Broadband imaging at a fault bound basin: case history of the PL 586 Pil discovery and Boomerang prospect, 2012-2015

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Abstract

Imaging in basins next to large bounding faults can have its challenges. We show here a case study where a combination of new broadband data, pre-conditioned with an extensive multiple suppression sequence, and using the most recent techniques in velocity model building has helped to improve seismic data. This update helped to confirm which geological model was correct in the vicinity of the fault.
Introduction

PL 586 is located on the Halten Terrace, close to the Vingleia Fault Complex and the Frøya High. In 2014 the partnership discovered hydrocarbons in Upper Jurassic sandstones in two separate prospects named Pil and Bue. The Upper Jurassic reservoir is mapped to continue towards the Vingleia Fault Complex where it forms a three-way dip closed structure against the fault, named the Boomerang prospect. Close to, the bounding fault the reservoir geometry is poorly imaged leading to different pre-drill geological models (Figure 1).

The data had been previously processed through a standard sequence of non-deghosted, 3D SRME, 2D SRME (delayed start targeting Base Chalk free surface multiples) and HR Radon demultiple in 2012. But it was thought that a newer broadband acquisition together with advanced depth processing would help to improve seismic data for reservoir model building and location of production wells and to decide which model was appropriate for the basin.

Therefore the primary objective of this project was to improve seismic definition in the Sandstone reservoir just below the BCU and thereby both the structural and stratigraphic interpretation at the fault. The secondary target was to image the major fault and position it correctly.

![Figure 1](image)

**Figure 1** Geological models that would be verified at the end of the project a) Scenario 1 on far-offset Kirchhoff image vs b) Scenario 2 on Beam image.

2012 processing and model-building

In 2012, a standard processing project was undertaken in this region. Input data came from conventional streamer data acquired in 2007 with 6m source depth, 7m receiver depth to create an acquired bin size of 6.25m x 25m, with 8 x 6000m streamers having separation of 100m and dual flip-flop (18.75m) source airgun arrays of 4130 cu.in with 50m lateral separation.

The vintage velocity model building consisted of 4 iterations using Kirchhoff TTI migration. Hyperbolic picking was used for RMO analysis and tomography, and the model was compared with sonic logs where available.

This process obtained an improved image below the BCU from vintage data, and this was good for a first attempt of geological analysis in the area. However, after interpreting strata around the fault, there was not a clear picture of what the structure should actually be in the vicinity of the fault. The previous beam image led to one geological model of the area and the Kirchhoff image led to another. Specifically: were the bedding planes abutting the fault, or onlapping? (Figure 1).

To help understand the target better, the region close to the fault needed to be imaged as well as possible, so it was decided to use new data that could open up the bandwidth, and have a more intensive, state of the art model building exercise focusing on the most relevant area close to the fault.
2015 data input and processing

New data were acquired in 2014 with 8m source depth, 20m receiver depth with acquisition bin size 6.25m x 18.75m, with 14 x 7050m streamers having separation of 75m and dual flip-flop (18.75m) source airgun arrays of 4130 cu.in with 37.5m lateral separation. This dataset was supplied after receiver deghosting and redatuming to 8m.

One of the more significant processes was the application of broadband processing in order to enhance the low frequencies by effective attenuation of the source ghost notch (Zhou et al., 2012). This process was designed and applied after noise attenuation and significantly contributed to the imaging of sub-BCU structures.

Multiple suppression comprised the improved combination of wavefield-extrapolation short-period multiple attenuation, 3D SRME and HR Radon demultiple.

Figure 2 2012 model, old data vs new data. Spectra included, red is 2015 data, blue is 2012 data.

Uplift is considered very good when comparing the conventional streamer data and the newer broadband Geostreamer data (Figure 2). In particular, imaging of the major fault is much clearer from the low frequency boost and the reflectivity is much stronger.

2015 model-building and analysis

Firstly the model was updated using well profiles after detailed interpretation. This updated model was used as a starting point in the new model-building round.

Five tomographic model building updates using Kirchhoff and beam TTI migration were employed (Jones 2010, 2015). This included using wavelet tracking non-parametric (generalised move-out) picking of offset or angle gathers (Fruehn et al., 2014, Luo et al., 2014) to update velocity and epsilon (as opposed to the vintage hyperbolic parametric picking). Preconditioning was optimized to use energy to far offsets and minimum smoothing as well as inserting the fault within the tomography as an interpretative constraint, which also helped gain a better result around the fault (Figure 3). Incorporating such explicit constraints within the tomography can prevent unwanted smoothing across fault boundaries during tomographic back-propagation.

As a final step, velocity scans were run to firstly look into the error around the fault, and secondly to check the image in this region. It was found that bulk changes in anisotropy helped enhance the image in the target area next to the fault.
Interpretation
The model-building was a very flexible and collaborative effort, along the way many things were tested to help achieve a better result. This included taking the basement velocities out of the model (exchanged with sediment velocities) to be certain that possible basin misinterpretation was not affecting the fault position. Furthermore, this process allowed interpreters to estimate uncertainty in the fault position and therefore improved estimation of potential volumes and risk assessment. In addition, the preconditioning was looked at closely to help in understanding what is within the basement – previous interpretation indicated that sediments were going across the fault plane – this turned out to be an artefact resulting from remnant multiple (Figure 4).

The update in data and model has helped to control and resolve the positioning of the fault in addition to determining the basin structure as it approaches the fault. Also, using the beam algorithm in model-building and interpretation helps understand the structure better (Figure 5).
Conclusions
We have had success in better imaging of the basin close to a major bounding fault. This comes from a combination of new broadband data pre-conditioned with an extensive multiple suppression sequence, and using the most recent techniques in velocity model building. In addition to this, good collaboration between client and contractor was key to gaining the best results.

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References
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