TECHNICAL BROCHURE

A Global Leading Geophysical Solution Provider

Contact Us

E-mail:

marketing@bgp.com.cn

Web:

www.bgp.com.cn

BUSINESS SCOPE

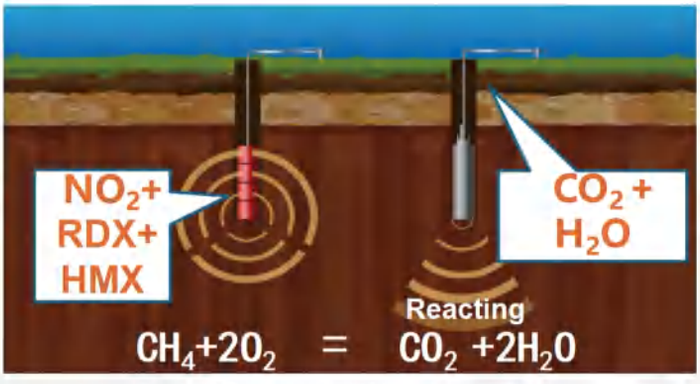
As a leading geophysical provider, BGP delivers fully integrated, end-to-end geophysical services and proprietary technologies for the energy industry. With operations spanning 88 countries and 300+ clients, BGP delivers reliable, high-quality services while striving to be a responsible and sustainable partner in the energy sector.

- Onshore Seismic Acquisition
- Offshore Seismic Acquisition
- Seismic Data Processing
- Seismic Data Interpretation & Reservoir Geophysics
- Geophysical R & D
- BGP Borehole Division Technology
- Non-seismic Surveys
- Geophysical Software Systems
- Equipment Manufacturing
- Multi-client Business
- New Energy Business

GAS IMPULSE SOURCE (GI SOURCE)

Basic principle

The gas impulse source utilizes a combustible gas–oxygen mixture as its energy carrier. The mixture is injected into a downhole chamber under controlled pressure and ignited electronically, producing a rapid combustion process that releases a substantial amount of energy within milliseconds.



Dynamite vs Gi-Source

Basic structure

Working process

Drilling

Loading

Hole sealing

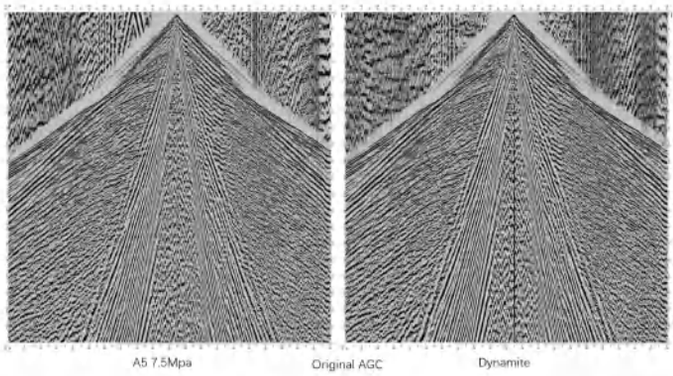
Injection

Shooting

Clearance

Application

Final migrated sections derived from both datasets show a high degree of consistency in major stratigraphic horizons and structural interpretations. In certain intervals, the gas impulse source data provide slightly clearer imaging of minor faults and intra-layer undulations, consistent with the observed spectral advantages.



Comparison between the gas impulse source (7.5 MPa) and the dynamite source (2 kg) under identical acquisition conditions (borehole depth: 12 m)

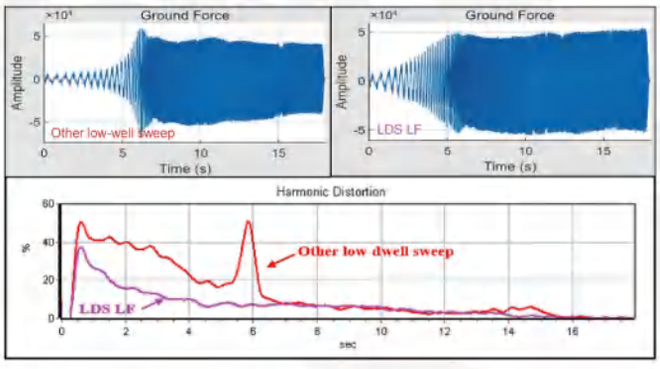
LOW DISTORTION SWEEP (LDS)

The LDS technique is a technology specifically developed by BGP for broadband seismic exploration using conventional vibrators. It mainly consists of two sub-techniques:

- Low frequency sweep with low distortion technique (LDS LF)
- Low harmonic distortion sweep technique (LDS LH)

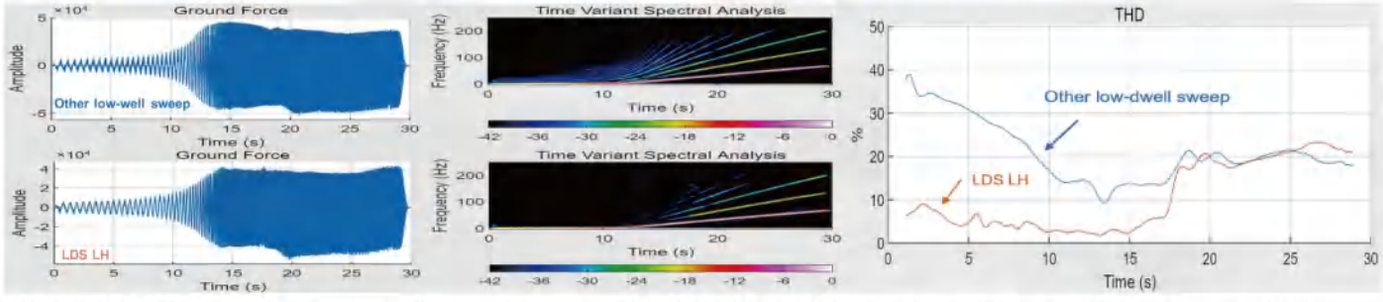
This technique primarily solves two problems existing in low-frequency sweeps, thereby enabling the acquisition of better quality broadband seismic data.

Suppression of abrupt harmonic distortion surges within the signal transition band



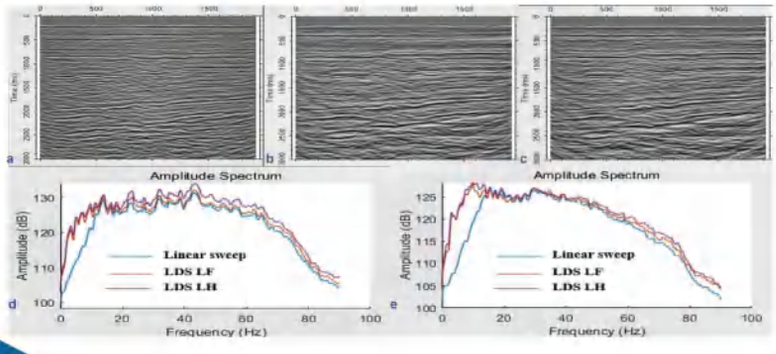
Sweep signals designed with LDS LF technique can reduce the average low-frequency distortion by more than 20%, with a reduction of over 40% specifically within the signal transition band.

Suppression of severe low-frequency harmonics



The LDS LH technique achieves over 42 dB of low-frequency harmonic attenuation.

Enhanced acquisition of broadband seismic data

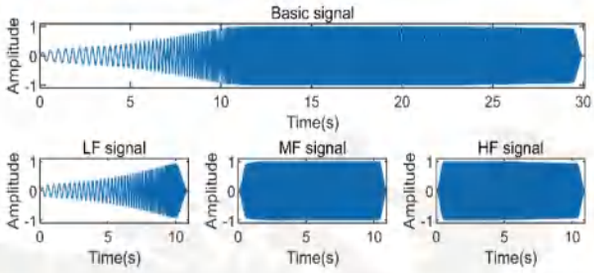


Linear sweep PSTM section (a), LDS LF PSTM section (b), LDS LH PSTM section (c), amplitude spectrum within time window 100-1300ms (d), amplitude spectrum within time window 1300-3000ms (e).

MULTI-FREQUENCY SIMULTANEOUS SWEEPING (MFSS)

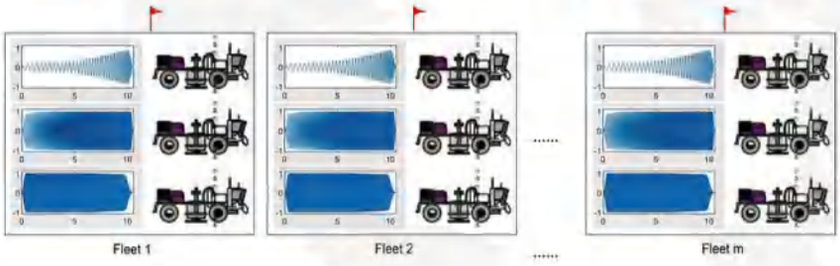
MFSS optimizes the efficiency-quality trade-off of conventional high-productivity vibroseis by replacing traditional sequential single-frequency sweeps with a simultaneous multi-frequency approach.

Signal decomposition



MFSS segments a long-duration sweep into multiple shorter signals. Specifically, the basic sweep signal (a) is divided into N segments (e.g., 3), as illustrated in (b).

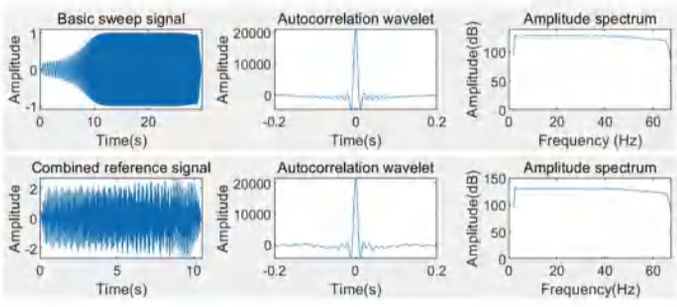
Simultaneous, multi-frequency sweeping



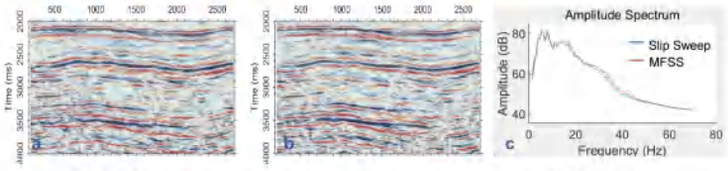
N distinct signal segments are distributed to N vibrators within a fleet. All vibrators in a fleet then sweep simultaneously at the same shot point.

Preprocessing of MFSS data

The N independent multi-frequency sweep signals are stacked to serve as the reference signal for correlation, as shown in the right figure. Subsequently, cross-correlation is applied to the acquired shot data to obtain the normal shot gather.



Applications of MFSS



PSTM profiles of (a) slip sweep and (b) MFSS, and (c) amplitude spectra

The N independent multi-frequency sweep signals are stacked to serve as the reference signal for correlation, as shown in the right figure. Subsequently, cross-correlation is applied to the acquired shot data to obtain the normal shot gather.

WEIGHT IMPULSE SOURCE (WI SOURCE)

WI is a spark-free, remotely controlled crawler-mounted weight-drop seismic source equipped with a high-precision Time Break acquisition system. A centralized on/off alternating technique was developed to support up to 20 groups of WI sources for high-efficiency seismic data acquisition. Over 430,000 seismic shots have been acquired in field operations. The technique is validated by high-resolution seismic profiles, delivering a highly efficient solution for shallow seismic exploration in complex areas.

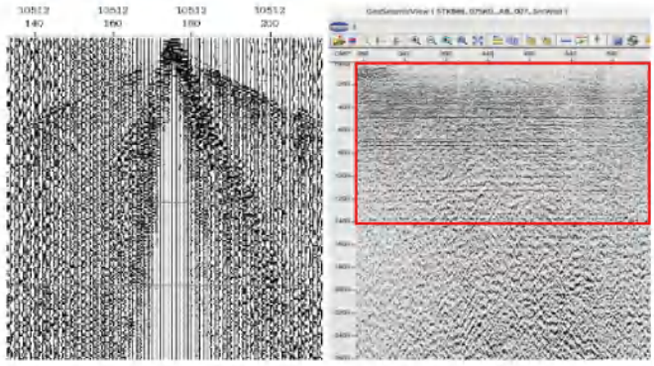
Spark-free remote-controlled Wi source and high-precision TB unit

System features

- Microsecond-level TB accuracy
- Non-electric spark
- Capable of climbing 45°slopes
- Supports synchronous 20 group sources for high-efficiency acquisition
- 75kg of weight drop & 500kg of total weight

High quality images of shallow target layers

- TB controller suitable for various weight drop seismic source.
- Shooting energy penetrate the shallow target layer up to TWT 0.6 to 1.2s.
- With the appropriate fold coverage, can get clear image of shallow target layer.



BGP INNOVATOR – HYBRID SEISMIC VESSEL

The BGP Innovator is the world's first dedicated hybrid node handling and multi-source vessel focused on shallow water OBN seismic operations, which has been designed to deliver superior acquisition solutions in shallow water areas through ocean bottom node seismic operations.

BGP INNOVATOR Key Specifications	
Flag	PANAMA
Class	BV and CCS
Year of Built	2022
Length	88.235 m
Breath	16.90 m
Minimum Working Draft	2.50 m
Maximum Working Draft	2.85 m
Air Draft	13.90 m
Dynamic Positioning System	MT
Propulsion Type	Full Diesel Electric Driven System
Main Generators	4 x Wartsila Generators Set
Main Propulsion	2 x ZF Azimuth Thrusters
Bow Thruster	3 x ZF Tunnel Thrusters
Fuel Capacity	470 m^3 (100%), 423 m^3 (90%)
Fresh Water Capacity	300 m^3
Economy Speed	9.0 Knots
Sailing Endurance	40 Days
Living Capacity	60 Persons Including Marine Crew

Seismic Equipment	
Node Capability	Up to 4000 Nodes
Source Capability	6 x Gun Arrays
	Single / Dual / Triple Gun Sources
Seismic Compressor	3 x 48 m^3/min
Working Pressure	2000 Psi
Source Controller	GunLink 4000

Main features

A) High-level vessel performance

- Dynamic positioning design
- Ultra shallow draft design
- Minimum draft 2.5 meters

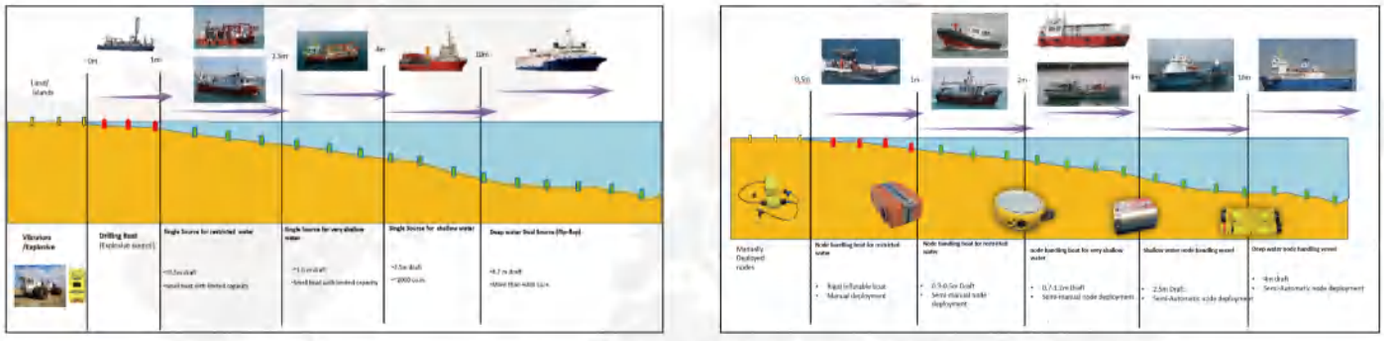
B) Multi-function seismic equipment

- Node handling function
  Modularized deployment and retrieval system for NOAR operation with a back deck storage capacity of up to 4,000 nodes and 240 nodes can be charged and downloaded simultaneously.
- Source operation function
  Featuring full-volume air gun sources to support triple-source operations, the vessel integrates the Gunlink 4000 digital gun controller for real-time source QC.
- Integrated navigation function
  On-board integrated navigation system, DolphinTM delivers multi-vessel navigation and high-precision source & receiver positioning capabilities.
- Onboard OBN data QC system
  BlueWhale™ on-board OBN seismic data QC and management system delivers a daily seismic data handling capacity of up to 10 TB via 10 computing nodes and 8 storage nodes.

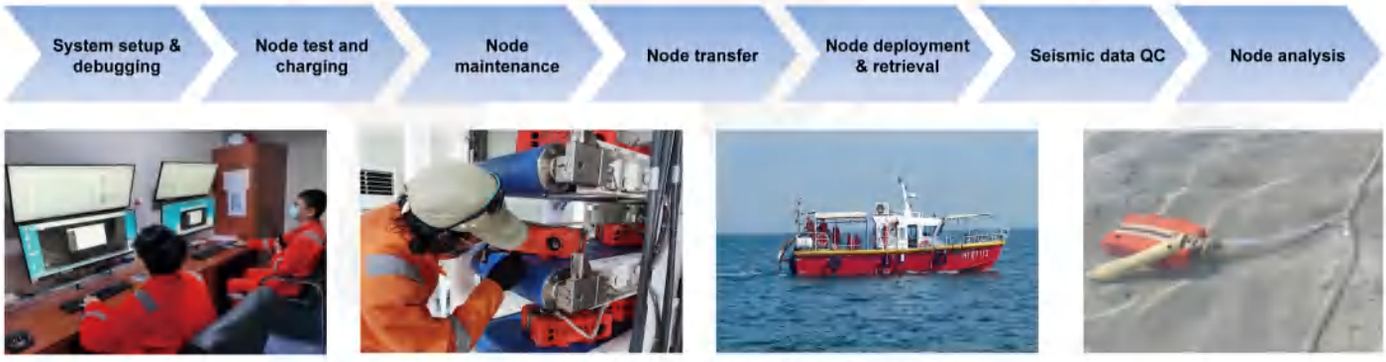
TRANSITION ZONE (TZ) SEISMIC SOLUTIONS

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

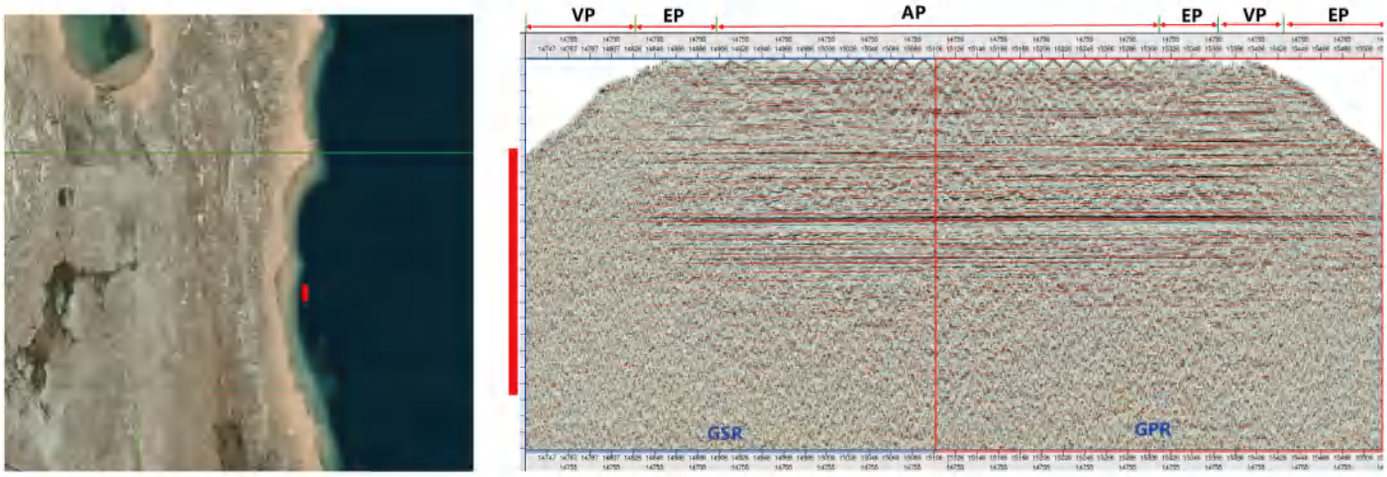
BGP has undertaken more than 20 transition zone projects, including extra-large projects in Kuwait, Saudi Arabia and the United Arab Emirates, etc., and provided high-quality seamless seismic data in TZ areas involving urban area, Gobi desert, rain forest, beach, extremely shallow water, shallow water,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



Full-terrain integrated source (left) and receiver (right) facilities for seamless acquisition



Node operation for TZ seismic acquisition



Integrated data after consistency processing

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 amount of multi-client seismic data in onshore and offshore basins in South America, Europe, Africa, Middle East and Asia Pacific. A 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

- Accessing high quality geophysical data at a lower cost
- Allowing exploration companies to prospect on trend or regional basis–promoting higher exploration and development success rates
- Ability to improve the knowledge base quickly, using readily available data
- Lowering the economic barriers to exploring and producing oil and gas, therefore allowing smaller E&P companies access and entry to riskier and often more expensive plays
- Improving the efficiency of E&P investments, resulting in better investments
- Reducing risks associated with survey permissions, acquisition and data processing

Suriname 3D multi-client project seismic section

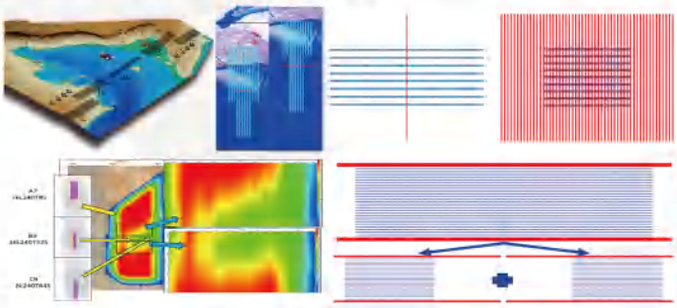
OBN SEISMIC EXPLORATION SOLUTIONS

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 SNR.

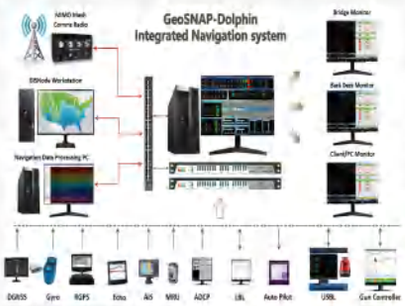
BGP OBN key techniques

1. OBN geometry design

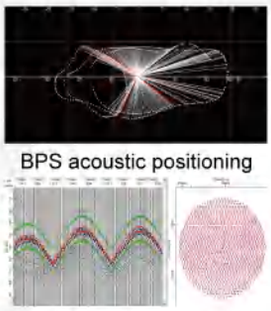


Geometry design for various terrains

2. Integrated navigation & positioning



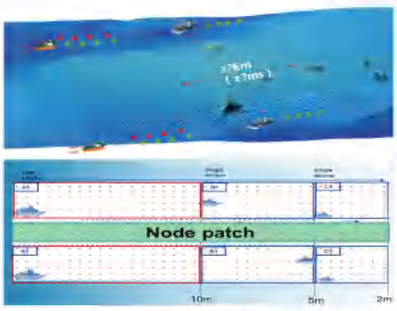
Dolphin integrated navigation system



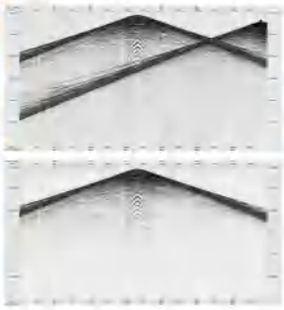
BPS acoustic positioning

BGP FBP solution

3. Marine seismic high-efficiency acquisition



Multiple sources blended shooting

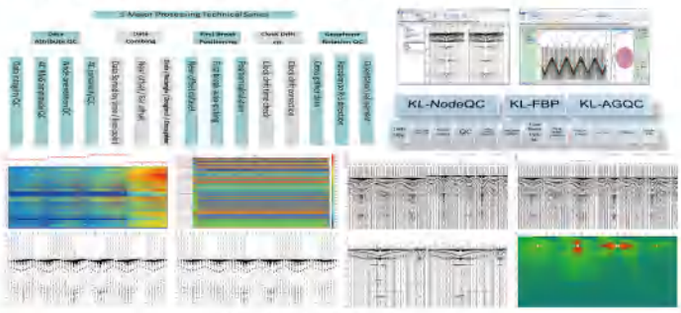


Data de-blending

4. OBN automatic deployment & retrieval system

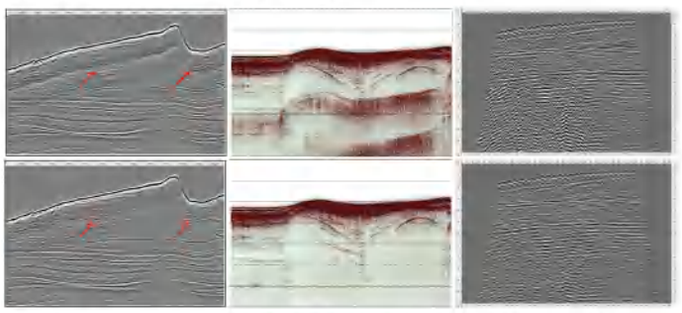
Module, sonveyor and deployment & retrieval system

5. OBN data quality control system



KL-NodeQC software

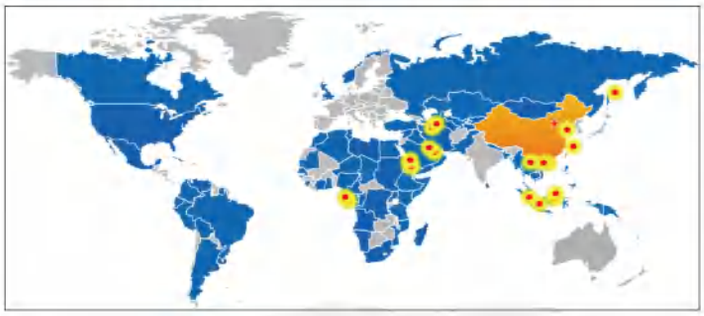
6. OBN data processing



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 due 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 SOLUTIONS

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 employed by 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.

Towed streamer acquisition with 12 x 8km cables and wide-towing triple source

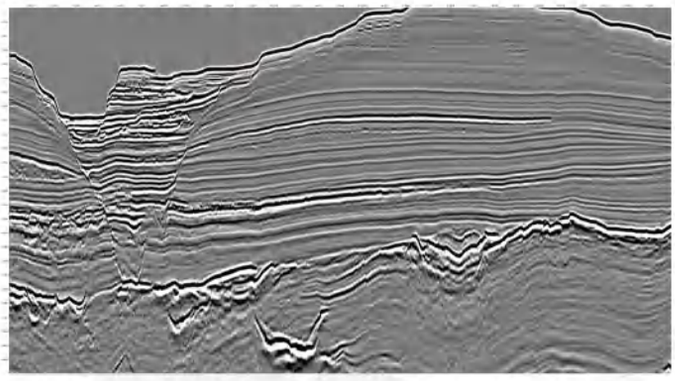
Source parameters

Port of Registry:	Nassau
Flag:	Bahamas
Class:	DNV
Year of Built:	2011
IMO Number:	9545986
Length:	100 m
Breadth:	24 m
Draft (min / max):	6.4 m / 7.3 m
Gross Tonnage:	10732
Economy Speed:	15 knots
Fuel Capacity:	3400 m^3
Main Thruster:	2 x RRM Bergen B32:40L8P CD, 2 x 4000 kw
Bow Thruster:	TT 200 Rolls Royce 883 kw
Auxiliary Engine	2 x RRM Bergen C25:33L8A CD
Generators	Main generator 2 x 2880 Kw Shaft generator 2*2765 Kw
Accommodation:	66 persons
Workboat:	2 x Norpower 30 ft
FRC:	1* Norsafe Magnum 750

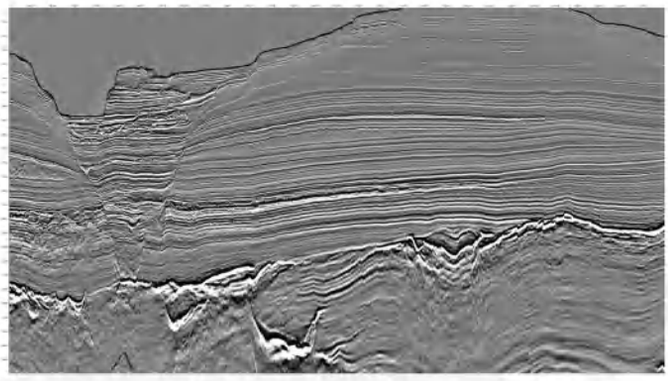
TOWED STREAMER SEISMIC SOLUTIONS

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.



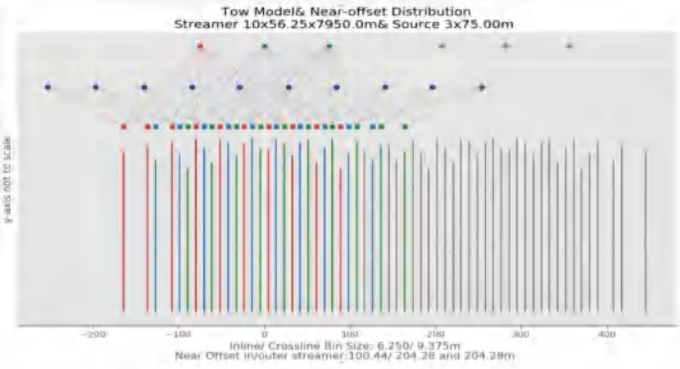
Before broadband processing



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

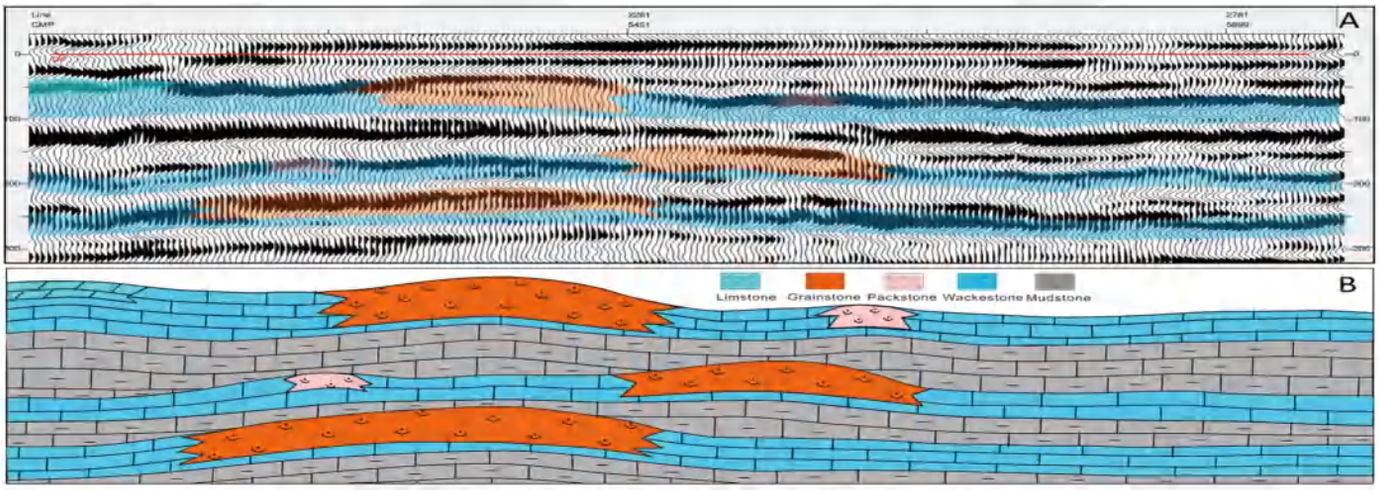
THE INTEGRATION OF SEISMIC, GEOLOGY AND ENGINEERING

Pilot horizontal well design

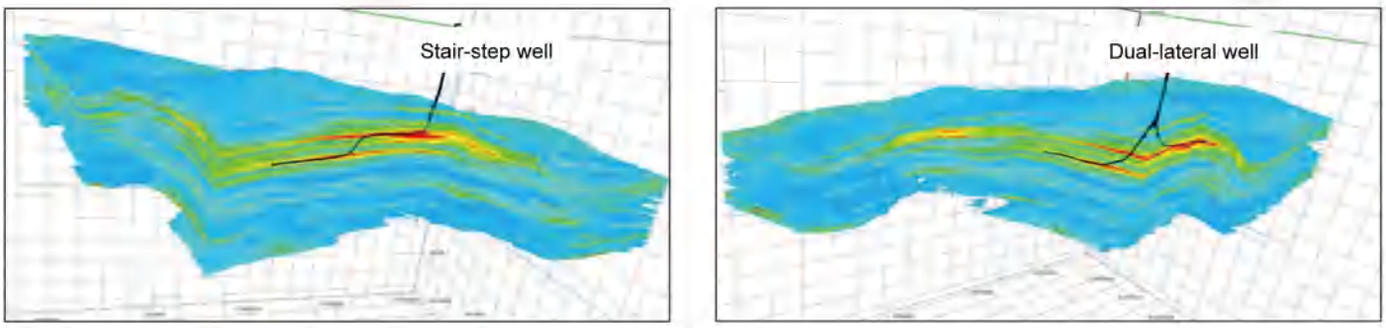
Sweet spot characterization is based on facies and analysis, seismic attribute analysis, seismic inversion and geological modeling, which can be used for different well types and well trajectories design. It can be integrated with reservoir simulation to optimize the design parameters for horizontal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

Advantages :

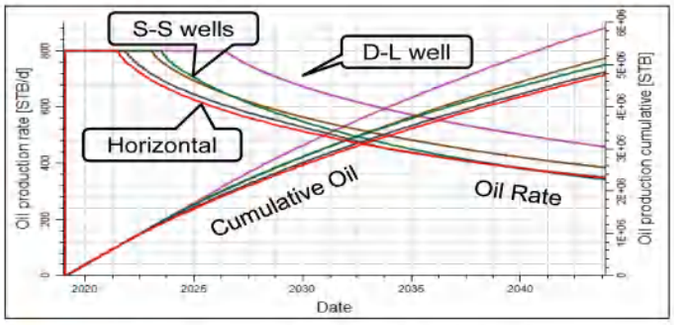
- Characterize sweet spot of tight reservoir and apply favorable area for well in placement.
- Improved reservoir penetration with a higher production rate.



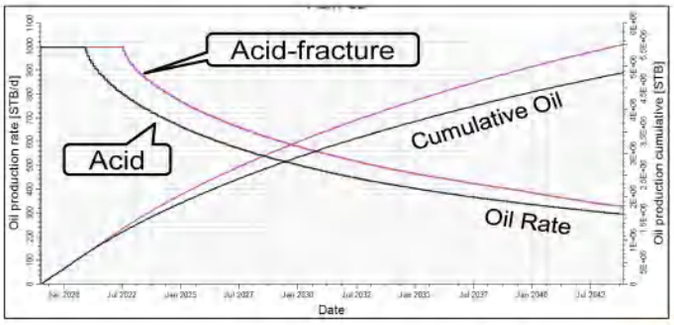
Seismic section and sedimentary facies analysis for sweet spots



Horizontal well trajectory design



Well type optimization (simulation)



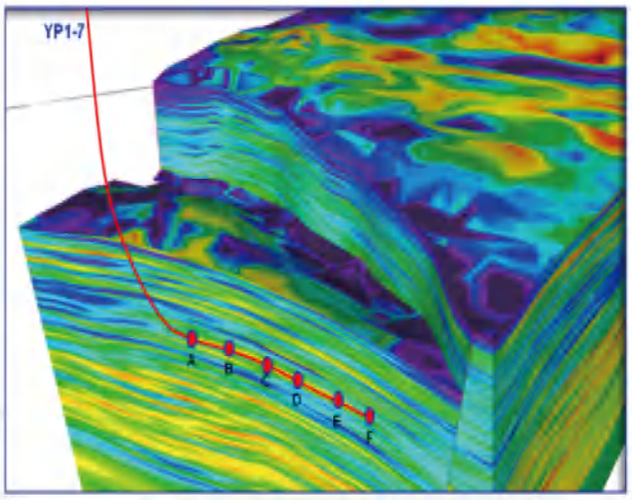
Production optimization (simulation)

SEISMIC AND GEOLOGY GUIDED DRILLING

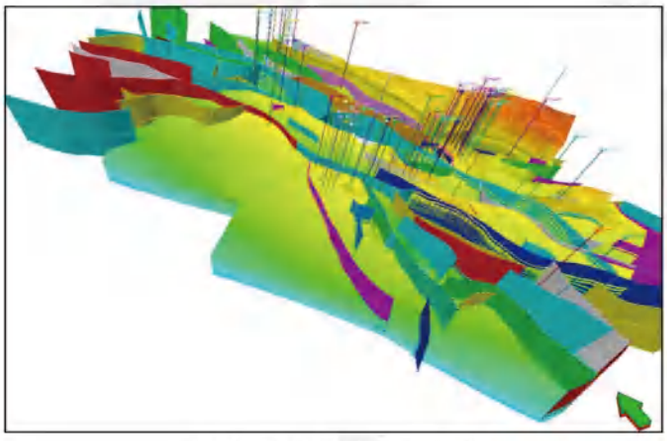
BGP's unique seismic and geology guided drilling (SGGD) tool maps target intervals and adjusts well trajectory to guide drill bit steering in real time based on LWD information and seismic inversion.

Advantages :

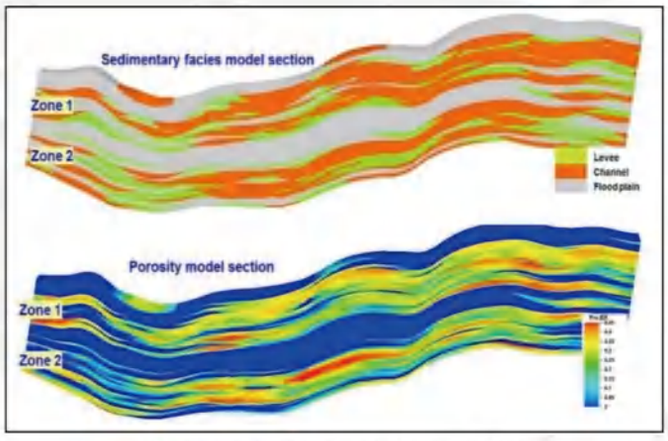
- Optimal horizontal well design
- Enhanced target-entering accuracy and precision
- Improved rate of well placement and reservoir penetration



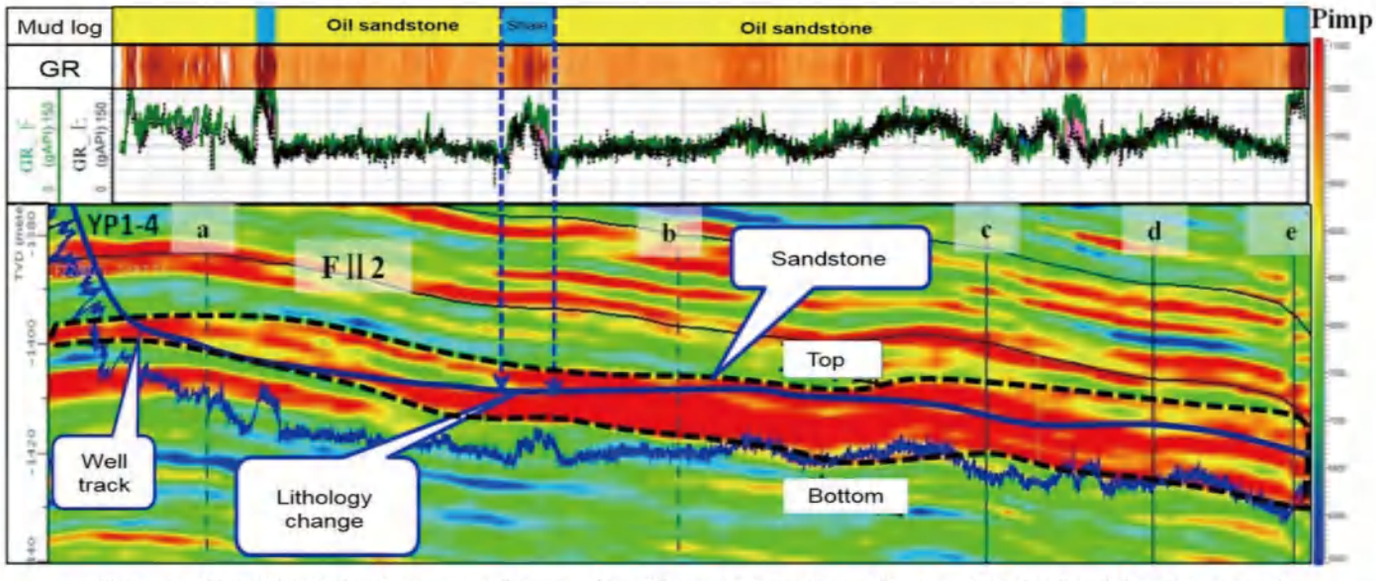
Horizontal well trajectory design



Fault and structure model



Reservoir petrophysical modeling

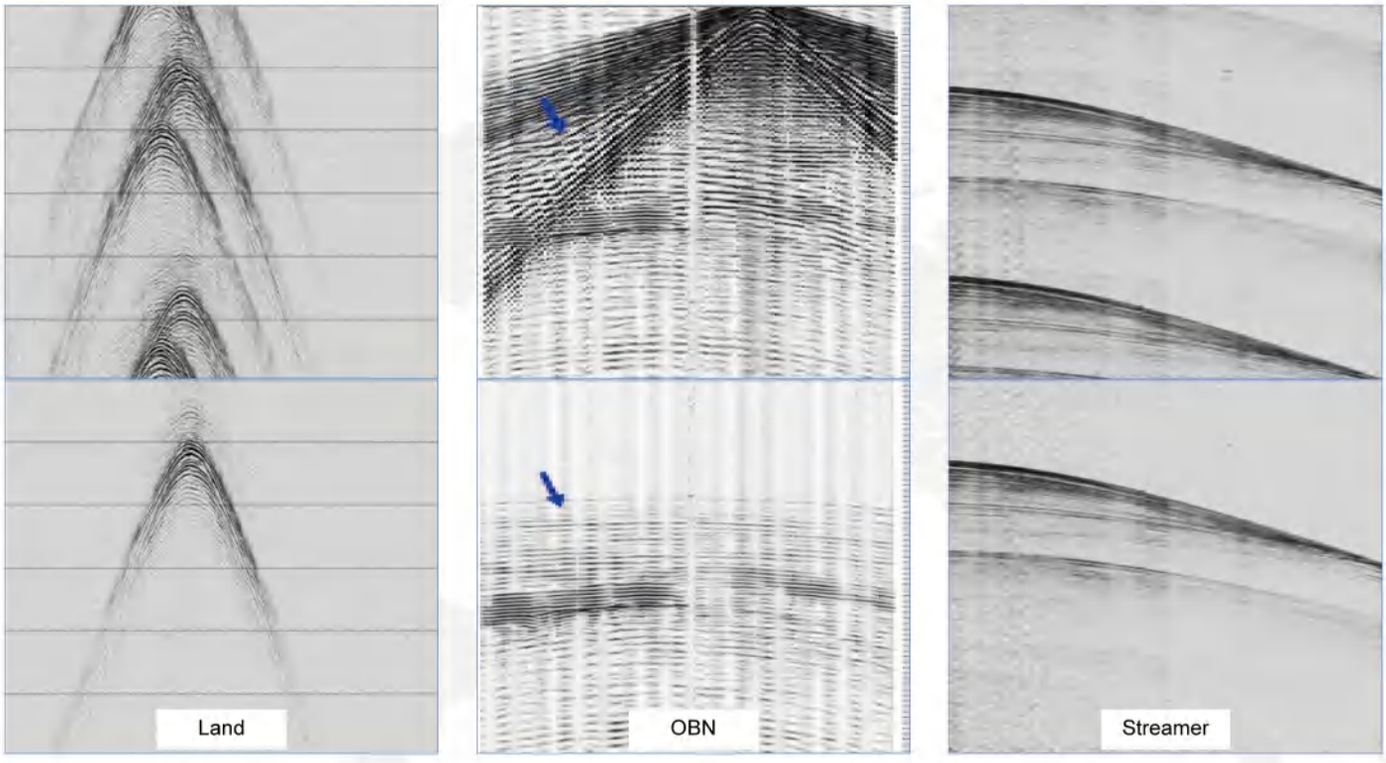


Case: sudden lithologic change warning, confirmation and trajectory adjustment for horizontal well segment

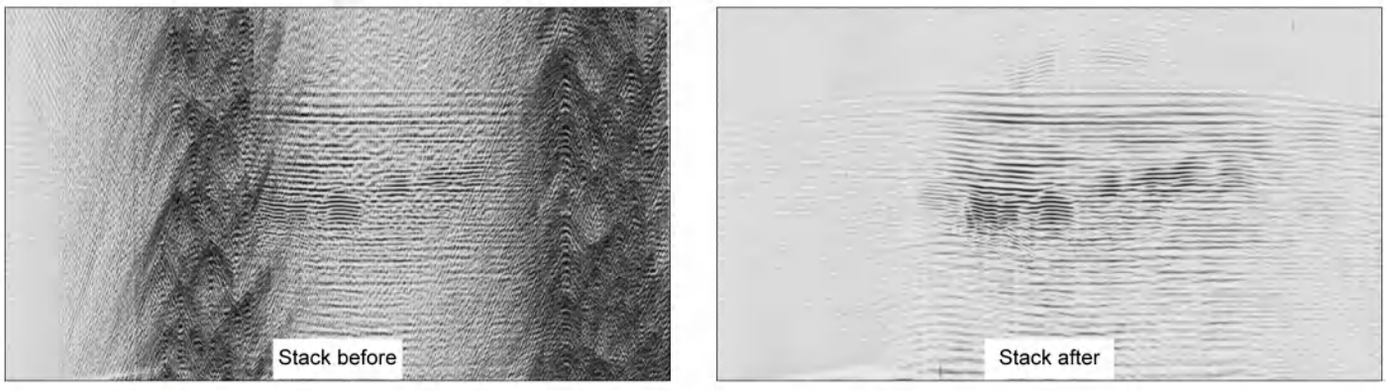
DEBLENDING

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.



Common shot gathers before deblending (top) and after deblending (bottom)



Stack section before deblending (left) and after deblending (right)

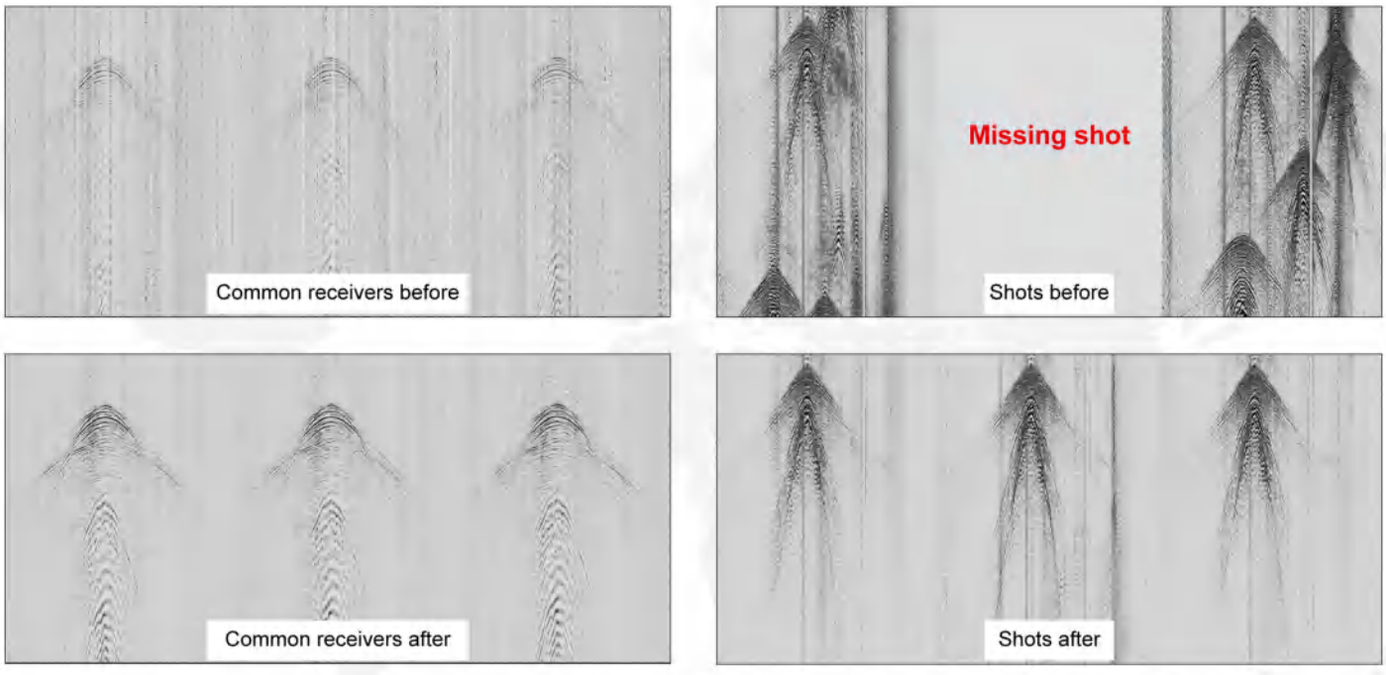
Features

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

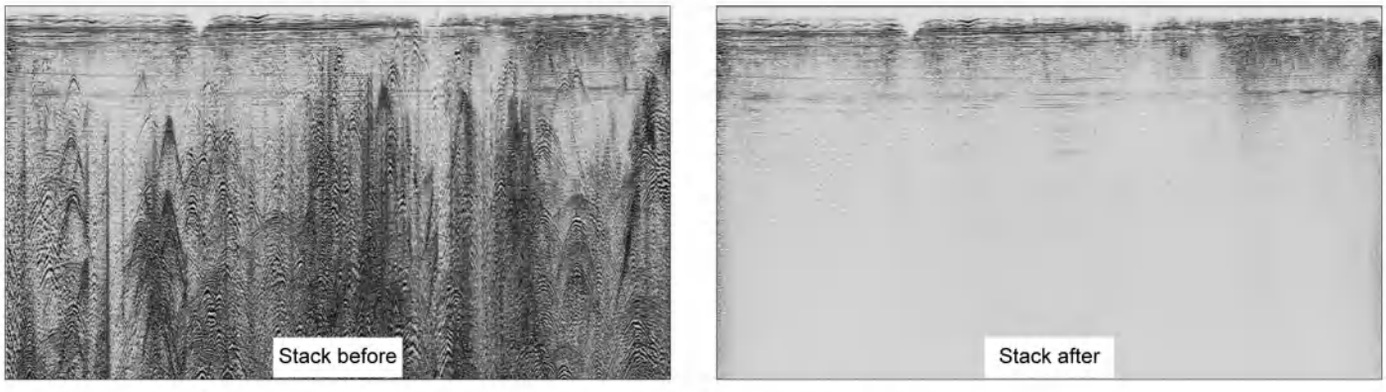
DEBLENDING

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.



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



Stack section QCs before and after deblending

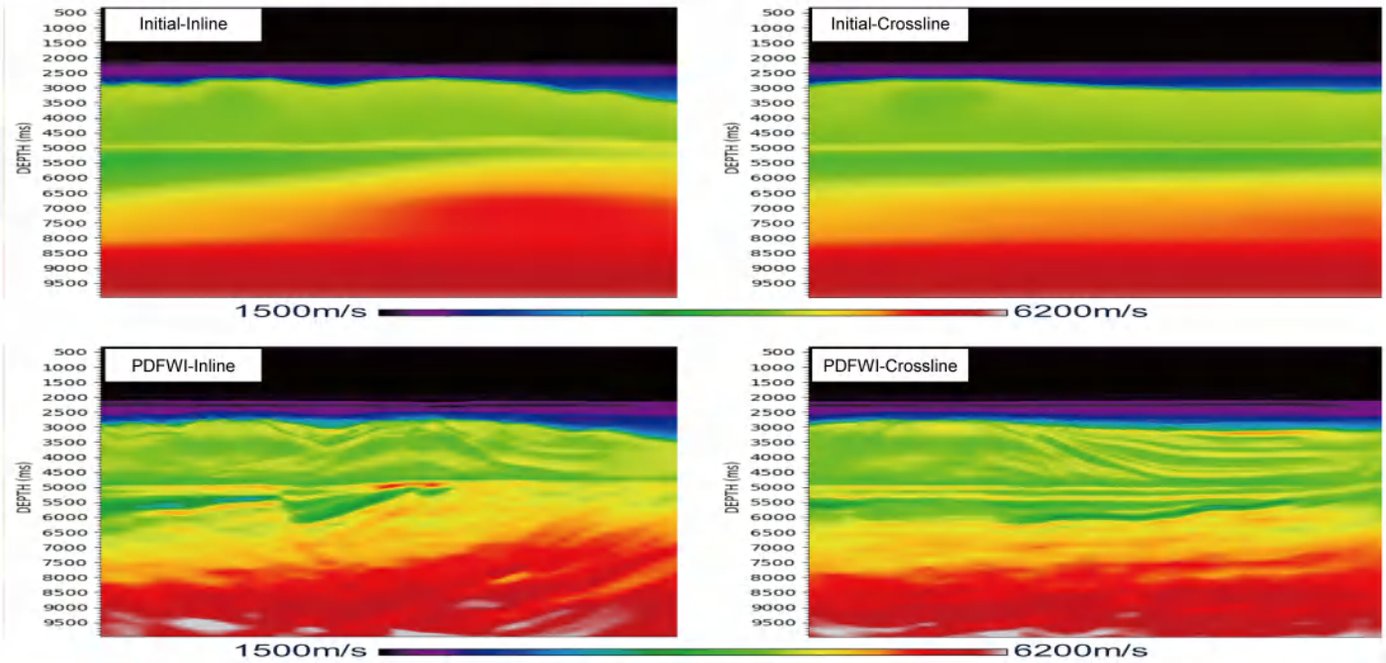
BGP's cutting-edge joint deblending and compressive sensing data reconstruction provides an efficient and high-quality processing technique which strongly supports CS based simultaneous shooting acquisition.

INTEGRATED FWI + FWII SOLUTIONS

BGP offers a comprehensive suite of inversion techniques, including Phase Driven Full Waveform Inversion (PDFWI), multi-parameter Full Waveform Impedance Inversion (FWII), and 4D FWI.

Acoustic PDFWI

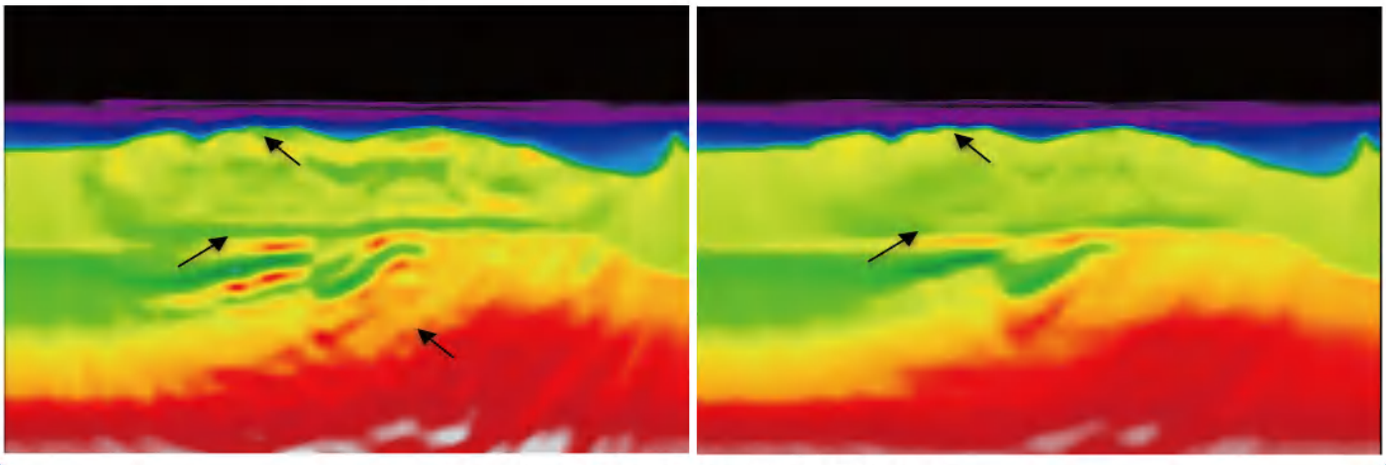
BGP's state-of-the-art PDFWI delivers efficient and high-precision velocity models. After FWI update the resolution has been enhanced and a significant amount of geological information can be observed in the inverted model.



20Hz PDFWI velocity model update

Elastic FWI

Comparison of acoustic and elastic, at low frequencies, EFWI reduces salt-halo effects, sharpens structure within and beneath salt, and substantially suppresses inversion artifacts compared with AFWI.

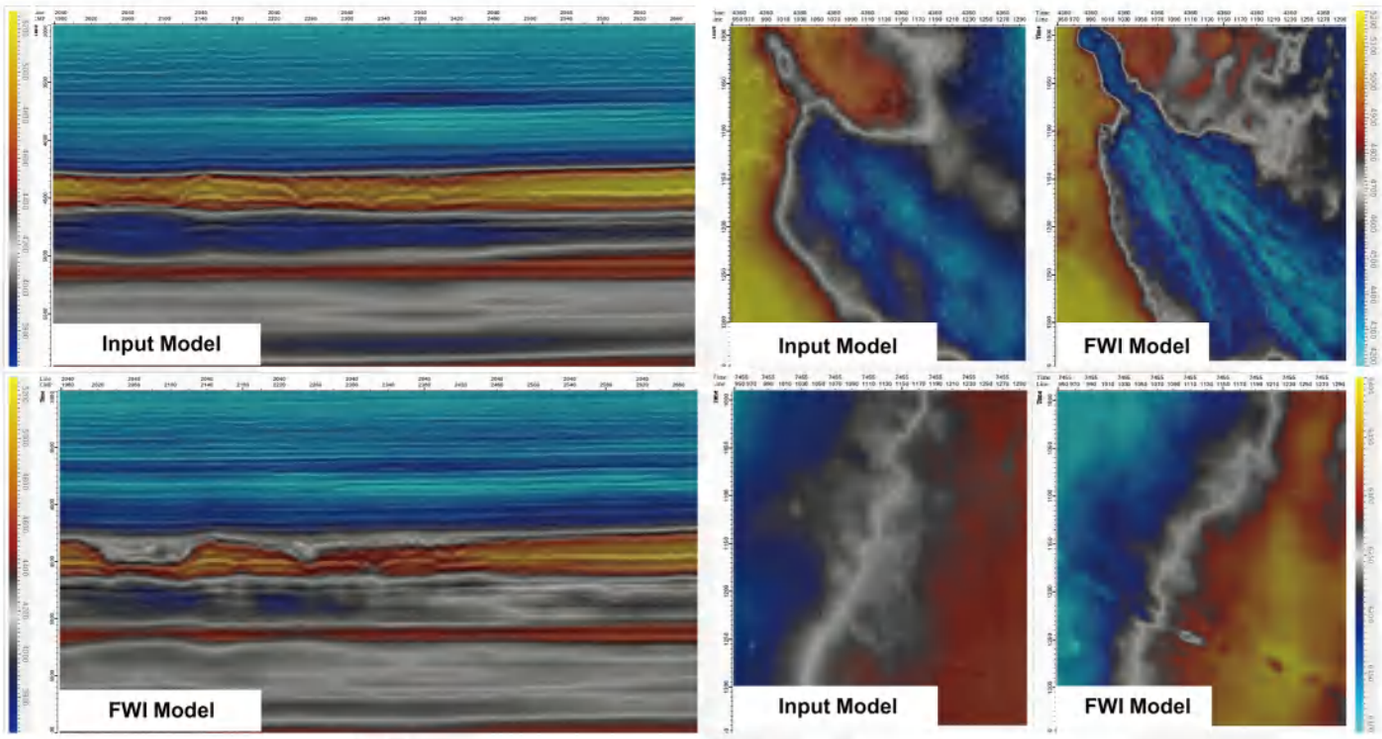


Comparison of acoustic and elastic FWI result

INTEGRATED FWI + FWII SOLUTIONS

Land FWI

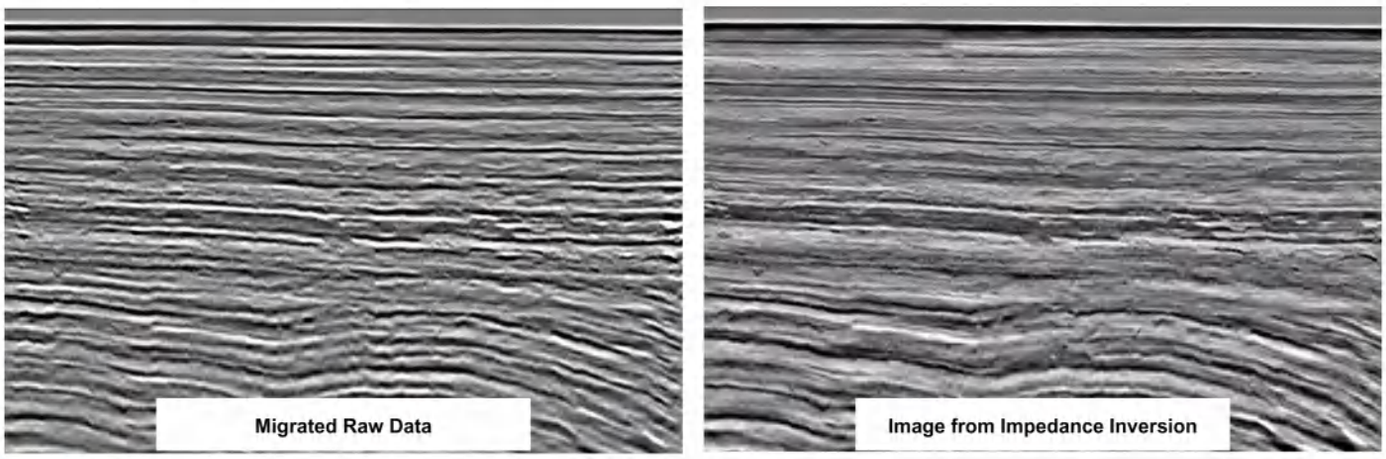
BGP's FWI framework supports ultra-deep imaging in complex geological environments. It adopts anti-cycle skipping algorithms and least-squares optimization to reduce traveltime misfit in data and image domains.



Overlay of velocity, migration profiles and slices before and after Land FWI

Full waveform impedance inversion

FWII inverts the full wavefield to produce the most accurate images bypassing the conventional pre-processing workflow. FWII refines impedance properties, outputting an Inverted Impedance model. From that, we derive the final Reflectivity, which can be used for high-resolution imaging.



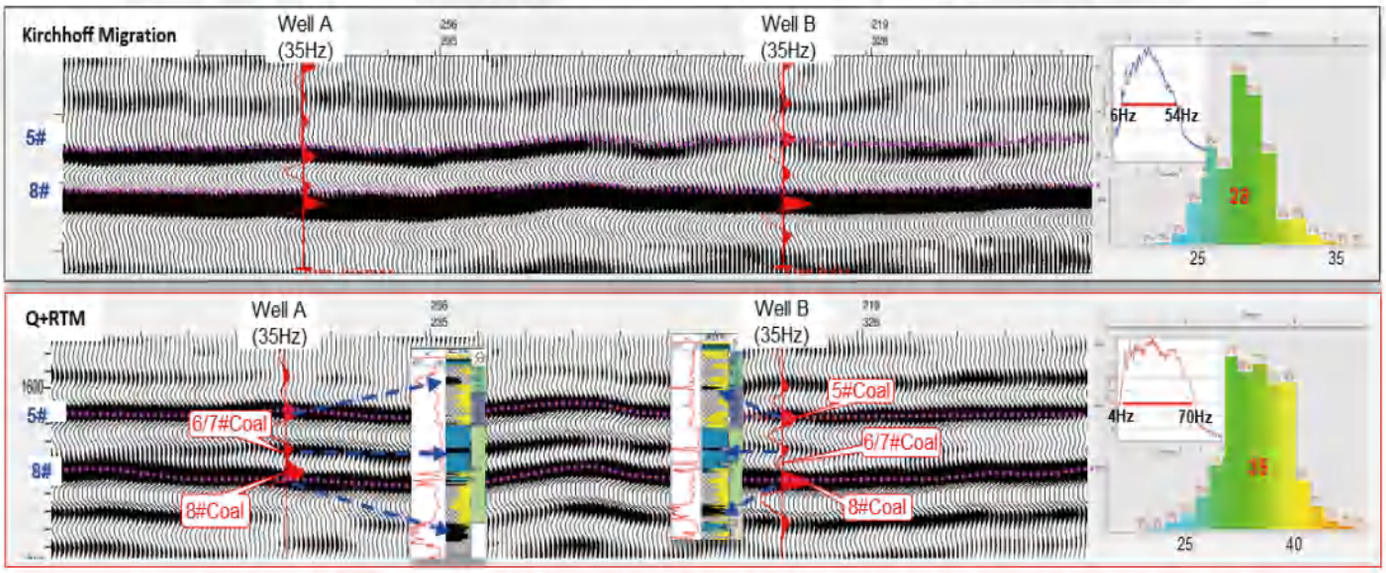
Comparison of RTM and elastic FWII result

LAND DATA PROCESSING IN COMPLEX AREA

BGP's advanced land 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 Least-Squares Migration algorithms make full use of land data wide-azimuth, broadband and high-density information to address dual complex geological conditions and High-Fidelity & High-Resolution Seismic Processing challenges.

High-fidelity & high-resolution seismic processing

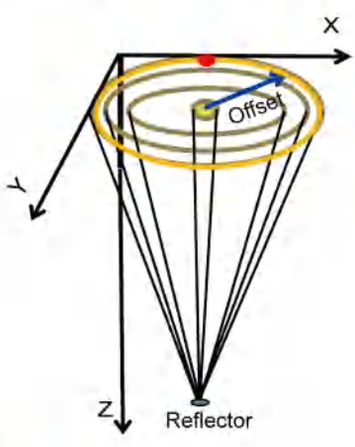
With advanced and customized high-fidelity and high-resolution processing workflows, BGP can address various geophysical challenges in complex lithology conditions.

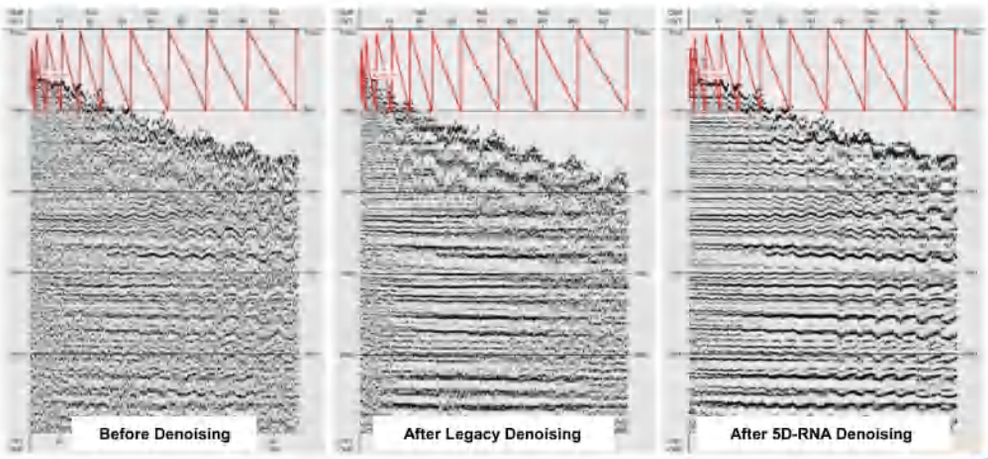


Comparison of legacy vs BGP PSTM stack sections after high-fidelity & high-resolution processing

5D prestack random noise attenuation

5D-RNA technology suppresses random noise via azimuth dimension, preserves true wavefield, and improves traveltime and amplitude fidelity of prestack gathers.



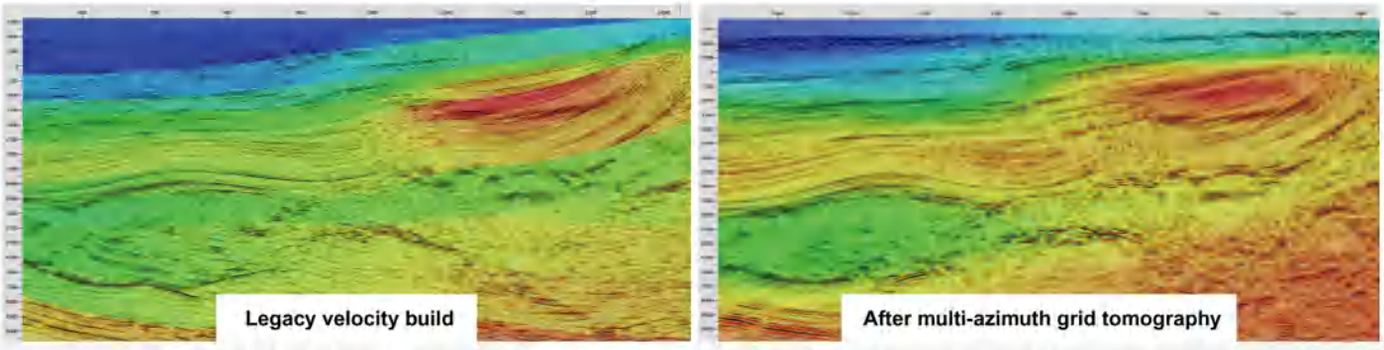


Denoising comparison: legacy method vs BGP 5D-RNA

LAND DATA PROCESSING IN COMPLEX AREA

Multi-azimuth grid tomography

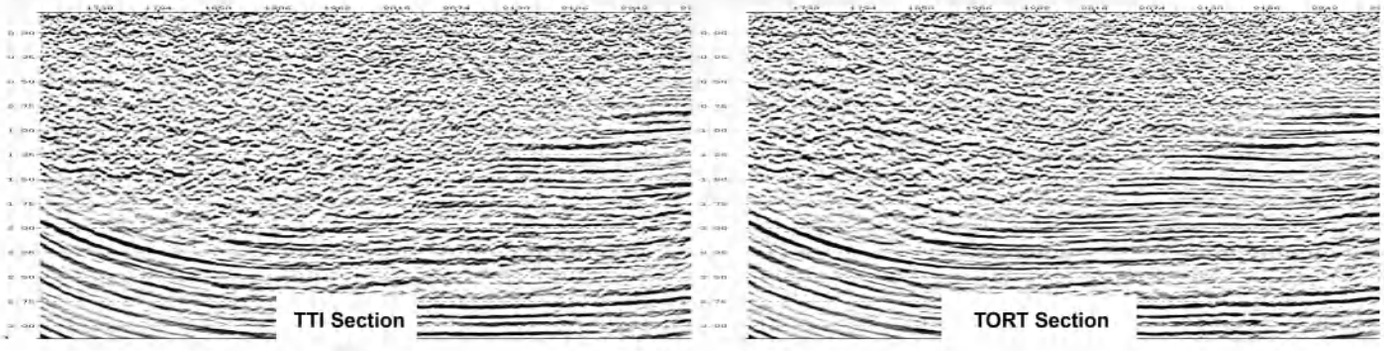
Multi-azimuth grid tomography utilizes wide-azimuth data and azimuth information to raise grid ray density, improving tomography accuracy and stability.



Velocity and section comparison: Legacy method vs BGP multi-azimuth grid tomography

Tilted orthorhombic anisotropy model building and imaging

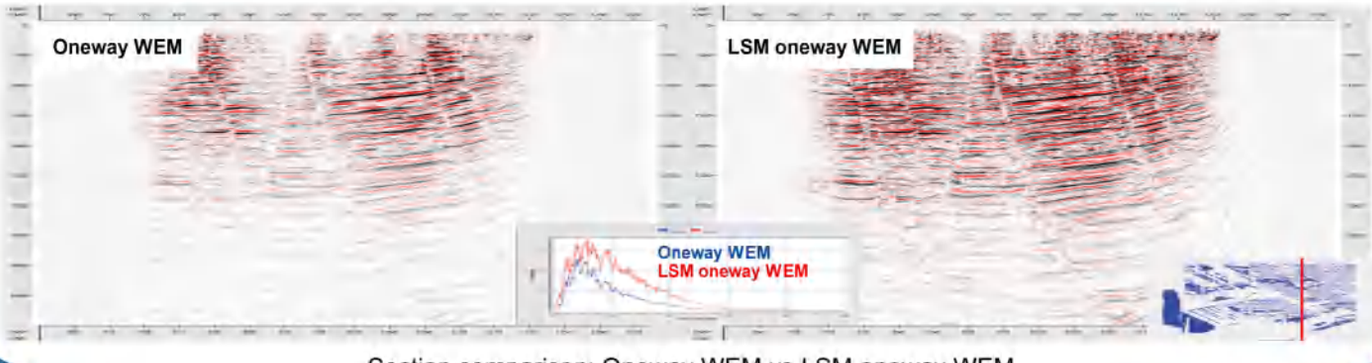
TORT modeling and migration reduces reflection angle distortion from anisotropy and azimuthal variation, improving imaging accuracy in complex geology.



TTI vs TORT imaging result

Least-squares migration

Least-squares migration imaging resolves lithological exploration challenges in complex onshore areas, improving data illumination, resolution, thin reservoir identification and fine sand body characterization.



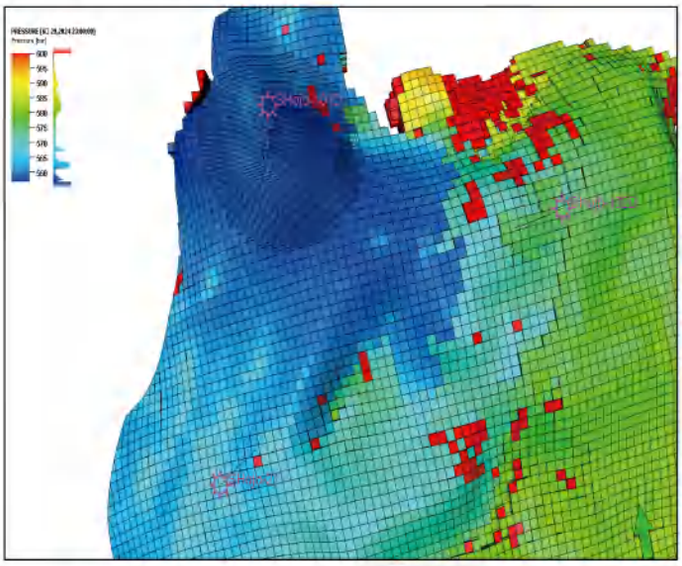
Section comparison: Oneway WEM vs LSM oneway WEM

MODELING AND NUMERICAL SIMULATION OF DUAL-MEDIA RESERVOIRS

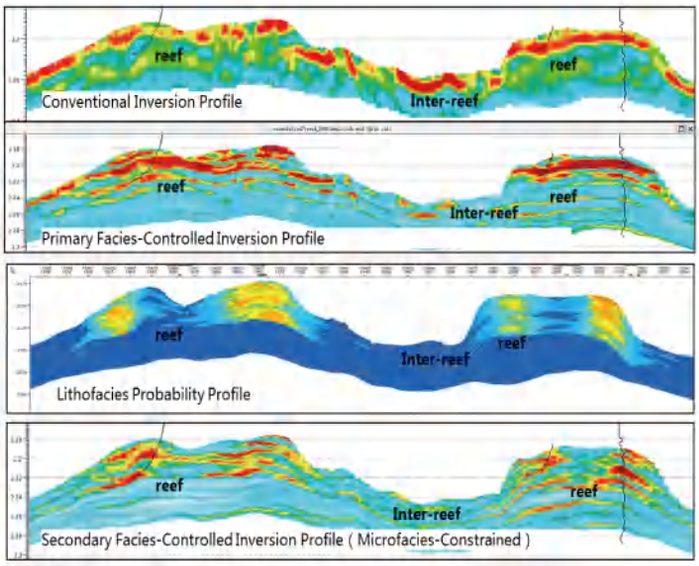
BGP can provide services such as fine Geological Modeling and Numerical Simulation of Dual-Media based on integrated seismic-geology-reservoir development studies.

Reservoir modeling under multi-stage facies-constrained inversion

Reef-shoal microfacies are identified via multivariate attribute analysis, and reservoir architecture is finely characterized using multi-level facies-controlled inversion and production performance.

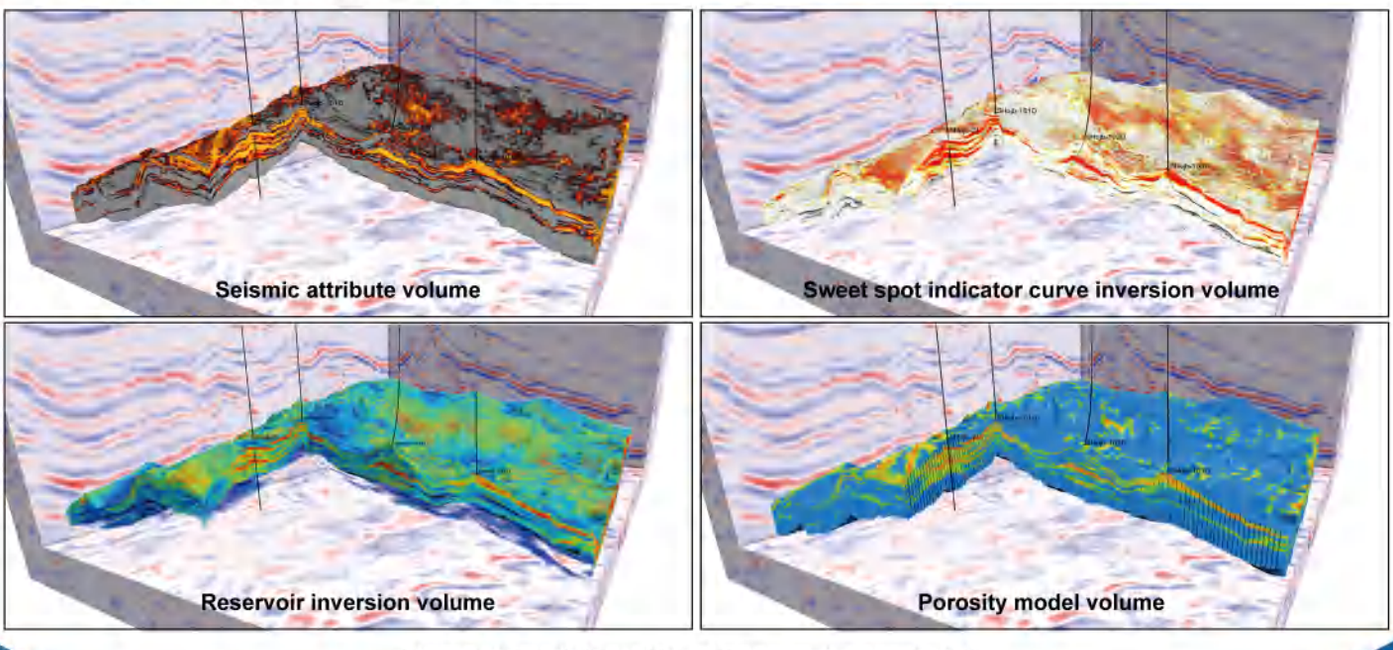


Numerical well test analysis of inter-well connectivity



Multilevel facies-controlled section

High-precision reservoir models are then constructed under multi-parameter constraints from seismic attribute and inversion volumes.

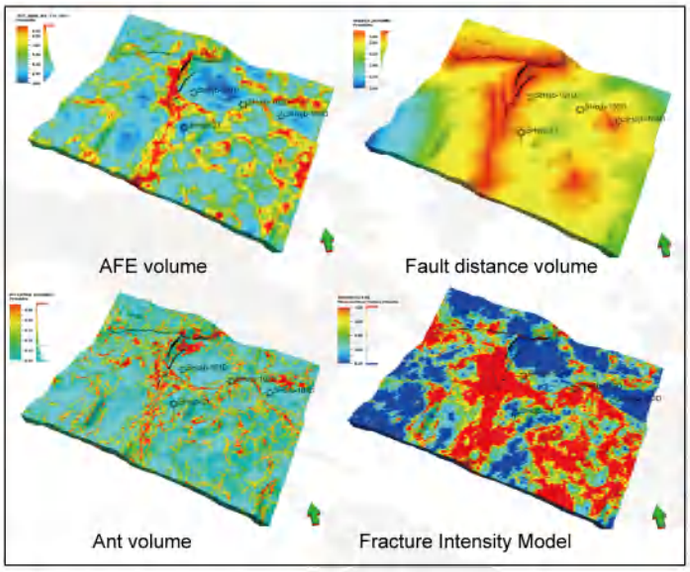


Reservoir modeling with multi-parameter constraints

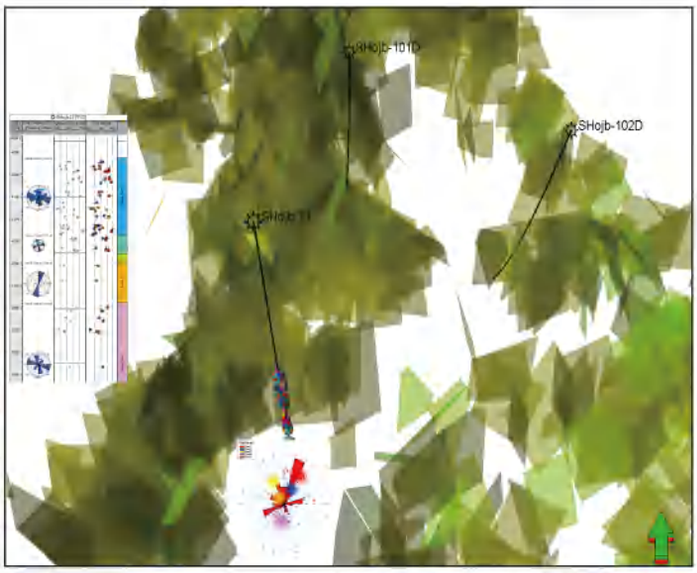
MODELING AND NUMERICAL SIMULATION OF DUAL-MEDIA RESERVOIRS

Innovative prediction of water invasion channels in dual-media reservoirs

A novel fusion method of fracture-sensitive attribute volumes is developed to build a fracture network model, calibrated by fracture effective permeability from PLT and production well tests. This enables coupling and iterative updating with dynamic flow data.

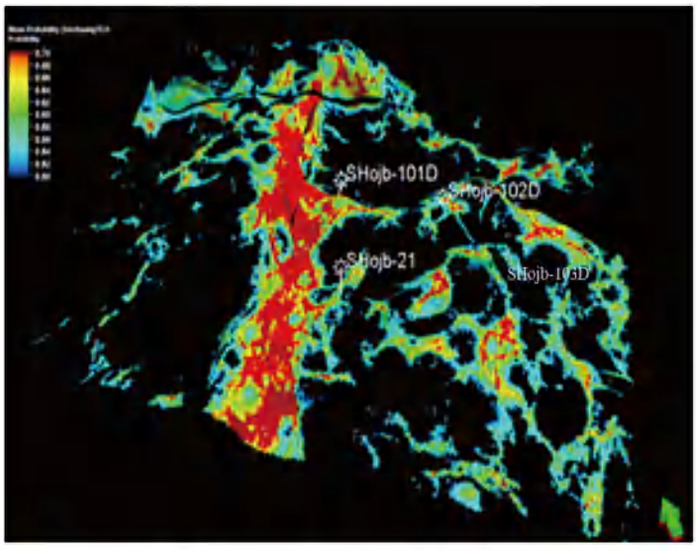


Fracture intensity model by multi-attribute sensitive volumes

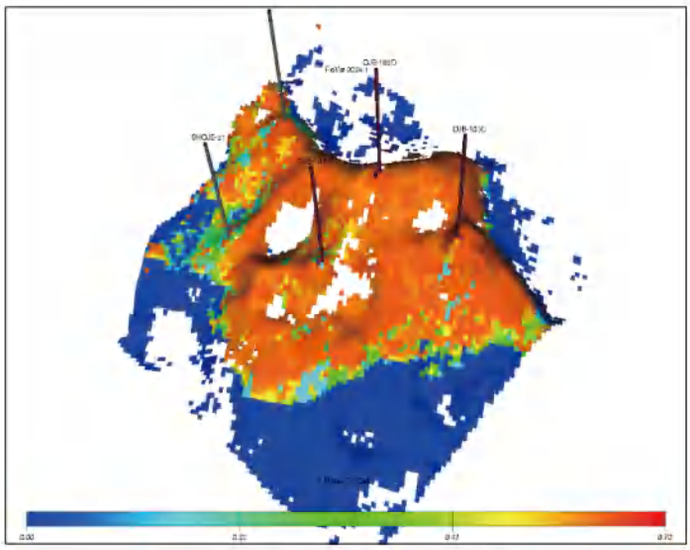


Improved fracture model

Based on reservoir and fracture models, reservoir heterogeneity is quantitatively characterized, water invasion channels in the gas field are delineated, simulating fluid changes and distribution in the gas reservoir, providing guidance for optimization of well placement, water control and management in gas wells and well, enhancing recovery factor.



Water influx channel characterization model



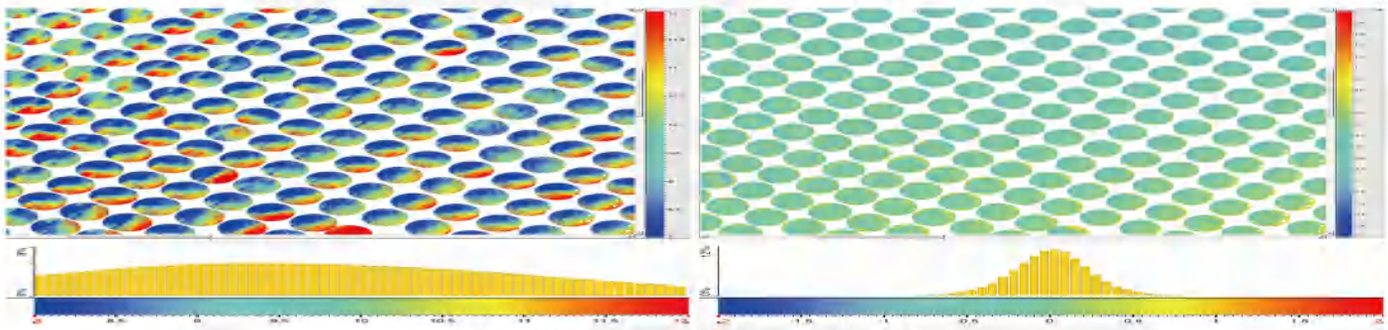
Numerical model of gas saturation

OBN DATA PROCESSING

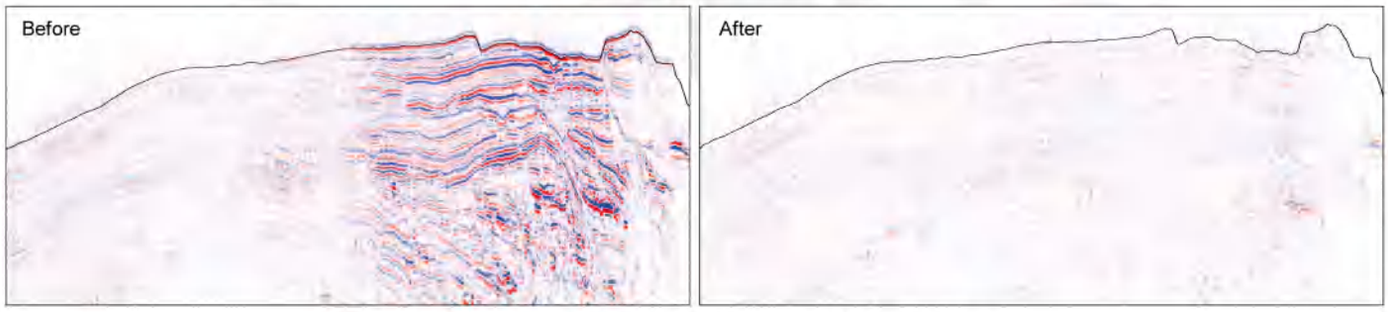
BGP's advanced Ocean Bottom Seismic processing and imaging technologies are systematically aiding our client's understanding of the subsurface. Industry leading pre-processing workflows as well as state-of-the-art Full Waveform Inversion and Impedance inversion algorithms make full use of OBN low-frequency,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

PTC (position, time, clock drift) inversion

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



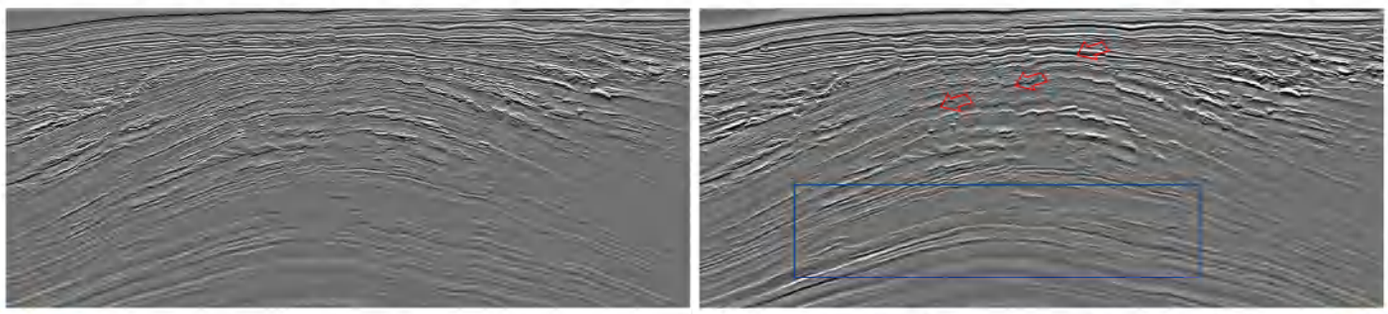
Time difference map before and after PTC



4D difference section before and after PTC inversion

3D directional de-signature

For broadband wavelet processing, we upgrade traditional 1D algorithms to full 3D techniques to break through inherent wavelet directionality limitations. This method better adapts to complex subsurface geological conditions, effectively improving multi-directional spatial consistency of wavelet features.



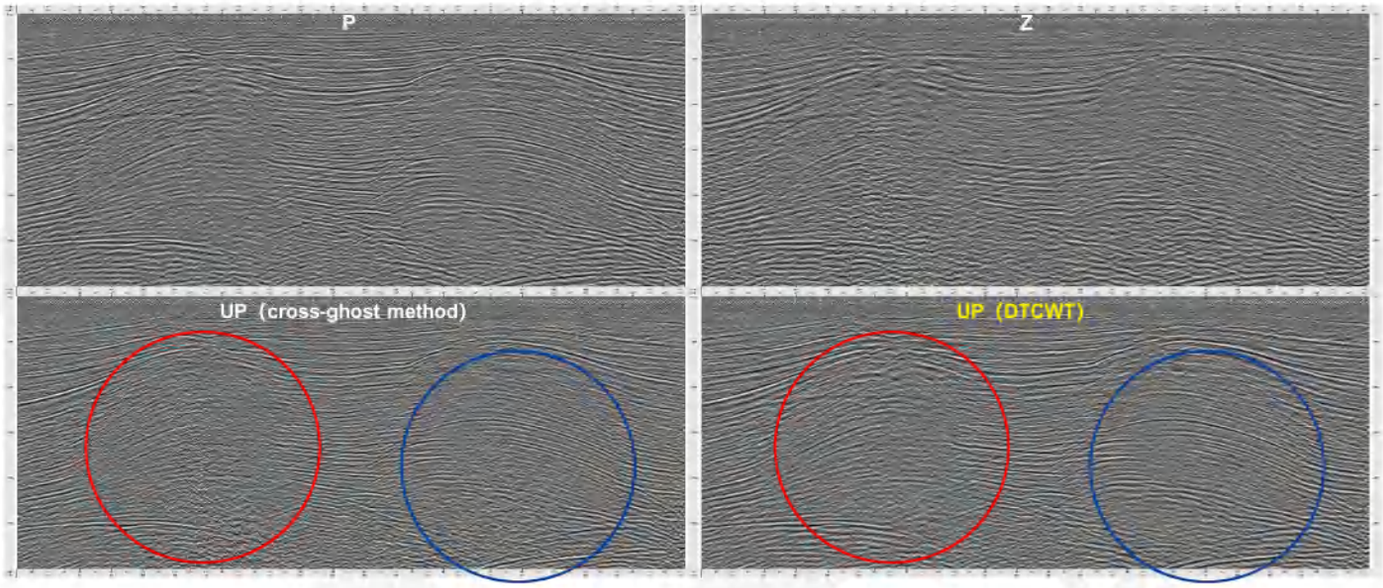
Legacy

Result with 3D directional de-signature

OBN DATA PROCESSING

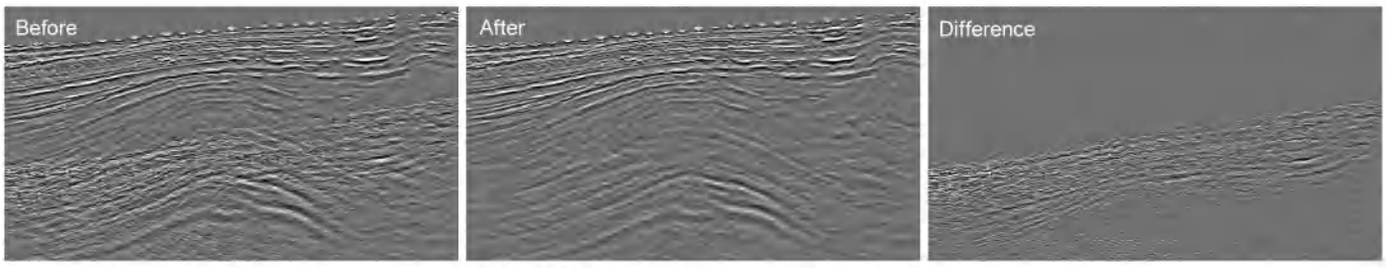
Wavefield separation

The dual-tree complex wavelet transform (DTCWT) is used for wavefield separation. Unlike conventional wavelet methods that lack directional sensitivity, DTCWT possesses strong directional selectivity and multi-scale decomposition capabilities, allowing it to accurately capture the directional characteristics of different wavefields.

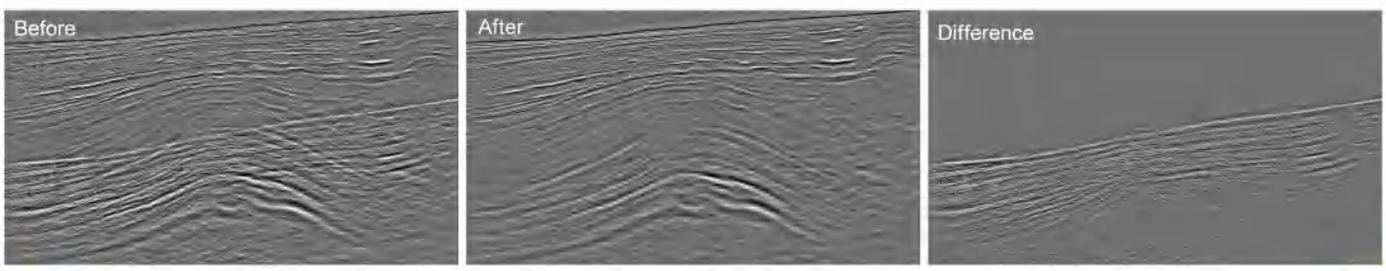


UDD-DDD

Up/Down Deconvolution and Down/Down Deconvolution rely on refined wavefield component decomposition of OBN seismic data. By fully utilizing the propagation differences between upgoing and down-going wavefields, these two techniques can accurately identify and isolate multiple interference components.



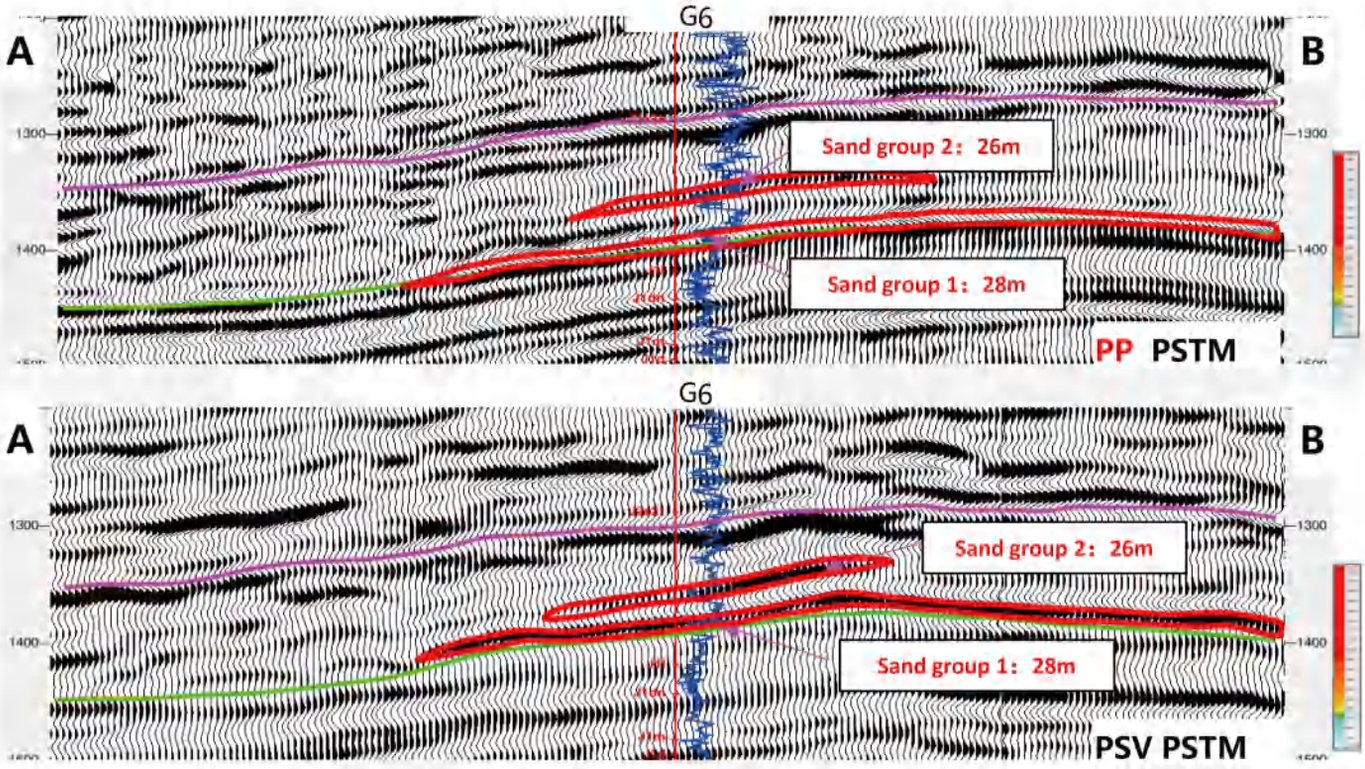
UDD-DDD for up-going wave de-multiple



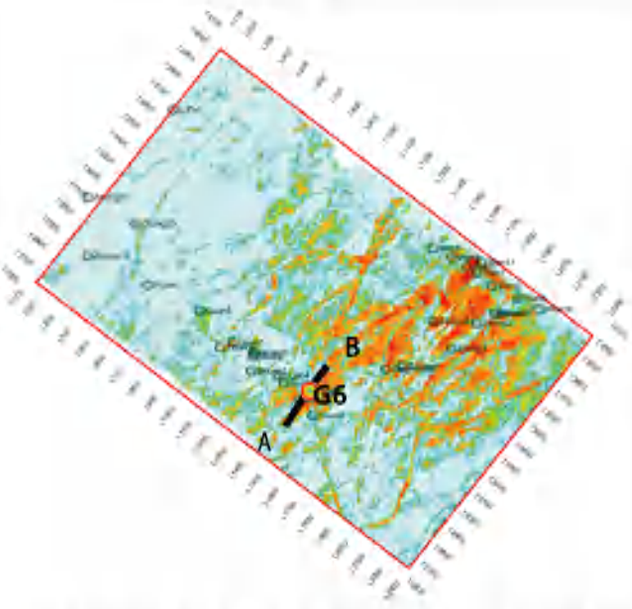
UDD-DDD for down-going wave de-multiple

P-SV WAVE PROCESSING

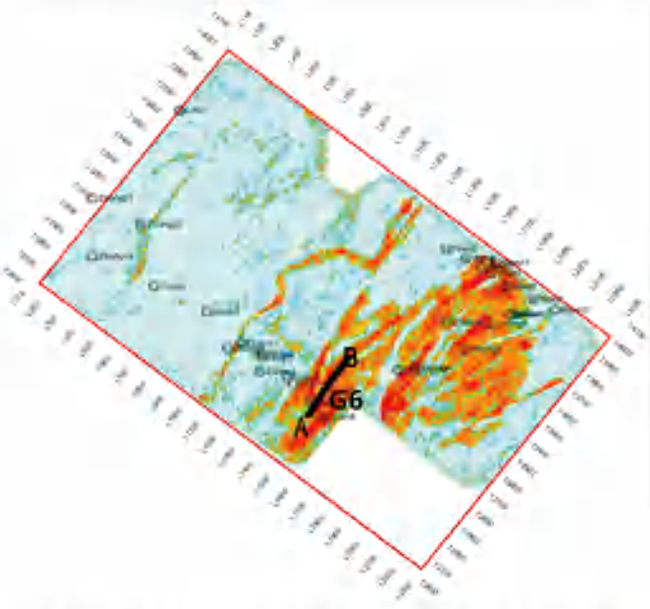
BGP has advanced processing and interpretation technologies for P-SV seismic data, committing to obtain the proper earth structure characters such as gas cloud conditions and detailed description of complex reservoirs.



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



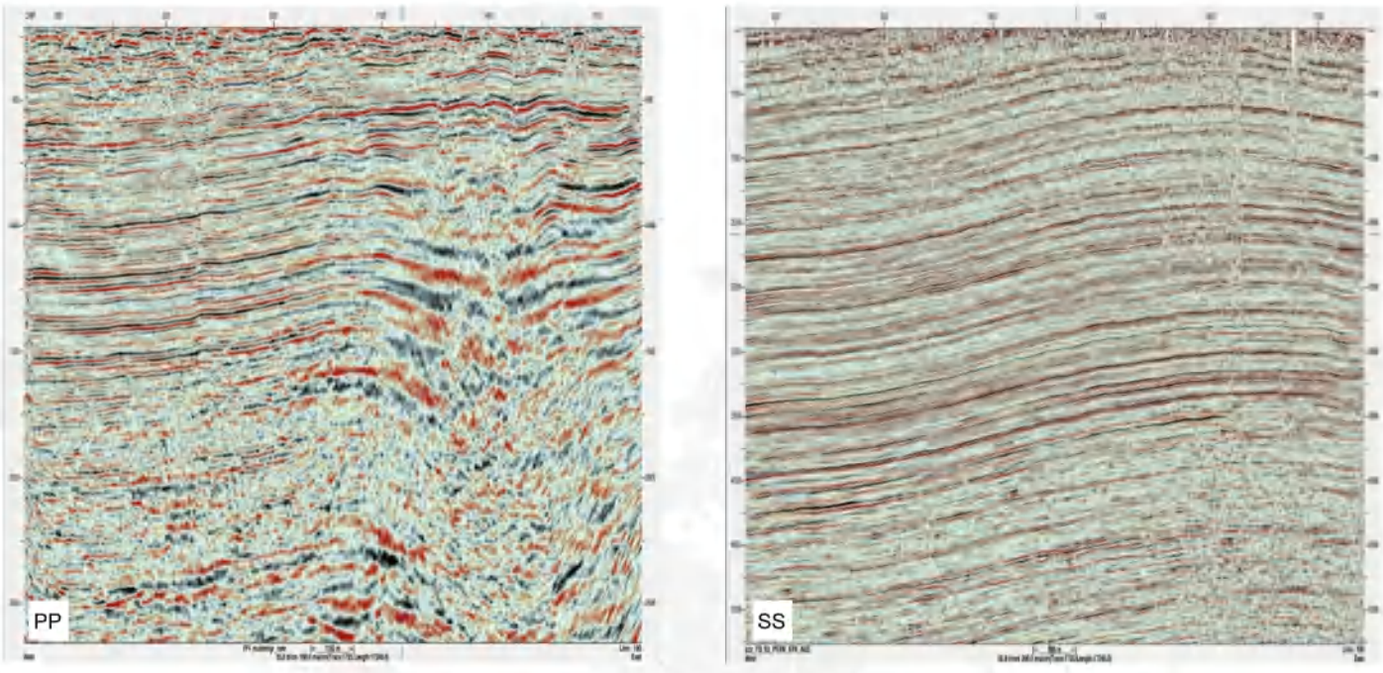
P wave average peak amplitude of sand group 1



P-SV wave average peak amplitude of sand group 1

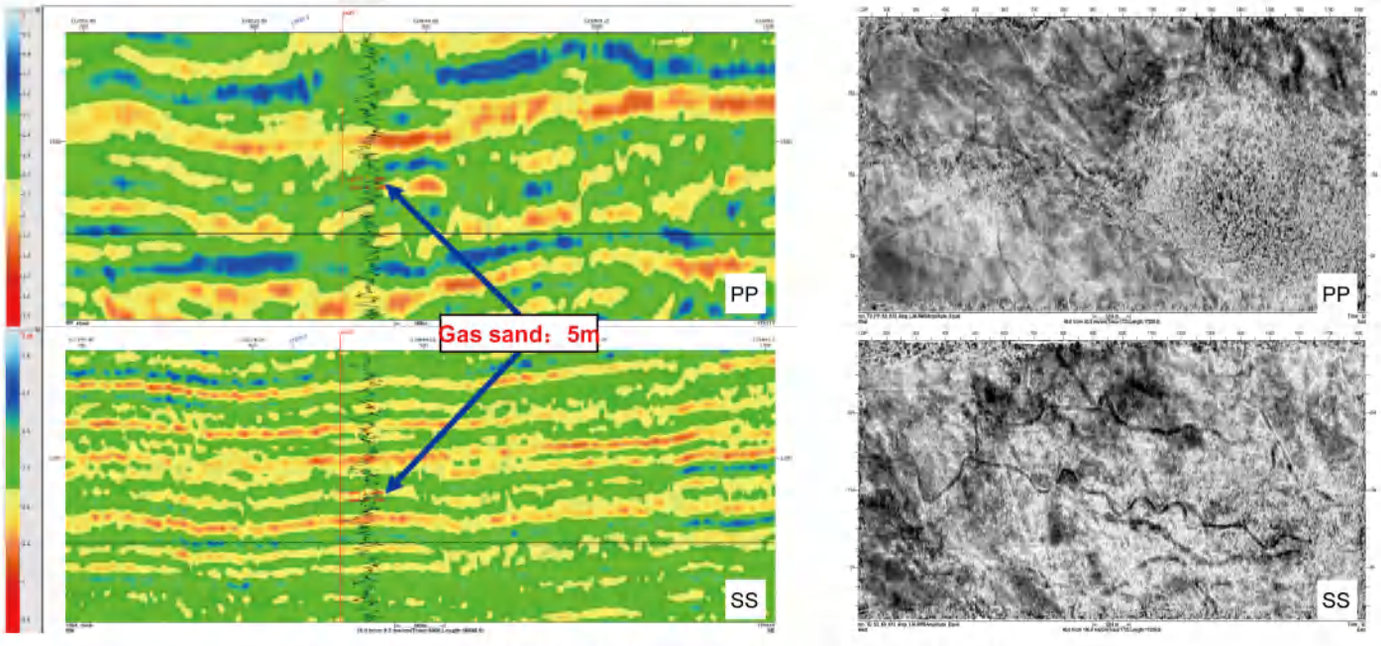
SHEAR WAVE PROCESSING

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 at the same location

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



Comparison of coherence slice and impedance inverted by PP and SS

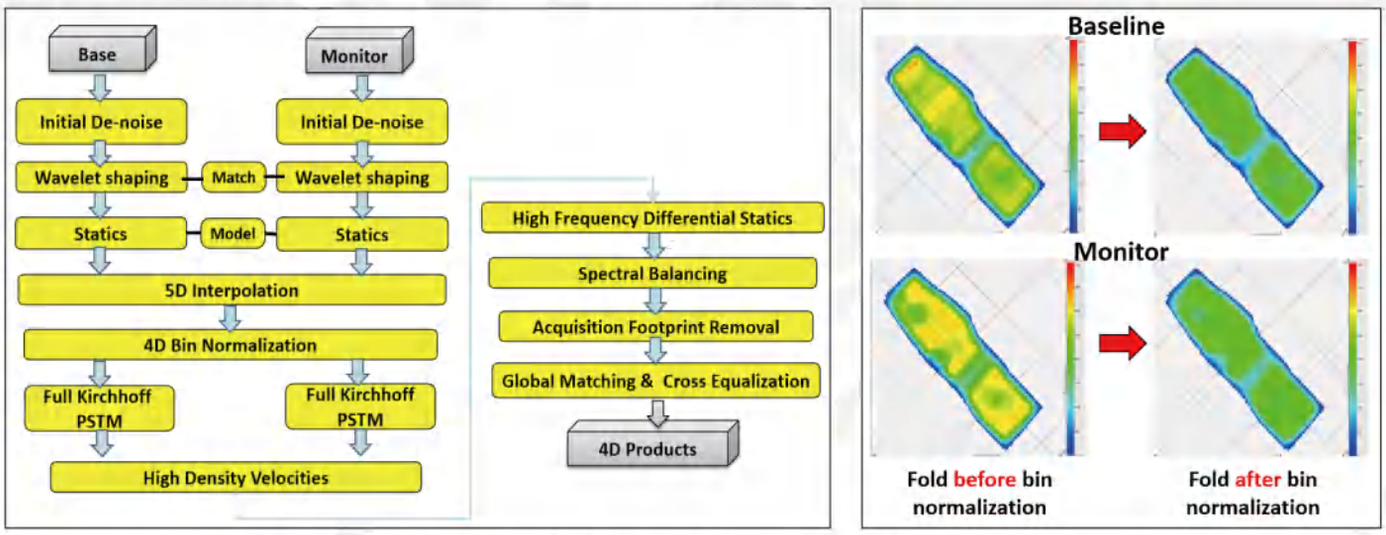
TIME LAPSE (4D) SEISMIC MONITORING

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.

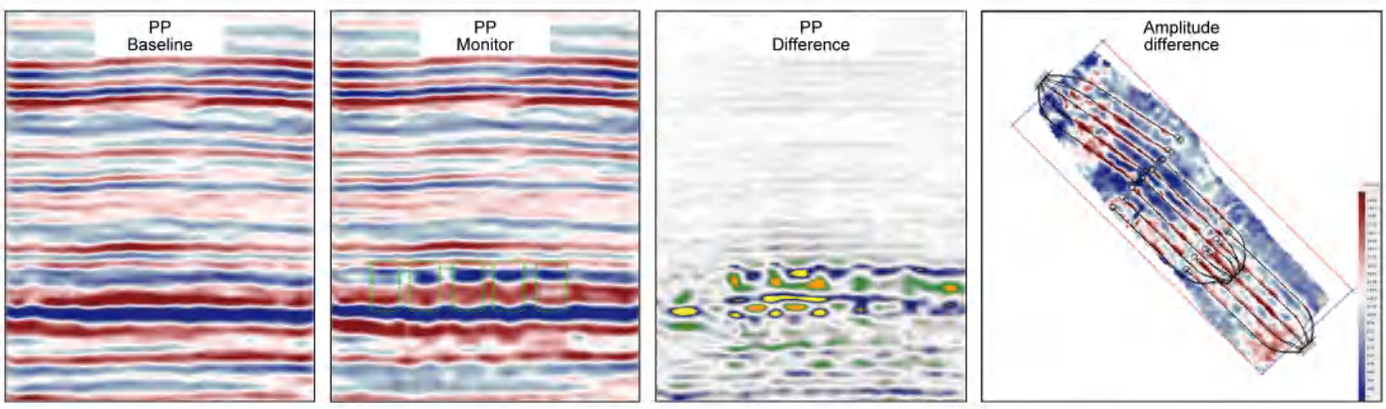
4D Multicomponent processing workflow

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.



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.

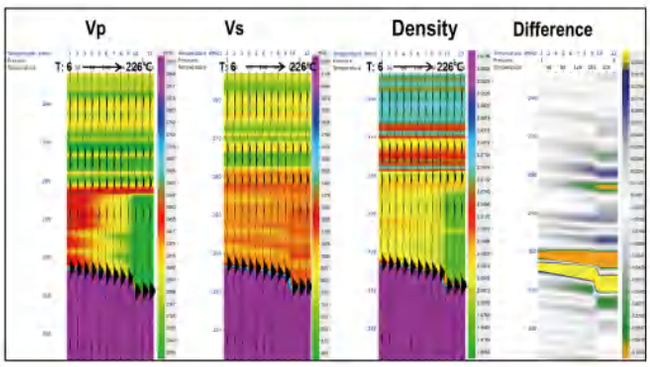


PP baseline stack section (left) ; PP monitor stack section (middle) ; difference stack and slice (right)

TIME LAPSE (4D) SEISMIC MONITORING

4D Rock physics analysis

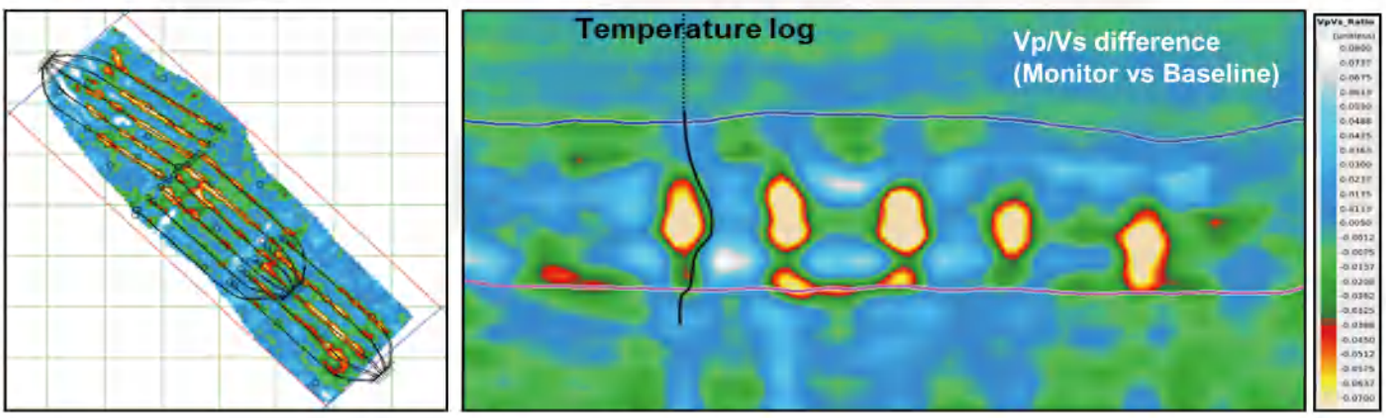
Rock physics analysis is an integral part of BGP's 4D qualitative and quantitative 4D seismic interpretation. Based on the improved Gassmann theory, time-lapse simulation of elastic parameters is conducted to gain insight into changes in seismic properties associated with the production of the field for oil and gas development or with CO2 injection for CCS.



Forward modelling

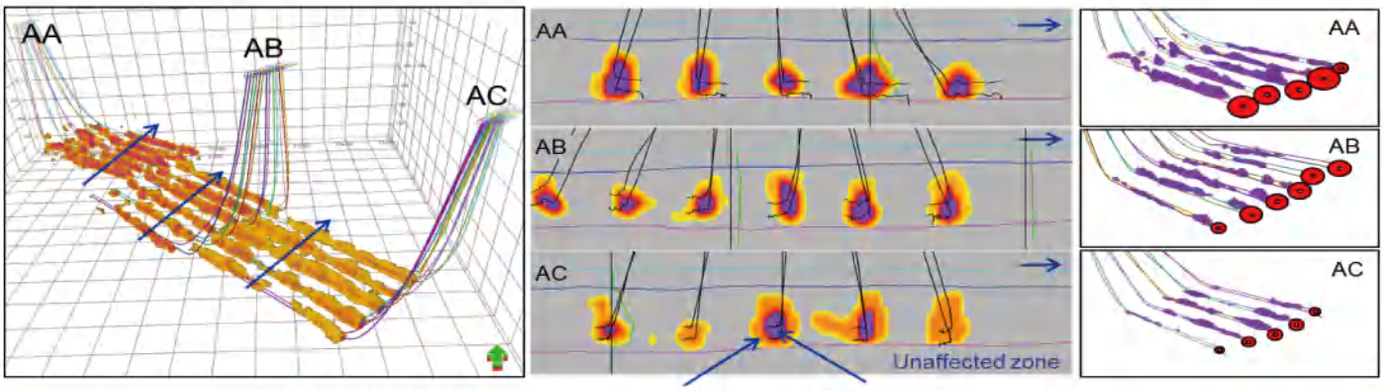
4D Seismic inversion

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.



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.



Comparison between cumulative production and predicted steam chamber

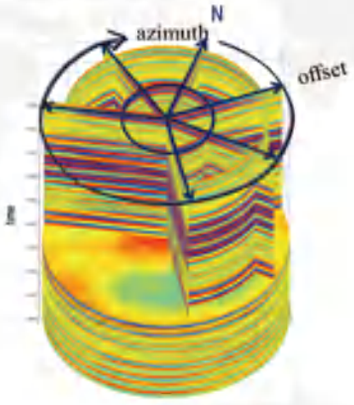
5D SEISMIC INTERPRETATION

Pre-stack 5D seismic data interpretation

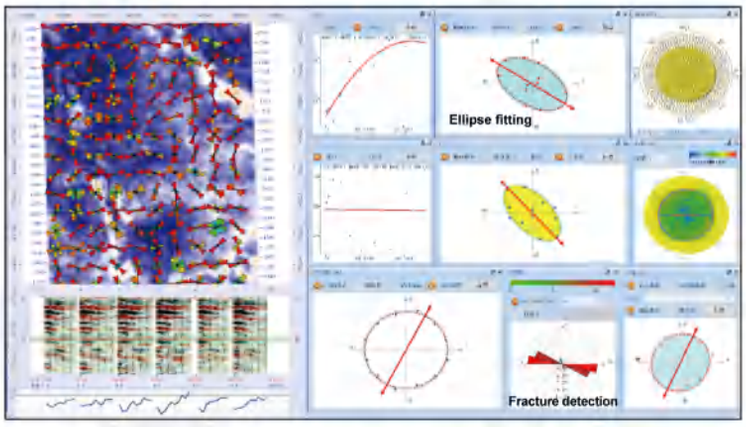
Pre-stack 5D interpretation techniques have been developed to fully extract pre-stack information. Compared to 3D interpretation, information in offset and azimuth dimensions is utilized to finely depict the distribution of fractures and hydrocarbons.

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.



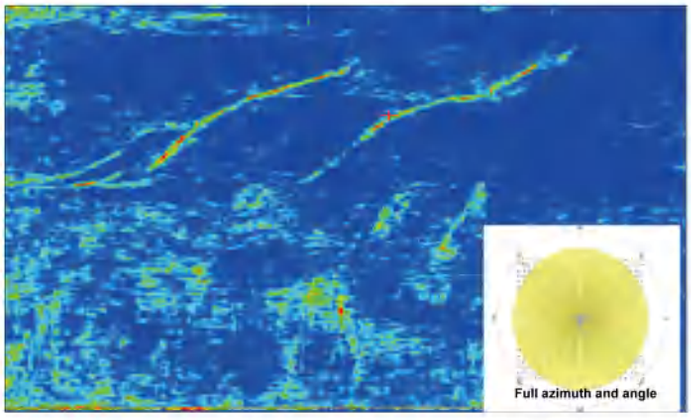
Prestack 5D gather



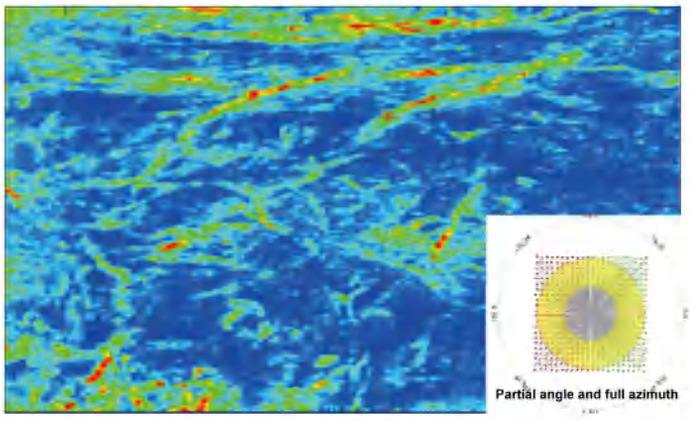
Interactive 5D seismic data analysis

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.



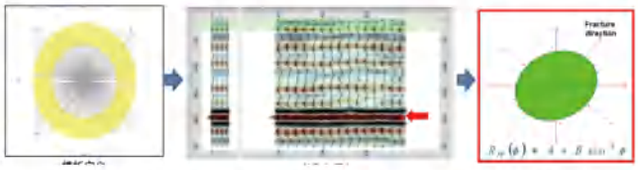
Full azimuth and angle stacking
suppress geological detail



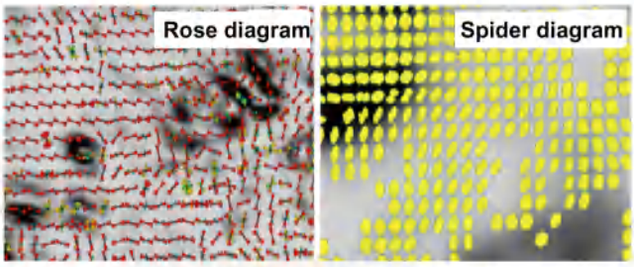
Partial azimuth and angle stacking
reveal more information

PRE-STACK FRACTURE PREDICTION BASED ON 5D SEISMIC DATA

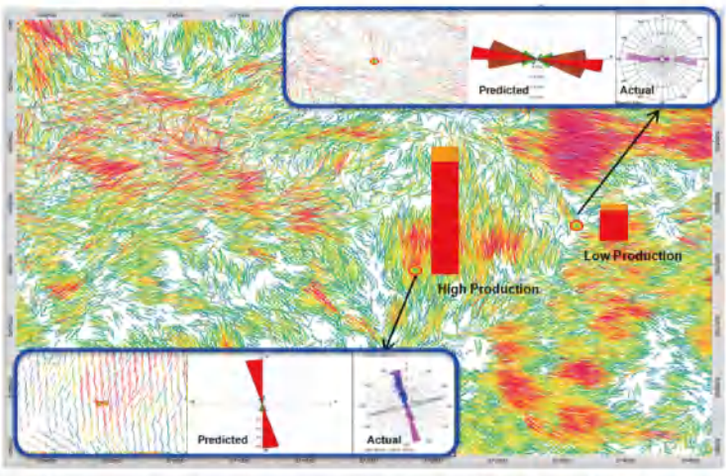
Based on the HTI theory, fracture azimuth, density and confidence interval are detected with the optimized 5D gather, where elliptical fitting or statistics is employed to analyze seismic attributes such as amplitude and travel times.



Anisotropy analysis based on optimal template



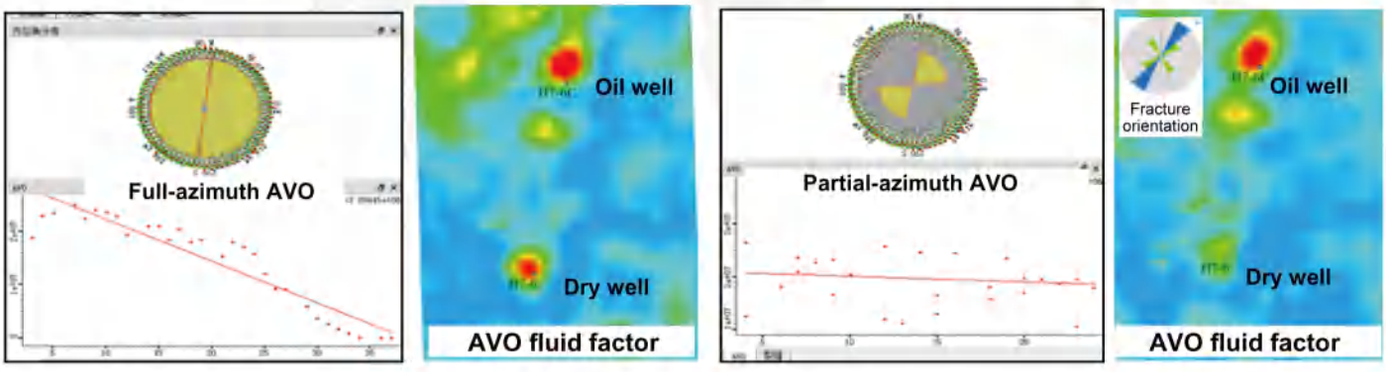
Various displays of fracture detection results



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

AVOAz

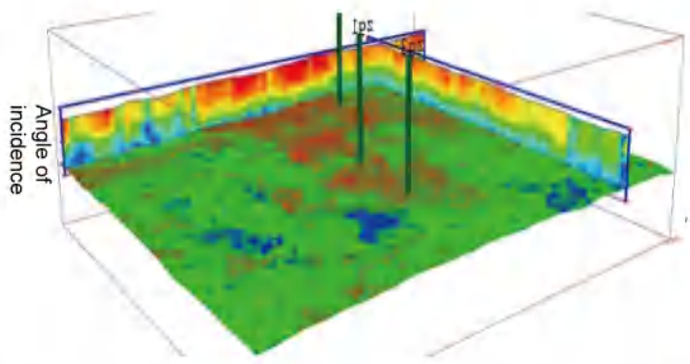
Azimuthal AVO analysis based on 5D gather data can effectively mitigate anisotropy impact on AVO response and thus improve hydrocarbon detection accuracy.



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.

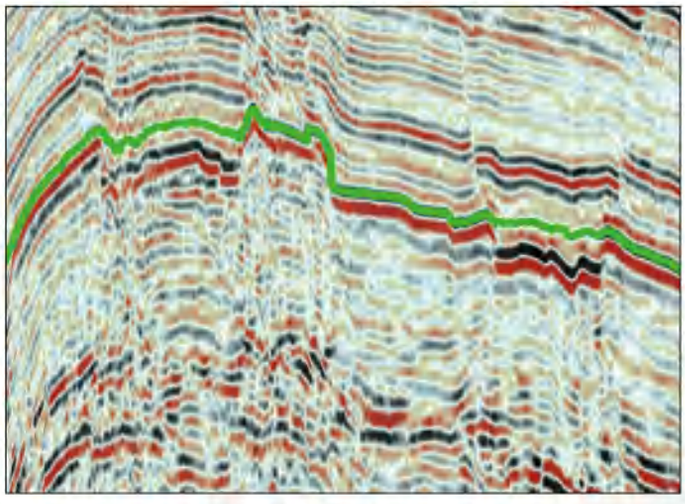


FVO gradient (plane) and frequency (section) along horizon

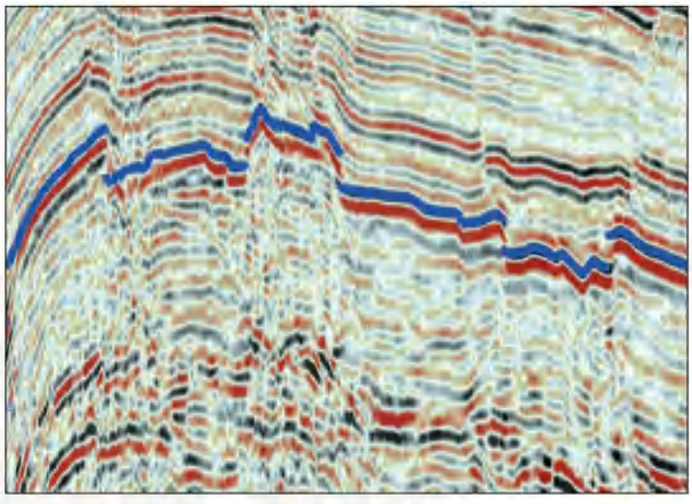
AI INTERPRETATION

AI horizon interpretation

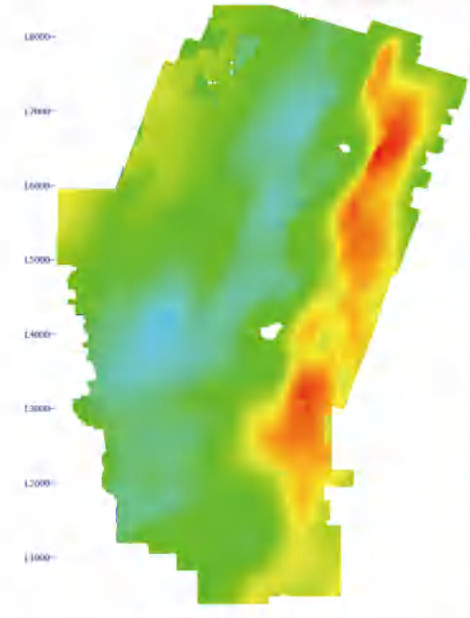
The traditional horizon auto tracking technique is usually based on waveform similarity or spatial density, which is not reliable when the seismic event crosses faults. However, even without fault constraints, the deep learning based horizon auto tracking technique is able to obtain decent results in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



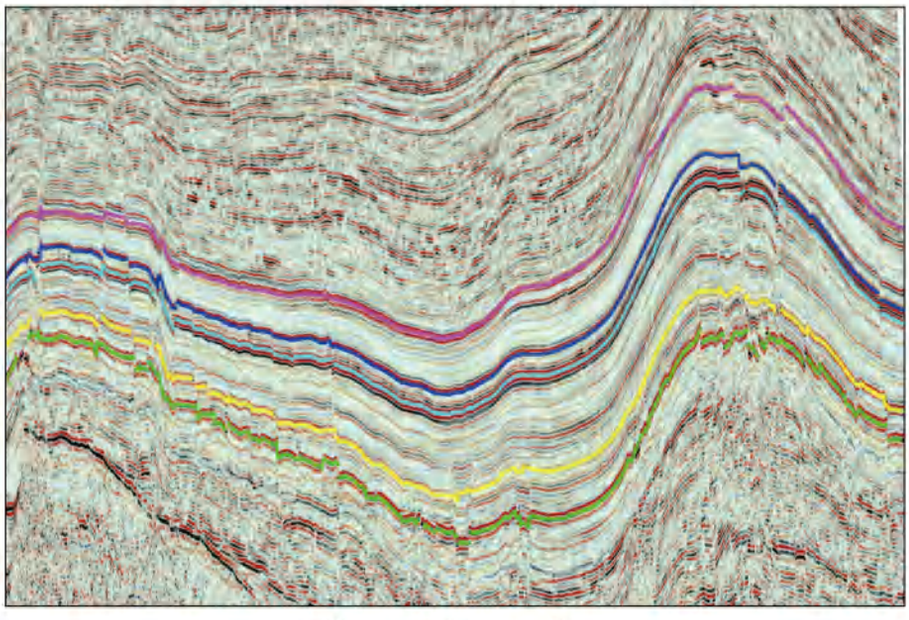
Traditional horizon auto tracking



Deep learning based horizon interpretation



AI horizon tracking



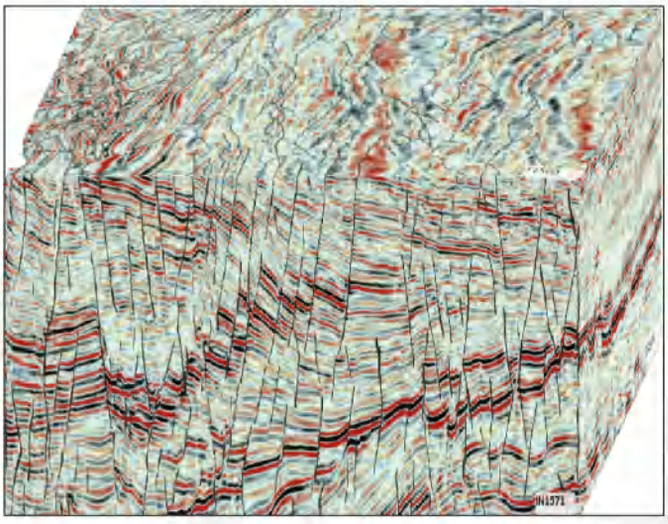
AI multi-horizon tracking

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.

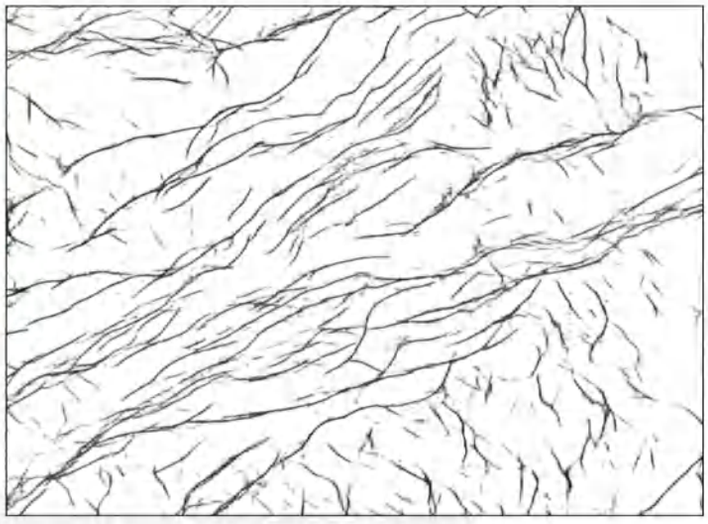
AI INTERPRETATION

AI 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.



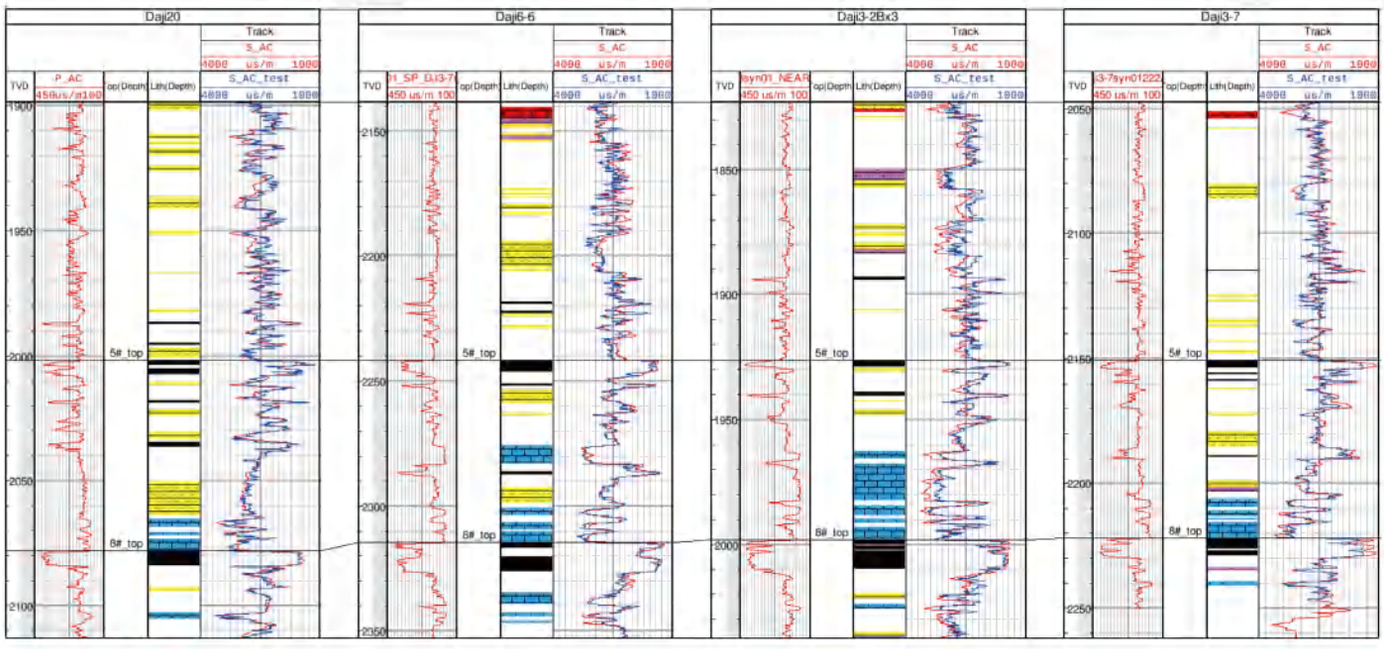
AI fault prediction cube



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.

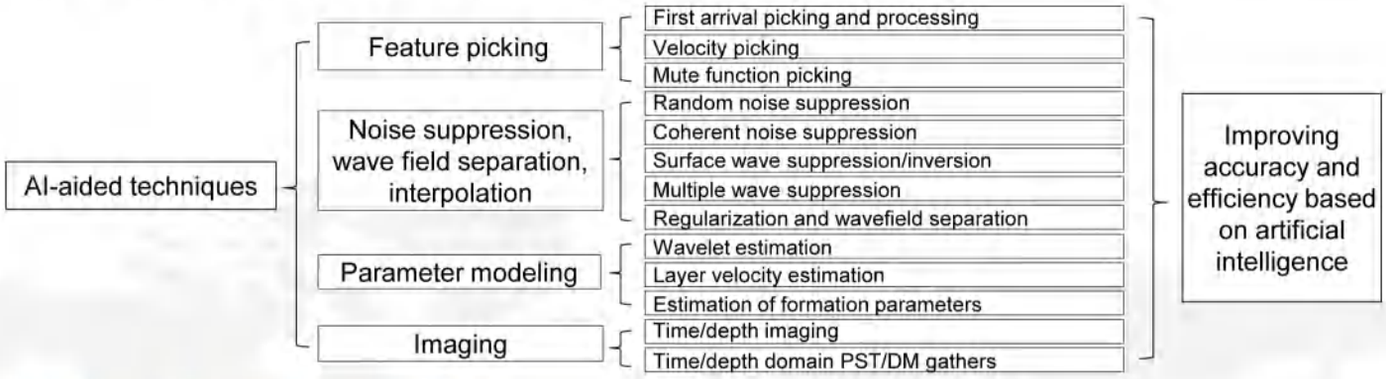


Red: Original curve
Blue: AI predicted curve

AI PROCESSING

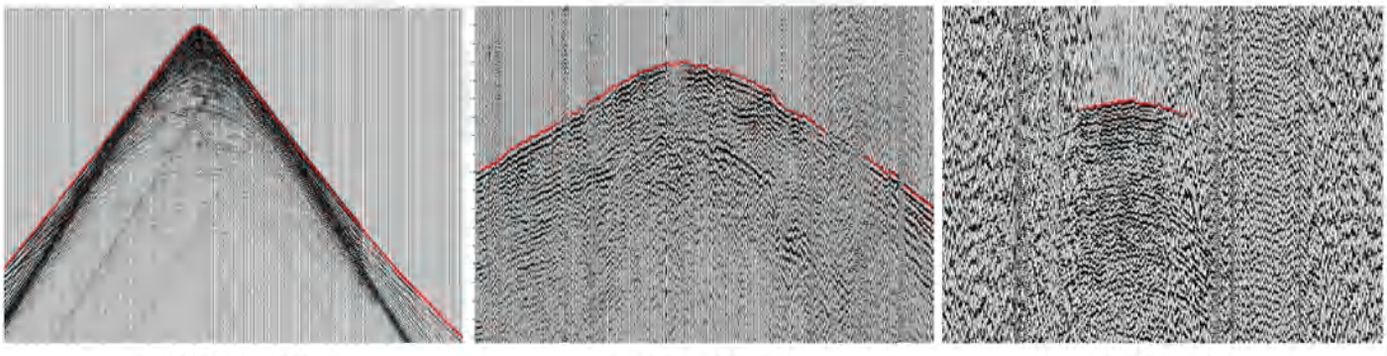
AI-aided seismic data processing

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.



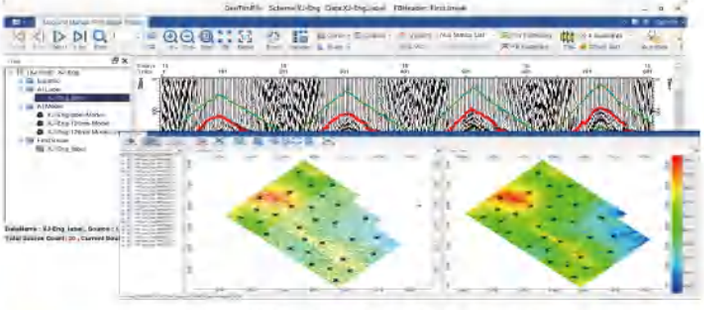
AI first-break picking

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.

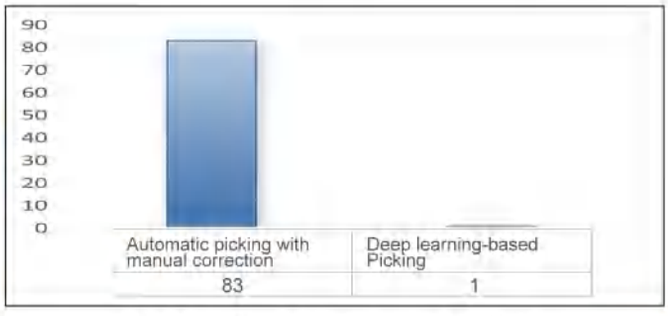


High S/N data | Middle S/N data | Low S/N data

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

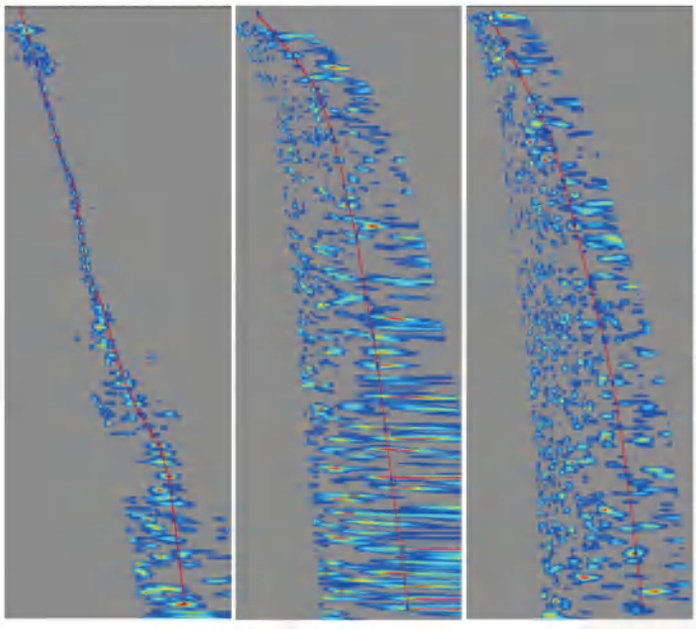


Computational efficiency comparison

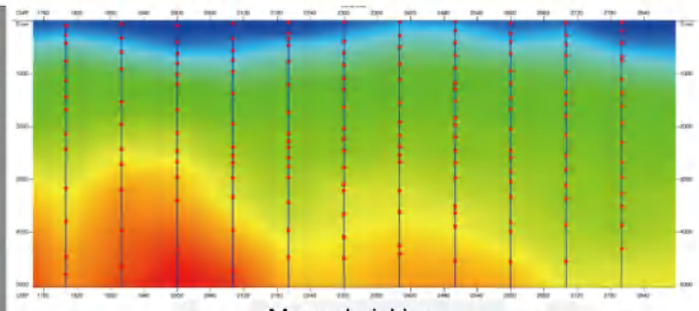
AI PROCESSING

AI velocity picking

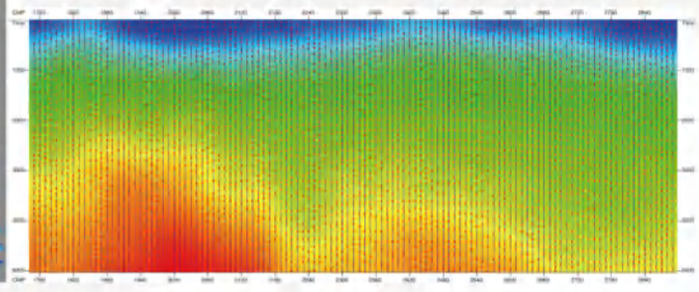
GeoEast provides a deep learning-aided velocity picking technique which can properly handel velocity spectra of different quality and give quality picking results.



Different S/N data

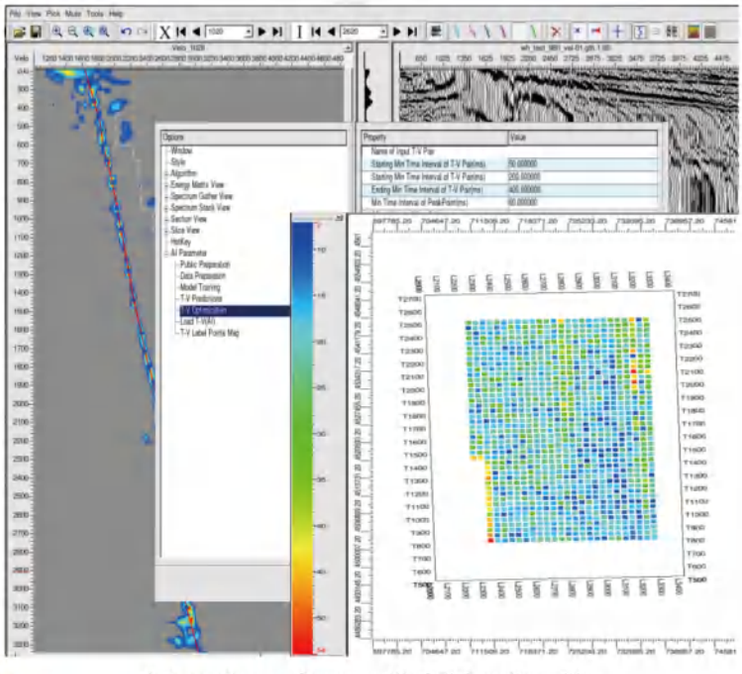


Manual picking

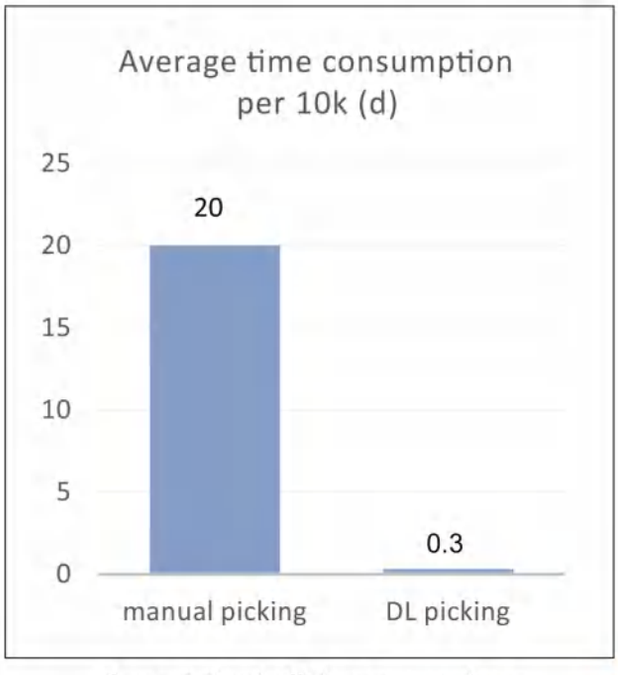


DL picking

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

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

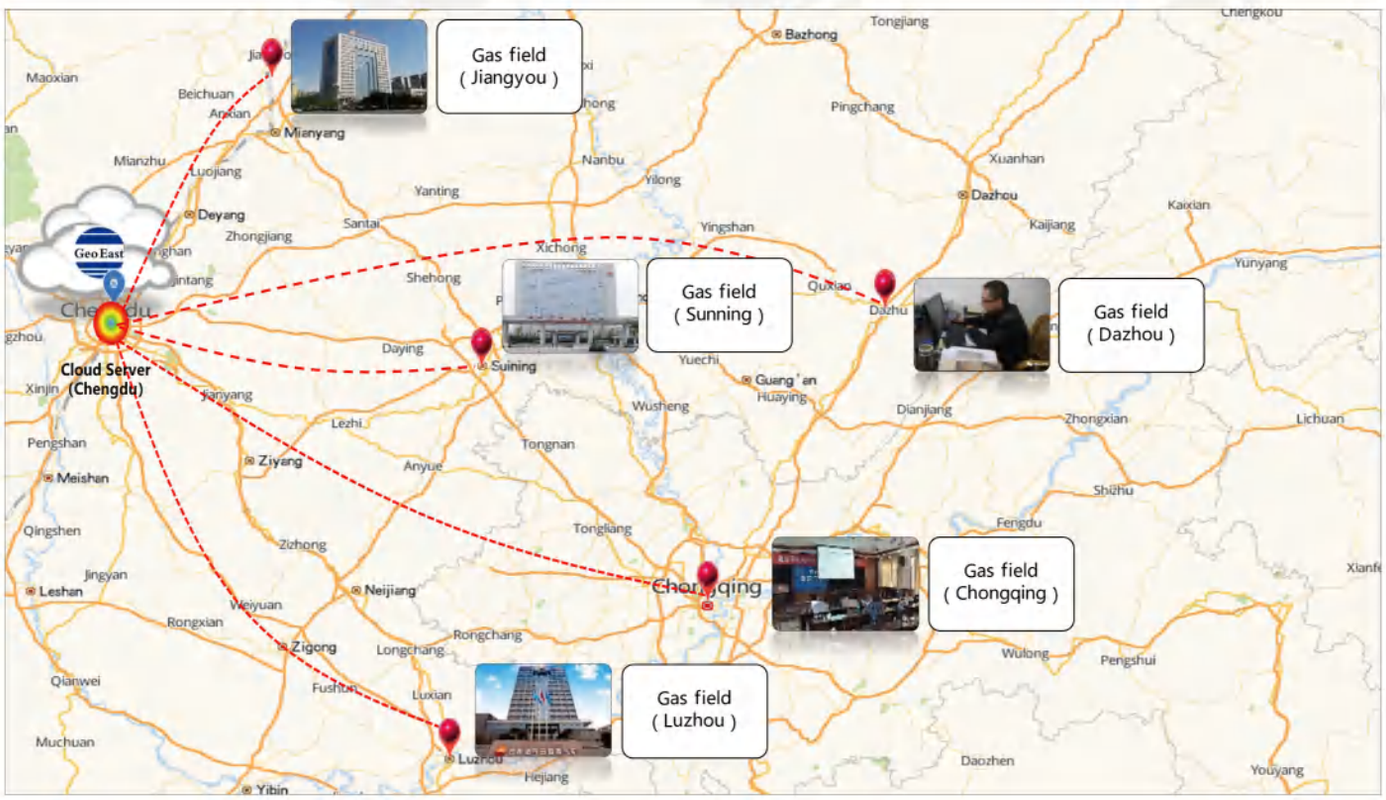
CLOUD COMPUTING MANAGEMENT SYSTEM

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



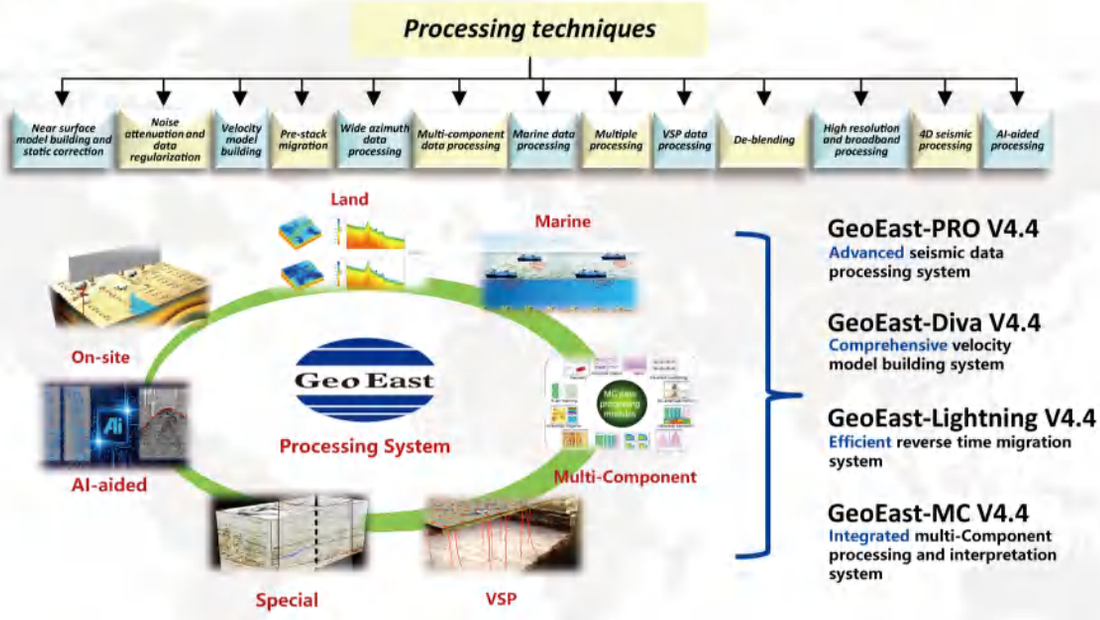
Application example

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.

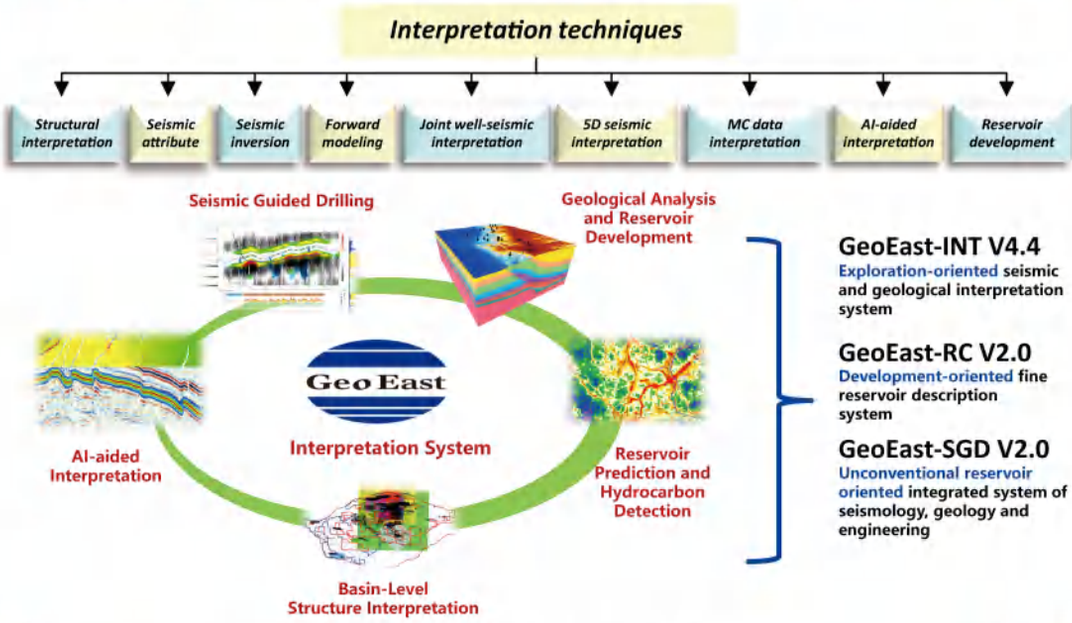
Processing software

■ 7 packages ■ 24 technology series ■ 400+ modules



Interpretation software

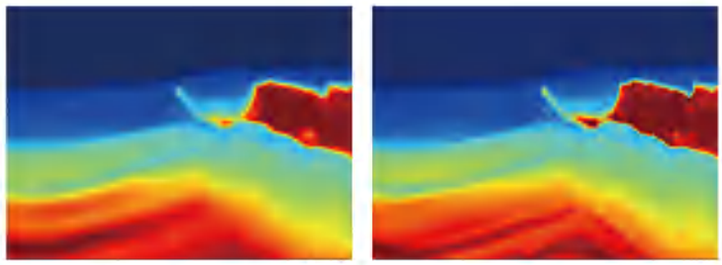
■ 5 packages ■ 21 technology series ■ 400+ modules



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.

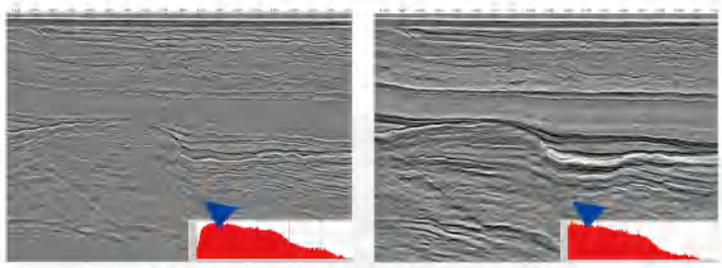


Legacy velocity model | JDFWI inverted velocity model

FWI imaging

Expanding low frequencies: Non-linear inversion can generate low frequencies that seismic waves do not possess.

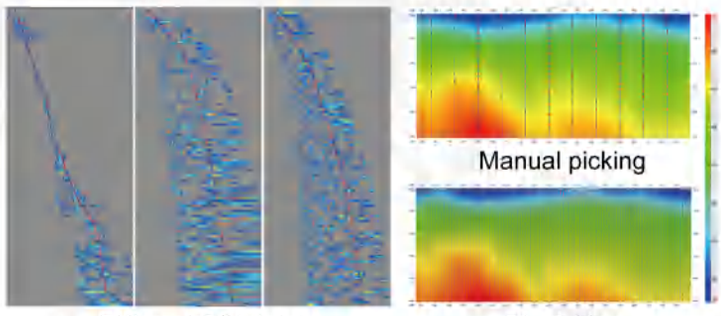
Expanding illumination: Non-reflective waves can cover illumination structures that reflective waves cannot.



PSDM | PSDM + FWI imaging

AI processing

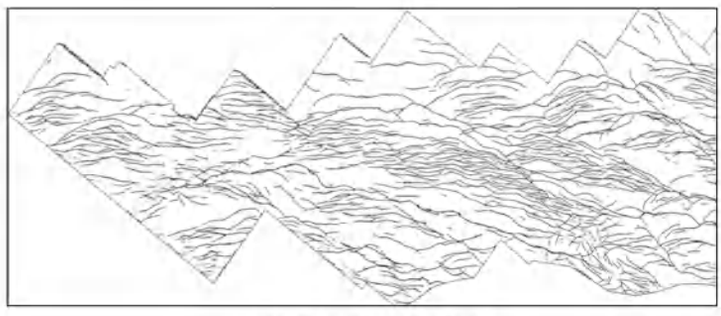
GeoEast has developed intelligent processing modules for time-consuming and labor-intensive processes such as first break picking, velocity picking, and noise attenuation. The accuracy and efficiency improved dramatically.



Different S/N data | DL picking

AI interpretation

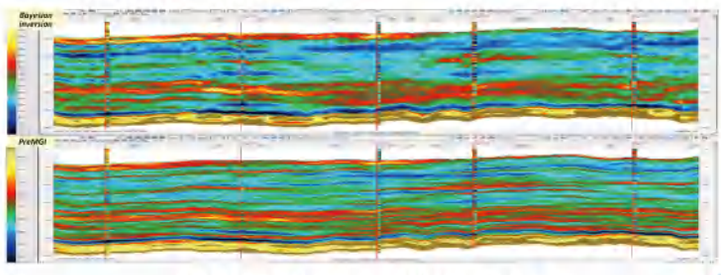
A deep learning-based artificial intelligence neural network has been developed, equipped with a series of intelligent interpretation technologies including horizon interpretation, fault identification, well log curve prediction, well log lithology prediction, and geological body identification.



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.



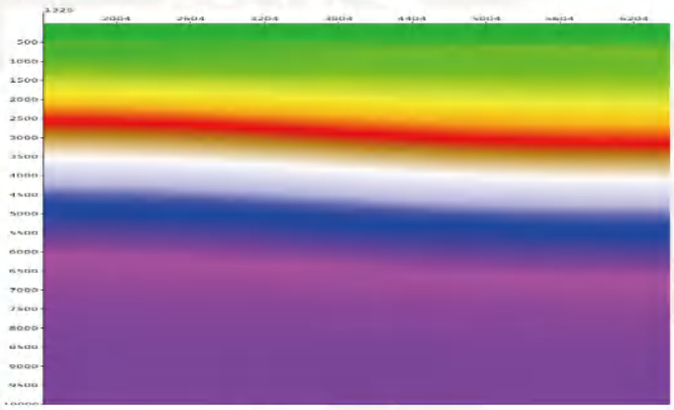
Inverted shear wave impedance

GEOEAST-FULL WAVEFORM INVERSION (FWI)

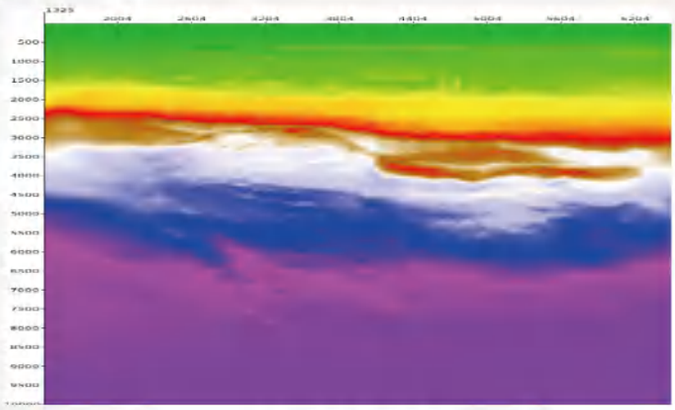
GeoEast Full-waveform inversion includes refraction inversion and reflection inversion. Several techniques for handling practical issues are provided, such as adaptive time FWI for handling cycle-skipping, and first-break FWI for complex and low SNR land data. The FWI inversions also consider earth Q 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.



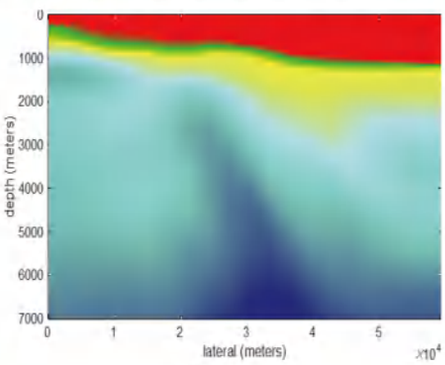
Initial velocity model



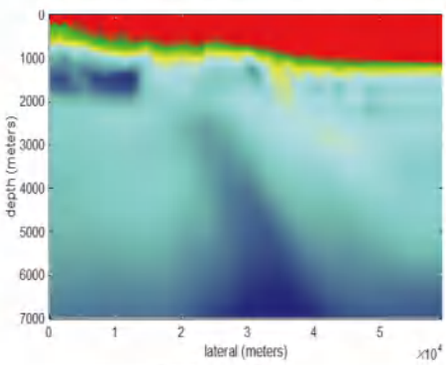
FWI velocity model

First-break FWI

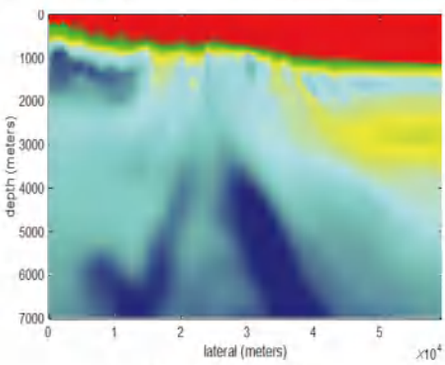
Inverting a land dataset is very challenging, because of the complexity of the data. Ground rolls and guided waves in land data are very hard to simulate accurately with wave equation modeling methods. Guided wave is a kind of refraction energy that bounces multiple times between surface and reflectors.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



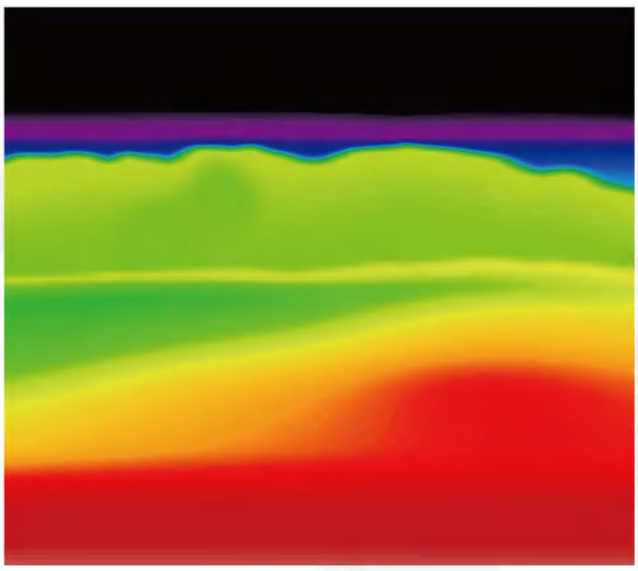
First-break FWI



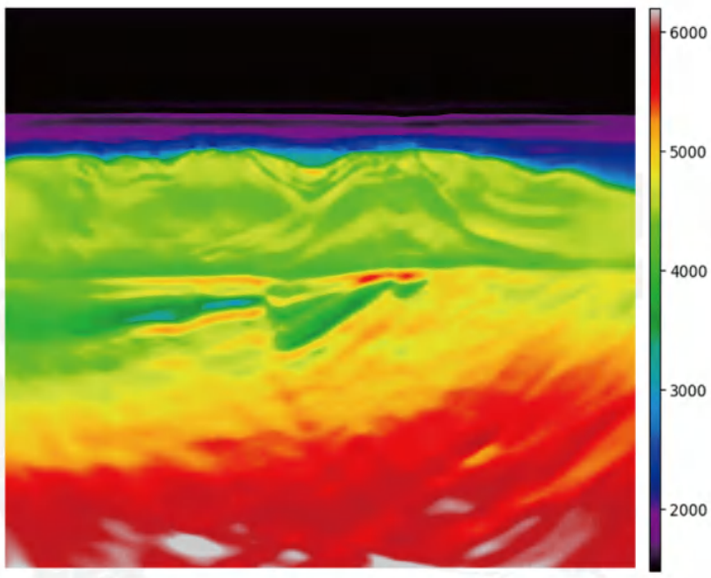
Conventional FWI

PHASE-DRIVEN FWI

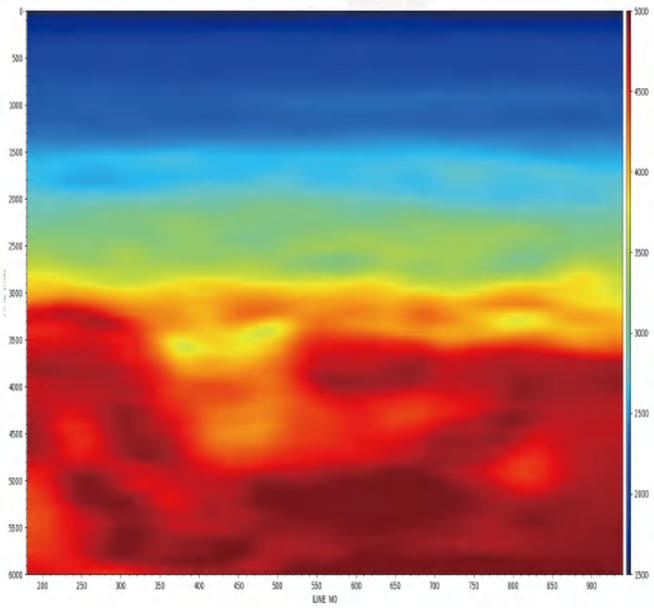
To tackle the cycle-skipping issue, we also developed phase-driven FWI, in which we minimize the cross-correlation time lag of modeled and observed data. This approach can allow our inversion scheme to rely on the time error of the events, instead of the phase error which is the main cause of the cycle-skipping 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.



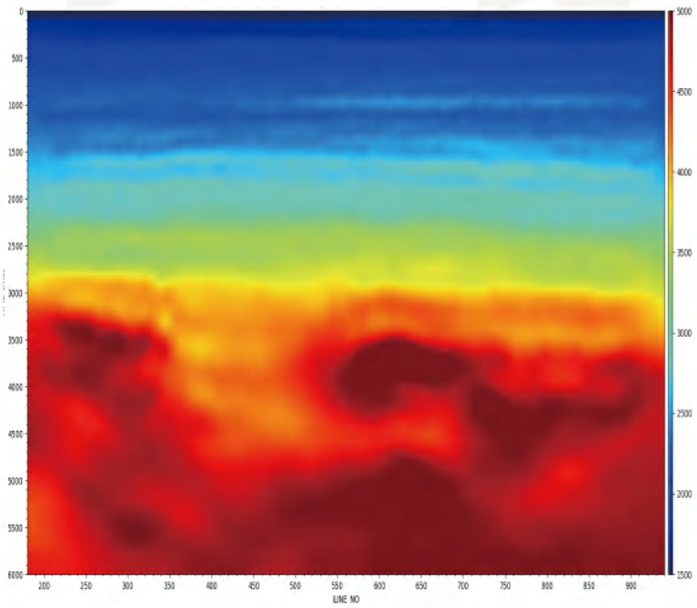
Initial velocity



20Hz FWI



Initial velocity



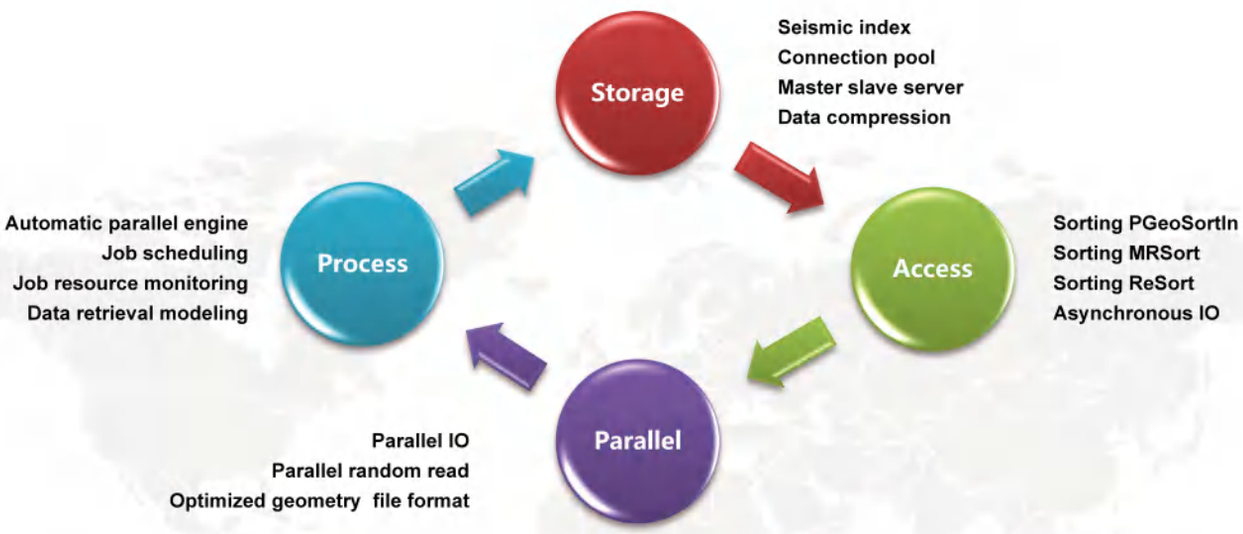
10Hz FWI

Updated velocity model through FWI

GEOEAST-IECO PLATFORM

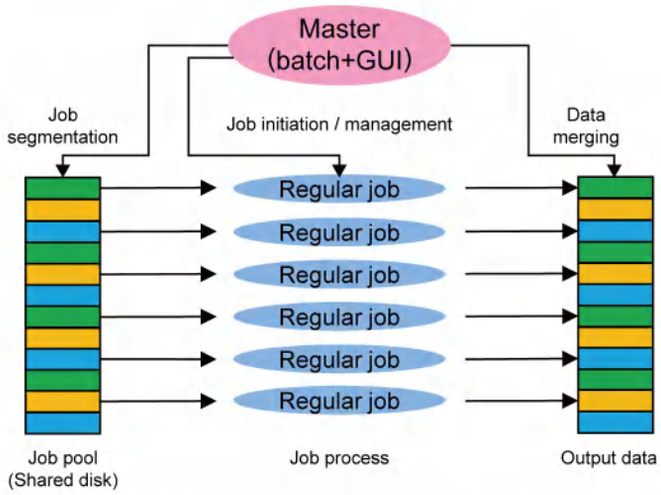
PB-scale massive data management

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.

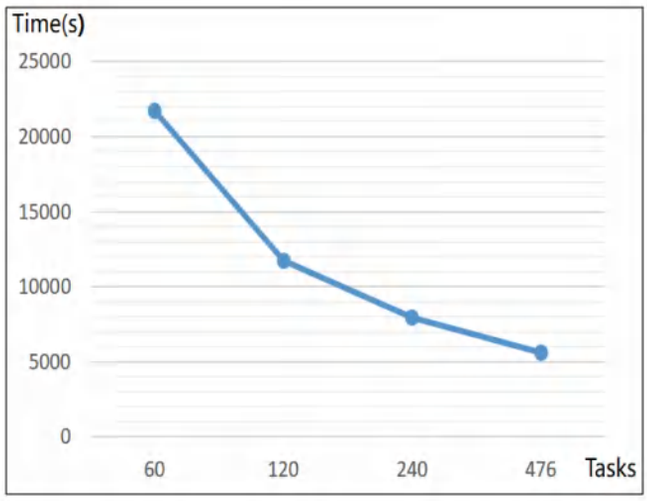


Automatic parallel engine (GeoNpe)

- 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

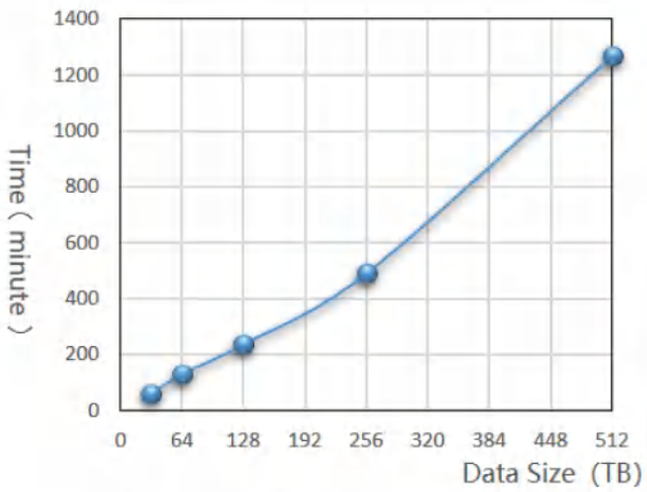


PB level data performance efficiency improvement

GEOEAST-IECO PLATFORM

Parallel trace sorting & seismic indexing

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



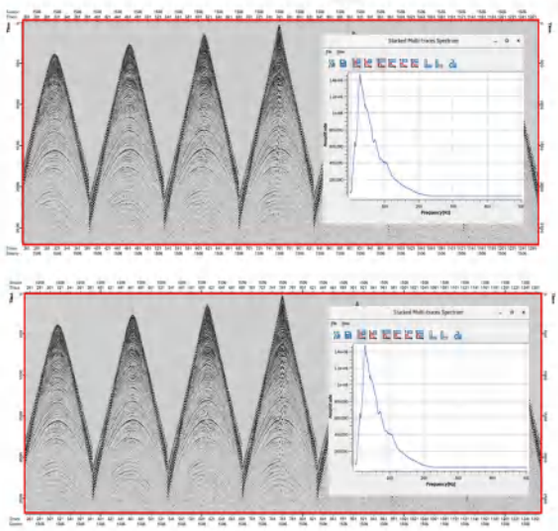
Support task migration for faulty nodes

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

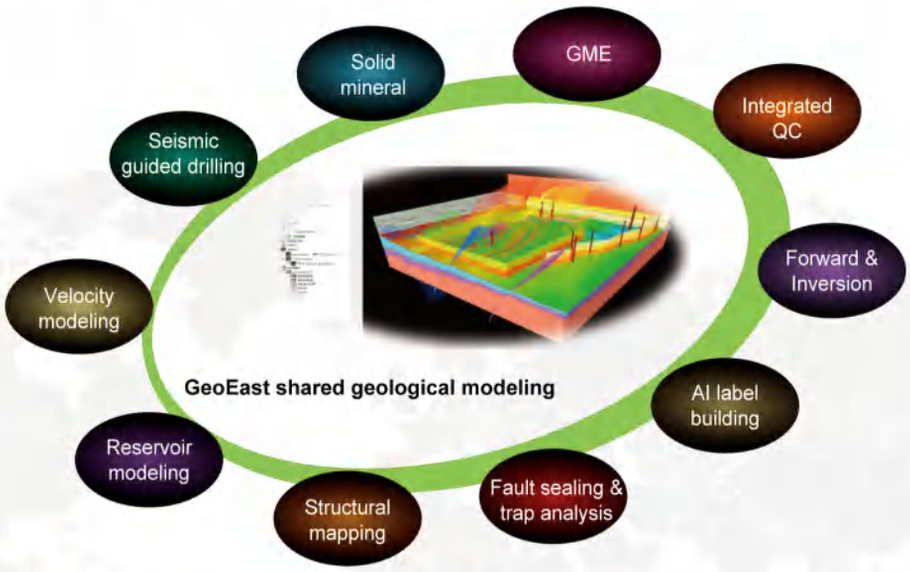
N of concurrent task	Type	Time (Original)	Time (Compression/ Decompression)	Original IO (MB/s)	Time variation
100	Read data	0:59:31	0:50:55	177	Reduce14.45%
100	R&W data	1:27:31	1:13:24	120	Reduce16.13%
50	R&W data	1:08:13	1:02:56	154	Reduce7.79%
1	R&W +Calculate	67:54:18	68:03:57	2.58	Increase0.24%,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

Effectively alleviate cluster storage IO load and improve performance

GEOLOGICAL MODELING

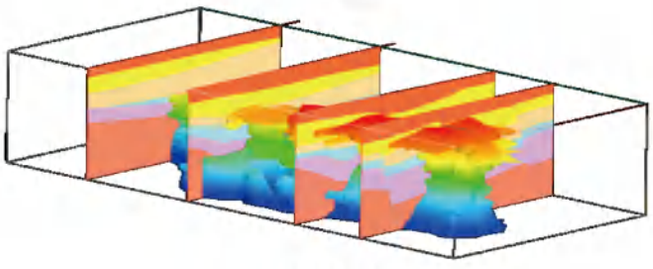
Shared geological modeling platform

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.

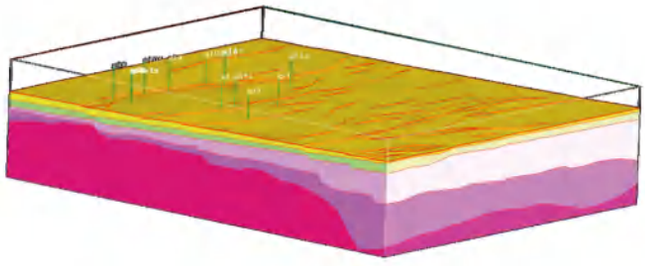


Sample application scenarios

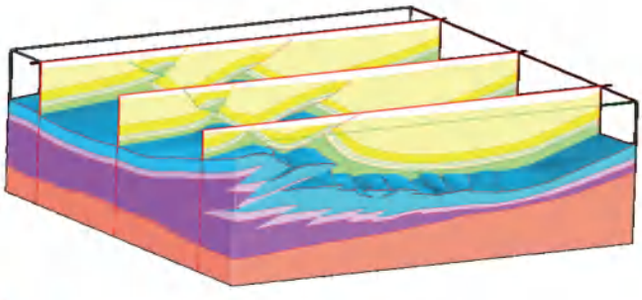
The shared modeling platform can applied in seismic, from data acquisition through interpretation, GME, solid mineral and reservoir development. It has been widely applied in seismic inversion initial model building, property modeling, forward modeling, geological anomalous body modeling, and geological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



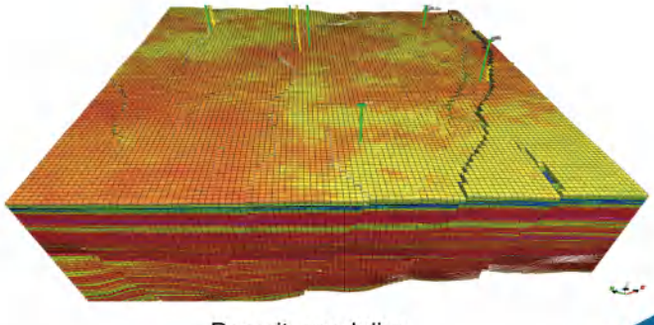
Solid mineral



Complex fault blocks



Overthrust structure

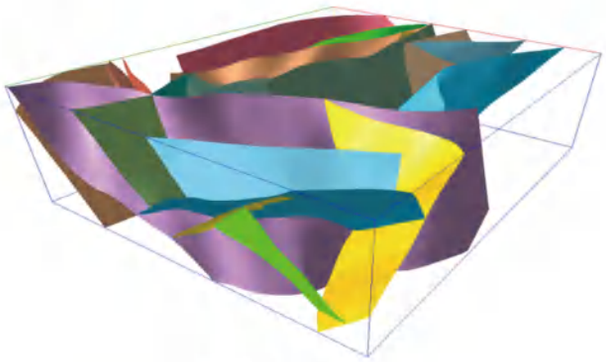


Porosity modeling

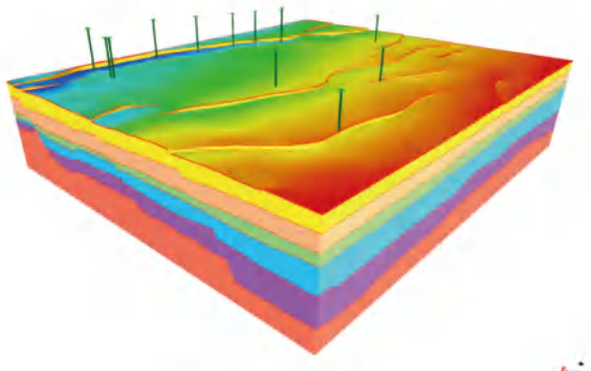
GEOLOGICAL MODELING

Structure model building

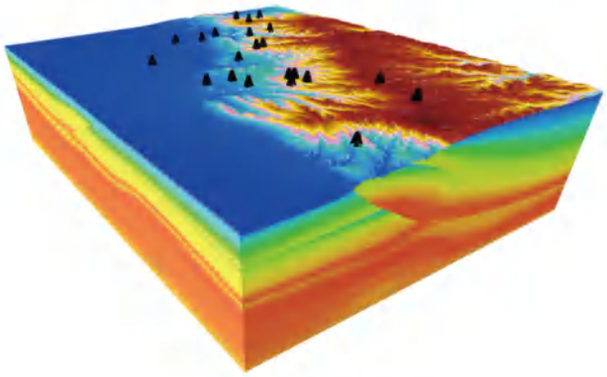
GeoEast provide an integrated interpretation and modeling functions. It offers a user-friendly approach in modeling complex structures such as normal and reverse faults, unconformities, etc.



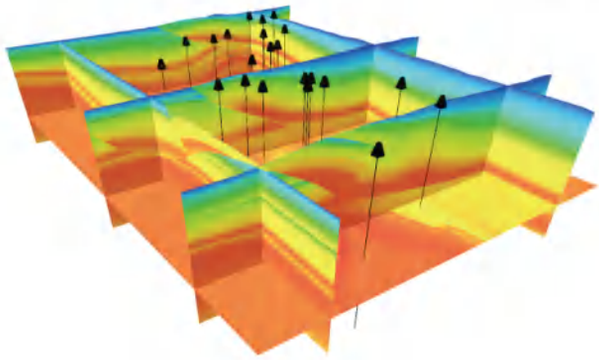
Fault surface model



Structure model



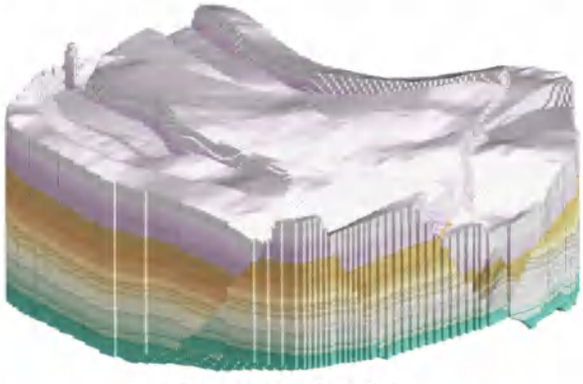
Velocity model



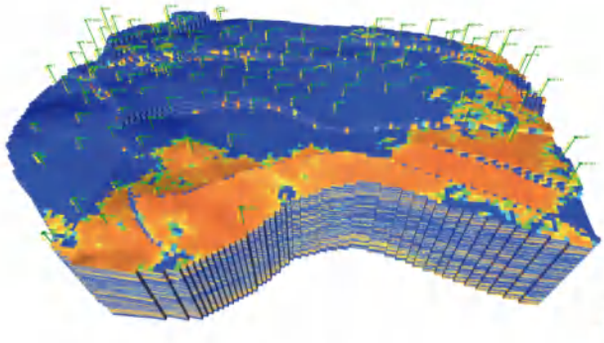
Model QC

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

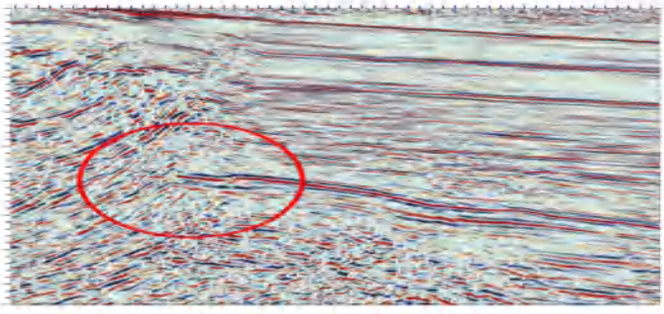
HIGH-ACCURACY PRE-STACK IMAGING

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. These imaging methods have very high computational efficiency.

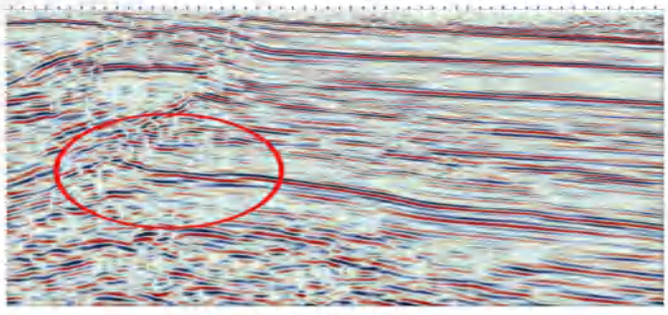
Migration Algorithm	Gather Output	GPU	Media	Inverse Q	Least-Squares Migration
RTM	ODCIG, ADCIG	✓	TTI, TORT	✓	✓
Kirchhoff	OVT, ODCIG ADCIG	✓	TTI, TORT	✓	✓
Gaussian Beam	OVT, ODCIG ADCIG		TTI, TORT	✓	✓
One-way Wave Equation	OVT, ODCIG ADCIG		TTI	✓	✓

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.



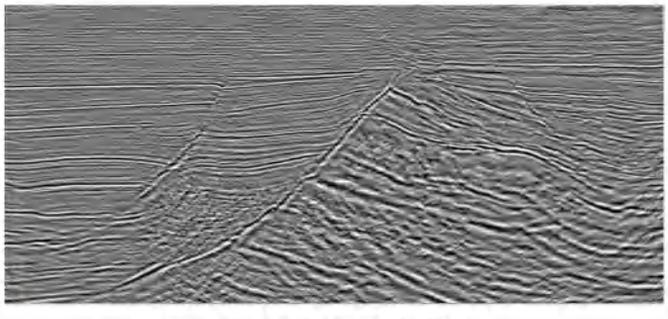
Kirchhoff PSDM image



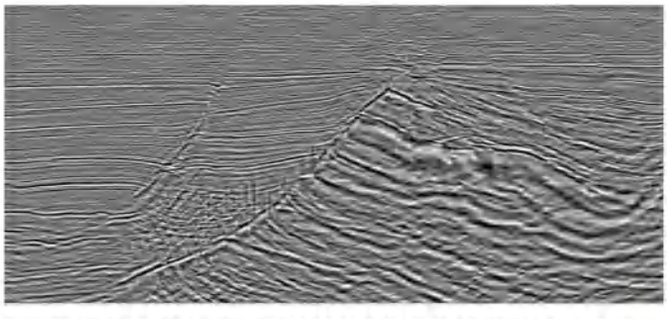
RTM PSDM image

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

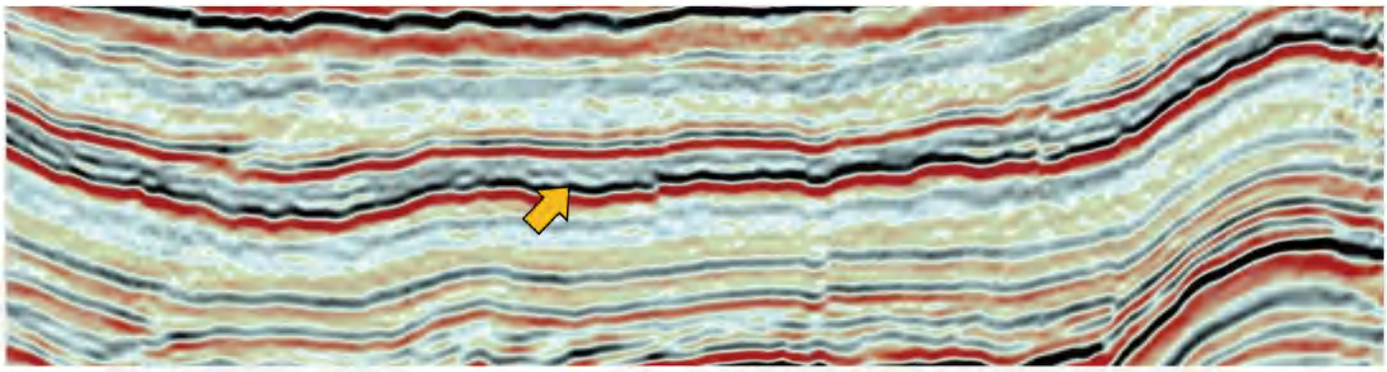


Gaussian beam PSDM image from another software

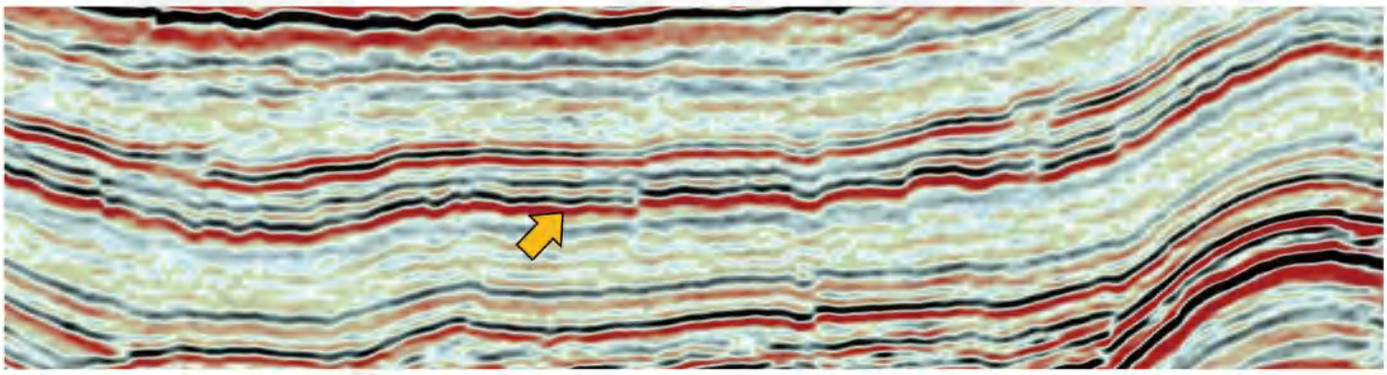
HIGH-ACCURACY PRE-STACK IMAGING

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.



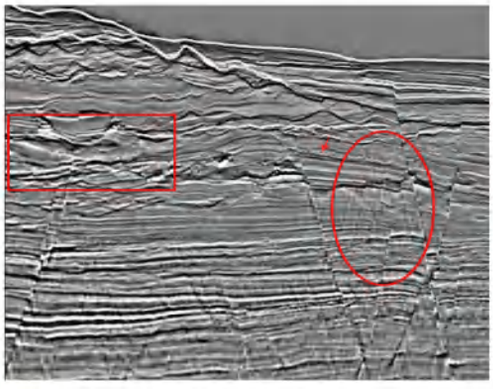
Conventional PSTM image



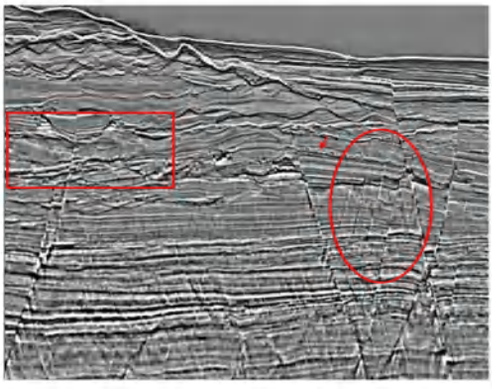
Q PSTM image

Least-squares migration

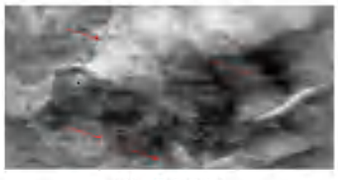
GeoEast provides least-squares migration (LSM) techniques of Kirchhoff, one-way and two-way wave equation algorisms. With these LSM techniques, seismic images can be effectively improved in terms of not only in resolution but also in illumination.



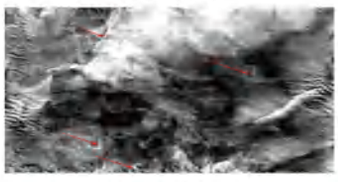
Kir-PSDM



LS-Kir-PSDM



Kir-PSDM

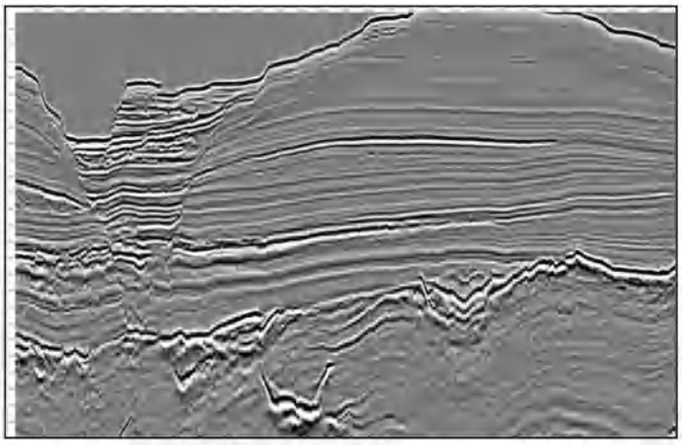


LS-Kir-PSDM

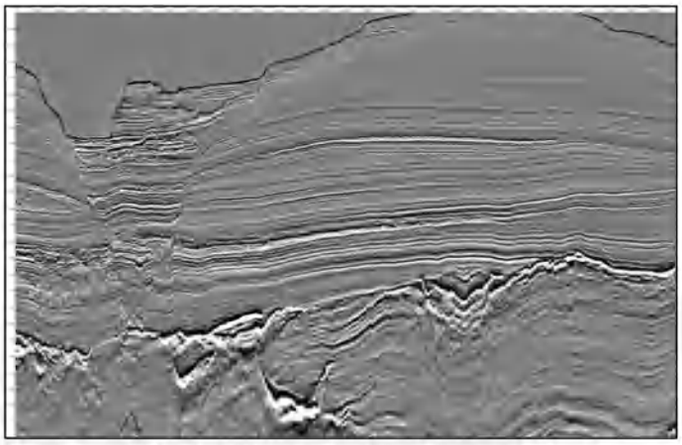
MARINE DATA PROCESSING

Streamer data processing

For streamer data processing, GeoEast provides a complete suite of processing functions, such as denoising, broadband processing, demulitple, velocity analysis, migration etc. It is available for different water depth data.



Section after conventional processing



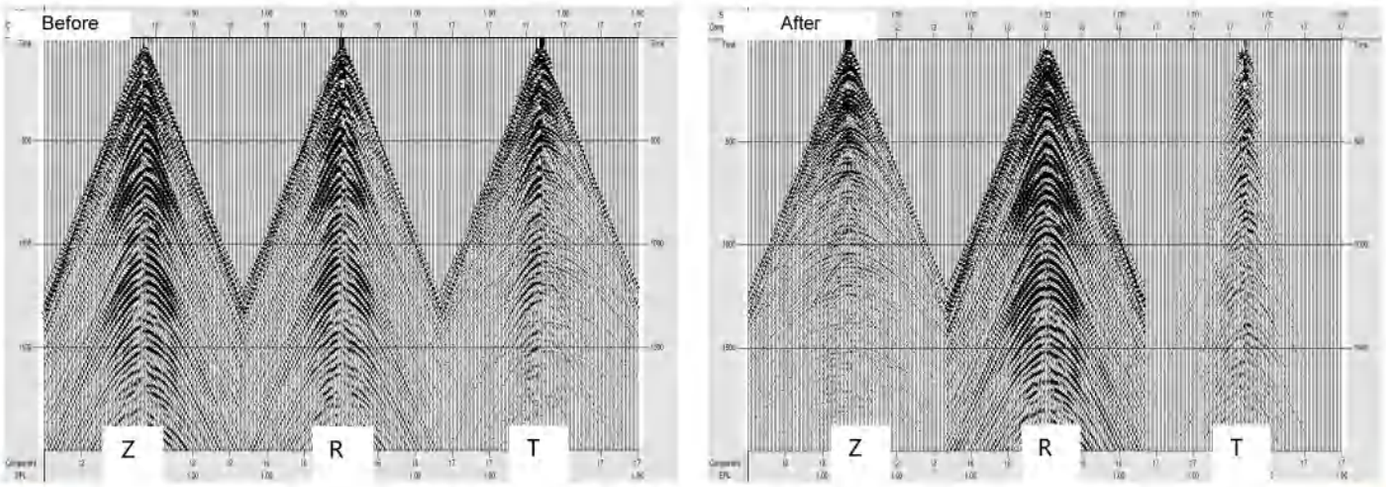
Section after broadband processing

Ocean bottom node(OBN) data processing

GeoEast has developed an integrated solution of P wave, including, geophone reorientation, PTC simultaneous inversion, directional designature, Vz noise suppression in the wavelet domain, cross-ghost up-down wavefield separation, SRME of OBN and streamer, and dual-datum modeling migration and so on. It can realize all the processing, from denoising, wave-field separation to migration.

Geophone re-orientation

The data-based three component analysis and reorientation do not depend on the field acquisition parameters and can check the correctness of the field orientation and reduce the impact caused by the placement direction.



The gather before and after geophone re-orientation

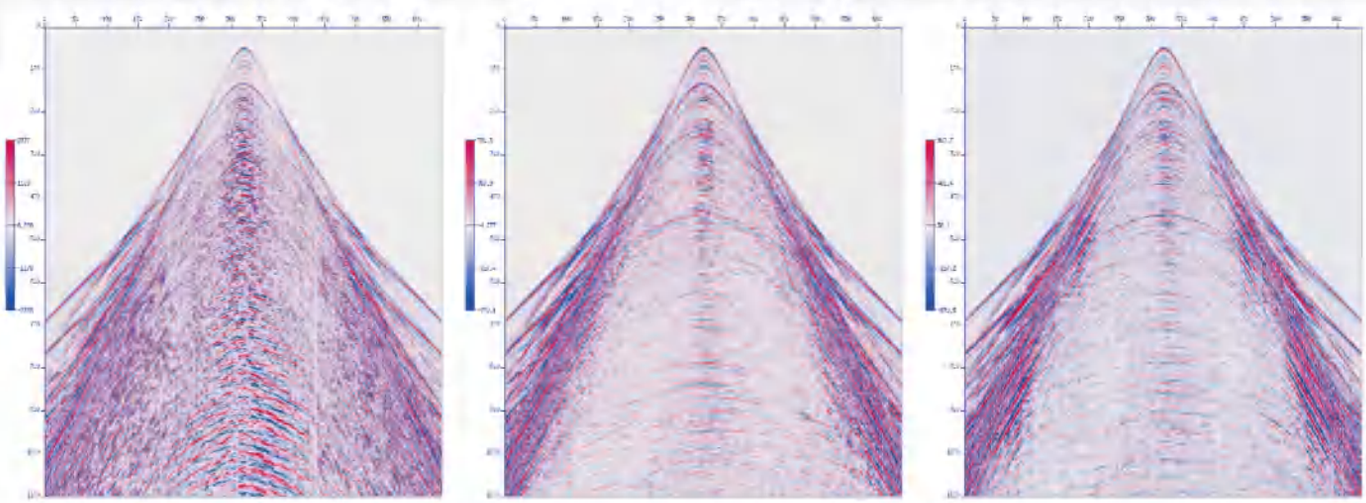
MARINE DATA PROCESSING

Ocean bottom node(OBN) data processing

GeoEast has developed an integrated solution of P wave, including geophone reorientation, PTC simultaneous inversion, directional designature, Vz noise suppression in the wavelet domain, cross-ghost up-down wavefield separation, SRME of OBN and streamer, and dual-datum modeling migration and so on. It can realize all the processing, from denoising, wave-field separation to migration.

Vz denoising

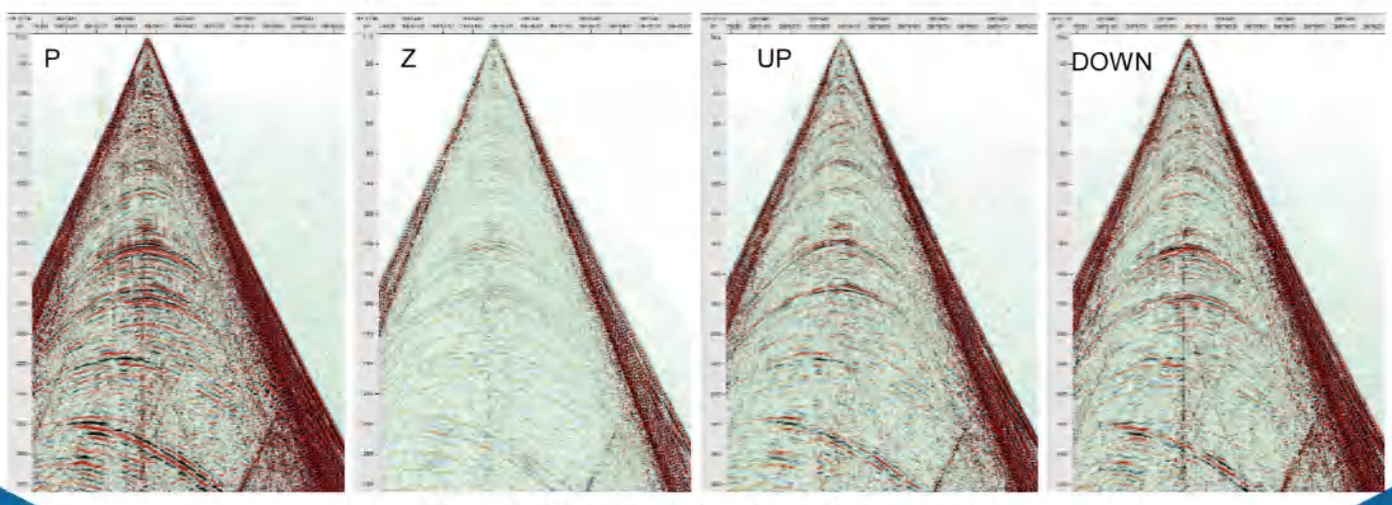
Pattern recognition Vz denoising method, DTCWT-domain Vz denoising method etc. can effectively eliminate the leakage of shear wave in Z component due to the inconsistency of P wave propagation direction and S wave polarising direction.



The gather before and after Vz denoising

Wavefield separation

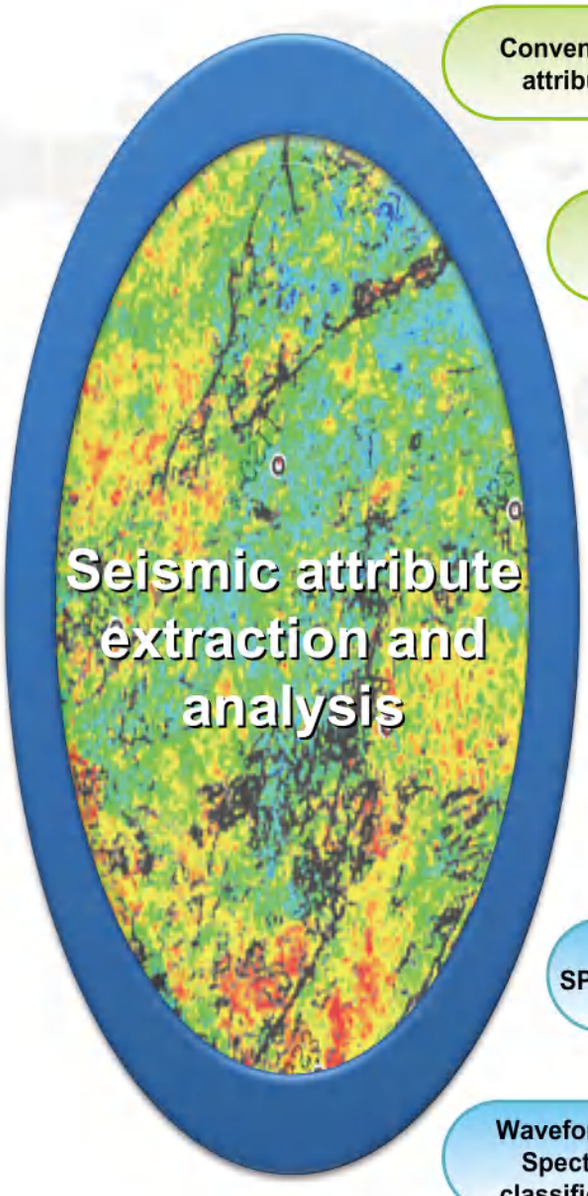
The wavefield separation methods create the up-going and down-going wavefields from the P and Z compoents, and prepare for the following processsing. The methods include minimum energy method, cross ghosting method, wavelet domain method etc.



The gather before and after wavefield separation

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

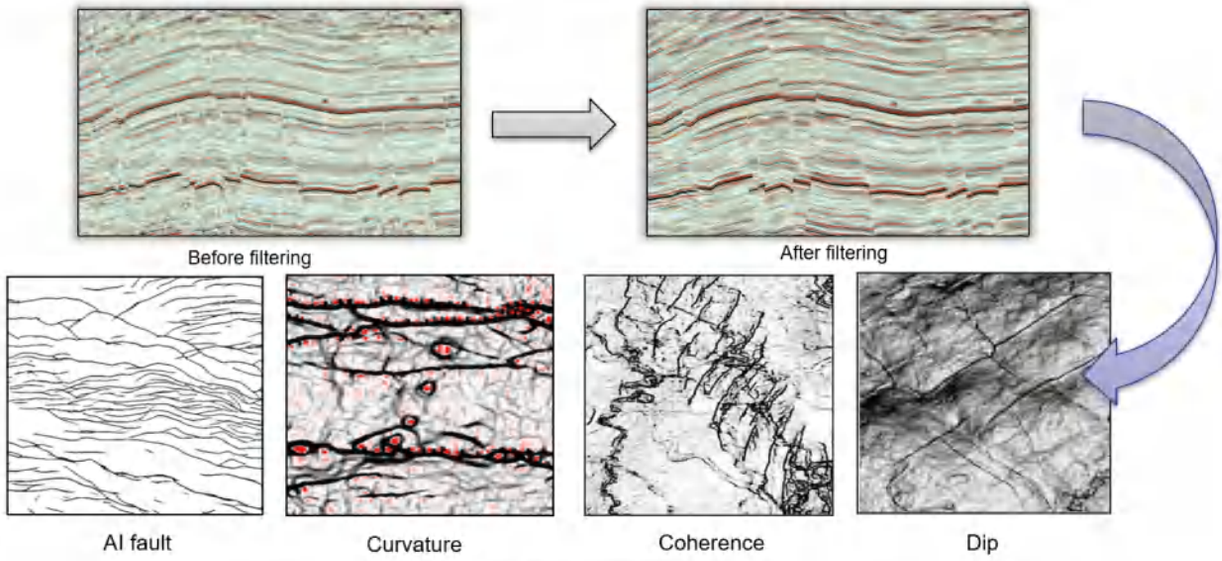
SPR without sample
- Self-organized manual analysis (SOMA)
- C-means algorithm
- Hierarchy classification (HC)
- Rival penalized competitive learning (RPCL)

Waveform and Spectrum classification
- Waveform classification
- Spectrum classification

MODERN SEISMIC ATTRIBUTE EXTRACTION AND ANALYSIS

Fault identification

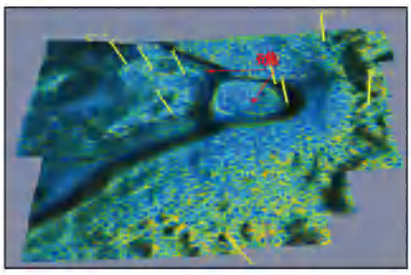
On the basis of structure-oriented filtering, multi-scale volume curvature, coherence, variance, edge detection, dip, ant volume, fault index, attribute fusion and other technologies are used to finely depict subtle faults.



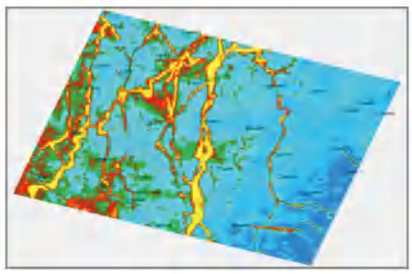
Attribute assist fault identification

Various types of reservoir prediction

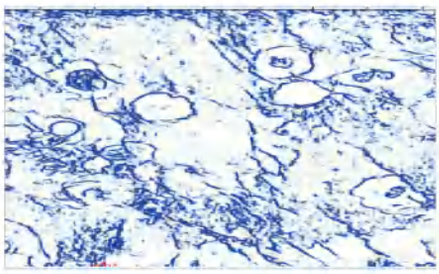
GeoEast provides a complete technique suite for diversified reservoir prediction. The modern seismic attribute and AI based attribute analysis functions are used for various type of reservoir characterization such as subtle fault or fracture, karst caves, channel, reef, volcano, and so on.



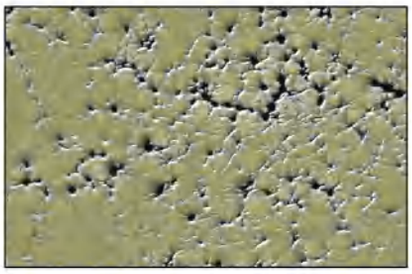
Reef



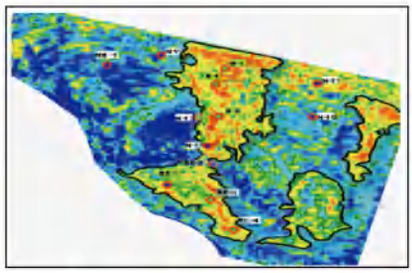
Channel



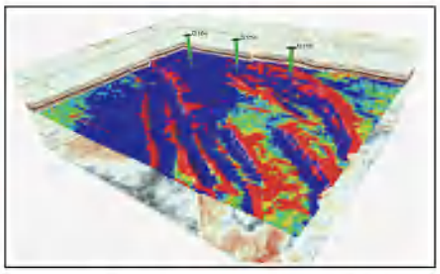
Volcano



Karst cave



Hydrocarbon detection



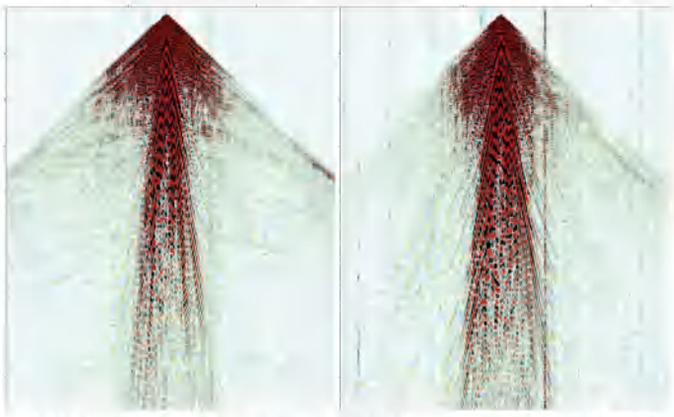
Sedimentary facies analysis

MULTI-COMPONENT PROCESSING

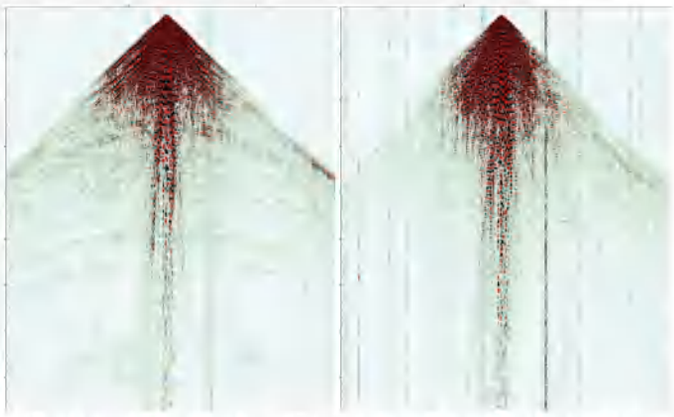
A comprehensive suite of functions for multi-component data processing and interpretation are available, including multi-component data preprocessing, PS-wave static correction, VTI multi-parameter iterative analysis, azimuthal anisotropic parameter estimation, VTI prestack time/depth migration, S-wave splitting analysis, multi-component horizon matching, multi-wave joint inversion and full-wave joint attribute extraction etc., which are well able to meet the processing demands of explorations such reservoirs as tight sandstone, carbonate rock, shale gas and heavy oil.

Polarization filtering

By utilizing the differences in polarization characteristics between desired waves and noise waves, the surface wave energy in multi-component seismic data is suppressed, thereby improving the signal-to-noise ratio of pre-stack multi-component seismic data.



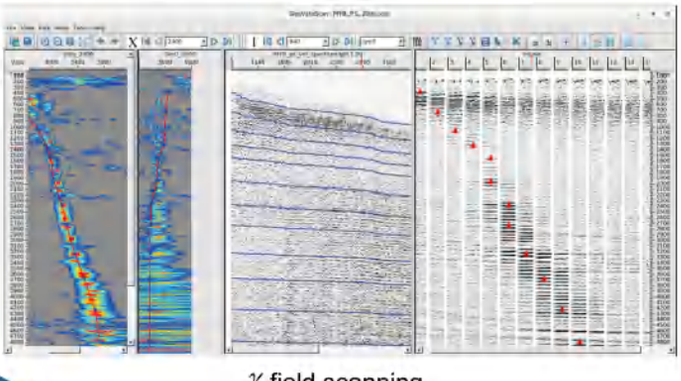
Z (left) and R (right) component before polarization filtering



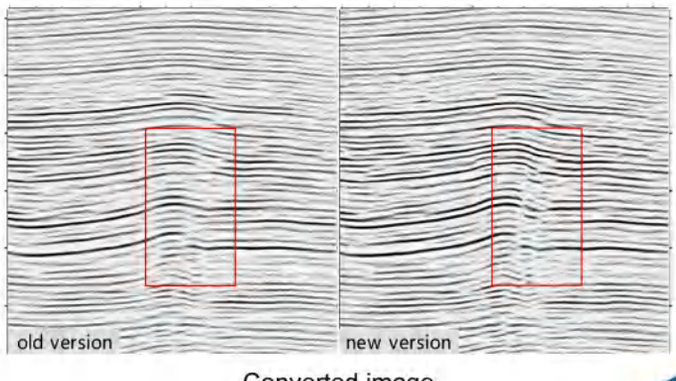
Z (left) and R (right) component after polarization filtering

VTI anisotropy multi-parameter iterative analysis

This technique features VTI bispectrum analysis, four-parameter analysis, and multi-azimuth multi-parameter analysis. The new version introduces gama field scanning function, which effectively improves the imaging of small faults in converted waves section.



γ field scanning

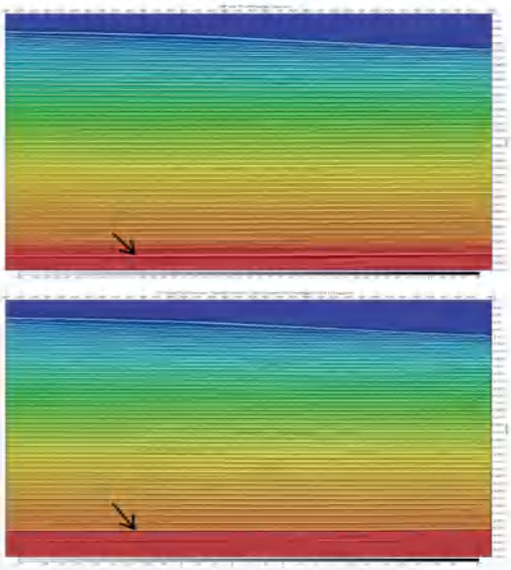


Converted image

MULTI-COMPONENT PROCESSING

Joint P and S wave tomography technology

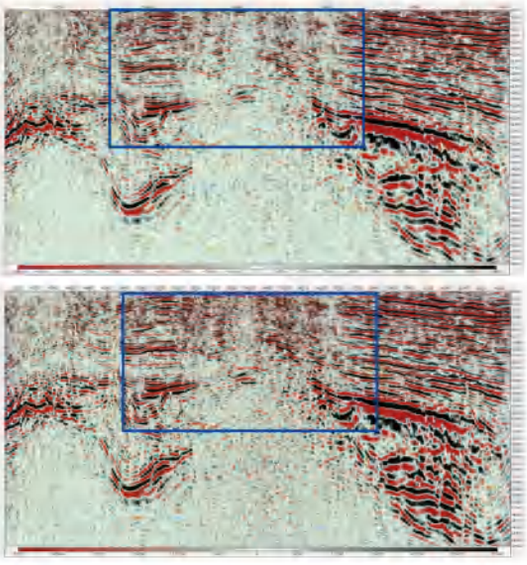
A joint tomography technology based on the constraint of imaging depth differences between P-waves and S-waves has been developed. The algorithm takes into account the asymmetry of source-receiver positions in converted-wave imaging gathers, which further improves the stability and accuracy of the algorithm.



► The converted-wave migration section before (upper) and after (lower) the S-wave velocity update, overlaid with the true Vp velocity

Converted-wave migration technology

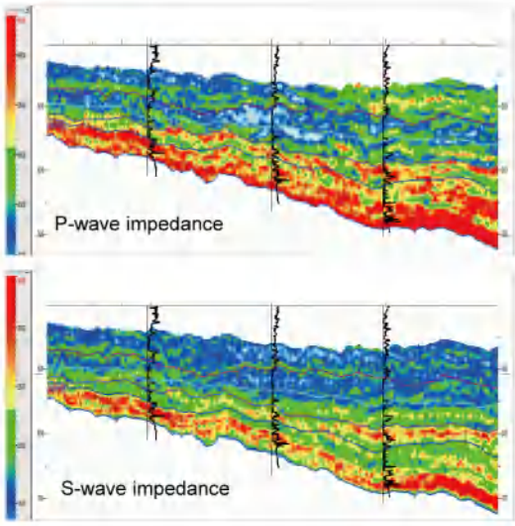
It supports converted-wave imaging in topographically varying surface (dual-datum) environments, incorporating VTI, TTI, and TORT anisotropy as well as viscoelastic media. The imaging accuracy and efficiency remain at the forefront of the industry.



◄ Comparison of conventional converted waves depth migration of (upper) and converted waves Q-compensated depth migration (lower)

Multi-component inversion: from qualitative to quantitative

The key technical bottlenecks were broken through of converted wave AVO inversion, elastic impedance inversion and multi-component post stack/pre-stack joint inversion. A series of multi-component inversion techniques have been formed from qualitative to quantitative.

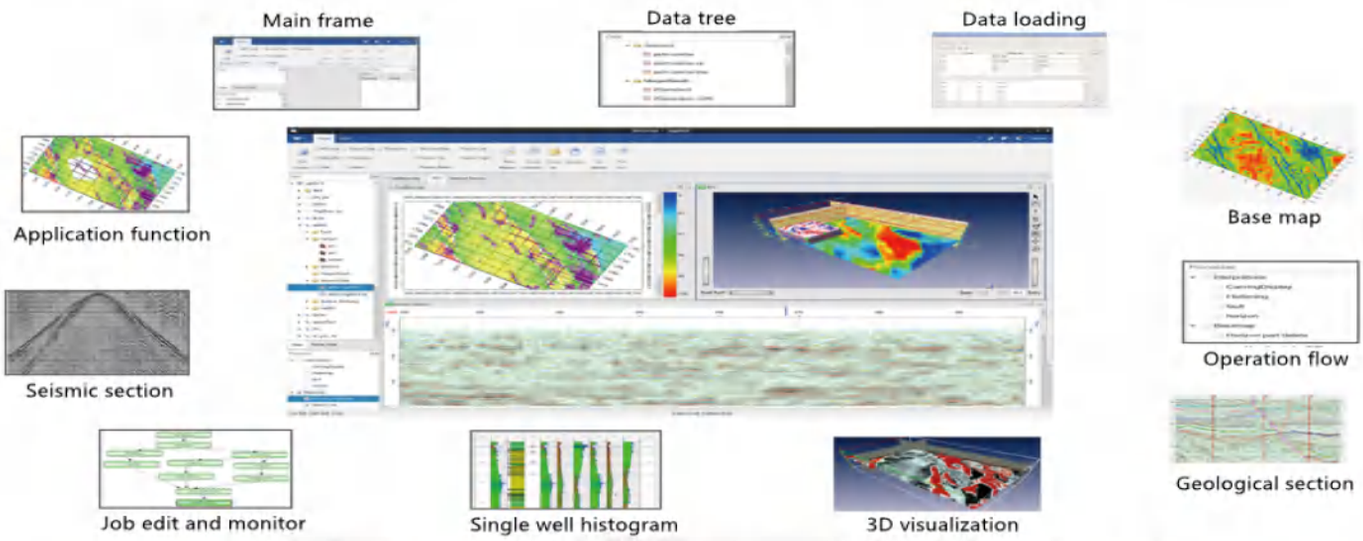


► Pre-stack joint inversion and interpretation results of field multi-component data

OPEN SOFTWARE DEVELOPMENT FRAMEWORK

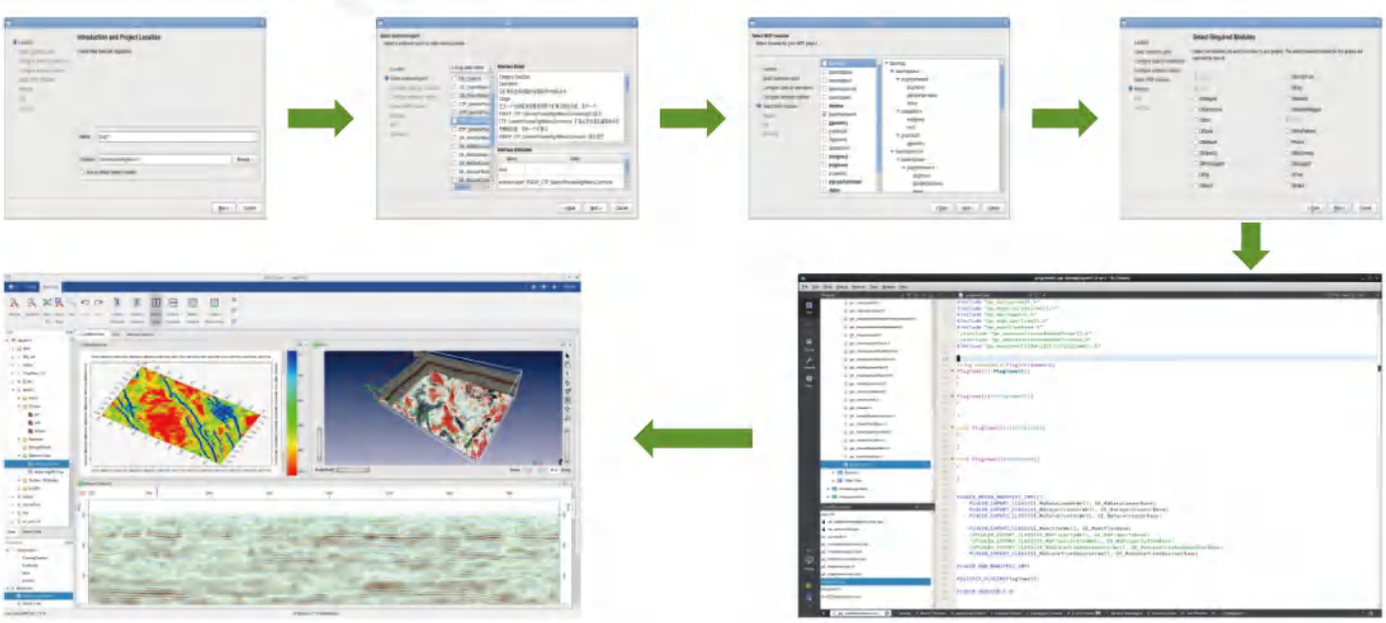
Interactive development framework technology based on typical scenarios

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

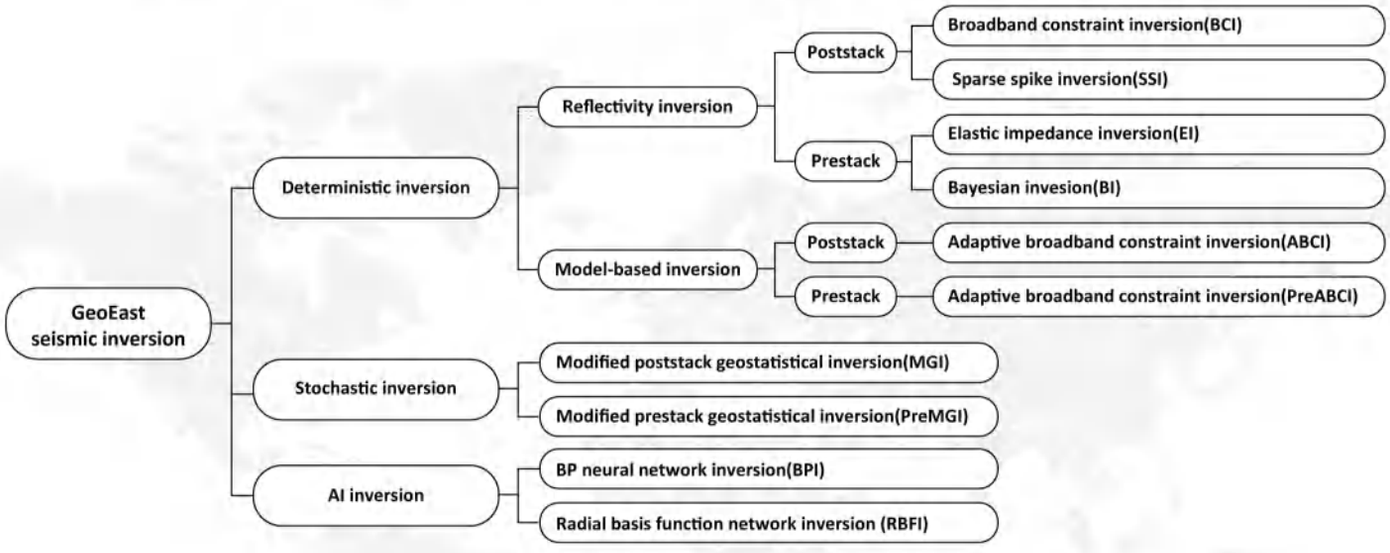
An IDE tool is available to develop plugins and functions, which improves the programming efficiency and quality significantly.



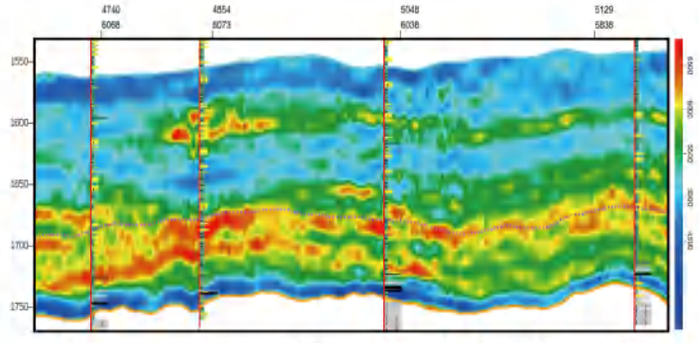
SEISMIC INVERSION

Family of seismic inversion techniques

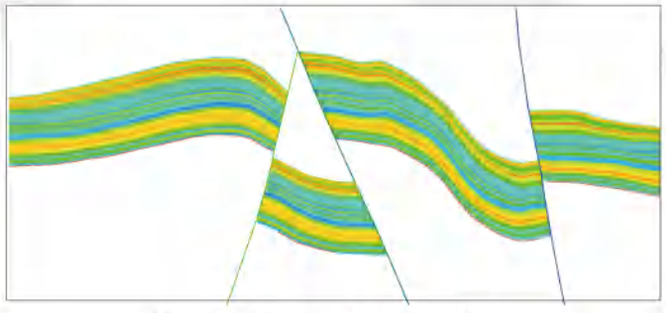
GeoEast provides a series of seismic inversion techniques, ranging from post-stack to pre-stack, from deterministic to stochastic, and from conventional to AI-aided, which meet the needs of reservoir prediction including thin clastic rocks, heterogeneous reservoirs, and complex structural reservoirs,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



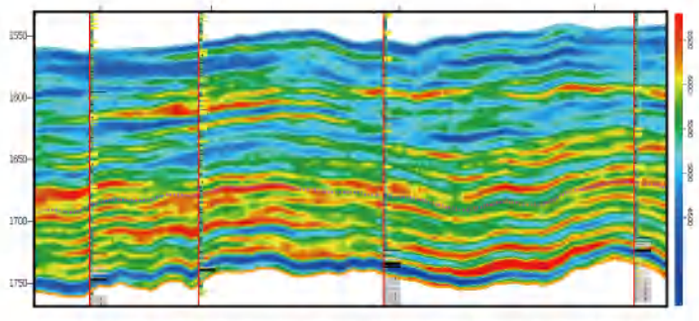
GeoEast seismic technical series



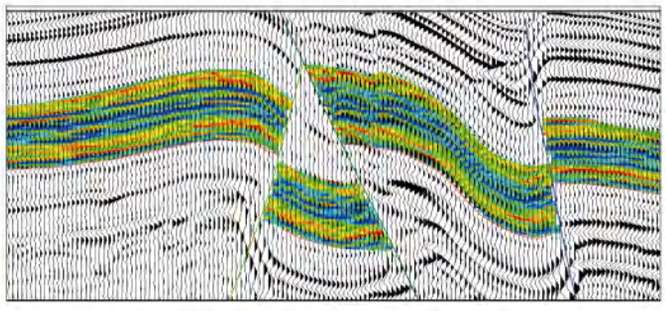
Conventional prestack inversion of S-impedance(BI)



Complex structure initial modeling



High resolution inversion of S-impedance(PreMGI)

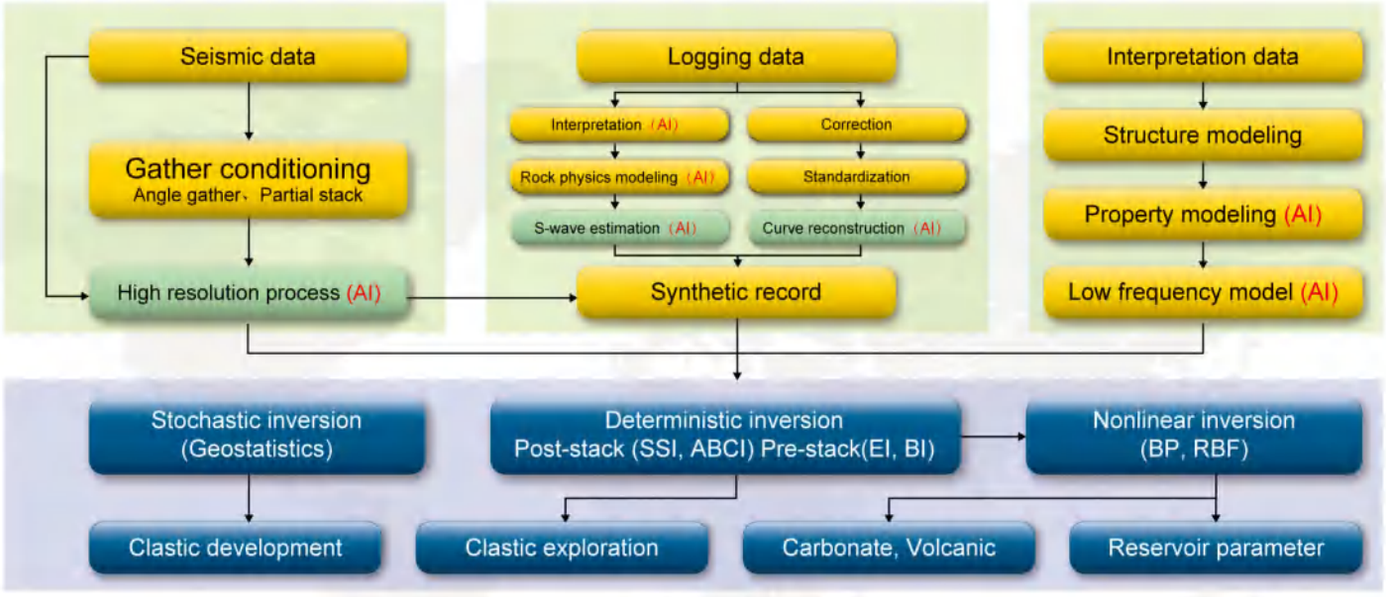


Complex structure constrained inversion

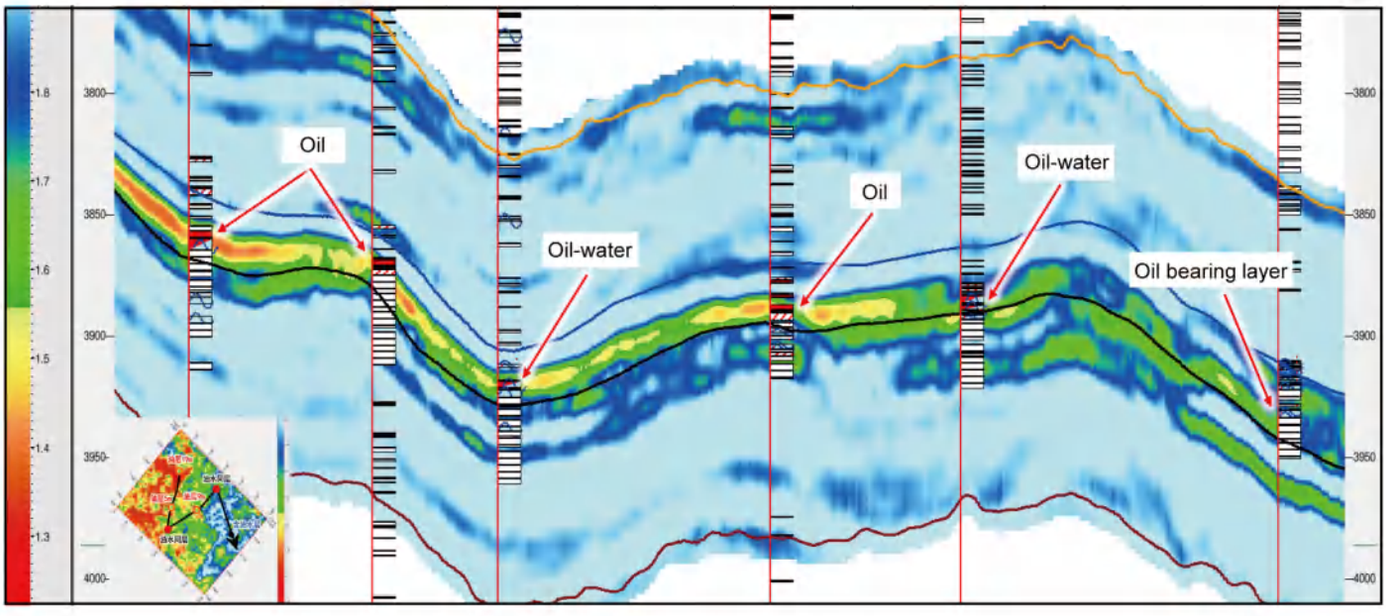
SEISMIC INVERSION

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

VELOCITY MODEL BUILDING FOR DEPTH IMAGING

Depth-domain velocity modeling technology

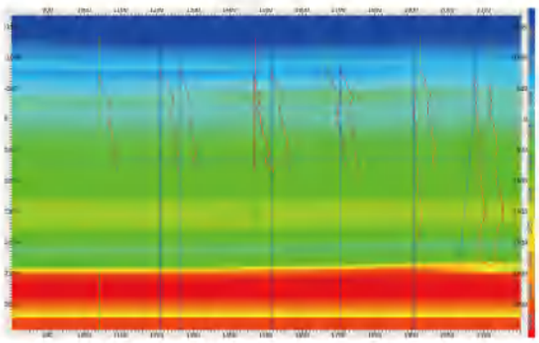
GeoEast-Diva supports 2D/3D P-wave and converted-wave data for onshore and offshore applications. It features TTI/TORT anisotropy, Q modeling, and well information integration.

Powered by OVT full-azimuth, Gaussian beam, fault-controlled and well-controlled tomography, it meets pre-stack depth migration modeling demands for diverse geological structures and data resolutions globally.

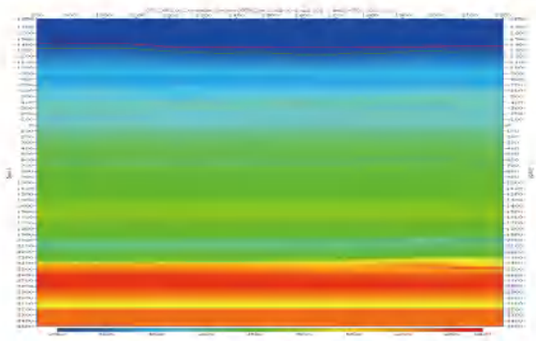
GeoEast-Diva

Geostatistical initial velocity modeling

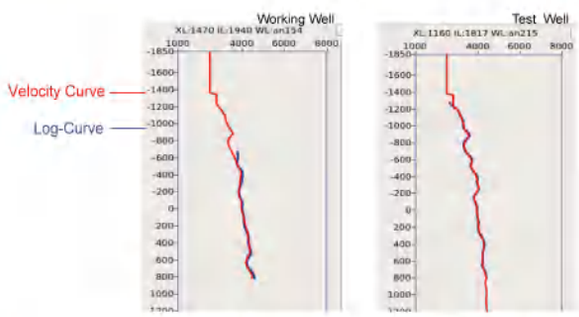
A new geostatistical initial modeling technique based on well interpolation is developed. Using the Kriging spatial interpolation algorithm constrained by structural information and well velocities, it achieves optimal attribute estimation in a geostatistical framework and constructs a geologically more meaningful velocity model. Applications to real data demonstrate good performance.



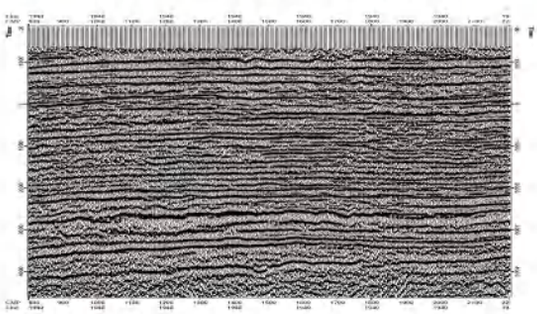
Well logs



Geostatistical initial velocity field



Velocity curve–well log comparison

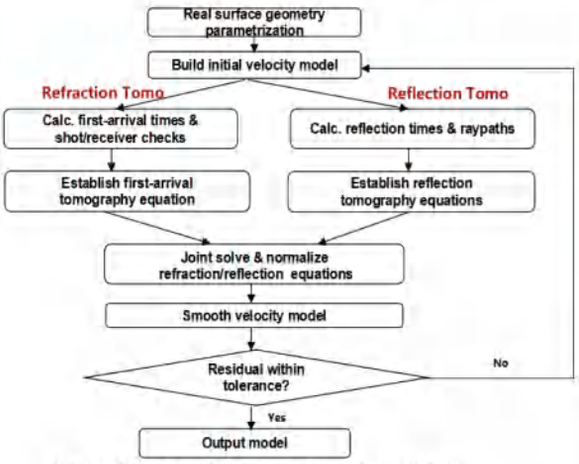


Initial velocity PSDM profile

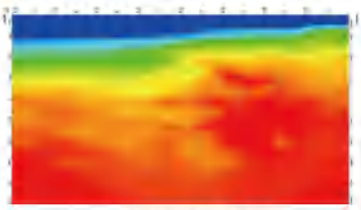
VELOCITY MODEL BUILDING FOR DEPTH IMAGING

Joint refraction-reflection tomography

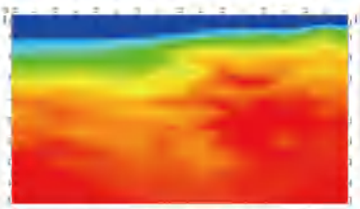
To address the limited accuracy of reflection tomography in shallow layers and insufficient illumination depth of first-arrival tomography in complex areas, we developed a joint refraction-reflection tomography method. By jointly inverting refraction and reflection traveltime equations, it complements the advantages of both, significantly improving full-depth velocity modeling accuracy and eliminating systematic errors from manual velocity splicing.



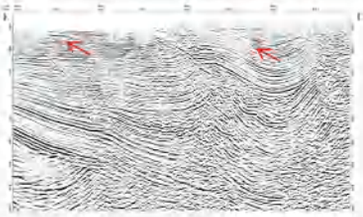
Joint refraction-reflection tomography workflow



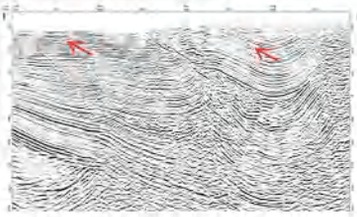
Velocity by Refl-Tomo



Velocity by Joint-Tomo



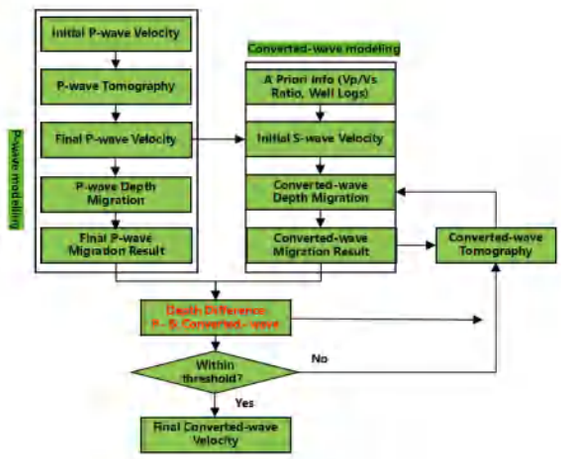
PSDM-Stk with Refl-Tomo velo



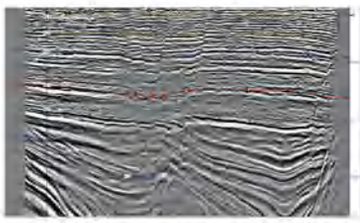
PSDM-Stk with Joint-Tomo velo

Joint P- and converted- wave tomography

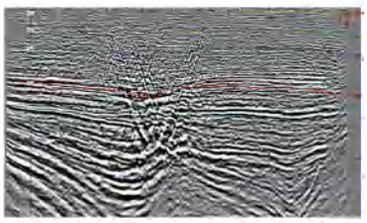
We propose a converted-wave tomography method constrained by depth differences between P-wave and converted-wave imaging profiles.Using multi-component seismic data and asymmetric common-image gathers for high-precision inversion, this method improves converted-wave velocity modeling accuracy and depth consistency of P- and S-wave imaging.



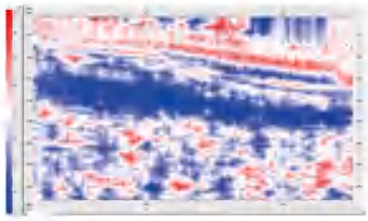
Joint Tomographic Modeling



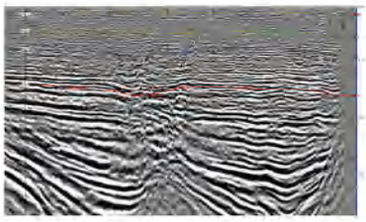
PSDM-Stk with P-wave velo



PSDM-Stk with S-wave initial velo



Depth difference

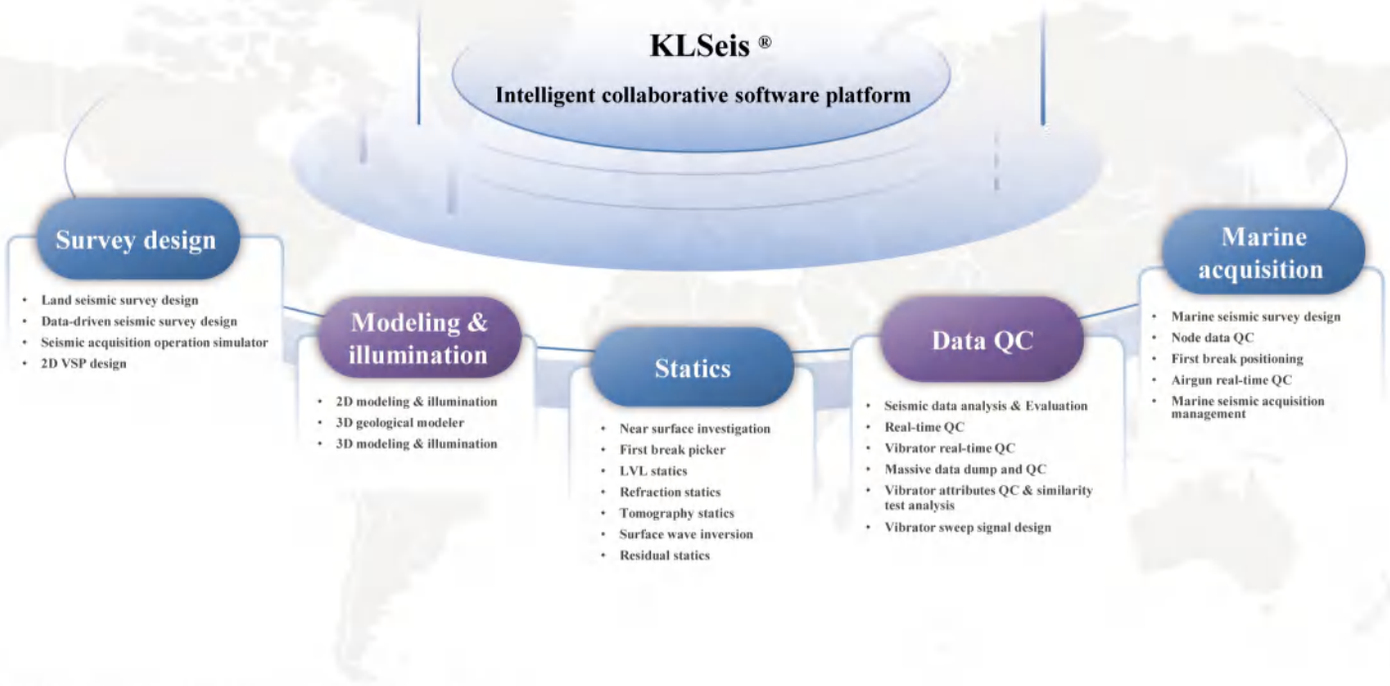


PSDM-Stk with S-wave updated velo

SEISMIC DATA ACQUISITION SOFTWARE SYSTEM

Overview

KLSeis® contains 5 packages: Survey Design, Modeling & Illumination, Statics, Data QC and Marine Acquisition and consists of 33 software modules, it can be used in all terrains such as land, transitional zone and marine, and is suitable for petroleum exploration, coal exploration and geology exploration. It can provide efficient and intelligent solutions to seismic acquisition.



The terrains that can be applied:

Sand dune

Loess plateau

Mountain

Gobi

Transitional zone

Deep sea

SEISMIC DATA ACQUISITION SOFTWARE SYSTEM

KLSeis

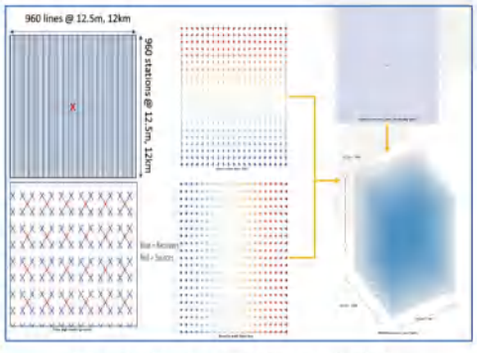
Billion level trace density geometry design & attribute analysis technique

To meet the requirements of ultra-high density projects, the billion level trace density geometry design & attribute analysis technique based on CS(Compressed Sensing) was developed.

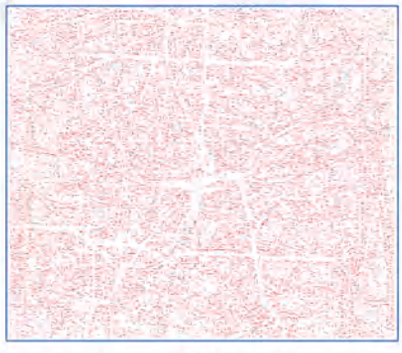
Field operation

Features

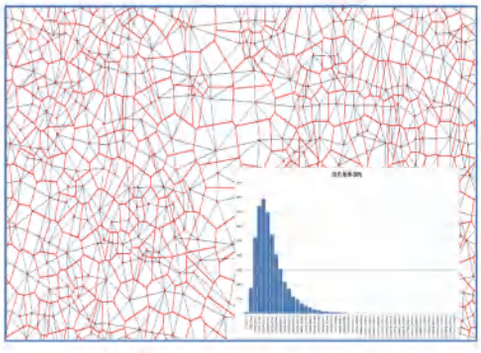
- Bilinear algorithm of rapidly constructing source & receiver relationship based on vector kernel
- Fast import of SPS relationship
- Bin attribute analysis with multidimensional spatial correlation indexing
- Compressed sensing design uniformity evaluation based on Thiessen polygons.
- Detailed workload simulation, performing Zipper design, deployment, and workload statistics



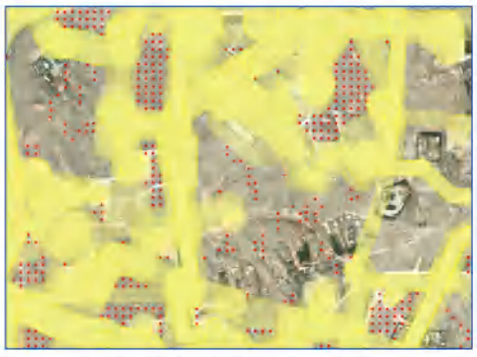
Bin attribute analysis principle



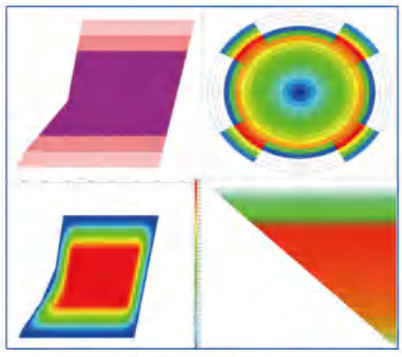
Test source point deployment



Thiessen polygon deployment



Physical point optimization



Attribute analysis for billion level trace density design

Zipper design

SEISMIC DATA ACQUISITION SOFTWARE SYSTEM

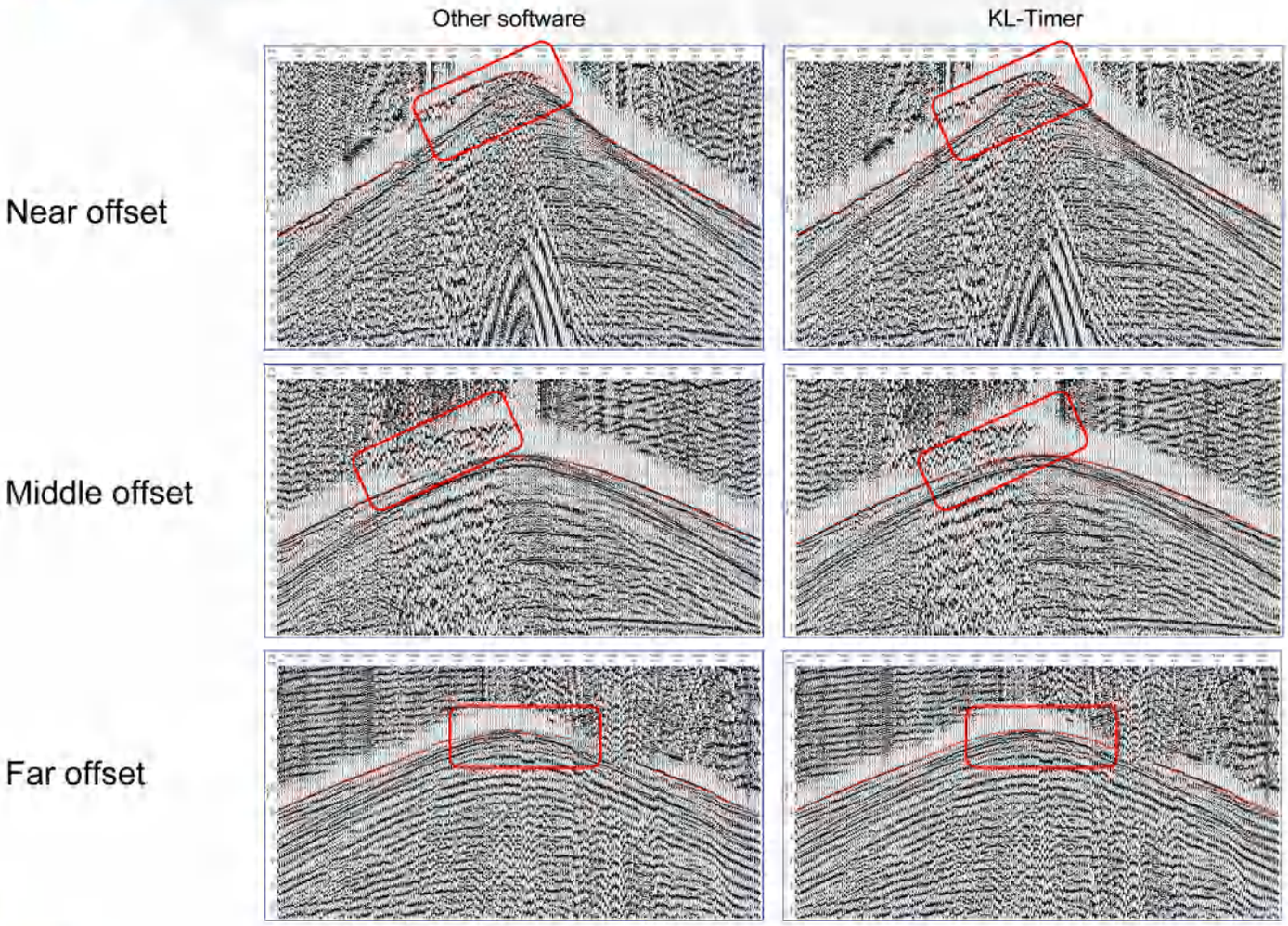
AI first break picker (KL-Timer)

KL-Timer uses seismic data to train and optimize deep network model, and then intelligently and automatically identifies and corrects abnormal first breaks to improve the accuracy and efficiency for auto-picking first breaks of massive data with low signal-to-noise ratio, which can meet the requirements for building velocity model and calculating statics.

Features

- Design multi-domain time-window and define the time-window range of first breaks.
- Intelligently detect first breaks
- Comprehensively identify abnormal first breaks
- Effectively correct abnormal first breaks

Application



SEISMIC DATA ACQUISITION SOFTWARE SYSTEM

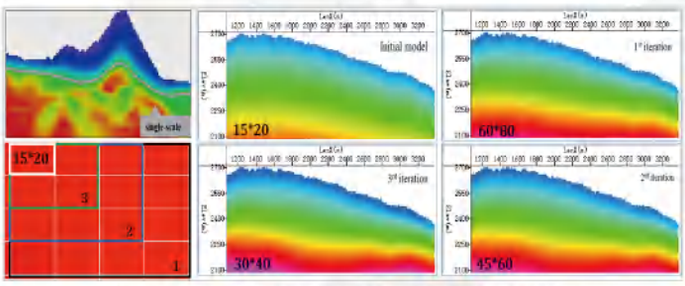
KLSeis

Multi-scale constraint tomography (KL-MCT)

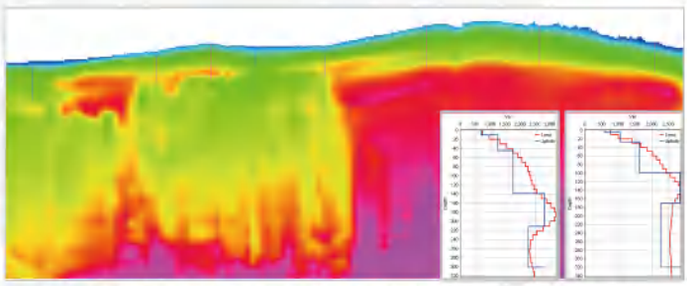
KL-MCT is used to create initial model and body constraint model based on high-precision near-surface investigation results. It utilizes multi-scale tomographic inversion techniques to provide high-precision near-surface model with stable velocity for “actual” surface offset. With the quick increase of data, KL-MCT can create the velocity model from ten billion level traces by one computer.

Features

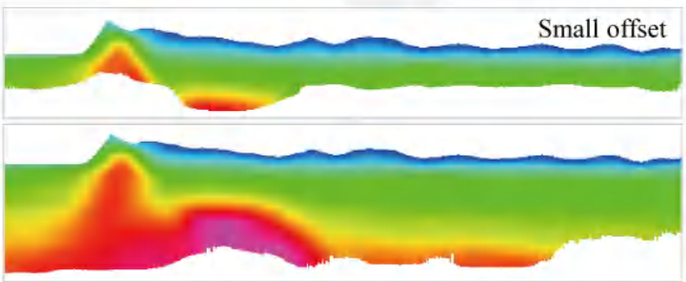
- Efficient tomography inversion calculation
- Tomography inversion technology constrained by sand dune curve
- Second inversion technology based on residual time difference
- Tomography inversion technology constrained by uphole
- Two-step method tomography
- Gradual multi-scale constraint technology



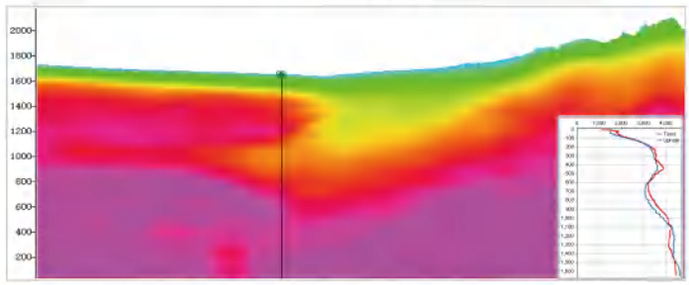
Gradual multi-scale tomography inversion



Uphole-constrained tomography inversion model with reverse velocity

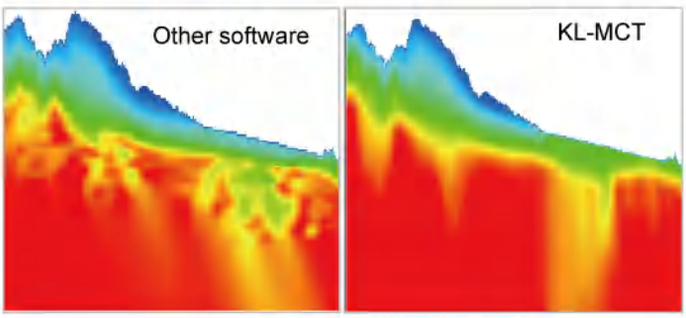


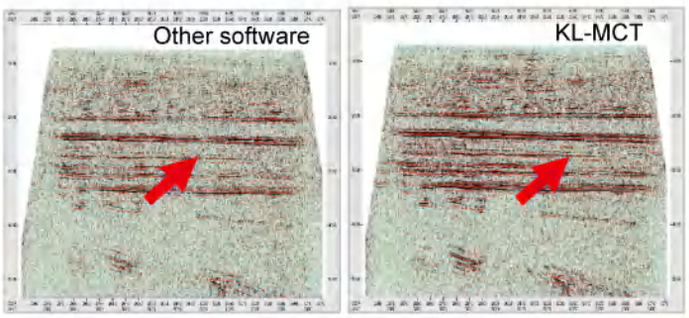
Two-step method tomography



Inversion model constrained by uphole and VSP, its depth: 1500m

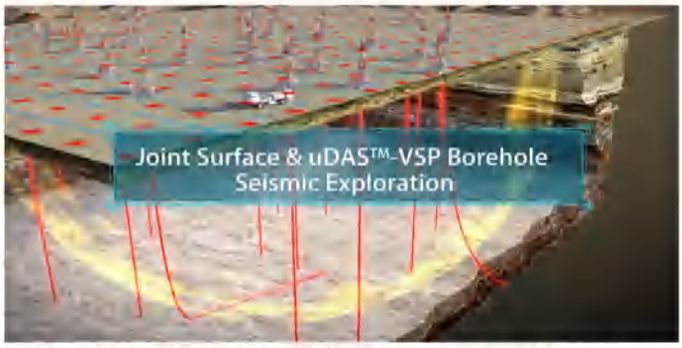
Application



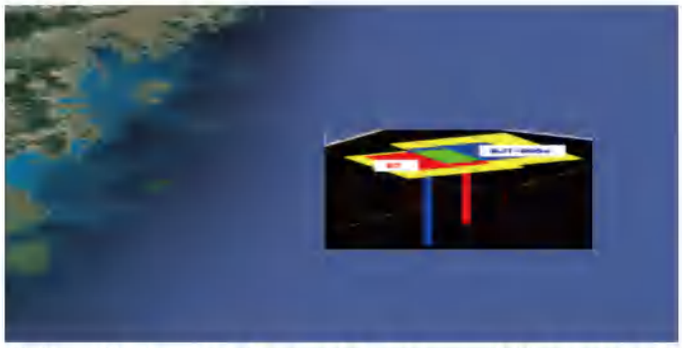


JOINT BOREHOLE–SURFACE EXPLORATION AND APPLICATIONS

The joint borehole–surface/ocean seismic technique is based on surface seismic acquisition, and simultaneously deploys fiber-optic sensing, in boreholes, enabling full well coverage, high-density, and high-coverage data acquisition.

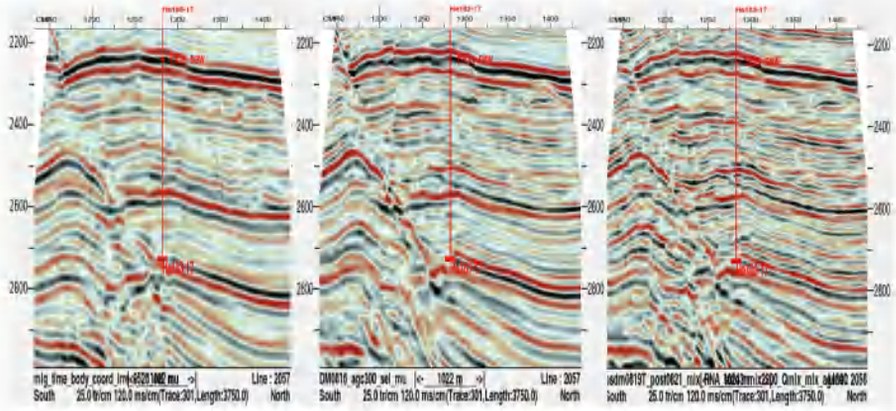


Joint borehole-surface exploration stereoscopic diagram

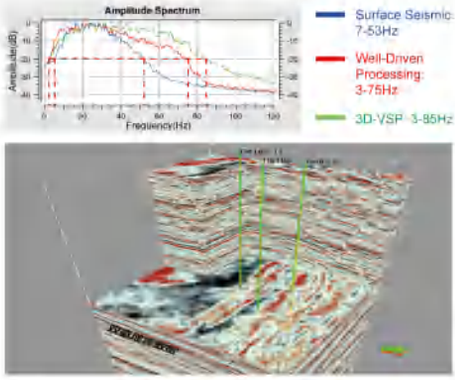


Schematic diagram of borehole-ocean acquisition coverage

A case study of surface–VSP data-driven imaging and interpretation in the shengli oilfield

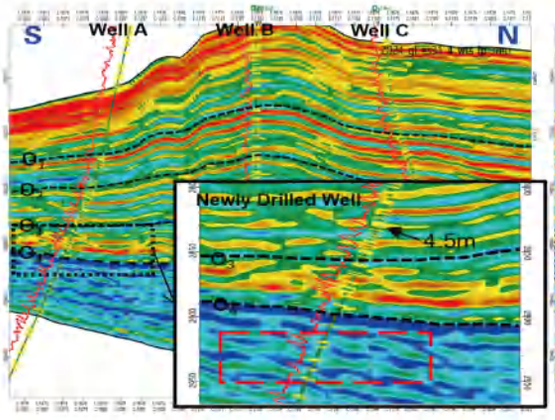


Surface seismic imaging | Well-driven imaging | 3D-VSP imaging

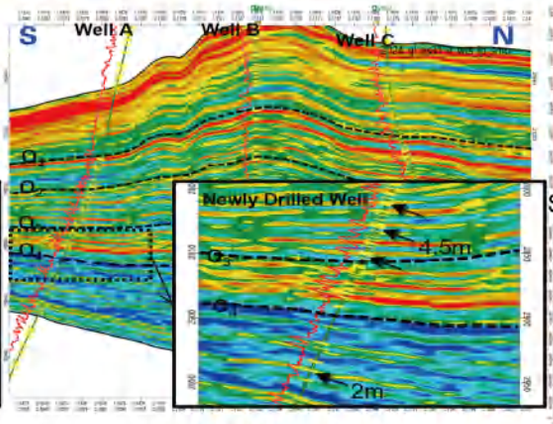


Joint VSP & surface seismic data interpretation & geological body carving

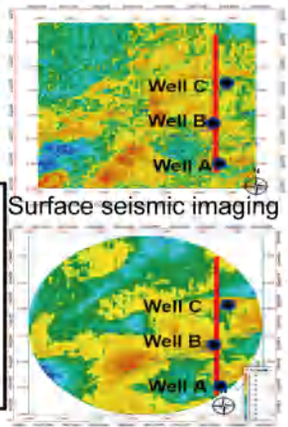
Thin sandstone formation inversion by joint surface & 3D VSP data acquisition in the jidong oilfield



Surface aeismic imaging



3D-VSP imaging



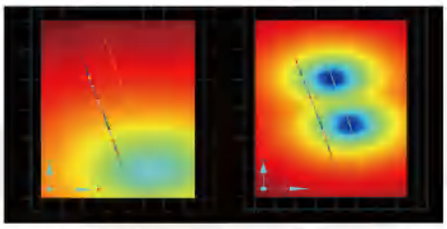
Surface seismic imaging | 3D VSP imaging

MICRO-SEISMIC MONITORING FOR HYDRAULIC FRACTURING

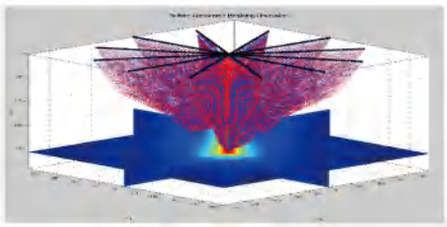
Micro-seismic monitoring technique records seismic waves generated by hydraulic fracturing, maps rock rupturing locations, evaluates fracturing results and guides the optimization of treatment parameters in real time.

Micro-seismic monitoring acquisition

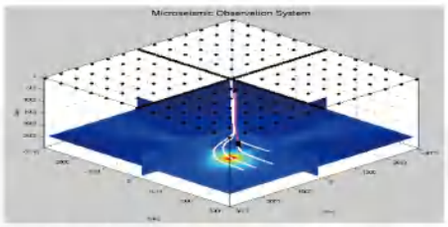
- Micro-seismic feasibility analysis
- Acquisition parameters demonstration
- Micro-seismic event location error prediction



Vertical and horizontal array monitoring



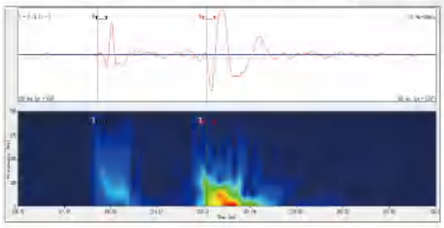
Surface array monitoring



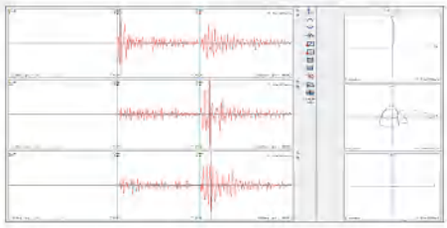
Borehole & surface long term monitoring

Micro-seismic monitoring real-time processing

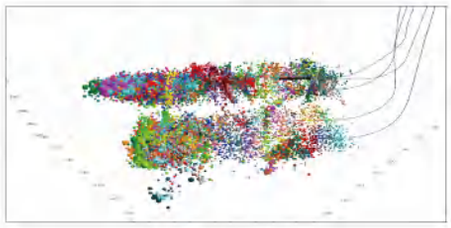
- Microseismic events identification
- First-break picking of P or S waves
- Polarization analysis
- Mapping microseismic events locations



First-break automatic picking



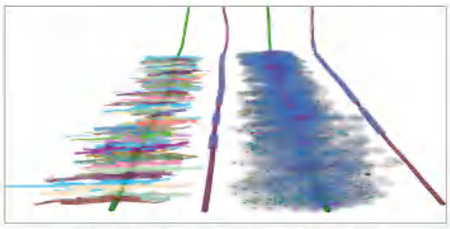
Polarization analysis



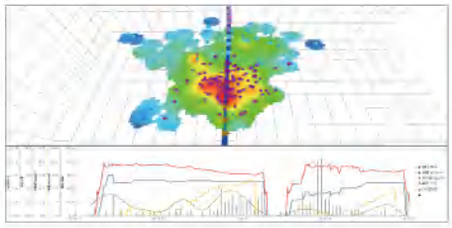
Events location

Micro-seismic monitoring interpretation

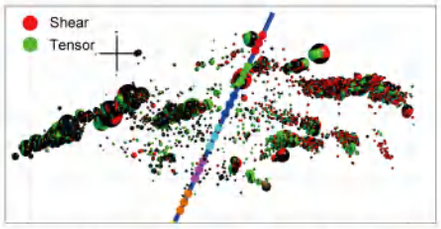
- Describing the dimensions of artificial fractures
- Comprehensive analysis of the fracturing curve
- Reckoning volumes of fractured rocks
- Inverting for local mechanisms



Continuous fracture network



Matching fracturing curve



Focal mechanism inversion

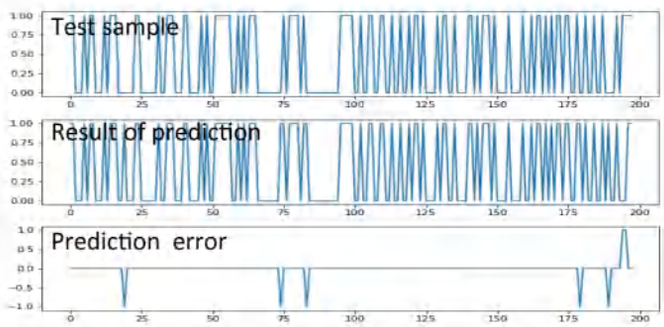
GEO-ENGINEERING INTEGRATION BASED ON MICROSEISMIC

Geo-engineering integration combines geophysical, geological and engineering data with micro-seismic data to predict sweet spots, to guide placements of well locations, to optimize horizontal well trajectory and to reduce engineering risks in advance.

Prediction hydraulic fracturing in advance

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

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

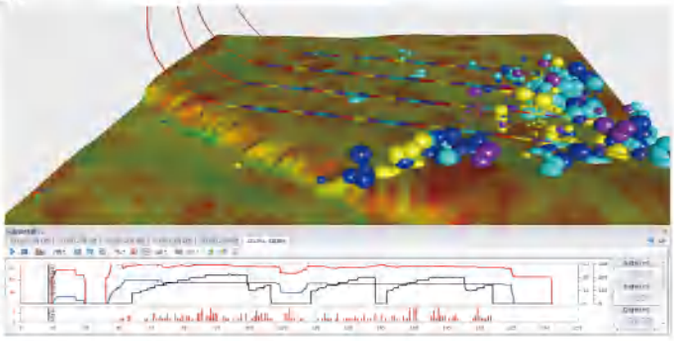


► Casing deformation prediction by using random forest

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 the treatment parameters in the field.

- Micro-seismic energy analysis
- Micro-seismic b-value analysis
- Comprehensive analysis of fracturing parameters and micro-seismic events

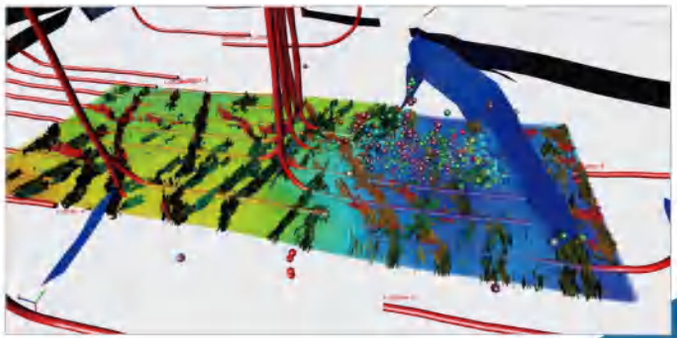


► Overlap display of micro-seismic events , of fracturing parameters and curvature attribute

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.

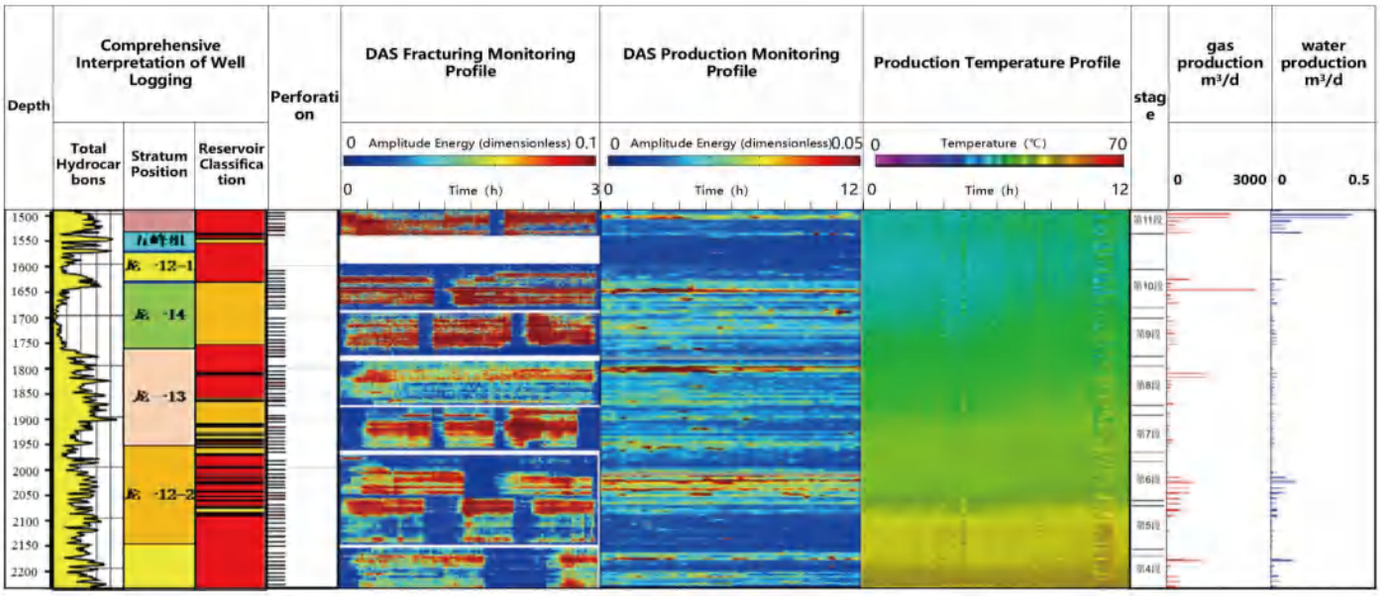
- Artificial fractures integrated interpretation with seismic, gelogical data
- Geomechanics prediction
- Well trajectory optimization



► Overlap display of micro-seismic events with nature fracture

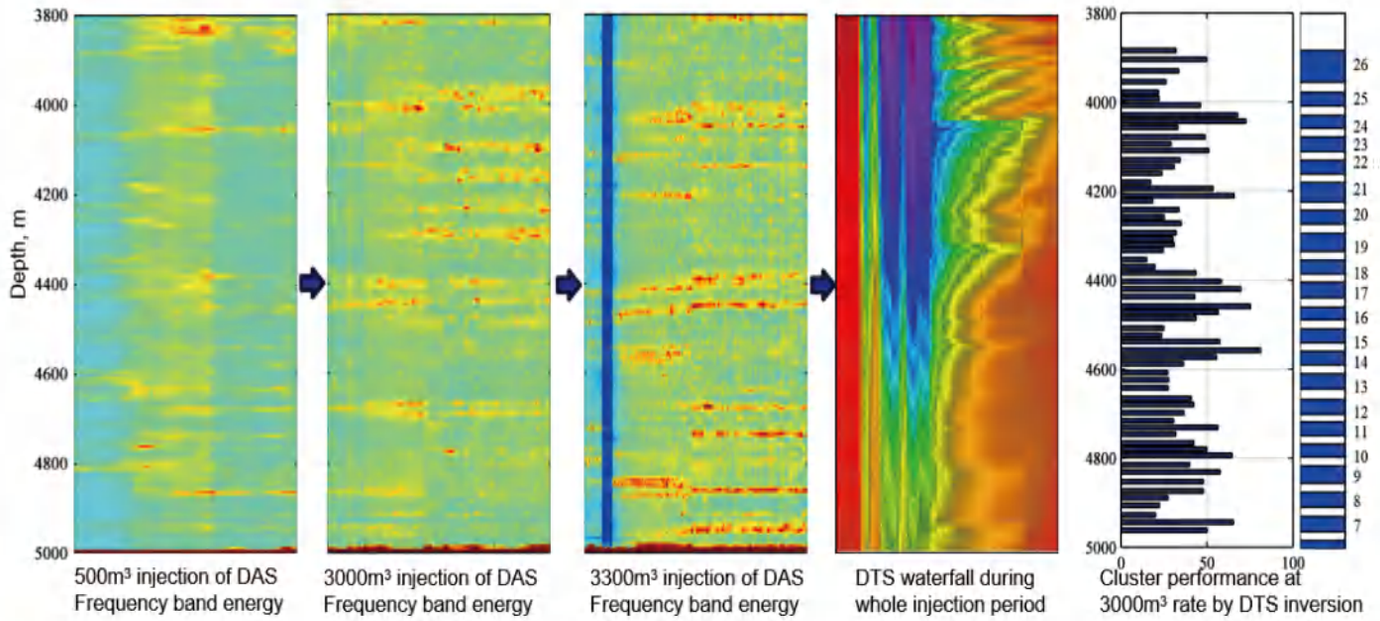
RESERVOIR STIMULATION AND PRODUCTION DYNAMICS MONITORING

Distributed fiber-optic sensing (DTS/DAS/DSS) enables real-time hydraulic fracturing and production monitoring, allows for performance evaluation, production profiling, fluid diagnostics, optimization, and assists EOR, and serving as an alternative to production logging/ tracer.



Fracturing & production integrated visualization

Fiber-optic based injection monitoring enables real-time optimization of shale oil injection system in the Dagang fault basin. Adjusting injection rate improves uniformity and injection performance, boosting daily production by 50% from the updated injection system.



500m³ injection of DAS Frequency band energy

3000m³ injection of DAS Frequency band energy

3300m³ injection of DAS Frequency band energy

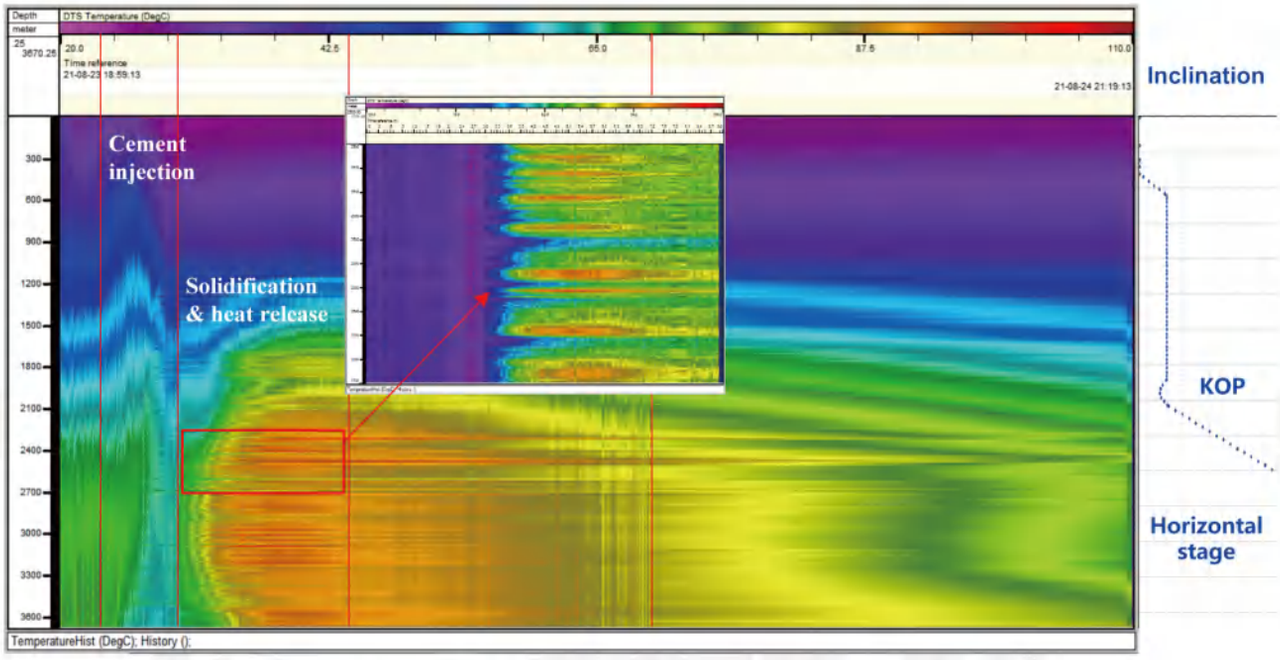
DTS waterfall during whole injection period

Cluster performance at 3000m³ rate by DTS inversion

Injection profile for different injection rates

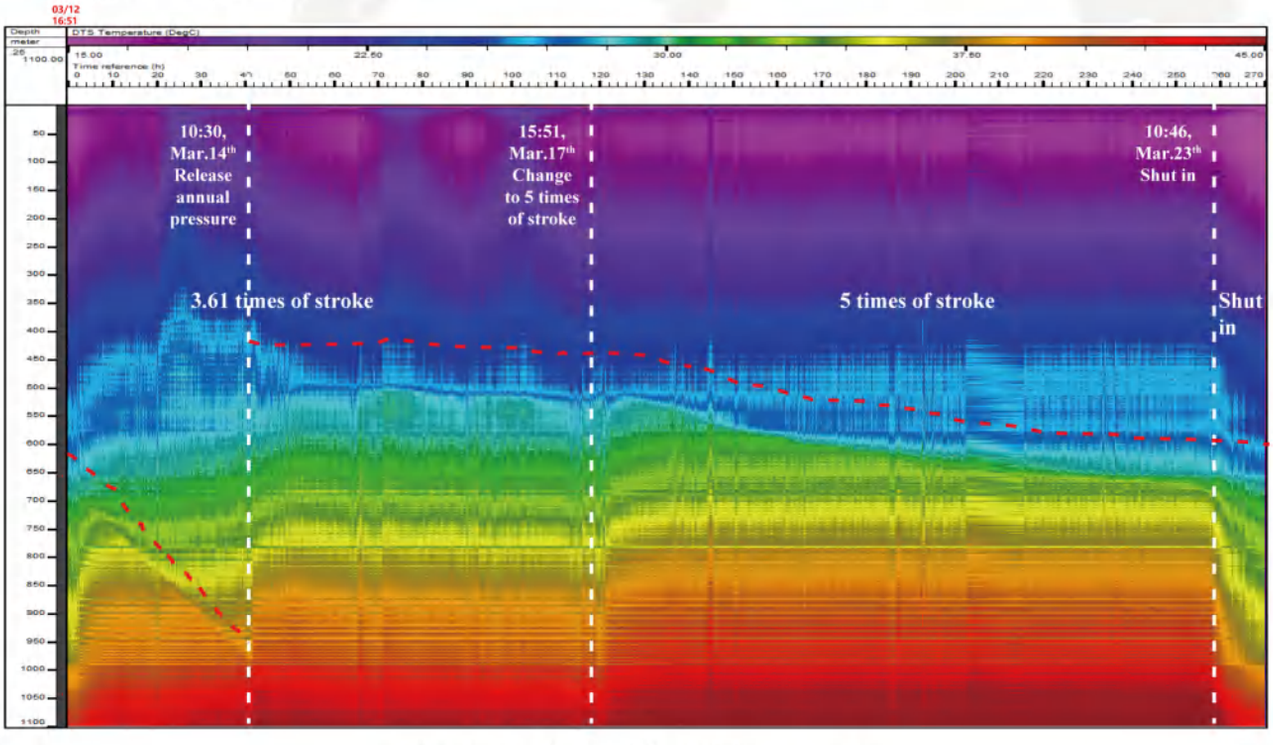
RESERVOIR STIMULATION AND PRODUCTION DYNAMICS MONITORING

Heat generated during cementing causes temperature changes at different depths, which can be monitored by DTS to evaluate cementing quality.



Cementing process monitoring and quality evaluation

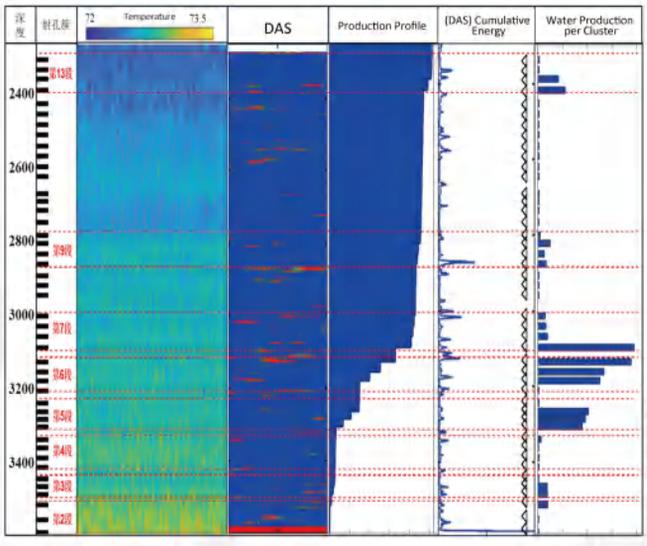
Heat capacity differences between gas and liquid produce distinct DTS temperature responses, enabling gas–water interface identification and dynamic liquid-level monitoring during production.



Injection profile for different injection rates

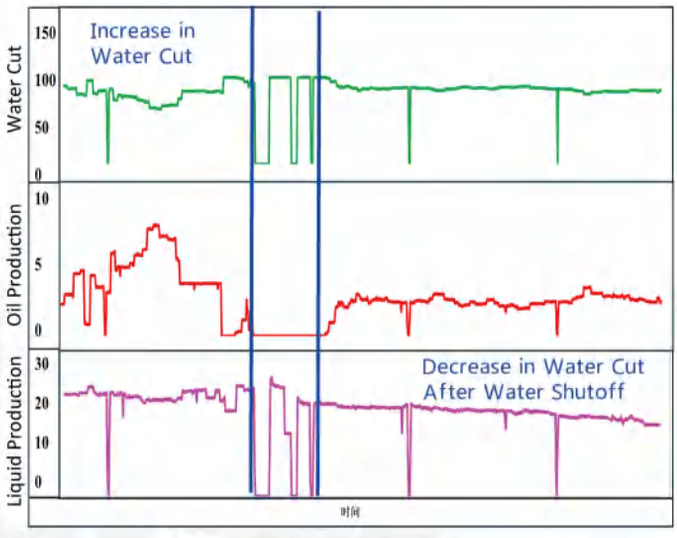
RESERVOIR STIMULATION AND PRODUCTION DYNAMICS MONITORING

High water cut in horizontal wells is a major challenge. Fiber-optic detections & diagnosis provide an effective solution for water breakthrough control and well management.



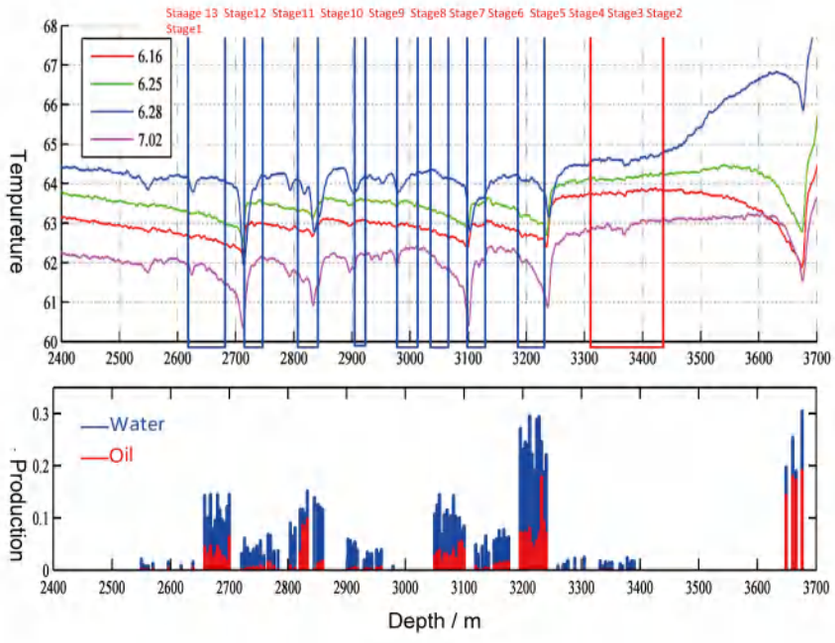
Fiber optic monitoring fluid production profile

Fiber optic fluid production profiling



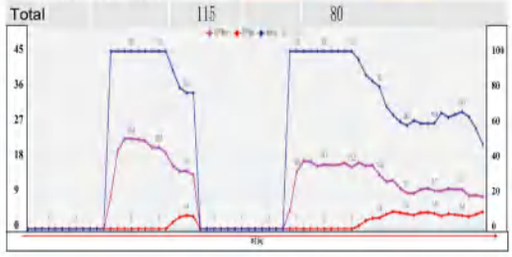
Production dynamic curve after water shutoff

DAS & DTS production profiles are used to identify under-stimulated zones and optimize acidizing design for enhanced oil recovery in mature wells, which are in decline trend.



Fiber optic monitoring of cluster production

Stage	Perforation Depth	Old Acid Volume		New Acid Production Volume		
1	3649-3677					
2	3332-3386			20	1	
3	3260-3305	45	1			
4	3196-3240			10	2	
5	3120-3176					
6	3050-3096					
7	2979-3026	35	2	20	3	0.7-1.0
8	2902-2959					
9	2804-2859					
10	2721-2783			10	4	
11	2658-2700	35	3			
12	2590-2638			20	5	
13	2542-2570					
Total		115		80		



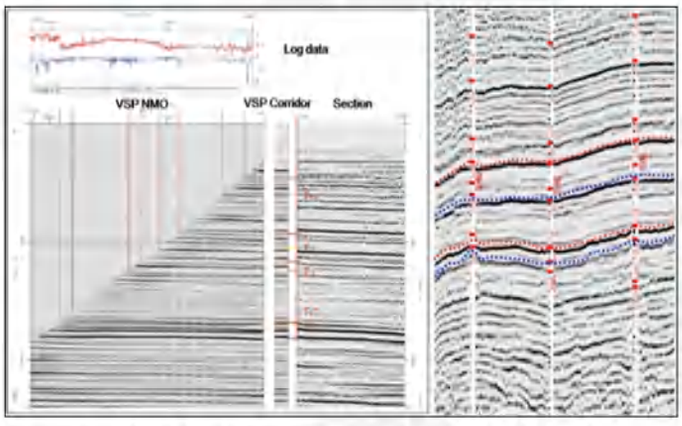
Optimized acidizing scheme

VSP TECHNOLOGY

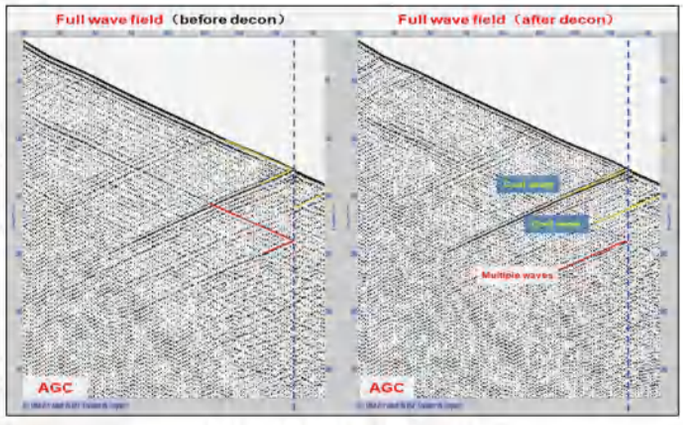
The Vertical seismic profile (VSP) adopts the observation method of surface excitation and well reception, which can establish accurate time depth relationships and obtain accurate velocity data such as average velocity and layer velocity, so as to accurately calibrate seismic and geological reflection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

Zero offset VSP

- Accurate time-depth relationship
- Multiple identification



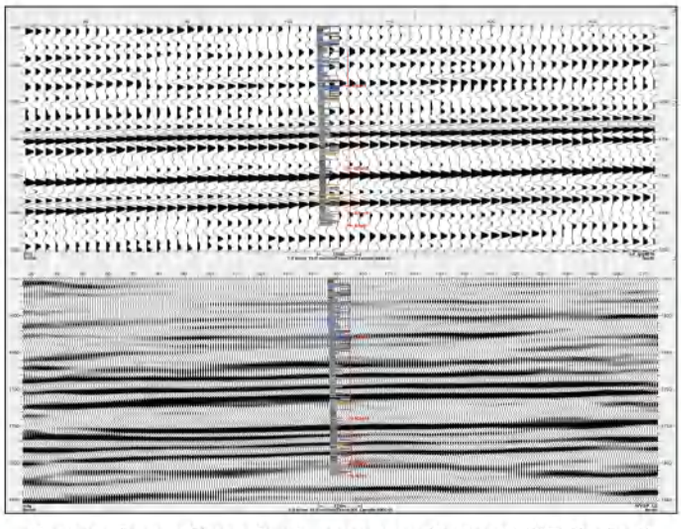
Calibration seismic data with VSP and logging



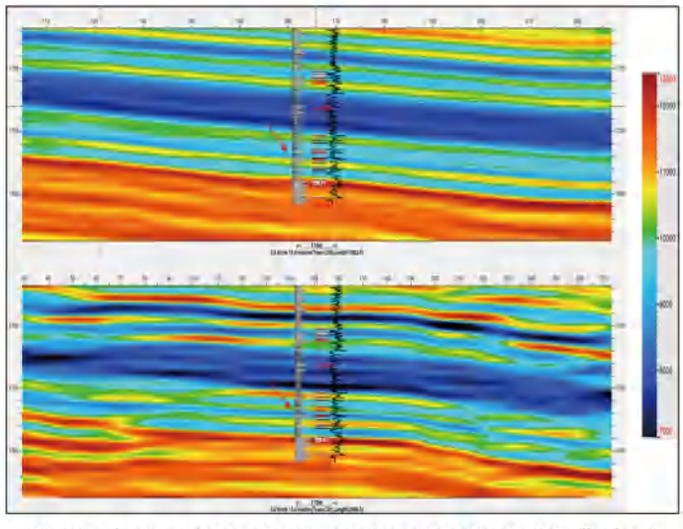
Analysis of multiple waves

Walkaway VSP

- High-precision & high-resolution near-well imaging
- High-precision near-well reservoir prediction
- Near-well time-lapse reservoir monitoring



Comparison of imaging between walkaway VSP (below) and surface seismic (above)

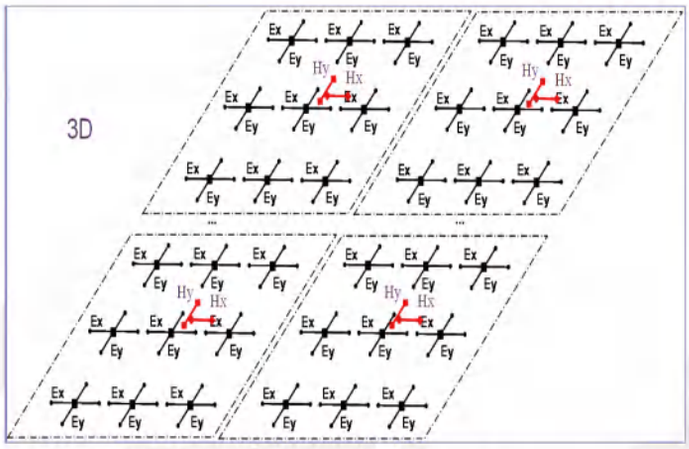


Comparison of inversion between walkaway VSP (below) and surface seismic (above)

3D GME SURVEY

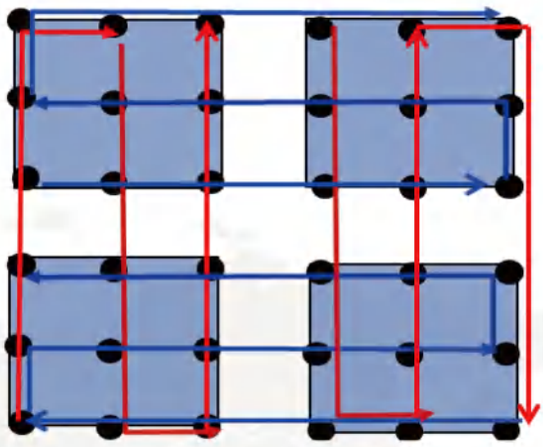
BGP provides an integrated solution with 3D GME (Gravity, Magnetic, Electromagnetic) & Seismic to identify subsurface structures in complex exploration areas.

Acquisition



3D small-bin MT/AMT acquisition

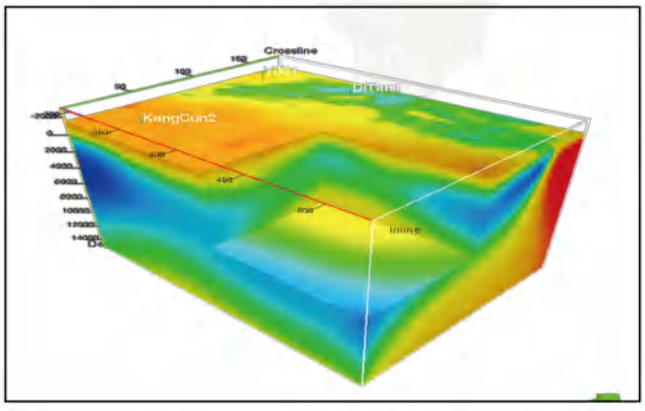
A 3D small-bin includes one 4-channel and eight 2-channel receiver systems, which is synchronized by GNSS satellites.



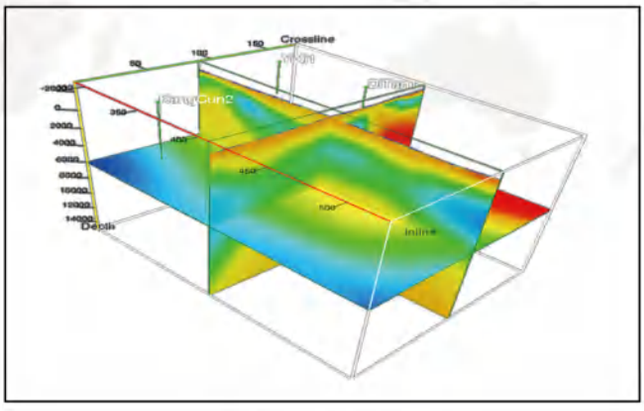
High accuracy 3D gravity & magnetic acquisition

Two independent observation loops make gravity and magnetic observation accuracy enabling a 100% increase.

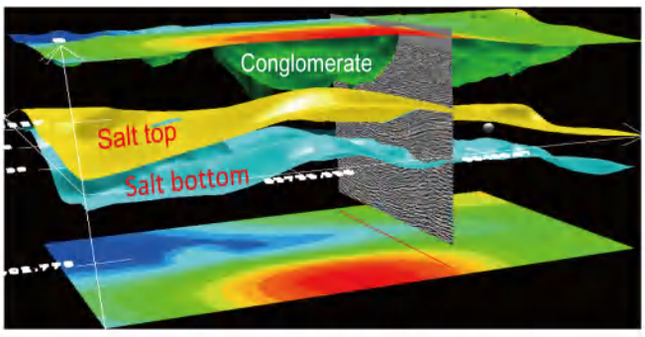
Processing & interpretation



3D MT apparent resistivity image



3D density image



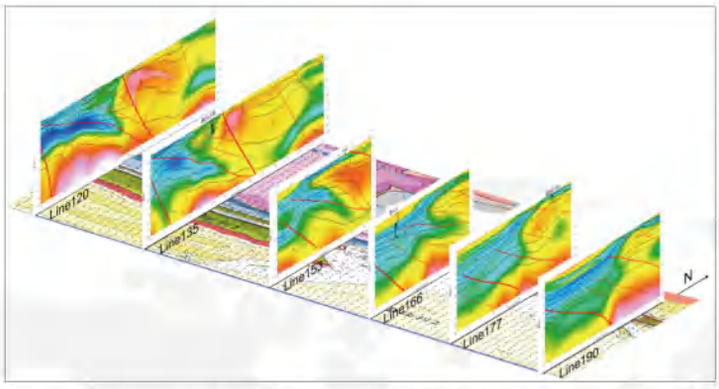
3D MT and gravity joint interpretation

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

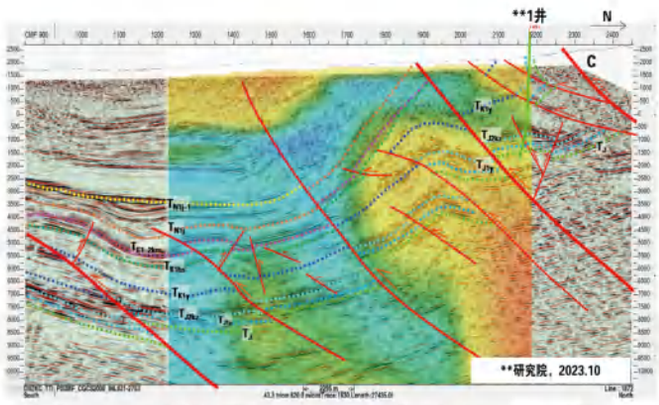
3D GME SURVEY

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.

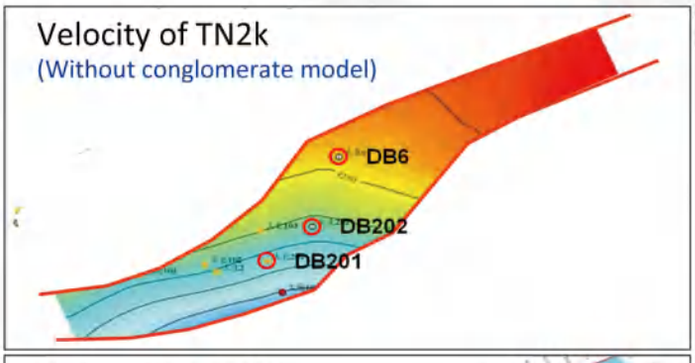


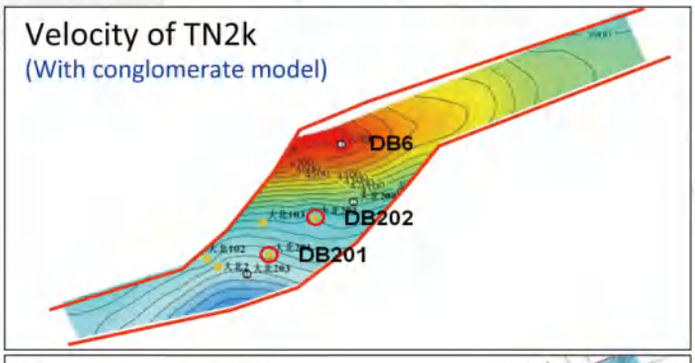
Joint interpretation sections with 3D gravity, magnetic and MT data

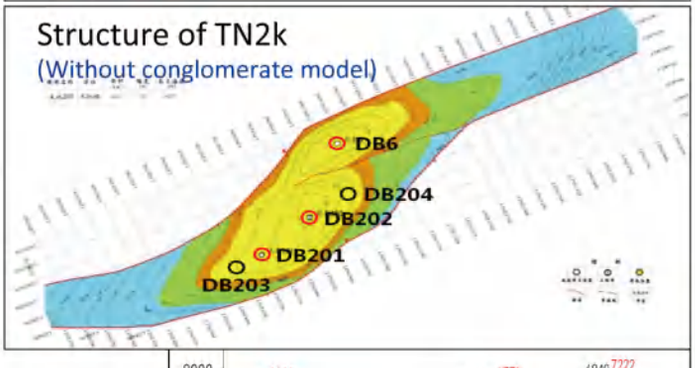


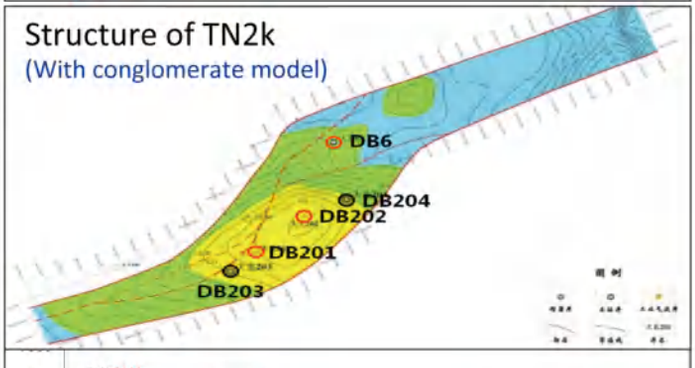
Overlay of 3D MT apparent resistivity and the 3D seismic section

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.

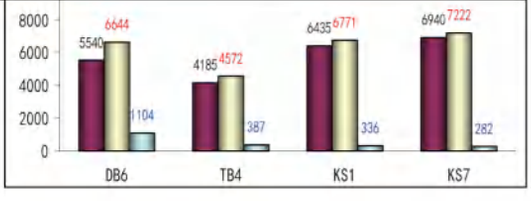


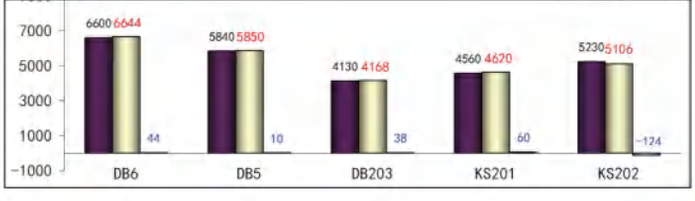






Depth error comparison

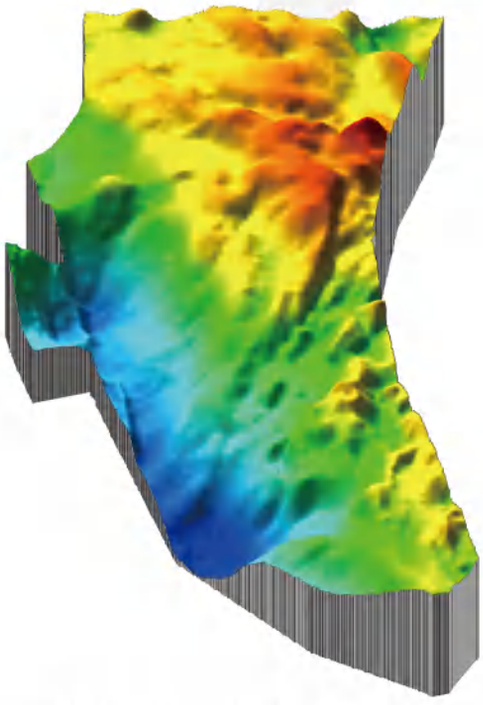




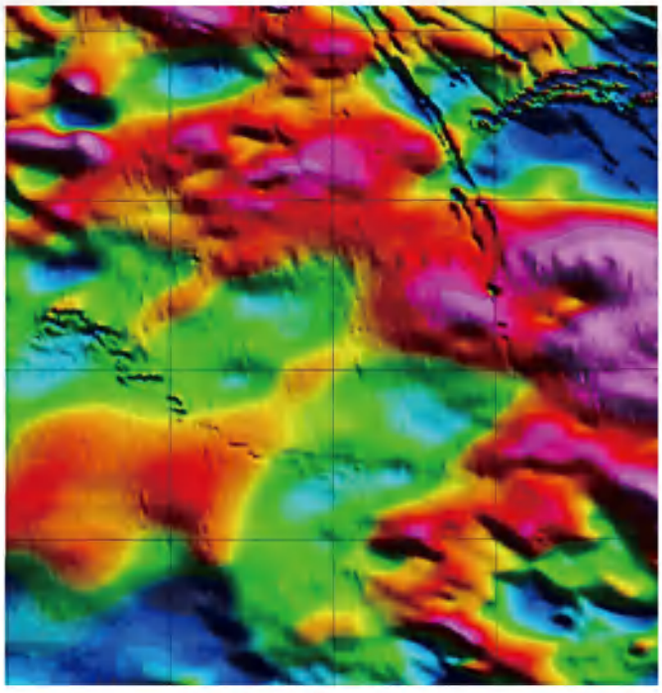
AIRBORNE GRAVITY AND MAGNETIC SURVEYS

BGP has carried out comprehensive geological studies with airborne gravity and magnetic data for more than 50 years and started acquiring airborne gravity and magnetic survey in 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 more than 220,000 Km of airborne gravity & magnetic survey lines in Africa and South America. BGP aims to continue to expand its airborne gravity and magnetic business in other parts of the world.

Airborne gravity and magnetic survey work team



Airborne bouguer gravity anomaly



Airborne total magnetic intensity

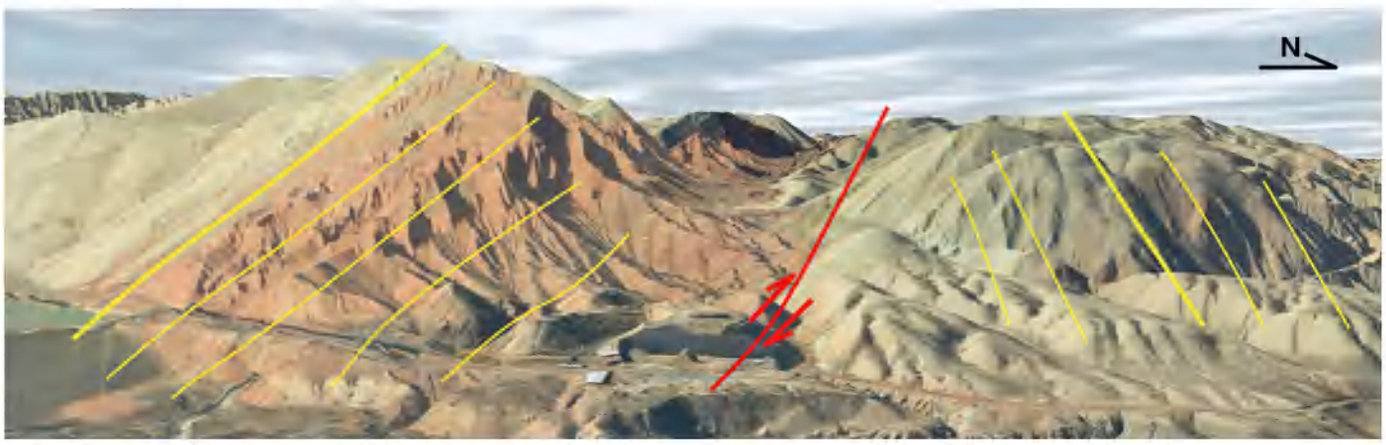
AIRBORNE LIDAR FOR OIL-GAS EXPLORATION AND DEVELOPMENT

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 cameras 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

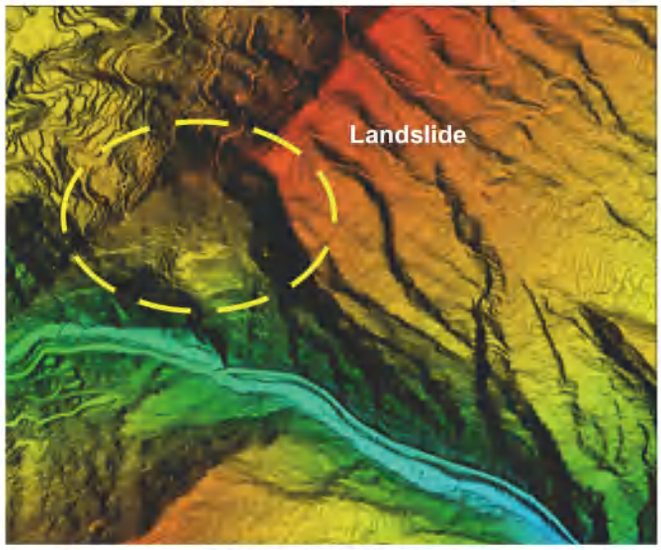
The high-precision and high-resolution LiDAR image can be used to optimize the survey design, especially for the selection of geophysical point location to improve the quality and efficiency of acquisition.

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 extremely useful in the optimization of drilling well site.

Geological hazards assessment

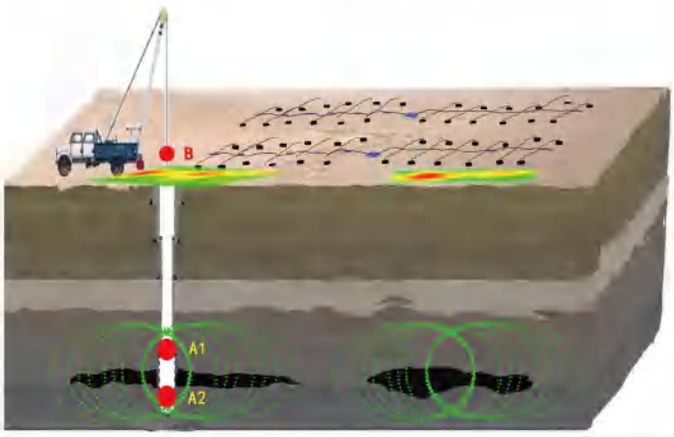
Digital orthophoto map



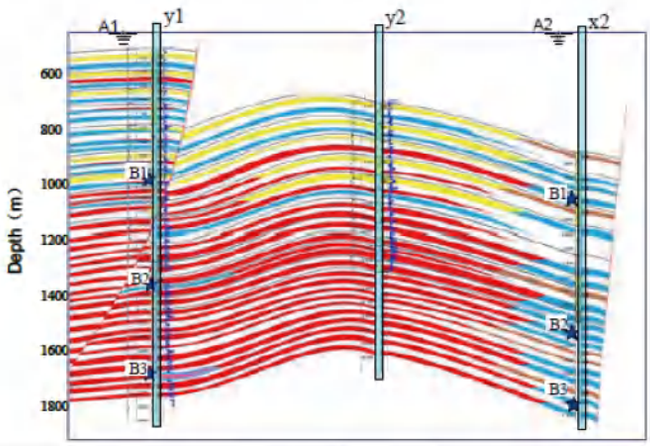
Digital elevation model

BSEM TECHNIQUE FOR OIL AND GAS EXPLORATION

The 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 has become a very attractive technique for the oilfield development process. BSEM surveys have also been applied in fracturing monitoring for HDR exploitation.

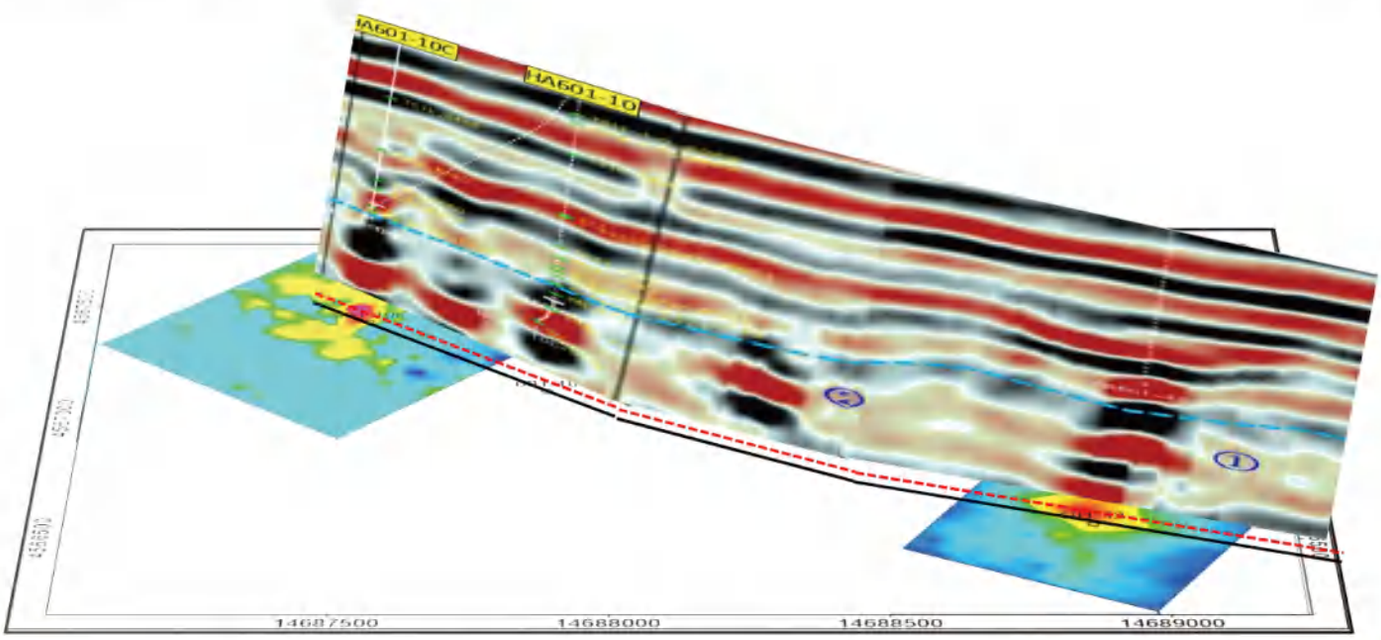


Schematic diagram of BSEM survey



BSEM downhole source layout diagram

A BSEM survey can be 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 a BSEM survey was proved by the client, which resulted in the well achieving commercial oil production.

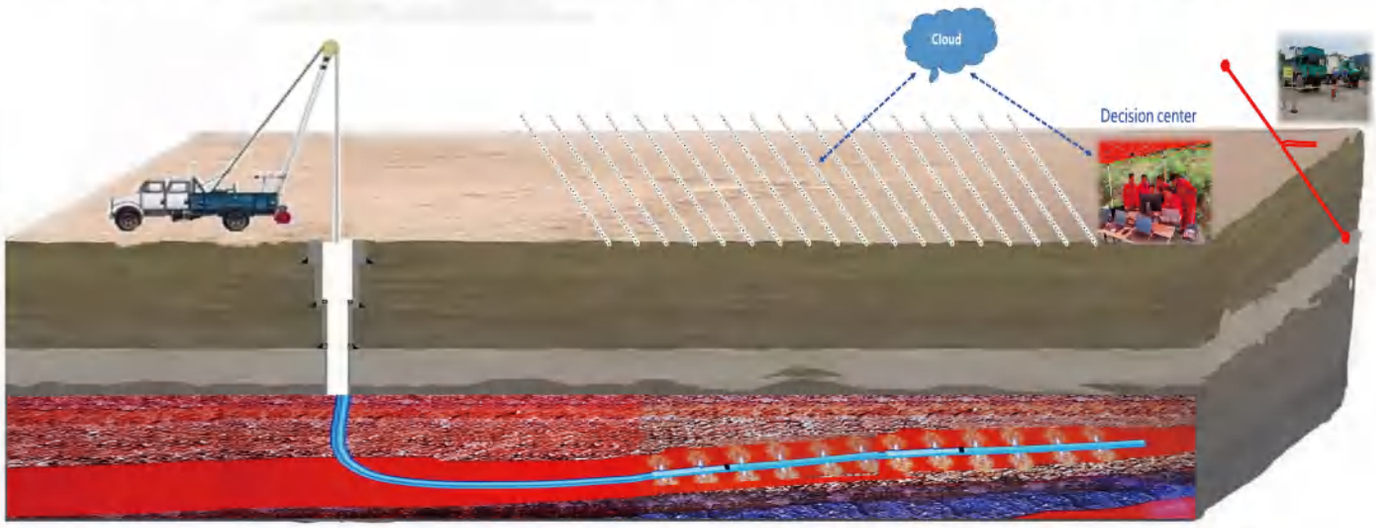


BSEM IP-R anomaly delineates the oil pool ranges, and guides the well location adjustment.

CSEM MONITORING FOR HYDRAULIC FRACTURING (IEOT)

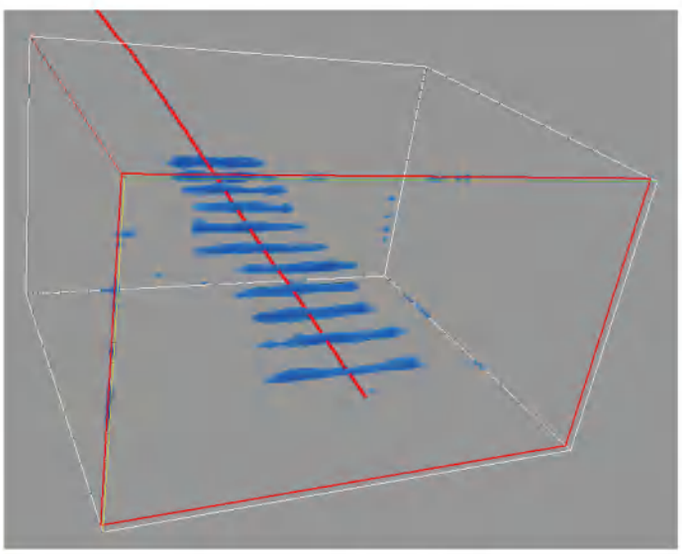
iEot is a characteristic monitoring technology for hydraulic fracturing developed by BGP on behalf of CNPC. This technique predicts the fracturing fluid distribution by studying the resistivity of oil & gas reservoir during hydraulic fracturing to evaluate the fracturing effect.

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.

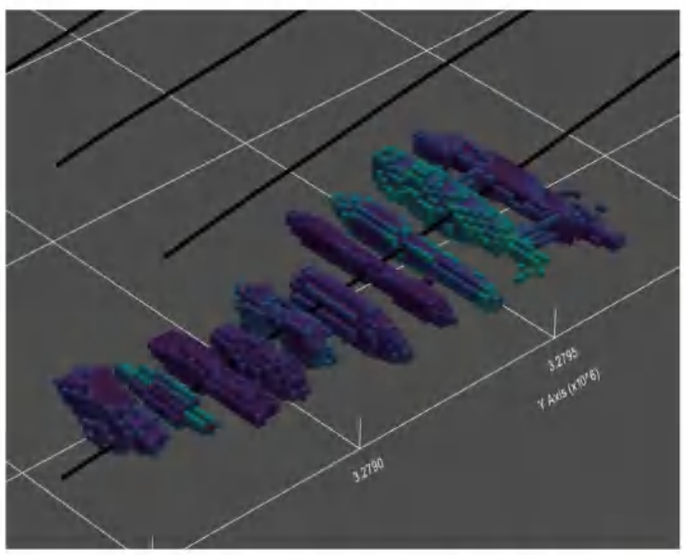


Schematic diagram of CSEM monitoring for hydraulic fracturing

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 the fracturing platform.



3D display of fracturing effect

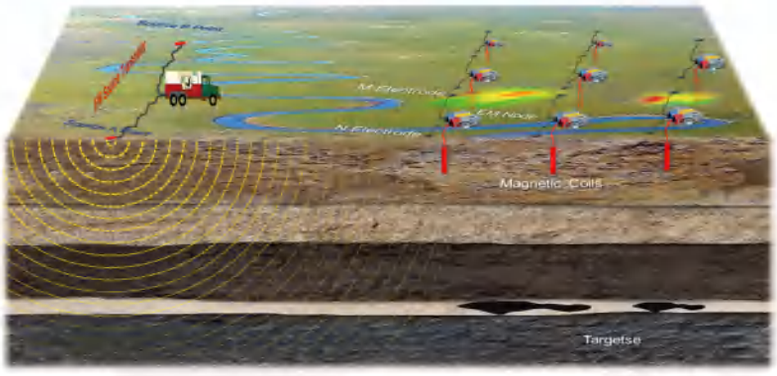


AI prediction image of fracturing monitoring

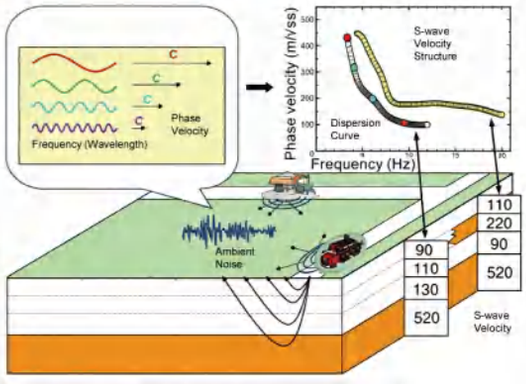
GEOTHERMAL EXPLORATION

Leveraging integrated geophysical surveying—from gravity and magnetics to seismic imaging—BGP has delivered geothermal and groundwater solutions across diverse geological settings, from the volcanic terrains of Iceland to the sedimentary basins of the Middle East and South America.

Proprietary geothermal exploration technique

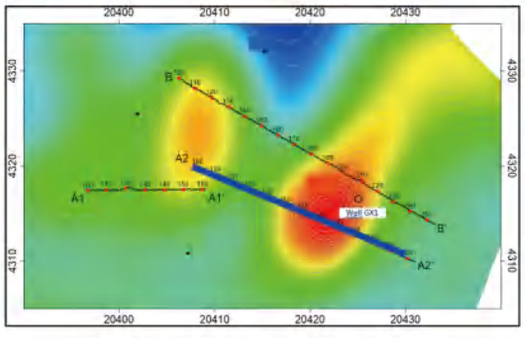


Time-frequency electromagnetic (TFEM)

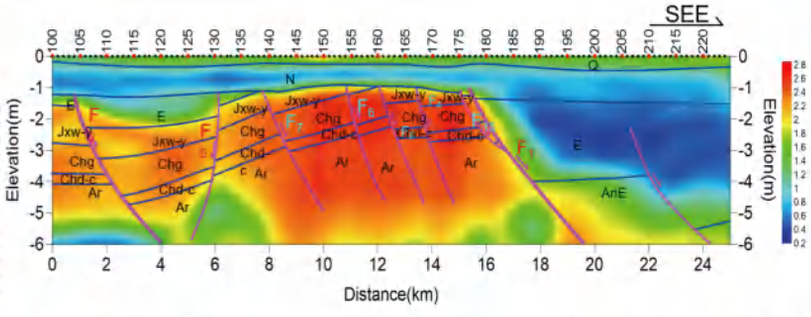


Ambient noise seismic

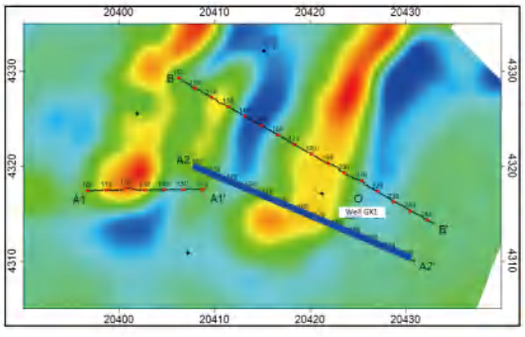
Application



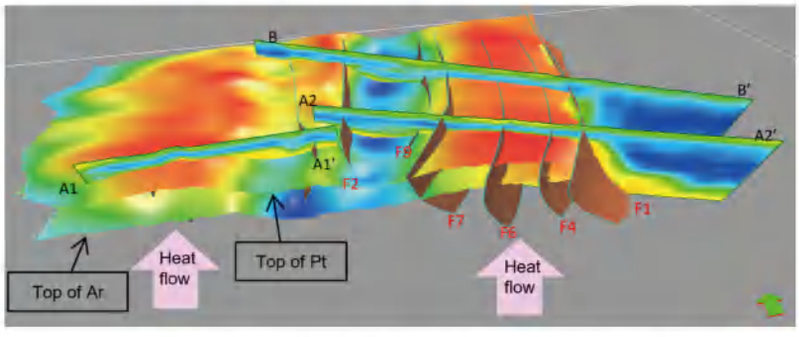
Total magnetic intensity (TMI)



Time-frequency electromagnetic (TFEM) resistivity profile of Line A2-A2′



Residual gravity anomaly



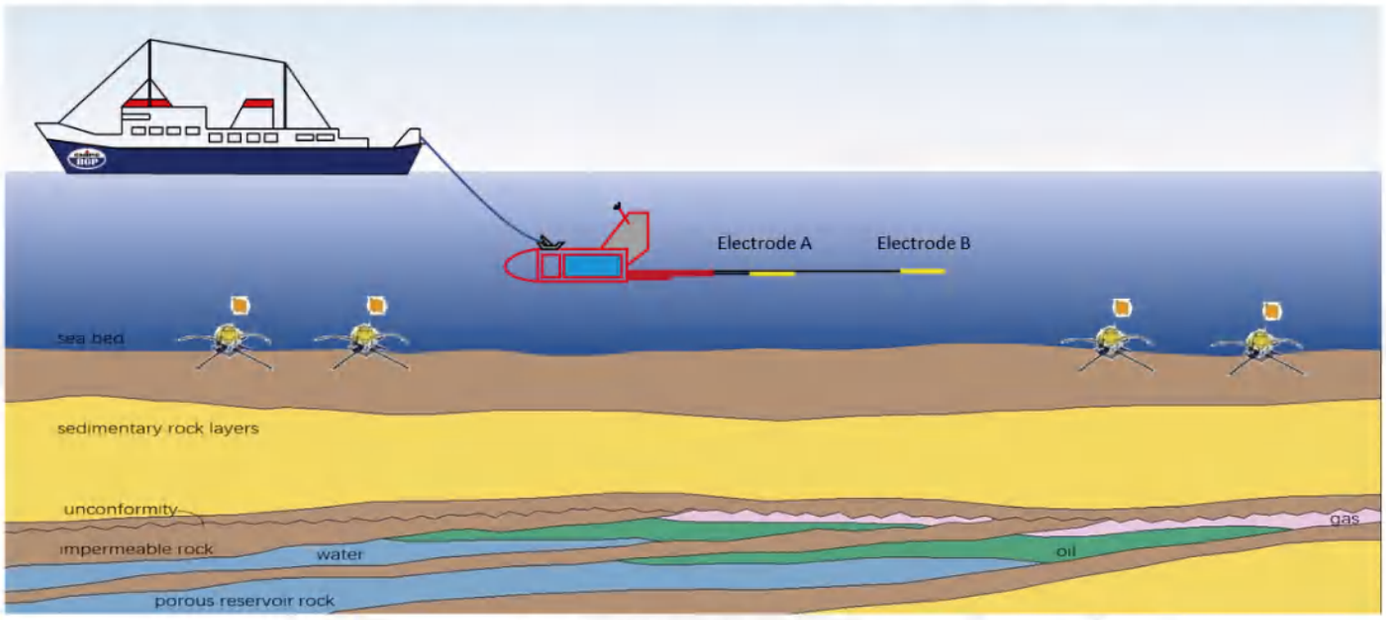
Geological model of Xiong 'An geothermal project

Gravity, magnetic, and TFEM data define the structural and thermal framework:

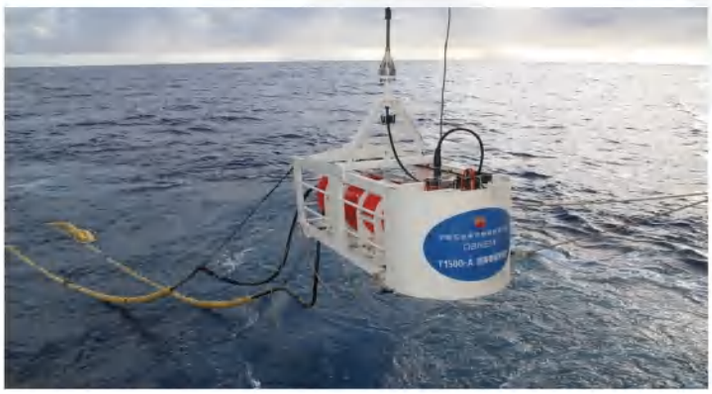
- Faults = conductive + convective heat pathways
- Shallow intrusions = localized heat sources
- Results guide reservoir prediction and drilling

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.

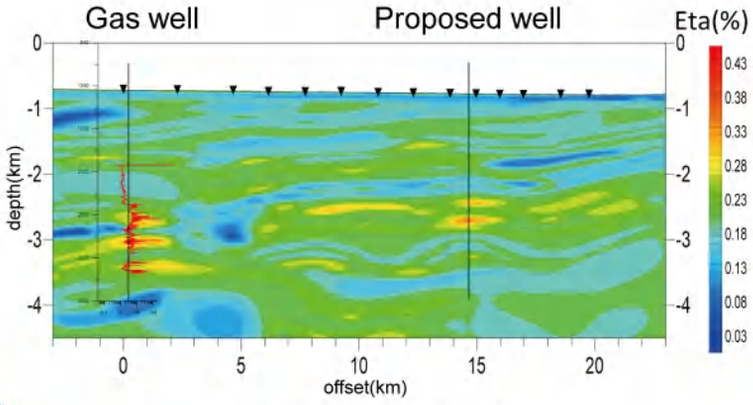


Schematic diagram of OBNEM survey



OBNEM transmitter

OBNEM receiver



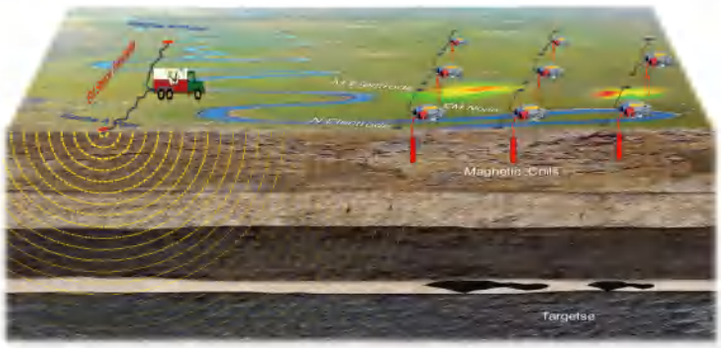
IP section from OBNEM

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.

TIME-FREQUENCY ELECTROMAGNETIC (TFEM)

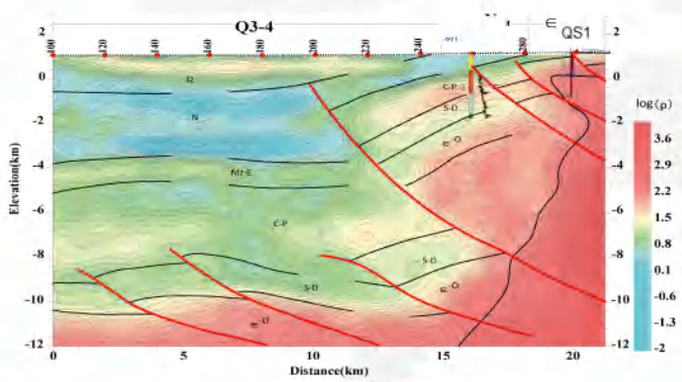
TFEM® method is a controlled source electromagnetic technique through which the EM fields could be acquired in both the frequency and time domains simultaneously. Resistivity and induced polarization anomalies could be measured to study the distribution and burial depth of minerals given that TFEM can penetrate depths beyond 10 kms.

- 27 invention patents
- 29 software copyrights
- 1 registered software trademark
- 3 technical codes
- 12 provincial and ministerial awards

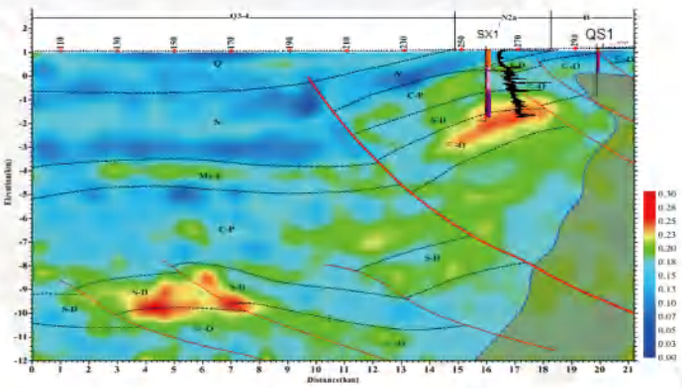


TFEM field operation configuration

Application

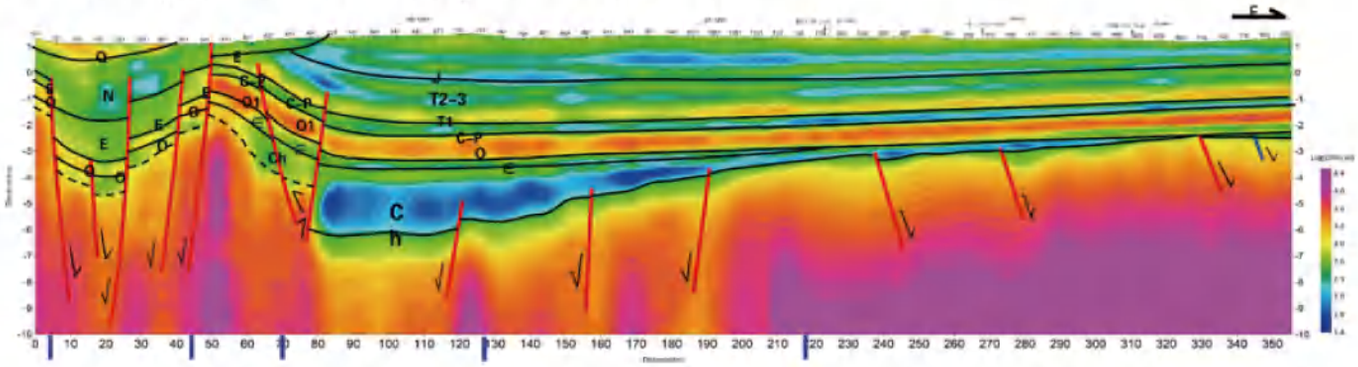


Resistivity profile



Induced polarization profile

Resistivity anomalies have revealed the distribution of hydrocarbon source rocks, while polarization rate anomalies have predicted the hydrocarbon potential of target traps, contributing to the breakthrough at the SX1 well.

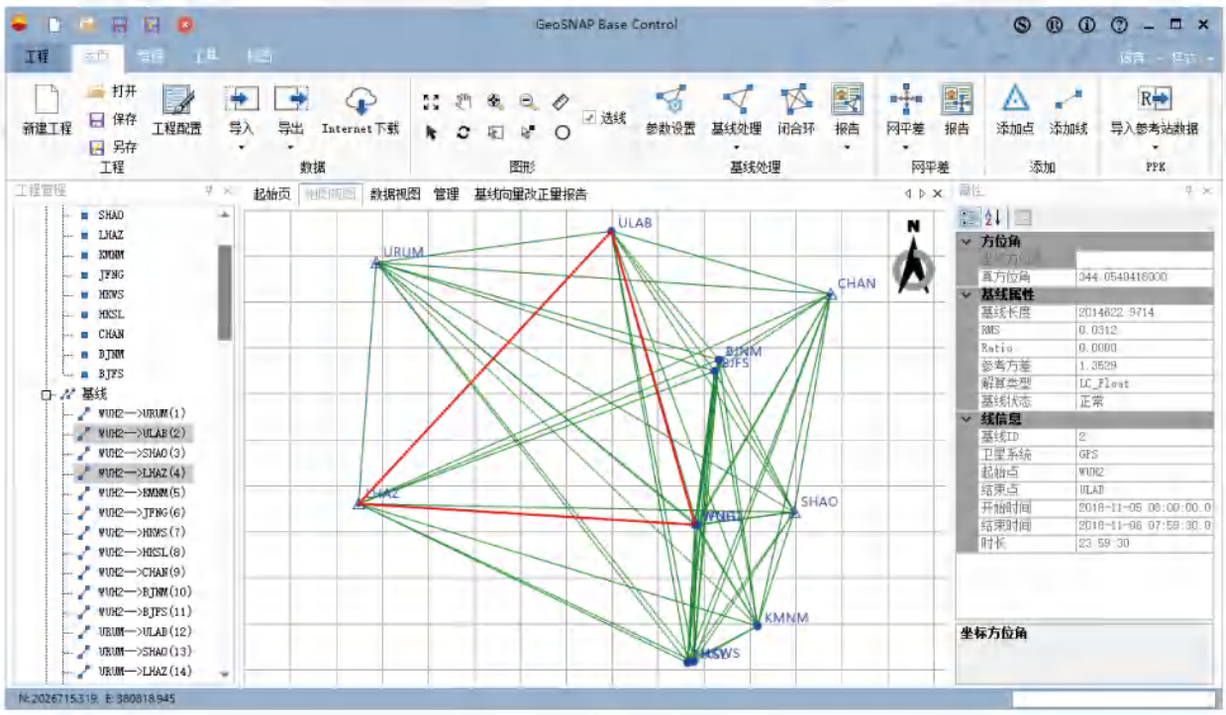


The TFEM result reveals the geological structure of major tectonic units and the distribution of Meso-Neoproterozoic rift, fault systems and Cambrian Strata in the north-eastern part of the basin.

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

HIGH-PRECISION GNSS POSITIONING SOFTWARE GBC

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

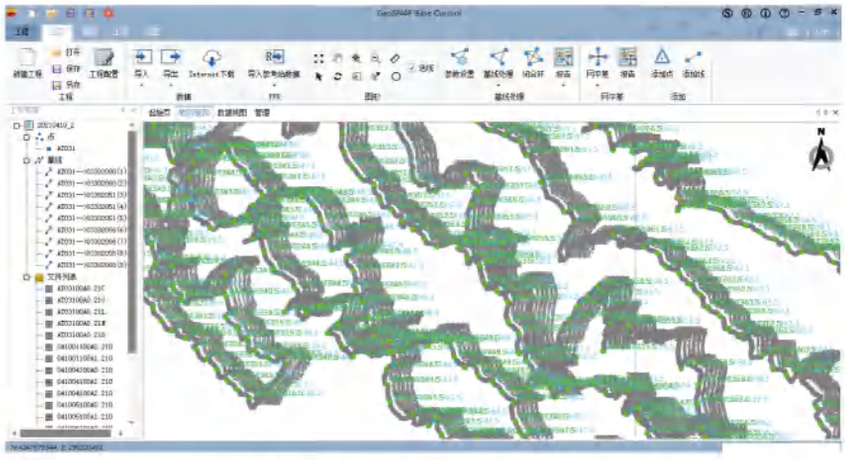
GBC baseline processing parameters and ITRF framework transforming

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

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.

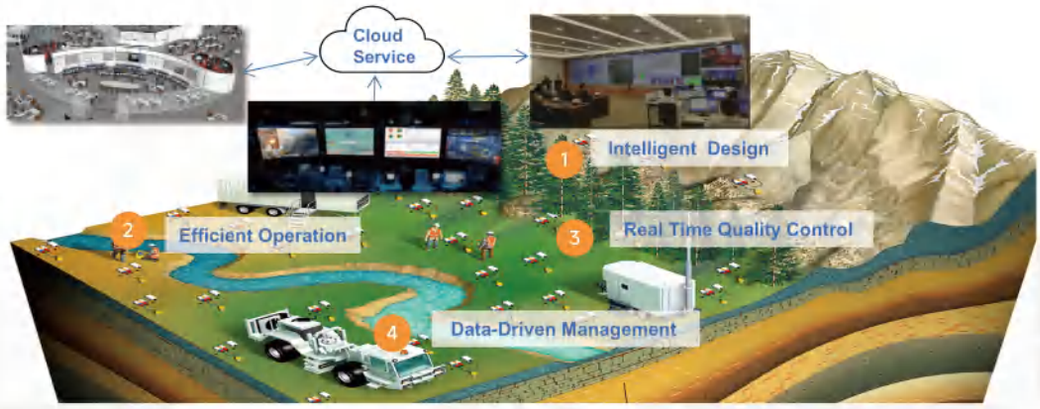


PPK + Vibrator data processing

GISEIS

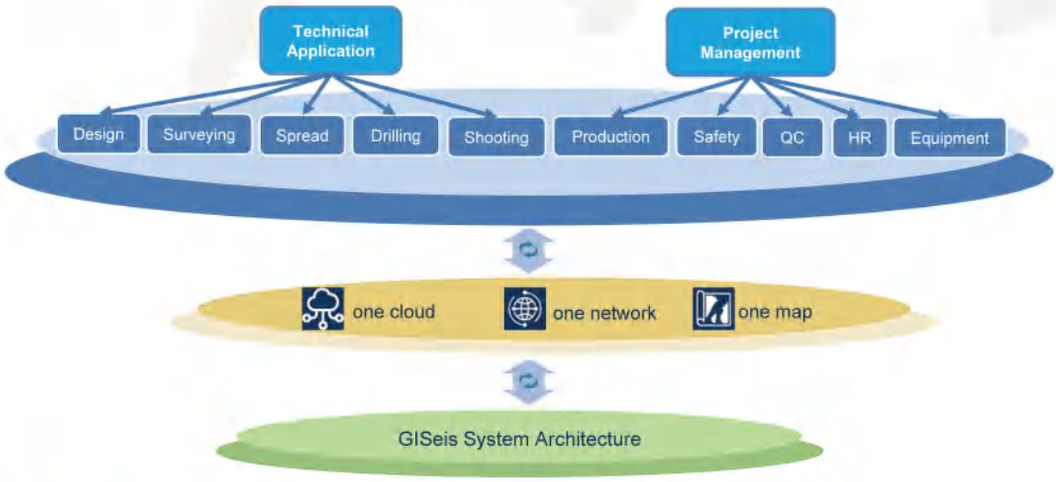
What is GISeis

GISeis transforms the seismic operation model through advanced digital technologies, unifying quality control, safety, operations, personnel, and equipment management into a comprehensive, intelligent platform for integrated geophysical acquisition and project management.



Architecture & features

GISeis adopts a '1+2' architectural pattern comprising one platform and two systems that covers the entire workflow management of key processes of the exploration production for the seismic crew. The system fully digitalizes exploration workflows and provides users with an intelligent visual display of work progress.



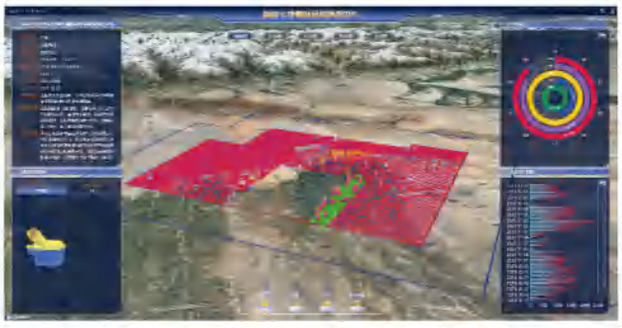
Application

GISeis has been applied to over 500 seismic projects in key exploration areas across China, serving more than 70,000 users since its official launch. It has significantly improved overall seismic operation efficiency, providing strong support for field operations, safety management, quality enhancement, and cost optimization.

GISEIS

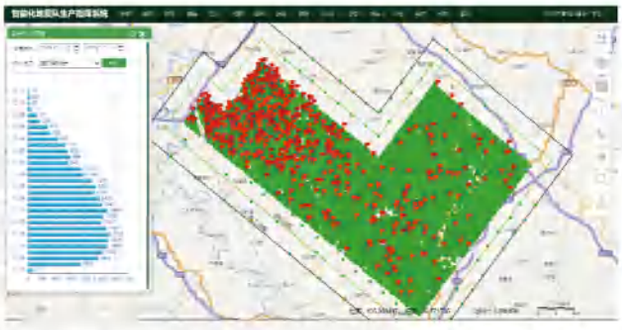
GISeis global command center

The Global Command Center leverages 3D digital twins to integrate worldwide project progress, displaying real-time status of all seismic exploration assets—empowering decision-makers to transcend boundaries and act swiftly.



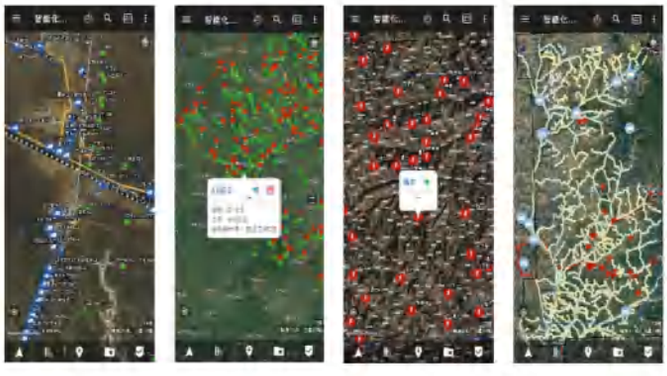
GISeis management center

The GISeis Management Center is an information visualization platform for management teams, enabling full-process workflow management of seismic crew operations—including surveying, drilling, loading, spread, and shooting.



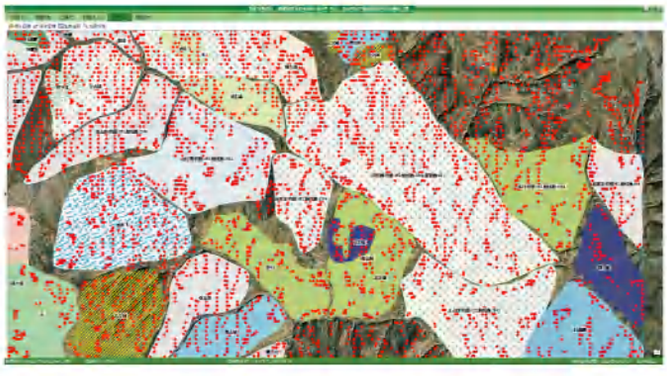
GISeis mobile

The GISeis Mobile App empowers field operators with positioning and navigation, risk alerts, surface feature collection and cloud sync, operational data capture, and progress analytics.



GISeis desktop

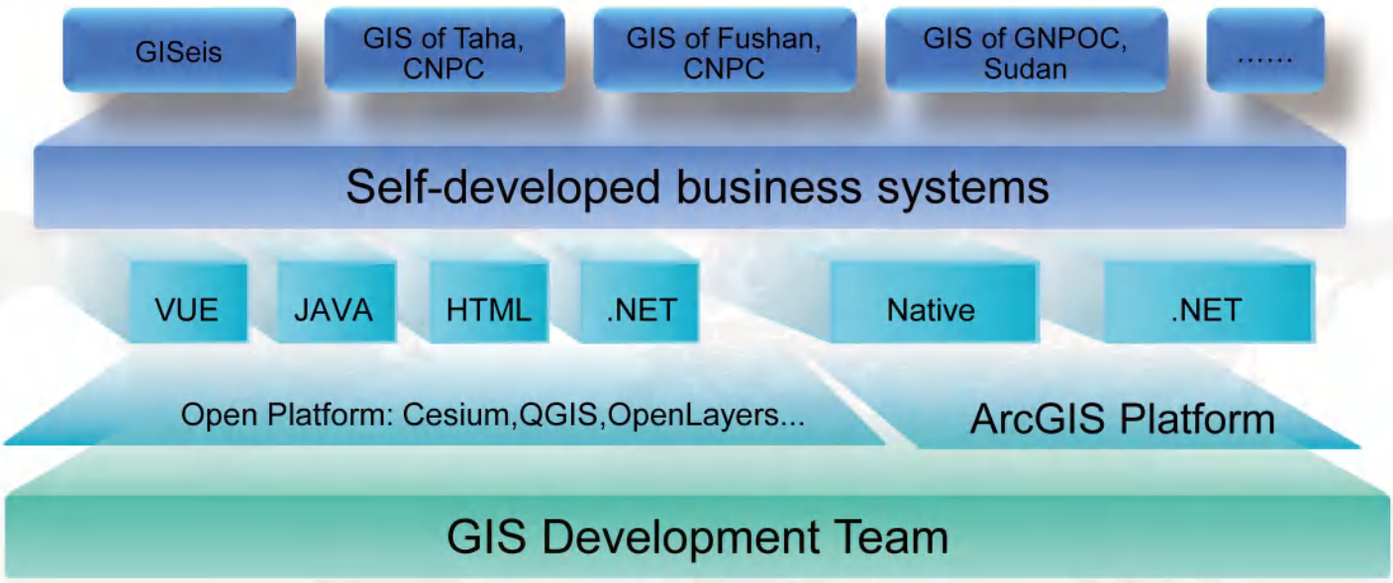
The GISeis Desktop enables terrain visualization and analysis, feature extraction, source point design, route planning, task distribution, AI-powered drilling QC, and real-time production monitoring.



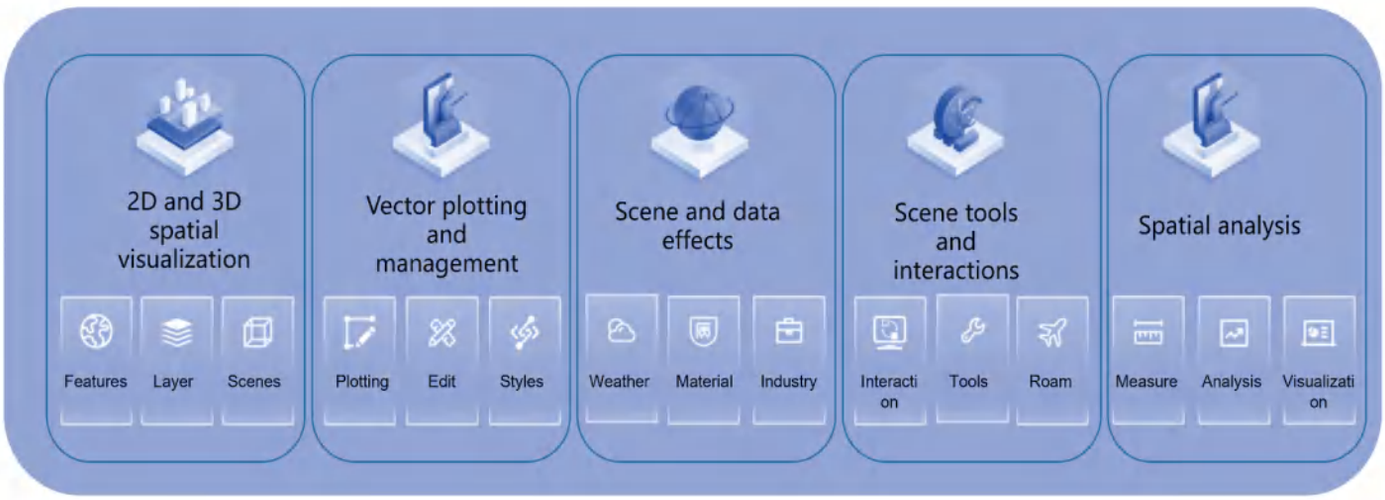
GIS SOLUTION FOR OIL FIELD

Introduction

Continuous product and service innovation: After years of technical evolution, BGP has built a series of self-developed products based on open-source platforms such as QGIS, Cesium as well as commercial platforms such as ArcGIS thereby forming a distinctive technical strengths.



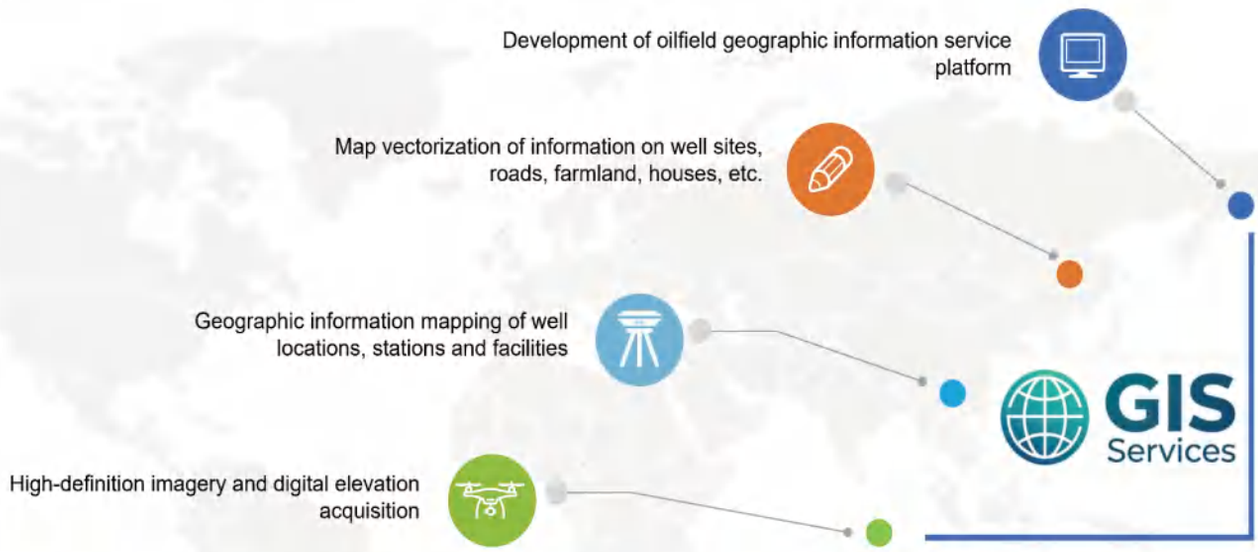
Our capabilities: Agile, efficient digital twin visualization development for enterprises accelerating digital transformation, comprehensive 3D Earth development solutions built from the ground up that empower clients to rapidly master and apply 3D visualization.



GIS SOLUTION FOR OIL FIELD

Solution:
Oil and gas field geographic information platform

BGP comprehensively carries out aerospace and aerial photogrammetry, oilfield geographic information collection, marine surveying and mapping, integrated navigation and positioning, and integrated 2D/3D geographic information platform development, providing customers with continuously innovative products and technical services.



Step1: low-altitude UAV aerial photography

Step2: facility surveying and mapping

Step3: indoor drawing and vectorization

Step4: map visualization and system development

GIS SOLUTION FOR OIL FIELD

Function 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 management

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

Measuring tools

Bookmark management

Layer management

Imagery and terrain services

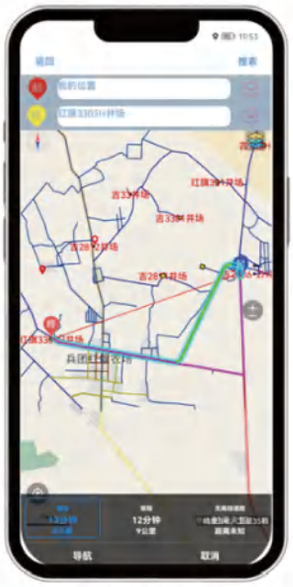
GIS SOLUTION FOR OIL FIELD

Design management

Based on planning data, the system optimizes well site placement through spatial analysis, with cloud synchronization enabling integrated office-field design workflows.

Navigation service

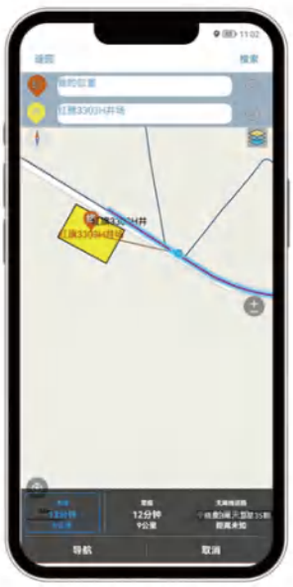
Using proprietary road data, the system establishes a road topology network and integrates public map resources, enabling seamless navigation between public and internal roads. This provides reliable technical support for field operations, emergency rescue, and related services.



Select a target

Start navigating

Public navigation



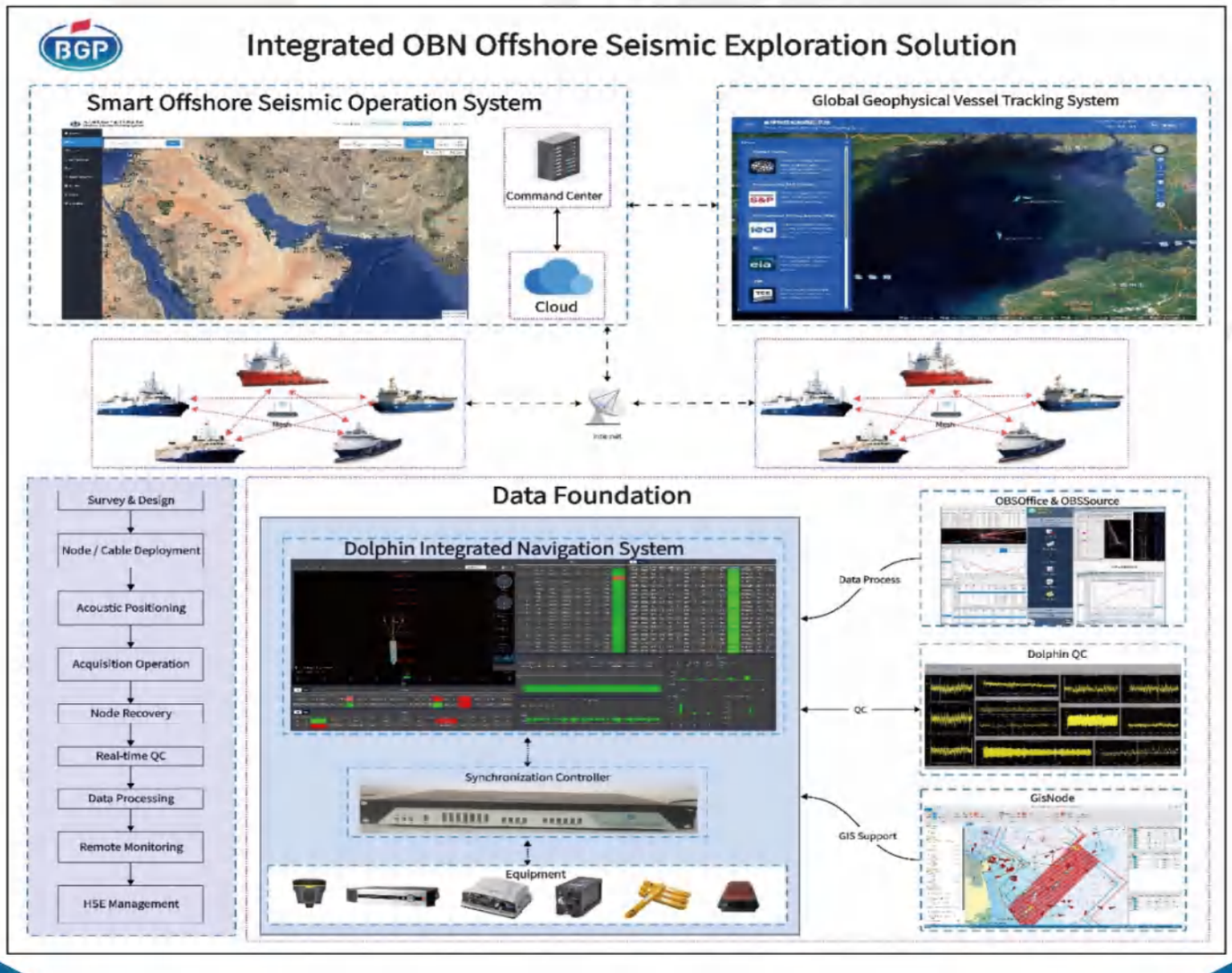
Internal navigation

INTEGRATED NAVIGATION SOLUTION FOR OBN SEISMIC ACQUISITION

Introduction

According to the OBN operation process, BGP proposes a complete set of integrated navigation solutions to support the efficient acquisition of OBN seismic exploration.

1	Dolphin INS	A complete integrated navigation system supporting efficient acquisition.
2	GISeis Offshore	A set of operation planning and production management system based on cloud service.
3	VTS System	A vessel position and status tracking system based on B/S.
4	GISNode	A set of professional fleet management system based on LAN.
5	OBSOffice	A lightweight navigation data management system.
6	OBSSource	Navigation data post processing system based on high precision baseline processing method.
7	Sync Controller	High-precision timing and control equipment for auxiliary navigation and positioning.



INTEGRATED NAVIGATION SOLUTION FOR OBN SEISMIC ACQUISITION

Core technologies

ISS Navigation
Support Independent Simultaneous Sources, Ensuring Data Independence for Seismic Acquisition.

4D Dynamic Shooting
Dynamically Modulates Firing Sequences based on Real-time Position Offsets.

MSI Shooting
Minimum Shot Interval, Significantly Enhancing Operational Efficiency.

Navigation Data Real-Time QC
Ensures Real-time Monitoring and Traceability through Customizable Visual Design.

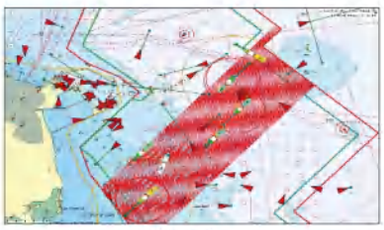
SIMOPS
Manage Simultaneous Multi-vessel Operations to Prevent Interference.

7 Days Look Ahead Planing
Isualize and Modify the Upcoming 7-day Operational Schedule Using Gantt Chart and List Views.

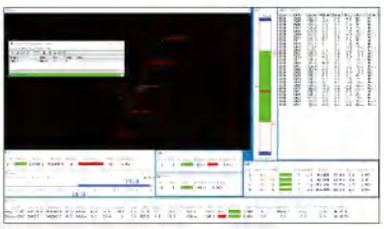
High-activity Nav Data Processing
High-activity Processing of Massive Navigation Data Leveraging a Multi-Threaded Parallel Architecture.

High Speed Mesh Ad-Hoc Networking
High-speed, Anti-interference, Long-range Wireless LANs(effectiverange ≥ 30 km) between Vessels.


4D dynamic shooting

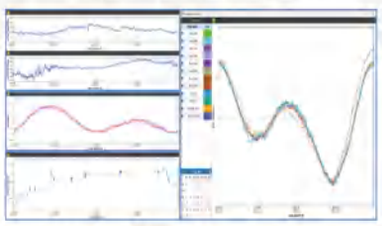

SIMOPS


ISS navigation


MSI shooting


Navigation data real-time QC


7 Days look ahead planing


High-activity nav data processing


High speed mesh Ad-hoc networking

In June 2022, the Dolphin INS passed the Verif-i audit, a globally recognized industry accreditation.


VERIF·i

BGP Dolphin Audit Certificate

BGP's Dolphin is an advanced set of tools to deliver a compact but capable integrated navigation package for Multi Vessel use within the Seismic Exploration industry. This audit is intended as a verification of the capabilities of Dolphin and its associated tools and is not intended as a comparison to other 3rd party independent navigation systems.

BGP provided a dedicated area within the test location containing the pre-built dual vessel configuration complete with an RF radio network to join the two vessels together. This enabled the tests to start immediately upon arrival. Simulators were provided to demonstrate real scenarios to the satisfaction of the auditor.

During the audit, the auditor was impressed by the openness and willingness of the BGP personnel to answer any questions and demonstrate any part of the Dolphin system even to the extent of showing code to enlightened and supplement explanations where necessary.

Dolphin's primary function is the management and control of all source and cable vessels within a seismic survey. It has a master / multi-slave architecture allowing independent autonomous control and operation on each vessel, but sets a remote control function allowing the master vessel to control the operations of the slaves.

Dolphin can interface to most standard receivers and provides industry standard shiing specifications. It provides well qualified standard UKOOA format deliverables that are capable of being read and processed by 3rd party independent tools. Dolphin also provides partial support for the newer OGP formats with development ongoing in this area. Dolphin Real time and Post Processed (QC) Source and QBS Offset provision competences using simulated data with noise applied were excellent with typical differences of <1m when evaluated against 3rd party post processing software.

Dolphin provides standard distance and time based shooting techniques with single/multiple array configurations in 2D, 3D and 4D modes of operation. Shots can be perturbed in the temporal domain using dithered shooting techniques.

In cable vessel mode, Dolphin can deploy and position OBS Cables using BGP's own proprietary acoustic positioning system (BPS) but also provides support for several 3rd party acoustic positioning systems.

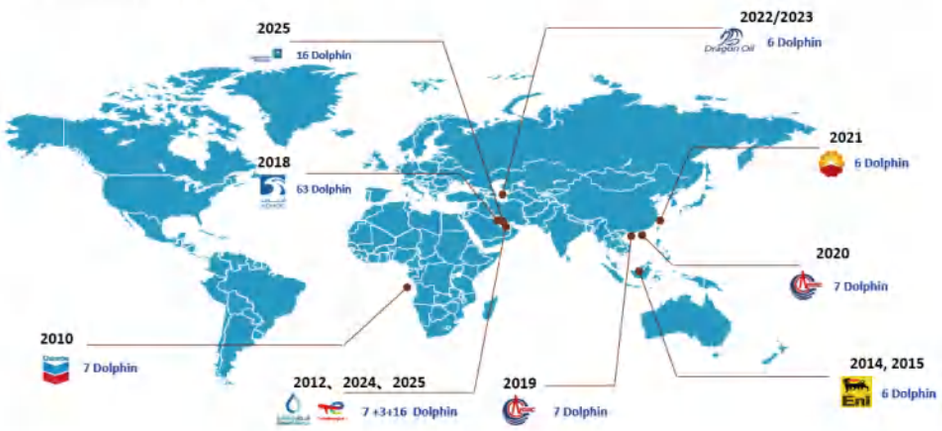
During shooting or pinging operations Dolphin provides vessel autopilot control, and the INS displays which are user configurable, provide good feedback to the navigators on the current state of the shooting or pinging operation.

Kevin Swetman
Managing Director
Verif-i (NO) Ltd
22nd June 2022

VERIF·i

Application and prospect

So far, the application rate of this solution in BGP's NOC project has reached 100%, and more than 170 sets of Dolphin INS have been used.



OSEIS OCEAN BOTTOM NODE SYSTEM

Introduction

The oSeis Ocean Bottom Node System is a series of omnidirectional four-component wireless seismic nodes for continuous underwater operation, with independent seismic signal sampling, recording and storage. Composed of oSeis nodes, charge/time modules, host storage and system software, it features flexible deployment, high data quality, high efficiency and low cost, including two models tailored for different water depths.

oSeis-SW (Shallow-Water Node): A high-precision shallow-water node acquisition system integrating wireless charging, data downloading and time service, with non-metallic housing, low power consumption and long battery life.

oSeis-DW (Deep-Water Node): A high-precision deep-water node acquisition system with low power consumption and long battery life, equipped with a high-stability MEMS clock for over 200 days of continuous operation.

Type	oSeis-SW	oSeis-DW
Working Depth	500m	3000m
Operating Life	63days @ 2 ms	205days @ 2 ms
Storage Capacity	64 GB	256 GB
Charge Time	<8 hours	<16 hours
Continuous Working Hours	63days@2 ms sample interval	205days@2 ms sample interval
Size	320*262*144 mm	409*358*134mm
Weight	11.4kg (in air) 3kg (in water)	26.2kg (in air) 13.2kg (in water)
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 (Customizable)	

oSeis-SW

oSeis-DW

QUANTUM NODAL SYSTEM

Quantum node introduction

Quantum is an all-in-one node designed to simplify field operations to support economical high density, long offset seismic surveys. The node allows deployment using either the internal high sensitivity geophone or an external geophone or marsh phone. Additionally, the node contains an internal GPS for timing and position, internal memory for seismic data storage, Analog-to-Digital converter and battery. The node is a single channel, self-contained acquisition unit. Key features and benefits of the Quantum node are shown in Figure 1, below.

Figure 1 Overview of Quantum node

Data download and charge equipment

Data is stored in internal node memory and downloaded later once source recording has concluded. To accomplish data downloading at large scale, racks are used to contain the node and connect to a data transcription computer. The Transcription computer, running iX Studio software, orchestrates data downloading and data management. Additionally, the internal battery is charged simultaneously with data downloading. Figure 2 shows an example of the standard rack, which accommodates 48 nodes. Racks can be daisy-chained together to achieve the required node processing capacity to support field operations.

Figure 2 Quantum racks

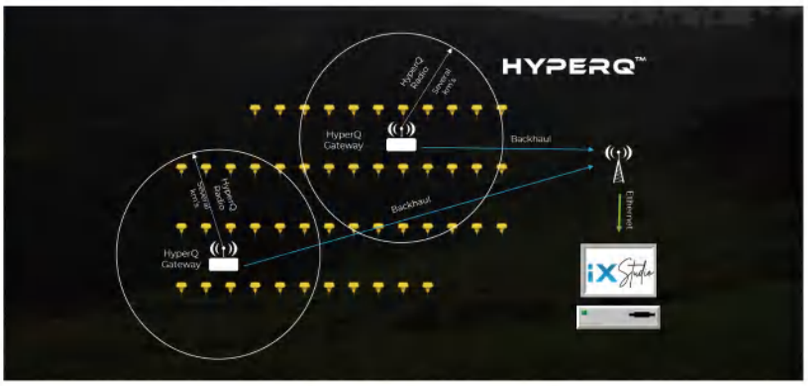


Figure 3 HyperQ long-range QC layout

QC system

One of the key advantages of the Quantum system is support for node field status QC. This can be done either using a handheld tablet via Bluetooth or long-range QC using HyperQ based on LoRa wireless technology or both depending on terrain, contract requirements and contractor preference. Figure 3 shows the layout of HyperQ.

The Quantum system also supports near real-time ambient noise monitoring capability through HyperQ SCANTM. This detects actual noise seen on the ground by using recording Quantum nodes, accounting for wind and other environmental noise sources.

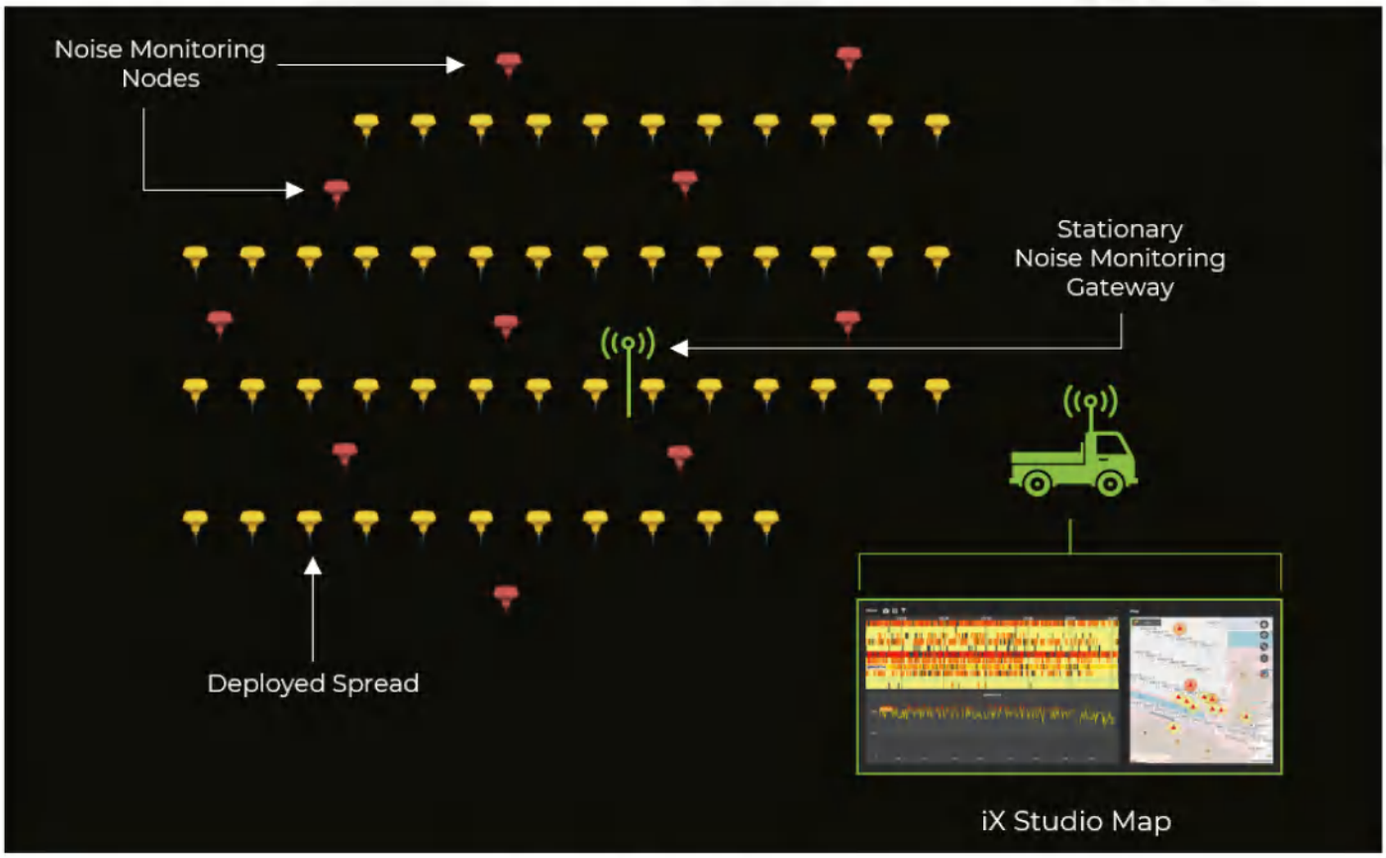
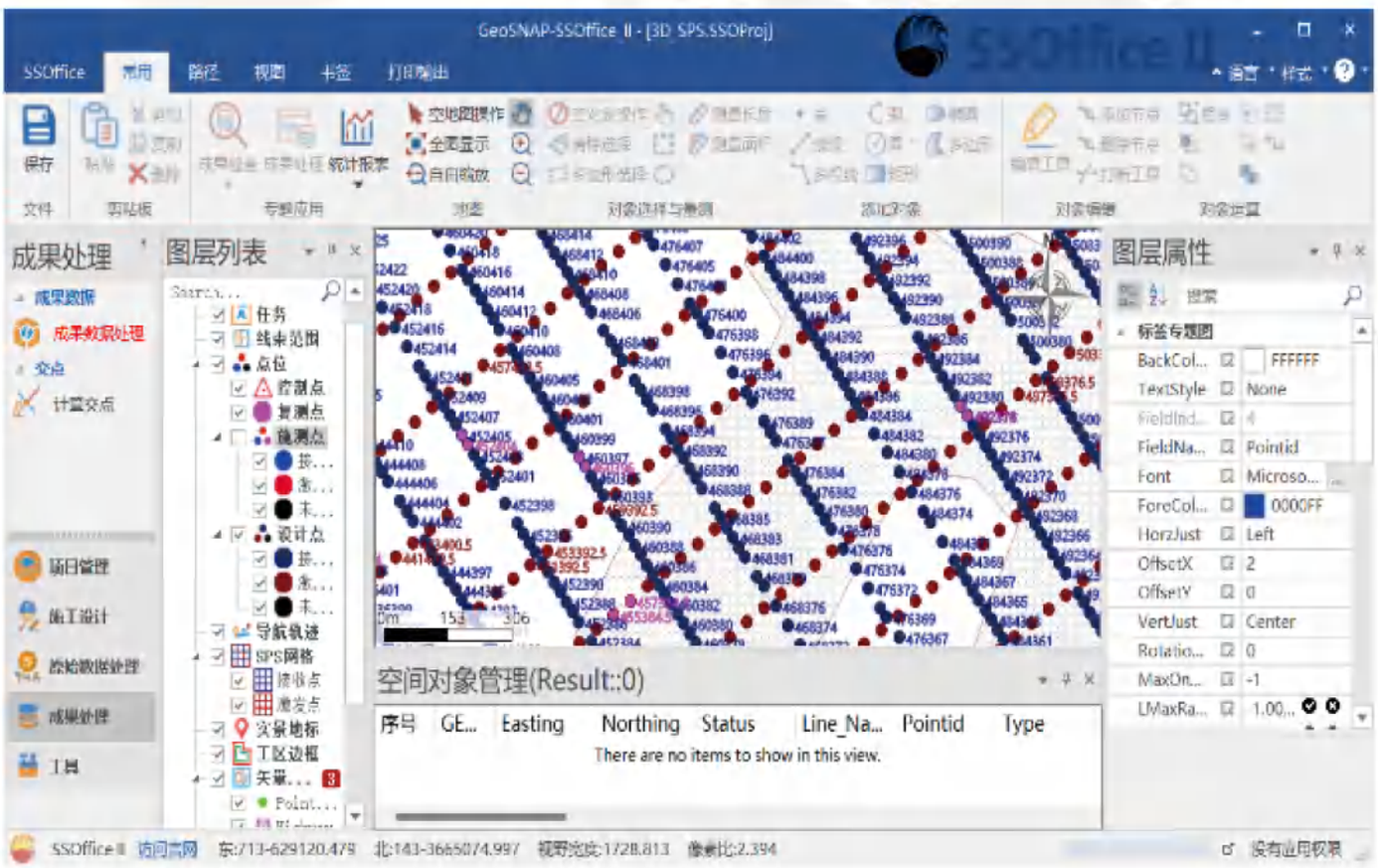


Figure 4 SCAN noise monitoring

SSOFFICELL

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.

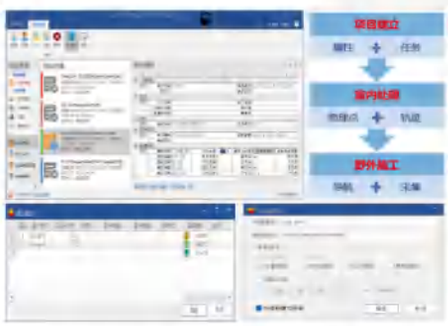


SSOfficeII

SSOFFICELL

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.

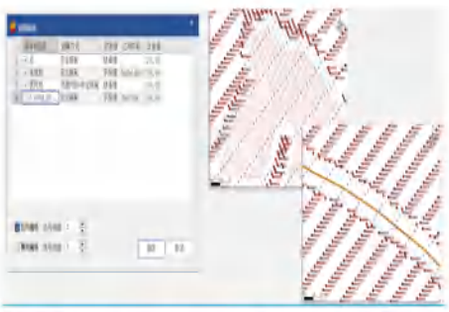


Integrated processing for project and task distribution

RTK surveying data processing

Node positioning data processing

Result data processing



Obstacle avoidance offset for source points

Track management

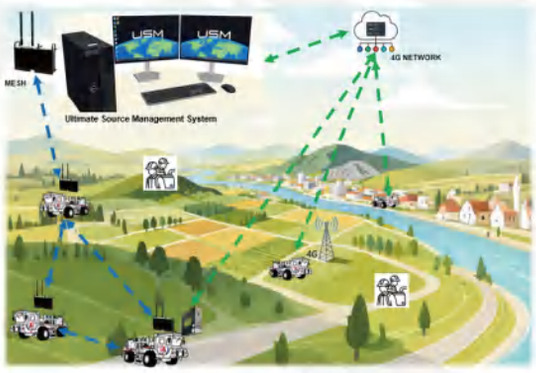
ULTIMATE SOURCE MANAGEMENT SYSTEM

Introduction

Ultimate Source Management (USM) is independently developed by BGP. It applies to vibroseis source and borehole shooting control in seismic exploration, supporting full-terrain and wide-area high-precision excitation operation.

Key features

- Multi type excitation source control.
- Remote control of source shooting.
- Excitation control based on TD rule.
- Decentralized adaptive excitation control.
- Remote real-time quality control.
- Automated quality reporting.



Schematic diagram of USM system operation scenarios

► Framework diagram of USM

Applications

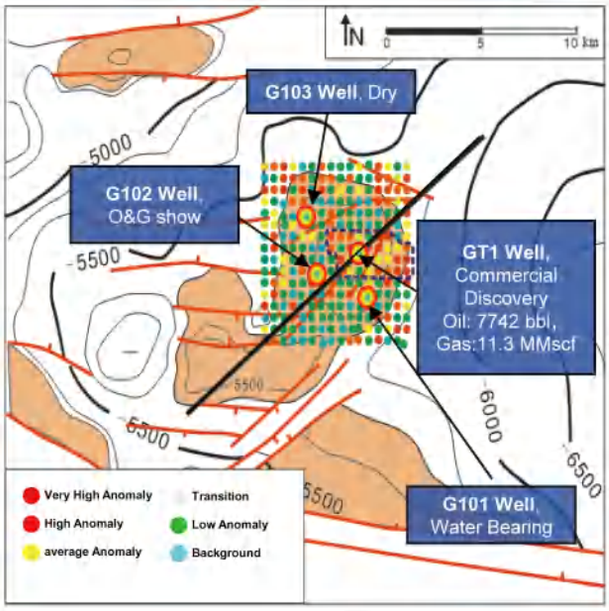
Typical application cases of operation areas

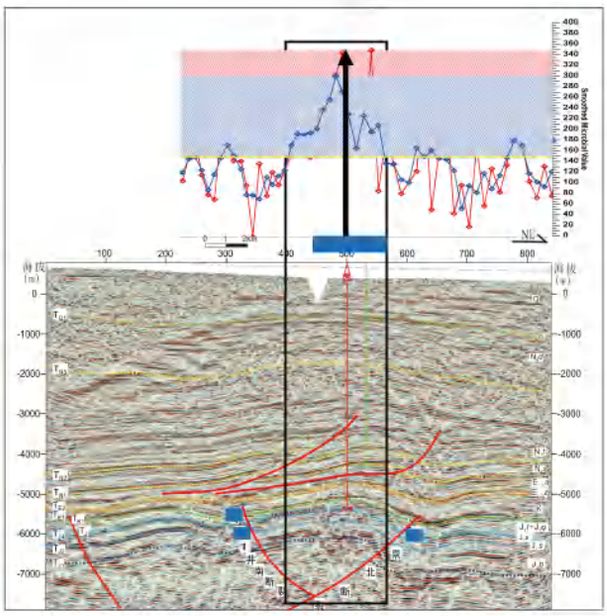
MICROBIAL GEO-CHEMICAL EXPLORATION（MGCE）

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

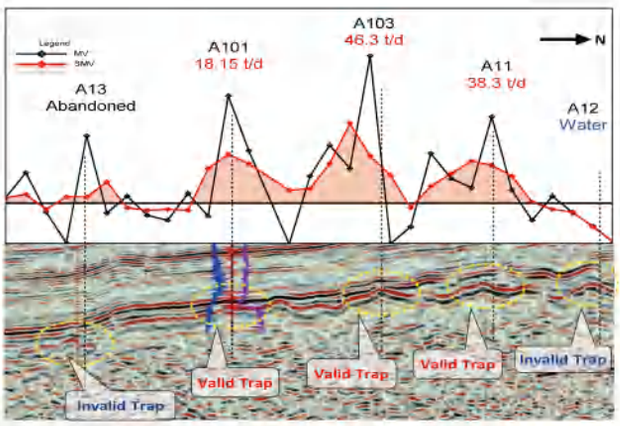




- **Seismic results:** 2D seismic identified a structural trap with size of around 40km2;
- **Geological risks:** unable to predict the trap is fully charged with HC or not and delineate the pool size;
- **MGCE results:** there was distinct microbial anomaly over the structure high with area extent less 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.

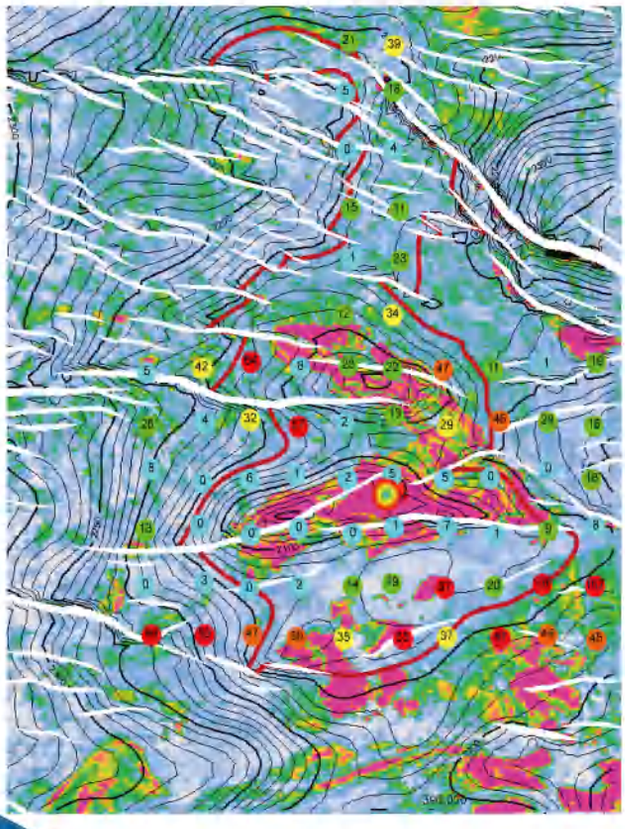
MICROBIAL GEO-CHEMICAL EXPLORATION（MGCE）

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.