SERCEL
A Viridien Business

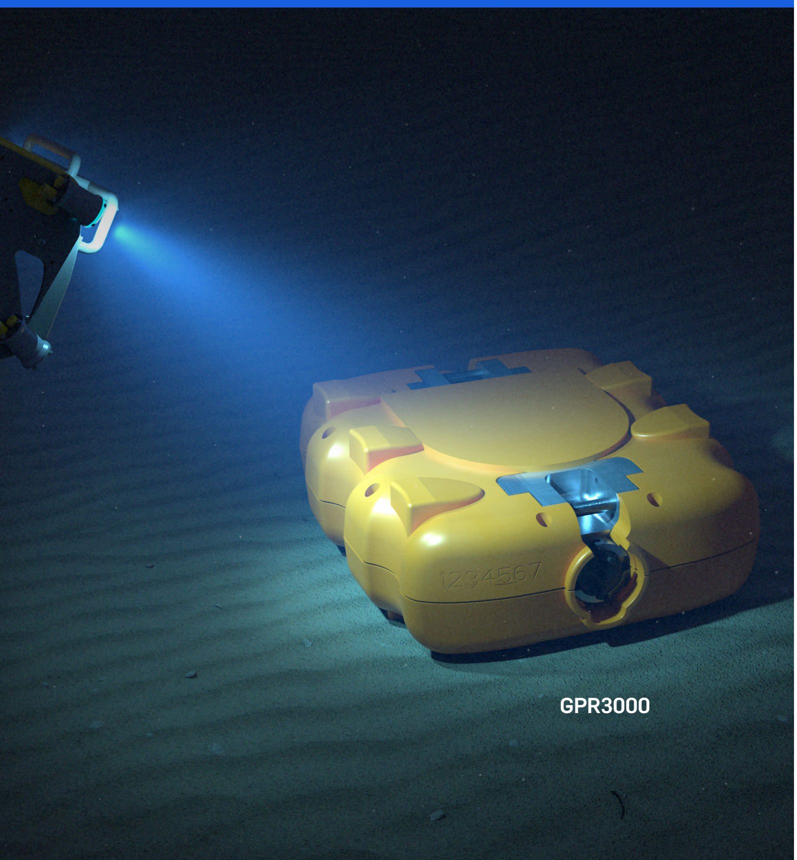
CASE STUDY

Delivering Value with the GPR Deepwater Solution

The QuietSeis® MEMS advantage

PROJECT SNAPSHOT

This case study evaluates the performance of the Sercel's QuietSeis® MEMS nodes used with the Tuned Pulse Source (TPS) during the Laconia Phase 1 seismic survey. Covering over 620 OCS blocks in the Garden Banks and Keathley Canyon areas, the Laconia 3D sparse OBN survey (Phase 1-3 and Momentum) is the largest long-offset, low-frequency OBN survey in the region. Sercel's nodes demonstrated outstanding signal-to-noise performance, especially at very low frequencies, outperforming OBNs equipped with geophones.



GPR3000

CHALLENGES

- **Low-frequency imaging:**
  Acquiring high-quality data at very low frequencies.
- **Data jitter:**
  Eliminating phase and amplitude distortions for reliable seismic imaging.
- **Noise control:**
  Minimizing instrument noise relative to ambient noise in deepwater conditions.
- **Vector fidelity:**
  Sensing the true three-component ground motion with minimal orthogonality error and sensing sensitivity difference along the three axes.
- **Seismic survey optimization:**
  Achieving synergy between sensor and source design for high-quality seismic acquisition.

SOLUTIONS OVERVIEW

Developed for deepwater exploration, Sercel's nodes support high-density OBN surveys. Each node is fitted with QuietSeis 3C MEMS sensor technology, offering unmatched digital fidelity and ultra-quiet performance, a step change in seismic data quality. The nodes remain fully operational down to 4,000 m and provide up to 200 days of battery life.

TPS (Tuned Pulse Source) is a low-frequency broadband seismic source. TPS enriches refracted and reflected waves by adding a low-frequency octave for deeper subsurface investigation and broader imaging. It also stimulates interface (Scholte) wave, which provides valuable information to characterize the near surface. TPS supports eco-conscious seismic acquisition and is suitable for both OBN and towed streamer surveys.

OUR APPROACH

Ten GPR3000 nodes were deployed by ROV in water depths of approximately 1,500 m. Positioned at the center of the spread and co-located with OBNs equipped with geophones, the deployment enabled comparison of both node types for low-frequency seismic data acquisition using the TPS. The analysis highlighted performance up to 2 Hz and demonstrated the capabilities of each technology in this critical range.

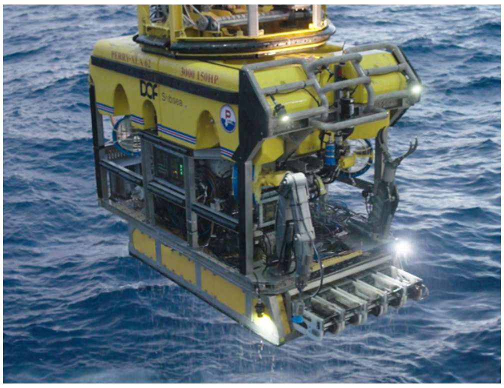


Fig. 1. ROV Deployment.

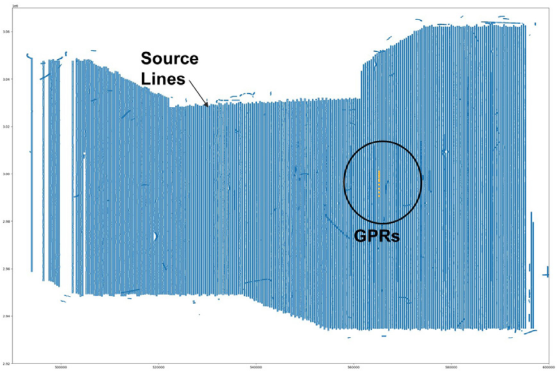


Fig. 2. Source Lines Geometry.

KX-KY DOMAIN ANALYSIS

To better illustrate the differences between the QuietSeis MEMS and the other nodes, the analysis was performed in the k_x-k_y domain for a number of time frequencies. In this domain we expect to see a disk whose radius corresponds to the propagation of sound in water (1,500 m/s). Everything inside the disk represents seismic signal, while everything outside corresponds to instrument and environmental noise.

Parameters	
Water velocity	1,500 m/s
Delta x	200 m
Delta y	50 m
Frequency	1.5 Hz

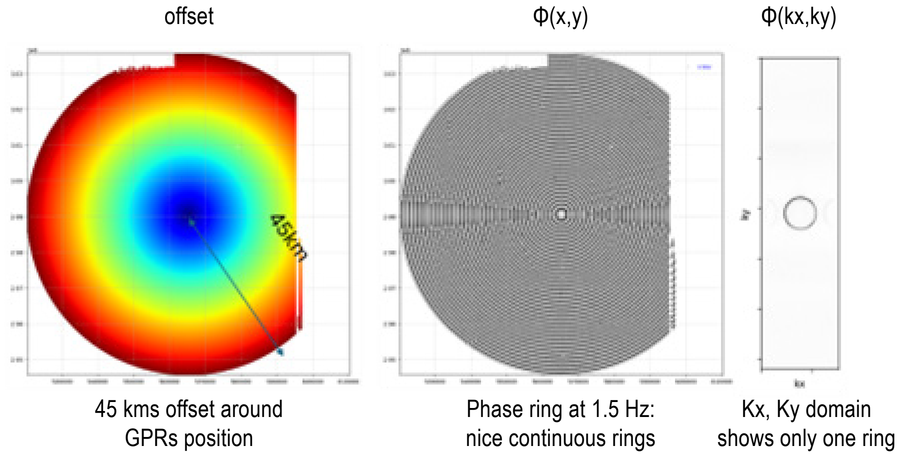


Fig. 3. A simulation example at 1.5Hz with a 45 km offset around the OBN location.

The data were first preprocessed with clock correction, and frequency-dependent instrument sensitivity correction.

The hydrophone data between the two collocated Ocean Bottom Nodes (OBNs) exhibited the same SNR across all low-frequency ranges. Notably, a signal appears at 1.2 Hz thanks to the very low-frequency energy emitted by the TPS.

Below is the amplitude ratio (GPR/GEO_OBN) expressed in dB:

- Signals are the same (white color)
- Noise level is not frequency-dependent

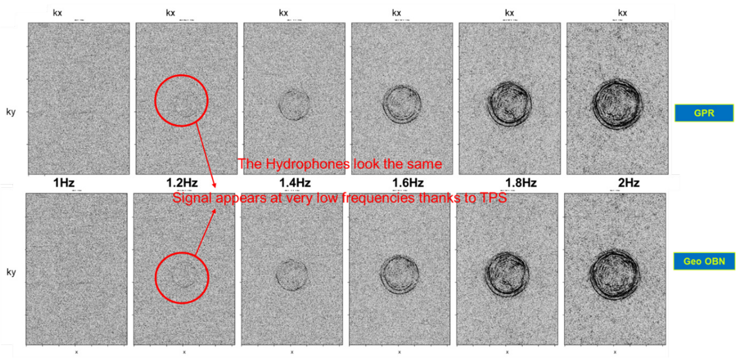


Fig. 4. Hydrophone (Kx, Ky) Frequency Slices.

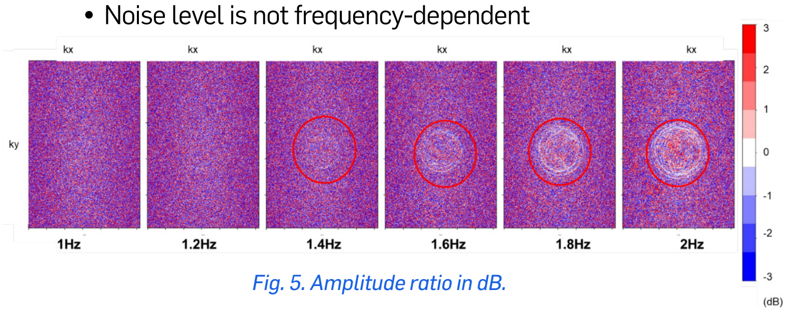


Fig. 5. Amplitude ratio in dB.

FURTHER DATA CONDITIONING AND 3C EUCLIDEAN NORM PROCESSING OF MEMS COMPONENTS

The data were corrected for instrument sensitivity and converted to particle velocity units ($m \cdot s^{-1}$). To avoid dependency on orientation differences between the nodes, the analysis was performed using the 3C Euclidean norm of the three-component data.

The figure opposite shows the magnitude of (Φ, kx, ky) slices across a range of frequencies.

- The signal improves on the GPR starting at 1.4 Hz.
- The OBNs with geophones exhibit higher low-frequency noise. Since the nodes are co-located and subject to the same ambient noise, this excess noise is attributed to the instrument itself.

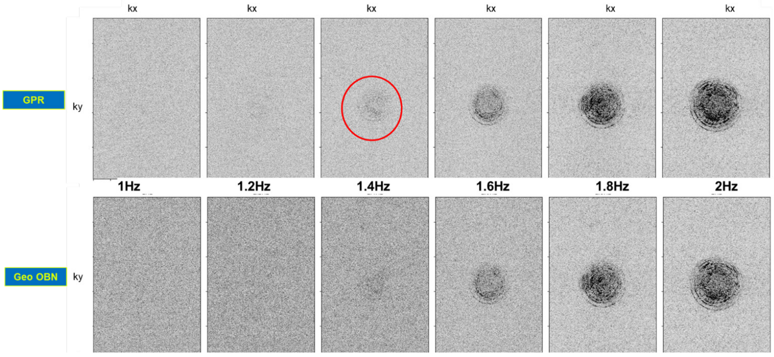


Fig. 6. Magnitude of Φ(kx, ky) slices across a range of frequencies.

Below is the amplitude ratio between the two nodes expressed in dB:

- Blue areas indicate that the OBNs equipped with geophones exhibit higher noise than the GPR at low frequencies
- The red circles highlight stronger signal for the GPR starting at 1.4 Hz.

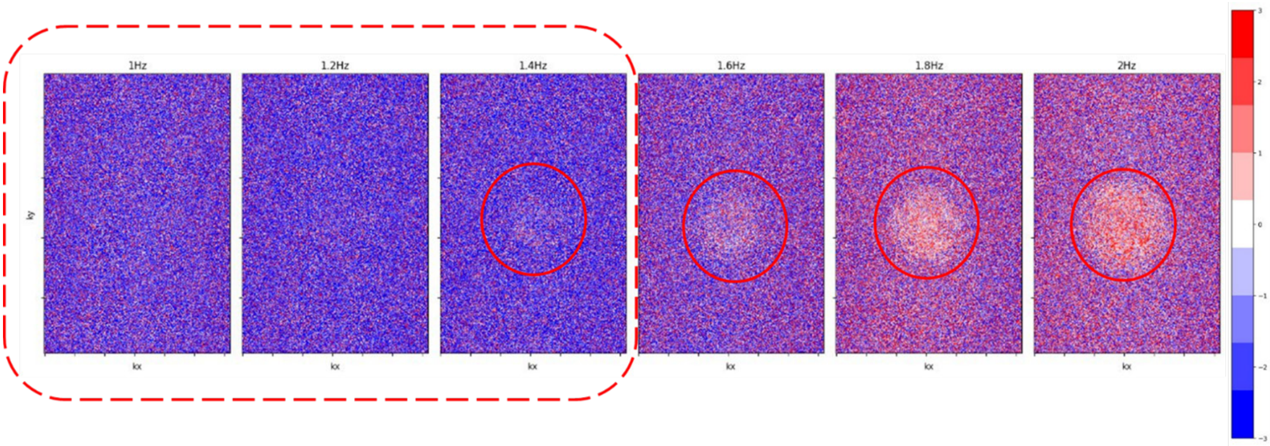


Fig. 7. Amplitude ratio between the two nodes in dB.

RESULTS

This case study demonstrates that the QuietSeis MEMS-powered GPR outperforms its counterpart in the low-frequency range.
The GPR also exhibits lower instrument noise levels, resulting in improved overall data quality.
The combination of GPR and TPS proves to be an ideal solution for acquiring high-quality seismic data, delivering uncompromising data quality at very low frequencies.

- **Enhanced Low-Frequency Response:**
  Exceptional sensitivity and stability.
- **Ultra-Low Noise:**
  Superior Signal-to-Noise Ratio (SNR) performance.
- **Sharper Imaging:**
  Improved data quality.
- **Optimized with TPS:**
  Seamless system integration and acquisition efficiency.
- **Consistent Performance:**
  Reliable, repeatable results, thanks to MEMS stability that ensures high vector fidelity and no data jitter, especially important in 4D OBN projects.

Sercel Headquarters
16, rue de Bel Air - 44470 CARQUEFOU - France
Tel: +33 (0)2 40 30 11 81

Sercel-UK
Concept Systems Ltd.
1 Logie Mill, Edinburgh, EH7 4HG, Scotland
Tel: (44) 131 557 5595

sercel.com