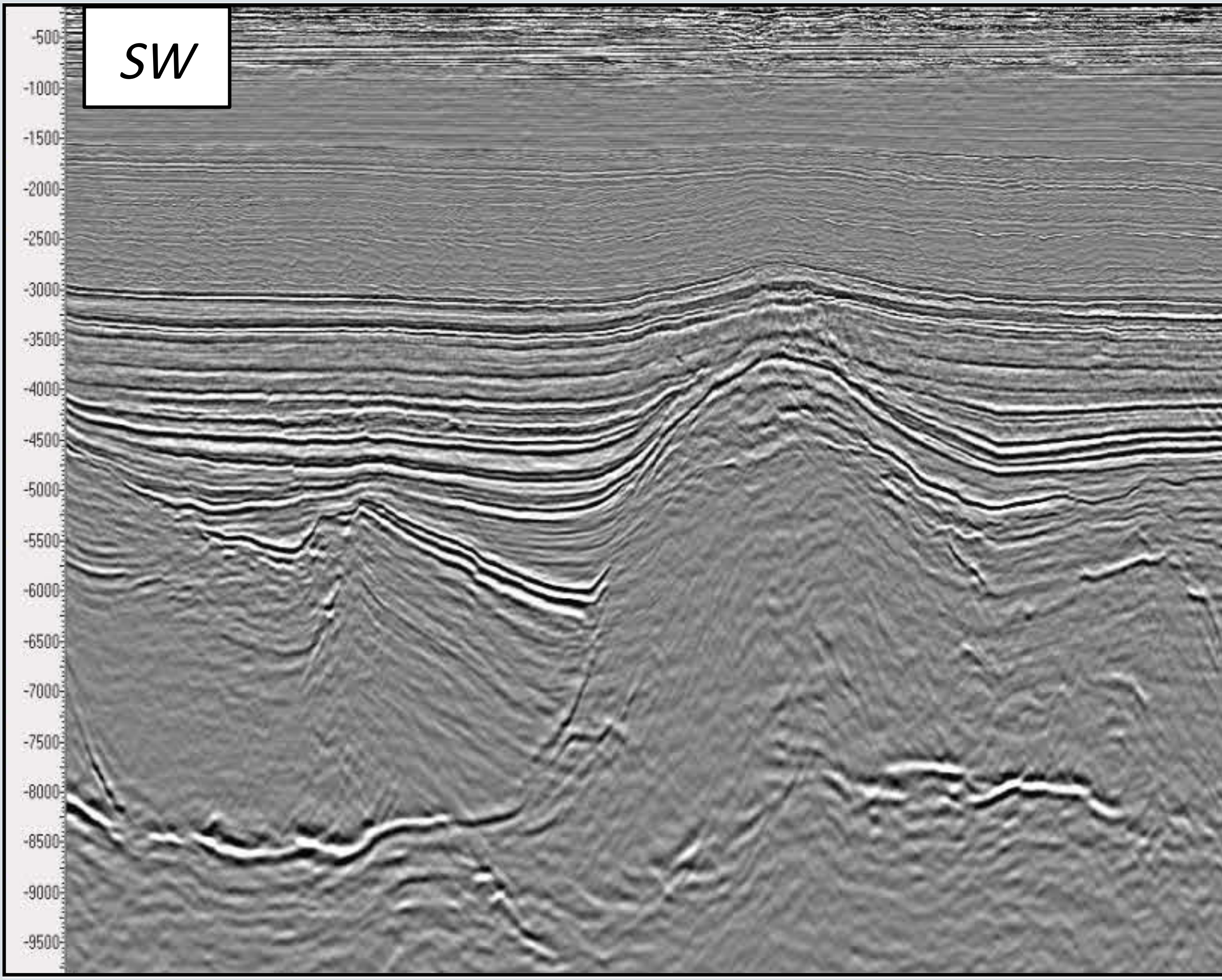
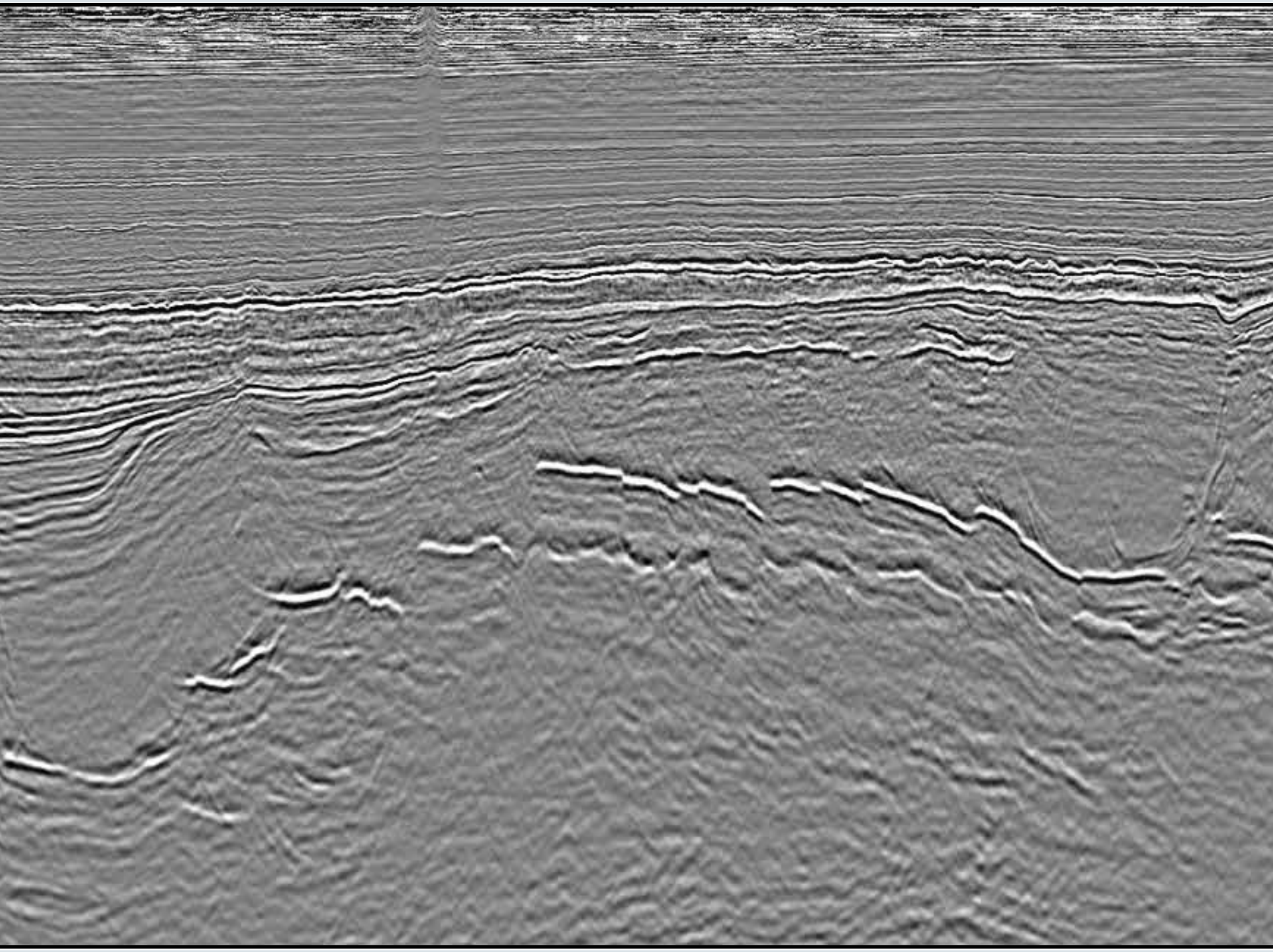
Central North Sea:

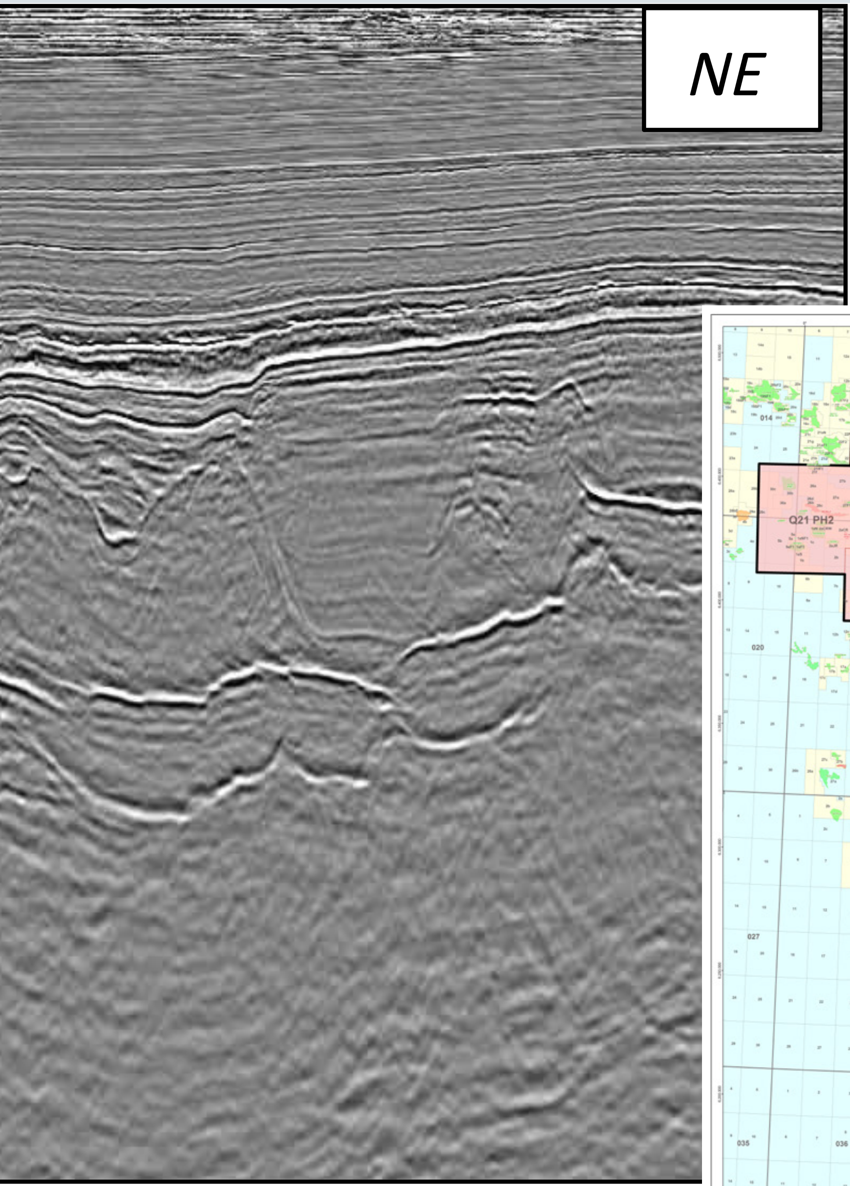
Advances in technology with

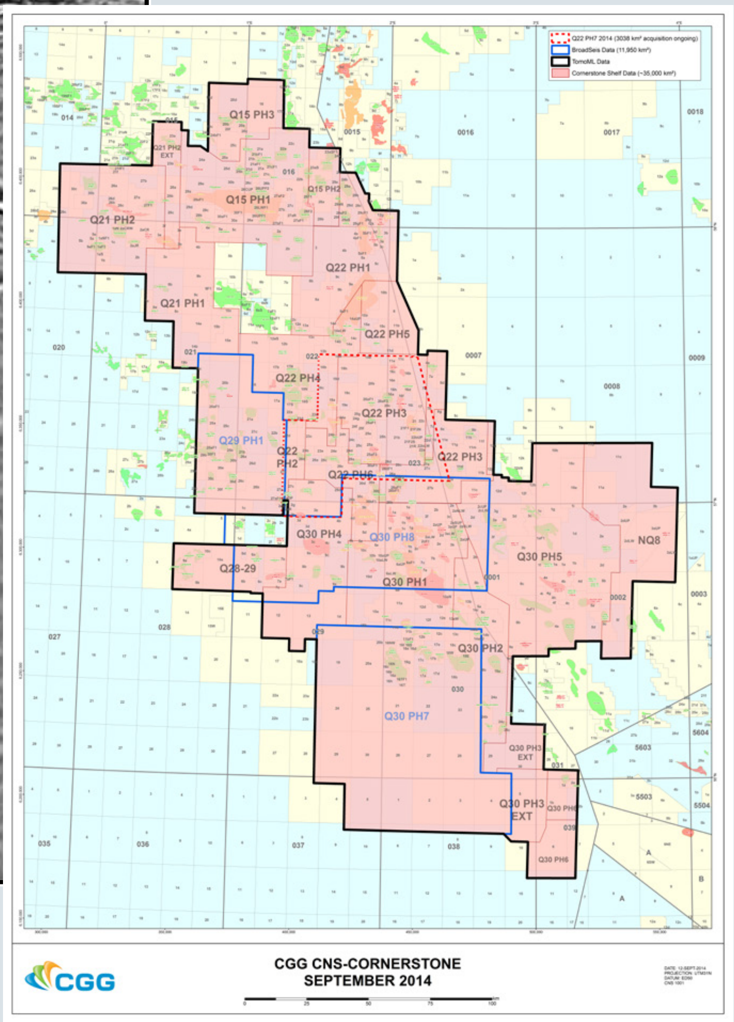


CGG's Cornerstone Data



There are a number of geophysical challenges when attempting to image the subsurface in the Central North Sea. These consist of shallow anomalies, heavy multiple contamination and sharp velocity contrasts. With a combination of broadband data and CGG's latest processing and imaging techniques, these challenges are significantly reduced.





Extracting more from a mature petroleum basin

CGG has made advances on its multi-client Cornerstone data in the Central North Sea, following the success of the long-offset, 3D pre-stack time-migrated dataset already available. The Cornerstone project now includes a fully merged, continuous Kirchhoff PSDM volume, covering over 35,000 km² of seismic data, using the latest multi-layer tomography and bandwidth extension technologies.

The project has used CGG's proprietary technology, TomoML, to build a more accurate TTI anisotropic velocity model, calibrated with over 120 wells throughout the Central North Sea. It also benefits from CGG's latest ghost compensation processing technique to extend the frequency bandwidth and improve the resolution of the conventionally-acquired phases of this data, providing a contiguous, broadband, depth-migrated dataset.

NORWEGIAN CENTRAL GRABEN

CGG's Cornerstone dataset extends across the UK and Norwegian parts of the Central North Sea. The Norwegian Central Graben is an area of high exploration and production, with major discoveries such as Ekofisk, Ula, King Lear and Oselvar. There are many prospective intervals, with hydrocarbons encountered within three main sequences; Upper Jurassic sandstones, Cretaceous chalks and Lower Tertiary submarine fan systems. Due to the maturity of the basin, advances in technology have continuously allowed new play models to be explored and new discoveries to be made.

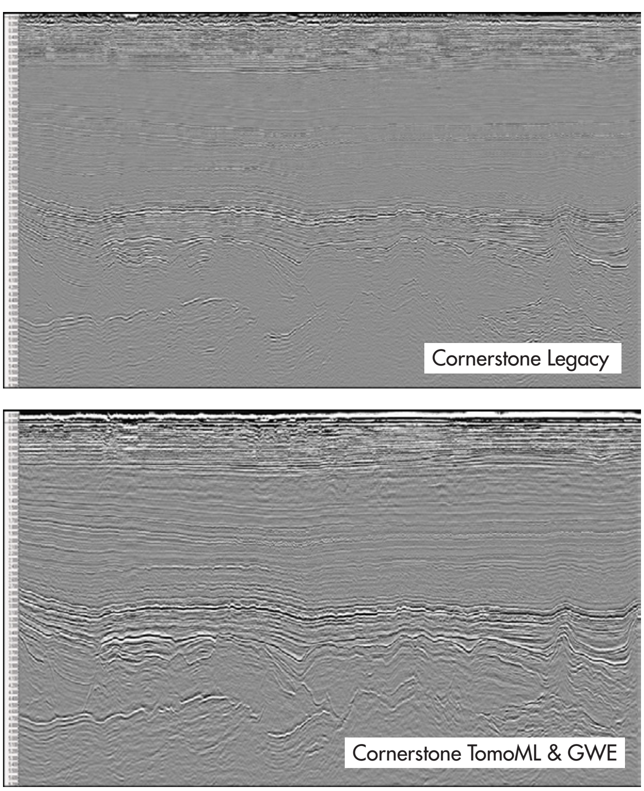


Figure 1: A regional seismic comparison of the Cornerstone legacy data and Cornerstone with TomoML and GWE applied (images courtesy of CGG Data Library).

MULTI-LAYER TOMOGRAPHY

TomoML is CGG's new, ray-based, multi-layer approach to reflection tomography. It replaces layer-stripping tomography with an efficient new workflow which performs a simultaneous update of the entire model in a single pass. Major velocity contrasts are intelligently repositioned, thus avoiding issues of incorrect horizon positions seen with conventional global tomography. A custom hybrid velocity model format has been developed for TomoML. It defines the velocity and anisotropy parameters for each layer as a mesh. Layer boundaries are accurately represented by bounding horizons. Tomography parameters can be individually tailored for each layer to make the most of available Residual Move Out (RMO) information and well data.

Multi-layer Tomography (TomoML) brings stability and accuracy to the velocity modeling in such areas, producing a more geologically plausible velocity model, honouring geologic constraints and providing improved imaging results. These techniques have been applied to the entire 35,000-km² Cornerstone dataset, using nine horizons and extensive well control to produce a regional anisotropic PSDM dataset with better local detail and definition than previous proprietary datasets tailored to specific local targets.

BROADBAND IMAGING OF CONVENTIONAL DATA

Advanced Ghost Wavefield Elimination (GWE) has been applied to all the legacy Cornerstone data to extend the bandwidth as near as possible to the new BroadSeis™ broadband data acquired in the Central Graben, so that it can be merged to create a single contiguous broadband pre-stack depth-migrated (PSDM) dataset. The bandwidth that can be achieved depends on the signal-to-noise ratio in the recorded data and so the ultra-low frequencies of BroadSeis true broadband data cannot be obtained. Nevertheless, considerable improvements have been delivered, providing an incredible 35,000-km² broadband PSDM dataset. Applying GWE has made it possible to broaden the bandwidth to provide sharper wavelets and improve visibility of impedance contrasts for enhanced interpretation. It also compensates for ghosts present in flat streamer data, within the constraints of the poor signal-to-noise ratio at low frequencies and in the ghost notches.

IMPROVEMENTS TO SEISMIC QUALITY

The near-surface of the Central North Sea features large-scale Quaternary channeling that strongly influences the imaging of deeper data. Accurate modeling of these shallow features is difficult using reflection tomography, due to the short offset range available. Traditionally, this type of anomaly has been compensated by 1D updates based on the depth distortion of a horizon picked below the anomaly. Recent advances in Dip-Constrained Tomography have allowed the building of highly detailed velocity models incorporating (and compensating for) these channels, resulting in more accurate imaging of deeper events.

Figure 2 shows 3D visualizations of the new Cornerstone data with frequency decomposition. The image is focused on two strong amplitude anomalies seen within the sequences below the Base Cretaceous Unconformity (BCU). One is already a discovered field and the other is a potential area of interest. Taking comparative seismic sections through the area of strong amplitudes from the legacy Cornerstone and new TomoML data (**Figure 3**), enhancements can be seen with the new data. The seismic appears less distorted and the amplitude response at reservoir level is sharper and more prominent. Illumination issues at the reservoir interval are resolved by the continuity of reflectors and increased accuracy in the positioning of top Zechstein, allowing for a truer geological model when mapping out the field and prospect.

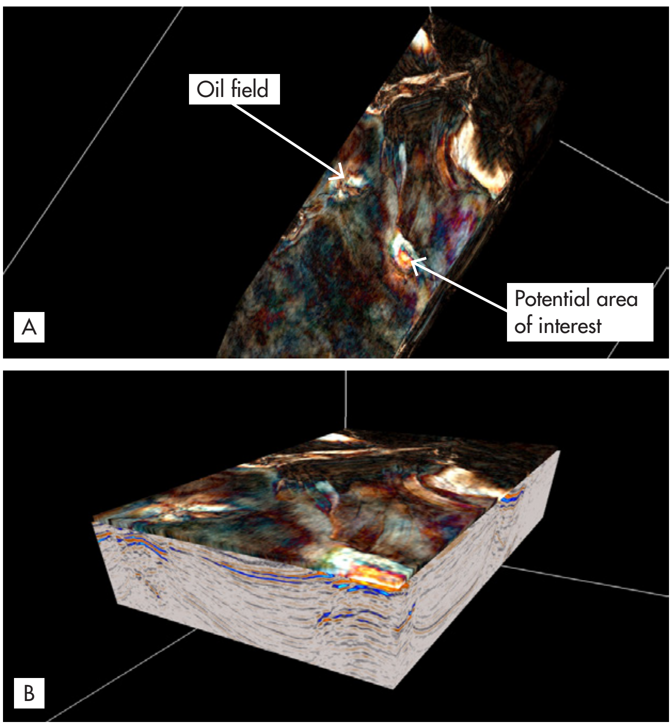


Figure 2: (A) Colour blend 3D visualisation highlighting strong amplitude responses to hydrocarbons.
(B) Seismic slice through potential hydrocarbon-bearing structure.

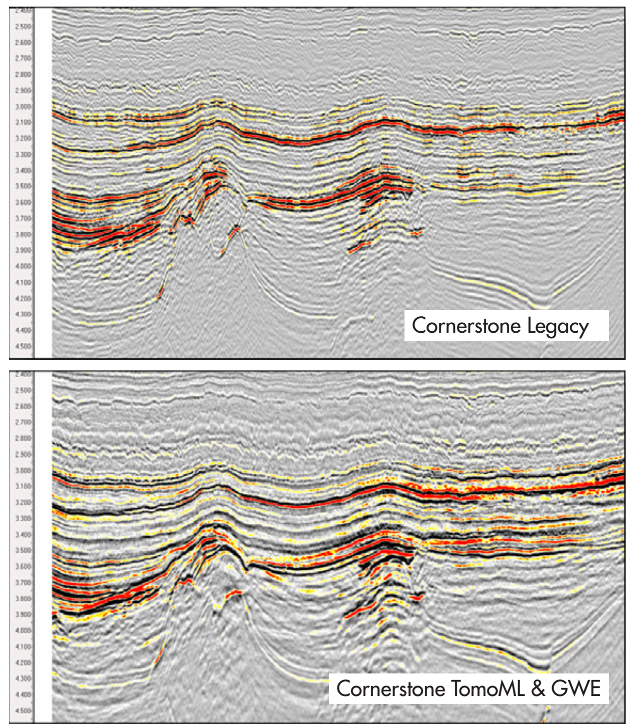


Figure 3: Seismic comparison of the Cornerstone legacy data and Cornerstone with TomoML and GWE applied. The lines transect the potential hydrocarbon-bearing structure (right) and adjacent oil field (left) seen in Figure 2. Strong amplitude responses can be seen at the same reservoir interval (images courtesy of CGG Data Library).

Figure 1 shows comparative regional seismic lines across quadrants 1, 2 and 7 in the Norwegian part of the Central Graben, highlighting a number of improvements with the new data. Reflectors located within the Cretaceous section show less distortion below the polygonal faults and improvement to the imaging of the complex faulted sequence.

There is a considerable marked improvement in the continuity of reflectors and strong velocity contrasts at the BCU and top and base Zechstein. Amplitude losses in the legacy data appear to be illuminated and the resolution of the sub-chalk section is significantly improved.

Deeper targets located beneath the BCU are of higher resolution and allow a more accurate interpretation of Jurassic and Triassic reservoirs. This is due to more detailed velocity modeling by TomoML in these particular areas beneath the complex overburden of chalk, allowing for a more plausible geological model.

The detail and clarity of the new Cornerstone data with TomoML and GWE applied emphasizes the great potential of this technology as an important tool to help map out new targets. Multi-layer tomography and broadband are advantageous in areas where complex structures are present with strong velocity contrasts. This technology provides enhancements to data where limitations occur, allowing improvements to the frequency bandwidth, well-to-seismic ties and better imaging to reduce interpretation uncertainty.

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