Potential Prospectivity Identified in the Orphan Basin

Offshore Newfoundland has promising hydrocarbon potential along the shelf and slope areas as proven by PGS Ultima.

It has a proven petroleum system and established play concepts. Recent drilling success on the **Grand Banks** (Cambriol and Capahayden) has revived the interest of both local and international investors. **PGS**, in partnership with **TGS**, has been acquiring modern **3D GeoStreamer data** offshore Newfoundland and Labrador since 2015. The availability of such data has been a critical component in the success of the **offshore Newfoundland and Labrador** Call for Bids from 2015 through 2020.

Access to 3D data provides confidence when bidding on prize blocks and the use of high-end technology shortens the time to first drill and potentially first oil. The PGS/TGS data library comprises approximately 35,000 sq. km of 3D GeoStreamer data in the Eastern Newfoundland region defined under the Land Tenure System. The Call for Bids for this area closes in November 2022. High-end imaging technology, like PGS Ultima, and quantitative interpretation

workflows, clearly demonstrate material size prospectivity in the eastern Newfoundland region, particularly in the underexplored **Orphan Basin**.

In this study, we demonstrate **PGS Ultima** provides not only the high-resolution velocity model but also relative impedance and relative density estimates in a challenging area in the Orphan Basin. The accurate inverted models provide additional understanding of prospectivity.
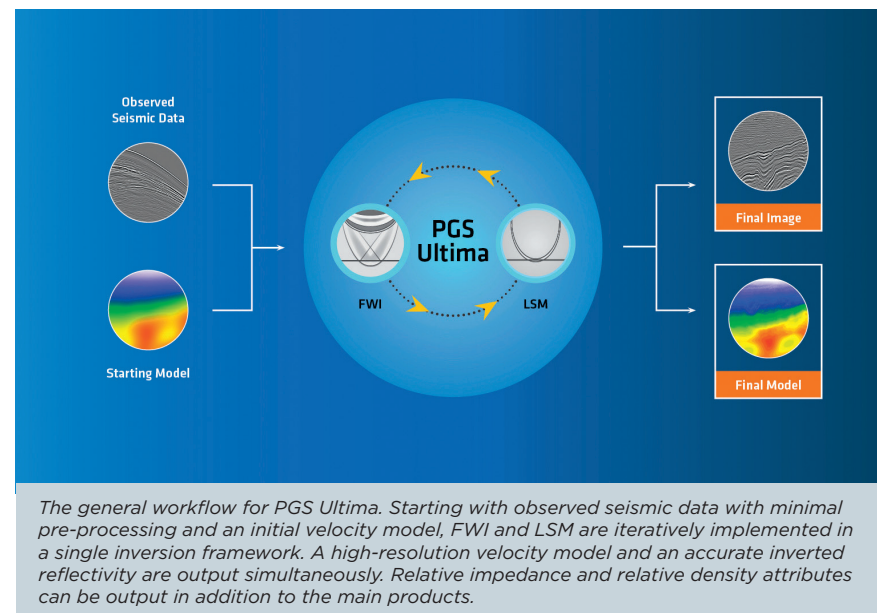
A 3D display of the relative density attribute is shown both on the sections and the map. It is time-consuming and data quality-dependent to extract this property from seismic data in a conventional manner. However, PGS Ultima is an entirely data-driven workflow and it delivers reflectivity and relative density properties in a much faster timeframe. A notional interpretation of the displayed map indicates the presence of two possible overlapping marine fans. The primary fan feature (orange) was identified on the 3D GeoStreamer Blomidon dataset (Figure 2). The area covered by the PGS Ultima test was 900 sq. km and it confirms the primary fan and revealed a secondary fan feature (yellow) thanks to the more accurate velocities and the improved low-frequency signal-to-noise ratio.

Joint PGS/ TGS library. The Blomidon survey is shown in orange and the PGS Ultima test area covers 900 sq. km of that survey. The survey is a part of 35 0000 sq. km of contiguous 3D coverage.
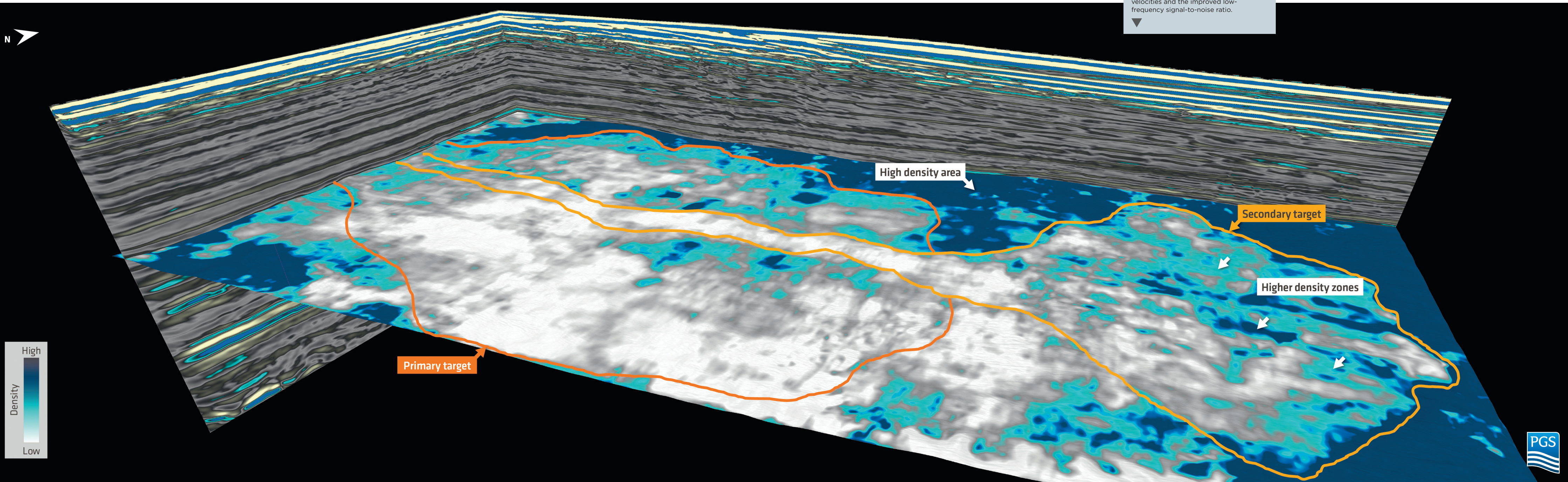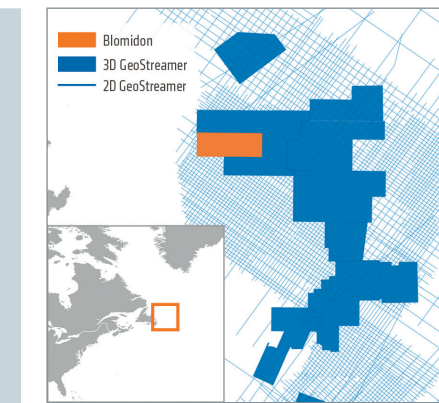
A Paradigm Shift in Data Imaging

Accurate velocity and reflectivity models are essential for high-fidelity seismic interpretation.

The general workflow for PGS Ultima. Starting with observed seismic data with minimal pre-processing and an initial velocity model, FWI and LSM are iteratively implemented in a single inversion framework. A high-resolution velocity model and an accurate inverted reflectivity are output simultaneously. Relative impedance and relative density attributes can be output in addition to the main products.

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Full Waveform Inversion (FWI) followed by Least-Squares Migration (LSM) is currently the high-end technique to invert for high-resolution velocity and reflectivity models. However, in a traditional sequential workflow, velocity and reflectivity are inverted separately and leakage between the two parameters is unavoidable.

FWI and data domain LSM share a similar framework, both aiming to minimize the misfit between modeled and recorded data. Accordingly, it is possible to solve both problems in a compact framework. **PGS Ultima** implements FWI and LSM in a joint scheme. The inversion scheme updates both velocity and reflectivity simultaneously at each iteration as summarised in the inversion workflow as shown in the figure above.

PGS Ultima has the potential to reduce the turnround time of a project as only a starting velocity model and minimal pre-processed data is required. A robust inverse-scattering image condition can efficiently separate the velocity and reflectivity updates and minimise the leakage between the two parameters.

The output of PGS Ultima is a high-resolution velocity model together with an accurate estimate of the earth's reflectivity with compensation for incomplete acquisition, poor illumination, and multiple crosstalks. Additional derivative properties such as relative density and relative impedance can be estimated directly from the inverted models.

DERISKING LEADS

The method was successfully applied to a dataset from **offshore Newfoundland and Labrador**. The resulting outputs deliver good amplitude fidelity and signal-to-noise ratio. The inverted models can be directly used to identify leads and reduce the risk when identifying prospects. The narrow azimuth (NAZ) 3D survey used for this study was acquired in 2020 using multisensor technology with 16 streamers, 100 m streamer separation and 8 km streamer length.

Of particular interest in this area are large-scale **Paleogene marine fan systems** that align along the shelf margin off the northeast Coast of Newfoundland. In this shallow water setting the main imaging challenges are multiples and strong velocity contrasts which make it difficult to identify prospects as the signal-to-noise ratio (SNR) is poor. The uplift from applying PGS Ultima to the data improves the identification and understanding of such prospects within the **Blomidon survey**.

The top image in the figure to the right is the relative impedance property extracted at the target interval. There are two potential reservoir fairways shown on the map. Both are notionally interpreted as marine fans. The primary target (orange outline) was delineated using the underlying data but PGS Ultima was able to improve the image in the distal part where a secondary fan feature (yellow) has become more apparent. This is thanks to the increased signal-to-noise ratio at low frequencies and more accurate velocities. Both the primary and secondary fan features have encouraging low relative impedance responses (light gray). Lateral heterogeneity is seen within the secondary fan, note the variation of the dark (harder rock) and light (softer rock) colours.

An overlay of the relative density map and the relative impedance is shown on the bottom image of the figure to the right. The joint interpretation of both attributes confirms the delineated secondary fan geometry and the relative density attribute provides additional insight. A higher relative density signals a change in the reservoir property or a different fluid phase in the distal part of the secondary fan feature. Revealing such details is important for risk mitigation in the Orphan Basin.

A RELIABLE SOLUTION

Traditionally, it has been difficult to produce a reliable density attribute as final and fully processed very high angle stacks (above 45 deg.) with a good signal-to-noise ratio would be required. This would mean that the exploration team would have to wait until the end of the data processing phase, which normally takes several months. Sometimes the duration of the processing phase overlaps with the bid round schedule and puts exploration teams under pressure to meet deadlines.

PGS Ultima can help in these situations. It is a fast data-driven approach that delivers direct estimates of the subsurface velocity, reflectivity, and their derivatives, relative impedance and relative density. Depending on the geological setting and the target level, it can even start from minimal pre-processed input data and can be run very effectively, enabling the technical teams to perform prospectivity and lead risk assessments in a shorter time frame. ■

All images courtesy of PGS
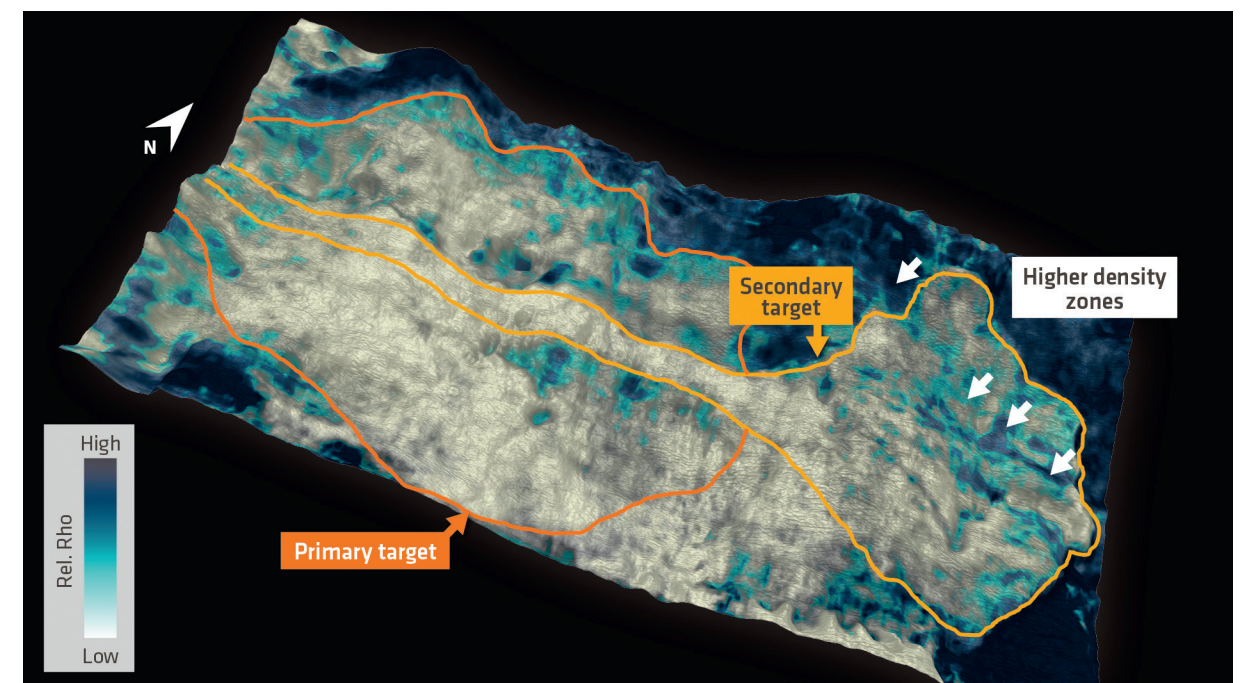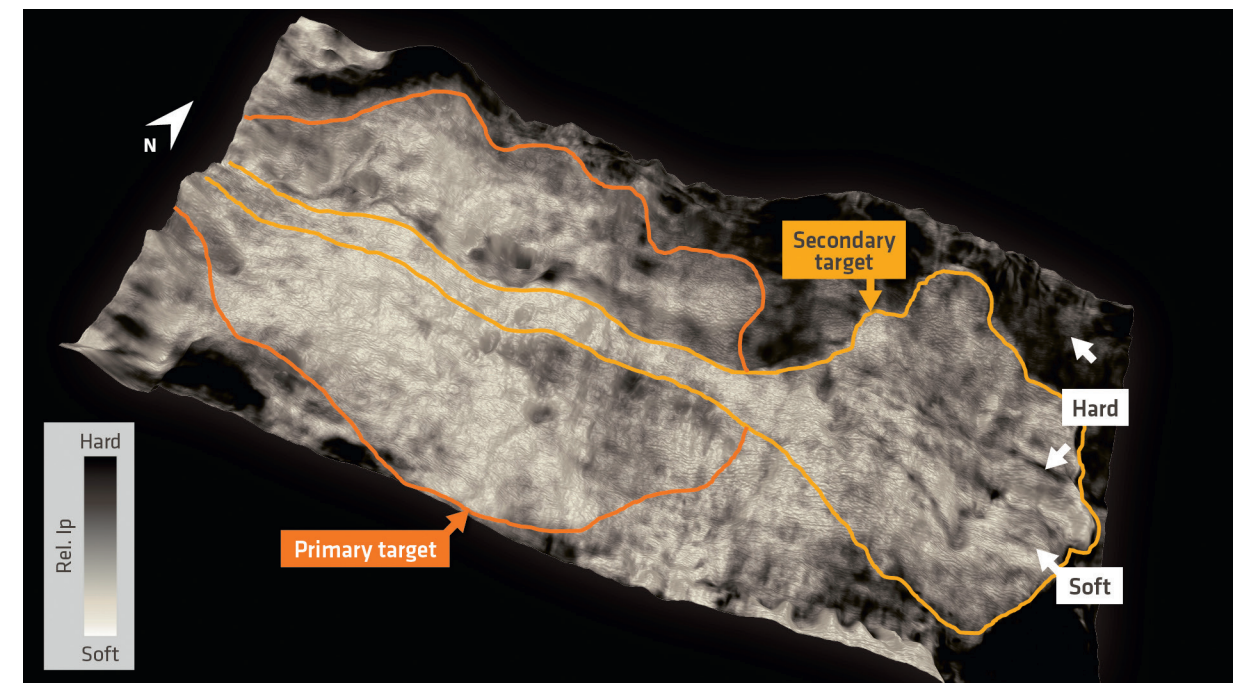
Examples of outputs from PGS Ultima: Top) the relative impedance (rel.Ip) map and Bottom) is the relative density (rel.Rho) overlayed with the impedance for a joint interpretation. There is general agreement between the two predicted properties. Both the primary and secondary fan features have a favourable low relative impedance response (light gray). When overlayed with the relative density on the bottom map the right portion of the secondary fan demonstrates a break in relative density, signaling a change in the reservoir property or a fluid change.