TOWED STREAMER EM

A Step Change in Acquisition Efficiency, Data Density and Seismic and EM Integration

A case study: High density 3D EM in the Barents Sea Southeast

Introduction

PGS' unique Towed Streamer EM technology enables industry leading volumes of high density 3D EM data to be acquired with an efficiency previously unknown. To further build the value proposition PGS is able to acquire 2D GeoStreamer seismic simultaneously with high density EM data using a single vessel.

This step change in EM acquisition efficiency enables dramatically more, higher density data to be acquired in a short timeframe than is possible with legacy EM acquisition systems. Couple this with PGS' seismic acquisition, processing and interpretation expertise and it becomes clear where the value to exploration and production companies comes from; the ability to use a single vessel to acquire EM and GeoStreamer data, with a single specialist company integrating them to maximise their value in the quest to better understand the sub-surface.

The Towed Streamer EM system is designed to operate in water depths of up to 500 m and to map sub-surface resistivity to a depth of 2,500 – 3,000 m below the mud line. PGS has acquired numerous EM surveys since 2008; both on a proprietary basis as well as under the MultiClient business model. 2014 saw PGS acquire almost 12,000 km2 of high density 3D EM data in less than four months in the Barents Sea Southeast. The final 2.5D and 3D unconstrained inversion sections and volumes have been delivered to pre-funders and are available for licensing in good time before the application deadline for the 23rd round. PGS is building on the success of this project by expanding on the 2014 coverage during 2015, mobilising the Nordic Explorer in the Barents Sea for simultaneous GeoStreamer and EM acquisition during June 2015.

Survey planning

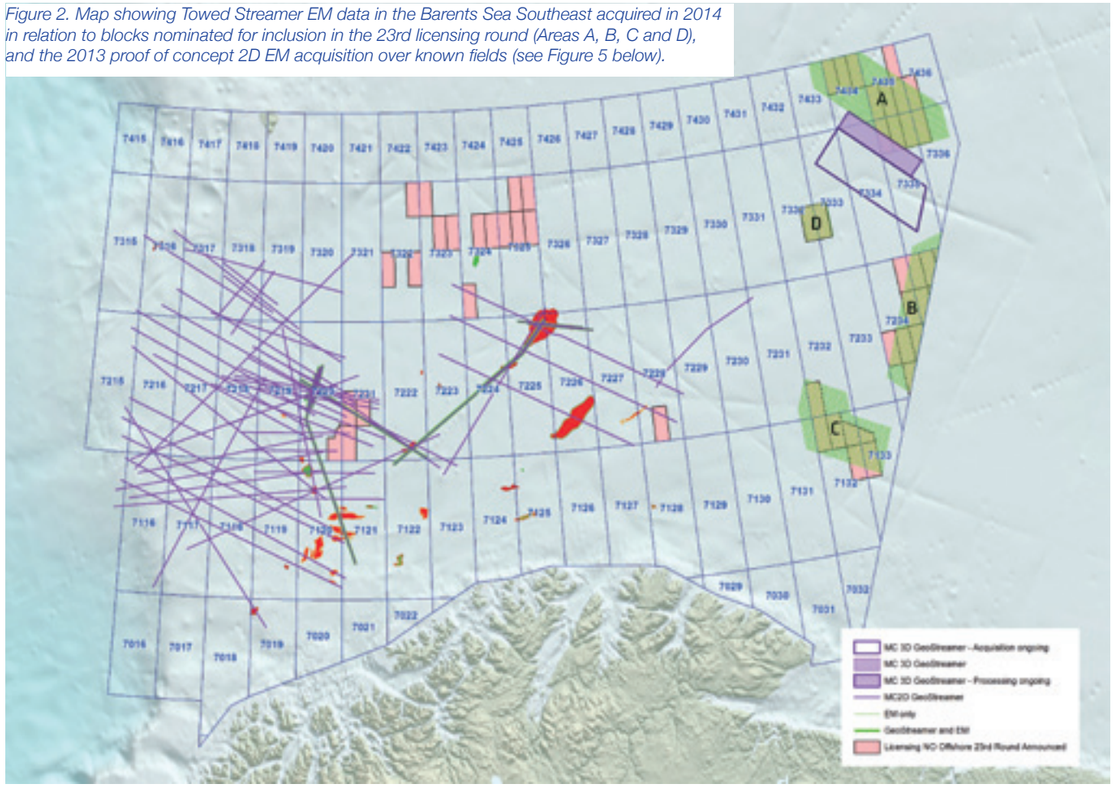
With over 25 years' experience in survey design and planning PGS draws on a wealth of knowledge to ensure a safe and efficient survey which delivers geophysical and operational objectives on time and within budget. The 3D EM survey undertaken in the Barents Sea Southeast was designed to overshoot the four seismic group shoot polygons, generating interest in this complementary dataset in over 30 companies. As the 3D seismic was available to the group shoot members PGS further reduced acquisition costs by acquiring EM only over the seismic, combined with the efficiency of acquiring EM using a streamer this enables PGS to be highly competitive while providing exceptionally high quality EM data on a MC basis.

Rigging and mobilisation

As the survey was designed to acquire EM data only the decision was taken to use a third party vessel in order to minimise acquisition costs. PGS' highly experienced operations team quickly secured the Geo Searcher for the job.

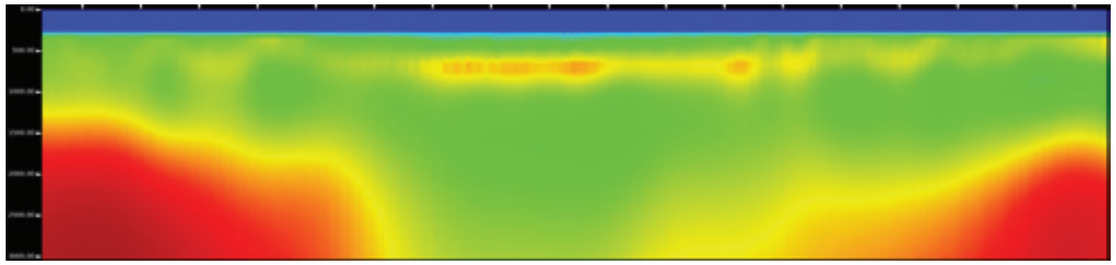
Figure 1. Geo Searcher alongside prior to acquiring almost 12,000 km2 of high density EM data in less than four months.

Figure 2. Map showing Towed Streamer EM data in the Barents Sea Southeast acquired in 2014 in relation to blocks nominated for inclusion in the 23rd licensing round (Areas A, B, C and D), and the 2013 proof of concept 2D EM acquisition over known fields (see Figure 5 below).



SEISMIC PROFILE TOWED STREAMER EM

Figure 3: Resistivity determined from unconstrained anisotropic inversion of data in the Barents Sea Southeast as a 2.5D section.



Rigging of the vessel took two weeks, PGS has rigged multiple vessels with Towed Streamer EM and this is a well-practiced process, resulting in a safe, expedient and cost effective rigging. As the EM equipment can be shipped in containers this flexibility enables PGS to deploy the equipment from a vessel of opportunity anywhere in the world without the cost and time required to steam highly specialised vessels long distances between surveys.

Operational efficiency

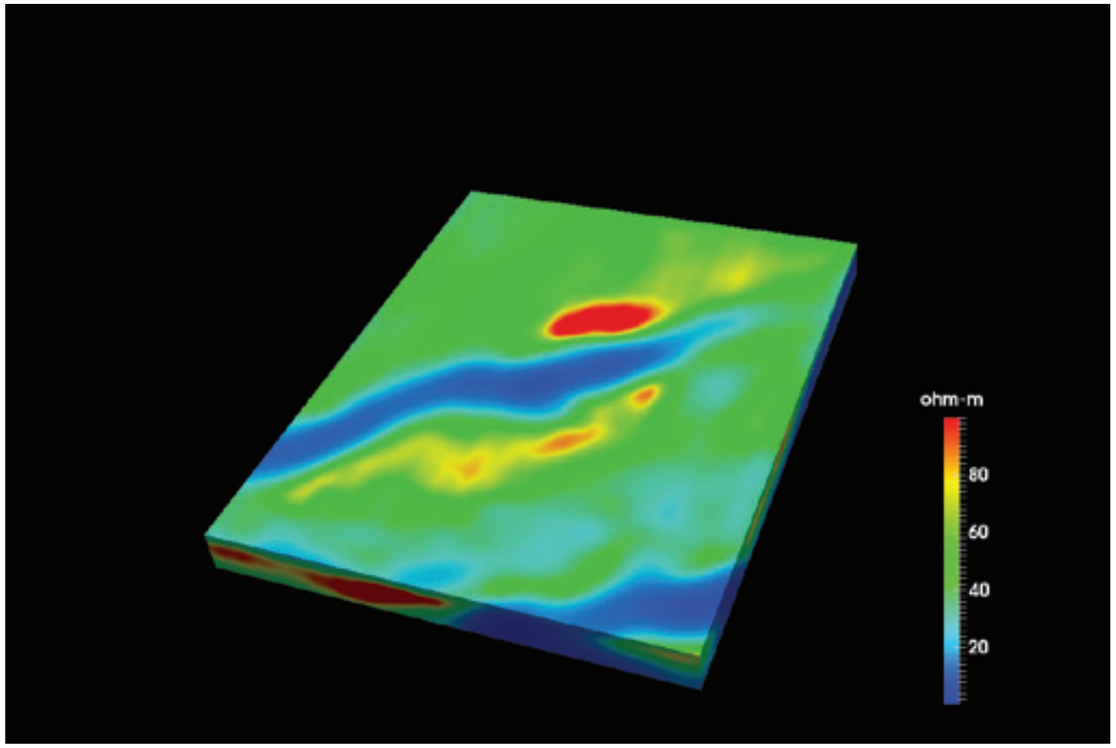
With an average speed of 4.6 knots and a line spacing of 1.25km the Geo Searcher acquired an average of 150 km2 a day during the survey, with production on one day reaching 250 km2 of 3D EM data. This impressive level of production resulted in almost 12,000 km2 being acquired in less than four months, even with crew change taking place in port due to the lack of a helipad on the vessel.

Unconstrained inversion

By performing unconstrained inversion of the Towed Streamer EM data to determine the sub-surface resistivity we aim to extract the maximum possible amount of information from the data before considering any constraints on the solution. The 2.5D unconstrained inversion is undertaken by PGS' EM Processing and Interpretation group in Oslo, in parallel the 3D unconstrained inversion is performed by TechnoImaging in Salt Lake City, providing an independent QC of the inversion process at an early stage.

PGS starts the 2.5D inversion process with a value assigned to a half space, in the Barents Sea this can be between 5-20 ohm m. Due to the density of data acquired when using the Towed Streamer EM system; varying this initial value doesn't have a significant effect on the final output of the inversion. The only significant impact on varying this starting value is the number of iterations the inversion has to

Figure 4: Resistivity determined from unconstrained anisotropic inversion of data in the Barents Sea Southeast as a 3D volume of 600 km2.



run through before it reaches the final model, the closer the initial value is to reality, the fewer the number of iterations required. This reliable approach to the inversion process is just one of the advantages which come as a direct result of the significantly higher volume of data acquired using Towed Streamer EM.

In Figure 3 the resistivity determined from unconstrained anisotropic inversion of data in the Barents Sea is shown as a 2.5D section:

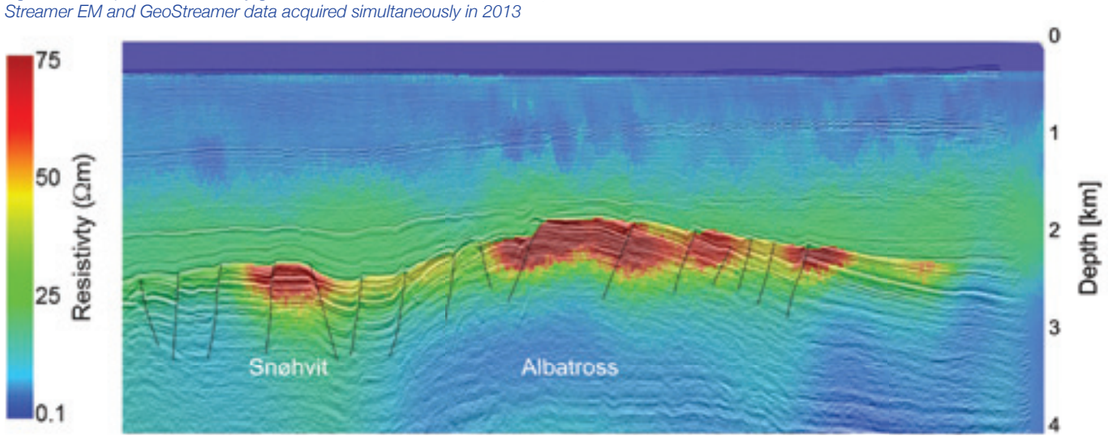
Seismically guided inversion

Companies with access to both the group shoot seismic data as well as the MultiClient Towed Streamer EM data are at an advantage from the perspective of the 23rd round; they're able to identify the blocks which possess a combination of structural seismic information and anomalously resistive features, dramatically de-risking the acreage prior to finalising a decision.

Group shoot members who are also pre-funders of the EM MultiClient survey have been able to interpret the seismic data and establish key horizons. The key horizons can be provided to PGS for use in seismic and EM integration in the form of seismically guided inversion.

Seismically guiding the inversion allows the inversion process to anticipate a significant change in sub-surface resistivity at a specified boundary, in this case an interpreted seismic horizon. This enables a higher resolution, seismic and EM integrated product to be produced, further increasing the understanding of the sub-surface and dramatically de-risking a frontier area when compared to using seismic alone. This integration of seismic and EM data highlights the benefit of high density EM data as acquired using the Towed Streamer EM system; 72 offset pairs in the streamer (channels) receive data from a 'shot' every 250 m, this unrivalled data density manifests itself in high resolution, accurate and reliable inversions.

Figure 5. Example of a seismically guided inversion from the Barents Sea, Towed Streamer EM and GeoStreamer data acquired simultaneously in 2013



The story continues – 2015 simultaneous GeoStreamer and EM acquisition

Due to the success of the 2014 3D EM campaign in the Barents Sea Southeast PGS decided to further expand its' MultiClient EM library in this highly prospective area. The Nordic Explorer is, at the time of writing, making excellent progress on another high density 3D EM survey in the Barents Sea Southeast. This time PGS is acquiring simultaneous EM and 2D GeoStreamer; it's this acquisition efficiency combined with PGS' ability to integrate EM and seismic data in a manner that adds significant value to both, which makes Towed Streamer EM the ultimate de-risking technology.

For more information please contact EM@PGS.com.

Author – Joshua May, Sales and Marketing Manager, PGS EM