PL754 Relinquishment Report

Document last updated 16-07-2015 13:19 CEST

PL754 Relinquishment Report

List of figures

List of tables

List of attachments

1 Key license history

The PL754 license was awarded the 7th of February 2014 as part of the APA 2013 licensing round. Rocksource Exploration Norway AS has operated the license with a 40% equity together with Centrica Resources (Norge) AS and Faroe Petroleum Norge AS, both with a 30% equity Fig. 1.1.

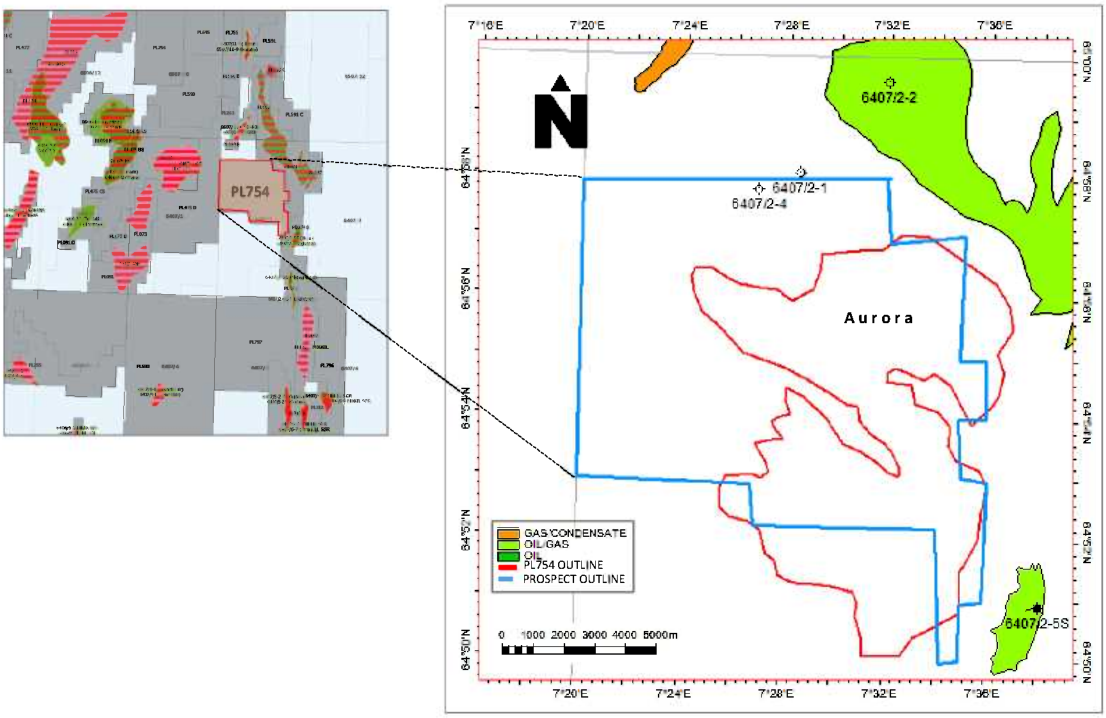


Fig. 1.1 PL754 license overview map. *Pl754 outline in red, the Aurora prospect in blue*

Table 1.1 summarizes the work obligations and duration of PL754 put forward by the Authorities. The work program was divided into four phases.

Table 1.1 Work program and duration

Phase	Work program	Duration (years)
1	Reprosess 3D seismic, within the 19th February 2015 o Decide on drilling exploration well or o acquire new 3D seismic or o relinquish	1
2	Drill exploration well, within the 19th February 2017 (or 2019) o Concretize (BOK) or o Drill exploration well or o relinquish	2 (4)
3	Concept studies within the 19th February 2019 (or 2021) o Continue (BOV) or o relinquish	2
4	Make development plan within the 19thFebruary 2020 (or 2022) o Submit PDO or o relinquish	1
	Extension period	15

Rocksource and partners have fulfilled and concluded on the technical work in phase 1 of this license and have decided to relinquish the license prior to the commitment deadline for drilling the first exploration well. Table 1.2 summarizes the work program for the license. The deadline for this decision was originally 19th of February 2015 with an extension approved by the MPE with a new deadline of phase 1 at 1st of May 2015. The license has fullfilled the original work program commitments (Table 1.1)

Table 1.2 PL754 license meetings. Summary of license meetings in PL754 since award, leading up to the relinquishment recommendation. Additional communication between the licensees has been through License web (L2S).

Meeting Description	Meeting date	Overview
EC/MC No. 1	3rd of March 2014	License start up meeting. Establishment of common database, prospectivity review, proposed work program and budget
EC/MC No. 2	13th of November 2014	3D seismic data reprocessing review, prospectivity update with fault seal- , semi-regional stratigraphic- and depositional study shown Budget recommendations 2015
EC/MC No. 3	13th of April 2015	Full license prospectivity review and license recommendation to drop the license due to high risk and low volume potential

An overview of the completed technical work within the license is provided later in this report.

2 Database

The license database immediately following award was established to include all publicly available seismic- and well data. The seismic database used in the evaluation of the Aurora prospect is shown in Fig. 2.1. Fig. 2.2 shows the well database for the license.

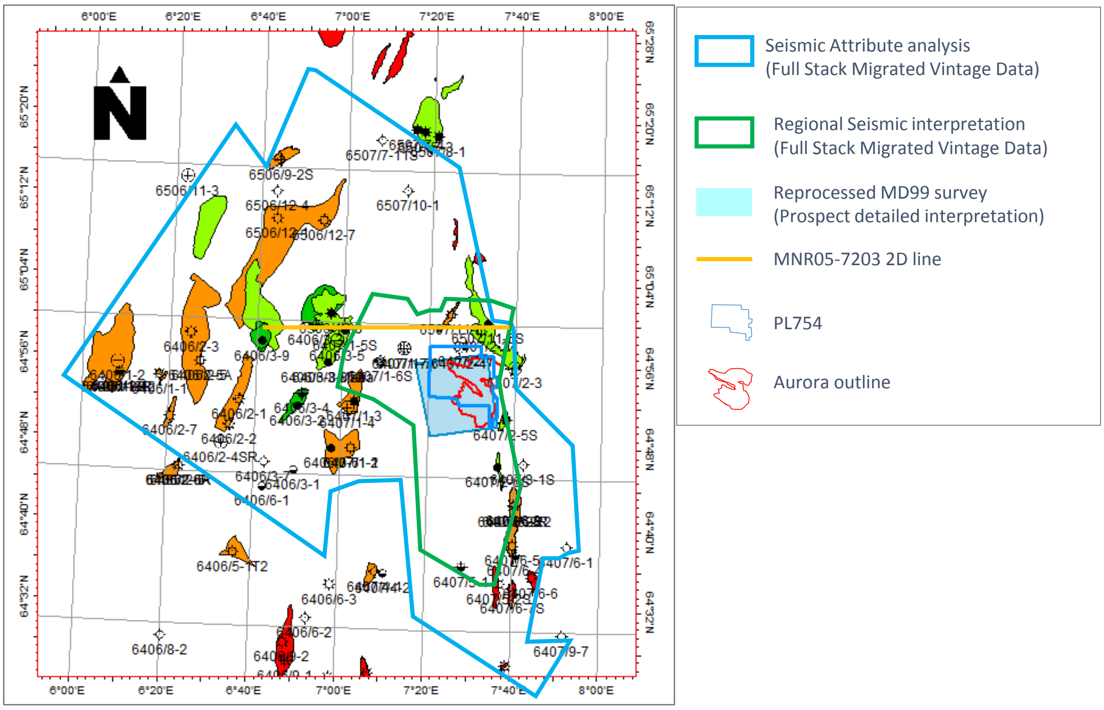
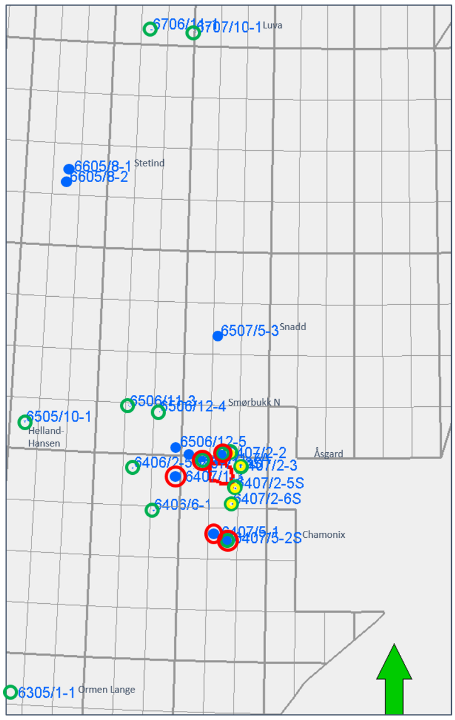


Fig. 2.1 Data coverage. *The seismic attribute analysis and the regional seismic interpretation are performed on the PGS Mega-Survey, while the prospect detailed seismic interpretation is performed on the reprocessed MD99 survey.*



Well	Name	Discovery in Lysing/Lange	Petro-physics	Geo physics	Sedimen tology	Fault / Seal
6305/1-1	Ormen Lange	-			X	
6406/2-5	Kristin	-			X	
6406/6-1	Eta	-			X	
6407/1-3	Tyrihans	-	X	X		
6407/1-6S	Rodriguez	Gas	X	X	X	
6407/1-7	Solberg	Gas	X	X	X	
6407/1-7A	Solberg	Gas	X			
6407/2-2	Åsgard	-			X	X
6407/2-3	Åsgard	-			X	X
6407/2-5S	Nona	-			X	X
6407/2-6S	Flyndretind	-			X	X
6407/5-1	-	shows	X	X		
6407/5-2S	Chamonix	-	X	X	X	
6505/10-1	Helland-Hansen	-			X	
6506/11-3	-	shows			X	
6506/12-4	Smørbukk N	shows			X	
6506/12-5	Smørbukk S	Oil	X			
6507/5-3	Snadd	Gas	X			
6605/8-1	Stetind	Gas	X			
6605/8-2	Stetind	shows	X			
6706/11-1	Ægir	-			X	
6707/10-1	Luva	Gas			X	

Fig. 2.2 Well database

A re-evaluation of the biostratigraphic dataset for the well 6407/1-6S (Rodriguez) has been done to better understand the relationship among the Aurora prospect and the nearby discoveries. The re-interpretation of the biostratigraphic data over the Cretaceous interval has allowed some improvement to the resolution.

3 Review of geological framework

3.1 Performed work and main results

The PL754 license is situated in the Gimsan Basin in the south east part of the Halten Terrasse (Fig. 1.1). The Gimsan basin developed during the Middle to Late Jurassic extensional tectonic phase as a large half-graben climbing towards the east against the Breimstein Fault Complex (BFC) separating the basin from the Trøndelag Platform. During the Callovian to Kimmeridgian the marine claystones and shales of the Melke- and Spekk Fms were deposited in the rift-basin, the latter forming the principal source rock for the prospect. During the post-rift thermal cooling the basin subsided rapidly and was gradually filled by a thick package of deep-marine sediments. A mid-Cretaceous extensional tectonic pulse in the Norwegian Sea caused renewed sand input to the Halten Terrace. The underlying Late Jurassic sea-floor topography and the fault lineaments affected the Cretaceous sediment distribution. Gravity flows tended to follow sea-floor depressions above older fault-lineaments and deposited turbidite sediments including the Lange and Lysing Mbs sands.Fig. 3.1

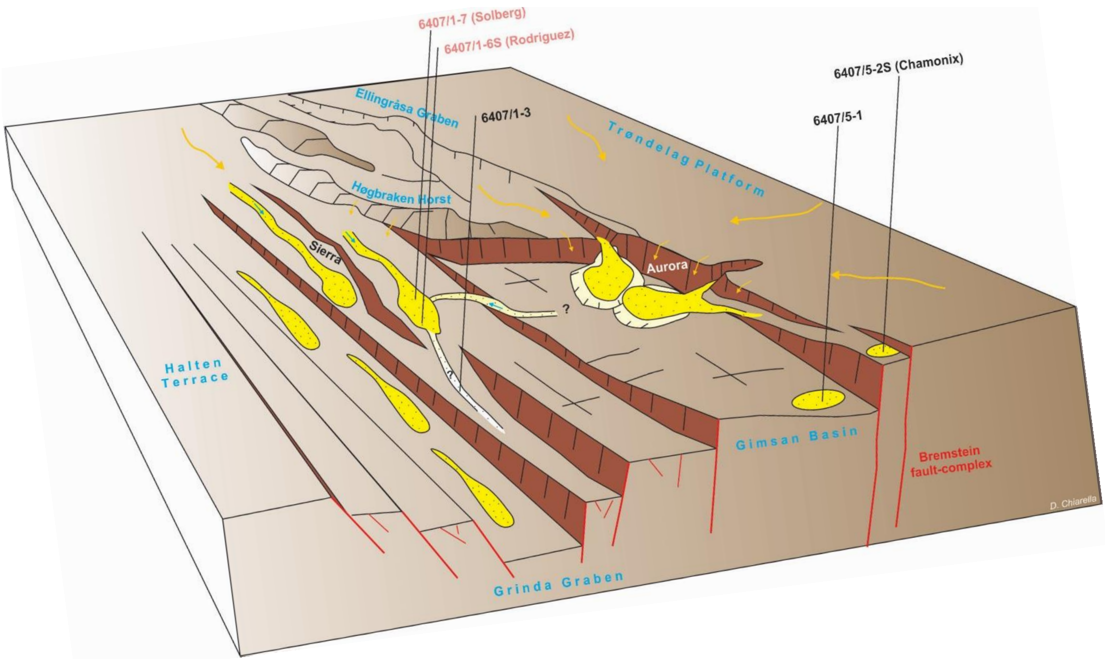


Fig. 3.1 Depositional model of the licensed area

The depositional model (Fig. 3.1) for the reservoir sandstone in the Aurora prospect is related to a shelf-fed system typical for passive and mixed systems. The sediments are sourced from the Nordland Ridge, the Trøndelag Platform and local erosion of Jurassic deposits along the Bremstein Fault Complex. Reservoir quality evaluation taking into account the neaby wells suggests poor reservoir quality for the Aurora sand.

Several feeder systems surrounding the Aurora prospect area are recognised (Fig. 3.2). These pathways corresponds with documented canyons developed along the Bremstein Fault Complex. In addition to the feeder systems, geometrical definitions of large bodies based on amplitude anomalies was performed. These bodies have been interpreted to be part of a a deep-marine fan system (Fig. 3.3).

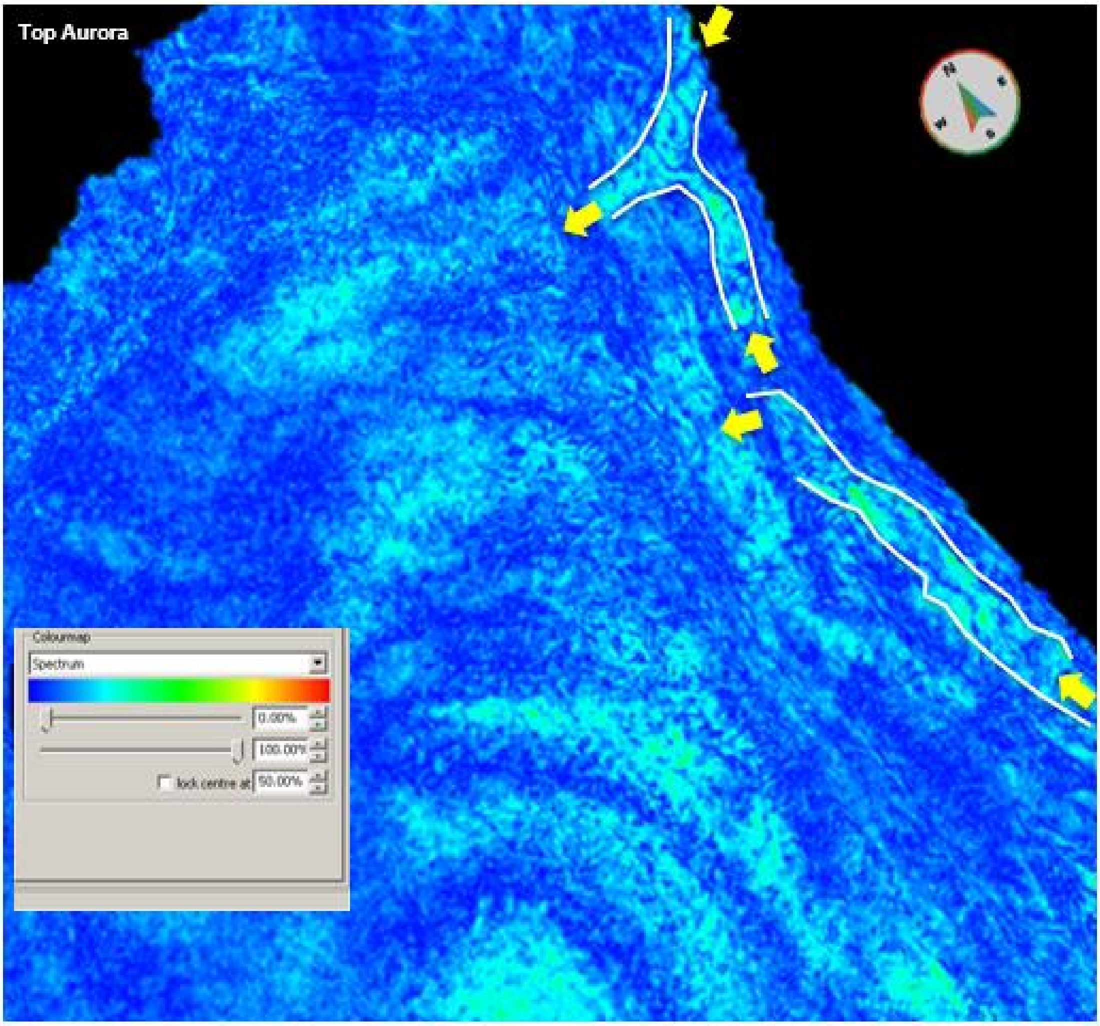


Fig. 3.2 Envelope amplitude map (GeoTeric) of Top Aurora reservoir

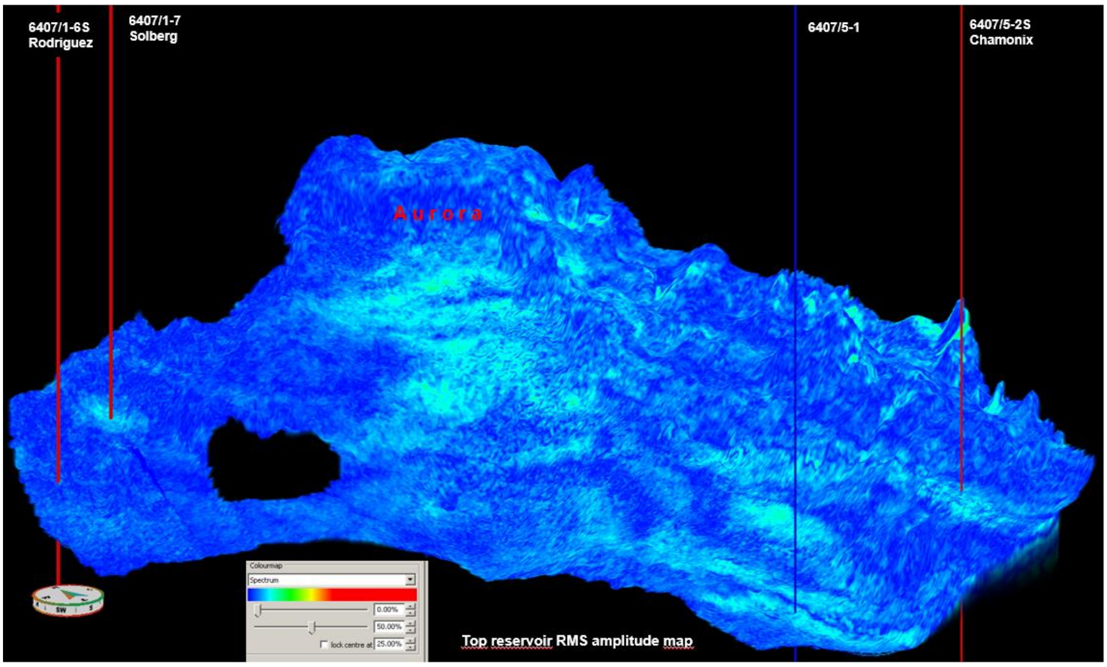


Fig. 3.3 RMS amplitude map of Aurora Top reservoir

Seismic interpretation

Seismic interpretation was performed on the different 3D cubes shown in Fig. 2. Key horizons were interpreted within the Cretaceous succession related to the identified reservoir stratigraphy being present within the prospect. Additional reflectors within the Tertiary and Jurassic was also interpreted to understand the overburden and the hydrocarbon migration. These horizons were used in the velocity- and basin model building. The main interpreted reflectors were seabed, Top Kai, BTU, BCU, Top Melke, Top Garn, Top Tilje and Top Åre (Fig. 3.4).

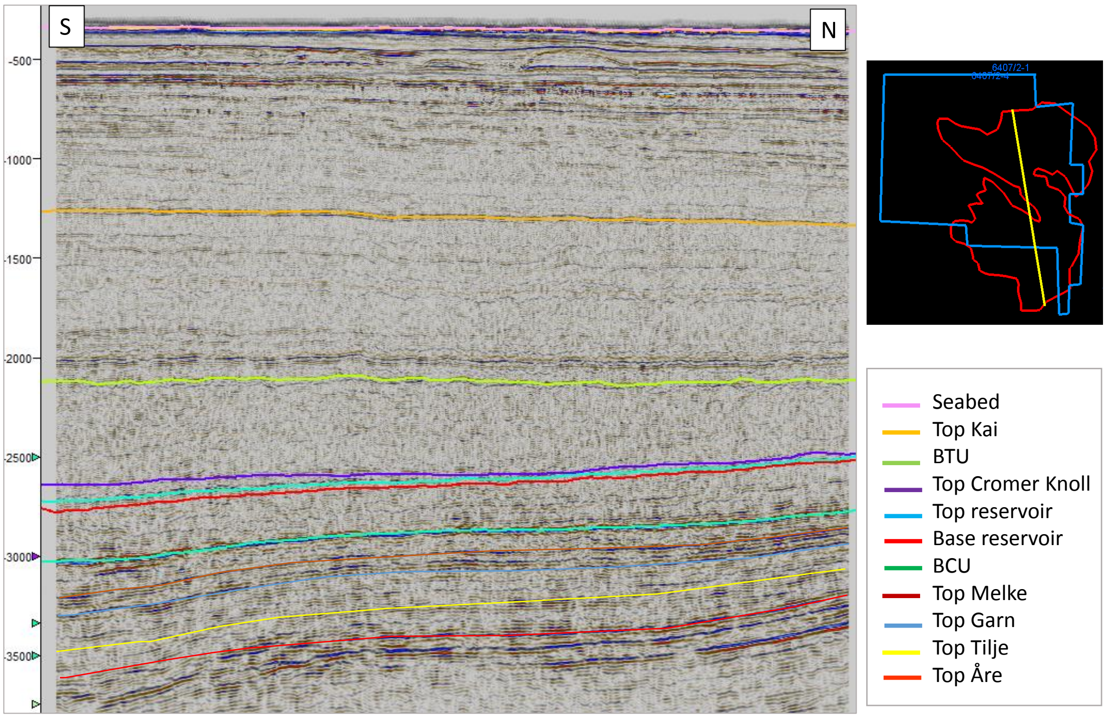


Fig. 3.4 Seismic line showing key surfaces in time

The PL 754 Aurora prospect consists of structural and stratigraphical trapped Cretaceous Intra Lange sandstones. A top reservoir map (in depth) of the Aurora prospect is shown in Fig. 3.5.

The observations made in the seismic data suggests that the prospect might be characterized by an intermediate situation between a mixed sand-mud fan, due to lobal shape, and a sand rich fan, due to an overall dimension of 10's of km (Fig. 3.6).

MD99 reprocessing

As part of the work program 3D survey MD99 reprocessed over the PL754 license area. The main objectives of the reprocessing were: i) Improve structural imaging at prospect target levels, and ii) Preserve amplitudes for reservoir characterization. The MD99 survey acquired by WesternGeco in 1999 using six cables with 4800m offset. The final image area for reprocessing was 142.5 sqkm. A larger input data used in reprocessing to provide migration aperture for the license area. Since the 3D survey didn't extend over the relevant wells in the area, a long offset 2D line (MNR05-7203) with 50km length included in the reprocessing project to tie the well 6407/1-6S (Rodriguez) to the Aurora prospect in the license area. Fig. 2.1 shows the outline of the MD99 reprocessed volume as well as all other seismic datasets that used in the evaluation of the PL754 license. The main stages of the reprocessing which started from field data

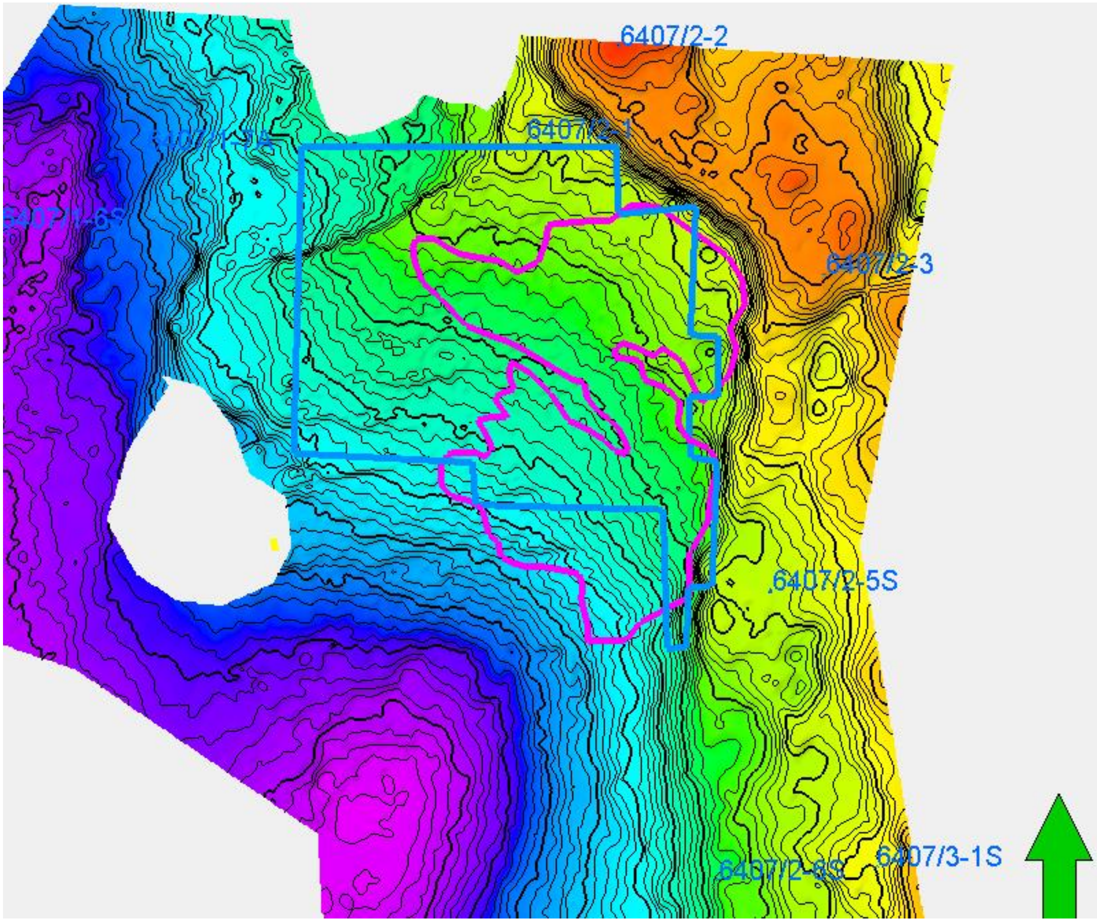


Fig. 3.5 Top reservoir depth map

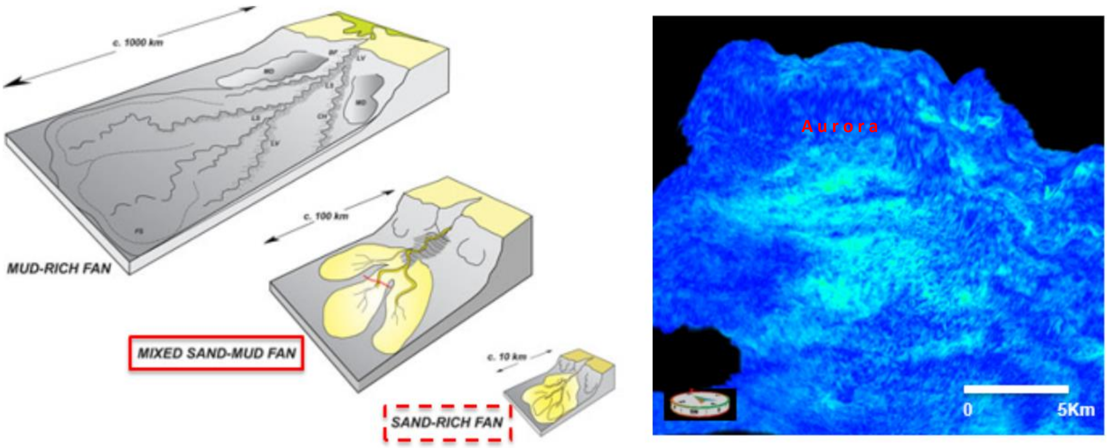


Fig. 3.6 Deep marine fans. *Deep marine fans' response at different grain sizes*

included noise removal, extensive multiple elimination processes, detailed geologically constrained velocity model building, and prestack time migration. Noise reduction processes applied in different stages on shot gathers, CMPs, pre-migration, and also post migration. Five stages of demultiple processes applied with four pre-migration and one after migration. The processes included standard demultiples such as tau-P applications as well as advanced applications such as 3D GSMP (Generalized Surface Multiple Predictions). Noise reduction and demultiple processes were the main pre-migration differences with the original processing of the data which improved considerably the data quality. Fig. 3.7 shows an example from original processing and reprocessed data at target and overburden level.

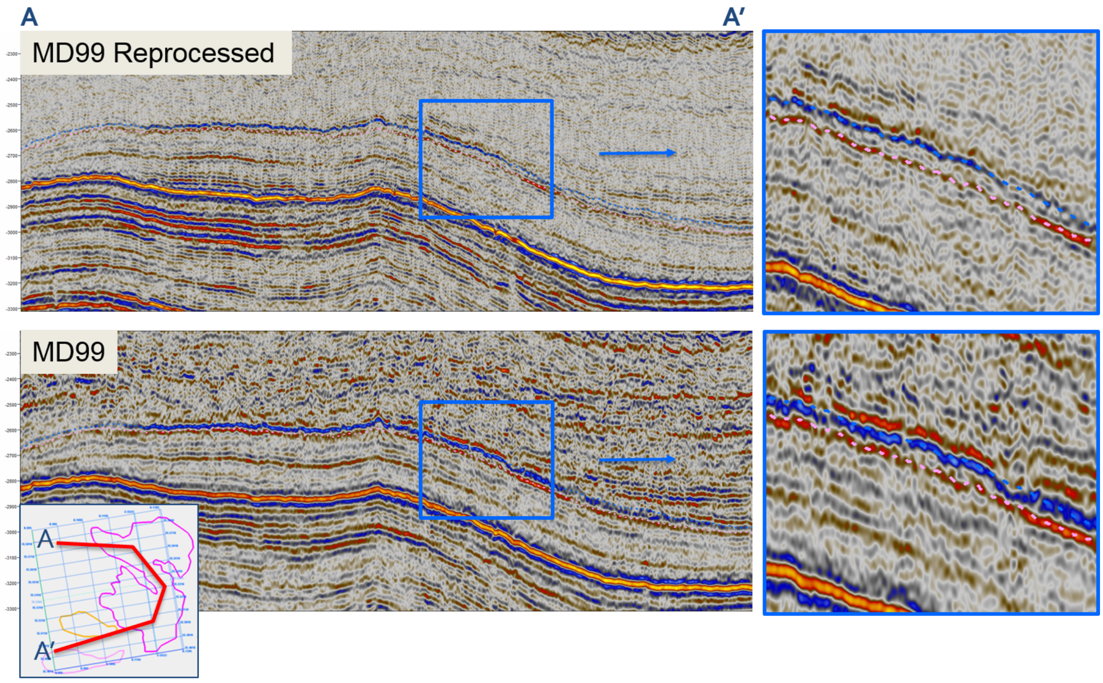


Fig. 3.7 Reprocessed data example. *Composite line crossing the Aurora prospect before and after reprocessing. The data quality at the target interval improved and noise content of the overburden reduced.*

Well-to-seismic tie

All the wells in the nearby area that have shown sand in the target interval have been tied. This includes wells 6407/1-3, 6407/1-6S (Rodriguez), 6407/1-7 (Solberg), 6407/5-1 and 6407/5-2S (Chamonix). The interface representing top Aurora is interpreted on a hard reflector, which corresponds to bright anomalies in the Aurora prospect and at different well positions. There is a discrepancy between these interpreted amplitude anomalies and the drilled sand in this play.

Depth conversion

A conventional layered velocity model consisting of seven layers, bounded by structural seismic interpretation surfaces has been applied. Each layer is filled with velocities extracted from well data, interpolated between wells. In one of the layers linear regression method is used, to honour the strong velocity-depth dependency observed for this layer. Hence, for this layer, rather than interpolation between the wells, a velocity prediction based on depth is applied. Eleven wells in the nearby area are applied for the model, all of them quality controlled, and several tied to seismic data. The velocity model is tied to several wells in the area and calibrated with seismic processing derived velocities which increase the reliablity of the depth conversion in and around the prospect.

Petrophysical work

A multi-well petrophysical study has been completed on key wells in and around the Aurora prospect (Fig. 2.2). The key wells that have been evaluated are 6407/1-3, 6407/1-6S (Rodriguez), 6407/1-7 (Solberg), 6407/5-1 and 6407/5-2S (Chamonix). Additional understanding has been gained through evaluation of wells 6506/12-5 and 6605/8-1 (Stetind) and 6605/8-2. The petrophysical workflow included a thorough examination of log data with corrections applied where necessary. The key data computed in each well are volume of shale (Vsh), effective and total porosity (Phie and Phit), water saturation (Swe) and also permeability where core plug data was available. From the computed curves a number of reservoir parameters were generated including Gross reservoir, Net reservoir, average porosity (Phie) and average permeability (core plug dependent).

In order to gain a more advanced understanding of the likely porosity and permeability at the Aurora prospect reservoir depth a number of depth trends have been created with associated ranges. The depth trends have been identified by plotting core plug porosity and permeability versus true vertical depth and a best fit applied. Where core plug data is not available but the well deemed significant to understanding the computed total porosity has been included on the plots.

Formation pressure measurement data has also been evaluated to identify the likely pressures expected at the Aurora prospect. With the exception of the Intra Lange sandstones present in the 6407/1-6S (Rodriguez) well which were found to be overpressure, the regional pressure is normal.

Rock physics and AVO modelling

Rock physics study and AVO modelling has been performed for the five key wells in the area (Fig. 2.1 and Fig. 2.2). Three of these have measured shear logs, and fluid substitution has been performed for 6407/1-7 (Solberg) and 6407/1-6S (Rodriguez). Solberg has good reservoir quality sand, and Rodriguez has good reservoir quality sand, but low net-to-gross, with three sand stringers adding up to 9m thickness in total. In the Intra Lange reservoir interval in 6407/5-2S (Chamonix) and 6407/1-3, the sand has very low porosity, while in 6407/5-1 consists of a very shaly sand interval.

The result of fluid substitution and AVO modelling for Solberg and Rodriguez is shown in Fig. 3.8. The Gas responce in the well 6407/1-7S (Solberg) correspond to a weak class III, while for water the near offset responce is positive amplitude which change to negative with offset. In the well 6407/1-6S (Rodriguez) there is no observable fluid response, and very low AVO gradients. While, top sand is soft in these two wells (full stack response), the responce in the wells with poor quality sand (6407/5-1, 6407/5-2S, and 6407/1-3) is hard.Average blocky modeling of Intra Lange sand AVO responses from the five wells around PL754 license (Fig. 3.9)shows that the HC bearing sands have soft response with some gradient while in the wells with poor quality sands the near offset response is hard which dims with offset.

Prestack data conditioning and qualitative AVO analysis

Available prestack data for the licence is showed in (Fig. 2.1) and includes a reprocessed 3D cube covering Aurora (but no wells), and the 2D long offset MNR line MNR05-7203 (Fig. 2.1) located approximately at Rodriguez well position. In order to optimize the data before a qualitative AVO study, different post migration processing steps were performed to condition the datasets. This reduced the noise content, improved the coherency of the data and flattened the gathers at the target interval (Fig. 3.10). Intercept and gradient volums were also created a subset of the 3D PSTM gather volume. The main Aurora interpretation is bright hard in near traces and amplitude decreases with angle. Soft reponses above and below the hard main Aurora interpretation are also seen as bright in near traces and have decreasing amplitude with offset. The observed Aurora response is compared to modelled AVO responses for nearby wells in Fig. 3.9. As 3D gather dataset does not cover any of the wells studied, only a qualitative AVO analysis could be performed. No similar response as that modelled for Solberg is seen for any of the reflectors near main Aurora interpretation in Aurora prospect.

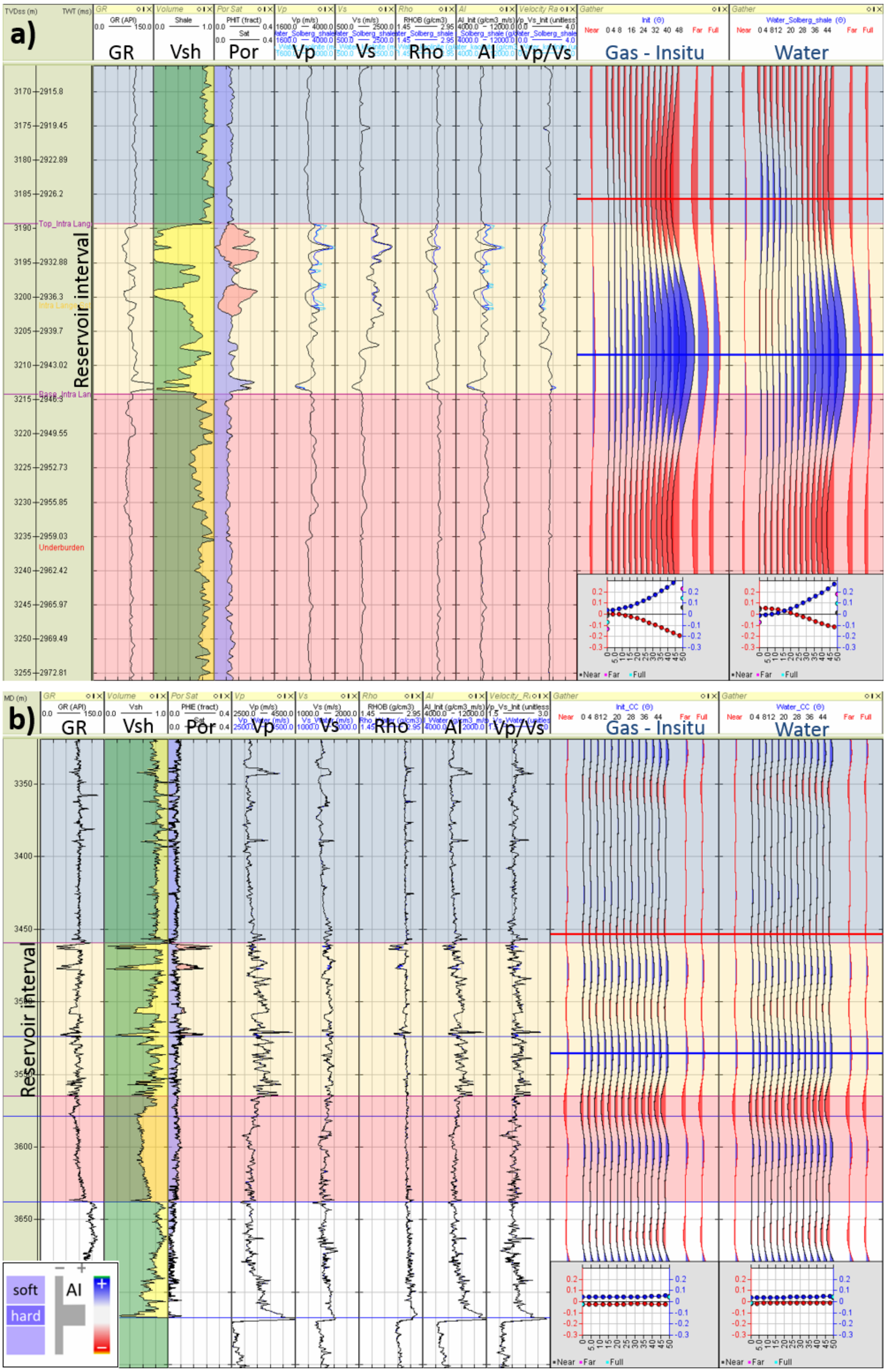


Fig. 3.8 Fluid substitution and modelled AVO responses for Solberg and Rodriguez. *Fluid substituted logs, and AVO modelling results for a) Solberg and b) Rodriguez wells. Black curves are insitu logs, blue are water substituted.*

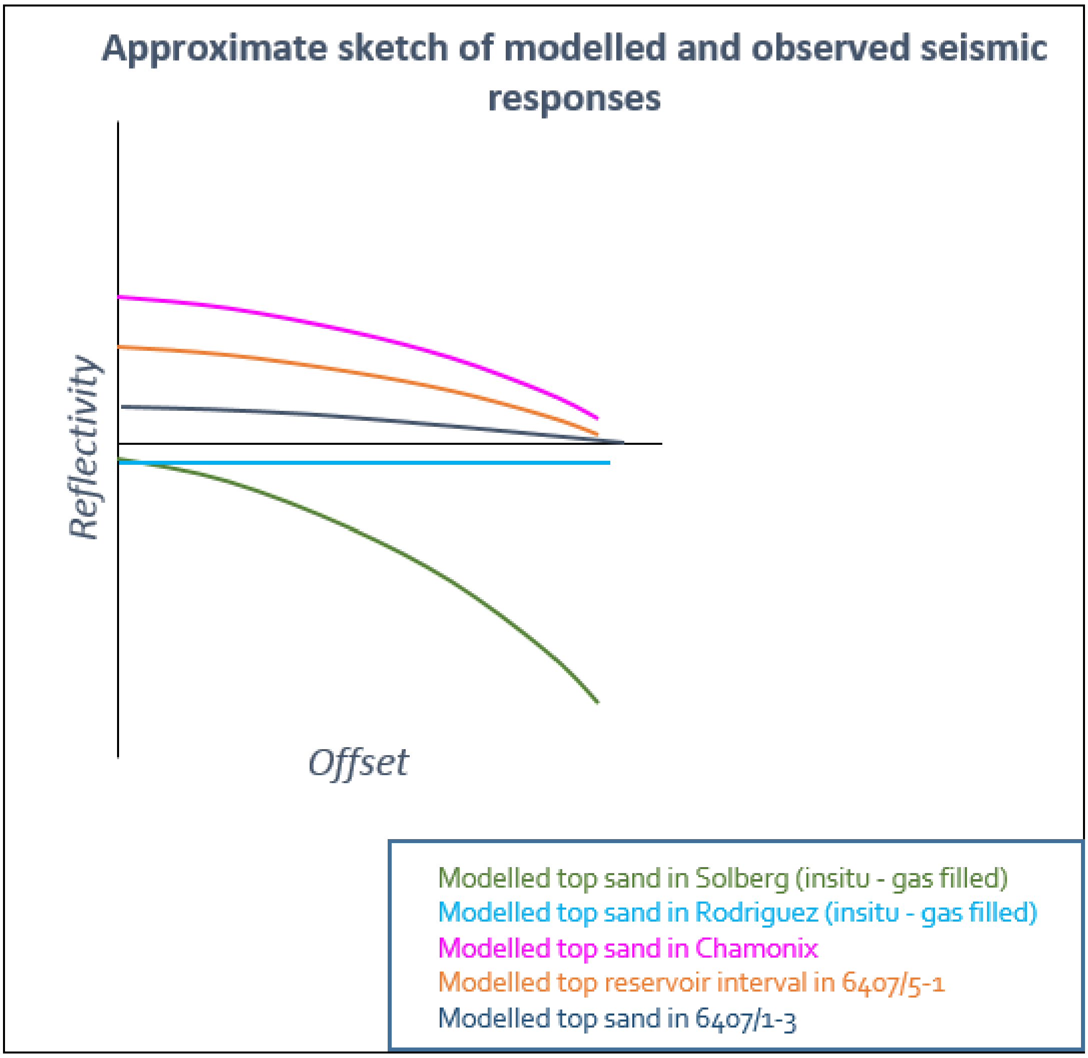


Fig. 3.9 Sketch of modelled and observed AVO responses. *Average blocky modeling of Intra Lange sand AVO responses from the five wells around PL754 license. The HC bearing sands have soft response with some gradient while in the wells with poor quality sands the near offset response is hard which dims with offset.*

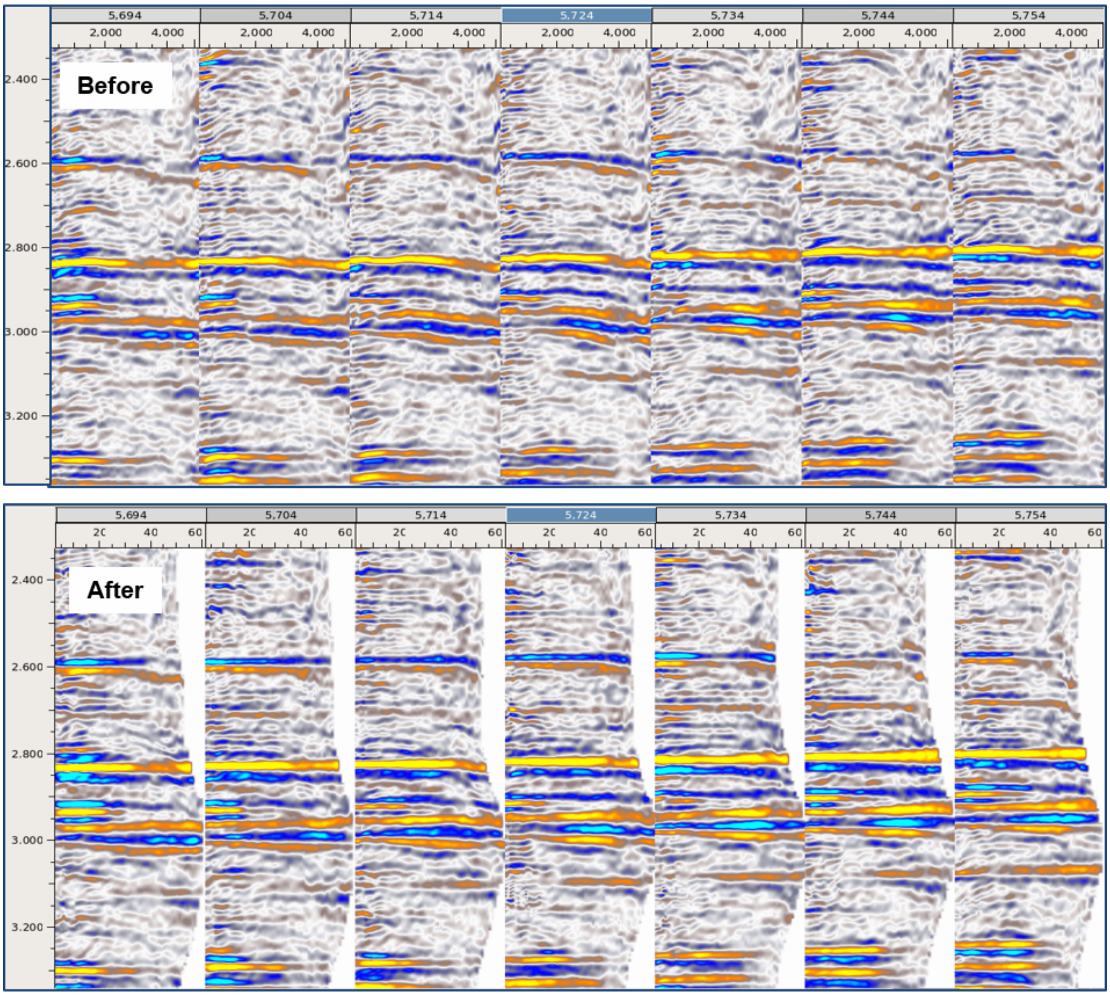


Fig. 3.10 Examples of PSTM gather conditioning. *PSTM gathers before and after post migration data processing (demultiple, noise reduction, and gather flattening).*

Special studies

- Regional and prospect scale integrated sedimentology of reservoir (including seismic attribute analysis)
- Quantitative evaluation of the Jurassic erosional product in the nearby area
- Semi-regional biostratigraphic and sediments provenance studies
- Fault seal analysis
- Source and migration study
- Rock Physics and AVO forward modelling study
- PSTM gather conditioning and qualitative AVO analysis

4 Prospect update

Prospectivity applied for: PL754 is located approximately 5 km from the Midgard Field in the Gimsan Basin at the Halten Terrace. The license was awarded in February 2014, based on an application related to APA 2013. The application focused on a Cretaceous prospect named Aurora.

The Aurora prospect is an unfaulted, combined structural-stratigraphic closure. The prospect area is 73 km^2 and the average reservoir thickness is 40 m. The reservoir within the trap is deposited as slope-to basin-floor turbidite fans in an under-filled, rifted basin of Jurassic origin. The closure is bound towards the east by the Bremstein Fault Complex (BFC) and pinches out towards the north, west and south. BCU structure map illustrates the Gimsan basin and the location of the Aurora prospect (Fig. 3.5).

The main source rock for the Aurora prospect is the Upper Jurassic Spekk Fm, secondary source rocks are the Middle-Upper Jurassic Melke Fm and Lower Jurassic Åre Fm. The Aurora prospect drains a large hydrocarbon kitchen area in the northern Gimsan Basin. A charge model, created for the application, involves vertical migration from the upper parts of the Spekk Fm through micro-fractures. The fracturing process may have been associated by rapid over-pressure build-up in the shales during the Plio-/Pleistocene burial. The Åre Fm is modelled to generate gas leaking up major faults along the margin of the basin (BFC).

The total probability of success was estimated to 14%. The key risk factor for the prospect is the reservoir as there is no direct well-tie to prove its presence and quality. The seismic AVO data is complex and show an AVO response gradually changing from class I to class IIp. The seismic post-DHI chance of success was therefore not calculated for the Aurora prospect.

The proposed work program in the application was focusing on the main risks (reservoir quality and presence). This included to aquire long offset seismic data (MD99).

Prospect update: The technical work performed in PL754 in the period from the license award until today has been described in the chapter 3 Review of geological framework. The volume estimates and risk assessment from this work are described in Section 4.3. Prospect volumes and 4.4 Prospect probabilities, respectively.

The reprocessing of the seismic cube MD99 has resulted in higher resolution and improved understanding of the Aurora prospect compared to the previous interpretation that was based on older 3D seismic data. Higher confidence in the reservoir thickness interpretation is given, even though the top reservoir reflector is weak and discontinuous in some areas. The new interpretation and depth conversion indicated a possible separation between the basin fan sands within the prospect polygon resulting in reduced hydrocarbon volumes. The results from the wells in the nearby license PL475 showing smaller gas discoveries led to a shift in phase from and oil/gas phase to a pure gas case.

The technical evaluation for PL754 have concluded that the volume potential of Aurora is too small to be regarded as commercial. From these conclusions, the management Committee does not recommend to drill a well in PL754.

Prospect volumes

The base mean case hydrocarbon recoverable resources from the APA 2013 application within the Lange Fm reservoir level was 20,3 MSm^3 and 1,80 GSm^3 gas.

Based on the work described in the chapter 3 Review of geological framework, updated volumes have been calculated (Table 4.1). Parameters used in the volume calculation are listed in Table 4.2.

Table 4.1 Prospect volumes (most likely)

Reservoir level	Updated Most likely volumes		APA 2013	
Lange Fm	Gas in place (GSm^3)	Recoverables (GSm^3)	HC in place (GSm^3)	Recoverables (GSm^3)
	15,50	10,90	Oil: 50,70 Gas: 2,60	Oil: 20,3 Gas: 1,80

Table 4.2 Input parameters (most likely)

Input parameters	Lange Fm (most likely)
Reservoir thickness	30
NTG	40
Porosity	20
Sg	70
1/Bg	270
Recovery factor	65

Prospect probabilities

Based on the work performed as described in the chapter 3 Review of geological framework the following risk assessments have been calculated (Table 4.3).

Aurora prospect

Trap structure and seal (72%).
Combined structural and stratigraphic trap defined on 3D seismic data. Main risk is leakage through eastern fault (BFC).

Reservoir presence and quality (40%)

Table 4.3 Prospect risk

Risk elements		Risk factors	
Trap	Structure (geometry) Seal Effectiveness)	90% 80%	72%
Reservoir	Presence Quality	80% 50%	40%
Charge	Source Migration	100% 70%	70%
Retention	-	100%	
Total		20%	

Improved seismic data supports the likelihood of reservoir presence. Main issue is thickness, NG and quality. The current model have 6-25m net sand probably interbedded over 20-40m, in a widespread sheetlike fan. The main uncertainty is whether the sands are clean "Solberg" sands (PL475) or immature cemented "Chamonix" sands or thin laminated "Rodrigues" sst. Seismic response indicate that this is different from the Solberg, thus hard and likely to have poorer quality.

Source and migration (70%)
Spekk- and Melke Fms present and mature in the Gimsan basin. Large fan is likely to capture vertical migration, but no obvious conduits. Mostly rich gas is proven in the area. Oil seems to be unlikely.

Retention (100%)
No late movement or major leakage seen. Very low risk.

Total risk: Pg: 20%

5 Evaluations and conclusions

Technical evaluations

A technical and economic evaluation of the Aurora prospect has been done. The closest existing infrastructure is Åsgard A (42 km), with a subsea tie-back concept.

The conclusion for any volumetric case (max or most likely), is that the Aurora development is a project with marginal economics. There are several "stranded" gas and oil discoveries in the area resulting in a limited capacity for tie-backs. Currently, there is also limited capacity at Åsgard A.

Conclusion

Based on results from the studies conducted during the first initial phase of the work program as described in this report, the Management Committee concluded that there are no commercial accumulations of hydrocarbons within PL754. Consequently, the partnership recommended to relinquish the license. The recommendation of the relinquishment and work obligations was signed by the partnership the 29th of April 2015. The approval of the relinquishment from the Ministry of Petroleum and Energy was received on the 8th of June 2015.

6 Appendix A

Enclosure 1

Stratigraphic Summary Chart, Well 6407/1-6S

Field : PL475
Location : NOCS
Range (MD) : 2990.00m - 4275.00m
Scale : 1:1000