Latest Advances in OBN Seismic Acquisition: From Transition Zone to Deep Water

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Summary

OBN seismic acquisition has advanced considerably, facilitating high-resolution subsurface imaging across diverse environments from transition zones to ultra-deep waters. This paper presents BGP's integrated geophysical solutions, emphasizing recent innovations in shallow and deep water OBN, 4D surveys, hybrid acquisitions, and newly developed products. Case studies from the UAE, West Africa, Southeast Asia, and the North Sea illustrate how these technologies enable full-azimuth, high-density data acquisition with enhanced operational efficiency and safety. Notable outcomes include superior imaging quality, novel hydrocarbon discoveries, and improved repeatability, highlighting OBN's critical role in offshore exploration.

Introduction

BGP Offshore, a subsidiary of China National Petroleum Corporation (CNPC), boasts over 20 years of global experience in OBN operations, positioning itself as a premier geophysical contractor, providing comprehensive solutions tailored to shallow-to-deep water settings. Key strengths comprise innovative offshore techniques, a full spectrum of OBN technologies from shallow to ultra-deep water with customized source and receiver methodologies, extensive global project experience, and robust support structures.

Latest Advance

BGP has cultivated a broad array of technical solutions for OBN acquisition, incorporating triple-source shooting, ROV node handling, Ultra-Short Baseline (USBL) positioning, 4D survey optimization, source and receiver repeatability, Simultaneous Operations (SIMOPS) management, variable-density node deployment, ultra-long offsets, and hybrid streamer-OBN integrations. Upcoming products, including air-gun source control systems, shallow/deep-water nodes (oSeis-SW and oSeis-DW), and the Dolphin II navigation system, promise further enhancements in efficiency and data quality.

1. Shallow water OBN acquisition

Seamless data acquisition across variable terrains is realized by tailoring sources and receivers to water depth variations (figure 01). Specialized equipment for tidal and ultra-shallow zones comprises drilling boats and ultra-shallow air-gun arrays. BGP Innovator vessel, commissioned in 2022, represents the world's first multifunctional platform for simultaneous source shooting and node operation (figure 02).

Automated node-handling systems facilitate deployment, retrieval, and harvesting while minimizing HSE risks. Their modular, containerized design enables installation within 30 days, compatibility with various nodes and vessels (figure 03). Acquisition efficiency can be significantly enhanced through the implementation of a multi-source, multi-vessel shooting methodology, a sophisticated technique widely adopted in OBN seismic surveys (figure 04).Two critical parameters govern the effectiveness of this method and the subsequent de-blending process: source distance, which determines the

spatial separation between sources to minimize interference, and dither time, which introduces controlled temporal offsets between shots to facilitate signal separation during processing.

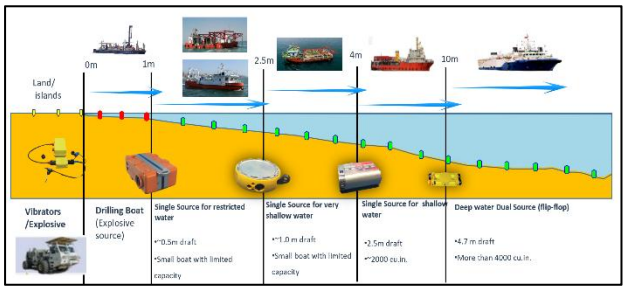

Fig.01 Seamless acquisition across multiple terrain.

Fig. 02 BGP Innovator

Fig.03 Automated Node deployment and retrieval systems

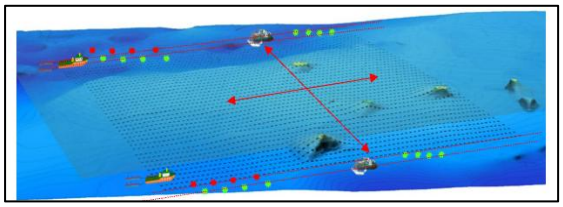

Fig.04 multi-vessel multi-source shooting

2. Deep water OBN acquisition

BGP Dragon delivered in 2023 with DP2 classification, wide-tow triple-source capabilities and speeds up to 7 knots enhance shooting productivity (figure 05). Node deployment and retrieval employ ROVs for water depth reaching 3,000 m, supporting dual-ROV functionality (figure 06). Positioning integrates USBL, Acoustic Doppler Current Profilers (ADCP), Pressure Inverted Echo Sounders (PIES), and comprehensive navigation systems, which strengthen the accuracy of deep node position.

Fig.05 High-end source vessel-BGP Dragon

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Fig.06 ROV operation

3. 4D OBN acquisition

4D surveys prioritize geometric repeatability to replicate historical ray paths, ensuring survey success. Source planning focuses on omni-directionality, high-density shooting strategies, including volume, pressure, gun types, geometries, and signature consistency. Receiver

planning standardizes node sensor responses and coupling.

Source repeatability is augmented through precise positioning relative to pre-plots, smoothing to mitigate noise, steering systems, and position-adjustment simulations. Receiver repeatability leverages acoustic or First-Break Picking (FBP) methods in shallow waters, or USBL. SIMOPS are managed via daily outlooks, pre-operation alerts, vessel monitoring, and access protocols to uphold safety and efficiency.

4. Hybrid acquisition

Hybrid methodologies integrate streamer and OBN techniques to optimize the balance between acquisition efficiency and imaging precision (figure 07). These approaches encompass various configurations, including simultaneous streamer-OBN recording, the use of short streamers to enhance OBN coverage for near-offset data, sparse OBN deployments for extended offsets, and OBN infills to address obstructions. Key advantages include the application of low-frequency sources, variable-density node arrangements, and offsets extending up to 30 km, all of which significantly enhance Full Waveform Inversion (FWI) and improve subsurface continuity.

5. BGP new product

The air-gun source control system accommodates up to 256 guns, 16 sources, and 256 NFHs, with support for dual NFH/pressure/depth sensors, continuous acquisition, bubble testing, 2.0 s cycle times, and ±2.5 μs timing accuracy (figure 08).

The Dolphin II integrated navigation system provides autopilot functions, sailing-track management, 4D modes, situational alerts, interfaces with external sensors, standard data logging (SPS, P190, P294), scalable licensing, and advanced online/offline QC tools (figure 09).

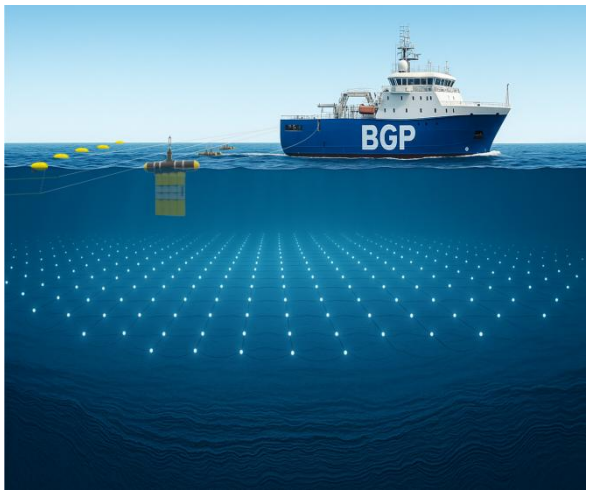

Fig.07 Hybrid steamer and OBN acquisition

The oSeis-SW node, designed for shallow-water applications with a depth rating of 500 meters, a 63-day battery life, and an Oven-Controlled Crystal Oscillator (OCXO) clock ensuring ±1.0 ms accuracy, along with the oSeis-DW node, engineered for deep-water operations with a 3,500-meter depth rating, a 205-day battery life, and a Micro-Electro-Mechanical Systems (MEMS) clock with ±1.0 ms accuracy, significantly enhancing their operational versatility and data transmission capabilities in challenging marine environments (figure 10).

Case studies

1) Offshore + TZ OBN project

Since 2019, BGP has executed a large-scale project in the UAE (figure 11), spanning 30,000 km² offshore and 10,000 km² in transition zones (TZ) amid complex terrains (e.g., Sabkha, tourist, industrial, environmental, royal, and restricted areas). Offshore operations involved four concurrent crews, 52 vessels, 32,000 nodes, and 1,000 personnel, featuring simultaneous sourcing, de-blending, and extensive QC. TZ efforts emphasized seamless acquisition amid intensive drilling and explosive workloads. Results yielded new discoveries, including over 3.5 trillion cubic feet of gas in offshore Block 2.

Fig.08 Air-gun source control system

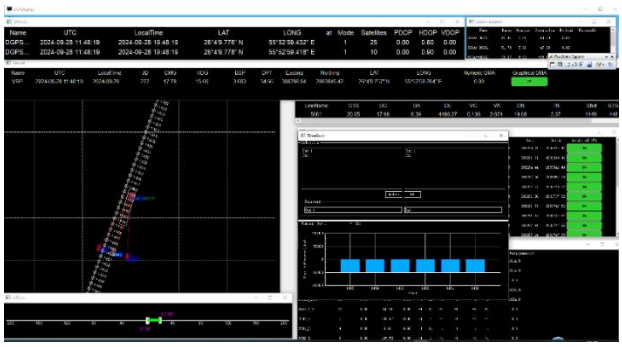

Fig.09 Integrated navigation system Dolphine II

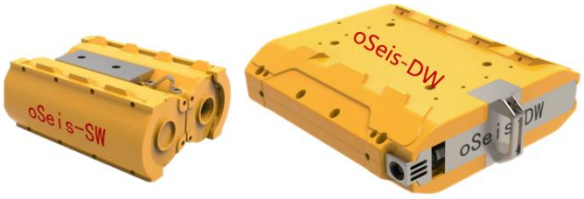

Fig.10 Shallow water node oSeis-SW(left) and deep-water node oSeis-DW

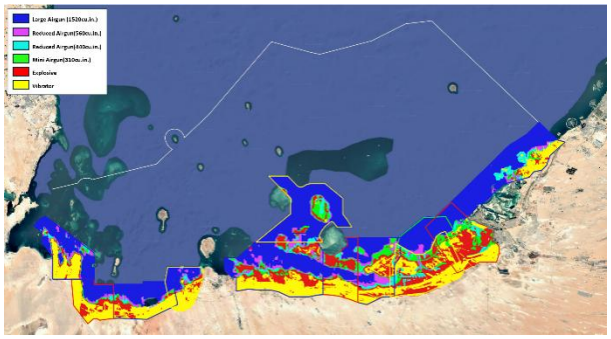

Fig.11 Location of offshore and TZ project

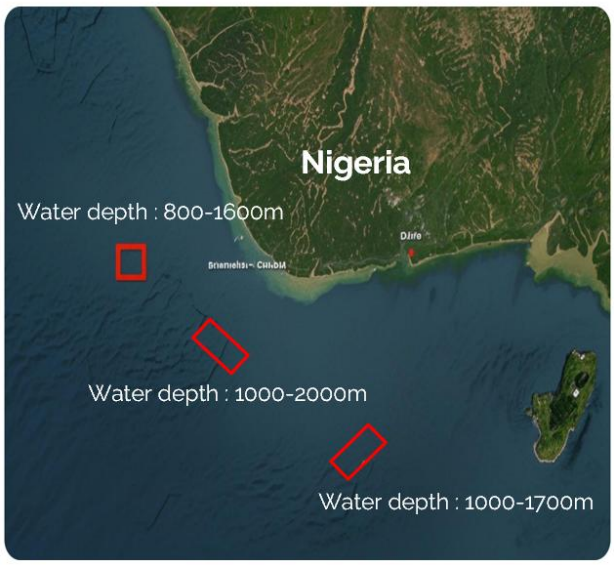

Fig.12 Location of deep water OBN project.

2) Deep water OBN project

In 2024, a deep-water Ocean Bottom Node (OBN) project conducted off the coast of West Africa, operating within water depths ranging from 800 to 2,000 meters, employed large-volume triple-source shooting techniques alongside Remotely Operated Vehicle (ROV) operations (figure 12). These operations incorporated Ultra-Short Baseline (USBL) positioning systems, High-Speed Loader (HSL) transfers, and dual-ROV configurations, optimizing node deployment and retrieval efficiency in challenging deep-water environments. Key features included flexible ROV maneuvers near obstacles and sparse, variable-density node layouts.

3) Southeast Asia OBN 4D survey

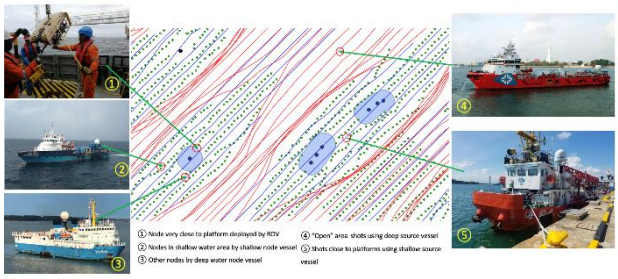

Fig.13 Integrated node handling and shooting solution for various sea conditions

The Brunei project was successfully executed under challenging marine conditions, characterized by a complex array of surface and subsea obstacles, including over 22 installations, anchor patterns, pipelines, platforms, wellheads, telecommunication cables, Simultaneous Operations (SIMOPS), fishing activities, and coral reef distributions. The deployment of integrated node handling and shooting methodologies was skillfully adapted to address the diverse environmental challenges encountered (figure 13). Moreover, source and receiver repeatability was rigorously maintained within 10 meters of pre-plotted positions, thereby ensuring the reliability and high fidelity of the acquired 4D seismic data.

4) North Sea Hybrid streamer & OBN acquisition

Conducted in approximately 370 m depths, this survey featured simultaneous streamer-OBN recording on a 900 × 900 m OBN grid (with local 300 × 300 m infills), partially blended triple-source shooting, and offsets up to 30 km (figure 14). Outcomes demonstrated improved FWI imaging for intricate structures and enhanced subsurface continuity.

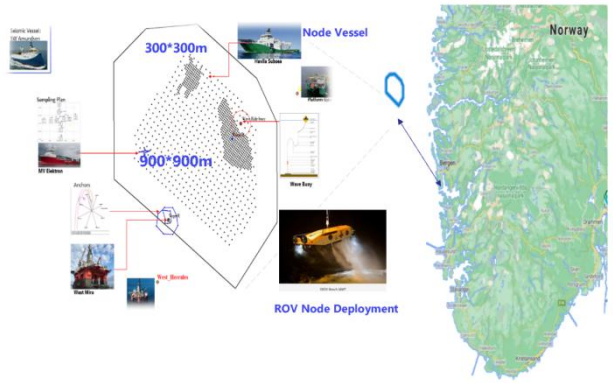

Fig.14 Location of North Sea hybrid streamer and OBN acquisition

Conclusions

OBN acquisition yields full-azimuth, high-density, ultra-long-offset data with superior signal-to-noise ratios, executed safely and efficiently. BGP's innovations in survey design, seamless shooting and recording, and specialized equipment enable accurate operations across all water depths. The introduction of advanced source control, navigation systems, and deep-water nodes will further elevate acquisition capabilities, promoting greater efficiency and precision.

Acknowledgments

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