wintershall dea

RELINQUISHMENT REPORT
PL 768/ 768B

concedo

OMV

equinor

petoro

Table of Contents

List of Figures

List of Tables

1 Key License History

eProduction License 768 was awarded in APA 2013 to Wintershall Norway as operator (30%), Concedo ASA (25%), OMV AS (25%) and Petoro AS (20%) and became effective on 07.02.2014. The license was located in blocks 7123/5, 7123/6, 7123/7, 7123/8, 7123/9, 7124/4, 7124/7, 7124/8 with the total area of 1047,1 km^2. The decision to drill an exploration well was scheduled for 07.02.2018.

The initial work commitment included acquisition of 2D seismic and the execution of G&G studies. An extensive G&G work program was planned and performed for PL 786 license to define and evaluate prospectivity in the Permian play, and to assess all the associated risk elements. The application for the area was based on the Andotten prospect of Permian age of which the crestal part largely extended to the west within held acreage at that time.

WIN14002 2D broadband seismic survey was acquired by CGG in July 2014 and final processed data delivered in May 2015.

In 2016 an area extension was granted as part of the APA 2015. The area extension contained the western part of the Andotten prospect area. The new production licence 768 B covering blocks 7122/8 and 7122/9 shared the same terms and commitments as PL768. The location map of the prospect and licensed area is shown in Fig. 1.1. In order to allow time to interpret all available seismic data and to re-evaluate the prospectivity, a one year extension was granted in February 2016. The new BoK was scheduled for 07.02.2019. After completion of seismic interpretation, in-house 2D seismic inversion, fault seal analysis and basin modelling it was concluded that risk related to the prospect trap effectiveness and charge elements remained high.

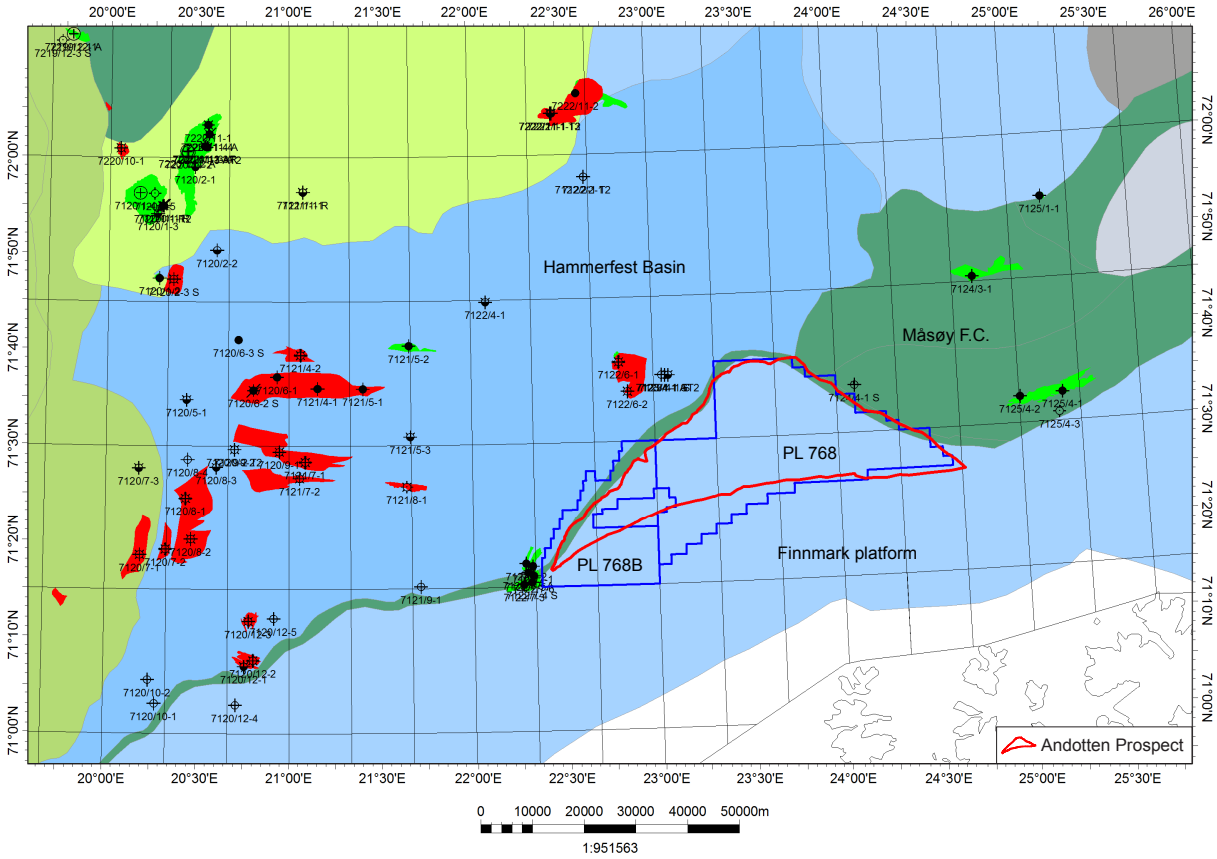

Fig. 1.1 Regional Province map

In order to mitigate the prospect risk further the decision to acquire 3D seismic data was taken by the license group in February 2017. In preparation of the planned seismic acquisition, an

in-house seismic survey design study was carried out with focus on parameter optimization for seismic imaging at target level. WIN17002 3D broadband seismic survey of 965 km^2 was acquired in September 2017 and final PSDM processed data was delivered by CGG in October 2018. Due to a three-month delay in delivery of final processed seismic data , additional time extension of the Drill and Drop (DoD) decision was requested for in order to perform full scope of the G&G work planned including a seismic elastic inversion study. An extension of 7 months was granted for PL 768/768 B license area in November 2018 and the new BoK was scheduled for 05.11.2019.

In December 2018 Equinor Energy ASA finalized farm-in to PL 768/768B licenses for 15% equity share taken over from Concedo ASA.

The Andotten prospect trapping mechanism combines a structural component (lateral closure to the west and east by regional TFFZ fault complex) and a stratigraphic part (pinch-out of Ørret Fm sandstones against the Røye Fm platform to the south). Using 7120/12-4 an 7120/12-2 wells as analogues, the Tempelfjorden Gp siliciclastic section is considered a good reservoir with relatively high porosity and high permeability. The Andotten prospect is assumed to be charged from the kitchen in the Hammerfest basin towards the west, where the organic-rich shales of Kobbe Fm are regionally present. Another possible charge scenario assumes vertical migration from underlying coal rich sequences of Tettegras Fm proven in 7128/4-1 and 6-1 wells. However, due to limited well control, Carboniferous source rock potential on Andotten block remains uncertain.

2 Database

This chapter describes the databases that have been used to evaluate the greater PL 768/768 B area.

2.1 Seismic data

The common seismic database of the PL 768 license consisted originally mainly of 2D and limited 3D seismic data. WIN14002 2D seismic survey of 1013 km was planned and acquired as an infill dataset to the pre-existing good quality BSSO1 seismic survey as part of the obligated work programme (Fig. 2.1). The WIN14002 seismic survey was acquired with a broadband source and receiver to extend seismic frequency spectra. Improved data quality and increased seismic resolution allowed for the interpretation of subtle stratigraphic sequences and internal structuring within the Andotten prospect. The second license commitment was completed by acquisition of WIN17001 3D broadband seismic survey extending into the most critical part of the PL768/768 B area in the west for the Andotten prospect evaluation. The WIN17001 together with the pre-existing 3D surveys are shown in Fig. 2.2

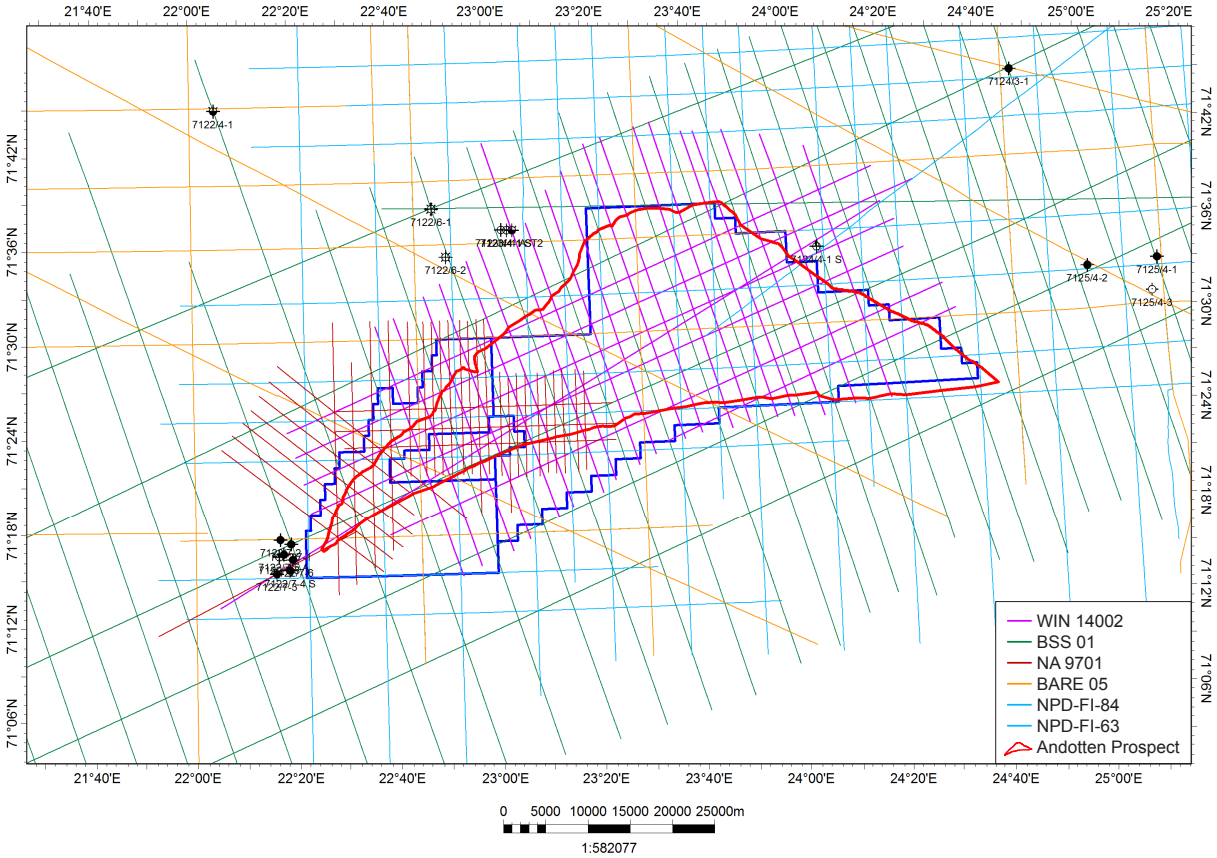

Fig. 2.1 2D seismic database

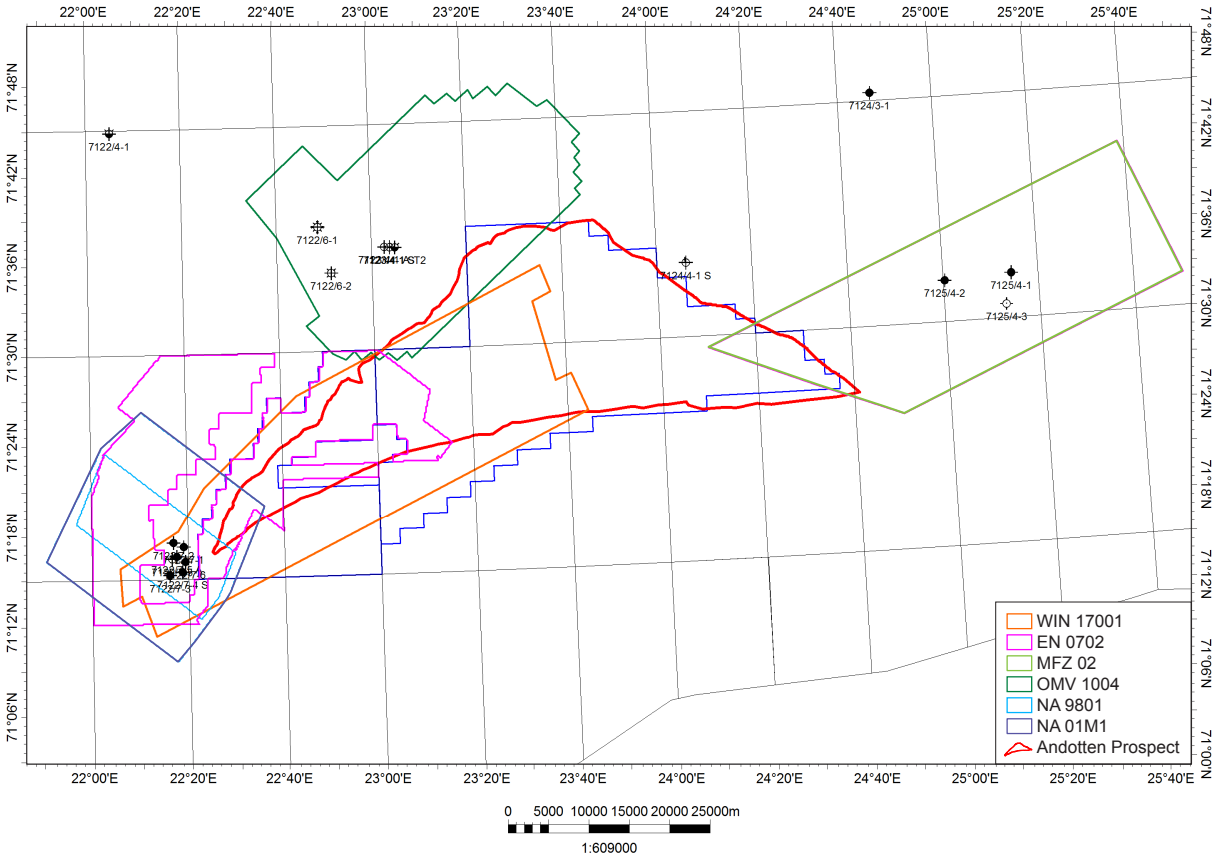

Fig. 2.2 3D seismic database

2.2 Well data

The well database includes 7 wells penetrating the Ørret Fm in the Hammerfest Basin and Finnmark Platform. These wells have wireline log data and compose the CPI database for PL 768/768B licenses. In addition, wells in the vicinity that have encountered hydrocarbons in Early and Middle Triassic age formations are key for understanding the petroleum system. Wells included in the well database are listed in Tab.2.1.

Table 2.1 Well database

Key wells	Other wells
7120/1-1	7120/9-2
7120/12-2	7120/12-1
7120/12-4	7122/6-2
7122/7-3	7125/1-1
7124/3-1	7125/4-1
	7222/11-1
	7226/11-1

3 Geological and Geophysical Studies

Basin Modelling

The objective of the in-house basin analysis was to evaluate the source rock potential for hydrocarbon migration and charge into the Andotten prospect. The Triassic Steinkobbe Fm shales are considered as the main source rock for the prospect. They would provide the lighter petroleum compounds confirmed by oil-prone facies in the Goliat field. The Total Organic Carbon (TOC) and Hydrogen Index (HI) measured in cuttings and core material reflect the present day potential. Based on maturity, the original source rock richness and quality for both Steinkobbe and Hekkingen Fm have been back calculated to initial TOC values. The Steinkobbe Fm of Anisian/Ladinian age is a good source rock for both oil and gas generation. The initial TOC and HI for the Steinkobbe Fm is about 3% and 300 mg HC/g TOC, respectively in the kitchen area to the west and south west from Andotten Prospect. The gross thickness of the Triassic source rocks are estimated to 200 m. Most of the petroleum has migrated from the mature area in the Hammerfest Basin at Kobbe Fm level southward against the Goliat Field, up against the TFFZ bounding fault and into the Andotten Prospect. The total amount expelled in the drainage area is in the order of $8 \bullet 10^9$ Sm3, and the migration into Goliat field and Andotten prospect is estimated at $2{,}9 \bullet 10^9$ Sm3 oil and 524 bcm gas, when a migration loss of $4 \cdot 10^6$m3 boe/km^2 is accounted for in the petroleum system basin modelling.

An alternative HC migration and charge model was evaluated that assumed the presence of local source rocks in Carboniferous coal rich sediments of Tettegras Fm. The local source rocks interpreted to be possibly present in the eastern part of Andotten block in the half graben infill setting are mainly in the mid to late oil maturity window at present day according to basin modelling study. Due to the burial history, erosion, uplift and isostacy, the source rocks are most likely not expelling petroleum present day. Based on the geochemical analyses of the Carboniferous source rocks in the two wells 7128/4-1 and 6-1 the initial Hydrogen Index have been around 300 mg/g TOC and TOC of 70%, which will expel both gas and oil. The total amount expelled is in order of $1{,}5 \bullet 10^9$ Sm3, and the migration into Andotten prospect is estimated at $1{,}2 \bullet 10^9$ Sm3 oil and 433 bcm gas.

The basing modelling gave a good overview about the potential of the two different charge mechanisms.

Integrated Structural Analysis

The study was performed internally in Wintershall and included:

- 2D kinematic restoration to better understand structural evolution through time
- Charge history of the prospect
- Fault geometry evaluation using displacement profile
- Assessing seal integrity and estimation of maximum column hight that can be hold by the bounding faults.
- Present-day fault stability analysis to access the potential leakage along fault dip

Well 7120/12-4 was used to build Vclay model for fault seal analysis. As a result a positive sealing potential of the most western fault zone was identified, due to the high fault throw (>1000 m) and the high Shale Gauge Ratio along the fault. Eastern part of the bounding fault is likely to hold smaller column due to smaller fault throw. However, for the Lower Ørret Fm reservoir it was concluded that the fault can hold an oil column of 200 m. Andotten prospect bounding faults are not critically stressed at present day.

A Regional Sequence stratigraphy and depositional model study

Well correlation and mapping of facies distribution has been carried out by Wintershall internally, with the objective to understand the greater context and connection between the proximal deltaic and shelfal facies to the distal basin floor fan setting. Well correlation and resulting

sequence stratigraphy concept for the Ørret Fm is shown in Fig. 3.1. The Lower Ørret coarsening upward succession is interpreted as a prograding lobe complex with channelized axial facies near the top. By-passed slope muds onlap the platform and pinch out up-dip. The basin floor deposits are then overridden by the late lowstand shelf edge delta of the Upper Ørret clinoform set. However, no core was cut in the Lower Ørret (wedge 1a) and its interpretation as detached gravity flow deposits is therefore uncertain.

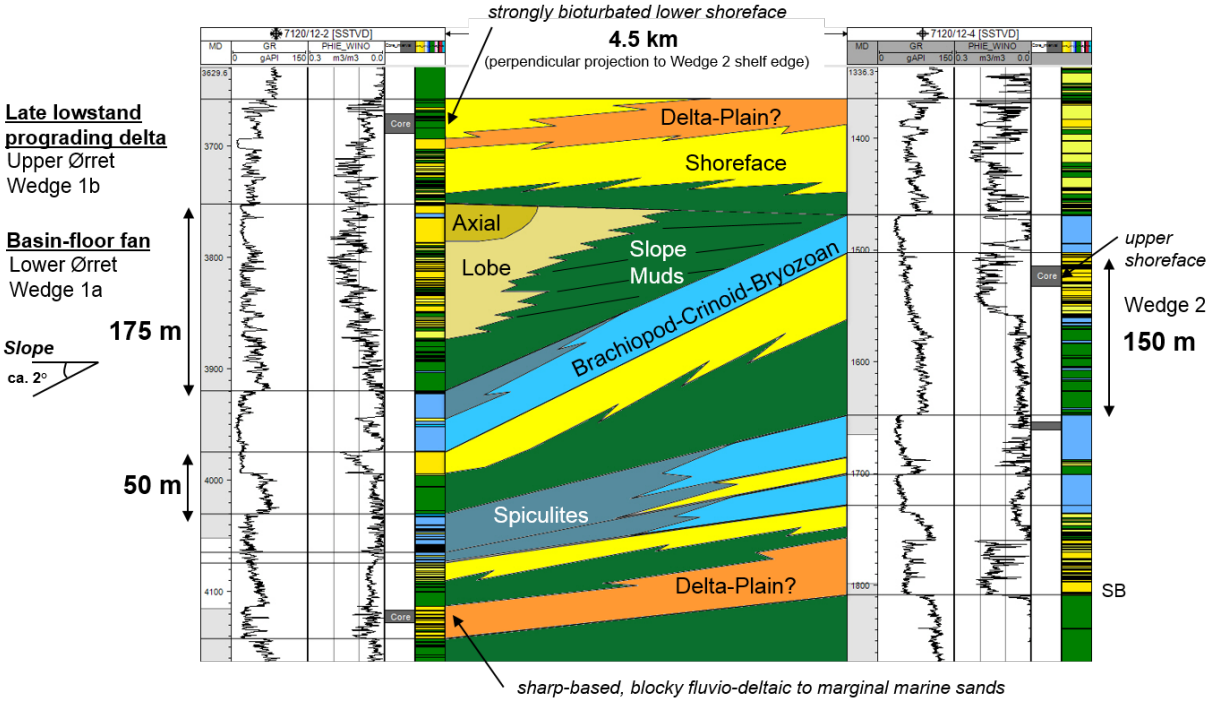

Fig. 3.1 Well correlation and sequence stratigraphy framework for wells 7120/12-2 and 7120/12-4

Log Based Seismic Modelling

The study focused on the Ørret Fm interval. Well 7120/12-4 was the only good analogue for modeling as it shared similar burial history to the Andotten prospect. However, the well has not drilled wedge 1a facies and shear log was not acquired which added to modelling uncertainty. The objective was to examine seismic amplitude sensitivity on hydrocarbon saturation and impedance anomaly, that was detected on 2D seismic data. This anomaly appears as a low acoustic impedance in the inverted acoustic impedance data.

The study concluded that the Ørret Fm sandstone intervals are characterized by very weak sensitivity to pore fluid types Fig. 3.2. According to the fluid substitution synthetic seismic modeling only in gas case amplitudes change would be detectable, provided high signal-to-noise ratio seismic data is used.

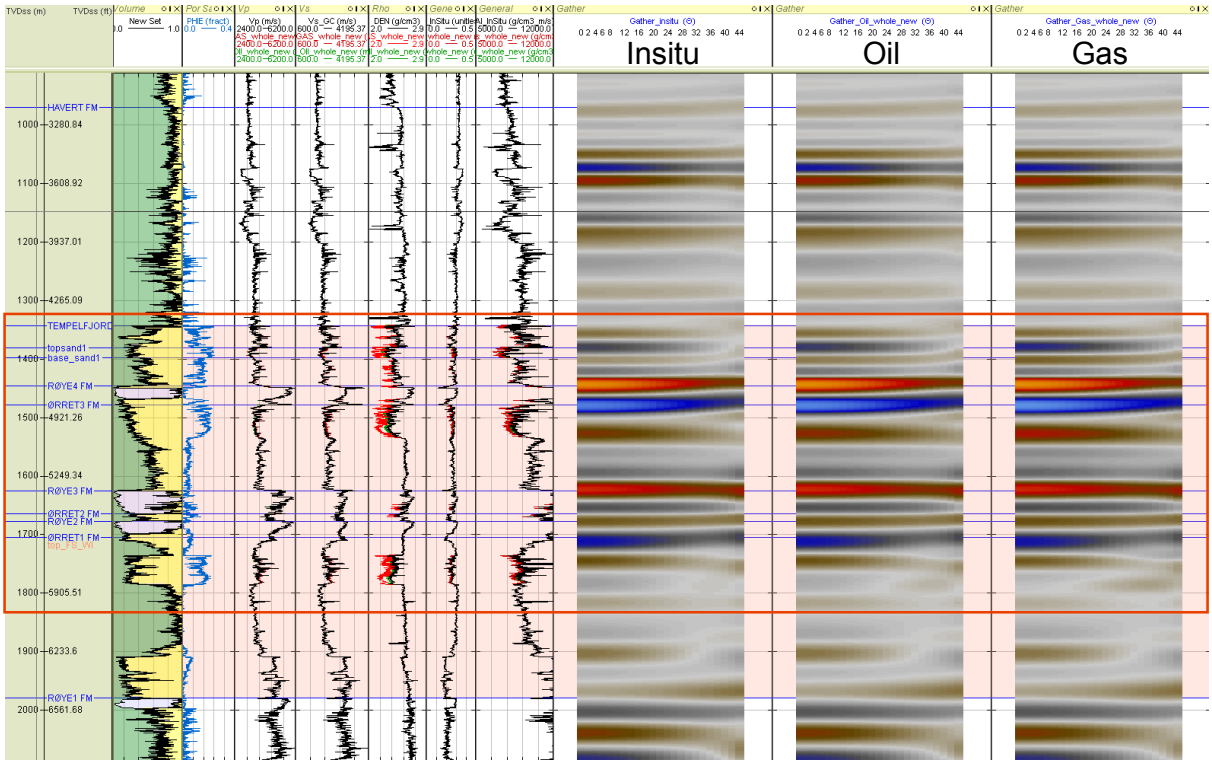

Fig. 3.2 Well 7120/12-4. Fluid substitution modelling

According to the modelling oil is not detectable by the seismic whereas very week sensitivity to gas saturation is observed at the near offset synthetic data.

2D AVO Analysis and seismic inversion

A reconnaissance AVO study was performed on AVO processed gathers, that included analysis of various attributes (e.g. AVO product, Fluid Factor). Within lower Ørret wedge no positive AVO anomaly was detected. AVO anomaly class IV was identified within the upper wedge located entirely within PL 229D/E licences.

A full stack acoustic impedance inversion was also performed on a number of WIN14002 2D seismic lines. Assuming a shaly background geology, low porosity sands would be imaged as an impedance decrease. A low acoustic impedance zone was identified updip lower Ørret wedge (Fig. 3.3). However, the crestal and thickest part of the wedge which is seen on the seismic data as weak reflectivity zone was not displaying as being anomalous on inverted data. An interpretation of this iso-impedance zone would be either pure shale, or high N/G sand sequence deposited at a high rate with very thin shale layers creating no acoustic contrasts. To increase the chance for a better discrimination between sand and background lithology and together with fluid effects, an elastic impedance inversion was planned to be carried out.

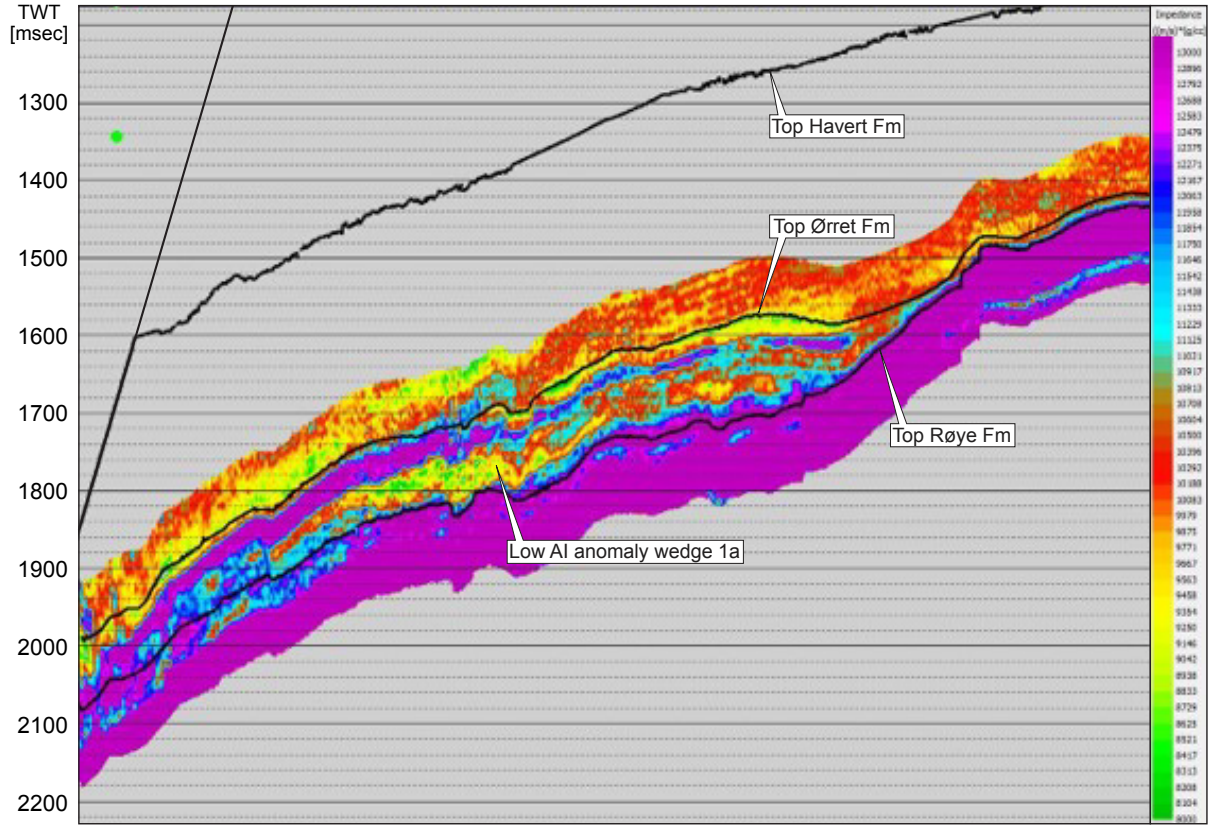

Fig. 3.3 WIN14002 - 2D line 104. Inverted acoustic impedance

Low AI anomally is indicated within Lower Ørret wedhge 1a.

Elastic Inversion

The 3D elastic inversion study was performed on final PSDM processed gathers. Resulting acoustic impedance and Vp/Vs volumes were generated and analysed. The only well that drilled through Permian within the 3D dataset was 7122/7-3 which was a major limitation for calibration of elastic parameters with lithology or fluid effects. This was due unfavourable location of the well, located much deeper in the Hammerfest Basin and with only a relatively thin section of Ørret Fm penetrated.

It was concluded, that the elastic inversion delivered meaningful results, however due to the lack of reliable well calibration and comprehensive measurements from one side and heterolithic nature of Permian lithologies and overall facies variability of reservoir and overburden , lithology differentiation based on AI-Vp/Vs cross plots from the inversion was difficult. Due to a lack of a clear depth contour conformance and rather weak Vp/Vs signal signature the variations in elastic properties were attributed to a changing and complex lithologies in upper Permian successions. Only an anomaly in upper wedge 1b mentioned earlier, was detected also as low Vp/Vs zone that also shown partial depth conformance. However due to being localised almost entirely within the PL 229D/E licences the anomaly was not part of PL 768 license prospectivity.

4 Prospect Update report

4.1 Prospect mapping

The area applied for in the APA 2013 was originally covered mainly by 2D seismic data. At the time of the application, Andotten was the only prospect identified in the area awarded as PL 768. However, the crestal and western part was located in the area to the west held by a different license group. As part of the initial licence commitment in PL 768, WIN14002 2D broadband seismic was acquired as infill to the existing datasets of various vintages and quality. The final result of the processed 2D broadband data was encouraging with respect to data quality. Extensive interpretation work was carried out regionally covering the Finnmark Platform and neighbouring areas from Hammerfest Basin to the western margins of the Nordkapp Basin and Måsøy Fault Complex. A set of regional marker horizons were interpreted on available 2D and 3D seismic and tied to offset wells (Fig. 4.1, Fig. 4.2 and Fig. 4.3). The improved seismic resolution of WIN14002 2D survey led to more detailed seismic interpretation of internal Ørret Fm sequences that were correlated to time equivalent stratigraphic boundaries found in exploration wells 7120/12-4 and 7120/12-2.

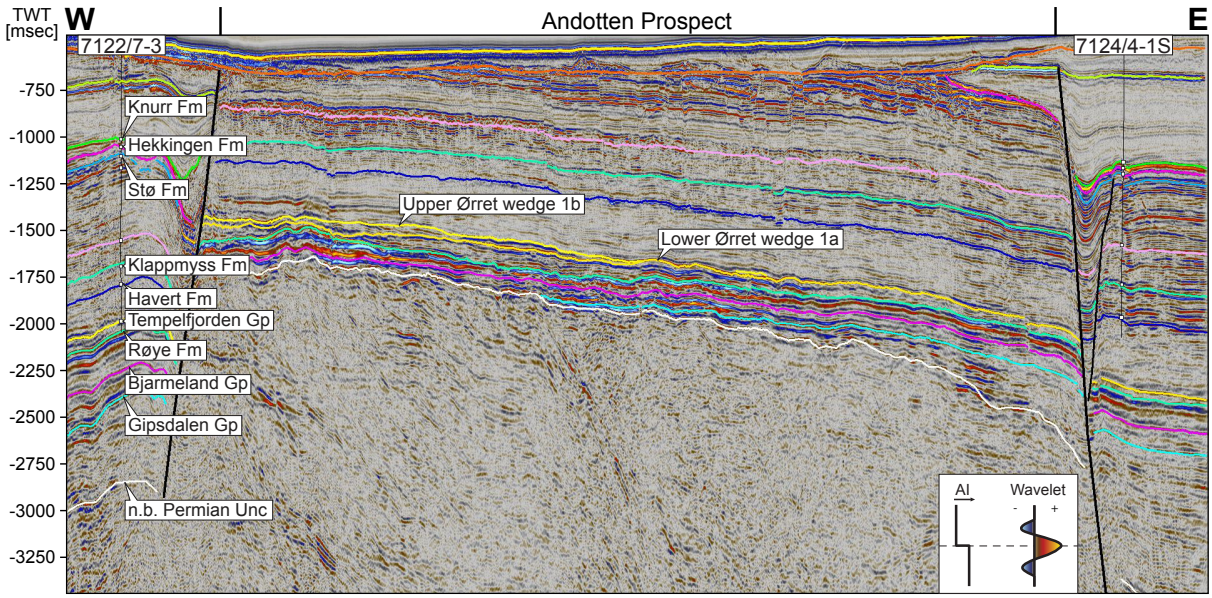

Fig. 4.1 WIN14002 2D seismic data. Line 205 transecting 7122/7-3 and 7124/1-4S
Seismic horizons interpreted

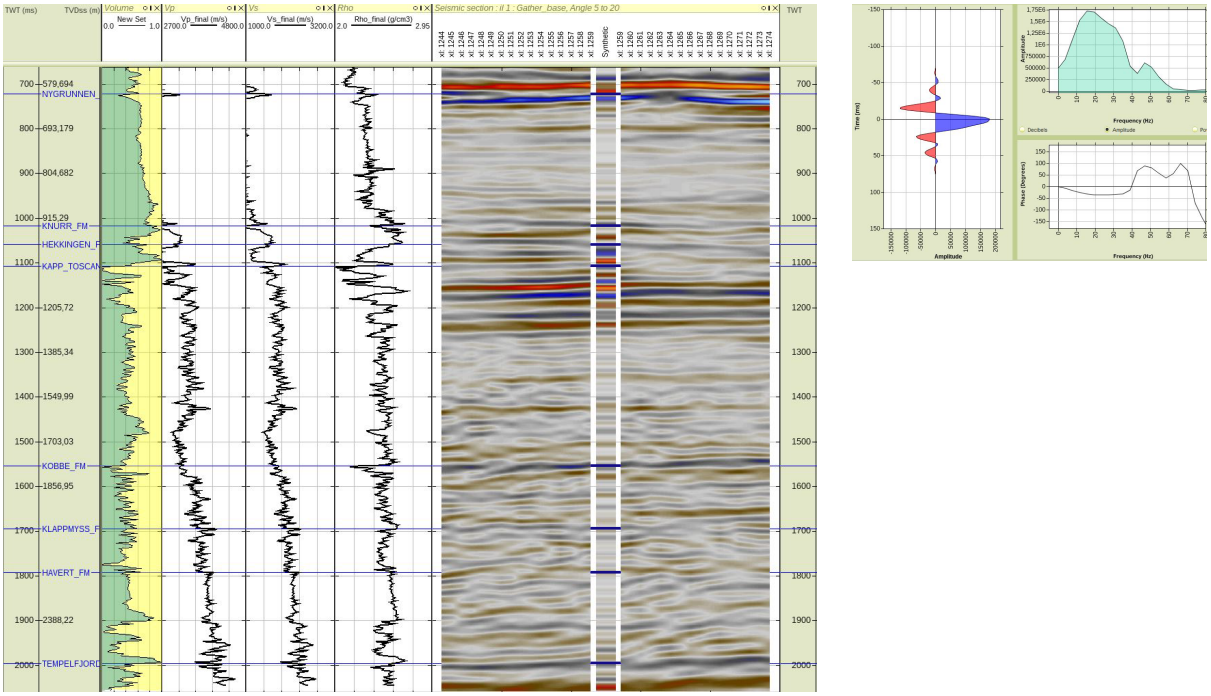

Fig. 4.2 Well 7122/7-3. Seismic to well tie

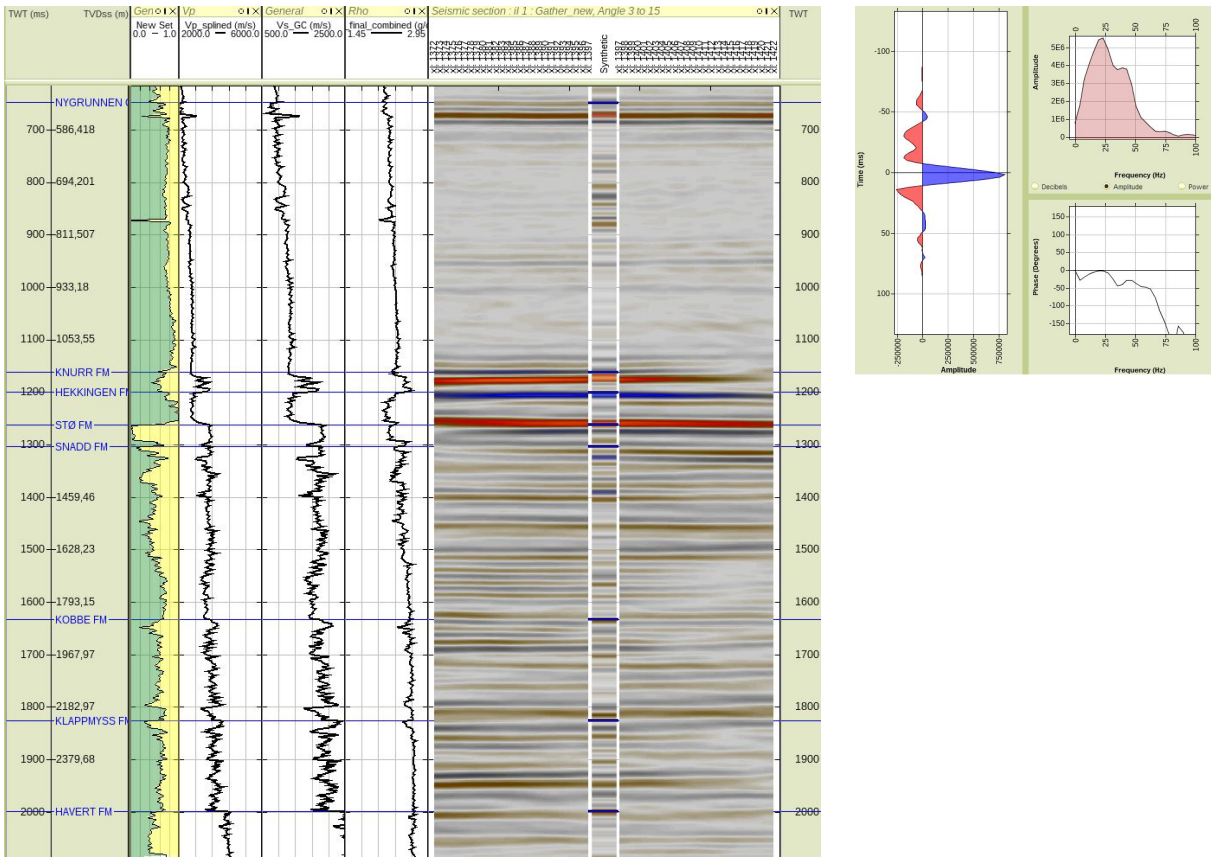

Fig. 4.3 Well 7123/4-1S. Seismic to well tie

After license extension was awarded in 2015 (PL 768 B), the license group decided to acquire 965 km^2 3D data covering the key prospect area. The purpose for the WIN17001 3D seismic survey was to mitigate two prospect major risk elements: charge and seal. The following work was conducted based on the 3D seismic survey: elastic inversion to investigate the acoustic

impedance anomaly identified on 2D seismic inversion data together with analysis of information derived from far offsets (Vp/Vs and shear impedance) and investigation of DHI . PSDM seismic processing and broadband technology improved the quality of the seismic image and optimized the interpretation of the reservoir section. Specifically the seismic section at the Permian-Triassic boundary brought out details that shed new light on interpretation of the depositional model and the sealing potential of the Andotten prospect. The final conclusion was that the top seal and trap effectiveness constitute a major risk for the Ørret Formation reservoir in the SW part of the prospect.

Below is a description related to the Andotten prospect elements:

Event mapping and geological model

Several events in the Permian package, from Top Ørret Fm down to the Permian-Carboniferous unconformity, were interpreted (Fig. 4.4). The purpose was to look for geometries and seismic signature in the up-dip direction that could be seen as a true updip sand pinch-out against the Røye Fm platform. The current sequence stratigraphic model divides the Ørret Fm in two intervals: a lower wedge section (which forms the Andotten prospect) interpreted to be deposited during early low stand as sand-prone basin floor fan deposits (Lower Ørret Fm wedge 1a), and a late low stand fan delta clinoform interval (Upper Ørret Fm wedge 1b) with dominant thin intercalated silts and shales layers (Fig. 4.5 and Fig. 4.6). Hence, the upper wedge clinoform toe set section forms a top seal for the south western part of the Andotten prospect.

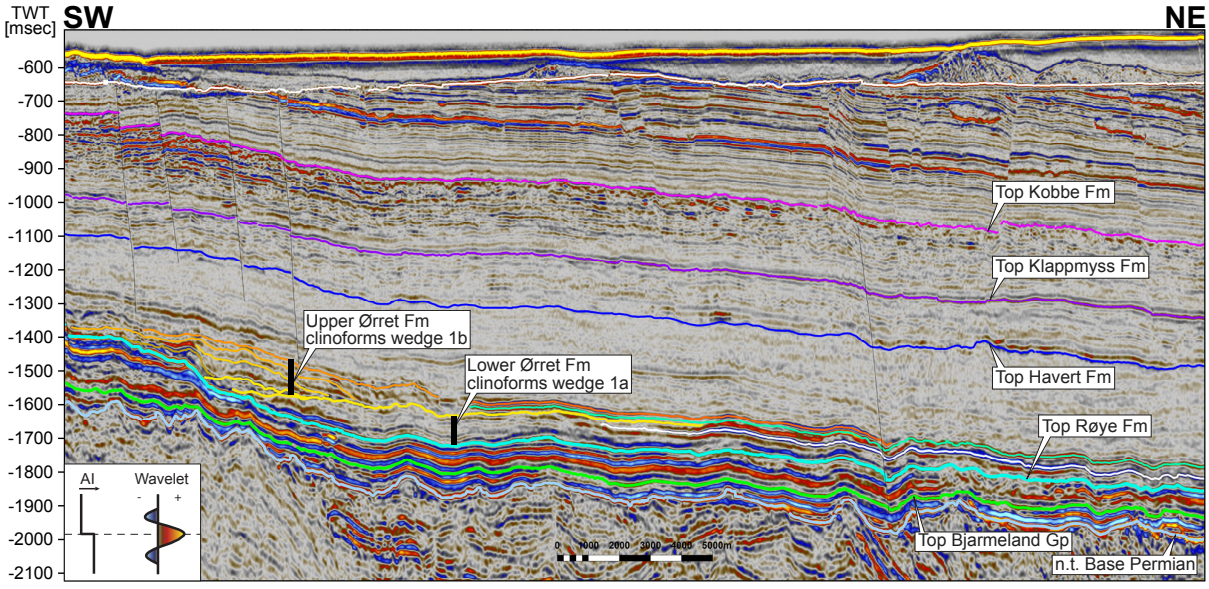

Fig. 4.4 WIN17001 3D seismic interpretation

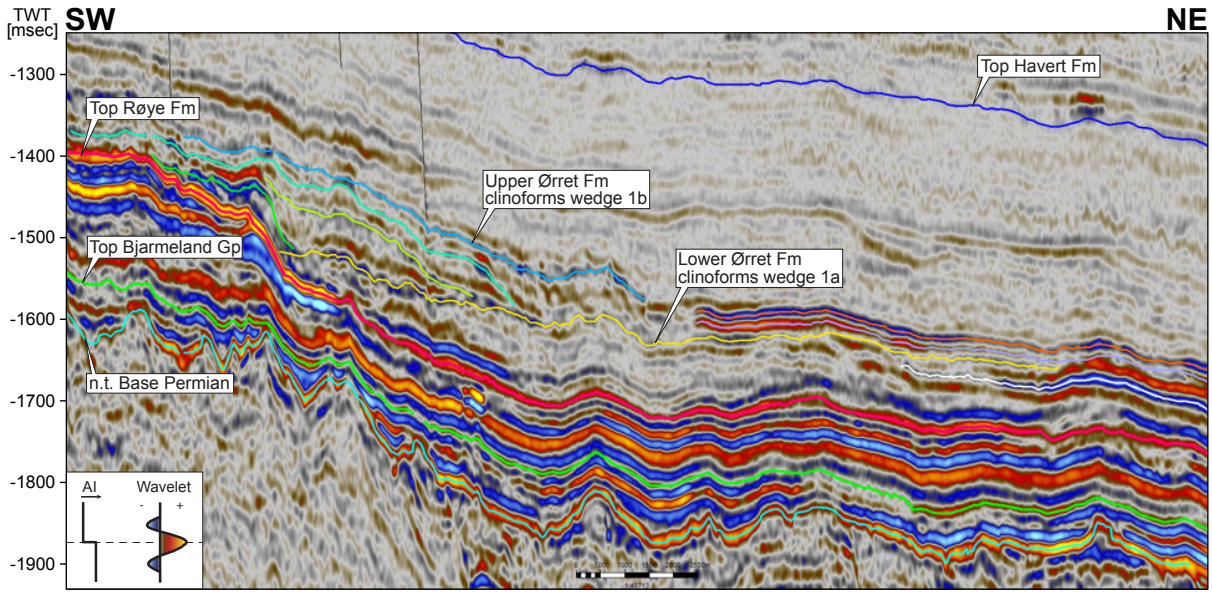

Fig. 4.5 Permian section seismic interpretation

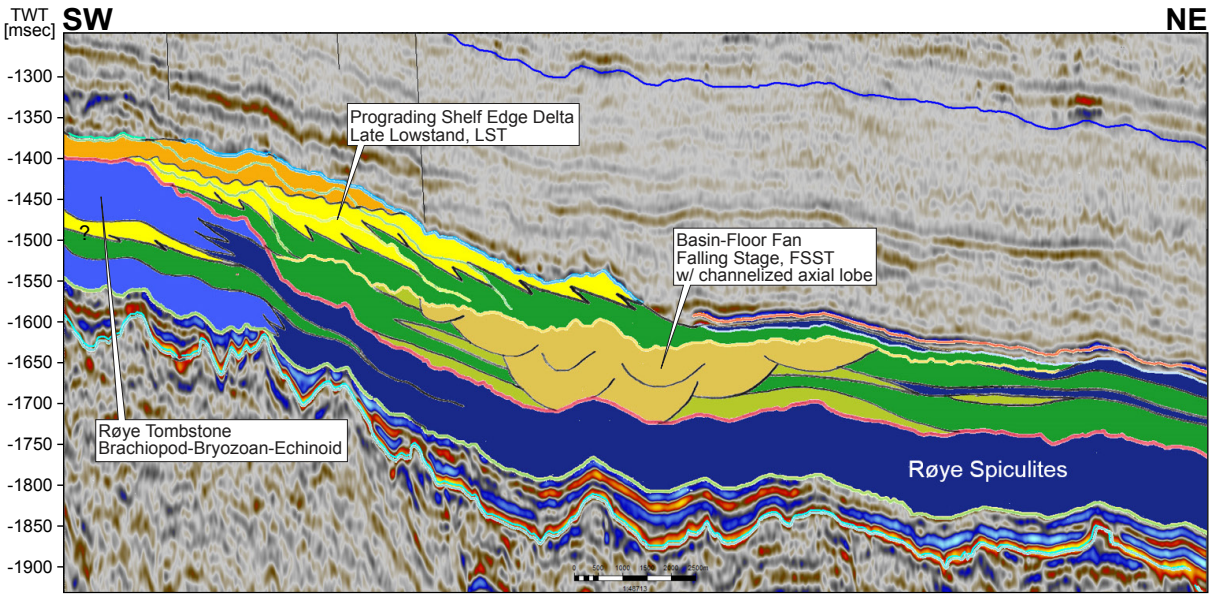

Fig. 4.6 Upper Permian geological model

Thin sandstone facies are expected to occur in the wedge 1b interval updip at the top sets of a highly condensed section that is interpreted to continue over the platform. No valid trap is identified for this interval within the PL 768. Based on regional interpretation and stratigraphic correlation of the Upper Permian section, early low stand Ørret Fm wedge 1a was only tested by 7120/12-2 well whereas wedge 1b top sets interval was penetrated by 7120/12-4 well on the Finnmark Platform and 7122/7-3 in the Hammerfest basin (Fig. 4.7 and Fig. 4.8). The depth map of the Andotten prospect lower Ørret Fm wedge is shown in Fig. 4.9 with HC distribution used in the prospect volumetrics.

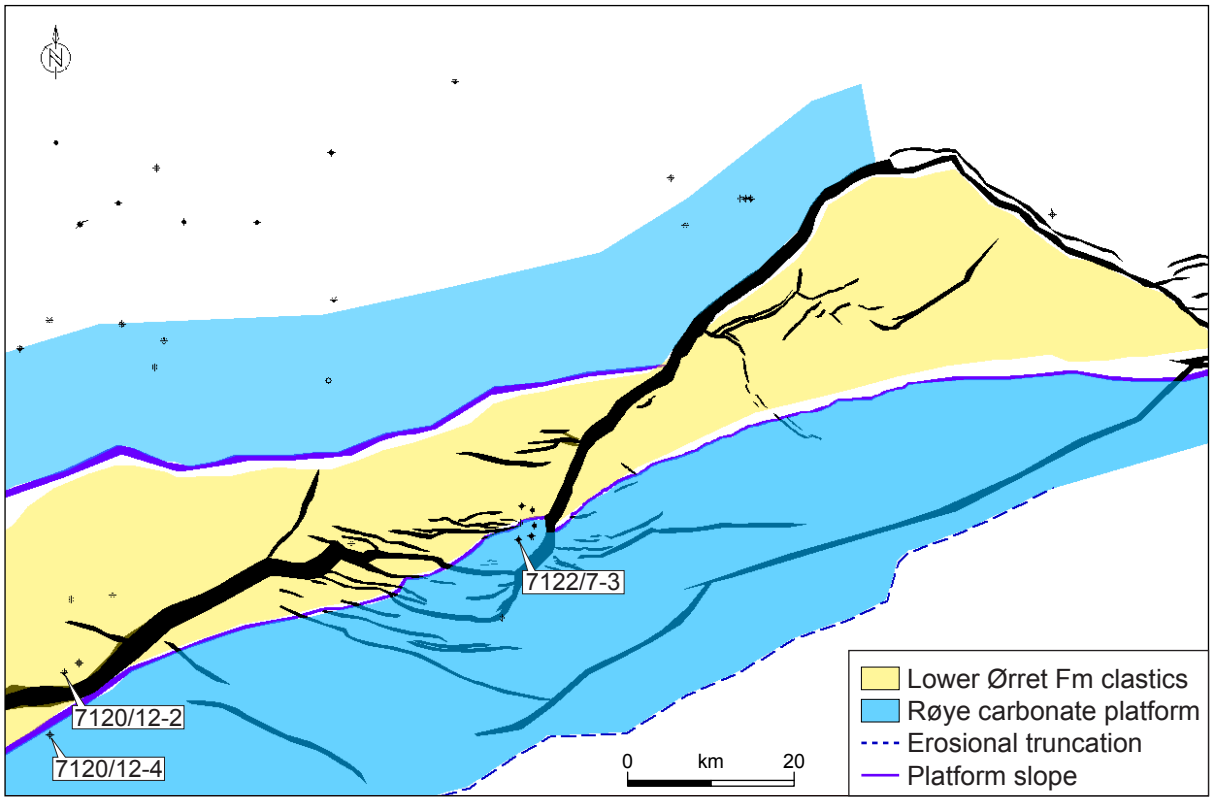

Fig. 4.7 Upper Ørret Fm wedge 1a regional extent and paleogeography
Well 7120/12-2 tested analogous facies to Andotten prospect

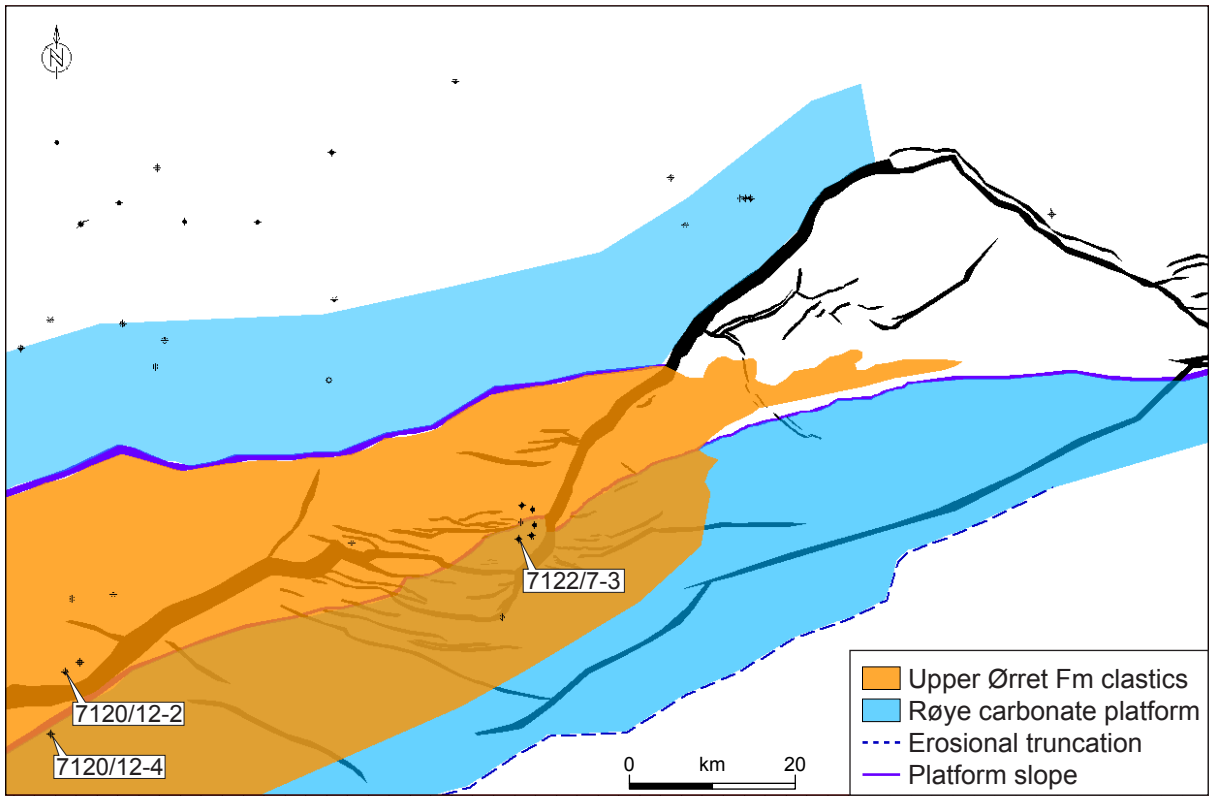

Fig. 4.8 Lower Ørret Fm wedge 1b regional extent and paleogeography
Wells 7120/12-4, 7120/12-2 and 7122/7-3 tested wedge 1b facies.

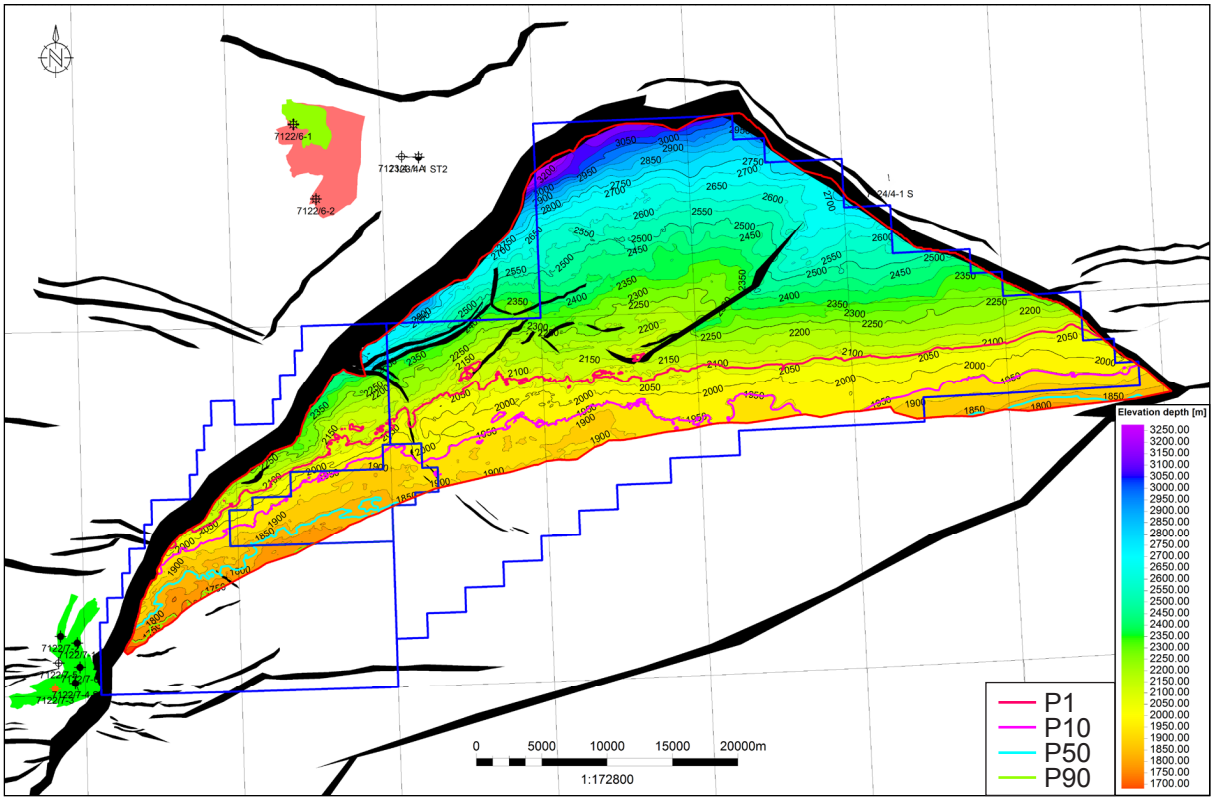

Fig. 4.9 The Andotten prospect. Top lower Ørret Fm wedge 1a depth map.
Hydrocarbon column distribution used in volumetric calculation is indicated.

Reservoir

The prognosed reservoir for the Andotten prospect are sandstones of the Lower Ørret Formation of Late Permian age. The reservoir is interpreted as a turbidite basin floor fan that entered the basin from SW and was deflected eastwards into the Andotten prospect area. There are no valid reference wells to directly constrain reservoir quality of the Lower Ørret Fm. Porosity is estimated to be in the range of 14-26 % considering global compaction curves and a paleo-burial depth of 2200 m. The estimate matches the porosity of clean shoreface sandstones in well 7120/12-4 (18 %), deposited in a different environment compared to Andotten, but buried to similar depth. Permeabilities are expected in the range of 10 to 500 mD. The Lower Ørret Fm reservoir thickness ranges from >190 m to 140 m. Net to gross is estimated to range from 30 to 70 % and a P50 oil recovery factor of 29% is assumed.

Seal

The top seal for the Lower Ørret Formation are downlapping delta front and pro-delta shales of the prograding Upper Ørret deltaic clinoforms. Where these pinch out, the regional shales of the Triassic Havert Formation form the top seal.

The Andotten prospect is dependent upon lateral sealing against the carbonate platform margin of the Røye Formation. Very low permeabilities are measured on core data from the Templefjorden Gp (7120/12-4 well) where fractures are intensely mineralized and pores are not-connected. A potential reservoir sandstone – carbonate platform juxtaposition is considered a main risk of the prospect (40% trap effectiveness). While carbonate karstification is unlikely to have affected the cold-water, siliceous tight Røye Fm, platform margin fractures are likely present. These could be open or cemented.

The presence of sealing faults are key for preserving a hydrocarbon column in the Andotten prospect since the closure is fault dependent. The prospect boundary faults to the northwest and northeast are basin boundary faults towards the Hammerfest Basin. These faults might

have been reactivated during the rifting, uplifts and erosion events of the Barents Sea. The western prospect boundary fault has a larger throw, in excess of 1000 m. The eastern fault throw is in the 300 meters range. Recent fault activity is recognised along the western prospect boundary fault. Large fault throw and predominately shaly Triassic lithology favour fault seal.

Source-Migration-Charge

The Andotten prospect area is a prolific oil and gas province with several fields and discoveries surrounding it in the Hammerfest basin (Goliat, Tornerose, Nucula). There are two source rock scenarios evaluated for the Andotten prospect. The first and main model assumes the Triassic Steinkobbe Fm spilling through Goliat field and the main TFFZ fault zone from Hammerfest Basin. The second scenario is a local source rock of Carboniferous age (Tettegras Fm) proven on the Finnmark Platform to the east in wells 7128/4-1 and 7128/6-1. The source rock thickness map was created based on interpretation of half-graben structures interpreted in the eastern part of the Andotten block and assumption of net thickness source rock at 5% of the mapped interval.

4.2 Resource estimation

Mean technical recoverable oil volumes of the Andotten prospect is estimated to about 412 mmbbls, i.e. a potentially large prospect. However, around 57% of the prospect volumes is located in the PL768/768B licences, whereas approximately 30% is located in a acreage covered by license PL229D/E. The remaining 13 % of the mean volumes is located in the SE corner of the Andotten block not opened for exploration. The Andotten prospect is evaluated to have a GPOS of about 15%. The main risk elements are Trap Effectiveness (40%), and Charge - Migration (70%).

Summary of final HC volumes, selected parameter distributions used as an input and risk assesment are shown in **Table 4.1.**

wintershall dea

Table 4.1 Prospect data

Block	7122/8, 7122/9, 7123/5,	Prospect name	Andotten	Discovery/Prosp/Lead	Prospect	Prosp ID (or New!)	NPD will insert value	NPD approved (Y/N)	
Play name	NPD will insert value	New Play (Y/N)		Outside play (Y/N)					
Oil, Gas or O&G case:	Oil	Reported by company	Wintershalldea	Reference document				Assessment year	2019
This is case no.:	1 of 1	Structural element	Finnmark Platform	Type of trap	Stratigraphic/structu	Water depth [m MSL] (>0)	400	Seismic database (2D/3D)	3D
Resources IN PLACE and RECOVERABLE		**Main phase**				**Associated phase**			
Volumes, this case		Low (P90)	Base, Mode	Base, Mean	High (P10)	Low (P90)	Base, Mode	Base, Mean	High (P10)
In place resources	Oil [10^6 Sm^3] (>0.00)	3.79		229.90	640.60	0.38		29.60	79.20
	Gas [10^9 Sm^3] (>0.00)								
Recoverable resources	Oil [10^6 Sm^3] (>0.00)	0.95		65.10	181.60	0.09		8.39	22.30
	Gas [10^9 Sm^3] (>0.00)								
Reservoir Chrono (from)	Upper Permian	Reservoir litho (from)	Ørret Fm	Source Rock, chrono primary	M. Triassic	Source Rock, litho primary	Kobbe Fm	Seal, Chrono	Upper Permian
Reservoir Chrono (to)	Upper Permian	Reservoir litho (to)	Ørret Fm	Source Rock, chrono secondary	U Carboniferous	Source Rock, litho secondary	Tettegrass Fm	Seal, Litho	Ørret Fm/Røye Fm
Probability [fraction]									
Total (oil + gas + oil & gas case) (0.00-1.00)		Oil case (0.00-1.00)	0.15	Gas case (0.00-1.00)		Oil & Gas case (0.00-1.00)			
Reservoir (P1) (0.00-1.00)	0.80	Trap (P2) (0.00-1.00)	0.40	Charge (P3) (0.00-1.00)	0.60	Retention (P4) (0.00-1.00)	0.80		

Parametres:	Low (P90)	Base	High (P10)	*Comments*
Depth to top of prospect [m MSL] (> 0)		1679		
Area of closure [km^2] (> 0.0)	3.0	39.7	199.4	
Reservoir thickness [m] (> 0)				
HC column in prospect [m] (> 0)	61	151	266	
Gross rock vol. [10^9 m^3] (> 0.000)	110.340	126.534	143.441	
Net / Gross [fraction] (0.00-1.00)	0.32	0.49	0.68	
Porosity [fraction] (0.00-1.00)	0.13	0.19	0.26	
Permeability [mD] (> 0.0)				
Water Saturation [fraction] (0.00-1.00)	0.38	0.28	0.19	
Bg [Rm3/Sm3] (< 1.0000)				
1/Bo [Sm3/Rm3] (< 1.00)	0.89	0.84	0.81	
GOR, free gas [Sm^3/Sm^3] (> 0)				
GOR, oil [Sm^3/Sm^3] (> 0)	53	129	231	
Recov. factor, oil main phase [fraction] (0.00-1.00)	0.16	0.28	0.40	
Recov. factor, gas ass. phase [fraction] (0.00-1.00)	0.16	0.28	0.40	
Recov. factor, gas main phase [fraction] (0.00-1.00)				
Recov. factor, liquid ass. phase [fraction] (0.00-1.00)				For NPD use:

Temperature, top res [°C] (>0)	50			Innrapp. av geolog-init:	NPD will insert value	Registrert - init:	NPD will insert value	Kart oppdatert	NPD will insert value
Pressure, top res [bar] (>0)	180			Dato:	NPD will insert value	Registrert Dato:	NPD will insert value	Kart dato	NPD will insert value
Cut off criteria for N/G calculation	1.	2.	3.					Kart nr	NPD will insert value

5 Technical evaluations

Several development cases were evaluated. A tie-back to Goliat was the most economical P50 case. In this case there were 11 oil producers and seven water injectors.

In the P10 case there was stand-alone two-phase development which were equal in size. Each phase had 20 oil producers and 10 water injectors. Two gas injectors were also included. The oil is stored and processed in an FPSO and exported to marked via shuttle tankers.

Production start-up was assumed in 2029.

6 Conclusions

As a result of the work conducted it has to be stated that the main geological risks of trap effectiveness as well as charge/migration are high. The updated volumetric calculation for the Andotten prospect significantly decreased the resource volumes comparing to the initial evaluation. However, the remaining potential is still seen as significant and above the economic threshold.

Wintershall Norge AS recommended the drill decision in August 2019. The license partners voted for license drop.