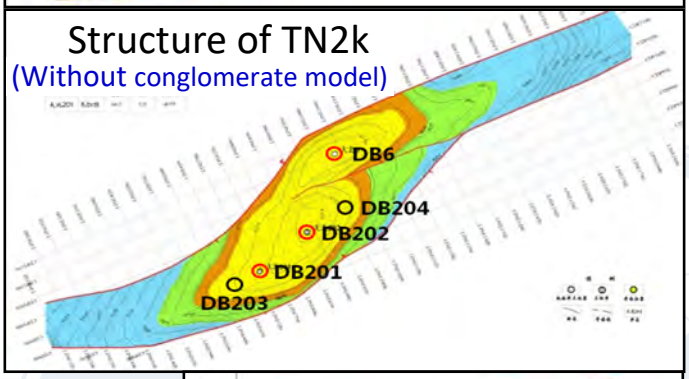


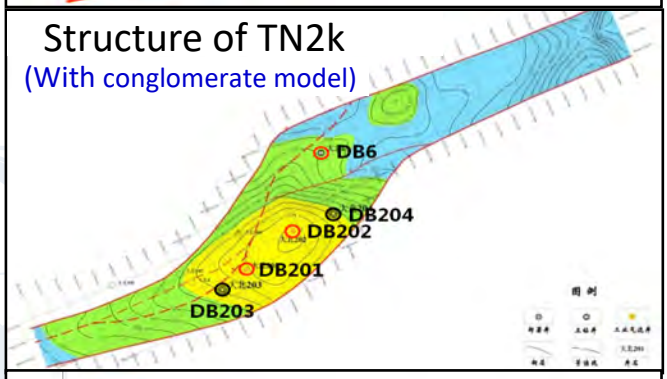
Overlay of 3D MT
apparent resistivity and the
3D seismic section

A Conglomerate model built with 3D GME data assists in seismic data reprocessing, and the interpreted traps are more reliable and the depth error reduced accordingly.

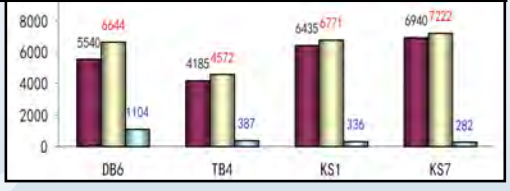


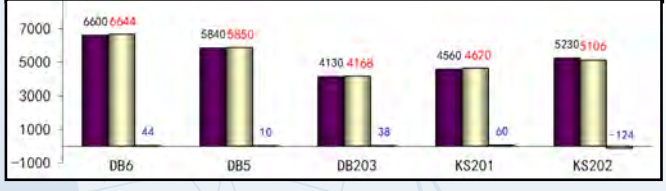






Depth error
comparison





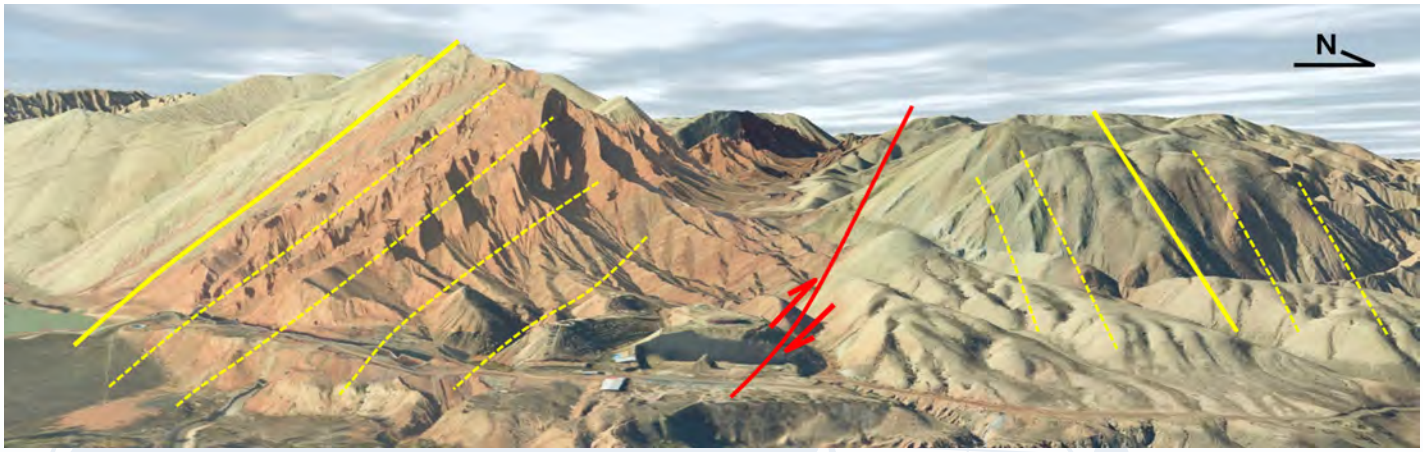
Airborne LiDAR for Oil-gas Exploration and Development

BGP has applied airborne LiDAR in oil and gas exploration and development, including geophysical survey design, geological outcrop analysis, well site optimization, ground infrastructure construction, geological hazards assessment etc.

Digital orthophoto map from LiDAR

LiDAR technology is a state of art surveying and mapping technology. It integrates laser ranging, GNSS, and digital camera to realize high-precision and high-resolution topographic surveying and mapping.

Geological outcrop analysis



Based on DOM (digital orthophoto map) and DEM (digital elevation model), the accurate topographic relief, formation distribution and near surface geological model can be established for digital geological mapping and guide geophysical data interpretation.

Airborne LiDAR for Oil-gas Exploration and Development

Geophysical survey design

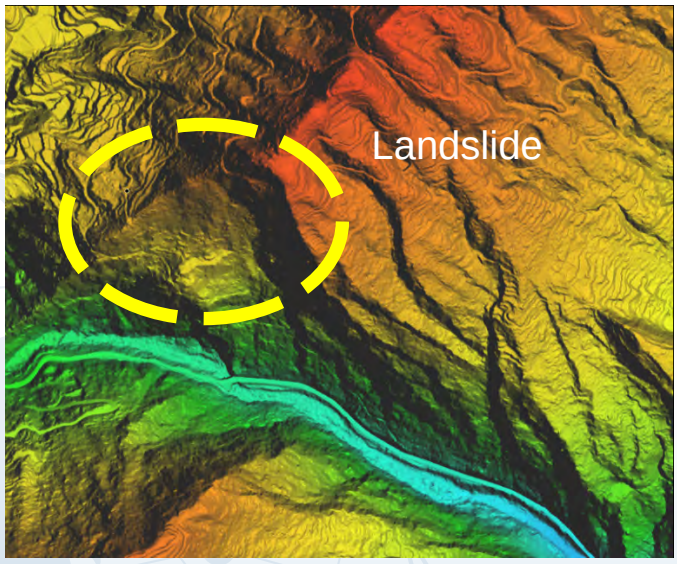
The high-precision and high-resolution LiDAR image can be used to optimize the survey design, especially for the selection of geophysical point location to improve the quality and efficiency of acquisition.

Well site optimization

The LiDAR data set can directly and accurately provide the information such as terrain undulation, slope, and relative position from site to obstacles, which is much useful to the optimization of drilling well site.

Geological hazards assessment

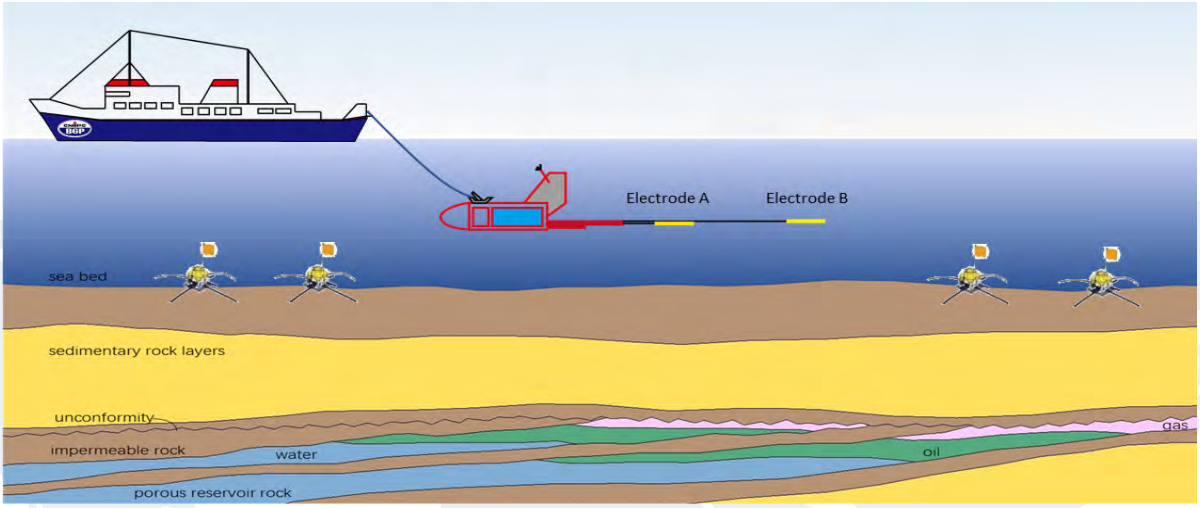
Digital orthophoto map



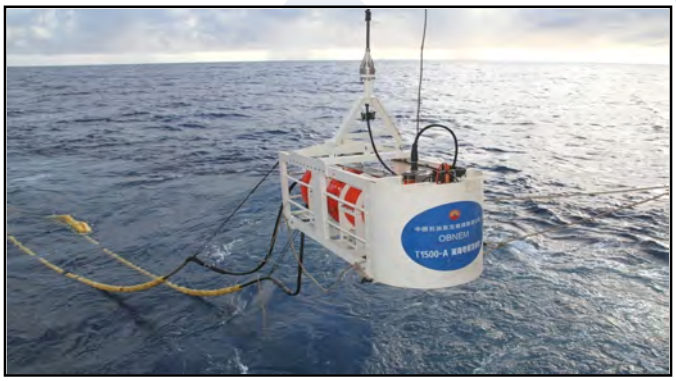
Digital elevation model

OBNEM Survey

OBNEM® (Ocean Bottom Node Electromagnetic) survey plays a remarkable role in marine oil & gas exploration. Since 2018, BGP has developed a series of relevant hardware and software, including high power transmitting systems, long-endurance receivers, reliable monitoring systems and integrated processing modules.

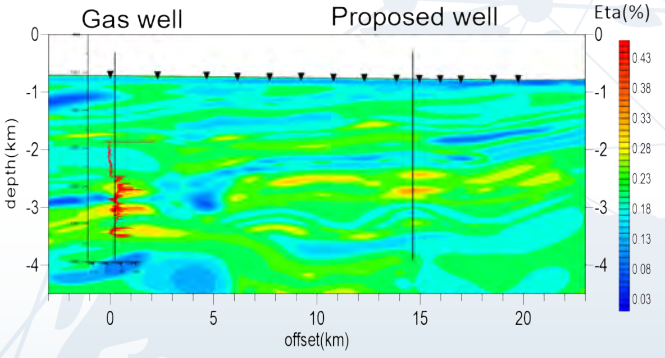


Schematic diagram of OBNEM survey



OBNEM transmitter

OBNEM receiver



IP section from OBNEM

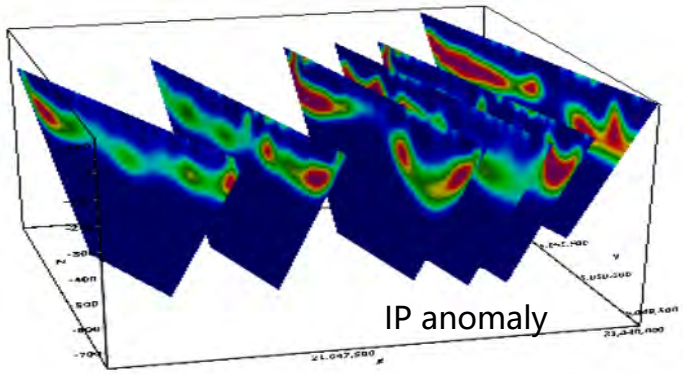
Based on oil/gas bearing structures producing high IP anomalies, high IP anomalies were used to predict the location of oil/gas bearing structures. An OBNEM section is always suggested to cross the proposed well and known oil/gas well if it is available.

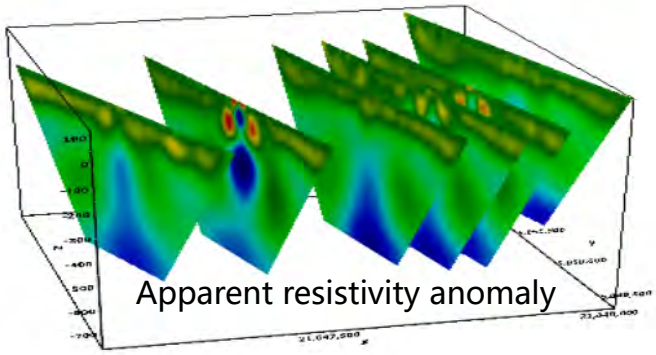
New Energy Technologies and Business

GME technologies are more effective in some of the new energy businesses. Some new technologies derived from traditional GME methods were presented and applied in new energy business, such as CCUS/CCS, geothermal energies, associated minerals of oil and gas.

Techniques for associated mineral survey

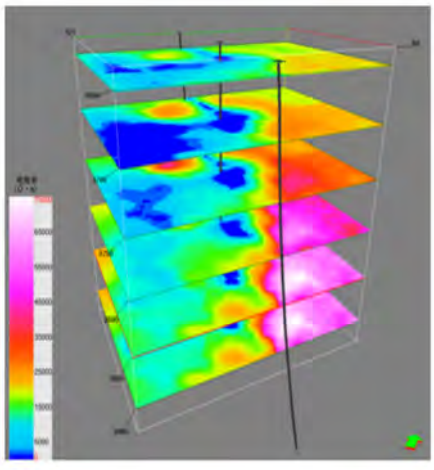
A phase IP method based on pseudo-random multi-frequency nested transmit signals was developed by BGP for the associated mineral survey. The three-step method for predicting and evaluating sandstone-type uranium mineralogical and geochemical exploration in petroliferous basins has been developed, and the national invention patent has been obtained.



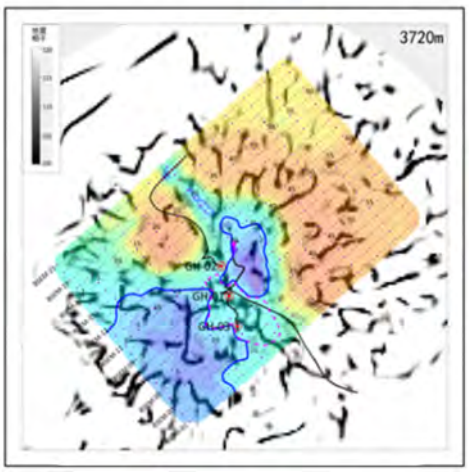


Monitoring techniques for Hydraulic Fracturing

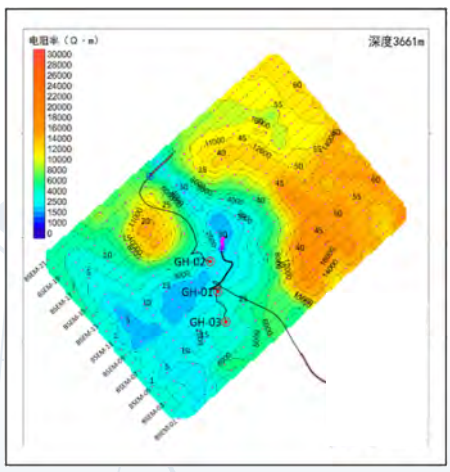
By using the VSP technology to detect the variation of velocity coherence property and combining this with the inversion resistivity of BSEM survey, the fracture distribution of hot dry rock after fracturing can be clearly described, and the joint state of fractures can be predicted.



Depth slices of 3D inversion resistivity



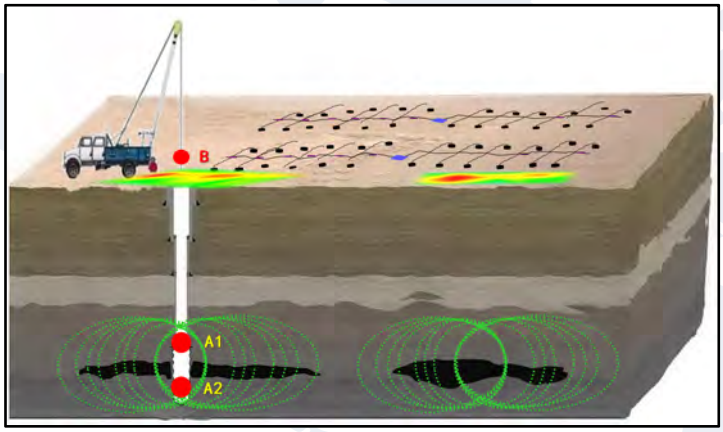
Overlay of seismic coherence attributes on apparent resistivity



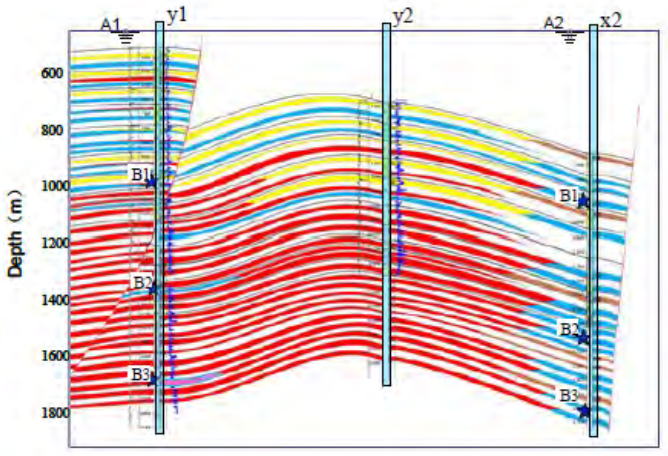
Apparent resistivity in a specific depth

BSEM Technique for Oil and Gas Exploration

BSEM (Borehole-to-surface Electromagnetic sounding) technique is a high precision electromagnetic prospecting method for reservoir boundary delineation. It can reduce the number of exploration and evaluation wells, provide a reliable basis for the deployment of development wells, and improve the drilling success rate. It has been successfully applied in more than 10 oilfields in China for about 20 years, and become a very attractive technique for oilfield development process. BSEM survey has also been applied in fracturing monitoring for HDR exploitation.

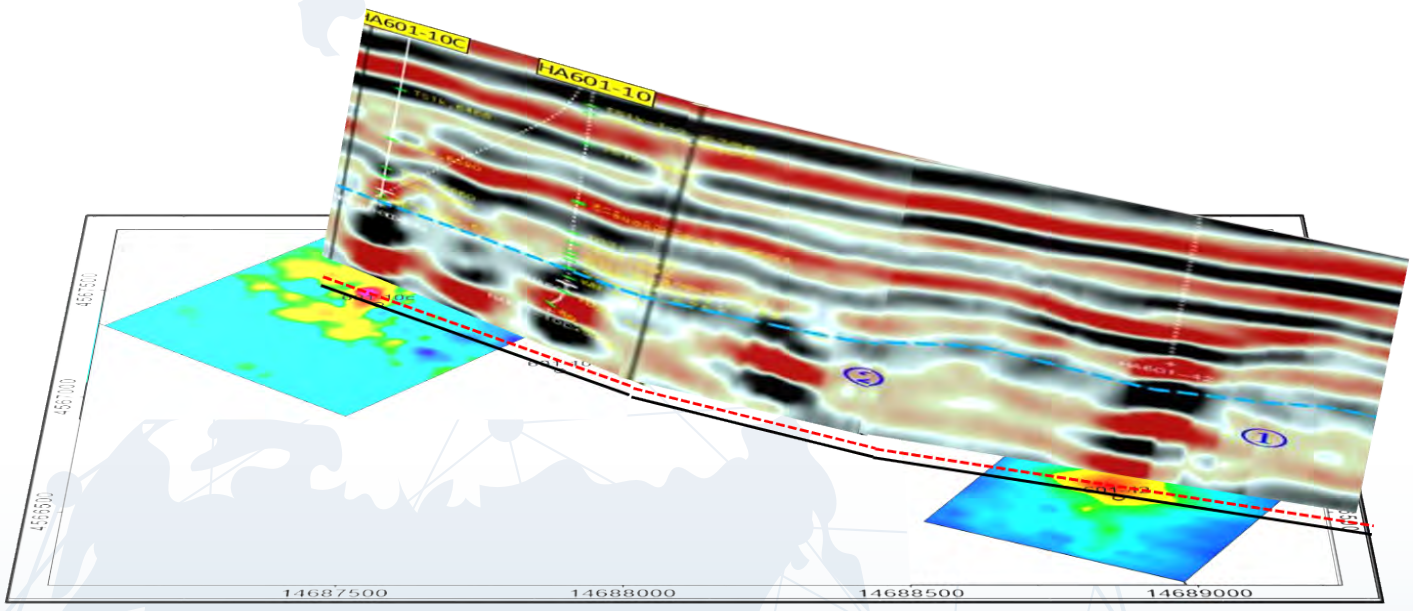


Schematic diagram of BSEM survey



BSEM downhole source layout diagram

BSEM survey is applied to evaluate crevice & hole reservoirs predicted with 3D seismic survey in X basin. A drilling design proposal with a 67m-adjustment to the north based on BSEM survey was proved by the client, and the well get a commercial oil production.

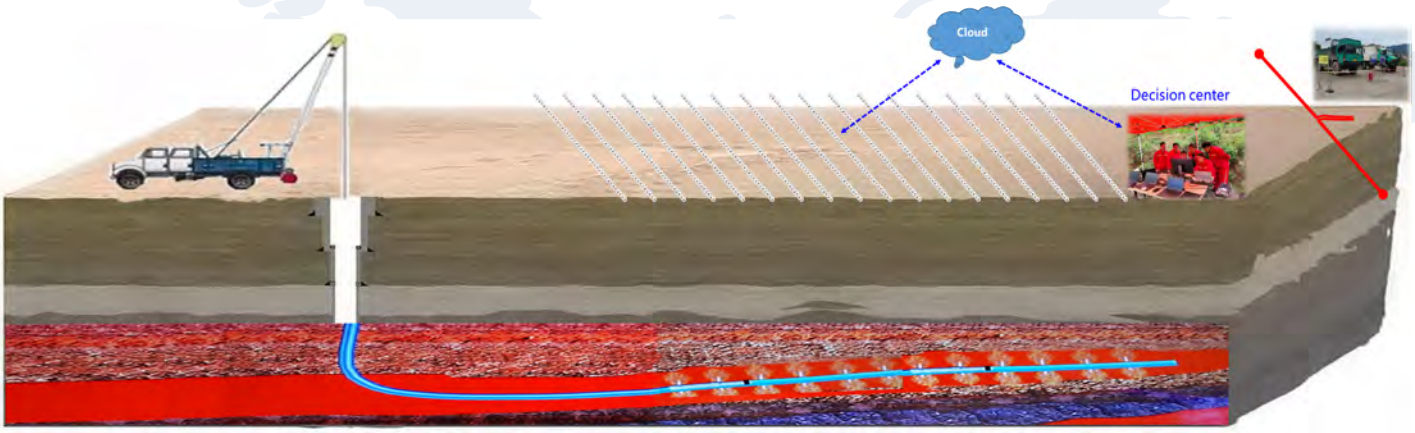


BSEM IP-R anomaly delineates the oil pool ranges, and guides the well location adjustment.

CSEM monitoring for hydraulic fracturing(iEot)

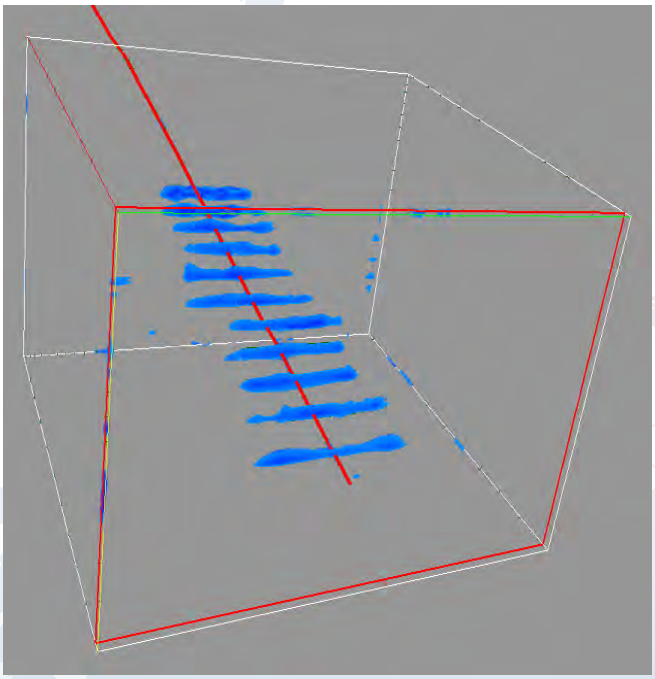
iEot is a characteristic monitoring technology for hydraulic fracturing developed by BGP dominated by CNPC. This technique predicts the fracturing fluid distribution by studying the resistivity of oil&gas reservoir during hydraulic fracturing to evaluated fracturing effect.

This technology has the advantages of high precision covering multiple fracturing sections, real-time data transmission of 5G electromagnetic node, intelligent data processing of cloud platform and fast artificial intelligence imaging, etc., it can be widely used in exploration and development of shale and tight oil and gas reservoirs.

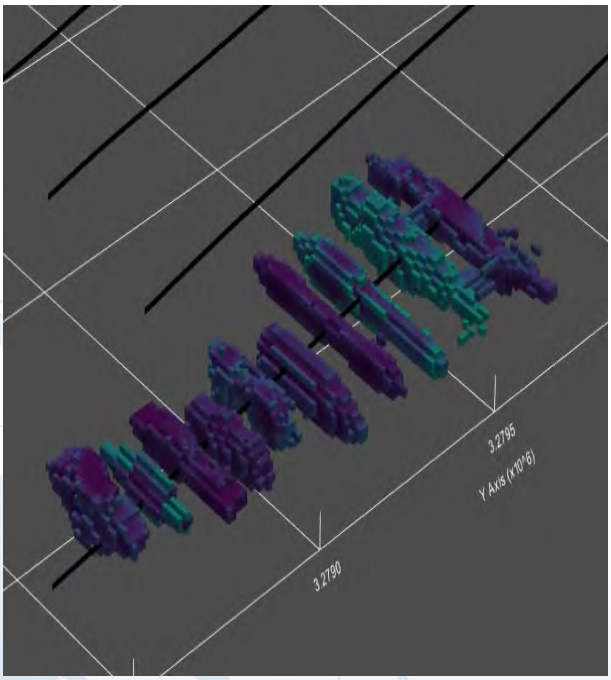


Schematic diagram of CSEM monitoring for hydraulic fracturing

iEot has been applied in monitoring of hydraulic fracturing of shale and tight oil&gas reservoirs in some basins. 10-minutes update rate provides strong support for real-time expert decision-making system of fracturing platform.



3D display of fracturing effect

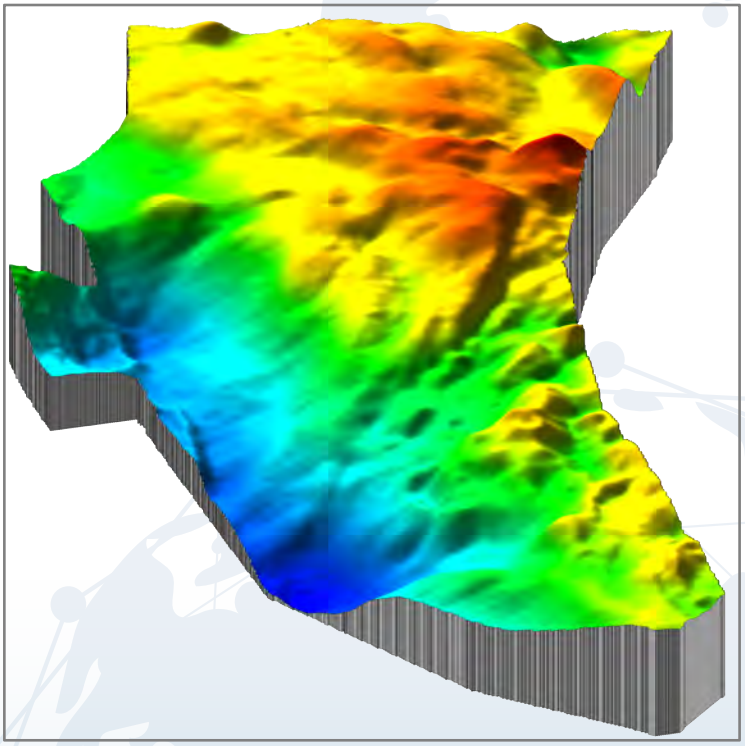


AI prediction image of fracturing monitoring

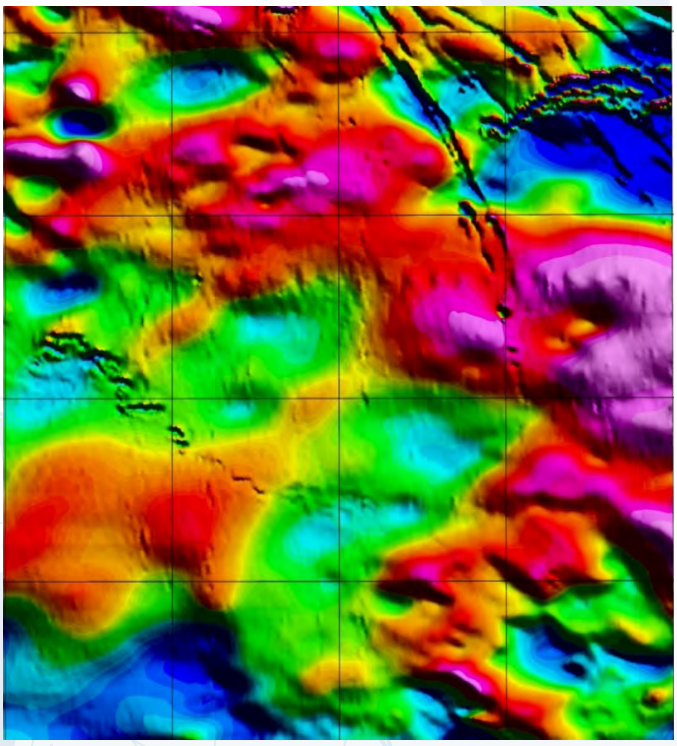
Airborne Gravity and Magnetic Surveys

BGP has carried out comprehensive geological study with airborne gravity and magnetic data for more than 50 years, and started airborne gravity and magnetic survey in the year of 2018. Up to now, BGP has developed airborne gravity and airborne magnetic data processing software, drafted an enterprise standard of airborne gravity and magnetic survey, and completed airborne gravity & magnetic survey line more than 220,000 km in Africa and South America. BGP would like to continue airborne gravity and magnetic business all over the world in the future.

Airborne gravity and magnetic survey work team



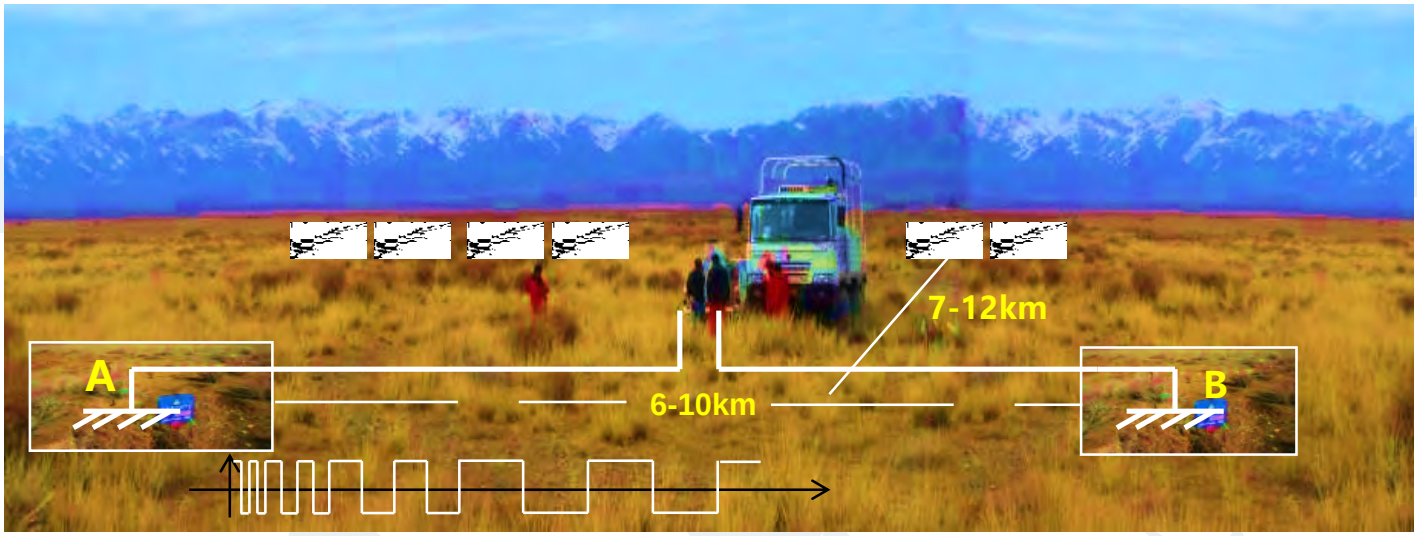
Airborne Bouguer Gravity Anomaly



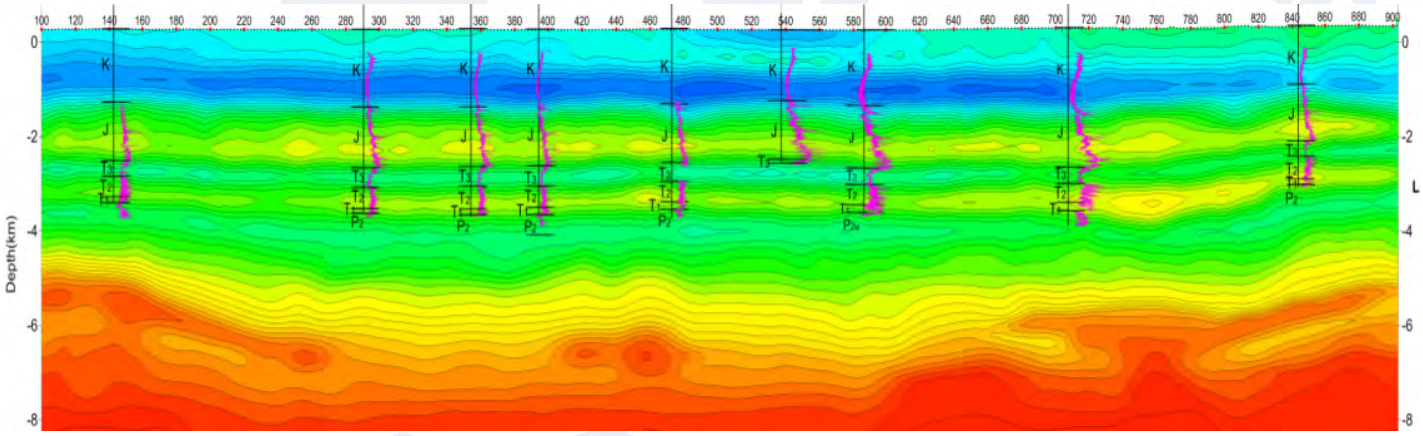
Airborne Total Magnetic Intensity

TFEM Technology for Oil and Gas Exploration

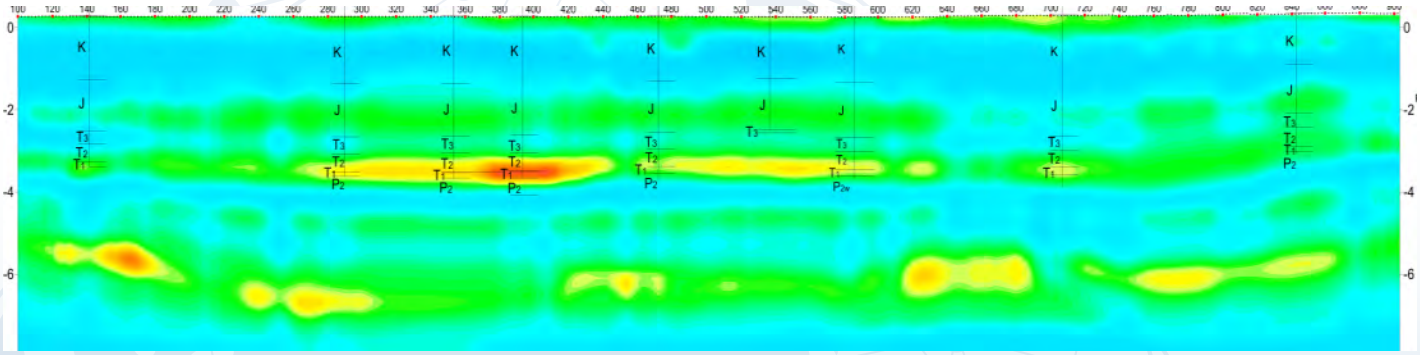
TFEM (Time-Frequency electromagnetic Sounding) technique was developed by BGP in 2010s. It studies resistivity and polarizability features simultaneously to identify and evaluate oil&gas targets especially interpreted from seismic survey. With techniques of excitation frequencies design for specific targets and multiply excitation for denoising, it can realize high-precision deep and ultra-deep exploration. At present, TFEM technique has been widely used in most oil fields in China and some oil fields in Middle East and Africa countries.



Schematic diagram of TFEM survey



Resistivity anomaly to study geoelectric structures, lithologic information, faults, structure zones and etc.



IP anomaly to analyze oil saturation, porosity, permeability to predict oil and gas potential areas.

EV-56 High Precision Vibrator

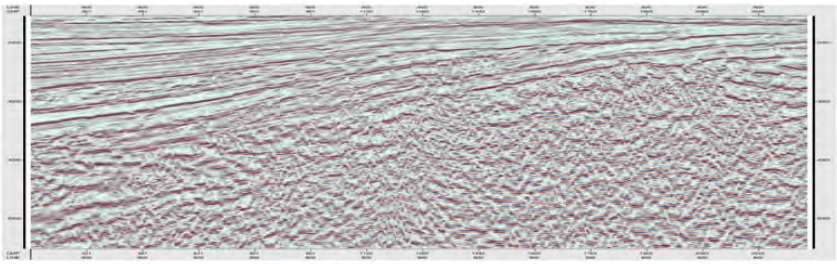
High precision seismic signal excitation source

The EV-56, a new generation of broadband vibrator, is one such invention that can generate reliable and stable linear sweeps from 1.5Hz to 160Hz, which is essential in enhancing resolution of full waveform inversion. High-precision, deep target seismic imaging has been applied and implemented in multiple projects.

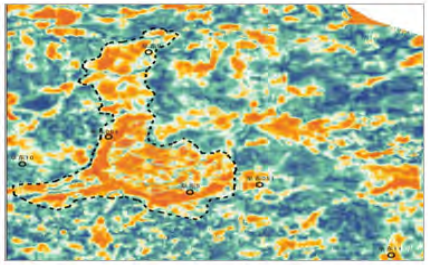
Specifications	
Max. HD, kN	310
Peak Force, kN	251
Limited Low Frequency, Hz	3
Recommended High Frequency, Hz	160
Max. Stroke, mm	210
Mass Weights, kg	5900
BP Weights, kg	2032
Mass/BP Ratio	2.9
Vibration HP, Mpa	21

Improvement of geological quality

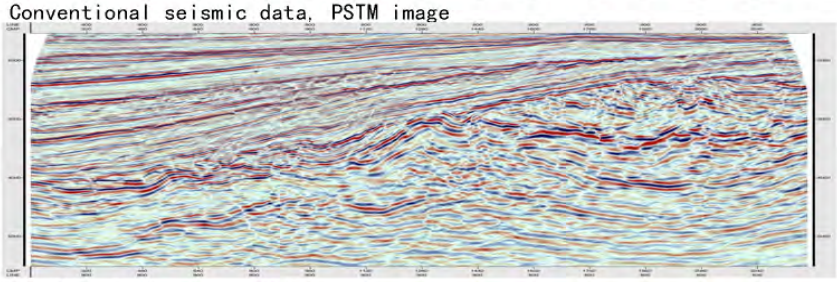
The high precision vibrator can improve the quality of seismic data and increase the signal-to-noise ratio (SNR) from the point of view of seismic excitation source, as can be seen from the following sections. The signal quality has been significantly improved.



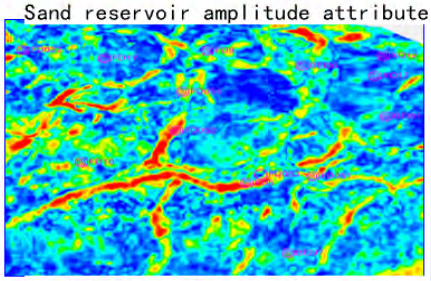
Conventional seismic data, PSTM image



Sand reservoir amplitude attribute



New 3D seismic data, PSTM image

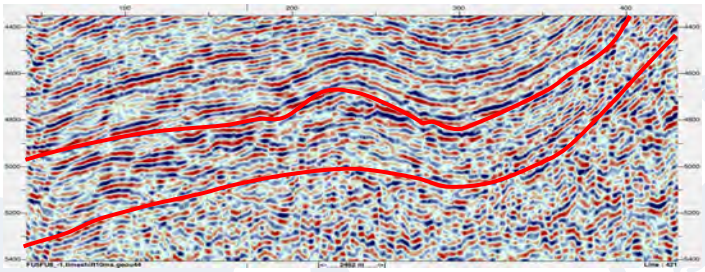


Sand reservoir amplitude attribute

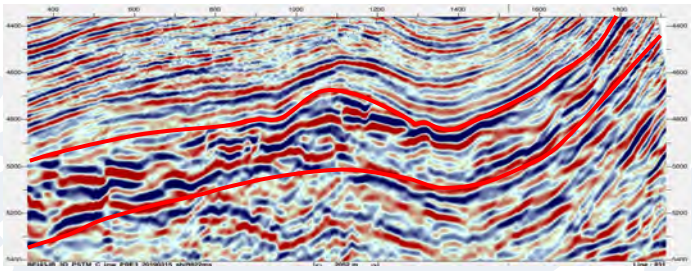
EV-56 High Precision Vibrator

Applications

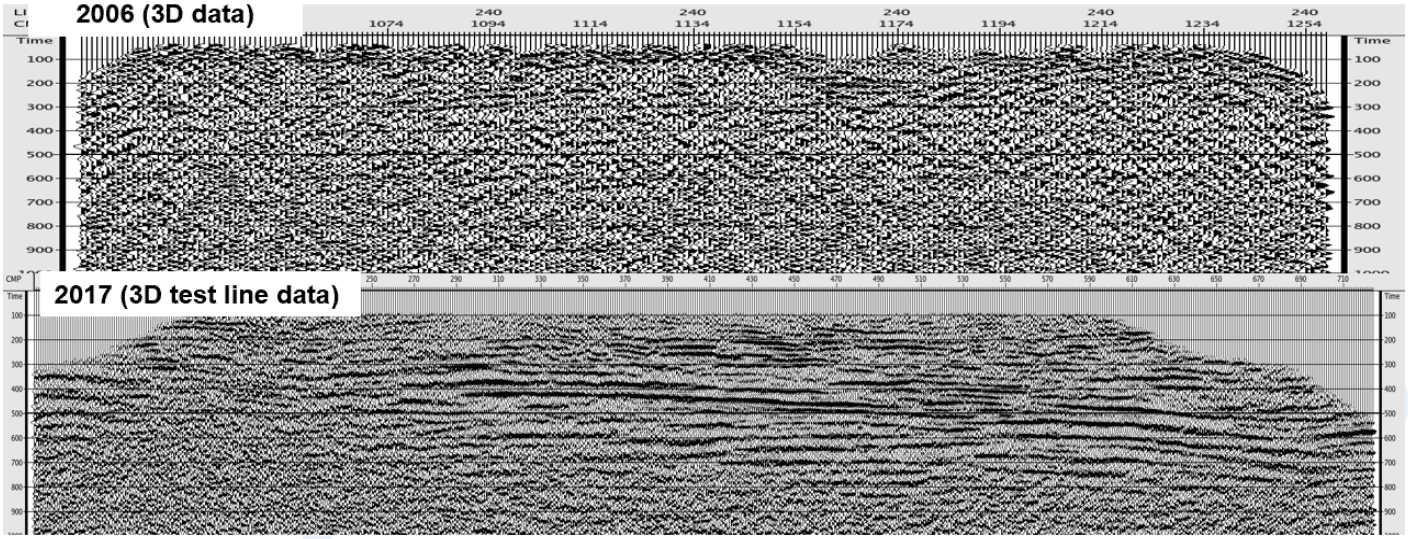
The top boundaries are sought. The low frequency information is richer, and the tectonic morphology of the Carboniferous System is identified, the petrographic phase and spreading characteristics of the volcanic rocks at the top of the Carboniferous System are implemented, and the lithology and fault lithology targets aging of the top interface and the inside of the Carboniferous is clearer.



Legacy 3D data

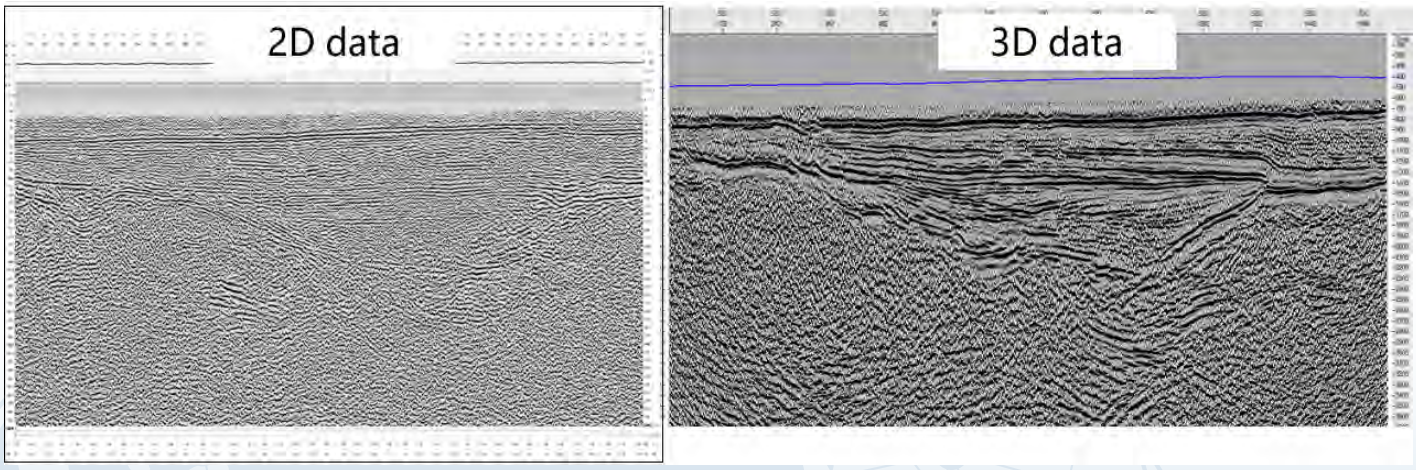


New 3D Carboniferous data



Geologic profile of coal mine

The EV-56 high precision vibrator has significantly improved the quality of geological data, especially in the imaging of deep targets. The exploration of special geological targets such as igneous rock and natural gas hydrate is of epoch-making significance.



Data comparison of domestic exploration

Ultimate Source Management System

System introduction

The Ultimate Source Management System (USM) integrates mature and efficient seismic acquisition technology, suitable for vibroseis、explosive and it mixes explosive in mountainous areas, Gobi, deserts and urban areas for both domestic and international operations. It is a brand-new source management system with stable and reliable communication, concise and efficient, and rigorously quality control in real time.

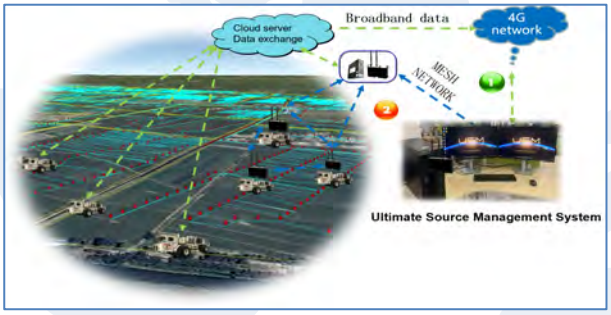
Technical Feature

1	Adapted for VibPro HD and VE464 vibrator electronic control systems, supporting various communications such as 4G network, MESH network, etc
2	Supporting vibrator and explosive mixed shooting in node recorder mode, one click switching shot source operation management
3	Supporting high productivity explosive acquisition (including explosive DS4, explosive T-D rule compliance acquisition, and other functions)
4	Supporting HPVA (High productivity vibroseis acquisition) related technology (including Flip-Flop, DS3, ISS, specific TD rule excitation control), Support efficient shot management for 64 VIBPRO HD and 100 VE464.
5	Cooperating with VSC (Vibrator Service Center) navigation system can realize the functions of remote real-time vibroseis excitation control, task distribution, parameter transmission, real-time precision monitoring, quality control, data recording, etc

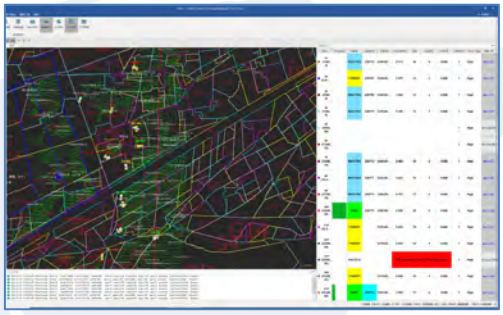
Ultimate Source Management System

Application Effect

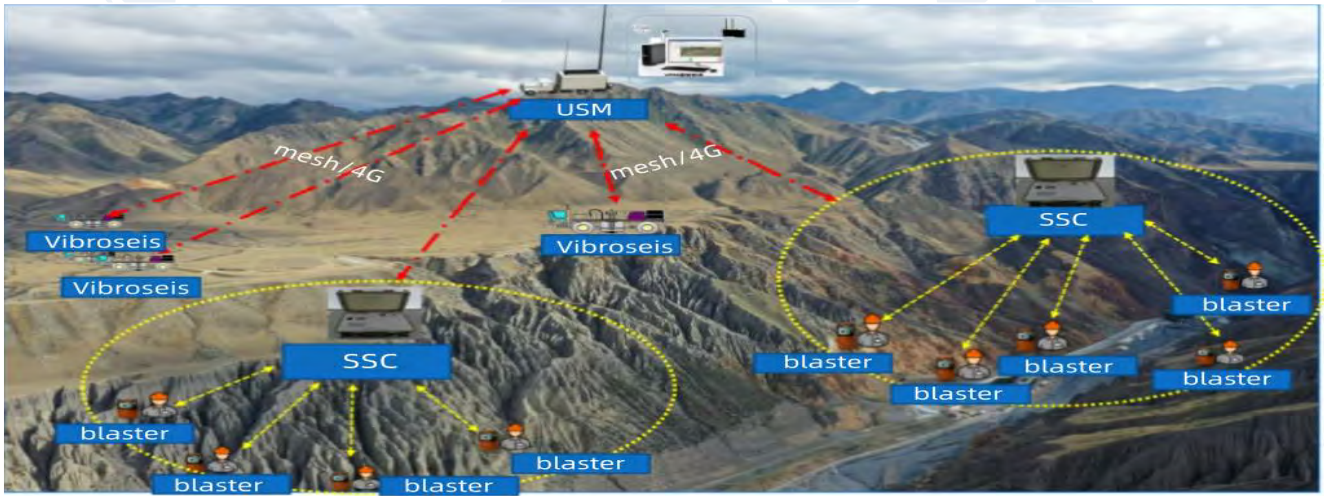
The Ultimate Source Management System has high adaptability in complex field operation environments, cooperating with node recorder and VSC (Vibrator Service Center) navigation system to achieve remote high productivity acquisition, with a communication distance that can be extended to nearly a hundred kilometers, and the return rate of the QC report reaches more than 99%. From 2020 to 2023, the USM system has been applied in more than 70 production projects in Changqing, Qinghai, Huabei, Xinjiang, Liaohe, Tuha, Xinxing, Daqing, Xinan and other exploration areas, with an average improved production efficiency of over 30% and has been highly praised by the BGP's geophysical exploration companies.



USM-Communication Mode



The Main Interface Of USM Software



Vibroseis And Explosive Mixed Acquisition Hardware Arrangement Schematic

Application Project

In February 2023, the Santanghu Basin acquisition project of the Tuha Geophysical Exploration Company conducted an ultra efficient mixed acquisition experiment with USM, achieving 0-second slip-sweep time shooting operation management for vibroseis, with a daily average of 9834.5 shots, maximum daily production of 12008 shots, and maximum hourly efficiency of 647 shots.

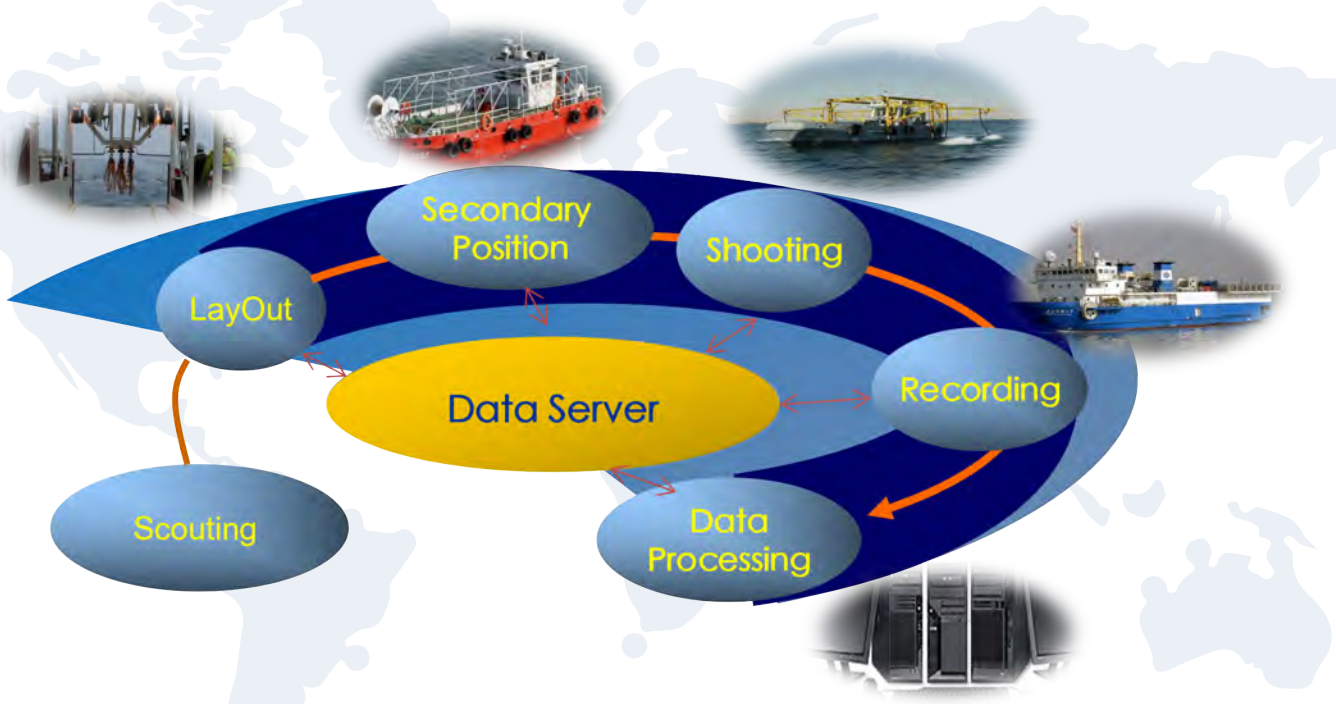
In August of the same year, the Mizhi 3D acquisition project of Changqing Geophysical Exploration Company, team 287, using the optimized timing sequence of shooting, constraint with T-D rule, explosive intelligent queuing and other functions of the USM system. The maximum hourly efficiency for explosive acquisition up to 405 shots, breaking through 60 blasters of high productivity explosive acquisition management.

In February 2024, the Ordos Basin Shanghai Temple area 3D acquisition project of Changqing Geophysical Exploration Company, team 280 using the "fleet without shooting " function of USM system to achieve uninterrupted automatic shooting, with a daily productivity of 8500 shots, exceeding expectations by 15%.

GeoSNAP-Dolphin: Integrated Navigation System for Ocean Bottom Seismic Exploration

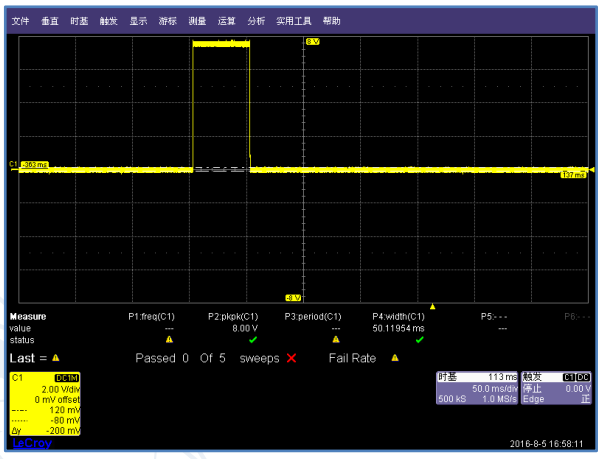
System introduction

GeoSNAP-Dolphin system is a set of navigation and positioning system for offshore OBC/OBN seismic exploration. It is independently developed by BGP INC., and can provide all the functions required by OBC / OBN navigation and positioning. Dolphin meets the requirements of navigation and synchronous control in the process of OBC / OBN operations and achieves the complete replacement of similar software.



Features

1	Real time accuracy is less than 10ms
2	Synchronization accuracy <10us
3	GPS timing accuracy is less than 4us
4	Expandable RS232 data interface
5	6-channels of TTL / close signal output
6	2-channels of TTL / closure signal input
7	Two analog signal AD acquisition interfaces

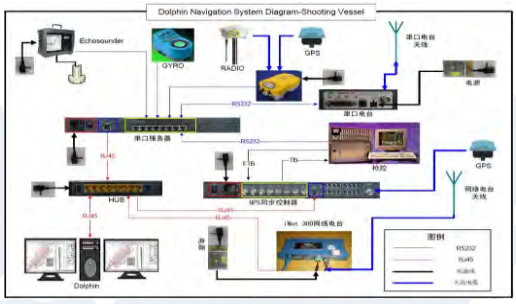


GeoSNAP-Dolphin: Integrated Navigation System for Ocean Bottom Seismic Exploration

Main Functions

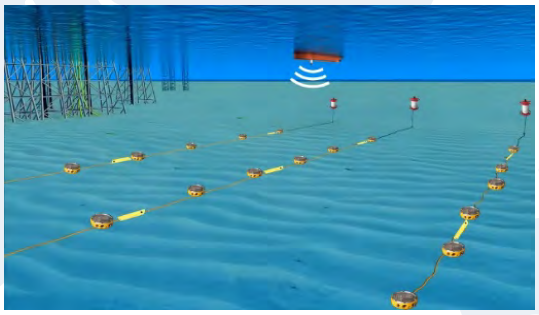
The dolphin system adopts the C/S architecture with the central database as the core and modular client. Wireless LAN is used for data exchange between ships. The key technologies include: centralized management and remote control, multi ship distributed operation, system synchronous acquisition timing, real-time data quality control, and multi-source independent control.

Real Time Quality Control



Equipment Connection Diagram

Remote Control



Acoustic Positioning

In November 2019, dolphin passed the scientific and technological achievements appraisal of CNPC and was highly praised as "it is advanced in the world and has a certain leading position". The rigorous certification by Verif-i, an international third-party auditing company, was passed in June 2022.

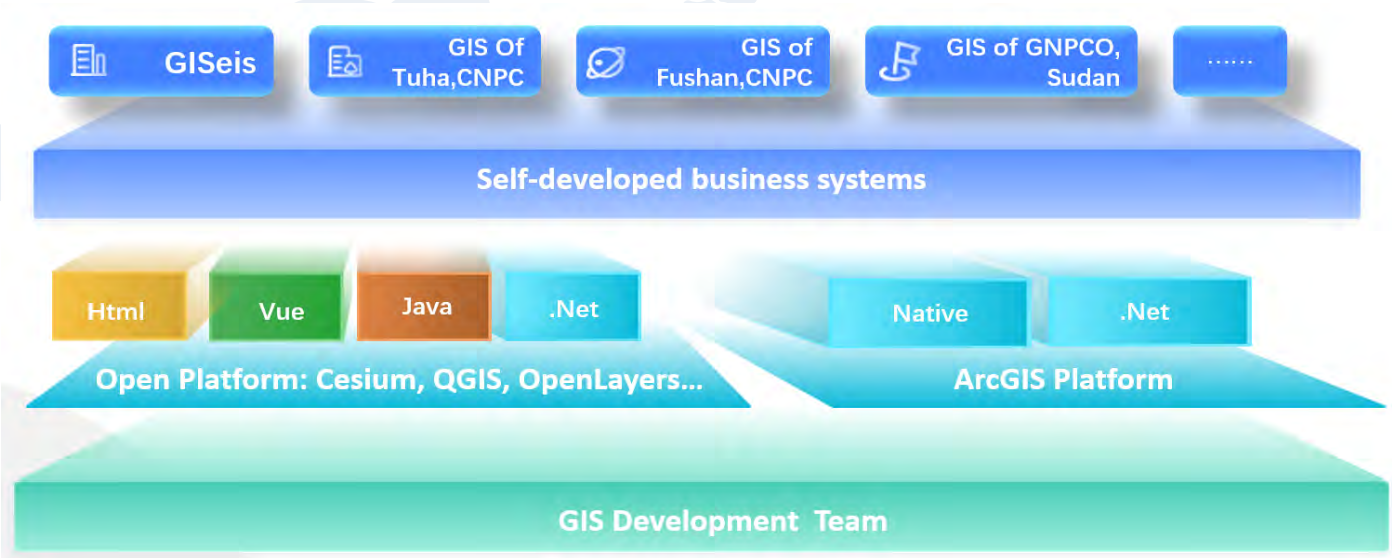
Application and Prospect

Since its successful development, GeoSNAP-Dolphin integrated navigation system has been widely used in many projects at home and abroad., It has been successively applied in seismic exploration projects such as Beibu Gulf of Hainan, ADNOC of the United Arab Emirates, S93 of Saudi Arabia, and 4D of the Cartel, etc., With a total of 148 sets of installations and applications, which has broken the monopoly of the similar products in the international high-end market for as long as 20 years. In the ADNOC project, the highest daily output reached 78,000 guns, setting a new record in the field of OBN seismic surveying. In the Cartel 4D project, it successfully passed the technical audit of Total, an international oil company, and successfully realized the 4D operation function, which improves the core competitiveness of BGP's marine business.

GIS System for Oil Field

System introduction

Continuous innovation of products and services: After years of technical evolution, BGP has developed many self-developed products based on open source platforms such as QGIS, cesium and commercial platforms such as ArcGIS so forming a unique technical advantage.



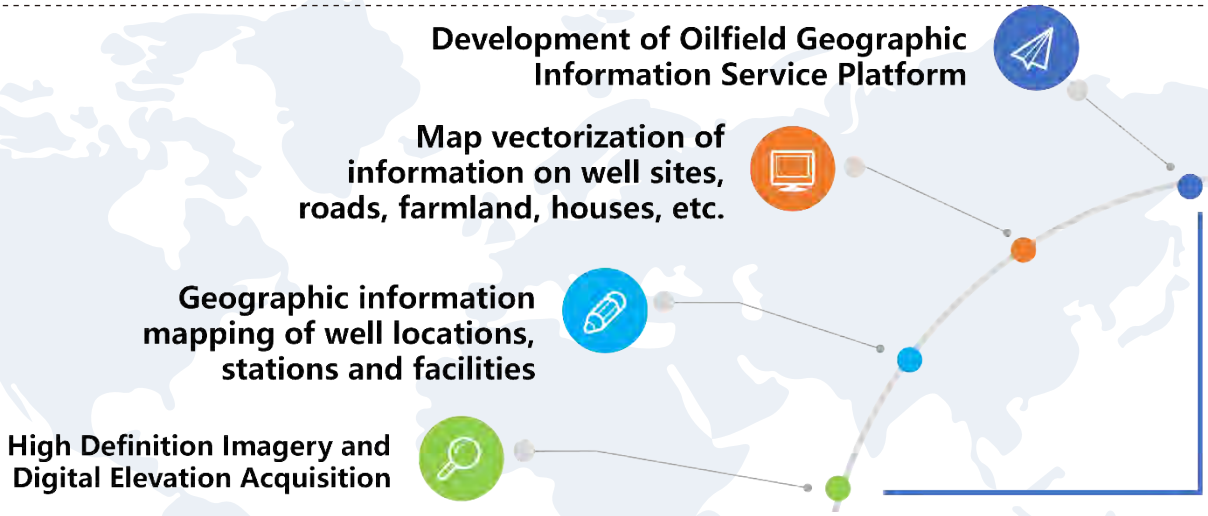
Our Capabilities: To provide agile and efficient digital twin visualization development capabilities for enterprises to accelerate digital transformation. To provide you with a complete set of 3D earth development solutions from 0 to 1, and quickly master and apply 3D visualization.

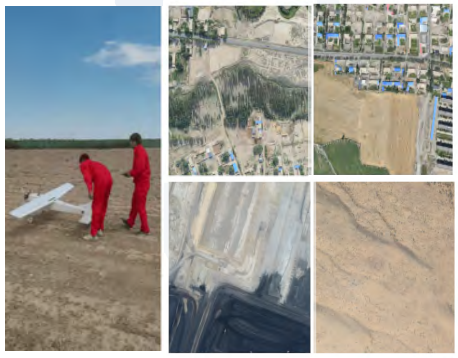
GIS System for Oil Field

Solution

Oil and gas field geographic information platform

The Dolphin System adopts the C/S architecture with the central database as the core and modular client. Wireless LAN is used for data exchange between ships. The key technologies include: centralized management and remote control, multi ship distributed operation, system synchronous acquisition timing, real-time data quality control, and multi-source independent control.





Step1: Low-altitude UAV Aerial photography

Step2: Facility surveying and mapping

Step3: Interior drawing and vectorization

Step4: Map visualization and system development

GIS System for Oil Field

Tools

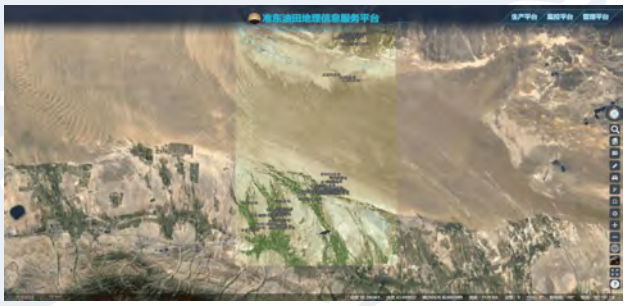
Includes coordinate positioning, spatial measurement, map marking, bookmark management, layer management and basic image services

Measuring tools

Bookmark management

Layer management

Imagery and terrain services



Data

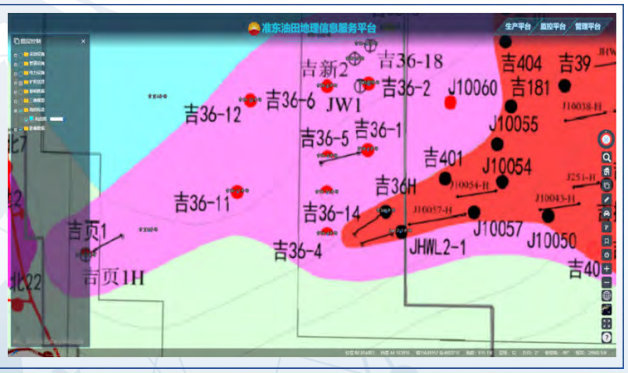
Includes oilfield facilities and equipment such as wells, firefighting, pipelines, electricity, mineral rights, etc., basic data such as water systems, roads, farmland, land familiarity and geological formations.

oilfield facilities and equipment data

Basic data

Land familiarity data

Geological formations



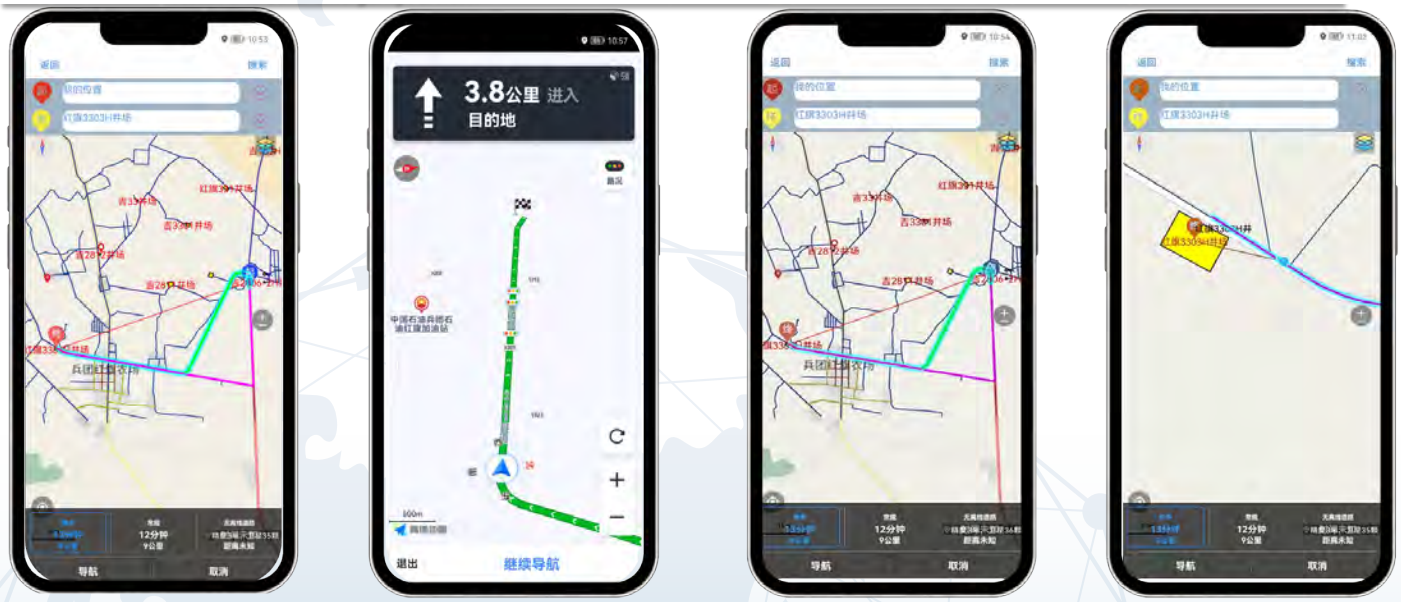
GIS System for Oil Field

Design

Based on planning data, reasonable well locations are laid out through spatial analysis and other means, and data synchronization is achieved through cloud services to realize integrated indoor-outdoor design.

Navigation

Based on the internal own road data to establish the road topology network, combined with public resources, to realize the seamless connection between the public road and the internal road navigation, to provide reliable technical services for the field survey, emergency rescue and other emergency services.



Select a target　Start navigating　Public navigation　Internal navigation

eSeis® Land Nodal Acquisition System

eSeis is a land seismic nodal acquisition system, independently developed by BGP. It consists of eSeis nodal units, harvest & charge integrated rack, 3D QC unit and a seismic data processing system. The eSeis nodal unit adopts true 32-bit Delta/Sigma AD converter, built-in high energy lithium battery, high precision clock training, large capacity continuous and reliable storage, automated manufacturing and detection, high integration, small size and light weight. The system has unlimited acquisition channels scalability, supporting modular field work containers and full-function QC enables it to achieve convenient exploration and field operations. With high-speed download of seismic data and high-efficient data processing, eSeis is a new generation of high-precision, high-stability, high-adaptability seismic exploration data acquisition equipment, and it is suitable for many complex terrain conditions.

Node Specifications

eSeis node

Weight	1.2kg(Internal & Neo) 0.8kg(External)
Size	(120×98×98) mm (Internal) (122×119×89) mm (External) (120×120×93)mm (Neo)
Operating Temperature	-40℃~+70℃
ADC Resolution	32-bits
Consumption	<200mW
Charging Time	<3hrs.
Channel Capacity	Unlimited

Harvest&Charge Integrated Rack

Weight	180kg
Size	1840mm×380mm×1840mm
Operating Temperature	-20℃~+60℃
Channels	48（8 Rows 6 Columns）
Download speed	>20MB/s
Charging Voltage	8.5V (Adjustable)
Charging Current	6A(Adjustable)

eSeis® Land Nodal Acquisition System

QC Unit

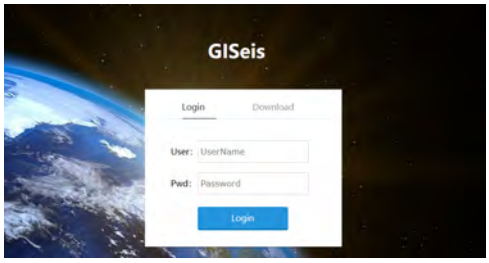
The eSeis node unit has three-dimensional QC methods such as phones, vehicles, and drones, with a maximum QC distance of 300m. The drone QC efficiency exceeds 10000 channels per day, and the data recovery rate exceeds 95%.

Data Management System

Node data download, cut and combine by Harvester Manger & Data Manger software
Massive seismic data processing capacity by high performance server
Supports common shot gathers or receiver gathers in SEGD or SEGY format
Supports cable and node system data fusion
Parameter configuration, firmware upgrade and system test management functions

GISeis

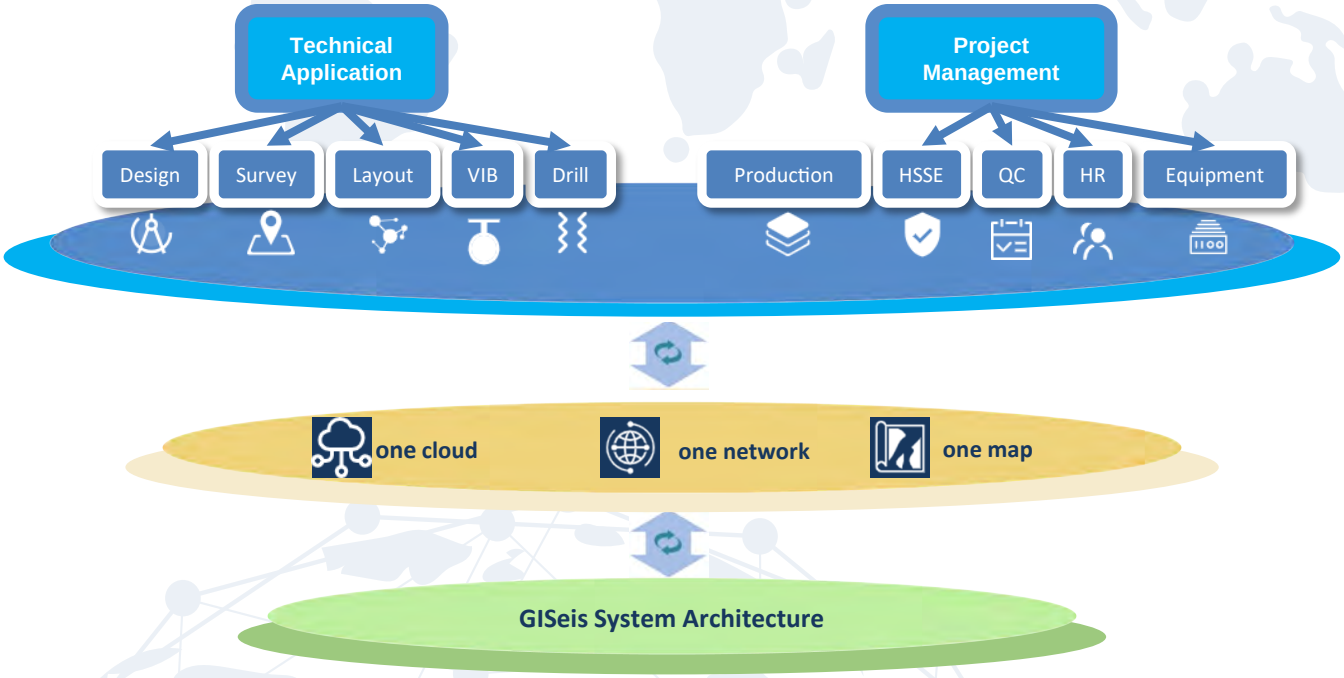
What is GISeis



GISeis is an intelligent and highly integrated system for geophysical exploration management and operation optimizing and conflating a series of operation management for geophysical exploration projects such as quality control, HSSE management, HR management, equipment management, etc, which utilizes IOT (Internet of Things), big data, cloud computing and artificial intelligence to deeply integrate and reconstruct geophysical acquisition design, survey stake-out, spread(layout) management, dynamite shooting, vibroseis excitation and data acquisition of geophysical exploration projects.

System Architecture

GISeis adopts a '1+2' Architectural pattern, including one platform and two systems, covering the whole process management of key processes for the exploration and production of the seismic crew such as survey, drilling, spread, and shooting, realizing the comprehensive information acquisition of exploration operations, intelligent display and statistics of production progress, real-time acquisition and safety alarm of risk information, remote quality control of seismic exploration and production, position monitoring of personnel and equipment in key positions, intelligent task distribution and management, as well as intelligent collection and sharing of geographic information data.

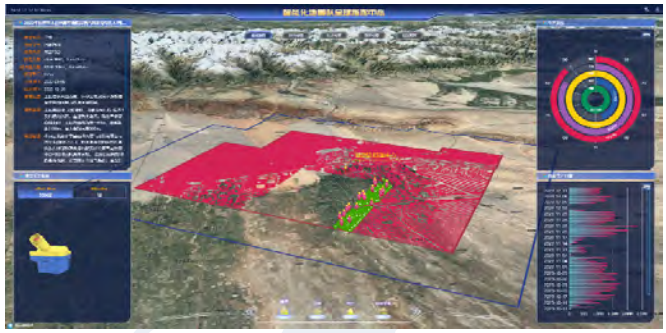


Application

Since its official launch and operation, the intelligent seismic team system has applied more than 200 seismic exploration projects in exploration areas such as Southwest, Changqing, North China, Turpan-hami, and Tarim in China, with over 32000 mobile users and over 3200 web users. The system has increased the overall speed and efficiency of seismic acquisition and production by more than 8%, providing strong support for the company's field seismic exploration and production, HSE, quality improvement and cost reduction.

GISeis Global Command Center

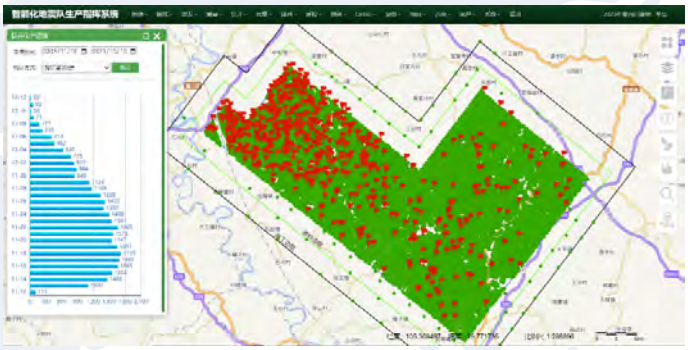
The Global Command Center employs advanced 3D visualization technology to create digital twins of projects, comprehensively interfacing with production progress data from both domestic and international land and sea projects. This approach provides a full-scale, three-dimensional representation of the real-time status of all geophysical exploration projects, while simultaneously integrating status updates of all equipment, vehicles, and vessels belonged to BGP. It enables decision-makers to transcend geographical boundaries, accurately grasp project dynamics, and swiftly formulate informed decisions.



GISeis Global Command Center

GISeis Management Center

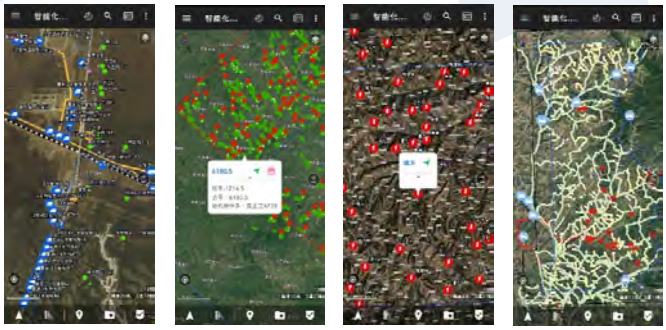
The Global Command Center employs advanced 3D visualization technology to create digital twins of projects, comprehensively interfacing with production progress data from both domestic and international land and sea projects. This approach provides a full-scale, three-dimensional representation of the real-time status of all geophysical exploration projects, while simultaneously integrating status updates of all equipment, vehicles, and vessels belonged to BGP. It enables decision-makers to transcend geographical boundaries, accurately grasp project dynamics, and swiftly formulate informed decisions.



GISeis Management Center

GISeis Mobile App

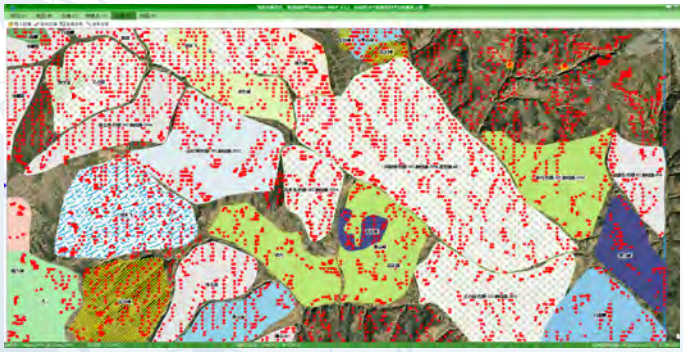
GISeis Mobile App is an app designed for seismic exploration field operators. It integrates modern information technology with field operation requirements, and can achieve functions such as positioning and navigation in the field, risk identification and alarm reminders, surface features acquisition and post back, production progress data collection, production progress query and statistics.



GISeis Mobile App

GISeis Desktop

By applying GIS, RS Technology, and AI, the system enables two-dimensional and three-dimensional visualization of work area terrains, conducts terrain analysis, extracts and analyzes ground features, facilitates indoor design of source points, divides operation sections for fieldwork, plans and designs indoor construction routes, designs production tasks and distributes them, conducts AI-powered quality control analysis of drilling videos, and monitors production dynamics for real-time adjustments and optimizations. These functions collectively assist seismic crew personnel in scientifically and efficiently organizing production activities, significantly enhancing construction efficiency.



GISeis Desktop

oSeis Ocean Bottom Node System

Introduction

oSeis Ocean Bottom Node is an omnidirectional four-component wireless node instrument which can continuously work in water and can sample, record, and store seismic signals independently. The oSeis system mainly composed of four parts: oSeis nodes, oSeis Charge and Time Module, host storage system and node system software. Its main characteristics are flexible deployment, good quality acquired data, high construction efficiency and low operation cost.

Specifications

Type	oSeis300	oSeis1000	oSeis3000
Working Depth	300m	1000m	3000m
Storage Capacity	32 GB	64 GB	128 GB
Charge Time	<5 hours	<7 hours	<10 hours
Continuous Working Hours	35days@2 ms sample interval	50days@2 ms sample interval	120days@2 ms sample interval
Size	348×216×124mm	383×240×140mm	411×380×149mm
Weight	11.4Kg（in air）	20Kg（in air）	29.6Kg（in air）
Seismic Data Channels	4		
Acquisition performance	Resolution	32bits	
	Pre-gain	0，6，12，18，24，32，36dB	
	Sampling Interval	0.25，0.5，1，2ms	
	Dynamic Range	125 dB @ 0 dB	
	Gain Accuracy	0.5%	
Built-in Attitude Sensor	Tilt Inclination ±1.5° Heading±5°		
Hydrophone	Sensitivity 8.9 V/Bar（3.4 Hz @ -3 dB）		
Geophone	15Hz@ -3 dB, 70%damped：Sensitity：56.8V/m/s		

oSeis300

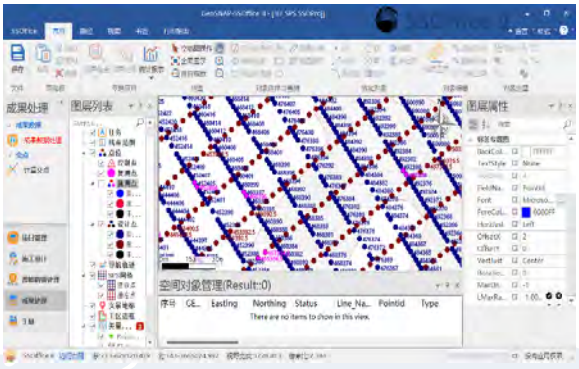
oSeis1000

oSeis3000

SSOfficeII

Software Brief

SSOffice II is a product upgraded from SSOffice, featuring not only the preservation of all functionalities and familiar operational procedures from its predecessor but also the integration GIS-powered data analysis capabilities and data processing and control functions tailored for operation plans. This upgrade aims to meet the current demands for processing and quality control of 2D, 3D seismic and non-seismic exploration survey data, culminating in an application platform that combines navigation and positioning, design and operation management. With a focus on addressing key issues such as geographic information sharing, remote quality control, support for new equipment and methodologies, massive data processing, and the efficient application of geographic information, SSOffice II is designed to adapt to the needs of node-based (including mixed) acquisition, highly efficient vibrator acquisition, and the implementation of information technology in seismic crew field management.

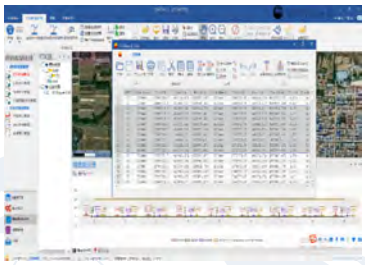


SSOfficeII

Featured Functions

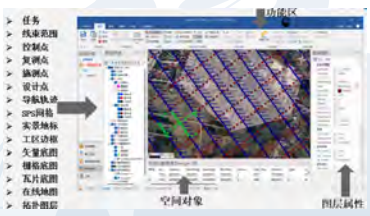
- Integrated with both seismic and non-seismic exploration data processing; Combining GNSS surveying, conventional surveying, vibrator navigation data, and node positioning data processing into one system;
- Combining data management, operation design and organization management into a unified system;
- Integrate geophysical exploration data standards customization, indoor design, data management, survey data processing with outdoor operations, vibrator navigation, and node deployment into a seamless workflow;
- Data editing is carried out using spreadsheets, capable of efficiently handling up to 10 million rows, and is equipped with flexible input and output functionalities.
- Full-map operations are supported, enabling the application of online maps within exploration design coordinate systems;
- The interface adopts a Ribbon-style taskbar and tabbed buttons, designed for ease of use and simplicity;
- Efficiently performs obstacle avoidance by offsetting the source points to ensure safety;
- Professional, systematic, and global, supporting worldwide geoid models;
- Compatible with a unified platform processing for various positioning data types, including RTK, vibrator, nodes, and conventional data.

Integrated processing for project and task distribution

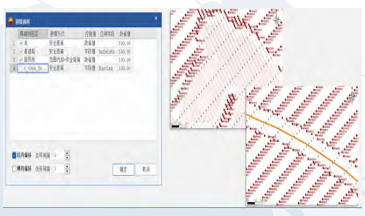


RTK surveying data Processing

Node positioning data processing



Result data processing



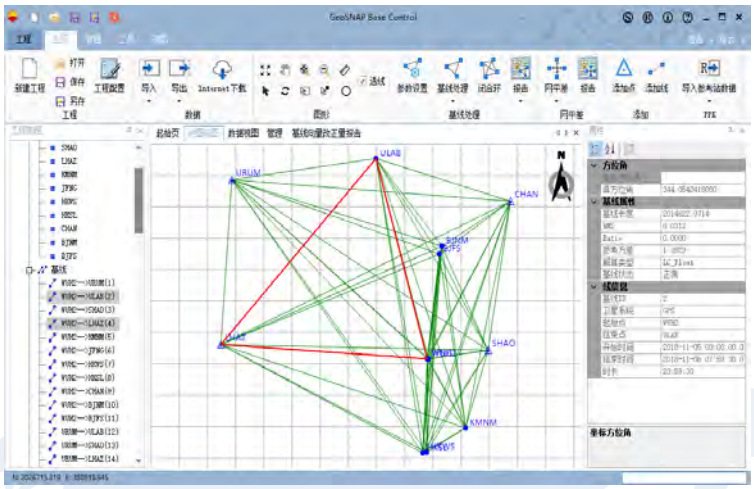
obstacle avoidance offset for source points

track management

High-precision GNSS positioning software GBC

GBC brief introduction

GeoSNAP Base Control (GBC) is a high-precision GNSS control network data processing software, with five main functions which are static baseline processing, dynamic baseline processing (PPK), network adjustment, ITRF framework transforming, and post PPP processing. GBC has completely independent intellectual property rights and is the only software in the world that is fully compatible with Beidou navigation system and petroleum geophysical GNSS data processing. In 2019, GBC software passed the appraisal of CNPC, and the result was leading in China, where it obtained three software copyrights from State Copyright Bureau.



GBC

Technical characteristics

- Embedded VMF3_GPT3, solid tide, FES2014b ocean tide correction models, etc.
- Embedded Global ITRF2020 and China Continental Plate Drift Velocity Field
- Static baseline processing with a maximum distance of 4000 kilometers
- The baseline adjustment adopts two algorithms sequential adjustment and Kalman filtering
- Multi threaded baseline processing to improve baseline processing efficiency
- Transforming between any ITRF framework and epochs
- IGS, Wuhan University GNSS Data Center, iGMAS, VMF3 raw data, product downloads

Technical Parameter

Baseline processing accuracy

- Short baseline: less than 5 millimeters
- Medium to long baseline: less than 2 centimeters
- Relative accuracy of ultra long baseline processing: 10-8

ITRF transforming accuracy

- China: sub centimeter level
- Global: centimeter level

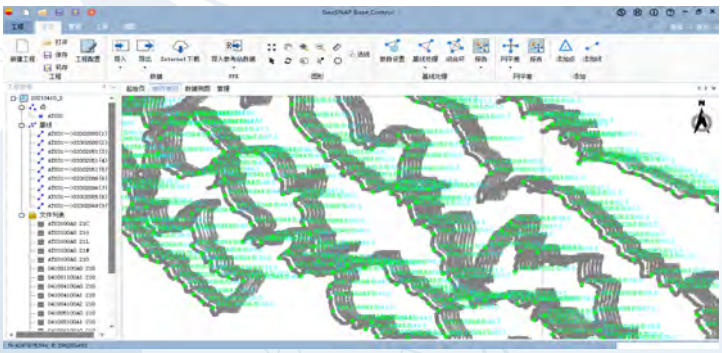
PPP processing accuracy

- Static: horizontal less than 2 centimeters, vertical less than 3 centimeters
- Dynamic: horizontal less than 5 centimeters, vertical less than 8 centimeters

GBC baseline processing parameters and ITRF framework transforming

Application

As of 2024, GBC has installed a total of 144 sets and has been widely used in domestic exploration areas such as Xinjiang, Qinghai, Changqing, North China, Daqing, and Liaohe, as well as ADNOC projects. GBC's unique PPK technology solves problems of survey and vibrator in areas without RTK signal coverage.



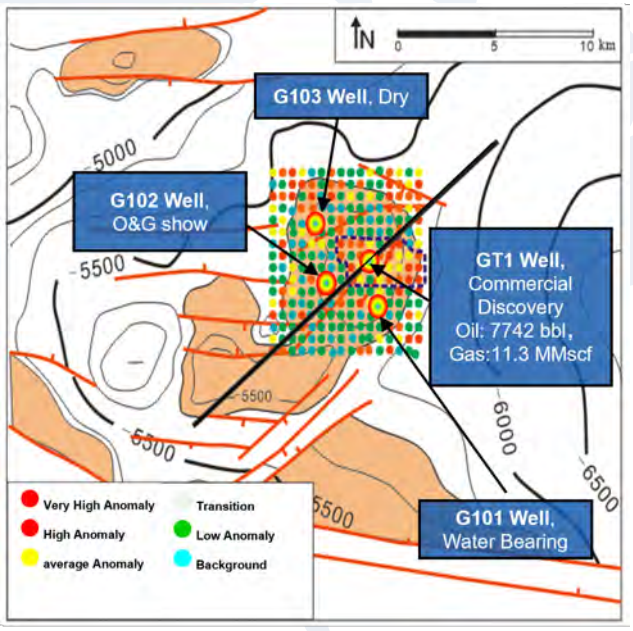
PPK + Vibrator data processing

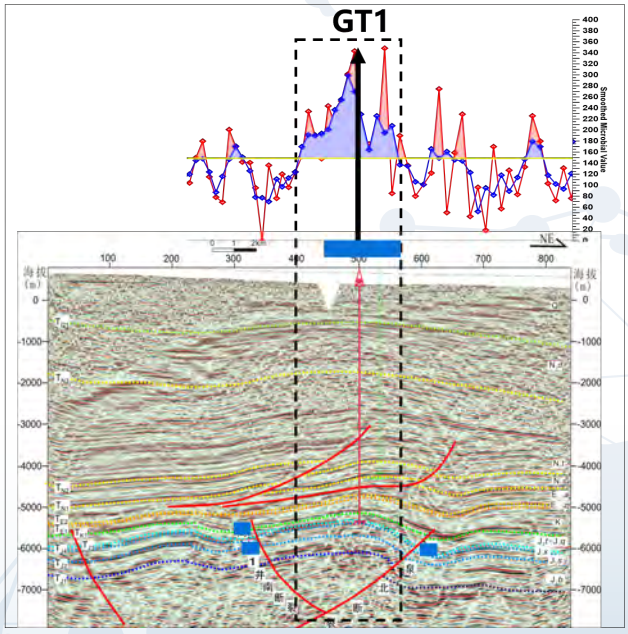
Microbial Geo-Chemical Exploration（MGCE）

MGCE is a surface direct hydrocarbon detection method for de-risking of O&G exploration. MGCE uses combined microbial anomalies and geochemical composition to predict the hydrocarbon potential and reservoir fluid properties of a trap at depths prior to drilling.

In 18 years, a total of 130 MGCE projects has been successfully completed, both onshore and offshore. Post-survey drilling results from 87 exploration wells show an integrated exploration success rate over 85% . Here are three common de-risking scenarios.

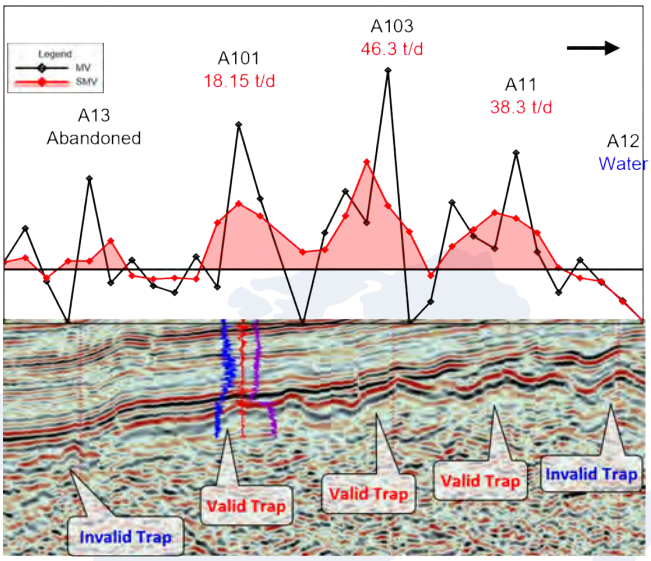
Scenario 1 Delineate Pool Size vs Trap Size





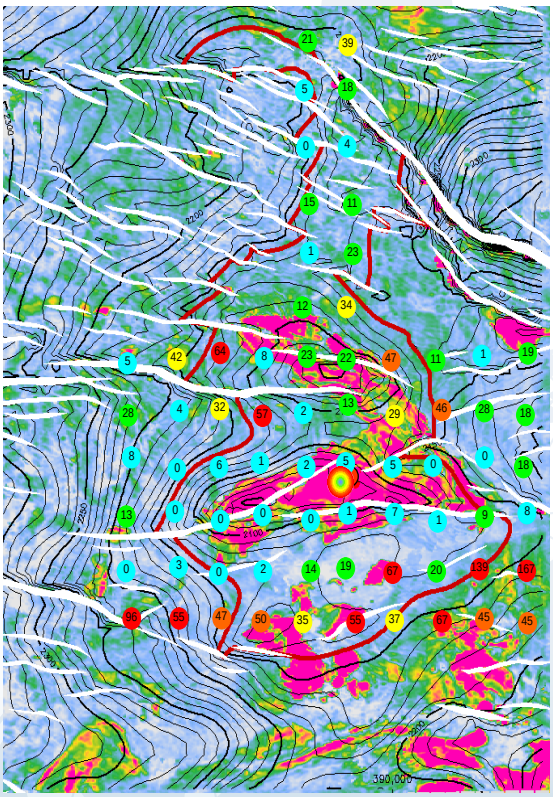
- **Seismic results:** 2D seismic identified a structural trap with size of around 40km2;
- **Geological risks:** unable to predict the trap is fully charged with HC or not and delineate the pool size;
- **MGCE results:** there was distinct microbial anomaly over the structure high with area extent less than 10 km2, indicating the trap was not fully charged with HC;
- **Drilling results:** the exploration well GT-1, which was drilled within the microbial anomaly over the structure high, achieved high production over 7000 bbl/d, while the other 3 appraisal wells drilled outside the anomaly area all failed.
- **Value proposition:** proper integration of seismic and microbial results can delineate the areal extent of HC accumulation, hence increase the drilling success rate of appraisal wells.

Scenario 2 Differentiate Valid Trap vs Invalid Trap



- **Seismic results:** 3D seismic identified 5 similar traps;
- **Geological risks:** unable to differentiate valid traps (charged with HC) and invalid traps (under-charged, breached, water bearing).
- **MGCE results:** surface microbial results predicted 3 valid traps out of these 5 traps and identified potential risk of 2 invalid traps;
- **Drilling results:** 3 commercial discoveries were achieved over traps with distinct microbial anomalies, while the traps with low/no microbial values were proven to be invalid traps (P&A and water bearing).
- **Value proposition:** proper integration of seismic and microbial results can help to high grade leads and prospects and increase drilling success rate.

Scenario 3 Predict HC vs Non-HC



- **Seismic results:** 3D seismic identified a faulted structural trap with an AVO anomaly over a structure high, indicating it is a gas-bearing trap;
- **Geological risks:** unable to predict whether it was charged with CH4 or non-HC gas (CO2);
- **MGCE results:** low microbial values over the structure indicated the risk of potential charge of non-HC gas;
- **Drilling results:** the exploration well was drilled with gas content of 95% CO2 and less than 3% CH4 ;
- **Value proposition:** proper integration of seismic and microbial results can predict the risk of non-HC gas, hence increase exploration success rate.