

PL651 Relinquishment Report

Table of Contents

1 Key License History	1
1.1 Introduction	1
1.2 Key license history.....	1
1.3 Reason for relinquishment.....	3
2 Database	4
2.1 Well database	4
2.2 Seismic database	6
2.3 Special studies	7
3 Review of Geological and Geophysical Framework	8
3.1 Performed studies	8
3.2 Results of block evaluation and major changes compared to original license application	10
4 Prospects update	11
4.1 Prospects originally presented in license application.....	11
4.2 Overview of PL651 prospectivity.....	13
4.3 Fløholmen prospect.....	14
4.4 Remaining prospectivity	17
5 Technical evaluation	18
6 Conclusion	19

List of Figures

2.1 3D/2D seismic part of the license common database.....	6
3.1 W-E cross section across 6610/7-1 well	9
3.2 Depositional environment map of Barremian	9
4.1 Prospects (full outlines) and leads (dotted outlines) map of prospectivity after APA2011 .	12
4.2 Prospects (full outlines) and leads (dotted outlines) map after PL651 evaluation in 2016 .	13
4.3 Seismic lines through the Fløholmen prospect	14
4.4 Fløholmen prospect map with contacts	14

List of Tables

1.1 Overview of held meetings	2
2.1 Well database	5
2.2 Special studies performed for PL651 prospectivity evaluation	7
4.1 Main prospectivity applied for in APA 2011 by licensees	11
4.2 Prospect and leads after PL651 evaluation	13
4.3 Changes in resource volume and probability estimates	15
4.4 Fløholmen resource volumes and probability estimates	16

1 Key License History

1.1 Introduction

The PL651 license is located in the Eastern part of the Helgeland Basin, an area of 1.337,942 km² in blocks 6610/8, 9, 11 and 12. DEA E&P Norge, as operator for the PL651, together with all the license partners, decided to surrender the license at the drill or drop decision point on 3rd of February 2017.

1.2 Key license history

Summary of award and participants

PL651 was originally awarded as part of the APA 2011, on the 3rd of February 2012. E.ON E&P Norge, now renamed DEA Norge, was appointed operator of the license with a 40% share and the remaining ownership was distributed as follow: Spring Energy Norway AS 35%, Dana Petroleum Norway AS 25%. In July 2016, Dana Petroleum Norway AS transferred their share to Tullow Oil Norge AS (formerly Spring Energy Norway AS). The initial drill or Drop decision date was set up the 3rd of February 2016.

Initial work obligations and work periods

Within 2 years of the award (initially by the 3rd of February 2014):

- Acquisition of a minimum 500 km of long-offset 2D-seismic data
- Perform geological and geophysical studies (including basin modelling)
- Decide to 3D-seismic acquisition or drop the license

Within 4 years of the award (initially by the 3rd of February 2016):

- Acquisition of a 3D-seismic
- Decide to drill or drop the license

Within 6 years of the award (initially by the 3rd of February 2018):

- Drill an exploration well
- Decide to concretise (BoK) or drop the license

Within 8 years of the award (initially by the 3rd of February 2020):

- Perform conceptual studies
- Decide to continue (BoV) or drop the license

Within 9 years of the award (initially by the 3rd of February 2021):

- Prepare and submit PDO (Plan for development and Operations) or drop the license

Any applications and grants for extension of deadlines

E.ON E&P Norge as operator of PL651 applied for a one-year extension to the Drill or Drop decision in December 2015. This one-year extension was granted by the authorities in February 2016. The operator applied for this extension to reprocess the 3D-seismic data: Due to a strong water bottom reflector the final 3D dataset contains high amplitude multiples and has a poor signal/noise ratio. This impacts the imaging at the Jurassic level and limits the usefulness of the data for detailed geophysical analysis. Consequently the risk associated with the main prospect is relatively high due to lack of precise definition of the bounding faults and the inability to use geophysics to determine indications of hydrocarbon presence.

Overview of meetings held

The table below contains the list of meetings held during the license period:

Table 1.1 Overview of held meetings

Meeting	Date	Overview
EC/MC meeting 1	23/03/2012	Establishment of the license, building the common database, sharing views on prospectivity, planning of 2D seismic acquisition, budget and work program
EC work meeting	27/06/2012	Planning of 2D seismic acquisition
EC/MC meeting 2	29/11/2012	Status on exploration, and 2D seismic acquisition and processing, budget and work program
EC work meeting	25/06/2013	Review and selection of the acquired 2D lines for the license common data base
EC/MC meeting 3	29/11/2013	Status on exploration (incl. Basin modelling), planning of 3D seismic acquisition, budget and work program
EC/MC meeting 4	17/01/2014	Status on exploration (incl. Basin modelling & prospectivity), seismic call for tender, budget and work program
EC work meeting	27/02/2014	Selection of seismic acquisition parameters
EC/MC meeting 5	25/11/2014	3D seismic acquisition and processing, budget and work program
EC/MC meeting 6	16/11/2015	3D seismic processing summary, status on exploration (regional geology, basin modelling, prospectivity), planning of 3D reprocessing, budget and work program
EC work meeting	17/03/2016	3D seismic reprocessing quick off
EC/MC meeting 7	21/11/2016	3D seismic reprocessing summary, prospectivity status (incl. risk and volume assessments), budget and work program

1.3 Reason for relinquishment

A full mapping of the license prospectivity has been performed and presented to the partners in November 2015. The resulting prospect ranking led to the definition of what is believed to be the most attractive prospect of the license: Fløholmen, a well-defined Lower Jurassic fault block. After the seismic reprocessing focused on this prospect, volume and risk assessments, reservoir profiles, field development and economic studies were performed leading to the following figures: 22% probability of finding Hydrocarbons, holding 101MSTB of recoverable resources of oil equivalent (mean case). The Fløholmen prospect is assumed to contain mainly oil. The key geological risks are linked to the charge as the Helgeland Basin is considered to be early mature with uncertain migration and no discovery were made in the basin, and to the retention as this area has been affected by a Late Tertiary uplift.

Due to the high risk / medium reward of the main prospect in the license, the partnership was unable to commit to a drill decision. DEA Norge, therefore, recommended surrendering the license in January 2017.

2 Database

2.1 Well database

During the PL651 activity, the well 6610/10-1 was drilled by Statoil in 2013 and the results included in the evaluation. No other well in the vicinity or at regional scale were drilled. The table below is listing the wells used in the license common database for the prospectivity evaluation.

Table 2.1 Well database

Well	Operator	Year	TD (mMD and age)	Results	Main use in the license evaluation
6508/5-1	A/S Norske Shell	1987	2586, Late Triassic	dry	Petrophysical evaluation
6510/2-1R	A/S Norske Shell	1997	4707, Early Triassic	shows	Seismic to well tie, Petrophysical evaluation, Calibration for Basin Modelling
6609/5-1	Den norske stats oljeselskap a.s	1985	3600, Mid Triassic	shows	Petrophysical evaluation
6609/7-1	Phillips Petroleum Company Norway	1983	1969, pre Devonian	dry	Petrophysical evaluation
6609/10-1	Saga Petroleum ASA	1983	2167, Late Triassic	dry	Petrophysical evaluation, Calibration for Basin Modelling
6609/10-2	Det norske oljeselskap ASA	2009	2528, Late Triassic	dry	Petrophysical evaluation, Calibration for Basin Modelling
6609/11-1	Norsk Hydro Produksjon AS	1983	3068, Late Triassic	dry	Seismic to well tie, Petrophysical evaluation, Calibration for Basin Modelling
6610/2-1S	Den norske stats oljeselskap a.s	1996	2673, Triassic	shows	Petrophysical evaluation
6610/3-1R2	Den norske stats oljeselskap a.s	1993-96	4200, Late Triassic	shows	Petrophysical evaluation
6610/7-1	Den norske stats oljeselskap a.s	1983	3333, Late Triassic	shows	Seismic to well tie, Petrophysical evaluation, Calibration for Basin Modelling
6610/7-2	Den norske stats oljeselskap a.s	1984	4215, Early Triassic	dry	Seismic to well tie, Petrophysical evaluation, Calibration for Basin Modelling
6610/10-1	Statoil Petroleum AS	2013	3006, Late Triassic	dry	Seismic to well tie, Petrophysical evaluation

2.2 Seismic database

The most recent interpretation has been performed on the MCG1202 (2D), EO14001 (3D) and EO14001RE16 (3D) surveys within and in the close vicinity of PL651. Figure 2.1 shows the location of those surveys as well as the location of the other 2D surveys part of the license common database.

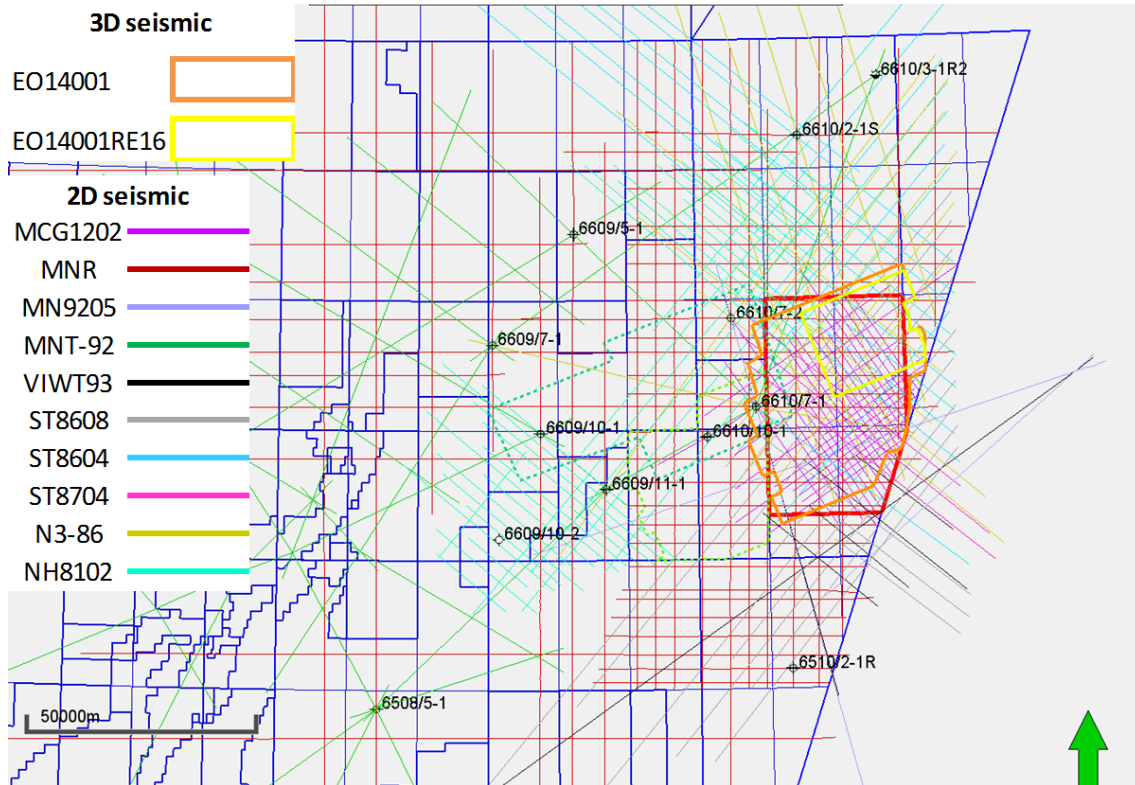


Figure 2.1 3D/2D seismic part of the license common database

- The 2D survey MCG1202 was acquired by Multiclient Geophysical AS and partially bought at a very early stage by each partner as part of the work commitment (phase 1). 1042 km of the MCG1202 survey were selected and became part of the license common database in 2013.
- The 3D survey EO14001 was acquired as part of the license work commitment during the summer 2014 (phase 2). The survey was acquired by Dolphin Geophysical on a proprietary basis, using the “Sanco Sword” vessel during 33 days (from 08/07/14 to 09/08/14) for an area of 1266 km². The PSTM processing was also performed by Dolphin Geophysical from august 2014 to May 2015.
- EO14001RE16 is a reprocessing of the EO14001 survey performed by CGG from March to September 2016. This reprocessing, focused on the main prospect, was decided by the license partnership to get better seismic quality, especially in the Jurassic level, to allow experts to perform an AVO analysis.

2.3 Special studies

In connection with the license work and the preparation of the drill or drop decision, the following geological and geophysical studies were undertaken:

Table 2.2 Special studies performed for PL651 prospectivity evaluation

Year (start)	Study	Author
2012	Seismic interpretation of 2D seismic surveys	DEA
2013	Basin modelling	DEA
2015	Seismic interpretation of EO14001	DEA
2015	Tertiary uplift and erosion assessment	DEA
2015	Detailed seismic stratigraphy study	Geolink
2015	Basin modelling update	DEA
2015	Fault seal analysis	DEA
2015	Rock physics / AVO analysis	DEA
2016	Seismic interpretation of EO14001RE16	DEA
2016	Fault seal analysis update	DEA
2016	Rock physics / AVO analysis	DEA

3 Review of Geological and Geophysical Framework

3.1 Performed studies

In connection with the license work the following geological and geophysical studies and results were used in the evaluation of the prospectivity of PL651:

- 2D/3D Seismic acquisitions and reprocessing of 3D seismic
- Basin modelling
- Detailed seismic stratigraphy
- AVO/rock physics

2D/3D Seismic acquisitions and reprocessing of 3D seismic

As part of the work commitment, the license acquired 2D then 3D seismics on the PL651 acreage. These have been used to better define the different prospects/leads. Some of the early prospectivity has been discarded after these steps allowing the partnership to focus on other prospects. However, due to a strong water bottom reflector and complex overburden the acquired 3D seismic EO14001 has a poor signal to noise ratio. A time reprocessing has been performed on the main prospect, focused on the Jurassic level to better define the bounding faults by improving the noise cancelation, demultiple and deghosting. These datasets have been extensively used for interpretation, fault seal analysis and AVO study.

Basin modelling

The main objectives of the 3D basin modelling study were to assess the potential source rocks in the drainage area of the prospects, their thickness, lateral extent and organic richness and to investigate the burial, thermal and maturity evolution and the timing of petroleum generation and calculate a range for the generated and accumulated HC volumes. The study area covered almost the whole Helgeland Basin in 2013, including 10 wells for calibration. The update of the basin modelling done in 2015 was more focused on the license area.

The model took into account only the proven source rock from the Kimmeridgian age. The Rhaetian to Sinemurian source rocks (Åre coals) were tentatively modelled, but due to their high heterogeneity it was inconclusive. The 3D basin model was built up on 21 layers from the basement to the Upper Naust layer (figure 3.1).

The basin modelling concluded that the Kimmeridgian source rock reached the early oil window in the center of the Helgeland basin, and the main oil window was reached in a more restricted area. The overall size of the mature area is uncertain, but could be constrained to cover at least the southern and middle part of PL651. Generation and expulsion have taken place since Early Tertiary times. Migration Modelling predicts successful entrapment of oil at the Fløholmen prospect; filling of the trap is consistently enhanced by a 'fill-spill chain' of small traps present on the migration route from the kitchen to the trap. This effectively enlarges the fetch area of this prospect, and decreases its overall sensitivity to heat flow, source potential, etc. However the migration pathway stay challenging as it needs a downward migration from the source rock (Kimmeridgian) to the reservoir (Pliensbachian) with no major fault between the kitchen and the reservoir facilitating.

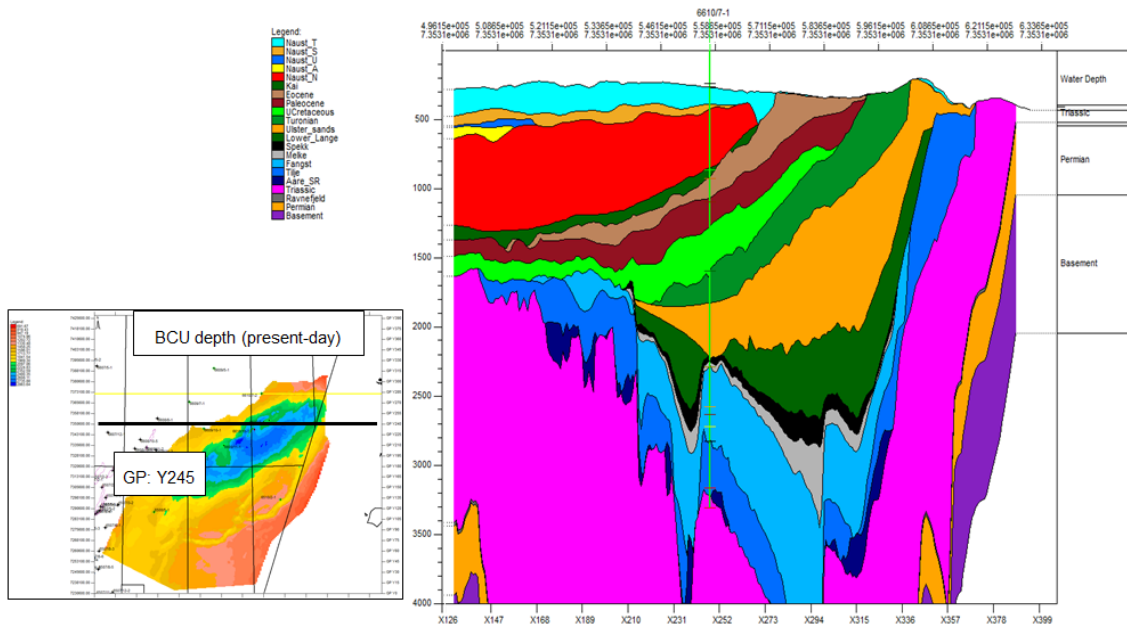


Figure 3.1 W-E cross section across 6610/7-1 well

Detailed seismic stratigraphy

The detailed seismic stratigraphy study was performed by Geolink and focused on the Lower Cretaceous prospectivity. The objective was to update the interpretation of the 2D/3D seismic database to produce new seismically controlled structure and facies maps in order to better screen and delineate potential prospectivity. It illustrated the high probability of finding sandy features in the Lower Cretaceous sediments like shingled turbidites or sandbars of the prograding system sourced from the North East (figure 3.2).

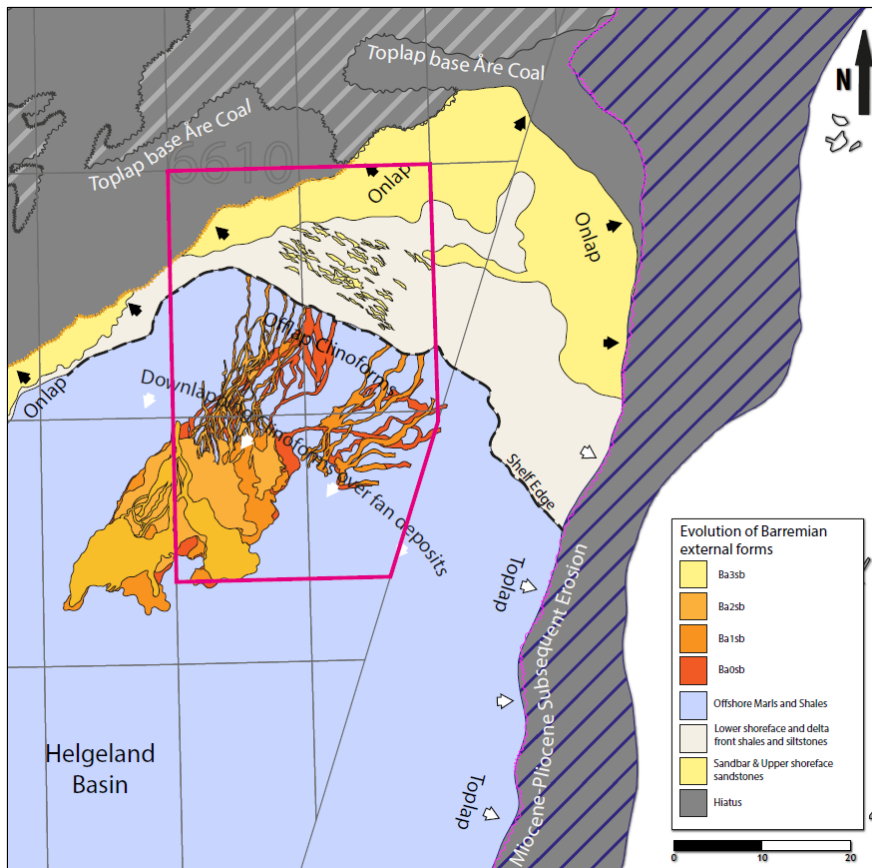


Figure 3.2 Depositional environment map of Barremian

AVO/rock physics

A rock physics / AVO analysis was performed on two 3D datasets: the original EO14001 and the reprocessed EO14001RE16. These have unfortunately not been conclusive due to poor seismic quality and lack of fluid data in the Helgeland Basin causing a large uncertainty on the synthetic modelling. However, oil with high density and low GOR is expected in this area due to late charge that should result in a weak AVO effect.

3.2 Results of block evaluation and major changes compared to original license application

The work carried out over the course of the initial license period was primarily to illuminate the structural geology of the Eastern part of the Helgeland Basin within the license area through the acquisition of 2D then 3D seismic surveys and assess its prospectivity. The license kept an open-mind in its review of the prospectivity and considered potential targets in Triassic, Jurassic, Cretaceous and Tertiary plays. The new structural picture provided by the acquisition of both 2D and 3D seismic surveys were key elements in the prospectivity evaluation. Used as input for detailed mapping, AVO studies and constrained basin modelling, they allowed the license to define the most prospective play in PL651: Lower Jurassic structural traps.

Several Lower Jurassic structures were highlighted as possible prospects and Cretaceous brightening identified as stratigraphic leads. Screening of the Tertiary and Triassic indicated little potential due to lack of structure in the Tertiary and because of the poor seismic imaging below the Jurassic.

4 Prospects update

4.1 Prospects originally presented in license application

The PL651 lies in the eastern side of the Helgeland Basin, and is bounded toward the north by the Nordland Ridge. The work carried on during the license period focused on the evaluation of the exploration potential of the Lower Jurassic prospects and on leads in the Tertiary, Cretaceous and Upper Jurassic levels. The companies that have been part of the license partnership identified different prospects/leads in the APA2011 application which are summarized in the table 4.1 and figure 4.1 below.

Table 4.1 Main prospectivity applied for in APA 2011 by licensees

Company	Name in APA2011	Type	Age of reservoir	Comments
DEA	Båvarden	prospect	Low Jurassic	Discarded after 2D/3D seismic acquisition
DEA	Buholmen	prospect	Low Jurassic	Discarded after 2D/3D seismic acquisition
DEA	Fløholmen	prospect	Low Jurassic	Main prospect after license evaluation
Tullow/ Dana	Lapins	prospect	Up Jurassic	Difficult to de-risk further
Tullow/ Dana	Ulster	lead	Cretaceous	Difficult to de-risk further

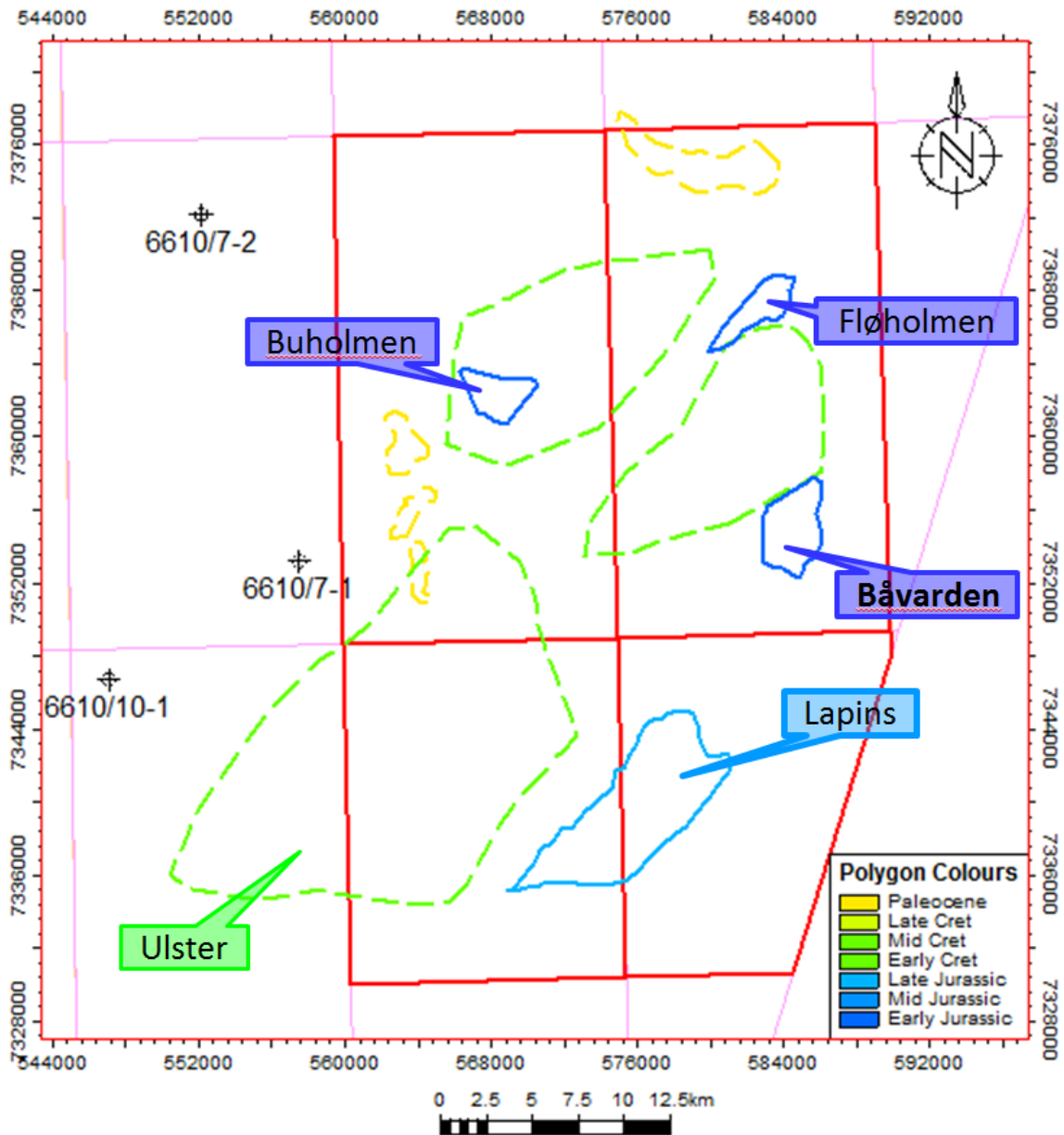


Figure 4.1 Prospects (full outlines) and leads (dotted outlines) map of prospectivity after APA2011

Following the acquisition and processing of the 2D survey MCG1202 and the 3D survey EO14001, the license was able to identify and evaluate structures that were not described in the initial application, and mature them into lead or prospect status. Reversely, some previously identified prospects were downgraded or even discarded as the structural pattern changed. Originally, during APA 2011 application, E.ON identified 3 main prospects in the license: Båvarden, Buholmen and Fløholmen. These prospects were interpreted on 2D seismic as a 3-way dip closure against a major fault for Båvarden and tilted fault blocks for the 2 others. The 2D and 3D data acquired showed that Båvarden's closure was much smaller than expected and Buholmen's structure was an artefact. The attention was then turned to other possibilities, including the Fløholmen prospect.

4.2 Overview of PL651 prospectivity

The prospectivity of PL651 after evaluation is summarized in the table 4.2 and illustrated in figure 4.2.

Table 4.2 Prospect and leads after PL651 evaluation

Prospect name	Status	Age of reservoir	Depth of crest (mSS)	Probability of finding HC (main risk)	Exp. Fluid	P90-P50- P10 total recoverable volumes (MSTBOE)	
Fløholmen	Main prospect	Low Jurassic	1910	22% (charge/retention)	Oil	3,4-49-267	
Utstein	Prospect	Low Jurassic	1180	11% (charge/trap validity)	Oil	13-55-244	
Røst	Lead	Low Jurassic	2580	16% (trap validity)	Oil	12-38-89	
Ulster	Central	Lead	Cretaceous	1500	10% (reservoir)	Oil	16-74-300
	South						Not calculated
	North						Not calculated
Lapins	Lead	Up Jurassic	2450	8% (reservoir)	Oil	Not calculated	

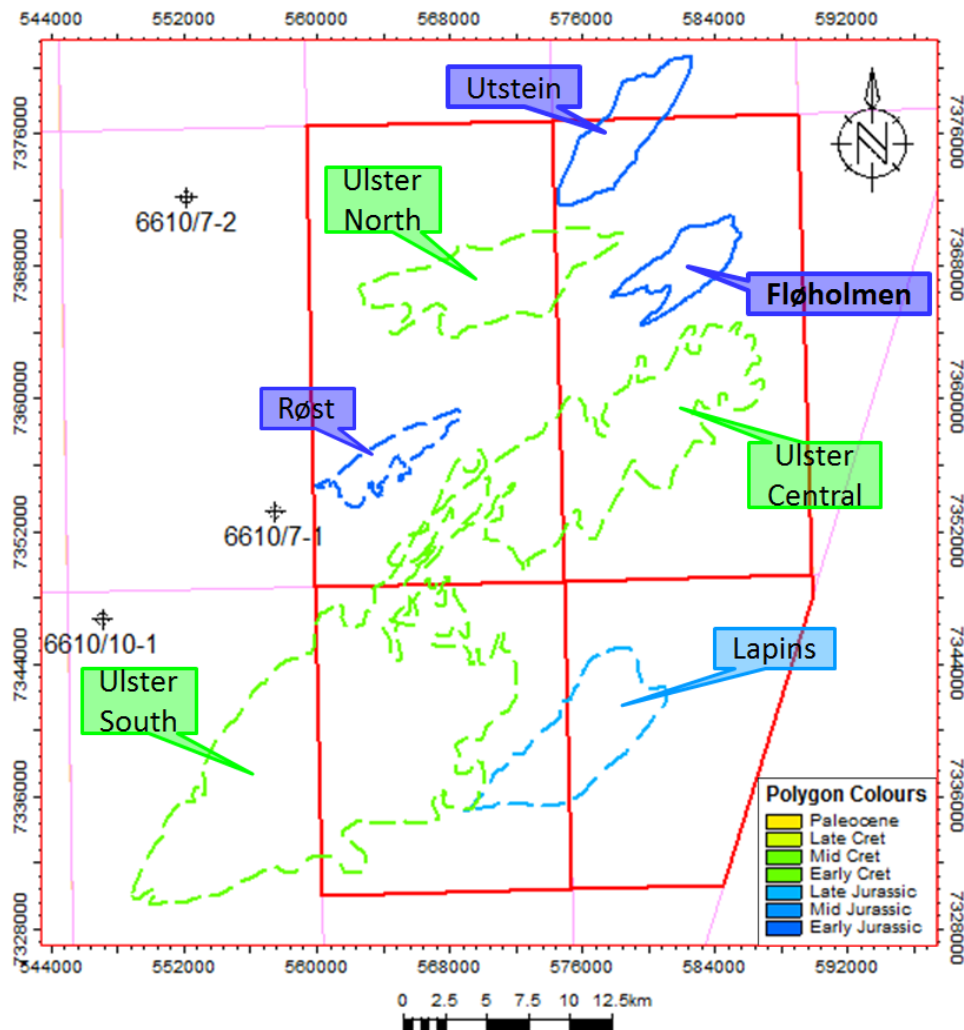


Figure 4.2 Prospects (full outlines) and leads (dotted outlines) map after PL651 evaluation in 2016

4.3 Fløholmen prospect

Fløholmen is a structural prospect made up of several fault blocks in contact (figure 4.3 & 4.4). It is composed of Lower Jurassic sediments (Tilje / Åre Formations) sealed by shales of the Middle and Upper Jurassic (Ror / Melke / Spekk Formations). Most of the wells in the Helgeland Basin (except 6510/2-1 well) give good confidence to have upper shoreface sandstones in the Tilje Formation and sand rich fluvial depositional environment in the Åre Formation with good properties; Tilje/Åre combined thickness between 240m and 600m, N/G ranging from 20% to 70%. The prospect is lying between 1900 and 2300mSS in a location where uplift is estimated to be 550m, indicating expected porosity in the Båt Gp between 17% and 28%.

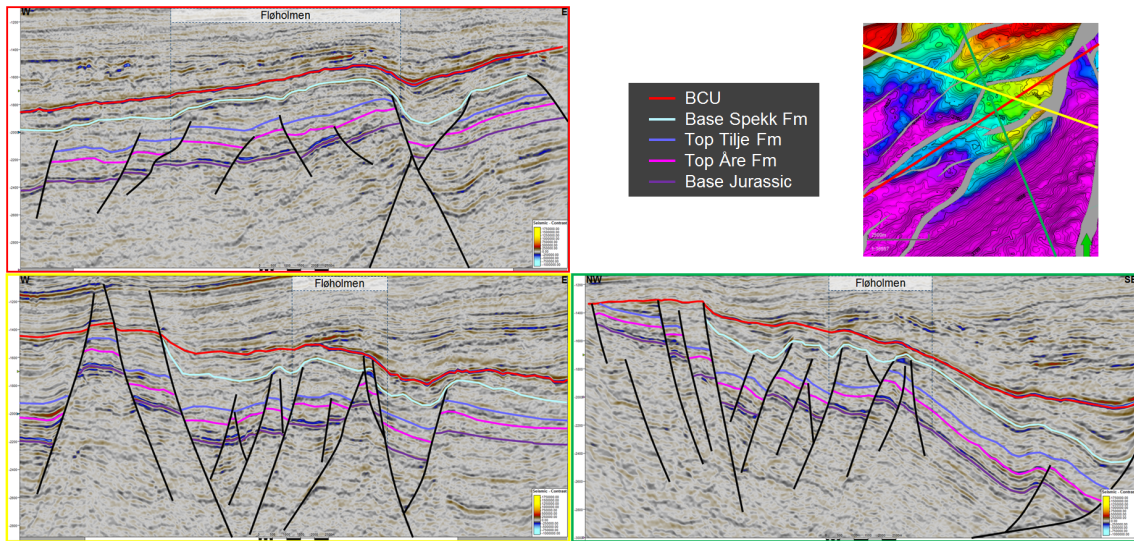


Figure 4.3 Seismic lines through the Fløholmen prospect

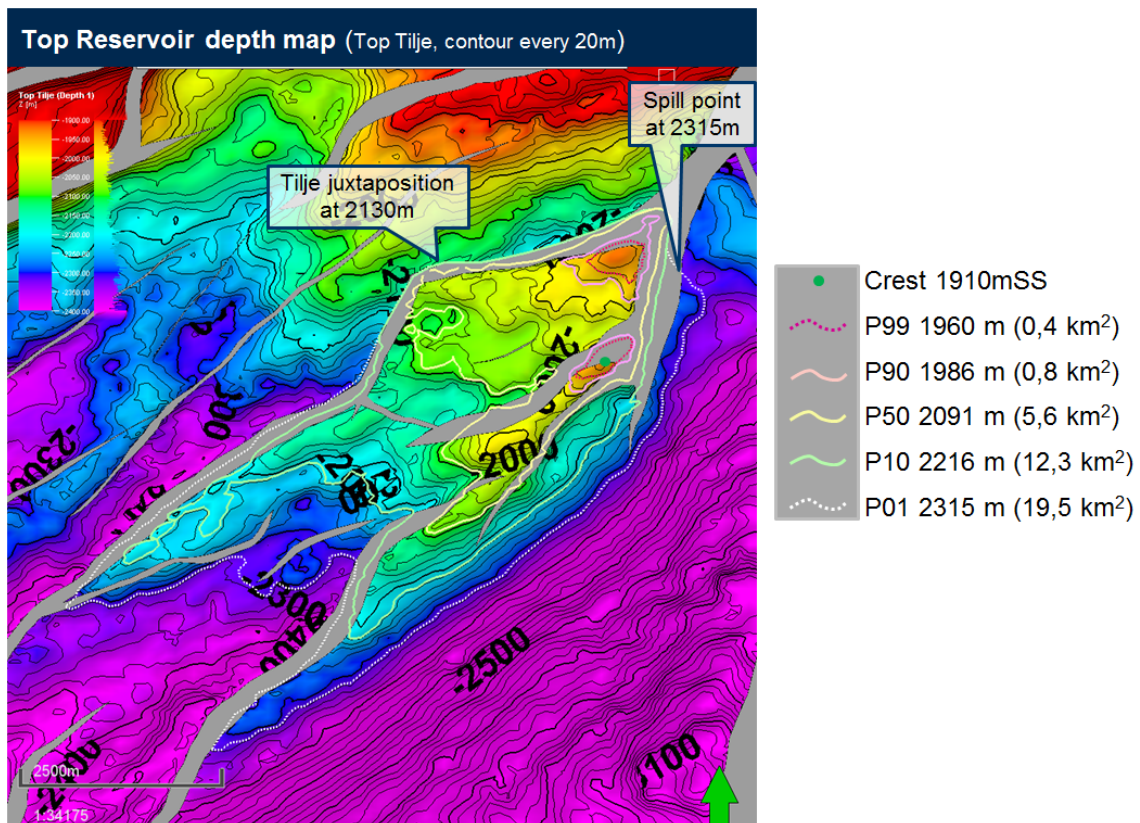


Figure 4.4 Fløholmen prospect map with contacts

The basin modelling performed during this evaluation took into consideration only the Upper Jurassic source rock (Spekk Formation) which is proven to be at least early mature in the Helgeland Basin. However, other source rocks could be considered such as the Åre and Permian source rocks. Due to the shallow maximum burial depth of the source rocks, all the hydrocarbons generated in the basin are expected to be oil with low GOR. The prospect lies in a favorable position regarding drainage area, even though migration pathways remain quite uncertain.

The main risk for this prospect is linked to the access to charge and retention of hydrocarbons. Regarding the access to charge, it is partially due to a low density of wells in the basin and none of them had been successful (all dry, some with shows). In addition, the basin modelling showed that migration is challenging for a Lower Jurassic reservoir as it needs vertical migration through the Middle Jurassic shales. However Fløholmen lies in the most favorable location in the Helgeland Basin to be charged. The 6610/7-1 well shows that retention is also problematic in Lower / Middle Jurassic faulted structures: 50 meters of continuous shows have been observed in the well which can be interpreted as an hydrocarbon paleocolumn in the Pliensbachian to Toarcian sediments. An explanation may be that the fault breached during the Late Tertiary uplift. Reservoir presence and quality are not seen as a major risk in this area as all of the surrounding wells encountered Lower Jurassic sandstones with good properties.

Changes in resource volumes and probability estimates are presented in table 4.3 below:

Table 4.3 Changes in resource volume and probability estimates

		APA 2011 Application			2016 Evaluation		
		P90	P50	P10	P90	P50	P10
In place	Oil (10 ⁶ Sm ³)	12,8	27,9	55,4	1,44	20,4	101,7
	Associated gas (10 ⁹ Sm ³)	0,55	1,48	4,07	0,07	0,99	5,27
Recoverable	Oil (10 ⁶ Sm ³)	5,6	12,2	25,9	0,52	7,36	40,5
	Associated gas (10 ⁹ Sm ³)	0,24	0,66	1,86	0,03	0,36	2,05
Probability of finding HC		13%			22%		

The probability of finding hydrocarbons in the Fløholmen prospect after the 2016 evaluation is estimated to be 22%, with a mean total resources of 16,1 10⁶ Sm³ OE (table 4.4).

4.4 Remaining prospectivity

- The Utstein prospect is similar to Fløholmen in terms of formations and depositional environment. It is a shallower tilted fault block partially eroded by the BCU. The lower probability of finding hydrocarbons is due to the location of the prospect regarding the migration (more distant from the kitchen and partly in the shadow of Fløholmen) and the top seal composed of shales from the Shetland Gp.
- The Røst lead is similar to Fløholmen in terms of formations and depositional environment. It is a 3-way dip closure against a major fault in the basin which also control the structure drilled by the 6610/7-1 well (shows). It is considered as a lead because of its relatively small size and its high dependency to the time-depth conversion.
- The Ulster lead (South, Central and North) is defined as a stratigraphic trap of channelized and turbiditic sandstones from the Hauterivian / Barremian age. It is considered as a lead because of the high risk on reservoir presence and quality, charge and retention.
- The Lapins lead is a stratigraphic trap in the Rogn Formation. It has not been possible to further de-risk the reservoir presence.

5 Technical evaluation

E.ON, then DEA Norge, has performed a full evaluation regarding a possible development in case of discovery for Fløholmen. Due to distance to existing infrastructures (closest liquid facility is Norne, ca. 130km to the WSW) the considered development is a stand-alone FPSO. Associated gas is re-injected and water injection is used for pressure support. Economic analysis suggests that a discovery in the P17+ size range could lead to a positive economy.

6 Conclusion

During the license period operated by E.ON E&P Norge, then DEA Norge, extending from 3rd of February 2012 to 3rd February 2017, the partnership of PL651 has evaluated what is believed to be the exploration potential of the blocks. Based on this technical work, Fløholmen is considered to be the main prospect of the license and the best candidate to be drilled in order to further de-risk prospectivity in the Lower Jurassic play. Fløholmen oil case was run providing recoverable resources of 101 MSTB (mean) with a probability of finding hydrocarbons of 22%. However, due to the remote location, the chance of commercial success drops to 10%.

As a result of the high risk /medium reward of the main prospect in PL651, the licence agreed that there is not sufficient basis for a positive drill decision and has therefore decided to surrender the licence.