



BGP – Beyond Geophysical Prospecting

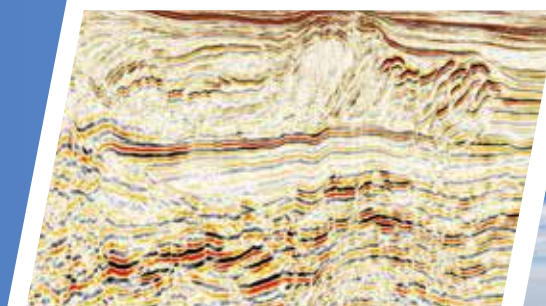
BGP



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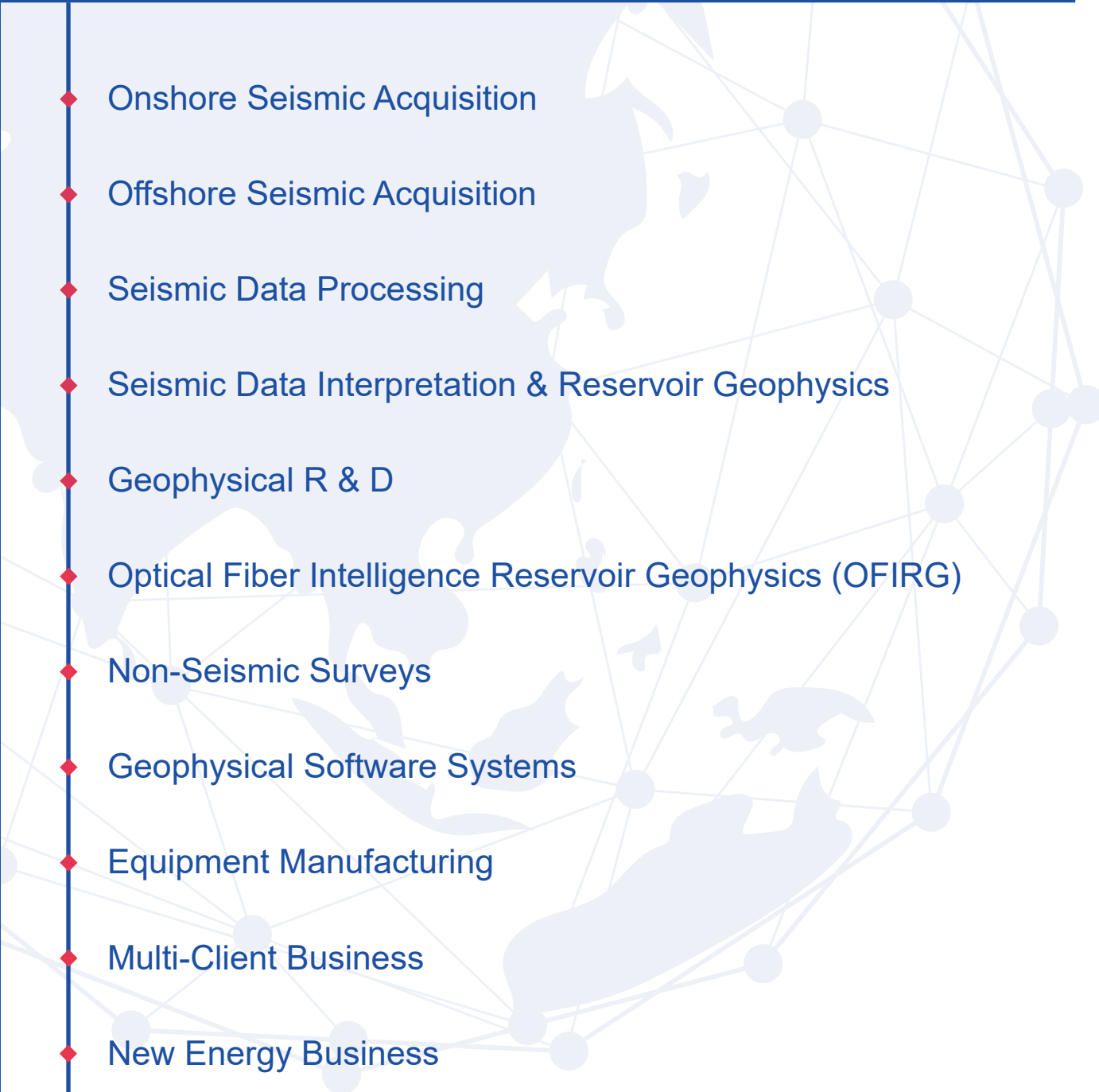


BGP

Company Profile

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

Business Scope

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

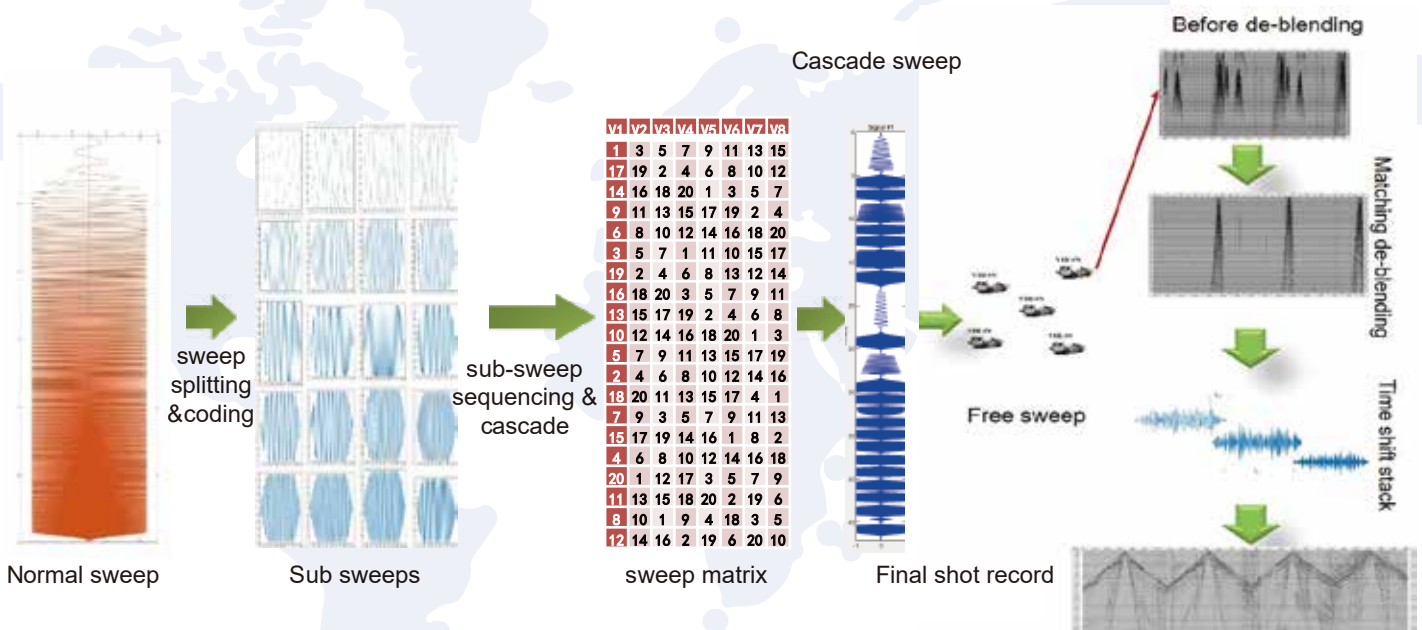


Frequency Separated Simultaneous Sweep (FSSS)

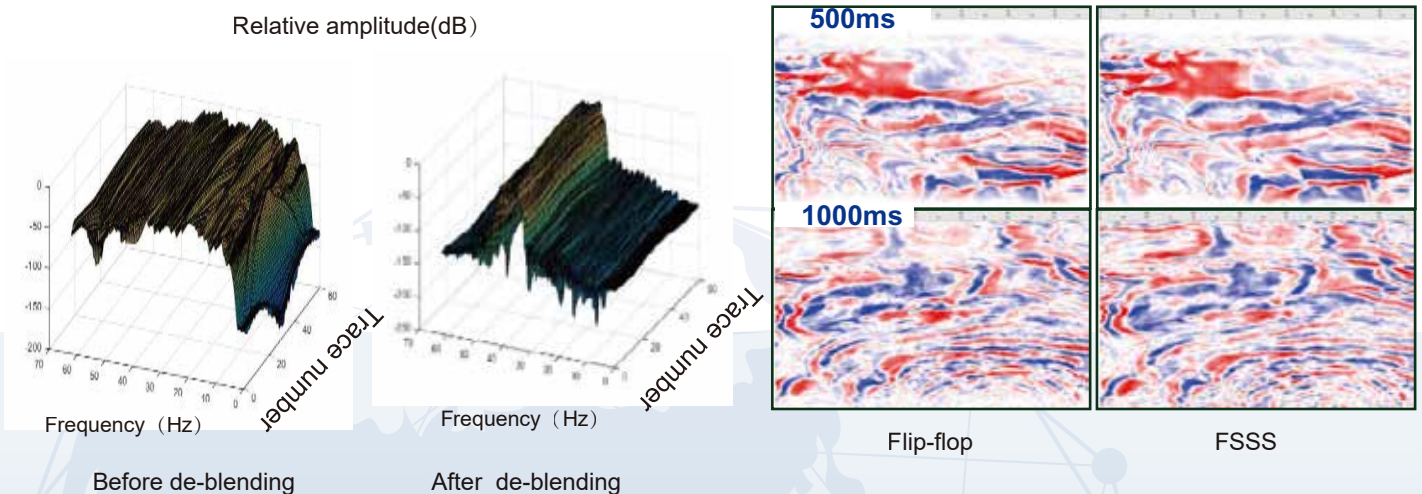
A High fidelity and productivity vibroseis acquisition method

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

FSSS Functional Diagram



FSSS results



Comparison of 2D FFT spectrum

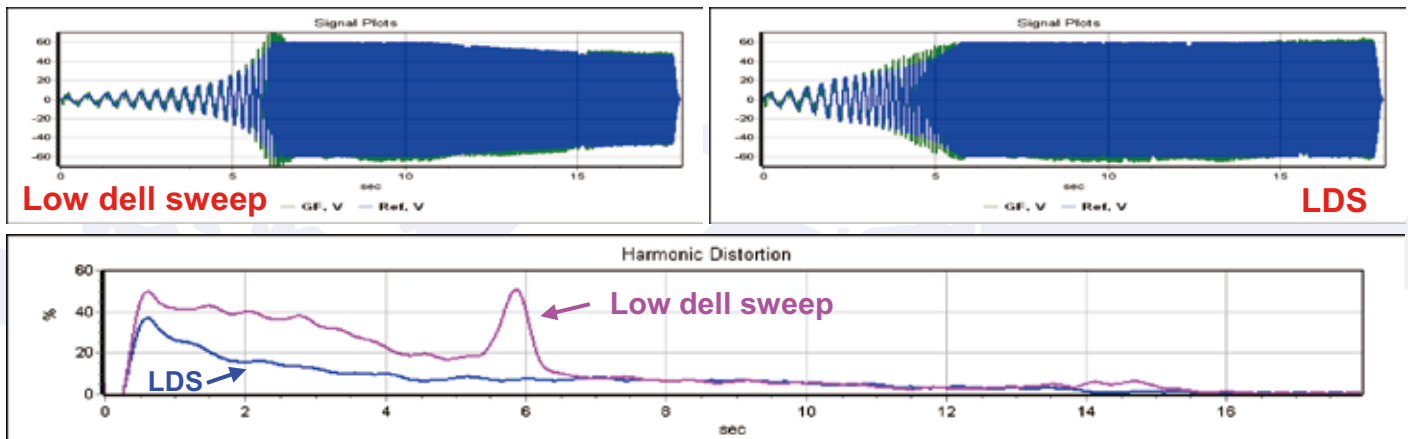
With same geometry, the daily productivity of FSSS is 6 times that of flip-flop



Low Distortion Sweep (LDS)

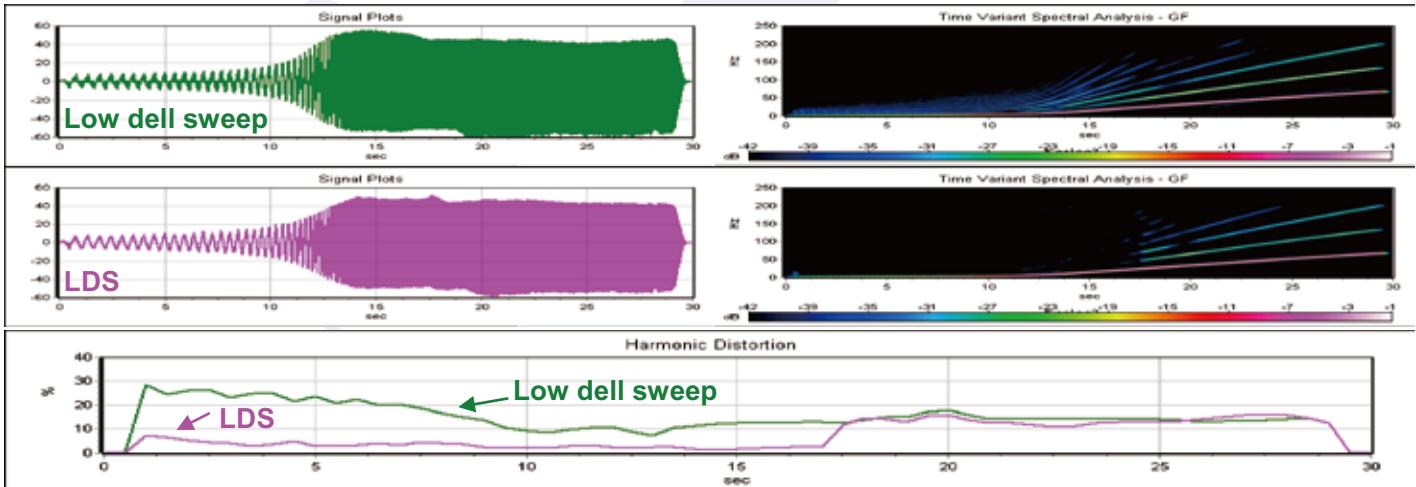
The Low Distortion Sweep (LDS) technique, especially developed by BGP for broadband surveys using conventional vibrators, mainly solves two low frequency sweep problems and can obtain better broadband seismic data.

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

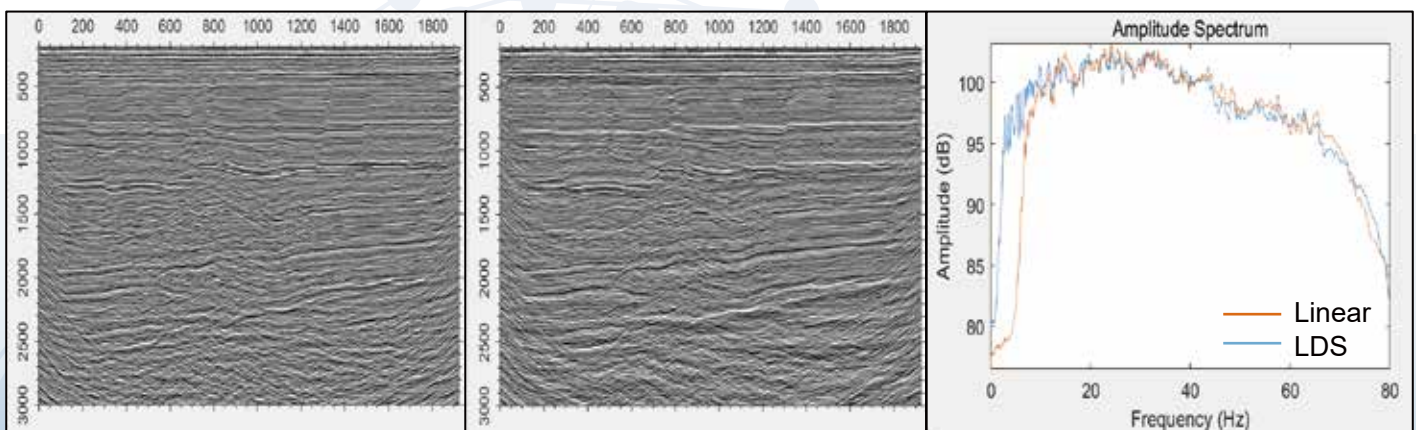


Using the LDS technique, the distortion is reduced by more than 20% on average and more than 40% in the transition zone of the sweep signal.

2. Suppression of the serious harmonics at low frequency



3. Acquisition of better broadband seismic data



Linear sweep (6-84Hz)

LDS (1.5-84Hz)



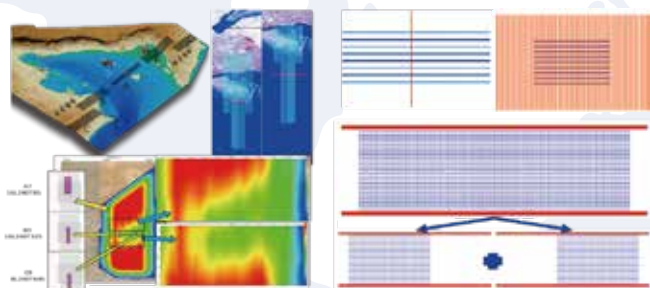
OBN Seismic Exploration Solutions

BGP OBN Briefing

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

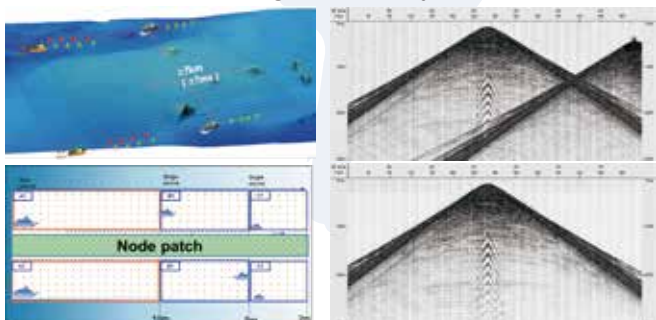
BGP OBN Key Techniques

1. OBN Geometry Design



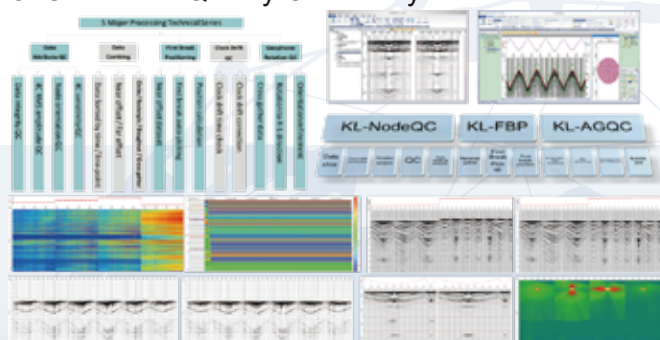
Geometry Design for Various Terrains

3. Marine Seismic High-efficiency Acquisition



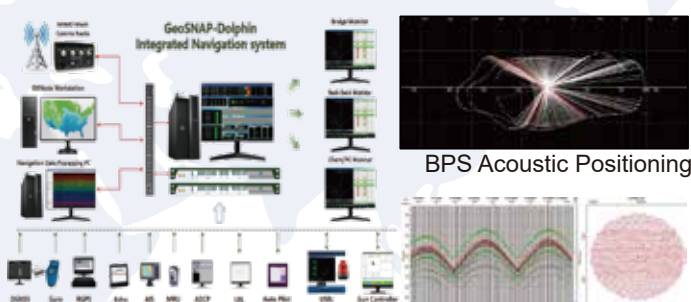
Multiple Sources Blended Shooting Data De-blending

5. OBN Data Quality Control System



KL-NodeQC Software

2. Integrated Navigation & Positioning



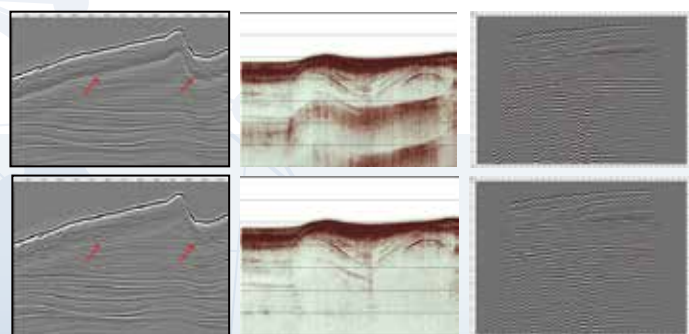
Dolphin Integrated Navigation System BGP FBP Solution

4. OBN Automatic Deployment & Retrieval System



Module, Conveyor and Deployment & Retrieval System

6. OBN Data Processing

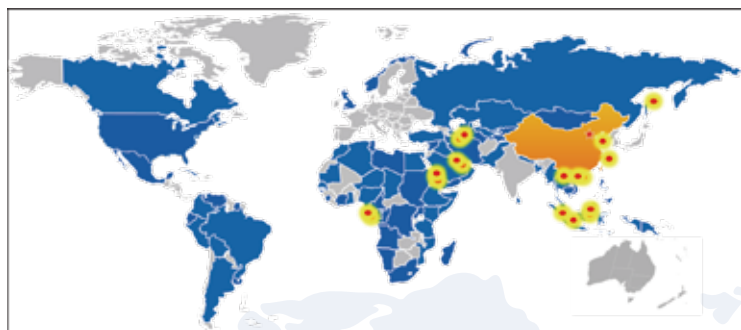


Broadband Processing / Multiple Removal / Vz Noise Suppression



OBN Seismic Exploration Solutions

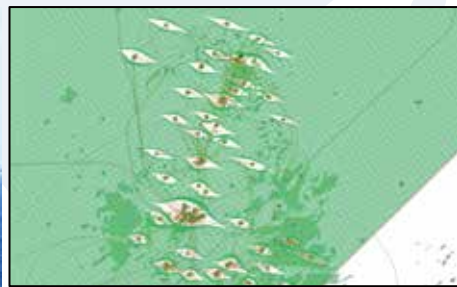
BGP OBN Experience



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

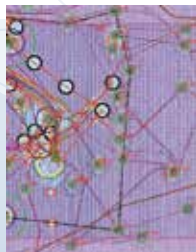
Brunei 3D/4D OBN Survey

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



Middle East OBN Survey

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



BGP's inversion based deblending algorithm dramatically improves productivity and efficiency in data acquisition and can handle any environment such as land, marine, towed streamer or OBN.

Applied on 3D common-receiver gathers, this method separates signal and noise iteratively in the frequency-wavenumber-wavenumber (f-k-k) domain.

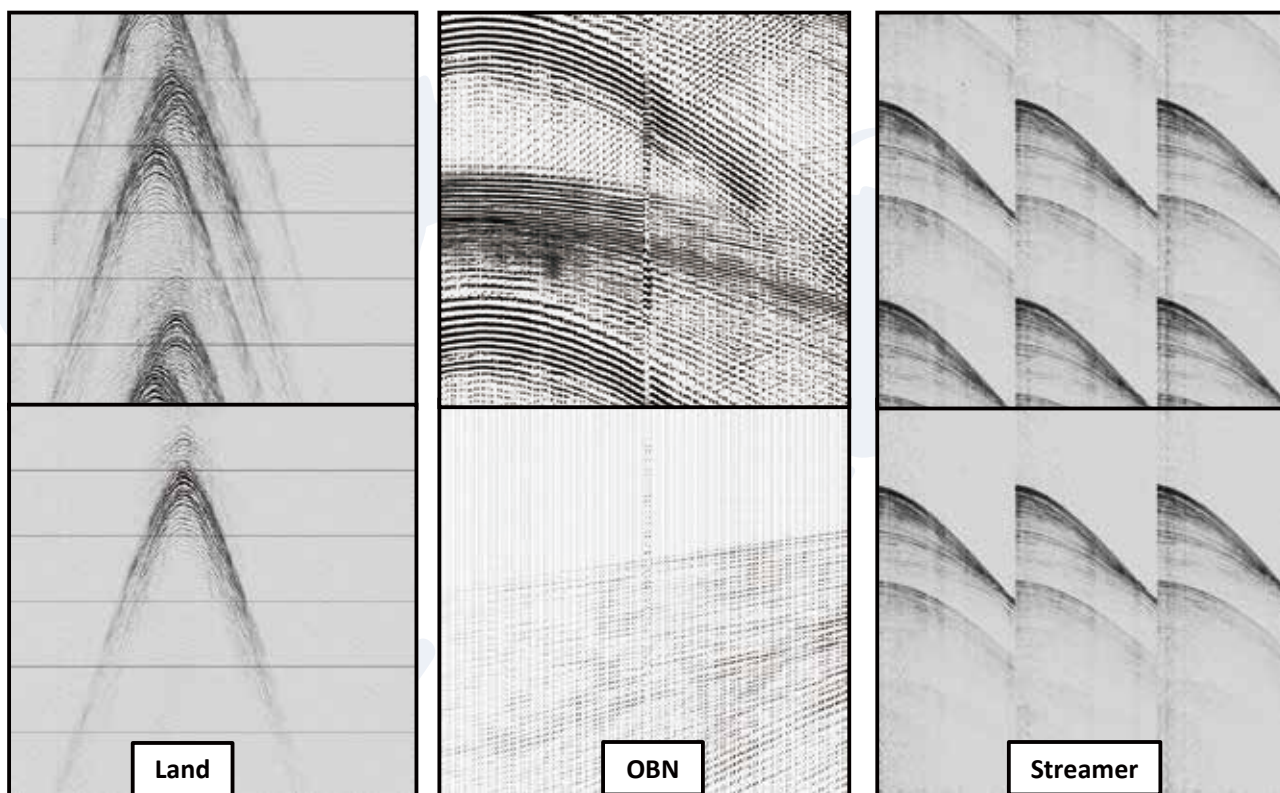


Figure 1: Common shot gathers before deblending (top) and after deblending (bottom)

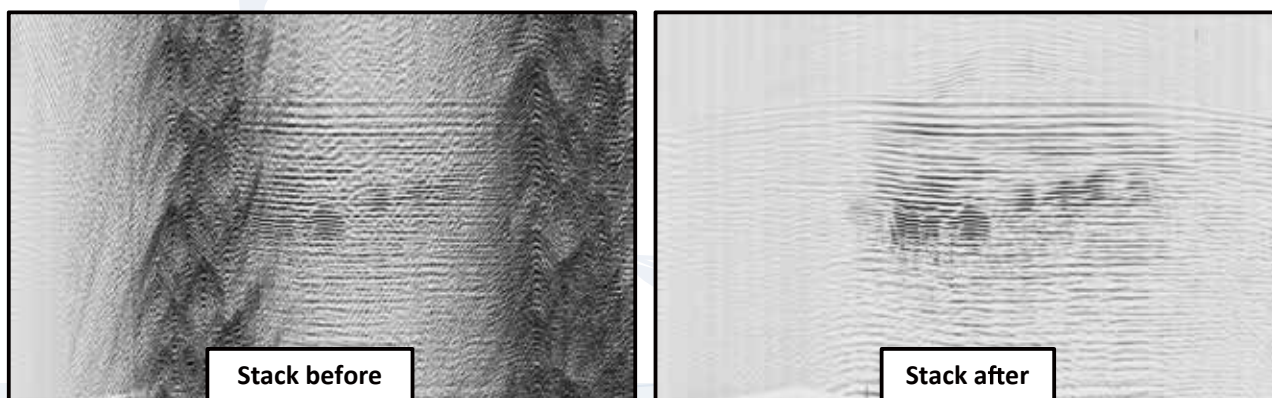


Figure 2: Stack section before deblending (left) and after deblending (right)

Features

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



Joint Deblending and Compressive Sensing Reconstruction

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

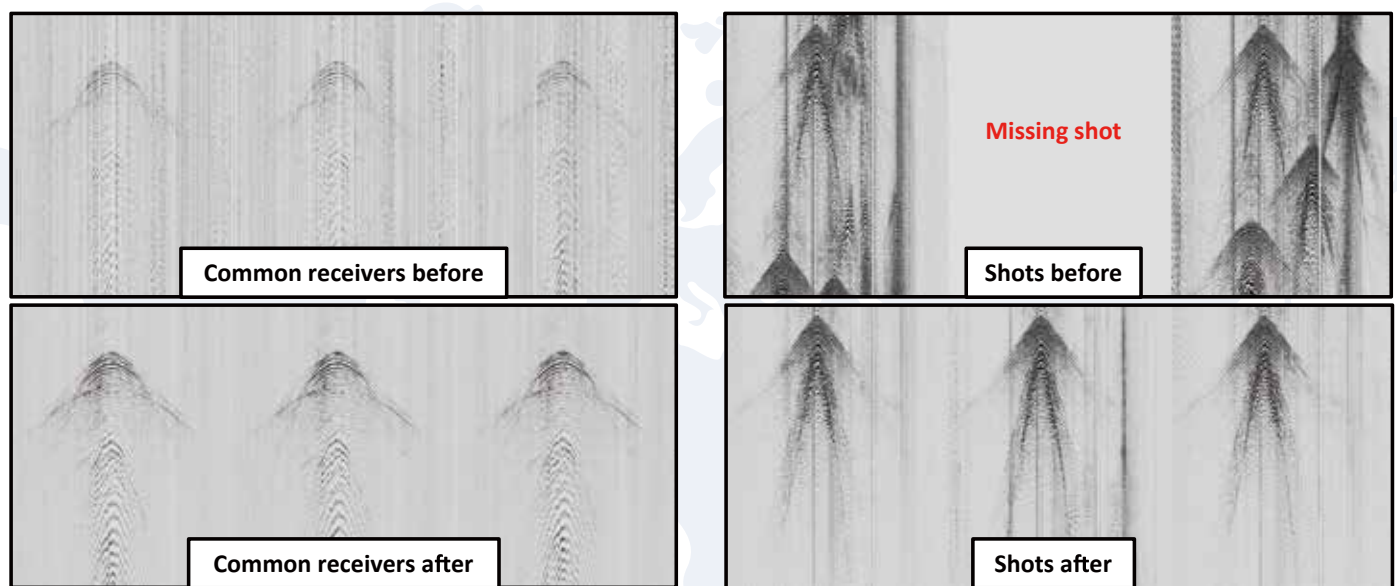


Figure 3: Shots and receivers before (top) and after (bottom) simultaneous deblending and compressive sensing

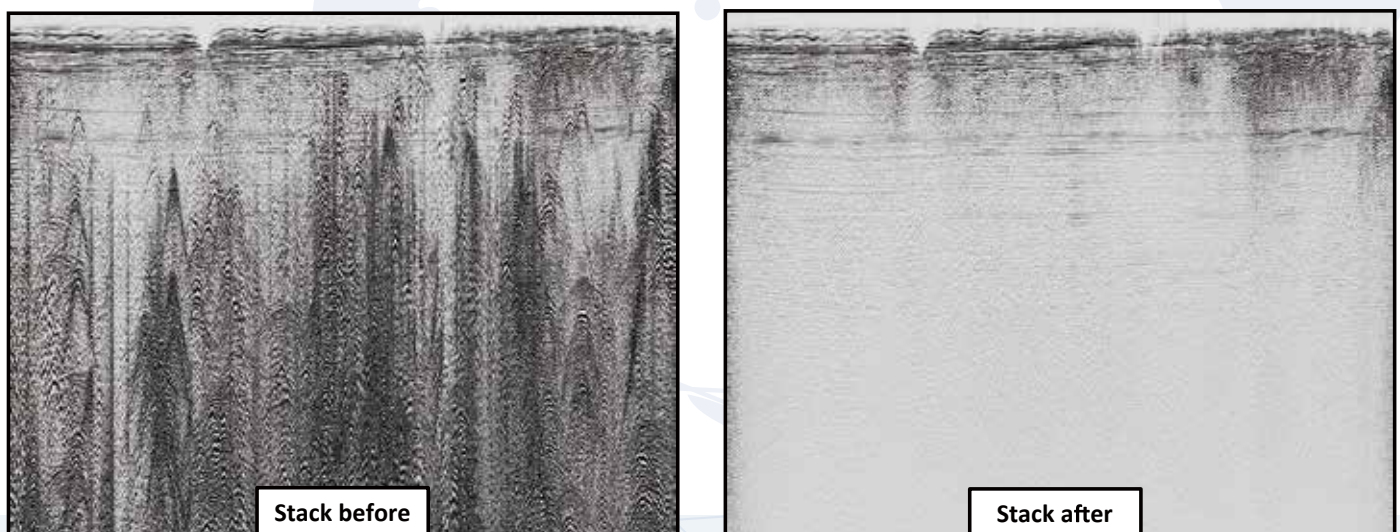


Figure 4: stack section QCs

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



OBS Data Processing

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

Optimized pre-processing workflows:

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

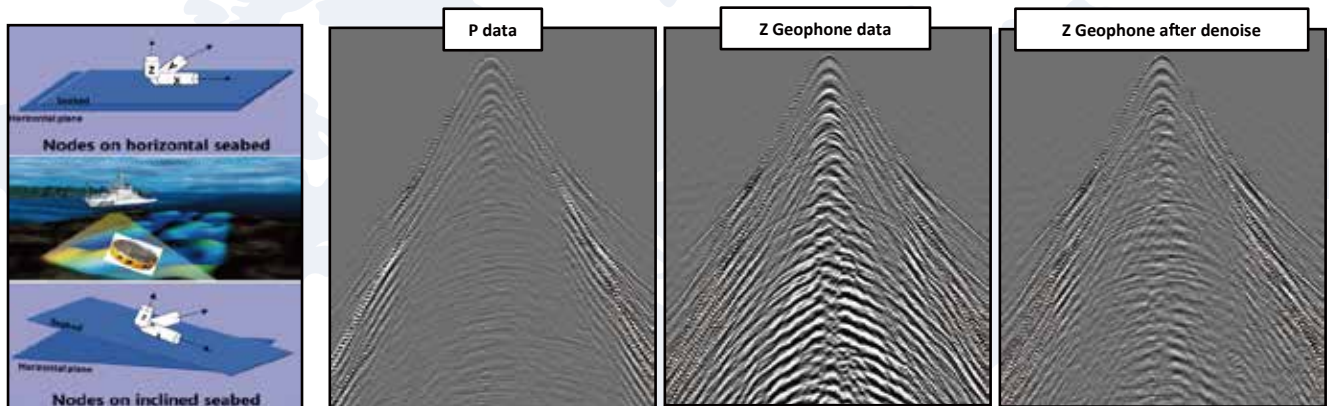


Figure 1:OBN denoise of vertical geophone

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

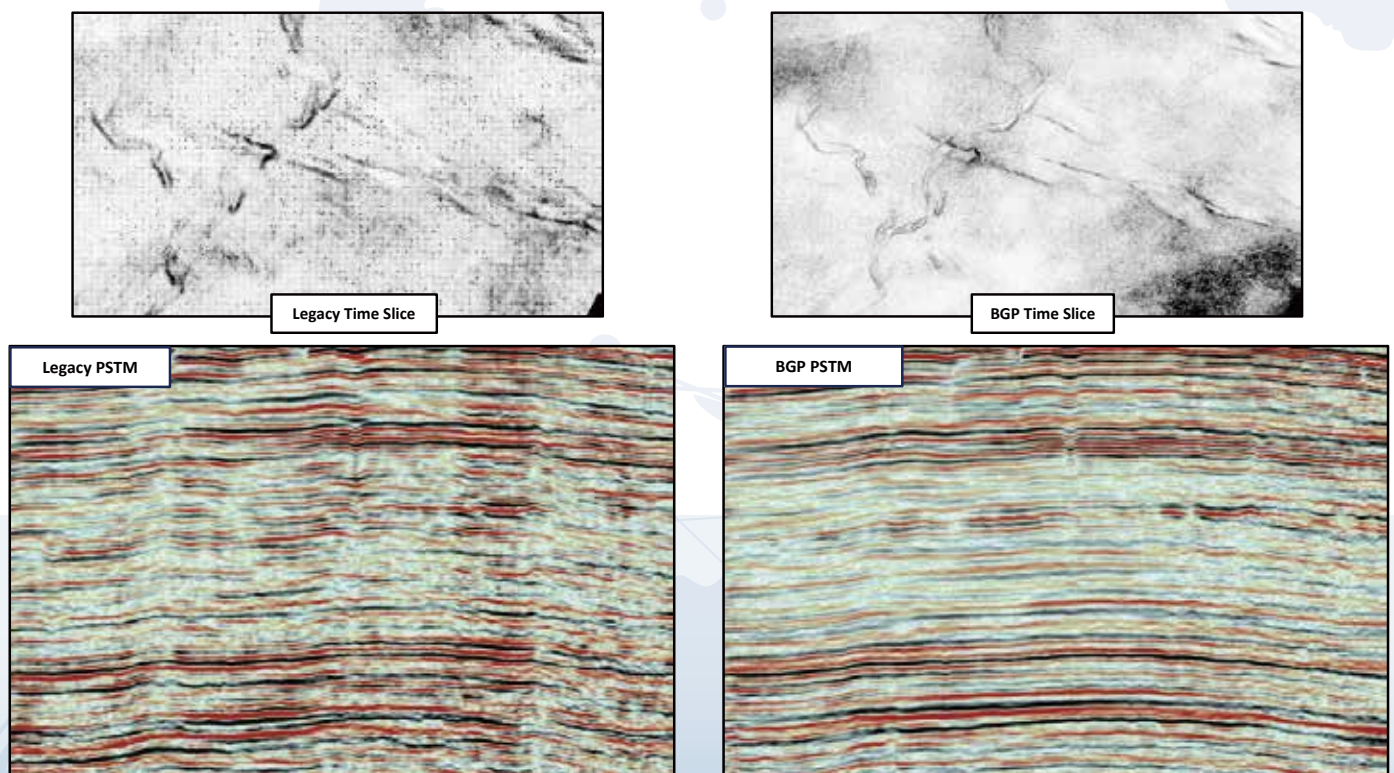


Figure 2: comparison of legacy vs BGP PSTM stack sections and time slices

Full Waveform Inversion FWI:

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

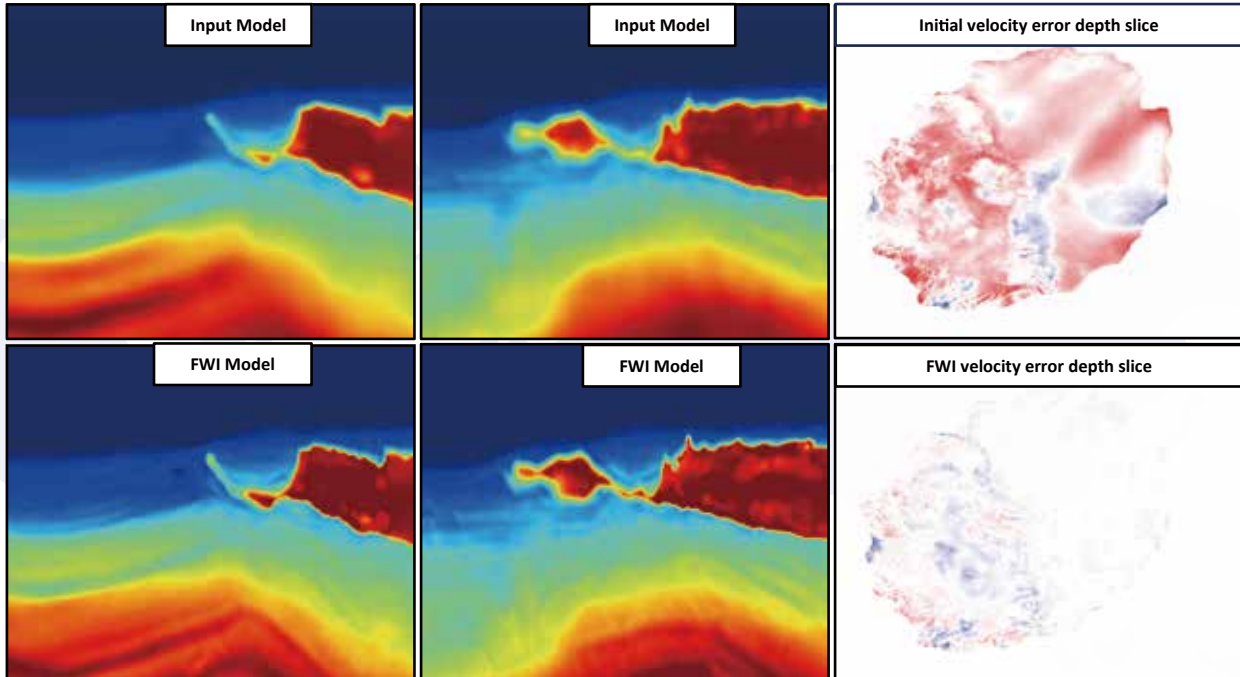


Figure 3: Deep water Gulf of Mexico OBN FWI

Full Waveform Impedance Inversion FWII:

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

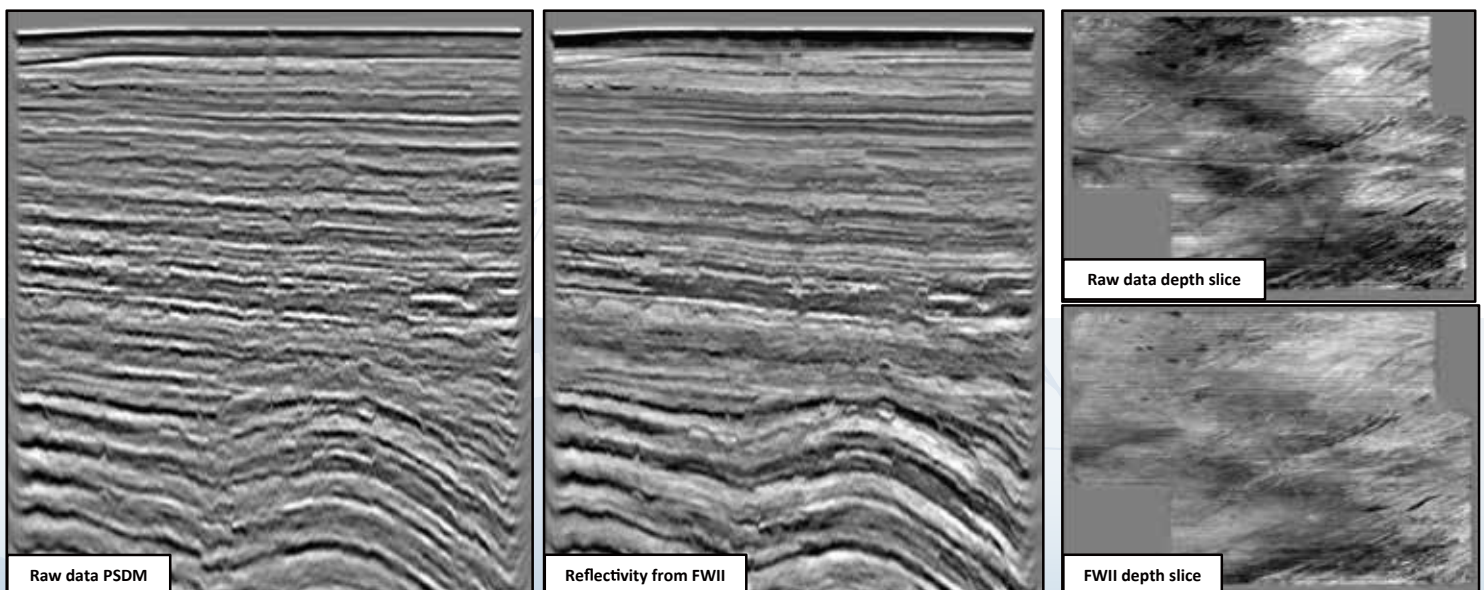


Figure 4: Full Waveform Impedance Inversion (comparison of FWII from raw data vs raw PSDM data)

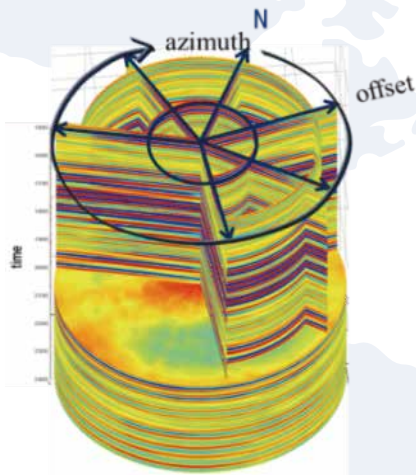
5D Seismic Interpretation

Pre-stack 5D Seismic Data Interpretation

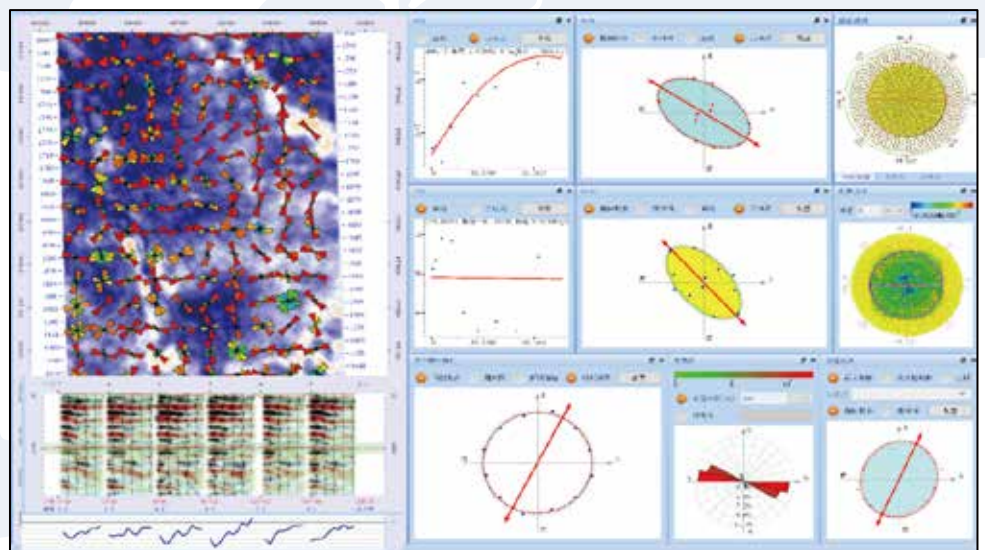
Pre-stack 5D interpretation techniques have been developed to fully extract pre-stack information. Compared to 3D interpretation, information in offset and azimuth dimensions is utilized to finely depict the distribution of fractures and hydrocarbons.

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.



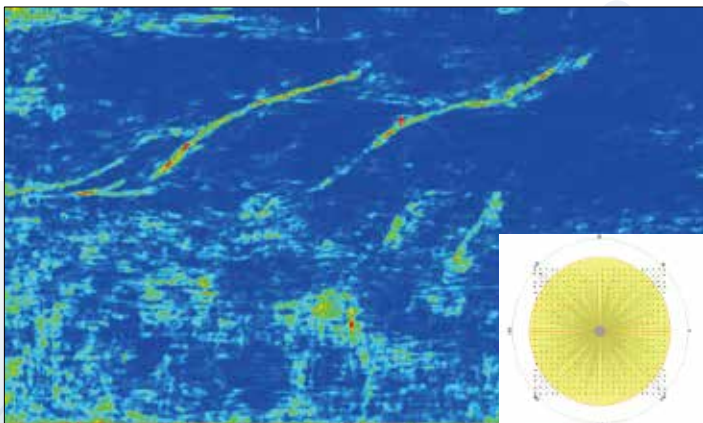
Prestack 5D gather



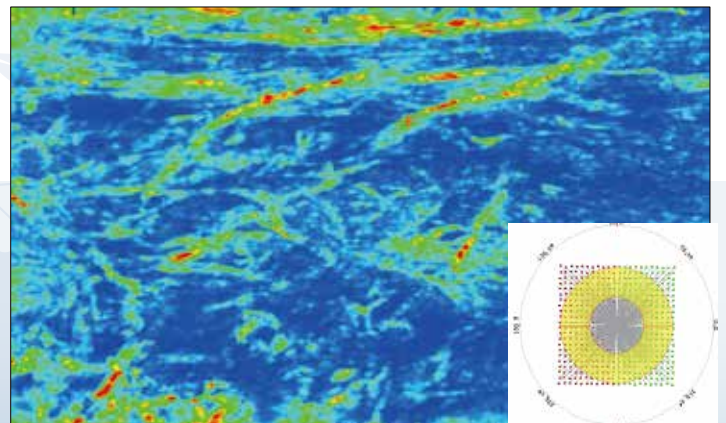
Interactive 5D seismic data analysis

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.



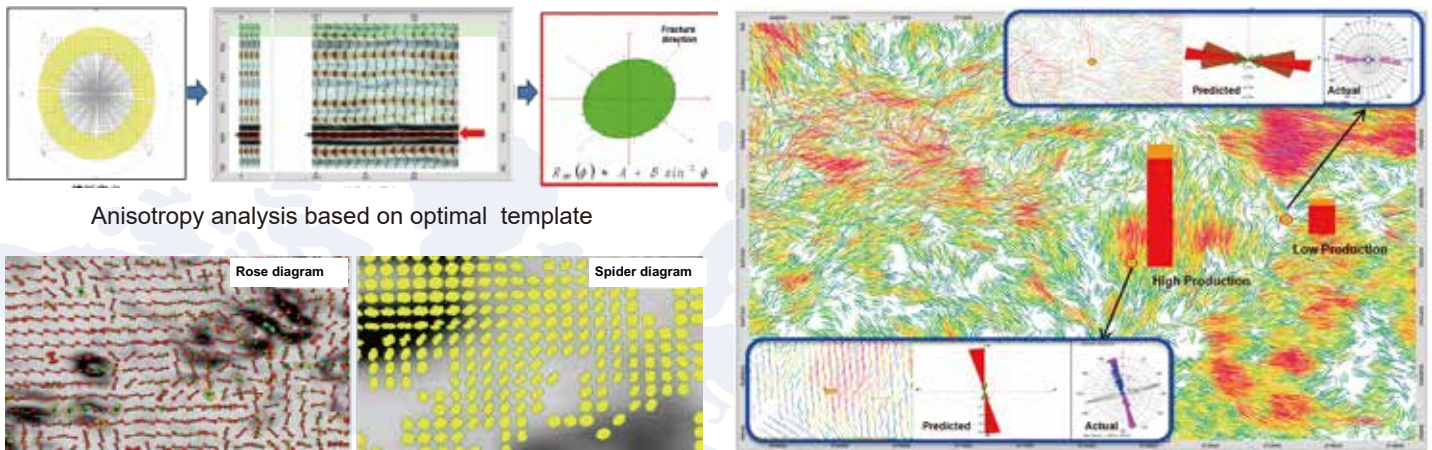
Full azimuth and angle stacking
suppress geological detail



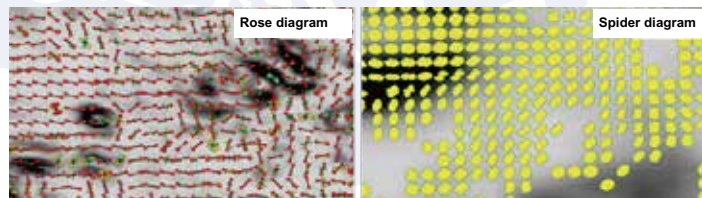
Partial azimuth and angle stacking
reveal more information

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

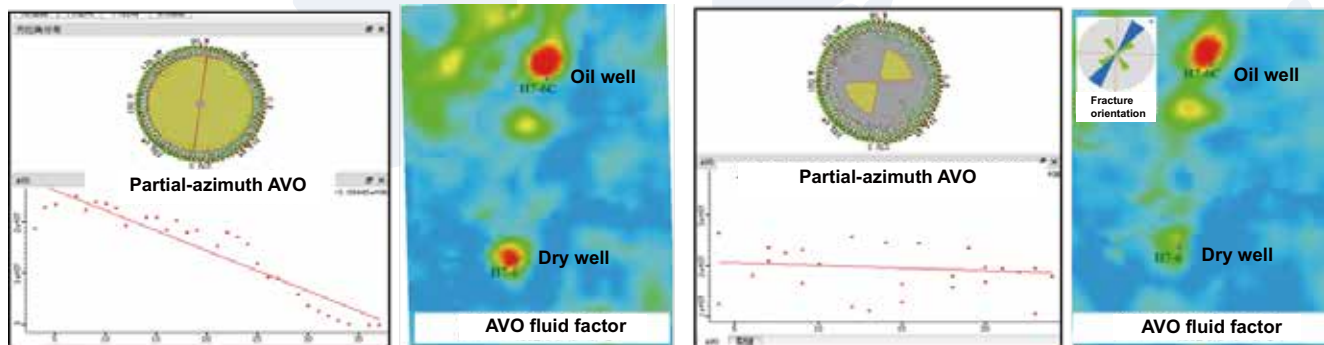


Various displays of fracture detection results

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

AVOAz

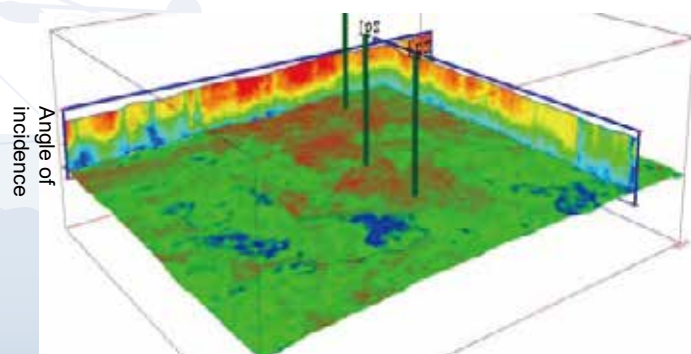
Azimuthal AVO analysis based on 5D gather data can effectively mitigate anisotropy impact on AVO response and thus improve hydrocarbon detection accuracy.



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



GeoEast - An Integrated Seismic Data Processing and Interpretation Software System



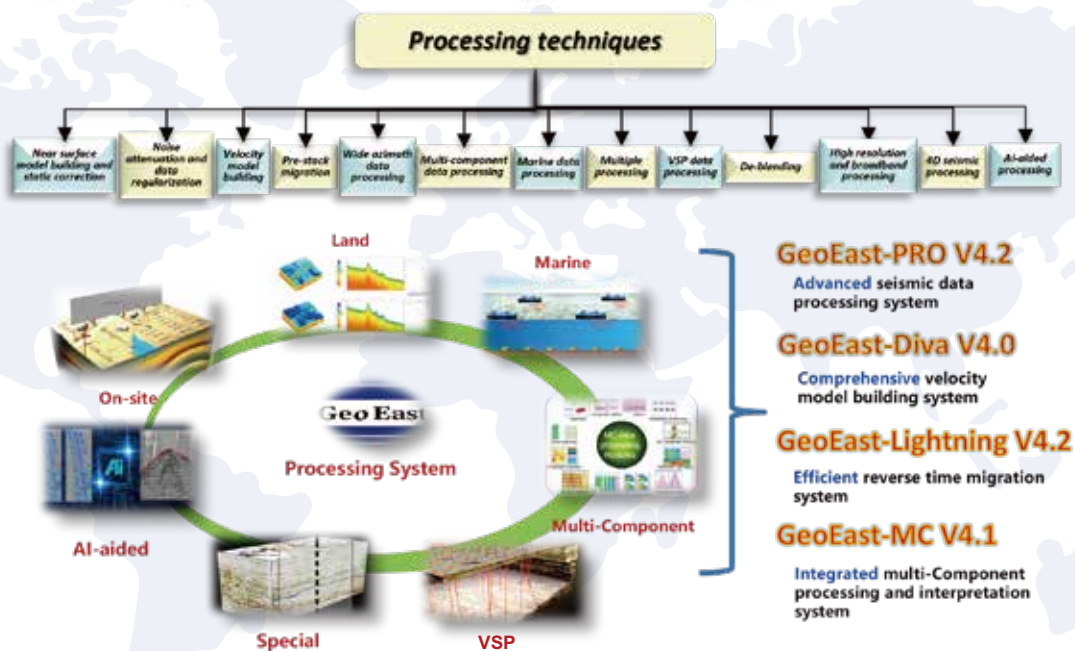
GeoEast is a comprehensive, large-scale geophysical data processing and interpretation software system. It can fully meet the demands of time domain and depth domain processing and interpretation of geophysical data acquired from complex geological and geophysical conditions of both land and marine.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

Processing Software

■ 7 packages

■ 24 technology series

■ 400+ modules

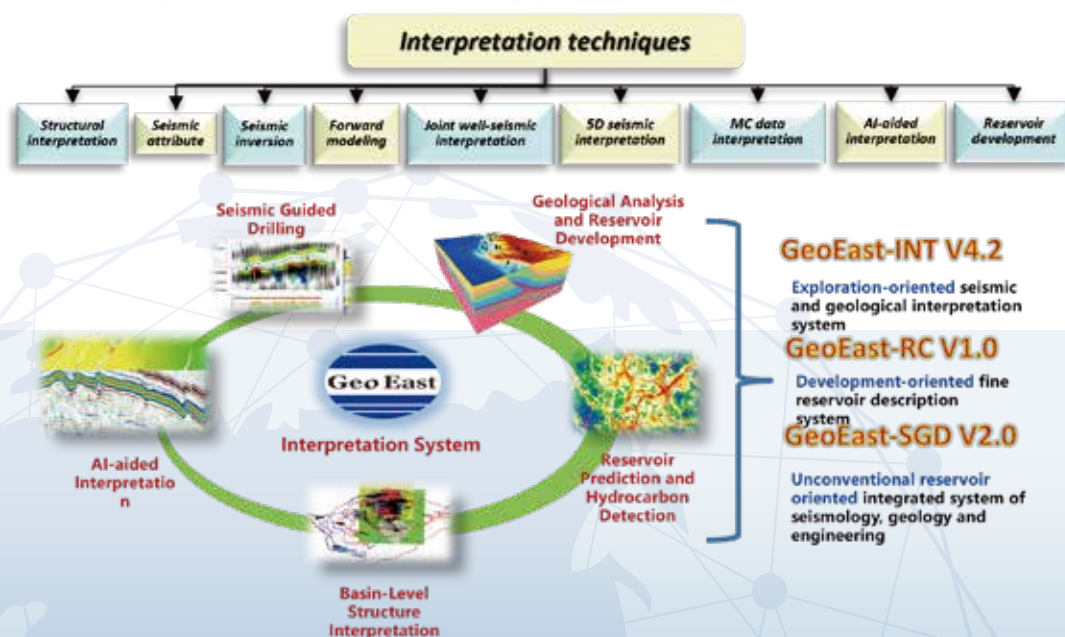


Interpretation Software

■ 7 packages

■ 24 technology series

■ 400+ modules





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.

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.

AI Processing

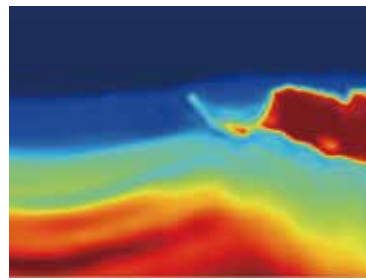
GeoEast has developed intelligent processing modules for time-consuming and labor-intensive processes such as first break picking, velocity picking, and noise attenuation. The accuracy and efficiency improved dramatically.

AI Interpretation

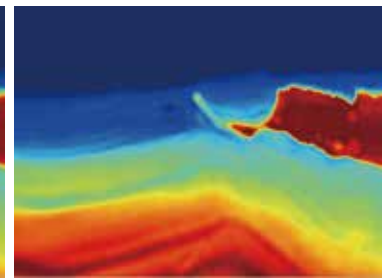
A deep learning-based artificial intelligence neural network has been developed, equipped with a series of intelligent interpretation technologies including horizon interpretation, fault identification, well log curve prediction, well log lithology prediction, and geological body identification.

Seismic Inversion

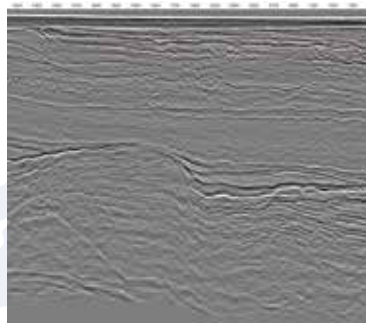
GeoEast provides rich pre-stack and post-stack seismic inversion methods and complete workflow, which can meet the needs of reservoir prediction in different stages of exploration and development.



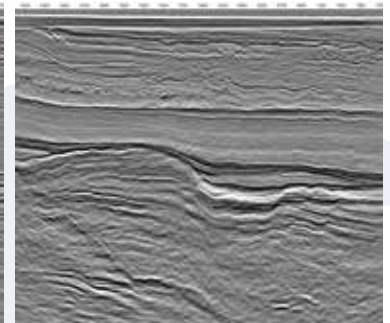
Legacy velocity model



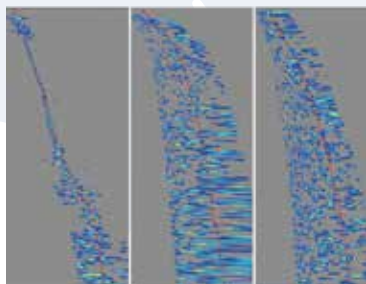
JDFWI inverted velocity model



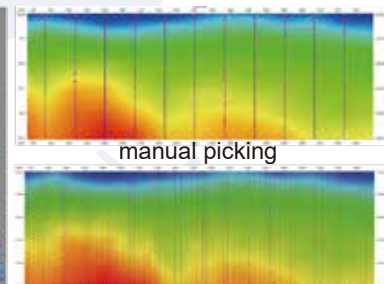
PSDM



PSDM + FWI



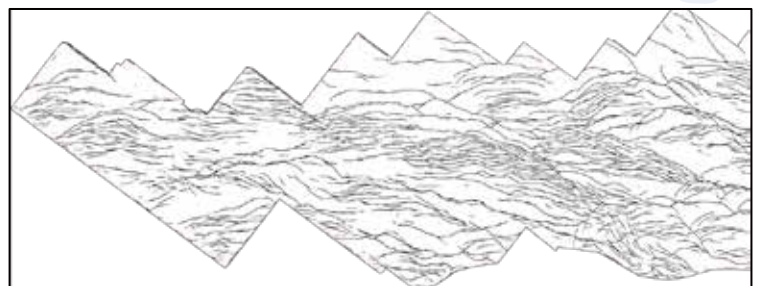
Different S/N data



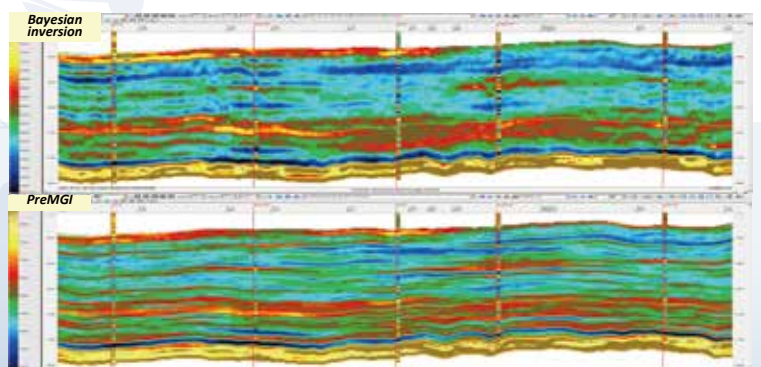
manual picking



DL picking



AI-aid fault prediction

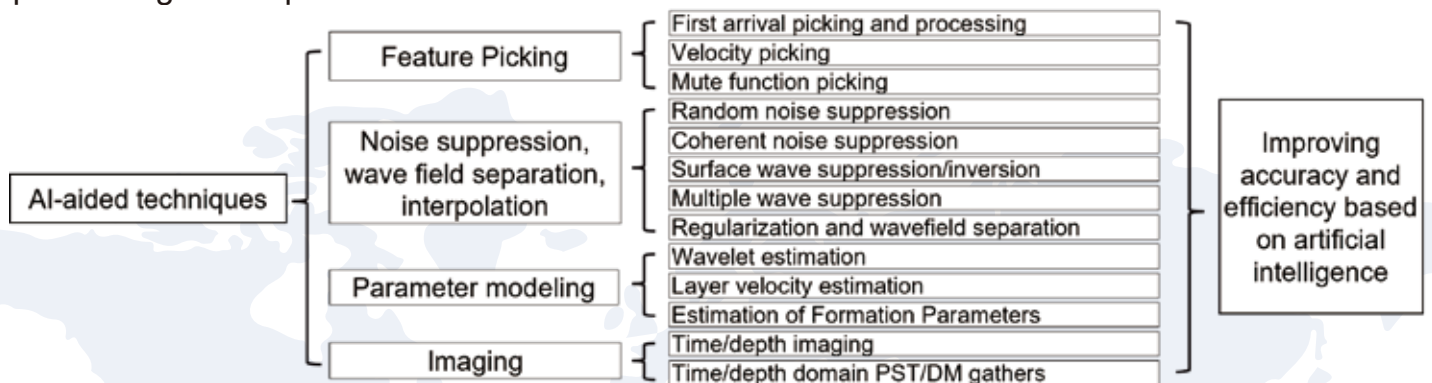


Inverted shear wave impedance

AI Processing

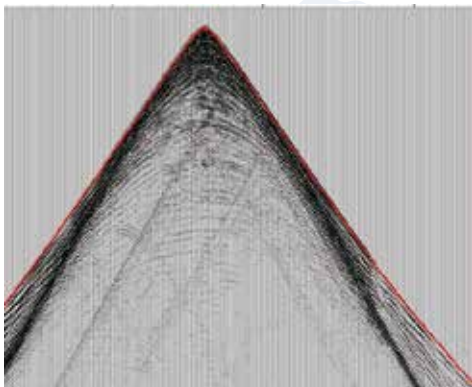
AI-aided Seismic Data Processing

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

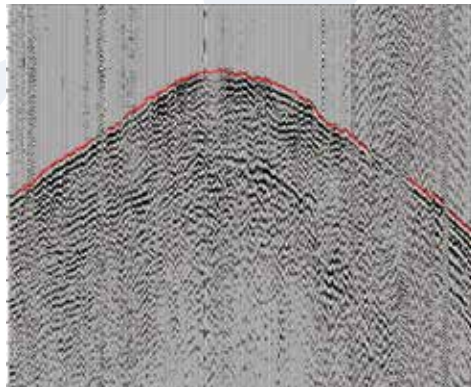


Deep Learning-based First-Break Picking

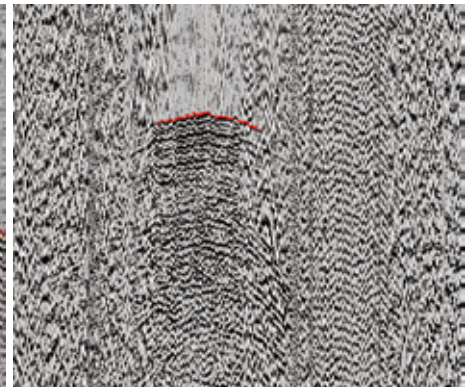
GeoEast provides a deep learning-aided first-break picking technique which can efficiently pick data of different S/N levels with very high accuracy. The technique has been applied on lot of processing projects with different S/N levels.



High S/N data

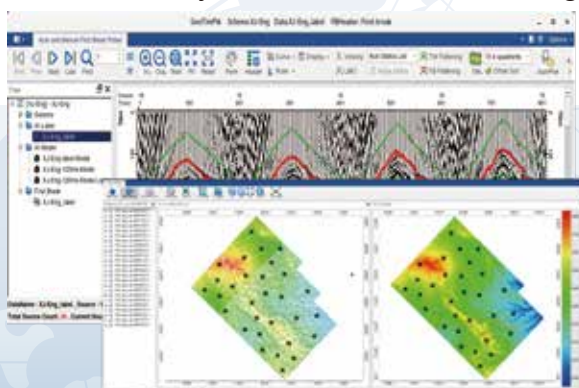


Middle S/N data

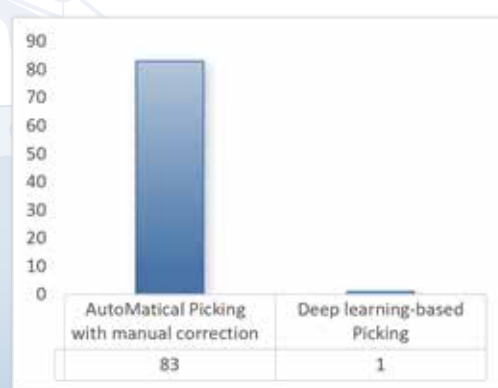


Low S/N data

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



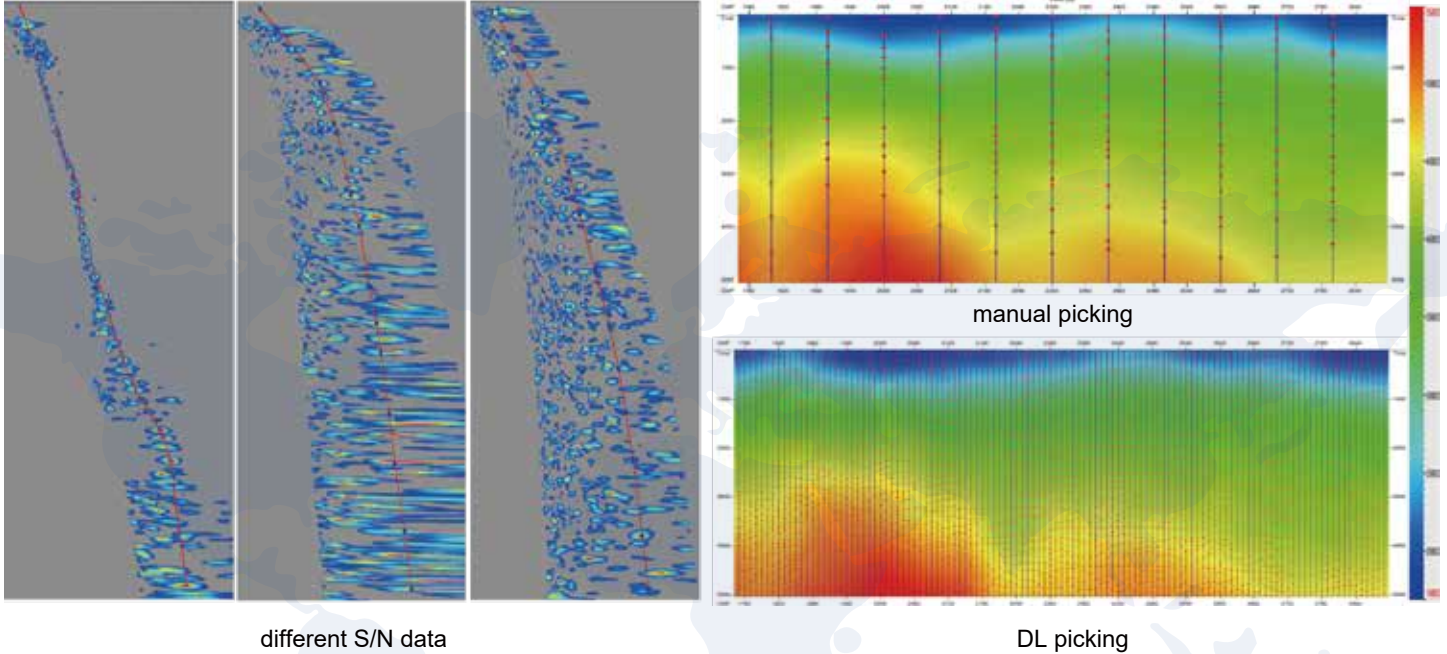
Interactive software with full functionality



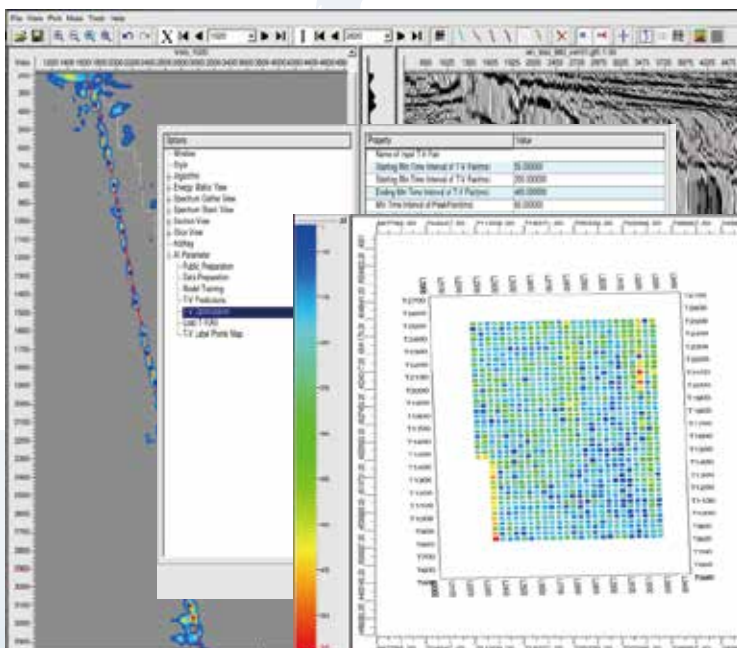
Computational Efficiency Comparison

Deep Learning-aided Velocity Picking

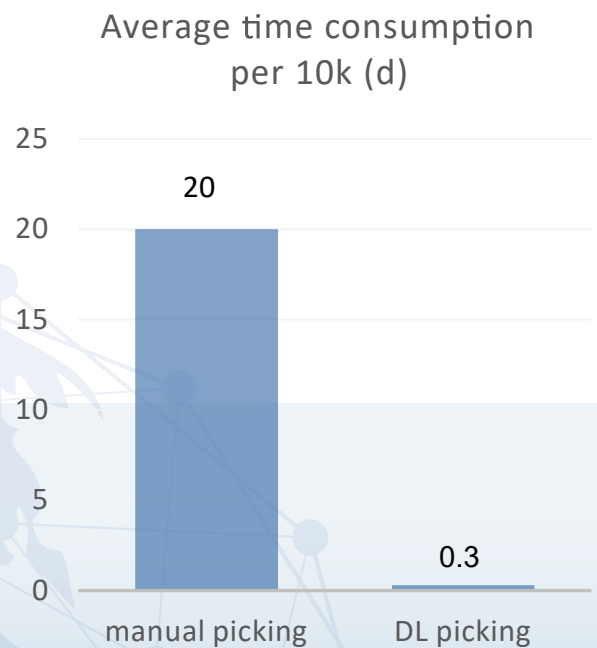
GeoEast provides a deep learning-aided velocity picking technique which can properly handle velocity spectra of different quality and give quality picking results.



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

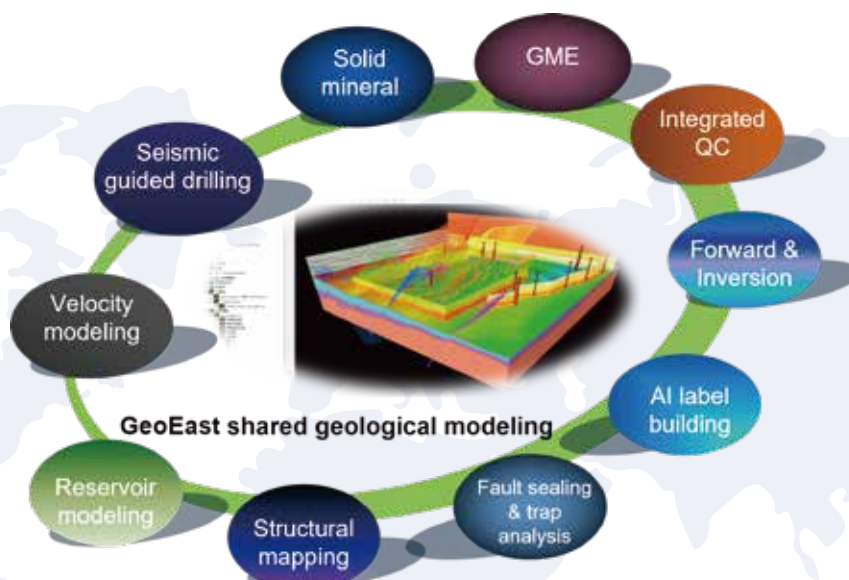


Computational Efficiency Comparison

Geological Modeling

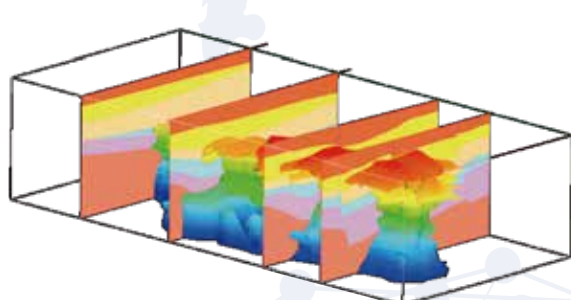
Reverse Time Migration

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

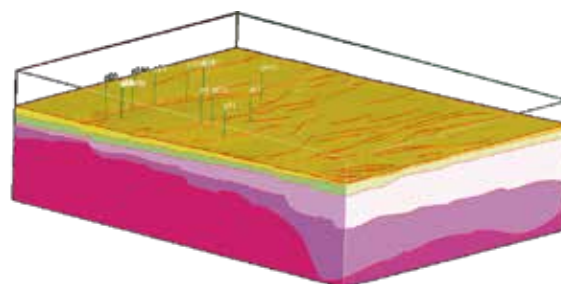


Sample application scenarios

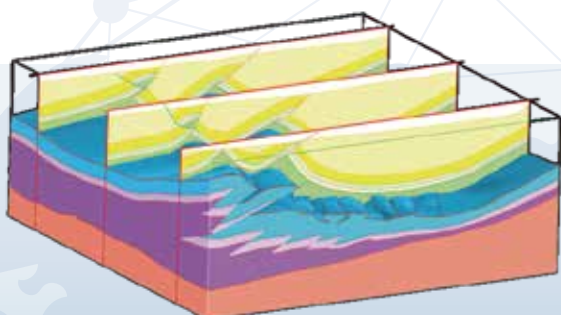
The shared modeling platform can be applied in seismic, from data acquisition through interpretation, GME, solid mineral and reservoir development. It has been widely applied in seismic inversion initial model building, property modeling, forward modeling, geological anomalous body modeling, and geological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



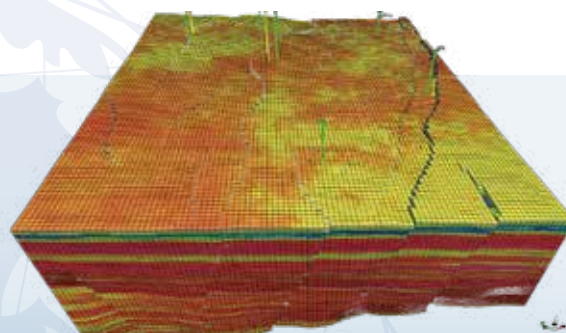
Solid mineral



Complex fault blocks



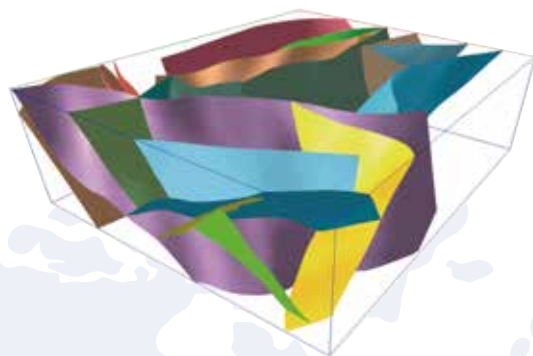
Overthrust structure



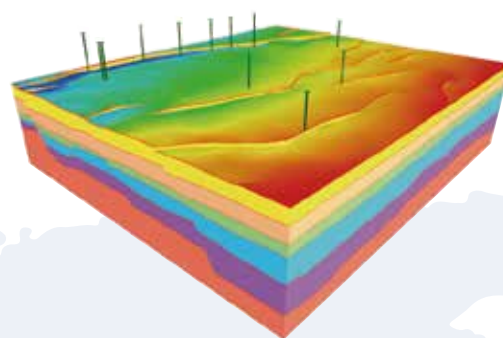
Porosity modeling

Structure Model building

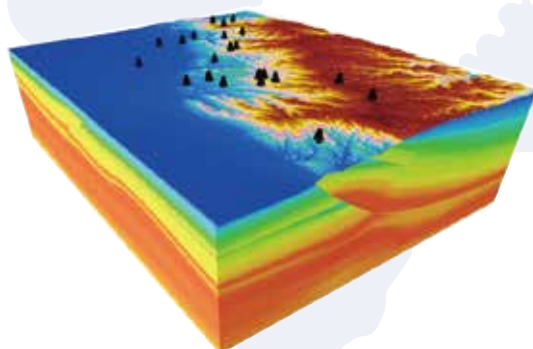
GeoEast provide an integrated interpretation and modeling functions. It offers a user-friendly approach in modeling complex structures such as normal and reverse faults, unconformities, etc.



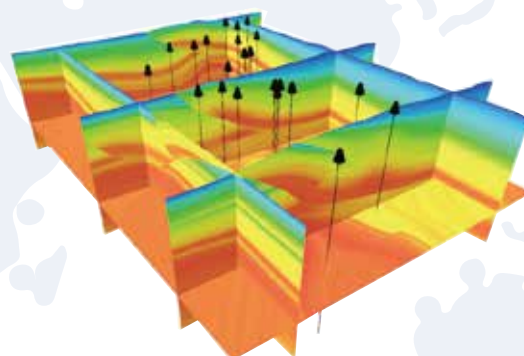
Fault surface model



Structure model



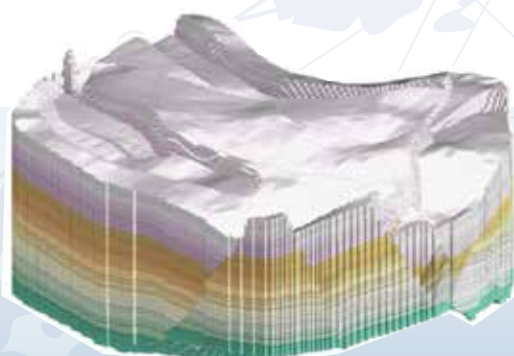
Velocity model



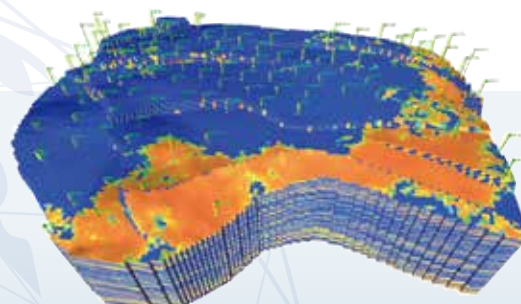
Model QC

Reservoir Modeling

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



Reservoir grid model



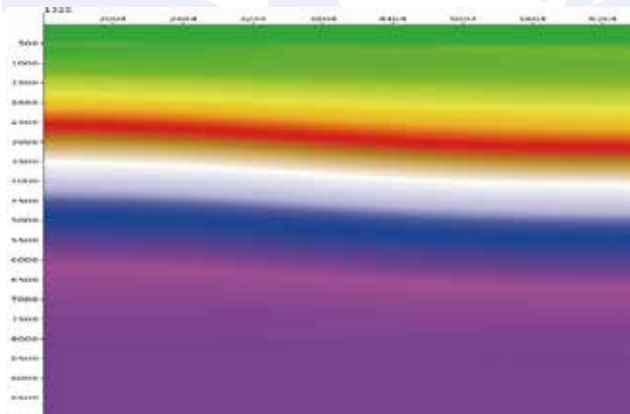
Reservoir property model

GeoEast-full waveform inversion (FWI)

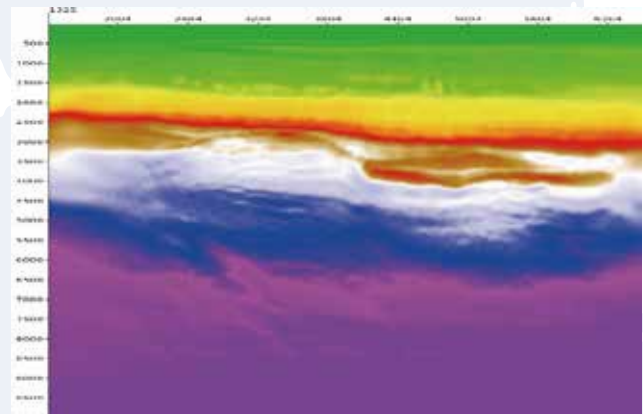
GeoEast Full-waveform inversion includes refraction inversion and reflection inversion. Several techniques for handling practical issues are provided, such as adaptive time FWI for handling cycle-skipping, and first-break FWI for complex and low SNR land data. The FWI inversions also consider earth Q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

Conventional refraction FWI

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



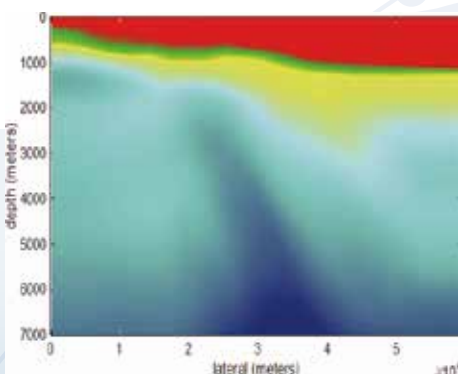
Initial velocity model



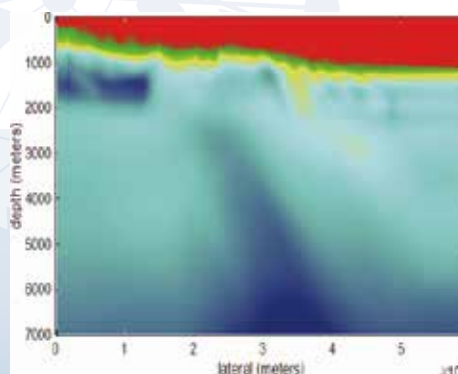
FWI velocity model

First-break FWI

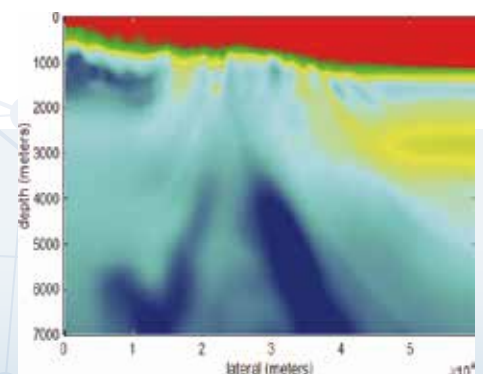
Inverting a land dataset is very challenging, because of the complexity of the data. Ground rolls and guided waves in land data are very hard to simulate accurately with wave equation modeling methods. Guided wave is a kind of refraction energy that bounces multiple times between surface and reflectors.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



Initial model



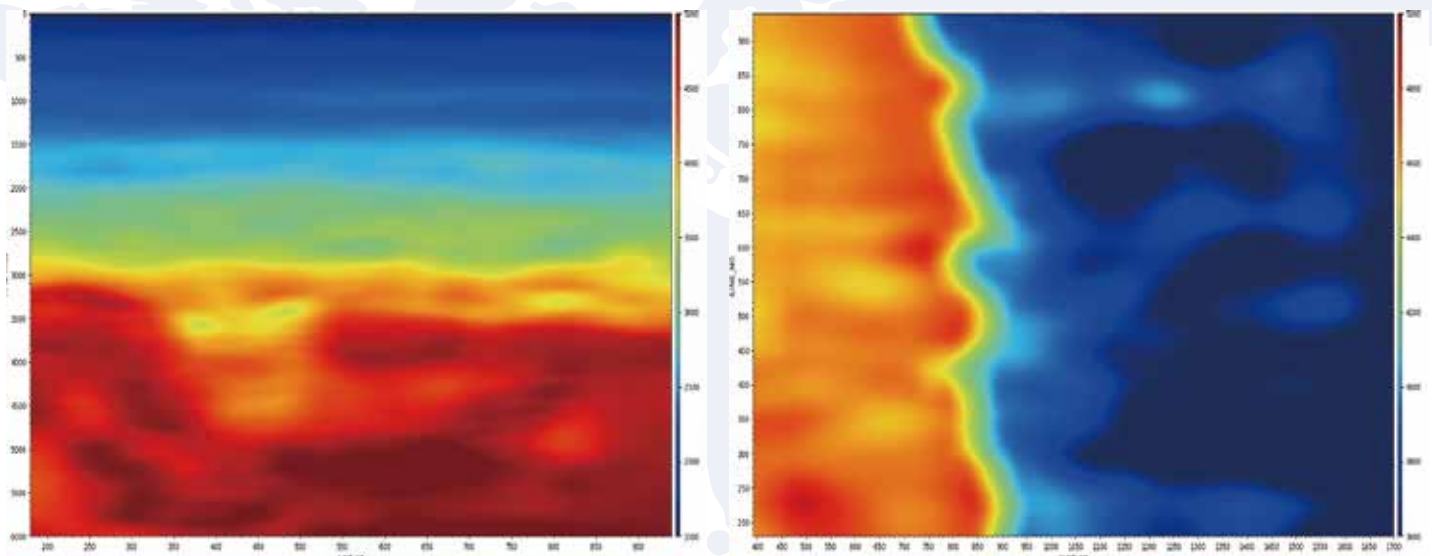
First-break FWI



Conventional FWI

Time-Adaptive FWI

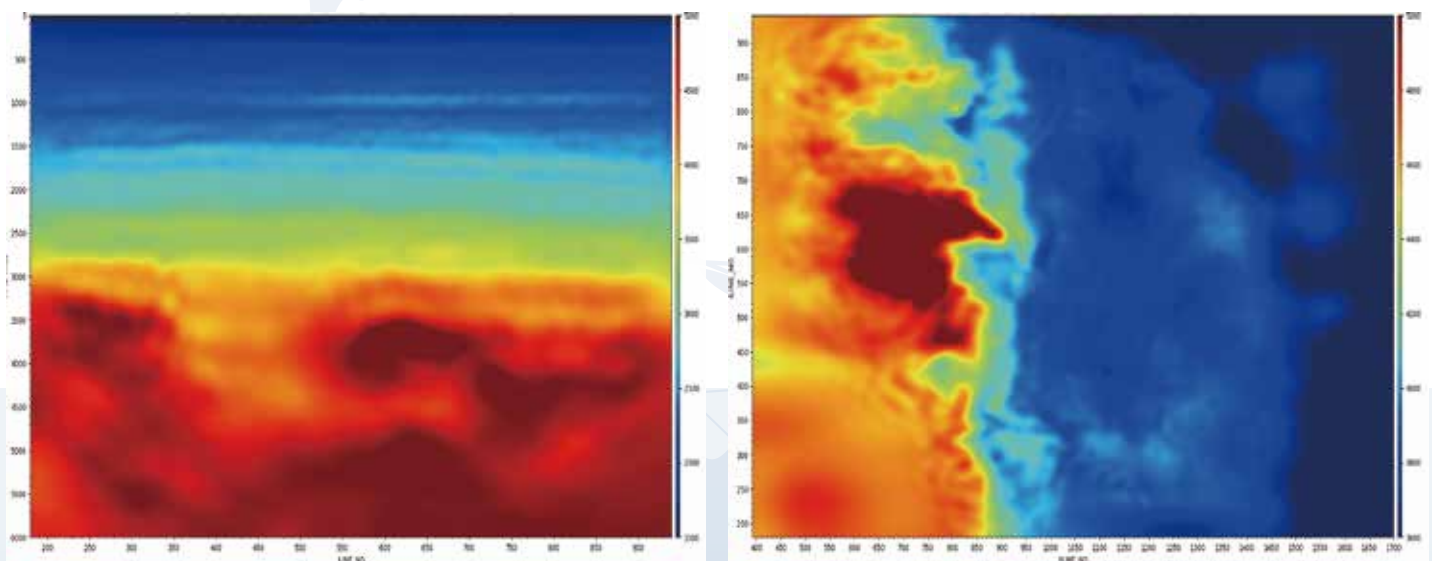
To tackle the cycle-skipping issue, we also developed time-adaptive FWI, in which we minimize the cross-correlation time lag of modeled and observed data. This approach can allow our inversion scheme to rely on the time error of the events, instead of the phase error which is the main cause of the cycle-skipping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



Inline

slice

Initial velocity model



Inline

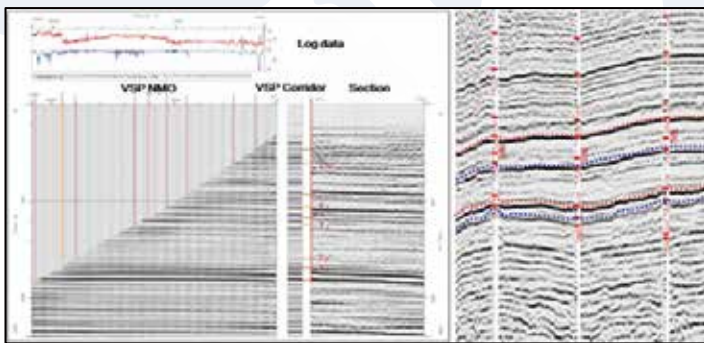
slice

Updated velocity model through FWI

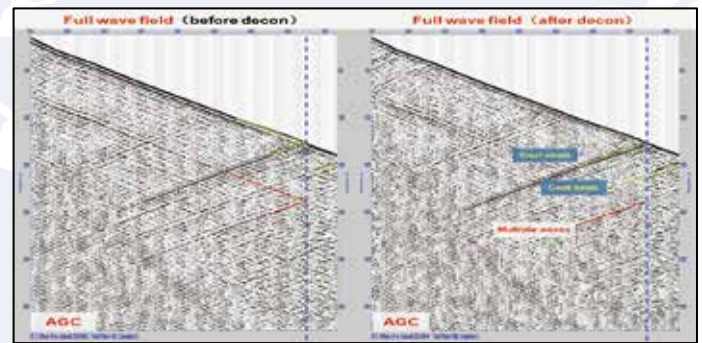
The Vertical seismic profile (VSP) adopts the observation method of surface excitation and well reception, which can establish accurate time depth relationships and obtain accurate velocity data such as average velocity and layer velocity, so as to accurately calibrate seismic and geological reflection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

Zero offset VSP

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



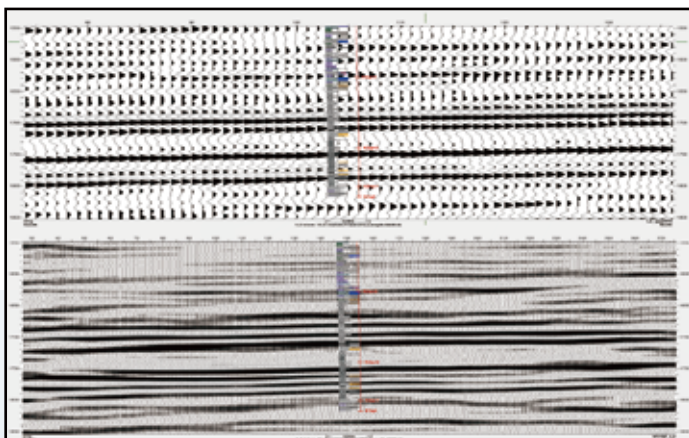
Calibration Seismic Data with VSP and Logging



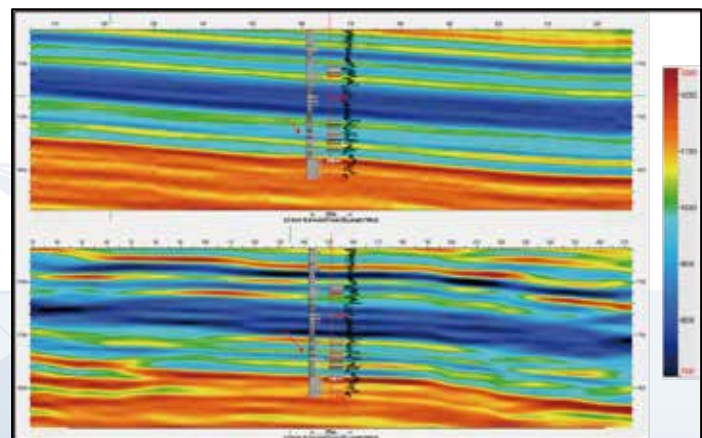
Analysis of Multiple Waves

Walkaway VSP

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



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

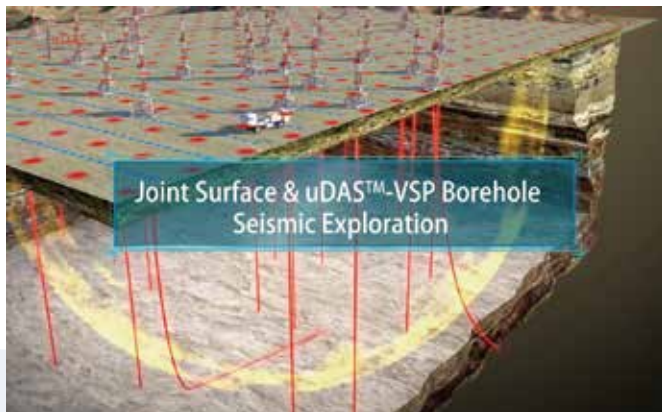


Comparison of Inversion Between Walkaway VSP (below) and Surface Seismic (above)

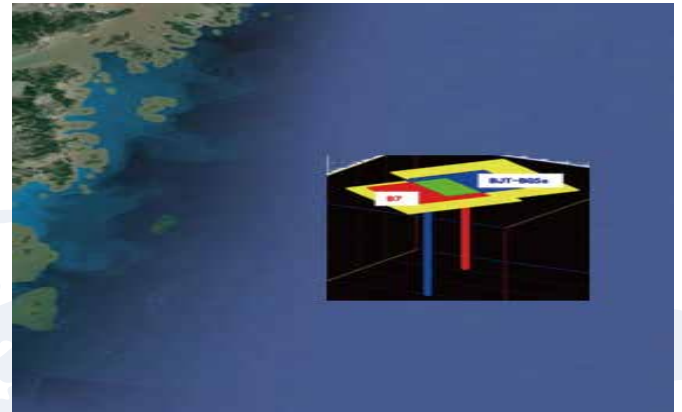


Joint Borehole-Ocean/Borehole-Surface Exploration Technology and Application Effect

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

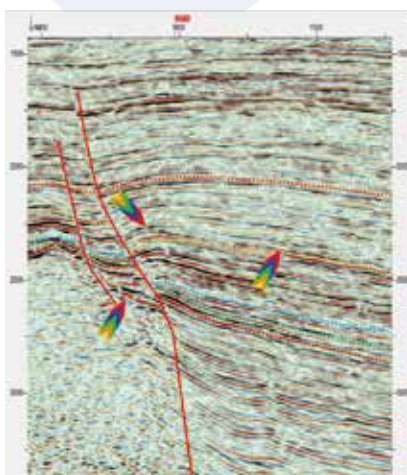


Borehole-surface Joint Exploration Stereoscopic Diagram

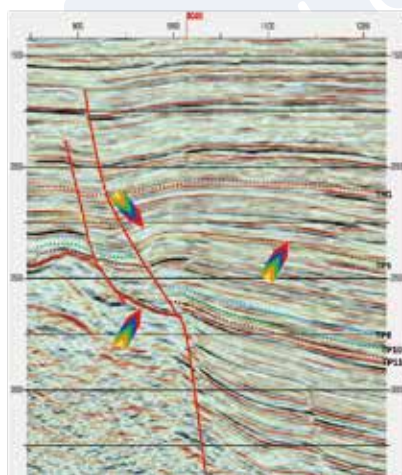


Schematic Diagram of Borehole-ocean Acquisition Coverage

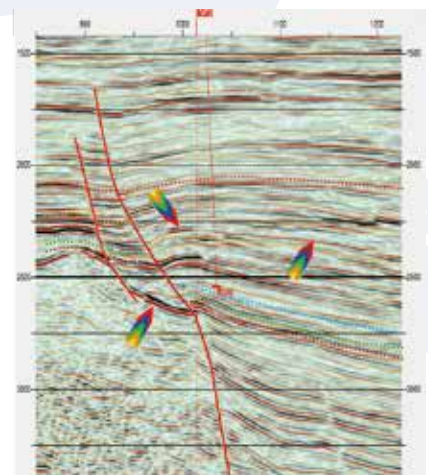
An application case of DAS joint exploration in Pinghu oil and gas field, East China Sea



Data on Towing Cables

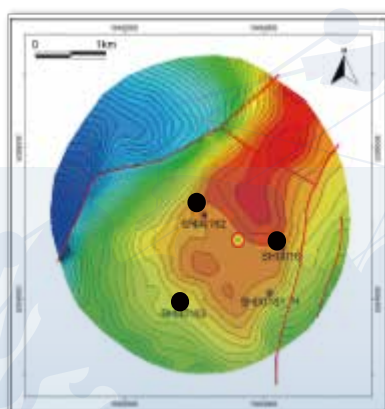


OBN Imaging

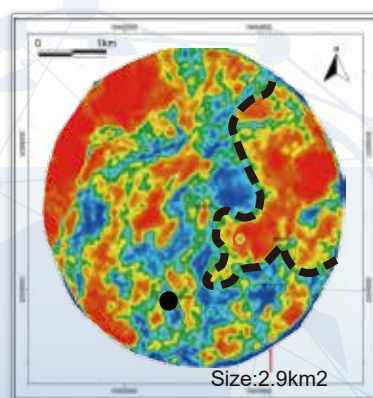


3D VSP Imaging

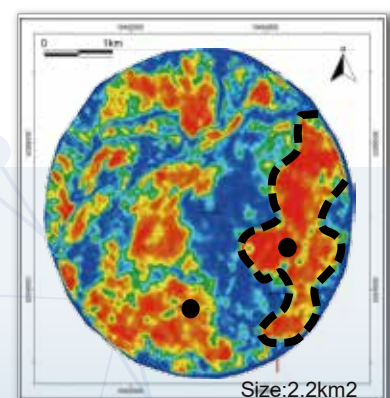
Seismic characterization technology of igneous rock masses using 3D VSP joint Borehole-surface exploration data in Shixi



Structure of the Top
Boundary of Carboniferous System



Attribute Plan of Volcanic Breccia
Section



Attribute Plan of Carboniferous
Weathering Crust

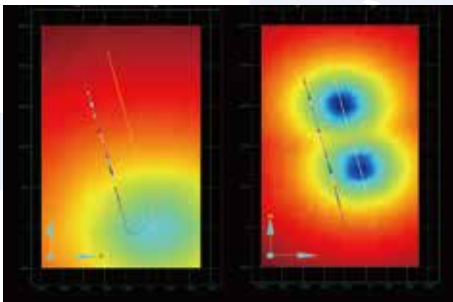


Microseismic Monitoring for Hydraulic Fracturing

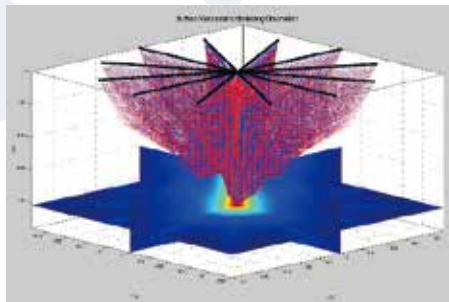
The microseismic monitoring technique records seismic waves generated by hydraulic fracturing, maps rock rupturing locations, evaluates fracturing results and guides optimizations of treatment parameters in real time.

Microseismic monitoring acquisition

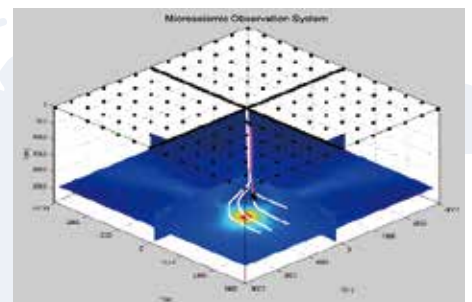
- ◆ Microseismic feasibility analysis
- ◆ Acquisition parameters demonstration
- ◆ Microseismic event location error prediction



Vertical and horizontal array monitoring



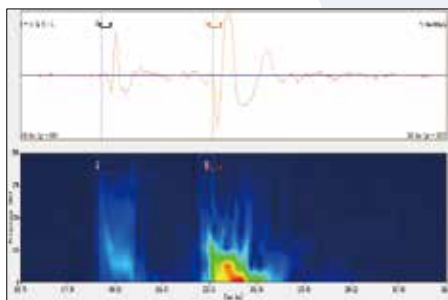
Surface array monitoring



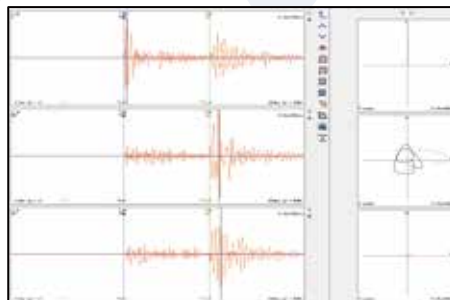
Borehole and surface long term monitoring

Microseismic monitoring real-time processing

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



First-break automatic picking



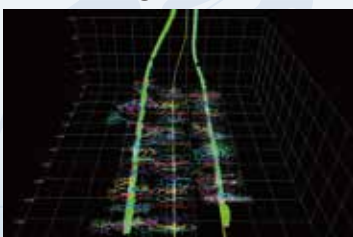
Polarization analysis



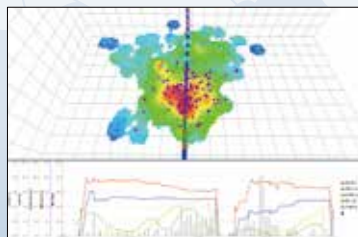
Events location

Microseismic monitoring interpretation

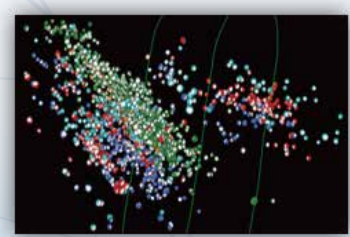
- ◆ Describing dimensions of artificial fractures
- ◆ Comprehensive analysis of the fracturing curve
- ◆ Reckoning volumes of fractured rocks
- ◆ Inverting focal mechanisms



Continuous fracture network



Matching fracturing curve



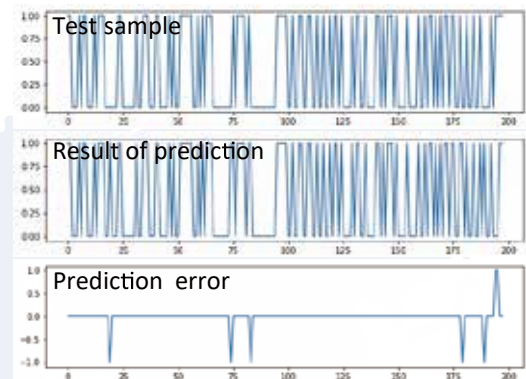
Focal mechanism inversion

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

Prediction hydraulic fracturing in advance

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

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

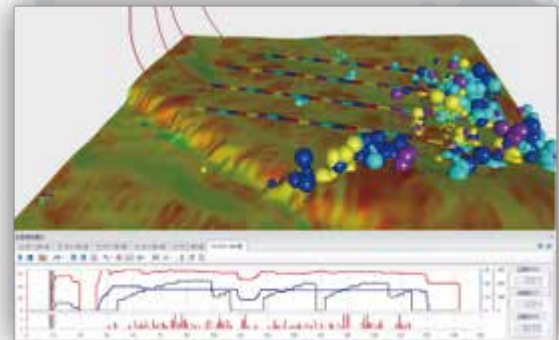


Casing deformation prediction by
using random forest

Real-time forecast and adjustment

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

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

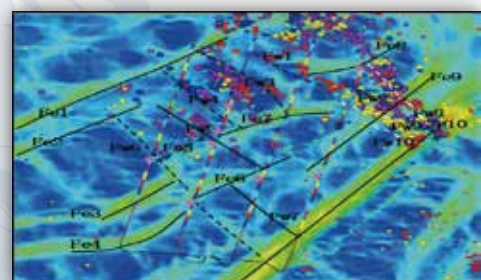


Overlap display of Microseismic events , of
fracturing parameters and curvature attribute

Post-hydraulic fracture evaluation

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

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

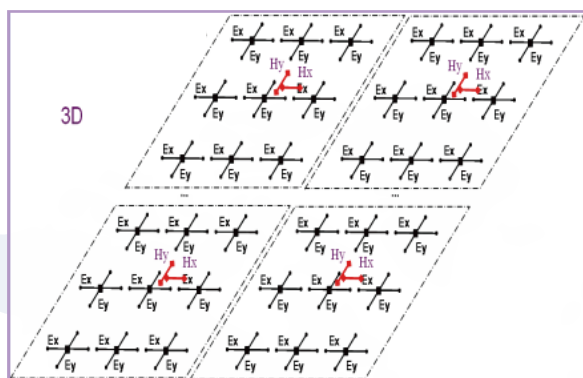


Overlap display of microseismic events
with nature fracture

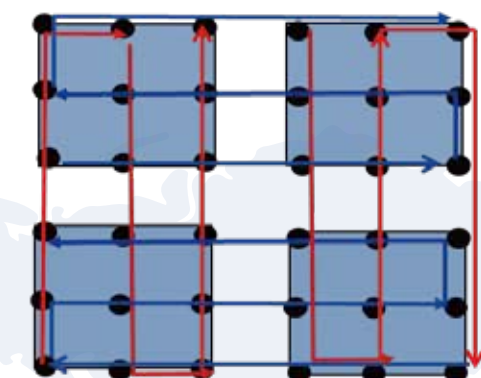
BGP provides an integrated solution with 3D GME (Gravity, Magnetic, Electromagnetic) & Seismic to identify subsurface structures in complex exploration areas.

Acquisition

3D small-bin MT/AMT acquisition



High accuracy 3D gravity & magnetic acquisition

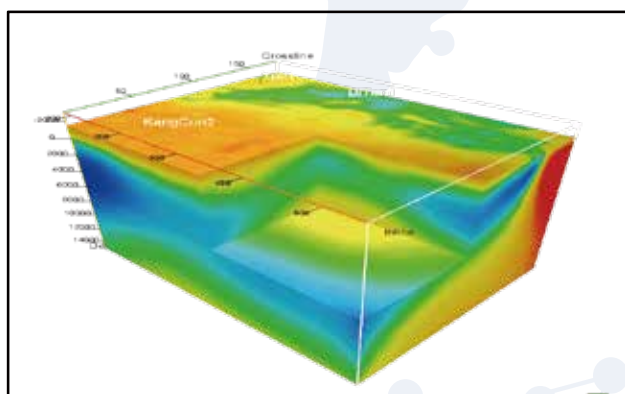


A 3D small-bin includes one 4-channel and eight 2-channel receiver systems, which is synchronized by GNSS satellites.

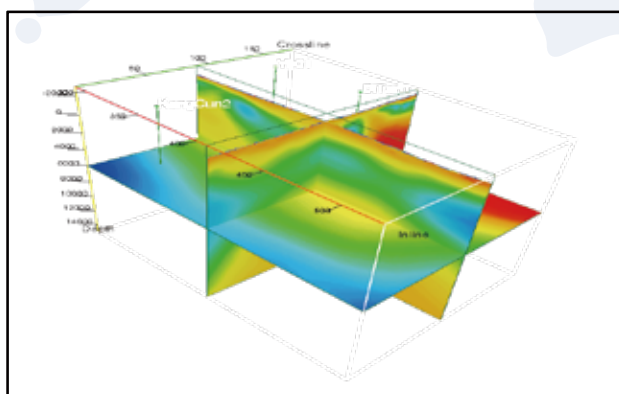
Two independent observation loops make gravity and magnetic observation accuracy 100% increasing.

Processing & Interpretation

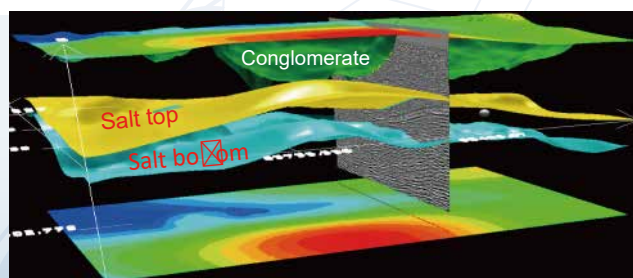
3D MT apparent resistivity image



3D density image



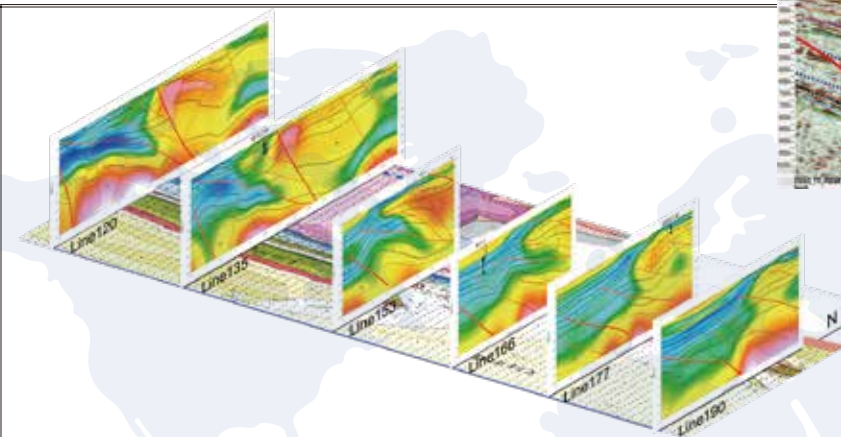
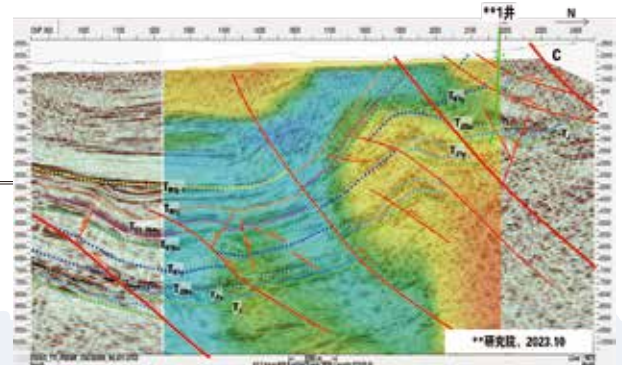
3D MT and gravity joint interpretation



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

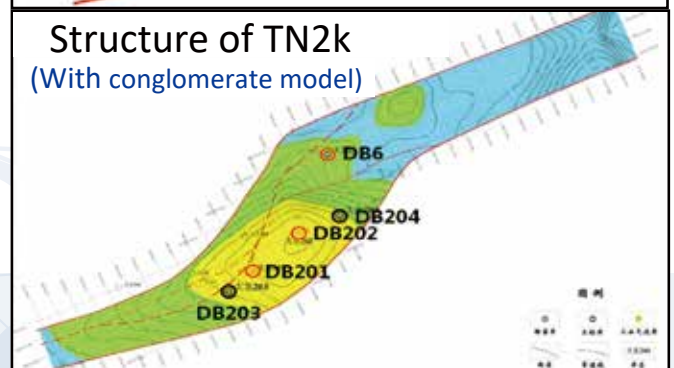
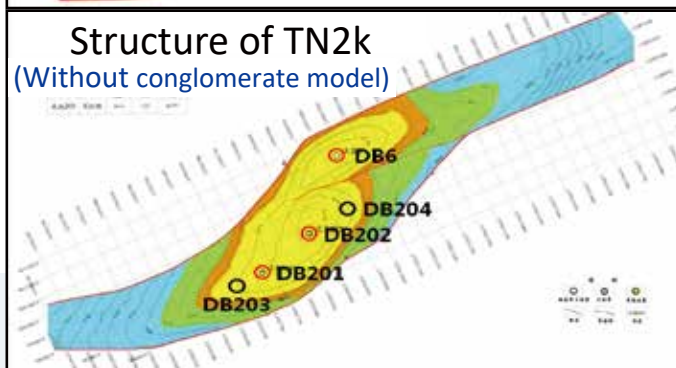
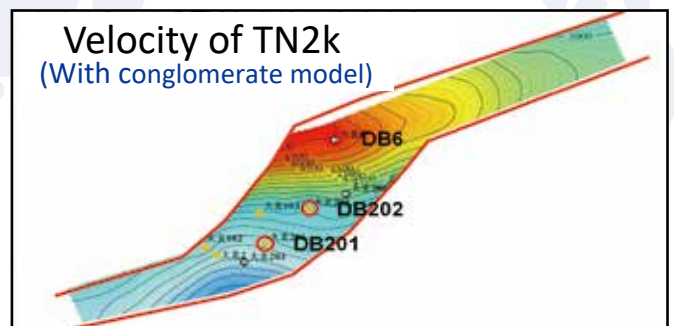
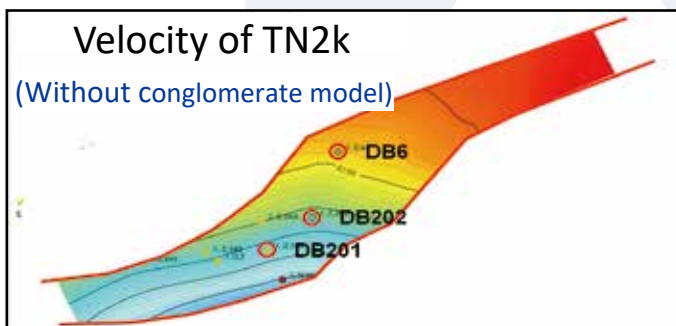
Integrated 3D GME with seismic, logging and geological data can map the distribution of lithology, layer and analyze the pattern of sedimentary deposits.

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

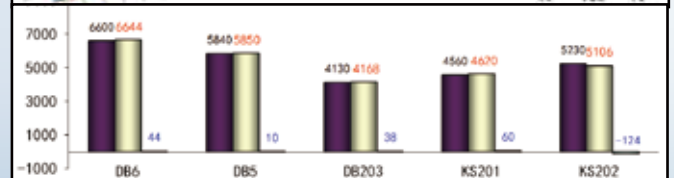
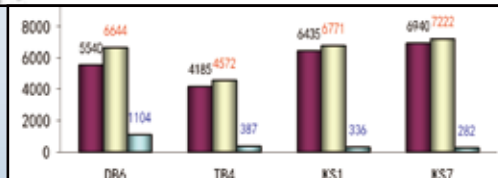


Overlay of 3D MT apparent resistivity and the 3D seismic section

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.



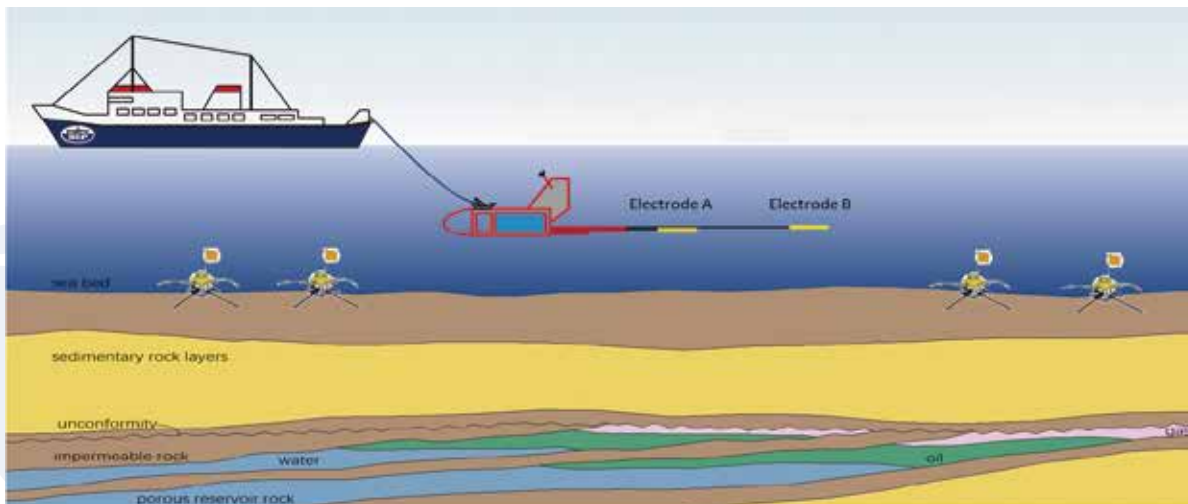
Depth error comparison



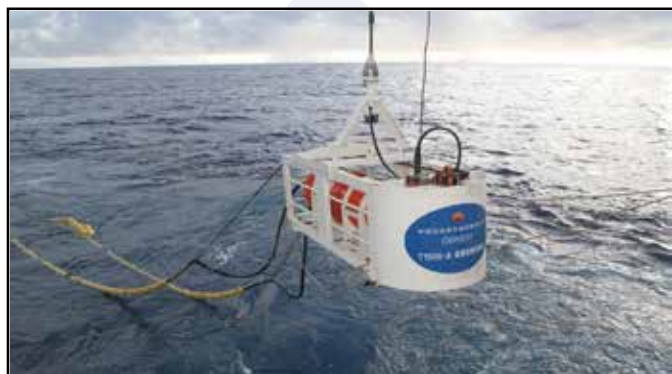


OBNEM Survey

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.



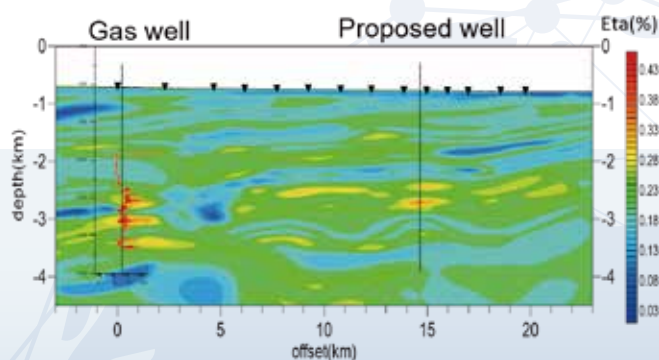
Schematic diagram of OBNEM survey



OBNEM transmitter



OBNEM receiver



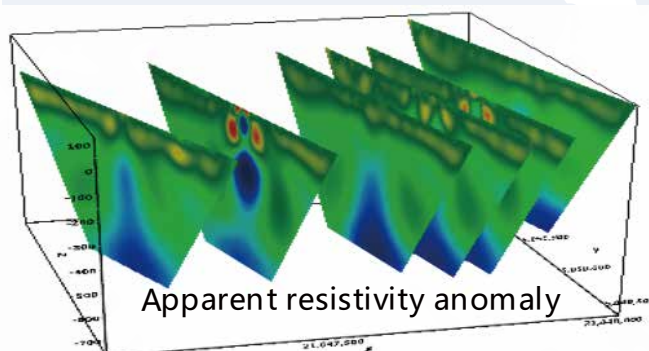
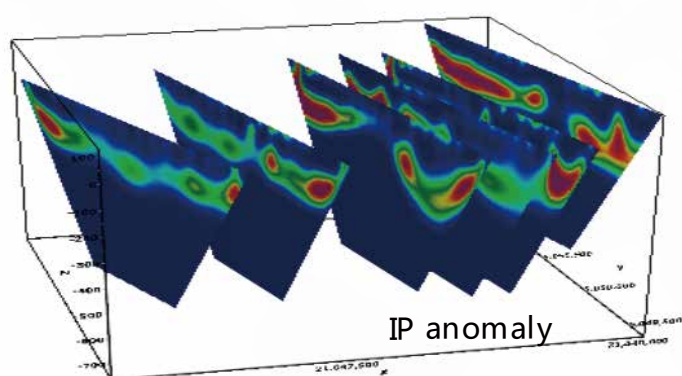
IP section from OBNEM

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.

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

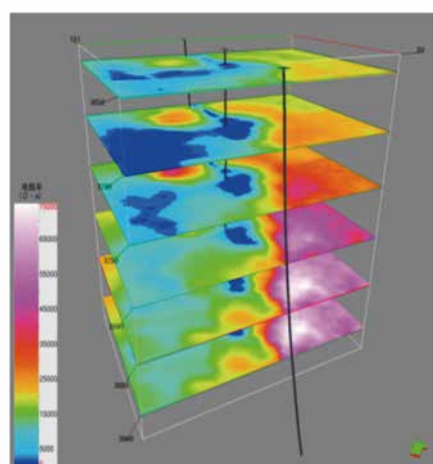
Techniques for associated mineral survey

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

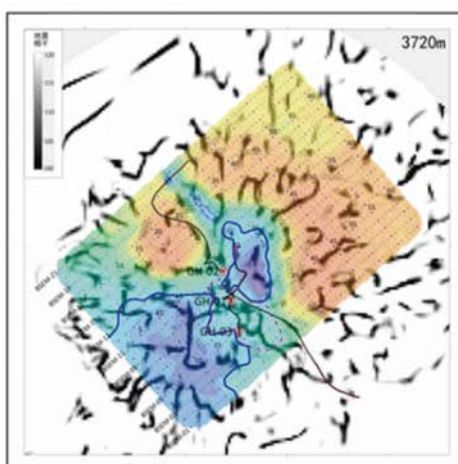


Monitoring techniques for Hydraulic Fracturing

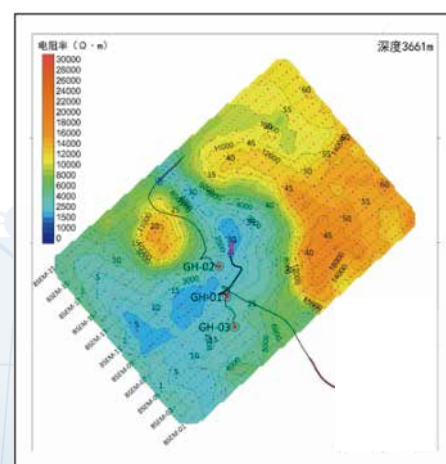
By using the VSP technology to detect the variation of velocity coherence property and combining this with the inversion resistivity of BSEM survey, the fracture distribution of hot dry rock after fracturing can be clearly described, and the joint state of fractures can be predicted.



Depth slices of 3D inversion resistivity



Overlay of seismic coherence attributes on apparent resistivity



Apparent resistivity in a specific depth



EV-56 High Precision Vibrator

High precision seismic signal excitation source

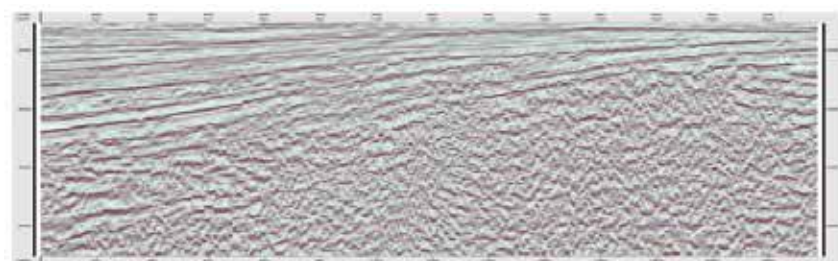
The EV-56, a new generation of broadband vibrator, is one such invention that can generate reliable and stable linear sweeps from 1.5Hz to 160Hz, which is essential in enhancing resolution of full waveform inversion. High-precision, deep target seismic imaging has been applied and implemented in multiple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



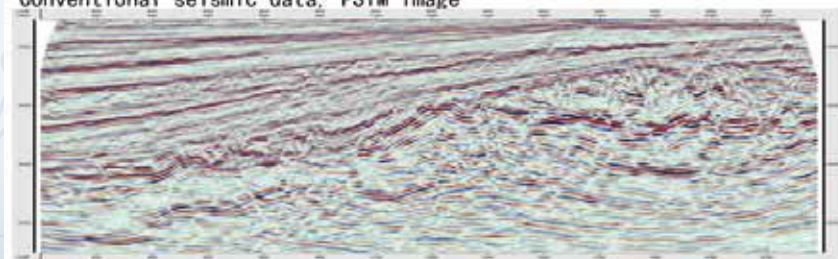
Specifications	
Max. HD, kN	310
Peak Force, kN	251
Limited Low Frequency, Hz	3
Recommended High Frequency, Hz	160
Max. Stroke, mm	210
Mass Weights, kg	5900
BP Weights, kg	2032
Mass/BP Ratio	2.9
Vibration HP, Mpa	21

Improvement of geological quality

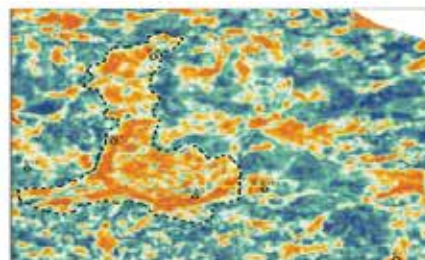
The high precision vibrator can improve the quality of seismic data and increase the signal-to-noise ratio (SNR) from the point of view of seismic excitation source, as can be seen from the following sections. The signal quality has been significantly improved.



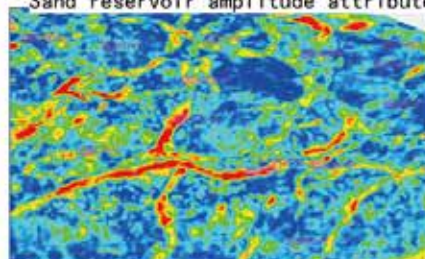
Conventional seismic data, PSTM image



New 3D seismic data, PSTM image



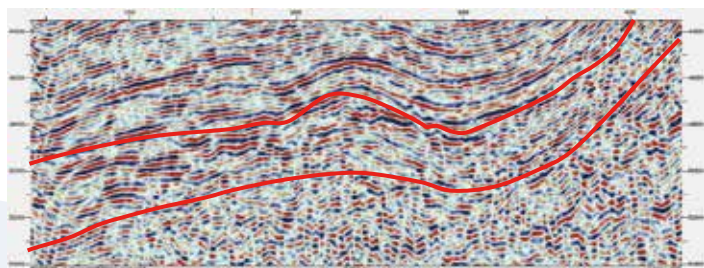
Sand reservoir amplitude attribute



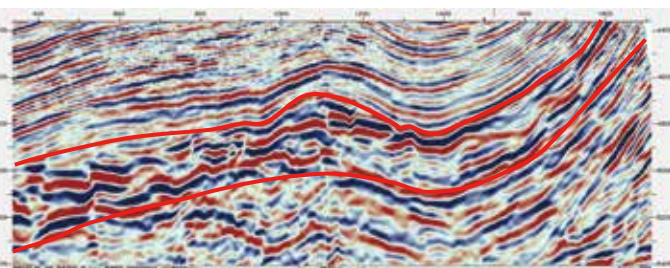
Sand reservoir amplitude attribute

Applications

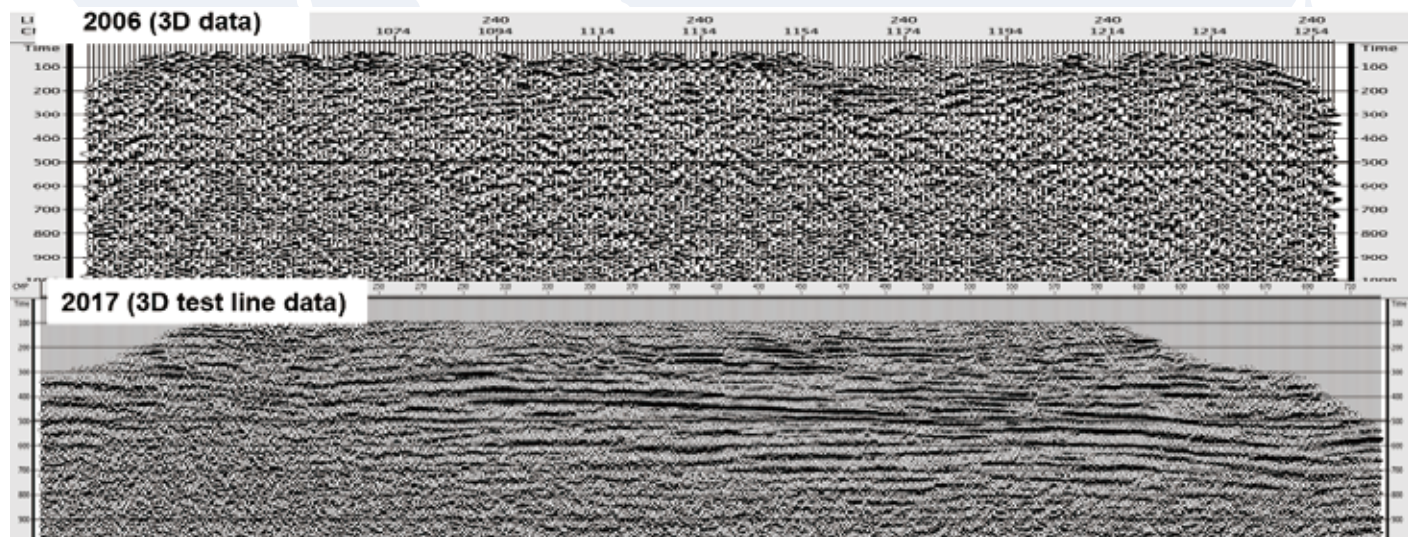
The top boundaries are sought. The low frequency information is richer, and the tectonic morphology of the Carboniferous System is identified, the petrographic phase and spreading characteristics of the volcanic rocks at the top of the Carboniferous System are implemented, and the lithology and fault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



Legacy 3D data

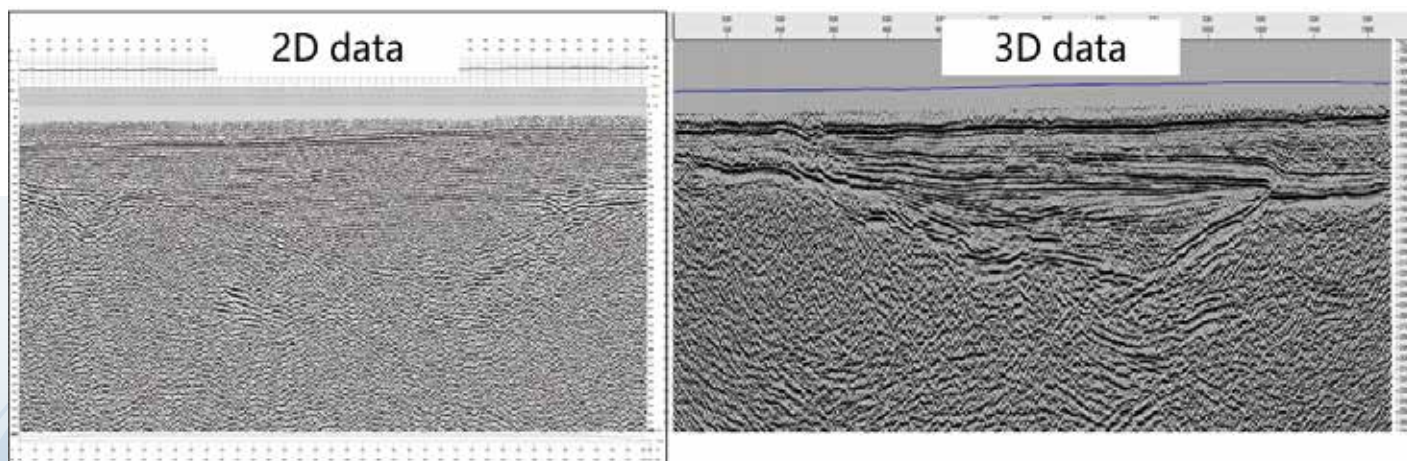


New 3D Carboniferous data



Geologic profile of coal mine

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



Data comparison of domestic exploration

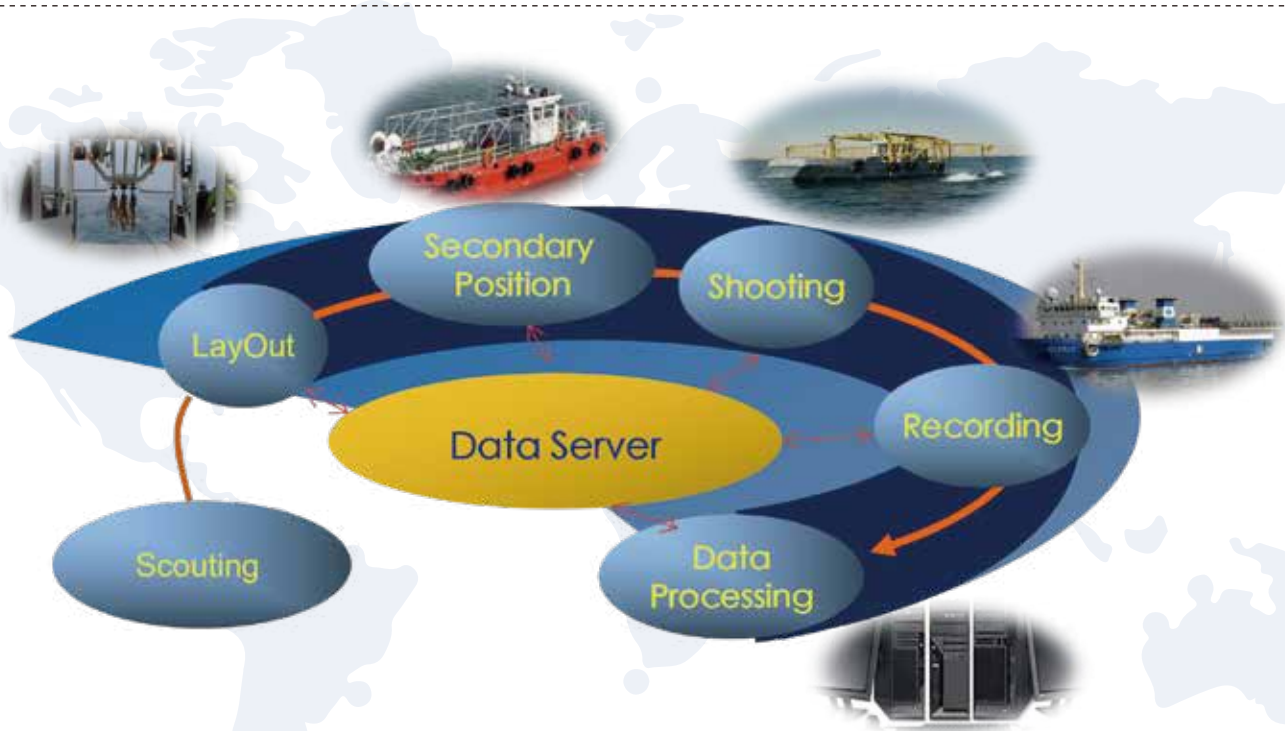


GeoSNAP-Dolphin: Integrated Navigation System for Ocean Bottom Seismic Exploration



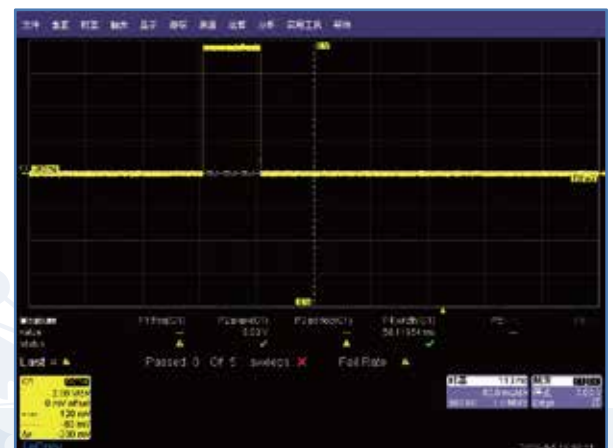
System introduction

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



Features

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





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

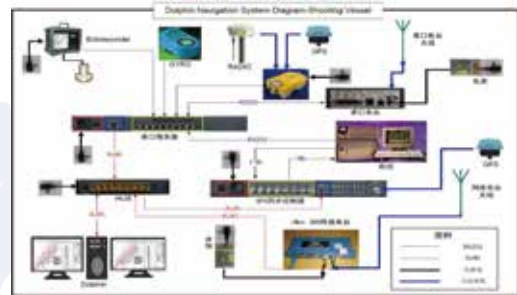


Main Functions

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



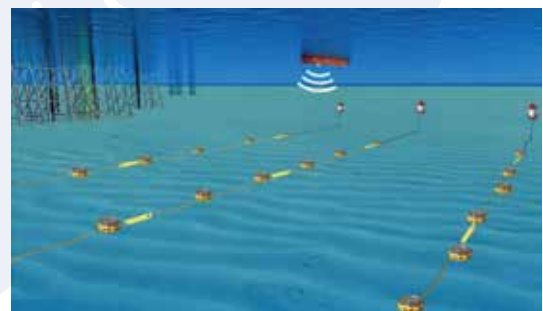
Real Time Quality Control



Equipment Connection Diagram



Remote Control



Acoustic Positioning

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

Application and Prospect

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



eSeis® Land Nodal Acquisition System

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

Node Specifications



eSeis node

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

Harvest&Charge Integrated Rack

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





eSeis® Land Nodal Acquisition System

QC Unit

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



Data Management System

Node data download, cut and combine by Harvester Manager & Data Manager software

Massive seismic data processing capacity by high performance server

Supports common shot gathers or receiver gathers in SEG-D or SEG-Y format

Supports cable and node system data fusion

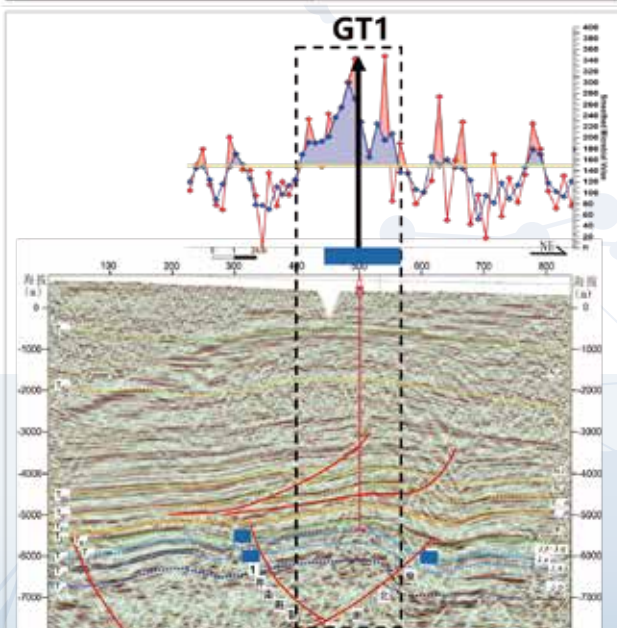
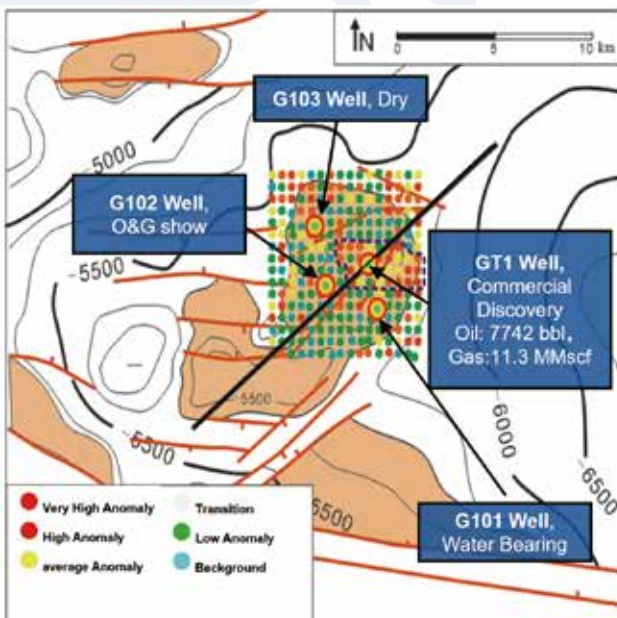
Parameter configuration, firmware upgrade and system test management functions



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

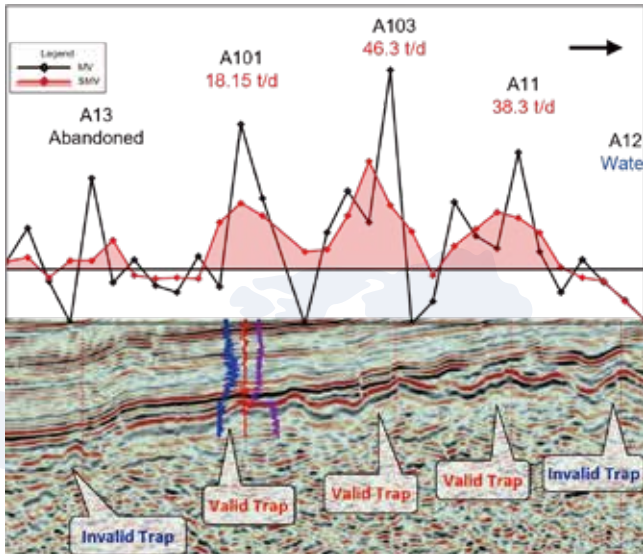
In 18 years, a total of 130 MGCE projects has been successfully completed, both onshore and offshore. Post-survey drilling results from 87 exploration wells show an integrated exploration success rate over 85% . Here are three common de-risking scenarios.

Scenario 1 Delineate Pool Size vs Trap Size



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

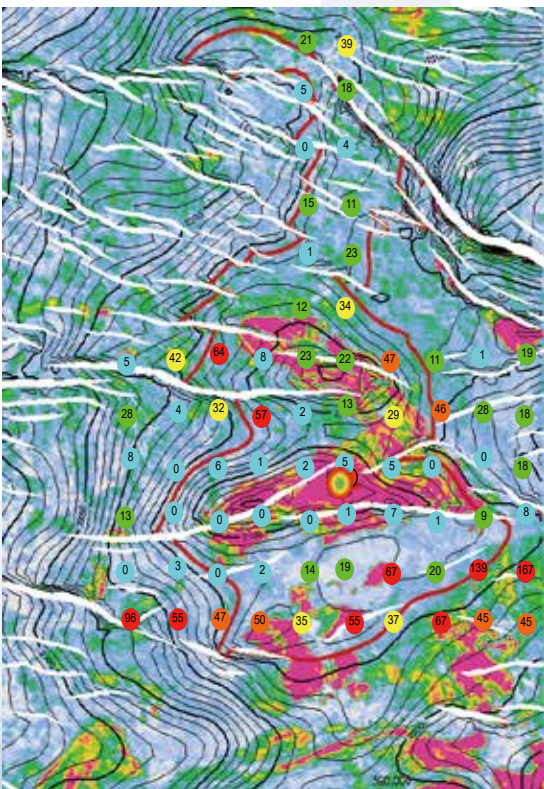
Scenario 2 Differentiate Valid Trap vs Invalid Trap



- ◆ **Seismic results:** 3D seismic identified 5 similar traps;
- ◆ **Geological risks:** unable to differentiate valid traps (charged with HC) and invalid traps (under-charged, breached, water bearing).
- ◆ **MGCE results:** surface microbial results predicted 3 valid traps out of these 5 traps and identified potential risk of 2 invalid traps;

- ◆ **Drilling results:** 3 commercial discoveries were achieved over traps with distinct microbial anomalies, while the traps with low/no microbial values were proven to be invalid traps (P&A and water bearing).
- ◆ **Value proposition:** proper integration of seismic and microbial results can help to high grade leads and prospects and increase drilling success rate.

Scenario 3 Predict HC vs Non-HC



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



Multi-Client Seismic Solutions

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

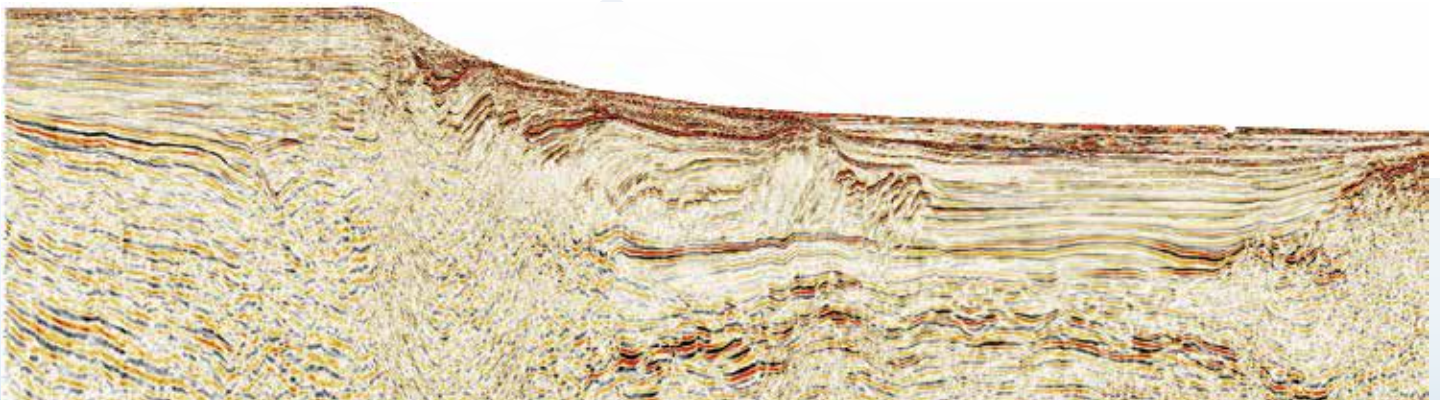
Features

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



MC activity map

Benefits



Reprocessed 2D Seismic Section in Brazil Equatorial Margin



oSeis Ocean Bottom Node System

Introduction

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

Specifications

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



oSeis300



oSeis1000



oSeis3000