PL687 Relinquishment Report

Final version, 06.05.2016

VNG Norge

ENGIE

explora PETROLEUM

petoro

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1 Key Licence History

Licence Award and Licencees

Production licence 687 (PL687) was awarded to VNG Norge AS (VNG Norge), GDF SUEZ E&P Norge AS (GDF), Explora Petroleum AS (Explora) and Petoro AS 8th February 2013 as part of the APA2012 concession round. VNG Norge is the operator with 40 % participation share and the other licencees with 20 % each. The PL687 licence area covers 513.168 km^2 in Blocks 36/1 and 35/3 (part) close to the Agat gas discovery in Block 35/3 to the west. See Fig. 1.1 for location map.

Work Programme

The initial licence period was eight years, valid until 8th February 2021, and the work obligations are as follows:

- Within 3 years from award (8th February 2016):
  - Acquire and consider to reprocess 3D seismic
  - Perform relevant geology and geophysical studies
  - Decision to drill an exploration well to test the Agat and Tryggvasson Formations or relinquish the licence
- Within 5 years from award, Decision to Concretize (BoK) or relinquish the licence
- Within 7 years from award, perform conceptual studies and Decision to Continue (BoV) or relinquish the licence
- Within 8 years from award, prepare development plan and decide to submit PDO or relinquish the licence

The work obligations for the first 3 year work period are fulfilled. 3D seismic reprocessing of the VNG13M04 survey, 3D acquisition and processing of the CGG14003 survey in the licence area and relevant geology and geophysical studies.

Licence Meetings

During the life of the licence, a number of meetings took place and were documented in Licence2Share (L2S) (Table 1.1).

Table 1.1 PL687 Licence Meetings

Date	Management Committee Meeting	Exploration Committee Meeting/ Informal Work Meeting
January 29th 2013	MC #1	EC #1
February 6th 2013		WM
August 22nd 2013		WM
October 2nd 2013		WM
October 21st 2013		WM
November 5th 2013	MC #2	EC #2
May 13th 2014		WM
June 3rd 2014		WM
August 12th 2014		WM
October 23rd 2014	MC #3	EC #3
March 20th 2015		WM
June 23rd 2015		WM
October 1st 2015	MC #4	EC #4

Reason for Relinquishment

The hydrocarbon potential for all large structures are tested and the remaining structural traps have limited volume potential. The main focus for the evaluation of the remaining resource potential were therefore to investigate stratigraphic and truncation traps in connection with the underlying major rotated fault blocks caused by easterly dipping faults. Main risk factors for prospectivity in Cretaceous levels are trap definition and retention. For the deeper reservoir levels, in Upper- and Middle Jurassic age, the main risk factors are trap definition, retention and petroleum charge. The prospect evaluation of the new seismic data have resulted in significantly increased prospect risk. Hence, the licence have not identified a valid drillable prospect and the remaining hydrocarbon potential is considered insignificant.

The license have made a unanimous decision to relinquish the licence.

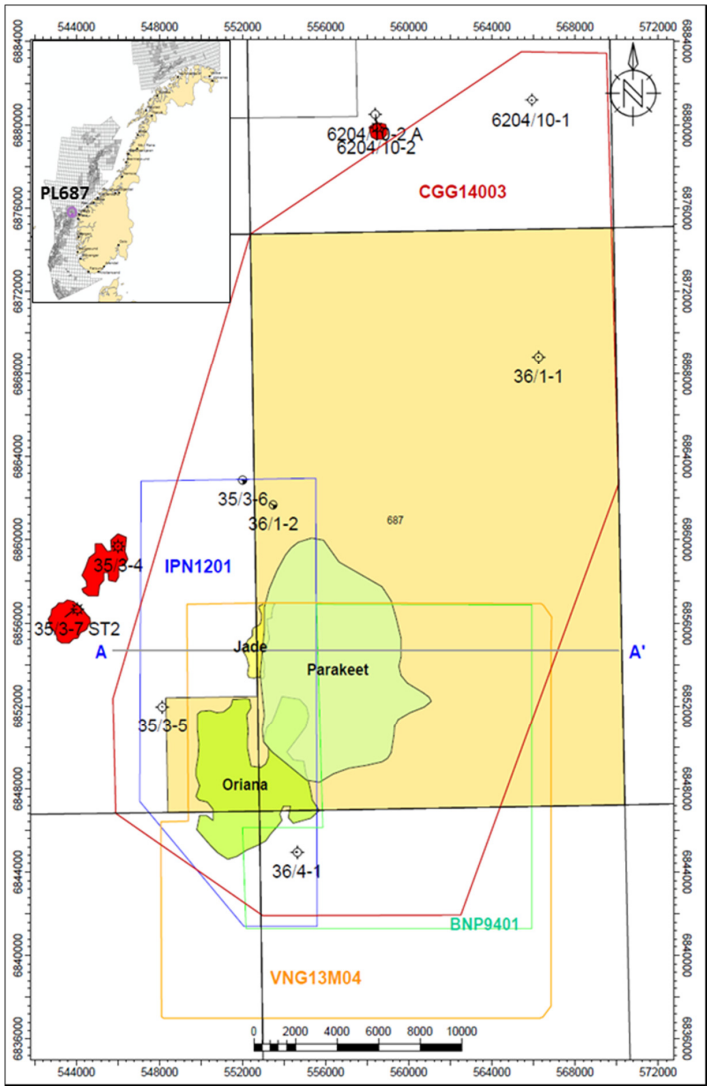

Fig. 1.1 PL687 Location Map
Prospect and Database Map

2 Database

Seismic Database

The following 3D seismic surveys have been added to the common seismic database during the licence period and is the fundament of the prospect evaluation:

- 3D VNG13M04
- 3D CGG140003, 718.5 km^2 part
- 3D IPN1201, 167 km^2 part (base survey for VNG13M04)
- 3D BPN9401, 250 km^2 part (base survey for VNG13M04)

The seismic database is illustrated in Fig. 1.1.

VNG13M04

The VNG13M04 survey is reprocessed by Geotrace Technologies Inc. based on agreed parts of surveys IPN1201 and BPN9401 and has been conducted in the licence period as part of the work obligations. The survey area covers the southern part of licence area (Fig. 1.1). The two main processing objectives were to optimize data for analysis of amplitude variations with offset (AVO) and of improving the vertical resolution. The reprocessing of the two surveys were merged pre-stack and migrated using Kirchhoff pre-stack time migration (PSTM). The seismic data quality was significantly improved compared to the base surveys. The angle stacks were improved even more by additional gather conditioning by Sharp Reflections AS and became robust data for seismic data analysis. This survey was the main dataset for AVO analysis of the Agat and Tryggvasson Formations.

All final seismic volumes, including full offset, 4 angle stacks and final gathers have been loaded into the DISKOS database.

CGG14003

The CGG14003 survey, 'HORDA Multiclient Broadseis/Broadband' (CGG name), was acquired and processed by CGG and PL687 licence purchased 718.5 km^2 to cover the complete licence area and key area wells as part of the work obligations. This acquisition covers the northern licence area that previously have had no 3D seismic coverage. The survey was acquired using CGG broadband & broadseis technology and processed using Kirchhoff PSTM. Compared to VNG13M04, the data quality has improved vertical resolution and imaging in the deepest part, 2-3 seconds TWT, i.e. above and below top acoustic basement reflector.

The evaluated seismic volumes have been based on a separate 'VNG priority' processing project covering the PL687 area. Data quality for seismic interpretation and prospect evaluation is good. Data quality for AVO analysis is, however poorer than for VNG13M04 mainly due to high frequency noise on the near traces.

The final data for the full area was not finalized before the drill or drop decision and have therefore not been part of the decision basis. The final seismic volumes for the CGG14003 have been loaded into the DISKOS database by CGG.

Well Database

The common well database includes all released wells in the area (Fig. 1.1 and Table 2.1).

Table 2.1 Well Database
Key wells marked in yellow

Well	TD (m RKB)	TD stratigraphy	Result	Completion date
35/2-1	713	L. Pliocene	Gas	28.08.2005
35/2-2	640	Pliocene	Gas	26.07.2009
35/3-1	4475	M. Jurassic	Dry	26.10.1976
35/3-2	4400	Pre-Devonian	Gas/Condensate	26.10.1980
35/3-3	900	Oligocene	Junked	28.11.1980
35/3-4	4089	Pre-Devonian	Gas/Condensate	06.06.1981
35/3-5	4114	Pre-Devonian	Dry	31.03.1981
35/3-6	3366	L. Jurassic	Dry	02.04.2002
35/3-7 S & T2	4051	M. Jurassic	Gas	01.10.2009
35/6-2 S	3700	E. Cretaceous	Dry	04.04.2009
35/9-3	2783	Pre-Devonian	Oil/Gas	11.11.1997
36/1-1	1596	Pre-Devonian	Dry	14.06.1975
36/1-2	3256	Pre-Devonian	Shows	27.10.1975
36/4-1	2717	Pre-Devonian	Dry	01.10.1996
36/7-1	2841	Pre-Devonian	Oil/Gas	07.05.1996
36/7-2	1435	Pre-Devonian	Oil	22.09.1997
36/7-3	2948	M. Jurassic	Dry	06.01.2002
6204/10-1	2709	Pre-Devonian	Dry	23.11.1995
6204/10-2	1145	Paleocene	Dry	12.02.1997
6204/10-2 A	2290	E. Cretaceous	Dry	04.12.1997
6204/10-2 R	2095	Pre-Devonian	Gas	21.11.1997
6204/11-1	2966	Triassic	Gas	14.11.1994
6204/11-2	2920	L. Jurassic	Oil shows	28.12.1997

The key wells used for the prospect evaluation are; 36/4-1, 35/3-5, 35/3-7 S &T2, 35/3-6, 36/1-2, 36/1-1 and 6204/10-1.

A biostratigraphy study was conducted by Ichron Limited. The study included wells; 36/4-1, 36/1-1, 36/1-2 and integration of wells 35/3-7S, 35/3-5 and 35/3-6 (Ichron, 2013). The report is posted on Licence2Share (L2S).

3 Review of Geological Framework

The licence group was established based on two separate applications. These were based on the Parakeet prospect in deep marine sandstones in Early Cretaceous, Agat Formation (VNG Norge and GDF, 2012) and on the Oriana prospect in Upper Cretaceous, Kyrre Formation (Explora, 2012), respectively. In addition, multiple leads in five stratigraphic levels were identified.

Fig. 3.1 shows the Base Cretaceous Unconformity (BCU) depth structure map for the PL687 licence area including the area wells.

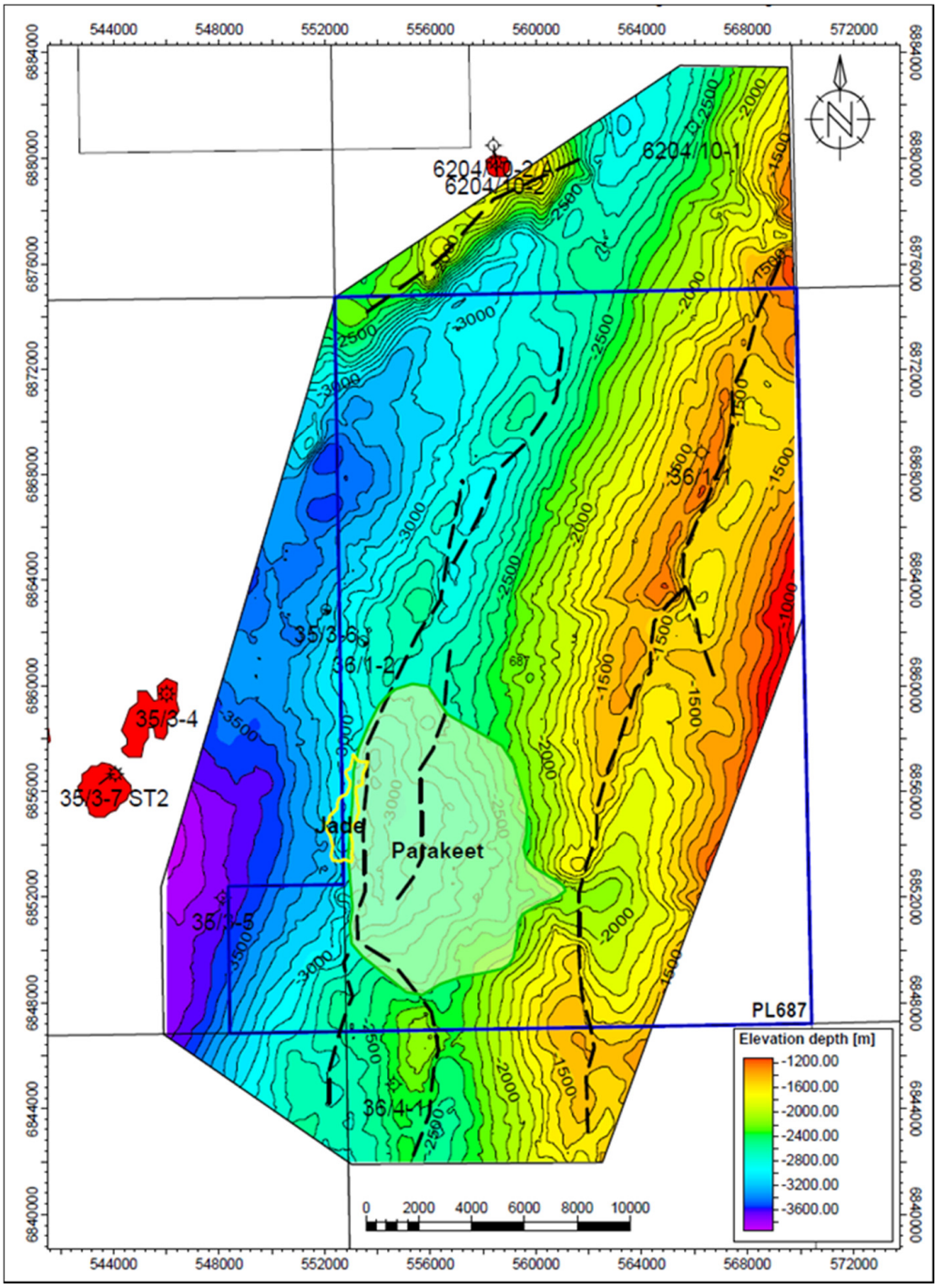

Fig. 3.1 Base Cretaceous Unconformity Depth Structure Map

The main structural faults marked as black dashed lines. The prospect outlines for Agat Formation are shown.

Seismic interpretation of VNG13M04 and CGG14003 confirmed previous work (VNG Norge and GDF, 2012 and Bugge et. al. 2001), hence the geological framework is not changed significantly.

The stratigraphy of the northern Viking Graben that is representative for PL687 area is displayed in Fig. 3.2. The main stratigraphic levels with regards to the prospectivity elements source, reservoir and seal and mapped horizons are also shown.

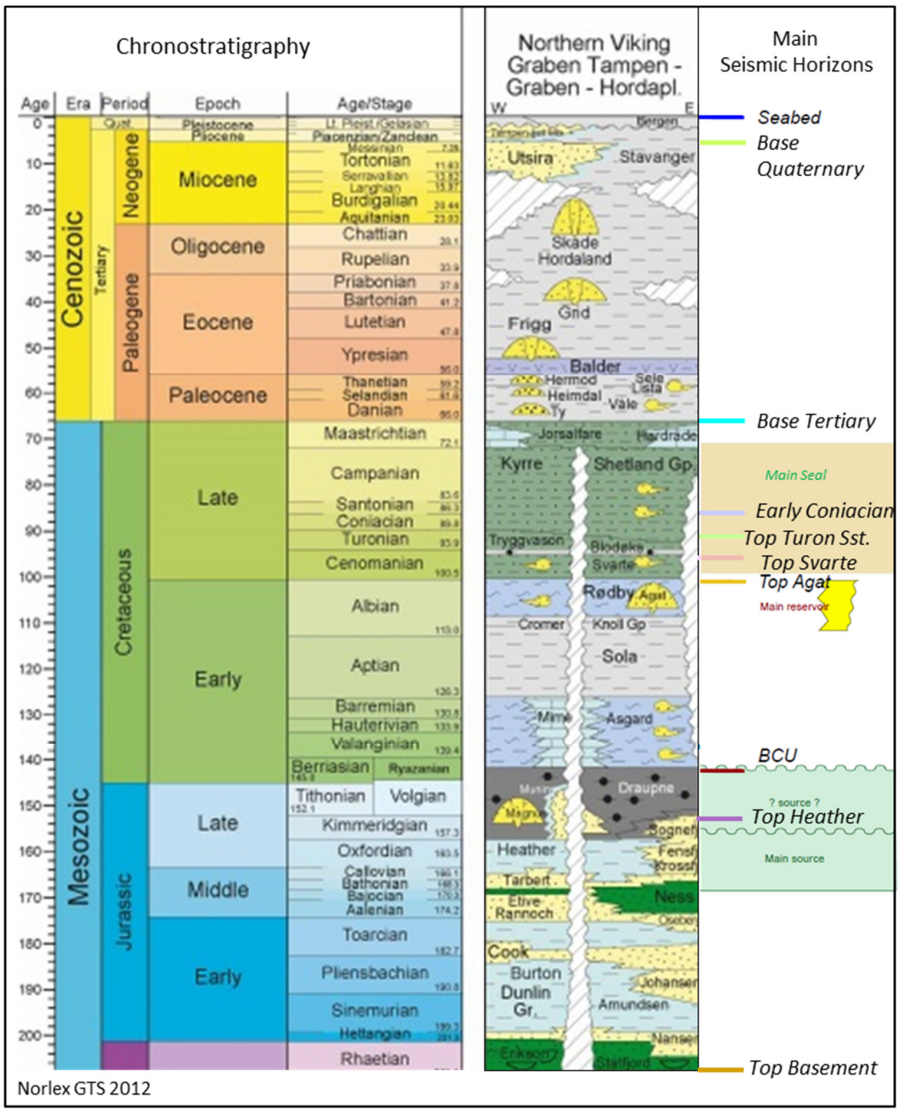

Fig. 3.2 Stratigraphy and Main Seismic Horizons
The stratigraphy of the Northern Viking Graben (modified from Norlex GTS2012)

General Prospect Risk Overview

Reservoir

Wells in the area have encountered sandstones of reservoir quality at multiple levels. Fig. 3.3 shows a geological East-West profile through the licence area illustrating the main reservoir levels.

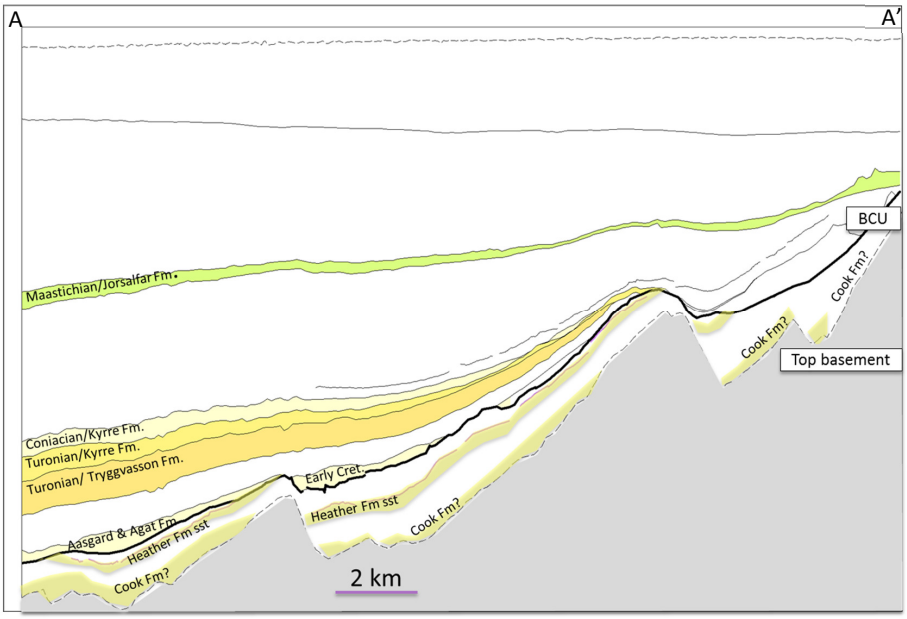

Fig. 3.3 Geological Type Section
Illustrating potential reservoir levels. See figure 1.1 for location

The main reservoir levels include Early Cretaceous sandstone of Barremian-Cenomanian age; the Åsgard and Agat Formations and Upper Cretaceous sandstones of Turonian-Early Coniacian age; Tryggvasson and Lower Kyrre Formations.

The geological deposition model for Agat sandstone presented in APA2012 application remains valid (Fig. 3.4).

In addition prospect screening have also been done on the following reservoir levels; Paleocene sandstone, Intra Heather sandstone (Upper Jurassic), Cook Formation (Lower Jurassic) and fractured basement.

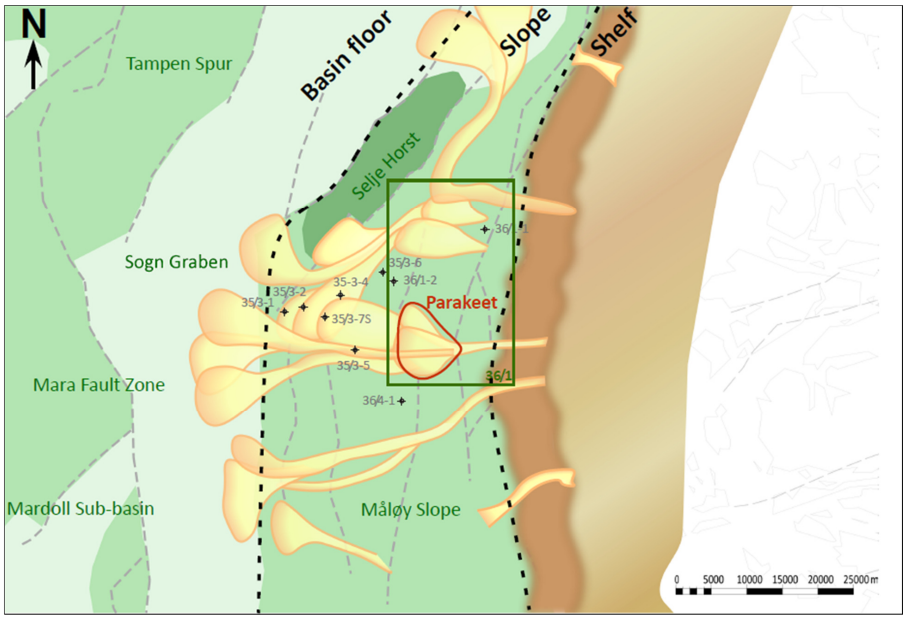

Fig. 3.4 Geological Deposition Model for Cretaceous Sandstone in PL687
(VNG and GDF APA2012)

Petroleum System

Hydrocarbon accumulations in PL687 are dependent on migration into the area from the West where mature Draupne and Heather Formations source rocks are known to be present.

The hydrocarbon indications in Agat discovery wells (e.g. 35/3-4 and 35/3-7 ST2) and wells 36/1-2 and 35/3-6 proves oil and gas migration in the Agat Formation. East of the fault block tested by wells 36/1-2 and 35/3-6, only very weak gas shows are encountered in the 36/1-1 and 36/4-1 wells. The risk for migration of hydrocarbons will increase going east of well 36/1-2 and into the PL687 licence area. Specifically this is expected to be the case for stratigraphy older than Agat sandstone because the basement highs will be a probable barrier for hydrocarbon migration towards East.

Trap

The hydrocarbon potential for all large structures are tested and the remaining structural traps have limited volume potential. Stratigraphic and truncation traps in connection with the underlying major North-East to South-West trending rotated fault blocks, caused by easterly dipping faults, have been investigated (Fig. 3.1 and Fig. 3.3).

The stratigraphic traps depend on a robust geological model and on support from geophysical data analysis, such as AVO analysis, in order to establish a prospect definition. Identifying valid trap mechanisms is the main and critical risk for the general prospectivity in the licence area.

Truncation traps for Upper Jurassic sandstones have been investigated. The identified potential truncation traps are small and located in the low part of the rotated fault blocks.

Seal/Retention

The amount of sand present at multiple levels and the severe thinning of the sealing package in Upper Cretaceous sediments (Kyrre Formation) will reduce the sealing capacity significantly towards the East. In addition, the base seal and lateral seal will be the critical risk for trap integrity and general identification of prospects.

AVO Analysis

Specialist geophysical data analysis have been conducted and have been crucial for the evaluation of the prospectivity in Agat and Tryggvsson Formations. Fluid factor cubes, based on the VNG13M04 survey, have been important for the understanding of the seismic responses and prospectivity as such. The Fluid Factor is the deviation from the background trend of water wet shales and sands.

Agat Formation Reservoir Level

Calibration and fluid substitution modelling of the wells in the Agat area (wells 35/3-5 and 35/7-3S), is the basis for understanding of the AVO responses. The analysis in the PL687 area is based on the assumption that the interface responses; shale-sand versus shale-shale is similar to that seen in the Agat area.

Jade prospect (Fig. 1.1) is a small 4-way closure that has been evaluated in former PL270 licence and is interpreted as gas-filled Agat sandstone. Jade prospect is approximately 40 % inside PL687 area, but has insignificant volume potential. The seismic AVO responses for Jade has, however been important as a calibration area for the AVO analysis.

The main conclusions are:

- Top Agat Formation sandstone is a clear soft event on all offsets, regardless of fluids, when it is a clean sand
- Well 35/3-5 modelling show that Agat sandstone has an AVO class 3 behaviour. This is confirmed

by the VNG13M04 data. That is a negative reflector (soft) getting more negative with offset.
- Gas filled reservoir creates a strong and characteristic amplitude anomaly that is clearly recognized on gathers

Lower Kyrre Formation Reservoir Level

Calibration and fluid substitution modelling based on well 36/4-1 is basis for understanding of the AVO responses in Turonian sandstones in lower Kyrre Formation (se chapter 4).

The main conclusions are:

- Two intervals with good porous sandstone is proven water-wet in well 36/4-1. The sand has a class 4 negative behavior. That is a negative reflector (soft) dimming with offset.
- It is possible to distinguish between good porosity sand and low porosity sand in lower part of Kyrre Formation in well 36/4-1 which is applicable for Oriana lead
- Amplitude anomalies seems to be related to lithology effects such as sand quality/porosity, hence no fluid effects are identified

4 Prospect Update

Parakeet Prospect

Fig. 4.1 displays a seismic dip line through the Parakeet prospect. The geological interpretation is that this is a clastic wedge that has been fed through a canyon that have been an entry point for sediments since Devonian time (Fig. 4.2). The age of the sediments above BCU may in the deepest parts of the sub-basins be older than Agat sandstone because of 'fill and spill mechanisms' of the deposition towards Agat area. In well 35/3-5 west of the licence area, this package have proven 385 m gross thickness Agat sandstone.

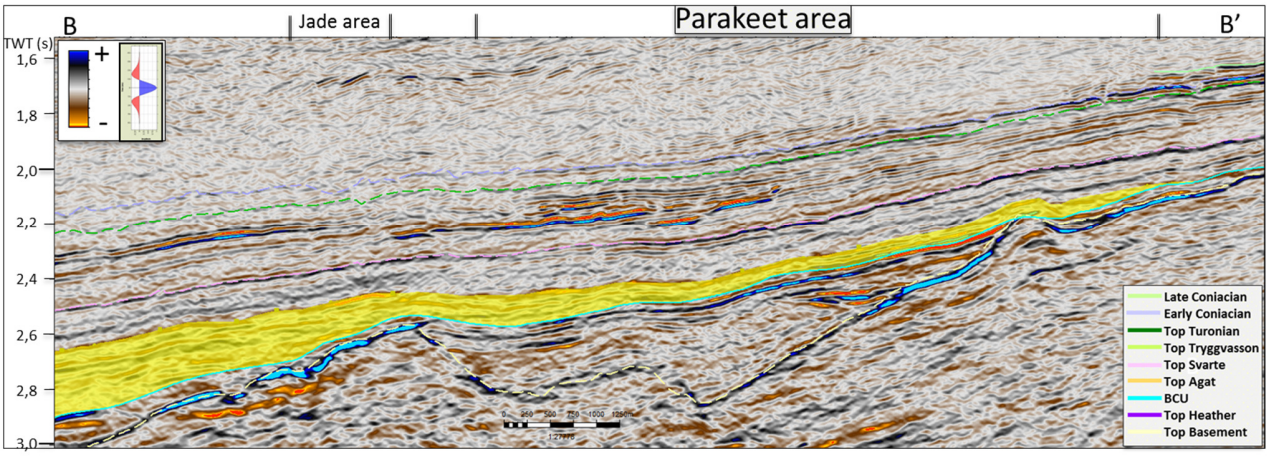

Fig. 4.1 Seismic East-west Profile for Parakeet Prospect
See figure 4.3 for location

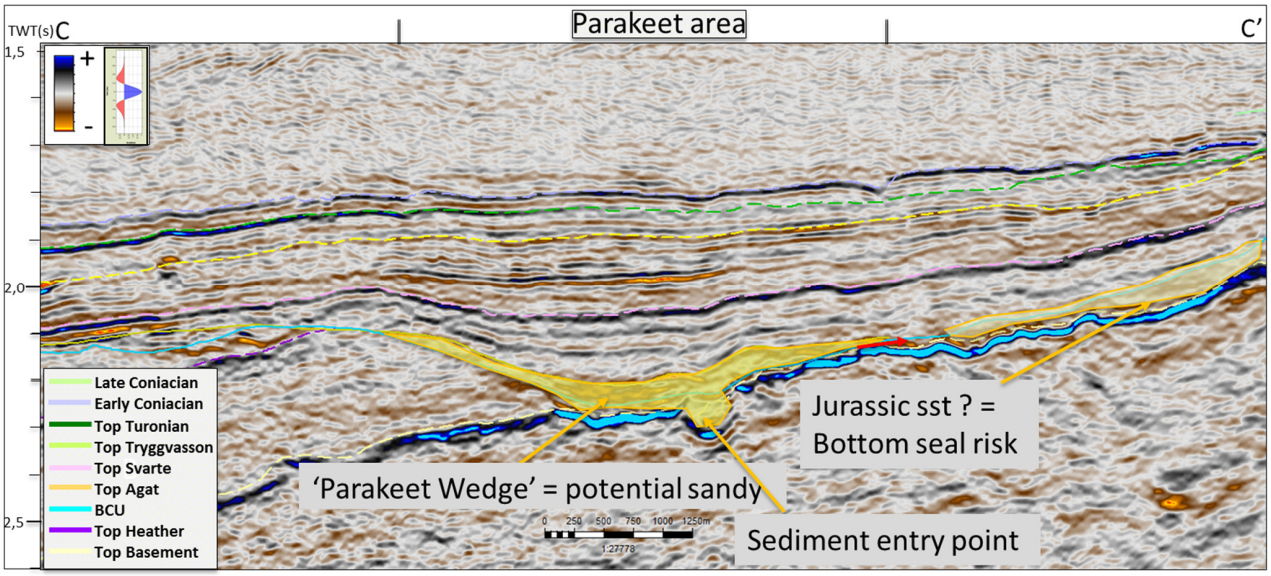

Fig. 4.2 Seismic Northwest-southeast Profile for Parakeet Prospect
See figure 4.3 for location

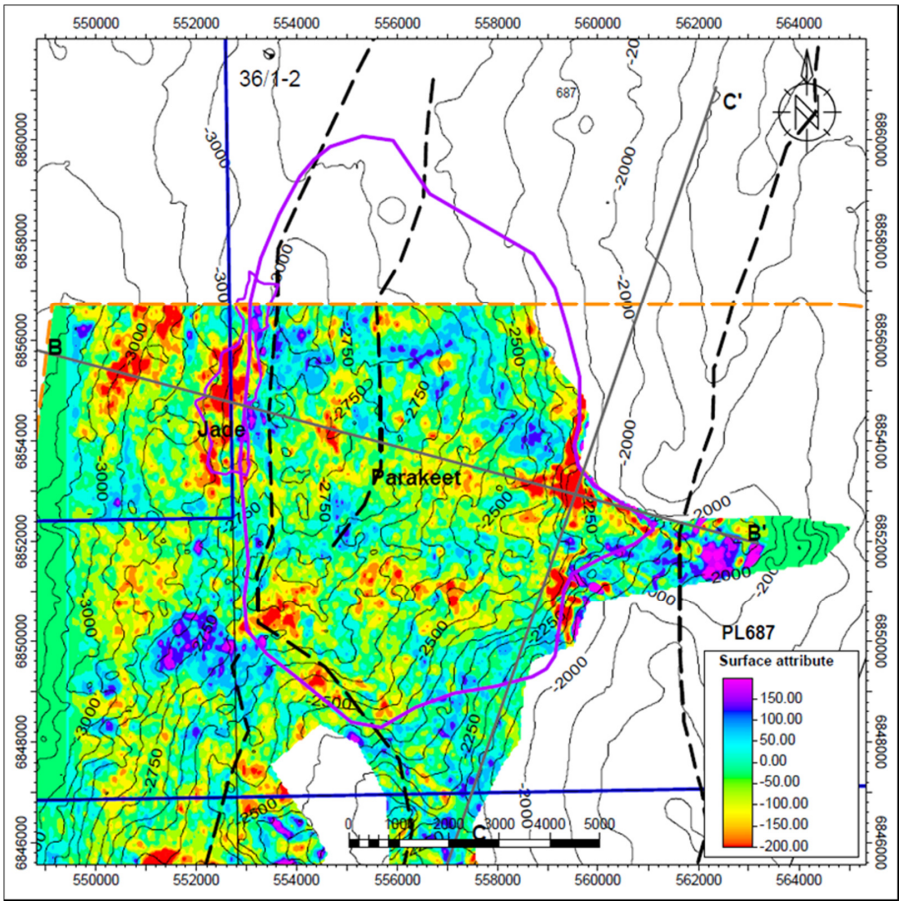

Fig. 4.3 Parakeet Prospect Map

Top Agat Combined Depth Structure (contours) and Mean Value Fluid Factor Map (colour scale) is shown where present within VNG13M04. Red colour represent AVO anomalies that may indicate porous sandstone and/or hydrocarbons. Base Cretaceous Depth Map shown in white colour defining the base surface for Parakeet. Orange line is the VNG13M04 survey outline, blue line is the licence area and the main structural faults marked as black dashed lines

Prospect Definition

Top Agat/Early Cretaceous is the top surface and BCU is the base surface defining the prospect. Fig. 4.3 shows the Top Agat depth structure contours in combination with a fluid factor map within the VNG13M04 area. The BCU surface is an unconformity that is seismically not well defined and the underlying geology is varying a lot, from Draupne Formation shales to potentially sandstone in Heather Formation. This seismic sequence in the Parakeet area is not clearly sealed off towards north where the sequence ties to a sandy package proven dry in well 36/1-1. The prospect definition depends on the reservoir terminating within an apparently continuous seismic sequence, which is considered unlikely unless supported by seismic data analysis. The structural component, where the top surface onlapping BCU/Top Basement is insignificantly small (at contour 2400 m).

The prospect evaluation of Parakeet prospect based on new seismic data do not confirm a well-defined and robust trap.

Prospect Risk and Volume Estimation

Table 4.1 lists the PL687 Prospect Data for the Parakeet prospect.

The Parakeet prospect has been evaluated to have a probability of discovery of 1%, including Direct Hydrocarbon Indicator (DHI) downgrade from 3.5 to 1 %. Main risks are closure definition and seal/ retention.

The estimated hydrocarbon volume range, P90-Mean-P10, is 2.2- 5.3- 9.7 10^9 Sm^3 of Recoverable Gas. Volume estimates have not been updated from the APA2012 application due to the high prospect risk.

Prospectivity Summary

- The seismic response of gas filled Agat reservoir is well understood
- Within the Parakeet prospect, only small 4-way closures displays the expected seismic response indicating gas filled reservoir (Fig. 4.3 and Fig. 4.4).
- It is unlikely that an economic oil accumulation would be found in an area with no gas cap or gas chimneys in the overburden
- It is unlikely that the proposed trap is sealing

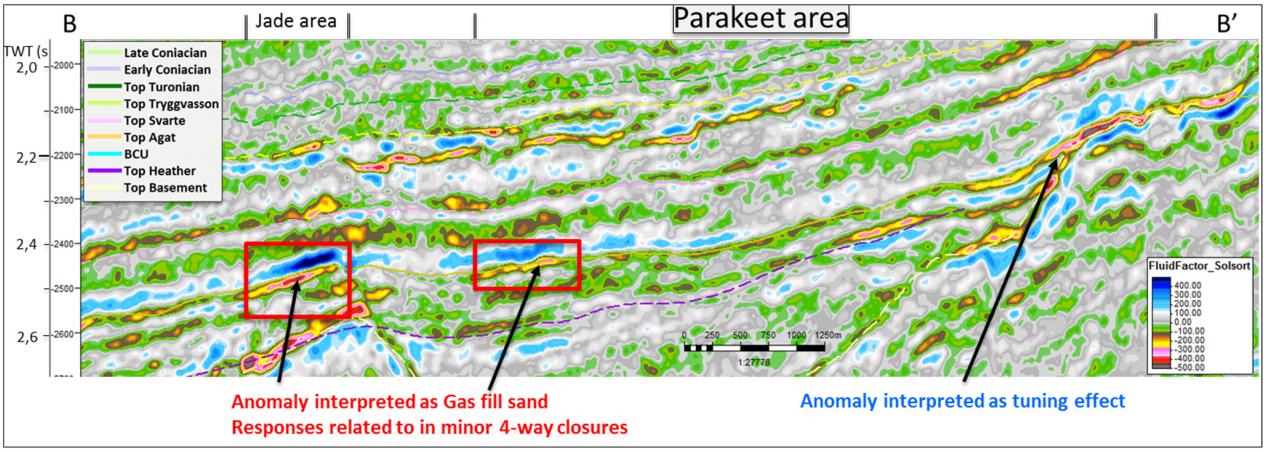

Fig. 4.4 Seismic East-west Profile - VNG13M04 Fluid Factor Cube
Geophysical analysis of Top Agat sandstone and Parakeet Prospect. Red colour represent AVO anomalies that may indicate porous sandstone and/or hydrocarbons

Oriana Lead

Fig. 4.5 displays a seismic line through the Oriana lead and Fig. 4.6 displays the Top Turonian sandstone depth map combined with the fluid factor. The reservoir objective are Turonian deep marine turbidities formed by widespread sheet sands. Well 36/4-1 encountered good, porous and water wet sand. The Turonian sandstone level has been mapped and evaluated in detail.

The original prospect concept requires that a 'channel-like feature' (Fig. 4.5) between Oriana area and the well seals in order to form a trap. These features are likely to have similar origin and lithology (sand to sand contact) as the Oriana reservoir and trap/seal potential for is therefore very low. The prospect evaluation of Oriana does not confirm a trap and therefore lack prospect definition as such.

Prospectivity Summary

- The seismic response of gas filled Turonian reservoir is well understood
- The observed seismic response suggests good, not gas filled, sand in approximately 1/3 of the prospect area (Fig. 4.5 and Fig. 4.6)
- The seismic response is similar to that seen in the water wet well 36/4-1
- The trap definition is weak and it is highly unlikely that the trap is sealing

Based on the above, the Oriana lead has not been evaluated further with volume estimate and updated risk.

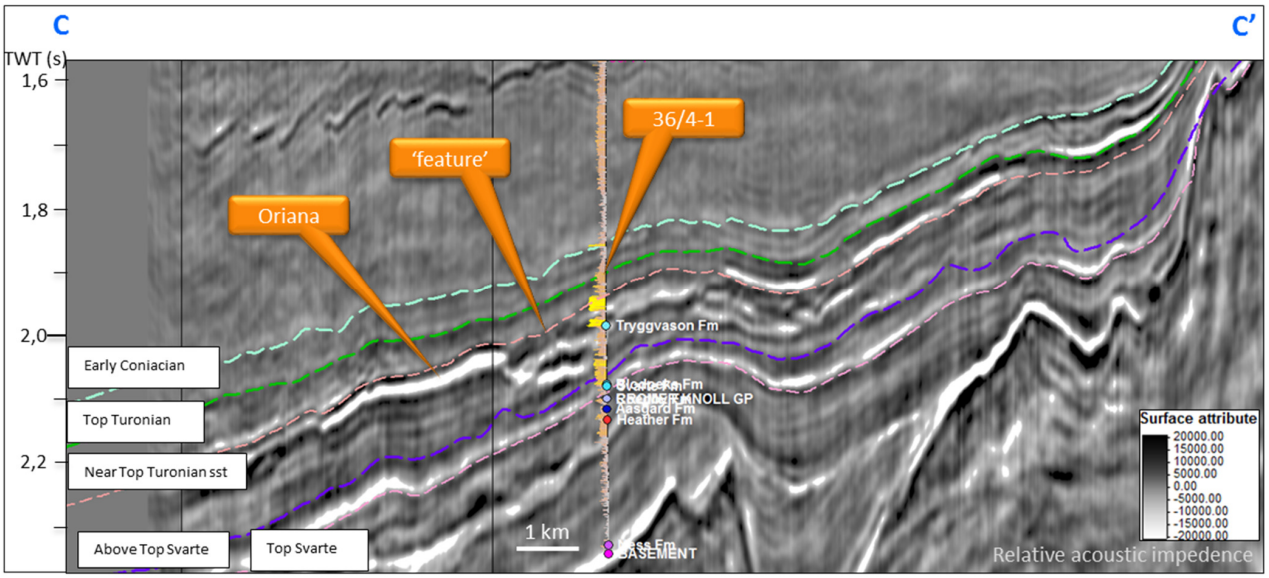

Fig. 4.5 Seismic Northwest-southeast Profile for Oriana
See figure 4.6 for location

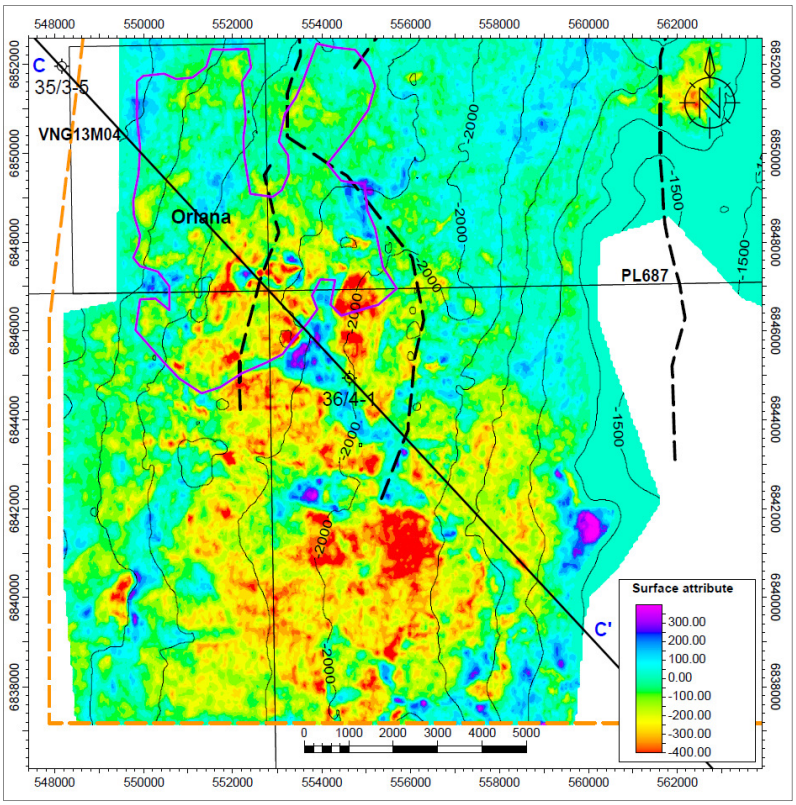

Fig. 4.6 Oriana Lead Map
Top Turonian sandstone Combined Depth Structure (contours) and Mean Fluid Factor (colour scale) Map. Red colour represent AVO anomalies that may indicate porous sandstone and/or hydrocarbons. Orange line is the VNG13M04 survey outline, blue line is the licence area and the main structural faults marked as black dashed lines

Table 4.1 PL687 Prospect Data (NPD Table 5)

		Block 36/1	Prospect name	Parakeet	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)	No	tstside play (Y/N)	No			
Oil, Gas or O&G case:			Reported by company	VNG Norge	Reference document				Assessment year
This is case no.:			Structural element		Type of trap	Stratigraphic	Water depth [m MSL] (>0)	235	Seismic database (2D/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
In place resources	Oil [10^6 Sm^3] (>0.00)								
	Gas [10^9 Sm^3] (>0.00)	6.40			15.00	25.80			
	Oil [10^6 Sm^3] (>0.00)								
Recoverable resources	Gas [10^9 Sm^3] (>0.00)	2.20			5.30	9.70	0.11		0.28
Reservoir Chrono (from)	Barremian	Reservoir litho (from)	Aasgaard Fm.	Source Rock, chrono primary	Kimmeridge	Source Rock, litho primary	Heather Fm.	Seal, Chrono	
Reservoir Chrono (to)	Albian	Reservoir litho (to)	Agat Fm.	Source Rock, chrono secondary	Callovian	Source Rock, litho secondary	Draupne Fm.	Seal, Litho	
Probability [fraction]									
Total (oil + gas + oil & gas case) (0.00-1.00)		Oil case (0.00-1.00)		Gas case (0.00-1.00)		Oil & Gas case (0.00-1.00)	0.01		
Reservoir (P1) (0.00-1.00)	0.70	Trap (P2) (0.00-1.00)	0.40	Charge (P3) (0.00-1.00)	0.40	Retention (P4) (0.00-1.00)	0.08		
Parameters:	Low (P90)	Base	High (P10)						
Depth to top of prospect [m MSL] (> 0)	2145	2145	2145						
Area of closure [km^2] (> 0.0)	23.0	39.0	53.0						
Reservoir thickness [m] (> 0)	210	210	210						
HC column in prospect [m] (> 0)	455	545	615						
Gross rock vol. [10^6 m^3] (> 0.000)	0.800	1,710	2,610						
Net / Gross [fraction] (0.00-1.00)	0.25	0.33	0.42						
Porosity [fraction] (0.00-1.00)	0.14	0.16	0.18						
Permeability [mD] (> 0.0)									
Water Saturation [fraction] (0.00-1.00)	0.50	0.40	0.30						
Bg [Rm3/Sm3] (< 1.0000)	0.0040	0.0035	0.0030						
1/Bo [Sm3/Rm3] (< 1.00)									
GOR, free gas [Sm^3/Sm^3] (> 0)	21320	19230	16500						
GOR, oil [Sm^3/Sm^3] (> 0)									
Recov. factor, oil main phase [fraction] (0.00-1.00)									
Recov. factor, gas ass. phase [fraction] (0.00-1.00)									
Recov. factor, gas main phase [fraction] (0.00-1.00)	0.30	0.35	0.40						
Recov. factor, liquid ass. phase [fraction] (0.00-1.00)	0.30	0.35	0.40	For NPD use:					
Temperature, top res [°C] (>0)	73			Innrapp. av geolog-init:		NPD will insert value	Registrert - init:	NPD will insert value	Kart oppdatert
Pressure, top res [bar] (>0)	225			Dato:		NPD will insert value	Registrert Dato:	NPD will insert value	Kart dato
Cut off criteria for N/G calculation	1	2	3						Kart nr

Volume estimate have not been updated since APA2012 application. PL687 evaluation have resulted in new prospect risk in which have resulted in reli
licence.

5 Technical evaluations

Because no drillable prospects are identified, no new technical evaluations are performed regarding possible development of opportunities in licence.

6 Conclusions

The hydrocarbon potential for all large structures are tested and the remaining structural traps have limited volume potential. Stratigraphic and truncation traps in connection with the underlying rotated fault blocks, have been investigated and found to have very high prospect risk or to be too small.

Wells in the area have encountered sandstones of reservoir quality at multiple levels and the wells just west of licence area, have proved gas and oil migration in the Agat Formation (Agat Discovery).

The licence applications were based on the Parakeet prospect in deep marine sandstones in Early Cretaceous, Agat Formation and Oriana prospect in Upper Cretaceous, Tryggvasson Formation. In addition to identified leads in several stratigraphic levels.

Main risk factors for prospectivity at Cretaceous levels are trap definition and retention. For the deeper reservoir levels; of Upper- and Middle Jurassic age, the main risk factors are trap definition, retention and petroleum charge.

The key to mitigating risk on the stratigraphic prospects was to improve data quality and establish good seismic understanding for the expected seismic responses for sand and fluid. A good seismic understanding of gas filled Agat sands is established and the conclusion is that gas filled reservoir can be recognized. The Parakeet area only have a few small areas at different depths that indicates gas filled reservoir. It is highly unlikely that the prospect area contain oil accumulation.

The prospect evaluation of the new seismic data have resulted in significantly increased prospect risk.

The licence have not identified a valid drillable prospect and the remaining hydrocarbon potential is considered insignificant. The license have made a unanimous decision to relinquish the licence.

7 References

VNG Norge and GDF, 2012. Application for award in predefined areas, Block 36/1

Explora, 2012. Application for award in predefined areas, Block 36/1

Ichron Report, 2013. A biostratigraphic evaluation of 3 wells in Block N36, Agat Field, Norwegian Sea.

Bugge, T., Tveiten, B. & Backstrøm, S. 2001. The depositional history of the Cretaceous in the northeastern North Sea. In: Martinsen, O. J. & Dreyer, T. (eds) Sedimentary Environments Offshore Norway - Palaeozoic to Recent, NPF Special Publication, 10, 279-291.