

PL948

Relinquishment Report



Myken



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1 LICENCE HISTORY

1.1 Licence Owners

The PL948 licence owners:

Operator: Aker BP ASA (40%)

Partners: Petrolia NOCO AS (30%) & Equinor Energy AS (30%)

1.2 Award and Work Program

Production Licence 948 was awarded in APA2017 on the 02.03.2018 with a drill decision within two (2) years and an initial period of seven (7) years. The licence area covers part of the block 6610/2, as seen in Fig. 1.1.

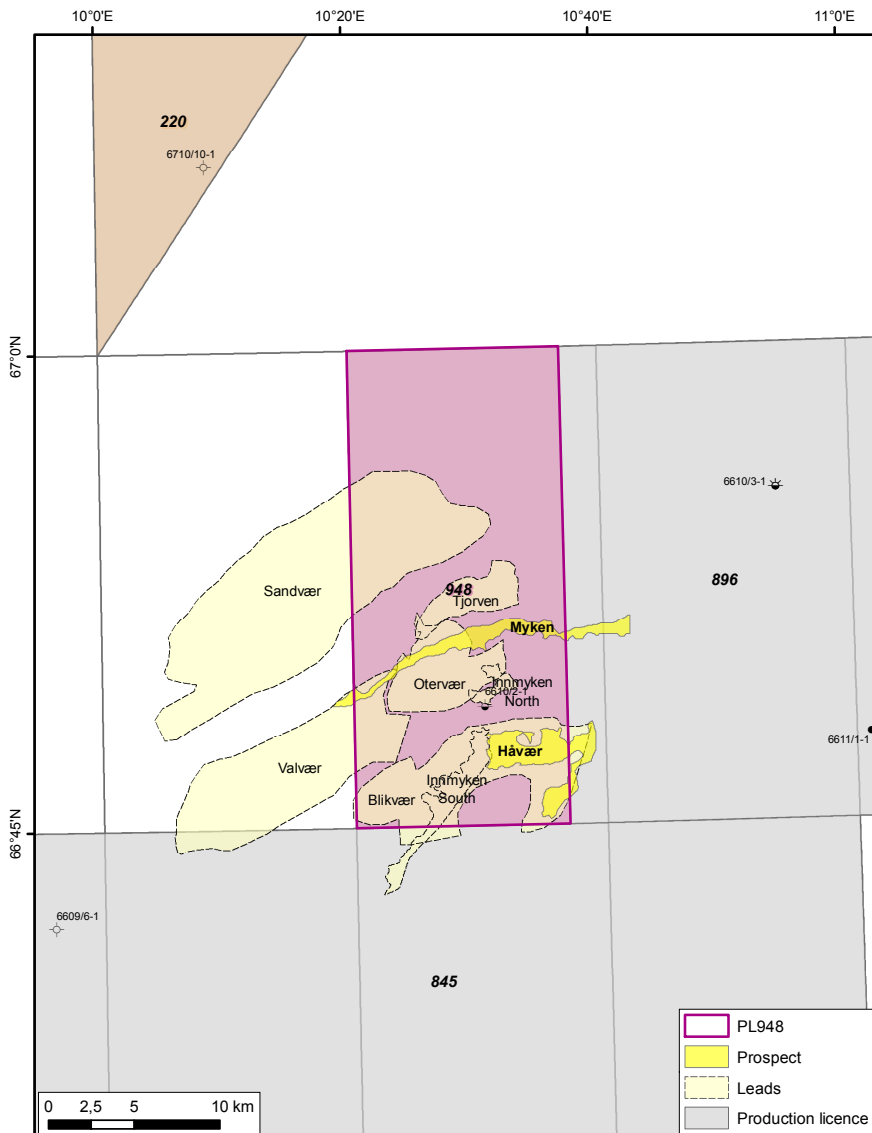


Fig. 1.1 PL948 prospects and leads overview map

The initial partners in the licence were Aker BP ASA (40% and operator), Petrolia NOCO AS (30 %) and Statoil Petroleum AS (30 %). In May 2018, Statoil Petroleum AS changed name to Equinor Energy AS.

The work commitment was to conduct geological & geophysical studies and an EM feasibility study leading to a drill-or-drop decision after two years. The licence drill or drop decision deadline was March 2, 2020.

During the licence period, six EC and/or MC meetings were held by the operator to share and discuss the database and prospectivity evaluations with the licence partners.

The work obligations have been fulfilled and the opportunities outlined in the licence were fully evaluated.

1.3 Identified Prospectivity

PL948 is located in block 6610/2, a part of the Grønøy High on the northeastern part of the Nordland Ridge (Fig. 1.2). The closest infrastructure is the Norne FPSO approximately 140km southwest, and Aasta Hansteen approximately 150km to the west.

The main identified prospects are the Cretaceous Myken Prospect and the Jurassic Håvær Prospect, but seven additional leads are also mapped within the license acreage, in respectively Kvitnos (Innmyken North and South), Lysing (Sandvær), Jurassic (Blikvær and Tjorven) and Triassic (Otevær & Valvær). The Sandvær and the Valvær leads extend into the relinquished license PL895 to the west, where the leads have been evaluated as high risk (Relinquishment Report PL895, 2019).

The main prospect, Myken, it is a 3-way dip-closure with fault seal towards the Grønøy High. The identified prospects in the license all have seal and charge as key risks.

Marginal resource potential and high risk prospectivity, makes it infeasible to take a drill decision. Therefore, a decision was taken to relinquish PL948.

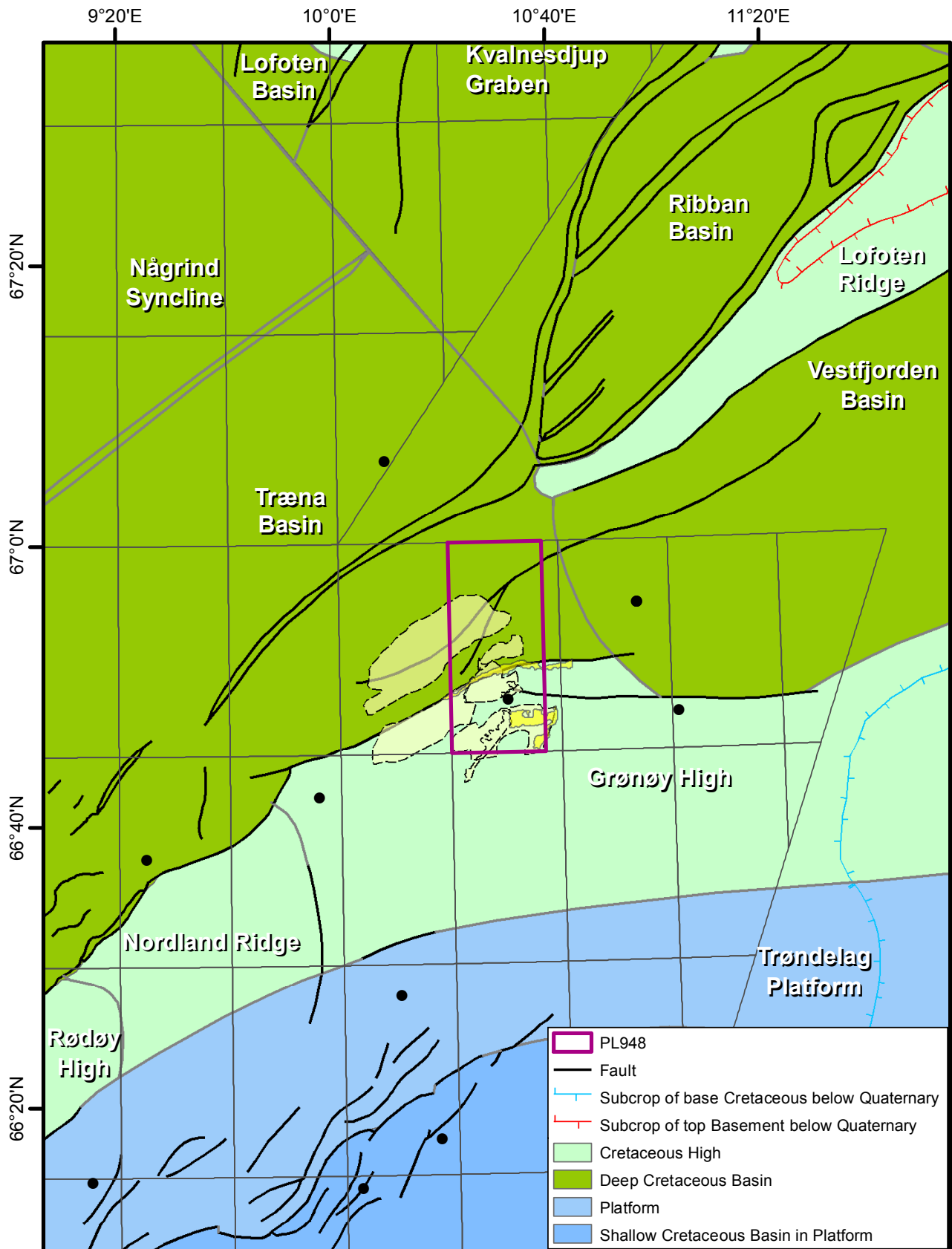


Fig. 1.2 Structural elements map

2 DATABASE

2.1 Seismic Database

The seismic database is listed in Table 2.1 and the survey outlines are shown in Fig. 2.1.

Table 2.1 Seismic data list

Survey name	Vintage	Company	NPD/Diskos survey ID	Public
NOR1001	2010 reprocessed	North Energy	7926615679	Yes
EO13002	2013	E.ON /Artemis Arctic	7854	Yes
PGS16005	2016	PGS MC	8321	No
ST9604	1996	Statoil	3831	Yes
ST9404R97	1997 reprocessed	Statoil	16147637	Yes
WIN12002WIM13	2012	Wintershall / Polarcus	8801715358	Yes
WIN16M01	2016 reprocessed	Wintershall	10085393196	Yes

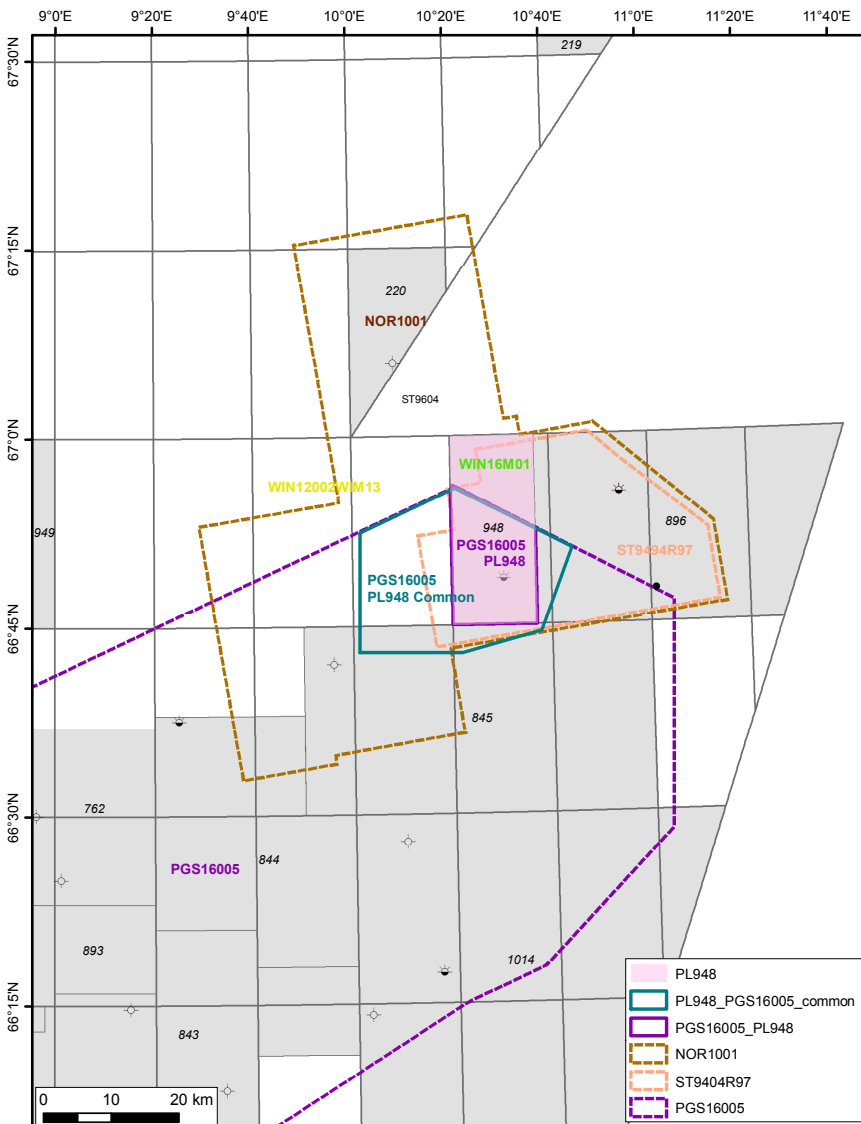


Fig. 2.1 Seismic database for PL948

The PGS16005 geostreamer 3D dataset has been used as the main survey for detailed prospectivity evaluation. It was also the basis for an inversion study in the licence. A part of this dataset was included in the licence common database (Blue polygon in Fig. 2.1). In addition, all relevant public data (especially NOR1001) has been used for the technical evaluation.

2.2 Well Data

The reference wells used in the geological and geophysical evaluation of the prospects and leads are listed in Table 2.2 and shown on the map Fig. 2.2. Key wells are marked in the table and highlighted on the map.

Table 2.2 Well database

Wells	Location	Year (completed)	TD Formation	Contents	NPDID	2 year released	Key wells
6608/8-1	Rødøy High	1997	Zechstein Group	Oil shows	2974	Yes	
6608/10-1	Dønna Terrace	1989	Åre Formation	Dry	1391	Yes	
6608/11-4	Sør High	2004	Red Beds	Oil	4939	Yes	
6608/11-5	Sør High	2006	Red Beds	Shows	5316	Yes	
6609/5-1	Nordland Ridge	1985	Red Beds	Shows	445	Yes	
6609/6-1	Nordland Ridge	2007	Red Beds	Dry	5626	Yes	X
6609/7-1	Nordland Ridge	1983	Basement	Dry	19	Yes	
6609/10-1	Trøndelag Platform	1983	Red Beds	Dry	24	Yes	
6609/10-2	Helgeland Basin	2009	Grey Beds	Dry	6188	Yes	
6609/11-1	Helgeland Basin	1983	Åre Fm	Dry	15	Yes	
6610/2-1 S	Grønøy High	1996	Red Beds	Shows	2874	Yes	X
6610/3-1 6610/3-1 R	Vestfjorden Basin	1993	Lange Fm /Red Beds	Shows	1864 2193	Yes	X
6610/7-1	Helgeland Basin	1983	Red Beds	Shows	12	Yes	
6610/7-2	Grønøy High	1984	Grey Beds	Dry	26	Yes	X
6710/10-1	Bivrost Lineament	2000	Springar Fm.	Dry	3941	Yes	

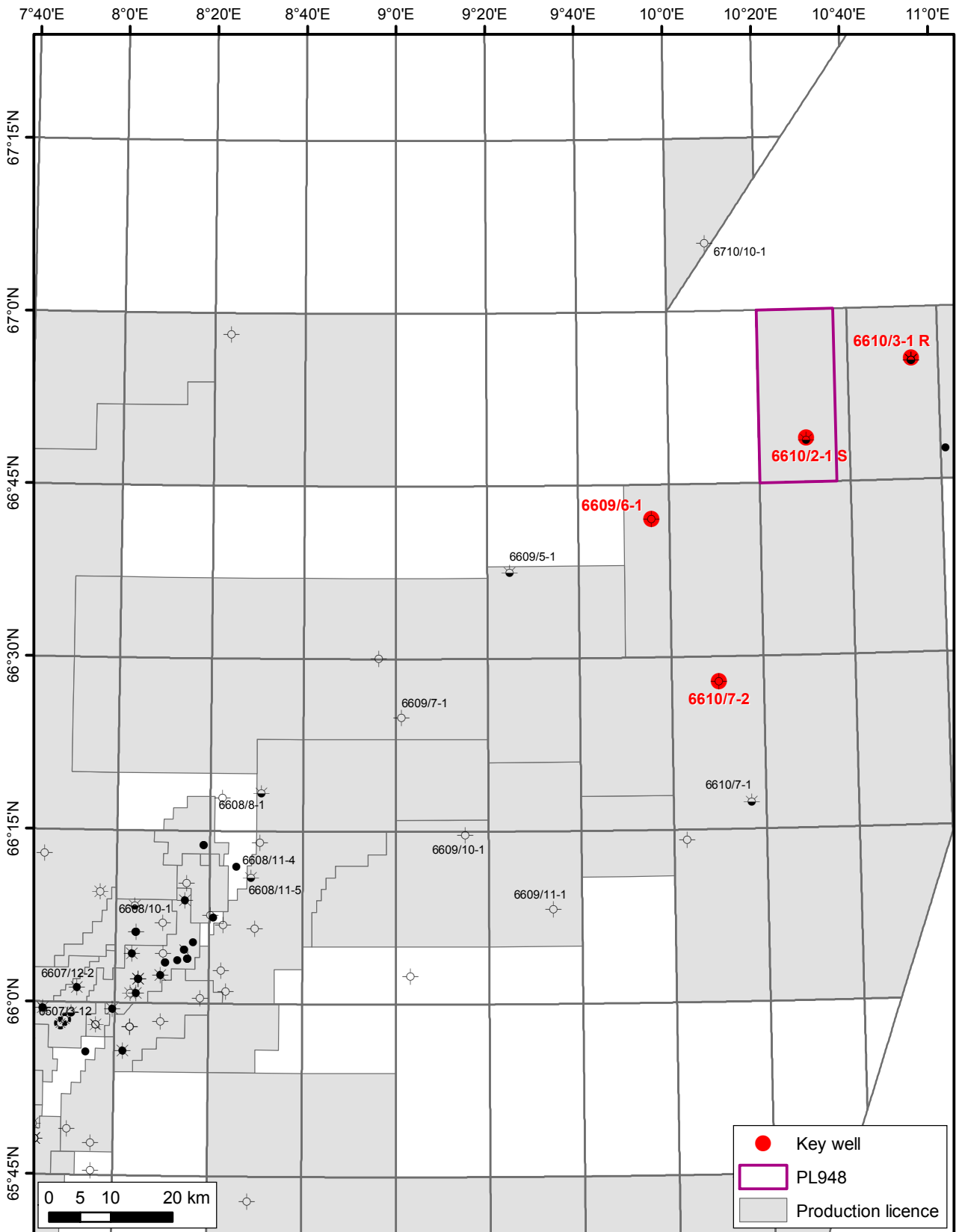


Fig. 2.2 Reference wells for PL948

3 Summary of geological and geophysical studies

Several geological and geophysical studies have been performed to enhance our understanding of the prospectivity in the licence area:

- Rock physics, AVO and an inversion study were performed to de-risk the Cretaceous and Jurassic prospectivity
- An EM feasibility study was performed for the licence prospectivity
- Evaluated the source rock potential and maturity of the Upper Jurassic as well as the source rock potential of the Cretaceous succession
- Internal petroleum system modelling and fluid inclusions studies were completed to increase understating of migration, timing and key uncertainties (Fig. 3.1)
- Internal sedimentological reviews of the Cretaceous and Jurassic stratigraphy and relevant facies in and around licence area

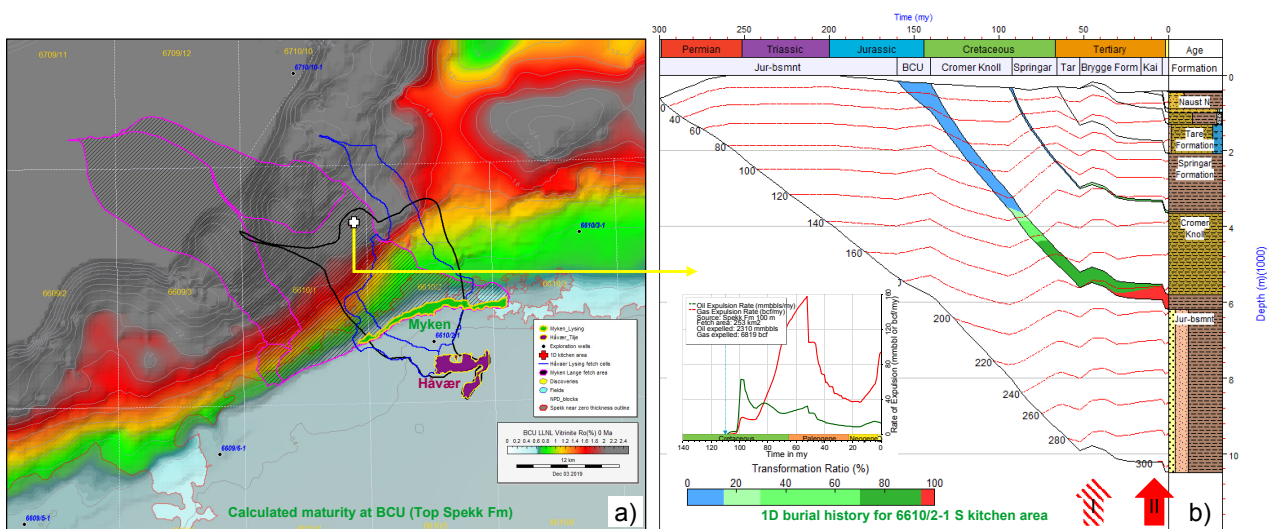


Fig. 3.1 Fetch areas and maturity evolution of Myken and Håvær prospect. a) Calculated maturity at BCU (Top Spekk Fm.) b) 1D burial history for 6610/2 kitchen area

Seismic interpretation in the licence area was primarily carried out on the PGS16005 seismic data. Seismic to well ties were performed for the relevant wells and the synthetic to real seismic match is good to moderate for the wells. Seismic horizons that were interpreted in the area are Seafloor, Top Shetland, Top Kvitnos, Top Lysing, BCU, Top Tilje and Intra Åre Coal. The Top Lysing surface has been used to define the 'Top of the reservoir interval' for the Myken prospect and it is soft on the far offset. Top Tilje defines the top of the Håvær Prospect, and Top Kvitnos is top of the Innmyken Lead. The interpretation was done in the time domain and then depth converted using model based on a combination of seismic and well velocities.

Extensive geophysical work has been carried out on both the PGS16005 and NOR1001 surveys. This includes de-noising, spectral balancing and variable time adjustment of every angle stack to

optimise for further AVO work. EEI cubes (Intercept vs Gradient rotations) resulting in lithology and fluid cubes were also produced. The presence of depth consistent anomalies and hydrocarbon indications were not observed as a result of the geophysical analysis.

A 2D EM feasibility was performed for the Håvær Prospect. The synthetic EM line crosses the Håvær Prospect from W to E, and has a background resistivity based on nearby well data. The high resistive layer is included to account for Åre Coal below the Tilje reservoir. The frequencies used are 0.1, 0.1 0.4 and 1.0 Hz. Fig. 3.2 shows the synthetic model and the inversion result for the 15 Ωm case. The result is very patchy, and it is not possible to distinguish between coal and reservoir resistivity response.

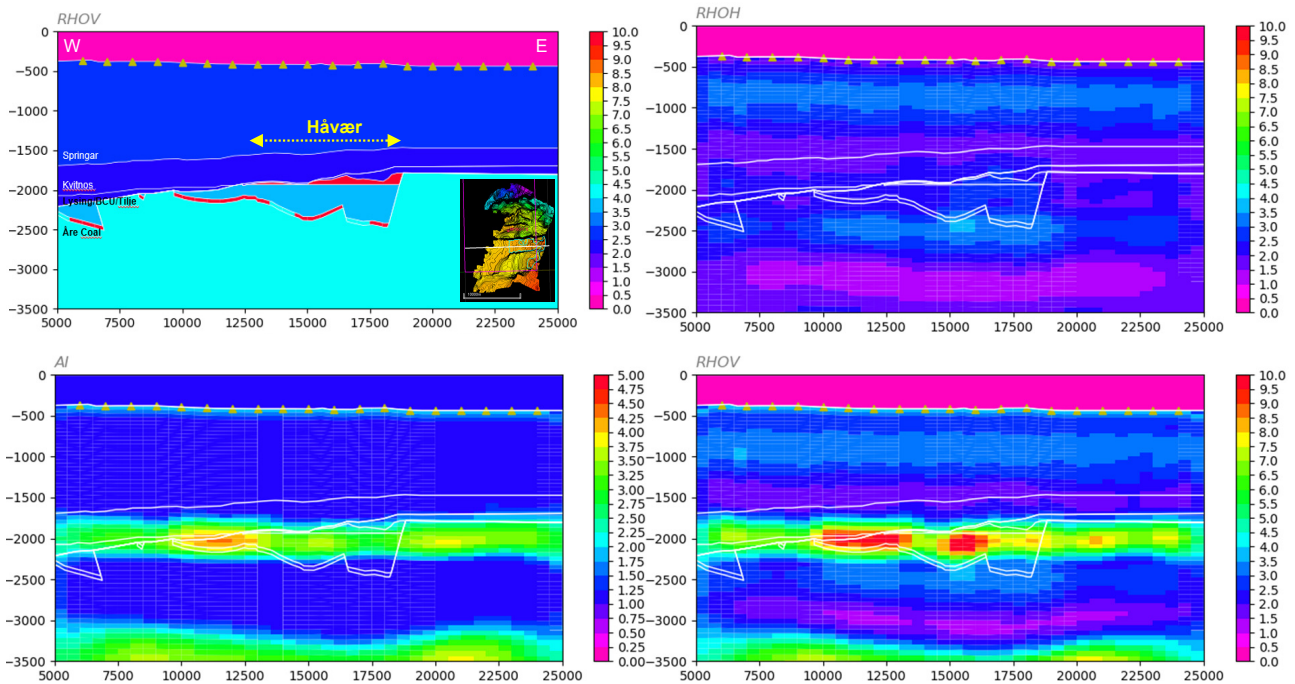


Fig. 3.2 EM feasibility model and inversion results. The Lower right panel shows the vertical resistivity responses and it is interpreted as inconclusive to distinguish between Åre coal and reservoir response.

Based on the new interpretation and studies completed compared with original application award, the following facts have been recognized:

- Reservoir characterization studies have not supported any Direct Hydrocarbon Indicators (DHIs) over Myken and other prospects
- The EM feasibility study completed for the Håvær Prospect concluded that EM is not optimal to de-risk the licence prospectivity. The Cretaceous Myken prospect is also considered unfit for EM.
- Petroleum system analysis has been integrated with geological and other studies. There is risk associated with charge, timing and some uncertainties related to biodegradation of hydrocarbons.
- The evaluation of Myken has resulted in a revised view on volume potential and risk, which differs significantly from the APA2017 application.
- Evaluation of the Håvær Prospect has also resulted in a slightly more negative view in terms of volume potential compared to the original application.
- The Innmyken prospect has been downgraded to a lead based on detailed G&G evaluation. Seal and trap are both highly uncertain and carry significant risk.

4 PROSPECTIVITY

4.1 Myken

The main prospect Myken is a Cretaceous hanging wall trap on the south-eastern flank of the Træna Basin. It is an elongated east-west structure, a 3-way dip-closure with fault seal towards the Grønøy High. In the east, the prospect seal potential is dependent on detachment of the reservoir sands and possible juxtaposition of the reservoir towards the heterolithic Triassic and Jurassic succession (Fig. 4.1).

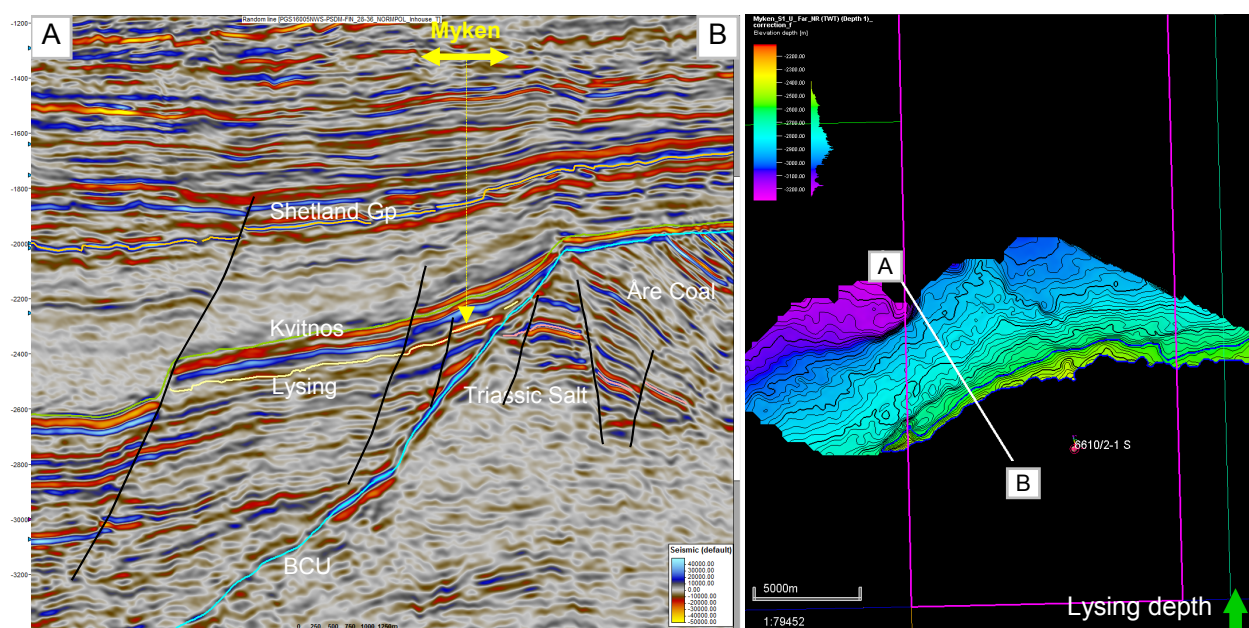


Fig. 4.1 Myken Prospect. Seismic section illustrating the prospect trapping geometry and potential risk on fault seal towards a footwall of Triassic Red Beds (left) and Lysing depth structure map showing prospect outline (right)

The reservoir is the Lysing Formation sandstone and it is interpreted to be density flow deposits along the flank of the Træna Basin, deposited after the Late Jurassic-Early Cretaceous rift period. The sands deposited within this basin can be interpreted to have different source areas. The Norwegian mainland was a dominating topographic high that was subject to erosion, but local highs (such as the Nordland Ridge Grønøy High) were also exposed, with Triassic successions being actively eroded and providing a sediment source for Cretaceous sediments. The 6610/3-1 R well, located northeast of the licence, proved a 40m sandy sequence within the Lysing Formation. The reservoir quality of the sand is moderate to poor, with an average 15% porosity and 50% net-to-gross.

The Myken Prospect is defined as a soft amplitude anomaly, brightening on offset data. Geophysical modelling of the 6610/3-1 R and 6610/2-1 S wells indicate that the soft amplitudes in the prospect are inconclusive. The amplitudes within the prospect are not depth consistent (Fig. 4.2), and it is therefore a significant risk that the observed anomalies mainly relate to lithology. The geophysical analysis has not supported any hydrocarbon presence in the Myken Prospect.

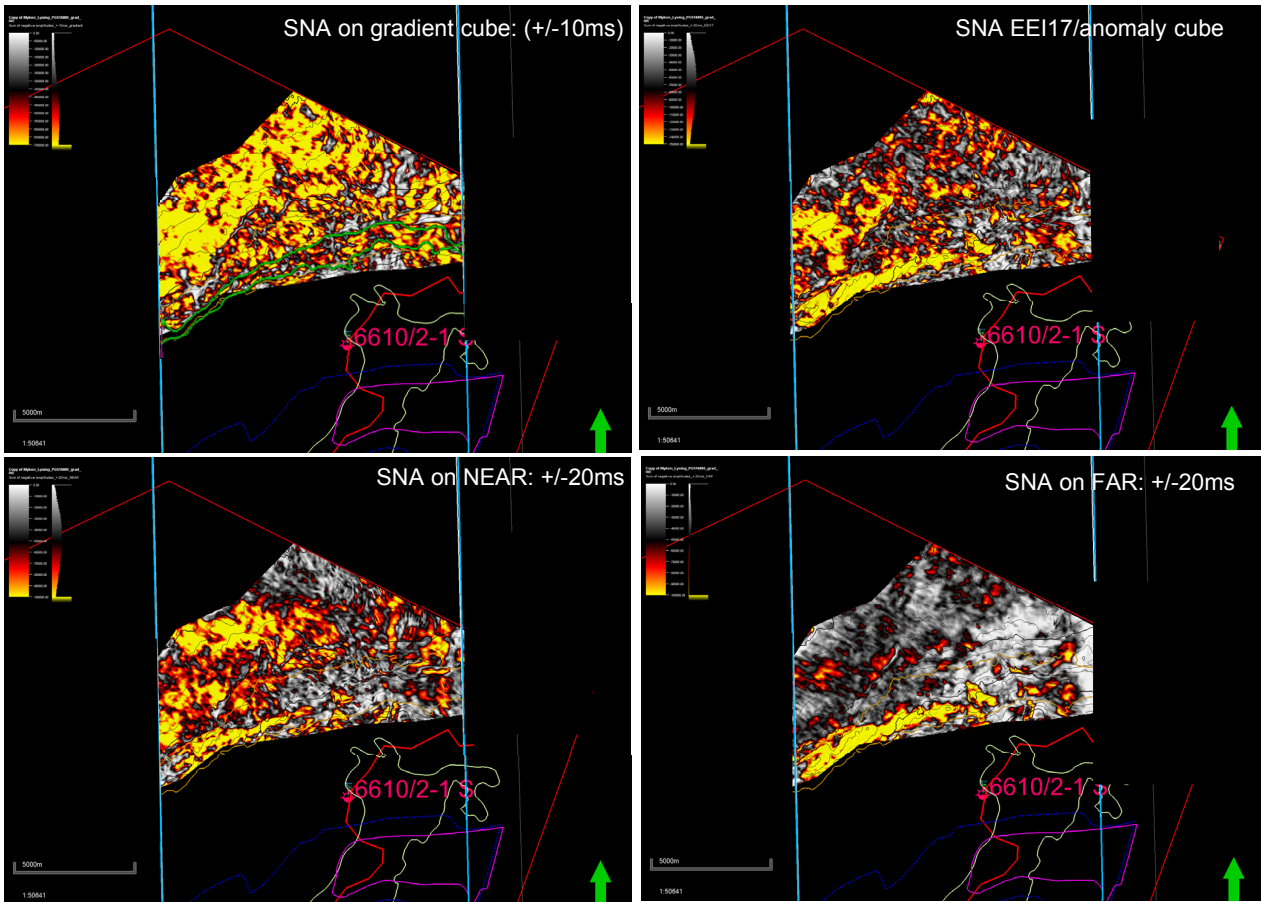


Fig. 4.2 Lysing time maps, sum of negative amplitude (SNA) maps on Gradient, EEI fluid and AVO cubes. No clear negative amplitudes in the fluid cube or the change in amplitudes vs angle follow the depth contours

The main risk for the prospect is seal, reflecting the dependency on fault seal towards a footwall block consisting of Triassic Red Beds and a Jurassic sequence.

The operator has conducted an extensive petroleum system study on a regional scale which proves the presence of Upper Jurassic source rock in Spekk and Melke Formations. Petroleum fluid inclusions and residual oil analysis indicate two distinct episodes of petroleum migration in the Northern Nordland Ridge.

The probability of discovery is estimated to 11% and the base case hydrocarbon recoverable reserves are estimated to $3.38 \times 10^6 \text{ Sm}^3 \text{ OE}$ total resources. The main risk associated with the Myken Prospect is seal and the secondary risk is the charge.

Table 4.1 shows the risk summary and resource distribution for Myken at the time of application award compared to final licence evaluation.

Table 4.1 Risk and resource summary of the Myken Prospect.

Descriptions		Myken (APA application)	Myken (PL948)
Risk factors		Risk	Risk
Reservoir	Reservoir Presence	0,8	0,8
	Reservoir Quality	0,6	0,7
Trap & Seal	Trap Geometry	0,8	0,8
	Seal Presence	0,5	0,35
Source	Source Presence	0,9	1
	Migration and timing	0,8	0,7
Retention	Retention	1	1
POS		0,14	0,11
Mean Rec. total resources (10⁶ Sm³ OE)		25,5	3,38

4.2 Håvær

The Håvær Prospect is a Lower Jurassic tilted and fault bounded dip closure with a truncation trap toward west. The top seal constitutes of clays of the Shetland Group/Upper Jurassic shale. Towards the east, the trap is dependent on fault seal towards Triassic Red Beds in the footwall position (Fig. 4.3). There is some distance to the source kitchen in the northwest, however, migrating sufficient amounts of hydrocarbons into Håvær is seen as viable. Working migration is also proven by good shows in the down-dip well 6610/2-1 S. Timing of migration is an issue, as well as the risk of biodegradation. The reservoir characterization study proved inconclusive for any fluid/DHI indications. Top seal is dependent on up-dip pinch-out of Kvitnos/Lysing Formation sandstone, and lateral fault seal is dependent on fault seal towards a footwall block consisting of Triassic Greybeds, Redbeds and Jurassic succession on the south and eastern faults.

The main risk associated with the Håvær Prospect is seal and the secondary risk is the charge. An analogue prospect was drilled by the 6611/1-1 Toutatis well in the neighbour licence (PL896) and was a very small discovery, emphasizing also the charge and seal risk.

Table 4.2 shows the risk summary and resource distribution for Håvær at the time of application award compared to final licence evaluation.

Table 4.2 Risk and resource summary of the Håvær prospect

Descriptions		Håvær (APA application)	Håvær (PL948)
Risk factors		Risk	Risk
Reservoir	Reservoir Presence	1	1
	Reservoir Quality	0,9	0,9
Trap & Seal	Trap Geometry	0,7	0,8
	Seal Presence	0,5	0,35
Source	Source Presence	0,9	1
	Migration and timing	0,6	0,7
Retention	Retention	1	1
POS		0,17	0,18
Mean Rec. total resources (10⁶ Sm³ OE)		13,1	9,72

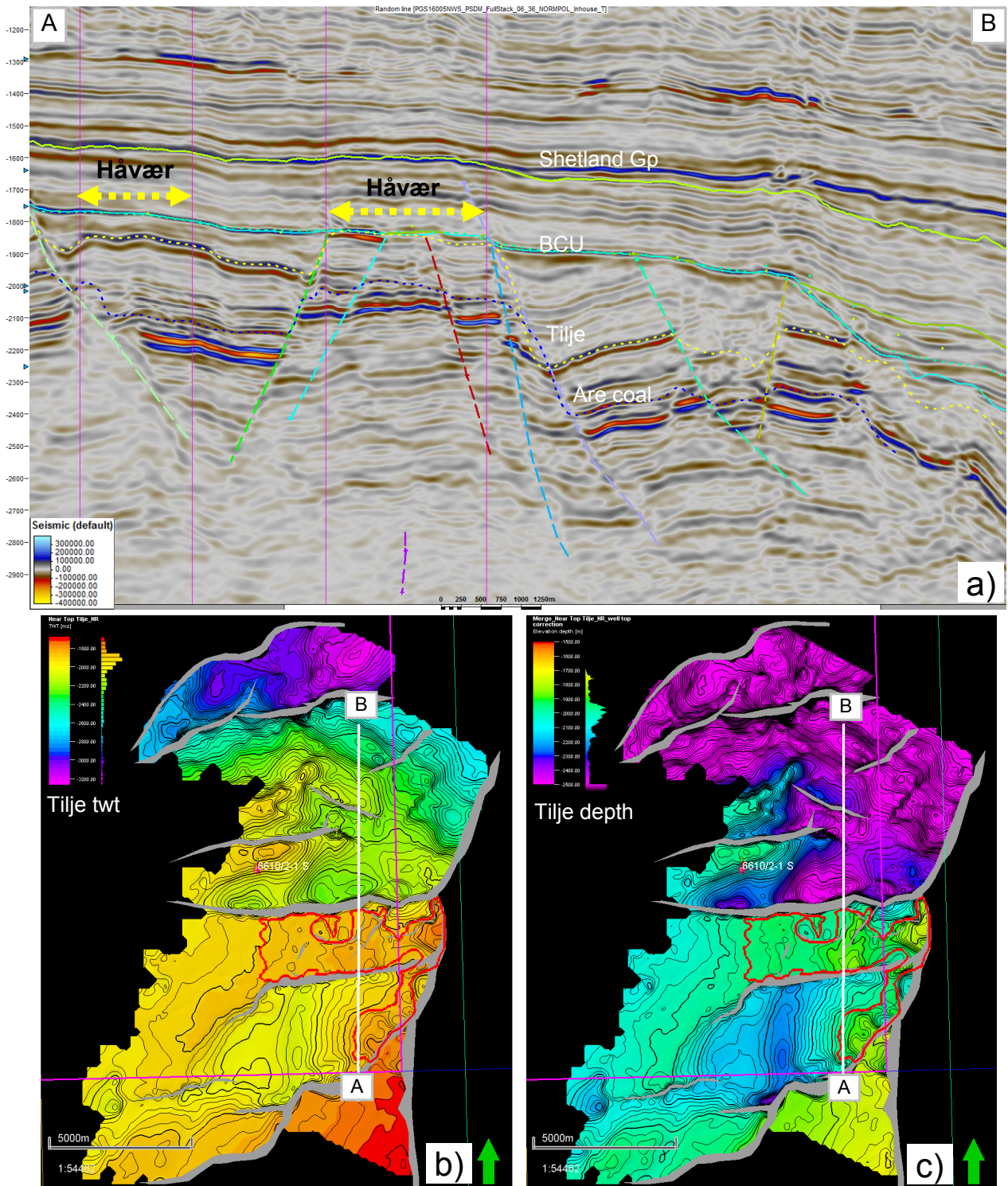


Fig. 4.3 Håvær Prospect a) Seismic section illustrating the prospect trapping geometry b) Top Tilje time structure map c) Top Tilje depth structure map

4.3 Other Leads

Innmyken North and South

Kvitnos Formation sandstones onlap the peneplained Grønøy High and pinch out up-dip. A stratigraphic trap with a dip closure to the west and north, and a stratigraphic closure to the east-southeast (Fig. 4.4). It is defined from seismic far angle amplitudes and the soft brightening on far offset seems to be a sand indicator, rather than a fluid indicator. The brightening is observed both up-dip and down-dip of the well 6610/2-1 S.

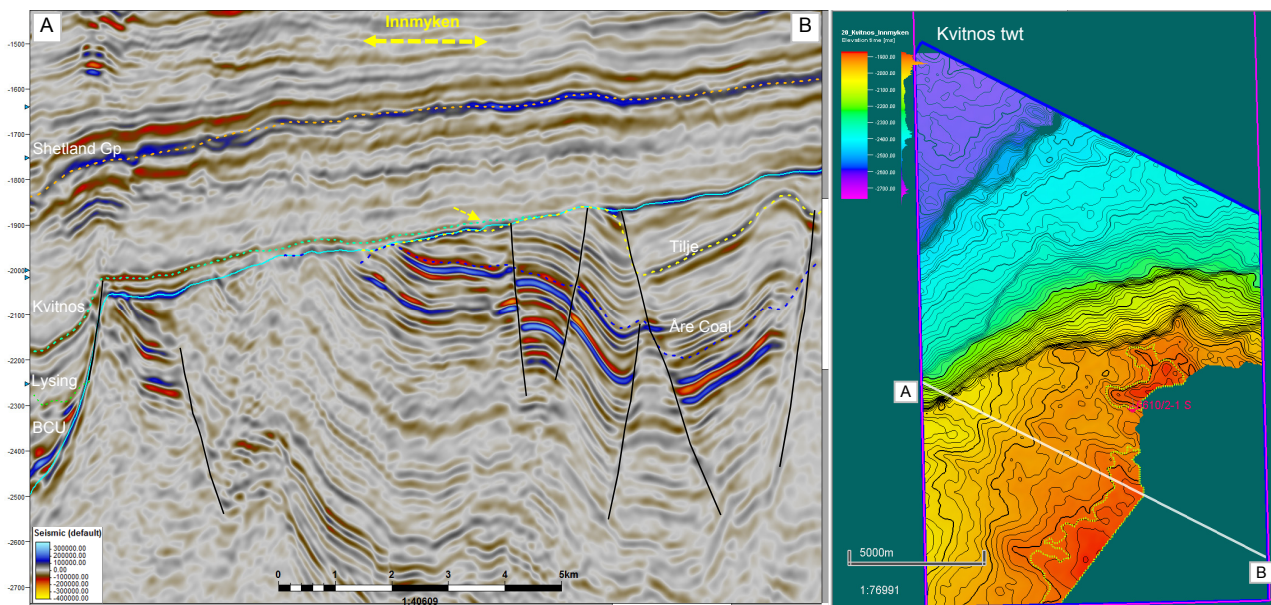


Fig. 4.4 Innmyken Lead *onlaps the Base Cretaceous Unconformity and it pinches out updip.*

The main risks are seal, trap and charge. Presence of seal is deemed highly unlikely. No direct hydrocarbon indicator (DHI) is observed.

Tjorven

The Tjorven Lead is a Jurassic combined structural-stratigraphic trap, defined by faults to the south, east and north and truncation to the west. The bounding fault to the southeast juxtaposes the reservoirs against the Triassic Grey Beds or Red Beds. Top seal is a high uncertainty with potential presence of Cretaceous thief sands to the southwest (Fig. 4.5). The lead is concluded as a small volume potential with very high risk.

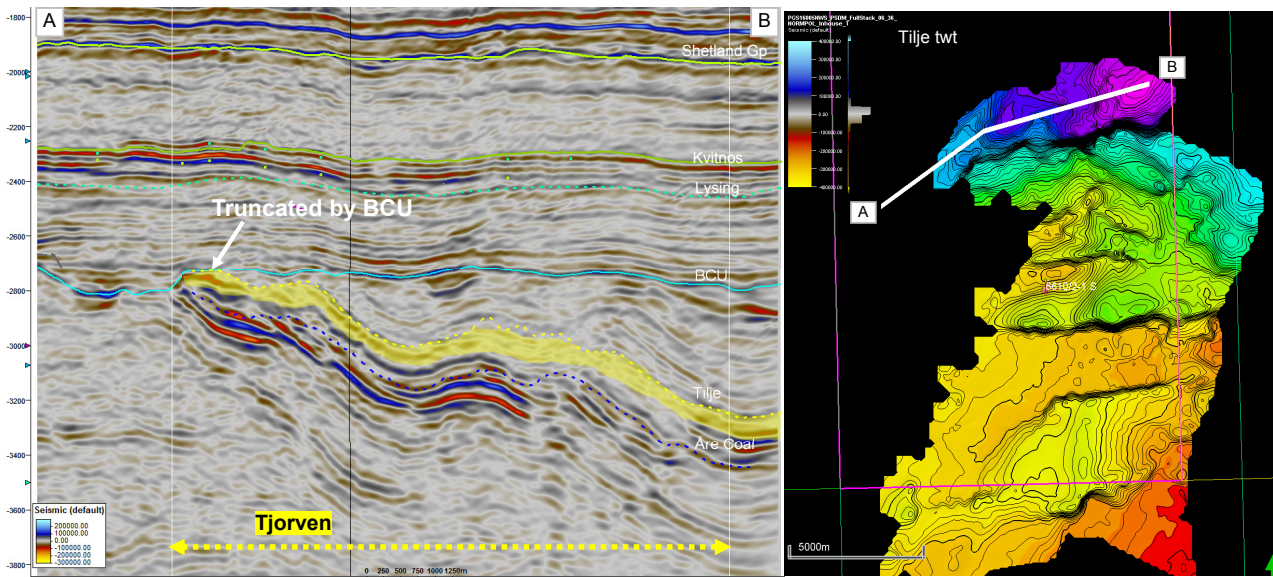


Fig. 4.5 Tjorven Lead. Seismic line that extends through the apex area and down into the Basin. Cretaceous thief sand is considered as high risk in the apex area.

Sandvær

A Lysing lead is defined partly within the license. The remaining part of the lead extends into the block 6610/1 in the west (Fig. 4.6). The lead is defined on an amplitude anomaly, soft response brightening with offset, and is dependent on a stratigraphic trap. The amplitude anomaly is believed to be a lithology effect rather than hydrocarbon indicator. Seal depends on sub-seismic sealing faults or sub-seismic stratigraphic pinch-out. No depth consistent amplitudes are observed.

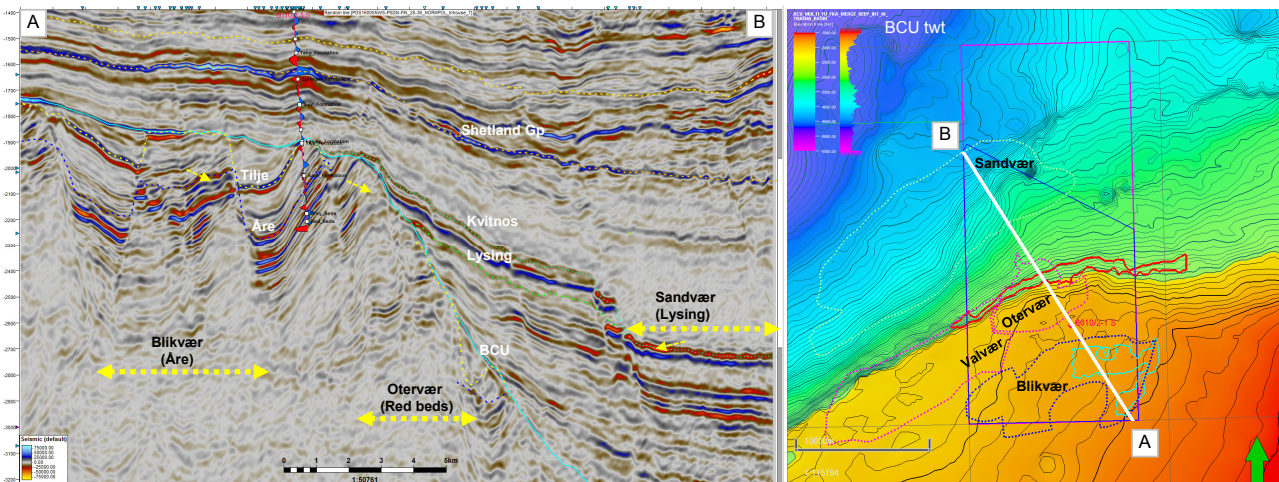


Fig. 4.6 Sandvær, Blikvær, Otevær and Valvær leads. Sandvær lead is a soft event on far offset along the southern rim of the Træna Basin. A top seal is very challenging for Blikvær (Åre Fm.). The Otevær is a large slide-block of Triassic.

Blikvær

Blikvær is an Åre Formation lead and the trap is defined as a combined structural-stratigraphic trap. Lysing sands act as possible carrier beds that onlap the trap from northwest. However, the same sands can also create a leakage route (Fig. 4.6). The risk is very high on the stratigraphic seal and additional risk is placed on migration.

Valvær and Otervær

Two sub-salt leads evaluated are the Valvær and Otervær leads. The Valvær Lead is a tilted fault block with a dip closure to the west that is partly within the licence (Fig. 4.6). The lead is defined as a sub-salt lead, and the top reservoir is interpreted on the lowermost salt layers in the Triassic. The crest of the structure is eroded, and Cretaceous sands are onlapping the high (present in 6610/2-1 S), leaving high risk on the trap. A main risk of Otervær is fault leakage into the Valvær lead.

4.4 Technical Evaluation

With the long distance to existing infrastructure, a stand-alone development is considered as the only development option. The resource potential of the identified prospectivity is too low to be of economic interest as a stand-alone candidate. Therefore, a full technical evaluation has not been carried out for the prospect. However, a preliminary technical economical evaluation has been completed for prospects and a Minimum Economical Field Size (MEFS) is estimated around 16 Mill Sm³ OE (recoverable). The calculated mean volumes in the remaining prospects are below this limit giving a high commercial risk. A combined development was considered an option should the 6611/1-1 Toutatis well be a success, however the well came in as a small discovery and consequently the commercial risk was not reduced.

5 CONCLUSION

Regional geologic studies carried out as part of the work program has significantly improved the understanding of PL948. Detailed seismic interpretation, geophysical evaluation, geological and petroleum system modelling study have highlighted the significant challenges when it comes to de-risking the seal potential of the main Myken Prospect and the secondary Håvær Prospect in the licence. Charge has also been identified as a secondary risk.

The seven mapped leads in Kvitnos, Lysing, Jurassic and Triassic all have significant risk on seal, trap and charge.

The prospectivity gives a relatively low resource potential and high risk picture. None of the prospects were viewed as drilling candidates and the licensees have thus concluded to relinquish the licence.

6 REFERENCES

Relinquishment Report PL895, 2019