RELINQUISHMENT REPORT PL641

A COMPANY IN THE
VNGGROUP

VNG Norge

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1 Key licence history

Production Licence (PL) 641 was awarded to VNG Norge AS (operator, 70%, referred to hereafter as VNG Norge) and Lundin Norway AS (partner, 30%) on 03 February 2012, as part of the APA 2011 licencing round. It covers 574 km^2 over parts of Blocks 6204/7, 8, 10 and 11. The initial work obligation was defined as follows:

- Within two years from award: reprocess 3D seismic and conduct relevant geological and geophysical studies before making a drill-or-drop decision (DoD) (03 February 2014).
- Within four years: drill an exploration well and decide to Concretize (BoK) or drop (03 February 2016)
- Within six years: perform conceptual studies and decide on Continuation (BoV) or drop (03 Fenruary 2018)
- Within seven years: prepare development plan and decide to submit PDO or drop. The initial period expires after 7 years (03 February 2019).

The work program involved reprocessing 3D seismic. This was delayed by over six months and as a result the licence group requested a one year extension of the drill-or-drop decision (18th November 2013). This application was granted by the Ministry on 03 February 2014 and the drill-or-drop date, as well as other subsequent decision gates, were then postponed by one year (DoD 03 February 2015).

During the licence period, a new prospect was identified that was not described in the initial application document. The Hahn prospect is a syn-rift Upper Jurassic Sognefjord deposit located between the Base Cretaceous Unconformity and the Basement. On 17 March 2013 VNG Norge completed an internal review, concluding that the PL 641 license potentially contained a significant resource base. An internal recommendation to drill a well on the Hahn prospect was made, conditional on VNG Norge reducing its equity to 40%. An attempt to farm down involved 11 companies attending a dataroom. Despite positive feedback from participants, a new partner could not be found and as a consequence, the license was forced to make a drop decision.

During the life of the licence, a number of meetings took place and were documented:

- 03 February 2012 - Joint Management Committee (MC) meeting No 1
- 20 November 2012 - Joint MC meeting and Exploration Committee (EC) meeting No 2
- 28 June 2013 - EC meeting No 3
- 18 November 2013 - Joint MC meeting No 3 and EC meeting No 4
- 20 March 2014 - EC work meeting
- 06 November 2014 - Joint MC meeting No 4 and EC meeting No 5

2 Database

The wells and seismic data used in the evaluation of the licence are show in Fig. 2.1.

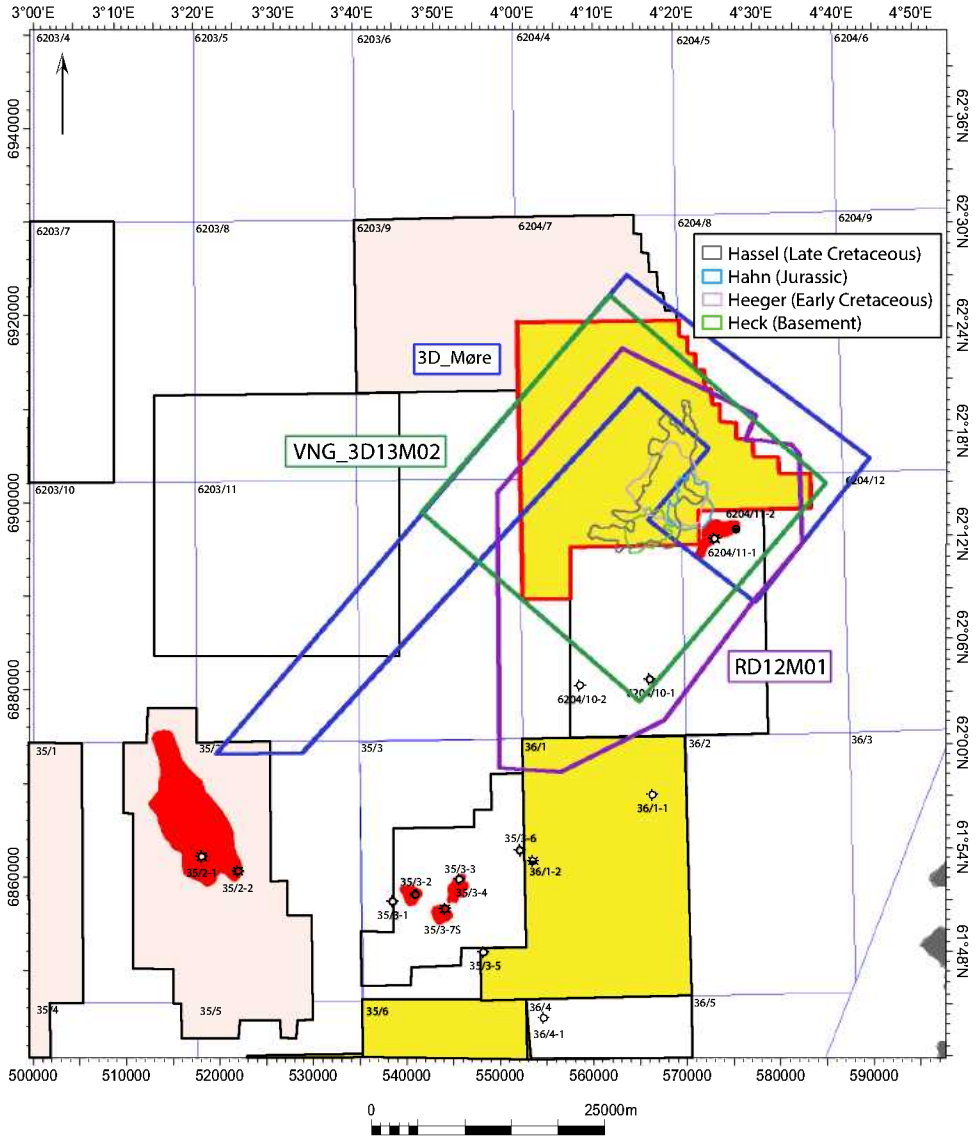

Fig. 2.1 Seismic database.
PL641 (red polygon), 3D Møre (blue), RD12M01 (purple) and the merged and reprocessed VNG13M02 is shown in green.

Seismic Database

The seismic evaluation of PL 641 was based on purchased and released data, as listed in the original application document (VNG Norge, 2011) (Fig. 2.1).

The following surveys were added to the licence database during the initial period:

- RD12M01
- 3DMØRE
- VNG13M02

RD12M01 is a reprocessed merge of the ST98M6 and ST9202 surveys. RD12M01 was reprocessed by the PL582 licence group and purchased by the PL641 licence in 2012. The PL641 licence group also purchased the CGG 3DMØRE survey which was first reprocessed to PSTM, then merged with RD12M01 and reprocessed to PSDM (APCBM and Kirchhoff),

forming VNG13M02. VNG13M02 had an estimated completion date of August 2013, however it was delayed and received 6 months late in January 2014. The data were received as time and depth volumes with full, near, mid and far stacks.

Despite the reprocessing, seismic data quality is poor and there are problems with imaging deeper levels, in part due to the fact that the underlying data, ST98M6 and ST9202 surveys, were shot with relatively short cables (3 km). In addition, there is a significant amount of seismic noise around the 6204/11-1 well, which was drilled on a local high, with gas at Trygvasson level. The signal to noise ratio is an issue with all cubes, especially in the prospect area, due to a lack of acoustic impedance contrast.

Well Database

The well database is as described in the original application document (VNG Norge, 2011), including 16 wells which are released or traded by the partnership. Once the regional mapping was completed and the Hahn prospect identified, the evaluation focused mainly on wells 6204/11-1 and 6204/11-2. These two wells both penetrate the Sognefjord Formation (the Hahn reservoir unit) and have been used for reservoir identification, log correlation, petrophysical calculations of reservoir parameters, seismic tie evaluations, seismic and maturity modelling.

3 Review of geological framework

The stratigraphy of the Northern North sea is well documented and shown in Fig. 3.1. Fig. 3.2 shows a regional line through the PL 641 with interpreted seismic horizons.

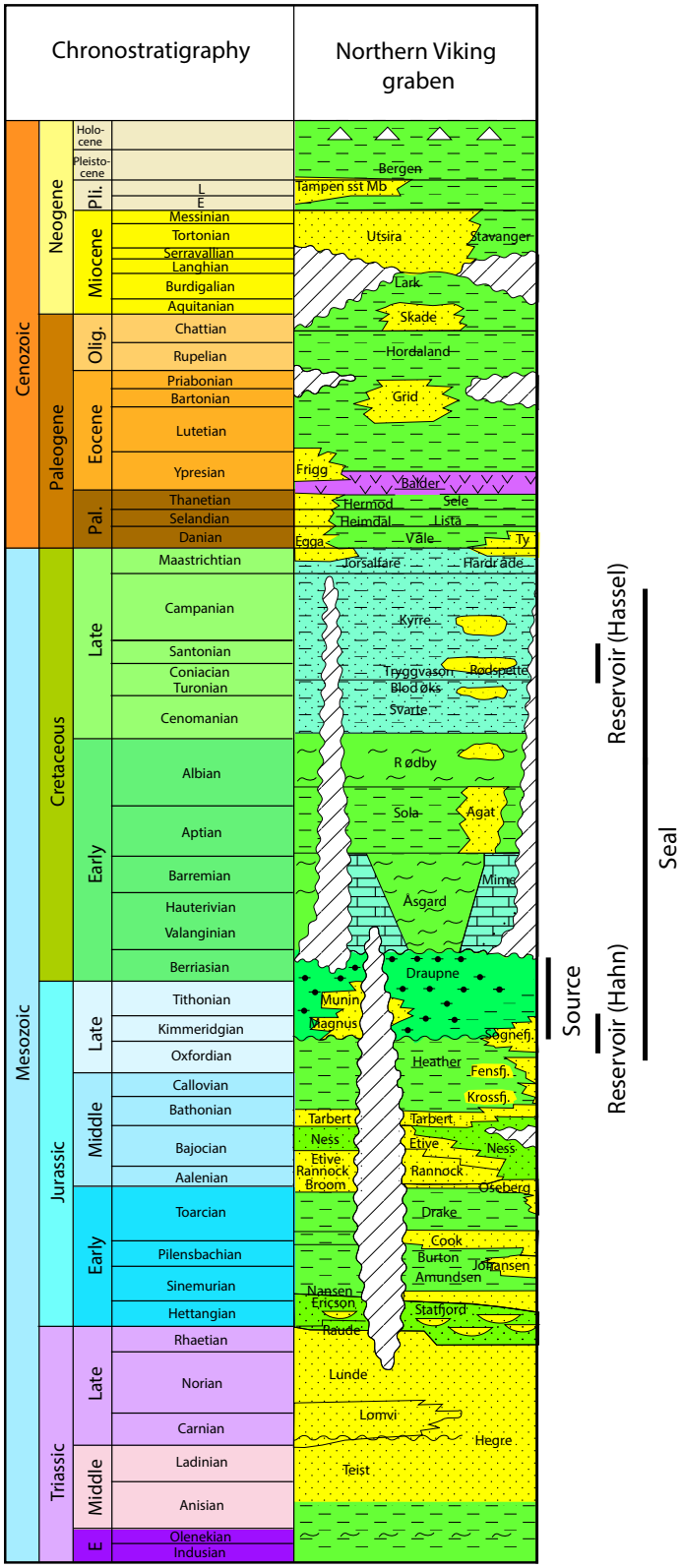

Fig. 3.1 Stratigraphic column for the Northen North Sea.

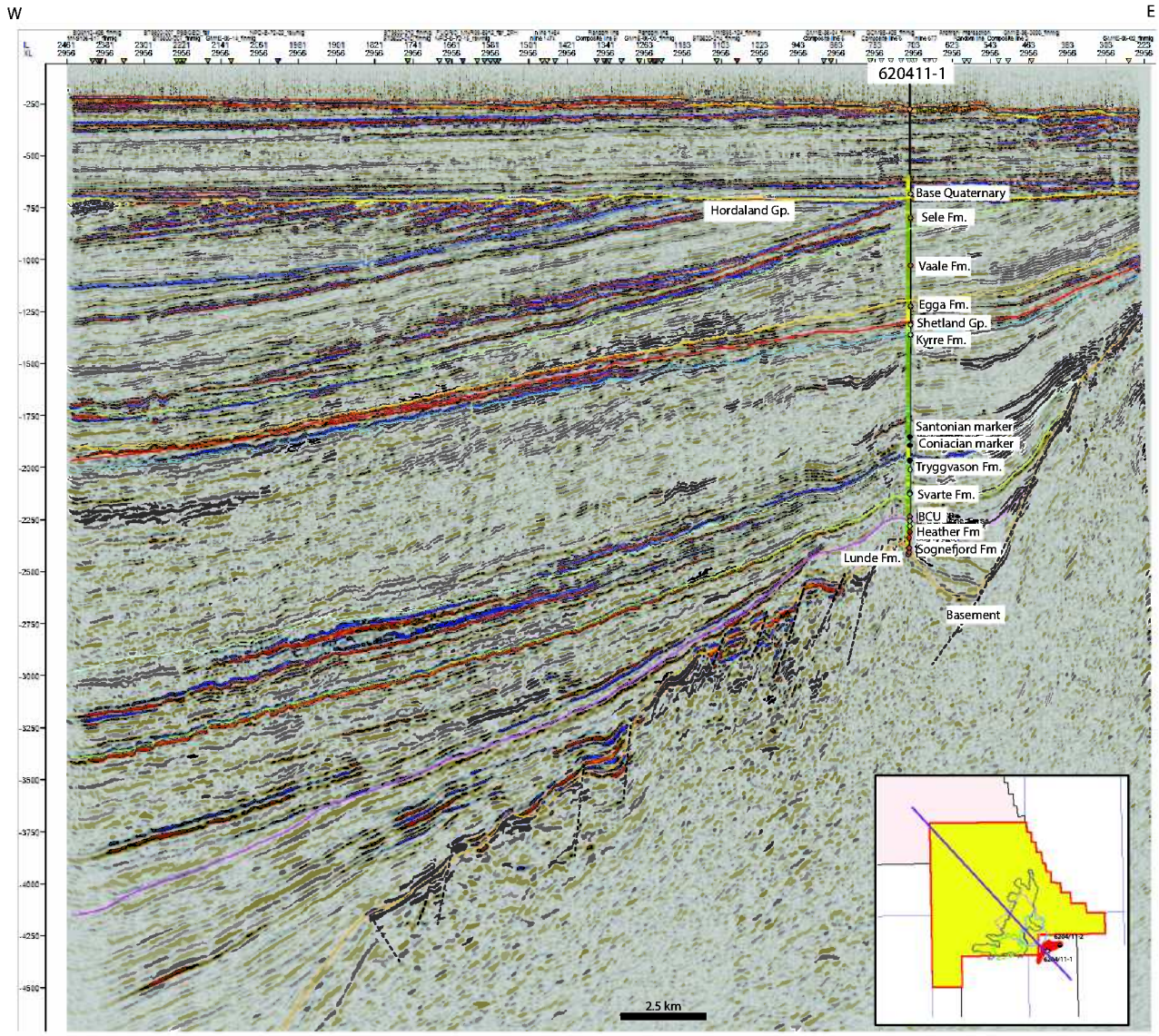

Fig. 3.2 Regional seismic line PL 641. RD12M01 Xline 2951

The original application concerned the Hassel prospect (VNG Norge, 2011) and the initial work program focussed on this.

Hassel is a Late Cretaceous (Kyrre Formation) slope fan system, previously interpreted as two separate fans (Hassel North and South) and now considered to be in connection. The main risk associated with the Hassel prospect is the trap. Large faults up dip of the Hassel prospect that were interpreted to be sealing during the application phase, were re-mapped on newer data and are now considered to be of less significance than previously thought.

The Hahn prospect was identified during initial regional mapping. Due to its significant potential resource base and lower associated risk, it was promoted to the main prospect in the licence.

Below is a brief summary of the studies conducted by the licence group, which helped to mature the geological framework within the PL 641 acreage. The following section is divided into those that focussed on the Late Cretaceous prospect (Hassel) and the Upper Jurassic Sognefjord prospect (Hahn).

a) Hassel Prospect

Sedimentology and Petrography

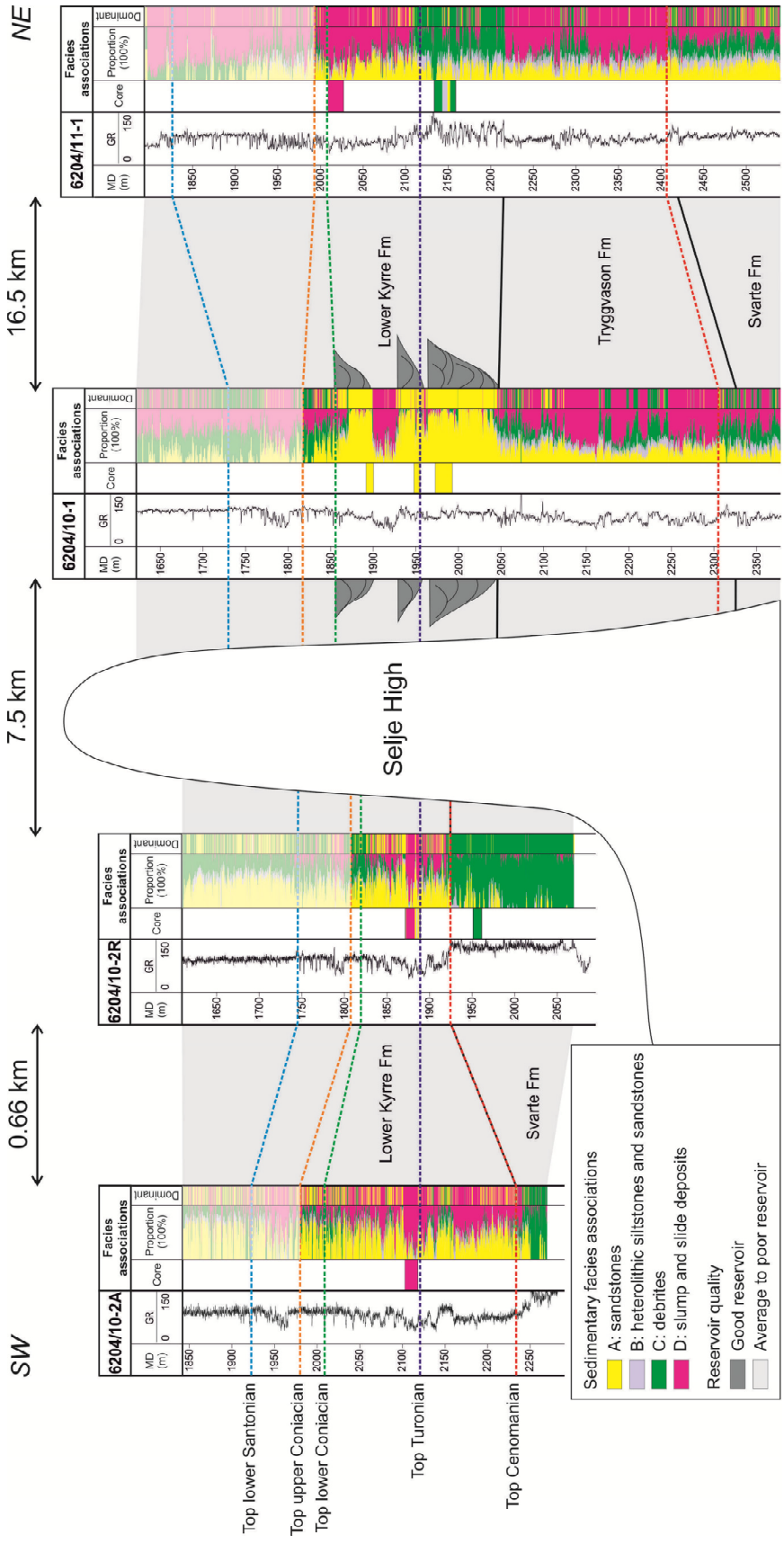

Fig. 3.3 Electrofacies correlation panel
(Prelat et al., in press). 6204/10-2A, 6204/10-2R, 6204/10/1 and 6204/11-1

In order to improve understanding of the distribution of sand and facies variability of the Kyrre Formation, VNG Norge sponsored a post Doctoral researcher from Imperial College London to describe the formation in cores from surrounding wells (6204/10-1, 6204/10-2A, 6204/10-2R, 6204/11-1 and 35/9-3T2). A number of deep water facies types can be recognised, including turbidites, slumps, debris flows and marly intervals.

A facies atlas for these sands was developed and combined with an internal VNG Norge thin-section description study (Baunack, 2013a). The interpreted facies associations from the cored intervals were incorperated with observed petrophysical properties and extrapolated to un-cored intervals (Fig. 3.3). Data from this study were published in Marine and Petroleum Geology *(Prelat et al., in press)*.

Seismic Data Analysis

In an attempt to identify potential locations for reservoir sand and hydrocarbons in the Hassel prospect and other potentially prospective levels, a comprehensive internal study in collaboration with PSS-Geo was initiated. Using gathers from the RD12M02 survey, a pre-stack inversion was completed. The key findings are summarised below:

- The Hassel prospect, defined by seismic amplitudes can be interpreted as a Class 4 AVO response
- This anomaly is also well defined using RGB blend.
- There is a problem with the phase in the seismic around the 6204/11-1 well, as well as a significant amount of noise on the seismic over a nearby local high.
- The quality of gathers is also poor and does not improve understanding of the reservoir.
- The presence of glauconite in these sands stiffens the rock frame resulting in lower sensitivity to fluid change, making if more difficult to differentiate between water and gas saturated sand.

b) Hahn Prospect
Structural restoration study

During the regional mapping, uncertainties arose regarding the position of the Base Cretaceous Unconformity (BCU), in particular deep into to the Slørebotn sub-basin where four possible candidates were interpreted. The position of the BCU has significant implications for both source rock generation and migration as well as for the development of potential reservoir. A structural reconstruction study with Badleys Geoscience Ltd, involving forward modelling and backstripping (Roberts, 2013) tested possible scenarios for the BCU using two 2D lines, one regional line (GMNR-94-102) and a local line covering only the PL 641 area (Xline 2938, RD12M01).

A number of models were tested, progressing from the Late Jurassic rift at 145 Ma through to the present-day. They attempted to match the major structural and stratigraphic features interpreted, using overlays of the present-day section and the backstripped sequence as constraints. The models incorperated well-known timing and basin-filling parameters from the North Sea.

A most probable candidate for the BCU was identified through a combination of forward modelling and backstripping. This places the Hahn prospect in shallow water during the time of Sognefjord deposition.

Sedimentology and Petrography

The 6204/11-1 discovery is located less than 1 km from the Hahn prospect and is the only well to core the Sognefjord Formation for many hundreds of kilometres. Three cores (Cores 4-6) and 21 thin sections from 6204/11-1 were described (Baunack, 2013b).

The Sognefjord Formation in this well is dominated by very fine- to medium-grained sandstones considered to represent a shallow marine shoreface and includes a unit of finer grained sediment which represents an offshore transition zone (Fig. 3.4). The cored section represents three incomplete coarsening upward cycles separated by distinct flooding surfaces. The un-cored section of Sognefjord Formation beneath has a similar log motif and is interpreted to represent another shoreface cycle.

The sandstones of the lower- and upper shoreface are of very good to excellent reservoir properties with average porosities between 21 - 23 % and average permeabilities between 124 - 509 mD. The most abundant cement phase is a pre- to syn-compactional, non-ferrous to ferrous calcite, which occurs in thick veins in the lower shoreface and transition zone, blocking all primary and most secondary pores and reduces the proportion of net reservoir slightly.

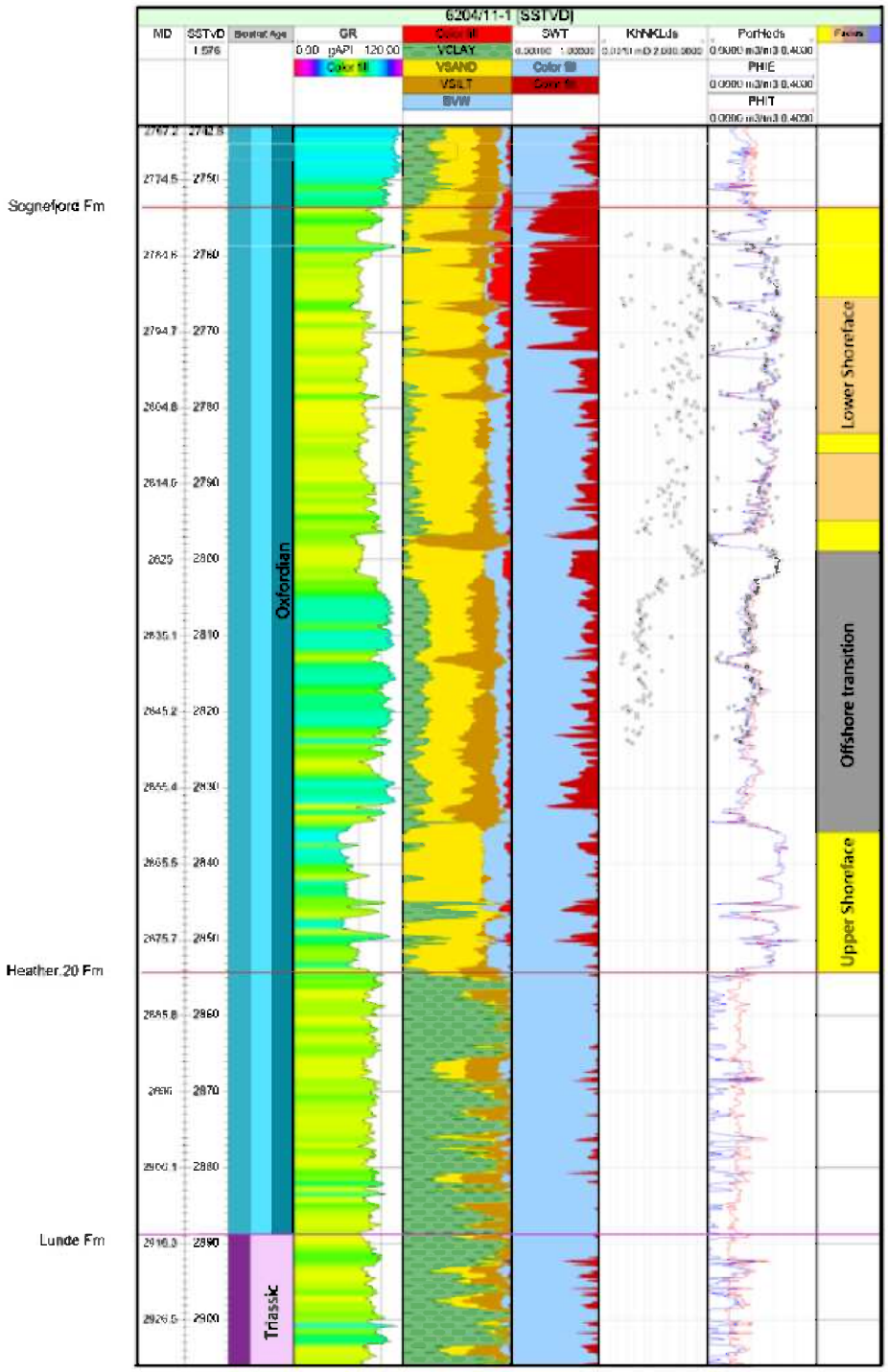

Fig. 3.4 Interpreted CPI for the Sognefjord interval in 6204/11-1.

4 Prospect update

All of the leads described in the application document were evaluated thoroughly. Three additional leads, were identified and are shown in Fig. 4.1.

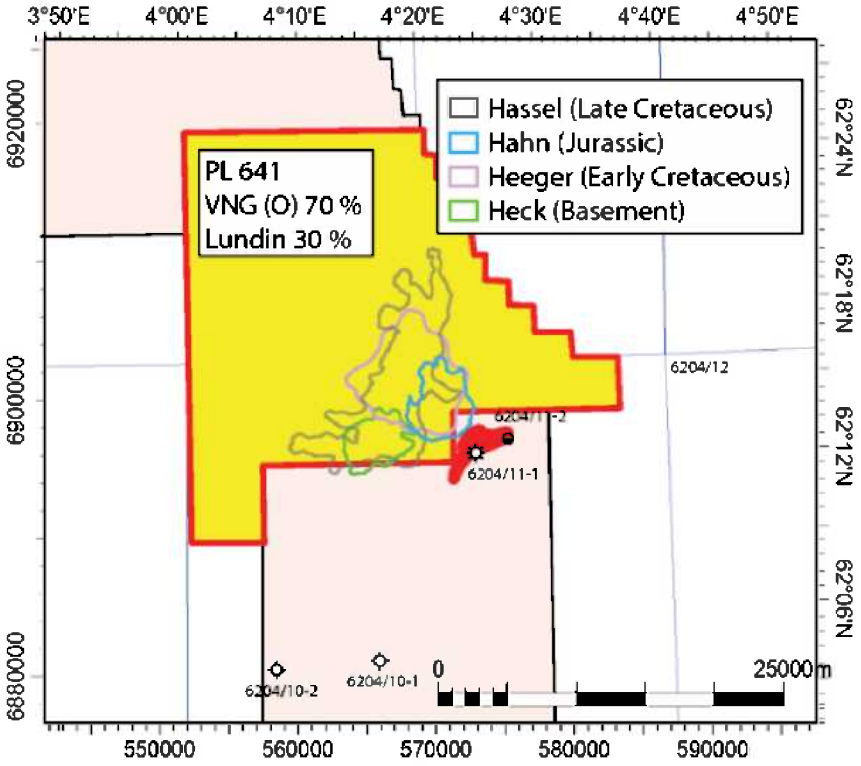

Fig. 4.1 Identified prospects and leads in PL641.

- Heeger is an Early Cretaceous fan. It remains a lead largely due to uncertainties regarding lithology as it cannot be tied to either of the local wells. A large section of pre-Cretaceous sediments are missing in wells 6204/11-1 and 6204/11-2.
- Hahn is considered the main prospect in the licence and is described below.
- Heck is interpreted to be a fractured, weathered basement play. None of the nearby wells have penetrated basement with reservoir characteristics and there are significant uncertainties around reservoir quality, volume and trapping.

Despite this, these leads are stacked and a well, targeting the Hahn prospect, could also test Heeger, Heck and Hassel, opening up potentially new play concepts in the area.

Hahn Prospect definition

The Hahn prospect is a shallow marine Upper Jurassic syn-rift deposit separated from up dip wells (6204/11-1, 6204/11-2) by a large fault. The souce is the Upper Jurassic Draupne Formation, Upper Jurassic Sognefjord Formation sands form the reservoir and the propsect is sealed by Lower Cretaceous shales.

The prospect was mapped on the RD12M01 PSTM full stack cube. Reflectivity of the reservoir is poor, in both the well and the prospect and faulting makes it difficult to correlate between the two. However, the BCU and Basement reflectors can be tied to the wells and mapped relatively easily. These horizons form a closed volume of rock with a pinchout to the North East (Lower Cretaceous shales on basement), and a fault closure to the South East, defining the prospect. A line showing the regional geology through the licence and prospect is shown in Fig. 4.2.

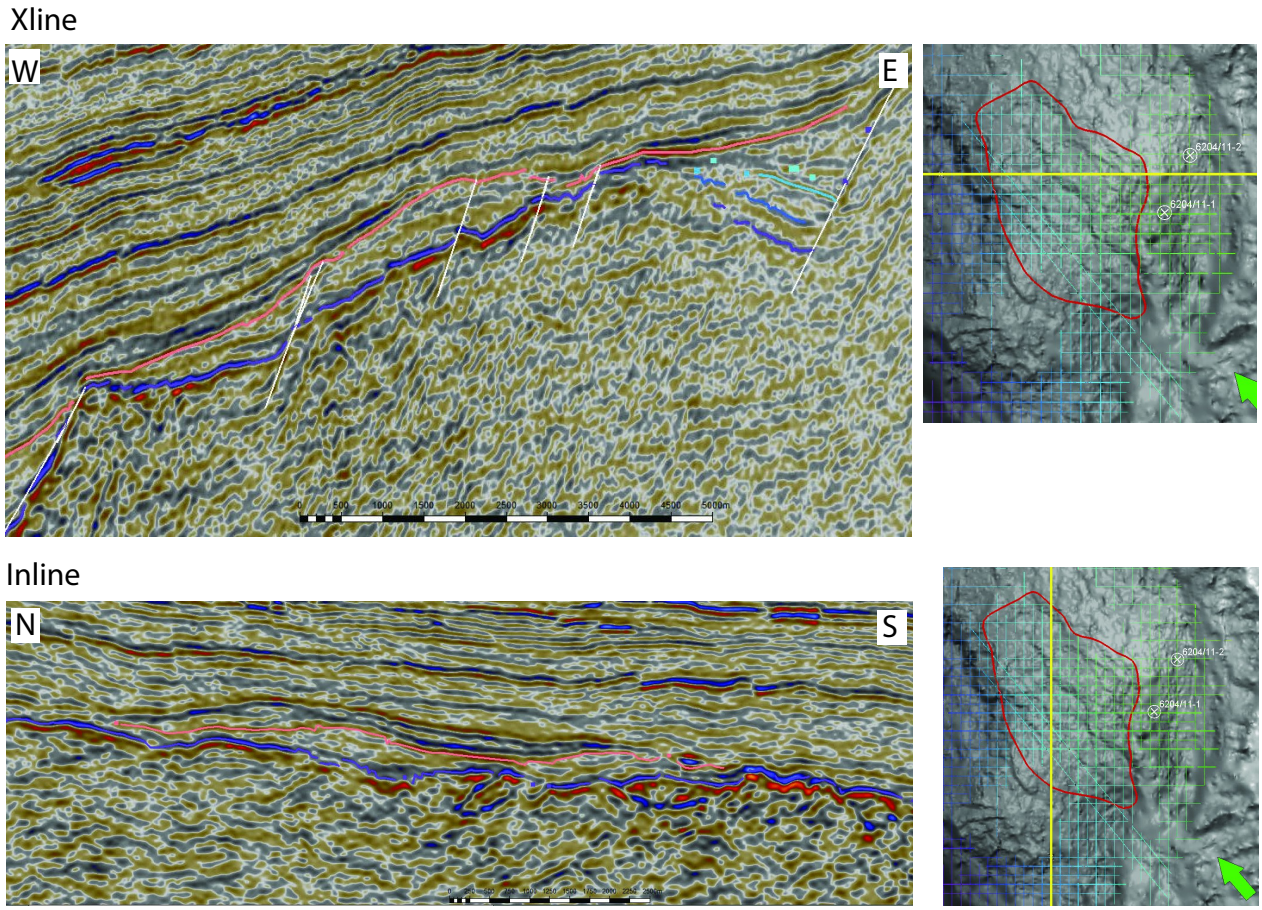

Fig. 4.2 Inline and Xline through the Hahn prospect.

A drop in acoustic impedance represents the Top reservoir in the 6204/11-1 discovery, although this is masked to some extent by a number of thin cemented layers. Modelling of the well demonstrates it is difficult to differentiate between a wet, oil and a gas case. The measured gas water contact in 6204/11-1 can not be identified in the seismic data and our conclusion is that the data quality at this depth is not good enough for seismic data analysis (SDA).

Reservoir

Seismic interpretation and a regional structural restoration study suggests that the prospect is filled with early syn-rift sediments deposited during an extensional regime.

The 6204/11-1 well contains 105 m of shallow marine Sognefjord Formation representing three progradational shoreface cycles, 18 m, 11.5 m and 30 m (The remaining 45 m representing an offshore transition zone). Analogues suggest shorefaces of this thickness typically prograde up to 10 km (Howell et al., 2008) and therefore the Hahn prospect, less than 1 km away, is interpreted to contain similar shoreface sands.

The Sognefjord in well 6204/11-1 has excellent reservoir properties with very little compaction and no significant depth trends in porosity. Net to gross is extremely high. The minimal non-net observed is due to the presence of early calcite cements, the thickest of which is 1.56 m. These show evidence of oil staining beneath, however their contacts are unconformable to bedding and it is considered unlikely that they are laterally extensive or a widespread barrier to flow.

Trap definition

A number of faults have been mapped based on the offset of the basement reflector. Including a large fault immediately west of well 6204/11-1. The prospect relies on a seal at this fault to avoid leaking into the 6204/11-1 well.

Fault seal analysis indicates no support from shale gouge as the reservoir is a clean sand and faulting occurred at relatively shallow depths. In this case the seal must rely on a displacement of over 90 m, giving sand shale juxtaposition and juxtaposition against the basement to form a trap. The measured displacement of more than 200 m is interpreted to be adequate to achieve this. (Fig. 4.3)

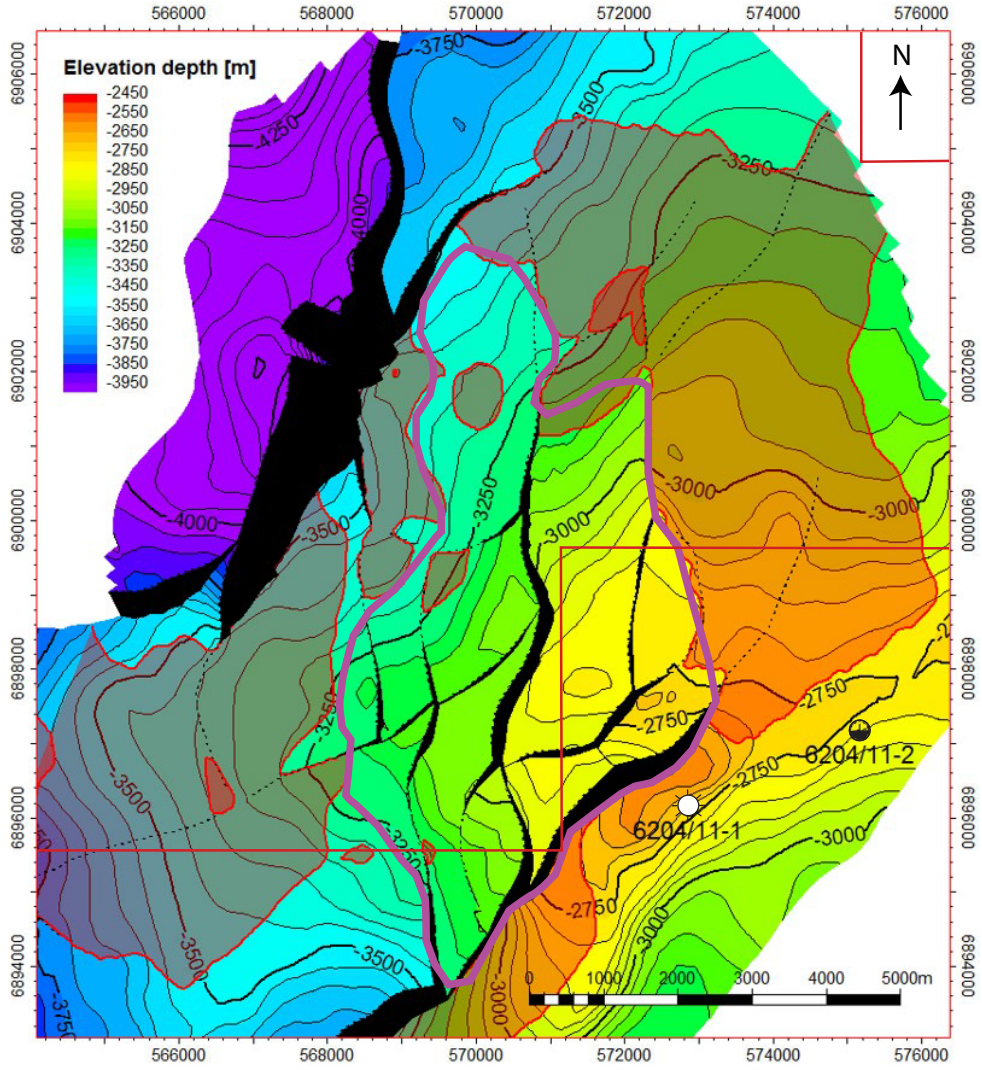

Fig. 4.3 Modelled top reservoir depth map.
Prospect outline in purple. Reservoir is eroded/not present in shaded areas.

Faults appear to die out on the maps generated although this is an artefact caused by the erosion of the basement by the BCU. In these locations this erosion means there is no offset on the 'top basement' reflector, creating the impression that there is no displacement on the fault.

Seal

well 6204/11-1 penetrated 125 m Draupne Formation and 200 m of Svarte Formation shale above the reservoir with no evidence of sandy sediments. Similar shale dominated overburden is expected directly above the prospect although the Lower Cretaceous sediments seen there correspond to a large unconformity in the well. If there are sands in the Lowermost Cretaceous there is a good chance that they will pinch out up dip and as such represent an upside potential in the license. The Heeger lead described briefly above is one such example of Lower Cretaceous potential.

Despite the dominance of shale in the sequence, the prospect also relies on a lateral seal to the North East where Cretaceous sediments sit directly on basement. In this area there is a risk that a permeable lag has developed above the basement that could act as a thief sand.

Source

The 6204/11-1 and 6204/11-2 wells have 130 and 45 m of Draupne Formation, classified as good to excellent source rocks based on their TOC % of 4.2-6.0 (Alderson et al., 2009). Basin modelling indicates that these source rocks are likely to be at peak oil generation towards the down dip extent of the prospect. In the deeper basin, 10 km from the prospect, the same source rocks are anticipated to be producing gas and it is likely that this gas production has been ongoing for some time.

A gas sample from the Sognefjord Formation in well 6204/11-1 has an estimated (using stable carbon isotope composition) vitrinite reflectance maturity of 1.1 %Ro , which is much higher than measured in the Draupne Formation in the well location, suggesting the gas has come from a much deeper source (4+ km). There are alternative migration routes North and South of the prospect such that the presence of gas does not indicate trap failure.

A gas chromatograph of hydrocarbons from the Sognefjord formation shows evidence of: biodegration, refilling with fresh oil and then later gas. The early alkanes are missing, perhaps as a result of evaporative fractionation which may or may not of occurred during the Neogene uplift and erosion event (2.8 Ma).

Probability of success

The probability of success for the Hahn prospect has been estimated at 27%. Seal/ retention is identified as the principal risk.

Volumetrics

As the top and base reservoir are not visible on seismic, a reservoir model was constructed to determine volumes, based on observations from offset wells. The thickness of the Sognefjord Formation in the prospect is uncertain, however the BCU and basement reflectors have been mapped on seismic and tied to wells. The reservoir is modelled as constant thickness, a constant distance from the basement, based on the 6204/11-1 data, except where the reservoir is eroded by the BCU.

The crest of the Hahn closure is located at 2800 m TVDss and a clear spill point has been identified on the base case model (Fig. 4.3). Despite the observed spill point, there are other risks of leakage, juxtaposition against a basement lag, juxtaposition against unidentified Lower Cretaceous sediments.(Fig. 4.3)

A number of key uncertainties were identified for the volume estimates including the contact height, the thickness of the reservoir and the thickness of the Lower Heather / Triassic section below the Sognefjord Formation. All of these were varied to achieve a likely distribution for the gross rock volume in the prospect.

The most likely hydrocarbon phase is considered to be gas, (80/20 Oil/Gas). In a gas case the partnership planned to produce gas from the 6204/11-1 discovery (P 50 Total resources 1.93 Mm3 oil equivalent).

Only one of the faults in the reservoir is anticipated to have sufficient displacement to form a seal. This fault splits the prospect into two segments, Hahn East and Hahn West. The two segments have similar risks and it is anticipated that if one is found to be hydrocarbon bearing, the other is likely to be hydrocarbon bearing too. This correlation is set at 80%.

A summary of prospect data is shown in Table 4.1.

The Agat discovery and appraisal wells were used as an analogue to estimate fluid parameters. The input ranges for the prospects are regional well- and field data to the south of PL 641 i.e. Gjøa, Knarr, Grosbeak, Fram and Troll. Key wells 35/9-3, 34/3-1S, 35/11-4 and 35/12-4S also contributed to the evaluation of the reservoir, though drillstem tests results, pressure and temperature measurements.

In order to produce from the Hahn prospect, the drainage strategy is natural depletion with an estimated mean recovery factor of 64 %. For the mean case, 8 production well; with a mixture of vertical to highly deviated, to ensure vertical connectivity to the multiple layers of stacked pay. The average gas production rate per well expected is 2 MSm3/d of gas. For the base case; the reserves per well is in order of 3.8 MSm^3 o.e. Fig. 4.4 shows the untruncated base production profile for the Hahn prospect.

Table 4.1 Prospect data for prospect Hahn. (NPD Table 1)

Block	6204/10 and 6204/11	Prospect name	Hahn	Discovery/Prosp/Lead		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:		Reported by company	VNG	Reference document	0			Assessment year	2014
This is case no.:		Structural element	Slørebotn Sub-basin	Type of trap	Structural	Water depth [m MSL] (>0)	180	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	High (P10)
In place resources	Oil [10^6 Sm^3] (>0.00)								
	Gas [10^9 Sm^3] (>0.00)	16,70	28,40	40,40	68,60				
Recoverable resources	Oil [10^6 Sm^3] (>0.00)								
	Gas [10^9 Sm^3] (>0.00)	10,20	15,60	25,90	45,40	0,93	1,77	2,43	4,36
Reservoir Chrono (from)	0	Reservoir litho (from)	0	Source Rock, chrono primary	0	Source Rock, litho primary	0	Seal, Chrono	0
Reservoir Chrono (to)	0	Reservoir litho (to)	0	Source Rock, chrono secondary	0	Source Rock, litho secondary	0	Seal, Litho	0
Probability [fraction]									
Technical (oil + gas + oil & gas case) (0.00-1.00)	0,00	Oil case (0.00-1.00)	0,00	Gas case (0.00-1.00)	0,00	Oil & Gas case (0.00-1.00)	0,00		
Reservoir (P1) (0.00-1.00)	0,00	Trap (P2) (0.00-1.00)	0,00	Charge (P3) (0.00-1.00)	0,00	Retention (P4) (0.00-1.00)	0,00		
Parametres:	Low (P90)	Base	High (P10)	*Comments*					
Depth to top of prospect [m MSL] (> 0)		2800							
Area of closure [km^2] (> 0.0)									
Reservoir thickness [m] (> 0)	30	100	200						
HC column in prospect [m] (> 0)	120	400	700						
Gross rock vol. [10^9 m^3] (> 0.000)	501,000	1269,000	2135,000						
Net / Gross [fraction] (0.00-1.00)	0,61	0,84	0,88						
Porosity [fraction] (0.00-1.00)	0,17	0,20	0,23						
Permeability [mD] (> 0.0)									
Water Saturation [fraction] (0.00-1.00)	0,60	0,69	0,80						
Bg [Rm3/Sm3] (< 1.0000)									
1/Bo [Sm3/Rm3] (< 1.00)									
GOR, free gas [Sm^3/Sm^3] (> 0)									
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)	0,50	0,63	0,80						
Recov. factor, liquid ass. phase [fraction] (0.00-1.00)	0,45	0,58	0,75	For NPD use:					
Temperature, top res [°C] (>0)				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)				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

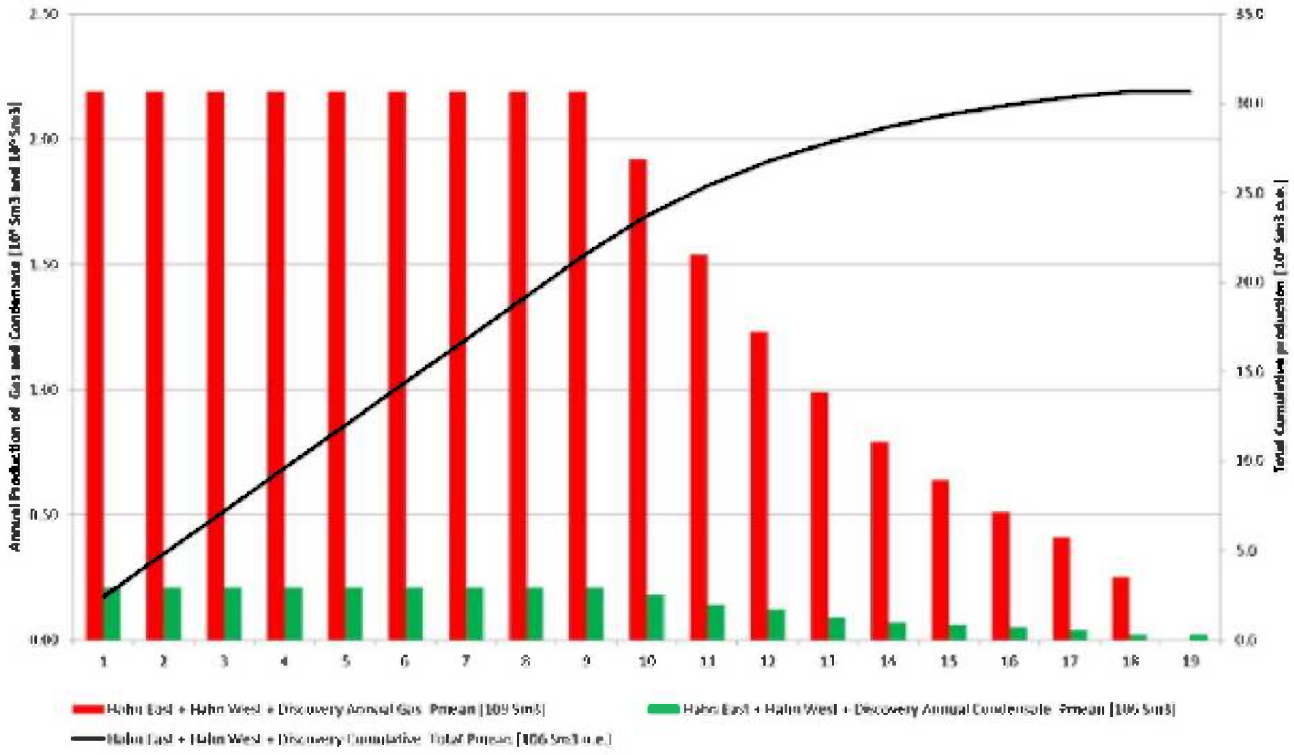

Fig. 4.4 Base production profile (untruncated).
Plateau production is expected to last for nine years, then gently decrease for the following nine years, yielding to a total production period of 18 years.

5 Technical evaluations

A technical and economical evaluation of the Hahn prospect was conducted in 2013-14. 'The evaluation is summerized below:

Field Development Plan

Hahn was planned to be developed as a gas field and the envisaged field development solution is shown in Fig. 5.1. The main properties of this solution are as follows:

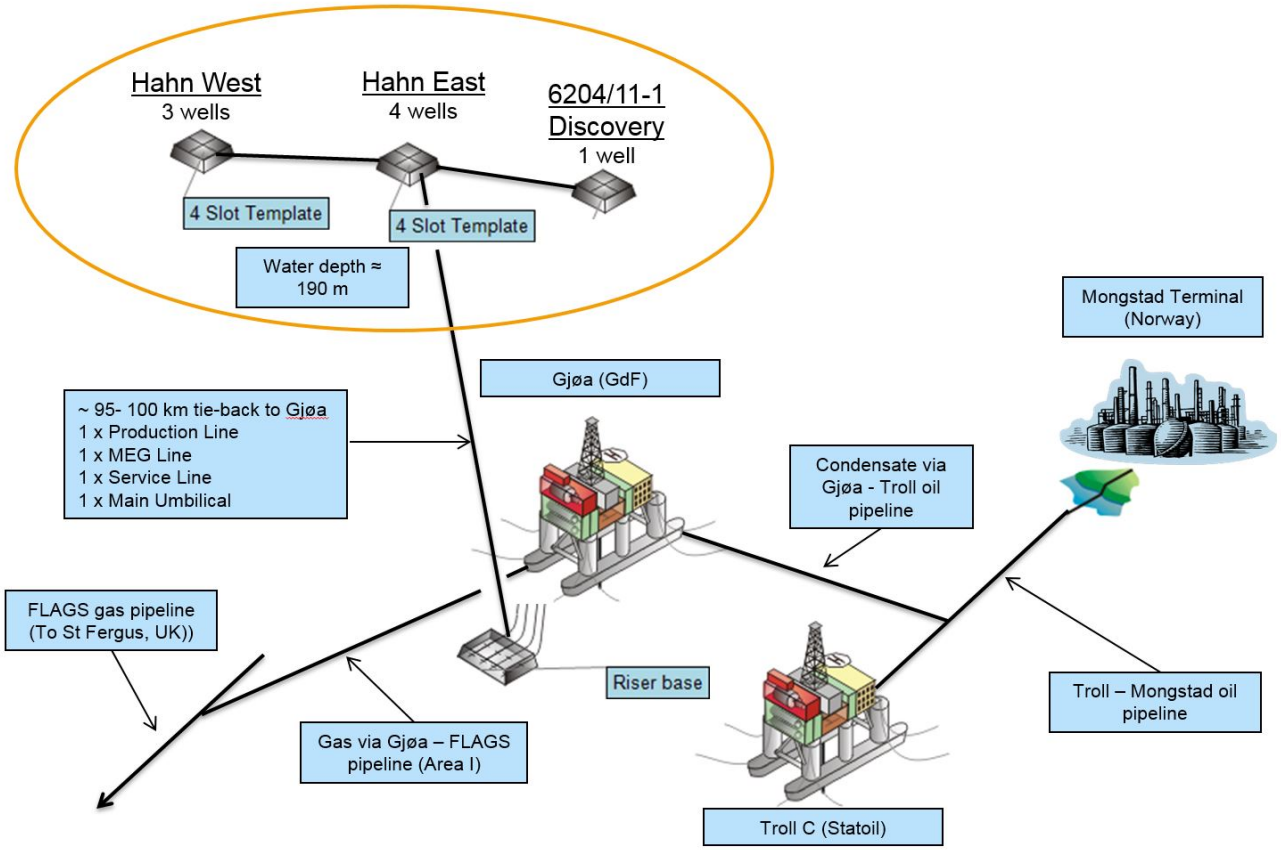

Fig. 5.1 Field development solution for the Hahn prospect

- 100 km Subsea tie-back to Gjøa
- Production flowline, Cladded Carbon steel (16'' ID), Reel installation
  - Assumed cladded carbon steel to mitigate against possible CO_2 and H_2S
- Separate MEG and Service line for hydrate mitigation (4-6")
- Continuous MEG injection assumed for hydrate control
  - Negligible water production assumed. The risk of salt cloffing Vega MEG regeneration system on Gjøa. Close monitoring of water breakthrough required.
- Gas production profile assumed constrained by Vega process train capacity (6MSm³/S)
- Two drill centres, each with a 4-slot template and a total of 6 production wells
  - Provides spare slots, optimises well locations and eliminates the need for heavy lift
- One satellite tree tied back to Hahn East template for 6204/11-4 (3 km assumed)
- Medium topside modifications at Gjøa assumed (500 MNOK)
- Low CO_2 and H_2S assumed based on nearby discoveries (Agat and Peon)
- Limited condensate production assumed to avoid slugging problems

The following development schedule was envisaged for the Hahn gas field:

- 2015: Exploration well and DST in Hahn East with a side track to Hahn West
- 2016: Appraisal well and side track into Hahn west (assuming a discovery in Hahn West)
- 2016: DG 1 and DG 2
- 2018: DG 3 (FEED and PDO)
- 2019-2021: Construction and installation of SURF and SPS and Topside modifications
- 2021-2022: Drilling of production wells (P Mean)
- 2022: Production start up

Development, Production and Decommissioning Costs

Th following costs are calculated for a 100% share in the licence.

Table 5.1 Development costs for the Hahn prospect

	Cost for PMean Case (MNOK)				
Scenario	**Exploration**	**CAPEX**	**OPEX**	**Tarrifs**	**Abandonment**
Hahn East + 6204/11-1	1510	9466	2806	6035	1298
Hahn East + West + 6204/11-1	1764	11058	4609	9034	1853

6 Conclusions

During the initial licence period, the PL 641 licence group evaluated all leads and prospects identified during the application phase, as well as identifying additional undescribed leads. A drillable prospect, Hahn, was identified.

The licence is located in the North eastern most part of the Northern North Sea, an area with very few exploration wells, which are all drilled on one side of a high. The licence group believes in the petroleum potential of the acreage and that a well in this area could test and open up several new plays in the region. However, the current resource potential and risk does not justify a well.

7 References

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